22nd International Spin Symposium

Sunday, 25 September 2016 - Friday, 30 September 2016

iHotel Conference Center

Programme

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Sunday 25 September 2016

Social: Registration - Knowledge (15:00-21:00)

Social: Opening Reception - Illinois Ballroom (19:00-22:00)

Monday 26 September 2016

Plenary: Welcome, Organization and Plenary I - Illinois Ballroom (08:30-10:50)

-Conveners: Naomi Makins

time	[id] title
08:30	**[1] Welcome to SPIN'16** *Presenter: GROSSE-PERDEKAMP, Matthias*
08:45	**[2] Organization of SPIN'16** *Presenter: VOSSEN, Anselm*
09:00	**[3] Searching for the Electric Dipole Moment of the Neutron, the Holy Grail of Precision Measurements** *Presenter: LIU , Chen-Yu* The Electric Dipole Moment (EDM) of the neutron is a probe for the violations in the combined Charge-conjugate and Parity reversal symmetry (CP). Many new theories beyond the Standard Model, which aim to unify the fundamental forces and solve the problem of Baryon Asymmetry of the Universe, also predict sizable EDM just lurking around the corner for discovery. Experimental search for the neutron EDM, since Ramsey's initial attempt in the 1950s, has been making steady improvements in its sensitivity. However, so far no experiment has reported an EDM. In this talk, I will discuss the techniques and challenges of the current generation of EDM experiments.
09:55	**[4] The Electron Ion Collider** *Presenter: ASCHENAUER, Elke-Caroline* The Revolution to our view of nucleon structure and the glue. The 2015 nuclear physics long-range plan endorsed the realization of an electron-ion collider as the next large construction project after FRIB. The electron-ion collider with its high luminosity (>10^33 cm–2s–1), wide kinematic reach in center-of-mass-energy (20 GeV to 145 GeV) and high lepton and proton beam polarization provides an unprecedented opportunity to reach new frontiers in our understanding of the spin and dynamic structure of nucleons and nuclei. This presentation will summarize the key physics highlights and the machine and detector designs at BNL and JLab.

Targets: Parallel I - Technology (11:05-12:55)

Polarized Ion and Lepton Sources and Targets

-Conveners: Christopher Keith

time	[id] title
11:05	**[51] Summary of PSTP2015** *Presenter: REICHERZ, Gerhard Alois* The 2015 International Workshop on Polarized Sources, Targets & Polarimetry took place at the Ruhr-University Bochum on September 14th - 18th 2015. The Workshop has been a tradition for more than 20 years, moving between Europe, USA and Japan. The XVIth International Workshop on Polarized Sources, Targets and Polarimetry (PSTP 2015) addresses the physics and technological challenges related to polarized gas/solid targets, polarized sources, polarimetry and their applications. A summary of the workshop will be presented.

11:30 **[52] Polarized 3He spin filters for neutron science**

Presenter: GENTILE, Thomas

The large spin dependence of the absorption cross section for neutrons by 3He gas provides a method to polarize neutron beams. For certain applications, such polarized 3He-based neutron "spin filters" have advantages over conventional neutron optical polarizing methods. Spin filters operate at all neutron wavelengths, can cover a large angular range and/or a large energy range, and decouple neutron polarization from energy selection. Both spin-exchange optical pumping (SEOP) and metastability-exchange optical pumping (MEOP) are currently being employed to polarize 3He spin filters at various neutron facilities worldwide. I will focus on the development and application of SEOP-based neutron spin filters at the National Institute of Standards and Technology, Center for Neutron Research (NCNR) [1]. The combination of long relaxation time spin filter cells, high power diode lasers spectrally narrowed with chirped volume holographic gratings, and the use of Rb/K mixtures have allowed us to reach 3He polarizations up to 85 % in spin filter cells ≈1 liter in volume [2]. Studies have revealed limits to the achievable polarization from temperature-dependent relaxation [3] and unexplained magnetic field dependence for relaxation in SEOP cells [4]. Applications include neutron scattering methods such as triple-axis spectrometry and small angle neutron scattering [5], and fundamental neutron physics. A measurement of the spin-dependence of the neutron-3He scattering length was performed with a small, polarized 3He cell in a neutron interferometer and a 3He spin filter for accurate neutron polarimetry [6]. Use of spin filters in high flux neutron beams have revealed beam-induced alkali-metal relaxation and long term effects on SEOP spin filter cells [7]. A recent focus has been application to wide-angle neutron polarization analysis [8], for which we have obtained nearly 80 % 3He polarization in unique "horseshoe" shaped cells to analyze a 220■ angular range. We are also currently pursuing application to polarized neutron imaging [9].

References

[1] W.C. Chen et al., Journal of Physics: Conference Series 294, 012003 (2011).
[2] W.C. Chen et al, J. Appl. Phys. 116, 014903 (2014).
[3] E. Babcock et al., Phys. Rev. Lett. 96, 083003 (2006).
[4] R.E. Jacob et al., Phys. Rev. A 69, 021401(R) (2004).
[5] W.C. Chen et al, Journal of Physics: Conference Series 528, 012014 (2014).
[6] M.G. Huber et al, Phys. Rev. C 90, 064004 (2014).
[7] E. Babcock et al., Phys. Rev. A 80, 033414 (2009);
[8] Q. Ye et al, Physics Procedia 42, 206-212 (2013).
[9] D.S. Hussey et al, Physics Procedia 69, 48-54 (2015).

11:55 **[53] Polarimetries for the Polarized 3He Target at JLab**

Presenter: TON, Ngyuen

At Jefferson Lab, a Polarized 3He Target has been used as an effective polarized neutron target for studying nucleon spin structure. For the 12 GeV program at JLab, the first stage upgrade of the target aim to increase factor of three the performance (Figure-of-Merit) and reach a systematic uncertainty of polarimetry below 3%. During the 6 GeV era, the target polarization was measured by two polarimetries: adiabatic fast passage-nuclear magnetic resonance (AFP-NMR) and electron paramagnetic resonance (EPR). With the upgrade, a new polarimetry, Pulse-NMR, is being studied in the lab. In this talk, we will discuss the detail study of AFP-NMR, EPR, Pulsed NMR measurements and their corresponding systematics.

12:20 **[54] Tensor Polarized Deuteron Target at Jefferson Lab**

Presenter: LONG, Elena

<u>Beams: Parallel I</u> - Excellence (11:05-12:55)

Accelerator, Storage and Polarimetry of Polarized Beams

-Conveners: Edward Stephenson

time [id] title

11:05 **[47] AGS intensity and polarization upgrade plan for RHIC**

Presenter: HUANG, Haixin

Currently, Brookhaven AGS (Alternative Gradient Synchrotron) provides 70% proton polarization with 2 × 1011 intensity. This is achieved by two partial snakes to overcome vertical intrinsic and imperfection resonances and a pair of horizontal tune jump system to overcome the week but many horizontal intrinsic resonances. Further gain was achieved by maintain smaller transverse emittance with same beam intensity. The main effort now is to reduce the emittance in the AGS and to reduce the resonance strength consequently. This paper summarizes the effort.

11:30	**[48] Tilted spin angle in RHIC** *Presenter: MÉOT, François* Spin tilt, about 16 and 9 degrees from vertical, in respectivley RHIC Blue and Yellow rings, has been observed during 255 GeV polarized proton RHIC run 13, at the p-carbon polarimeters, about 70 m away from IP12. A possible origin of this y-normal tilt is in a spin rotation angle defect at one of, or both, RHIC helical snakes. This possible cause has been investigated by scanning the rotation axis of both snakes, as well as their spin rotation angle, in the vicinity of their regular operation values. The simulations presented and discussed here show that such snake angle defects may potentially contribute a substantial amount in the observed spin tilt.
11:55	**[49] Proton Polarimetry with the Hydrogen Jet Target at RHIC in Run 2015** *Presenter: EYSER, Oleg* The Relativistic Heavy Ion Collider (RHIC) has provided polarized proton-proton collisions to experiments for the past decade with beam polarizations of P=55% at beam energies of up to 255 GeV. The polarization of the proton beams is measured through spin dependent elastic scattering off a polarized hydrogen jet target and similarly monitored with Carbon fiber targets several times throughout the typical 8 hours of a stored RHIC fill. With recent advancements in beam luminosities, the largely increased data sets have enabled unprecedented possibilities to study systematic effects in the polarimeters. We will discuss details of the background contributions, properties of the polarized beams, and their implications on systematic uncertainties from proton and ion beam operations in the RHIC Run 2015. The beam polarization as well as its uncertainty are vital input to the RHIC experiments since they directly affect the scale uncertainty of any polarized observable.
12:20	**[50] Measurement of p↑ Au and p↑ d Analyzing Power at low momentum transfer 0.002 < −t < 0.020 (GeV/c)2 for incident proton energies of 10, 19, 31, and 100 GeV.** *Presenter: POBLAGUEV, Andrei* The RHIC Run16 included 5 weeks of d-Au Energy Scan. We employed the Polarized Atomic Hydrogen Gas Jet Target (HJET, the absolute polarimeter for RHIC pp program) to measure elastic scattering of polarized protons on deuterium and Gold nuclei at four energies: 10 GeV, 19 GeV, 31 GeV, and 100 GeV. The measurements were performed in parallel with the main RHIC program. Analyzing power, as a function of momentum transfer was measured in the momentum transfer range 0.002 < –t < 0.020 (GeV /c)2. The results will be compared with similar measurements of proton scattering on p, Au, and Al at 100 GeV obtained in RHIC Run15.

Low Energy: Parallel I - Loyality (11:05-12:55)

Low Energy Spin Physics with Lepton, Photon and Hadron Probes

-Conveners: Ian Cloet

time	[id] title
11:05	**[44] Hadron spectroscopy COMPASS** *Presenter: FRIEDRICH, Jan Michael*
11:30	**[45] A Composite Fermion Approach to Heavy Pentaquarks** *Presenter: BHATTACHARYA, Aparajita* The ground state masses of the heavy-light pentaquark baryons like θ0c, N0c, Ξ0c and θ+b, N+b, Ξ+b for different spin states have been investigated in the frame work of diquark-diquark-antiquark configuration where the light quarks are supposed to combine to form diquarks. A composite fermion model of quasi particle has been employed to describe the diquark in an analogy of state of an electron in strong magnetic filed. An electron in crystal behaves like a composite fermion absorbing a substantial amount of magnetic flux. We have suggested that the diquarks in presence chromo-magnetic field behaves like a composite fermion. Diquarks in this model behaves like an independent entity like a quasiparticle which is weakly interacting within the system.Mass has been computed in a gauge invariant way [see asbtract pdf for formula]. The higher states (l>0) are investigated in the mass loaded flux tube model where two light diquarks are supposed to be linked by a flux tube to the heavy quark. The Regge trajectories (Total angular momentum J vs energy E) for heavy pentaquarks have been investigated.The Regge slope(α) of θ0c, N0c and Ξ0c have been obtained as ~1 GeV2 which indicates that the Regge trajectory follows the linearity conditions with universal value of α(~1GeV2) where as relatively higher value of α have been observed for θ+b, N +b and Ξ+b. The results are compared with available experimental and theoretical estimates and some interesting observations are made.
11:50	**[46] Study of baryon form factor at BESIII** *Presenter: LIN, Dexu*

TMDs: Parallel I - Alma Mater (11:05-13:10)

3D structure of the nucleon: TMDs

-Conveners: Andreas Metz

time	[id] title
11:05	**[39] Overview on TMDs** *Presenter: ANSELMINO, Mauro* The Transverse Momentum Dependent Partonic Distributions (TMD-PDFs) and Fragmentation Functions (TMD-FFs) should reveal new properties of the 3-dimensional structure of nucleons and of the quark hadronization process. Many experimental data are now available, much progress has been made in their phenomenological interpretation, future facilities and experiments are being planned. A short summary of the situation is presented
11:30	**[42] Overview on gluon TMDs** *Presenter: SCHLEGEL, Marc* In this talk I will present an overview of recent developements on gluon transverse momentum dependent (TMD) parton distributions. Such non-perturbative objects might be feasible in high-energy proton collisions at the LHC, but also at a future Electron-Ion Collider (EIC). Most interestingly, due to the gluon's transverse momentum the gluon can have a linear polarization which is encoded in a particular TMD parton distribution. Since the linear gluon distribution generates new observables like non-isotropic azimuthal dependences of the proton-proton cross section this function may be considered as a useful tool in particle physics.
11:55	**[40] Transverse single-spin asymmetries for gauge boson production at RHIC** *Presenter: OGAWA, Akio*
12:20	**[41] Polarized Drell-Yan at the COMPASS experiment: transverse spin physics program** *Presenter: PARSAMYAN, Bakur* The COMPASS experiment (SPS, CERN) covers a broad range of physics aspects in the field of hadron structure and spectroscopy. Particular focus is given to the exploration of the transverse spin structure of the nucleon via the study of spin (in)dependent azimuthal asymmetries measured in semi-inclusive deep inelastic scattering (SIDIS) and Drell-Yan (DY). Within QCD parton model approach, these phenomena give access to the set of transverse momentum dependent (TMD) parton distribution functions (PDFs) parametrizing the spin structure of the nucleon. Between 2002 and 2010 COMPASS performed series of SIDIS measurements, using a longitudinally polarized muon beam of 160 GeV/c momentum and transversely polarized 6LiD and NH3 targets. COMPASS Drell-Yan measurements with a 190 GeV/c pion beam and transversely polarized NH3 target started in 2015 and are planned to be continued in 2018. The measurement of the Sivers and all other azimuthal asymmetries in polarized SIDIS and Drell-Yan at COMPASS provides a unique possibility to test predicted universal and process dependent features of TMD PDFs using a similar experimental setup and exploring a comparable kinematic domain. The main focus of this talk will be set on the physics aspects of the COMPASS polarized Drell-Yan program and related SIDIS results.
12:45	**[43] TMDs from precision spectrometer experiments in Jlab Halls A and C: Existing results and outlook** *Presenter: PUCKETT, Andrew* Studies of the Transverse Momentum Dependent parton distributions (TMDs) of the nucleon in the valence quark region have emerged as one of the flagship physics programs of the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. The TMDs of the nucleon describe the spin-dependent, three-dimensional distributions of its constituent partons in momentum space. The simplest and best-understood process relevant to the extraction of TMDs from both the experimental and theoretical points of view is single-hadron semi-inclusive deep inelastic scattering (SIDIS), N(e, e0h)X. Experiments using precision magnetic spectrometers in JLab's Halls A and C have made and will continue to make unique contributions to the precision mapping of the relevant observables of the SIDIS process, with the ultimate goal of facilitating a model-independent, global extraction of TMDs. In this talk, I will review the existing and forthcoming results on SIDIS and TMDs from experiments using precision magnetic spectrometers in JLab's experimental halls A and C.

Helicity & Lattice joint: Parallel I - Lincoln (11:05-12:55)

-Conveners: Kehfei Liu

time	[id] title
11:05	**[35] New global QCD analysis of polarized parton distributions** *Presenter: SATO, Nobuo*

11:30	**[36] Nucleon Helicity and Transversity Parton Distributions from Lattice QCD** *Presenter: CHEN, Jiunn-Wei* We present the first lattice-QCD calculation of the isovector polarized parton distribution functions (both helicity and transversity) using the large momentum effective field theory (LaMET) approach for direct Bjorken-x dependence. We first review the detailed steps of the procedure in the unpolarized case, then generalize to the helicity and transversity cases. We also derive a new mass-correction formulation for all three cases. We then compare the effects of each finite-momentum correction using lattice data calculated at Mπ ≈ 310 MeV. Finally, we discuss the implications of these results for the poorly known antiquark structure and predict the sea-flavor asymmetry in the transversely polarized nucleon.
11:55	**[37] Quark flavour decomposition in proton spin** *Presenter: LIANG, Jian* We report the status of our lattice QCD calculation of the quark flavor decomposition of the proton spin. The quark spin calculation is recently carried out from the anomalous Ward identity (AWI) with chiral fermions and is found to be small mainly due to the large negative pseudoscalar coupling in the AWI which may help to solve the proton spin crisis. We also report a scheme of constructing improved currents on the lattice to reduce the finite lattice spacing artifact of axial charge gA.
12:20	**[38] Gluon structure of the nucleon** *Presenter: YANG, Yi-Bo* I shall report on the glue-momentum fraction in the proton, based on the covariant decomposition, and the necessary perturbative calculation to convert them from the lattice regularization to MS-bar scheme at 2 GeV. The strategy of the lattice simulation for the spin decomposition based on Xiang-Song Chens scheme, and the preliminary result of the glue spin component, will also be reported.

Beyond SM: Parallel I - Innovation (11:05-12:55)

Fundamental Symmetries and Spin Physics Beyond the Standard Model

-Conveners: Buddhini Waidyawansa

time	[id] title
11:05	**[31] Searching for dark matter with atoms, nuclei and ultracold neutrons** *Presenter: STADNIK, Yevgeny*
11:30	**[32] Parity Violation in Deep Inelastic Scattering with the SoLID Spectrometer at Jlab** *Presenter: ZHAO, Yuxiang* We discuss the measurements of parity-violating asymmetries in DIS region (PVDIS) using SoLID spectrometer at JLab Hall A in the 12 GeV era. Mea-surements with polarized electron beam on unpolarized deuteron and proton targets have been approved with an A rating. The deuteron measurement aims to measure weak mixing angle sin2(θW) with precision of ± 0.0006 as well as access a fundamental coupling constant C2q with high precision, which is ide-ally suited for the Standard Model test while with potential to probe charge symmetry violation and resolve the quark-quark correlations in the DIS region. The proton experiment provides a clean measurement of d/u ratio in the high-x region free of nuclear corrections. To achieve the goals, the SoLID spectrometer, based on a solenoid magnet, was designed to handle high luminosity with large acceptance. In this talk, we will go through the details of the approved measurements and also mention new ideas with PVDIS using a polarized 3He target to access new γZ interference polarized structure functions and an unpolarized 48Ca target to study the EMC effect.
11:55	**[33] Towards atomic parity violation measurements in laser-trapped francium** *Presenter: GWINNER, Gerald*
12:20	**[34] The role of spin in n-nbar transformations** *Presenter: GARDNER, Susan* The observation of the transformation of a neutron into an antineutron would reveal that B-L symmetry is broken and thus that dynamics beyond the Standard Model exists. Notably it would establish that neutrons can act as their own antiparticles, making the process a hadronic analog to neutrinoless double beta decay. I will discuss the role of spin, highlighting how external fields or sources can help mediate the effect.

TMDs: Parallel II - Illinois Ballroom A (14:30-16:20)

3D structure of the nucleon: TMDs

-Conveners: Yoshitaka Hatta

time	[id] title
14:30	**[59] Combining TMD factorization and collinear factorization** *Presenter: COLLINS, John* I examine some of the complications involved when combining (matching) TMD factorization with collinear factorization to allow accurate predictions over the whole range of measured transverse momentum in a process like Drell-Yan. Then I propose some improved methods for combining the two types of factorization. (This talk is based on work reported in arXiv:1605.00671.)
14:55	**[60] Phenomenology of TMD evolution: recent progress** *Presenter: Dr. KANG, Zhongbo*
15:20	**[61] TMDs: entering the precision era** *Presenter: G. ECHEVARRÍA, Miguel*
15:40	**[66] Recent and future measurements of transverse momentum distributions in SIDIS** *Presenter: SBRIZZAI, Giulio* Precision measurements on the transverse momentum dependent hadron multiplicities in semi-inclusive deep inelastic scattering is, with unpolarised azimuthal asymmetries, crucial in the determination of the quark intrinsic transverse momentum and in TMD evolution studies. COMPASS has measured differential multiplicities of hadrons using a deuteron target in a four-dimensional space. This data set is, to date, the only one that study the PhT-dependent production of hadrons in simultaneous bins of x, Q2, and z, and that covers a wide range in Q2. The measurement of hadron multiplicity as a function of PhT using a liquid hydrogen target is foreseen based on data currently being collected by COMPASS and which will last until 2017. SIDIS data are collected in parallel to the deeply virtual Compton scattering reaction. A review of the latest results on deuteron target will be given and the status about the foreseen measurements on proton target will be discussed.
16:00	**[62] Extraction of unpolarized TMDs** *Presenter: DELCARRO, Filippo*

Targets: Parallel II - Technology (14:30-16:10)

Polarized Ion and Lepton Sources and Targets

-Conveners: Andreas Thomas

time	[id] title
14:30	**[71] Latest results and future direction of the Bochum Polarized Target Group** *Presenter: REICHERZ, Gerhard Alois* The Bochum polarized target group is involved in the fixed target experiments COMPASS at CERN and baryon spectroscopy at ELSA and MAMI. The experiments at Bonn and Mainz are focused on the study of the nucleon resonance region with polarized beam and target with 4 detection system. The focus of the COMPASS experiment is the study of hadron structure and hadron spectroscopy with high intensity muon and hadron beams. In this talk technical achievements, the first polarization results of the active target experiment at MAMI Mainz and the future activities of Bochum Polarized Target group will be presented.

14:55	**[72] Polarized Target Activity at the University of Virginia** *Presenter: CRABB, Donald* Most of the activity in the Polarized Target Lab. at the University of Virginia has centered around the preparation of polarized targets for experiments at Fermilab and TUNL(Duke U.), while investigating some special features for experiments at JLab. For experiment E1039 at Fermilab a magnet/ 4He refrigerator combination that had been in storage for 15 years has been modified and restored to operation. A dilution refrigerator, originally from CERN, has been modified for operation at TUNL for experiments with polarized photons incident on a polarized deuteron target. To meet a requirement at JLab on maintaining a high deuteron tensor polarization we are investigating the hole burning technique with deuterated butanol with a view to establishing a high (>30%) tensor polarization in ND3 , which the experiments require. The technique of Adiabatic Fast Passage (AFP) for rapid reversal of the spins has been applied successfully to both NH3 and ND3. Other areas of attention have included the freezing and irradiation of NH3 and ND3, and of production of CD3 and CD4 prior to studying the polarization properties with radiation doping. Software has been developed to optimize the microwave frequency while polarizing a given material. Finally, In collaboration with ORNL, various protein samples have been polarized.
15:20	**[73] Tensor polarization optimization and measurement for solid spin 1 targets** *Presenter: KELLER, Dustin* A discussion of dynamic orientation using optimized radio frequency (RF) irradiation produced perpendicular to the holding field is presented for the spin-1 system required for tensor polarized fixed target experiments. The rate equations are solved numerically to study a semi-saturated steady-state resulting from the two sources of irradiation, microwave from the DNP process and the additional RF used to manipulate the tensor polarization. The steady-state condition and continuous wave NMR lineshape are found that optimize the spin-1 alignment in the polycrystalline materials used as solid polarized targets in charged beam nuclear and particle physics experiments. Measurement of the tensor polarization is achieved using the constraints from the rate equations for various RF manipulated lineshapes.
15:45	**[74] Vertical pointing transverse polarized target system for the Drell-Yan experiment (E1039)** *Presenter: YUROV, Mikhail* The University of Virginia (UVA) polarized target group in cooperation with Los Alamos National Lab has designed and built a solid polarized target system for the anticipated Fermilab E1039 Drell-Yan experiment. We report the completion of refurbishing the 5T superconducting Oxford magnet and 1K evaporation refrigerator. Recent tests performed at UVA will be presented.

Beams: Parallel II - Illinois Ballroom C (14:30-16:10)

Accelerator, Storage and Polarimetry of Polarized Beams

-Conveners: Edward Stephenson

time	[id] title
14:30	**[67] COSY optics and spin tracking** *Presenter: DUTHEIL, Yann* The COOler SYnchrotron is at the forefront of precise spin dynamics. The facility can accelerate polarized protons at up to 3.7 GeV/c. Numerous specialized devices such as electron coolers, a stochastic cooler and more recently a superconducting solenoidal snake make this accelerator complex unique. As new opportunities and challenges come into perspective of the facility, it calls in particular for new simulation tools. The Bmad library is a versatile and self contained accelerator simulation code for beam, spin and even photon dynamics. With methods ranging from particle tracking using a Runge-Kutta integrator to Taylor maps produced by the analytical description of a magnetic element, it can be applied to a wide variety of problems. We will present the COSY machine in the context of polarized protons and deuteron operations. We will then discuss the specificities of the Bmad code applied to spin dynamics and to the COSY machine. Some of the latest simulations as well as experimental results will be discussed.

