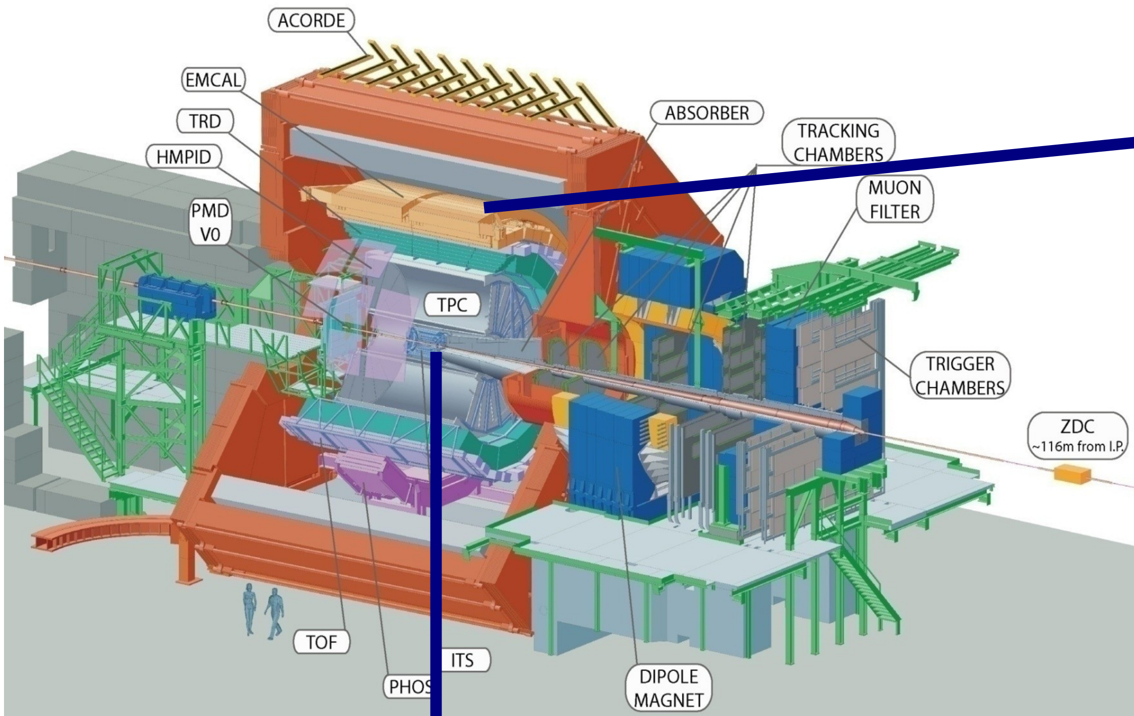
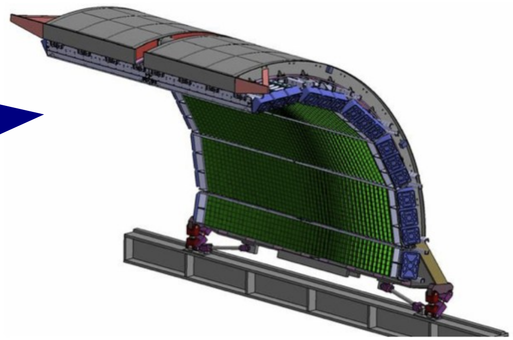
Measuring cold nuclear matter effects via dijets in p-Pb collisions with ALICE

Marta Verweij
Wayne State University
on behalf of the ALICE collaboration

Hard Probes 2013

Jets in ALICE





EMCal is a Pb-scintillator sampling calorimeter

Charged hadronic correction prevents double counting

Tracking:|η|<0.9, 0<φ<2π
TPC: gas detector
ITS: silicon detector

→ ***Charged constituents*** → **JET** ← ***Neutral constituents***

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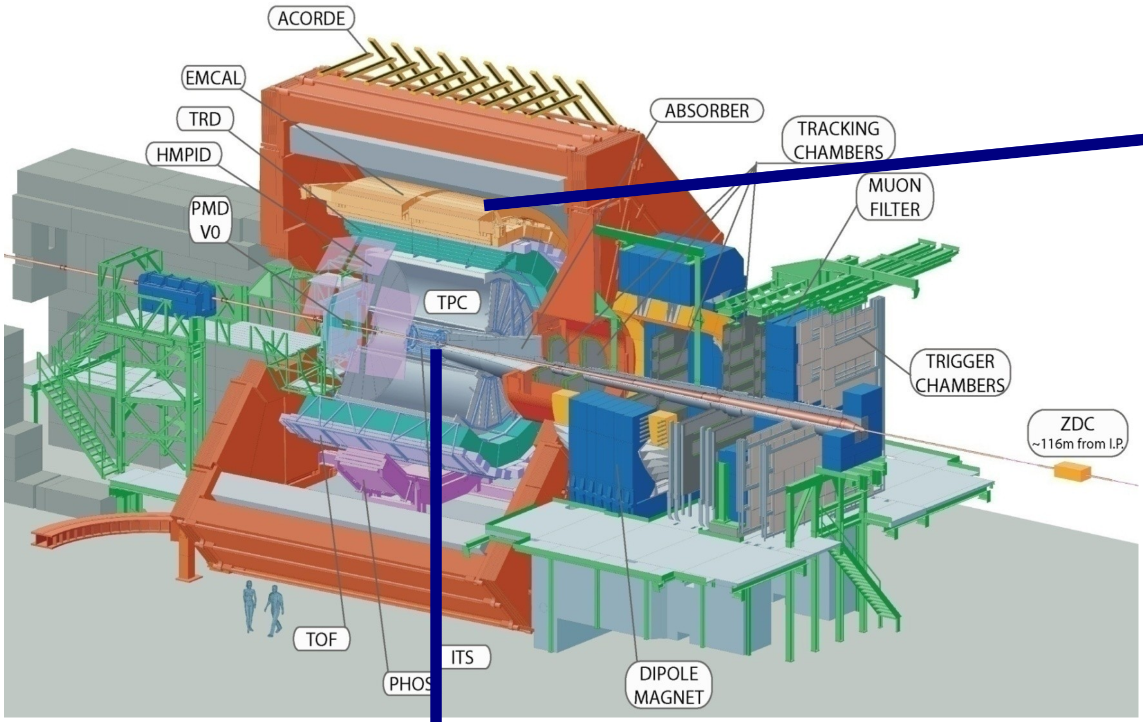

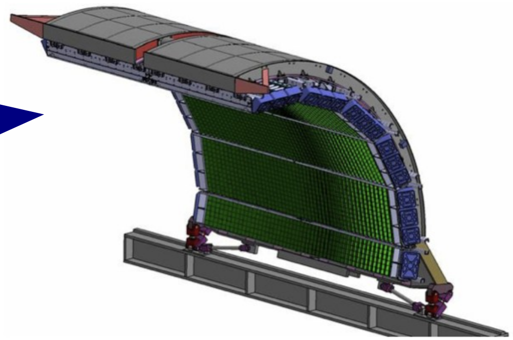

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Analysis presented here based on "charged jets"
EMCal used for jet trigger

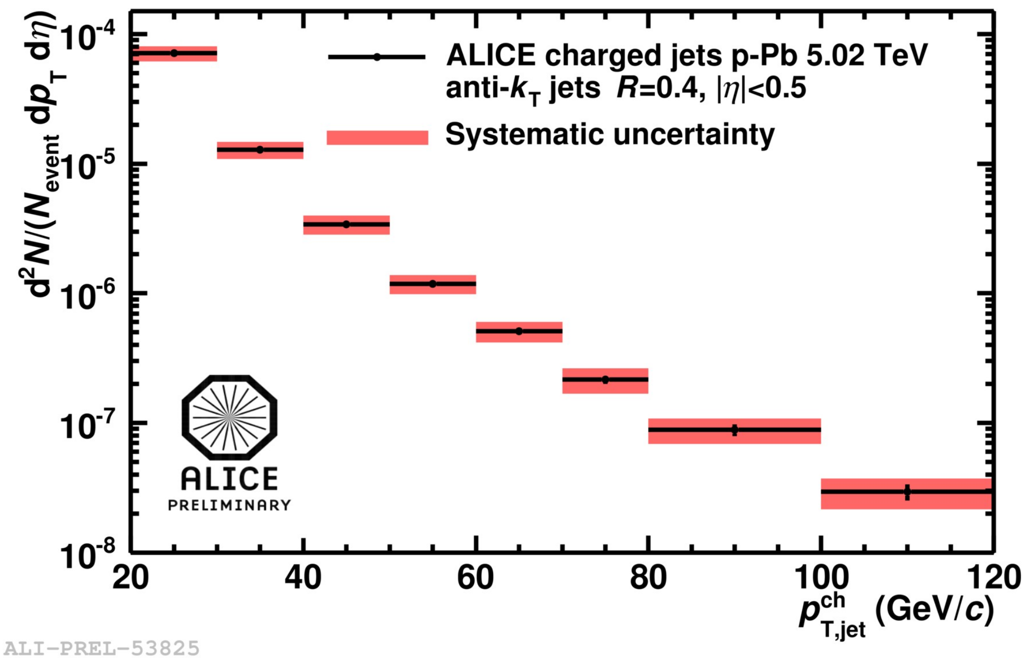
Charged jets in ALICE

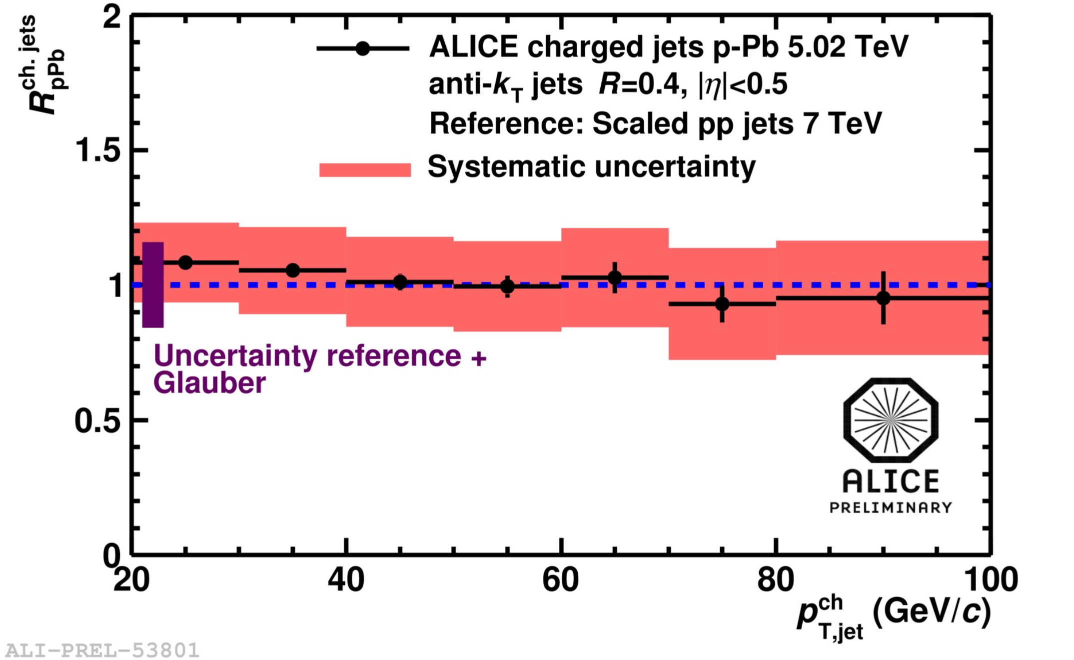
- Jet reconstruction with charged tracks reconstructed in tracking detectors (ITS + TPC):
  - High precision at particle level
    - Uniform η-φ acceptance: $|\eta|<0.9$, $0<\varphi<2\pi$

