



sPHENIX Highlights

JaeBeom Park (University of Colorado Boulder)
on behalf of the sPHENIX Collaboration

2025 RHIC/AGS Annual Users' Meeting

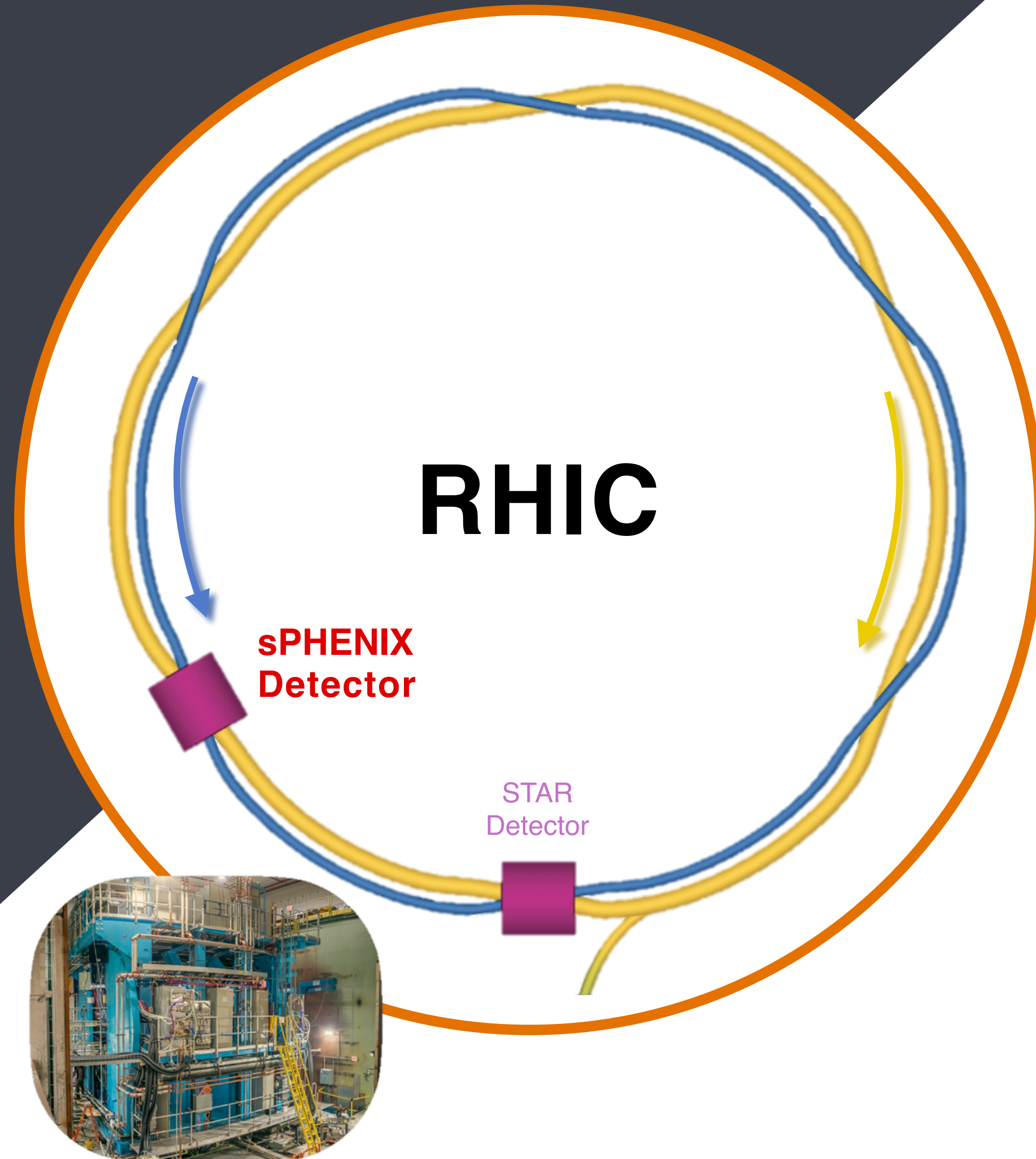
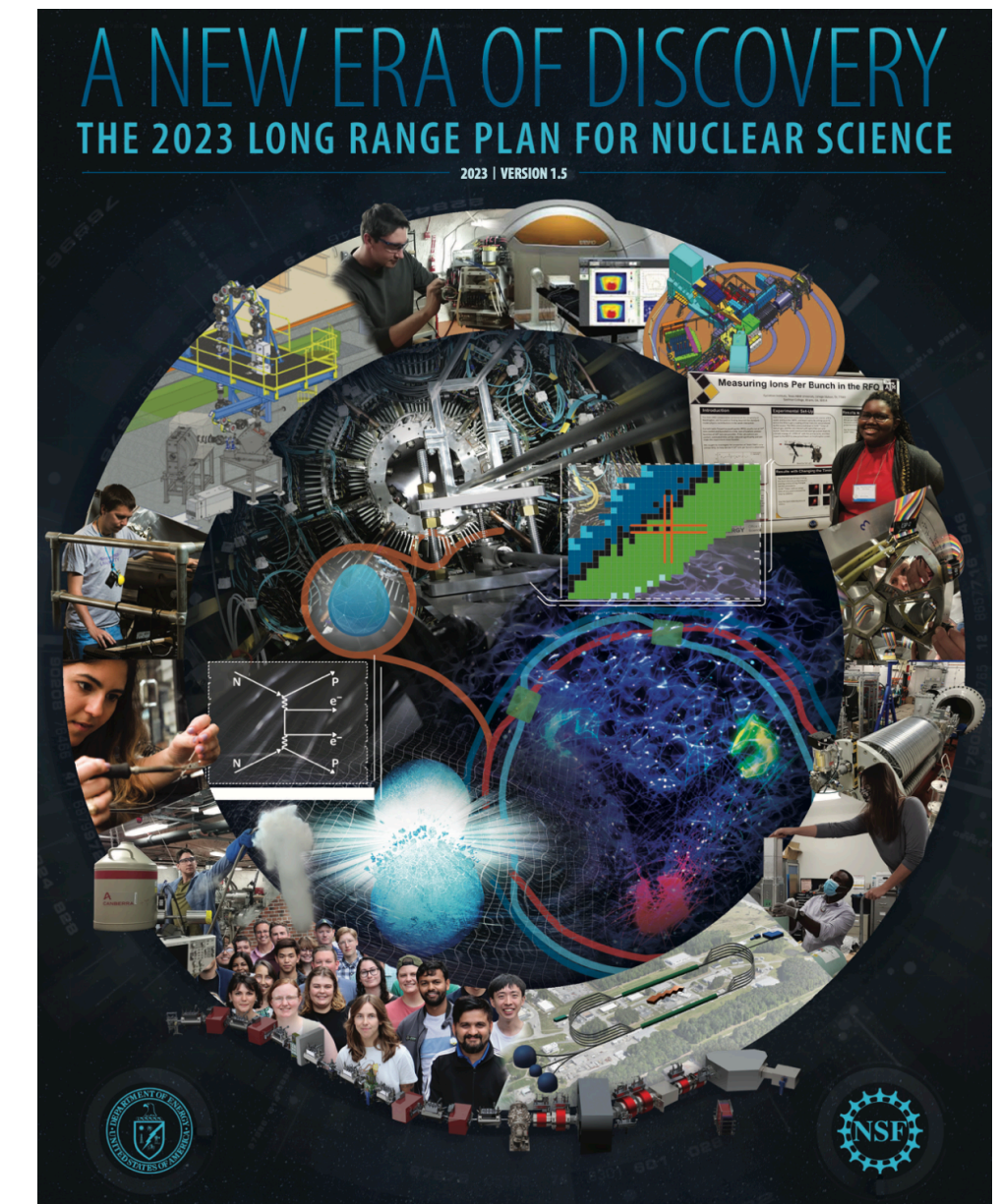
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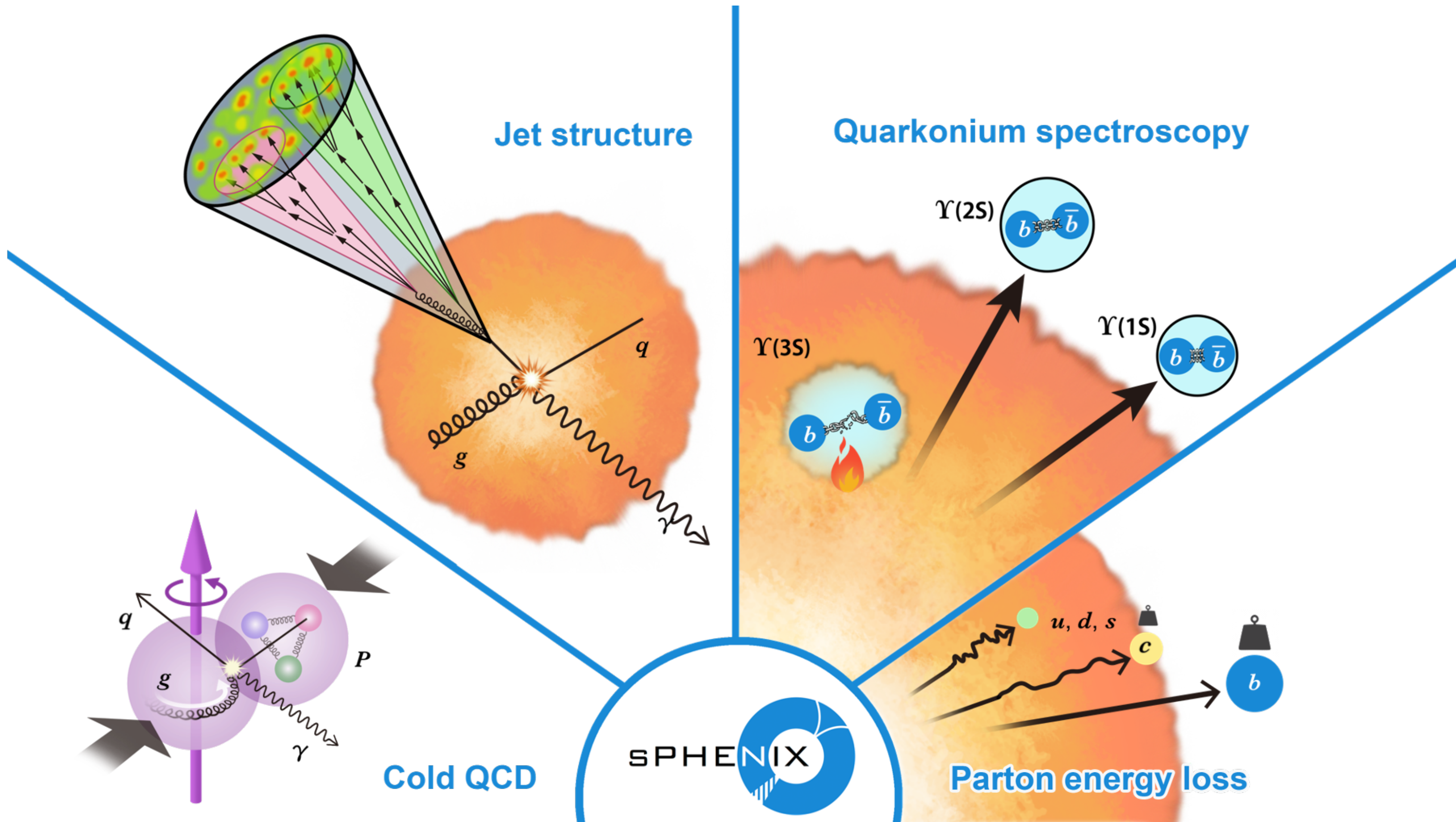


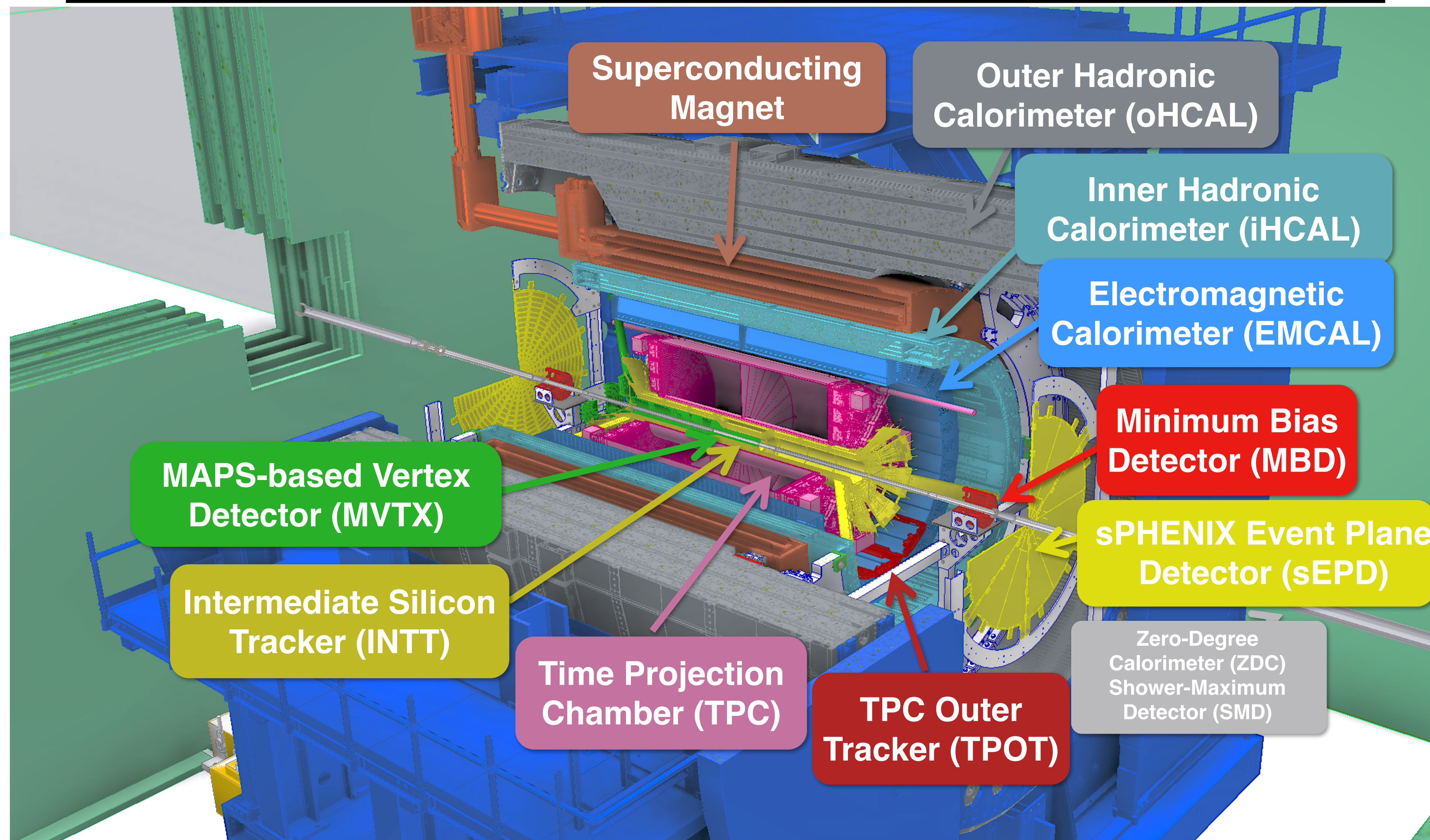
sPHENIX Science Mission

2023 Nuclear Physics Long Range Plan

To successfully conclude the RHIC science mission, it is essential to (1) **complete the sPHENIX science program as highlighted in the 2015 Long Range Plan**, (2) complete the concurrent STAR data collection with the forward upgrade, and (3) analyze the data from all RHIC experiments.

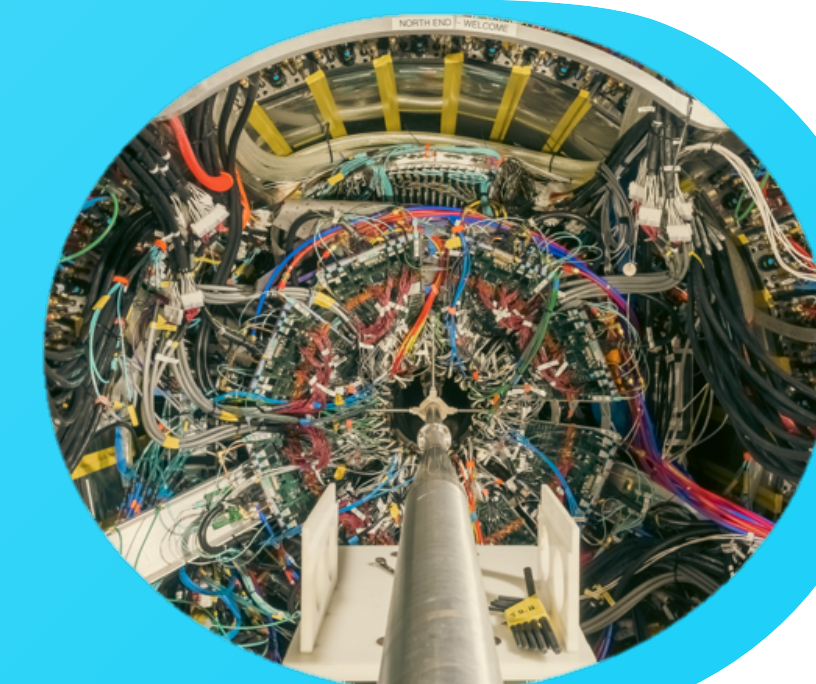






Excellent tracking system

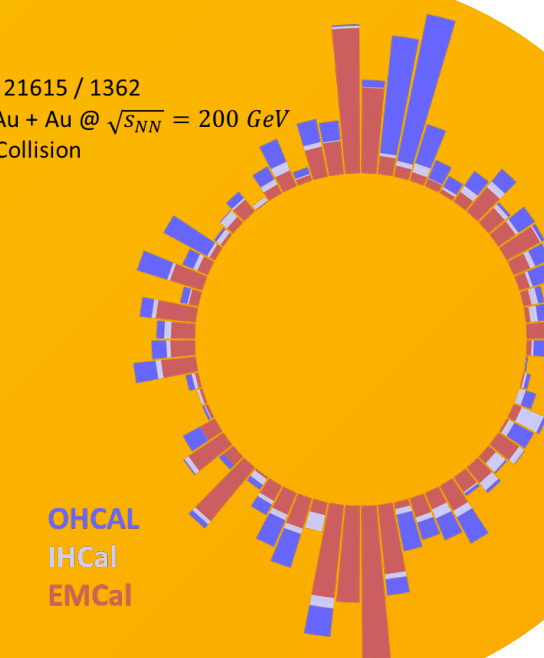
- Precision vertexing $O(10 \mu\text{m})$
- Momentum resolution $\Delta p/p \sim 1\%$ at 500 MeV
- PID with dE/dx at low momentum



Full calorimetry system

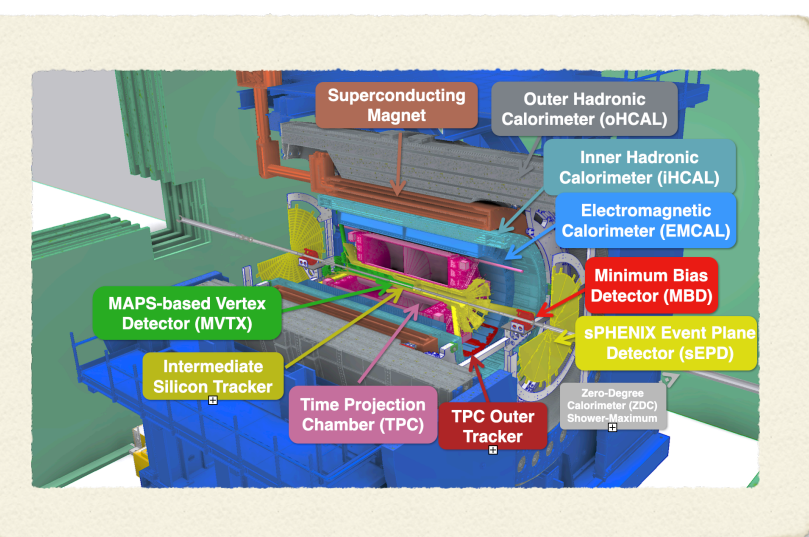
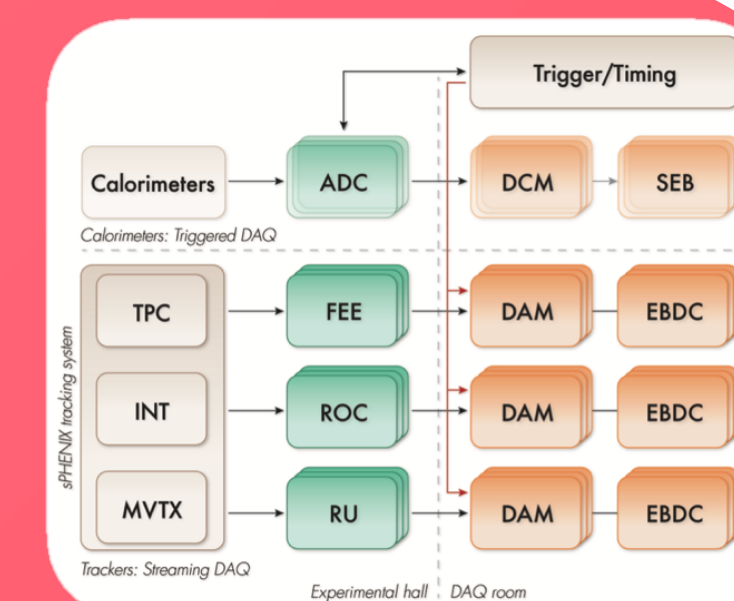
- First barrel hadronic calorimeter at RHIC
- Full azimuthal coverage of EMCal + HCal
- Measurements of full jets & high- p_T photons

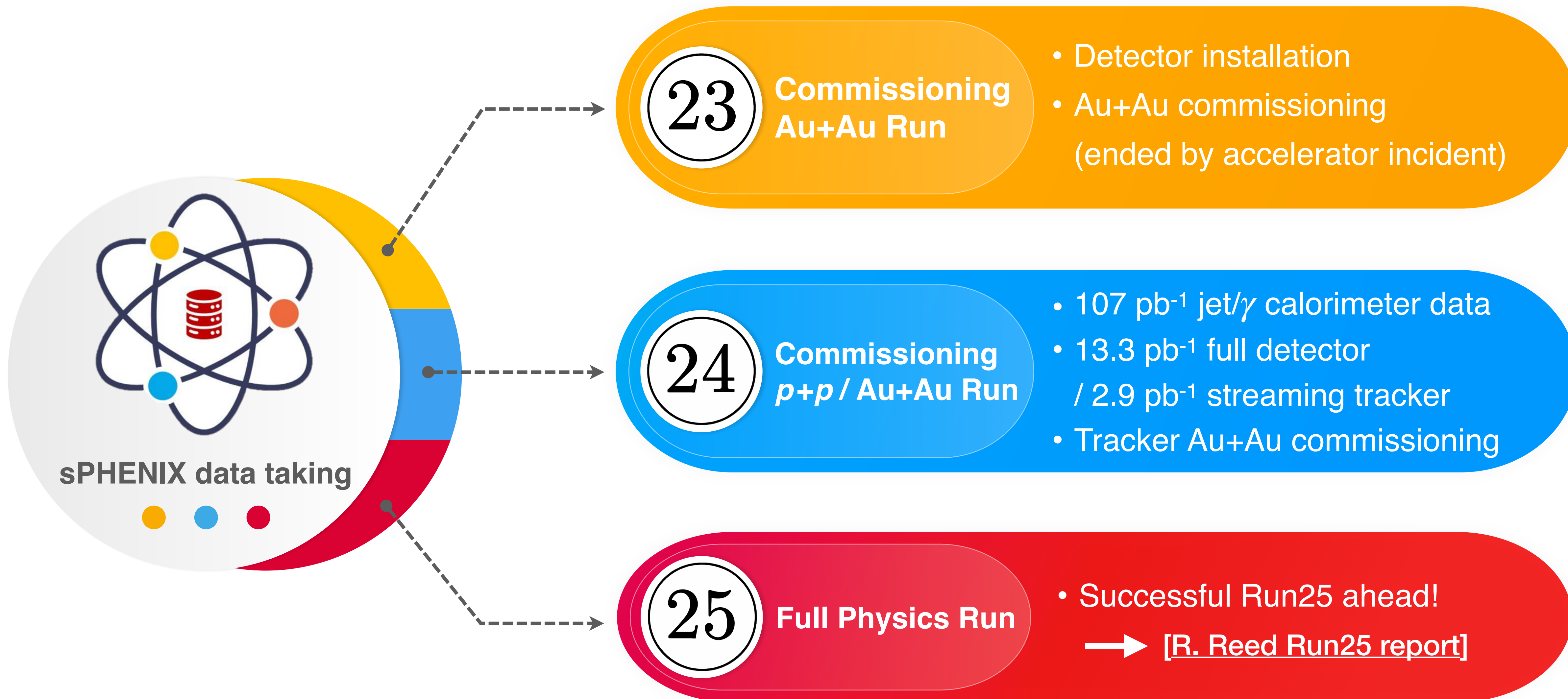
sPHENIX
Run/Event: 21615 / 1362
Collisions: Au + Au @ $\sqrt{s_{NN}} = 200 \text{ GeV}$
Peripheral Collision



Dual fast DAQ system / Global detectors

- High trigger rate capacity (15kHz of Au+Au)
- Streaming mode for trackers (200 kHz of p+p)
- Forward detectors for event characterization

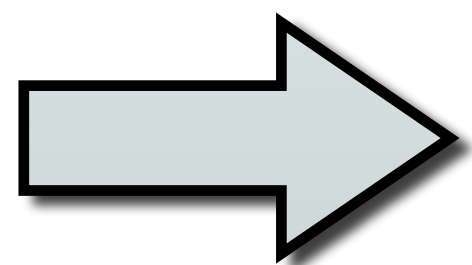




Final physics results

1. Transverse energy density in Au+Au 200 GeV
[arXiv:2504.02242 \(sPH-BULK-2025-02\)](#)
2. Charged particle multiplicity in Au+Au 200 GeV
[arXiv:2504.02240 \(sPH-BULK-2025-01\)](#)

- First sPHENIX final results submitted for publication!
- Preliminary results documented in paper-style conf-note
- All materials including performance plots / event displays accessible in the sPHENIX public web page

