Relativistic Heavy Ion Physics
Part2

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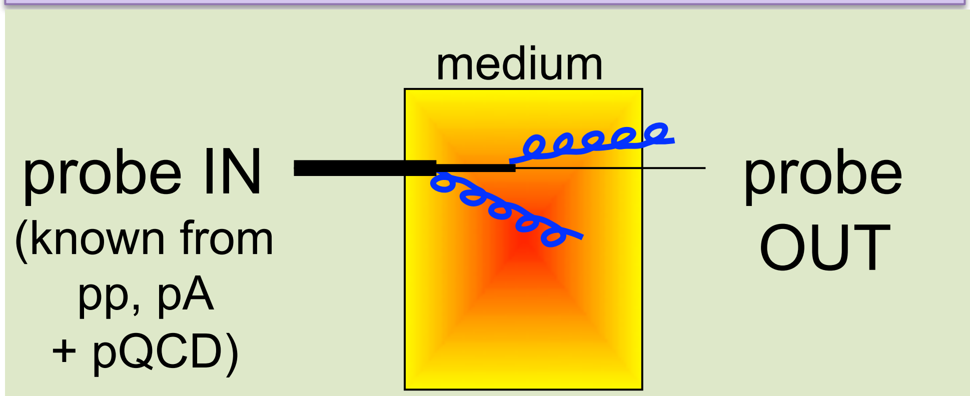
Rutgers University

Hard probes

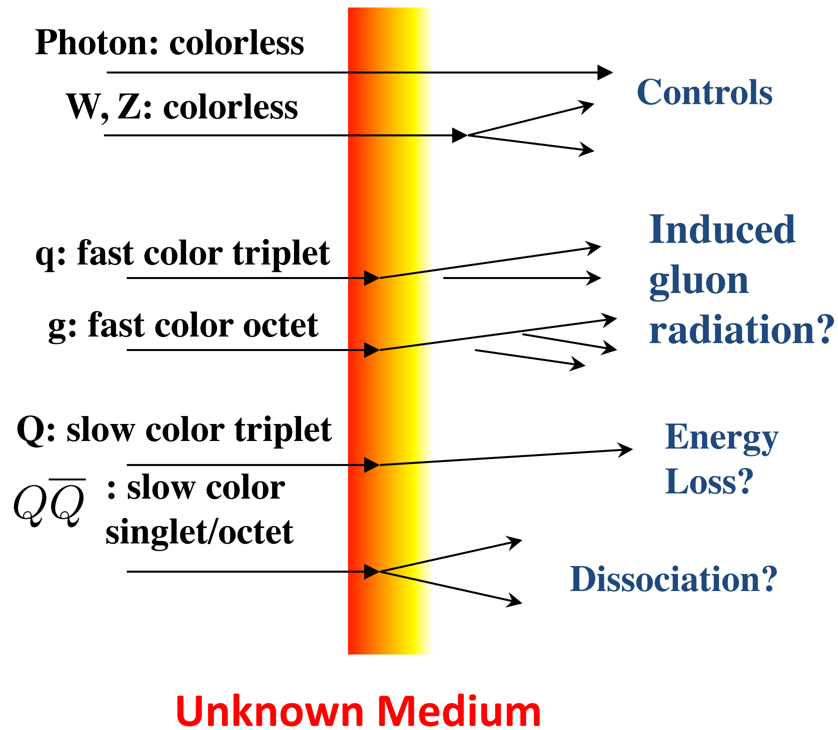
'Hard' processes have a *large scale in the calculation that makes perturbative QCD applicable:*

- *high momentum transfer* Q^2
- *high mass* m
- *high transverse momentum* p_T

Hard Probes of QGP: Jets, W, Z , photons …



Diagnosing QCD medium: (simplified idea)
pass a QCD-sensitive probe through it, then look for any modifications due to the medium.



Experimental search for "interesting" phenomena

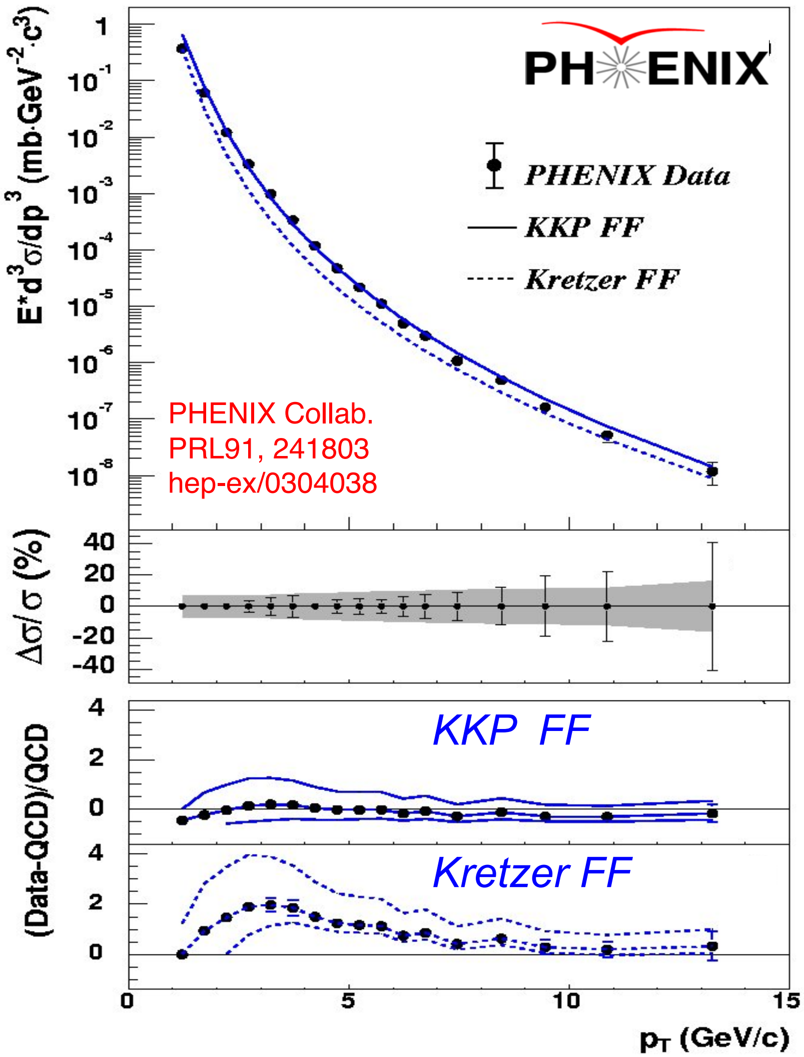
- Look at elementary p+p collisions
  - Measure an observable (e.g. Jet production)
- Look at Heavy Ion collisions
  - Measure the same observable as we do in p+p
- Compare them, is there something new?

But how good is our baseline data?

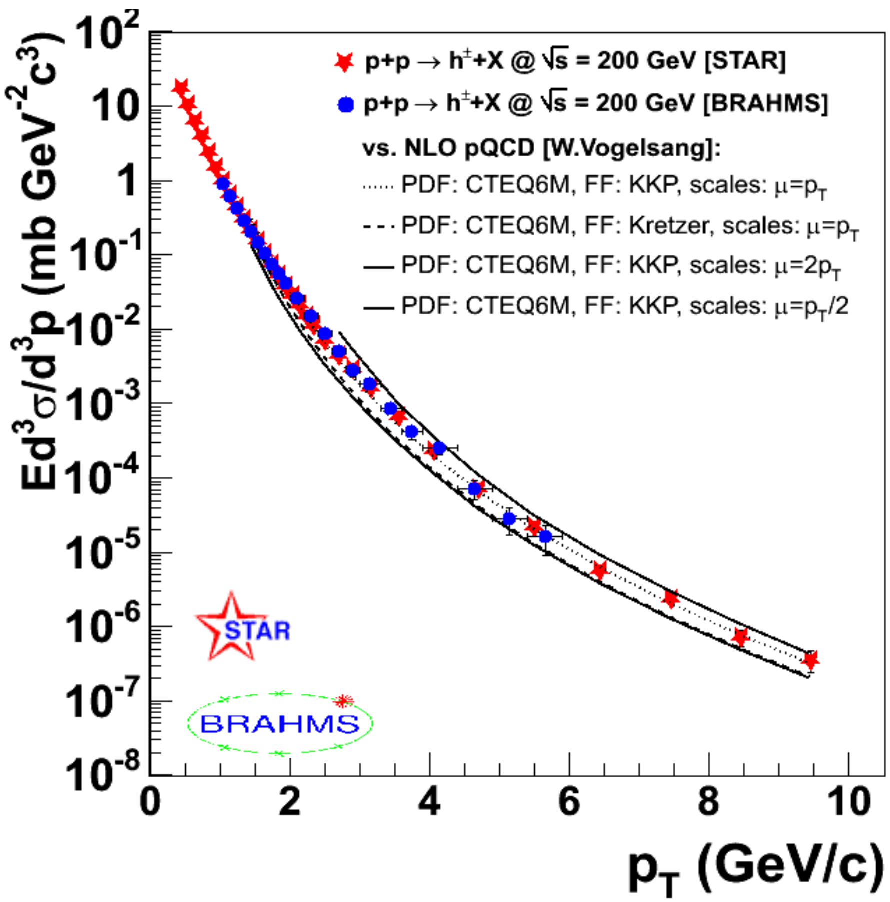
High-p_T p+p Baseline Data Well Described by pQCD

NLO pQCD

$p+p \rightarrow \pi^0 X$



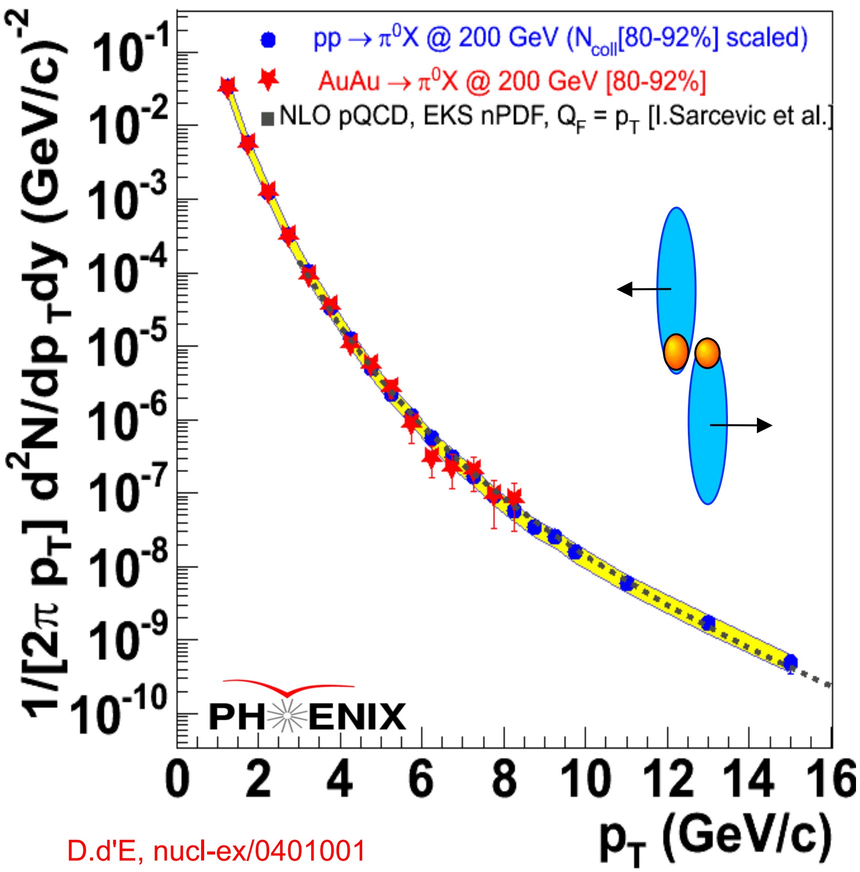
$p+p \rightarrow h^{\pm} X$ (non singly diffractive)



Well calibrated (experimentally & theoretically) p+p references at hand

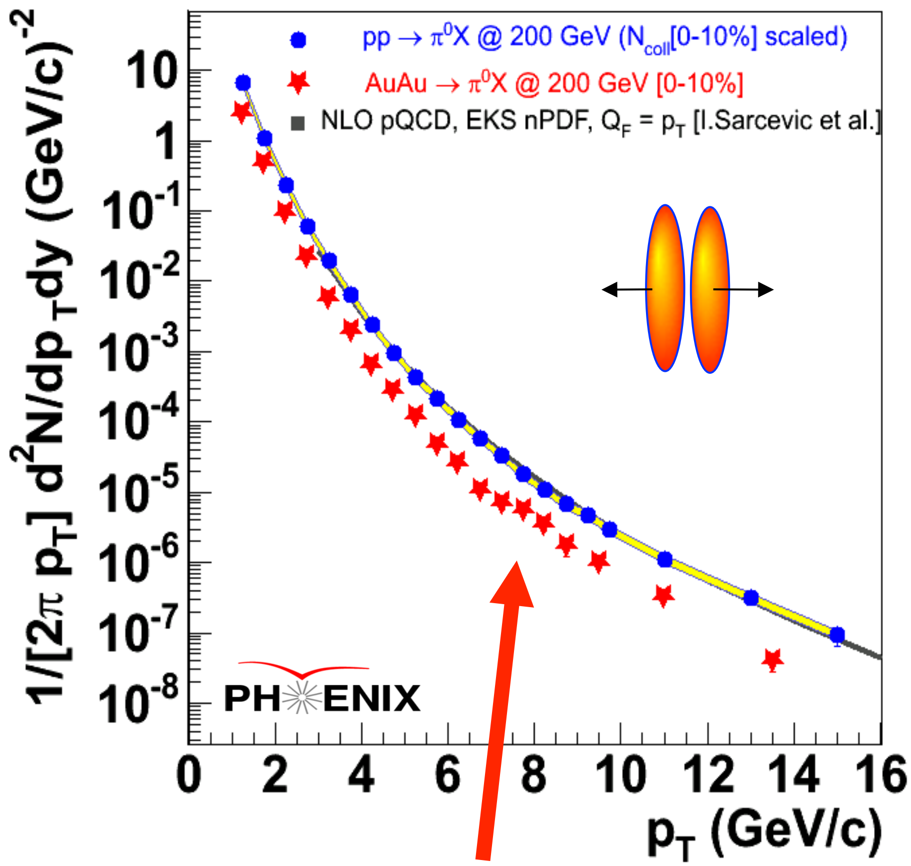
Suppressed High-p_T Hadroproduction in Au+Au @ RHIC !

(peripheral)



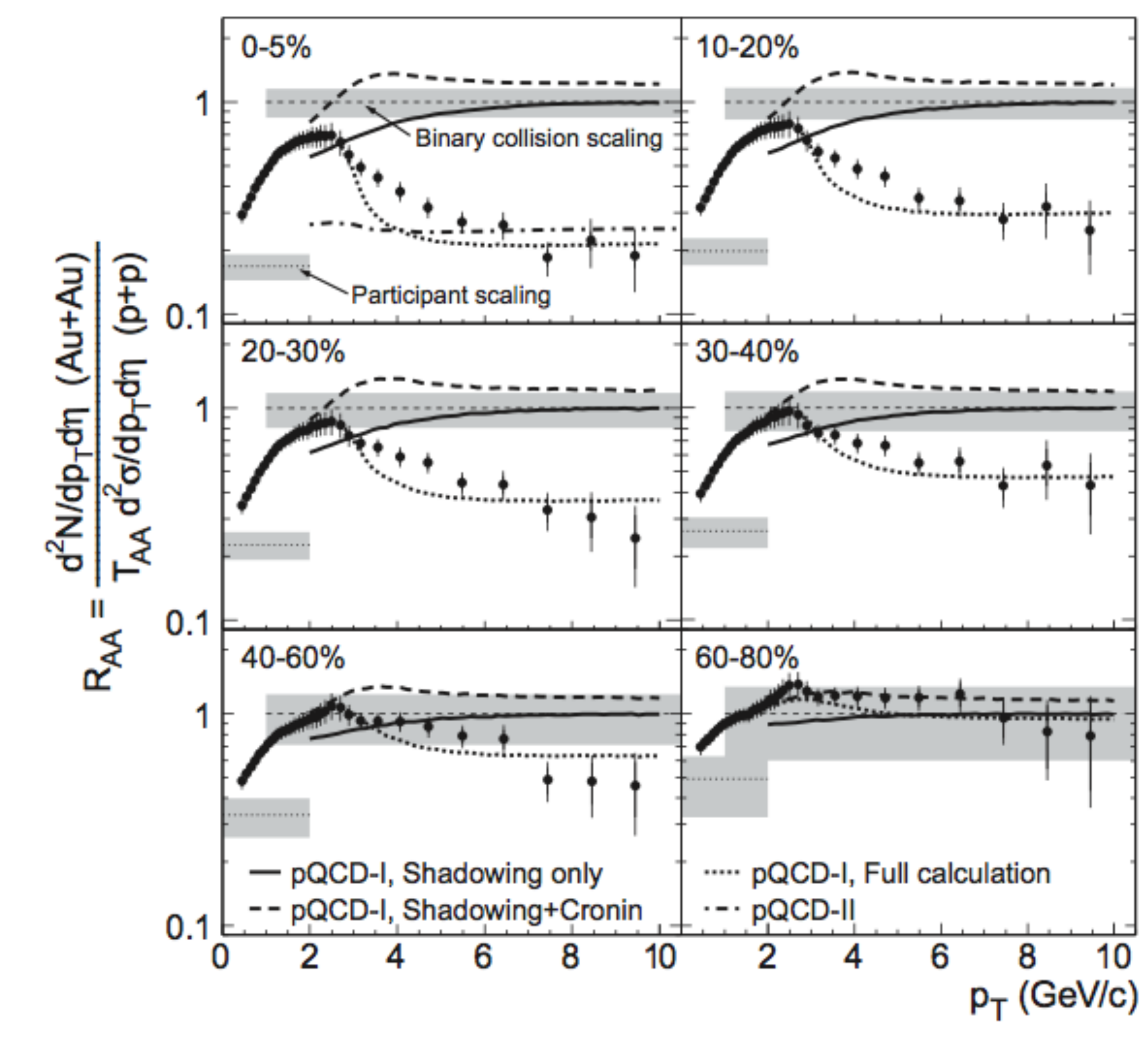
Peripheral data agree well with p+p (data & pQCD) plus N_{coll}-scaling

(central)



Strong suppression in central Au+Au collisions

Nuclear Modification Factors



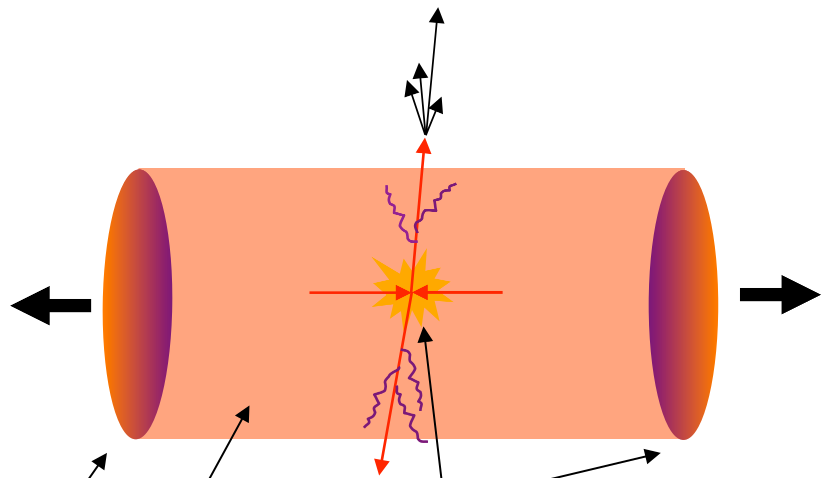
$$\equiv \frac{\text{Yield in Au+Au Events}}{N_{Bin}(\text{Yield in p+p Events})}$$

R_{AA} is sensitive to the details of the quenching parameters at high p_T

Phys. Rev. Lett. 91 (2003) 172302

High p_T hadron suppression as a signature of the jet-medium interaction.

What happens to the jets in a head-on Nuclear collision?



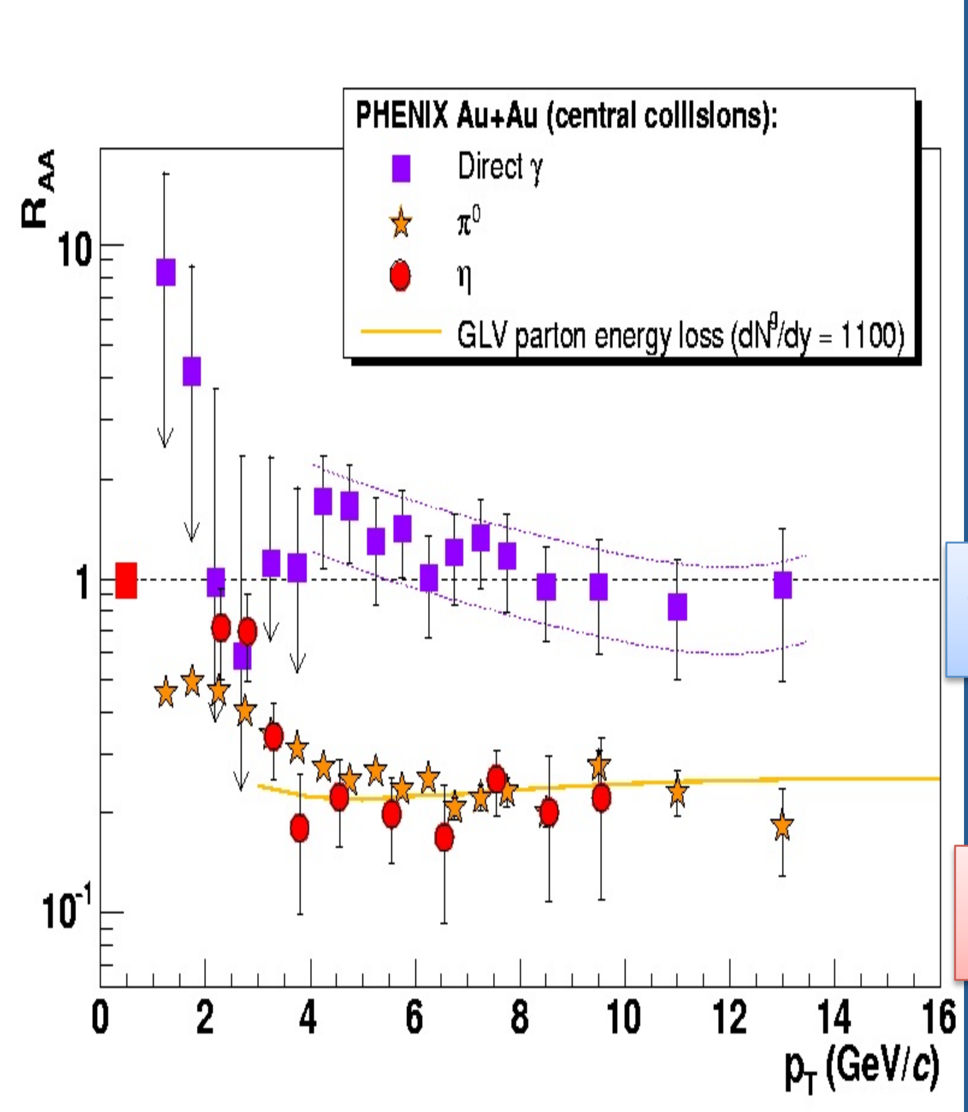
Speeding Nuclei

Hot, Dense region… QGP?

Jets have to pass through Hot, Dense Zone!

Quarks and gluons lose energy through in dense medium generated in collision

Nuclear Modification Factors



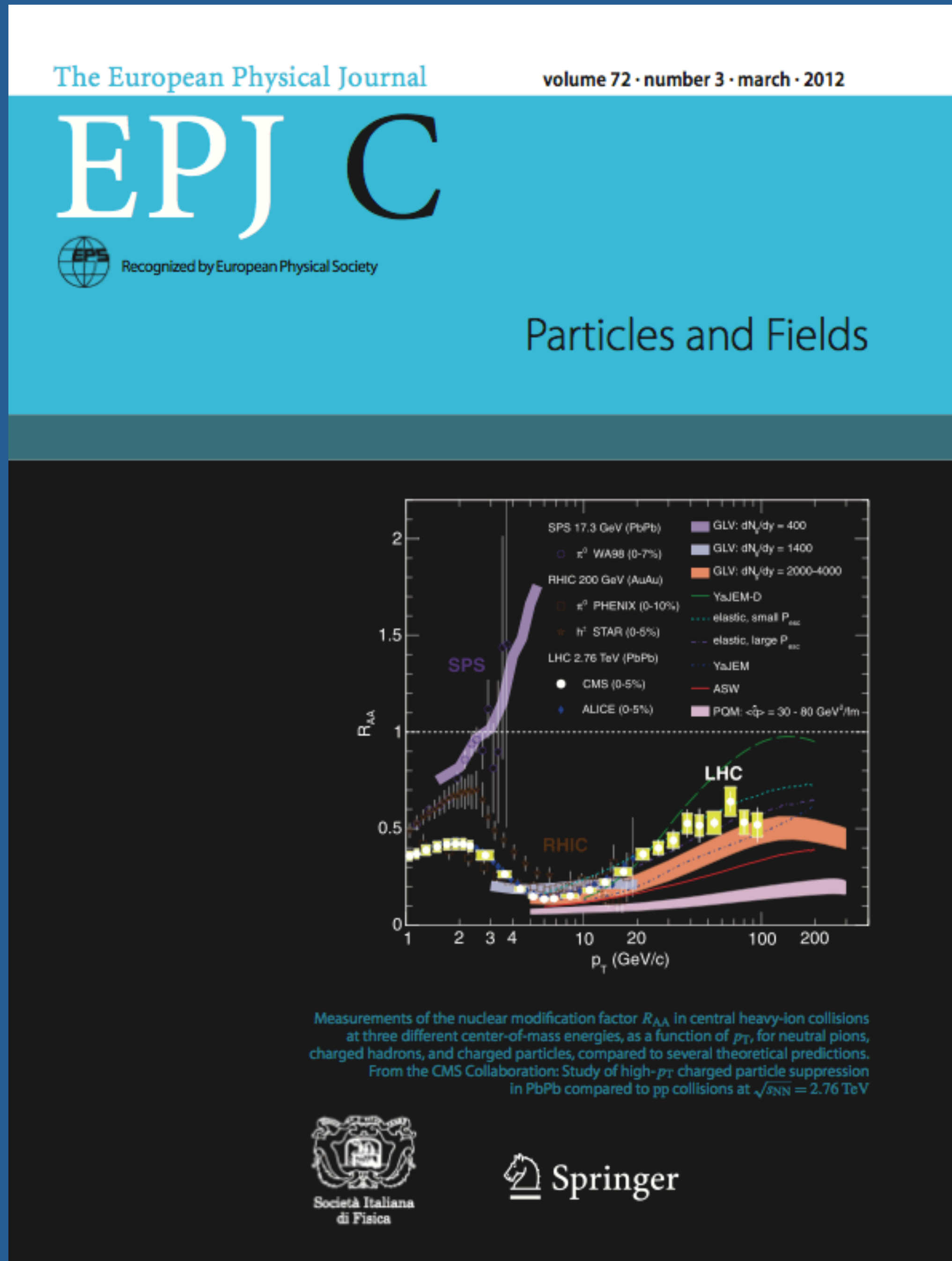
$$\equiv \frac{\text{Yield in Au+Au Events}}{N_{Bin}(\text{Yield in p+p Events})}$$

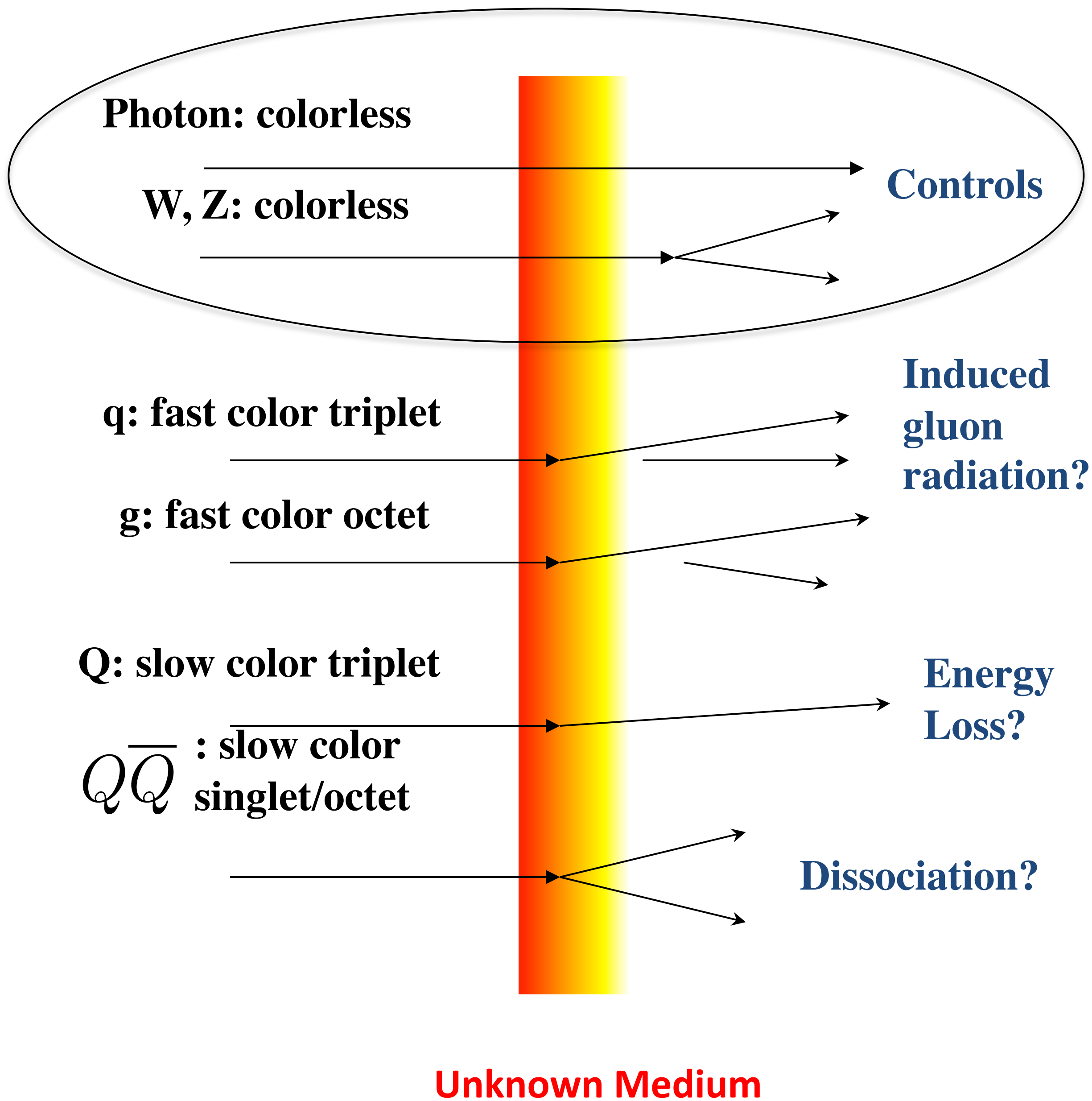
Medium seems to be transparent to photons → colored medium.

