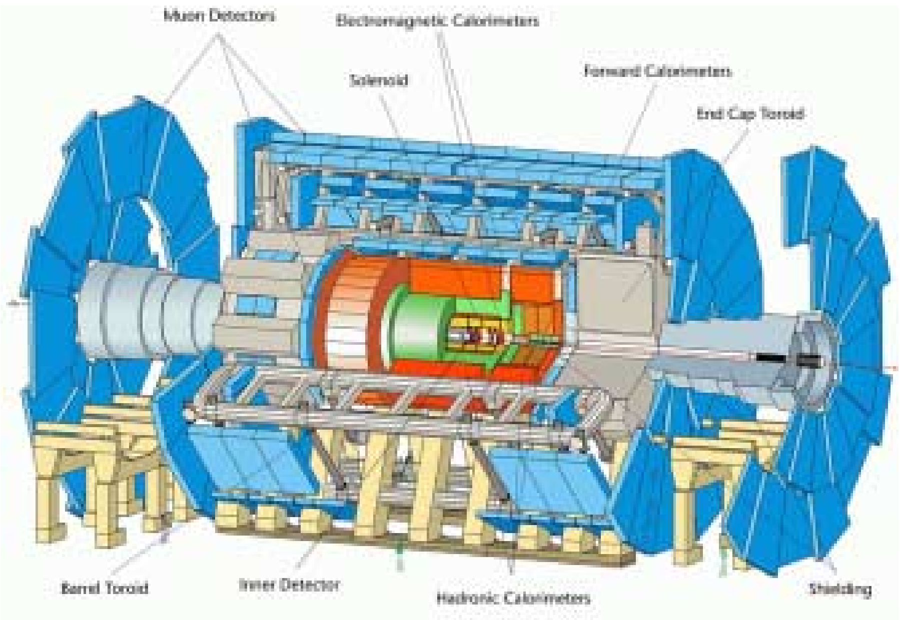
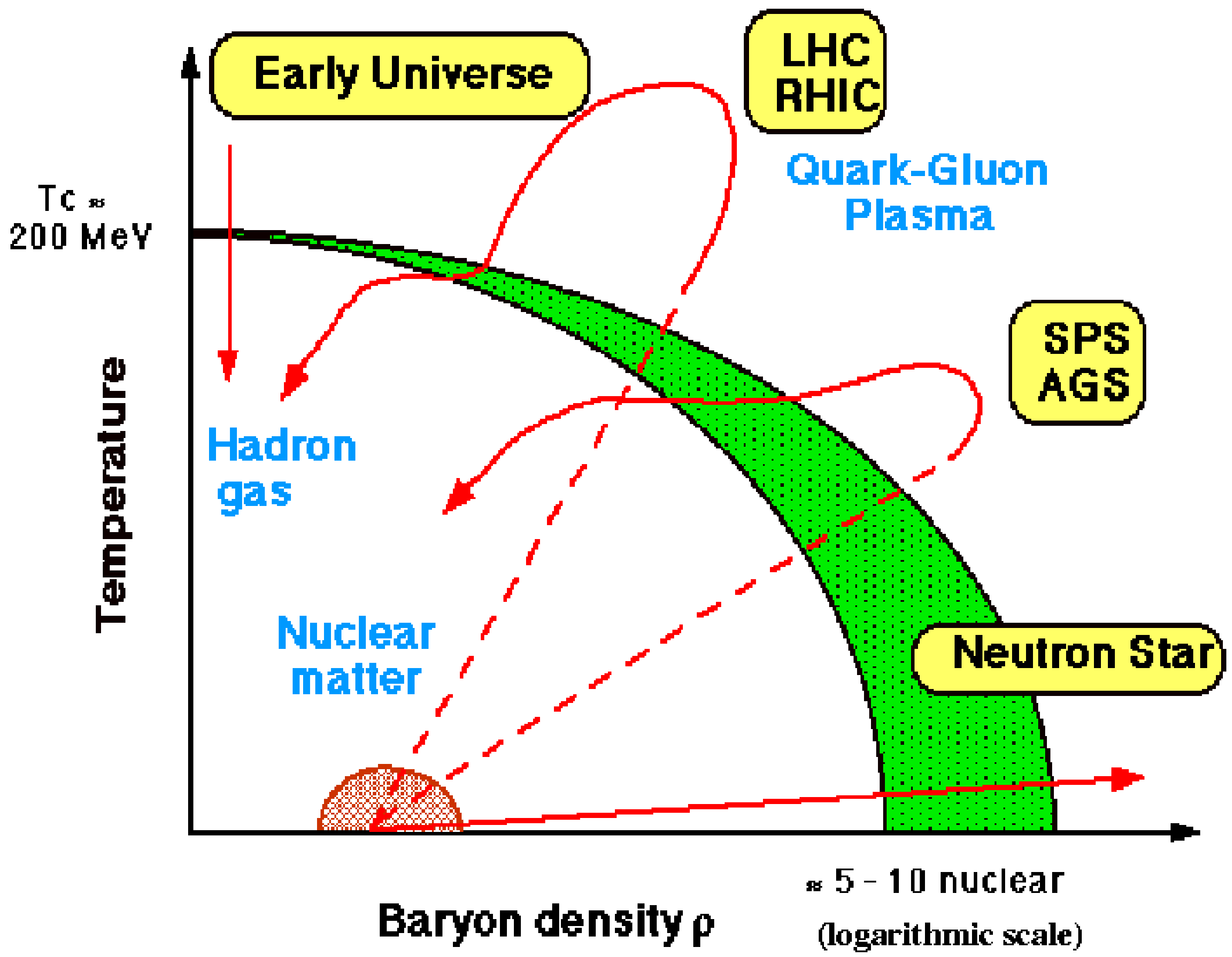
Physique des ions lourds avec ATLAS