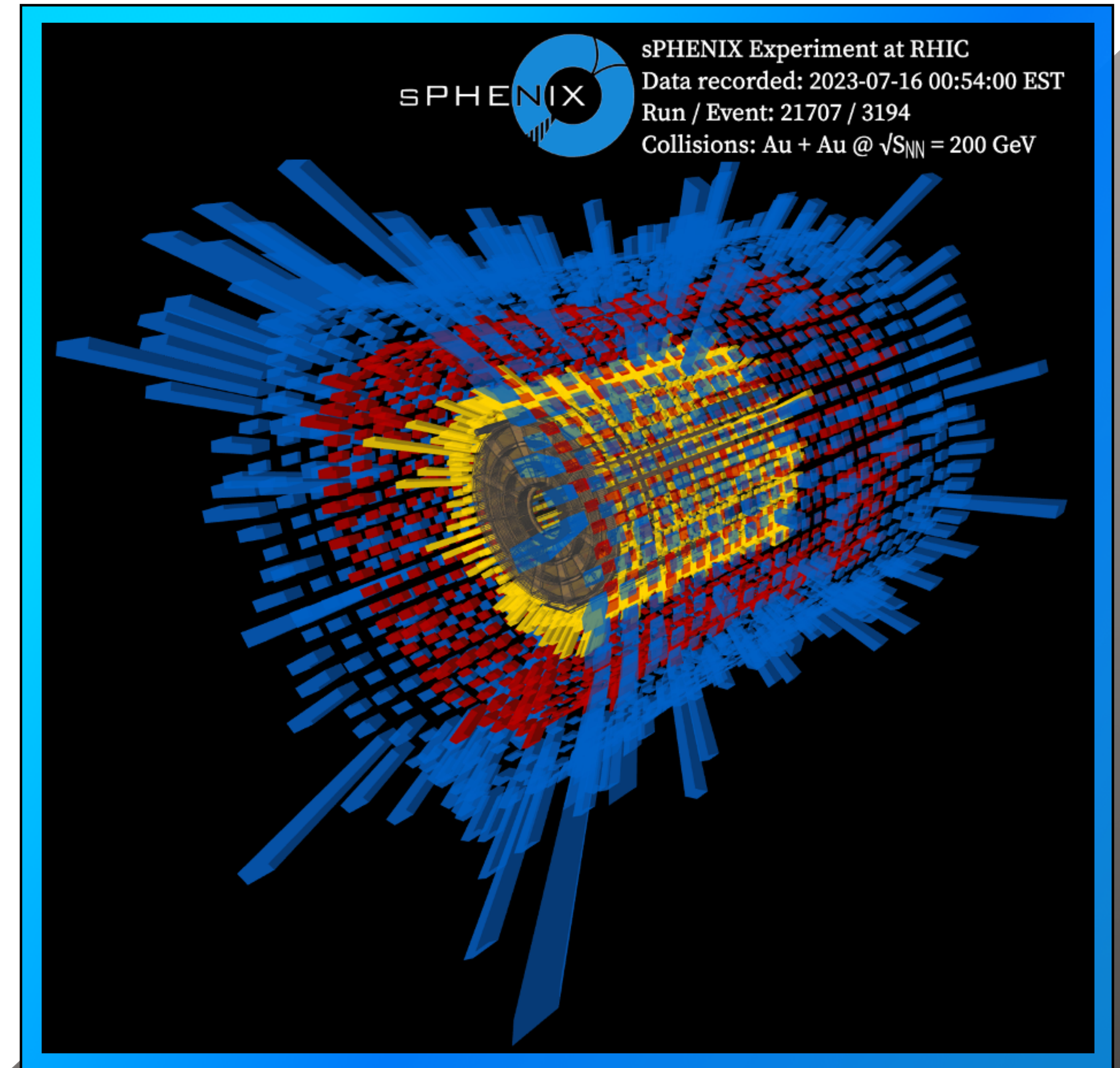
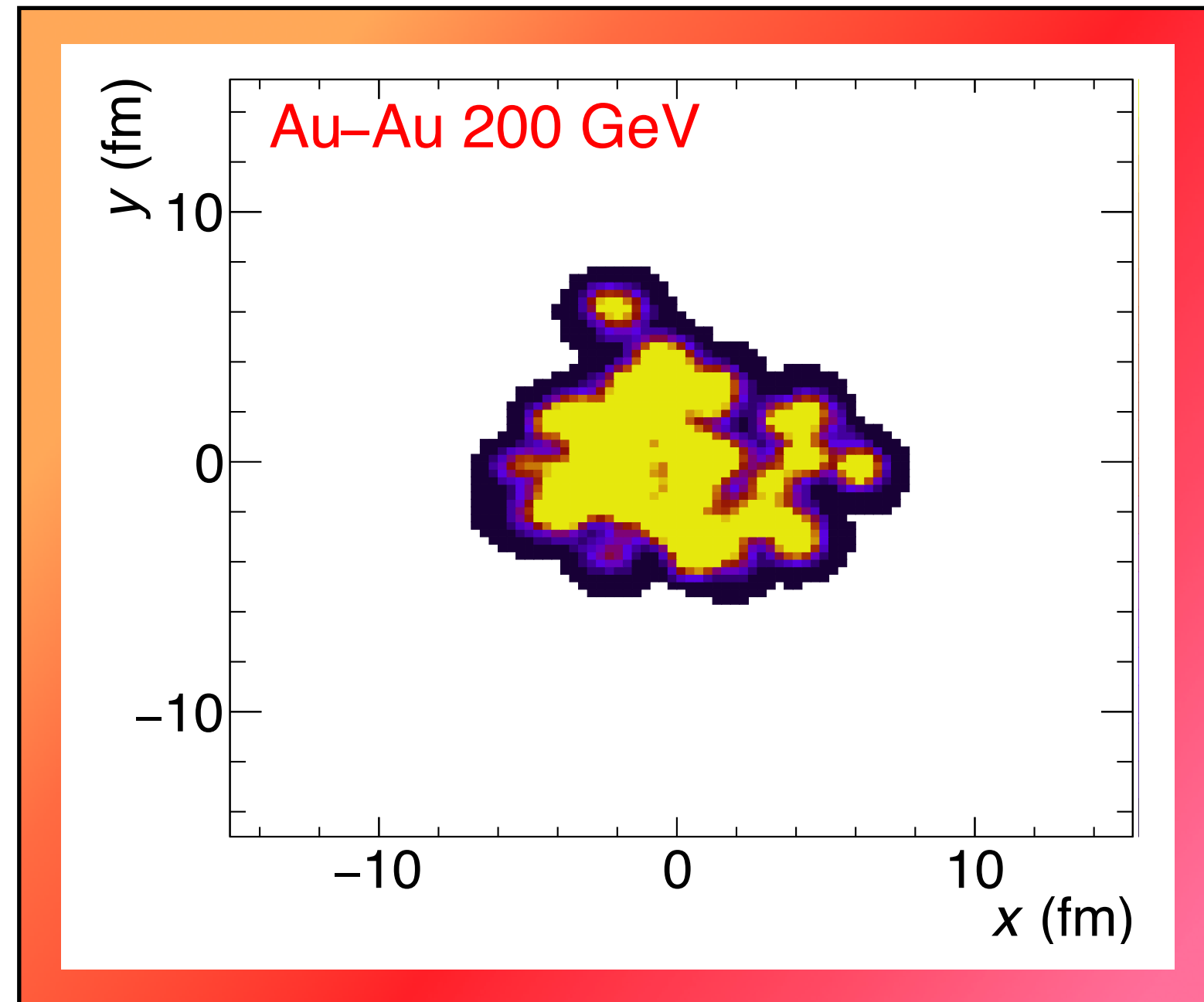


[sPHENIX Public Page](#)

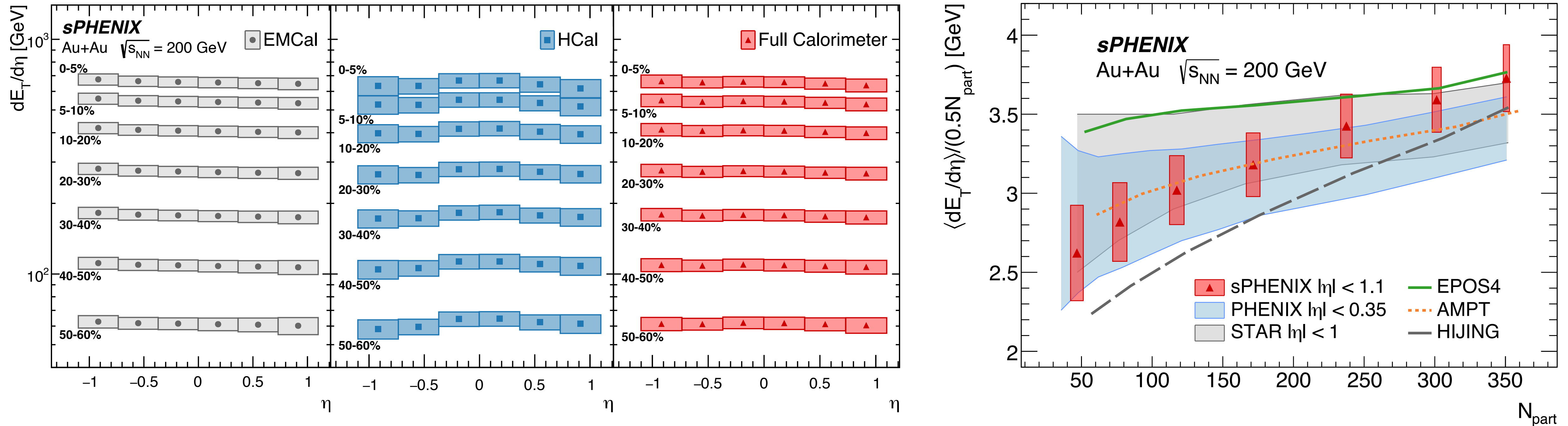
Preliminary physics results

1. π^0 v_2 in Au+Au 200 GeV
: [sPH-CONF-BULK-2024-01](#)
2. Neutral meson transverse single-spin asymmetry in $p\uparrow + p$ 200 GeV
: [sPH-CONF-COLDQCD-2025-01](#)
3. Dijet imbalance in $p+p$ 200 GeV
: [sPH-CONF-JET-2025-01](#)
4. Isolated photon in $p+p$ 200 GeV
: [sPH-CONF-JET-2025-02](#)
5. Inclusive jet in $p+p$ 200 GeV
: [sPH-CONF-JET-2025-03](#)
6. Underlying event & jet background in Au+Au 200 GeV
: [sPH-CONF-JET-2025-04](#)

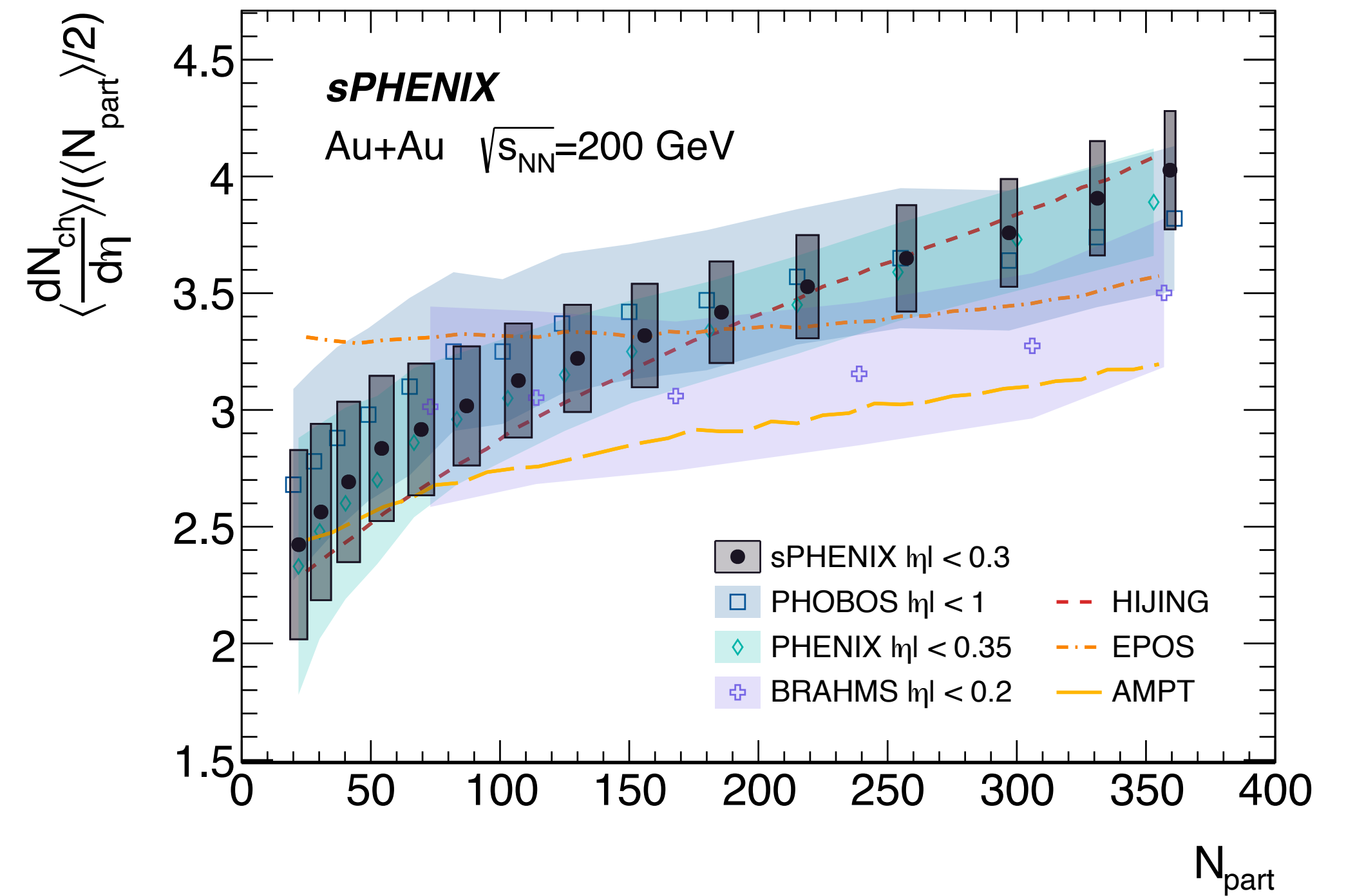
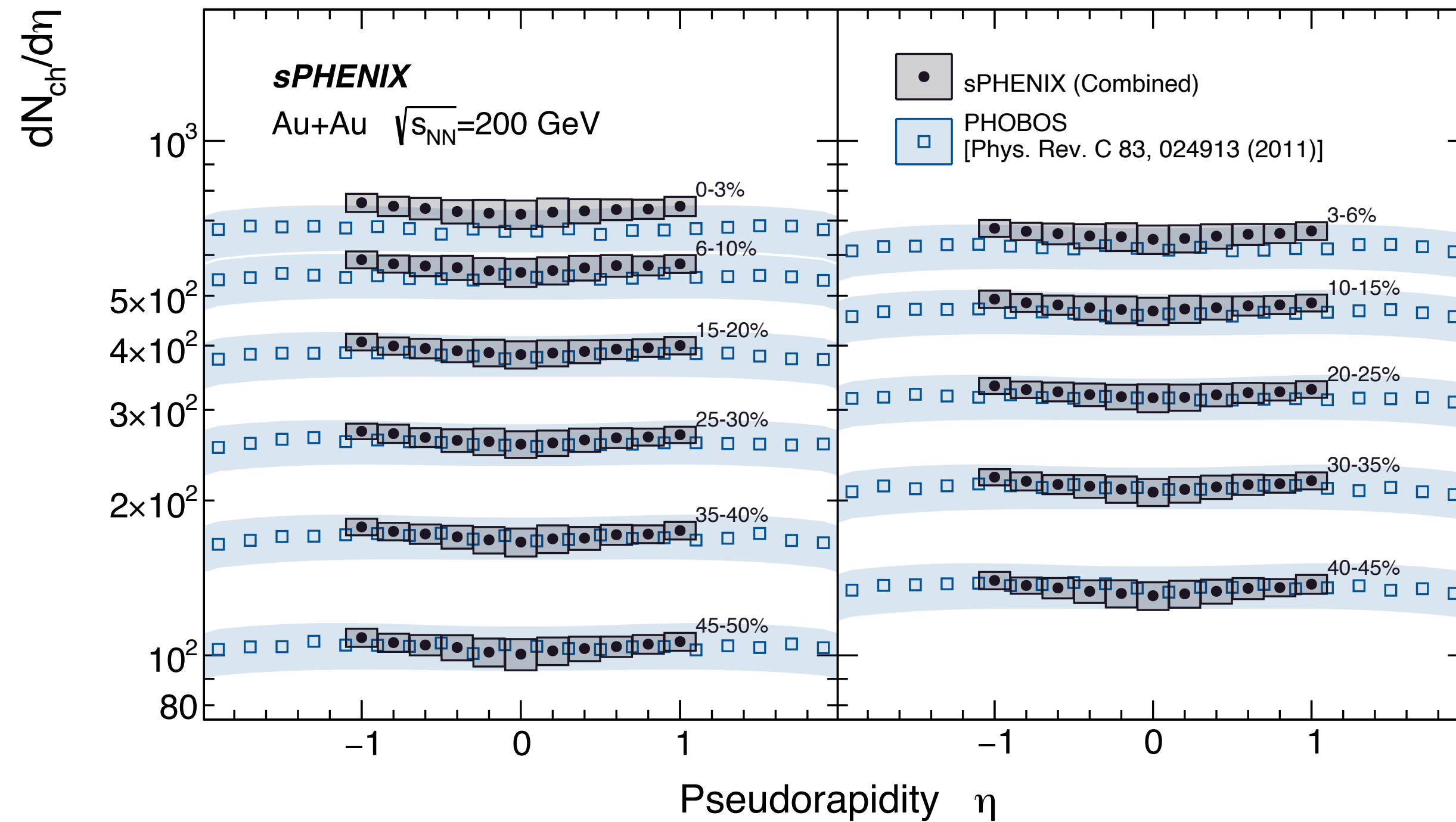
QGP Bulk Properties with sPHENIX



Transverse Energy Density in Au+Au

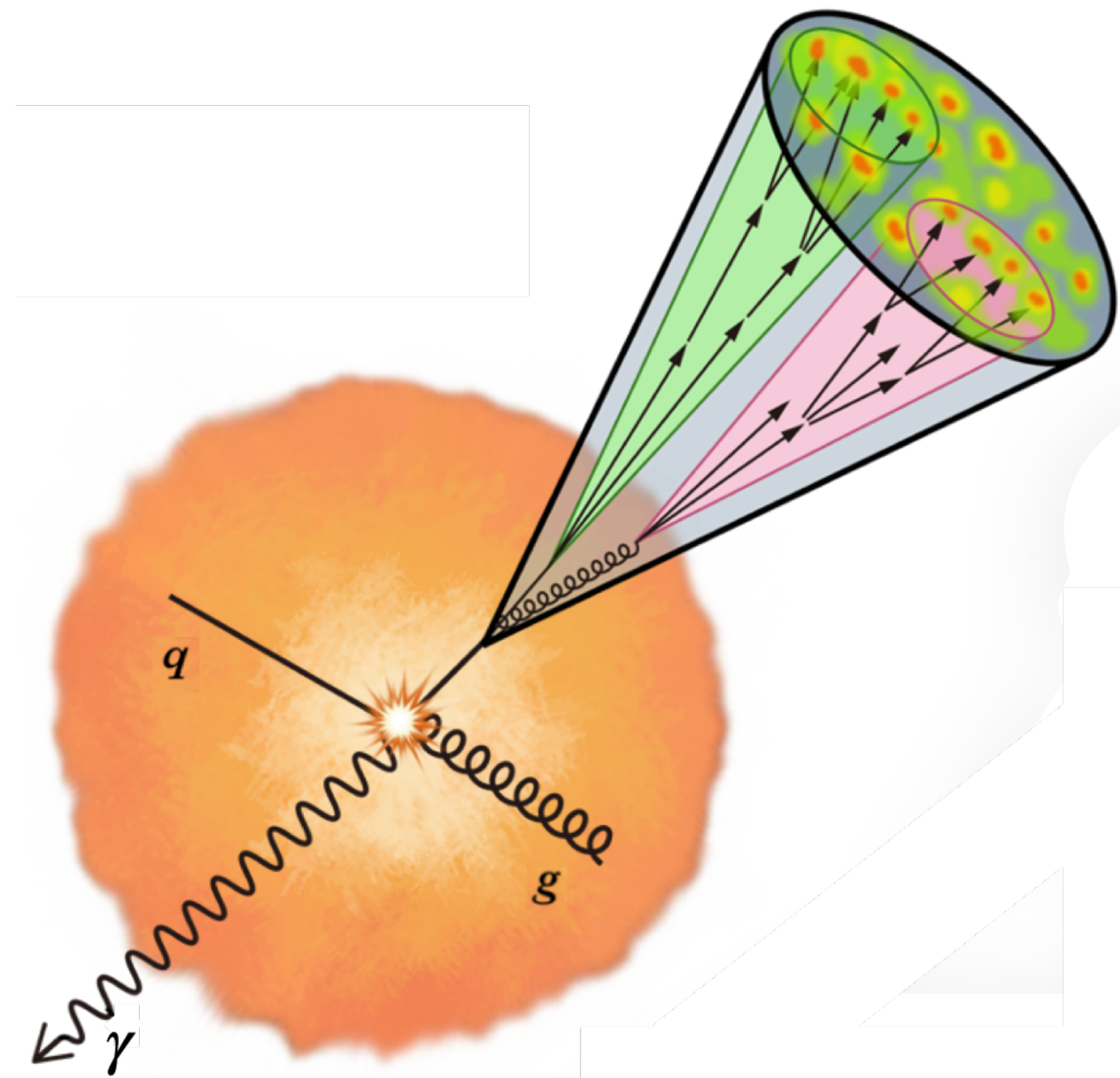
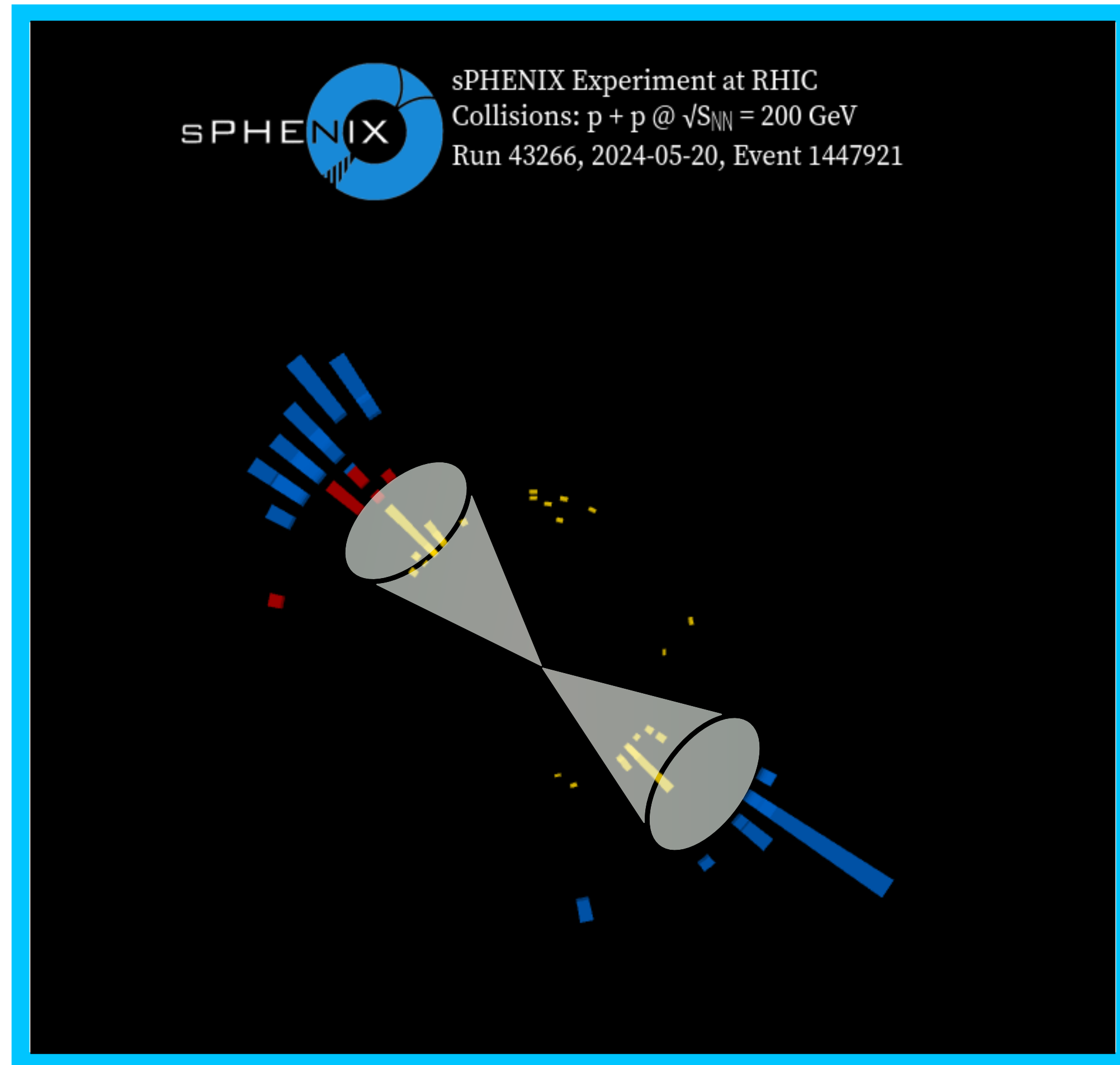


- **First sPHENIX papers** after 5 months from completing data taking! [\[arXiv:2504.02242\]](https://arxiv.org/abs/2504.02242)
- $dE_T/d\eta$ measured using EMCAL and HCal separately
- Verification of calorimeter energy calibration / Consistent with previous RHIC results