14:55	**[68] Polarized beam experiments with polarized internal storage cell targets at COSY** *Presenter: Dr. LORENTZ, Bernd Alfred* The construction of the PAX installation was inspired by the idea to make a beam of polarized antiprotons available for future experiments with stored antiproton beams. A spin filtering experiment with internal polarized proton storage cell target was realized using the PAX low-beta installation at COSY. The results of this measurement are in perfect agreement with the FILTEX experiment. Spin filtering is a viable method to produce a stored beam of polarized antiprotons. Another experiment which can be pursued using the PAX installation is the test of Time Reversal Invariance at COSY (TRIC). The goal of the TRIC experiment is to improve the present upper limit on violation of the T-odd P-even interaction by an order of magnitude using a genuine null observable available in a double polarized pd scattering. In this presentation the necessary steps in the accelerator setup for these type of internal storage cell target experiments will be discussed. This includes the particle optical requirements that need to be met and the necessary steps in the machine preparation as well as the requirements for storage, acceleration and polarimetry of polarized proton beams.
15:20	**[69] Calibration of the PEPPo polarimeter** *Presenter: ADEYEMI, Adeleke* The PEPPo (Polarized Electrons for Polarized Positrons) experiment at Jefferson Lab (Jlab) investigated a new approach of developing polarized positron source. The PEPPo concept relies on the production of polarized e-/e+ pairs from the bremsstrahlung radiation of a longitudinally polarized electron beam interacting within a high Z conversion target. PEPPo measured the positron polarization with a Compton transmission polarimeter, where the incoming longitudinally polarized positrons transfer their polarization into circularly polarized photons subsequently analyzed by a thick polarized iron target and upon exiting the iron target. The photons are detected in at 3x3 CsI crystal arrays. The experimental asymmetry was measured with respect to the orientation of the target polarization (±) or the helicity (±) of the incoming leptons provided the measurement of their polarization. Similar measurements with a known electron beam were also performed for calibration purposes. A model of the PEPPo Compton polarimeter was created in Geant4 to simulate the positron analyzing power. This model was tested by benchmarking the simulation for electrons with a directly measured analyzing power for electrons. This presentation will describe the experimental procedure and the layout of the PEPPo experiment with emphasis on the reconversion target, the analyzing magnet and the polarimeter. Additionally, the Geant4 modelling of the PEPPo Compton polarimeter, some sensitivity studies and the results of the simulations are also discussed.
15:45	**[70] Polarization in FCC-ee** *Presenter: KOOP, Ivan*

Lattice: Parallel II - Loyalty (14:30-15:45)

Mini Symposium on Nucleon Spin Structure and Lattice QCD

-Conveners: William Detmold

time	[id] title
14:30	**[63] Nucleon Structure and Neutron Electric Dipole Moment** *Presenter: BHATTACHARYA, Tanmoy* Physics beyond the standard model involving heavy particles can be parameterized by effective field theories of new interactions between the standard model particles. The new interactions involving quarks and gluons are, however, dressed by the strong interactions before they can be observed as low energy properties of hadrons. Lattice QCD is currently the only systematically improvable approximation giving access to the hadronic structure describing this dressing. I will discuss the calculation of nucleon matrix elements like the tensor charge and the chromoelectric operator and their relevance to the electric dipole moment of the neutron.
14:55	**[64] Nucleon TMDs from Lattice QCD** *Presenter: YOON, Boram* We present a lattice QCD calculation of transverse momentum dependent parton distribution functions (TMDs) of protons using staple-shaped Wilson lines. For time-reversal odd observables, we calculate the generalized Sivers and Boer-Mulders transverse momentum shifts in SIDIS and DY cases, and for T even observables we calculate the transversity related to the tensor charge and the generalized wormgear shift. The calculation is done on two different nf = 2 + 1 ensembles: domain-wall fermion (DWF) with lattice spacing 0.084 fm and pion mass of 297 MeV, and clover fermion with lattice spacing 0.114 fm and pion mass of 317 MeV. The results from those two different discretizations are consistent with each other.

15:20	**[65] Lattice Generalized Parton Distributions of Nucleon and Form Factors** *Presenter: Prof. CONSTANTINOU, Martha* In this talk we will discuss recent progress in nucleon structure using Lattice QCD simulations at or near to the physical value of the pion mass. Main focus will be given in observables such as the nucleon axial charge and the first moments of parton distributions, for both the valence and sea quark contributions, and discuss their implications on the spin content of the nucleon. We will highlight developments on the evaluation of the gluon momentum fraction, and updates on a new direct approach to compute quark parton distributions functions on the Lattice.

Helicity: Parallel II - Lincoln (14:30-16:20)

Nucleon helicity structure

-Conveners: Gerhard Mallot

time	[id] title
14:30	**[55] Final COMPASS results on the spin dependent structure functions g1d and g1p** *Presenter: WILFERT, Malte Christian* The COMPASS experiment at the CERN SPS has taken data with a polarised muon beam scattering off a polarised NH3 target in 2007 and 2011 and scattering off a 6LiD target from 2002-2004 and 2006. The 2006 measurement increases the statistics from 2002-2004 by roughly a factor of two. For the measurement in 2011 the beam energy has been increased from 160 GeV to 200 GeV thus higher values of Q2 and lower values of x are reached. The new results from the 2011 and 2006 data taking on the longitudinal double spin asymmetry Ap,d1 and on the spin dependent structure function gp,d1 will be shown and compared to the previous results. Using the combined deuteron data set the first moment of gd1 is calculated. From the first moment the quark contribution to the nucleon spin can be calculated. This quantity is also obtained from a NLO QCD fit to the world data including our data. The final deuteron results together with the two measurements on the proton are used to update the results on the Bjorken sum rule connecting the first moment of the non-singlet structure function to the ratio of the weak coupling constants.
14:55	**[56] Nucleon spin structure studies at JLAB** *Presenter: DEUR, Alexandre*

15:20 **[57] Tensor-polarized structure function b_1 in the standard convolution description for the deuteron**

Presenter: KUMANO, Shunzo

There exist new polarized structure functions b1–4 for spin-one hadrons such as the deuteron. These functions probe very different nature of hadron spin physics from the longitudinally polarized distributions measured by g1 for the nucleon. The twist-two structure functions b1 and b2 are expressed by tensor polarized parton distribution functions, which indicate unpolarized parton distributions in the tensor-polarized spin-one hadron [1, 2]. In this work, we investigate the function b1 in the standard convolution model for describing the deuteron. There are such initial studies in Ref. [1]. The purposes of this work [3] are to test their numerical result and then to compare our function b1 with the HERMES measurement [4]. In particular, there is an interesting indication that the magnitude of the HERMES data is much larger than the standard deuteron model predication. Before stepping into possible exotic mechanisms, such as hidden color [5], to interpret the HERMES b1, we need to confirm that the data really cannot be explained by the standard model for the deuteron. Using a convolution integral for calculating nuclear structure functions, we obtain the structure function b1 which is expressed by the lightcone momentum distribution for the nucleon in the deuteron and the unpolarized structure function F1 for the nucleon [3]. Then, the lightcone momentum distribution is calculated by using a momentum space wave function for the deuteron with D-state admixture. The structure function F1 is calculated by the unpolarized parton distribution functions with a typical parametrization for the longitudinal-transverse ratio R. We found that the function b1 calculated in this standard description is very different from the HERMES measurement [3]. It suggests that new hadron physics should be needed for explaining the HERMES measurement. Since there is an approved experiment at JLab [6] to measure b1 and polarized proton-deuteron Drell-Yan process could be possible at Fermilab [7], it is an interesting hadron-physics topic with the possibility of creating a new field in high-energy spin physics.

References

[1] P. Hoodbhoy, R. L. Jaffe and A. Manohar, Nucl. Phys. B 312, 571 (1989); H. Khan and P. Hoodbhoy, Phys. Rev. C 44, 1219 (1991).
[2] S. Kumano, J. Phys. Conf. Ser. 543, 012001 (2014).
[3] W. Cosyn et al., KEK-TH-1912/J-PARC-TH-0054, to be submitted for publication.
[4] A. Airapetian et al. (HERMES Collaboration), Phys. Rev. Lett. 95, 242001 (2005); S. Kumano, Phys. Rev. D 82, 017501 (2010).
[5] G. A. Miller, Phys. Rev. D 89, 045203 (2014).
[6] Proposal to Jefferson Lab PAC-38, J.-P. Chen et al. (2011).
[7] S. Kumano and Qin-Tao Song, arXiv:1606.03149 [hep-ph].

15:40 **[58] Spin asymmetry for proton-deuteron Drell-Yan process with tensor-polarized deuteron**

Presenter: SONG, Qin-Tao

Tensor-polarized parton distribution functions are new quantities in spin-one hadrons such as the deuteron, and they could probe new quark-gluon dynamics in hadron and nuclear physics. In charged-lepton deep inelastic scattering (DIS), they are studied by the twist-two structure functions b1 and b2 [1, 2]. The HERMES collaboration found unexpectedly large b1 values than a naive theoretical expectation based on the standard deuteron model [3]. The situation should be significantly improved in the near future by an approved experiment to measure b1 at JLab (Thomas Jefferson National Accelerator Facility). There is also an interesting indication in the HERMES result that finite antiquark tensor polarization exists. It could play an important role in solving a mechanism on tensor structure in the quark gluon level. The tensor-polarized antiquark distributions are not easily determined from the charged-lepton DIS; however, they can be measured in a proton-deuteron Drell-Yan process with a tensor-polarized deuteron target. In this article, we estimate the tensor-polarization asymmetry for a possible Fermilab Main Injector experiment by using optimum tensor-polarized PDFs to explain the HERMES measurement. We find that the asymmetry is typically a few percent. If it is measured, it could probe new hadron physics, and such studies could create an interesting field of high-energy spin physics. In addition, we find that a significant tensor-polarized gluon distribution should exist due to Q2 evolution, even if it were zero at a low Q2 scale. The tensor polarized gluon distribution has never been observed, so that it is an interesting future project. In this talk, I show our estimate on the spin asymmetry for the proton-deuteron Drell-Yan process with tensor-polarized deuteron [4].

References

[1] P. Hoodbhoy, R. L. Jaffe and A. Manohar, Nucl. Phys. B 312 (1989) 571.
[2] S. Kumano, J. Phys. Conf. Ser. 543 (2014) 012001.
[3] A. Airapetian et al. (HERMES Collaboration), Phys. Rev. Lett. 95 (2005) 242001.
[4] S. Kumano and Qin-Tao Song, arXiv:1606.03149 [hep-ph].

16:05 **[257] Towards a self-consistent determination of fragmentation functions**

Presenter: GONZALEZ, Osvaldo

To obtain sensible information about hadronization in the current region from experiment, it is essential to understand the kinematical range of applicability of the formalism of fragmentation functions, which is often overlooked in phenomenological applications. In this talk, I will describe how one may identify the current region and argue that at low Q2 the distinction between current and non-current regimes starts to fade.

Helicity: Parallel III - Lincoln (16:40-18:30)

Nucleon helicity structure

-Conveners: Emanuele Roberto Nocera

time	[id] title
16:40	**[75] The spin structure function of the proton at low x and low Q2 from COMPASS** *Presenter: ANDRIEUX, Vincent* We present COMPASS results on the longitudinal double-spin asymmetry, Ap1, and the spin dependent structure function of the proton, gp1, in the quasi-real photoproduction regime. Data were collected by scattering a longitudinally polarised muon beam off a longitudinally polarised proton target. Two data sets with a beam energy of respectively 160 and 200 GeV were taken, which improve, once combined, the statistical precision on Ap1 and gp1 by a factor of 12 compared to the previous SMC experiment covering a similar kinematic region. The high statistical precision allows Ap1 and gp1 to be measured in several 2-D grids, (x, Q2), (ν, Q2), (x, ν) and (Q2, x) within the following kinematic domain: 4.0 × 10–5 ≤ x ≤ 4.0 × 10–2, 0.001 ≤ Q2 ≤ 1 (GeV/c)2 and 14 ≤ ν ≤ 194 GeV. The presented measurements provide inputs to better constrain non-perturbative models of electroproduction.
17:00	**[76] The proton spin-dependent structure function g2 at low Q2** *Presenter: ZHANG, Jixie* Measurements of the nucleon spin-dependent structure functions have provided powerful tools to test the validity of effective theories of Quantum Chromodynamics (QCD). The neutron spin structure functions, gn1 and gn2, and the proton spin structure function, gp1, have been measured over a wide kinematic range. However, the proton spin structure function, gp2, is mostly unknown. Recently an experiment (E08-027, also named G2P) is carried out at Jefferson Lab in Hall A to measure the proton g2 structure function in the low momentum transfer region covering 0.02 < Q2 < 0.20(GeV2). In this kinematic region, this experiment allows us to extract the generalized longitudinal-transverse spin polarizability (δLT) in order to provide benchmark test to the Chiral Perturbation Theory (χPT), and also to test the Burkhardt-Cottingham sum rule at low Q2. The details of the experiment and the preliminary results will be presented.
17:20	**[77] The generalized GDH sum rule: measuring the neutron and 3He spon structure at low Q2** *Presenter: PENG, Chao* The Gerasimov-Drell-Hearn (GDH) sum rule, as a fundamental sum rule for real photon absorption, relates the anomalous magnetic moment to the spin structure of the nucleon. The generalized form of GDH sum rule extends this relation to finite four-momentum transfer squared (Q2). Jefferson Lab experiment E97-110 was performed with a High Resolution Spectrometer (HRS) and a septum magnet in Hall A at Jefferson Lab. The experiment aims to precisely extract the first moments of the neutron spin structure functions g1 and g2 using polarized electron scattering from a polarized 3He target. The covered kinematics comprised the quasi-elastic, resonance and deep inelastic regions in a Q2 range from 0.02 to 0.24 (GeV/c)2. This low Q2 range allows us to extrapolate the generalized GDH integrand to the real photon point. Predictions by Chiral Perturbation Theory of various sum rules will be used to make a bench-mark test in this low Q2 region. In this talk, we will present the results on the moments of the neutron spin structure functions and the current status of the analysis.
17:40	**[78] Helicity evolution at small x** *Presenter: Prof. KOVCHEGOV, Yuri*
18:05	**[79] The spin of the proton in chiral effective theory** *Presenter: WANG, Ping* Proton spin is investigated in chiral effective field theory through an examination of the singlet axial charge, a0, and the two non singlet axial charges, a3 and a8. Finite-range regularization is considered as it provides an effective model for estimating the role of disconnected sea-quark loop contributions to baryon observables. Baryon octet and decuplet intermediate states are included to enrich the spin and flavour structure of the nucleon, redistributing spin under the constraints of chiral symmetry. In this context, the proton spin puzzle is well understood with the calculation describing all three of the axial charges reasonably well. The strange quark contribution to the proton spin is negative with magnitude 0.01. With appropriate Q2 evolution, we find the singlet axial charge at the experimental scale to be ˆa0 = 0.31^+0.04_–0.05, consistent with the range of current experimental values.

Beams: Parallel III - Illinois Ballroom C (16:40-18:15)

Accelerator, Storage and Polarimetry of Polarized Beams

-Conveners: Edward Stephenson

time	[id] title
16:40	**[88] Spin Dynamics and Control in JLEIC** *Presenter: LIN, Fanglei* An Electron-Ion Collider (EIC) is proposed as the first lepton- hadron collider in the world with both beams polarized. The envisioned nuclear physics program requires high polarizations, long polarization lifetimes, and unprecedented capabilities of polarization control in both collider rings. The electron polarization must be longitudinal at the interaction points while the light ion polarization must be adjustable to transverse and longitudinal directions in the whole energy range. This talk presents an elegant spin dynamics design based on figure-8 rings adopted by Jefferson Labs EIC (JLEIC) that meets all of these requirements. A highly polarized electron beam is injected from CEBAF into the electron collider ring at full energy of 3 to 10 GeV. The electron polarization is designed to be vertical in the arcs to minimize spin diffusion and turned to the longitudinal in the straights for experiments. The turning is done by universal spin rotators, which utilize solenoids separated by bends to control the polarization in the whole energy range without affecting the design orbit. The figure-8 shape removes the spin tune energy dependence significantly reducing quantum depolarization as verified by spin tracking simulations. High polarization level is maintained by continuous topoff injection. For ions (p, d, He3, Li6, Li7 ...), the figure-8 booster and collider ring geometries allow one to preserve and control the polarization of any ion species during their acceleration and storage at any energy. Lack of a preferred polarization direction in a figure-8 ring makes it possible to control the ion beam polarization and to stabilize it in any desired orientation by using magnetic field integrals that are small in comparison to those of Siberian snakes and conventional spin rotators. A single weak solenoid is sufficient to maintain the polarization in the 8 GeV booster. 3D spin rotators consisting of weak solenoids and dipoles completely control the ion polarization in the 8-100 GeV/c collider ring allowing any polarization direction to be obtained including spin flip. We present analytic analysis of the spin dynamics in the figure-8 ion collider ring and verify its validity by spin tracking simulations.
17:25	**[89] Polarization, snakes and rotators in eRHIC** *Presenter: PTITSYN, Vadim* An electron-ion collider is being considered as a next large facility for nuclear physics studies in United States. Using polarized beams of electrons, protons, and, possibly, light ions is an essential requirement for this collider. eRHIC, the electron ion collider designed in BNL, takes a big advantage of using existing world-class polarized proton facility RHIC. The polarized electron beam with the energy up to 20 GeV will be delivered either by using an energy-recovery linac accelerator or from a storage ring. In any case spin rotators have to be accommodated in the design to produce longitudinally polarized electrons in collision points in a wide energy range. In the storage ring design approach special spin matching conditions have to be satisfied in order to minimize the depolarization. This presentation describes all aspects of achieving highly polarized beams in eRHIC, including possible modifications in RHIC towards higher polarization of protons and using polarized light ions (3He).
17:50	**[90] Spin resonance free electron ring injector** *Presenter: RANJBAR, Vahid* We have developed a circular electron accelerator that is free of intrinsic resonances. This lattice could be placed in the existing RHIC tunnel and accelerate electrons from 100 MeV to 20 GeV avoiding all major polarization loss usual in such machines.

TMDs: Parallel III - Illinois Ballroom A (16:40-18:55)

3D structure of the nucleon: TMDs

-Conveners: Marco Contalbrigo

time	[id] title
16:40	**[80] 2+1d Imaging the momentum structure of nucleons at an EIC** *Presenter: ASCHENAUER, Elke-Caroline*
17:05	**[82] COMPASS measurement of the P_T weighted Sivers asymmetry** *Presenter: BRADAMANTE, Franco*

time	[id] title
17:30	**[83] New pole contribution to Ph -weighted single-transverse spin asymmetry in semi-inclusive deep inelastic scattering** *Presenter: YOSHIDA, Shinsuke* We discuss a new hard pole contribution to the transverse- momentum weighted single-transverse spin asymmetry in semi inclusive deep inelastic scattering. We perform a complete next-to-leading order calculation of the Ph⊥-weighted cross section and show that the new hard pole contribution is required in order to obtain the complete evolution equation for the Qiu-Sterman function.
17:55	**[84] A direct extraction of the Sivers function from SIDIS data** *Presenter: MARTIN, Anna* We present a point-by-point determination of the Sivers parton distribution function. The extraction is similar to the one already performed for the transversity distribution, namely it is based on the simultaneous use of proton and deuteron semi-inclusive deeply inelastic scattering data. Since the Sivers asymmetries involve the ordinary unpolarized fragmentation functions, SIDIS data are sufficient to extract the Sivers function, with no need of other measurements. The method has the advantage that it does not require a specific parametrization of the Sivers function: only simple assumptions are used to extract both the valence and the sea distributions. The results obtained using the published COMPASS data are presented and discussed. They are relevant also for the planning of future experiments.
18:10	**[85] The measurement of the gluon Sivers asymmetries in COMPASS at CERN** *Presenter: SILVA, Luis* In the context of the nucleon spin structure the Sivers effect, which describes the correlation between the nucleon spin and the orbital motion of partons, may give information on the gluon orbital angular momentum, one of the missing elements in th nucleon spin sum rule. The gluon Sivers function can be accessed via the photon-gluon fusion process. To enhance the fraction of photon-gluon fusion events in the sample containing also the quark photo-absorption and QCD Compton scattering, SIDIS events with high transverse momentum hadron pair are selected. A method to extract the asymmetries simultaneously for all the three processes involved is presented. A Neural Network, trained with Monte Carlo data, is used in the analysis to assign probabilities for the three processes. Finally the gluon Sivers asymmetries measured from proton and deuteron data are given.
18:25	**[86] Target longitudinal spin dependent single-hadron asymmetries in SIDIS at COMPASS** *Presenter: PARSAMYAN, Bakur*
18:40	**[87] Azimuthal asymmetries in SIDIS di-hadron muoproduction o longitudinally polarized protons at COMPASS** *Presenter: SIRTL, Stefan* In recent years, measuring azimuthal asymmetries in semi -inclusive deep-inelastic scattering (SIDIS) off polarized targets emerged as a powerful tool to investigate the nucleon spin structure, one of the main objectives of the COMPASS physics program. The two-stage COMPASS spectrometer at the CERN SPS is characterized by a large acceptance and a broad kinematic coverage. It makes use of a tertiary longitudinally polarized high-energetic μ+ beam, impinging on a transversely or longitudinally polarized ammonia target. In this talk we present first results on both leading and subleading longitudinal target spin dependent asymmetries arising in the di-hadron SIDIS cross section. The results provide new insights to the longitudinal spin structure of the nucleon, addressing the role of spin-orbit couplings and quark-gluon correlations in the framework of collinear or transverse momentum dependent factorization.

Targets: Parallel III - Technology (16:40-18:20)

Polarized Ion and Lepton Sources and Targets

-Conveners: Gerhard Alois Reicherz

time	[id] title
16:40	**[91] A New Solid Polarized Target for CLAS12** *Presenter: Dr. MAXWELL, James* With Jefferson Lab's upgrade to a 12 GeV electron beam comes a new, improved detector system in Hall B: CLAS12. The dynamically polarized solid target, which was a mainstay of double-polarized scattering experiments in the 6 GeV era, must also be rebuilt to accommodate the new constraints. The new target and its horizontal refrigerator will fit in a space restricted by the new CLAS12 5 T solenoid and detector package, making the center of the target sit within a narrow clearance that tapers from 30 to 10 cm in diameter over a length of 2.3 m. The target will dynamically polarize NH3 and/or ND3 in two target cells at 5 T and 1 K using 140 GHz microwaves, and will provide protons and deuterons polarized to above 90% and 40%, respectively. We will present the proposed design of the new polarized target system for Hall B, and discuss the progress and challenges of the project.

17:05 **[92] eHD at Jefferson Lab**

Presenter: HANRETTY, Charles

The HDice frozen spin, solid Hydrogen-Deuteride target has been used in recent years with photon beams in Jefferson Lab's Hall B. With the recent upgrade of the Hall's CLAS detector and Jefferson Lab's CEBAF accelerator come new physics opportunities to study the 3D structure of the nucleon. In this vein, there are presently three A-rated experiments which have been designated as having a "high impact" for the Hall B physics program, each requiring the use of a transversely polarized target. Targets with spin transverse to electron beams pose a challenge, since the associated holding fields bend the beam into the detector. Frozen-spin targets that require only modest magnetic fields present a potential solution. However, new depolarization mechanisms arise when using the HDice target with charged particle beams. In order to study these mechanisms and methods to abate them, a new low-energy accelerator is being built at Jefferson Lab. This accelerator (the Upgraded Injector Test Facility, or UITF) will deliver electrons to the HDice target at an energy of ~10 MeV. Although energy loss varies rapidly with beam energy, it is dominated by bremsstrahlung that has no effect on the HD material. The energy deposited in the target, which does influence performance, is almost independent of beam energy. As a result, effects studied at the UITF can be directly related to the expected performance with 10 GeV beams delivered to HDice in Hall B. Depolarization mechanisms from charged particles, the UITF eHD tests, as well as plans for running e+HD experiments in Hall B with CLAS12 will be discussed.

17:30 **[93] Magnesium di-Boride: A novel solution for a transversely polarized target holding field in CLAS12**

Presenter: LOWRY, Michael

Three A-rated proposals to study the 3D structure of the nucleon with the CLAS12 detector require a transversely polarized target [1]. A minimal R B × dL is needed to limit beam deflection by the transverse holding field of such a target. At the same time, the axial field of the CLAS12 central solenoid must be canceled over the same region. Finally, adequate field uniformity to allow NMR polarization monitoring is highly desirable. Magnesium di-Boride, a high Tc superconductor [2], offers a novel solution to these requirements. A cylindrical shell of the material can simultaneously trap and maintain a uniform transverse internal field while shielding the external axial field. This passive solution has significant advantages over designs utilizing current carrying coils including improved performance, reduced dE/dx and simplicity of fabrication and operation. A series of calculations with ELEKTRA, one of the OPERA suite of programs [3], has been carried out that define a base design diameter, length and thickness. Validation of the calculations has been made through modeling and comparison to measurements with a two-thirds scale prototype MgB2 cylinder under test at Universit`a di Ferrara in cooperation with Edison-Milan [4].

References

[1] https://www.jlab.org/Hall-B/clas12-web/clas12-expt2.jpg.
[2] J.J. Rabbers. et al, Supercond. Sci. Technol. 23 (2010) 125003.
[3] Cobham Technical Services - Vector Fields Software.
[4] M. Statera, et al, IEEE Transactions on Applied Superconductivity, Vol. 25, No. 3 (June, 2015) 4501004.

