

# Physics and Detector Opportunities for a Fixed-target Program in EIC

Cesar Luiz da Silva

Los Alamos National Lab

RHIC & AGS Users Group Meeting 2026



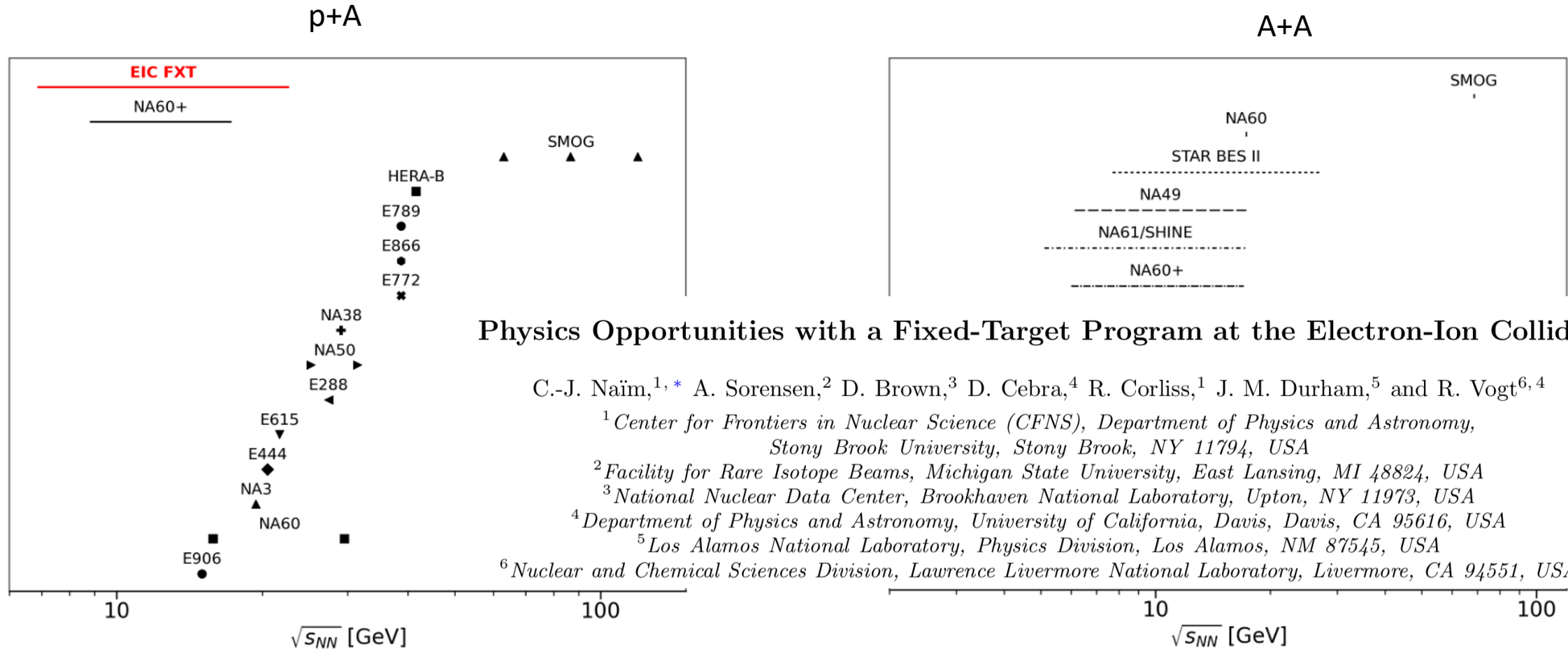
U.S. DEPARTMENT OF  
**ENERGY**

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Office of Science

# Collision Energy Range.

Physics Opportunities with a Fixed-Target Program at the EIC. arXiv:2603.00265



## Physics Opportunities with a Fixed-Target Program at the Electron-Ion Collider

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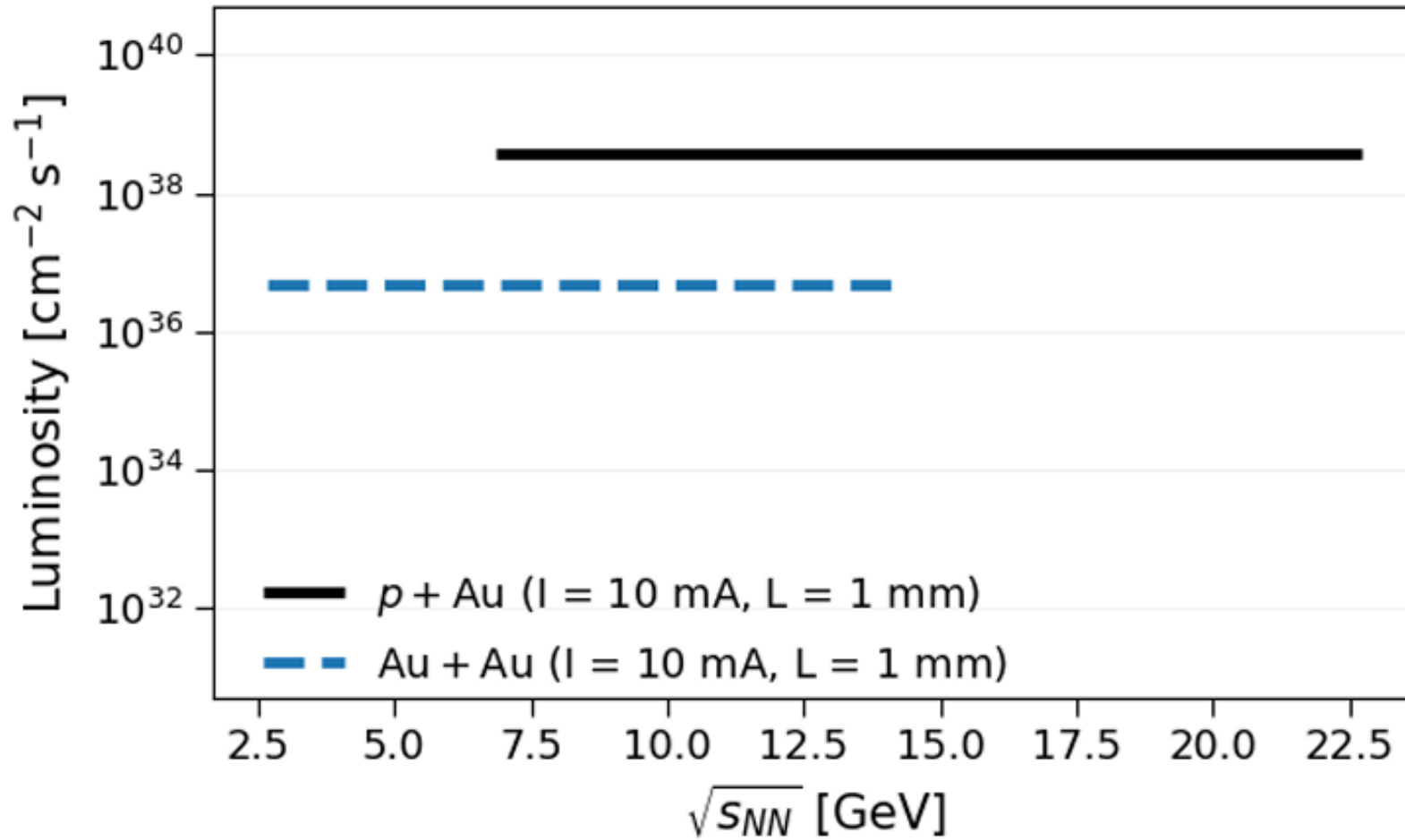
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<sup>5</sup>Los Alamos National Laboratory, Physics Division, Los Alamos, NM 87545, USA

<sup>6</sup>Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, Livermore, CA 94551, USA

