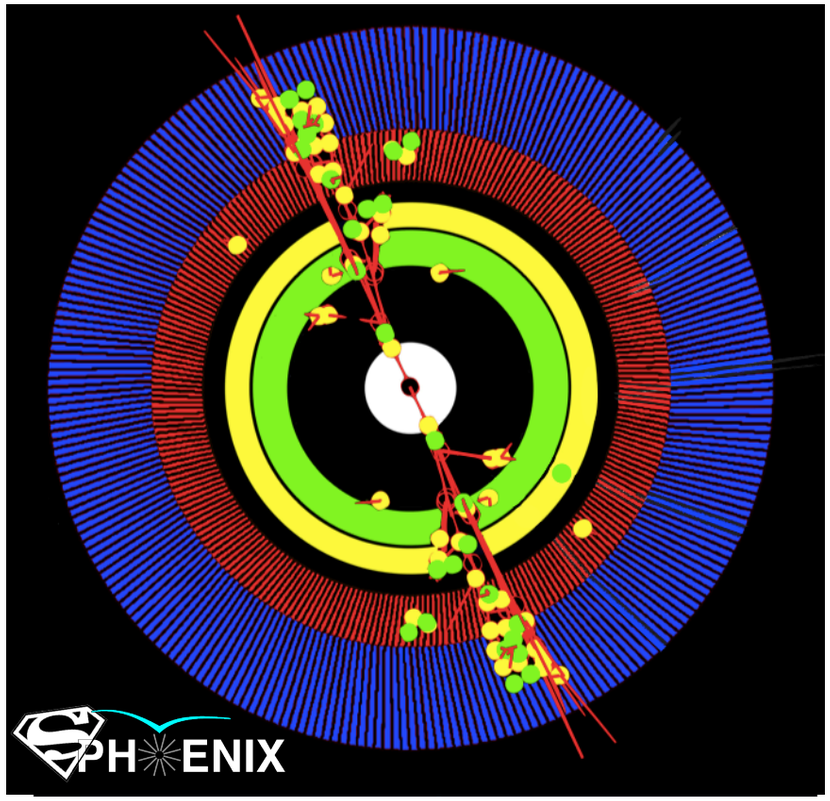
Future Jets at RHIC with sPHENIX



Ali Hanks

for the PHENIX Collaboration

August 23rd, 2012

Jet Modification in the RHIC and LHC era

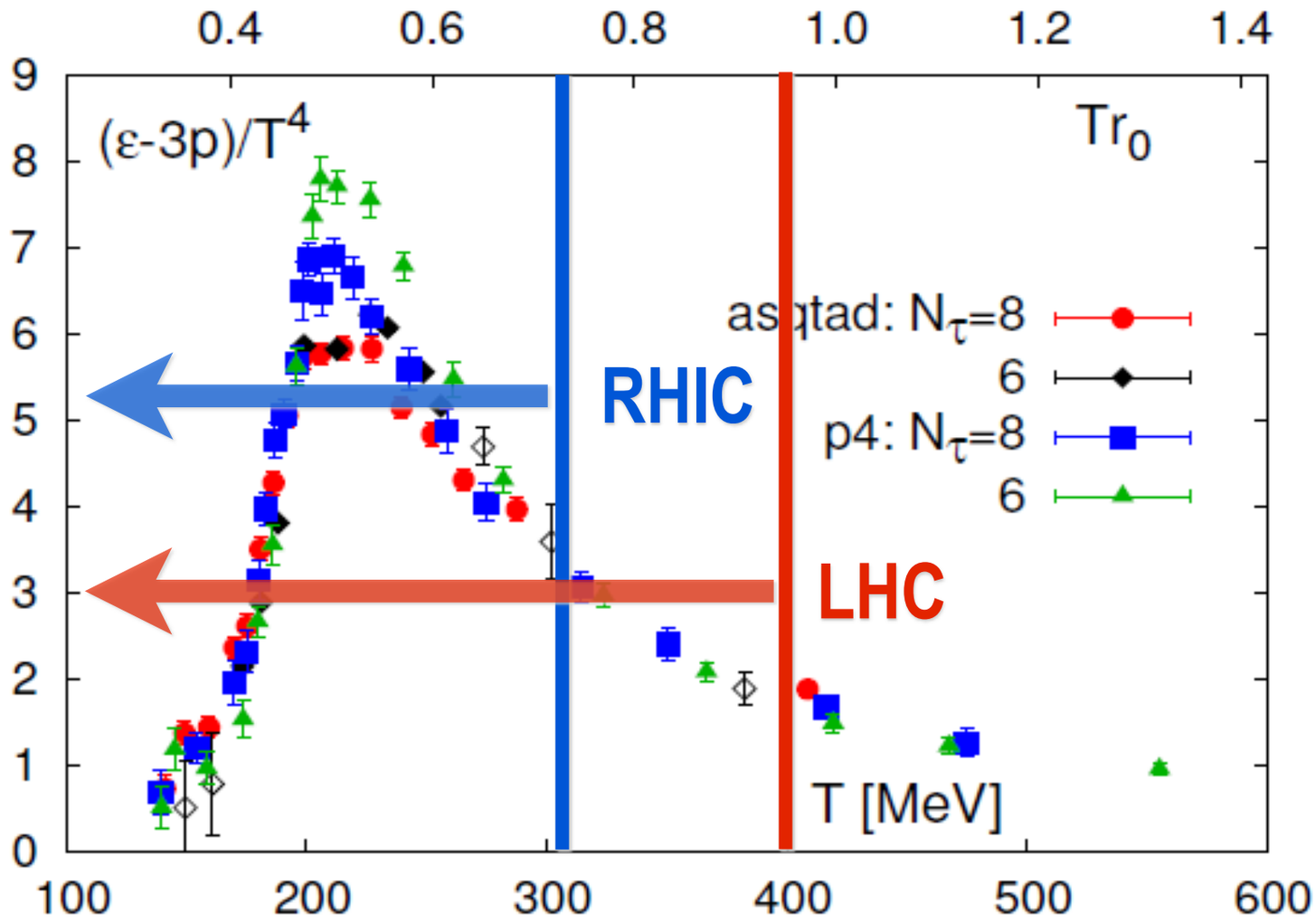
Stony Brook University | The State University of New York

Two questions to answer

- Can we learn from full jet measurements at RHIC in the LHC era?

- Can we measure jets at RHIC?
  - untriggered and at high rates

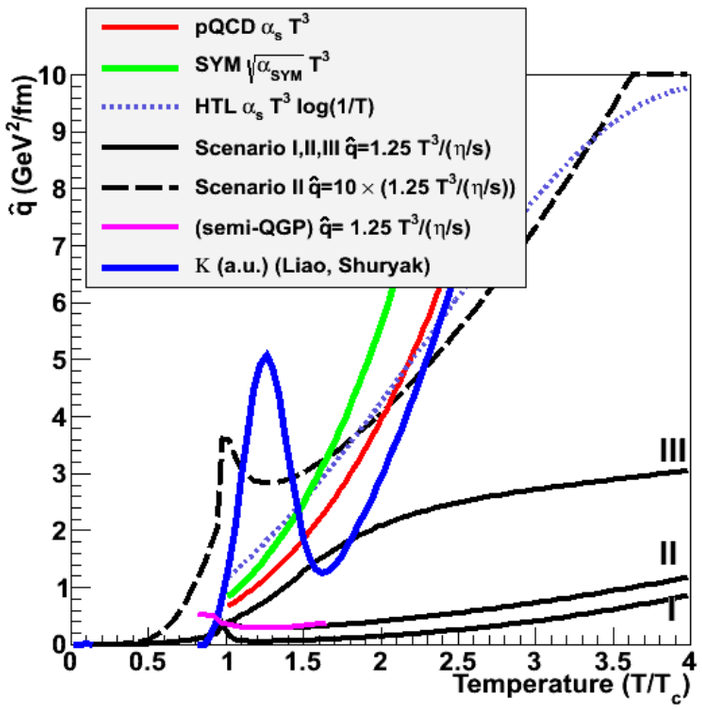
Probing properties of the QGP



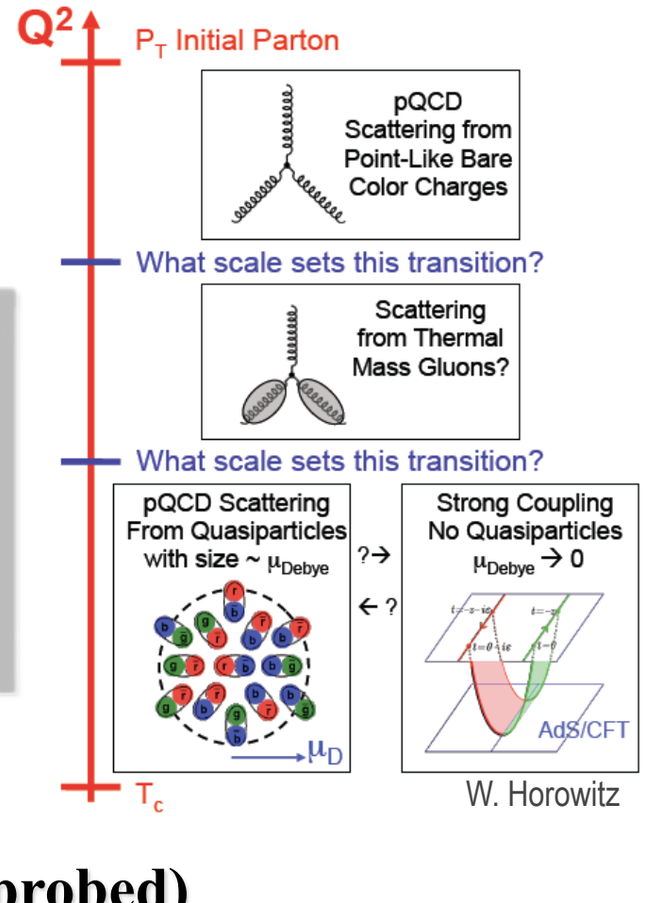
- Measurements integrate over time evolution of medium
  - all properties are varying: T, η/s, q-hat, e-hat
- How can we unambiguously see changes near T_c?
  - run through same time history at different T_0

Investigating the QGP along multiple axes

What is the temperature dependence for the QGP ?



What are the inner workings (quasi-particles, strong fields, ...)?



T

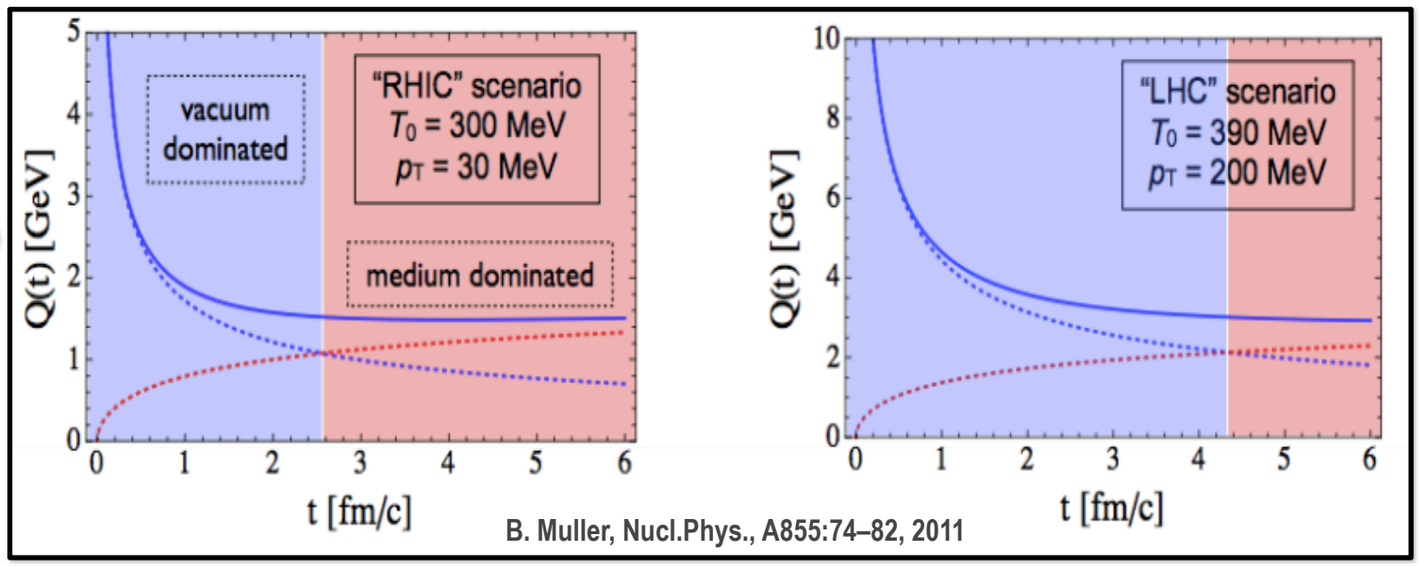
λ

(length scale probed)

$Q^2(t)$

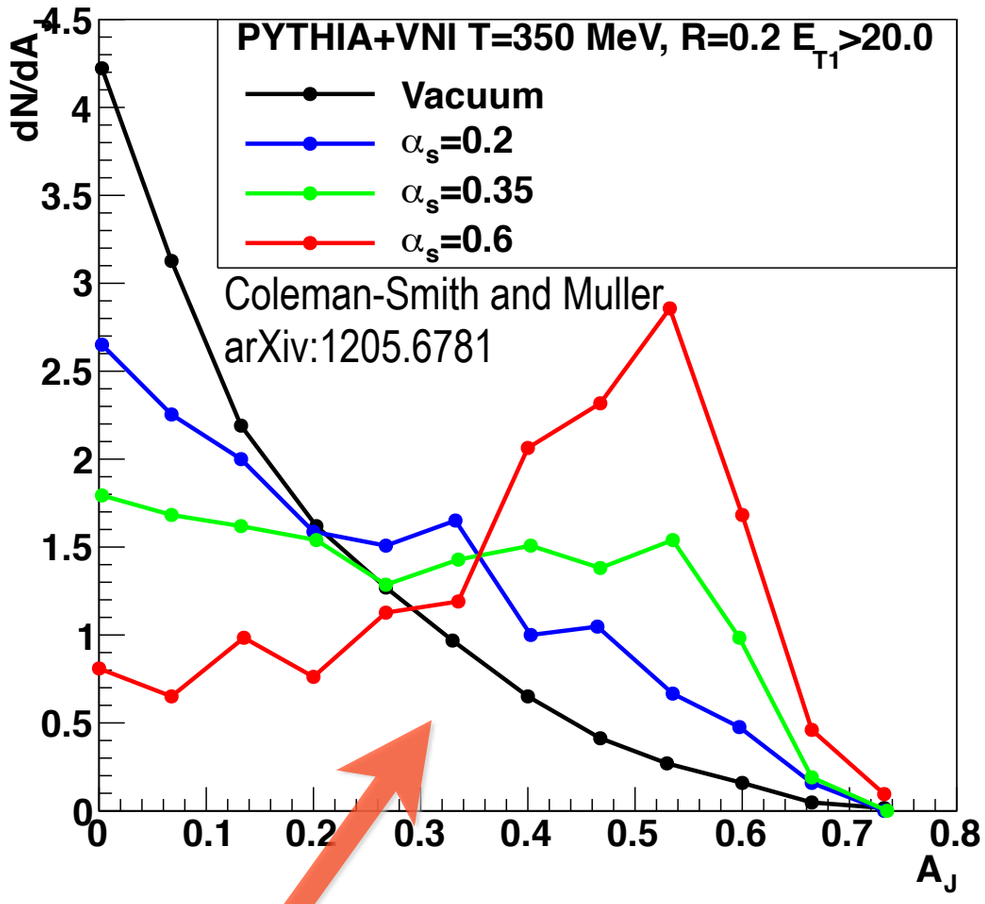
(virtuality of hard process)

How does the medium evolve?



B. Muller, Nucl.Phys., A855:74–82, 2011

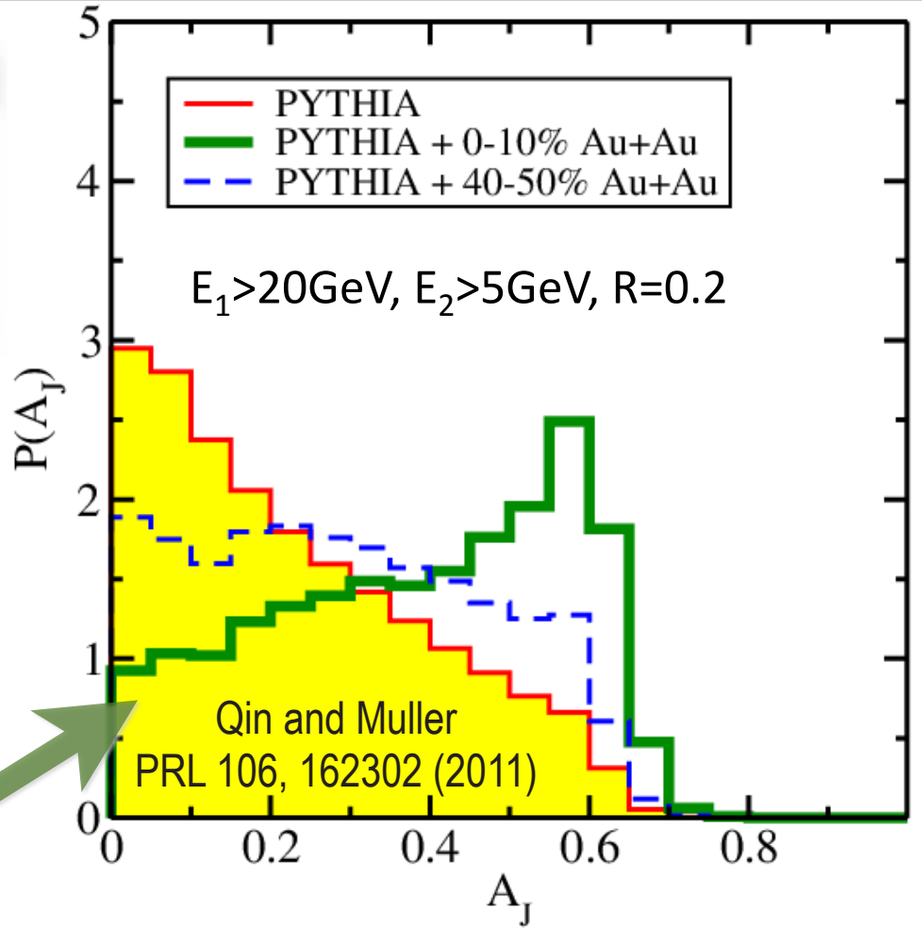
Jet abservables at RHIC



Sensitivity to *effective* coupling

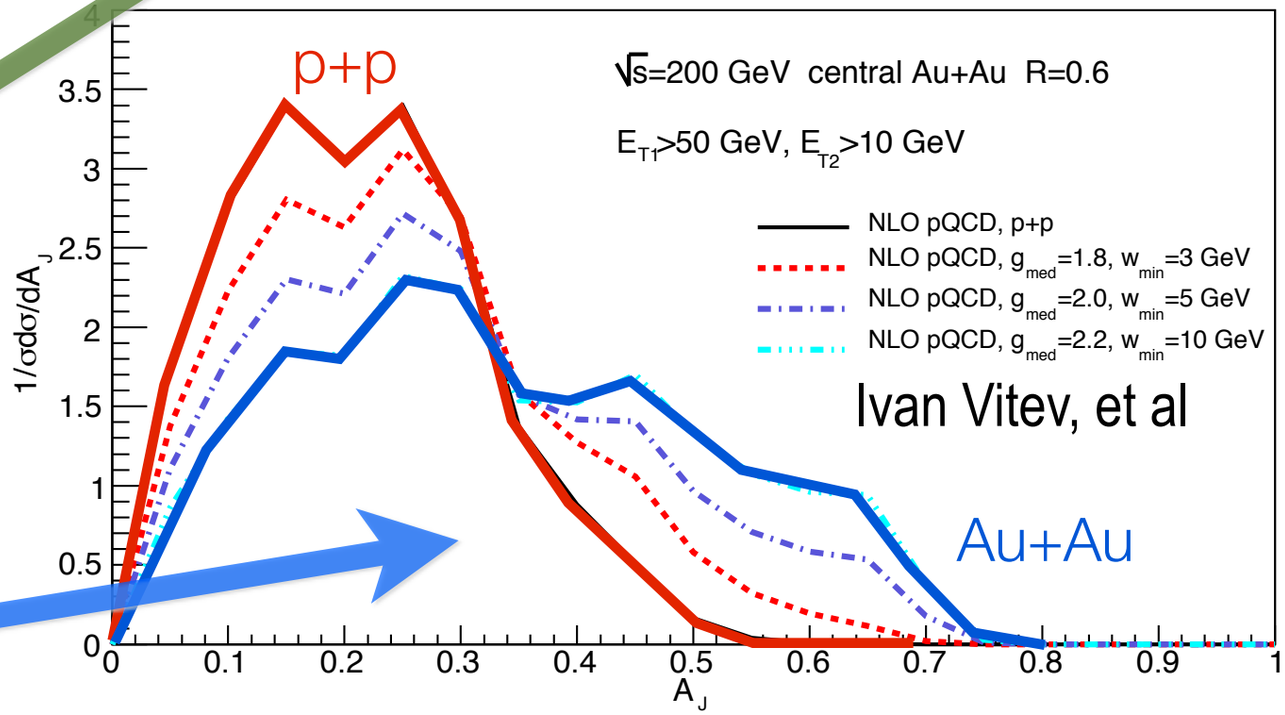
JET Collaboration

Models constrained by LHC data



Sensitivity to interaction of jet with medium

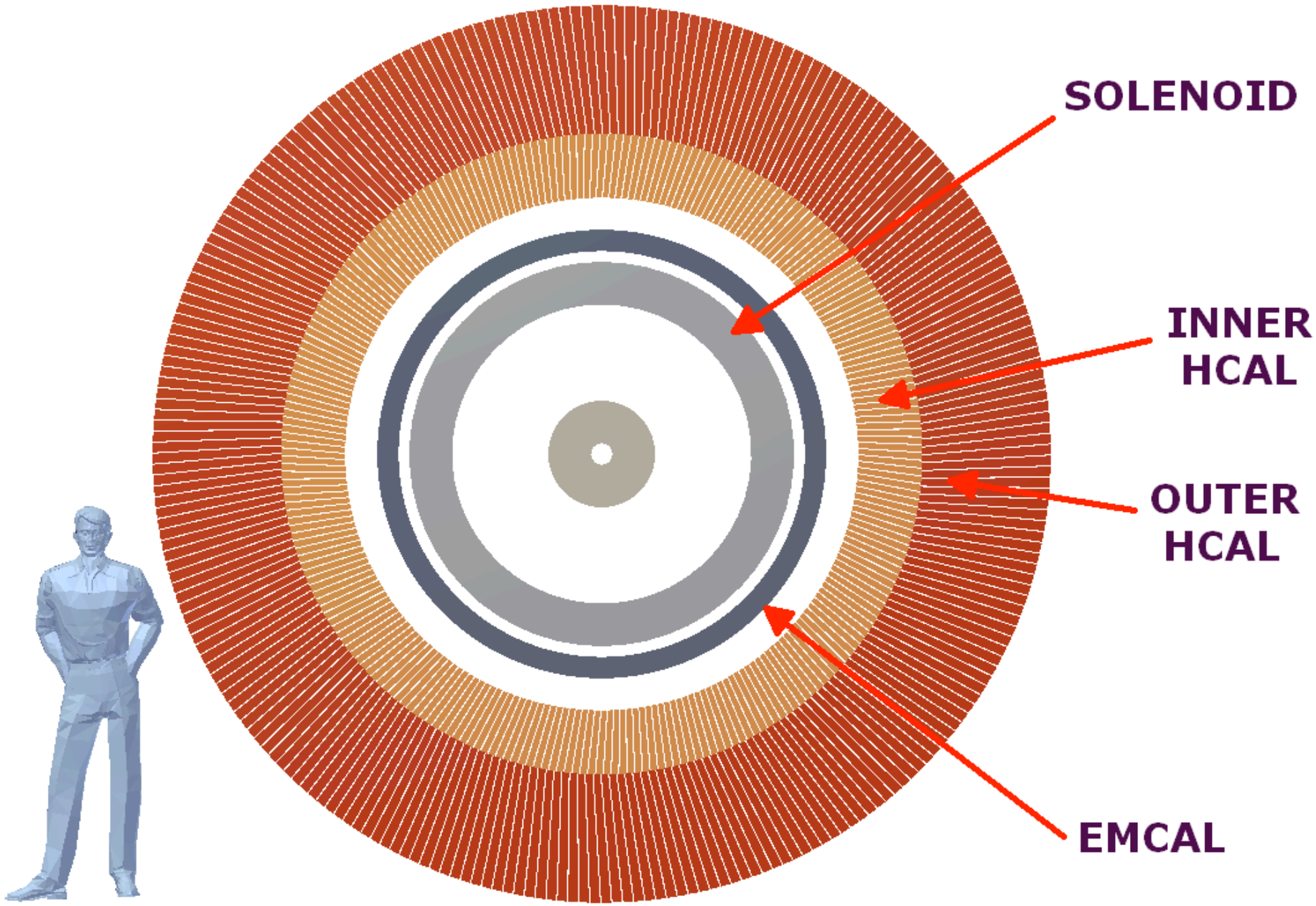
Sensitivity to the effective constituents of the QGP?