- Jet reconstruction with FastJet:
  - Charged particles: $\boldsymbol{p_T > 150}$ **MeV/*c***
  - anti-k_T jet algorithm for signal (stable area), $R = 0.2$ and 0.4
  - k_T jet algorithm to estimate background density: $\langle\rho\rangle = 1$ GeV/c in p-Pb
  - Boost invariant p_T recombination scheme

Jet spectrum in p-Pb

Minimum bias p-Pb events at √s = 5.02 TeV





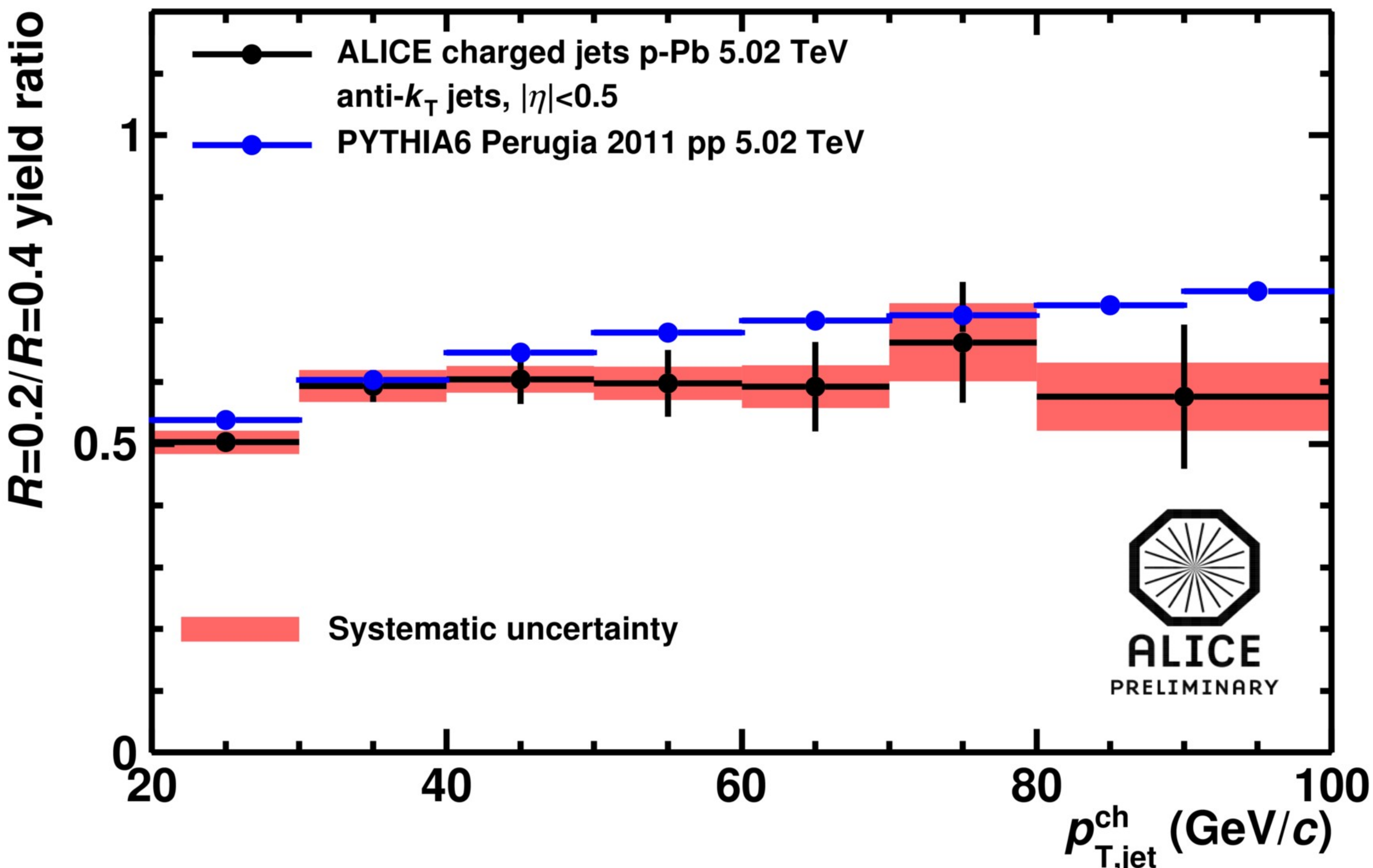
Jet spectrum corrected for background from underlying event and detector effects.

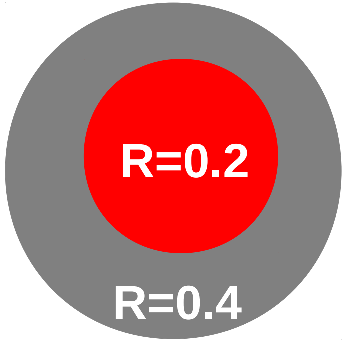
No jet suppression in minimum bias p-Pb collisions within uncertainties

No significant cold nuclear matter effects
→ jet suppression in Pb-Pb final state effect

Jet transverse structure p-Pb

Cross section ratio



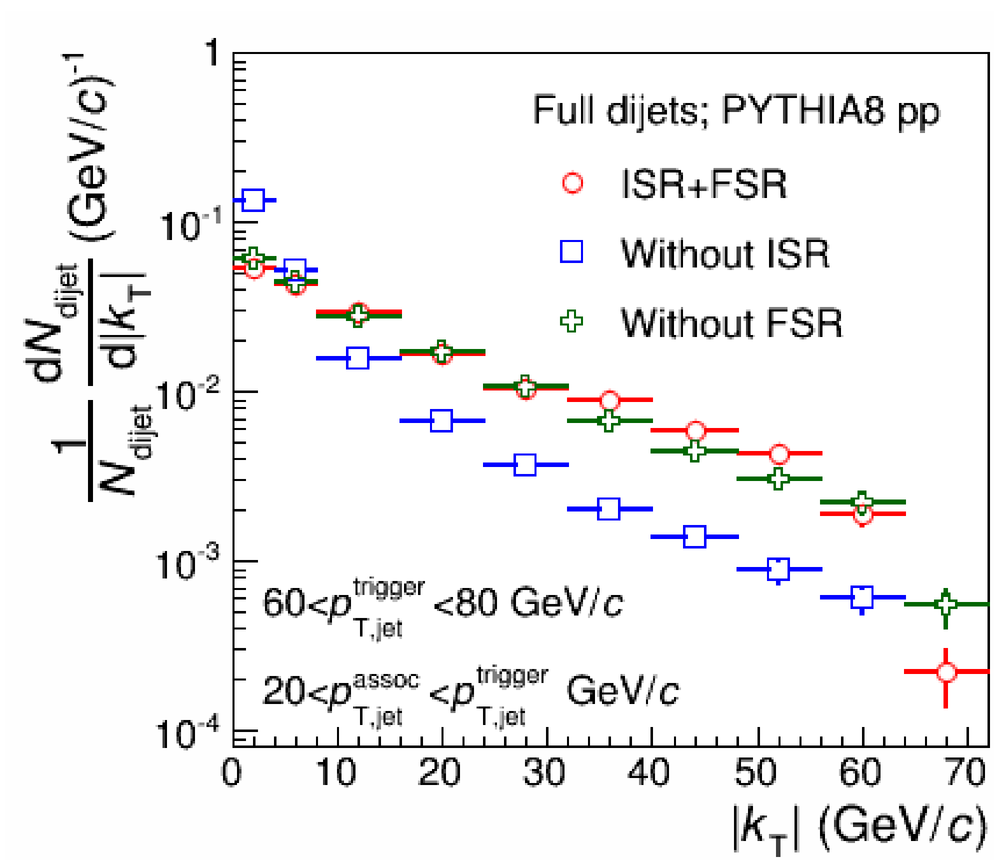


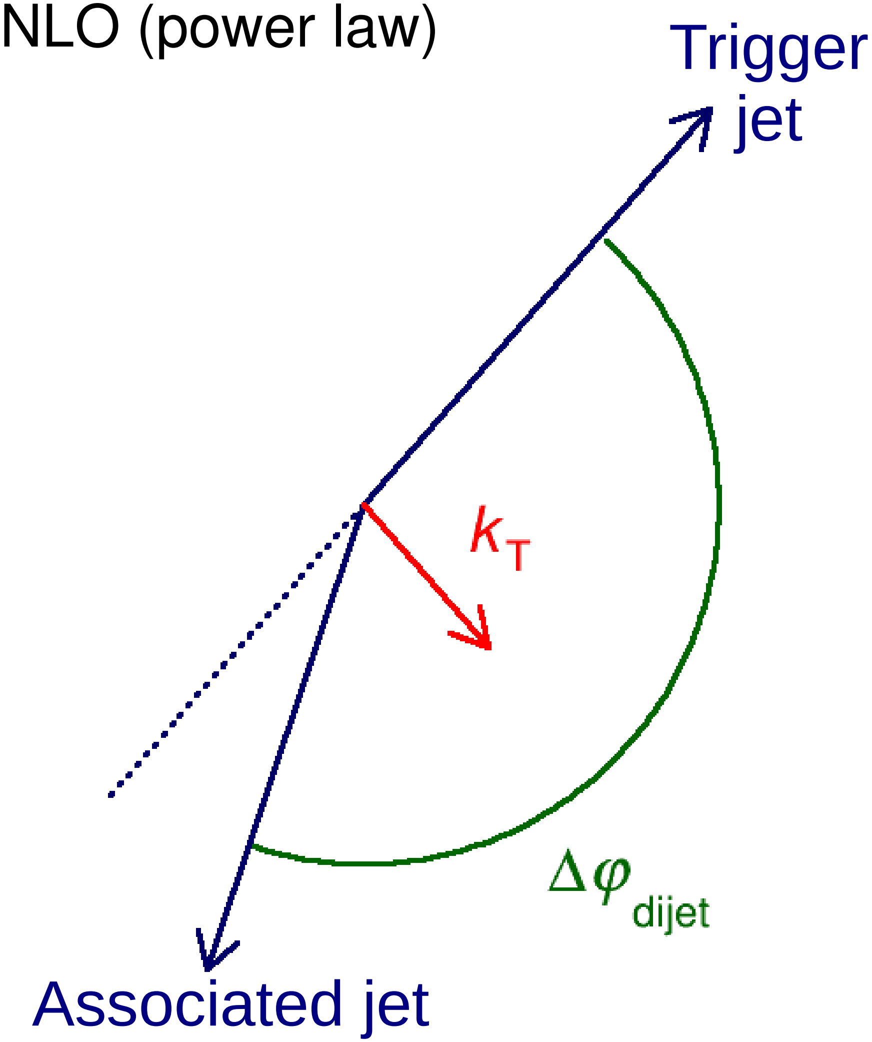
Jet cross section ratio compatible with PYTHIA in p-Pb collisions

