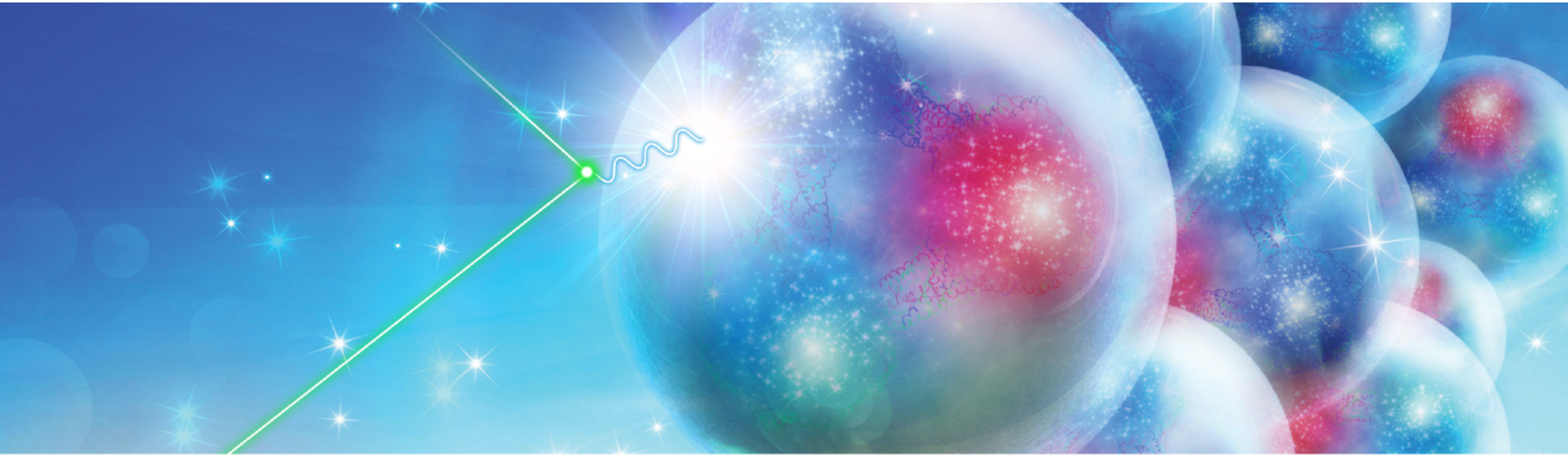


WG6 Summary Talk

Future Experiments

DIS 2022

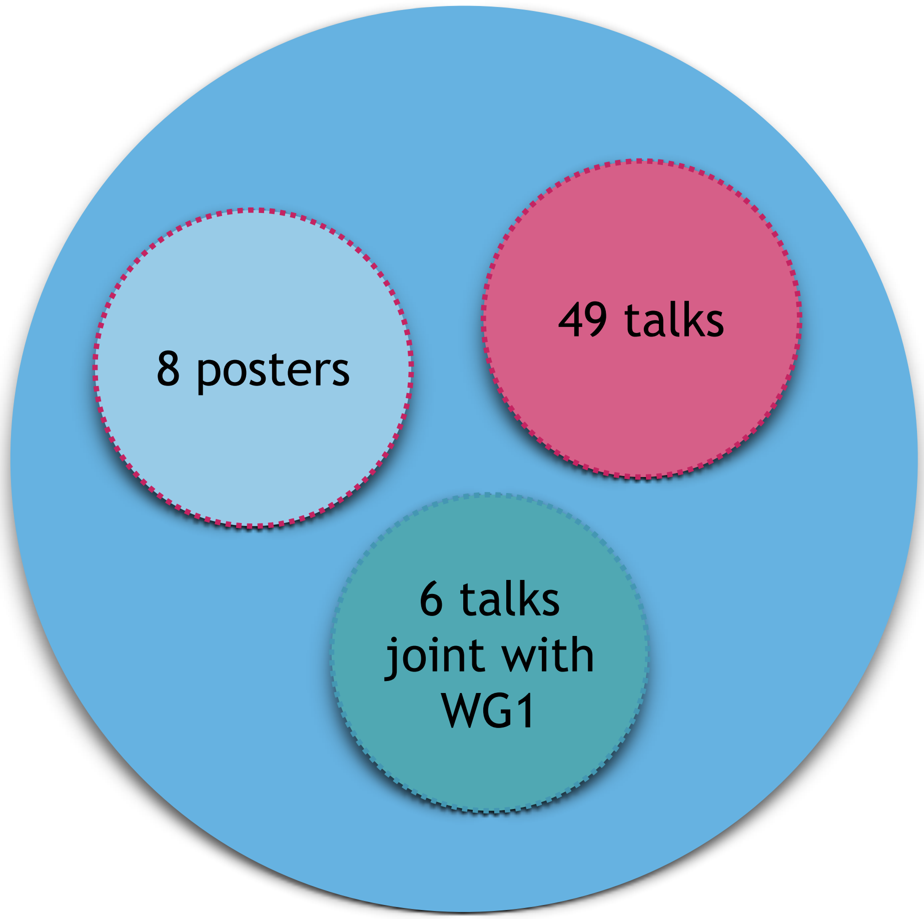
02-06 May 2022

Santiago De Compostela

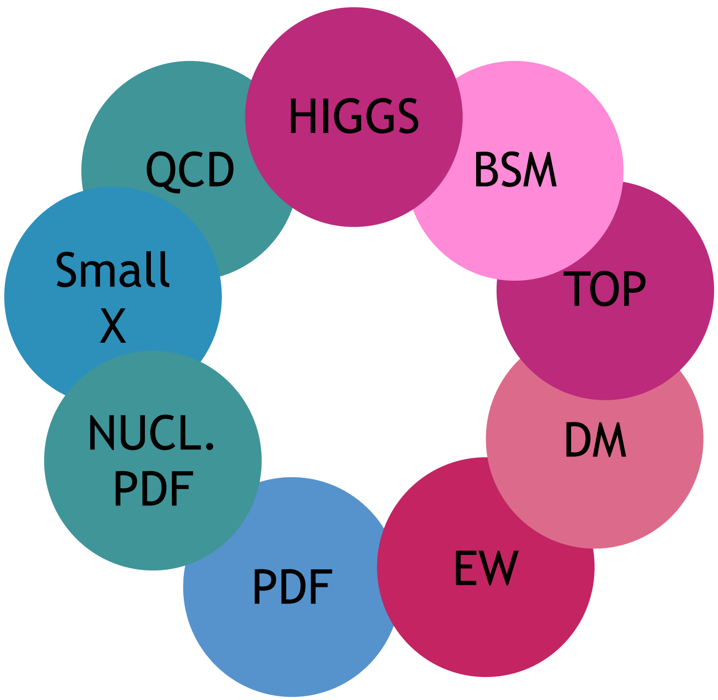
Michela Chiosso (University of Torino and INFN)
Yulia Furletova (JLAB)
Alessandro Polini (INFN Bologna)

WG6: Future Experiments

83 abstracts were submitted to WG6



WG6: Future Facilities



LHeC, FCC-eh

e+e- colliders (FCC-ee, CLIC, ILC)

