CHIPP 2024 Poster session

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Book of Abstracts

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Searching beyond the Standard Model with n2EDM

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The next-generation neutron electron dipole moment (EDM) measurement is currently ongoing at the Paul Scherrer Institute (PSI): the n2EDM experiment. n2EDM will deliver, at minimum, an order of magnitude better sensitivity as compared to current limits on the neutron EDM. This increased sensitivity on the neutron EDM will provide stringent constraints on time-reversal violating processes and deeply probe physics beyond the Standard Model (BSM).

This poster will highlight the recent achievements and successes during commissioning and will outline how we will reach an nEDM sensitivity of 10ˆ-27 e.cm.

2

A novel range telescope concept for proton CT

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Proton beam therapy can potentially offer improved treatment for cancers of the head and neck and in pediatric patients. Proton therapy is a promising new type of cancer treatment, can be targeted more directly at the tumor and does less damage to other tissue. Treatments are currently planned using conventional X-ray CT images. It is happening due to the absence of devises able to perform high quality proton computed tomography (pCT). However, this system (X-ray image + proton therapy) increases the dose obtained by the patients. To avoid this a new plastic-scintillator-based range telescope concept, named ASTRA, is proposed to measure the proton's energy loss in a pCT system. The performance of ASTRA has been tested by simulating the imaging of phantoms. The results show excellent image contrast and relative stopping power reconstruction.
The first tests of selected kind of scintillators and the SiPMs were performed by the DPNC at the University of Geneva and the University of Birmingham, the prototype and the readout system (using the BabyMind CITIROC) will be prepared by the DPNC group at the University of Geneva.
In this poster I present a concept of ASTRA, the simulation results and further development of the project.

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Human-in-the-loop Reinforcement Learning for Data Quality Monitoring in Particle Physics Experiments

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Data Quality Monitoring (DQM) is a crucial task in large particle physics experiments, since detector malfunctioning can compromise the data. DQM is currently performed by human shifters, which is costly and results in limited accuracy. In this work, we provide a proof-of-concept for applying human-in-the-loop Reinforcement Learning (RL) to automate the DQM process while adapting to operating conditions that change over time. We implement a prototype based on the Proximal Policy Optimization (PPO) algorithm and validate it on a simplified synthetic dataset. We demonstrate how a multi-agent system can be trained for continuous automated monitoring during data collection, with human intervention actively requested only when relevant. We show that random, unbiased noise in human classification can be reduced, leading to an improved accuracy over the baseline. Additionally, we propose data augmentation techniques to deal with scarce data and to accelerate the learning process. Finally, our studies can be found in arXiv by the following link: https://arxiv.org/abs/2405.15508.

4

HLT b-tagging in ATLAS with transformer network for 2024 data-taking

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Jets originating from b-quarks (b-jets) are produced at collider experiments in many interesting physics processes, making them a key signature to trigger events.

Trigger developments for the beginning of LHC Run 3 introduced fast b-tagging algorithms running in the early steps of High-Level Trigger (HLT) with partial reconstruction of the event, allowing to perform early background rejection, saving CPU ressources.

The success of fast b-tagging in the first years of LHC Run 3 data-taking encouraged the development of new algorithms to reach better performances in HLT b-tagging.

The GN2 algorithm is a transformer based b-tagger used in ATLAS HLT for 2024 data-taking. A description of its architecture and a comparison of its performance with respect to previous algorithms will be presented.

5

Convolutional Neural Network Approach for the Measurement of Non-Fiducial Electrons Cosmic-Rays Using the DAMPE Experiment.

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The Dark Matter Particle Explorer (DAMPE) is a space-based cosmic-ray
observatory with the aim, among others, to study cosmic-ray electrons (CREs) up to 10 TeV. Due to the low CRE rate at multi-TeV, we increase the acceptance by selecting events outside of the fiducial volume. Non-fiducial events, with their complex topology, do however require special treatments with sophisticated analysis tools. We propose therefore a Convolutional Neural Network to identify non-fiducial CREs and reject background, based on their interaction in DAMPE's calorimeter. We will show how this method can recover those events.