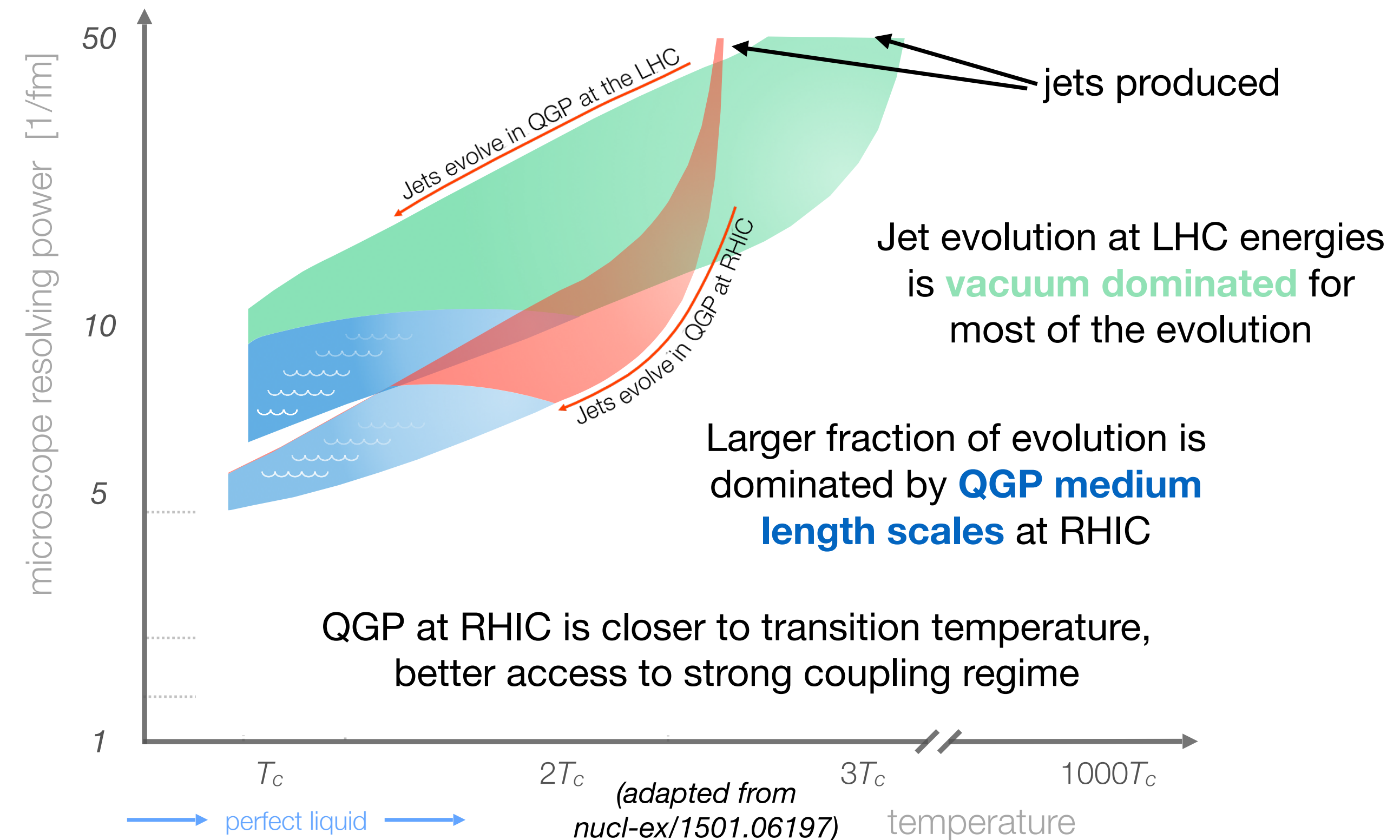
- **First sPHENIX papers** after 5 months from completing data taking! [\[arXiv:2504.02240\]](https://arxiv.org/abs/2504.02240)
- $dN_{ch}/d\eta$ measured using tracklets from INTT detector
- INTT clustering & tracklet reconstruction demonstrated / Consistent with previous RHIC results

sPHENIX Jet Physics Program

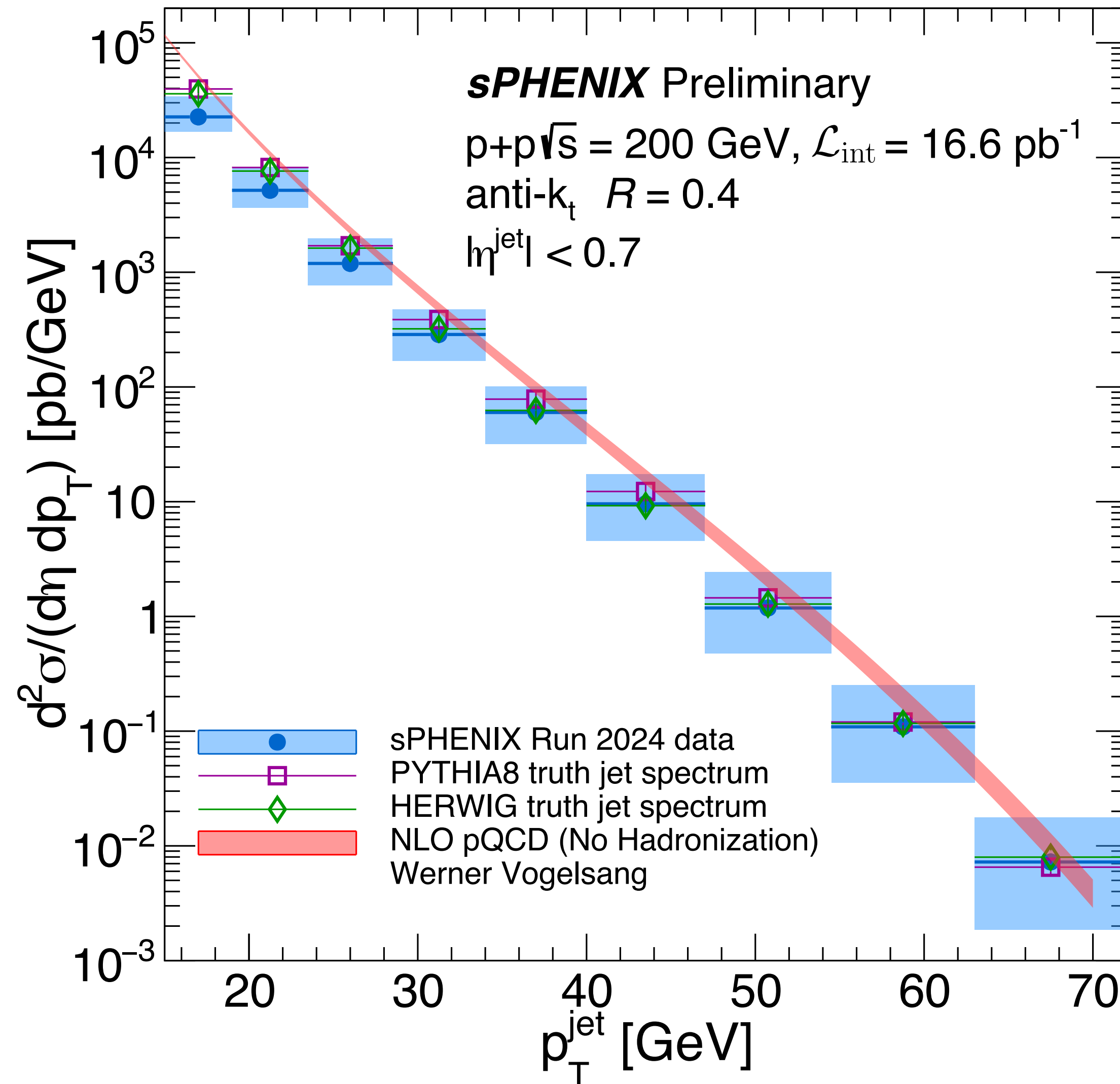


Why jets at RHIC?

- Softer spectra / different color charge jets compared to LHC
- Fast evolution of parton virtuality
- Sensitive to the scale of the medium
- Complementarity with LHC measurements in overlapping kinematic regions



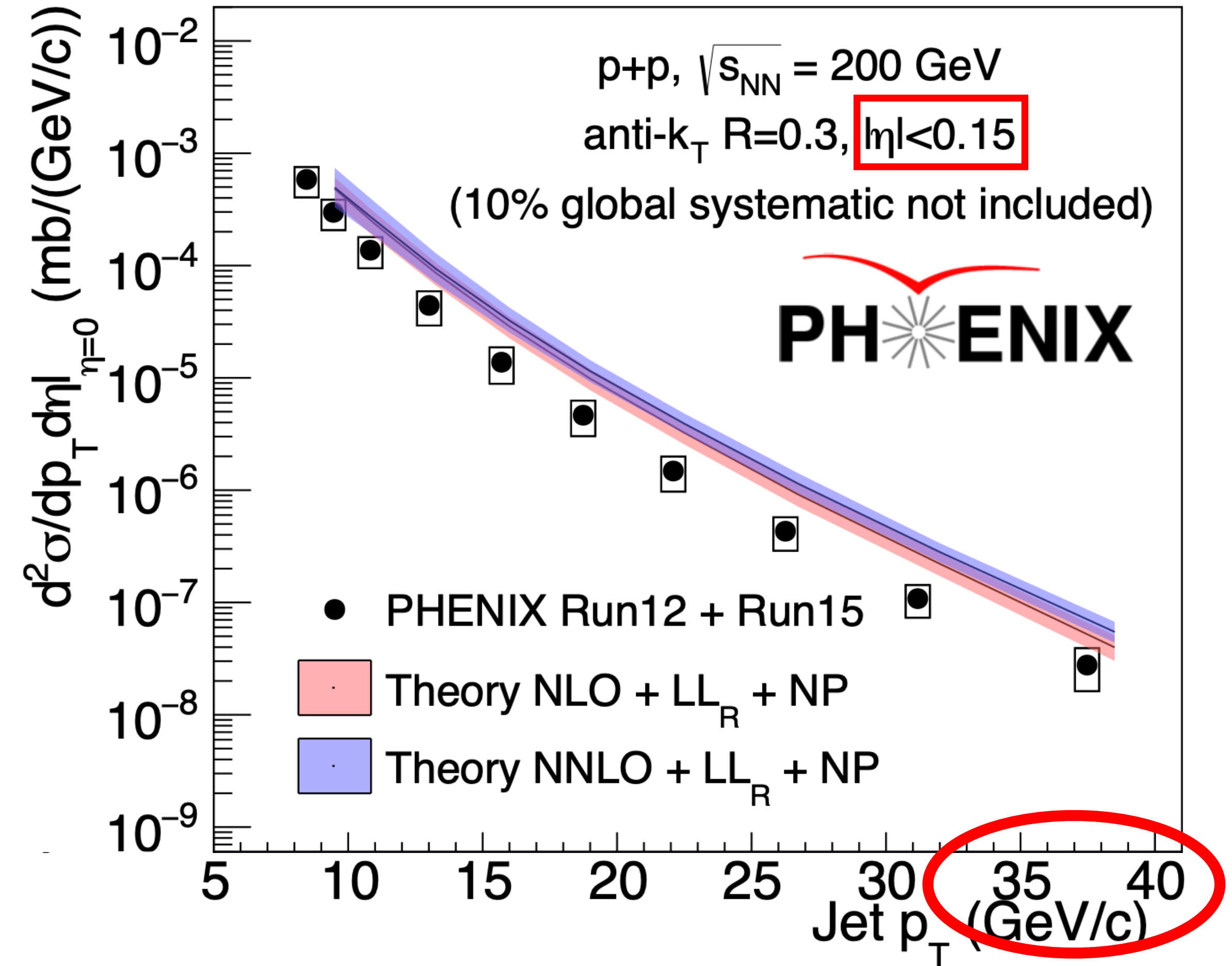
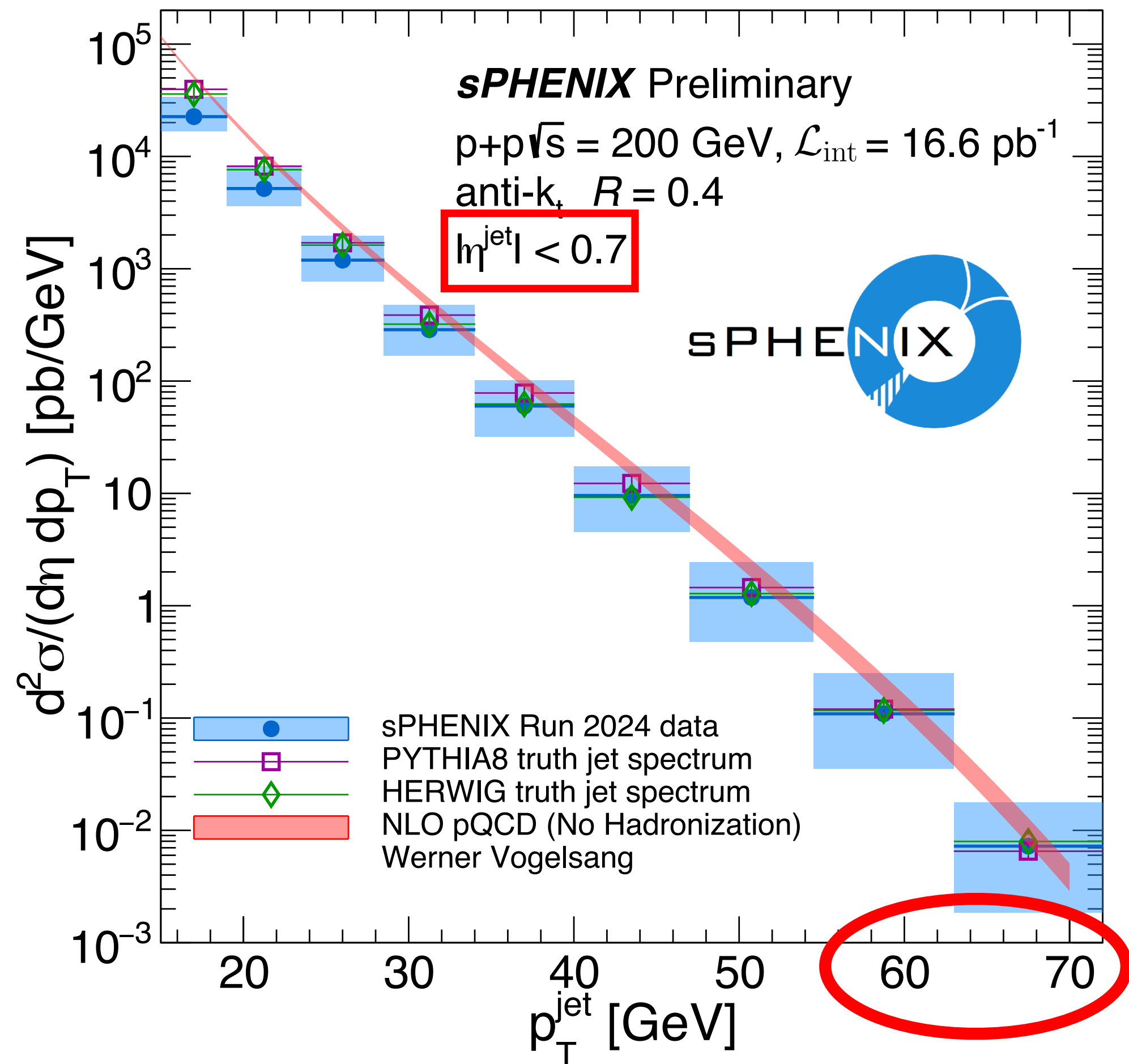
[D. Lis (Jet Workshop) sPH-CONF-JET-2025-03]



- First measurement of full jets with EMCal + HCal at RHIC measured up to $p_T = 70 \text{ GeV}$!
- Only using **15% of full statistics!**
 - Full reconstruction production underway
- Jet energy scale
 - Dominant systematic uncertainty
 - Expected to be reduced with data-driven corrections using full statistics

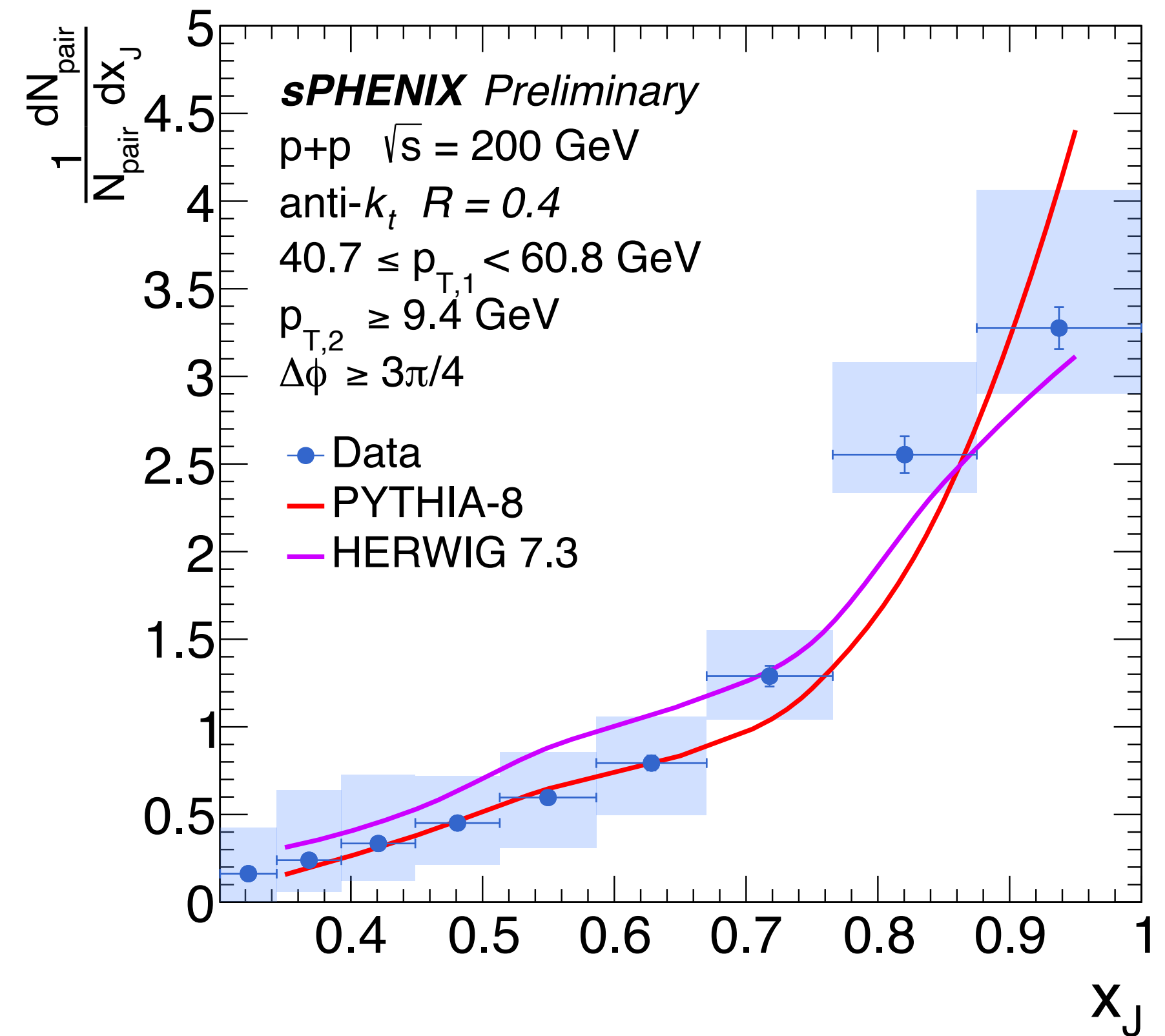
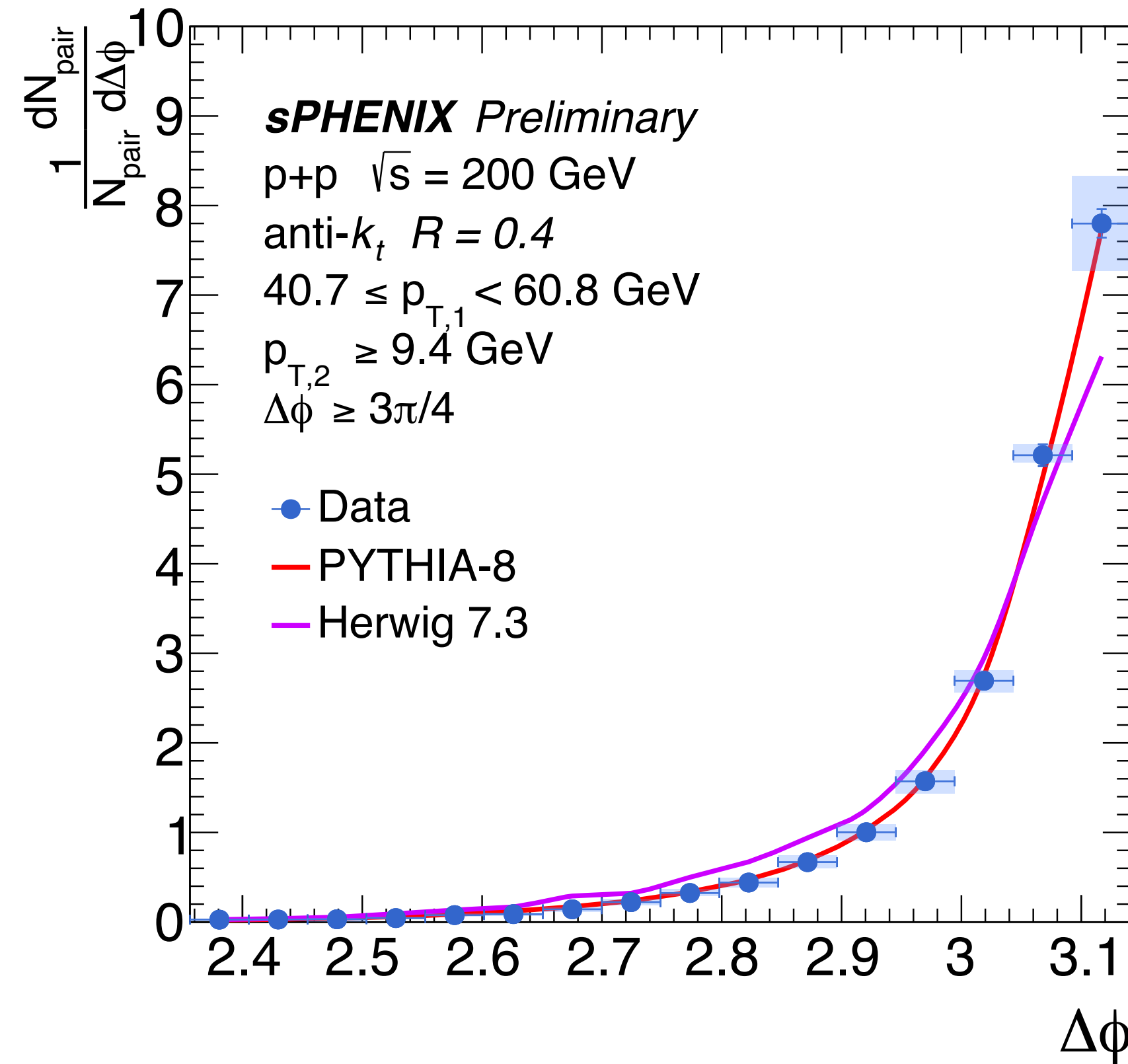
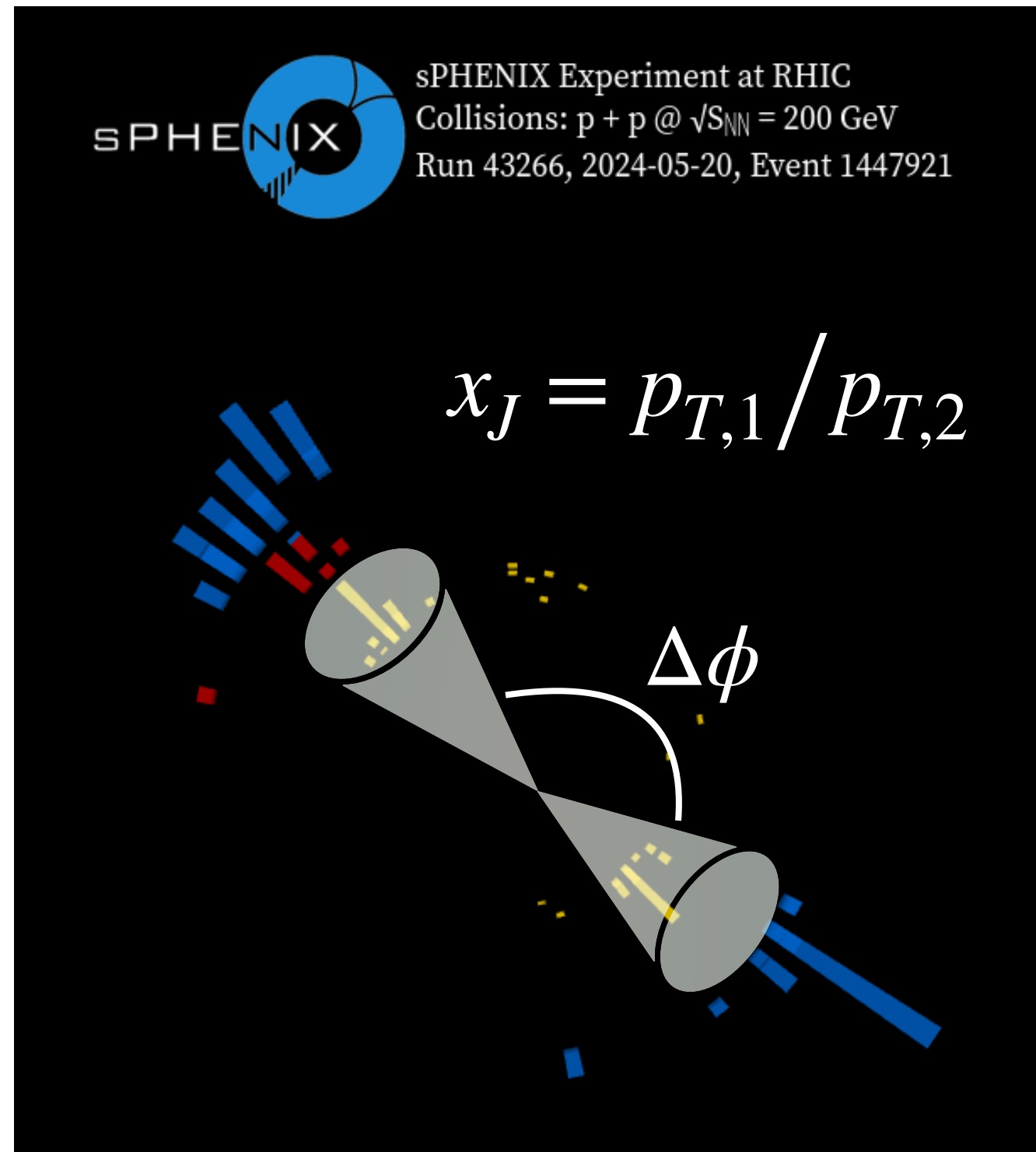
[sPH-CONF-JET-2025-03]

[arXiv:2408.11144]



