Universiteit Utrecht

Measurement of jet spectra with charged particles in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV with the ALICE detector

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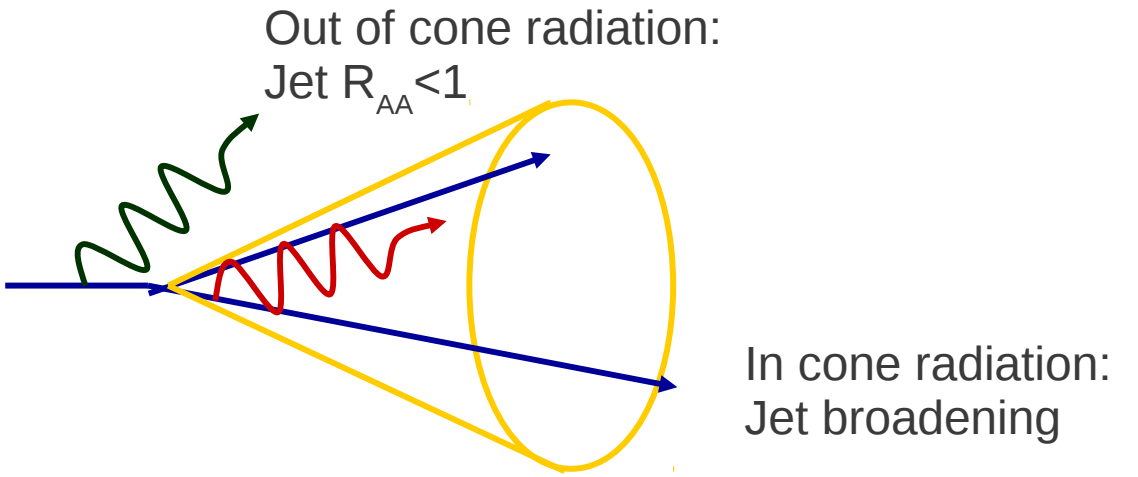
for the ALICE collaboration

Quark Matter 2012, Washington

Jets in Heavy-Ion Collisions

- Probes to study properties of medium
- Due to interaction of the jet with the medium, the jet is modified: Jet Quenching



Experimental challenge in HI collisions:

Separate jet signal from large soft background originating from bulk

- In this analysis R=0.2 and R=0.3 anti-k_T jets with $p_{T,track}$>150 MeV/c

Jets in HI events: background

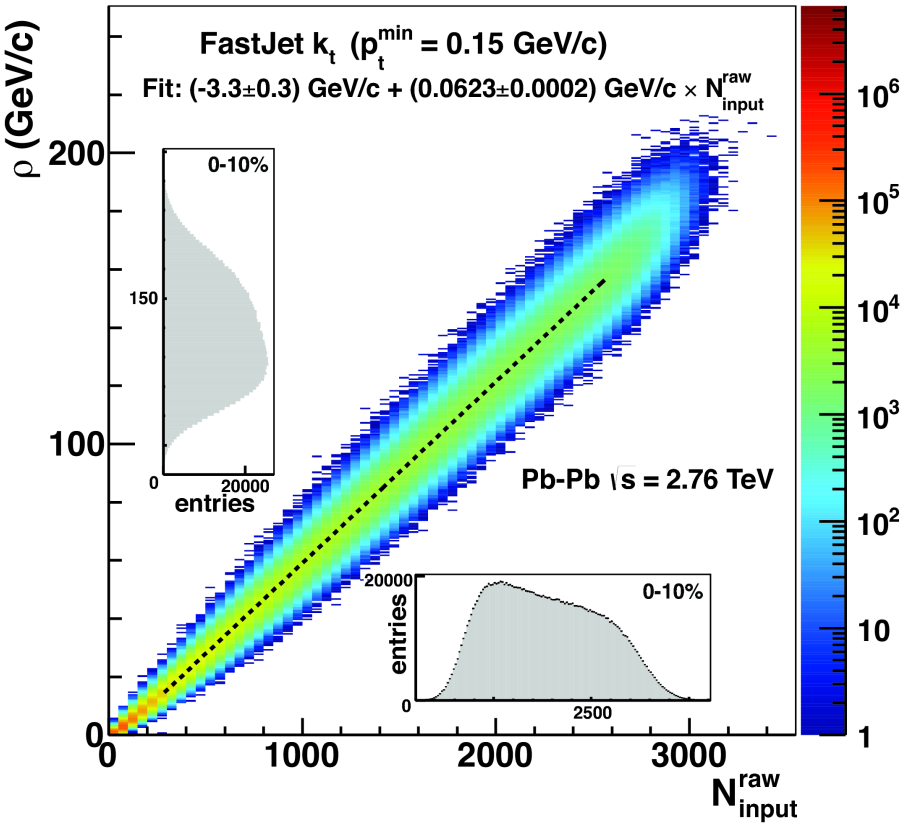
Event-by-event subtraction of average background momentum density ρ.

Background fluctuations quantified by embedding high p_T probes in Pb-Pb events

Width of fluctuations for jets with constituent p_T>150 MeV/c:

$\sigma(\delta p_T, R=0.2)$ = 4.5 GeV

$\sigma(\delta p_T, R=0.3)$ = 7.1 GeV



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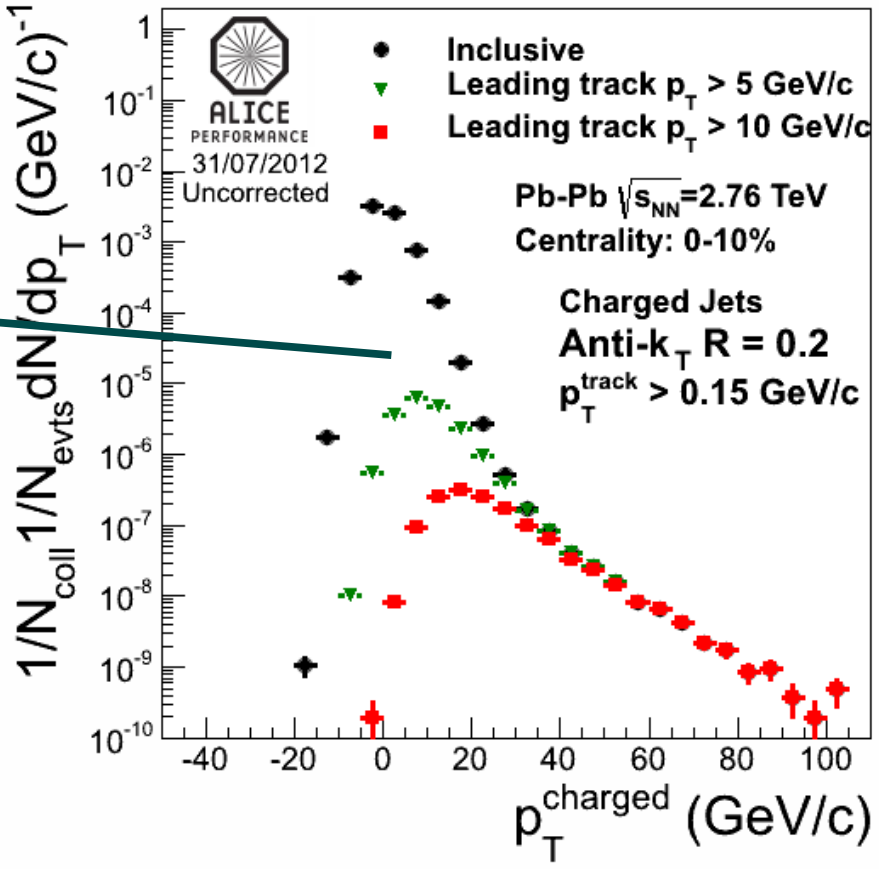
Jets in HI events: background

Combinatorial jets: clusters which do not originate from a hard process.
Reduced by triggering jets with a leading track of p_T > 5 and 10 GeV/*c*.

