Jet Structure in pp and Pb-Pb Collisions at ALICE

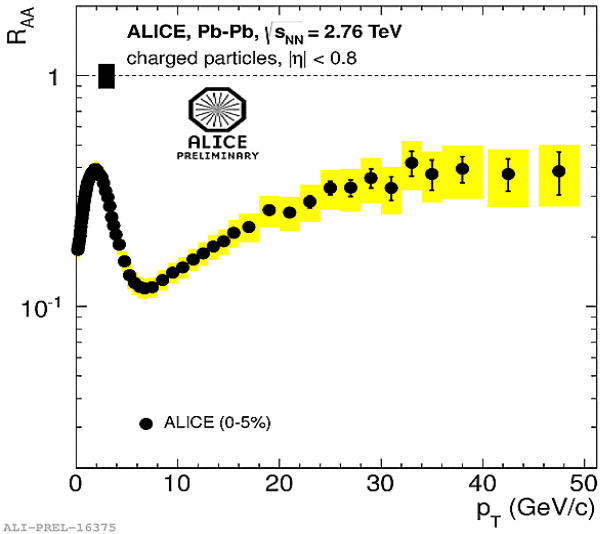
Oliver Busch for the ALICE Collaboration

- Motivation
- ALICE experiment
- Jet structure in pp
- Hadron triggered recoil jets
- Di-Hadron correlations

BMBF Forschungsschwerpunkt ALICE Experiment 201

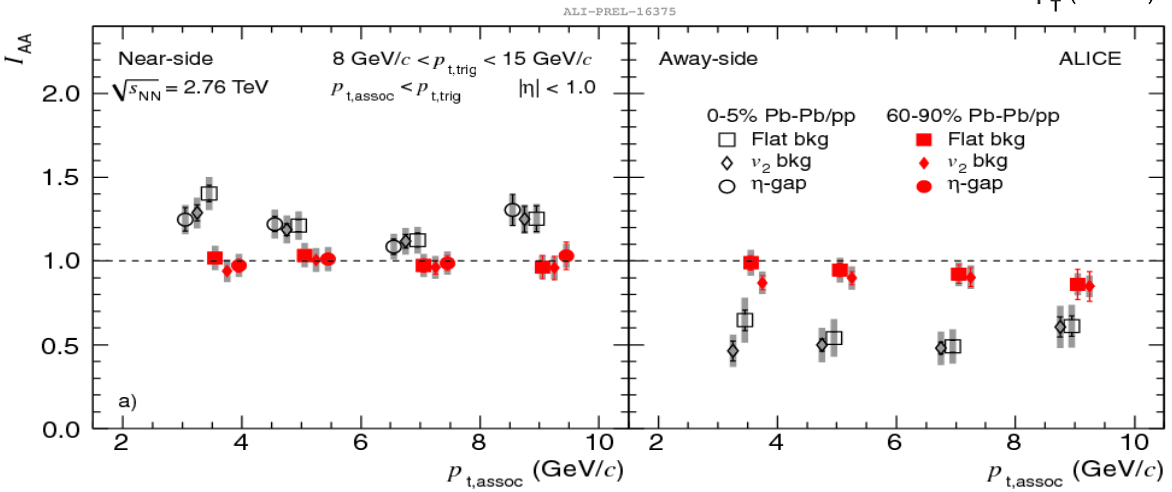
Motivation

Indications of parton energy loss in Pb-Pb collisions at 2.76 TeV
- inclusive hadron and jet R_{AA}
- away-side yield I_{AA}
- Dijet and γ-jet imbalance



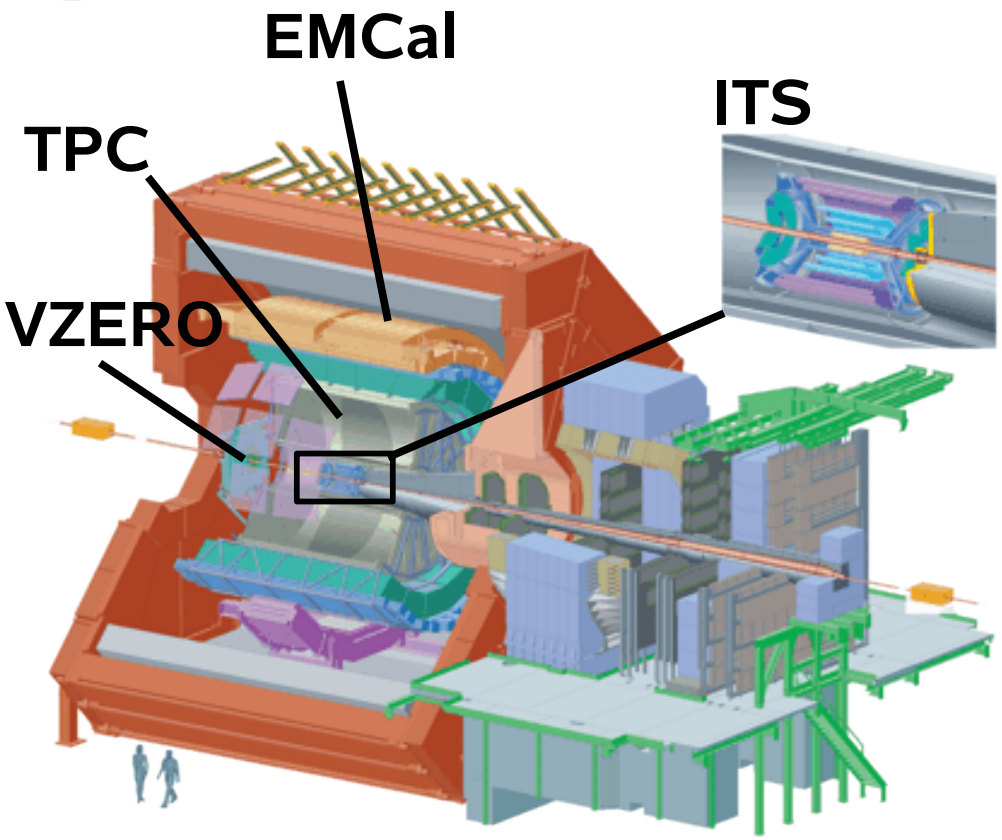
- Medium induced pQCD gluon radiation for leading fragment ?

- Coupling at lower scales (o (T_{med})) ?



→ modified jet fragmentation & structure ?

ALICE



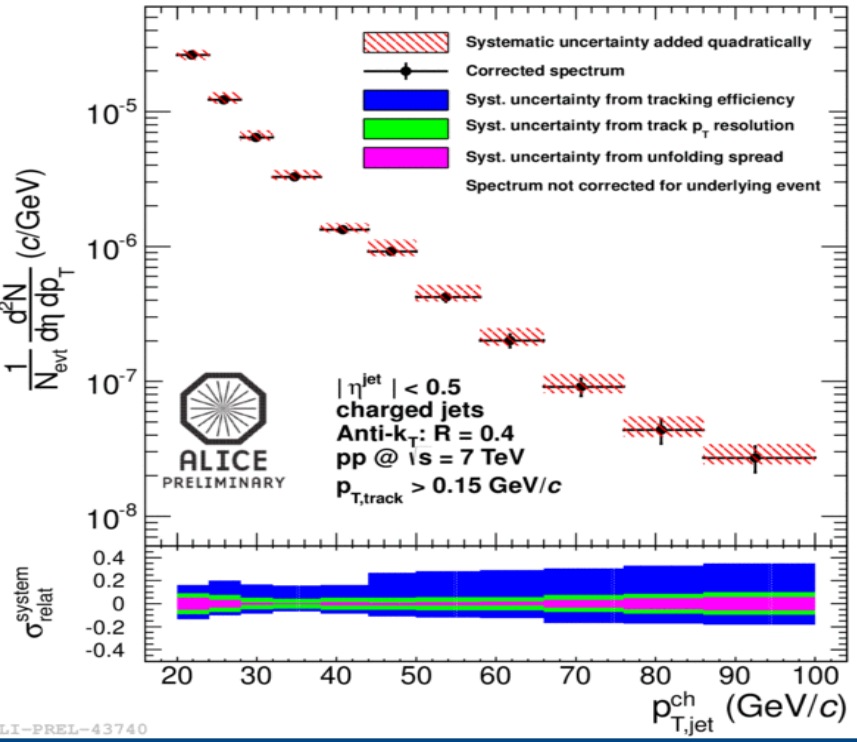
- VZERO
  - MB trigger and centrality
- ITS and TPC:
  - charged particle tracking
  - $|\eta| < 0.9$, p_T>150 MeV/c
- EMCal: neutral particles
  - $|\eta| < 0.7$, $1.4 < \varphi < \pi$
  - cluster E_T > 300 MeV
  - jet trigger

