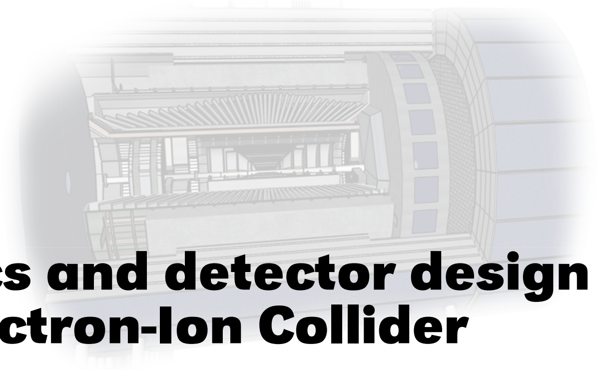
ICHEP 2022 BOLOGNA



ECCE forward physics and detector design at the future Electron-Ion Collider

ICHEP, Bologna
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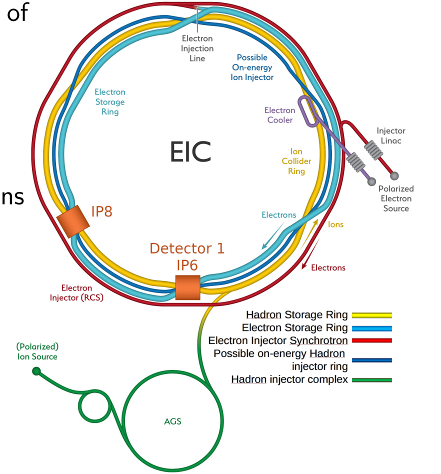
Nicolas Schmidt (ORNL)
for the ECCE Collaboration

Oak Ridge National Laboratory

The Electron-Ion Collider at BNL

- **New electron accelerator and storage ring** at RHIC as part of $2B project
- More than 1300 physicists from over 250 institutes worldwide
- Center-of-mass energies of $\sqrt{s} = 20 - 140$ GeV
- **High luminosity** of $10^{33} - 10^{34}$ cm^{-2}s^{-1} for $e + p(A)$ collisions
- **High polarization** ($\sim 70\%$) of both electron and ion beams
- **Two interaction points** for instrumentation

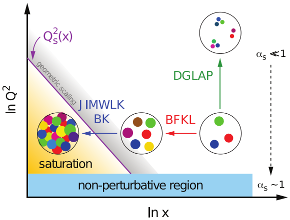


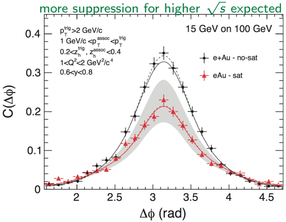
see talk by Silvia Verdú-Andrés

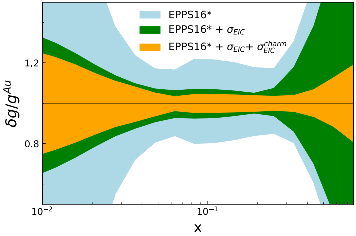
Select physics at the EIC

- Gluon **saturation**
  → possible signatures in back-to-back hadron/jet correlations or nuclear modification factor
- Gluon **TMDs**
  → constrained via quarkonium or charm jet production
- **Nuclear modification** of particle production
- PDFs and nPDFs in e–p and e–A collisions
  → strong constraints over large kinematic range
  → DIS kinematics require good tracking for jet and electron reconstruction
- **Single particle measurements**, e.g. π^0
  → also needed for SIDIS or exclusive DIS
- ***Vast physics program outlined in Yellow Report!***