17:55 **[94] Automated Microwave Frequency Control of Dynamically Polarized Targets**

Presenter: DARSHANA-PERERA, Gonaduwage

In scattering experiments that use targets relying on dynamic nuclear polarization (DNP), target materials must be irradiated using microwaves at a frequency determined by the difference in the nuclear Larmor and electron paramagnetic resonance (EPR) frequencies. Since the resonance frequency changes with time as a result of radiation damage, the microwave frequency should be adjusted accordingly. Manually adjusting the frequency can be difficult, and improper adjustments negatively impact the polarization. Therefore, two controllers were developed which automate the process of seeking and maintaining the optimal frequency: one being a standalone controller for a traditional DC motor and the other a LabVIEW VI for a stepper motor configuration. The relationship between microwave frequency and corresponding polarization growth and decay rates in DNP experiments were extensively studied while developing this method. As a result, a Monte-Carlo simulation was developed which can accurately model the polarization over time as a function of microwave frequency. In this talk, analysis of the simulated data and recent improvements to the automated system will be presented.

Tuesday 27 September 2016

Helicity: Parallel IV - Lincoln (09:00-10:50)

Nucleon helicity structure

-Conveners: Gerhard Mallot

time	[id] title
09:00	**[99] Gluon polarization from Longitudinally polarized proton collisions at STAR** *Presenter: RAMACHANDRAN, Suvarna* The contribution to the spin of the proton from its constituents has been one of the unresolved questions in nuclear physics. The longitudinal spin program at STAR is exploring a wide range of measurements to determine the gluon helicity distribution inside the proton. The inclusive jets and pions in the kinematic range accessed by RHIC are dominated by quark-gluon and gluon-gluon scattering processes. The longitudinal double-spin asymmetry (ALL) is sensitive to polarized parton distributions and can be used to extract information about the gluon helicity contribution (ΔG) to the spin of the proton. The 2009 STAR inclusive jet ALL measurements at √s = 200 GeV showed the first evidence of polarized gluons for gluon momentum fractions above 0.05. The data collected at √s = 510 GeV will extend the current constraints on ΔG to lower gluon momentum fractions, and the measurement of dijet ALL will allow for the reconstruction of the partonic kinematics at leading order. This presentation will focus on the recent results from the ALL measurements at STAR, and how they extend the sensitivity to the gluon spin contributions at lower momentum fractions.
09:25	**[100] Recent PHENIX measurements sensitive to the gluon polarization in the proton** *Presenter: YU, Haiwang* Understanding the proton spin structure in terms of quark and gluon degrees of freedom is one of the key open questions in the field of hadron physics. Gluon helicity, Δg(x), related measurements play an important role in solving this "Spin Puzzle". The polarized proton+proton collisions at the Relativistic Heavy Ion Collider provide unique opportunities for studying Δg(x) by accessing it via a variety of probes through gluon-gluon or quark-gluon interactions at leading order. The double-helicity spin asymmetries (ALL) for π0 and jet production were measured at PHENIX and STAR, respectively, in 2009 using polarized p + p collisions at 200 GeV center-of-mass energy, revealing for the first time evidence of nonzero Δg(x) for Bjorken-x in the range 0.05 < x < 0.2. Yet Δg(x) for x < 0.05 is still poorly constrained. In this talk, we will report recent PHENIX measurements sensitive to the gluon polarization. The π0 ALL measurements at central rapidity (|η| < 0.35) at √s = 510 GeV can provide constraints on gluon polarization down to x near 10–2. At forward rapidity (1.2 < |y| < 2.2), also at 510 GeV, the measurement of ALL for J/ψ production has sensitivity to Δg(x) for x ≈ 2 × 10–3.
09:50	**[101] Measurement of double helicity asymmetries in charged pion production at mid-rapidity at PHENIX** *Presenter: MOON, Taebong* One of the main goals of the RHIC spin program is the determination of the gluon helicity contribution to the proton spin. This can be accessed by measuring double spin asymmetries (ALL) of pion production at mid-rapidity in longitudinally polarized proton collisions with the PHENIX experiment. The ordering of the asymmetries with the charge of the final state pions can in addition directly infer the sign of the gluon spin contribution. Charged pions are reconstructed in the central PHENIX tracking system. The asymmetries are evaluated between collisions of bunches with the same and opposite helicity after correcting for differences in luminosity and for beam polarizations. The ALL measurements of pion production at √s = 200 GeV have been published previously. To extend our understanding of the gluon polarization to a lower gluon momentum fraction (x), high statistics data was collected at a higher √s =510 GeV in 2012-2013. We present the physics motivation, the analysis procedure and current status of the π ±ALL measurements at mid-rapidity.
10:10	**[102] Longitudinal Double Spin Asymmetries with π0- Jet Correlations in Polarized Proton Collisions at √s= 510 GeV at STAR** *Presenter: WANG, Yaping*

10:30 **[104] Review of recent direct gluon polarization measurements**

Presenter: KLIMASZEWSKI, Konrad

Starting with the discovery of EMC that quarks are not the only building blocks of the nucleon spin its structure has been a topic of intense studies for numerous experiments. With precision measurements of quark and gluon polarisations by SMC, HERMES, COMPASS, STAR and PHENIX collaborations we are closing to an answer. The quark contribution is already determined with good accuracy and results of determination of the gluon contribution will be presented hereafter. However this does not solve the puzzle of the nucleon spin and impact of partons orbital motion is actively pursued in Deeply Virtual Compton Scattering (DVCS) experiments at Jefferson Laboratory and COMPASS.

While precise asymmetry measurements from polarised colliders (RHIC) provide input for global NLO QCD fits with great success, more direct measurements of gluon polarisation are possible with fixed target experiments. Both HERMES and COMPASS collaborations have performed such measurements in several channels. These results provide important contribution as they are independent of assumptions about behaviour of Δg outside of the measured region.

Hereafter we review the recent results of gluon polarization measurements which finally indicate a small but non zero gluon contribution to the nucleon spin with focus on fixed target experiments.

TMDs: Parallel IV - Illinois Ballroom A (09:00-10:50)

3D structure of the nucleon: TMDs

-Conveners: Akio Ogawa

time [id] title

09:00 **[105] Di-hadron production in proton-proton collisions andthe universality of the transversity distribution**

Presenter: RADICI, Marco

The transversity distribution was recently extracted from deep inelastic scattering processes producing hadron pairs in the final state because it is involved, together with a specific chiral-odd di-hadron fragmentation function, in the elementary mechanism that generates a transverse-spin asymmetry in the azimuthal distribution of the detected hadron pairs. The same elementary mechanism was predicted to generate an analogous asymmetry when the hadron pairs are produced in proton-proton collisions with one transversely polarized proton. Recently, the STAR Collaboration has observed this asymmetry. We analyze the impact of these data on our knowledge of transversity.

09:25 **[106] Illuminating QCD and Nucleon Structure Through the Study of Hadrons Within Jets and Dihadron Correlations at RHIC**

Presenter: DRACHENBERG, James

Over the last decade, theoretical and experimental engagement of the oft challenging phenomena of nucleon transverse-spin has unlocked tantalizing opportunities for new insight into nucleon structure and more expansive formulations of QCD, e.g. with higher dimensions in momentum space. The RHIC experiments continue this exploration through an array of measurements from high-energy polarized-proton collisions. Among these studies are the azimuthal distributions of hadrons within jets and dihadron correlations. Recent breakthroughs may illuminate further longstanding questions: Do factorization and universality extend to collinear transversity and transverse-momentum-dependent (TMD) formulations of QCD? How do TMD functions evolve with changing kinematics? Beyond existing probes, future measurements will enable even wider frontiers in understanding QCD and nucleon structure.

09:50 **[107] Nonperturbative Transverse Momentum E ects in Dihadron and Direct Photon-Hadron Angular Correlations**

Presenter: OSBORN, Joseph

Two-particle angular correlations have long been used as an observable for measuring the initial-state partonic transverse momentum kT . Sensitivity to this small transverse momentum scale allows nonperturbative transverse momentum dependent (TMD) effects to be probed in high pT dihadron and direct photon-hadron correlations. The observable pout, the out-of plane transverse momentum component from a near-side π0 or direct photon, is sensitive to initial-state kT and final-state fragmentation transverse momentum jT and thus can probe nonperturbative TMD effects. In the TMD framework, nearly back-to-back particle production in p+p collisions with a measured final-state hadron has been predicted to break factorization due to the possibility of gluon exchange with colored remnants in the initial and final states. For this reason, the interacting partons are predicted to be correlated; however, there is so far no quantitative prediction for the magnitude of such effects. In this talk, recent measurements of dihadron and direct-photon hadron correlations in p+p collisions at √ s=510 GeV at the PHENIX experiment will be presented.

10:05 **[108] Transverse spin-dependent azimuthal correlations of charged pion pairs measured in p↑+p collisions at √ s = 500 GeV**

Presenter: SKOBY, Michael

The transversity distribution is a fundamental component of the spin structure of the nucleon, and is only loosely constrained by existing semi-inclusive deep inelastic scattering data. The di hadron interference fragmentation function (IFF), which describes the fragmentation of transversely polarized quarks, is expected to give rise to spin-dependent di-hadron correlations in p↑+p collisions. Significant asymmetries in di-hadron correlations have already been measured at RHIC in p↑+p collisions at √s = 200 GeV at mid-rapidity. In 2011, STAR collected an integrated luminosity of 25 pb–1 from p↑+p collisions at √s = 500 GeV, allowing STAR to extend these di hadron asymmetries into a previously unexplored kinematic region. The charge-ordered pion pair asymmetry measurement from √s = 500 GeV p↑+p collisions at STAR is presented as a function pion pair transverse momentum, invariant mass, and pseudorapidity.

10:20 **[109] Recursive Monte-Carlo code for polarized quark jet**

Presenter: KERBIZI, Albi

A Monte-Carlo code of jet generation by a transversely polarized quark is proposed. It is based on the recursive splitting of a string, like in the symmetric Lund fragmentation model, together with the 3P0 model of quark-antiquark pair creation. The code involves a complex mass parameter, in addition to the usual Lund parameters. The Collins effect is obtained and the related asymmetries, their dependence on the quark flavor, on the hadron species and on energy are studied. Azimuthal correlations and di-hadron asymmetries are also investigated. The results can help improving quark polarimetry.

10:35 **[110] Spin asymmetries for vector boson production in polarized p+p collisions**

Presenter: HUANG, Jin

We investigated the cross section and the associated spin asymmetries for vector boson (W^\pm/Z_0/γ*) production in polarized proton-proton collisions at tree level within the TMD factorization formalism. Besides the well-known Sivers function f_1T, the single transverse asymmetry could also probe the transversal helicity distribution g_1T via the parity-violating nature of W/Z_0 production. Contrary to Sivers function, which is expect to change sign from SIDIS to DY-type of processes, transversal helicity is universal between SIDIS and DY. To assess the feasibility of experimental measurements, we estimate the spin asymmetries for W^\pm/Z_0 boson production in polarized proton-proton collisions at the Relativistic Heavy Ion Collider (RHIC) by using current knowledge of the relevant TMDs. We find that both the parityconserving and parity violating single transverse asymmetries can be sizable, if the suppression effect from TMD evolution is not too strong.

Beyond SM: Parallel IV - Innovation (09:00-10:40)

Fundamental Symmetries and Spin Physics Beyond the Standard Model

-Conveners: David Kawall

time [id] title

09:00 **[95] Electric Dipole Moment Measurements at Storage Rings**

Presenter: PRETZ, Joerg

Electric Dipole Moments (EDM) of elementary particles including hadrons, are considered as one of the most powerful tools to discover CP violation beyond the Standard Model. Such CP violating mechanisms are required to explain the dominance of matter over anti-matter in our universe. Up to now experiments concentrated on neutral systems (neutron, atoms, molecules). Storage rings offer the possibility to measure EDMs of charged particles by observing the influence of the EDM on the spin motion. The Cooler Synchrotron COSY at the Forschungszentrum J¨ulich provides polarized protons and deuterons up to a momentum of 3.7 GeV/c and is thus an ideal starting point for such an experimental programme. Plans for measurements of charged hadron EDMs and results of first test measurements will be presented.

09:25 **[96] Search for a permanent electric dipole moment of 129Xe**

Presenter: ZIMMER, Stefan

A permanent electric dipole moment (EDM) of the isotope 129Xe would imply a breakdown of both parity P and time reversal symmetry T and, through the CPT theorem, a breakdown in CP, the combined symmetries of charge conjugation C and parity P. Our goal is to improve the present experimental limit (dXe < 3 · 10–27 ecm) by about three orders of magnitude. The most precise EDM limit on diamagnetic atoms was measured on 199Hg (dHg < 7·10–30 ecm). To get more stringent limits, we perform a 3He/129Xe clock comparison experiment with the detection of free spin precession of gaseous, nuclear polarized 3He or 129Xe samples with a SQUID as magnetic flux detector. The precession of co-located 3He/129Xe nuclear spins are used as an ultra-sensitive probe for non-magnetic spin interactions of type Δν ~ dXe · E. With our experimental setup at the Jülich research center we are able to observe spin coherence times of about 1 day for both species. We report on first experimental results achieved within the MIXed-collaboration.

09:50	**[97] The neutron electric dipole moment (nEDM) experiment at the Spallation Neutron Source** *Presenter: TANG, Zhaowen*
10:15	**[98] Neutron EDM measurement at PSI** *Presenter: RAWLIK, Michal*

GPDs: Parallel IV - Alma Mater (09:00-10:40)

3D structure of the nucleon: GPDs and Form Factors

-Conveners: Nicole D'Hose

time	[id] title
09:00	**[111] Introduction to GPDs** *Presenter: BURKARDT, Matthias*
09:25	**[112] The physics and applications of the D-term** *Presenter: SCHWEITZER, Peter*
09:50	**[113] The Flexible Spectator Model of Spin Dependent Quark and Gluon GPDs: Implications for Deeply Virtual Lepton Scattering** *Presenter: GOLDSTEIN, Gary* The "flexible" parametrization of quark and gluon Generalized Parton Distributions (GPDs), based on spectator models and Regge behavior, will be presented. The Chiral Even GPDs, constrained by nucleon form factors and PDFs, determine deeply virtual Compton scattering amplitudes and are compared with cross section and polarization data. The Chiral Odd GPDs, including "transversity", contribute to pseudoscalar leptoproduction and are compared to recent experimental data. The spectator scheme is extended to new quark-sea and gluon GPDs. Predictions for an array of spin-dependent angular distributions and asymmetries in Deeply Virtual Scattering processes related to these distributions is explored.
10:15	**[114] Form Factor and Proton Radius at MAMI and with ISR experiments** *Presenter: MUELLER, Ulrich* An overview of the form factor programme of the A1 Collaboration at MAMI is given. Results on the electromagnetic form factors of the proton measured with elastic electron scattering at four-momentum transfers Q2 between 0.003 and 1 GeV2/c2 are reported, which allow an extraction of the electric and magnetic radii and a determination of the two-photon exchange correction. The analysis of proton data taken at Q2 up to 2 GeV2/c2 as well as the analysis of deuteron data are ongoing. A novel technique to measure the electric form factor of the proton at very low Q2 using initial state radiation (ISR) is presented and first results from a pilot experiment are reported. Future plans at Mainz include an ISR measurement with a new gas jet target and a new experiment to measure the neutron electric form factor.

Lattice: Parallel IV - Loyalty (09:00-10:40)

Mini Symposium on Nucleon Spin Structure and Lattice QCD

-Conveners: Huey-Wen Lin

time	[id] title
09:00	**[115] Hadron electric polarizability from lattice QCD** *Presenter: ALEXANDRU, Andrei* Electromagnetic polarizabilities are important parameters for understanding the interaction between photons and hadrons. For most hadrons these quantities are poorly constrained experimentally since they can only be measured indirectly. Lattice QCD can be used to compute these quantities directly in terms of quark and gluons degrees of freedom, using the background field method. We present results for the electric polarizability for two different quark masses, light enough to connect to chiral perturbation theory. These are currently the lightest quark masses used in polarizability studies. For each pion mass we compute the polarizability at four different volumes and perform an infinite volume extrapolation. We also discuss the effect of turning on the coupling between the background field and the sea quarks.
09:25	**[116] Nuclear structure from lattice QCD** *Presenter: DETMOLD, William*

09:50	**[117] Strange contributions to proton electromagnetic form factors** *Presenter: ORGINOS, Kostas*
10:15	**[118] Strange Quark Magnetic Moment of the Nucleon at Physical Point** *Presenter: SUFIAN, Raza* We present a lattice QCD calculation of the strange quark contribution to the proton's magnetic moment and the charge radius at the physical pion mass. We perform a model independent extraction of the strange magnetic moment and strange charge radius from the electromagnetic form factors in the momentum transfer range of 0.051 GeV2 <~ Q 2 <~ 1.31 GeV2. The finite lattice spacing and finite volume corrections are included in a global fitting on three lattices with different lattice spacings, different volumes, and three sea quark masses. We obtain the strange magnetic moment GsM(0) = –0.073(17) μN and strange charge radius < r2s >E= –0.0047(22) fm2. Additionally, we present our results of the disconnected u, d quarks contribution to the proton's electromagnetic form factors.

Low Energy: Parallel IV - Illinois Ballroom B (09:00-10:40)

Low Energy Spin Physics with Lepton, Photon and Hadron Probes

-Conveners: Steffen Strauch

time	[id] title
09:00	**[119] Compton Scattering and Nucleon Polarizabilities at High Intensity Gamma-Ray Source** *Presenter: LI, Xiaqing*
09:25	**[120] Wide-Angle Compton Scattering** *Presenter: WOJTSEKHOWSKI, Bogdan*
09:50	**[121] Compton scattering** *Presenter: DOWNIE, Evangeline*
10:15	**[122] Measurement of analyzing powers for p-3He scattering with polarized 3He target** *Presenter: WATANABE, Atomu* One of the main interest of nuclear physics is to understand nuclear properties based on bare nuclear forces. Recently, it is indicated that the three-nucleon forces (3NFs) is essential to clarify various nuclear phenomena. Few-nucleon scattering at intermediate energies (~ 100 MeV/nucleon) is one of good approach to investigate dynamical aspects of 3NFs. In the last decade study of nucleon-deuteron (three-nucleon system) as well as deuteron breakup channels has been extensively performed both experimentally and theoretically. Direct comparison between the data and the rigorous numerical calculations in terms of Faddeev theory showed clear evidence of 3NFs effects [1]. In order to explore the properties of the 3NFs in four-nucleon systems, we are planning measurements of p–3He elastic scattering at intermediate energies. As a first experiment, we performed the measurement of 3He analyzing power at 70 MeV/nucleon with polarized 3He target at the Cyclotron and Radioisotope Center (CYRIC), Tohoku University. Proton beams were injected to polarized 3He target, and scattered protons were detected by using E – ΔE detectors which consisted of plastic and NaI(Tl) scintillators. Measured angles were from 50■ to 110■ in the laboratory system. Polarized 3He was produced by the spin-exchange optical pumping (SEOP) method, and typical values of 3He polarizations were 10 ■. In the conference we will report a recent result of this experiment. References [1] See, e.g., K. Sekiguchi et al., Phys. Rev. C 65, 034003 (2002); ibid. 89, 064007 (2014).

Beams: Parallel IV - Illinois Ballroom C (09:00-10:40)

Accelerator, Storage and Polarimetry of Polarized Beams

-Conveners: Wolfram Fischer

time	[id] title
09:00	**[123] Acceleration of polarized He-3 in Booster and AGS** *Presenter: HOCK, Kiel*

09:25	**[258] Design and Simulation of a Polarized Pure Photon Source for Compton Scattering from Solid Polarized Targets** *Presenter: ZHANG, Jixie* Wide angle compton scattering from polarized protons holds great promise: access to the generalized parton distribution functions He and E with different weighting and moments than in other hard exclusive processes, emphasizing the u-quarks and the valence region. Previously, experiments were proposed using bremsstrahlung from polarized electrons striking a radiator. Unfortunately the mixed electron-γ beam limits the polarized target performance due to radiation damage and restricted luminosity owing to the heat load. We have designed a pure photon beam line by placing a dipole magnet after the radiator which deflects the electrons away from the target and into a beam dump. This approach has many benefits which include an order of magnitude increase in the photon luminosity and unrestricted use of transversely polarized targets while preserving robust target performance. We will discuss the physics motivation, the design (of two different options) as well as the G4beamline simulation results of the source.
09:50	**[125] CEBAF 5 MeV Mott polarimeter** *Presenter: GAY, Timothy*

Targets: Parallel IV - Technology (09:00-10:15)

Polarized Ion and Lepton Sources and Targets

-Conveners: Christopher Keith

time	[id] title
09:00	**[126] Development of deuterated polymer polarized targets** *Presenter: WANG, Li* The Dynamic Nuclear Polarization (DNP) is an efficient technique to enhance the nucleus polarization by the so-called ‘Radiation doping’ or ‘Radical chemically doping’ methods in the field of polarized solid targets for their use in nuclear and particle physics experiments. Polymer materials have been used since 1994 due to the advantage of its easy handling at room temperature and shape controlling in a special thin target. We studied the deuteron polarization of polymer materials, D-polyethylene and D-polystyrene, with ‘Radiation-doping’ and ‘Radical chemically doping’, respectively. By the irradiation with 20MeV electrons from the Bonn Linac of the ELSA accelerator on D-polyethylene at a range from 1.0x1015-1.0x1017e-/cm2, a polarization of 31% has been obtained at the DNP conditions of 2.5T and 150mK. In the case of chemical doping method (TEMPO or Trityl Finland D36), no remarkable polarization has been obtained. The problem of Finland D36 seems to be its solubility into the solvent. On the other hand, D-polystyrene material was prepared for the DNP by doping it with the radical ‘Finland D36’, which is a prominent member of the trityl radicals. A deuteron polarization of 32% has been measured at 2.5T and 1K. At 5T and 400mK, this value has been considerably improved to >60% with a polarization build-up time of a few hours.
09:25	**[127] Influence of Irradiation on Dynamic Nuclear Polarization of polyethelyne and polypropylene** *Presenter: REEVE, Scott*
09:50	**[128] A thin, superconducting magnet for the Polarized Target** *Presenter: BORNSTEIN, Marcel*

Future: Parallel IV - Excellence (09:00-10:40)

Future Facilities and Experiments

-Conveners: Charles Hyde

time [id] title

09:00 **[129] The RHIC cold QCD plan for 2017 to 2023: a portal to the EIC**

Presenter: FATEMI, Renee

In light of the recent recommendation by the Nuclear Science Advisory committee to construct a U.S. based Electron Ion Collider (EIC), the spin community at the Relativistic Heavy Ion Collider has developed a program of must-do experiments to be run during the period leading up to the turn on of the EIC. These experiments will utilize the unique capabilities of the world's only polarized proton-proton collider to make measurements that will, when combined with data from the EIC, test the limits and validity of factorization and universality. This program includes measurements of observables that are sensitive to the universality and evolution of initial and final state transverse momentum distributions, the transversity distributions at high x and gluon fragmentation functions. The timeline and detector requirements for implementation will be discussed.

09:25 **[130] fsPHENIX: A Detector Evolution for the Study of Nucleon Spin Structure and Cold NuclearMatter at RHIC**

Presenter: LAJOIE, John

In a few short years, the Relativistic Heavy Ion Collider (RHIC) will embark on detailed studies of the Quark Gluon Plasma with a major new jet-optimized detector known as sPHENIX. On the same timescale, the recent RHIC Cold QCD plan outlines a compelling program of key measurements in spin-polarized p+p and p+A collisions that can be realized on the road to an Electron Ion Collider (EIC). To fully exploit the capabilities of sPHENIX and RHIC we consider new instrumentation in the forward direction (proton-going in p+A collisions and at the EIC) as an addition to the baseline sPHENIX detector. This evolution, known as fsPHENIX, will enable new measurements of spin asymmetries in jet production (both inter- and intra-jet), Drell Yan, and studies of cold nuclear matter utilizing the unique capabilities of the RHIC collider. I will give an overview of the fsPHENIX design, its relationship to sPHENIX and a future EIC detector, and the physics goals of the Cold QCD Plan.

09:50 **[131] Design of a Fully Optimized DIS Detector at eRHIC**

Presenter: Dr. PETTI, Richard

The 2015 Nuclear Physics Long Range Plan has endorsed the realization of an electron-ion collider as the next large construction project in the US after FRIB. The machine is planned to be high luminosity, exceeding 10^33 cm–2 s–1, with highly polarized electron and proton/light ion beams, wide kinematic reach and ability to collide a variety of hadron species from p to Pb. The facility and associated experiment(s) will address fundamental questions in QCD. A detector designed to efficiently register and identify deep inelastic electron scattering (DIS) processes in a wide range of center-of-mass energies available with the new collider is one of the key elements of such an upgrade. The progress on the detector and interaction region design work will be shown, and the simulation results presented.

10:15 **[132] Spin physics experiments at NICA-SPD with polarized proton and deuteron beams**

Presenters: KOVALENKO, Alexander, SAVIN, Igor

Measurements of asymmetries in the inclusive and exclusive production of Lepton pairs (DY pairs) in collisions of non-polarized, longitudinally and transversally polarized proton and deuteron beams are suggested to be performed at the NICA collider of the JINR using the specialized Spin Physics Detector. These measurements can provide an access to all leading twist collinear and TMD PDFs of quarks and anti-quarks in nucleons. Status of NICA and SPD project will be reported.

