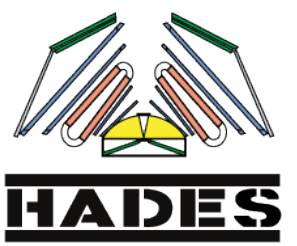
Reaction plane reconstruction in HADES with FW in Au+Au beam test run

Alexander Sadovsky
sadovsky@inr.ru

Institute for Nuclear Research RAS,
Moscow

Introduction
Guideline from simulation
What do we learn from test beam data
Backup

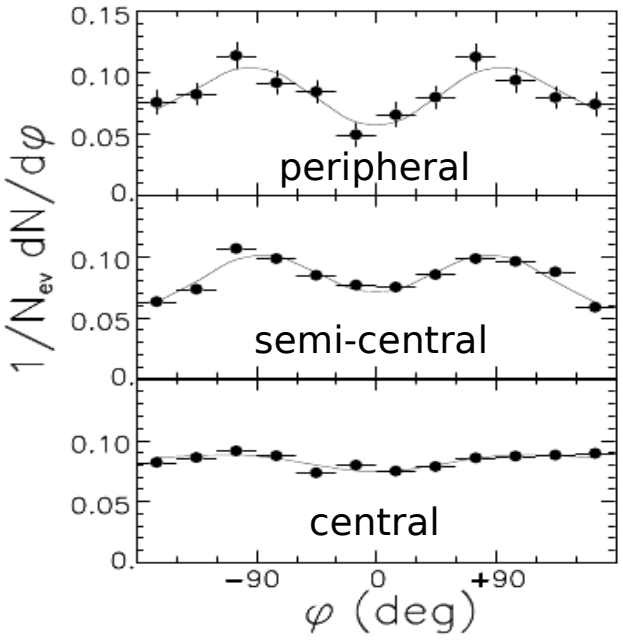
EMMI mini-Workshop
on Reaction Plane Reconstruction and Flow
March 16, 2012
GSI, Darmstadt



Flow analysis and azimuthal angular distributions

Azimuthal angular distribution of K^+ for peripheral, semi-central and central events in collisions of *(Au@1AGeV)+Au by KaoS collaboration. PRL.81(1998)1576-1579*

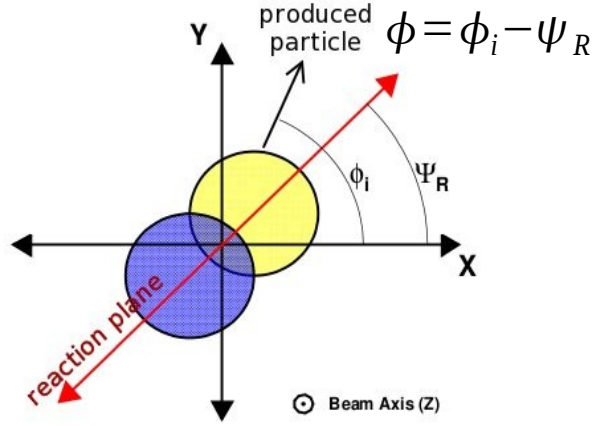
K^+ in (Au@1AGeV)+Au by (KaoS)



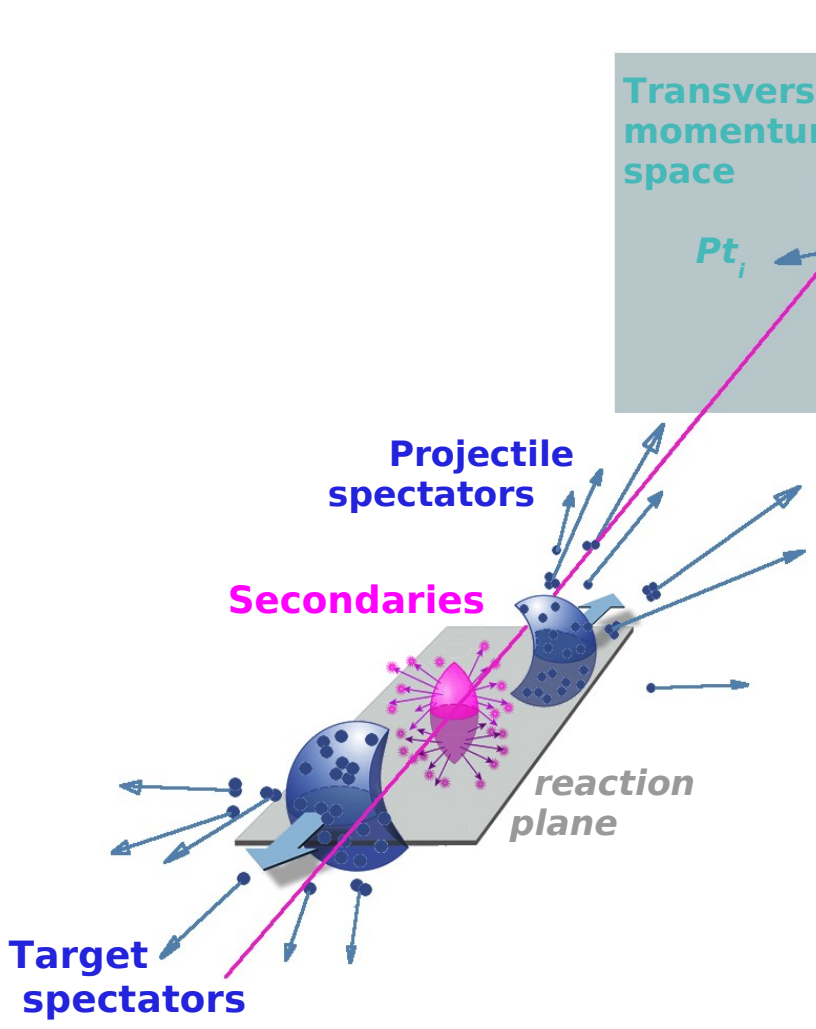
In the frames of Fourier decomposition of obtained azimuthal distributions:

$$\frac{dN}{d\phi} = C\left(1 + 2a_1\cos(\phi) + 2a_2\cos(2\phi)\right)$$

which allows determination of directed (a_1) and elliptic (a_2) flows one may draw conclusions about the in-plane and out-of plane emission of K^+, in medium potential...



Reconstruction of reaction plane
(transverse momentum method)



$$\vec{Q} = \sum_{i=1}^{Nsp} w_i \vec{p}_i^{\,t}$$

where:

Q – reaction plane vector;
Nsp – number of spectators detected;
w_i – weight factor:

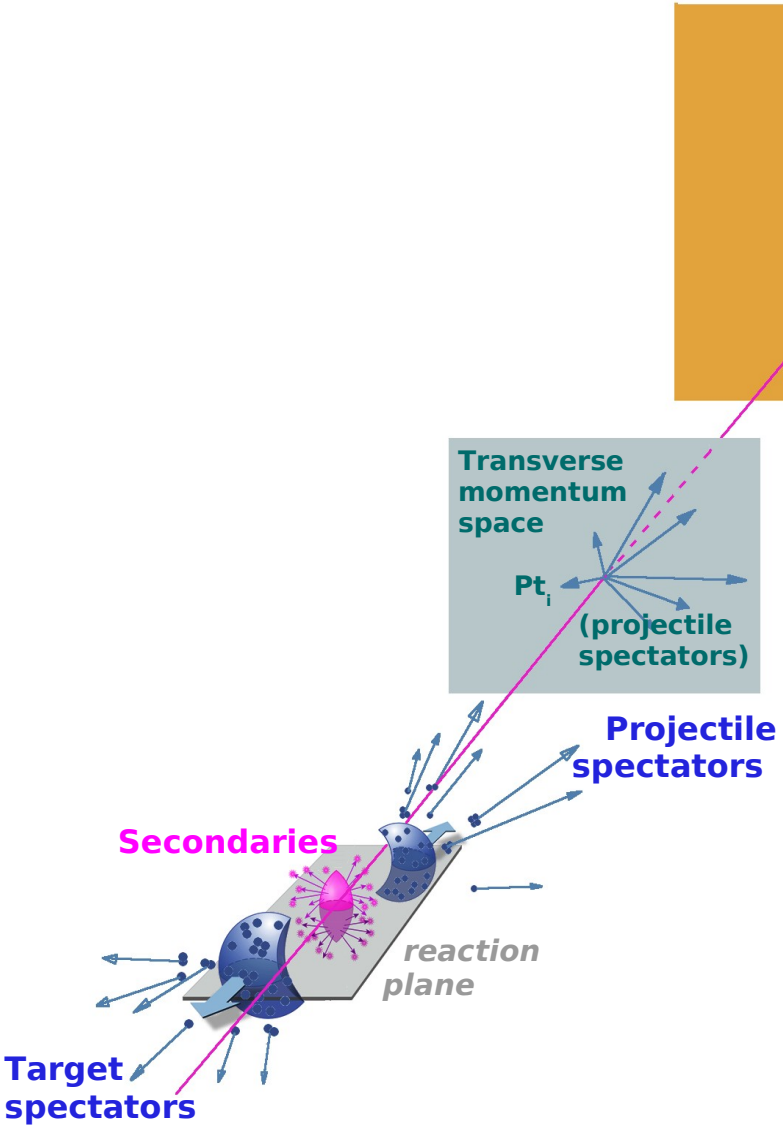
$w_i > 0$ flying forward,

$w_i < 0$ flying backward;

p_i^t – transverse momentum vector.

See e.g. [PL.157B,146,1985].

Reconstruction of reaction plane
(modified transverse momentum method)



$$\vec{Q} = \sum_{i=1}^{Nsp} w_i \frac{\vec{r}_i}{|\vec{r}_i|}$$

where:

Q – reaction plane vector estimate;
Nsp – number of fragments;
w_i – weight factor:

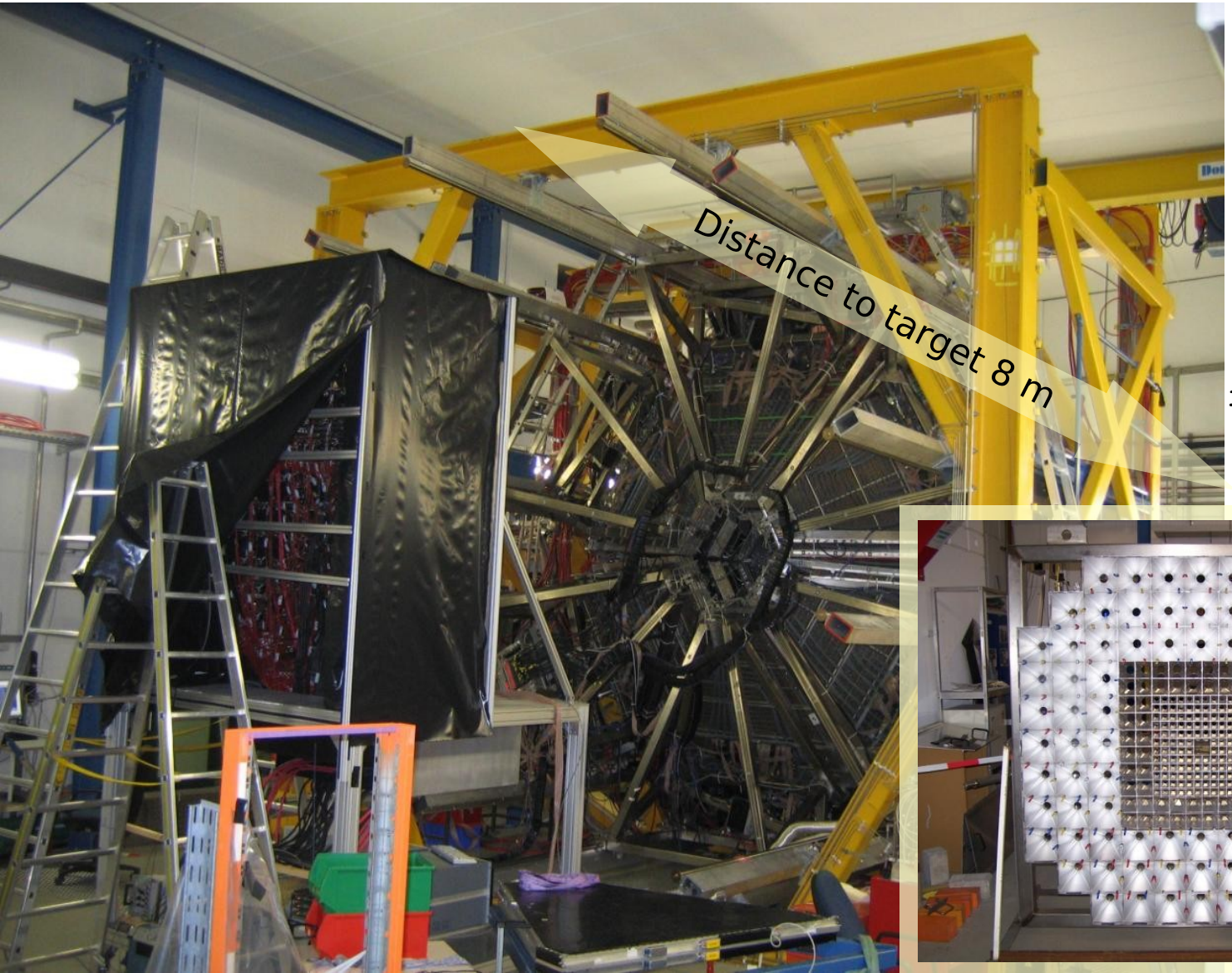
$w_i > 0$ if flying forward,

$w_i < 0$ if flying backward,

absolute value is set to mass (m) or charge (Z) of the spectator;

