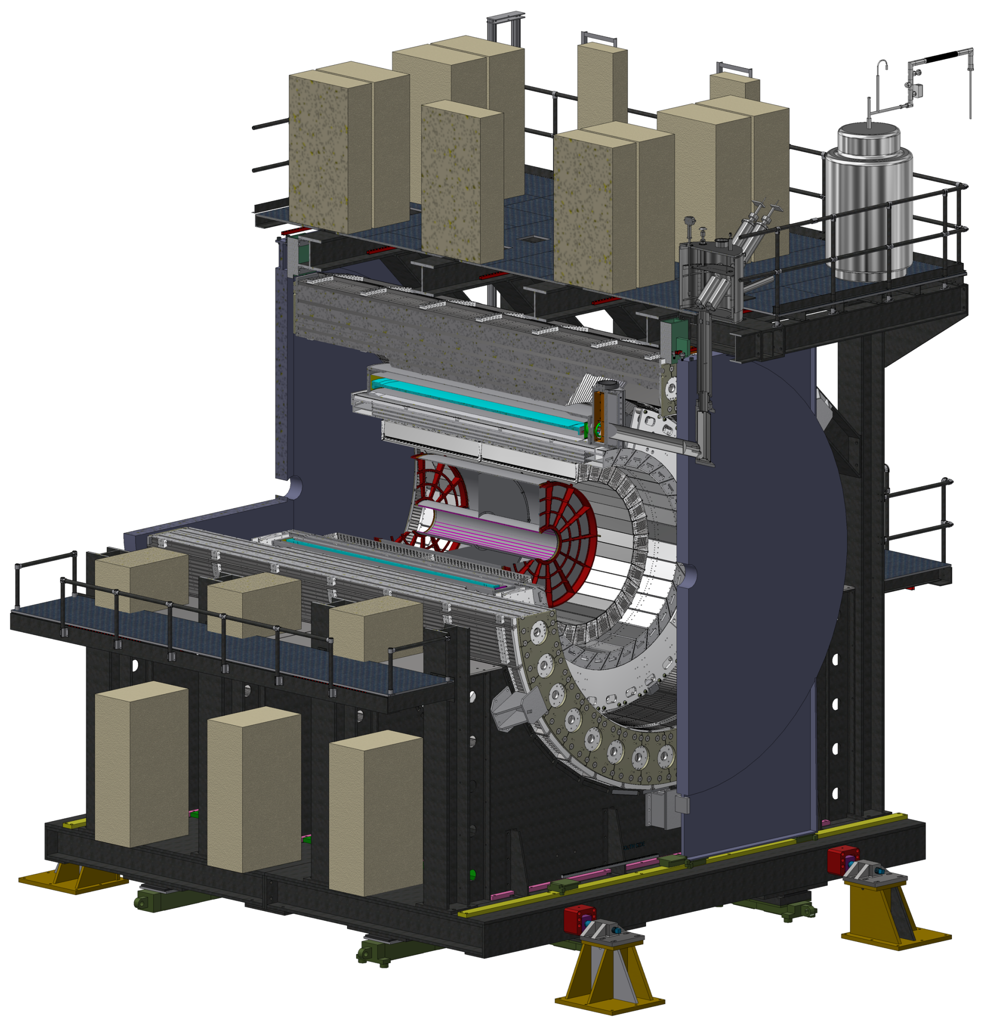
sPHENIX Progress

David Morrison (BNL)
Gunther Roland (MIT)

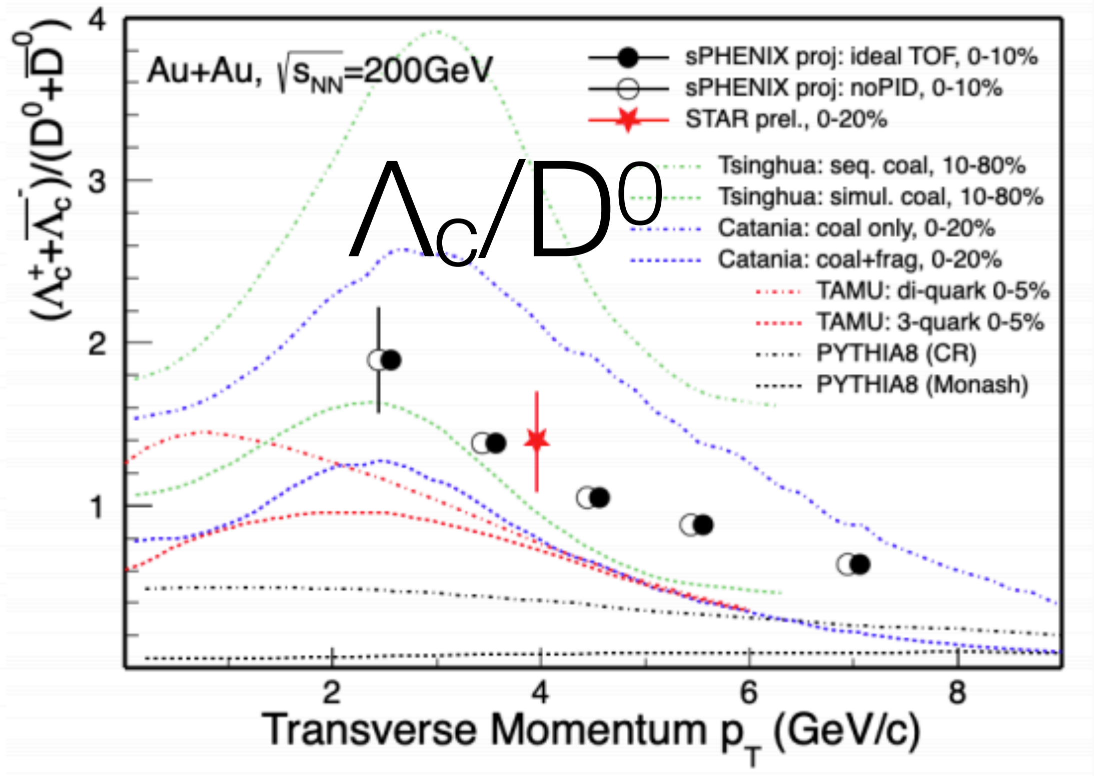
co-spokespersons

Developments on many fronts since last PAC

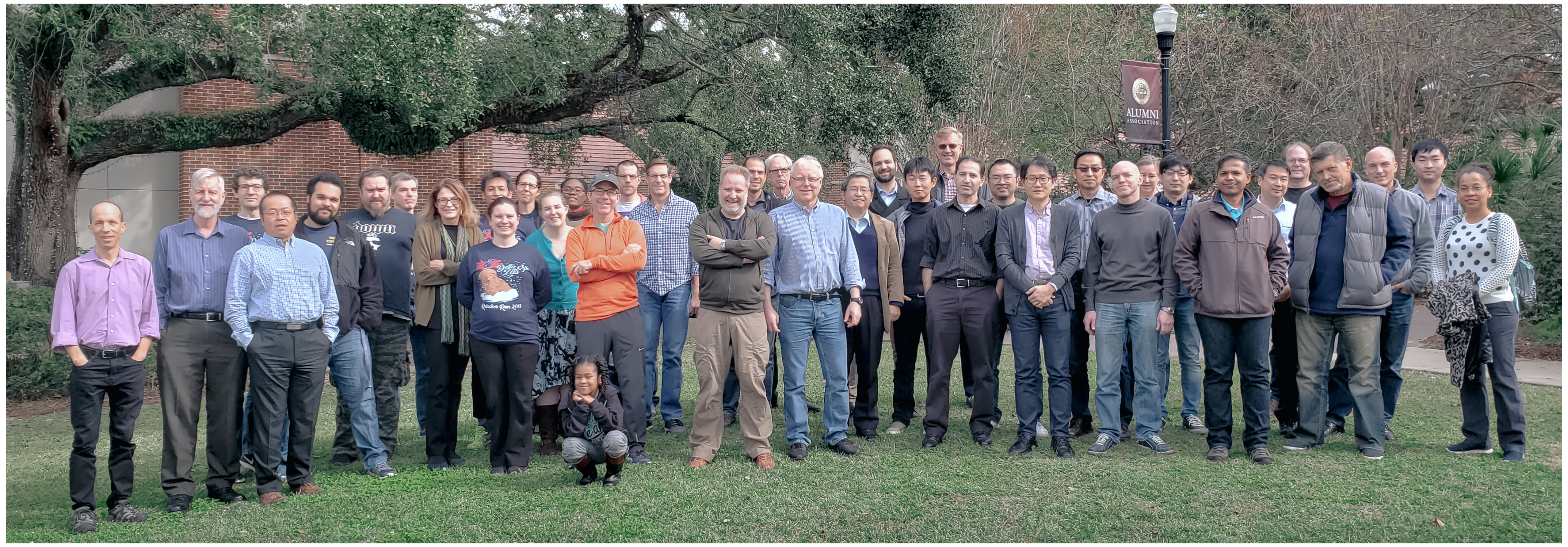
Progress on the project



Progress on the science

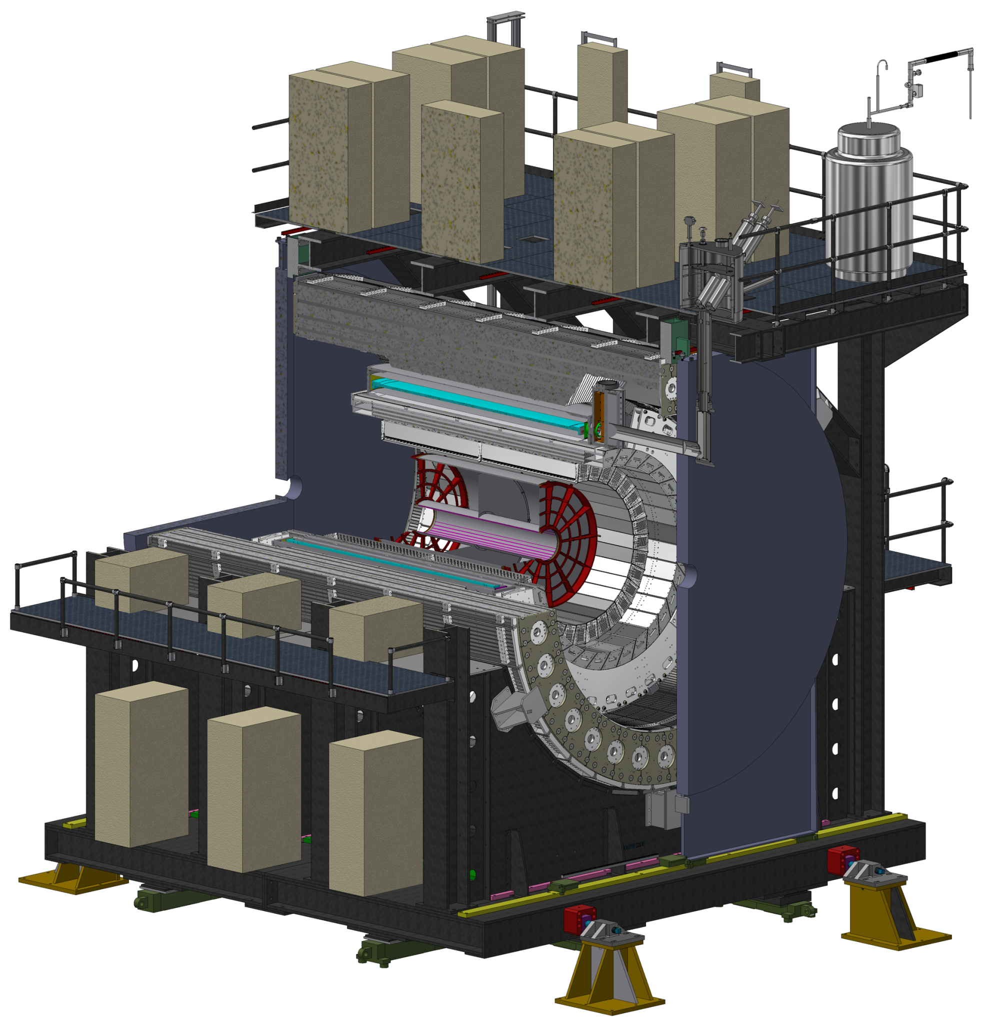


Progress on the collaboration

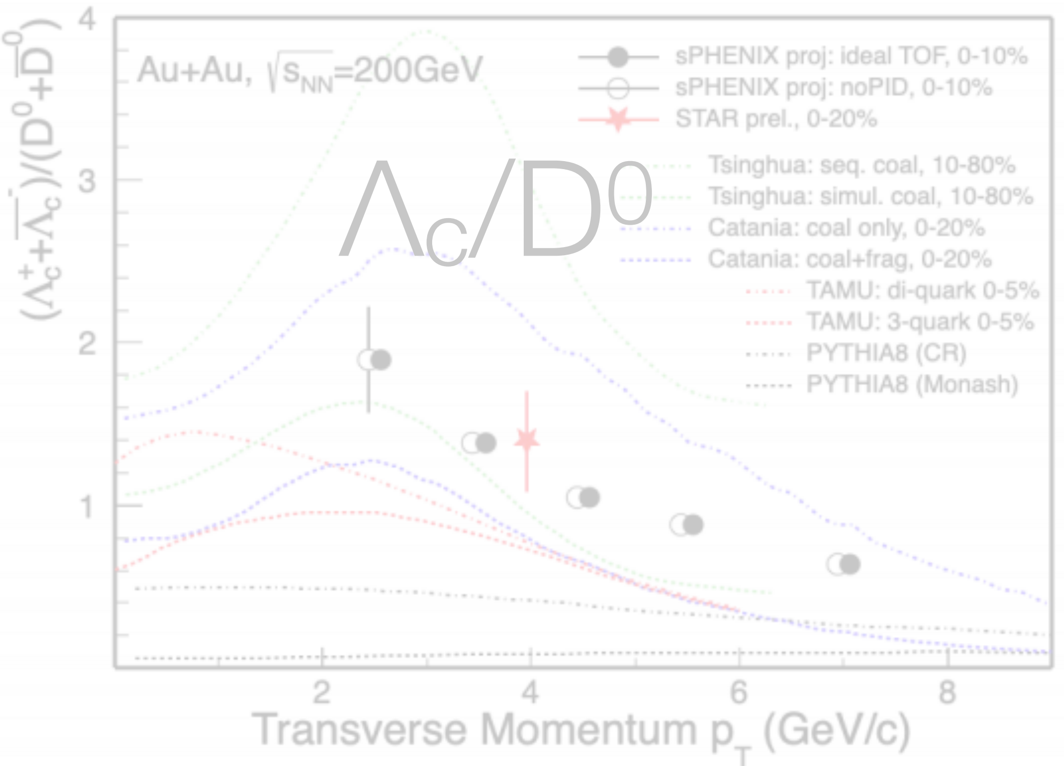


Developments on many fronts since last PAC

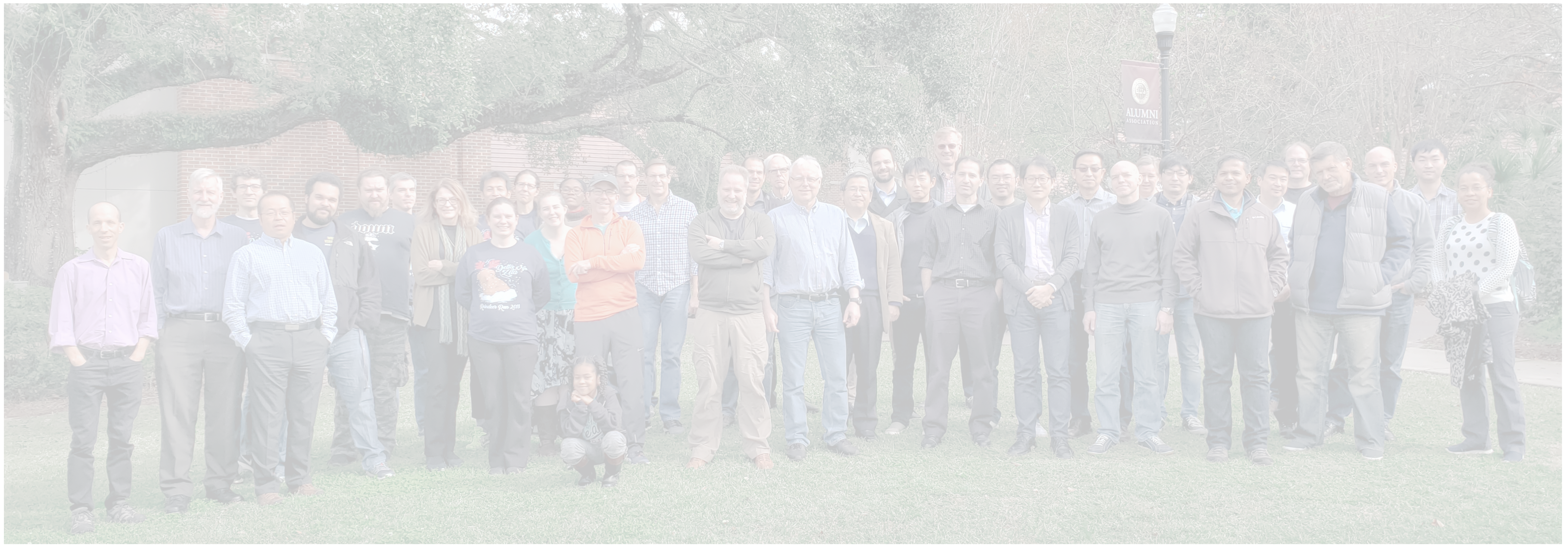
Progress on the project



Progress on the science

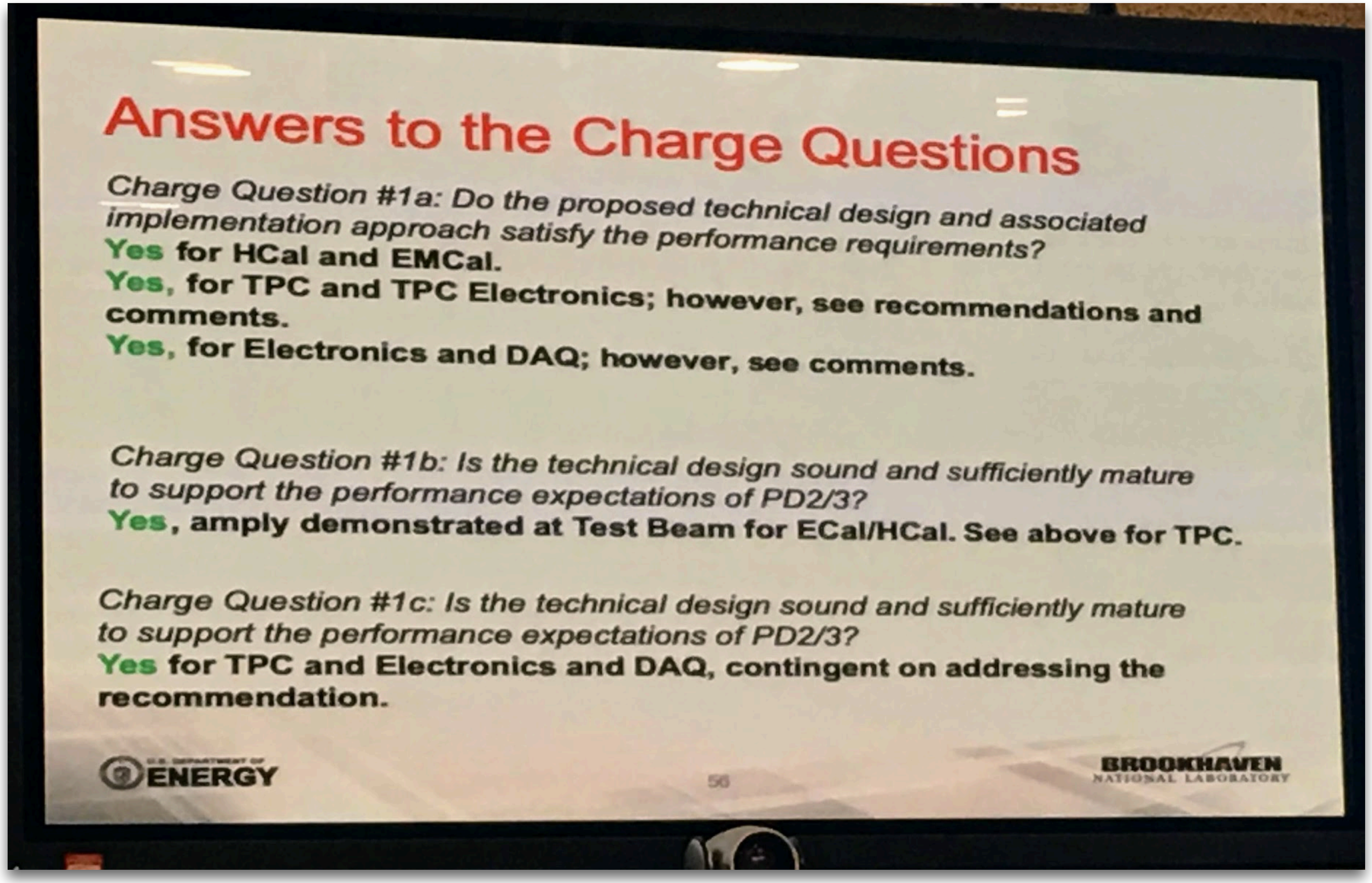


Progress on the collaboration

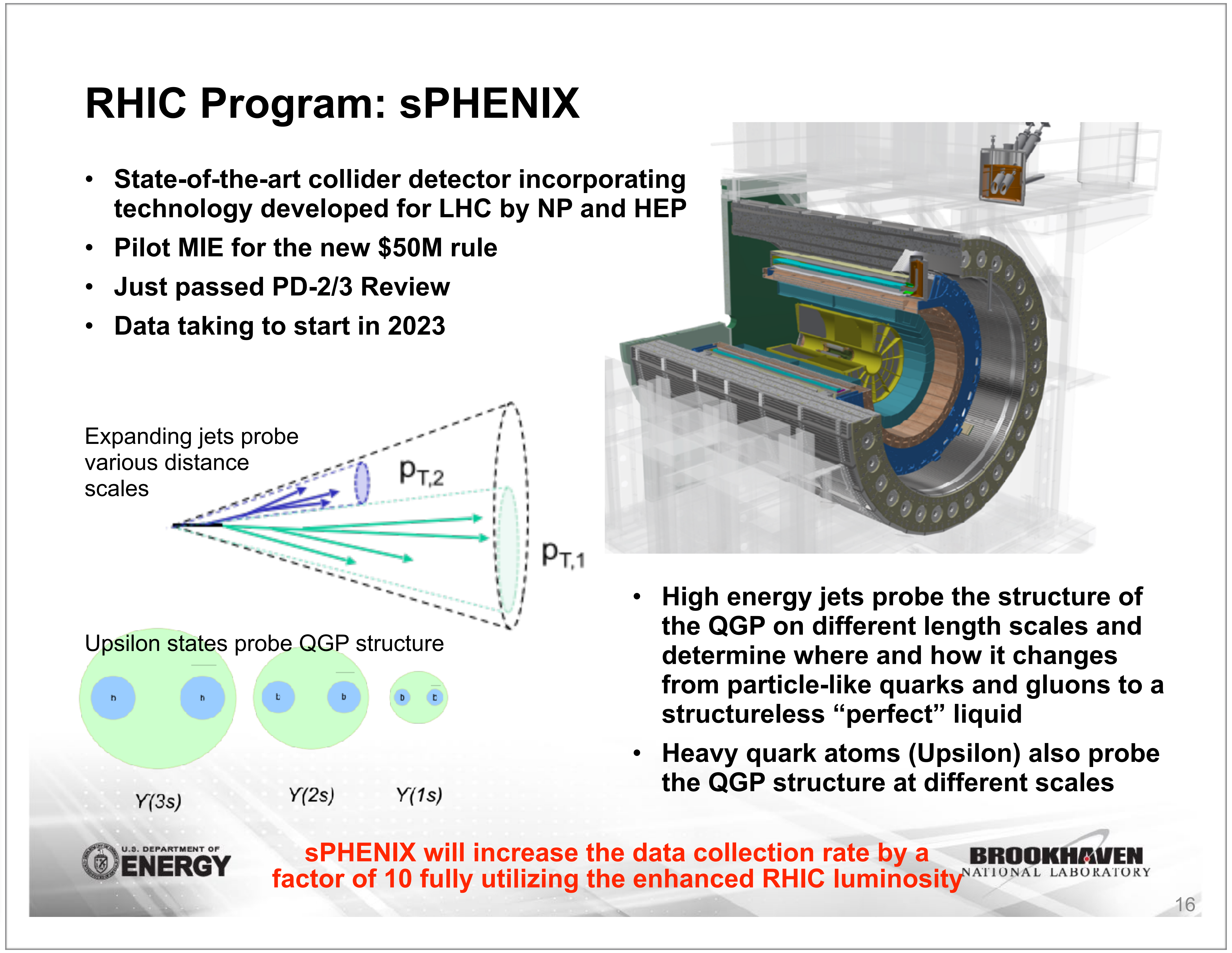


sPHENIX MIE PD-2/3 review – May 28-30, 2019

very positive review, few recommendations, looking forward to approval this summer



Closeout of PD-2/3 review



ALD @ RHIC AUM, June 6

sPHENIX MIE PD-2/3 review – May 28-30, 2019

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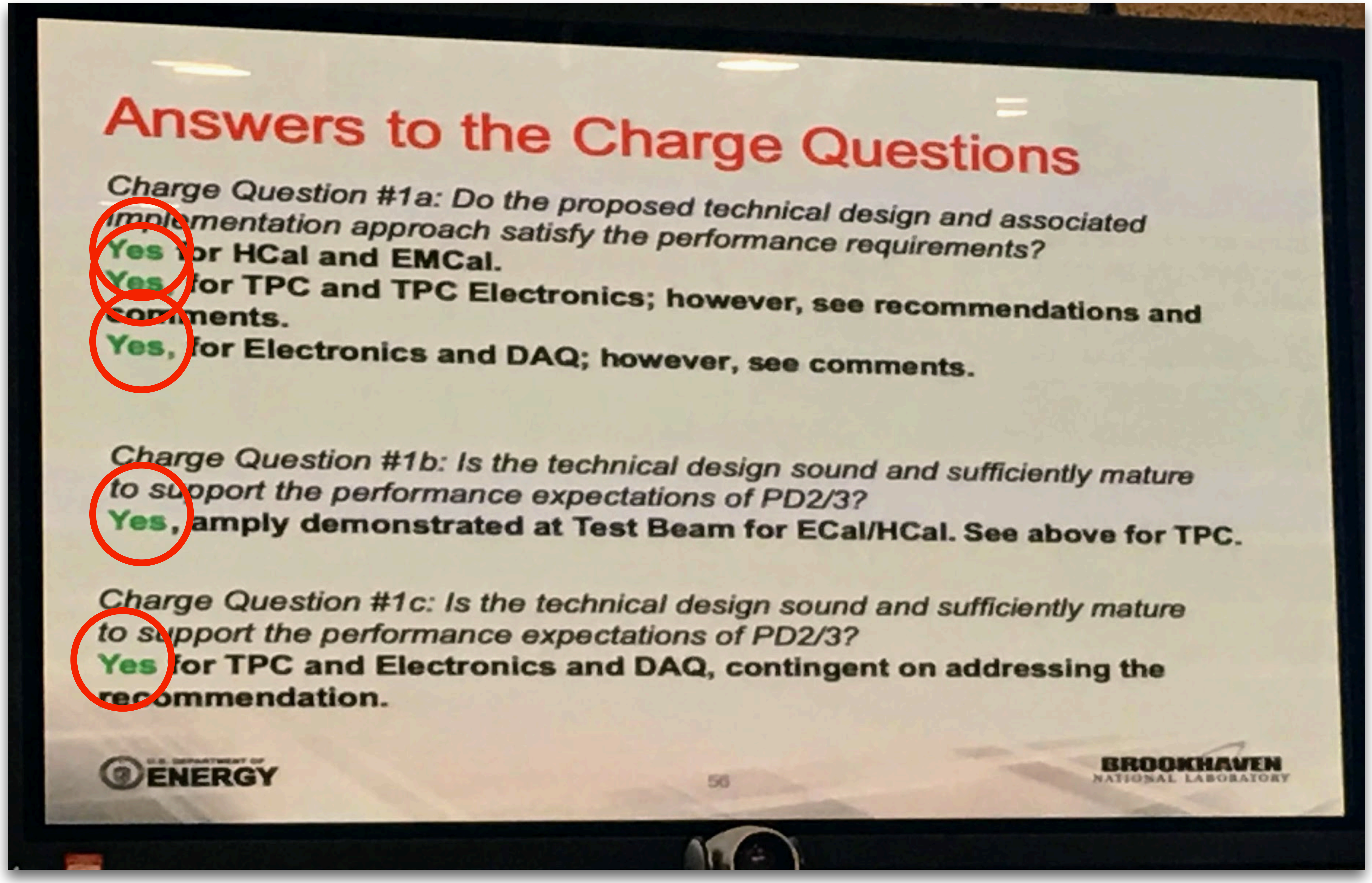
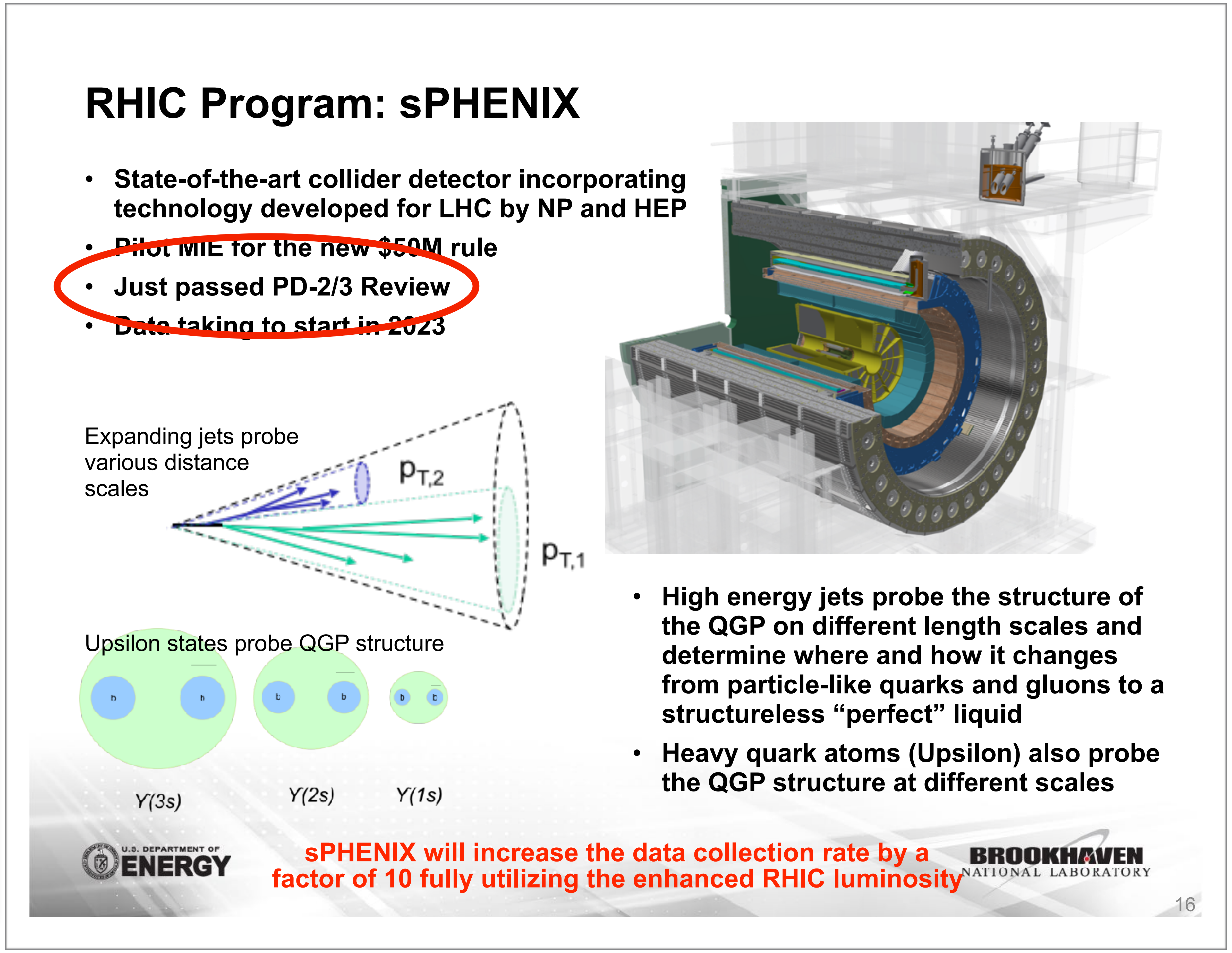
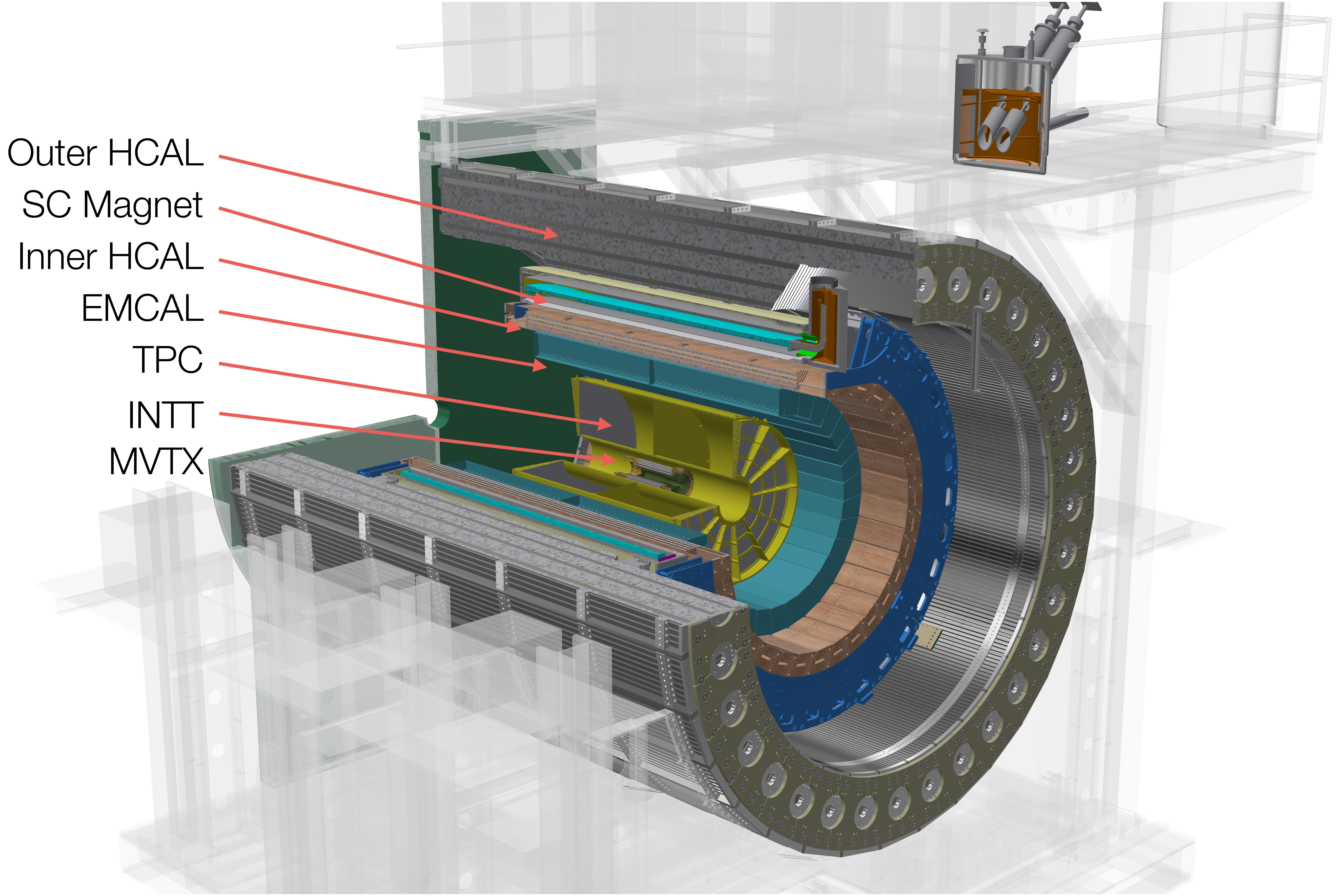




