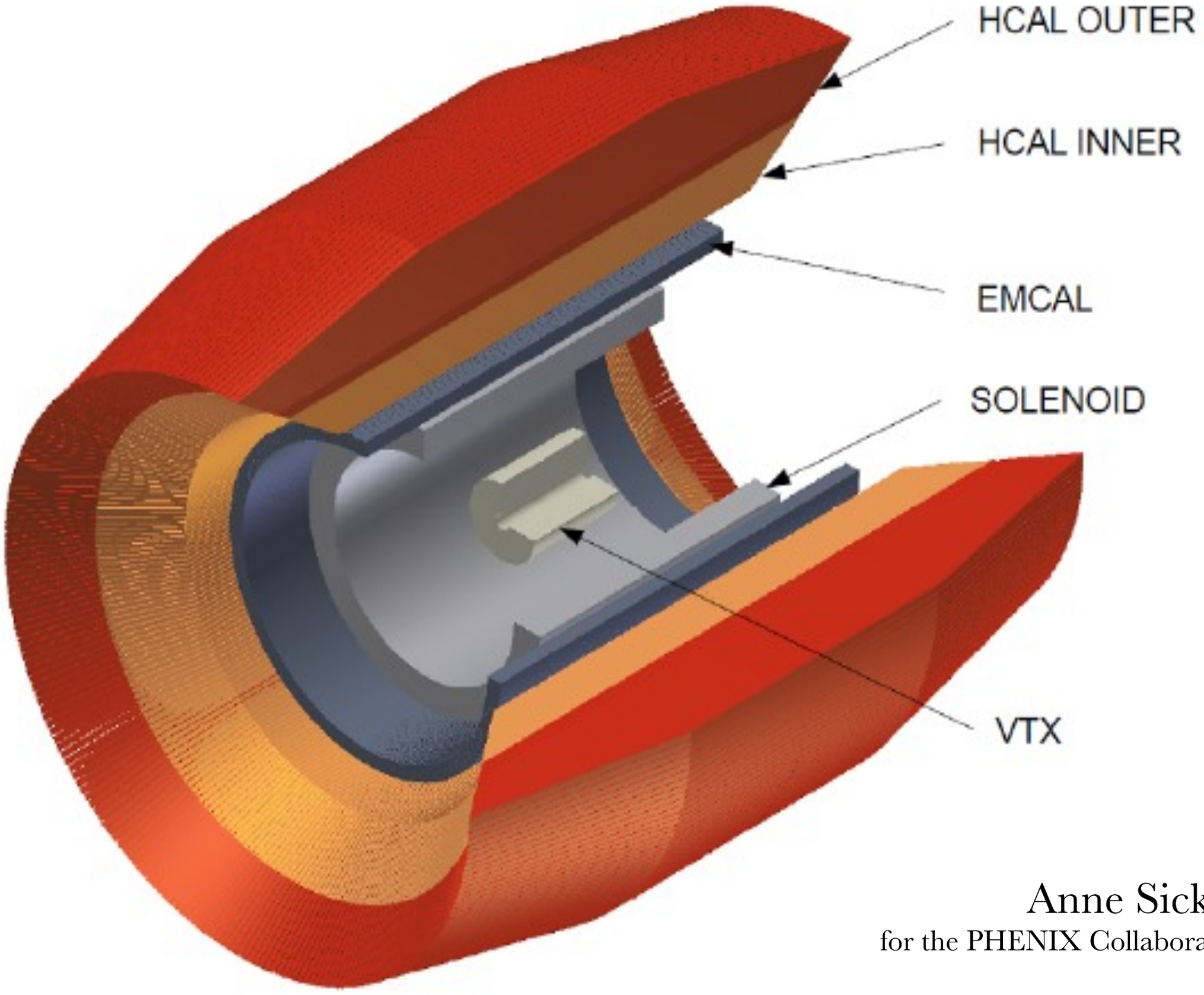
(super)Physics of sPHENIX



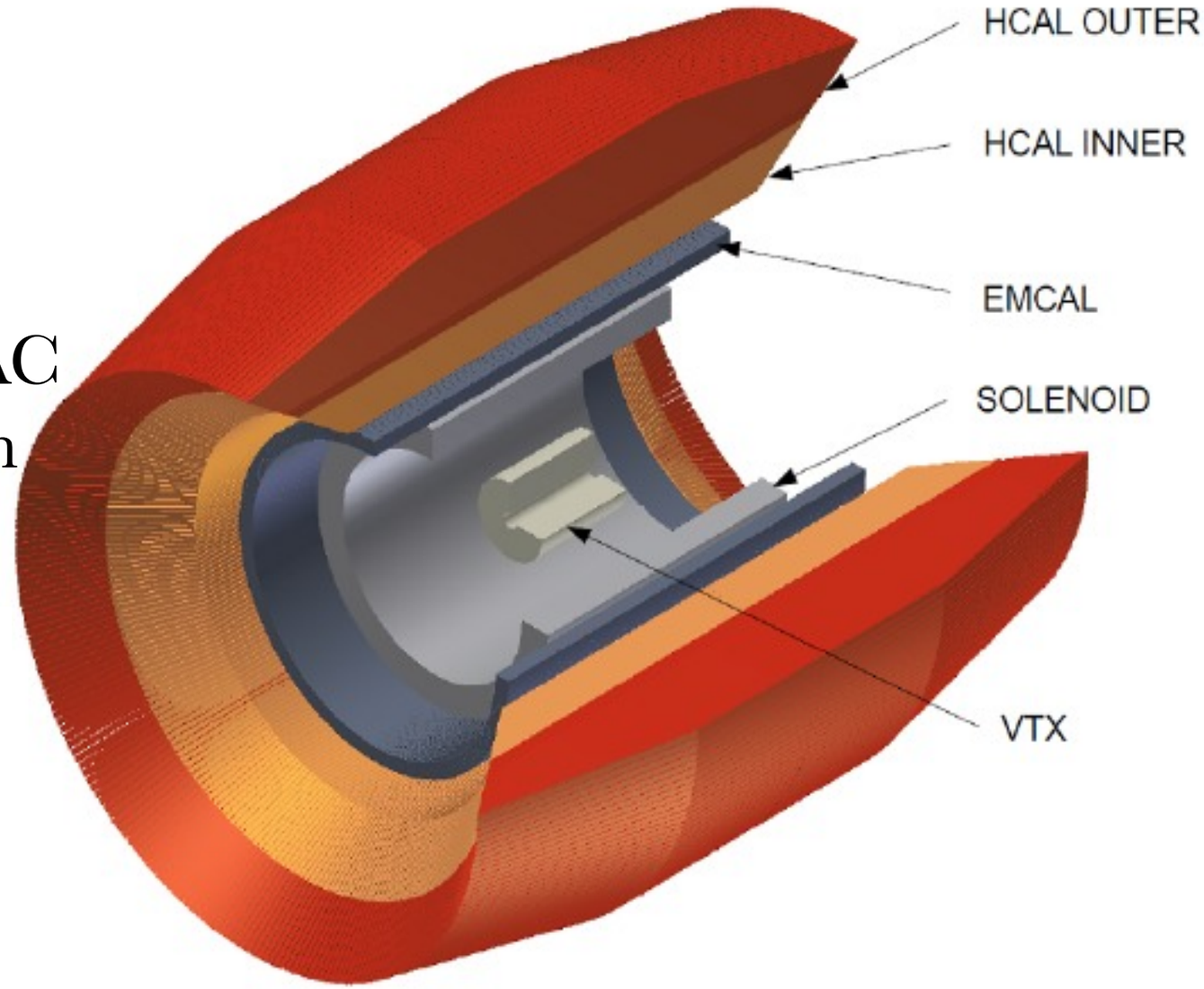
Anne Sickles
for the PHENIX Collaboration

decadal planning 2010

- what physics is exciting out to 2020 at RHIC?
- what is beyond near term upgrades to PHENIX & STAR?

- jet measurements in heavy ions
- high rate, hadronic calorimetry, uniform acceptance over $|\eta|<1$

- encouragement from DOE & PAC to move forward agressively, both with physics case & design



lots of work!

September 2011 – Brookhaven workfest

December 2011 – Boulder workfest

January 2012 – Tennessee workfest

February 2012 – Columbia workfest

March 2012 – Florida State collab. meeting

April 2012 – Boulder workfest

May 2012 – Brookhaven/Boulder writing

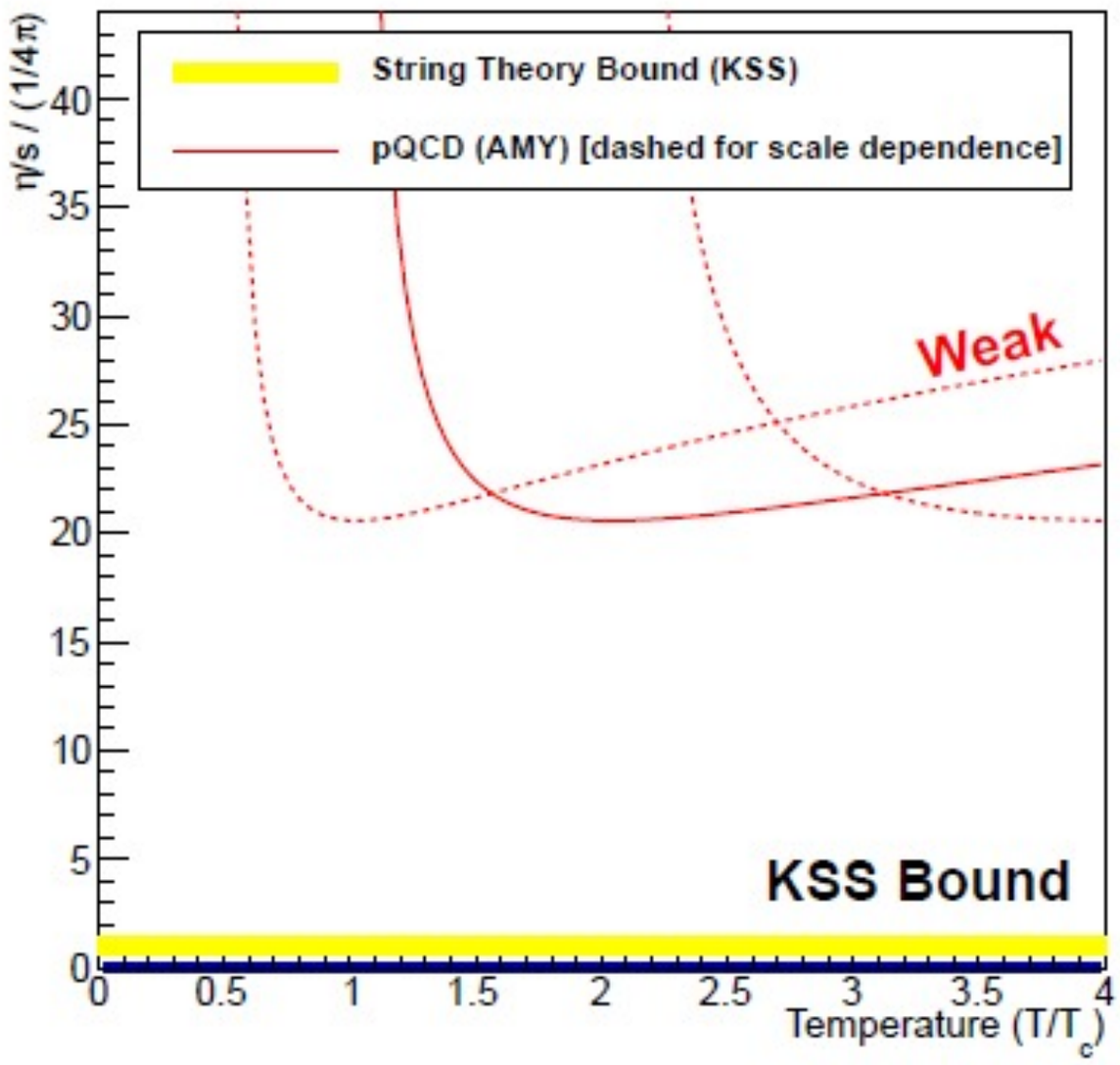
30+ people working with sPHENIX
focus for 5 days at each workfest

Theoretical Engagement

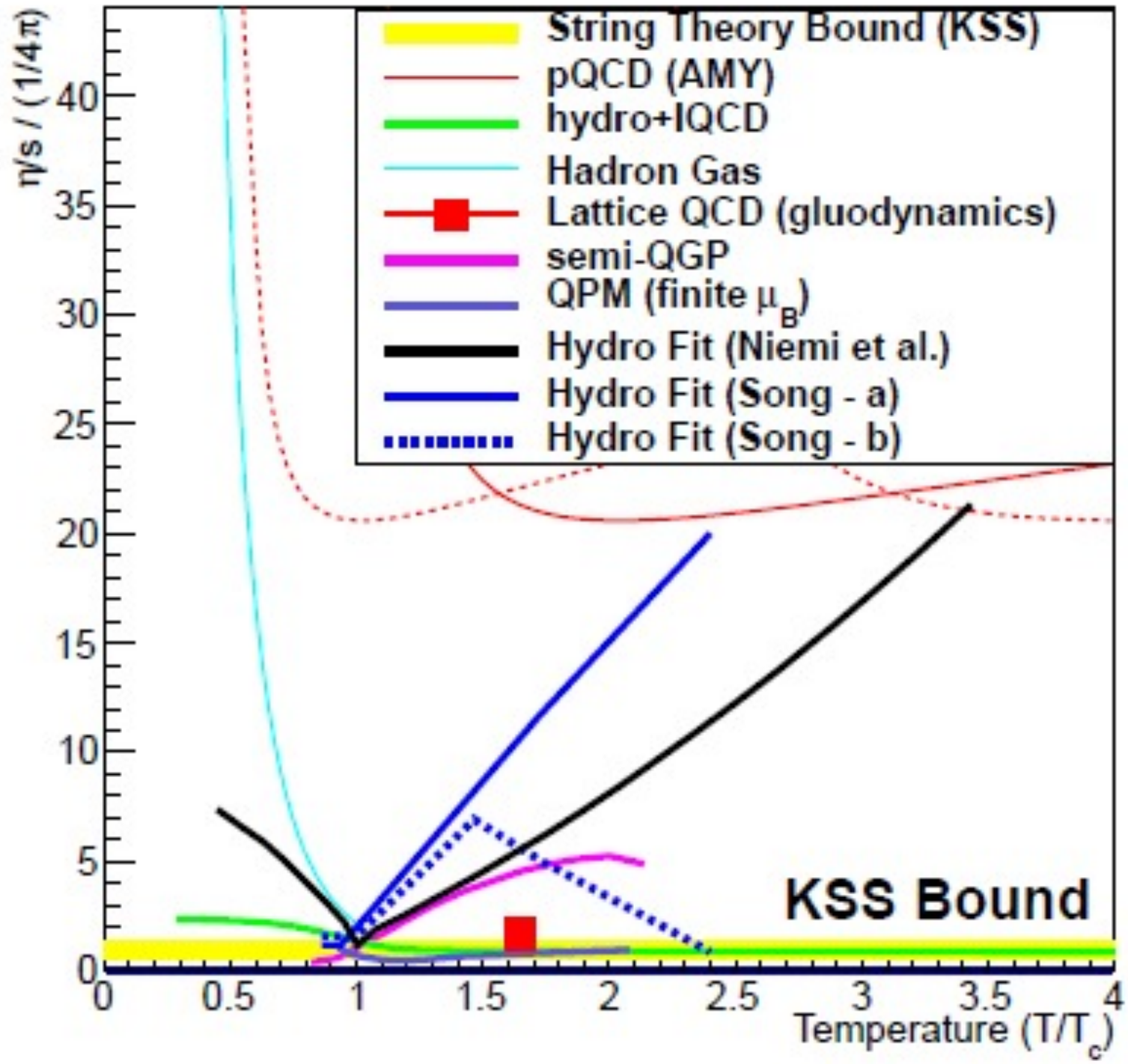
March 3-4, 2012
Duke University
participation from theorists, RHIC & LHC experimentalists
with follow-up discussions and real work

Understanding the sQGP

- goal: a fundamental understanding of how the perfect fluid emerges at strong coupling near Tc from asymptotically free QCD

