

Measurement of jet shapes in 2.76 TeV PbPb collisions with CMS

Yaxian MAO
for the CMS Collaboration



VANDERBILT
UNIVERSITY

Quark Matter Conference, Washington DC

August 18th, 2012



Jet Quenching in CMS



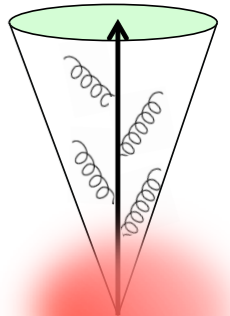
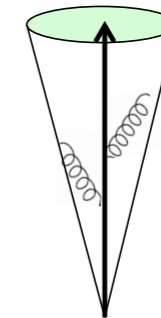
CMS Experiment at LHC, CERN
Data recorded: Sun Nov 14 19:31:39 2010 CEST
Run/Event: 151076 / 1328520
Lumi section: 249

1. Di-jet properties (PRC 84 (2011) 024906; PLB 712 (2012) 176;
arXiv:1206.0206)

2. Anatomy of the jets: First detailed study of jet
structure in HI

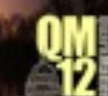
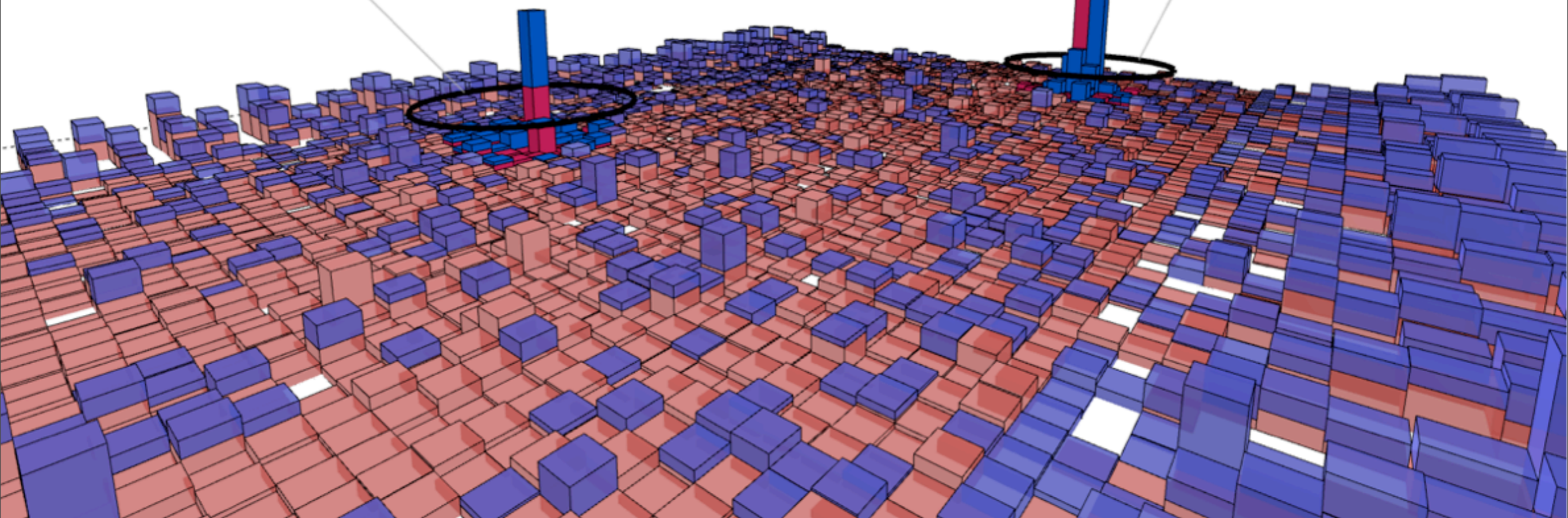
Vacuum
(pp reference)

Jets in Medium
(jet broadening)