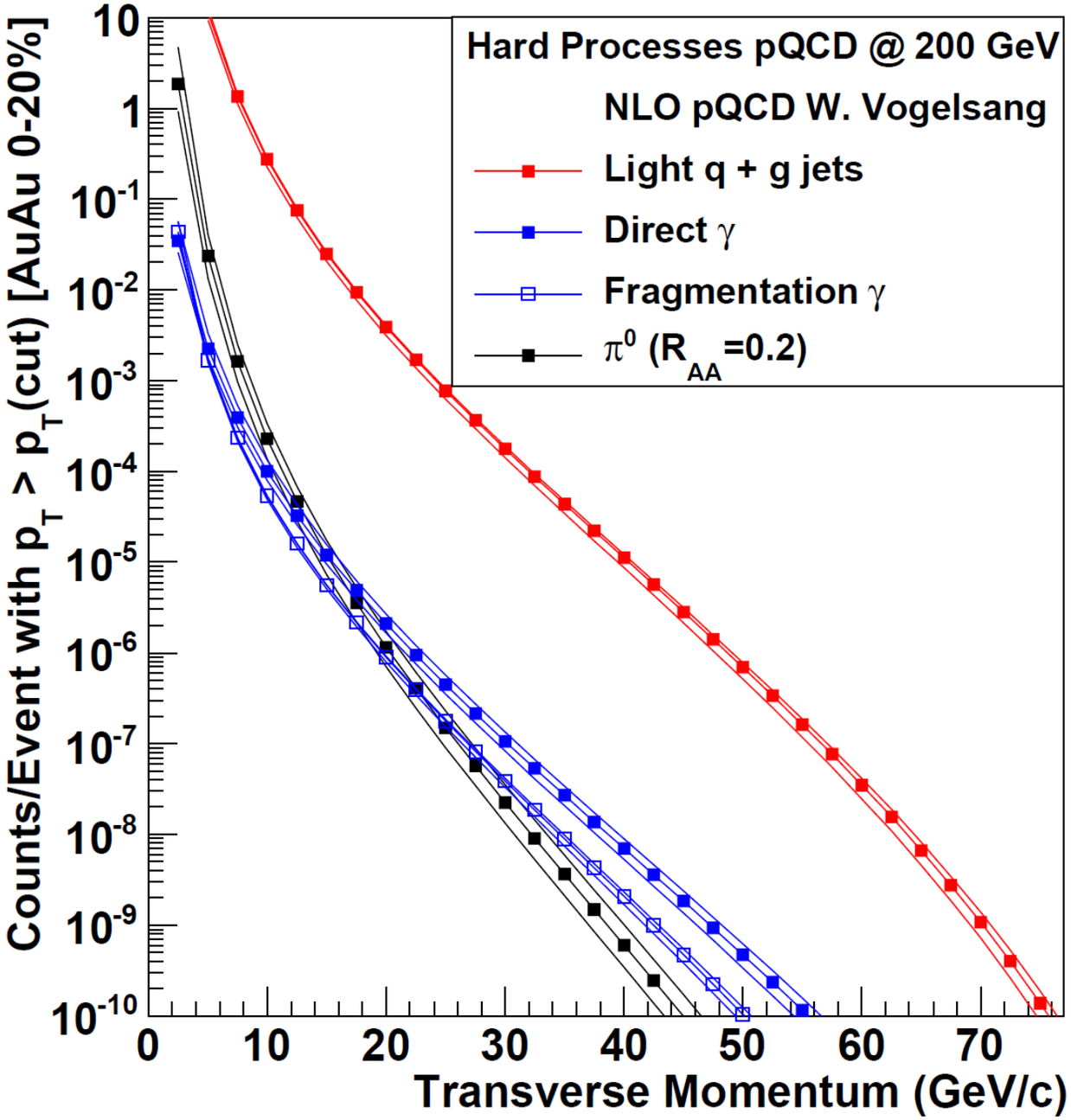
sPHENIX stage I design

Make use of new technologies to get something that is:

- compact (cheap)
- uniform
- fast



Rates at RHIC for 20 week Run



Huge rates allow differential measurements <u>with</u> geometry (v_2, v_3, A+B, U+U, …)
precise control measurements (d+Au & p+p).
Over 80% as dijets into $|\eta|<1$

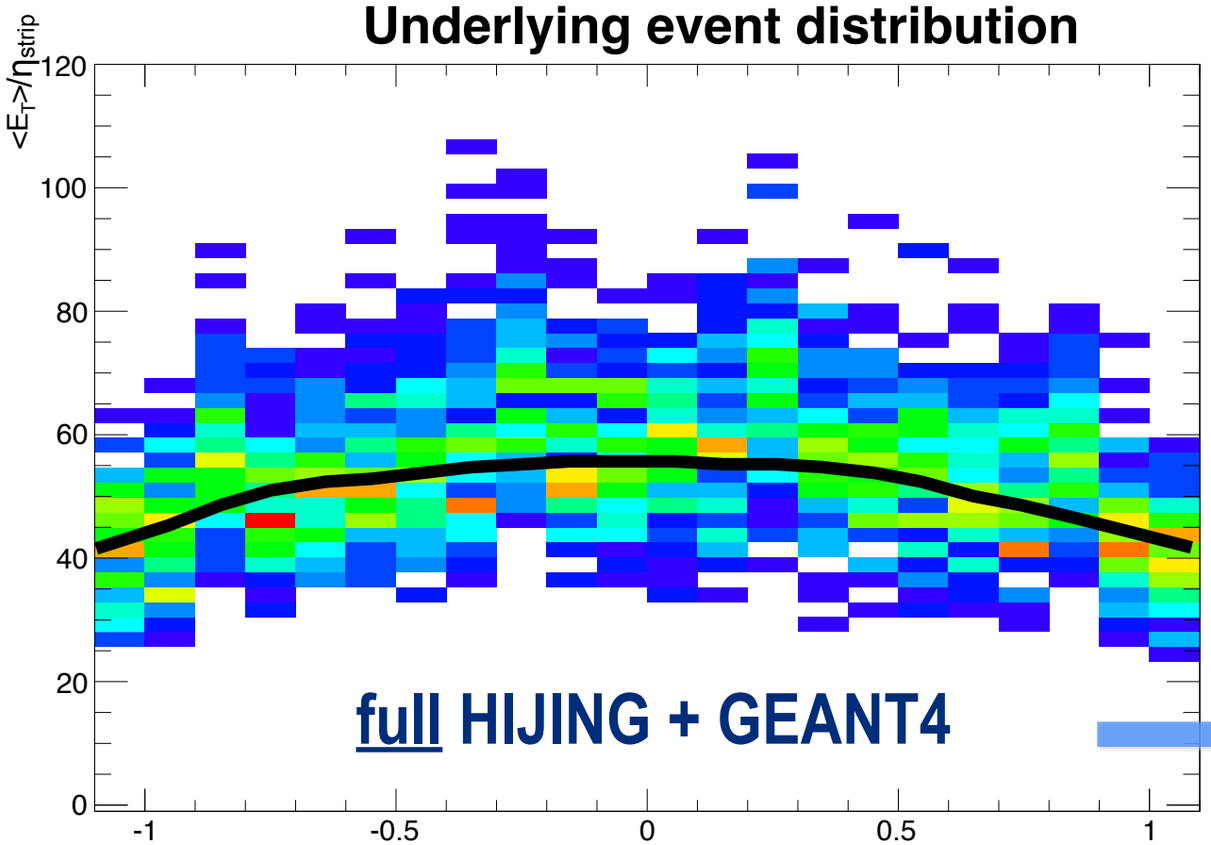
	Au+Au central 20%	p+p	d+Au
>20 GeV	10^7 jets 10^4 photons	10^6 jets 10^3 photons	10^7 jets 10^4 photons
>30 GeV	10^6 jets 10^3 photons	10^5 jets 10^2 photons	10^6 jets 10^3 photons
>40 GeV	10^5 jets	10^4 jets	10^5 jets
>50 GeV	10^4 jets	10^3 jets	10^4 jets

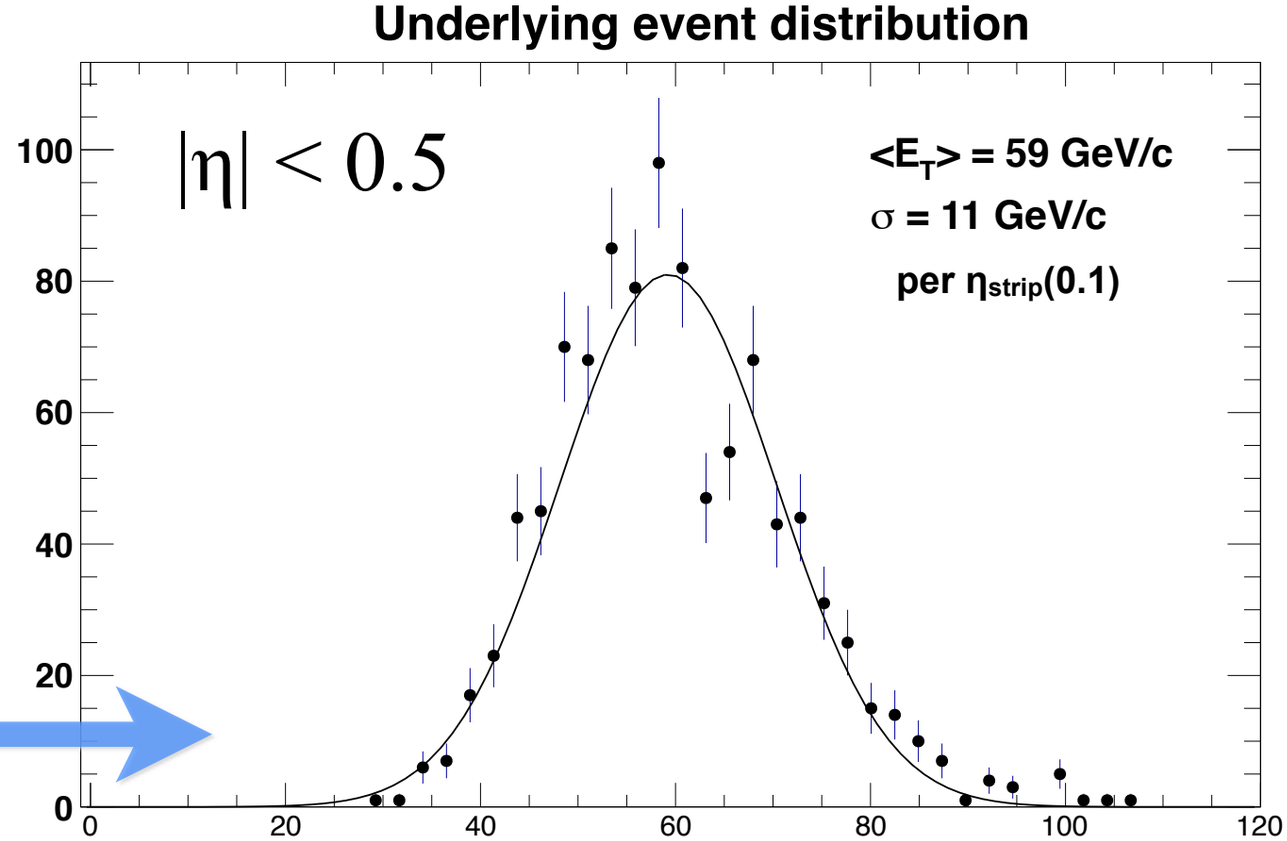
Cu+Au ~ Au+Au/5
U+U (tip-tip) ~ Au+Au/500

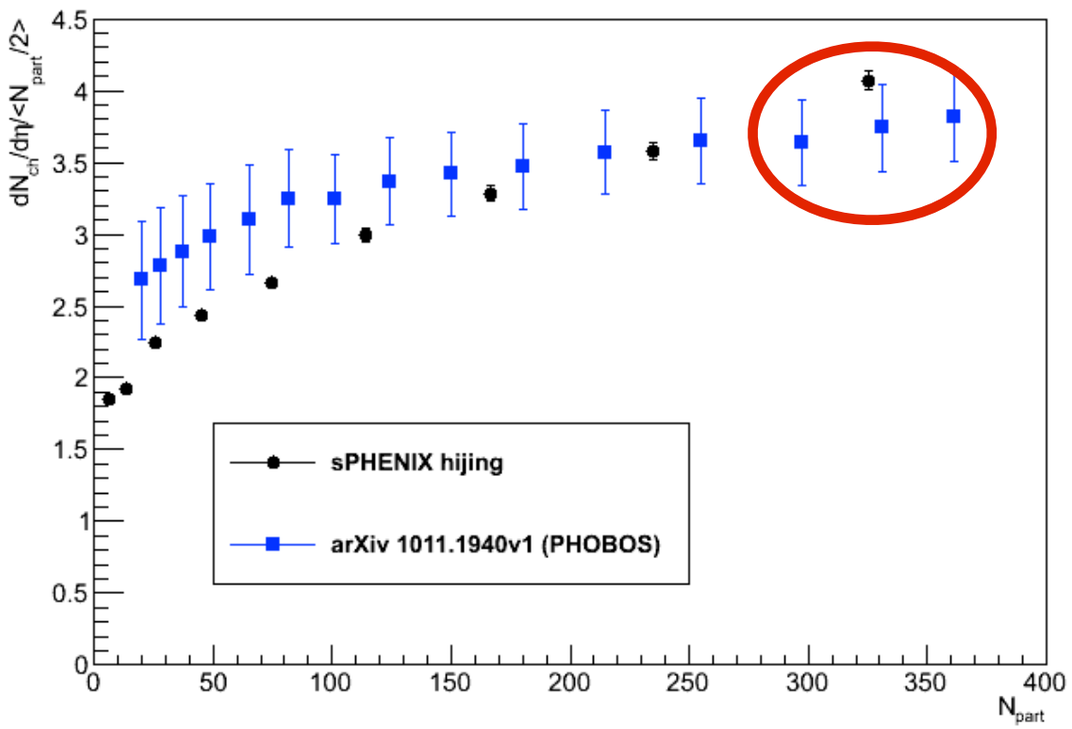
Only stochastic cooling of Au beams assumed

Greater rate and p_T reach than singles

Simulating 200 GeV Au+Au with HIJING







Clear η dependence for larger acceptance motivated ATLAS/CMS-like method

HIJING seems to get overall multiplicities correct for RHIC energies

Large background/fluctuations motivate careful study of subtractions and fake rates

Iterative jet finding algorithm

Run jet reco (anti-k_T) algorithm on 0.1x0.1 calorimeter cells

inspired by ATLAS

J.A. Hanks et al., Phys. Rev. C 86, 024908 (2012), arXiv:1203:1353

Iterative jet finding algorithm

Run jet reco (anti-k_T) algorithm on 0.1x0.1 calorimeter cells

Determine set of R=0.2 seed jets

1st pass: towers in jet satisfy $\frac{E_{T,max}}{< E_T >} > 3$

2nd pass: jet $E_T > 20$

Determine v_2 for event

- exclude towers within $\Delta\eta < 0.4$ of seed jet

Determine background E_T in η strips

- demodulate by v_2
- exclude towers within $\Delta R < 0.4$ of seed jet

Subtract background from jets tower-by-tower

- first remodulate background by v_2

Subtract background from event tower-by-tower

- first remodulate background by v_2

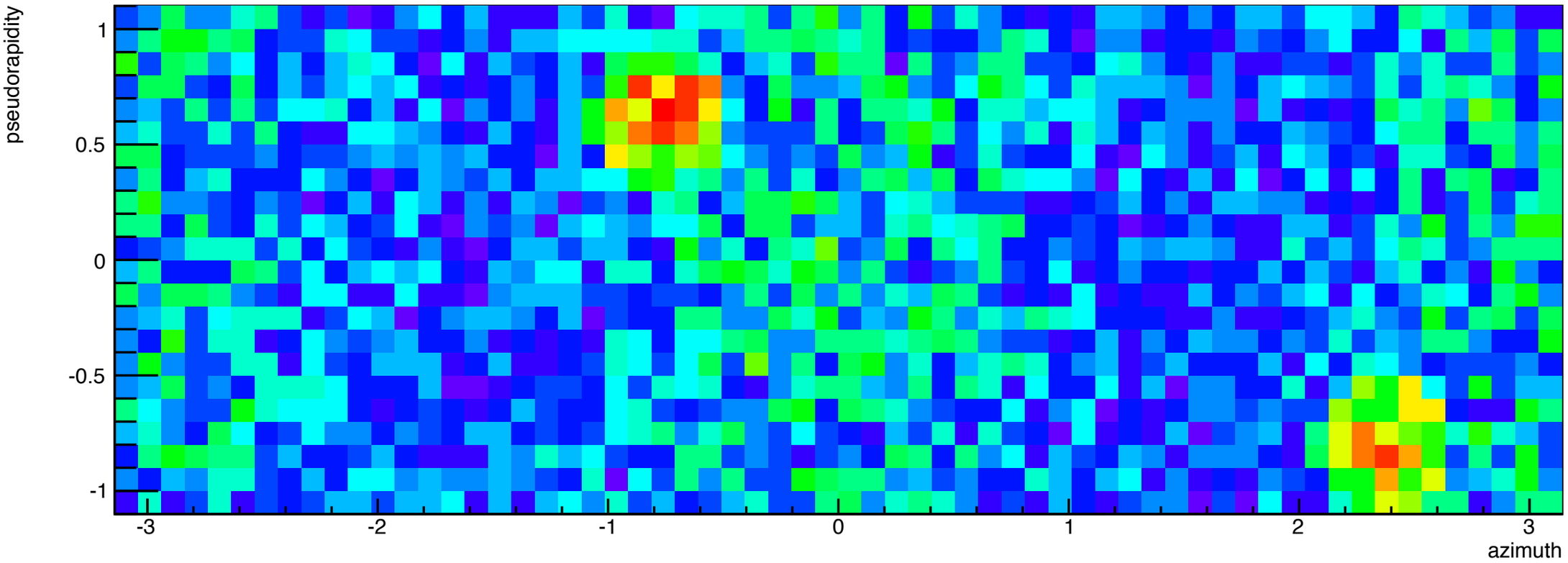
Run jet reco algorithm

Output: background subtracted reco jets of various R values

inspired by ATLAS

J.A. Hanks et al., Phys. Rev. C 86, 024908 (2012), arXiv:1203:1353

Stepping through the subtraction procedure



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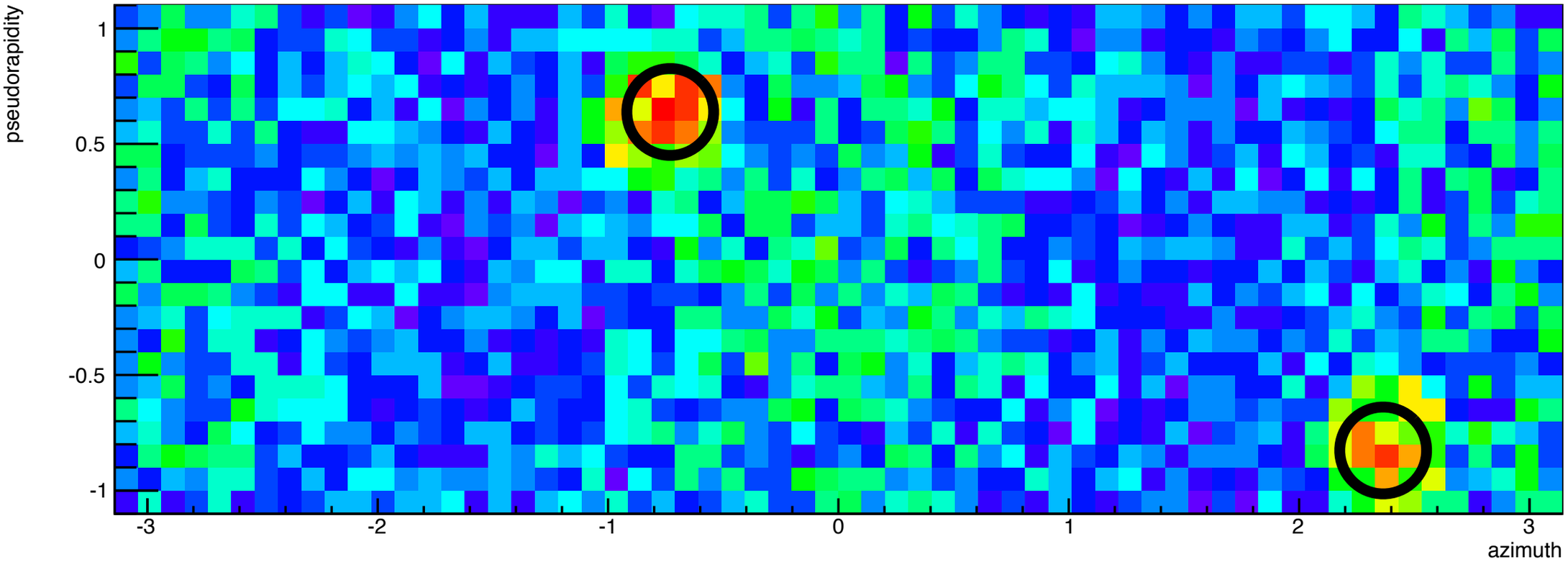

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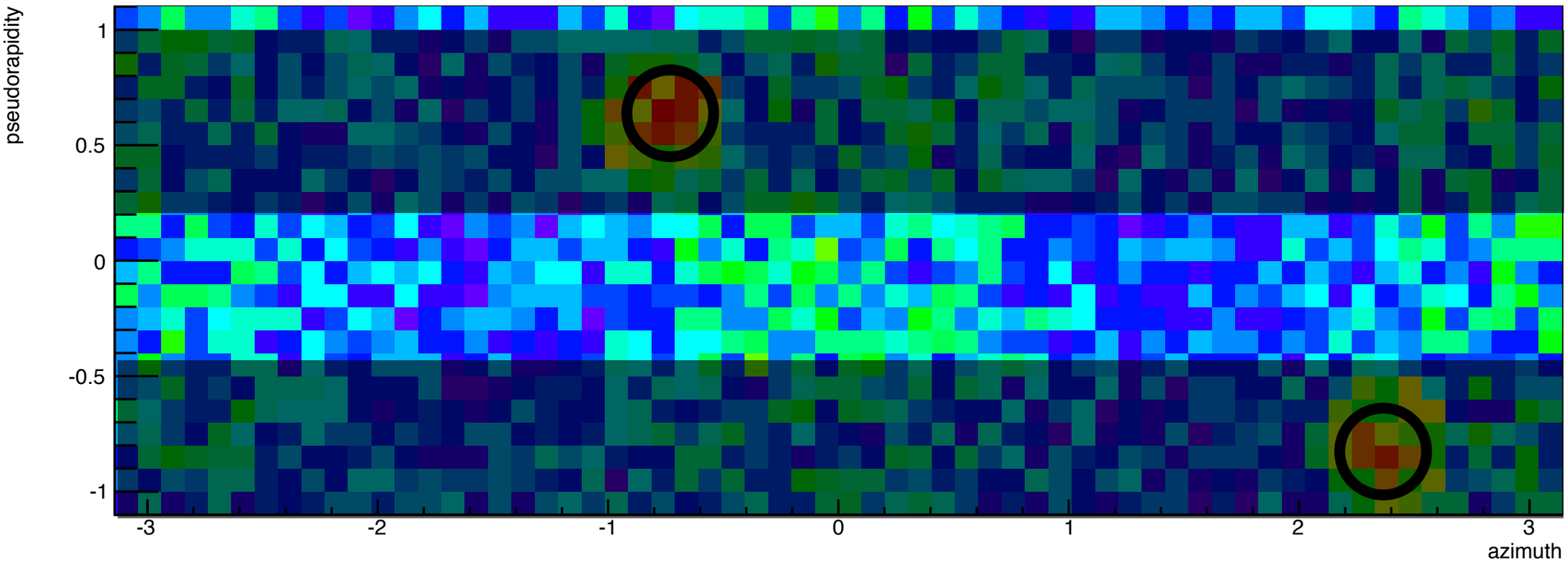

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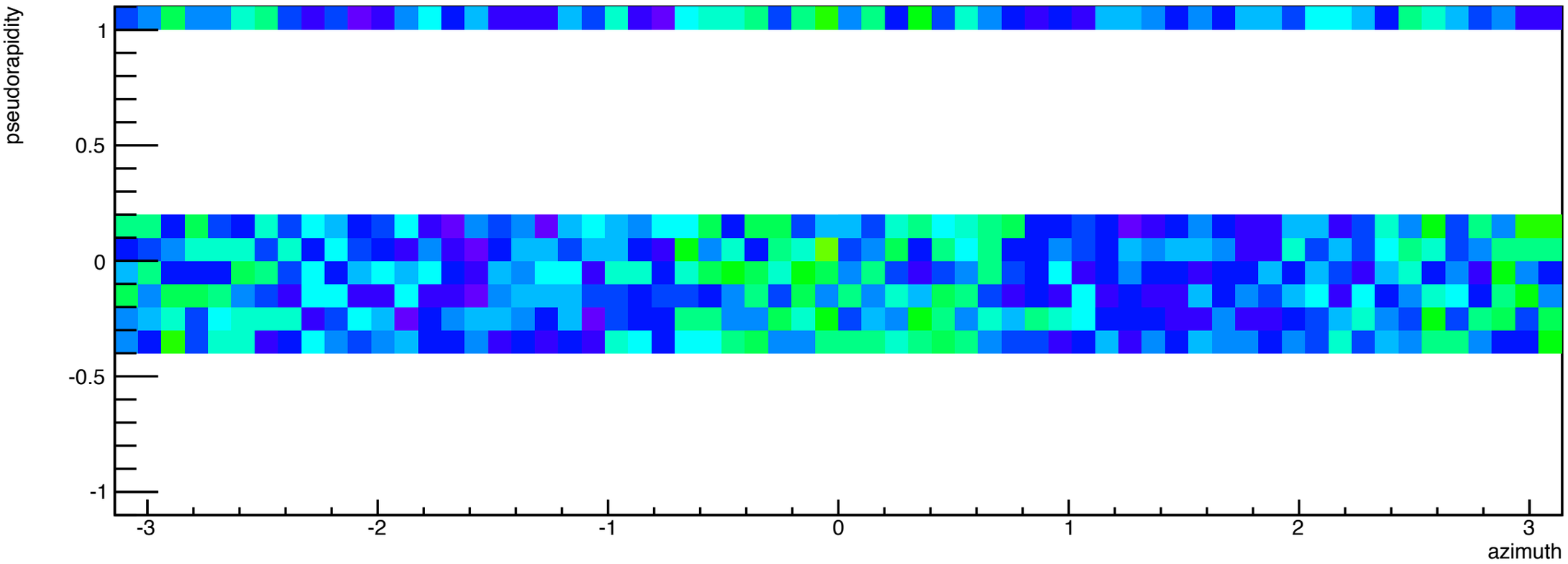

