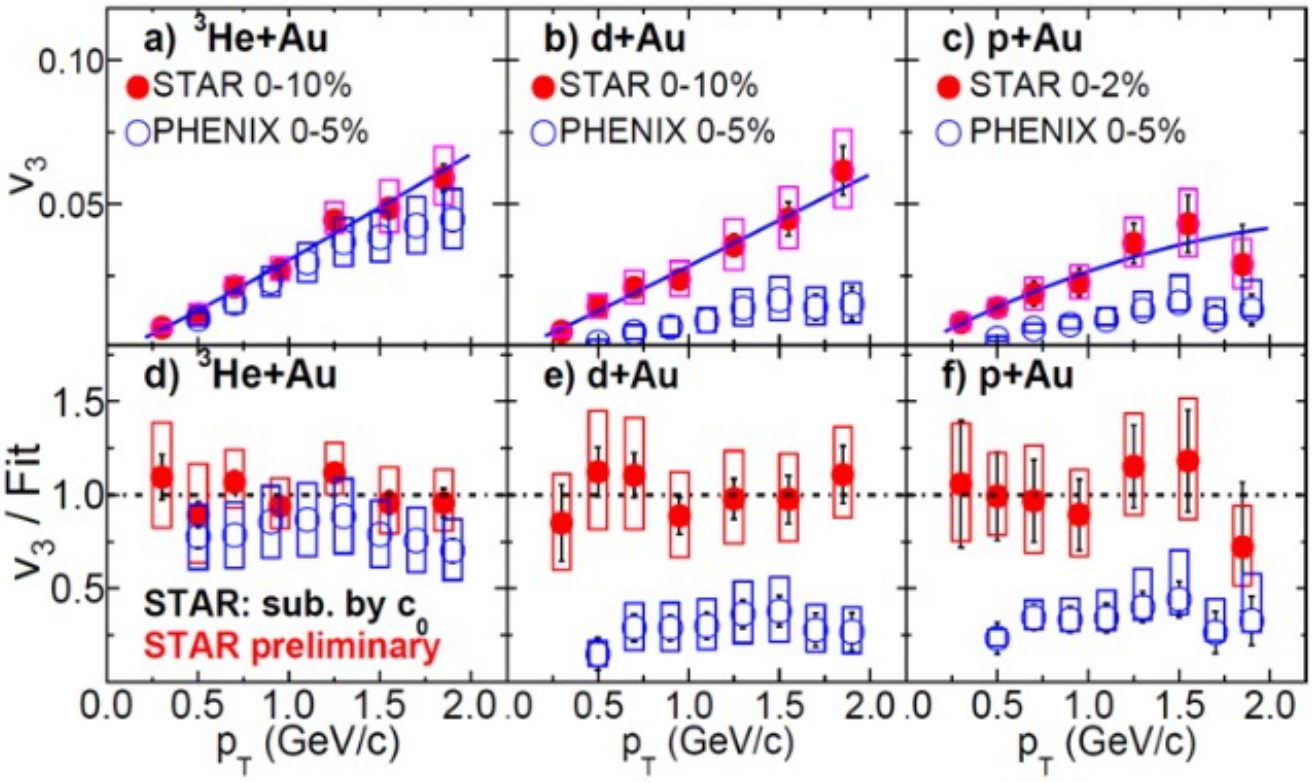
Report from Task Force on Small Systems Flow

James Dunlop

Starting Point



STAR QM2019

Quark Matter 2019: STAR preliminary results in conflict with PHENIX published results

Conflict is in v_3 in the 2 smallest systems, p+Au and d+Au

In response to 2020 PAC recommendation(s), B. Mueller formed task force to investigate apparent discrepancy

Membership:

Constantin Loizides, Oak Ridge National Laboratory
Jean-Yves Ollitrault, Institute of theoretical Physics, Saclay, France
Sergei Voloshin, Wayne State University

Methodology

- Task force invited collaborations to present current status and answer detailed questions
  - Leads from collaborations identified, spokespeople also invited
    - PHENIX: R. Belmont and J. Nagle
    - STAR: S. Huang and R. Lacey
  - Meetings as needed for further exploration
    - First meeting Dec. 2020, prior to Initial Stages 2021
    - In 2021, B. Mueller passed on coordination of task force to JCD
    - Final meeting in April, conclusions written in May
  - Collaborations very frank and receptive to “opening their books”: Thank you!
  - Many of the conclusions are already in wide discussion in the community, driven by the new results PHENIX showed at Initial Stages (see R. Belmont’s talk)

Conclusions in a Nutshell

- In summary, there is no sign that any of the two analyses is technically wrong. We believe that all the observed differences could be ascribed to the different treatment of nonflow effects and of the flow (and non-flow) rapidity dependence.