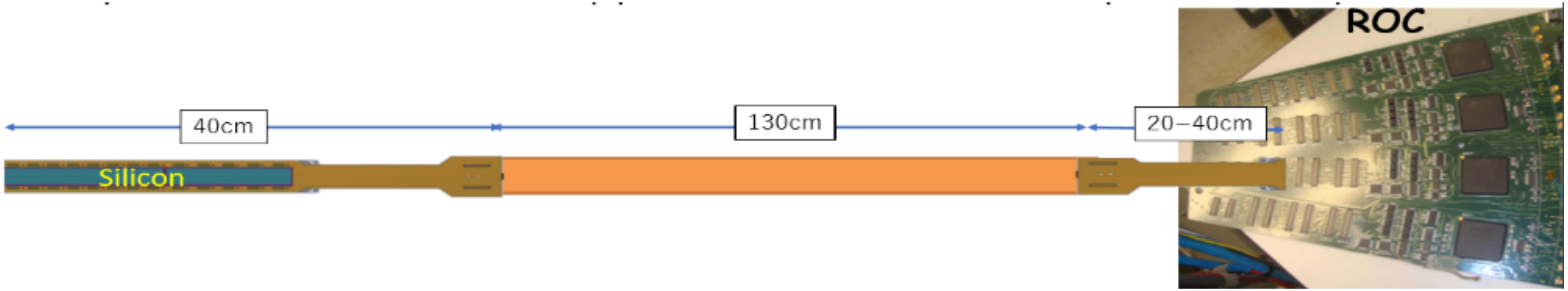
Closeout of PD-2/3 review

ALD @ RHIC AUM, June 6


Outer HCAL
SC Magnet
Inner HCAL
EMCAL
TPC
INTT
MVTX


EMCal Sector-0 BNL
EMCal Blocks UIUC
TPC Outer Field Cage- SBU
Splice Plate
Pucks
Pins
HCal Sectors, flux return BNL
TPC 3D model BNL
SAMPA v5 Sao Paulo
Digitizer Crate Columbia
X-ray gun
GEM X-ray test BNL
MBD - RIKEN
TPC FEE
GEM STACK
SiPM Testing U Mich/Debrecen
HCal Tiles- Uniplast, GSU

Intermediate silicon strip tracker (INTT) – RIKEN contribution



- Unique among sPHENIX tracking detectors – single event timing capability
- Si Modules tested in 2018
- Track resolution measurements and full readout chain test taking place at FNAL
- Includes multi-layer Flexible Printed Circuit bus extender from sensor to Readout Cards

sPHENIX officially a "CERN recognized experiment"

List of Recognized Experiments

http://committees.web.cern.ch/rec/list.html

Ref.	Experiment	RE status at CERN since	RE status at CERN until
⋮			
RE 33	LIGO	2016	31-MAR-2022
RE 34	JUNO	2017	31-MAR-2020
RE 35	SNO+	2017	31-MAR-2020
RE 36	Mu3e	2018	31-MAR-2021
RE 37	DarkSide 20k	2018	31-MAR-2021
RE 38	DAMIC-M	2019	31-MAR-2022
RE 39	sPHENIX	2019	31-MAR-2022

The ALICE ITS lab at CERN

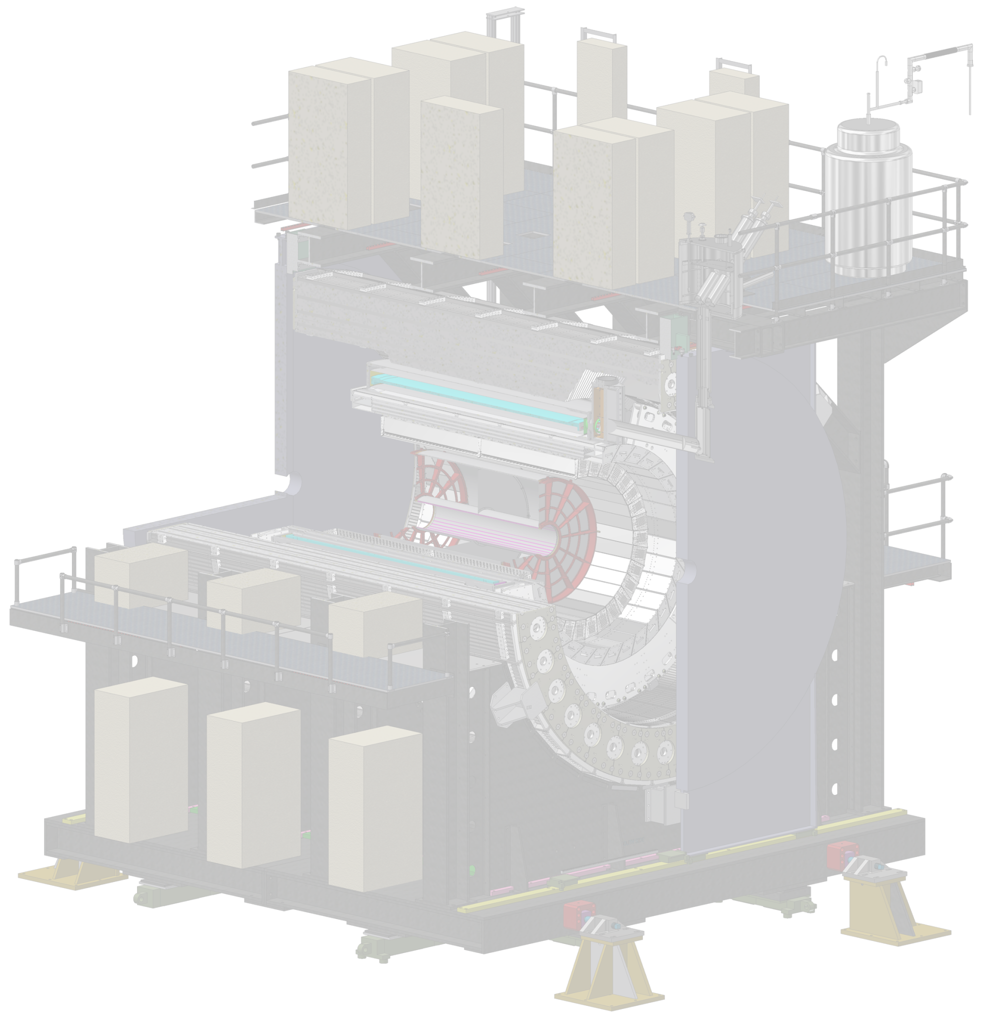
ALICE ITS

ALICE ITS – inner barrel

sPHENIX collaborators – MIT students and postdocs – at CERN developing detector control and quality monitoring software for the ALICE ITS. Part of sPHENIX contribution to ITS production, validates appropriateness of sPHENIX as CERN recog. exp't.

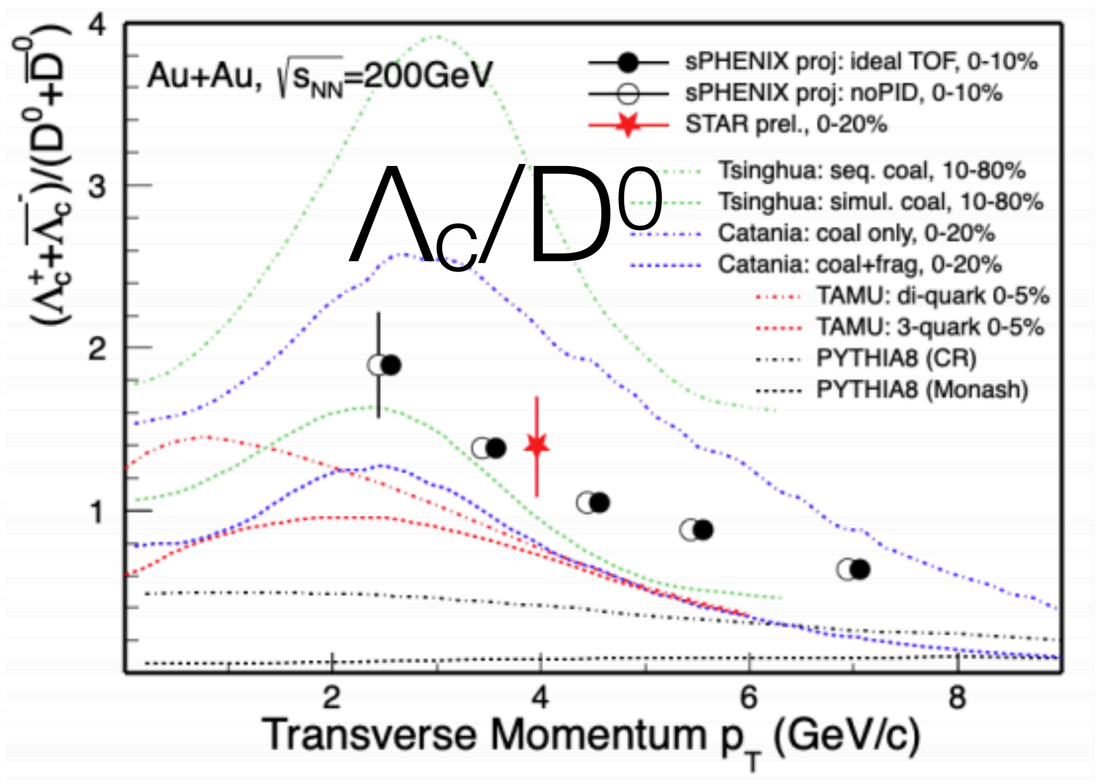
Funds from BNL sent to CERN to build add'l staves of ITS IB design, to be shipped to BNL.

Developments on many fronts since last PAC

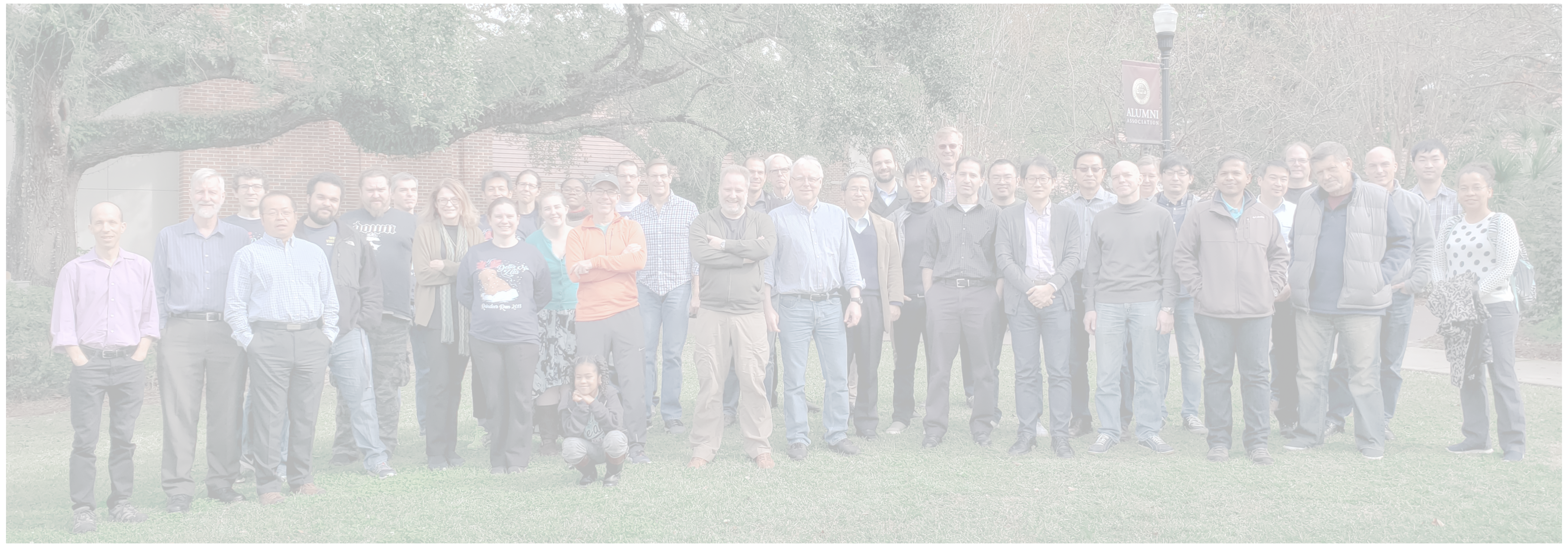


Progress on the project

Progress on the science

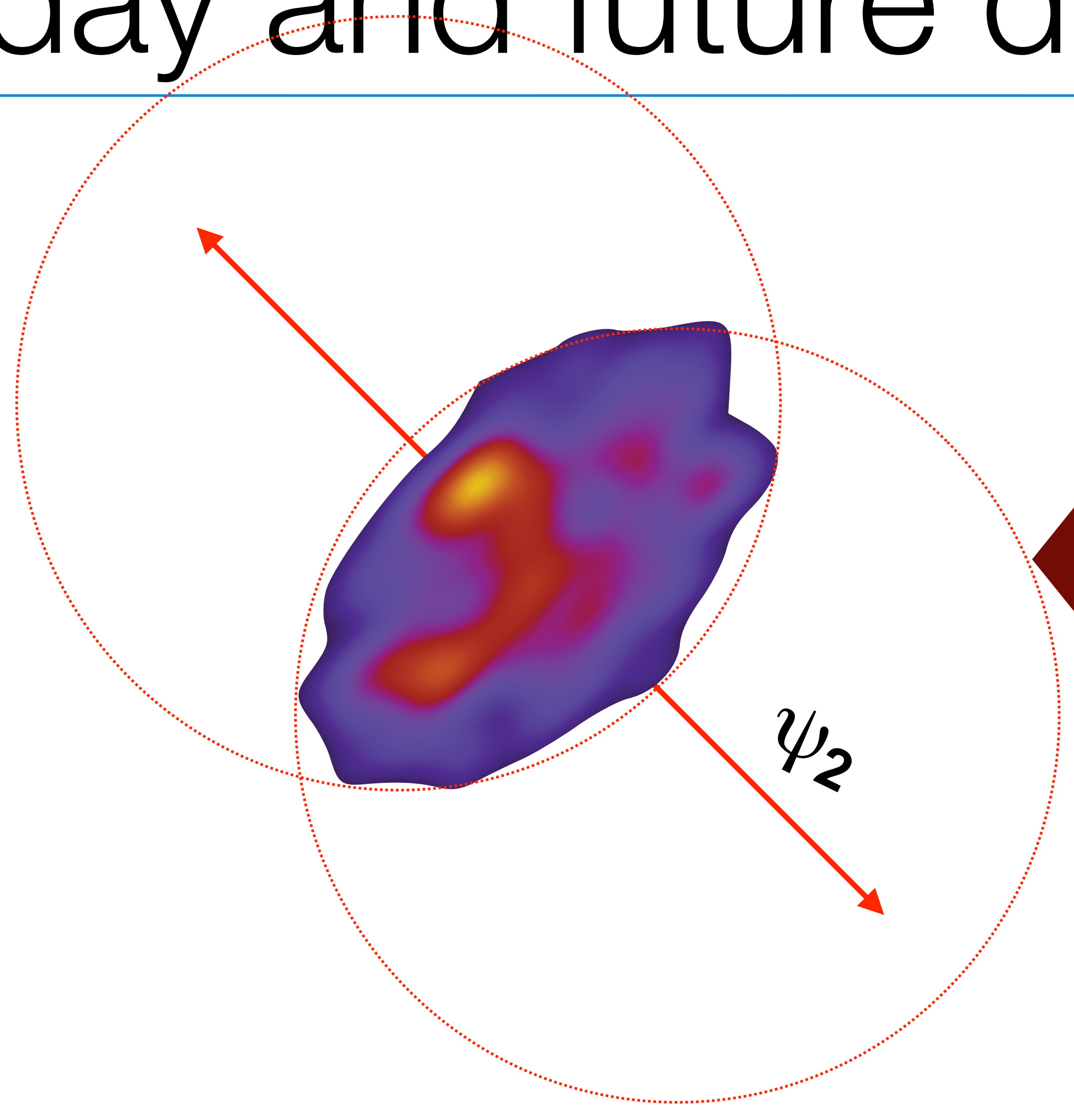


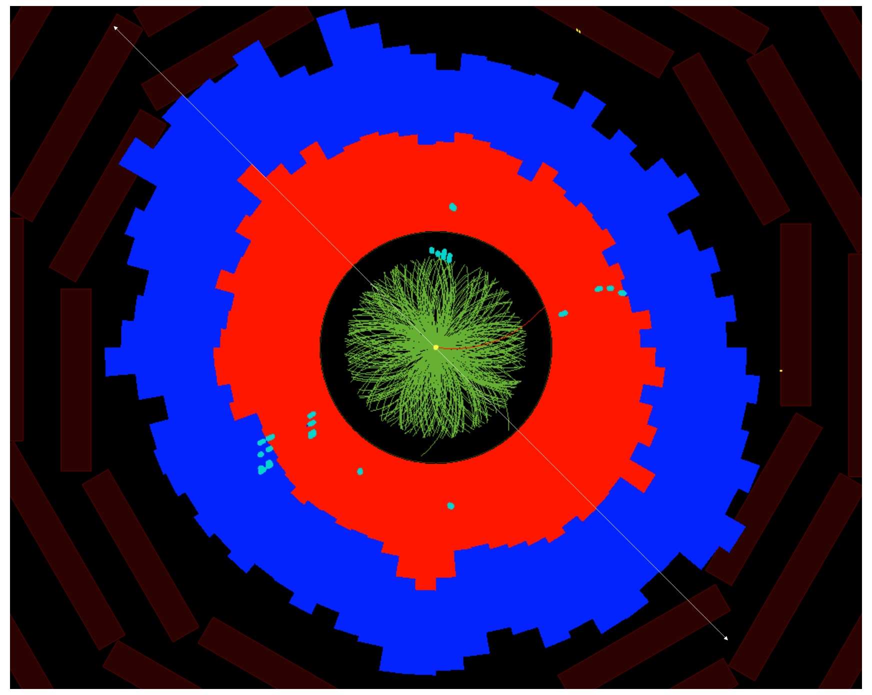
Progress on the collaboration



Hot QCD – today and future directions

theory



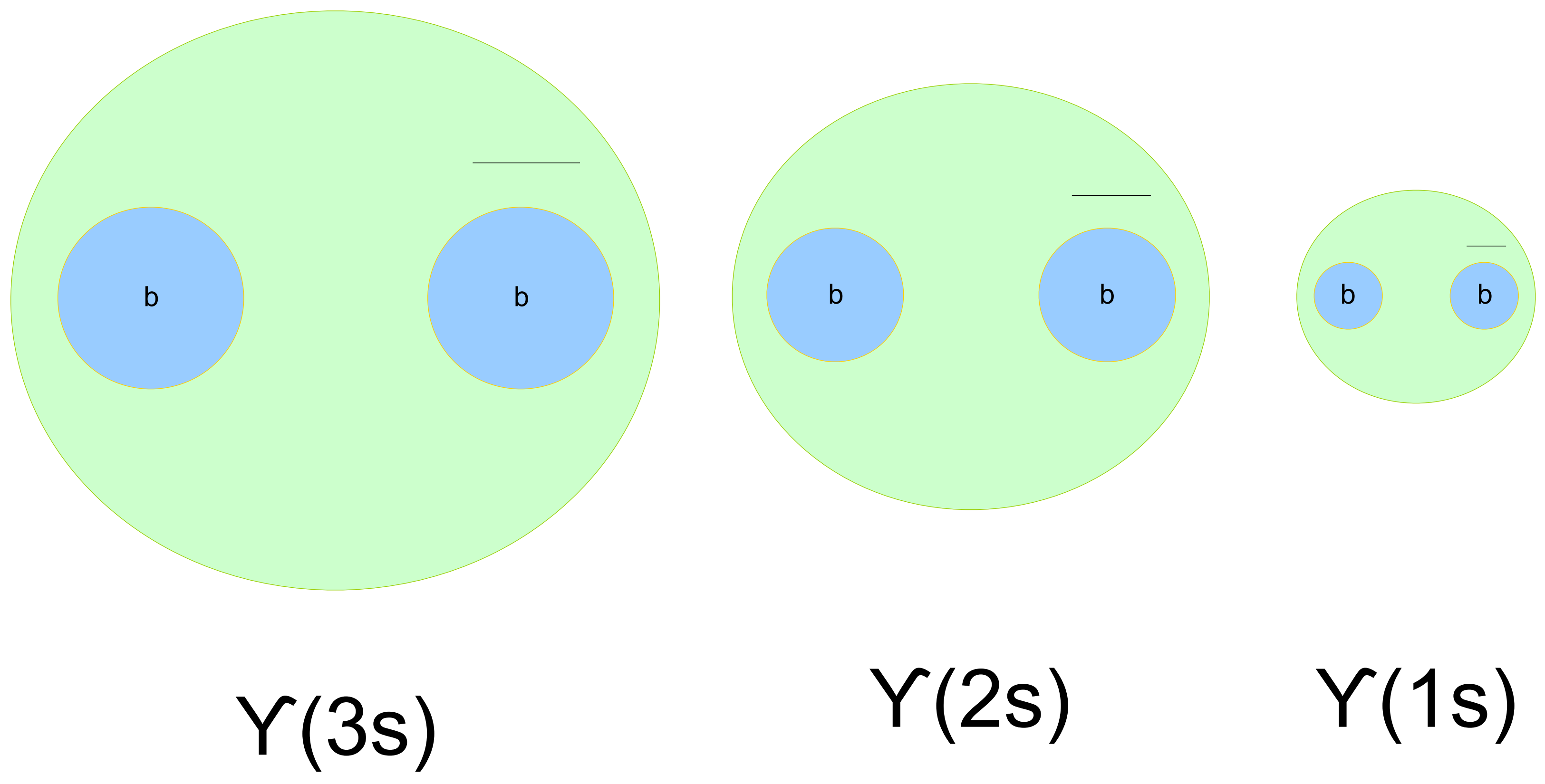


experiment

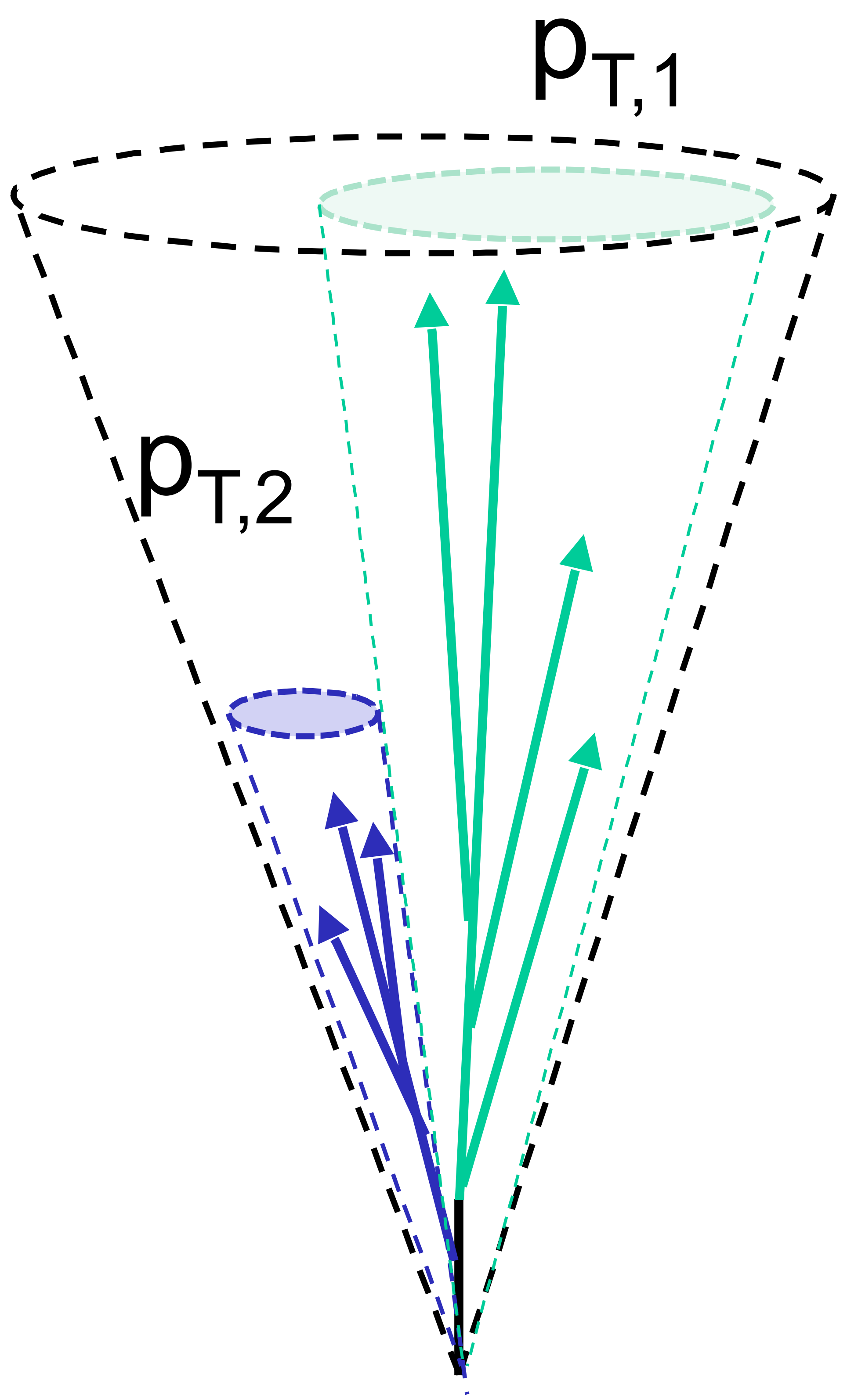
- First RHIC results demonstrated surprising properties of **Quark-Gluon Plasma created in heavy-ion collisions**: near perfect fluidity and extreme opacity
- Precision studies at RHIC and LHC show that many aspects of final state structure can be understood via relativistic viscous hydrodynamics applied to QGP evolution
- Success of LHC experiments in HI physics demonstrates importance of large acceptance, high resolution tracking, high collision rates and full EM+Hadronic calorimetry
- Coming decade: **Improved instrumentation at RHIC and LHC to understand emergence of QGP properties from underlying (asymptotically) weakly coupled interactions**

Studying the QGP at multiple scales with sPHENIX

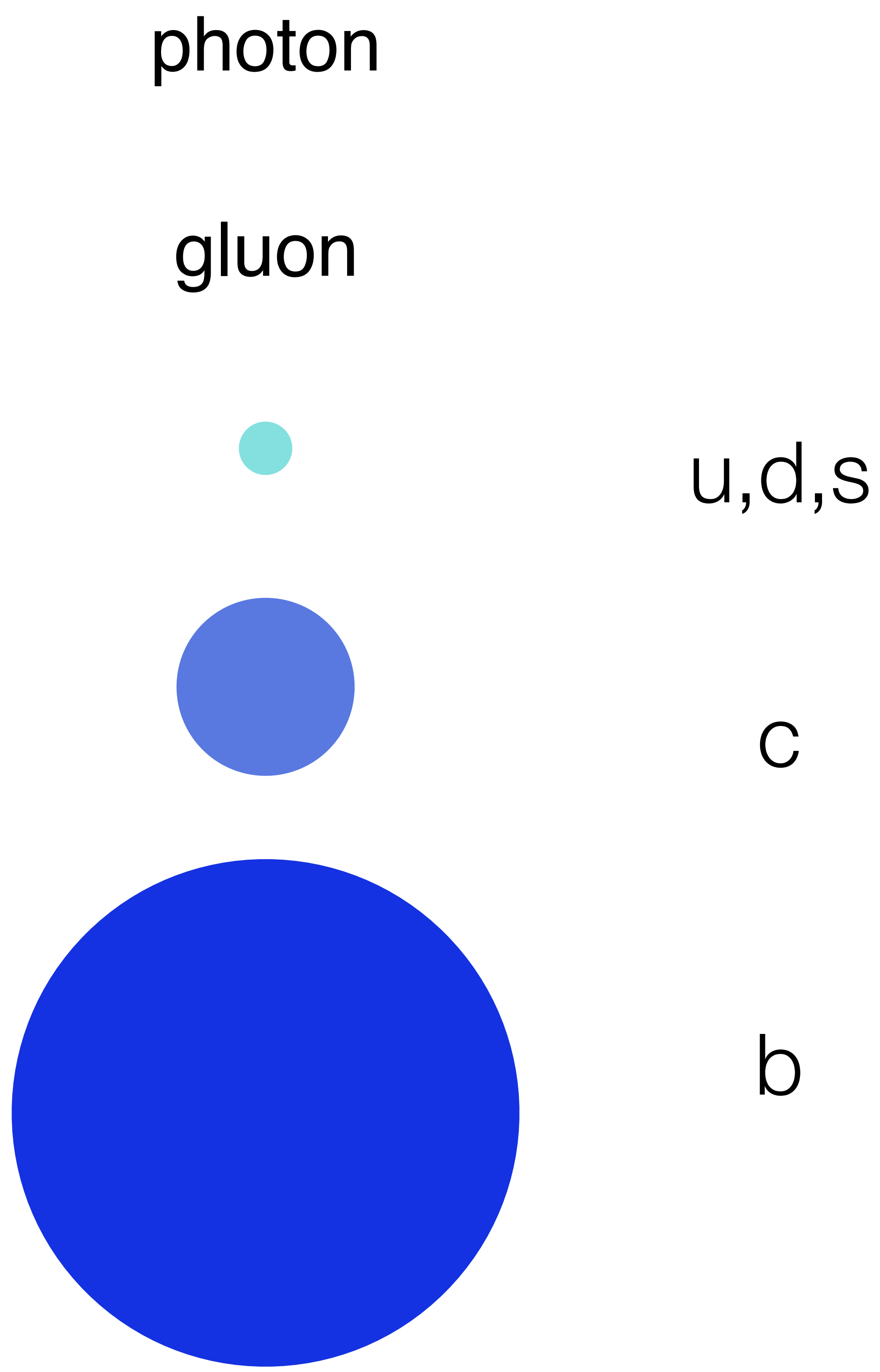
Quarkonium spectroscopy
vary size of probe



Jet structure
vary momentum/angular scale of probe



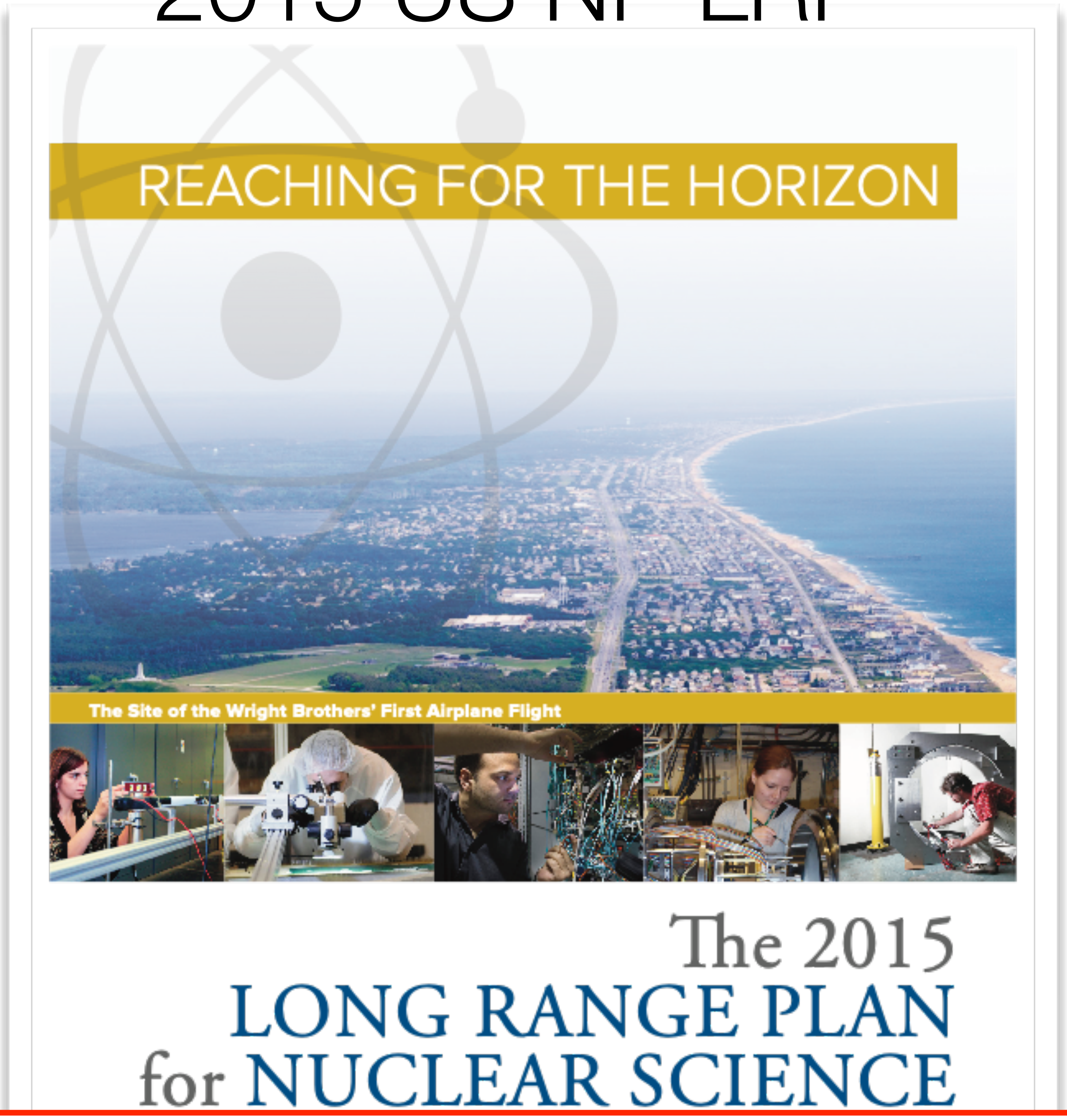
Parton energy loss
vary mass/momentum of probe



Continue developing more detailed connections between particular measurements and underlying physics – driving work with theory community generally and specific efforts like JETSCAPE.