Jet 0, pt: 205.1 GeV

Jet 1, pt: 70.0 GeV

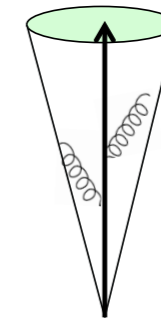


Objective

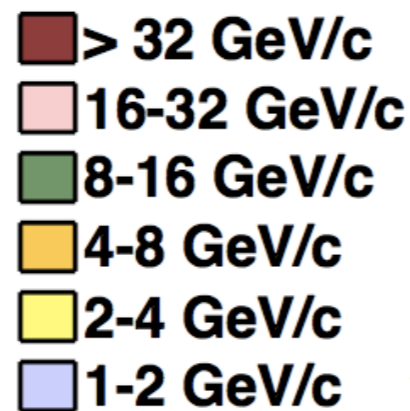
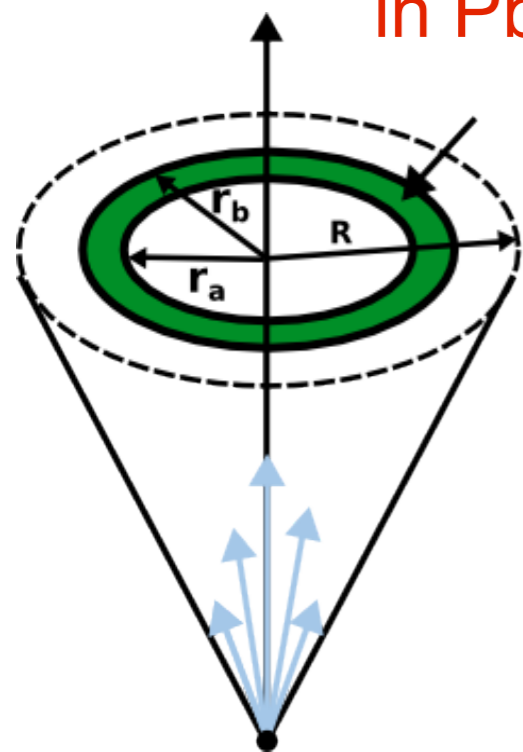
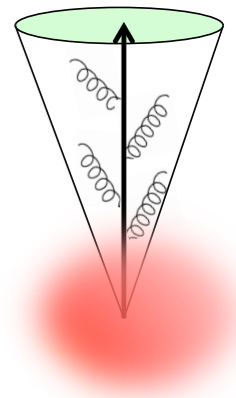
- Understand how jets interact with the QGP medium by studying the energy flow inside the jet

→ question to address: is the jet energy in PbPb redistributed radially ?

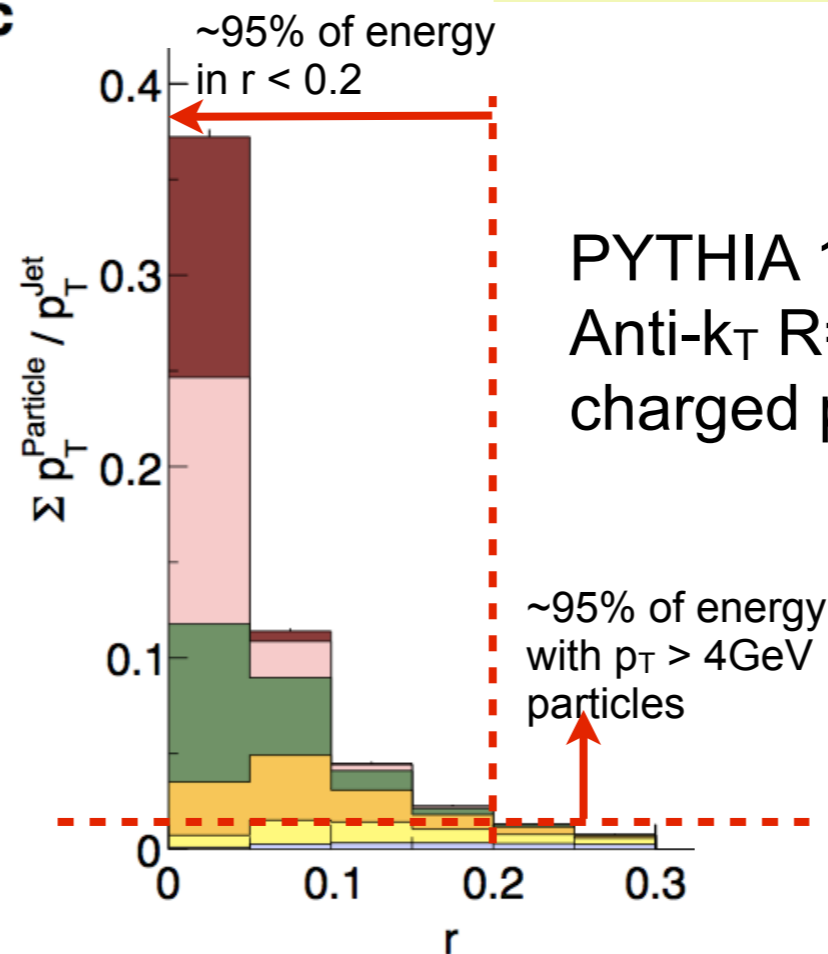
Vacuum
(pp reference)



