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Energy flow and impact parameter determination in heavy ion collisions with CMS HF calorimeter

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Why we need HF for heavy ion physics?

Main motivation:

very forward pseudorapidity region $3 \leq |\eta| \leq 5$ is almost free of final state re-interactions

$\downarrow$

energy deposition in CMS HF is determined by initial nuclear geometry rather than by details of final state nuclear dynamics

$\downarrow$

the advantage to determine impact parameter via (transverse) energy deposition in HF

Other motivations:

fluctuations of HAD/EM energy ratio ("Centauro"-like events), fast inelastic event selection

Main tools:

HIJING generator + CMSIM 120 (adapted for HI)

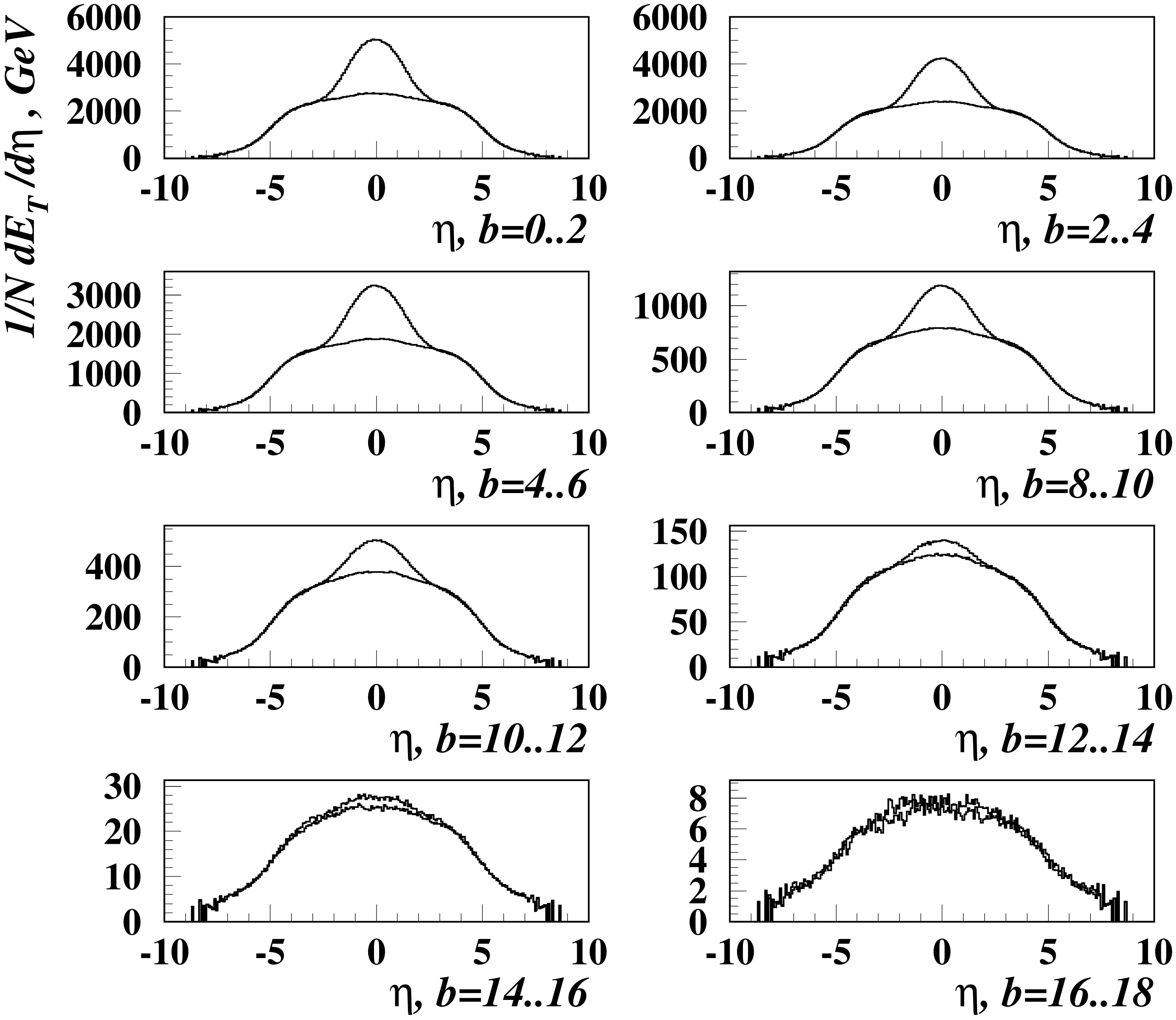
Why we need an impact parameter b?