Planning for the coming decade in hot QCD

2015 US NP LRP



Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of [RHIC and the LHC] is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX.

WG5 for 2019 ECFA document

Conclusions of the Town Meeting:
Relativistic Heavy Ion Collisions
https://indico.cern.ch/event/746182

On Wednesday 24 October 2018, a Town Meeting was held at CERN to collect input on the section of relativistic heavy ion collisions in the update of the European Strategy for Particle Physics. The meeting featured short presentations of existing and planned future heavy ion experiments at the CERN LHC, the Brookhaven RHIC, the CERN SPS, the FAIR facility in Darmstadt and the JINR in Dubna. In addition, the meeting provided a forum in which individual scientists and groups could contribute with short comments and statements. The meeting counted 421 registered participants that covered all experimental and theoretical activities in the field. The meeting concluded with an open 2-hour discussion of the priorities in the field.

The following text is not endorsed officially by any of the experimental collaborations and facilities mentioned, but summarizes the ***consensus view*** of the scientific community on the priorities of the field, as expressed by the participants of the town meeting. It is submitted to the Open Symposium of the European Strategy Group in Granada, Spain by the convenors of the Town Meeting,

F. Antinori, B. Erazmus, P. Giubellino, K. Redlich and U.A. Wiedemann.

The study of matter under extreme conditions, aside from its intrinsic interest, is central to our understanding of the early Universe and the evolution of massive stars. At high temperature and density, new states of matter are dominated by quark and gluon degrees of freedom. Such states are studied by colliding heavy ions at ultra-relativistic energies. At the highest energies available at the Large Hadron Collider, the quark gluon plasma (QGP) is created and diagnosed at nearly vanishing (net)baryon density, i.e. under conditions prevailing in the very early Universe. Lower beam energies, currently available at the CERN-SPS, RHIC in Brookhaven and at future facilities such as FAIR in Darmstadt and NICA in Dubna, probe the baryon rich quark matter under conditions encountered in various astrophysical settings.

Considering the fundamental physics questions that are coming into experimental reach in the coming decade, the Town Meeting highlighted the following opportunities for fundamental progress:

1. ***The top priority for future quark matter research in Europe is the full exploitation of the physics potential of nucleus-nucleus and proton-nucleus collisions at the LHC.***

Since its start in 2010, the LHC heavy ion programme has established in PbPb collisions abundant and numerically large signals for dense, collectively evolving matter on transverse momentum scales ranging from ~ 100 MeV to 1 TeV. This has opened a broad phenomenology of strong interaction matter under extreme conditions, including amongst many important features an unprecedentedly detailed characterization of collective flow in all soft observables and of jet quenching in all hard hadronic observables. The wealth of data collected and analyzed by all four LHC experiments bears proof that the properties of strong interaction matter can be accessed with controlled and increasingly precise experimentation in heavy ion collisions at the multi-TeV scale. It also demonstrates the powerful complementarities of the four LHC experiments, ALICE, ATLAS and CMS and LHCb with precision tracking down to very low

The Town Meeting observes that the recently approved sPHENIX proposal targets these opportunities by bringing greatly extended capabilities to RHIC …

jet structure topical group

Rosi Reed (Lehigh)
Dennis Perepelitsa (Colorado)

co-conveners

CERN Yellow Report projections for Runs 3, 4

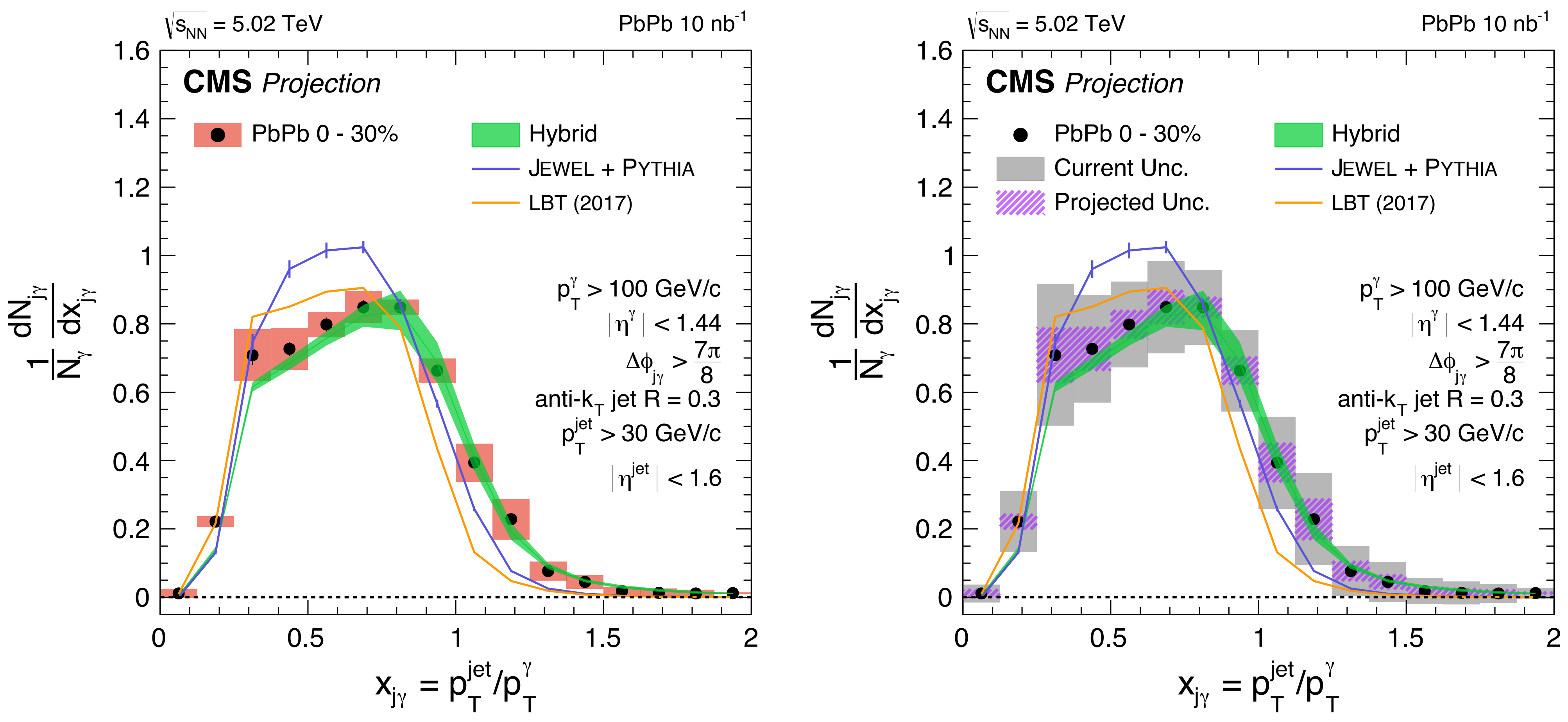
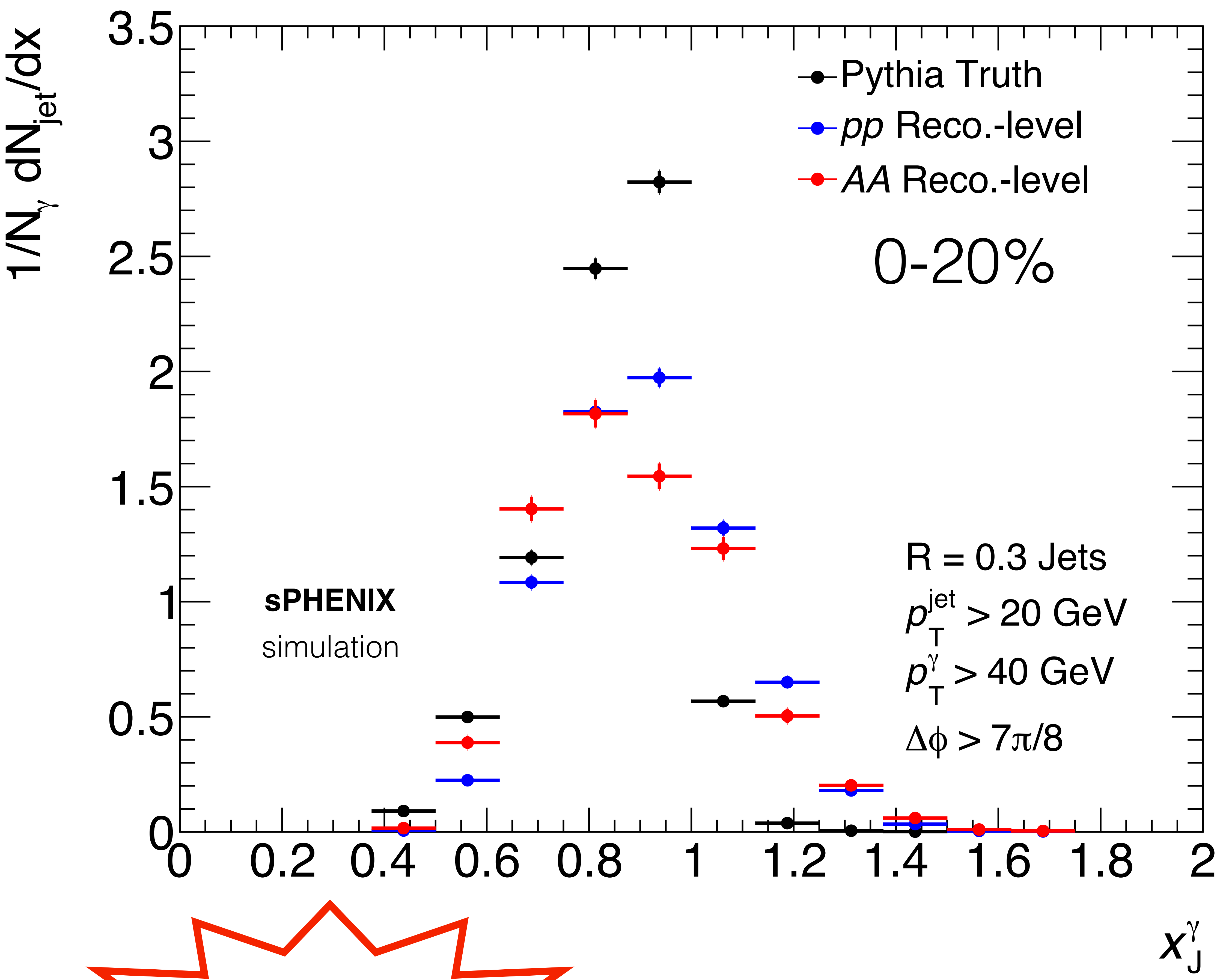


Fig. 29: (Left Panel) Photon-jet momentum balance $x_{j\gamma}$ distribution for isolated-photon+jets of $p_\gamma >$ 100 GeV/c and $|\eta_\gamma| < 1.44$, $p_{jet} > 30$ GeV/c and $|\eta_{jet}| < 1.6$ in the HL-LHC data (Right Panel). Comparison between the current performance with 0.4 nb^{-1} of Pb–Pb data collected in 2015 and with HL-LHC data [8].

Photon-tagged jets in sPHENIX

CMS photon+jet (above) — c.f. sPHENIX version (right)

- ➡ similar jet low p_T reach in both cases (30 GeV vs. 20 GeV), photon selection quite different (>100 GeV vs. > 40 GeV)
- ➡ matched cone sizes (R=0.3)
- ➡ expect sharper $x_{J\gamma}$ distribution at RHIC – smaller ISR + FSR & smaller UE effects



Updated!

Comparison of projected FF uncertainties

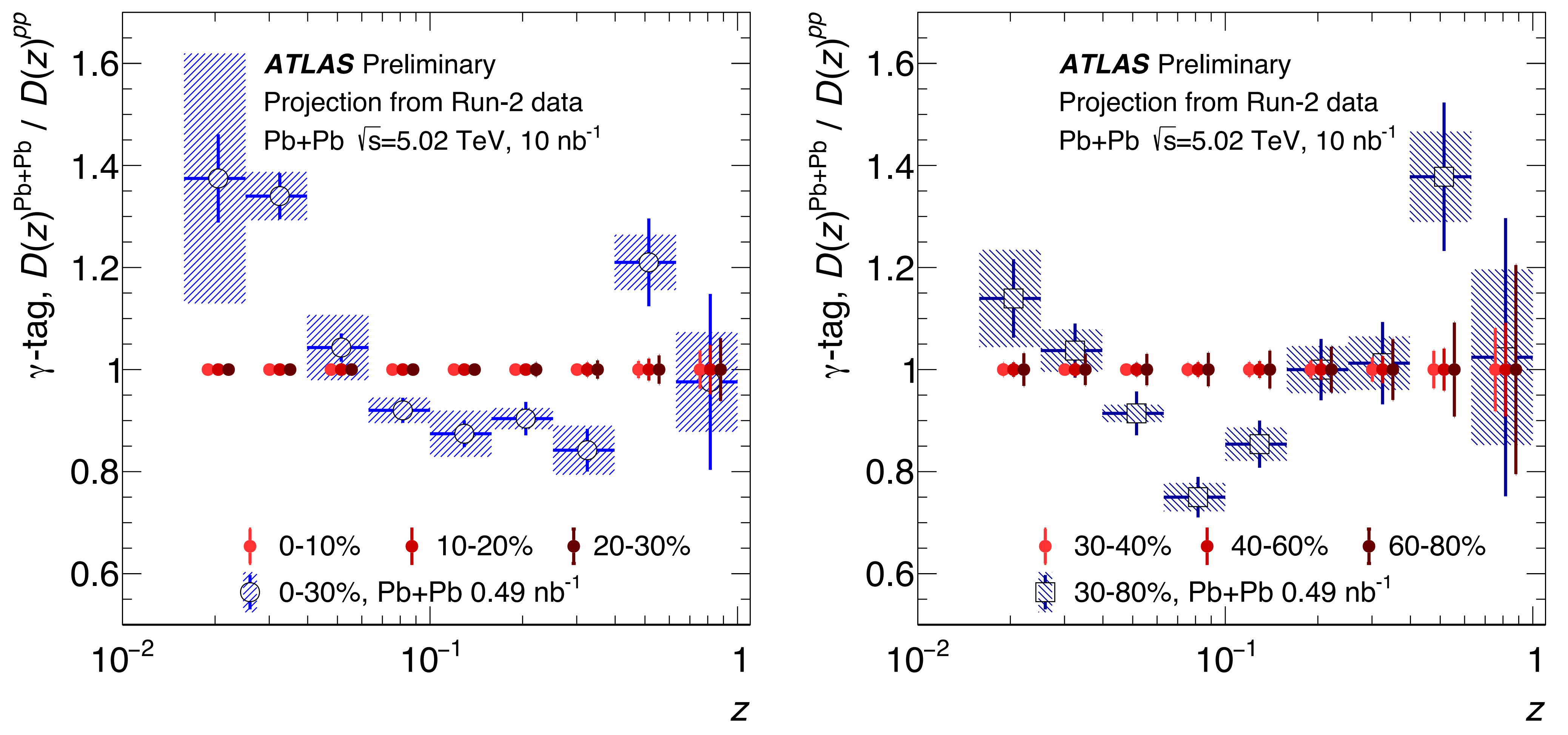


Fig. 35: Projection of the statistical precision that can be reached for the ratio of jet fragmentation functions in Pb–Pb and pp collisions, $R_{D(z)}$, of jets recoiling from a photon. The left panel shows the projection for the most central collisions while the right panel for the more peripheral events [5].

CERN Yellow Report projections for Runs 3, 4

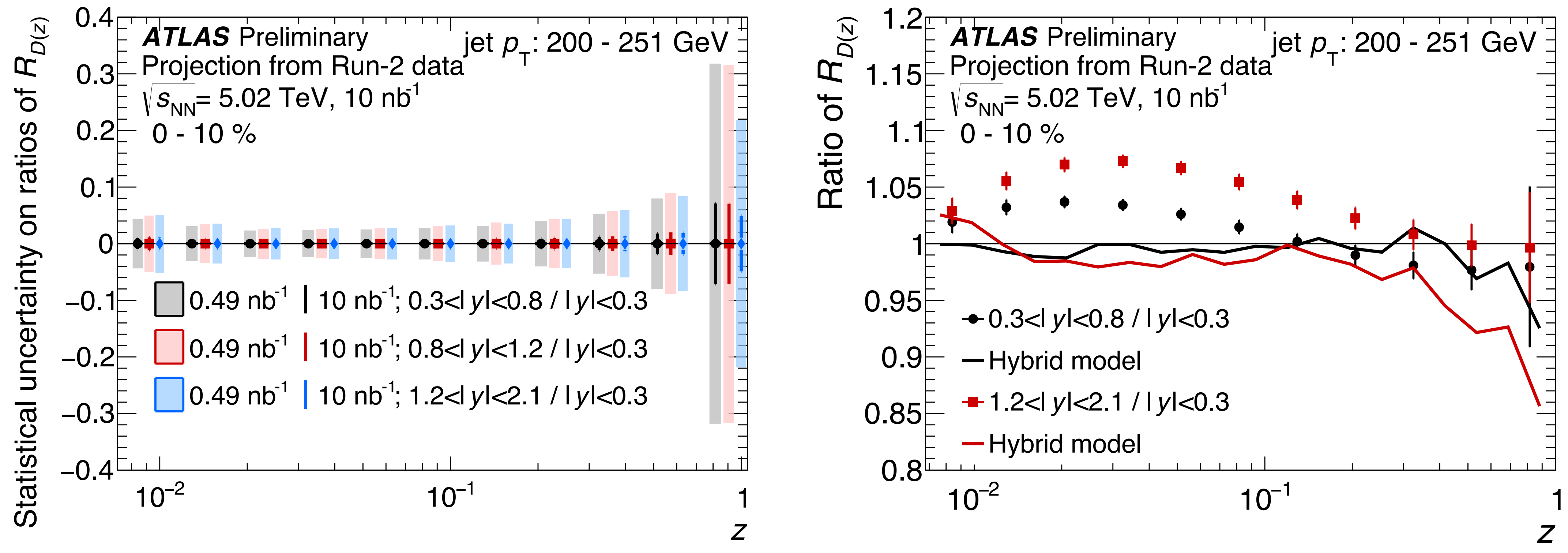
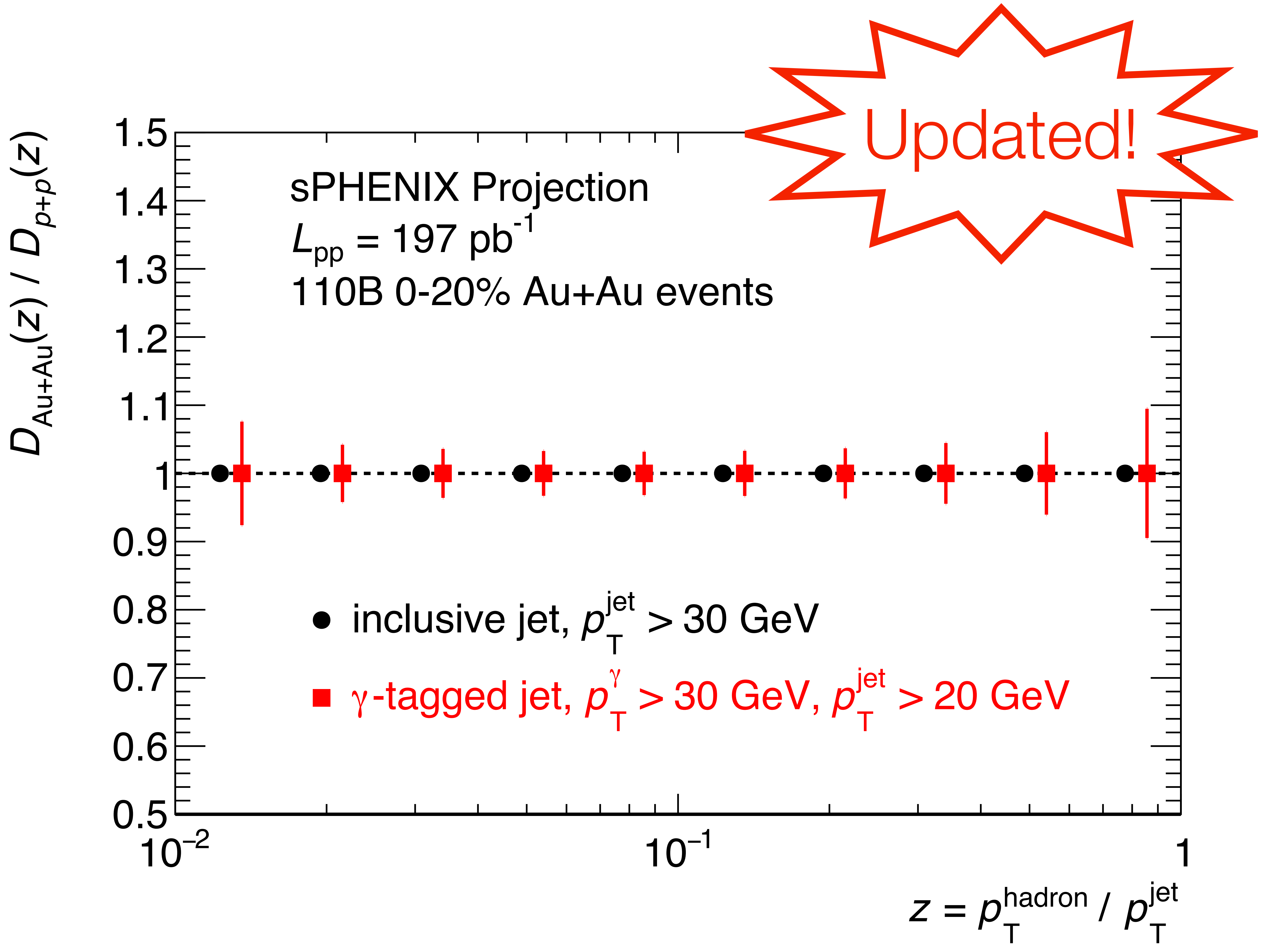
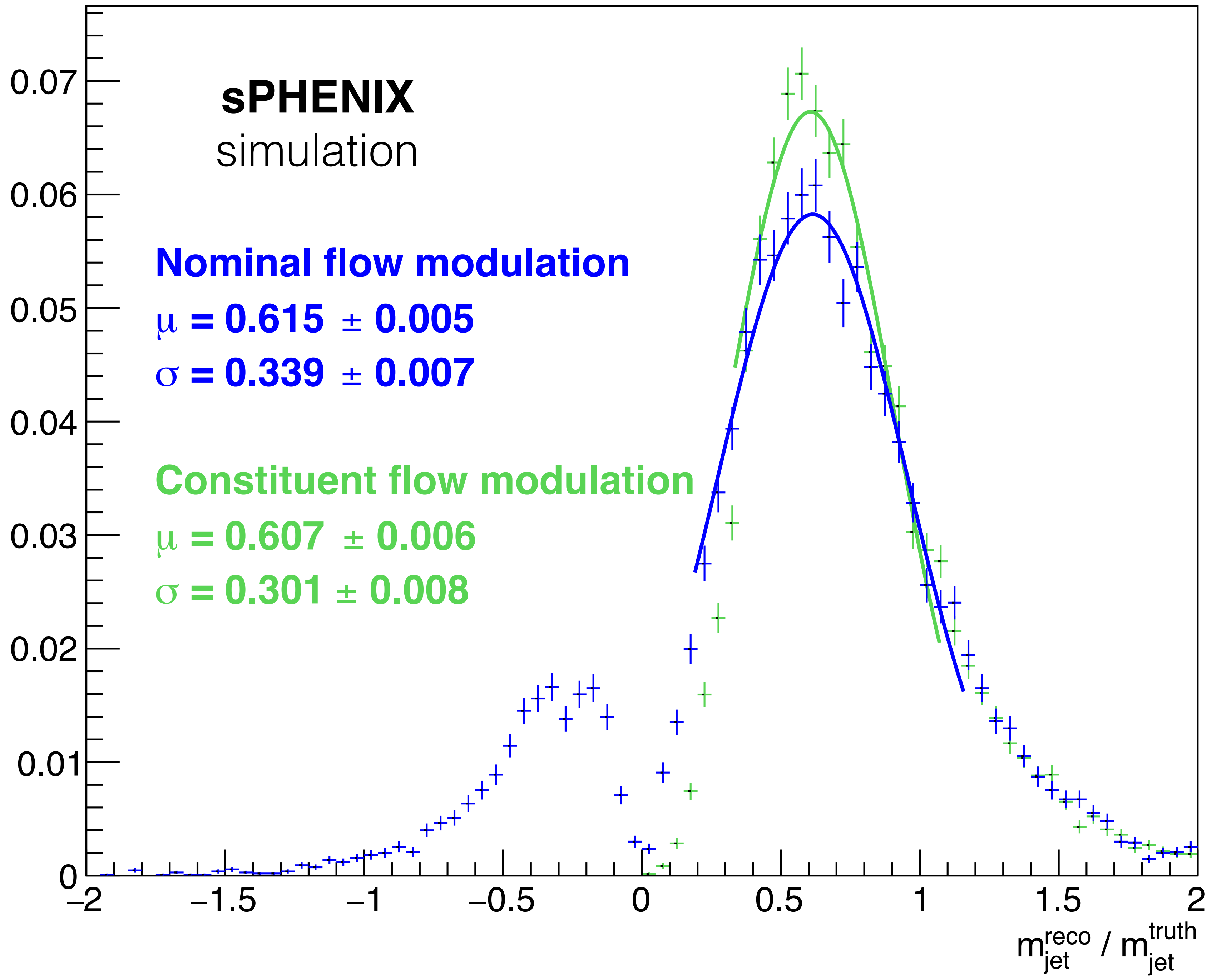


Fig. 33: Projection of the precision that can be reached for the modification of jet fragmentation function, $R_{D(z)}$, measured in jet p_{T} interval $200 - 251$ GeV/c. In the left panel the statistical uncertainty on the measurement with the shaded boxes corresponding to $0.49\ \mathrm{nb}^{-1}$ while the vertical bars are for $10\ \mathrm{nb}^{-1}$. The right panel shows a comparison of $R_{D(z)}$ with a theory model (see text for more details) [5].

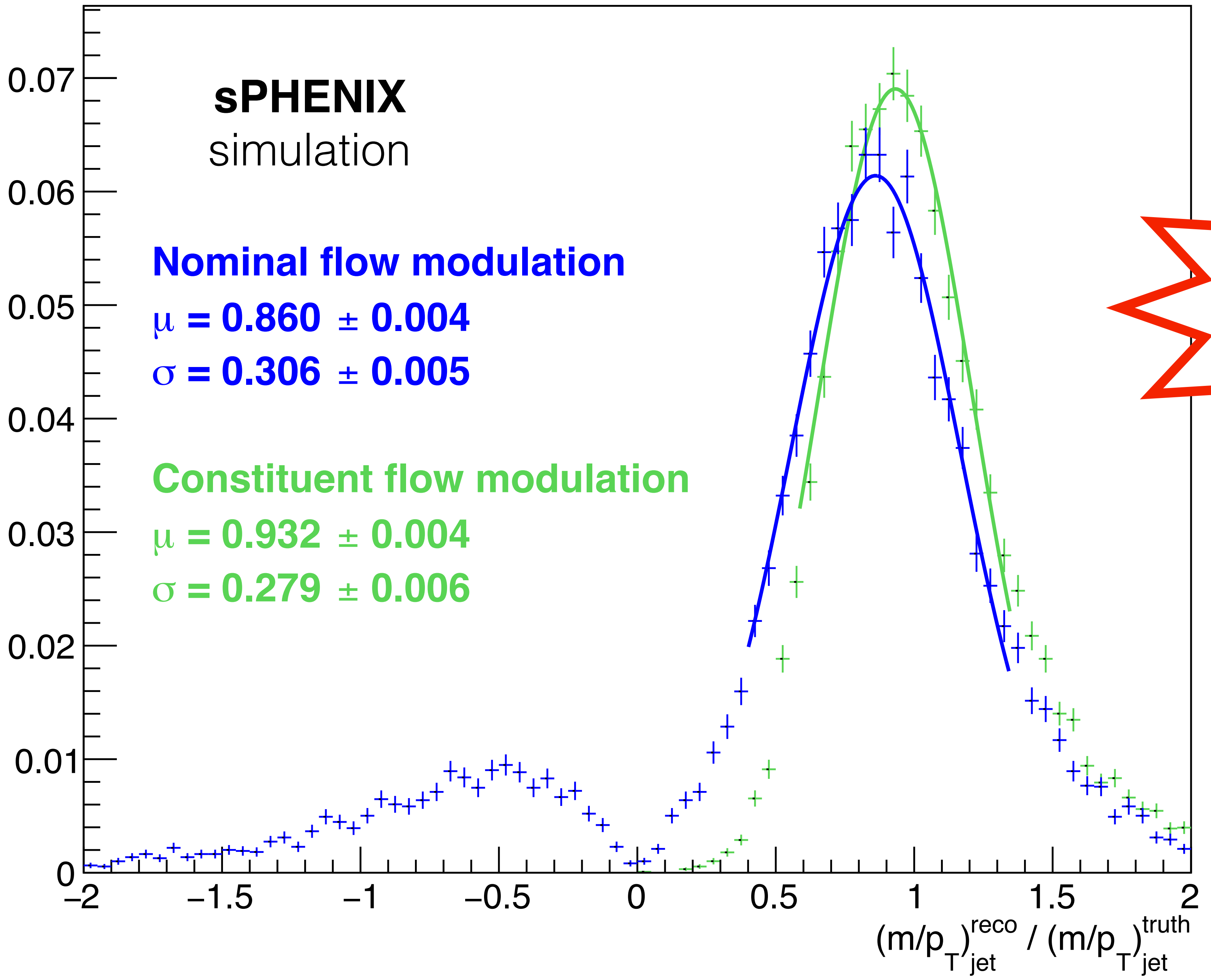


- different min. hadron & jet p_{T} at LHC (>1 GeV, ~100’s of GeV) vs. RHIC (>0.4 GeV, ~30-40 GeV), but coincidentally similar low-z reach
- matched x-axis range & binning, jet cone size, etc

Alternative UE subtraction methods – constituent subtraction



Absolute (ungroomed) mass response



m/p_T response

New!