Future: Parallel V - Excellence (11:05-12:45)

Future Facilities and Experiments

-Conveners: Alexander Kiselev

time [id] title

11:05 **[169] TMD Physics with SoLID at Je erson Lab 12GeV**

Presenter: ZHAO, Zhiwen

There have been many efforts to access the transverse momentum dependent parton distributions (TMDs) by using the semi-inclusive deep inelastic scatterings (SIDIS) processes. The next generation SIDIS experiments with the proposed Solenoidal Large Intensity Device (SoLID) in Hall A at Jefferson Lab, will fully utilize the great physics potential of the 12-GeV energy upgrade by combining high luminosities and large acceptance. We will use 11 GeV and 8.8 GeV electron beams on transversely and longitudinally polarized 3He targets and a transversely polarized proton target with detection of charged pions and electrons in coincidence. The SoLID SIDIS experiments will provide 4D (x, z, Q2 , PT) mappings of Sivers, Collins, pretzelosity and worm-gear asymmetries in the valence quark region with unprecedented precision. In this talk, we will present the experiment plans and the expected physics results on TMD extractions, transversity distributions, and the tensor charge of u and d quarks. The constraint on quark electric dipole moments (EDMs) with the tensor charge measurement and neutron EDM experiments will also be discussed.

11:30	**[170] A Drell-Yan experiment with a transversely polarized target at SeaQuest** *Presenter: KLEIN, Andi* We will discuss the new E1039 experiment at Fermilab to measure the single spin asymmetry of the Drell-Yan process on a transversely polarized target. This measurement can be used to determine the sign and magnitude of the Sivers asymmetry. A non-vanishing Sivers asymmetry requires a non-zero orbital angular momentum contribution of the sea quarks to the nucleon spin. This will be the first ever measurement of the Sivers asymmetry for the u-bar quark. The experiment will be a continuation of the current unpolarized SeaQuest program at Fermilab.
11:55	**[171] Predicting the sin ϕS Transverse Single-spin Asymmetry of Pion Production at an Electron Ion Collider** *Presenter: WANG, Xiaoyu* We study the transverse single-spin asymmetry with a sin φS modulation in semi-inclusive deep inelastic scattering after the transverse momentum of the final state hadron is integrated out. In particular, we consider the case in which the transverse momentum of the final state hadron is integrated out. Thus, the asymmetry is merely contributed by the coupling of the transversity distribution function h1(x) and the twist-3 collinear fragmentation function H˜ (z). Using the available parametrization of h1(x) from SIDIS data and the recent extracted result for H˜ (z), we predict the sin φS asymmetry for charged and neutral pion production at an Electron Ion Collider. We find that the asymmetry is sizable and could be measured. We also include the QCD evolution effect of the transversity h1(x) and the fragmentation function H˜ (z) , which affects the sin φS asymmetry at EIC considerably.
12:20	**[254] Spin Physics at the Electron Ion Collider: The JLEIC Detector Concept** *Presenter: HYDE, Charles* A high luminosity polarized electron ion collider offers an unprecedented probe of the QCD dynamics of hadron and nuclear structure. I will present the JLEIC accelerator, interaction region, and detector design in the context of its impact on spin physics. The ion beams will include longitudinally and transversely polarized protons and 3He, as well as both vector and tensor polarized deuterons. The detector design emphasizes nearly hermetic acceptance, including a high resolution far forward spectrometer to identify deep exclusive and diffractive DIS events, the target fragmentation jet, and spectator fragments from light nuclei. Particle ID (e/γ/π/K/p) is matched to the kinematics, to allow detailed flavor tagging in polarized SIDIS reactions.

Targets: Parallel V - Technology (11:05-12:45)

Polarized Ion and Lepton Sources and Targets

-Conveners: Jaakko Henrik Koivuniemi

time	[id] title
11:05	**[166] COMPASS Polarized Target for Drell-Yan** *Presenter: MATOUSEK, Jan* In the polarized Drell–Yan experiment at the COMPASS facility in CERN a pion beam with momentum of 190 GeV/c and intensity about 108 pions/s interacted with transversely polarized proton target. The muon pair produced in Drell–Yan process was detected. The measurement was done in 2015 as the 1st ever polarized Drell–Yan experiment. The solid-state NH3 as polarized proton target was polarized by dynamic nuclear polarization in 2.5 T field of a large-acceptance superconducting magnet. A large helium-3/4 dilution cryostat was used to cool the target down below 100 mK. Polarization reached during the data taking was about 80%. Two target cells, each 55 cm long and 4 cm in diameter were used. In total the target material volume was about 690 cm3 . The upgrade of the target system, initial commissioning and operation will be presented.

11:30	**[167] The Polarized Target for Polarized Drell-Yan Experiment in COMPASS at CERN** *Presenter: NUKAZUKA, Genki* A COMPASS (Common Muon Proton Apparatus for Structure and Spectroscopy) group researches hadron structure and hadron spectroscopy with high intensity muon and hadron beams. In 2015, COMPASS performed a polarized DY experiment to measure transverse momentum dependent parton distributions. A π– beam with momentum 190 GeV/c and a transversely polarized proton target (PT) were used. The COMPASS PT system consists of a dilution cryostat, polarization measurement system, solenoid and dipole magnets. Solid ammonia beads with paramagnetic centers are used as a proton target material. The ammonia beads are contained in 2 target cells of 55 cm long and 4 cm diameter. The target cells are put on beam line with 20 cm gap. The dilution cryostat can cool down to 50 mK and achieve the high cooling power 350 mW at 300 mK. High polarization about 80 - 90% can be obtained by dynamic nuclear polarization method. The polarization is measured by nuclear magnetic resonance. In the polarized DY experiment, targets were polarized to longitudinal direction with the 2.5 T solenoid magnet. The maximum polarization was about 80% in 24 hours. After polarization, the direction of the polarization was rotated to transverse direction by changing the field of the solenoid and the 0.6 T dipole magnet. The polarization was kept with the dipole magnet while physics data taking. The polarization was decreased exponentially in this duration. The relaxation time was typically 1000 hours. It was the first attempt to irradiate high intensity hadron beam on PT at COMPASS and the effect of secondly particles on the maximum polarization and the relaxation time was observed. In this talk, the proton polarization, the COMPASS PT, results of the polarized DY experiment will be discussed.
11:55	**[255] GDH Sum Rule Test of Deuteron from Photodisintegration below 20 MeV using HiFROST** *Presenter: SEO, Pilneyo* The Collaboration measures the integrand of the GDH integral for the deuteron below 20 MeV. Mono-energetic and polarized intensive gamma rays produced by HIγS at Duke Free Electron Laser Laboratory are incident on longitudinally polarized deuteron target, using HIFROST. Neutrons from photodisintegration reaction on the deuteron target are detected by 88 BC505 liquid scintillators, which cover ¼ of 4π. This is the first experiment using the polarized target at HIgS, HIFROST. For the initial measurements, beam energies of 8, 12, 16 MeV are employed. I will talk about the target system HIFROST as well as measurement.
12:20	**[168] Polarized 3He Target at JLab** *Presenter: CHEN, Jian-Ping* Polarized 3He gas targets have been used successfully at Jefferson Lab (JLab) for a number of electron scattering experiments to study 3He spin physics and more importantly, as an effective polarized neutron target, to study the neutron spin physics, including longitudinal and transverse spin structure and 3-d structure. The performance of the JLab target reached the highest polarized luminosity and highest figure of-merit (FOM) for high-energy nuclear experiments using a polarized-target. It has gone through continuous improvements over the decade and has been providing a powerful tool for precision study of the neutron and 3He spin physics. The achievements and progresses of the JLab polarized 3He target system will be reviewed in this talk. Several high-impact experiments are planned for the near- and long-term future at JLab using the polarized 3He target. An upgrade to meet the even-more demanding high precision experimental requirements is under way. It consists two stages, each stage aims to improve the FOM by about a factor of 3. Details of the upgrade plan and progress will also be discussed.

Beams: Parallel V - Illinois Ballroom C (11:05-12:45)

Accelerator, Storage and Polarimetry of Polarized Beams

-Conveners: Wolfram Fischer

time	[id] title
11:05	**[162] Current results on implementation of the Nucletron/NICA R&D program with polarized beams** *Presenter: Prof. KOVALENKO, Alexander* Preparation of the research program at the Nuclotron and the future NICA collider facility is carried out during the last years. The problems of design, construction and tests of new polarized ion source (protons and deuterons), reconstruction of a front end part of the existing linac LU-20, preparation of polarimeters these are current works have been performed within the last few months. In the report, we present current results on implementation of the Nuclotron/NICA R&D program with polarized beams including the first tests of the above mentioned systems at the Nuclotron in June 2016. Near future work plan aimed at NICA collider spin physics research is discussed also.

11:30	**[163] Lattice design for quasi-frozen spin EDM searches** *Presenter: VALETOV, Eremey*
11:55	**[164] Stern-Gerlach Polarimetry** *Presenter: TALMAN, Richard* Authors: R. Talman, Cornell University; J. Grames, R. Kazimi, M. Poelker, R. Suleiman, Thomas Jefferson National Laboratory; B. Roberts, University of New Mexico It is explained how the CEBAF 123 MeV injection line can serve as one big Stern-Gerlach (S-G) polarimeter measuring the polarization state of the injected beam. No physical changes to the line are required and (though not optimal) resonant beam position monitors (BPMs) already present in the line detect the S-G signals. The historical Stern-Gerlach apparatus used a uniform magnetic field (to orient the spins) with (skew) quadrupole magnetic field superimposed (to deflect opposite spins oppositely) and a neutral, somewhat mono-energetic, unpolarized, neutral atomic beam of spin 1/2 particles. For the highly-monochromatic, already-polarized beams produced by Jefferson Lab electron guns, the uniform magnetic field has become superfluous, and every quadrupole in the injection line produces polarization-dependent S-G deflections. Dual CEBAF electron beam guns produce superimposed 0.25 GHz (bunch separation 4 ns) electron beams for which the polarization states and the bunch phases are adjusted individually. The (linear) polarizations are opposite and the bunch arrival times are adjusted so that (once superimposed) the bunch spacings are 2 ns and the bunch polarizations alternate between plus and minus. The effect of this beam preparation is to produce a bunch charge repetition frequency of 0.5 GHz different from the bunch polarization frequency of 0.25 GHz. Along with low frequency modulation of the polarizations, this difference will make it possible to distinguish Stern-Gerlach-induced bunch deflections from spurious charge-induced excitations. The paper calculates the S-G signals to be expected at each existing BPM position during routine (alternating polarization) CEBAF 123 Mev electron injection line in a ``proof-of-principle" test. Once successful, this should motivate the development of a passive (non-destructive) form of high analyzing power, precision polarimetry.
12:20	**[165] Resonant polarimetry: a new way to noninvasive fast measurement of beam polarization?** *Presenter: HILLERT, Wolfgang* In principle, resonant cavities can be excited by magnetic moments of a polarized beam, thus allowing to determine the beam’s polarization by measuring the amplitude of the resonating cavity’s fields. The steady state field amplitude can be determined by calculating the energy transferred from the beam to the resonator’s fields. Analytic formulas for different cavity modes are obtained by integrating over the longitudinal relativistic Stern-Gerlach force. It is shown that in case of ultra relativistic electrons the signal for transverse polarization is independent of beam energy whereas the signal for longitudinal polarization scales with 1/gamma. The expected signal power is derived for different cavity modes and compared with thermal noise and background by cavity excitation due to charge interaction. A possible layout for first prove-of-principle experiments at CEBAF/JLAB and ELSA/Bonn is presented.

Low Energy: Parallel V - Illinois Ballroom B (11:05-12:45)

Low Energy Spin Physics with Lepton, Photon and Hadron Probes

-Conveners: Ian Cloet

time	[id] title
11:05	**[158] The SANE Experiment and QCD Color Forces** *Presenter: ARMSTRONG, Whitney* QCD Confinement precludes experiments from resolving colored quarks in order to understand the strong forces between them, however, polarized DIS experiments uniquely provide a clean measurement of observables used in determining an average color Lorentz force on the struck quark. Within the operator product expansion framework, the twist-3 matrix element, dp2 =Rx2(2g1+3g2)dx, is proportional to the average color Lorentz force on the quark (moving in the infinite momentum frame) the instant after being struck by a virtual photon. The Spin Asymmetries of the Nucleon Experiment (SANE) measured the proton’s polarized spin structure functions g1 and g2 in a range of Bjorken x, 0.3 < x < 0.8, where the dp2 integral is most sensitive. The data was taken from Q2 equal to 2.5GeV 2 up to 6.5GeV 2 allowing for the Q2 dependence of dp2 to be studied. In addition to presenting the latest results on spin structure functions, we will discuss the physics impact and extraction of dp2.

time	[id] title
11:30	**[159] SIDIS from spin-1 targets** *Presenter: COSYN, Wim* We consider the process of DIS on a (polarized) deuteron with detection of a nucleon in the nuclear fragmentation region (spectator tagging). Its advantages and complications compared to inclusive scattering are discussed with emphasis on the method of pole extrapolation to obtain on-shell nucleon structure in a model independent way and the issue of nuclear final-state interactions (FSIs). The general structure of the cross section for SIDIS on a spin 1 target is outlined, which has additional tensor polarisation structures compared to the familiar spin 1/2 (nucleon) case. We introduce a factorized model, where deuteron structure is described using the NN light-front wave function and which accounts for relativistic spin effects and can include FSIs in the high-x region. Applications discussed in the model are a) comparison with existing unpolarized measurements (Deeps & BONuS @JLab); b) pole extrapolation of F2n using the BONuS data; c) neutron spin structure measurements possible at an EIC; d) tensor polarized deuteron structure.
11:55	**[160] Nucleon and Nuclear structure studies in electroproduction with CLAS at Jefferson Lab** *Presenter: STEPANYAN, Stepan*
12:20	**[161] Using A=3 mirror nuclei to study the nucleon structure** *Presenter: WAIDYAWANSA, Buddhini*

Lattice: Parallel V - Loyalty (11:05-12:45)

Mini Symposium on Nucleon Spin Structure and Lattice QCD

-Conveners: Kostas Orginos

time	[id] title
11:05	**[154] Matching for quasi parton distribution functions** *Presenter: ISHIKAWA, Tomomi* In recent years, the quasi parton distribution has been introduced to extract the standard parton distribution functions by lattice QCD simulations. The quasi and standard distribution share the same collinear IR singularity and the quasi distribution can be factorized into the normal distribution with perturbative matching factors. The quasi parton distribution is known to have power-law UV divergences, which is quite different from the normal distribution. We discuss the UV renormalization scheme in the matching. We also show a demonstration of perturbative matching of the quasi quark distribution between continuum and lattice.
11:30	**[155] Towards Lattice QCD Studies of High Moments of Parton Distribution Functions** *Presenter: DAVOUDI, Zohreh* Lattice quantum chromodynamics is well suited for evaluating matrix elements of local operators and so naturally provides the moments of distribution functions as defined through the operator product expansion procedure. Unfortunately, the reduced symmetry of the (hypercubic) lattice means that as the continuum limit is approached, the matrix elements of higher spin operators evaluated on the lattice become severely contaminated by contributions from lower dimensional operators, with coefficients that diverge as inverse powers of lattice spacing, requiring unrealistically high statistical precision to reliably isolate the desired contributions. In this talk, I will present a proposal for devising and implementing a new lattice operator that is defined over a length scale much smaller than the hadronic scale but much larger than the lattice spacing, and has well-defined rotational properties in the continuum limit. Within lattice perturbation theory, this operator can be shown to evade the power divergence problem. Numerical investigations are underway to verify the advantages of such operator in calculating higher moments of parton distribution functions.
11:55	**[156] Form factors from moments of correlation functions** *Presenter: CHANG, Chia Cheng*
12:20	**[157] The connected and leading disconnected diagrams of the hadronic light-by-light contribution to muon g-2** *Presenter: JIN, Luchang* We report our recent lattice calculation of hadronic light-by-light contribution to muon g–2 using our recent developed moment method. The connected diagrams and the leading disconnected diagrams are included. The calculation is performed on a 483 × 96 lattice with physical pion mass and 5.5 fm box size. We expect sizable finite volume and finite lattice spacing corrections to the results of these calculations which will be estimated in calculations to be carried out over the next 1-2 years.

GPDs: Parallel V - Alma Mater (11:05-12:55)

3D structure of the nucleon: GPDs and Form Factors

-Conveners: Matthias Burkardt

time	[id] title
11:05	**[149] Photon electroproduction at Jefferson Laboratory-Hall A** *Presenter: DEFURNE, Maxime* We will review the experimental program dedicated to photon electroproduction running in the Hall A of Jefferson Laboratory. First we will talk about the latest results of the E00-110 experiment running in 2004, published in Phys.Rev.C last year. Then we will present new results of photon electroproduction cross sections in the valence region (xBj=0.36) at three Q2-values (1.5, 1.75 and 2 GeV2)from the E07-007 experiment which was running in 2010. Unlike the E00-110 experiment, each kinematical setting was run with two beam energies. It allows, for the first time, to perform a Rosenbluth separation on the photon electroproduction. These new results bring new information about the generalized parton distributions and their contributions.
11:30	**[150] Exclusive single-photon muoproduction at COMPASS** *Presenter: FERRERO, Andrea* Investigation of GPDs and TMDs represents one of the major goals of the COMPASS-II program. Together, GPDs and TMDs provide the most complete description of the partonic structure of the nucleon. GPDs are experimentally accessible via lepton-induced exclusive reactions, in particular DVCS and DVMP. At COMPASS, these processes are investigated using a 160 GeV high intensity muon beam and a 2.5 m long liquid hydrogen target. In order to optimize the selection of exclusive reactions at these energies, the target is surrounded by a new barrel-shaped time-of-flight system to detect the recoiling particles. The pure DVCS cross-section and its |t|-dependence are extracted from the sum of cross-sections measured with opposite beam charges and polarizations. From this measurement, the first model-independent estimate of the transverse size of the nucleon in the uncharted xBj domain from 0.01 to 0.15 will be given.
11:55	**[151] Partonic Orbital Angular Momentum in QCD** *Presenter: RAJAN , Abha* We show that Generalized Transverse Momentum Distributions (GTMDs) and Generalized Parton Distributions (GPDs) can be connected by Lorentz Invariant Relations (LIRs). The GTMDs have an explicit dependence on the partonic intrinsic transverse momentum and the case of unpolarized quarks in a longitudinally polarized proton is known to connect to Orbital Angular Momentum (OAM) through the GTMD F14. In a separate approach, the GPD E˜2T can be shown to connect to OAM. However, since GPDs are collinear we need to look at a higher twist GPD (like E˜2T) that includes implicit quark gluon interaction to imitate the effects of intrinsic transverse momentum in GTMDs. We show that these two definitions are infact connected by an LIR. These relations are valid for other GTMDs and GPDs as well such as the GTMD G11 which describes quark spin orbit correlations in the proton.
12:15	**[152] The MUSE experiment and the Proton Radius** *Presenter: COLLICOTT, Cristina*
12:35	**[153] The PRad experiment at JLab** *Presenter: XIONG , Weizhi* In order to investigate the proton radius puzzle, the PRad experiment (E12-11-1062) was recently performed with 1.1 and 2.2 GeV unpolarized electron beam on a windowless H2 gas flow target in Hall B at Jefferson Lab. The experiment aims to extract the electric form factor of proton in an unprecedented low four-momentum transfer squared region, Q2 =2 × 10–4 – 0.1 (GeV/c)2, with a sub-percent precision. The PRad experiment utilizes a non-magnetic calorimetric method with a high efficiency and high resolution calorimeter (HyCal), and two world-largest, high spatial resolution Gas Electron Multiplier (GEM) detectors. The systematic uncertainties are well controlled by two main advantages of this experiment: (1) The absolute e – p elastic scattering cross section will be normalized to the well-known Møller scattering process, which is measured simultaneously within similar kinematics and experimental acceptances; (2) The gas flow target has no cell windows at both up- and downstream, which was one of the primary background sources in the previous e – p elastic scattering experiments. Thus the PRad experiment has systematic uncertainties totally different from the previous magnetic spectrometric e – p elastic scattering experiments. In this talk, we will present the details of the experiment and preliminary analysis of the 1.1 GeV and 2.2 GeV data.

Beyond SM: Parallel V - Innovation (11:05-13:10)

Fundamental Symmetries and Spin Physics Beyond the Standard Model

-Conveners: Buddhini Waidyawansa

time [id] title

11:05 **[133] Improved limit on the radium-225 electric dipole moment**

Presenter: MUELLER, Peter

Searches for permanent electric dipole moments (EDMs) are sensitive to time-reversal, parity, and charge-parity (CP) violation, and, as such, are excellent probes for physics beyond the Standard Model. 225Ra (t1/2=15d, I=1/2) is a particularly attractive system to use for an EDM search because its large nuclear octupole deformation makes it uniquely sensitive to CP violating interactions in the nuclear medium. We have developed an experiment to measure the EDM of 225Ra based on laser cooling and trapping techniques, demonstrated a first proof-of principle measurement [1], and, most recently, have significantly improved the sensitivity of our instrument to set an upper limit for the 225Ra EDM of 1.4×10–23 e cm (95% C.L.) [2]. Upcoming experimental upgrades have the potential to improve our EDM limit by additional orders of magnitude.

[1] R.H. Parker et al., PRL 114, 233002 (2015)
[2] M. Mishof et al., PRC 94, 025501 (2016)

11:30 **[134] The PULSTAR systematic studies test apparatus for the SNS neutron electric dipole moment experiment**

Presenter: LEUNG, Kent

In the Spallation Neutron Source based neutron Electric Dipole Moment (SNS nEDM) experiment, spins of polarized ultracold neutrons and polarized 3He will be manipulated in a 0.3 - 0.5 K superfluid 4He bath. Measurements will be made using two different modes: free precession and critical dressed spin. In the former, both spin species undergo a π/2 flip and then precess at their Larmor frequency in a B0 ~ 30 mG field. In the latter, after a π/2 flip, a large off-resonance RF-field is used to make the two species have the same effective precession frequency. The PULSTAR test apparatus will investigate the techniques required to perform these operations experimentally using a full sized measurement cell without an electric field, and using neutrons from the NC State PULSTAR ultracold neutron source. This apparatus allows significantly shorter cooling and turn around times than the full-size SNS nEDM experiment. Other planned investigations using this apparatus include: the difference in motion between the 3He and neutron in superfluid helium that can cause a false EDM signal, and the pseudo magnetic field caused by the spin-dependent difference of the n -3He scattering length. The apparatus is currently under construction with commissioning beginning towards the end of this year.

11:55 **[135] The Muon g-2 Experiment at Fermilab**

Presenter: FLAY, David

Precision measurements of the anomalous magnetic moment of the muon, aμ ≡ (gμ – 2)/2, provide an excellent test of the Standard Model with sensitivity to physics beyond the Standard Model. The most recent measurement of aμ at Brookhaven National Laboratory (E821) differs from the Standard Model prediction by roughly 3.5 standard deviations. Currently under construction at Fermilab is a new experiment, E989, with the aim of improving the precision on aμ by a factor of four to 140 parts per billion (ppb). E989 will use a magnetic storage ring into which polarized muons will be injected and two frequencies will be measured: the rate at which the muon polarization rotates relative to its momentum, ωa, and the magnetic field normalized to the free-proton Larmor precession frequency, ωp.
In this talk, a brief overview of the previous aμ measurements and theoretical efforts will be presented. The main discussion will focus on the motivation for E989 along with the details of how the measurements will be conducted, with an emphasis on the magnetic field work to date.

12:20 **[136] Measurement of muon g-2 and EDM with ultra-cold muon beam at J-PARC**

Presenter: MIBE, Tsutomu

The J-PARC E34 experiment aims to measure the anomalous magnetic moment (g-2) and electric dipole moment (EDM) of the positive muon with a novel technique utilizing an ultra-cold muons accelerated to 300 MeV/c and a 66 cm-diameter compact muon storage ring without focusing electric field. This measurement will be complementary to the previous BNL E821 experiment and upcoming FNAL E989 experiment with the muon beam at the magic momentum 3.1GeV/c in a 14 m diameter storage ring. In this talk, I'd like to discuss the present status and prospects.