1. Central collisions, $b \sim 0 \ll R_A$
Maximal energy density in mid-rapidity
$\varepsilon_0 \sim 0.5$ **TeV/fm**$^3 \gg \varepsilon_{crit} \sim 1$ **GeV/fm**^{3}
and maximal volume of the reaction result in the strongest quark-gluon plasma signals at CMS (quarkonia and high-mass dimuon suppression, jet quenching)

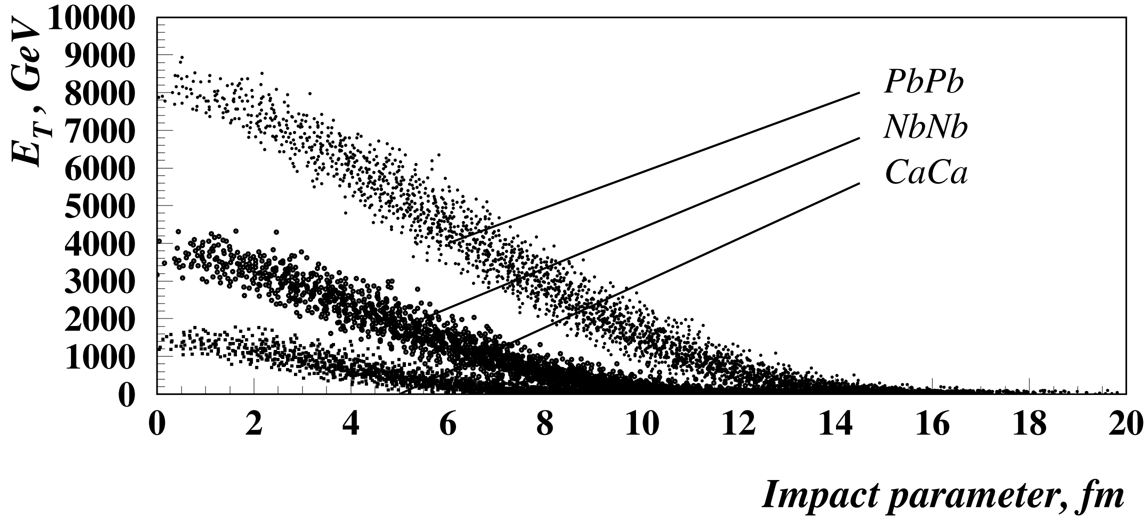
2. Semi-central collisions, $b \sim R_A$
Azimuthally non-symmetric volume of the reaction can result in some interesting phenomena (e.g. azimuthal anisotropy of jet production)

3. Peripheral collisions, $b \gtrsim 2R_A$
Electromagnetic interactions,
diffractive phenomena,
coherent nuclear effects

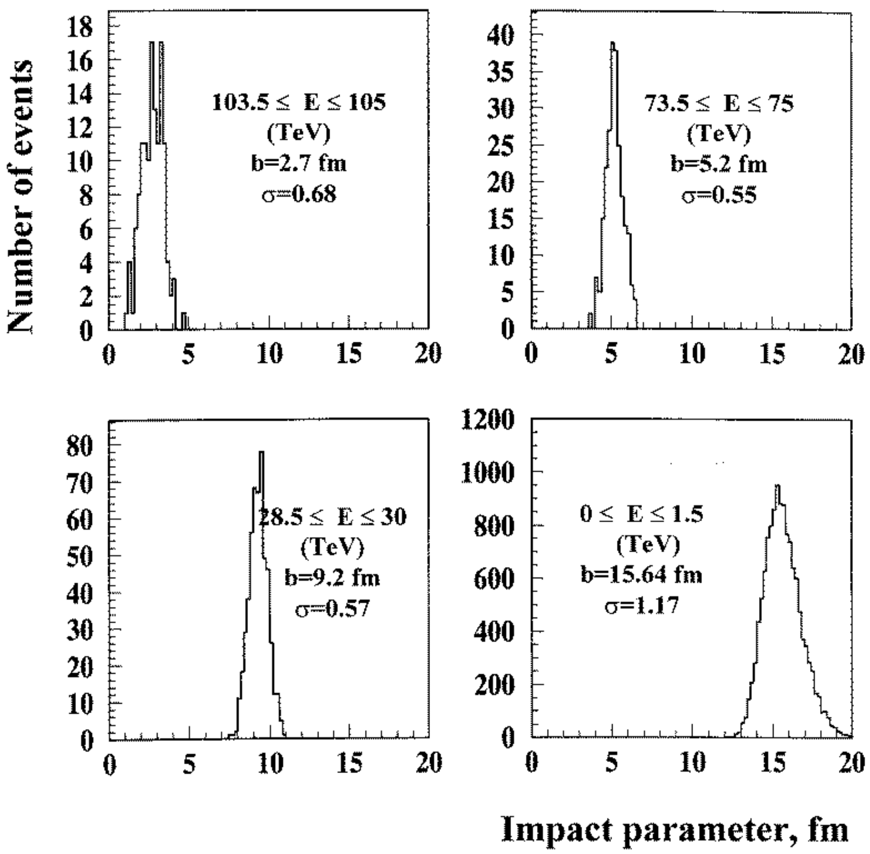
Distribution E_T over η,
10.000 minimum bias Pb−Pb collisions
with (top) and without (bottom) "jet quenching"



