



Kandinsky

Fixed-Target Initiative at the EIC (FIXE)

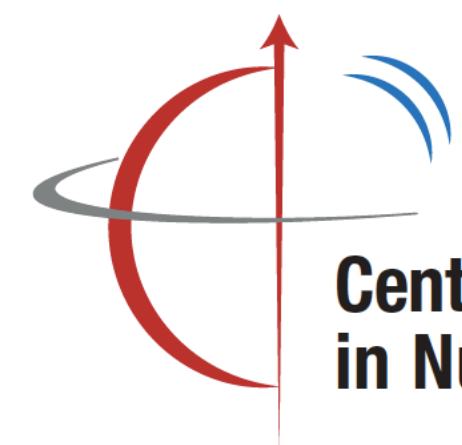
Charles Joseph Naim

In collaboration with A. Sorensen (Michigan State University), D. Brown (Brookhaven National Laboratory), D. Cebra (UC Davis), R. Corliss (Stony Brook University), M. Durham (Los Alamos National Laboratory), R. Vogt (UC Davis & Lawrence Livermore National Laboratory)

2026 RHIC/AGS Annual Users' Meeting



Stony Brook
University



Center for Frontiers
in Nuclear Science

Objectives

- Establishing the Physics Case (**why?**)
- Sharing and Discussing This Opportunity (**how?**)
- Building a Community (**who?**)



CFNS Workshop

September 2025

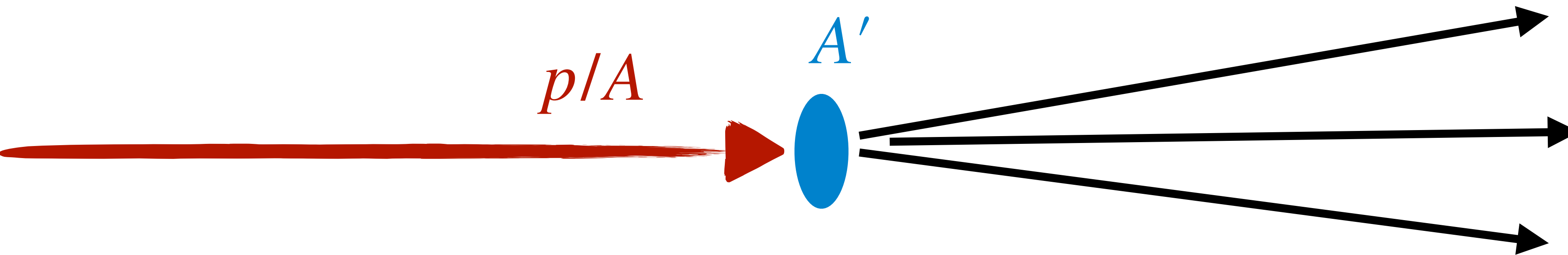


White Paper

February 2026



A Fixed-Target Program



$$\gamma_{cm} \simeq \sqrt{\frac{E_{beam}}{2m_p}}$$

Boost in the forward direction

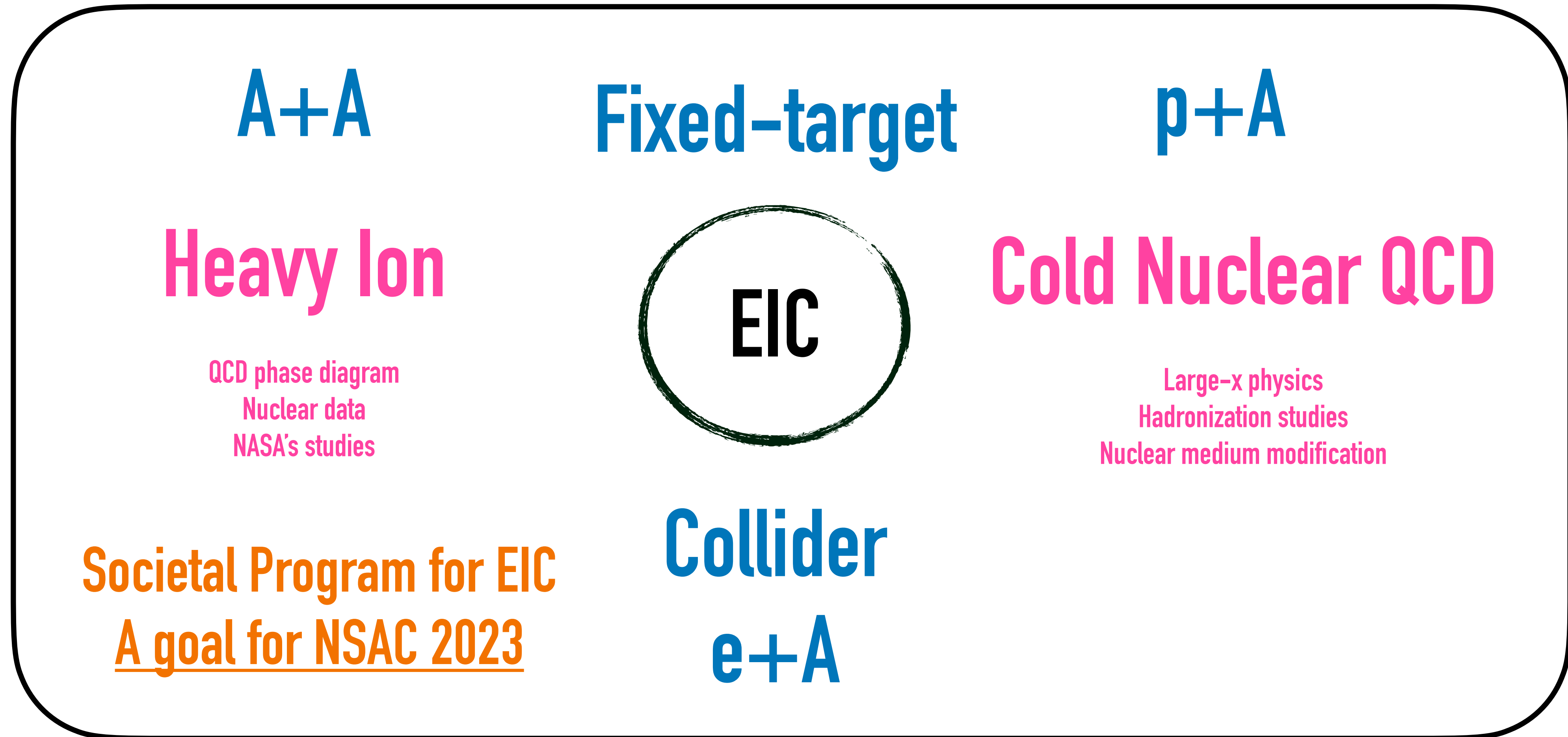
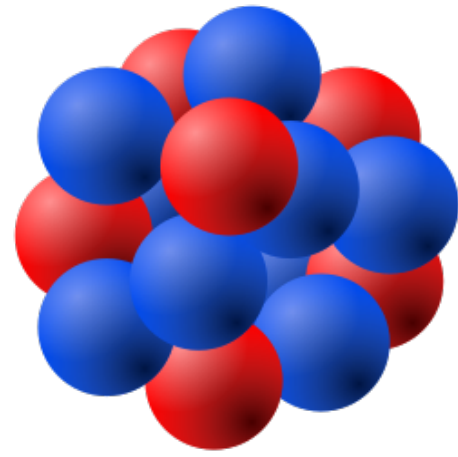
Access to large η

Access to small p_{\perp}

- Unique opportunities to have **p+A** and **A+A** collisions **at the same place**
- **Access to large rapidity** (large Bjorken- x of the beam)
- Enable new studies with light ion D-He (**polarized**) + A (**unpolarized**) collisions

Atoian et al [2510.10794](https://arxiv.org/abs/2510.10794)

