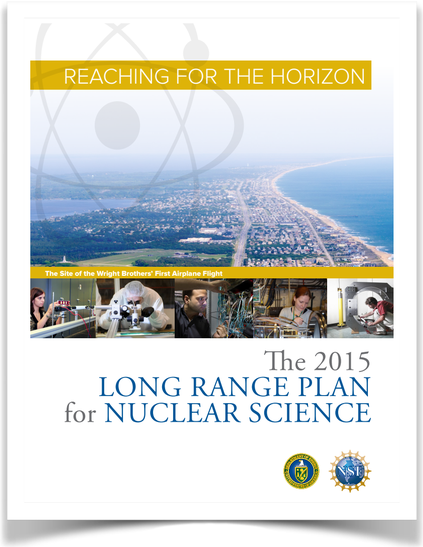
RHIC Retreat

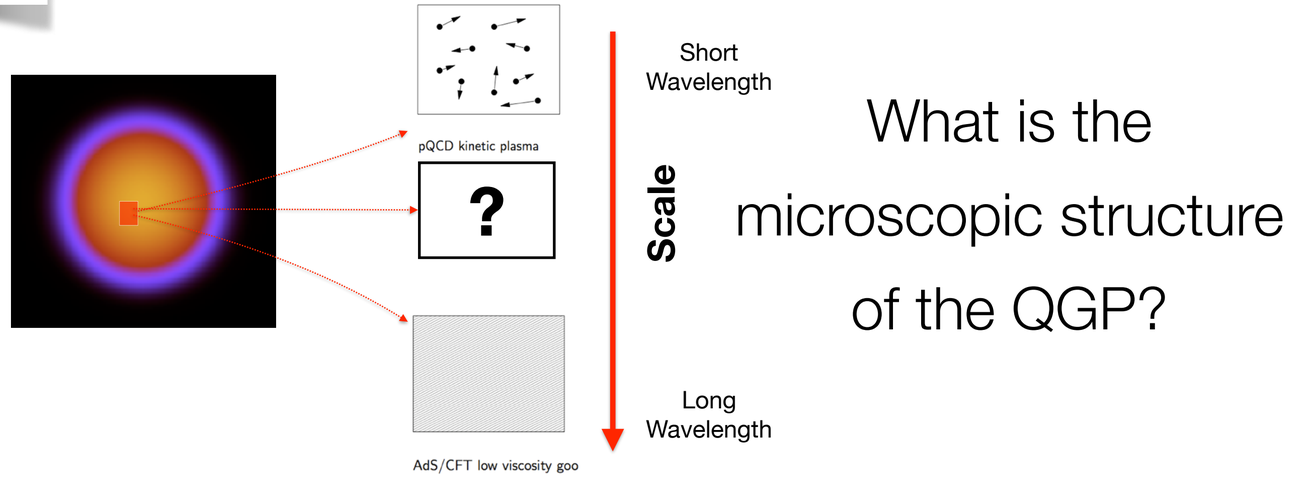
David Morrison (BNL)
Gunther Roland (MIT) | co-spokespersons

sPHENIX Science Mission



Section 2.2, page 22

There are two central goals of measurements planned at RHIC, as it completes its scientific mission, and at the LHC: **(1) Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of the two facilities is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX. (2) Map the phase diagram of QCD with experiments planned at RHIC.**

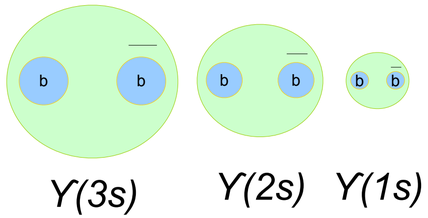


What is the microscopic structure of the QGP?

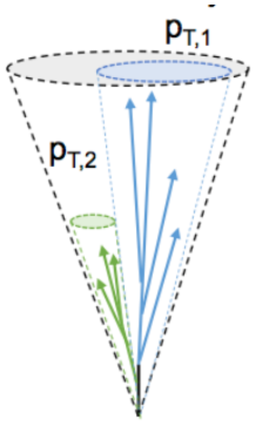
Core sPHENIX science program

Three key approaches to study QGP structure at multiple scales

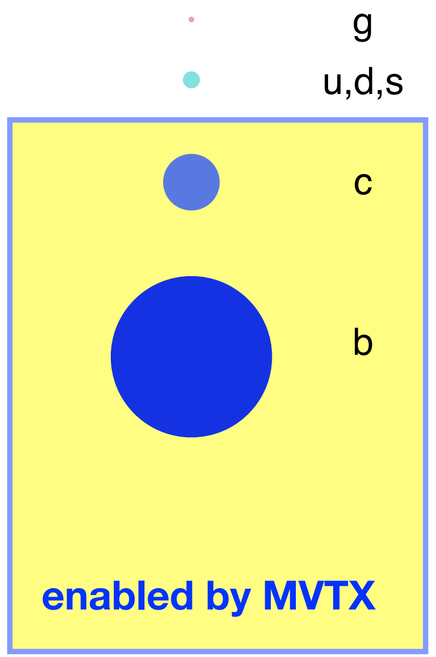
Quarkonium spectroscopy
vary size of probe



