Centrality Determination

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JINR, Dubna, Russia

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Available on CMS information server

CMS NOTE 2001/055

The Compact Muon Solenoid Experiment

CMS Note

Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

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Heavy ion studies with CMS HF calorimeter

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CMS Note

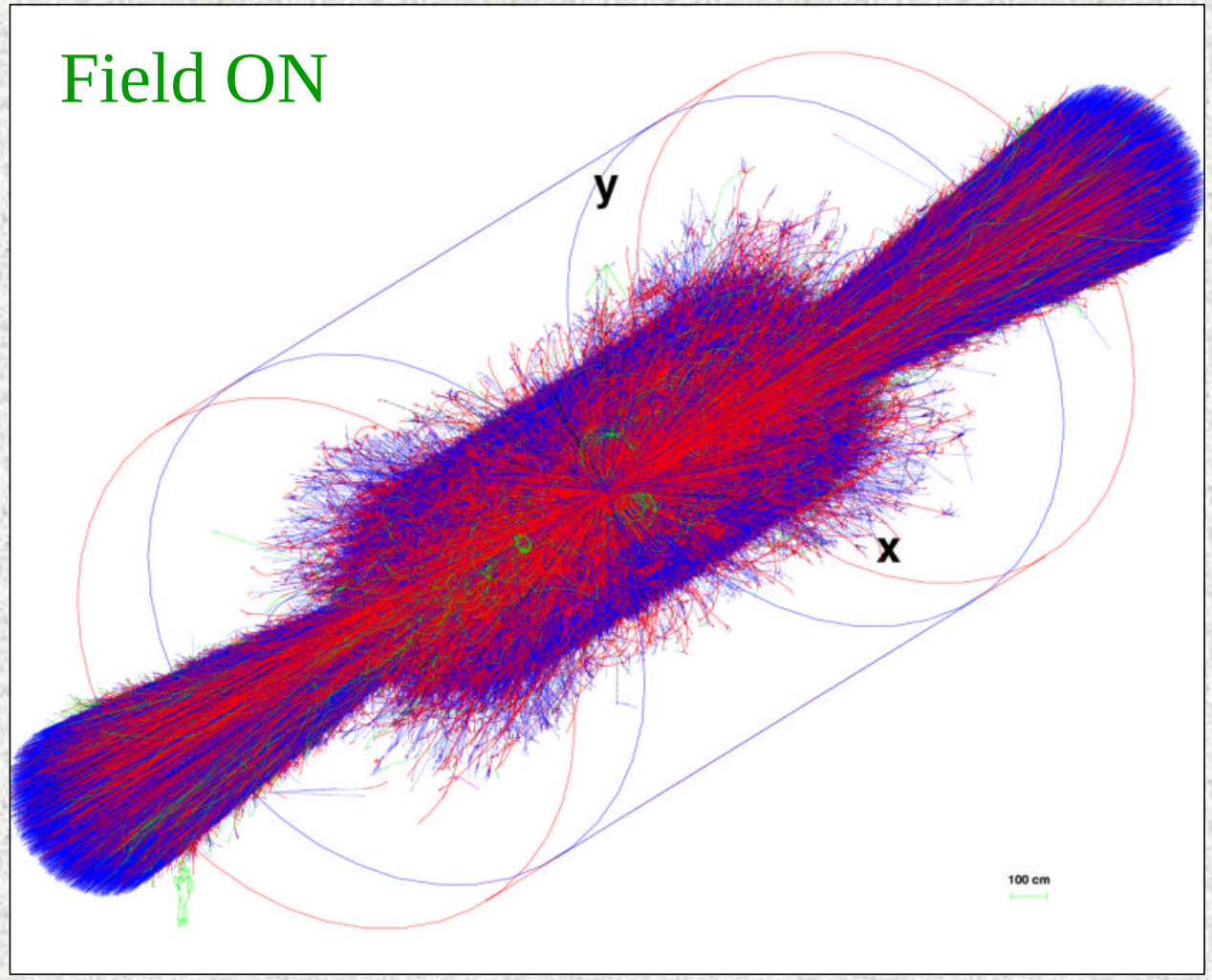
Abstract

We discuss the capability of the very forward (HF) calorimeter of CMS detector at LHC to be applied to specific studies with heavy ion beams. The simulated responses of HF calorimeter to nucleus-nucleus collisions are used for analysis of the different problems: reconstruction of total energy flow in the forward rapidity region, accuracy of determination of the impact parameter of collision, study of fluctuations of hadronic-to-electromagnetic energy ratio, fast inelastic event selection.

http://cmsdoc.cern.ch/cgi-doc/Grep_Search_F/documents/allxx.html?STRING=NOTE2001055

HIJING & CMSIM115

PbPb central collision at $\sqrt{S} = 5.5$ ***TeV / nucleon***



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HIJING & CMSIM115

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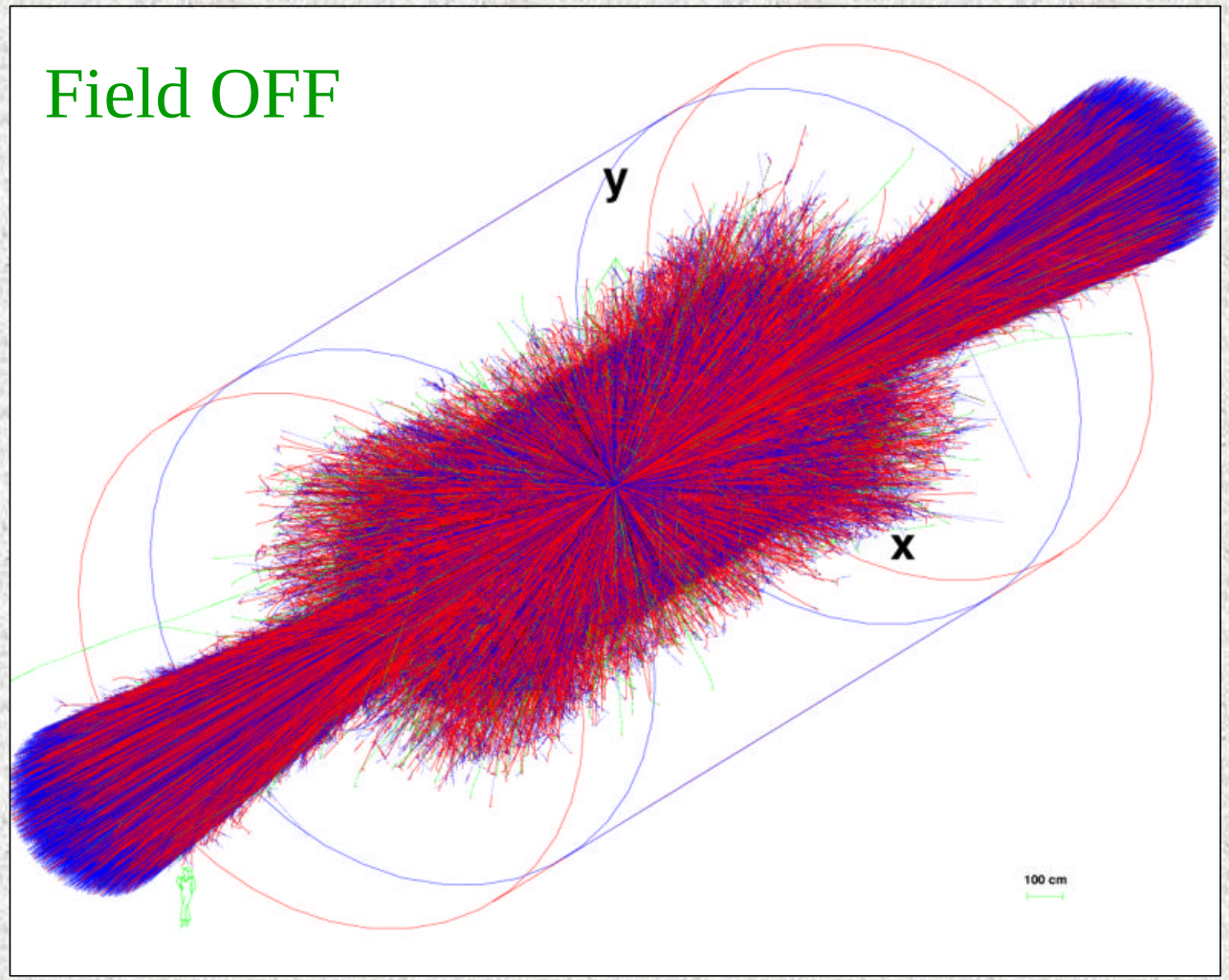

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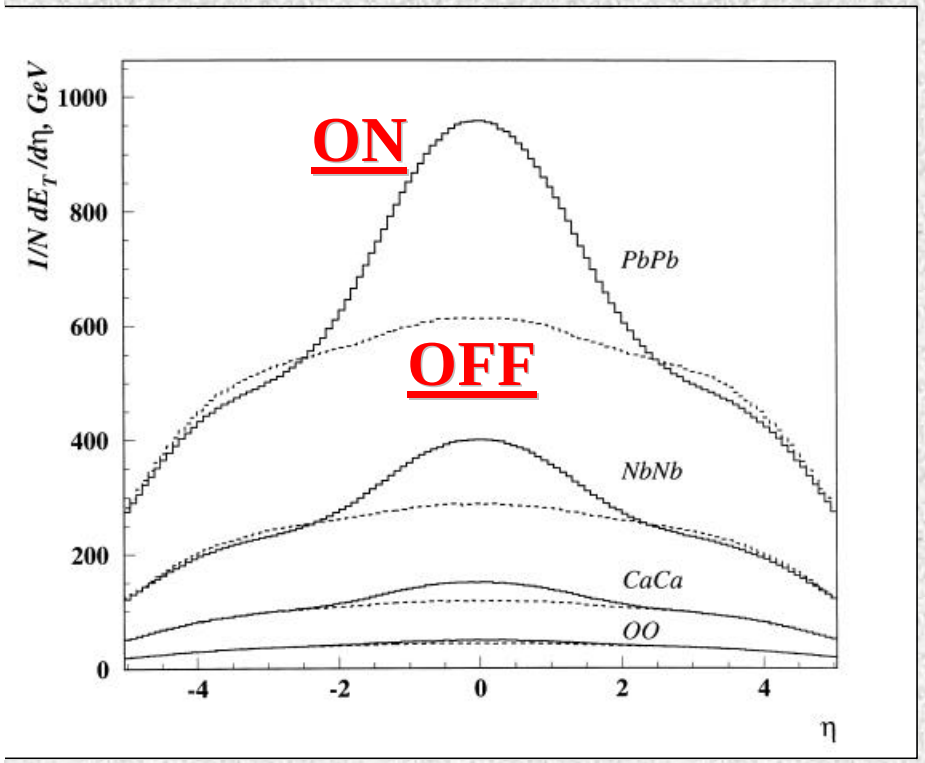
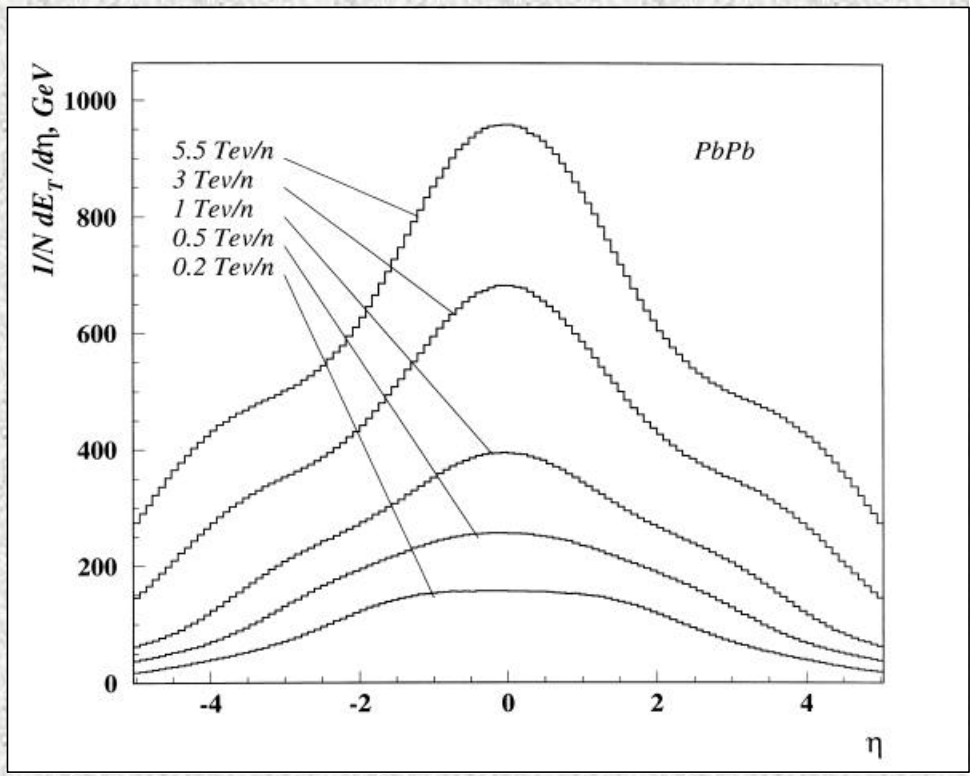
The BUMP