The EIC as a Cornerstone Facility



TODAY

QCD Phase Transition

*Mikhail Stephanov
(University of Illinois)*

*Lipei Du
(McGill University)*

Nuclear Data

*David Brown
(BNL)*

Cosmic Rays

*Philip von Doetinchem
(University of Hawaii)*



Cold Nuclear Matter

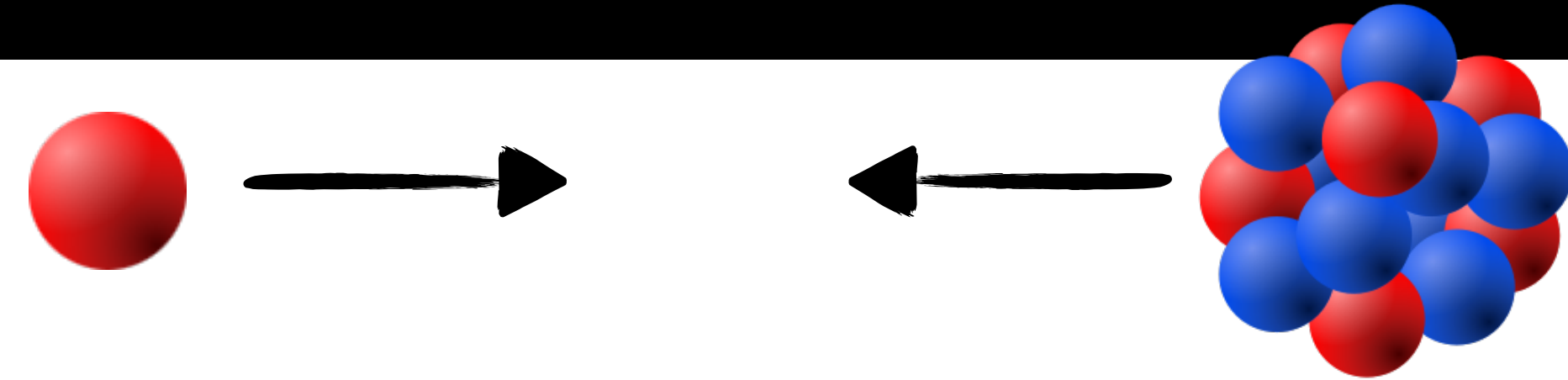
*Ramona Vogt
(LLNL, UC Davis)*

*Cesar da Silva
(LANL)*

Lessons Learned from the STAR FXT

*Daniel Cebra
(UC Davis)*

Cold Nuclear Matter Effects



Initial-state effects

Final-state effects

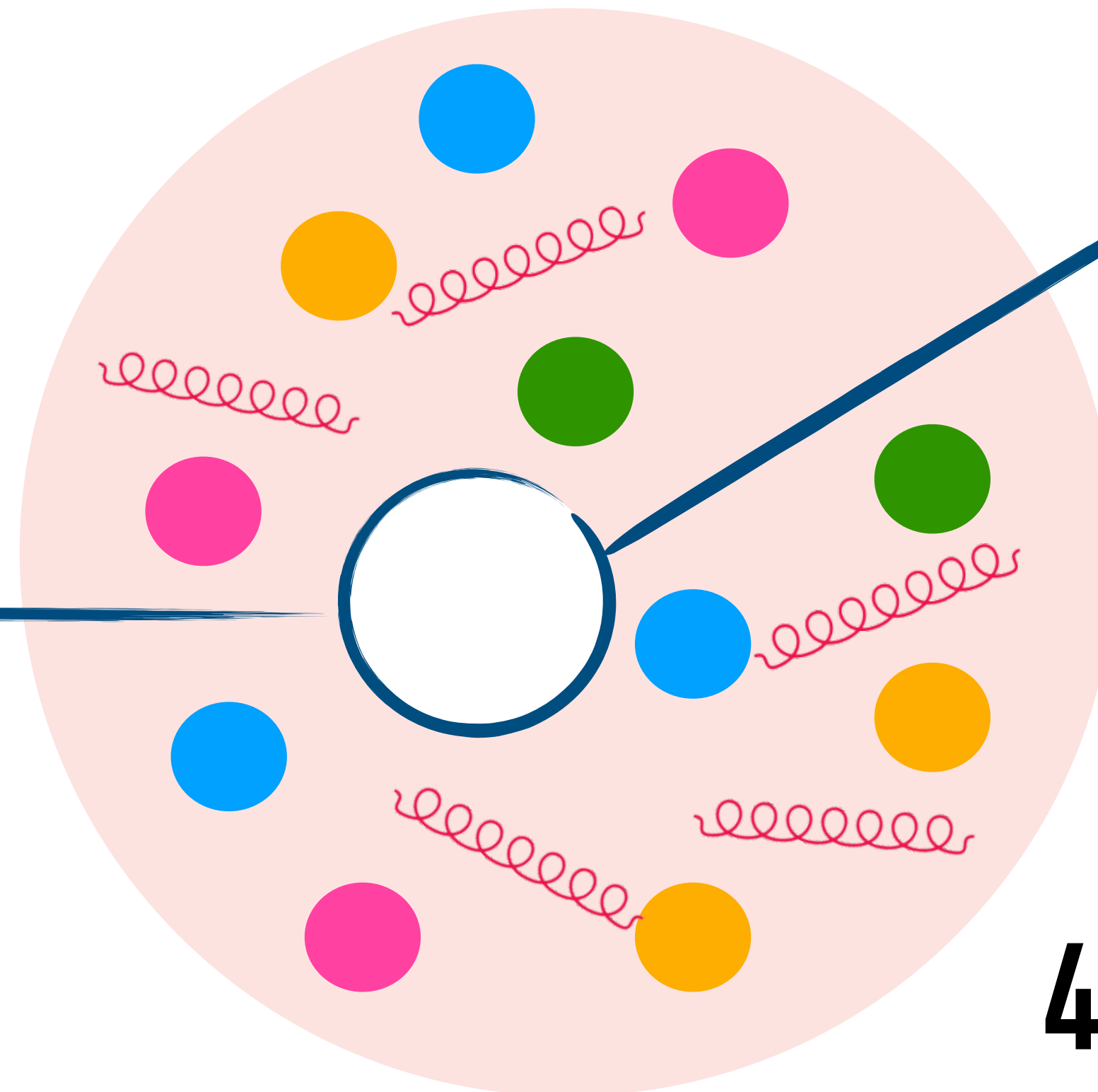
Leading-twist nPDF

Impact parameter dependence of nPDF

Saturation

Intrinsic charm

QCD radiative energy loss



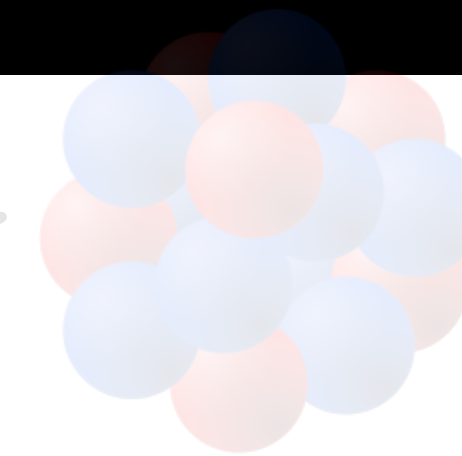
Nuclear absorption

Comovers

QCD radiative energy loss

**40 years of puzzle!
from the SPS to the LHC**

Unraveling the Puzzle: towards a coherent picture



Initial-state effects

Final-state effects

First Perspective article accepted in Physical Review C

Leading-twist nPD

Nuclear Cold QCD: Review and Future Strategy

repton

Impact parameter

F. Arleo,¹ P. Caucal,¹ A. Deshpande,^{2,3} J. M. Durham,⁴ G. M. Innocenti,⁵ J. Jalilian-Marian,^{6,7} A. Kusina,⁸ M. X. Liu,⁴ Y. Mehtar-Tani,³ C.-J. Naïm,^{2,*} H. Paukkunen,^{9,10} S. Platchkov,¹¹ F. Salazar,^{3,12,13} I. Vitev,¹⁴ and R. Vogt^{15,16}