Laurent Rosselet

Phase diagram

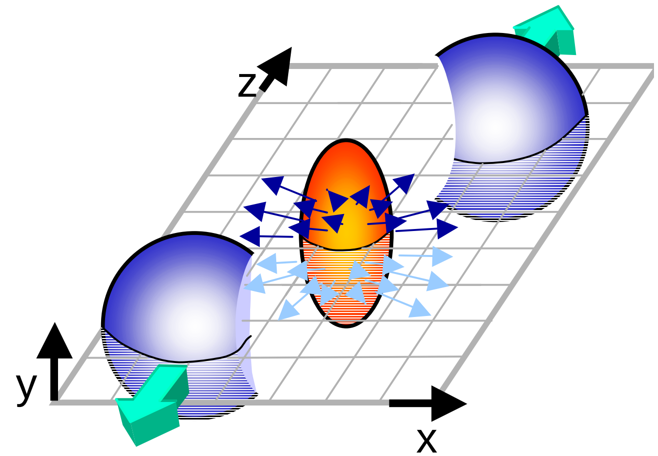


Physics program

- **Global variable measurement**

  dN/dη dE_T/dη   elliptic flow

  azimuthal distributions



- **Jet measurement and jet quenching**
- **Quarkonia suppression**

  J/Ψ   ϒ

- **p-A physics**
- **Ultra-Peripheral Collisions (UPC)**

Direct information from QGP

Idea: take full advantage of the large calorimeter and μ-spectrometer

Central Pb-Pb collision (b=0-1 fm)

- Simulation: HIJING+GEANT3

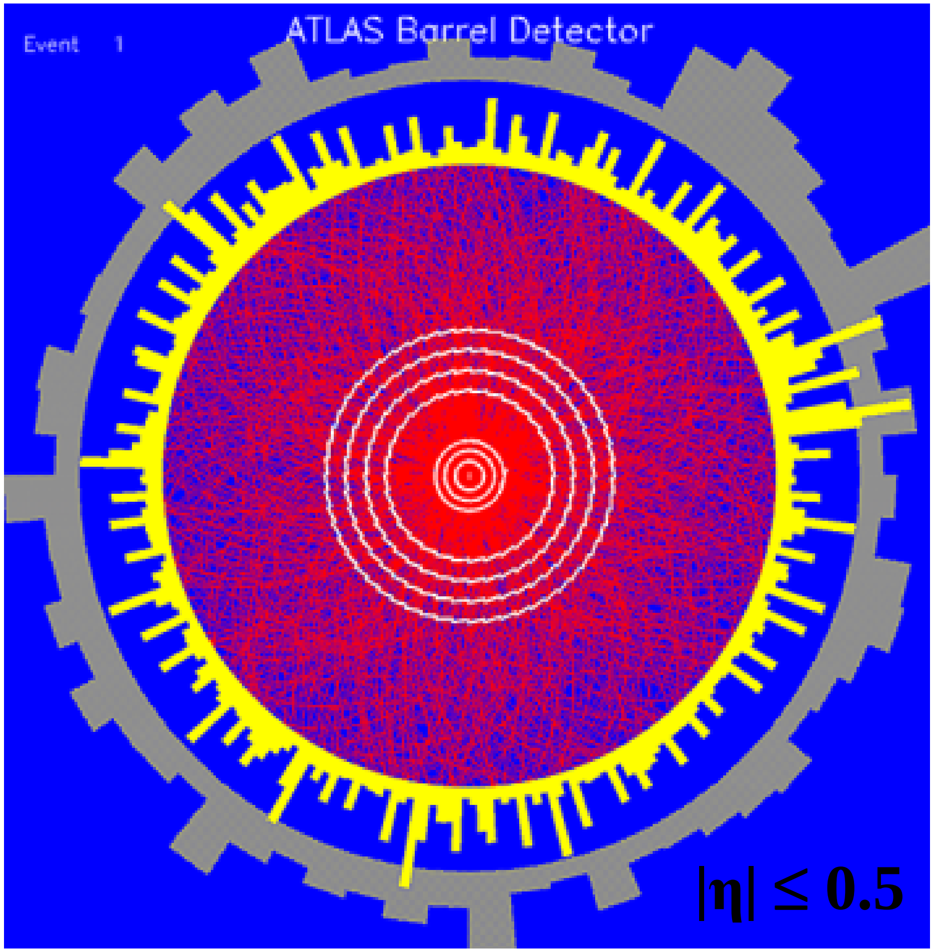
$dN_{ch}/d\eta|_{max}$~ 3200 in central Pb-Pb

c.f. 1200 from RHIC extrapolation

- 75000 generated stable particles/ev

→ 280 with p_T>3 GeV

→ 0.2 μ in μ-spectrometer



- Large bulk of low p_T particles are stopped in the first layer of the EM calorimeter