12:45	**[137] Preparation for the Time Reversal Invariance experiment at COSY (TRIC)** *Presenter: VALDAU, Yury* The Universe around us consist mainly of matter although it is assumed that in the Big Bang an equal amount of antimatter has been produced. The Standard Model prediction for the proportion for the number of the baryons and antibaryons differs from the Astrophysical observations by eight orders of magnitude. To explain this phenomenon, which is usually called the Baryon Asymmetry of the Universe (BAU), a strong CP or T violation must be found. A possible discovery of a T-symmetry violation in a system of baryons would be a strong indication for the existence of the physics beyond the Standard Model. Using a polarized proton beam of the Cooler-Synchrotron COSY-Jülich and tensor polarized deuterium target, located at the internal PAX target place, we have access to the unique genuine Todd P-even null observable Ay,xz. It will be determined in the transmission experiment where the total cross section of the double polarized pd scattering will be determined from the difference in beam current slopes for two beam-target spin configurations. Hence, in addition, to the polarized beam and target, a dedicated high precision beam current measurement system is under the preparation for the TRIC experiment. During an experiment in June 2016 a polarized proton beam of COSY, a deuterium target at PAX, and a high precision beam current measurement system will be commissioned. In addition, during this beam time the first measurement of the AY and AY,Y observables in pd scattering at 135 MeV can be obtained using the TRIC method. In this contribution an overview of activities towards realization of the TRIC experiment as well as preliminary results from the test beam time will be presented.

TMDs: Parallel V - Illinois Ballroom A (11:05-13:05)

3D structure of the nucleon: TMDs

-Conveners: Jen-Chieh Peng

time	[id] title
11:05	**[143] AN at RHIC: What have we learned?** *Presenter: LAJOIE, John* Measurements of single single spin asymmetries (AN) in spin-polarized proton-proton collisions are a relatively straightforward experimental measurement that offers insight into the structure of the proton. However, AN integrates over both initial and final state effects, making the interpretation of a single measurement in terms of the underlying physical processes difficult. The RHIC experiments have provided a wealth of AN measurements for more than a decade, with exciting new measurements on the horizon. In this talk I will review the history of single-spin asymmetry measurements from the RHIC experiments and highlight how they have challenged our understanding of fundamental QCD and driven theoretical development. Future measurements in RHIC Run-17, as well as the prospect of expanded measurements with improved forward instrumentation offer the promise a continued window into the unsolved problem of proton structure.
11:30	**[144] Spin observables in twist-3 approach** *Presenter: KOIKE, Yuji*
11:55	**[145] Transverse Single Spin Asymmetries in Hard Processes (AN)** *Presenter: GAMBERG, Leonard*
12:15	**[146] Comparison of Forward π0 Asymmetries in Polarized p+p and p+A Collisions at STAR** *Presenter: HEPPELMANN, Steven* In 2015 the first collisions between polarized protons and nuclei occurred at the Brookhaven Relativistic Heavy Ion Collider (RHIC). This talk will present preliminary measurements of the forward transverse single spin asymmetries AN in p+p and p+A collisions with CM energy of √sNN = 200 GeV. Photons from π0 decays were measured with the STAR FMS electromagnetic calorimeter that had been upgraded for this run, resulting in significantly improved stability, resolution and photon/electron identification. The STAR FMS observed π0 photons in the forward direction relative to the polarized proton beam, in the pseudo-rapidity range 2.6 < η < 4.0, and in the transverse momentum range 1.5 < pT < 7 GeV/c. At this energy and within this kinematic range, STAR has previously reported an unexpected upward trend in the pT dependence of the π0 AN asymmetry. We will discuss the impact of previous and current measurements of nuclear modification effects in this forward region, including unique information on the nuclear dependence of AN, in comparison with models with saturation effects.

12:35 **[147] Single transverse spin asymmetries of forward neutron production in √ sNN = 200 GeV polarized p+A collisions at PHENIX**

Presenter: KIM, Minjung

The first high energy polarized proton-nuclei collisions at RHIC in 2015 give us opportunities to study unexplored reaction mechanisms of hadron production in the forward region. In PHENIX, single transverse spin asymmetries (AN s) of forward (6.8 < η < 8.8) neutron production in √sNN = 200 GeV p+Al, and p+Au collisions are measured, and an unexpected strong A dependence in AN is found. The cross section and AN from the p + p data, which covers the nonperturbative region (pT < 0.2 GeV/c), have been well described by a one pion exchange (OPE) model in Regge theory. In the OPE model, AN arises mainly from the interference of the helicity flip amplitude via pion exchange and the helicity nonflip amplitude via a1-Reggeon exchange. However, this model cannot describe the observed A dependence.
Since our data covers small –t range (< 0.5 (GeV/c)2), electromagnetic interaction may not be ignorable for the large Z nucleus, and ultra peripheral collisions (UPC) and Coulomb nuclear interference (CNI) can also play important role in asymmetry. In order to study competing effects, a correlation study using beam beam counters (which detect charged particles at 3.1 < η < 3.9) was done which can reduce or enhance their relative contributions. The resulting asymmetries demonstrated drastic dependence depending on hit requirements in the beam beam counters.
In this talk, the AN results and current progress in the interpretation of the data will be presented.

12:50 **[148] Transverse single asymmetries in neutral pion production in p + p, p+Al and p+Au collisions at mid-rapidity using the PHENIX detector system**

Presenter: NOVITZKY, Norbert

Historically, large transverse single spin asymmetries (SSA) have been measured in protonproton collisions which are nearly independent of the collision energy. At RHIC, both PHENIX and STAR experiments measured SSA's in neutral pion and η meson production from p + p collisions, in central and forward pseudo rapidity regions (η). The central η measurements were found to be consistent with zero and the forward measurements showed non-vanishing asymmetries and an increase with increasing Feynman-x. Efforts to understand their origins have resulted in very substantial improvements in our understanding of QCD and the nucleon structure. The nuclear effect on SSA may deepen our understanding in strong interaction dynamics in nuclear collisions. In polarized proton nucleus collisions already new surprises were found in very forward neutron asymmetries which warrant to study also the A dependence of the pion asymmetries. In this talk we present the status of the mid rapidity single spin asymmetry measurements of neutral pions in p + p, p+Al and p+Au collisions at √s = 200 GeV.

Helicity: Parallel V - Lincoln (11:05-12:55)

Nucleon helicity structure

-Conveners: Emanuele Roberto Nocera

time [id] title

11:05 **[138] Measurement of W single spin asymmetries and W cross section ratios at STAR**

Presenter: GUNARATHNE, Devika

The STAR experiment at RHIC has provided significant contributions to our understanding of the structure of the proton. The STAR experiment is well equipped to measure W± → e± +ν in √s = 510 GeV longitudinally polarized p + p collisions at mid rapidity (|η| < 1). The longitudinal single spin asymmetry in W production, AL, measured as a function of decay positron (electron) pseudo-rapidity η for W+(W–) is sensitive to the individual helicity polarizations of u and ¯d (d and ¯u) quarks. Due to maximal violation of parity during the production, W bosons couple to left-handed quarks and right-handed anti quarks and hence offer direct probes of their respective helicity distributions in the nucleon. The published STAR AL results (combination of 2011 and 2012 data) have been used by several theoretical analyses suggesting a significant impact in constraining the helicity distributions of ¯u, and ¯d quarks. In 2013 STAR collected a dataset at √s = 510 GeV with a total integrated luminosity of ~300 pb–1 with an average beam polarization of ~54%, a figure of merit three times larger than the dataset used by previous analyses. We will report the status of the analysis of the STAR 2013 W AL along with the future plans for final W AL results by combining both STAR 2012 and 2013 data of total integrated luminosity of about ~400 pb–1.

W cross section ratio (W+/W–) measurements at STAR are sensitive to unpolarized u, d, ¯u, and ¯d quark distributions. At these kinematics, STAR is able to measure the quark distributions near Bjorken-x values of 0.1 at a Q2 scale set by the W mass. The increased statistics from the STAR 2013 data collection, will lead to a higher precision measurement of the W+/W– cross section ratio. An update of the W cross section ratio analysis from the STAR 2011, 2012 and 2013 runs is presented.

11:30 **[139] PHENIX W measurements in polarized pp collisions**

Presenter: PARK, Sanghwa

The measurement of the single spin asymmetry of parity violating W boson production in longitudinally polarized proton collisions provides unique and clean access to the light sea quark helicity distributions. The W boson couples only to left handed quark and right-handed anti quark, and hence one can directly relate the charge of the W with initial state quark flavors. The PHENIX experiment at RHIC has performed the single spin asymmetry measurements at $\sqrt{s}$ = 510 GeV in 2011-2013. W bosons are accessed through their lepton decays at PHENIX, electrons at mid-rapidity ($|\eta| < 0.35$) and muons at forward rapidity ($1.2 < |\eta| < 2.4$). The analysis status and recent results will be presented.

11:55 **[140] Exploting nucleon spin structure through neutrino neutral-current interactions**

Presenter: WOODRUFF, Katherine

The net contribution of the strange quark spins to the proton spin, Δs, can be determined from neutral current elastic neutrino-proton interactions at low momentum transfer combined with data from electron-proton scattering. This is because the probability of neutrino-proton interactions depends on the axial form factor, which represents the spin structure of the proton and can be separated into its quark flavor contributions. Low momentum transfer neutrino neutral current interactions can be measured in MicroBooNE, a high-resolution liquid argon time projection chamber (LArTPC) in its first year of running in the Booster Neutrino Beamline at Fermilab. The signal for these interactions in MicroBooNE is a single short proton track. We present our work on the automated reconstruction and classification of proton tracks in LArTPCs, an important step in the determination of neutrino-nucleon cross sections and the measurement of Δs.

12:15 **[141] Strange quark-antiquark asymmetry of the nucleon sea from Lambda/Lambdabar polarization**

Presenter: DU, Xiaozhen

The existence of intrinsic quark and antiquark in the nucleon and their asymmetric distribution were suggested some time ago, but there is still no convinced evidence. We investigate the difference between quark to Λ and Λ longitudinal spin transfers in the light-cone quark-spectator diquark model at COMPASS, E665 and HERMES kinematic domains. Such a difference can provide additional information about the spin structure of the nucleon sea, i.e., the asymmetric strange-antistrange distribution of the nucleon sea. Our calculation shows that the asymmetric nucleon strange sea input gives a better description of the experimental data compared to the symmetric strange sea input. This can be regarded as a strong support to the existence of intrinsic strange quark sea and the asymmetric strange- antistrange distribution.

12:35 **[142] The strange quark polarization puzzle and the role of fragmentation functions**

Presenter: LEADER, Elliot

Targets: Parallel VI - Technology (14:30-16:30)

Polarized Ion and Lepton Sources and Targets

-Conveners: Thomas Gentile

time [id] title

14:30 **[200] A renewed dual hydrogen and deuterium polarized target at COSY in the PAX frame**

Presenter: CIULLO, Giuseppe

In the main frame of the experiment programs on COSY ring, more precise measurements on spin dependent cross sections for the spin filtering process (PAX experiment) and on the Time Reversal Invariance test at COSY (TRIC), required the upgrading of the gaseous internal polarized target and the whole system of it: the pABS (polarized atomic beam source), the cell (openable) and the diagnostics tools of the target itself - the TGA (Target Gas Analyzer) and the BRP (Breit-Rabi-Polarimeter).

In the presentation the whole upgrading of the system, for the fixed target, will be reported.

The target, in a fixed cell, was already commissioned for a preliminary test on TRIC experiment.

In the pABS the switching from H to D, without hardware change, is already implemented.

The monitoring and measuring vector and tensor polarization (the last only for D) by the BRP, will be performed thanks to a new Dual Cavity, already installed and now under test. And also, in order to gain longer lifetime of the stored beam, an openable cell has to be set up. We will report on the status of the apparatus for future plans.

14:55 **[201] A HERMES-type GasTarget, Internal to the LHC for the Study of pp Single-spin and Heavy Ion Collisions**

Presenter: LENISA, Paolo

15:20	**[202] Polarized 3He ABS for nEDM Experiment at SNS** *Presenter: TSENTALOVICH, Evgeni*
15:45	**[203] The PULSTAR systematic studies test apparatus for the SNS nEDM experiment** *Presenter: LEUNG, Kent* In the Spallation Neutron Source based neutron Electric Dipole Moment (SNS nEDM) experiment, spins of polarized ultracold neutrons and polarized 3He will be manipulated in a 0.3 - 0.5 K superfluid 4He bath. Measurements will be made using two different modes: free precession and critical dressed spin. In the former, both spin species undergo a $\pi/2$ flip and then precess at their Larmor frequency in a B0 ~ 30 mG field. In the latter, after a $\pi/2$ flip, a large off-resonance RF-field is used to make the two species have the same effective precession frequency. The PULSTAR test apparatus will investigate the techniques required to perform these operations experimentally using a full-sized measurement cell without an electric field, and using neutrons from the NC State PULSTAR ultracold neutron source. This apparatus allows significantly shorter cooling and turn-around times than the full-size SNS nEDM experiment. Other planned investigations using this apparatus include: the difference in motion between the 3He and neutron in superfluid helium that can cause a false EDM signal, and the pseudo-magnetic field caused by the spin-dependent difference of the n-3He scattering length. The apparatus is currently under construction with commissioning beginning towards the end of this year.
16:10	**[204] Enhanced Quantum E ciency of Strained GaAs/GaAsP Superlattice Photocathode with Distributed Bragg Reflector** *Presenter: LIU, Wei* Photocathodes with higher polarization and quantum efficiency (QE) can significantly enhance the physics capabilities of electron accelerators. In this submission, we describe the characteristics of strained GaAs/GaAsP superlattice photocathodes fabricated with a Distributed Bragg Reflector (DBR). The distributed Bragg reflector (DBR) concept was proposed to enhance the QE of strained-superlattice photocathodes by increasing the absorption of the incident photons using a Fabry-Perot cavity formed between the front surface of the photocathode and the substrate that includes a DBR, without compromising electron polarization. A typical strained GaAs/GaAsP superlattice photocathode provides polarization near 90% and QE ~ 1%. Simulations suggest that a properly fabricated DBR photocathode structure will increase QE by a factor of five. Presently, we measure a polarization of 90.7% but only 0.92% QE at the laser wavelength of 780nm. We continue to try to enhance the QE beyond the nominal 1% value by optimizing the DBR structure.

Applications: Parallel VI - Loyalty (14:30-16:10)

Application of Nuclear Polarization Techniques to Other Fields

-Conveners: Caroline Kathrin Riedl

time	[id] title
14:30	**[206] A Large-Area Planar Drift Chamber for the COMPASS experiment at CERN** *Presenter: HEITZ, Robert Shannon* The large-area planar Drift Chamber 5 (DC05) was constructed in 2014 and 2015 at the University of Illinois and Old Dominion University to replace an aging detector in COMPASS at CERN. It was assembled at CERN and installed to the large angle spectrometer of COMPASS during the spring of 2015. It has a sense-wire to sense-wire pitch of 8 mm, an active area of approximately 249x209 cm2, and an expected position resolution of 200-250 microns. Drift Chamber 5 includes 8 views, 4 of which measure coordinates in the horizontal and vertical axes as well as 4 views which measure ± 10 degrees about the horizontal axis for increased multiplicity ambiguity. COMPASS successfully collected Drell-Yan data in 2015 with DC05 included and DC05 is an important part of the COMPASS spectrometer for the 2016 and 2017 Generalized Parton Distribution runs. By comparing particle tracks reconstructed using COMPASS detectors with hits registered in DC05, the resolution and e■ciency of DC05 are being determined to evaluate the performance of this drift chamber.

14:55 **[205] Blue Waters, A Petascale Computer Facility, for the reconstruction of CERN COMPASS-II data.**

Presenter: MEYER, Marco

An exploratory phase to evaluate performances of COMPASS-II data processing using Blue Waters was granted from May 2016 through November 2016. The evaluation of COMPASS software and data transfer rates between CERN and Blue Waters is currently in full swing at Blue Waters and is extremely promising. A suitable data production model must be continuously improved to meet the expectations of raw data processing for the recent and the next measurements performed at COMPASS. From 2015 to 2018, the measurement campaign at CERN will produce 17 petabytes of experimental and Monte-Carlo data. For the reconstruction of recent and future data, the COMPASS-II experiment requires a performing and a competitive computing facility for physics analysis. Since 2002, the wordwide Large Hadron Collider (LHC) computing grid has introduced a new way to analyze and reconstruct data all over the world. This data production model is becoming increasingly essential and this technique of aggregating new computer centers into the COMPASS data production model must be considered. In case of success of this exploratory phase, Blue Waters facility would become an excellent TIER-1 center for COMPASS data. In two projects lasting two years each and one campus project, Blue Waters would provide valuable support to the COMPASS-II collaboration for data production.

15:20 **[207] Preliminary Results of a Tungsten Powder Epoxy Scintillating Fiber EMCAL for sPHENIX**

Presenter: LOGGINS, Vera

The sPHENIX detector is a proposed new detector at the Relativistic Heavy Ion Collider (RHIC). The sPHENIX physics program focuses on jets and hard probes of the quark gluon plasma (QGP). The sPHENIX detector will also have the ability to study jets in polarized proton-proton and proton-nucleus collisions and could also serve as part of a detector for an electron ion collider. The proposed design of the electromagnetic calorimeter (EMCAL), made of a tungsten powder and epoxy composite with embedded scintillating fibers, is designed to have a small Molière radius and short radiation length. It will be located at a radius of about 90 cm from the interaction region. It will have an energy resolution around 12\sqrt(E) and will be used in conjunction with a new hadronic calorimeter (HCAL) to provide a jet energy resolution of about sigma_E/E=120\sqrt(E). This design is to resolve single photons and electrons, as well as photon jets, in the high multiplicity environment of central heavy ion collisions. The eta and phi segmentation of the EMCAL is 0.024 x 0.024. The April 2016 calorimeter beam test has taken place at Fermilab. In this talk, I will discuss the construction of the EMCal and the analysis of the data in light of the sPHENIX performance requirements.

Nuclear: Parallel VI - Excellence (14:30-16:10)

Spin physics in Nuclear Reactions and Nuclei

-Conveners: Tomohiro Uesaka

time [id] title

14:30 **[209] Elastic scattering of neutron-rich 6He nuclei from polarized protons at 200 A MeV**

Presenter: CHEBOTARYOV, Sergey

Spin-orbit coupling plays an important role in nuclear structure and reactions. Scattering asymmetry in differential cross section of elastic scattering, i.e. analyzing power, is a a direct consequence of the spin-orbit coupling between the proton and the target nucleus. Extensive experimental data exist for stable nuclei on this subject, while almost no experimental attempts have been made for unstable nuclei. It is interesting to investigate how an exotic structure of the neutron-rich nucleus affects the spin-orbit coupling in proton-nucleus scattering. As unstable nuclei are short-lived and provided as a radioactive-ion (RI) beam, a spin-polarized proton target is required to probe spin-dependent interactions. Until recent, such measurements have not been possible due to the lack of target capable to work under conditions of RI beam experiments. Namely, to measure proton elastic scattering, accurate measurement of proton angle is required. Conventional polarized targets, which work under high magnetic fields of about 2.5 T severely distort protons trajectory. To overcome this a target capable to work at a low magnetic field of 0.1 T was developed by Center for Nuclear Study (CNS), University of Tokyo and RIKEN group. With this target it becomes possible to accurately measure trajectory of recoil protons.

In summer of 2016 we carried out an experiment at RIKEN, RIBF on p– 6He scattering at 200 A MeV to probe spin-orbit potential between a proton and 6He. 6He beam at intensity of 500 kpps was provided to the polarized proton target. Recoil protons were measured by Recoil Proton Spectrometers (RPS) developed in RIKEN. RPS consists of a drift chamber, plastic scintillator for energy loss measurement and NaI(Tl) calorimeters. Two spectrometers were placed symmetrically to the left and right of the beam line at 1 m distance from the target to cover 55■–70■ angular region in the laboratory frame. In addition, for determination of absolute target polarization, p–4He elastic scattering was measured.

In this presentation we are going to describe our experimental setup and provide preliminary results. Brief overview of other experiments at RIBF, which were made with polarized target will be given.

14:55	**[210] Study of Discrete Symmetry Breaking Effects in Neutron-induced Compound States** *Presenter: SHIMIZU, Hirohiko* The neutron absorption in eV region is dominated by capture process via well-resolved compound states. The breaking of the spatial inversion symmetry is known to be largely enhanced in p wave compound resonances according to the interference in the entrance channel between neighboring resonances with different angular momentum of incident neutrons. The entrance channel interference naturally implies the interference between components with different channel spins. Such interference is theoretically predicted to cause an enhancement in the observation of T-odd spin correlation terms which may contained in meson-nucleon interactions. Assuming the CPT-theorem, the enhanced sensitivity to T-violation introduces a new type of CP violation search beyond the standard model, which may be competitive with other experimental searches such as the neutron electric-dipole-moment measurement. We discuss the study of the interference mechanism to quantify the experimental sensitivity to T-violation and discuss possible experiments with the pulsed neutron beam from intense spallation neutron sources.
15:20	**[211] Observation of the Competitive Double-gamma Nuclear Decay** *Presenter: SCHEIT, Heiko*
15:45	**[212] Spinning Triaxial Nuclei Wobble: Sometimes Transverse, At Others Longitudinal** *Presenter: GARG, Umesh*

Beams: Parallel VI - Illinois Ballroom C (14:30-16:10)

Accelerator, Storage and Polarimetry of Polarized Beams

-Conveners: Wolfram Fischer

time	[id] title
14:30	**[196] RF Wien Filter Method for EDM search with CW-CCW Beams** *Presenter: ROSENTHAL, Marcel* Searches for permanent electric dipole moments (EDMs) bear the potential to reveal physics beyond the Standard Model. The JEDI (Jülich Electric Dipole moment Investigation) collaboration explores the prospects for measurements of charged nuclei, i.e. proton, deuteron and Helium-3 EDMs in dedicated storage rings. As an intermediate step, a first direct measurement of the deuteron EDM is planned at the existing conventional magnetic storage ring in Jlich, the Cooler Synchrotron COSY. The proposed measurement methods require an initial beam polarization precessing perpendicular to the stable spin axis of the storage ring. A radiofrequency Wien filter is employed to excite a spin resonance related to the magnitude of a potential EDM. This leads to a slowly increasing polarization component along the stable spin direction. Imperfections and misalignments of the magnetic elements may enhance or reduce the associated buildup rate. Studies of these systematic contributions using the software framework COSY INFINITY have been conducted. Results of the expected order of magnitude are presented within this contribution. Furthermore, methods making use of clockwise (CW) and counterclockwise (CCW) beams to disentangle these effects from a potential EDM are discussed.
14:55	**[197] RF Wien Filter Design** *Presenter: SLIM, Jamal* The JEDI (Jülich Electric Dipole Investigations) Collaboration aims for measuring the electric dipole moments (EDMs) of charged particles (deuterons and protons) at the COoler SYnchrotron (COSY). To make this possible, a new, high precision novel waveguide RF Wien filter is planned to be integrated in COSY to modulate the spin of deuterons and protons. With a Wien filter, the force of the radial electric field is canceled by the vertical magnetic force. So it is possible to directly manipulate the polarization vector of the particles without introducing any beam oscillations. This RF Wien filter is designed to operate at harmonics of the spin precession frequency ranging from 0.1 to 2 MHz. The working principle is based on the Transverse Electromagnetic (TEM) mode of a parallel-plates waveguide structure that is able of fulfilling the Wien filter condition by-design while being capable of generating high quality electromagnetic fields to the level of 10–5 to 10–6. For systematic investigations of sources of false EDM signals, the waveguide RF Wien filter can be rotated by 90■ around the beam axis.

15:20 **[198] Long polarization lifetimes and feedback control of polarization direction**

Presenter: STEPHENSON, Edward

The observation of an electric dipole moment (EDM) or its upper limit at levels near 10■29 e cm would either uncover new forms of CP violation or put at risk many models that seek to explain the excess of matter over anti-matter in the present universe. This talk presents new results on studies of the feasibility of conducting an EDM search using a polarized deuteron beam circulating in a storage ring. In the EDM experiment, the selection of an appropriate match of electric and magnetic bending fields makes possible holding the direction of the polarization always parallel to the momentum. In this configuration, the transverse electric field always present in a storage ring will rotate the polarization into the vertical direction at a rate proportional to any EDM on the deuteron. For this, it is necessary to maintain the polarization for times up to a thousand seconds to allow an opportunity for the EDM signal to become observable despite the instability of this configuration.
A time-marking system for polarimeter events has been installed on the COSY Synchrotron at the Forschungszentrum-Jülich in Germany. The clock time information makes possible the unfolding of the anomalous precession (~ 120 kHz at pd = 0.97 GeV/c) so that polarimeter events may be sorted according to the direction of the rotating polarization assuming a precise value for the precession rate. From this analysis it is possible to measure the magnitude of the in-plane polarization (IPP) as a function of time and determine the rate at which the polarization decoheres. This tool allows the study of ways to lengthen the IPP lifetime even though the polarization direction is not locked to the momentum. A combination of beam bunching, electron cooling, and the adjustment of ring sextupole fields permits the cancellation of decoherence that arises from transverse betatron oscillations in the beam.
This talk will present the most recent results taking advantage of sextupole magnet settings that also give zero chromaticity. From runs made in 2015, it has now been demonstrated that IPP lifetimes can exceed 1000 seconds.
The data acquisition and analysis system also yields the phase (or direction at a particular time) of the rotating IPP. Drifts in the COSY storage ring are slow enough that the phase may be tracked smoothly over many 1-second time bins. This capability now makes it possible to consider using the phase information in a slow feedback stream to the ring rf cavity so that the direction may be made to point in a particular place and held over time. Such a capability is essential for the EDM search. Results will be shown illustrating the operation and calibration of this feedback system. With the use of the rf solenoid in the ring, a mock EDM-type experiment was run in which the solenoid was used to drive a vertical accumulation of the polarization.