→ no significant change of transverse distribution of hadrons with R<0.4

k_T via dijets in p-Pb

- k_T
  - Intrinsic k_T + initial and final state radiation
    + cold nuclear matter (CNM) effects
  - Radiation: soft (Gaussian) + hard from NLO (power law)
  - CNM: scattering of parton in nucleus





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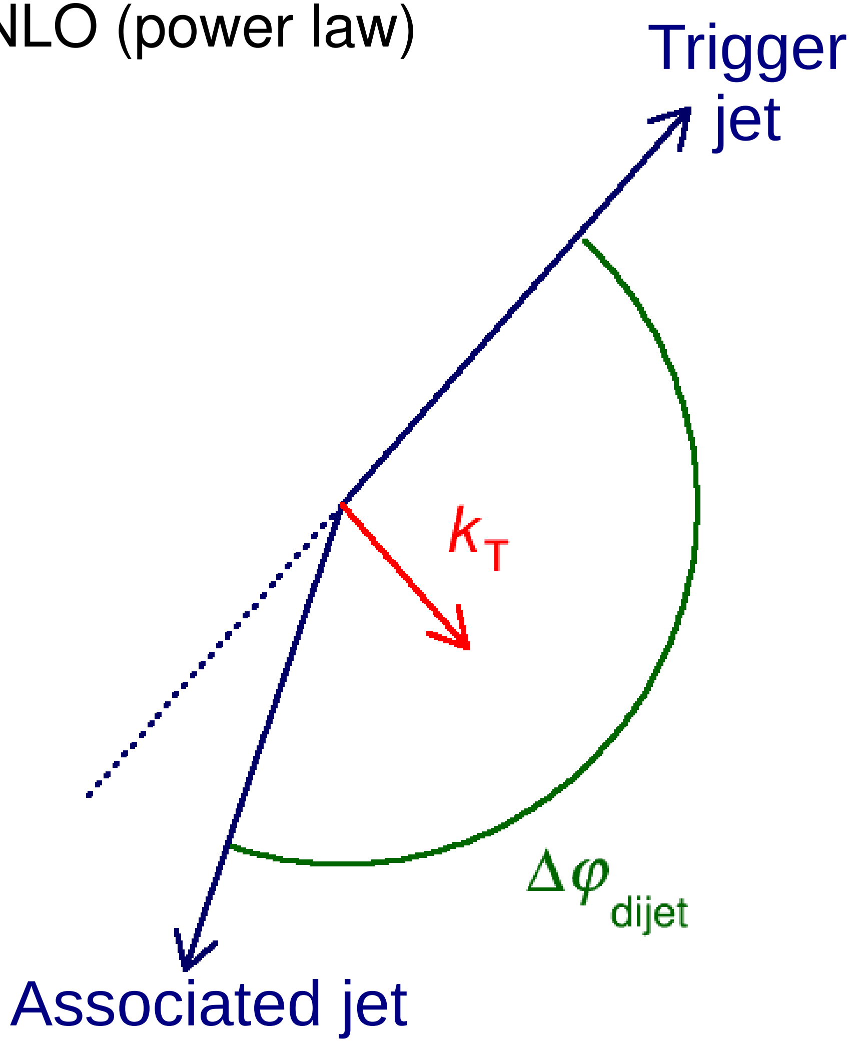
- Definition in this analysis:

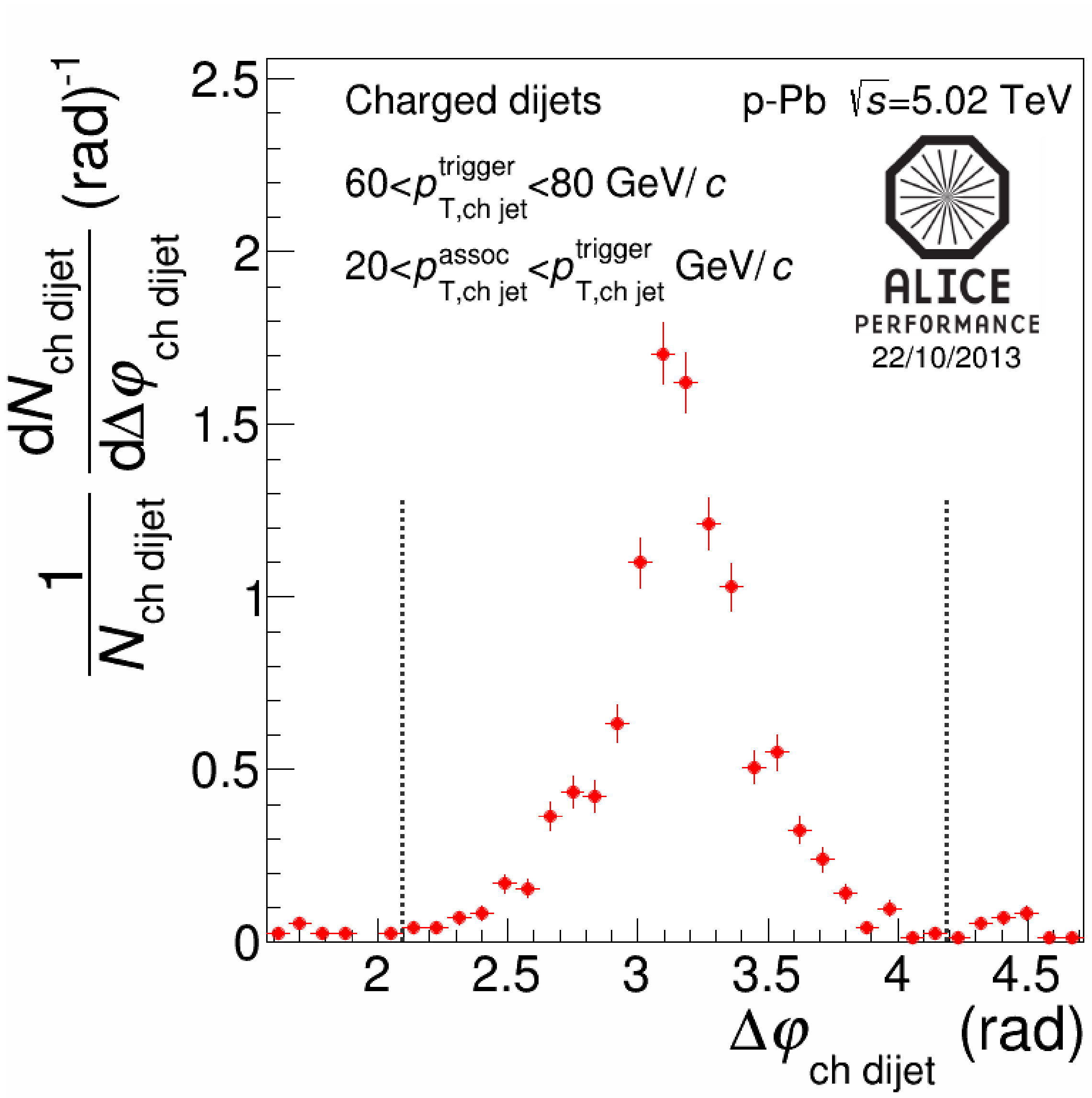
$$k_T = p_{T,\text{ch jet}}^{\text{trigger}} \sin(\Delta\varphi_{\text{dijet}})$$

Transverse component of k_T vector is used.

- We report $|k_T|$ (symmetric distribution)



Azimuthal correlation



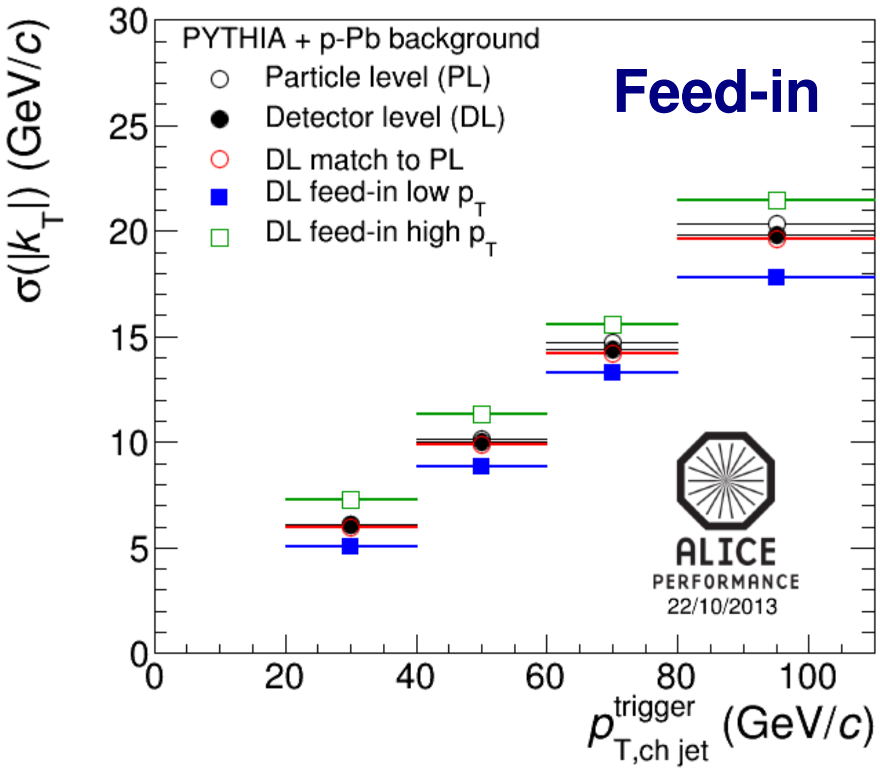
Azimuthal distribution of dijets.