EIC, EICc

Muon collider

Fix target experiments at CERN

JLAB future experiments

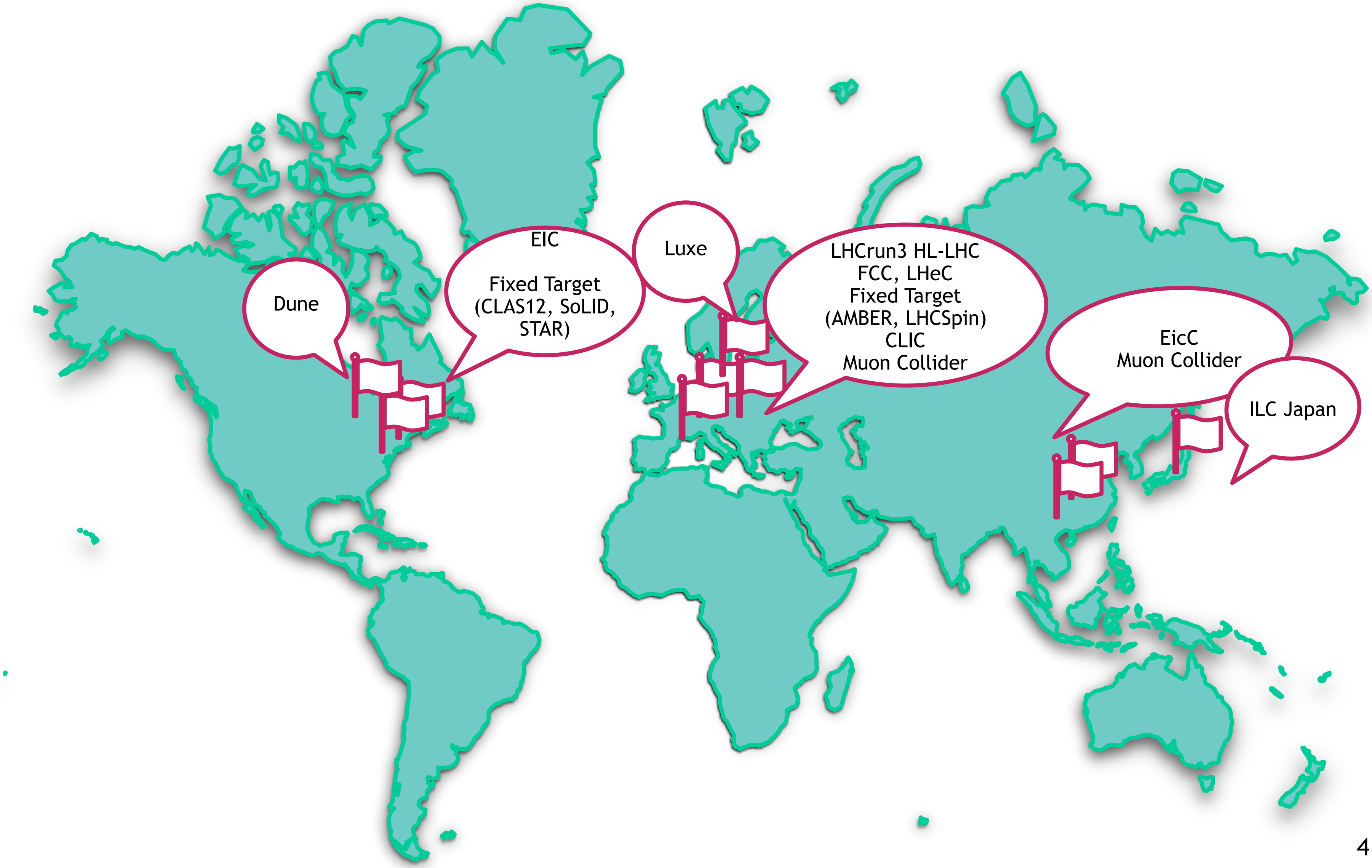
Neutrinos experiments

Dark Matter searches

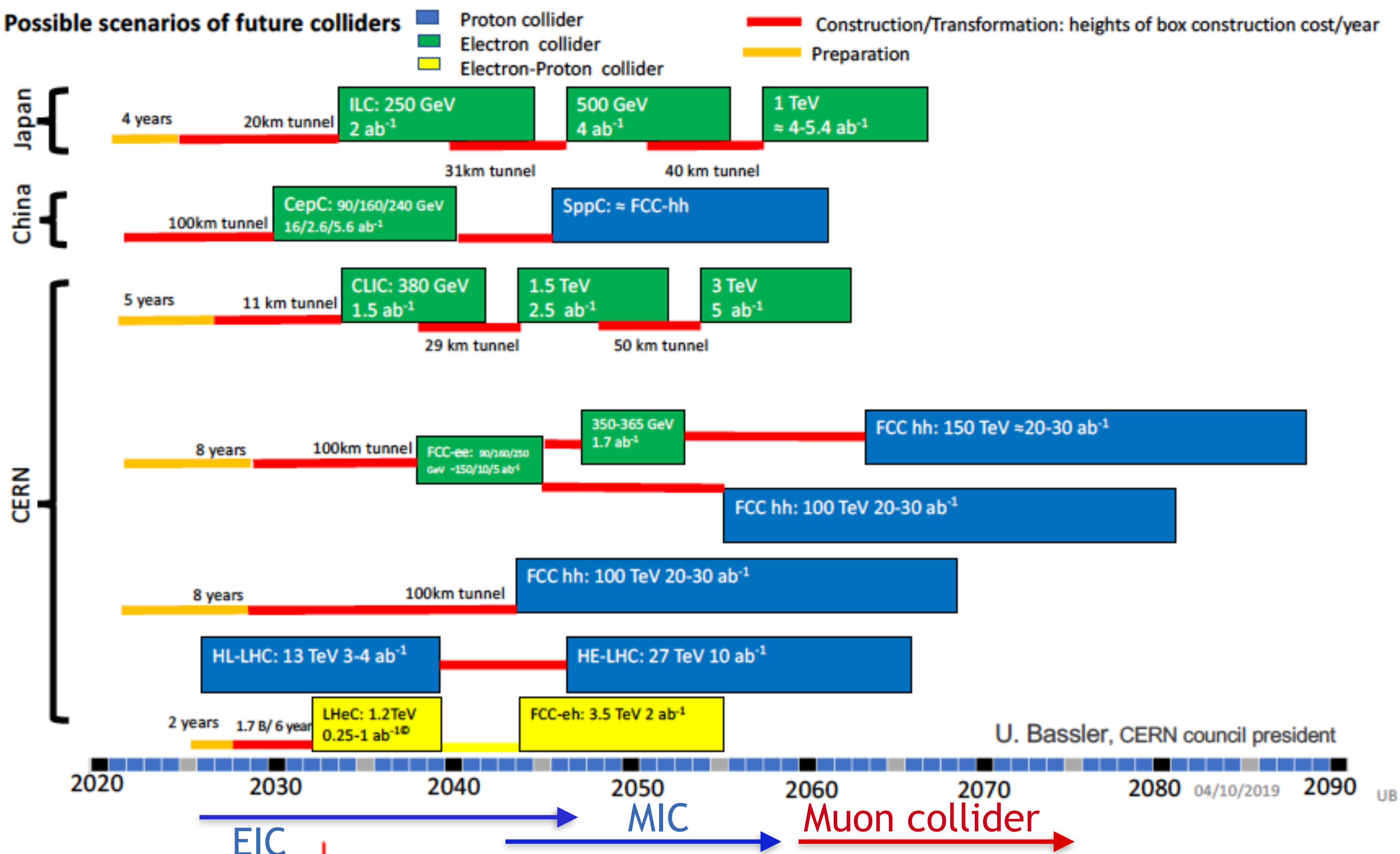
Other future experiments and upgrades

New Analysis Methods

WG6: Future Facilities



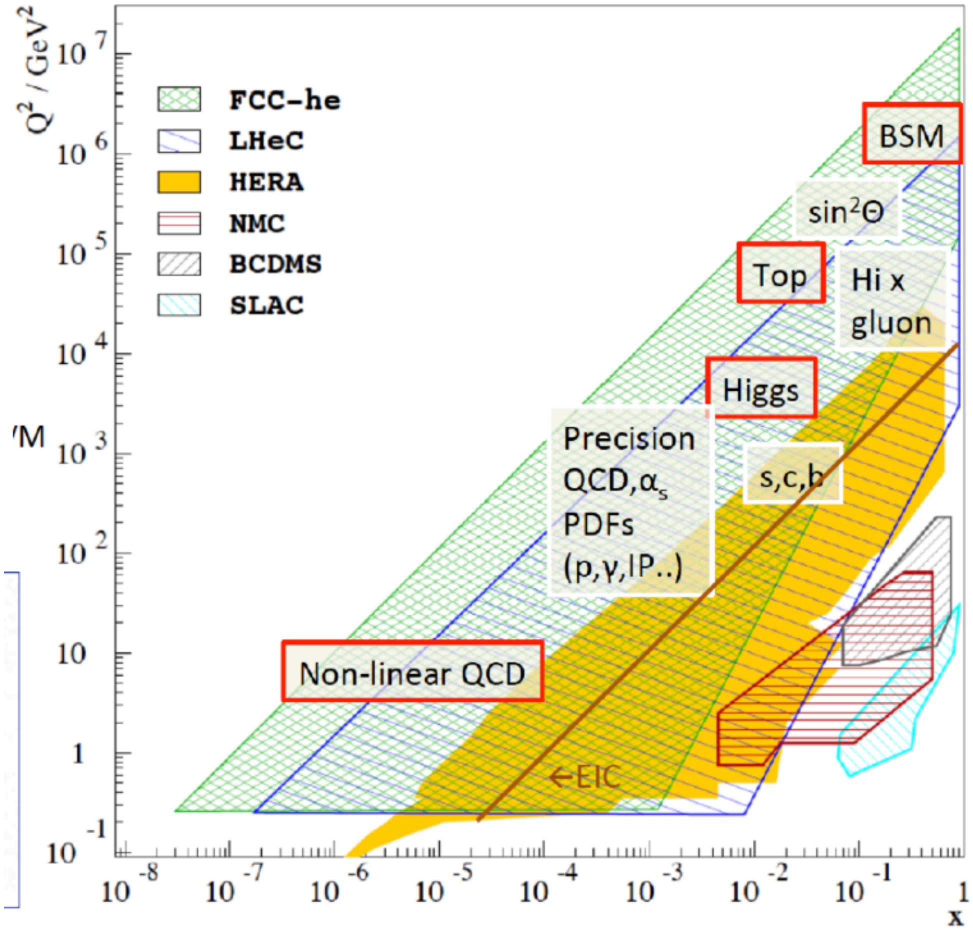
Timeline of Future Colliders



LHeC: installation during **LS4**;

concurrent operation through LHC **Runs 5/6**; and period of **dedicated running**, arXiv:1810.13022

LHeC and FCC-eh



Overview on the LHeC and FCC-he
Christian Schwanenberger

Parton structure at the LHeC and FCC-he
Claire Gwenlan

New top and BSM Physics at the LHeC and FCC-he
Oliver Fischer

New EW and Higgs Physics with the LHeC and FCC-he
Christian Schwanenberger

The impact of energy frontier DIS on future hadron collider physics (HL-LHC and FCC-hh)
Daniel Britzger

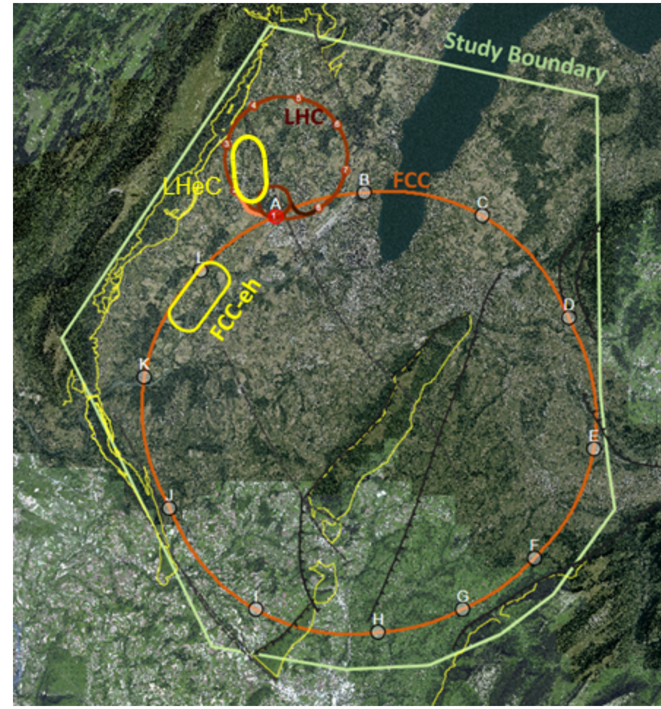
Unraveling non-linear parton dynamics at small x through high energy ep and eA scattering
Anna Stasto

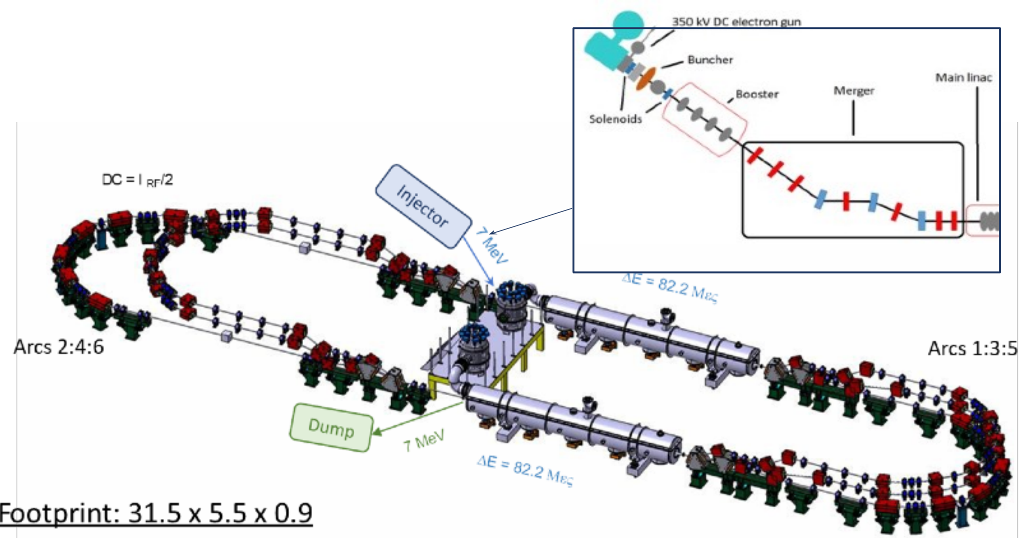
High energy photon-photon interactions at the LHeC (and FCC-eh)
K. Piotrzkowski

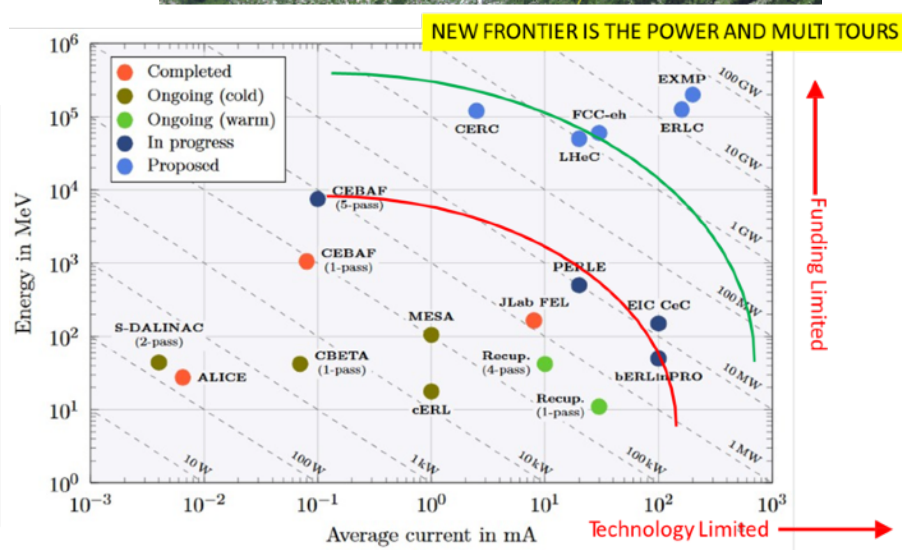
Terascale DIS: Perle, LHeC, FCC-eh

- LHeC CDR in 2012 and updated in 2020 including HL-LHC and future

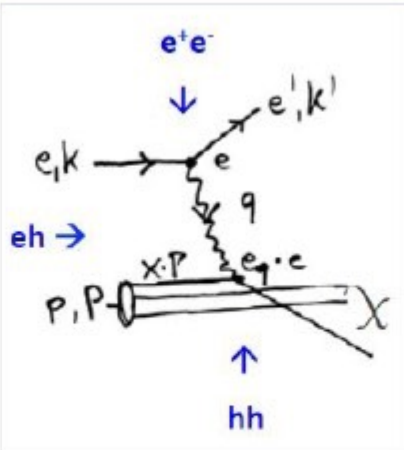
- PERLE Energy Recovery Linac
- https://perle-web.ijclab.in2p3.fr/
  - 2 Linacs (Four 5-Cell 801.58 MHz SC cavities)
  - 3 turns (164 MeV/turn)
  - Max. beam energy 500 MeV

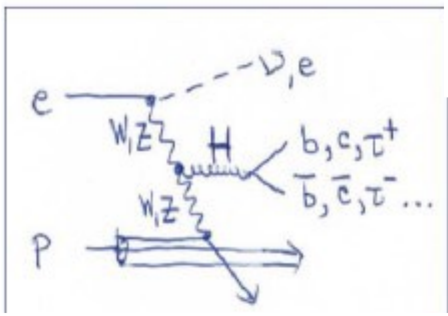


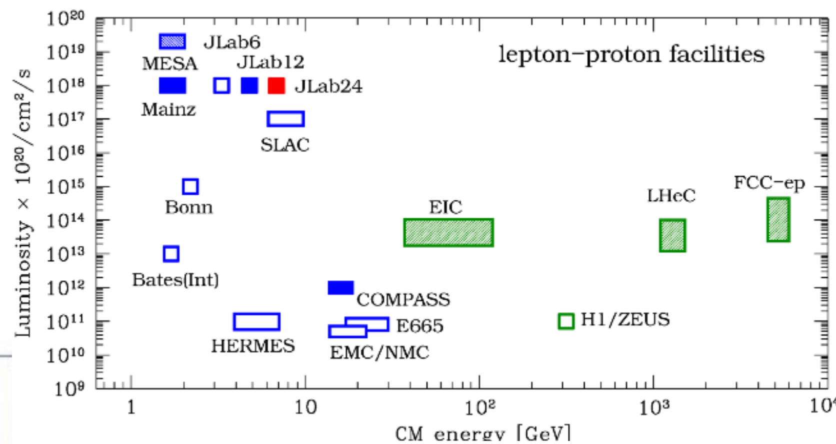


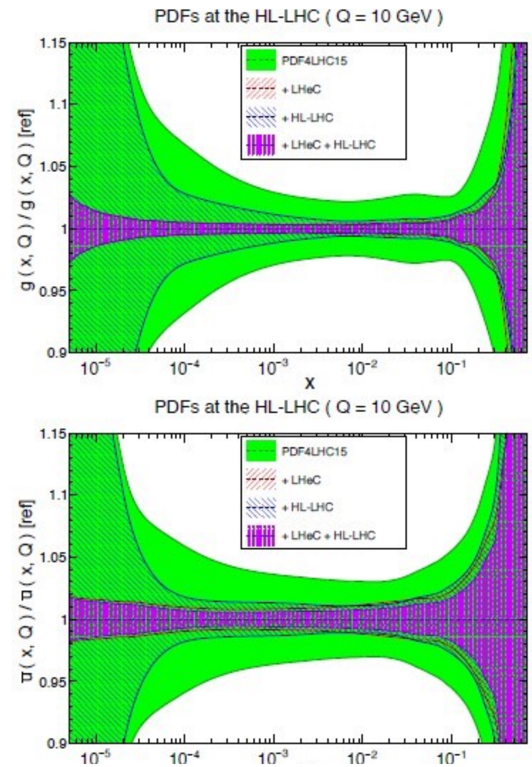


LHeC and FCC-eh

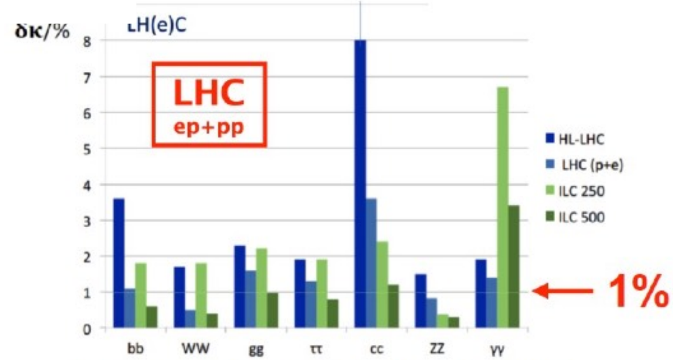








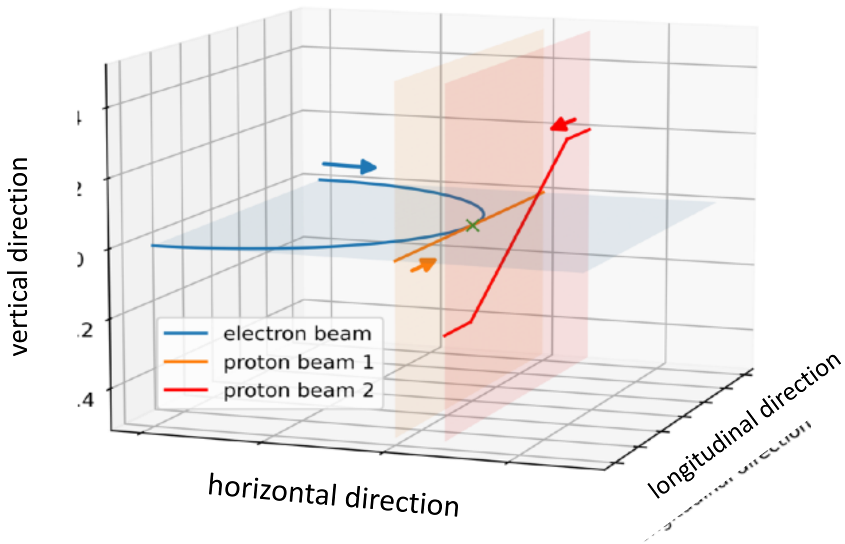
- cleanest high resolution microscope: QCD discovery
- empowering the LHC/FCC search program
- precision Higgs facility together with LHC/FCC-hh
- precision and discovery facility (top, EWK, BSM)
- unique nuclear physics facility