Saturation

F. Arleo et al. [2506.17454](#)

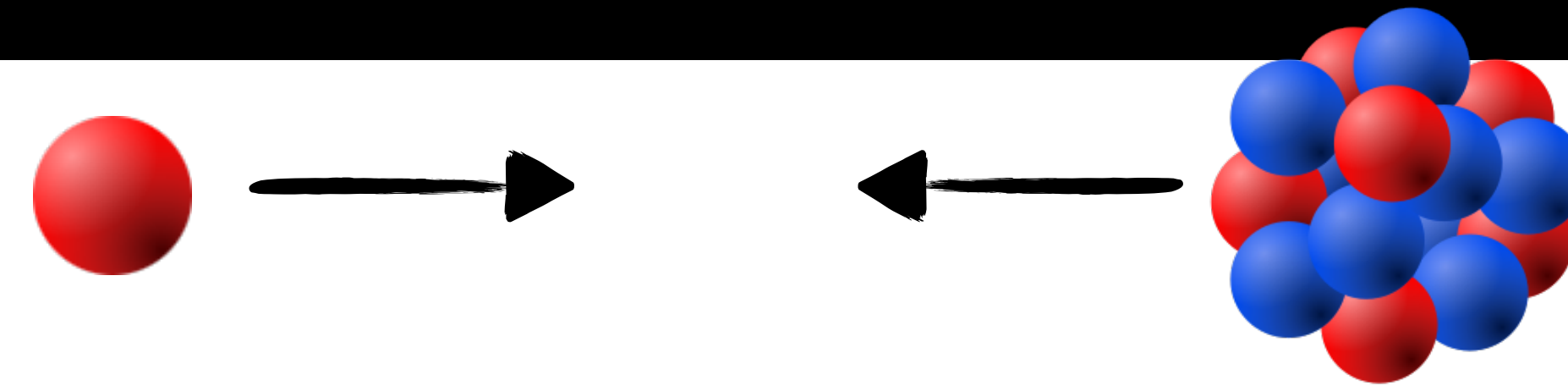
QCD radiative energy loss

Intrinsic charm

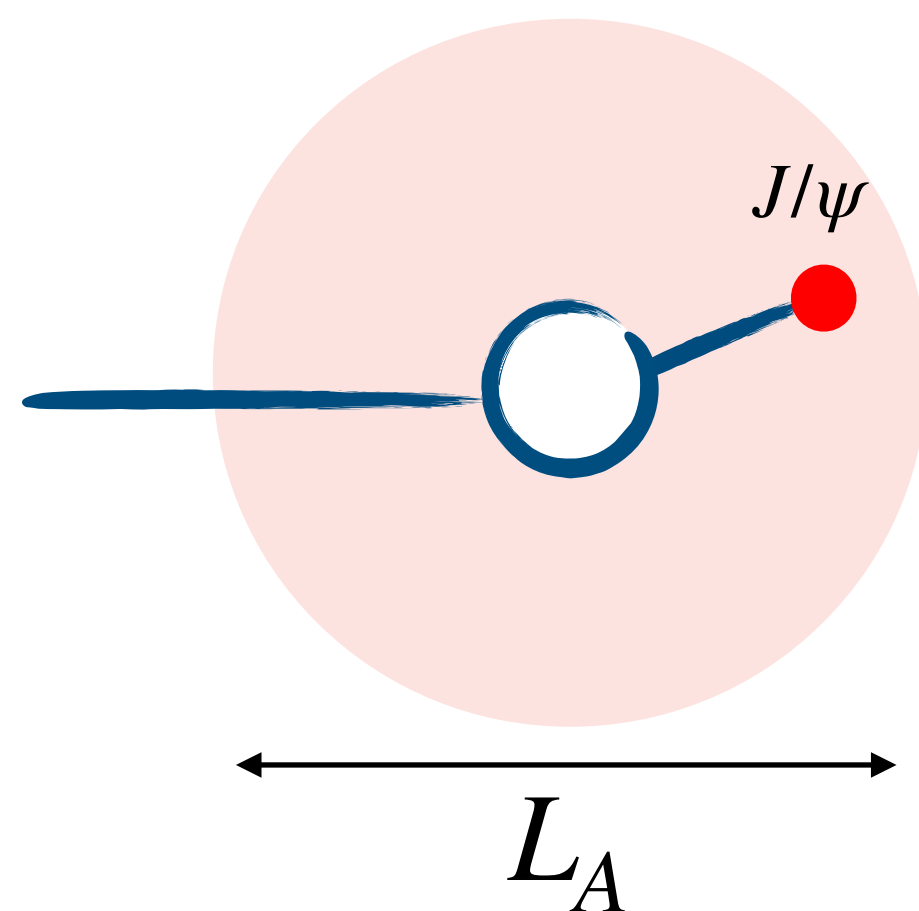
QCD radiative energy loss

40 years of puzzle!
from the SPS to the LHC

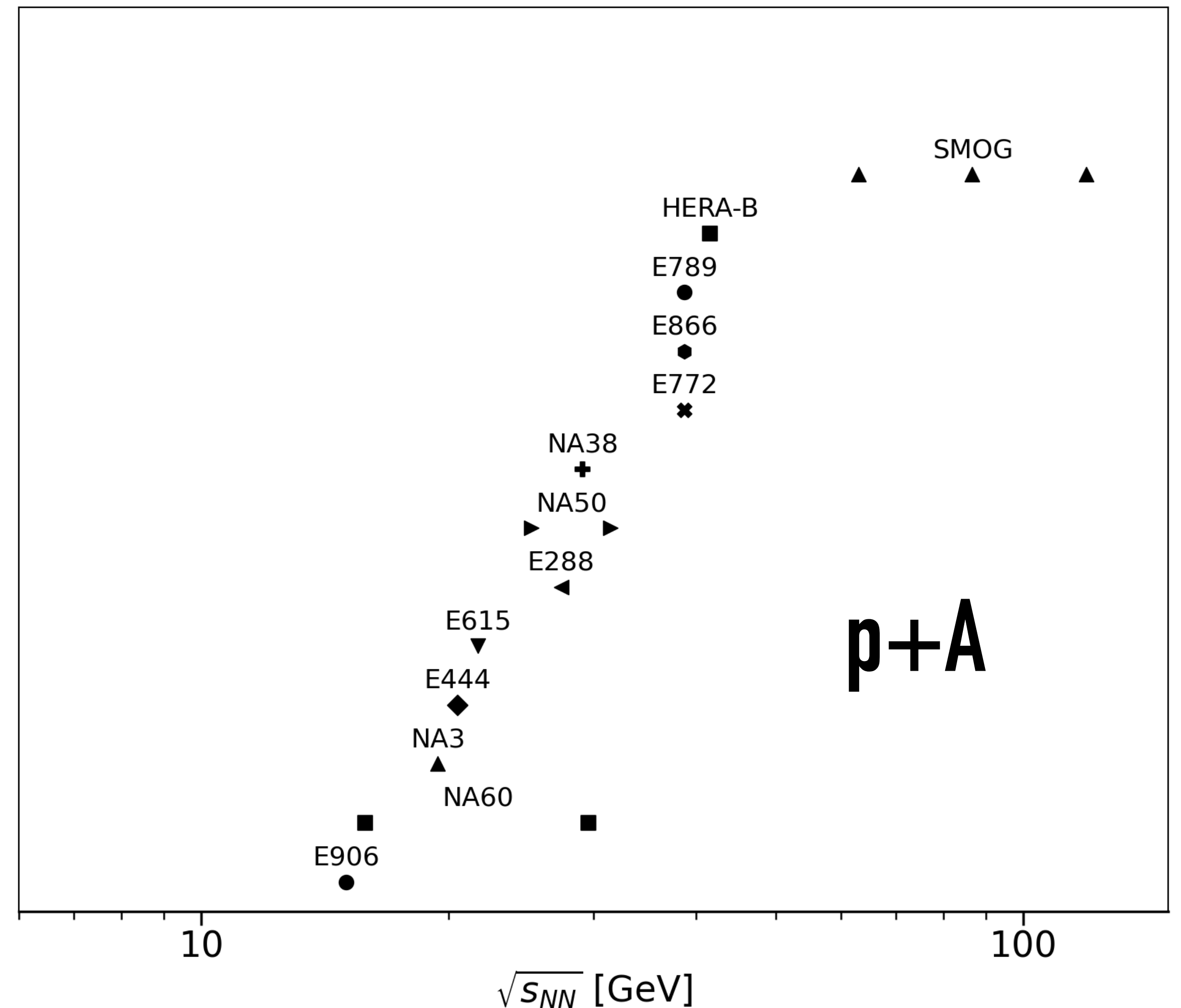
Proton-Nucleus Collisions



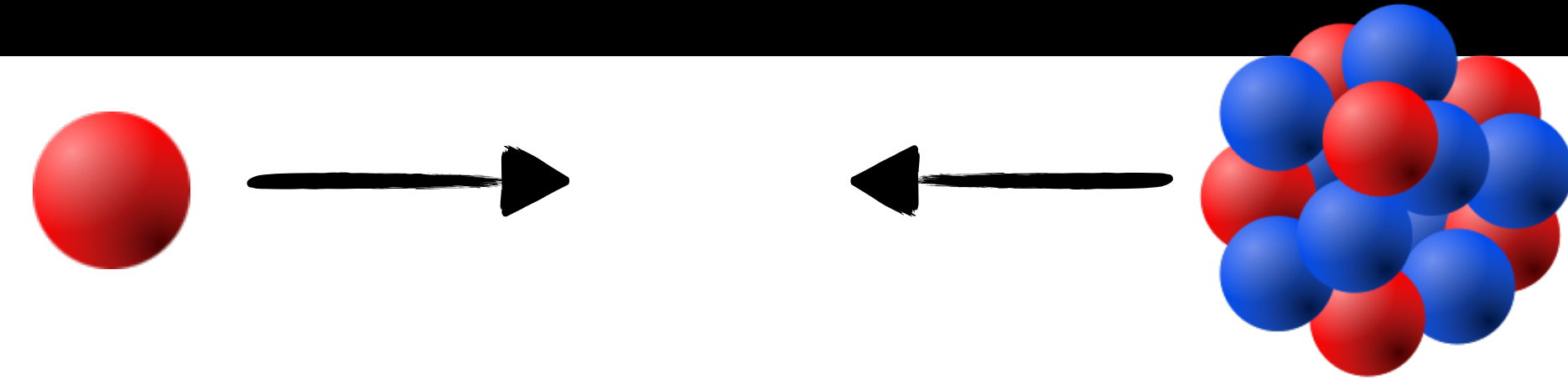
- SPS energies ($\sqrt{s} \sim 15\text{--}38$ GeV):
→ Quarkonia & Drell-Yan
- Coherence length $l_{coh} \lesssim$ nuclear size



