Status of Jet-finding Studies

ALICE-USA Collaboration Meeting

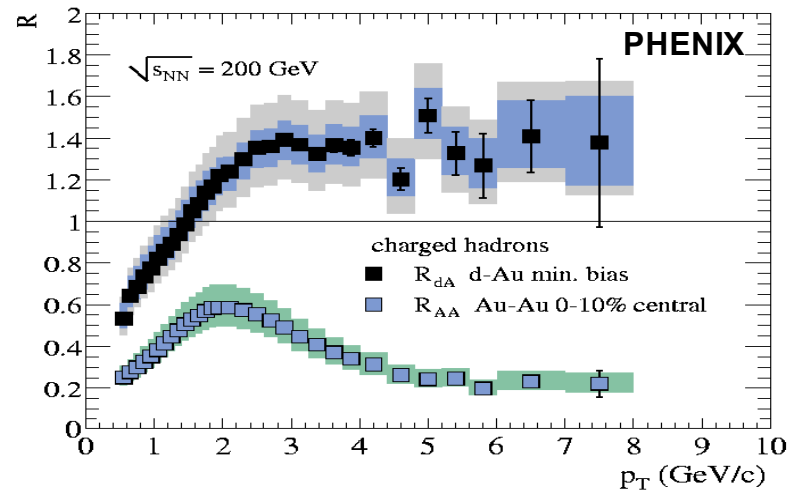
Sarah Blyth

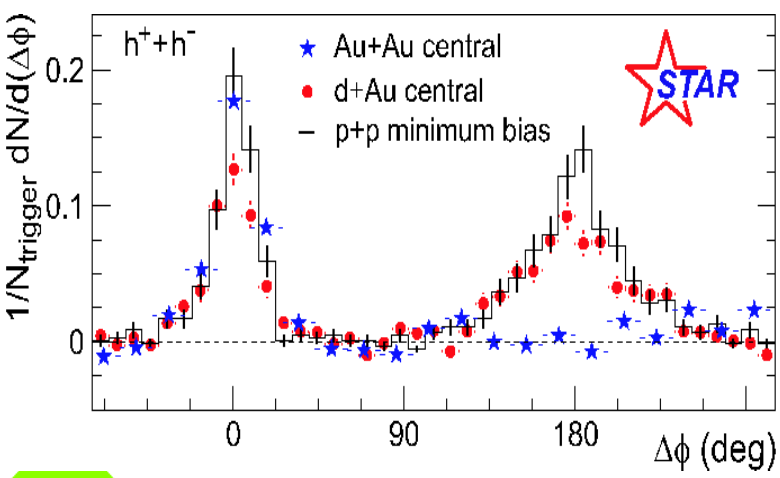
October 2005

Motivation

Properties of the medium created in heavy-ion collisions can be probed by studying modifications to jet properties:

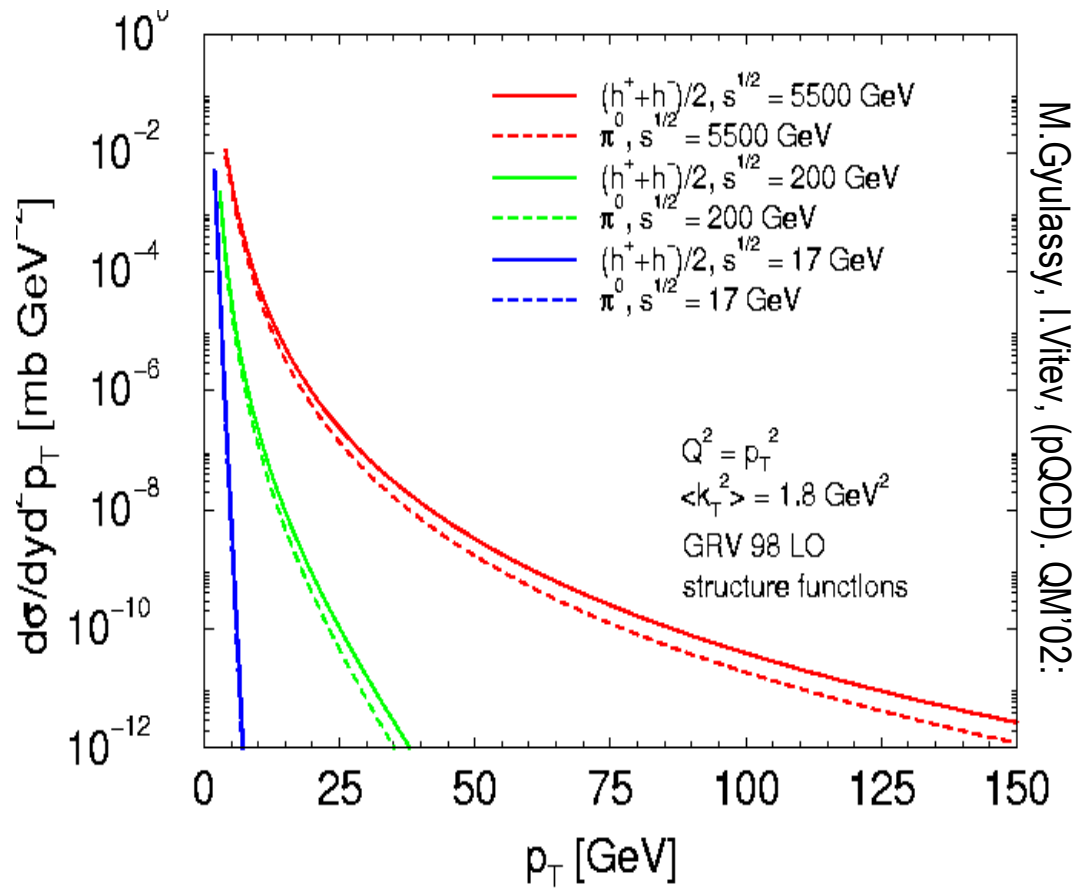
RHIC





Phys. Rev. Lett. **91**, 7,(2003) Cover

LHC: *cross-section for high-p_T jet production, orders of magnitude > RHIC*



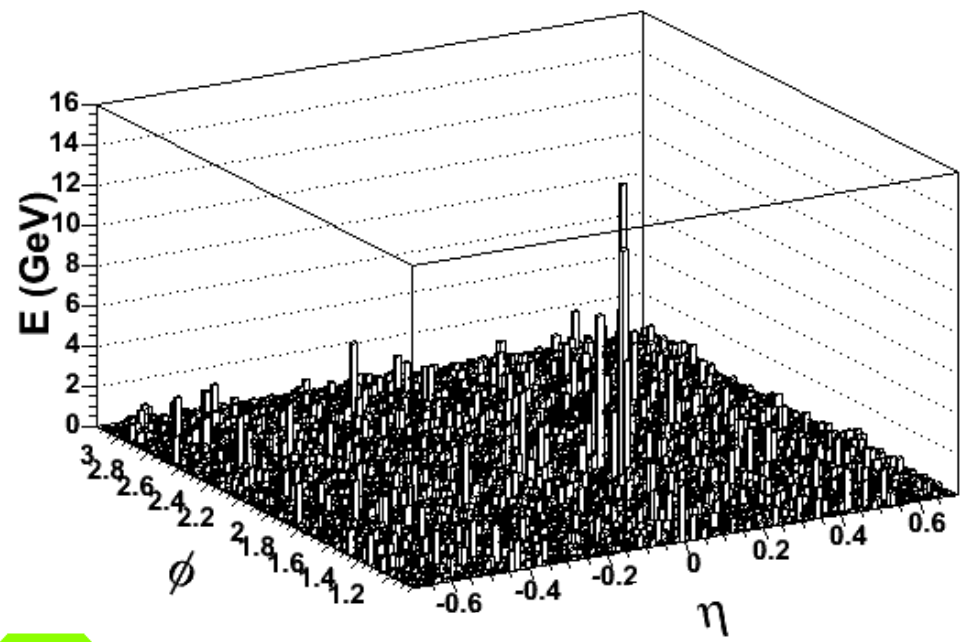
M.Gyulassy, I.Vitev, (pQCD). QM'02:

The JetFinder (HIJA)

Algorithm details

We developed a jet-finding algorithm, HIJA, based on the UA1 cone method, and optimised it for the heavy-ion environment at LHC:

- *Based on UA1 cone algorithm*
- *Uses combination of tracking and EMCal data (p_T + E_T)*
- *Analysis performed on "grid" in (η , ϕ) = granularity of EMCal*



Parameters:

- *Charged track p_T cut*
- *Cone Radius, R*
- *E_{Tseed}*
- *E_{Tcone}*

Sub-methods:

- *Hadron correction*
- *Background estimation*

Jet Simulations

Details

Jets in HI collisions were simulated for a range of jet energies to test the sensitivity of the algorithm to finding and reconstructing jets:

Jet Simulations:

- *Pb+Pb jets = PYTHIA + Central HIJING (0 < b < 5 fm)*
- *3 mono-energetic jet samples (50GeV, 75 GeV, 100GeV)*
- *1 cross-section weighted sample (20 GeV < E_T < 180 GeV)*

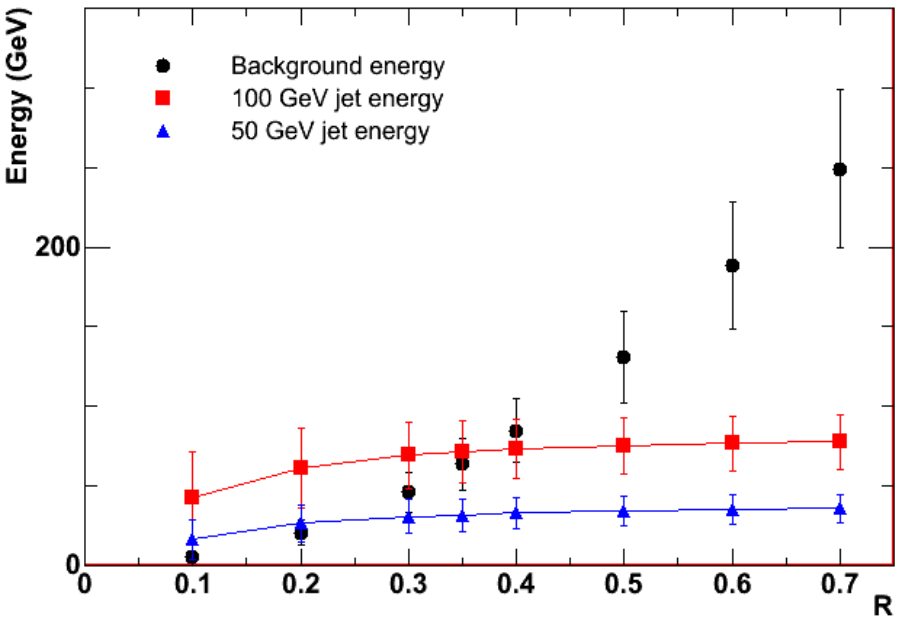
Detector simulation:

- *Fast tracking simulations with momentum smearing and 90% tracking efficiency (Full TPC tracking simulation was not yet available)*
- *Full GEANT response of ALICE and EMCal in original design/geometry:*
  - *$-0.7 < \eta < 0.7$*
  - *$\pi/3 < \phi < \pi$*
  - *13824 towers (96η x 144ϕ)*

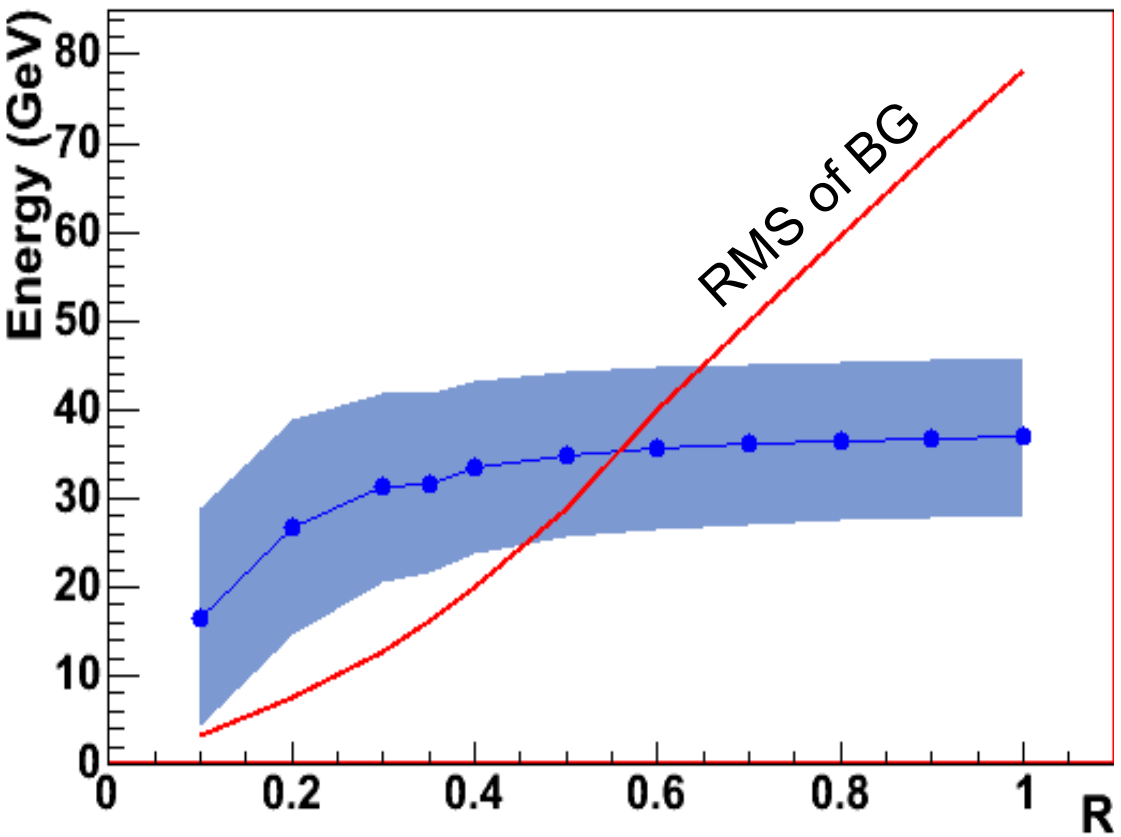
Background Study

Background fluctuations

The main cause of complexity in jet reconstruction in HI collisions is the magnitude of the event-by-event background energy fluctuations:



- *Background fluctuations > E_{jet} for R>0.5*



- *E_{BG} >> E_{jet} for R>0.3 (50 GeV Jets)*

BUT…

Optimisation

Background estimation

Three methods were developed to estimate the background energy contribution inside the jet cone:

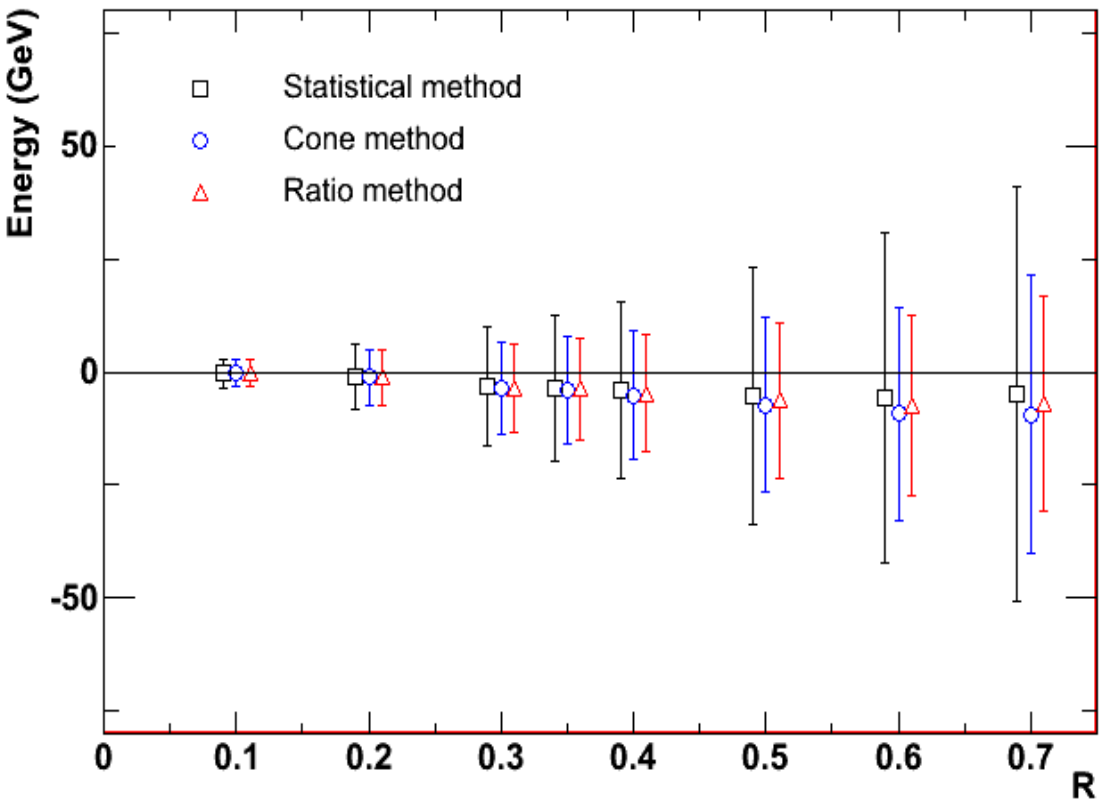
Statistical method:

- *Average over large event sample to estimate mean E_{BG} in cone*

Event-by-event methods:

- ***Cone**: Use grid E outside cone to estimate E_{BG} inside*
- ***Ratio**: Adapt cone method to include information pre-cuts and over large sample to reduce fluctuations*

Estimated E_{BG} – Actual E_{BG}



Optimisation

Background estimation

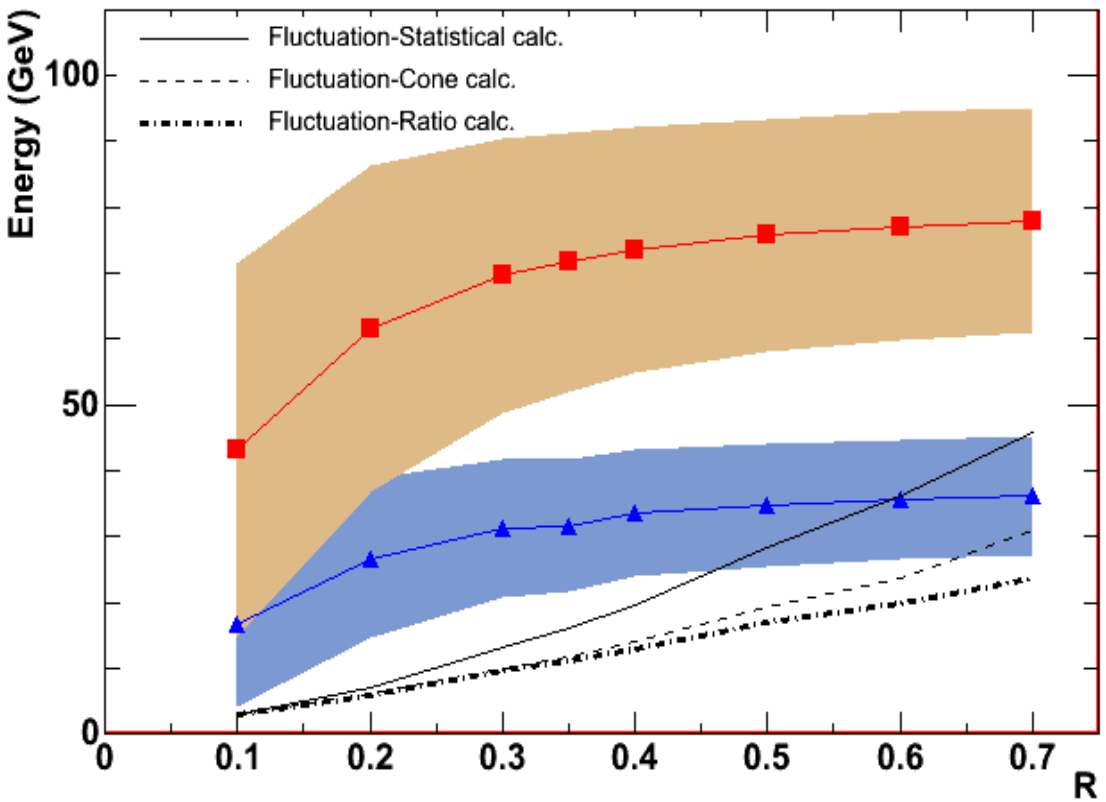
Three methods were developed to estimate the background energy contribution inside the jet cone:

Statistical method:

- *Average over large event sample to estimate mean E_{BG} in cone*

Event-by-event methods:

- ***Cone**: Use grid E outside cone to estimate E_{BG} inside*
- ***Ratio**: Adapt cone method to include information pre-cuts and over large sample to reduce fluctuations*