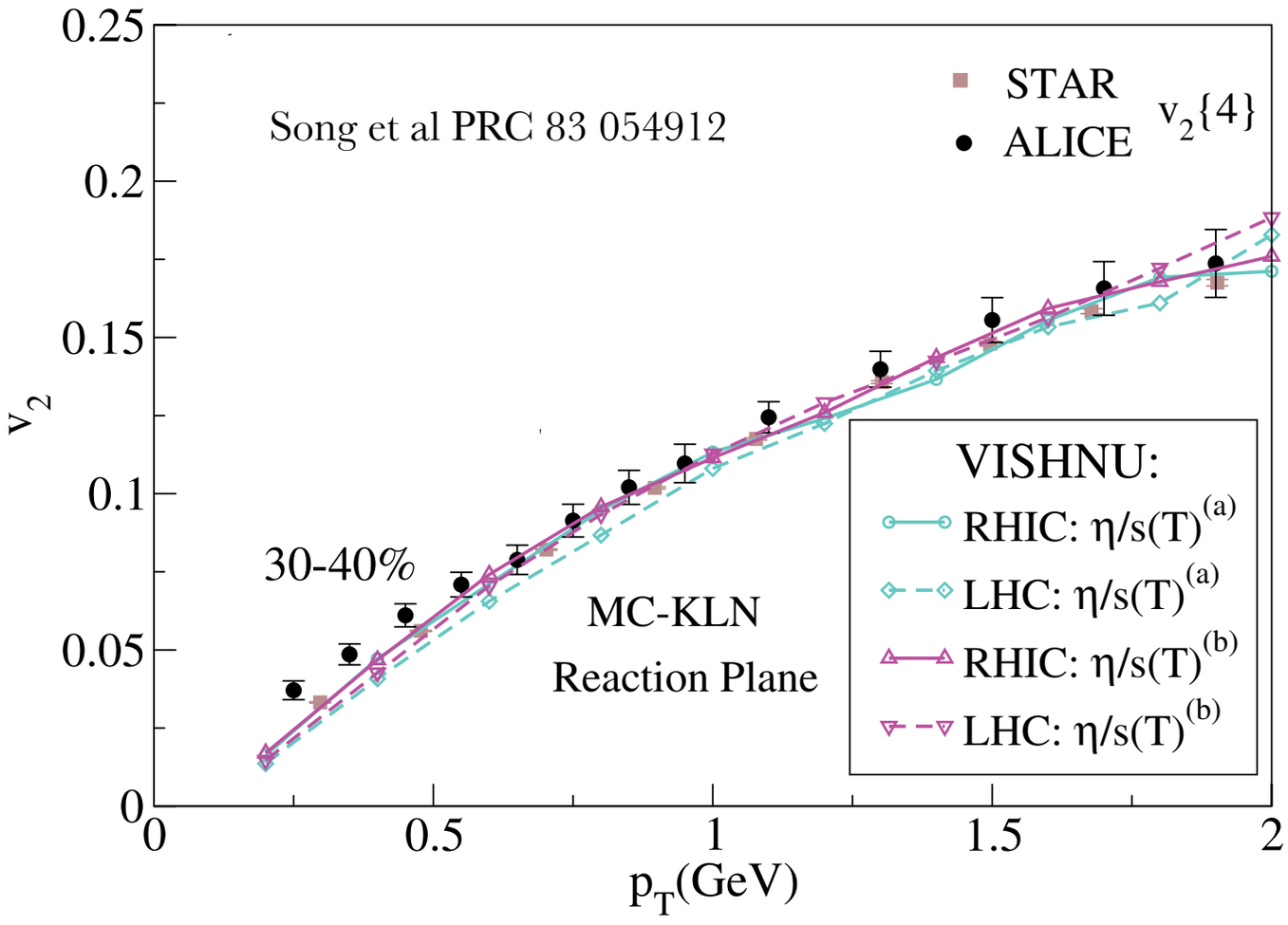


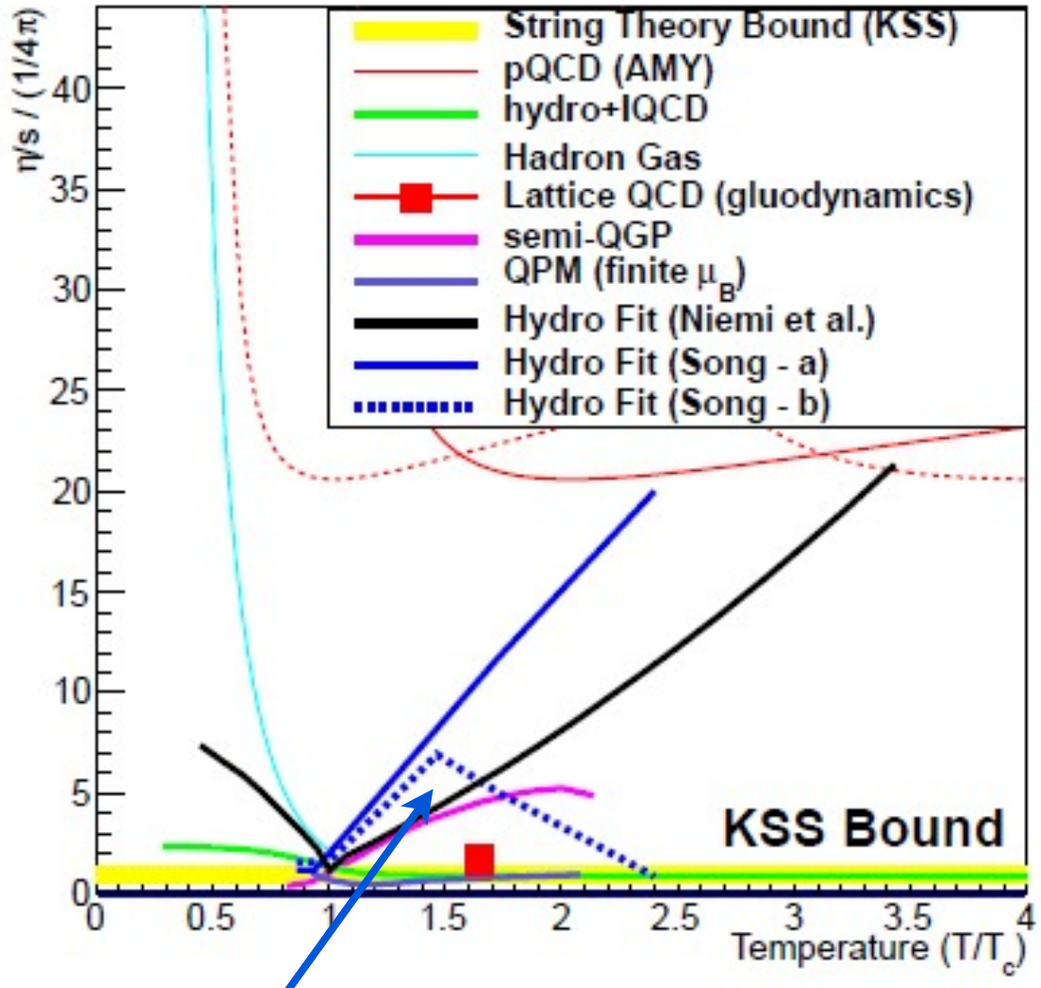
theoretical understanding



Song, et al PRC83 054912

sensitivity of flow observables?





- two very different $\eta/s(T)$ give the same v_2, within the same framework

Song, et al PRC83 054912

connecting η/s & jet quenching

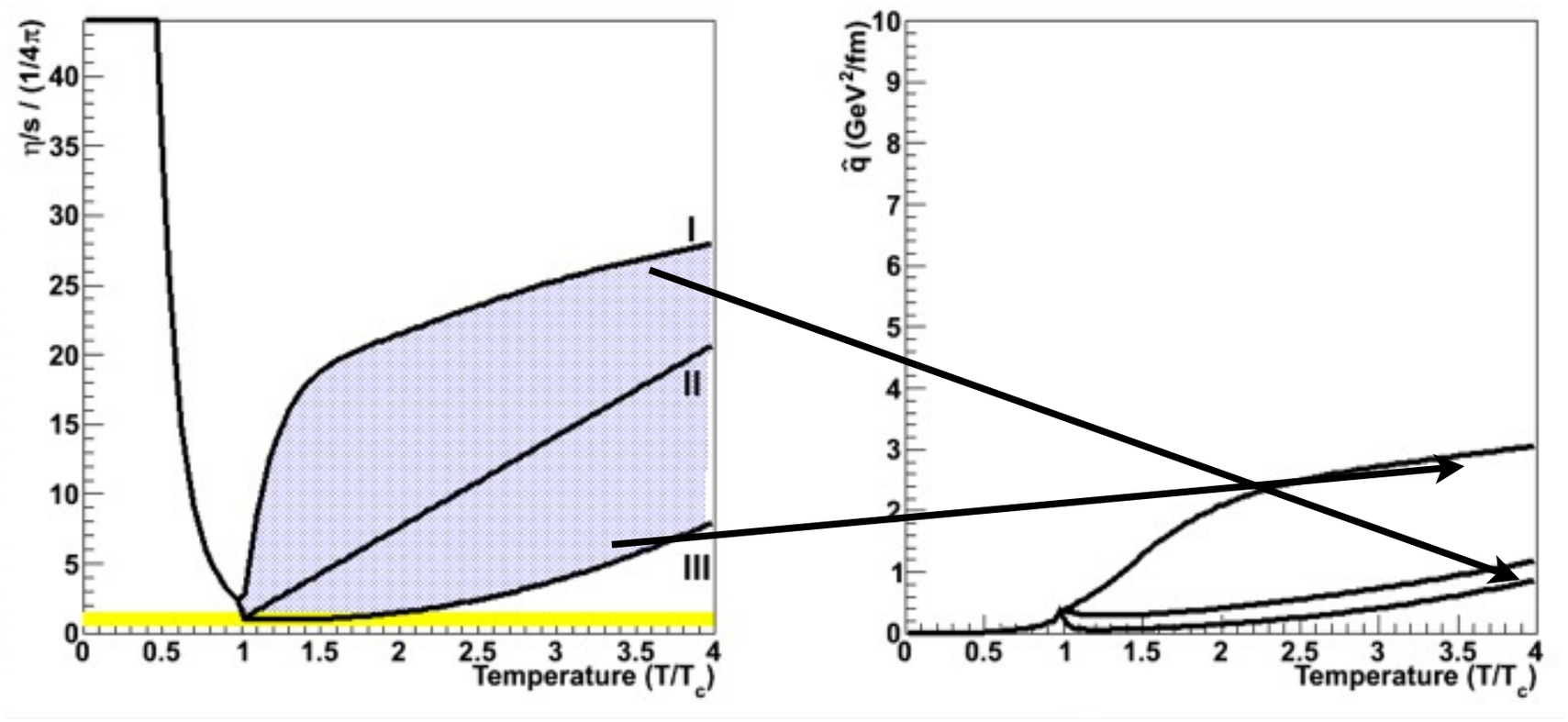
PRL **99,** 192301 (2007) PHYSICAL REVIEW LETTERS week ending 9 NOVEMBER 2007

Small Shear Viscosity of a Quark-Gluon Plasma Implies Strong Jet Quenching

Abhijit Majumder,[1] Berndt Müller,[1] and Xin-Nian Wang[2]

at weak coupling: $\frac{\eta}{s} = 1.25\frac{T^3}{\hat{q}}$

SYM: $\frac{T^3}{\hat{q}} \ll \frac{\eta}{s}$



- key: independently measure BOTH qhat(T) & η/s(T)

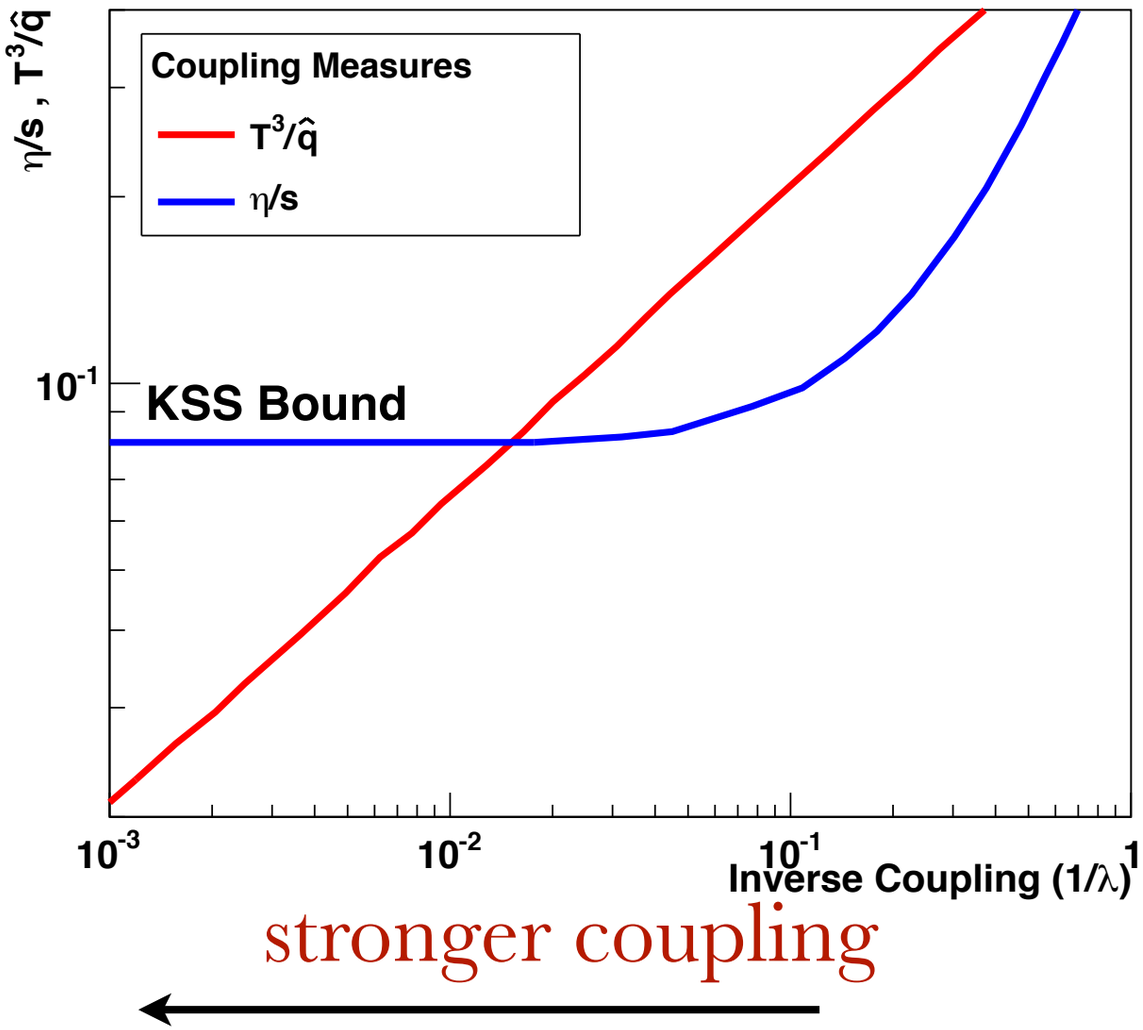
at strong coupling

PRL **99,** 192301 (2007) PHYSICAL REVIEW LETTERS week ending 9 NOVEMBER 2007

Small Shear Viscosity of a Quark-Gluon Plasma Implies Strong Jet Quenching

Abhijit Majumder,[1] Berndt Müller,[1] and Xin-Nian Wang[2]

- at strong coupling qhat/T^3 is a better measure of the coupling (λ) than η/s



stronger coupling

jets @ RHIC temperatures very interesting!

very strong coupling

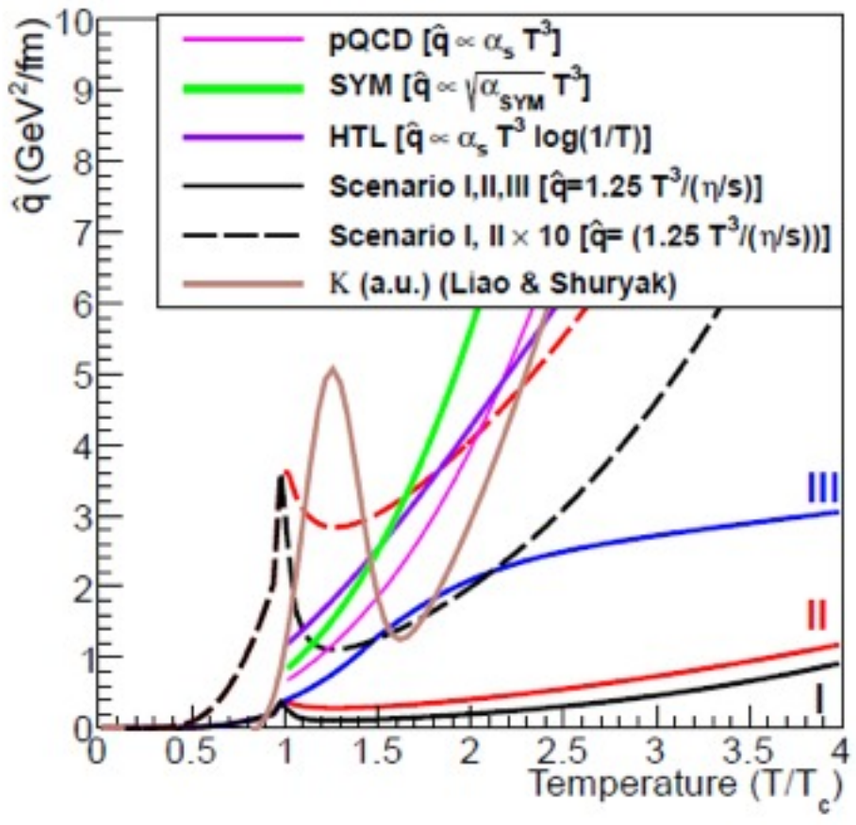
Angular Dependence of Jet Quenching Indicates Its Strong Enhancement near the QCD Phase Transition

Jinfeng Liao[1,2,*] and Edward Shuryak[1,†]

[1]*Department of Physics and Astronomy, State University of New York, Stony Brook, New York 11794, USA*
[2]*Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA*
(Received 22 October 2008; revised manuscript received 19 February 2009; published 22 May 2009)

We study dependence of jet quenching on matter density, using ''tomography'' of the fireball provided by RHIC data on azimuthal anisotropy v_2 of high p_t hadron yield at different centralities. Slicing the fireball into shells with constant (entropy) density, we derive a ''layer-wise geometrical limit'' $v_2^{\max}$ which is indeed above the data $v_2 < v_2^{\max}$. Interestingly, the limit is reached only if quenching is dominated by shells with the entropy density exactly in the near-T_c region. We show two models that simultaneously describe the high p_t v_2 and $R_{A\text{-}A}$ data and conclude that such a description can be achieved only if the jet quenching is few times stronger in the near-T_c region relative to QGP at $T > T_c$. One possible reason for such enhancement may be recent indications that the near-T_c region is a magnetic plasma of relatively light color-magnetic monopoles.

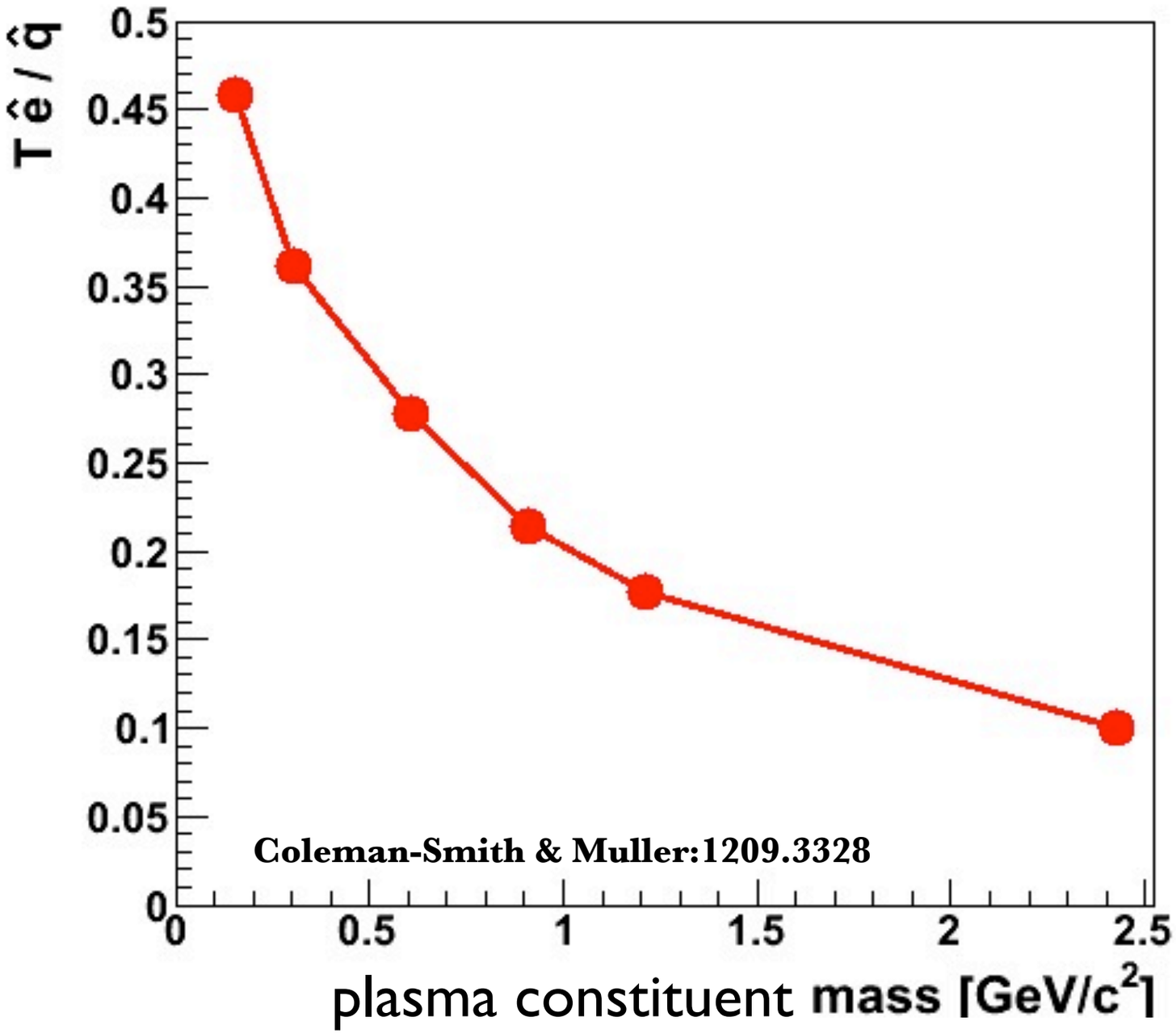
motivated by RHIC high p_t v_2 results!



what is the QGP made of?

warrants serious discussion. Similarly, it will be important to explore the sensitivity of jet transport coefficients to the medium structure; after all, we don't just want to learn something about the dynamics of jets in a dense QCD medium, but gain insight into the structure of the quark-gluon plasma itself.