Strong CNM effects expected



Proton-Nucleus Collisions



- Constrain CNM effects using low energy data is critical

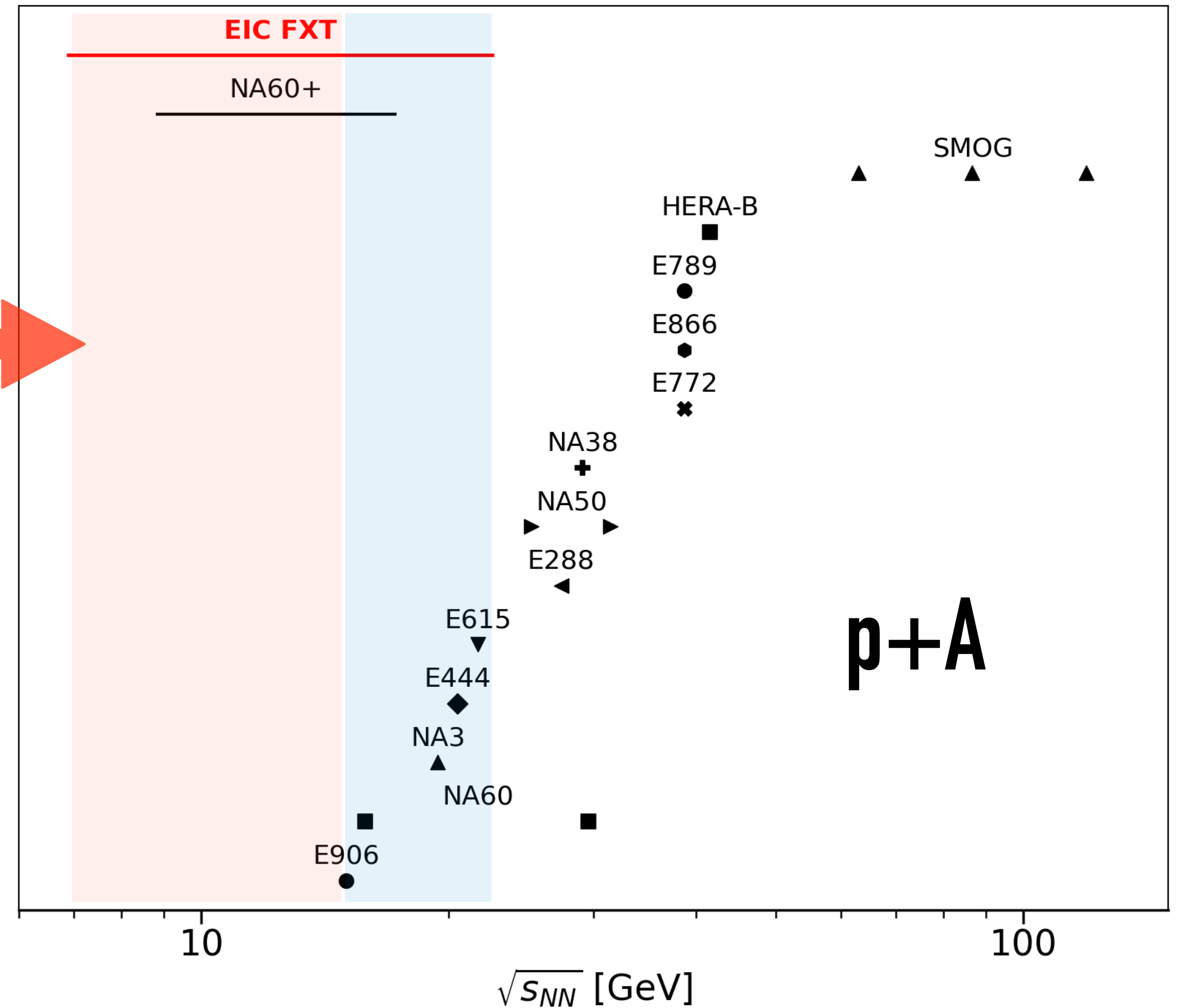
- **No data available**



EIC Fixed-target energy range

$$6.8 \lesssim \sqrt{s} \lesssim 22.7 \text{ GeV}$$

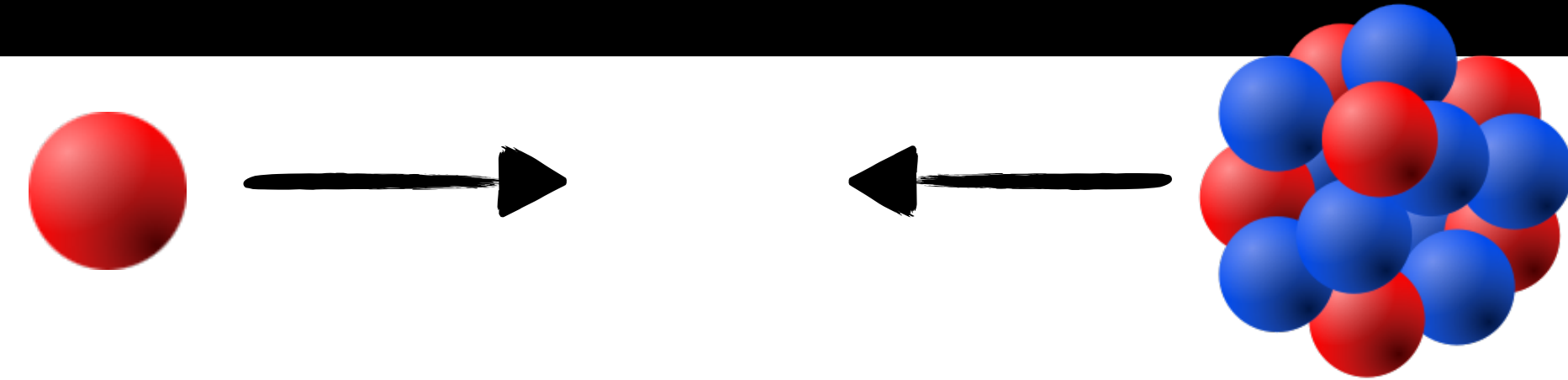
Beam energy scan



p+A

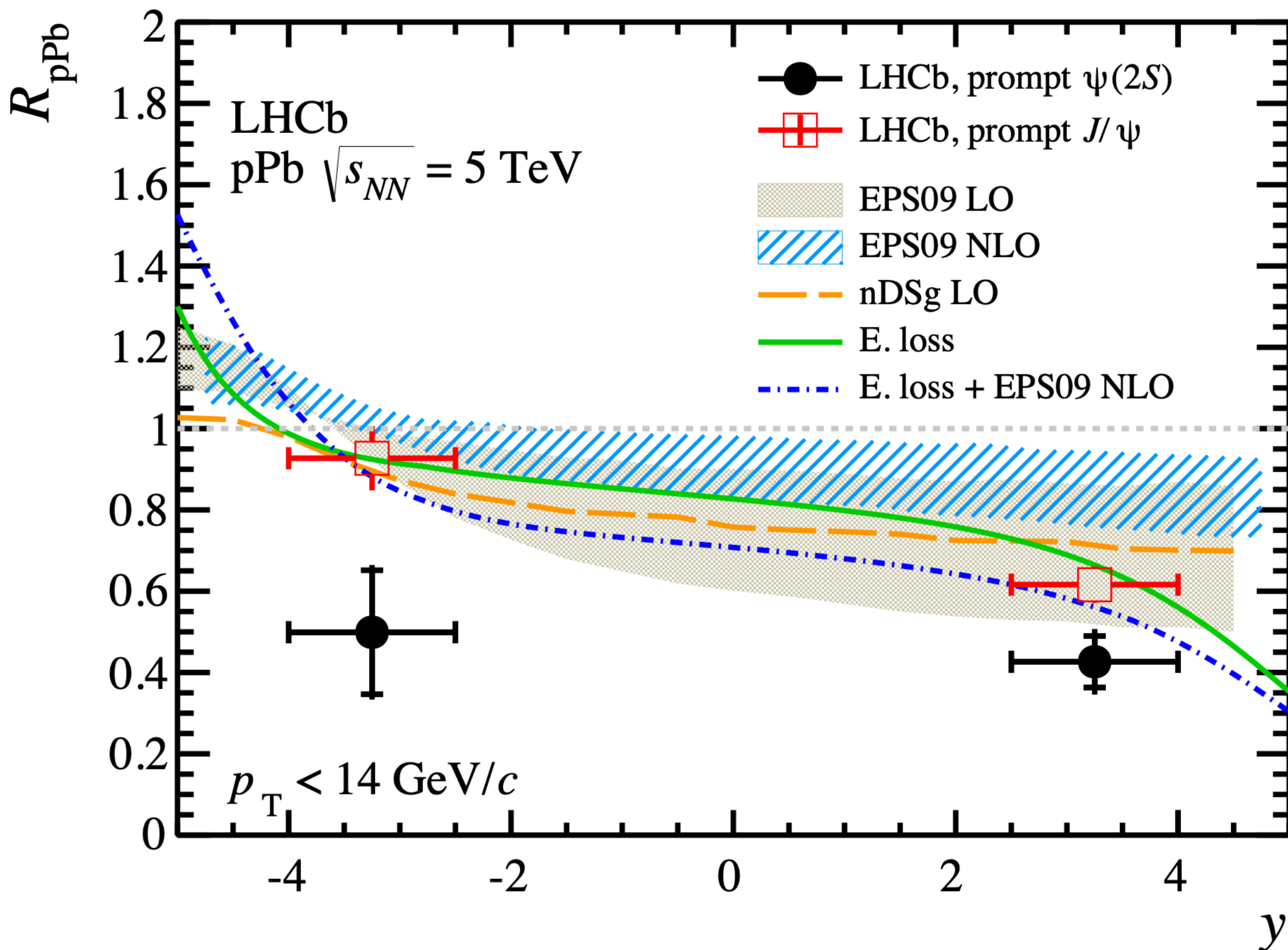
CNM vs hot QCD at LHC

Quarkonia excited states



LHCb [1601.07878](#)

J/ψ vs. ψ'



- CNM struggles to explain the suppression of excited states
- Recent studies suggest the presence of QGP effects

Strickland et al. [2401.16704](#)

Du Rapp [1808.10014](#)

p+A data at LHC:

not a clean baseline for CNM studies?

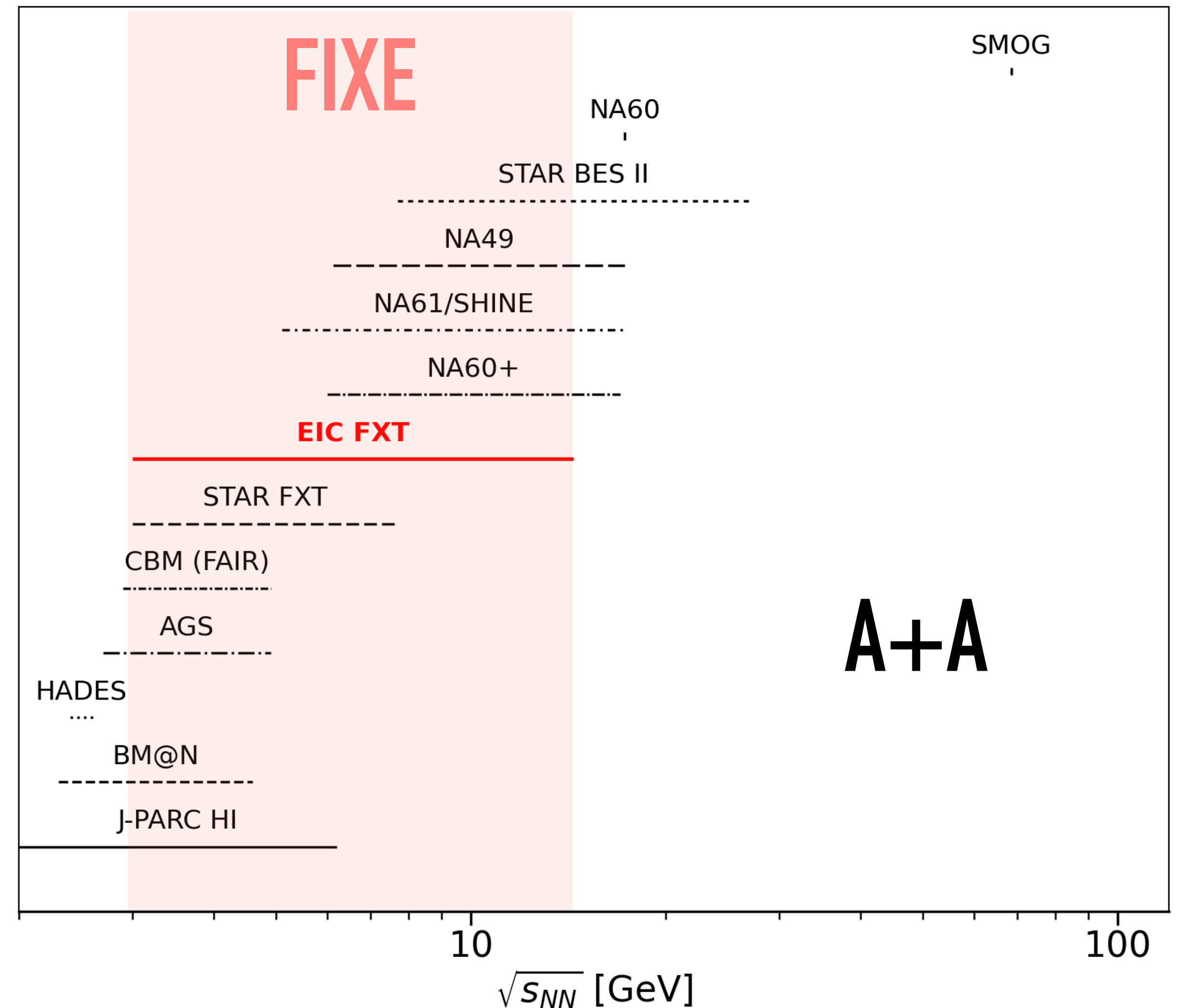
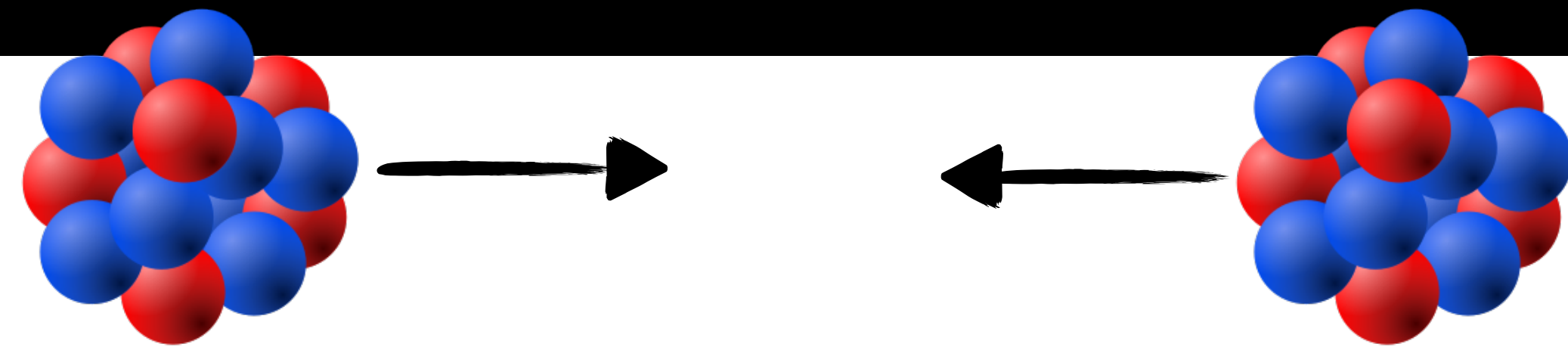
Nucleus-Nucleus Collisions

- Onset of QGP Formation
- **Simultaneous** **p+A / A+A measurements**
- Unique exploration of A(**polarized**)-A(**unpolarized**) collisions

EIC Fixed-Target energy range

$$3.0 \lesssim \sqrt{s} \lesssim 14.4 \text{ GeV}$$

Beam energy scan



Disentangling **Cold** Nuclear Matter from **Hot** QCD

- **Pb+Pb @ LHC:** R_{AA} established, but CNM effects contaminate the signal specially at small p_{\perp}
- **Small systems (p+Pb, O+O) @ LHC:** CNM effects large & poorly constrained, mimic QGP signatures
- **Crisis:** collective flow & strangeness seen even in p+Pb → **p+A no longer a clean CNM reference**