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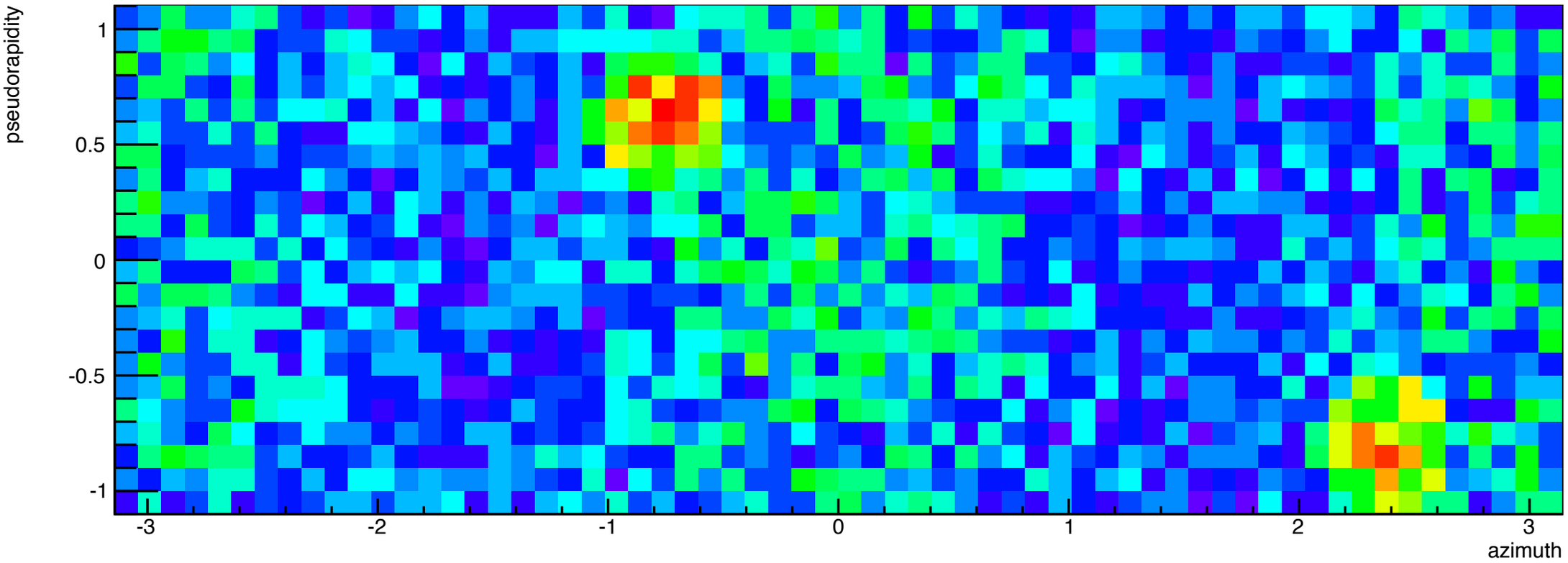

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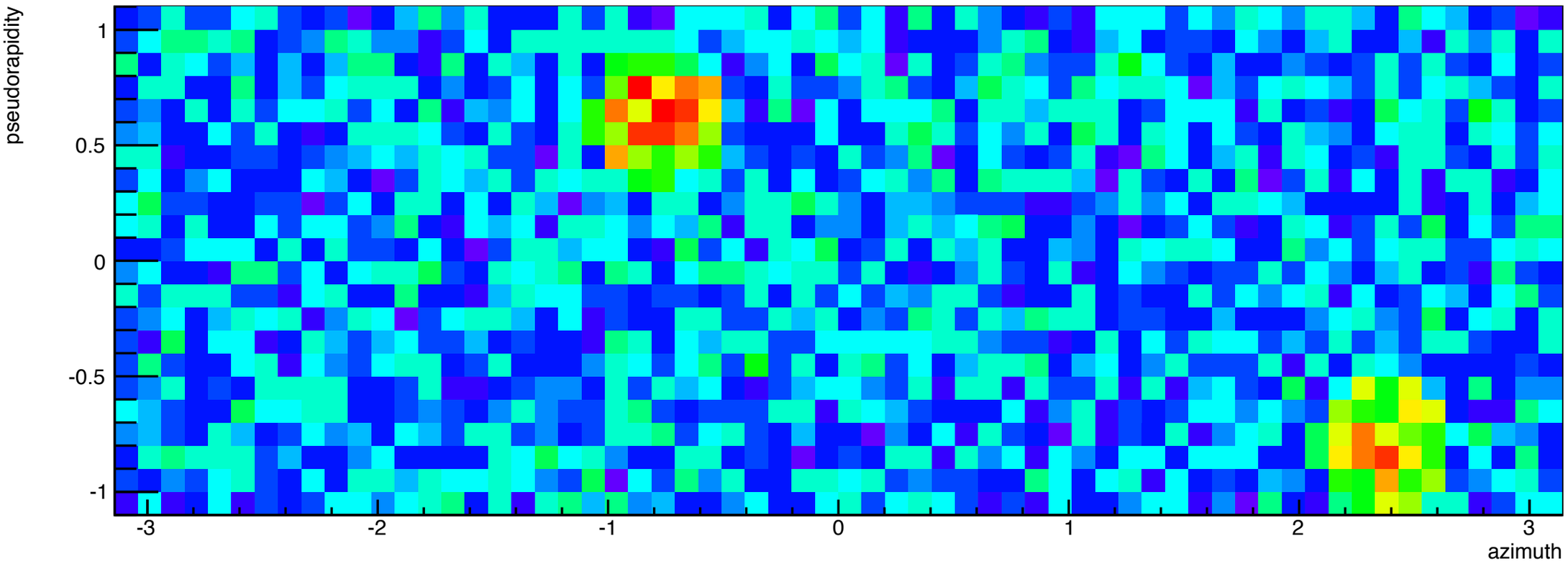

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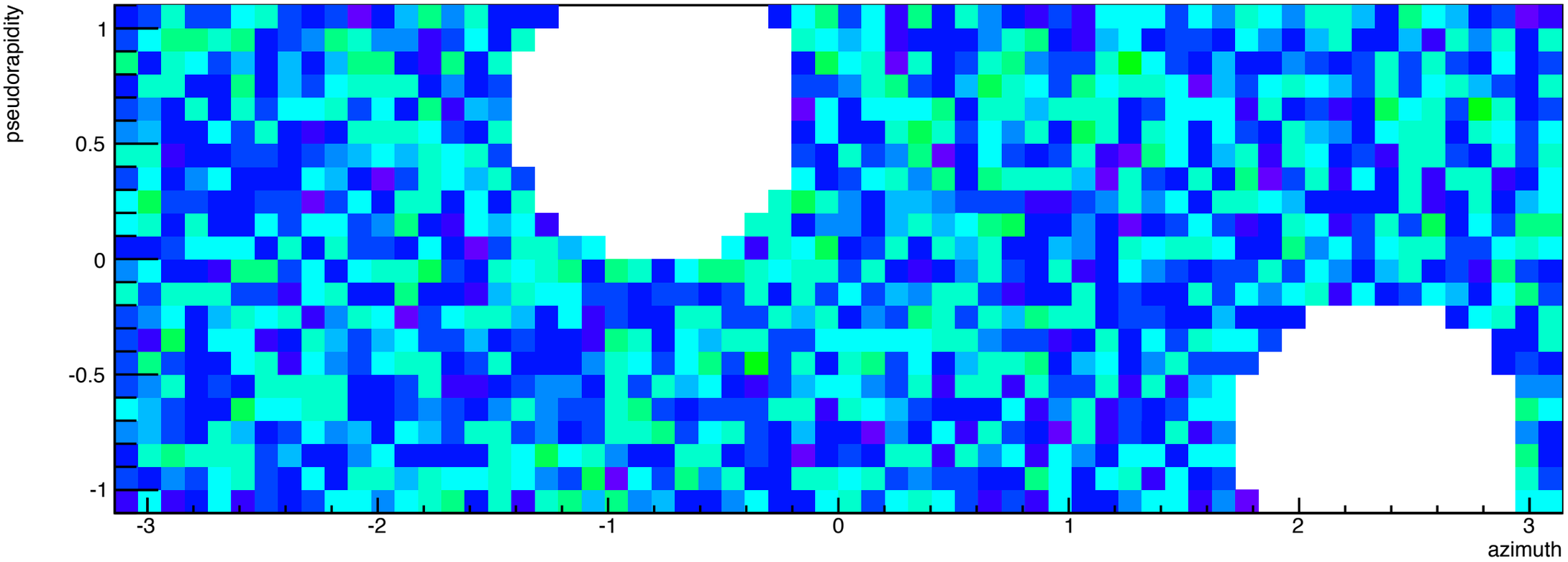

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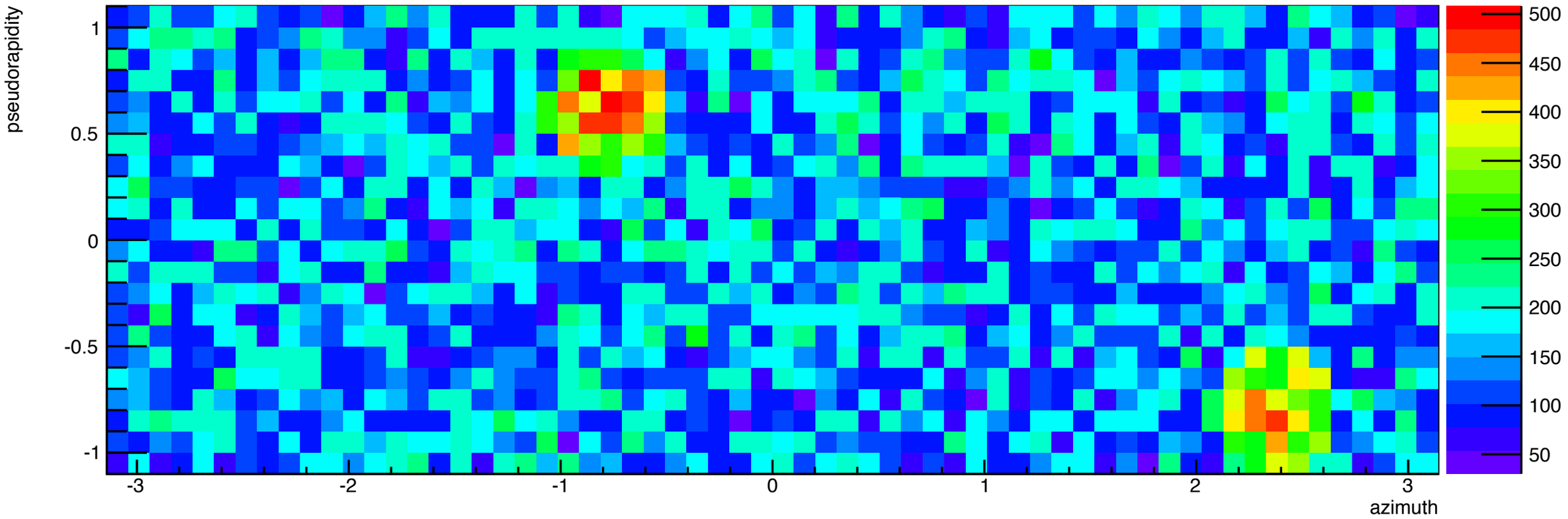

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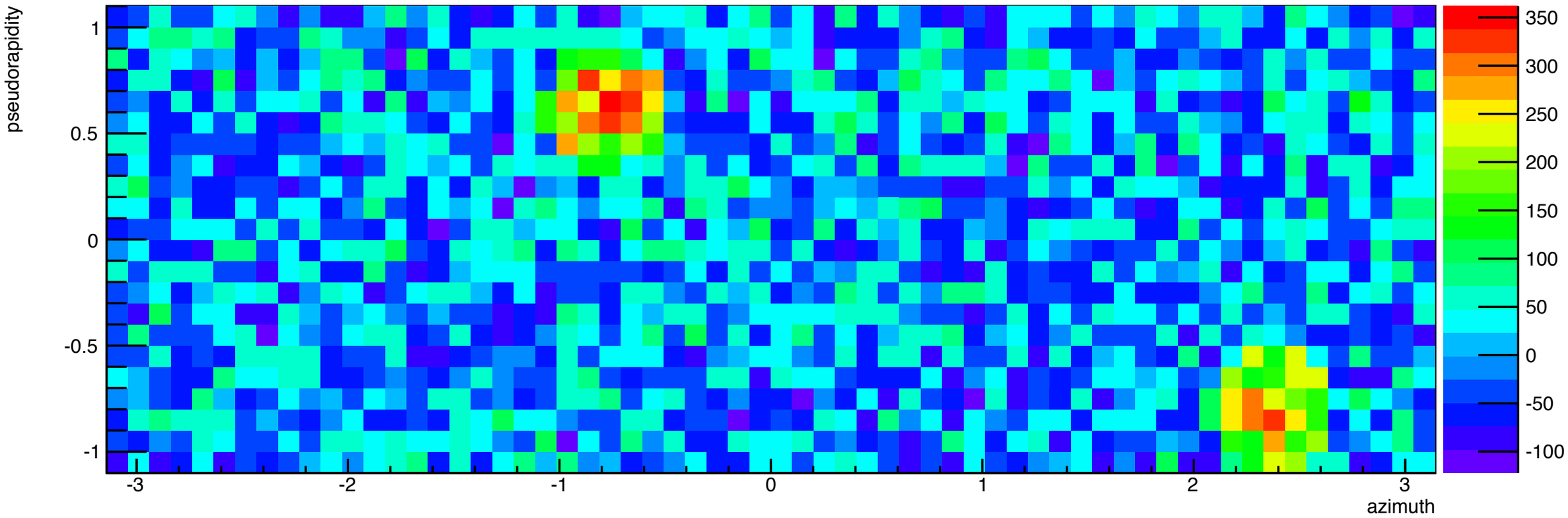

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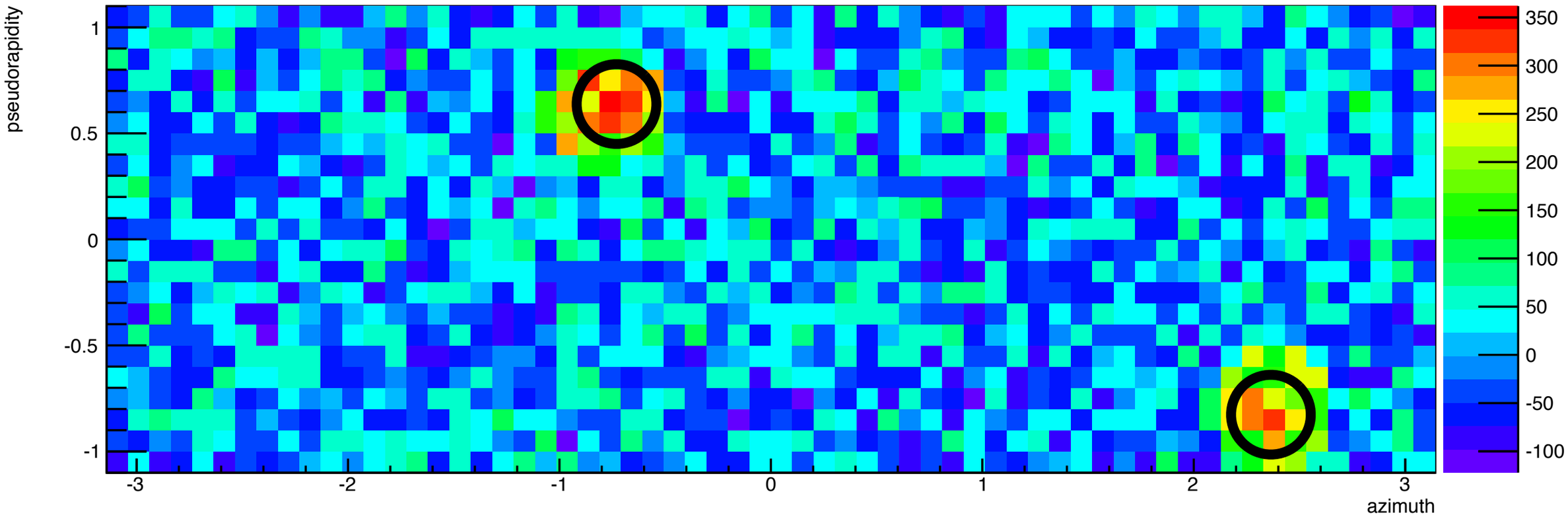
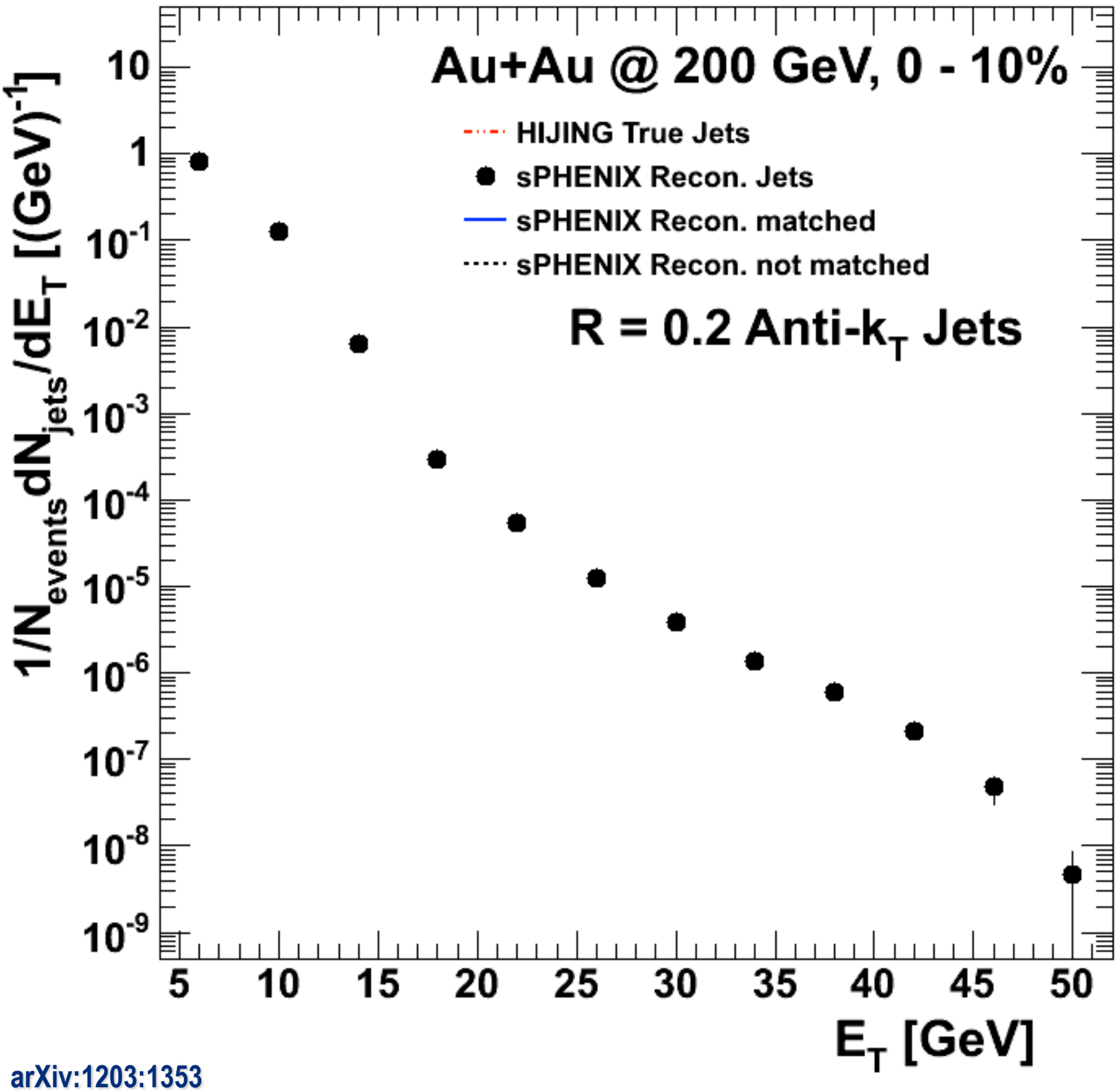


Fake Jets at RHIC (R=0.2)



arXiv:1203:1353

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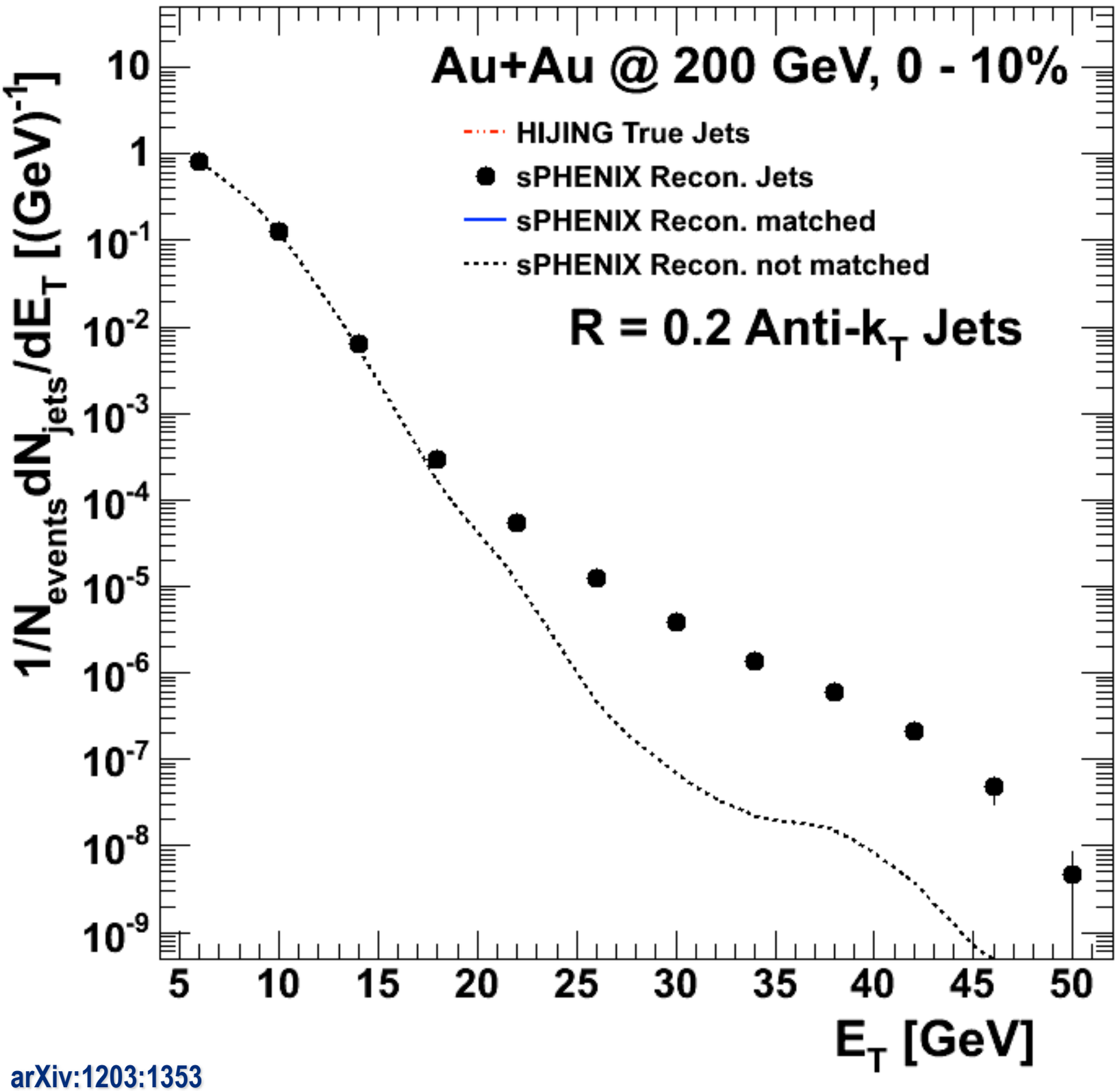