# Expected Luminosity

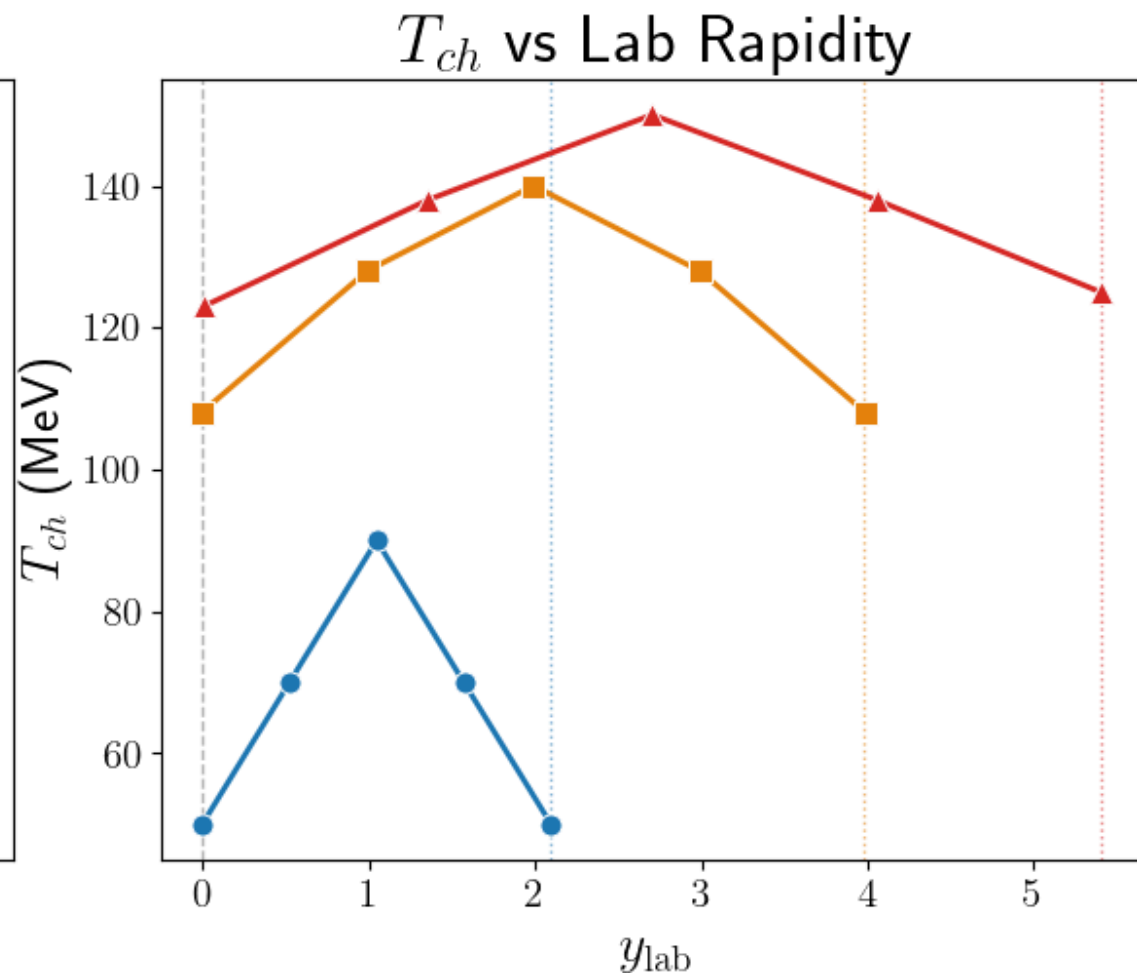
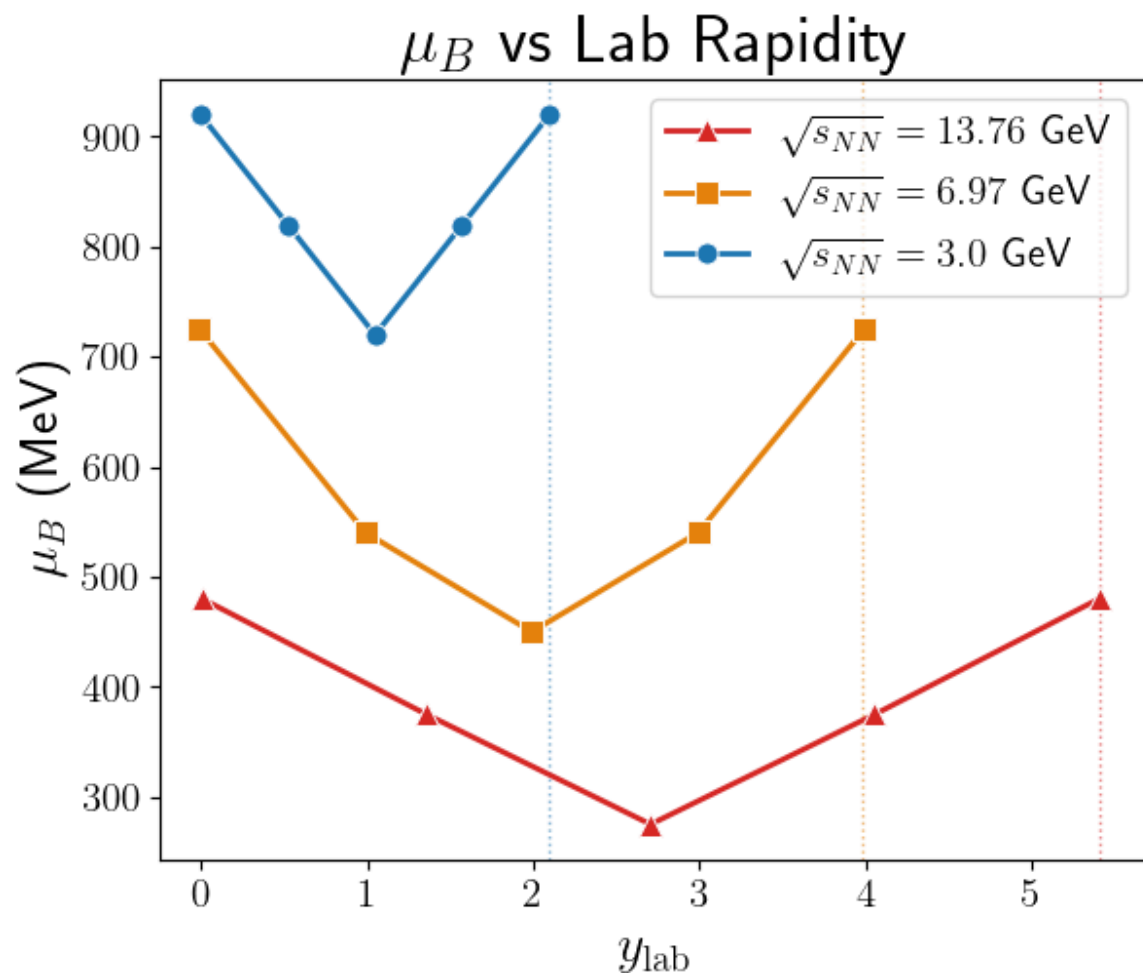
Physics Opportunities with a Fixed-Target Program at the EIC. arXiv:2603.00265



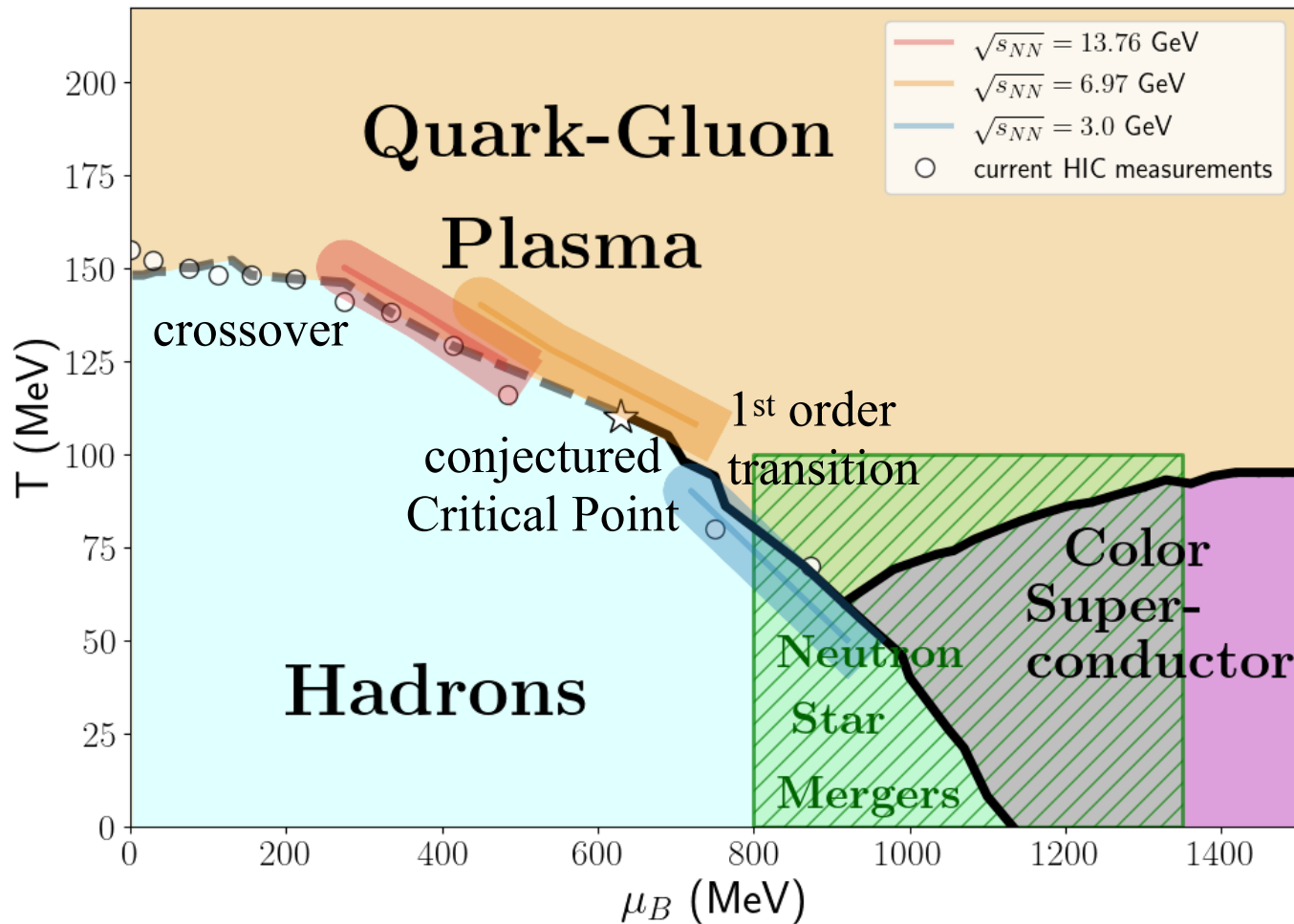
# QCD phase space exploration.

Based on parametrizations describing SPS  
and RHIC data :

J. Manninen & F. Becattini: arXiv:0806.4100 (2008),  
F. Becattini, J. Manninen & M. Gazdzicki: PRC 73, 034905 (2006),  
Cleymans & Worku: hep-ph/0701029.



# QCD phase space exploration.



- Measurements based on identified particle ratios **at freeze-out**
- Rapidity dependent measurements cover a broader QCD phase space range than mid-rapidity measurements, better chance to find the QCD critical point
- Low-energy fixed target starts to overlap with QCD phase space of neutron star merger conditions
  - a field expected to grow fast with the new gravitational wave experiments