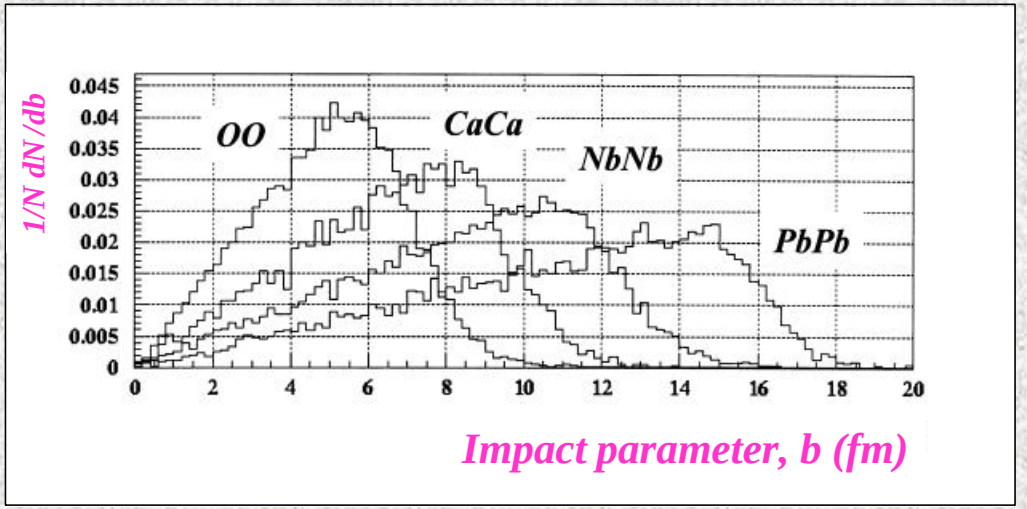
HIJING key
Quenchning

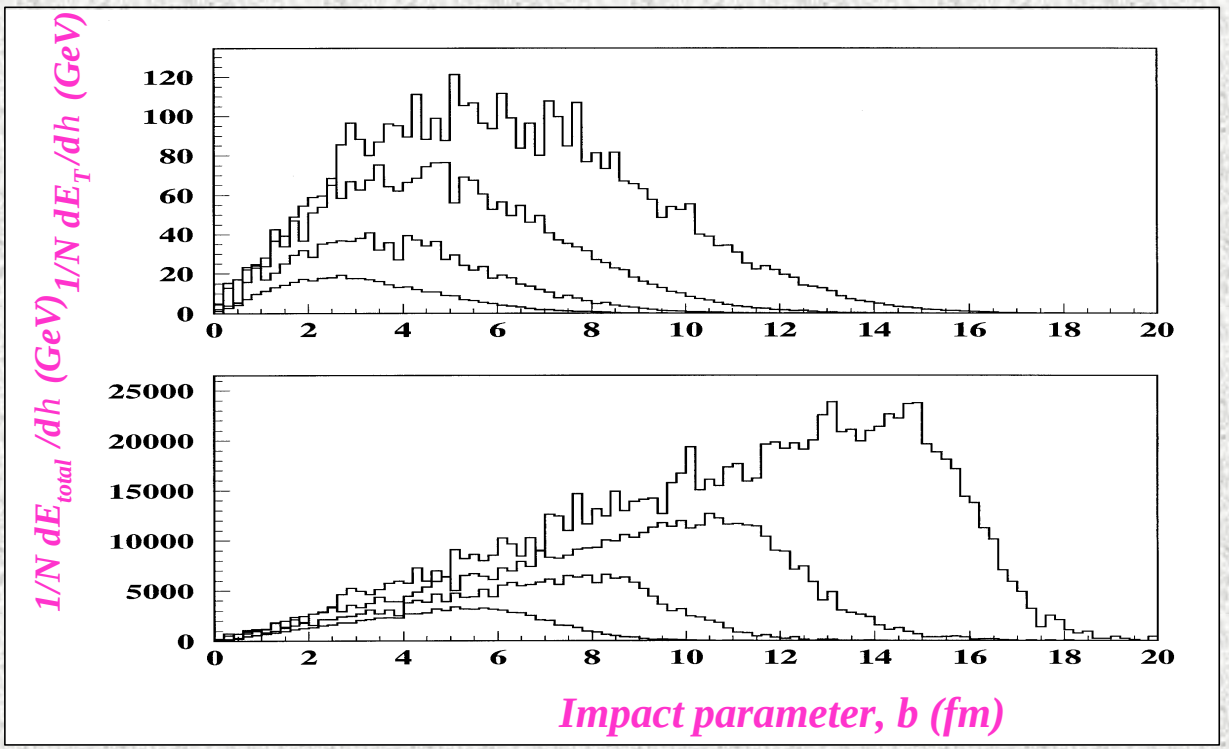
RHIC ® LHC





HIJING impact parameter distributions for AA collisons





Problem: impact parameter cannot be measured directly in experiment

Solution: to find well measurable in experiment variable correlating with i.p

.

Selection criteria of experimentally measurable variable

- be described by the theory (pQCD) with acceptable accuracy of evaluations
- not dependent on possible signals of “new” physics.
- be good experimentally measurable

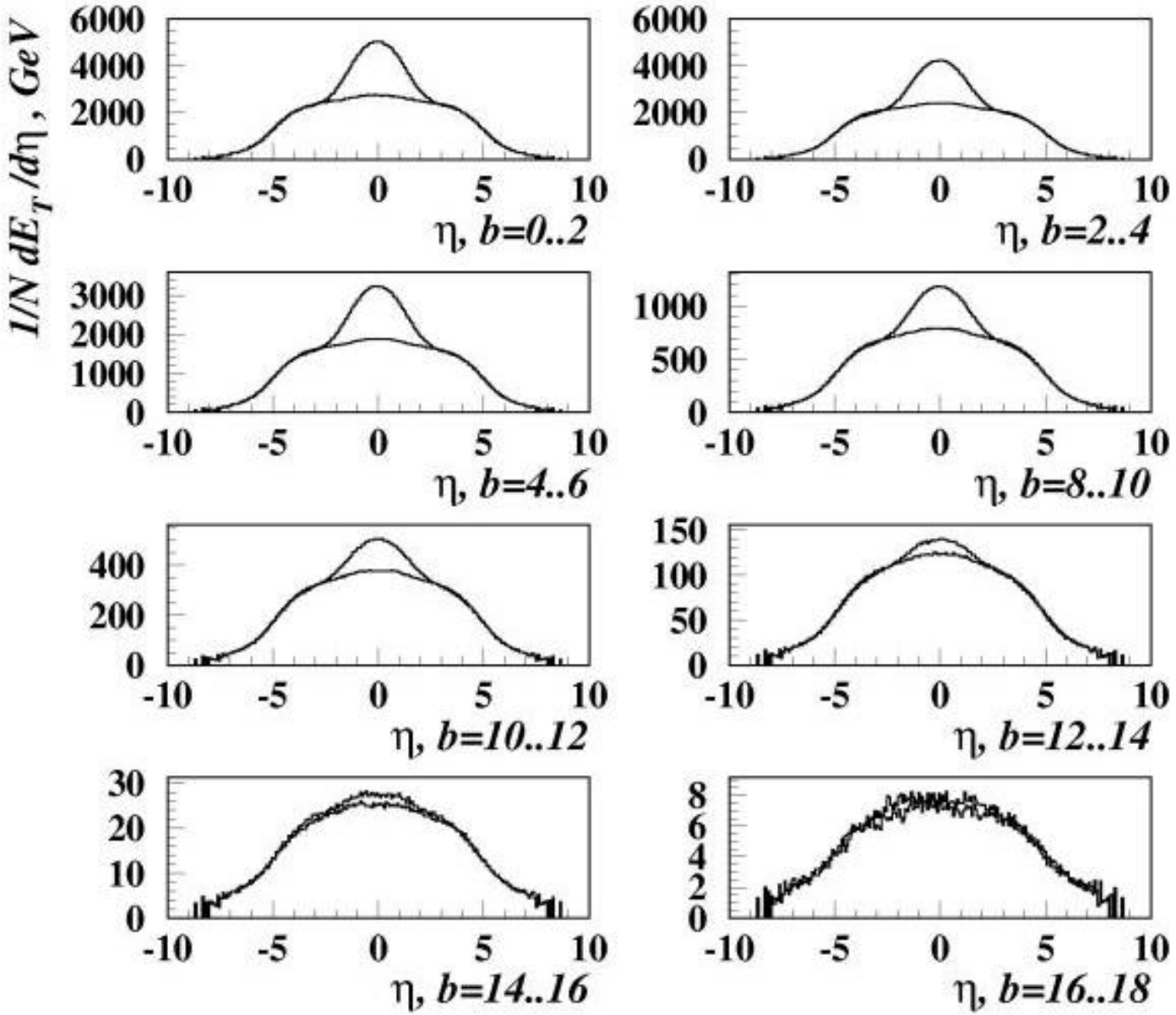
$$E_t \; ^{o} \; E_{total}.\sin\theta$$

Selection of the pseudorapidity interval

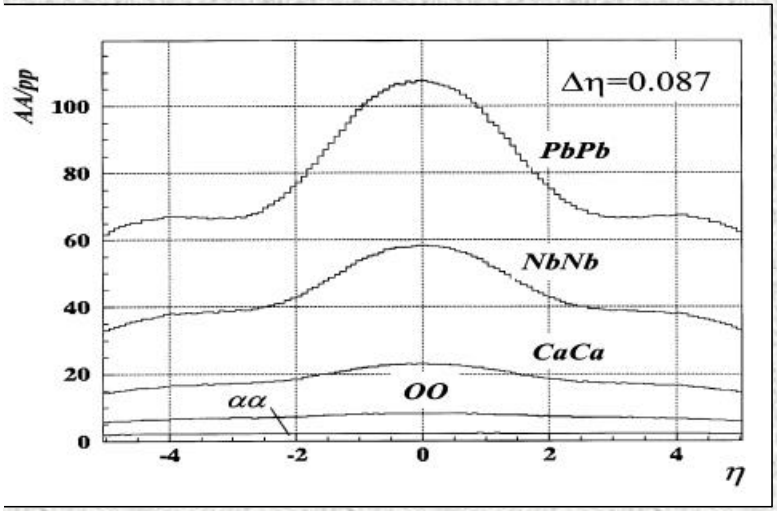
$$3 \pounds |\eta| \pounds 5 \; (???)$$

Pb-Pb

Global E_T flow with variation of impact parameter



Choice of pseudorapidity interval



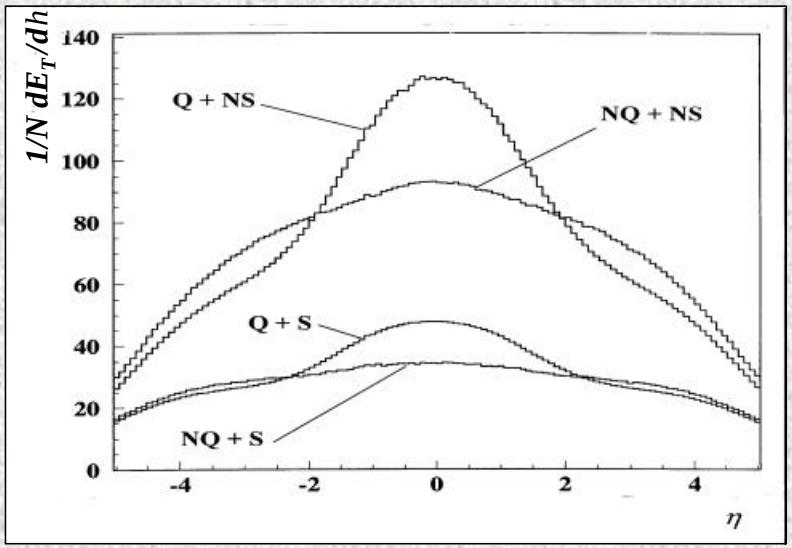
HF calorimeter region (3 £ |h| £ 5)
is not sensitive to a jet quenching effect
(one of QGP predictions),