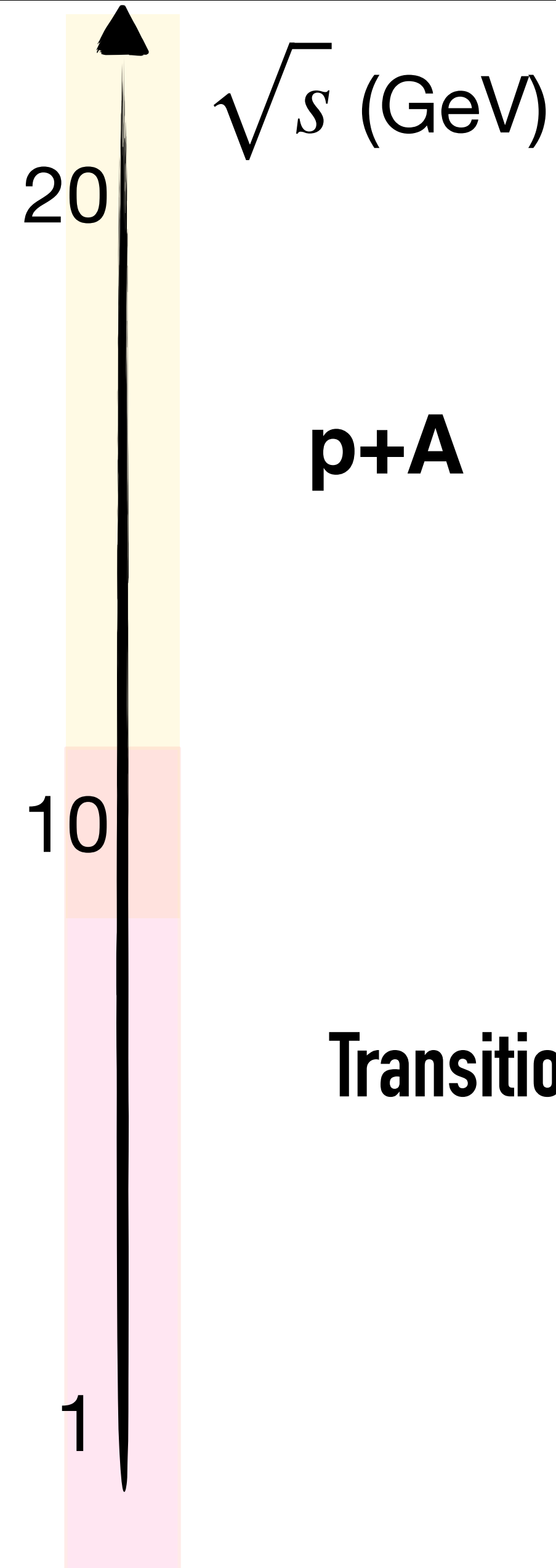
Andronic Araldi [2501.08290](#)

Jonas et al. [2602.15928](#)

Fixed-Target p+A & A+A at $\sqrt{s} \sim 10\text{--}20$ GeV

- **Unambiguous CNM baselines:** clean p+A reference below QGP threshold, no collectivity ambiguity
- **QCD phase transition:** scanning the hadronic-to-partonic crossover, mapping the onset of QGP
- **Universality test:** cross-check CNM suppression between e+A (EIC collider) and p+A (fixed-target) at overlapping kinematics, bridging the two QCD frontiers

QCD Effects by System



A+A

p+A

Cold Nuclear Matter vs Hot QCD

QCD phase transition study

$$\sqrt{s_{NN}} \sim 4 - 8 \text{ GeV}$$

→ ideal for critical-point searches

Hippert et al. [2309.00579](#)

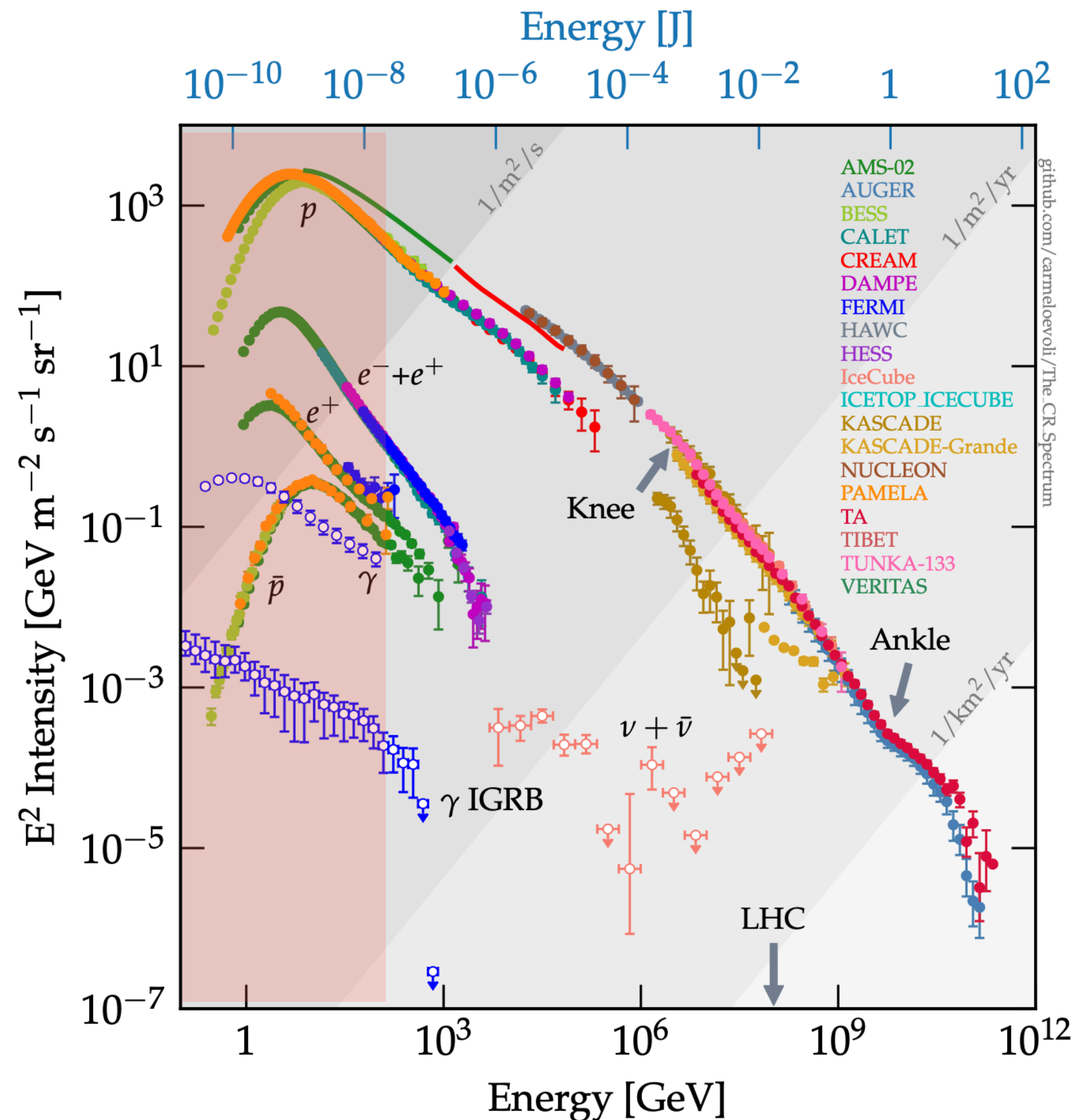
Shah et al. [2410.16206](#)

Transition from Hadronic to Partonic Description

$$Q^2 \lesssim 1 \text{ GeV}^2$$

Nuclear Data

Maurin et al. [2503.16173](#)



Cosmic rays: charged particles from space, dominated by protons and helium (9%)

~ 1 Sv total dose over a 3-year Mars mission

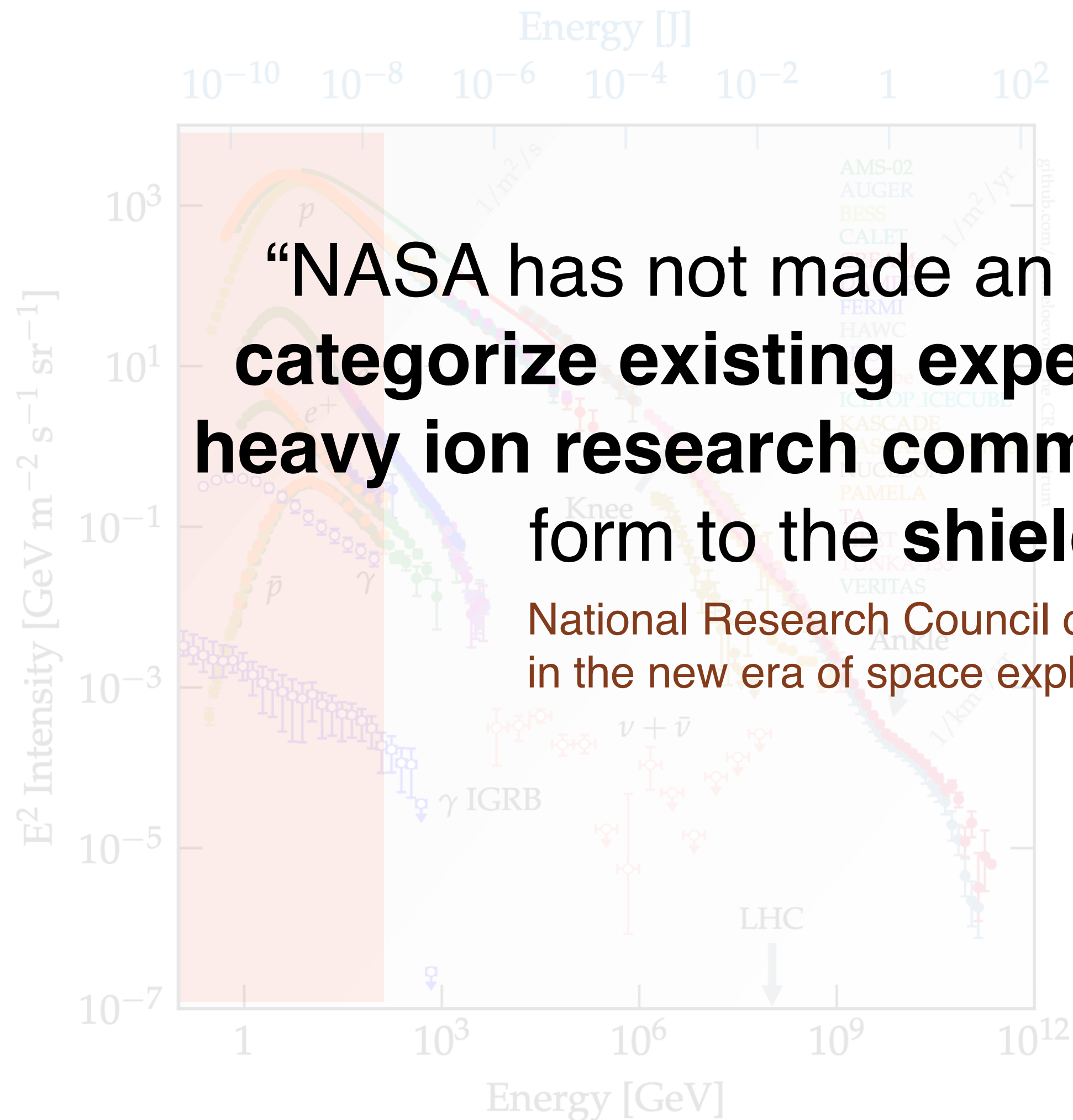
Nuclear data are critical for shielding studies

- **Structural materials:** Fe, Ni, Cr, Al
- **Electronics:** Si, Ge, Ga, N
- **Human body:** C, O, N, Ca

Critical for future space missions to the Moon and Mars

Nuclear Data

Maurin et al. [2503.16173](#)



“NASA has not made an adequate effort to collect, catalogue and categorize existing experimental data obtained by the worldwide heavy ion research community and make it available in appropriate form to the shielding engineering community.”