B. Muller 1207.7302



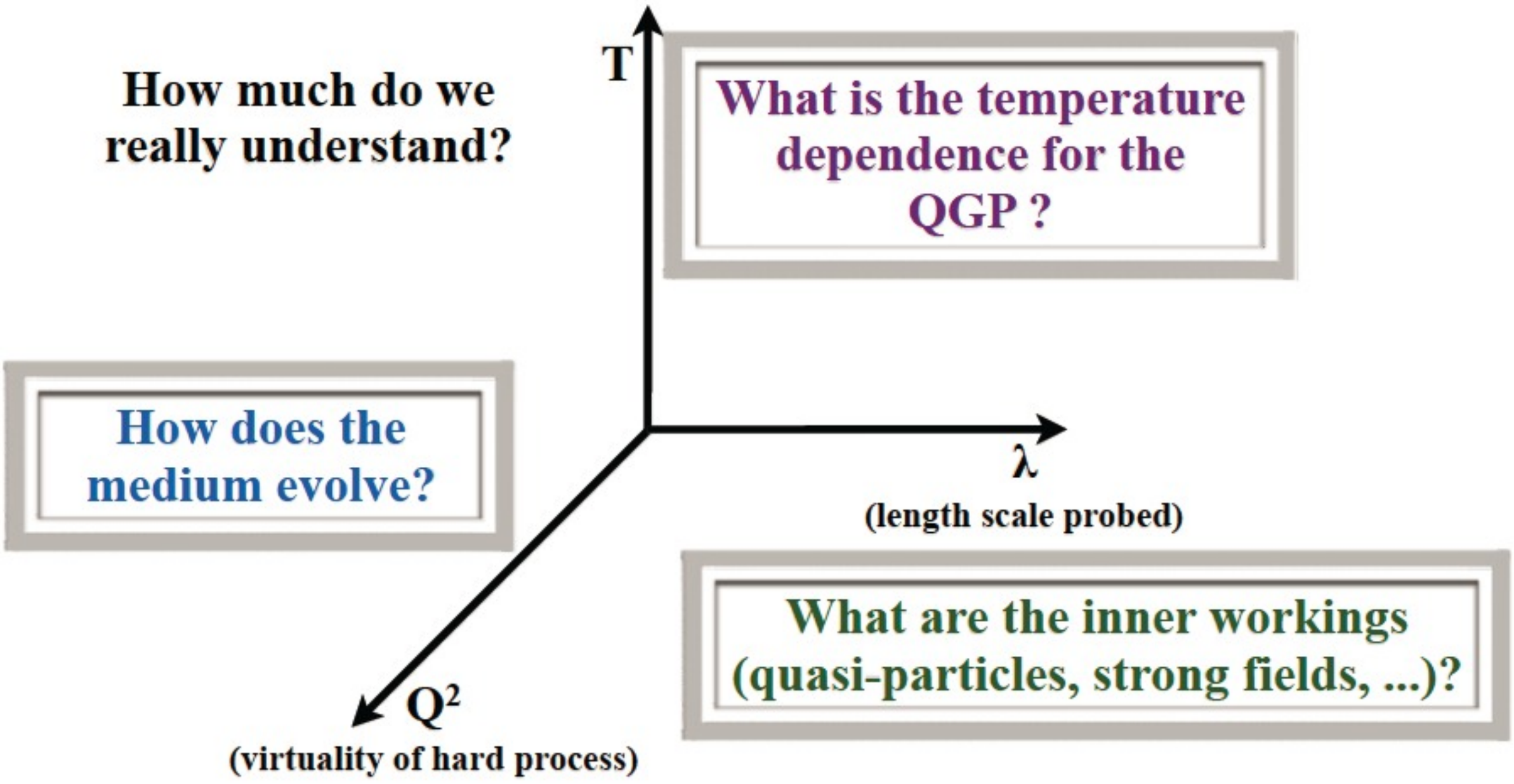
qhat: energy lost via radiation

ehat: energy lost to the matter

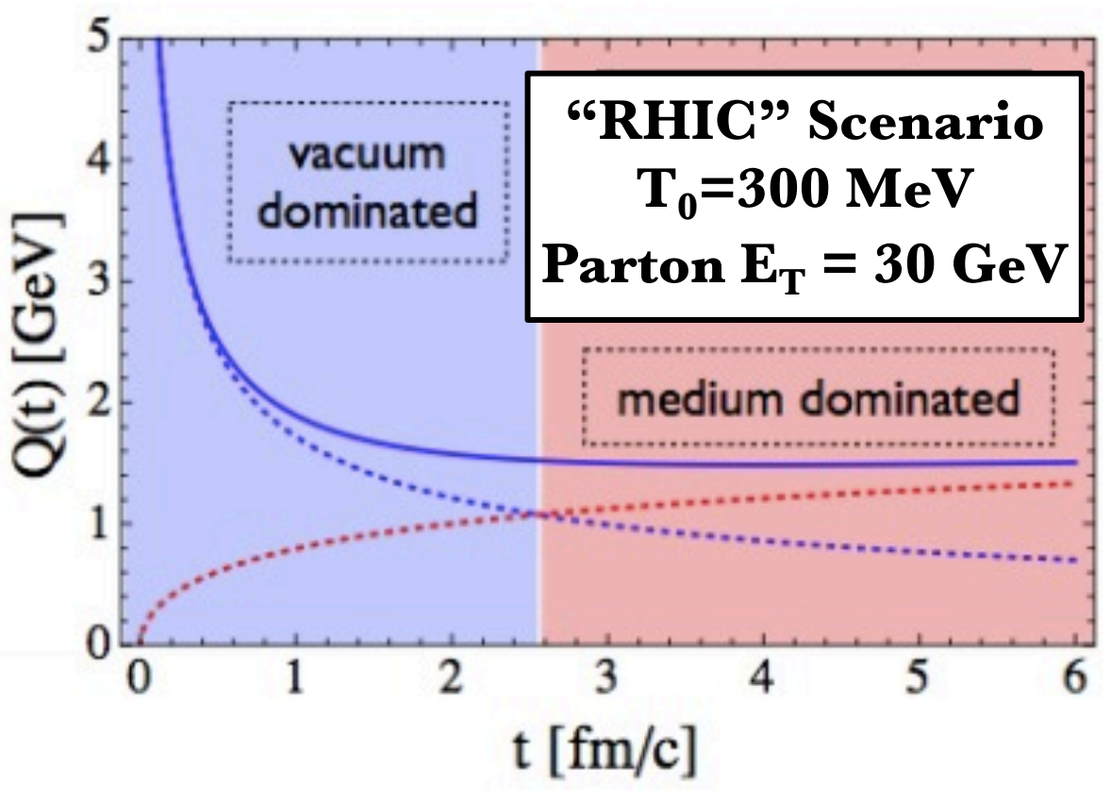
mass →∞,
all rad. energy loss

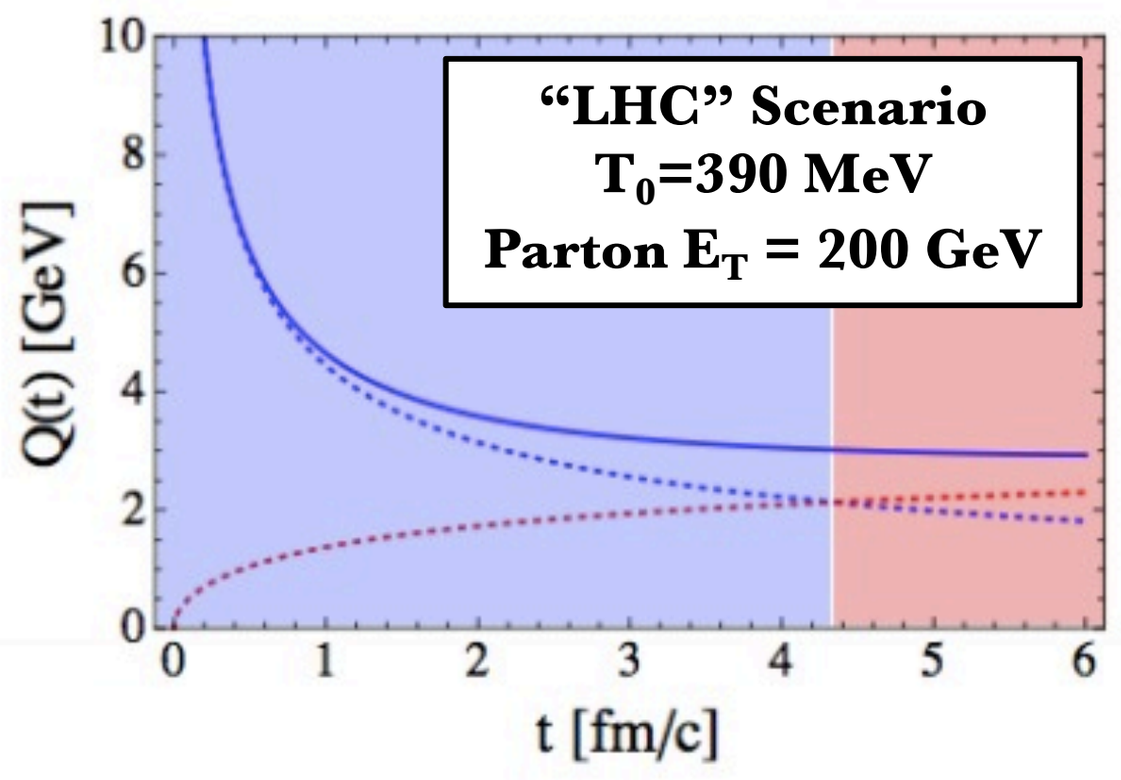
other directions

How much do we really understand?



virtuality matters

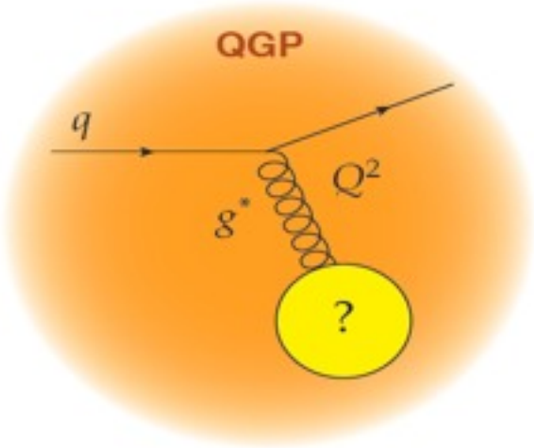




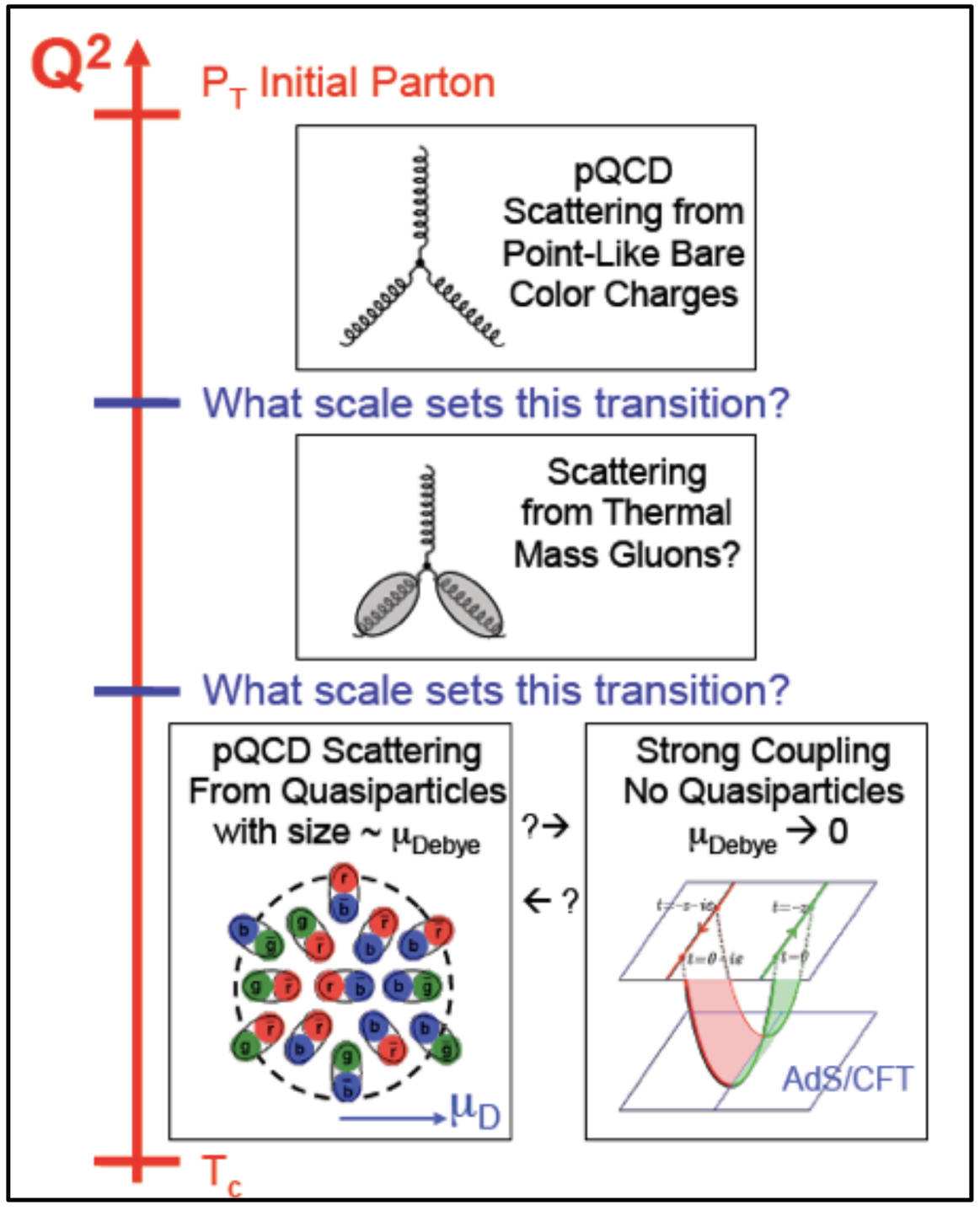
the vacuum contribution to the parton virtuality to fall below the in-medium contribution in the pQCD scenario. This effect is due to the collinear splitting in pQCD, which reduces the parton energy only gradually and thus leads to an increase in time dilation as the virtuality drops. This means that the very energetic parton hardly notices the medium for the first 3 – 4 fm of its path length. On the other hand, in the AdS/CFT scenario, parton energy and virtuality

B. Muller NPA 855 74

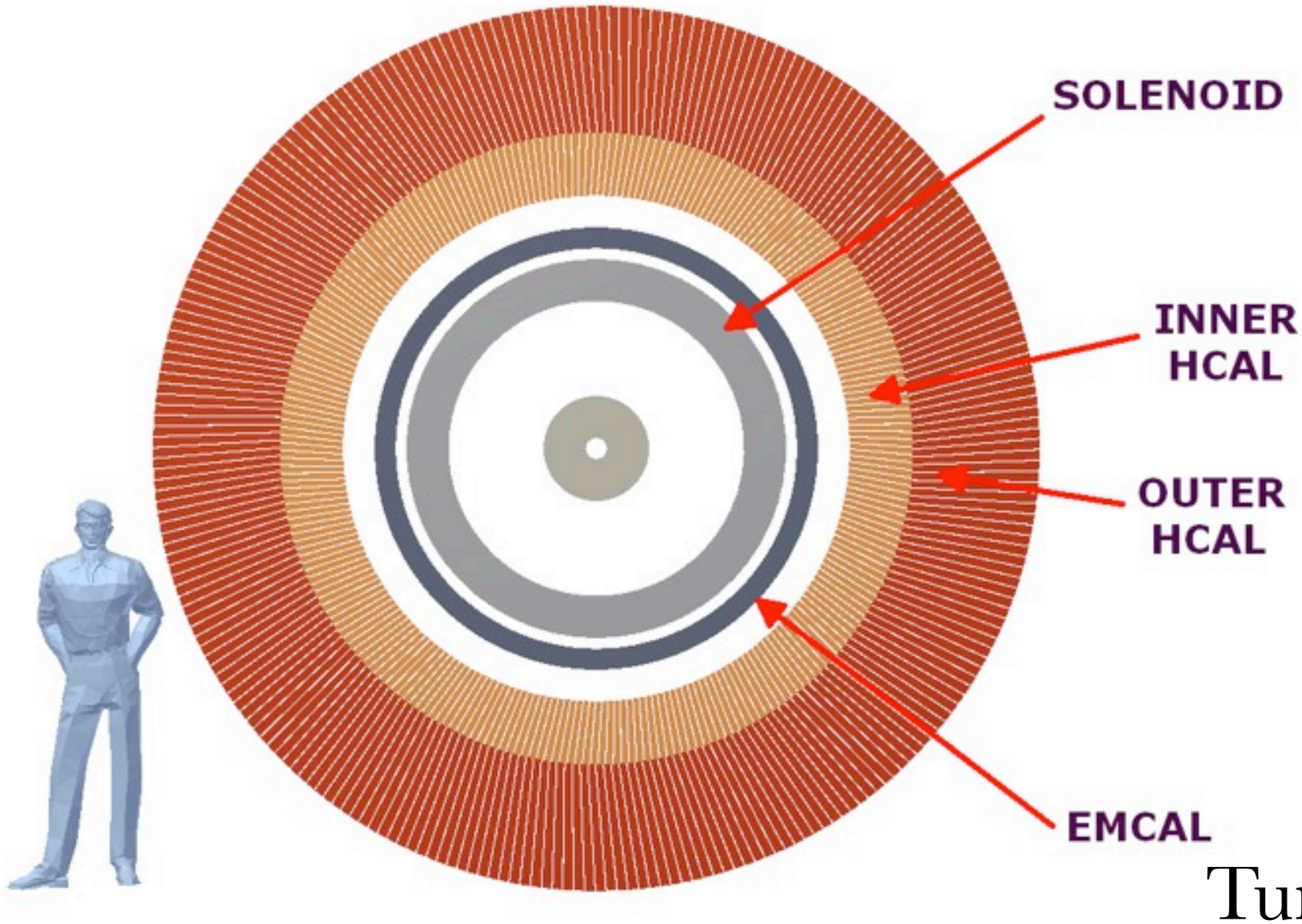
medium length scale



- total coherent energy loss?
- exchange gluon momentum?
- impact of deconfinement?