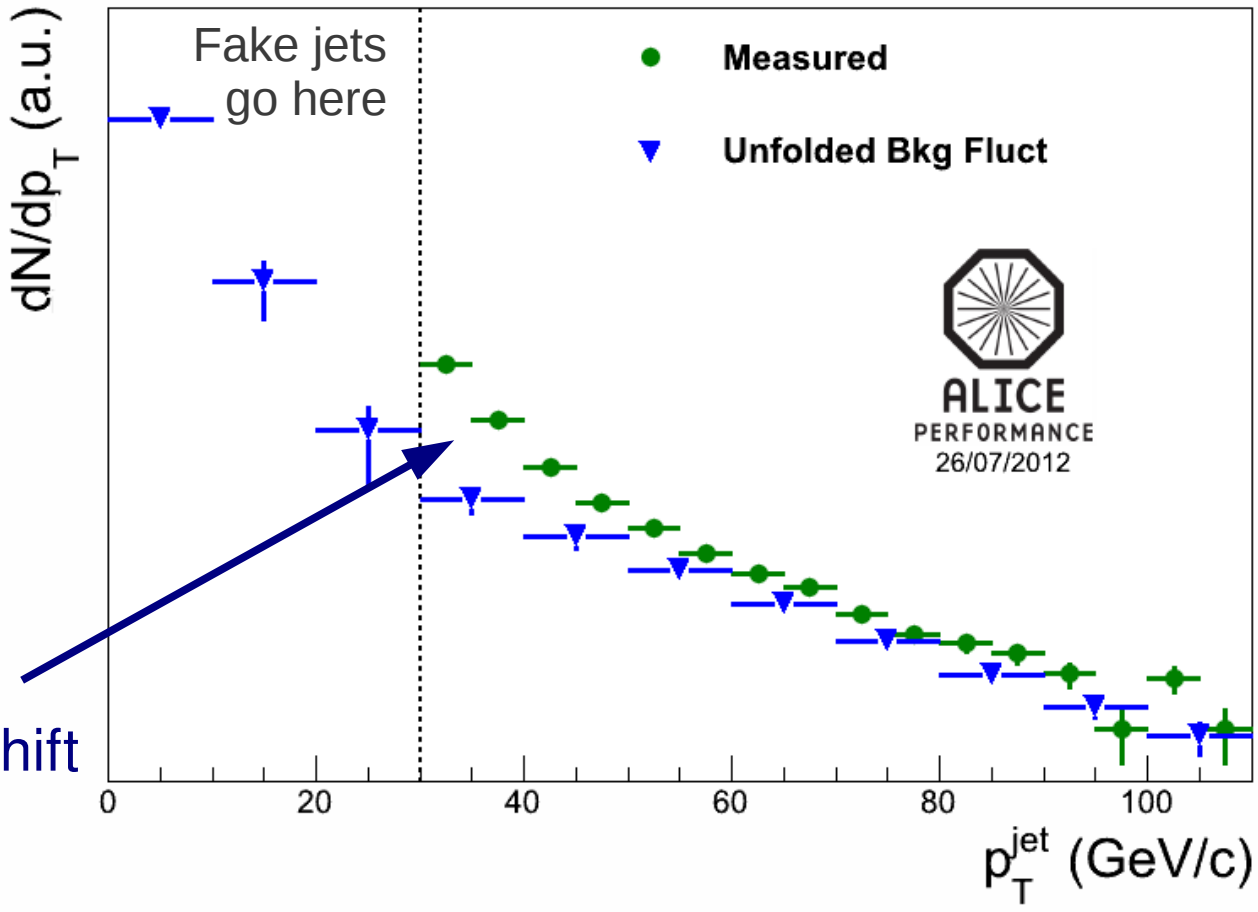
Combinatorial / fake jets



Jets reconstructed from charged particles with p_T>150 MeV/*c*.

Unfolding

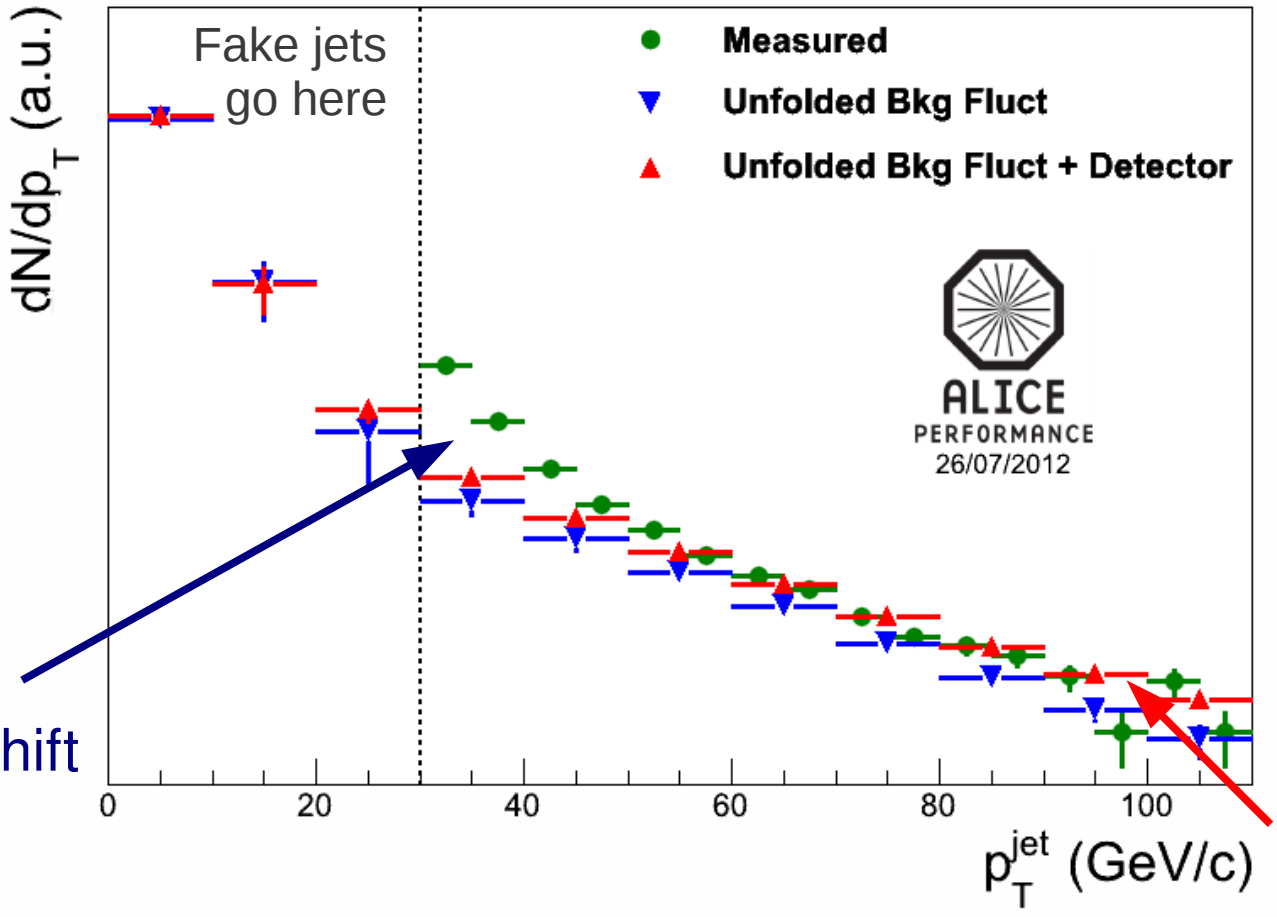
Raw jet spectra need to be corrected for background fluctuations