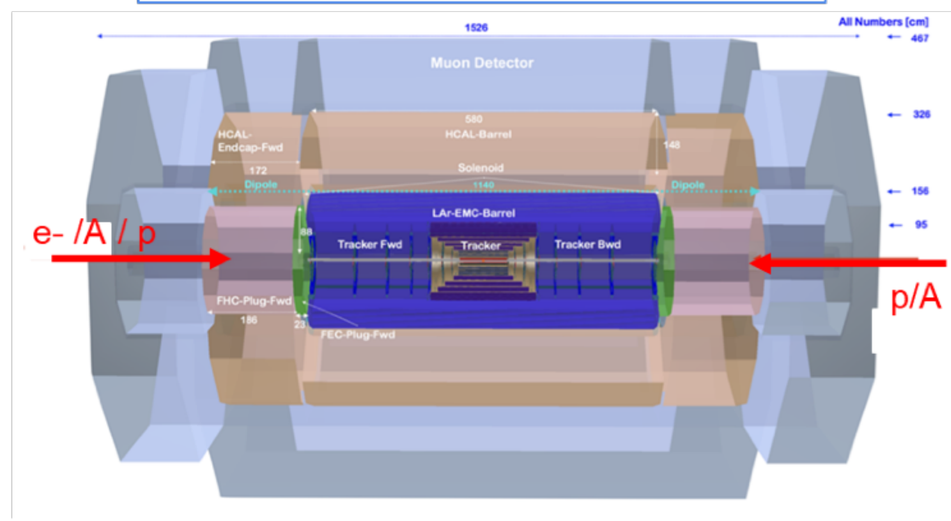
→ adding electrons makes the LHC a Higgs precision facility

LHeC and FCC-eh

- More advanced machine and machine interface design
- Common interaction region for eh, hh
- Possibility for merged program with HI physics and detector cross calibration



e-h & h-h detector design for the LHeC

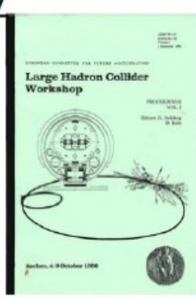


LHeC history

LEP×LHC

1984

s ~√1.3TeV
L ~ 1fb^{-1}/y



HERA *ep*

1992

s ~√0.3TeV
L ~ 0.5fb^{-1}

LHC × e$^-$

2012

s ~√1.5TeV
L ~ O(100fb^{-1})

HL-LHC×ERL & Higgs

2020

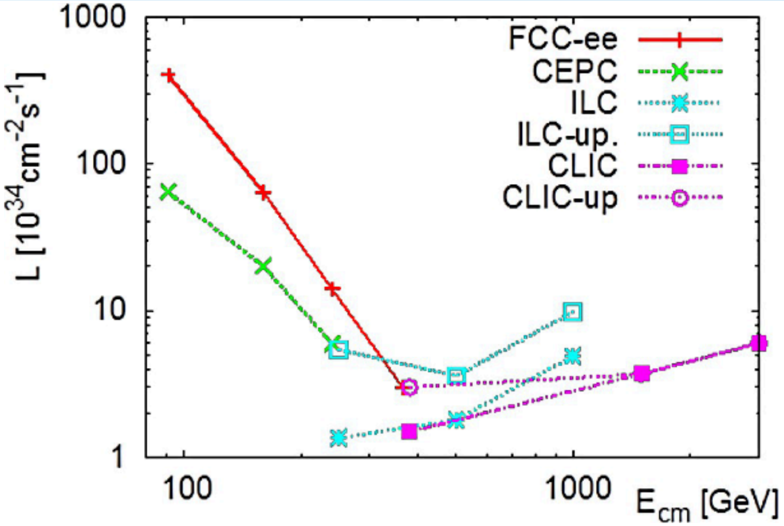
s ~√1.3TeV
L ~ 1 ab^{-1}

LHeC

'30

e+e- collider:
FCC-ee, CEPC, ILC, CLIC

QCD at FCC-ee
Eduardo Ploerer



Unique QCD precision studies accessible at FCC-ee (CEPC, ILC):

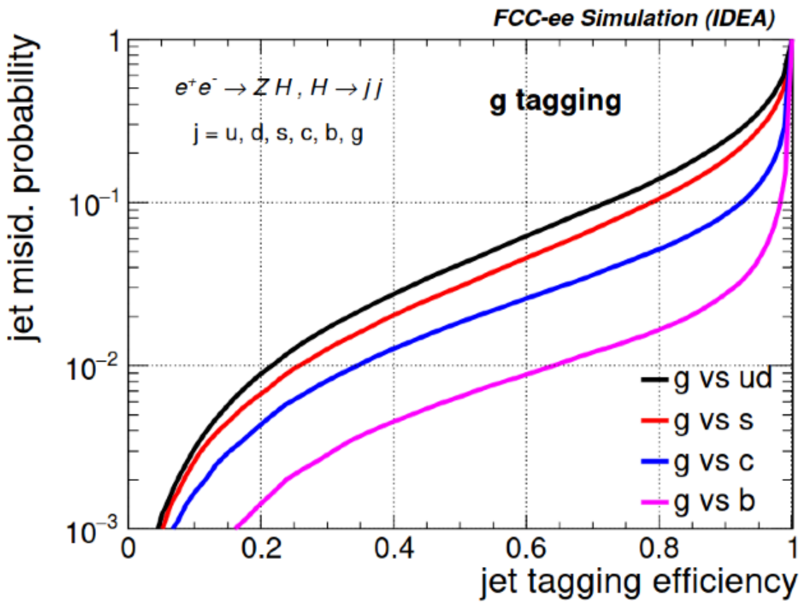
NnLO+NnLL jet substructure

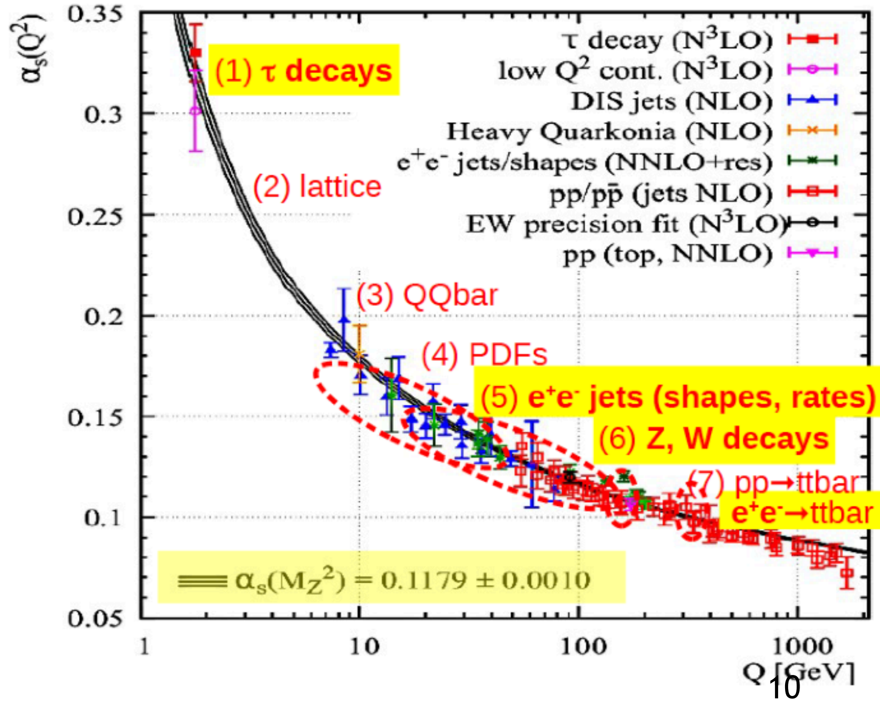
<1% control of colour reconnection

High-precision hadronization

Per-mille a_s via hadronic Z,W,t decays, evt shapes...

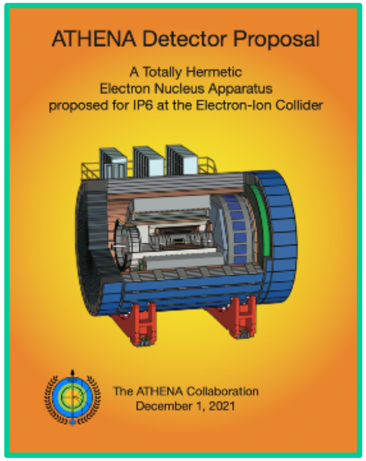
Quark-gluon discrimination



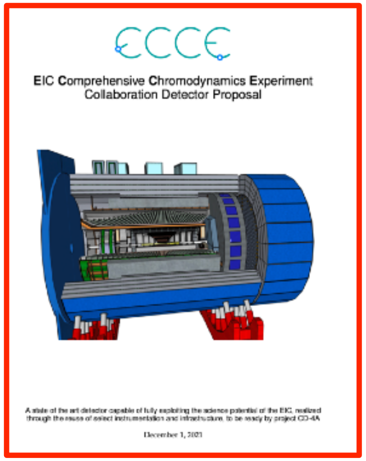


EIC

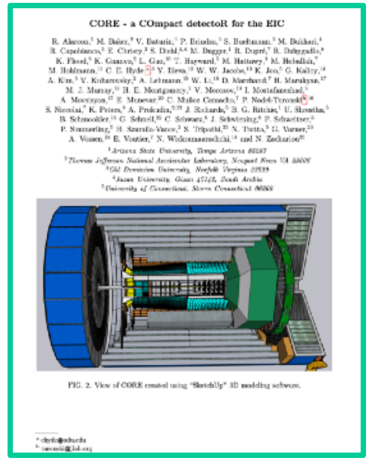
ATHENA



ECCE



CORE

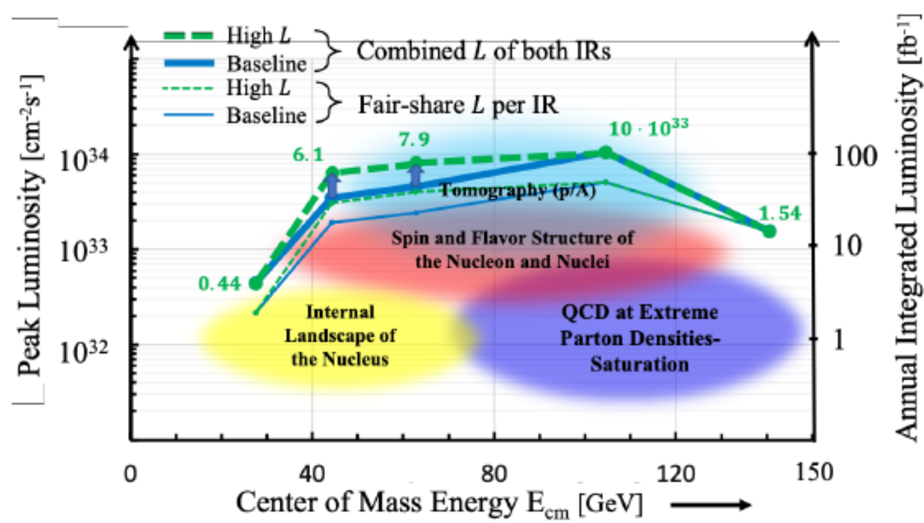


Overview of the physics performance of the ECCE detector
Charlotte Van Hulse
ATHENA – A new detector proposed at the Electron-Ion Collider
Bernd Surrow
CORE - a Compact Detector for the Electron-Ion Collider
Gunar Schnell

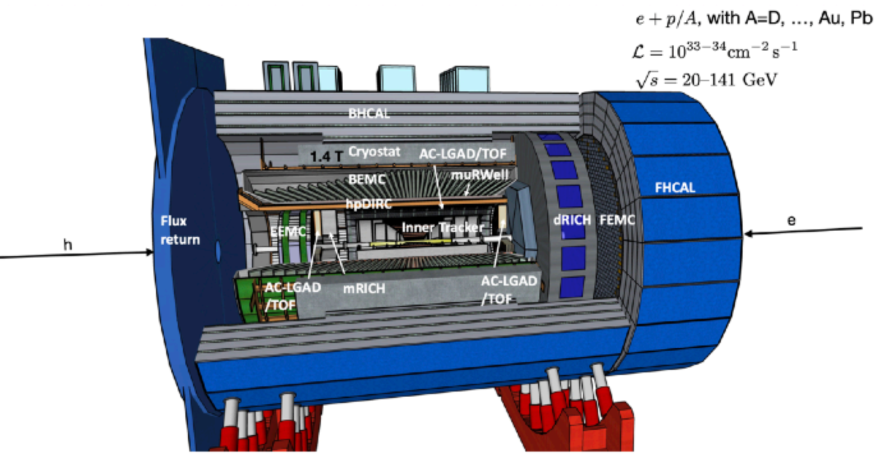
Review of EIC detector proposals concluded in March 2022
ECCE was selected as the EIC project detector reference design.