inside sPHENIX



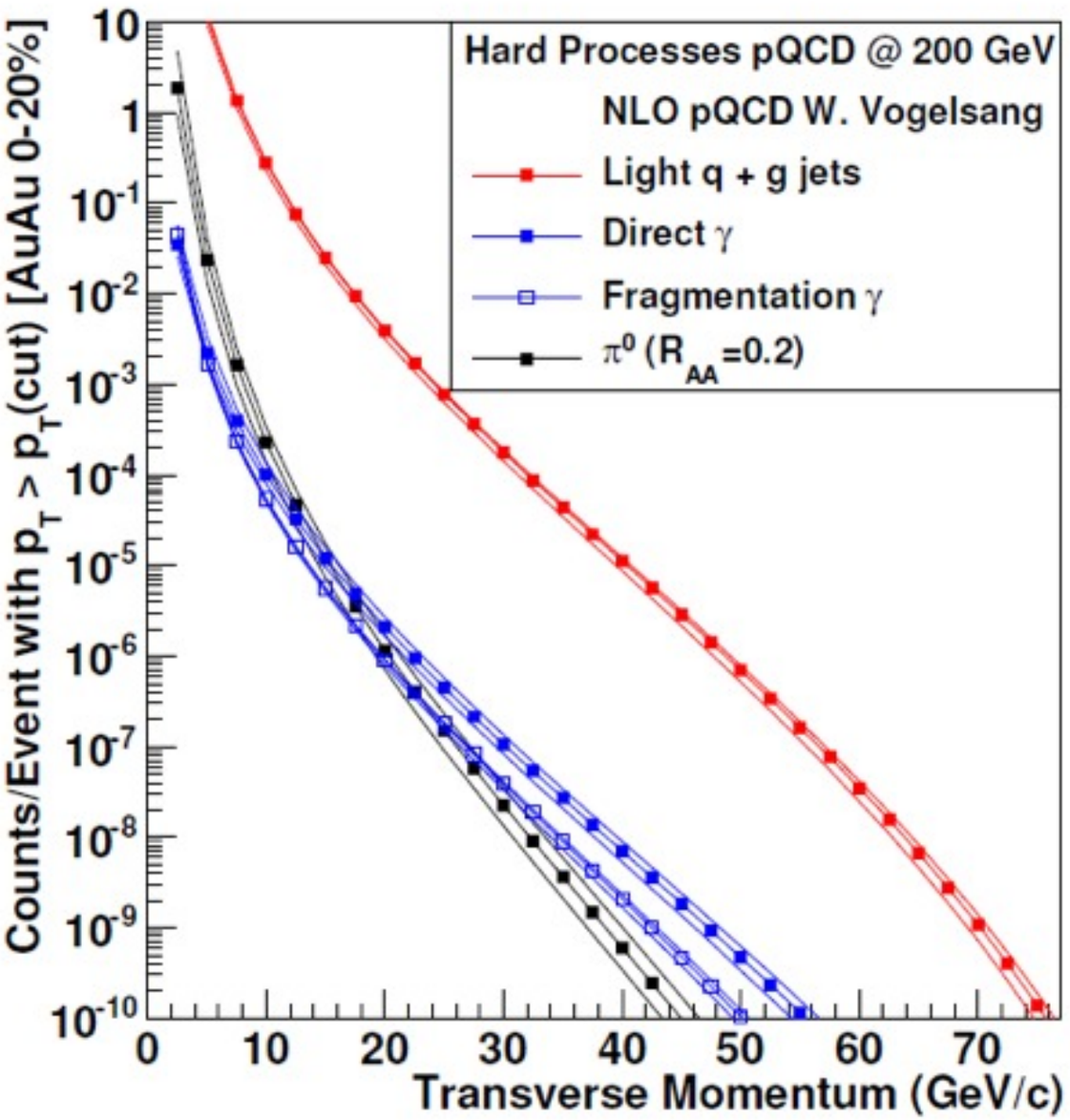
Rin = 70cm
2T, 1X_0

Fe-Scintillator HCal

Tungsten-scintillator accordion, 10cm thick

How Realistic Is this at RHIC?

RHIC Jet Rates

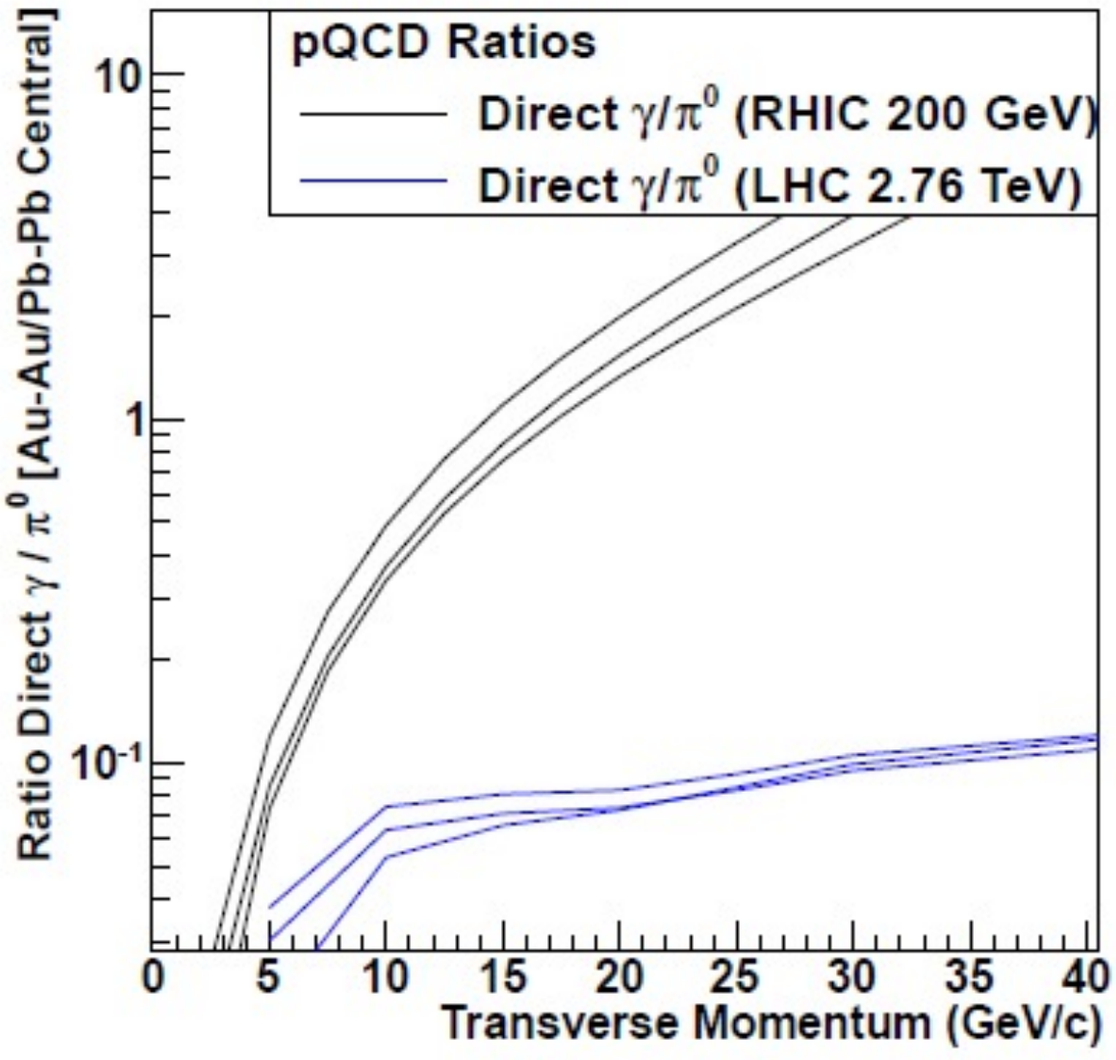


rates based on full stochastic cooling, but no additional accelerator upgrades

	Au+Au (central 20%)	p+p	d+Au
>20GeV	10^7 jets 10^4 photons	10^6 jets 10^3 photons	10^7 jets 10^4 photons
>30GeV	10^6 jets 10^3 photons	10^5 jets 10^2 photons	10^6 jets 10^3 photons
>40GeV	10^5 jets	10^4 jets	10^5 jets
>50GeV	10^4 jets	10^3 jets	10^4 jets

Huge rates allow differential measurements with geometry (v_2, v_3, A+B, U+U, …) & precise control measurements (dAu & pp) over 80% as dijets!

Direct Photons



- γ/π^0 very large at RHIC
- good S/B >20GeV
- substantial rate even >30GeV
- RHIC a very good place for γ-jet correlations

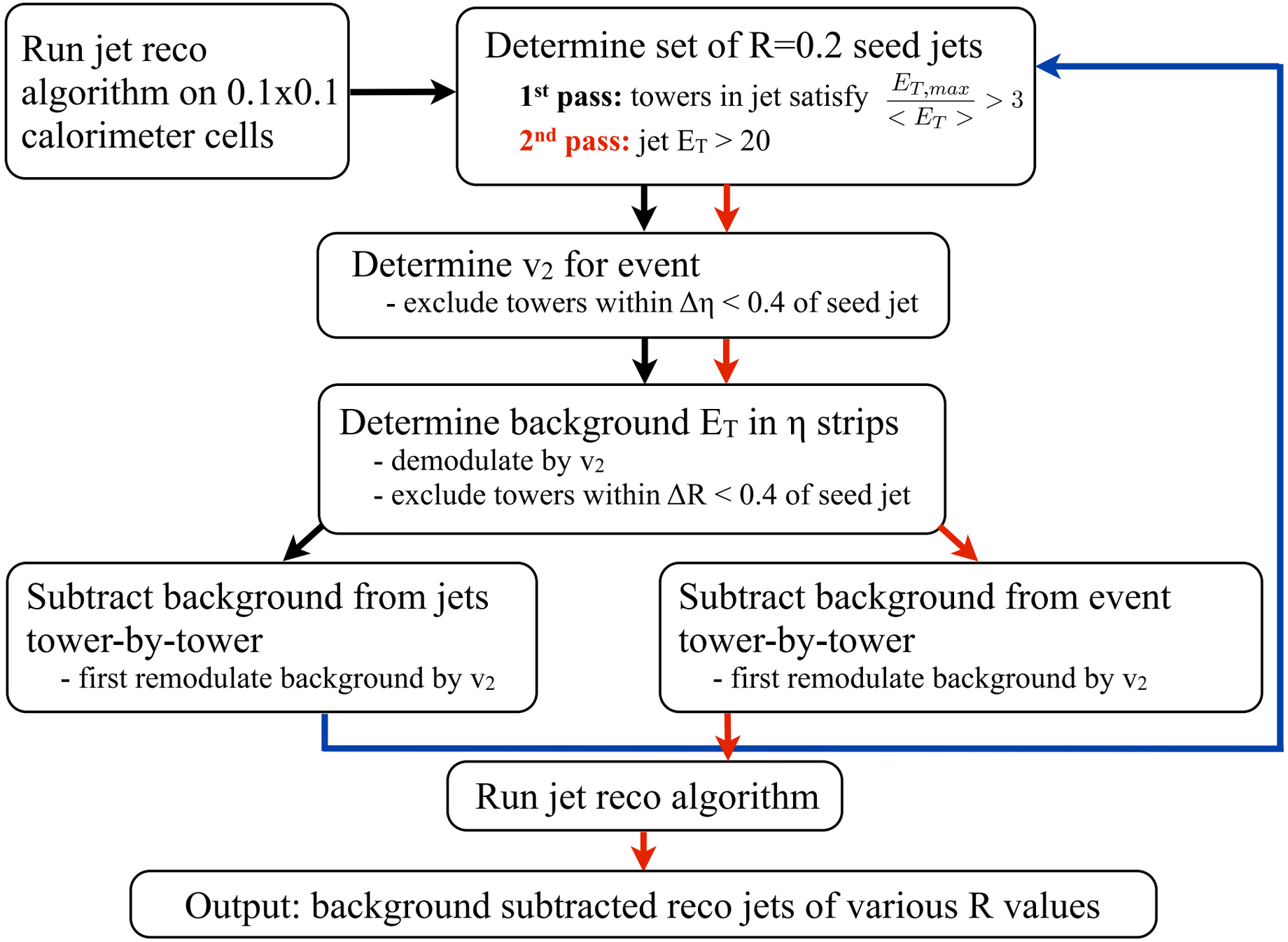
two questions

- how well can we measure real jets?
  - jet energy scale, jet energy resolution
- how are the jet measurements impacted by background fluctuations masquerading as jets--fakes

- large HIJING study
  - embedding PYTHIA jets into HIJING events to evaluate jet reconstruction performance
  - 750M minimum bias HIJING events to study relative rates of fake and real jets in HI background

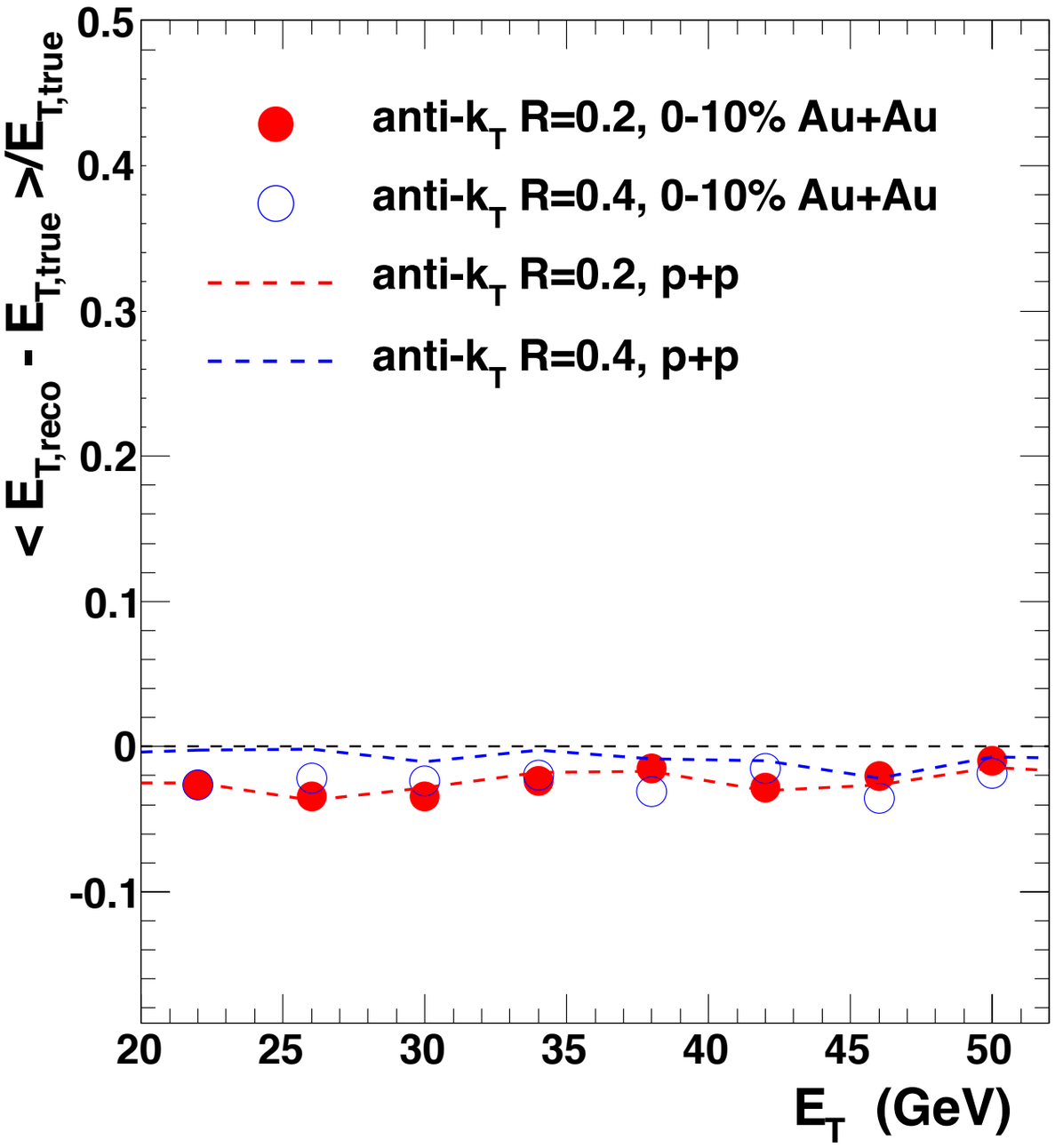
detailed study in: Hanks, Sickles et al: PRC86 024908