Background fluctuations shift low p_T jets to high p_T

Background and detector corrections

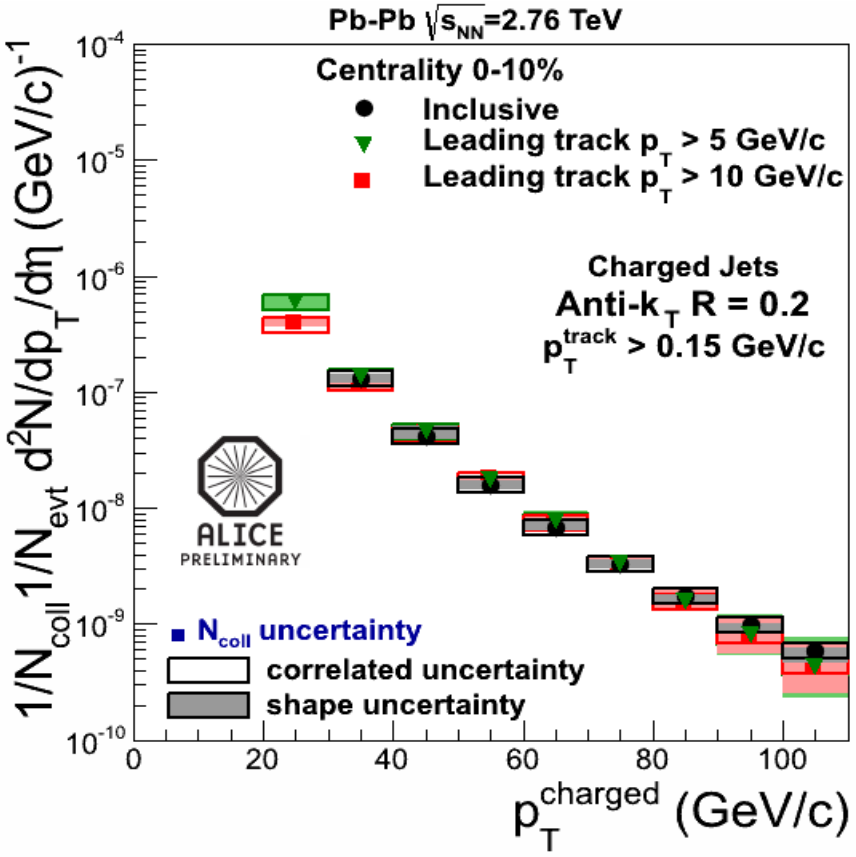
Raw jet spectra need to be corrected for background fluctuations and detector effects.



Background fluctuations shift low p_T jets to high p_T

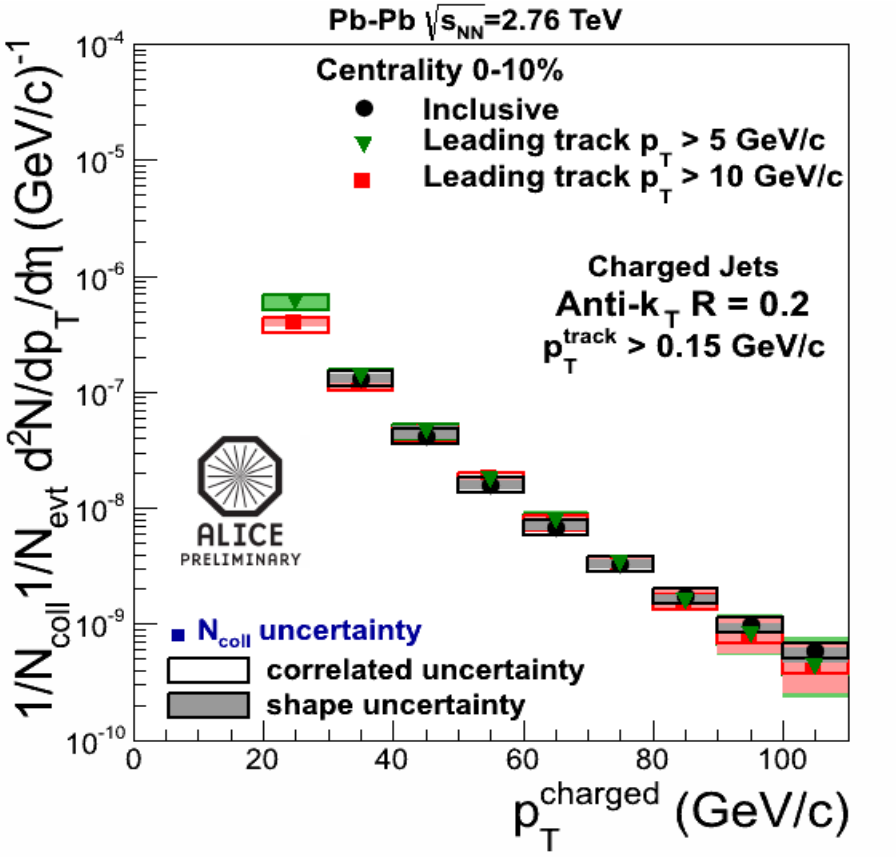
Detector effects shift jets to lower p_T

