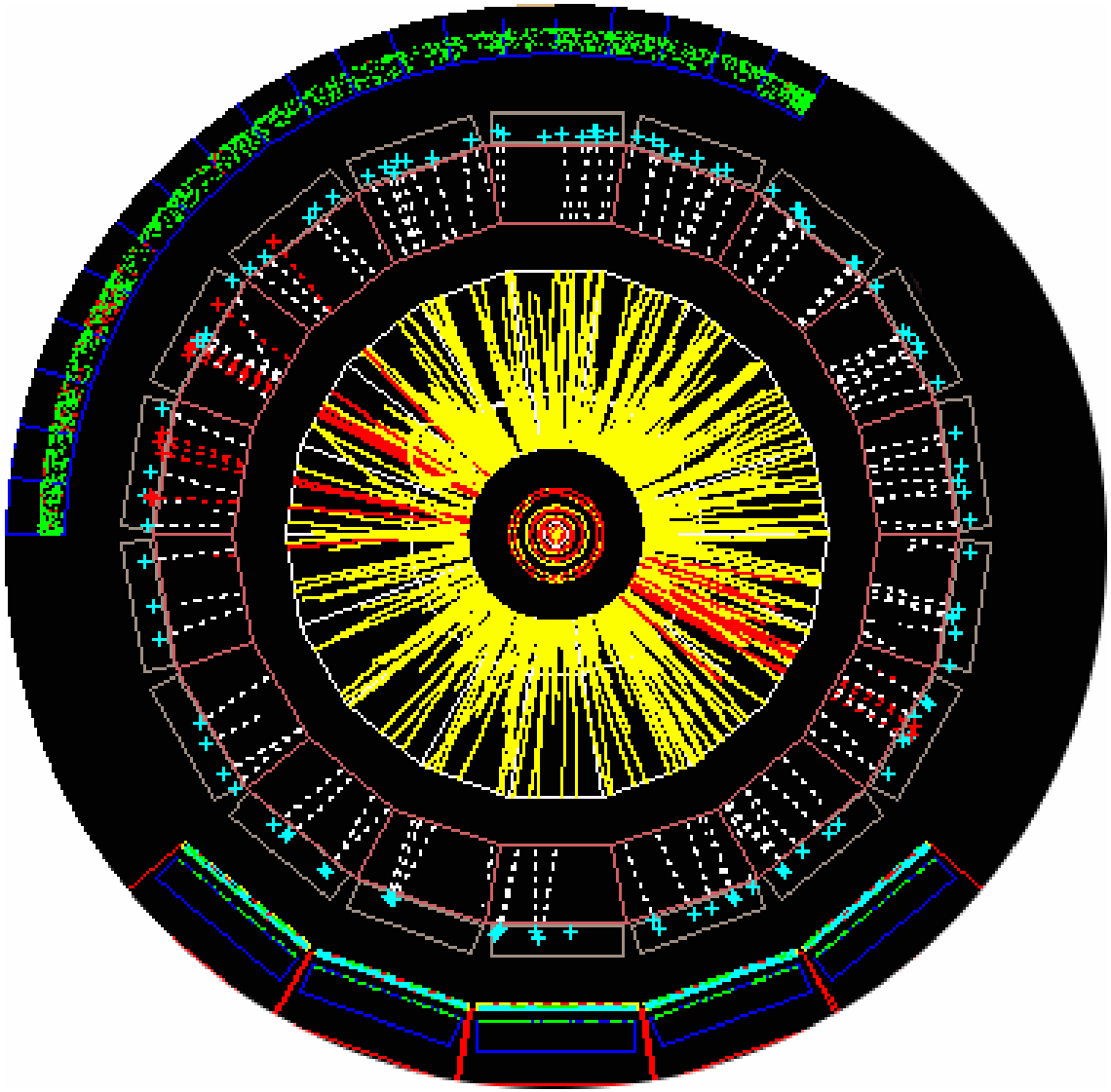
Jet Study in Ultra-Relativistic Heavy-Ion Collisions with the ALICE Detector at the LHC

QM2004

Sarah Blyth

for the ALICE-USA Collaboration

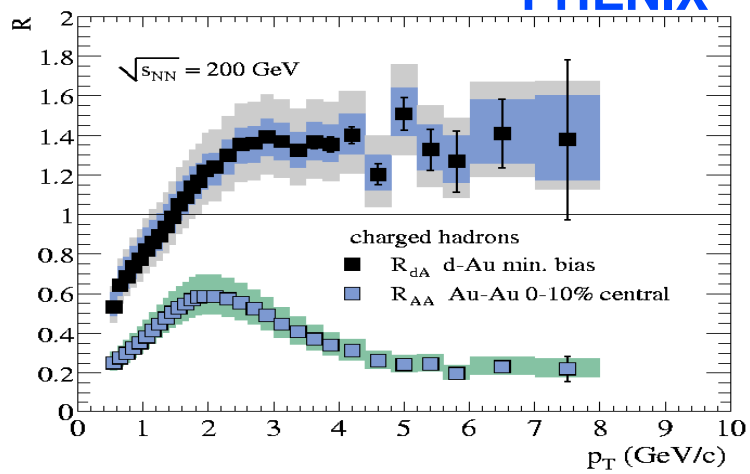


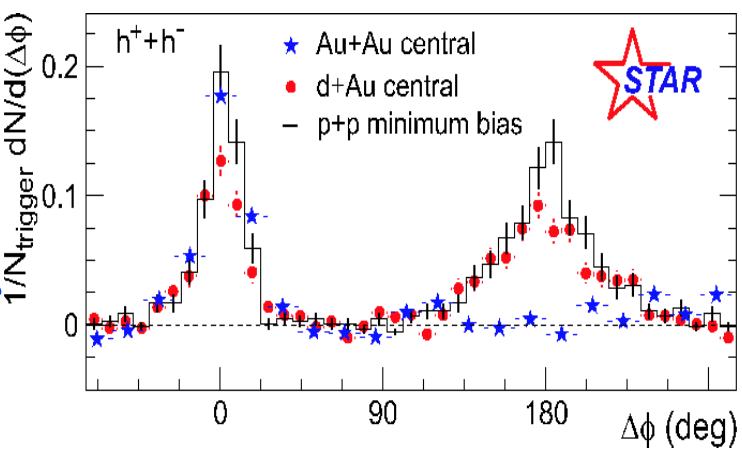
Introduction 1

Jet Quenching

First signals for jets and jet-quenching have been seen at RHIC...