Jets in Medium
(jet broadening)



G. Roland's talk, Monday

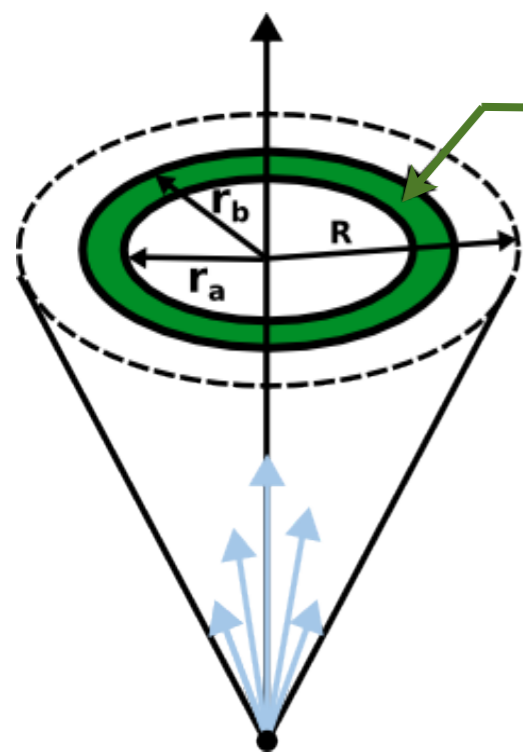


PYTHIA 100 GeV inclusive jet
Anti- k_T $R=0.3$ jet
charged particle energy fraction

$$r = \sqrt{(\eta_{\text{jet}} - \eta_{\text{ch}})^2 + (\varphi_{\text{jet}} - \varphi_{\text{ch}})^2}$$

Jet shape definition

Differential jet shape: average fraction of the jet p_T inside an annulus in the η - ϕ plane concentric to the jet axis



$$\rho(r) = \frac{1}{f_{ch}} \frac{1}{\delta r} \frac{1}{N_{jet}} \sum_{jets} \frac{p_T(r - \delta r / 2, r + \delta r / 2)}{p_T^{jet}},$$

$$\int \rho(r) dr \equiv 1$$

f_{ch} : p_T fraction carried by charged particles

N_{jet} : total number of selected jets

$\delta r = 0.05$ is annulus width

HI theory papers:

arXiv:0810.2807, I. Vitev, et. al

arXiv:0907.4706v2, N. Amesto, et. al

CMS pp results at $\sqrt{s} = 7$ TeV :
JHEP06 (2012) 160

Analysis strategy

- **inclusive jet selection:**

- ➔ Anti- k_T particle flow jet finding algorithm

- ➔ $R = 0.3, |\eta| < 2.0, p_T^{\text{jet}} > 100 \text{ GeV}/c$

- **track selection:**

- ➔ $|\eta| < 2.4, p_T > 1 \text{ GeV}/c$

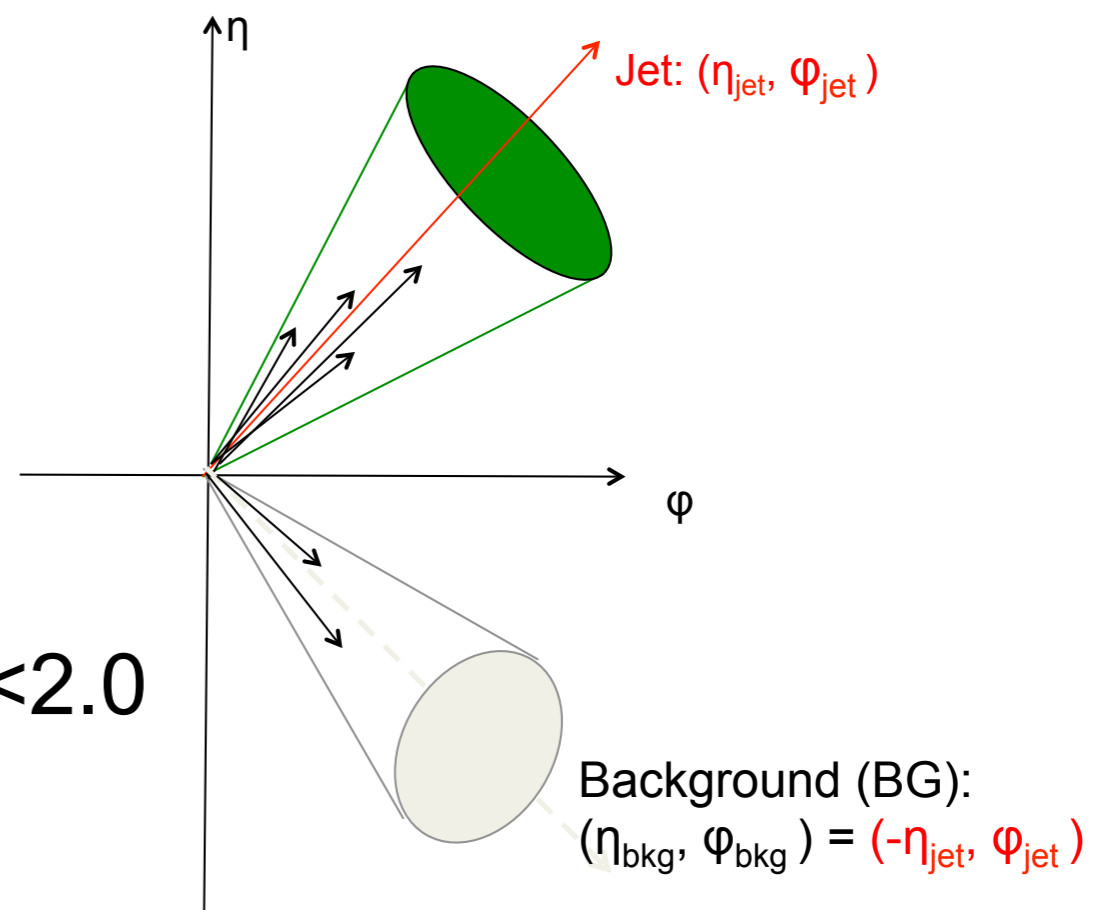
- **background subtraction:**

- ➔ η reflected cone : $R = 0.3, 0.3 < |\eta| < 2.0$

- **pp reference:**

- ➔ smear pp jet spectra by the difference of the PbPb and pp jet resolution

- ➔ re-weighted to match distributions in PbPb