- In conclusion, this controversy brings up useful physics questions. Resolving them will require more data, taken with upgraded STAR and the sPHENIX detectors, and probably improved methods of analysis.

Rapidity Coverage

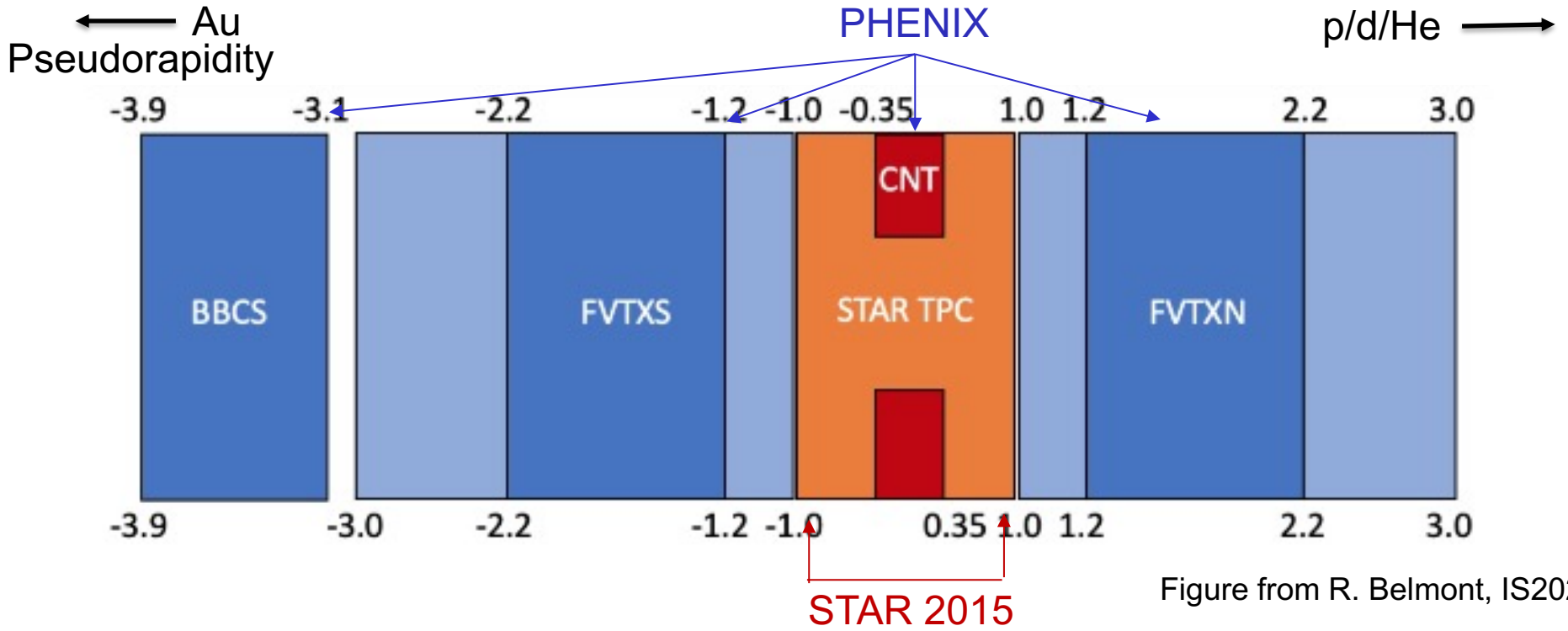
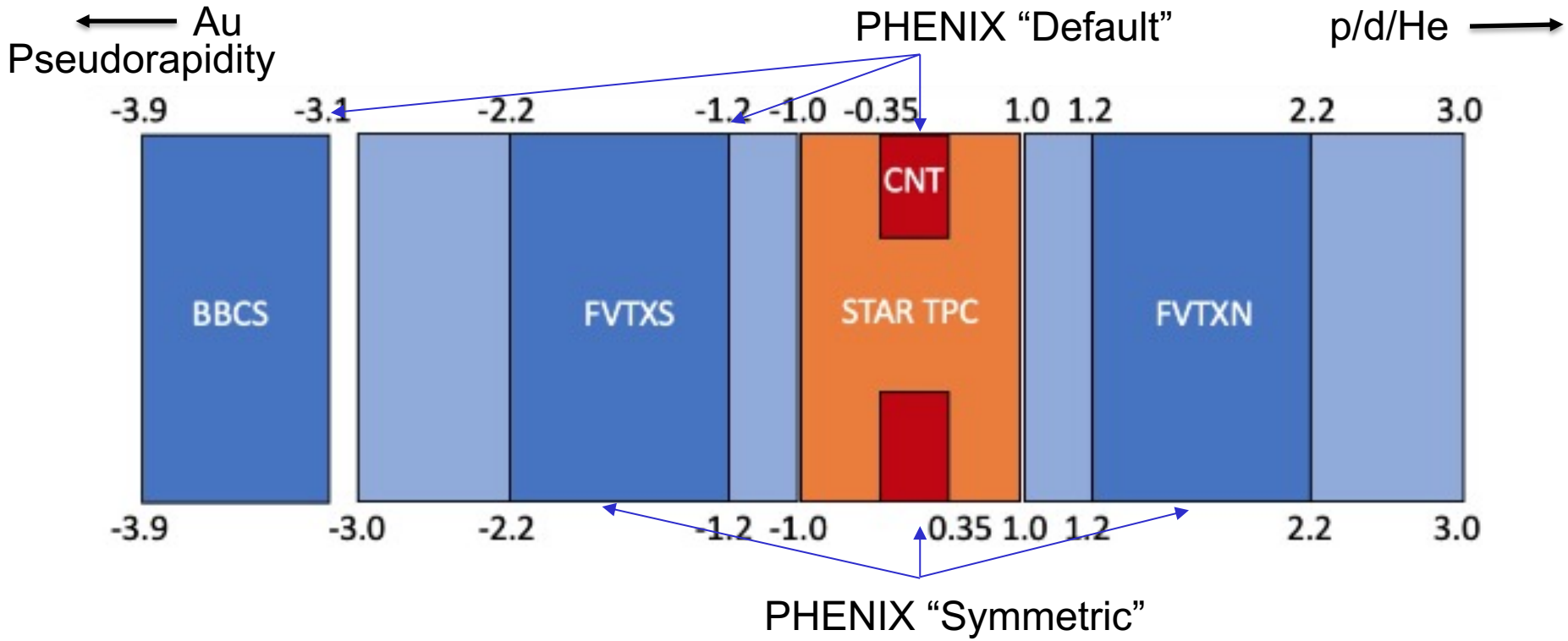