6

The SuperFGD: a novel highly segmented neutrino detector for the T2K experiment

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T2K is a long baseline neutrino oscillation experiment with world-leading precision on the measurement of the CP violating phase $_{CP}$ in the lepton sector of the Standard Model. The T2K Near Detector is undergoing an hardware upgrade with the installation of 4 sub-detectors: two High-angle TPCs, a TOF detector, and the Super-FGD. Some of the remarkable advantages of the upgrade are larger fiducial mass of the active neutrino target, improved proton momentum detection threshold, and capability of neutron detection. The upgraded detector will significantly improve the measurements of neutrino-nucleus interactions, representing a major systematic uncertainty in long-baseline neutrino experiments.
The Super-FGD is the active target of the detector, capable of 3D tracking in a 2-tons fiducial mass. It consists of 2 milions scintillating cubes of 1 cm^3 volume, read by nearly 60 thousand wavelength shifting optic fibers. One of the challenging points is the development of the read out electronics, due to the large number of MPPC channels and the high performance required.
This work presents the performance and hardware tests of the read-out electronics, relevant or timing and dynamic range requirements, the first results from the detector commissioning runs and MC-data comparisons, as well as studies of PID by time of flight measurement with the new Near Detector, thanks to the interplay of the Super-FGD and the TOF detector.

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Bayesian tuning of the Compact Muon Beam Line for the Mu3e experiment

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Currently PSI delivers the most intense continuous muon beam in the world with up to few 10ˆ8 μ+/s and aims at keeping its leadership upgrading its beamlines within the HIMB project to reach intensities up to 10ˆ10 μ+/s, with a huge impact for low-energy, high-precision muon based searches.

The use of hyper parameter search algorithms has shown that not only the stringent rate requirements can be met, but that higher phase space quality can be achieved. To reach such high quality tunes during commissioning, a novel tuning strategy is required, due to the large aberrations introduced by the employment of solenoidal elements along the HIMB beamlines. We present here the preliminary tests carried out in December 2023 at the Compact Muon Beam Line (CMBL) at PSI, serving the Mu3e experiment, where for the first time a tuning of low energy muon transfer lines with Bayesian algorithms was performed. The method was explored with both point-like detectors to maximize the rate on-axis and arrays of plastic scintillators to tune the delivered rate and the beam spot size at once.

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Measurement of BR(Bs->KSKS) with Run 2 LHCb data

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The decays $B^0_{(s)} \to K^0_S K^0_S$ proceed via flavor changing neutral currents that are suppressed in the Standard Model and therefore provide greater sensitivity to new physics. The latest measurements of their branching fractions exhibit some tension with the SM.

Since the time of the existing measurement, the LHCb experiment has collected a large amount of data and has had several improvements to its online selection. This allows one to significantly improve the precision using Run 2 data.

The current work presents a status report on the ongoing measurement of the $B^0_s \to K^0_S K^0_S$ and $B^0 \to K^0_S K^0_S$ branching fractions.

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Fast identification of GW signals at the future Einstein Telescope

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The Einstein Telescope, the proposed next-generation European ground-based GW observatory, will dramatically increase our capability to detect GW signals. The number of detections is expected to grow from the current O(1/week) to O(1/minute), which will have a revolutionary impact on both our ability to study the dark universe and on multi-messenger science. In order to fully benefit from this potential, it is important to quickly detect GW signals, with sufficient fidelity to inform the wider multi-messenger community. Such an objective necessitates the development of new algorithms for fast signal identification; this contribution will discuss our efforts towards addressing this challenge.

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First evaluation of the jet energy resolution using pileup events with the ATLAS detector

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For the first time, the R=0.4 jet energy resolution (JER) is evaluated using a dataset reconstructed from pileup events with the ATLAS detector. Traditionally, JER evaluated using the pT imbalance of dijet events is limited by the available statistics at low pT due to the increasingly prescaled jet triggers. An alternative approach is to utilize pileup events, which are recorded at the same time with otherwise-triggered events. This provides a much larger statistics at low pT compared to the traditional approach, and thus allows higher precision for the determination of the low pT R=0.4 JER. The pileup JER results presented now, are using the full 2017 and 2018 proton-proton collision dataset. A comparison is made to official ATLAS JER measurement from 2017 and the benefits of the pileup approach are discussed.

