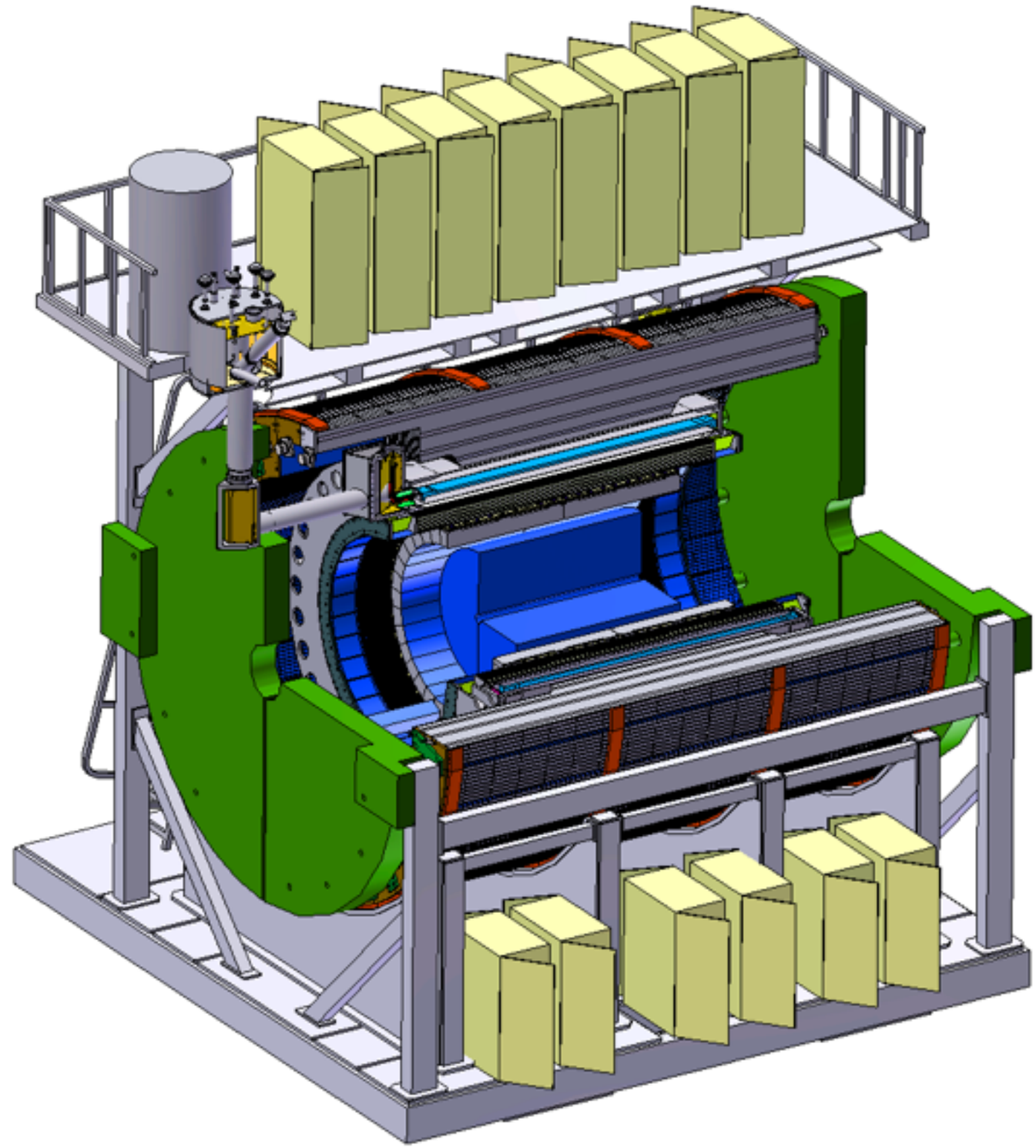
Future plans from PHENIX

Dave Morrison (BNL)
for the PHENIX Collaboration



There's the future … and then there's the future

BNL's plan for the coming decade

2016 will be the last run of PHENIX – focus of current beam use proposals

sPHENIX runs in 2021-2022

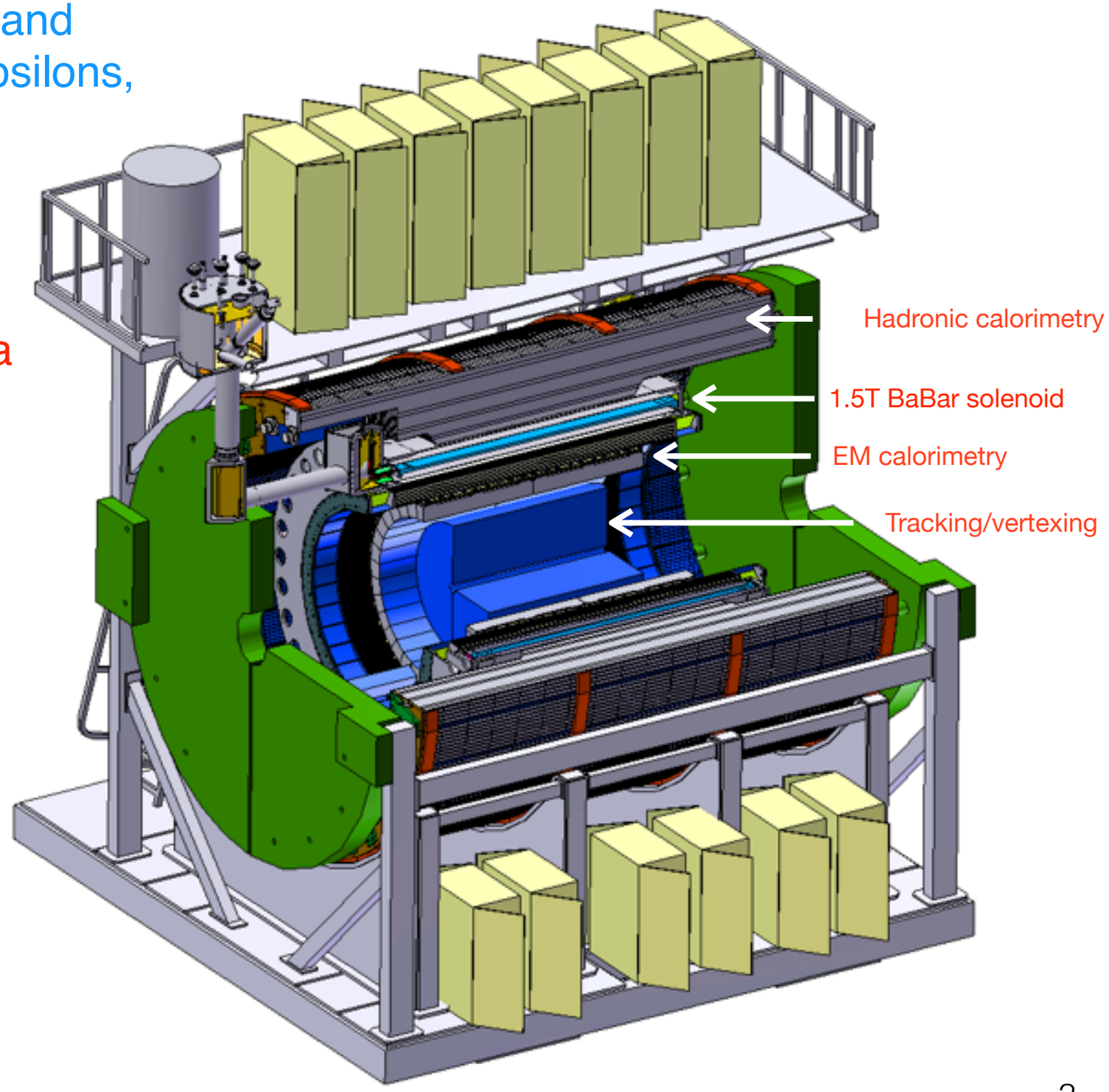
Years	Beam Species and Energies	Science Goals	New Systems Commissioned
2014	Au+Au at 15 GeV Au+Au at 200 GeV ^{3}He+Au at 200 GeV	Heavy flavor flow, energy loss, thermalization, etc. Quarkonium studies QCD critical point search	Electron lenses 56 MHz SRF STAR HFT STAR MTD
2015-16	p↑+p↑ at 200 GeV p↑+Au, p↑+Al at 200 GeV High statistics Au+Au Au+Au at 62 GeV ?	Extract η/s(T) + constrain initial quantum fluctuations Complete heavy flavor studies Sphaleron tests Parton saturation tests	PHENIX MPC-EX STAR FMS preshower Roman Pots Coherent e-cooling test
2017	p↑+p↑ at 510 GeV	Transverse spin physics Sign change in Sivers function	
2018	No Run		Low energy e-cooling install. STAR iTPC upgrade
2019-20	Au+Au at 5-20 GeV (BES-2)	Search for QCD critical point and onset of deconfinement	Low energy e-cooling
2021-22	Au+Au at 200 GeV p↑+p↑, p↑+Au at 200 GeV	Jet, di-jet, γ-jet probes of parton transport and energy loss mechanism Color screening for different quarkonia Forward spin & initial state physics	sPHENIX Forward upgrades ?
≥ 2023 ?	No Runs		Transition to eRHIC

sPHENIX refresher

sPHENIX is a next-generation, high-rate detector with a full program of light and heavy-flavor jets, direct photons, upsilons, and correlations to investigate the underlying dynamics of the QGP

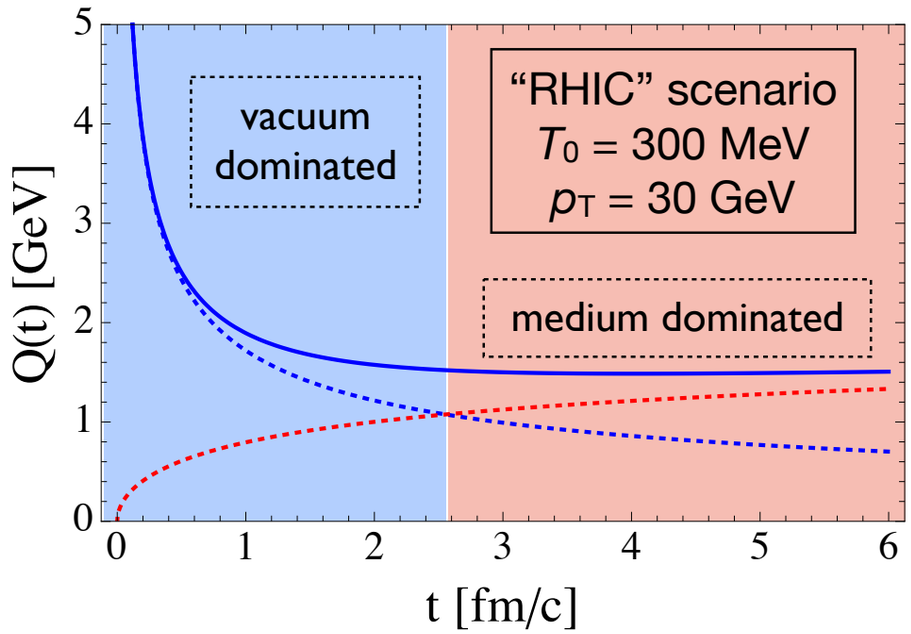
Key observables:

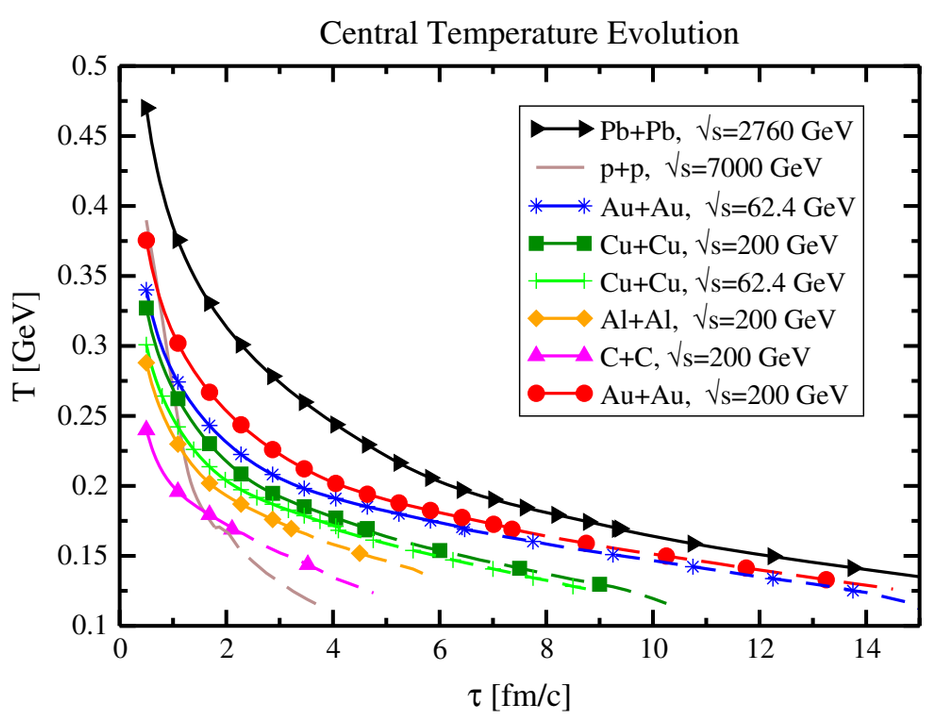
- modifications of single jet spectra
- heavy-flavor tagged jets
- hadrons to high p_T
- fragmentation functions to high z
- direct photons
- high p_T Ds
- upsilons
- *X*+jet correlations



Combining time evolution of virtuality and temperature

Berndt Mueller, RHIC/AGS 2011





Habish, Nagle, Romatschke, Eur. Phys. J. **C75** (2015) 1

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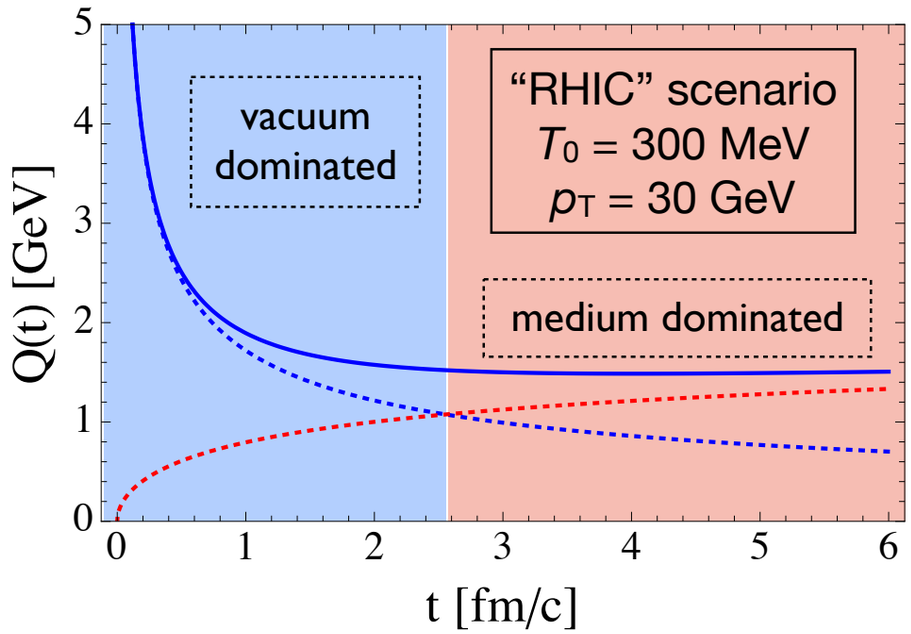
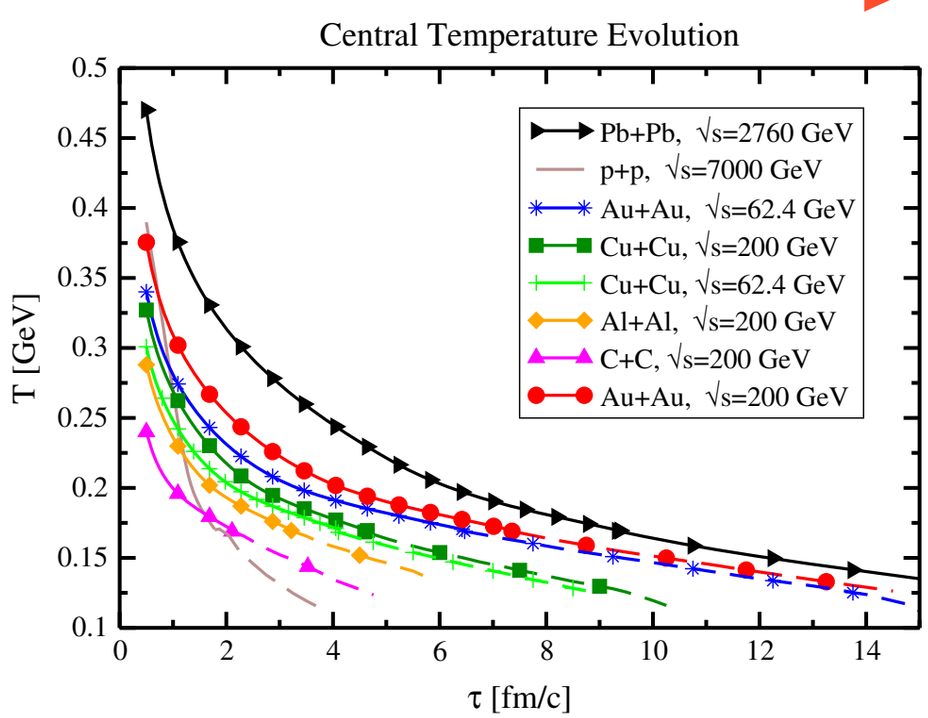
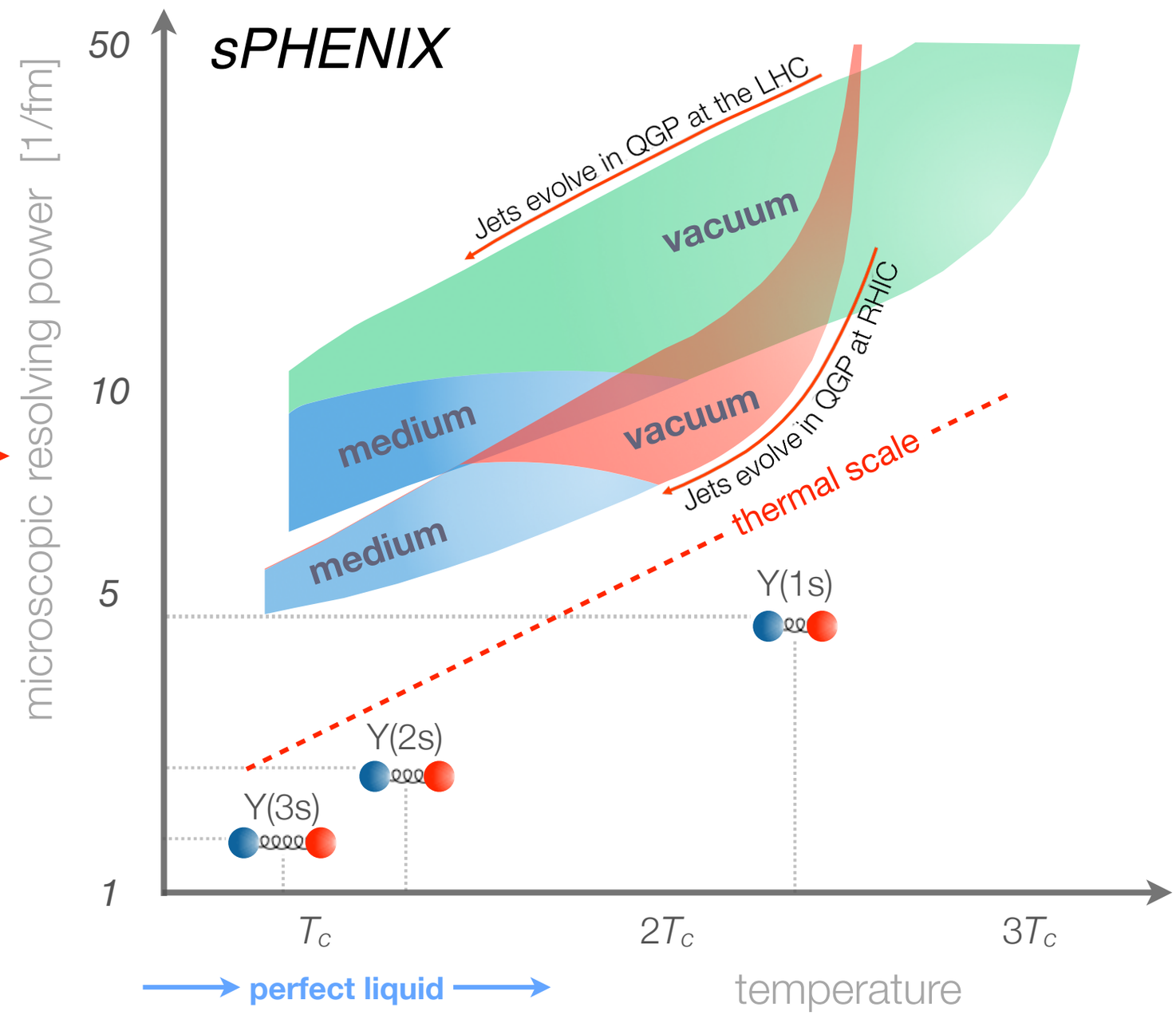