High p_T hadron suppression as a signature of the jet-medium interaction.

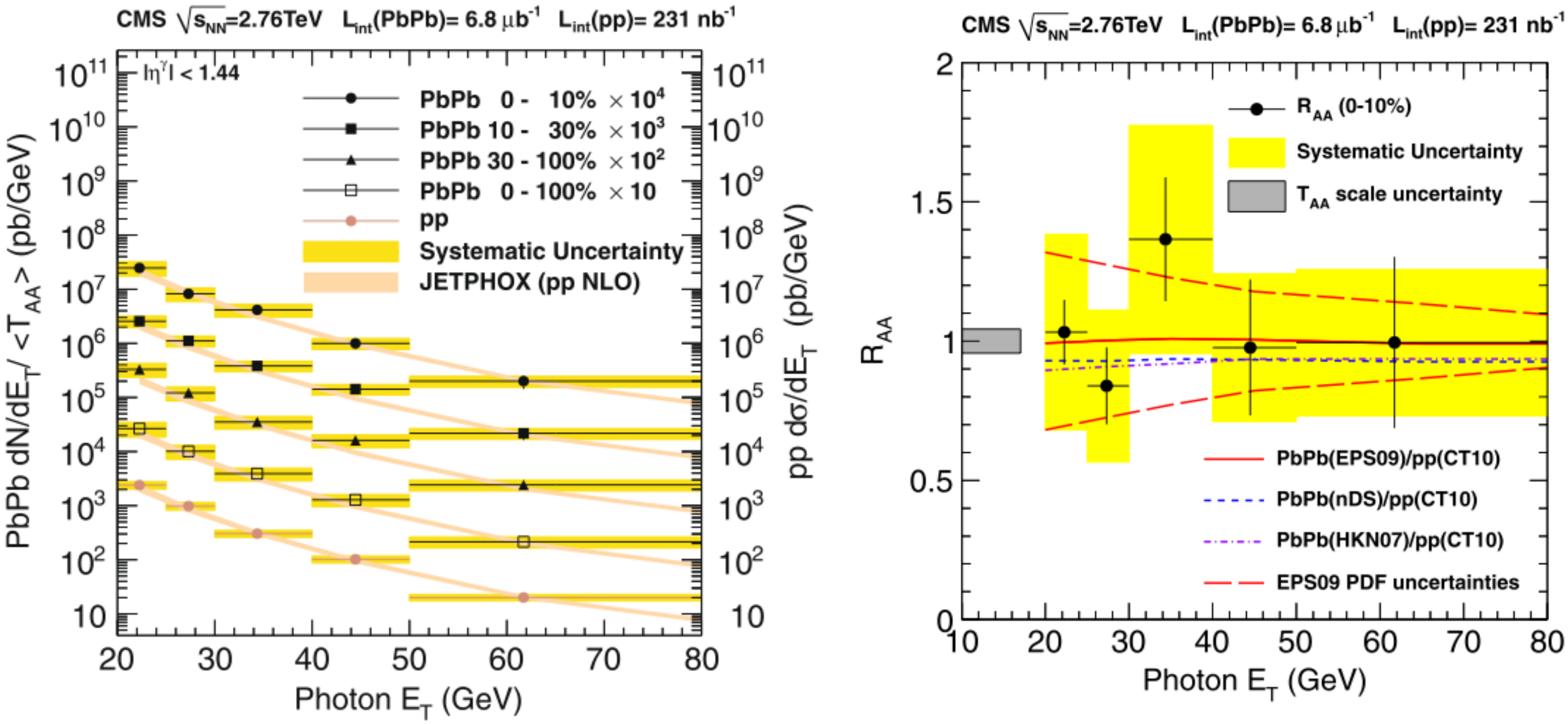

PHYSICAL
REVIEW
LETTERS
14 January 2002
Volume 88, Number 2
Au+Au √sNN= 130 GeV
central 0-10%
(h⁺+h⁻)/2
π0
α+α CERN-ISR
π0
Pb+Pb(Au) CERN-SPS
RHIC
Member Subscription Copy
Library or Other Institutional Use Prohibited Until 2007
APS
Published by The American Physical Society


PHYSICAL
REVIEW
LETTERS
Articles published week ending
15 AUGUST 2003
Volume 91, Number 7
PHENIX
PHOBOS
70-100%
40-70%
20-40%
0-20%
BRAHMS
STAR
η=0
Au + Au Central
d + Au Central
p+p Minimum Bias
Nuclear Modification Factor
Member Subscription Copy
Library or Other Institutional Use Prohibited Until 2008
APS
Published by The American Physical Society


The European Physical Journal
volume 72 · number 3 · march · 2012
EPJ C
EPS
Recognized by European Physical Society
Particles and Fields
SPS 17.3 GeV (PbPb)
π⁰ WA98 (0-7%)
RHIC 200 GeV (AuAu)
π⁰ PHENIX (0-10%)
h± STAR (0-5%)
LHC 2.76 TeV (PbPb)
CMS (0-5%)
ALICE (0-5%)
GLV: dNg/dy = 400
GLV: dNg/dy = 1400
GLV: dNg/dy = 2000-4000
YaJEM-D
elastic, small Pesc
elastic, large Pesc
YaJEM
ASW
PQM: <q̂> = 30 - 80 GeV²/fm
SPS
RHIC
LHC
RAA
pT (GeV/c)
Measurements of the nuclear modification factor RAA in central heavy-ion collisions at three different center-of-mass energies, as a function of pT, for neutral pions, charged hadrons, and charged particles, compared to several theoretical predictions. From the CMS Collaboration: Study of high-pT charged particle suppression in PbPb compared to pp collisions at √sNN = 2.76 TeV
Società Italiana di Fisica
Springer


Photon: colorless
W, Z: colorless
Controls
q: fast color triplet
g: fast color octet
Induced
gluon
radiation?
Q: slow color triplet
$Q\overline{Q}$: slow color singlet/octet
Energy
Loss?
Dissociation?
Unknown Medium

Control Probes at LHC: Photons



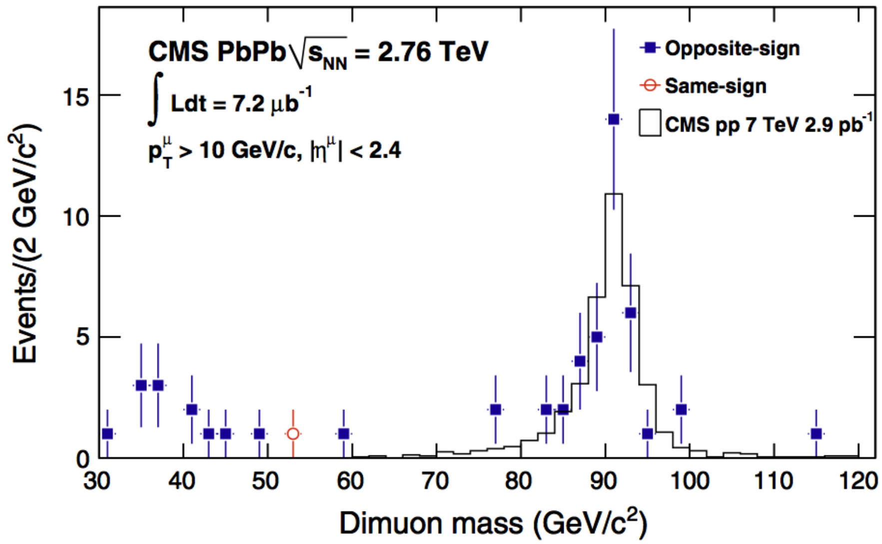
CMS, PLB 710 (2012) 256

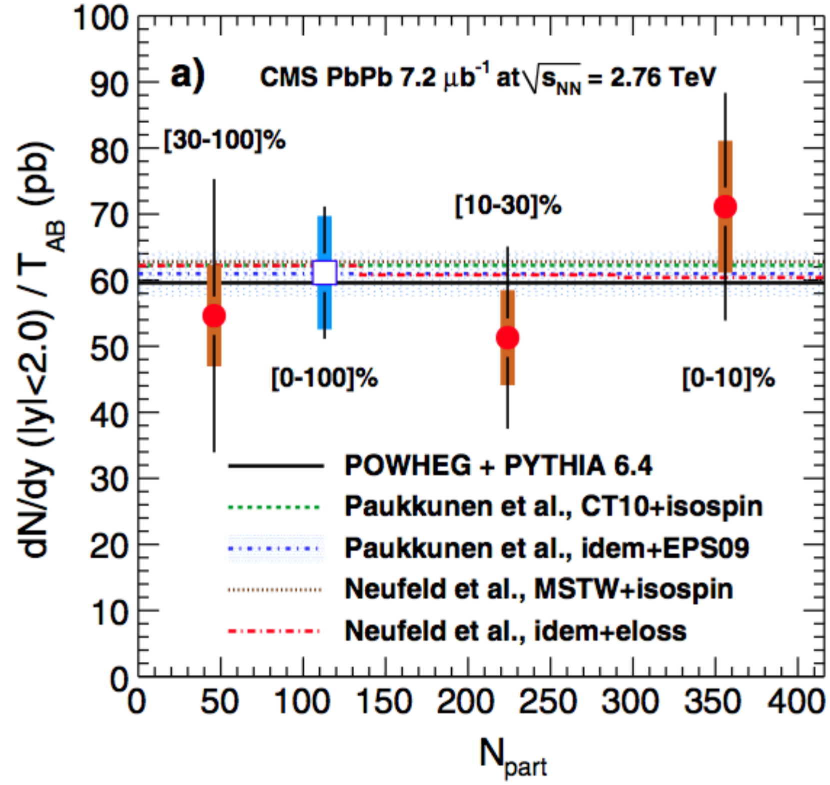
Good agreement data – NLO for both pp & PbPb systems.

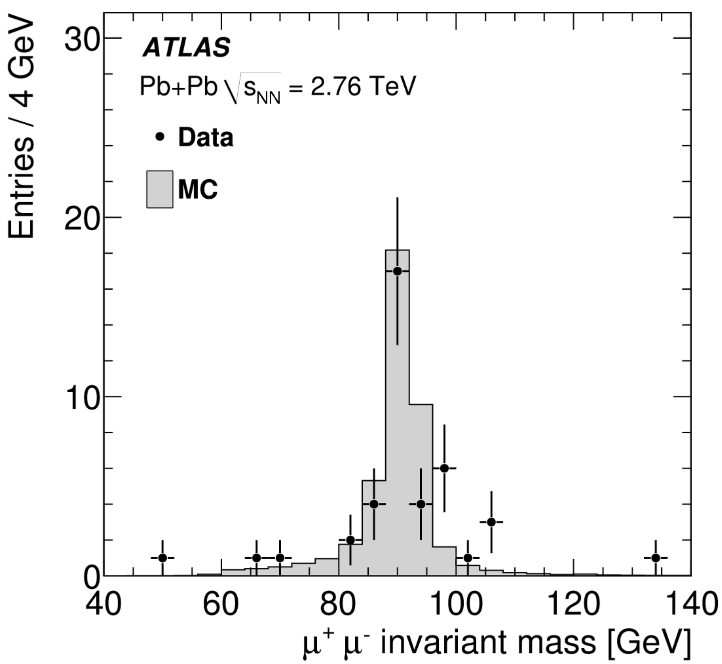
Like at RHIC: No modification of initial state

Hard scattering processes scale with <Ncoll> calculated by Glauber model

Control Probes at LHC: Z Bosons







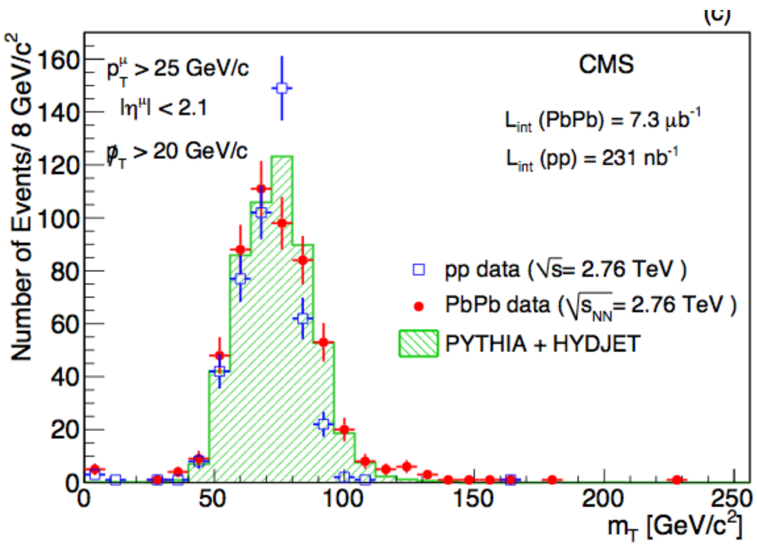
ATLAS, PLB 697 (2011) 294

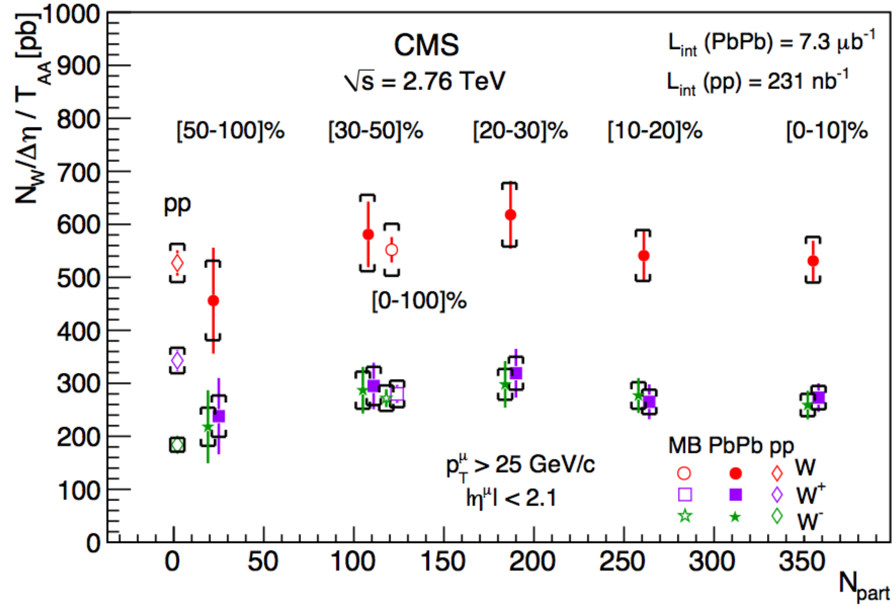
CMS, PRL 106 (2011) 212301

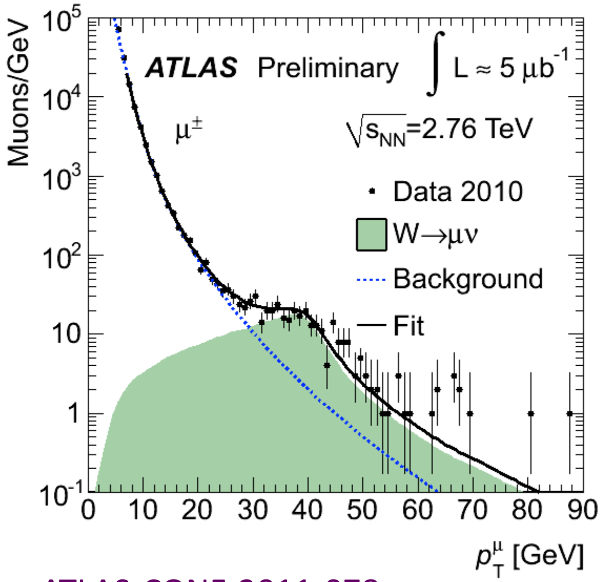
Clean Z signal from opposite-sign di-muon

Z yields consistent with pp & pQCD NLO (small nuclear PDF modifications) for all PbPb centralities.

Control Probes at LHC: W Bosons







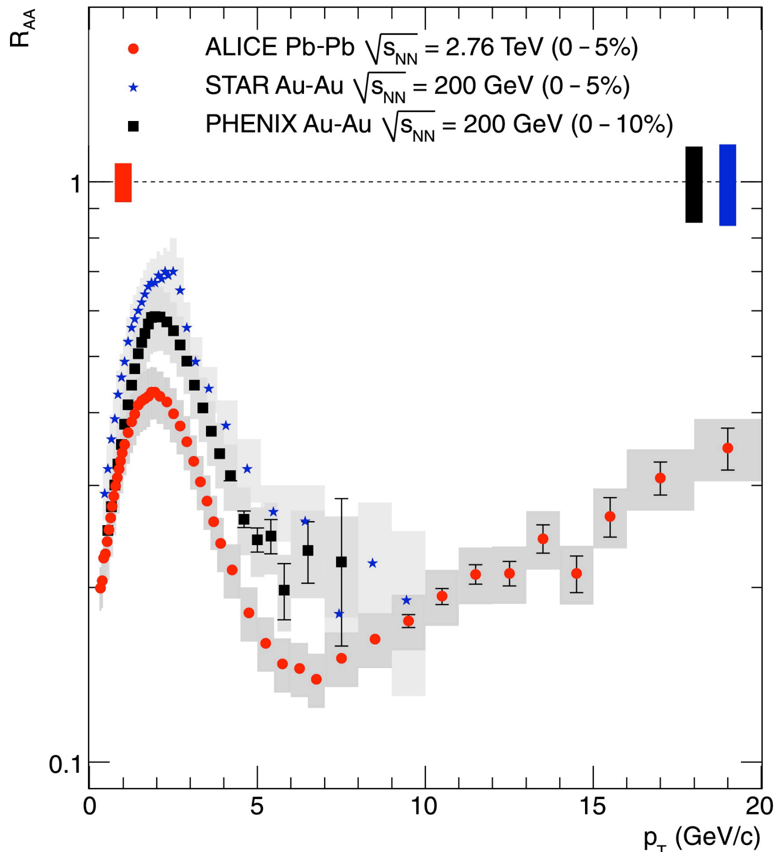
Good agreement in PbPb data and MC.

PbPb W yields consistent with pp & pQCD NLO (RAA~1):RAA(W) = 1.04 ± 0.07 ± 0.12

Electroweak bosons – control probes (γ,W,Z) are unsuppressed!

ATLAS-CONF-2011-078
CMS CMS-HIN-11-008, CERN-PH-EP-2012-144

Jet Suppression in A+A

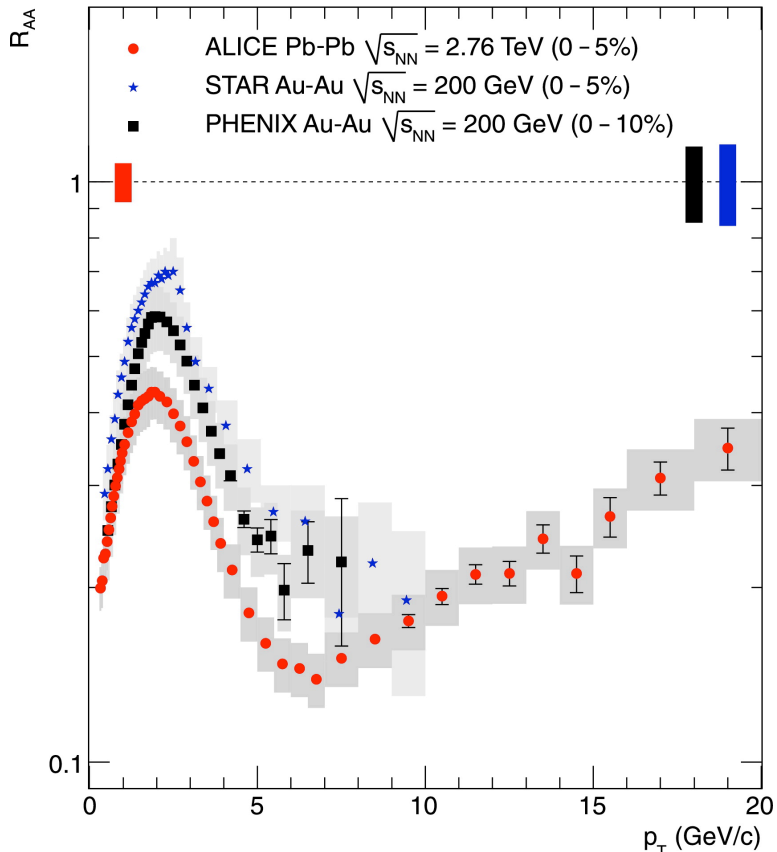


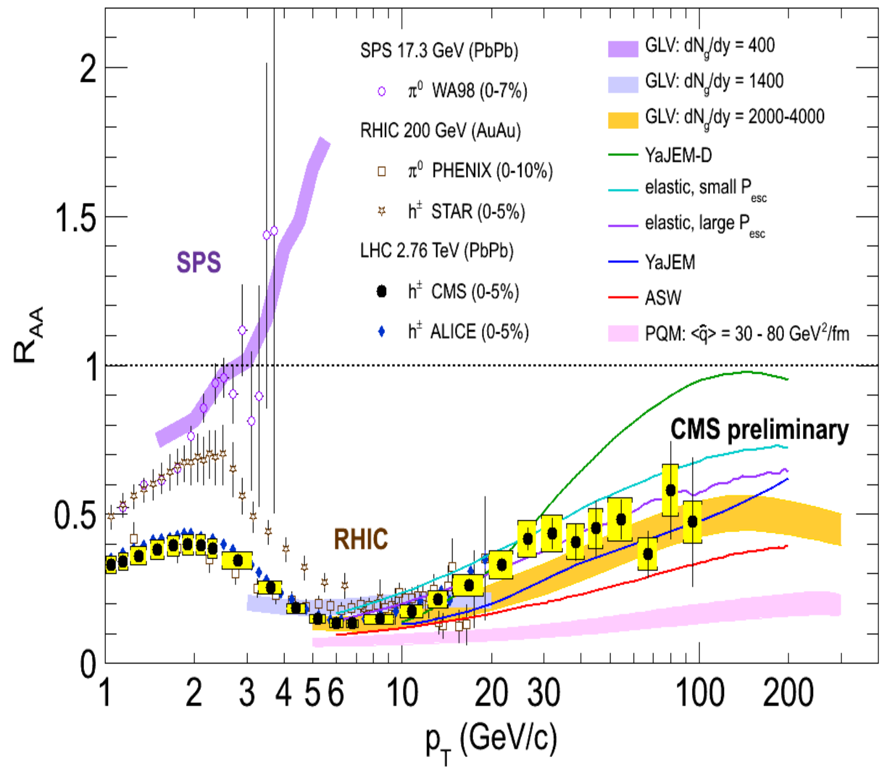
ALICE, PLB 696 (2011) 30
ATLAS-CONF-2011-079

Phys.Rev.Lett.106:212301,20
arXiv:1201.3093
arXiv:1201.5069

LHC hadrons suppressed by up to factor of ~6 at pT~7 GeV.

Jet Suppression in A+A



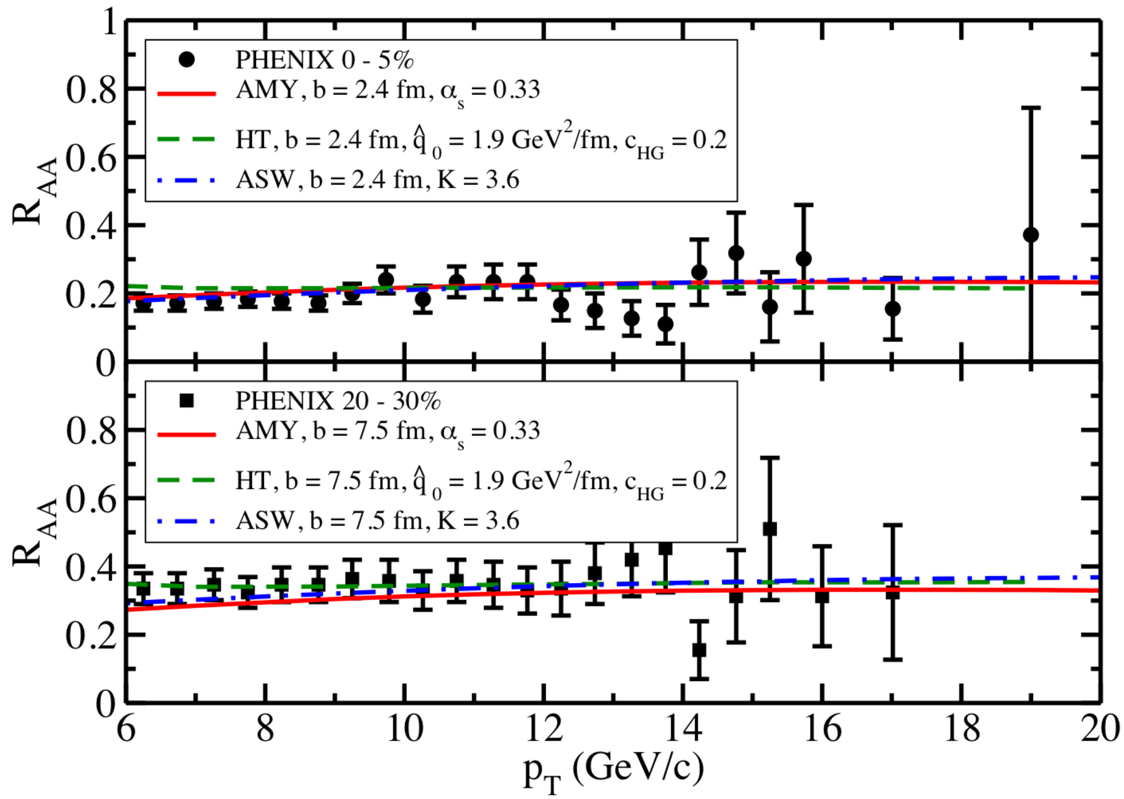


ALICE, PLB 696 (2011) 30
ATLAS-CONF-2011-079

Phys.Rev.Lett.106:212301,20
arXiv:1201.3093
arXiv:1201.5069

LHC hadrons suppressed by up to factor of ~6 at pT~7 GeV.
Slow rise and plateau at RAA~ 0.5 in pT~40 – 100 GeV

Quantative Jet Suppression in A+A



S. A. Bass et al. PRC79 (2009) 024901

Parameters can be adjusted to describe data well: $\hat{q}$ varies between 4-18 GeV/c^2

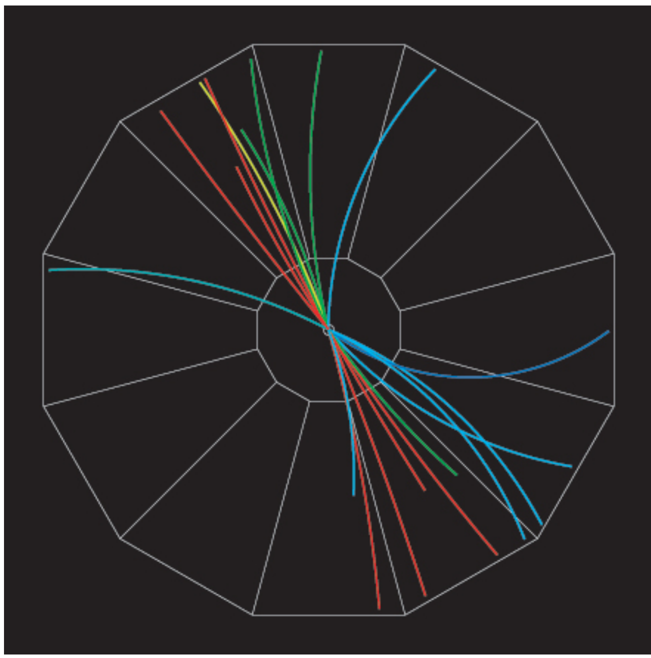
Strong discrimination power for parton radiative energy loss models but **limited discrimination of underlying physics**.