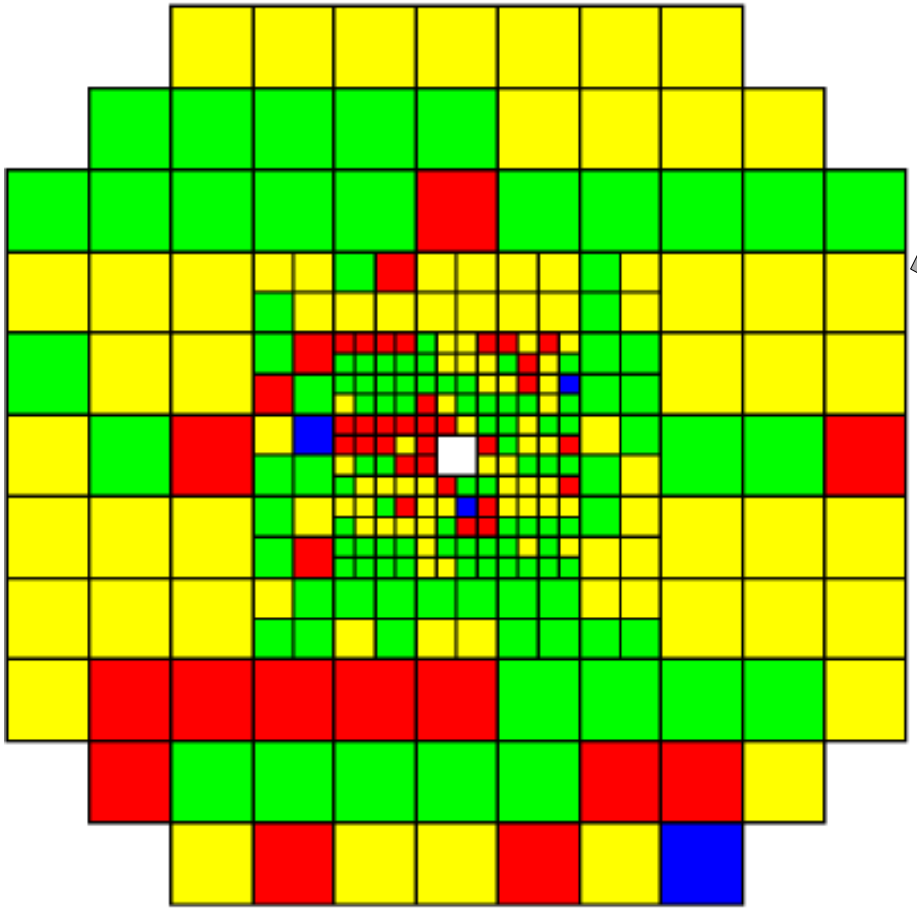
r_i – position vector of cell with a hit-i.

HADES Forward Wall, installed: March 2007
Fully operational: summer 2010, 2011



140 small 4x4cm
64 middle 8x8cm
84 large 16x16cm
cells

HADES Forward Wall, installed: March 2007
Test beam 2011 status



Temporary dead cells

Working cells:

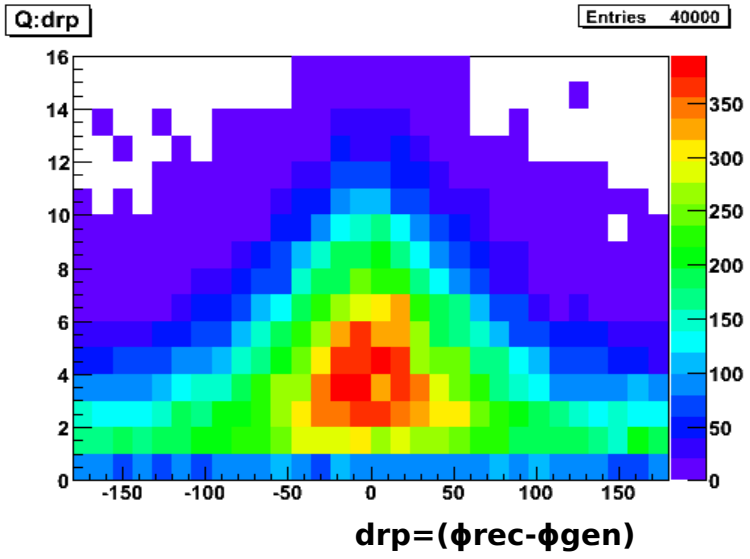
Z=(1,2} separation

Z={1,2,3} separation

Z={1,2,3,..} separation

Internal report
Yu.Sobolev

Simulation (Au@1.25AGeV)+Au SHIELD + hGeant



FW is 8m from target, spectators selected by time-of-flight.

All Z treated as Z=1

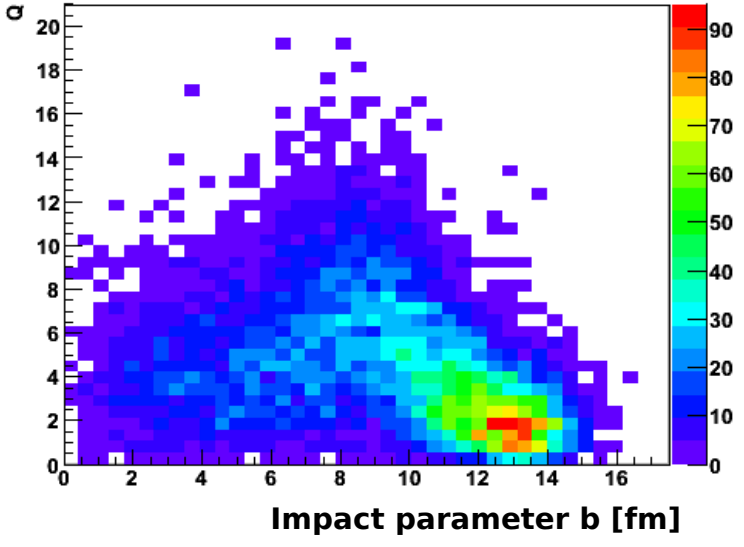
(no PID for spectators)

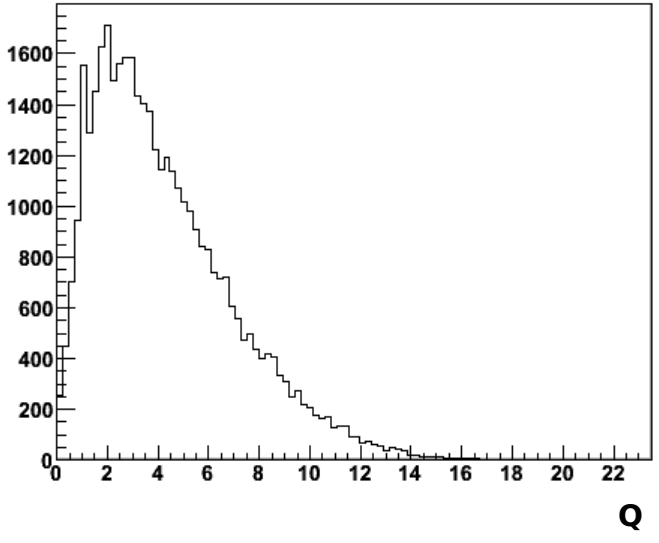
Higher values of |Q| lead to better reaction plane determination:

0<|Q|<4 : poor RP angle resolution

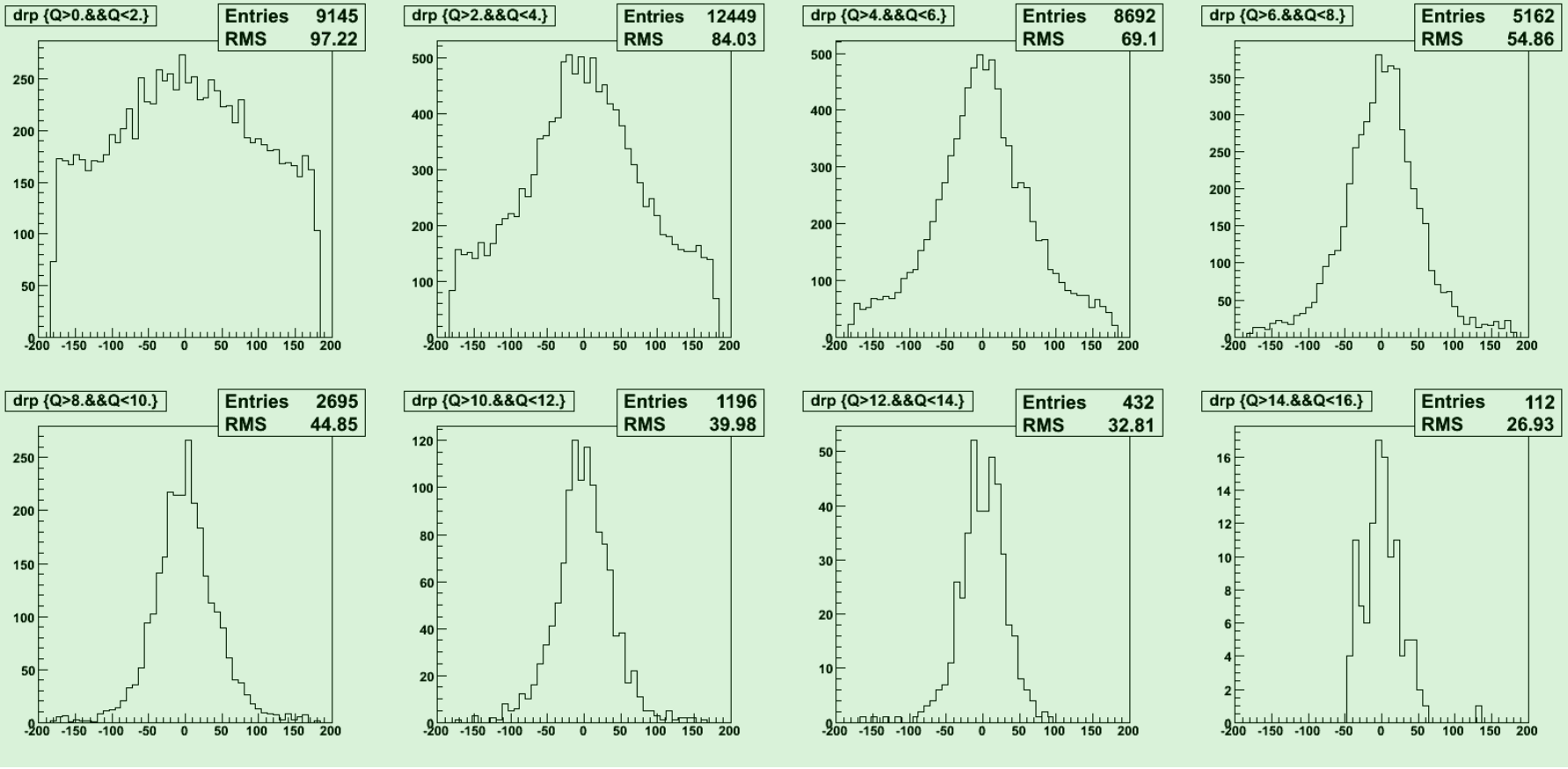
4<|Q|<14 : higher resolution

By selecting |Q|>4 we also suppress peripheral events





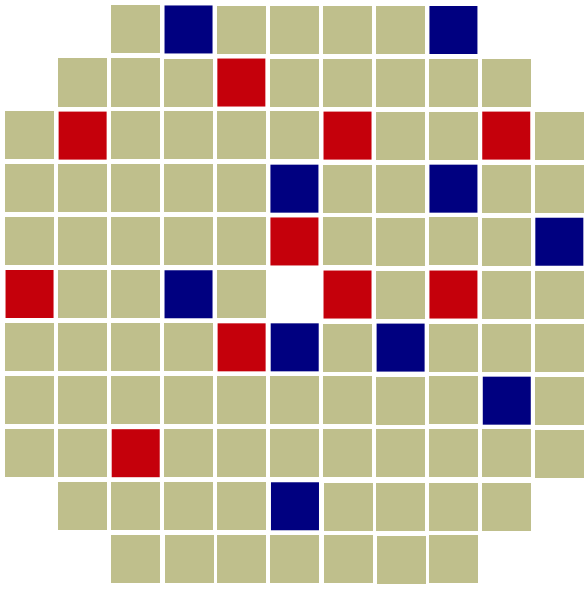
Simulation (Au@1.25AGeV)+Au
SHIELD + hGeant

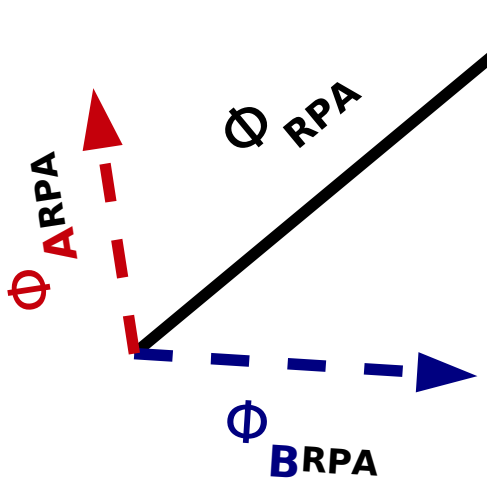


Distribution of reconstructed reaction plane angle (RPA) compared to generated in simulation RPA

$$drp = dN/d(\phi_{rec}-\phi_{sim})$$

Method to determine resolution of reaction plane angle (RPA) suitable for real data

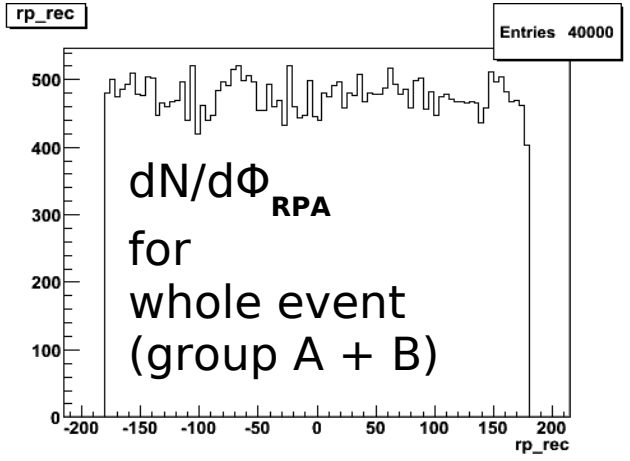


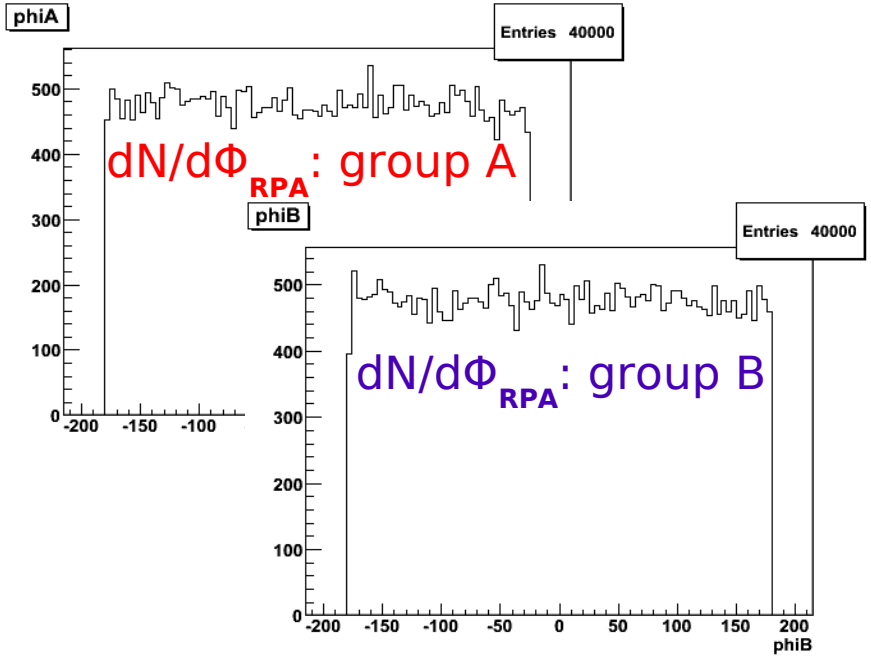


Hits in each event are randomly divided into two equal subgroups: A and B and RPA determination is done separately for cells A and B.

Difference between the reaction plane reconstruction in two subgroups can be used to estimate the reconstruction accuracy of the reaction plane determination in the whole event.

Method to determine resolution of reaction plane angle (RPA)



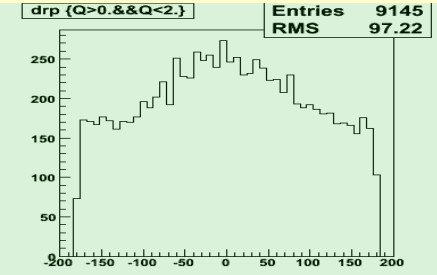


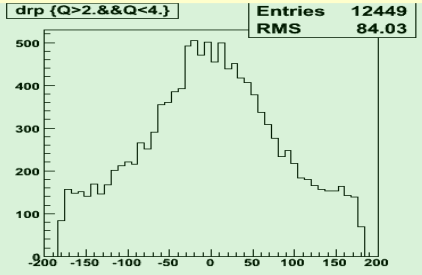
But first we apply it for simulation
Hits of an event are randomly divided into two equal groups: A and B determining the reaction plane in each group separately.

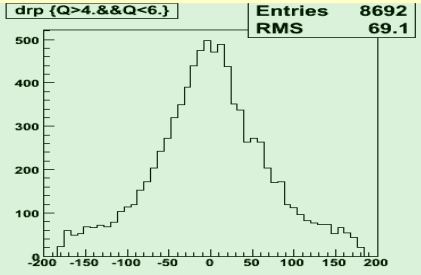
Reaction plane angle determination based on whole hits in FW of the event and in two subgroups A and B show flat distribution.

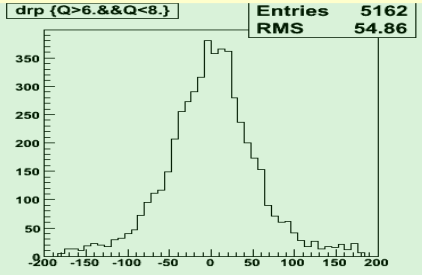
Difference between the reaction plane reconstruction in two subgroups indicates the reaction plane resolution of the whole event.

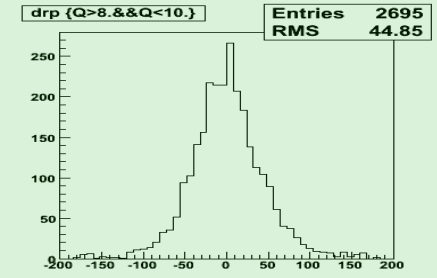
Simulation (Au@1.25AGeV)+Au
SHIELD + hGeant