Habish, Nagle, Romatschke, Eur. Phys. J. **C75** (2015) 1

You want *rate*? I've got your rate right here.

- sPHENIX DAQ builds upon the PHENIX 15 kHz capable DAQ – able to record 100 billion Au+Au events in a 20 week RHIC year

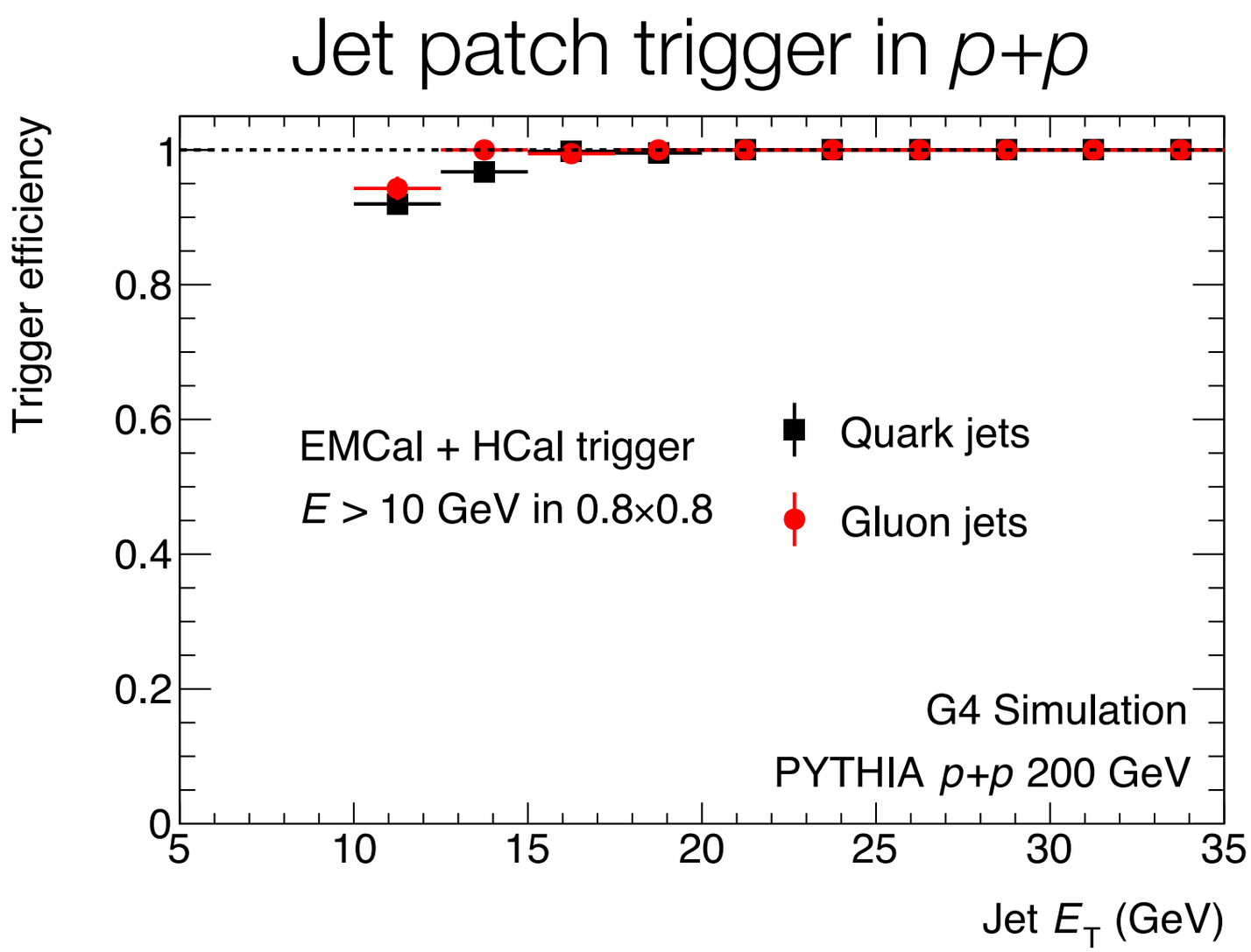
- High RHIC luminosity $\longmapsto$ sample 0.6 *trillion* Au+Au events/year

  - relevant for measurements using the full z-vertex range (e.g. gamma+jet)

  - sample the jet spectrum to the kinematic limit

Joey Chestnut sampling a minimum bias collection of hot dogs – it's one strategy

Unbiased triggering with deep calorimetry

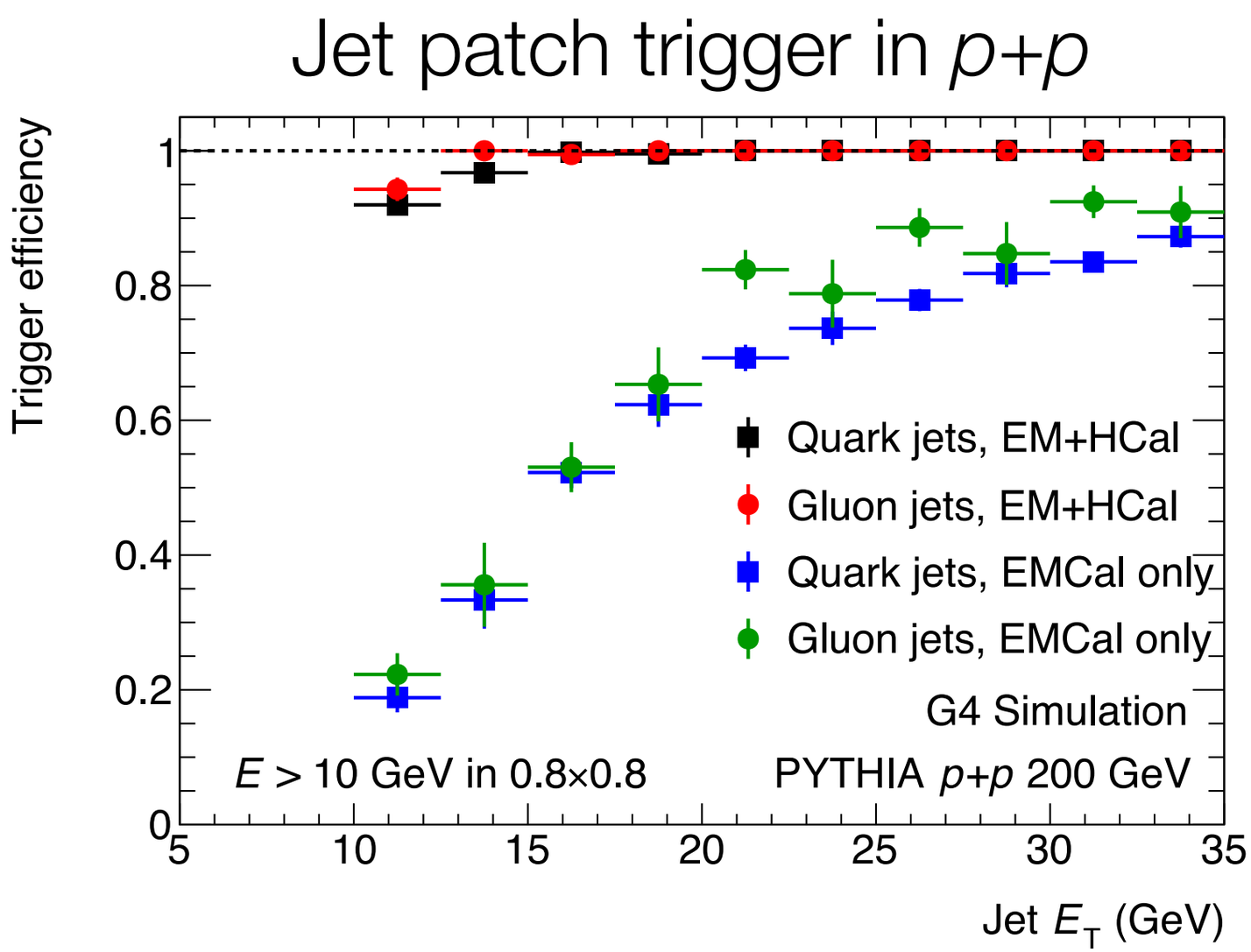


Triggering needed in *p*+*p* and *p*+A – crucial to control biases introduced by triggering

Full hadronic and EM calorimetry enables very effective, very low bias triggering

Enables full exploitation of excellent RHIC luminosity

Unbiased triggering with deep calorimetry



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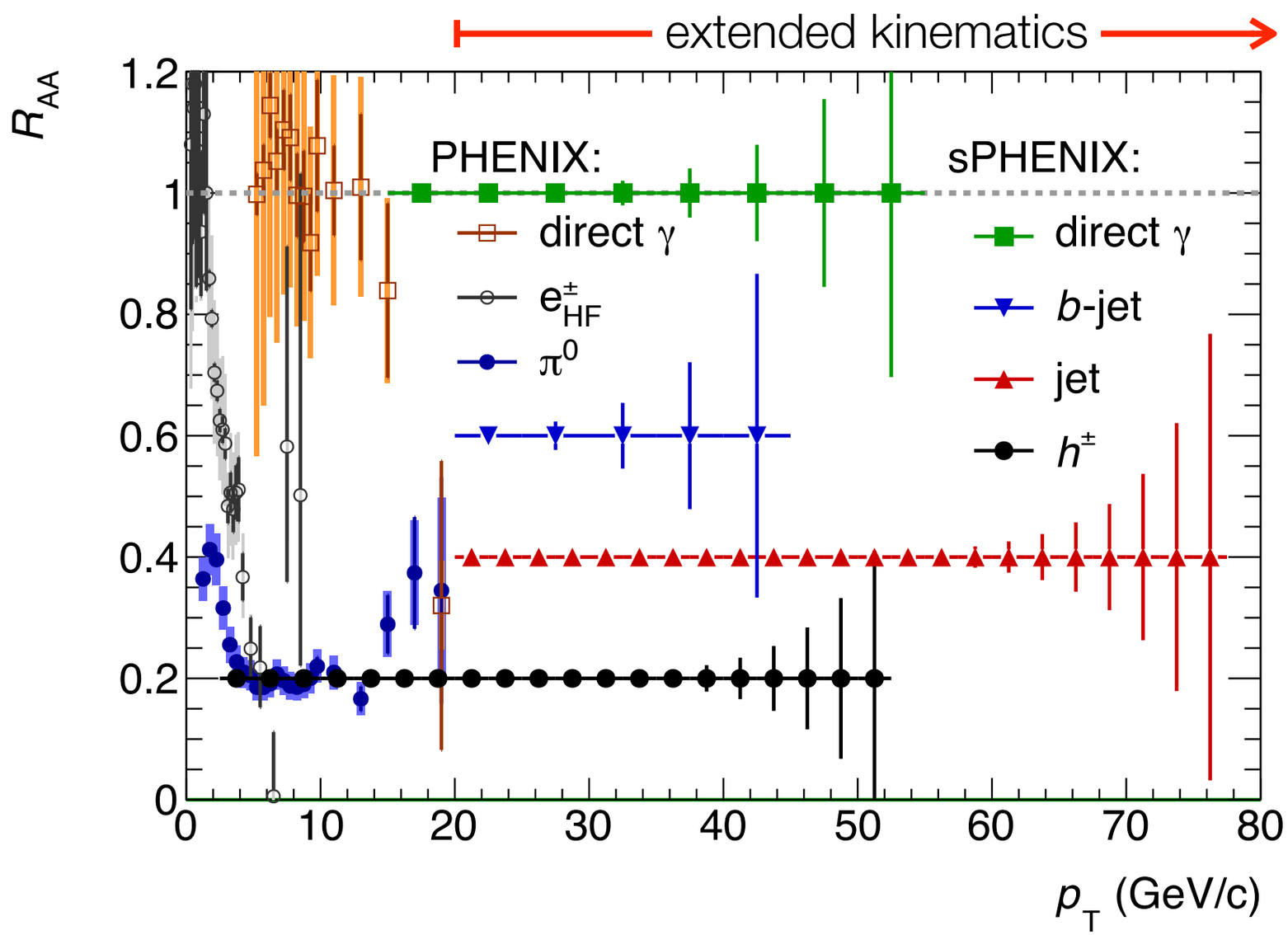
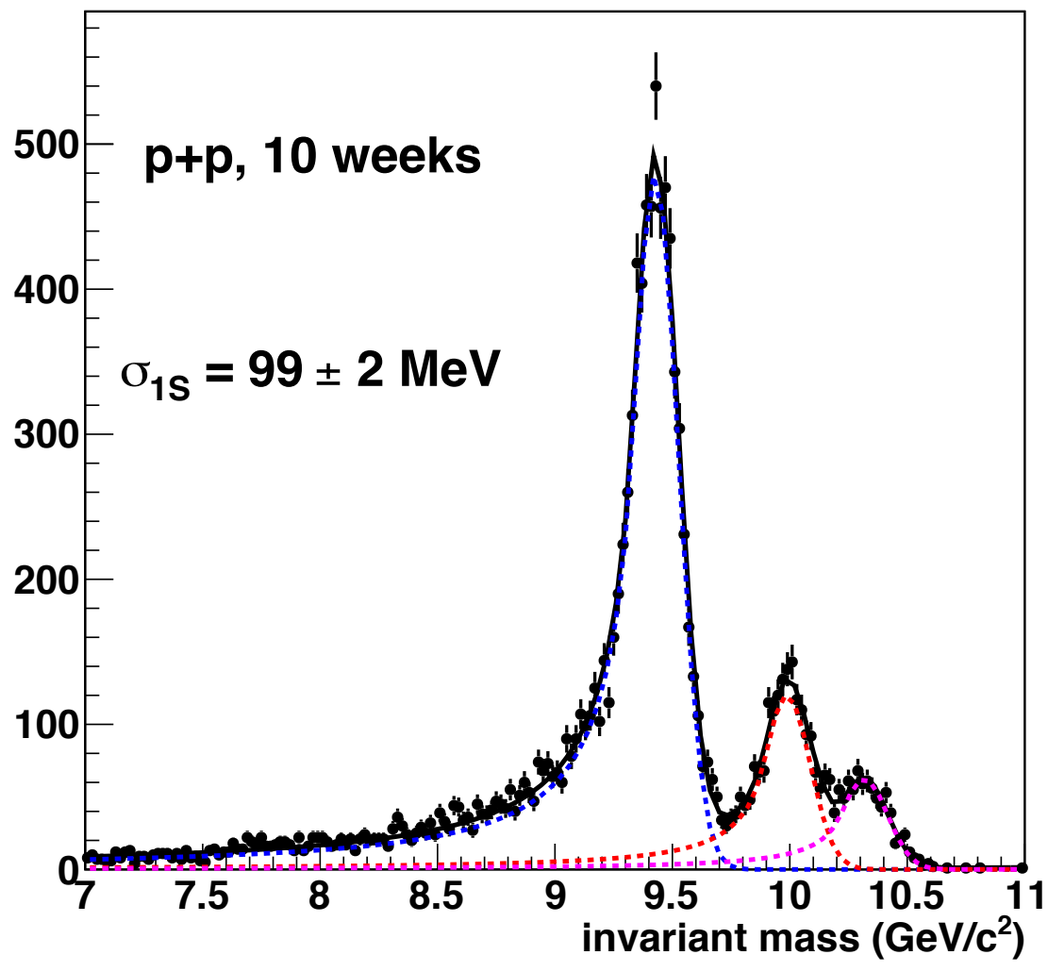
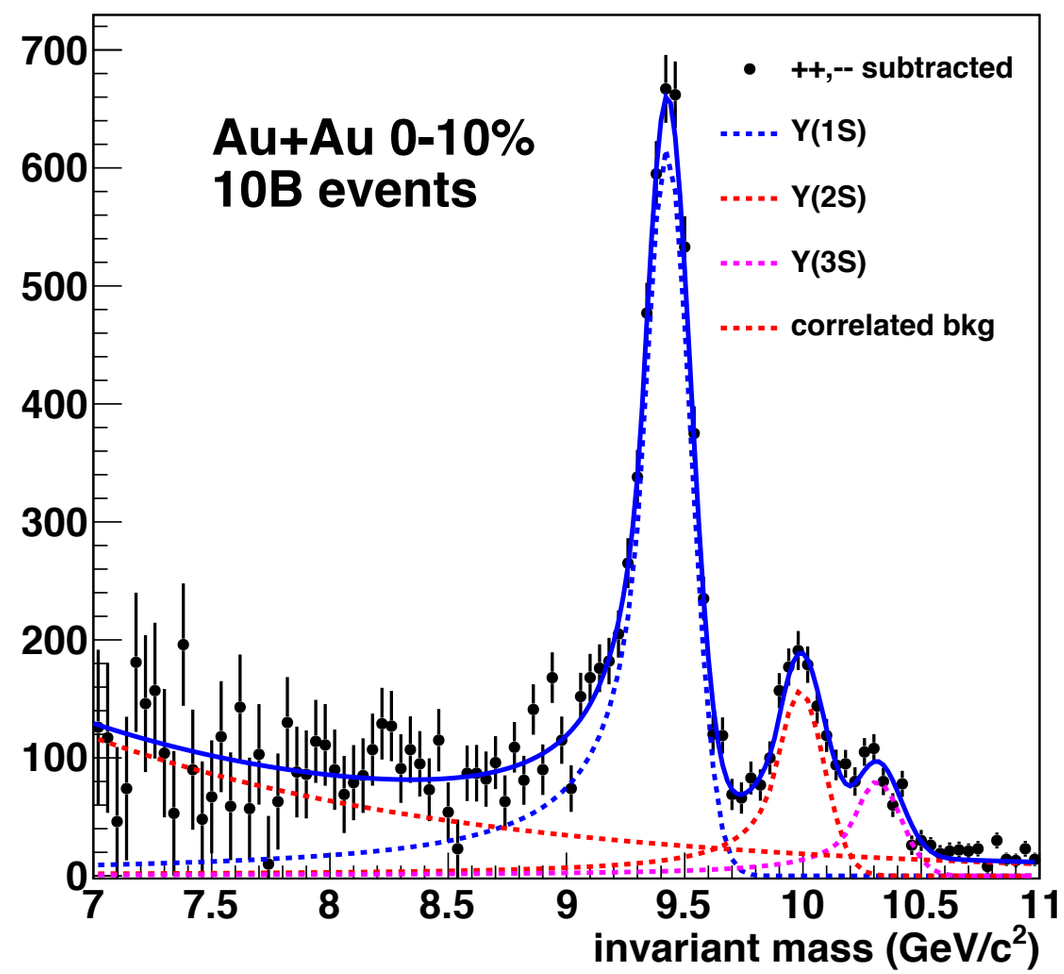
Resolving power and kinematics