but

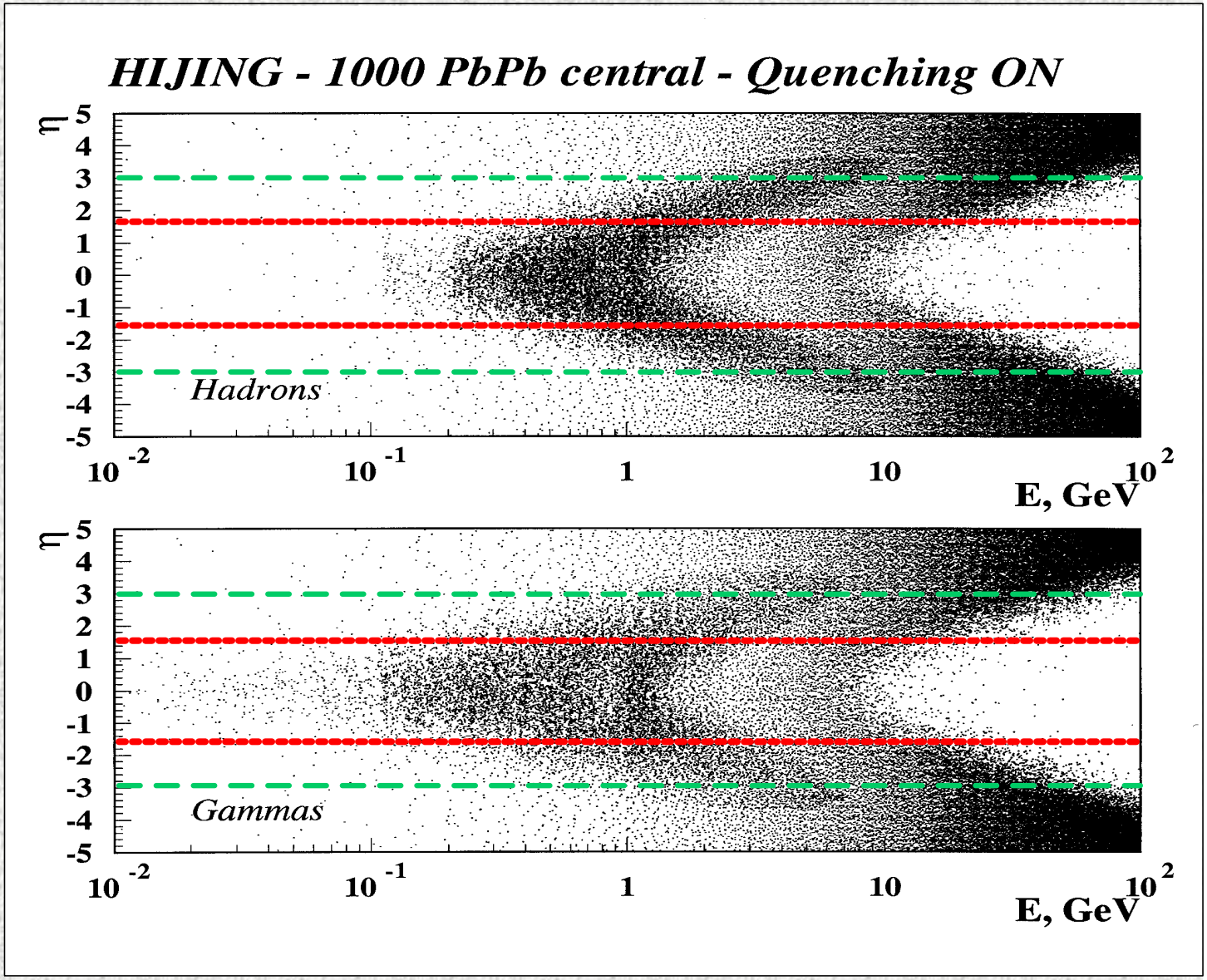
is crucical enough to various shadowing models.

It is necessary to fix (though approximately) the shadowing scenaria.

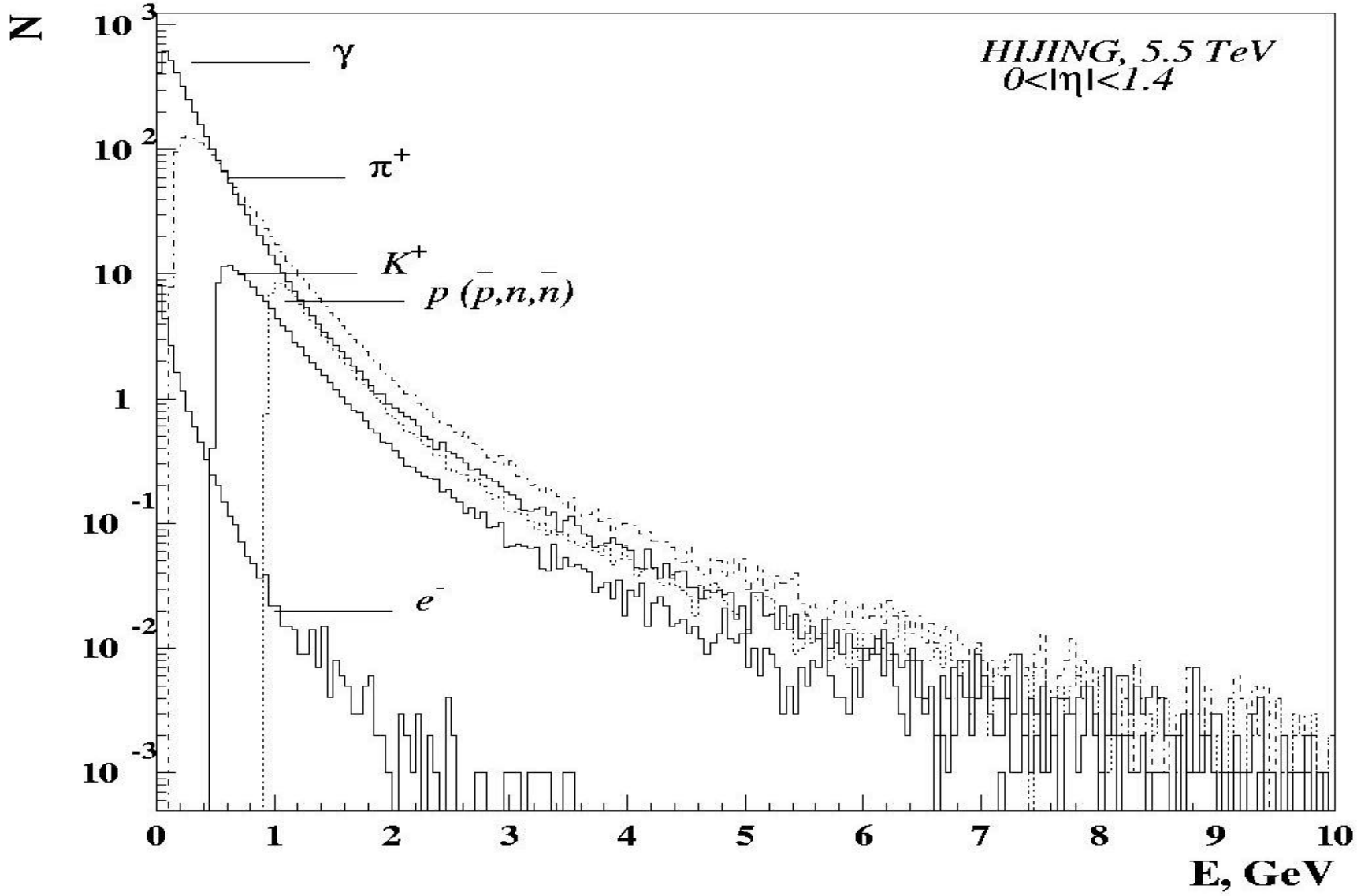
PbPb collisions
(0 £ b £ 3 R_A, fm)
Ös$_{nn}$= 5.5 TeV



Correlation between produced particle energy and pseudorapidity

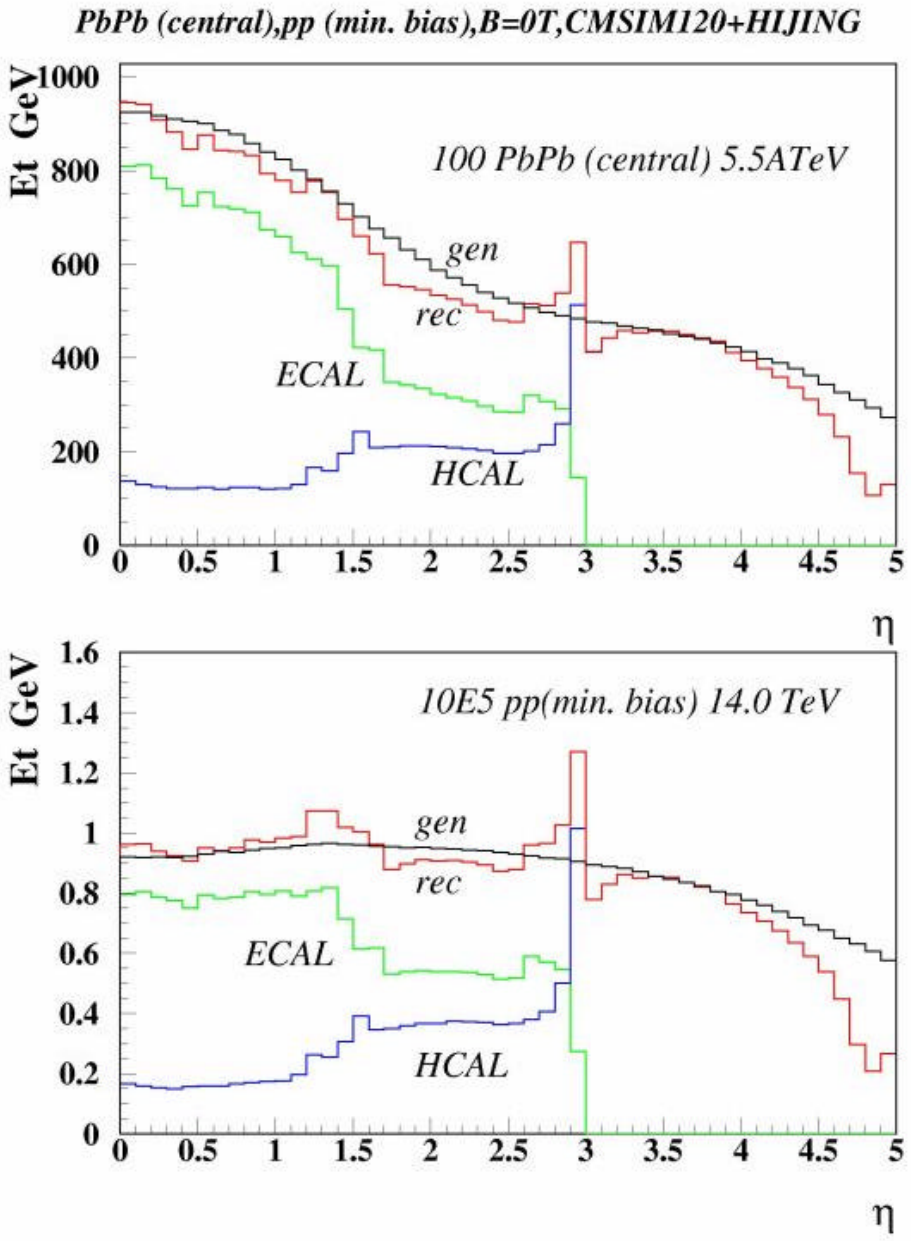


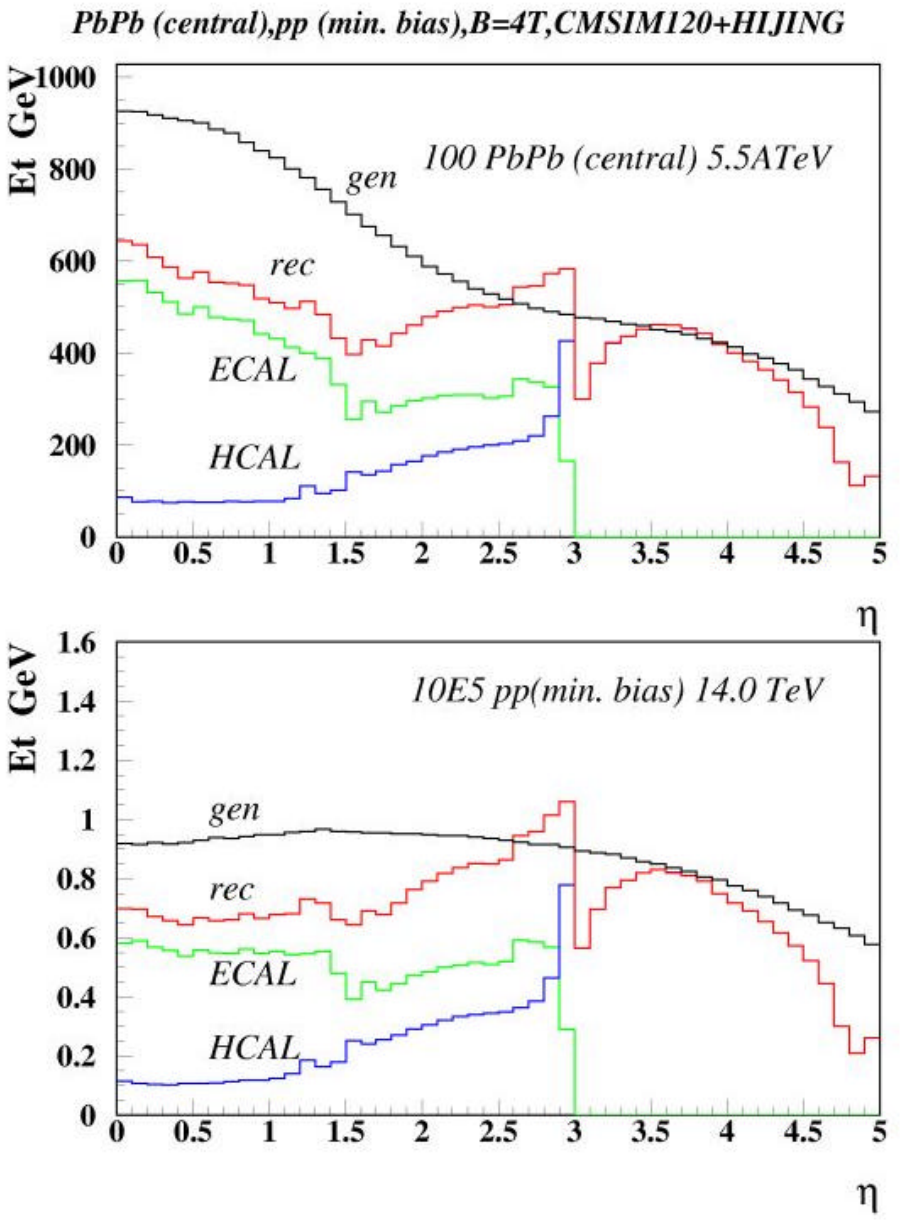
Particle composition in the CMS barrel part