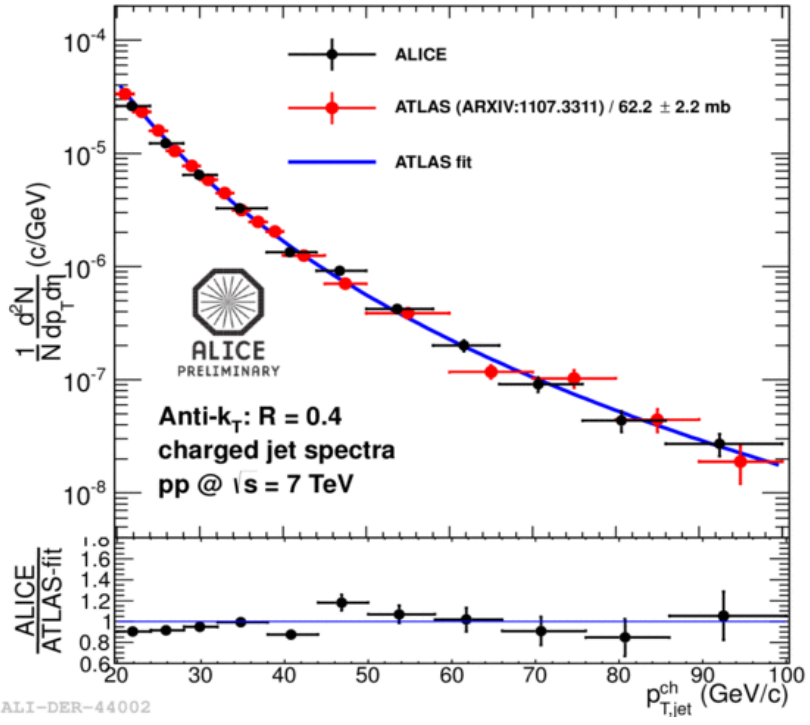
- Jets from charged tracks in central barrel
- FastJet anti-k_T R=0.2, ...,0.4, $|\eta^{jet}| < 0.9 - R$

full jets with EMCAL:
C. Nattrass, Thursday

pp charged jet cross sections

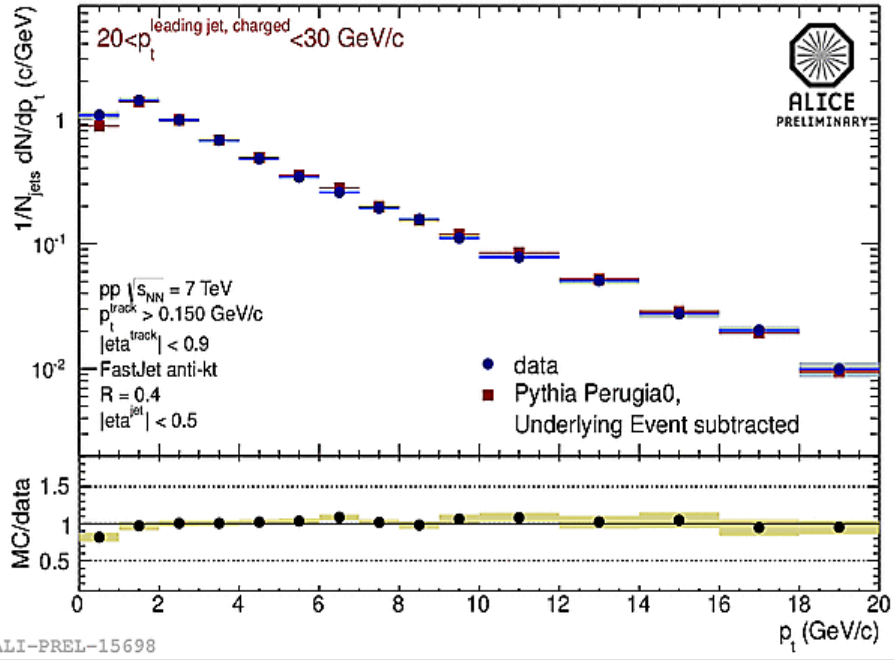
- Measured in minimum bias collisions at $\sqrt{s}$ = 7 TeV
- Good agreement with ATLAS charged jet measurements (despite slightly different acceptance, track p_T range and ALICE UE subtraction)

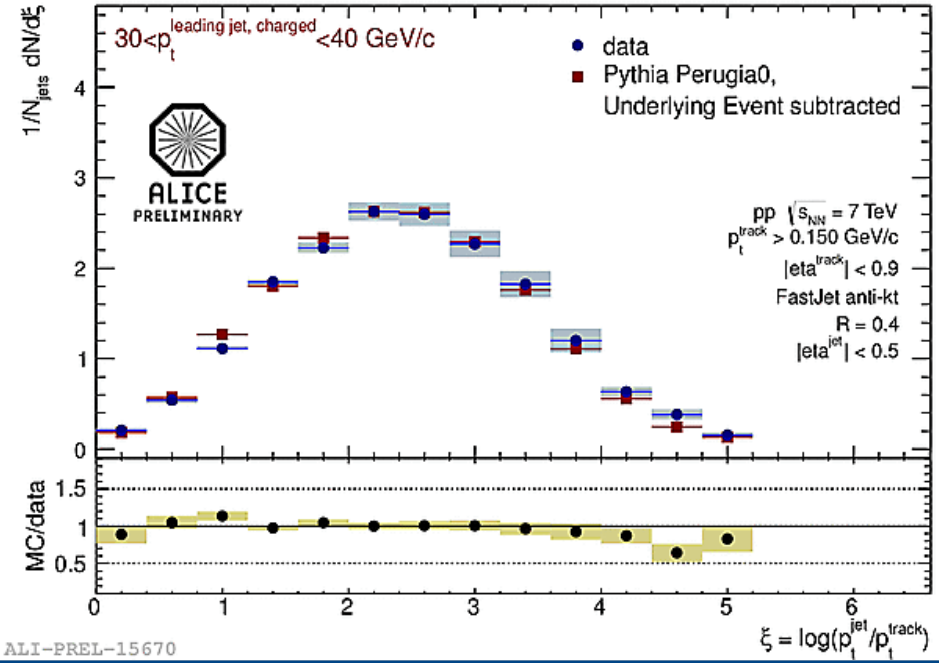




pp charged jet fragmentation at $\sqrt{s}$ = 7 TeV

- p_T distribution of particles in jet
- Scaled momentum $\xi = ln\,(p_{\mathrm{T}}^{\mathrm{jet,ch}}/p_{\mathrm{T}}^{\mathrm{particle}}) \rightarrow$ hump-backed plateau
- Underlying event subtracted from data + and PYTHIA MC

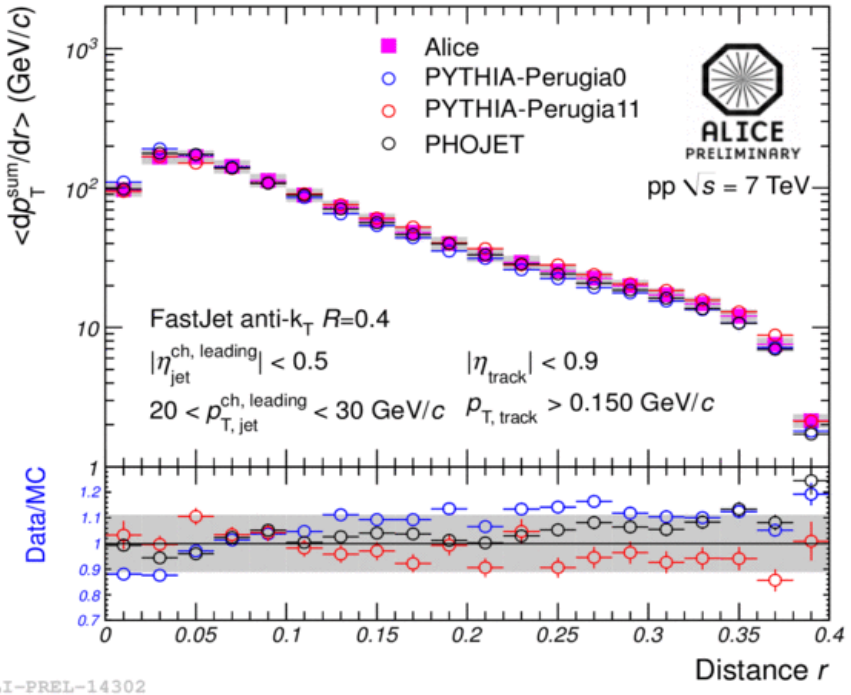




pp charged jet shapes at 7 TeV

- Transverse structure: p_T sum in radial slices
- Increasing collimation for higher p_T jets