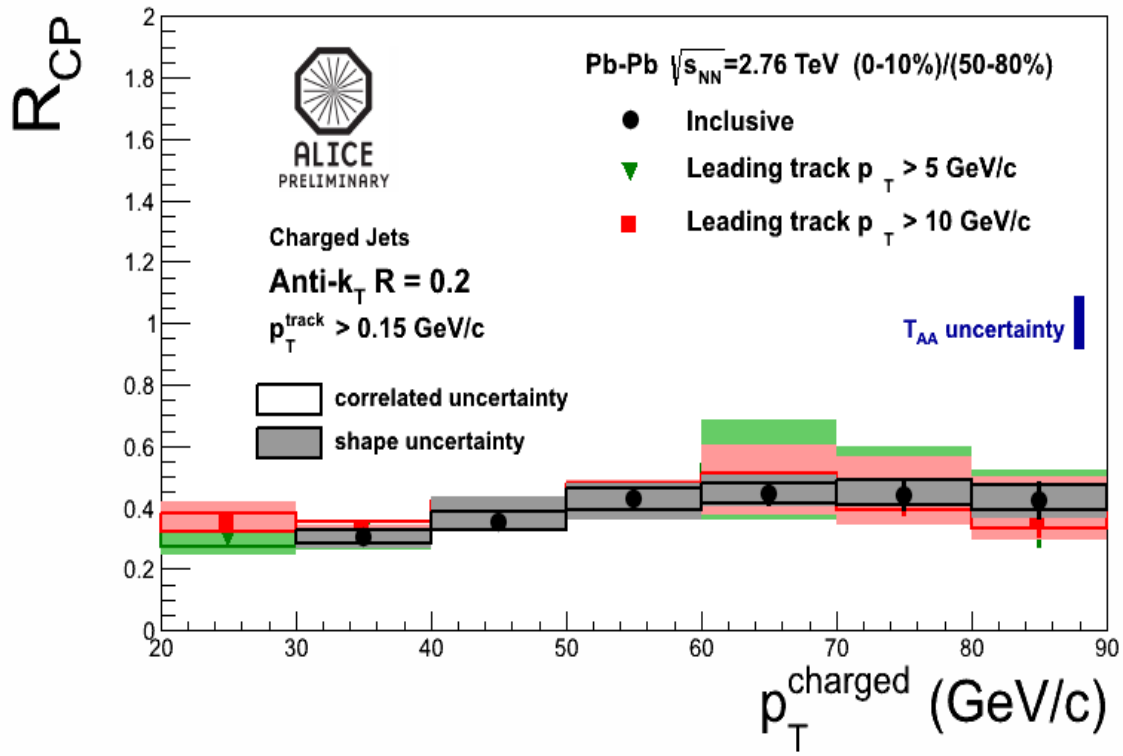
Jet Suppression



Corrected jet spectra:
Leading track requirement → fragmentation bias at low p_T

Jet Suppression



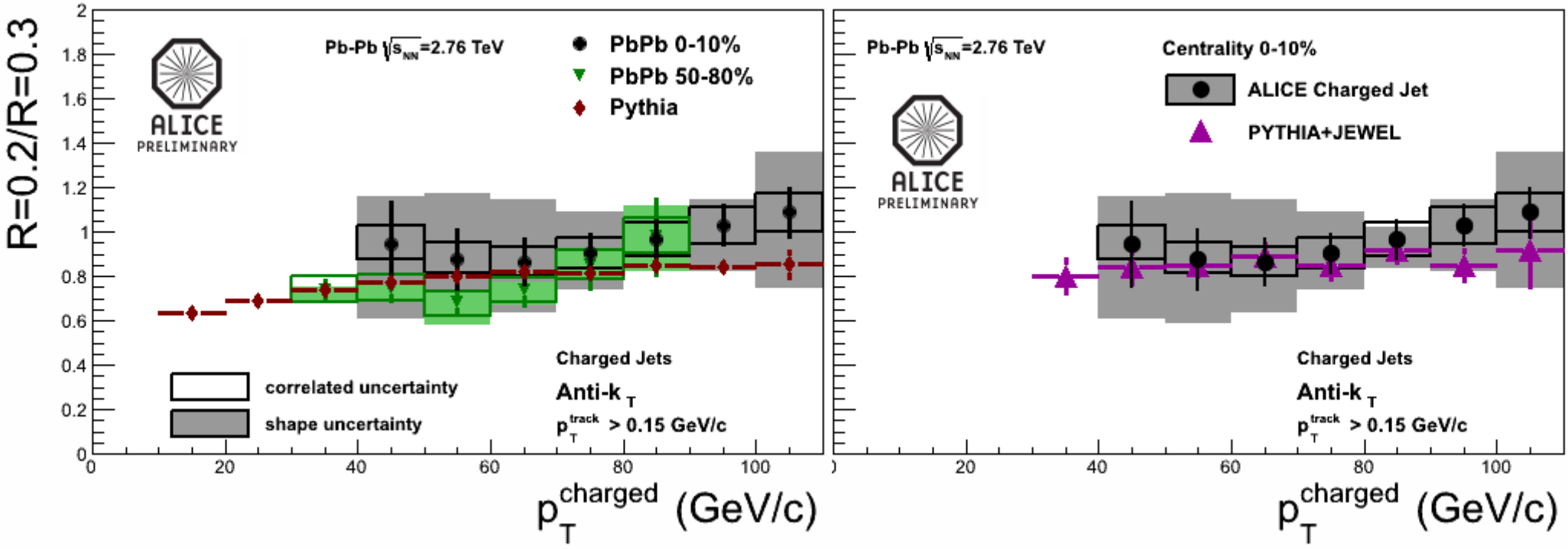


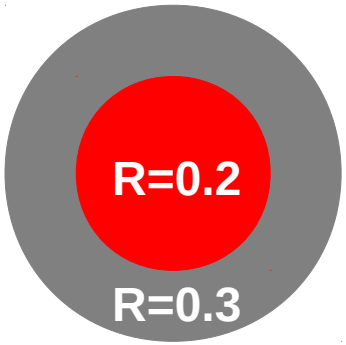
Corrected jet spectra:
Leading track requirement → fragmentation bias at low p_T

Strong jet suppression observed.
Fragmentation bias the same for central and peripheral events.

Ratio of jet cross sections

R=0.2/R=0.3





σ(R=0.2)/**σ**(R=0.3) consistent with vacuum jets for peripheral and central collisions

→ no sign of jet broadening

Good agreement with energy loss MC JEWEL.

JEWEL: Zapp, Krauss Wiedemann arXiv:1111.6838

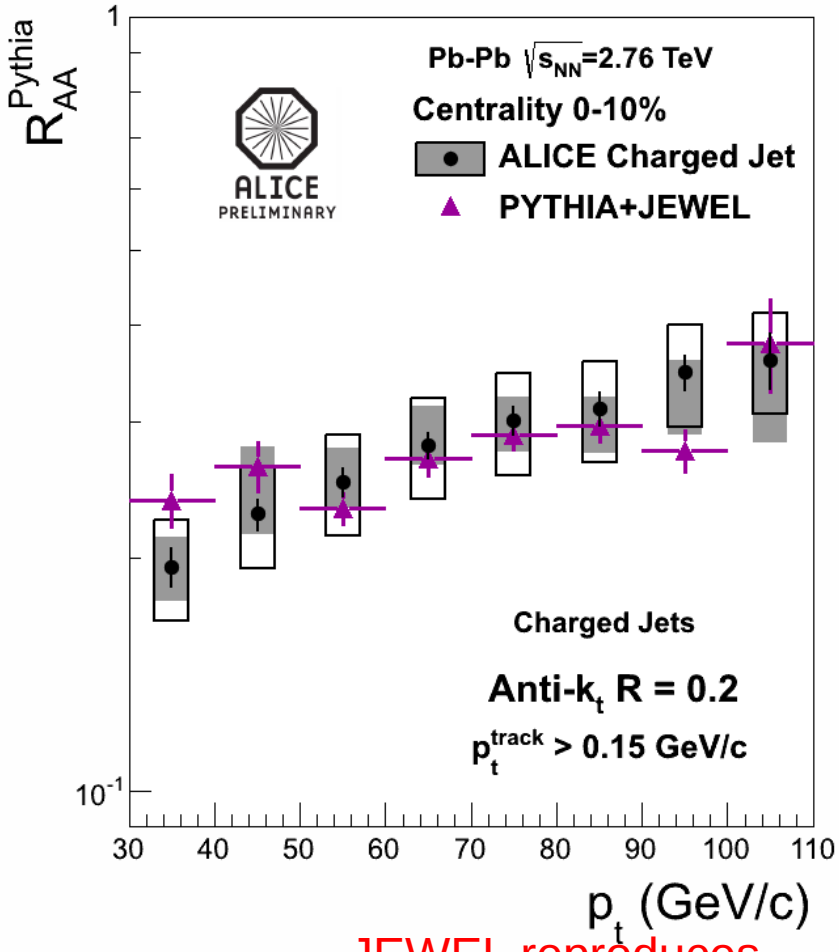
Summary

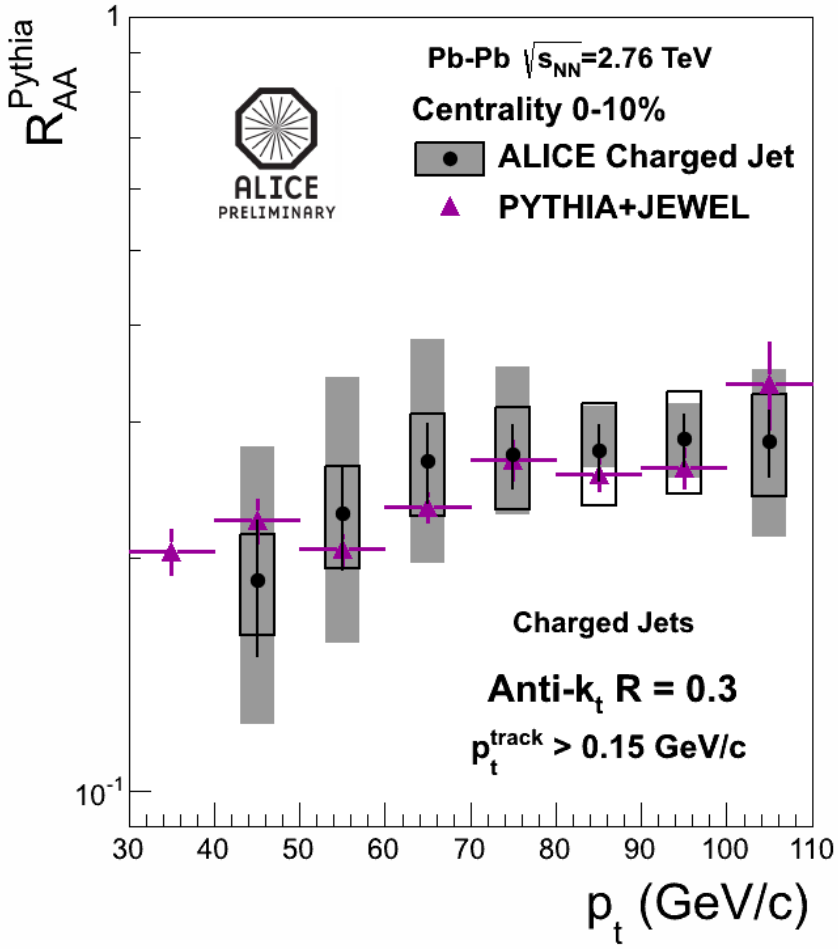
- ALICE measures charged particle jets with constituents p_T>150 MeV/c
  - Average HI background is subtracted event-by-event
  - Background fluctuations and detector effects are corrected by unfolded
- Strong jet suppression in central events
  - Fragmentation bias due to leading track requirement the same for central and peripheral events
- No signs of modified jet structure observed in ratio of jet cross sections $\boldsymbol{\sigma}$**(**R=0.2)/$\boldsymbol{\sigma}$**(**R=0.3)