Field OFF

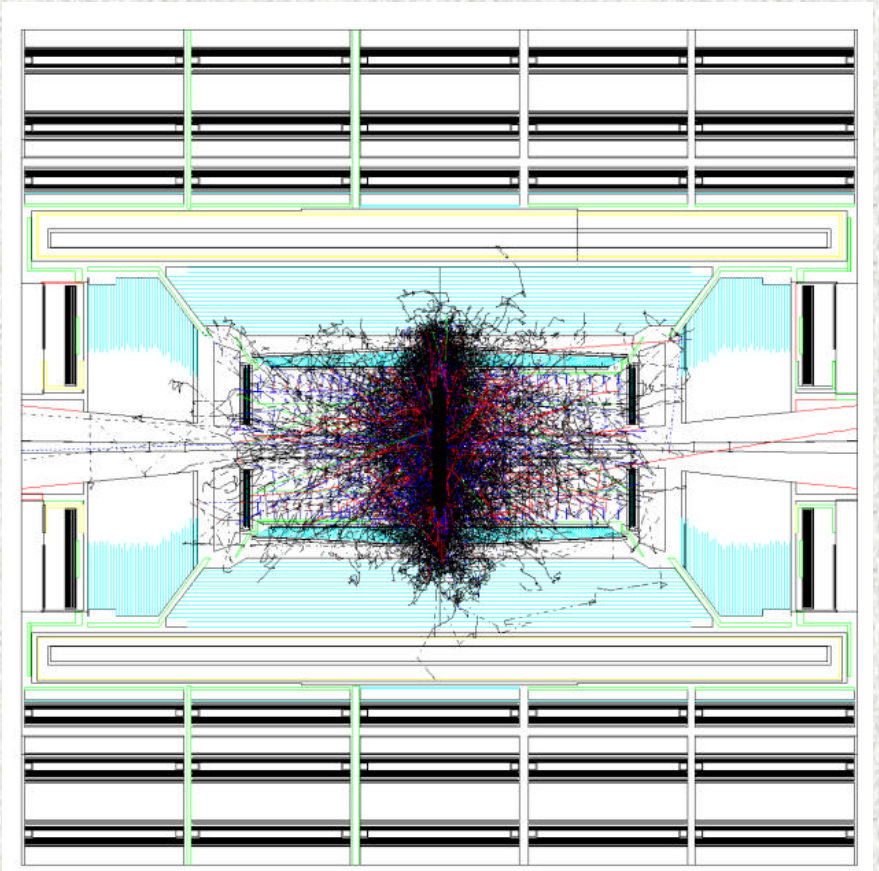
Field ON

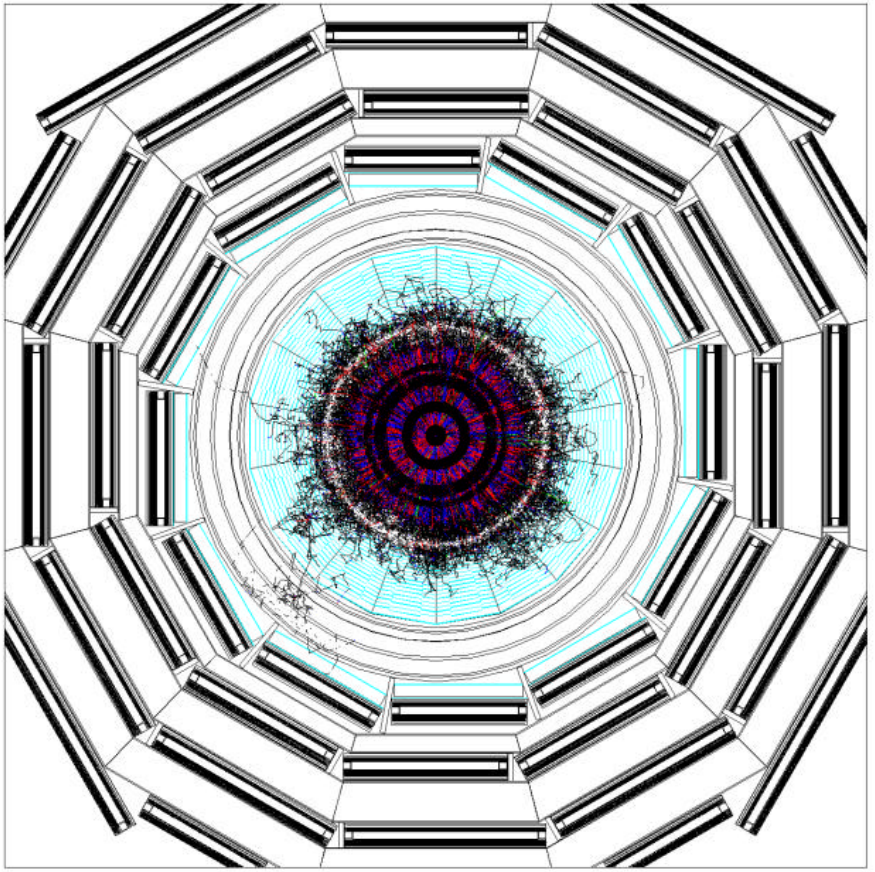




Min. bias Pb-Pb Collision in CMS

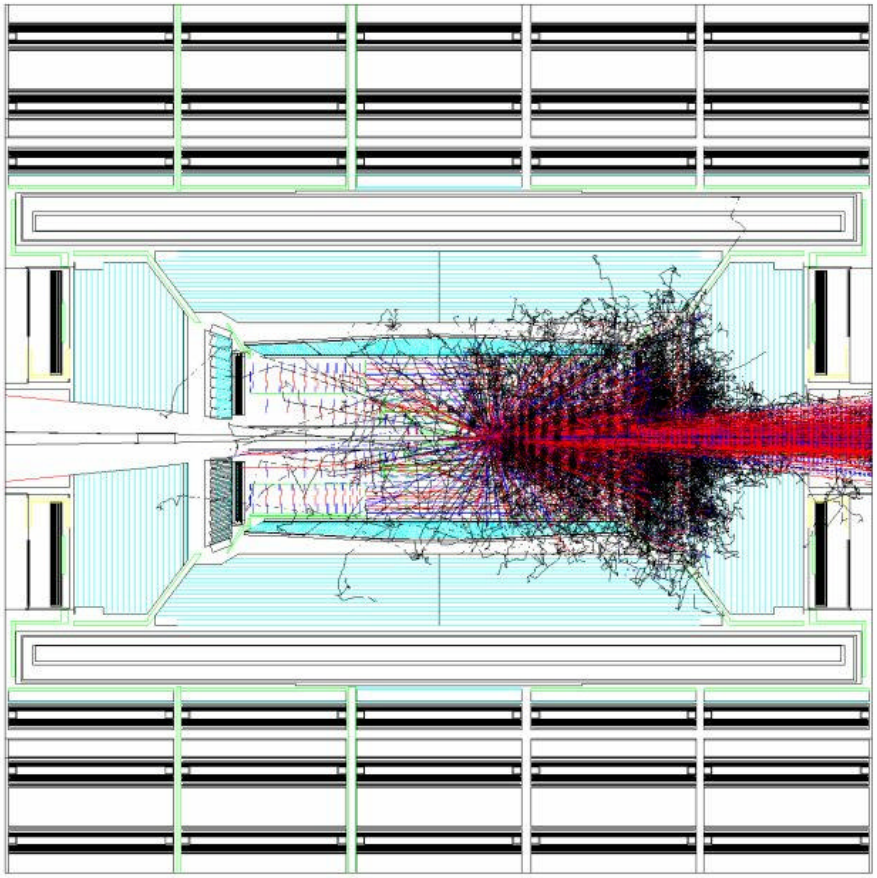
ïhï< **0.1**





Min. bias Pb-Pb Collision in CMS

3<h<5



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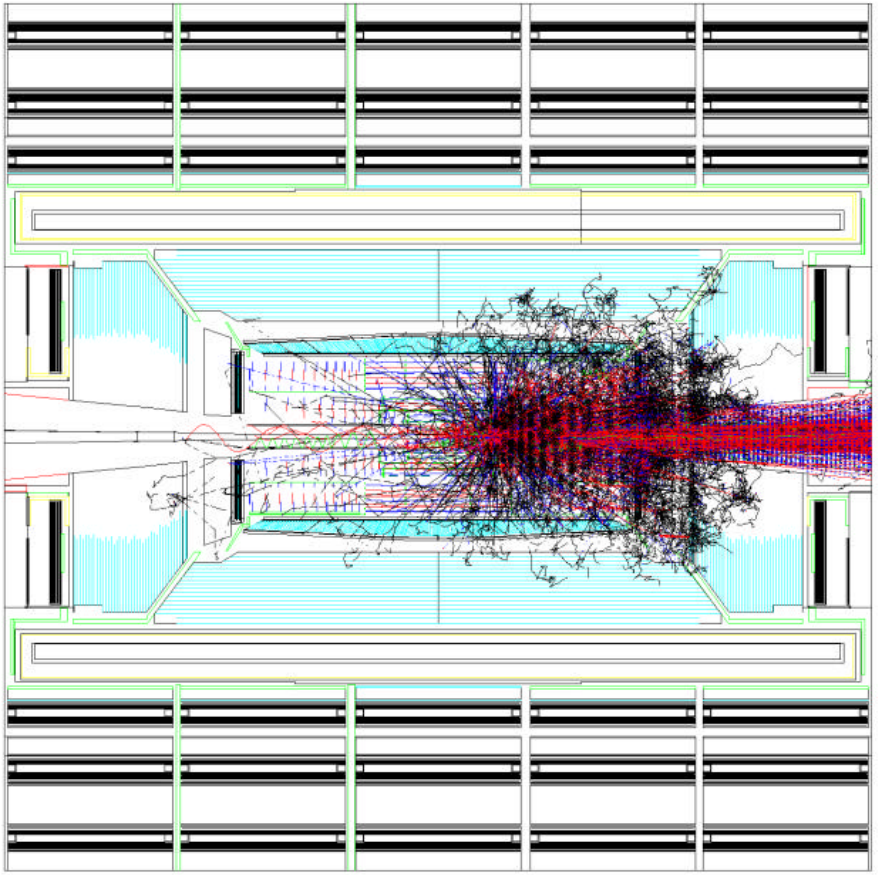

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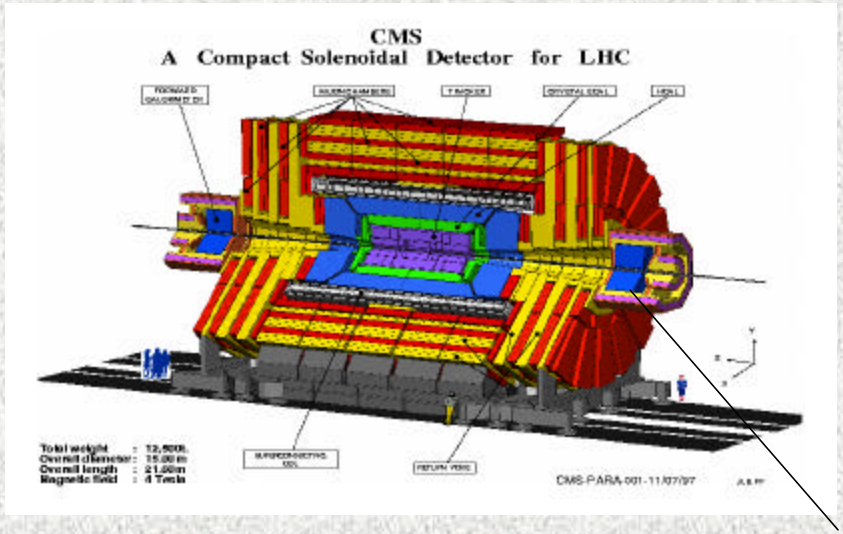
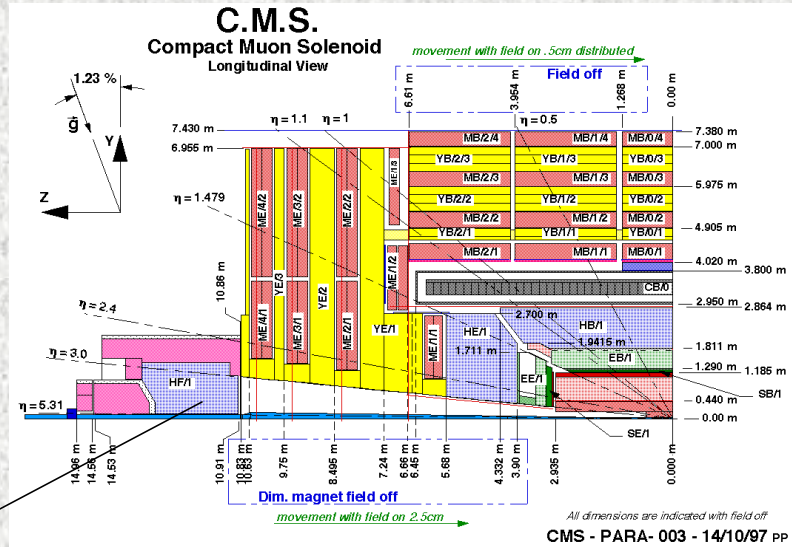
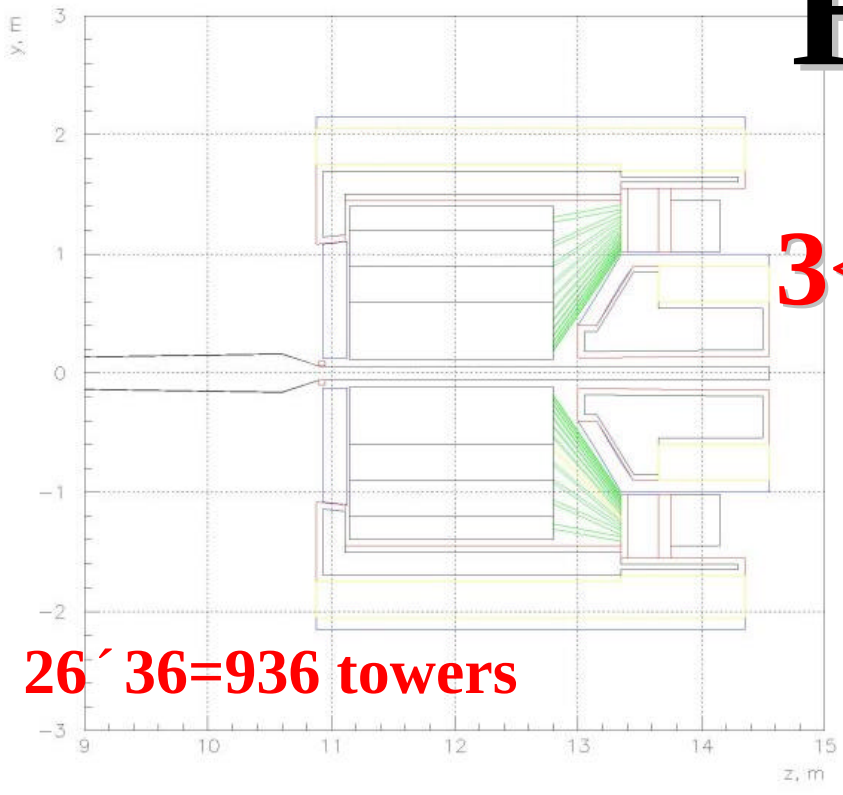