high-rate DAQ, full calorimetry, exploiting high RHIC luminosity
$\Longrightarrow$ huge range of microscope "resolving power"



Fully resolved Upsilon mass states



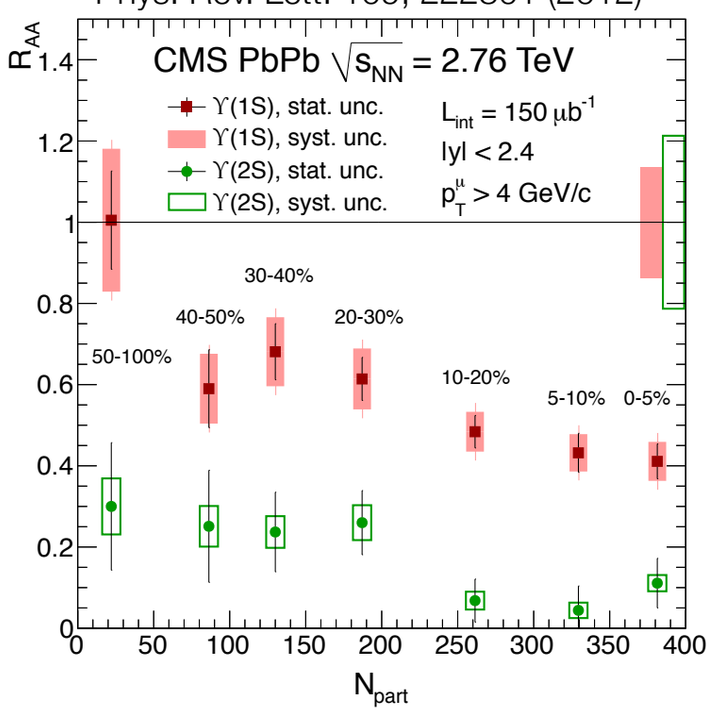


Upsilon statistics in *p+p* – the denominator in determining R_{AA} – benefits from recent C-AD luminosity projections. In Au+Au, record outright 100 billion minimum bias events. Mass resolution better than 100 MeV/c^2.

Color screening – RHIC and LHC

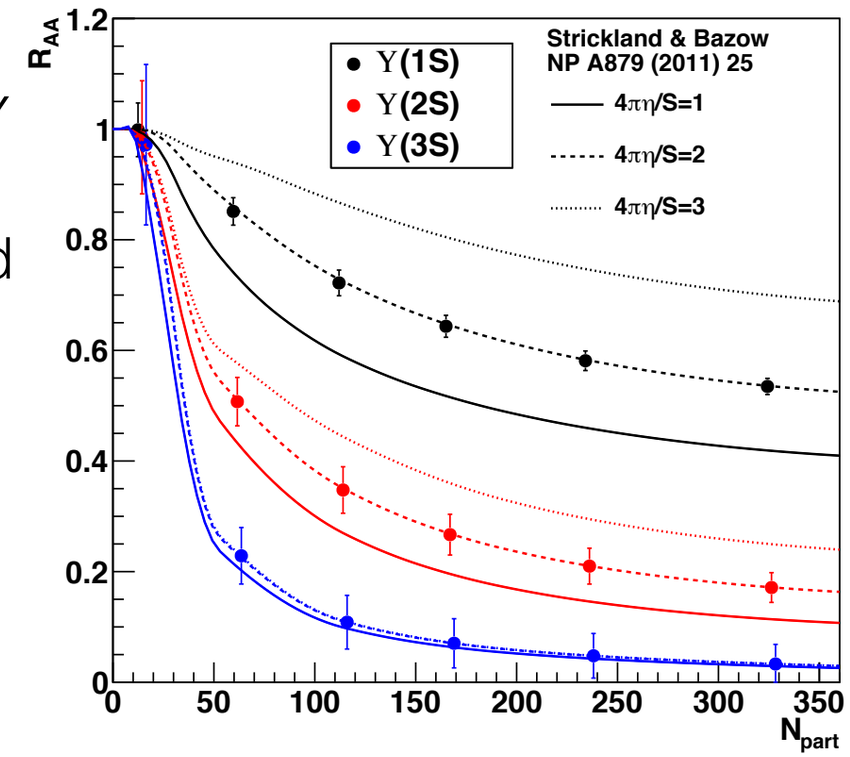
Pronounced suppression of Y(1S) and Y(2S).
Negligible recombination at RHIC and LHC.
Much more data coming in Run 3

Phys. Rev. Lett. 109, 222301 (2012)



Color screening – RHIC and LHC

sPHENIX – projected Υ yields and S/B compared to Strickland and Bazow model



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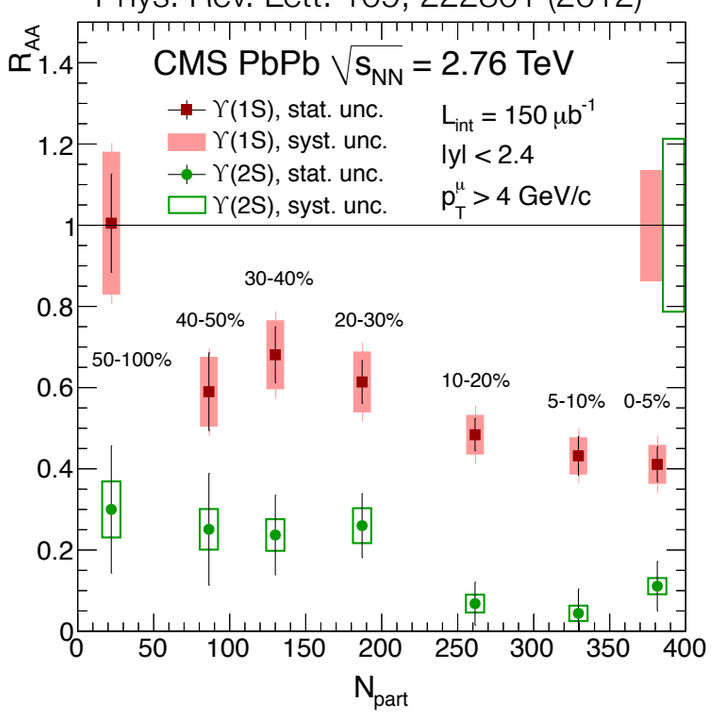

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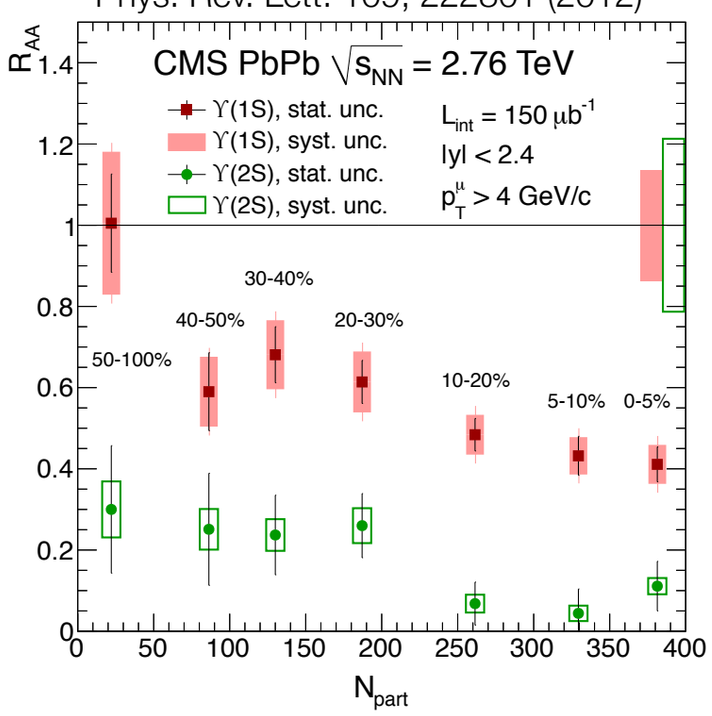

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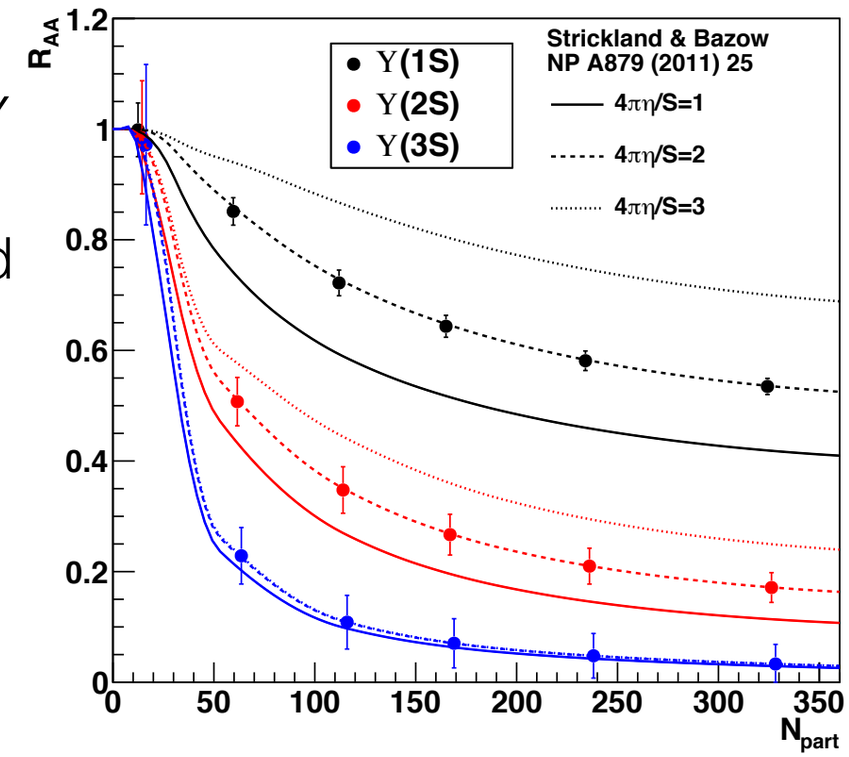
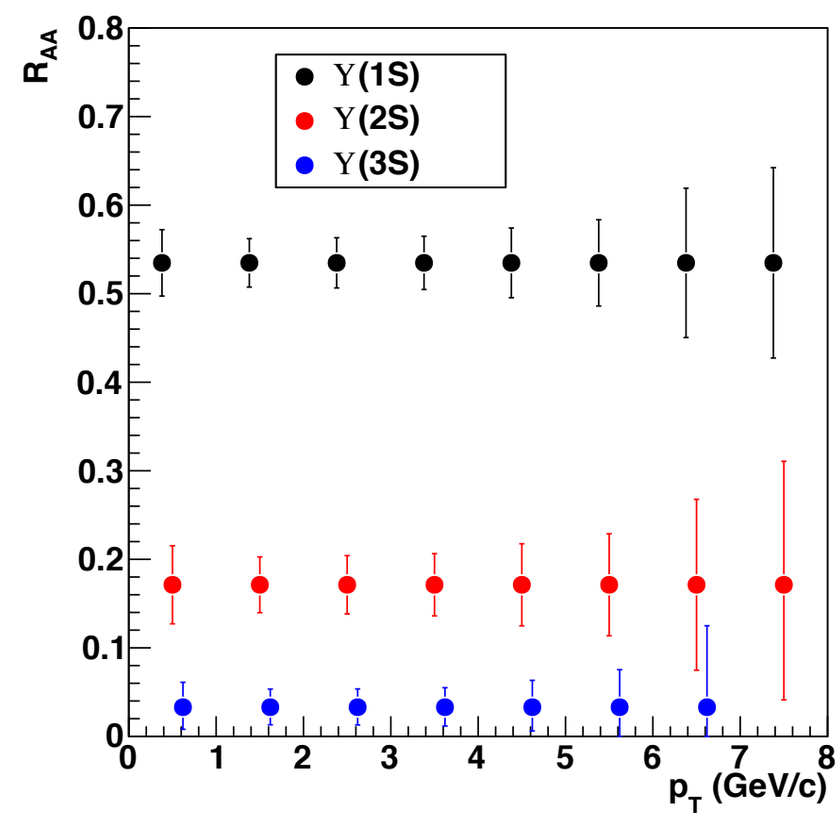