Optimisation

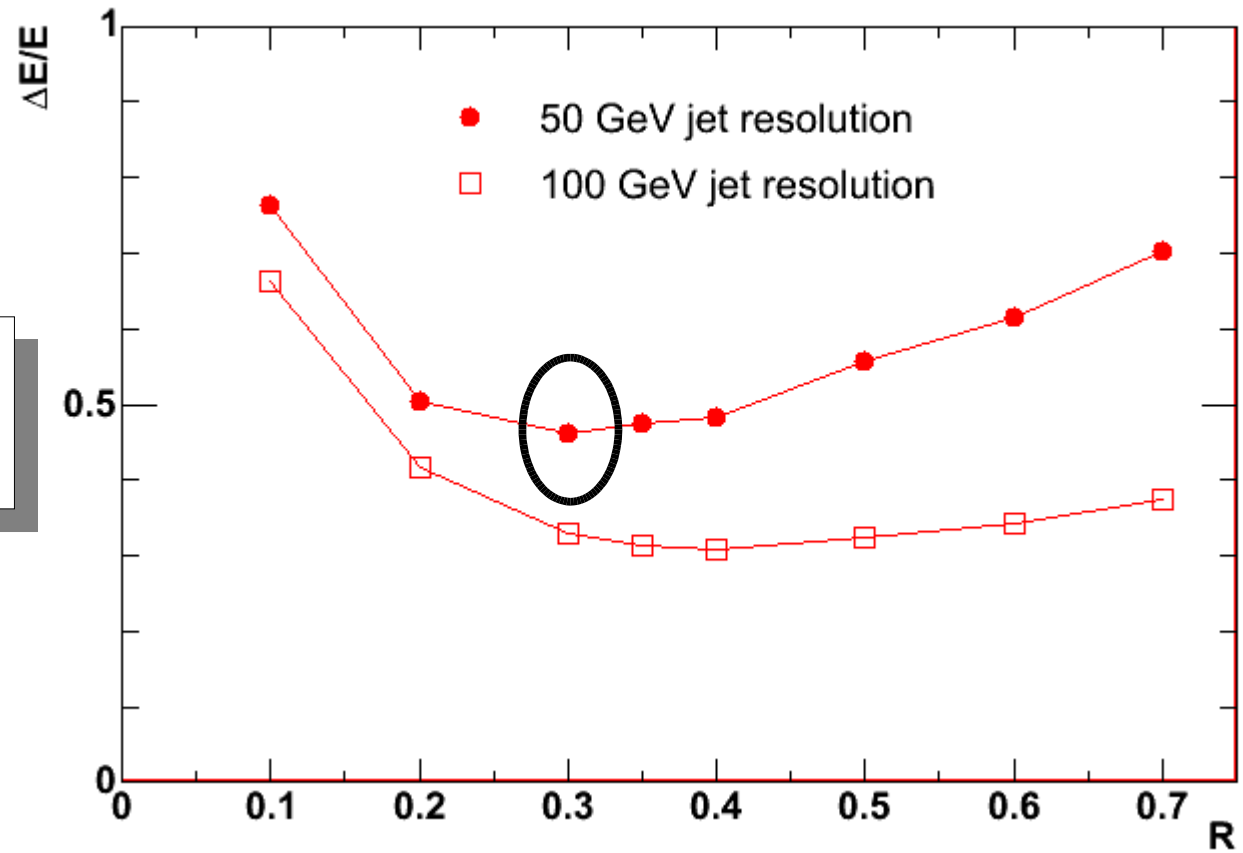
Cone Radius, R

Since the background fluctuations are of the order of the jet energy for 50 GeV jets at R=0.6, a smaller cone radius is required:

- *R chosen to give best energy resolution for 50 GeV jets:*

$$\Delta E / E = \frac{1}{E_{jet}} \sqrt{RMS^2_{jet} + RMS^2_{Ratio}}$$

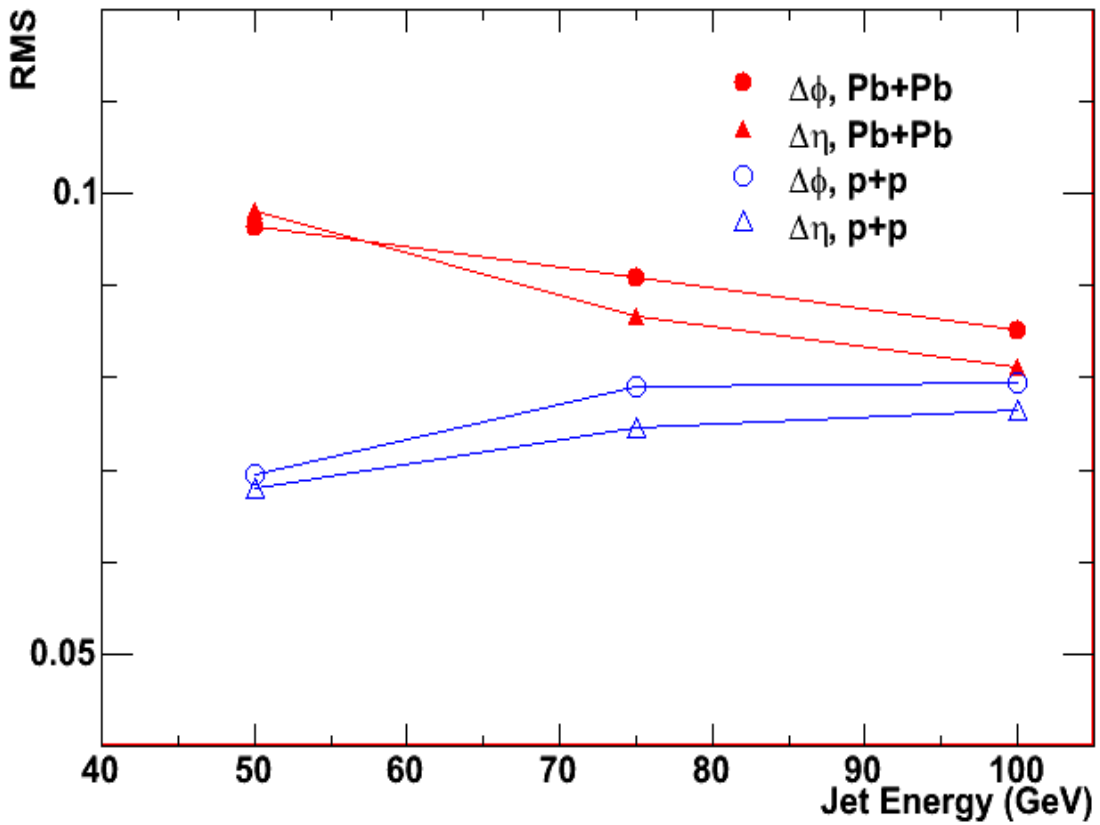
- ***R=0.3***



Results

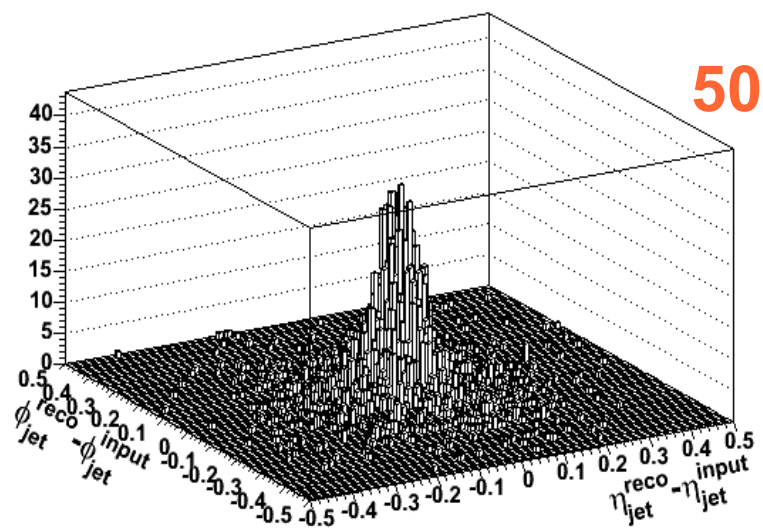
Direction reconstruction

Jets in simulated Pb+Pb collisions can be be found and their directions accurately reconstructed by HIJA:



Optimised Parameter Values:

- *Charged track p_T cut =* ***2 GeV/c***
- *Cone Radius,* ***R = 0.3***
- E_{Tseed} = ***4.6 GeV***
- E_{Tcone} = ***14 GeV***