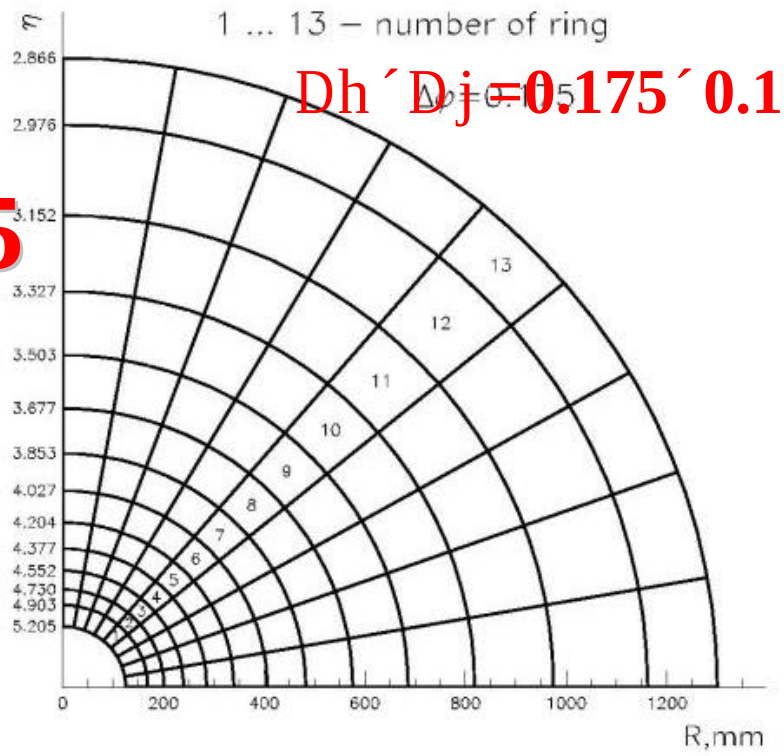


H F



26´36=936 towers

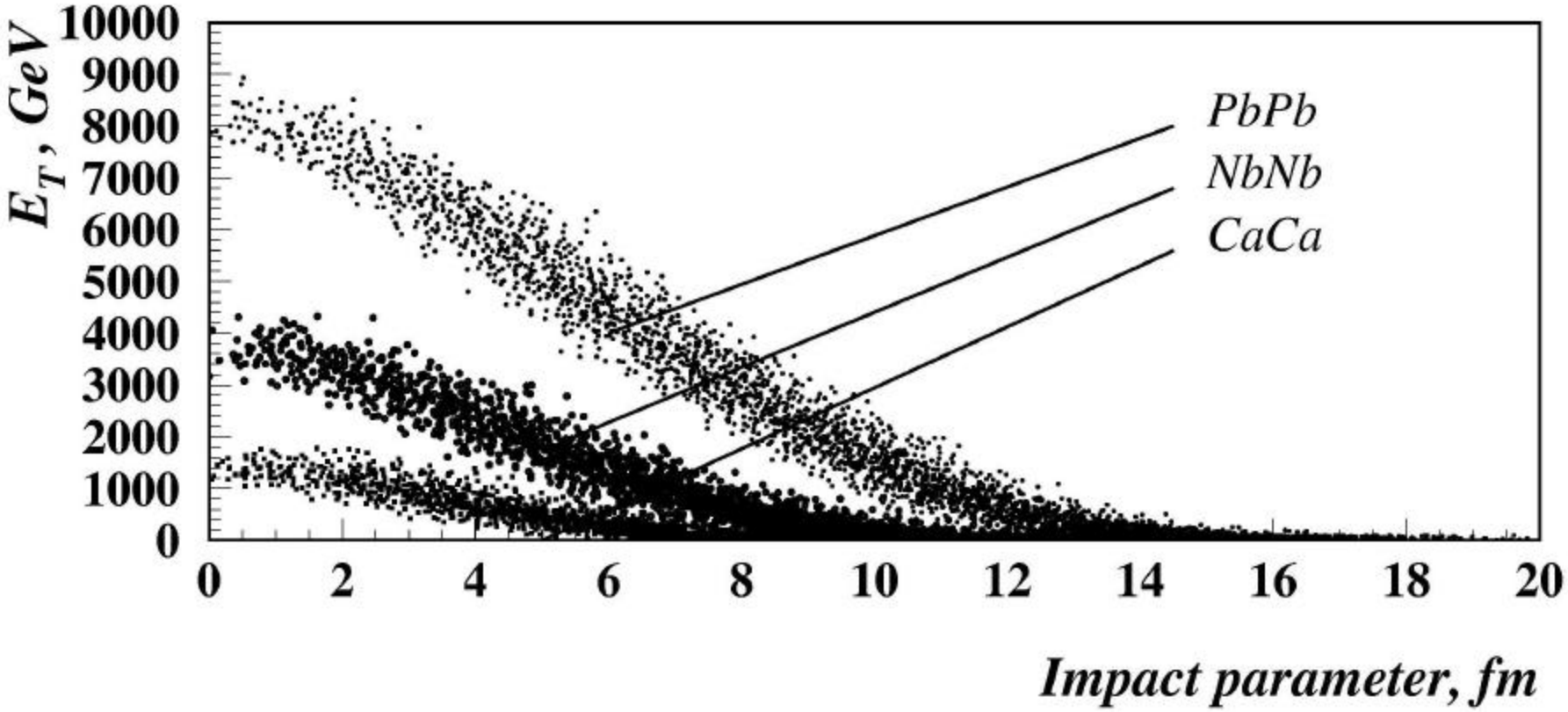
3<h<5



Dh´Dj=0.175´0.175

Transverse energy vs impact parameter

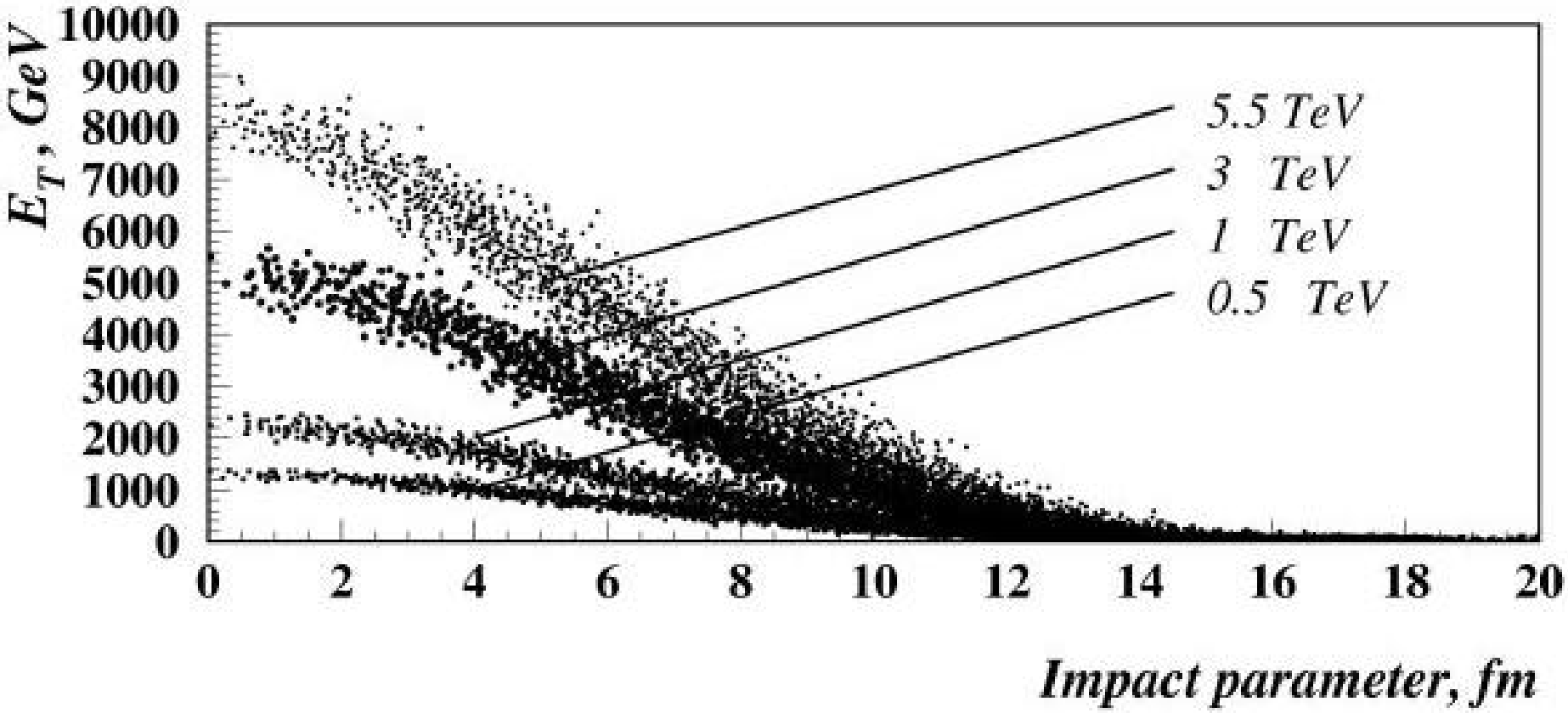
3<h<5



Mass number variation

Transverse energy vs impact parameter

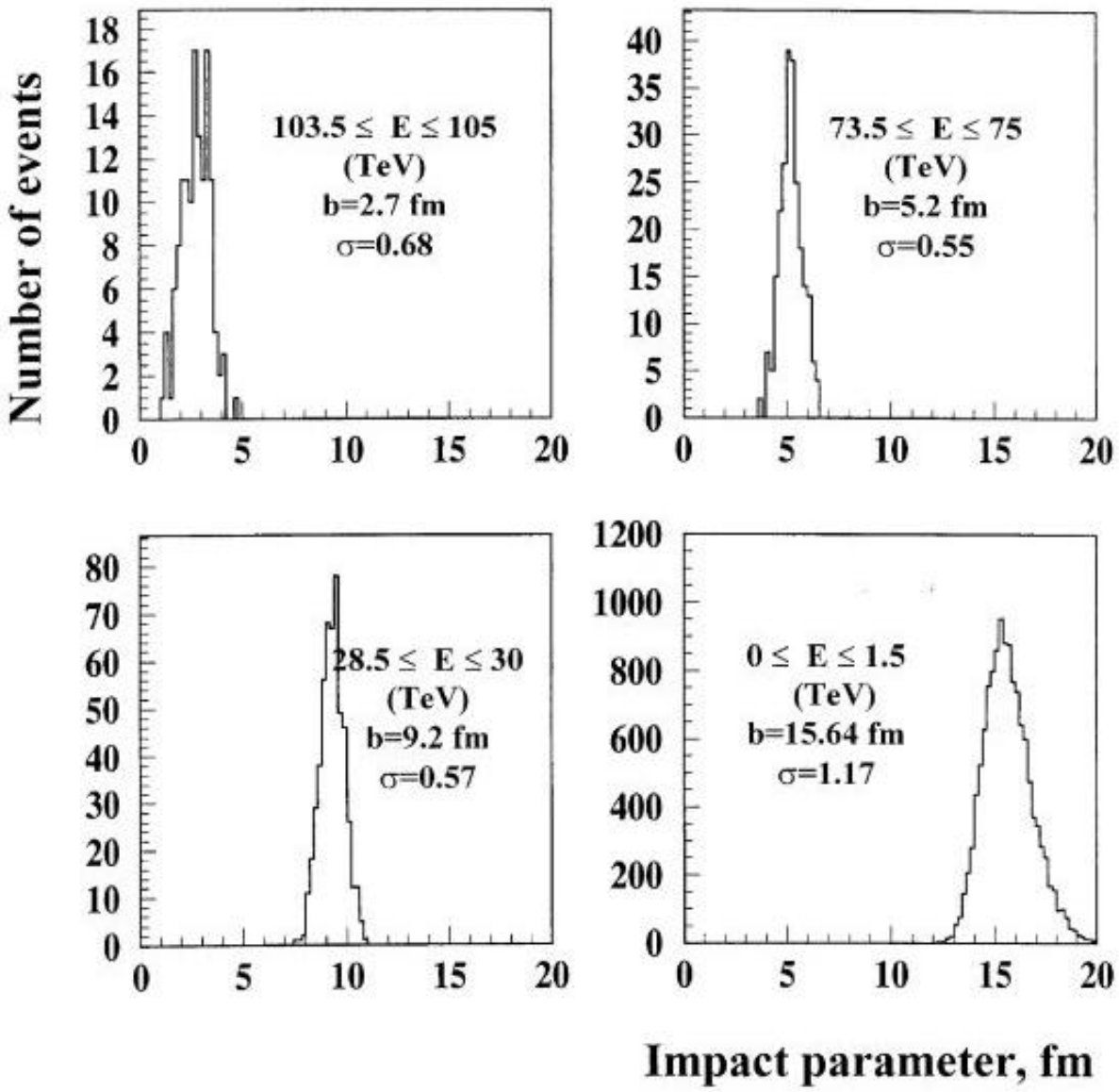
3<h<5



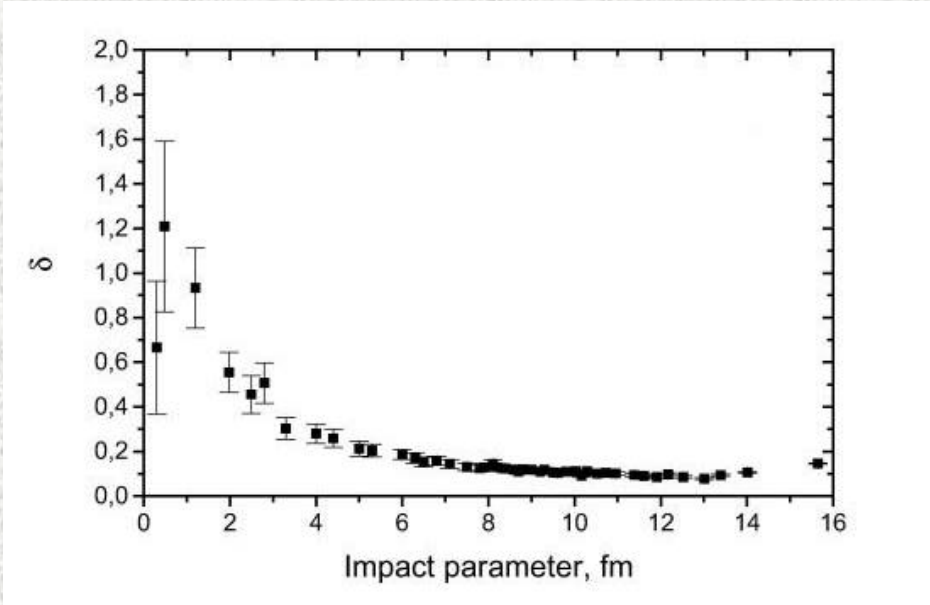