not matched jets:
no nearby HIJING jets
"fakes"

arXiv:1203:1353

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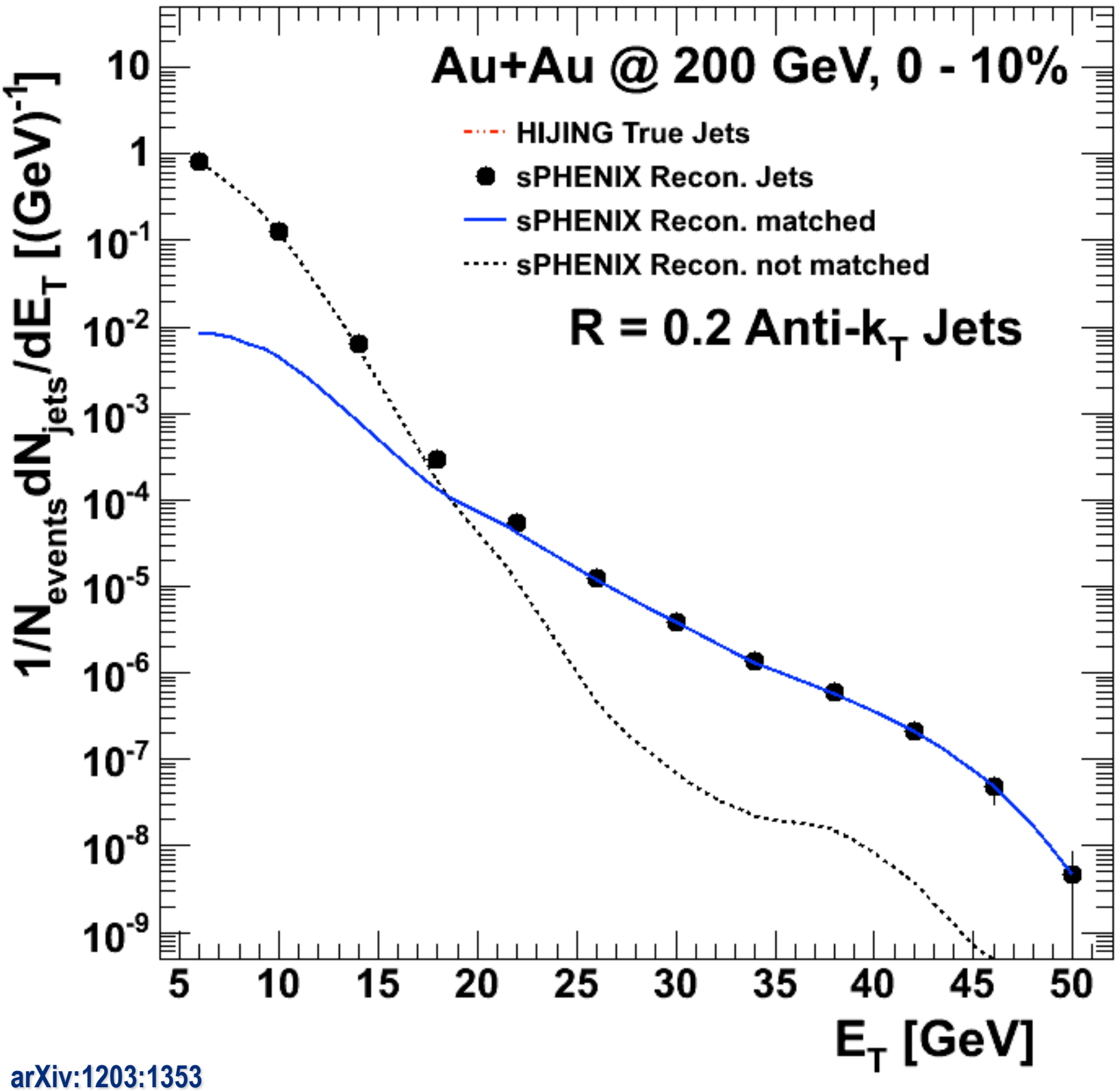

not matched jets:
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matched jets:
within ΔR< 0.25 of a
HIJING truth jet (>5GeV)

arXiv:1203:1353

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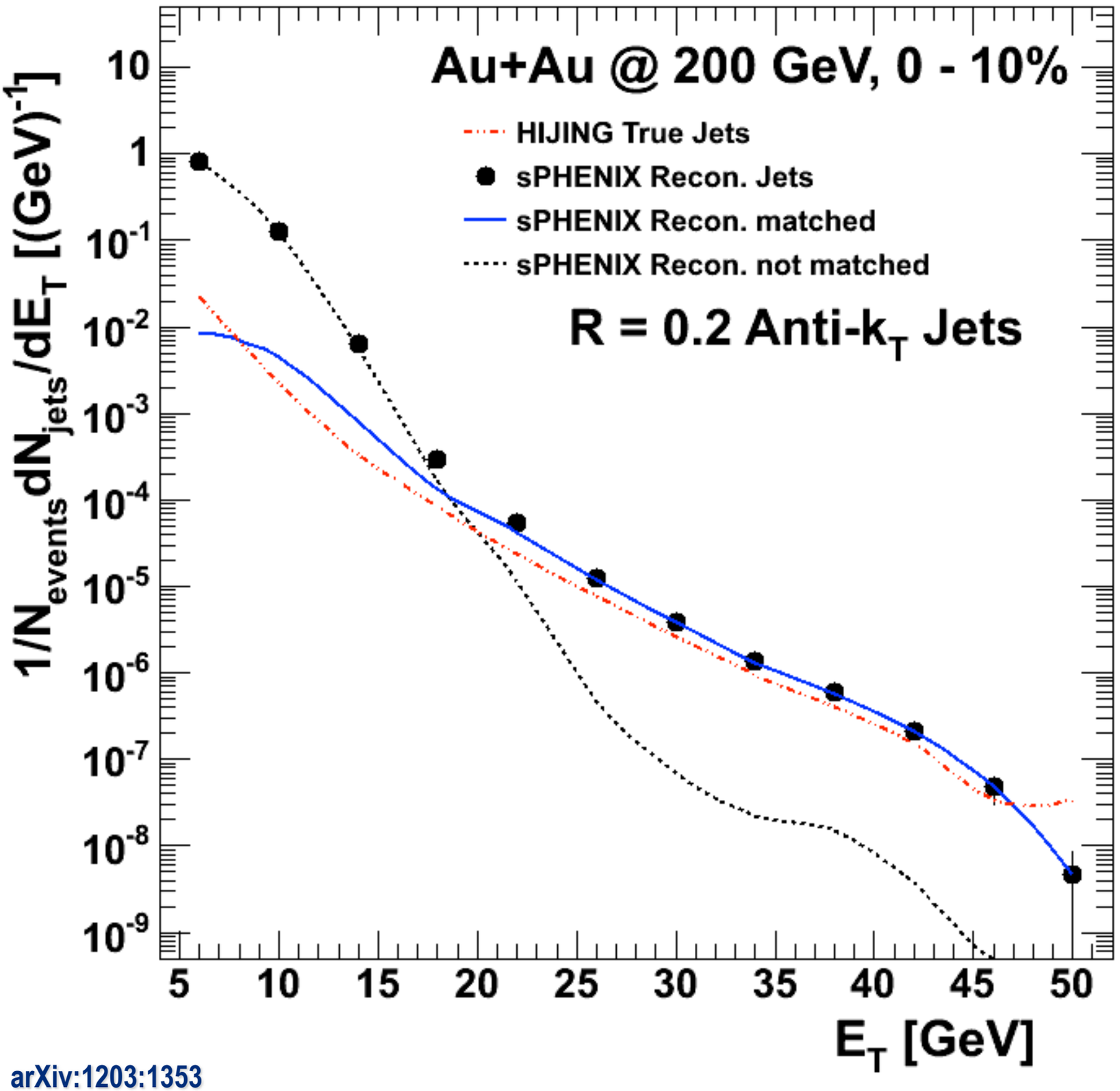


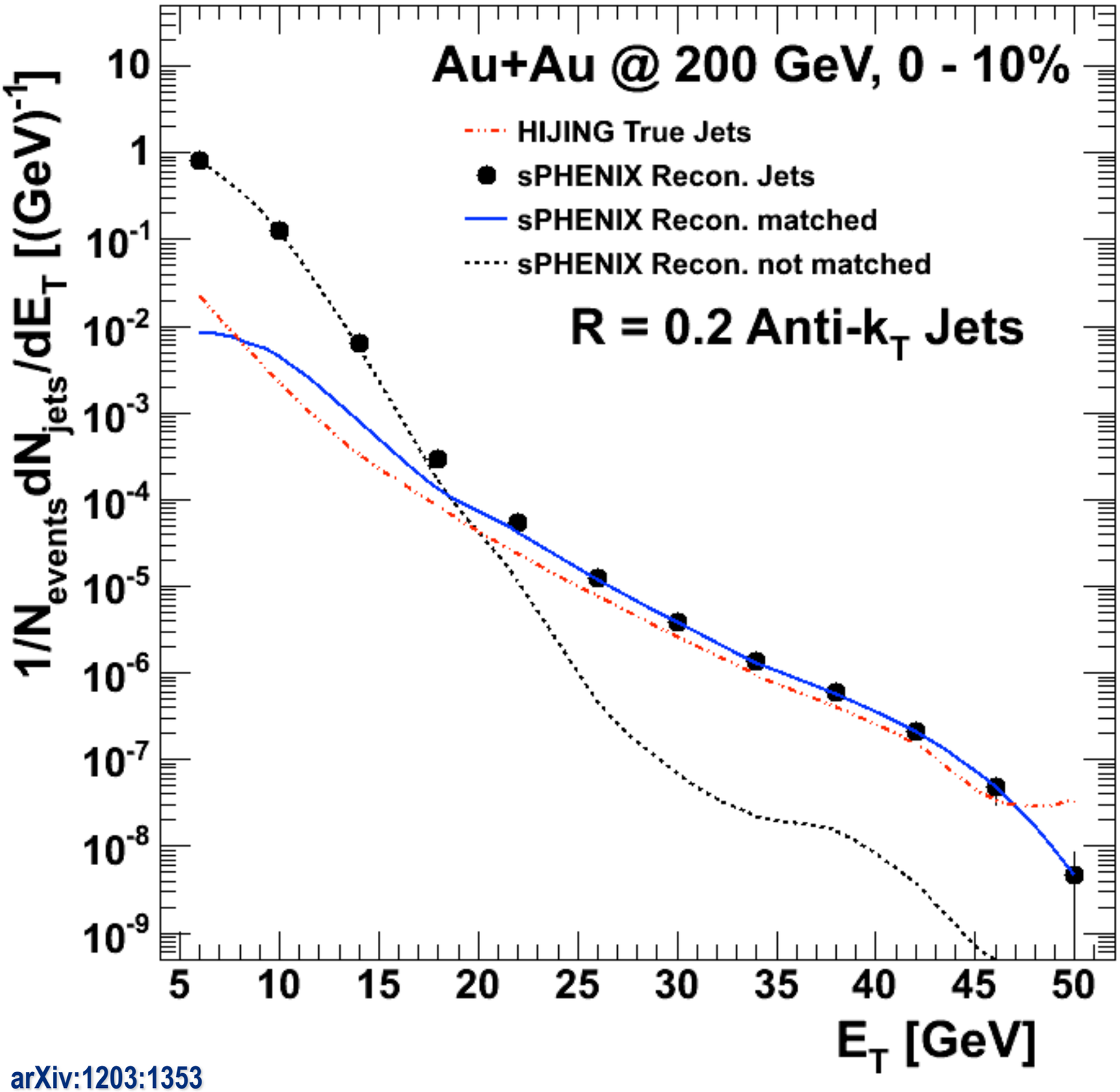
not matched jets:
no nearby HIJING jets
"fakes"

matched jets:
within ΔR< 0.25 of a HIJING truth jet (>5GeV)

HIJING true jets:
reconstruct jets directly from simulated fragmentation

arXiv:1203:1353

Fake Jets at RHIC (R=0.2)



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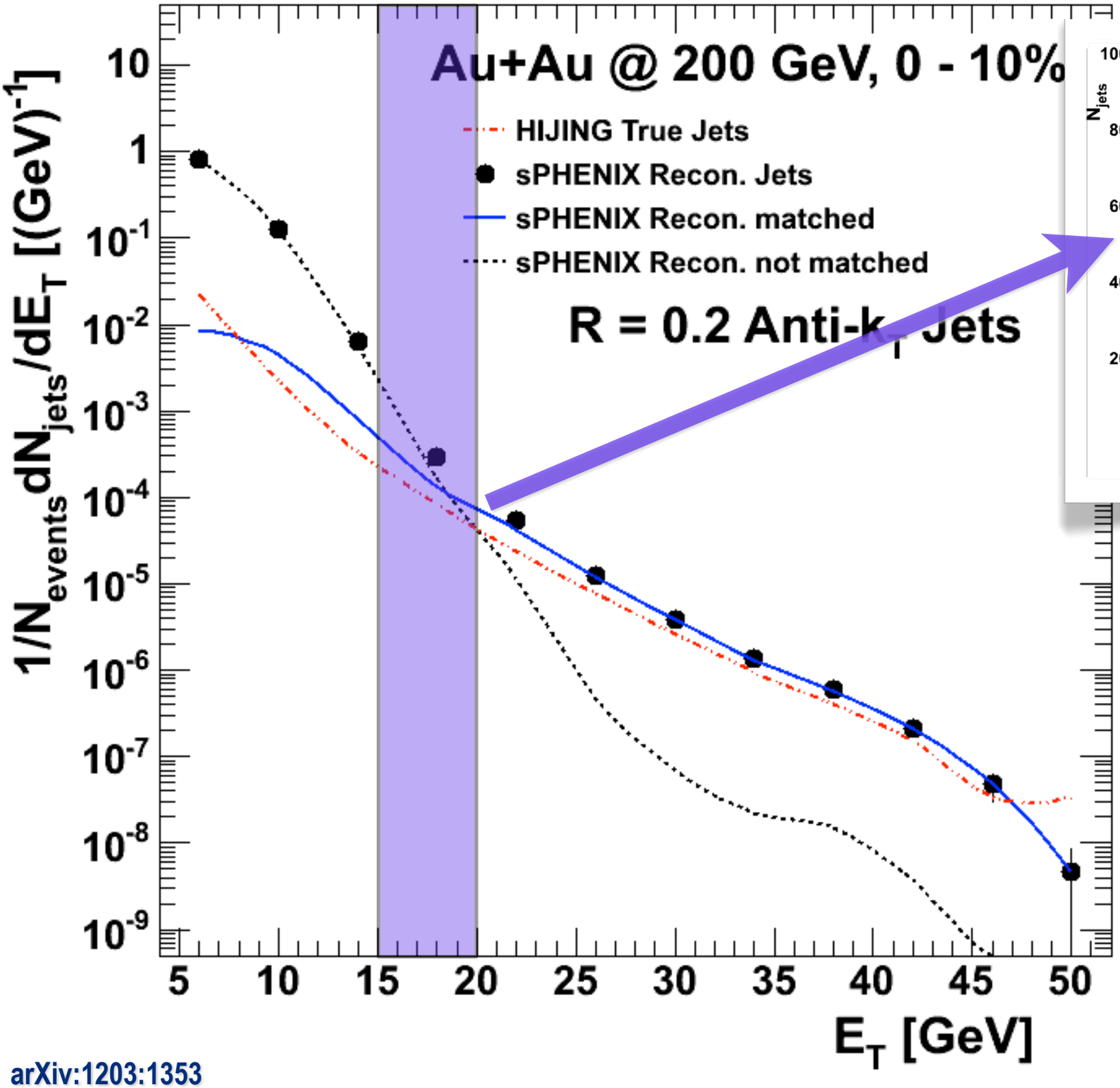

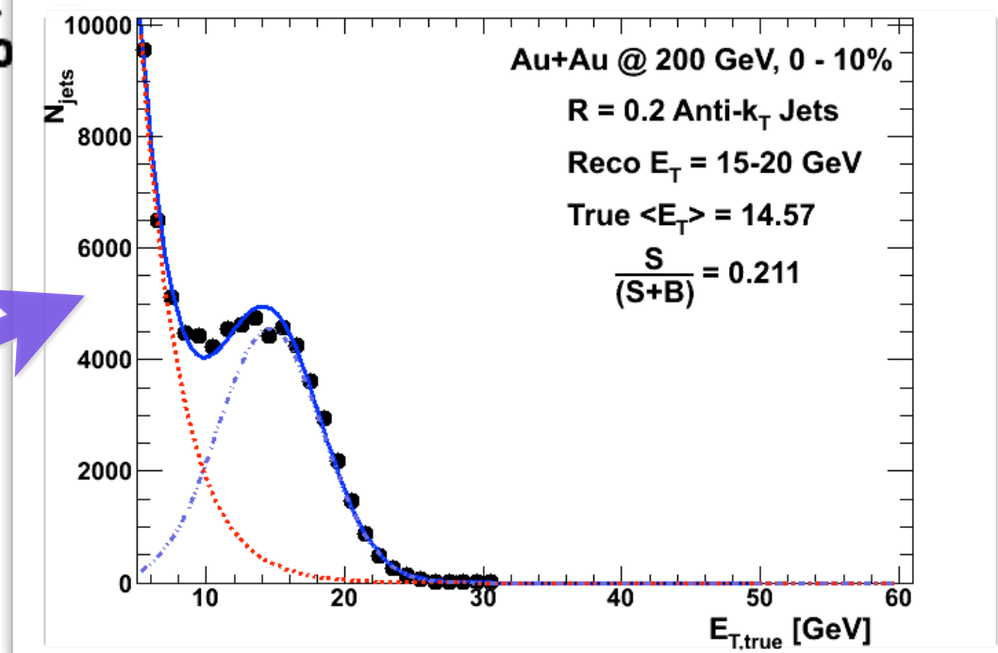

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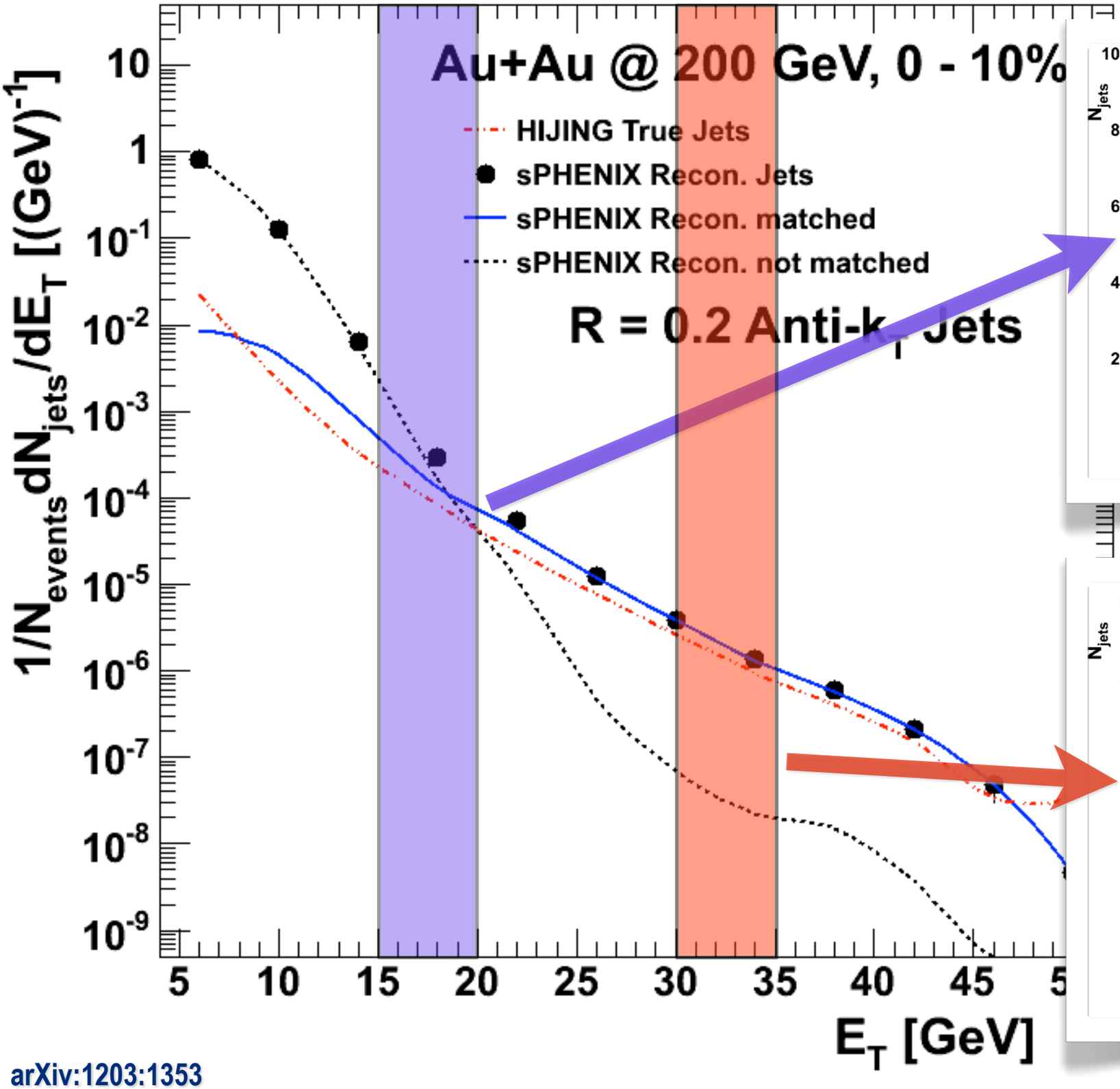
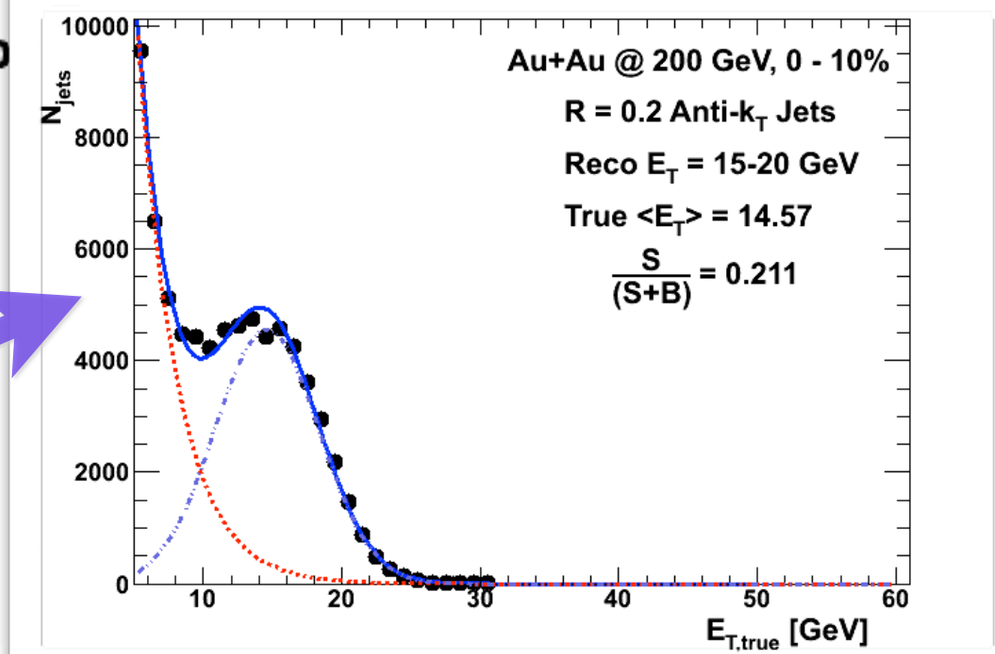
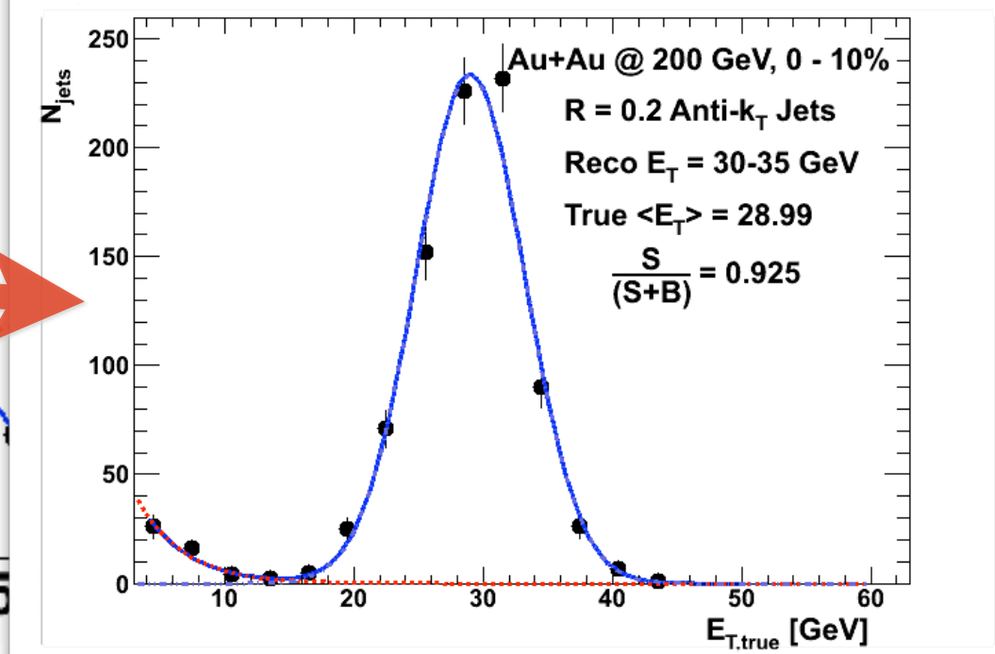
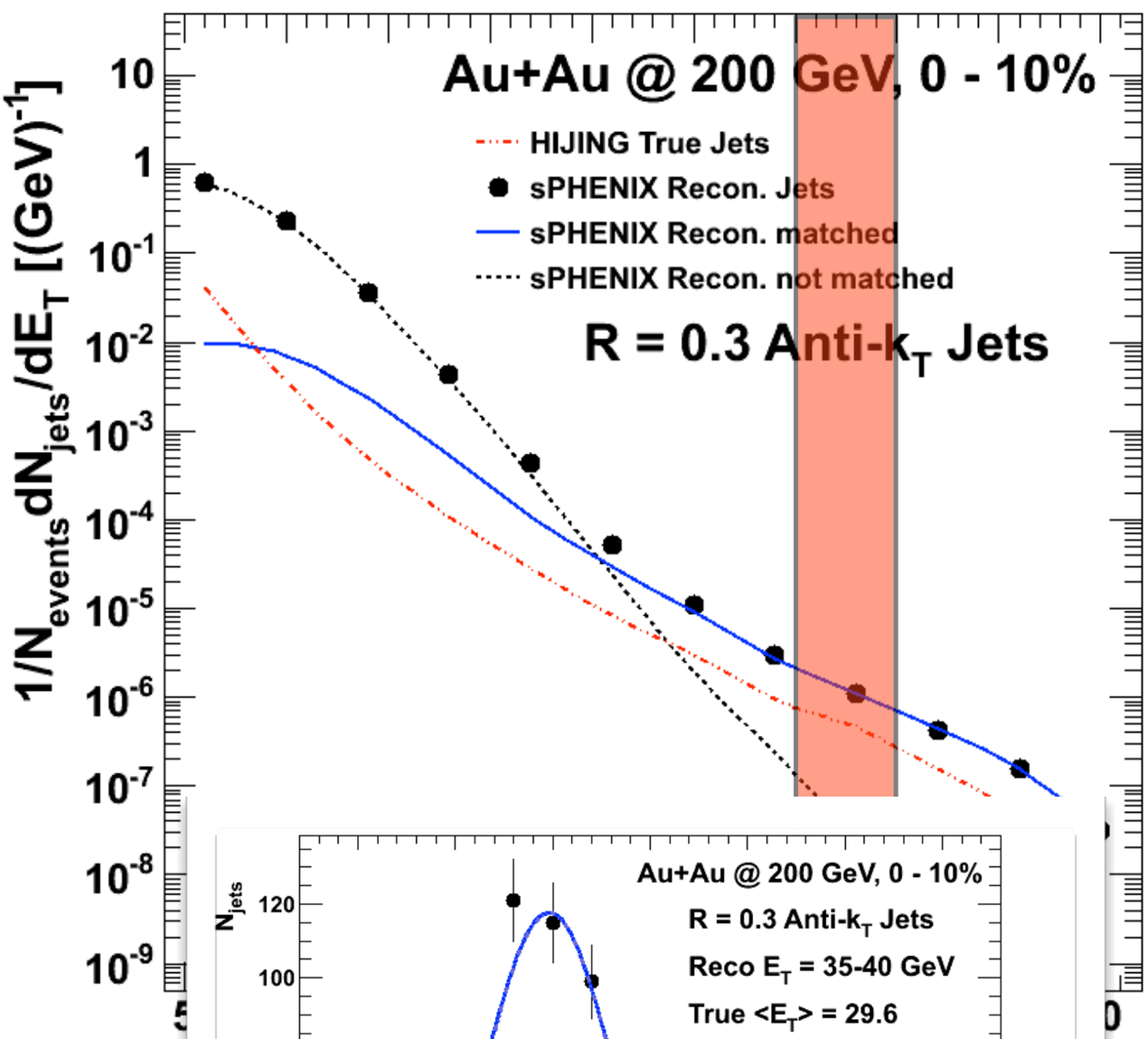