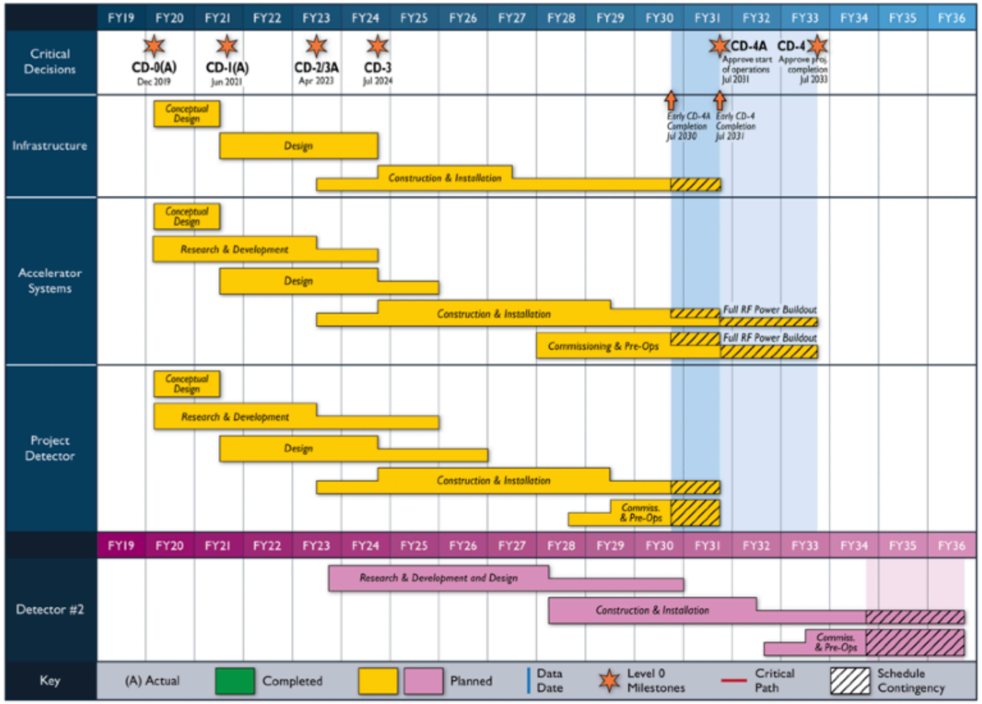
Next steps:
reference design optimization and consolidation phase, with joints efforts from ATHENA and ECCE.
towards the formation of a new detector 1 collaboration.

2nd experiment (DETECTOR 2) planned on a different timescale, e.g. CORE proposal!

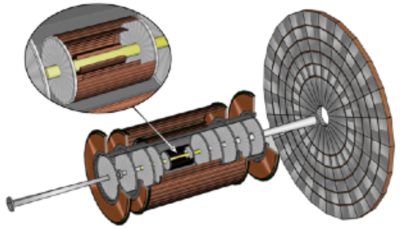


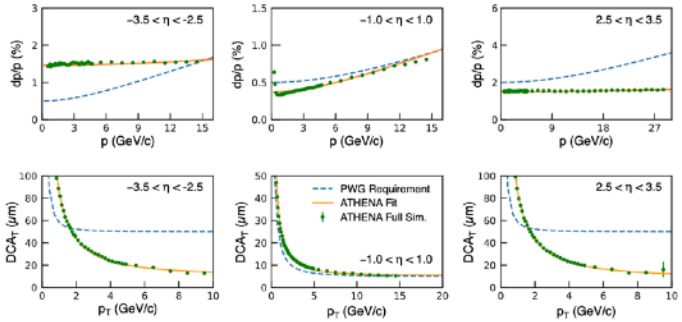
EIC detector

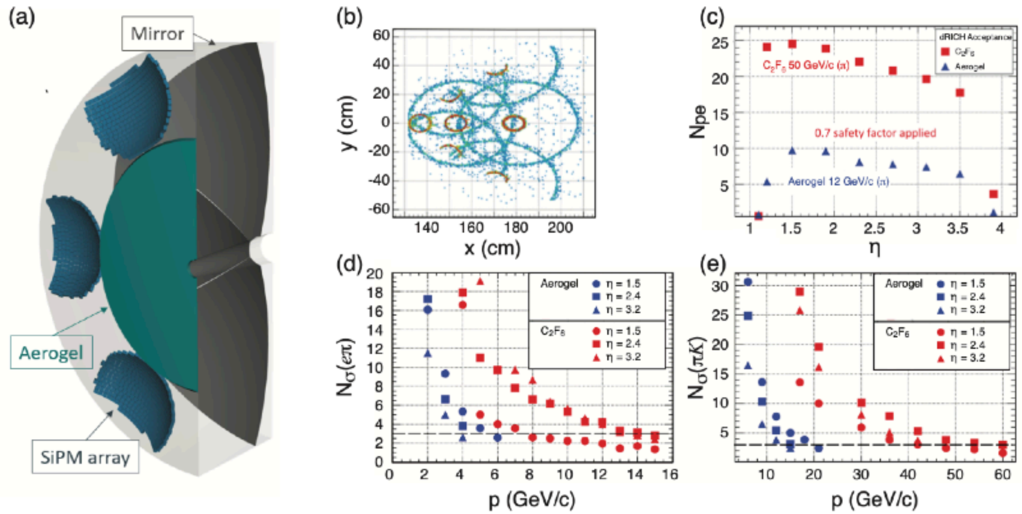




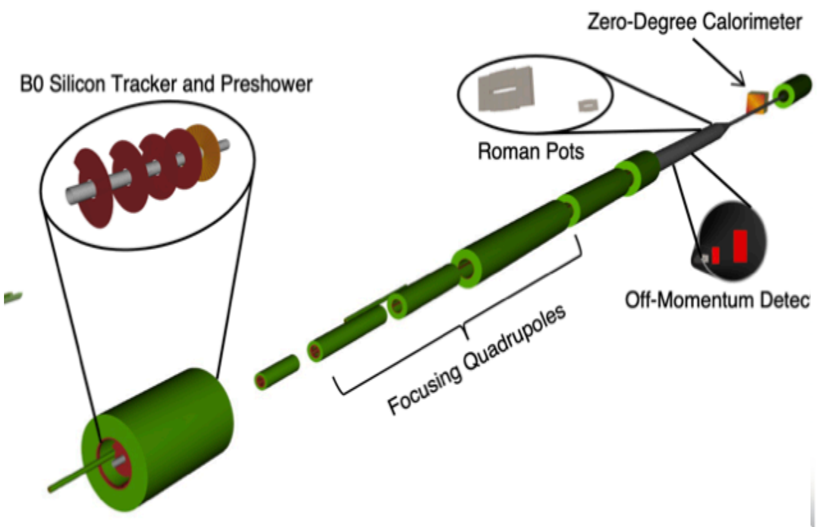
Merging of ATHENA and ECCE proposal efforts forming a new collaboration (DETECTOR 1) - Ongoing process!



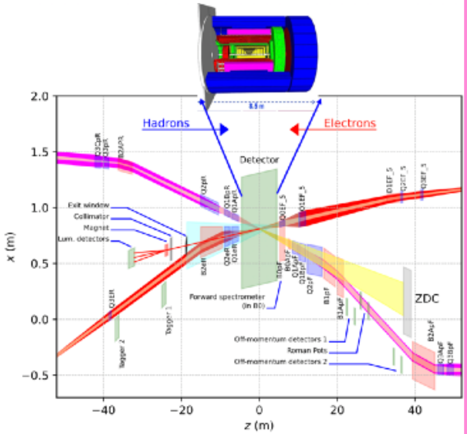




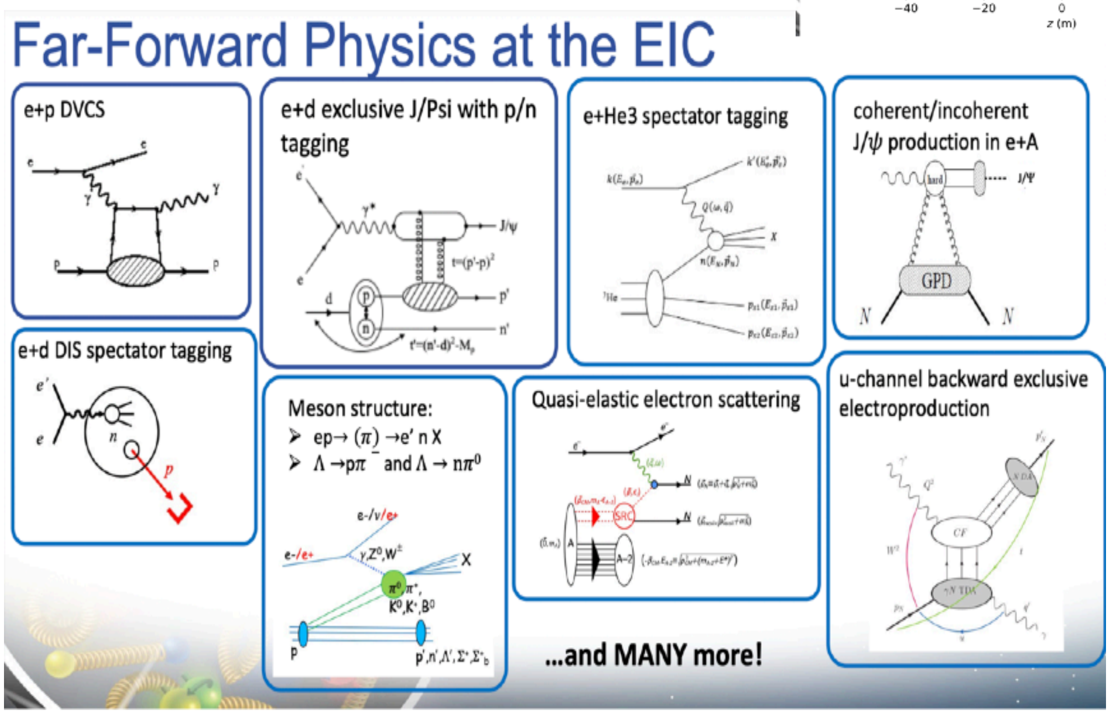
EIC Far-Forward

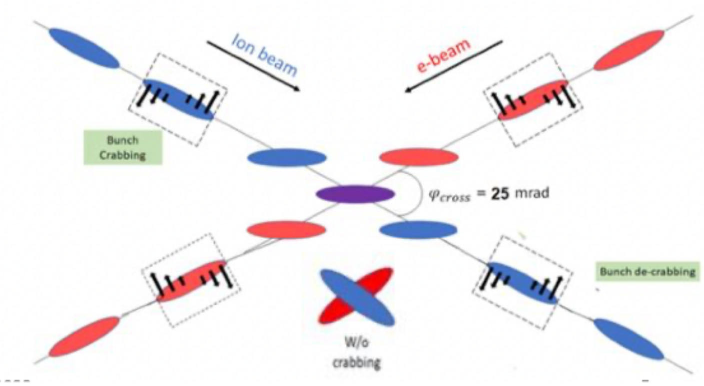


Far-forward/backward area at EIC : +/-40m



Far-Forward Detector Instrumentation for the ATHENA Collaboration at the EIC
Alex Jentsch
Coherent Deep Virtual Compton Scattering on ^{4}He with CORE@EIC
Andrey Kim
Incorporating Critical Beam Effects into Physics and Detector Simulations for the Electron-Ion Collider
Brian Page
Study of exotic nuclei made easy – a potentially novel topic for physics at the EIC
Brynna Moran

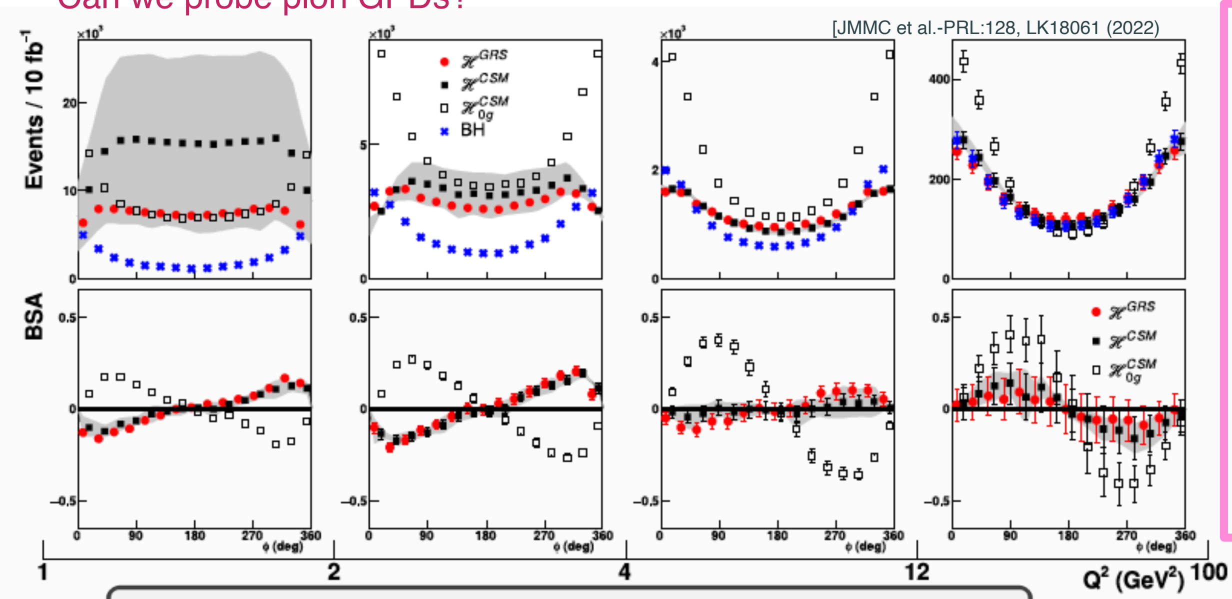




Simulating Beam Effects in PYTHIA
- ➢ Collision Vertex
- ➢ Beam Momenta
- ➢ Final State Particle Distributions

3D structure and spin physics @ EIC

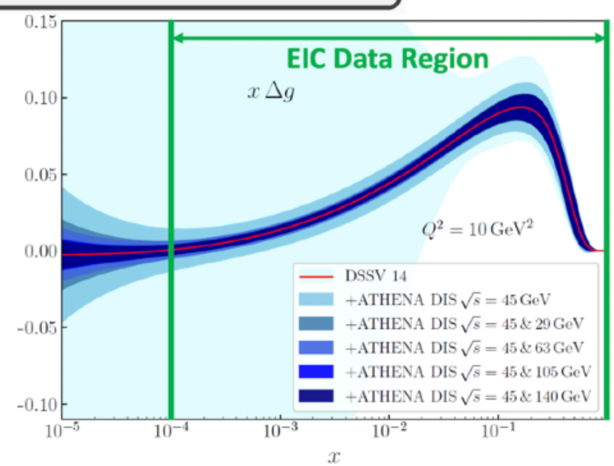
Can we probe pion GPDs?