20-30 GeV/c jets



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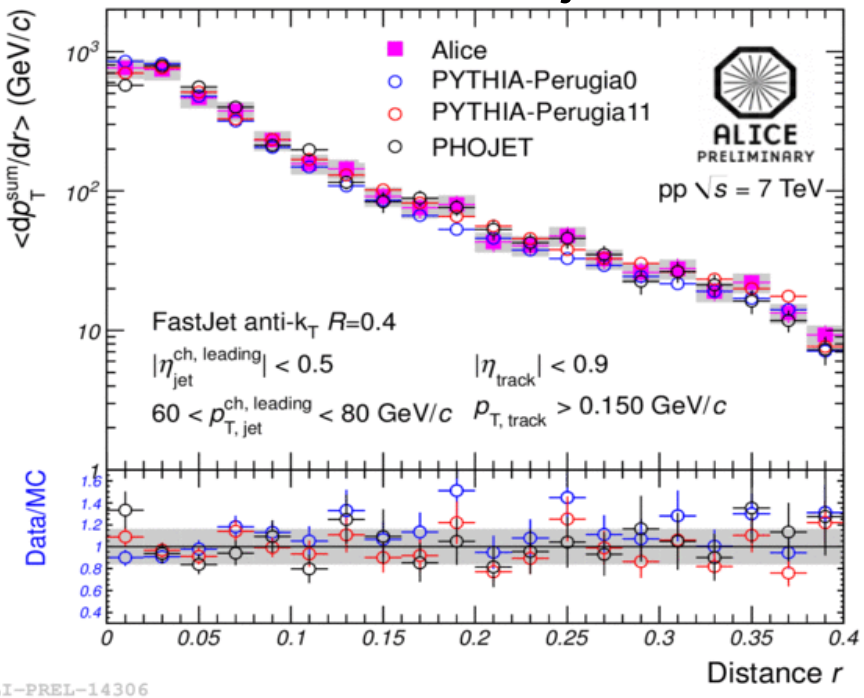
60-80 GeV/c jets



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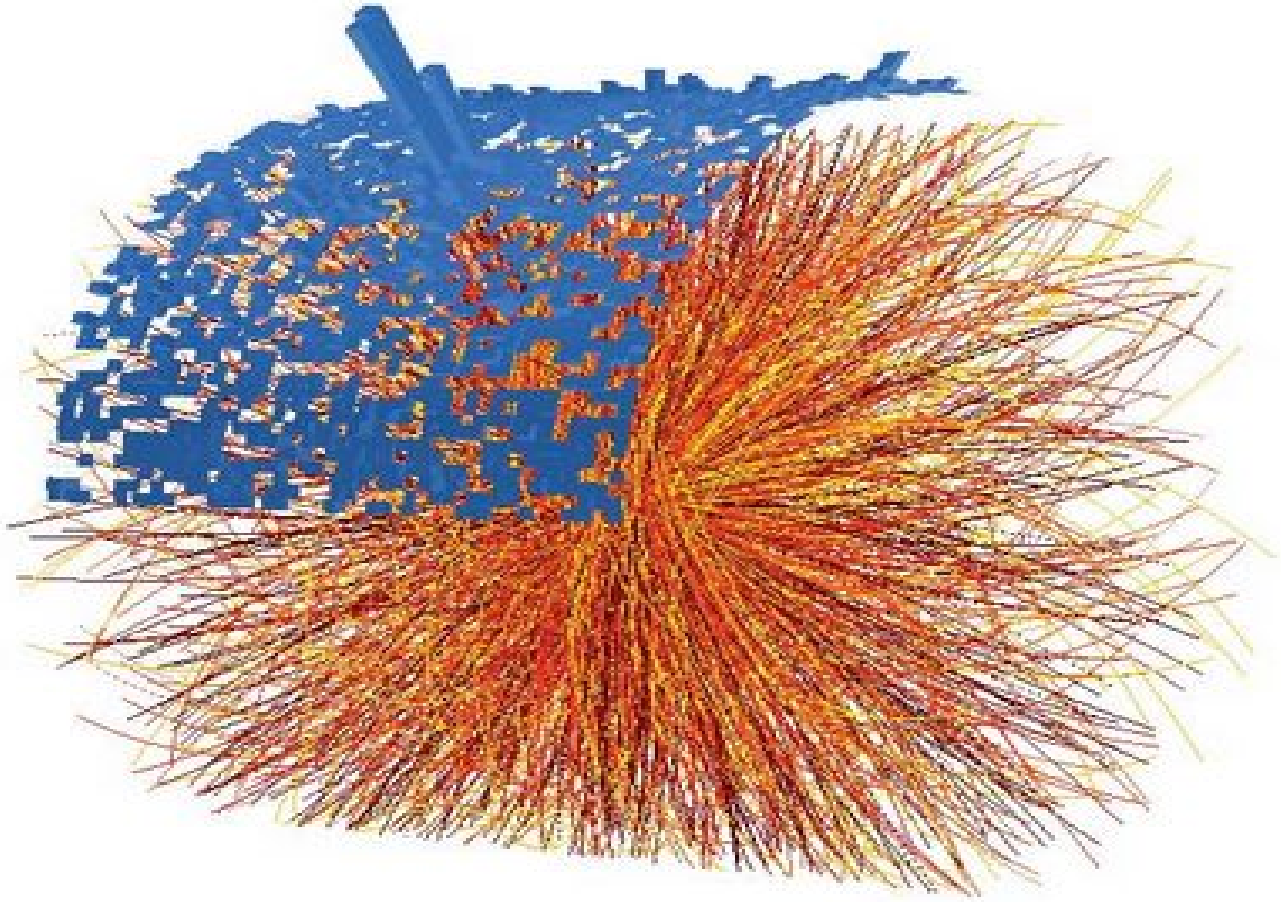
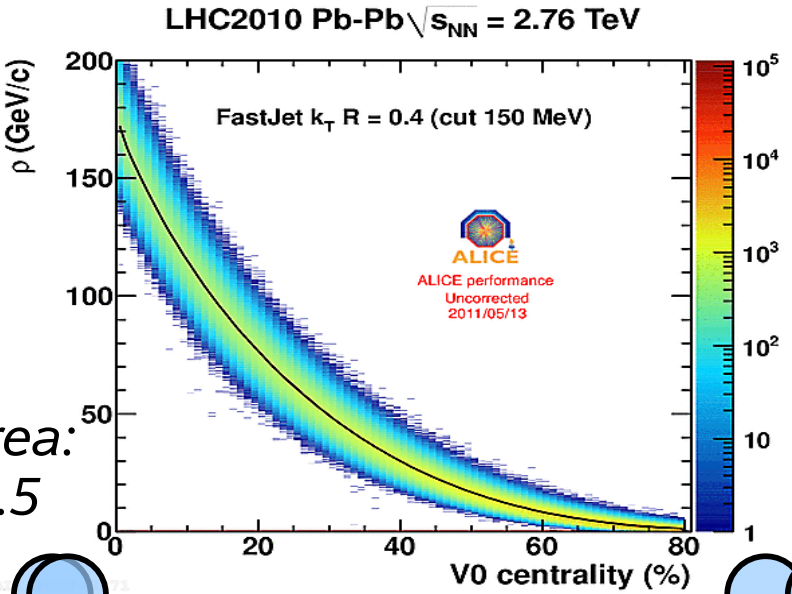
- Fragmentation and jet structure reasonably described by event generators

Jets in Heavy-Ion Collisions

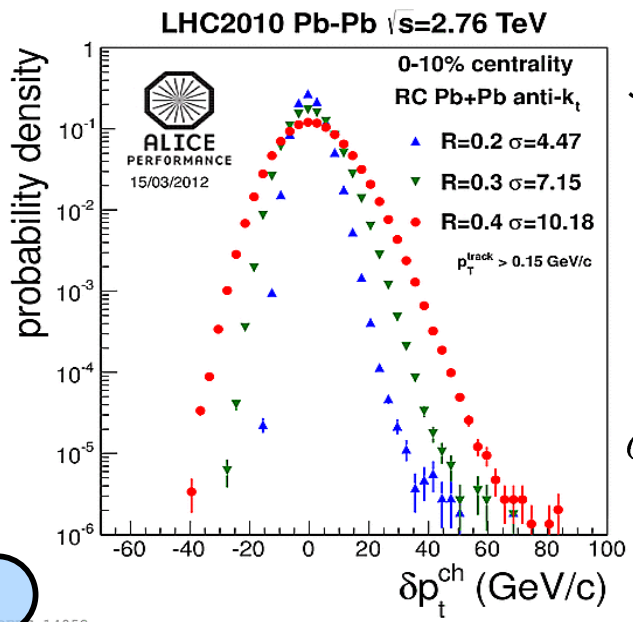


Jets in heavy-ion collisions

- Underlying event: large abundance of low momentum particles
  - uncorrelated background to ‘true’ hard scattering
  - purely combinatorial 'low'-momentum jets
- Average Background ρ : median p_T density / area from k_T clusters
- Subtract jet by jet: $p_{\mathrm{T}}^{\mathrm{jet}} = p_{\mathrm{T,raw}}^{\mathrm{jet}} - \rho \times A$
- Correct for background fluctuations and detector effects via unfolding