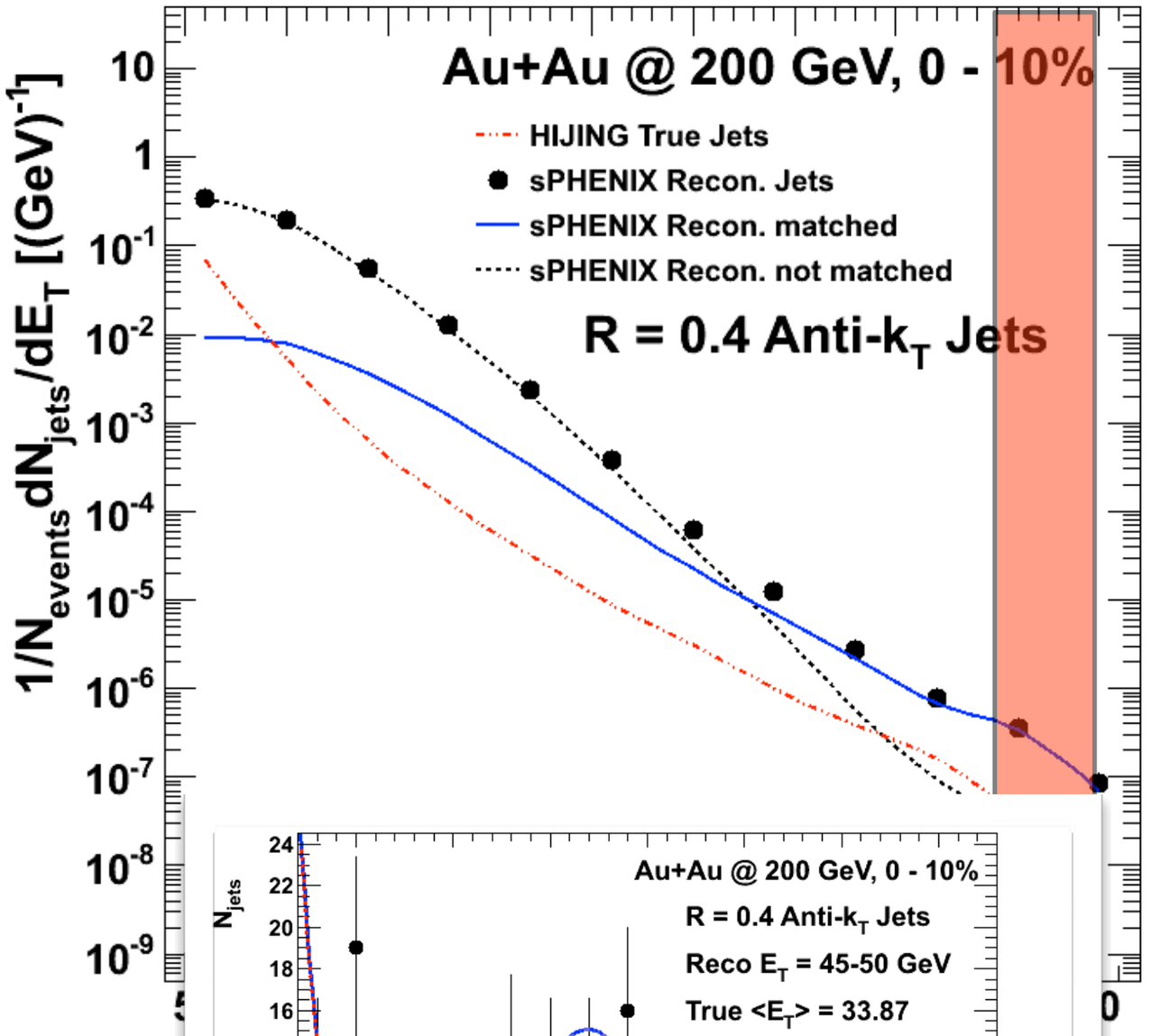




arXiv:1203:1353

Fake Jets at RHIC vs R



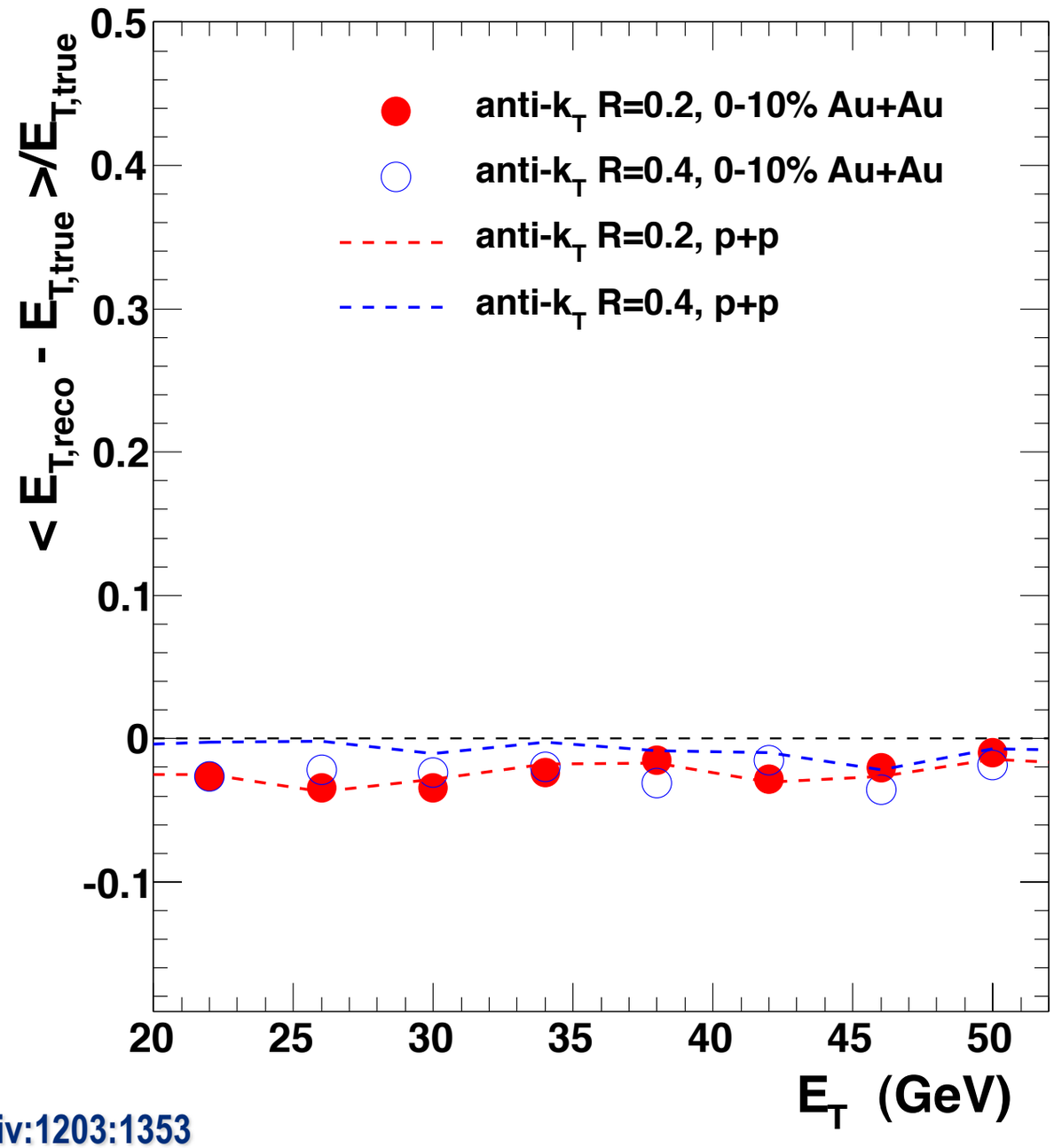


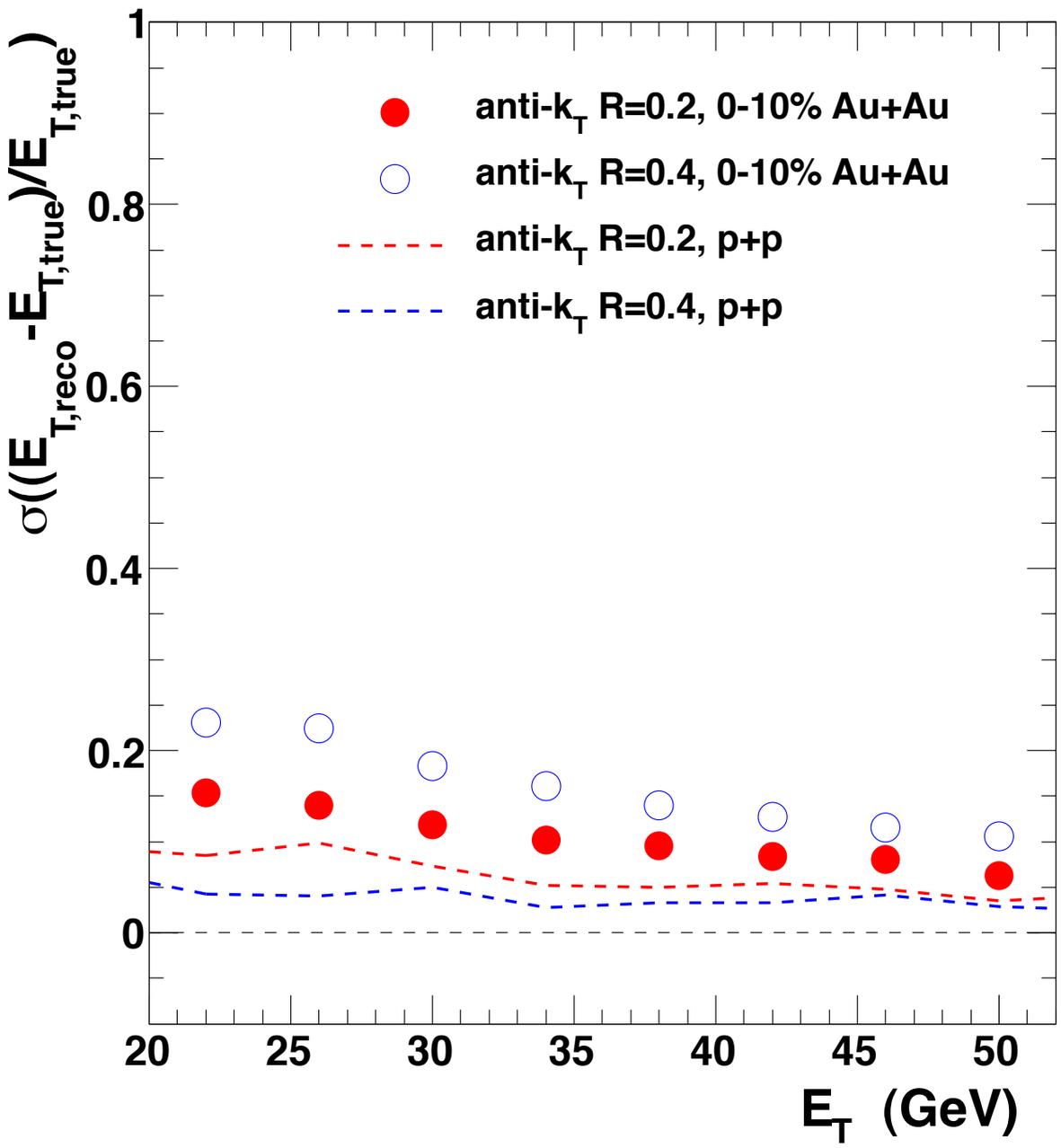
arXiv:1203:1353

How well are we doing for real jets?

Embed PYTHIA jets in HIJING background

p+p shows effect of discretizing PYTHIA





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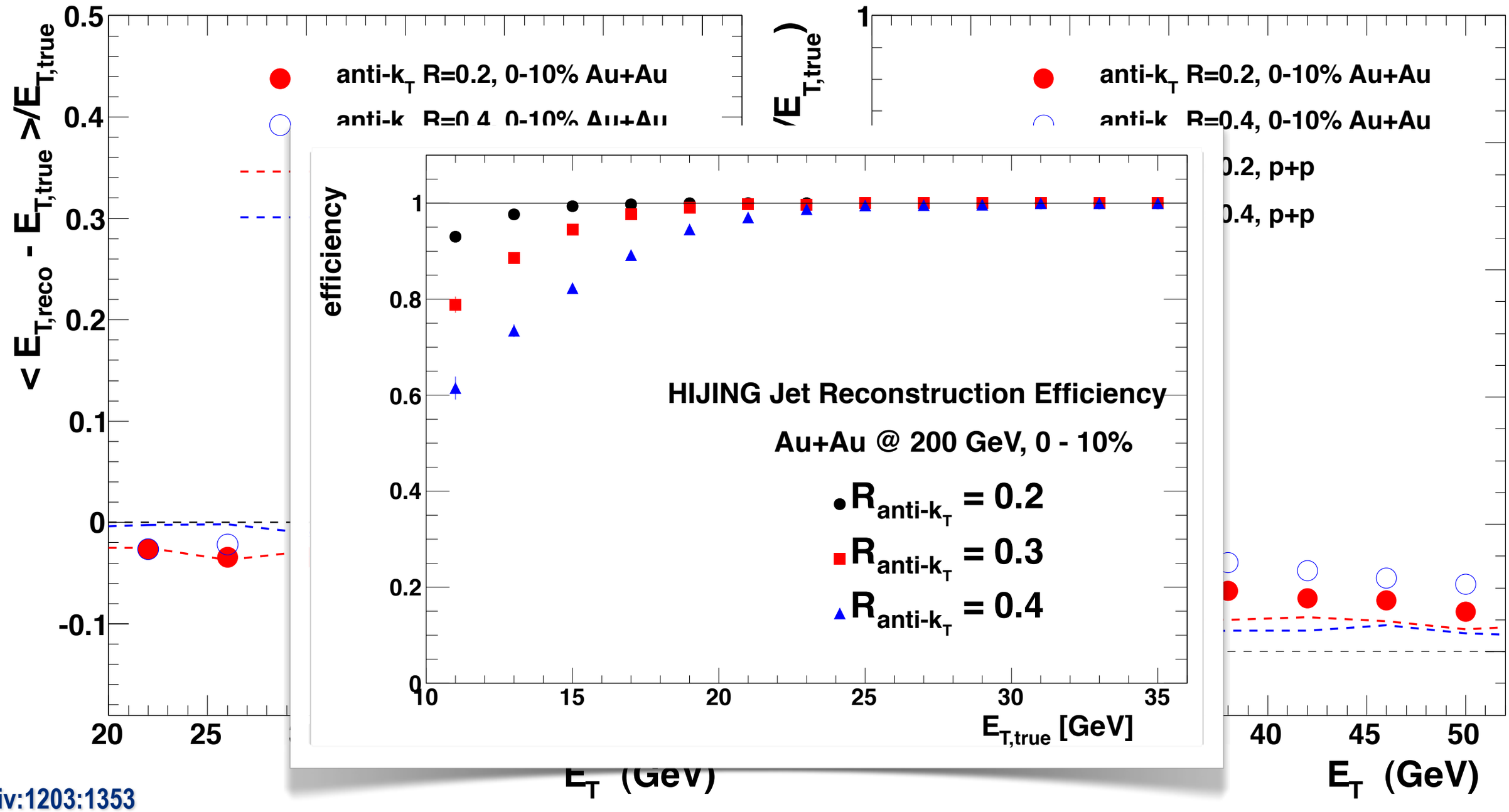
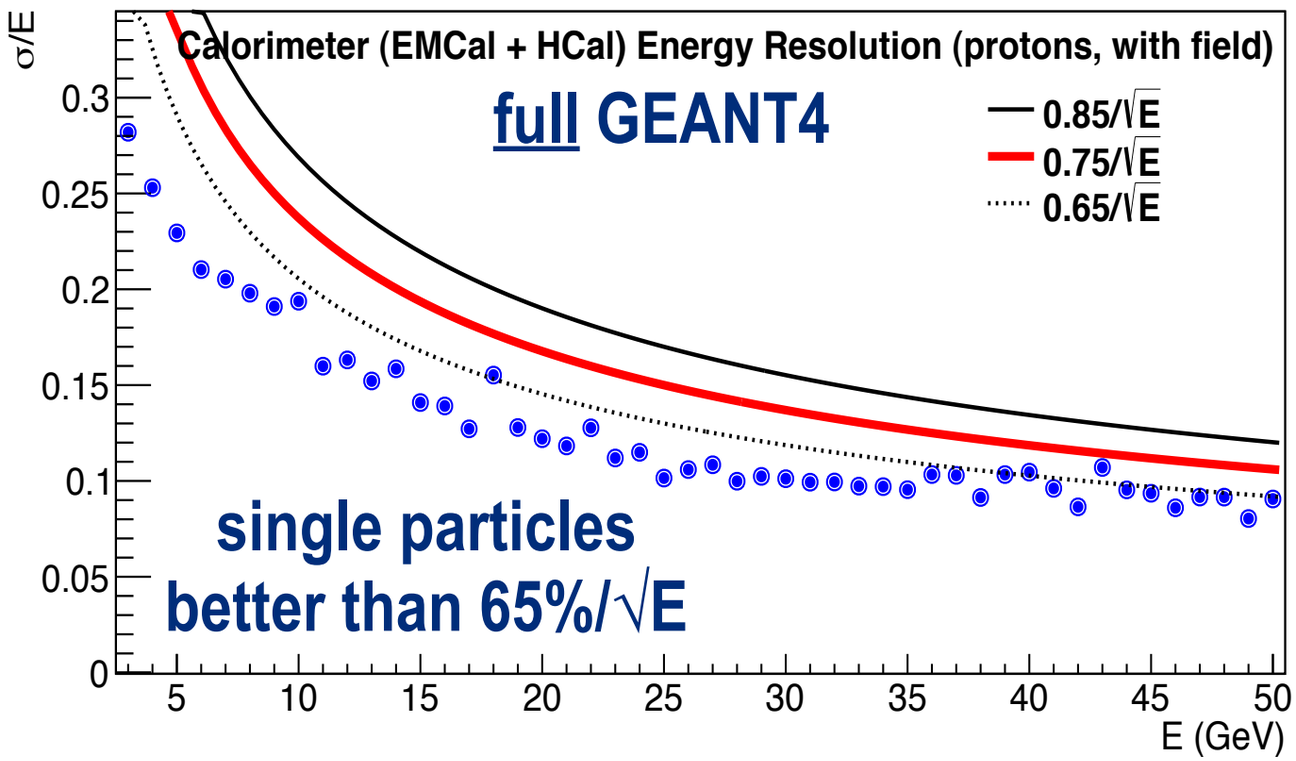
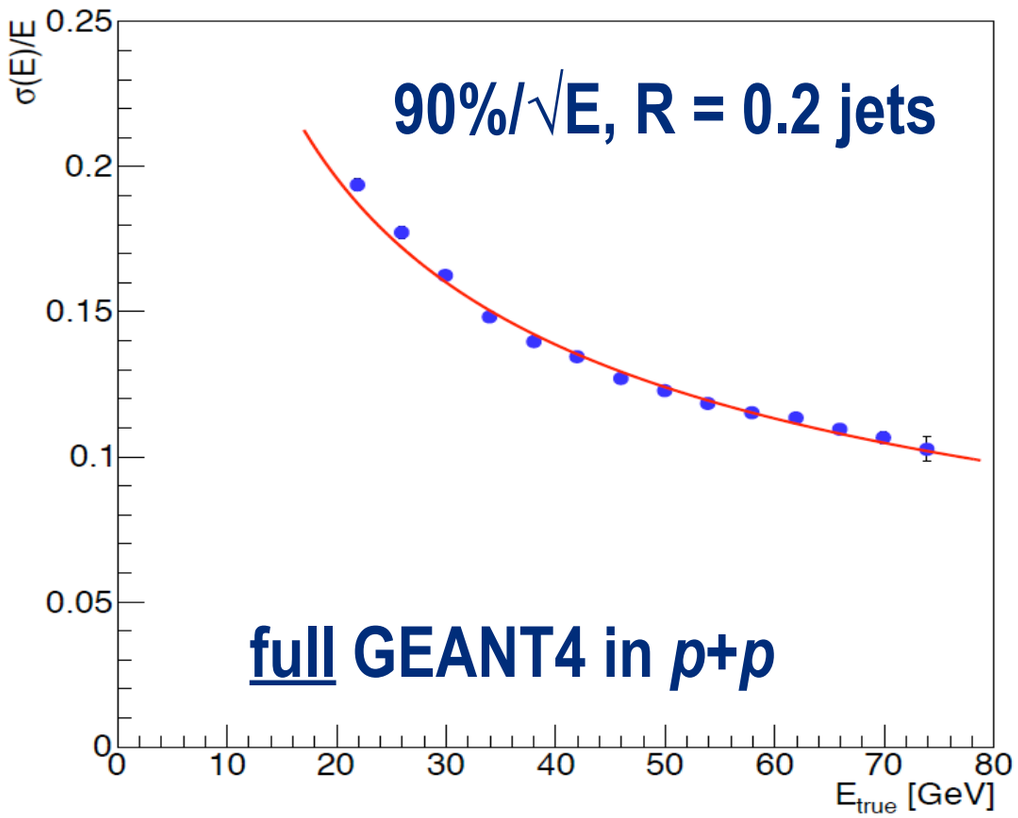
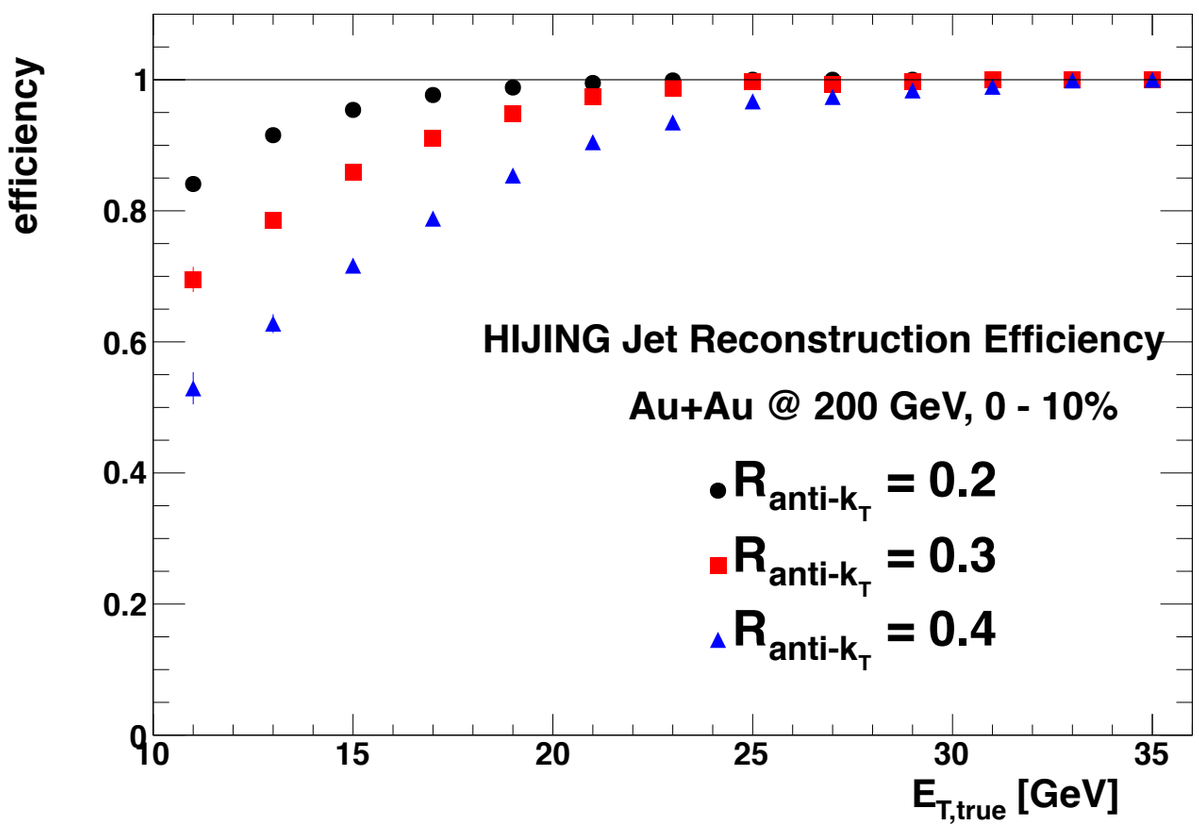