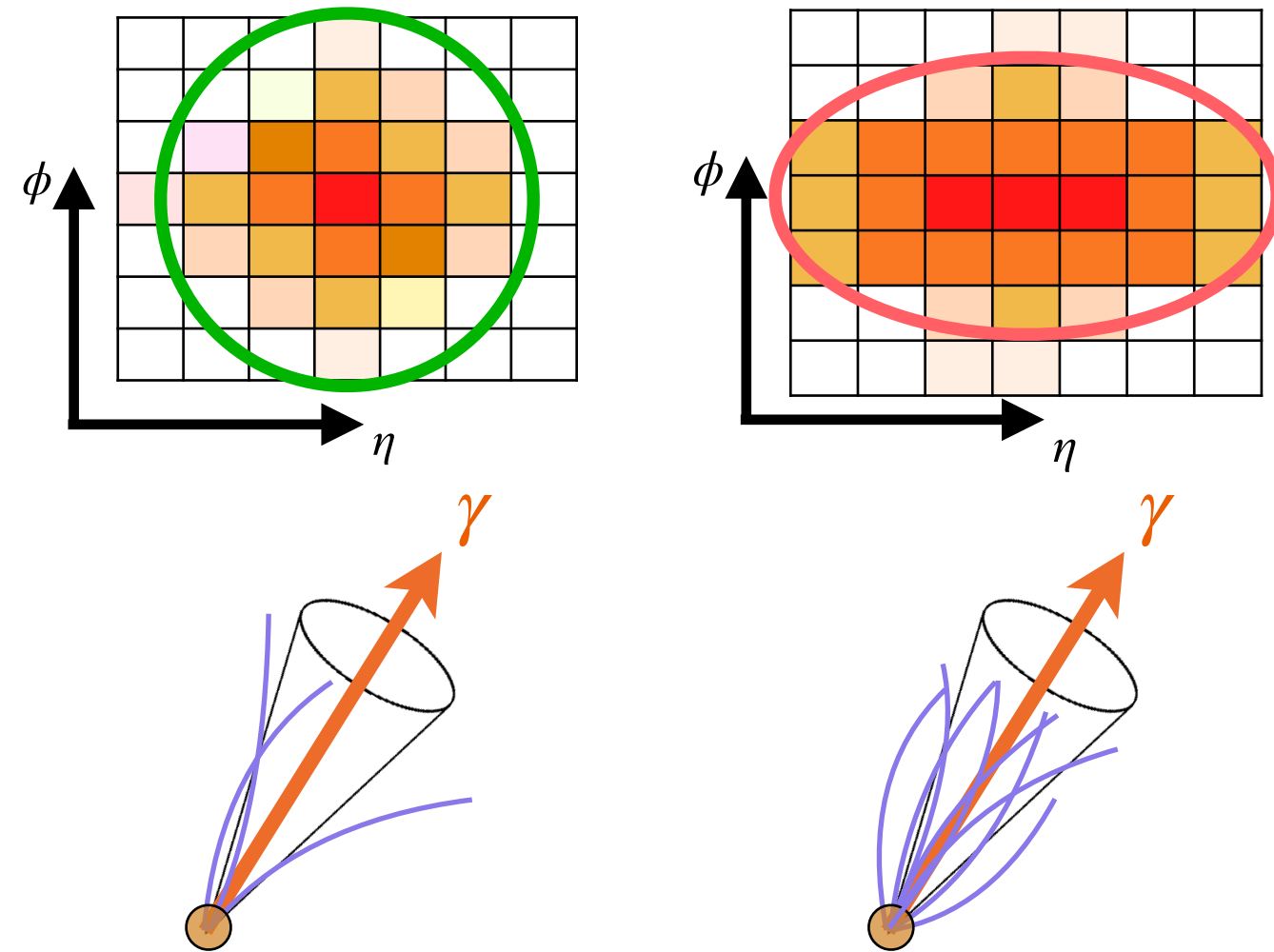
- Significant improvement in the kinematic reach (wider acceptance & full calorimetry)

[D. Lis (Jet Workshop) sPH-CONF-JET-2025-01]

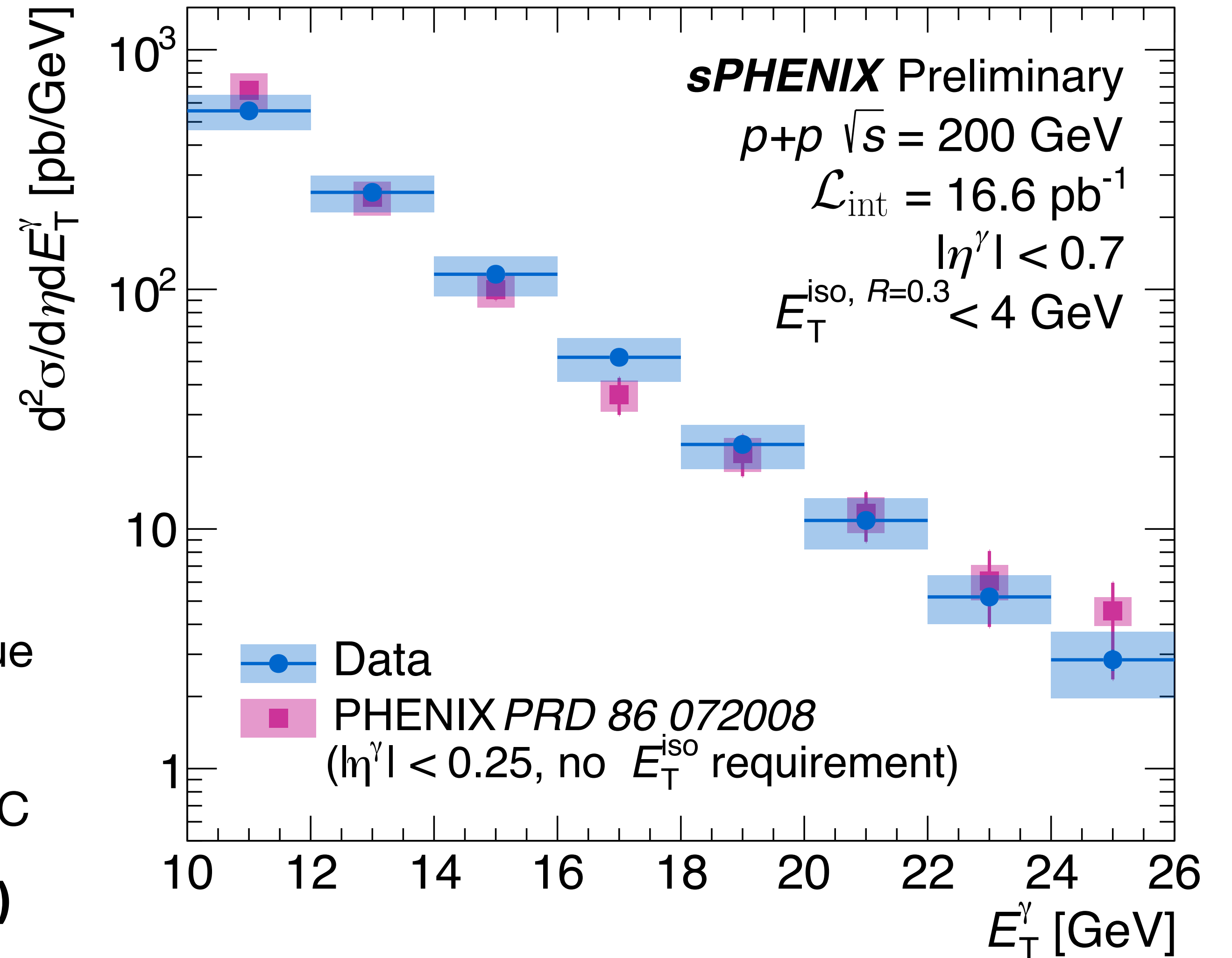


- Clear back-to-back dijets $\rightarrow$ Symmetrically balanced (x_J peaked at 1)
- Important reference for comparison to Au+Au

[D. Lis (Jet Workshop) sPH-CONF-JET-2025-02]

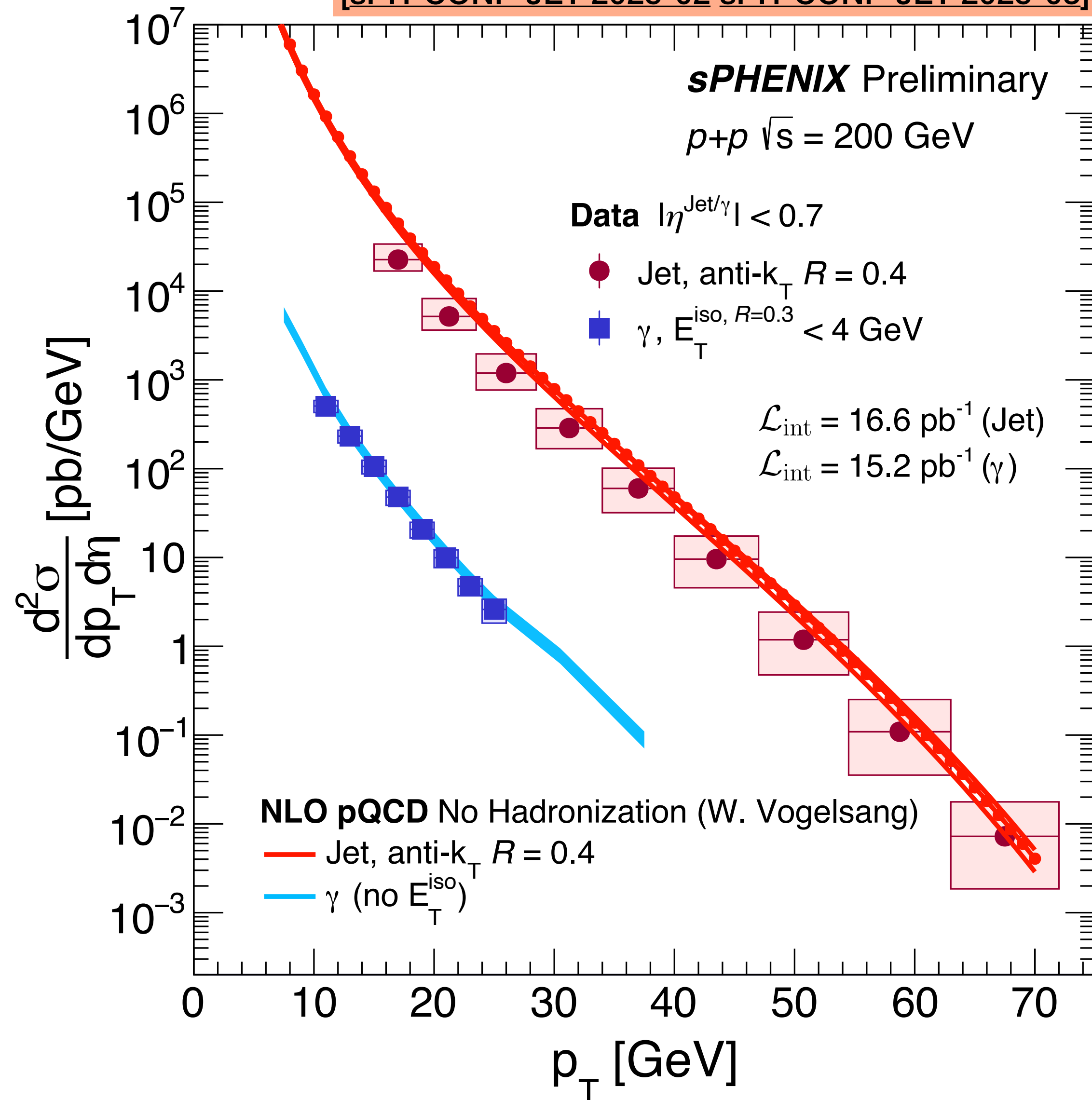


- Proxy of initial parton energy
→ Important reference for Au+Au
- Signal extracted using 2D sideband technique with shower shape & isolation cut
- Statistical significance surpass previous RHIC results! (Yet only **15% of full statistics used**)



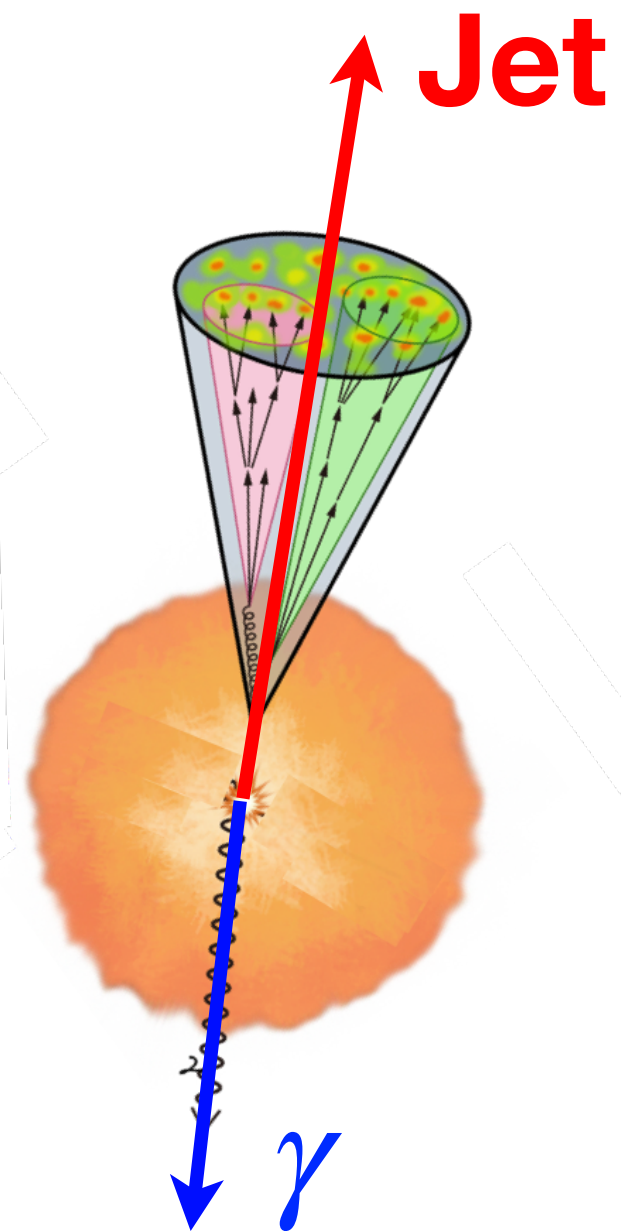
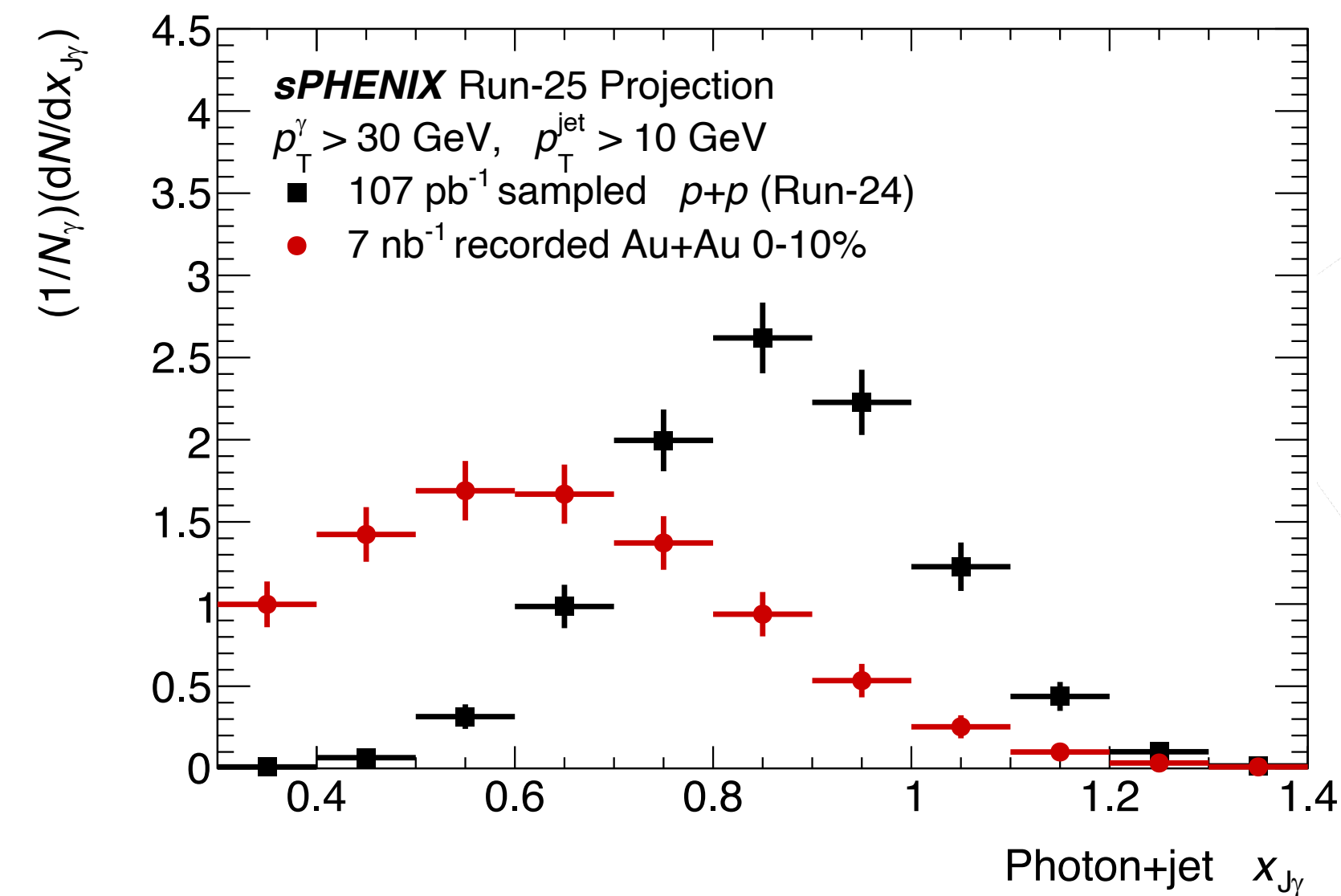
[sPH-CONF-JET-2025-02 sPH-CONF-JET-2025-03]

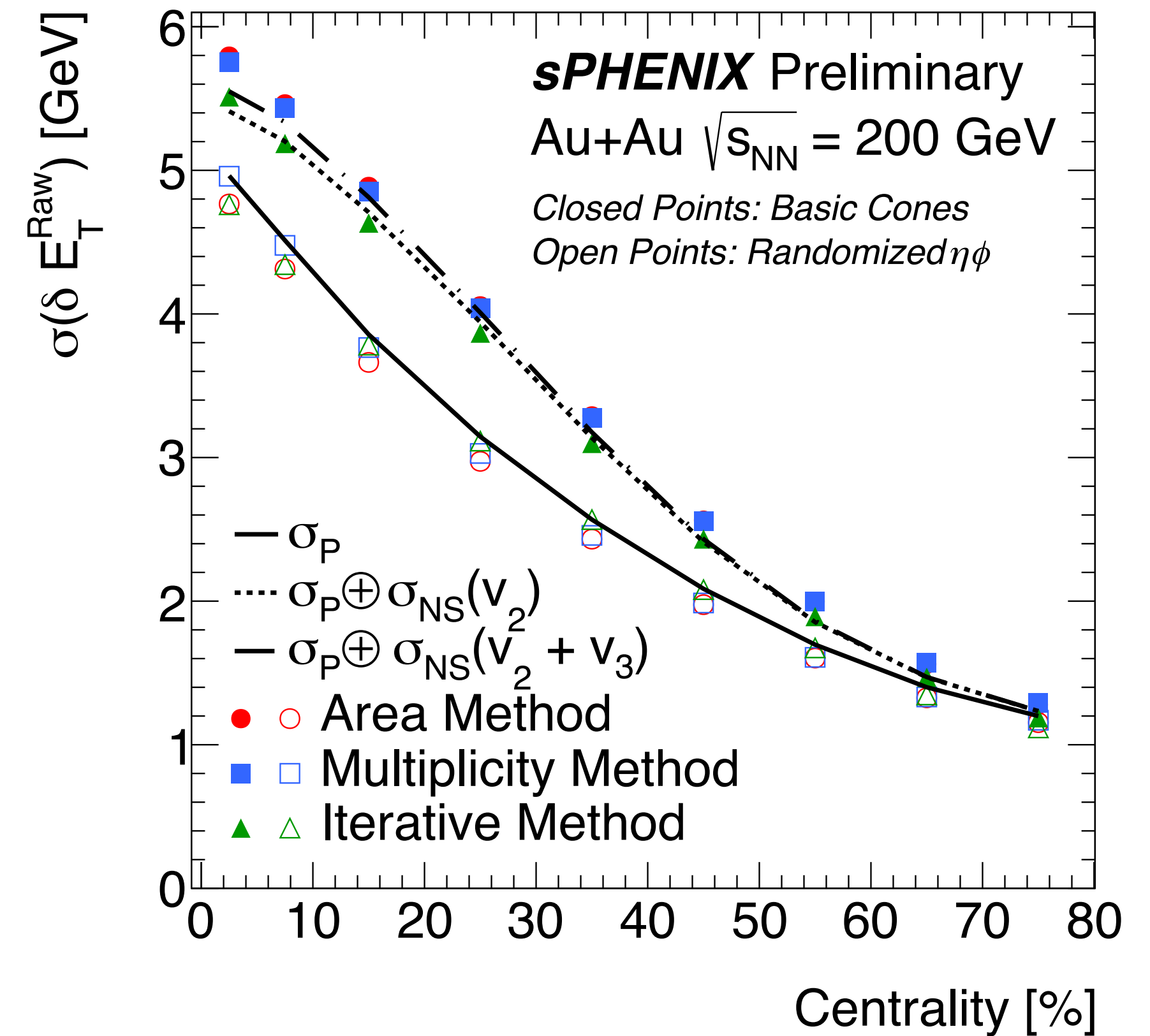
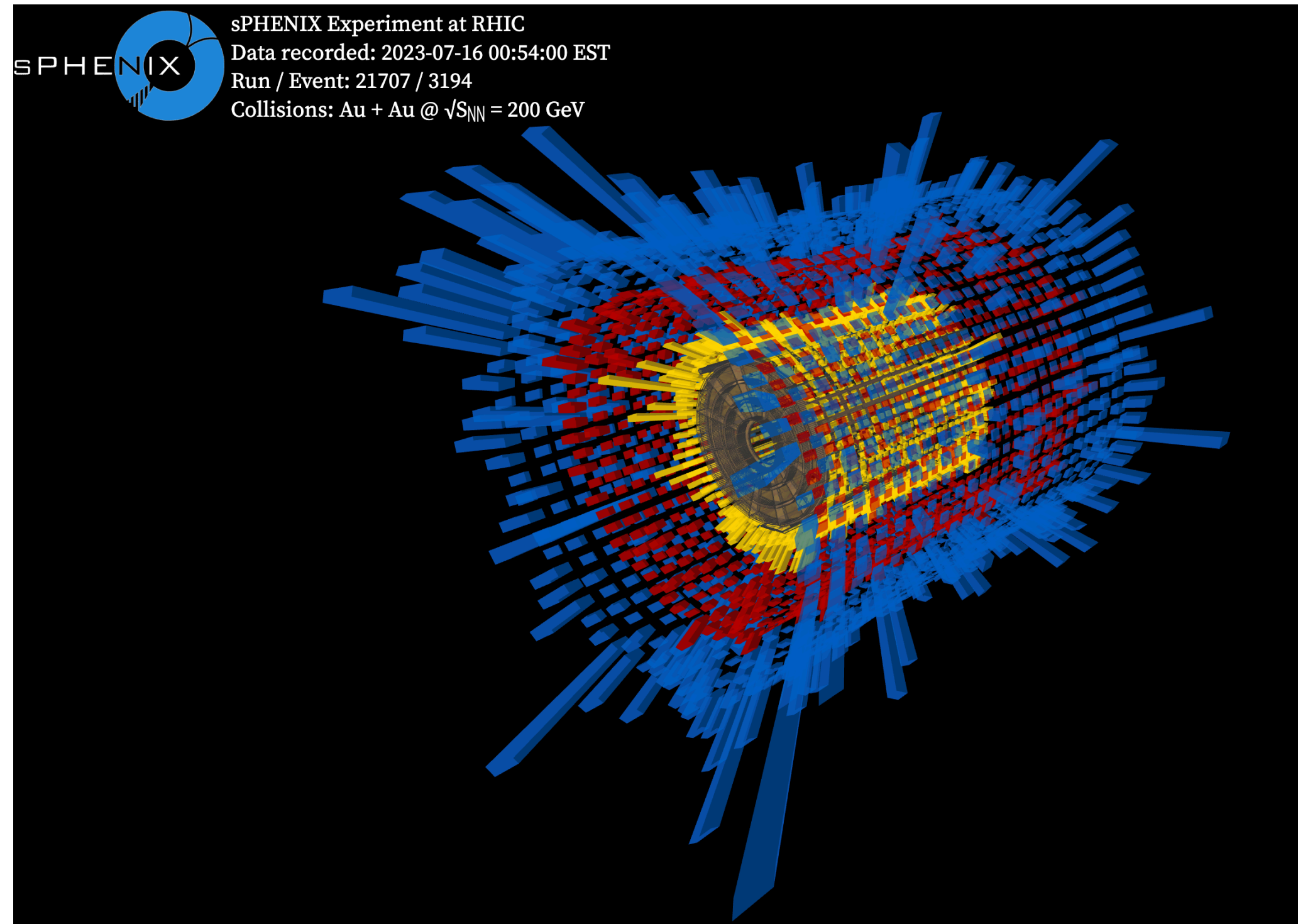
[D. Lis (Jet Workshop)]



- sPHENIX calorimetry system capacity for measuring high- p_T **jets** and **isolated photons**
- Clear pathway towards gamma-jet measurements : Golden probe for QGP study with sPHENIX!