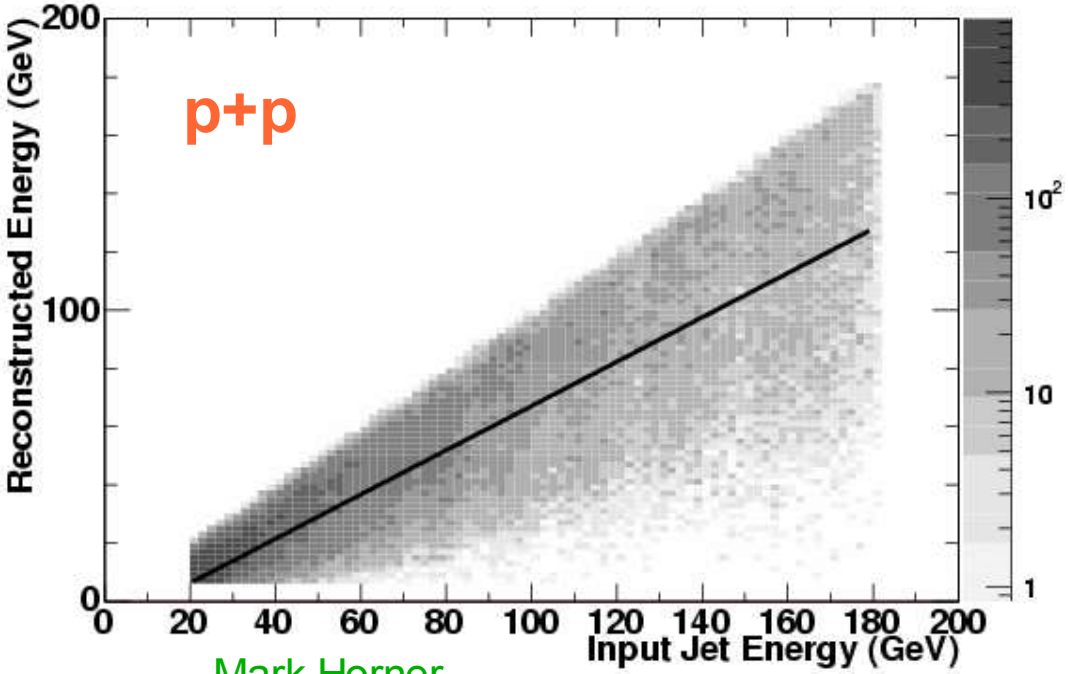


Results

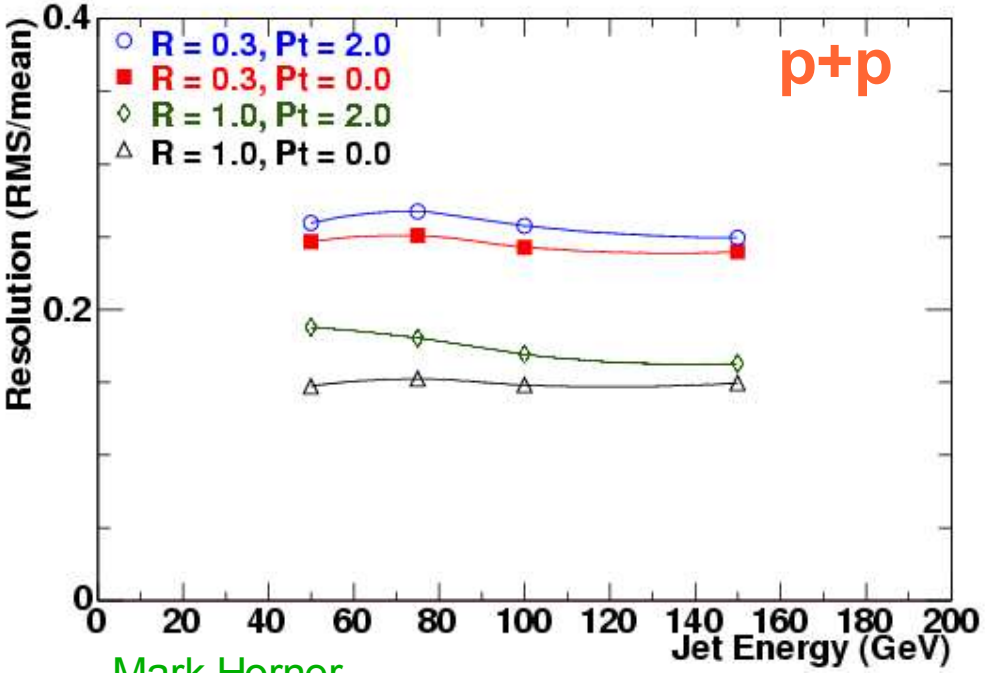
Jet energy resolution

The pure HIJA energy resolution for p+p jets was measured using PYTHIA input and comparing to the PYCELL result:

- *Broadening of energy distribution due to undetectable particles*
- *Line = mean reconstructed E_{Jet}*



Mark Horner



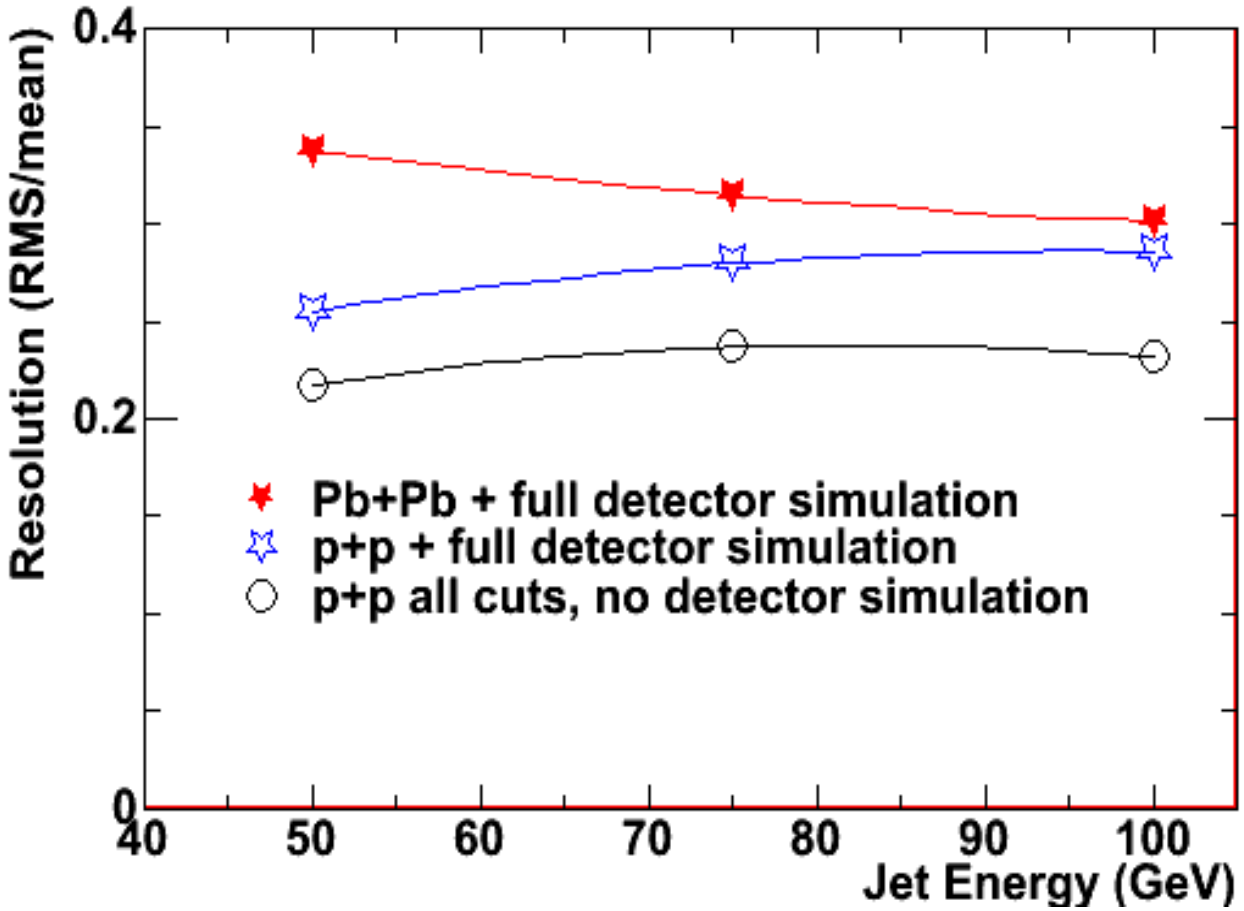
Mark Horner

- *Optimal energy resolution of HIJA = 15 % (no detector effects)*
- *Necessary analysis cuts result in best possible resolution ~25% (no detector effects)*