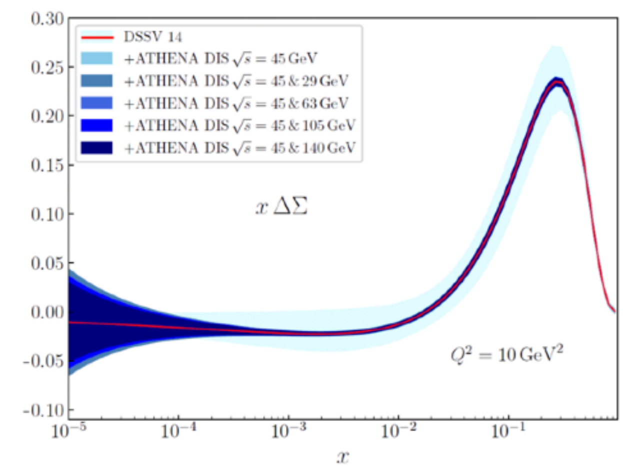


- **Signal expected at EIC kinematics**
- **Gluon-quark "destructive interference"**
- **Gluon dominance: Beam spin asymmetry sign change**

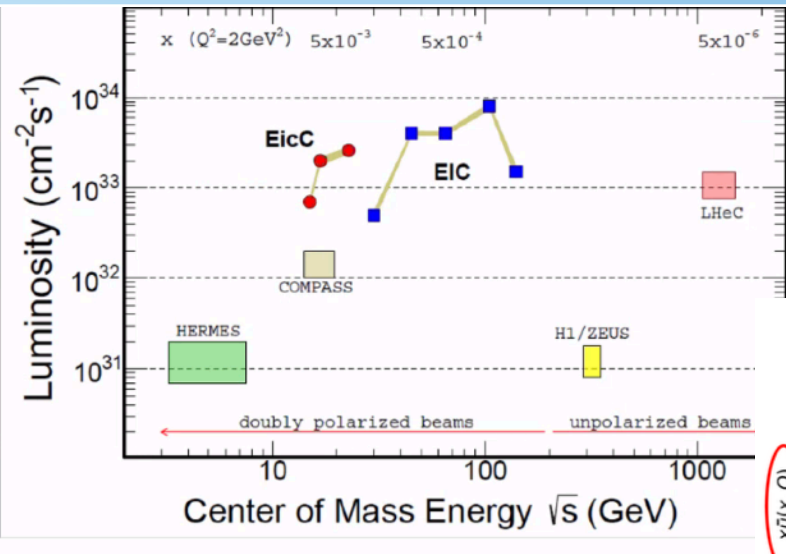
The 3D structure of pions at future electron-ion colliders
Jose Manuel Morgado Chávez
Probing the origin of nucleon spin with ECCE
Tyler Kutz
Probing nucleon spin structure with inclusive DIS at EIC-ATHENA
Barak Schmookler
Exploring the origin of the EMC effect with electron-deuteron DIS and spectator nucleon tagging at EIC
Zhoudunming Tu

Analyses by the DSSV and the JAM collaborations show that inclusive electron-proton scattering at the EIC will constrain the polarized gluon PDF to a remarkable degree

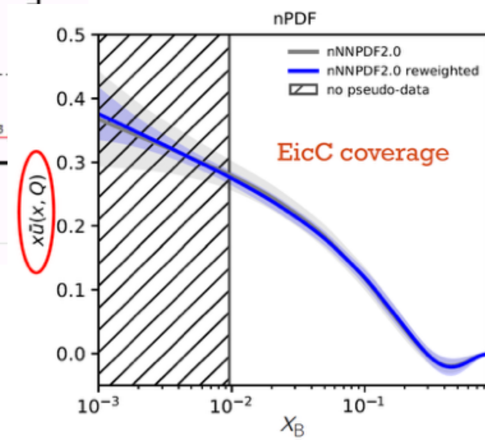




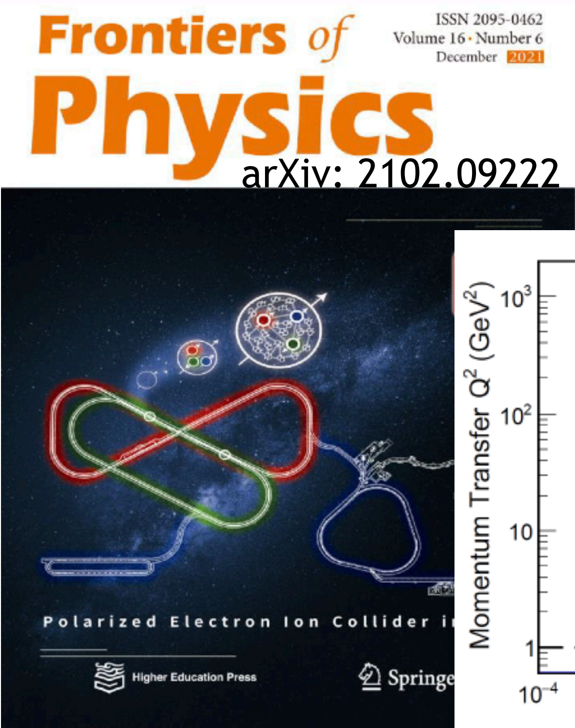
EIC and EIcC



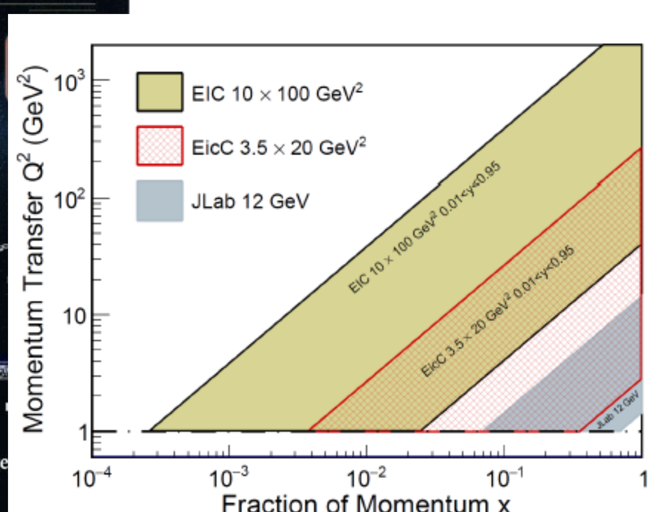
HIAF construction is near complement
Aiming to finish EicC CDR by 2023
Hope to get support in the next 5-year-plan and first collision in 2032



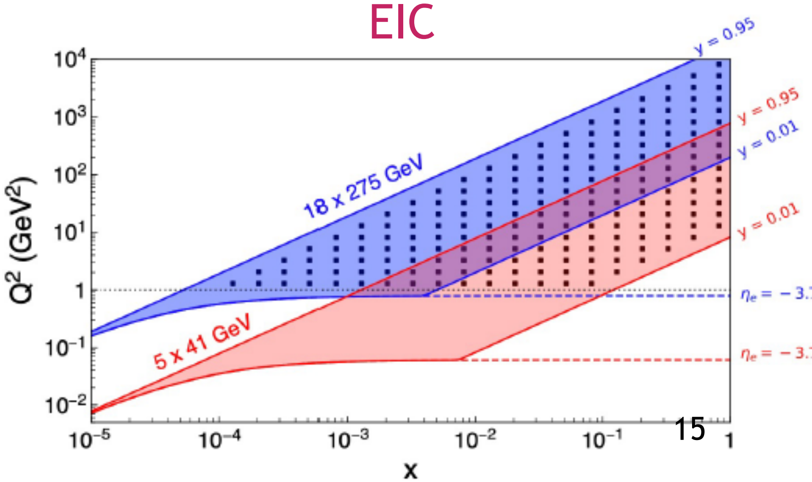
SIDIS reconstruction and observables at EIC with ATHENA
Connor Pecar
Exclusive Lepton Pairs at the Electron-Ion Collider
Krzysztof Piotrzkowski
Study of SIDIS observables with the Athena Detector
Duane Byer
Proton and Nuclear Collinear Parton Densities at the Electron Ion Collider using simulated ATHENA Data
Paul Richard Newman
Overview of Electron-ion collider in China
Jinlong Zhang



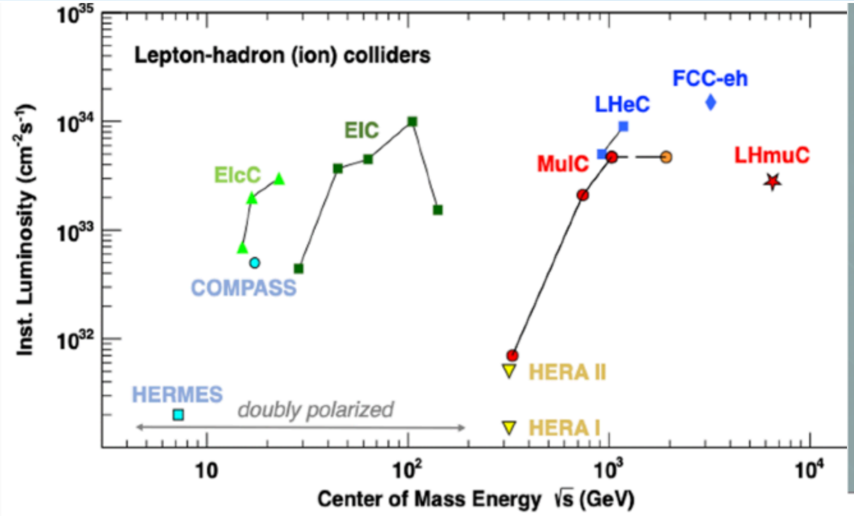
arXiv: 2102.09222

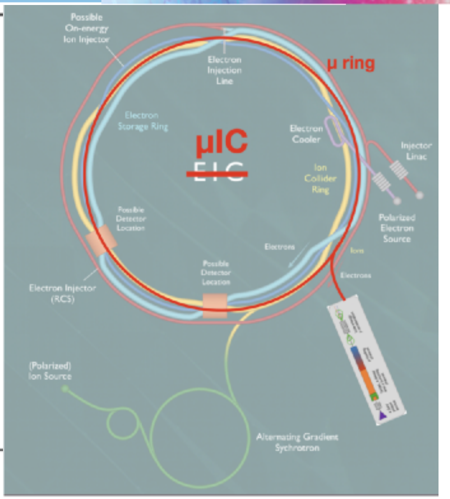


EIC



Muon Colliders

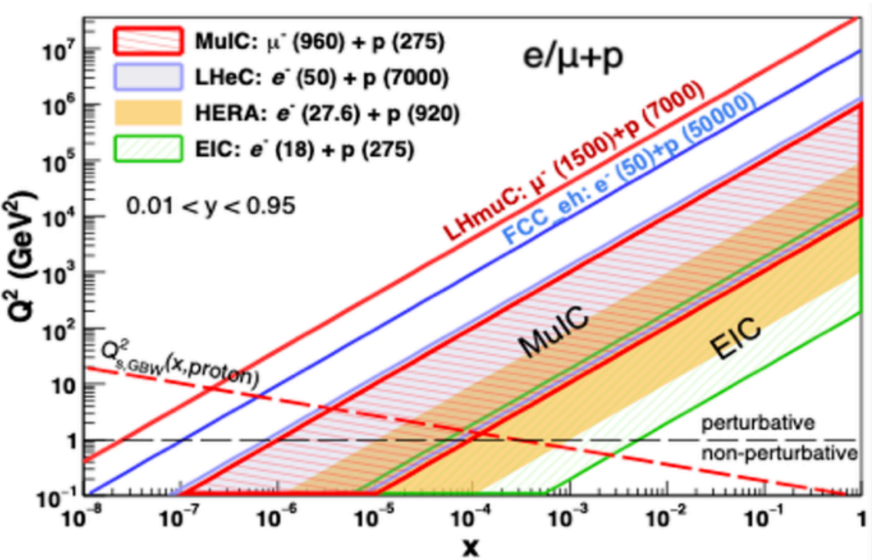




The Physics Potential of a TeV Muon-Ion Collider
Darin Acosta

A Future Muon-Ion Collider at Brookhaven National Laboratory
Ethan Cline

Detector design for a multi-TeV muon collider
Nazar Bartosik



multi-TeV Muon Collider facility

The extensive physics program at a Muon Collider requires a multipurpose detector