jet area: ~ 0.5

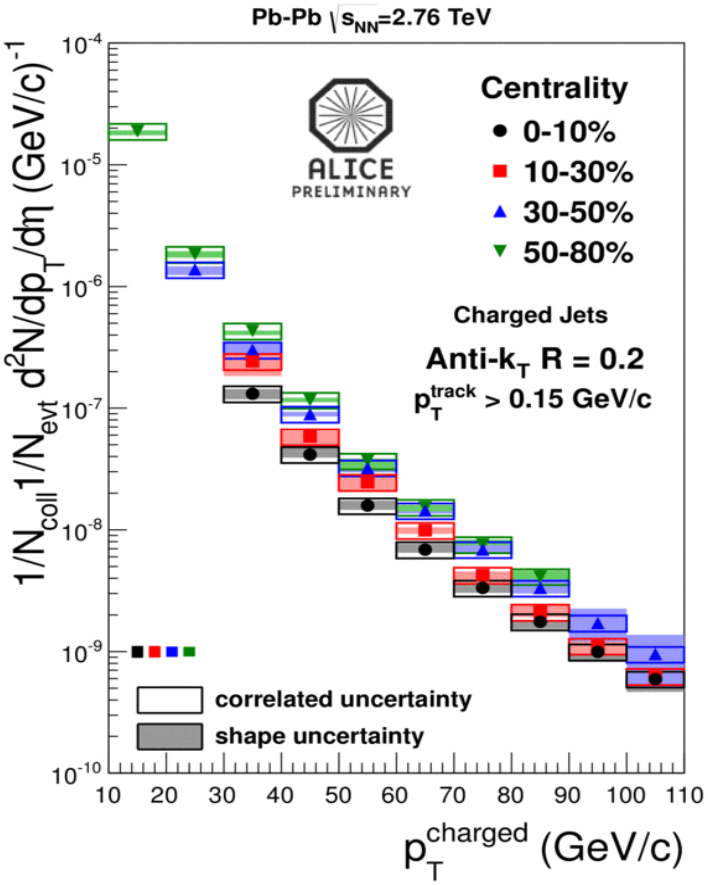


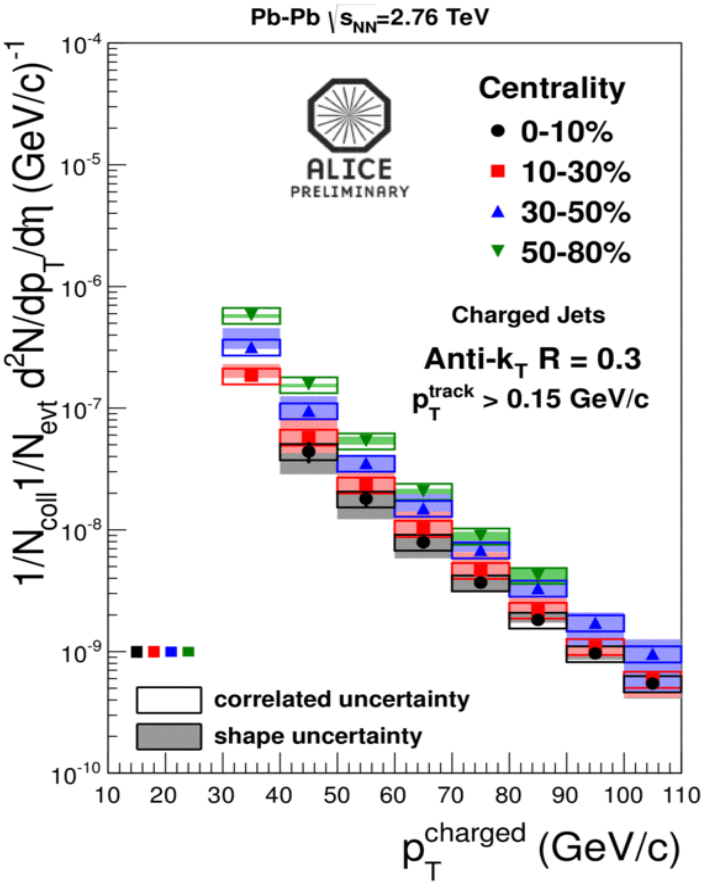
JHEP 03 (2012) 053

$$\delta p_{\mathrm{T}} = p_{\mathrm{T}}^{\mathrm{cone}} - \rho \times \pi \mathrm{R}^2$$

Charged jet spectra

- $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV, R = 0.2, 0.3
- Strong centrality dependent suppression





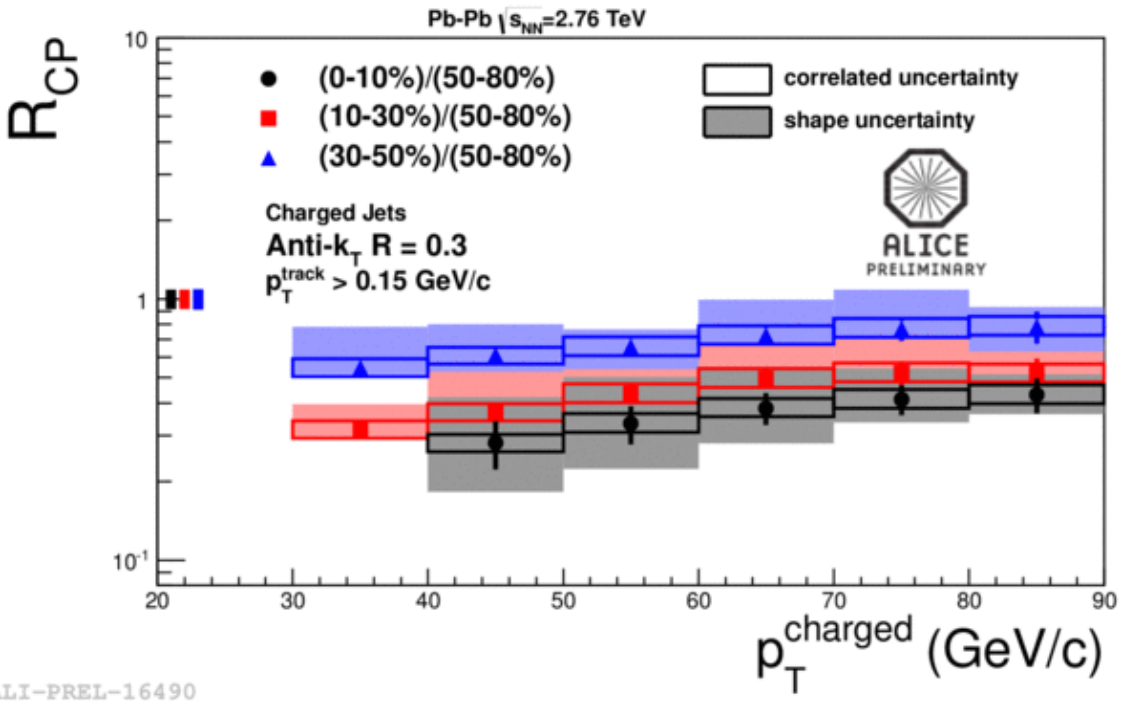
Charged jet R_{CP}

- R_{CP} : reference from peripheral Pb-Pb events

$$R_{CP}(p_{\mathrm{T}}) = \frac{\langle N^{p}_{coll} \rangle}{\langle N^{c}_{coll} \rangle} \frac{\mathrm{d}^2 N^{\mathrm{c}}_{\mathrm{ch}}/\mathrm{d}\eta\,\mathrm{d}p_{\mathrm{T}}}{d^2 N^{\mathrm{p}}_{\mathrm{ch}}/\mathrm{d}\eta\,\mathrm{d}p_{\mathrm{T}}}$$

- ~ similar to charged hadrons
- Momentum dependent suppression

R = 0.3



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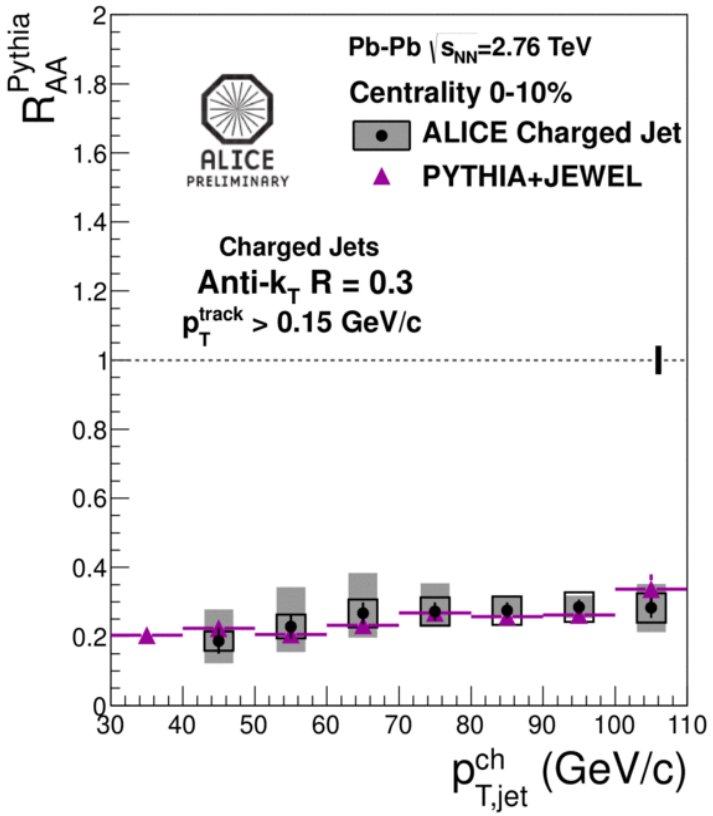
Comparison to models

- Charged jet R_{AA} with PYTHIA pp MC reference
- Well described by JEWEL energy loss MC