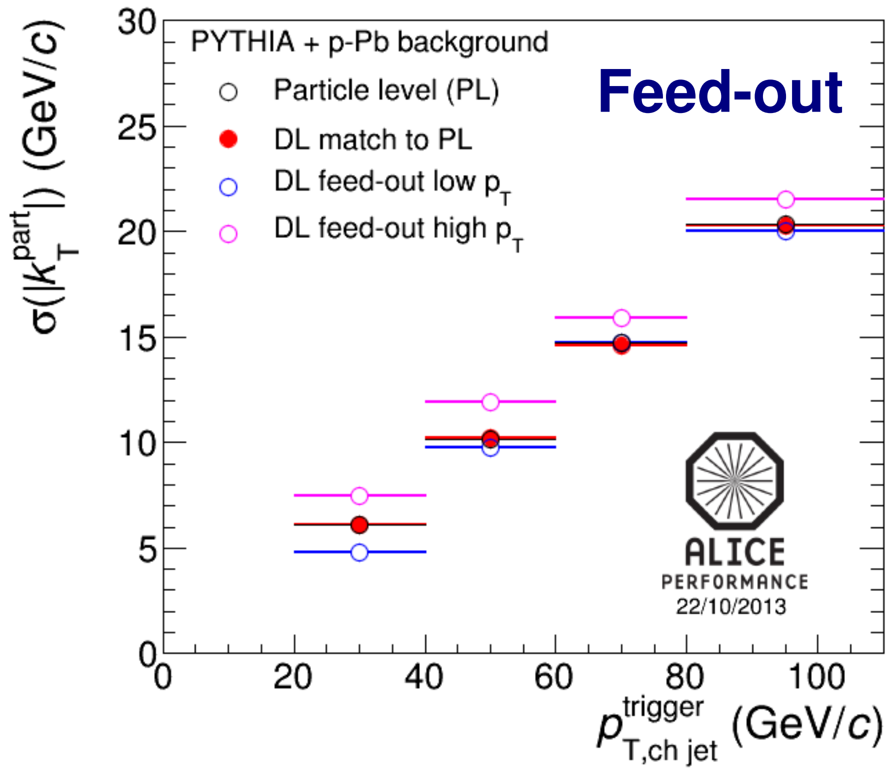
Each trigger jet is correlated to the leading jet in the opposite hemisphere.

Dijets are selected when $|\Delta\varphi_{dijet} - \pi| < \pi/3$ (dotted lines)

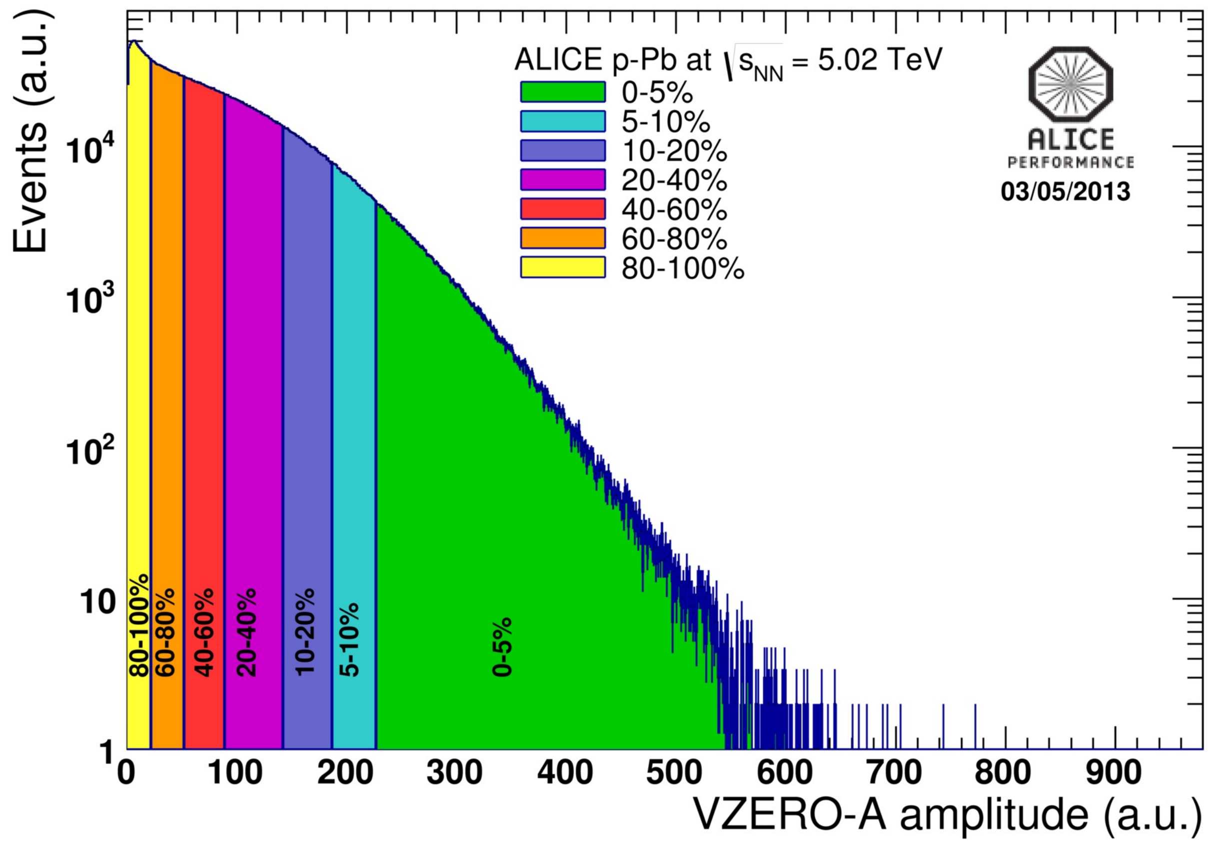
Corrections

- Detector effects: PYTHIA + detector simulation
- Background fluctuations: p_T smearing on top of detector effects
- Contamination: feed-in of triggers in selected kinematic window (left figure)
- Efficiency: feed-out of triggers (right figure)
- Canceling effects → correction for shape of k_T-distribution small





V0A event classes



ALI-PERF-51387

Particle multiplicity measured in V0A detector used to define event classes.

V0A is located in Pb-going direction for this data set

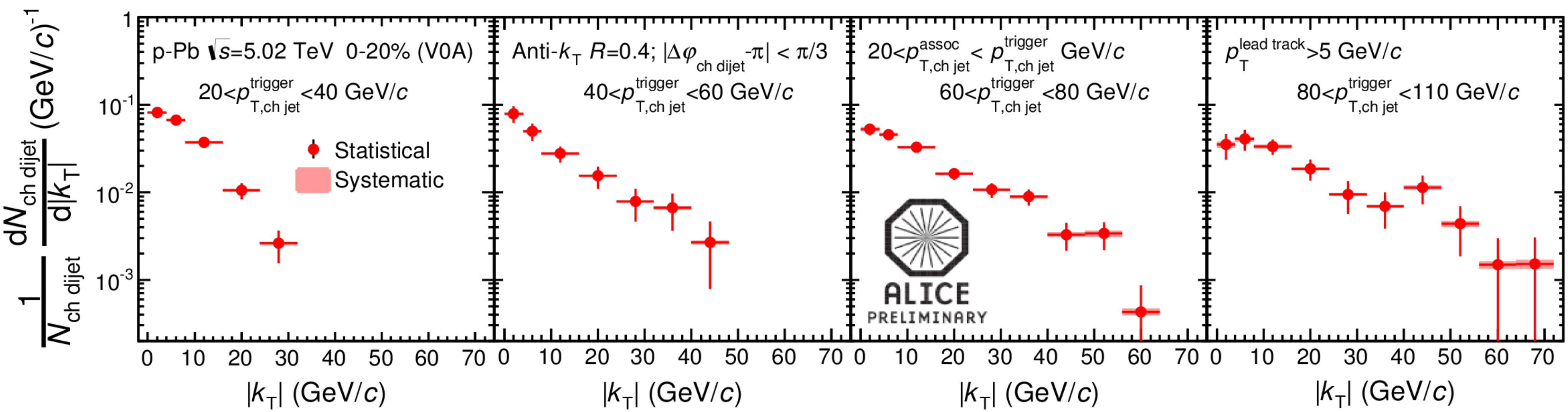
V0A: z = 340 cm

$2.8 < \eta_{lab} < 5.1$

See talk by Chiara Oppedisano Thursday 13.30

k_T vs trigger p_T

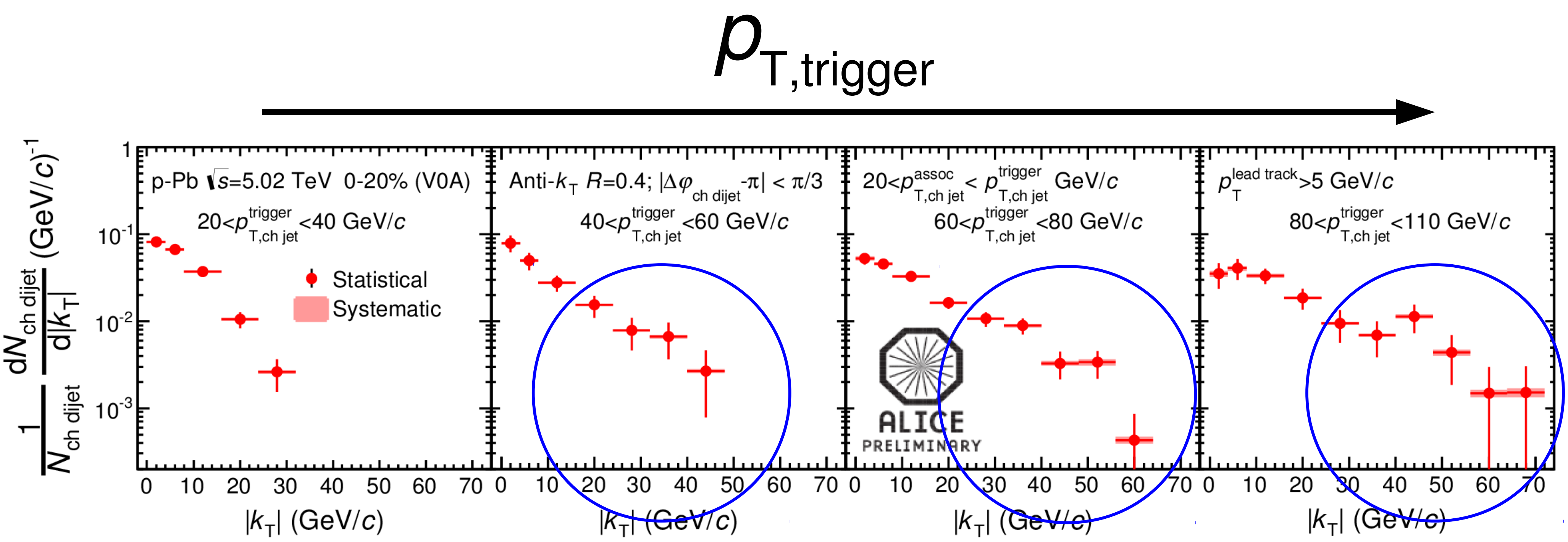
$p_{T,\text{trigger}}$



Measured k_T-distribution for different kinematic intervals of trigger jet.