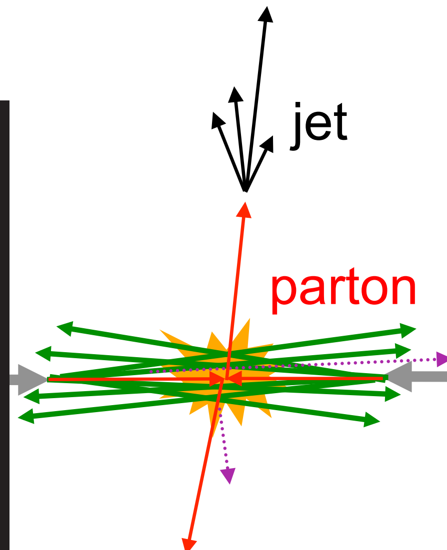
QGP properties to be derived next!

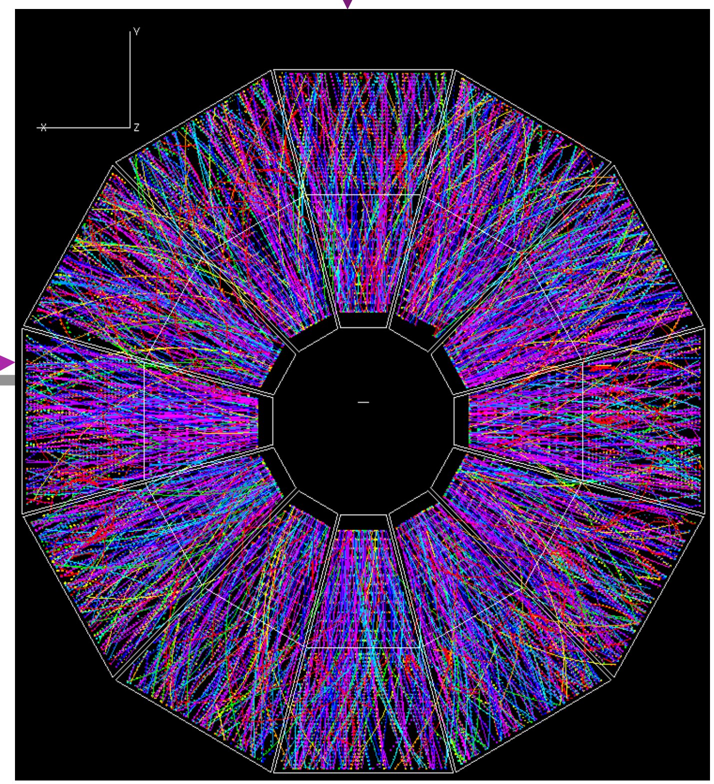
Jets in Heavy Ion Collisions

Find this …

in this !!!





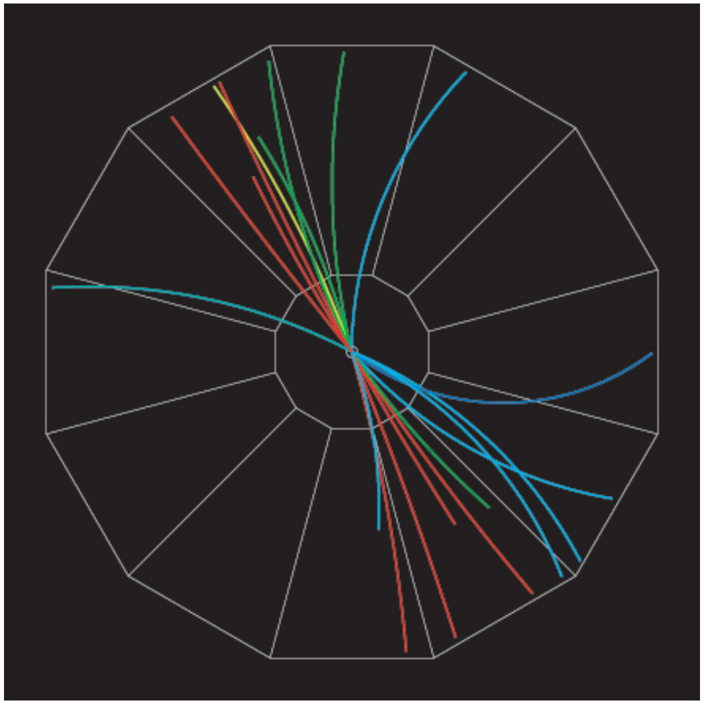


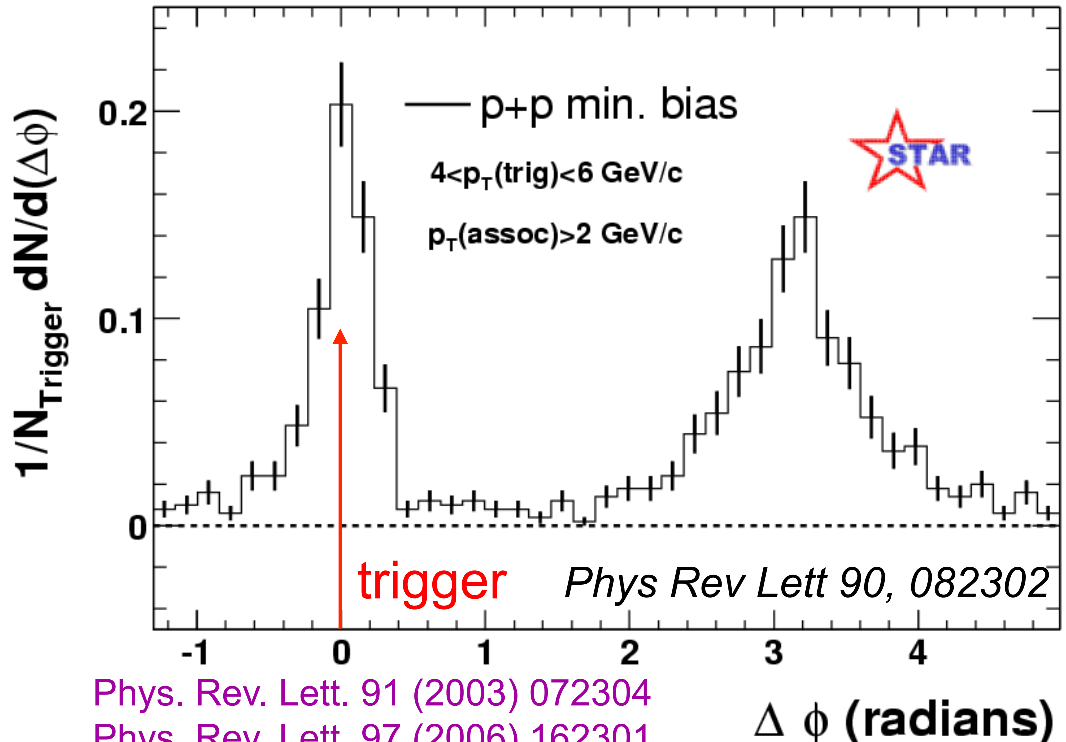
p+p →jet+jet
(STAR@RHIC)

Au+Au →???
(STAR@RHIC)

Jets and Two-Particle Azimuthal Distributions

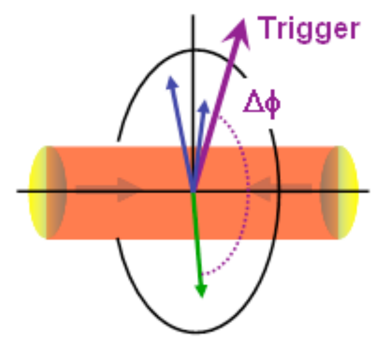
p+p → dijet



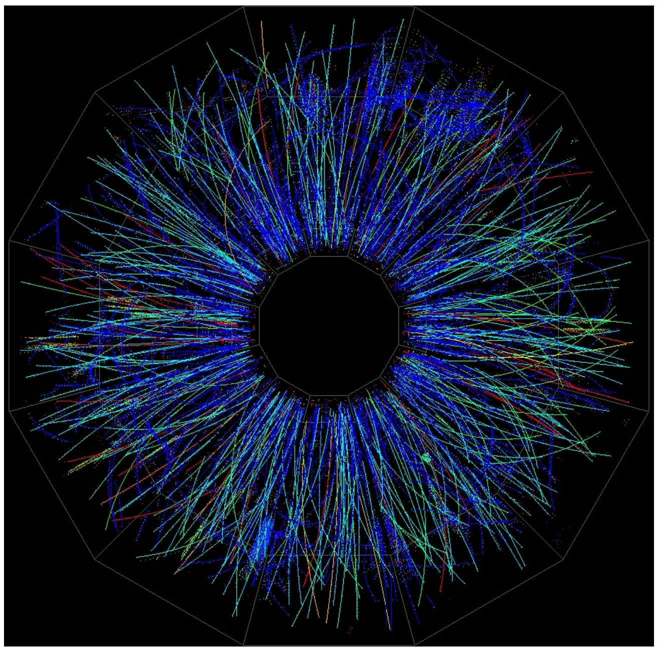


Phys. Rev. Lett. 91 (2003) 072304
Phys. Rev. Lett. 97 (2006) 162301

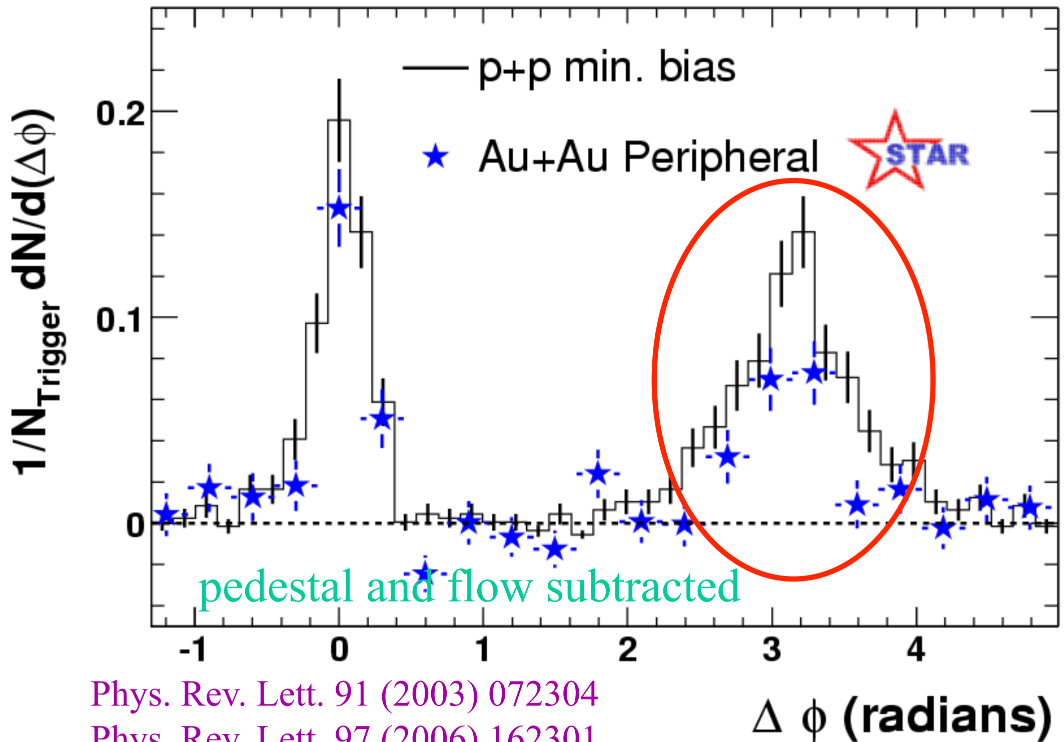
- Trigger: highest p_T track, p_T>4 GeV/c
- Δφ distribution: 2 GeV/c < p_T < $p_T^{trigger}$
- normalize to number of triggers



Jets and Two-Particle Azimuthal Distributions

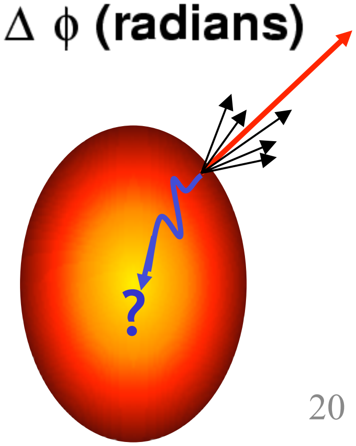


peripheral Au+Au collisions

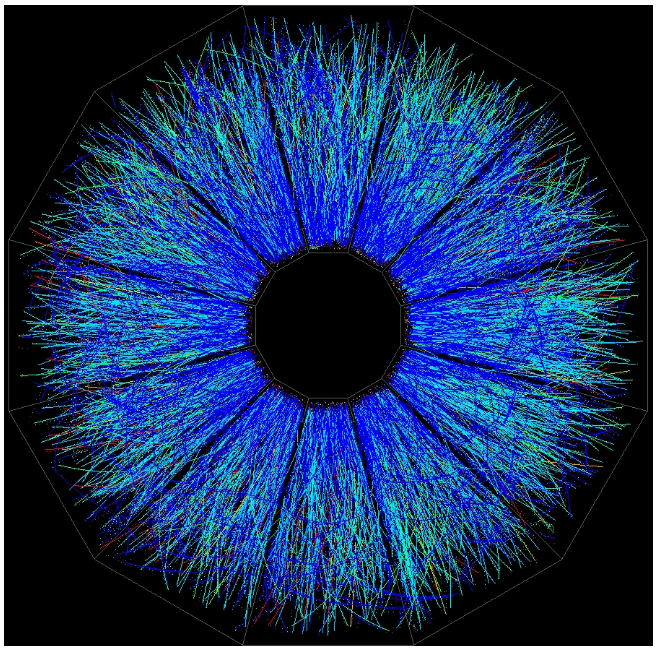


Phys. Rev. Lett. 91 (2003) 072304
Phys. Rev. Lett. 97 (2006) 162301

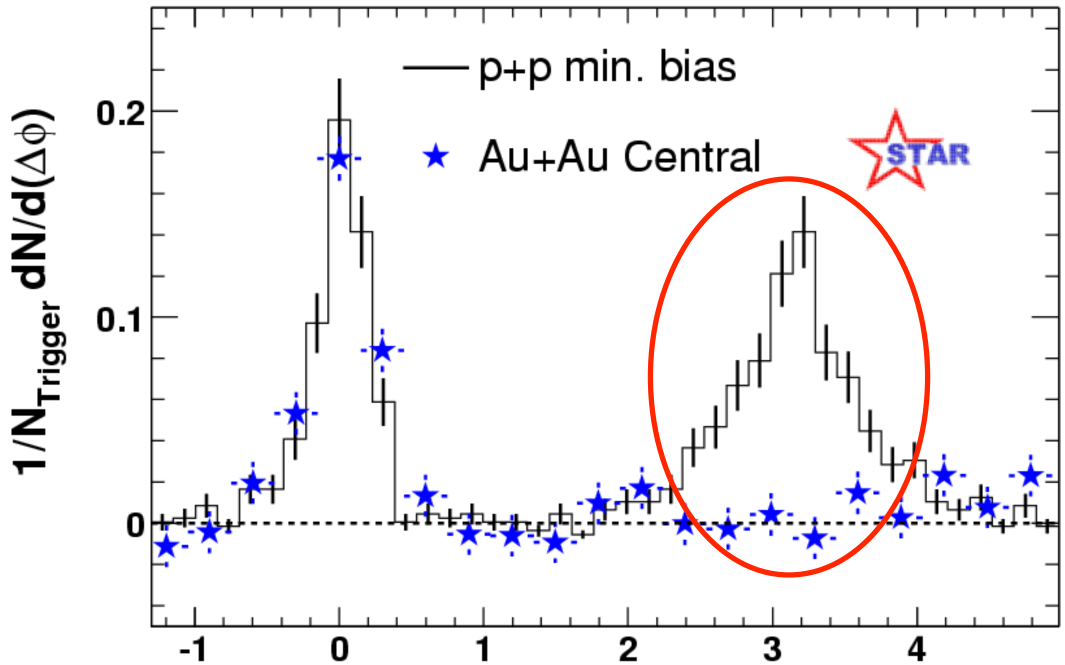
Near side $\Delta\phi \approx 0$: p+p, Au+Au similar



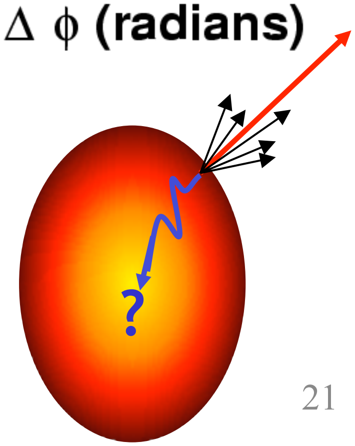
Jets and Two-Particle Azimuthal Distributions



central Au+Au collisions

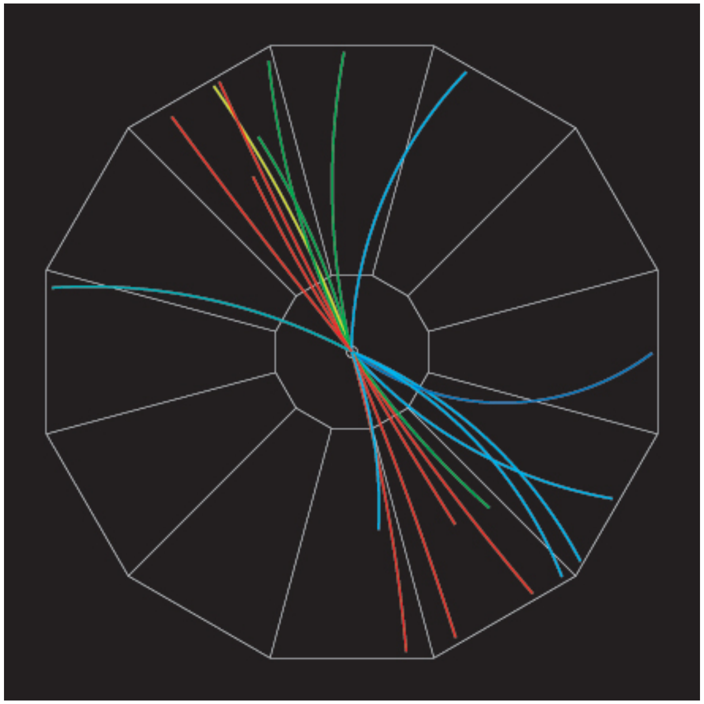


Phys. Rev. Lett. 91 (2003) 072304
Phys. Rev. Lett. 97 (2006) 162301

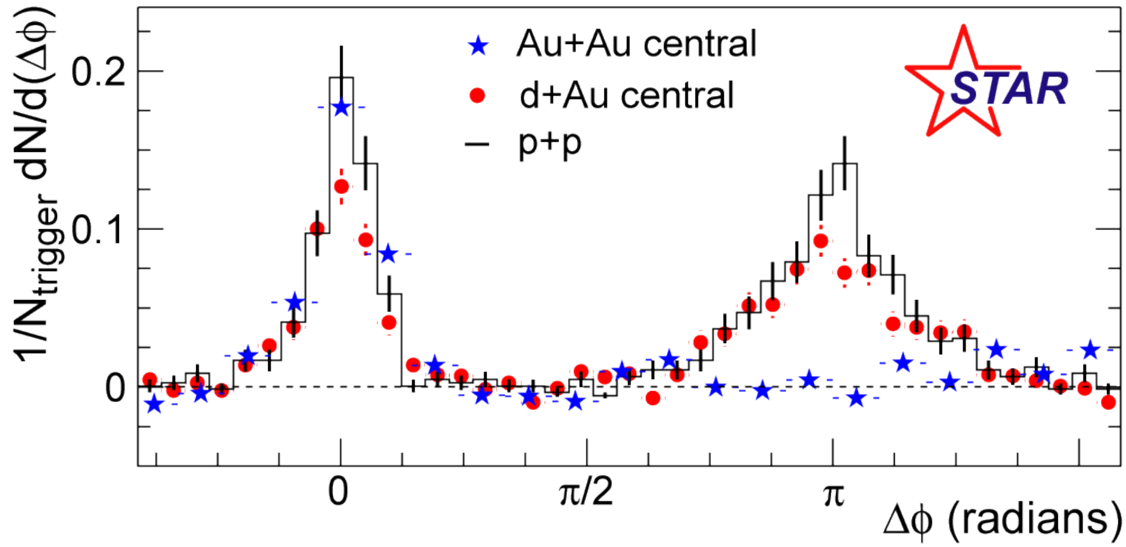


$\Delta\phi \approx 0$: peripheral and central Au+Au similar to p+p
$\Delta\phi \approx \pi$: strong suppression of back-to-back correlations in central Au+Au

Jets and Two-Particle Azimuthal Distributions



d+Au Collisions



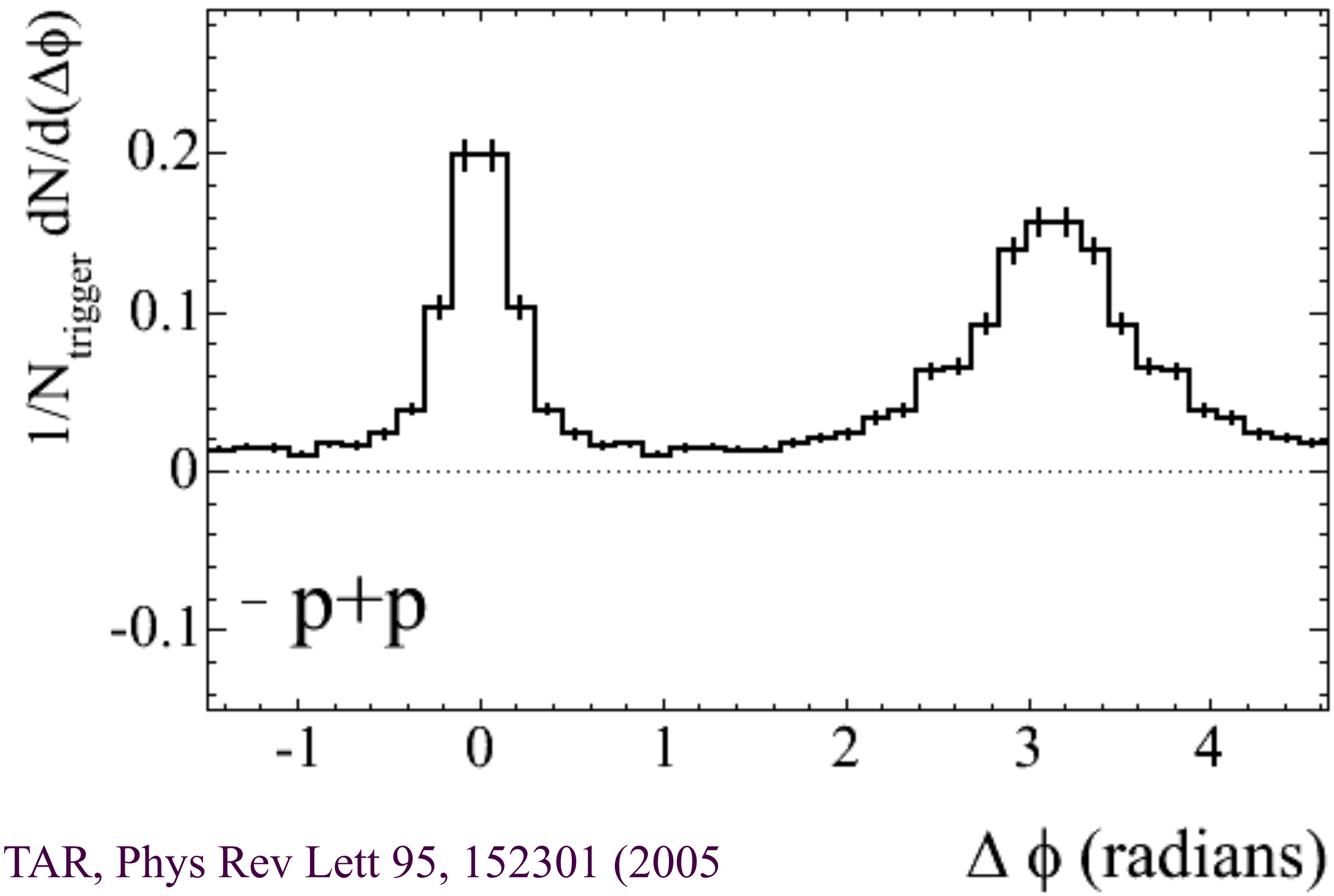
Phys. Rev. Lett. 91 (2003) 072304
Phys. Rev. Lett. 97 (2006) 162301

Near side $\Delta\phi \approx 0$: p+p, d+Au, Au+Au similar

Back-to-back $\Delta\phi \approx \pi$: Au+Au suppressed relative to p+p **and** d+Au

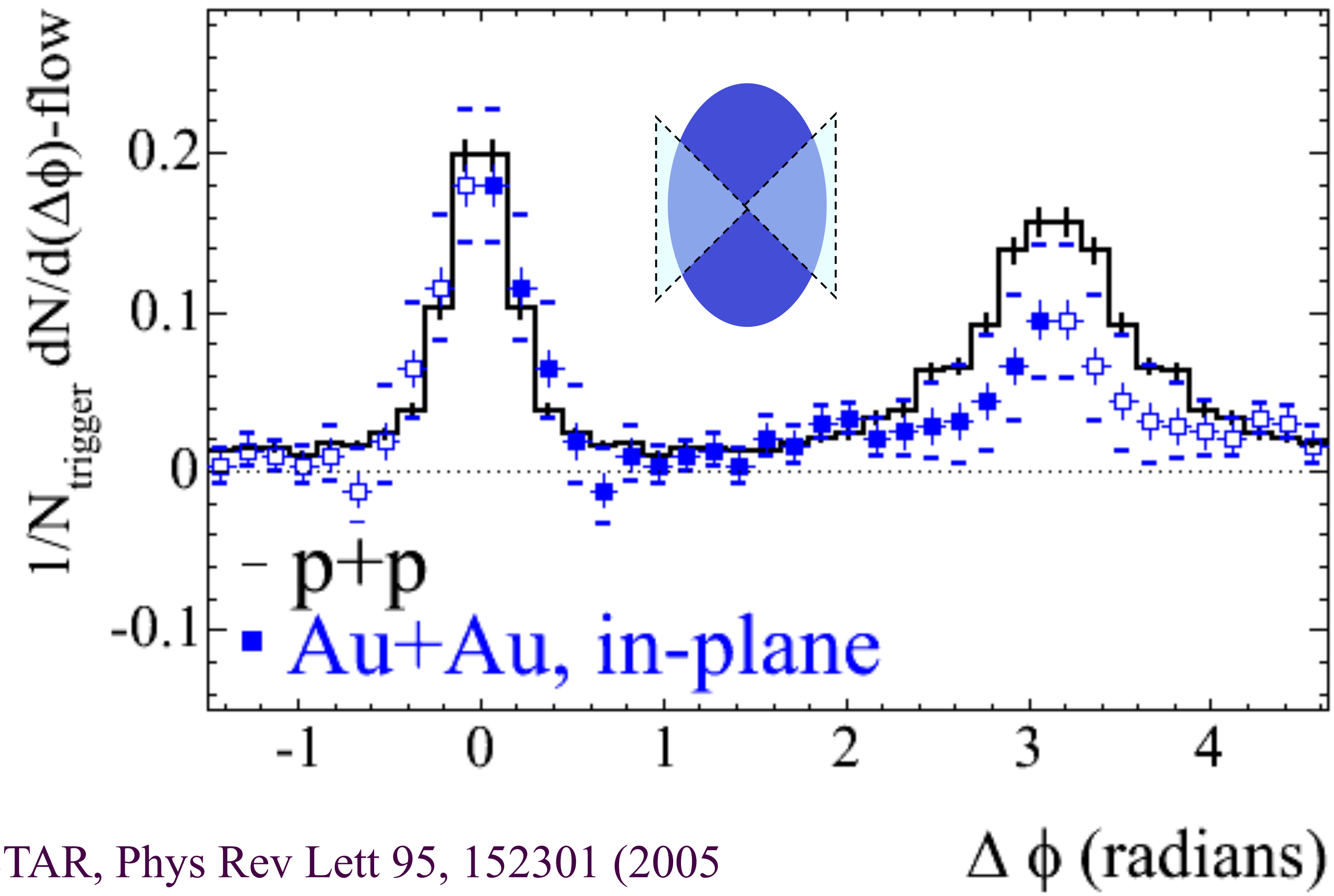
Suppression of back-to-back correlations in central Au+Au is a final-state effect

Di-Jet Tomography: Geometry Matters



STAR, Phys Rev Lett 95, 152301 (2005

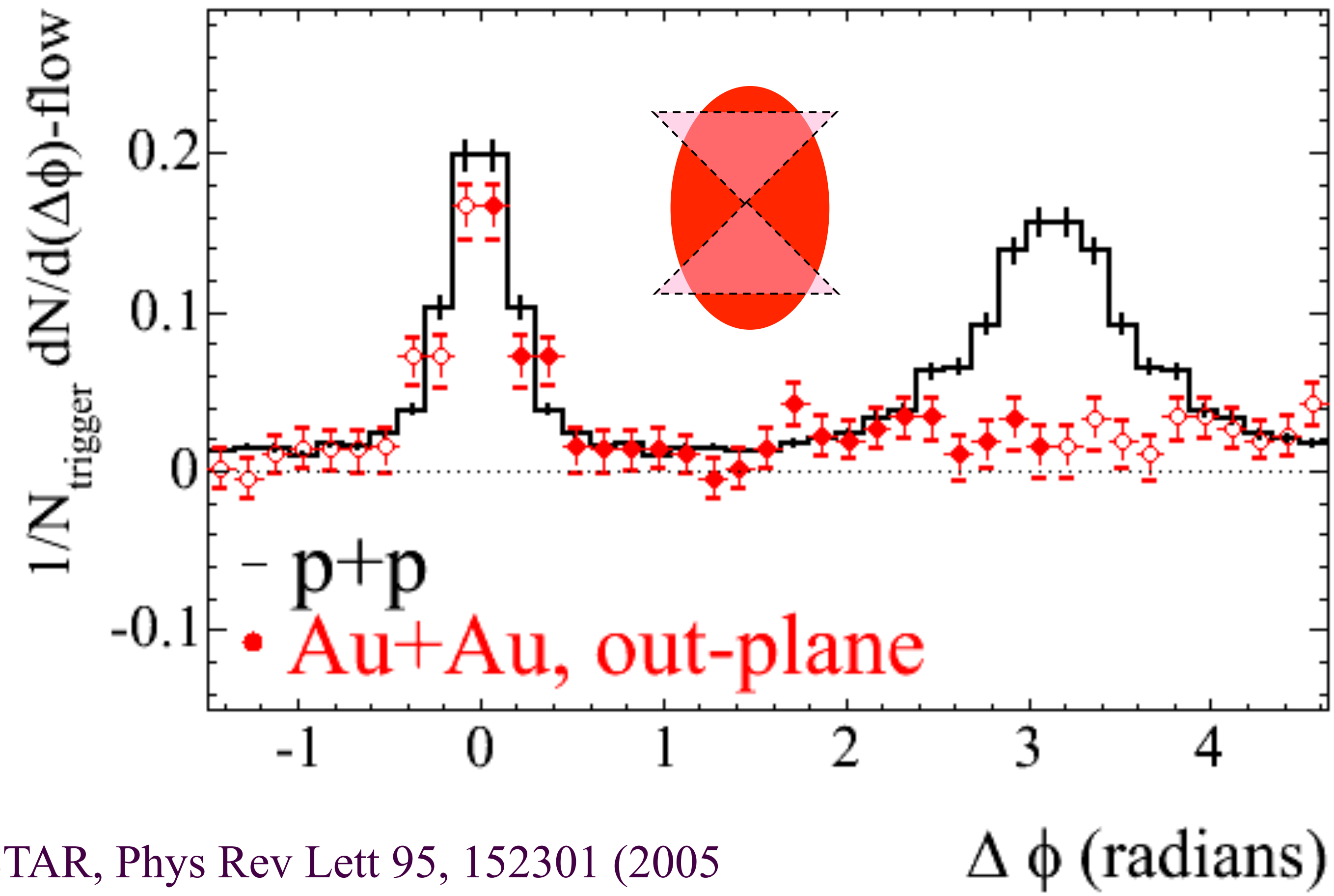
Di-Jet Tomography: Geometry Matters



STAR, Phys Rev Lett 95, 152301 (2005

- Au+Au: Away-side suppression is smaller in-plane (shorter distance!)