sPHENIX – p_T dependence of Y R_{AA} for central events



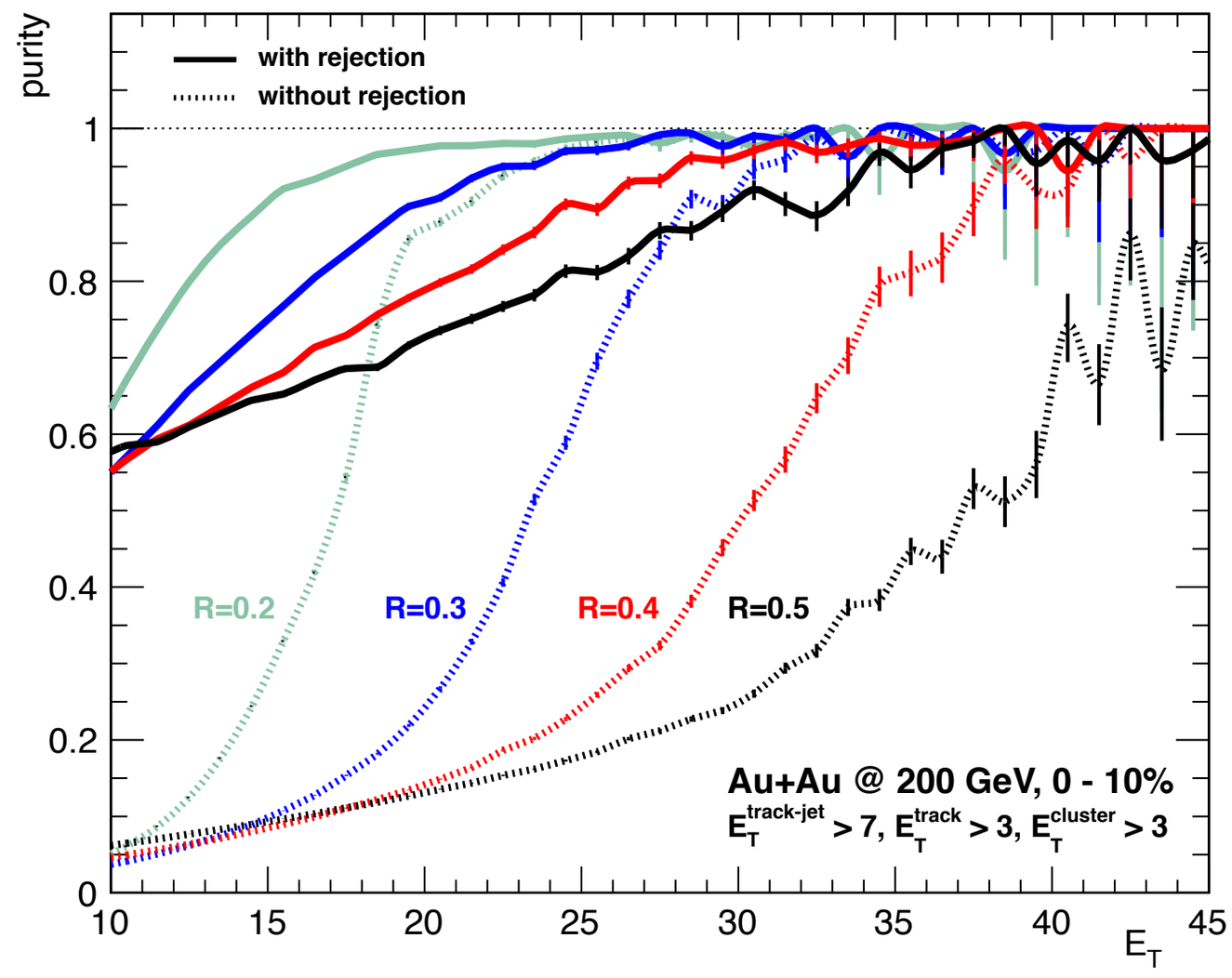
Jets in *p+p* and in heavy-ion collisions

- One method for identifying single jets in HI background published as Phys. Rev. C86 (2012) 024908 (“ATLAS” approach)

- sPHENIX can use other methods, too
  - ensemble approach (STAR, ALICE)
  - particle-flow algorithms (CMS)
  - fake jet rejection

Fake jet rejection

- Different approaches possible
- Place some hardness requirement on jet constituents
- Resulting jets are biased, but manipulating that bias is a way to access physics



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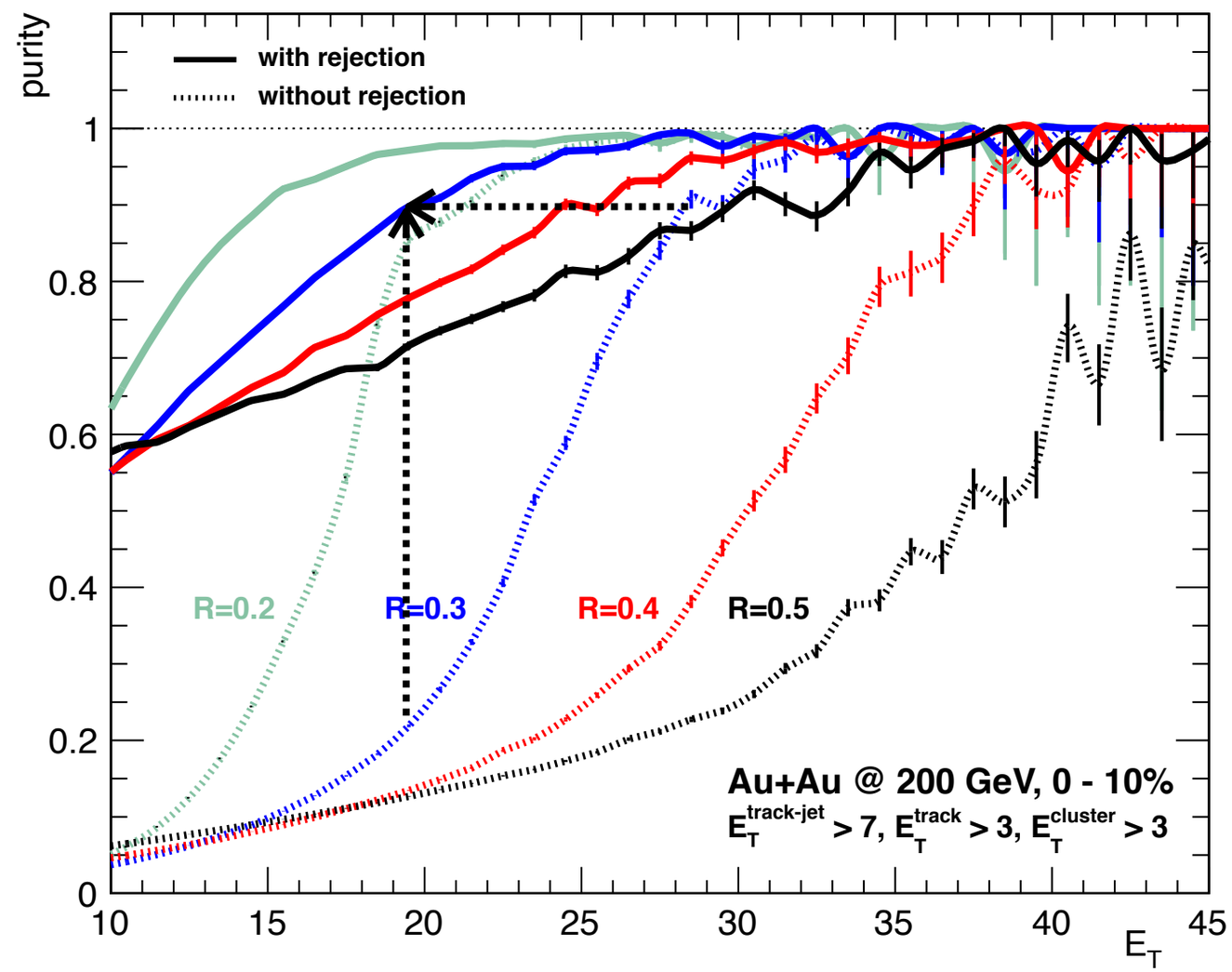
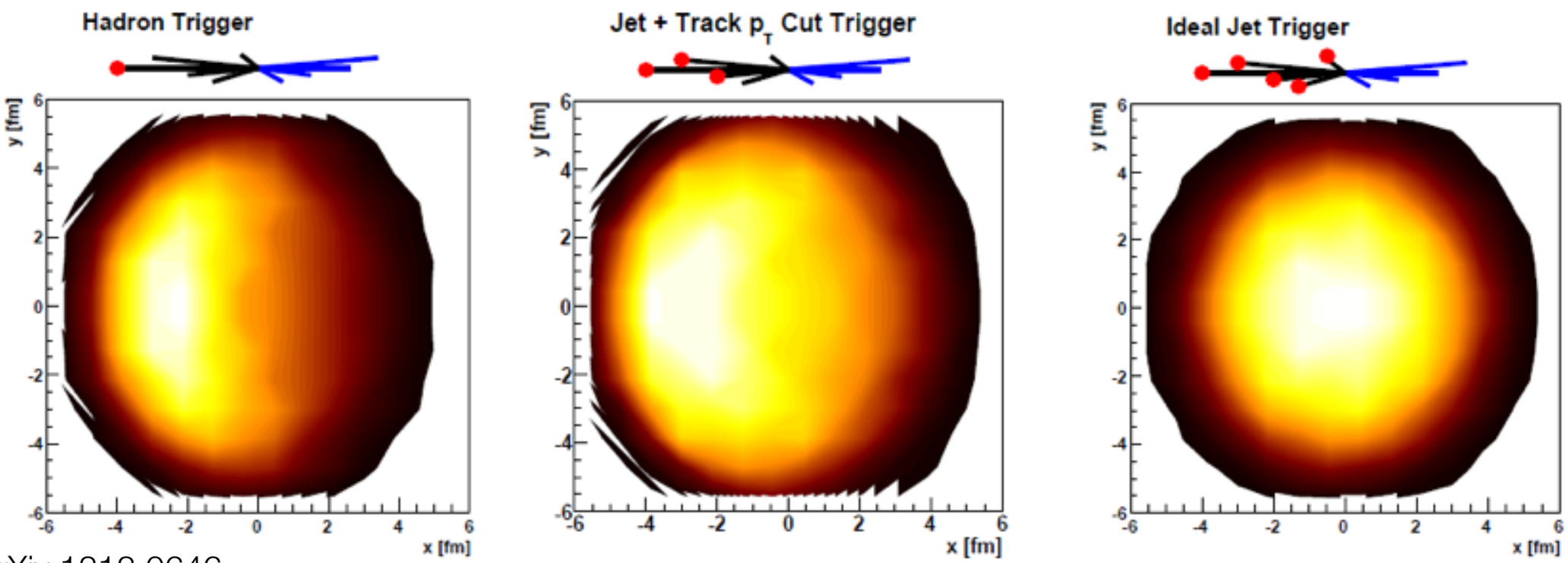


Bias manipulation

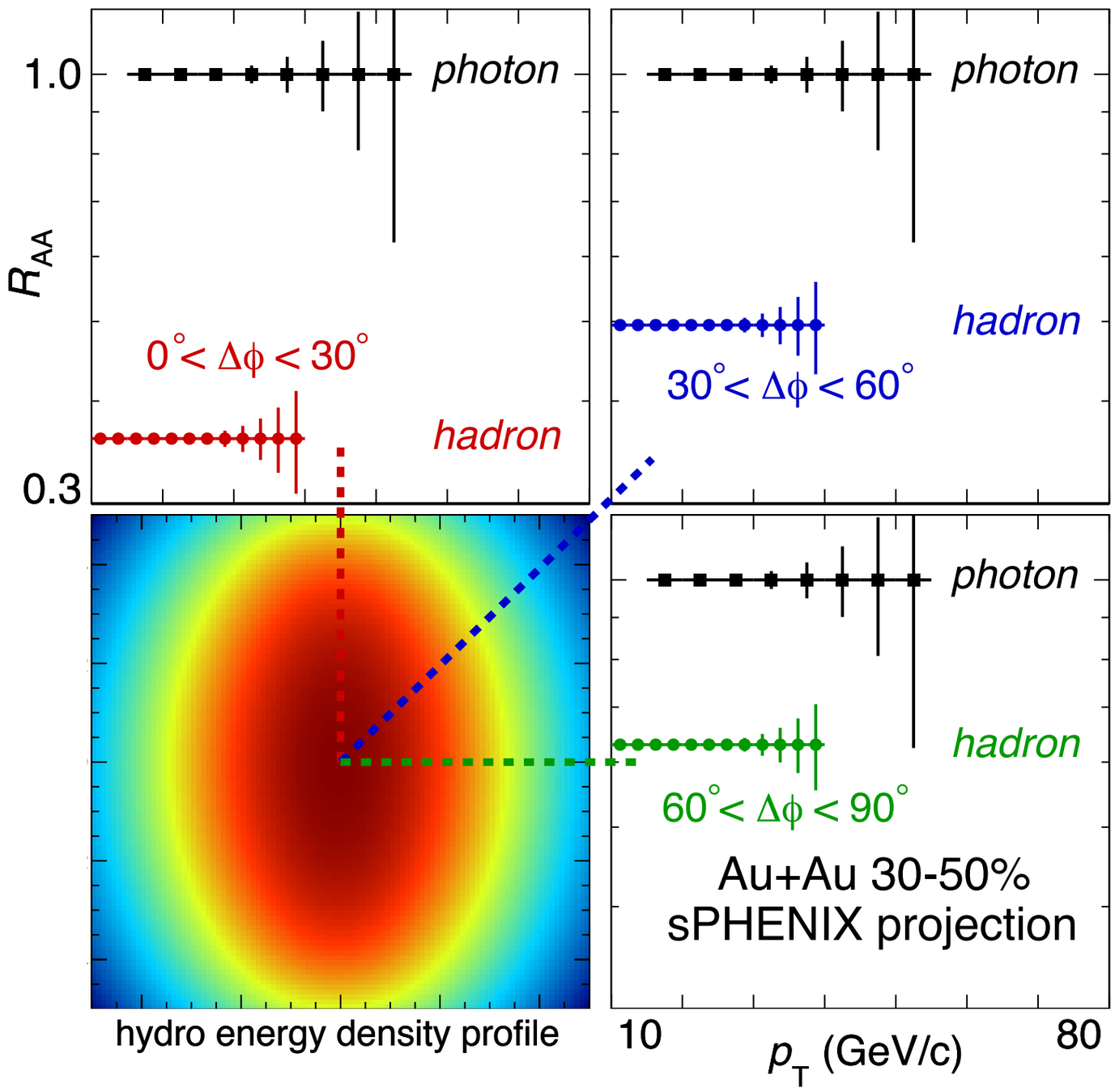


arXiv:1212.0646

Thorsten Renk – (x,y) of initial hard scattering for an object going to left. How you define and detect that object biases the set of initial hard scattering locations.

The steeper the p_T spectrum, the stronger the effect.

Mid-central Au+Au collisions

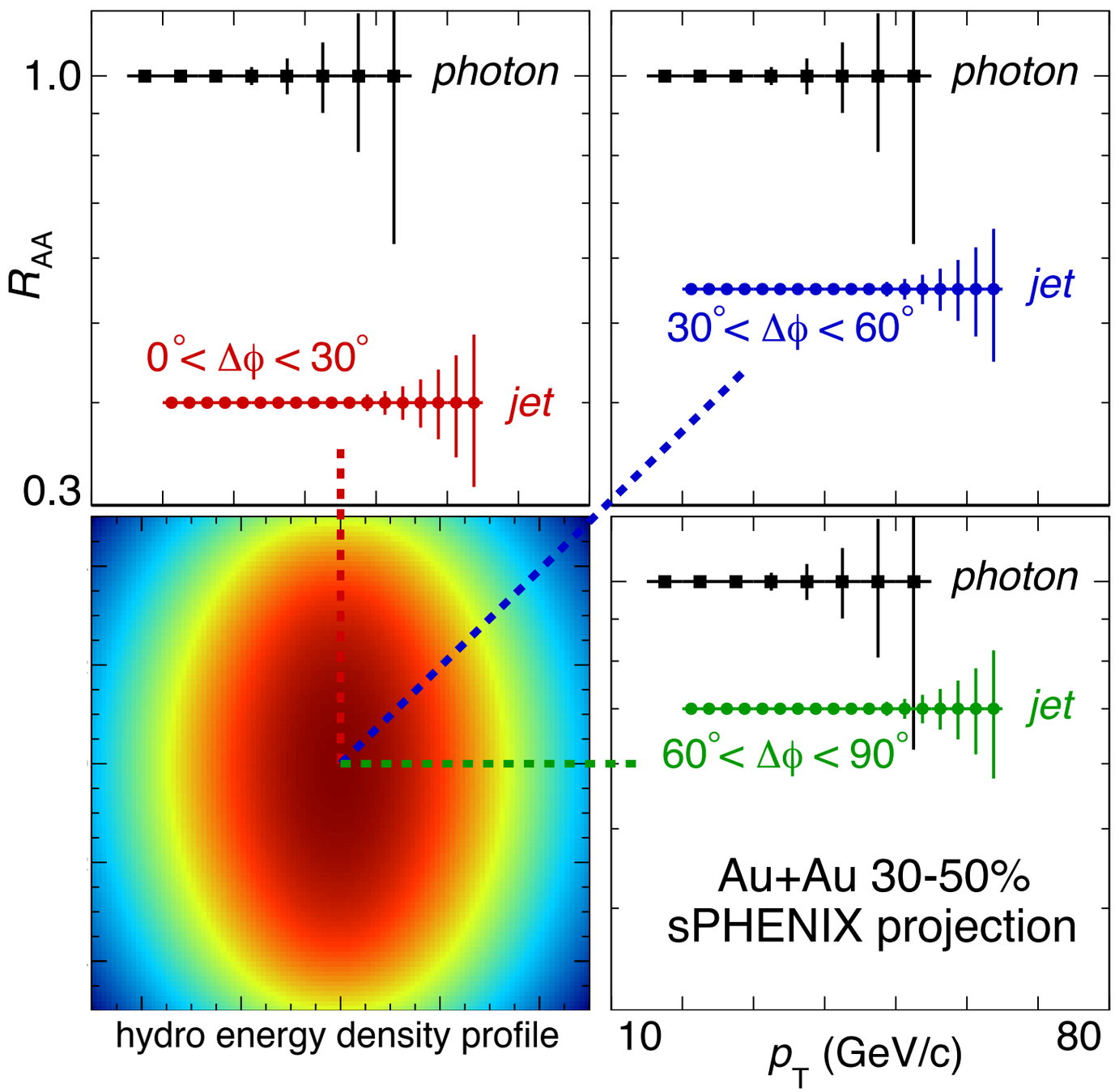


Large Au+Au statistics enables more differential measurements –

Binning mid-central events by reaction plane orientation selects path length in the medium