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Fibre Detector for the Mu3e Experiment

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Mu3e is an experiment under construction at PSI in Villigen, Switzerland looking for the charged lepton flavor violating decay μ+->e+e+e-. The goal is to reach a sensitivity for a branching ratio of 10ˆ{-15}. To achieve this, the world highest intensity continuous surface muon beam is used, and an excellent background rejection is needed.

I will present the scintillating fiber detector, which is being developed in order to get a very precise measurement of the time of decay particles, while affecting their trajectories as little as possible. It consists of three layers of 250 um fibers, resulting in a thickness of less than 0.2% of a radiation length, and it can achieve a time resolution of around 250 ps at an efficiency 97%.

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Measuring the boron-to-carbon flux ratio with the DArk Matter Particle Explorer

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The DArk Matter Particle Explorer (DAMPE) has been in operation since December 2015 and has been continuously detecting cosmic rays (CRs) for more than 8 years. With its large acceptance (0.3 m^2 sr) and deep calorimeter (32 X_0), DAMPE allows to measure proton amd heavy nuclei fluxes up to hundreds of TeV with an improved energy resolution and statistics.

CRs can be classified as primaries and secondaries either if they have been originally injected into space or produced in the interaction of the primary particles with the interstellar medium (ISM)

during their propagation. Boron is believed to be mainly produced by the fragmentation of heavier nuclei, such as carbon and oxygen, with the ISM, therefore, the boron-to-carbon flux ratio (B/C) is extensively measured by space instruments to probe the CR propagation.

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MONOLITH - picosecond capability in a high granularity monolithic silicon pixel detector

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The MONOLITH H2020 ERC Advanced project aims at producing a high-granularity monolithic silicon pixel detector with picosecond-level time stamping. To obtain such extreme timing the project exploits: i) a fast and low-noise SiGe BiCMOS electronics; ii) a novel sensor concept, the Picosecond Avalanche Detector (PicoAD), that uses a patented multi-PN junction to engineer the electric field and produce a continuous gain layer deep in the sensor volume. The result is an ultra-fast current signal with low intrinsic jitter in a full fill factor sensor. A proof-of-concept monolithic PicoAD demonstrator provided full efficiency and 13 ps at the center of the pixel, while the time resolution raised to 25 ps in the inter-pixel region. The first batch of PicoAD prototypes with different geometries and gain-layer implant doses was delivered in January 2024; testbeam results will be shown.

In addition, a prototype without internal gain layer was produced in 2022. Testbeam measurements showed full efficiency and 20 ps time resolution at a power consumption of 1 W/cmˆ2 and a sensor bias voltage HV = 200 V. This prototype after being irradiated up to 1x10ˆ16 neq/cm2, still provides an efficiency of 99.7% and 45 ps at HV = 300 V.

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Search for Axion-Like Particles in Photonic Final States with the FASER Detector at the LHC

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FASER, an experiment at the LHC, aims to search for light, weakly interacting particles produced in proton-proton collisions at the ATLAS interaction point and travel in the far-forward direction. First search of detecting a light, long-lived particle decaying into photon pairs, using 2022 and 2023 collision data will be reported. Targeting axion-like particles (ALPs) primarily coupling to weak gauge bosons, the analysis identifies one event against an expected background of 0.42 ± 0.38 events, largely due to neutrino interactions. This yields world-leading constraints on ALPs of masses up to 300 MeV and coupling strengths of around 10^{-4} GeV^{-1}, exploring previously unexplored region of parameter space.

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New Higgses at the Electroweak Scale

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Many LHC measurements with multi-lepton final states and missing energy, in particular top differential distributions, show strong tensions with the SM predictions. I discuss how they can be explained by new physics within the Δ2HDMS and show the correlations to the hints for narrow resonances at the electroweak scale.