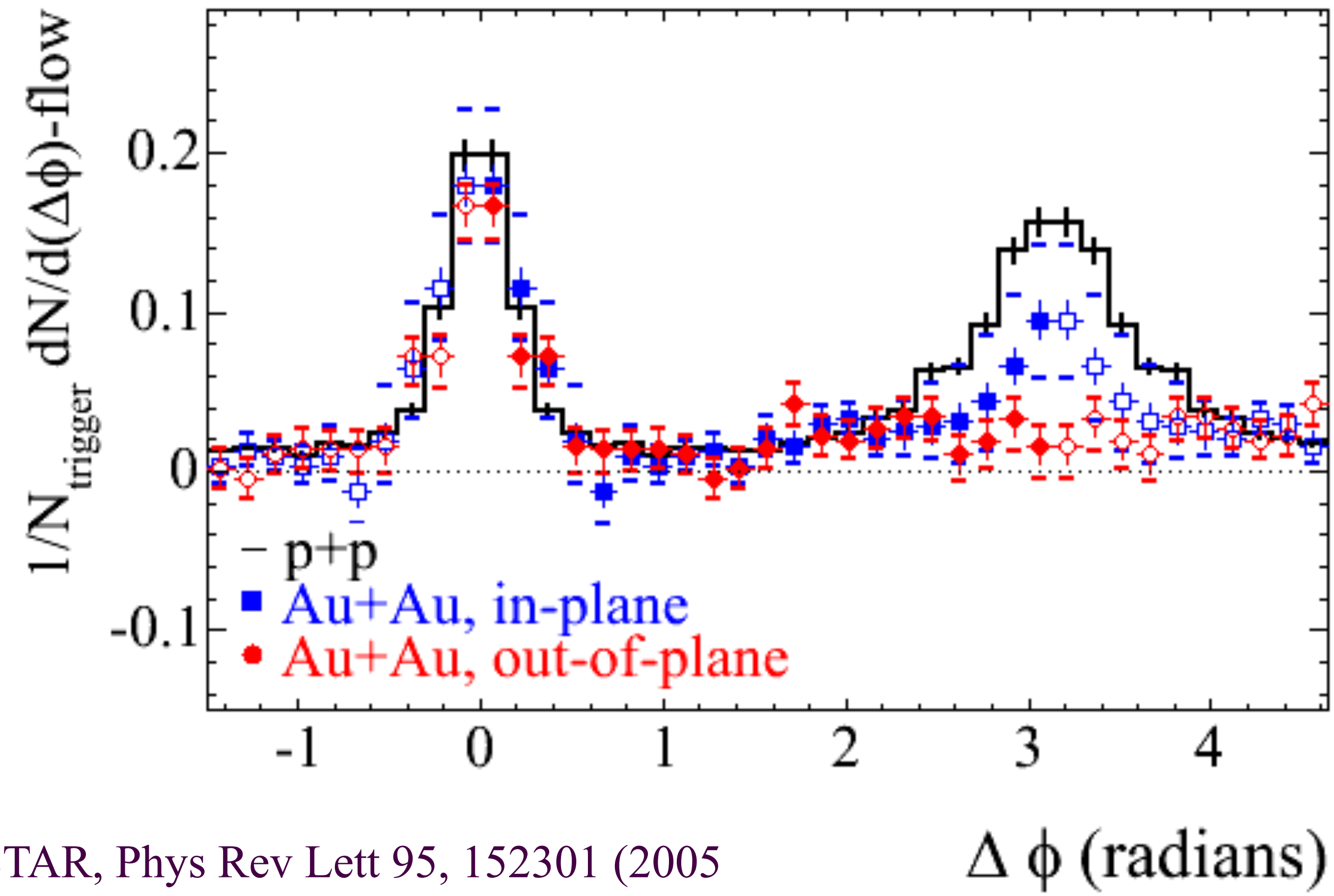
Di-Jet Tomography: Geometry Matters



STAR, Phys Rev Lett 95, 152301 (2005

➢ Au+Au: Away-side suppression is larger in the out-of-plane direction compared to in-plane

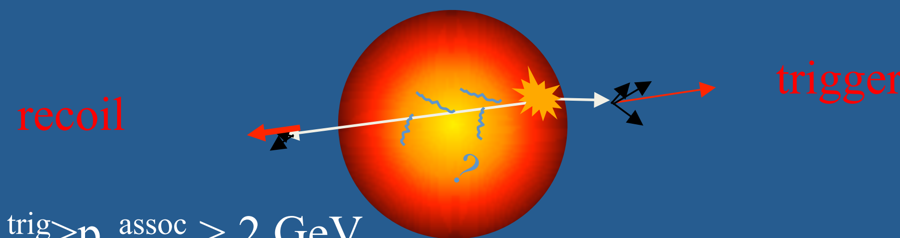
Di-Jet Tomography: Geometry Matters



STAR, Phys Rev Lett 95, 152301 (2005

➢ Au+Au: Away-side suppression is larger in the out-of-plane direction compared to in-plane

Jet quenching: Recoiling jets are strongly modified



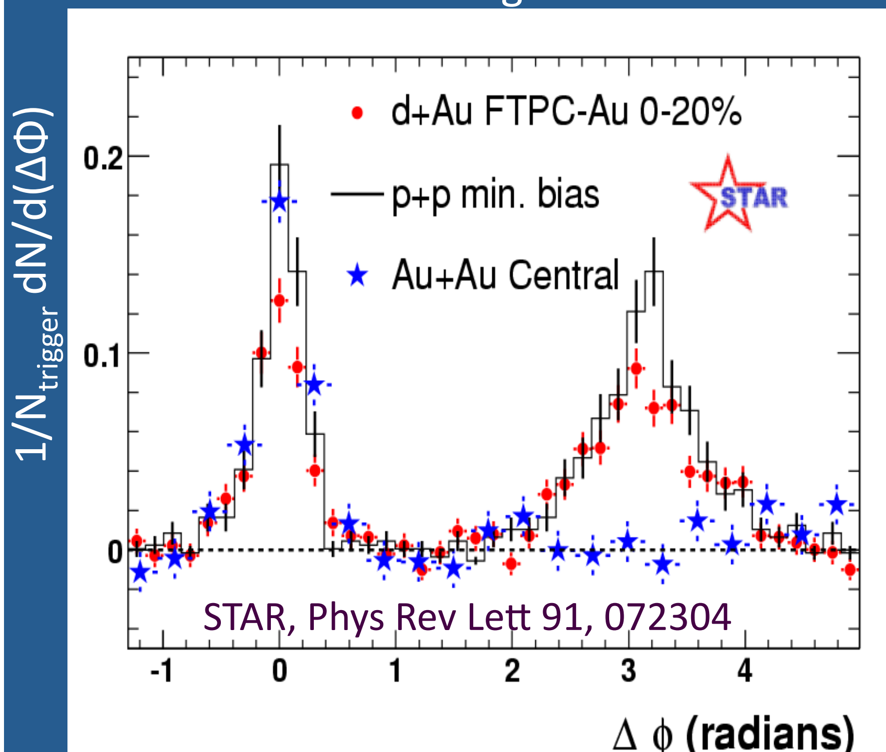
$4 < p_T^{trig} < 6$ GeV

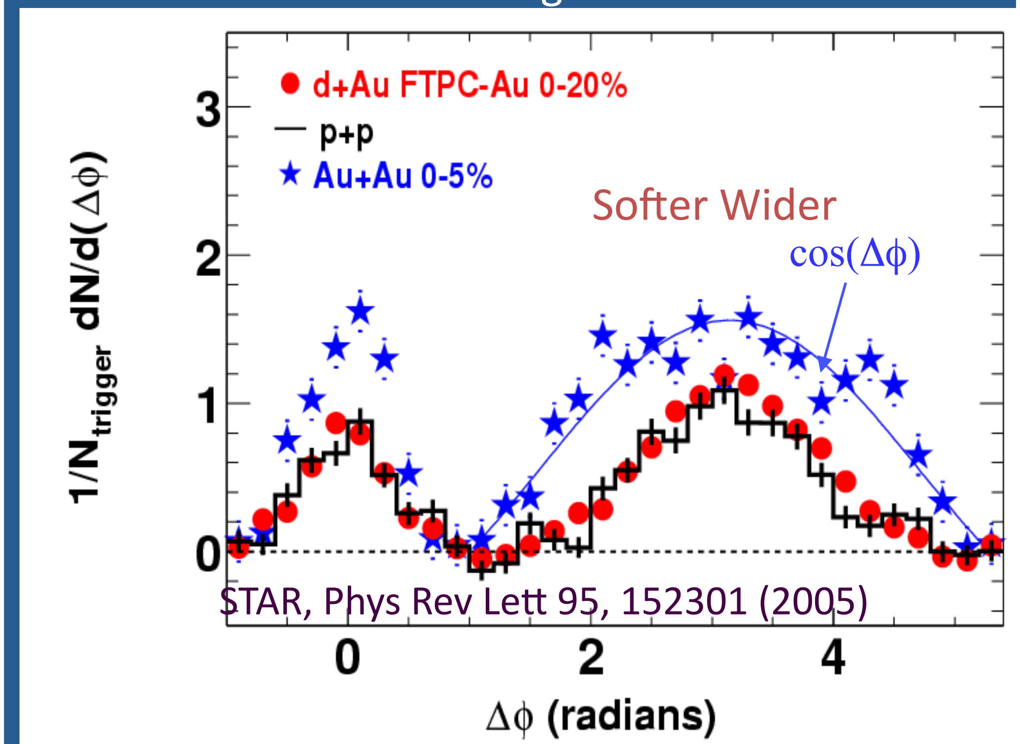
$p_T^{trig} > p_T^{assoc} > 2$ GeV

Hard recoiling hadrons

$p_T^{trig} > p_T^{assoc} > 0.15$ GeV

All recoiling hadrons



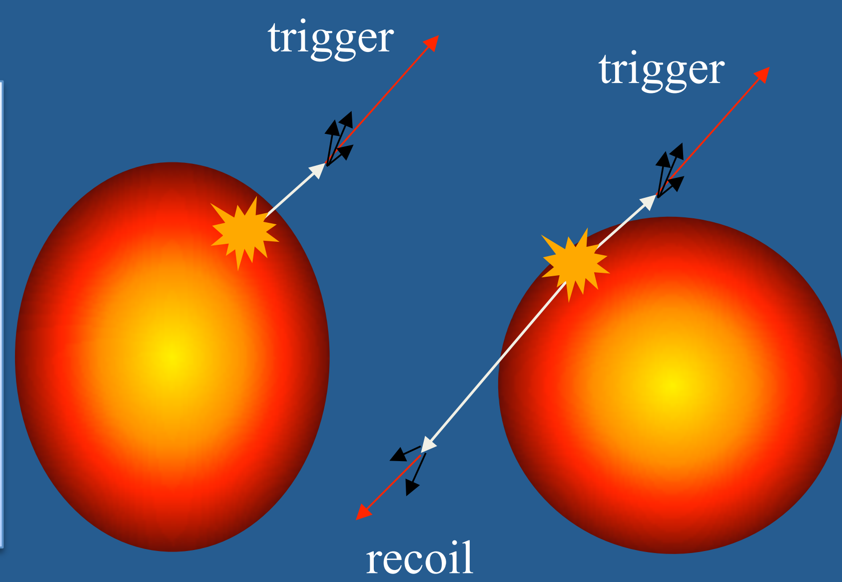


Conservation of Energy: Qualitatively large effects-conclusive evidence for large partonic energy loss in dense matter (final state effect)

So what is missing?

High p_T (leading) hadrons bias towards jets that have *not* interacted

- indirect measurement of jet quenching
- little sensitivity to dynamics and modification of jet structure
- little sensitivity to medium response

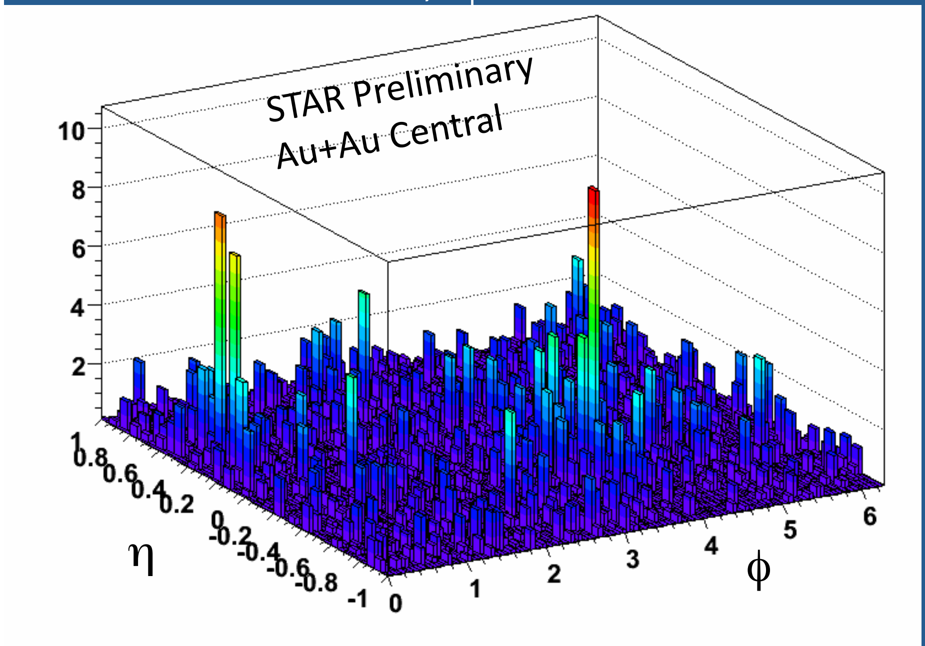


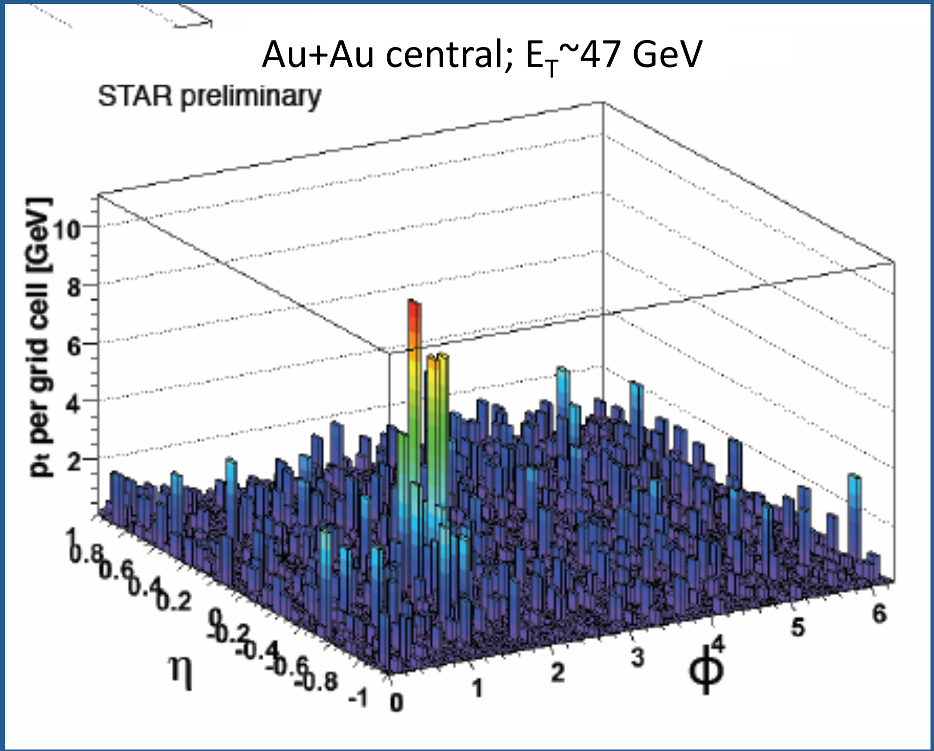
How to do better? Full jet reconstruction

- Recover full energy/momentum flow → unbiased view of quenching
- New observables with sound basis in QCD theory

Jets in Au+Au@200 GeV data

Au+Au central; E_T~21GeV



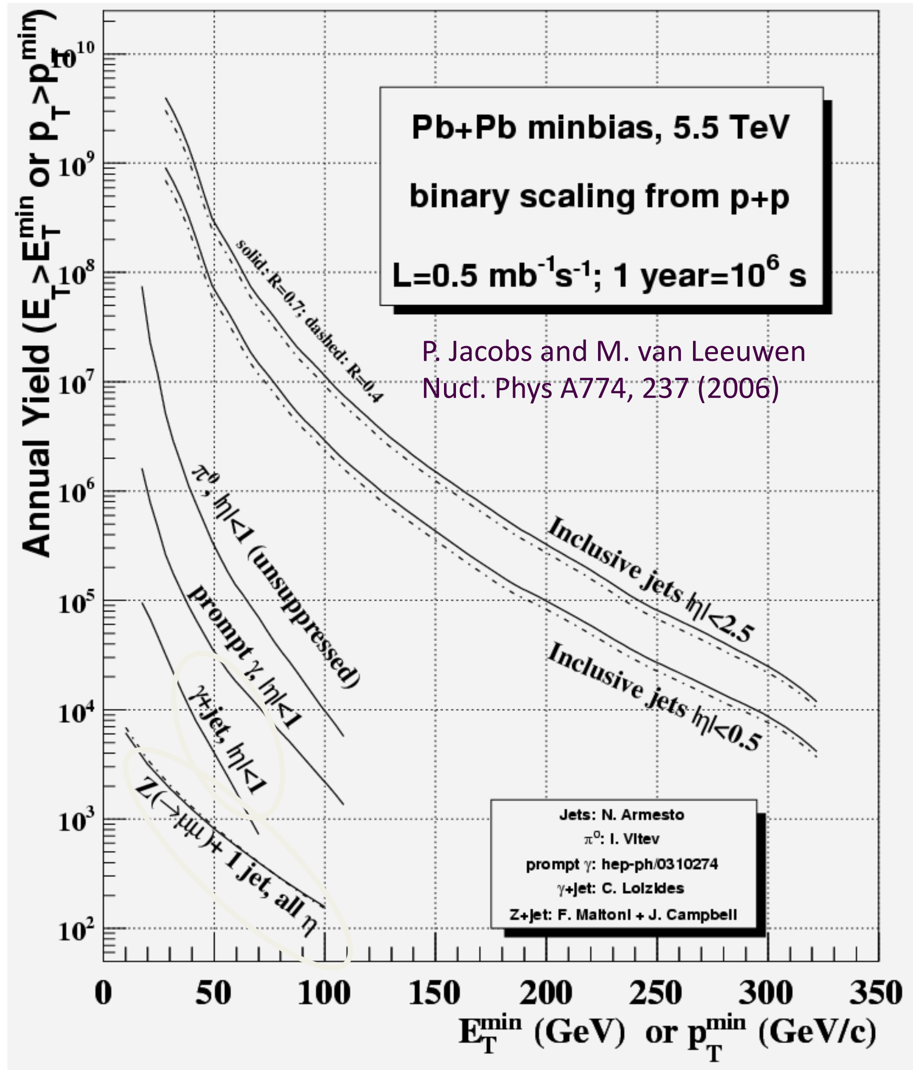


Too much grass!
→ Uncertainty Jet Energy scale

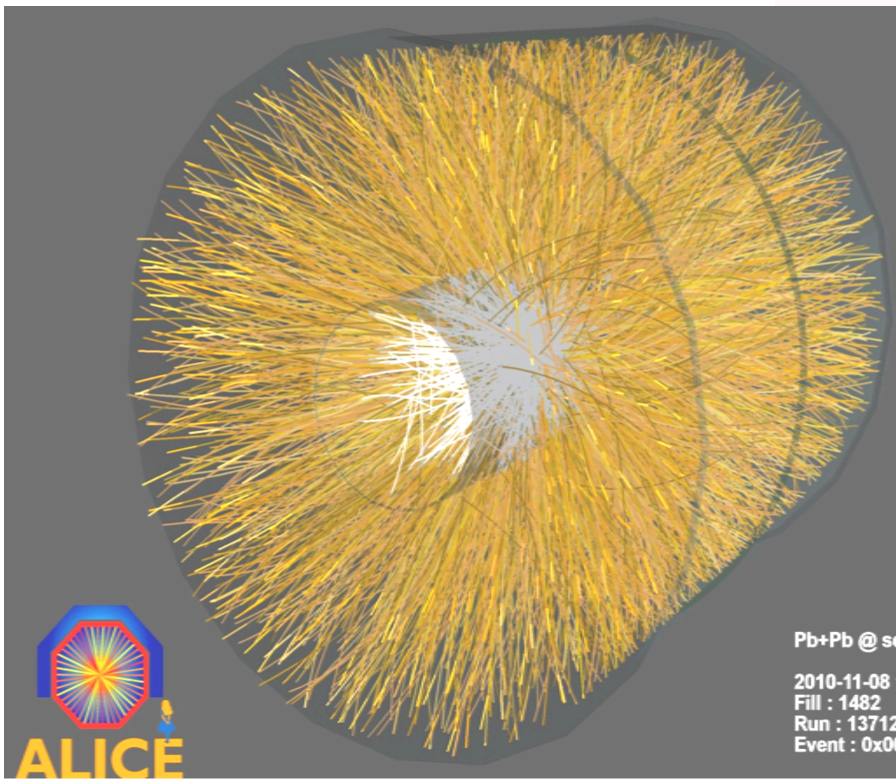
A better way: Reconstruct Jets at LHC

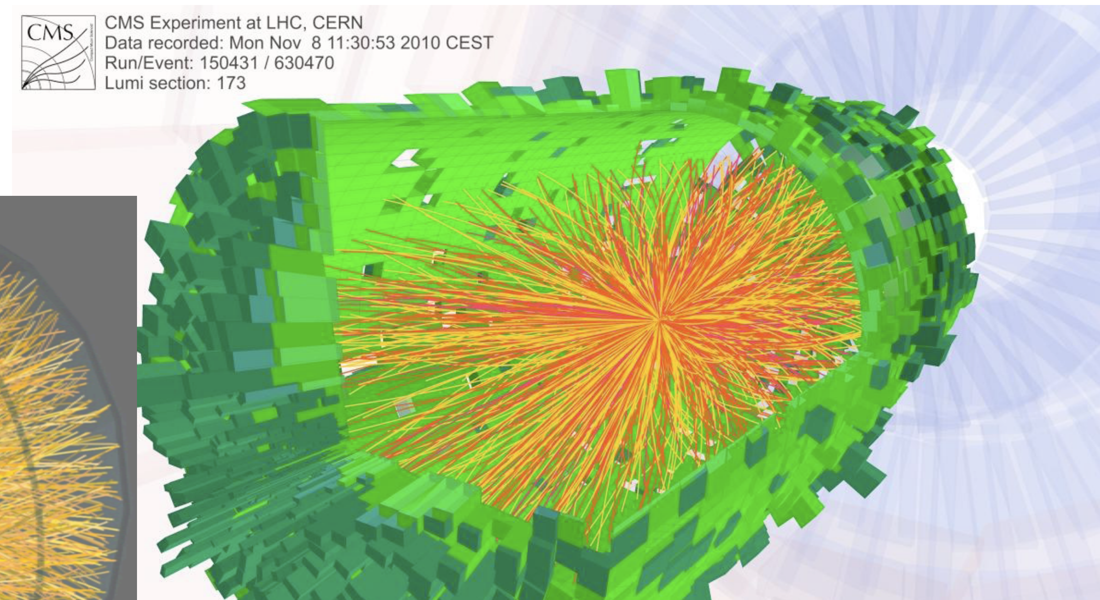
LHC is a jet machine!

Reconstruct jets →
Access to:
The full final state hard scattering to characterize the interactions of partons with the hot & dense matter.