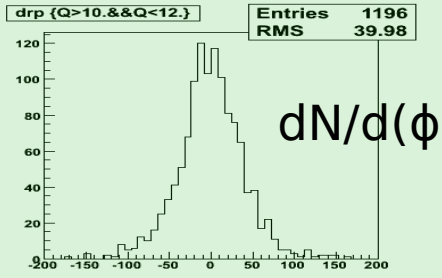


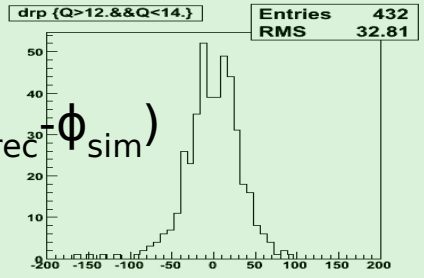


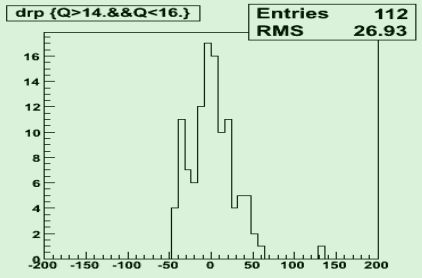




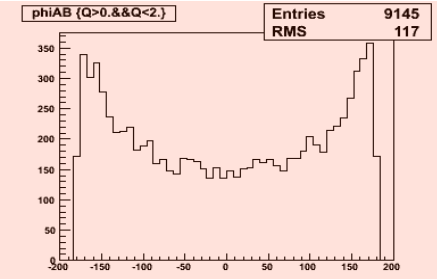


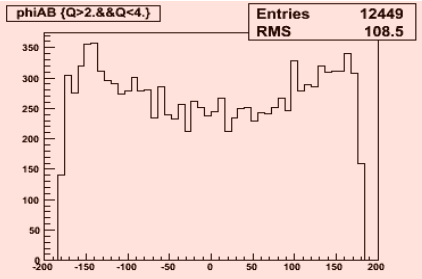


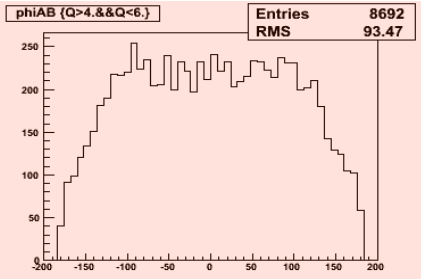


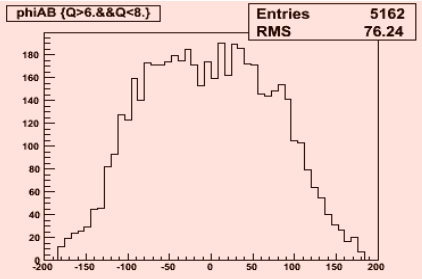


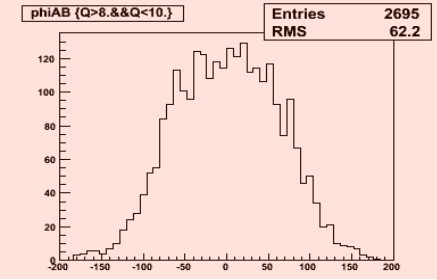
$dN/d(\phi_{rec}-\phi_{sim})$

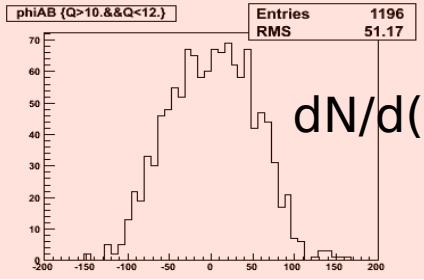


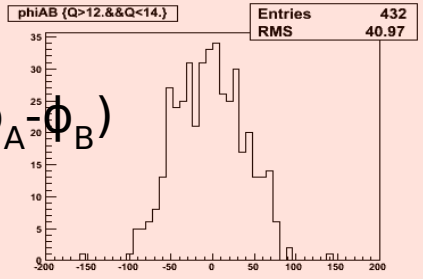


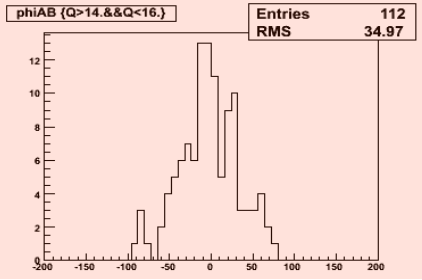






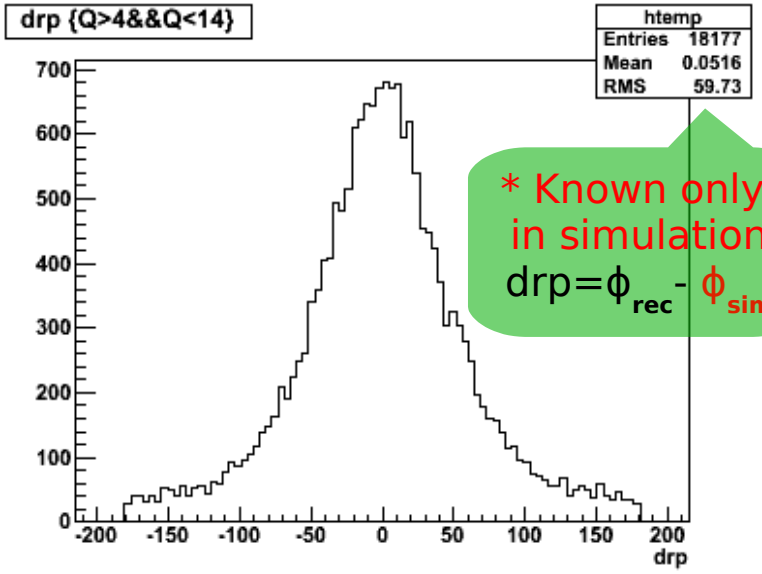




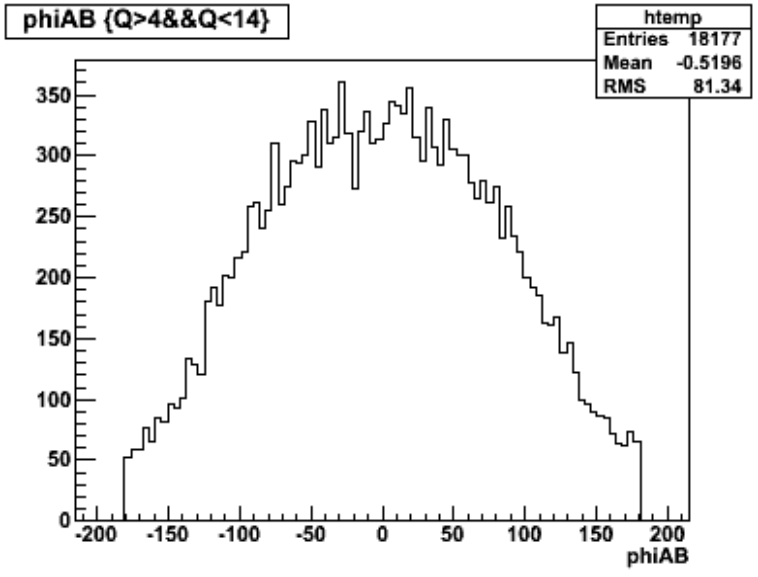


$dN/d(\phi_A-\phi_B)$

Simulation (Au@1.25AGeV)+Au SHIELD + hGeant



* Known only in simulation
$drp = \phi_{rec} - \phi_{sim}$



Simulation w/o trigger conditions:
Event selection: for $4<|Q|<14$

Error of reaction plane angle estimate for all hits in FW from each event:
$RMS=60^{o}$

Gaussian fit $sigma=48^{o}$ (in central part)

Gaussian fit sigma=37° {5<b<10 & Q>6} / K.Lapidus HADES coll.meeting. 2010 /

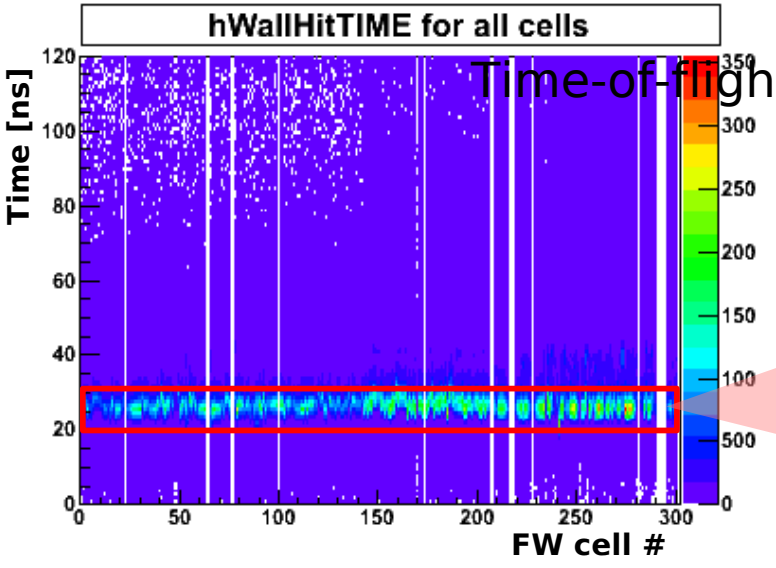
NB: the estimate is done comparing with reaction plane from SHIELD.

Estimate of reaction plane determination error based on two subgroups (A and B) of hits in each event: $RMS=81.34^{o}/\sqrt{2} = 58^{o}$

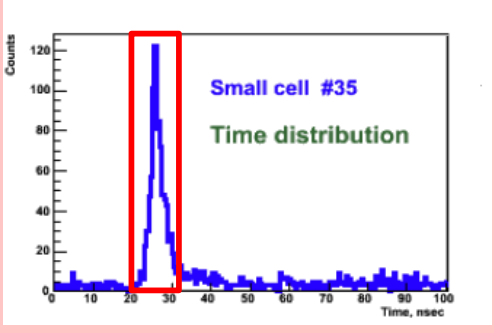
i.e. in a good agreement with the one obtained with knowledge of reaction plane angle from simulation.

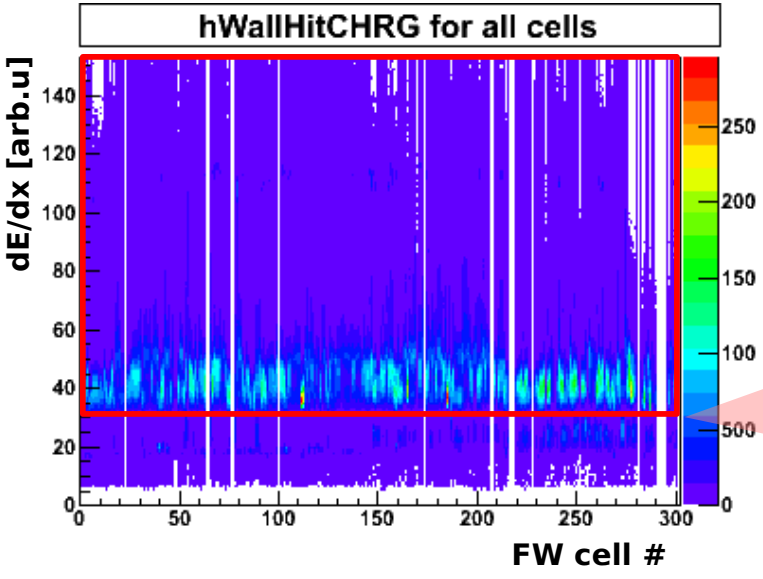
NB: this estimate is also applicable to exp. data.

(Au@1.25AGeV)+Au HADES 2011 test beam (spectators selection by FW information)

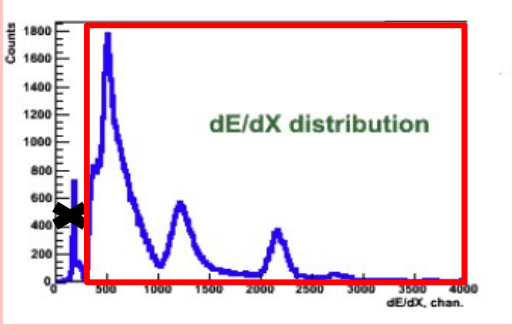


Time-of-flight needed by spectators to travel from target is selected

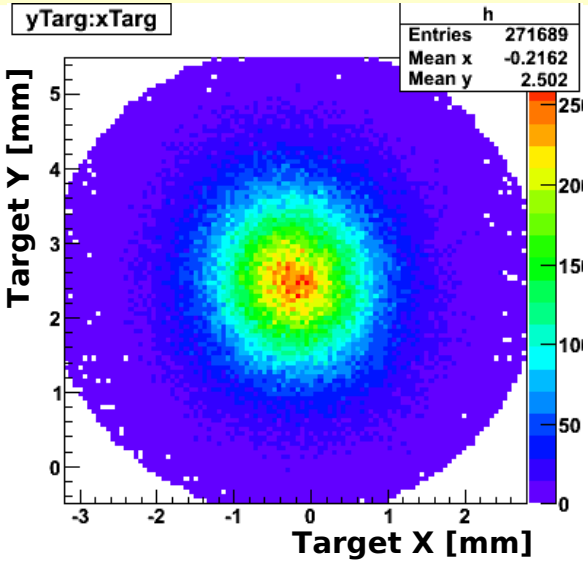




All charges accepted, but pedestals are taken away



(Au@1.25AGeV)+Au HADES 2011 test beam (events selection: target)



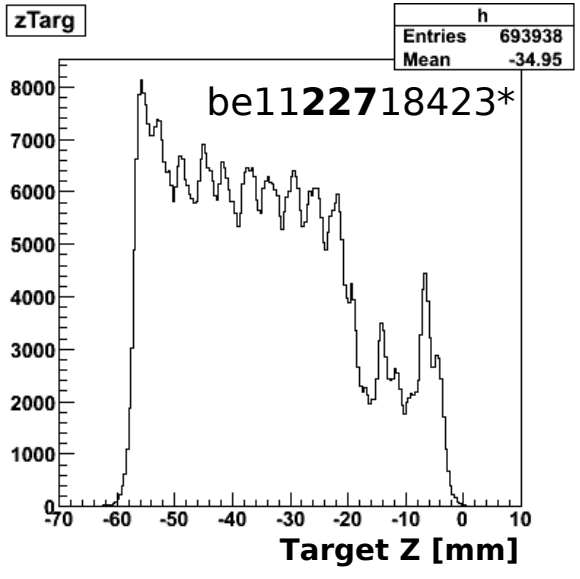
Data selection:
several files from day 227, 229, 230

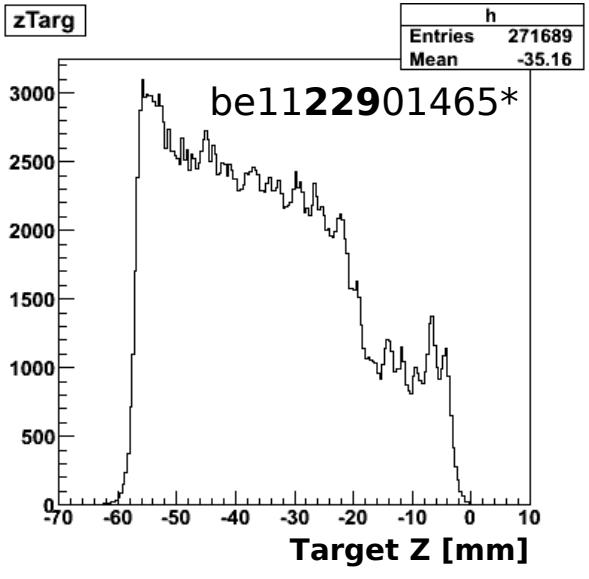
Target selection:

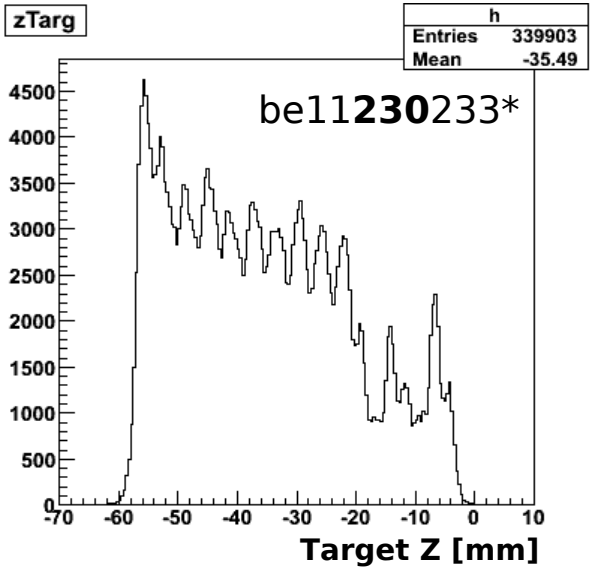
$\{(x^2+y^2)^{1/2}<3.33mm\}$ && z-unrestricted

3<vertex.Chi2<60

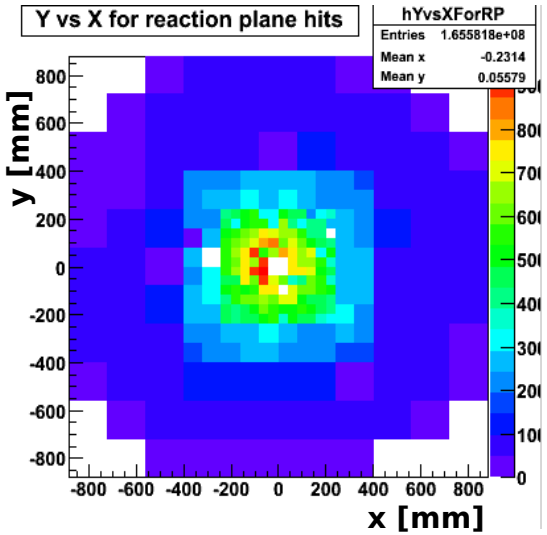
vertexClus.getSumOfWeights>6





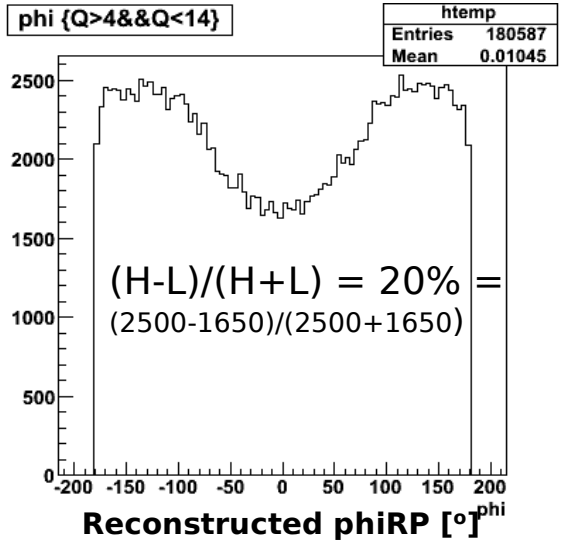


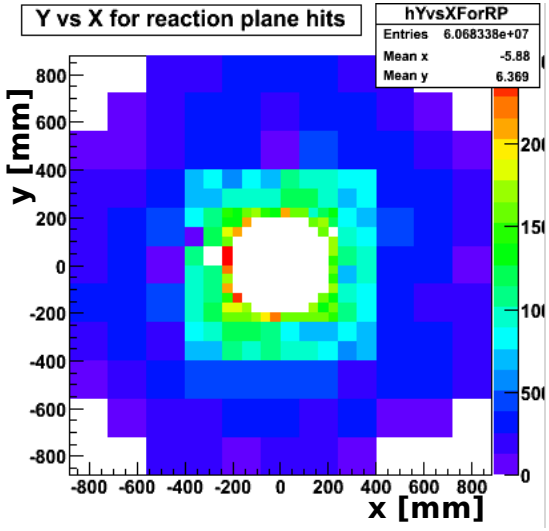
(Au@1.25AGeV)+Au HADES 2011 test beam FW azimuthal anisotropy (day 229 be1122901465*)



$$\vec{Q} = \sum_{i=1}^{Nsp} \frac{\vec{r}_i}{|\vec{r}_i|}$$

All sp. charges are treated as Z=1 (w_i=1)

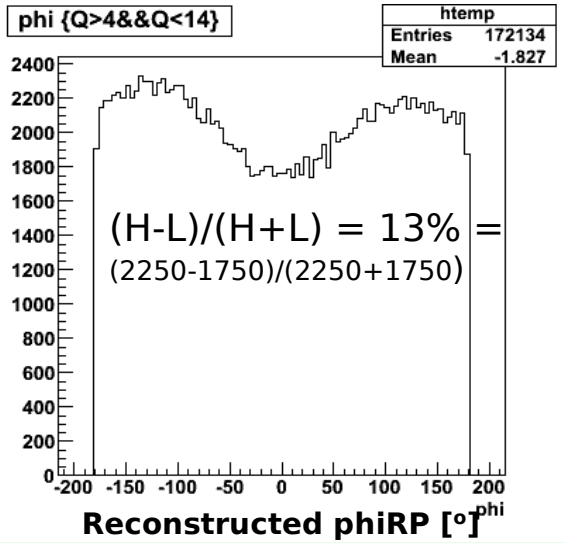




Adjusting for beam shift

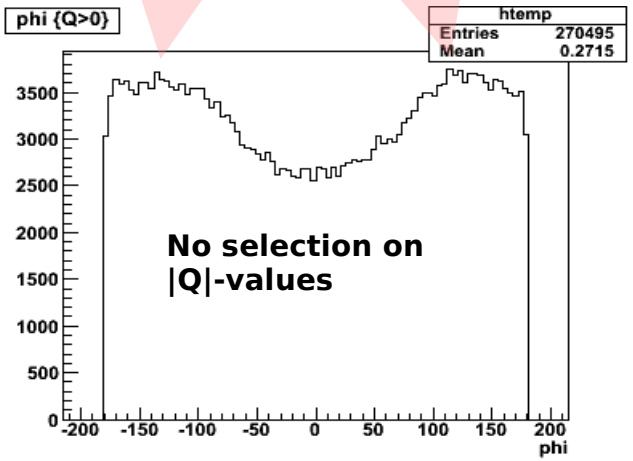
x = x - (0mm)
y = y - (0mm);
Rmin = 220mm

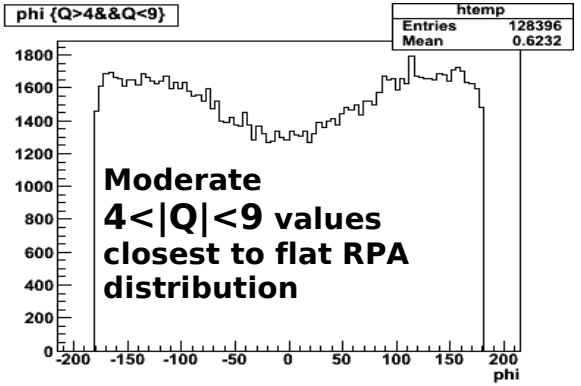
(to gain isotropy)

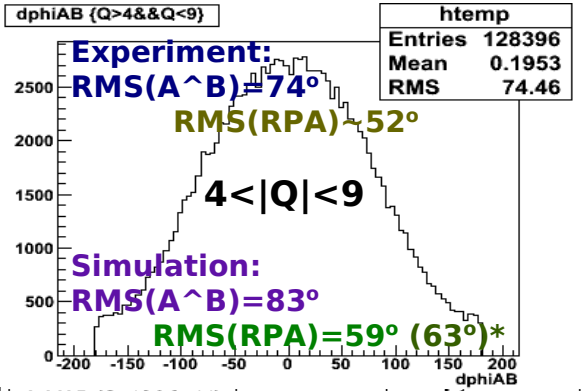


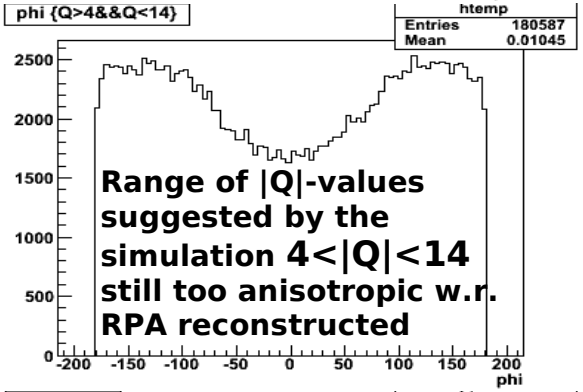
(Au@1.25AGeV)+Au HADES 2011 test beam RPA distribution (Rmin=220mm)

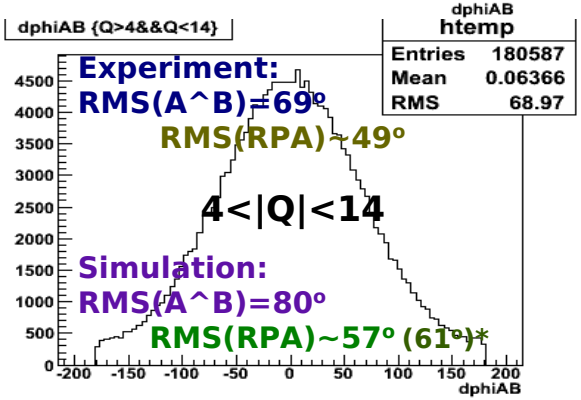
Preferable directions (systematics)
Data files:
be11**229**01465*