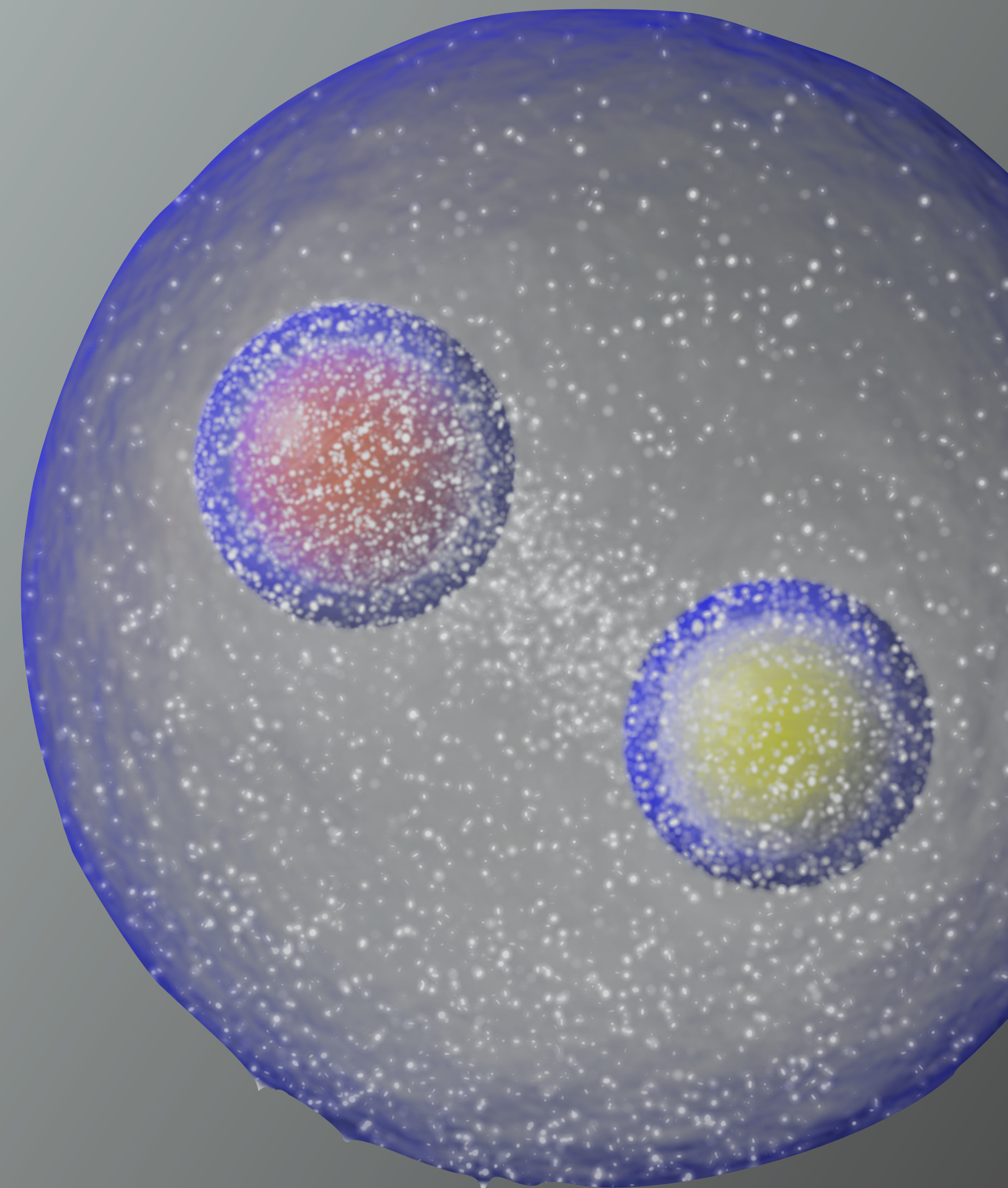
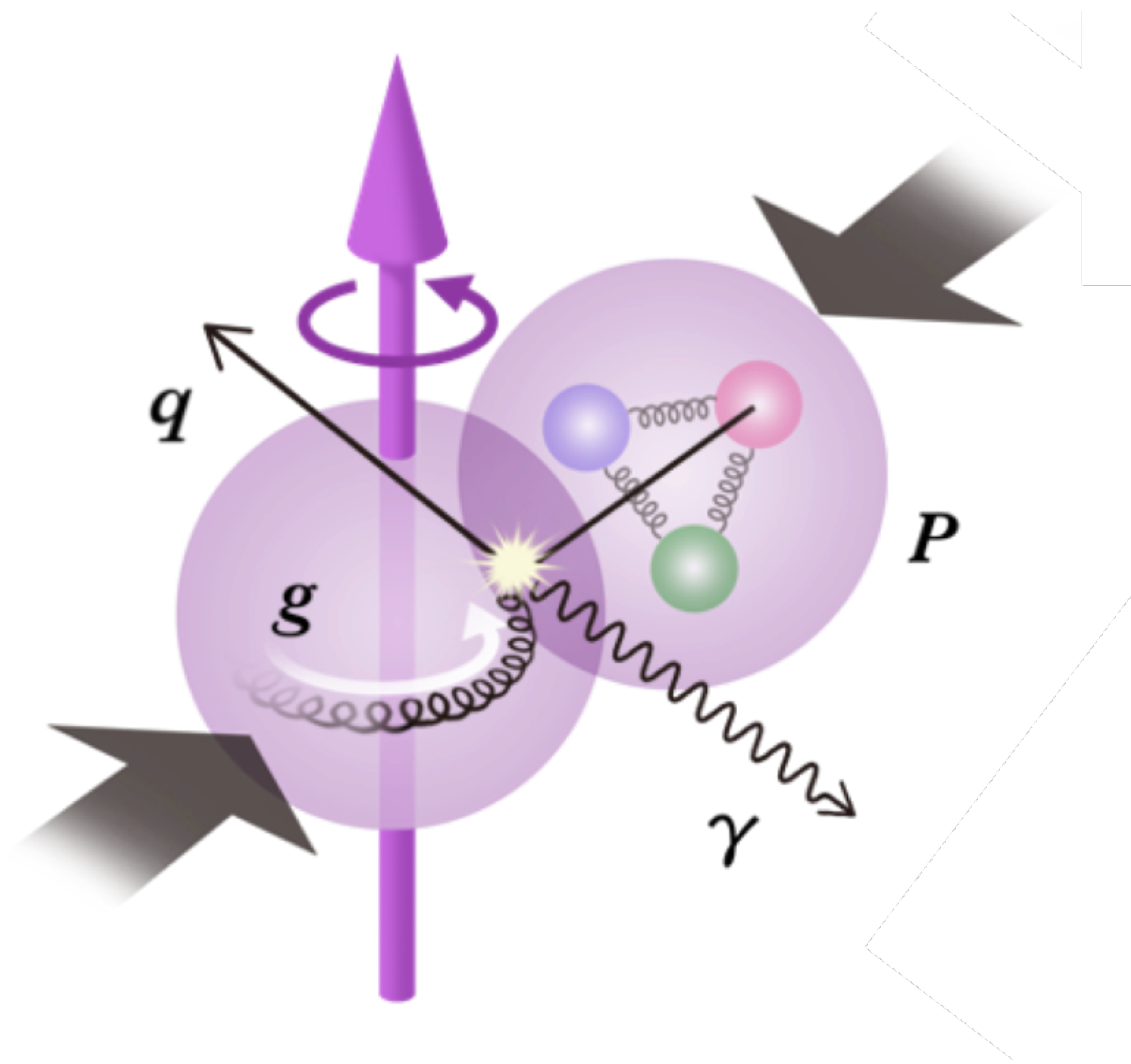
[BUP 2025]





- Underlying event studied for jet reconstruction in heavy ion collisions
- Multiple subtraction methods studied to better understand the correlation and fluctuations

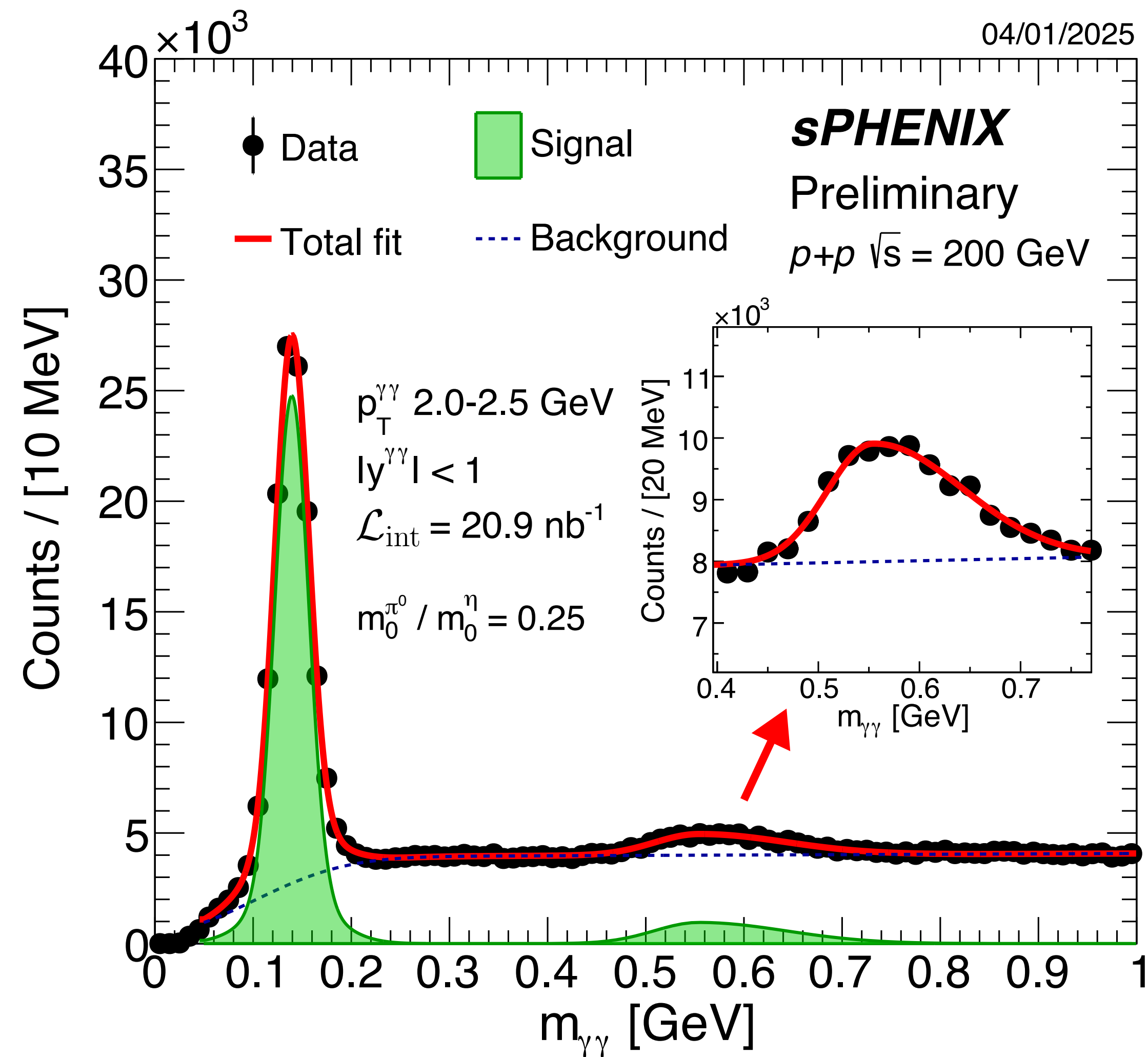
Cold QCD at sPHENIX



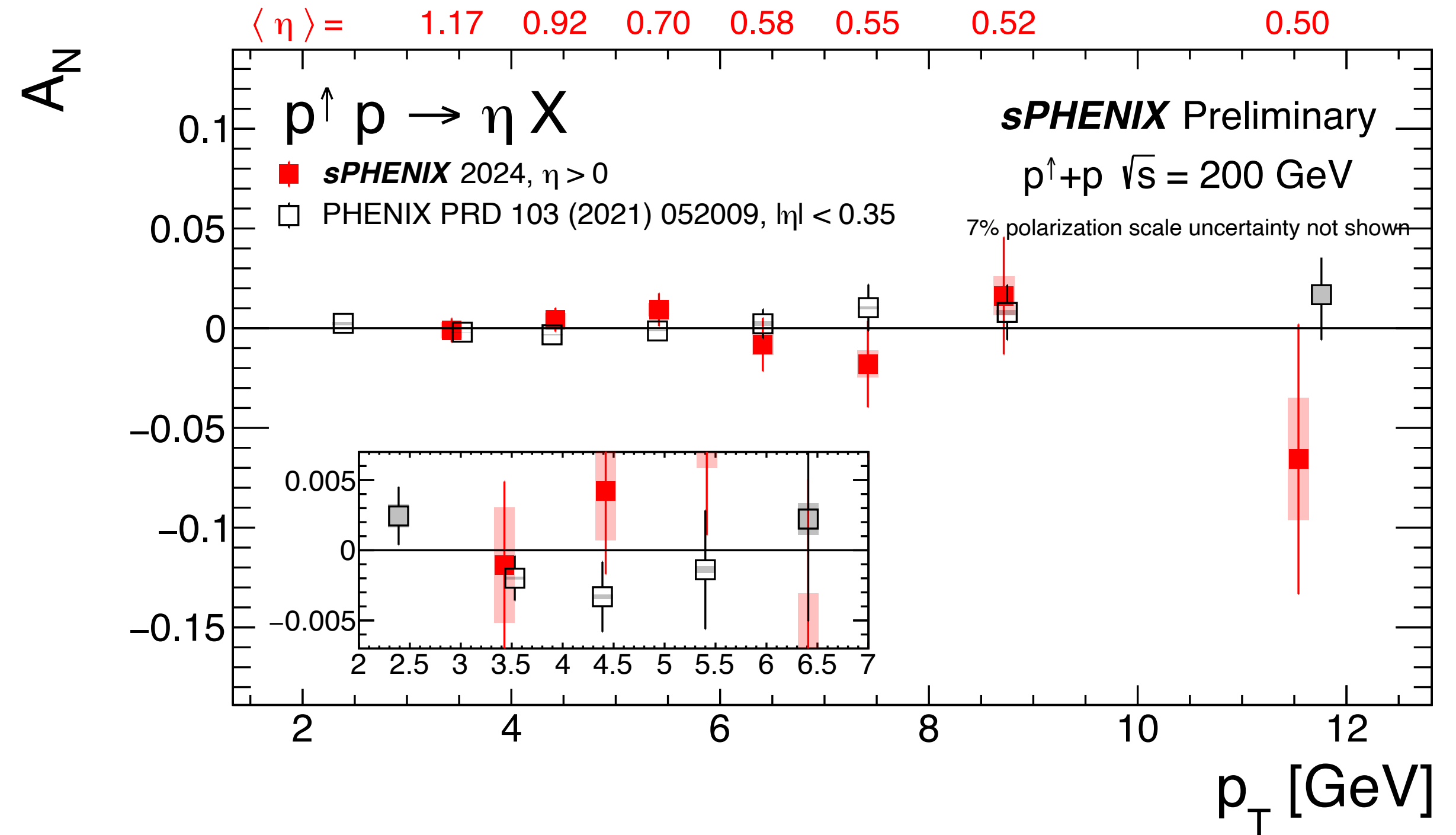
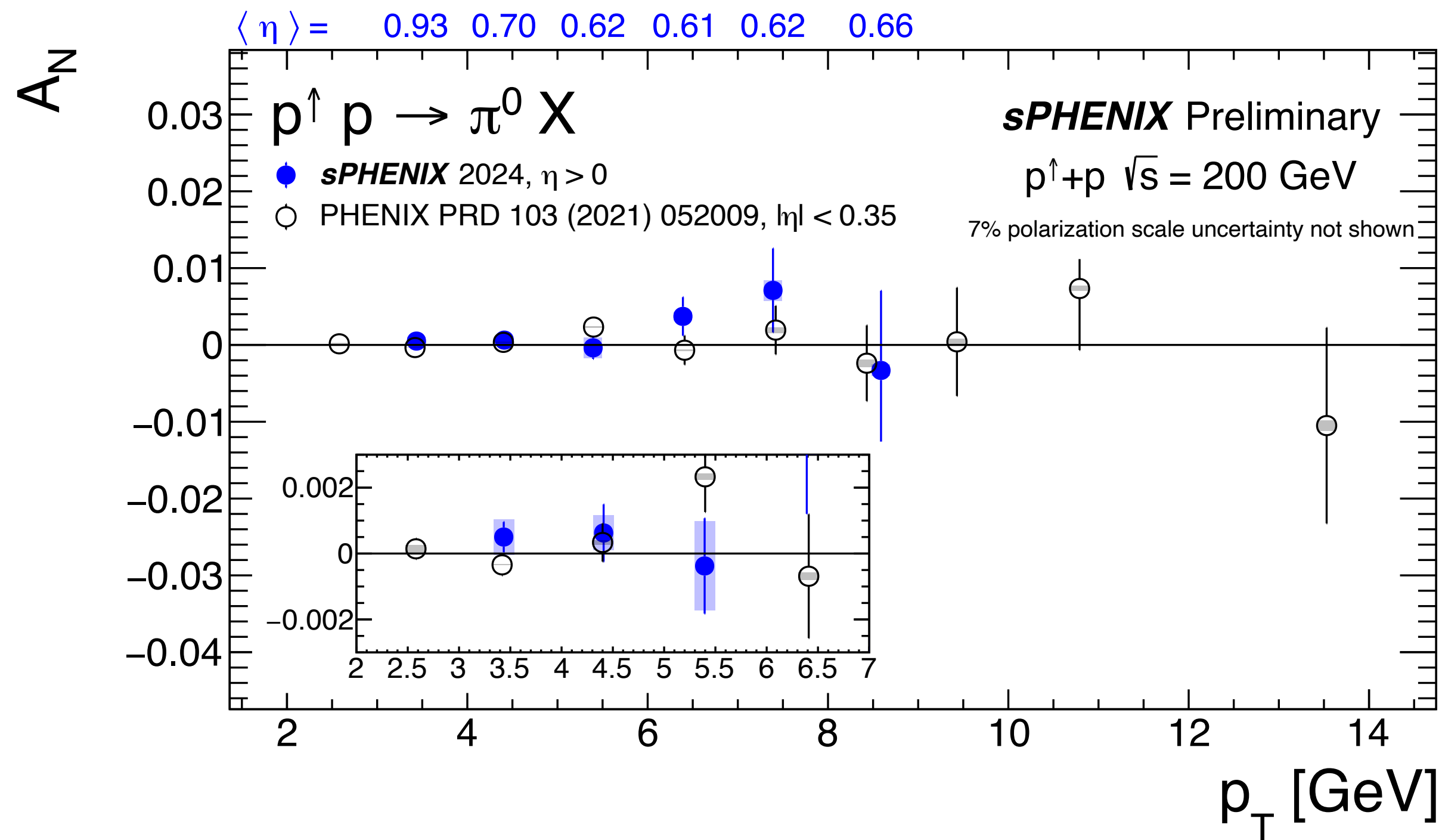
$$p^\uparrow + p \rightarrow \pi^0/\eta X$$

$$A_N \propto \frac{d\sigma^\uparrow - d\sigma^\downarrow}{d\sigma^\uparrow + d\sigma^\downarrow}$$

- Transverse Single-Spin Asymmetry of neutral mesons measured with EMCal clusters
- Sensitive to twist-3 and TMD effects

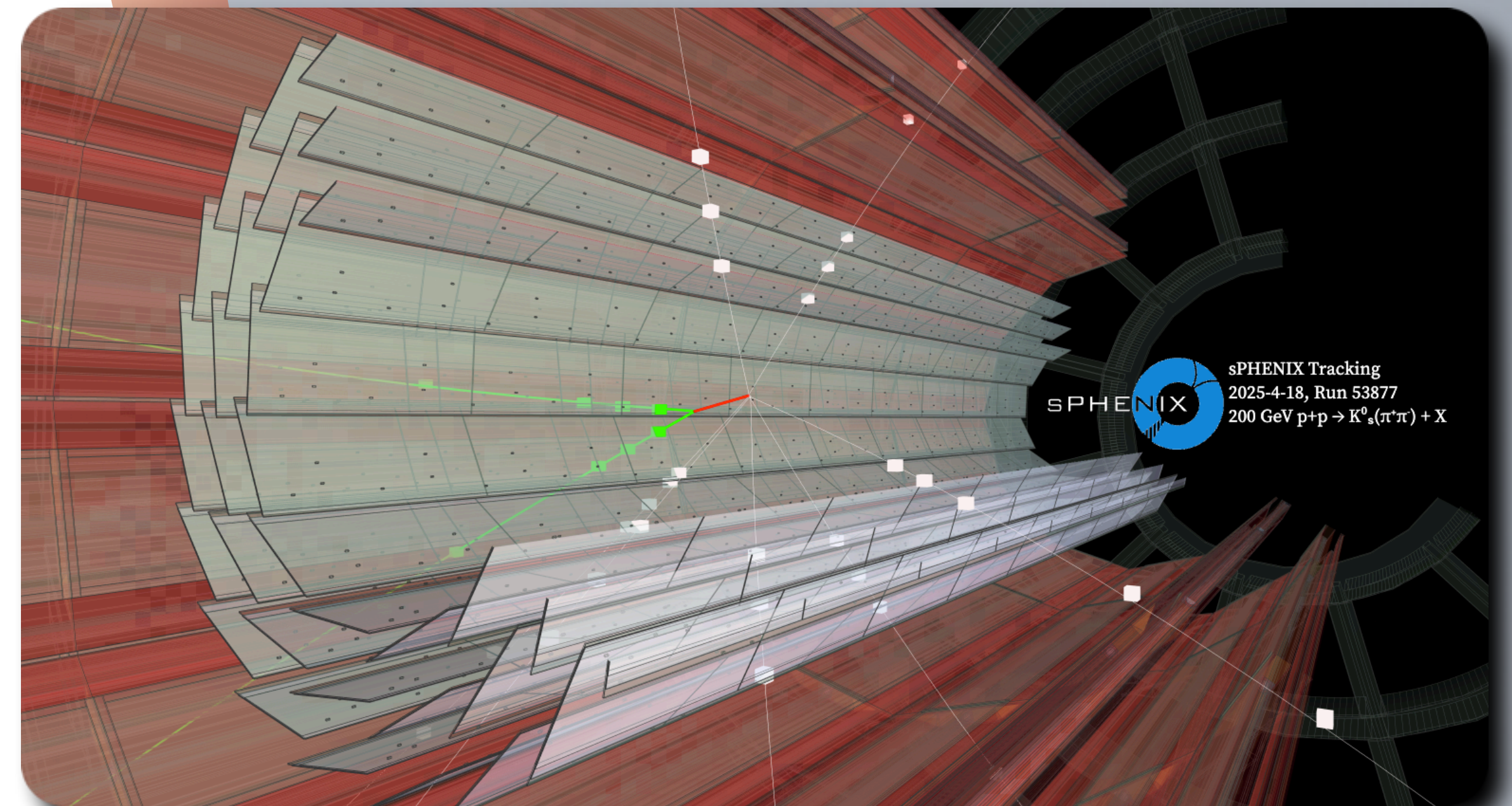
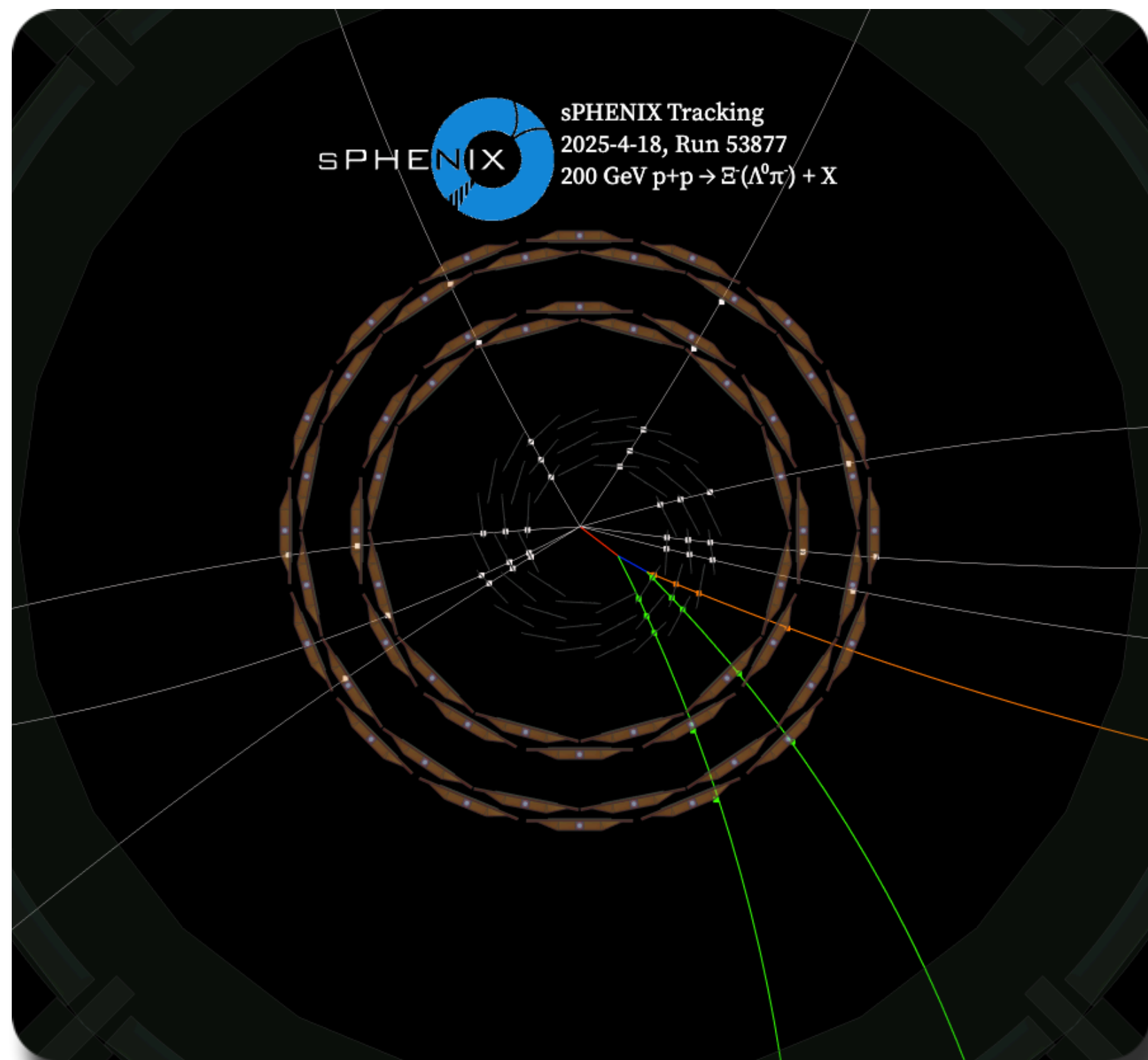