- **Standard subtraction** w/ calo jets can result in $E_{jet} < |p_{jet}|$ due to resolution effects, e.g. $m_{jet}^2 < 0$ (represented here as $m_{jet} < 0$)
- **Constituent subtraction** has $m_{jet} > 0$ from pos-def. condition
  - and better mass resolution & m/p_T scale

cf. Berta, Spousta, Miller, Leitner, JHEP 1406 (2014) 092

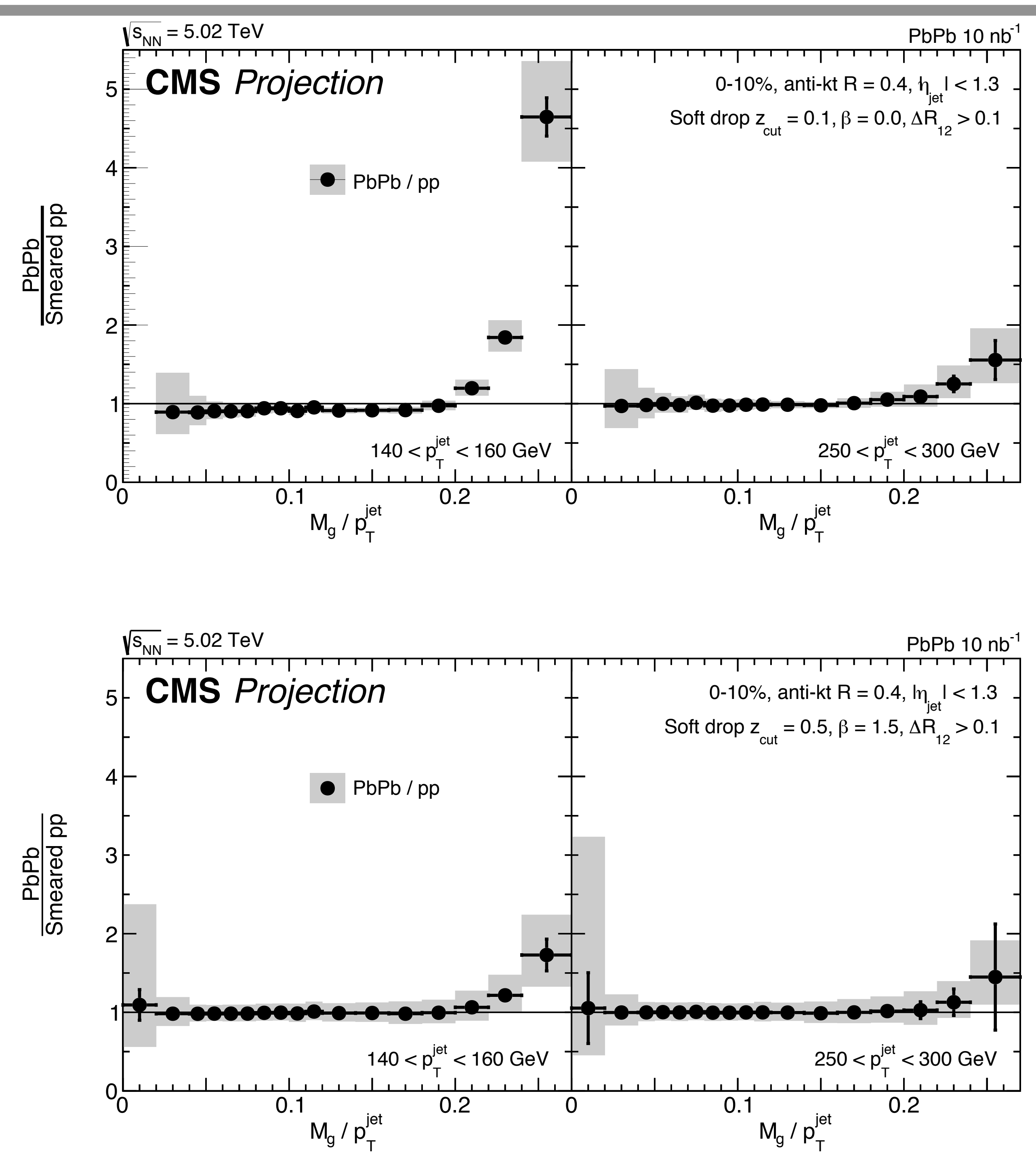
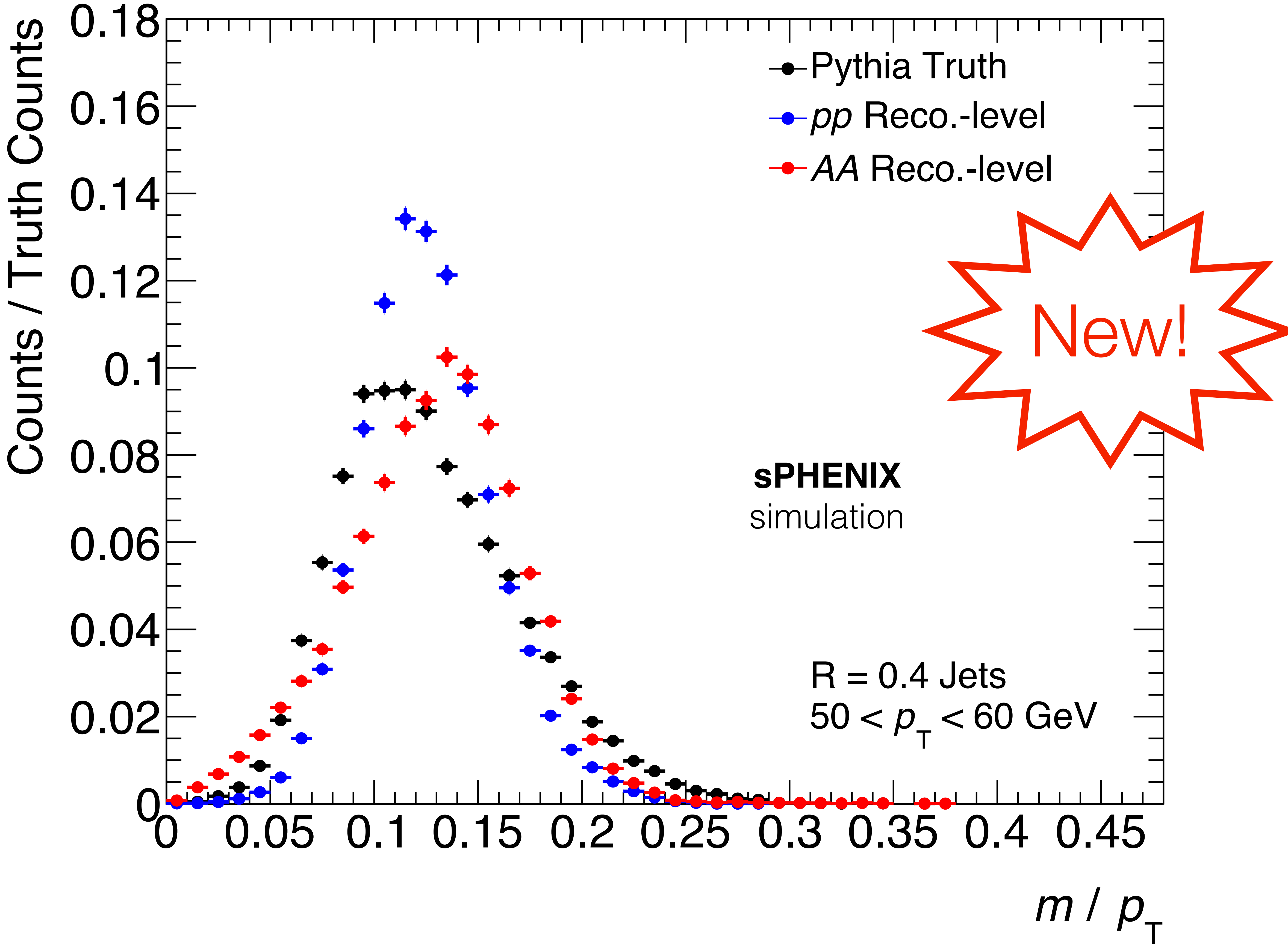


Fig. 37: Jet mass distribution with grooming setting $(z_{cut}, \beta) = (0.1, 0.0)$ (Upper panels) and $(z_{cut}, \beta) = (0.5, 1.5)$ (Lower panels). [8]

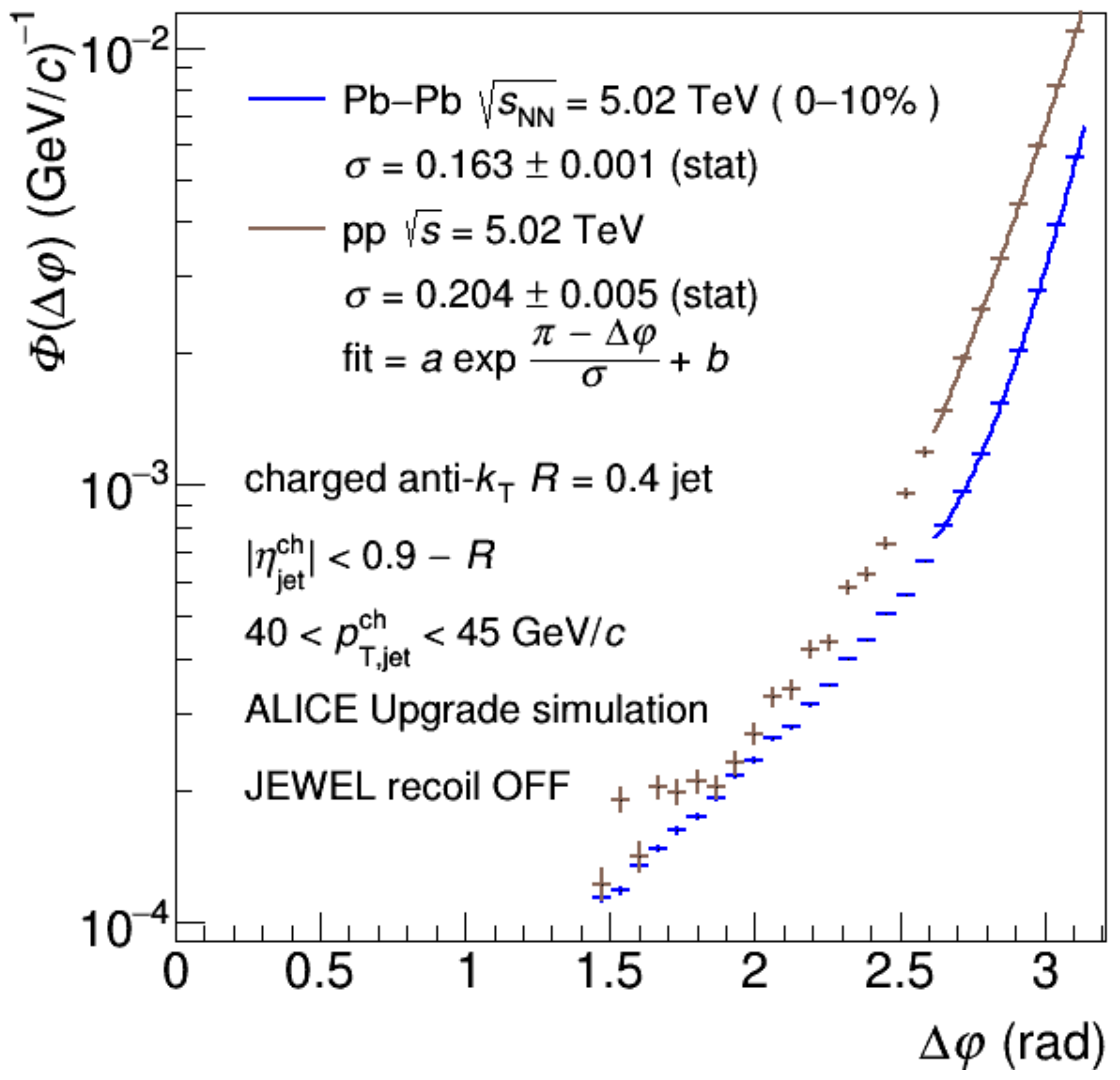
CERN Yellow Report projections for Runs 3, 4



CMS groomed mass / p_T (left) — c.f. sPHENIX version w/ ungroomed mass (right)

➡ new observable enabled by constituent mass subtraction

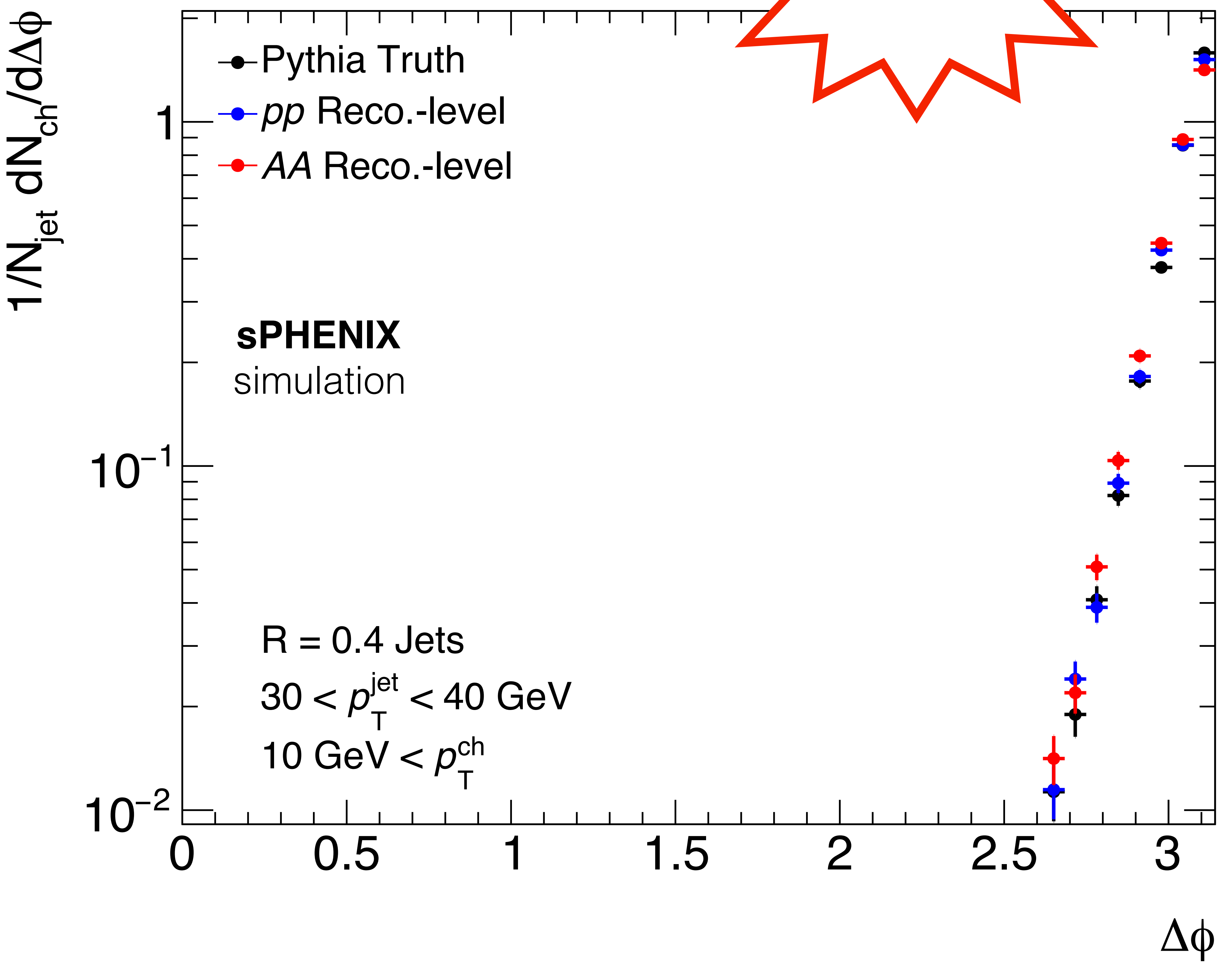
➡ general conclusion: can pick kinematic regions where UE effects are small



CERN Yellow Report projections for Runs 3, 4

Fig. 31: JEWEL simulation of the angular distribution of charged jet yield in the ALICE acceptance for $40 < p^{ch}_{T,jet} < 45$ GeV/c and $R = 0.4$ recoiling from a high-p_T reference hadron ($20 < p_{T,trig} < 50$ GeV/c), for central Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with 10 nb^{-1} int. luminosity, and pp collisions at $\sqrt{s} = 5.02$ TeV with 6 pb^{-1} int. luminosity. The recoil jet azimuthal angle $\Delta\varphi$ is defined with respect to the reference axis. The observable shown is $\Phi(\Delta\varphi)$ which incorporates statistical suppression of uncorrelated background. Figure from Ref. [1].

New!



ALICE hadron+jet **Δϕ** balance (left) — c.f. sPHENIX version (right) — new!

➡ reasonable match to ALICE kinematics (p_T^h ~ 10's of GeV, p_T^{jet} ~ 40 GeV)

➡ but note: charged jet (ALICE) vs. full jet (sPHENIX) difference

➡ sharper **Δϕ** correlation at RHIC (smaller ISR + FSR, modest UE effects)

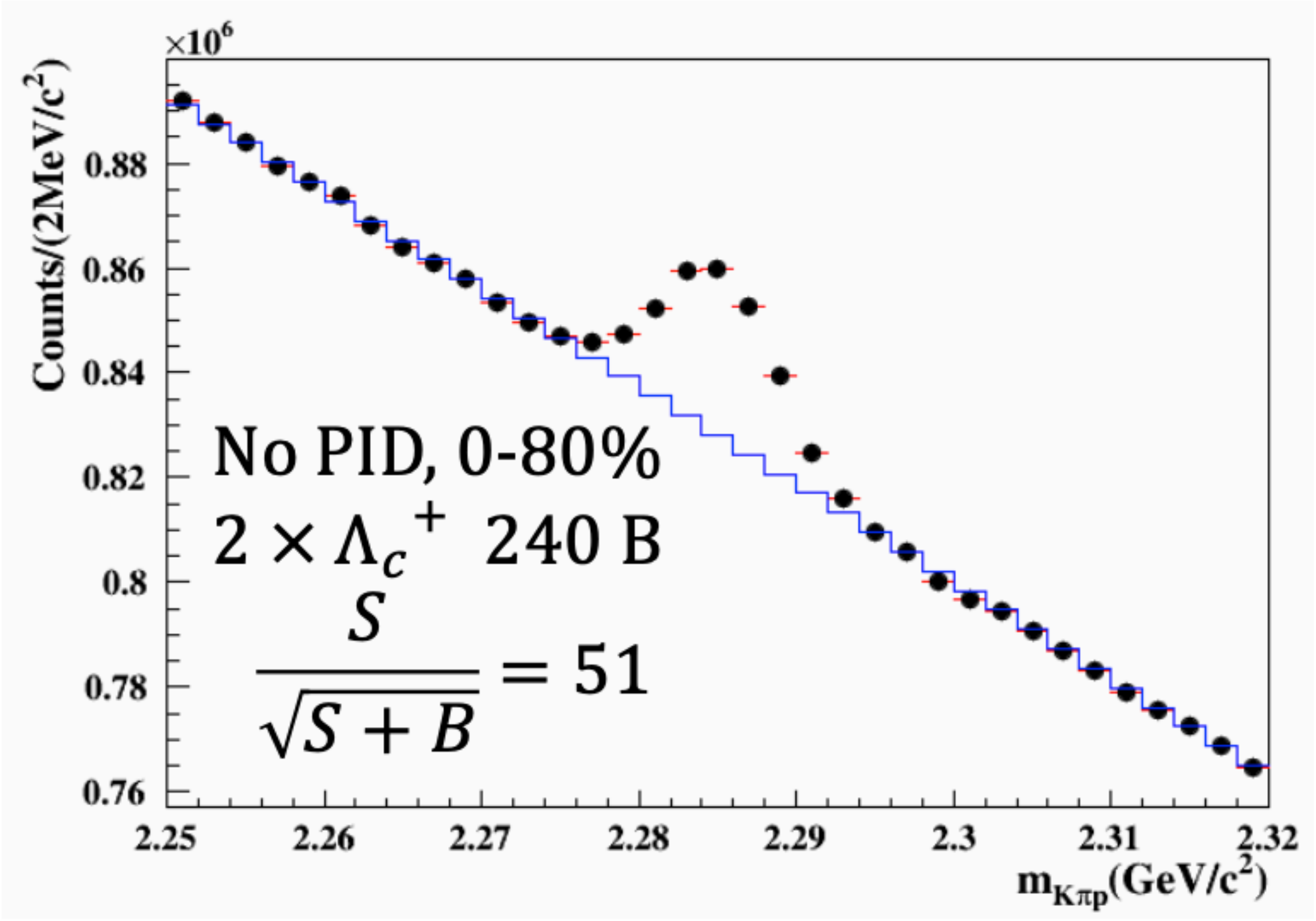
➡ matched jet *R* value, x-axis range to ALICE plot

heavy flavor/jet topical group

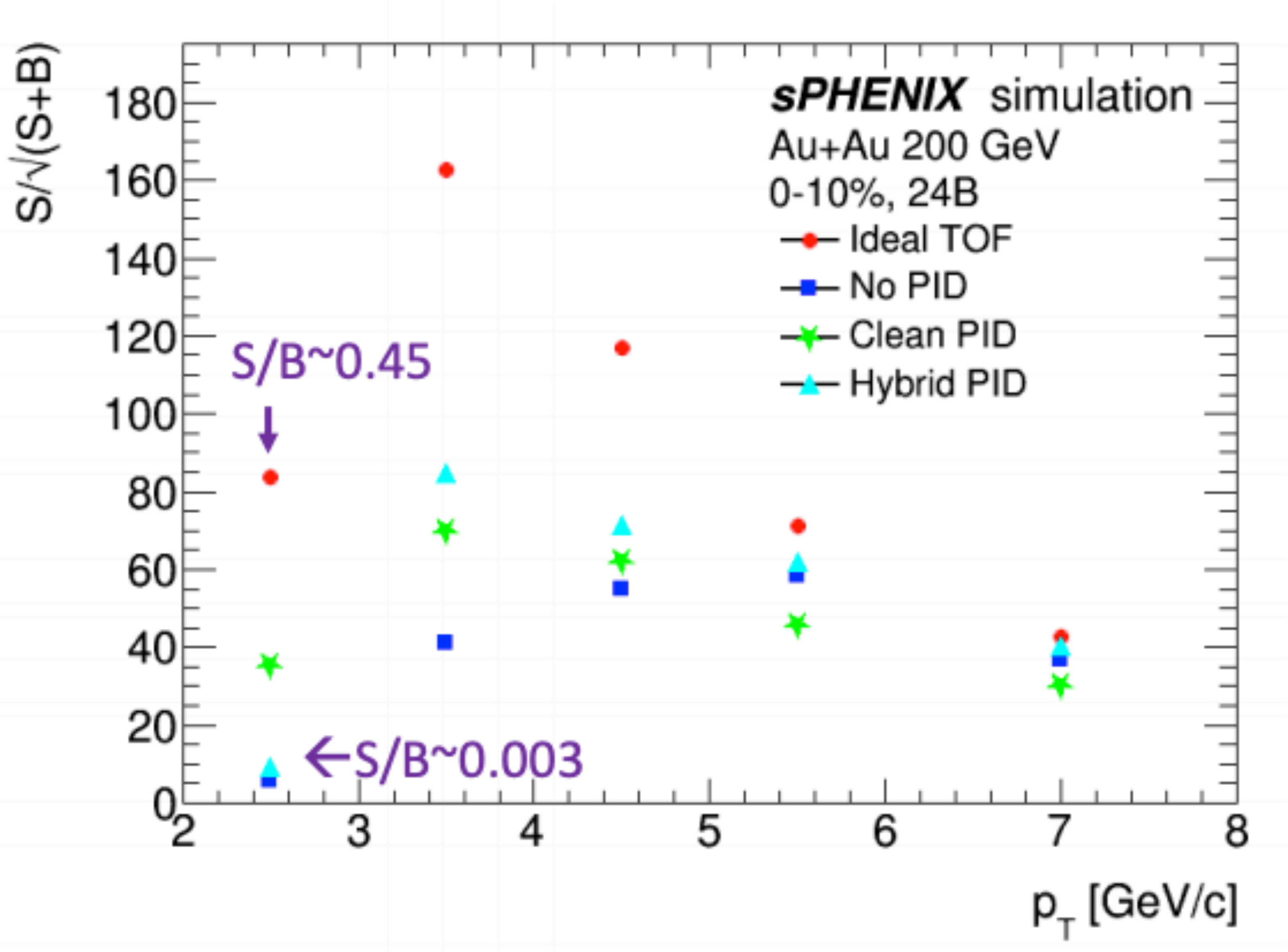
Xin Dong (LBNL)
Jin Huang (BNL)

co-conveners

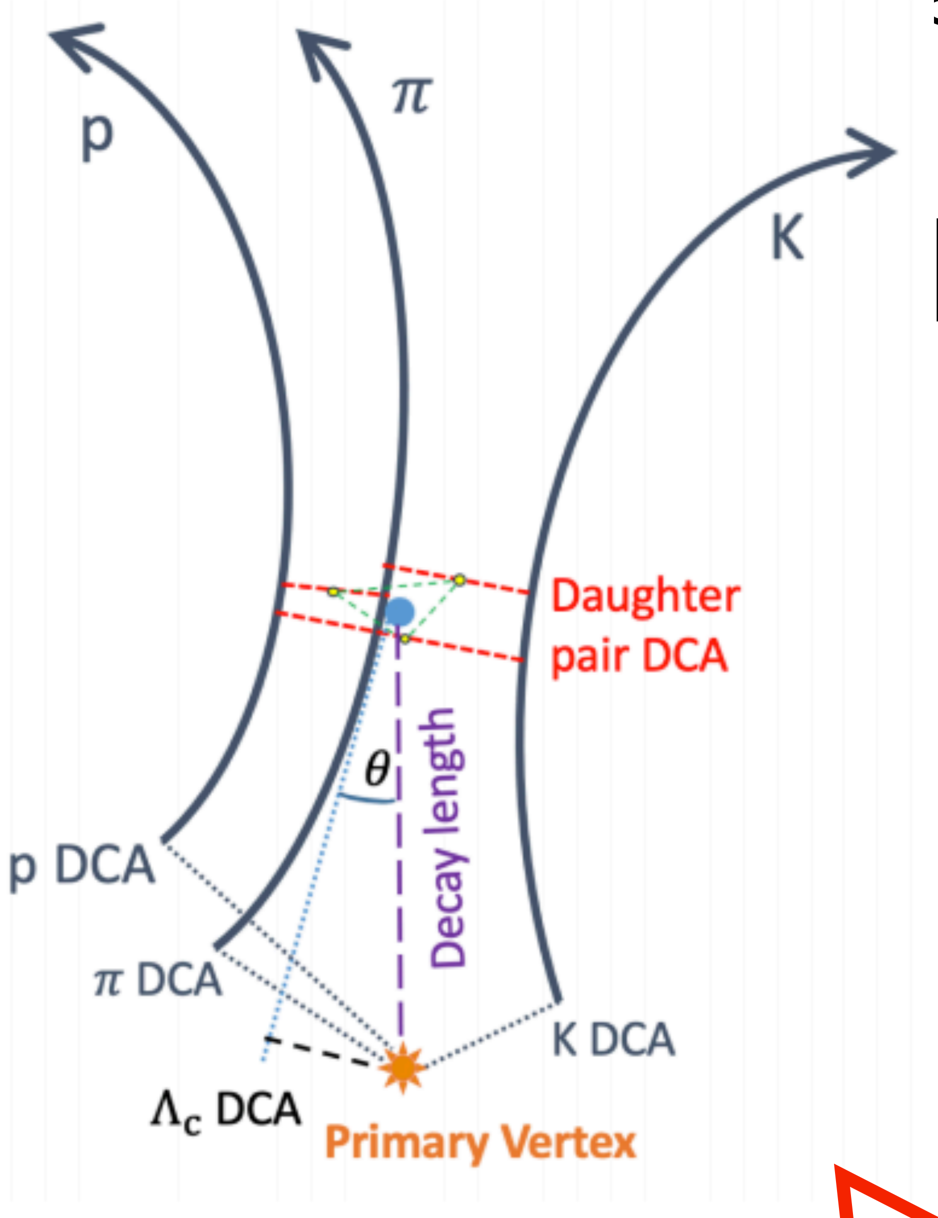
Λ_C - Hadronization

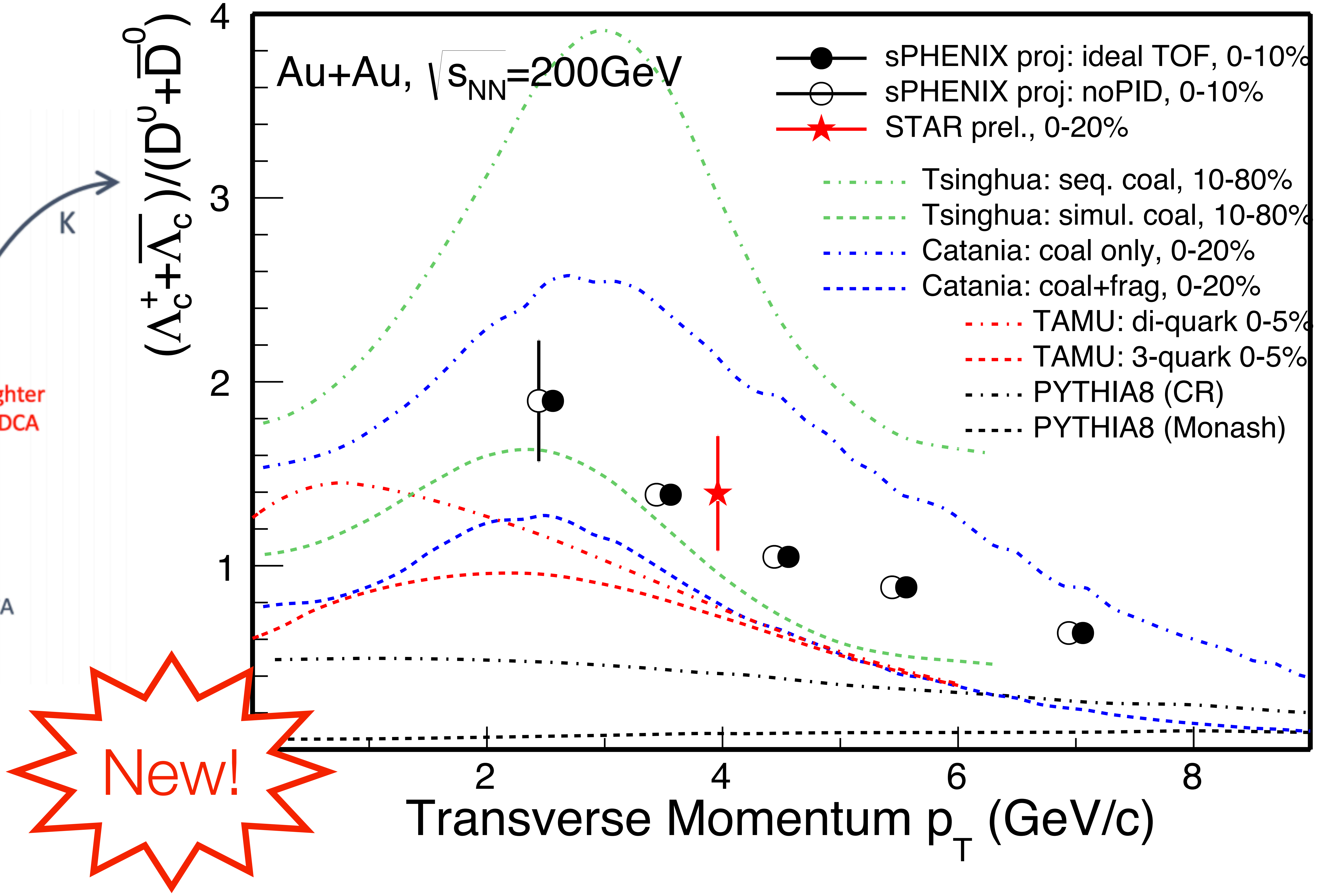


Yuanjing Ji (USTC/LBNL)



complex decay topologies enable high S/B in baseline sPHENIX

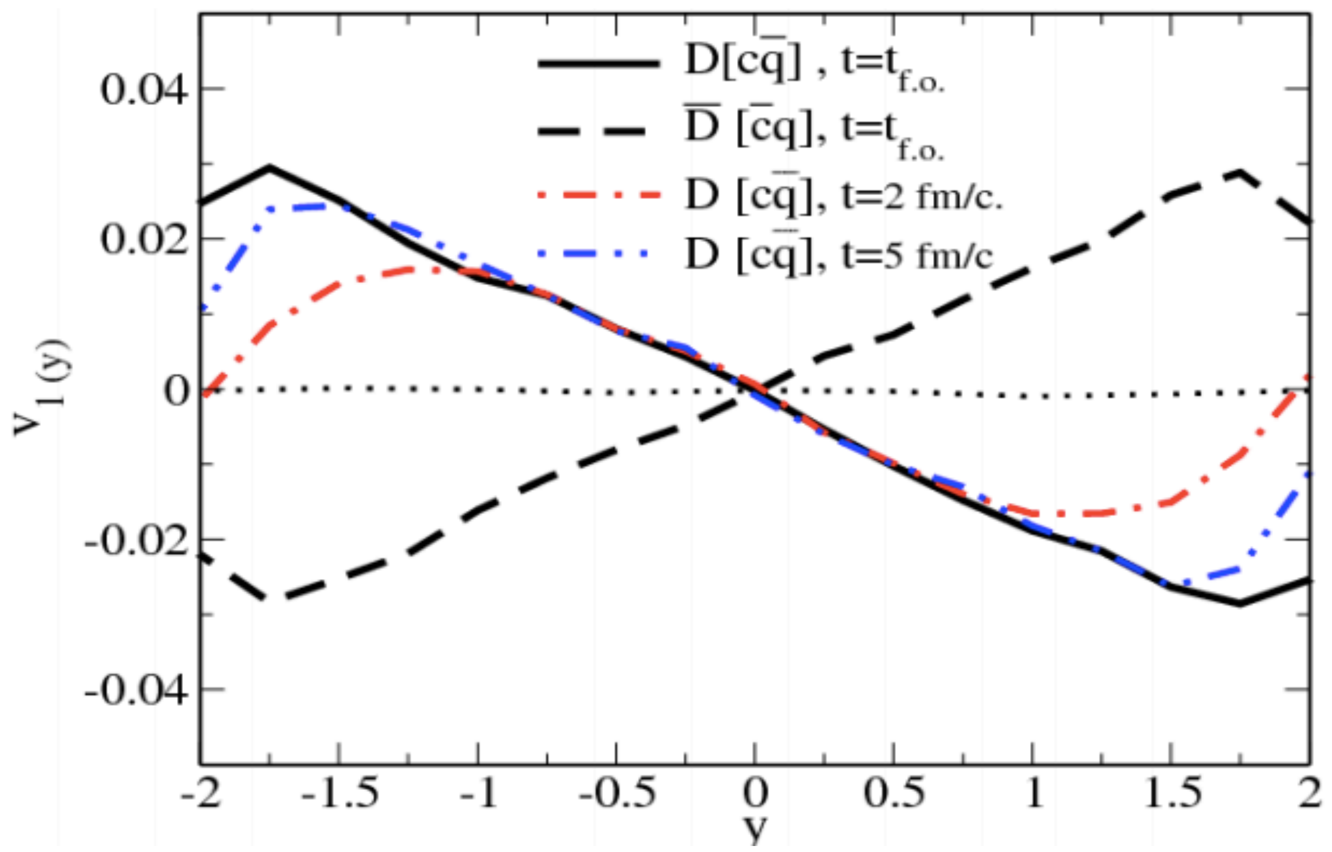




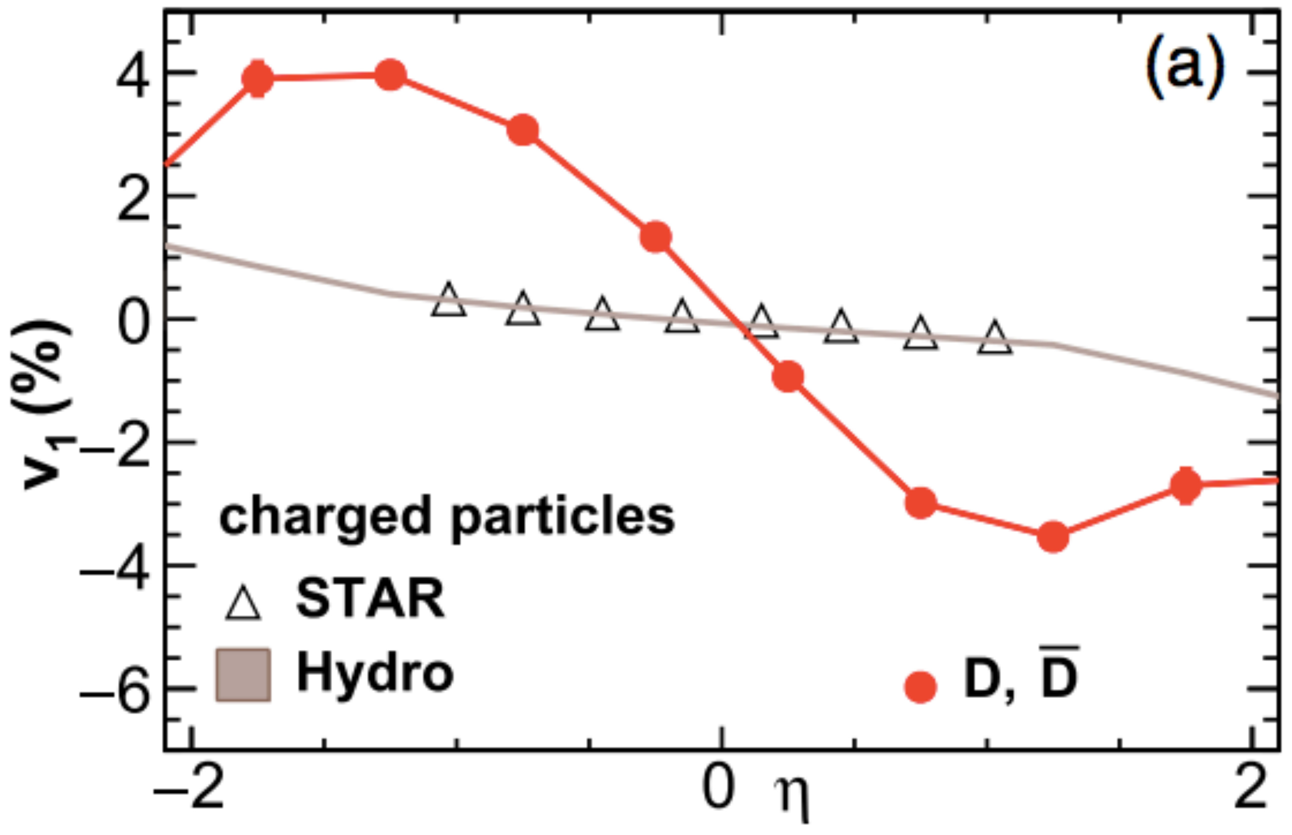
D^0 v_1 - Direct Access to Initial B Field