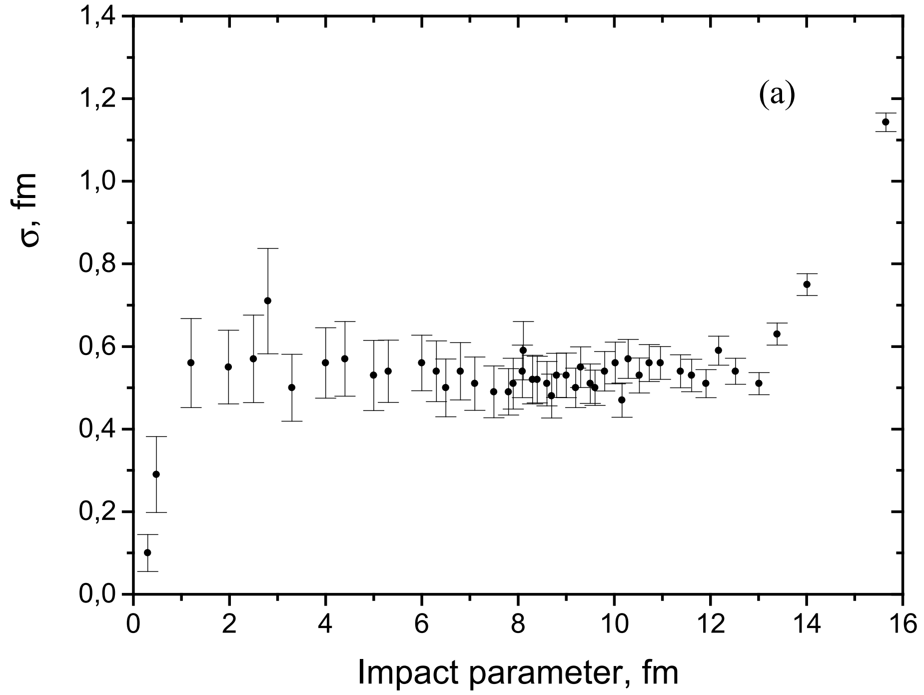
$E_T - b$ correlation at very forward rapidity $3 \le |\eta| \le 5$