Also too many particles…





Central collision (b≈0 fm) at $\sqrt{s_{NN}}$ = 2.76 TeV

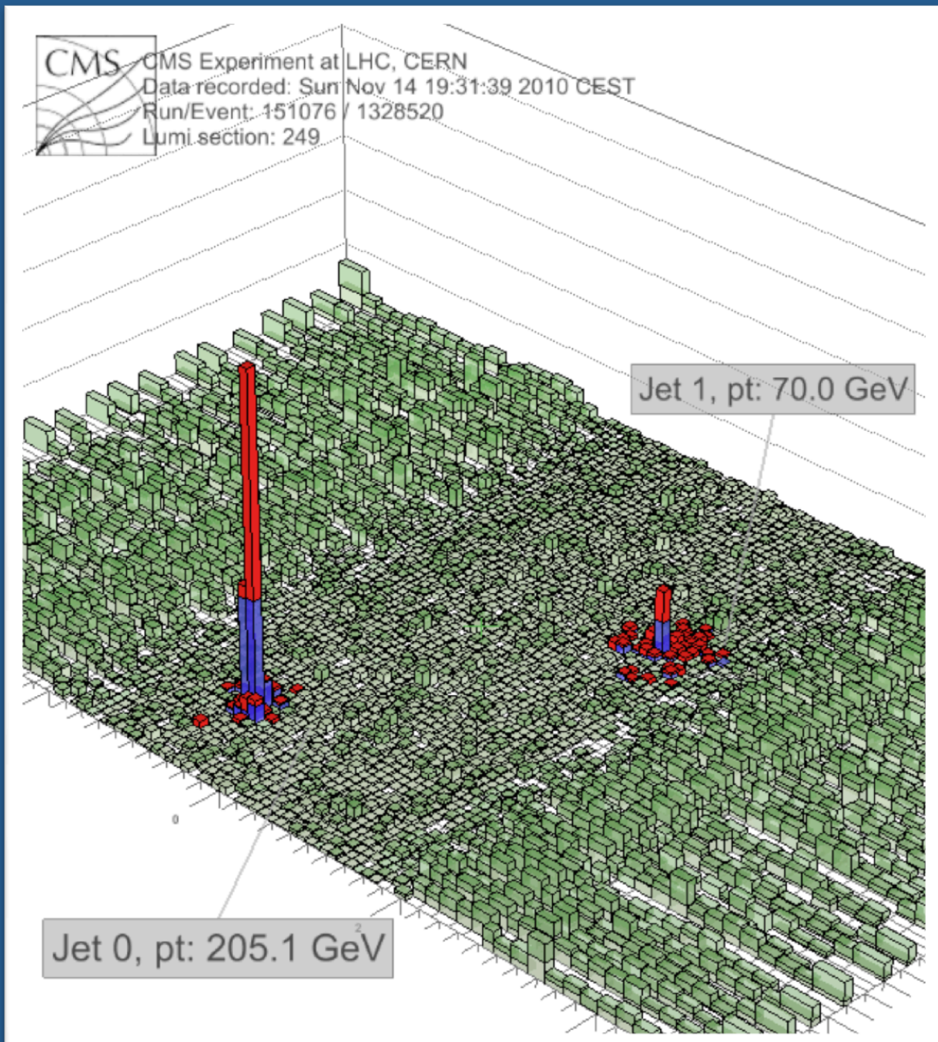
>10000 charged particles produced

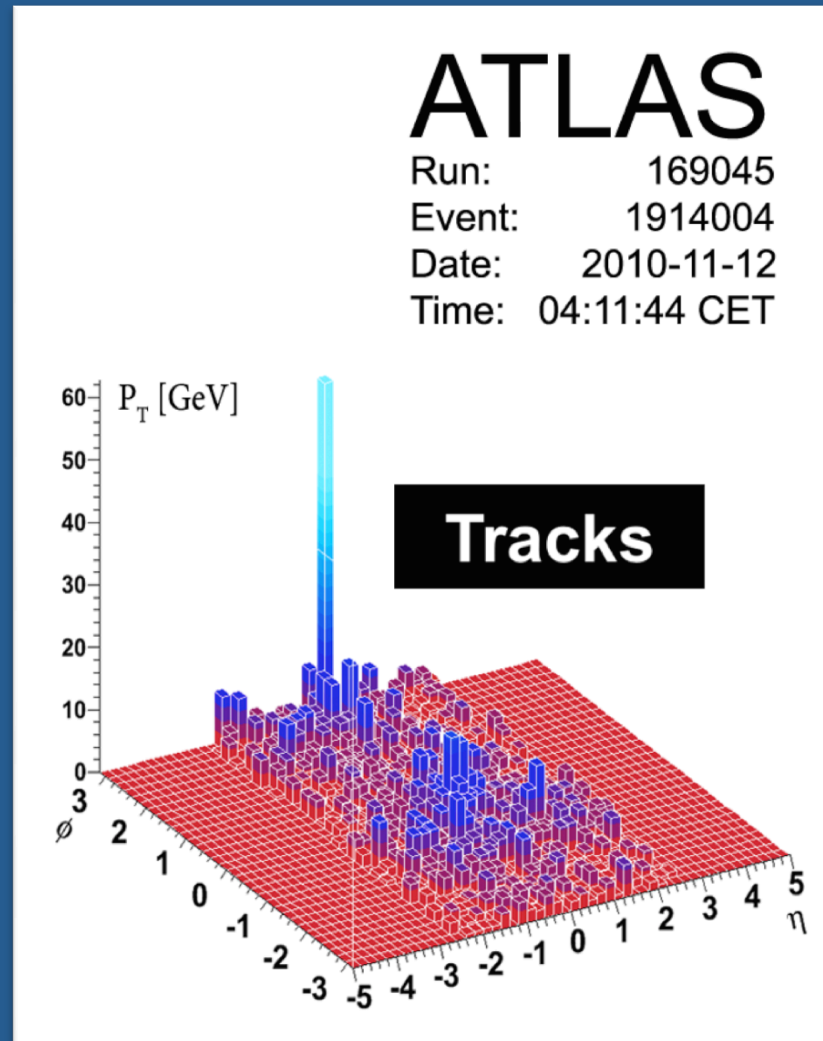
How to beat the background?

One of the tools: →Use di-jets

Fast partons from hard scattering are almost always accompanied by a second parton with close to the same transverse momentum and back-to-back in azimuthal angle.
Requiring di-jets reduces the effect of background fluctuations.
But biases the jet sample!

But can go to higher jet p_T





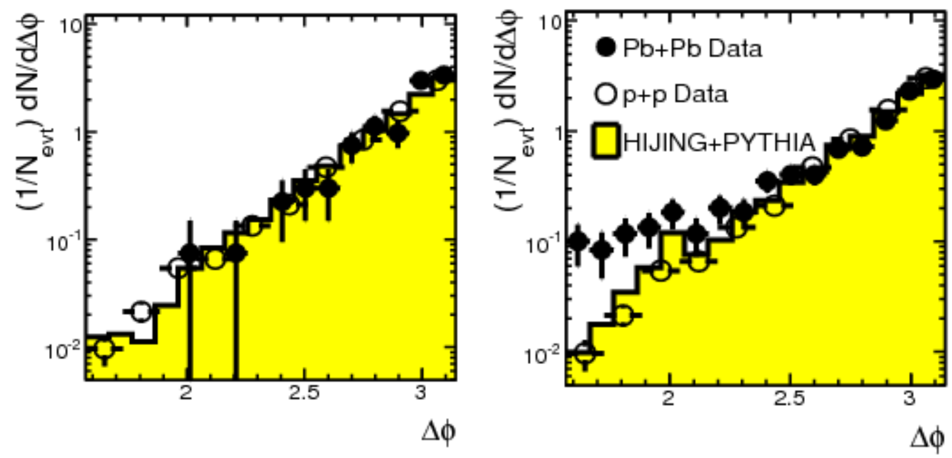
In central collisions many of the di-jets are observed to be not balanced!

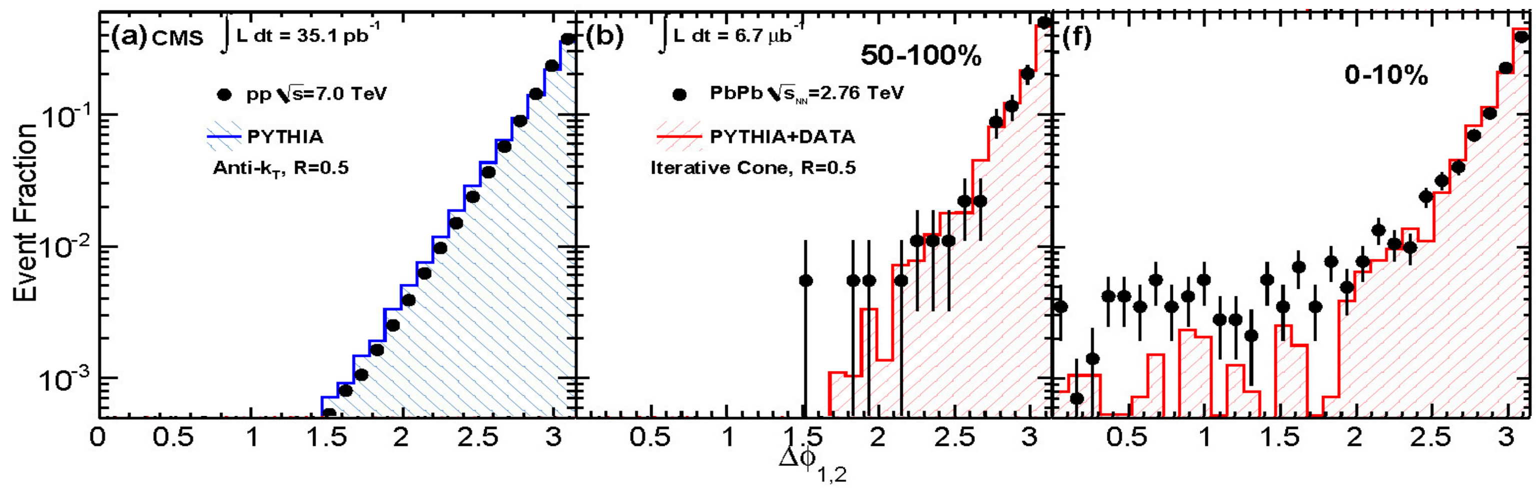
First Di-jet Measurements with 2010 Data

The leading jet of $E_T^1 > 100, 120$ GeV

The sub-leading jet $E_T^2 > 25, 50$ GeV

stay essentially back-to back ($\Delta\phi = \pi$)





PRC84 (2011) 024906

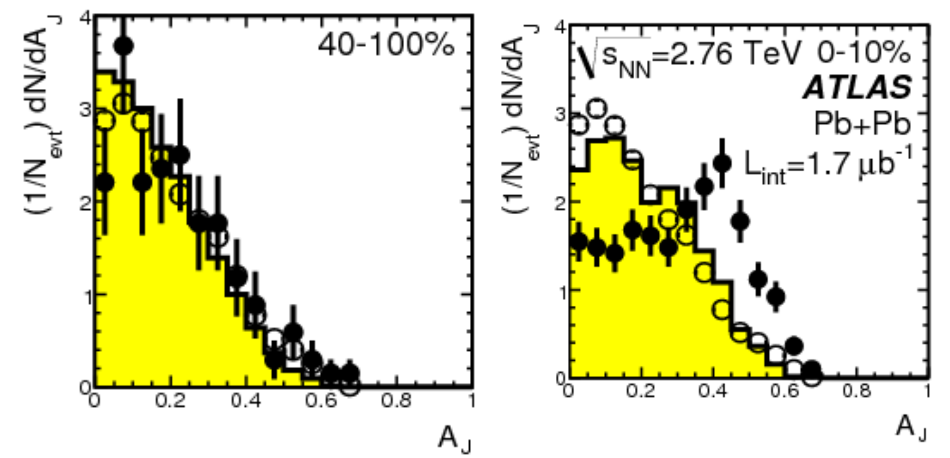
Angular correlations is unchanged by the medium

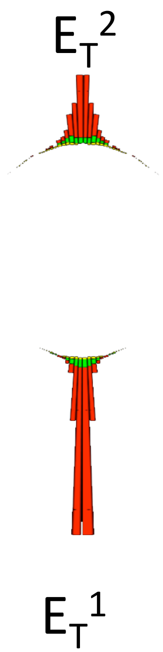
Quantifying Di-jet Measurements

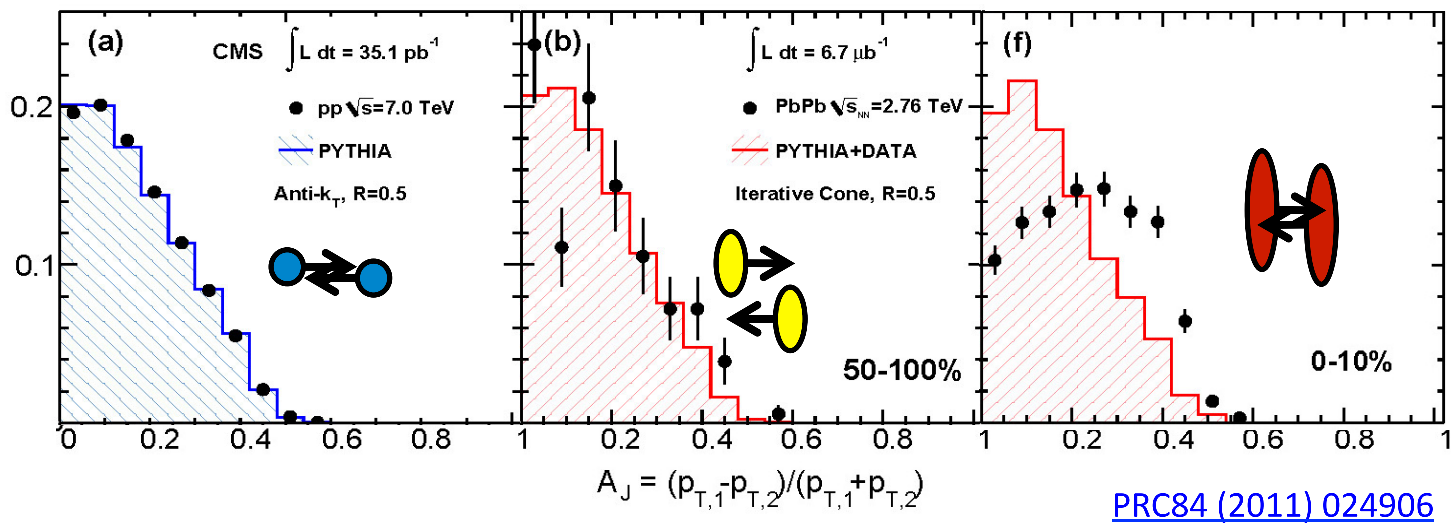
Phys.Rev.Lett. 105 (2010) 252303

Use Asymmetry ratio :

$$A_j = \frac{E_T^{j1} - E_T^{j2}}{E_T^{j1} + E_T^{j2}}$$



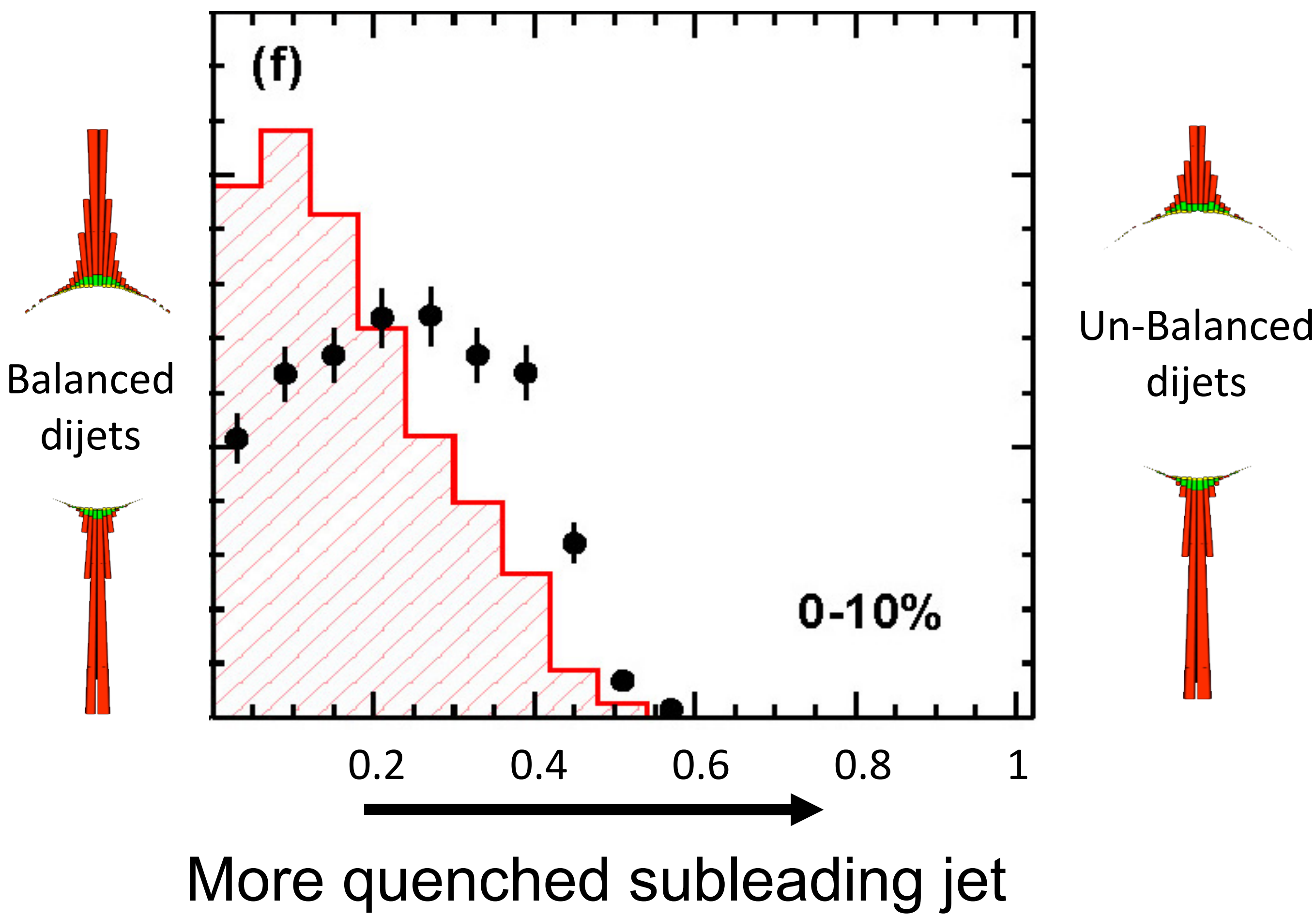




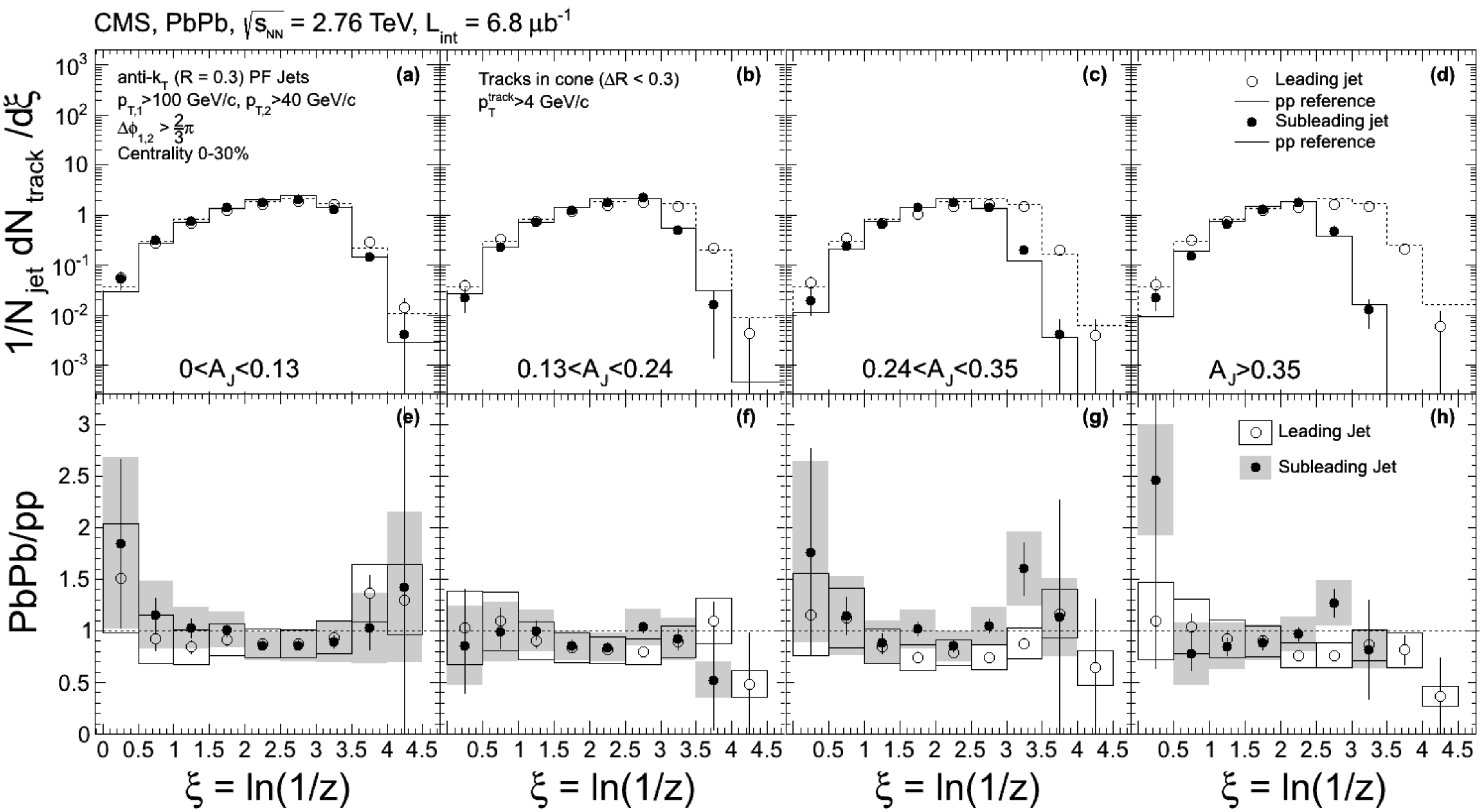
PRC84 (2011) 024906

Large dijet momentum imbalance in central bins!

Quantifying Di-jet Measurements: Probing effects of quenching on the hard fragmentation...



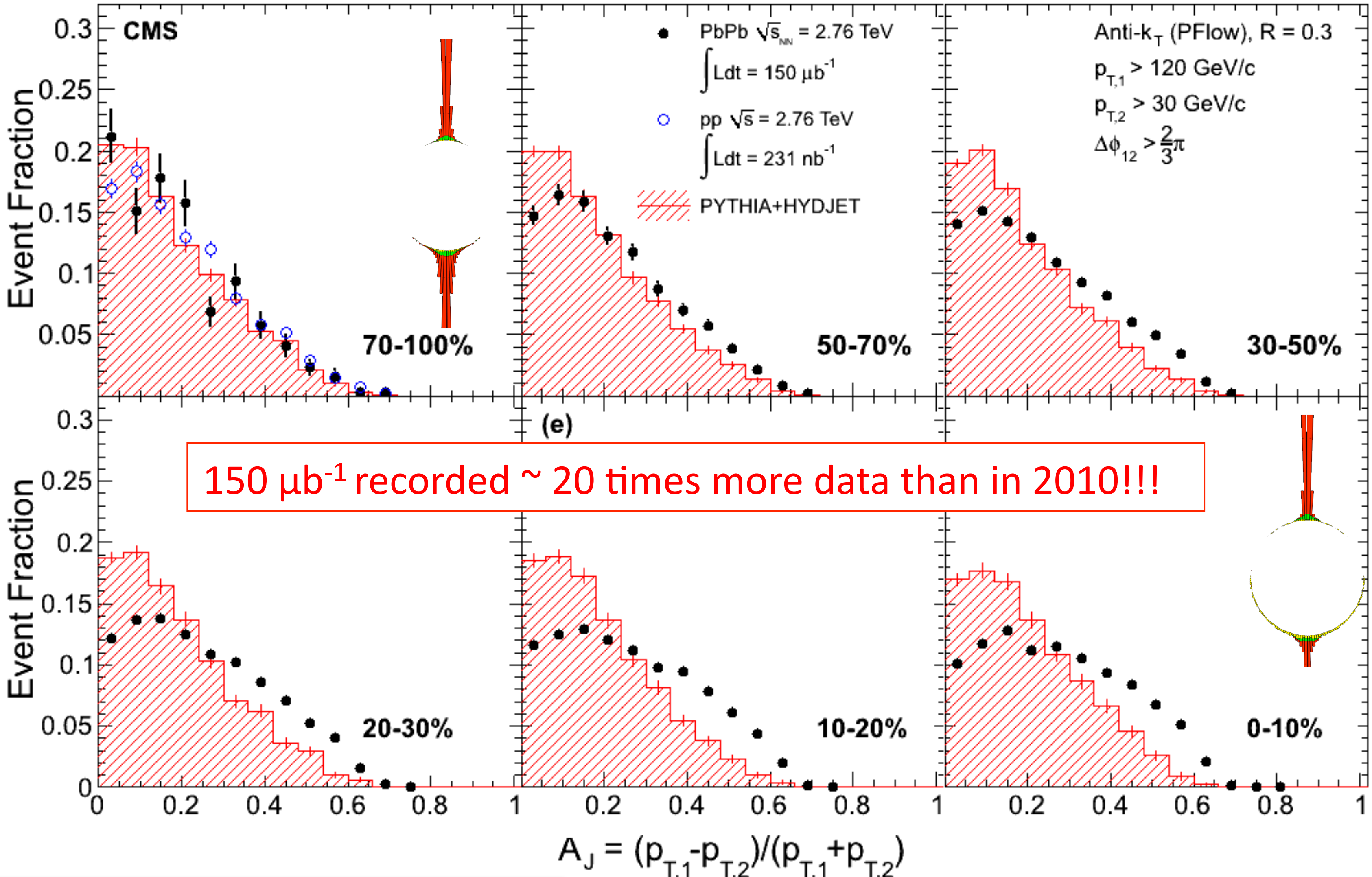
Fragmentation Functions:



CMS-PAS-HIN-11-004
CERN-PH-EP-2012-143
arXiv:1205.5872

Structure of reconstructed jets resemble those that were produced in vacuum.

More on Di-jet Measurements



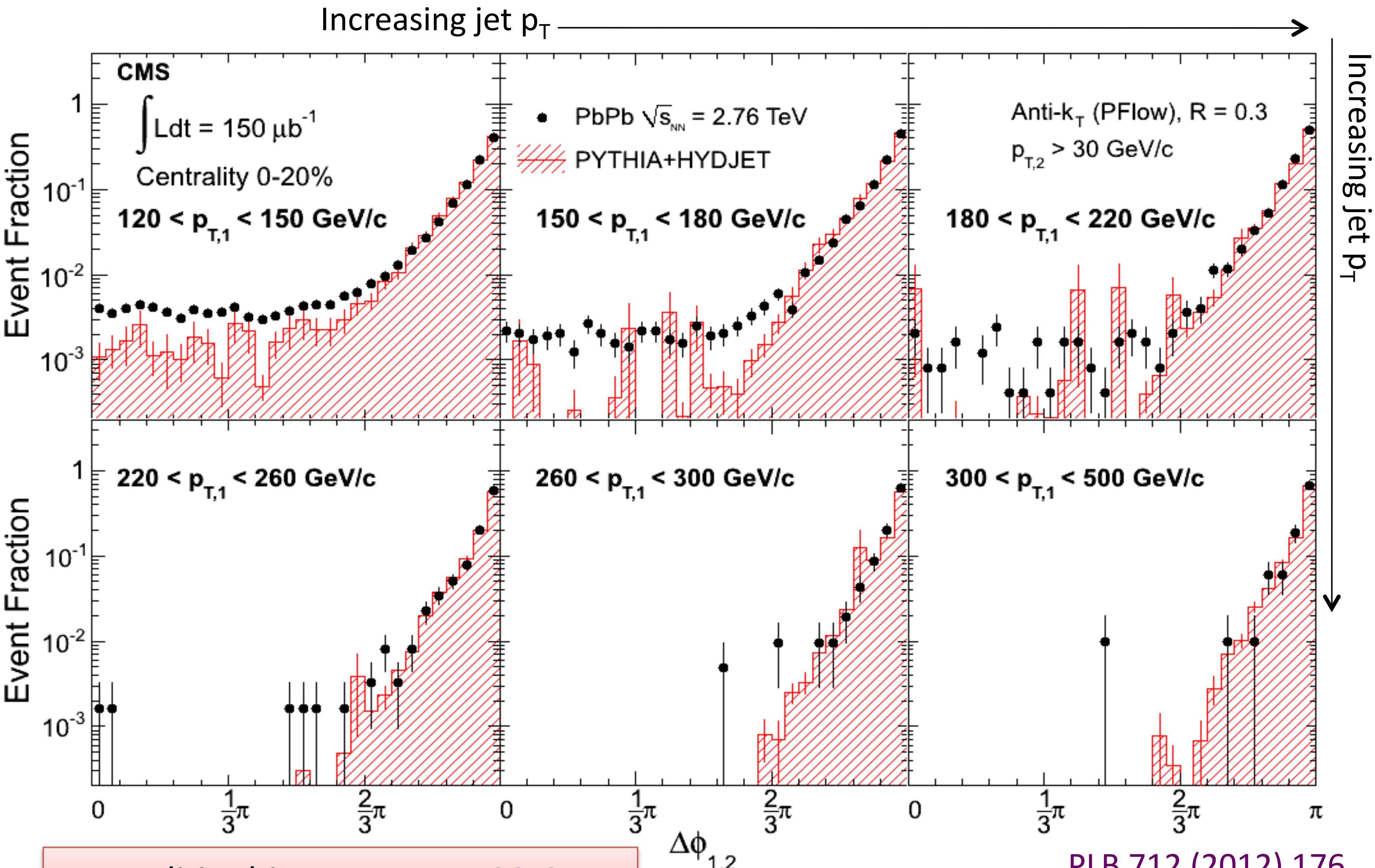
150 μb^{-1} recorded ~ 20 times more data than in 2010!!!