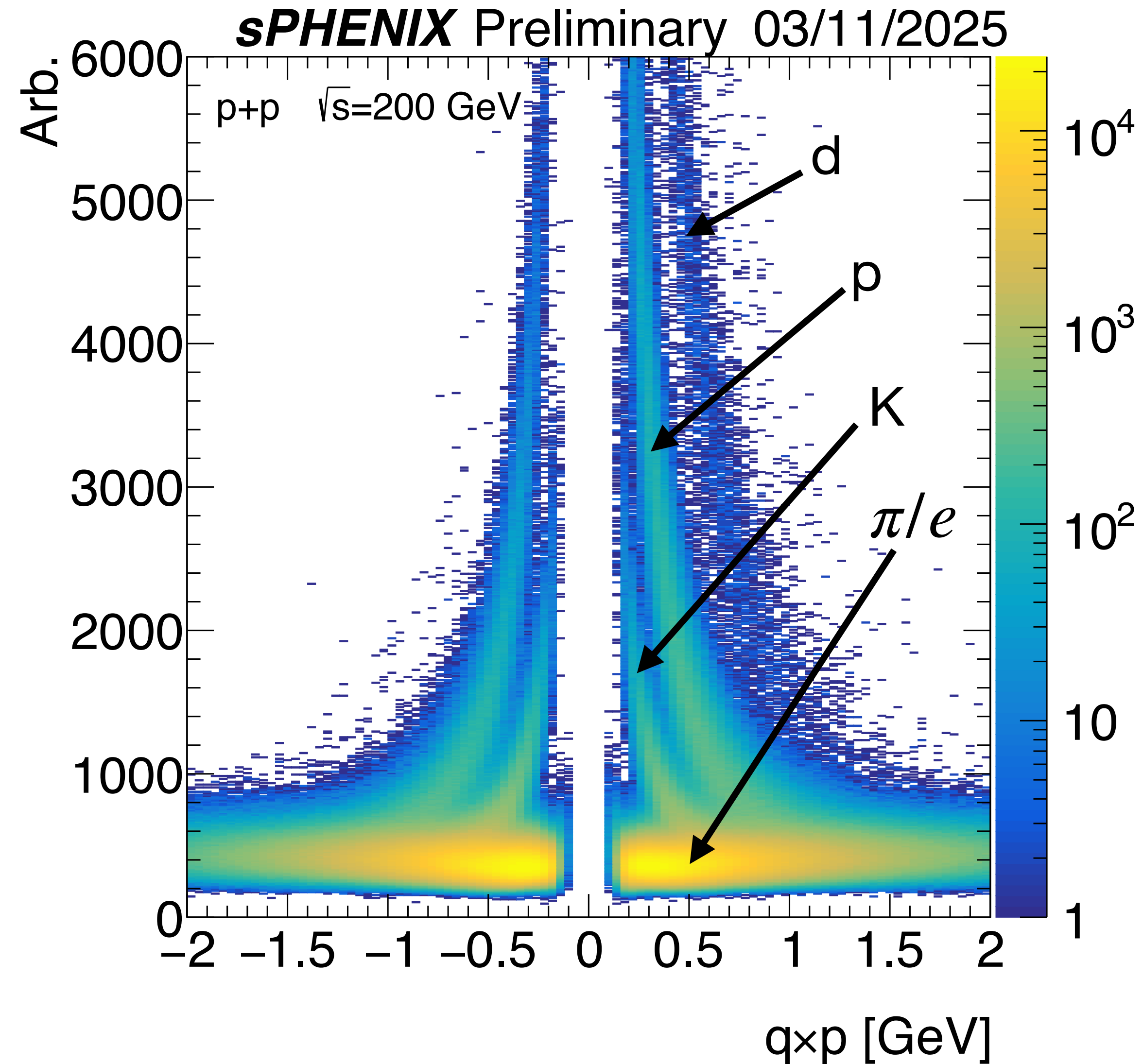
[Virgile Mahaut (EIC Workshop), sPH-CONF-COLDQCD-2025-01]



- Transverse single-spin asymmetry (TSSA) measured for π^0 and η mesons with $\gamma\gamma$ decay over wide rapidity
- Compatible with zero and agreement with previous PHENIX results (35% of total lumi. used for sPHENIX)

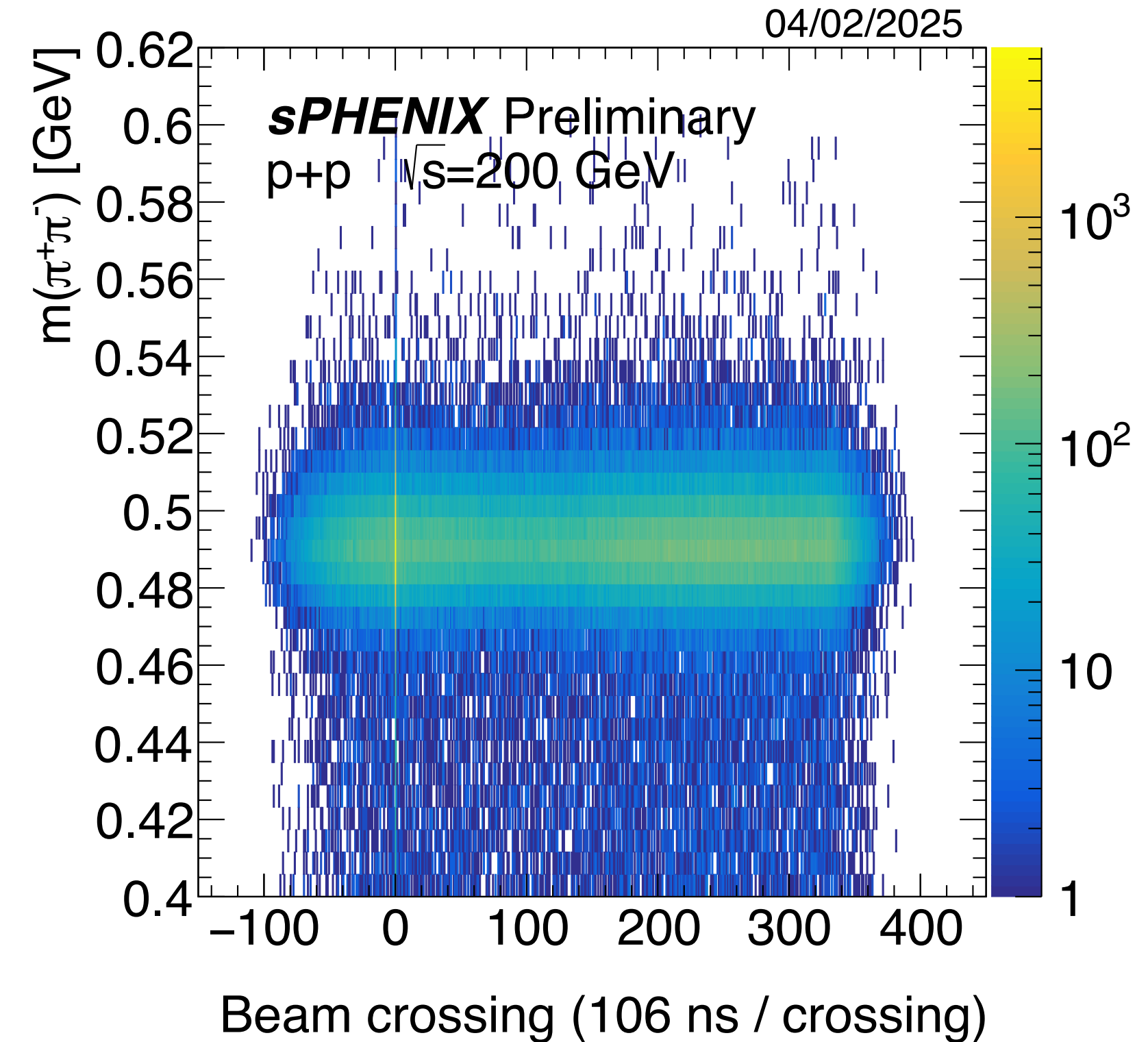
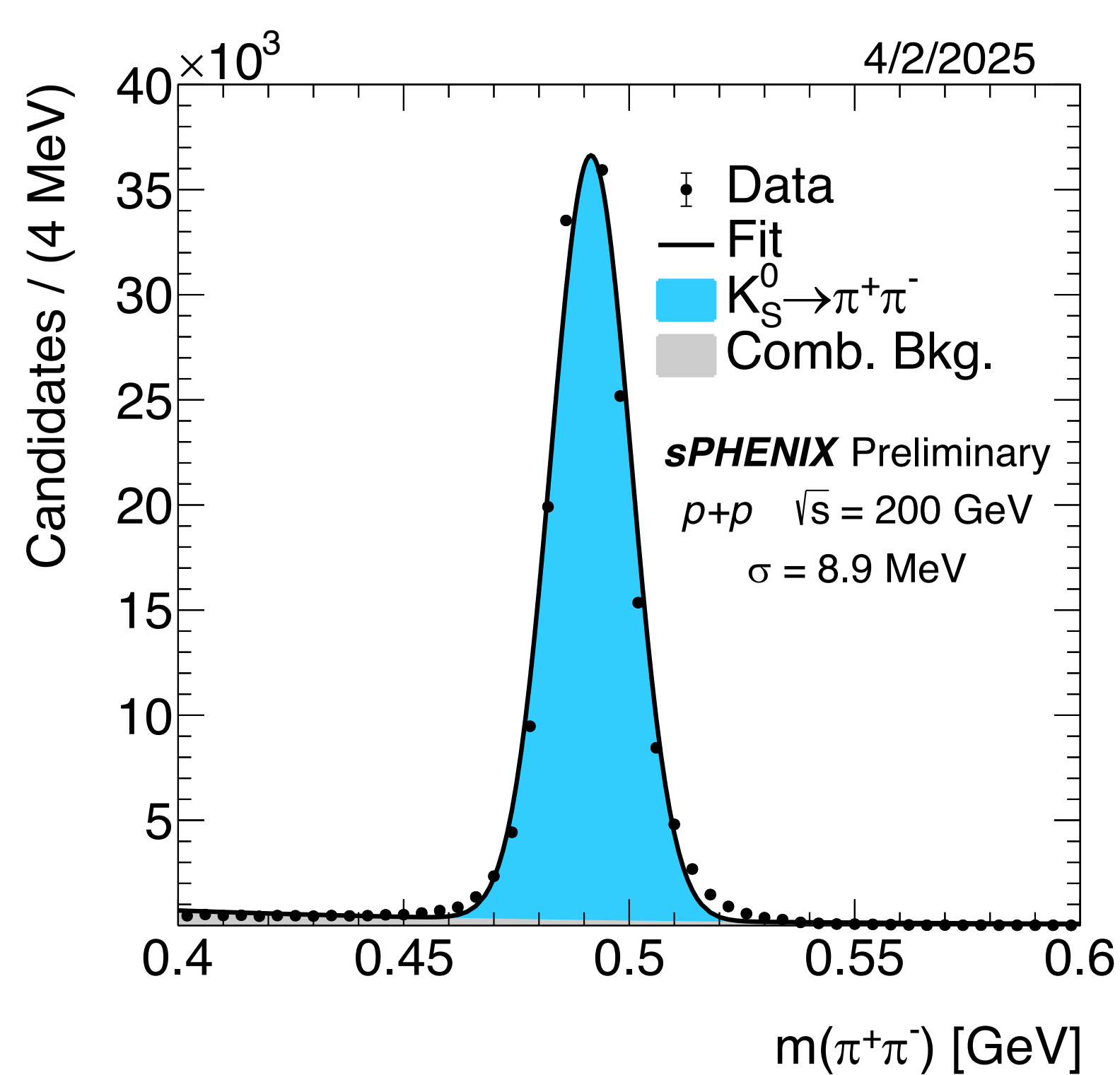
sPHENIX Tracking Performance



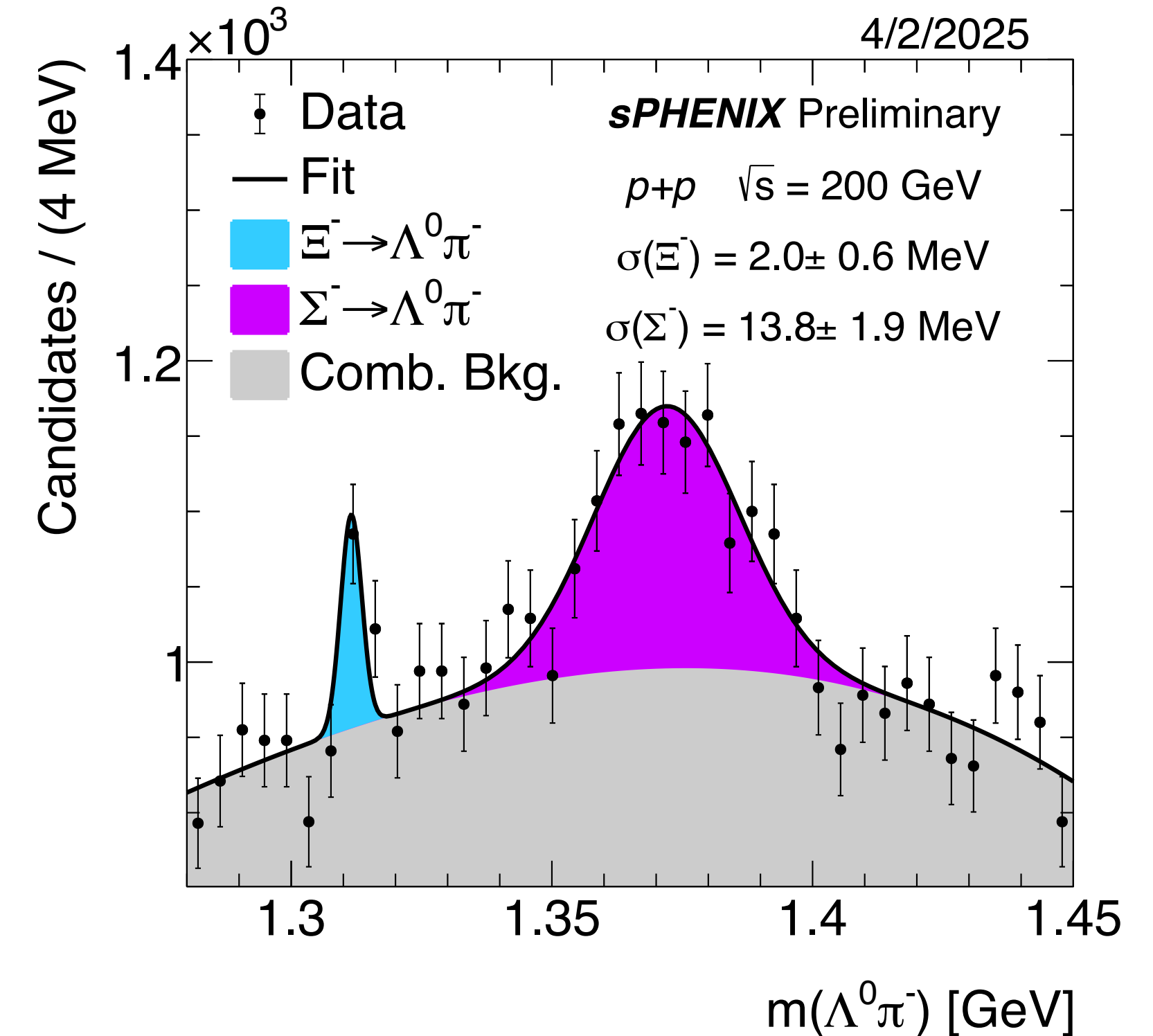
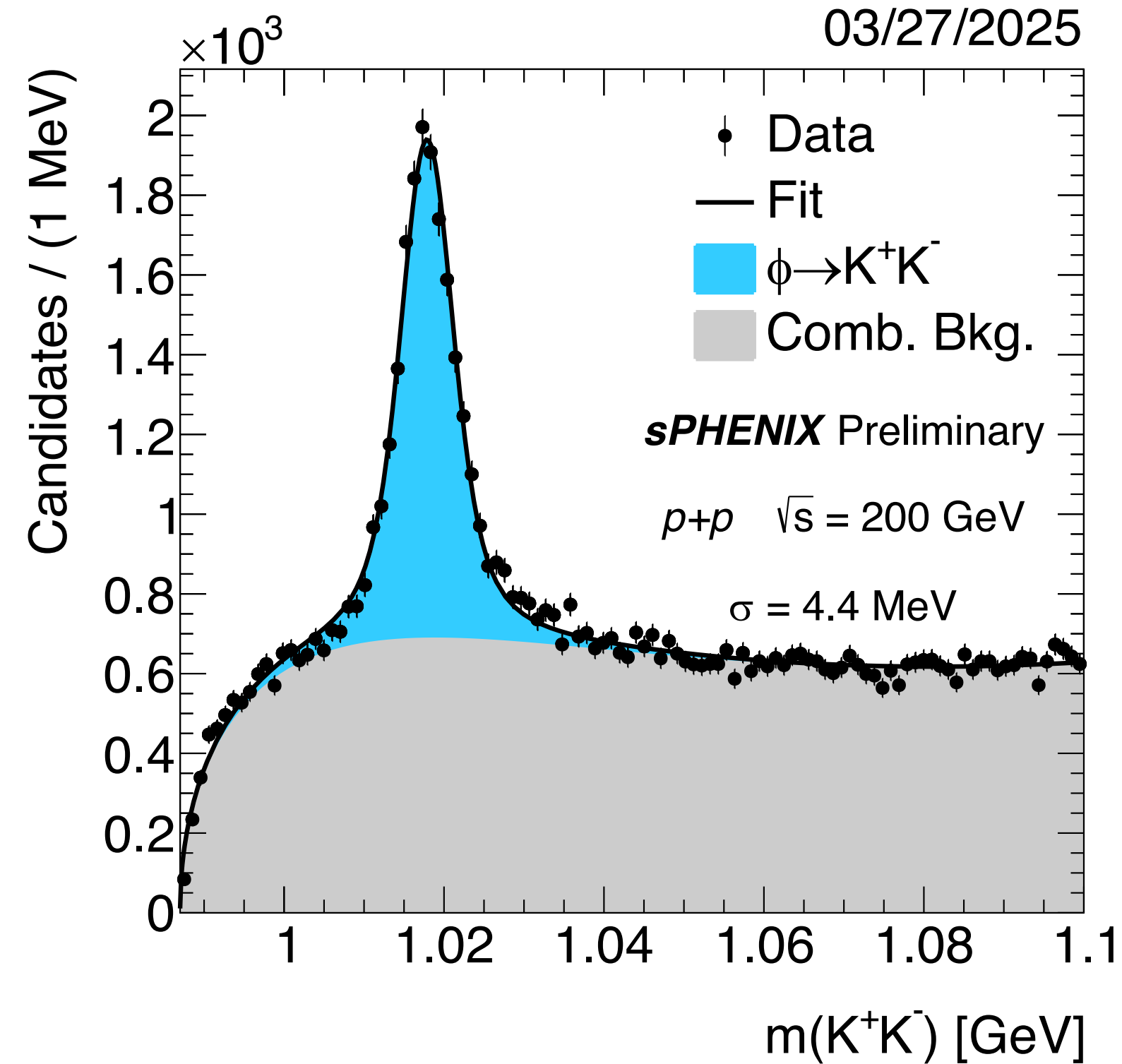
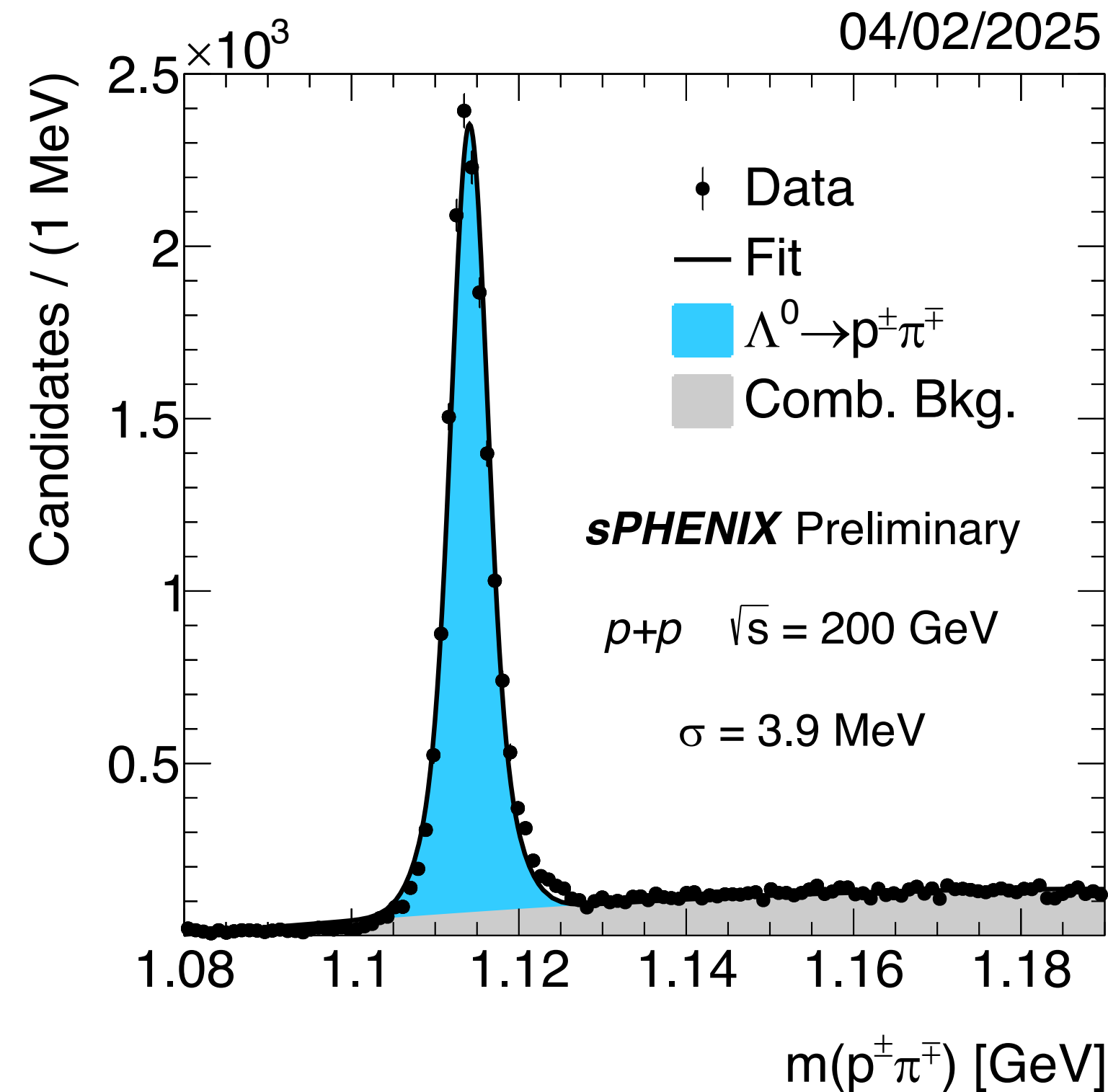


Particle Identification with TPC

- PID with dE/dx & momentum from TPC
 - Although not designed for PID separation
- Used for improving signal purity at low- p_T
- Still at early stage of full calibration plans



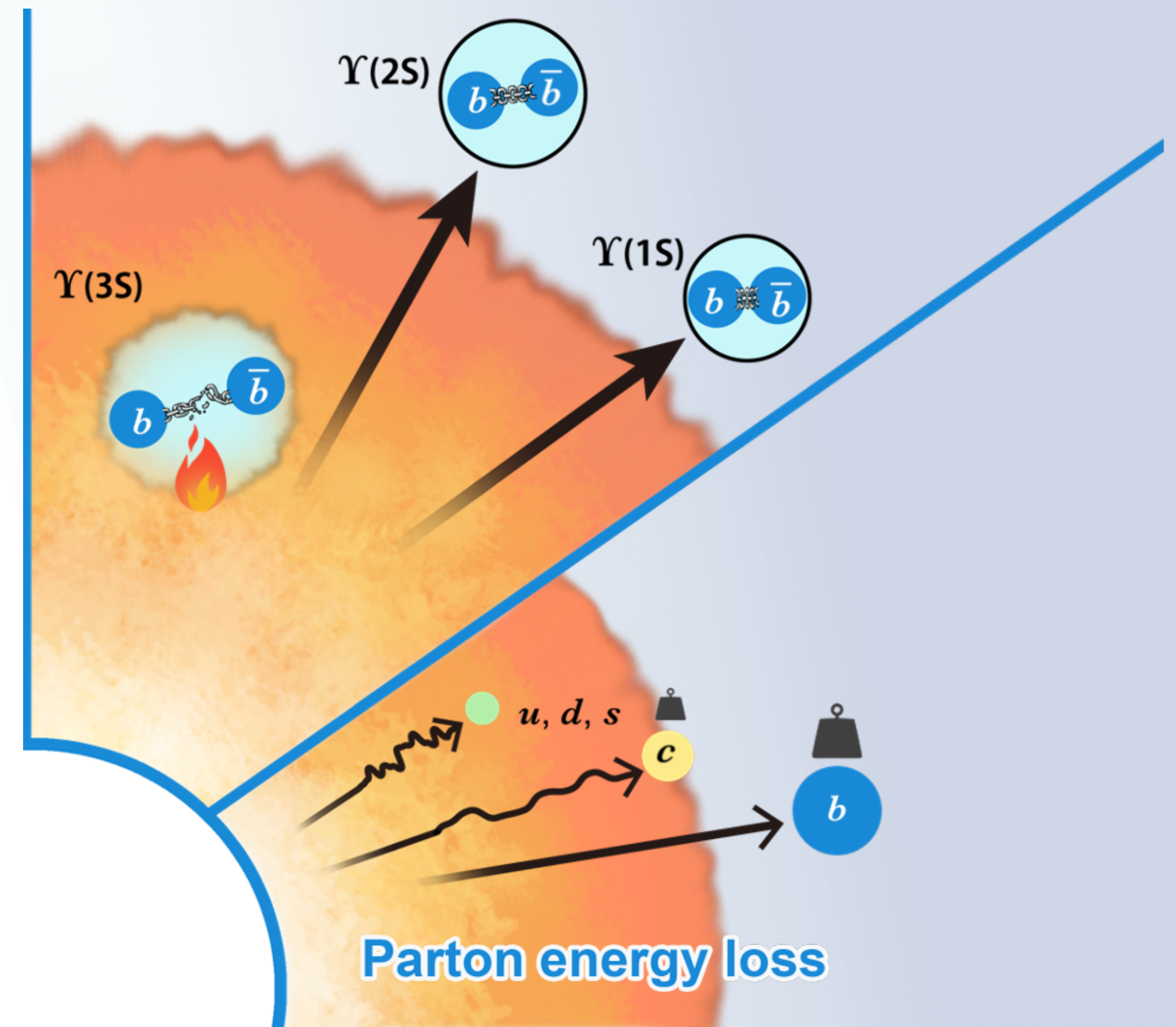
- sPHENIX streaming readout for trackers → Recorded ~200 kHz of unbiased p+p collisions
- Clear K_S^0 mass peak observed with two pion decay channel
- Mass peak consistent for all beam crossing : Successful reconstruction of streaming readout