Results

Jet energy resolution

The energy resolution for Pb+Pb, using HIJA and simulated EMCal response, compares well with p+p results and improves as jet energy increases:



- *$\Delta E/E$ (100GeV) = 30%*

Summary

Status:

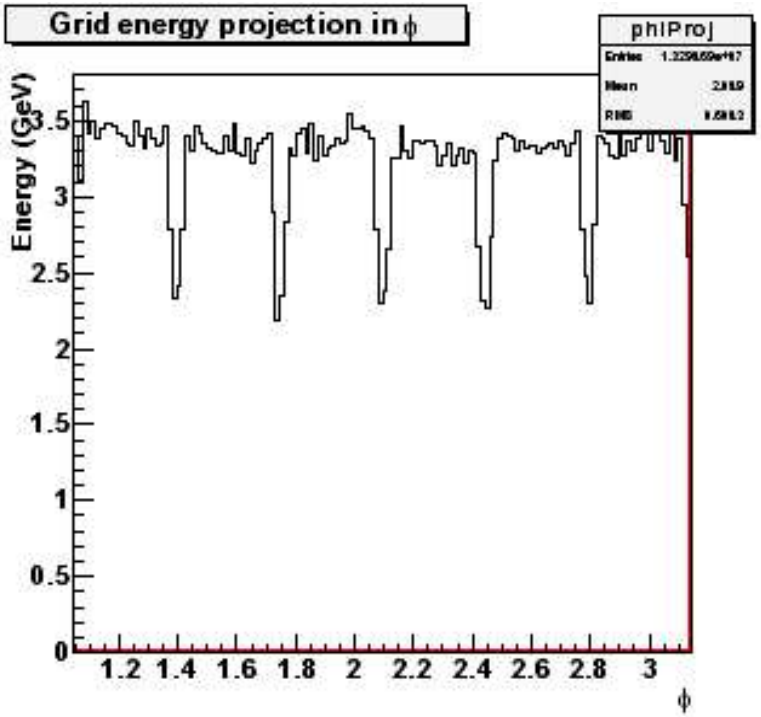
- *HIJA developed and optimised for jet-finding at ALICE using EMCal and tracking info*
- *Paper containing jet study in process of submission to NIM*
- *Full HIJA code written in C++ and in AliRoot CVS*
- *16 page manual written with code explanation and example macros*

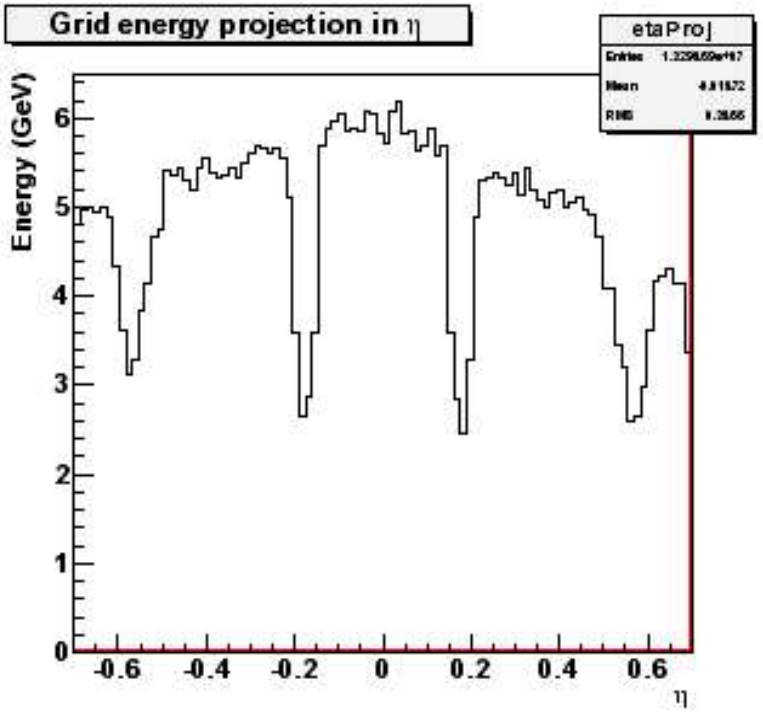
Next steps:

- *Perform jet study using new updated EMCal geometry*
- *Tune HIJA cuts and methods further:*
  - *Introduce E_T cell cut to further reduce background*
  - *Estimate background contribution using full 2π TPC acceptance*
  - *Introduce correction for η -dependence of energy deposition in EMCal*
  - *Improve on hadron correction*

Extra slides…

η dependence of BG





- *ϕ projection of energy deposition is flat (excluding acceptance effects)*
- *η projection is NOT flat – needs to be corrected for in the future*