# *AZIMUTHAL ASYMMETRY IN HEAVY ION COLLISIONS*

*I.P.Lokhtin, S.V.Petrushanko, A.M.Snigirev, L.I.Sarycheva*

**Institute of Nuclear Physics**
**Moscow State University**

**2001**

## The Main Idea

Non-central heavy ion collisions ($b \neq 0$)

$\downarrow$

Non-symmetric volume of quark-gluon plasma

$\downarrow$

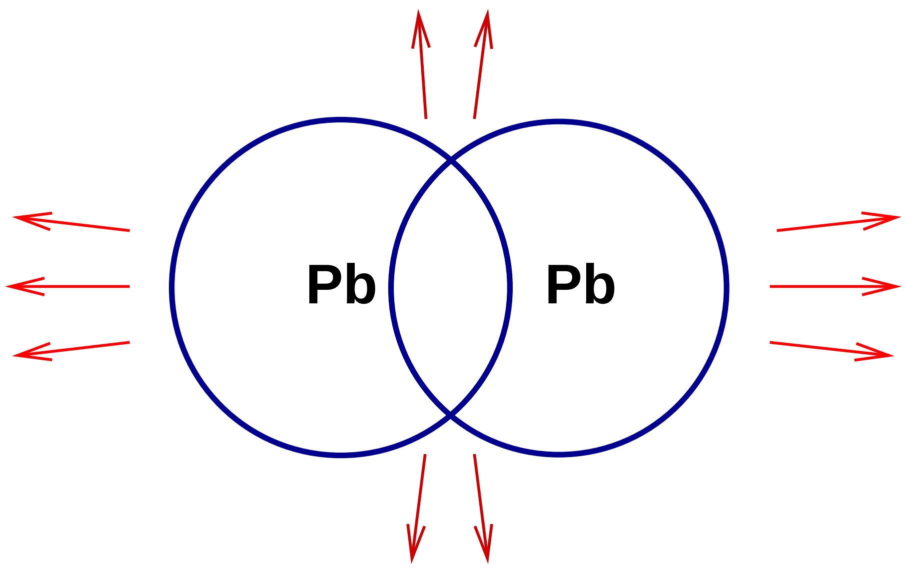
Effective transverse size depends on jet azimuthal angle $\varphi$
relatively to reaction plane

$\downarrow$

Jet energy loss depends on $\varphi$

$\downarrow$

Jet rate depends on $\varphi$




## The Main Problem

How to determine azimutal angle of reaction plane?
Due to jet quenching semi-hard particles flow ($p_t \geq 2 \div 4$ GeV/c) reflects azimuthally asymmetric reaction volume!

## The Common Practice

Reconstruction of the tracks of the secondary particles:
(using tracker):

$$tan(2\varphi_{rec}) = \frac{\sum\limits_i \omega_i \sin 2\varphi_i}{\sum\limits_i \omega_i \cos 2\varphi_i}$$

$$\omega_i = 1, p_t^i, (p_t^i)^2$$

## CMS detector at LHC

TOO HUGE quantity of secondary particles!
It's impossible to reconstruct tracks.

But we can use HCAL towers!

$$tan(2\varphi_{rec}) = \frac{\sum\limits_{towers} \omega_{tower} \sin 2\varphi_{tower}}{\sum\limits_{towers} \omega_{tower} \cos 2\varphi_{tower}}$$

