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Suppression of Charged Particle Production at High p_T in ALICE

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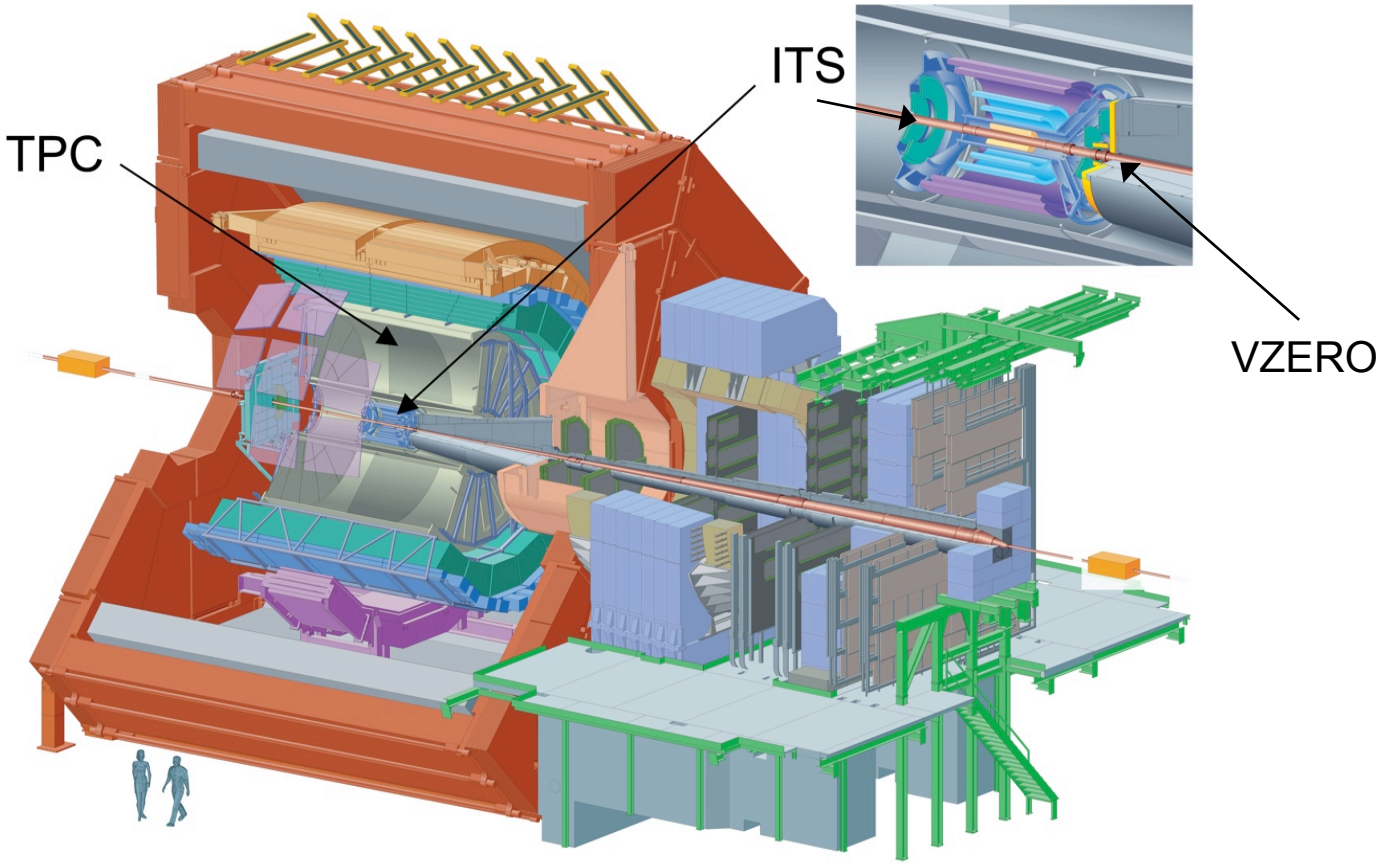
on behalf of the ALICE Collaboration