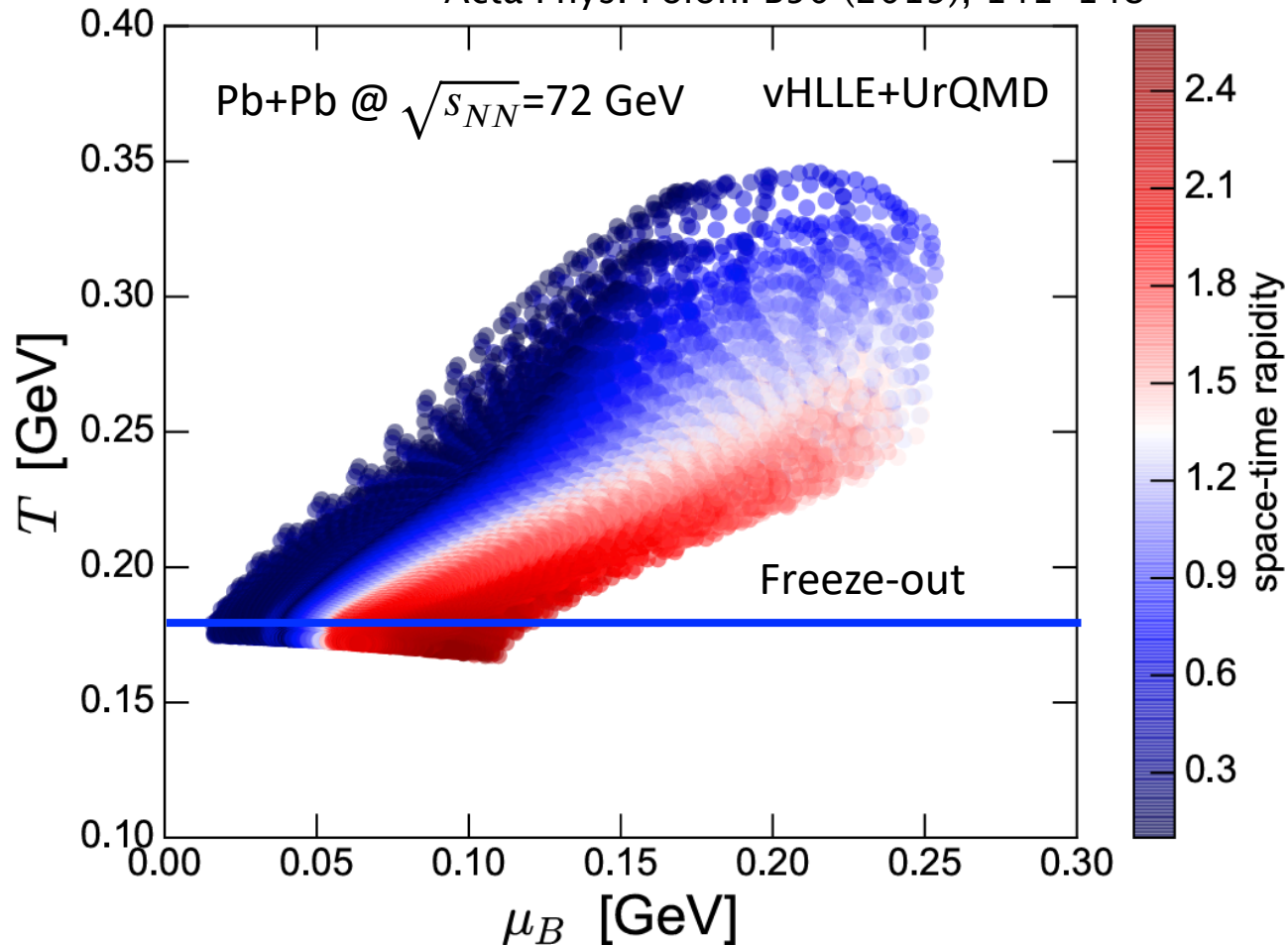
More on QCD phase space in Mikhail Stephanov and Lipei Du presentations in the afternoon.

# What is the peak temperature in these collisions?

## Do they form QGP?

T at  $\tau_0 = 0.64$  fm/c

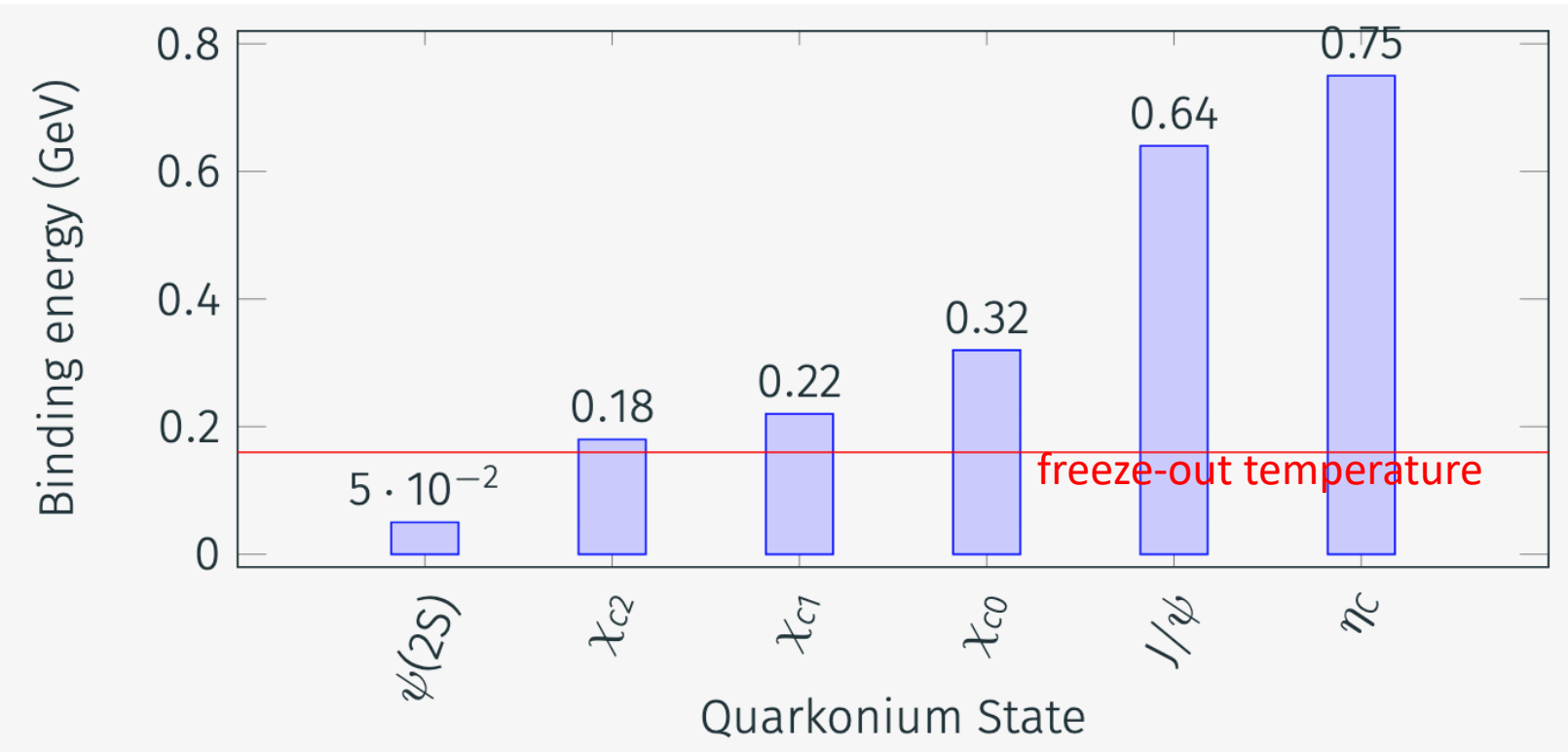
Acta Phys. Polon. B50 (2019), 141-148



Peak temperatures are not accessed by particle ratios. Need probes produced at initial states which are sensitive to local temperatures:

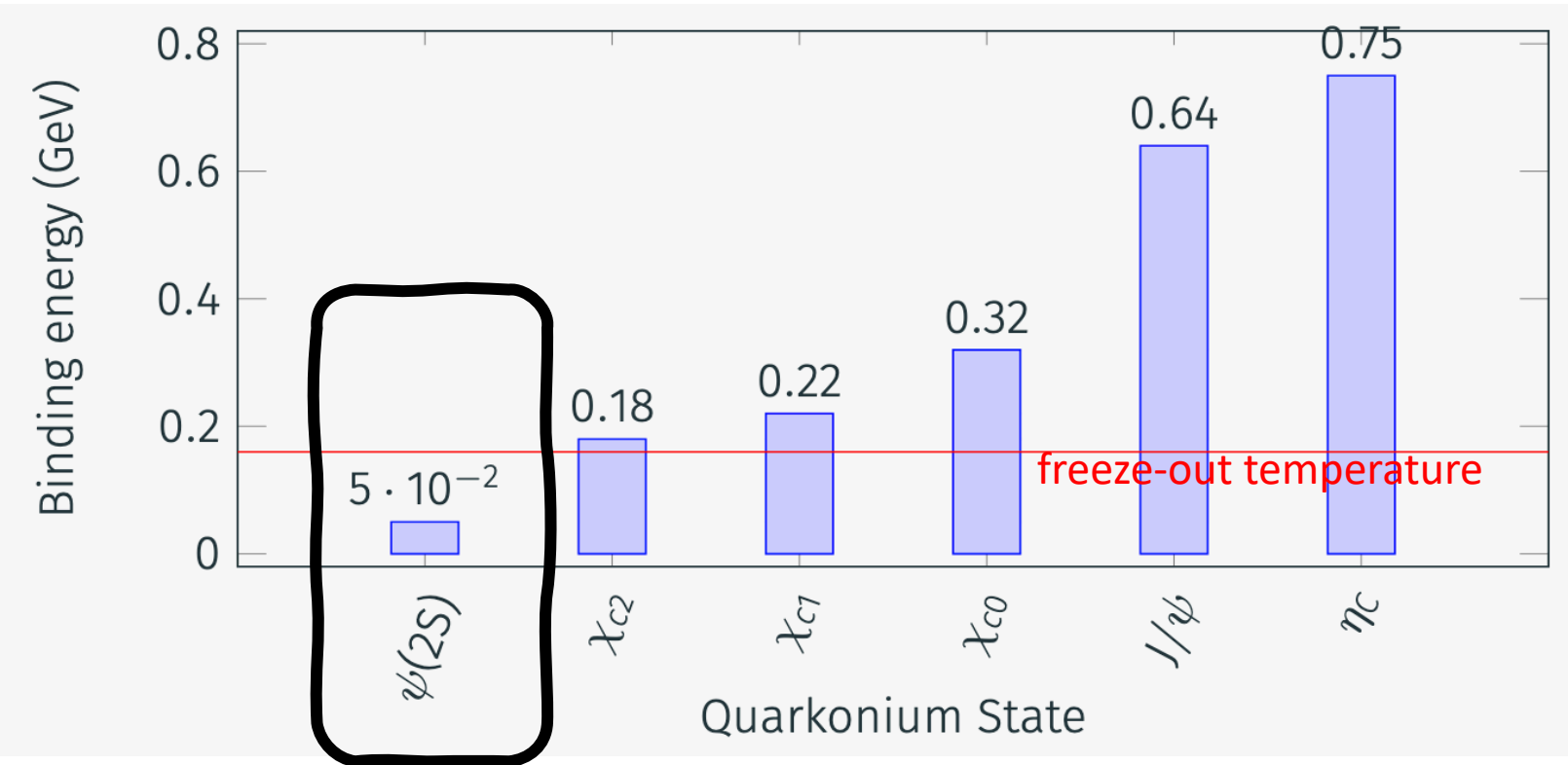
- Thermal photons and dileptons access average temperatures over the medium evolution:
  - CERES at  $\sqrt{s_{NN}} = 17.2$  GeV
- Charmonium states dissociation

# What is the peak temperature in these collisions? Do they form QGP?



Quarkonia states work as fuses which blowup if the local peak temperature is larger than its binding energy.