Systematic uncertainties

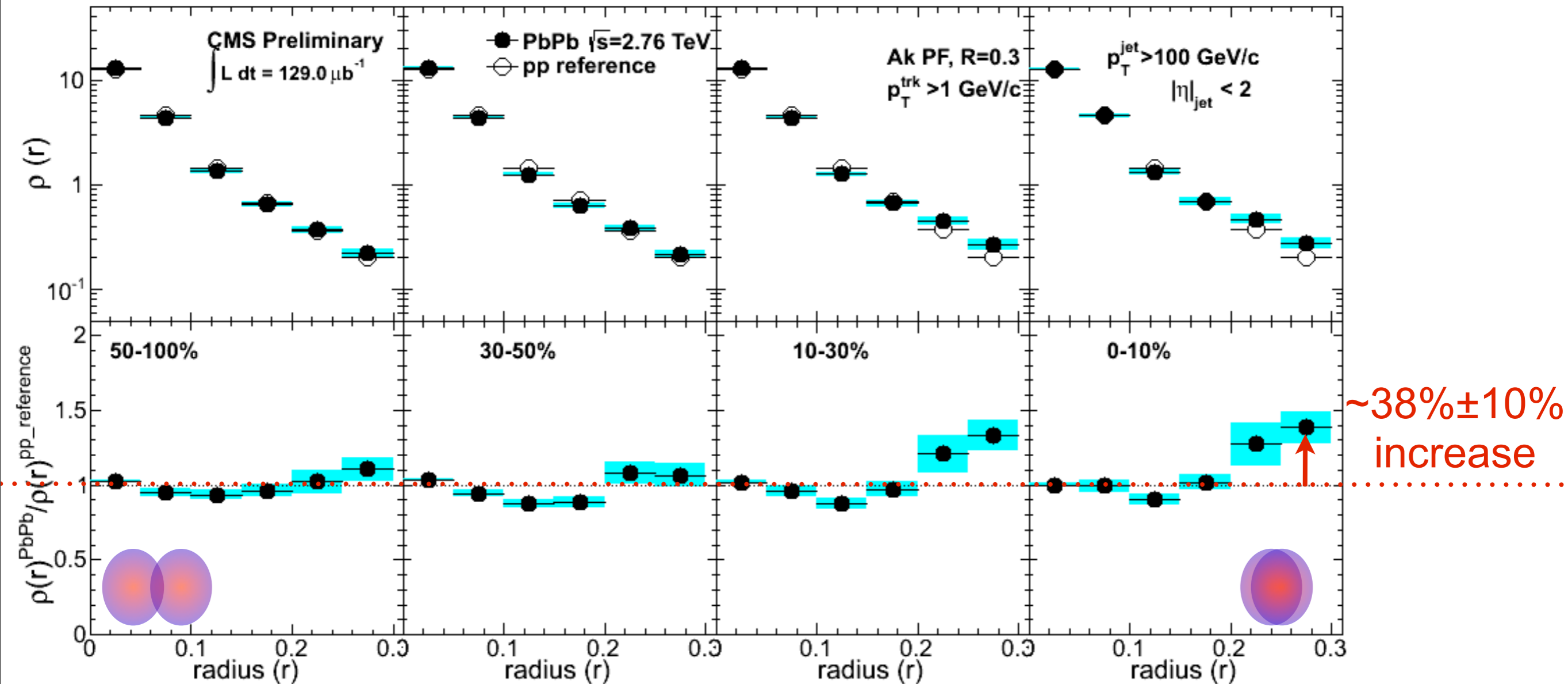
P. Kurt's talk, Wednesday

- **Background uncertainty**
 - ➔ difference of the jet shapes by using η -reflected cone background and event mixing background subtraction
- **Radius-dependent tracking efficiency**
 - ➔ tracking efficiency closure
- **Jet energy resolution and jet energy scale**
 - ➔ jet p_T dependent jet shape

source	radius $r \leq 0.1$		radius $r \geq 0.2$	
	spectra	ratio	spectra	ratio
Bkg subtraction	1%	1%	8%	8%
tracking efficiency	3%	3%	9%	7%
Jet energy resolution & scale	1%	<1%	7%	2%
total	~4%	~4%	~14%	~10%

Differential jet shapes (PbPb vs pp: “ R_{AA} ”)