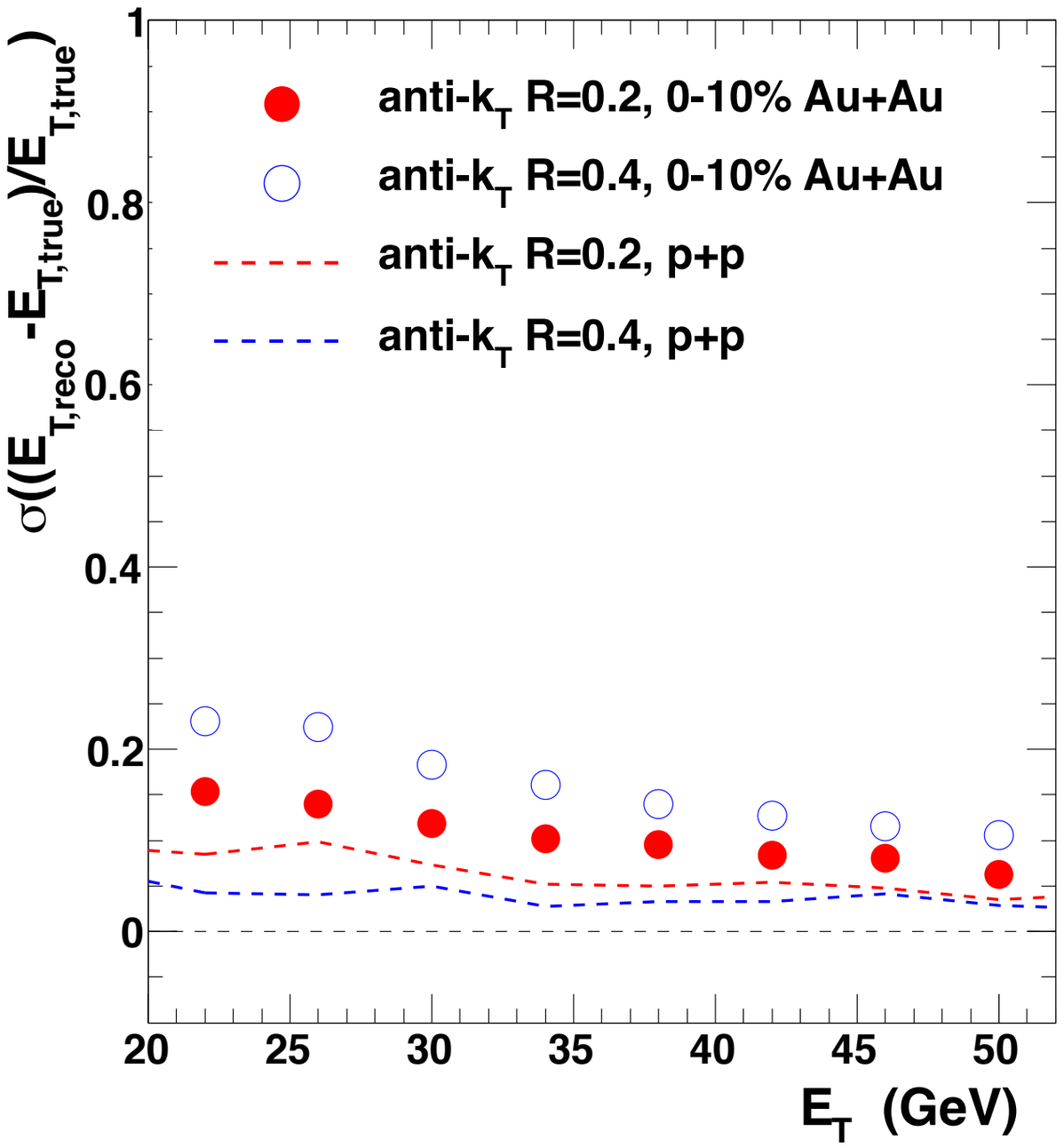
iterative jet finding algorithm



- uses anti-k_T algorithm
- inspired by ATLAS algorithm

reconstruction performance





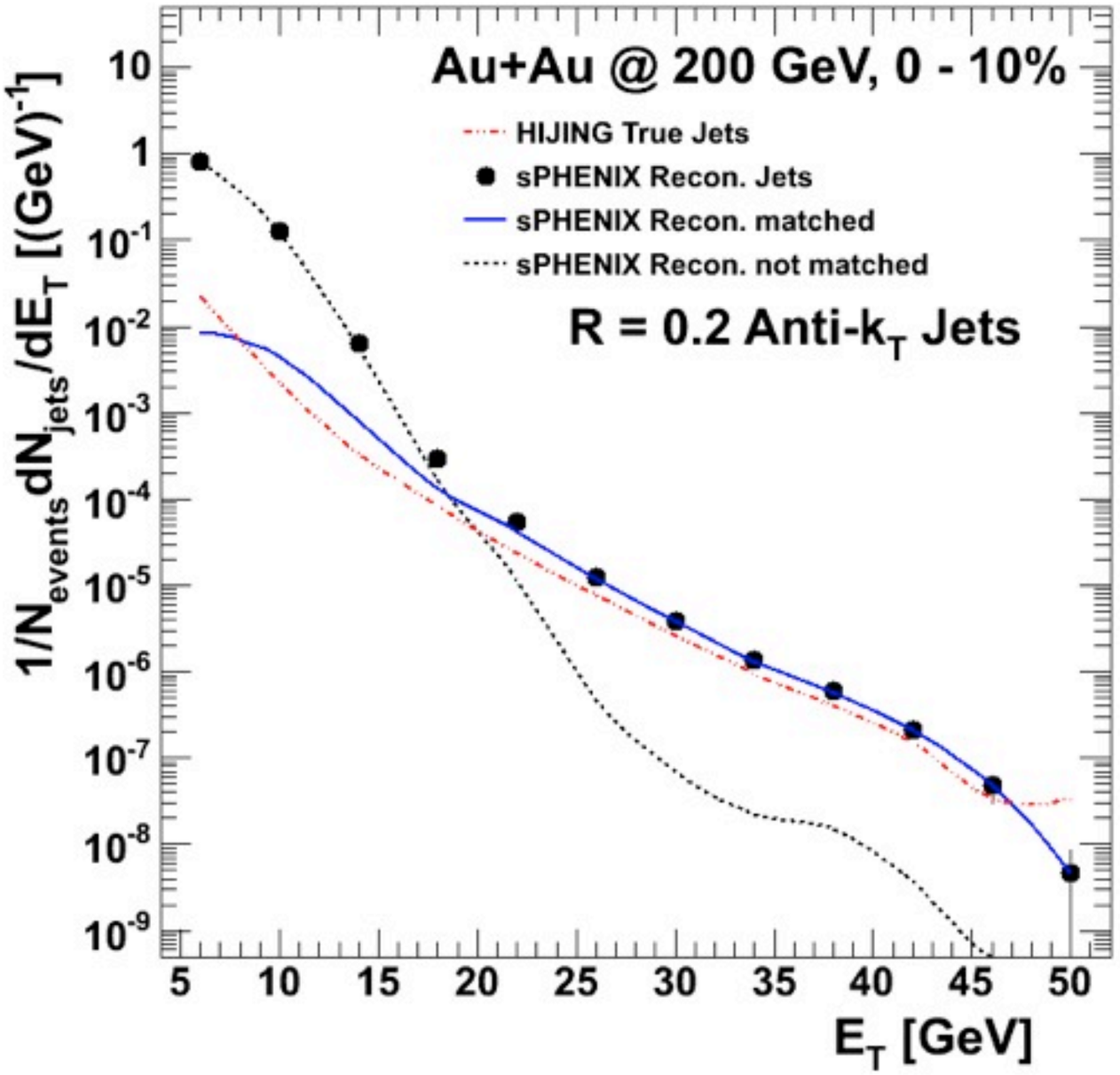
- good performance in heavy ion background
- resolution only from the underlying event, no detector resolution included

reconstructed jets

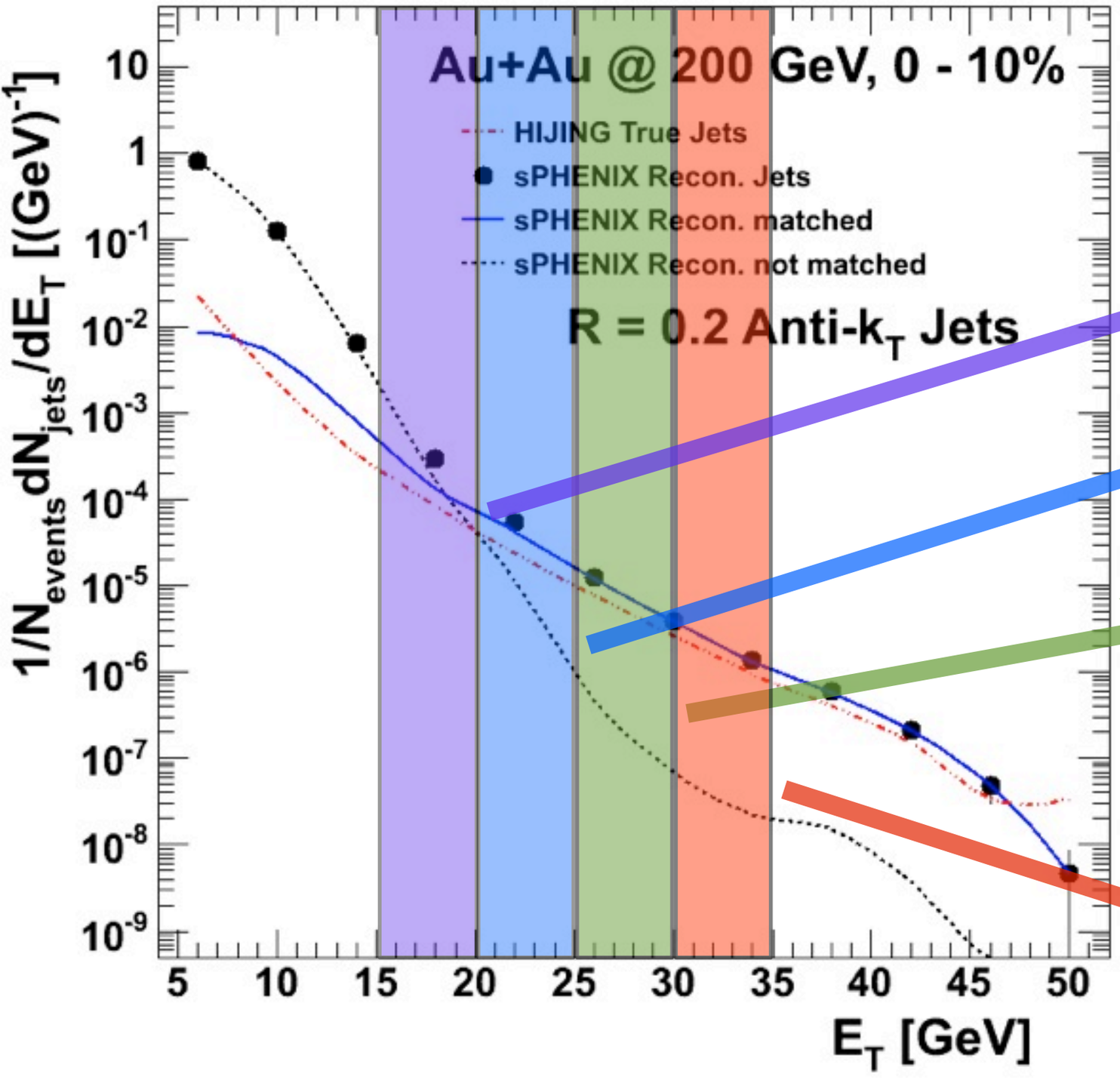
reconstructed jets

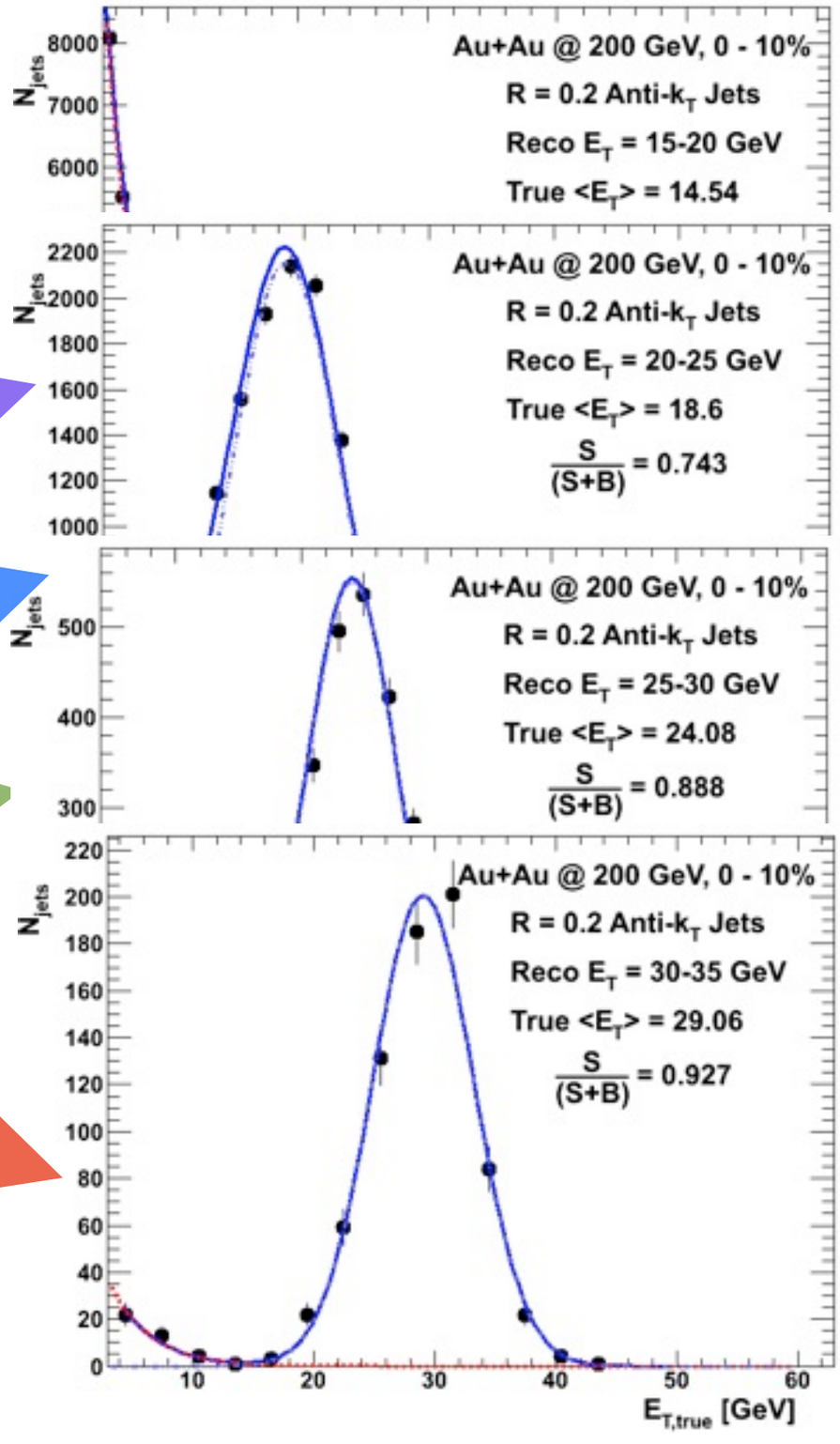
matched jets:
within $\Delta R < 0.25$ of a HIJING truth jet (>5GeV)

not matched jets:
no nearby HIJING jets
"fakes"

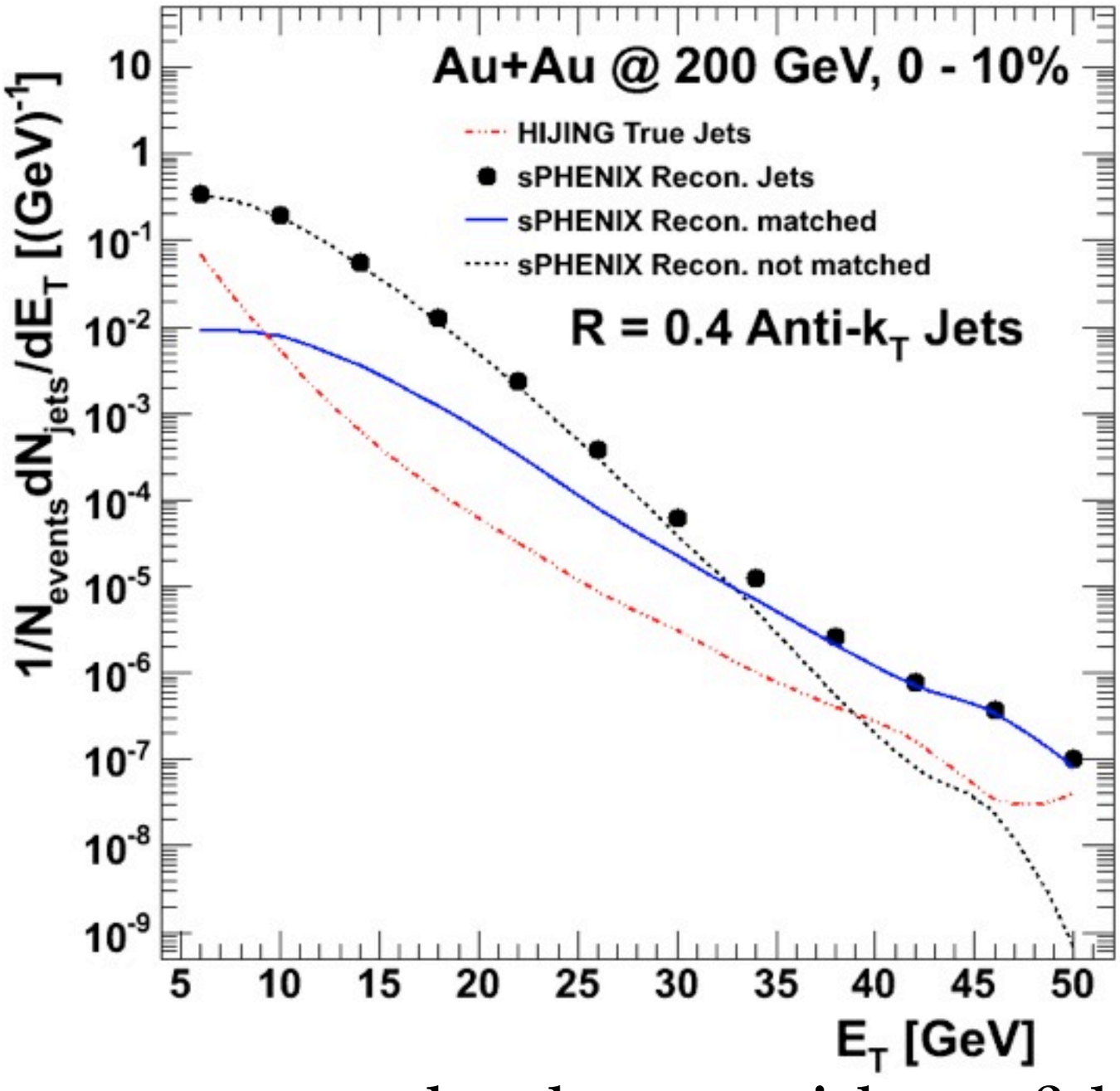


Fake Jets at RHIC (R=0.2)





Fake Jets at RHIC (R=0.4)