Track reconstruction

—Only Pixel and SCT detectors

—At least 10 hits out of 11 per track

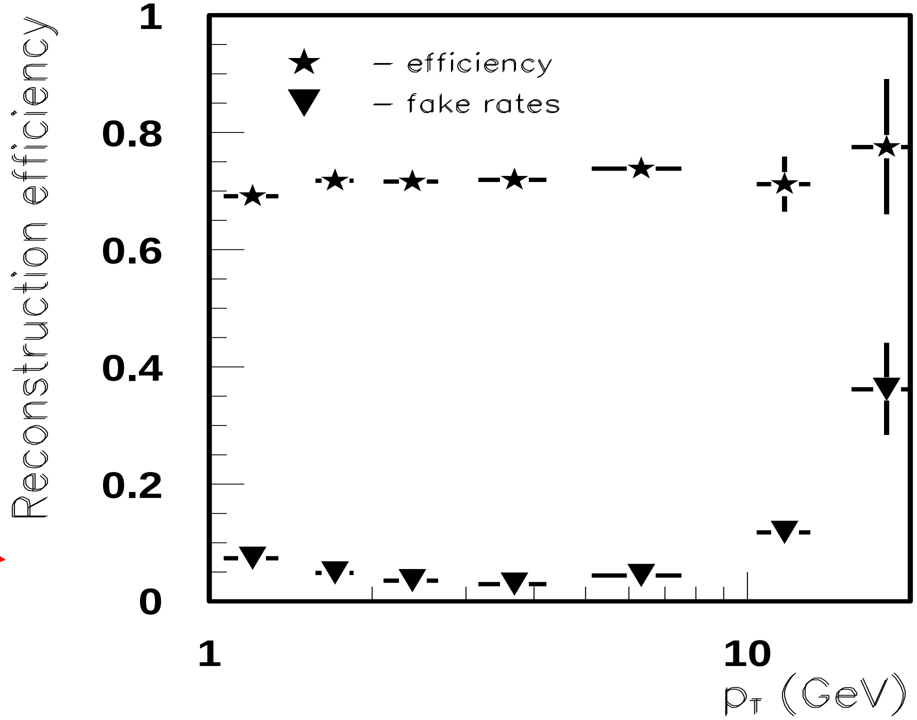
—At most 1 shared hits

—For p_T: 1 - 10 GeV/c:

efficiency > 70%

fake rate ~ 5%

p_T-resolution ~3%



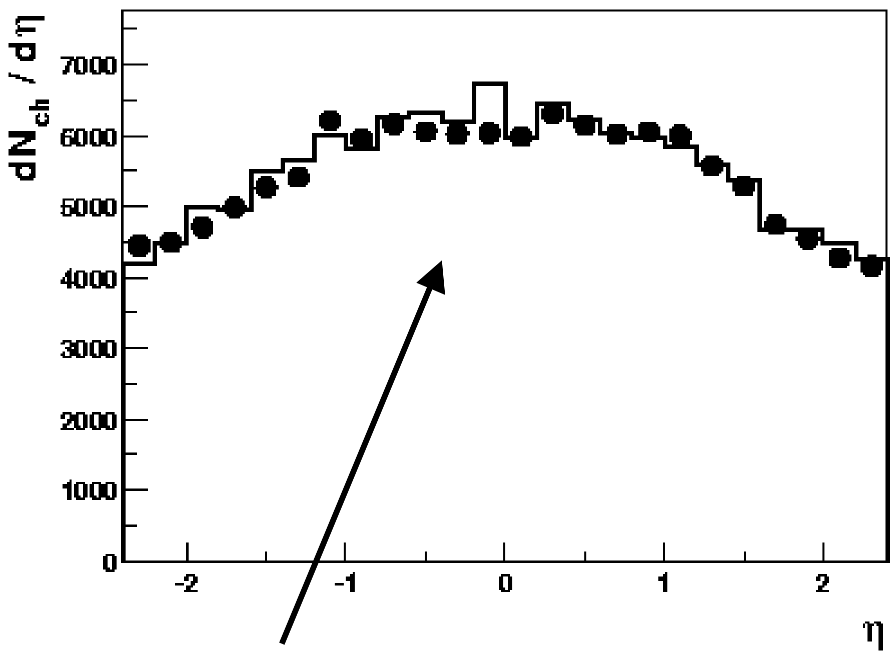
• 2000 reconstructed tracks from HIJING (b=0) events with p_T > 1 GeV and $|\eta| < 2.5$

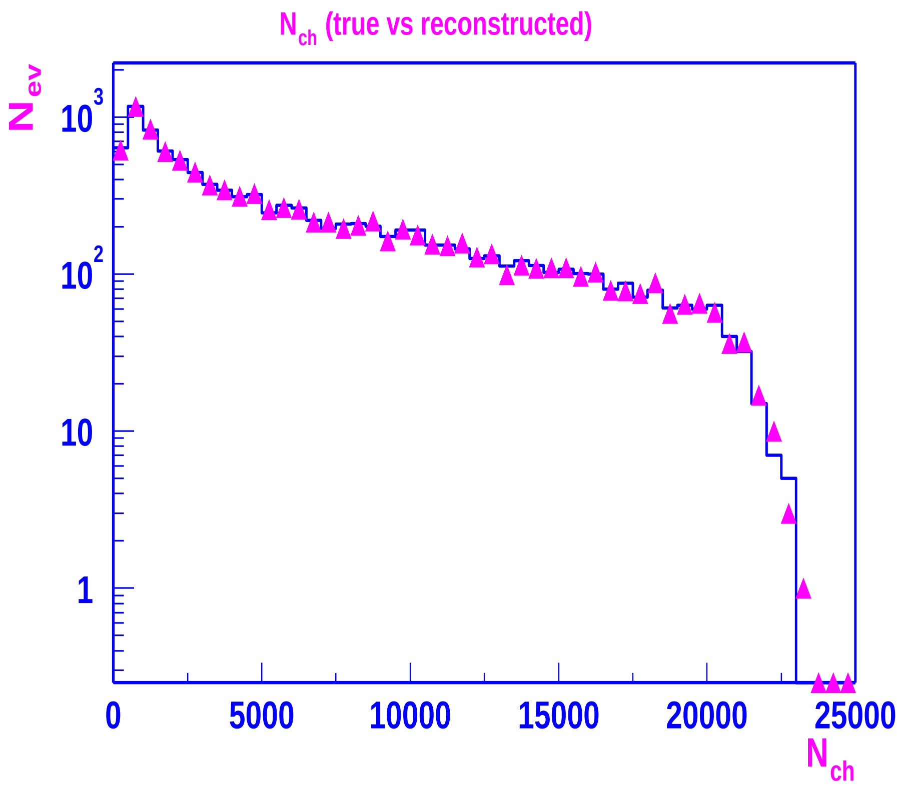
• Fake rate at high p_T can be reduced by matching with calorimeter data