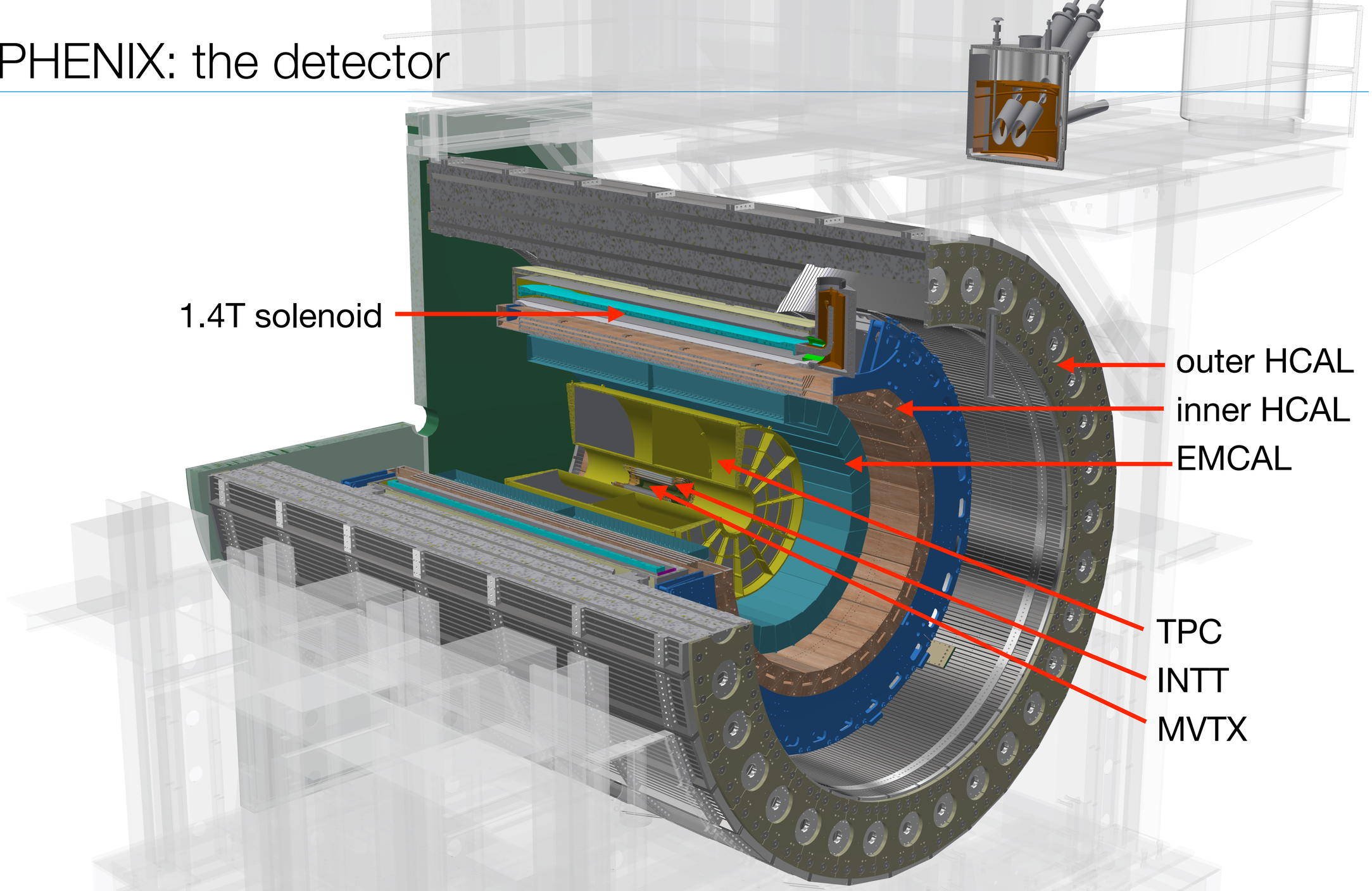
Jet structure
vary momentum/angular scale of probe



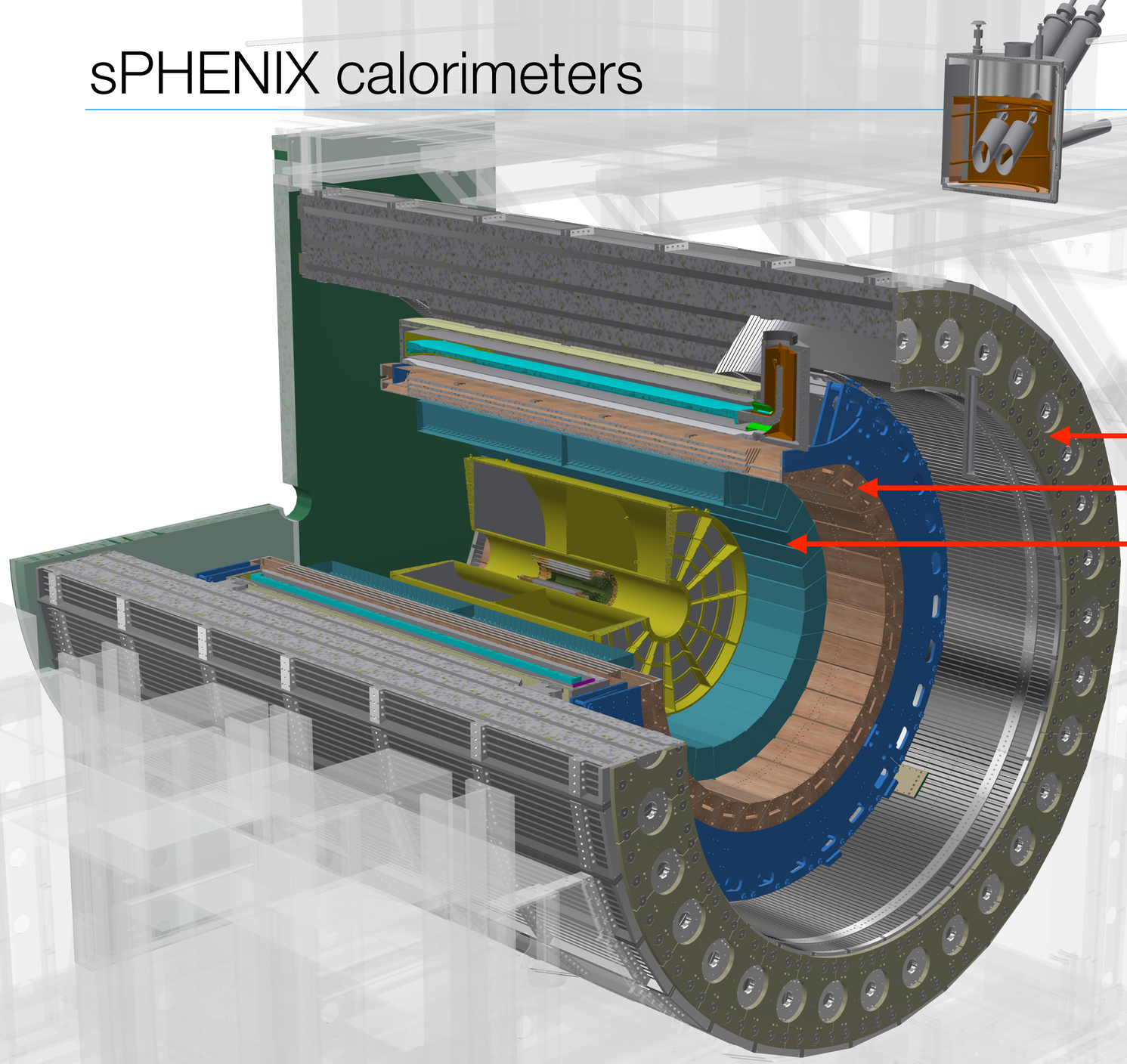
Parton energy loss
vary mass/momentum of probe