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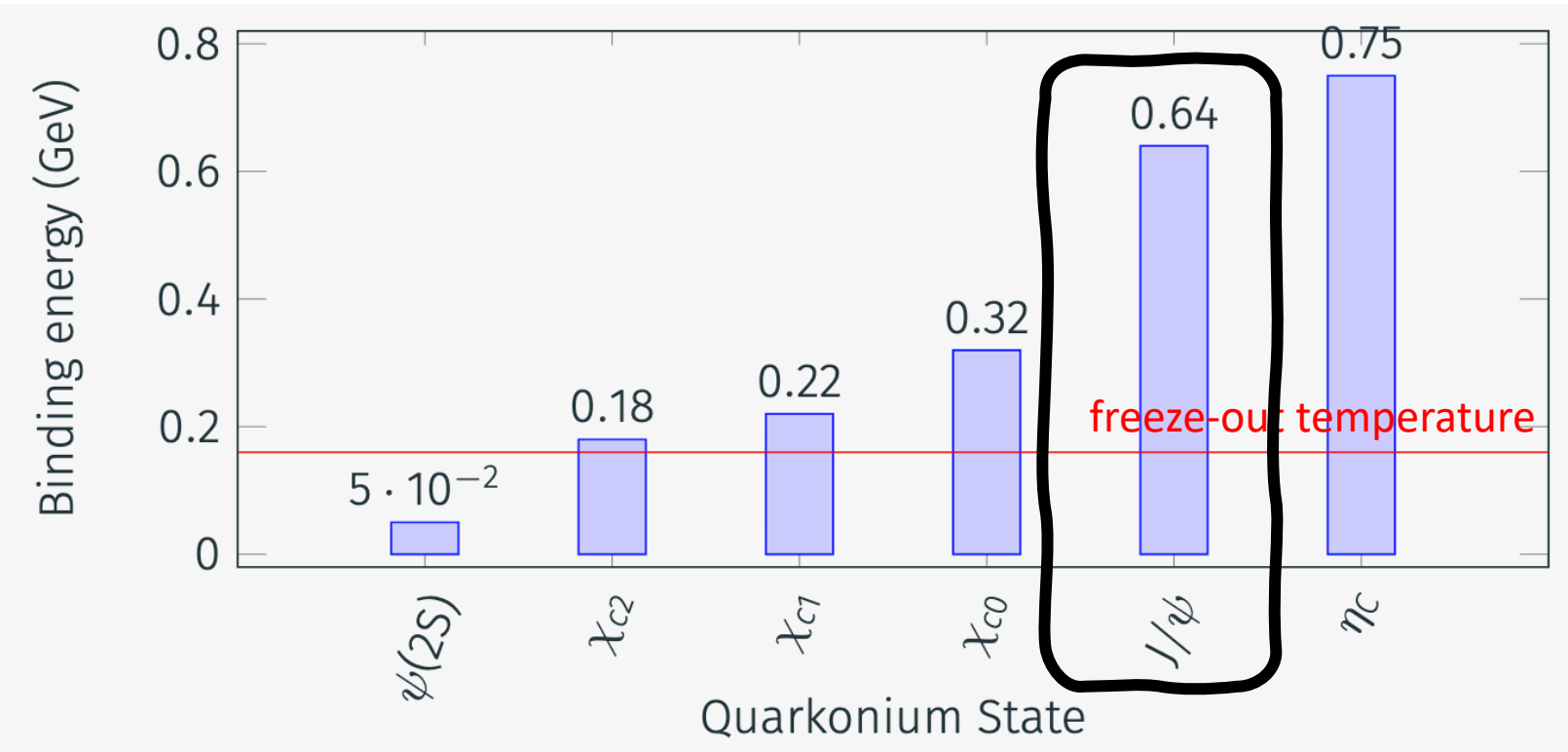


Quarkonia states work as fuses which blowup if the local peak temperature is larger than its binding energy.

QGP formation is not a requirement to dissociate  $\psi(2S)$  states.

# What is the peak temperature in these collisions?

## Do they form QGP?

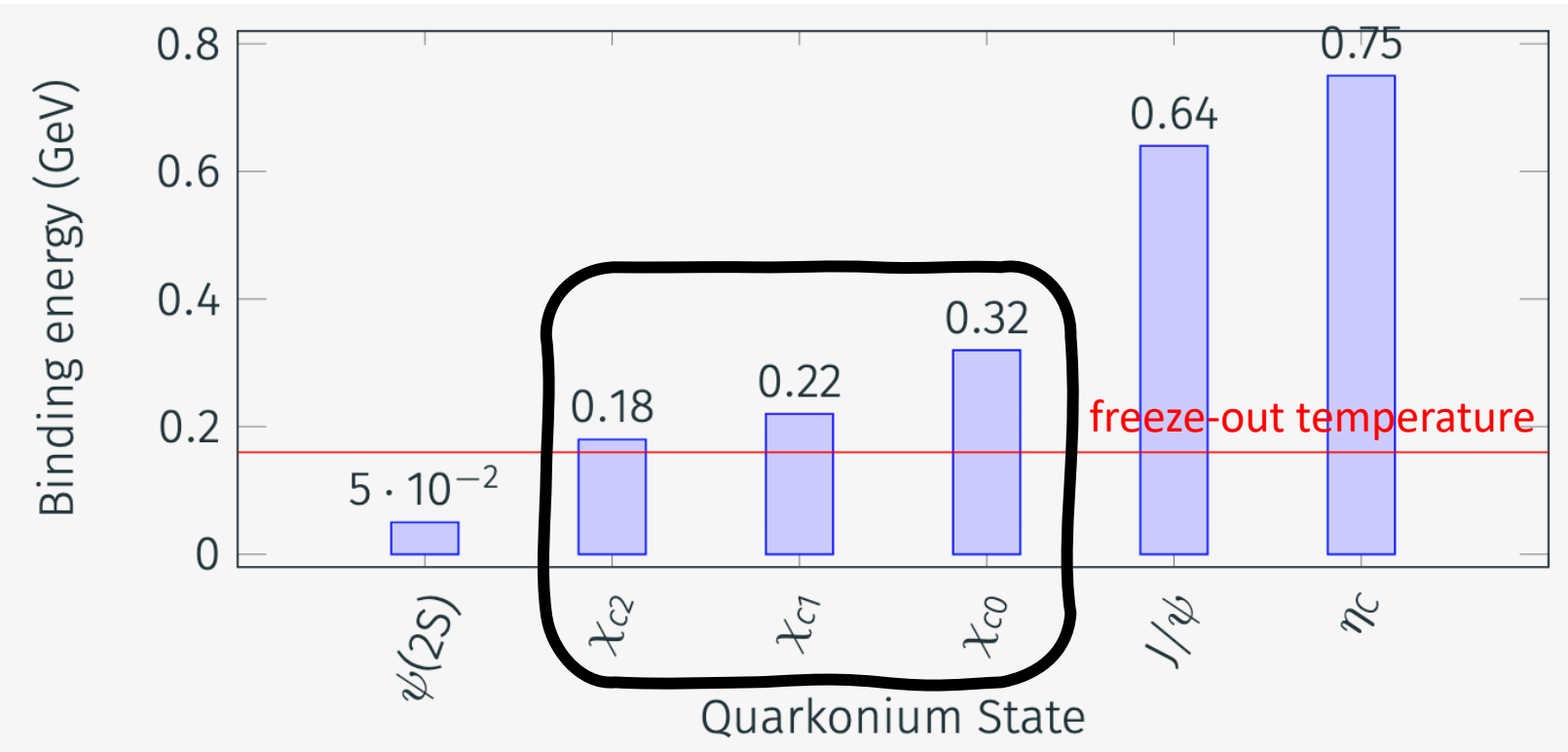


Quarkonia states work as fuses which blowup if the local peak temperature is larger than its binding energy.

- It takes  $T > 600$  MeV to break direct  $J/\psi$ , may not be achieved at low energy collisions.
- $J/\psi R_{AA}$  is easy to measure but plagued with CNM and feed-down effects.
- $J/\psi/D^0$  yield ratio is a much better way to check if the  $J/\psi$  is dissociated

# What is the peak temperature in these collisions?

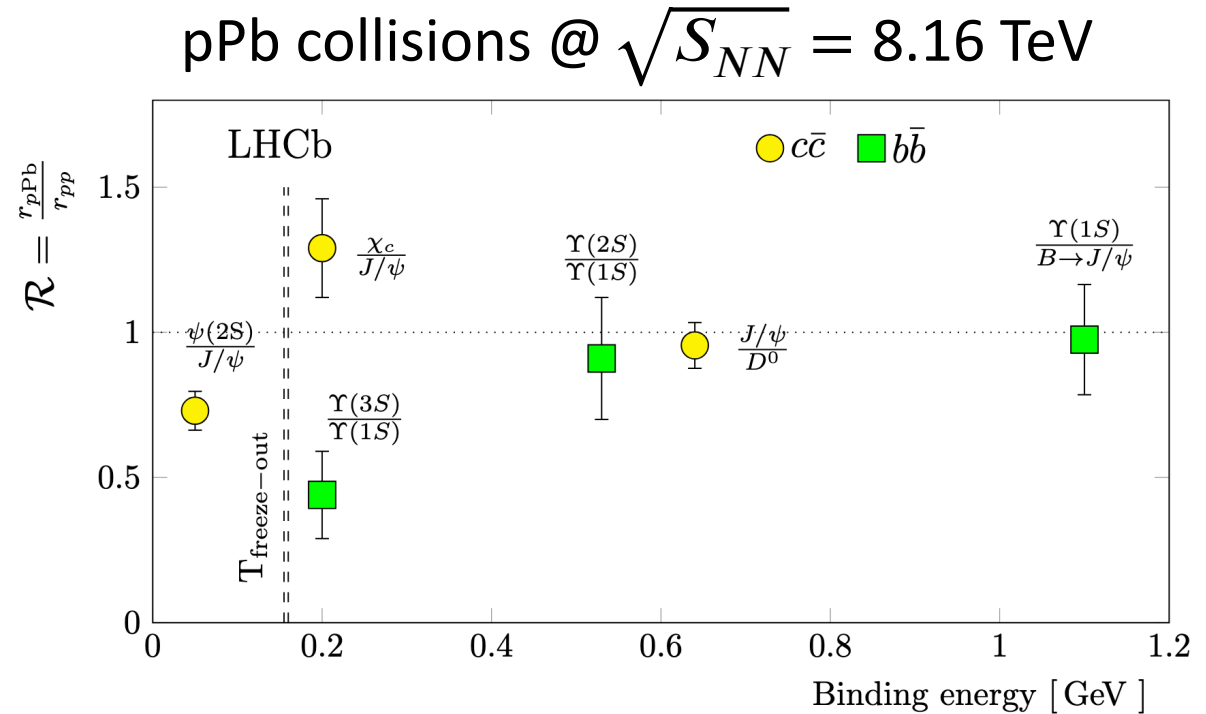
## Do they form QGP?