Underlying event in mid-central events is much smaller than in central events – aids in pushing jet finding to lower jet p_T

Mid-central Au+Au collisions



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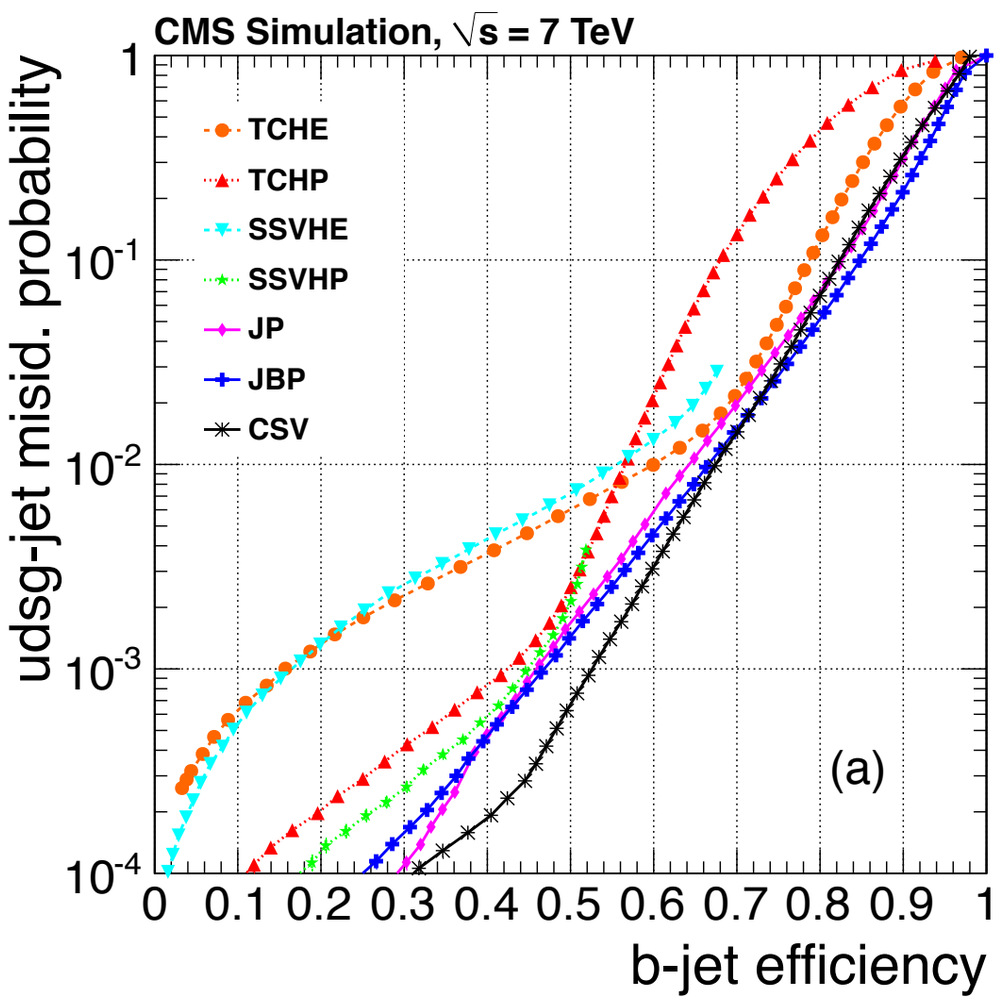
Heavy flavor jets in sPHENIX

JINST 8 (2013) P04013

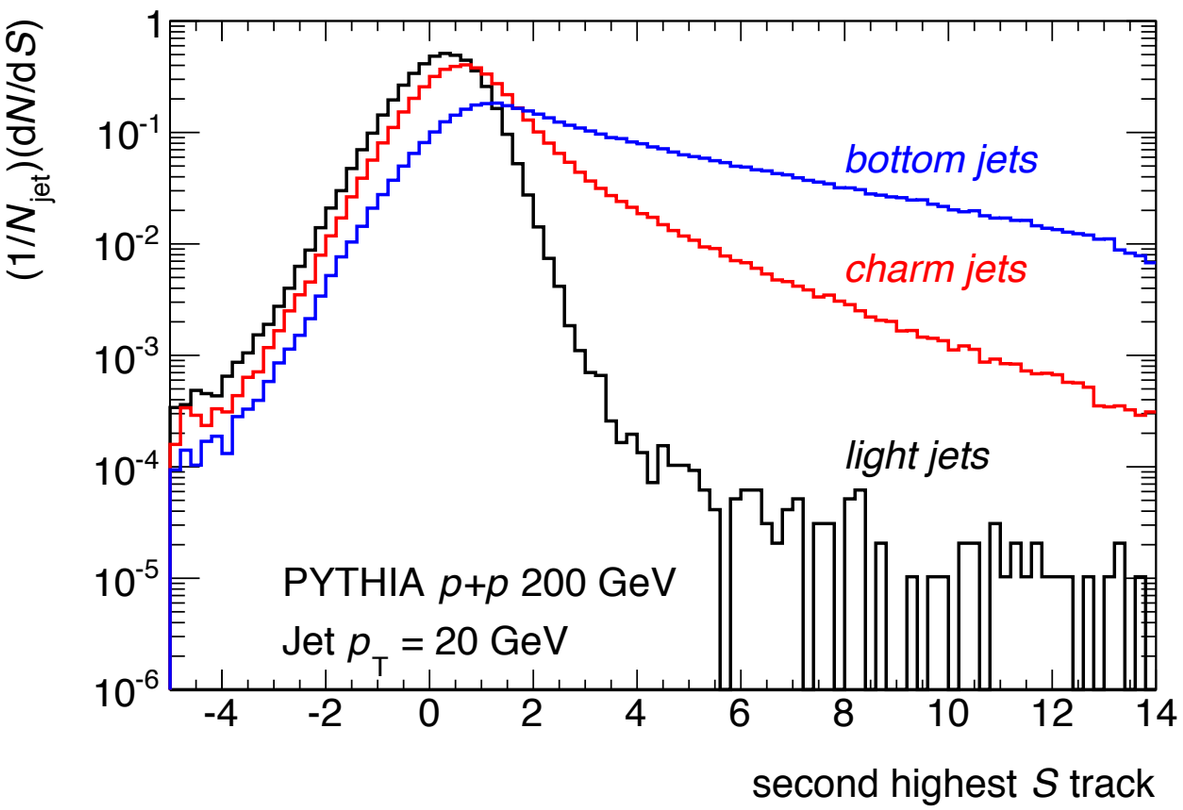


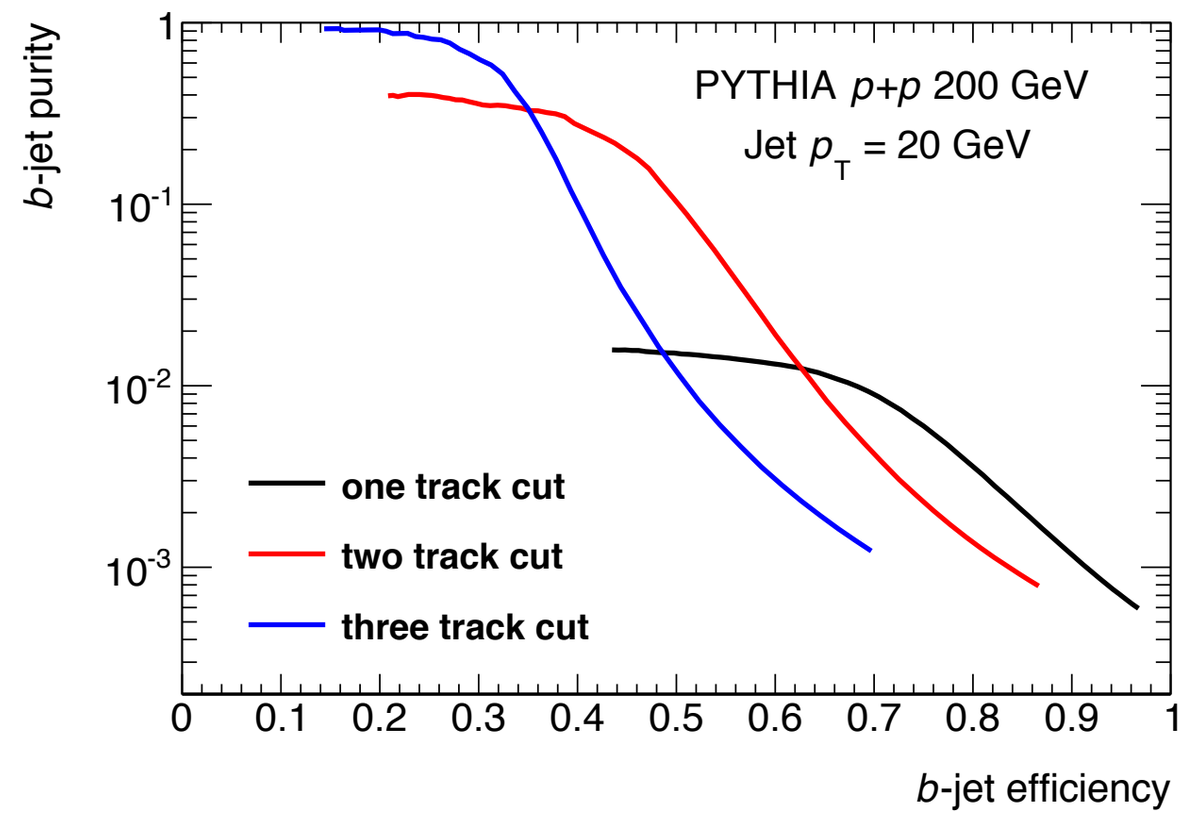
Variety of algorithms for identifying HF jets – B,D mesons have long lifetimes and distinctive decays

With excellent calorimetry and tracking, sPHENIX is suited for using a number of modern algorithms

e.g., reconstructed secondary vertex, track counting

One algorithm: track counting



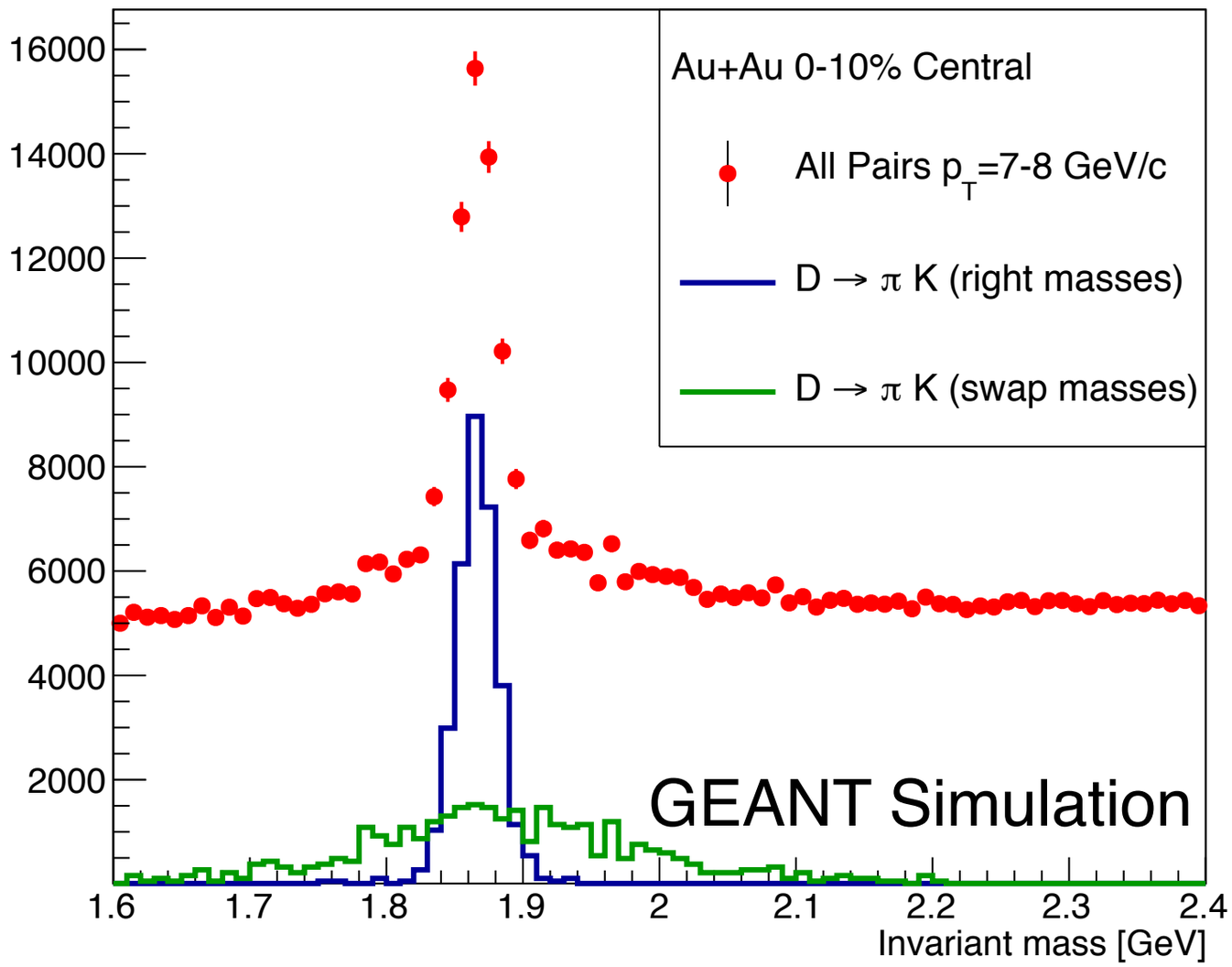


S = "significance" = DCA/σ_{DCA}

large, positive significance indicates a track consistent with a displaced vertex in the direction of the jet

Particular cut on significance translates into a particular trade-off between efficiency and purity

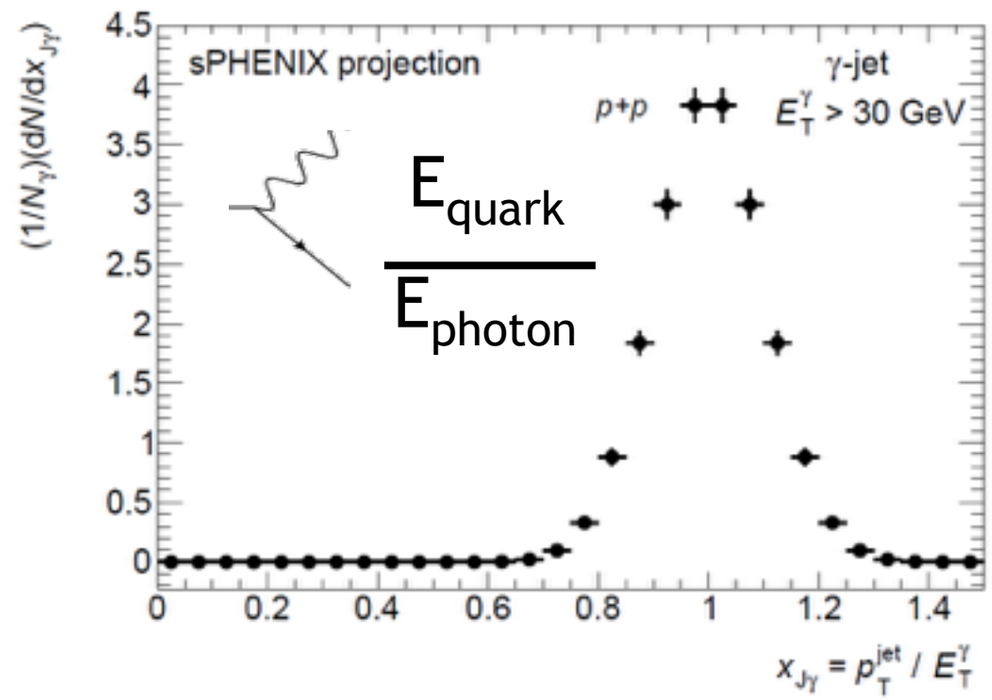
High p_T open charm



Pairs of high p_T tracks from a secondary vertex, even with no PID, produce a clear *D* meson mass peak in central Au+Au – look at charm fragmentation modification

Photon-jet correlations

For E_γ = 20 GeV, S/B at RHIC is **20x** higher and U.E. is **2.5x** smaller than at the LHC



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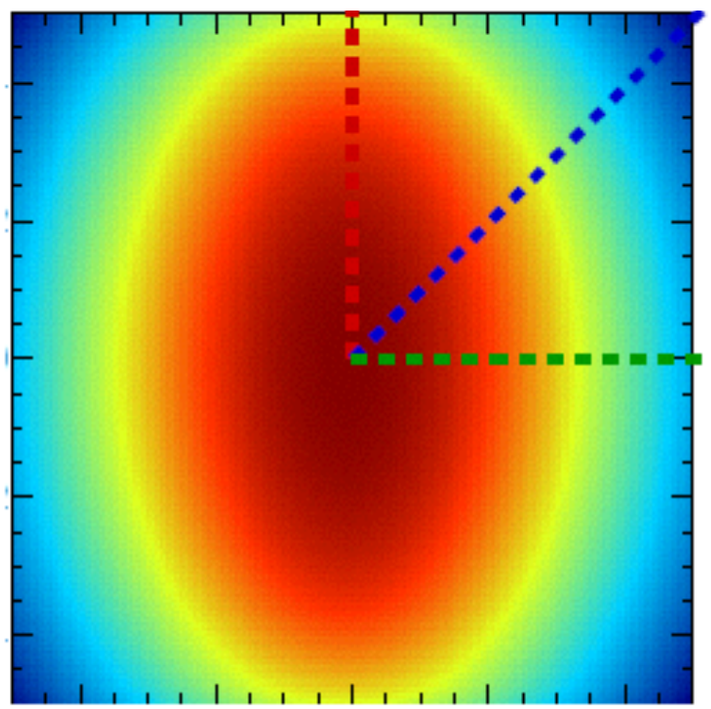