$$\omega_{tower} = E^{tower}, E_t^{tower}$$

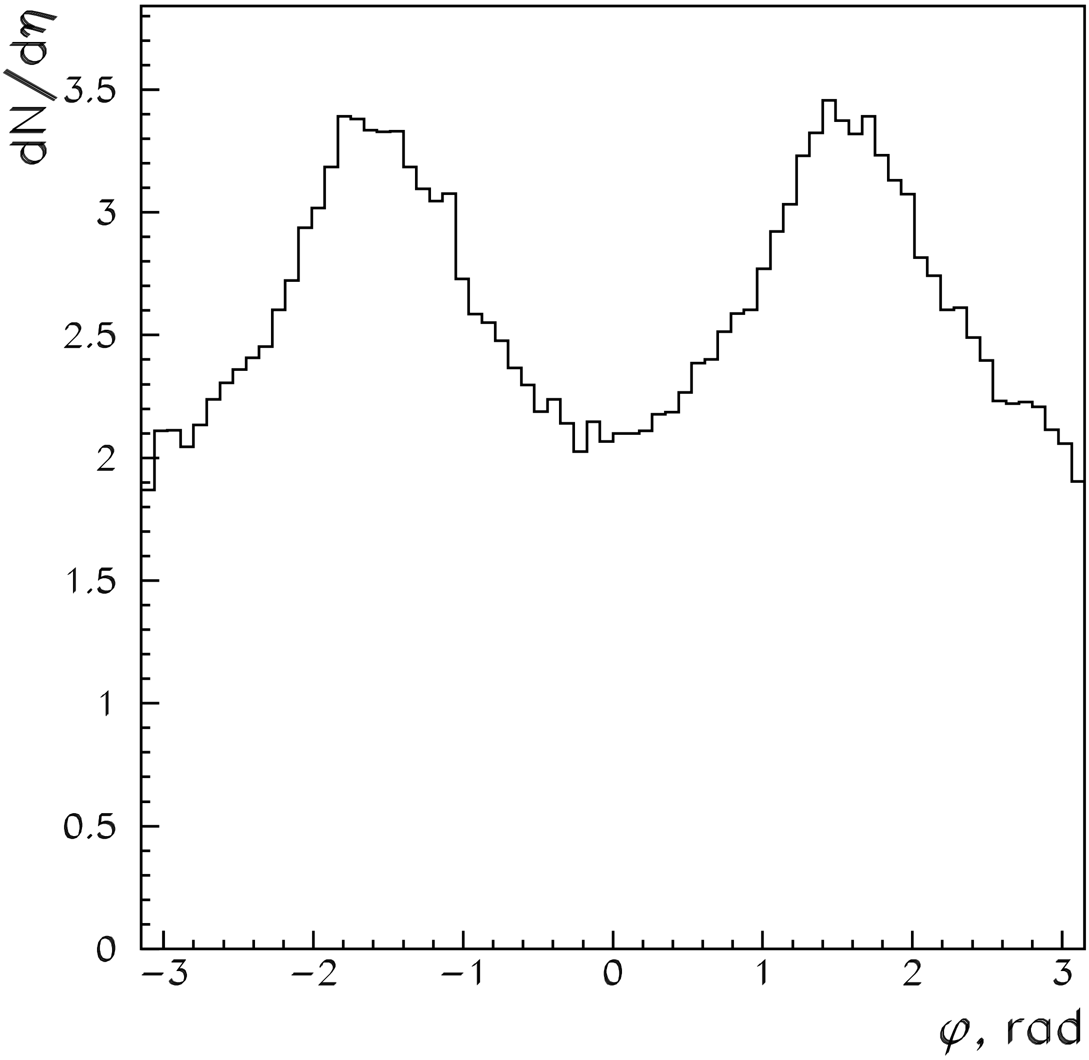
Ellipticity $v_2 = \frac{1}{2}\frac{E_{max}-E_{min}}{E_{max}+E_{min}} = 0.1$ (b=6 fm)

## Monte-Carlo simulation of Pb–Pb collisions

Simple hydrodynamical model by
N.A.Kruglov, I.P.Lokhtin, L.I.Sarycheva, A.M.Snigirev.
Z. Phys. C 76 (1997) 99