PYTHIA:
JHEP 05, 026 (2005)

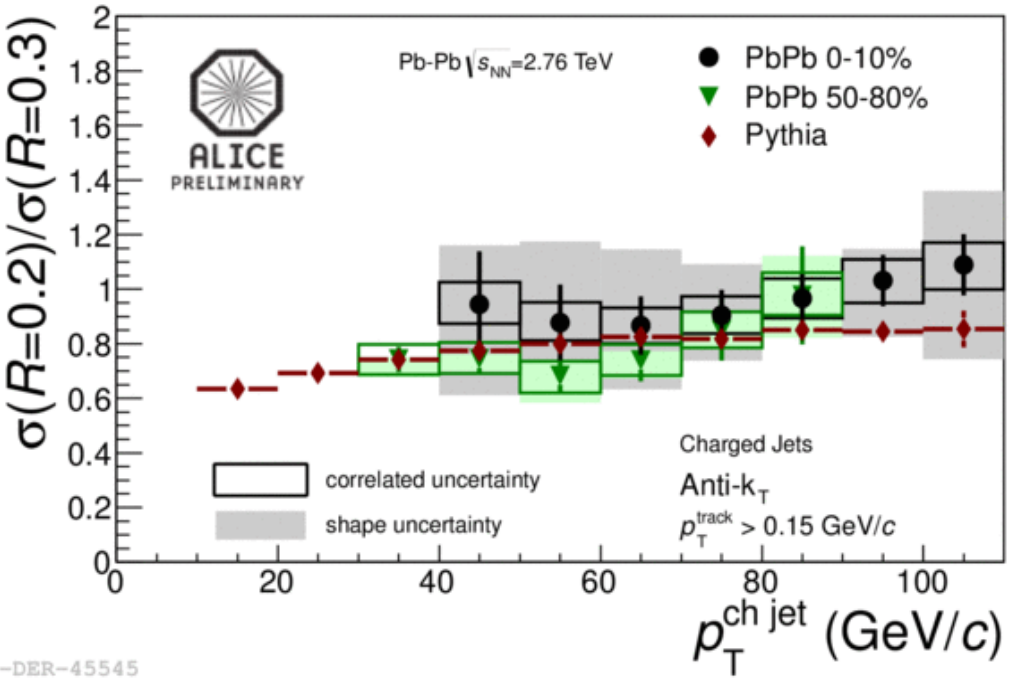
JEWEL:
hep/ph 1212.1599

Jet structure

- Spectral ratio R=0.2 / 0.3: indirect measure of jet structure
- Consistent with PYTHIA

  → 'vacuum fragmentation' in small cones

  (for detected energy) ?



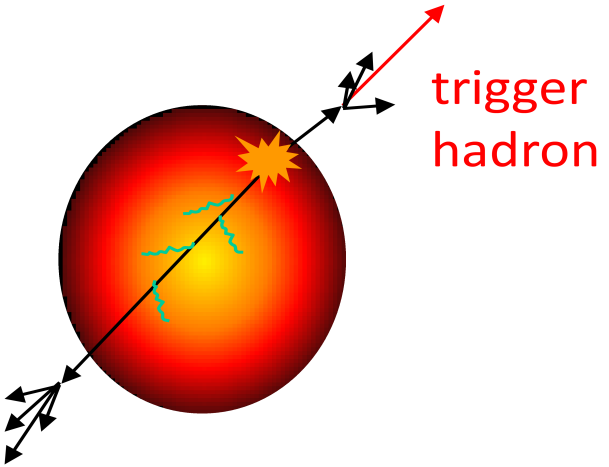
PYTHIA:
JHEP 05, 026 (2005)

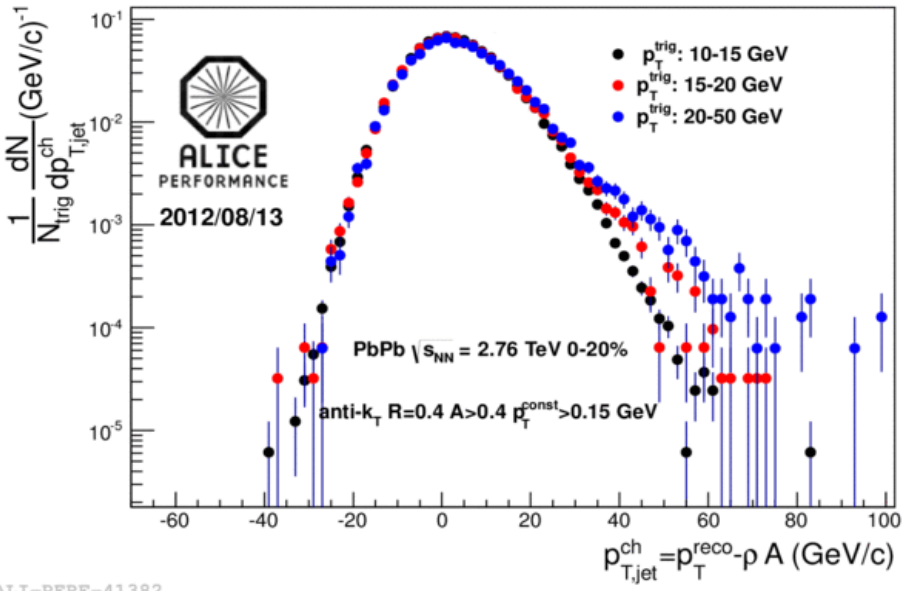
Hadron triggered recoil jets

- Jets recoiling from charged hadron
- Δ_{recoil}: remove residual combinatorial jets
  $\rightarrow$ extended low p_{T} reach and larger R

(G. de Barros, arXiv: 1208.1518)

- Sensitive to:
  - Q^2 dependence of jet quenching
  - path length dependence of energy loss





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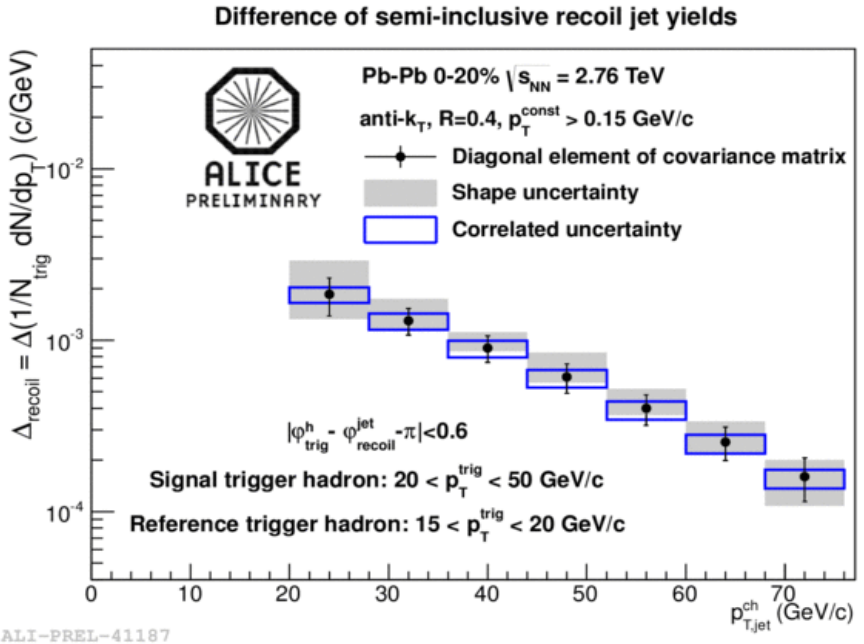