PHENIX





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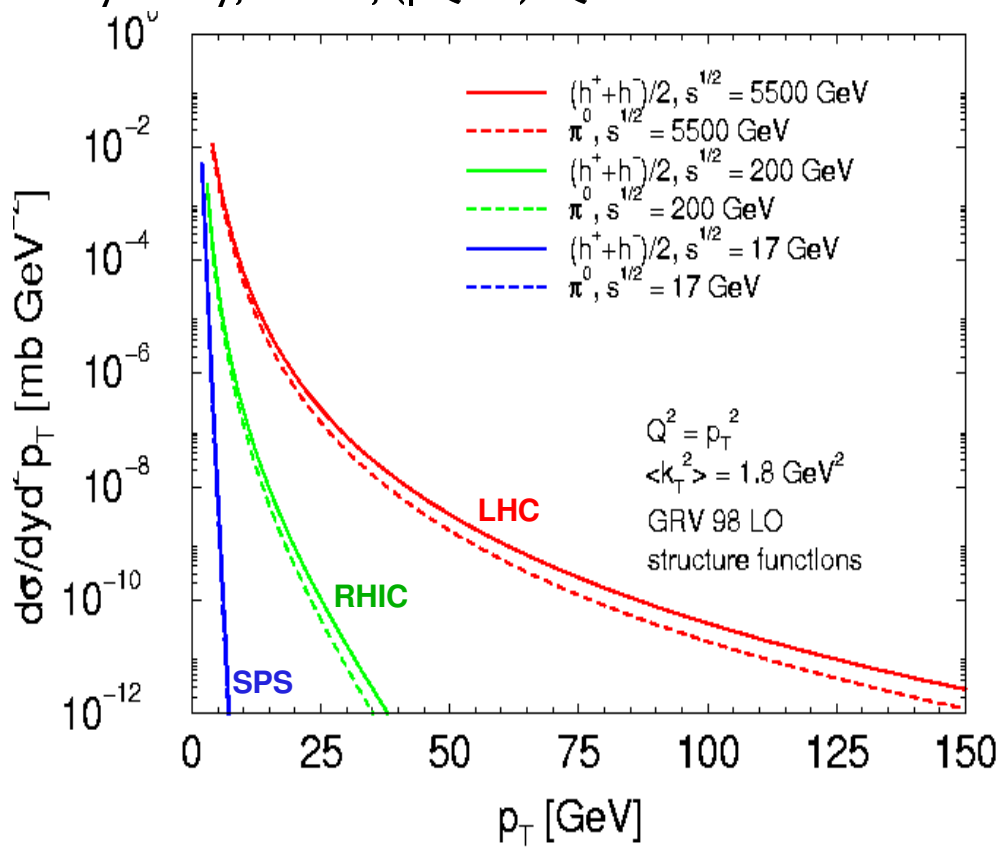
Predicted cross-section for high-p_T jets at LHC is orders of magnitude higher than at RHIC:

M.Gyulassy, I.Vitev, (pQCD). QM'02:

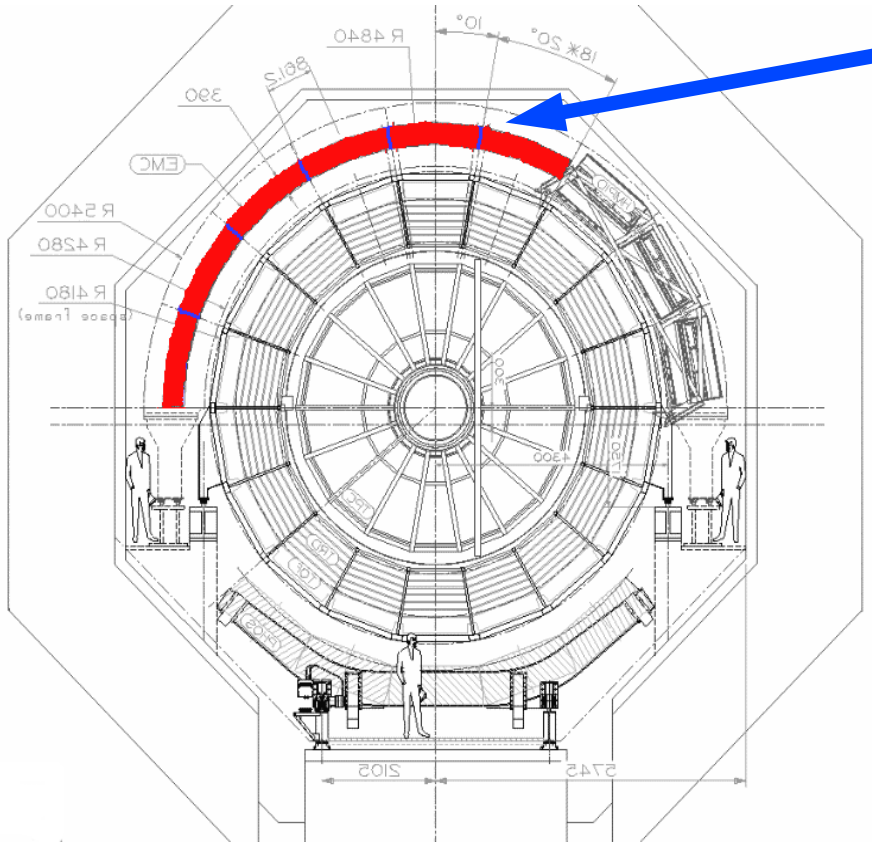


Introduction 2

ALICE

ALICE is the dedicated heavy-ion experiment at LHC

- *Excellent tracking detector*



*ALICE-USA collaboration proposed electromagnetic calorimeter **(EMCAL)**, to:*

- *Extend jet p_T range > 250GeV/c*
- *Improve jet energy resolution*
- *Trigger on jets, enhance yields 200x*

- *Pb-scintillator – linear response*
- $-0.7 < \eta < 0.7,\ 2\pi/3 < \phi < \pi$
- *12 super-modules*
- **19152** *towers*
- *Energy res ~* $\frac{15}{\sqrt{E}}\%$

See M.Horner poster session

Introduction 3

ALICE

Full *jet energy range can be studied at ALICE...*

Soft | **Semi-Hard** | **Hard**

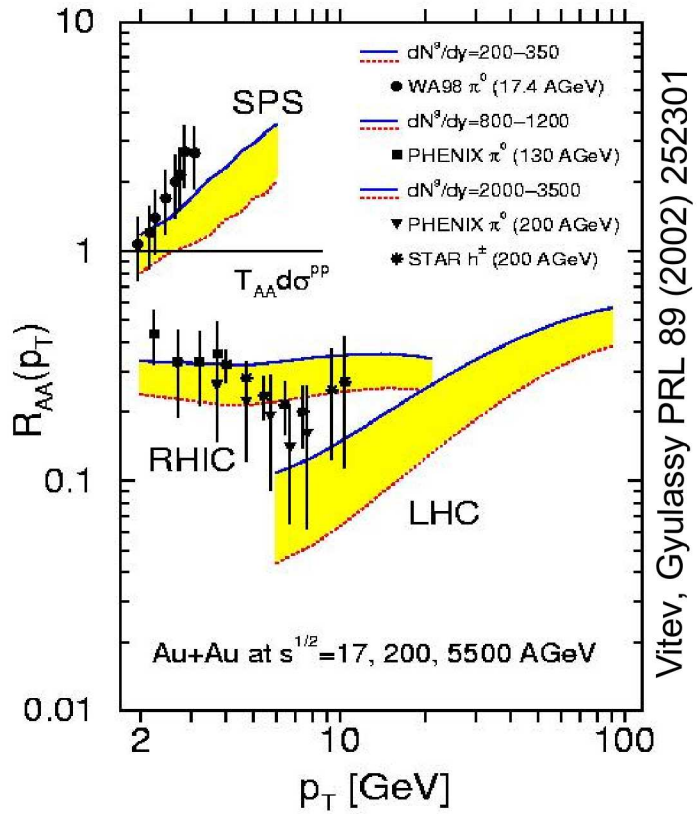
- 2 GeV
- Mini-jets (100/ev)