↳ **the latest design of the CLIC experiment taken as a starting point** *(e^+e^- collider)*

LHC experiments have demonstrated the great power of the Particle Flow approach which relies on high-granularity calorimeter data and high-quality track reconstruction

The main components of the baseline detector:

- **Tungsten nozzles** extending over 6cm → 6m from the interaction point (IP)
- **All-silicon tracker** with double-layer structure in the Vertex Detector
- **High-granularity sampling calorimeters**
  - **ECAL** 40 layers of **W + Si**
  - **HCAL** 60 layers of **Fe + scintillator + SiPM**
- **Superconducting solenoid:** B = 3.57T magnetic field
- **Muon spectrometer:** 7 layers of **Fe + RPC**

Fix target experiment at CERN

AMBER
Apparatus for Meson and Baryon Experimental Research

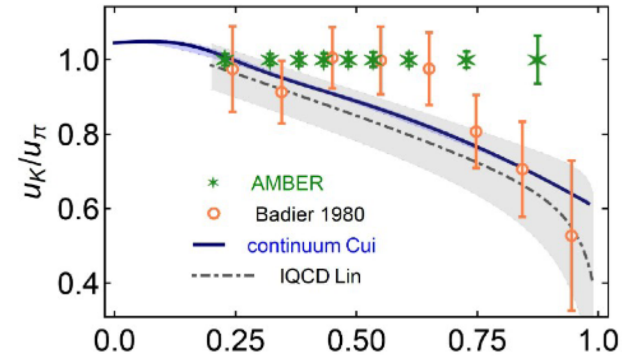
- The AMBER experiment at the CERN M2 beamline is a new “QCD Facility” to investigate the Emergence of Hadron Mass
- AMBER phase-I was approved in December 2020, for measurements on
  - Proton radius from muon-proton elastic scattering
  - Pion structure from pion-induced Drell-Yan and Charmonium production
  - Antiproton cross-sections – input for Dark Matter searches

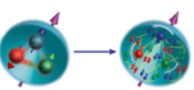
- The planned upgrade of the M2 beamline will provide radio-frequency separated hadron beams.
- High purity kaon beams are being proposed for a phase-II of AMBER:
  - Kaon structure from kaon-induced Drell-Yan and Charmonium production
  - Gluon content in the kaon from direct-photon production
  - Light meson spectroscopy using kaon beams
  - Kaon charge radius from elastic kaon-electron scattering

The LHCspin project
Shinichi Okamura

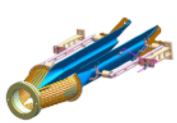
Hadron structure at AMBER
Carlos Davide Da Rocha Azevedo

Z-F. Cui, *et al.* EPJC80(2020)1064, H-W. Lin *et al.*, PRD103(2021)014516

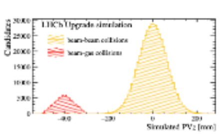




First spin-physics program at LHC



Unpolarised physics program



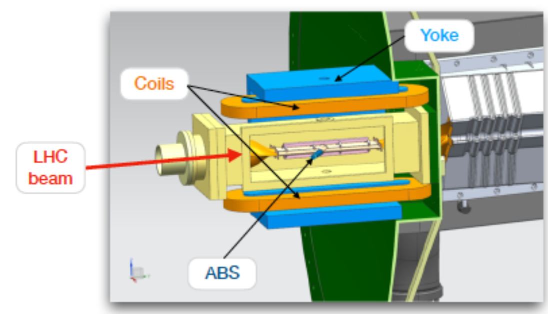
Run in parallel with collider mode

LHCspin

Extending the fixed-target program in Run4

LHC + LHCb + transverse polarised target $H^\uparrow, D^\uparrow$

Unique kinematic conditions



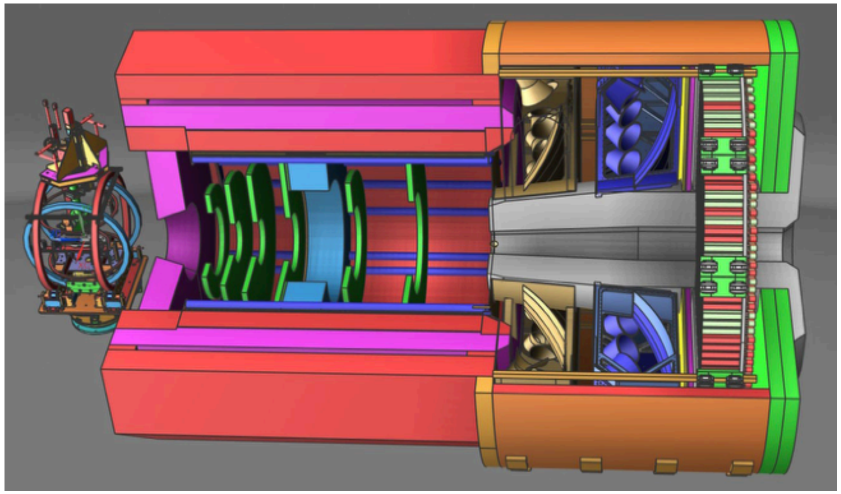
Target Cell

- Almost same position of the SMOG2 cell (L = 20 cm, D = 1 cm)
- Inject both unpolarised and **polarised gas** (only way to bring polarised physics at LHC)
- $P \simeq 85\ \%$ achieved at HERMES

JLAB future experiments

U.S. DEPARTMENT OF ENERGY | Office of Science

SoLID



The Future of CEBAF
Reza Kazimi

Deeply virtual Compton scattering with polarized positrons : perspectives for Jefferson Lab
Silvia Niccolai

Measurement of Lepton-Charge Asymmetry Using a Positron Beam at Jefferson Lab
Xiaochao Zheng

3D Nucleon Structure with SoLID
Chao Peng

CLAS12 luminosity upgrade and future physics opportunities
Stepan Stepanyan

	Present (Design)	Possible	Challenges
Luminosity increase	Hall A & C @11GeV Total < 85 μA (< 82 μA Each dump limit)	Hall A & C @11GeV Total < 140 μA (< 82 μA Each dump limit)	▪ RF Beam Loading ▪ Dump Cooling ▪ BBU Instability
Positron option	Not Yet an Option	>100 nA Unpolarized Or >10 nA Polarized e+	▪ Target Design ▪ e+ Collection ▪ Beam dynamics, Injector and Main ▪ High Intensity e- Beam (~1 mA) Need ▪ Production Energy Choice and Design ▪ Gaining Experience
Energy increase	Up to 11 GeV to A, B, or C 12 GeV to D	20 – 24 GeV	▪ Scaling Up FFA Optics to Several GeVs ▪ Dump Cooling & Enviro. Evaluation ▪ Injector Energy increase ~ factor 4. ▪ BBU instability

The Future of CEBAF - Reza Kazimi (*DIS2022 May 3*) 23 Jefferson Lab

PEPPo(**P**olarized **E**lectrons for **P**olarized **Po**sitrons) => ***demonstrate feasibility***of using bremsstrahlung radiation of **MeV energy Polarized Electrons** for production of **Polarized Positrons**.

DVCS with polarized positrons beam at JLab

'he important of beam-charge asymmetry for DVCS was highlighted by the pioneering HERMES experiment
)isposing of a polarized positron/electron beams at JLab → new observables = different sensitivities to GPDs
;eam Charge Asymmetries proposed to be measured at **CLAS12**:
The unpolarized beam charge asymmetry A^C_{UU}, which is sensitive to the **real part of the CFF** → D-term, forces in the proton
The polarized beam charge asymmetry A^C_{LU}, which is sensitive to the **imaginary part of the CFF**
The neutral beam spin asymmetry A^0_{LU}, which is sensitive to **higher-twist effects**

σ: polarization independent CS
σ̃: polarization dependent CS

New GPD Observables @ JLab

Physics goal: beam-charge asymmetry for DVCS with polarised electrons and positrons → **separation of DVCS and DVCS-BH interference amplitudes, sensitivity to real part of GPDs**

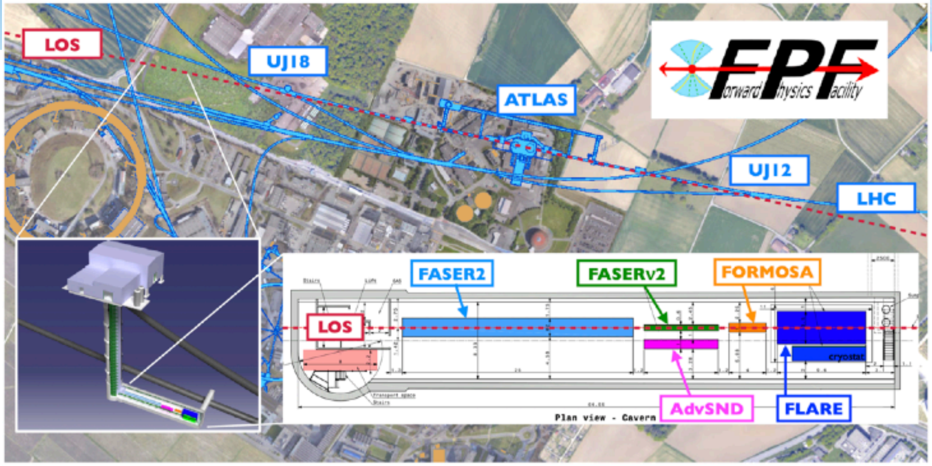
$$A^C_{UU} = \frac{(Y^+_+ + Y^+_-) - (Y^-_+ + Y^-_-)}{Y^+_+ + Y^+_- + Y^-_+ + Y^-_-} = \frac{\sigma_{INT}}{\sigma_{BH} + \sigma_{DVCS}}$$

$$A^C_{LU} = \frac{(Y^+_+ - Y^+_-) - (Y^-_+ - Y^-_-)}{Y^+_+ + Y^+_- + Y^-_+ + Y^-_-} = \frac{\tilde{\sigma}_{INT}}{\sigma_{BH} + \sigma_{DVCS}}$$

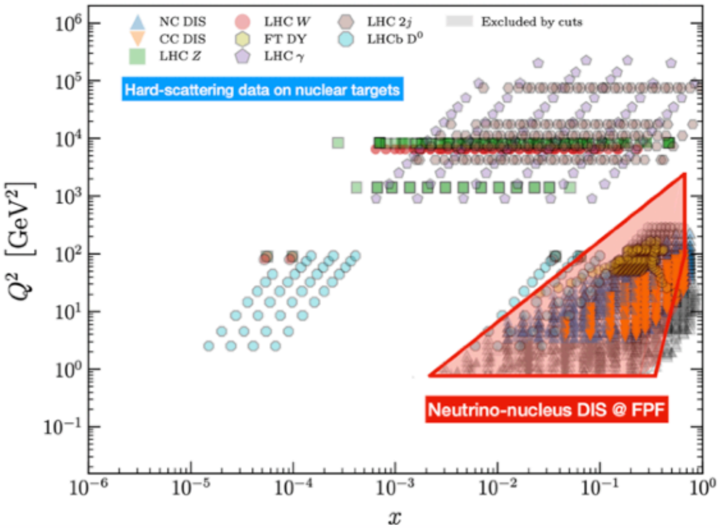
$$A^0_{LU} = \frac{(Y^+_+ + Y^-_+) - (Y^+_- + Y^-_-)}{Y^+_+ + Y^+_- + Y^-_+ + Y^-_-} = \frac{\tilde{\sigma}_{DVCS}}{\sigma_{BH} + \sigma_{DVCS}}$$

$$A^C_{LU} \neq A^{\pm}_{LU} = \frac{\pm(\tilde{\sigma}_{INT} \pm \tilde{\sigma}_{DVCS})}{\sigma_{BH} + \sigma_{DVCS} \pm \sigma_{INT}}$$

Neutrinos Experiments



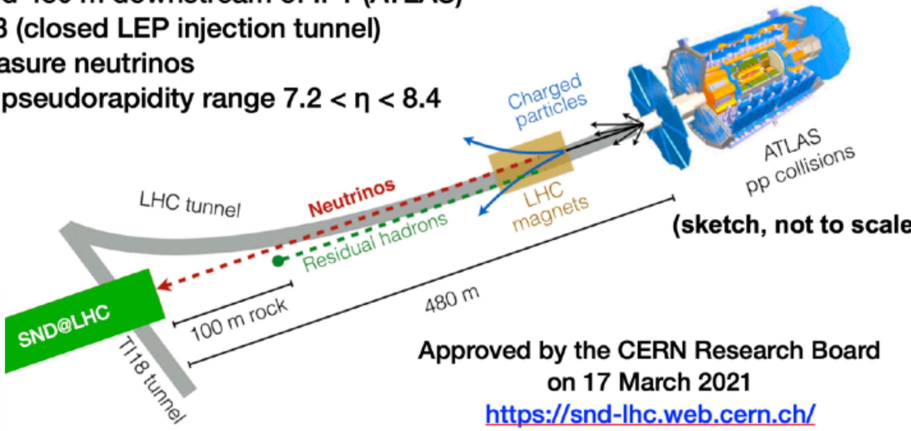
No modifications to the HL-LHC required!