Investigate Energy Loss vs Jet $p_T \rightarrow$ Di-jet asymmetry measurements in multiple jet p_T bins!

Also pp data at the same $\sqrt{s}$ is available!

PLB 712 (2012) 176

Dijet Angular Correlations



Many di-jet bins up to p_T=500 GeV.

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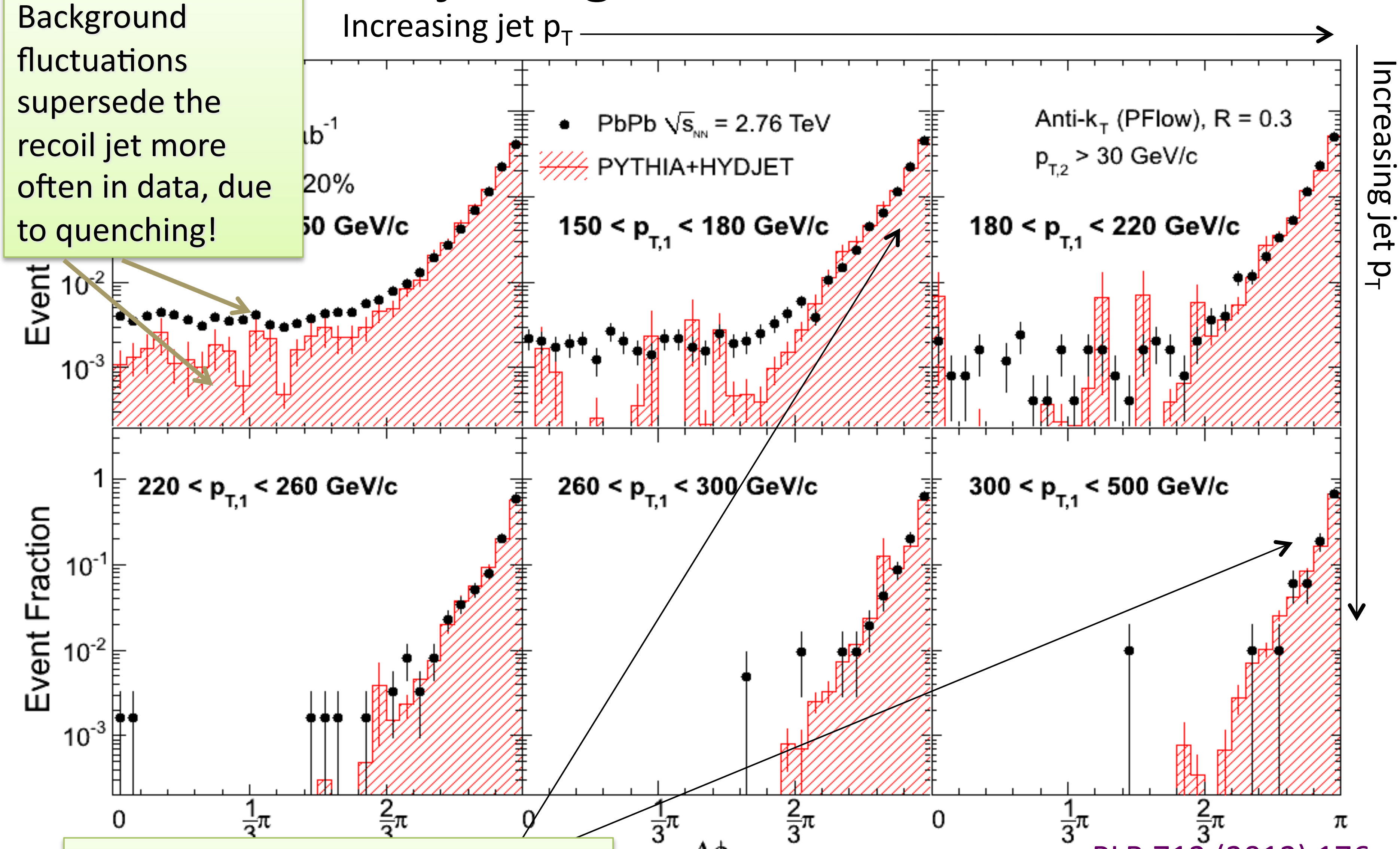
Dijet Angular Correlations

Background fluctuations supersede the recoil jet more often in data, due to quenching!



Correlation peak is the same in data and Pythia across all values of p_T

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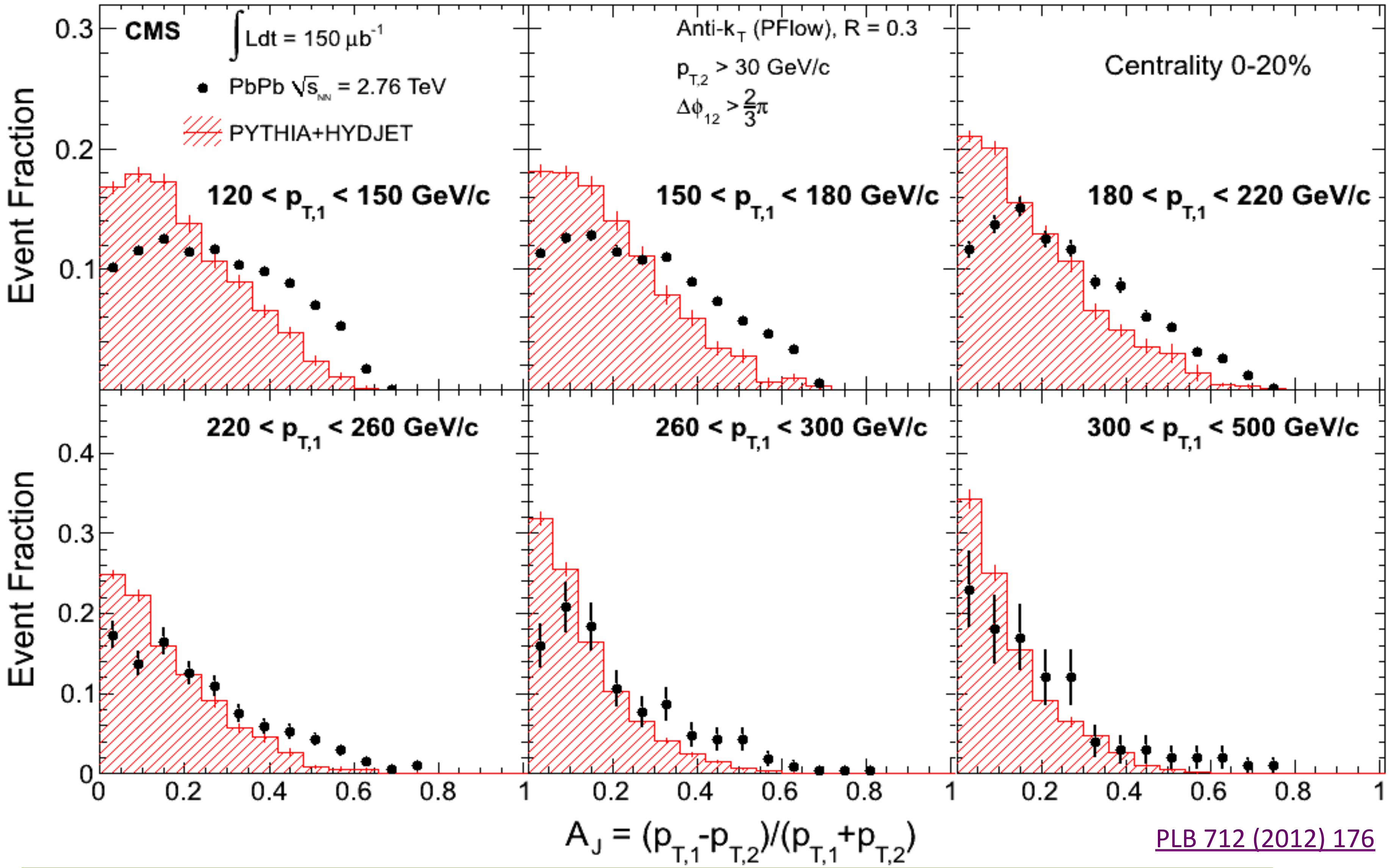
Jets are undeflected!

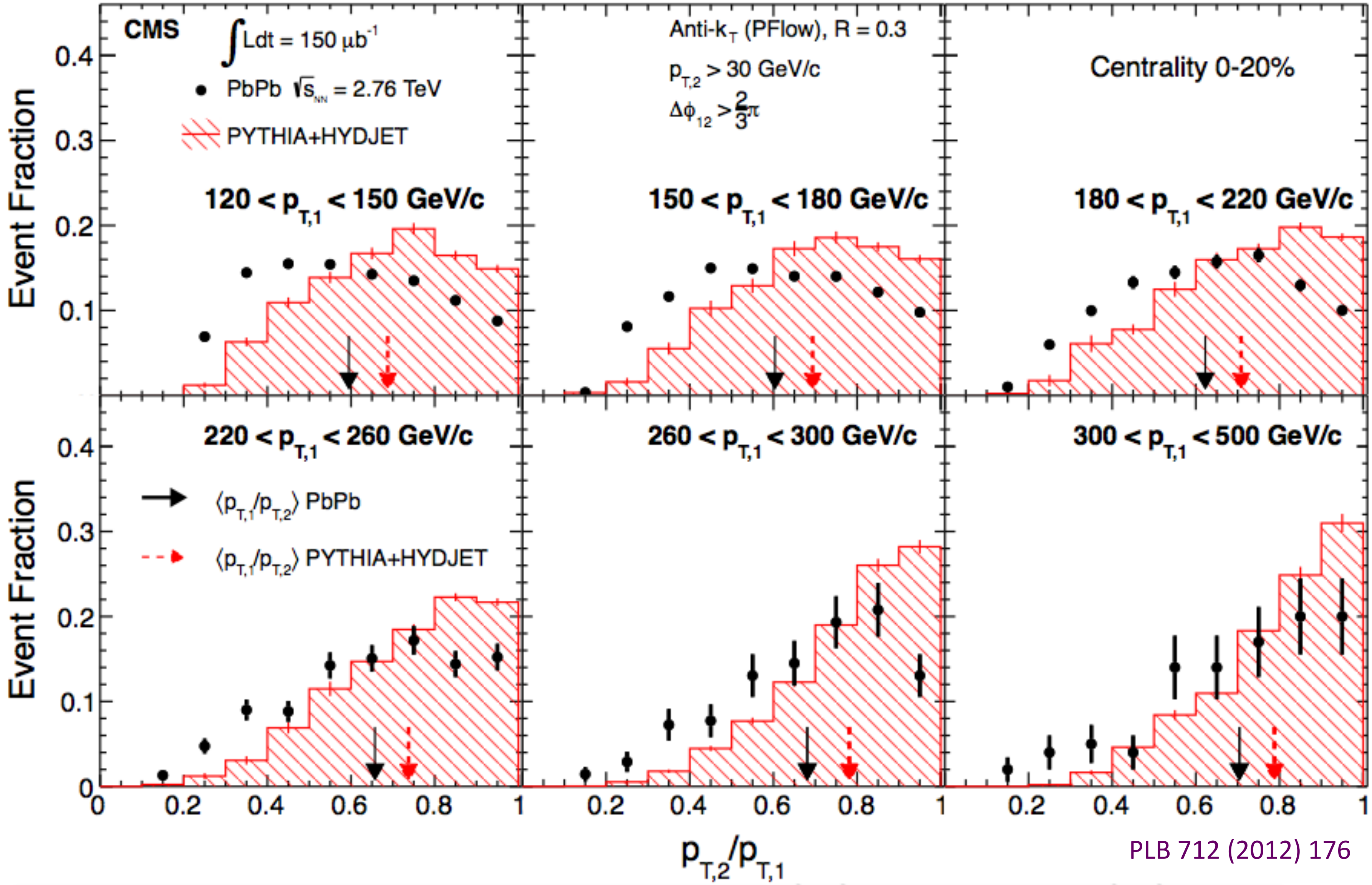
The p_T dependence of the di-jet imbalance



PLB 712 (2012) 176

Dijets in PbPb are more imbalanced than Pythia at **all bins of leading jet p_T.**

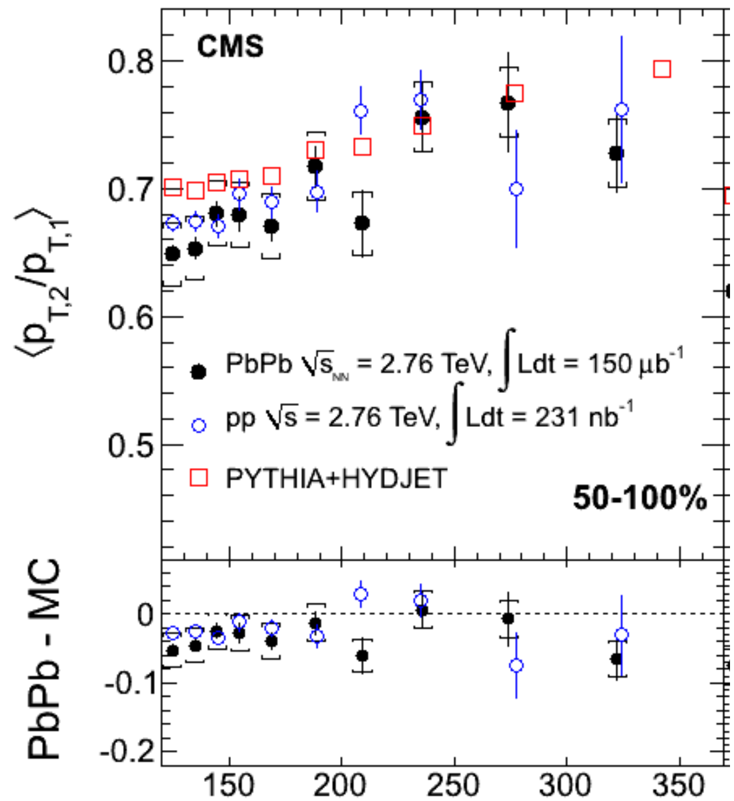
The p_T dependence of the di-jet imbalance



PLB 712 (2012) 176

Dijets in PbPb are more imbalanced than Pythia at **all bins of leading jet p_T**

The p_T-dependence of jet quenching



Statistical and systematic errors are included.
- p_T dependent residual energy scale
- Underlying event on the jet resolution

- $p_{T,2}/p_{T,1}$ increases with p_T
  - Less jet splitting, better resolution
  - Reference is PYTHIA+HYDJET

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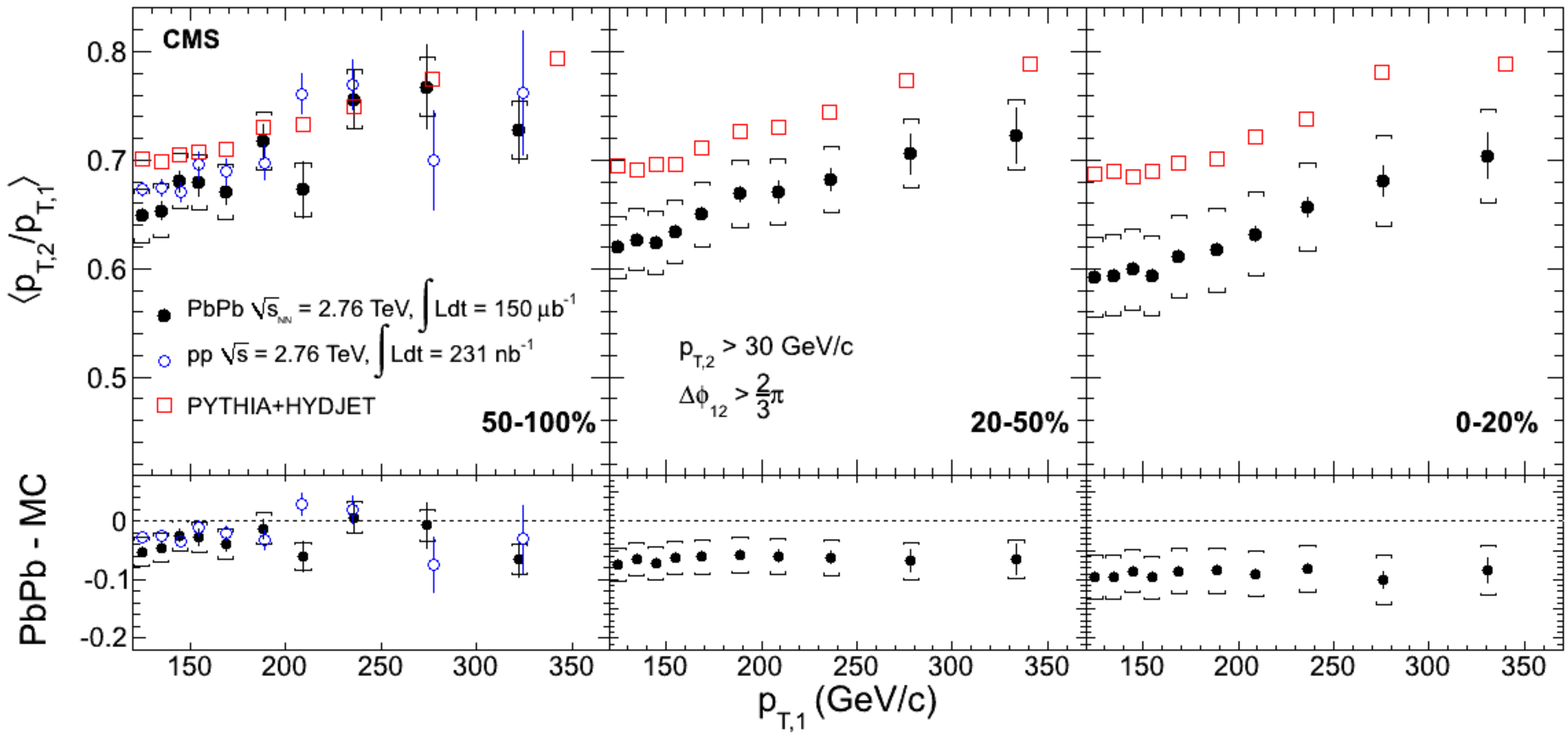
The p_T-dependence of jet quenching



- $p_{T,2}/p_{T,1}$ increases with p_T
  - Less jet splitting, better resolution
  - Reference is PYTHIA+HYDJET

In central events, significant energy loss!

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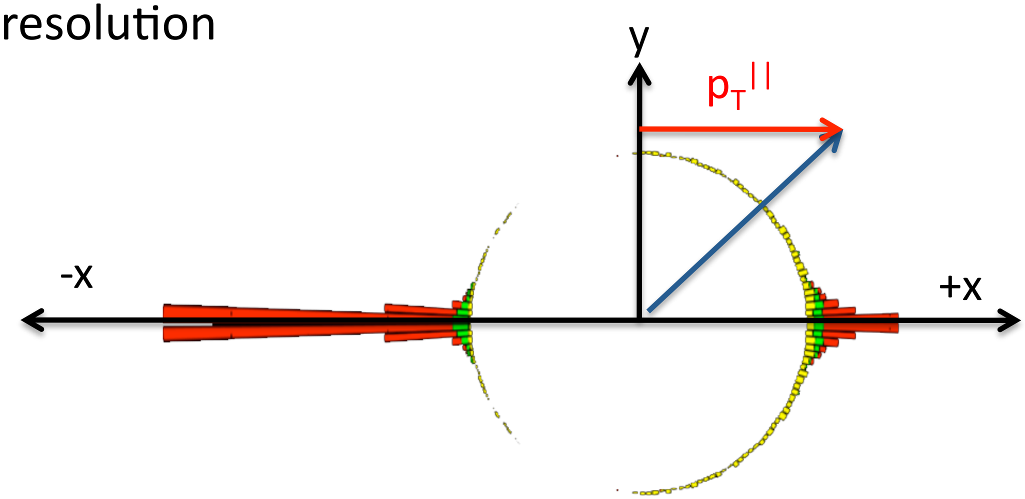
Where does the energy go?
Finding the missing p_T

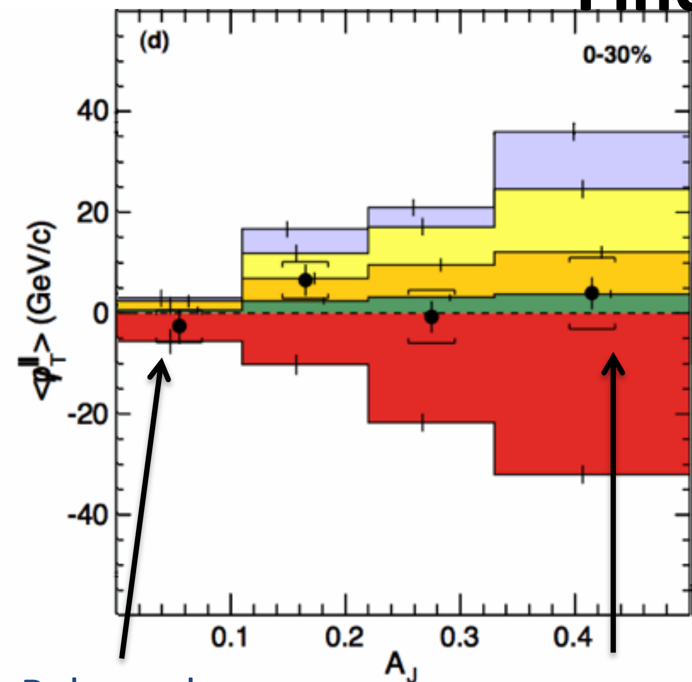
Add up the total component of transverse momentum along an axis parallel to the leading (highest p_T) jet (x-axis shown below)

Chose direction opposite to leading jet to be positive Use charged particle tracks for best pT resolution



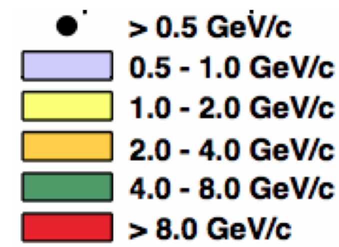
Missing $p_T^{||}$: $$\not{p}_T^{\|} = \sum_{\text{Tracks}} -p_T^{\text{Track}} \cos\left(\phi_{\text{Track}} - \phi_{\text{Leading Jet}}\right)$$

Where does the energy go?
Finding the missing p_T



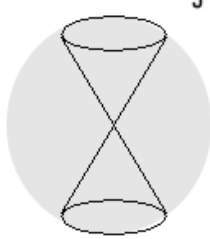
Excess away from leading jet

Excess towards the leading jet



Balanced

Unbalanced

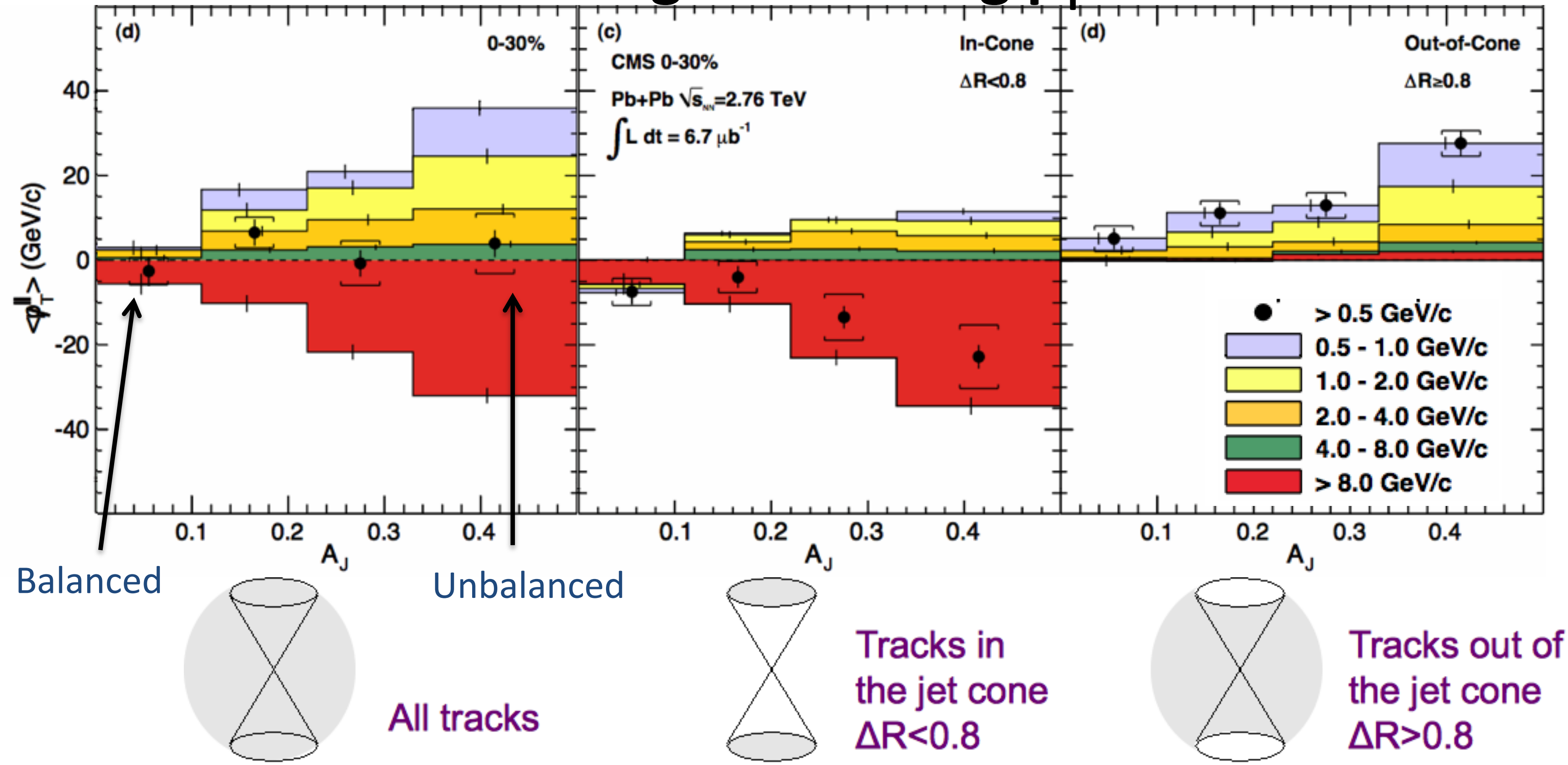


All tracks

Look separately at “missing” $p_T^{||}$ in the cones around the jet and away from those cones

PRC84 (2011) 024906

Where does the energy go?
Finding the missing p_T



PRC84 (2011) 024906

The global event properties are modified with the existence of quenching
The missing energy is found at large angles from the jet axis

Surprising Jet results:

- Little modification of jet fragmentation function
- Lost energy goes to low p_T particles at large angle
- Little modification of di-jet angular correlation

What about other probes?