sPHENIX

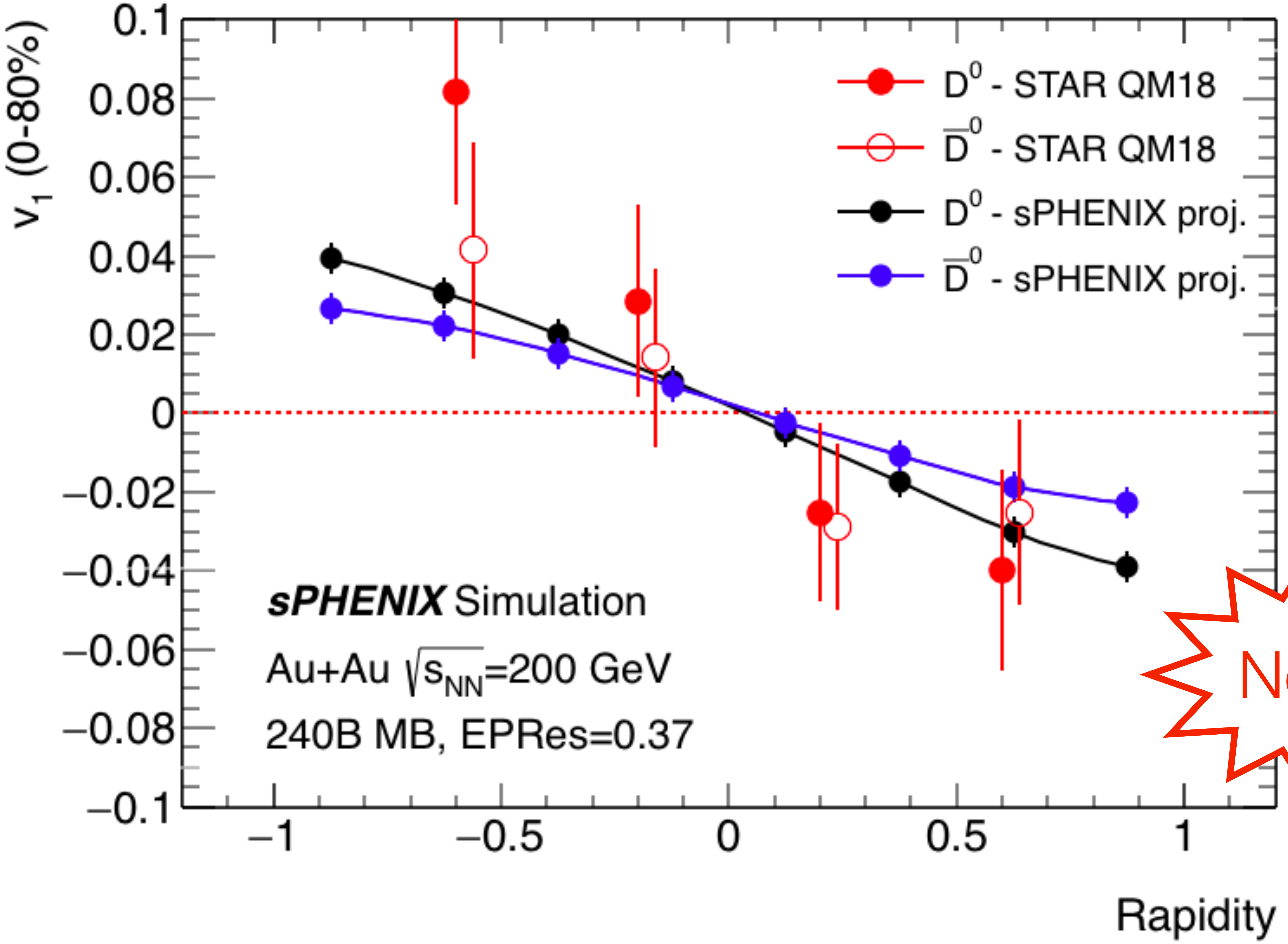
init. B -> v1(D) = -v1(Dbar)



tilt QGP -> v1(D) = v1(Dbar) >> v1(h)



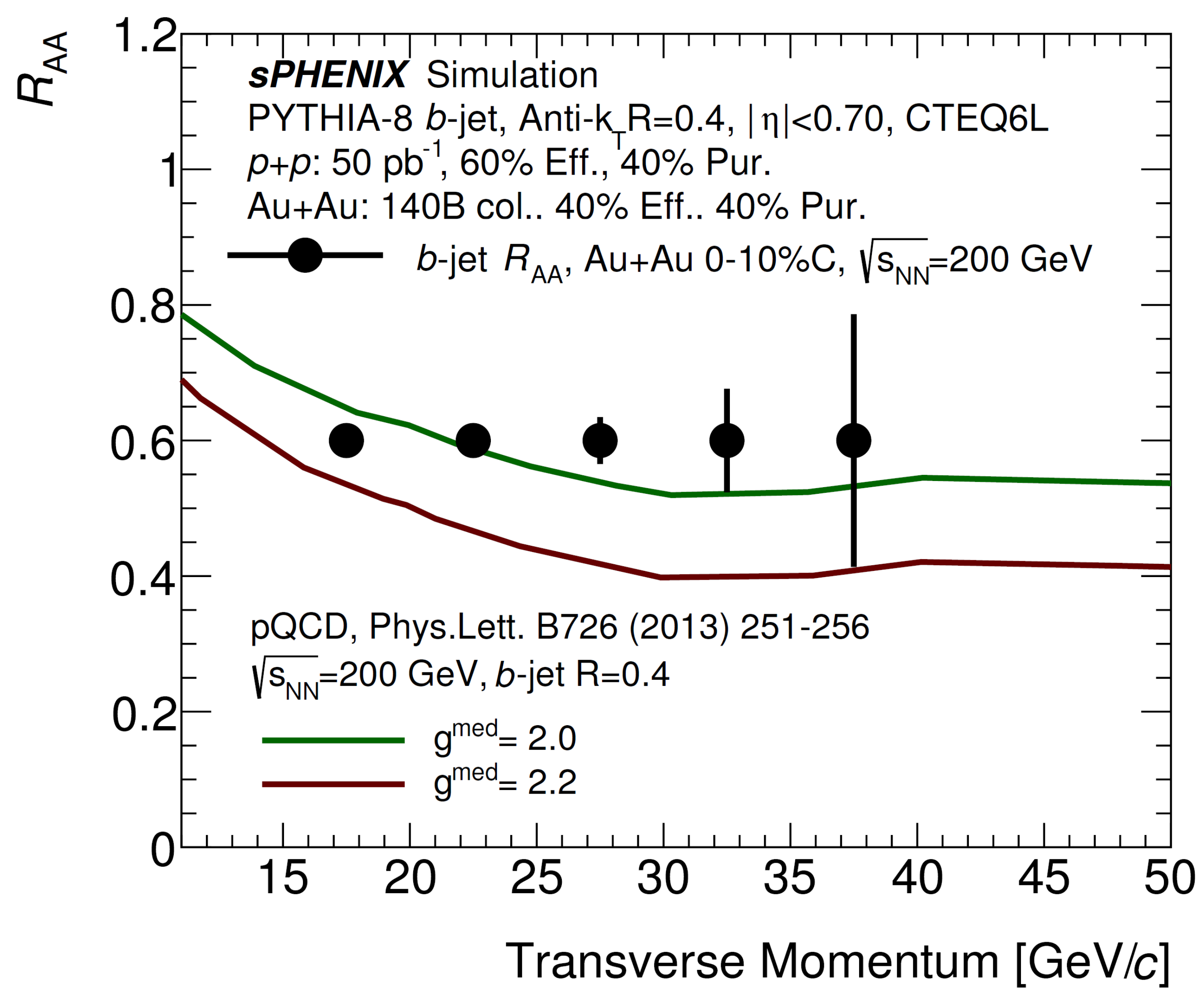
Need: Good ZDC-SMD detector to improve 1[st] EP resolution

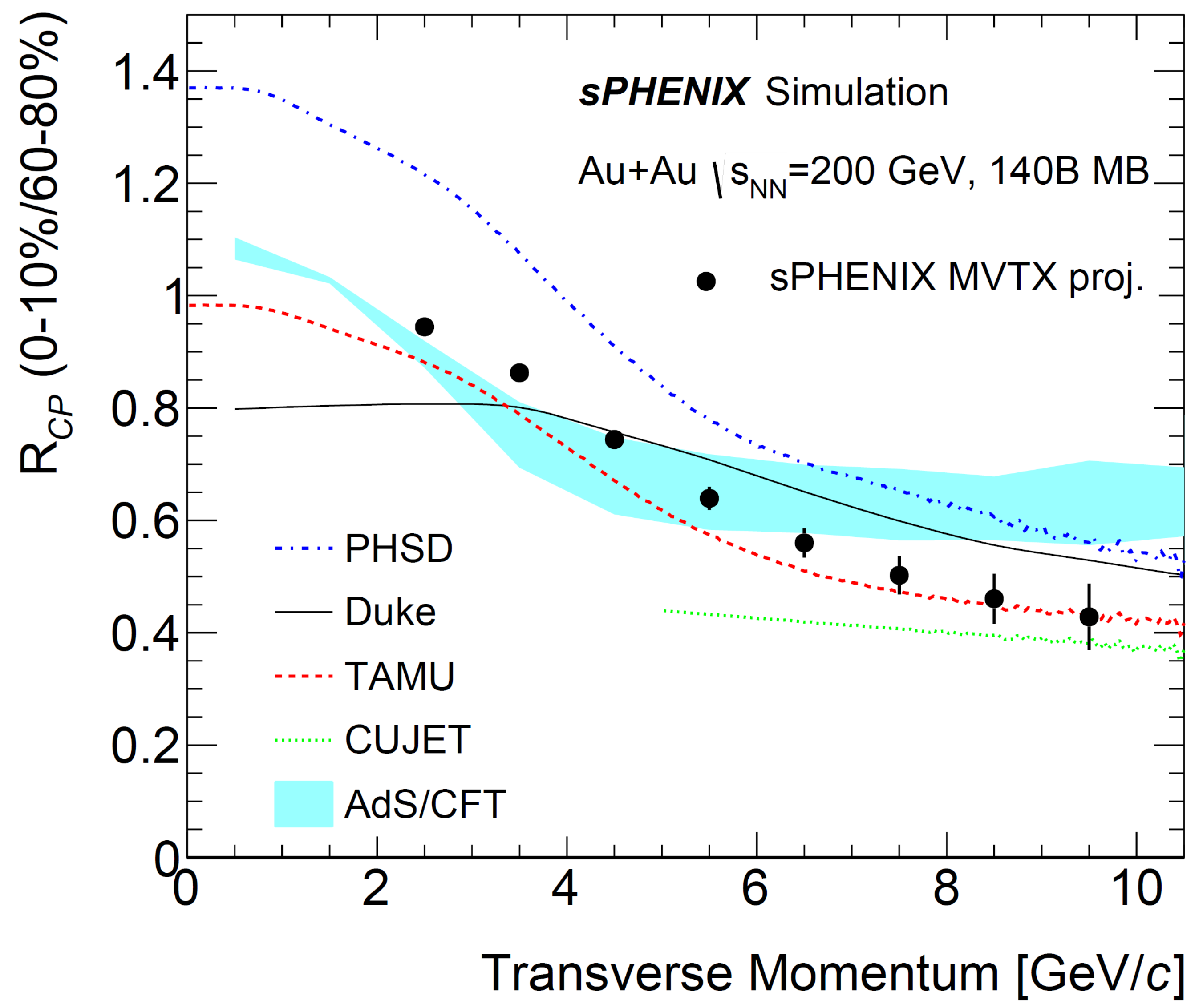


New!

Open HF observables – b-tagged jets, B mesons

b-tagged jet R_{AA}

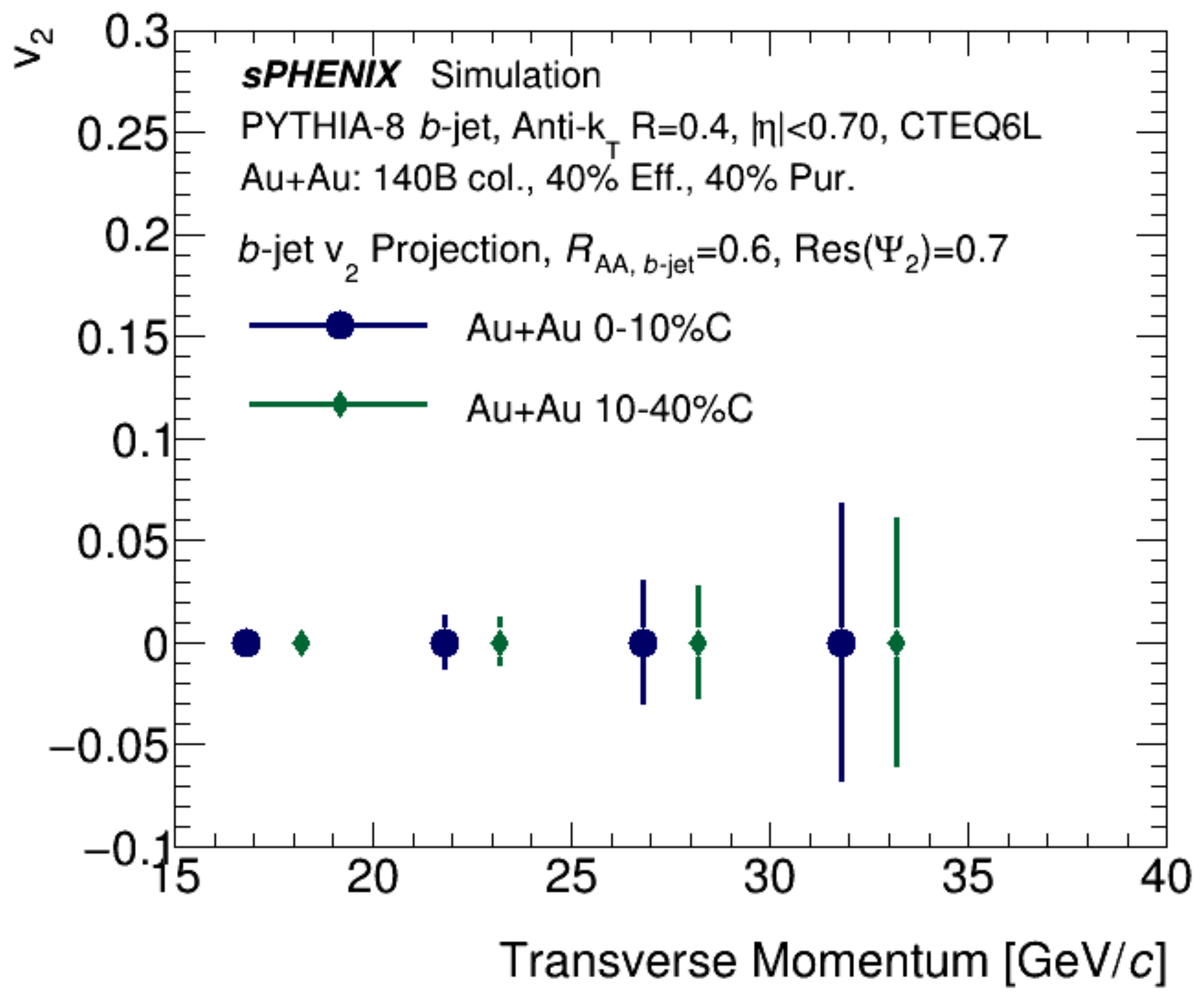


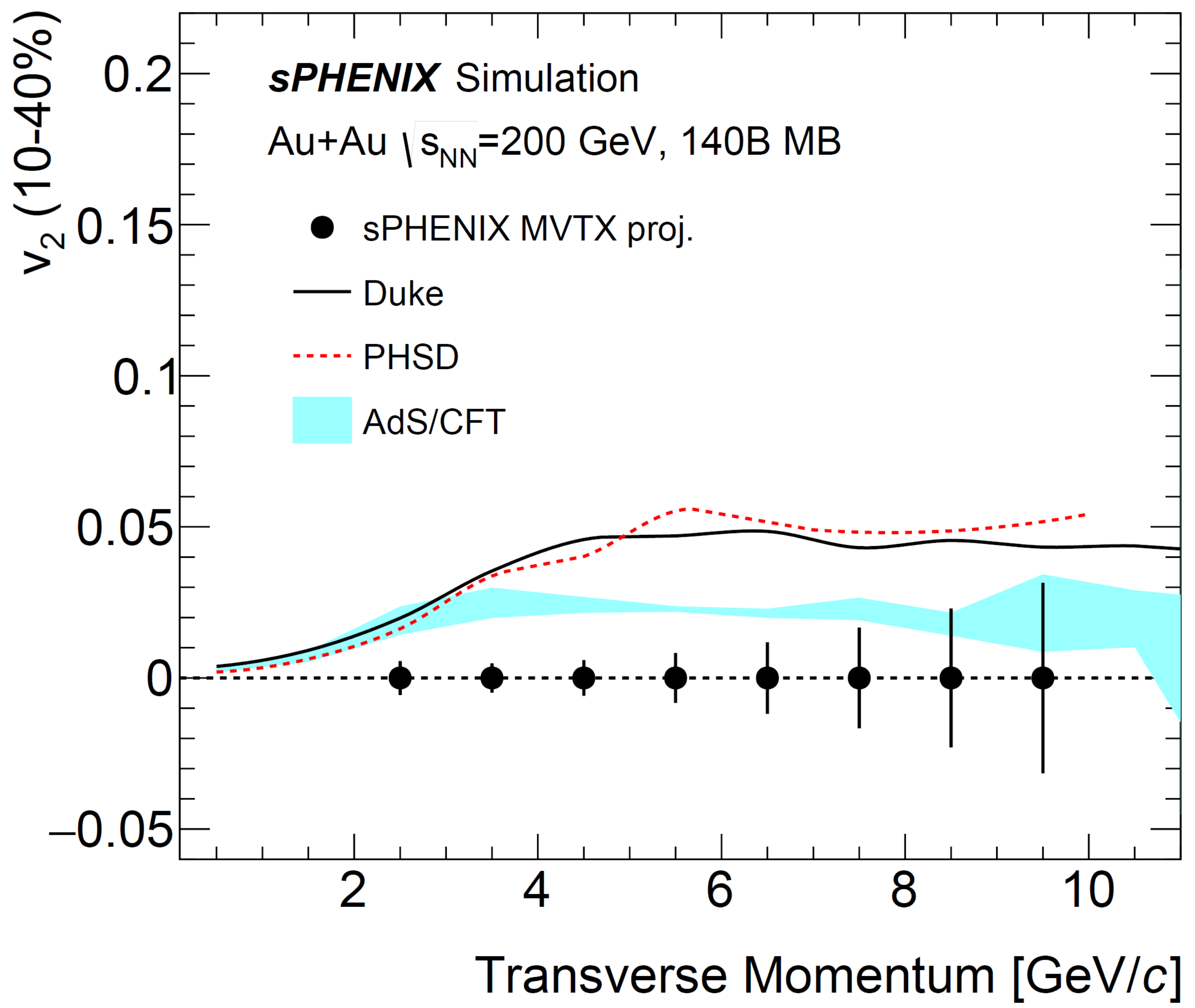


B-meson R_{CP}

Updated!

b-tagged jet v_2



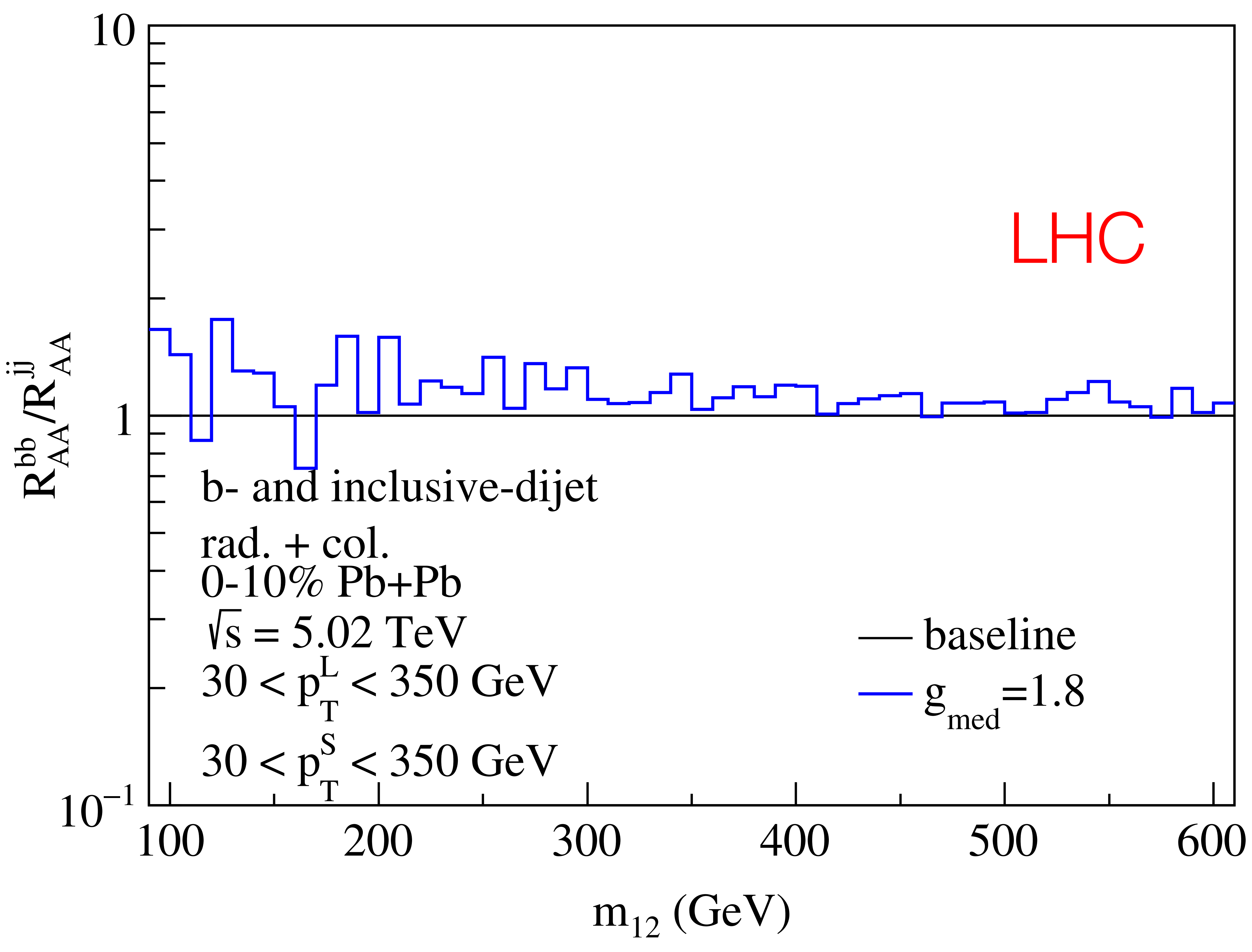


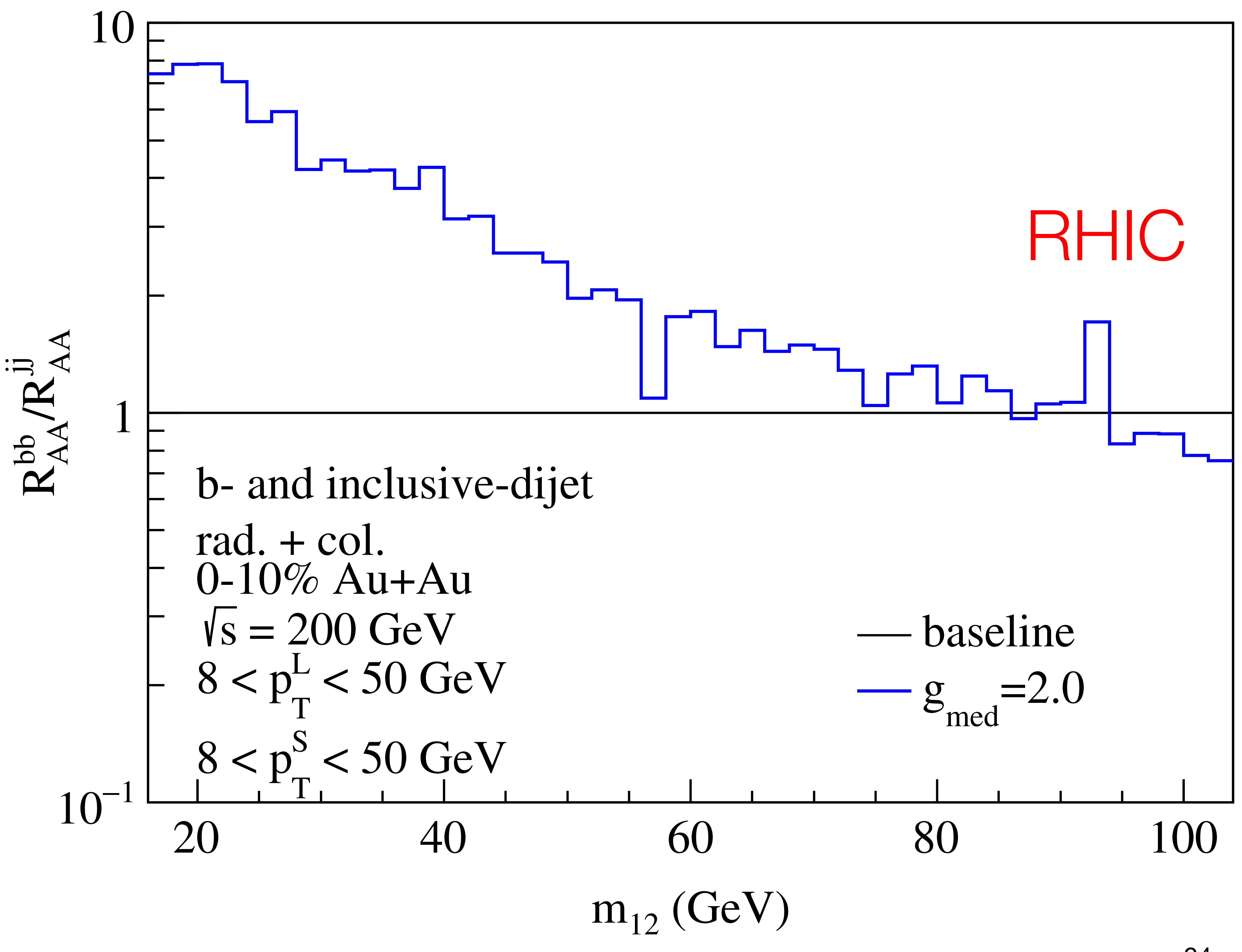
B-meson v_2

Examples of theory progress connected to sPHENIX activity

Z-B Kang, J Reiten, I Vitev, B Yoon, "Light and heavy flavor dijet production and dijet mass modification in heavy ion collisions", Phys. Rev. D99 034006 (2019) Partly supported by LANL LDRD motivated by and connected to sPHENIX

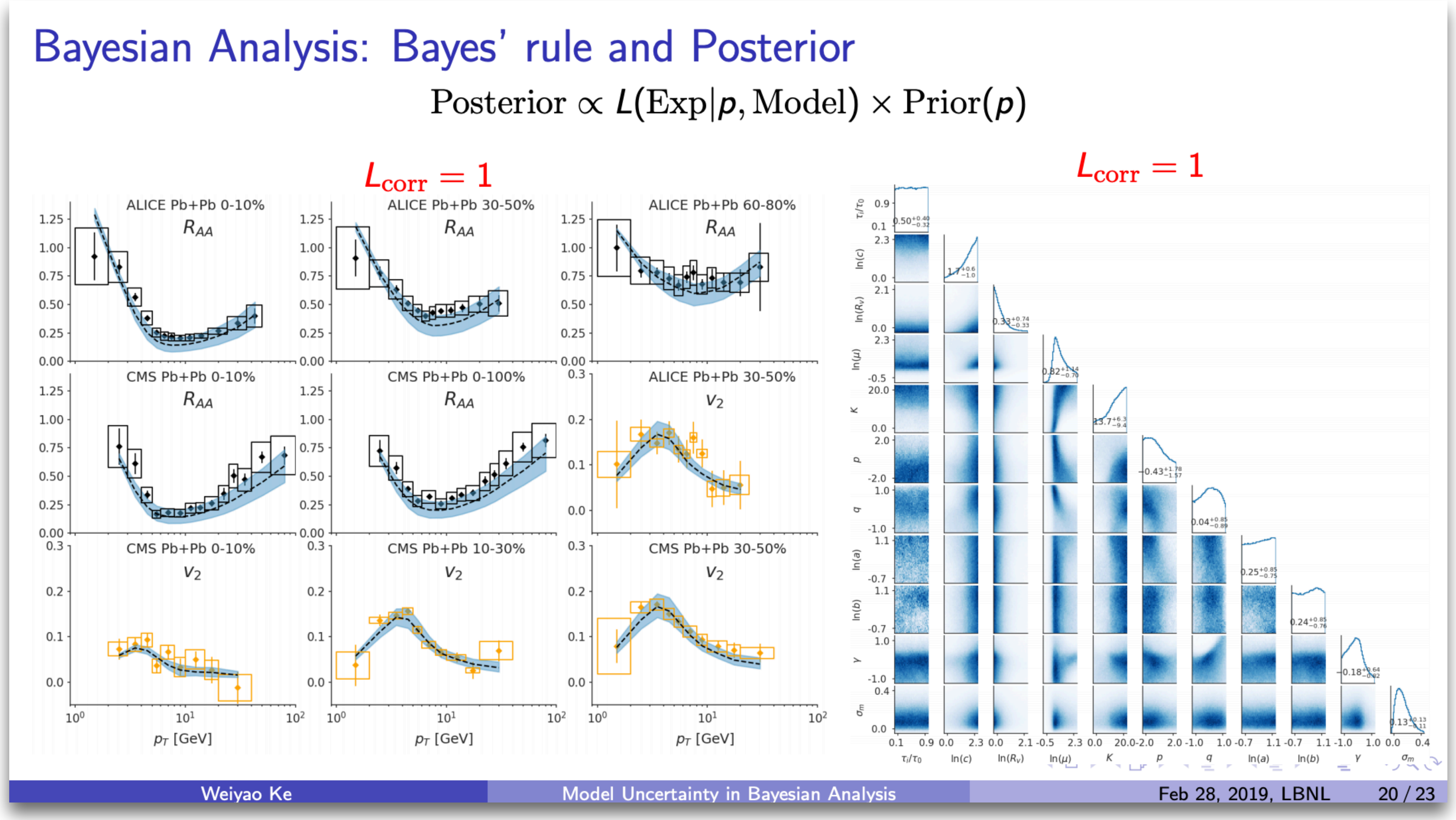
Increased coupling to the medium near T_C ⇔ stronger b-dijet effect at RHIC