sPHENIX: the detector



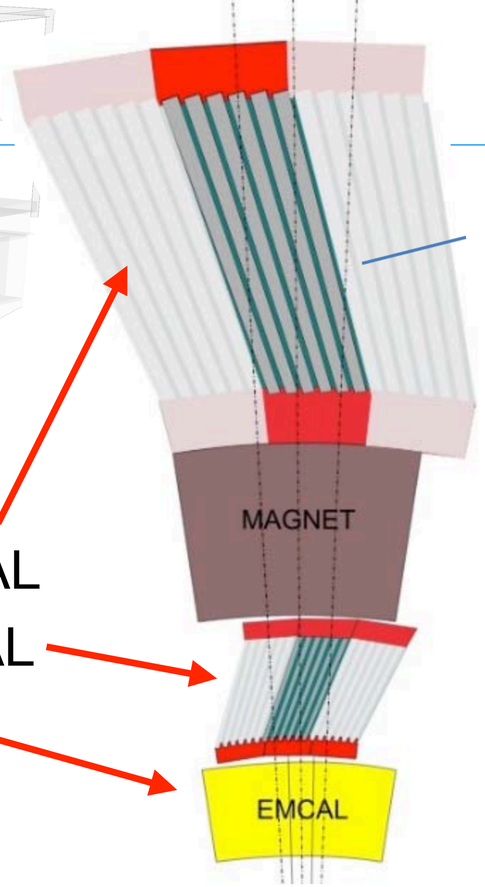
sPHENIX calorimeters



outer HCAL

inner HCAL

EMCAL

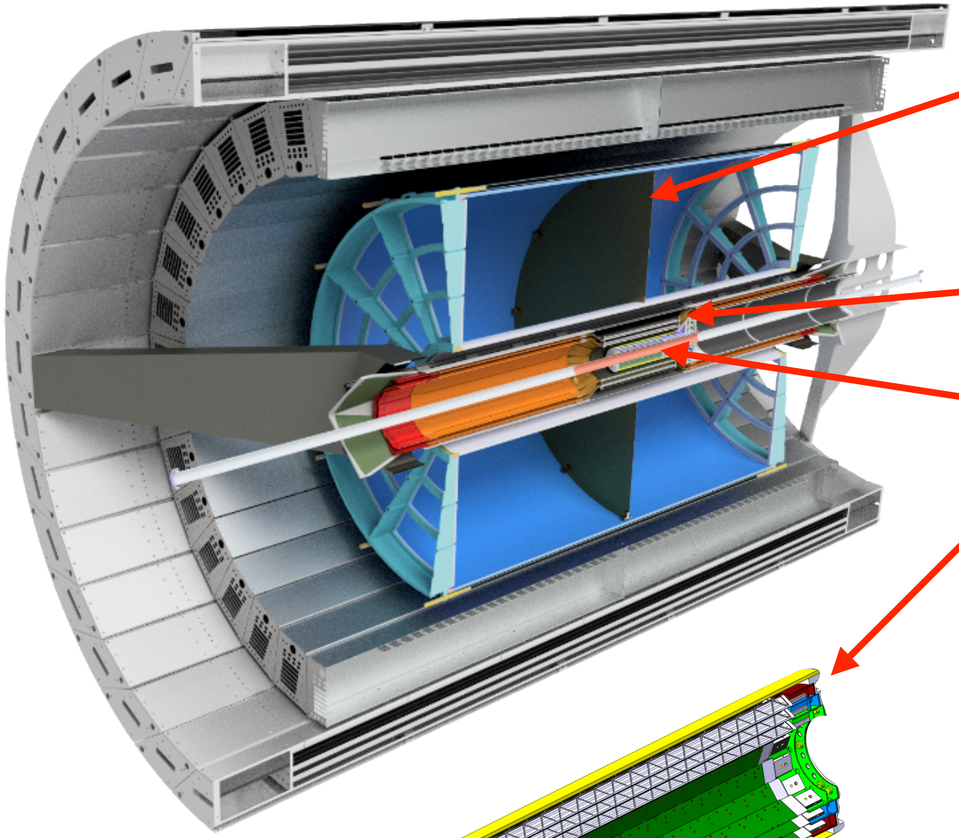


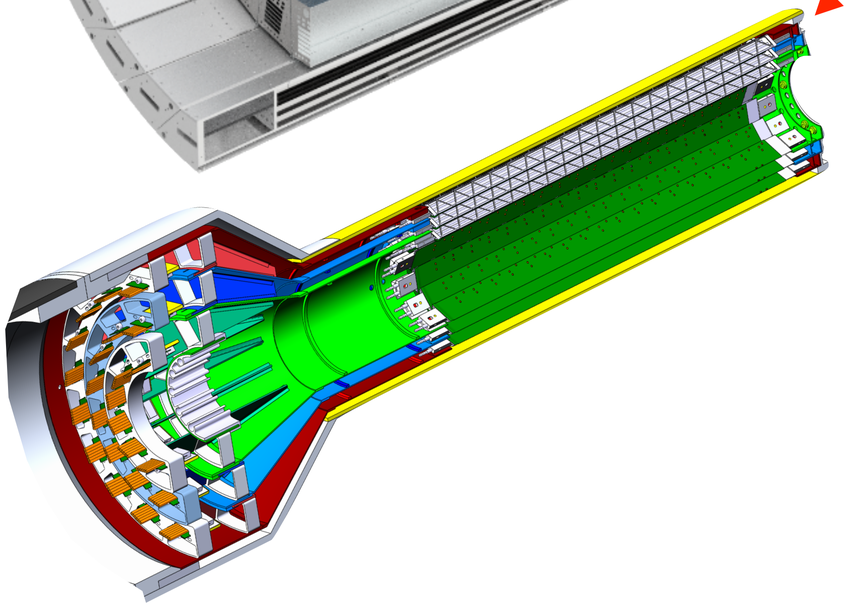
First @ RHIC: Full calorimeter stack incl. hadronic calo

Challenge:

- Absolute calibration of jet response (JES, JER)

sPHENIX Tracking detectors





Continuous readout TPC (R = 20-78cm)
- shares many concepts with ALICE TPC upgrade

Si strip intermediate tracker (INTT, R = 7-11cm)

3 layer MVTX vertex tracker (R = 2.3, 3.1, 3.9cm)
- based on ALICE ITS IB detector

First @ RHIC: Large acceptance high-rate tracking

Challenges:
- track reconstruction CPU time
- TPC distortion correction

sPHENIX run schedule

Each of run period has distinct, critical role for sPHENIX science mission

- 2023 - commissioning of detector, RHIC and data operations with Au+Au
- 2024 - high statistics p+p reference and p+A cold QCD data
- 2025 - high statistics Au+Au data
- This is the minimal “safe” schedule
  - ensure safe combined operation of detector and collider
  - provide development time for calibration and reconstruction to ensure successful completion of science mission before transition to EIC
- For successful completion of sPHENIX science mission, **each** of these runs needs to be successful