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Growing Evidence for a Higgs Triplet

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Despite intensive searches at the LHC, no new fundamental particle has been discovered since the discovery of the 125 GeV Higgs boson. However, several recent LHC searches with multiple leptons in the final state point towards the existence of a new Higgs boson with a mass in the 140-160 GeV range, decaying mostly to a pair of W bosons. This dominant decay mode motivates a Higgs triplet with zero hypercharge, which also predicts a heavier-than-expected W-boson as indicated by the CDF-II measurement. Therefore, we study this model and use it to explain the recent excesses in the associated di-photon production analysis of ATLAS using Run 2 data. Based on this analysis, we obtain a significance of 4.3 sigma for a new Higgs boson of mass 152 GeV.

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Indirect search for dark matter in the gamma-ray flux with DAMPE

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Weakly interacting massive particles (WIMPs) are promising candidates for dark matter. Their annihilation or decay might result in almost monochromatic gamma rays, which the Dark Matter Particle Explorer (DAMPE) could identify over the Galaxy astrophysical gamma-ray emissions. In this contribution, the first steps of the analysis: the selection of the gamma-ray events with the DAMPE satellite is presented. To enhance the photon event selection, two machine-learning algorithms that outperform all the standard methods have been developed and adopted. The gamma-ray spectral energy distribution and the full sky map using eight years of data will be shown, demonstrating the effectiveness of the selection process. The so-obtained clean sample is now being used to search for lines in the gamma-ray flux coming from several regions of interest where the dark-matter signal-to-noise ratio is maximal.

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A deep learning method for the gamma-ray identification with the DAMPE space mission

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The Dark Matter Particle Explorer (DAMPE) is the largest calorimeter-based space-borne experiment. Since its launch in December 2015, DAMPE detects electrons, positrons and gamma rays from few GeV to 10 TeV, as well as protons and heavier nuclei from 10 GeV to 100 TeV. The study of galactic and extragalactic gamma-ray sources and diffuse emissions as well as the search for dark-matter signatures in the gamma-ray flux are main objectives of the DAMPE mission. In this contribution we present a convolutional neural network (CNN) model developed for the gamma-ray identification with the DAMPE calorimeter. It is shown that this method significantly outperforms all the existing algorithms, both in gamma-ray efficiency and proton rejection. Good agreement between simulation and real data is demonstrated.

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A deep learning method for the trajectory reconstruction of gamma rays with the DAMPE space mission

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The Dark Matter Particle Explorer (DAMPE), a satellite-borne experiment capable of detecting gamma rays from few GeV to 10 TeV, studies the galactic and extragalactic gamma-ray sky and is at the forefront of the search for dark-matter spectral lines in the gamma-ray spectrum. In this contribution we detail the development of a convolutional neural network (CNN) model for the trajectory reconstruction of gamma rays. Four distinct models, each taking a different resolution Hough image of the DAMPE silicon-tungsten tracker converter (STK) as input, were trained with Monte-Carlo data. Their standalone and sequential-application performance was benchmarked, and a proof-of-concept with flight data was realized. The results indicate that the developed CNN is a viable approach for the gamma-ray track reconstruction. Further studies aimed at pushing the CNN performance beyond the conventional Kalman algorithm are ongoing.

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The LUX ZEPLIN Experiment

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The LUX-ZEPLIN (LZ) experiment is a 7 ton active mass dual-phase liquid xenon time projection chamber with the goal of making direct observation of Weakly Interacting Massive Particles interactions with standard matter. LZ
published first results of data taken from December 2021 to May 2022, finding it
consistent with background only, no WIMP hypothesis. Since first publishing,
LZ has continued to acquire more science data as well as publishing additional
physics analysis searches. I will present an overview of the LZ experiment and current status.

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Toward an improved measurement of the muon EDM

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We present the current status of the first phase of the muon EDM experiment, which aims to directly measure the electric dipole moment (EDM) of muons using the frozen-spin technique. A non-zero EDM value for muons would indicate an excess of CP violation beyond what the Standard Model predicts, potentially shedding light on the observed matter-antimatter asymmetry in the universe. The first phase of this experiment proposes a sensitivity of 10ˆ(-21) ecm, with the second phase targeting an enhanced sensitivity of 10ˆ(-23) ecm, which is four orders of magnitude improvement over previous direct measurements.