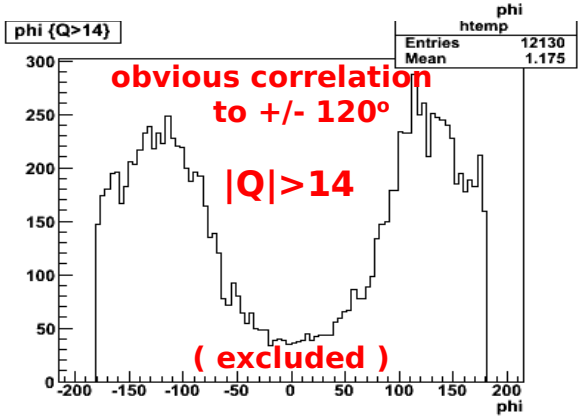








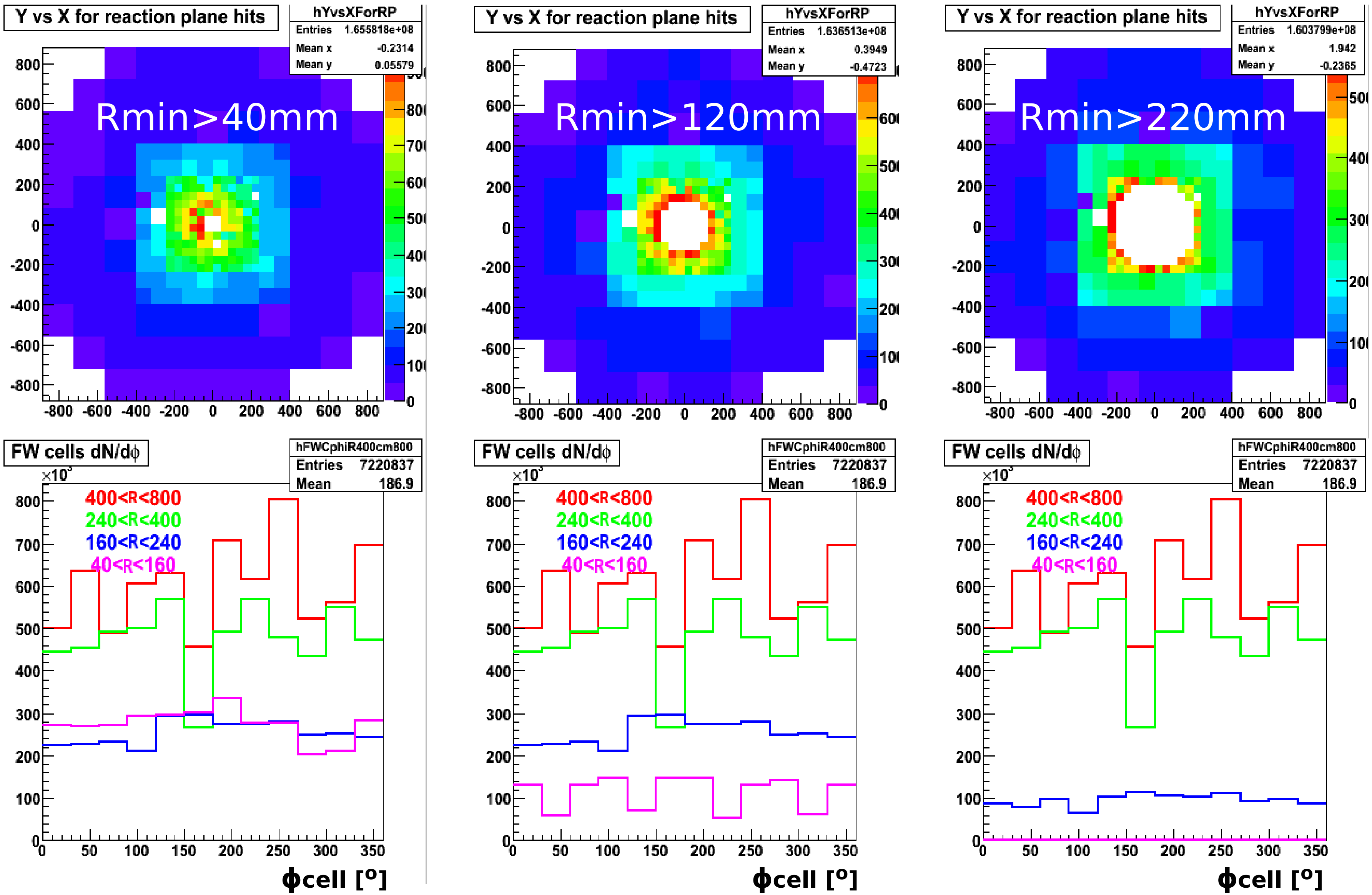




NB:
partially explained by the azimuthal anisotropy in phiRP of 13%

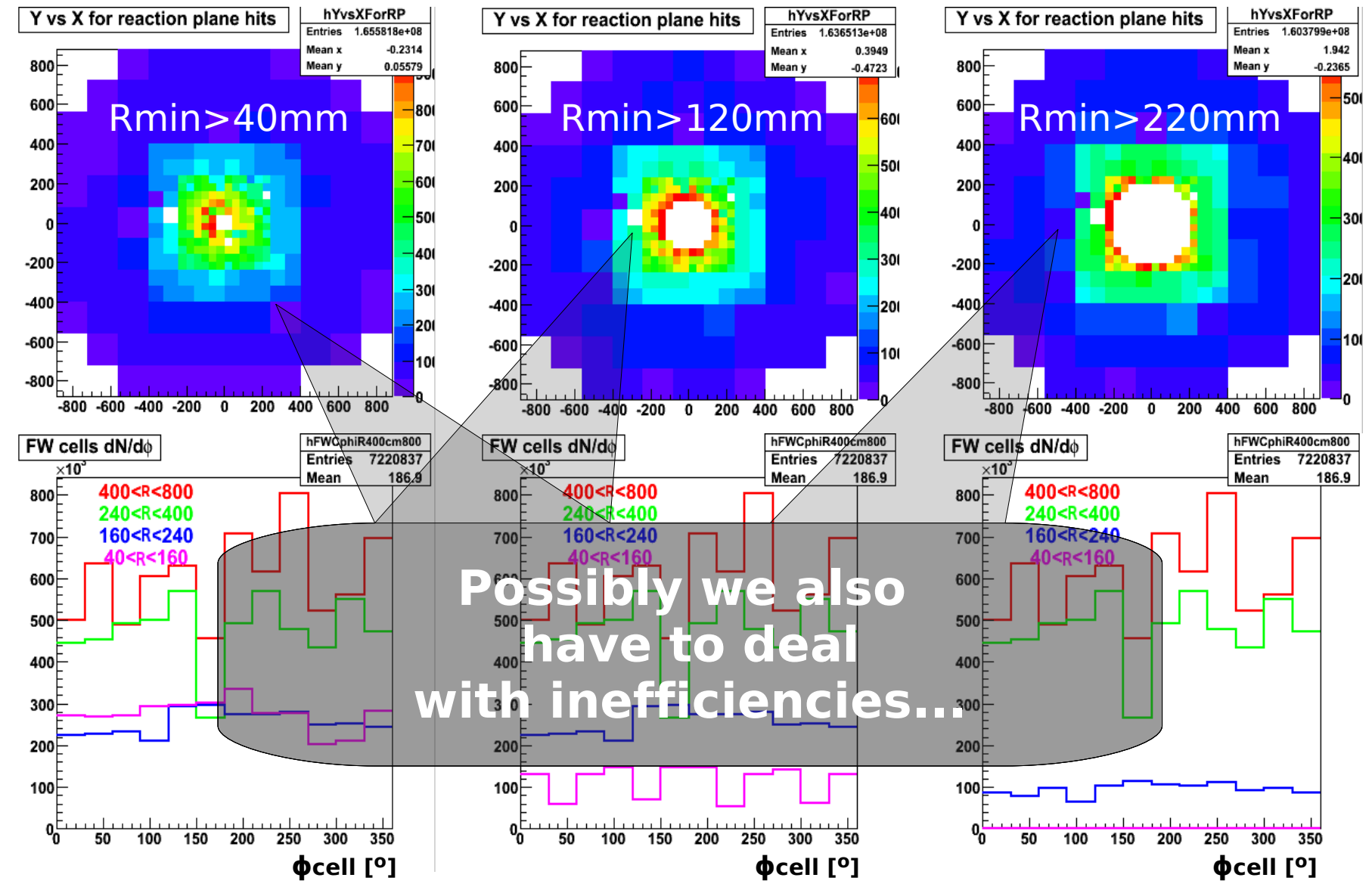
FW ϕ(cell) distributions for different Rmin cut

(beginning of beam time, day 227: be1122718423*)



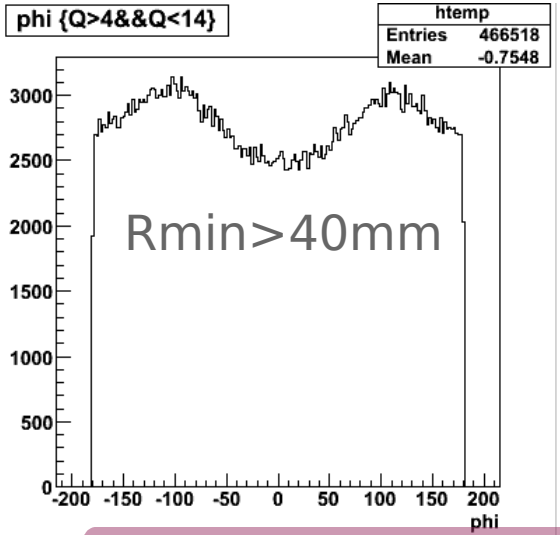
FW ϕ(cell) distributions for different Rmin cut

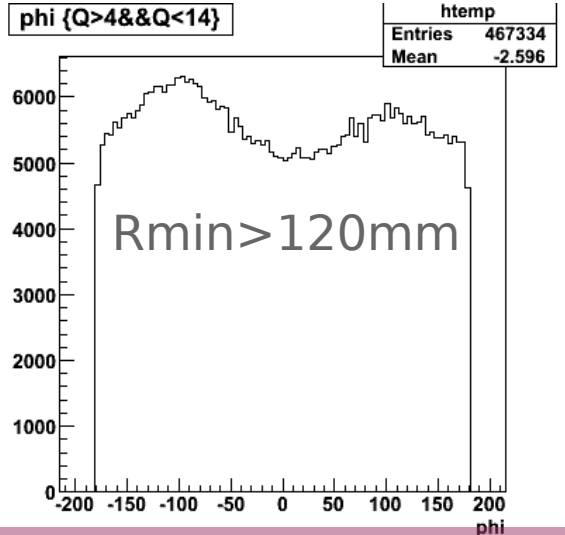
(beginning of beam time, day 227: be1122718423*)

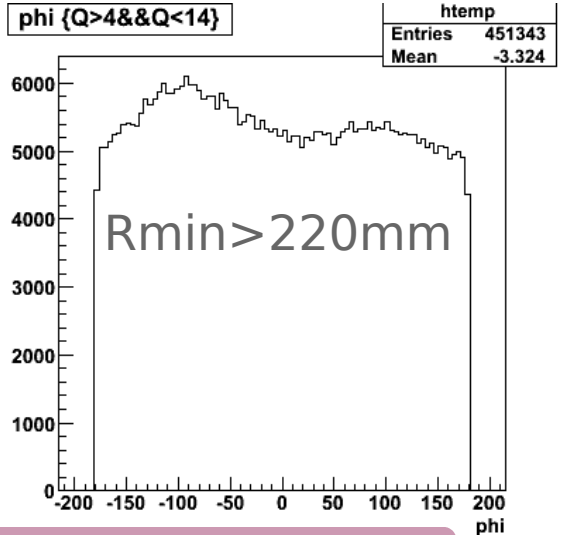


RPA, ϕ(A^B) distributions for different Rmin cut

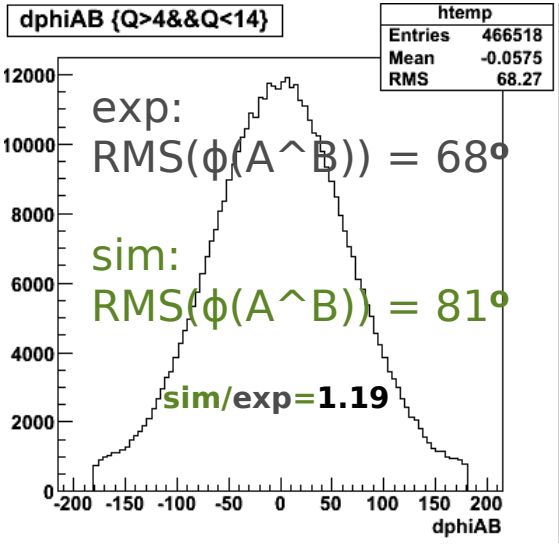
(beginning of beam time, day 227: be1122718423*)