arXiv:1203:1353

Including detector effects



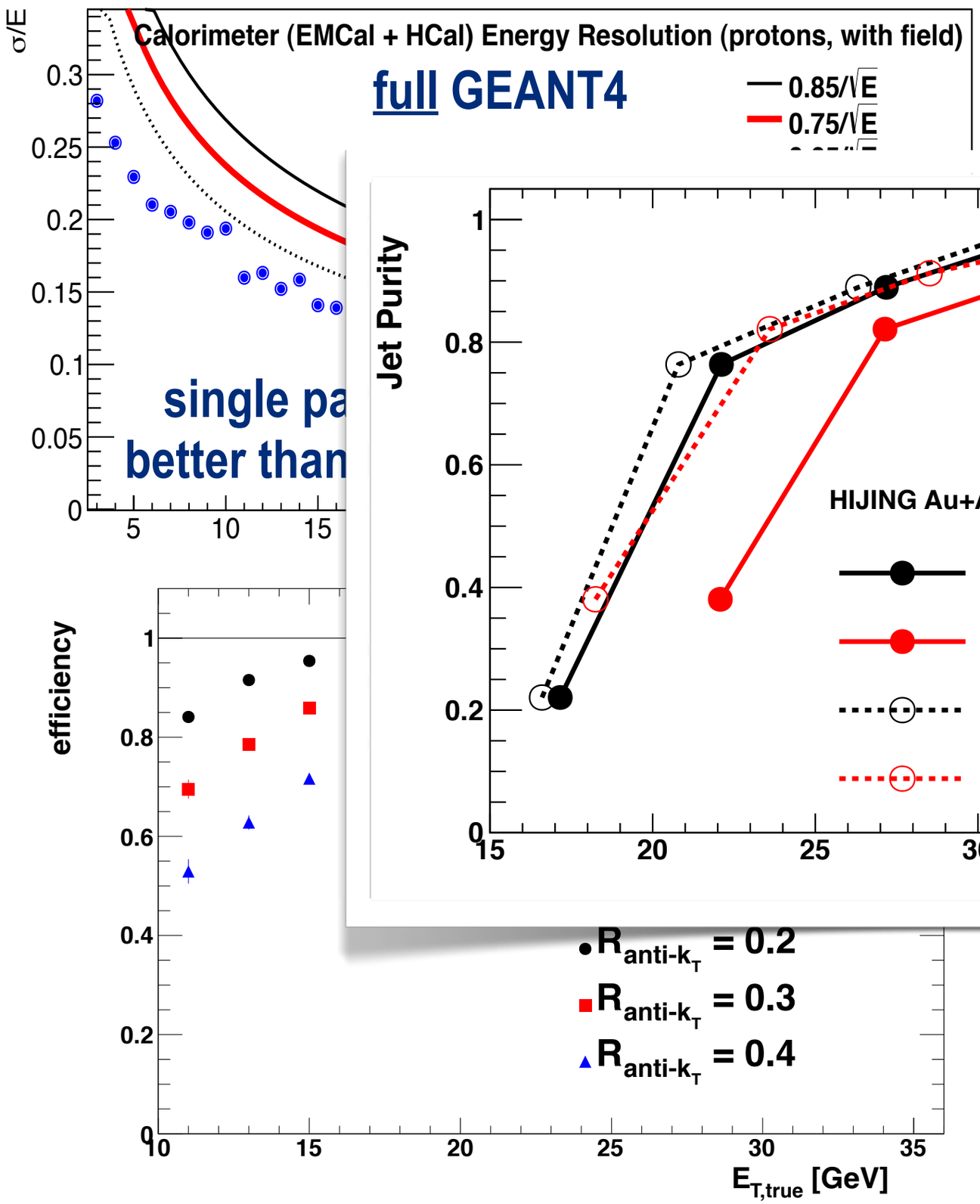


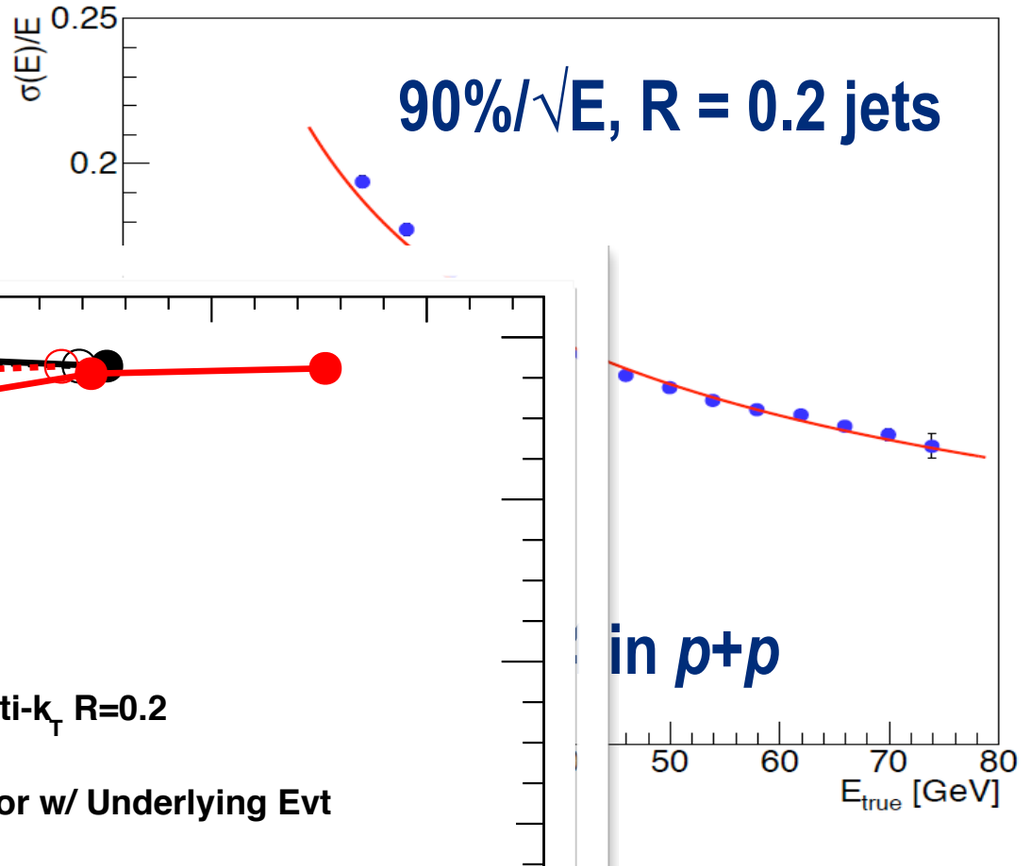


Parameterize single particle resolution and apply to cells used to measure jets in HIJING

- (check that effective resolution is comparable to GEANT4 in p+p)

Including detector effects

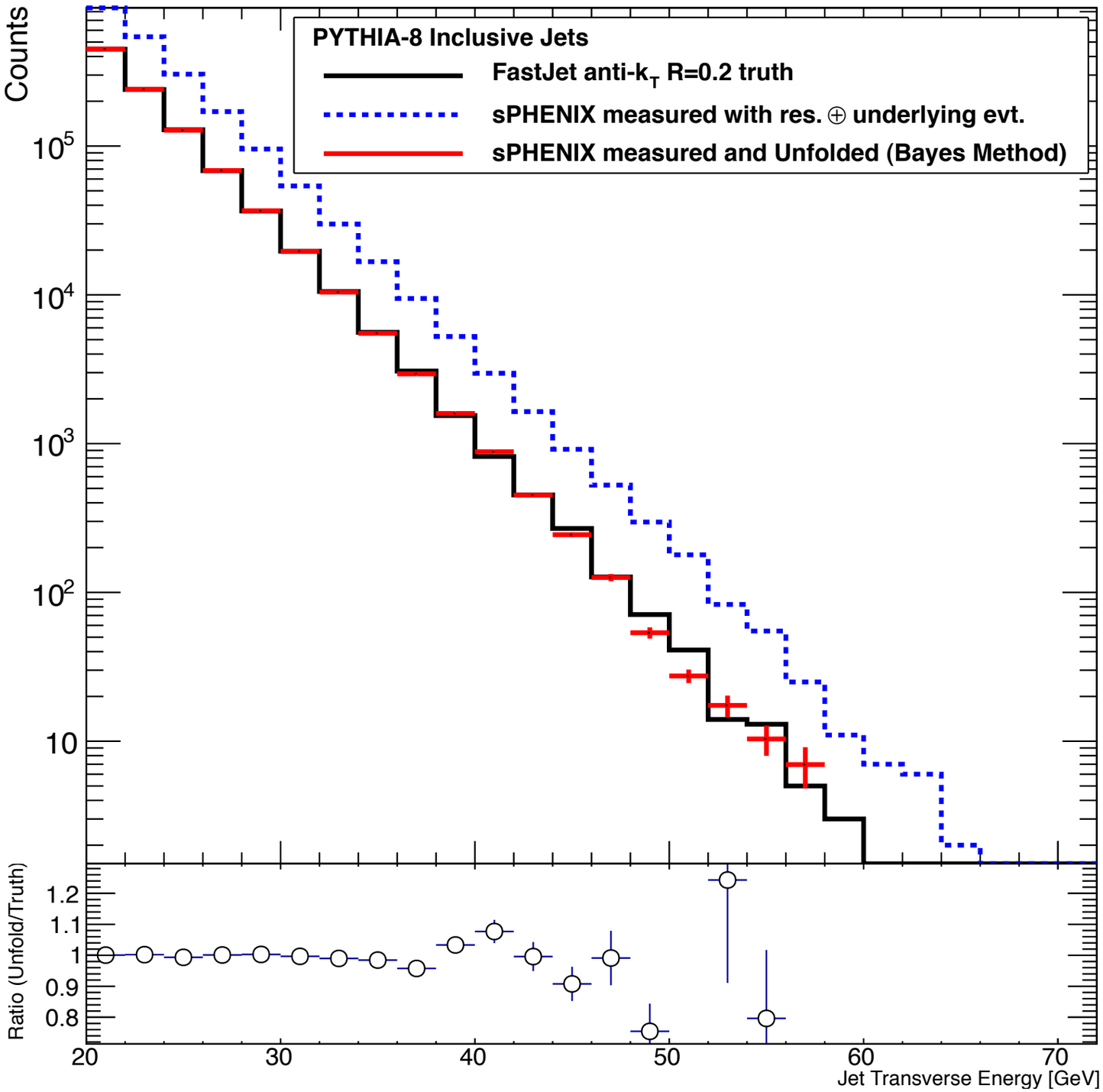




rticle
cells used
to measure jets in HIJING

- (check that effective resolution is comparable to GEANT4 in p+p)

Unfolding detector effects



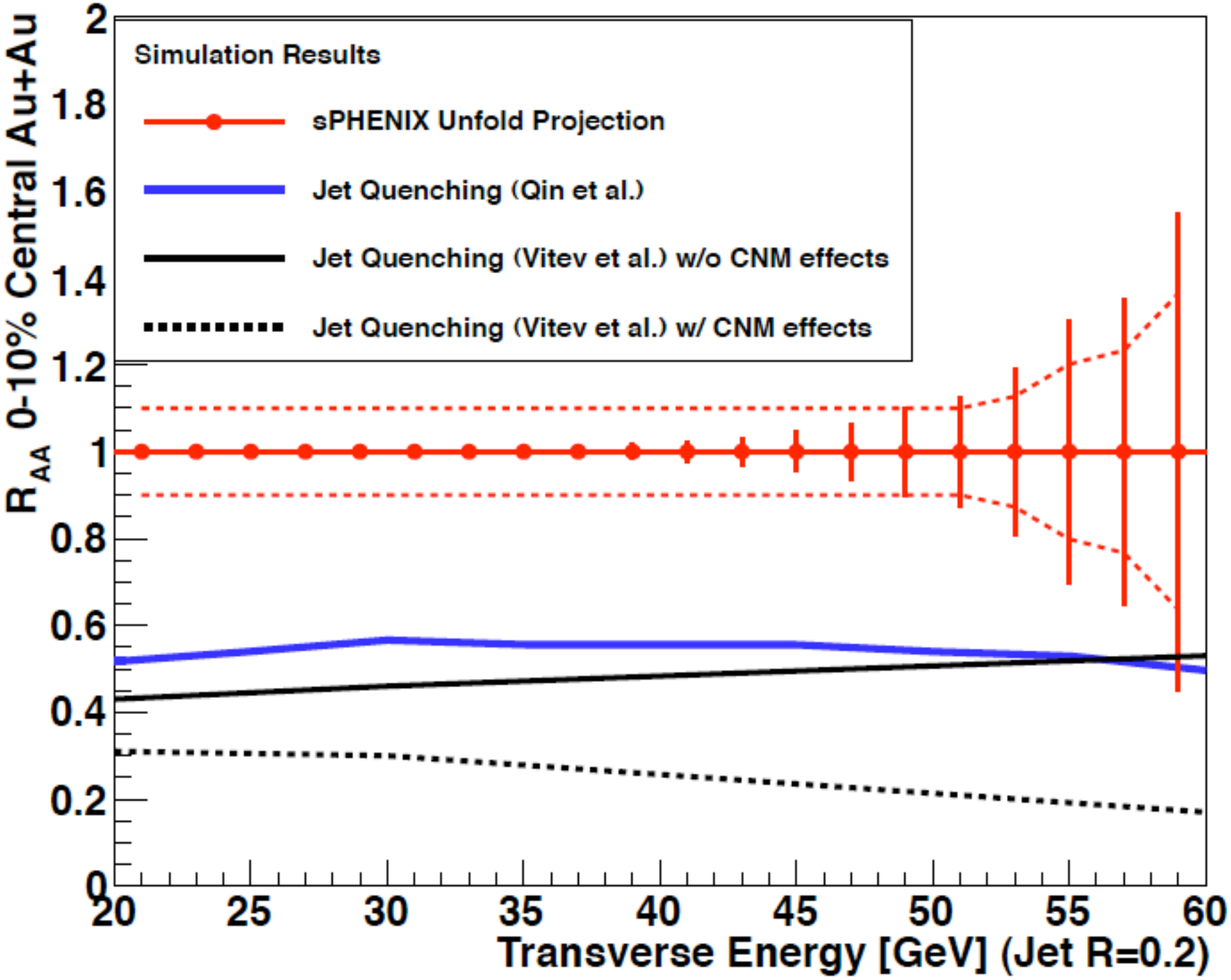
PYTHIA jets plus underlying central Au+Au event plus detector smearing

use ROOUNFOLD Iterative Bayes' method

recovers truth spectrum

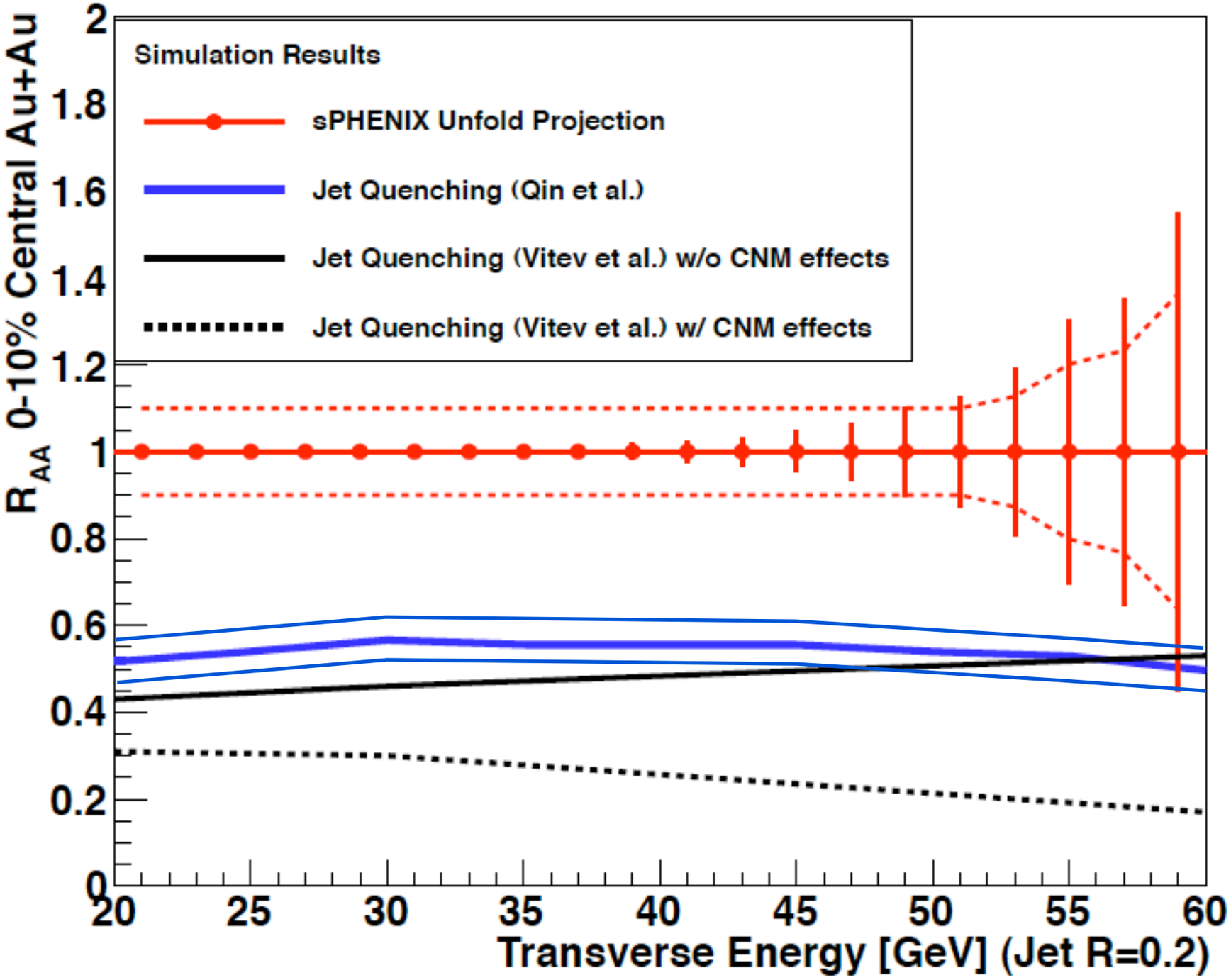
jet R_{AA} to high p_T possible

Sensitivity to inclusive jet-quenching



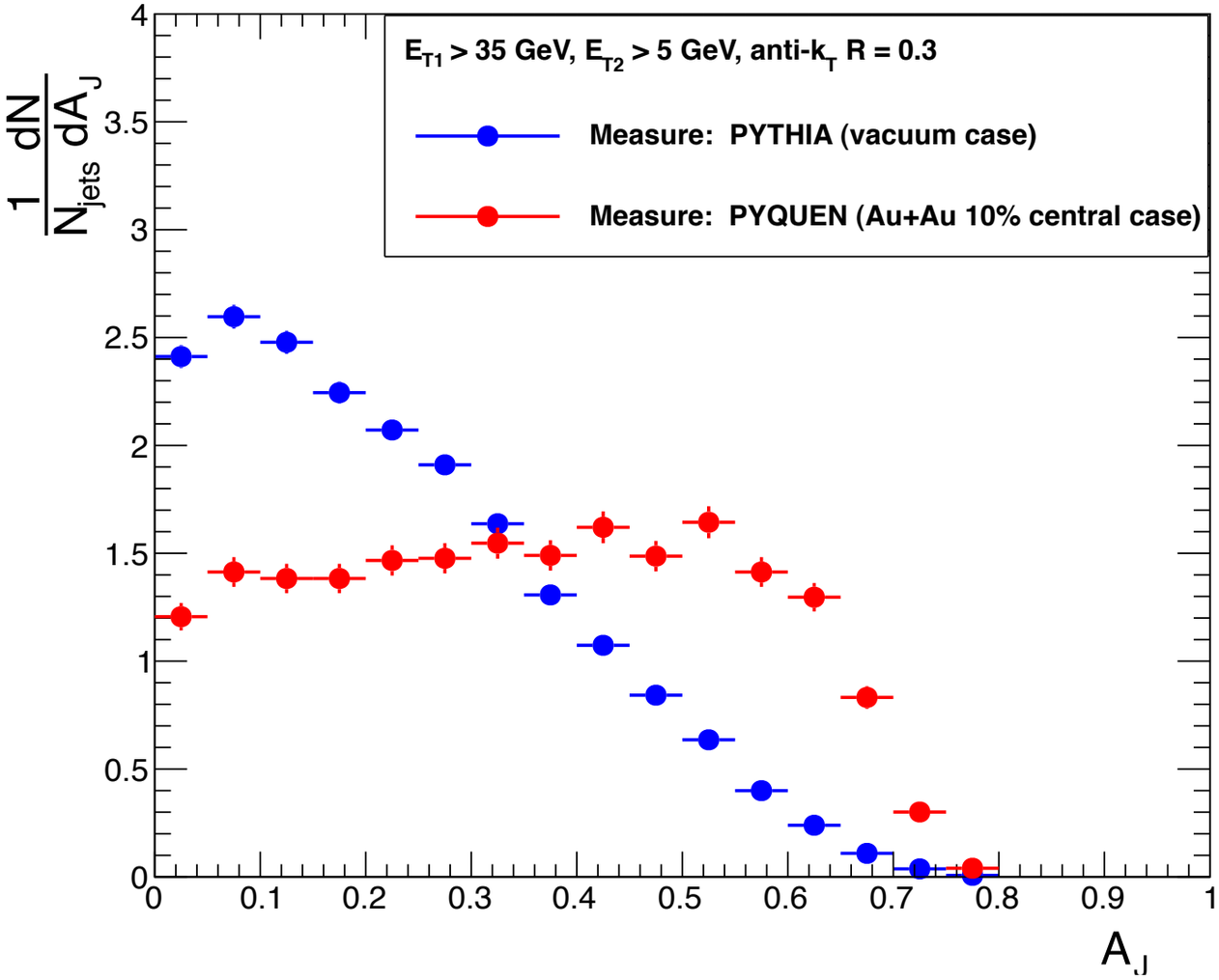
~10% systematic from unfolding

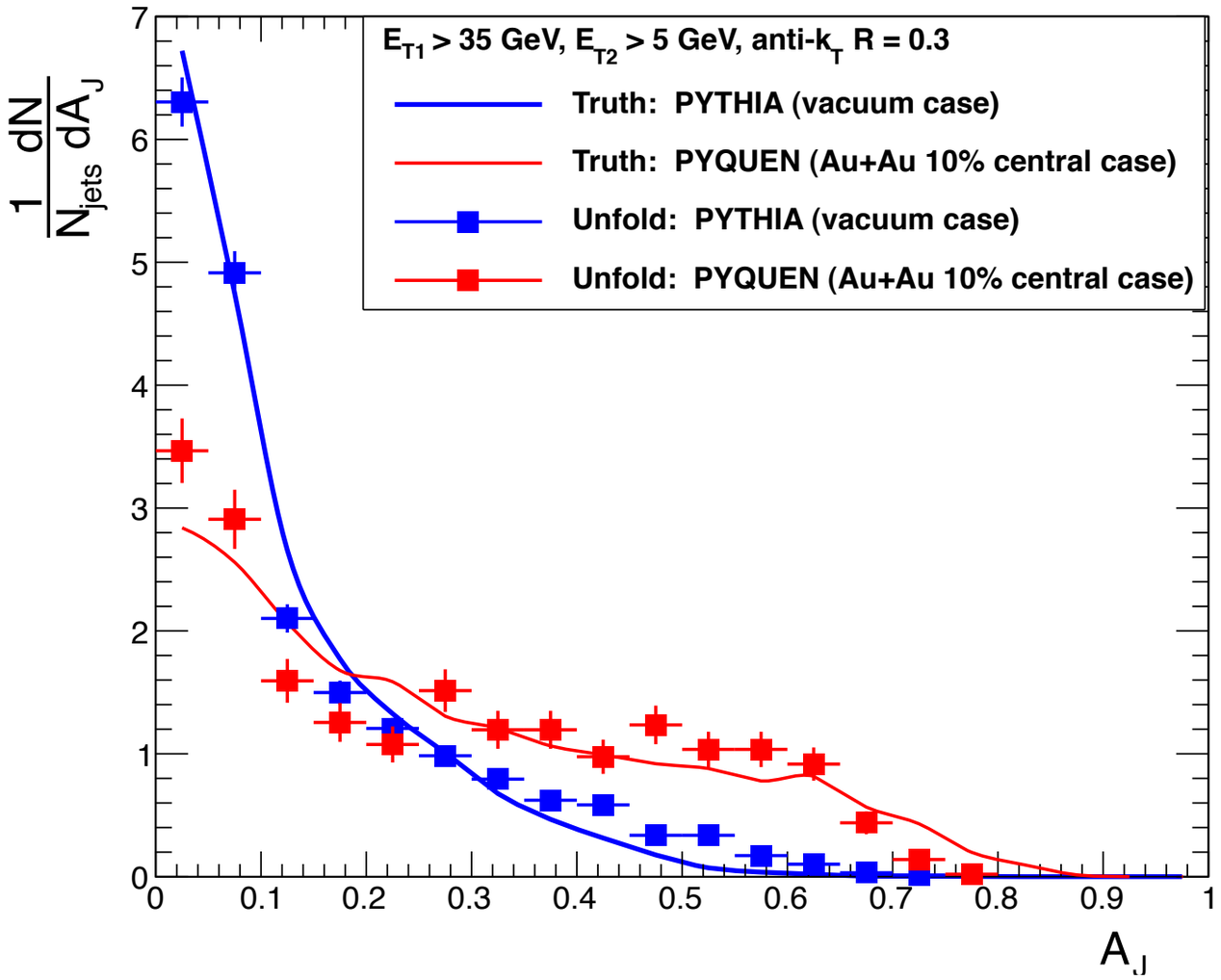
Sensitivity to inclusive jet-quenching



~10% systematic from unfolding

Sensitivity to di-jet asymmetry





Uncertainties shown correspond to statistics available from ~1yr (20 wks)