Ongoing heavy flavor work with theory community

https://sites.google.com/lbl.gov/hfmvtxlbnl2019/home



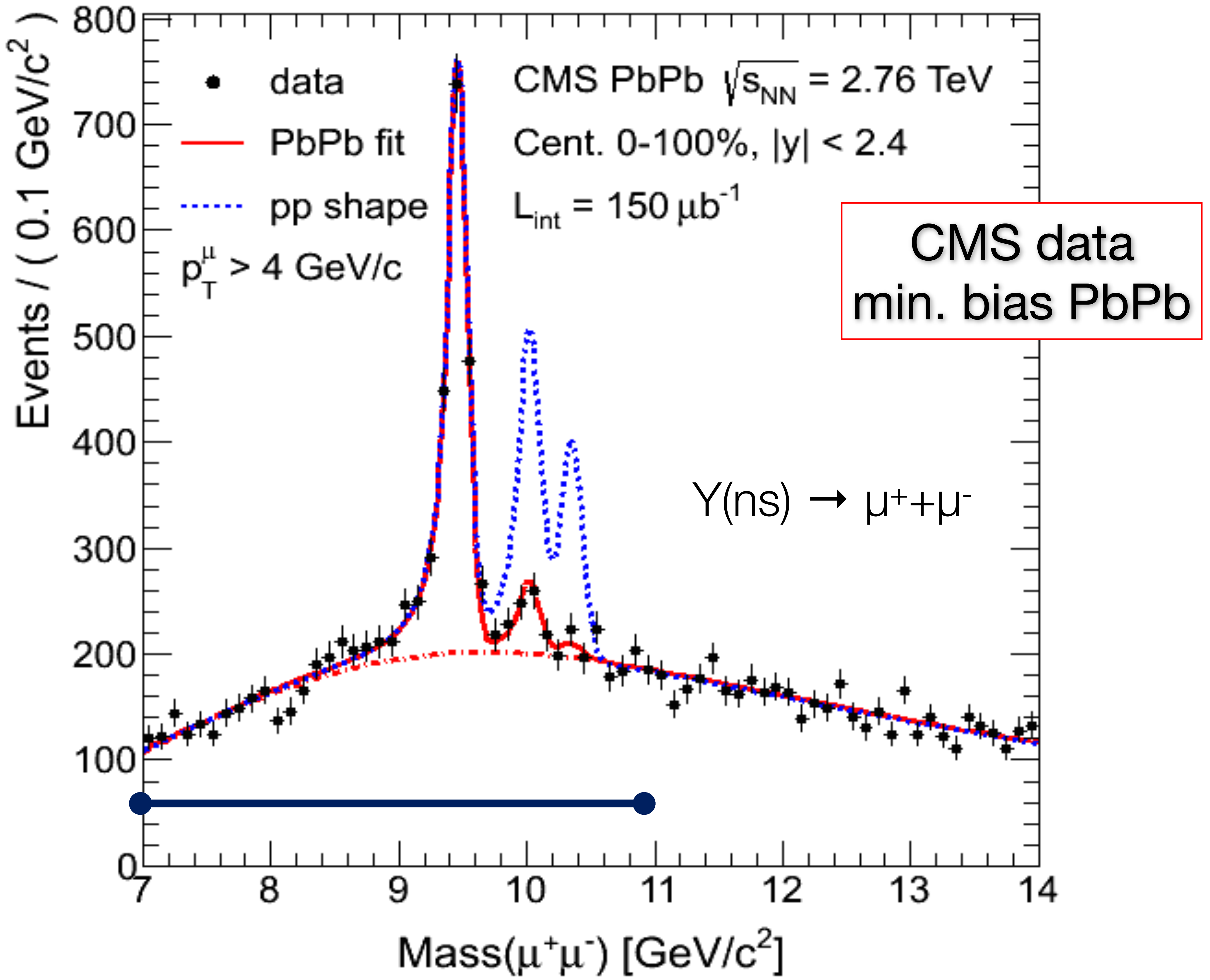
- Working with theory group at Duke (Weiyao Ke) to quantify power of sPHENIX data to constrain HQ transport parameters
  - Model: Linearized Boltzmann with diffusion model (LIDO) [DOI: 10.1103/PhysRevC.98.064901]
  - Bayesian fit to sPHENIX projected uncertainties of B and D meson R_{cp} and v_2

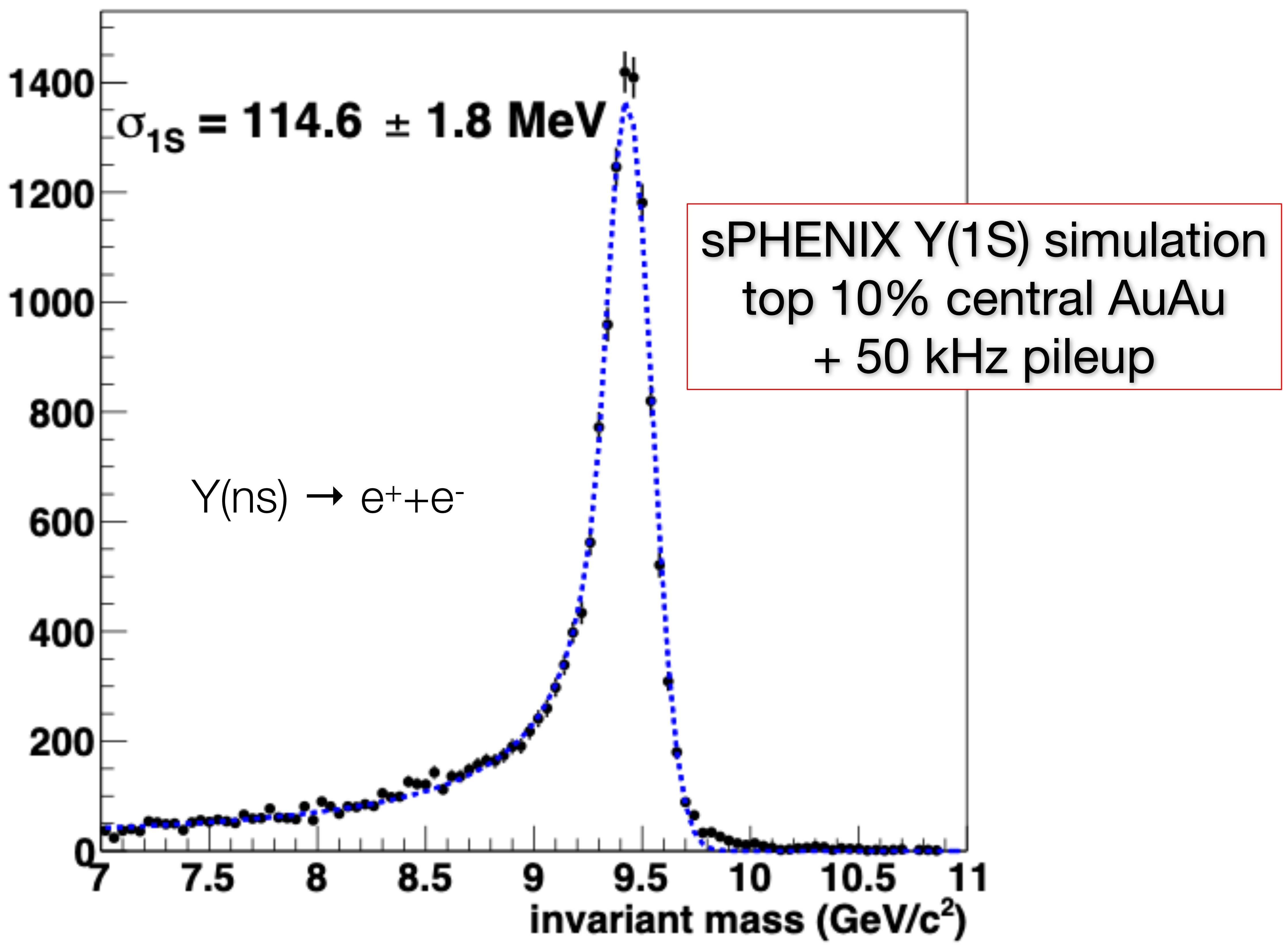
quarkonia topical group

Marzia Rosati (ISU)
Tony Frawley (FSU)

co-conveners

Upsilons at sPHENIX and LHC





Differential suppression of Υ(nS), temperature dependence of QGP Debye screening length

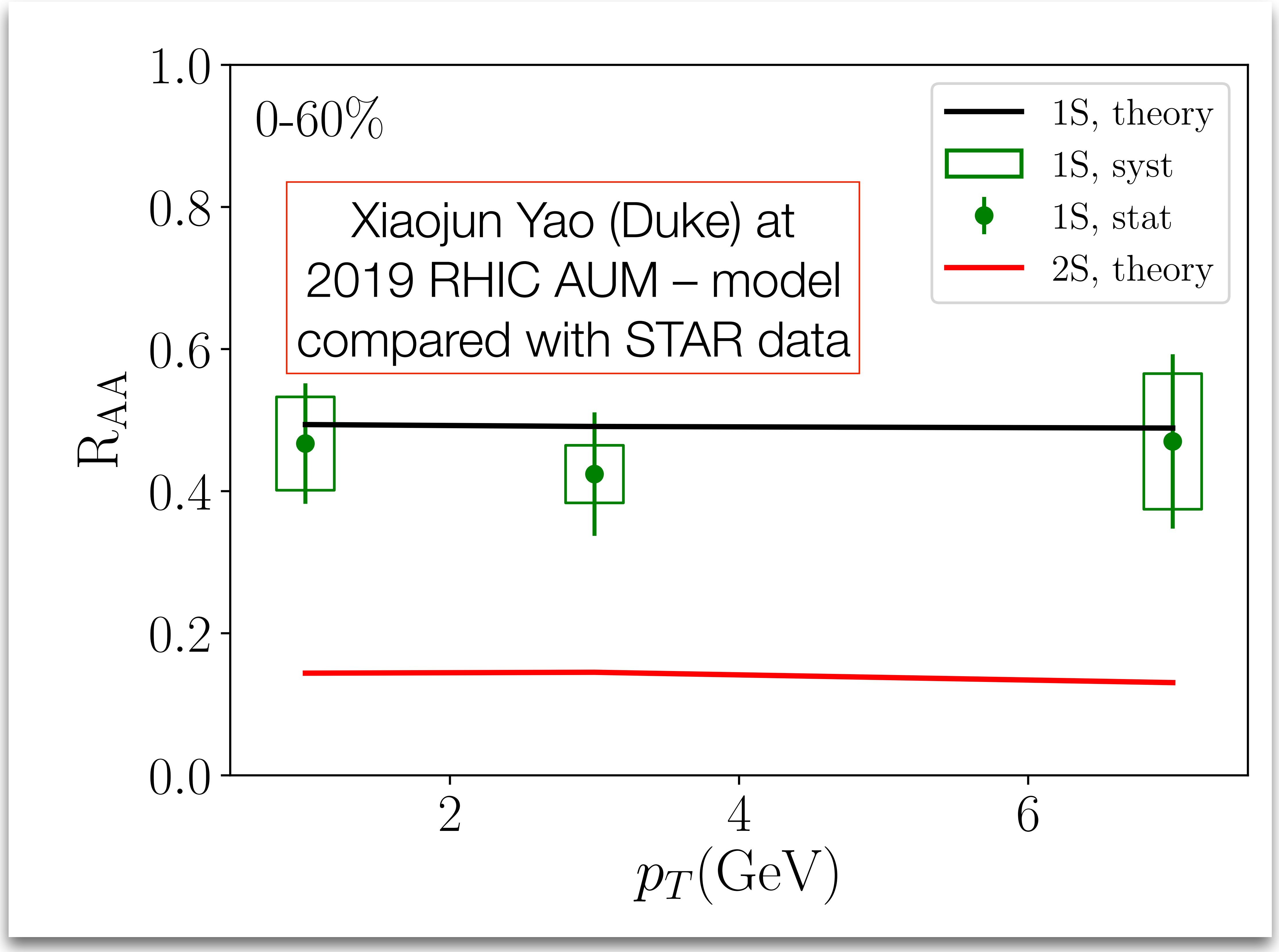
Updated!

Υ(1S) width key f.o.m. in work of Inner Detector Optimization Task Force – deciding INTT configuration (pattern recognition vs. radiative tails and conversions)

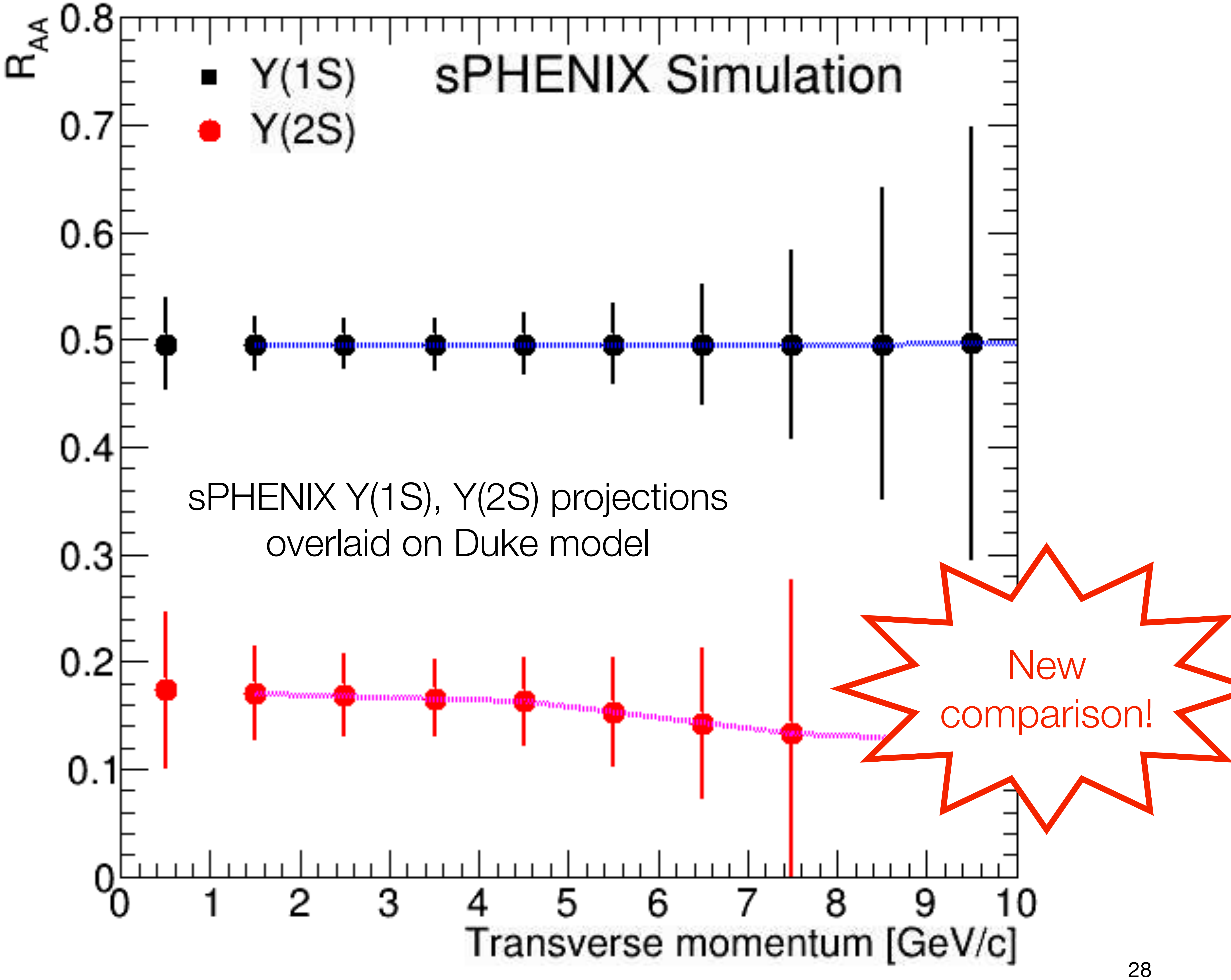
Quarkonium in the medium – recent work

Detailed balance affected by dissociation, strong energy loss of bare HQ, recombination

See X. Yao, B. Mueller, arXiv:1811.09644



Following discussions with sPHENIX collaborators X.Yao generated projections in sPHENIX acceptance



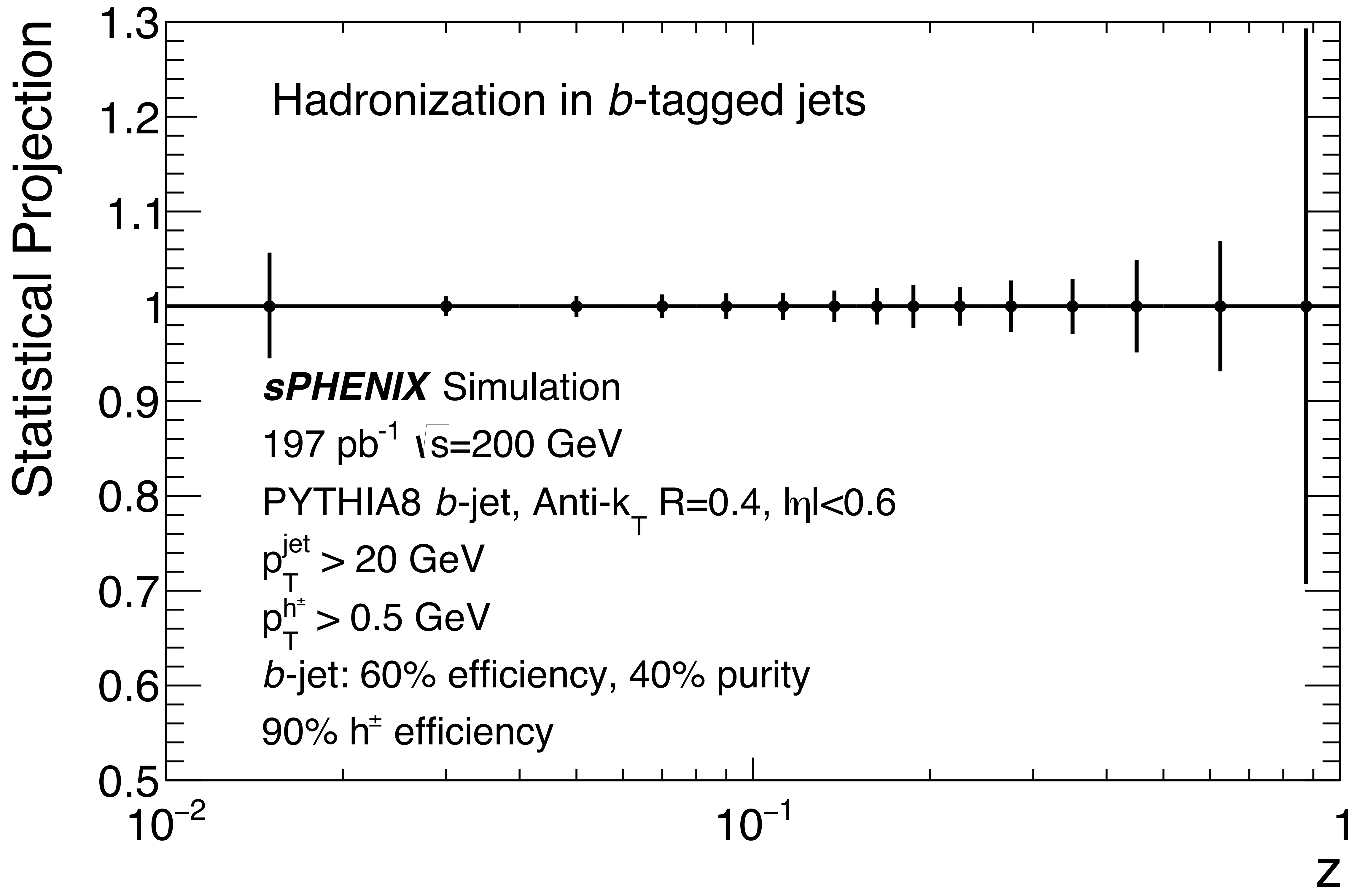
cold QCD topical group

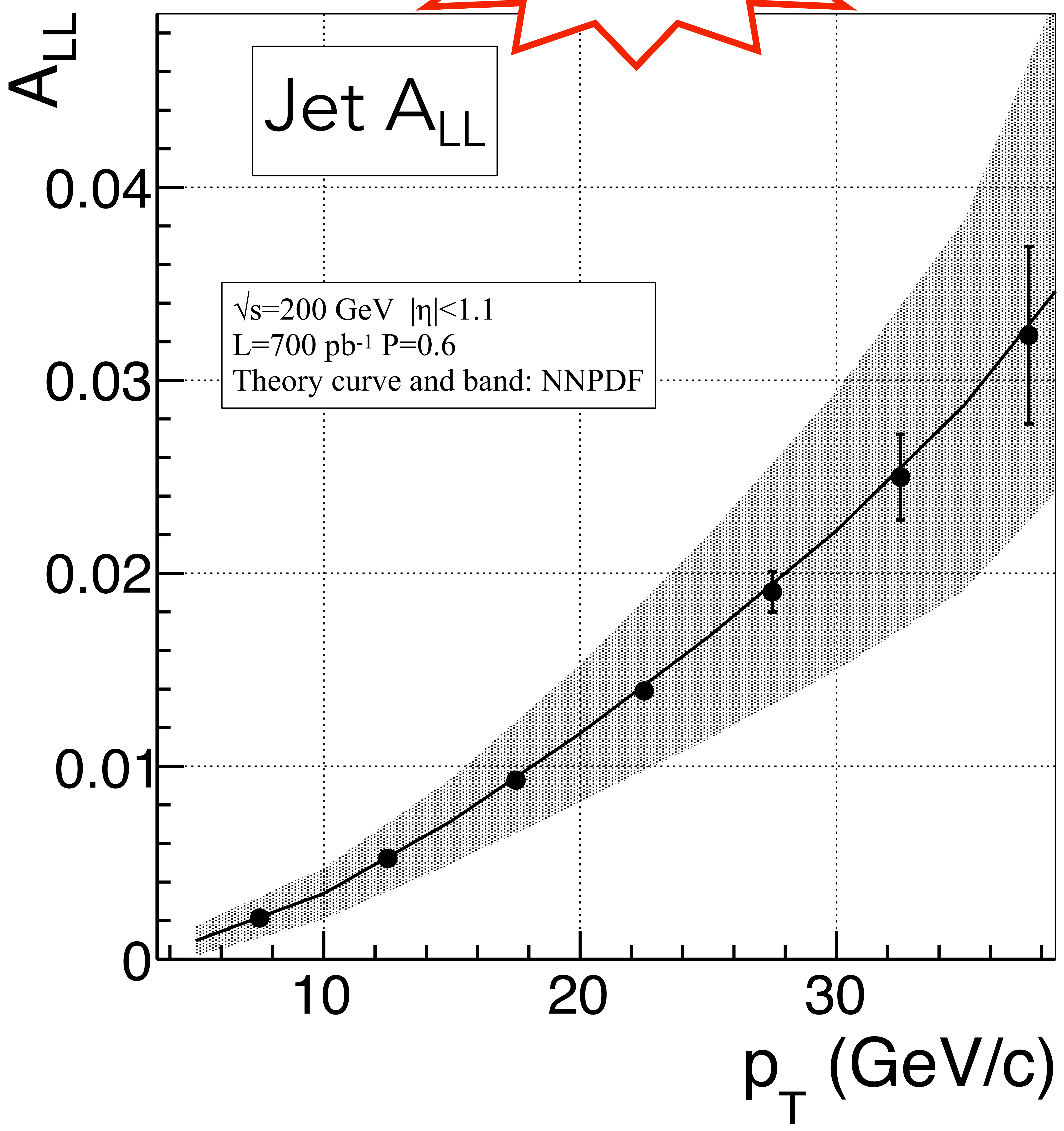
Christine Aidala (MIchigan)
Sasha Bazilevsky (BNL)

co-conveners

Central Barrel Opportunities

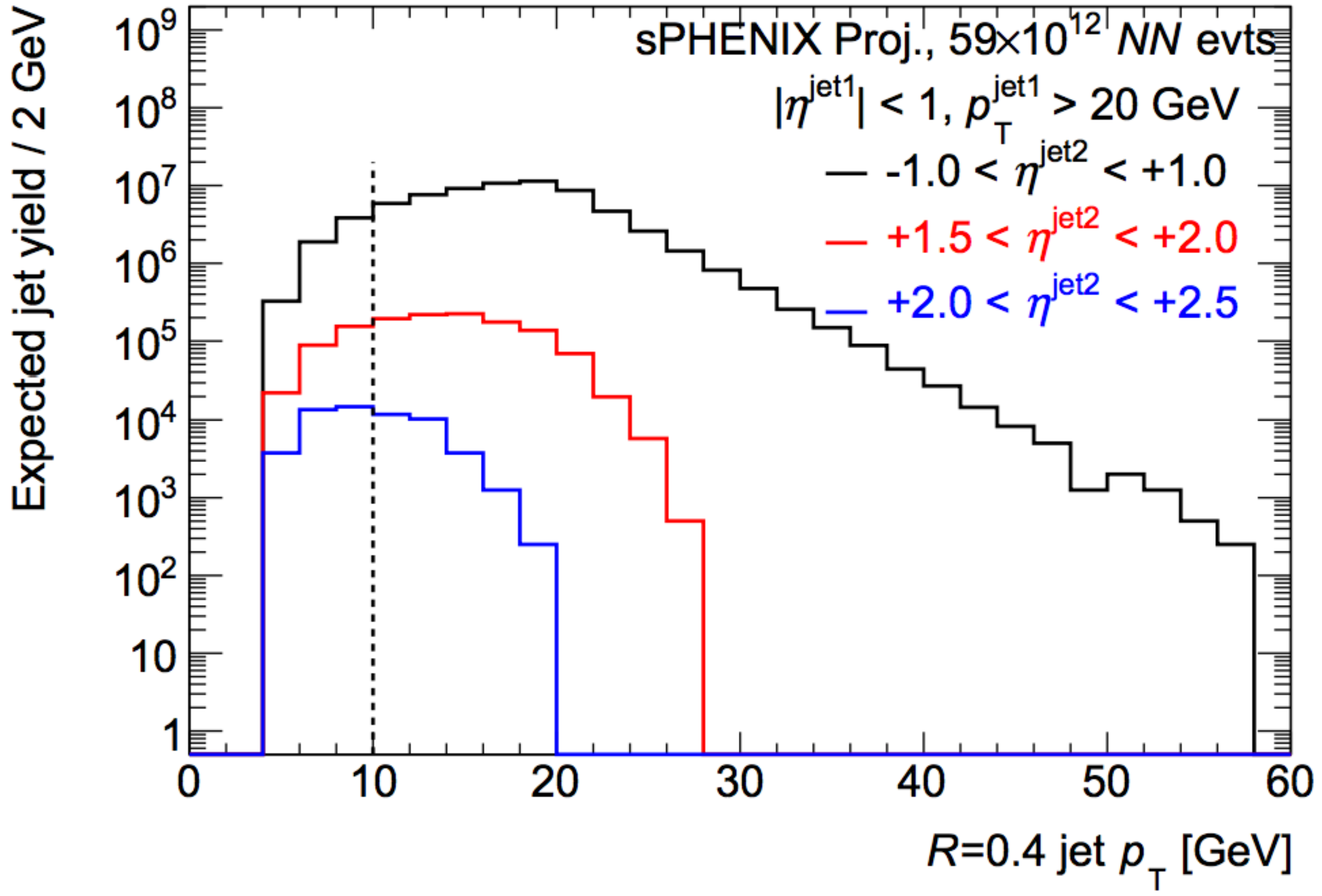
Updated!

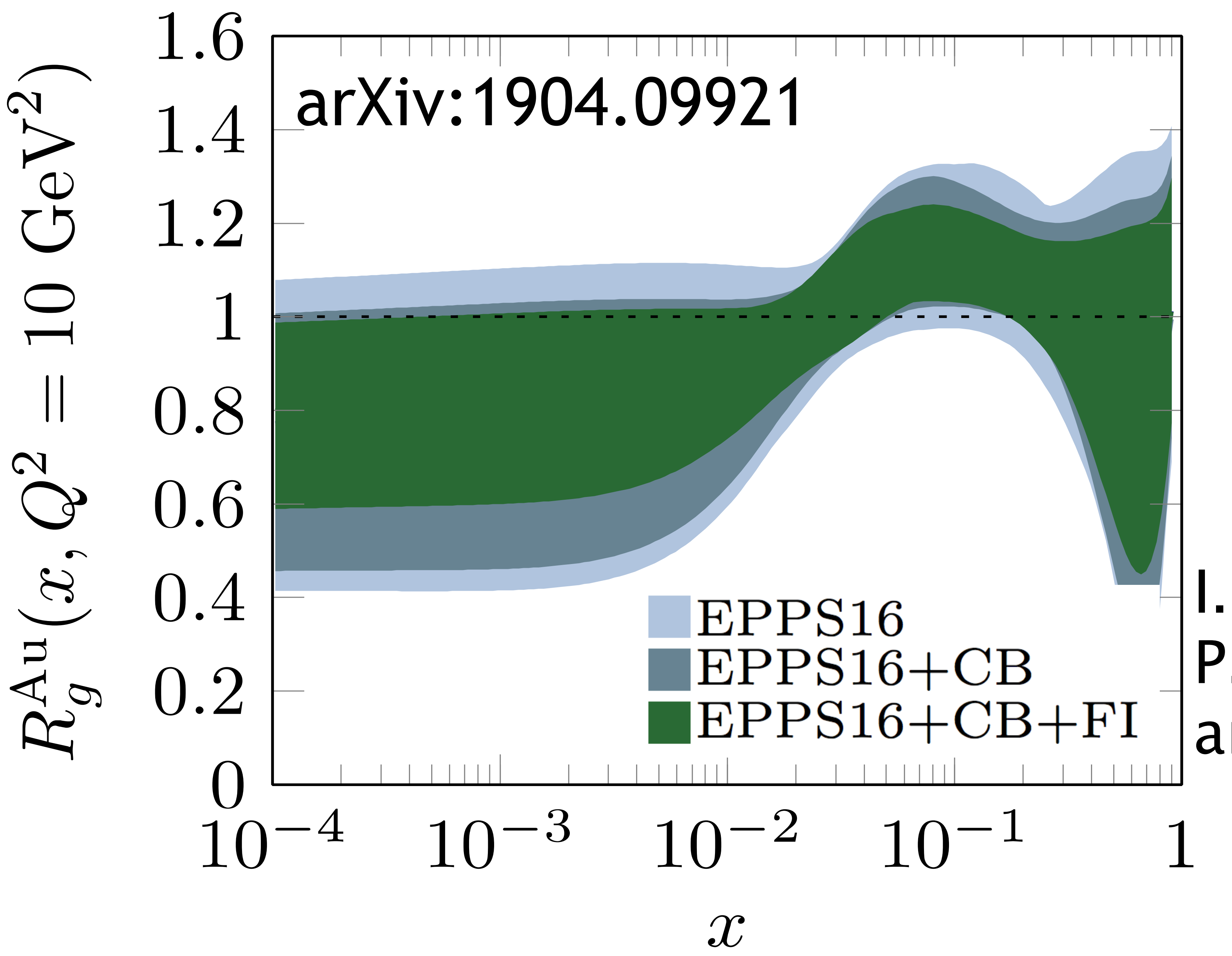




- Builds on October 2017 study of ME physics with sPHENIX barrel (https://indico.bnl.gov/event/3866/)
- Spin structure, parton dynamics, hadronization, (n)PDFs, quarkonia…
- Utilize jet, heavy flavor, and direct photon strengths of sPHENIX barrel