High p_T at the LHC, March 2012

H-QM | Helmholtz Research School Quark Matter Studies

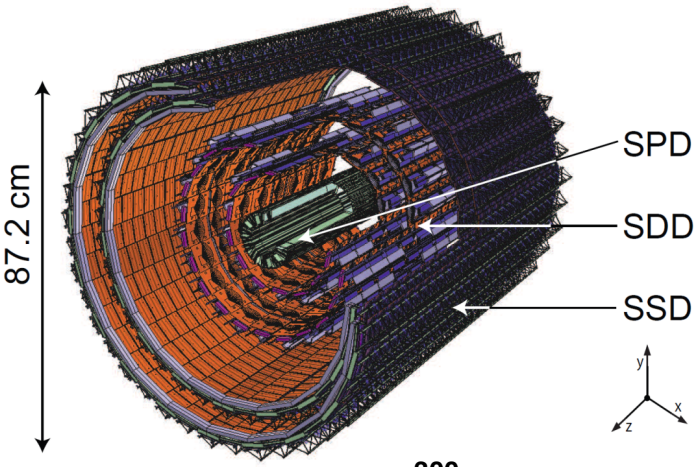
IKF Institut für Kernphysik Frankfurt

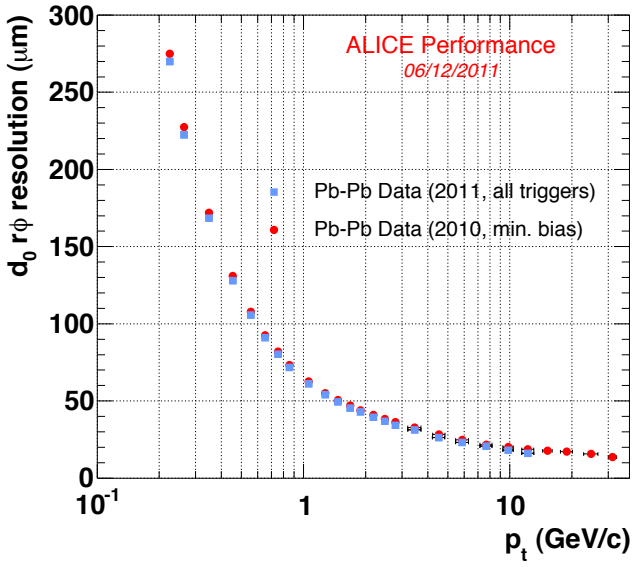
The ALICE Experiment



Tracking: ITS + TPC **Centrality: VZERO**

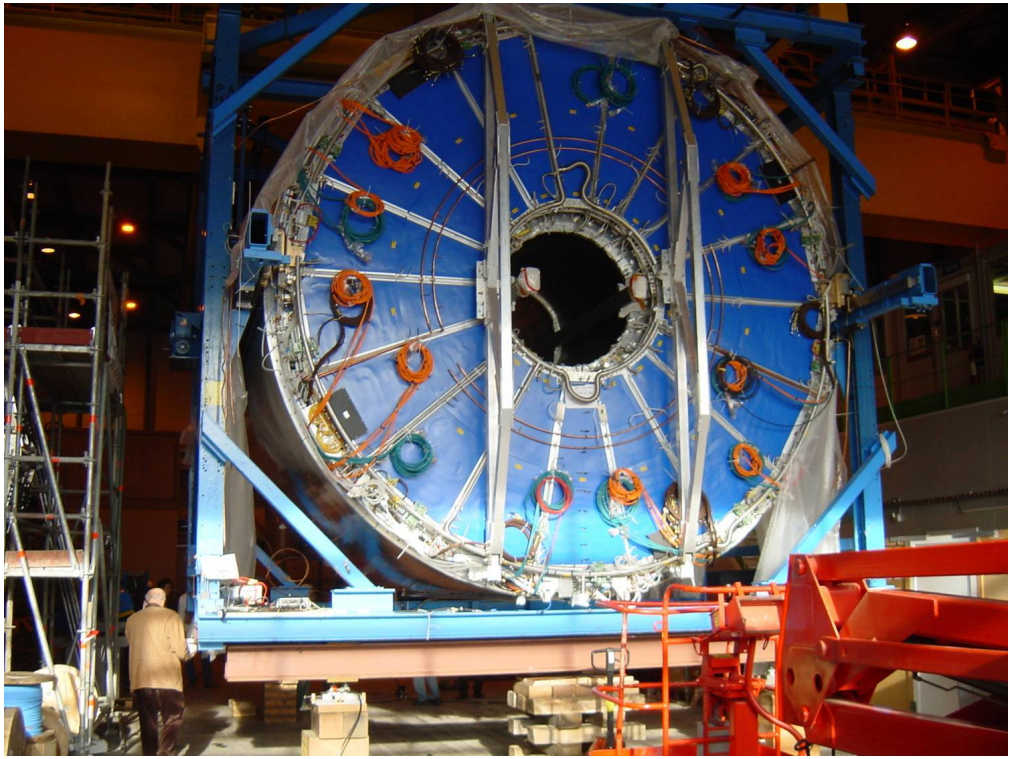
ALICE Inner Tracking System





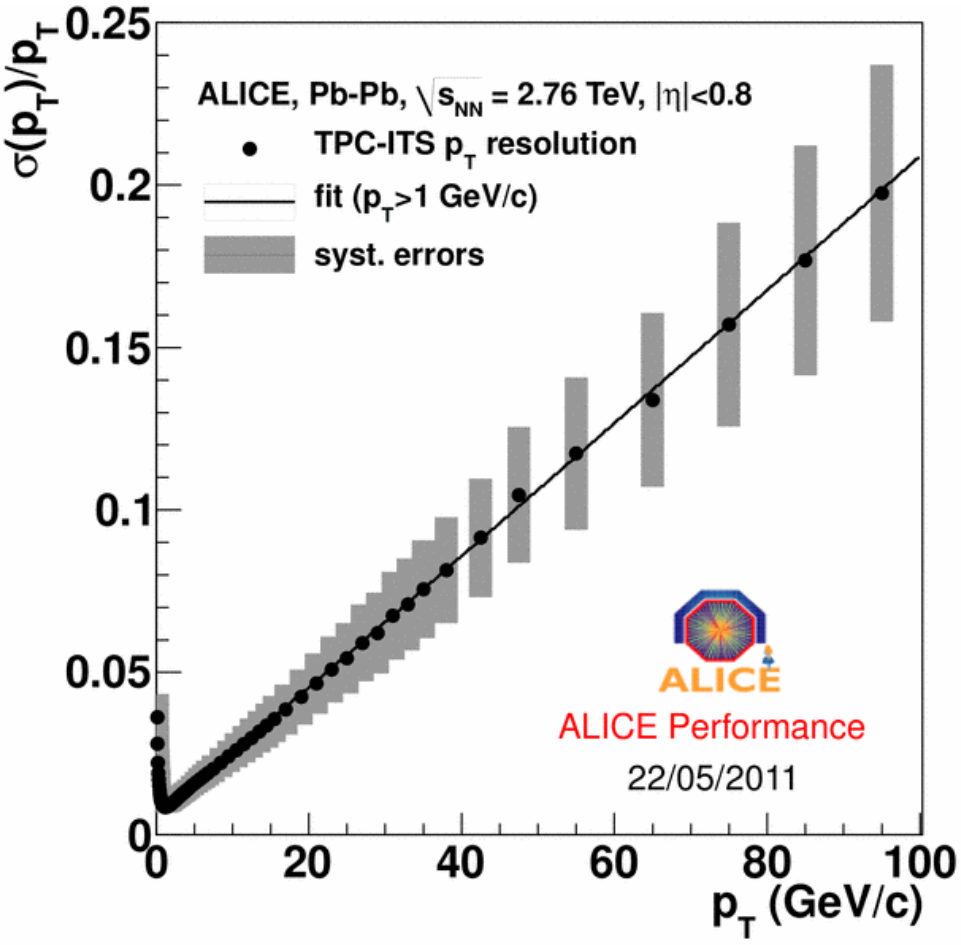
- **Inner Tracking System (ITS) to reconstruct primary vertex with high precision**
- **~ 12.7 M channels**
- **3 different technologies: Silicon Pixel Detector (SPD), Silicon Drift Detector (SDD), Silicon Strip Detector (SSD)**