Figure from R. Belmont, IS2021

2015: PHENIX and STAR rapidity coverage has no overlap

- Default PHENIX: correlate Au-going FVTXS and BBCS with mid-η CNT
  - Explorations of other choices shown to committee and in conferences, and will be published
- Default STAR: symmetric correlations with $|\eta|<0.9$, $|\Delta\eta|>1.5$
  - Committee: “explore in further detail” “within acceptance of TPC”, “even though the range is limited"

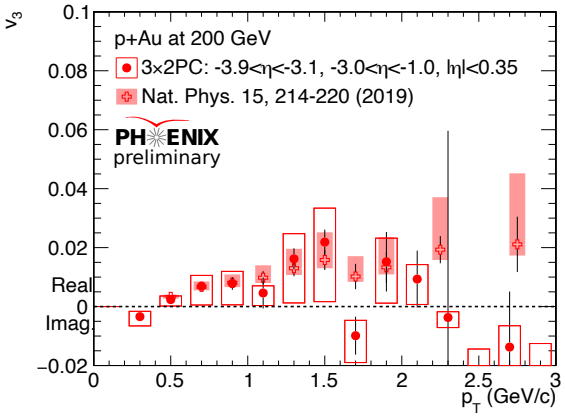
Indications of Rapidity Dependence

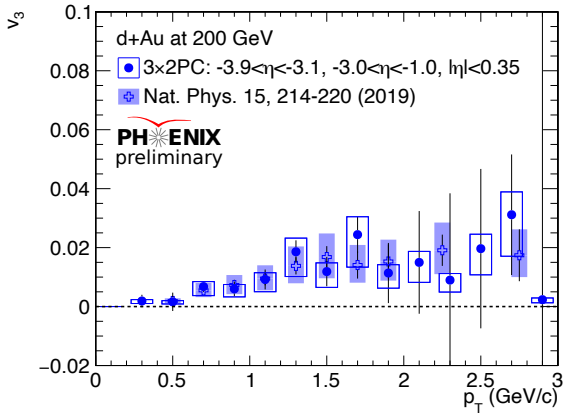


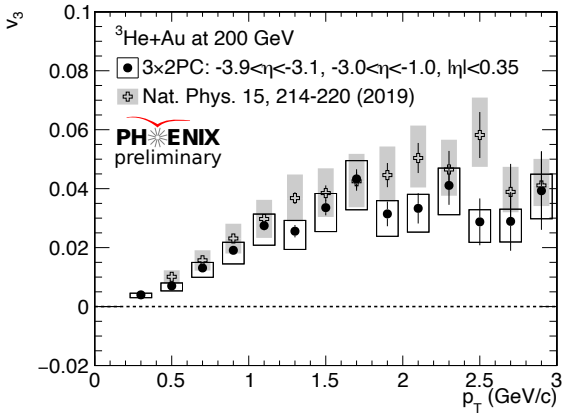
- PHENIX sees large changes in v_3 when changing η
  - For example, the "symmetric" case, by including FVTXN in the 3-particle correlation technique, makes v_3 imaginary
  - PHENIX plans to publish a long paper with all correlation combinations
    - Committee: "The forthcoming publication by PHENIX with the detailed rapidity dependence of the correlations will be a very useful input"

PHENIX η dependence: Default vs. Symmetric

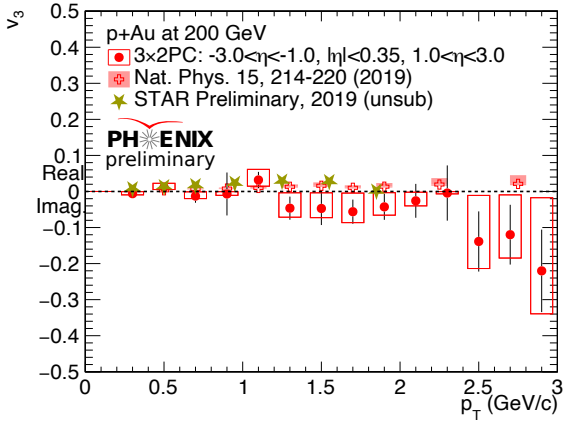
Default:

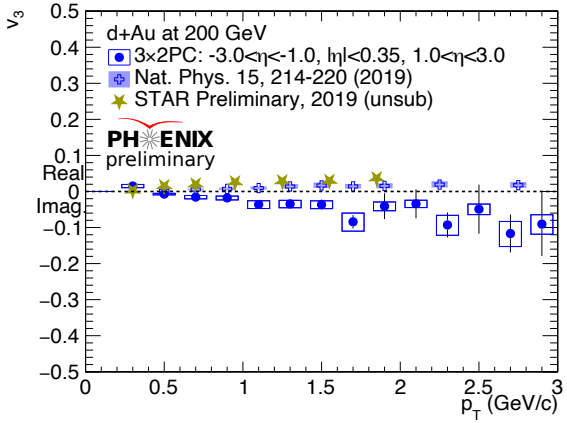


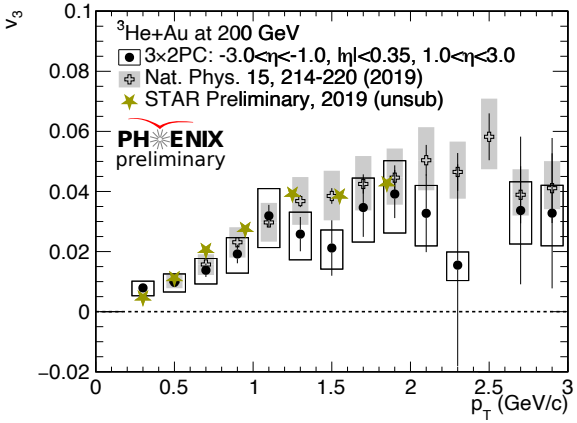




Symmetric:







Figures from R. Belmont, IS2021

- Symmetric case: imaginary v_3 in p+Au and d+Au
- Dependence on η in p+Au and d+Au: all details to be published