Run plan for 28 week scenario

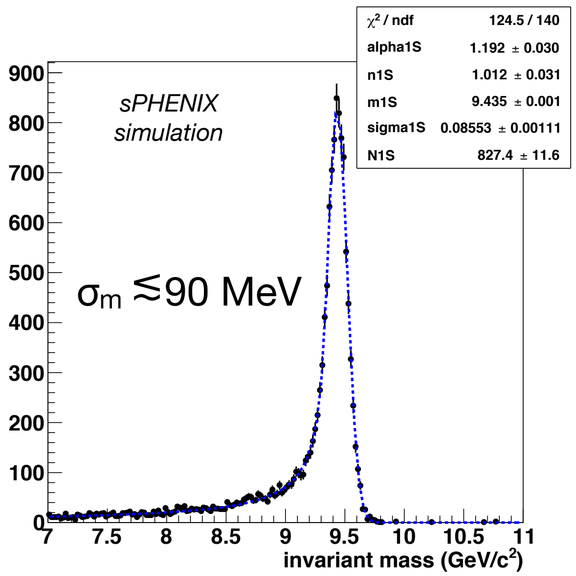
Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\lvert z\rvert$ <10 cm	Samp. Lum. $\lvert z\rvert$ <10 cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}
2024	$p^{\uparrow}p^{\uparrow}$	200	24 (28)	12 (16)	0.3 (0.4) pb^{-1} [5 kHz] 4.5 (6.2) pb^{-1} [10%-*str*]	45 (62) pb^{-1}
2024	$p^{\uparrow}$+Au	200	–	5	0.003 pb^{-1} [5 kHz] 0.01 pb^{-1} [10%-*str*]	0.11 pb^{-1}
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb^{-1}	21 (25) nb^{-1}

Unchanged compared to 2020 BUP

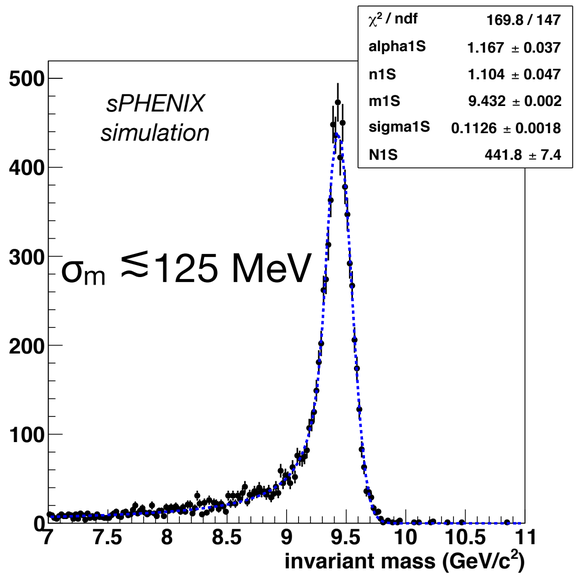
- Focus on core science mission
- Minimization of risk guides ramp-up, commissioning and running conditions
- Maximize science output for investment (MIE, research effort, RHIC operations)

Performance simulation: Upsilon mass resolution

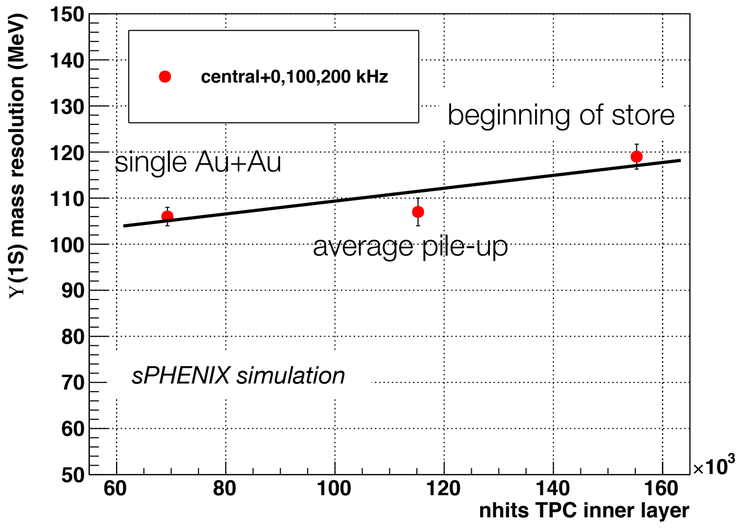
p+p √s = 200GeV



Au+Au + pileup √s = 200GeV



Y(1s) mass resolution vs multiplicity (instantaneous luminosity)



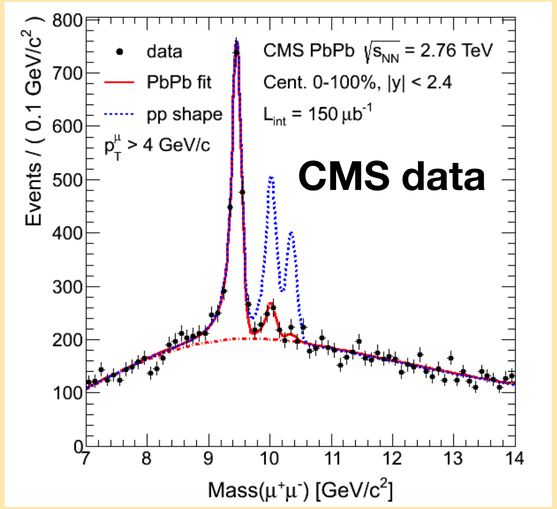
Mass resolution sufficient to resolve Υ(nS).