ALICE Time Projection Chamber



- main tracking device
- 85 m³ $NeCO_2N_2$
- ~ 560.000 channels
- 92 µs max. drift time
- $|\eta| < 0.9$
- $p_T > 0.15$ GeV/c
- particle identification via specific energy loss

Transverse Momentum Resolution



- **combined tracking: ITS + TPC**
- **only small multiplicity dependence**
- **estimate from covariance matrix in Kalman filter**
- **verified using K^0_s invariant mass distribution**
- **systematic uncertainty: 20%**
  - estimated using K^0_s, constant in p_T
- **improvement in resolution compared to previous publications (e.g. arXiv:1007.0719)**

Event and Track Selection

- centrality quality cuts (for Pb-Pb)
- select long tracks in the TPC, two hits in the ITS, one in the Pixels
- cuts on primary vertex
- tracks must pass additional quality cuts
  (e.g. chi2 ITS, chi2 TPC, chi2 TPC constrained vs. global)

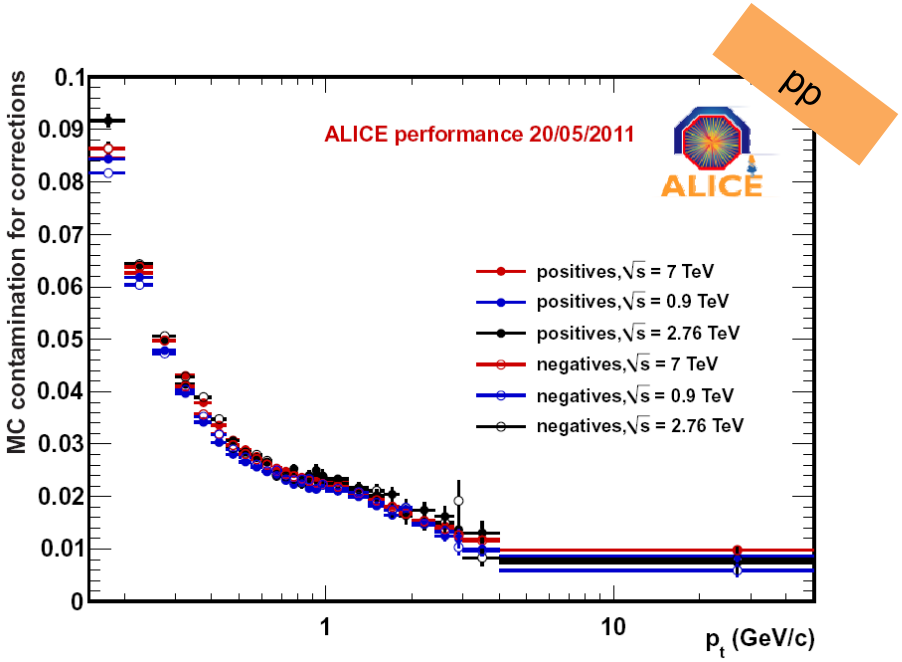
all events taken with Minimum Bias (MB) Trigger

total numbers: ~15 M evts. @ Pb-Pb, $\sqrt{s_{NN}}$ = 2.76 TeV (2010)

~65 M evts. @ pp, $\sqrt{s}$ = 2.76 TeV (2011)

(after offline trigger and event selection)

Contamination

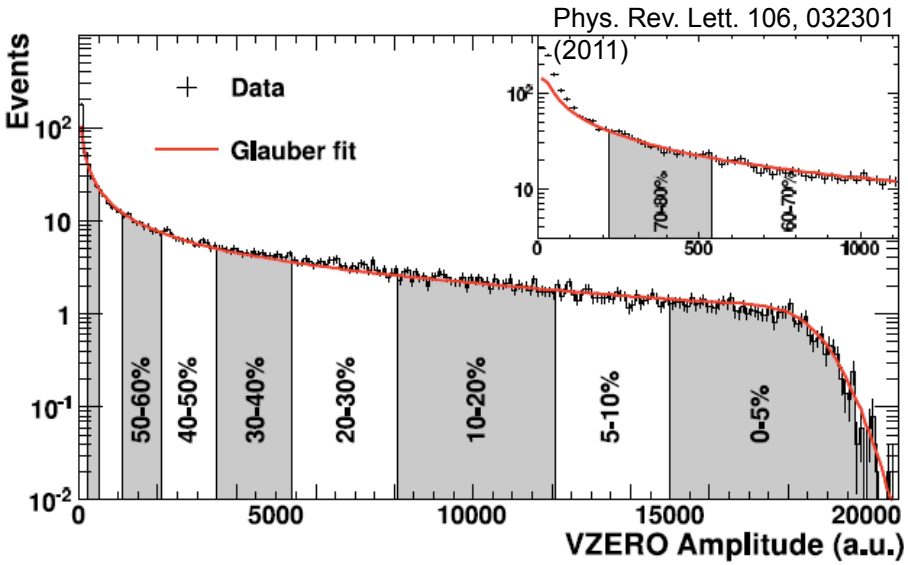


- contamination is corrected for the underestimation of strangeness production in MC
- track cuts remove most secondaries
- remaining secondaries <1% for p_T > 4 GeV/c
- pp corrected for trigger efficiency

VZERO and Centrality Determination

VZERO Detector:

- **on both sides of the ITS**
- **$2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$**
- **scintillators**



Centrality Determination:

- **compare VZERO signal to Glauber MC**
- **determine percentage intervals**

- **fit amplitude below 87% to avoid contamination from ultra-peripheral collisions**
- **calculate N_{part}, N_{coll} using Glauber**