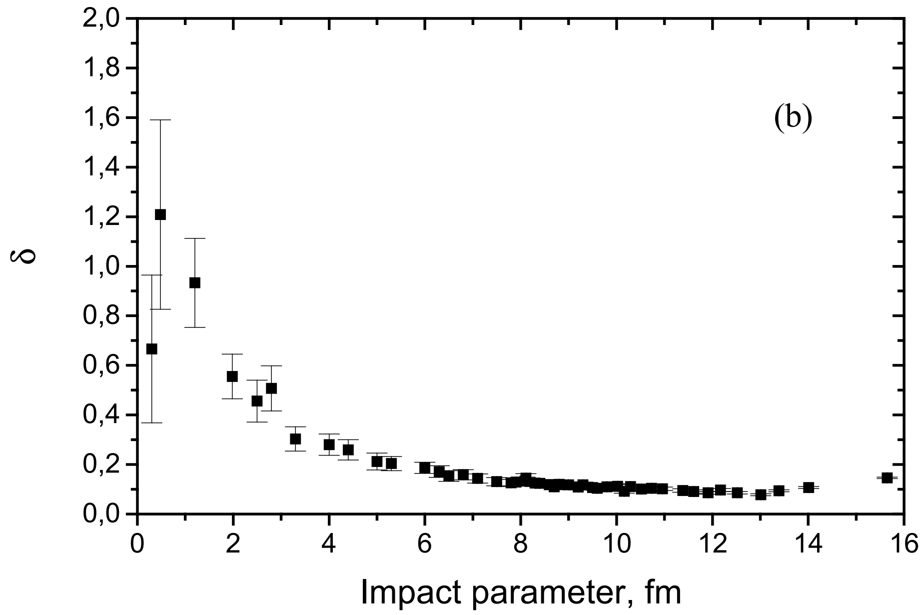


Pb−Pb event distribution over b at fixed E

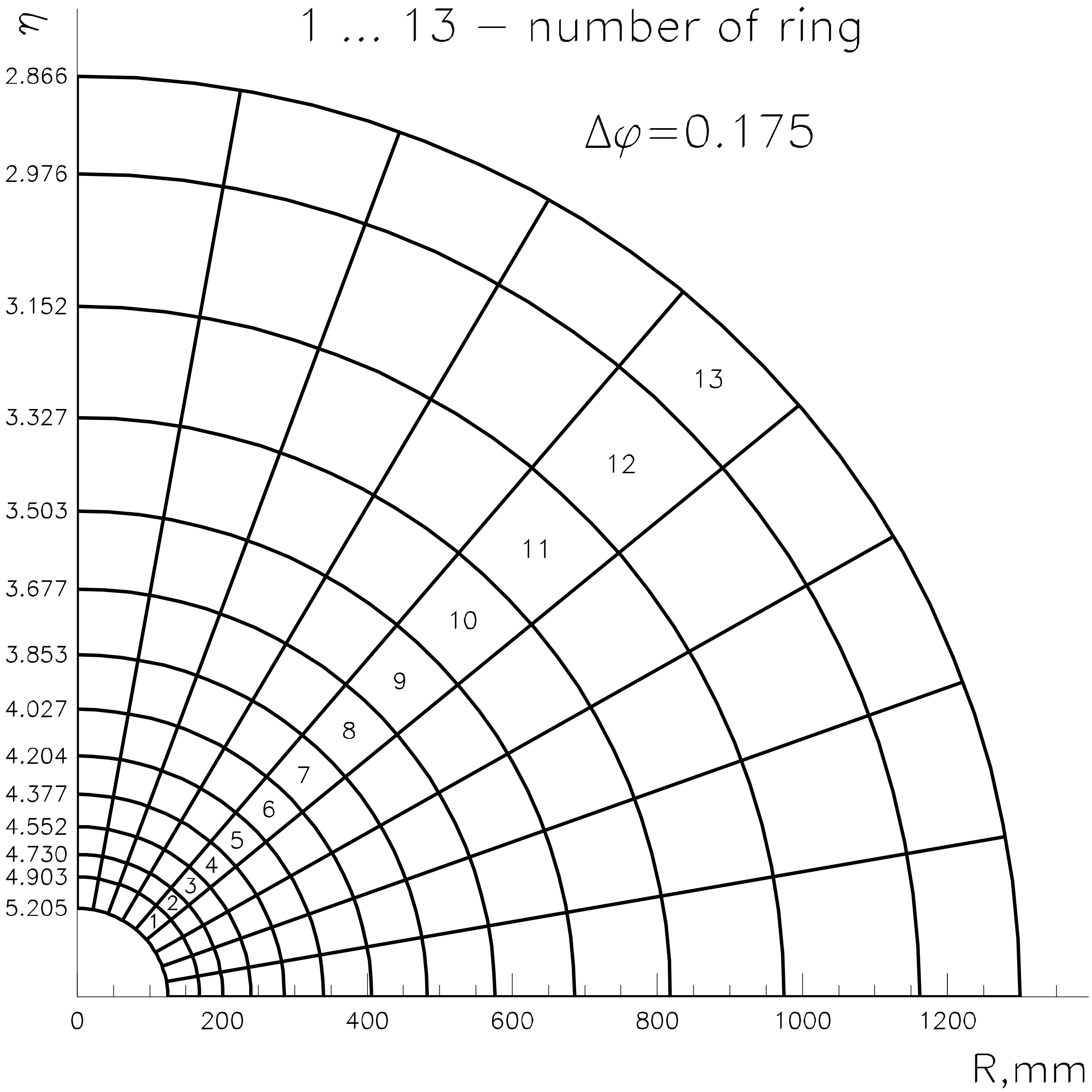


Gaussian width σ_b and the relative error $\delta = 2\sigma_b/b$ as a function of b for Pb−Pb collisions