15:45 **[199] Stabilization of the Deuteron Spin Tune in a Storage Ring Using Active Feedback**

Presenter: HEMPELMANN, Nils

Permanent electric dipole moments (EDM) in elementary particles would violate CP-symmetry. The JEDI (J¨ulich Electric Dipole moment Investigations) collaboration will measure the EDM of charged hadrons using a storage ring. To keep the spin oscillation in phase with an external frequency, which is a requirement for EDM measurements in magnetic storage rings, an active feedback system was developed and tested with a polarized deuteron beam at the Cooler Synchrotron (COSY).
The feedback system determines the spin polarization using information from the polarimeter EDDA. Data measured over a time of about one second are analyzed to determine the necessary correction. The phase of the spin rotation is continuously adjusted by modifying the accelerator frequency, which changes the beam velocity and hence the rate of spin precession.
The effects of the EDM in a storage ring were mimicked using an rf-solenoid whose frequency was locked with respect to the spin oscillation. Like an EDM, the solenoid gradually tilts the spin from a horizontal to a vertical direction.
The results of the tests of the feedback system demonstrate that the method is suitable for a future proof of principle experiment for EDM measurements at COSY.

Low Energy: Parallel VI - Illinois Ballroom B (14:30-16:25)

Low Energy Spin Physics with Lepton, Photon and Hadron Probes

-Conveners: Jan Michael Friedrich

time [id] title

14:30 **[191] Baryon Spectroscopy with Polarized Photoproduction Observables from CLAS**

Presenter: STRAUCH, Steffen

Meson photoproduction is an important tool in the study of baryon resonances. The spectrum of broad and overlapping nucleon excitations can be greatly clarified by use of polarization observables. The N* program at Jefferson Lab with the CEBAF Large Acceptance Spectrometer (CLAS) includes experimental studies with linearly- and circularly-polarized tagged photon beams, longitudinally- and transversely-polarized nucleon targets, and recoil polarizations. An overview of these experimental studies and recent results, particularly from single- and double-pion-production channels, will be presented

14:55 **[192] Recent results from photoproduction off Mesons at A2**

Presenter: WALFORD, Natalie

In order to understand the strong interaction in the non perturbative region, the excitation spectrum of nucleons is one of the most important tools to use. Recent experiments using the Crystal Ball/TAPS setup at the MAMI accelerator in Mainz, Germany continue to study these properties and the excitation spectrum with meson photoproduction. Electromagnetic excitations of the proton and neutron are essential for understanding their isospin decomposition. The electromagnetic coupling of photons to protons is different than that of neutrons in certain states. Hence, a complete partial wave analysis (PWA) can assist in yielding more information about any reaction, but requires the determination of polarization observables. Polarization observables play a crucial role as they are essential in disentangling the contributing resonant and non-resonant amplitudes, whereas cross-section data alone is not sufficient for separating resonances. Preliminary results of polarization observables (E, T, and F) of η, single, and double π production off a polarized neutron (D-butanol) target will be shown with comparison to predictions of recent multipole analyses. These results will allow for significantly developing the world database.

15:20 **[193] Two- and Three-body Photo-disintegration of 3He with Double Polarizations at 29.0 and 16.5 MeV**

Presenter: LASKARIS, George

We report on the first measurements of the two- and three-body photodisintegration of longitudinally polarized 3He using a circularly polarized γ-ray beam at the incident photon energies of 29.0 MeV and 16.5 MeV, respectively. The experiments were carried out at the High Intensity γ-ray Source facility located at the Triangle Universities Nuclear Laboratory. A highpressure 3He target, polarized via spin exchange optical pumping with alkali metals, was employed. The protons from the two-body photo-disintegration were detected using 72 silicon surface barrier detectors placed at 4 different angles between 45■ and 120■ while the neutrons from the three-body photo disintegration were detected using 16 liquid scintillators positioned in horizontal reaction plane in the lab frame at 8 angles between 30■ and 165■. Results on the spin-dependent double- and single-differential cross sections, the spin dependent total cross sections and the GDH sum rule integrand will be presented for the first time and compared with the state of-the-art three-body calculations.

15:45 **[194] Double-spin observables in charged pion photo-production from polarized neutrons in solid HD using the CLAS at Jefferson Lab**

Presenter: KAGEYA, Tsuneo

Recent Lattice QCD calculations have supported the long standing quark model expectation of many more excited states of the nucleon than have been experimentally observed. Detailed partial-wave analyses (PWA) fit to many polarization observables are required to search for such ”missing states. Furthermore, the separation of isoscalar and isovector couplings to isospin 1/2 resonances requires information from both proton and neutron reactions. The present data base of neutron reactions is very sparse. To address this issue, the Jlab g14/E06-101 experiment was performed during 2011-2012 using the CLAS with circularly and linearly polarized photons incident on longitudinally polarized Deuterons in frozen-spin targets of solid Hydrogen-Deuteride (HD). Studies of experimental and theoretical methods that infer ”free neutron” spin observables from deuteron data are ongoing. Preliminary results for the single-pion channel, $\gamma + n\ (p) \rightarrow \pi^- + p\ (p)$, will be discussed. Beam-target helicity asymmetries (E) have been extracted from data with circularly polarized photons. Data with linearly polarized photons have been used to extract the beam asymmetry Σ , along with the beam-target asymmetry G. The preliminary results for the E, Σ and G asymmetries will be compared to existing PWA predictions.

16:05 **[195] Probing the Neutron Structure with the Bonus Experiment**

Presenter: EHRHART, Mathieu

Electron-proton scattering experiments have been providing a large amount of data on the proton structure function. However, because of the instability of the free neutron, fewer experiments have been able to study the neutron structure function. The BONuS collaboration at Jefferson Laboratory addresses this challenge by scattering electrons off a deuterium target, using a RTPC capable of detecting the recoiling low-momentum spectator protons near the target. Events of electrons scattering on almost free neutrons are selected by constraining the spectator protons to very low momenta and very backward scattering angles.

In 2005, BONuS successfully measured the neutron structure with scattering electrons of up to 5.3 GeV energy. An extension of this measurement has been approved using the newly upgraded 11 GeV electron beam and CLAS12 (CEBAF Large Acceptance Spectrometer). For this new set of measurements, a new RTPC detector using GEM trackers is being developed to allow measurements of spectator protons with momentum as low as 70 MeV/c. Results from the previous run, as well as upgrades and developments of the future run, will be presented.

GPDs: Parallel VI - Alma Mater (14:30-16:10)

3D structure of the nucleon: GPDs and Form Factors

-Conveners: Nicole D'Hose

time	[id] title
14:30	**[187] Understanding the Helicity Structure of DVCS** *Presenter: GONZALEZ, Osvaldo* Deeply virtual Compton scattering (DVCS) has received a lot of attention as a process to understand the transverse structure of nucleons. One feature of this cross section is the contamination from the Bethe Heitler piece, which results in cumbersome expressions. In this talk, I will discuss the helicity amplitude formalism in DVCS and its relevance in phenomenological applications.
14:55	**[188] Exclusive pi0 production at COMPASS** *Presenter: GORZELLIK, Matthias* At COMPASS DVCS and DVMP processes are studied in order to probe the partonic structure of the nucleon by constraining GPD models. Extending beyond semi-inclusive deep inelastic scattering, the measurement of lepton-induced exclusive reactions enables the study of GPDs, which ultimately reveal the three dimensional picture of the nucleon and the decomposition of its total angular momentum. The COMPASS experiment at CERN uses a high intensity tertiary muon beam with a momentum of 160GeV/c impinging on a 2.5m-long unpolarized liquid hydrogen target. To ensure the exclusivity and precision of the measurement, the wide angle electromagnetic calorimetry together with the two-stage magnetic spectrometer is complemented with a new barrel-shaped time-of-flight system surrounding the target. Exploiting the flavour filtering character of DVMP measurements, the COMPASS experiment is able to access different combinations of quark and gluon GPDs by determining the cross sections for various mesons. We report on the first extraction of the exclusive pi0 cross section in the intermediate xB domain ranging from 0.01 to 0.15. Supported by BMBF and the DFG Research Training Group Programme 1102 ``Physics at Hadron Accelerators''.
15:20	**[189] Exclusive pi0 production at JLab** *Presenter: DEFURNE, Maxime* Although being a higher-twist contribution, the transverse response was assumed to be responsible of the large π0 electroproduction cross sections measured by the Hall A and CLAS collaboration. However no Rosenbluth separation has been performed yet to verify this assumption. We will present new results of π0 electroproduction cross sections in the valence region (xBj=0.36) at three Q2 -values (1.5, 1.75 and 2 GeV2). Unlike the previous data sets, each kinematical setting was run with two beam energies. It allows to perform, for the first time, the separation of the longitudinal and transverse contributions.
15:45	**[190] Last results on exclusive meson production at HERMES** *Presenter: VAN HULSE, Charlotte* The HERMES experiment has collected a wealth of deep inelastic scattering data using the 27.6 GeV polarized lepton beam at HERA and various pure gas targets, both unpolarized and polarized. This allowed for a series of diverse and unique measurements. Among them are measurements that provide information on the three-dimensional structure of the nucleon both in momentum space and in mixed momentum and position space. Results on hard exclusive processes, sensitive to generalized parton distributions and thus to the three dimensional nucleon structure in mixed momentum and position space, are shown. In particular, spin density matrix elements and transverse-target spin asymmetries in exclusive omega production on unpolarized protons and deuterons and on transversely polarized protons, respectively, as well as helicity amplitude ratios from exclusive rho production on transversely polarized protons are presented.

TMDs: Parallel VI - Illinois Ballroom A (14:30-16:20)

3D structure of the nucleon: TMDs

-Conveners: Franco Bradamante

time [id] title

14:30 **[181] Angular Distributions of p+p Induced Drell-Yan Dimuons at Fermilab Experiment 906/SeaQuest**

Presenter: RAMSON, Bryan Joseph

In two π + W induced Drell-Yan experiments at CERN and Fermilab, angular distributions of the resultant dimuons showed a violation of the Lam-Tung relation, a perturbative QCD, "Callan-Gross-like" relationship between the polar and azimuthal angles made by the initial hadronic plane and final state dimuon plane in the Collins-Soper frame. At these energies, the violation manifests itself as a nonzero cos(2ϕ) modulation in dimuon azimuthal distributions, naively suggesting a double spin-flip in a single photon process or a contribution from the Boer-Mulders distribution, a transverse momentum dependent distribution function describing the correlation of motion of unpolarized nucleons with their constituent polarized partons. Fermilab Experiment 866/NuSea saw a Lam-Tung violation in p+d induced Drell-Yan characterized by a smaller cos(2ϕ) dimuon azimuthal modulation while p+p induced Drell-Yan saw results consistent with no violation of the relation. Fermilab Experiment 906/SeaQuest is currently investigating the possible violation of the Lam-Tung relation at a higher target x range than any previous Drell-Yan experiment. Studies of the angular distributions of p+p dimuons in SeaQuest will be presented.

14:50 **[182] Precision measurements with W and Z/γ bosons with the ATLAS detector**

Presenter: ANULLI, Fabio

15:10 **[183] Interpretation of Angular Distributions of the Drell-Yan Process**

Presenter: PENG, Jen-Chieh

15:30 **[184] Azimuthal Angular Distributions using Unpolarised Drell-Yan data from COMPASS at CERN**

Presenter: QUARESMA, Marcia

Pion-Induced reactions offer an unique opportunity to test the Quantum ChromoDynamics improved quark-parton model using angular distributions of unpolarised Drell-Yan process. Early experiments clearly showed a strong violation of the Lam-Tung relation from their angular distributions. This violation may indicate that the QCD mechanism needs to go beyond collinear by including the intrinsic quark transverse momentum dependence. This can be achieved by using the Transverse Momentum dependent Boer-Mulders function, which describes the correlation between the quarks transverse spin and the transverse momentum of the parent nucleons. COMPASS, a fixed target experiment located in the SPS accelerator at CERN, collected Drell-Yan data using a negative pion beam, at 190 GeV/c, impinging on a transversely polarised ammonia and unpolarised tungsten targets. Some recent results will be presented and the impact of these data will be discussed.

15:50 **[185] Transverse Single Spin Asymmetry in Heavy-flavor Muon Production in Polarized p + p and p + Au Collision at √ s = 200 GeV**

Presenter: CHEN, Xu

Transverse single spin asymmetries (SSAs) quantify the asymmetry of particle production relative to the transverse spin axis of a polarized hadron. SSAs have come to be recognized as a means of accessing QCD dynamics, both within initial-state hadrons and in the process of hadronization from partons. At √s = 200 GeV, heavy flavor single-spin asymmetries in proton proton collisions provide access to gluon dynamics within the nucleon. Previous measurements of J/ψ and heavy flavor to single muon SSAs have been performed at RHIC with 2006, 2008 and 2012 datasets at both central and forward rapidities. In 2015, PHENIX collected data from transverse polarized p + p collision data at √s = 200 GeV with a total integrated luminosity of 50 pb–1, about 2 times as large as the datasets in 2006, 2008, and 2012 combined. Furthermore, analysis of p + Au collisions from 2015 offers good opportunities for tests of saturation physics. The status of the J/ψ and heavy flavor to single muon SSA measurement will be presented.

16:05 **[186] Linearly Polarized Gluons in J/ψ and Y Production**

Presenter: RAJESH, Sangem

It has been recently pointed out that gluons can be linearly polarized even inside an unpolarized hadron provided that gluons should have non-zero transverse momentum with respect to the parent hadron. The effect of linearly polarized gluons on transverse momentum (PT) and rapidity (y) distributions of J/ψ and Y production is studied within the framework of transverse momentum dependent (TMD) factorization employing color evaporation model (CEM) in unpolarized proton proton collision. The estimated PT and y distributions of J/ψ and Y have been modulated by the presence of linearly polarized gluons inside unpolarized proton at LHCb, RHIC and AFTER energies. Therefore, quarkonium production is a handy process to extract the unknown density function of linearly polarized gluons.

Helicity: Parallel VI - Lincoln (14:30-16:25)

Nucleon helicity structure

-Conveners: Gerhard Mallot

time [id] title

time	[id] title
14:30	**[176] Threshold resummation and higher order QCD corrections for longitudinally polarized processes** *Presenter: RINGER, Felix* Longitudinal spin asymmetries have been a prime source of information on the nucleon's spin structure for several decades. In order to match the precision of currently available and future data taken at Compass, JLab, RHIC and a future EIC, it is of great importance to understand higher order corrections in QCD. We review the current status of higher order QCD corrections for longitudinally polarized processes for both lepton-hadron and proton-proton collisions. Besides calculations at next-to-leading order in the strong coupling constant, we focus in particular on threshold resummation. Large logarithmic corrections arise near the exclusive phase space boundary, where real gluon emission is suppressed. Threshold resummation addresses these logarithms to all orders in the strong coupling constant. In addition, spin observables that involve jets in the final state, depend on potentially large logarithms in the jet radius parameter R which can also be resummed to all orders.
14:55	**[177] Next-to-next-to-leading-order spin-dependent parton distribution function** *Presenter: KHANPOUR, Hamzeh*
15:20	**[178] Fragmentation functions and their uncertainties** *Presenter: NOCERA, Emanuele Roberto* In recent years, the NNPDF Collaboration has developed a new methodology to determine the parton distribution functions (PDFs) of the proton. This is based on a Monte Carlo sampling and representation of PDFs, a parametrization of PDFs based on neural networks, and closure tests for a full characterization of procedural uncertainties. The aim is to provide minimally biased parton sets in which PDF uncertainties due to the methodology used to determine them from experimental data are reduced as much as possible. I review the NNPDF methodology and I show how it can be applied to a determination of fragmentation functions from a global analysis of electron-positron annihilation data up to next-to-next-to leading order accuracy in quantum chromodynamics.
15:40	**[179] Charged-hadron lepto-production off unpolarized protons and deuterons at HERMES** *Presenter: SCHNELL, Gunar* The HERMES Collaboration has measured charge-separated pion and kaon multiplicities in semi- inclusive deep-inelastic scattering using a 27.6 GeV electron or positron beam scattering off a hydrogen or deuterium target. The results are presented as functions of the Bjorken variable x, the negative squared four momentum transfer Q2, the hadron fractional energy, and the hadron's transverse momentum. These data will be very useful to understand the quark-fragmentation process in deep- inelastic hadron electro-production and will serve as crucial input in the understanding of charge/flavour separated fragmentation functions. Furthermore, it provides important information on the transverse-momentum dependence of hadron production. Using the multiplicity data base, the distribution of strange quarks has been investigated at leading order in QCD. Limits on using multiplicities for making statements about flavor-separated quark distributions are also discussed.
16:05	**[180] Multiplicities of charged pion, kaon and unidentified hadrons from COMPASS** *Presenter: MAKKE, Nour* Final results on the measurement of charged pion, kaon and unidentified hadron multiplicities in semi-inclusive deep inelastic scattering at the COMPASS experiment at CERN are presented and discussed. Measurements are performed using data collected in 2006 by scattering a 160 GeV muon beam off an isoscalar target, and cover a wide kinematic range defined by Q2 > 1 (GeV/c)2, 0.1 < y < 0.7 and 0.004 < x < 0.7. Results are compared to existing measurements in the overlapping kinematic regions. Collinear fragmentation functions for pions and kaons are extracted from a leading order fit to COMPASS data, these data will also serve as inputs to global QCD fits.

Beyond SM: Parallel VI - Innovation (14:30-16:35)

Fundamental Symmetries and Spin Physics Beyond the Standard Model

-Conveners: David Kawall

time	[id] title
14:30	**[172] Parity Violation and Rare Higgs Decays from a Dark Force** *Presenter: DAVOUDIASL, Hooman*
14:55	**[173] A direct measurement of the proton's weak charge** *Presenter: MCHUGH, Marty*
15:20	**[174] The P2 experiment: A high precision determination of the weak mixing angle $\sin^2\theta W$** *Presenter: BAUNACK, Sebastian*

15:45	**[175] The MOLLER Experiment- Parity-Violating Møller Scattering at Jefferson Lab** *Presenter: SANJEEWA BEMINIWATTHA, Rakitha* Parity Violating Electron Scattering (PVES) is an extremely successful precision frontier tool that have been used for testing the Standard Model (SM) and understanding nucleon structure. Several generations of highly successful PVES programs at SLAC, MIT-Bates, MAMI-Mainz, and Jefferson Lab have contributed to understanding of nucleon structure and testing the SM. But missing phenomena like matter antimatter asymmetry, neutrino flavor oscillations, and dark matter and energy suggest that the SM is only a low energy effective theory. The MOLLER experiment at Jefferson Lab will measure the weak charge of the electron, Qe W = 1–4sin2 θW , with a precision of 2.3% by measuring the parity violating asymmetry in electron-electron (Møller) scattering and will be sensitive to subtle but measurable deviations from precisely calculable predictions from SM. The MOLLER experiment will provide the best contact interaction search for leptons at low OR high energy makes it a probe of physics beyond the Standard Model with sensitivities to mass scales of new PV physics up to 7.5 TeV.
16:10	**[256] Precise Measurement of Muonium HFS at J-PARC MUSE** *Presenter: UENO, Yasuhiro*

Social: ISPC Meeting - Illinois Ballroom (16:00-18:00)

Targets: Parallel VII - Technology (16:40-18:20)

Polarized Ion and Lepton Sources and Targets

-Conveners: Matt Poelker

time	[id] title
16:40	**[229] Polarized 3He++ Ion Source Developnent for RHIC** *Presenter: ZELENSKI, Anatoli*
17:05	**[230] Polarized Ion Sources Development at RHIC** *Presenter: ZELENSKI, Anatoli*
17:30	**[231] Moleculer Beam of Polarized Hydrogen** *Presenter: TOPORKOV, Dmitriy* Hydrogen and deuterium exists as two spin isomers, ortho and para, with the nuclear magnetic moments of the atoms either parallel or antiparallel. The spatial separation of the orthohydrogen molecules with respect to their nuclear moment in strongly inhomogeneous field of superconducting sextupole magnets is described. The scheme of the experimental setup and the results obtained under the study are presented.
17:55	**[232] Optical pumping of negative ions** *Presenter: DUDNIKOV, Vadim* Optical pumping is a convenient method of polarization of atoms, broadly used for production of polarized atoms. Positive ions can be pumped some times, but spectrum of positive ions excitation often is not available for existing lasers. It is possible to use the optical excitation of some negative ions. Optical pumping with circular polarization in magnetic field can be used for polarization of the negative ions.

Nuclear: Parallel VII - Excellence (16:40-18:20)

Spin physics in Nuclear Reactions and Nuclei

-Conveners: Tomohiro Uesaka

time	[id] title
16:40	**[233] Constraining the spin orbit force using the 34Si bubble nucleus** *Presenter: LEPAILLEUR, Alexandre*
17:05	**[234] Nuclear matter Equation of State studied by polarized proton inelastic scarttering** *Presenter: HASHIMOTO, Takashi*

time	[id] title
17:30	**[235] Various structures of the neutron-rich nucleus 31Mg investigated by beta-gamma spectroscopy of spin-polarize 31NA** *Presenter: NISHIBATA, Hiroshi*
17:55	**[236] Novel nuclear structure towards extremes of spin and isospin** *Presenter: ZHAO, Pengwei* The development of worldwide rare isotope beam facilities has brought many new insights in nuclear physics. In particular, novel structure in nuclei towards extreme isospin and spin has acquired great interest over the years for the challenges and implications it involves. Theoretically, covariant density functional theory (CDFT) has achieved great success in describing many nuclear phenomena over the past several decades. In particular, a new covariant functional PC PK1 has been developed recently. It considerably improves the isospin dependence of nuclear properties, and is more reliable for the description of neutron-rich nuclei. Based on this density functional, CDFT has also been extended for nuclear spectroscopic properties within the tilted-axis-cranking approach. The extended CDFT has provided successful description of many novel rotational structure in nuclei towards high spin, such as the magnetic rotation, antimagnetic rotation, reorientation for nuclear spin, etc. These successes have also stimulated a number of new measurements, and the interactive research between theorists and experimentalists has presented many novel rotational phenomena; several examples associated with the novel spin modes in triaxial nuclei can be seen. The success of CDFT in nuclear spectroscopic properties with high spin is not the only accomplishment recently achieved. Going to both the extreme isospin and spin, the anomalous rod shape in carbon isotopes has been investigated in cranking covariant density functional theory, and the coherent effects between the high spin and isospin have been discussed for the first time in the stabilization of such a novel shape. By adding valence neutrons and rotating the system, it is found that the spin and isospin effects enhance the stability of the rod-shaped configuration. This provides a strong hint that a rod shape could be realized in nuclei towards extreme spin and isospin.

TMDs: Parallel VII - Illinois Ballroom A (16:40-19:20)

3D structure of the nucleon: TMDs

-Conveners: Marco Radici

time	[id] title
16:40	**[213] Overview of TMD results from HERMES** *Presenter: SCHNELL, Gunar*
17:05	**[214] TMDs in the Small-x Region: an Overview** *Presenter: XIAO, Bowen*
17:30	**[215] Gluon TMDs for polarized targets and the small-x limit** *Presenter: VAN DAAL, Tom* We investigate the spin structure of gluon transverse momentum dependent (TMD) correlators defined as Fourier transforms of matrix elements of nonlocal operator combinations. At the operator level these correlators include gauge links that bridge the nonlocality. In contrast to the collinear PDFs, the gauge links are no longer unique for TMD PDFs (TMDs). The single Wilson loop operator is important when one considers the small-x limit for gluon TMDs and provides the link between TMDs and the dipole picture. We look at gluon TMDs for unpolarized, vector polarized, and tensor polarized targets.
17:45	**[216] Overview of model results on TMDs** *Presenter: SCHWEITZER, Peter*
18:10	**[217] Twist-3 fragmentation contributions to the polarized hyperon production in unpolarized proton-proton collisions** *Presenter: YABE, Kenta* We study the contribution of the twist-3 fragmentation function to the production of transversely polarized hyperons in unpolarized proton-proton collisions in the framework of the collinear factorization. Taking into account the constraint relations among twist-3 fragmentation functions which follow from the QCD equation-of-motion and the Lorentz invariance property of the correlation functions, we present the leading-order cross section for this contribution.