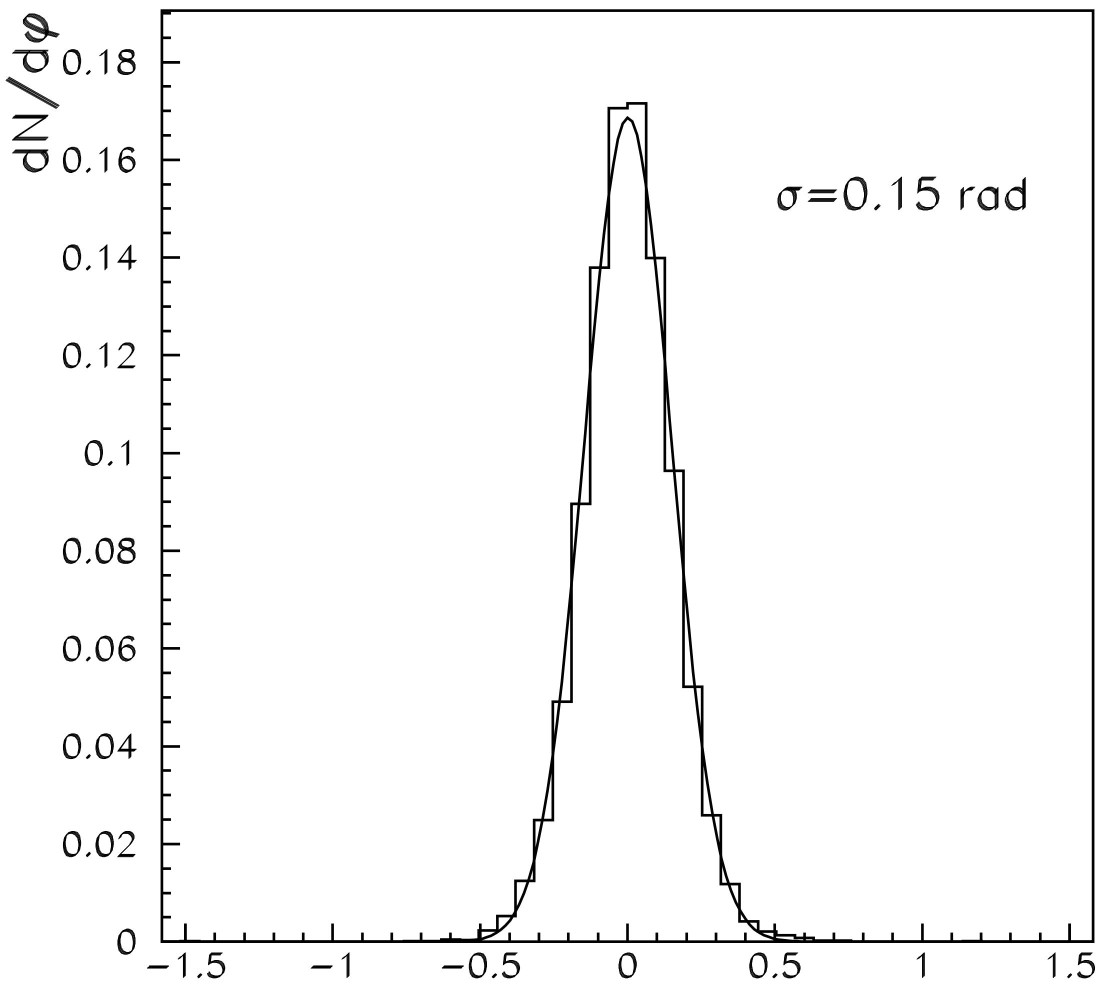
CMSIM 122 to get HCAL towers responses.