Quarkonia states work as fuses which blowup if the local peak temperature is larger than its binding energy.

- $\chi_c$  breaking measured by  $\frac{\chi_c}{J/\psi}$  yield ratio is the real smoking gun for QGP signature at low-energy collisions
  - $\chi_c$  measurement requires the identification of a  $J/\psi$  and a soft photon in ECAL
  - Low signal/background: requires high statistics that a fixed target can provide

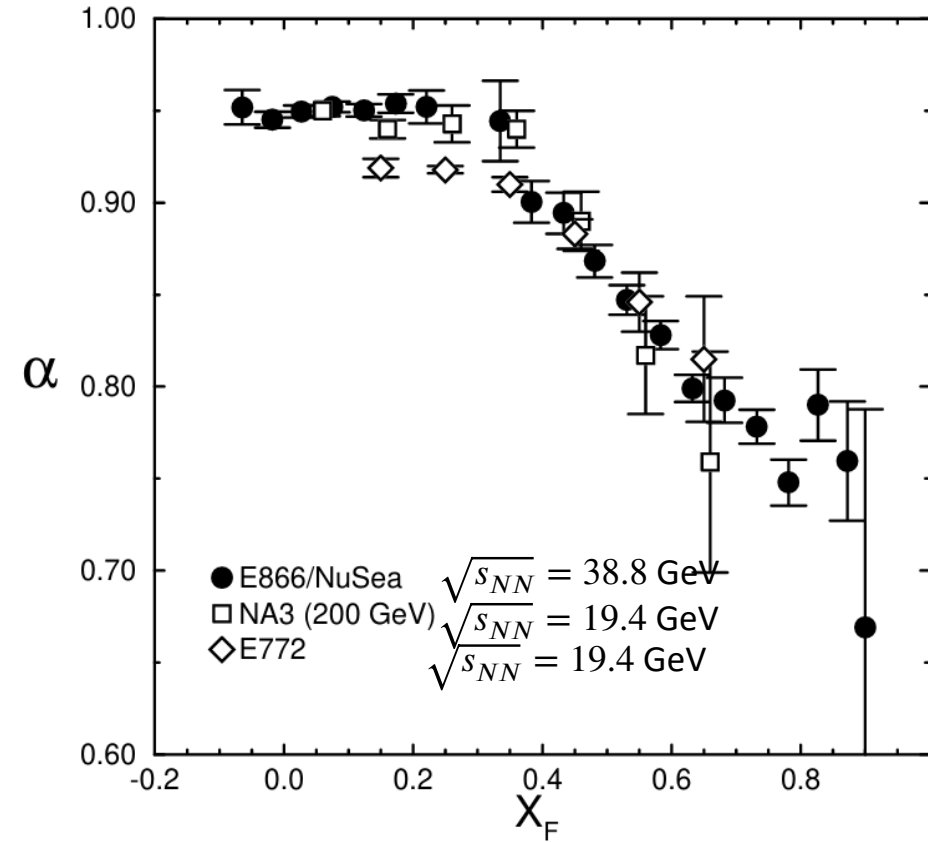
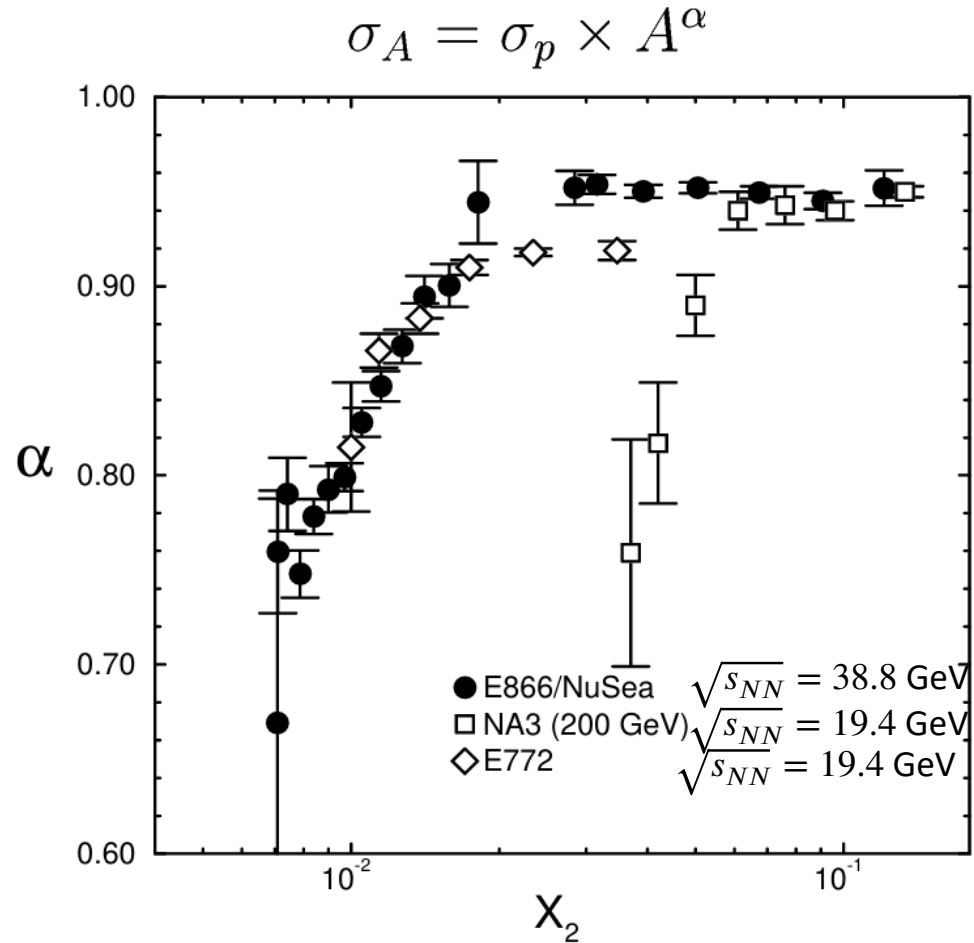
# $\chi_C$ measurements in heavy ions



$\chi_C$  is NOT dissociated in pPb collisions at LHC -> not affected by CNM effects

Quarkonia state ratios are insensitive to CNM effects.

# Probing nPDFs



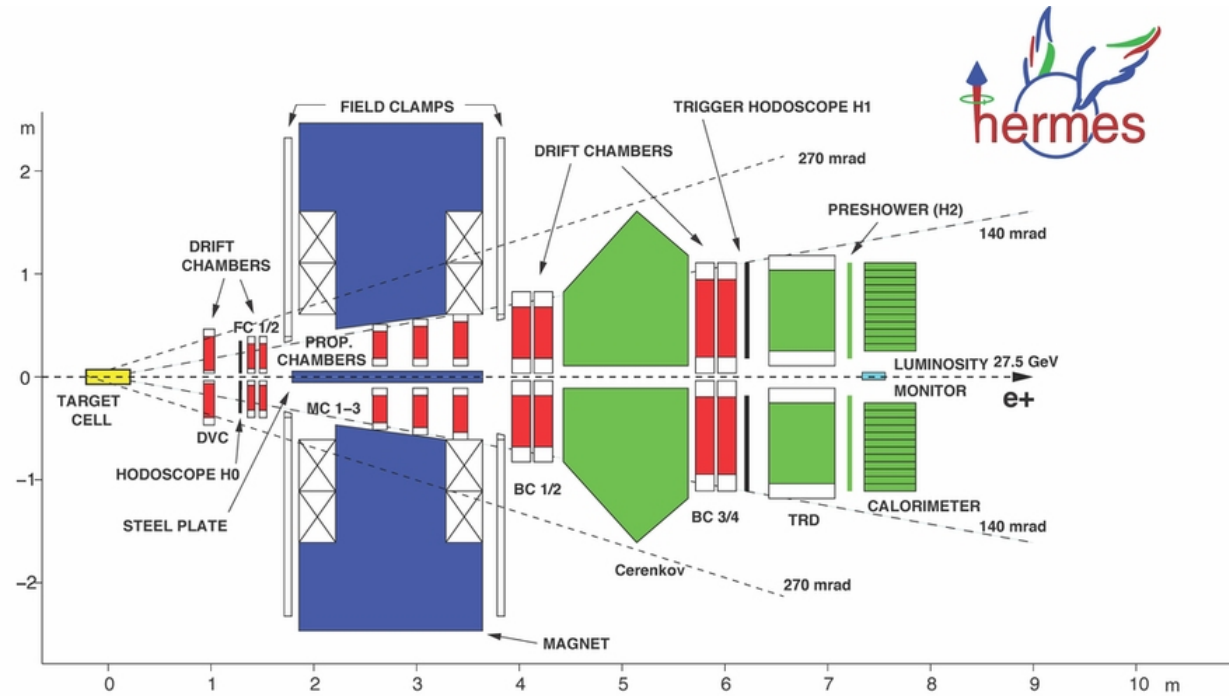
$J/\psi$  measurements indicates a complex pattern of CNM effects along different x-regions

High-statistics heavy flavor, Drell-Yan, direct photon measurements are essential to disentangle initial-state effects.