Global observables

Day-one measurements: **N_{ch}, $dN_{ch}/d\eta$, ΣE_T, $dE_T/d\eta$, b**

e.g. $dN_{ch}/d\eta$ and charged particle multiplicity distribution





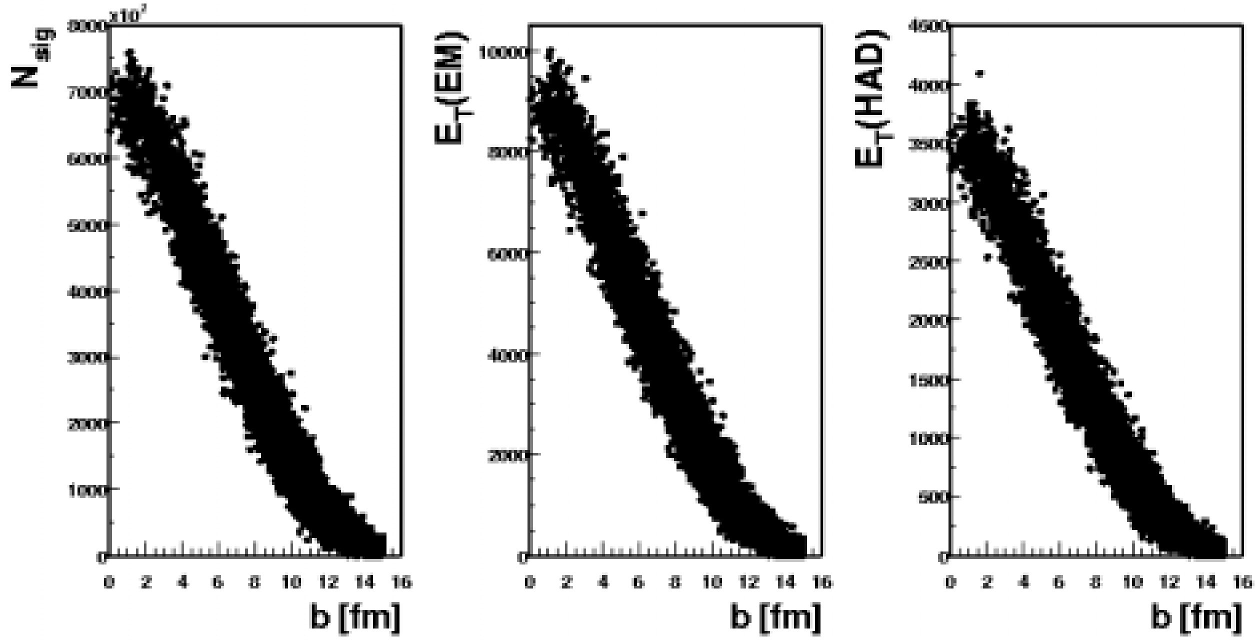
single Pb-Pb event b=0-1 fm

error ~5%

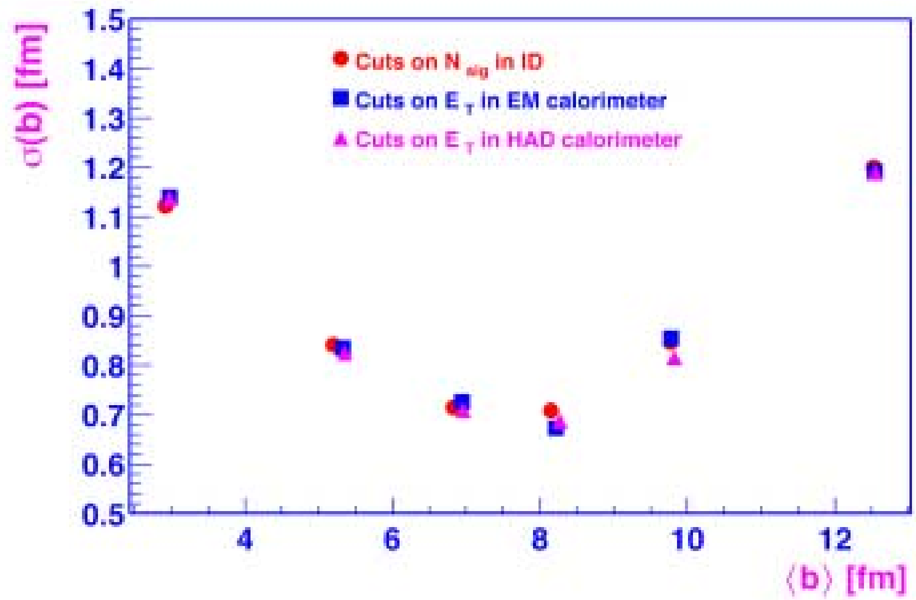
generated vs estimation from pixel counting, **no track reconstruction!**