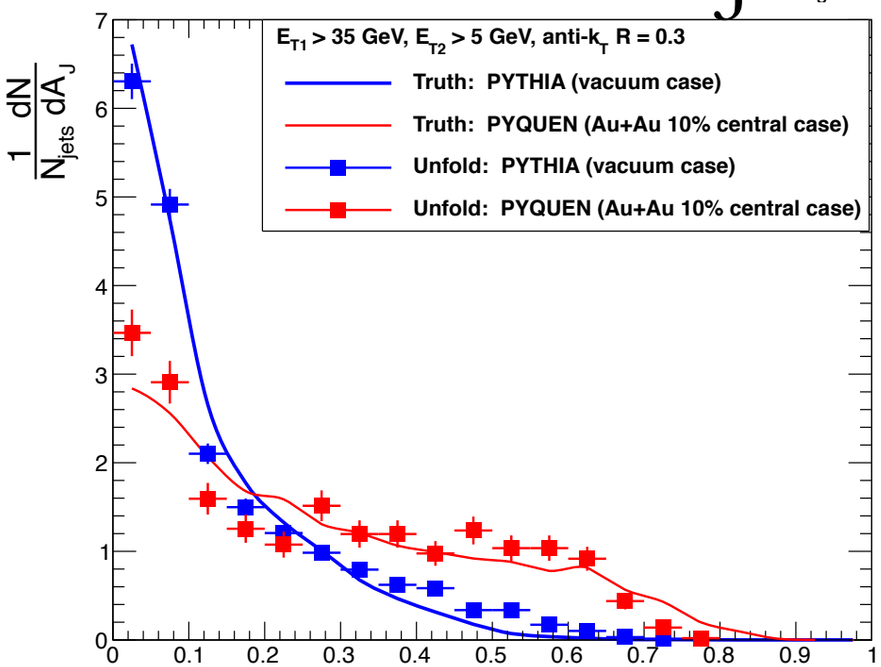


results shown with no fake jet rejection

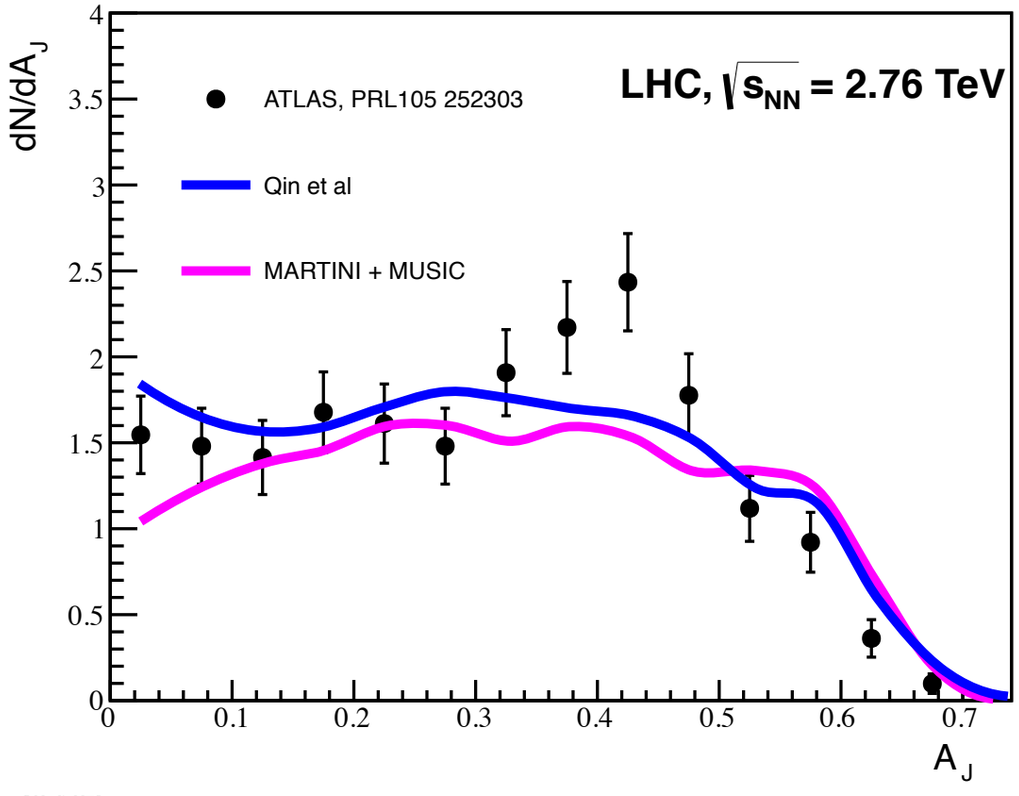
starting to look at associating track jets as used in ATLAS

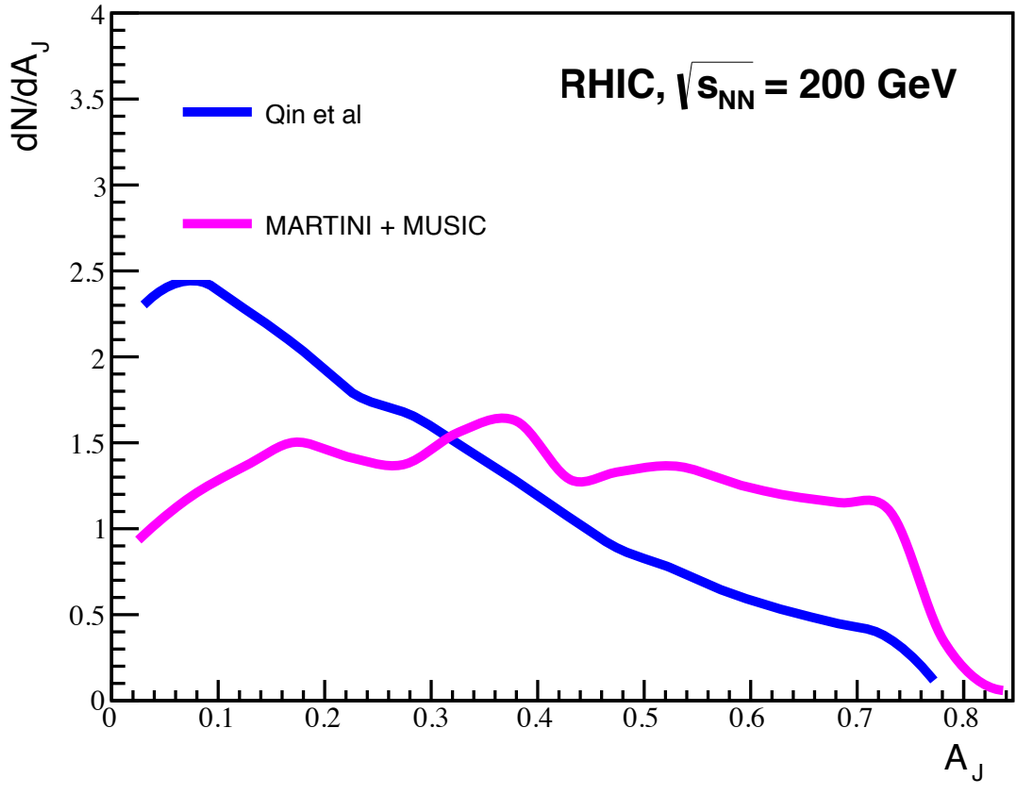
dijet asymmetry

sPHENIX Projection



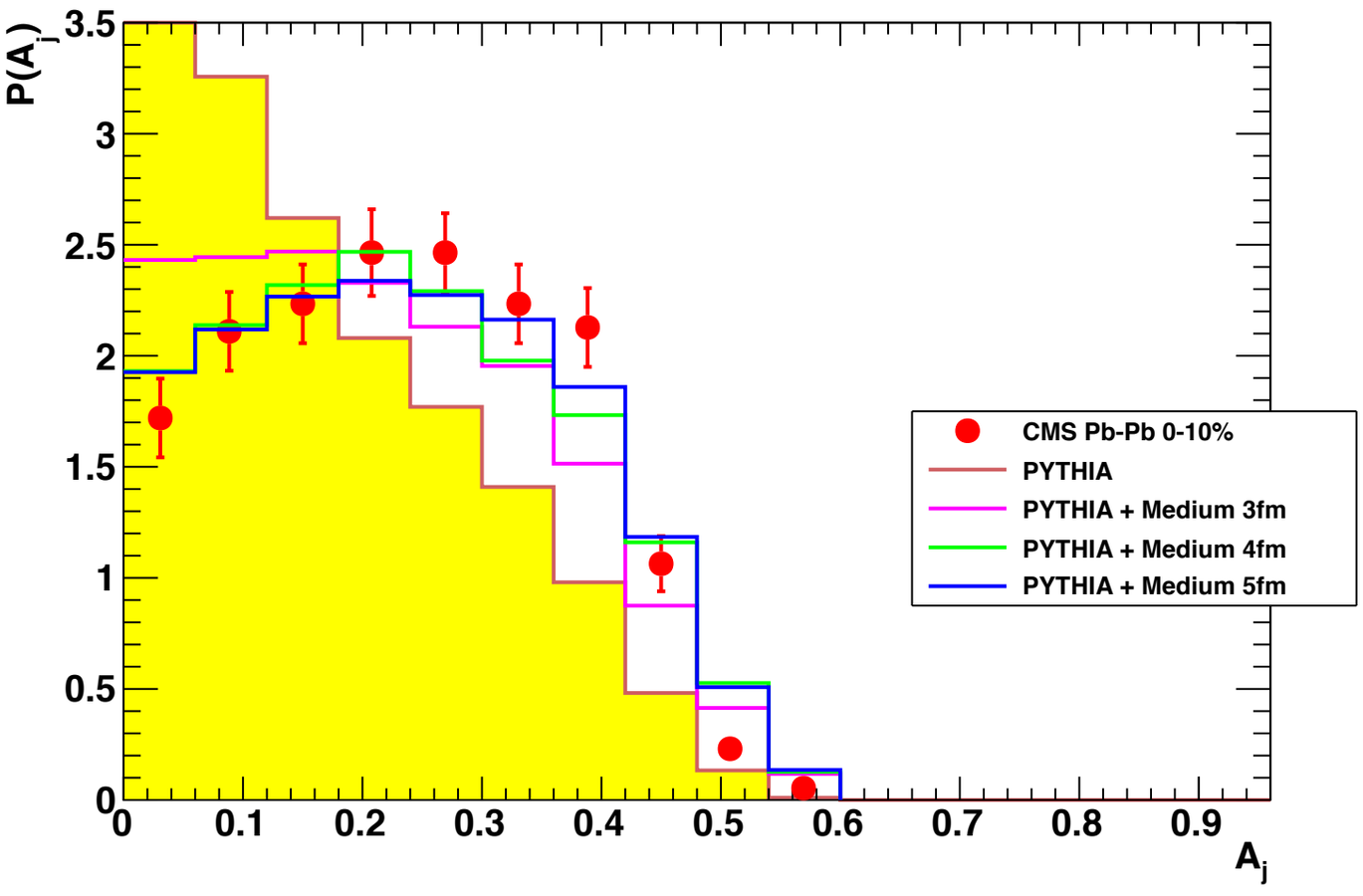
- Guang-You Qin et al & MARTINI +MUSIC (Young, Schenke et al.) both describe LHC, but predict different results for RHIC

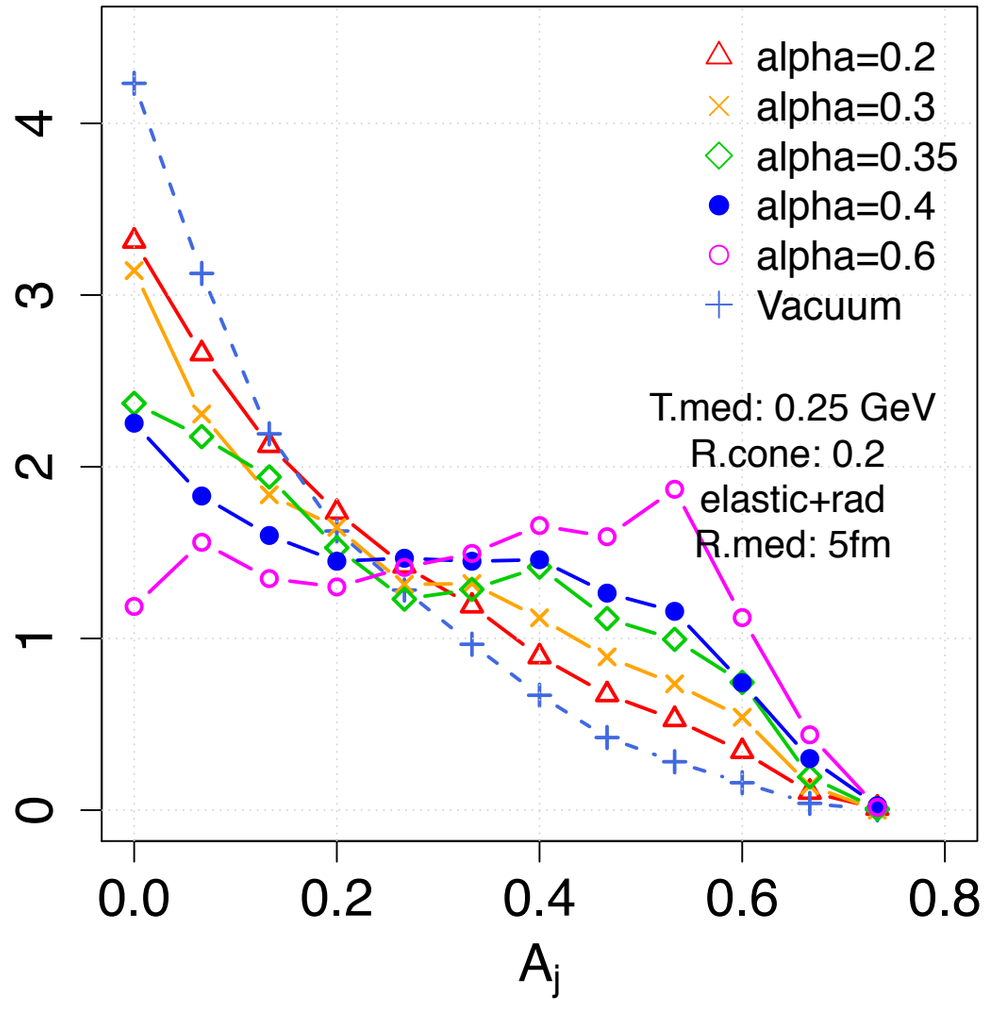




sensitivity to effective coupling

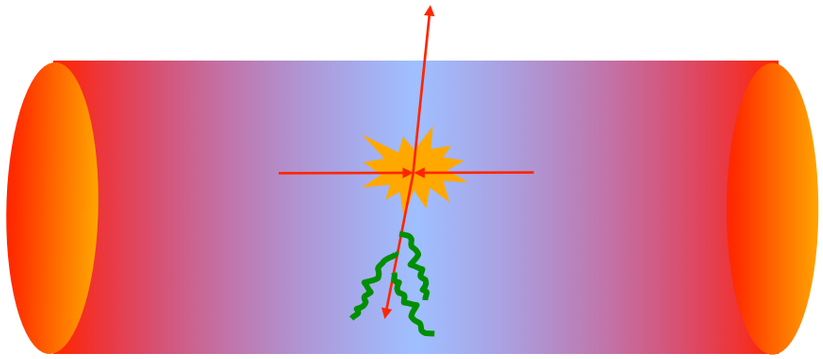
RHIC predictions,
varying effective coupling