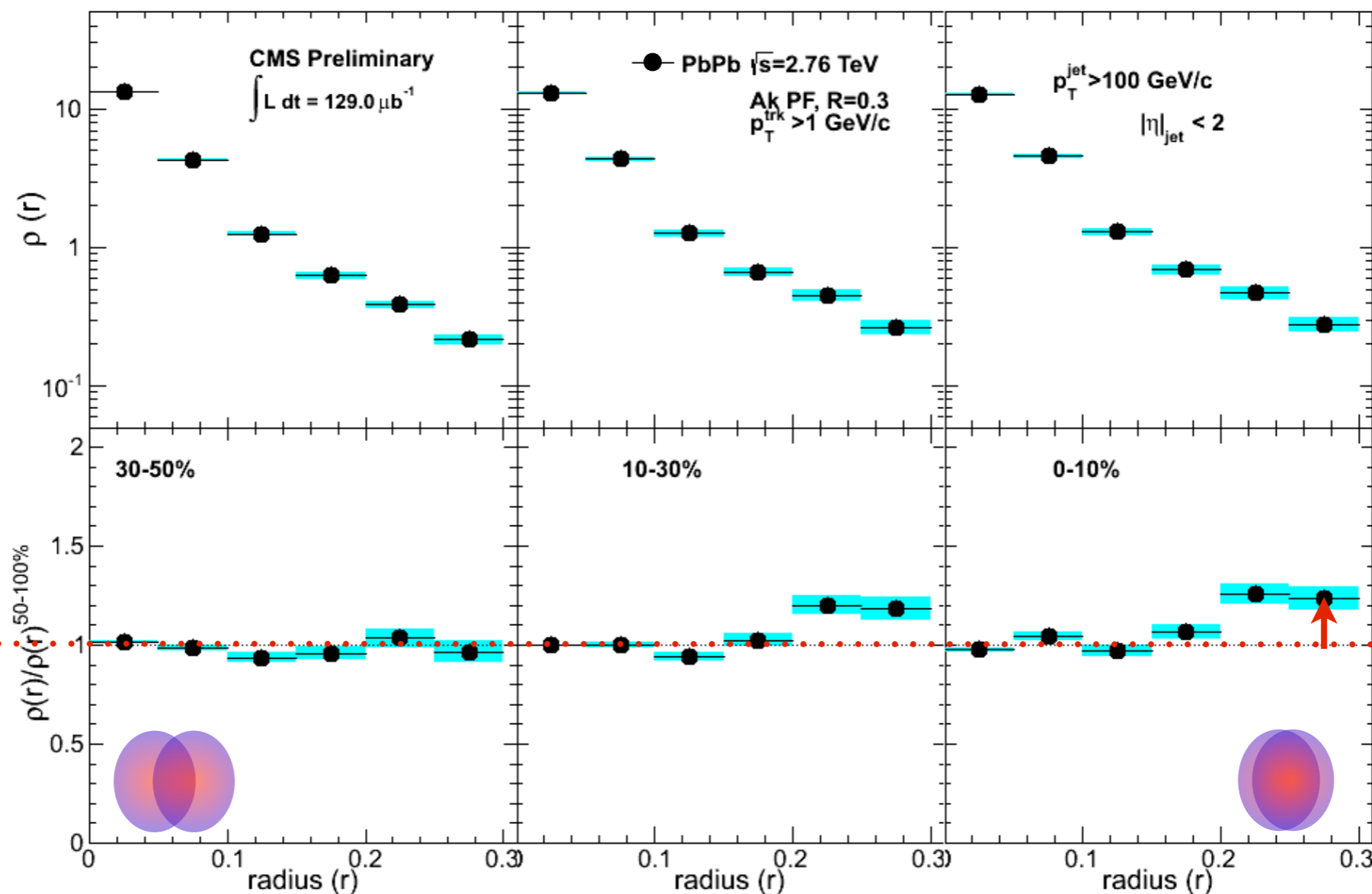
In presence of medium effect \rightarrow ratio expected to deviate from 1



- Ratio close to unity for non-central (30-100%) collisions
- **A rising trend** towards large radius r for mid-central (10-30%) and most central (0-10%) collisions

Differential jet shapes (central vs peripheral: “R_{CP}”)

In presence of medium effect → ratio expected to deviate from 1
Reduce the systematic uncertainties



- **A rising trend** towards large radius r for mid-central (10-30%) and most central (0-10%) collisions

Conclusions

- The jet shapes in PbPb collisions at $\sqrt{s} = 2.76$ TeV have been measured for the first time
- Measured jet shapes are compared in PbPb and pp collisions at the same center-of-mass energy:
 - For semi-peripheral (30-50%) and peripheral collisions (50-100%) the shape is similar to the shape in pp reference
 - For central collisions (0-30%) the results indicate a moderate, but significant modification of the jet structure
 - Observation is consistent with the jet quenching picture

Thank you very much!

谢谢！