- 20 GeV
- (1/ev)

- 100, 200 GeV
- (100k/year)

Event structure & properties

- Correlation studies



Event-by-event distinguishable objects

- Reconstructed jets

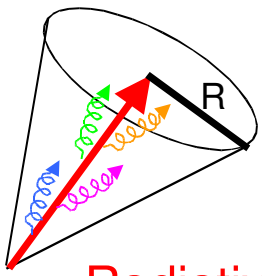
SEE Posters:

- *G. Conesa, Photon-tagged jets*
- *A. Morsch, Jet physics with ALICE detector*

Introduction 4

Analysis Goals

Goal to determine medium properties with jet reconstruction - fragmentation functions:



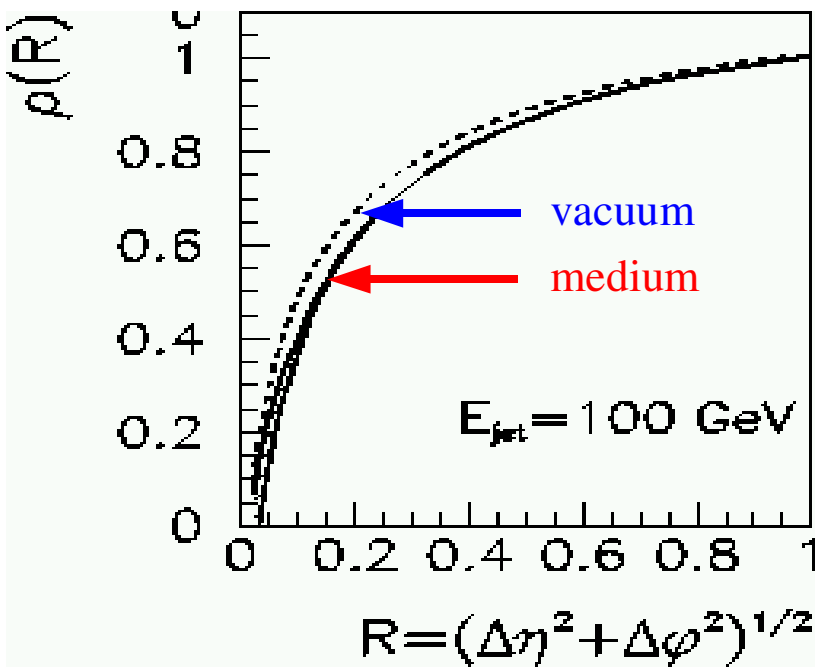
Most energy radiated INSIDE cone...

Radiative energy-loss

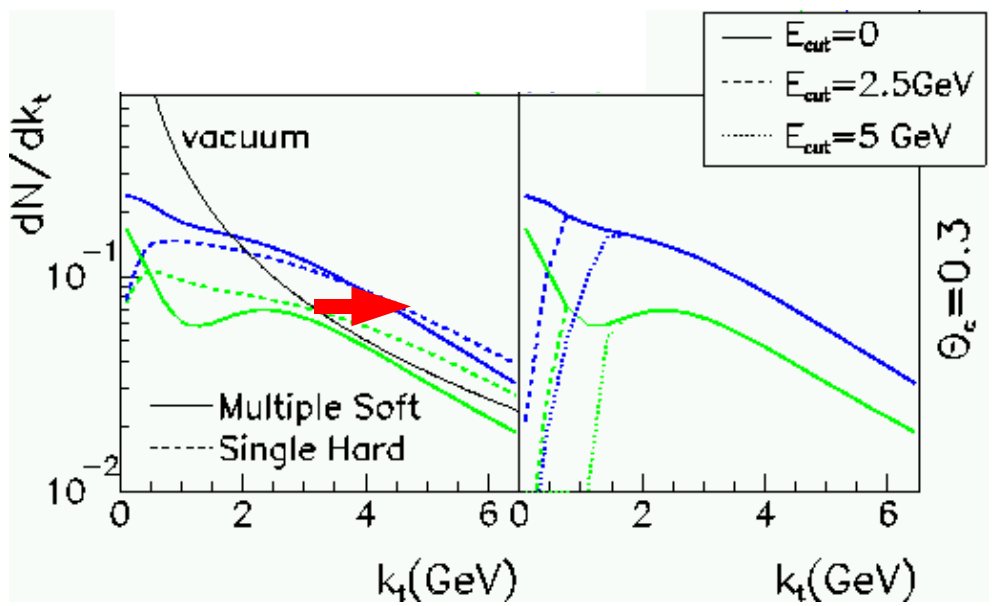
Need to measure jet fragmentation **(needs tracking!)**

$$D(z) = \frac{1}{N_{Jets}} \frac{dN_{ch}}{dz} \quad \textit{where} \quad z = p_L / E_{Tjet}$$

Wiedemann QM2004



Wiedemann QM2004



Methodology 1

Soft Background

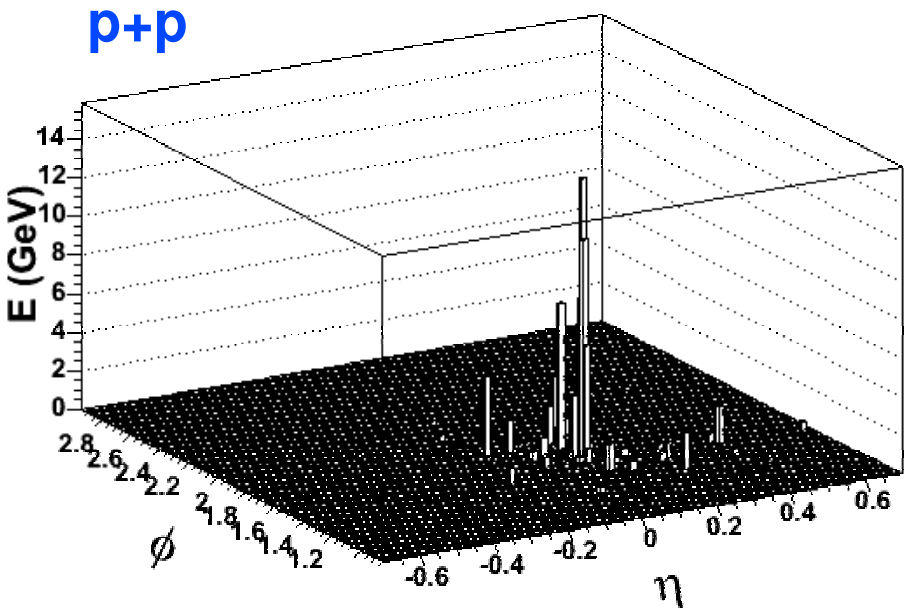
Event = PYTHIA + Central (b<5fm) HIJING event