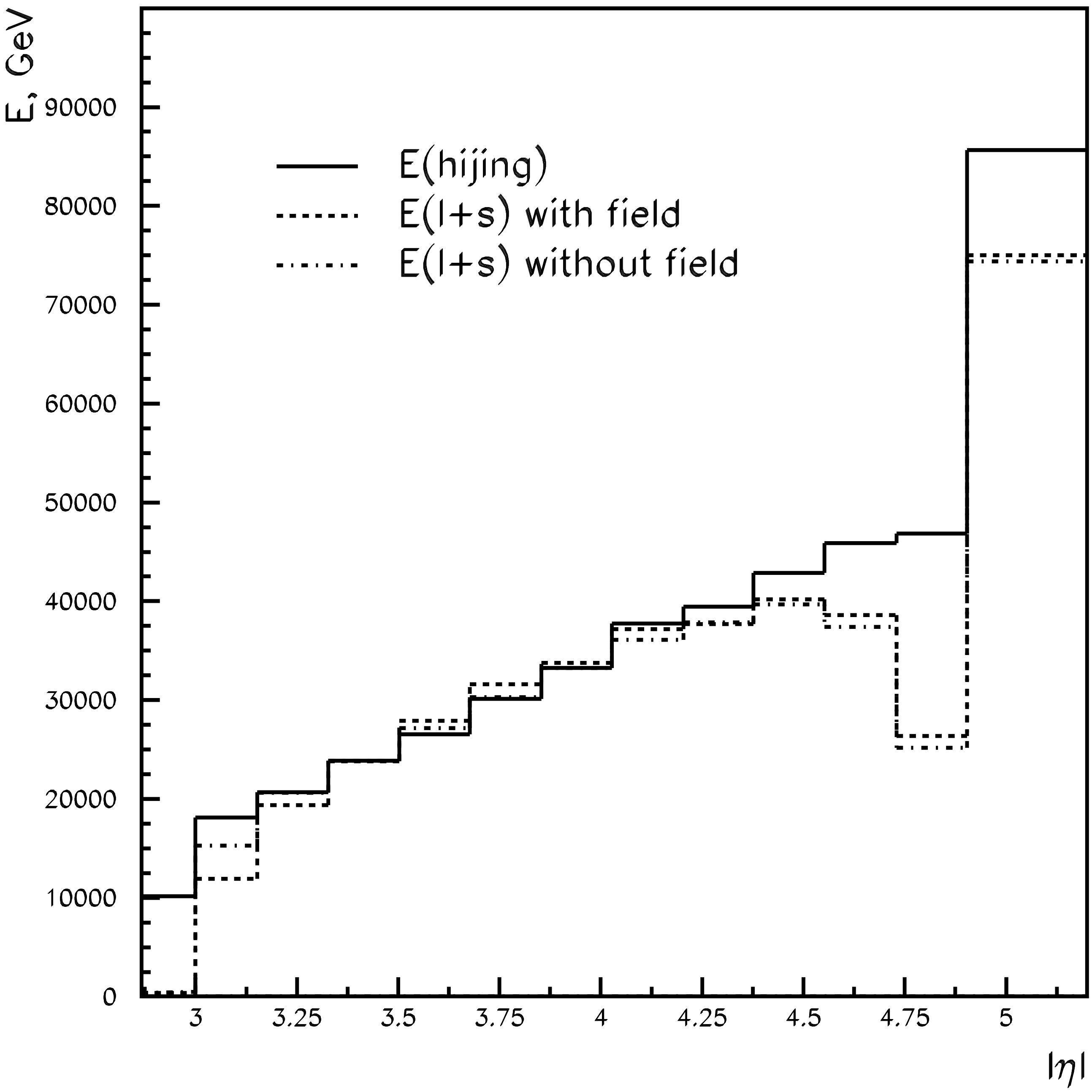




Hadron Forward Calorimeter: the transverse view



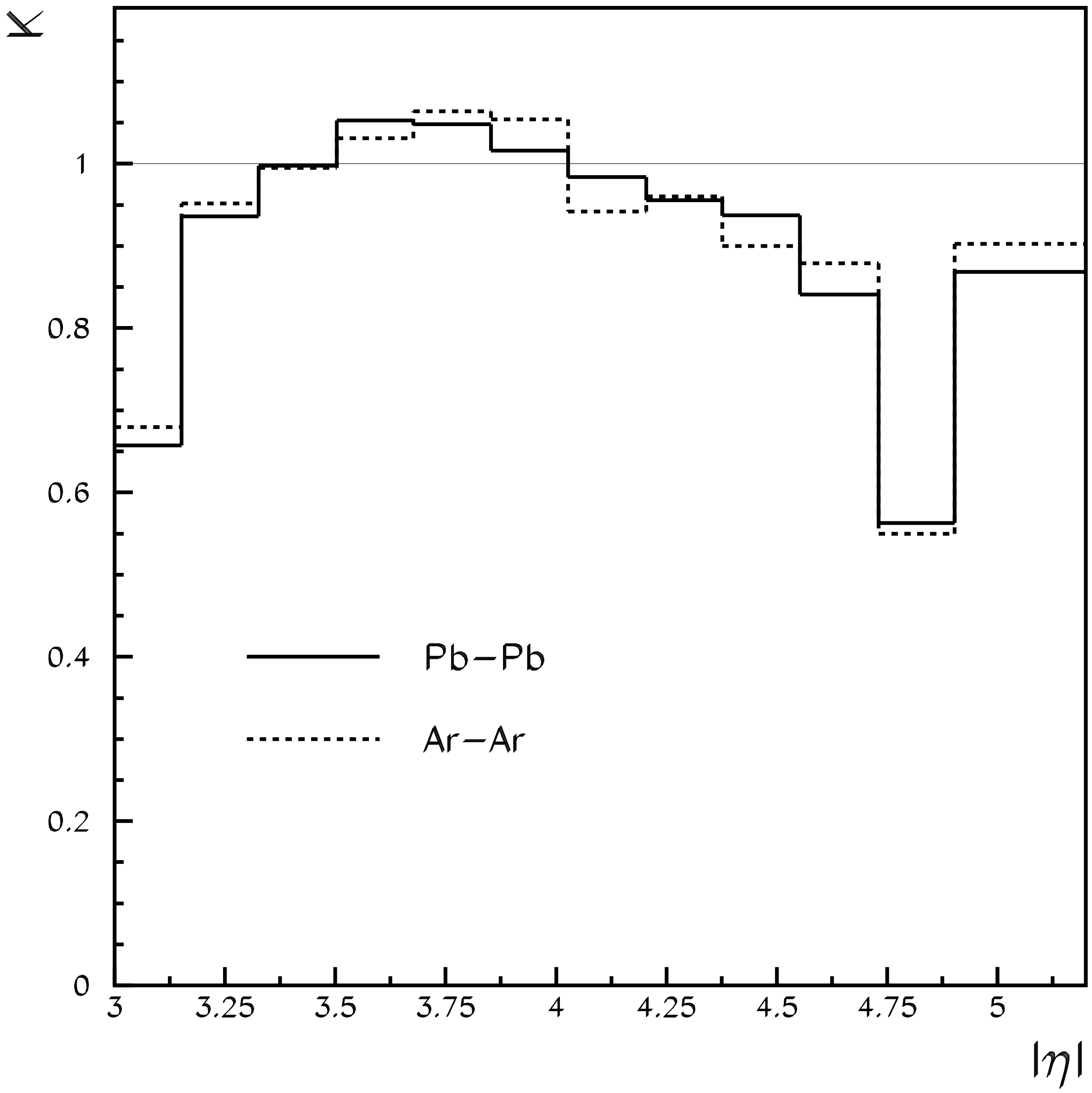
HIJING total energy $E(hijing)$
and
HF calorimeter response $E(l+s)$
for central Pb–Pb collisions