backup

Model Comparison

Jet R_{AA}: ALICE vs JEWEL





JEWEL reproduces

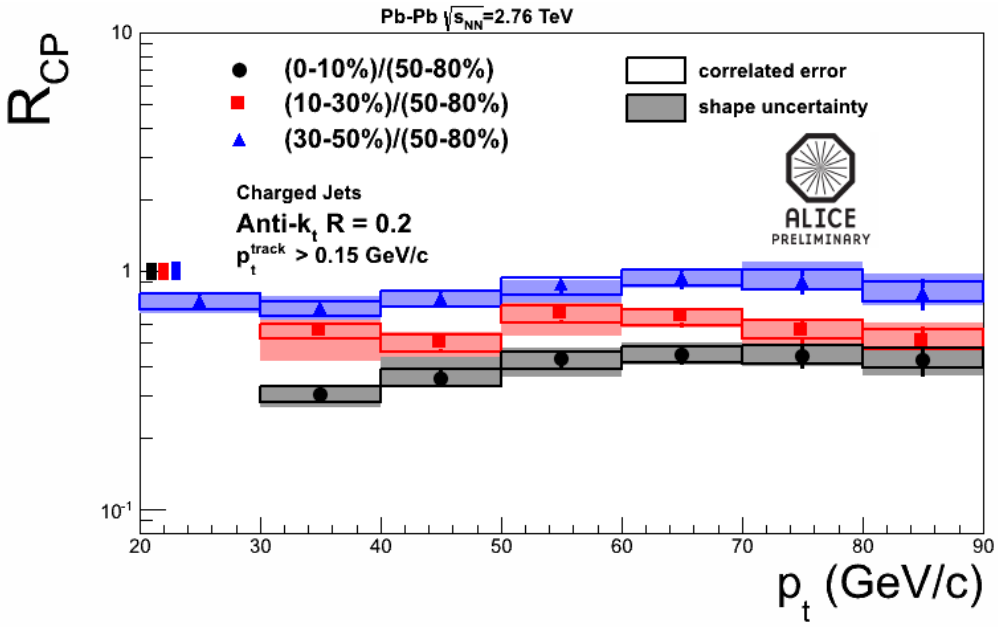
→ Hadron R_{AA} (*Zapp, Krauss Wiedemann arXiv:1111.6838*)

→ Charged jet R_{AA} for R=0.2 and R=0.3

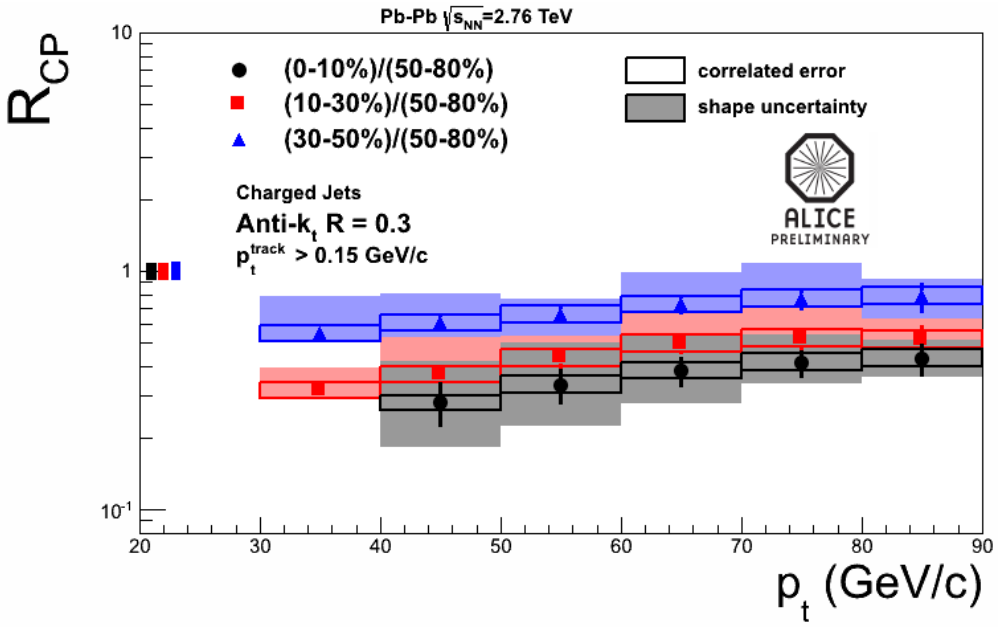
JEWEL jet results: private communication

Jet R_{CP}

R=0.2



R=0.3

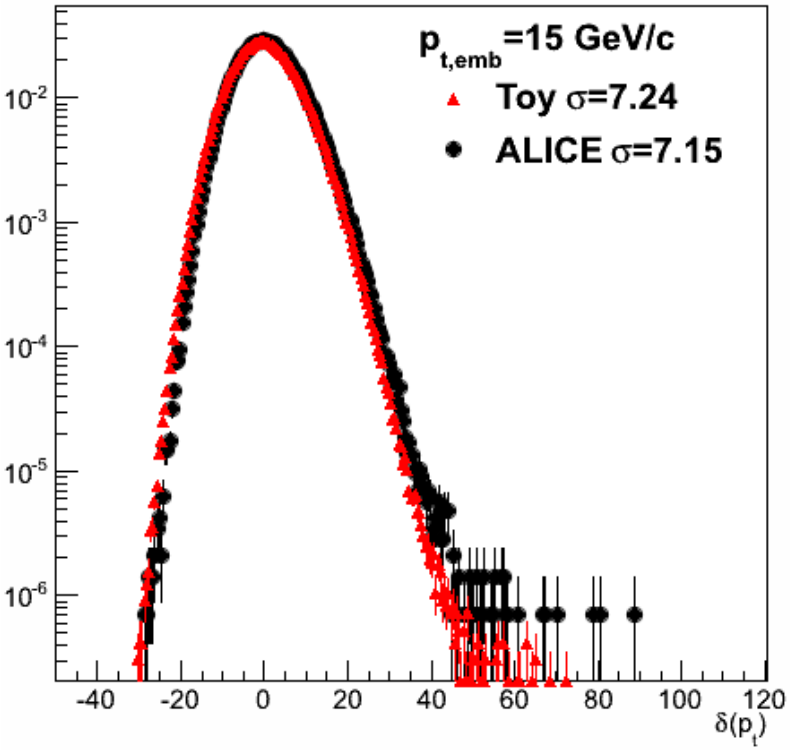


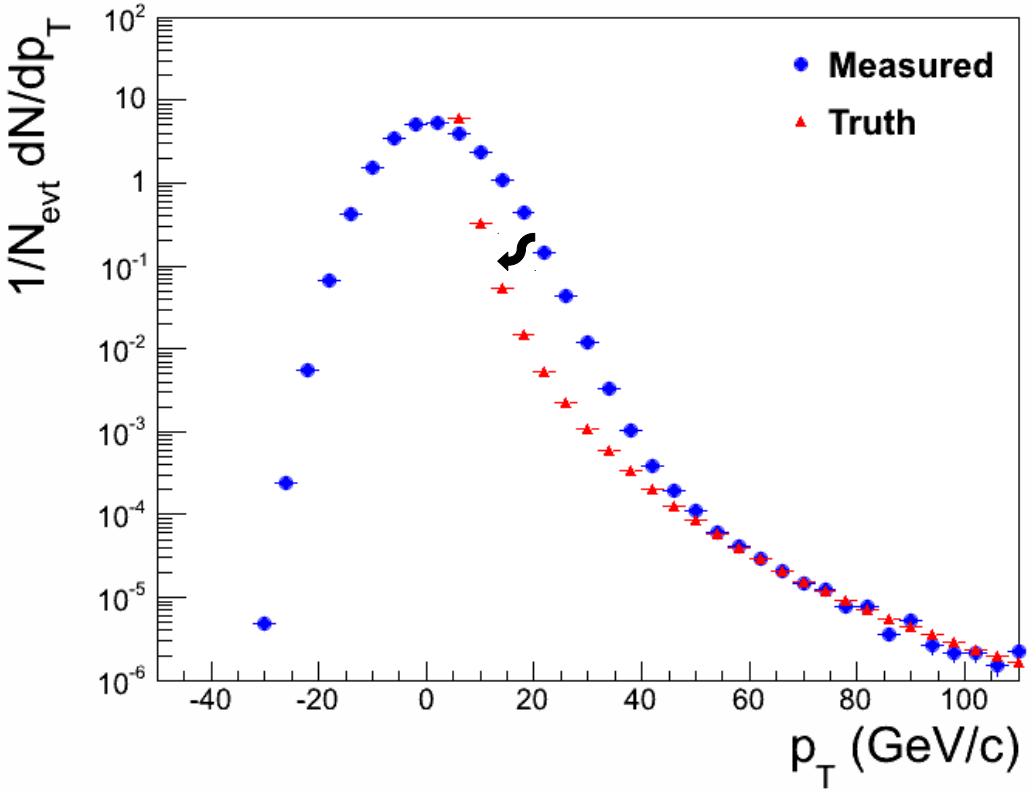
Strong suppression for jets
No strong p_t dependence

Central events jet R_{CP} ~ 0.5
Peripheral closer to 1

Unfolding the background

- Need to **unfold** measured jet spectrum to obtain 'real' jet spectrum (Truth)
- Low p_t jets are dominated by random collections of particles → background jets. These appear up to very high p_t.