Nuclear Modification Factor

- **comparison of hard probes in pp and AA collisions**

$$R_{AA} = \frac{d^2N^{AA}/dp_T d\eta}{\langle N_{coll}\rangle d^2N^{pp}/dp_T d\eta}$$

$$\langle N_{coll}\rangle = \langle T_{AA}\rangle \cdot \sigma_{pp}^{INEL}$$

- **no medium effects: $R_{AA} = 1$**
- **suppression of high p_T particles observed at RHIC**
- **different centrality corresponds to different system size**
- **determination of a pp reference: different methods**

pp Reference

For the first publication:

- **no measurement at the same center-of-mass energy**
  - determination of a pp baseline using interpolation / scaling method

- **Measurement in 2011 for pp @ $\sqrt{s}$ = 2.76 TeV:**
  - extrapolation of measured data to high p_T

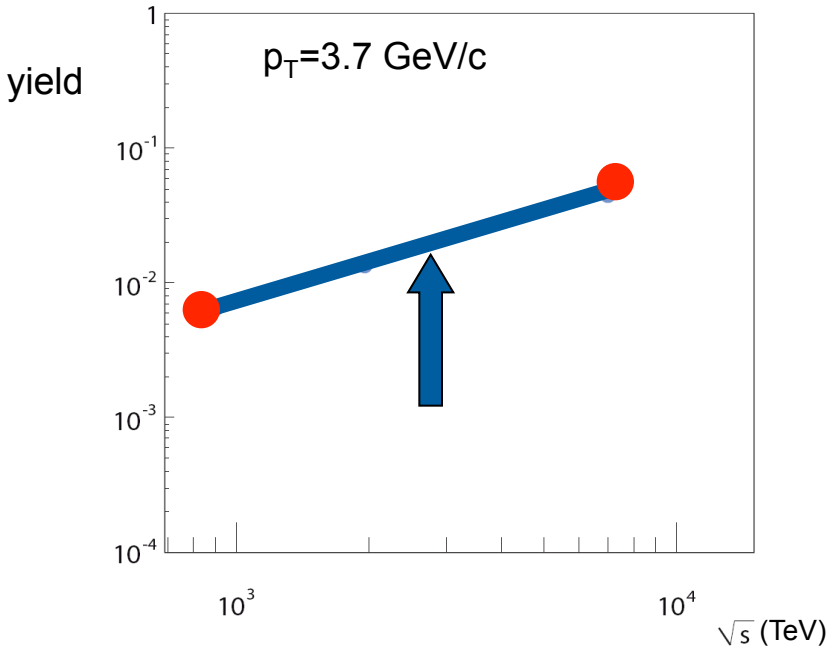
In this talk:

- **comparison of all methods**

Interpolation or Scaling

Interpolation

- **Compare measured yield at a fixed p_T for different √s**



pQCD scaling

- **Use ratio from pQCD calculations to scale measured yield to √s = 2.76 TeV**

$$Y(2.76) = \frac{Y(2.76, pQCD)}{Y([0.9,7], pQCD)} \cdot Y([0.9,7], measured)$$

$$Y = Yield$$

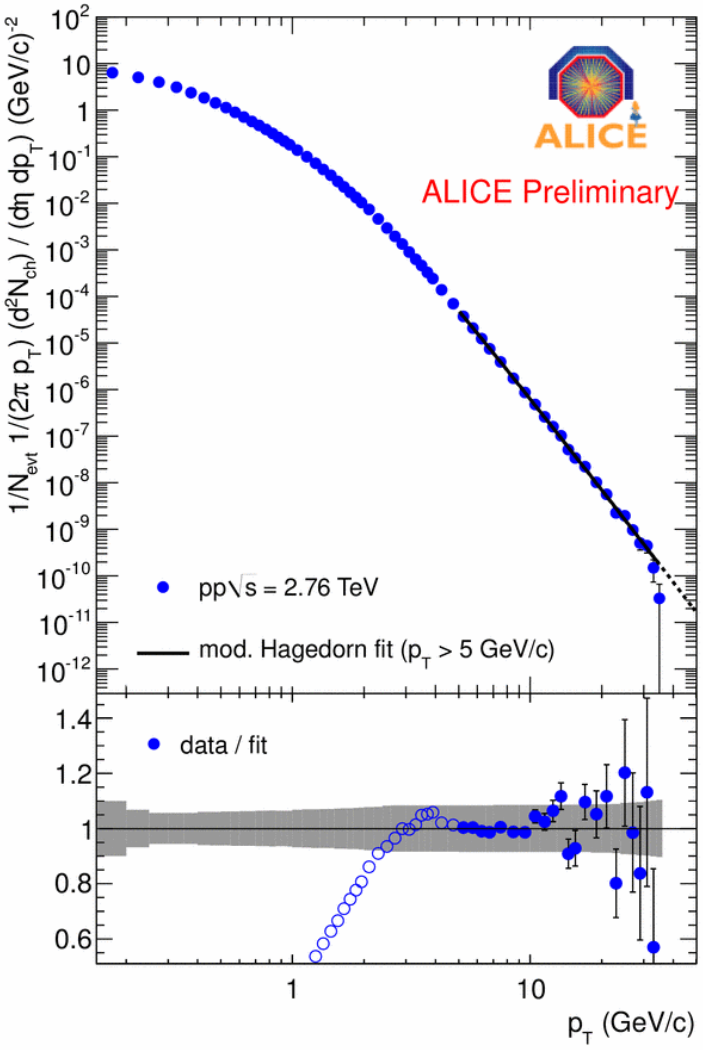
Extrapolation

- **use modified Hagedorn function:**

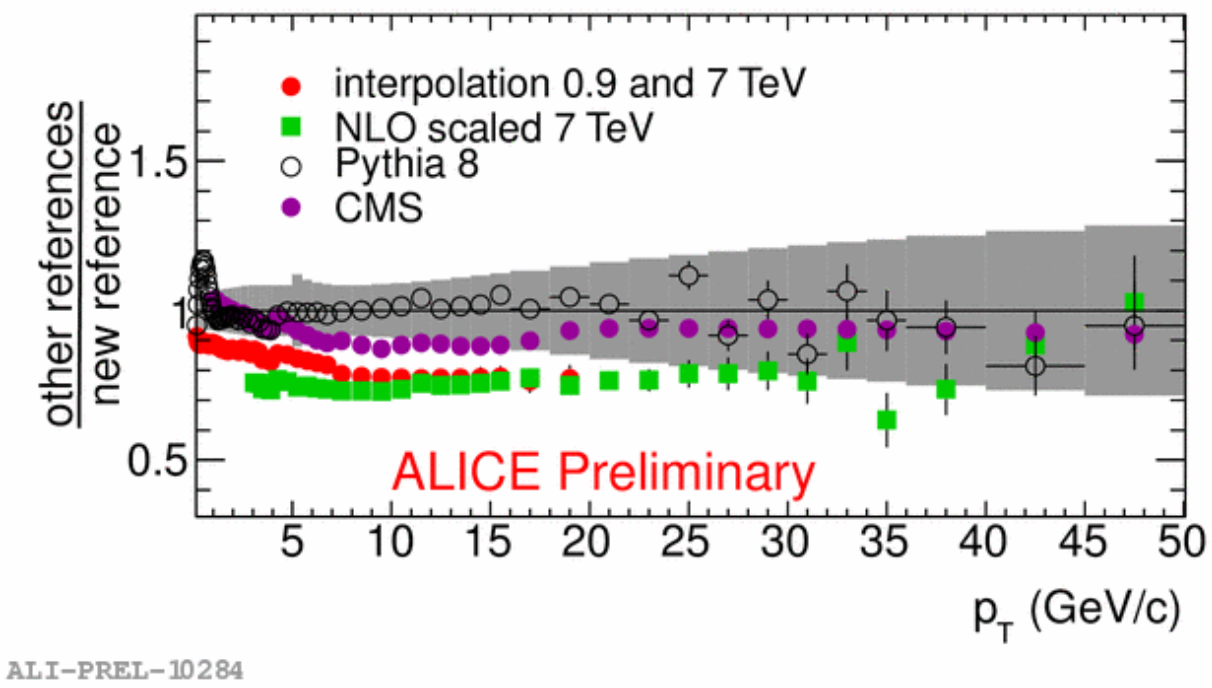
$$h(p_T) \propto \left(1 + \frac{p_T}{p_0}\right)^{-n}$$