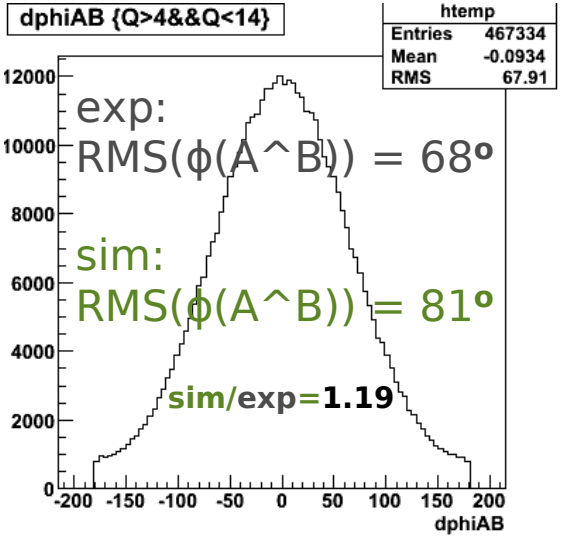


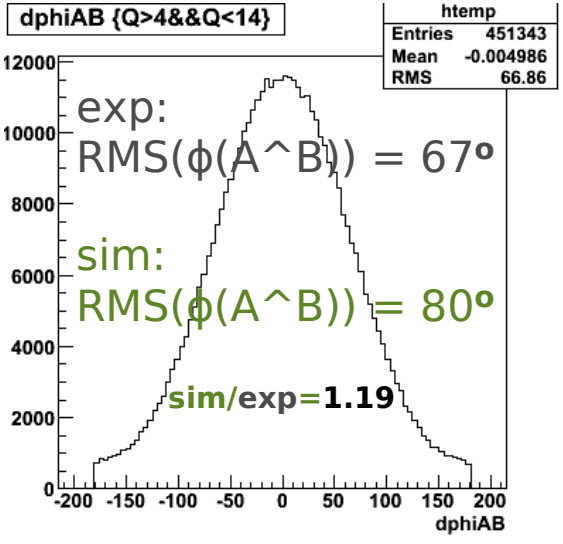




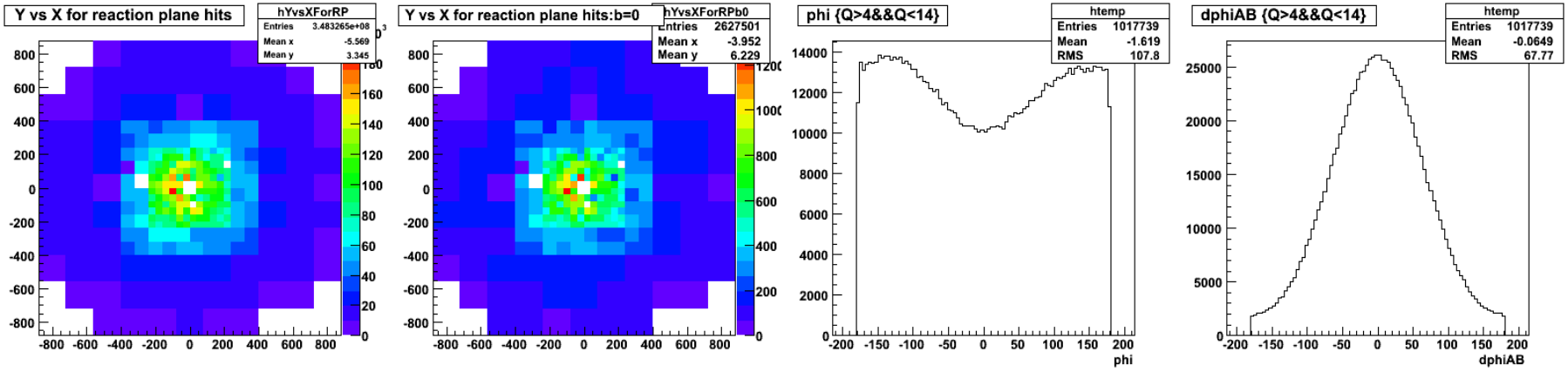
Moderate transverse momentum transfer selected 4<|Q|<14



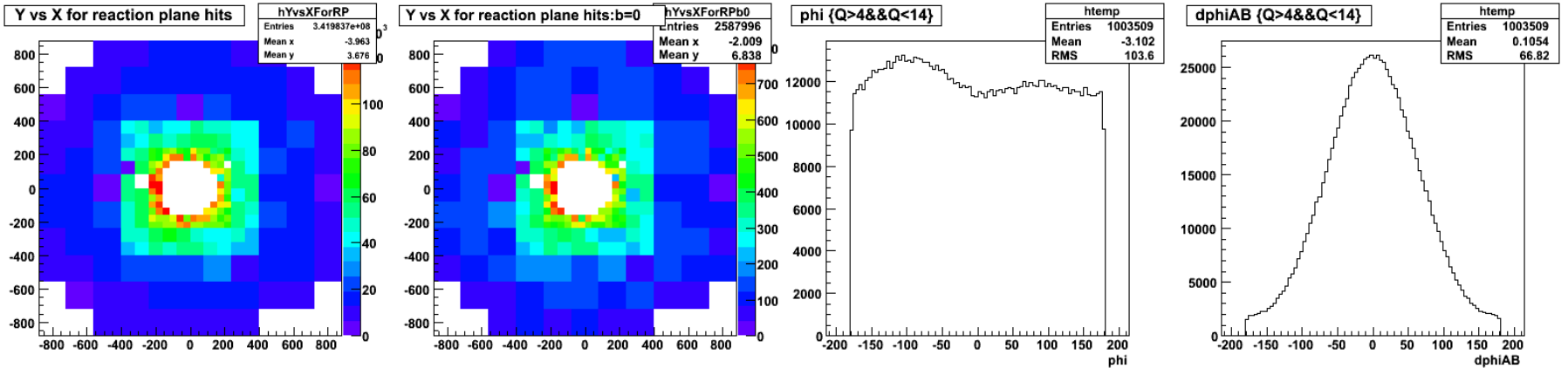




Last day (231) files between 00:00-00:59 approaching center of gravity

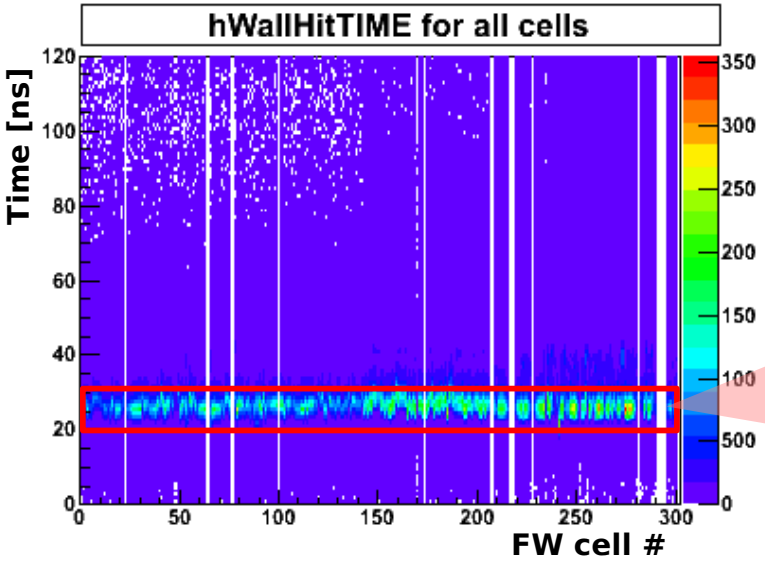


(0<R<1000)mm, no center of gravity shift in (X,Y), 4<|Q|<14

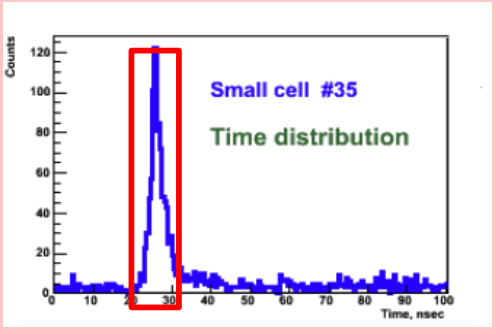


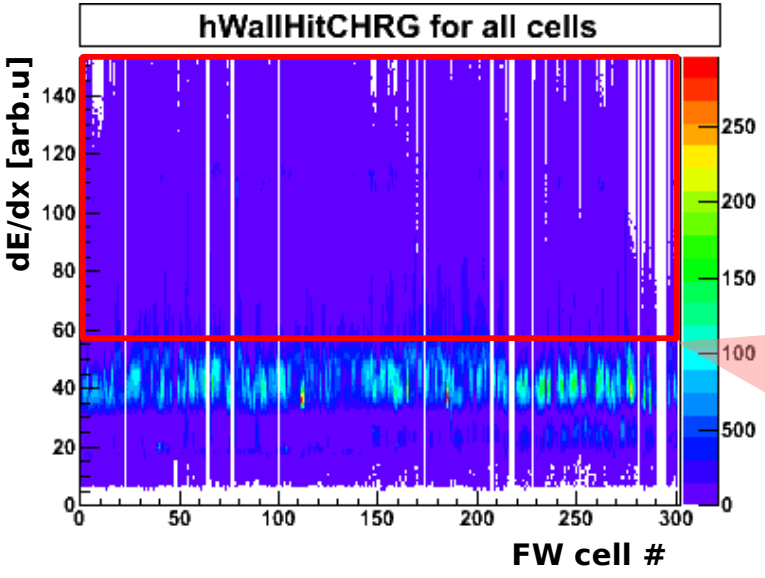
(170<R<1000)mm, center of gravity shift in (X=X-4.5, Y=Y+0.0), 4<|Q|<14

(Au@1.25AGeV)+Au HADES 2011 test beam (spectators selection by FW information)

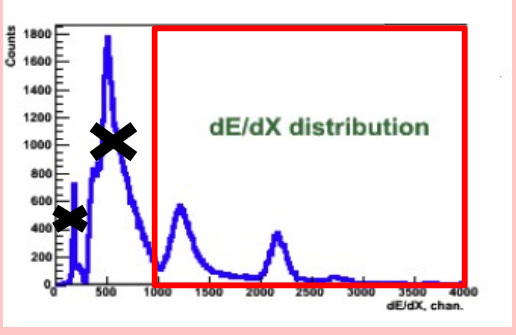


Time-of-flight needed by spectators to travel from target to FW cell is selected

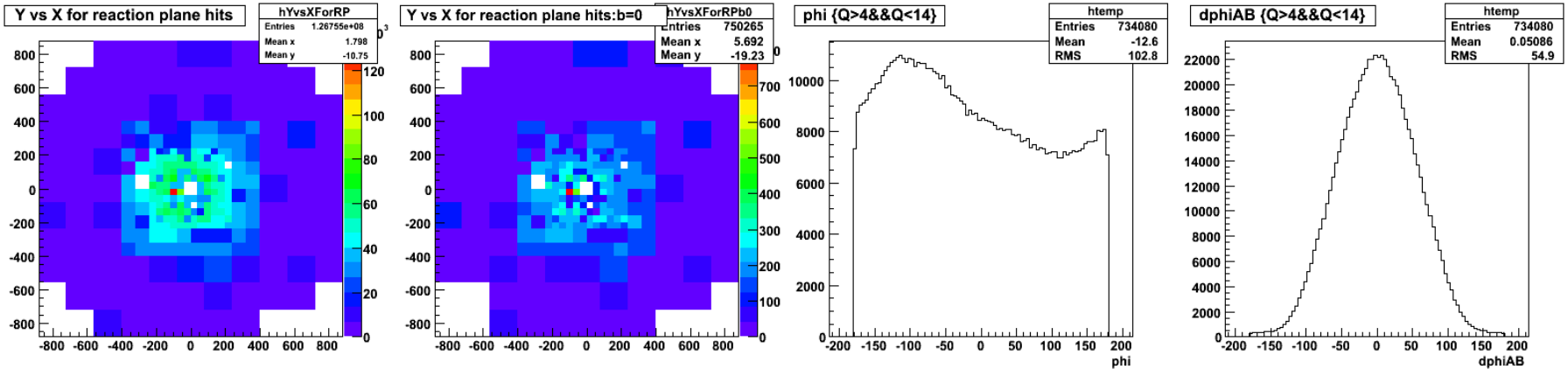




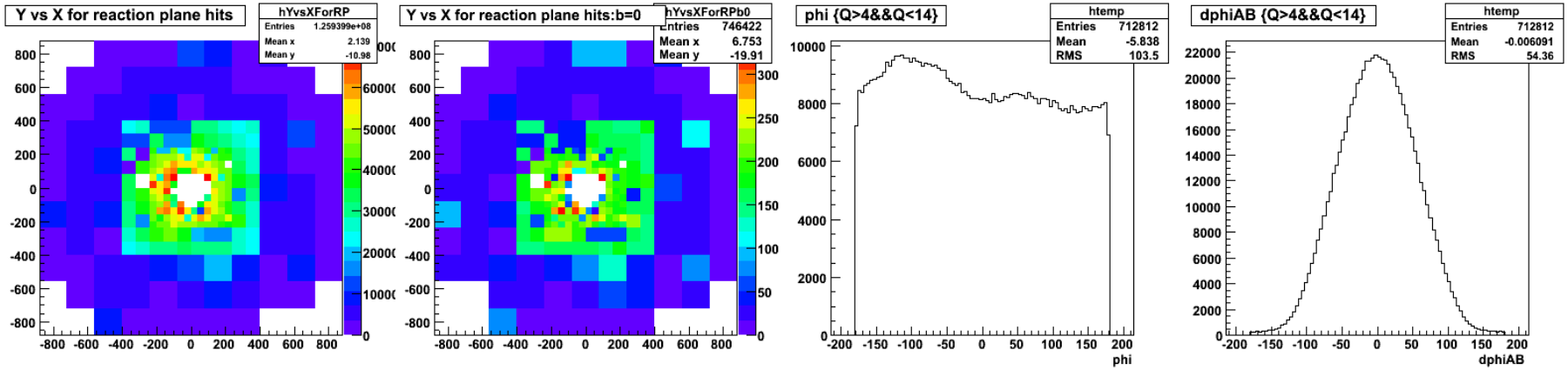
All charges accepted, but pedestals **and the 1st peak** are taken away



Last day (231) files between 00:00-00:59 approaching center of gravity



(40<R<1000)mm, no center of gravity shift in (X,Y), 4<|Q|<14



(105<R<820)mm, no center of gravity shift in (X,Y), 4<|Q|<14

Conclusion

First test beam Aug'11 data of (Au@1.25AGeV)+Au reaction were analyzed aiming determination of the reaction plane angle from FW.