Committee Speculations: Origin of Differences

- Nonflow
  - "There is no robust way of eliminating nonflow, and the two analyses differ in how they treat them"
    - "We recommend that STAR continues to explore the robustness of their results with respect to the subtraction method."
    - "We also recommend that PHENIX carry out additional estimates of the magnitude of the residual nonflow correlation, in addition to the systematic uncertainty estimated in earlier publications."
- Longitudinal decorrelations
  - "The two collaborations also differ in how they model the rapidity dependence of anisotropic flow"
    - STAR: leads to overestimate
    - PHENIX: leads to underestimate
- Centrality
  - "The comparison between the two collaborations should be carried out within similar centrality ranges."
- Rapidity dependence of properties of system?
  - "More detailed studies of the rapidity dependence might even reveal that at negative rapidities (Au going direction, where PHENIX evaluates the event-plane), anisotropic flow is determined by the positions of participant nucleons, while at midrapidity probed by STAR, it is mostly due to fluctuations at the sub-nucleonic scale. In this case, not only the analyses, but also the interpretation of the results by the collaborations would both be correct."

Future: Detailed Rapidity Structure

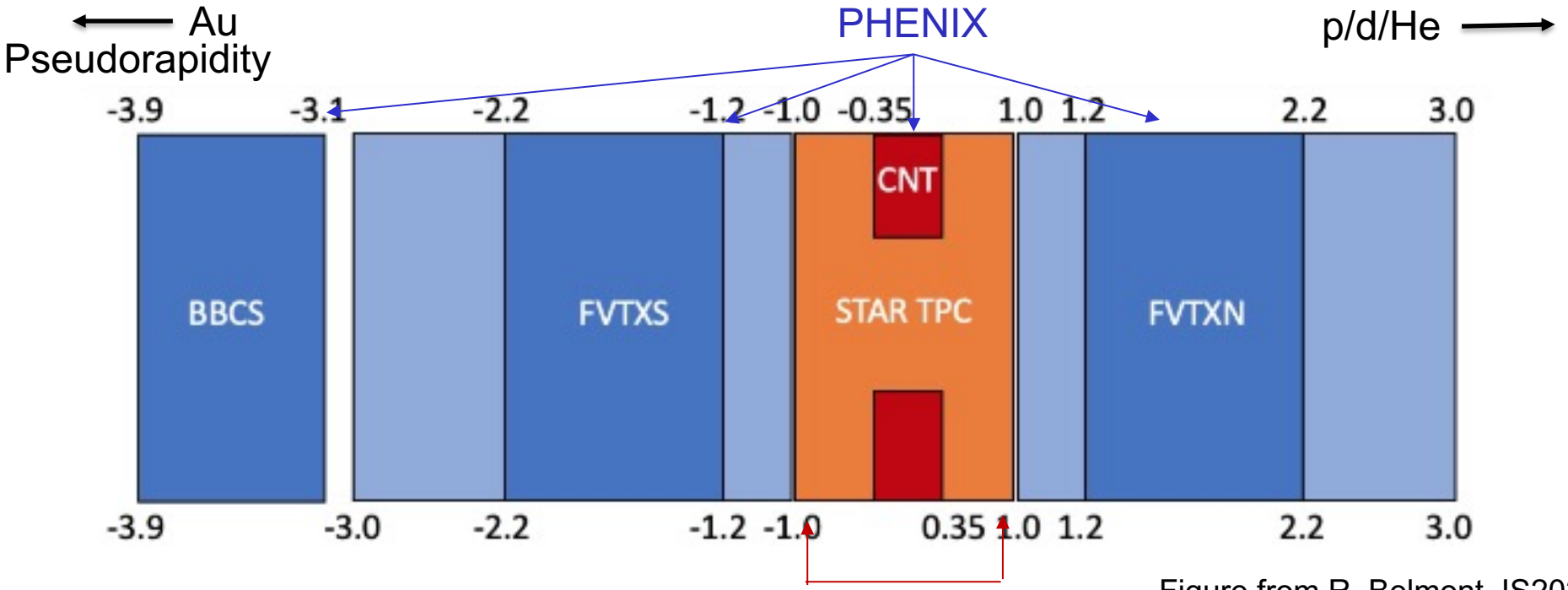


Figure from R. Belmont, IS2021

Now:

STAR EPD (2.1-5.1) | STAR iTPC(-1.5-1.5) | STAR EPD

2024:

sPHENIX EPD? (2.1-5.1?) | sPHENIX (-1.1-1.1) | sPHENIX EPD?

"We furthermore recommend that more data will be taken in the future, with the upgraded STAR and the new sPHENIX detectors which significantly extend the rapidity coverage."

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