- **parameterize for p_T > 5 GeV/c**
- **extrapolate to higher p_T**

- **function describes data well for p_T > 5 GeV/c**

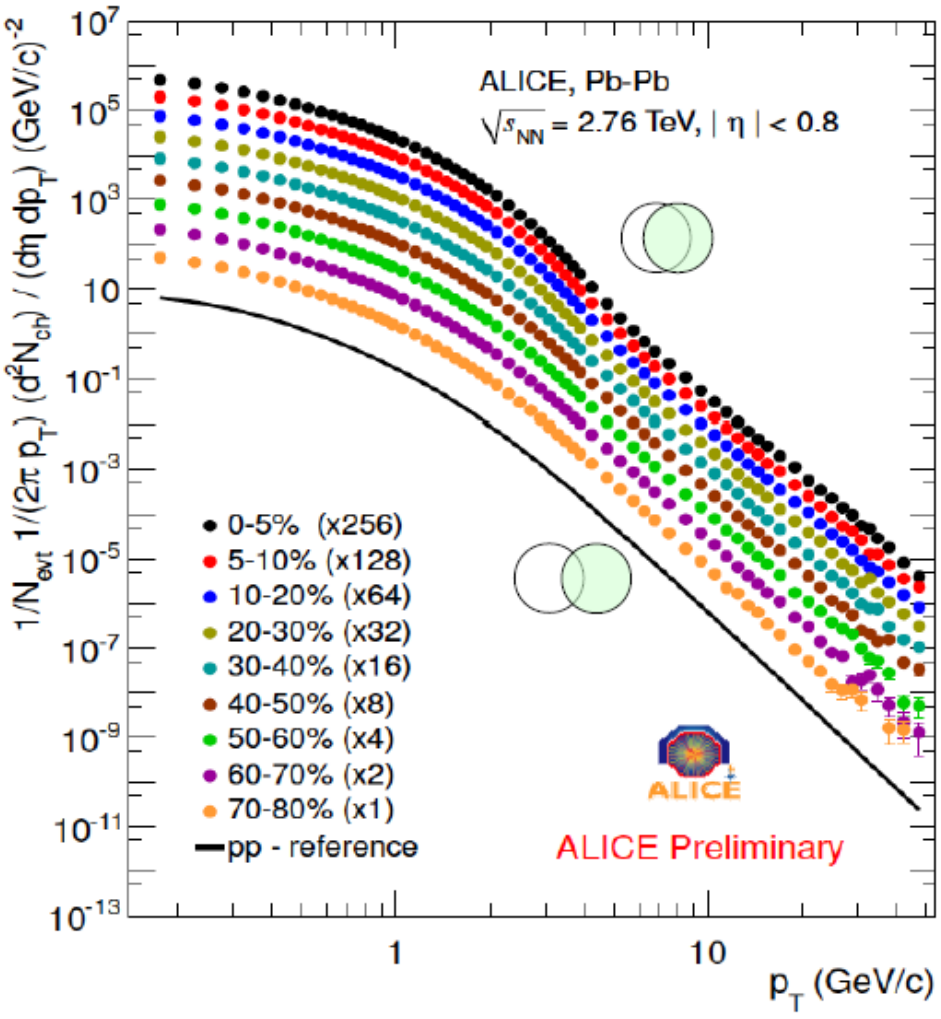


References – Comparison



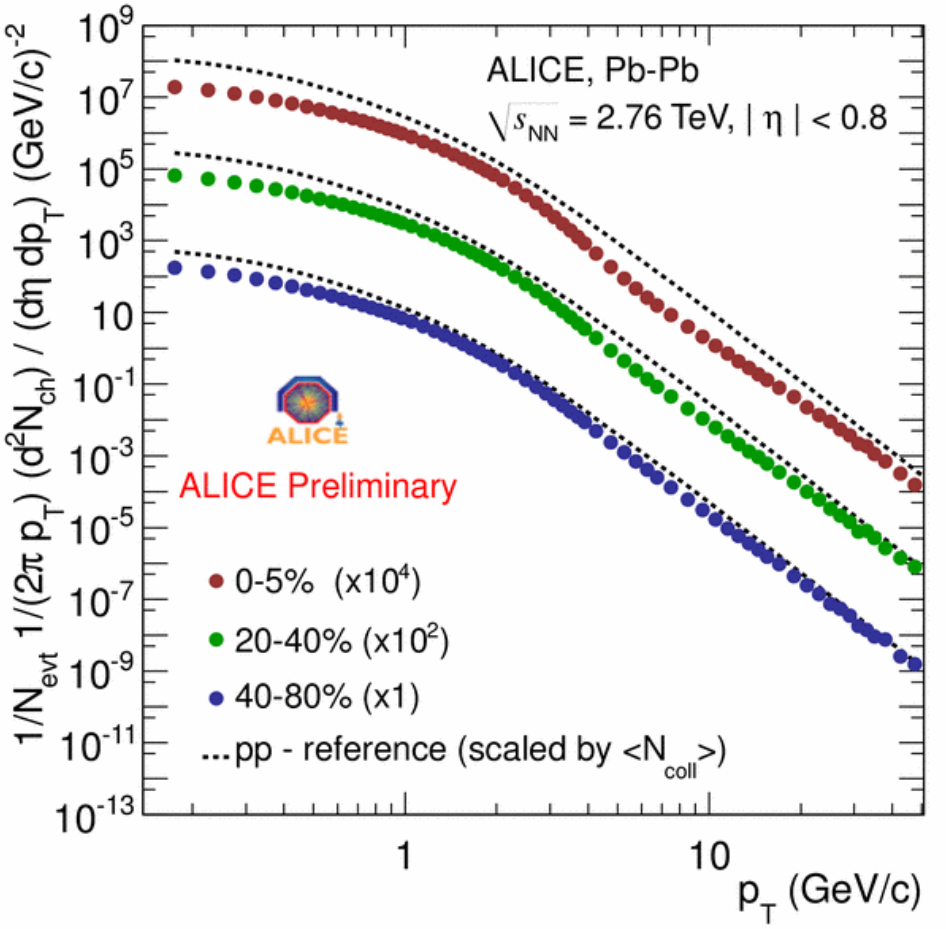
- **shape similar for all methods**
- **CMS interpolated reference (QM 2011) agrees with ALICE within systematic uncertainties**
- **simulations can describe the high p_T part of the spectrum**

Transverse Momentum Spectra



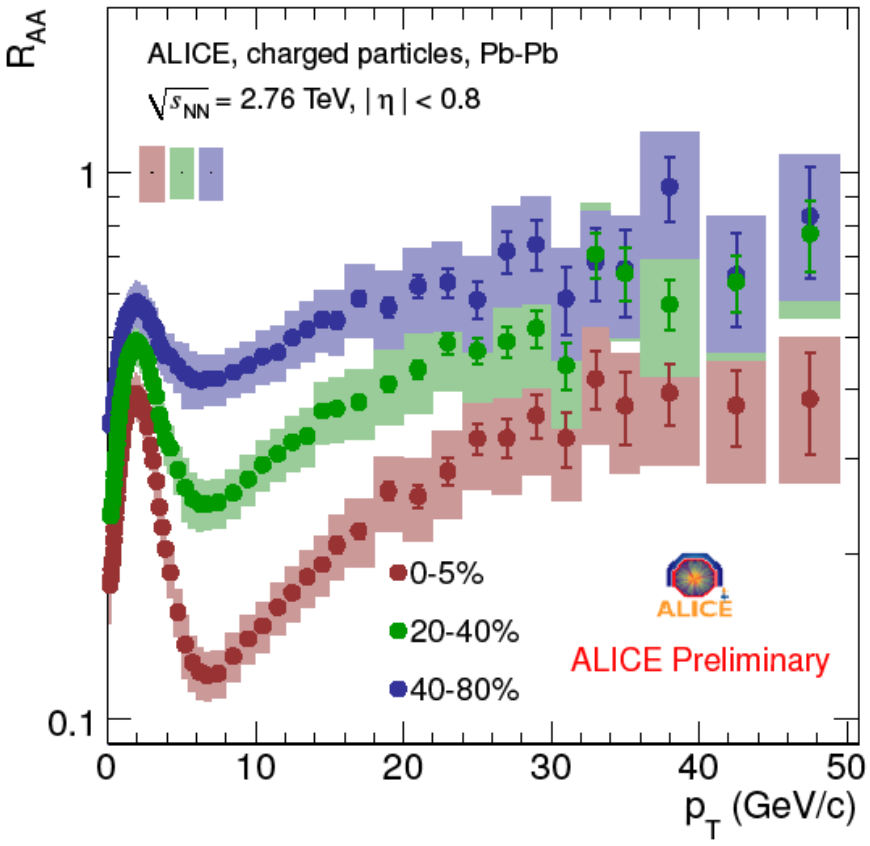
- **~ 15 M MB events (after event selection) from the 2010 Pb-Pb run**
- **shape in Pb-Pb differs from pp reference**
- **p_T range up to 50 GeV/c**