$$E(\eta,\phi)=E_{TPC}(\eta,\phi)+E_{EMCal}(\eta,\phi)\pm Corr$$

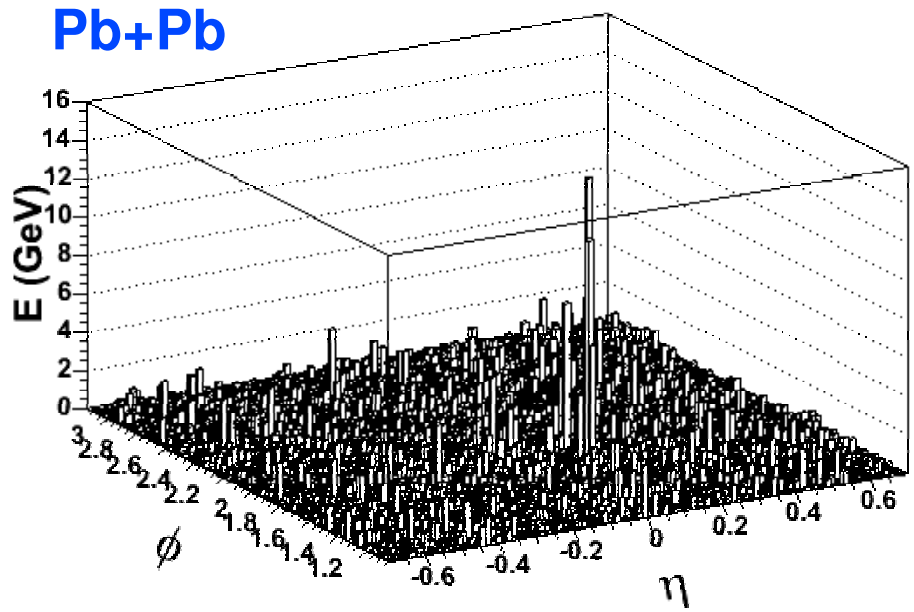
(Granularity defined by EMCal towers)

Reduce background:
Track p_T-cut = 2GeV/c

p+p



Pb+Pb



Methodology 2

Jetfinding Algorithm

- ***Modified UA1 cone algorithm***
- ***Uses combination of tracking + calorimeter data***

Jet Properties:

$$\eta_{Jet} = \frac{1}{E_{Tjet}} \sum_{i \subset C} E_{Ti}\, \eta_i$$

$$\phi_{Jet} = \frac{1}{E_{Tjet}} \sum_{i \subset C} E_{Ti}\, \phi_i$$

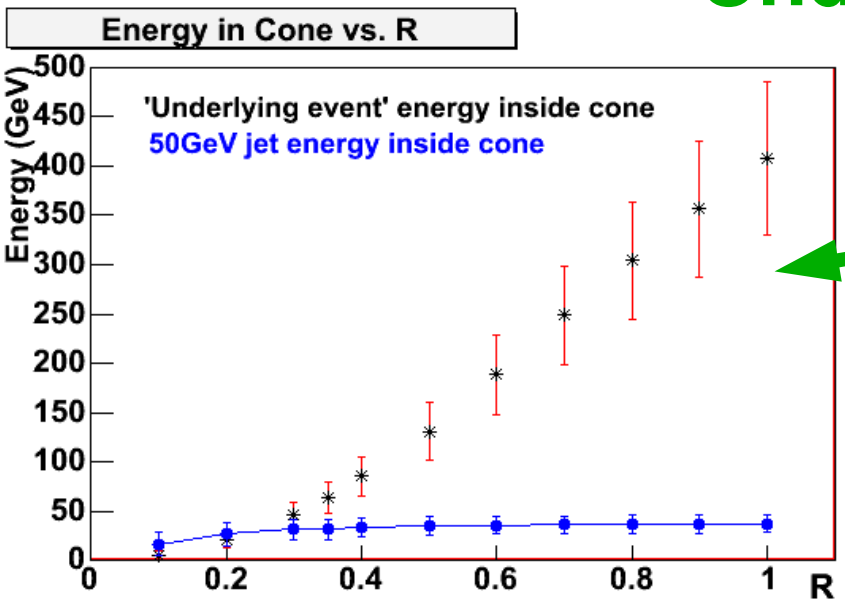
$$E_{Tjet} = \sum_{i \subset C} \left(E_{Ti} - E_{BGpercell} \right)$$

Algorithm Parameters:

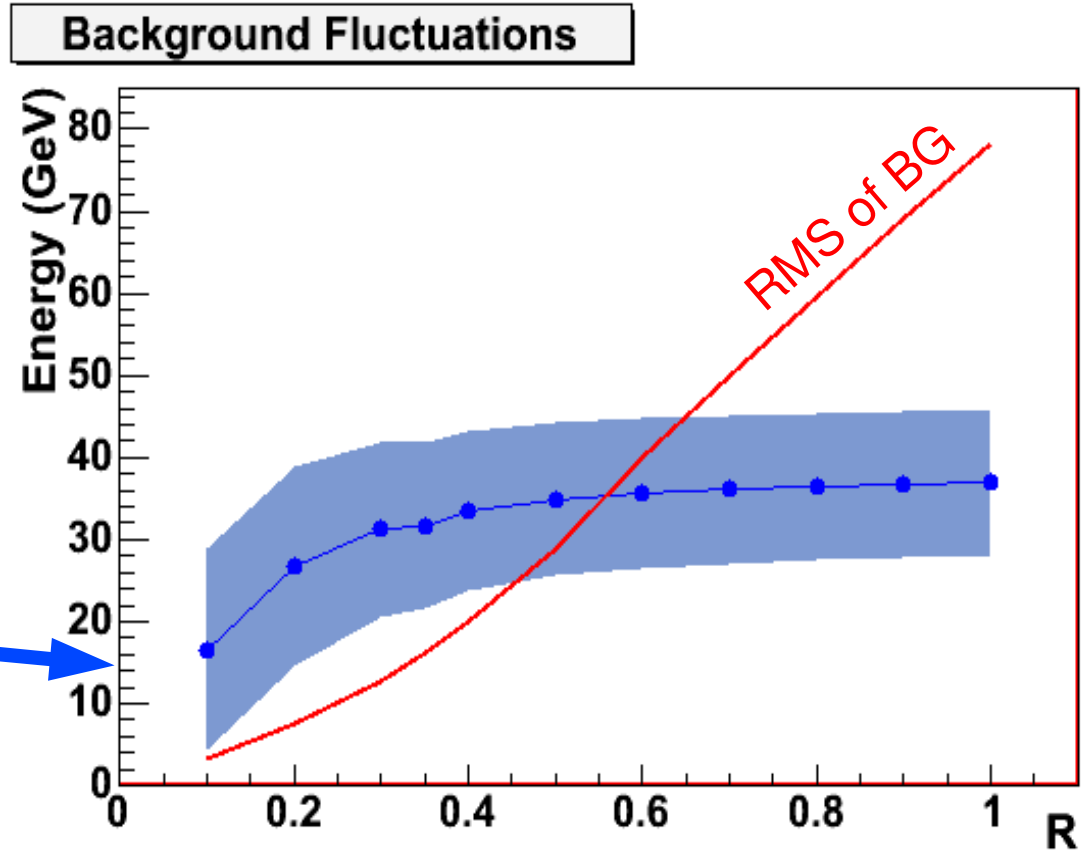
- Cone radius: R = 0.3
- Seed Energy = 4.6 GeV
- Minimum jet energy = 14 GeV