18:30	**[218] Study on the transverse polarization of Λ and ¯Λ in e+e− annihilation at Belle** *Presenter: GUAN, Yinghui* Spontaneous hyperon polarization has been a long standing issue for about 40 years. The so called polarizing Fragmentation Function(FF), D⊥ 1T(z, p2⊥), describes the production of a transversely polarized hadron from an unpolarized quark, where z denotes the fractional energy of the hadron and p⊥ the transverse momentum with respect to the fragmenting quark. The polarizing FF can be determined by measurement of the transverse polarization of hyperons. Because of the chiral-even nature, the polarizing FF sign is possible to be unambiguously measured. It provides a unique opportunity to test the universality of the FFs. The large e+e– annihilation data sample collected by the Belle experiment at the KEKB storage ring allows a precision study of the production of transversely polarized hyperons and check our current understanding of the associated QCD dynamics. The status of the analysis on the transverse polarization of Λ(Λ) in the ¯ inclusive production in e+e annihilation at Belle will be presented for both cases of with and without a light hadron to tag the flavor of the quark fragmenting to the Λ(Λ).
18:50	**[219] Transverse Spin Transfer to Λ and ¯ Λ Hyperons in Transversely Polarized Proton+Proton Collisions at √ s=200GeV** *Presenter: MEI, Jincheng* The transverse spin transfer to Λ hyperon can provide insights into the polarized fragmentation function and the transversity distribution which play important roles in understanding the spin structure of the nucleon. In 1997, significant spin transfer along the normal direction of the Λ production plane was observed at large xF by Fermilab E704 Collaboration. In this contribution we report an update to our analysis of the transverse spin transfer for Λ and Λ hyperons along the polarization direction of the outgoing quark or hyperon in polarized proton+proton collisions. The data were taken in 2012 with STAR detector at RHIC at center of mass energy of 200 GeV with beam polarization about 63% and cover hyperon transverse momenta up to 8 GeV/c.
19:05	**[220] Azimuthal and spin asymmetries in e+e− → V πX at high energies and 3D fragmentation functions** *Presenter: CHEN, Kaibao* Semi-inclusive vector and pseudoscalar meson production in e +e– annihilation at high energies is an ideal place to study three dimensional fragmentation functions, especially for the tensor polarization dependent part. We present the complete general kinematic analysis of this process and show that the cross section should be expressed by 81 independent structure functions, and give the results of azimuthal and spin asymmetries as well as hadron polarizations in terms of these structure functions. We also present the parton model calculation results for this process up to twist-3 level in leading order pQCD. We get the relationships between these structure functions and fragmentation functions, also the azimuthal asymmetries and hadron polarization results in the form of convolutions of these fragmentation functions. In this way, we show that these three dimensional fragmentation functions can be accessed in experiments through these measurable quantities. References [1] S. Y. Wei, K. b. Chen, Y. k. Song and Z. t. Liang, Phys. Rev. D 91, no. 3, 034015 (2015) [arXiv:1410.4314 [hep-ph]]. [2] K. b. Chen, W. h. Yang, S. y. Wei and Z. t. Liang, arXiv:1605.07790 [hep-ph].

Future & GPD joint: Parallel VII - Alma Mater (16:40-18:20)

-Conveners: Alexander Kiselev

time	[id] title
16:40	**[221] Physics opportunities at the future eRHIC** *Presenter: FAZIO, Salvatore* The 2015 nuclear physics long-range plan endorsed the realization of an electron-ion collider as the next large construction project after FRIB. eRHIC, the Brookhaven realization of the electron-ion collider with its high luminosity (> 10^33cm–2s–1), wide kinematic reach in center-of-mass-energy (45 GeV to 145 GeV) and high lepton and proton beam polarization provides an unprecedented opportunity to reach new frontiers in our understanding of the spin and dynamic structure of nucleons. This presentation will highlight several key measurements which will provide definite answers to the following questions: How are the sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon? How are these quark and gluon distributions correlated with overall nucleon properties, such as spin direction? What is the role of the orbital motion of sea quarks and gluons in building up the nucleon spin?

17:05 **[222] Time Like Compton Scattering**

Presenter: NADEL-TURONSKI, Pawel

Generalized Parton Distributions (GPDs) provide a theoretical tool for 3D tomography of the nucleon in transverse coordinate- and longitudinal momentum space. The simplest and cleanest way to access the GPDs of the nucleon is Deeply Virtual Compton Scattering (DVCS). The inverse process, where the incoming photon is real and the outgoing one has a large timelike virtuality (subsequently producing a lepton pair) is known as Timelike Compton Scattering (TCS). Measuring both can not only reduce uncertainties in the determination of GPDs, but also demonstrate their universality – as was done for PDFs by measuring (spacelike) DIS and (timelike) Drell-Yan. This talk will focus on the TCS program at Jefferson Lab, where experiments E12-12-001 (with CLAS12 in Hall B) and E12-12-006A (with SoLID in Hall A) have been approved for running with circularly polarized photon beams and unpolarized targets, while other beam- and target polarizations will follow in the future. In different kinematics, probing the sea quarks at lower x, TCS would also be an important measurement for a future Electron-Ion Collider (EIC).

17:30 **[223] QCD mechanisms for accessing the nucleon GPDs with the exclusive pion-induced Drell-Yan process at J-PARC**

Presenter: TANAKA, Kazuhiro

Generalized parton distributions (GPDs) encoding multidimensional information of hadron partonic structure appear as the building blocks in a factorized description of hard exclusive reactions. The nucleon GPDs have been accessed by deeply virtual Compton scattering and deeply virtual meson production with lepton beam. A complementary probe with hadron beam is the exclusive pion-induced Drell-Yan process. We discuss recent theoretical advances on describing this process in terms of the partonic subprocess convoluted with the nucleon GPDs and the pion distribution amplitudes [1]. Furthermore, we address the feasibility of measuring the exclusive pion-induced Drell-Yan process via a spectrometer at the High Momentum Beamline being constructed at J-PARC in Japan [1]. We also discuss the possible soft QCD mechanisms beyond the QCD factorization approach, which could give important corrections at J-PARC kinematics caused by the treatment of the pion pole contribution arising in the relevant GPDs in the ERBL region, the parton transverse momentum to regularize the endpoint singularities, the so-called soft-overlap mechanism, etc., and present an estimate making use of dispersion relations and quark-hadron duality [2]. Realization of the measurement of the exclusive pion-induced Drell-Yan process at J-PARC will provide a new test of perturbative QCD descriptions of a novel class of hard exclusive reactions. It will also offer the possibility of experimentally accessing nucleon GPDs at large timelike virtuality.

References
[1] T. Sawada, W. C. Chang, S. Kumano, J. C. Peng, S. Sawada and K. Tanaka, Phys. Rev. D 93, 114034 (2016) [arXiv:1605.00364 [nucl-ex]].
[2] K. Tanaka, in preparation.

17:55 **[224] Future Studies of Hadron Structure with High Intensity Kaon and Anti-Proton Beams at the CERN SPS M2 beamline**

Presenter: ANDRIEUX, Vincent

Single transverse Spin Asymmetries (SSA) were first observed in hadro-production of inclusive charged pions at the ZGS at ANL in 1976. Over 40 years, these large asymmetries were found to persist in reactions at increasing center of mass energies in experiments at the AGS, FNAL and RHIC. Measurements of SSA in SIDIS at HERMES, COMPASS and Jefferson Laboratory were employed to separate competing mechanisms that can contribute to the inclusive SSA observed in hadron reactions: correlations between hadron spin and intrinsic transverse quark momentum in the initial state proposed by Denis Sivers, correlations between quark spin and intrinsic transverse quark momentum in the initial state first discussed by Daniel Boer and Piet Mulders and correlations between the transverse spin of the struck quark and the transverse momentum of hadrons in the final state suggested first by John Collins.
Significant theoretical progress has been achieved in understanding the origin of SSA in hard scattering processes based on a systematic treatment of transverse momentum dependent (TMD) degrees of freedom in QCD. The COMPASS experiment at CERN is presently verifying the surprising theoretical finding of TMD-QCD, that naïve T-odd distributions - i.e. the Sivers- and Boer-Mulders quark distributions, are process dependent and change sign between SIDIS and Drell-Yan processes.
In this paper, we will present the unique opportunity that will arise from measurements of di-muon Drell-Yan production with RF-separated anti-proton-, kaon- and pion-beams at the SPS M2 beamline for studying the TMD structure of protons and mesons. Measurements with the anti-proton beam will be used to achieve a model independent extraction of the proton Boer-Mulders quark distributions. With this input, the meson beams enable measurements of Boer-Mulders quark distributions for Kaons and Pions, for the first time. These data will make it possible to study the mass dependence of TMD effects in hadrons and to compare Boer-Mulders distributions for 2-quark and 3-quark bound states.
We will conclude with a discussion of cross section measurements that can be performed simultaneously and will yield greatly improved information on the quark-structure of Kaons and Pions. RF-separated hadron beams will provide unique insight in meson structure.

Low Energy: Parallel VII - Illinois Ballroom B (16:40-18:10)

Low Energy Spin Physics with Lepton, Photon and Hadron Probes

-Conveners: Evangeline Downie

time	[id] title
16:40	**[225] Spin polarizabilities and Compton scattering form Chiral EFT** *Presenter: GRIESSHAMMER, Harald*
17:05	**[226] Measurement of the Two-Photon Exchange Contribution to Elastic Lepton-Proton Scattering at the OLYMPUS Experiment** *Presenter: HENDERSON, Brian* Measurements of the ratio of the proton elastic form factors (μpGE/GM) using Rosenbluth separation and those using polarization-based techniques show a strong discrepancy, which increases as a function of Q2 . The contribution of hard two photon exchange (TPE) to ep scattering, which is neglected in the standard treatments of elastic ep scattering, is the most widely-accepted hypothesis for the explanation of this discrepancy. While calculations of the hard TPE contribution are highly model dependent, the effect may be quantified experimentally by precisely measuring the ratio of the positron proton and electron-proton elastic scattering cross sections. The OLYMPUS experiment collected approximately 4 fb–1 of e+p and e–p scattering data at the DORIS storage ring at DESY in 2012, with the goal of measuring the elastic σe+p/σe–p ratio over the kinematic range (0.4 ≤ ■ ≤ 0.9), (0.6 ≤ Q2 ≤ 2.2) GeV2/c2 at a fixed lepton beam energy of 2.01 GeV. Initial results from OLYMPUS will be presented.
17:30	**[227] Deuteron Analyzing Powers for dp Elastic Scattering at Intermediate Energies and Three Nucleon Forces** *Presenter: SEKIGUCHI, Kimiko* Few-nucleon scattering at intermediate energies (E/A ~ 200 MeV) is one attractive approach to investigate the dynamical aspects of 3NFs, such as momentum and/or spin dependences. Direct comparison between the data and the rigorous numerical calculations based on bare nuclear potentials provides information of 3NFs. So far large 3NF effects are theoretically predicted and experimentally confirmed in the cross section minimum for dp scattering at ~ 100 MeV/nucleon. With the aim of clarifying roles of the 3NFs in nuclei the experimental programs with polarized deuterons beams at intermediate energies are in progress at RIKEN RI Beam Factory (RIBF) [1]. We have measured all deuteron analyzing powers (iT11, T20, T21, and T22) for deuteron–proton (dp) elastic scattering at 70 300 MeV/nucleon, typically in step of 50 MeV/nucleon. The vector and tensor polarized deuteron beams were accelerated by three cyclotrons, AVF, RRC and SRC. The measurement of deuteron analyzing powers for elastic dp scattering was carried out using the polarimeter BigDpol installed at the extraction beam line of the SRC. The deuteron beams bombarded a polyethylene (CH2) target in the scattering chamber. Scattered deuterons and recoil protons were detected by plastic scintillators in kinematical coincidence conditions. The obtained high precision data are compared with the results of three-nucleon Faddeev calculations based on the nucleon nucleon (NN) potentials; i.e. CD Bonn, Argonne V18, Nijmegen I, and II, alone or combined with the Tucson-Melbourne'99 and the Urbana IX 3NFs. Large discrepancies between the pure NN theory and the data, which are not resolved even by adding the current 3NFs, are found at the c.m. backward angles for almost all the deuteron analyzing powers with increasing an incident energy. In the conference the comparison between the data and the calculations based on the χ EFT potentials [2] will also be presented. [1] K. Sekiguchi et al., Phys. Rev. C 83, 061001 (2011); K. Sekiguchi et al., ibid 89, 064007 (2014). [2] S. Binder et al., Phys. Rev. C 93, 044002 (2016).
17:50	**[228] np Charge Exchange Polarimetry in GeV Region** *Presenter: PISKUNOV, Nikolay* Analyzing powers for polarized neutrons exist only for thin hydrogen targets. Cross section and analyzing powers for np, for both elastic and charge exchange are known up to 29 GeV/c. No data are known to exist for thick analyzers, made of scintillator material. A scintillator polarimeter target is required to make a coincidence trigger for both reactions. The recoil proton of elastic scattering gives a scintillator signal, and the forward neutron goes to the hadron calorimeter. For charge exchange, the forward particle is a proton, and the recoil neutron gives a signal in the scintillator target. A measurement of the angular dependence of Ay for the neutron, both elastic and charge exchange, on CH and up to 4.5 GeV/c, is essential to the continuation of neutron form factor measurements to the highest possible Q2 at JLab. Data on cross section and analyzing power for charge exchange and elastic np scattering are collected. Predictions are done on the Figure of Merit for these two reactions. The results of testing the experimental setup ALPOM2 on neutron and proton beams are presented. The measurements of analyzing powers will be done in the end of this year.

Social: ISPC Dinner (18:30-21:30)

-Conveners: Matthias Grosse-Perdekamp

Wednesday 28 September 2016

Helicity & Future Joint: Parallel VIII - Lincoln (09:00-11:00)

-Conveners: Alexander Kiselev

time	[id] title
09:00	**[237] The EIC plan in China** *Presenter: CHEN, Xurong* In this talk, we present an overview of the scienti■c opportunities that would be addressed by the China Electron-Ion-Collider (EIC). In the ■rst phase the China EIC will be 3 ~ 5 GeV polarized electron on 12 ~ 23 GeV polarized proton (and ions about 12 GeV/nucleon), with luminosity 1 ~ 2 × 1033cm– 2s– 1 . we will focus on discuss the EIC plan and its exciting physics po-tentials with the lowest experimental conditions. It converges towards a set of golden experiments that illustrate the science reach on such a facility. It will open up a new window to study the three dimensions (3D) nucleon structure for both sea and valence quarks in both momentum and coordinate space and help fully understand the strong interaction.
09:25	**[238] How to unravel the nucleon helicity structure at an EIC** *Presenter: PAGE, Brian*
09:50	**[239] Electroweak physics at the EIC** *Presenter: ZHAO, Yuxiang* We discuss measurements of parity violating asymmetries in the DIS region at an EIC. With γZ interference in the electroweak processes, the parity violating asymmetries are associated with a new series of structure functions, FγZ1, FγZ3, gγZ1, gγZ5, which provide unique combinations of unpolarized/polarized parton distribution functions. We will present the projections of these structure functions from electron-proton collisions at future EIC with different beam energy configurations considering QED, QCD radiative corrections as well as corrections of detector smearing. We will also present the weak mixing angle sin2(θW) study at much higher Q2 range than fixed target measurements using electron-deuteron collisions at an EIC.
10:15	**[240] Quarkonium production at a future electron-ion collider** *Presenter: METZ, Andreas* We discuss results for exclusive quarkonium photo- and electro production off the nucleon using the framework of generalized parton distributions (GPDs). A particular emphasis is on the gluon GPD Eg, which is related to the total angular momentum of gluons inside the nucleon. At present, Eg is basically unconstrained. On the basis of different models for Eg we estimate the transverse target spin asymmetry for typical kinematics of a future electron ion collider. We also explore the potential of measuring the polarization of the recoil nucleon.

Nuclear: Parallel VIII - Excellence (09:00-10:40)

Spin physics in Nuclear Reactions and Nuclei

-Conveners: Tomohiro Uesaka

time	[id] title
09:00	**[250] The PolFusion project: more insight on d–dspin dependent cross–sections** *Presenter: CIULLO, Giuseppe* The chance to run and to optimize a fusion reactor with the use of nuclear–polarized fuel is discussed since many years. Furthermore the idea to construct a neutron-lean tokamak reactor still relies on our knowledge on the double–polarization cross–sections of the d–d reactions at the relevant very low energies, which have not yet been measured. Various theoretical predictions cover a wide range of values, especially for the Quintet Suppression Factor (QSF), whereas the only two parametrizations of d–d experimental data clearly predict no neutron suppression by polarizing the deuterons in the quintet state. In order to investigate the spin correlation cross-sections directly, a double-polarized d–d fusion experiment is under preparation at the PNPI in Gatchina (St Petersburg/Russia). The experimental program will consist of the measurement of the asymmetries in –→d + –→d → 3He + n and –→d + –→d → t + p .As a first goal the spin-correlation coefficients Cz,z and Czz,zz will be measured to determine the Quintet Suppression Factors for both reactions. In the case of finding strong quintet state suppression this could constitute a milestone for the design of future neutron–lean fusion reactors. The total cross section modifications for polarized d–d fusion will also be investigated in analogy to the d + 3He and d + t reactions, where an increase of the cross–section by a factor of about 1.5 over the unpolarized case has been deduced. The experimental setup and the future upgrade plans will be described.

09:25	**[251] Performance of laser-polarized 3He in tokamak fuel pellets** *Presenter: MILLER, Wilson* Nuclear fusion has long been considered an ultimate solution for clean energy production. Despite decades of research, ignition, or self-sustained energy production, has been elusive. The use of spin-polarized fuel in a tokamak reactor would provide a significant boost. The cross section for the D + T $\rightarrow \alpha$ + n reaction would be enhanced by 50% if the deuterium and tritium nuclei were fully polarized along the local magnetic field. Realizing such benefits requires the polarization to survive in the plasma environment for the energy containment time. A multicenter collaboration, including Jefferson Lab, University of Virginia, and DIII-D/General Atomics, is planning the first direct test in the DIII-D tokamak in San Diego, using the mirror reaction D + 3He $\rightarrow \alpha$ + p. This proof-of-principle experiment would use inertial confinement fusion (ICF) pellets containing either hyperpolarized D (in the form of solid HD) or hyperpolarized 3He, which would be injected directly into the plasma core. ICF pellets are polymer shells that can be filled by permeation at elevated temperatures and sealed by cooling. While deuterium can be permeated through the shell wall and then polarized using standard nuclear physics protocols, 3He must be polarized first (e.g. by spin-exchange optical pumping) and then permeated through the shell wall. To be useful, the 3He polarization must survive permeation and have a sufficiently long spin-relaxation time (T1) within the shell. In this talk, we present preliminary results on ICF pellets filled with laser polarized 3He, using data acquired with a clinical 1.5-T magnetic resonance imaging (MRI) scanner. A 0.5-mm spatial resolution, which is sufficient for resolving the 2-mm diameter pellets used in this study, was achieved by using specially designed RF coils and MRI pulse sequences. Permeation loss at room temperature was extracted from a time series of 3He images, by comparing the signal magnitudes inside and outside a pellet. An absolute calibration was obtained by imaging a room-temperature mixture of 3He and O2 at thermal equilibrium polarization. Spin-relaxation times were measured over a range of holding temperatures. The T1 of a polarized 3He pellet cooled to 77K is greater than 6 hours, which is sufficient for the planned tokamak experiment.
09:50	**[252] Spin polarized fuel in tokamak fusion reactors** *Presenter: SMITH, Sterling* We have carried out calculations demonstrating the benefits of having spin polarized fuel in future tokamak fusion reactors and the viability of testing spin polarized fuel in current tokamaks. The cross section for D-T (deuterium-tritium) fusion is increased by 50% when the nuclei spins are parallel to the tokamak guide field. In future magnetic confinement fusion reactor power plants the increased reactivity of using spin polarized fuel would lessen the engineering requirements (magnetic field, plasma current, major radius) on those reactors or increase their power output for the same engineering parameters. Of particular concern for future reactors is any degradation over time in capability of the various components due to prolonged high neutron fluence from the D-T reactions; using spin polarized fuel could mitigate the consequences of moderate degradation. For instance, using fuel that is completely spin polarized could yield an increase in reactivity to make up for a 13% loss in toroidal magnetic field. On the other hand, with fixed engineering parameters, complete spin polarization of the fuel would yield a 75% increase in power output due to non-linear stabilization of heat transport at the higher pressures. An outstanding question for the future viability of spin polarized fuel in magnetic confinement reactors is whether the spin polarized fuel can retain its polarization through injection into the plasma and then through the energy containment period. We have carried out simulations that show that introducing spin polarized D and He3 pellets in high performance discharges in the DIII-D tokamak will produce measurable levels of fusion products, whose poloidal distribution and quantity can be unique to the spin states of the fuel, and can then be used as an indicator of the retention of polarization through the fusion process. Ongoing research at Jefferson Lab, University of Virginia, and General Atomics is focused on refining existing methods and technology to prepare spin polarized fuels for injection into burning plasma scenarios in order to verify these results in existing tokamaks.
10:15	**[253] Molecular Beams of Polarized Hydrogen** *Presenter: TOPORKOV, Dmitriy* Hydrogen and deuterium exists as two spin isomers, ortho and para, with the nuclear magnetic moments of the atoms either parallel or antiparallel. The spatial separation of the orthohydrogen molecules with respect to their nuclear moment in strongly inhomogeneous field of superconducting sextupole magnets is described. The scheme of the experimental setup and the results obtained under the study are presented.

Targets: Parallel VIII - Alma Mater (09:00-10:40)

Polarized Ion and Lepton Sources and Targets

-Conveners: Joe Grames

time [id] title

09:00	**[246] Developing a vortex electron beam source for nuclear physics** *Presenter: DUTTA, Dipangkar* Electron vortex beams provides an entirely new and unexplored degree of freedom for use in nuclear and particle physics-namely quantized orbital angular momentum (OAM). For example it may be used to explore the fundamental question of the contribution of of the orbital angular momentum of quarks and gluons to the spin of the proton. Such a source is under development at Jefferson Lab. However, such a source would require a electron scattering based observable to verify that the electrons carry OAM. Recent theoretical calculations predict that there are significant differences in the Mott scattering cross sections for plane wave electrons compared to vortex electrons. If Mott scattering measurement can verify these predictions it would provide a scattering based tool for monitoring vortex electrons. Such a tool would allow us to verify the OAM preserving acceleration of vortex electrons and eventually lead to high electron beams carrying quantized OAM. We will discuss simulations of Mott scattering with vortex electrons and the effort underway at Jefferson Lab to verify the theory predictions for Mott scattering.
09:25	**[247] High energy X-ray vortex generation using inverse Compton scattering** *Presenter: Dr. TAIRA, Yoshitaka* An optical vortex forming a helical wave front along the direction of propagation of the beam has been actively investigated over the past few decades. Such vortices possess a phase singularity at the center of the beam, and the field strength there is zero. More importantly, it has been shown that an optical vortex which possesses a phase term exp(imϕ) carries discrete values m■ of orbital angular momentum per photon. Fundamental and applied research on optical vortices using visible wavelength lasers is ongoing. However, vortex beams are not limited to visible light but include the sub-MeV electron vortex, ~10 keV X-ray vortex, terahertz wave vortex, and cold neutron vortex. It has been proposed on theoretical grounds that high energy X-ray vortices in the MeV and GeV range could be generated using inverse Compton scattering between an electron and an optical vortex laser. A high energy X-ray vortex providing an additional degree of freedom will open new research opportunities. Potential applications include nuclear physics, magnetic Compton scattering in solid state physics, and electron-positron pair production generated from an X-ray vortex. In this presentation, we will present a development of high-energy X-ray vortex using inverse Compton scattering at the Thomas Jefferson National Accelerator Facility. Basic experiments including the generation of the optical vortex laser by a hologram and interferometric measurement will be reported. Also a feasibility study for storing the optical vortex laser in a Fabry-Perot optical cavity already installed at the Continuous Electron Beam Accelerator Facility (CEBAF) will be presented.
09:50	**[248] eRHIC high-current, high-charge polarized electron source R&D in BNL** *Presenter: WANG, Erdong* In order to construct a future electron ion collider with high luminosity, a high average current and high bunch charge polarized electron source is under R&D at Brookhaven National Laboratory. A prototype of a high average current polarized electron funneling gun as an eRHIC injector has been built and in testing in Stonybrook University. Recently, polarized electron gun has been identified as one of the risk factors in BNL eRHIC design. The current, low-risk, eRHIC plan is based on the state of the art performance for the polarized electron gun. It uses a number of individual guns to produce individual electron beams, which are then combined with an RF deflector “tree” to meet the high average current requirement. A polarized electron gun capable of delivering mA average current and 5 nC simultaneously has not yet been demonstrated. In this talk, we will present the latest results of beam combining test using our funneling gun. Also, we will present the research plan and strategy to demonstrate high current high charge polarized electron beam from the source.
10:15	**[249] Electron Source for MESA** *Presenter: AULENBACHER, Kurt*

TMDs: Parallel VIII - Illinois Ballroom (09:00-10:50)

3D structure of the nucleon: TMDs

-Conveners: Gunar Schnell

time	[id] title
09:00	**[241] Overview of TMD results from Hall B at Jefferson Lab** *Presenter: AVAKIAN, Harut*

09:25 **[242] The fragmentation function program at Belle**

Presenter: SEIDL, Ralf

Fragmentation functions describe the transition from asymptotically free, high energetic partons into final state hadrons. Since fragmentation functions are non-perturbative objects, they need to be measured experimentally. In particular electron-positron annihilation provides very clean input into fragmentation functions as no hadrons are involved in the initial state. The Belle experiment has provided various polarized and unpolarized fragmentation function measurements such as the single pion, kaon and proton cross sections, identified di-hadron cross sections in various topologies as well as transverse spin dependent asymmetries related to Collins and interference fragmentation functions. Several more measurements, including the intrinsic transverse momentum dependence are ongoing. The most recent results and the status of ongoing fragmentation function analysis will be presented.