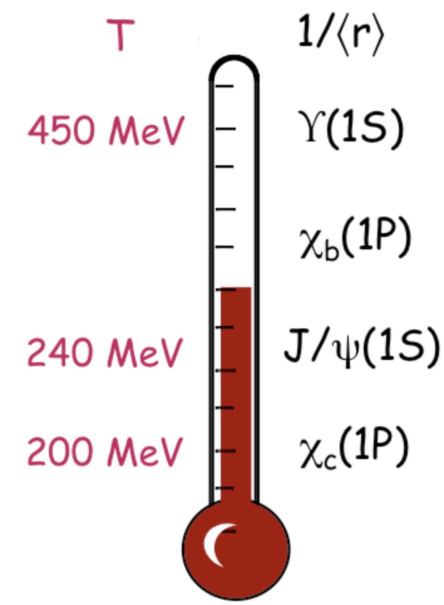
Charmonia: J/Ψ, Ψ' , χ_c Bottomonia: ϒ(1S), ϒ(2S), ϒ(3S)

Quarkonia Melt in the plasma

Color screening of static potential between heavy quarks:

Suppression of states is determined by T_C and binding energy

Lattice QCD: Evaluation of spectral functions $\Rightarrow T_{melting}$



Sequential disappearance of states:

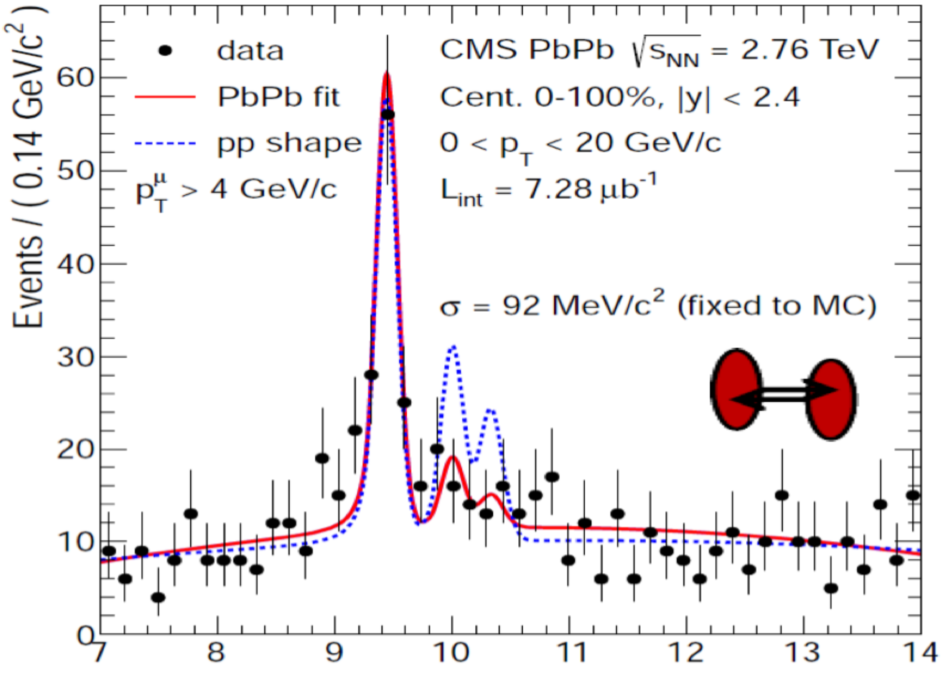
⇒ Color screening ⇒ Deconfinement

⇒ QCD thermometer ⇒ Properties of QGP

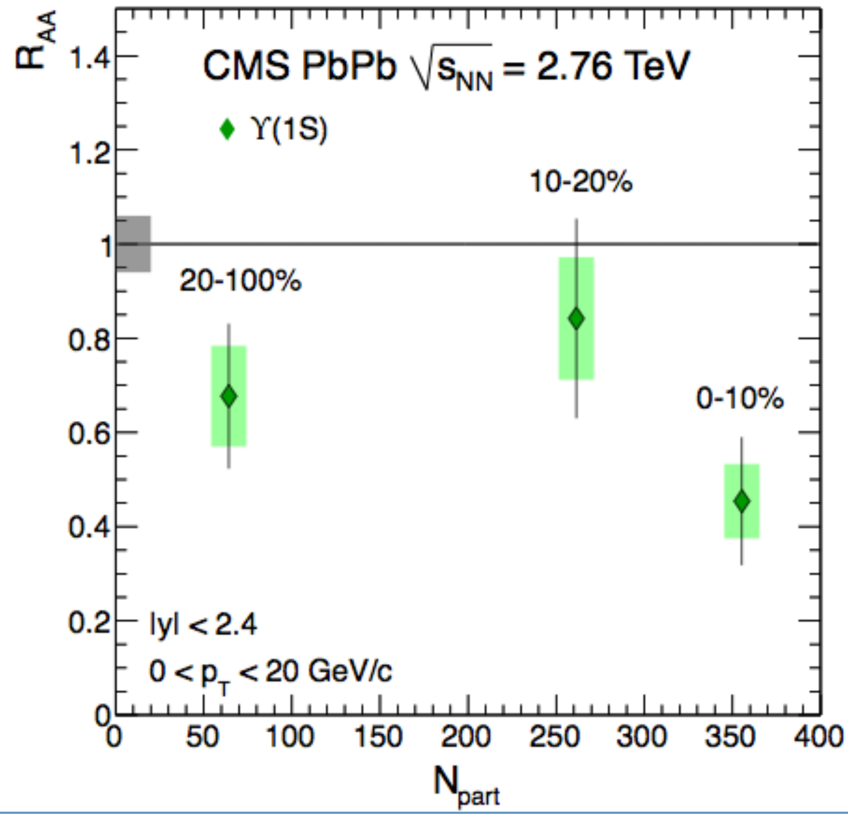
Quarkonia's suppression pattern ➔ **QGP thermometer**

What about other heavy probes?

Hard Probes: Bottomonia: $\Upsilon(1S)$, $\Upsilon(2S)$, $\Upsilon(3S)$



JHEP 1205 (2012) 063

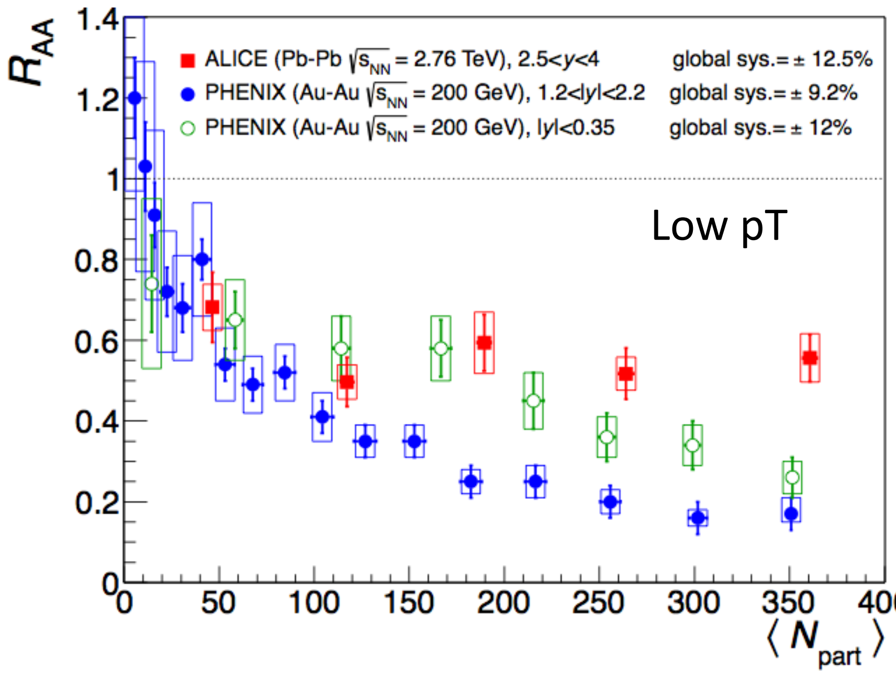


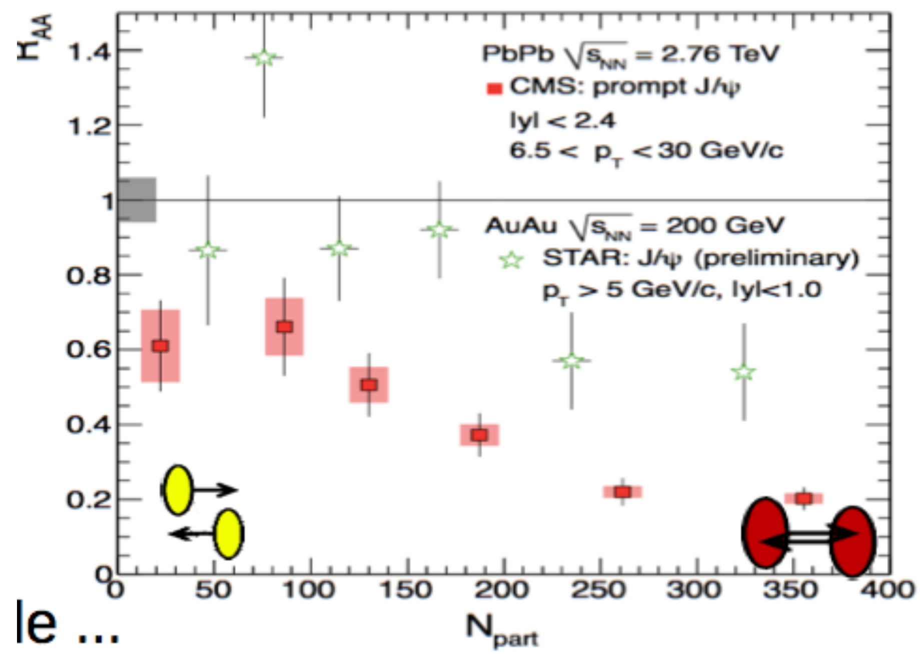
Sequential disappearance of states: ⇒ Color screening ⇒ Deconfinement

Quarkonia's suppression pattern ➔ **QGP thermometer**

What about other heavy probes?

Hard Probes: Charmonia: J/Ψ, Ψ'



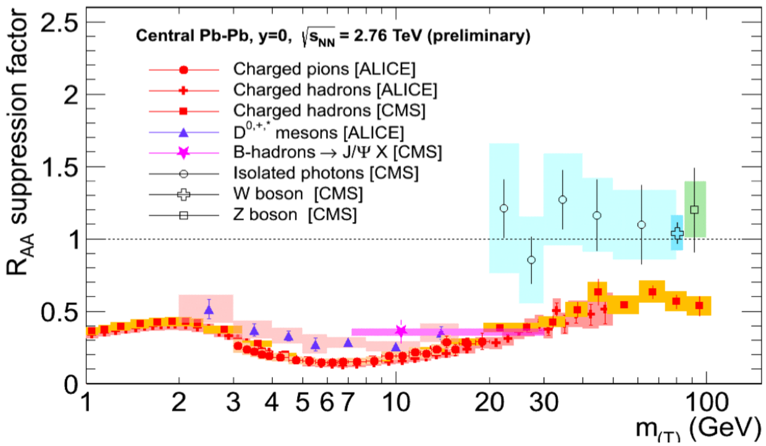


CMS, arXiv:1201.5069
ALICE, arXiv:1202.1383
CMS, PRL107 (2011) 052302

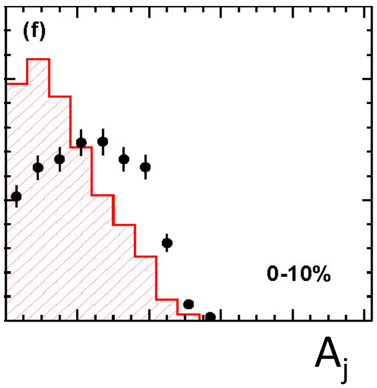
J/ψ suppression LHC ≠ RHIC:
weaker at low p_T, stronger at high p_T

New constraints on models of energy loss!

Conclusions:



- Pions are suppressed
- Electroweak probes (γ,W,Z) are unsuppressed
- B-mesons (secondary J/Ψ) are suppressed
- D-mesons (D0,±,*) are suppressed



- Dijet imbalance provides unambiguous evidence of energy loss of fast partons. Large imbalance of di-jet energies exists at all jet p_T.
- Jets are undeflected i.e., angular correlation is conserved.
- Energy lost from the jet is transferred to many low p_T particles at large angles to the jet direction.

Tomographic probes can be measured well by experiments.
How best to use them to extract medium properties is limited by theory!

Last 10 Years of Discoveries

- **Collective Flow:**

  → behaves more like liquid rather than gas.

  → small viscosity perfect liquid.

- **Particle Production:**

  → recombination/coalescence dominates over fragmentation at medium p_T

- **Jet Quenching:**

  → opaque to fast partons

Only a small fraction of the experimental results are covered. For much more, go to:

RHIC:
http://drupal.star.bnl.gov/STAR/publications
http://www.phenix.bnl.gov/WWW/talk/pub_papers.php
http://www.phobos.bnl.gov/Publications/Physics/phobos_physics_publications.htm
http://www4.rcf.bnl.gov/brahms/WWW/publications.html

LHC:
aliceinfo.cern.ch/ArtSubmission/publications
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ HeavyIonsPublicResults

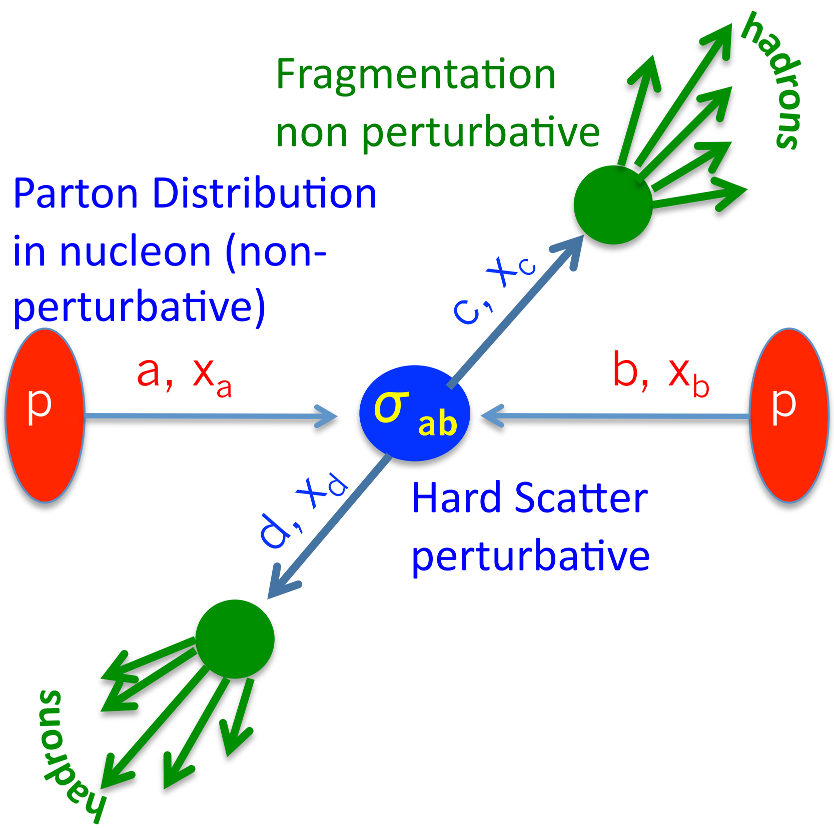
Hard = pQCD + Factorization + Universality

pQCD Factorization:

Collins, Soper, Sterman
Nucl. Phys. B263 (1986) 37

$$E\frac{d^3\sigma}{dp^3} \propto f_{a/A}(x_a, Q^2) \otimes f_{b/B}(x_b, Q^2) \otimes \frac{d\hat{\sigma}^{ab\to cd}}{dt} \otimes D_{h/c}(z_c, Q^2) \otimes D_{h/d}(z_d, Q^2)$$

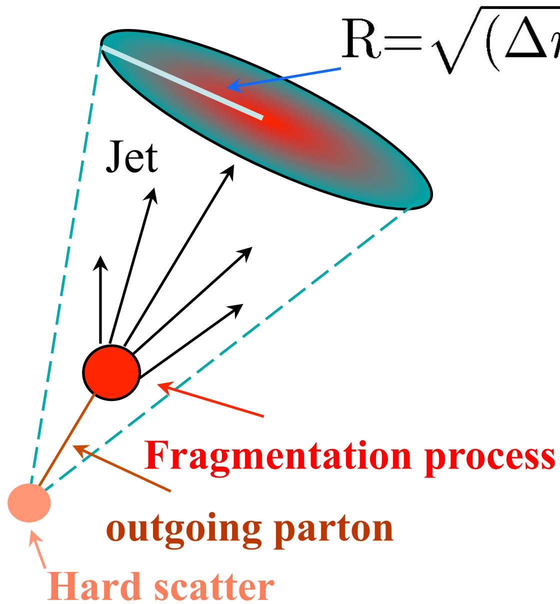
PDF — Partonic x-section — Fragmentation function



Factorization: assumed between the perturbative hard part and the universal non-perturbative fragmentation (FF) and parton distribution functions (PDF)

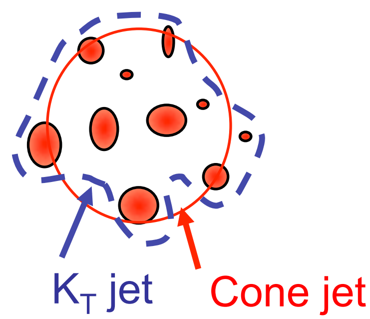
Universality: fragmentation functions and parton distribution functions are universal (i.e. FF from ee, PDF from ep, use for pp)

Jet Reconstruction Algorithms:



Cone Algorithm

1. Leading Order High Seed Cone (LOHSC)
2. Mid Point Cone: Merging & Splitting



Sequential recombination

3. KT
4. Anti-KT
5. Cambridge/ Aachen

Explore systematics: Use both Clustering & Cone algorithms.

How different is it?: A+A vs p+p or e+p Collisions

- Atomic weight A introduces new hard scattering scale $Q^2 \sim A^{1/3} Q_0^2$
- Different from previous (fixed target) heavy ion facilities
  - – E_{CM} increased by order-of-magnitude
  - ➡Accessible x (parton momentum fraction) decreases by ~ same factor $x \sim \frac{2\ p_T}{\sqrt{s}}$
  - ➡Access to perturbative phenomena
    - Heavy Flavor
    - Jets

Jargon Alert:

$\sqrt{s}$ = Center-of-mass energy (per nucleon collision)

p_T = transverse momentum

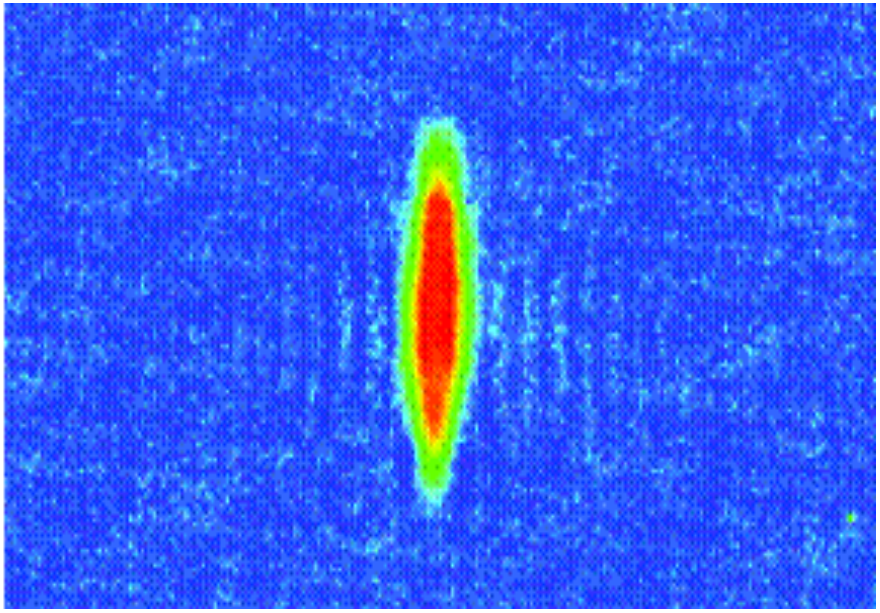
Q^2 = (momentum transfer)^2

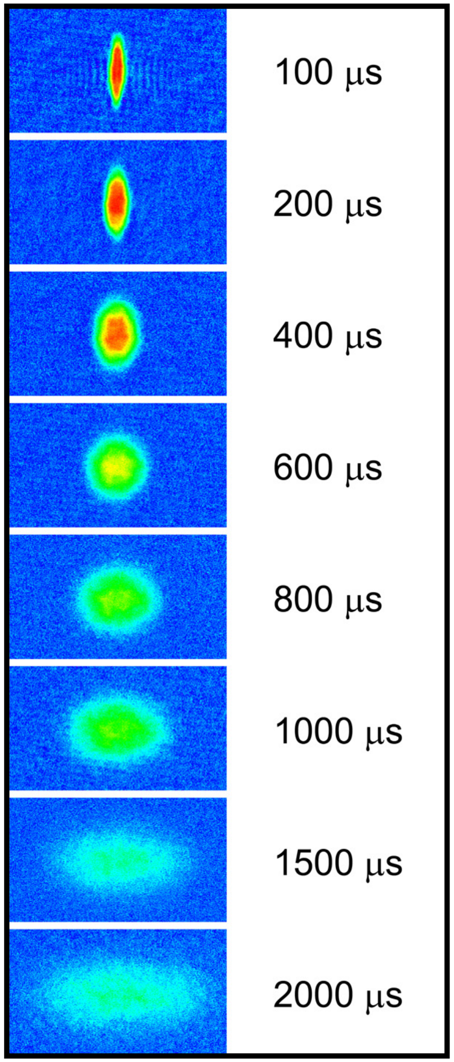
Analogy in Atomic System

Same phenomena observed in gases of strongly interacting atom (Gehm et al. Science 298 (2002) 2179)

Gas of trapped ^{6}Li atoms: excite Feshbach resonance via magnetic field (38th vibrational Li_2 state) → 0 energy, huge cross-section

⇒ explodes hydrodynamically, shows elliptic flow

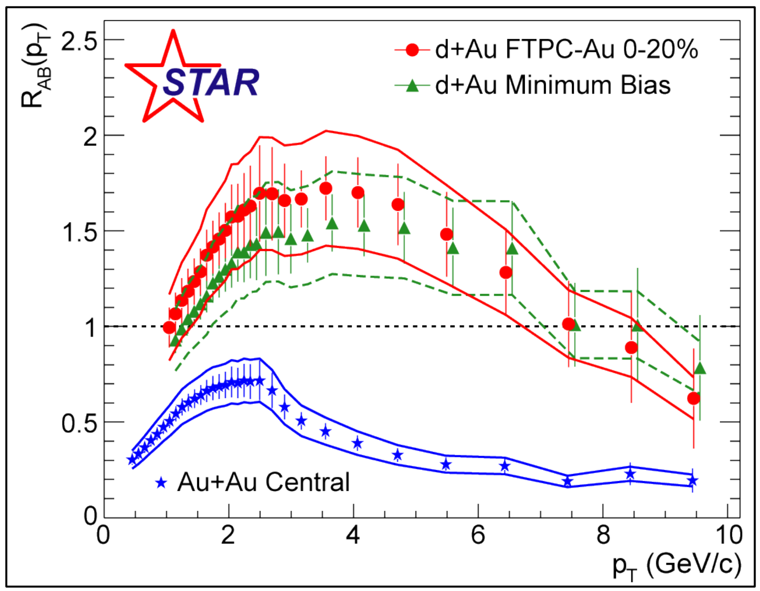




The RHIC fluid behaves like this, that is, a strongly coupled fluid.

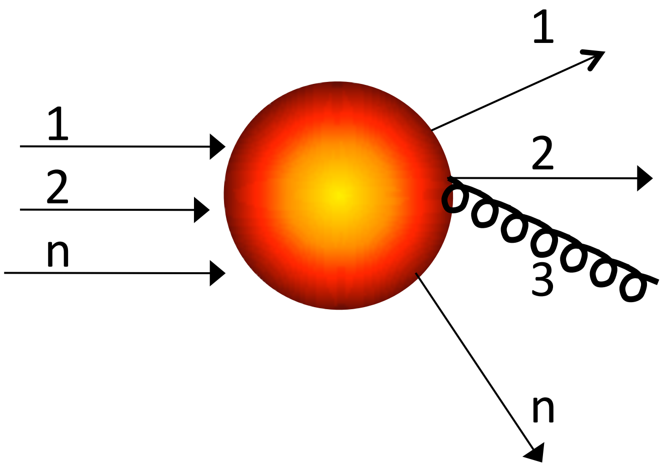
Is The Suppression Always Seen at RHIC?

- NO!
- *A crucial control measurement* via d-Au collisions



What does this all mean? Look for hard probes specifically jets in detail…

Energy loss in matter



Elastic interactions:
Collisional Energy Loss (Medium excitation)

$$\sum particles^{in} = \sum particles^{out}$$

$$\Delta E = c_1 L$$

(L is the extend of the medium)

Inelastic interactions:
Radiative Energy Loss
(Gauge boson bremsstrahlung)

$$\sum particles^{in} < \sum particles^{out}$$

$$\Delta E = c_2 E L$$

Bethe H. A (1930-32) Bloch F (1932)
Weizsacker C et al (1934)
Landau, Pomeranchuk and Migdal (1953)

Predictions for expanding medium is still under development.

So is there a QGP?

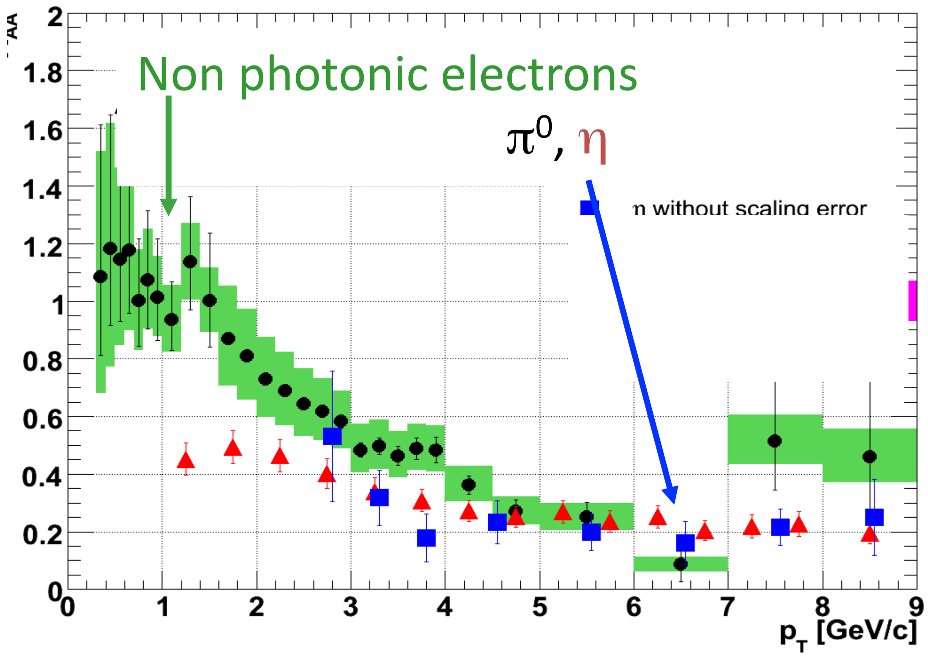
- Experiments & Theory provide overwhelming evidence for new state of matter
  - Extreme initial conditions (hydrodynamics, lattice, pQCD)
    - $dN_{glue}/dy \approx 1000$
    - $\varepsilon \approx 15\text{-}20\ GeV/fm^3$
  - Hydrodynamic behavior (collective flow, low-p_T spectra)
  - Chemical Equilibrium (particle yields)
  - Jet suppression (opacity, extreme medium density)
- This state of matter is not what we expected when we started our journey
  - no weakly interacting plasma (wQGP)
  - no phase transition observed (no latent heat, discontinuities, spikes)
- New state of matter seems to be strongly interacting, nearly-perfect fluid (sQGP)
- Next decade should be very exciting (GSI + RICH-II + eRHIC + LHC)
  - Understanding perfect liquid behaviour
  - Is there a weakly coupled state (wQGP) in the initial state at LHC ?
  - Understand the nature of deconfinement and the degrees of freedom

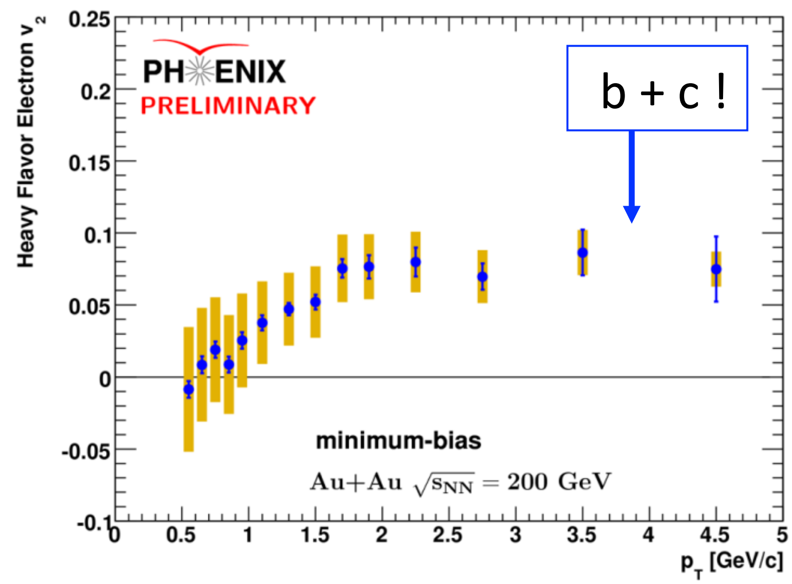
What about other heavy probes?