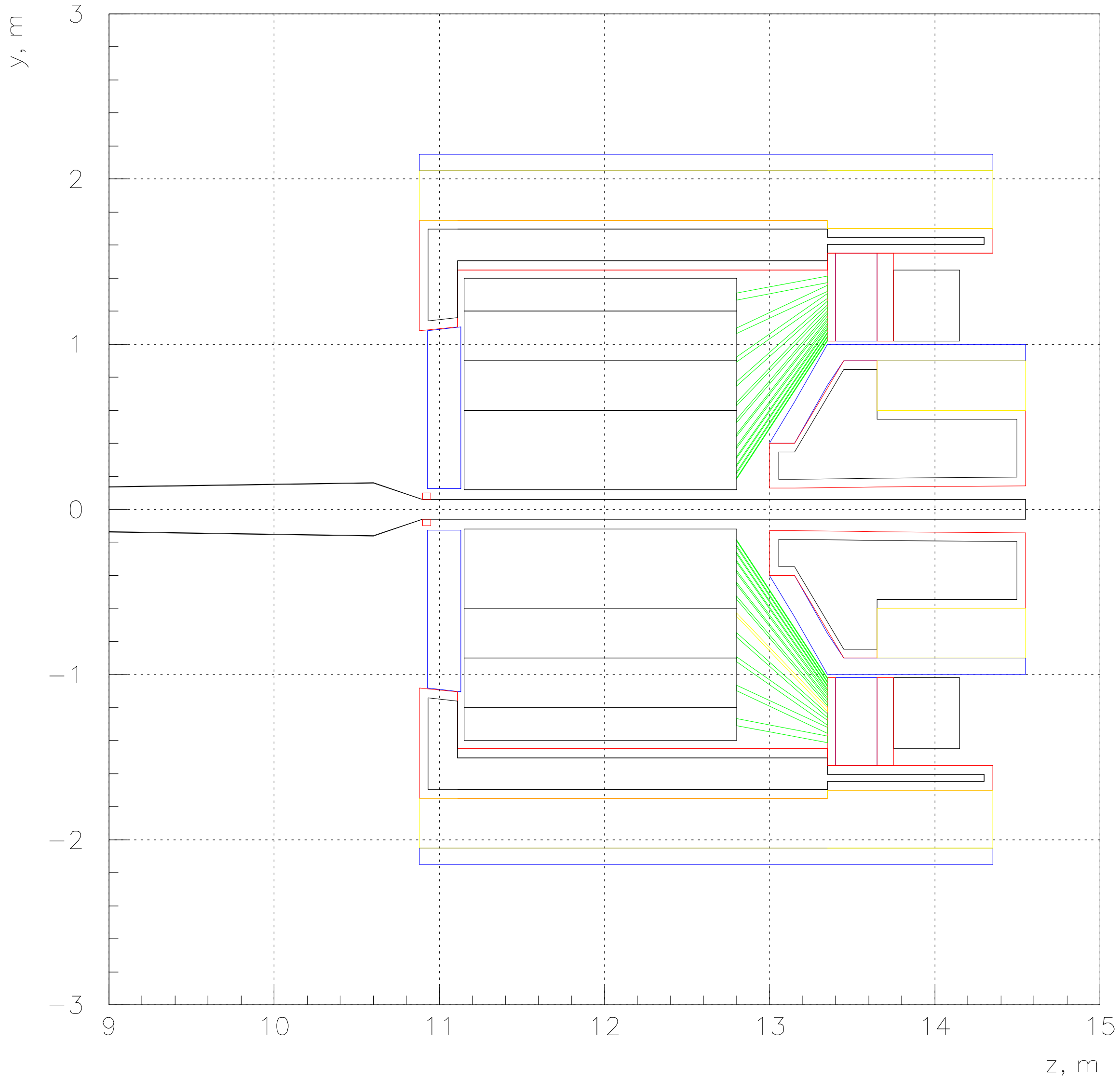
Reconstructed-to-generated energy ratio

$K = E(l+s)/E(hijing)$

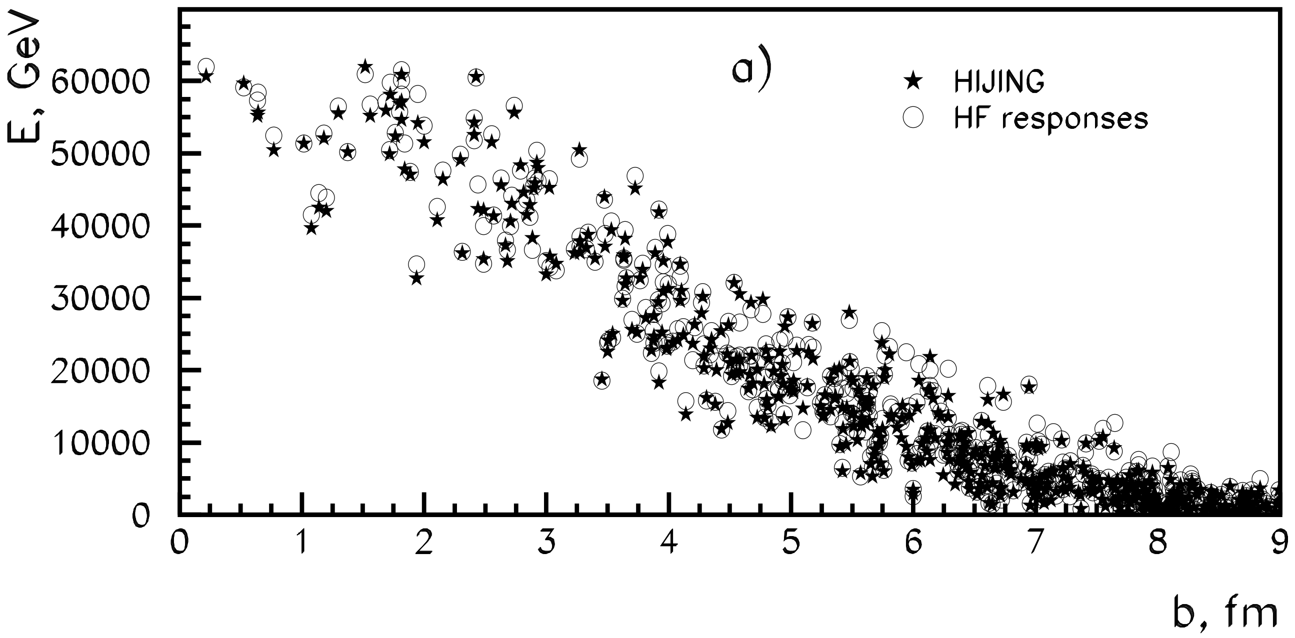
for central Pb–Pb and Ar–Ar collisions