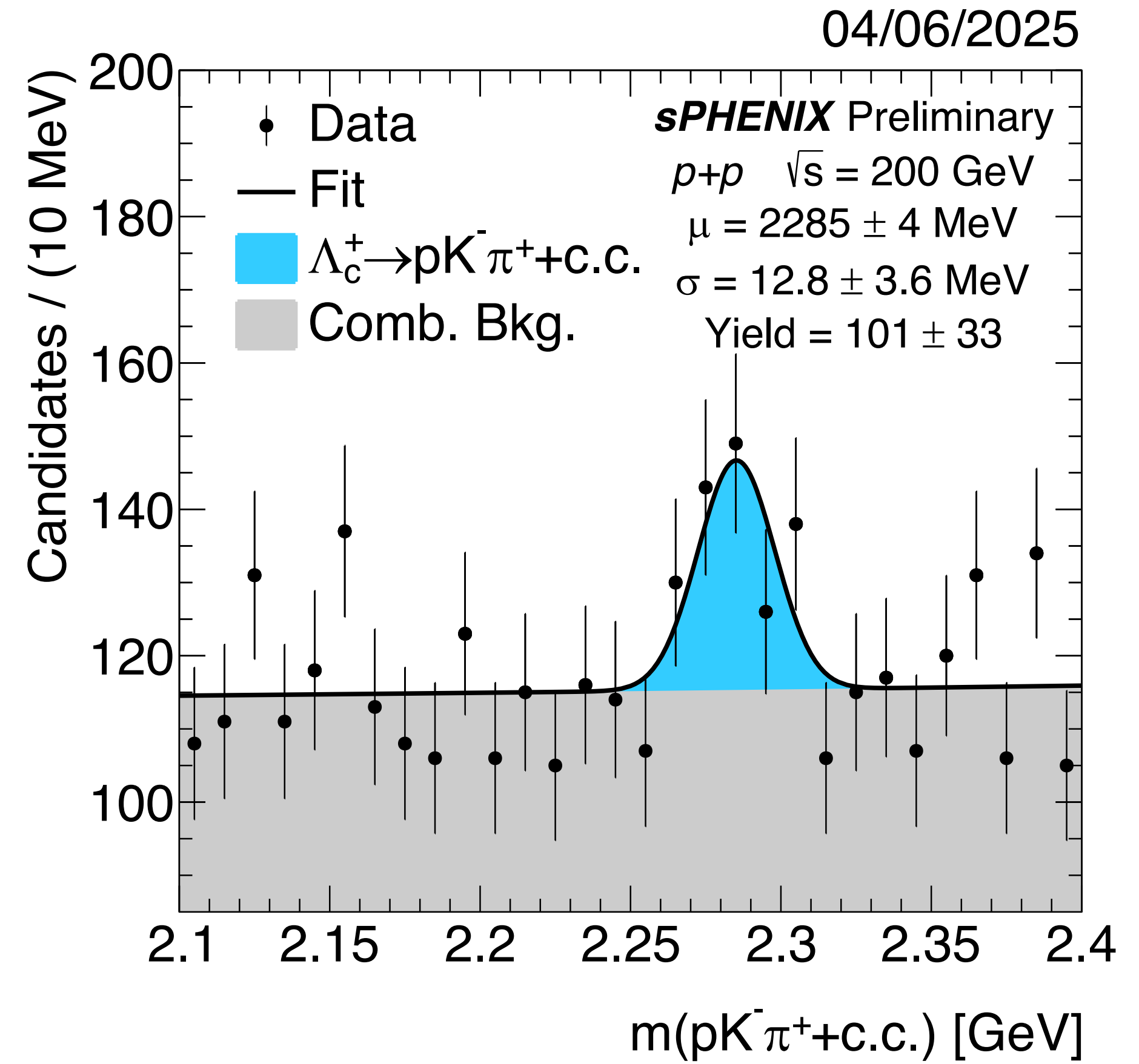
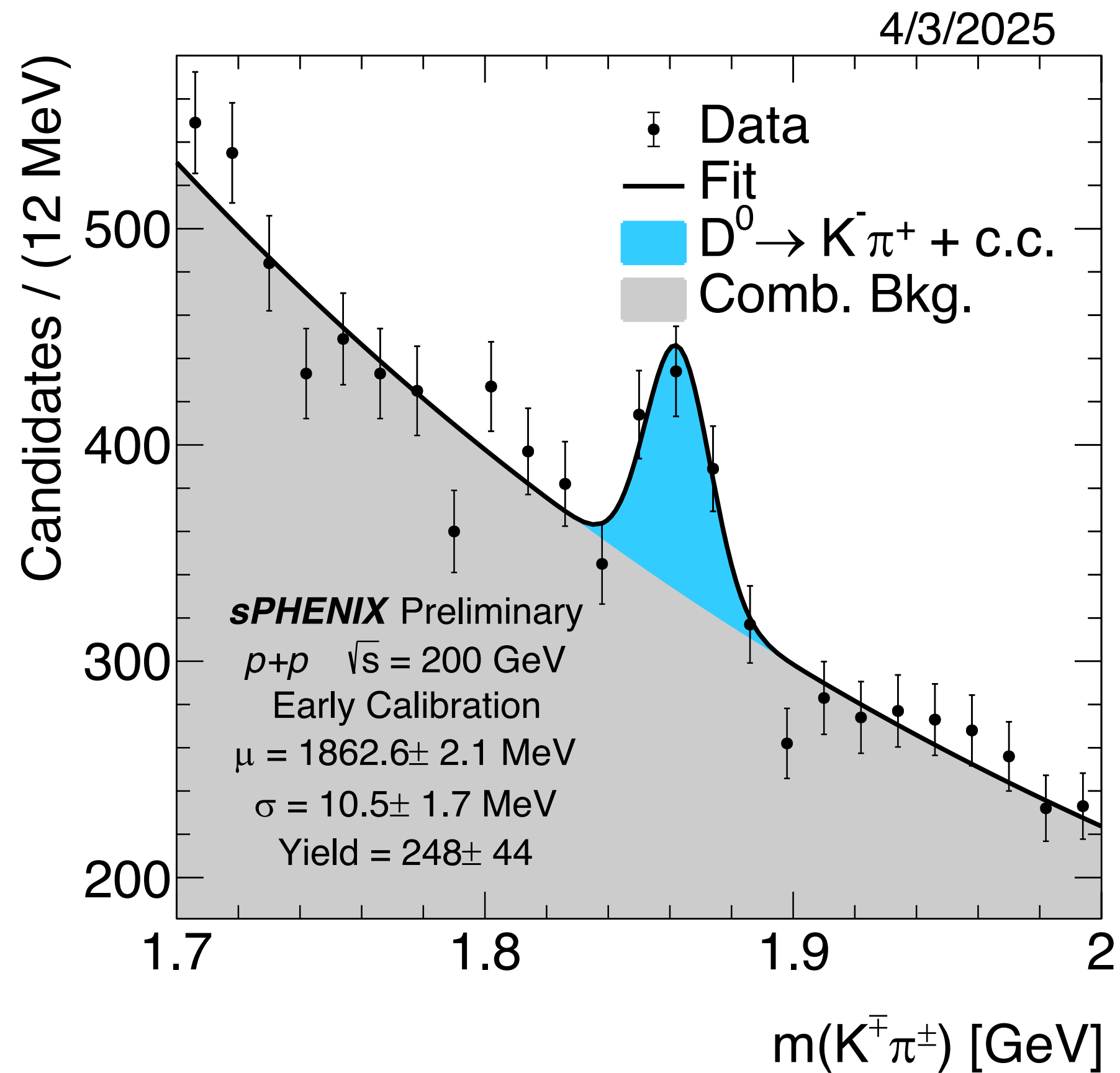


- Clear peaks visible for various hadrons including long-lived resonances decay channels
- Plots represent only 1h of data taking with early calibration!
→ Expect precision measurements with full statistics & final calibration

Tracking → Heavy Flavor / Quarkonia

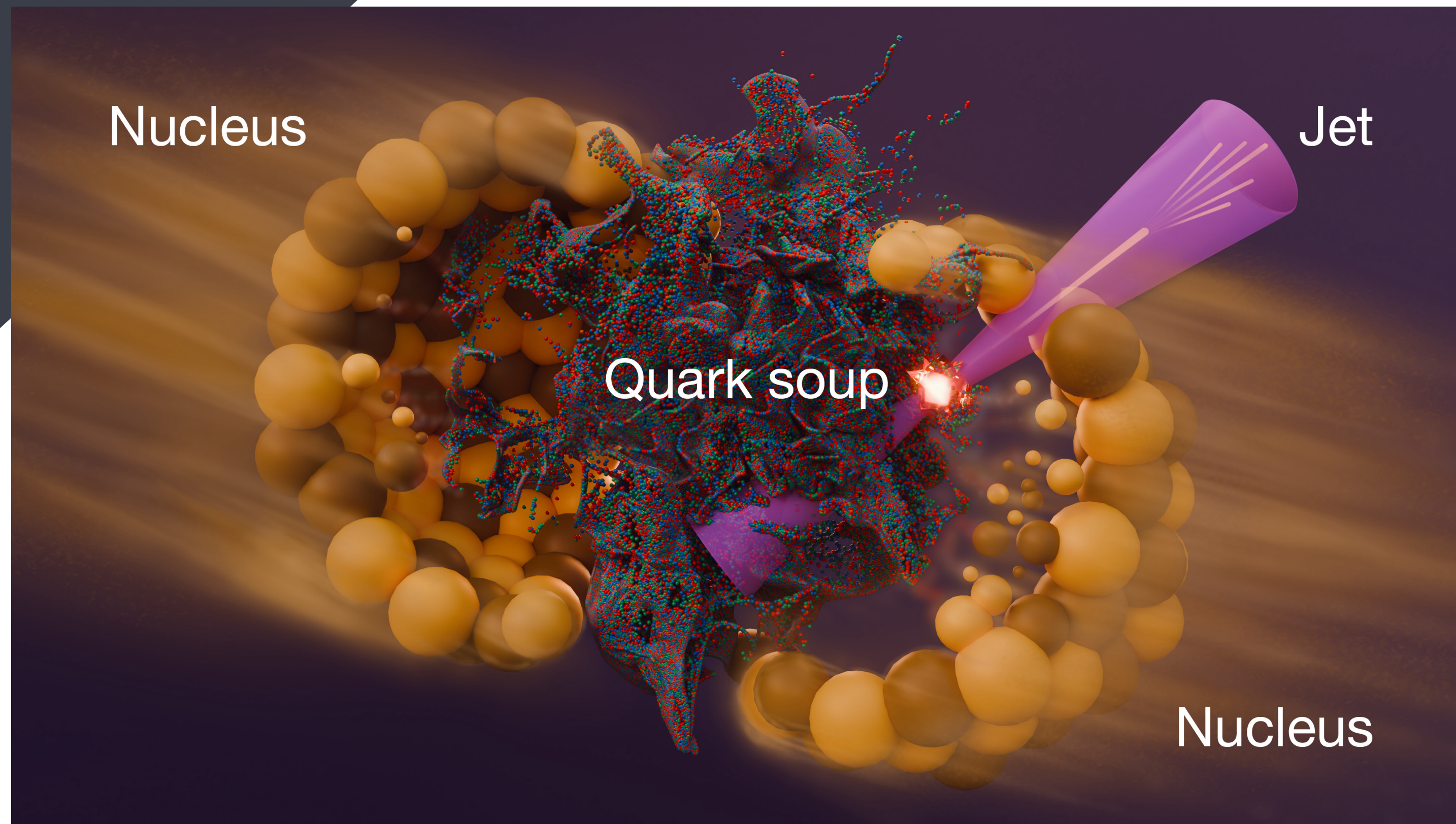
- **Shorter** medium evolution at RHIC energies
- $m_Q \gg \Lambda_{\text{QCD}}/T_{\text{QGP}}$
 - Production calculable in perturbative QCD (even down to $p_T = 0$ GeV)
 - Negligible contribution from thermal production
 - Experience whole space-time evolution
- **HF** enable the understanding of drag / diffusion coefficients, in-medium interactions etc.
- **QQ** for deconfinement studies in heavy ion collisions
 - Probing transport coefficients, heavy-quark potential, (p)NRQCD formalism etc.

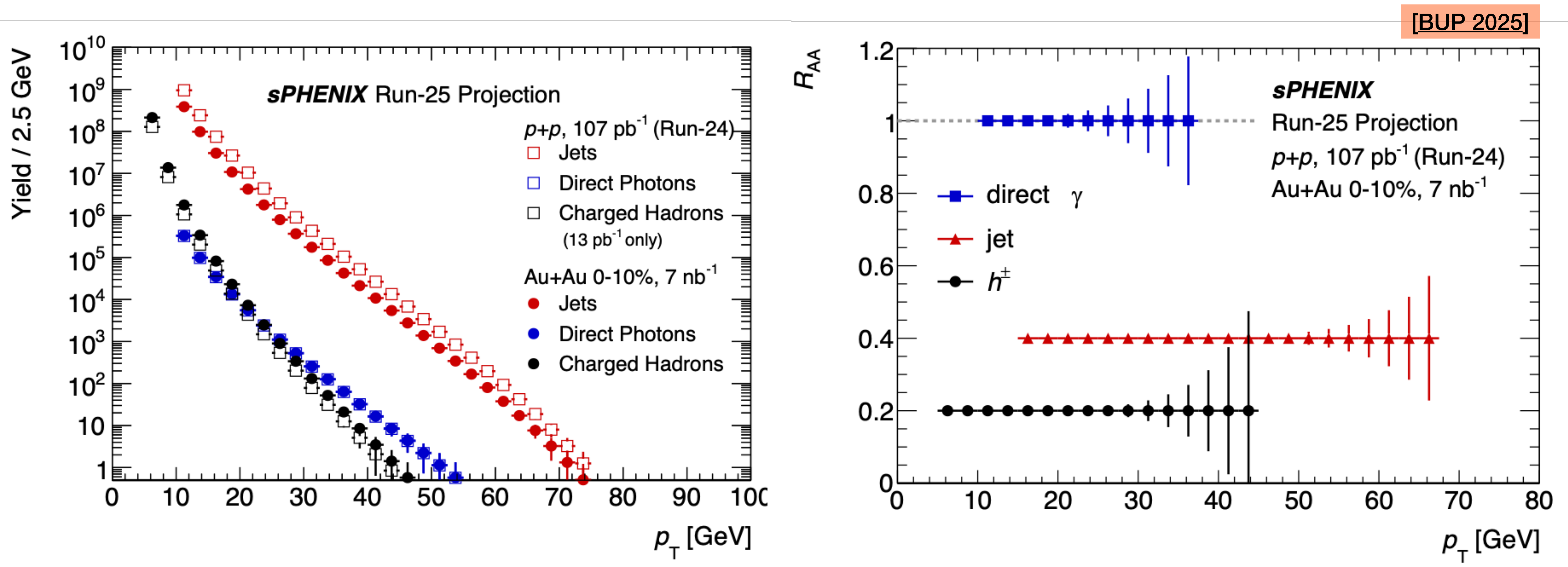




- D^0 and Λ_c signal observed with statistical significance using only ~ 1 h of data taking
- First measurement of Λ_c at RHIC in p+p collisions!

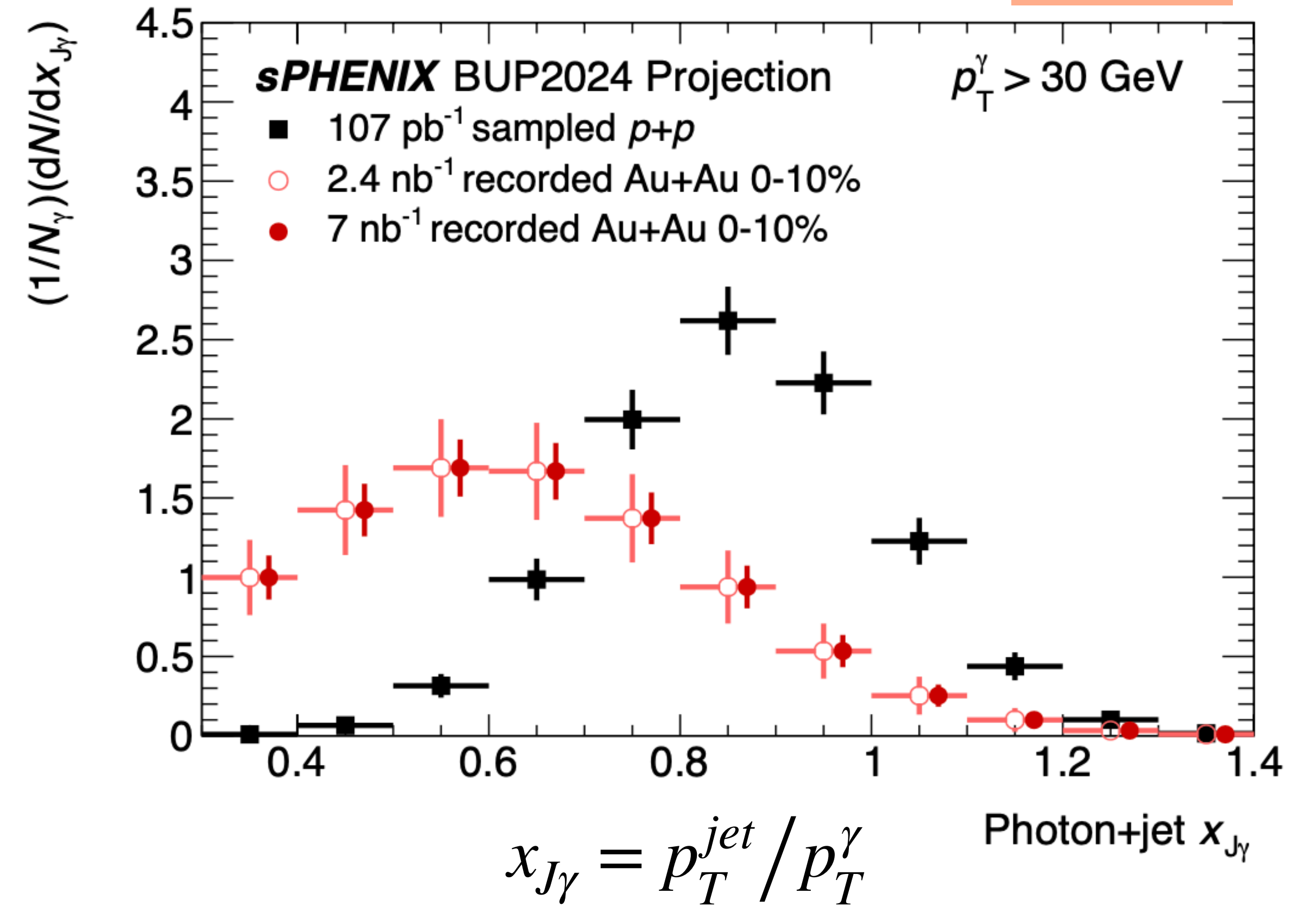
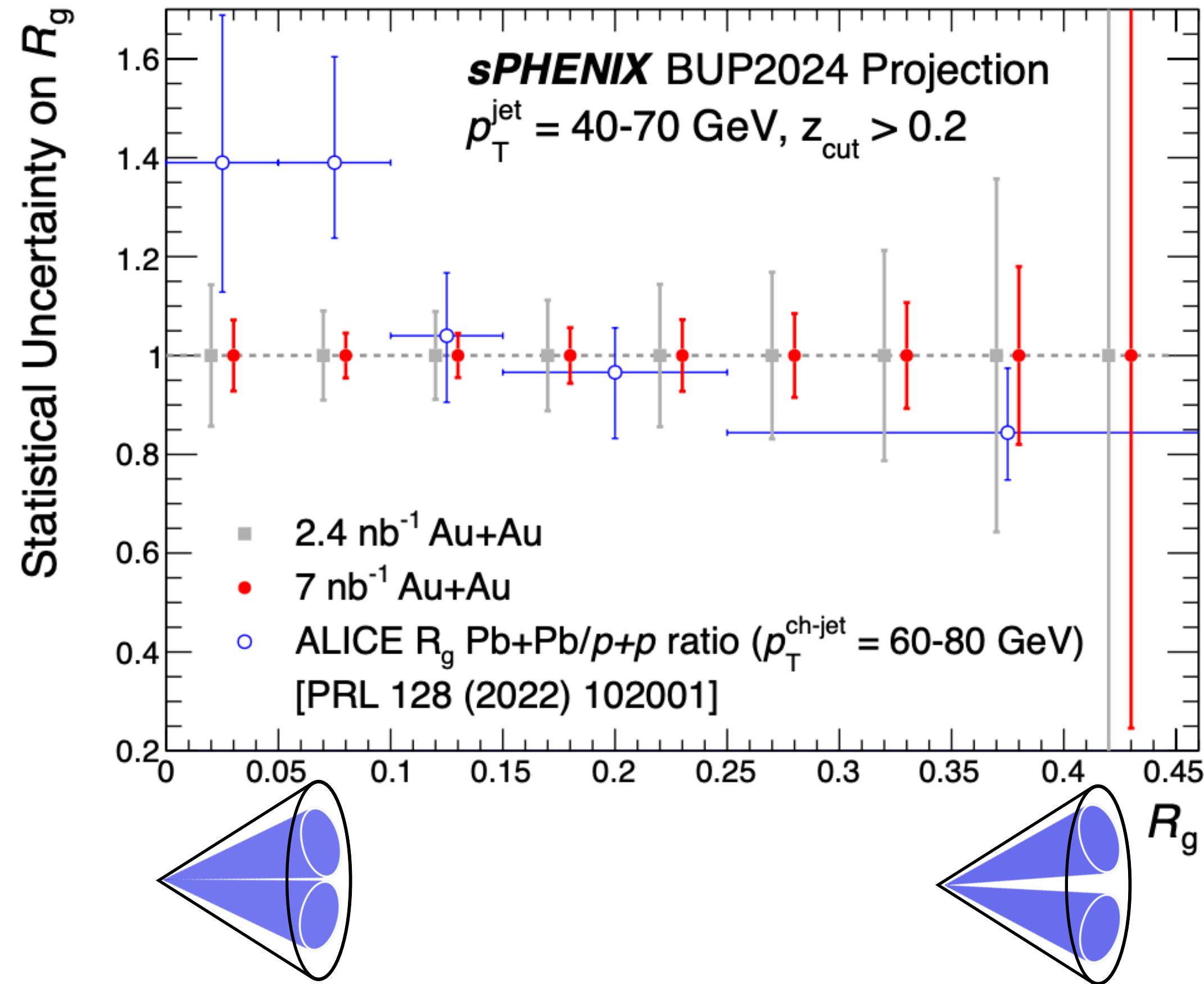
Physics Projections With Future Data Taking