Prediction: less energy loss than light quarks

large quark mass reduces phase space for radiated gluons

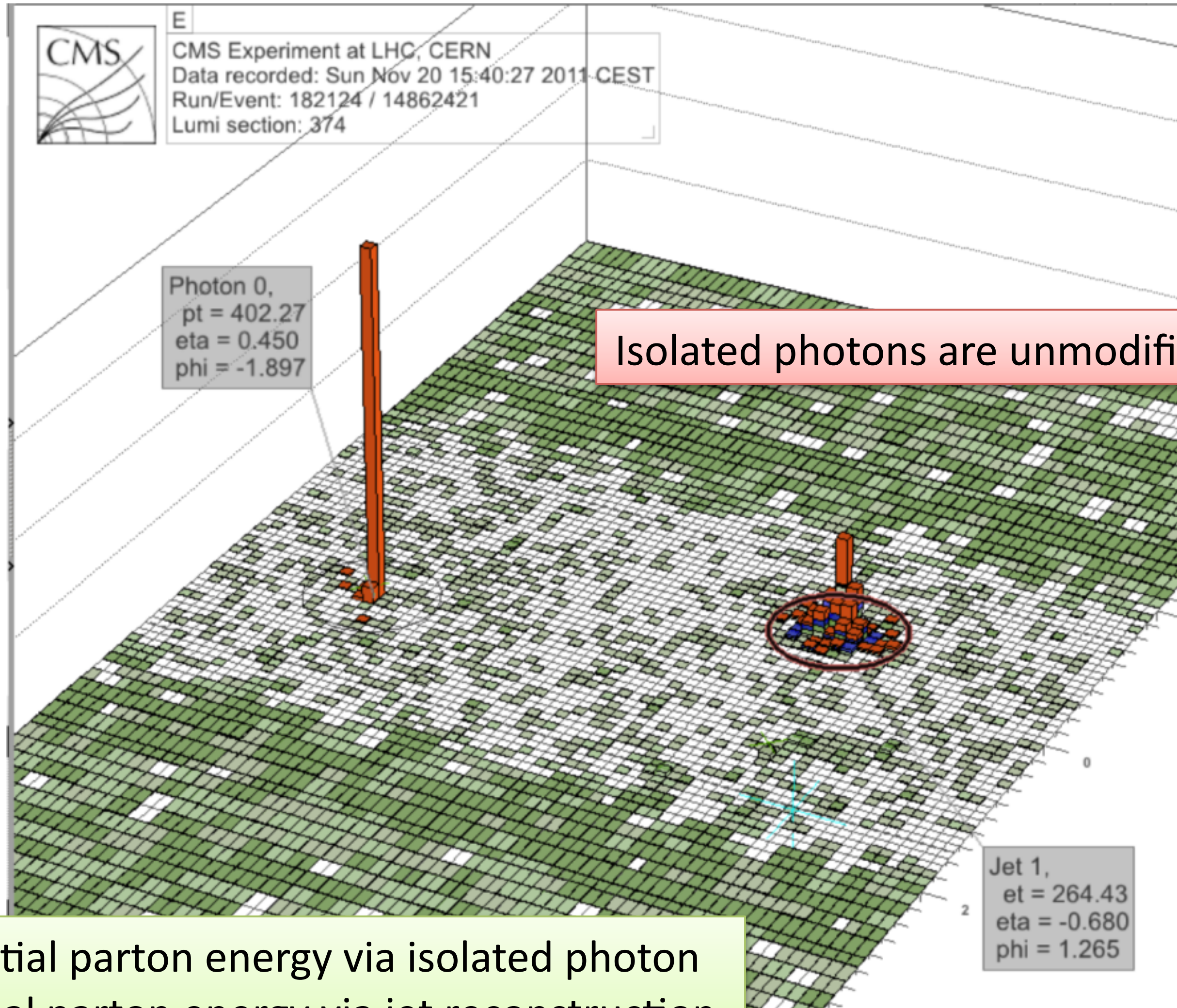
Measure via semi-leptonic decays of mesons containing charm or bottom quarks





- ▶ Energy loss similar to pions!
- ▶ charm quarks flow along with the liquid

Photon+Jet



Isolated photons are unmodified

Access to the initial parton energy via isolated photon
Access to the final parton energy via jet reconstruction

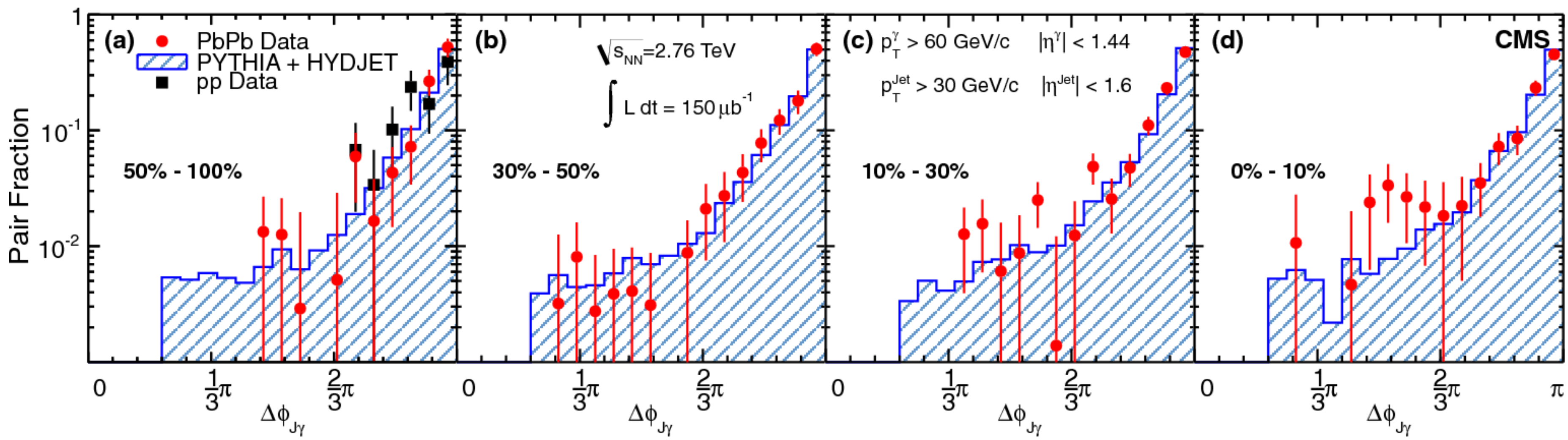
P. Stankus, Ann. Rev. Nucl. Part. Sci. 55, 517 (2005)
X. Wang, Z. Huang, Phys.Rev.C55:3047-3061 (1997)

Photons pass through the medium without interacting so their energy “tags” the original energy of the jet: **Direct measurement of the parton energy loss!**

Isolated Photon+Jet

1) Azimuthal decorrelation:

- p_T^{γ} > 60 GeV/c (to have sufficient phase space)
- p_T^{Jet} > 30 GeV/c (constrained by efficiency)



CMS-HIN-11-010,C
ERN-PH-EP-2012-089.
e-Print: **arXiv:1205.0206**

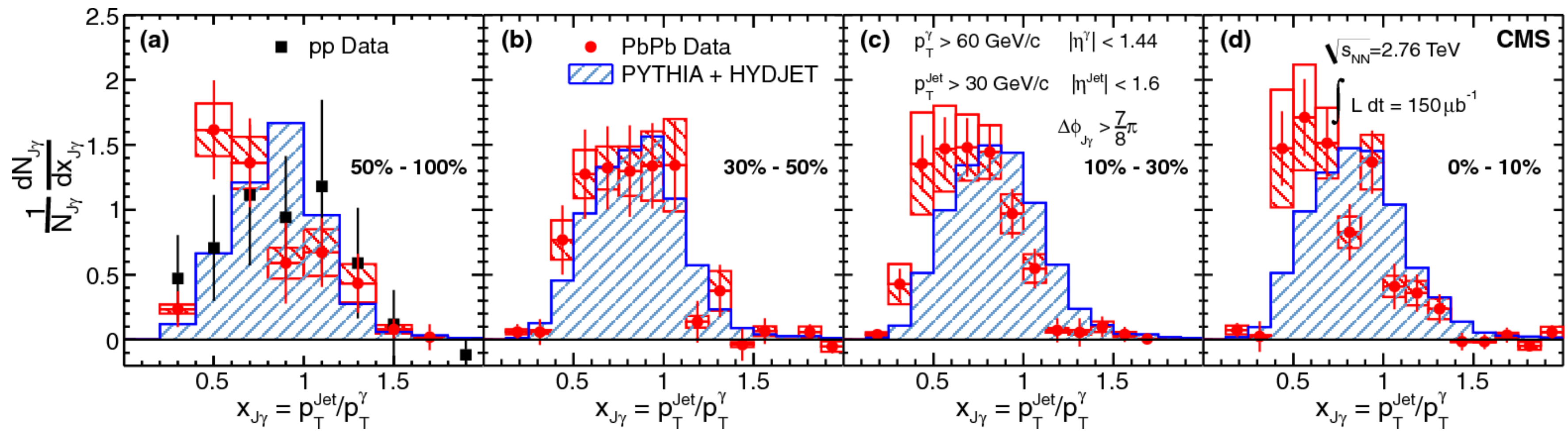
Distribution is consistent with pp & PYTHIA+Hydjet

Quenched jet is back-to-back to γ:
Energy not lost in single hard gluon-radiation.

Isolated Photon+Jet

2) Momentum Imbalance:

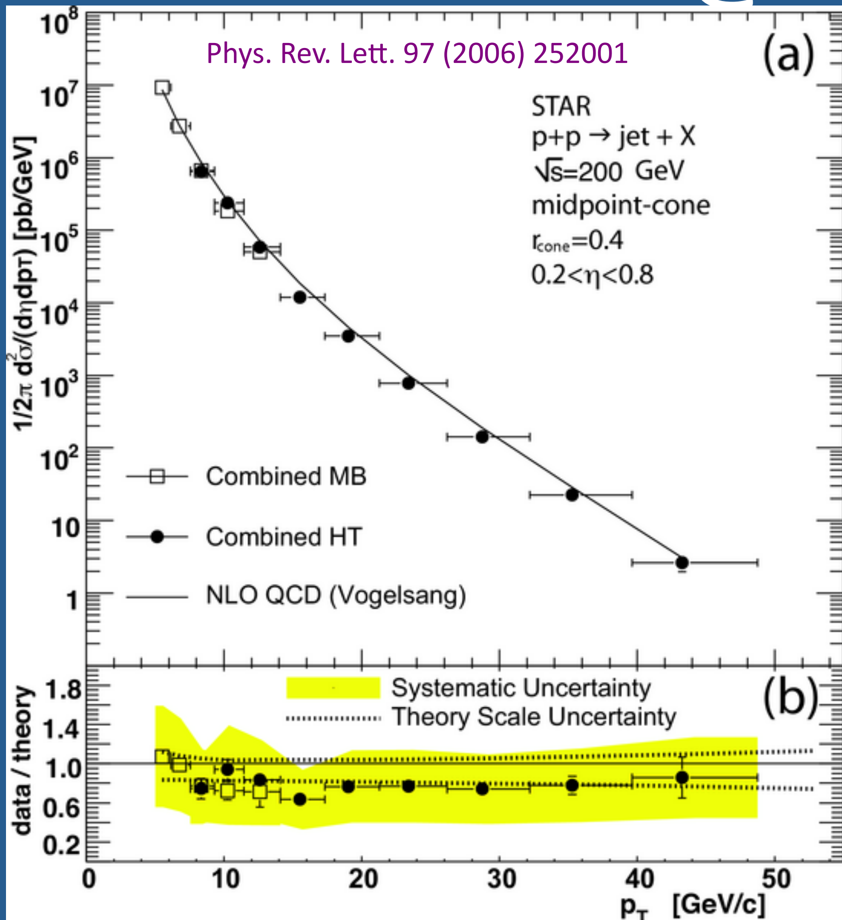
- p_T^{γ} > 60 GeV/c (to have sufficient phase space)
- p_T^{Jet} > 30 GeV/c (constrained by efficiency)

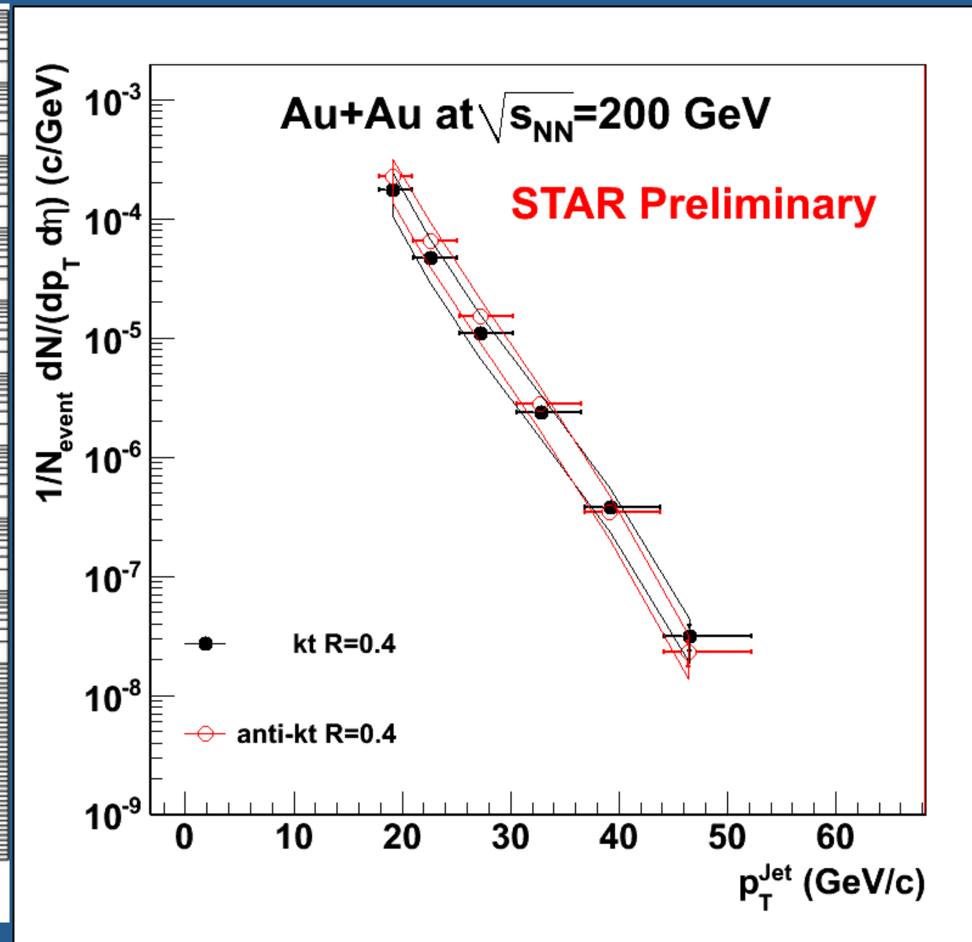


CMS-HIN-11-010,C
ERN-PH-EP-2012-089.
e-Print: **arXiv:1205.0206**

Energy lost (momentum ratio shifts) depends on centrality.

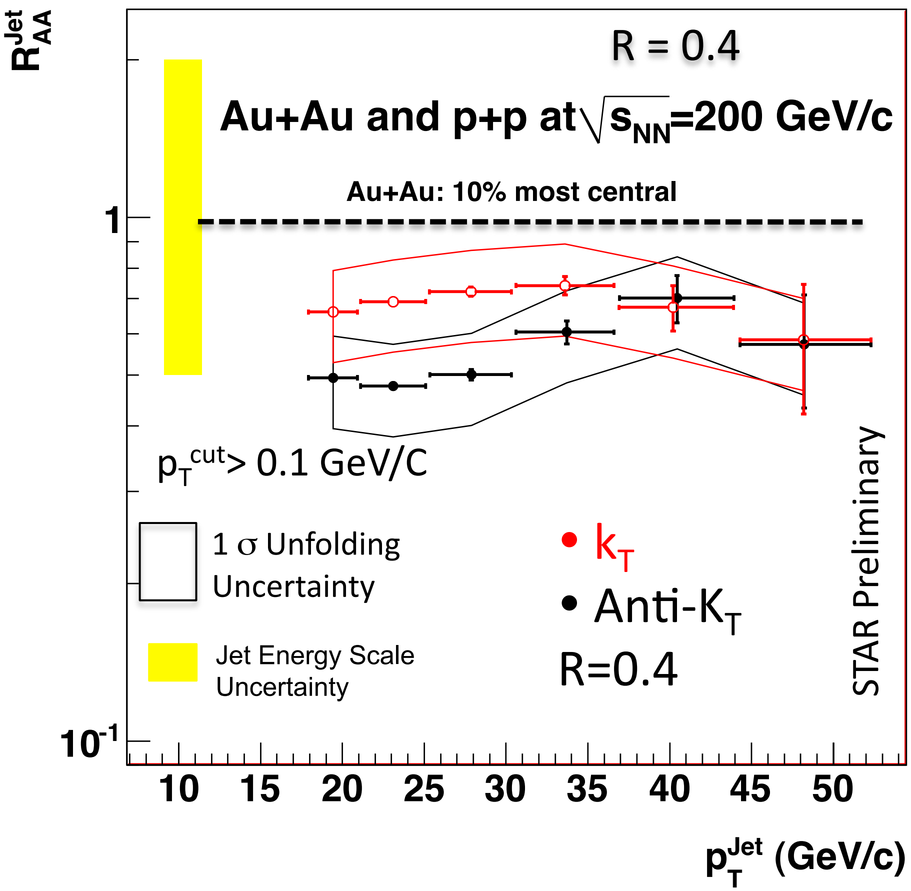
Jets in @200 GeV data





Increase in the kinematic reach up to 50 GeV!
Different algorithms are consistent.
Jet Energy scale is the biggest uncertainty.

R_{AA} of Jets at RHIC

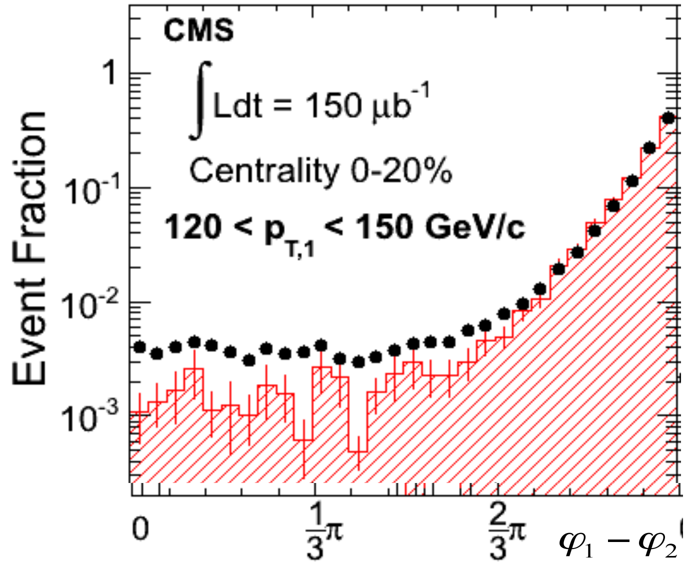


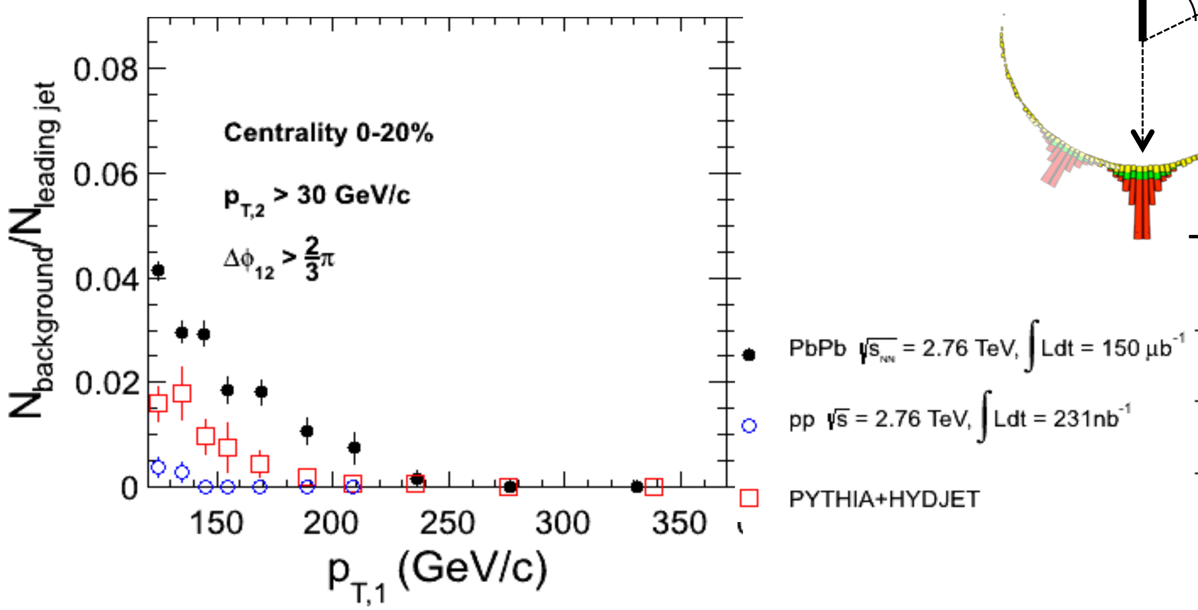
A large fraction of jets are reconstructed!
(Compare pion R^{π}_{AA} = 0.2)

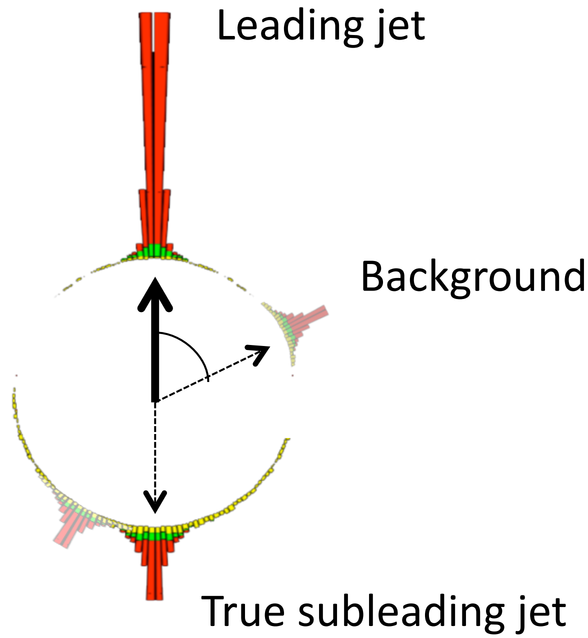
R_{AA} < 1 : unable to recover complete jet energy - jet broadening

R_{AA} = 1 : recover complete jet energy

Dijet Correlation and Background





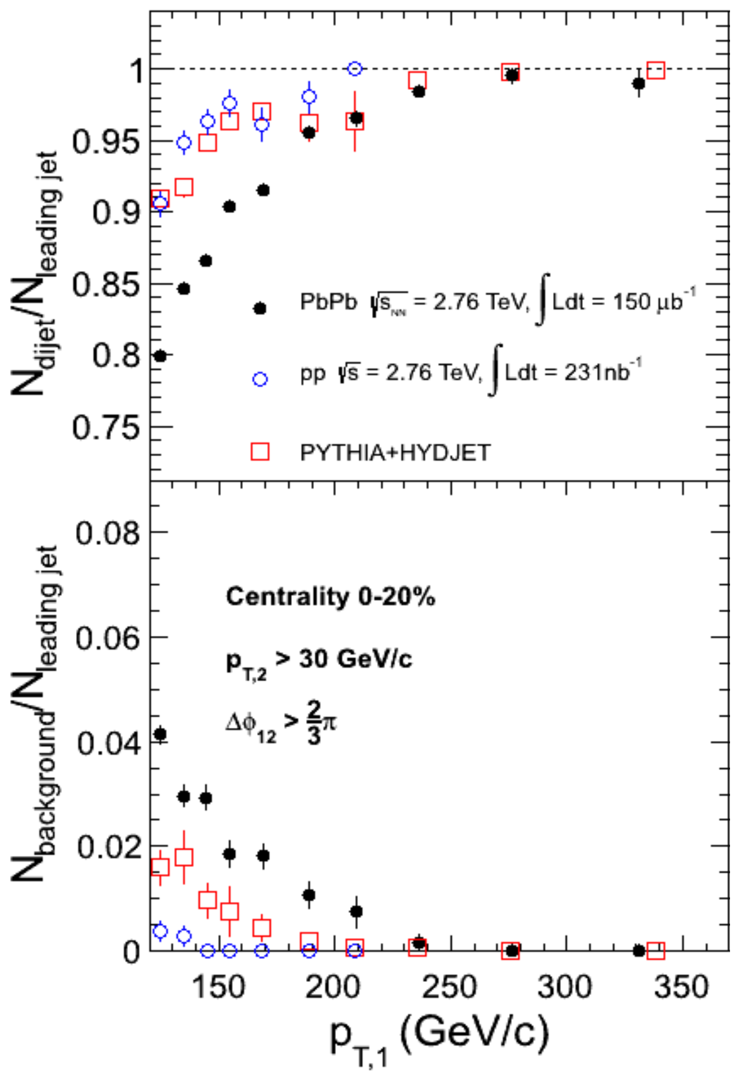


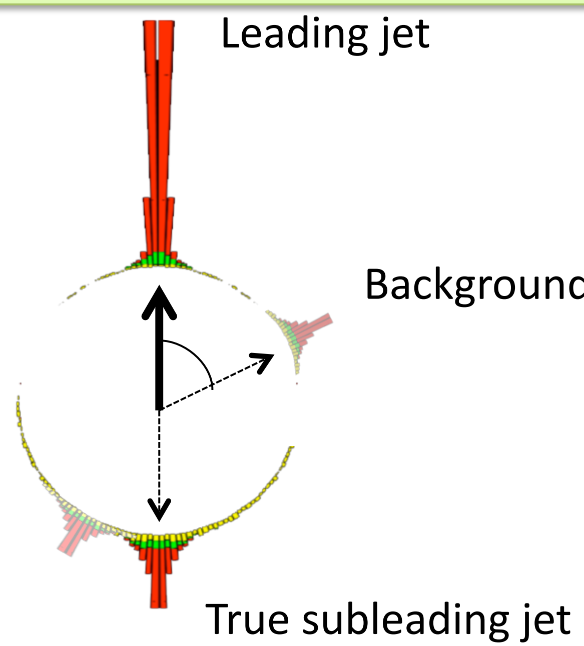
Background is enhanced with quenching but very little at high p_T

PLB 712 (2012) 176

Dijet Correlation and Background

With leading jet p_T > 180 GeV/c, more than 95% of the leading jets are correlated with a subleading jet. → Only few of the away side jets are lost!





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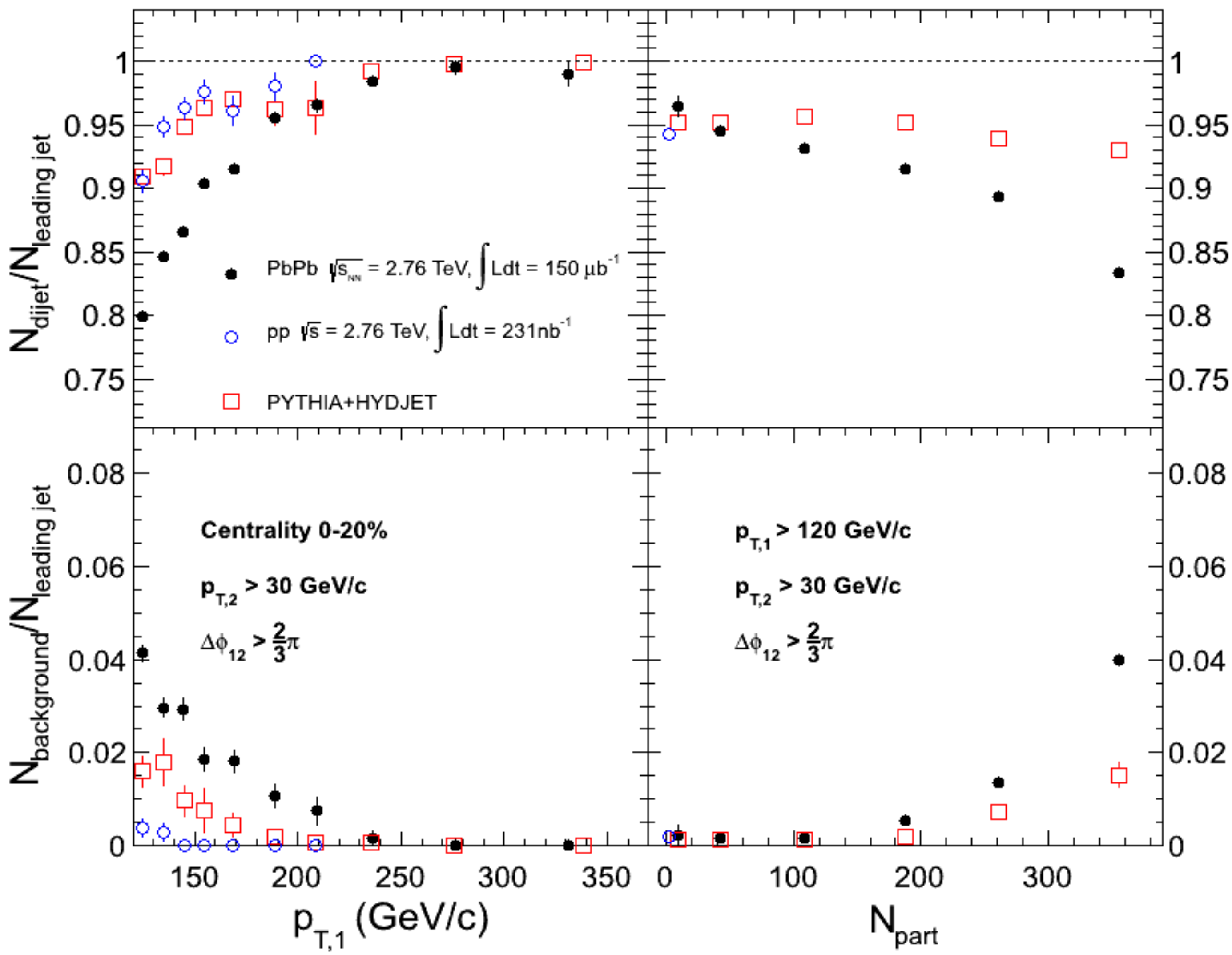
Dijet Correlation and Background



Background increases with centrality:
- Larger UE
- More quenching

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