Methodology 3

Underlying Event Fluctuations 1



$E_{BG} \gg E_{Jet}$ Fluctuations important!



At LHC, physics REQUIRES:

R=0.3 so that $\sigma(E_{BG}) < E_{Jet}$

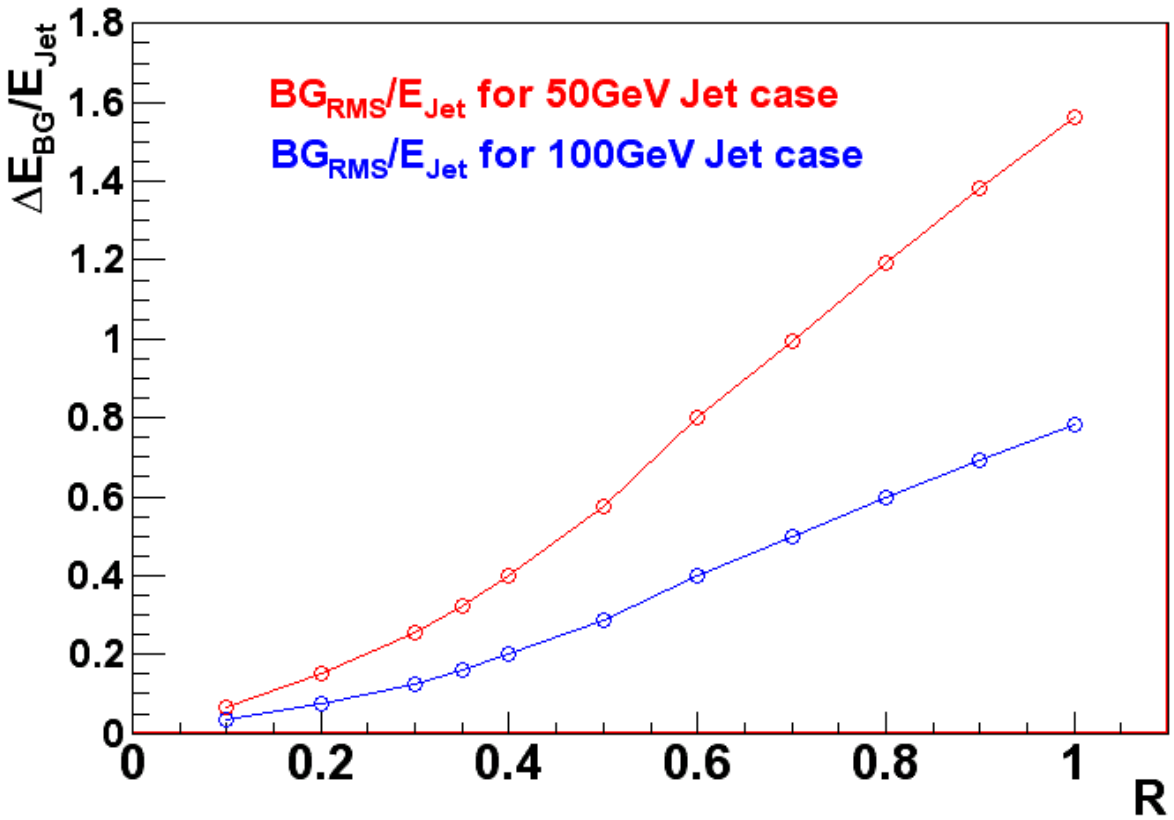
Methodology 4

Underlying Event Fluctuations 2

$$\sigma(E_{Reco}) = \sqrt{(\sigma(E_{BG}))^2 + (\sigma(E_{Jet}))^2}$$

Underlying event fluctuations limit the reconstructed jets resolution!