Transverse Momentum Spectra



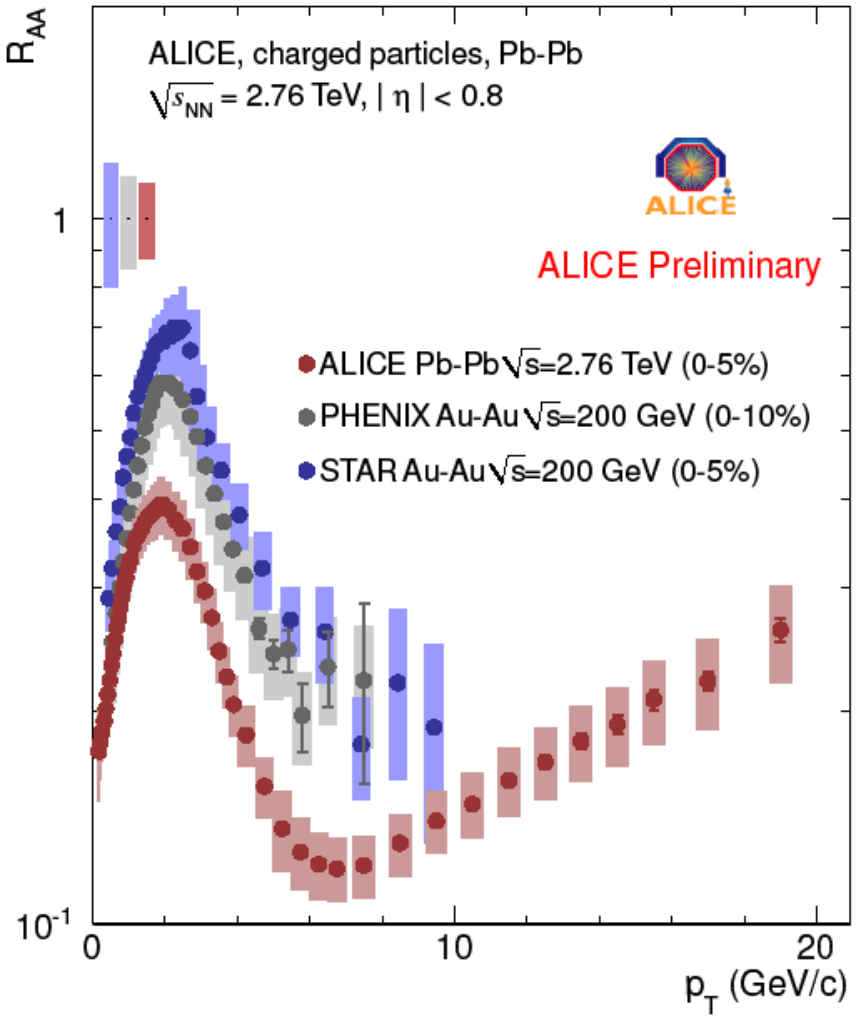
- **clear change with centrality in shape visible**
- **small suppression visible already for peripheral collisions**

Charged Particle R_{AA}



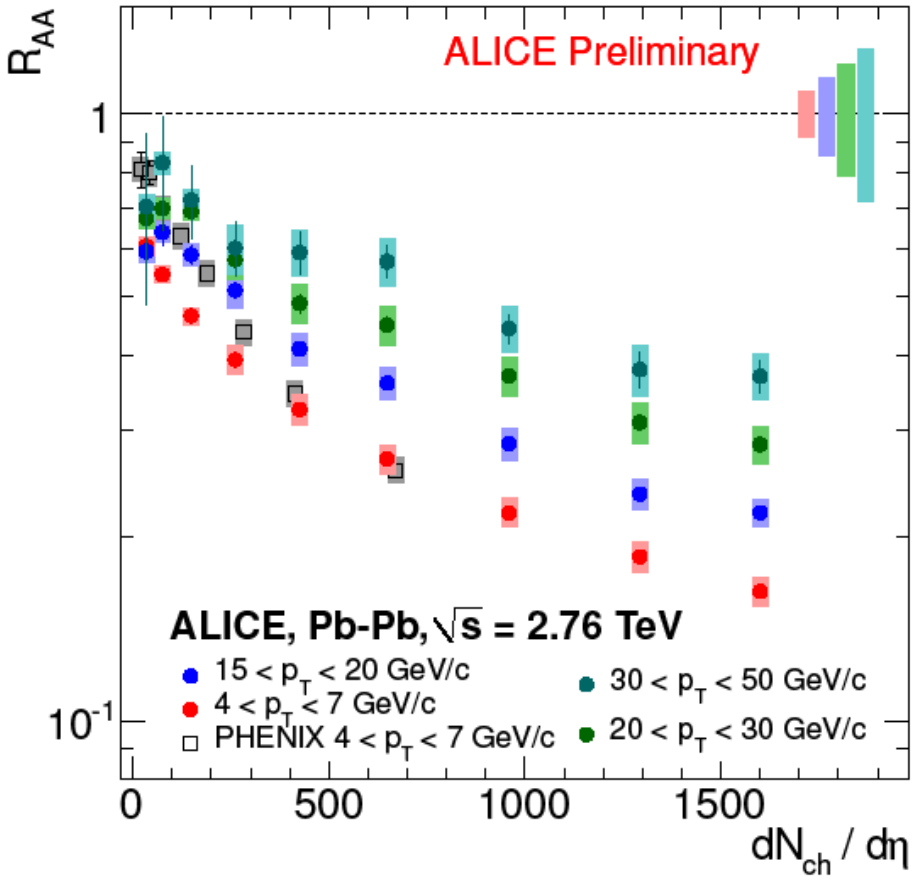
- R_{AA} decreases with centrality
- very strong suppression for most central events
- minimum of R_{AA} at p_T = 6-7 GeV/c
- less suppression for high p_T