More on CNM effects in the next talk by Ramona

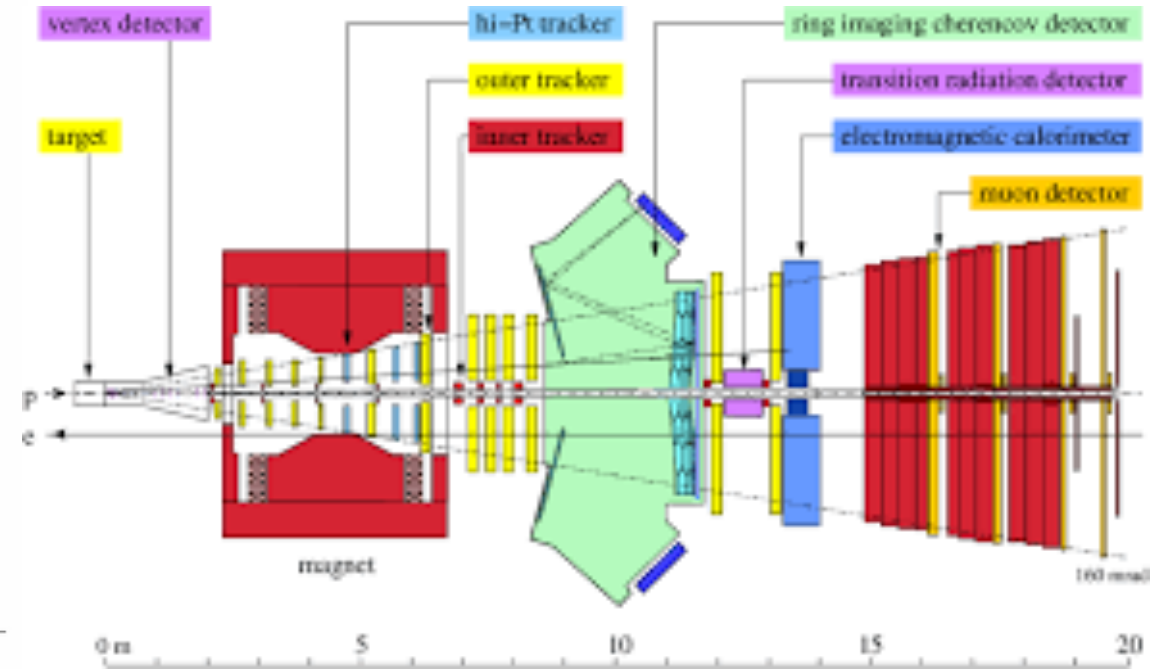
# EXPERIMENTAL APPROACHES

# Fixed Target Experiments at HERA



- Polarized gas target cell
- Dedicated to spin physics

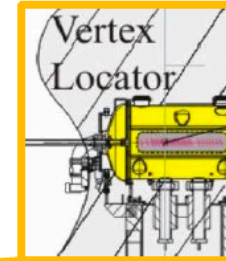
## HERA-B



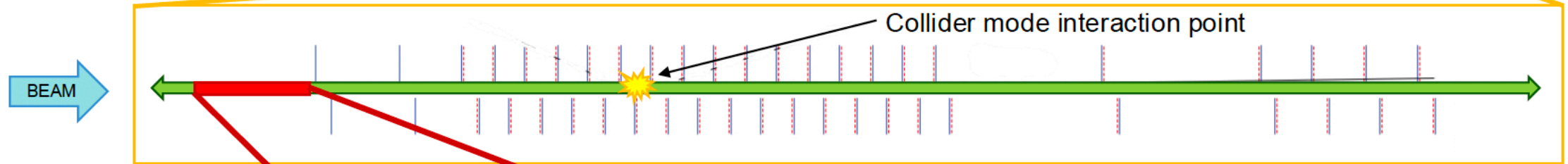
- Wire target at the proton beam halo
- Dedicated to flavor physics

# The LHCb fixed-target program

System for **M**easuring **O**verlap with **G**as



2



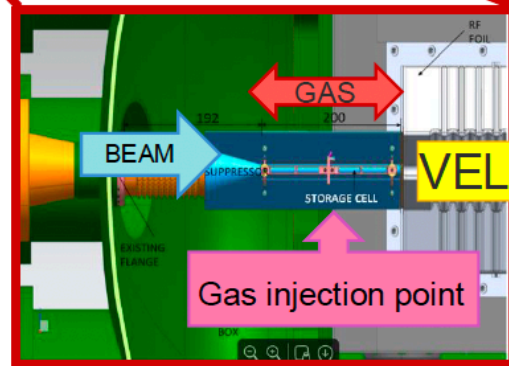
**Run 2** (2015 – 2018)

SMOG

$\sim 10^{-7}$  mbar on +/- 20 m

Gases: Ar, Ne, He

Beams:  $p$ , Pb



LHCb-PUB-2018-015

- Higher gas pressure
- Higher luminosity
- SMOG2 cell before VELO
- Taking collider and fixed-target data **simultaneously**
- Injection of non-noble gases

**100 times larger statistics!**

**Run 3** (2023 – 2026)

SMOG2

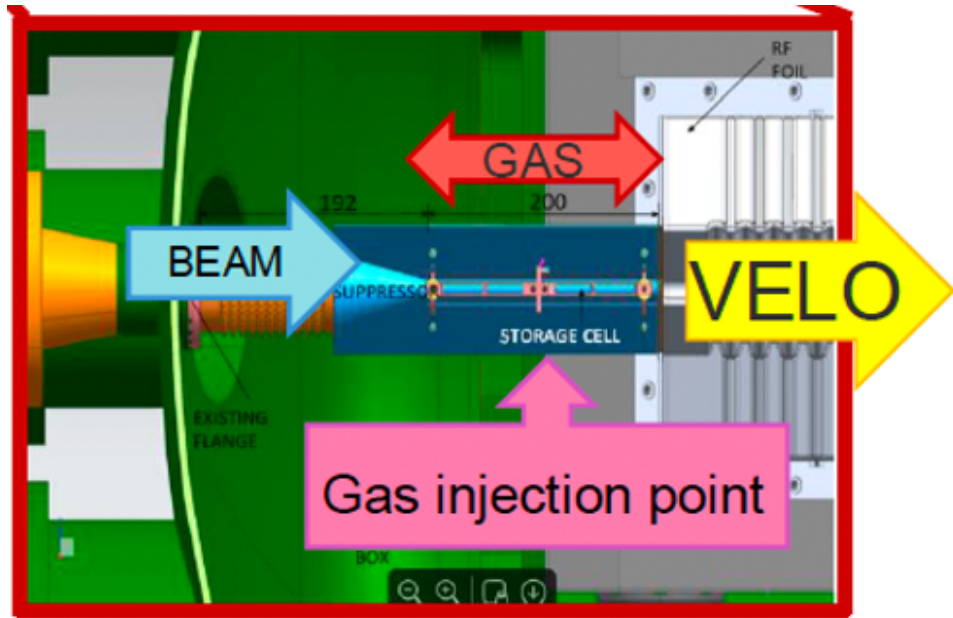
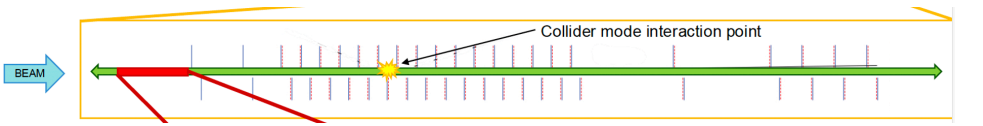
$\sim 10^{-5}$  mbar on 20 cm

Gases: Ar, Ne, He, H<sub>2</sub>, D<sub>2</sub>, O<sub>2</sub>

Beams:  $p$ , Pb, O, Ne

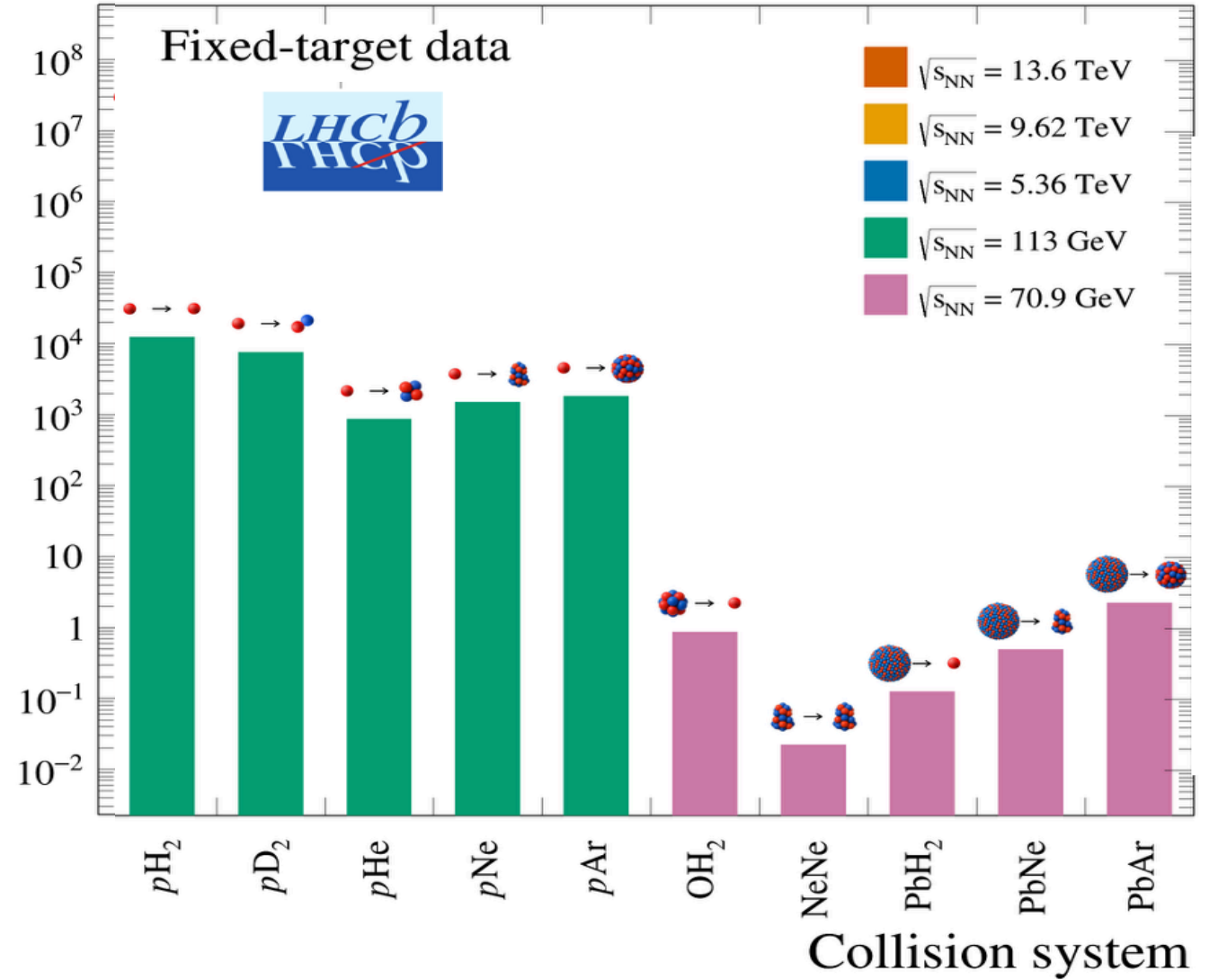
Phys. Rev. Accel. Beams **27**, 111001

# The LHCb fixed target program



[LHCb-PUB-2018-015](#)

Integrated recorded luminosity [ $\text{nb}^{-1}$ ]