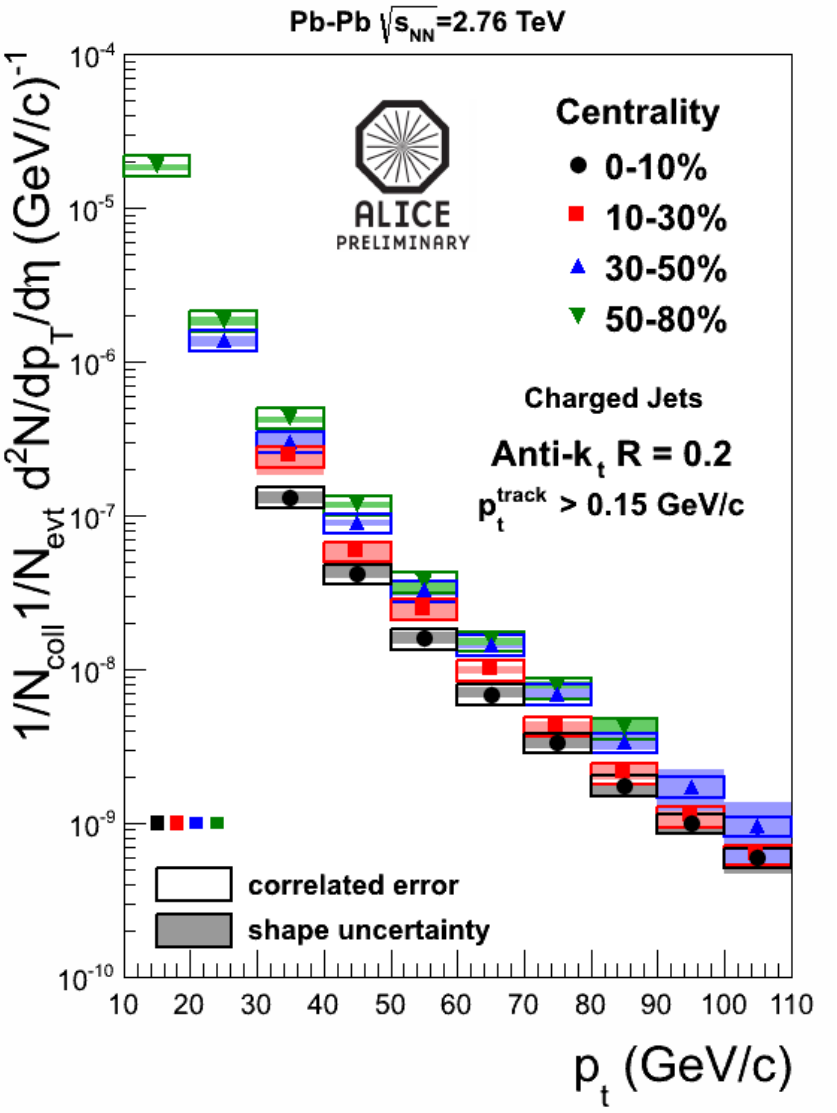
Jet Reconstruction

- ALICE uses sequential recombination algorithms from FastJet package:
  - anti-k_t for signal (stable area)
  - k_t to estimate background density
  - Boost invariant p_t recombination scheme (sets jet mass to zero)
  - Charged tracks with **p_t > 150 MeV/c**
- Jet reconstruction with charged tracks reconstructed in tracking detectors (ITS + TPC):
  - High precision on particle level
  - Uniform η-φ acceptance: $|\eta|<0.9$ $0<\varphi<2\pi$
  - Neutral energy missing, eg. π^0, n, γ
    measurement not corrected for neutral energy
  - No correction for hadronization effects