Estimate of collision centrality

Monotonic relation between number of hits in the Pixel detector and b



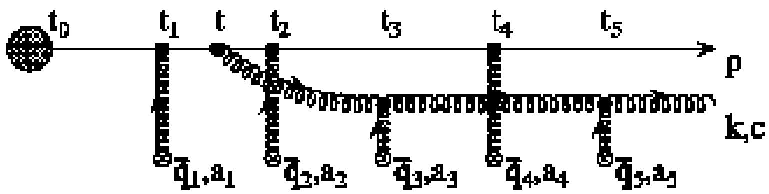
Accuracy on the determination of b with 3 distinct techniques

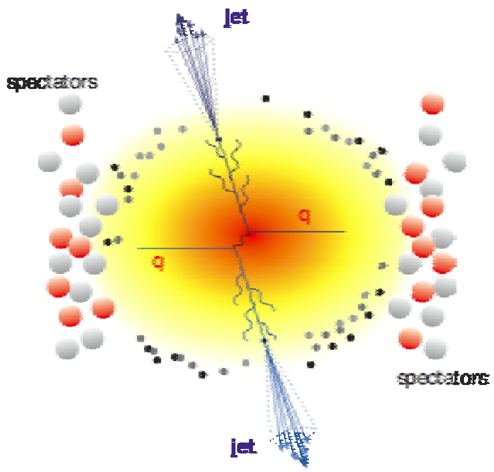


Jet quenching

Energy loss of fast partons by excitation and gluon radiation

larger in QGP





- Suppression of high-z hadrons and increase of hadrons in jets.

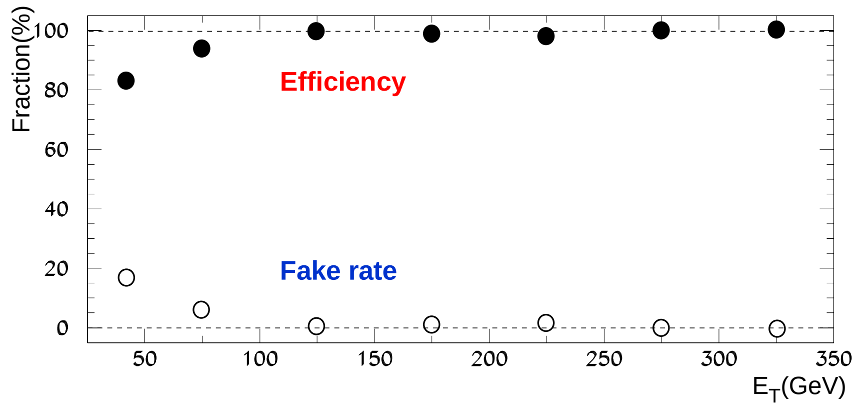
- Induced gluon radiation results in the modification of jet properties like a broader angular distribution.

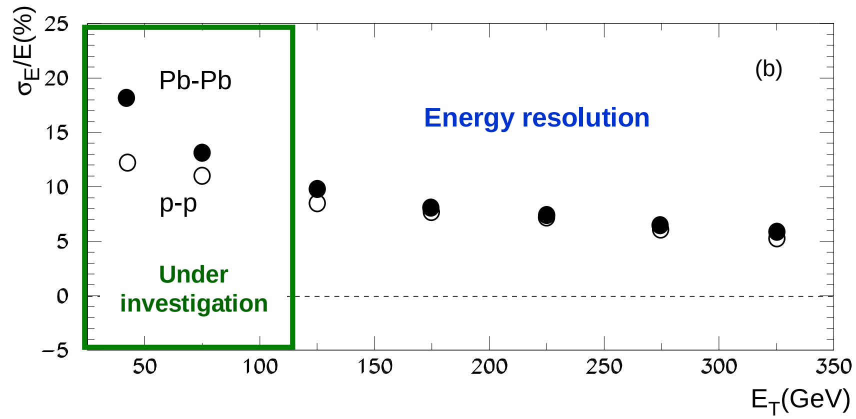
Could manifest itself as an increase in the jet cone size or an effective suppression of the jet cross section within a fixed cone size.

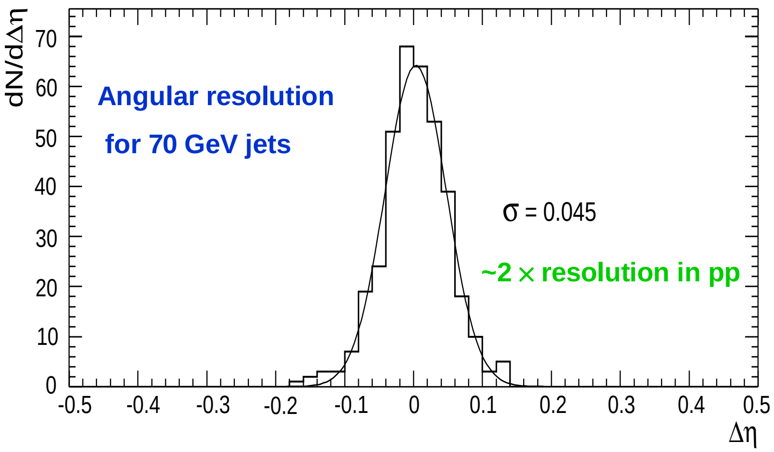
- Maximum effect might be for low to moderate E_T jets