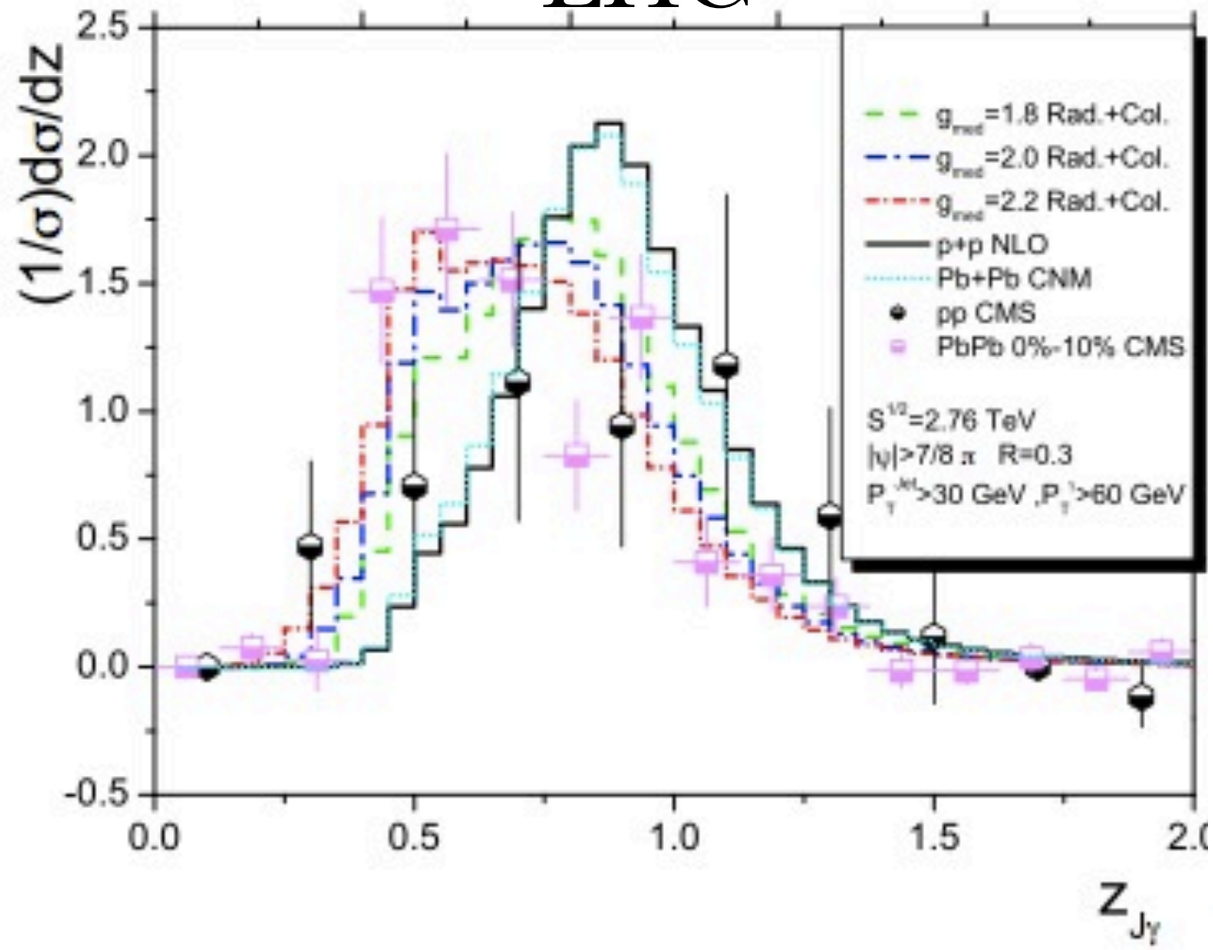


Coleman-Smith & Muller: 1209.3328

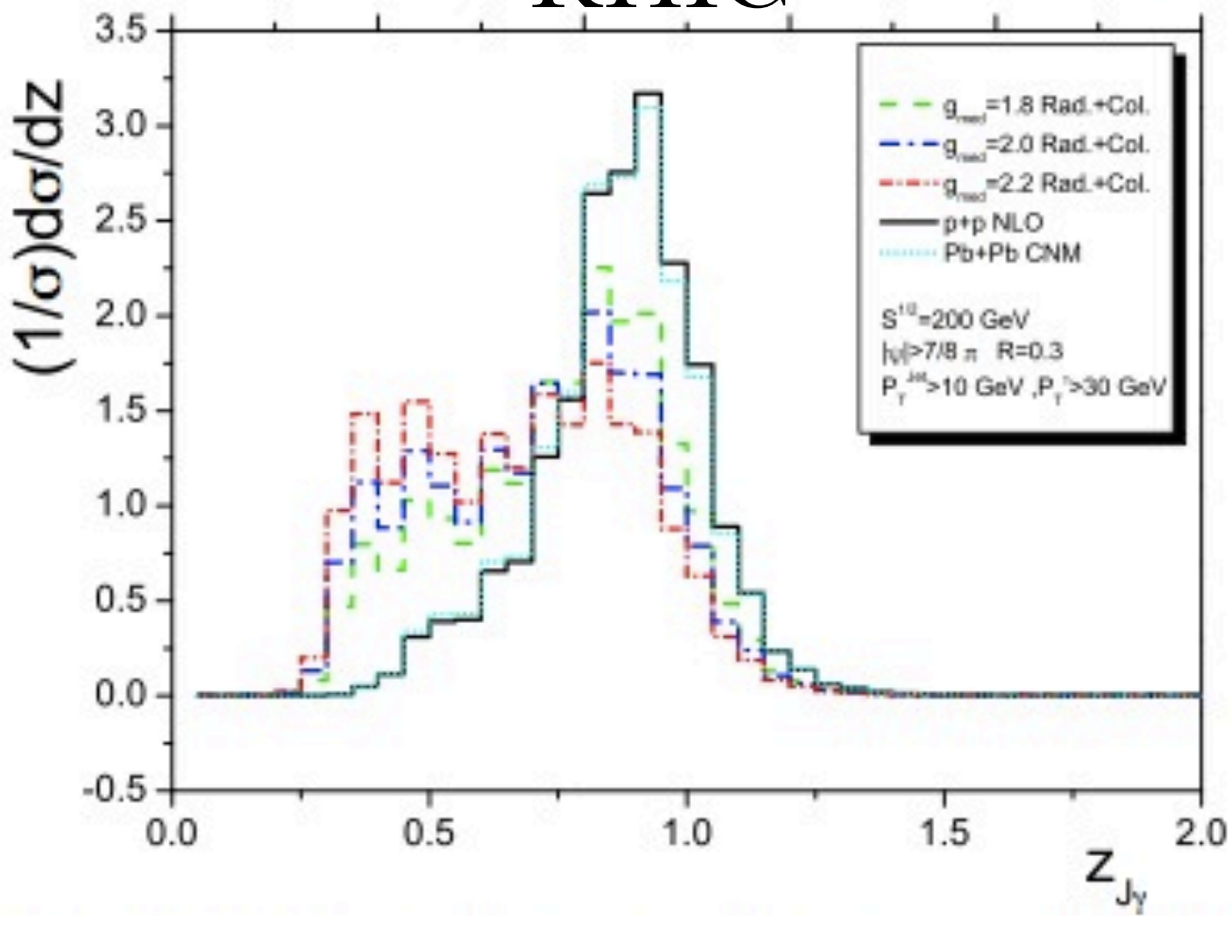
photon-jet



LHC



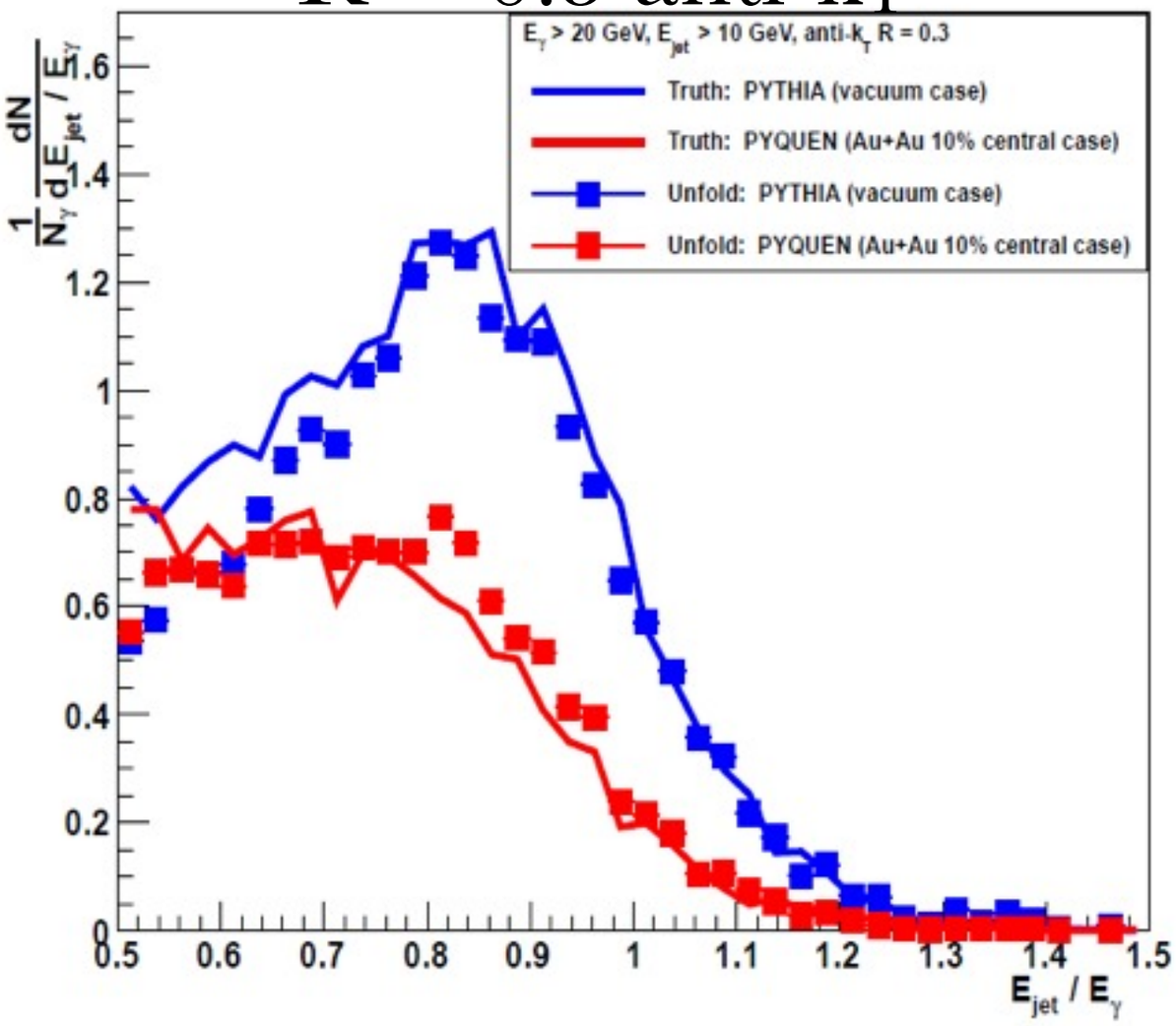
RHIC



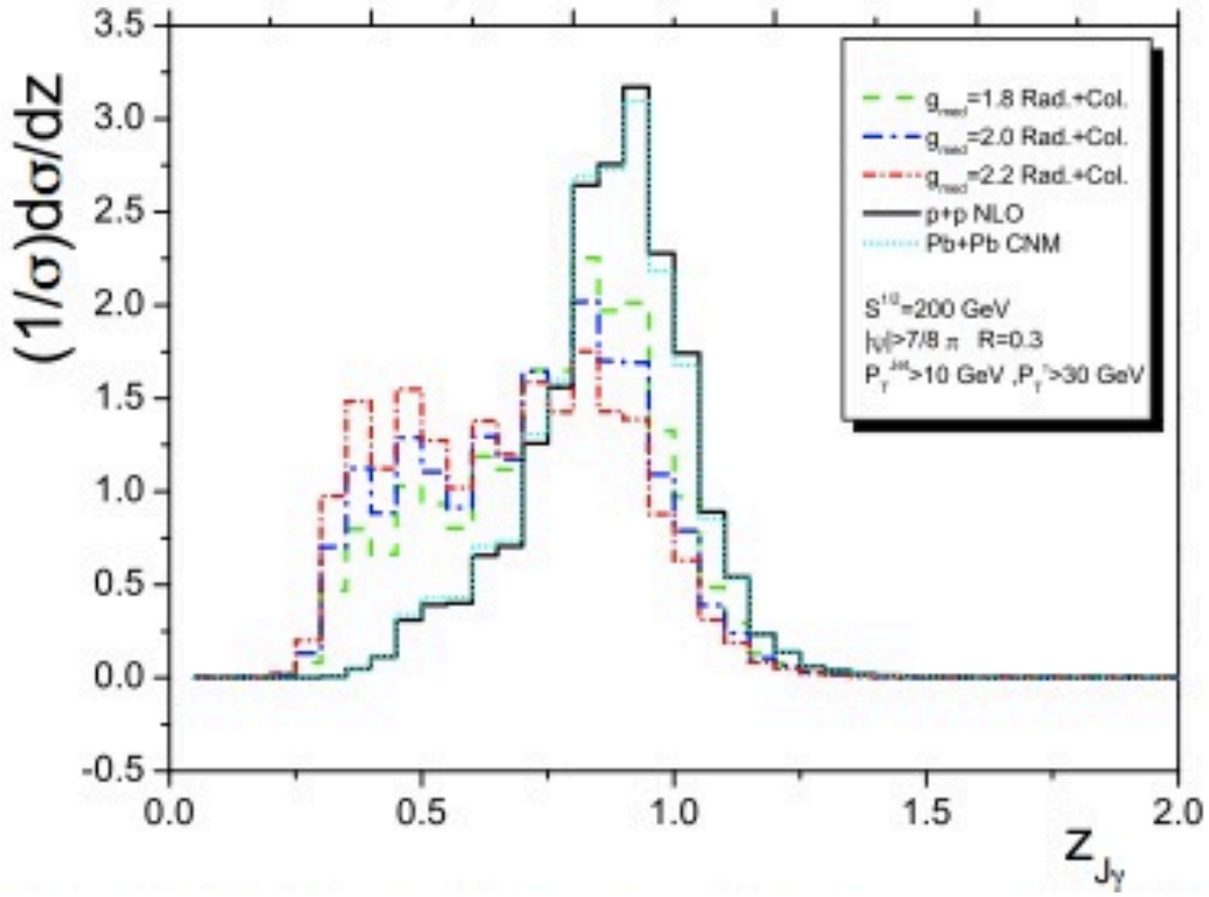
Dai, Vitev, Zhang: 1207.5177

photon-jet

sPHENIX Projection
R = 0.3 anti-k_T

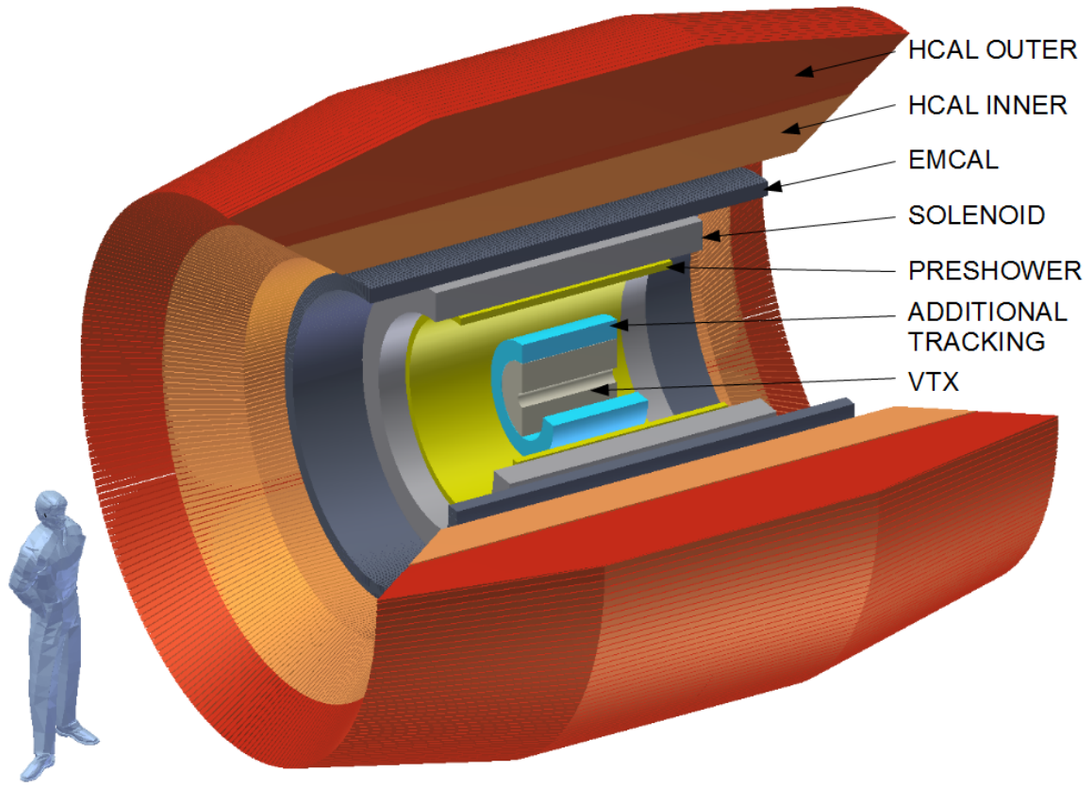


Dai, et al



- unfolded result including HIJING background, detector effects & jet reconstruction

sPHENIX additions



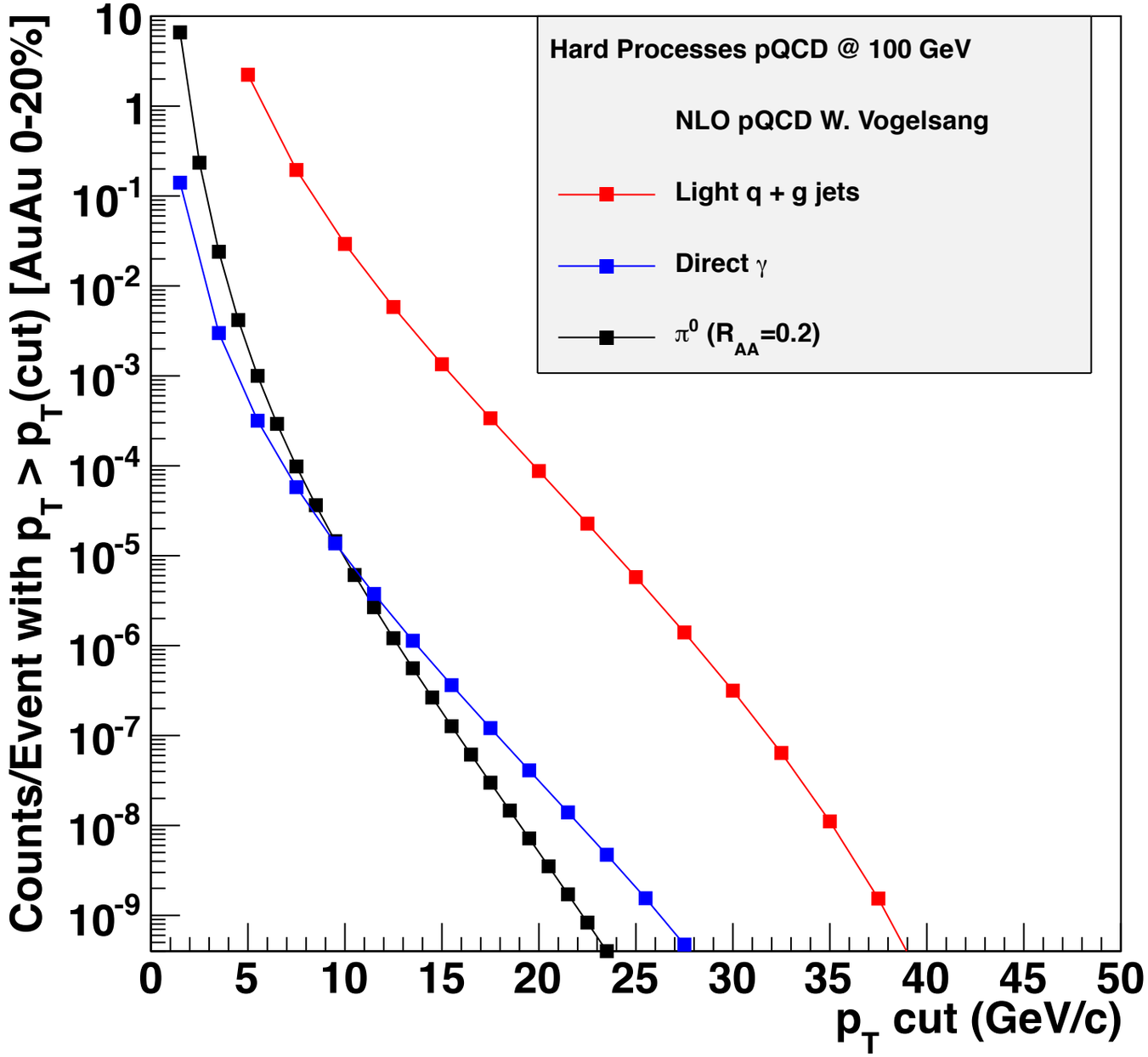
- very interested in additional tracking & a preshower detector to enable additional compelling physics on a similar timescale
  - preshower: heavy flavor jets, upsilons & π^0 detection
  - additional tracking to extend fragmentation functions to high z