- embedded in 0-10% HIJING

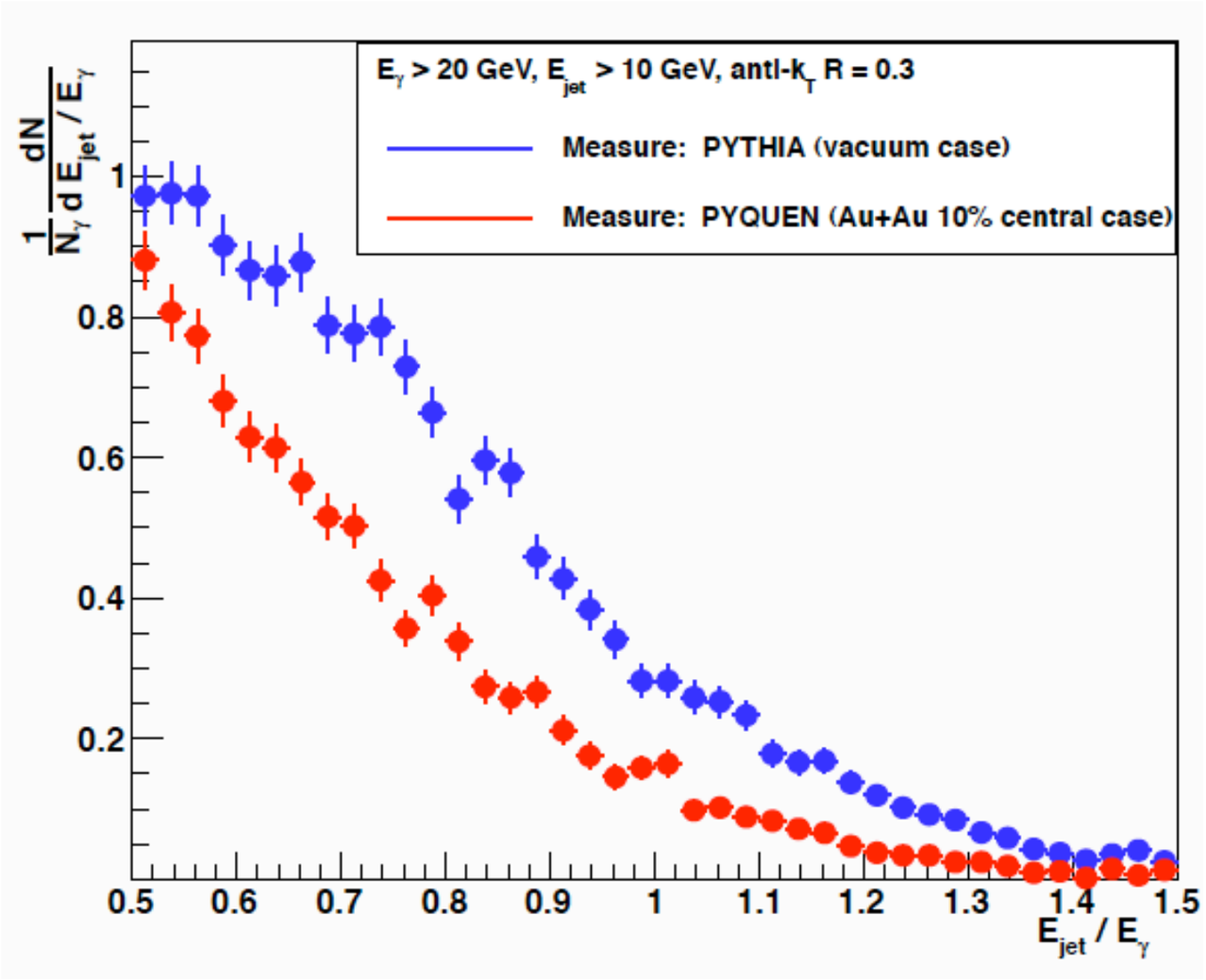
Approximate unfolding:

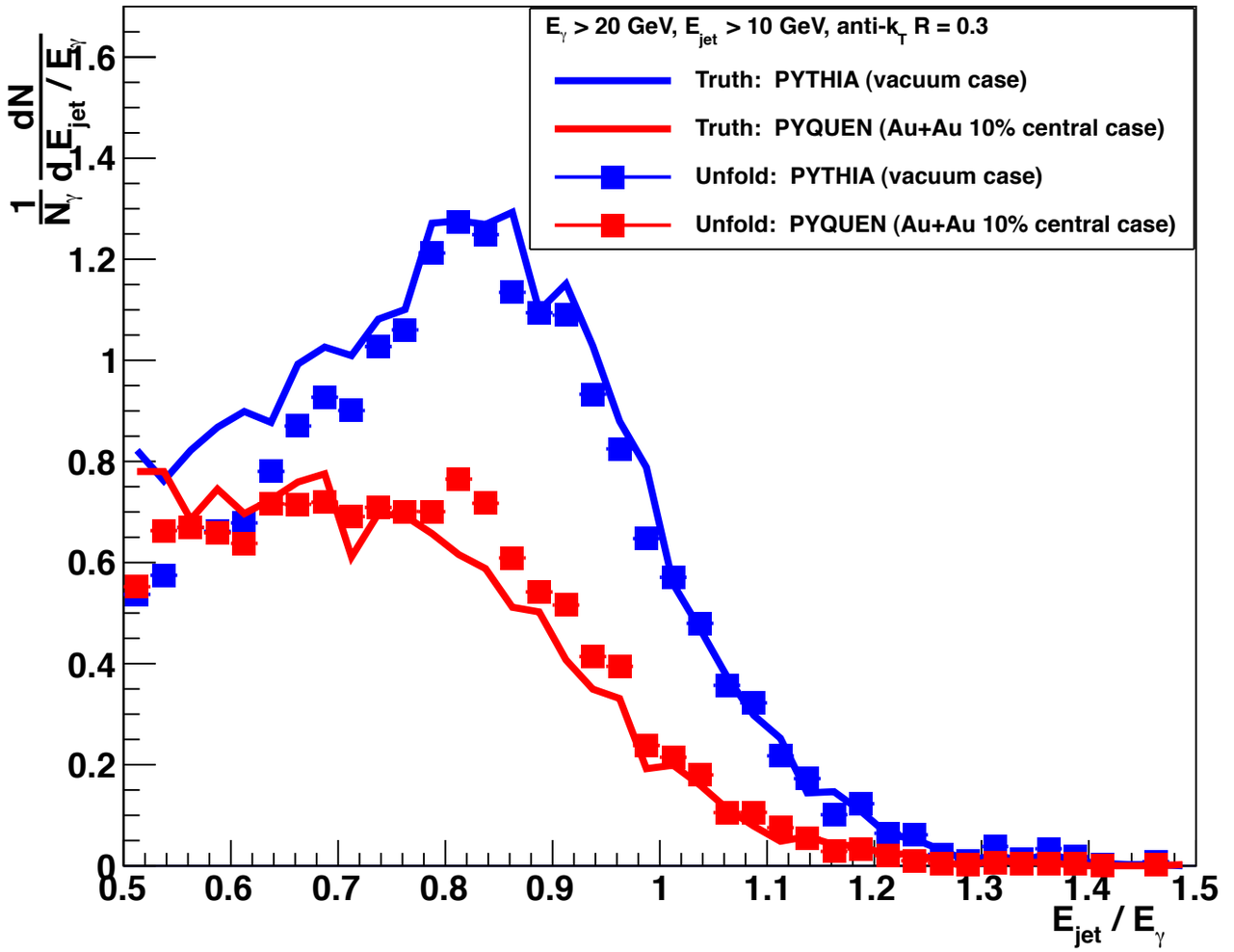
- apply $\langle \Delta E_T \rangle$ shift to leading jet

≈ recover underlying asymmetry

⇒ remain sensitive to modification!

Sensitivity to γ-jet asymmetry





Uncertainties shown correspond to statistics available from ~1yr (20 wks)

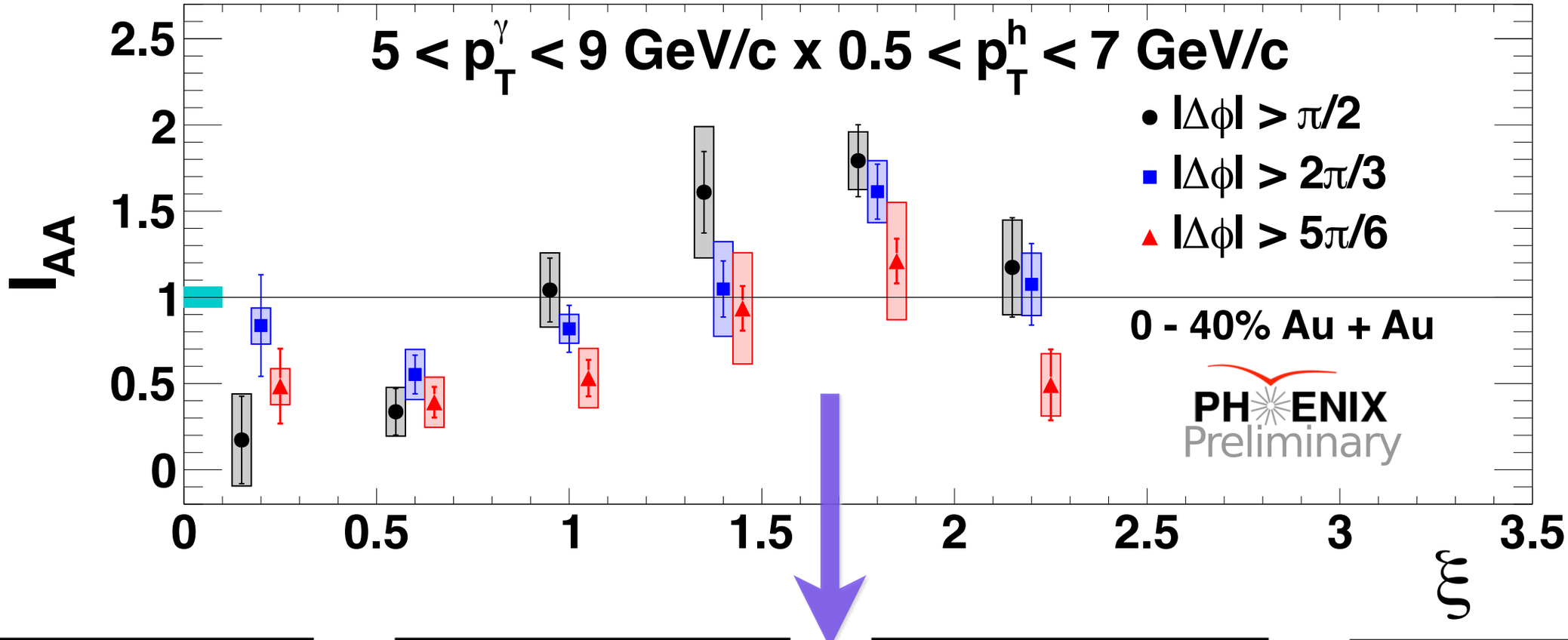
- embedded in 0-10% HIJING

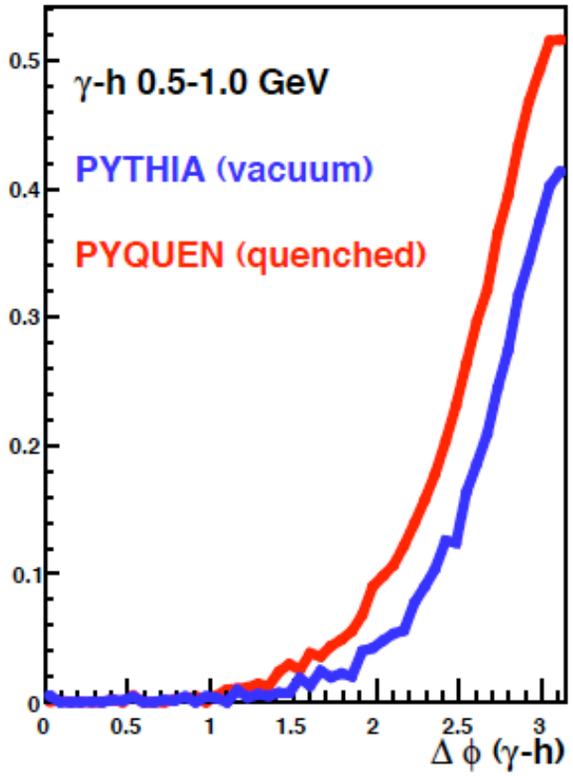
Full unfolding with ROOUNFOLD

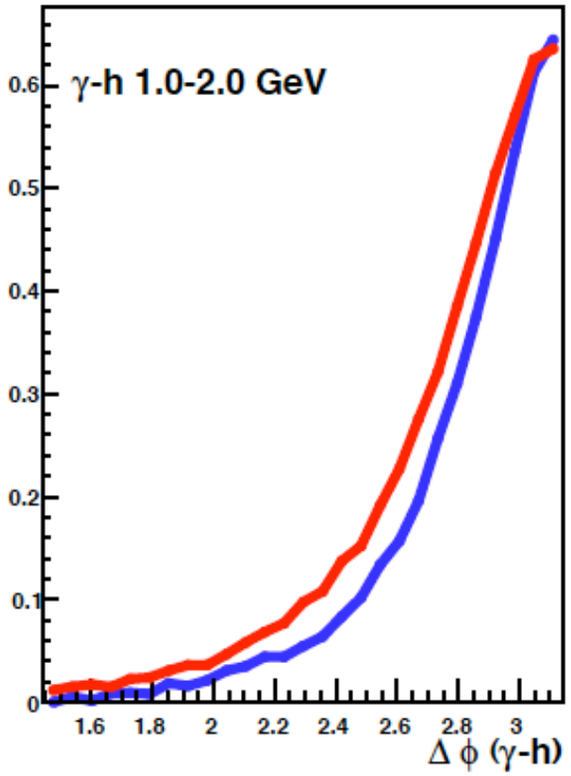
≈ recover underlying asymmetry

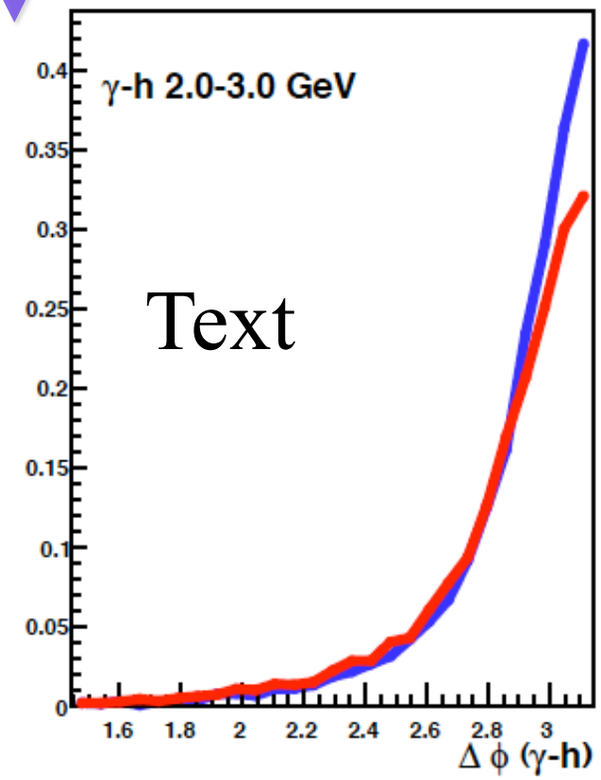
⇒ more sensitive to modification!