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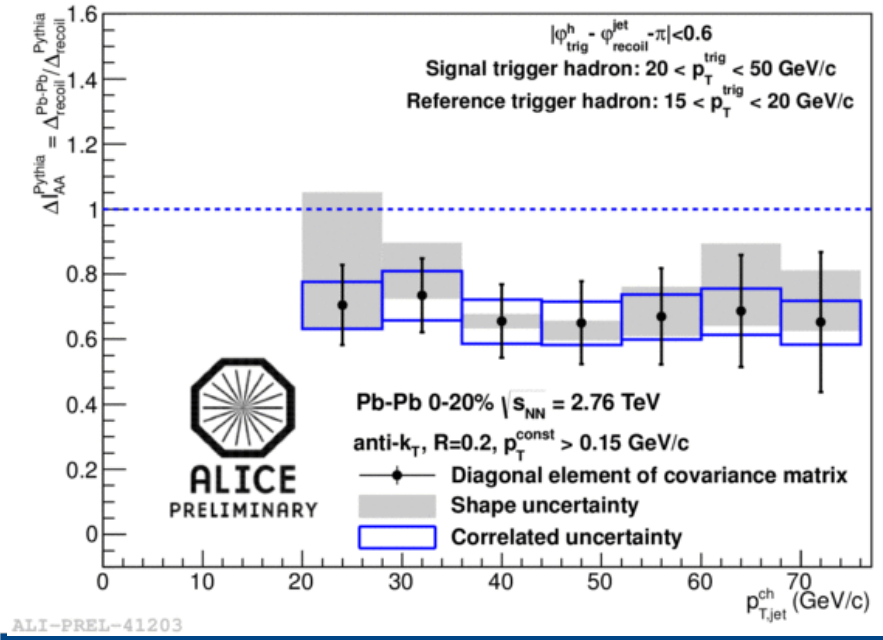
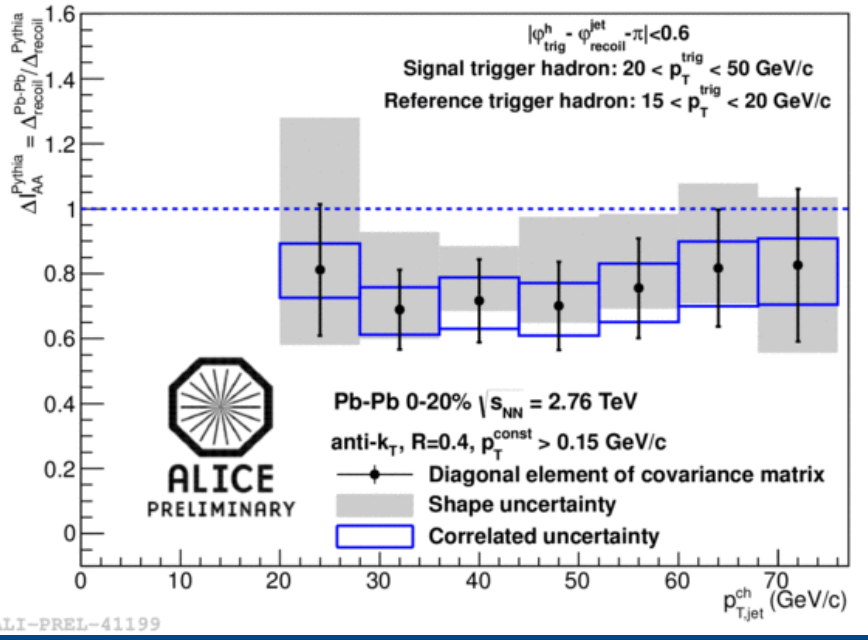
ΔI_{AA}

- ΔI_{AA} : Δ_{recoil} divided by PYTHIA reference
- $\Delta I_{AA} > R_{AA}$:
  - tangential emission? Medium-Shower interaction ?
  - gluon filtering + Q^2 bias ?
  - flatter parton spectrum?
- Similar for both R: no large energy redistribution

R = 0.2

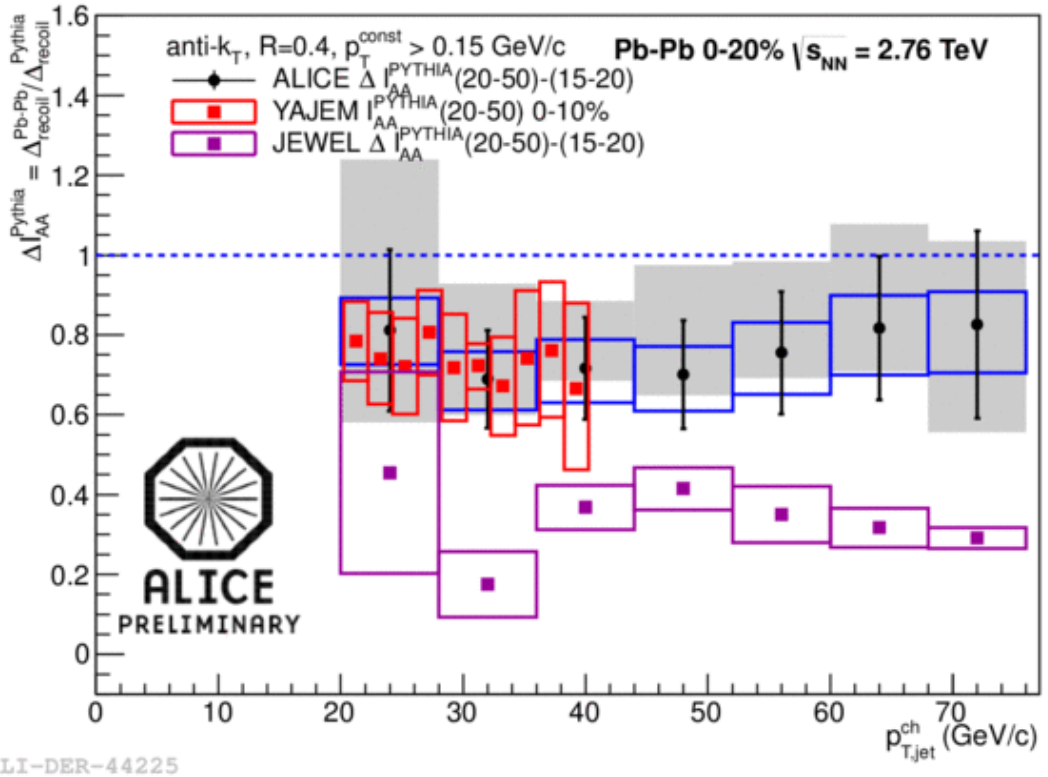


R = 0.4



ΔI_{AA} : model comparison

- Well reproduced by YAJEM
- Strong discrepancy to JEWEL+PYTHIA (preliminary)
- Note: R_{AA} and ΔI_{AA} sample energy loss differently



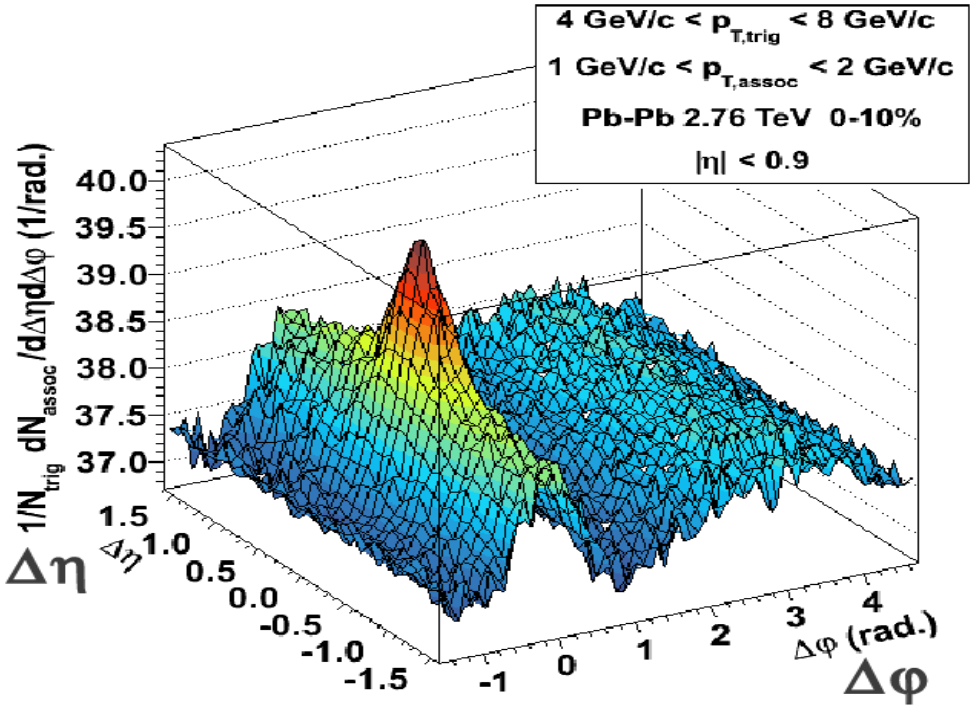
YAJEM: Phys. Rev. C 83 (2011) 02490867

Di-Hadron Correlations

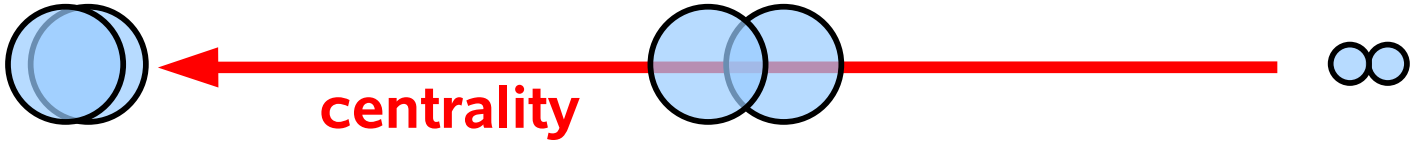
Di-Hadron correlations

- allow to study low p_T fragmentation in presence of a large background
- angular correlations in $(\Delta\phi, \Delta\eta)$ between intermediate p_T trigger and low p_T associated charged particles
- remove long range correlations (mostly flow) subtracting side-bands $1 < |\Delta\eta| < 1.6$

  → study near-side
- corrections for tracking efficiency, secondaries contamination and acceptance