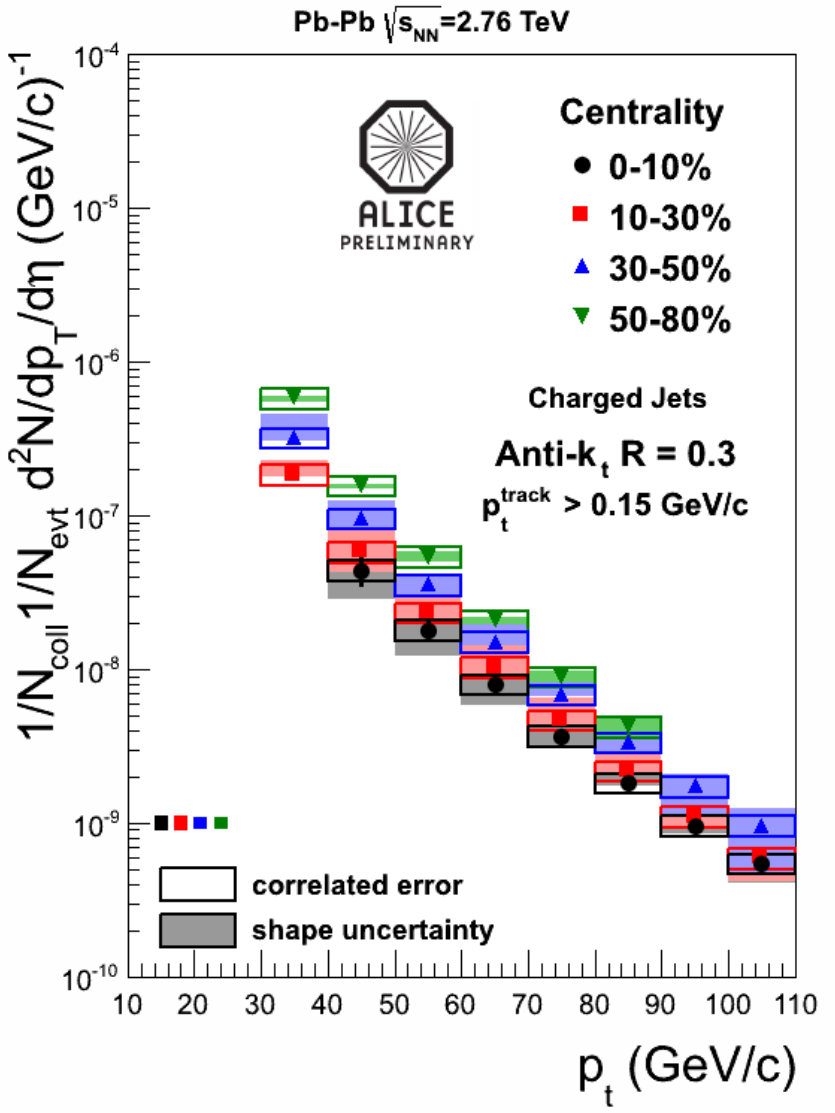
15M events from 2010 Pb-Pb run

Pb-Pb Jet Spectrum

R=0.2



R=0.3

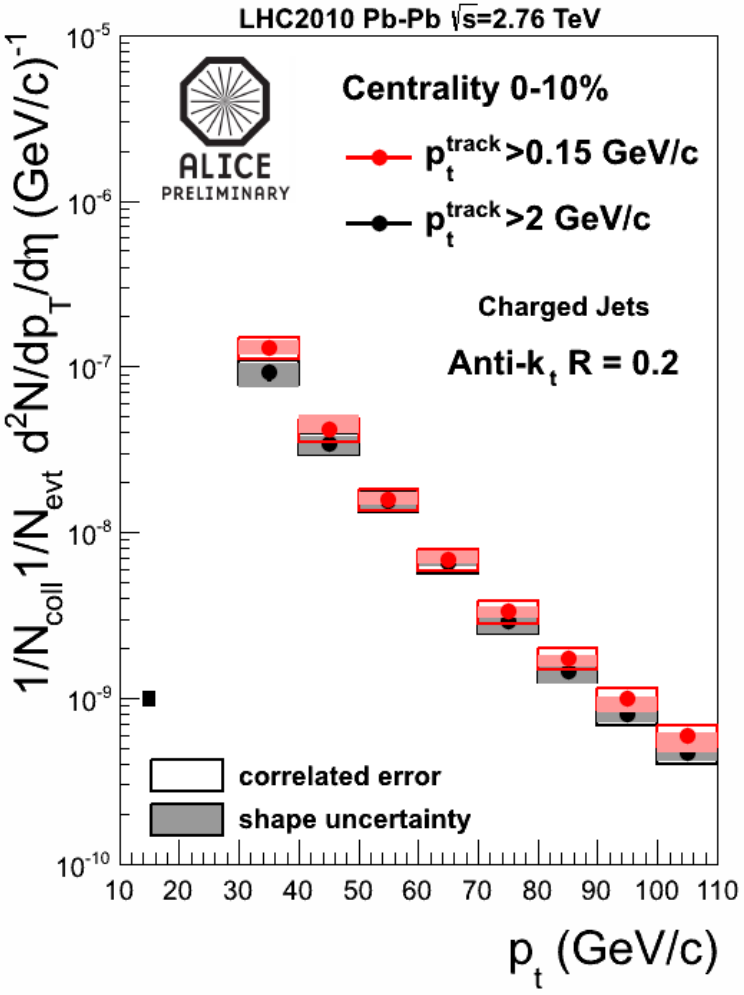


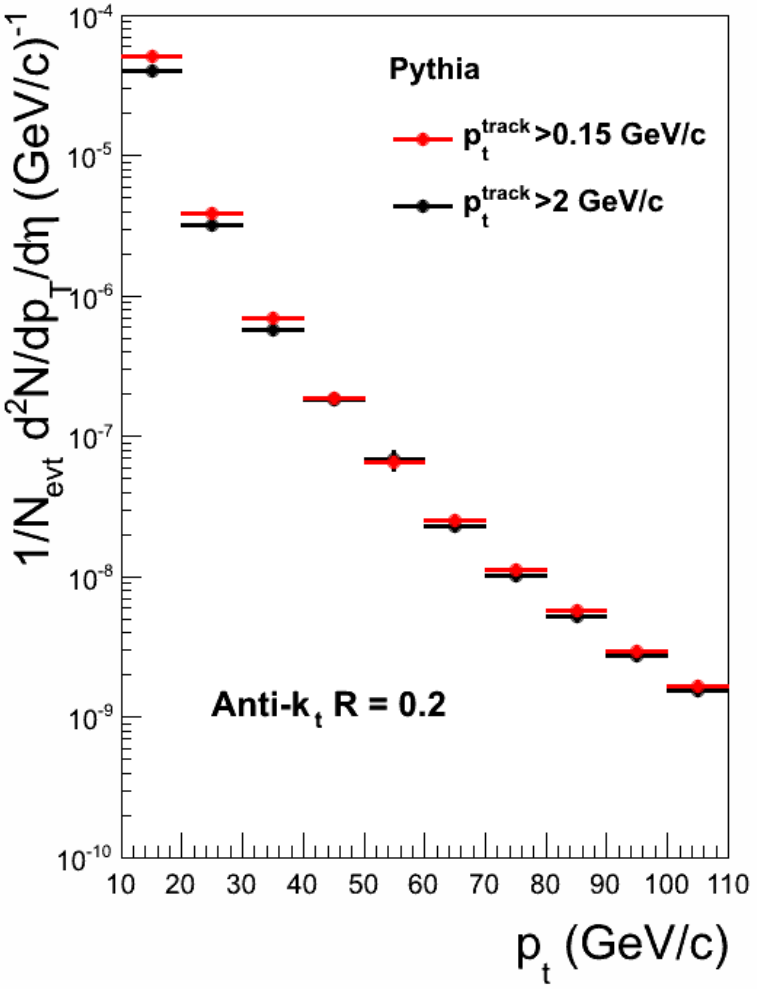
Jet spectra have been measured for 2 cone radii and 4 centrality bins

Jet Constituents

Spectra corrected for detector level effects for particles with $p_t > p_{t,min,track}$

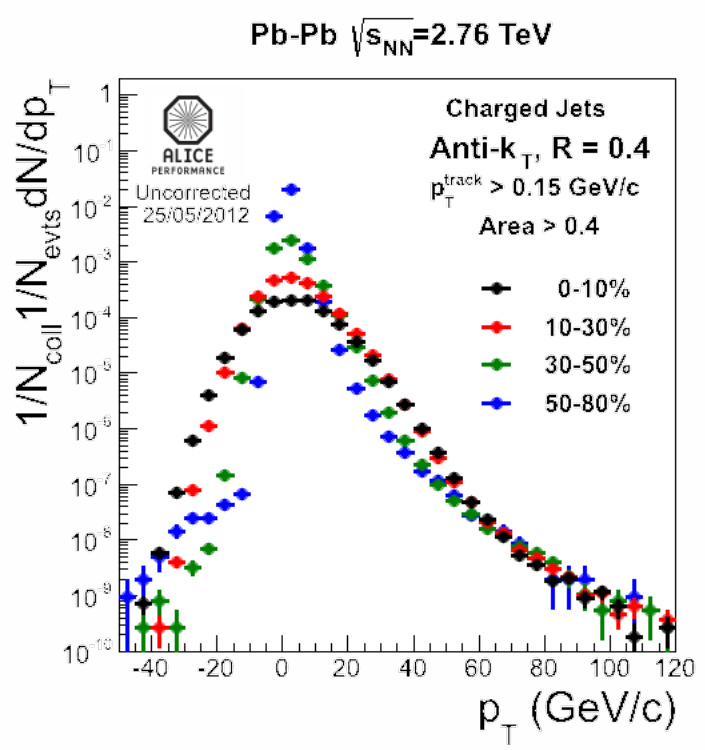
R=0.2: PbPb very similar to Pythia → shift of spectrum in pt for PbPb and Pythia.
Not many soft particles in small cone of R=0.2.