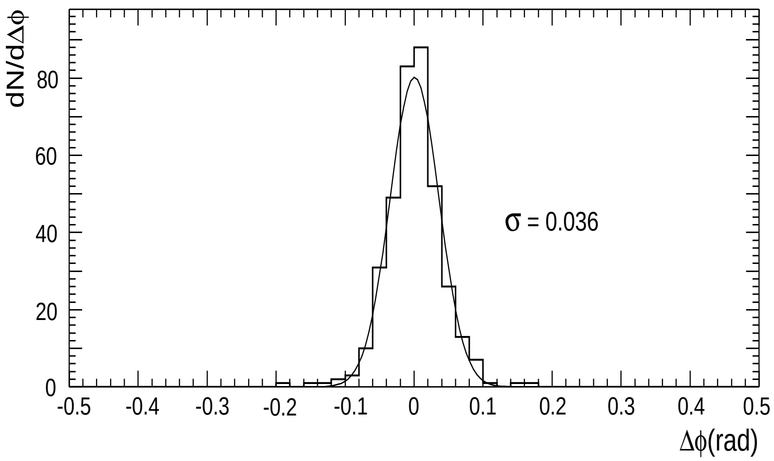
Jet reconstruction efficiency

Pb-Pb collisions (b= 0 –1 fm)







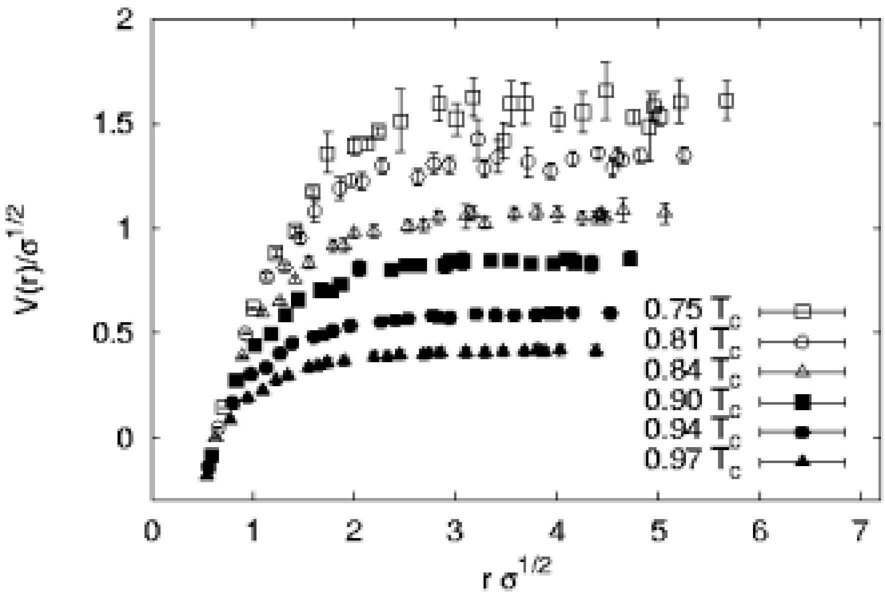


- For E_T > 75GeV: efficiency > 95%, fake < 5%
- Good energy and angular resolution

•Next: use tracking information to lower the threshold and reduce the fakes

Quarkonia suppression

Color screening prevents various ψ, ϒ, χ states to be formed when $T \rightarrow T_{trans}$ to QGP (color screening length < size of resonance)



Modification of the potential can be studied by a systematic measurement of heavy quarkonia states characterized by different binding energies and dissociation temperatures

~thermometer for the plasma

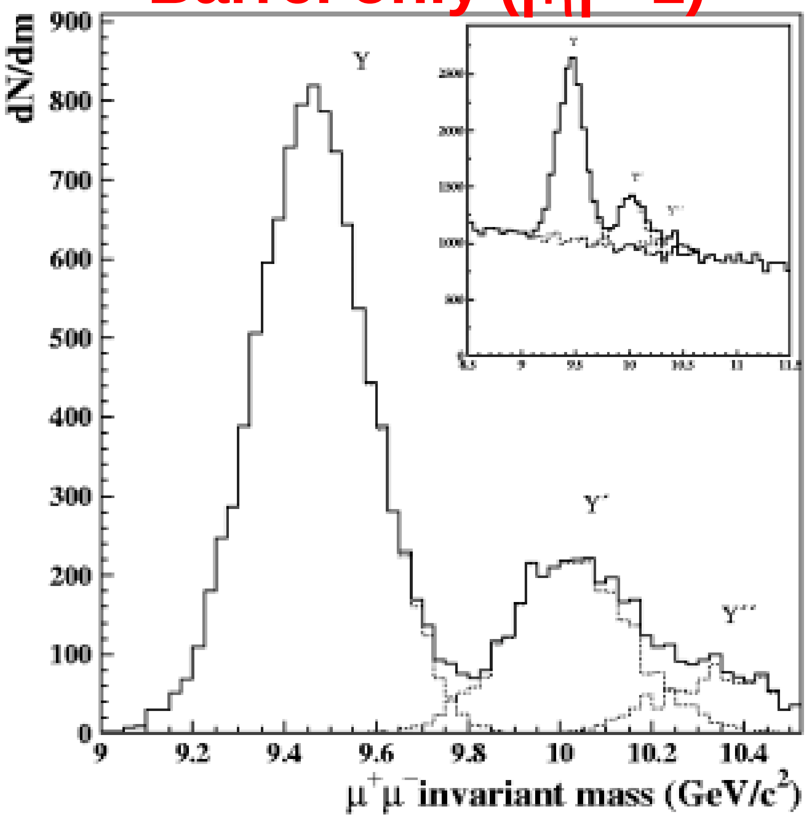
Upsilon family	ϒ(1s)	ϒ(2s)	ϒ(3s)
Binding energies (GeV)	1.1	0.54	0.2
Dissociation at the temperature	$\sim 2.5T_{trans}$	$\sim 0.9T_{trans}$	$\sim 0.7T_{trans}$

=>Important to separate ϒ(1s) and ϒ(2s)

$\Upsilon \to \mu^+\mu^-$ reconstruction

	$\|\eta\| < 1$	$\|\eta\| < 2.5$
Acceptance +efficiency	4.9%	14.3%
Resolution	126 MeV	152 MeV
S/B	1.3	0.5
Purity	94-99%	91-95%

Barrel only ($|\eta| < 1$)



A compromise has to be found between acceptance and mass resolution to clearly separate Υ states with maximum statistics.