EIC Yellow Report - arXiv:2103.05419



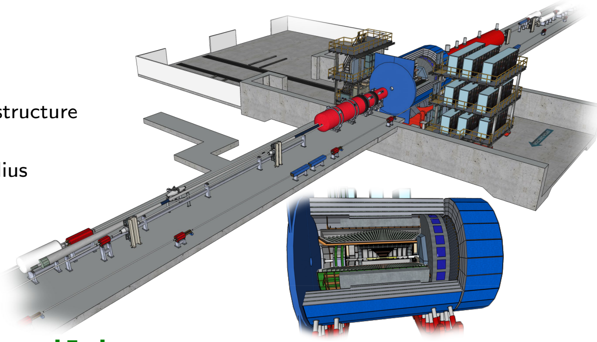


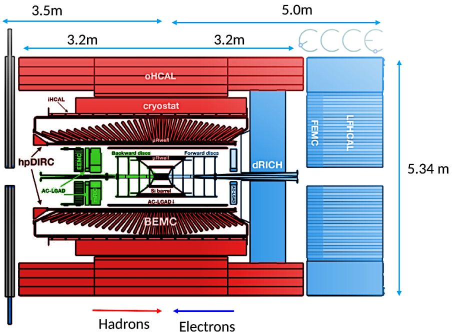


The ECCE detector at the EIC

EIC Comprehensive Chromodynamics Experiment

- Chosen as **reference design for EIC project detector 1**
- **Reuse of existing components**
  $\rightarrow$ 1.5T BaBar solenoid, certain subdetectors and infrastructure
- Designed for IP6 and 25mrad crossing angle
  $\rightarrow$ compact design with $\sim$ 8.5m length and $\sim$ 2.7m radius

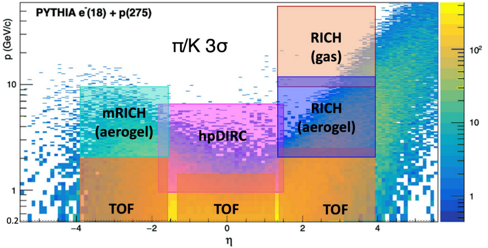


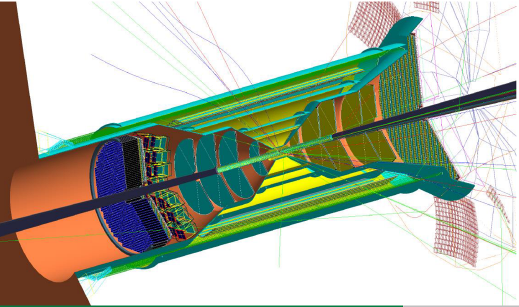


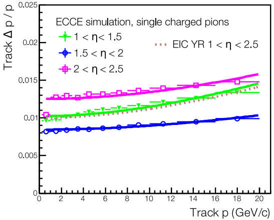
- **Backward Endcap**
  $\rightarrow$ $PbWO_4$ ECal, MAPS tracking, mRICH and AC-LGAD PID
- **Central Barrel**
  $\rightarrow$ SciGlass ECal, Fe/Sc sPHENIX HCal, MAPS and μRWell tracking, hpDIRC and AC-LGAD PID
- **Forward Endcap**
  $\rightarrow$ Pb/SciFi shashlik ECal, Fe/Sc longitudinally separated HCal, MAPS tracking, dRICH and AC-LGAD PID

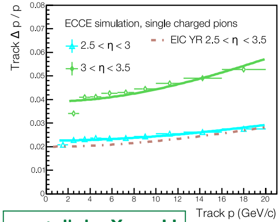
Forward tracking and PID

- **Monolithic Active Pixel Sensor (MAPS)** based tracking system
  $\rightarrow$ 5 disks at different z positions with 10μm pixel size
- Tracking and TOF PID via **AC-LGAD disk**
  $\rightarrow$ derived from CMS ETL [CERN-LHCC-2019-003]
- **Dual-Radiator Ring Imaging Cerenkov Detector (dRICH)**
  $\rightarrow$ AI-optimized design [JINST 15 (2020) 05, P05009]
  $\rightarrow$ excellent PID
- Tracking performance within boundaries set by Yellow Report
- PID coverage over a wide kinematic range