sPHENIX

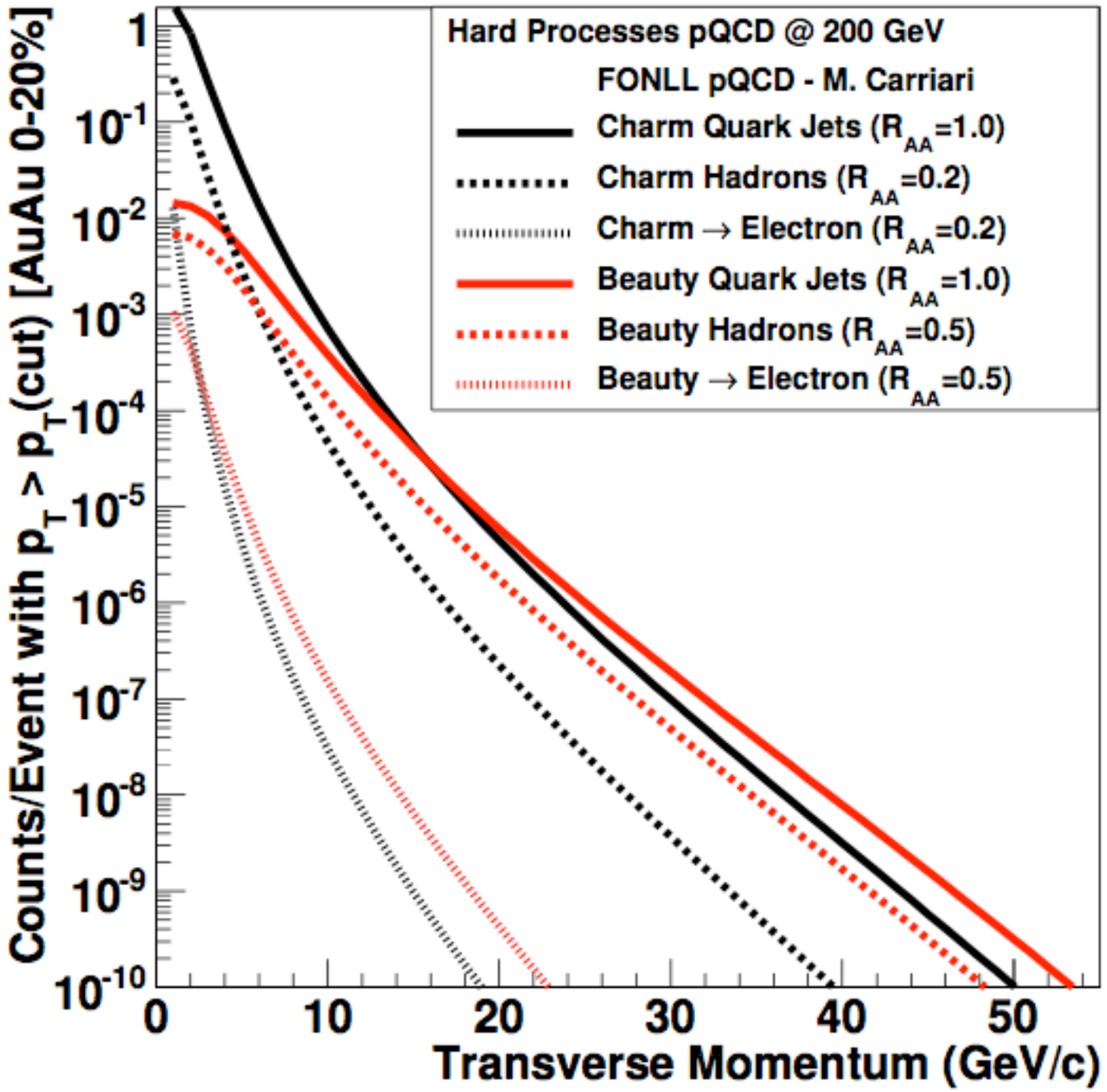
- **high rate calorimetric jet measurements at RHIC**
  - jets, dijets, γ-jets
  - other very interesting possibilities: jet v_N, jet-hadron correlations
  - heavy quark jets: requires additional tracking beyond VTX
  - variety of systems for precise of control initial state effects and geometry
- **together with LHC constrain physics of QGP near Tc**
- **novel detector concept**
  - exploits recent technological advances
  - becomes part of future ePHENIX detector
- **aggressively moving forward!**
  - review at BNL in early October
  - timeline for commissioning ~2019

sPHENIX Proposal arXiv:1207.6378

further exploration of T dependence

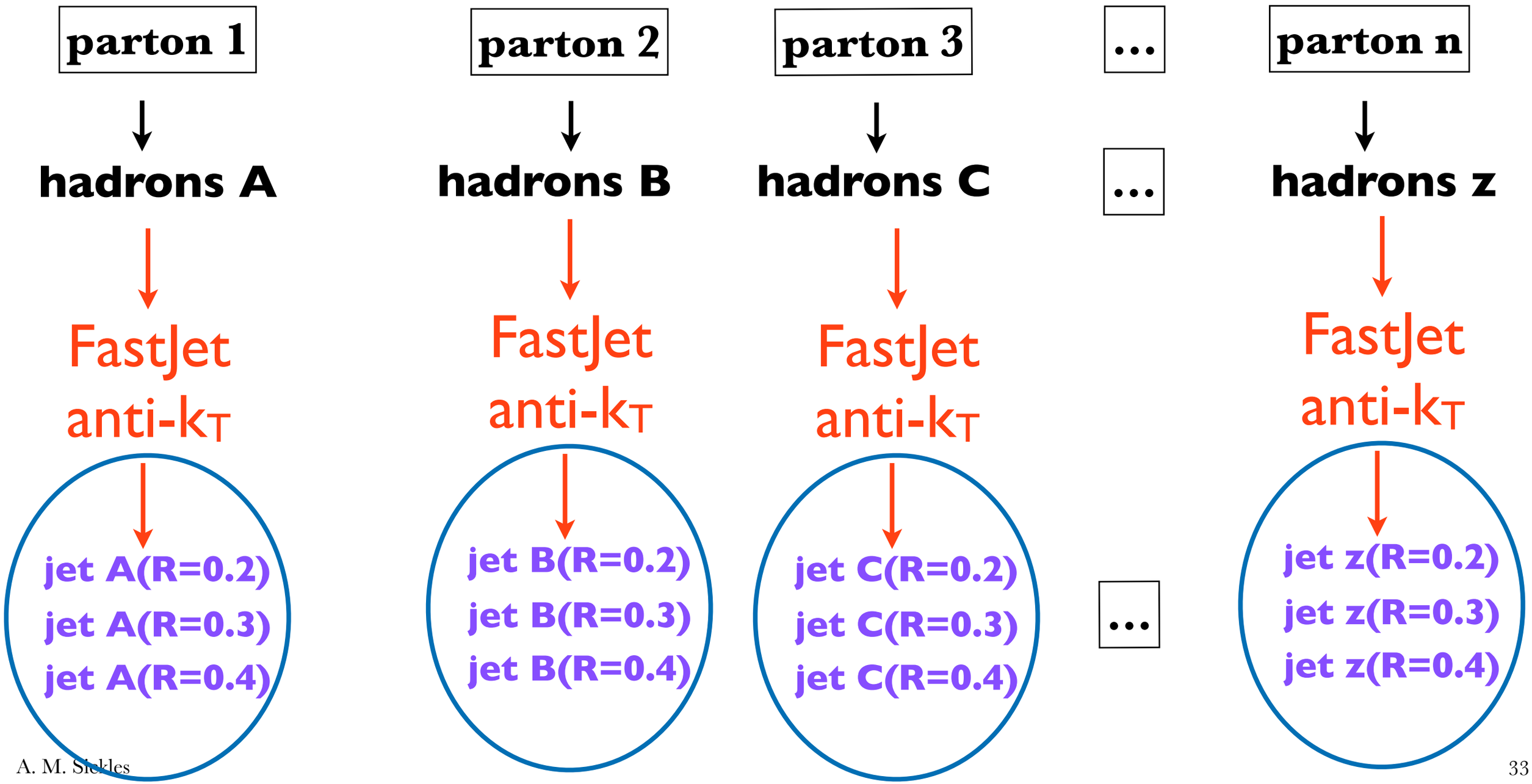


heavy quarks



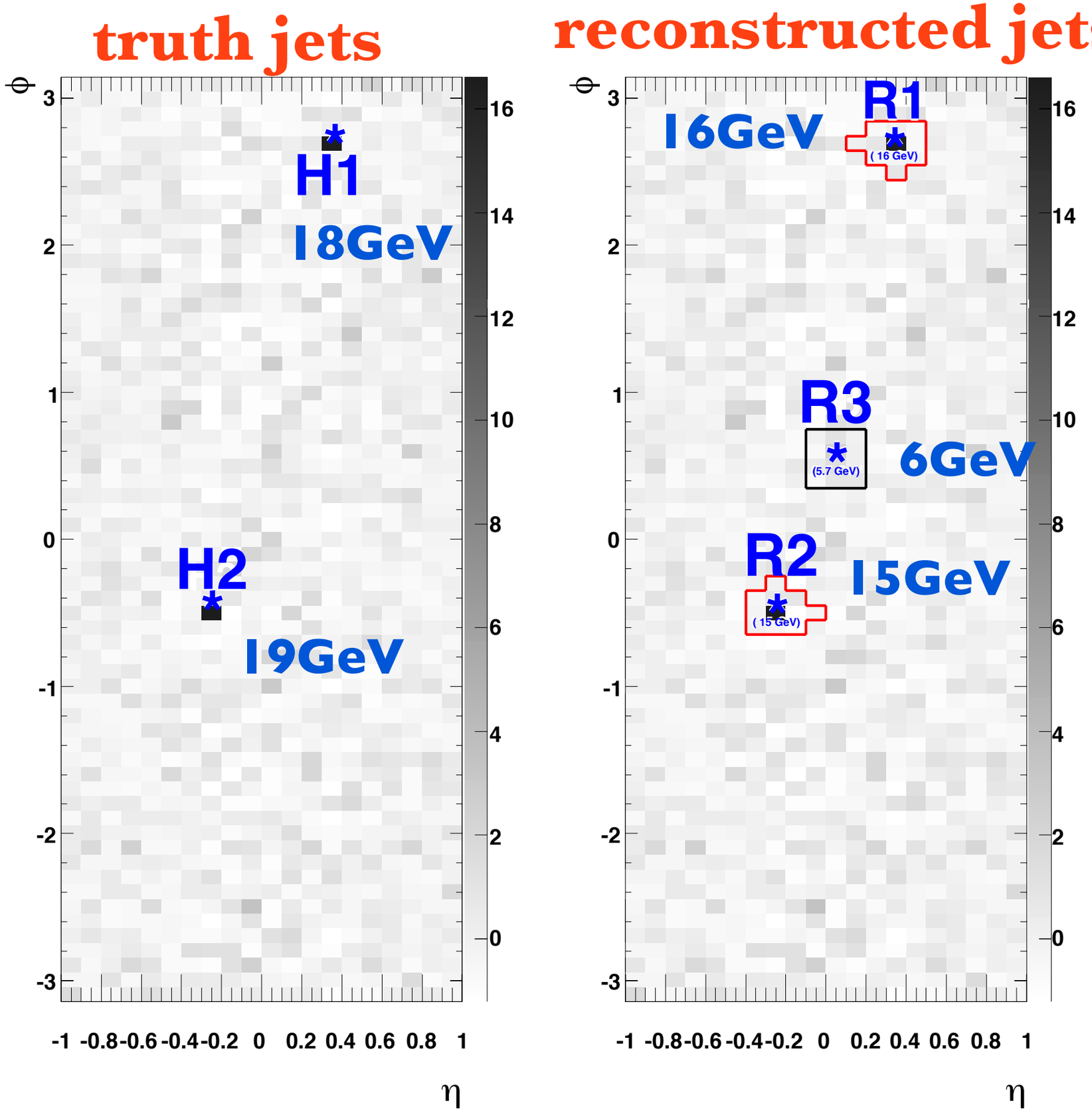
identifying truth jets

deep within the HIJING Event Generation...



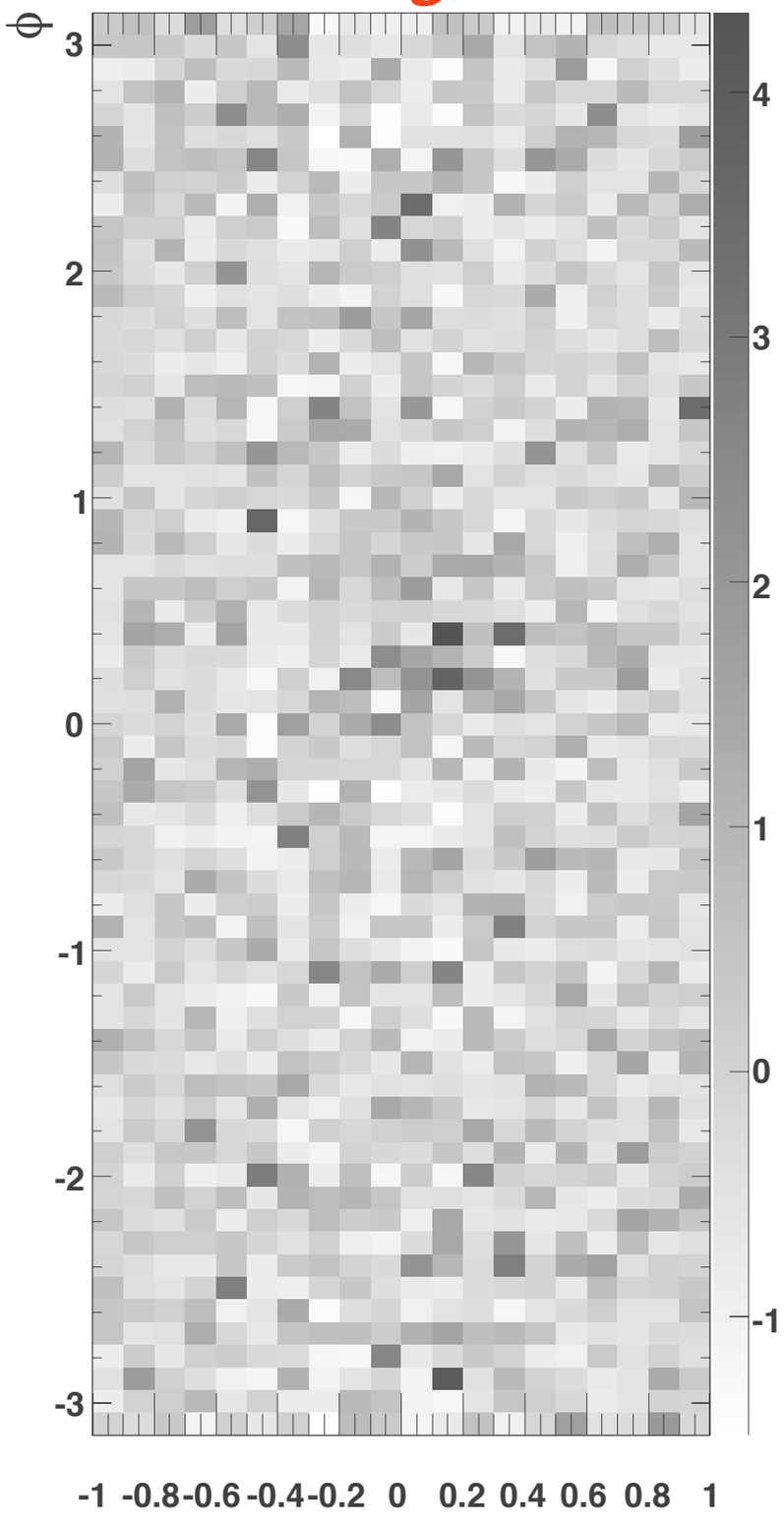
well reconstructed jets

- b = 1.8fm HIJING dijet event
- well reconstructed with anti-k_T R=0.2

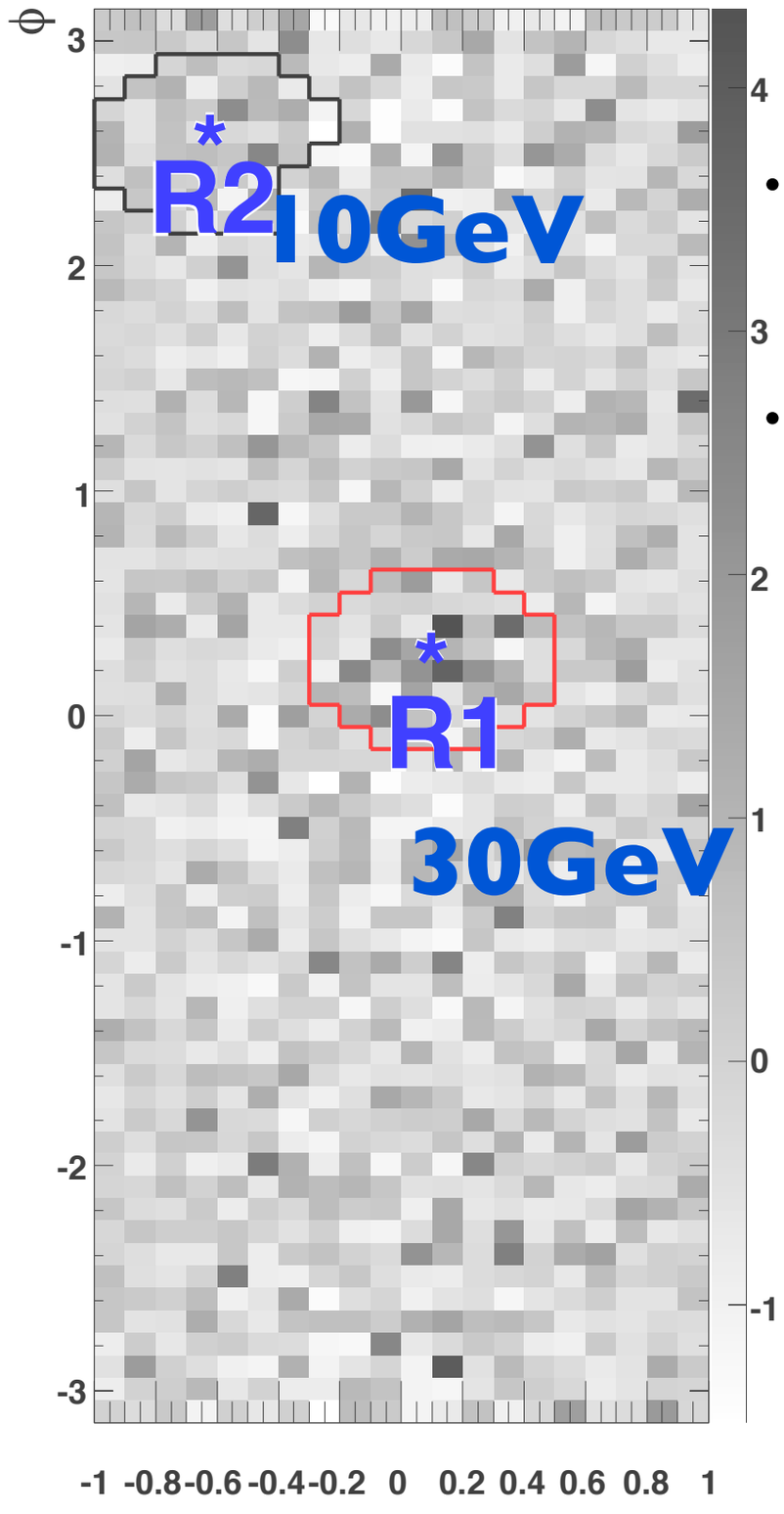


fake jets

truth jets



reconstructed jets



- b=2.4 HIJING event, no true jets
- 30 & 10GeV fake jets with anti-k_T R=0.4

however, we looked at 750M+ events! need quantitative rate assessment