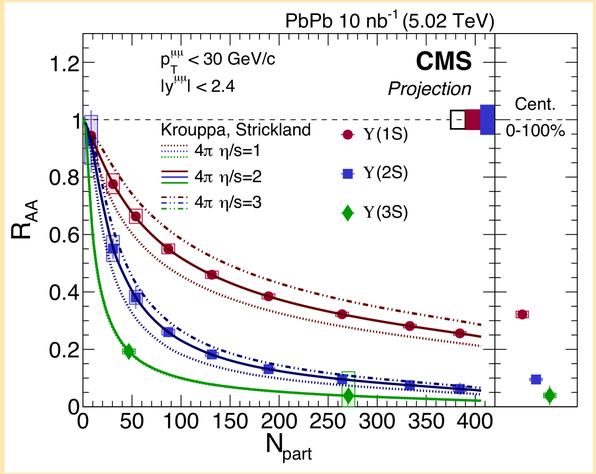
Current TPC cluster finder does not include deconvolution of overlapping clusters → multiplicity dependence

Simulations indicate Υ(1s) mass resolution better than 125 MeV

(averaged over in-store luminosity evolution)

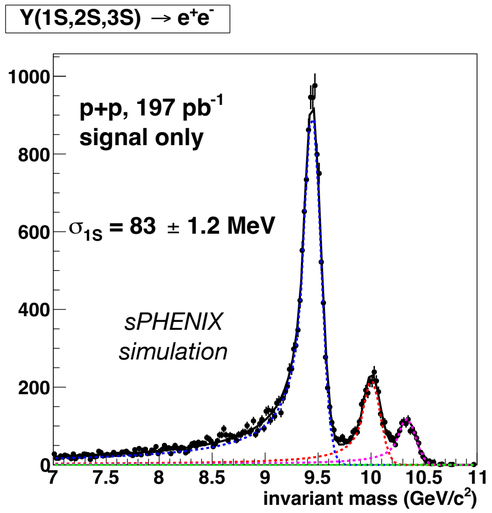
Physics projection: Upsilons at sPHENIX cf. LHC

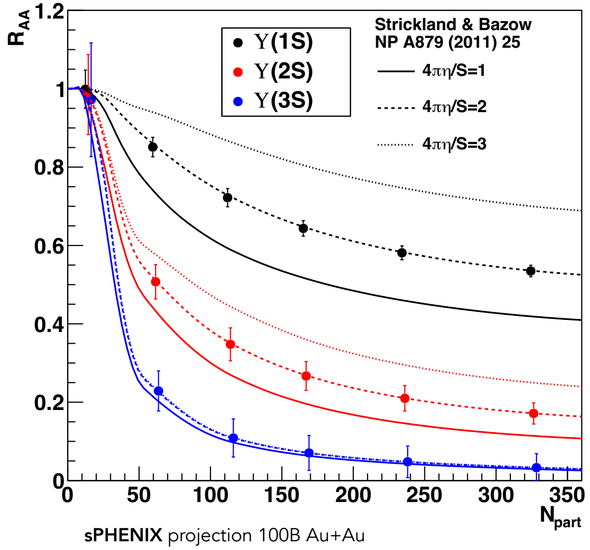




LHC projection for Run III+IV

Differential suppression of Υ(nS) states depends on QGP Debye screening length

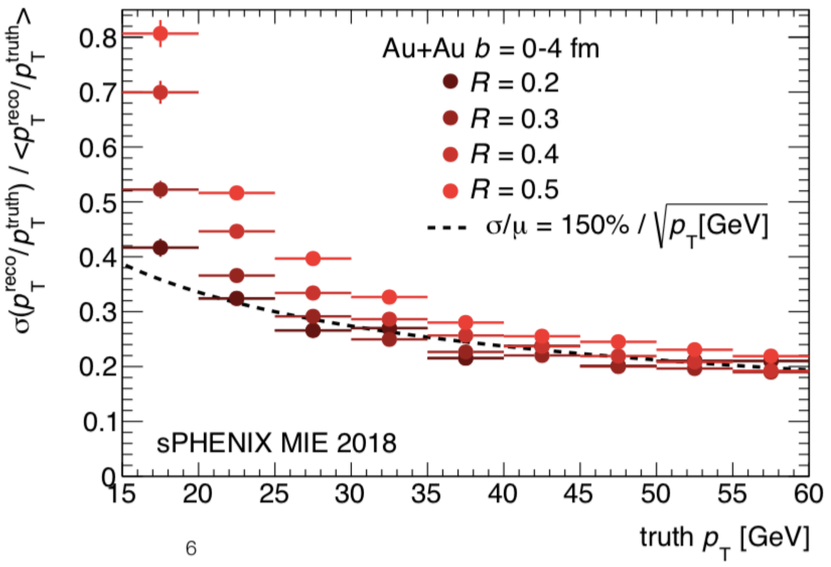




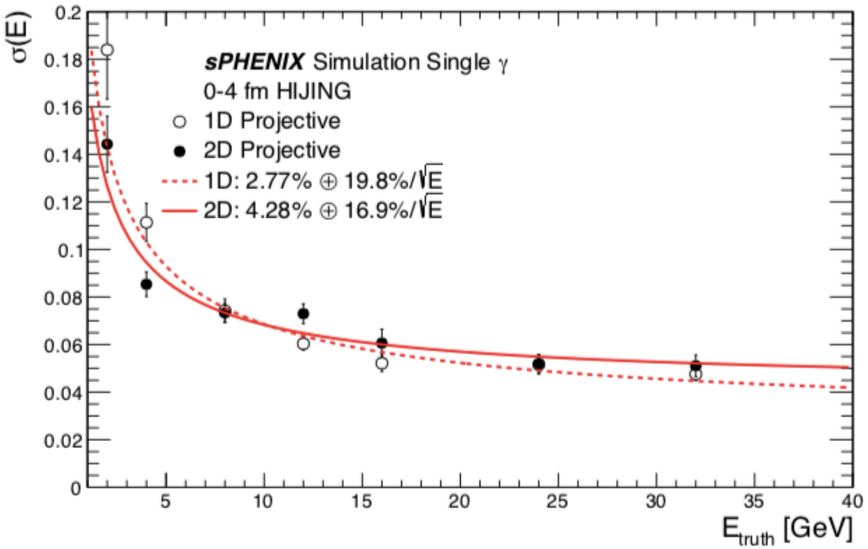
sPHENIX projection

Performance simulation: Jet and γ resolution

Single jet resolution (central Au+Au)



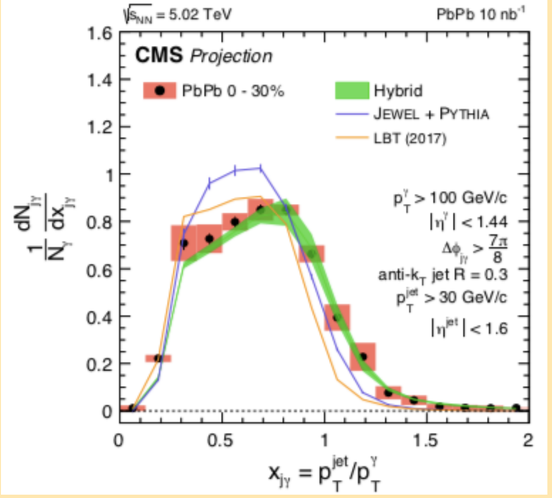
Single photon resolution (central Au+Au)



Calorimeter-related performance studied using GEANT simulations verified with test beam data – meets performance needed for science program