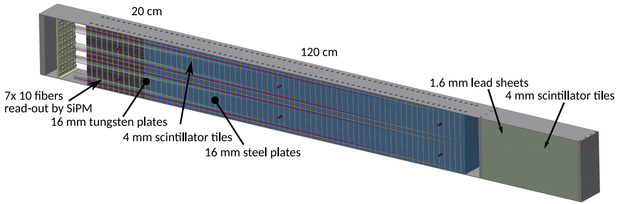


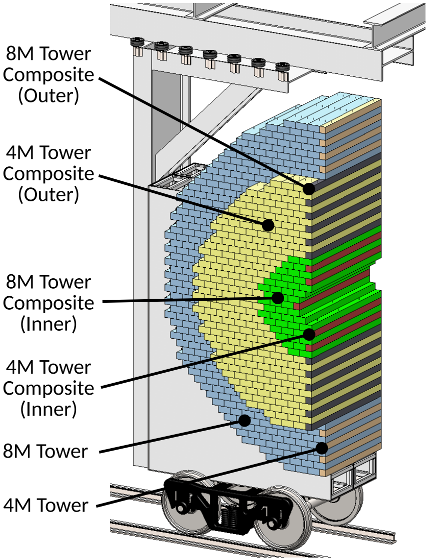


see talk by Xuan Li

Forward calorimetry

- **Forward ECal (FEMC)** - Pb/Sci shashlik
  - → similar to ALICE, STAR and PHENIX ECals
  - → 66 layers (1.6mm Pb + 4mm Sci) → 18.5 X/X_0
  - → 1.65 × 1.65 × 37.5cm towers
- **Longitudinally separated forward HCal (LFHCAL)** - Fe/W/Sci
  - → similarities with PSD calorimeter at NA61
  - → 70 layers (16mm Fe/W + 4mm Sci) → 6.9λ/λ_0
  - → 5 × 5 × 140cm towers
  - → 7 longitudinal segments (10 layers each)
- **Modern approaches** for better performance
  - → sub-Molière radius towers
  - → longitudinal separation
  - → SiPM readout
- Energy resolution of calorimeters better than YR requirement





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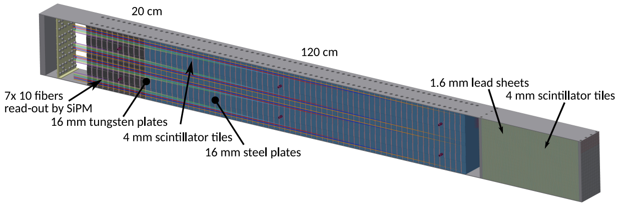
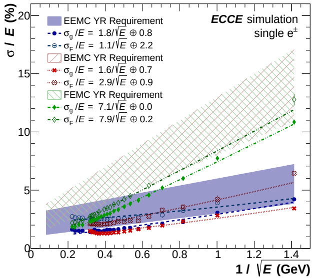
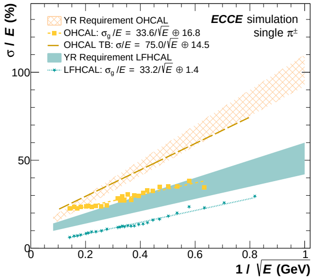


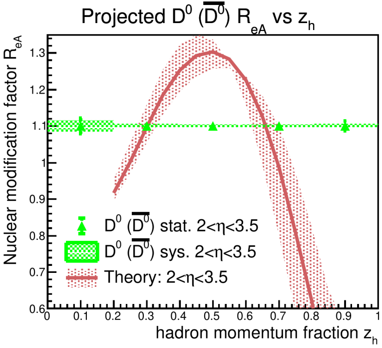




Physics performance prospects

Nuclear effects for jets and D^0:

- Large statistics allow for precise D^0 measurements
  $\rightarrow$ high resolution tracking and vertex finding required
- Jet reconstruction profits from high tracking and calorimeter resolution
  $\rightarrow$ small number of constituents requires high efficiency
- Charged jet energy resolution about 10–25%
  $\rightarrow$ further improvements possible with full particle flow
- Jet R_{eA} probes anti-shadowing and EMC regions of nPDFs at large x
  $\rightarrow$ clear suppression observed
- Jet R_{eA} double ratio approximately flat versus p_{T}
  $\rightarrow$ probes final state effects, but insensitive to $< 10\%$ effects within uncertainties



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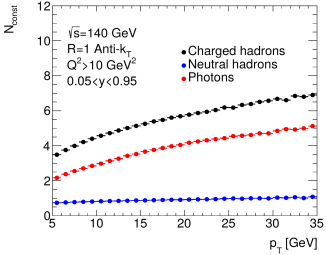

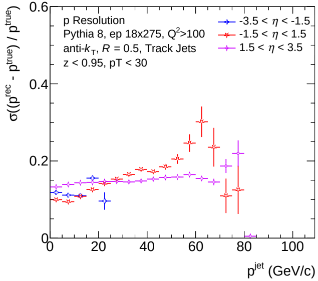

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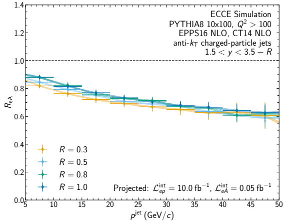
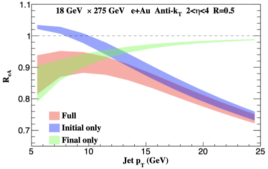
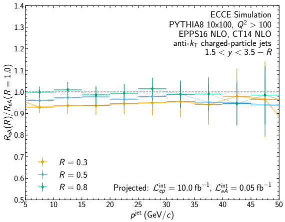
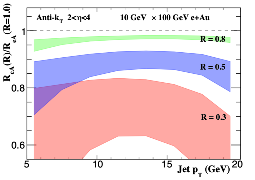


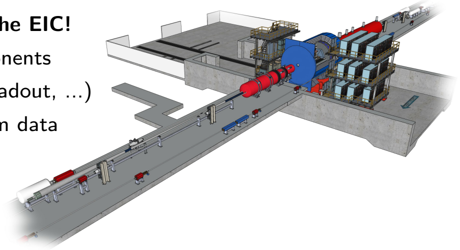


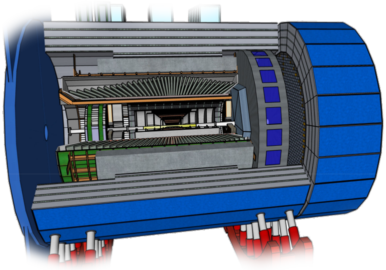




Summary and Outlook

- **ECCE/Detector-1 designed to explore rich physics program at the EIC!**
- Comparably low risk detector with reuse of several existing components
- Modern approaches for detector design (AI optimization, SiPM readout, ...)
- Technology choice evaluation via Geant4 simulations and testbeam data
- Physics performance presented for exemplary R_{eA} measurements



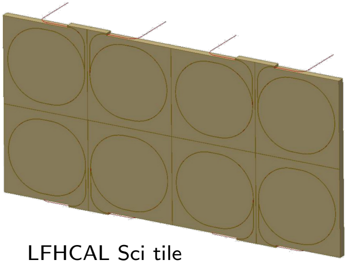


Towards EIC Project Detector 1:

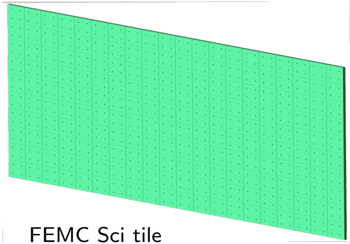
- Further evaluation of detector performances and physics impacts
- Selection of final technologies
- Prototype design and testbeam studies
- First data in ~ 10 years

Backup

Forward calorimeter details



LFHCAL Sci tile



FEMC Sci tile