Kinematic limit: $k_{T,max} = p_{T,trigger,max}$ sin(2π/3) → increases with $p_{T,trigger}$

k_T vs trigger p_T



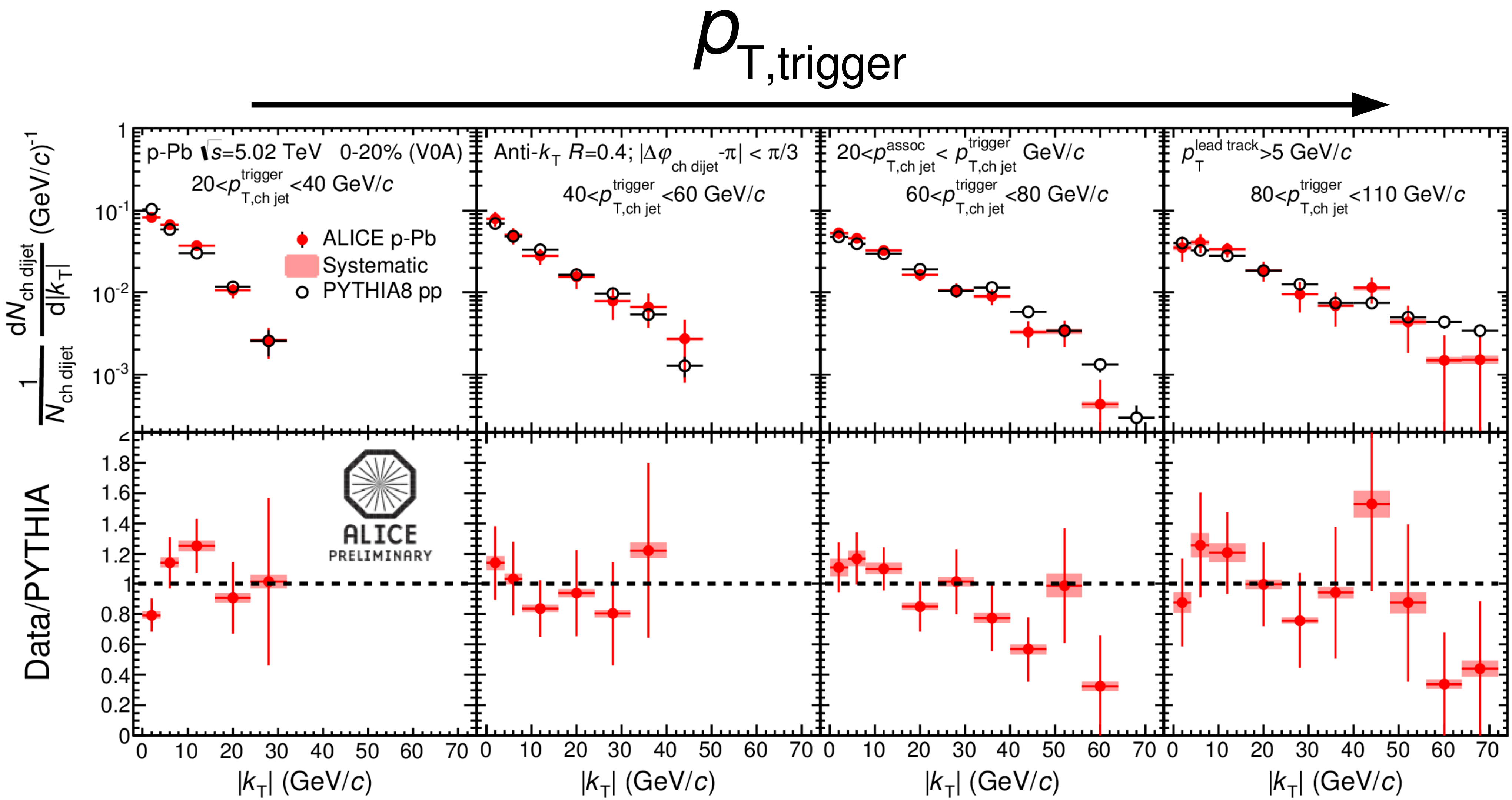
Measured k_T-distribution for different kinematic intervals of trigger jet.

Kinematic limit: $k_{T,max} = p_{T,trigger,max} \sin(2\pi/3)$ → increases with $p_{T,trigger}$