Collision energy variation

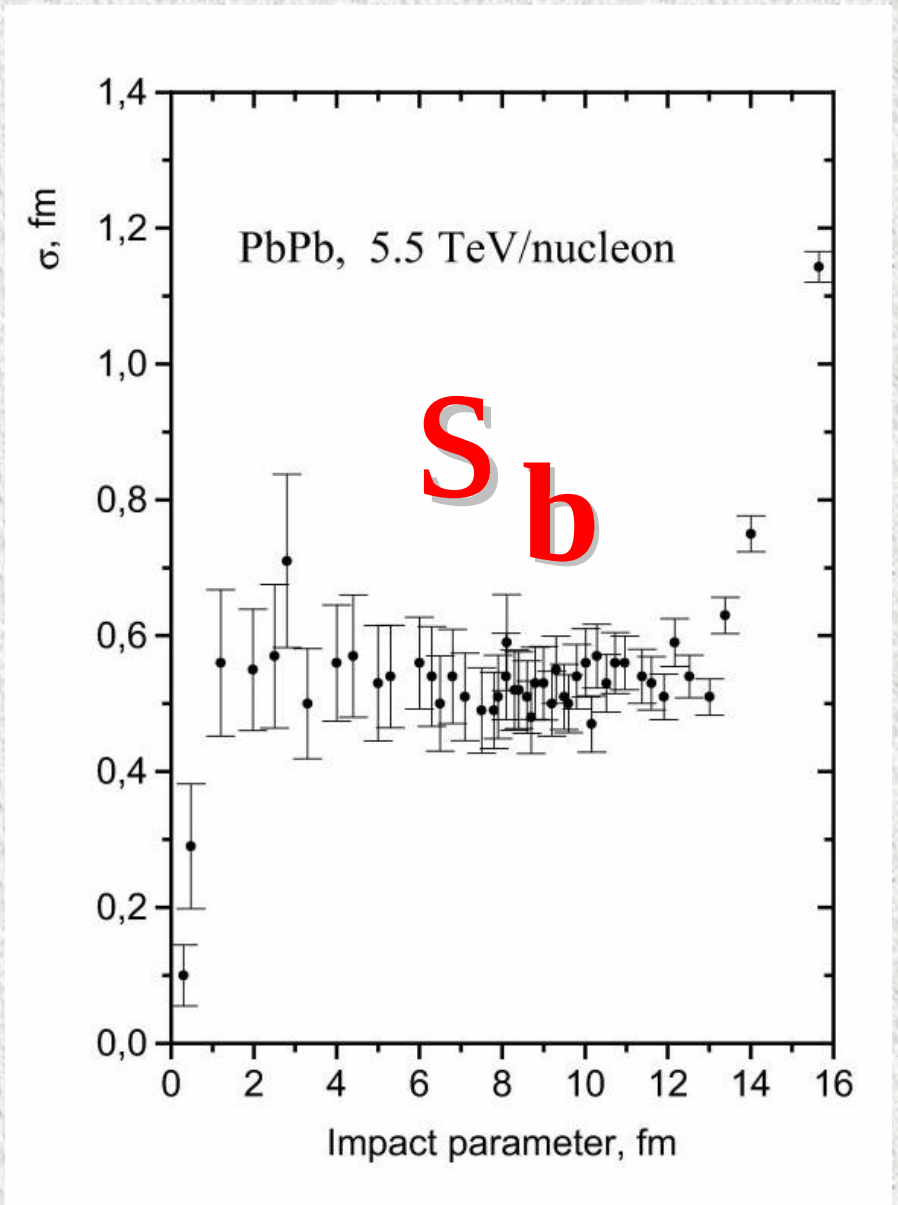
Impact parameter distributions in various energy bins

3<h<5



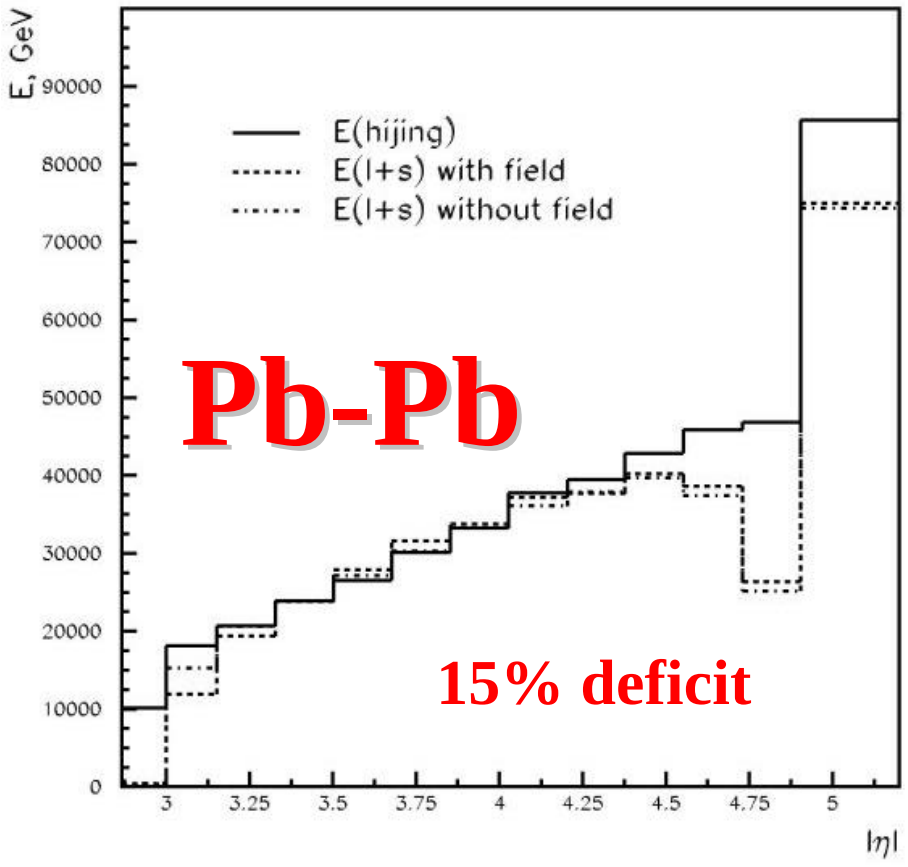
$d = s_b / b$

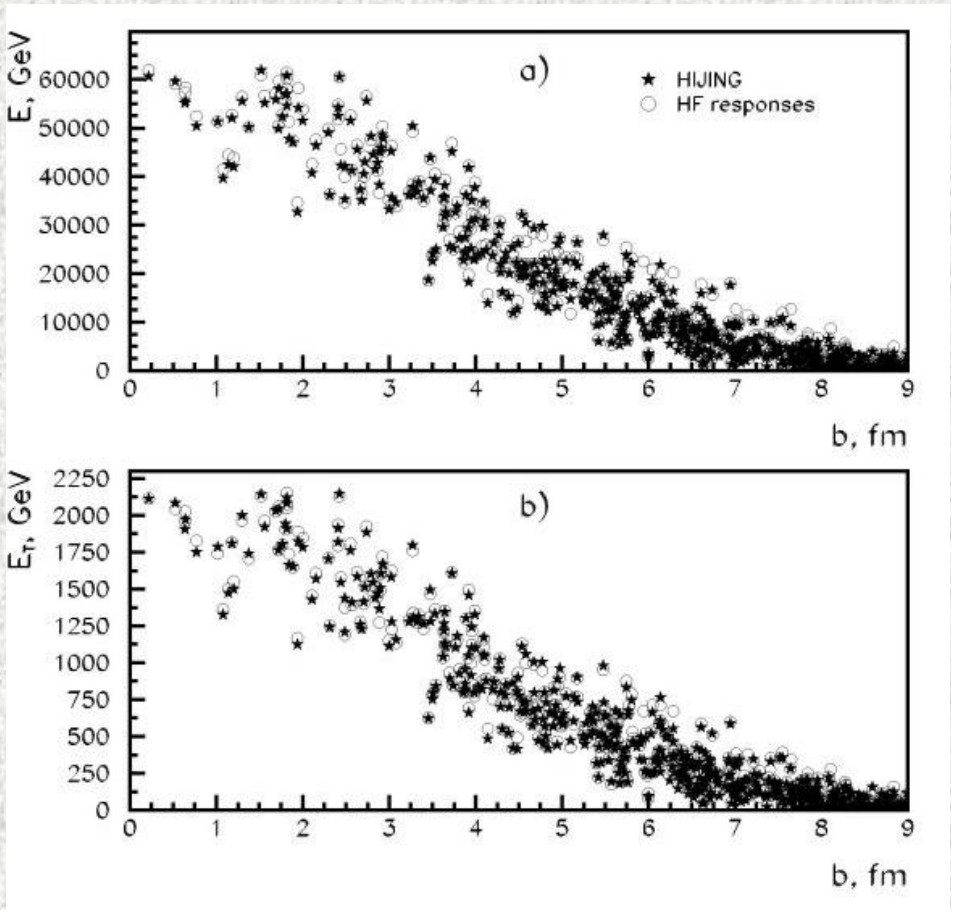

δ
Impact parameter, fm


σ, fm
PbPb, 5.5 TeV/nucleon
S_b
Impact parameter, fm

HIJING +CMSIM120 (Moscow Univ. Group)