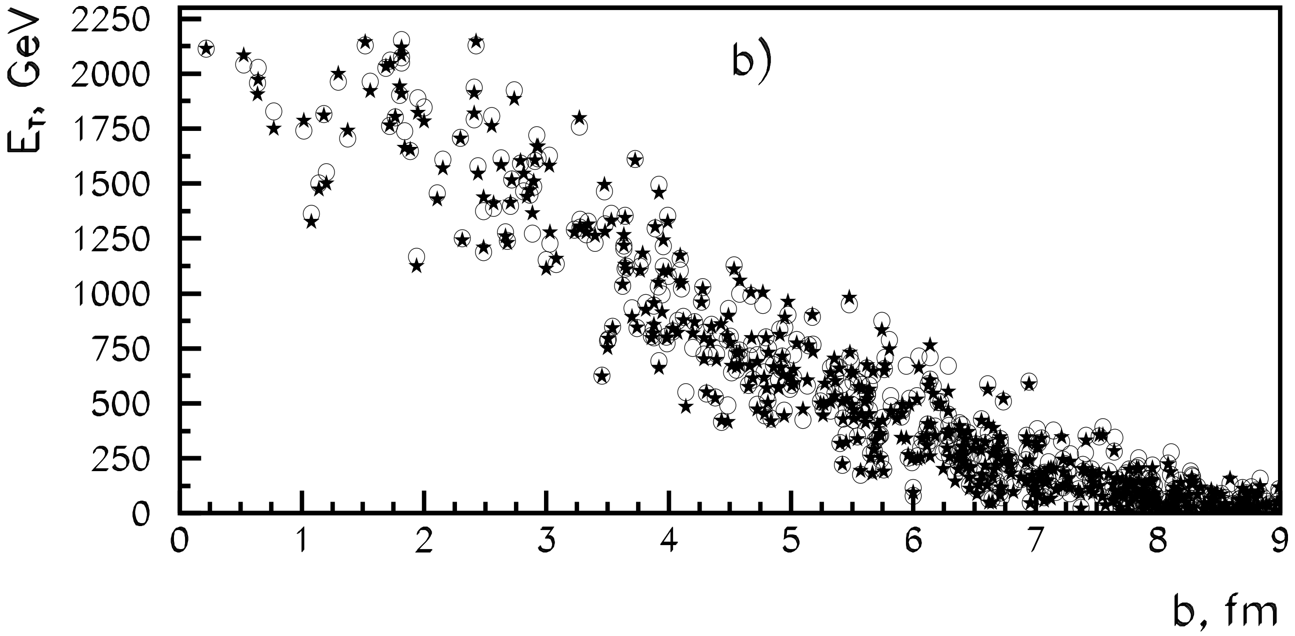


Beam pipe in the front of HF calorimeter



Generated and reconstructed $E - b$ and $E_T - b$ correlations for 500 minimum bias Ar–Ar collisions