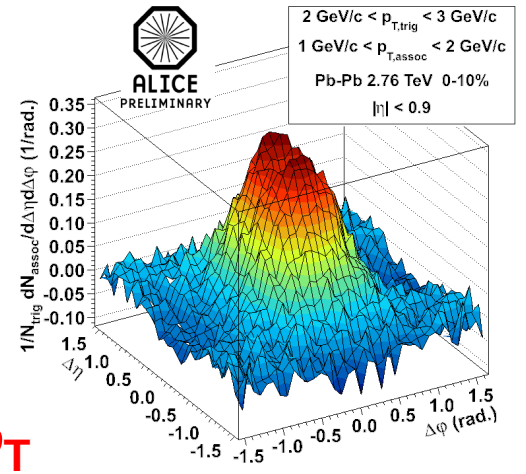


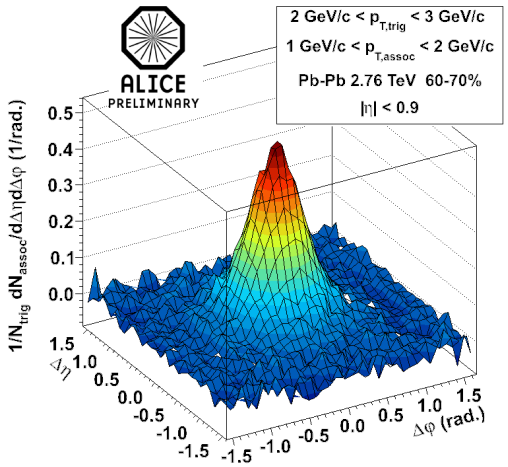
Shape evolution

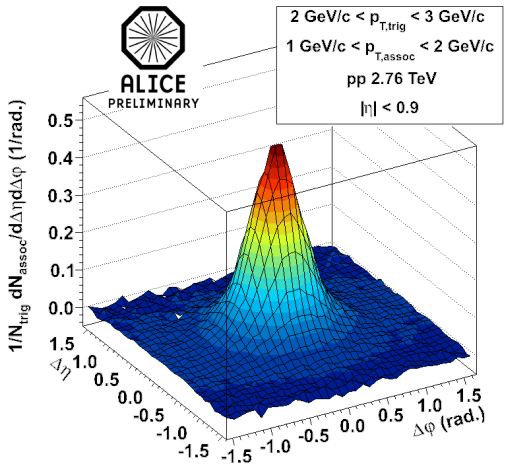


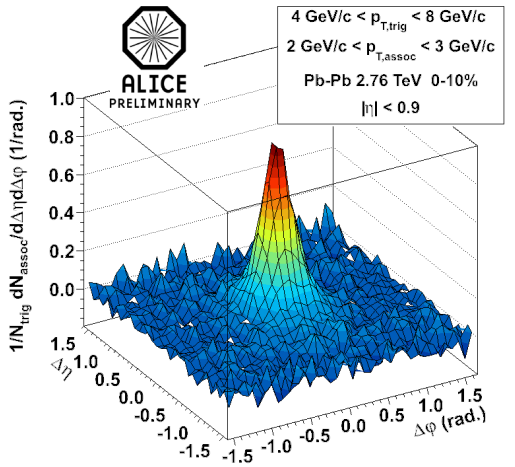
centrality

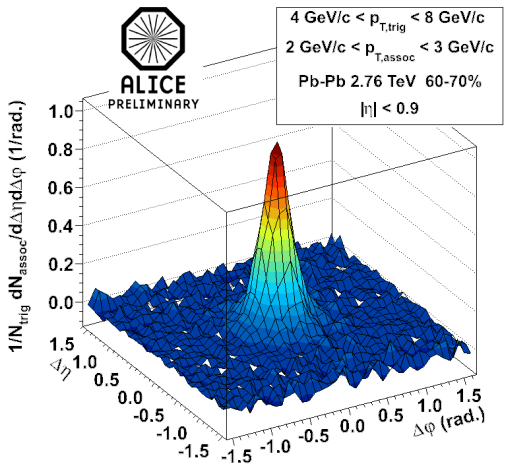
p_T

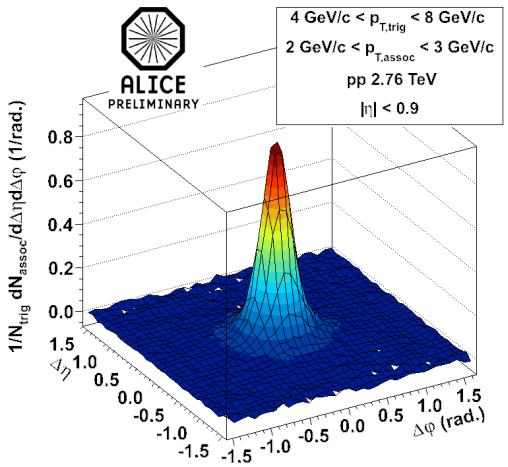










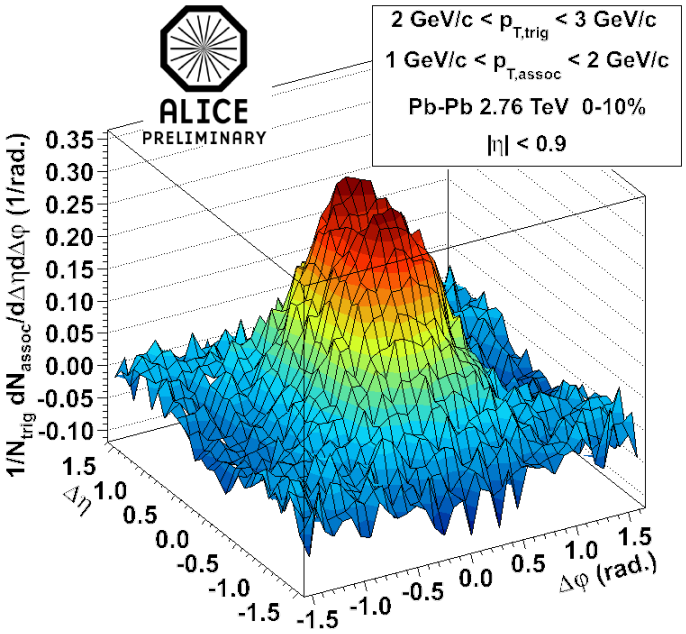


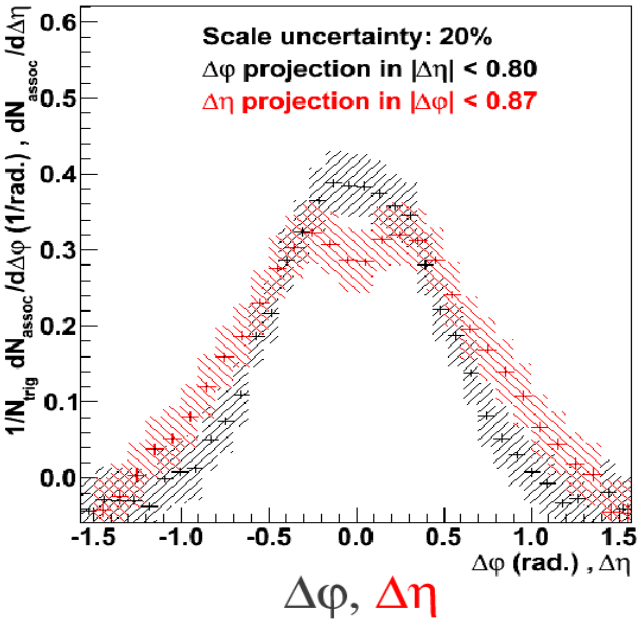
Lowest ($p_{T,trig}$,$p_{T,assoc}$) bin

- $2 < p_{T,trig} < 3$ GeV/c , $1 < p_{T,ass} < 2$ GeV/c
- strong asymmetry

  → fragments coupling to longitudinal flow ?

  (compare *N. Armesto, C. Salgado, U. A. Wiedemann, PRL 93 242301 (2004)*)





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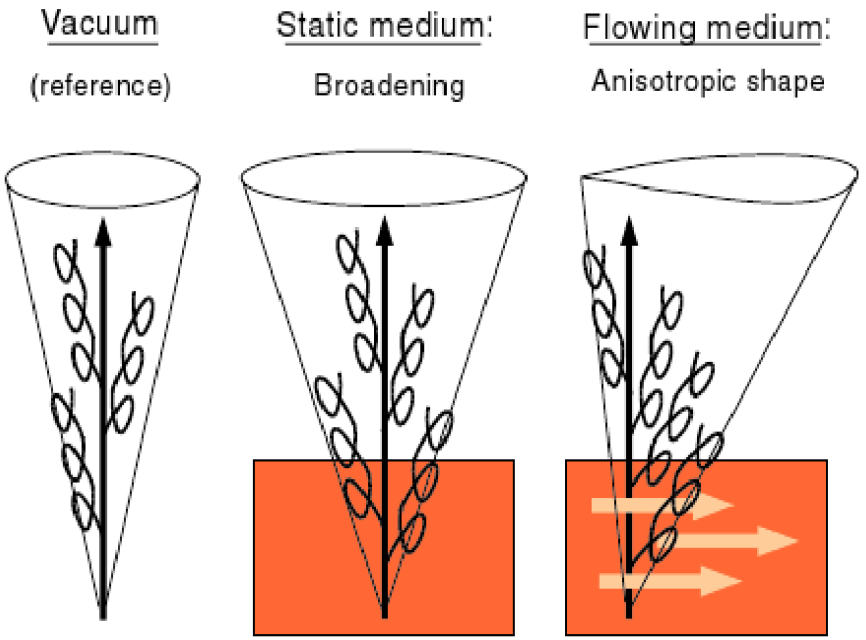