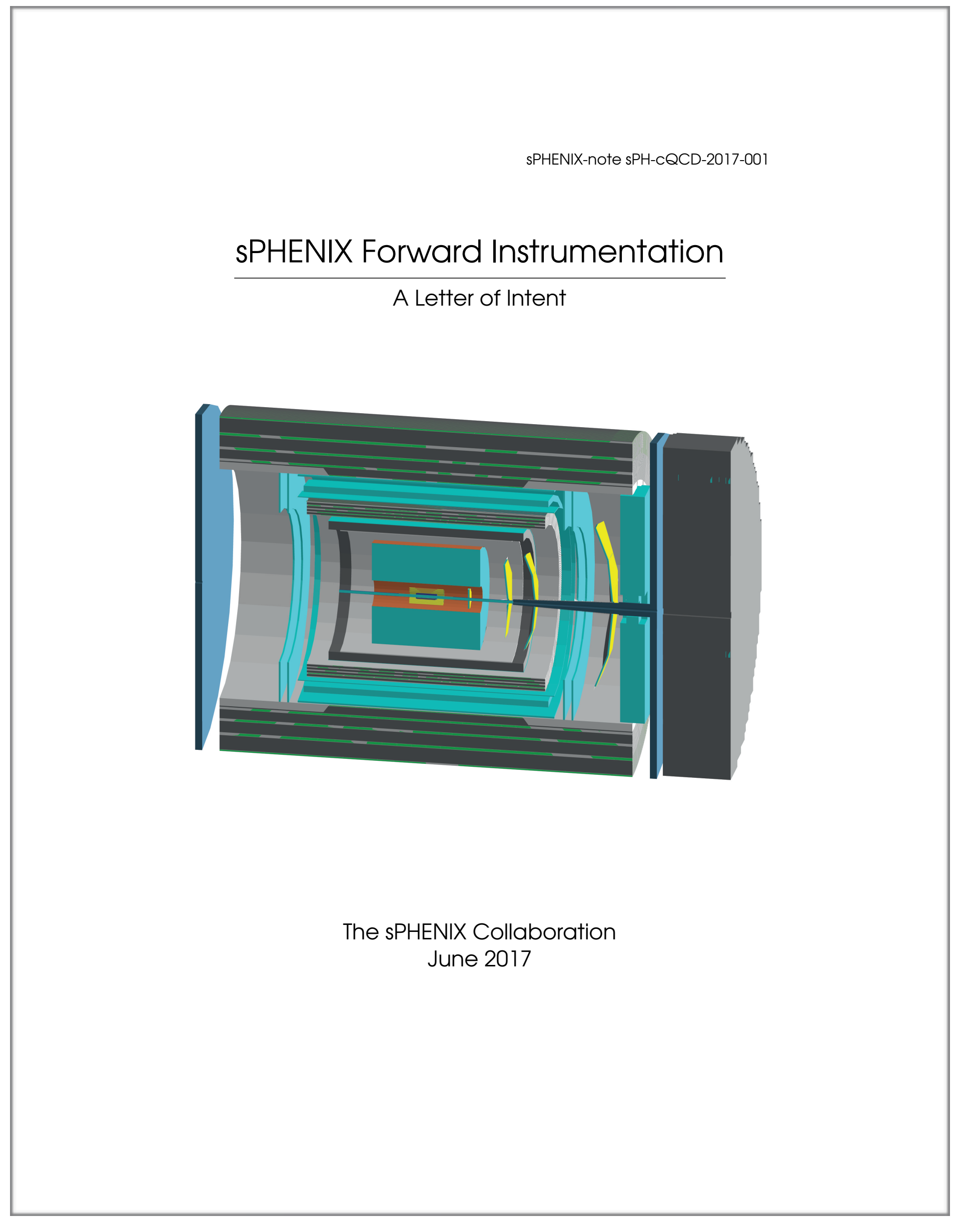
Forward Arm Physics



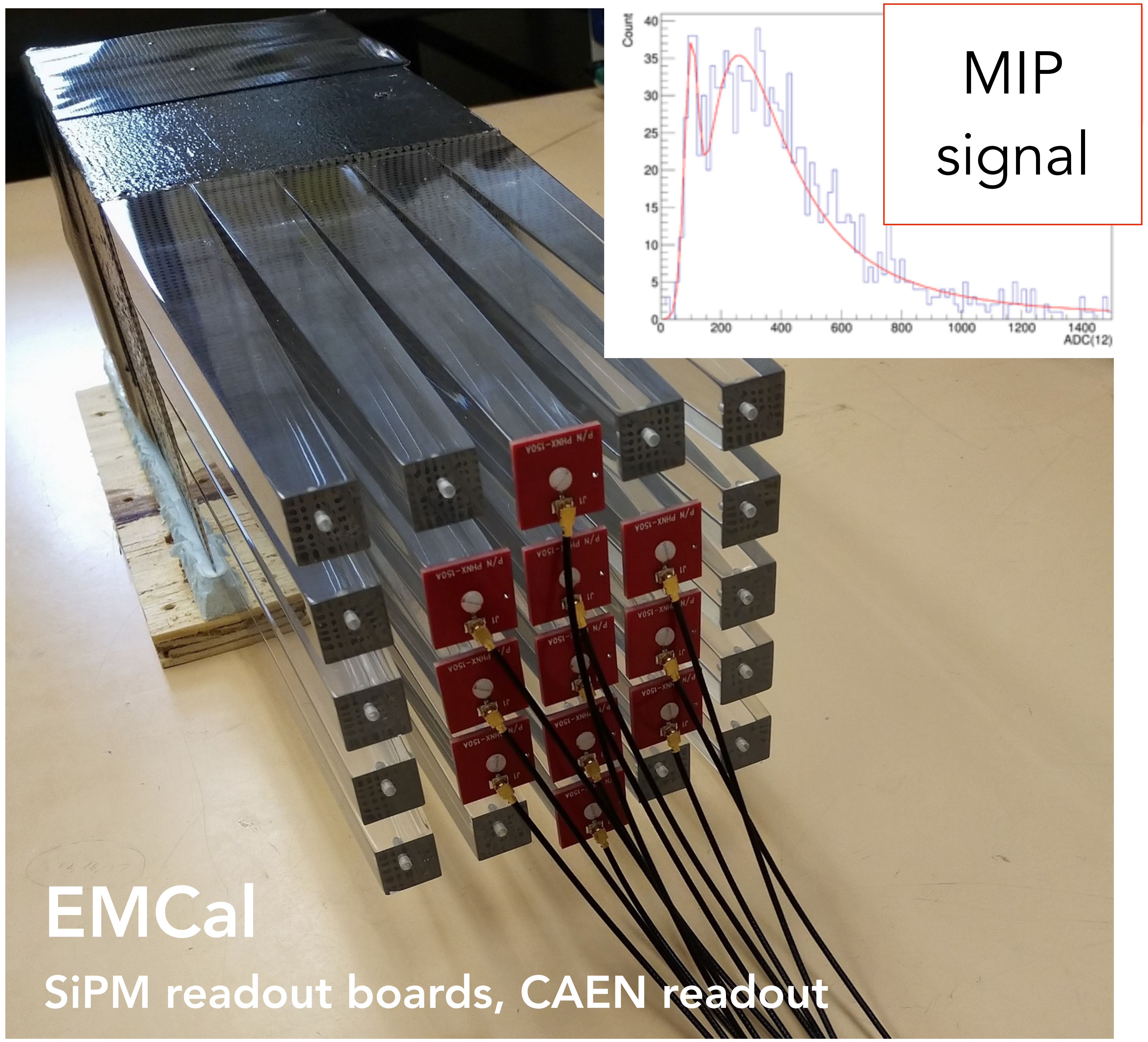


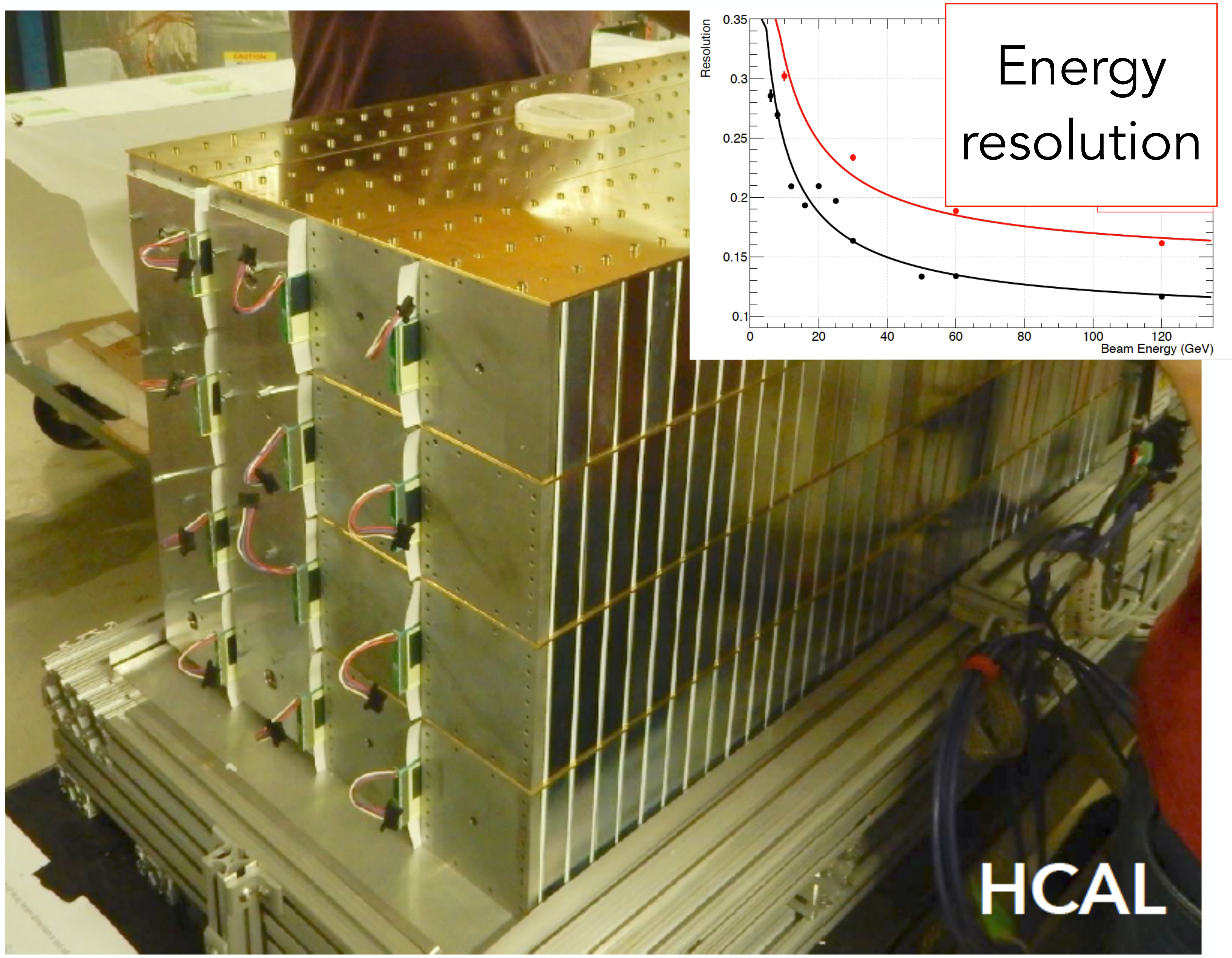
- Builds on June 2017 study of forward instrumentation (https://indico.bnl.gov/event/3867/)
  - Forward calorimetry expands sPHENIX QGP jet tomography program
  - Long range correlations (p+p→p+A→A+A)
  - Enables robust nPDF measurements, noted by broader nHEP community
  - Forward spin phenomena
  - Direct photons
  - Forward quarkonia

I. Helenius, J. Lajoie, J. Osborn, P. Paakkinen, H. Paukkunen arXiv:1904.09921



Strong potential of forward upgrades for sPHENIX





Cut E864 module for use as a high granularity EMCal: cosmic tests ongoing at Iowa State University

Hadronic calorimeter: test beam recently finished by RIKEN in collaboration with STAR/UCLA

Continued EIC-focused enthusiasm and work in the collaboration

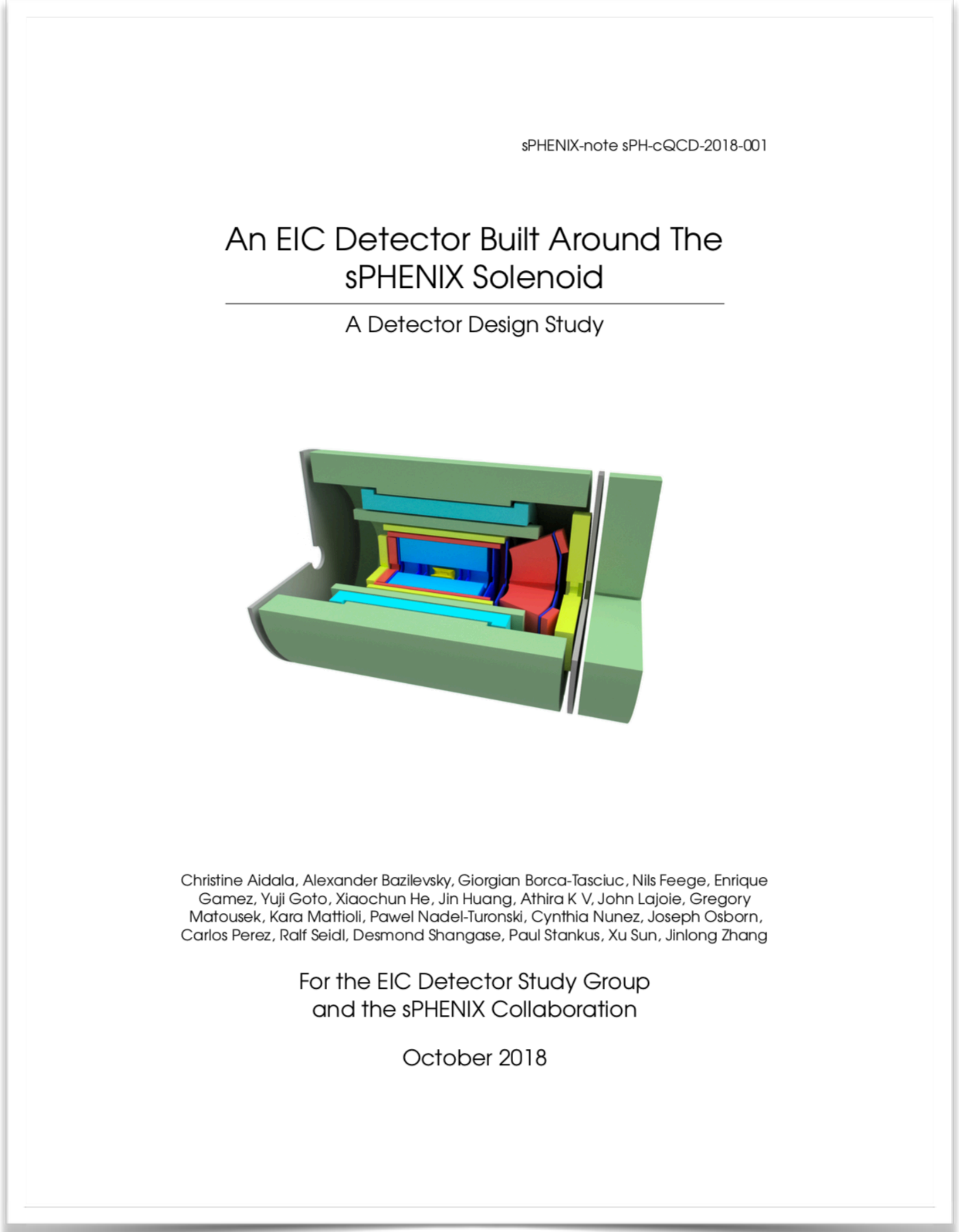
I am therefore asking you to establish a detector study group consisting of members of the sPHENIX Collaboration and other individuals interested in EIC science from outside the sPHENIX Collaboration to update the Letter of Intent for an EIC detector built around the BaBar solenoid in the context of the eRHIC pre-CDR. The Letter of Intent should contain an outline of the expected physics program for the detector in the first five years of running, using estimates of the luminosity development anticipated for initial EIC operation.

In parallel, I am asking you to perform a cost estimate of the construction costs in FY2018 dollars. This estimate should be performed with the methodology that the NPP Director for Project Planning and Oversight of Accelerator Projects, Diane Hatton, has developed for the EIC and that Elke Aschenauer and her group are using to develop a cost estimate for a generic EIC detector in conjunction with the ongoing pre-CDR cost estimation process. Please, do not include the cost estimate in the updated Letter of Intent, but transmit it as a separate document.

A brief presentation on the physics capabilities of the detector should be prepared for the PAC meeting in June 2018. After receiving comments from the PAC, I expect to be able to provide feedback and further guidance with respect to the process and goals of developing the updated LoI. The final versions of the revised LoI and the associated cost estimate should be submitted to me by September 30, 2018. The NPP Director for Project Planning and Oversight of Detector Projects, Maria Chamizo Llatas, will then convene a review with external experts, as appropriate.

charge from ALD

- deliberate choice: follow closely the design in 2013 LOI (arXiv:1402.1209)
- effort coordinated and led by sPHENIX cold QCD topical group conveners Christine Aidala (Michigan), Nils Feege (SUNYSB)
- updated studies of detector performance and capabilites


sPHENIX-note sPH-cQCD-2018-001

An EIC Detector Built Around The sPHENIX Solenoid

A Detector Design Study

Christine Aidala, Alexander Bazilevsky, Giorgian Borca-Tasciuc, Nils Feege, Enrique Gamez, Yuji Goto, Xiaochun He, Jin Huang, Athira K V, John Lajoie, Gregory Matousek, Kara Mattioli, Pawel Nadel-Turonski, Cynthia Nunez, Joseph Osborn, Carlos Perez, Ralf Seidl, Desmond Shangase, Paul Stankus, Xu Sun, Jinlong Zhang

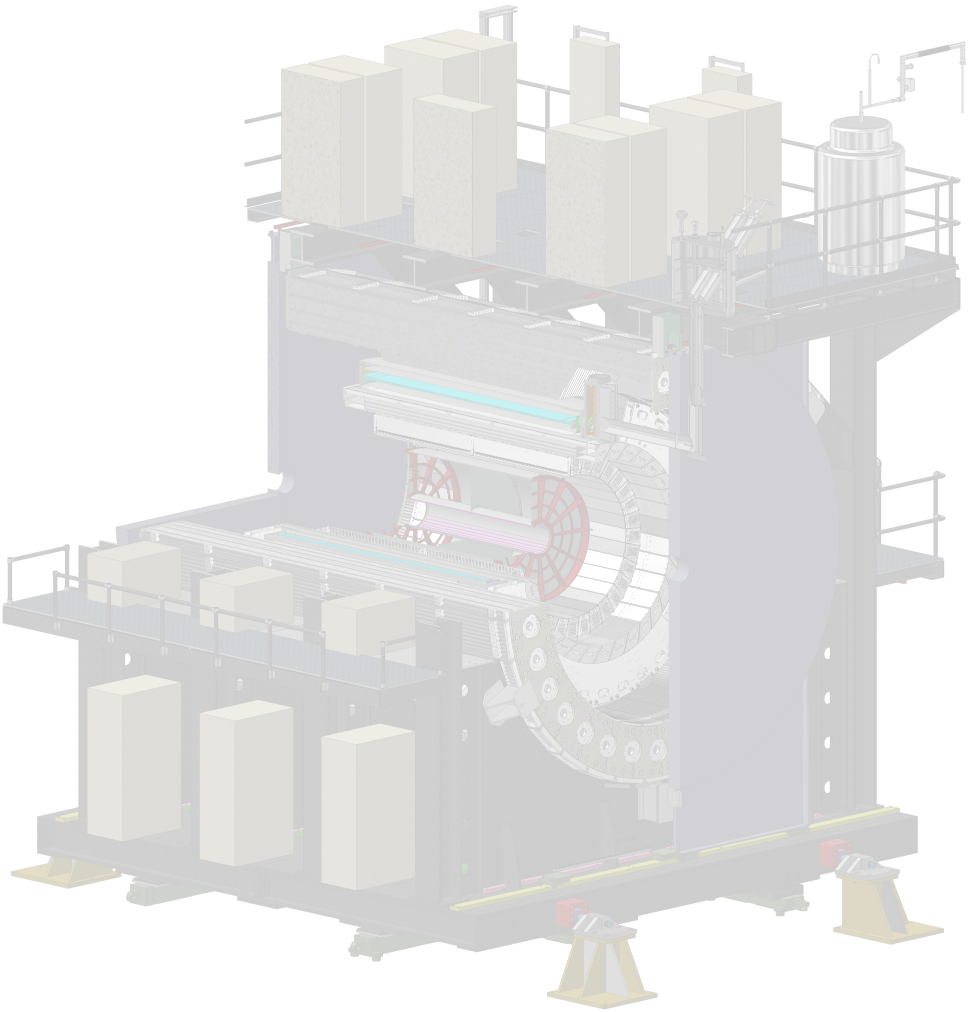
For the EIC Detector Study Group and the sPHENIX Collaboration

October 2018

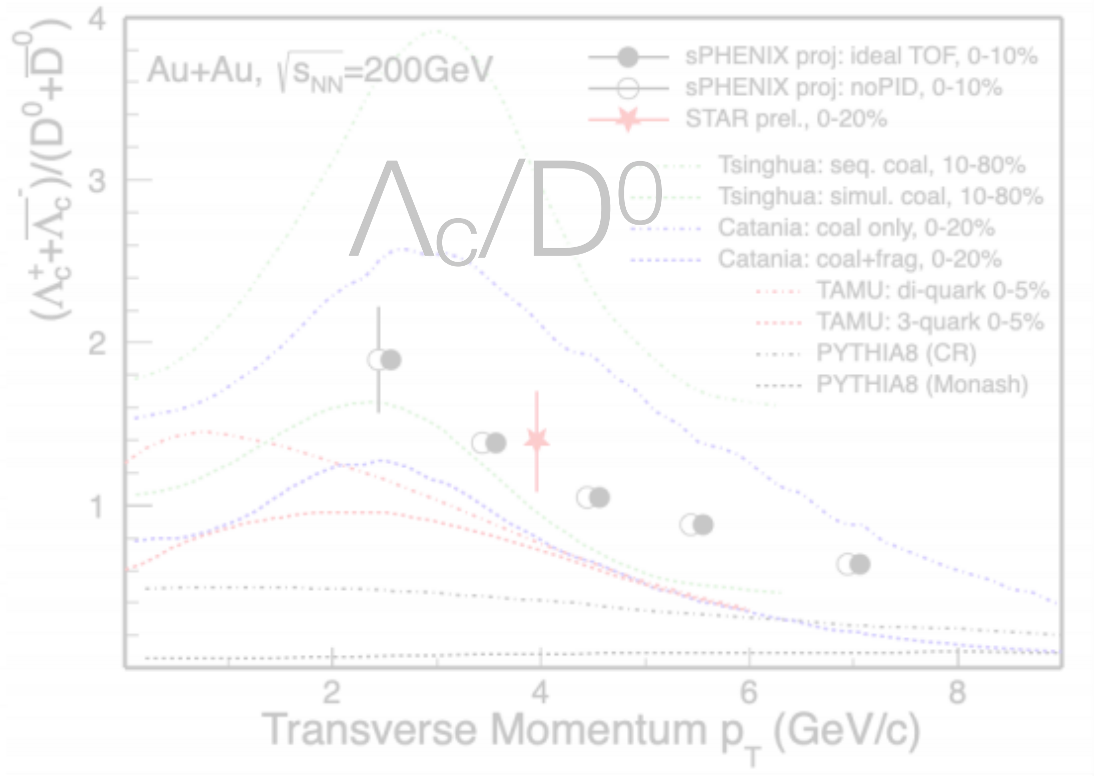
Updated!

Developments on many fronts since last PAC

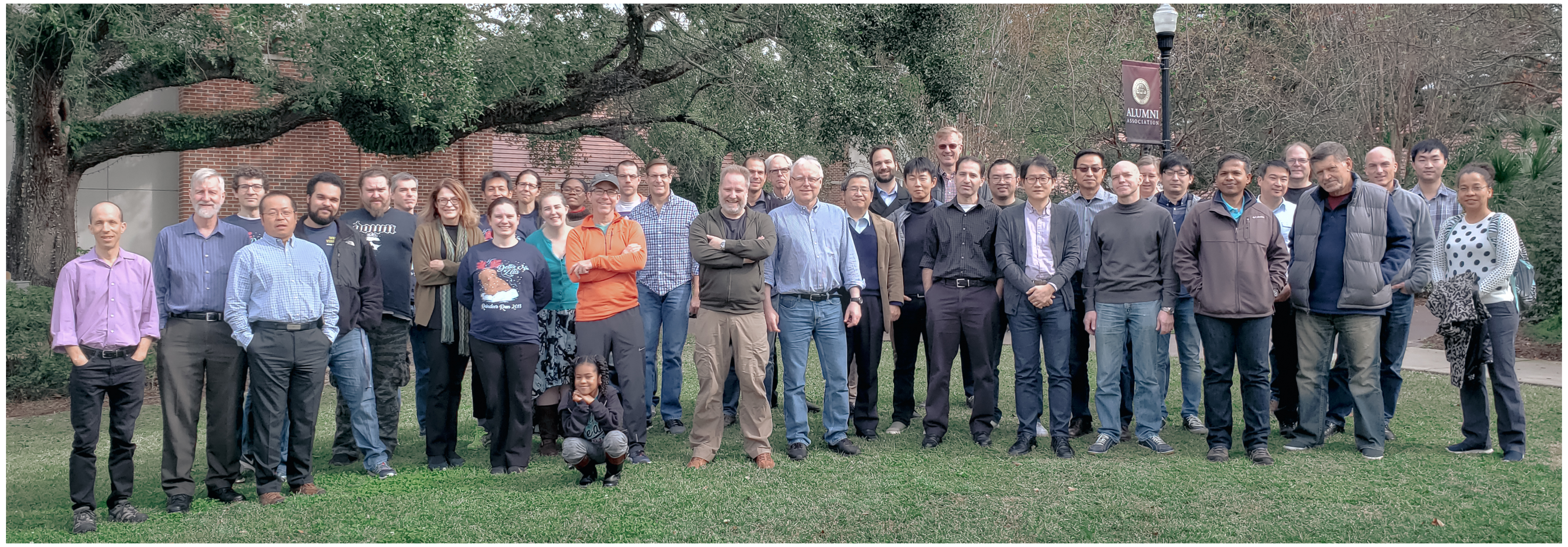
Progress on the project



Progress on the science



Progress on the collaboration

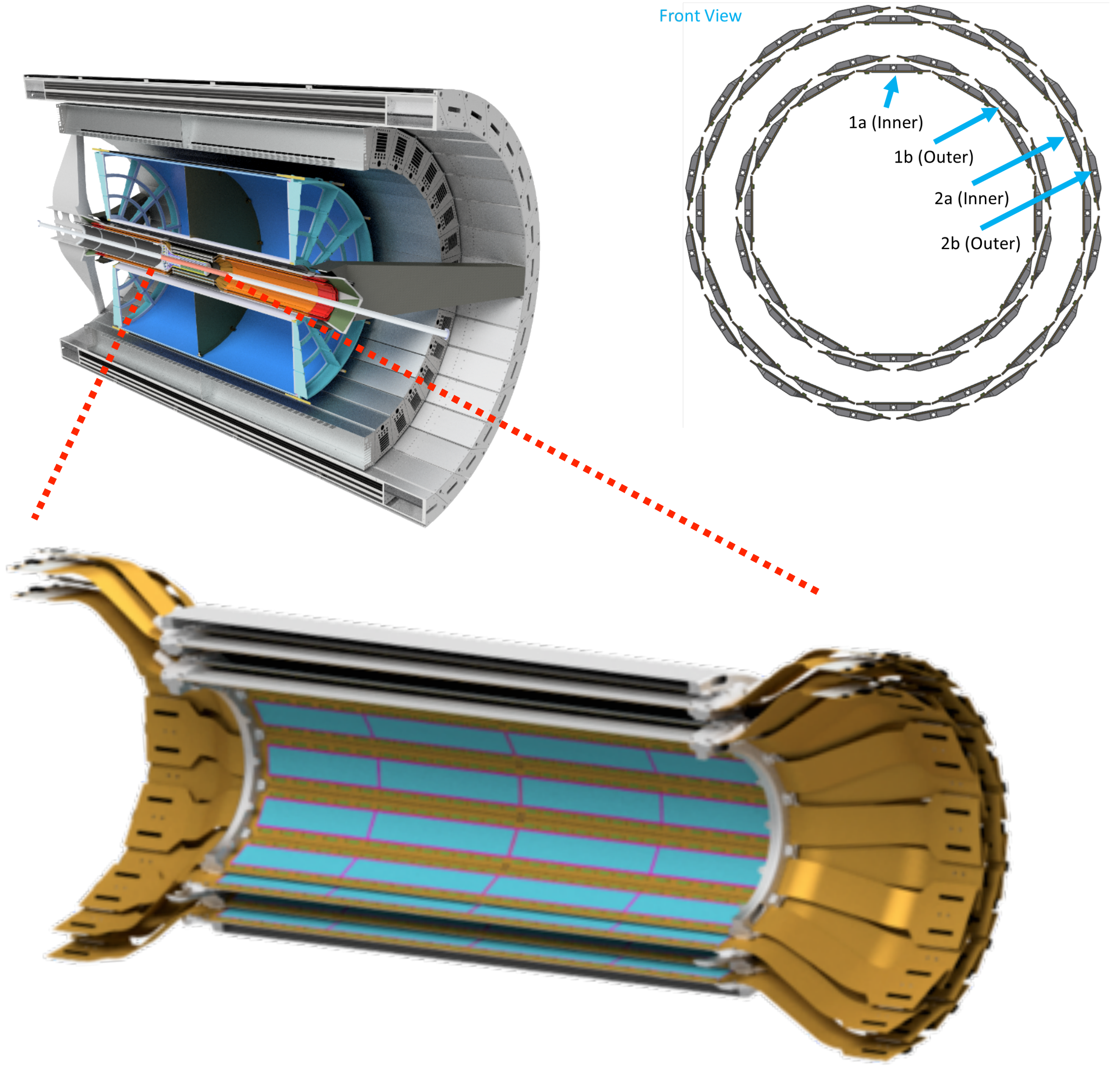


Compelling physics, future potential ⇒ strong collaboration

- Currently 77 institutions, 17 have joined since collaboration formed in December 2015
  - Adding institutions with world-class expertise in relevant physics, silicon, TPCs, calorimetry, electronics, computing
- Concluding survey of institutional board members to update current roster of collaborators
- Very positive contributions across wide spectrum of institutions – hosting collaboration meetings, workshops, regional meetings (e.g., sPHENIX meeting in Asia, March 2019, hosted by NCU)
- Additional expressions of interest from strong institutions in Asia and Europe

Task forces – key interactions of sPHENIX project and science

- Inner detector optimization TF – concluded its work and recommended number of INTT layers – very complex interplay of pattern recognition, impact on Upsilons, service routing, carbon fiber structure design



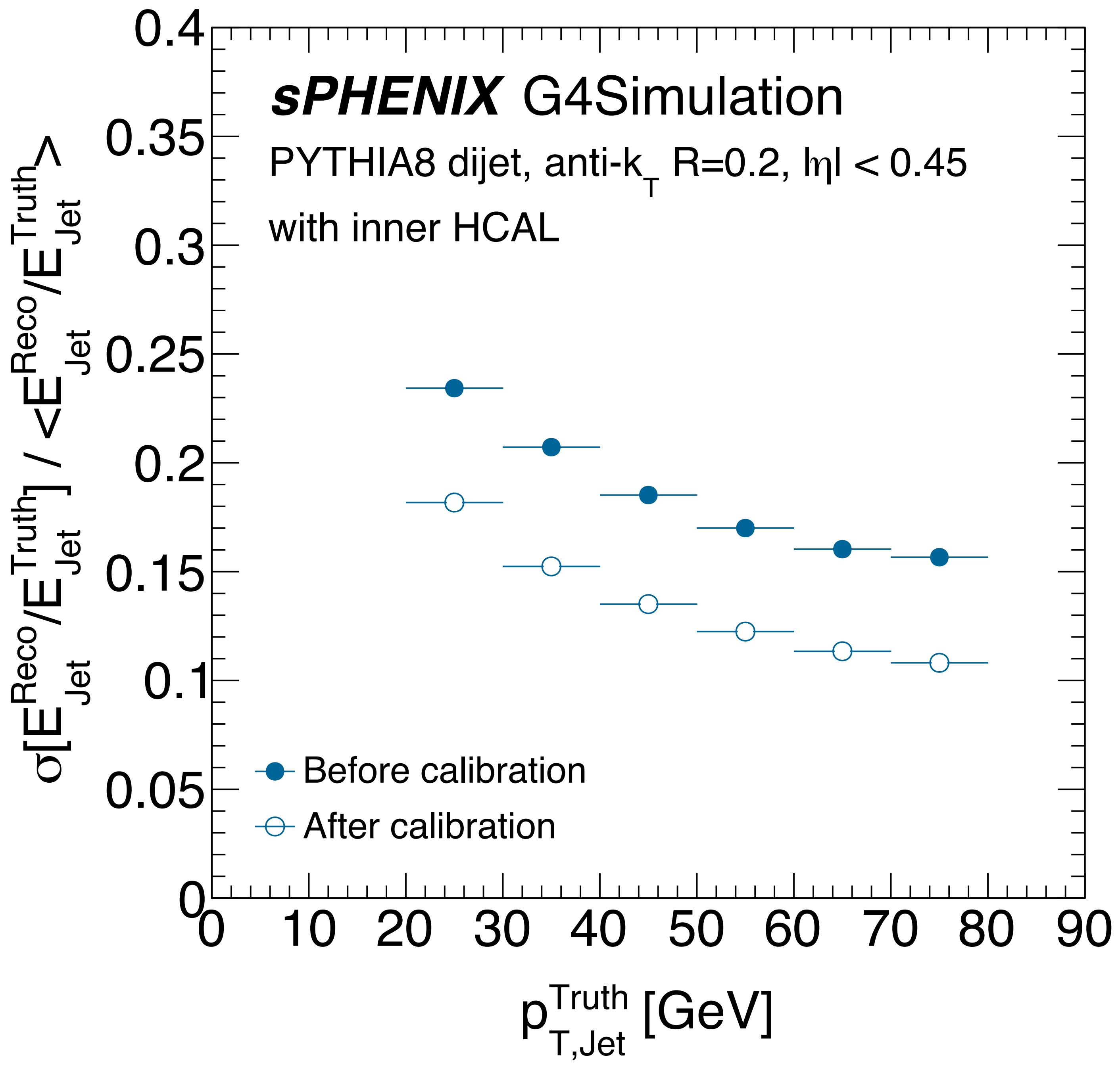
- Computing TF (Chair: Ron Soltz (LLNL)) – describe computing model, determine needed resources

- Calibration TF (Co-chairs: Christof Roland (MIT), Takao Sakaguchi (BNL)) – articulate a strategy for obtaining initial and continuing calibrations of sPHENIX detectors, strong interplay with Computing TF

  - Upcoming sPHENIX/ALICE TPC calibration workshop July 11-12 at CERN

On our radar screens …

- NSF/sPHENIX news from last week …
  - MRI proposal to instrument the inner HCal not funded. Collaboration is exploring all options to fund iHCAL instrumentation; window in which to realize suitable funding within constraints of MIE schedule is challenging
  - Megan Connors (GSU) awarded CAREER grant for proposal “Jet Measurements and a Novel Hadronic Calorimeter at the Relativistic Heavy Ion Collider”
- May 1, 2019 formation in BNL Physics Department of HEP/NP software group headed by Torre Wenaus is the identified resource for any add’l BNL computing effort for sPHENIX
  - Very new arrangement – potentially beneficial, but manpower and priorities would have to align with sPHENIX needs



from NSF MRI proposal

Summary

- Progress toward realizing full baseline sPHENIX detector very encouraging – very successful PD-2/3 review is a key part of that.
- All topical groups have been very active developing new observables and updating projections, engaging the broader experimental and theory community
- Continued enthusiasm for science enabled by forward instrumentation in conjunction with capabilities of sPHENIX barrel and high rate DAQ
- EIC detector design study update latest addition to extensive studies of sPHENIX as foundation for highly capable detector
- Collaboration continues to grow, adding strong institutions with relevant science and technical expertise
- Assessing recent news about NSF MRI proposal; relying on new BNL software group

Extras

A corpus of one, many to come

Citesummary excluding self-citations or RPP citations

Generated on 2019-06-10

1 papers found, 1 of them citeable (published or arXiv)

Citation summary results	Citeable papers	Citeable papers excluding self cites
Total number of papers analyzed:	1	1
Total number of citations:	9	6
Average citations per paper:	9.0	6.0
Breakdown of papers by citations:		
Renowned papers (500+)	0	0
Famous papers (250-499)	0	0
Very well-known papers (100-249)	0	0
Well-known papers (50-99)	0	0
Known papers (10-49)	0	0
Less known papers (1-9)	1	1
Unknown papers (0)	0	0
h_{HEP} index [?]	1	1

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 65, NO. 12, DECEMBER 2018 2901

Design and Beam Test Results for the sPHENIX Electromagnetic and Hadronic Calorimeter Prototypes

C. A. Aidala, V. Bailey, S. Beckman, R. Belmont, C. Biggs, J. Blackburn, S. Boose, M. Chiu, M. Connors, E. Desmond, A. Franz, J. S. Haggerty, X. He, M. M. Higdon, J. Huang, K. Kauder, E. Kistenev, J. LaBounty, J. G. Lajoie, M. Lenz, W. Lenz, S. Li, V. R. Loggins, E. J. Mannel, T. Majoros, M. P. McCumber, J. L. Nagle, M. Phipps, C. Pinkenburg, S. Polizzo, C. Pontieri, M. L. Purschke, J. Putschke, M. Sarsour, T. Rinn, R. Ruggiero, A. Sen, A. M. Sickles, M. J. Skoby, J. Smiga, P. Sobel, P. W. Stankus, S. Stoll, A. Sukhanov, E. Thorsland, F. Toldo, R. S. Towell, B. Ujvari, S. Vazquez-Carson, and C. L. Woody

Abstract—**The super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX) at the Relativistic Heavy Ion Collider will perform high-precision measurements of jets and heavy flavor observables for a wide selection of nuclear collision systems, elucidating the microscopic nature of strongly interacting matter ranging from nucleons to the strongly coupled quark–gluon plasma. A prototype of the sPHENIX calorimeter system was tested at the Fermilab Test Beam Facility as experiment T-1044 in the spring of 2016. The electromagnetic calorimeter (EMCal) prototype is composed of scintillating fibers embedded in a mixture of tungsten powder and epoxy. The hadronic calorimeter (HCal) prototype is composed of tilted steel plates alternating with the plastic scintillator. Results of the test beam reveal the energy resolution for electrons in the EMCal is $2.8\% \oplus 15.5\%/\sqrt{E}$ and the energy resolution for hadrons in the combined EMCal plus HCal system is $13.5\% \oplus 64.9\%/\sqrt{E}$. These results demonstrate that the performance of the proposed calorimeter system satisfies the sPHENIX specifications.**

Index Terms—**Calorimeters, electromagnetic calorimetry, hadronic calorimetry, performance evaluation, prototypes, Relativistic Heavy Ion Collider (RHIC), silicon photomultiplier (SiPM), simulation, "Spaghetti" Calorimeter (SPACAL), super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX).**

Manuscript received June 28, 2018; revised August 23, 2018; accepted September 7, 2018. Date of publication November 1, 2018; date of current version December 14, 2018. This work was supported in part by the Office of Nuclear Physics in the Office of Science of the Department of Energy and in part by the National Science Foundation.