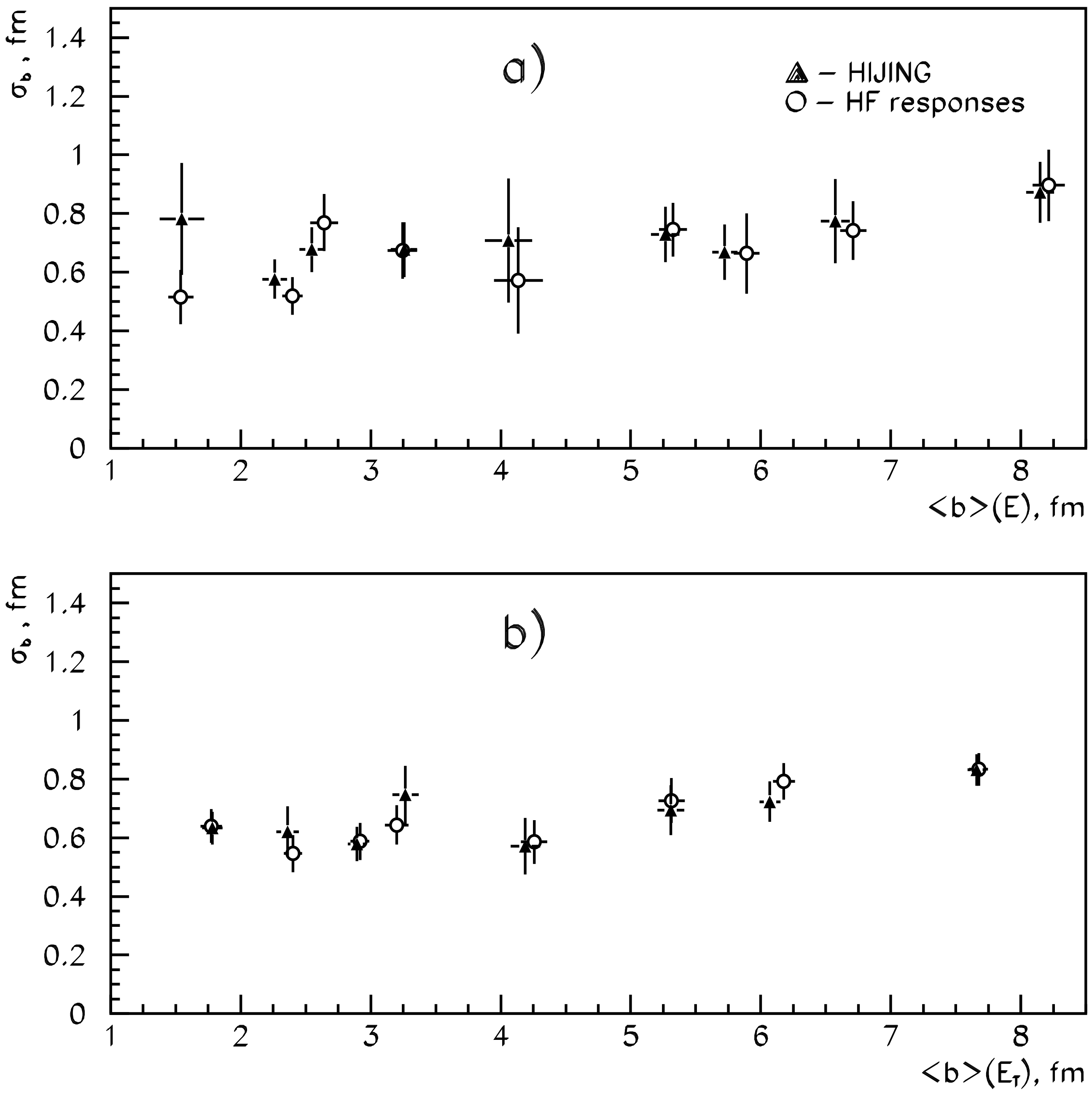




Gaussian width σ_b

(Ar–Ar event distribution over b fixing E, E_T)

as a function of b



Summary

The total energy flow in very forward rapidity region can be reconstructed by HF calorimeter when the correction procedure is applied. However there exist the degradation of the reconstructed energy at $\eta \sim 4.8$ due to the screening of this ring from produced particles by the LHC beam pipe in the front of HF calorimeter.

The influence of CMS magnetic field on the energy reconstruction efficiency is not expected to be significant for HF domain.

The finite energy resolution of HF calorimeter is shown to result in no substantial degradation of accuracy of impact parameter determination, which is of the order of $1-1.5$ fm for Ar–Ar and Pb–Pb collisions up to $b \sim 2R_A$ and gets worse by the factor ~ 2 for very peripheral ($b > 2R_A$) events.