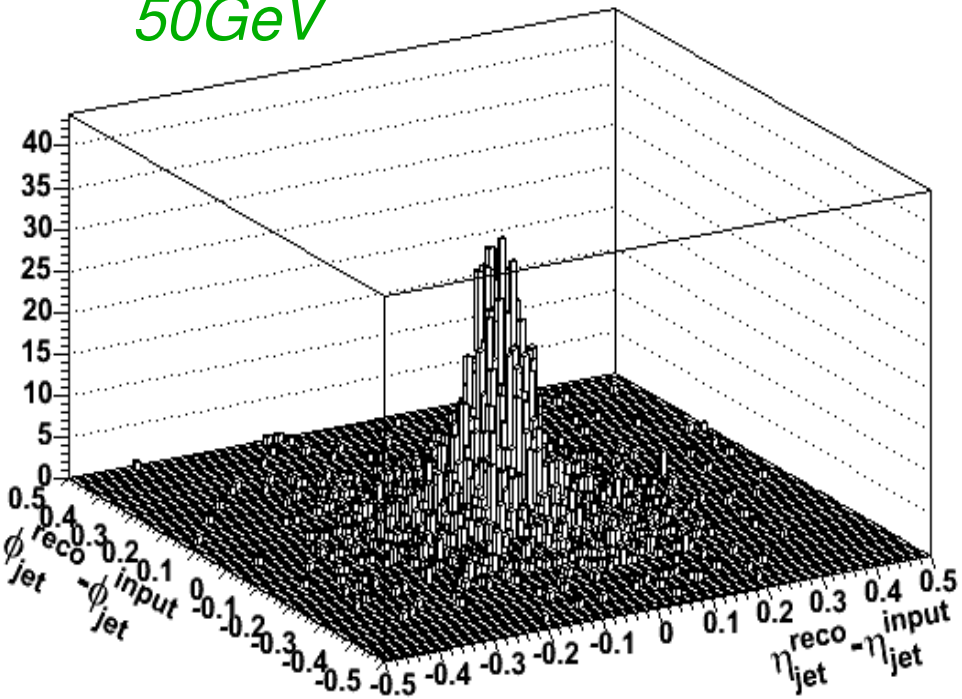
So NEED small R



Results 1

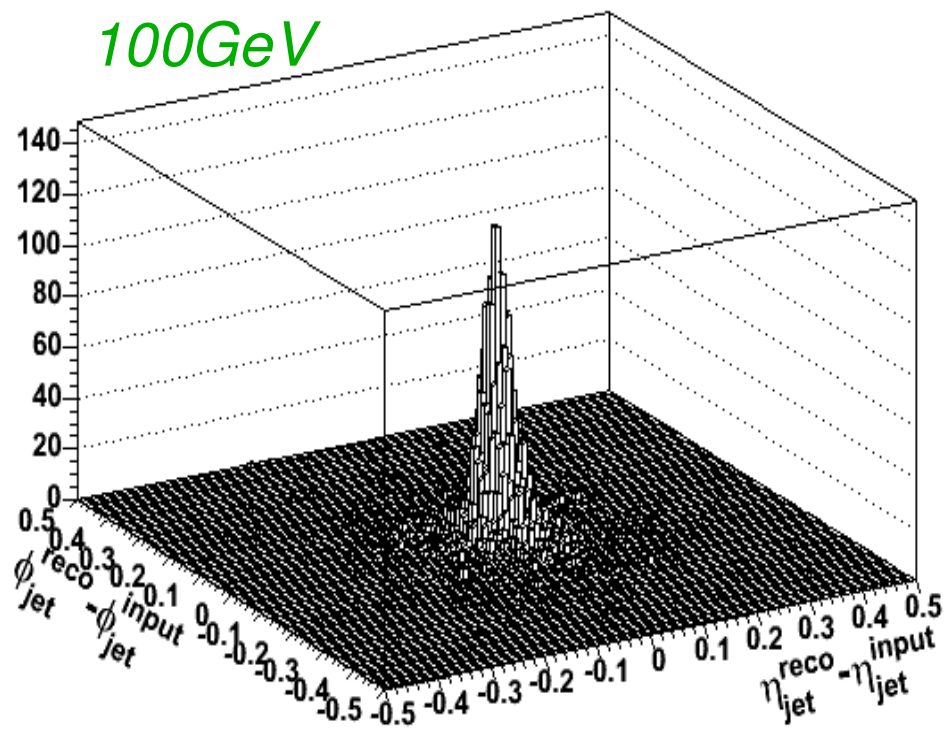
Reconstructed Jet Directions

50GeV



Excellent accuracy!

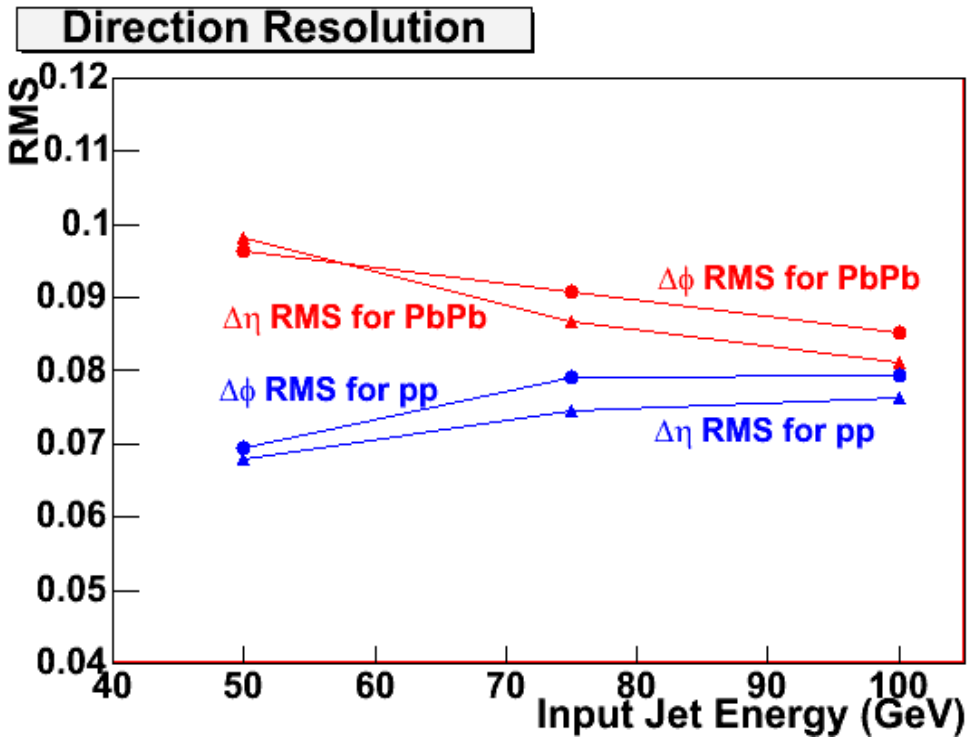
100GeV

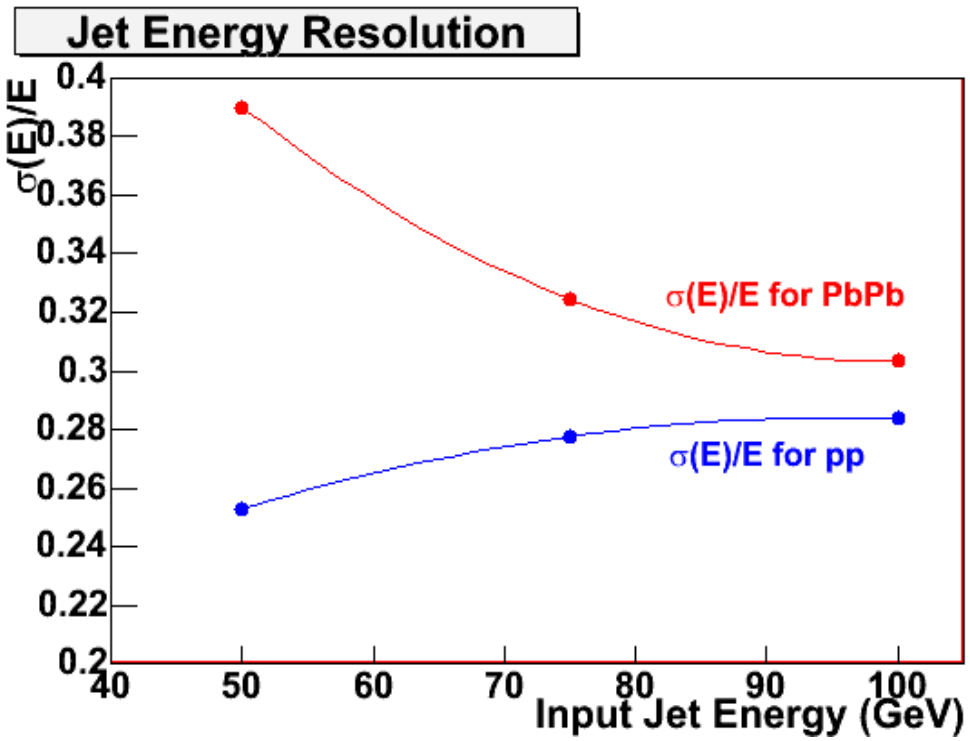


Results 1

Jet Resolution

Good energy resolution...