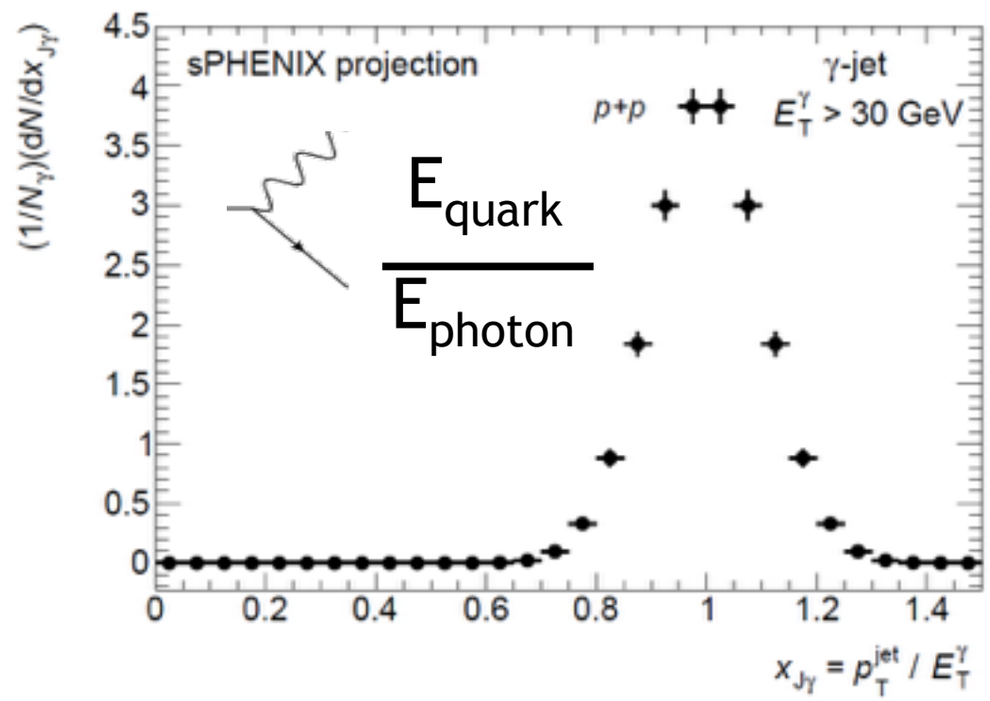

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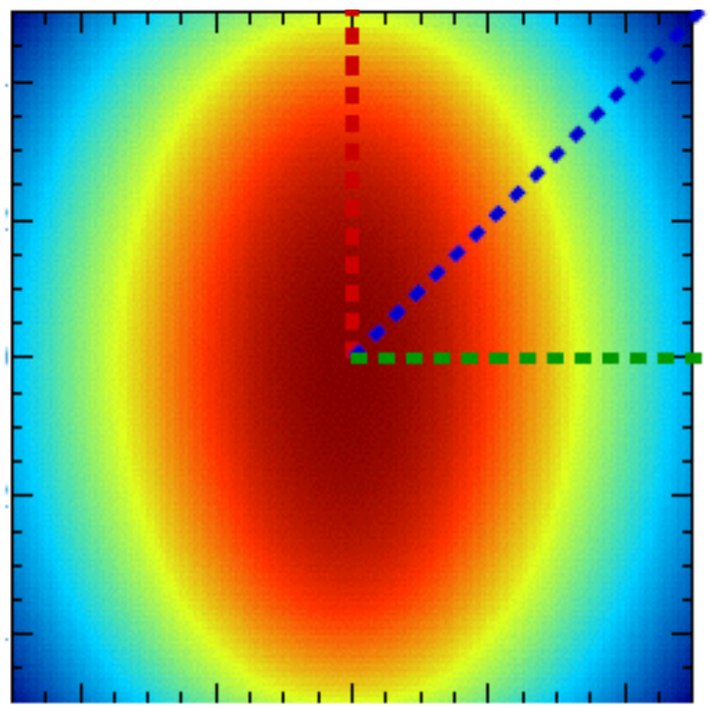

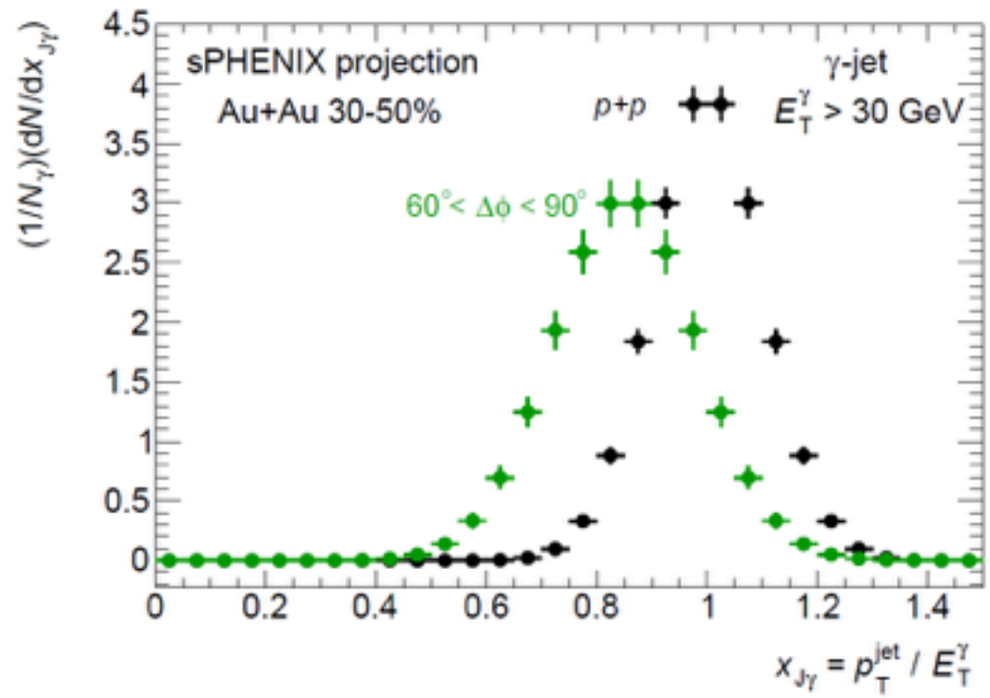

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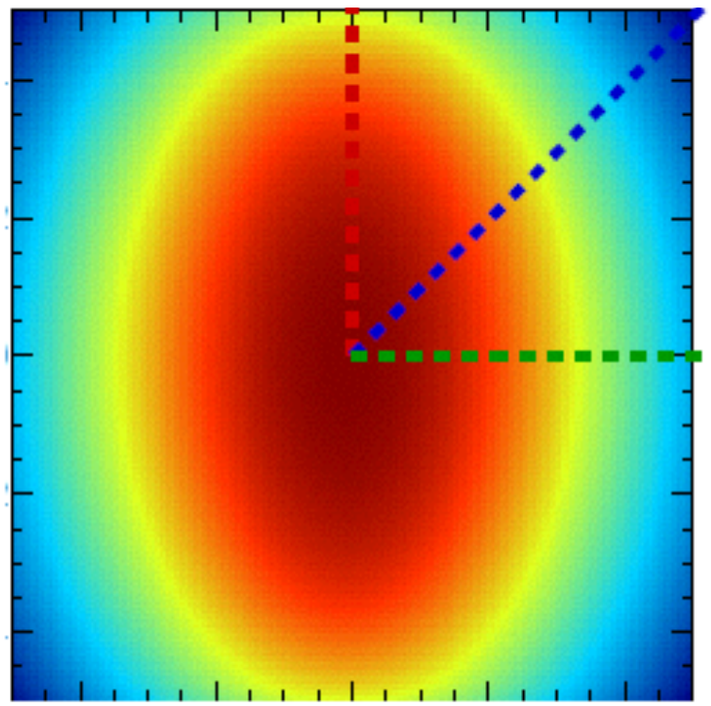

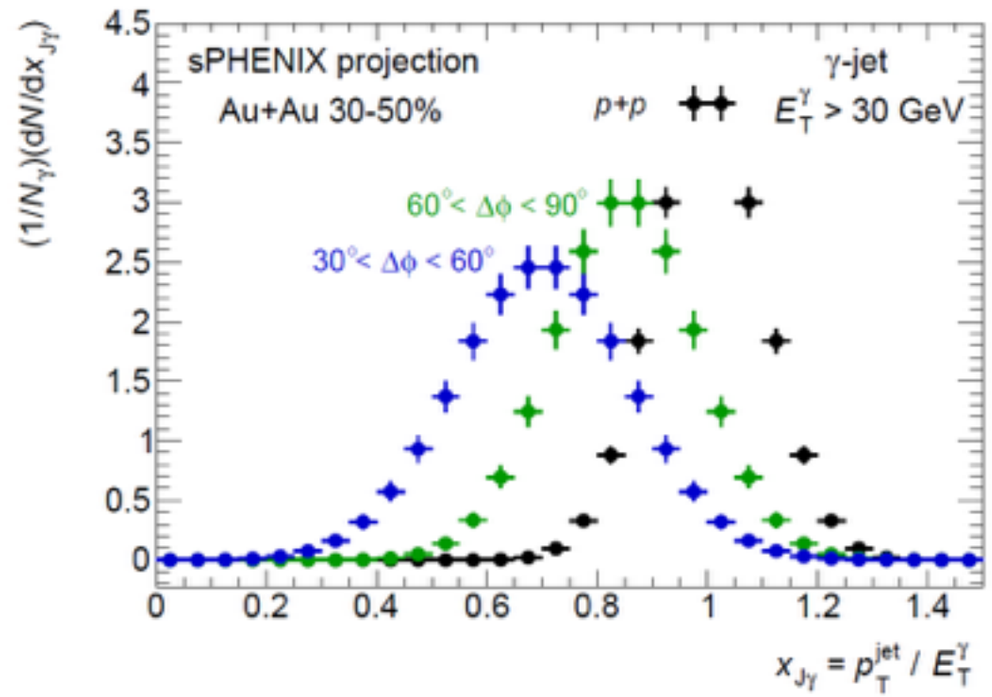

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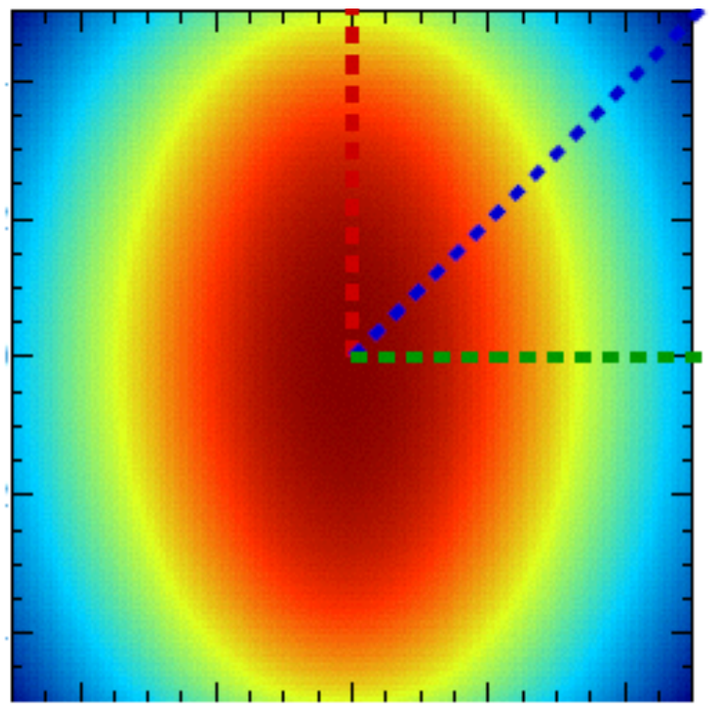