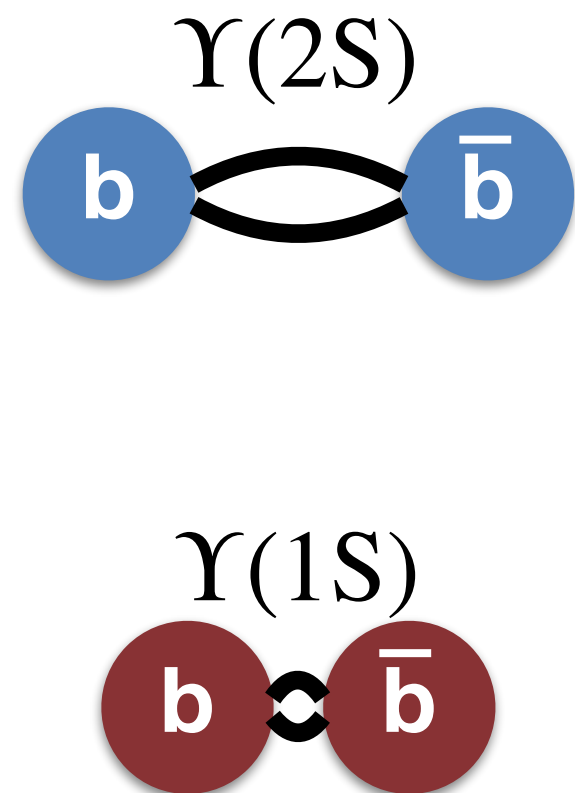
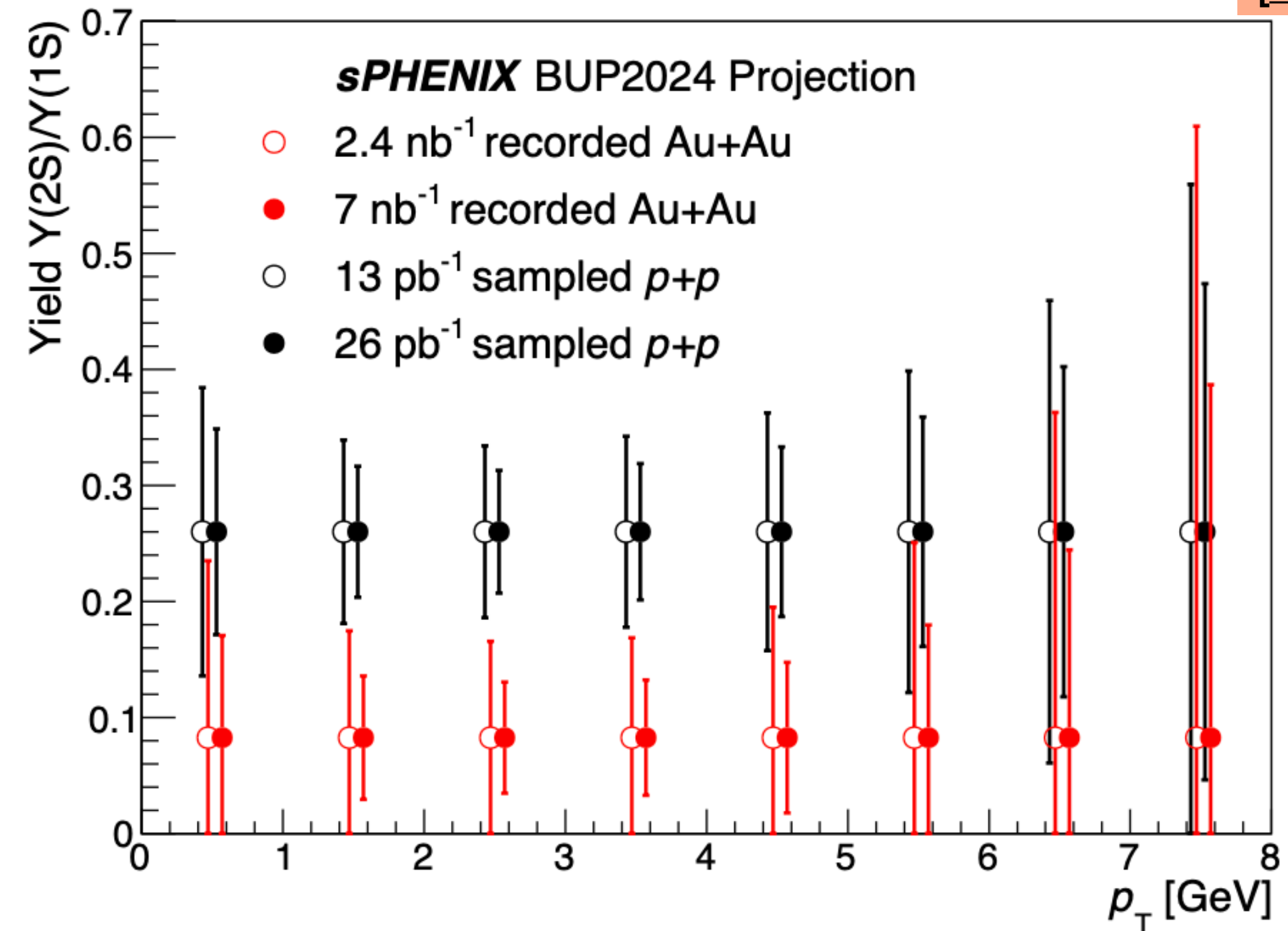
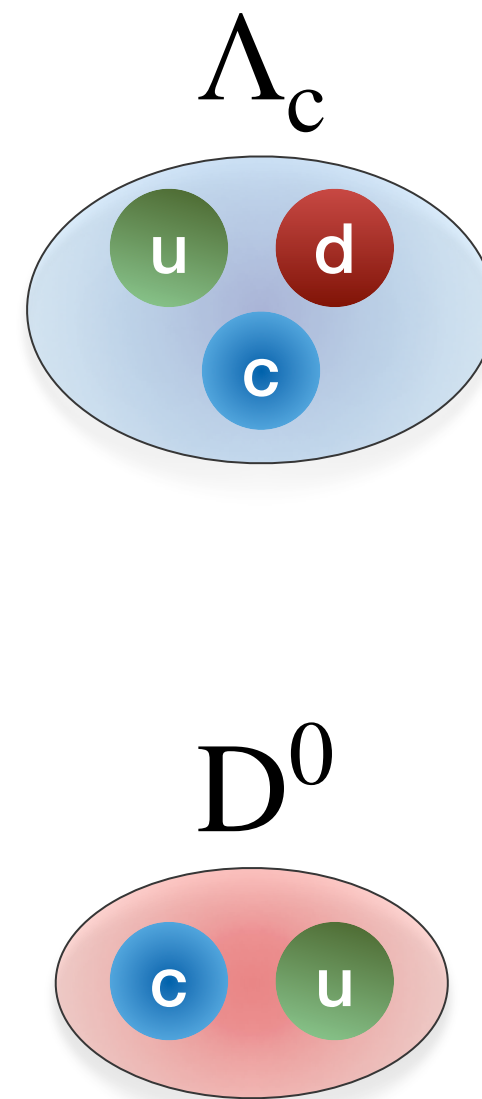
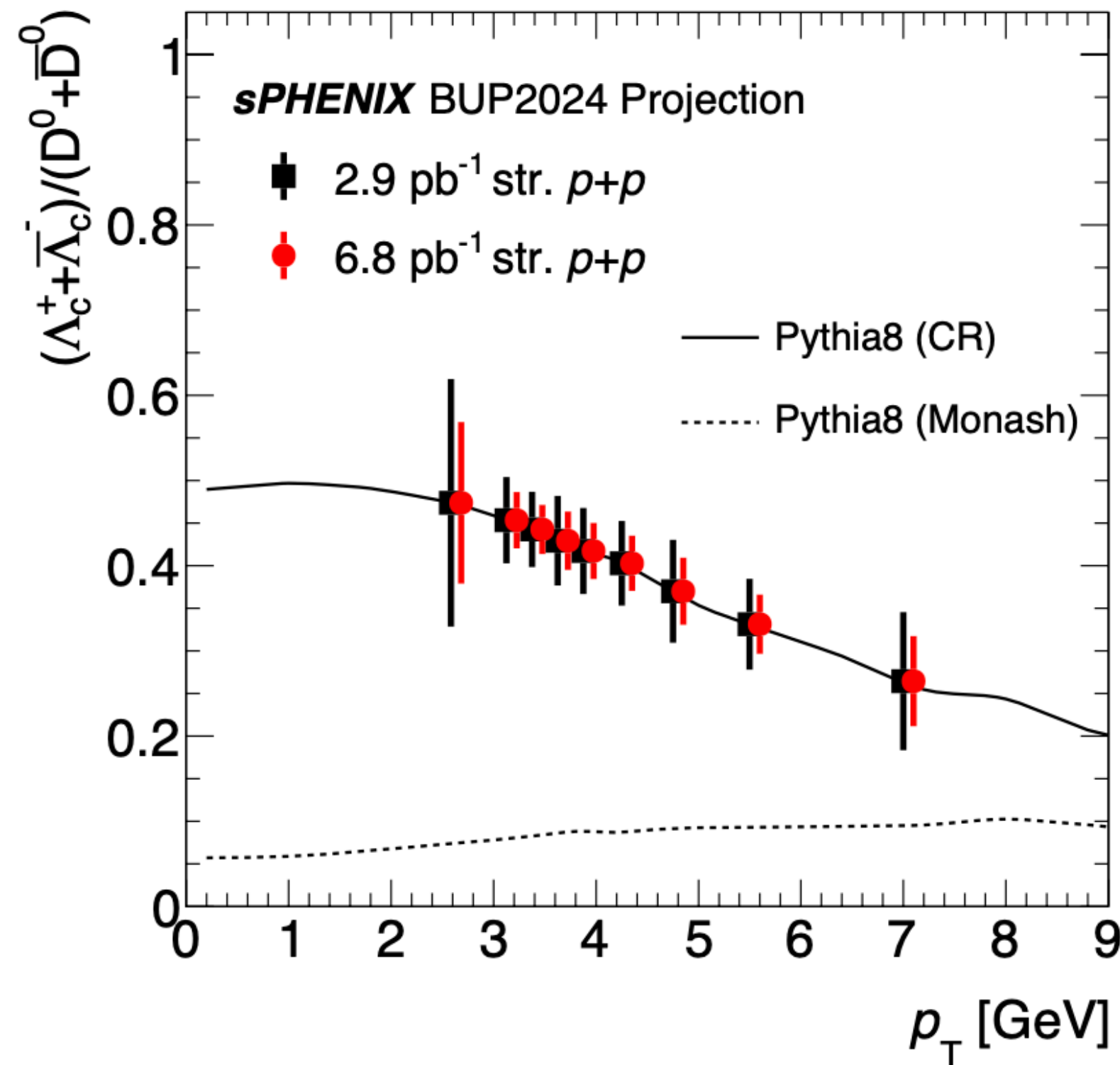
- PAC24 Report : “sPHENIX collects at least 7/nb of data as the highest priority for Run 25”
- Unprecedented kinematic reach at RHIC energies with sPHENIX!

[BUP 2025]



- Importance of having full 7 nb⁻¹ for precision jet substructure measurements

[BUP 2025]



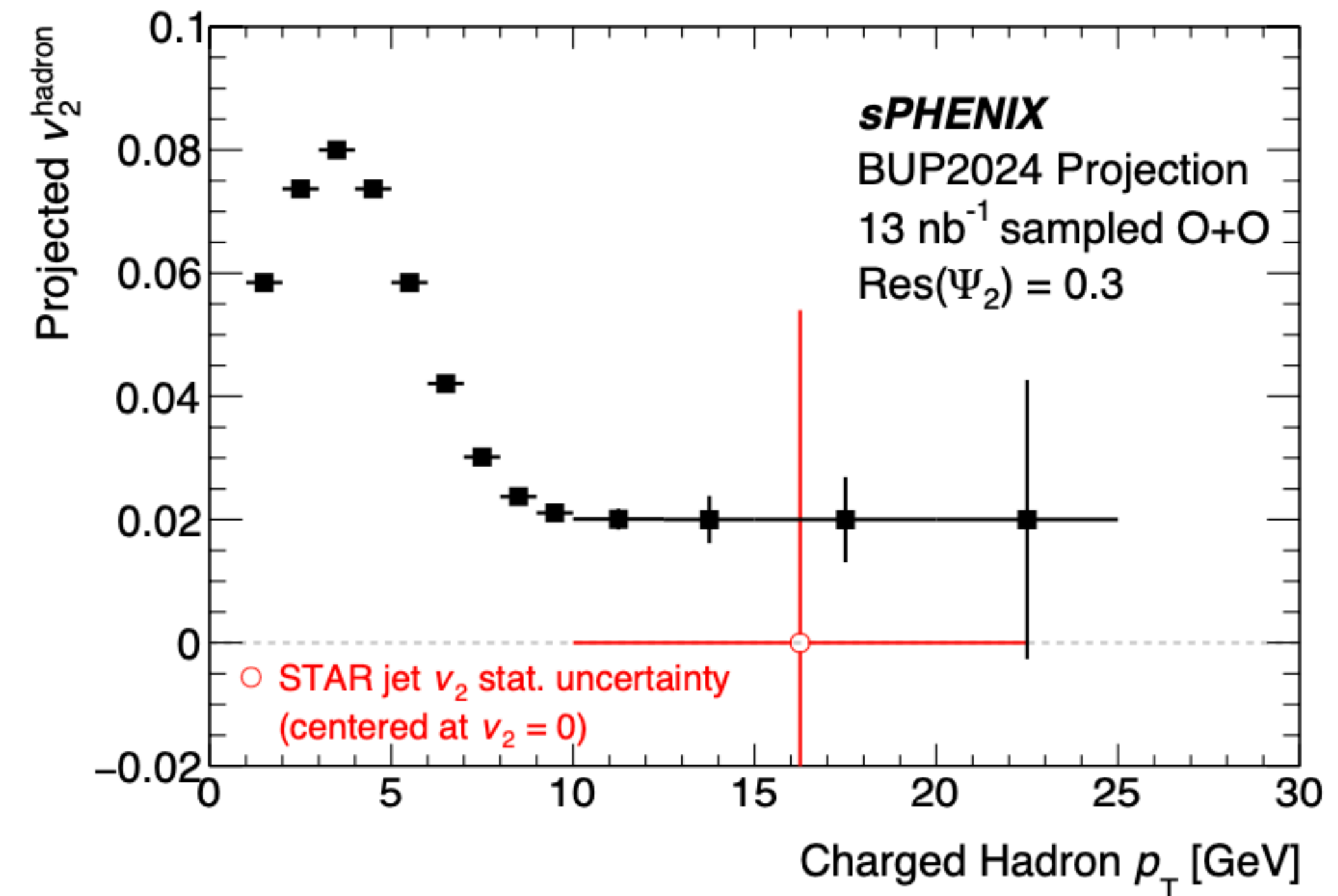
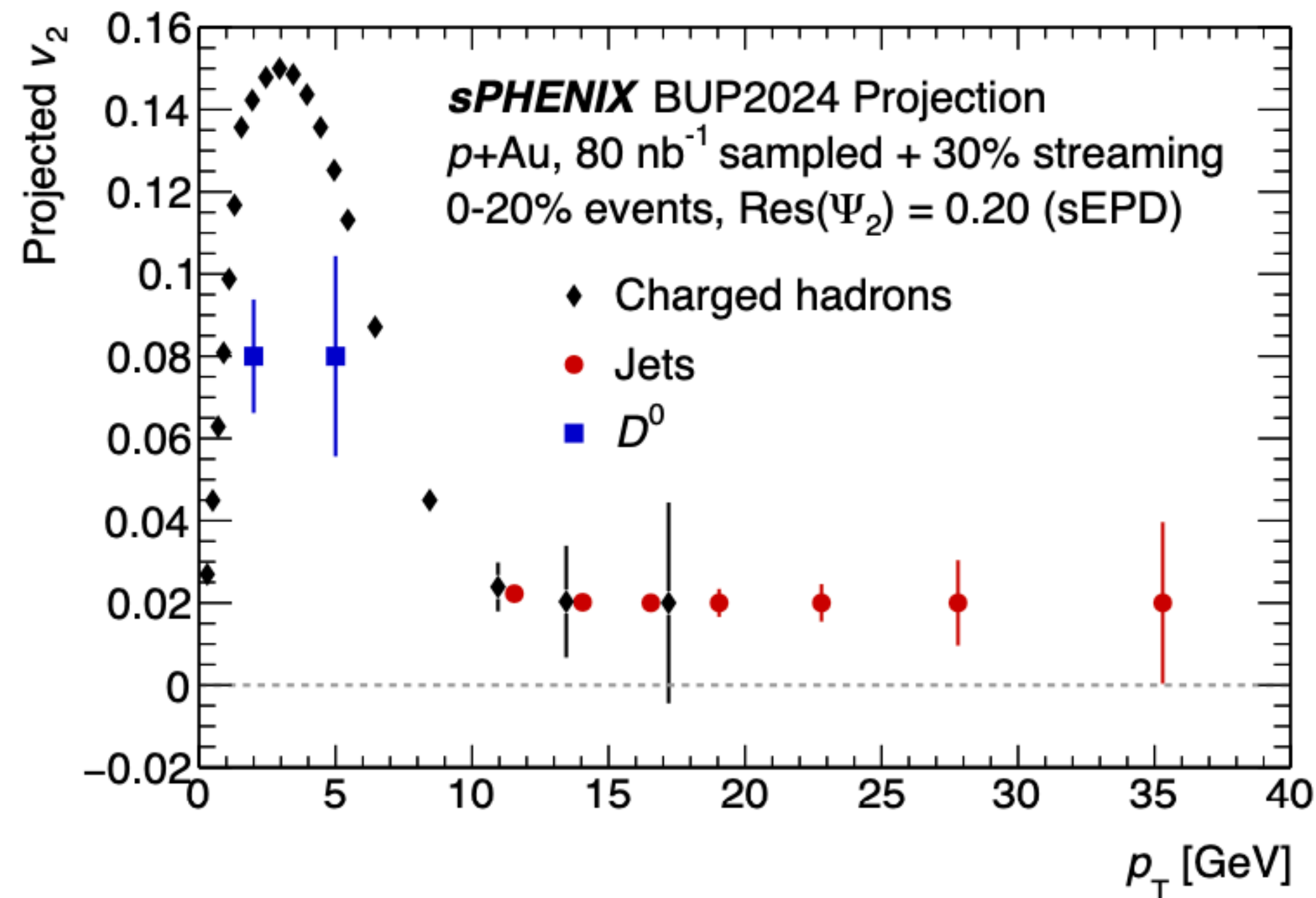
- PAC24 Report : “The PAC sees all three of these proposed runs as fully aligned with RHIC’s core scientific mission, and in fact as key elements of completing that mission”
- Crucial for **Upsilon** physics program, **HF** production/hadronization, HF-jets / HF-spin

Projections for p+Au and O+O

~5 weeks of p+Au

~2 weeks of O+O

[BUP 2025]



- PAC24 Report : “The PAC sees all three of these proposed runs as fully aligned with RHIC’s core scientific mission, and in fact as key elements of completing that mission”
- Unique opportunity in understanding of collective behavior and characterization small systems

- Successful installation and commissioning of the sPHENIX detector
- Begin to deliver physics results already surpassing previous RHIC kinematic reach
 - sPHENIX public results : [Public Page](#)
- Requirements to complete RHIC's science mission (2023 Nuclear Science Long Range Plan)
 - At least **7 nb⁻¹ of Au+Au**
 - Additional **13 pb⁻¹ of p+p** for the **Upsilon** program
 - **p+Au** and **O+O** provide unique opportunity to address key questions in small systems
 - Valuable connection towards EIC physics

sPHENIX at 2025 AUM



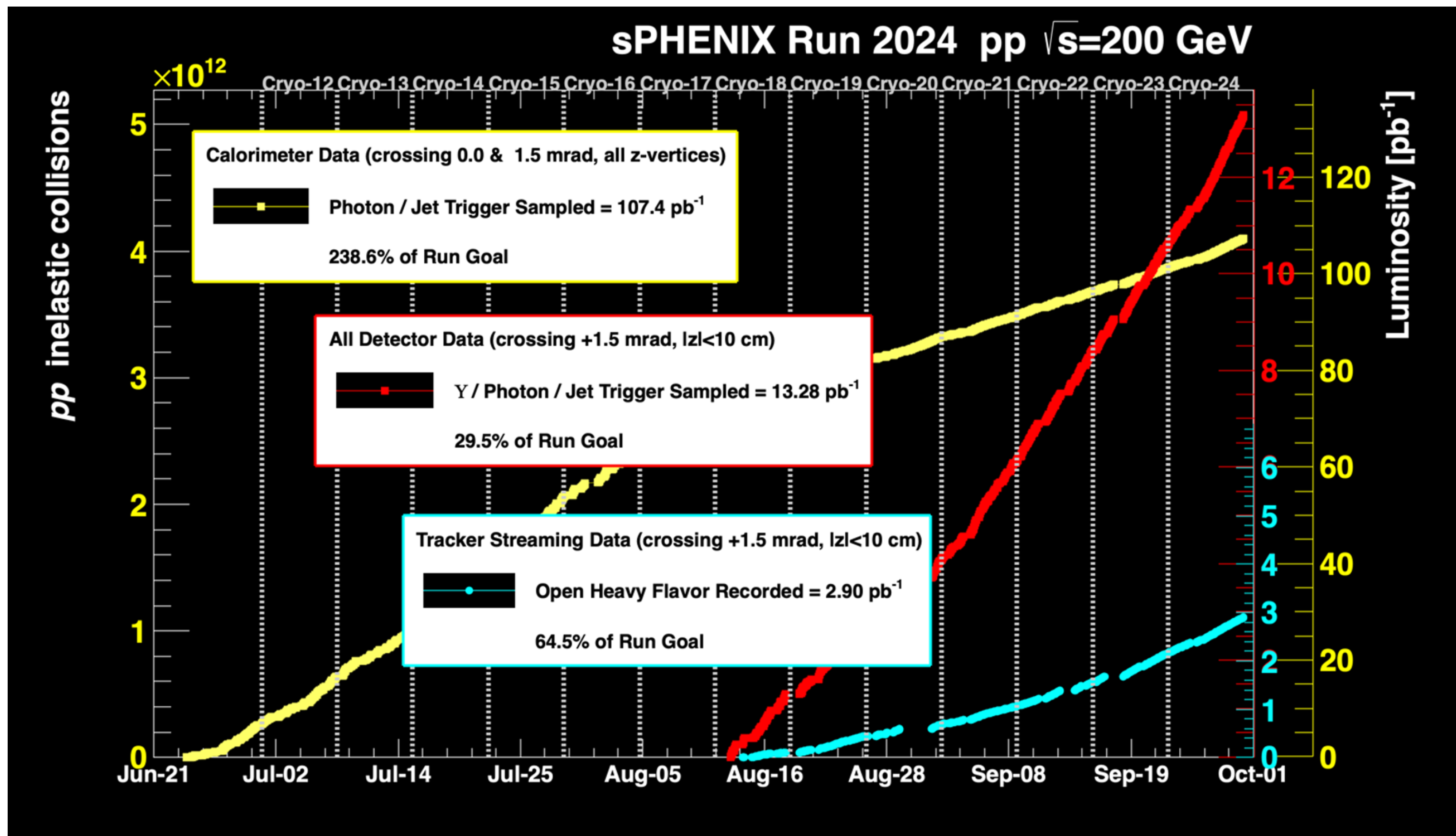
List of talks

1. Rosi Reed “sPHENIX Run 25 Report”
2. Daniel Lis “High-pT physics in sPHENIX”
3. Alexander Patton “sPHENIX Heavy Flavor Overview”
4. Virgile Mahaut “The Cold QCD Program at sPHENIX”

List of posters

1. Yuko Sekiguchi “sPHENIX measurement of long-range two-particle correlations in high-multiplicity p+p collisions”
2. Tanner Mengel “Underlying event fluctuations and jet background in 200 GeV Au+Au collisions with the sPHENIX detector”
3. Mariia Mitrunkova “sPHENIX Alignment of the TPC Tracking Detector”
4. Chenxi Ma “sPHENIX Armenteros-Podolanski plot”
5. Itsuka Omae “The study of v_2 vs. multiplicity with ZDC categorization at 200GeV in AuAu at RHIC”
6. Ryotaro Koike “Sub-bunch-crossing Time Resolution of the sPHENIX Intermediate Silicon Tracker”
7. Takahiro Kikuchi “Measurement of the MBD Cross Section in Run24 Au+Au Collisions in the sPHENIX Experiment”
8. Jaein Hwang “sPHENIX Performance of the Intermediate Si Tracker”
9. Shuhang Li “Measurement of isolated prompt photons in p + p collisions at 200GeV with the sPHENIX detector”

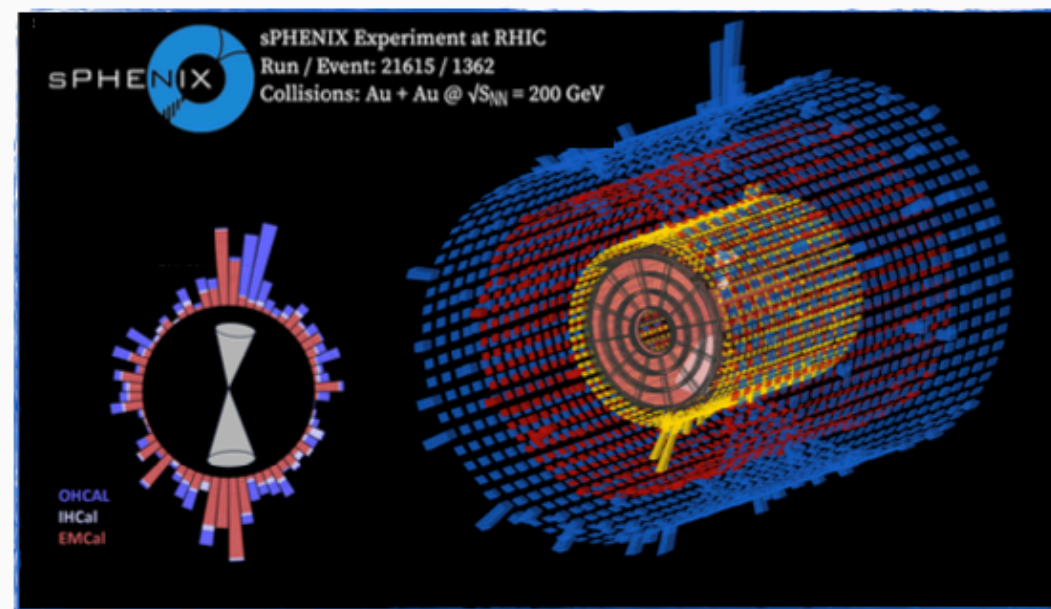
Back-up



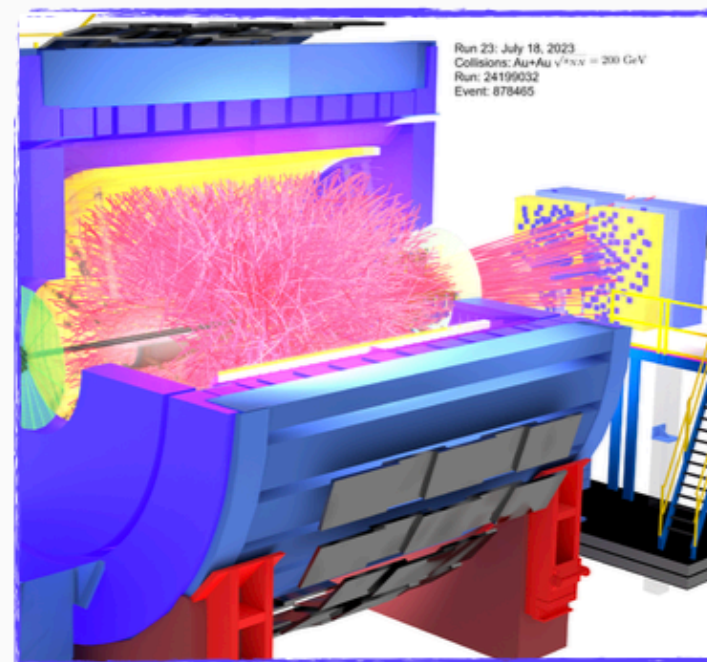
Highlights in 2025 AUM for unique opportunities in p+Au

[Riccardo Longo (Wed 21 May) : Jets at the LHC]

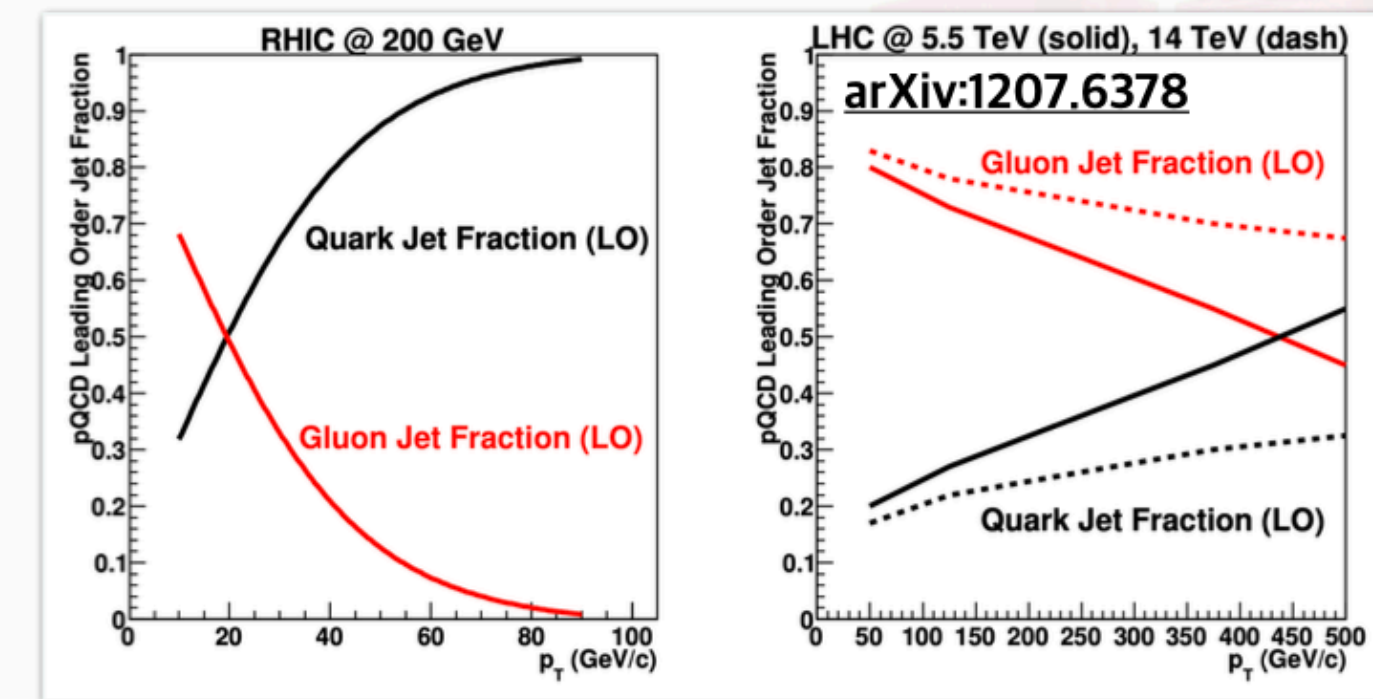
A last, and personal, opinion



After outstanding efforts, sPHENIX is now shining!



STAR Forward Upgrade is a major leap in the experiment capabilities for p+A



- Jets @ RHIC have very different q/g mixing compared to LHC
→ Ideal to study parton energy loss in a complementary regime
- Great opportunities are available for cold nuclear matter studies, color-fluctuations measurements, low-x investigations in p+Au... it would be invaluable to have a p+Au run before RHIC shutdown!
- I am firmly convinced we would regret not taking this opportunity

Riccardo Longo

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21st May 2025