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S. Beckman, R. Belmont, J. L. Nagle, and S. Vazquez-Carson are with the Department of Physics, University of Colorado Boulder, Boulder, CO 80309-0390 USA.

C. Biggs, S. Boose, M. Chiu, E. Desmond, A. Franz, J. S. Haggerty, J. Huang, E. Kistenev, J. LaBounty, M. Lenz, W. Lenz, E. J. Mannel, C. Pinkenburg, S. Polizzo, C. Pontieri, M. L. Purschke, R. Ruggiero, S. Stoll, A. Sukhanov, F. Toldo, and C. L. Woody are with the Brookhaven National Laboratory, Upton, NY 11973-5000 USA (e-mail: jhuang@bnl.gov).

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Digital Object Identifier 10.1109/TNS.2018.2879047

I. Introduction

THE super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX) is a planned experiment [1] at the Relativistic Heavy Ion Collider (RHIC). RHIC is a highly versatile machine that collides a diverse array of nuclear beams from protons to heavy ions and supports a very broad physics program for the study of both hot and cold quantum chromodynamics matter. sPHENIX is specifically designed for the measurements of jets, quarkonia, and other rare processes originating from hard scatterings to study the microscopic nature of strongly interacting matter ranging from nucleons [2] to the strongly coupled quark–gluon plasma (QGP) created in collisions of gold ions at $\sqrt{s_{NN}} =$ 200 GeV [3]–[6]. sPHENIX is equipped with a tracking system and a three-segment calorimeter system, both of which have a full 2π acceptance in azimuth and a pseudorapidity coverage of $|\eta| < 1.1$. sPHENIX has acquired the former BaBar magnet, which has an inner radius of 1.4 m and an outer radius of 1.75 m [7]. The sPHENIX calorimeter system includes an electromagnetic calorimeter (EMCal) and an inner hadronic calorimeter (HCal), which sit inside the solenoid, and an outer HCal located outside of the magnet. The EMCal will be used for identifying photons, electrons, and positrons. Photons can be used to tag the energy of opposing jets traversing the QGP, while electrons and positrons will

First peer-reviewed sPHENIX paper

Multi-year run plan for sPHENIX

sPHENIX

Year	Species	Energy [GeV]	Phys. Wks	Rec. Lum.	Samp. Lum.	Samp. Lum. All-Z
Year-1	Au+Au	200	16.0	7 nb^{-1}	8.7 nb^{-1}	34 nb^{-1}
Year-2	p+p	200	11.5	—	48 pb^{-1}	267 pb^{-1}
Year-2	p+Au	200	11.5	—	0.33 pb^{-1}	1.46 pb^{-1}
Year-3	Au+Au	200	23.5	14 nb^{-1}	26 nb^{-1}	88 nb^{-1}
Year-4	p+p	200	23.5	—	149 pb^{-1}	783 pb^{-1}
Year-5	Au+Au	200	23.5	14 nb^{-1}	48 nb^{-1}	92 nb^{-1}

Campaign 1 (Year-1 – Year-3); Campaign 2 (Year-4 – Year-5)

https://indico.bnl.gov/event/4788/attachments/19066/24594/sph-trg-000_06142018.pdf

- Minimum bias Au+Au at 15 kHz for primary vertex |z| < 10 cm (in acceptance of silicon trackers):

  47 billion (Year-1) + 96 billion (Year-3) + 96 billion (Year-5) = 240 billion events recorded

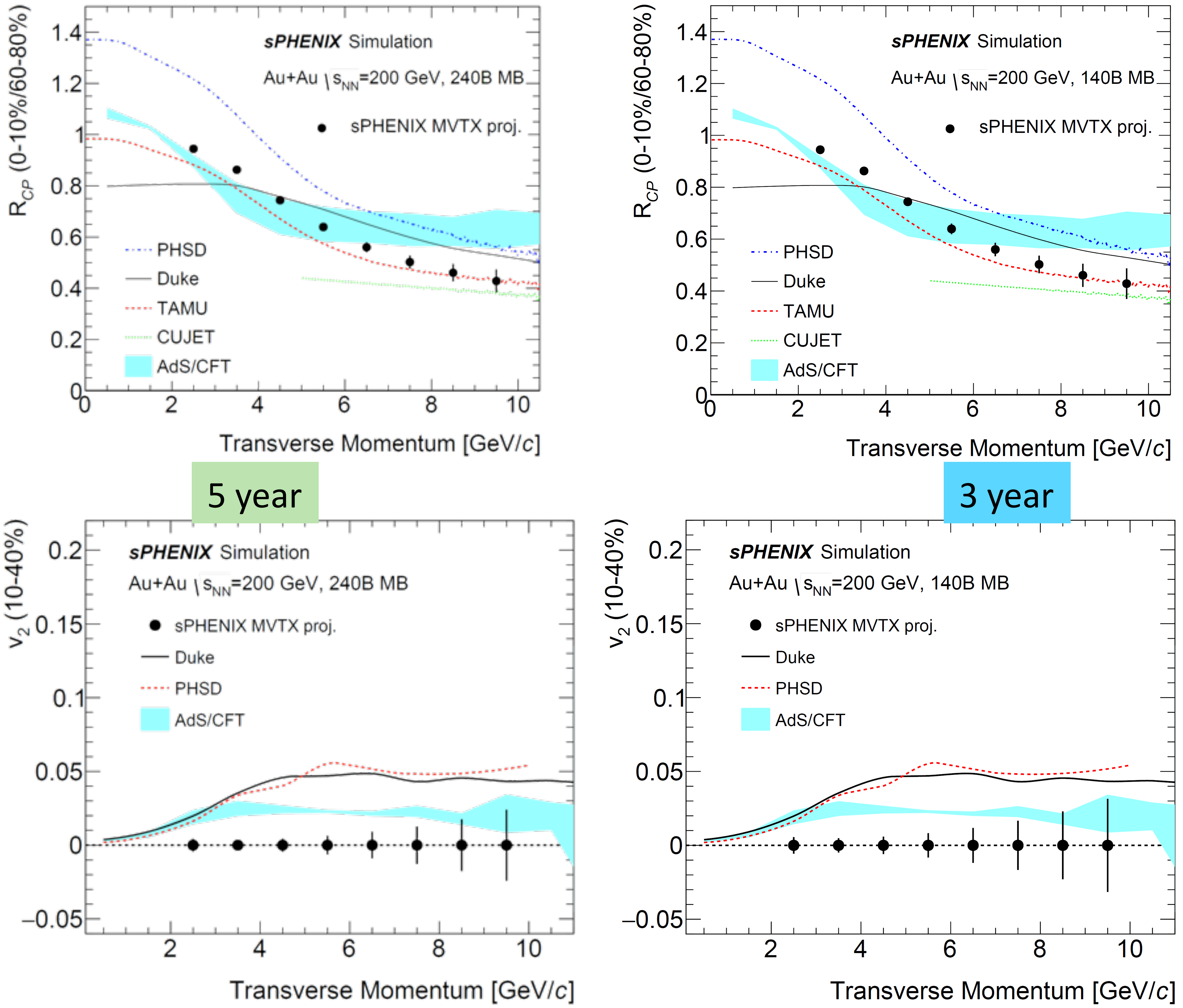
- cf. STAR 2016 200 GeV Au+Au data set of 6.5 billion events [PAC 2017 presentation]

} ~40x more

- Topics with Level-1 selective trigger (e.g. high p_T photons) can sample 0.5 trillion events within |z| < 10 cm

Ongoing discussions with C-AD to optimize RHIC running for sPHENIX

5-yr vs. 3-yr


sPHENIX Simulation
Au+Au \ s_NN=200 GeV, 240B MB
sPHENIX MVTX proj.
PHSD
Duke
TAMU
CUJET
AdS/CFT
R_CP (0-10%/60-80%)
Transverse Momentum [GeV/c]
5 year
sPHENIX Simulation
Au+Au \ s_NN=200 GeV, 140B MB
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v_2 (10-40%)
Transverse Momentum [GeV/c]
sPHENIX Simulation
Au+Au \ s_NN=200 GeV, 140B MB
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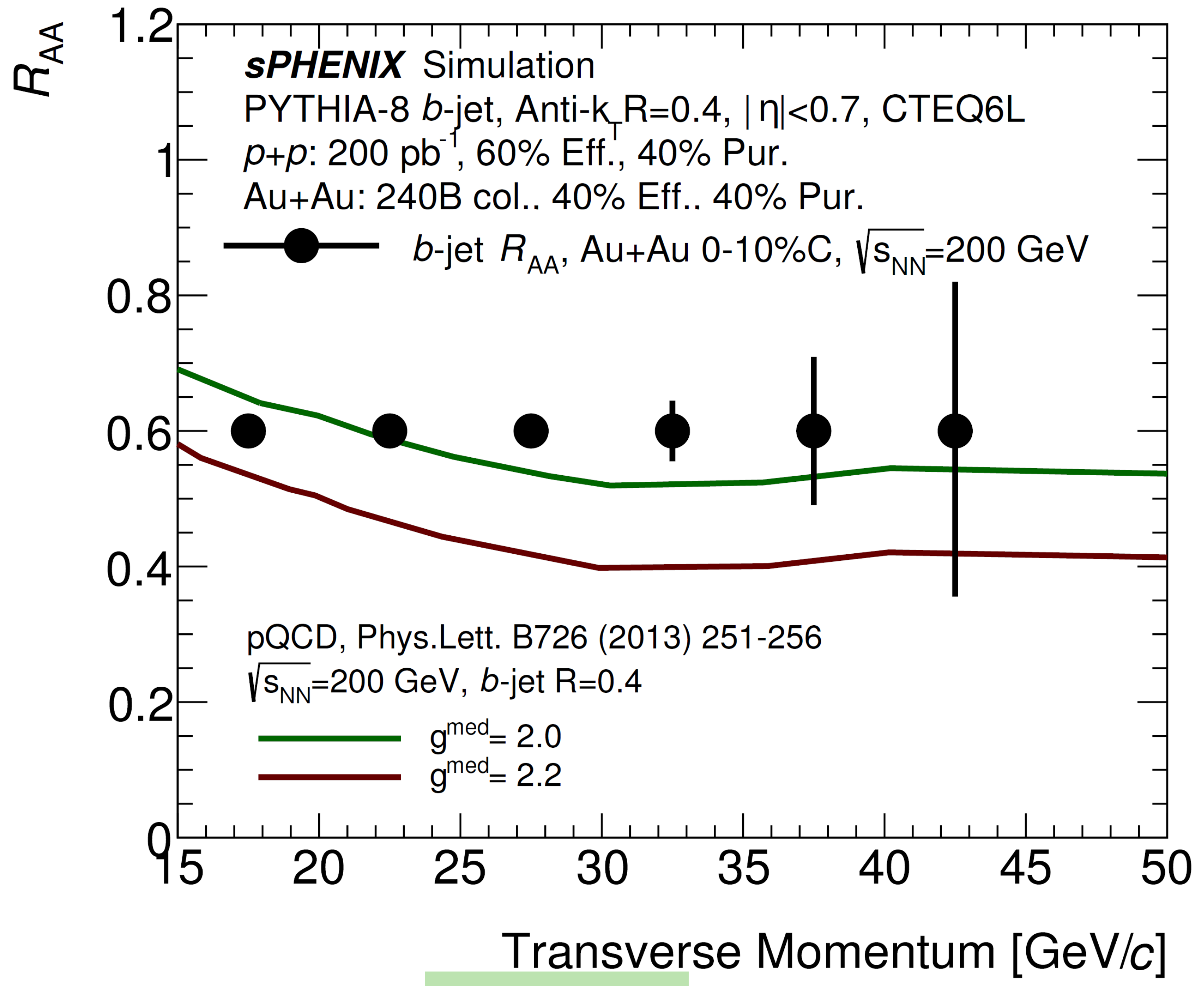
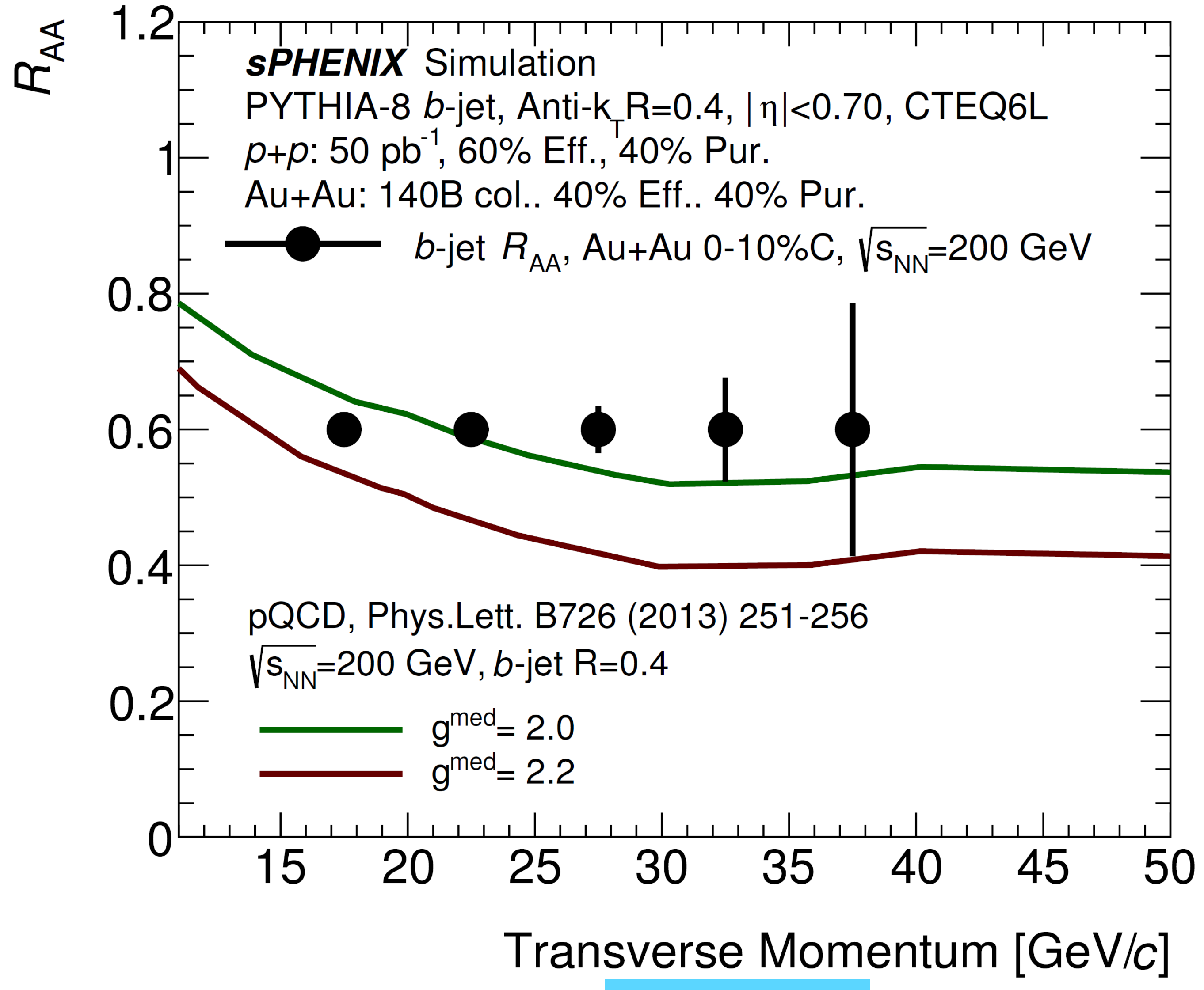
Duke
PHSD
AdS/CFT
v_2 (10-40%)
Transverse Momentum [GeV/c]

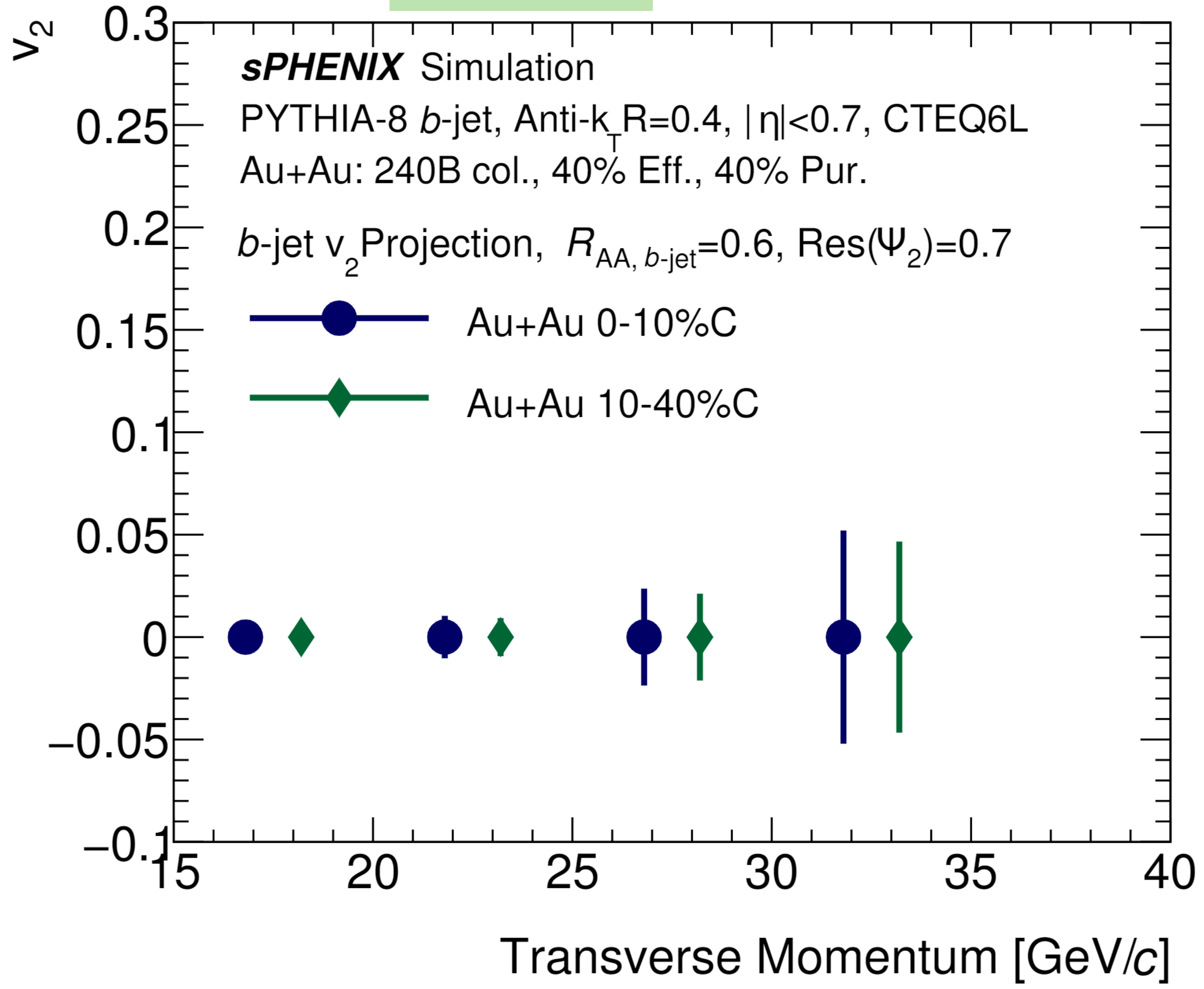
5-yr vs. 3-yr

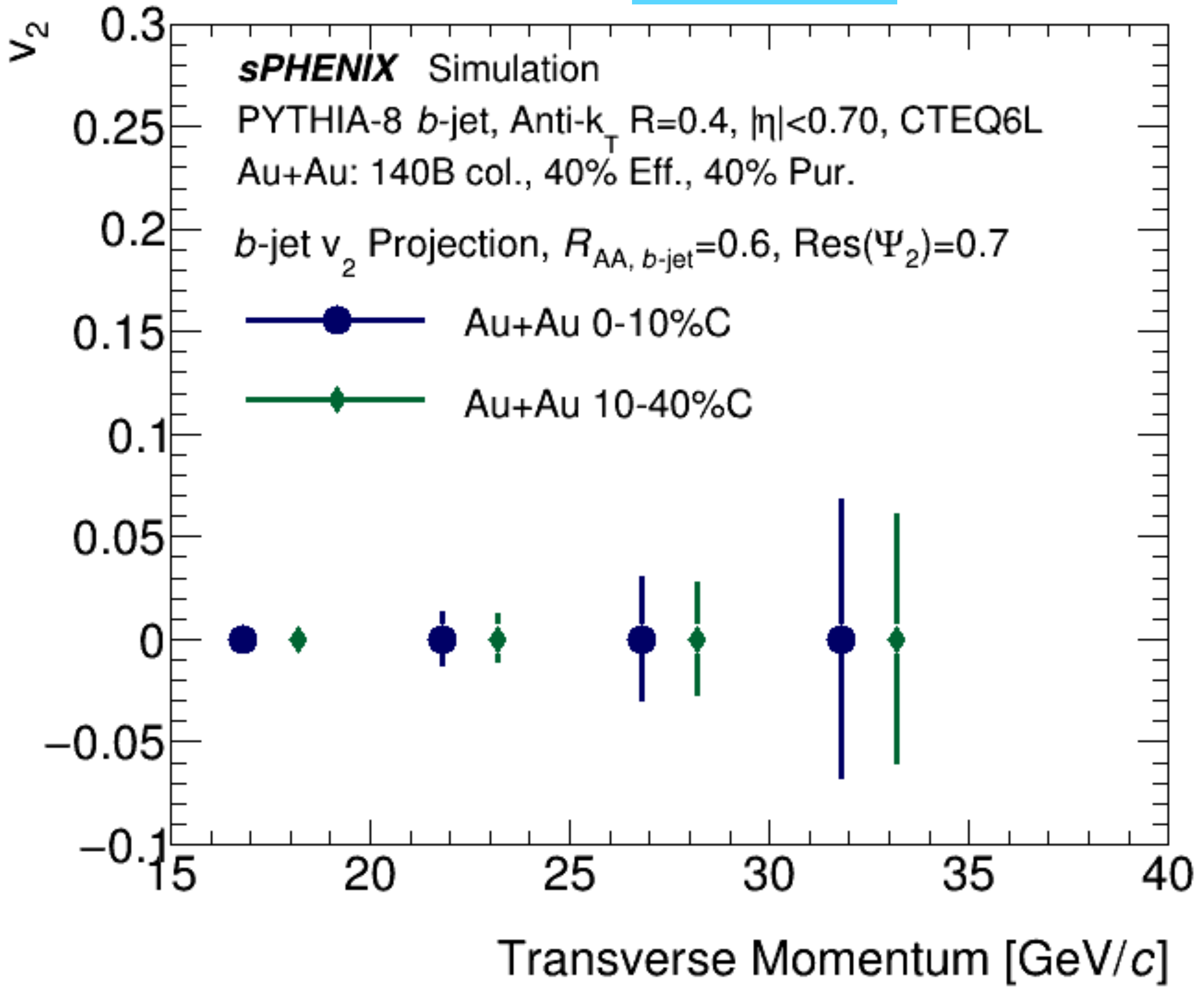




5 year

3 year





sPHENIX attracting visitors

On the occasion of the PD-2/3 Review

sPHENIX attracting visitors

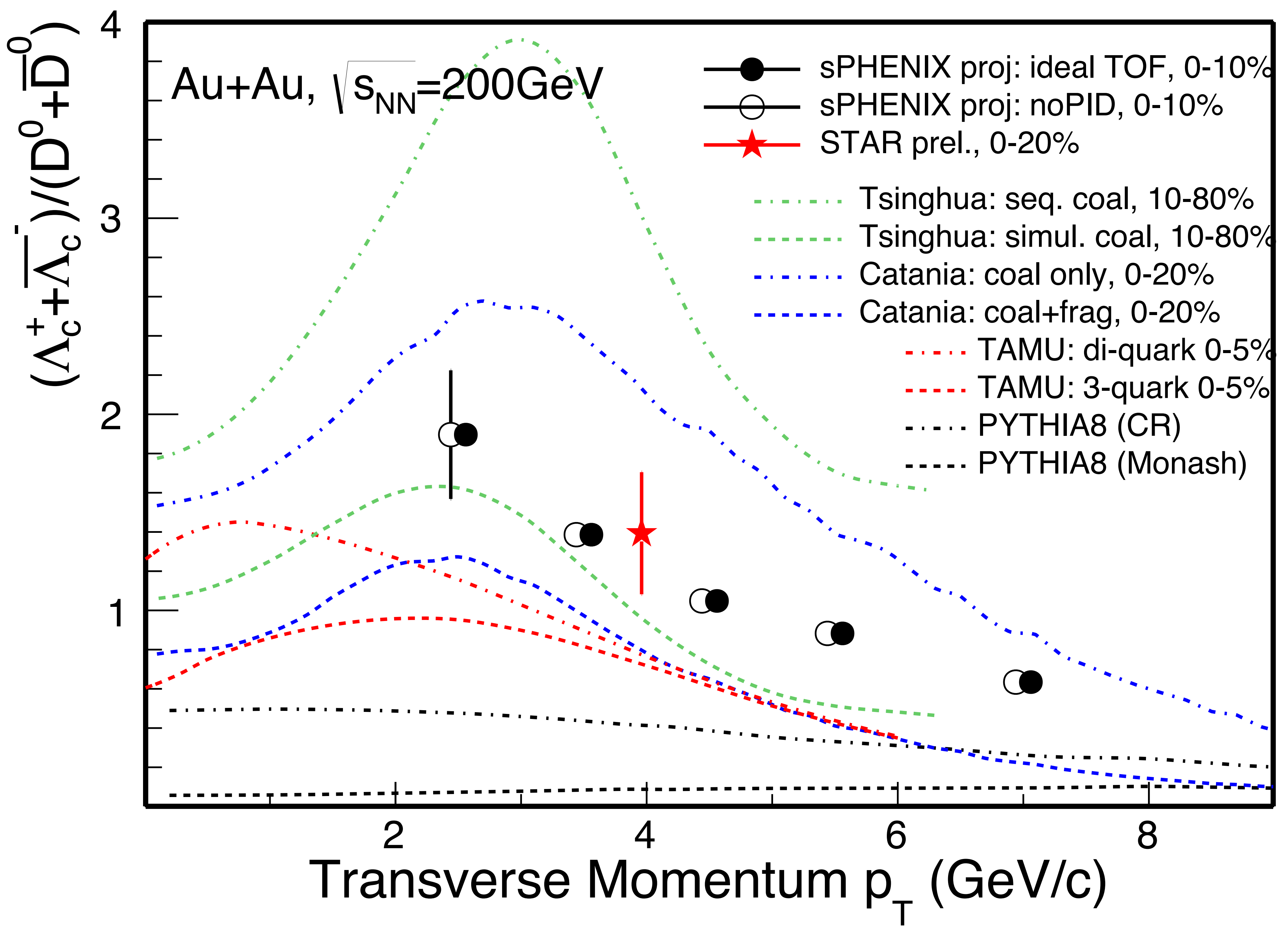
Members of the RBRC Scientific Steering Committee

sPHENIX attracting visitors

Visit by Japanese Embassy Science Counselor Seiichi Shimasaki

From this morning's session at SQM'19

sPHENIX

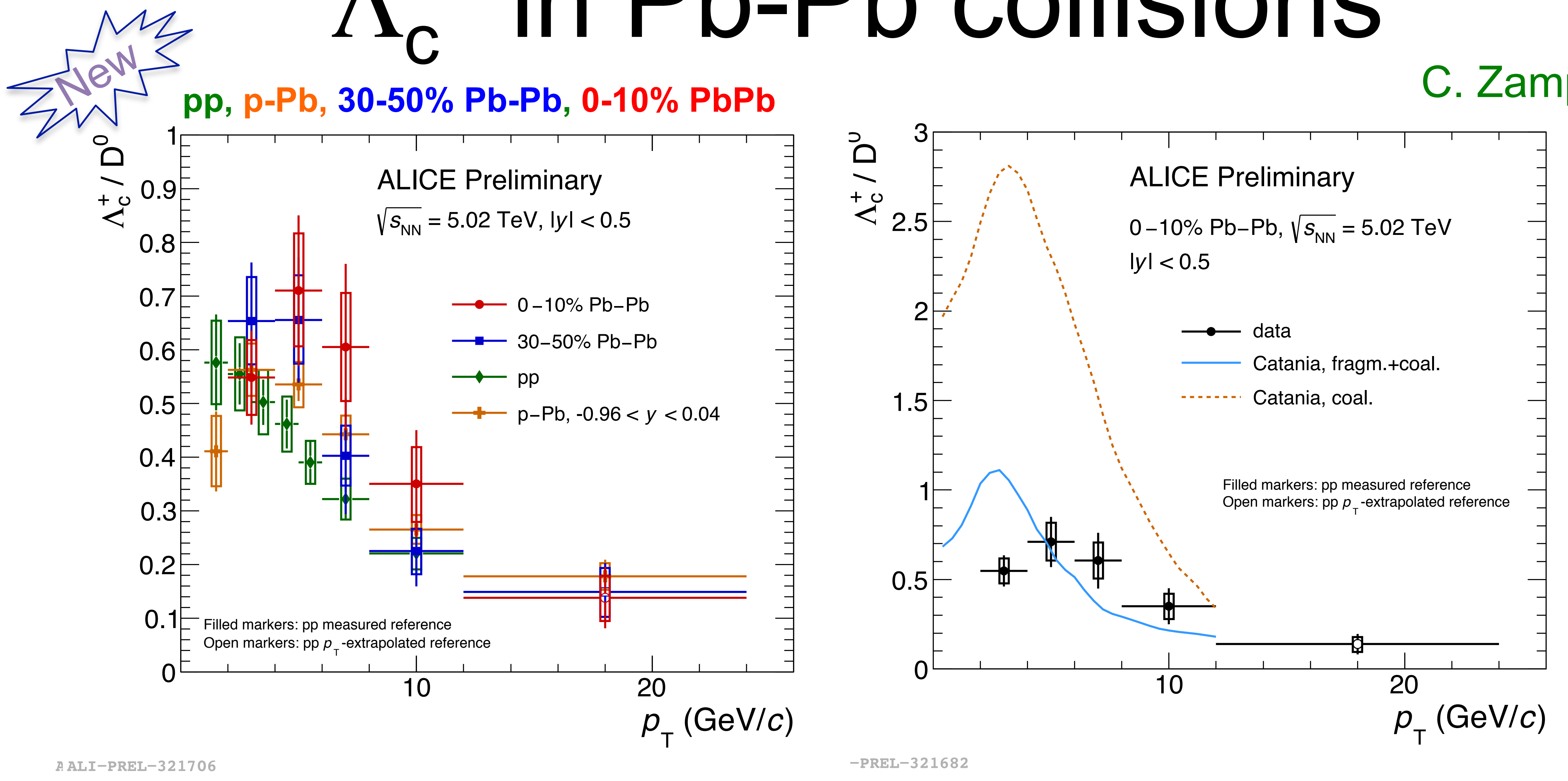


A. Rossi, Padua INFN

Λ_c^+ in Pb-Pb collisions

C. Zampolli

ALICE



- **Hint of higher Λ_c^+/D^0 ratio in 0-10% Pb-Pb collisions w.r.t. pp collisions**
- More precision needed to imagine a trend from pp to p-Pb to Pb-Pb
  - Understanding of pp data is fundamental: not granted that Λ_c^+ is "enhanced" in the same way in Pb-Pb and pp (w.r.t. e^+e^-)
- **Λ_c^+/D^0 ratio in Pb-Pb collisions described by Catania model including both coalescence and fragmentation** Catania: S. Plumari *et al.*, EPJC (2018) 78: 348