Physics projections: Jets in sPHENIX cf. LHC

γ+Jet momentum balance



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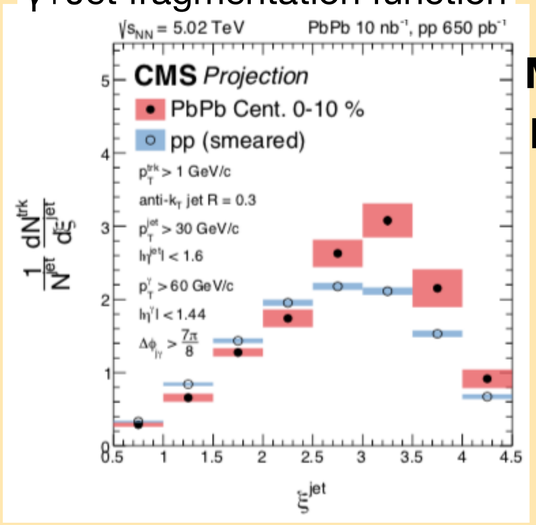

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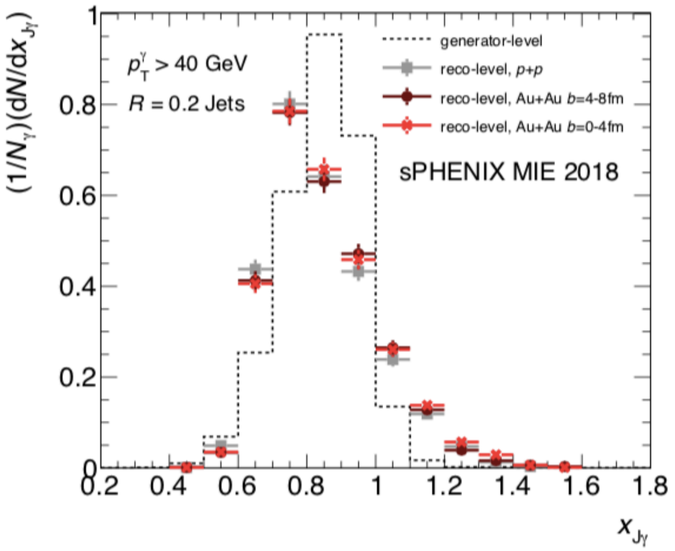
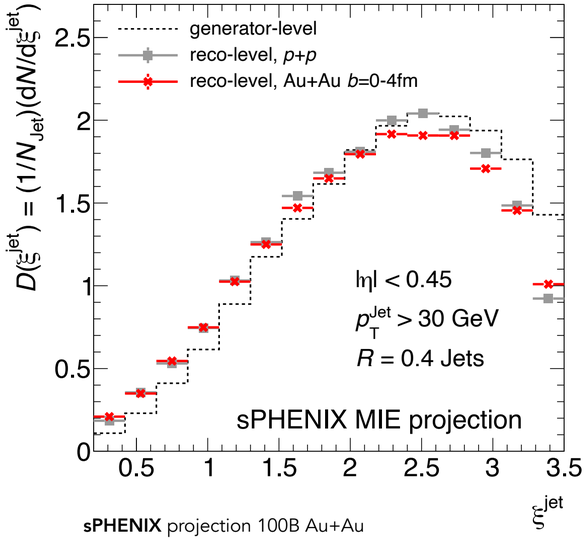


sPHENIX projections



sPHENIX projection 100B Au+Au

Heavy flavor science program

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D^0	61%	123
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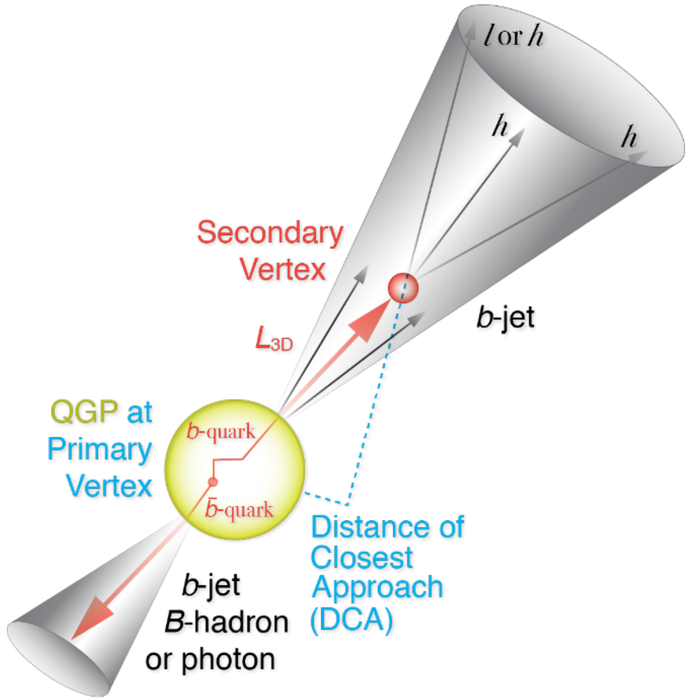
B_s	10%	453
Λ_b	10%	435



b-tagged jet and cor. p_T>15 GeV

$B \to \overline{D}^0 + X$ 60%

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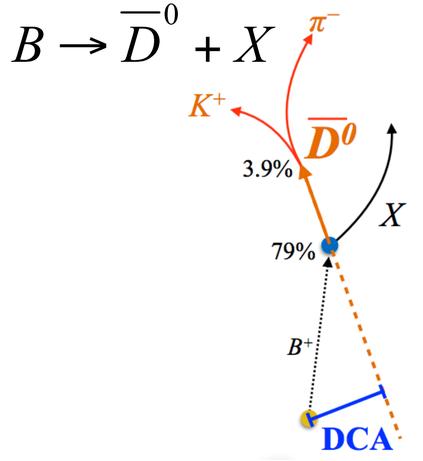

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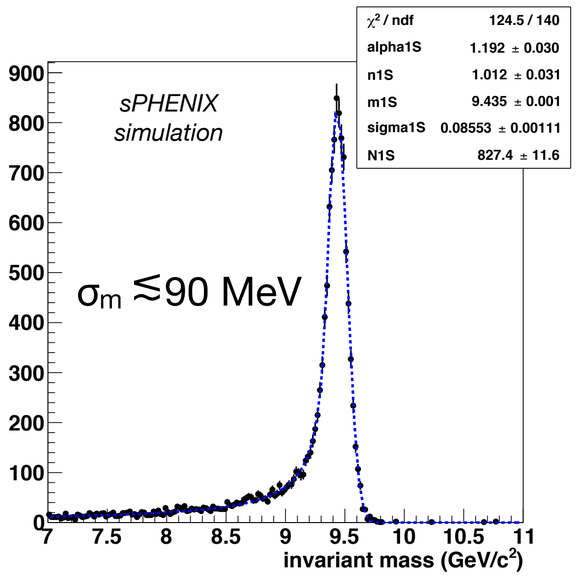