09:50 **[243] Measurement of the Collins asymmetries as a function of energy and transverse momentum for kaons and pions at BABAR**

Presenter: ANULLI, Fabio

Inclusive hadron production cross sections and angular distributions in e+e– collisions shed light on fundamental questions of hadronization and fragmentation processes. We present measurements of the Collins azimuthal asymmetries in inclusive production of hadron pairs, in the e+e– → h1h2X annihilation process, where the hadrons h1,2 (either kaons or pions) are produced in opposite hemispheres. The data collected by the BABAR detector allow the determination of the Collins fragmentation function dependence on hadron fractional energy and transverse momentum for the up, down and, for the first time, strange quarks. These data can be combined with semi-inclusive deep-inelastic-scattering data to extract the transversity distribution function, which is the least known leading-twist component of the QCD description of the partonic structure of the nucleon.

10:10 **[244] Partonic Angular Momentum and Spin Orbit Correlations**

Presenter: Prof. LIUTI, Simonetta

We present a framework to study the quark Orbital Angular Momentum OAM component of the proton spin, including the spin orbit interaction term. As shown recently in [1], quark OAM can be described in terms of either a Generalized Transverse Momentum Distribution (GTMD), or a twist three GPD, the two distributions being connected through a Lorentz Invariance Relation. A similar relation exists for the spin orbit component. We will discuss how the proposed framework allows one to connect experimental measurements of orbital angular momentum with lattice QCD calculations and theoretical models. Our presentation will also include a discussion of the gauge link structure in both the Jaffe Manohar and Ji definitions of OAM.

[1] A. Rajan, A. Courtoy, M. Engelhardt and S. Liuti, arXiv:1601.06117 [hep-ph].

10:30 **[245] QCD Wigner distribution at small-x**

Presenter: HATTA, Yoshitaka

Plenary: Plenary II - Illinois Ballroom (11:05-12:55)

-Conveners: Caroline Kathrin Riedl

time [id] title

11:05 **[5] 12 GeV CEBAF: The Physics and Experiments**

Presenter: BURKERT, Volker

12:00 **[6] 12 GeV CEBAF: Accelerator Systems and Polarized Beams**

Presenter: POELKER, Matt

The final nuclear physics experiments with “6 GeV CEBAF” were conducted in 2012 at which point the accelerator complex was upgraded to double the beam energy and add a fourth experimental hall. The accelerator upgrade was split into two periods, a six month period preceding the final 6 GeV operations and an 18 month period post 6 GeV operations. Following completion of the upgrade work, the new accelerator was commissioned over a roughly two year period during five distinct runs totaling 36 weeks of operation. Milestones for these commissioning periods focused on achieving incremental success in different technical areas including learning how to simultaneously operate two cryoplants, finding optimum operating parameters for new “C100” cryomodules that employ new RF control systems, commissioning the new Hall D beam transport line, and multi-hall operation at the highest passes using new 750 MHz separator cavities. During the final commissioning run, the linacs operated at maximum design energy enabling 12 GeV beam delivery to Hall D and 11 GeV beam delivery to Hall A at high average current. Fall 2016 saw the official start of the 12 GeV physics program, with nuclear physics experiments performed at Halls A, B and D during an 11 week run. All of the halls received polarized beam, although only Hall A required it. Polarization was high (> 80%) at 11 GeV eliminating concerns that increased levels of synchrotron radiation at the higher passes would serve to dilute beam polarization. The future holds challenges, notably, improving machine reliability and up-time, and maintaining linac gradient. This talk presents a summary of the CEBAF 12 GeV Upgrade – successes and setbacks – and future plans.

Plenary: Plenary III - Illinois Ballroom (14:30-16:20)

-Conveners: Erhard Steffens

time [id] title

14:30 **[7] Spin Physics in Exotic Nuclei and Perspectives for FRIB**

Presenter: IWASAKI, Hironori

Spin observables in nuclear structure and reaction studies have played a critical role in characterizing the nature of the nuclear force and dynamics. It is now well established that properties of nuclei at the limits of stability are very different from those found near the stability, representing the need to redefine the paradigms of nuclear structure physics. One such example can be found in so-called nuclear halo or skin where valence neutrons have spatially extended wave functions and therefore may induce new structural
phenomena.

The decoupled structure of nuclear halo composed of valence neutrons and core is expected to provide a new degree-of-freedom in collective modes. However, due to experimental difficulties, the information on halo excitation modes has been limited so far to the electric dipole mode (spatial oscillation between halo neutron and core), hampering detailed characterization. As a way to observe unique forms and dynamics of exotic isotopes which are often produced in very low amounts, the advanced gamma-ray array GRETINA (Gamma-Ray Energy Tracking In-beam Nuclear Array) has been employed in fast rare-isotope beam programs at NSCL. In the campaign, excited state lifetime measurements were performed for very neutron-rich C and Ne isotopes close to the drip line, in order to measure magnetic transition rates in these nuclei. The magnetic transition in atomic nuclei can probe the nuclear oscillation in spin spaces, and therefore can quantify spin responses of nuclear halo. This talk will provide an overview of the program and highlight physics results obtained for halo nuclei. Data are compared to modern nuclear structure calculations and possible impacts due to the three body force and continuum effects will be discussed. Perspectives for future opportunities at FRIB will also be provided.

15:05	**[8] Polarized Fusion, its Implications and Plans for Direct Measurements in a Tokamak Plasma** *Presenter: SMITH, Sterling* We have carried out calculations demonstrating the benefits of having spin polarized fuel in future tokamak fusion reactors and the viability of testing spin polarized fuel in current tokamaks. The cross section for D-T (deuterium-tritium) fusion is increased by 50% when the nuclei spins are parallel to the tokamak guide field. In future magnetic confinement fusion reactor power plants the increased reactivity of using spin polarized fuel would lessen the engineering requirements (magnetic field, plasma current, major radius) on those reactors or increase their power output for the same engineering parameters. Of particular concern for future reactors is any degradation over time in capability of the various components due to prolonged high neutron fluence from the D-T reactions; using spin polarized fuel could mitigate the consequences of moderate degradation. For instance, using fuel that is completely spin polarized could yield an increase in reactivity to make up for a 13% loss in toroidal magnetic field. On the other hand, with fixed engineering parameters, complete spin polarization of the fuel would yield a 75% increase in power output due to non-linear stabilization of heat transport at the higher pressures. An outstanding question for the future viability of spin polarized fuel in magnetic confinement reactors is whether the spin polarized fuel can retain its polarization through injection into the plasma and then through the energy containment period. We have carried out simulations that show that introducing spin polarized D and He3 pellets in high performance discharges in the DIII-D tokamak will produce measurable levels of fusion products, whose poloidal distribution and quantity can be unique to the spin states of the fuel, and can then be used as an indicator of the retention of polarization through the fusion process. Ongoing research at Jefferson Lab, University of Virginia, and General Atomics is focused on refining existing methods and technology to prepare spin polarized fuels for injection into burning plasma scenarios in order to verify these results in existing tokamaks
15:40	**[9] Spin Physics at the A2 Real Photon Facility at MAMI** *Presenter: THOMAS, Andreas* The A2 Collaboration at the Mainz Microtron MAMI measures photon absorption cross sections using circularly and linearly polarized 'Bremsstrahlung' photons up to an energy of 1.5 GeV and a polarized Frozen Spin Target. We use a 4 π detection system with the 'Crystal Ball' as central part. One important experimental topic is the investigation of the baryons excitation spectrum. Measurements with both longitudinally and transversely polarized protons and deuterons are essential to disentangle the broad and overlapping resonances. Several recently published data for single and double polarization observables will be presented. We have started a new program to measure double polarized Compton scattering in a wide kinematic range, which will allow for the determination of the 'Spin Polarizibilities'. As a technical highlight in this challenge we have used an active polarized proton target in our dilution refrigerator in June 2016 for the first time.

Plenary: Plenary IV - Illinois Ballroom (16:40-18:30)

-Conveners: Franco Bradamante

time	[id] title
16:40	**[10] Transverse Spin Physics: Theory** *Presenter: PROKUDIN, Alexei*
17:15	**[11] Experimental Overview of Transverse Spin Physics** *Presenter: Dr. EYSER, Oleg*

17:50 **[12] Nucleon Spin Structure from Experiments using the Drell-Yan Process**

Presenter: MARQUES QUINTANS, Catarina

In spite of its apparent simplicity, the Drell-Yan process continues to attract increasing levels of interest both in experiment and theory. Spin dependent Drell-Yan scattering provides unique access to transverse momentum dependent distribution functions of the nucleon, while the parton structure of unstable mesons can be probed from the unpolarized Drell Yan case.

Drell-Yan scattering mediated by photons or Z-bosons is currently being studied through collider experiments at LHC and RHIC, as well as through measurements with fixed target spectrometers at FNAL and CERN. Future experiments in Europe (CERN, JINR), Japan (JPARC) and the USA (FNAL, RHIC) are also being planned. The complementarity of this wide range of measurements will be discussed.

Early experimental results on Drell-Yan dilepton angular distributions will be revised in line with their modern interpretations. Recent results from STAR on polarized Drell-Yan and LHC experiments on unpolarized Drell Yan will be discussed. Finally, first preliminary results from COMPASS measurements of pion induced Drell-Yan off a transversely polarized proton target will be presented.

Blue Waters: Open House (18:30-19:30)

Poster: Poster Session - Lincoln (20:00-22:00)

Appetizers will be served. A beer and wine cash bar will be open.

Please hand your poster to the organizers on Wednesday afternoon. It will be prepared for your presentation on poster walls during the tour to Blue Waters, which you thus can join.

Formats: Landscape / horizontal preferred. Vertical is probably OK except if it is an extreme aspect ratio.

-Conveners: Caroline Kathrin Riedl

[id] title	board
[263] Longitudinal Double-Spin Asymmetries for Forward Di-jet Production in Polarized pp Collisions at √ s = 200 GeV *Presenter: LIN, Ting* One of the primary goals of the STAR spin program is to determine the spin-dependent gluon distribution, ΔG, of the proton. Recent measurements of the longitudinal double-helicity asymmetry, ALL, from inclusive jets place strong constraints on ΔG and, for the ■rst time, ■nd evidence for non-zero gluon polarization values for partonic momentum fraction x greater than 0.05. In contrast to inclusive jets, di-jet correlation measurements provide access to partonic kinematics, at leading order, and thus give better constraints on the behavior of ΔG as a function of gluon momentum fractions. Furthermore, di-jet measurements at forward rapidity probe the lower x values where ΔG is poorly constrained. Status of the ■rst measurement of ALL for di-jet with –0.8 < η1 < 0.8 and 0.8 < η2 < 1.8, from 2009 proton+proton collisions at √s = 200 GeV will be presented.	
[261] Characterizing SQERP, The SeaQuest Event Reconstruction Program *Presenter: AYUSO, Catherine* The E-906/SeaQuest experiment has a new event reconstruction program available which will be used to perform future experiment analyses and cross-check various existing results. The focus of this poster will be on a dimuon mass spectrum and tracker efficiency study conducted with SQERP, focusing on dimuons produced via the Drell-Yan process. A mass spectrum study will isolate processes that produce dimuons and carefully adjust our measured events relative to background. It will also verify the efficacy of SQERP in relation to the main SeaQuest tracker, kTracker. Efficiencies in tracking vary with beam intensity, hit location in the detectors and whether we are dealing with the detection of single tracks or pairs. A study on these three tracking effects will be conducted, along with an efficiency comparison to kTracker. Both of these studies will contribute to the complete characterization of SQERP for event reconstruction. Moreover, having a good understanding of tracking efficiencies is important for any analysis requiring absolute normalization, such as invariant cross-section measurements.	

[269] The Drell-Yan Process from Pions on Transversely Polarized Proton Targets at COMPASS

Presenter: HEITZ, Robert Shannon

The COMPASS spectrometer at CERN took data in 2015 from a 190 GeV pion beam impinged on a vertically polarized proton target. The proton target consisted of two cells oppositely polarized with the polarization switched after each week. The goal of the 2015 COMPASS Drell-Yan data taking is to measure the Sivers amplitude from single spin asymmetries and therefore be able to determine a sign change between the Sivers function in semi-inclusive deep inelastic scattering (SIDIS) and the Drell Yan process. COMPASS data has previously measured a non zero Sivers function from SIDIS and therefore COMPASS offers a unique opportunity with similar experimental setups and kinematic parameters to find a sign change between the Drell Yan and SIDIS processes. Three of nine physics periods have been reconstructed.

[262] Analysis of Drell-Yan longitudinal double spin asymmetries at PHENIX

Presenter: DARSHANA-PERERA, Gonaduwage

[259] Geometric Cliford Algebra and Quantum Interpretation of the Proton's Anomalous Magnetic Moment

Presenter: SUISSE, Michaele

The role of the anomalous moment in the geometric Cli■ord algebra of proton topological mass generation suggests that the anomaly is not an intrinsic property of the free space proton, but rather a topological e■ect of applying the electromagnetic bias ■eld required to de■ne the eigenstates probed by the magnetic moment measurement [1]. Quantum Interpretations try to explain emergence of the world we observe from formal quantum theory. This variant on the canonical measurement problem [2] is examined in the larger context of Quantum Interpretations [3].

[1] P. Cameron, “Impedance Representation of the S-matrix: Proton Structure and Spin from an Electron Model”, submitted to SPIN16. Also available at http://vixra.org/abs/1605.0150
[2] P. Busch and P. Lahti, “Measurement Theory”, Compendium of Quantum Physics: Concepts, Experiments, History, and Philosophy, p.374-379, Springer (2009)
[3] M. Suisse and P. Cameron, “Quantum Interpretation of the Impedance Model”, accepted for presentation at the 2014 Berlin Conference on Quantum Information and Measurement. Available at http://vixra.org/abs/1311.0143

[268] TBA

Presenter: GORMAN, Waverly

[267] Measurement of transverse single-spin asymmetries for di-jet production in polarized p+p collisions at √s = 200 GeV at STAR

Presenter: LIU, Huanzhao

The spin structure of the proton is of extreme complexity and remains one of the unresolved physics problems. The STAR experiment, located at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL), is performing a wide range of measurements to deconstruct the partonic contributions to the spin of the proton by analyzing polarized pp collisions. The Sivers effect considers a correlation between the nucleon spin (ST) and the parton transverse momenta (pT) in the nucleon, an effect that can be probed by searching for a pT imbalance in produced di-jets that changes sign when the beam polarization direction is reversed. A previous analysis by STAR using a small dataset taken in 2006 at √s = 200 GeV (about 1 pb-1) did not find a significant effect due to limited statistics. STAR has now accumulated much larger datasets (~20× integrated luminosity) at √s = 200 GeV. We are also investigating methods to tag the flavor of the fragmenting partons, to avoid cancellation between u and d quark effects, which are thought to have opposite signs. This poster will present the status of the analysis and studies.

[266] Study of transverse single-spin asymmetries in heavy flavor production in p + p collisions using the PHENIX Forward Vertex Detector

Presenter: BOK, Jeongsu

Transverse single-spin asymmetries provide valuable information on the spin structure of the nucleon. At RHIC energies, heavy ■avor production is dominated by gluon-gluon fusion, and the transverse single-spin asymmetry is sensitive to the tri-gluon correlations in the twist-3 collinear factorization. Study of this asymmetry for single muons from heavy ■avor decays in the PHENIX experiment serves as a clean probe for this process. In 2012, PHENIX presented the ■rst measurement of the traverse single-spin asymmetries of muons from semi leptonic decays of heavy mesons in the forward rapidity region 1.2 < |eta| < 2.0 in transversely polarized p +p collisions at sqrt(s) = 200 GeV. In the 2015 data from transversely polarized collisions, the Forward Vertex Detector, FVTX, allowed us to measure the Distance of Closest Approach (DCA) of displaced vertices, exploiting the different lifetimes of muons from ■± or ± and muons from charm and bottom mesons. By DCA measurement and track matching between the PHENIX Muon Tracker and the FVTX, we expect to be able to study separately the contributions from charm and bottom, in addition to removing the background from light mesons. In this poster, we present the status of the study of transverse single-spin asymmetries of single muons from heavy ■avor decay at forward-rapidity. In addition, we report on the progress in the work on charm/bottom separation using the FVTX detector.

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[265] Longitudinal Double Spin Asymmetry in Jets in s = 510 polarized p+p

Presenter: PATEL, Milap

The longitudinal double-spin asymmetry (ALL) is spin-polarized p+p collisions provides insight into the gluon contribution to the proton's spin by accessing the gluon helicity distribution ∆g. The PHENIX π0 and STAR jet ALL measurement show a non-zero asymmetries and hence indicate a nonzero ∆g in an NLO analysis. The STAR measurements of jet A LL in √s = 200 and 510 GeV polarized p+p collisions provide the strongest constraints on ∆g at intermediate to high x. Using new jet reconstruction techniques developed for the PHENIX detector, a measurement of the jet ALL at √s = 510 GeV in PHENIX will provide an important cross check on the results from STAR. In this poster I will highlight the progress of this analysis e■ort in PHENIX.

Thursday 29 September 2016

Plenary: Plenary V - Illinois Ballroom (09:00-10:50)

-Conveners: Mauro Anselmino

time	[id] title
09:00	**[13] AFTER@LHC: The Spin Physics Program** *Presenter: KIKOLA, Daniel* A fixed-target experiment using the LHC beams (AFTER@LHC) with a polarized target offers a unique opportunity to study the transverse spin structure of a polarized nucleon in a wide kinematical range. Recent studies have shown that a number of single transverse-spin asymmetries (STSA) are large enough to be precisely measured in the kinematical region accessible with AFTER@LHC, in particular for the Drell-Yan process as well as for single-pion, isolated photon, and jet productions. Such measurements would provide a precise handle on the quark Sivers effect. Moreover, AFTER@LHC is the ideal experimental set-up to measure also STSA sensitive to the gluon Sivers effect, of which very little is known, in processes like quarkonium (J/ψ, ψ(2S), Upsilon(1S,2S,3S) even χc) and open charm production. In this presentation, we will first review the recent ideas about the implementation of the AFTER@LHC with a polarized target: internal - inspired by the LHCb SMOG and HERMES gas-target systems - or used with a beam extracted by a bent crystal - inspired by the LUA9 technology. We will then discuss sensitivity studies for STSA measurements of Drell-Yan, quarkonium, and open charm production.
09:35	**[14] Parton Fragmentation within Spin-Dependent TMD and Collinear Observables** *Presenter: PITONYAK, Daniel* We review the recent progress on what is known about the transverse spin structure of hadrons, in particular from observables that can be analyzed within a collinear framework. These effects have been around for 40 years and represent a critical test of perturbative QCD. We look at both proton-proton and electron-nucleon collisions for various final states. While the main focus is on transverse single-spin asymmetries, we also discuss how longitudinal-transverse spin asymmetries offer a complimentary yet equally important source of information on the quark-gluon content of hadrons. We also give an outlook on future directions of research.
10:10	**[15] MESA: Status and Physics Program** *Presenter: AULENBACHER, Kurt*

Plenary: Plenary VI - Illinois Ballroom (11:05-12:55)

-Conveners: elke-caroline Aschenauer

time	[id] title
11:05	**[16] Lattice QCD Overview** *Presenter: LIN, Huey-Wen*
11:40	**[17] Hadronic Light by Light Contributions to the Muon Anomalous Magnetic Moment from Lattice QCD Calculations** *Presenter: BLUM, Thomas*
12:15	**[18] The Anomalous Magnetic Moment of the Muon: Future Measurements** *Presenter: WINTER, Peter*

Plenary: Plenary VII - Illinois Ballroom (14:30-15:45)

-Conveners: Donald Crabb

time [id] title

14:30	**[19] Frozen Spin Targets for Nuclear and Particle Physics** *Presenter: KEITH, Christopher* Frozen spin polarized targets are perhaps the most complex and demanding target systems used in nuclear and particle experiments. The scattering sample is polarized in a very high magnetic field and at a sub-kelvin temperature, before being cooled to an even lower, millikelvin temperature for data taking. In some examples, the polarization and data acquisition even occur in different locations. Despite the difficulty of building and operating these devices, they have been successfully utilized at a number of laboratories around the world. The principles, design, advantages, and disadvantages of frozen spin targets will be presented.
15:05	**[20] Production of Highly Polarized Positrons Using Polarized Electrons at MeV Energies** *Presenter: GRAMES, Joe* The Polarized Electrons for Polarized Positrons (PEPPo) experiment at the injector of the Continuous Electron Beam Accelerator Facility has demonstrated for the first time the efficient transfer of polarization from electrons to positrons produced by the polarized bremsstrahlung radiation induced by a polarized electron beam in a high-Z target. A dedicated 3m long beam line was installed for the PEPPo experiment which included: the e+/e– production target, a quarter-wave solenoid to collect positions within a large divergence angle, a combined-function spectrometer to select and focus discrete positron momenta slices, a pair of coincidence positron annihilation detectors, and a second solenoid to transport and focus positrons through an Al window to a Compton transmission polarimeter. Positron polarization up to 82% has been measured for an initial electron beam momentum of 8.19 MeV/c, limited only by the electron beam polarization. This technique extends polarized positron capabilities from GeV to MeV electron beams, and opens access to polarized positron beam physics to a wide community.

Social: Excursion - General (16:30-22:30)

Friday 30 September 2016

Plenary: Plenary VIII - Illinois Ballroom (09:00-10:50)

-Conveners: Paolo Lenisa

time	[id] title
09:00	**[21] High Precision beta decay measurements with polarized neutrons and nuclei** *Presenter: YOUNG, Albert*
09:35	**[22] GPDs: Status and Future** *Presenter: KUMERICKI, Kresimir*
10:10	**[23] Accessing GPDs in High Energy Exclusive Processes** *Presenter: MUNOZ CAMACHO, Carlos*

Plenary: Plenary IX - Illinois Ballroom (11:05-12:55)

-Conveners: Anna Martin

time	[id] title
11:05	**[24] The Longitudinal Spin Structure of the Proton: a Theory Overview** *Presenter: NOCERA, Emanuele Roberto* I will review recent theoretical progress in our understanding of the longitudinal structure of the proton. My focus will be on the framework provided by perturbative quantum chromodynamics, and will include a discussion on the determination of helicity-dependent, collinear, parton distribution functions. Connections with nonperturbative models of nucleon structure will also be outlined. I will present some open issues in our present knowledge of the proton helicity structure, and comment on how these could be addressed in the future.
11:40	**[25] Nucleon Helicity Structure: Experimental Overview** *Presenter: BAZILEVSKY, Alexander* The current understanding of the nucleon helicity structure will be reviewed based on the recent results from the Deep Inelastic Scattering experiments at DESY (HERMES), CERN (COMPASS) and Jefferson Laboratory, and polarized proton-proton collisions at RHIC. The advent of high luminosity and high center-of-mass energy Electron Ion Collider (EIC) will open new era in the nucleon helicity structure studies with unprecedented precision and wide kinematic reach. The assessment of how further the future EIC measurements could constrain the parton helicity distributions in the nucleon will be presented.
12:15	**[26] Recent RHIC Performance Improvements with Polarized Beams** *Presenter: SCHOEFER, Vincent*

Plenary: Plenary X - Illinois Ballroom (14:30-16:20)

-Conveners: Hideto Enyo

time	[id] title
14:30	**[27] Tetra-Neutron System Populated by Exothermic Double-Charge Exchange Reaction 4He(8He,8Be) at 190 MeV/u** *Presenter: SHIMOURA, Susumu*
15:05	**[28] Nucleon Spin Structure with Lepton Beams at low Q2** *Presenter: SLIFER, Karl*

15:40	**[29] Precision Electroweak Physics Using Parity Violating Electron Scattering** *Presenter: PASCHKE, Kent* The measurement of the violation of parity symmetry in electron scattering has proven to be a powerful technique for exploring nuclear matter and for the search for new fundamental forces. A successful history of measurements has set the stage for a series of ultra high-precision measurements, to be made over the next decade, which will test the completeness of the Standard Model description of the parity-violating neutral current coupling. Measurements of elastic electron-electron and electron-proton scattering at very low Q2, and of deep inelastic scattering from the deuteron, will face significant technical challenges but provide a powerful reach for new interactions. The implications of recent results and development of this next generation of experiments will be reviewed.

Plenary: Plenary XI - Illinois Ballroom (16:40-17:45)

-Conveners: Alan Krisch

time	[id] title
16:40	**[30] State and Future of Spin Physics** *Presenter: MILNER, Richard*