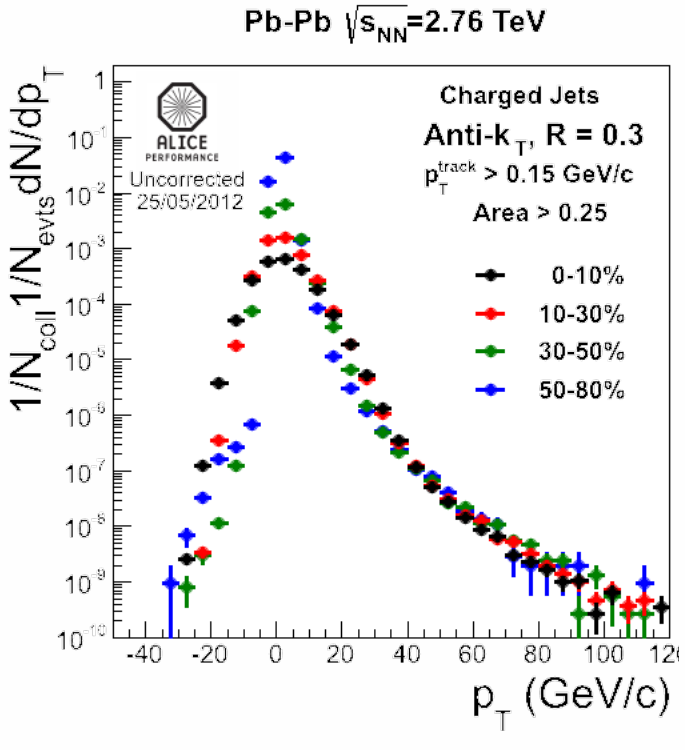
Uncorrected Jet Spectra

R=0.4



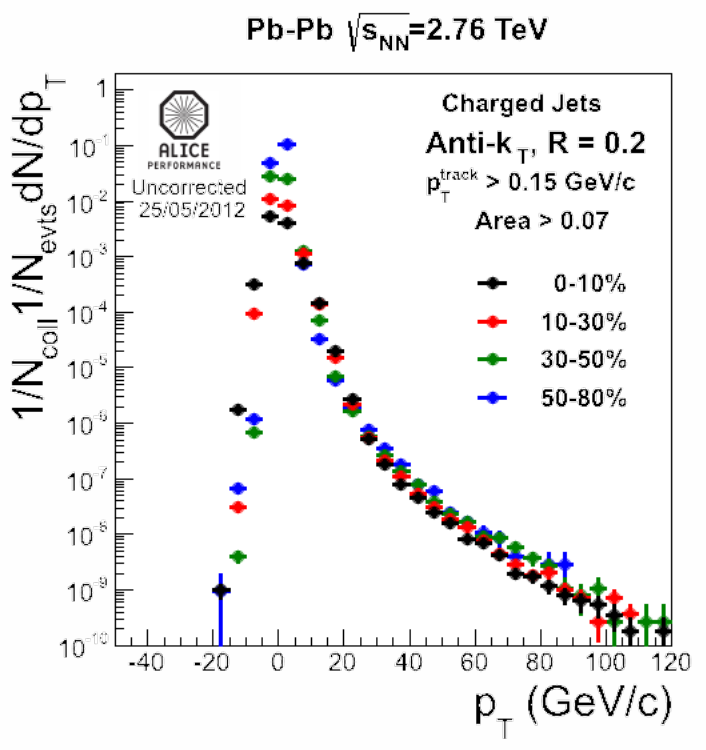
$\sigma(\delta p_t)$~11 GeV

R=0.3



$\sigma(\delta p_t)$~7 GeV

R=0.2



$\sigma(\delta p_t)$~4.5 GeV

$\sigma(\delta p_t)$ values for central events

$p_{t,track}$ > 0.15 GeV/c

Smaller Jets → Less Background Fluctuations

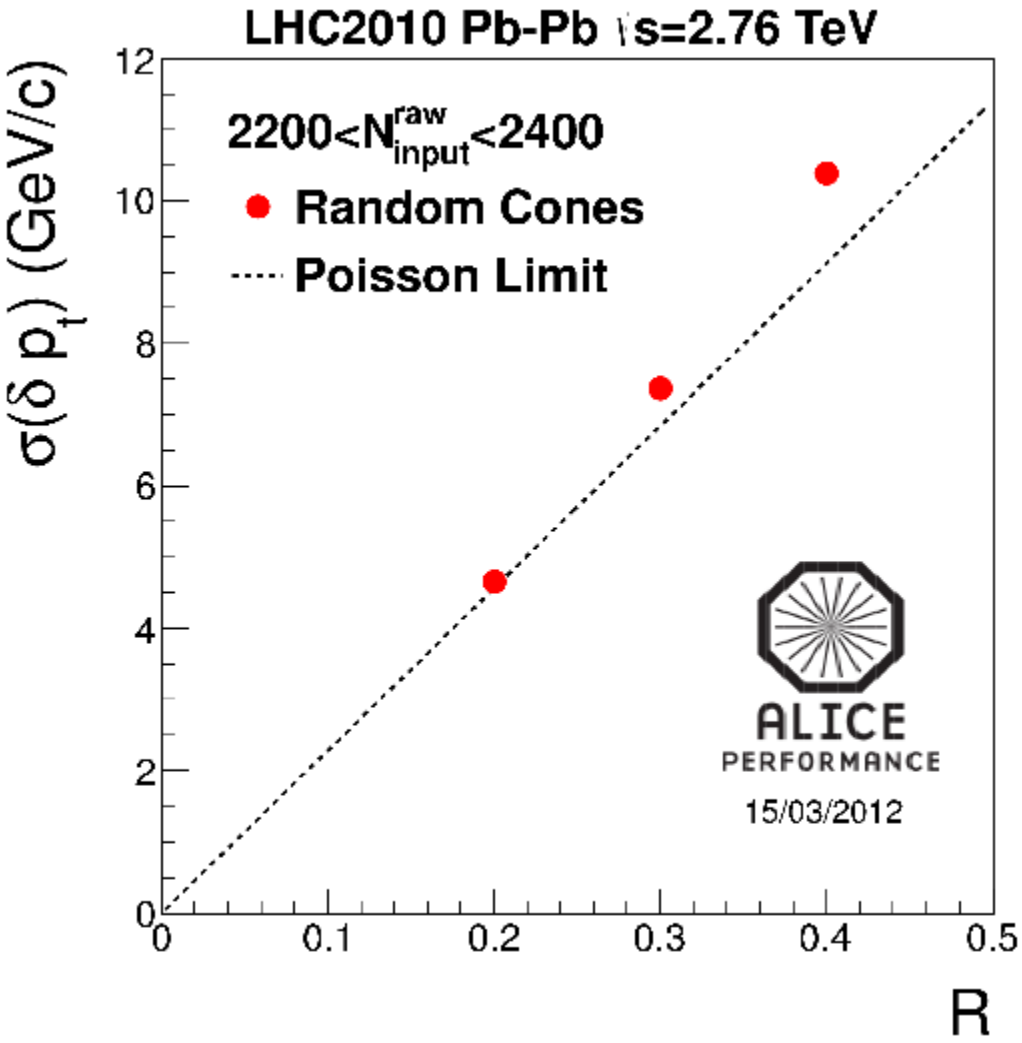
Area dependence

- Multiplicity bin typical for 10% most central events
- Reduced background fluctuations for smaller jet areas
-

$$\sigma(\delta p_t) = \sqrt{N_A \cdot \sigma^2(p_t) + N_A \cdot \langle p_t \rangle^2}.$$

- Measured $\sigma(\delta p_T)$ larger than naive expectation from only statistical fluctuations

  → flow and hard jets

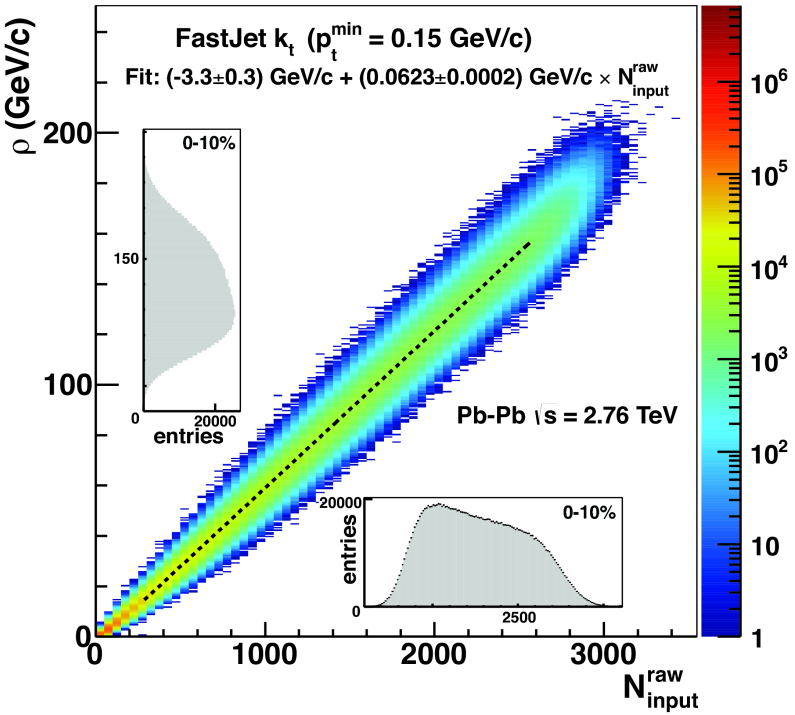


Background Fluctuations

- Background fluctuations estimated by studying the response of embedded high p_T probe in heavy ion event.
- Data driven approach to estimate influence of background fluctuations on jet reconstruction.
- We embed different kind of probes:
  - Random cones
  - Single tracks
  - Jets from full detector simulation pp @ 2.76 TeV
- Response is quantified by comparing the reconstructed jet to the embedded probe:

$$\delta_{p_T} = p_{T,jet}^{rec} - \rho A - p_T^{probe}$$

Event Background



- Event-by-event background subtraction

$$\rho = median\left(\frac{p_T^{jet,i}}{A_i^{jet}}\right)$$

- Background density scales with event multiplicity:
  $\rho \sim N \langle p_T \rangle$
- 0-10% centrality:
  $\langle \rho \rangle$ ~ 140 GeV/area
  → 70 GeV/c for R=0.4 cone
- Event-by-event fluctuations of ρ for fixed multiplicity.