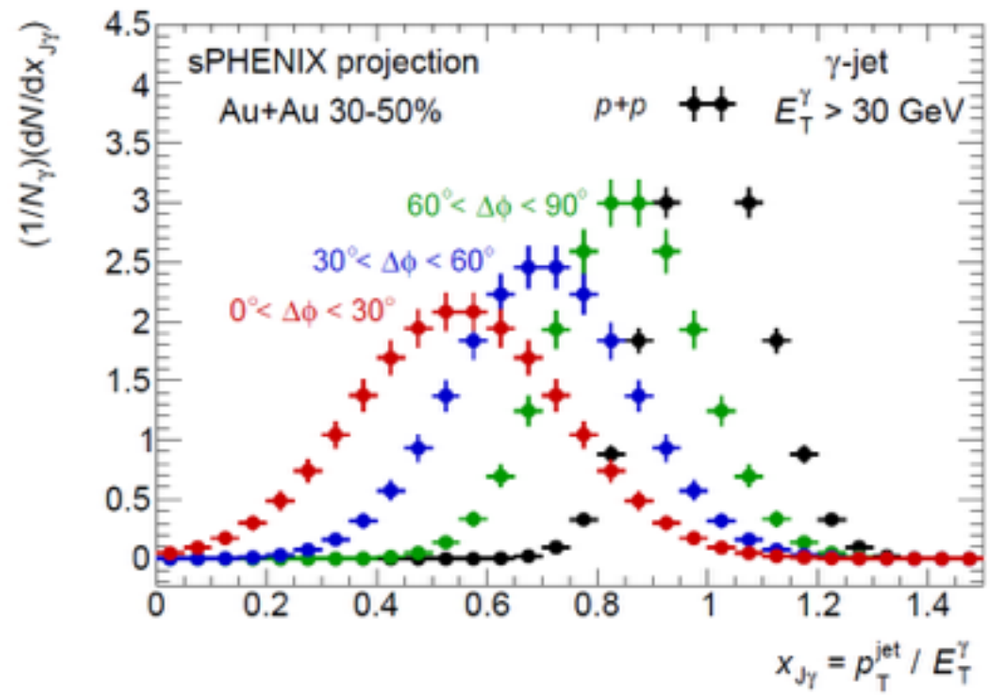

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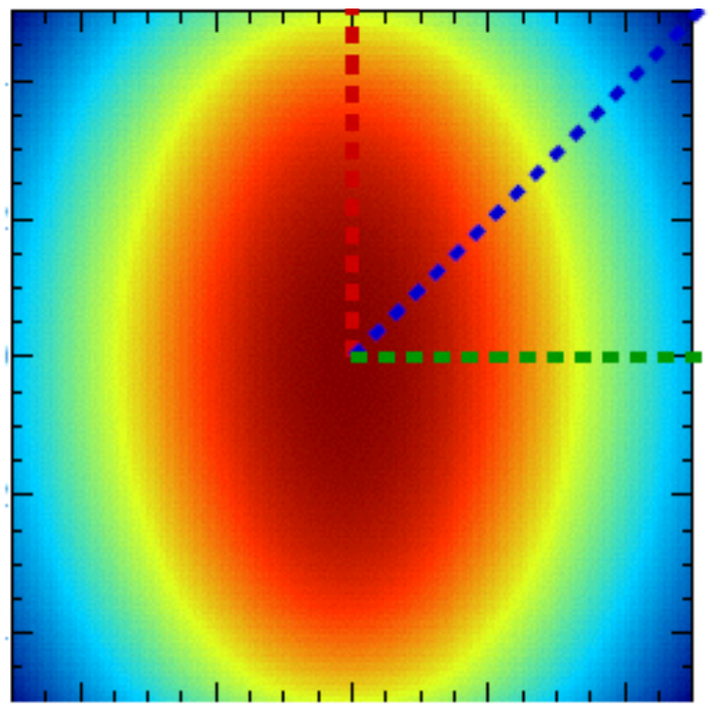
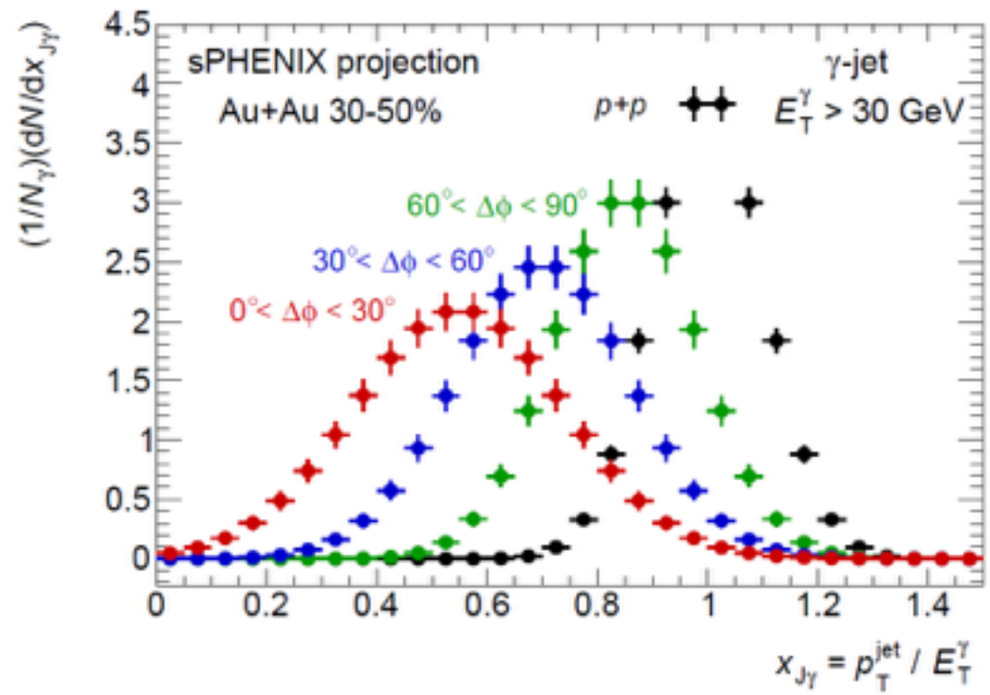
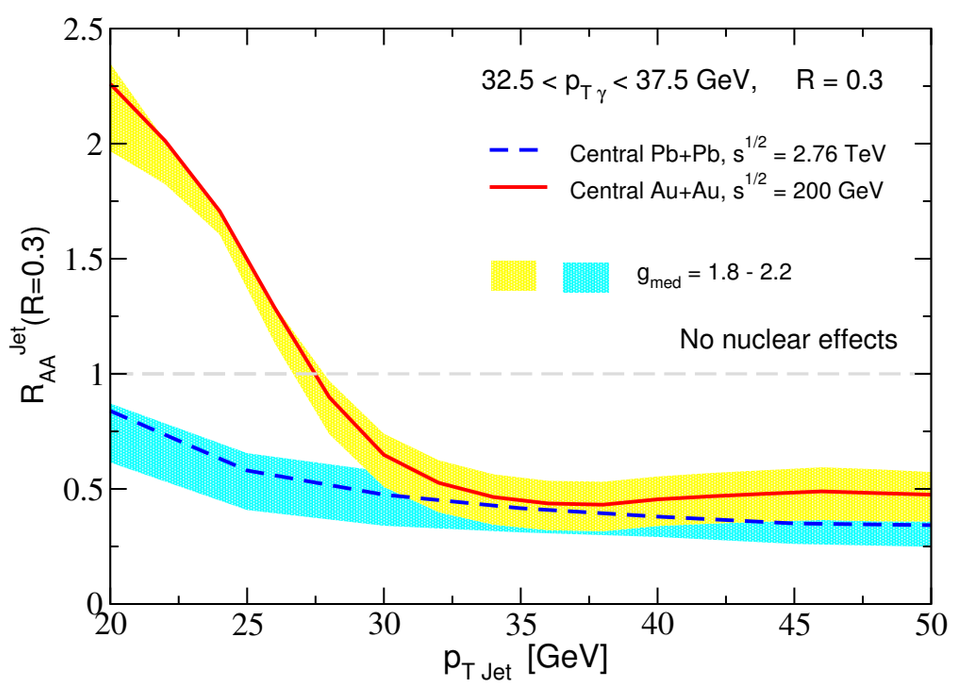
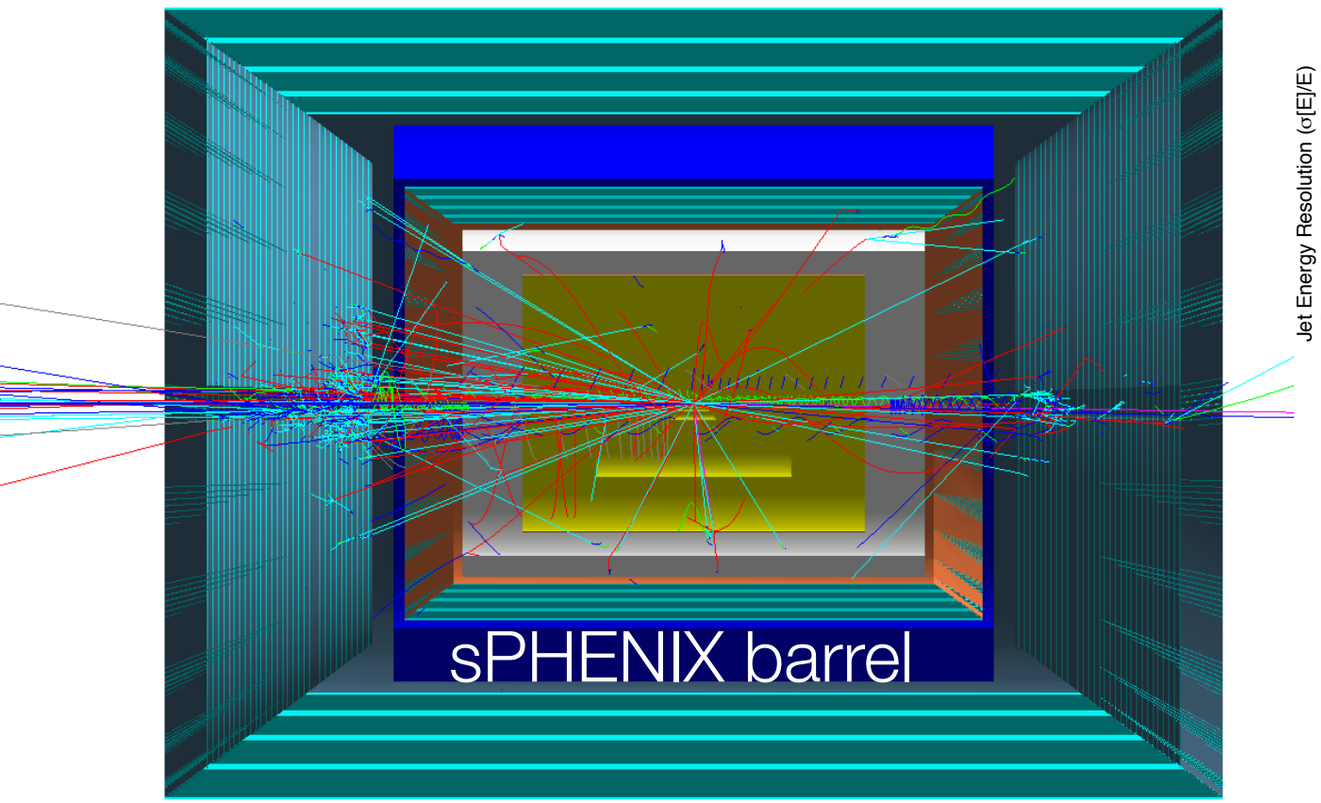




Wei Dai, Ivan Vitev, Ben-Wei Zhang
Phys. Rev. Lett., 110:142001, 2013



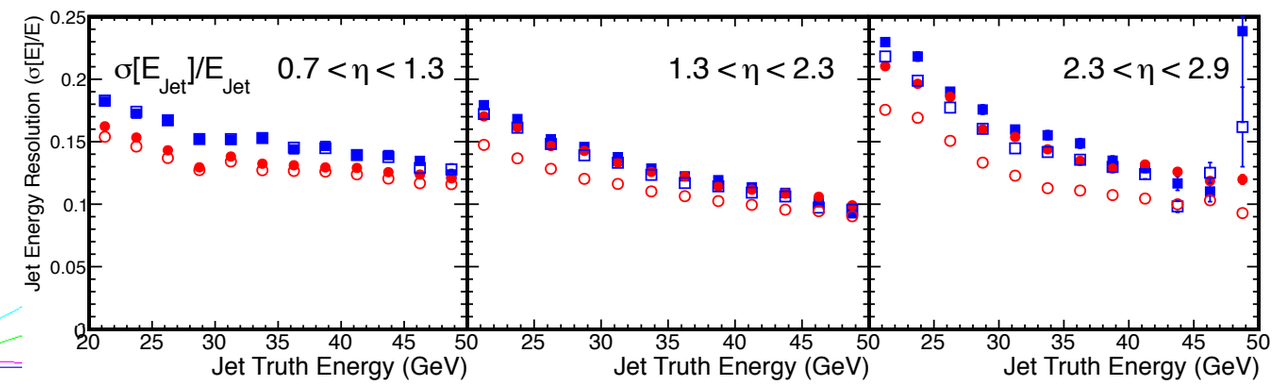
Spin physics capabilities of sPHENIX



conceivably instrument HCal encaps as "active" flux return – enabling jet and dijet measurements potentially up to η = 4

great enthusiasm in Collaboration for the physics potential, strong RIKEN interest in forward HCal

Jet energy resolution with an HCal endcap

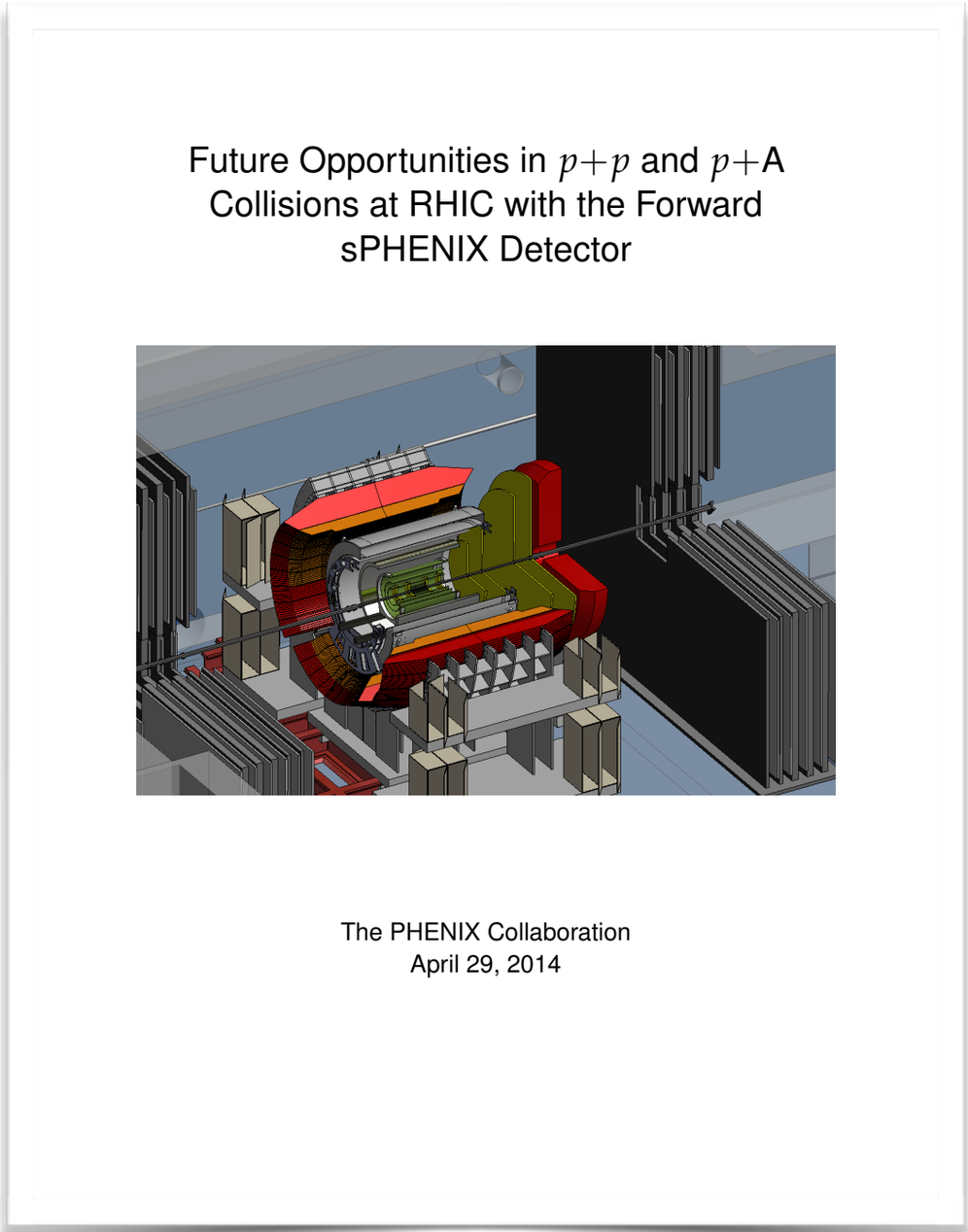


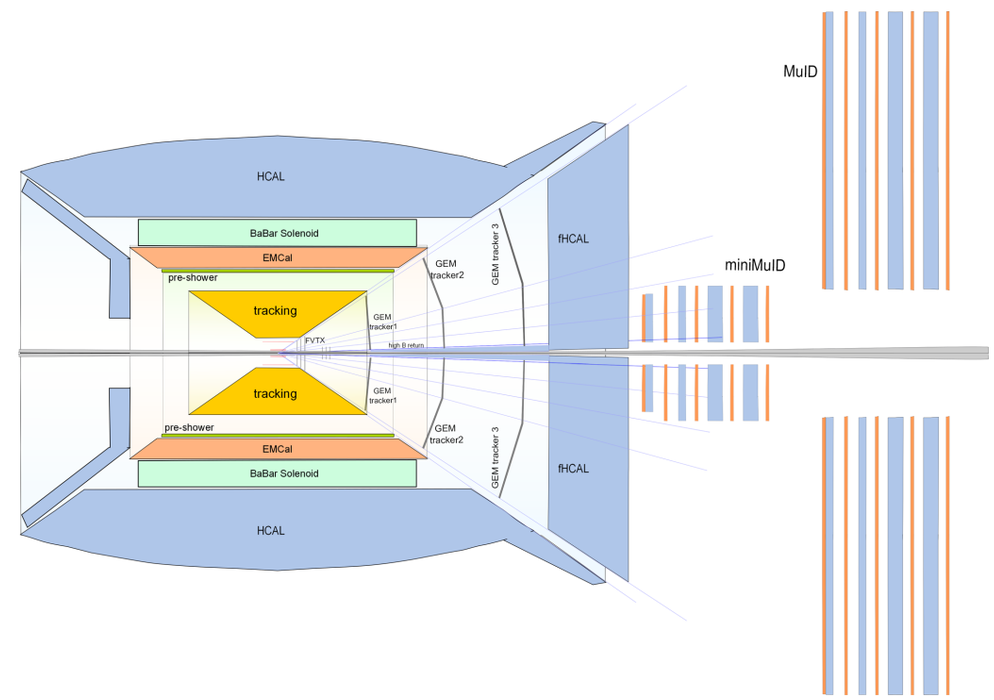
A^{jet}_N in $p^{\uparrow}+p^{\uparrow}$ and $p^{\uparrow}$+Au with full hadronic calorimetry – analysis of Run-15 MPC-EX results will inform this

di-jets and hadron-jet and gamma-jet correlations in p+Au (CGC inspired disappearance of away-side jet)

fsPHENIX – *forward* sPHENIX adds more capability

White paper charged by ALD Berndt Mueller and shown to PAC last year
https://indico.bnl.gov/materialDisplay.py?materialId=5&confId=764