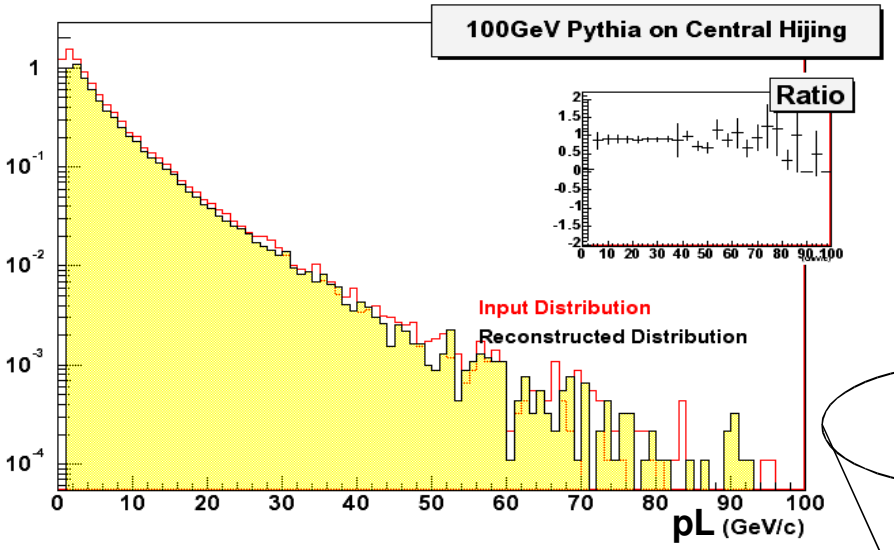


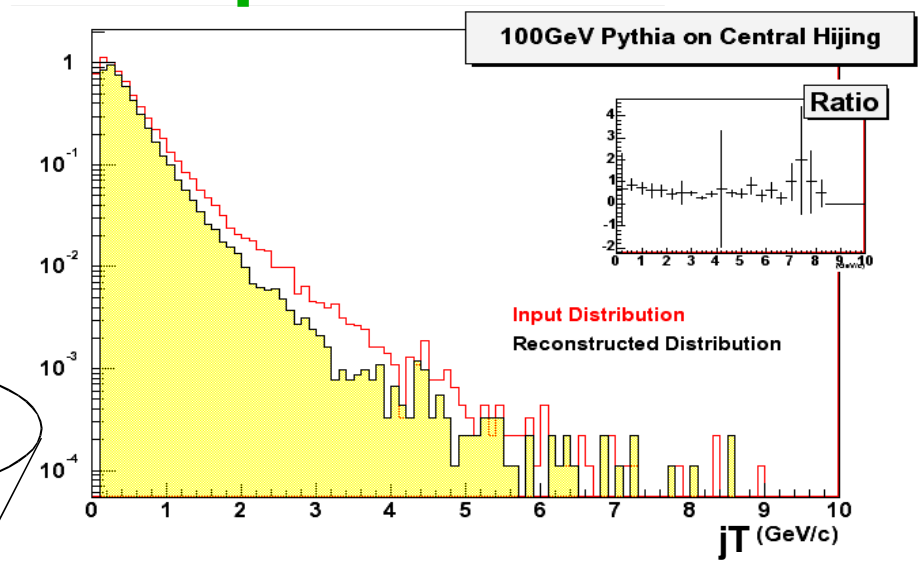


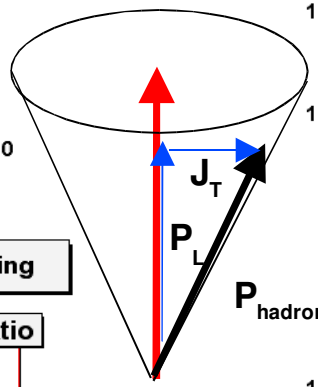
Excellent direction reconstruction!