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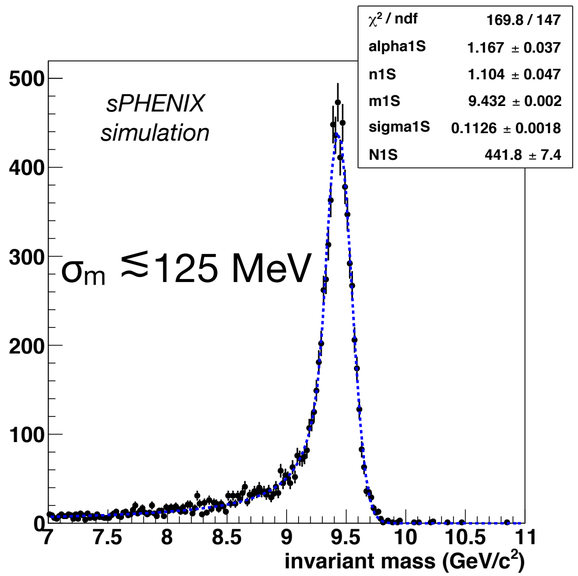

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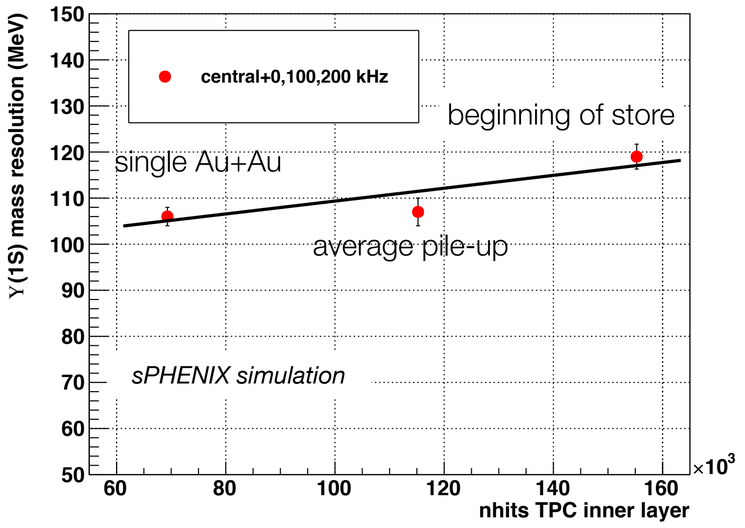

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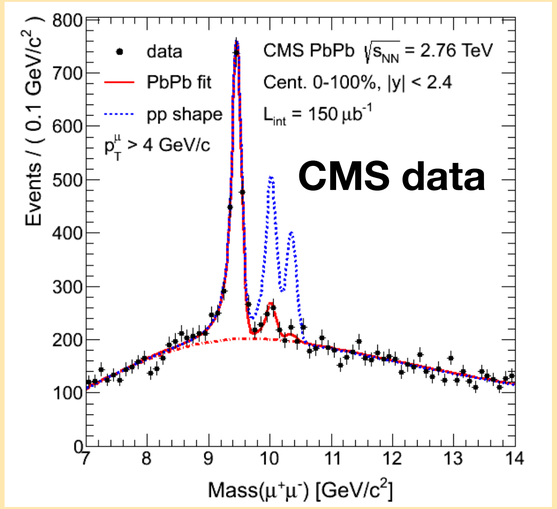

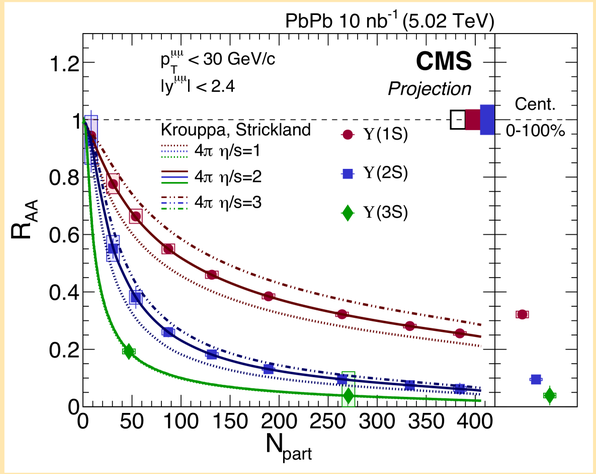

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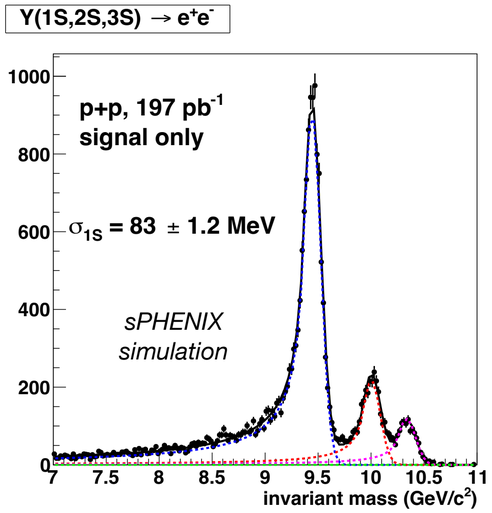

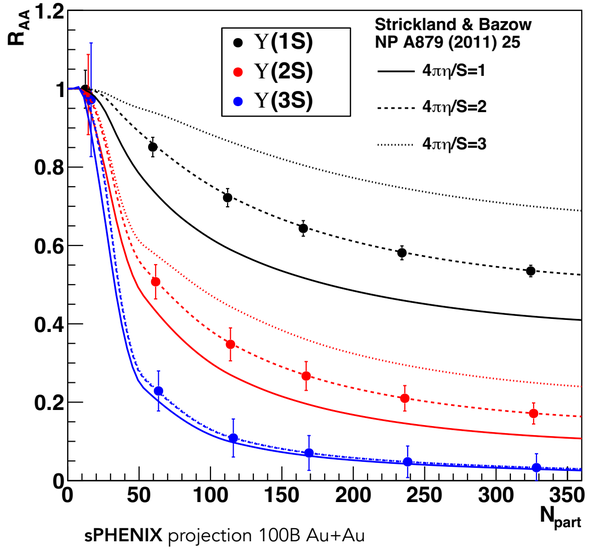

sPHENIX projection

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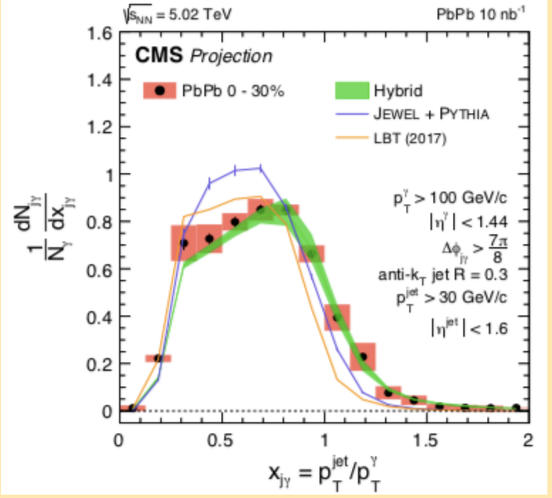