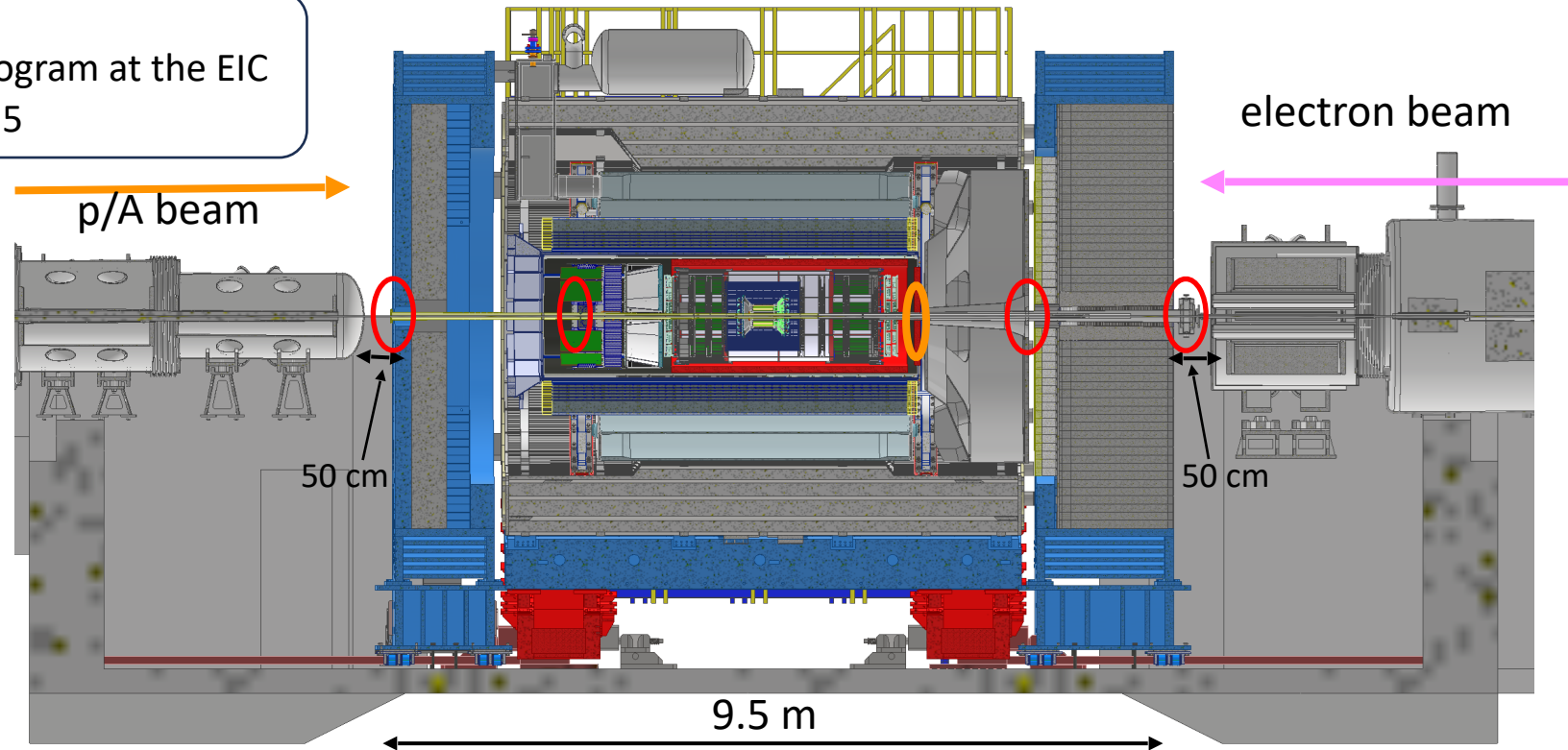


# How to integrate a fixed Target into ePIC

E.C. Aschenauer

Exploring a fixed Target Program at the EIC

September 30<sup>th</sup> – 31<sup>st</sup>, 2025



Fixed targets can be integrated **at flanges** at indicated locations

there is space to integrate foils and maybe a HERMES like storage cell for a gas target, but there is no space for a polarized target.

Electrons:  $E_B$ : 3 to 18 GeV with being polarized 5 to 18 GeV

Hadron beams like RHIC →  $E_B$ : 26 GeV to 275 GeV for polarized protons

Tracking far from FXT points (Cesar)

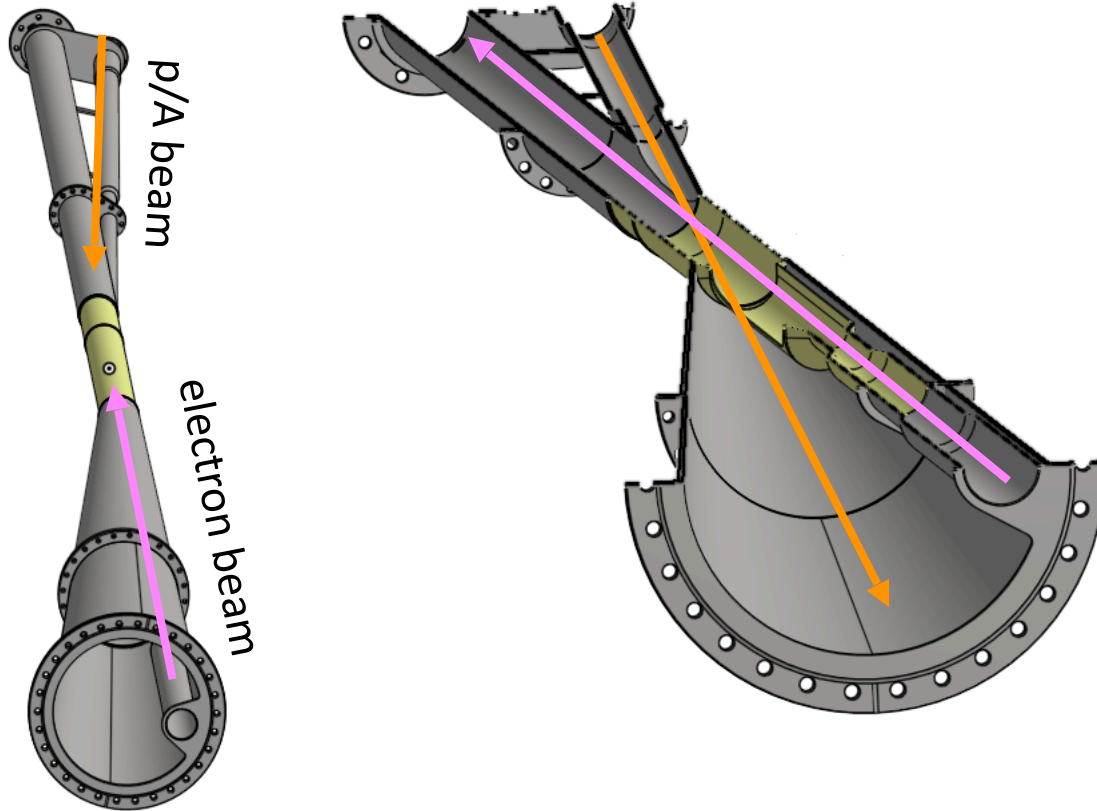
→  $E_B$ : 10 GeV to 110

GeV for Au and scaled respectively with  $\sim A/Z$ ,

can also run the beam energies below injection as for STAR beam energy scan-II

# What you need to consider for a EIC FXT program

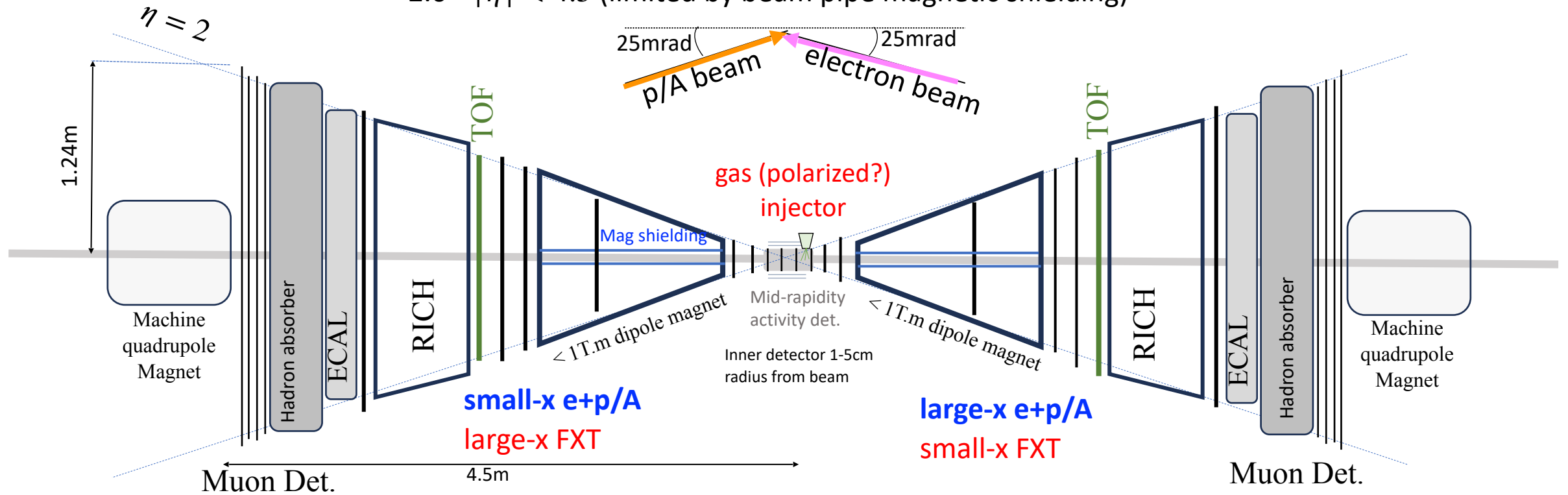
- EIC is running with a crossing angle IP-6: 25 mrad  
future IP-8: 35 mrad
- impacts kinematic: see [here](#) for details
- ePIC is aligned with the electron beam - axis
- Beam pipe is complex



E.C. Aschenauer  
Exploring a fixed Target Program at the EIC  
September 30<sup>th</sup> – 31<sup>st</sup>, 2025