National Research Council of the National Academy of Sciences, Managing space radiation risk in the new era of space exploration, The National Academies Press, Washington D.C. (2008).

Cosmic rays: charged particles from space, dominated by protons and helium (9%)

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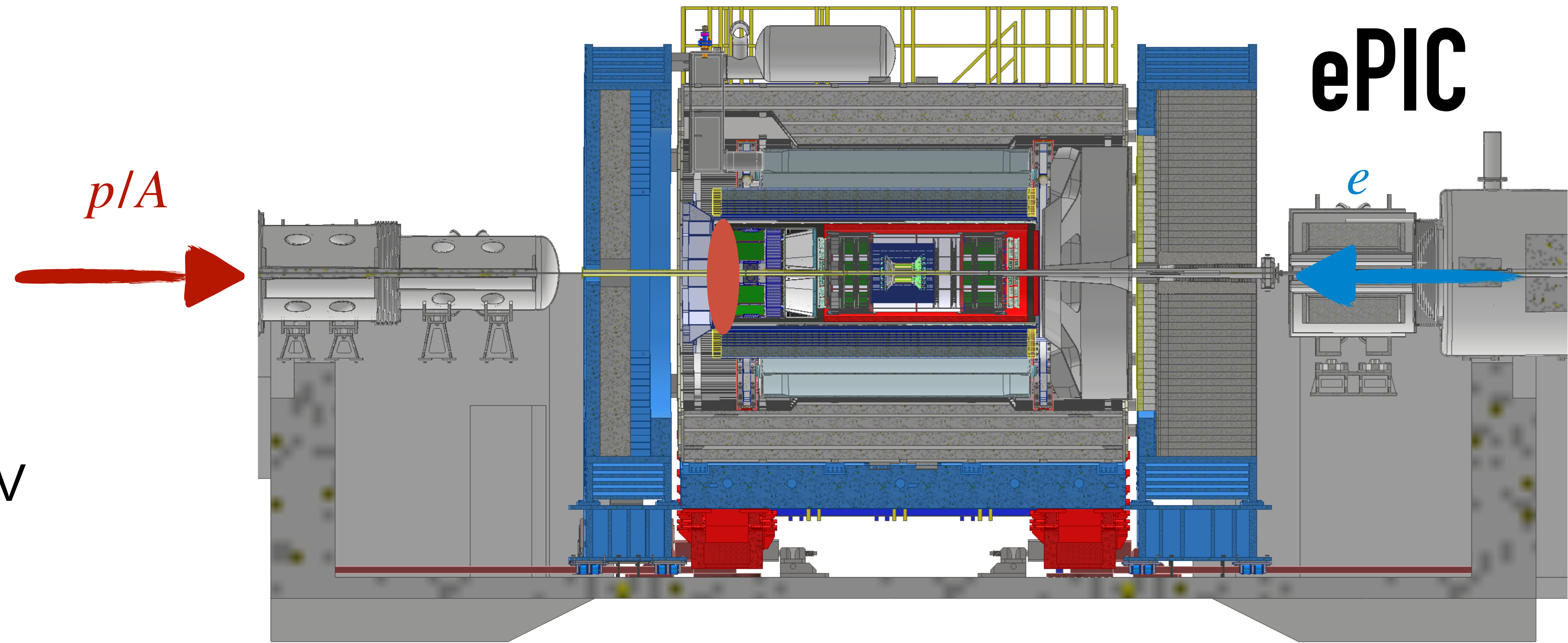
- Structural materials: Fe, Ni, Cr, Al
- Electronics: Si, Ge, Ga, N
- Human body: C, O, N, Ca

Critical for future space missions to the Moon and Mars

ePIC Detector

Polarized p:
 $E = 26 \text{ to } 275 \text{ GeV}$

Polarized D-He, A:
 $E = \text{a few GeV to } 110 \text{ GeV}$



- **Target position:** Impact the geometry acceptance
- **Type of Target? (not enough place for polarized target)**
 - Solid, high luminosity, heavy nuclei
 - Gaz, lower luminosity, light nuclei

The cost is minimal

A Foil Target: Pioneered by STAR Experiment

The success of the beam pipe studies motivated installing an internal gold target

Target design:

Gold foil

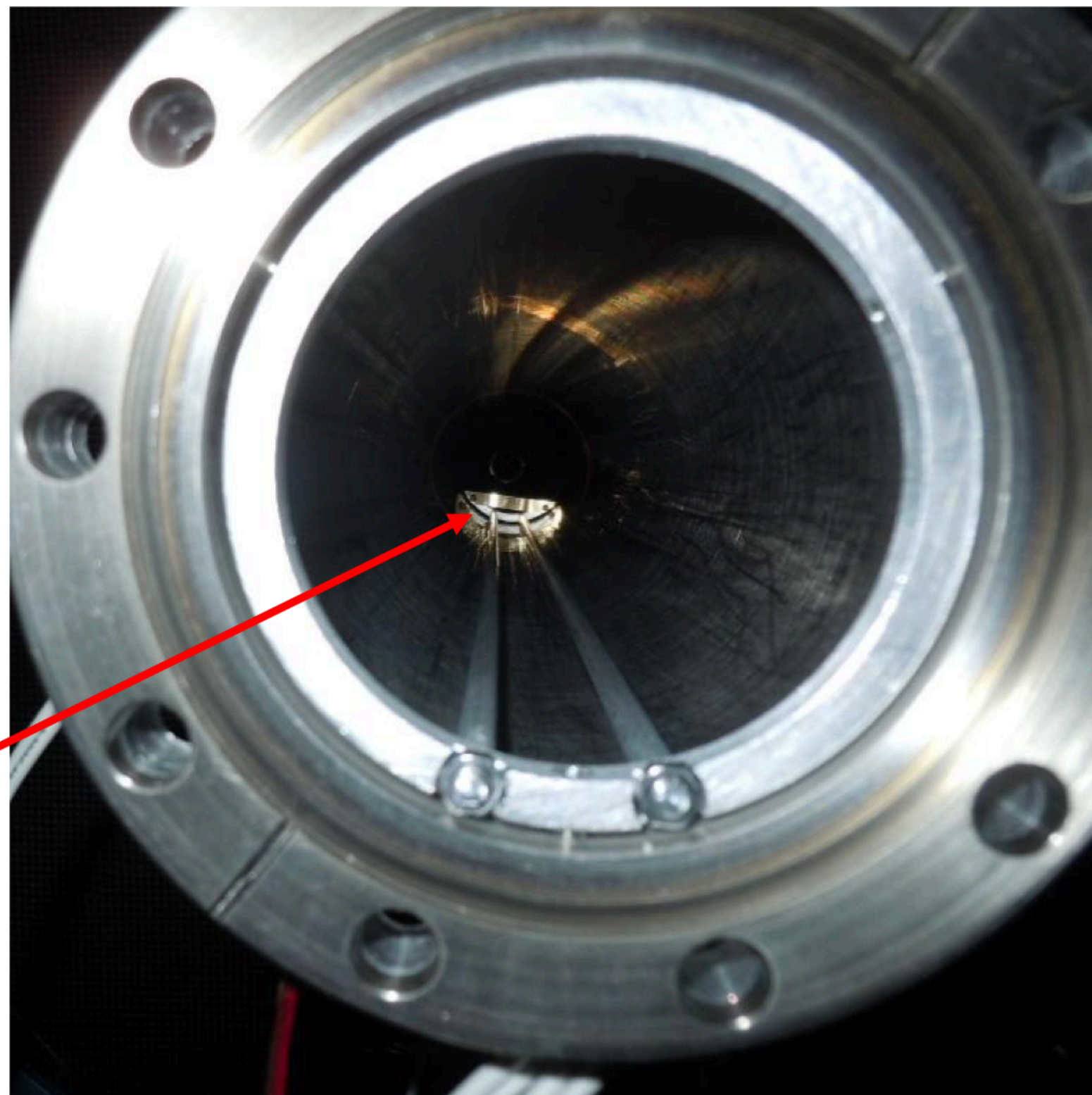
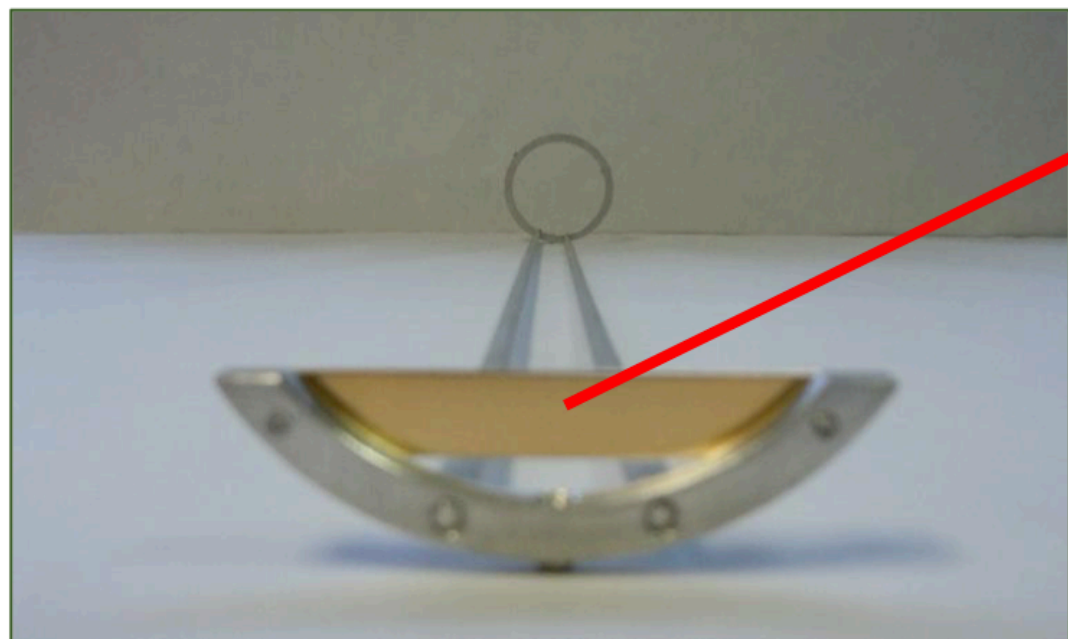
1 mm Thick (4%)