Scattering and Neutrino Detector at the LHC
Marco Dallavalle
Deep-inelastic scattering with TeV neutrinos at the Forward Physics Facility
Juan Rojo
Precision measurements of (anti)neutrinos interactions with the SAND detector at the DUNE near site
Gabriele Sirri
Probing Free Nucleons with (Anti)neutrinos
Riccardo Petti

Stand-alone experiment,
located 480 m downstream of IP1 (ATLAS)
in TI18 (closed LEP injection tunnel)
to measure neutrinos
in the pseudorapidity range $7.2 < \eta < 8.4$

SND@LHC

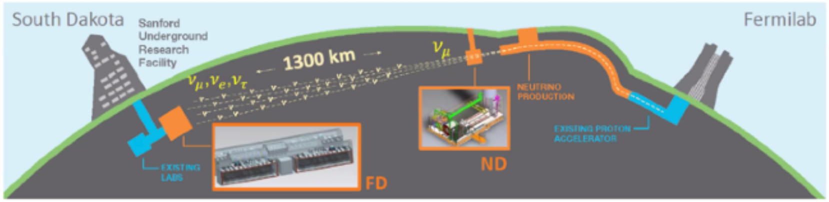


(sketch, not to scale

Approved by the CERN Research Board
on 17 March 2021
https://snd-lhc.web.cern.ch/
to take data in 2022-2025

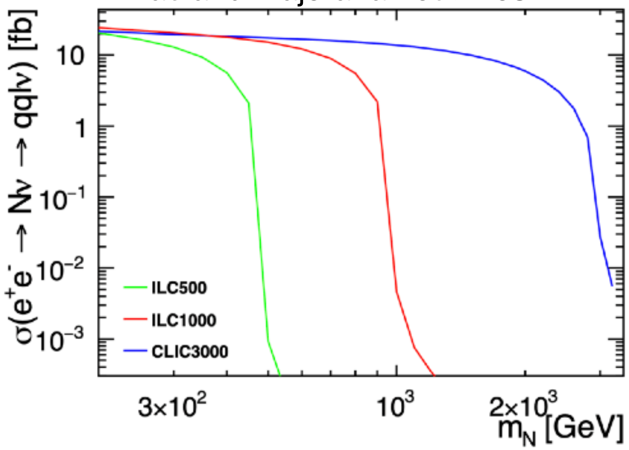
2

DUNE: Deep Underground Neutrino Experiment



Other Future Facilities

Dirac and Majorana neutrinos



LR polarisation, including beam spectra

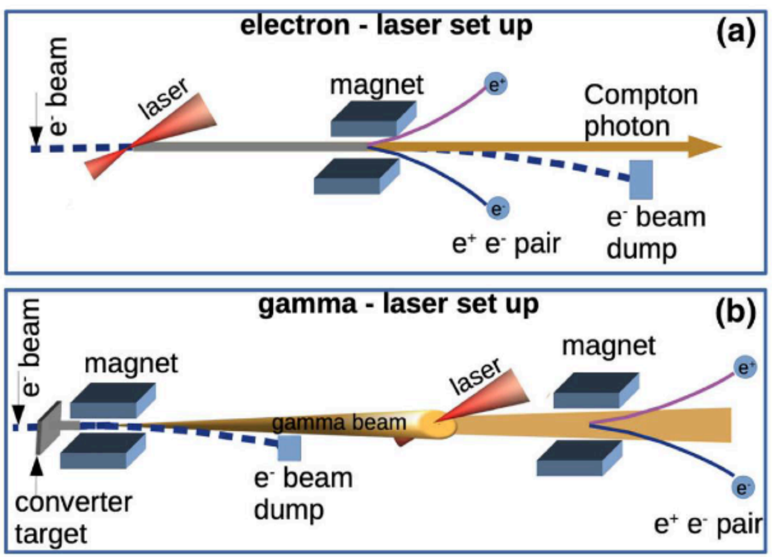
considered collider scenario:
ILC 500 GeV, 1.6 ab^{-1}, $(e^-, e^+) = (-80\%, +30\%)$
ILC 1 TeV, 3.2 ab^{-1}, $(e^-, e^+) = (-80\%, +20\%)$
CLIC 3 TeV, 4.0 ab^{-1}, $(e^-, e^+) = (-80\%, 0\%)$

Heavy Neutrinos at Future Linear e+e- Colliders
Krzysztof Mekala

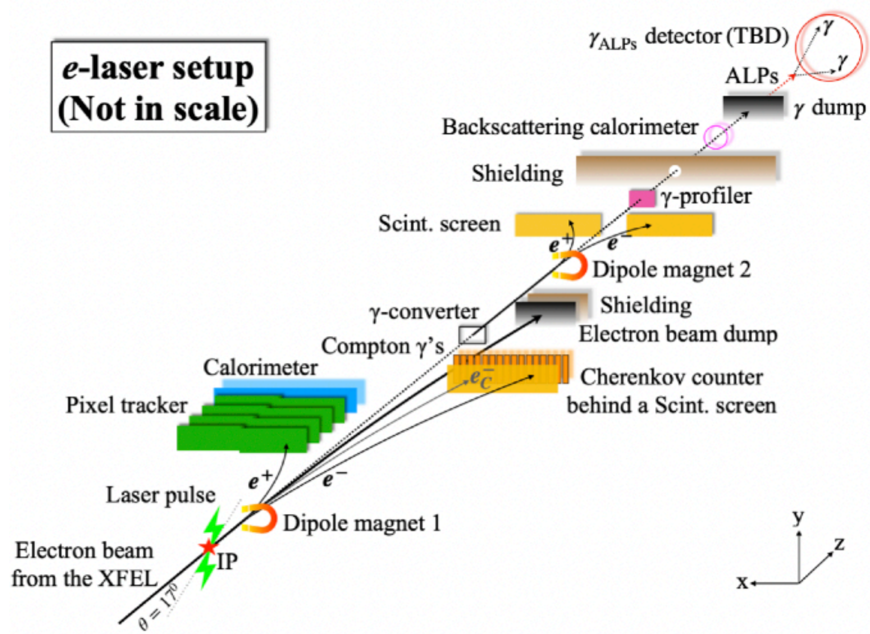
LUXE: A new experiment to study non-perturbative QED in electron-LASER and photon-LASER collisions
Aharon Levy

Exciting opportunity to explore QED in a new regime using EU.XFEL electrons and high power laser.

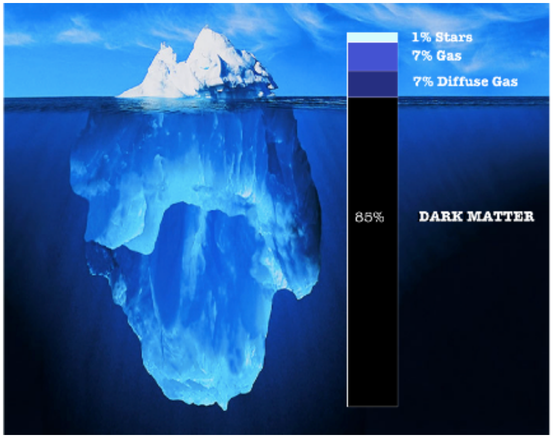
- Observe transition from perturbative to non-perturbative QED.
- Parasitically use for BSM physics.

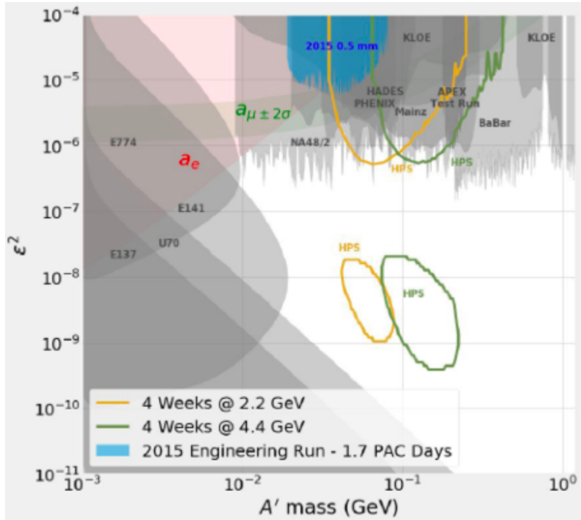


XFEL @DESY



Dark Matter searches



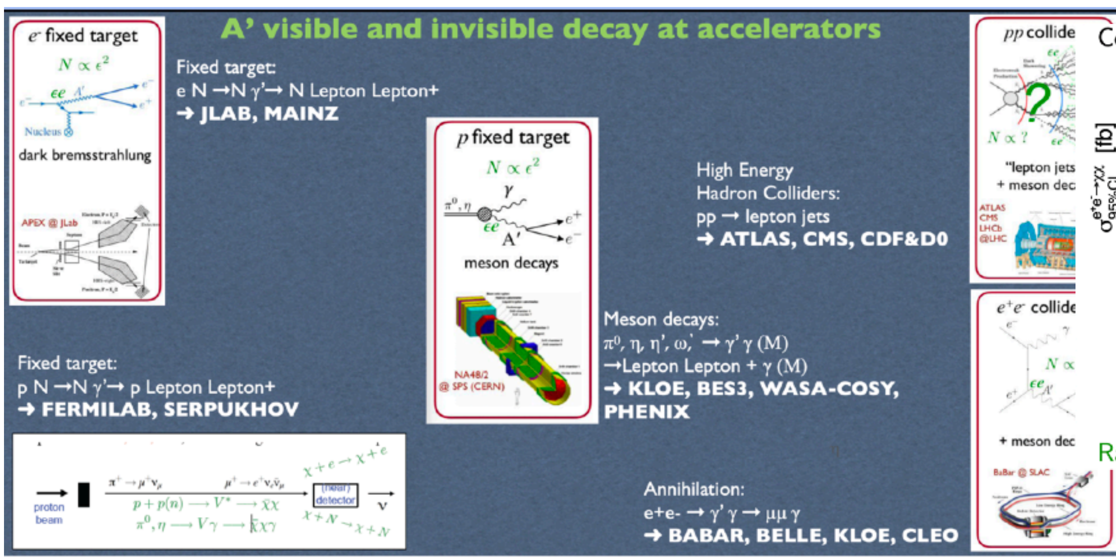


@nJLab BDX experiment

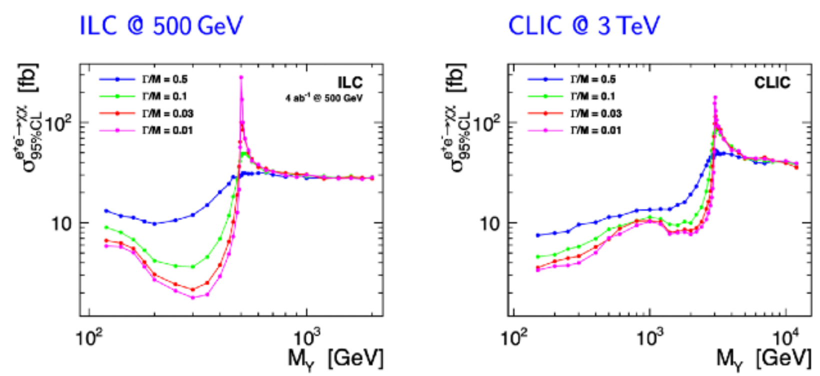
Dark Sector searches at the intensity frontier
Marco Battaglieri
Dark matter production with light mediator exchange at future e+e- colliders
Aleksander Zarnecki

@ ILC and CLIC

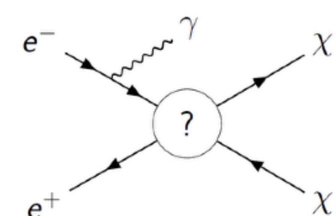
Future e+e− colliders: complementary option for DM searches.
New framework for mono-photon analysis developed



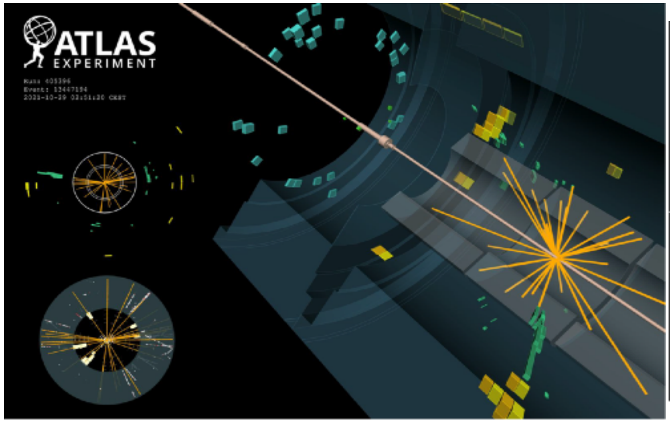
Combined limits for Vector mediator

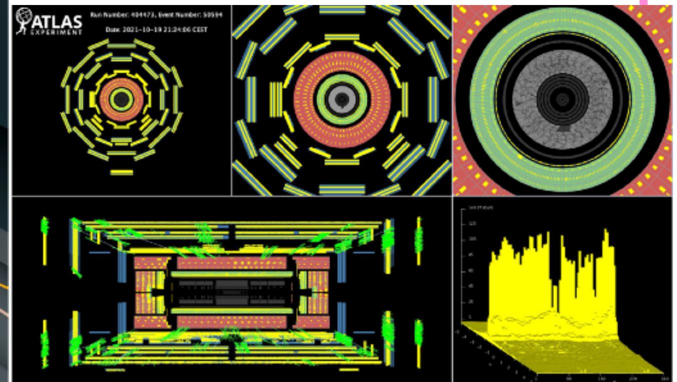


Radiation suppressed for narrow mediator with $M_Y \sim \sqrt{s} \Rightarrow$ weaker limits