**Azimuthal asymmerty of charged particles**
**with $|\eta| < 3$, $p_t > 1$ GeV/c**
**Pb − Pb collisions, b = 6 fm**



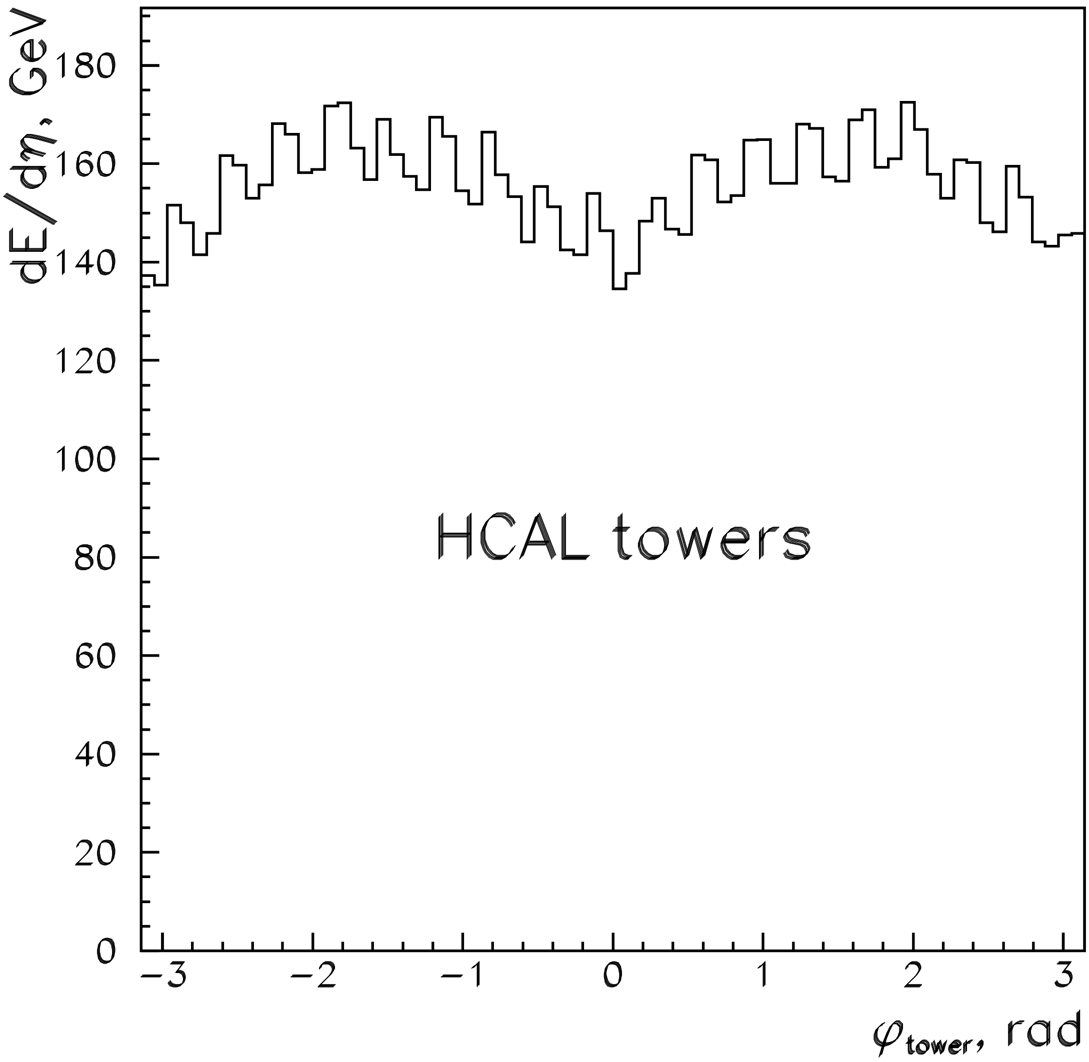
**The differences between generated and reconstructed azimuthal angle of the reaction plane**

(charged particles with $|\eta| < 2.4$, $p_t > 2$ GeV/c, Pb − Pb collisions, b = 6 fm)




$$tan(2\varphi_{rec}) = \frac{\sum_i p_t^i \sin 2\varphi_i}{\sum_i p_t^i \cos 2\varphi_i}$$