H F 750 Ar-Ar

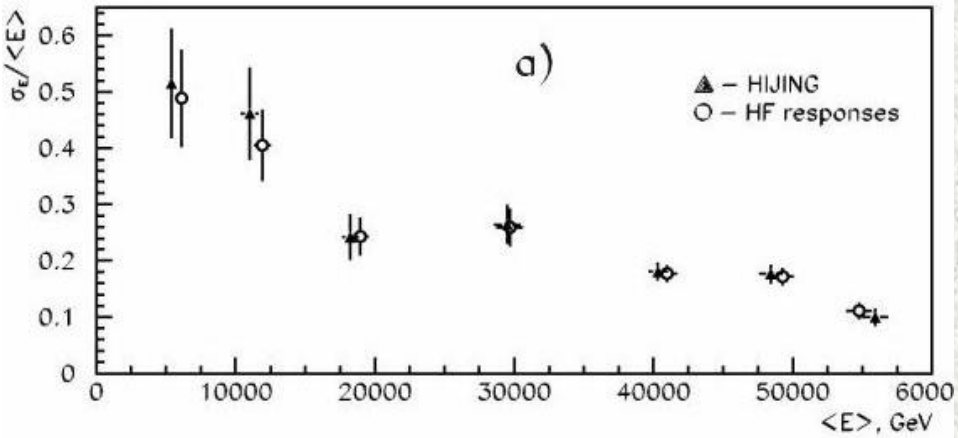


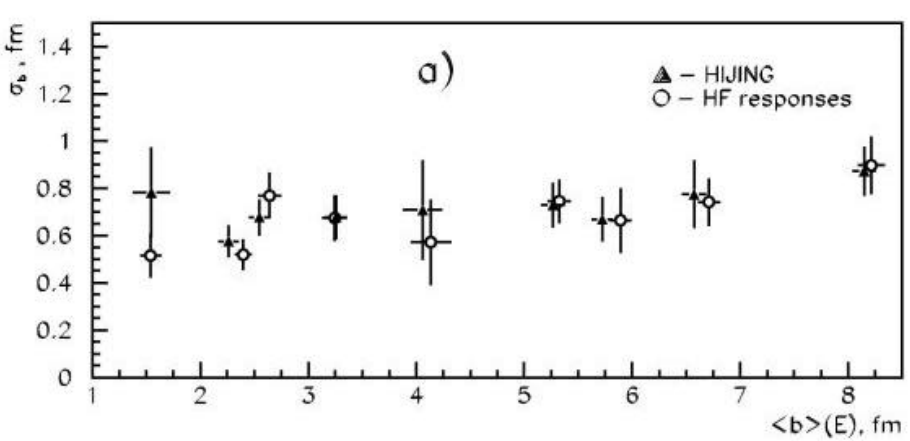


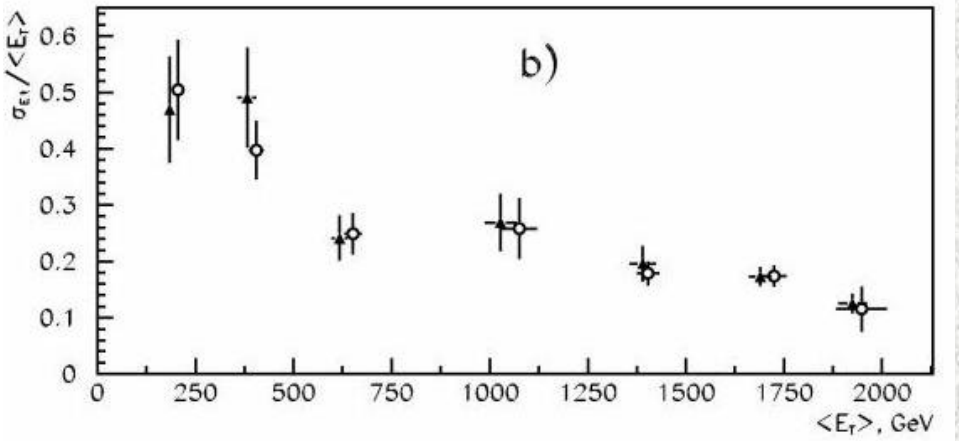
HIJING +CMSIM120

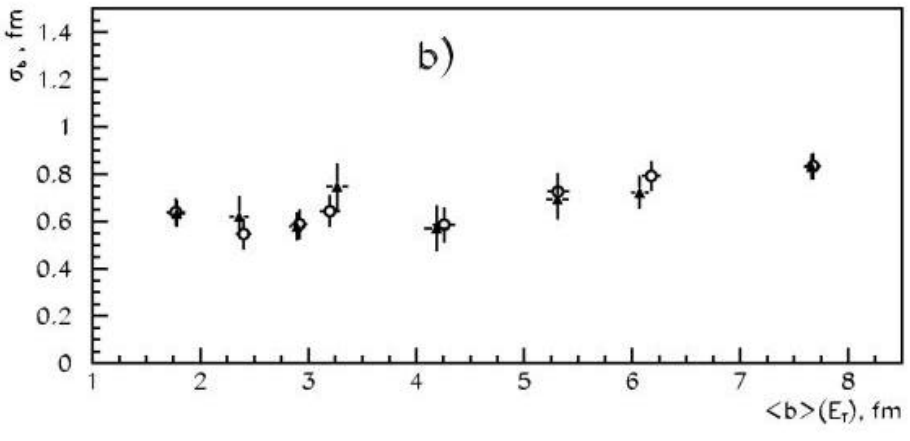
(Moscow Univ. Group)

Impact Parameter Resolution









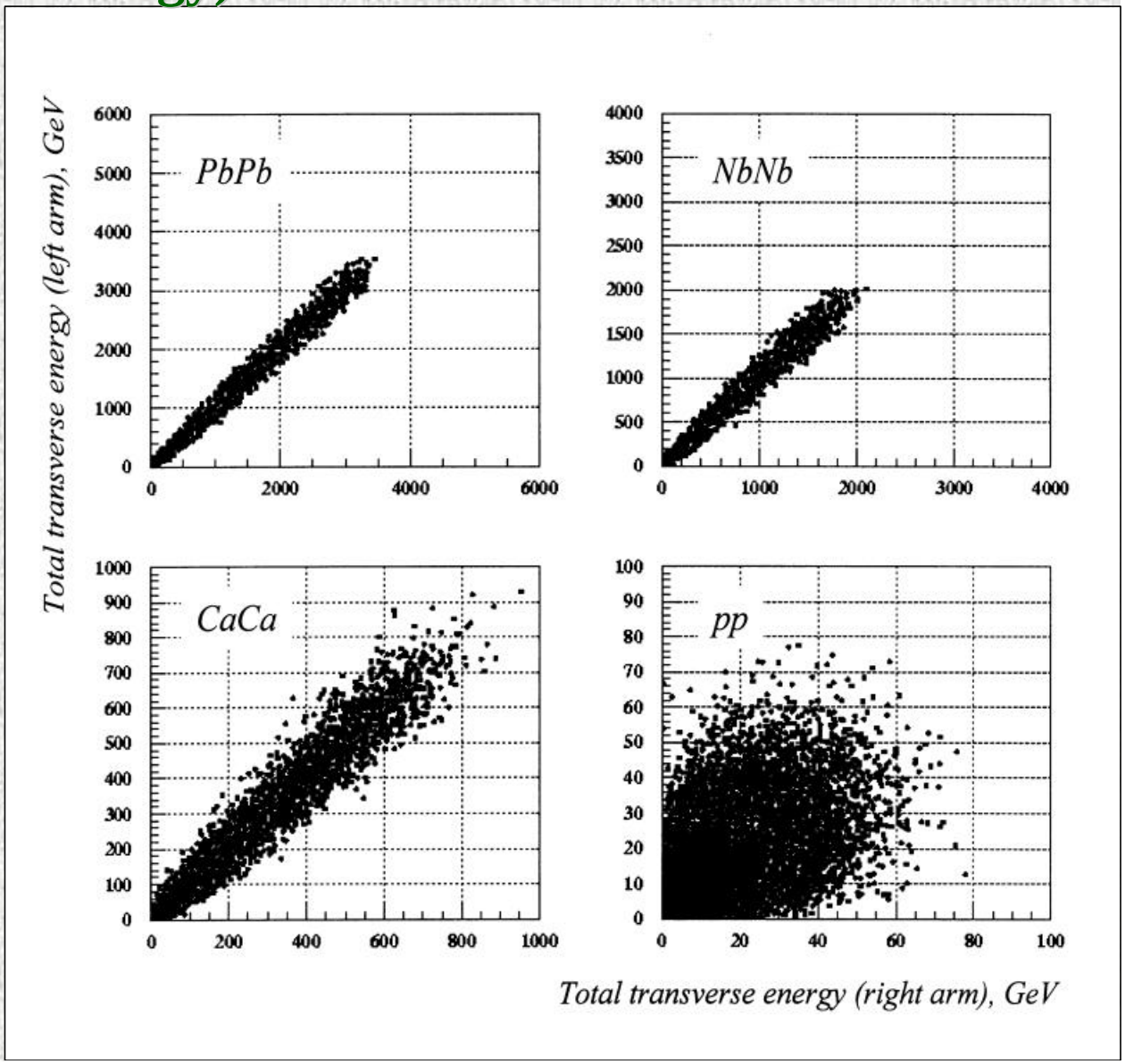
Energy flow correlations of two HF calorimeter arms (total transverse energy)

AA collisions

$0 \pounds b \pounds 3R_A$

at

$\ddot{O}S_{nn} = 5.5$ TeV



Energy flow correlations of two HF calorimeter arms (total energy)

AA collisions

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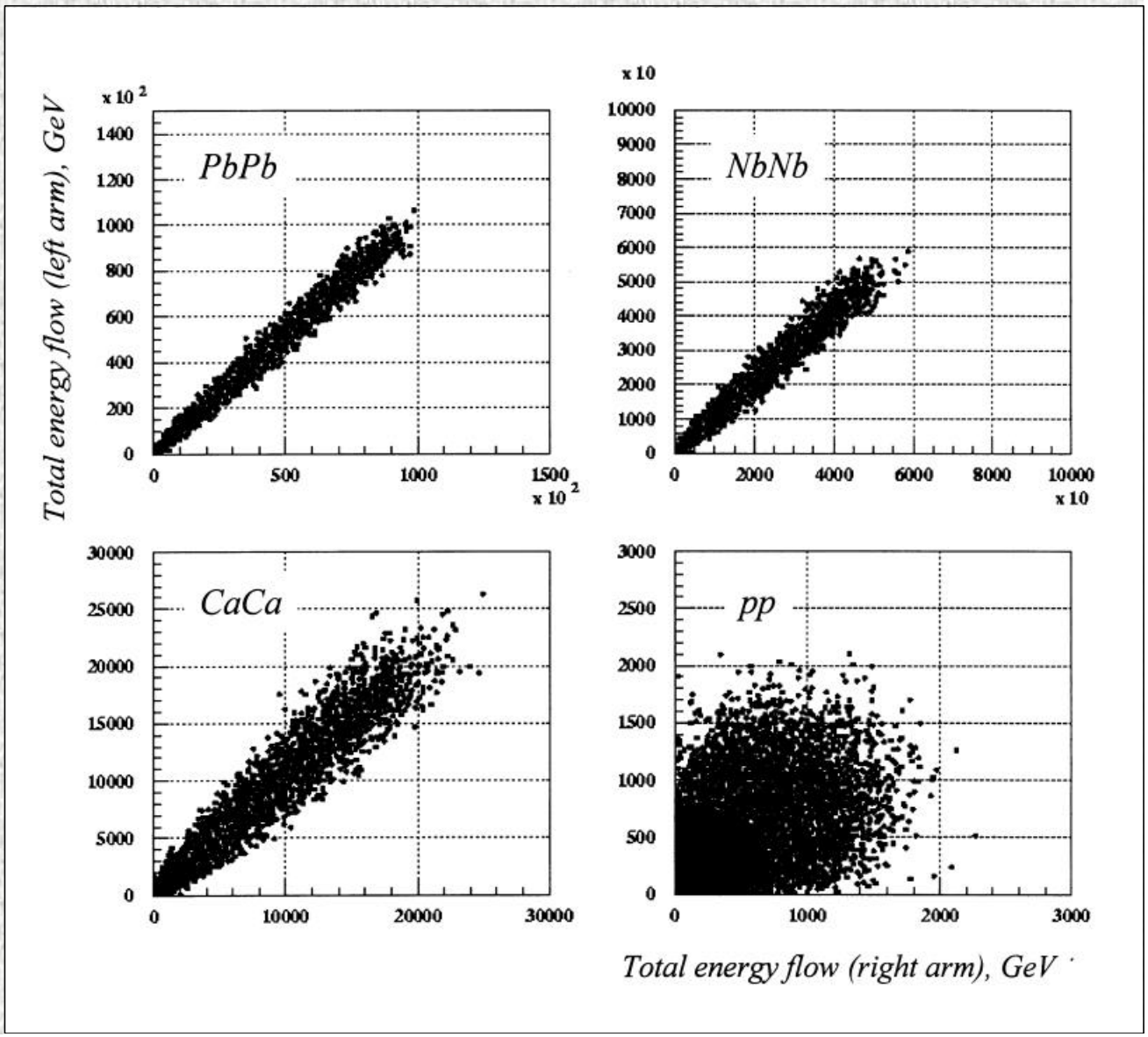


Main Idea of 1st Level Trigger

Time coincidence of two HF calorimeter arm signals for event counting with a resolution of the order of 1ns

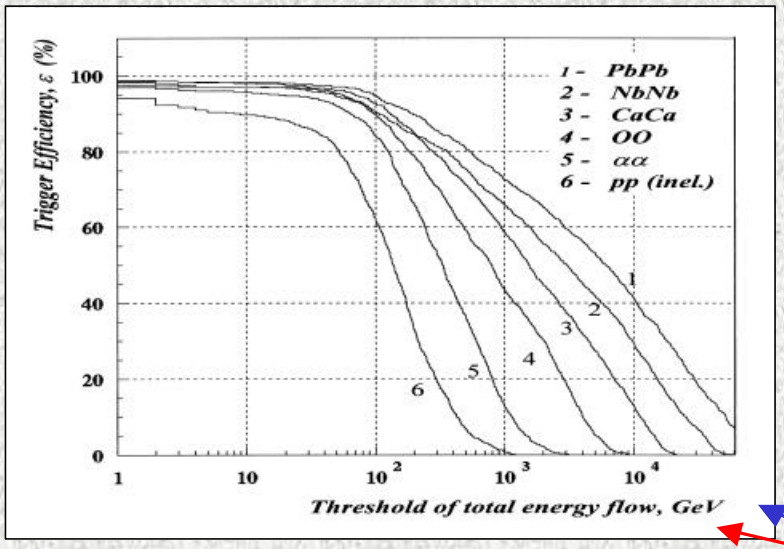
Trigger:

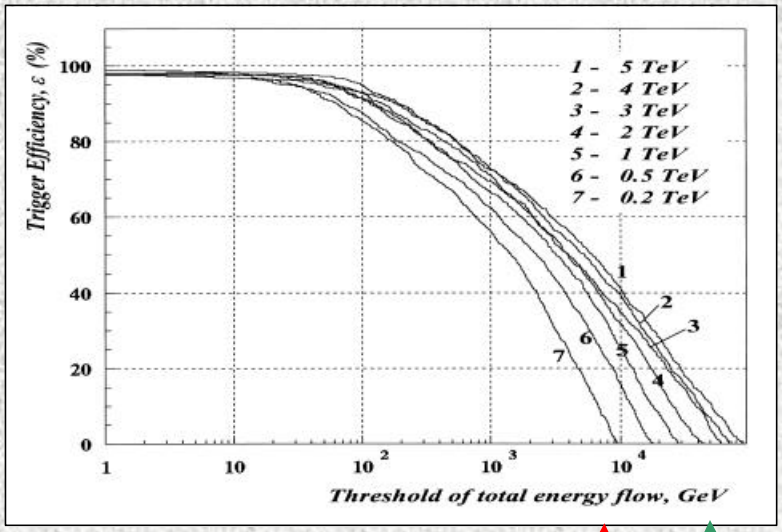
$$(E_{HF+} \geq E_{thr}) \bullet (E_{HF-} \geq E_{thr})$$

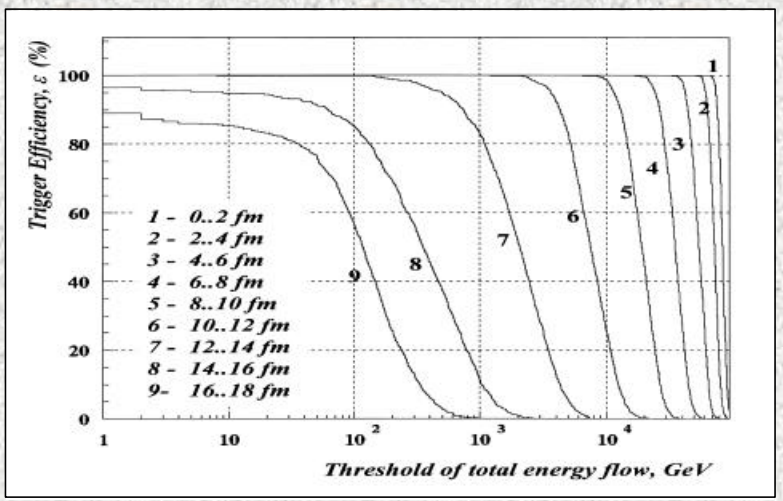
$$\textbf{Efficiency:} \quad e = \frac{N_{trigger}}{N_{simulated}} \times 100\%$$

Efficiency dependence on calorimeter thresholds (particle level)

The trigger efficiency *vs* energy threshold for various atomic numbers, c.m.s. energy and impact parameters of colliding nuclei







$\sqrt{S_{nn}}$=5.5 TeV

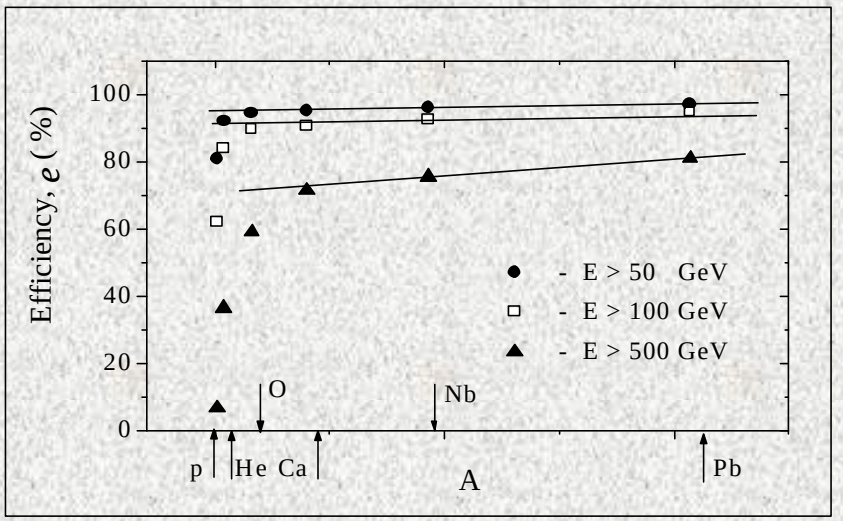
0 £ b £ 3 R_A fm

PbPb collisions

Efficiency *vs* atomic number of colliding nuclei

$\sqrt{S_{nn}}$=5.5 TeV

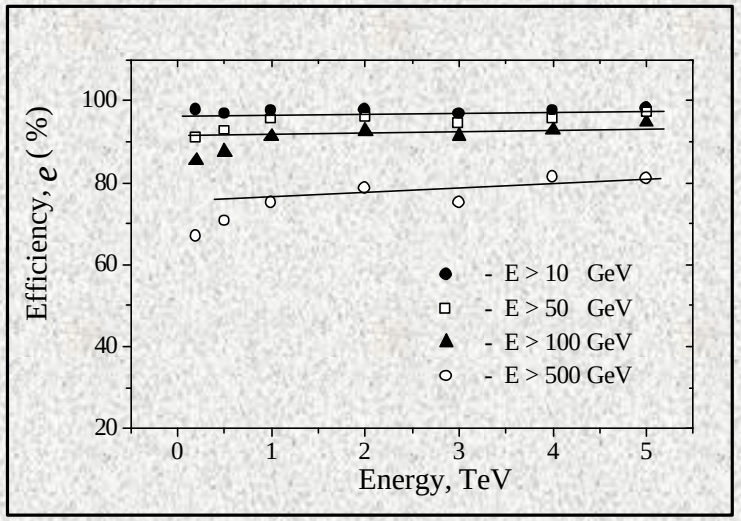
$0 \pounds b \pounds 3R_A$ fm



Efficiency *vs* c.m.s. energy of colliding nuclei

PbPb collisions

$0 \pounds b \pounds 3R_A$ fm



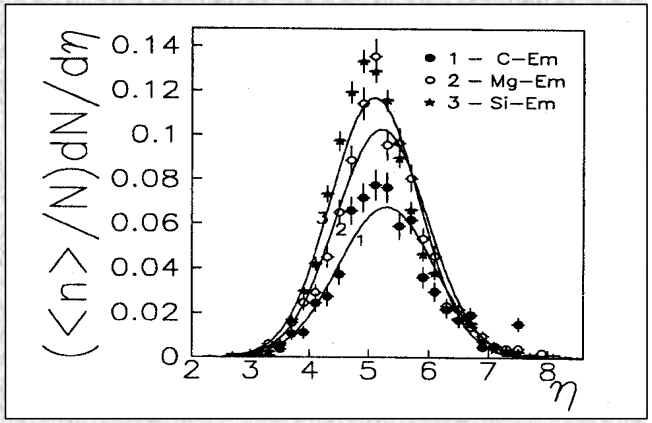
Choice of the pseudorapidity interval

Pseudorapidity distributions of double charged fragments (EMU01 Collaboration)

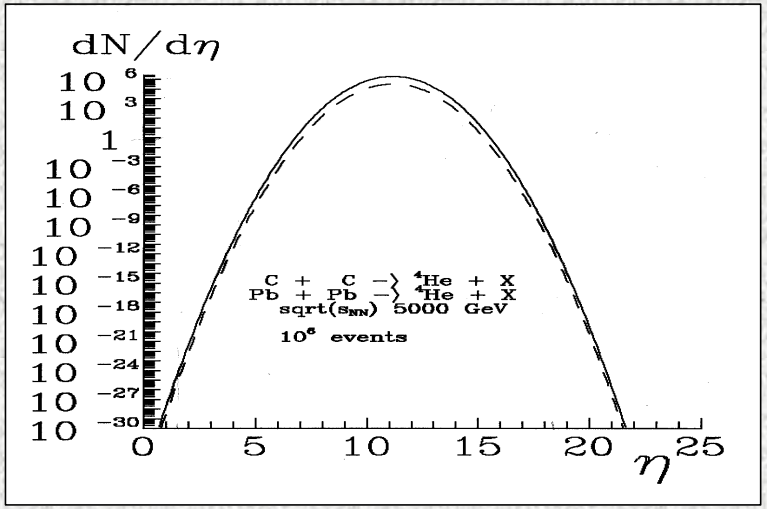
$$\frac{dn_{ch.fr}}{dh} = \langle n_a \rangle \frac{1}{\sqrt{2ps^2}} e^{-(h-\langle h \rangle)^2/2s^2},$$

$$\langle n_a \rangle|_{PbPb} = 4.37 \pm 0.09$$

(V. Uzhinskii)



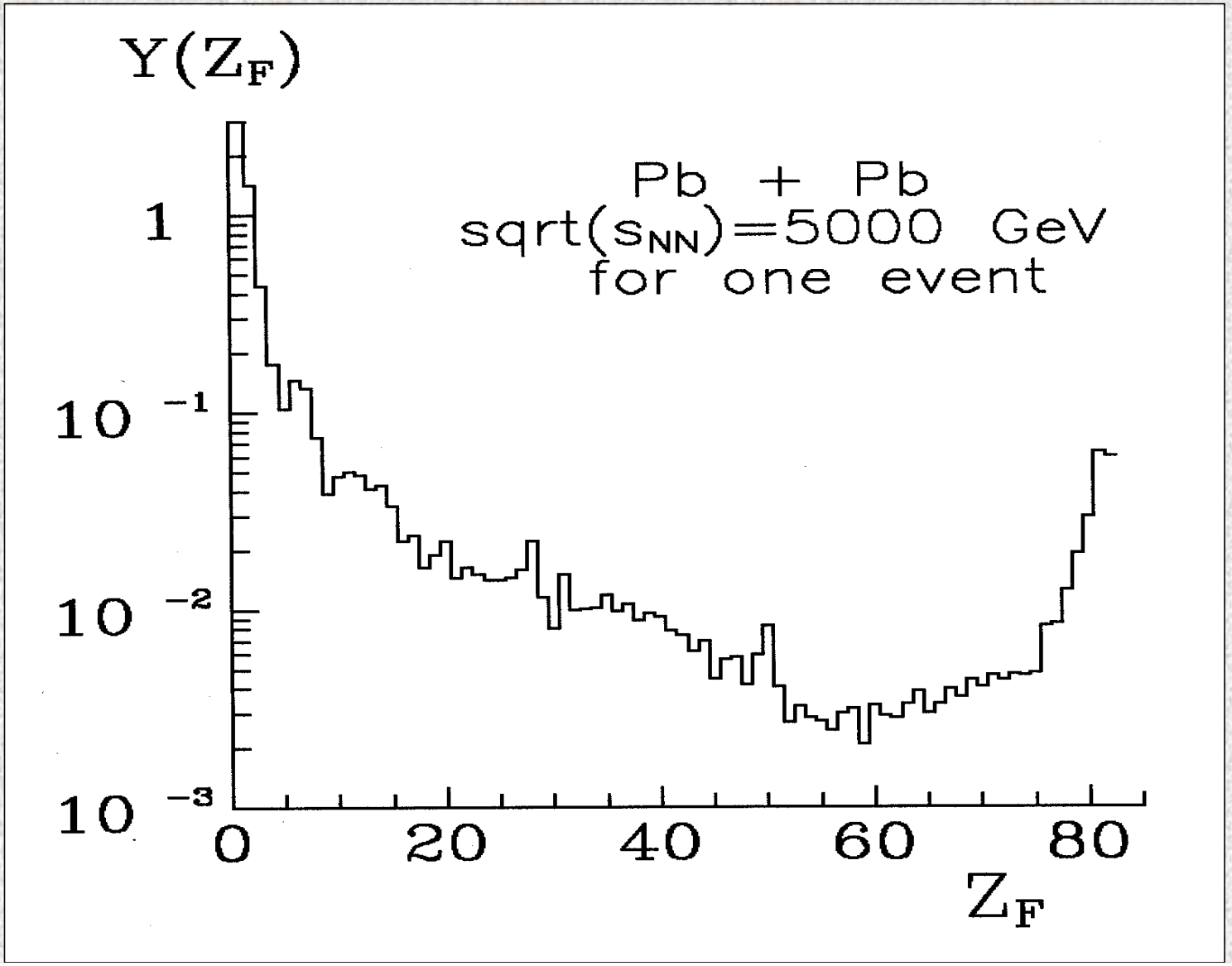
Pseudorapidity distributions of ^{4}He production at the LHC energy



in the 3£|h| £ 5
less then 1 event per year
of PbPb running

is not sensetive to a charged fragment production !!!

Zero Degree Fragmentation



Conclusions

A way of impact parameter estimation is proposed.

It has been demonstrated

- **total energy (transverse energy) produced in the 3£|h| £ 5 pseudorapidity interval correlates with i.p.**

- **the CMS HF calorimeter is able to provide an adequate estimation of a collision impact parameter**

  minimal dependence dynamic details in the central rapidity region (no jet quenching effect)

  no sensitivity to magnetic field

  no sensitivity to a nuclear fragments

  for an inelastic nucleus-nucleus collisions a fast trigger might be applied - the idea is to use a signal time coincidence from two HF calorimeter arms

Hit Density per 1 mm^2