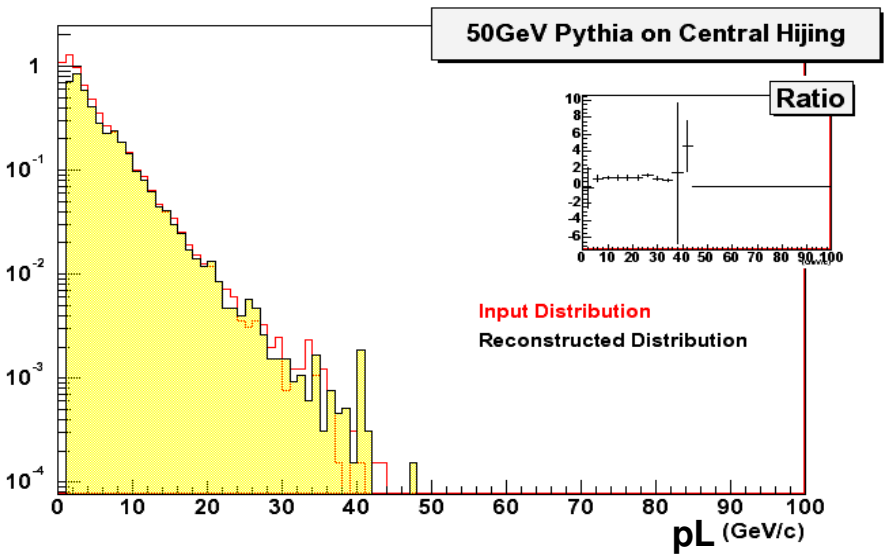
Results 3

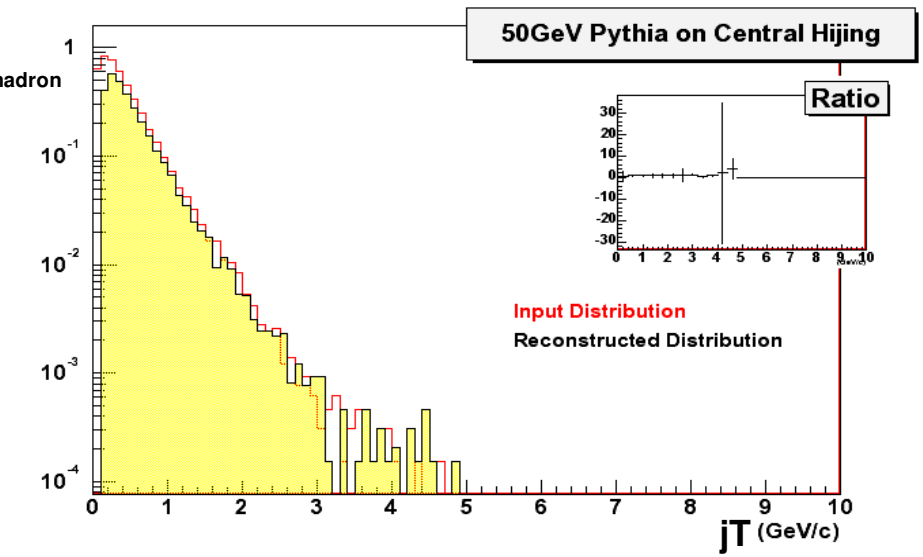
p Distributions 1











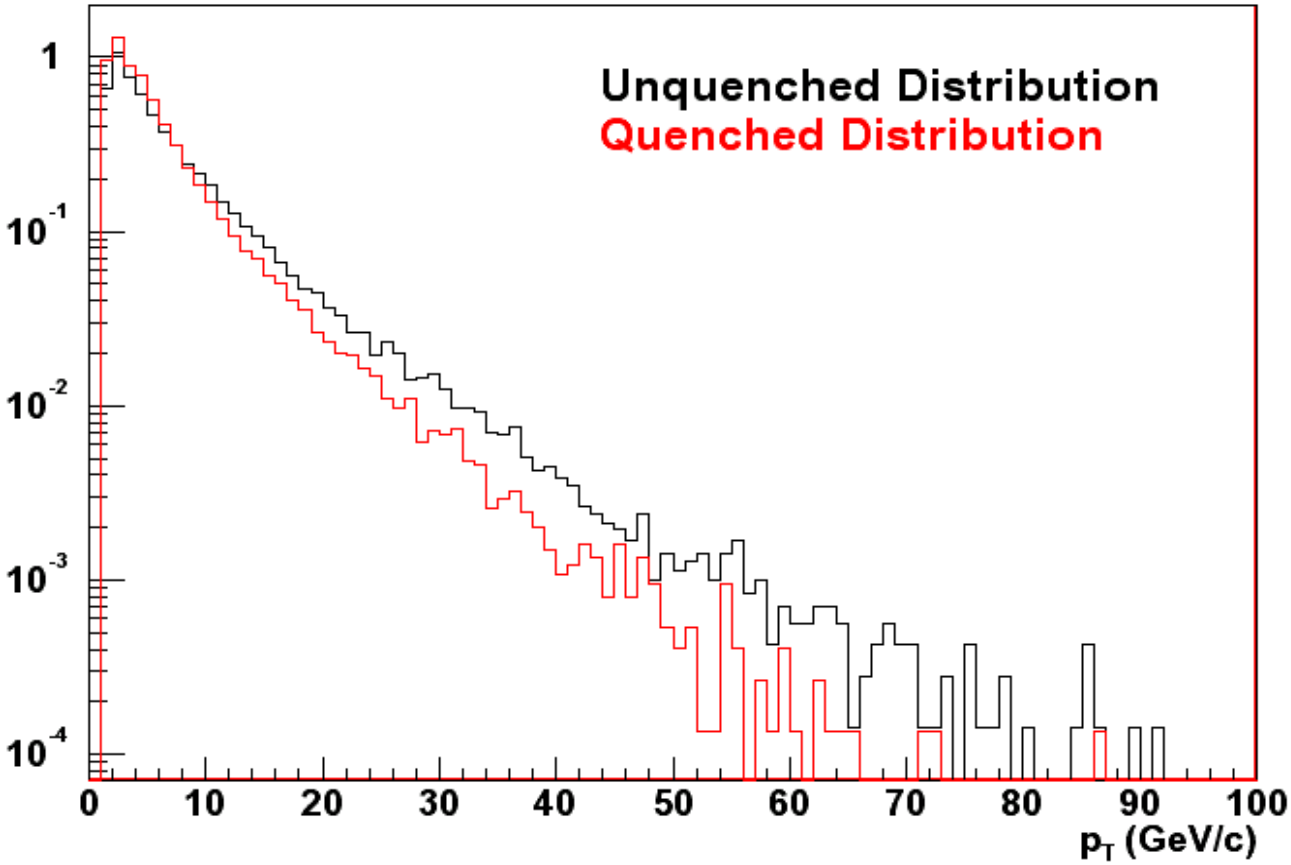
Results 4

p Distributions 2

Quenched jets ***can be*** *differentiated from un-quenched jets!*

- *Toy model of quenching:*

Quenched 100GeV jet = 80GeV PYTHIA + 20GeV PYTHIA



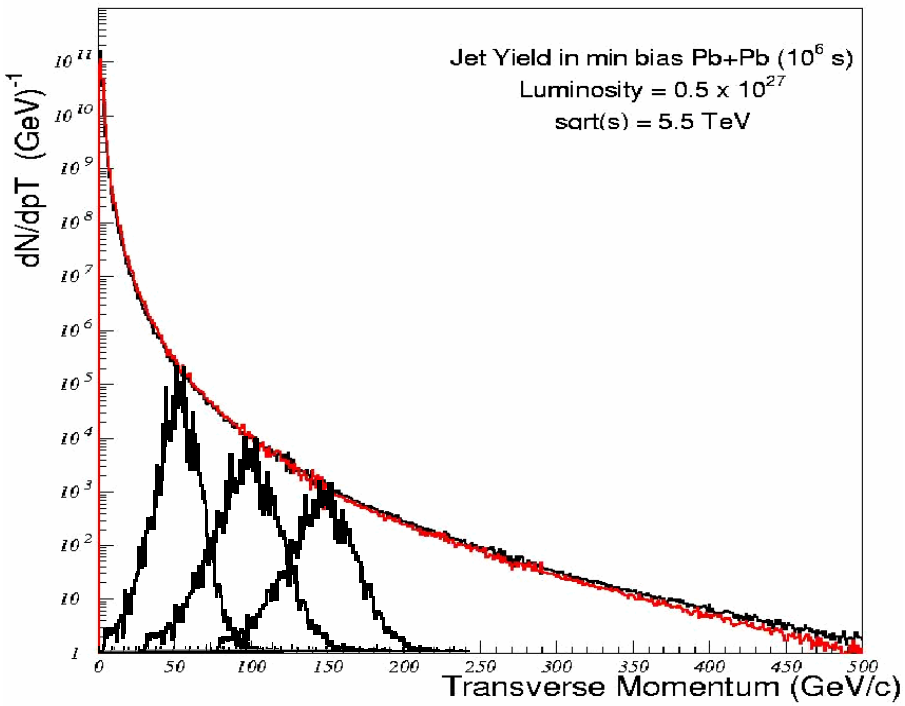
Summary and Outlook

Conclusions

Conclusions:

- ***Jets can be reconstructed*** *in HI collisions at LHC using optimised cone algorithm on combination of tracking & calorimeter data*

- ***Jet Fragmentation*** *can be measured (statistically)*



Next Steps:

- ***Jet energy calibration*** *(γ-jet)*

- ***Hadron correction*** *- Fine-tuning*

ALICE-USA Collaboration

Creighton University
Kent State University
Lawrence Berkeley National Laboratory
Michigan State University
Oak Ridge National Laboratory
Purdue University
The Ohio State University
University of California, Berkeley
University of California, Davis
University of California, Los Angeles
University of Houston
University of Tennessee
Vanderbilt University
Wayne State University