Comparison to RHIC



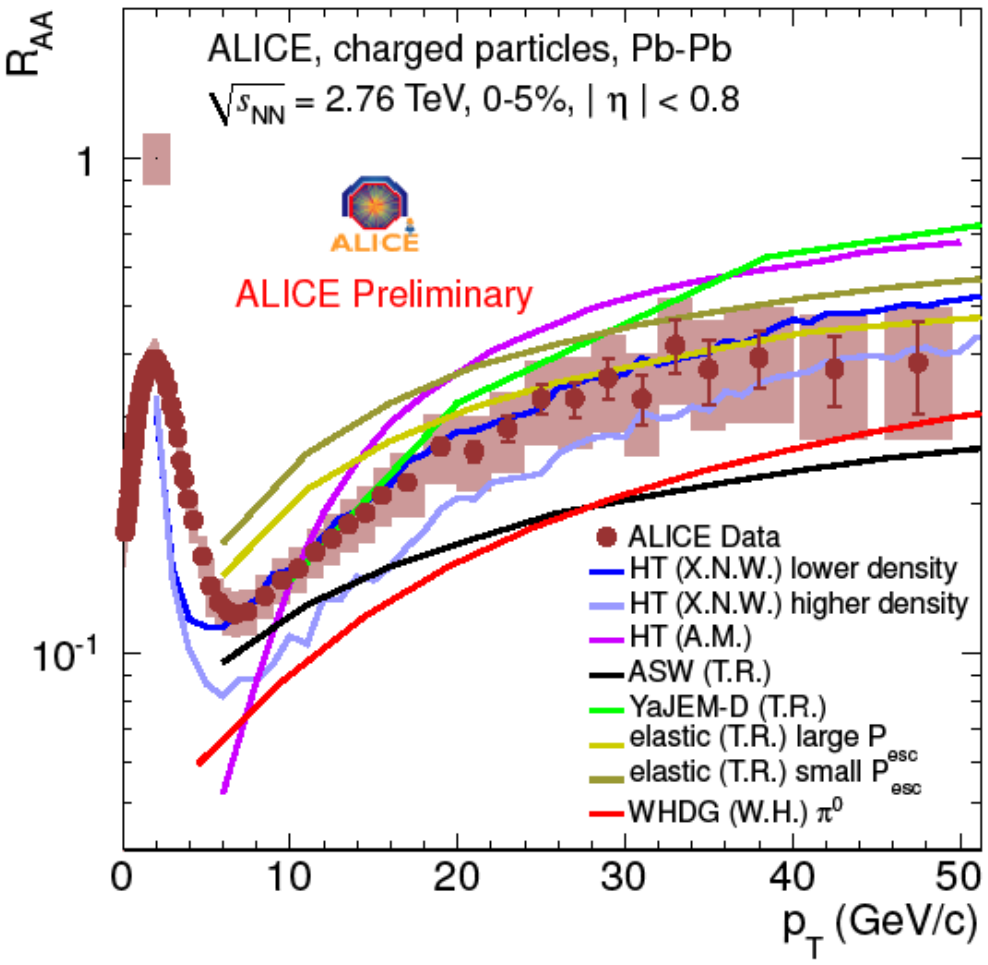
- **much stronger suppression compared to RHIC**
- **indicates denser medium**
- **similar shape, but rise above p_T = 7 GeV/c**

Charged Particle R_{AA}



- strong dependence on centrality
- less pronounced for higher p_T
- similar trend observed at PHENIX

Model Comparison



- **rise of R_{AA} with p_T predicted by all models**
- **magnitude depends on the energy loss mechanisms**
  - constrain models
- **ASW, WHDG (radiative energy loss) predict even larger suppression**

HT: X-N Wang et al, arXiv:1102.5614 (PRC)
HT: Majumder, Shen, arXiv:1103.0809
TR: T. Renk et al, arXiv:1103.5308 (PRC)
WHDG: Horowitz and Gyulassy, arXiv:1104.4958

Summary and Outlook

- **different methods to determine a pp baseline for R_{AA} have been presented**
  - interpolation, pQCD scaling, extrapolation to high p_T
  - shape similar for these three methods

- **R_{AA} shows strong medium effects in central Pb-Pb collisions**
- **But: R_{AA} depends also on initial PDF and fragmentation function**
  - additional modifications in Pb-Pb compared to pp
  - p-Pb end of this year
- **R_{AA} vs. reaction plane: additional information on path-length dependence**
- **improve pp reference**

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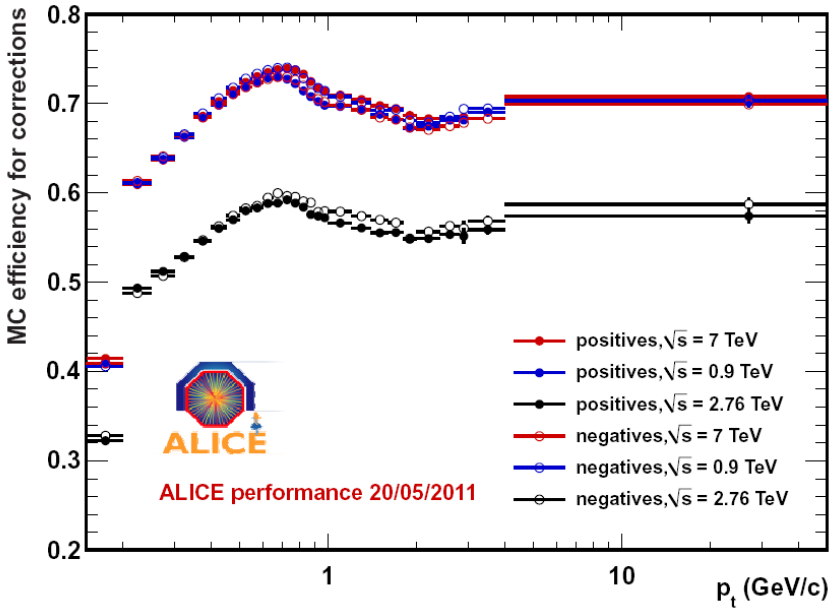
Backup

Corrections



- **Pb-Pb very similiar to 7 TeV, 900 GeV**
- **2.76 TeV data sample: without SDD (Drift) detector**
- **Small differences pos/neg**
  - production mechanisms different
- **Differences between data and MC: main source of systematic uncertainties**
- **corrections for: e.g. efficiency, material budget...**

Old vs New ref