NLO processes: power-law tail

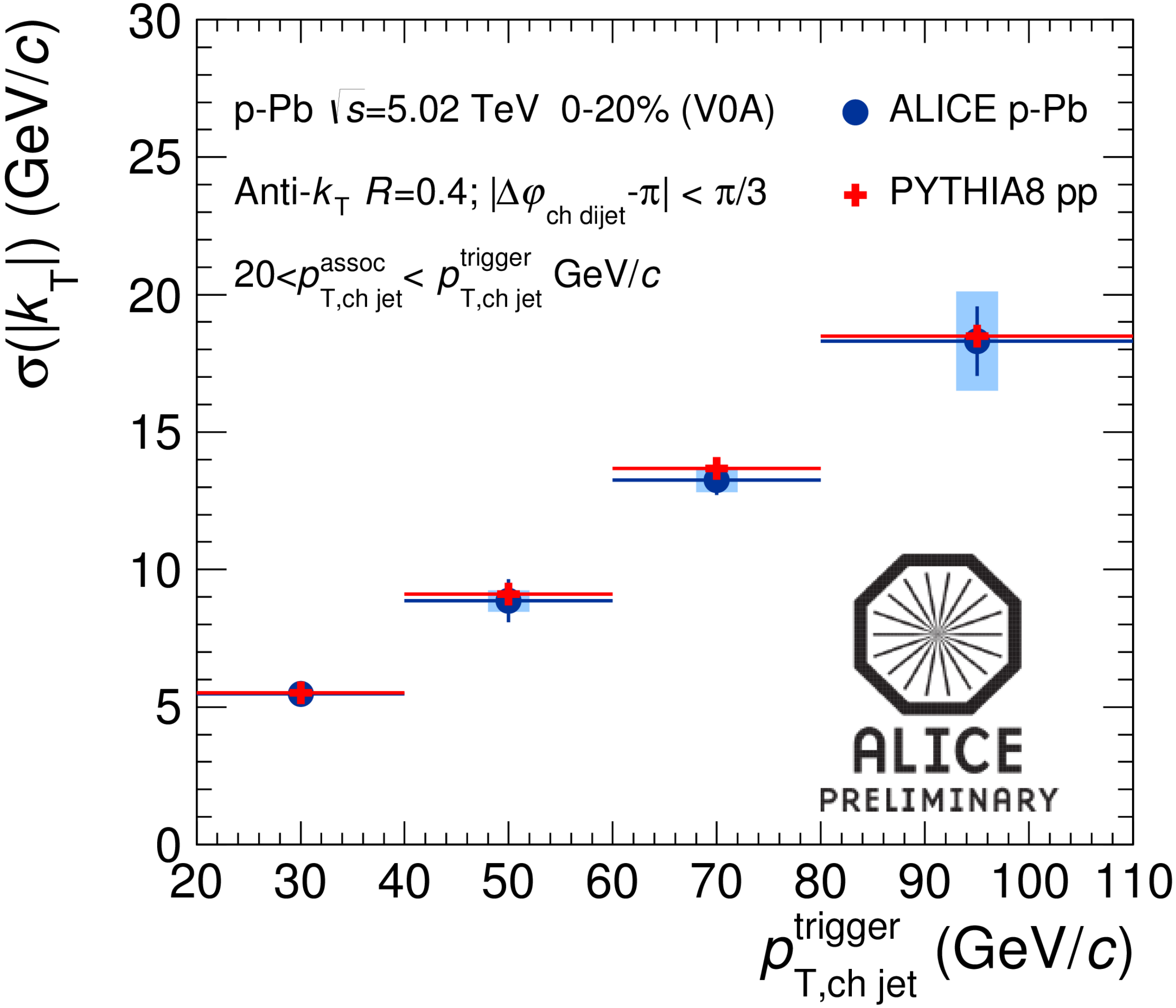
k_T vs trigger p_T

Comparison to PYTHIA8 Tune 4C K_{factor} = 0.7



No significant deviation in p-Pb compared to PYTHIA

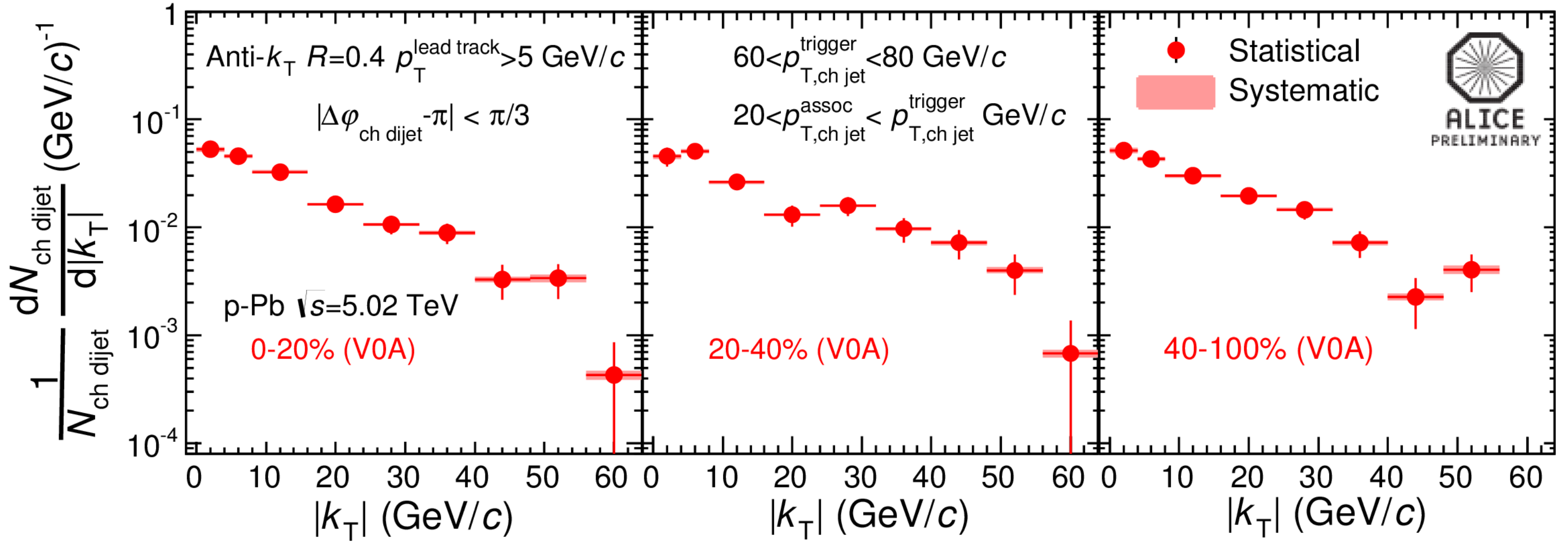
k_T width

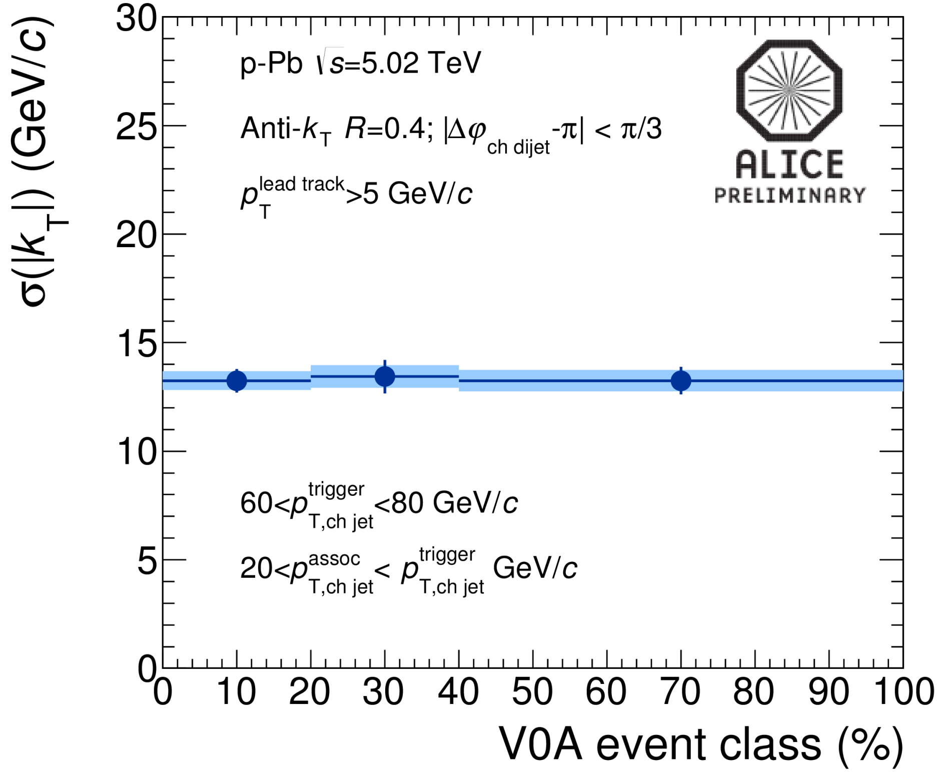


No CNM effects observed as function of trigger jet p_T

- k_T width characterized by extracting RMS from measured distributions.
- Measured k_T-distributions are extrapolated with PYTHIA template
  → systematic uncertainty
- k_T width increases with trigger jet p_T
- k_T width compatible in p-Pb data and PYTHIA

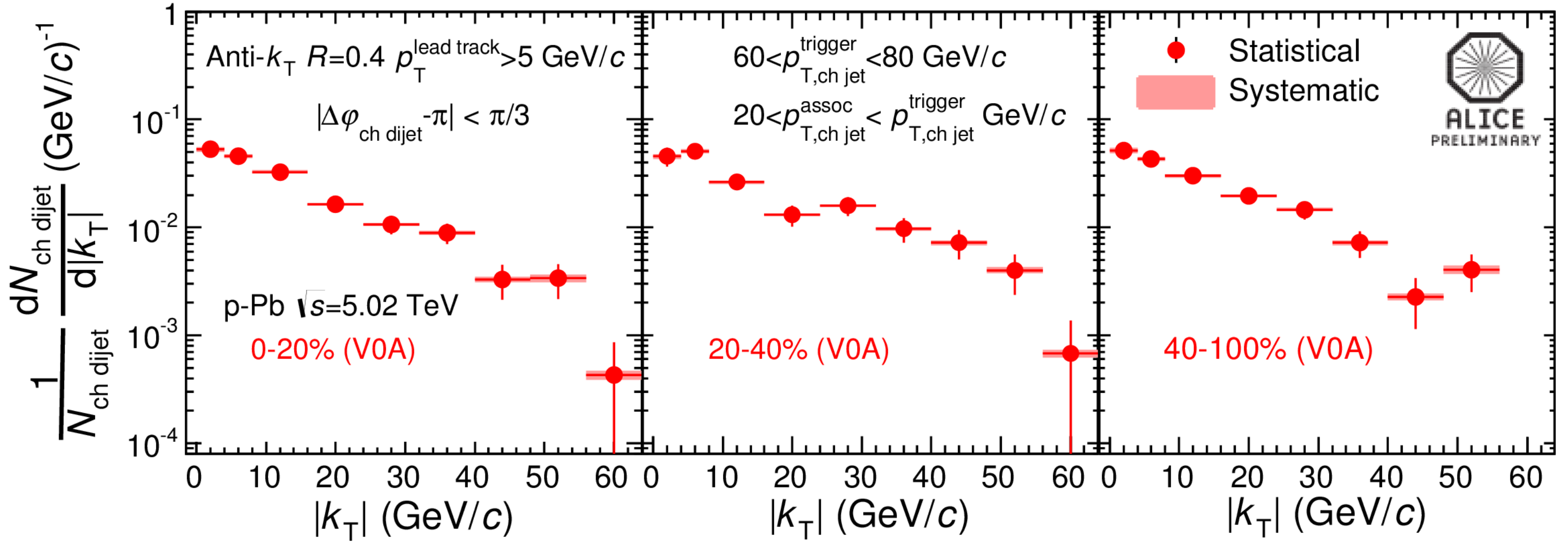
k_T: multiplicity evolution

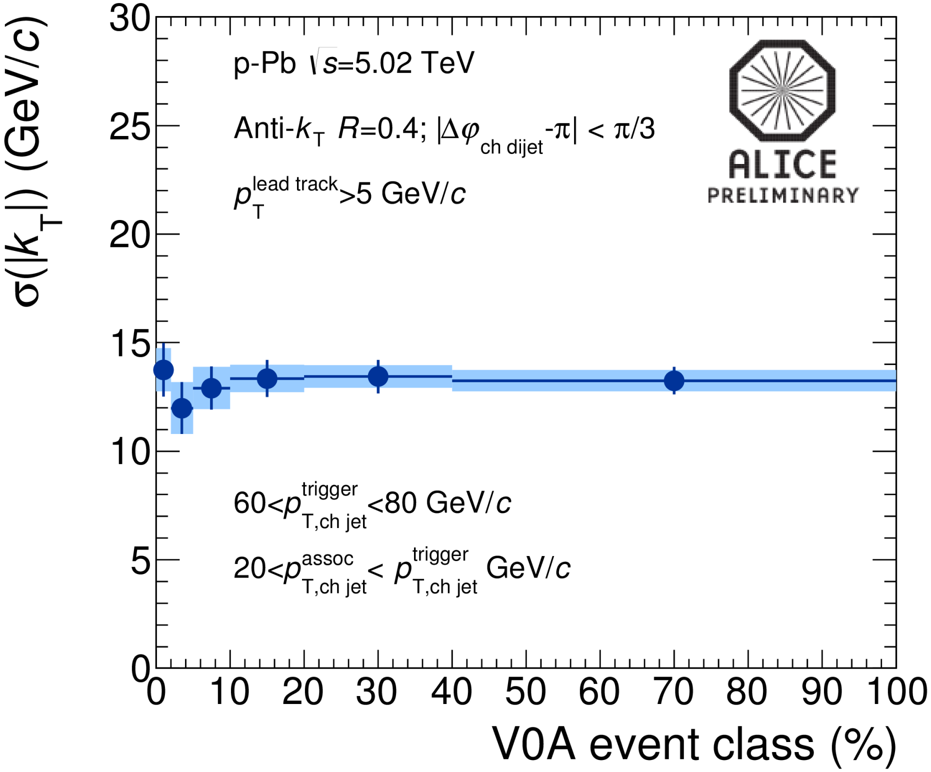




- k_T for different event classes defined by V0A multiplicity estimator
- No modification of k_T-distribution and width observed