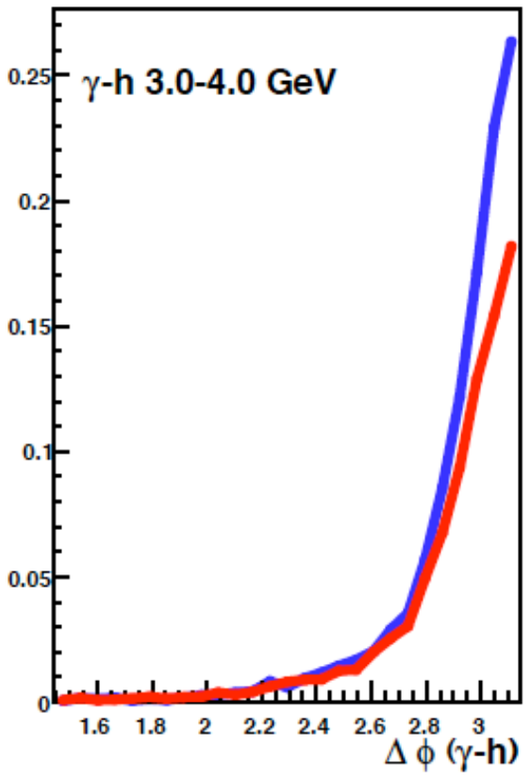
Recovering 'lost' energy



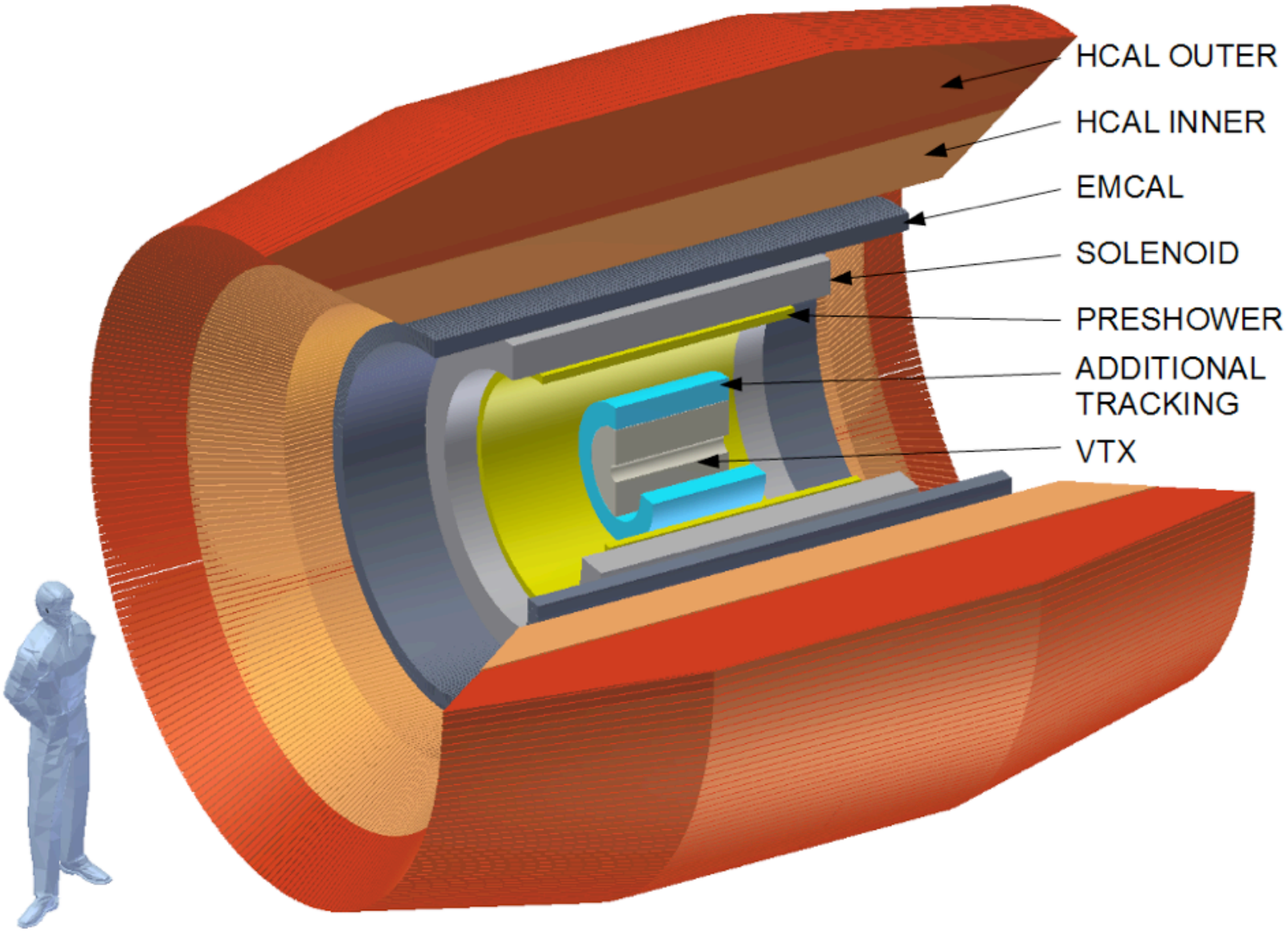








A few key future additions

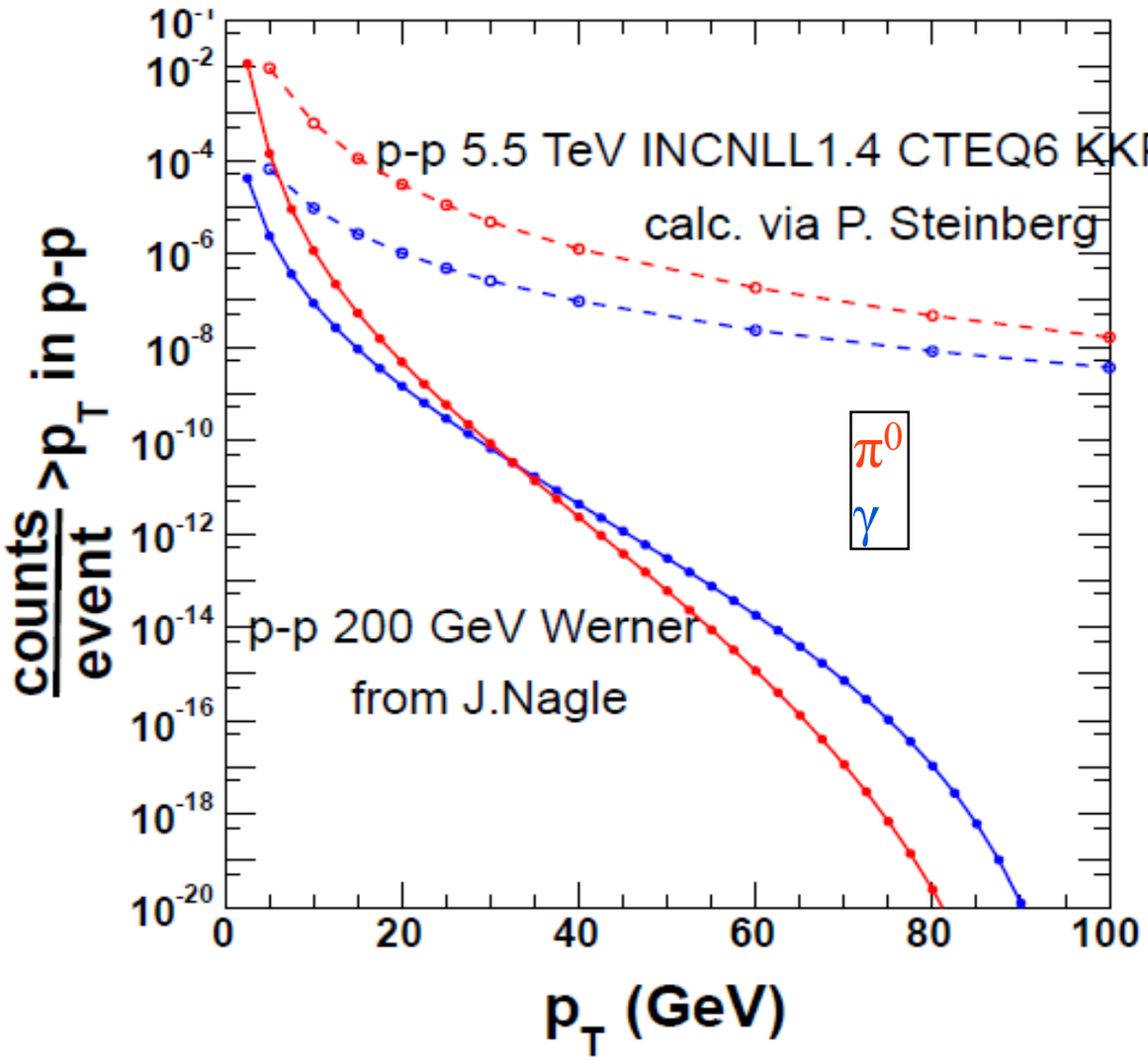


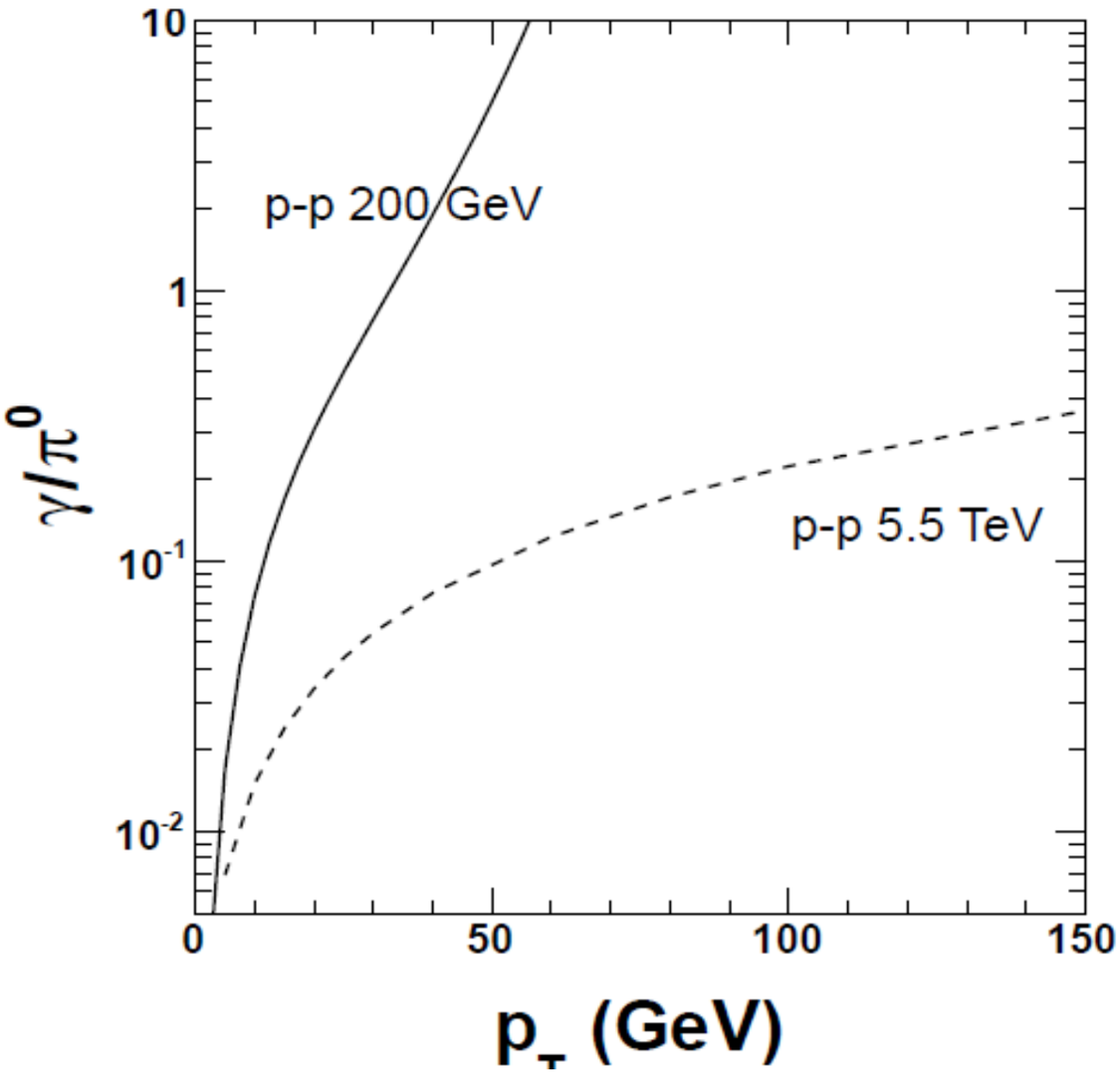
There is a future for jets at RHIC!

sPHENIX plan well suited for a variety of jet measurements!

Backup Slides

Direct photons at RHIC





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

Identifying truth jets

deep within the HIJING Event Generation...

Identifying truth jets

deep within the HIJING Event Generation...

---

parton 1

Identifying truth jets

deep within the HIJING Event Generation...

---

parton 1

↓

hadrons A

Identifying truth jets

deep within the HIJING Event Generation...

---

parton 1

↓

hadrons A

↓

FastJet

anti-k_T

Identifying truth jets

deep within the HIJING Event Generation...

---

parton 1

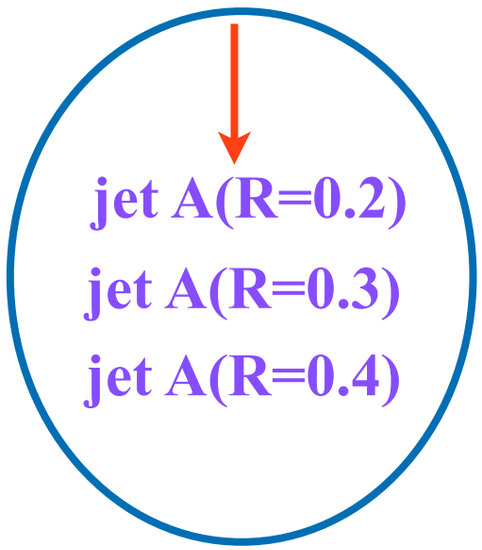
↓

hadrons A

↓

FastJet

anti-k_T



Identifying truth jets

deep within the HIJING Event Generation...

---

parton 1 → **hadrons A** → FastJet anti-k_T → **jet A(R=0.2)**, **jet A(R=0.3)**, **jet A(R=0.4)**

parton 2 → **hadrons B** → FastJet anti-k_T → **jet B(R=0.2)**, **jet B(R=0.3)**, **jet B(R=0.4)**

Identifying truth jets

deep within the HIJING Event Generation...

---

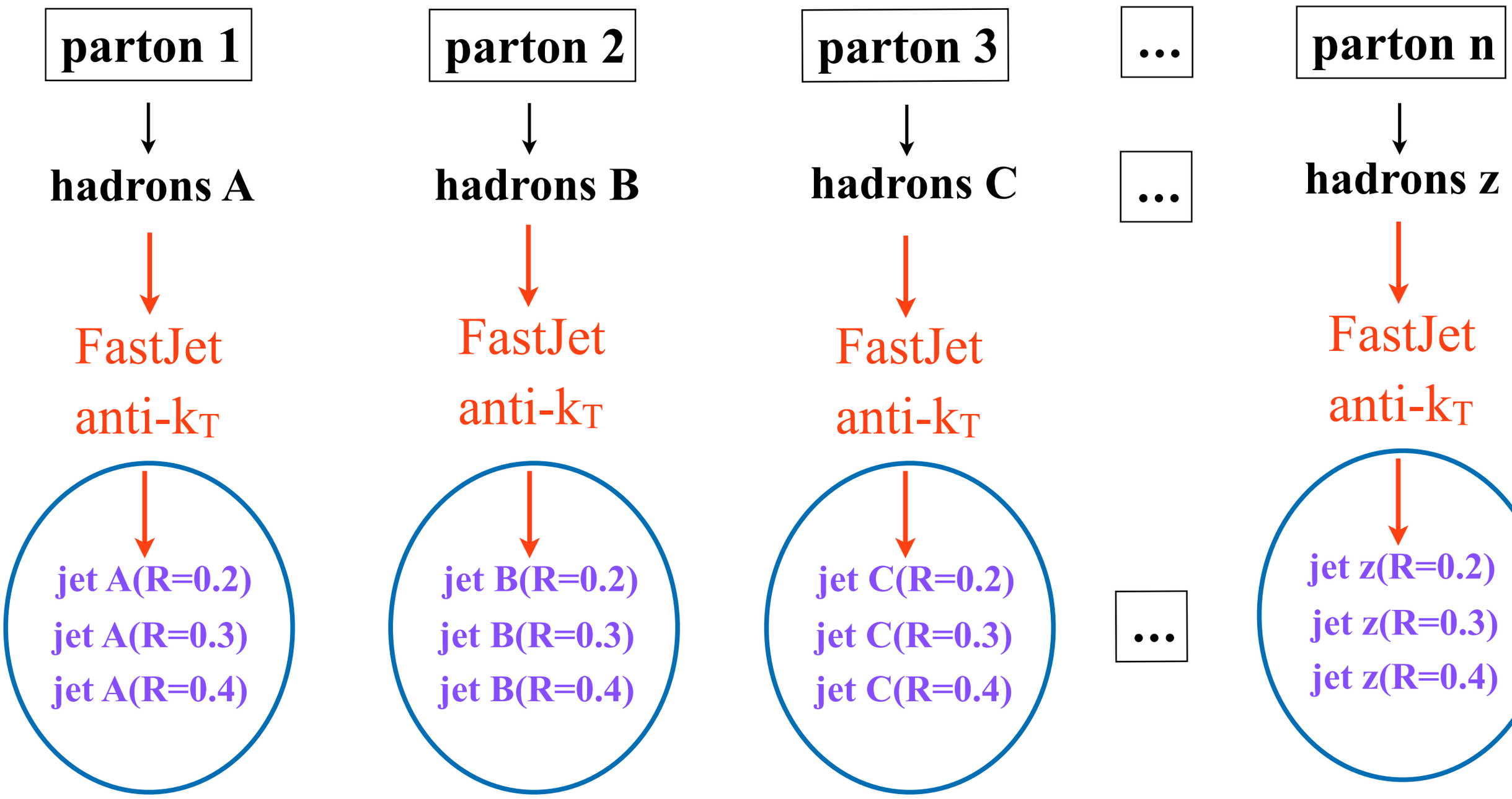
parton 1 → **hadrons A** → FastJet anti-k_T → **jet A(R=0.2)**, **jet A(R=0.3)**, **jet A(R=0.4)**

parton 2 → **hadrons B** → FastJet anti-k_T → **jet B(R=0.2)**, **jet B(R=0.3)**, **jet B(R=0.4)**

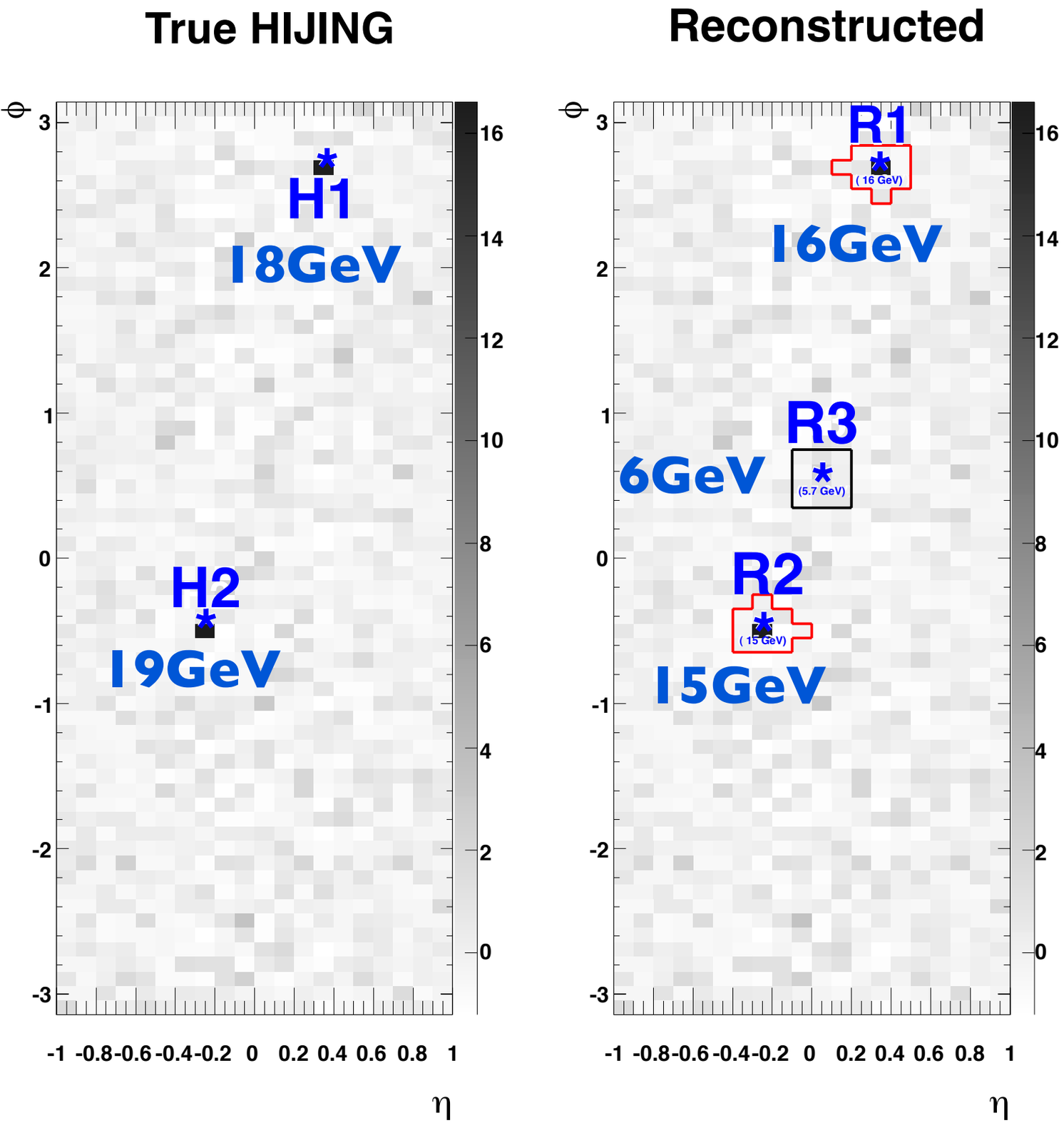
parton 3 → **hadrons C** → FastJet anti-k_T → **jet C(R=0.2)**, **jet C(R=0.3)**, **jet C(R=0.4)**

Identifying truth jets

deep within the HIJING Event Generation...



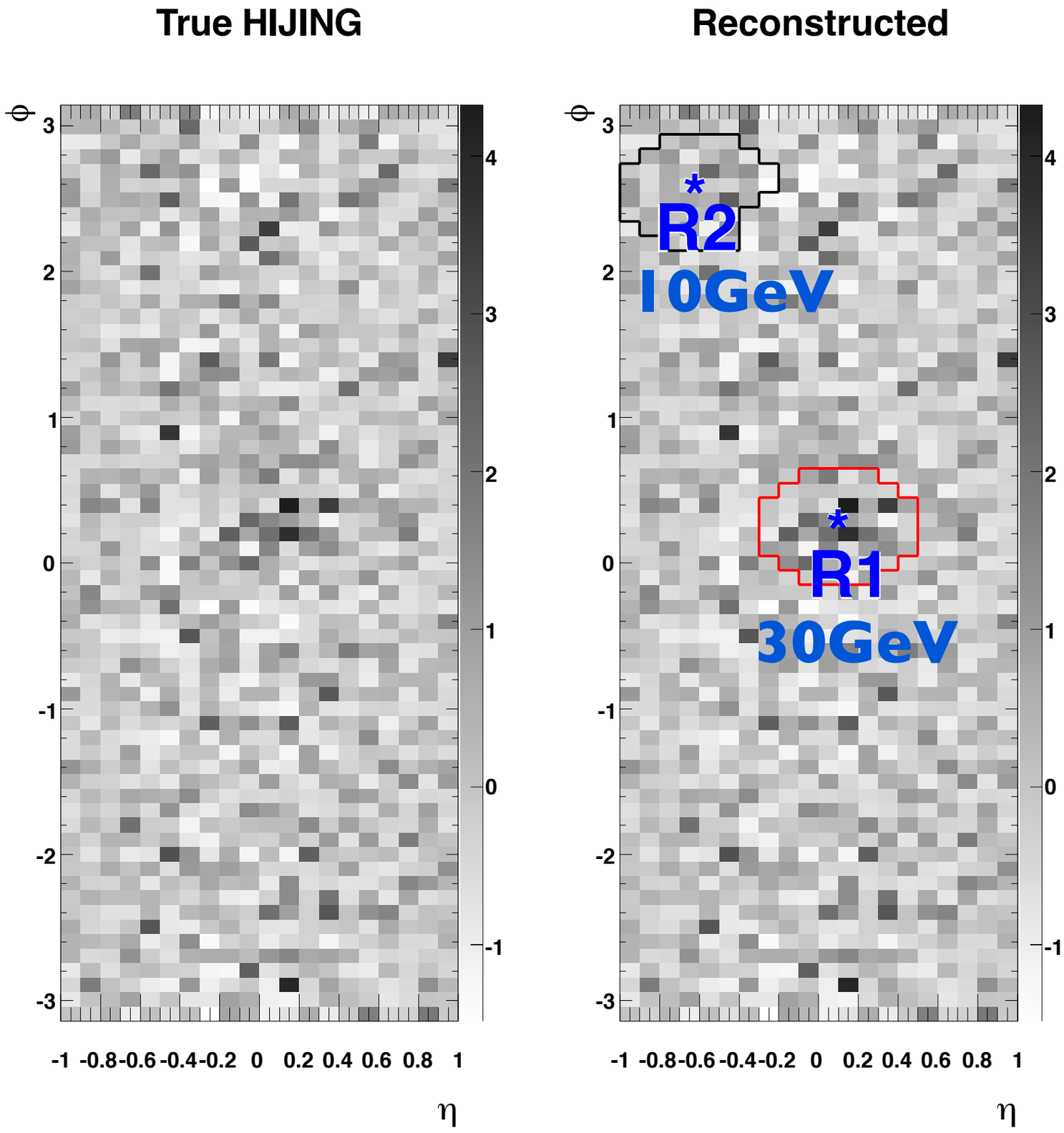
Well reconstructed jets



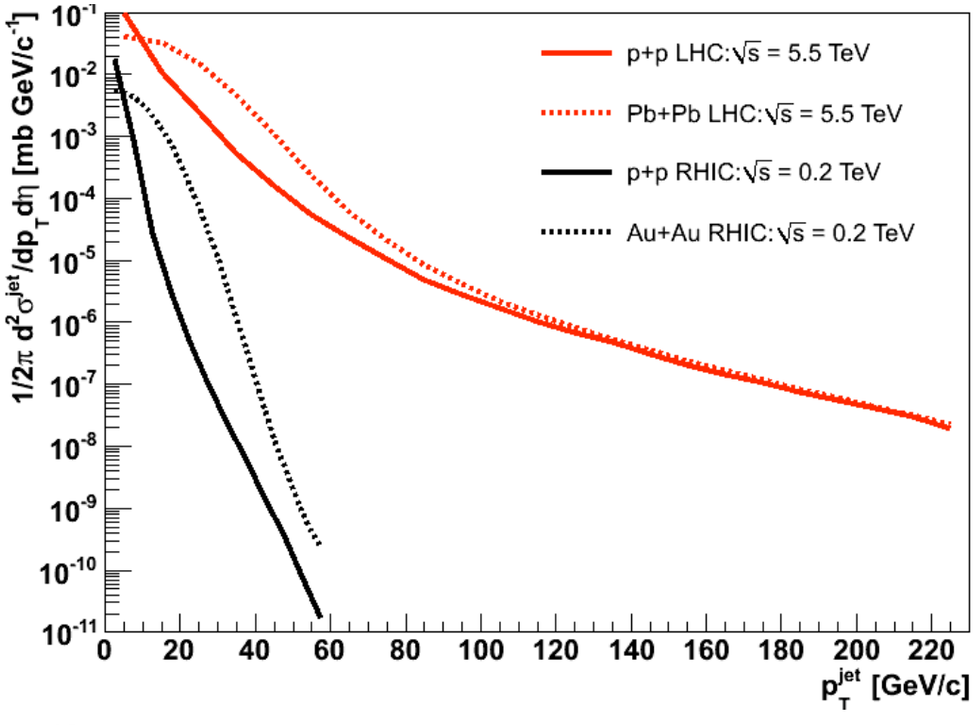
- b = 1.8fm HIJING event, R=0.2 anti-k_T dijet
- well reconstructed above background fluctuations after subtraction

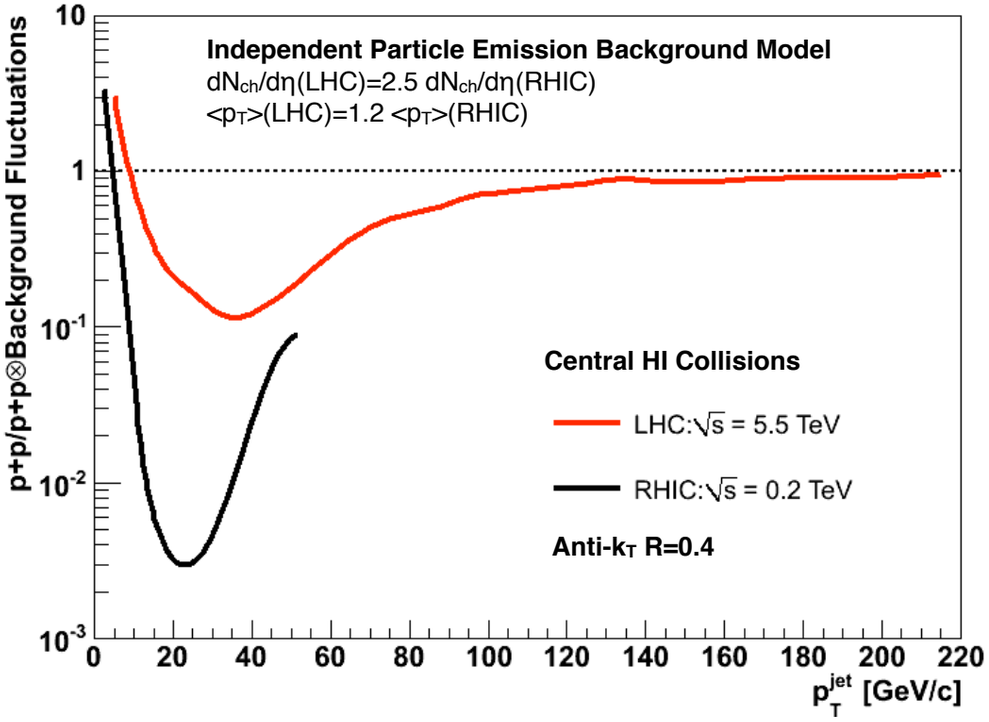
Fake jets

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



Jets at RHIC, really?





- smearing from very, very low p_T
- jets are not independent fluc's over full solid angle
- w/calorimetry what matters is no. of jet "patches"
- R can be smaller than 0.4 (say, 0.2)
  - agree that R = 0.4 at 20 GeV/c is B.G.
- energy in a cone doesn't look like a jet
- jets from soft fluctuations ⇒modified FF's
- internal CMS study: jets have a high p_T hadron
- ATLAS is going to ~40 GeV/c with fake rejector

Jörn Putschke (HP'12, RHIC/AGS '11); also Cacciari, Salaam, Soyez, Eur.Phys.J.C71:1692,2011