E.g. for $|\eta| < 1.2$ (6% acc+eff) **we expect 10^4 Υ/month of 10^6s at $L=4\times10^{26}$ cm^{-2} s^{-1}**

$J/\psi \to \mu^+\mu^-$ - a study is under way (σ_{mass} =53 MeV).

Summary

- ATLAS has an excellent calorimeter/muon-spectrometer coverage suitable for heavy-ions physics
- Except TRT, detector performances are not significantly deteriorated
- Global observables can be measured accurately even on ev-by-ev basis
- Jet physics (jet quenching) is very promising,

  jet reconstruction is possible despite the additional background

  jet energy resolution comparable to pp for E_T>100 GeV
- Heavy-quarkonia physics (suppression in dense matter) well accessible,

  capability to measure and separate Υ and Υ', and

  to reduce background from π and K at an acceptable level

Extra slides:

ATLAS heavy-ion working group

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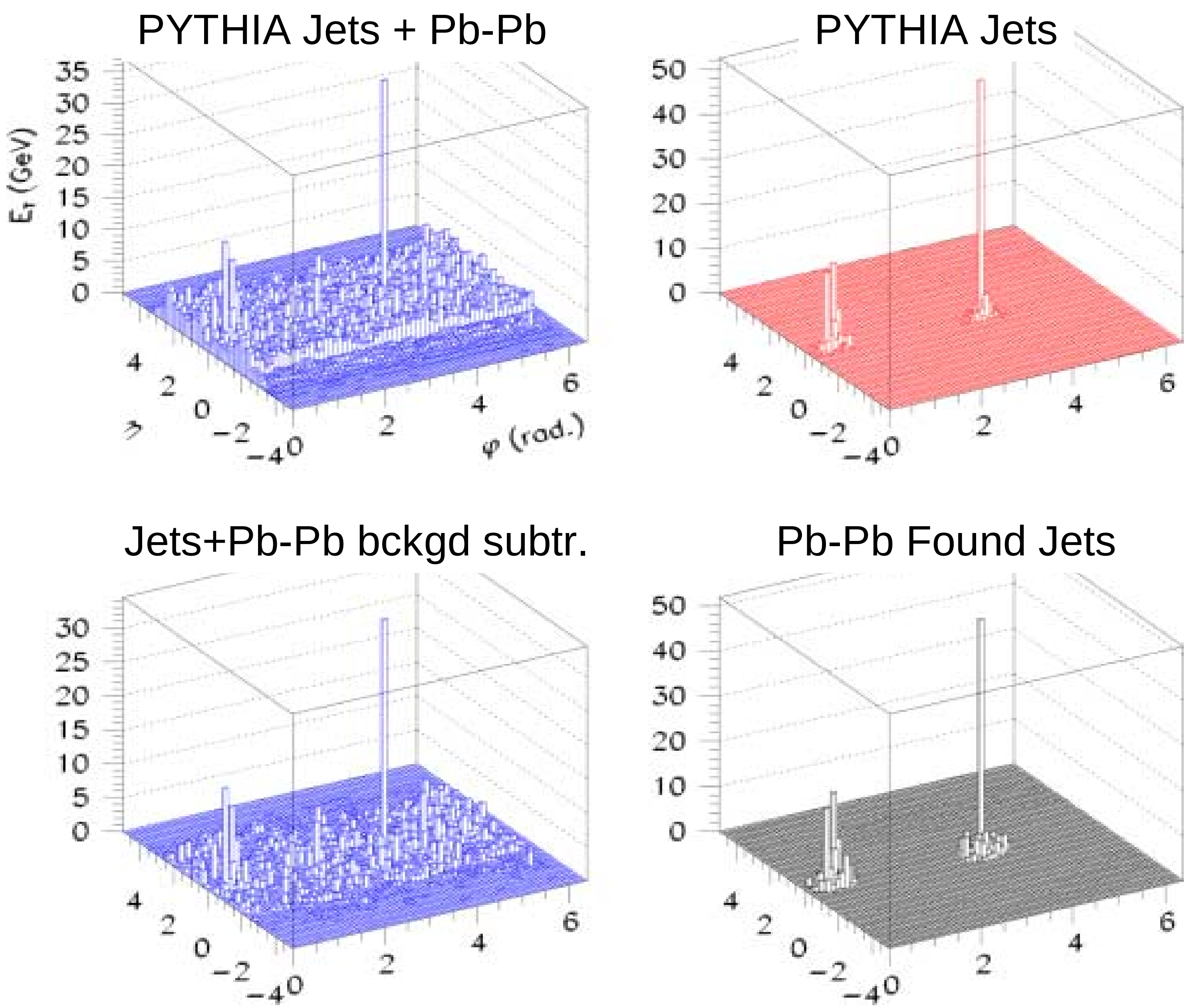
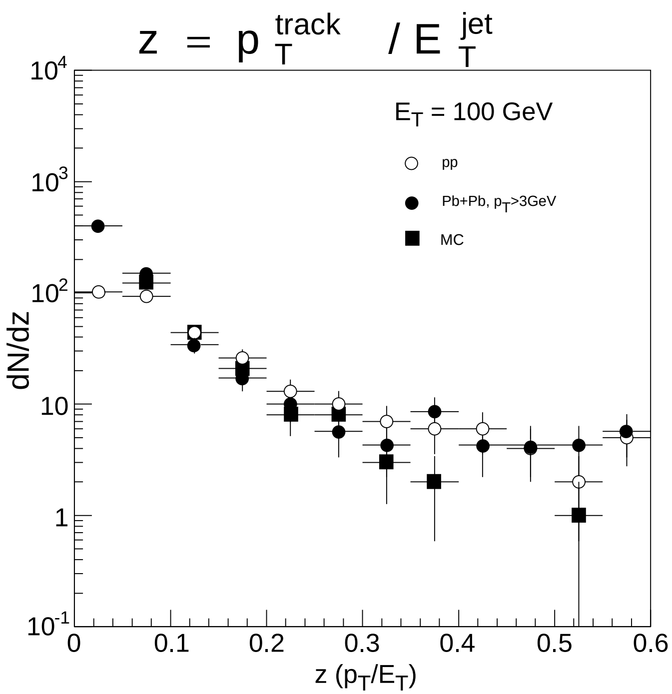
Lebedev Institute of Physics, INFN
Institute of Particle and Nuclear Physics, Prague
Universidade Federal do Rio de Janeiro