N. Armesto, C. Salgado, U. A. Wiedemann
PRL 93 242301 (2004)

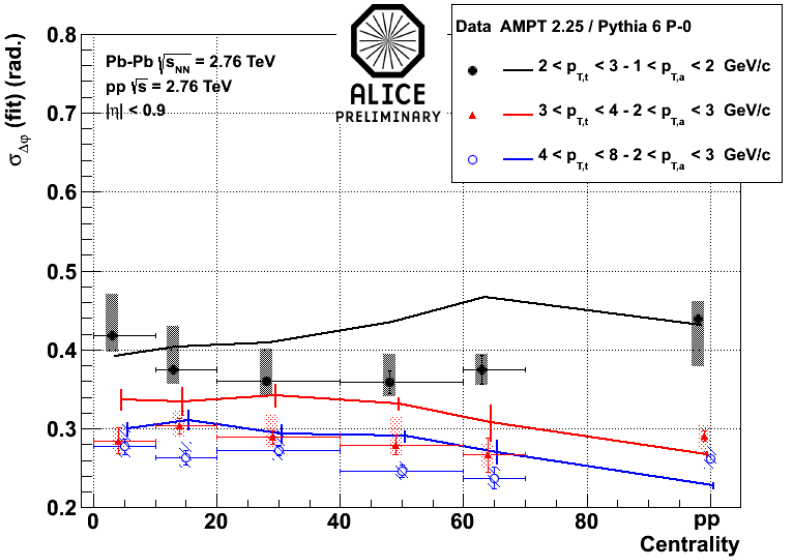
Model comparison

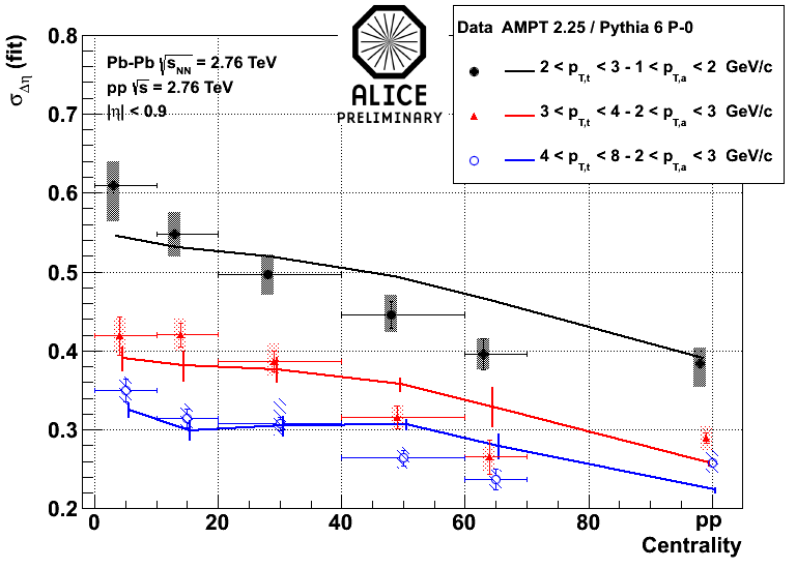
- Double 2-D Gaussian fit:

$$N(\alpha\, Gauss(0,0,\Delta\phi,\Delta\eta) + (1-\alpha)\, Gauss(0,0,\Delta\phi,\Delta\eta))$$

- Asymmetry reproduced by AMPT 2.25 *(Phys. Rev. C 72, 064921 (2005))*
- AMPT: describes collective effects (flow) at LHC,

  jet-medium interactions: parton transport, recombination
- pp: PYTHIA Perugia0 *(Phys. Rev. D 82, 074018 (2010))*





Conclusions & outlook

- Spectra, jet fragmentation & structure in pp
- Charged jet spectra and first investigations of jet structure in Pb-Pb
- Strong, energy dependent suppression of jet yield, jet structure consistent with pp

  → full jets R_{AA}: talk by C. Nattrass, Thursday

- Hadron triggered recoil jets allow to go to higher R with minimal fragmentation bias

  → results for R=0.5 under preparation

- Di-Hadron correlations show asymmetric jet broadening at lowest constituent p_T

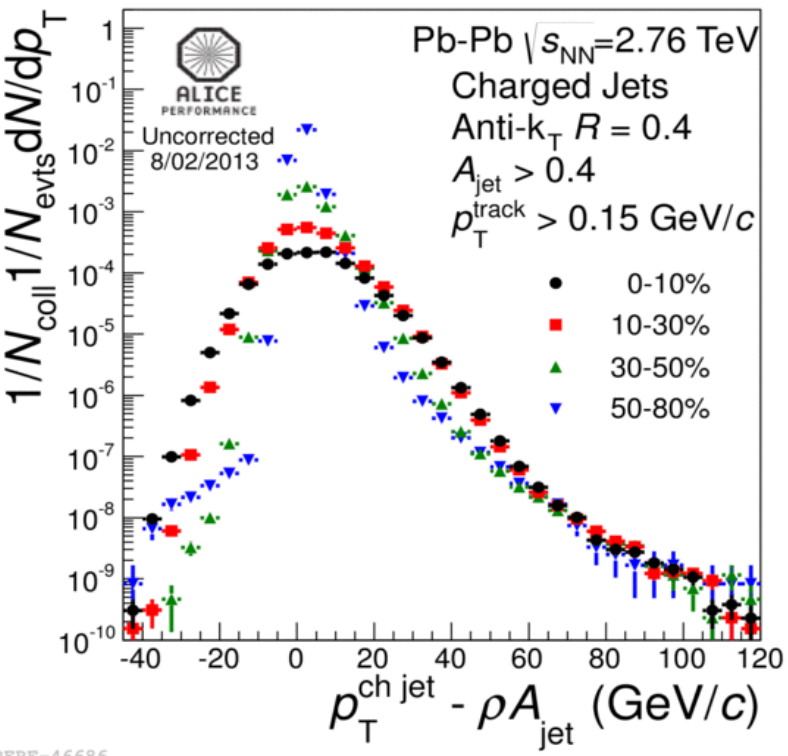
- backup -

- Tracking jets:
  - $|\eta|^{track} < 0.9$
  - R = 0.4, $|\eta|^{jet} < 0.5$
  - $p_T^{track} > 0.150$ GeV/c
  - hybrid approach for uniform tracking efficiency: combine tracks with / without full ITS
  - momentum resolution: $\delta dp_T/p_T$ = 4% (7%) at 40 GeV/c
- Full jets including EMCAL:
  - $|\eta| < 0.7$, $1.4 < \Phi < \pi$
  - cluster $E_T > 300$ MeV
  - hadronic correction for charged particles

Raw charged jet spectra

- Less background by smaller R
- Caveat: may also reduce sensitivity to jet quenching

R = 0.4



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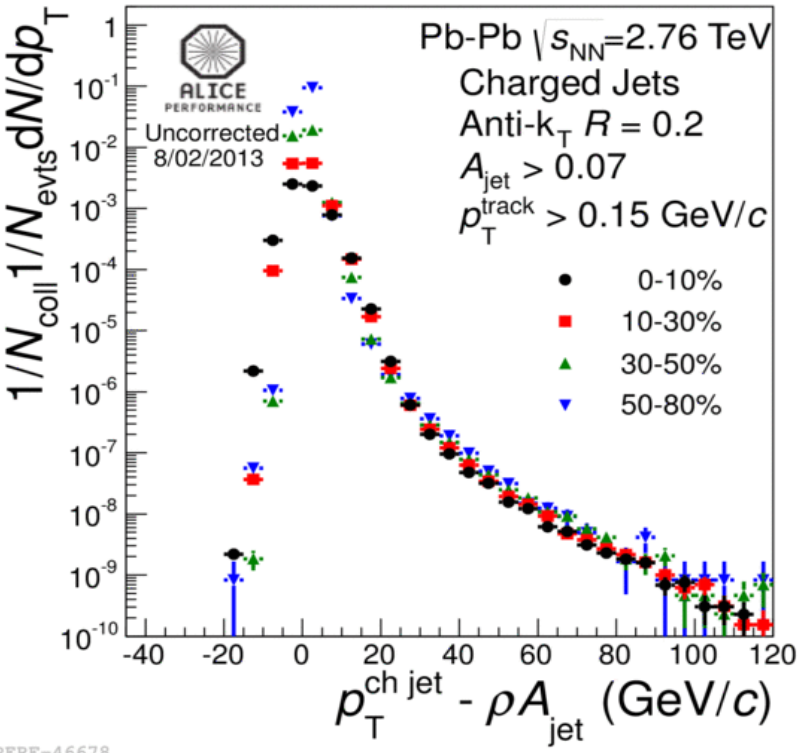
R = 0.2



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Full jet R_{AA}

- Complete jet reconstruction from charged particles + EMCal
- R=0.2, 5 GeV/c fragmentation bias to reduce combinatorial jets
- Strong jet suppression: $R_{AA} \leq 0.5$