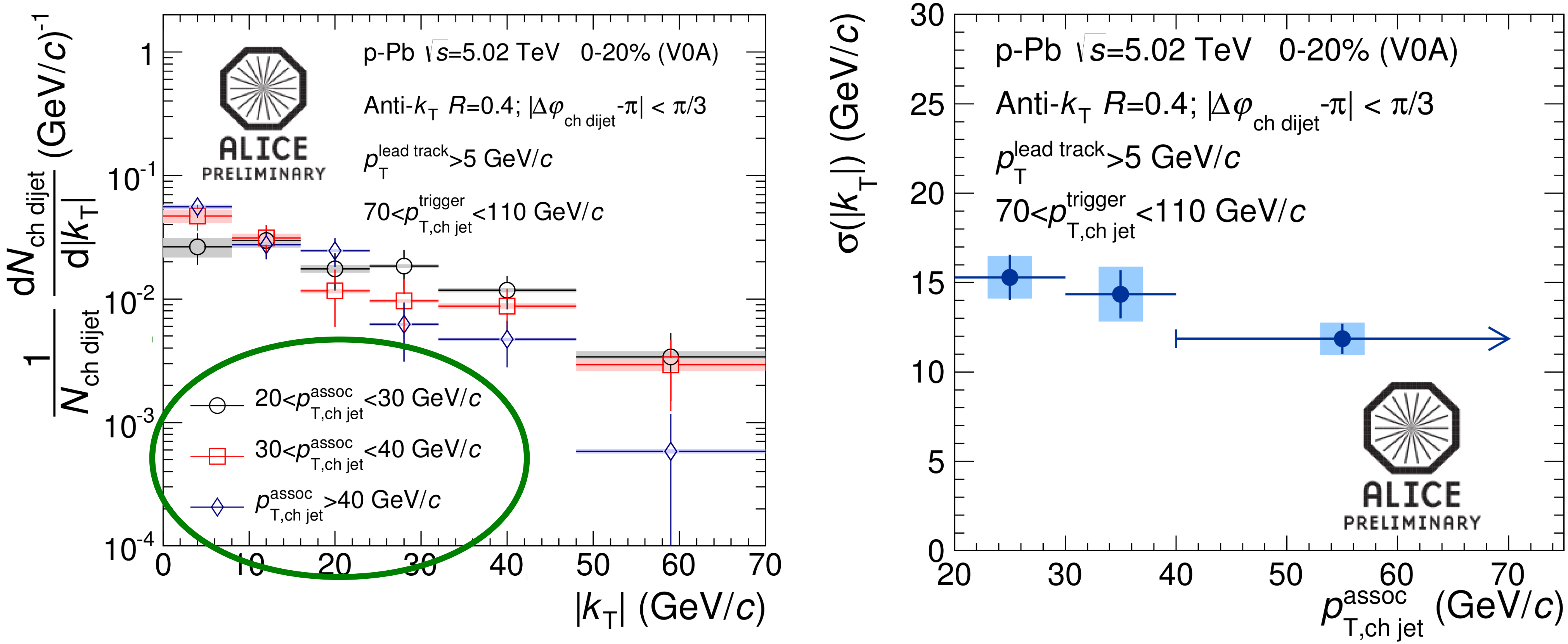
k_T: multiplicity evolution





- k_T for different event classes defined by V0A multiplicity estimator
- No modification of k_T-distribution and width observed
- Also not in very high multiplicity events

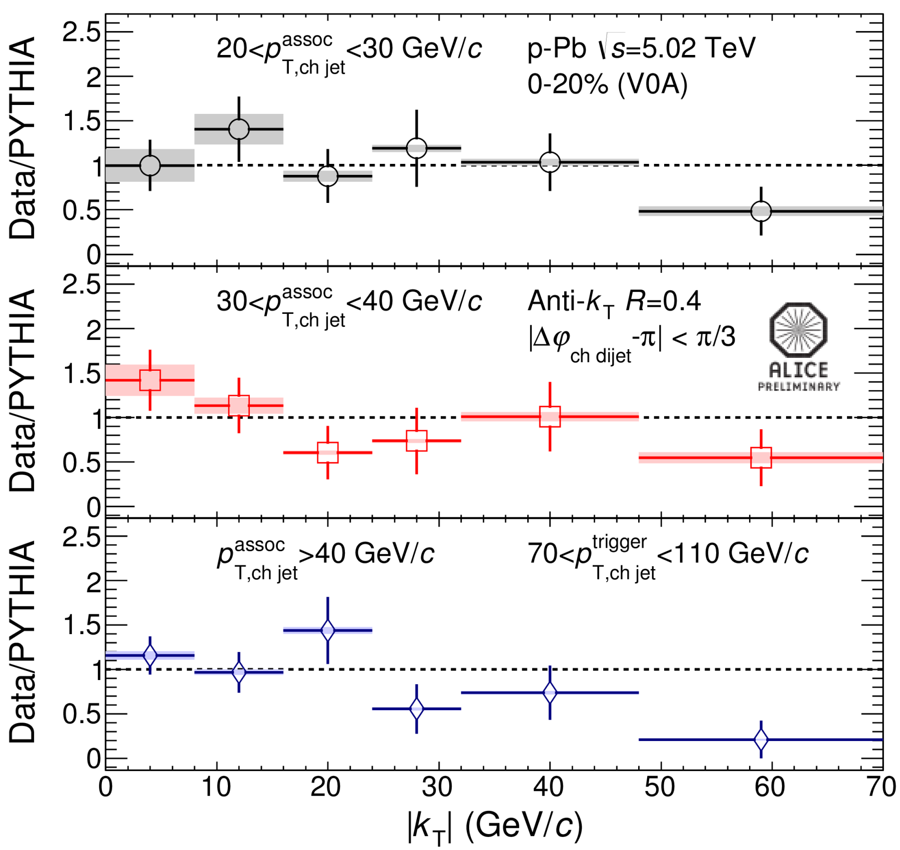
Balancing jets



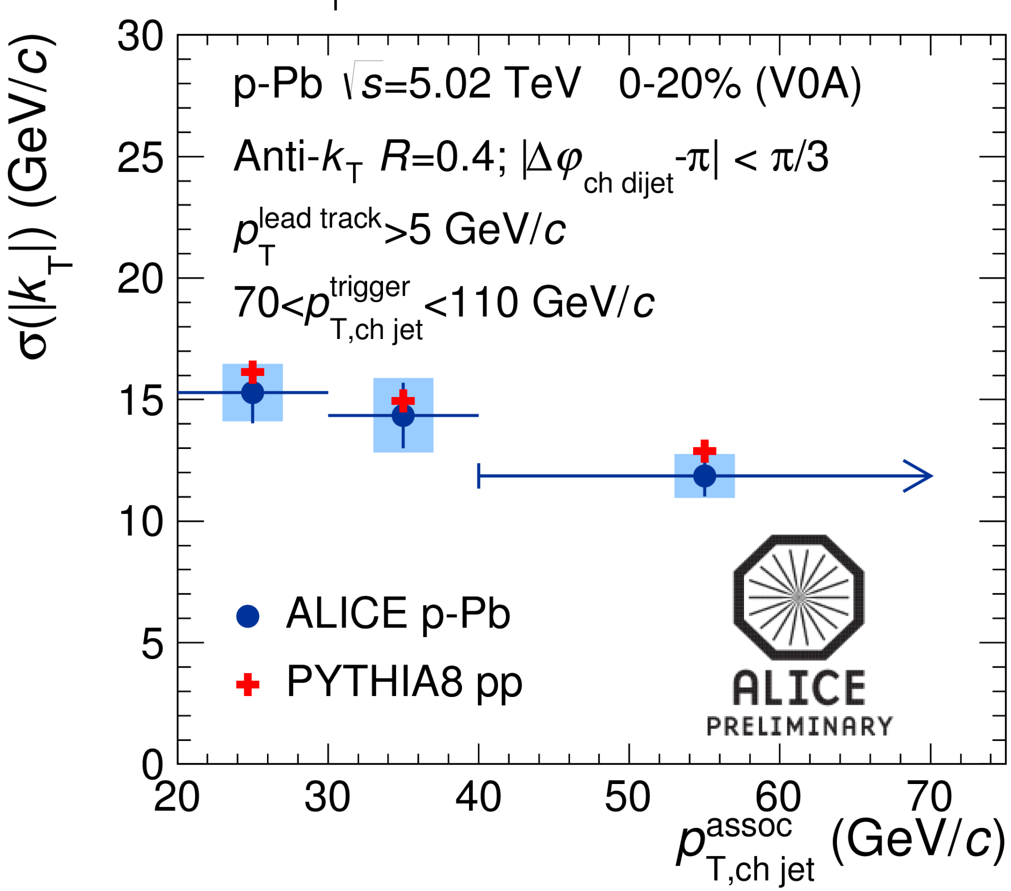
Balanced and imbalanced jets selected by varying kinematic interval of associated jet

Balancing jets data vs PYTHIA8

Ratio of k_T-distributions: DATA/PYTHIA



k_T width in data and PYTHIA



Similar narrowing while balancing jets in p-Pb data and PYTHIA

Summary

- No significant cold nuclear matter effects observed in:
  - p-Pb jet spectra
    R_{pPb}~1 and jet cross section ratio consistent with PYTHIA
  - $|k_T|$ as function of
    - Trigger jet p_T: $\sigma(|k_T|)$ increases
    - Associated jet p_T: balanced vs imbalanced jets
    - Event multiplicity: constant

  not significantly different from PYTHIA expectation
  Used PYTHIA tune: PYTHIA8 Tune 4C $K_{factor} = 0.7$

backup

Reference for R_{pPb}

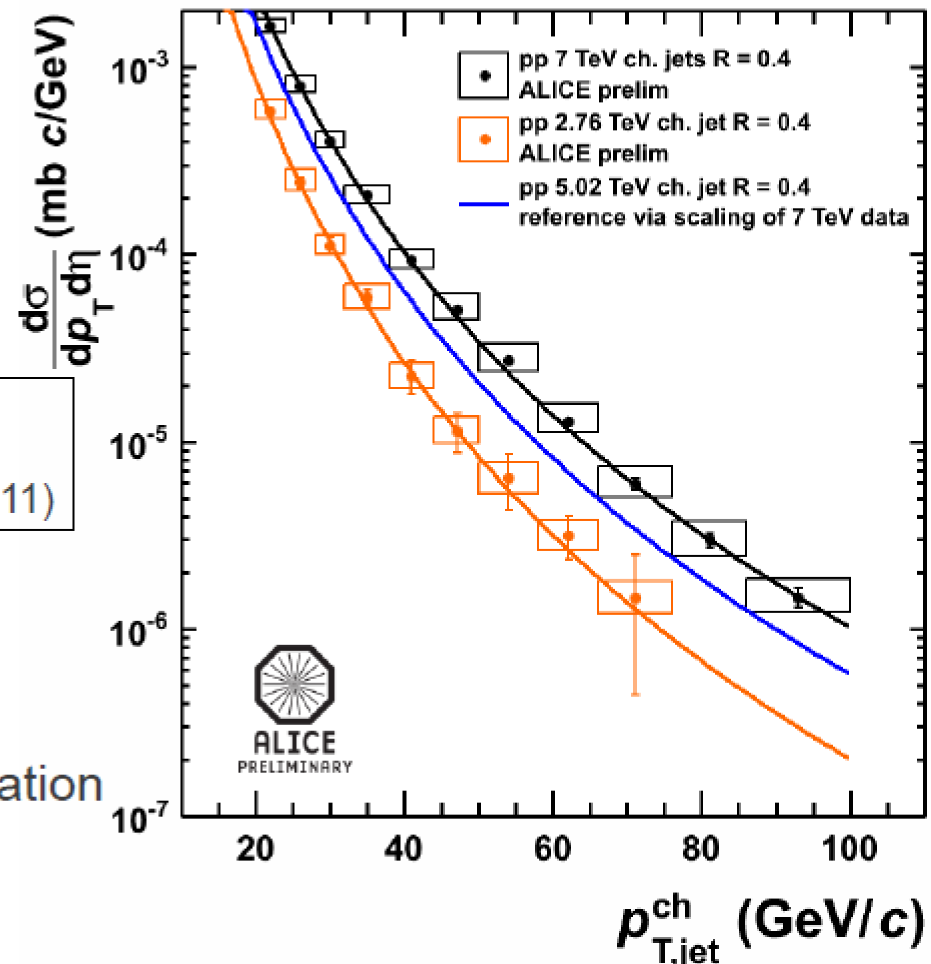
General approach:

- Downscaling of measured 7 TeV pp jets to 5.02 TeV
- Scaling done bin-by-bin with:

$$p = \frac{\text{yield}(5.023\ \text{TeV})}{\text{yield}(7\ \text{TeV})}$$

yields taken from MC generator (PYTHIA Perugia 2011)

- Systematic uncertainty: 15%
  - From scaling method
    - Comparison to power-law interpolation between 2.76 TeV and 7 TeV measured pp data
    - Comparison for different generators and tunes
  - From uncertainty of 7 TeV spectrum



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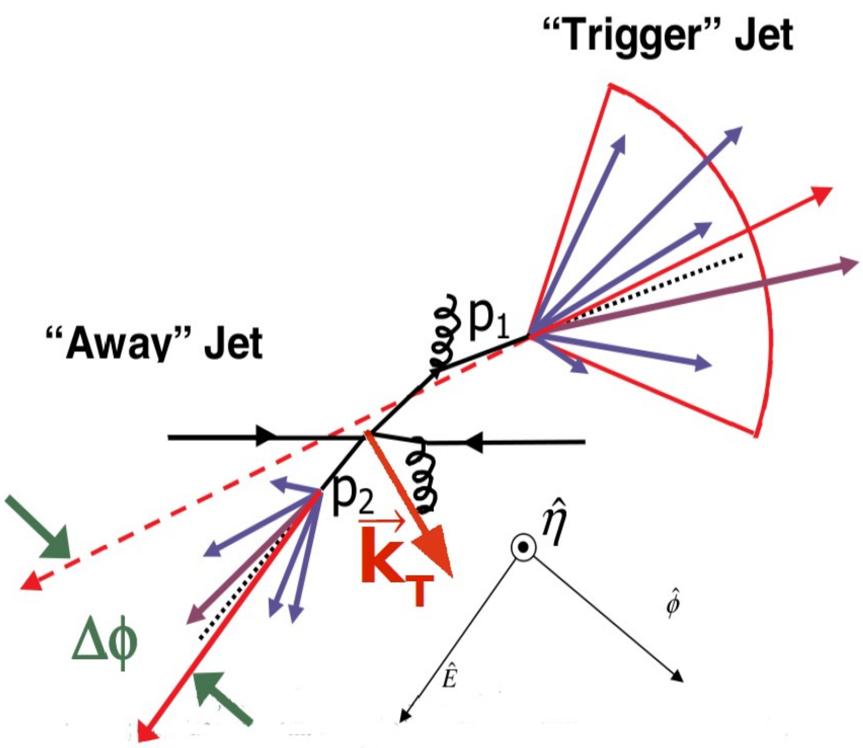


- Definition in this analysis:

$$k_T = p_{T,trig}\sin(\Delta\varphi_{dijet})$$

Only azimuthal projection of k_T vector is used. √2 smaller than k_T of dijet

- We report $|k_T|$ (symmetric distribution)

Picture from Jan Kapitan HP2010

Jet acoplanarity: k_T

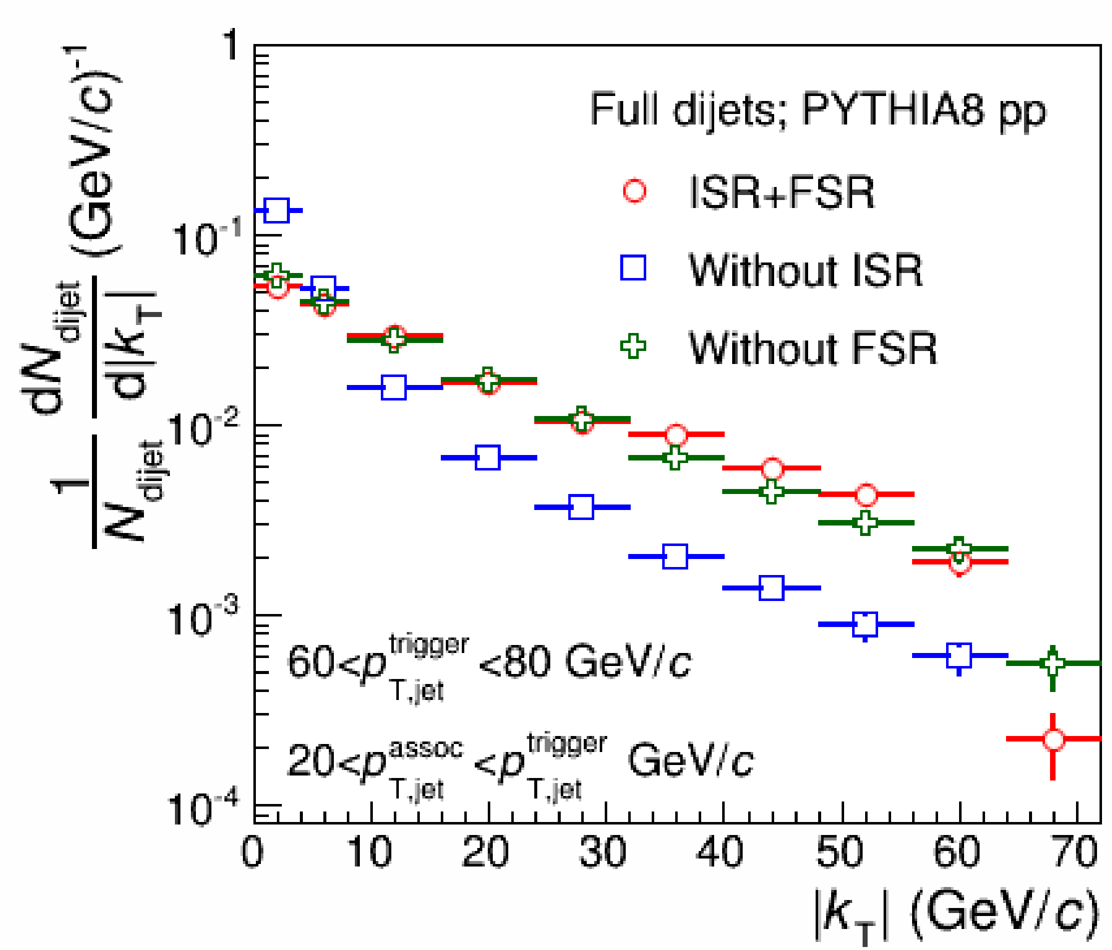
$$k_T = k_{T,\text{intrinsic}} \oplus k_{T,\text{soft}} \oplus k_{T,\text{NLO}}$$

Intrinsic:
partonic transverse motion within colliding protons

Soft:
soft radiation (ISR,FSR)

NLO:

ISR, FSR (3-jet events)
non-Gaussian



Background in p-Pb

Background[1]

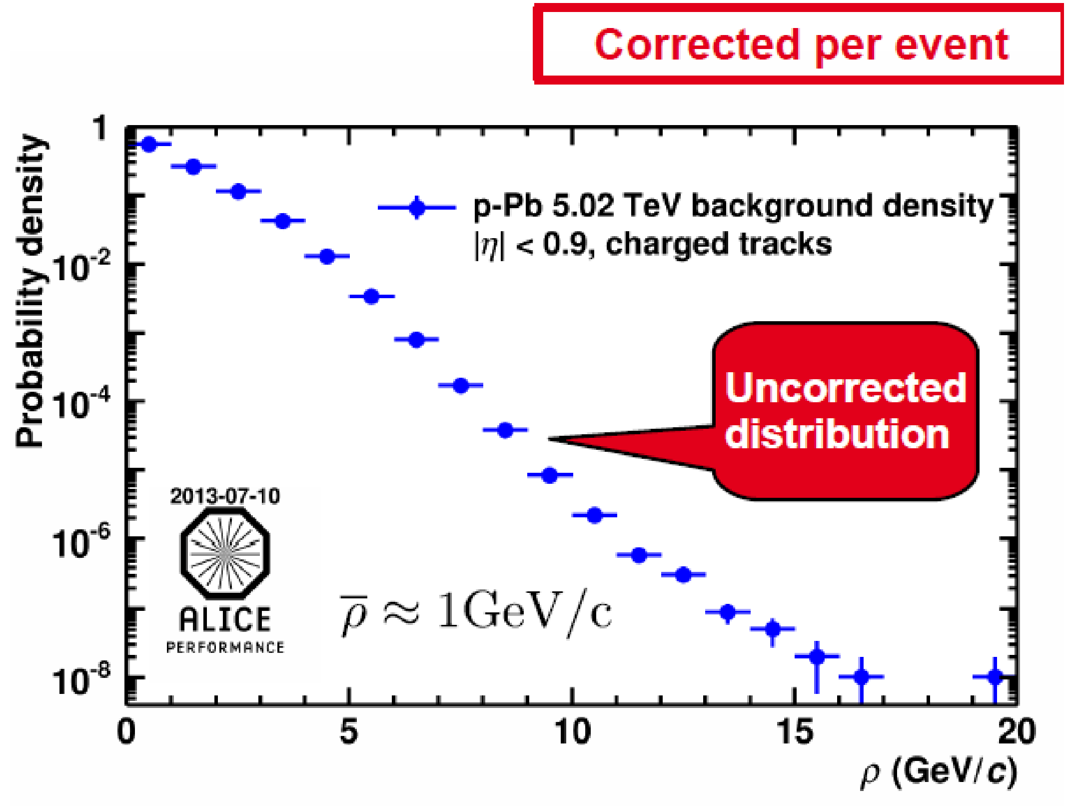
(everything not coming from hard collision)

- clusterize k_T jets (susceptible to background)
- take median of the p_T densities

$$\rho = \text{median}\left\{\frac{p_{T,i}}{A_i}\right\}_i \cdot C$$

- correct for event occupancy

$$C = \frac{\text{Area of } k_T \text{ jets containing tracks}}{\text{Area of all } k_T \text{ jets}}$$



R. Haake at EPS-HEP 2013

[1] Approach derived from arXiv:1207.2392 [hep-ex]

EMCal triggers

- EMCal triggers on integrated energy deposits in a given area
- Triggers are formed by sliding window algorithms of different granularity and steps
- L0 (600ns), 4x4 towers
- L1 (~5µs), 4x4 towers without FEE HW borders
- L1 (~5µs), 32x32 towers, jet trigger