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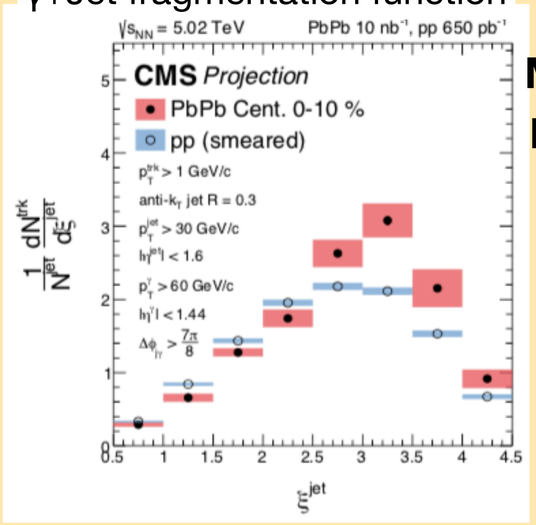

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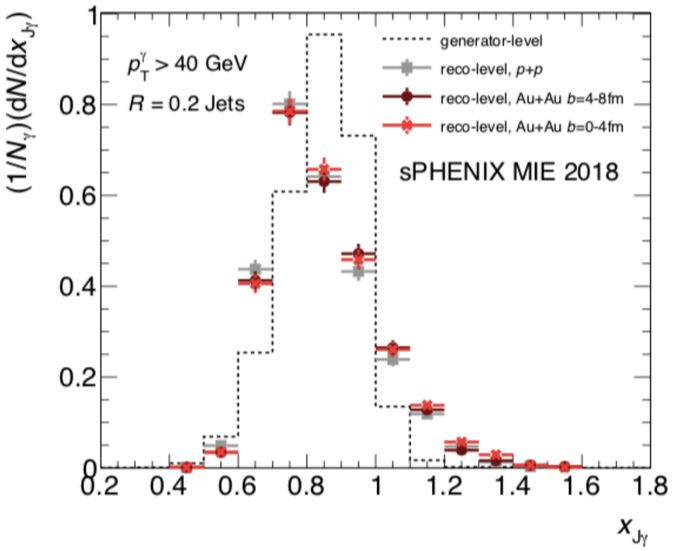
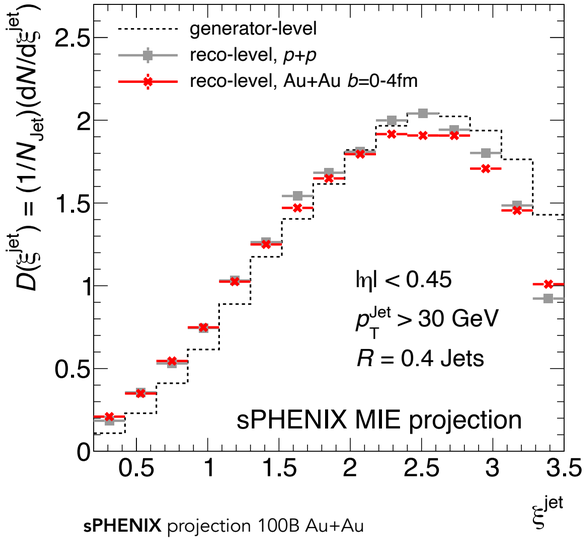


sPHENIX projections



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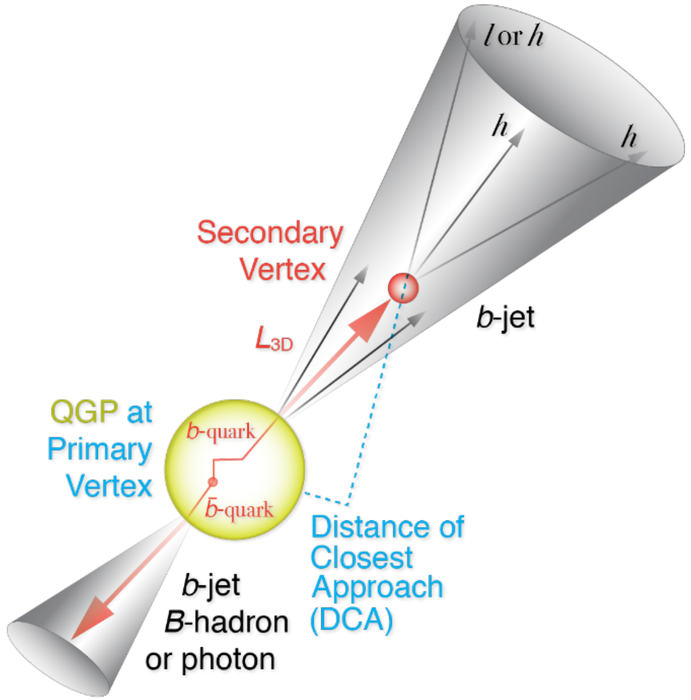

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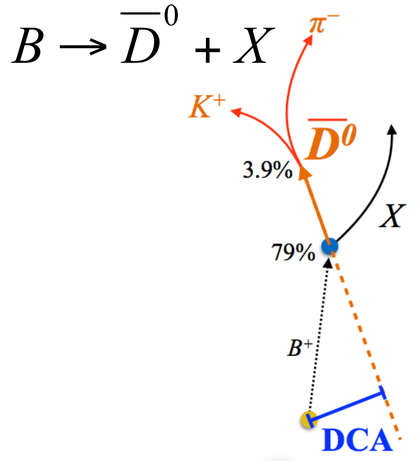

Preparation for sPHENIX science

- Collaboration: 80 institutions, 350 collaborators, growing
- Collaboration meeting going on right now!
- More students, postdocs, faculty coming to BNL