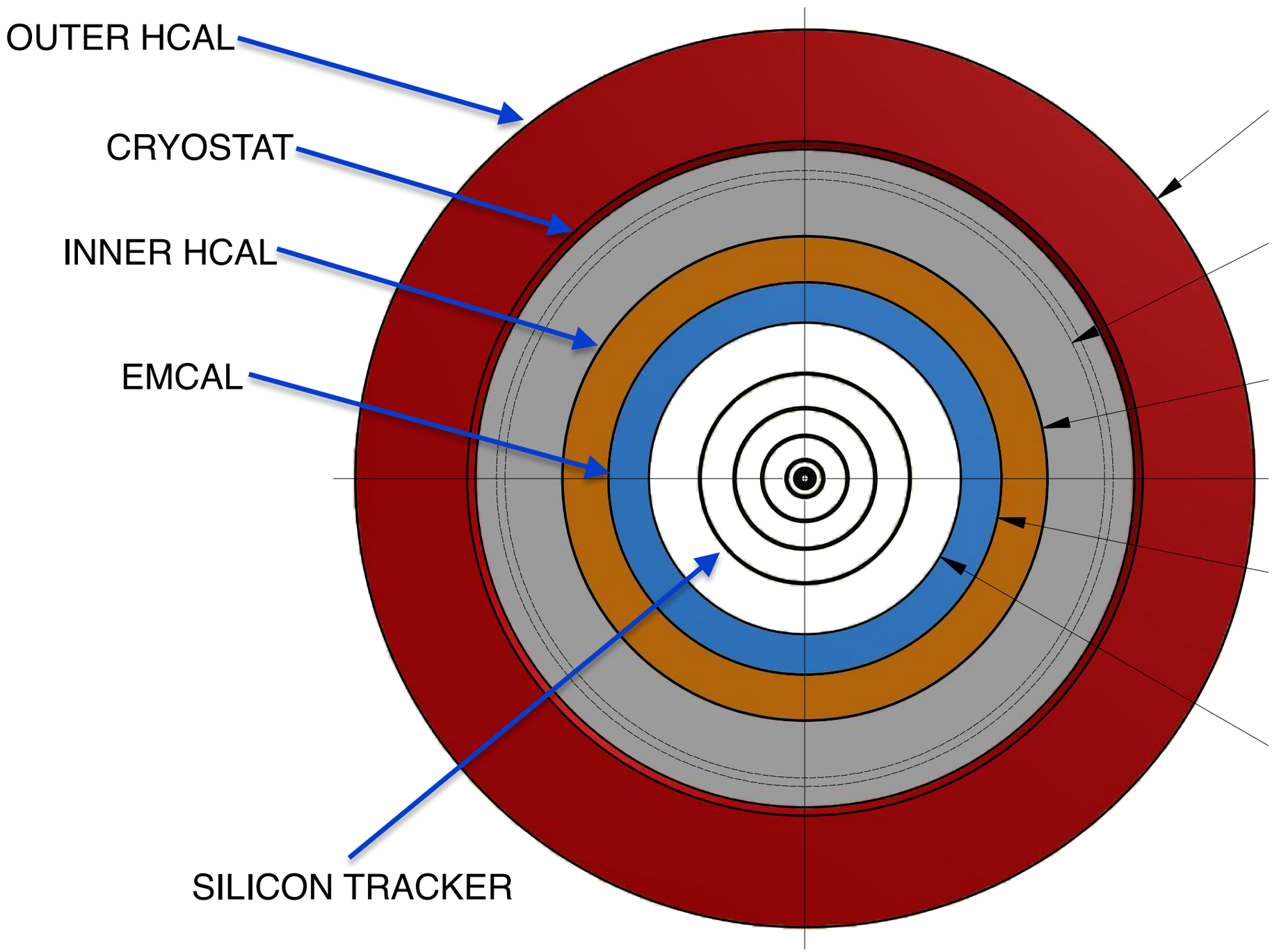




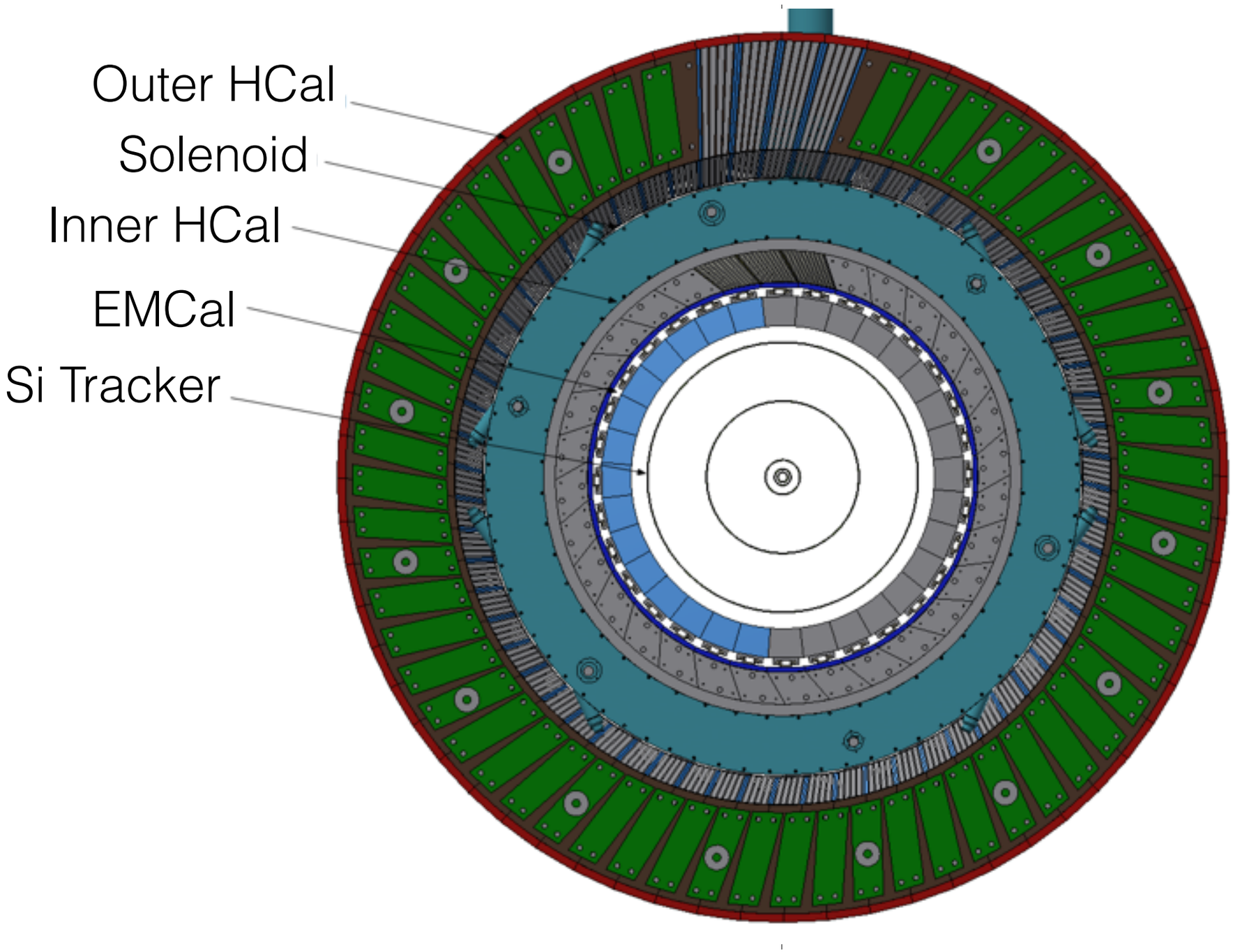
More ambitious detector concept, also more capabilities –
- shaped field for high η bending power,
- reconfigured FVTX for precision near vertex,
- forward GEM tracking,
- reuse/augment MuID

Possible step toward a day-1 EIC detector

Progress parallel to the science case

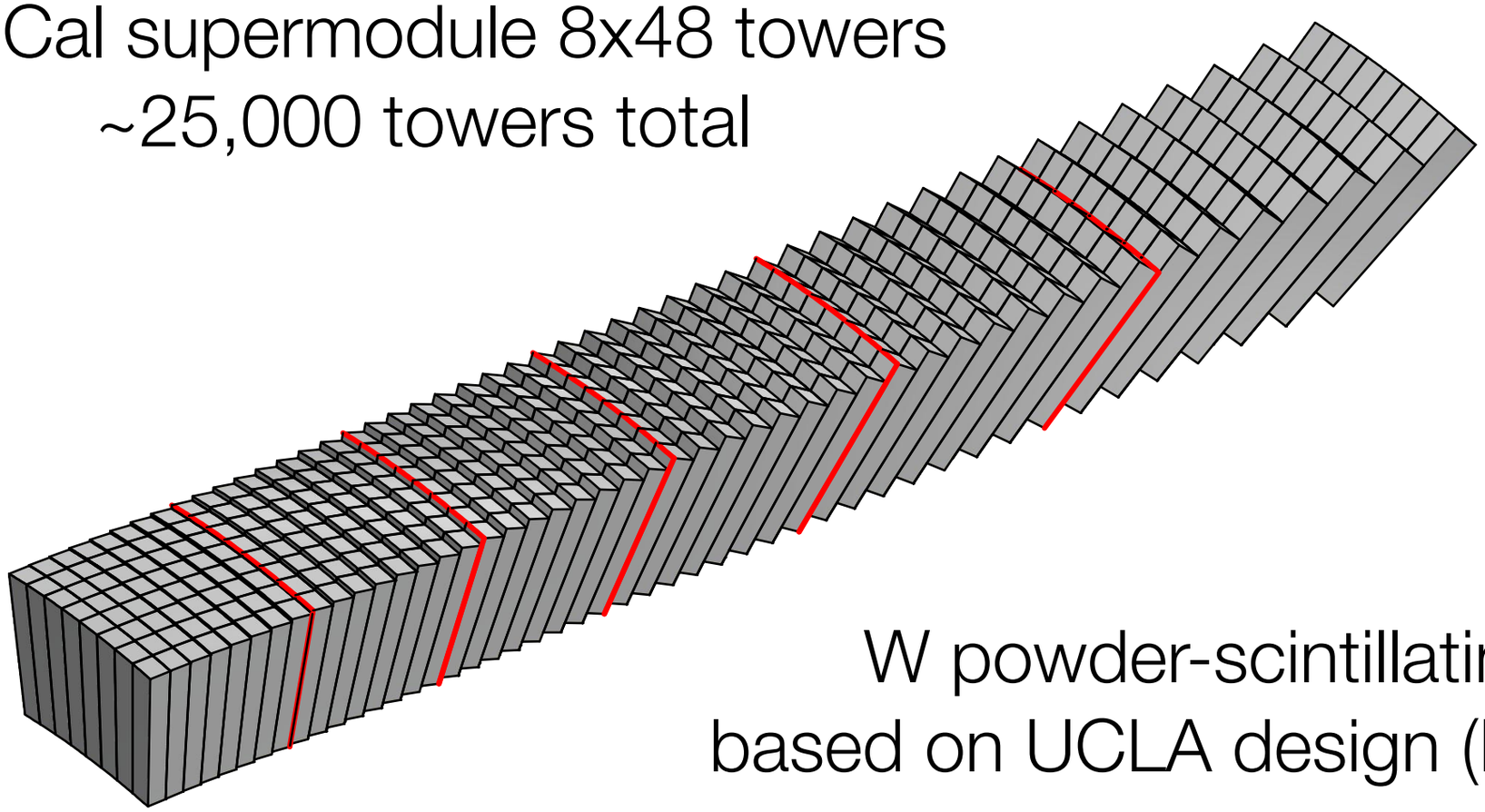


Progress parallel to the science case



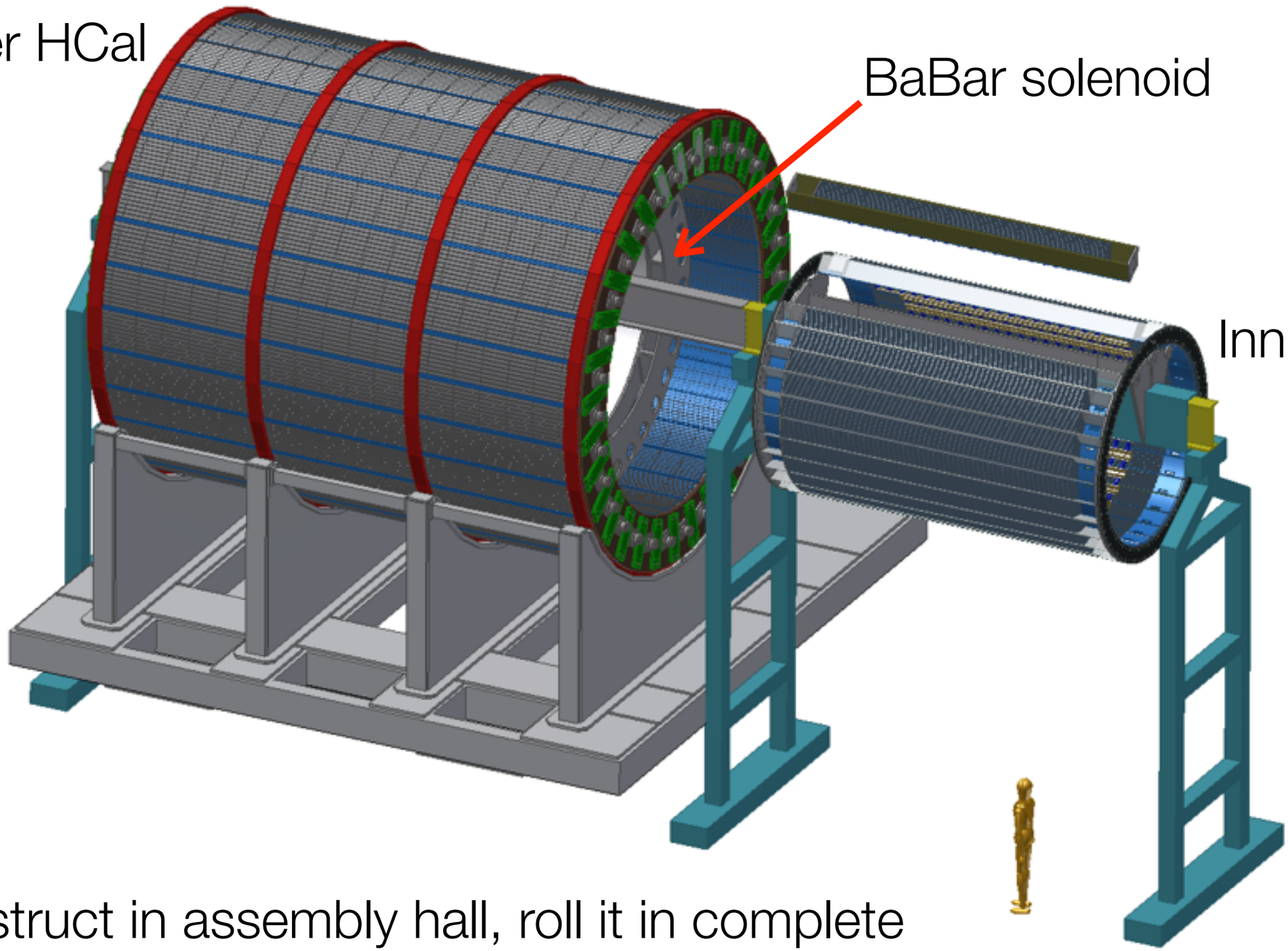
Engineering – keeping it *real*

EMCal supermodule 8x48 towers
~25,000 towers total



W powder-scintillating fiber
based on UCLA design (Huang, Tsai)

Engineering the installation

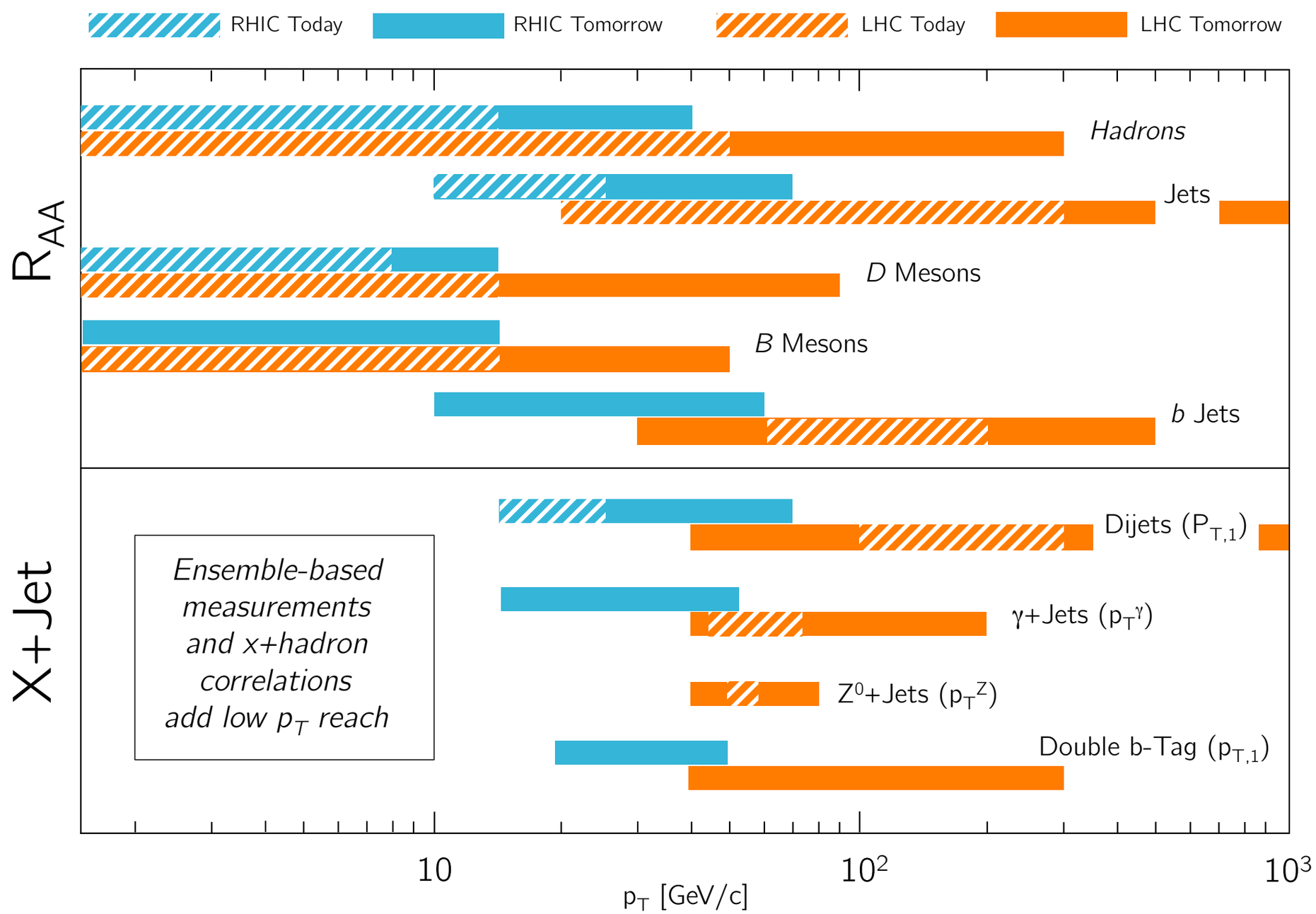


Construct in assembly hall, roll it in complete

California (SLAC)

New York (BNL)

sPHENIX and LHC complement each other



Adapted from slides by G. Roland at the QCD Town Meeting at Temple University.

DOE review of sPHENIX science case

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April 30, 2015 at BNL

Wide range of panel expertise

- RHI experiment and theory
- QCD theory
- HEP calorimetry
- HEP jets

Very successful, very positive review – no recommendations

http://www.bnl.gov/lajudr2015/

A Large-Acceptance Jet and Upsilon Detector for RHIC

General Workshop Registration (Deadline: June 12, 2015 12:00 AM)
Please note, this workshop is open to the public.

Begin Workshop Registration

Workshop Announcement

In April 2015, the Office of Nuclear Physics in the Department of Energy conducted a review of the science program enabled by a new detector, sPHENIX, that focuses on large acceptance, ultra-high rate measurements of fully reconstructed jets and high resolution spectroscopy of Upsilon states at RHIC. The outcome of that review was very positive and, while there are important elements of the DOE review process that remain to be completed, the Laboratory believes it is timely to organize a one-day workshop that will serve as an initial step toward the formation of a new scientific collaboration, which will further refine the science priorities; develop the formal proposal to build and operate the detector; and, if successful, exploit its unique physics capabilities.

Workshop Date
June 16, 2015

Workshop Location
Brookhaven National Laboratory
Upton, NY 11973 USA

Physics Department (Bldg 510)
Large Seminar Room

Directions and Maps
To Event | To BNL

Workshop Coordinator
Fran Capasso
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Email: capasso@bnl.gov

Add to Calendar