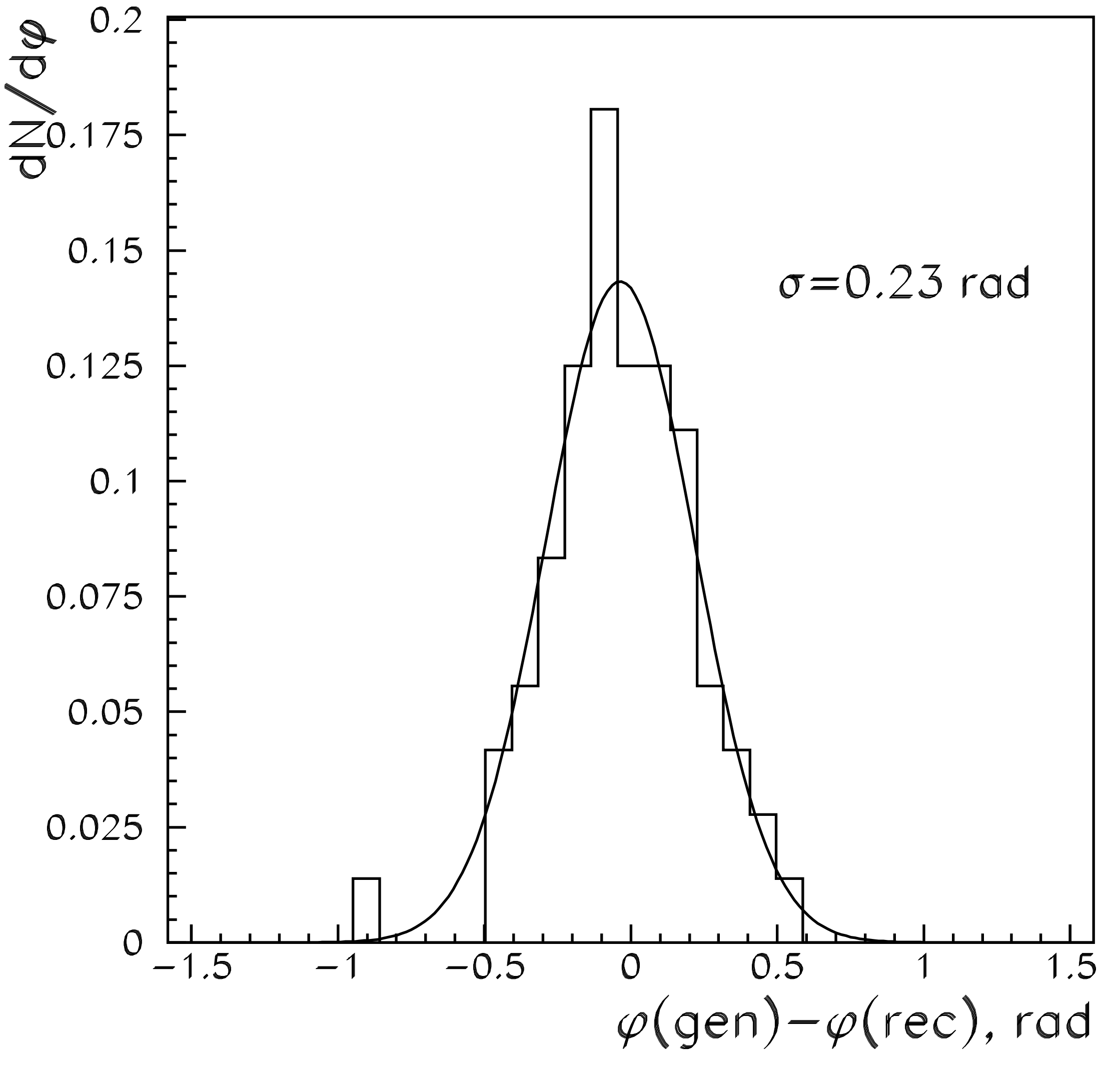
**Energy responses in HCAL towers for Pb — Pb collisions, b = 6 fm**




Ellipticity $v_2 = \frac{1}{2}\frac{E_{max}-E_{min}}{E_{max}+E_{min}} = 0.1$

**The differences between generated and reconstructed azimuthal angle of the reaction plane**

(by HCAL towers, Pb − Pb collisions, b = 6 fm)




$$tan(2\varphi_{rec}) = \frac{\sum\limits_{towers} E^{tower}\sin 2\varphi_{tower}}{\sum\limits_{towers} E^{tower}\cos 2\varphi_{tower}}$$

## SUMMARY

1. The common practice of using reconstructed tracks of the secondary particles to determine azimuthal angle of the reaction plane of the heavy ion collision is not useful for CMS due to the very high occupancy of the tracker detector. But we can use HCAL towers instead of reconstructed tracks. In this case one HCAL tower is a "particle", which equal to some real particles.

2. The error of determination of the azimuthal angle of the reaction plane when we use HCAL towers is almost the same that in case of using generated particle tracks.

$$\sigma_{HCAL} = 0.23 \approx \sigma_{tracks} = 0.15$$