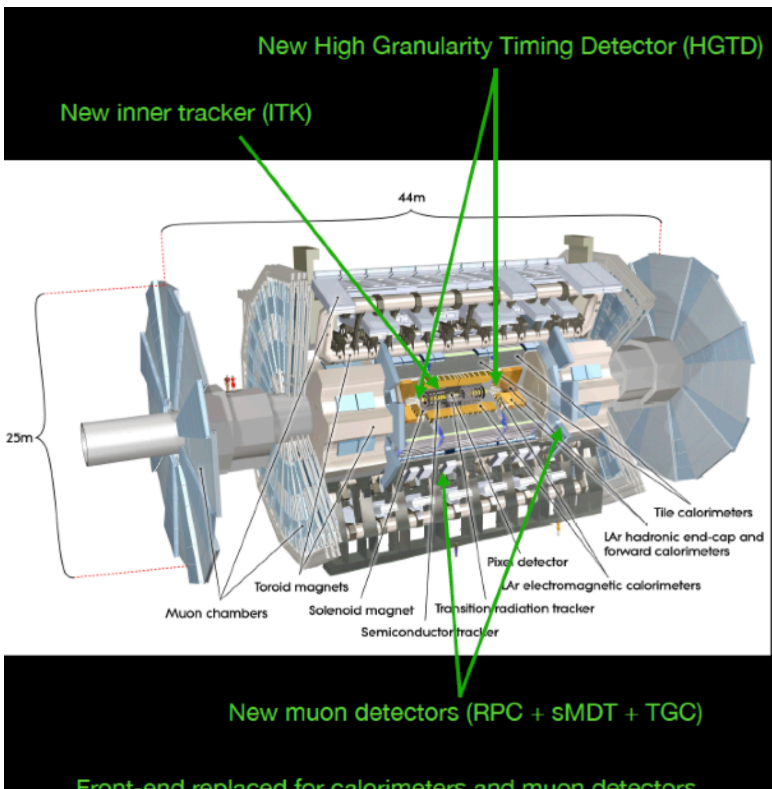


Detectors Upgrades @LHC



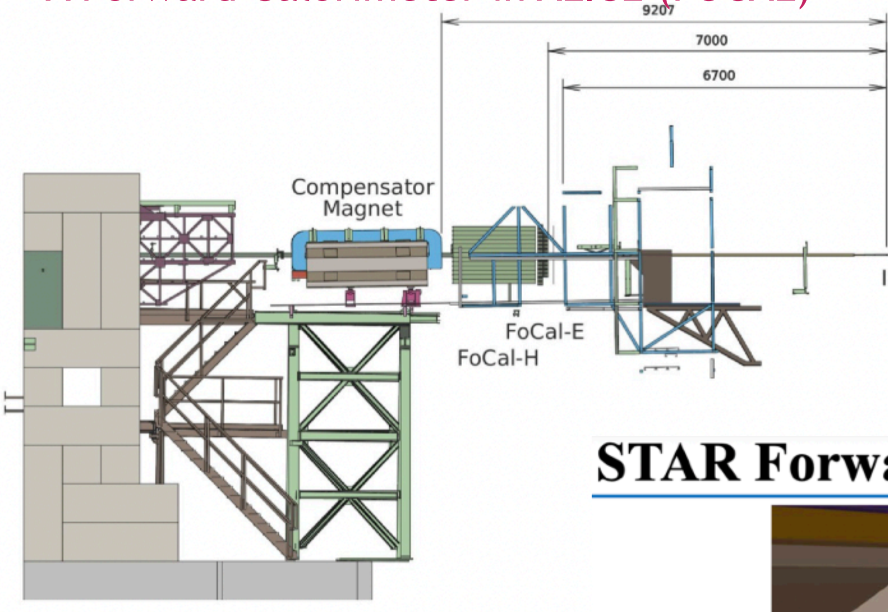


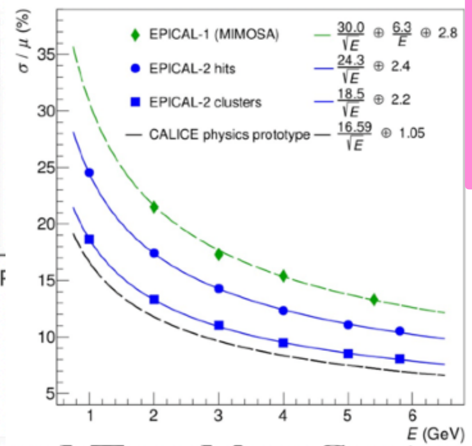
Upgrade of ATLAS Hadronic Tile Calorimeter for the High Luminosity LHC
Tibor Zenis
The ATLAS Experiment Upgrade Program
Riccardo Vari
ATLAS LAr Calorimeter Commissioning for LHC Run-3
Sumit Keshri
Overview of ATLAS forward proton detectors for LHC Run 3 and plans for the HL-LHC
Pragati Patel



Detectors Upgrades @LHC and @ RHIC

A Forward Calorimeter in ALICE (FOCAL)





The STAR Forward Upgrade
Zhenyu Ye
A Forward Calorimeter in ALICE
Ionut Cristian Arsene

STAR Forward Tracking System in Run22

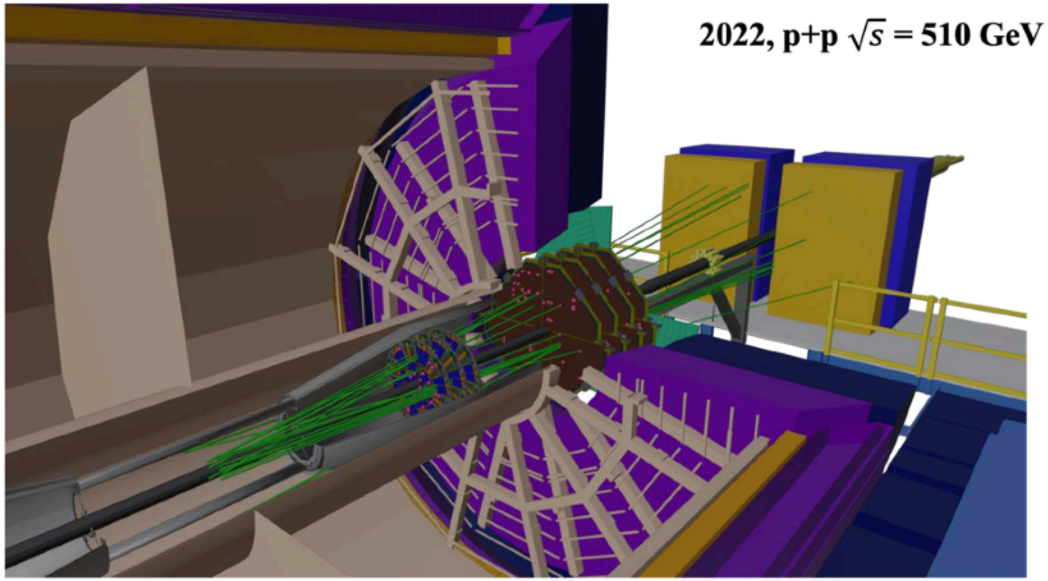
Rapidity coverage:
$2.5 < \eta < 4$ (similar to EIC hadron endcap)

Goal:
Charge separation; e, γ and π^0 identification

Components:
- Forward Silicon Tracker (**FST**)
- Forward sTGC Tracker (**FTT**)
- EM Calorimeter (**ECal**)
- Hadronic Calorimeter (**HCal**)

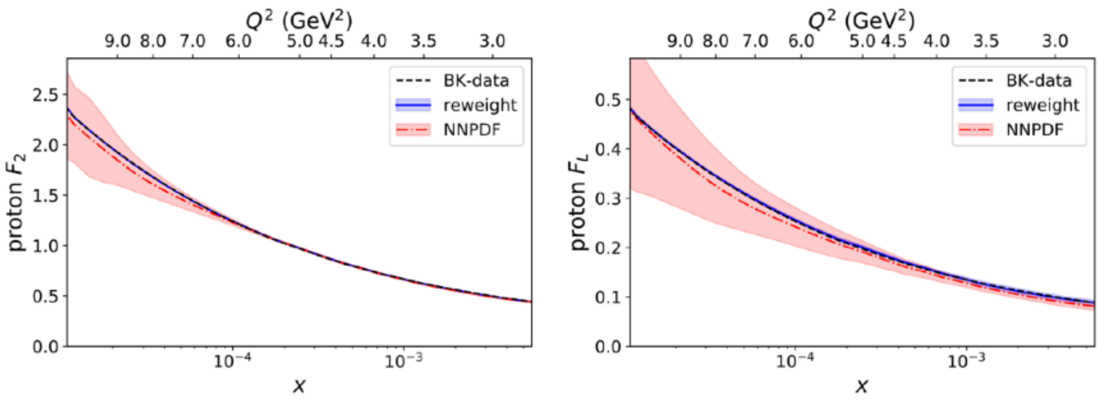
Requirements:

Detector	pp and pA	AA
ECal	$\sim 10\%/\sqrt{E}$	$\sim 20\%/\sqrt{E}$
HCal	$\sim 50\%/\sqrt{E} + 10\%$	-
Tracking	charge separation, photon suppression	$\delta p_T/p_T \sim 20-30\%$ for $0.2<p_T<2$ GeV/c



Both FST and FTT were successfully commissioned and took data in Run22 (12/2021-4/2022). Preliminary tracking from FTT is promising

Bayesian and deep learning techniques



(a) F_2 (b) F_{L}

The structure functions for proton as a function of x at $Q^2 \approx 10Q_s^2(x)$

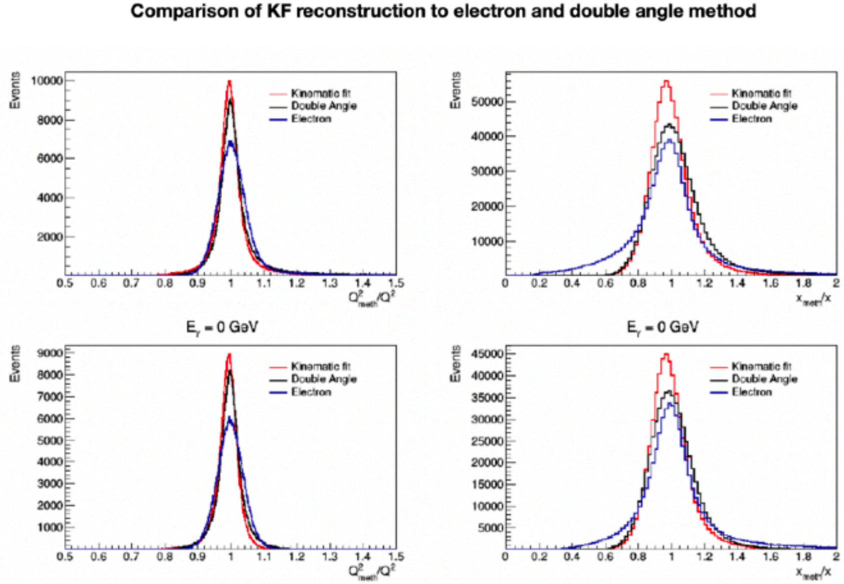
- Separate matching for proton F_2 and F_{L} are both almost perfect

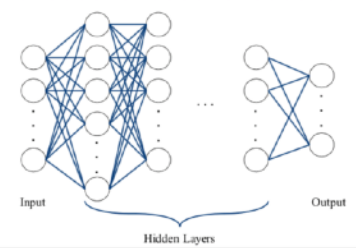
Signatures of gluon saturation in future DIS experiments
Mirja Tevio

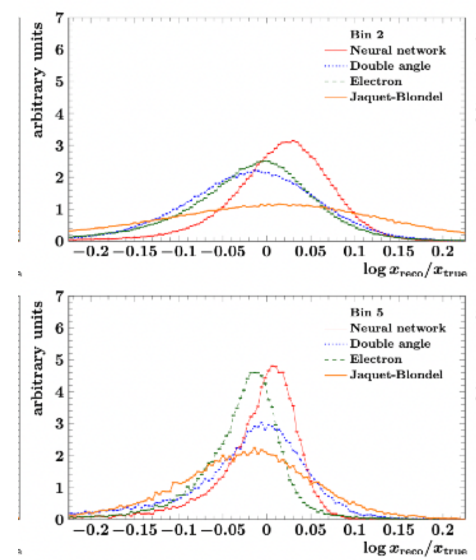
Kinematic fitting of Neutral Current events in Deep Inelastic ep Collisions
Allen Caldwell

Reconstructing DIS Kinematics at the EIC Using Deep Learning
Abdullah Farhat

Comparison of KF reconstruction to electron and double angle method







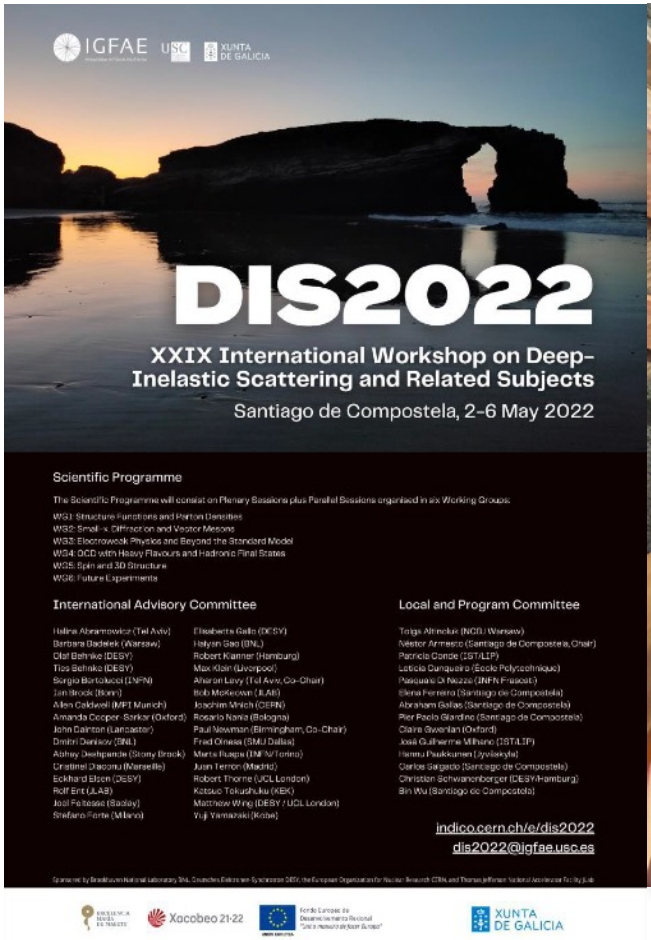
Kinematic Fit: Use the information from the electron and hadronic system to reconstruct three pieces of information.
Bayesian approach - build in knowledge of distributions

Summary

We have a very rich, diverse and challenging Physics Program for the next decades

WG6: Future Experiments

Thank you to all the speakers
and to the organisers!



Yulia from remote!