# Detector 2 Concept

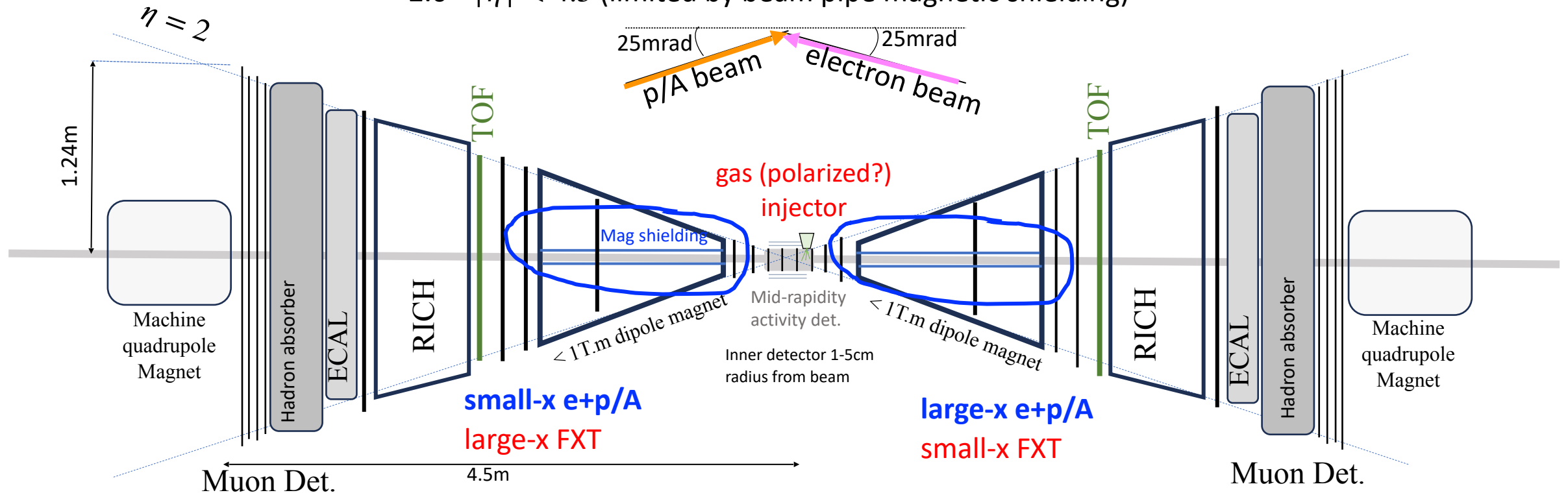
$2.0 < |\eta| < 4.5$  (limited by beam pipe magnetic shielding)



- Compact detector to complement EPIC physics capabilities, some overlap with EPIC acceptance for measurement cross-checks
- Operation in collider and fixed target mode like in LHCb/SMOG
- **TDC resolution < 5ns in all detectors** for synchrotron radiation suppression and real time 4D GNN tracking
- ~ \$80M, 3% of the total EIC cost (machine + detector), potential foreign funding

# Detector 2 Concept

$2.0 < |\eta| < 4.5$  (limited by beam pipe magnetic shielding)

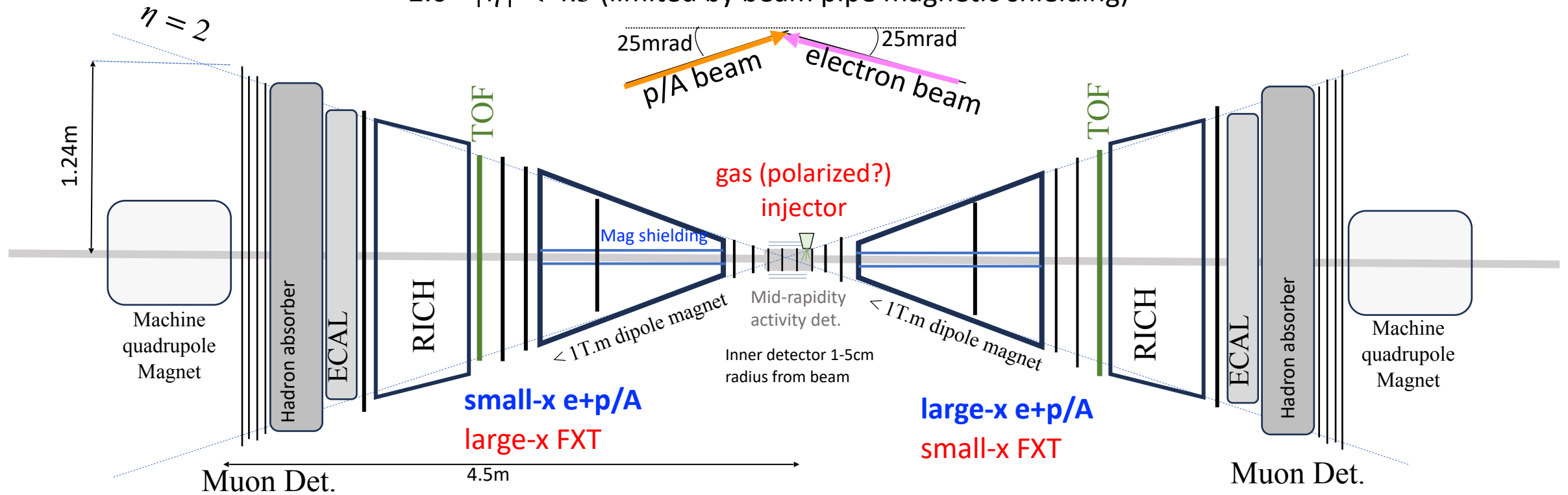


Back to envelope estimation for the magnetic shielding

- Piggybacking from the septum plate magnet used in HERMES detector
- 7mm soft iron + 1mm gap w/ saddle coils (5A) + 2mm mu-metal liner
- < 0.5 mT residual field on beam

# Detector 2 Concept

$2.0 < |\eta| < 4.5$  (limited by beam pipe magnetic shielding)



LHCb-SMOG like gas injector:

- Luminosity measurement  $< 1\%$
- Fixed target covering  $1.5 < y_{\text{lab}} < 4.5$ , depending on the position of the hadron+gas collision
- Space to polarize the gas, like in HERMES
  - a new spin program at EIC: transverse spin asymmetry, DY

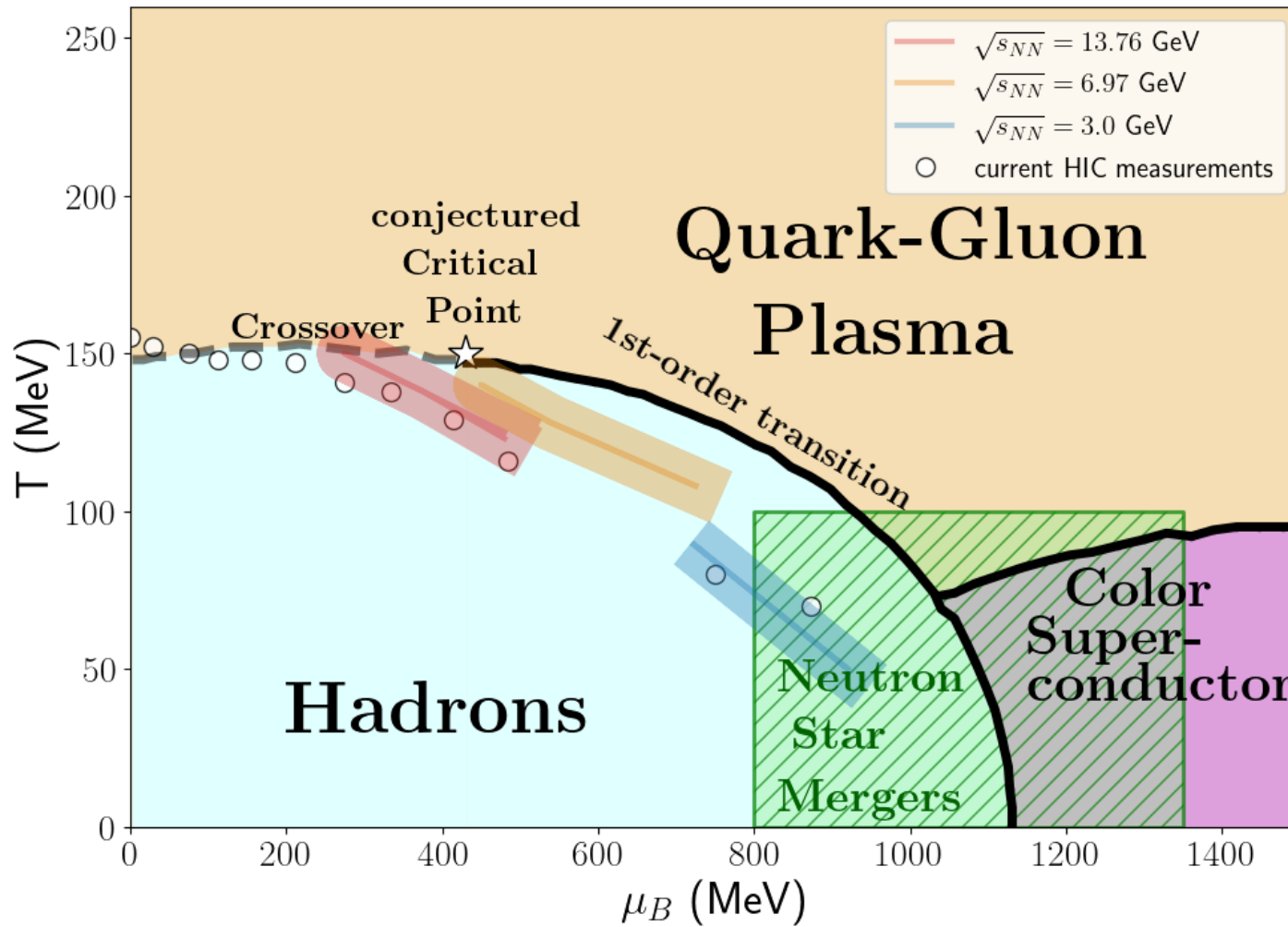
See FXT logistics talk by Daniel Cebra in the afternoon.

# Reflections

- DIS experiments have permeated particle physics for almost 60 years, and still requires decades of experimental/theoretical work ahead
- HI physics is still in its infancy. RHIC and LHC have left many questions and guidance for the next steps in the formulation of a standard model of multi-particle and hot QCD
- A fixed target in EIC could provide a broader QCD phase space coverage exploring broad rapidity ranges. High potential for critical point searches and reproduce astrophysical conditions such as neutron star mergers.
- High luminosity of fixed target mode enables the use of hard probes at low energies
- A forward/backward detector 2 configuration would be the ideal configuration to explore fixed target in EIC and opens the possibility to extend the spin physics with a polarized target

# BACKUP SLIDES

# QCD phase space exploration.



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