55 GeV jet PYTHIA+HIJING event



Fragmentation f. from tracks

- Jets with $E_T = 100$ GeV
- Cone radius of 0.4
- Track $p_T > 3$ GeV

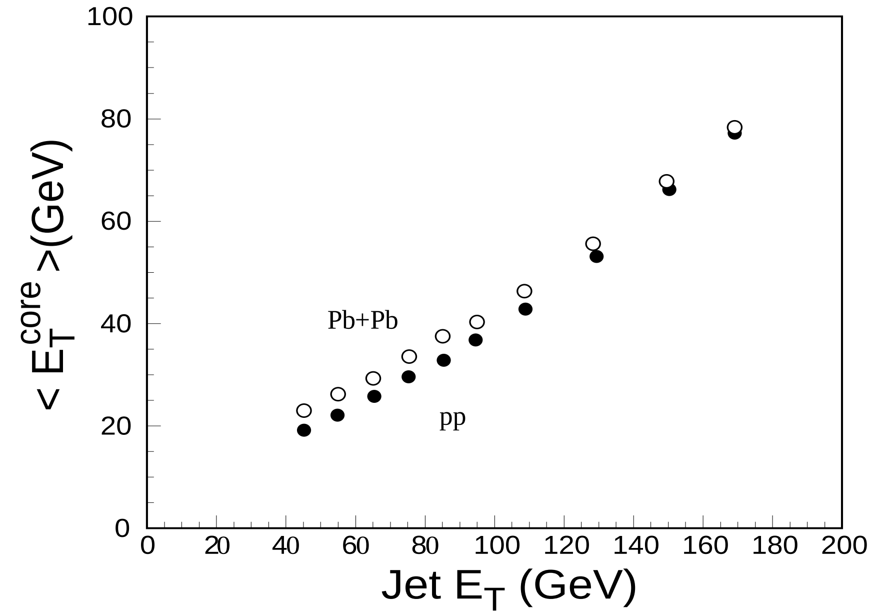


Reconstructed PbPb ≈ HIJING ≈ pp

E_T^{core} measurements

Energy deposited in a narrow cone R~0.1 selects leading hadrons,reduces effects of fluctuation in fragmentation.

The background has not been subtracted:
$\langle E_T^{core} \rangle^{PbPb} > \langle E_T^{core} \rangle^{pp}$



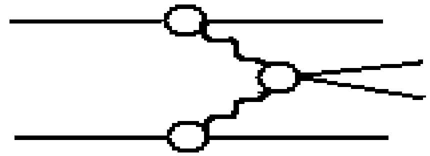
$\langle E_T^{core} \rangle$ sensitive to ~10% change in E_T^{jet}

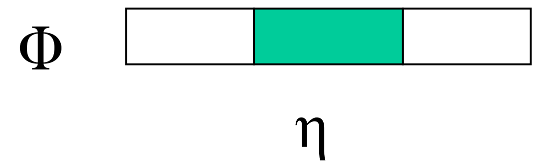
First look, but already promising!

Ultra-Peripheral Collisions (UPC)

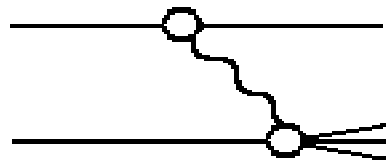
b > 2R   only electromagnetic interactions

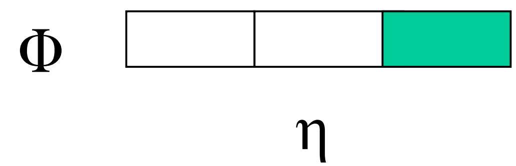
γ–γ



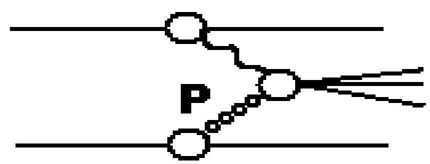


γ–N

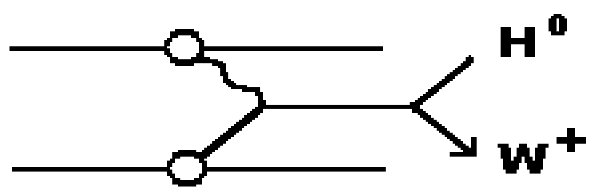




γ–P with/without nucleus diffraction



γ–W



$\sigma(\gamma-\gamma) \sim Z^4$ W γ–γ $< 2\gamma\hbar c/R_A$ =200 GeV for Pb