~1 cm High

~4 cm Wide

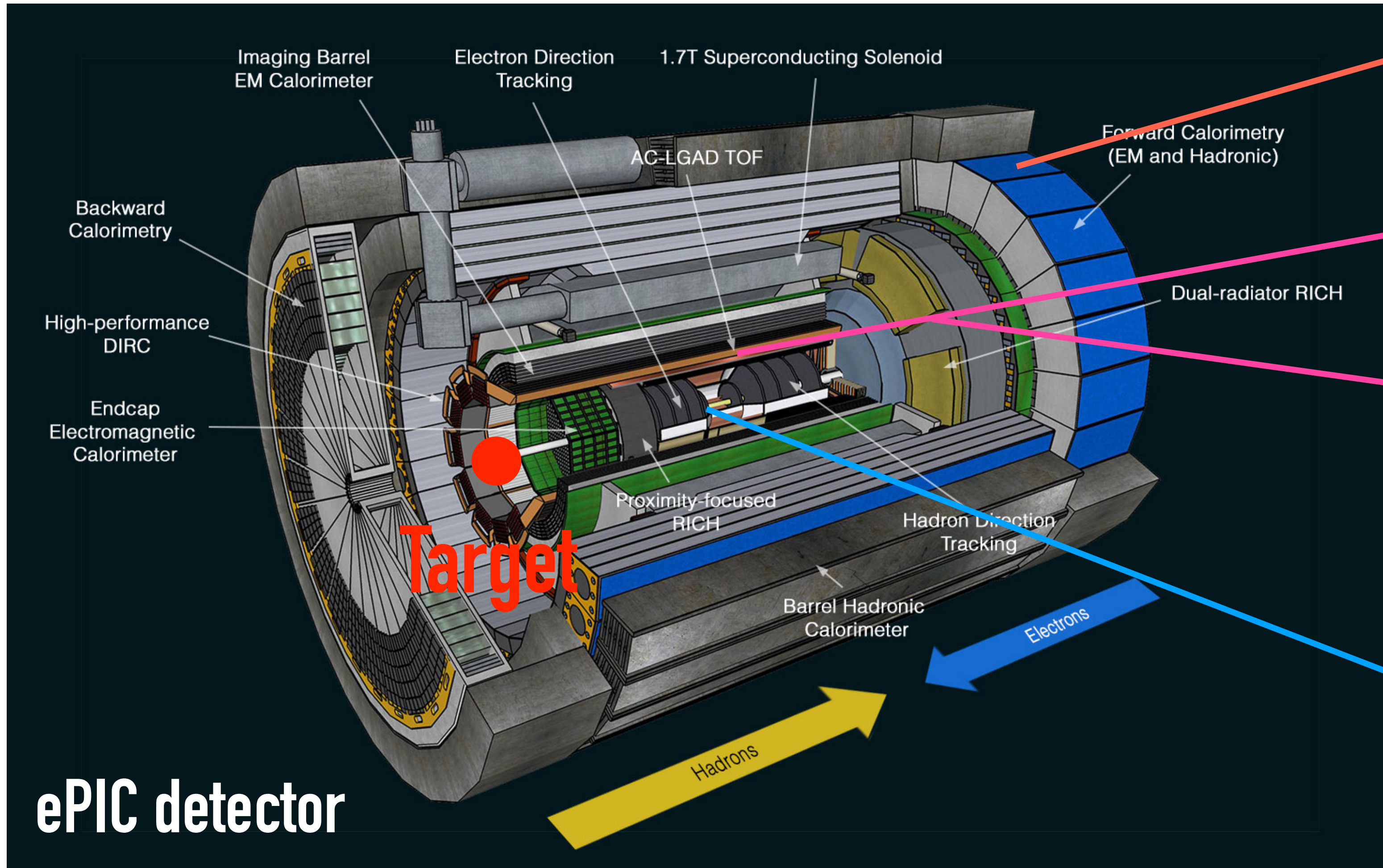
~2 cm below beam axis

210 cm from IR



RHIC beam halo steered into Au foil
→ fixed-target Au+Au collisions

What we need?



Muon Identification
Forward EMCal

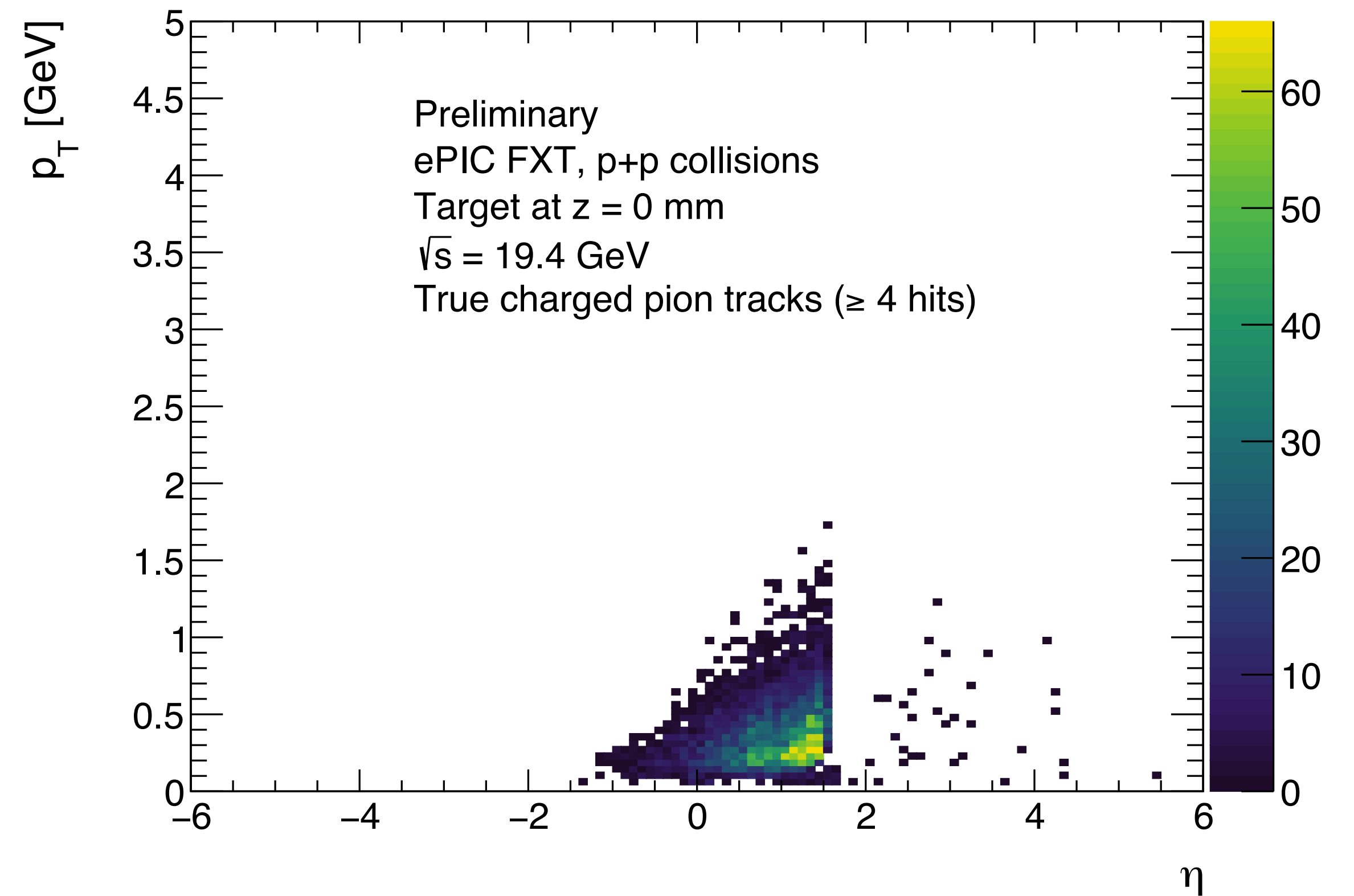
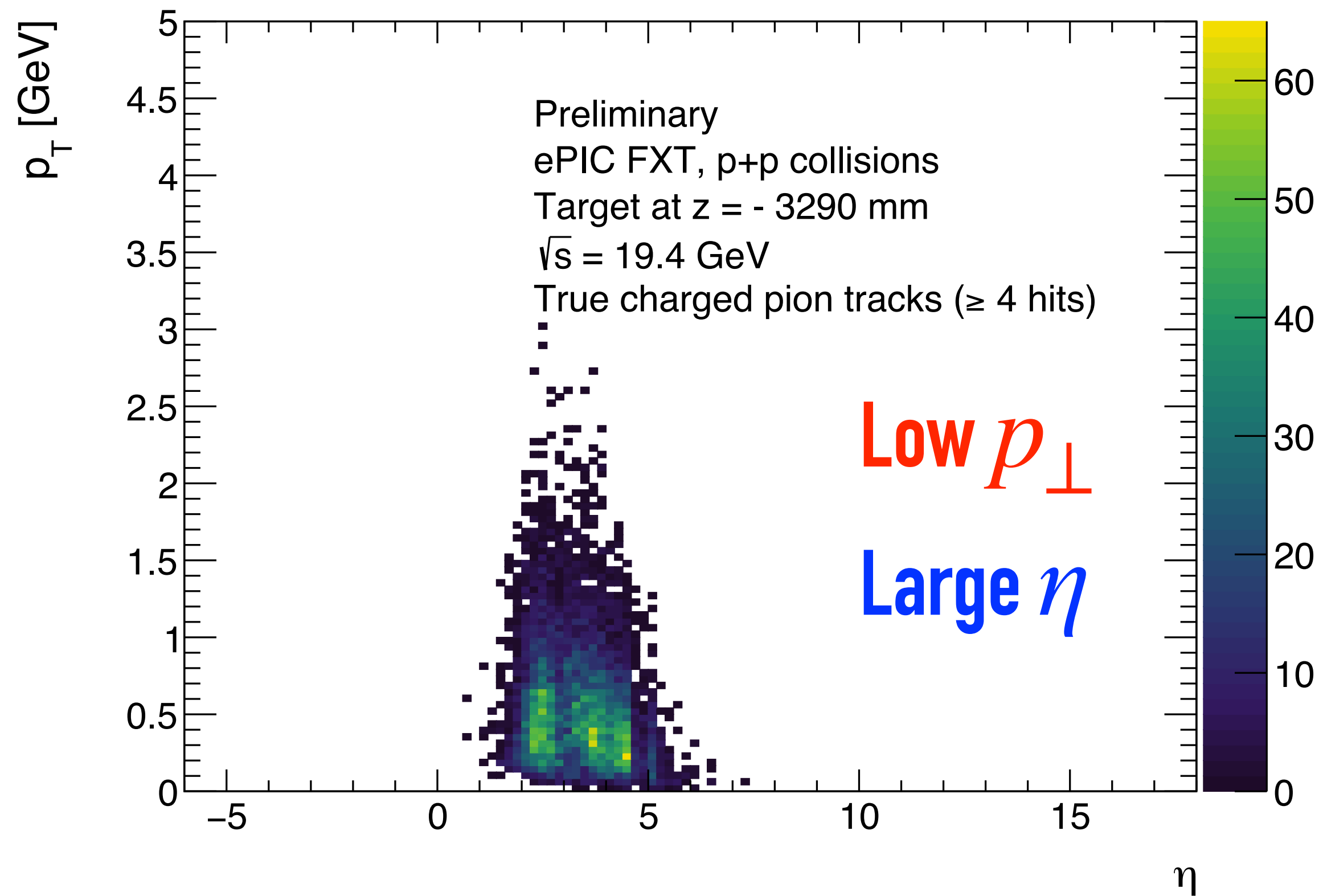
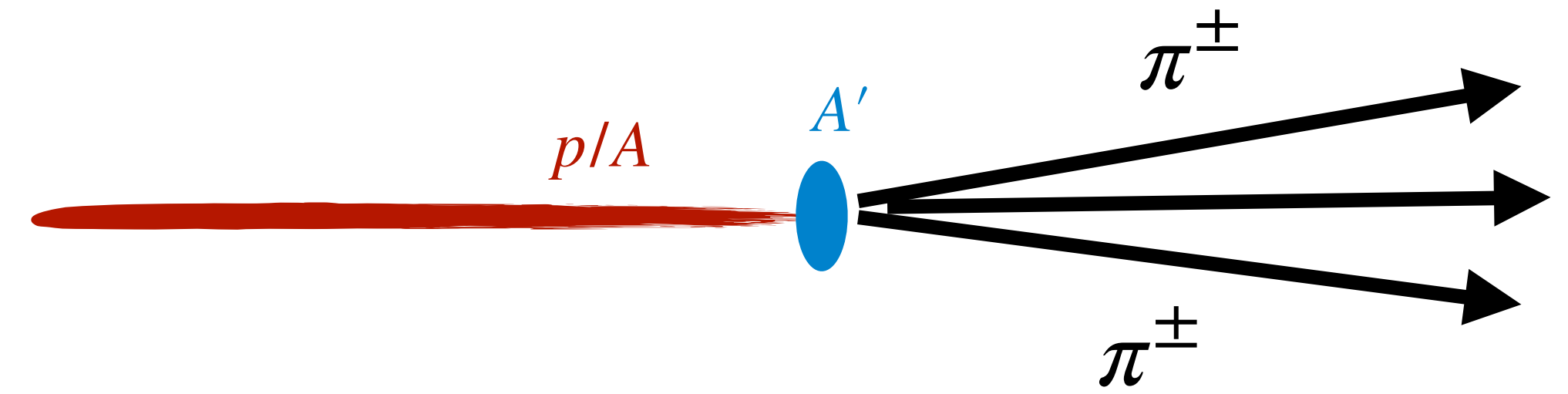
Particle Identification
Time of Flight
small momentum $\lesssim 2$ GeV
dRICH:
large moment up to 50 GeV

Tracking System:
Micro-Pattern Gaseous
High-resolution silicon

Kinematic Phase Space

Charged-pion production in p+p (FXT) collisions

Condition: at least 4 hits in the tracking system

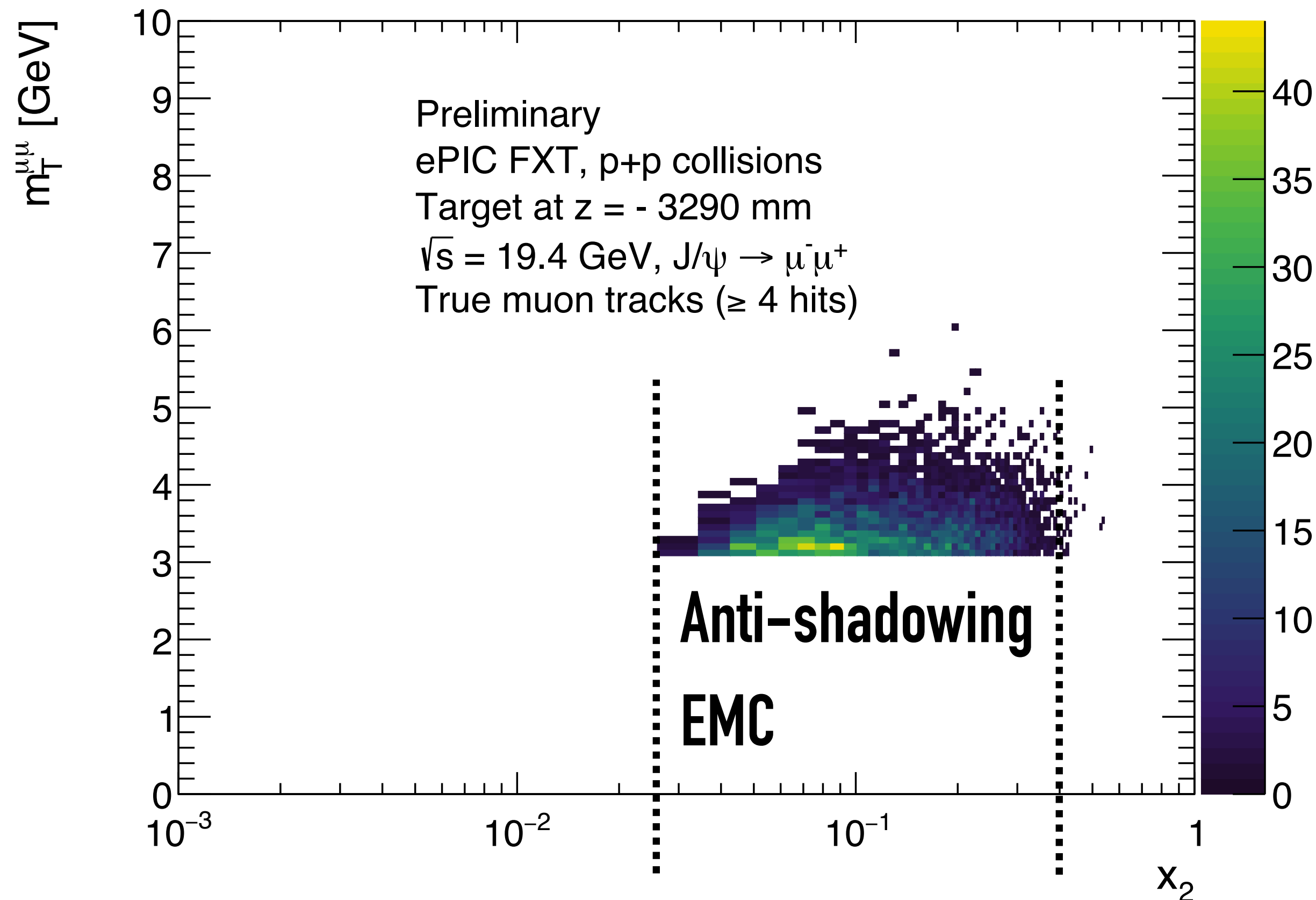
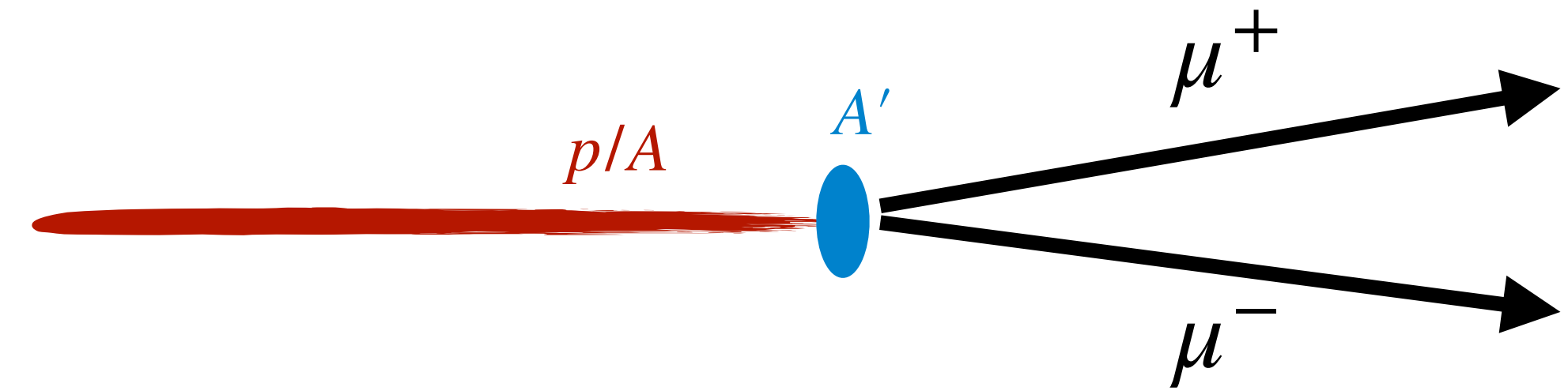


The geometry acceptance depends on the target position

Kinematic Phase Space

Dimuon (J/ψ) production in p+p (FXT) collisions

Condition: at least 4 hits in the tracking system



$$x_2 = \frac{m_{\perp}}{\sqrt{s}} e^{-y} \quad \text{Bjorken-}x \text{ of the target}$$

- Direct access to the large- x gluon density
- Access to gluon-TMD
- Excellent probe for CNM effects

**Beam Energy Scan
of Quarkonium Dynamics**

Maintaining US leadership in high-energy nuclear physics

- The US nuclear physics community achieved global leadership in high-temperature QCD through decades of RHIC research and groundbreaking results
- US expertise expanded via major contributions to the heavy-ion programs at the LHC (ALICE, ATLAS, CMS, LHCb)
- The LHC remains the only facility currently delivering heavy-ion collisions
- Incorporating a **fixed-target program at the EIC will allow the US to sustain and extend world leadership in high-density QCD well into the 2030s and beyond**

A unique opportunity for disentanglement of CNM and QGP contributions

QCD Phase Transition

**Nuclear Data
Cosmic Rays**

FIXE

Cold Nuclear Matter

**Three experiments
for the price of one**