Investigated error of RPA estimate as dependence on |Q| value in SIM.

Test data were used to quantify an estimate of reaction plane determination accuracy.

Experimental observables were compared with simulation (based on SHIELD model).

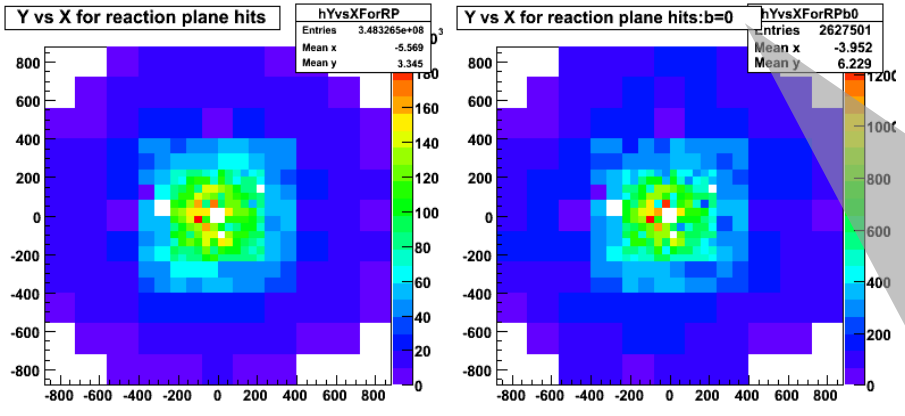
Some non-trivial azimuthal anisotropy of beam profile on FW is seen. This leads to non-flat distribution of reconstructed reaction plane angle. Source of the anisotropy is under investigation:

- Beam profile
- Cell inefficiency
- Spectator selection

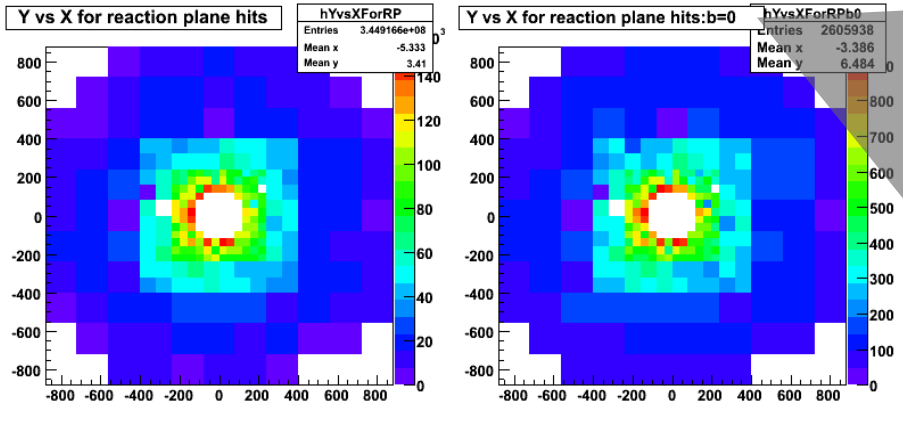
Forward wall team:
INR Moscow:
O.Busygina, M.Golubeva, F.Guber, A.Ivashkin, A.Reshetin, A.Sadovsky, E.Usenko
NPI Řež:
A.Kugler, Yu.Sobolev, O.Svoboda, P.Tlusty, V.Wagner.

Backup slides

Last day (231) files between 00:00-00:59

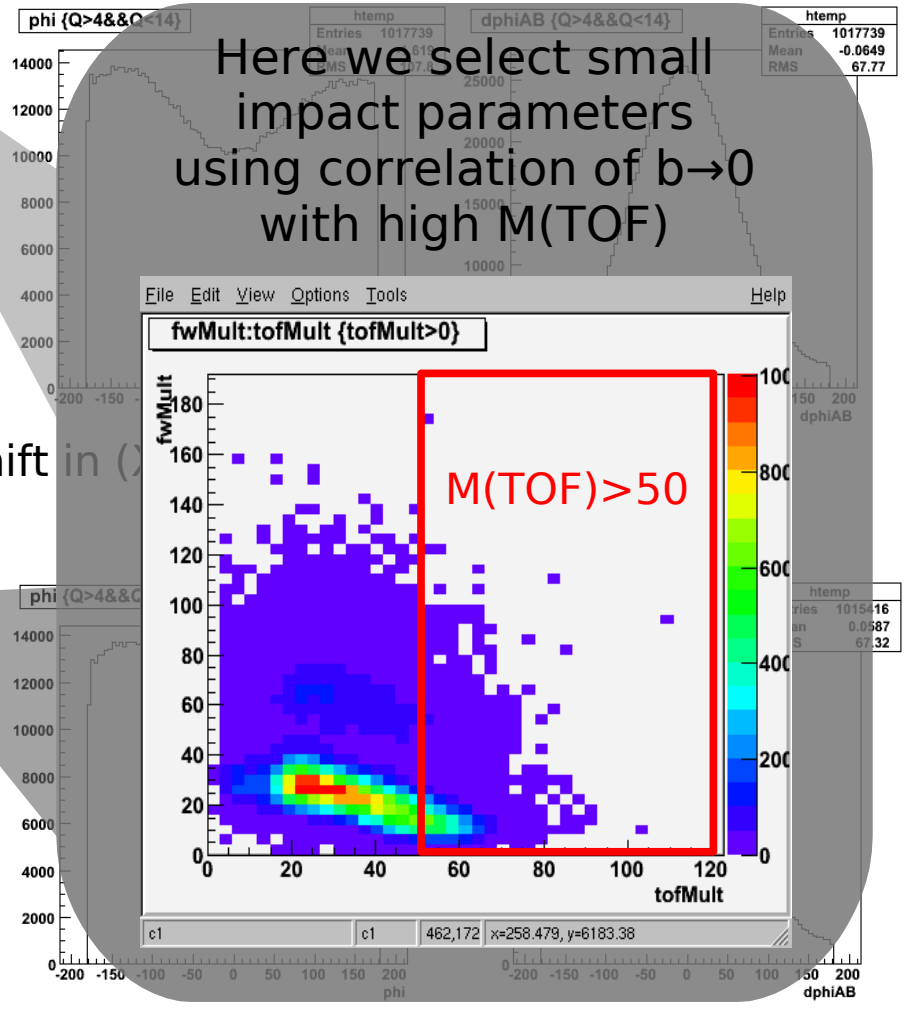


(0<R<1000)mm, no center of gravity shift in (X,Y)

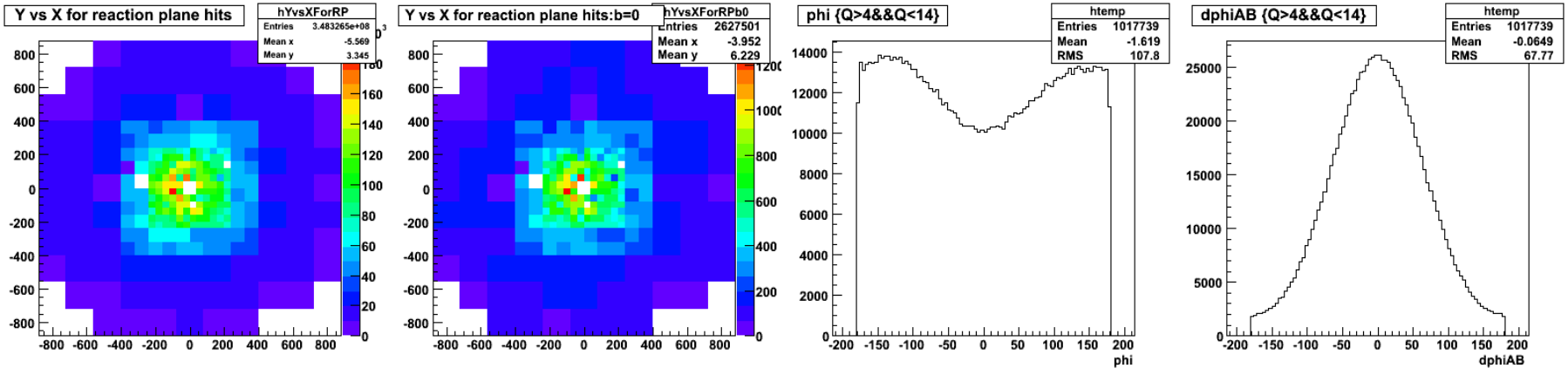


(120<R<1000)mm, no center of gravity shift in (X,Y)

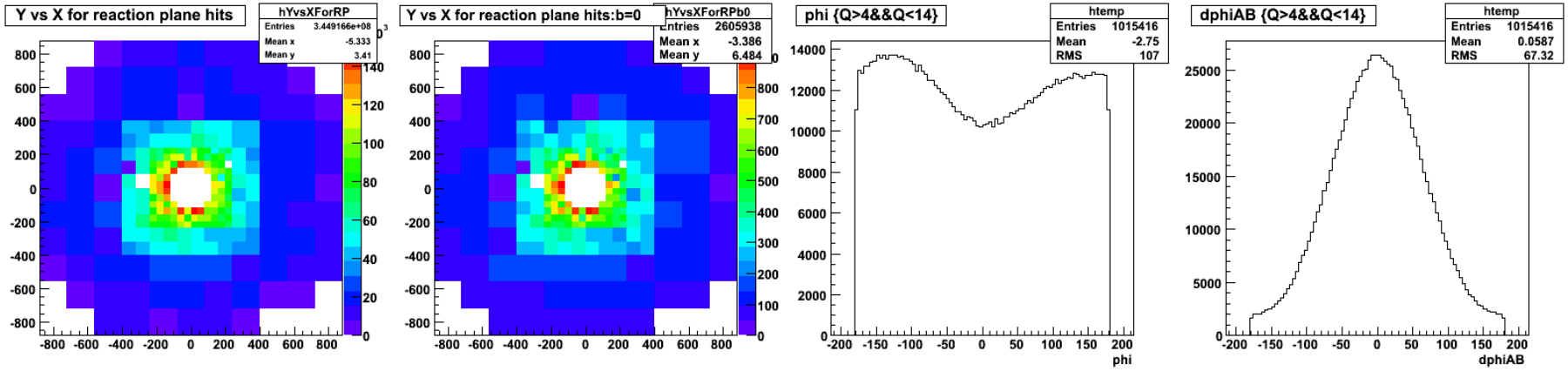
Here we select small impact parameters using correlation of b→0 with high M(TOF)



Last day (231) files between 00:00-00:59 approaching center of gravity

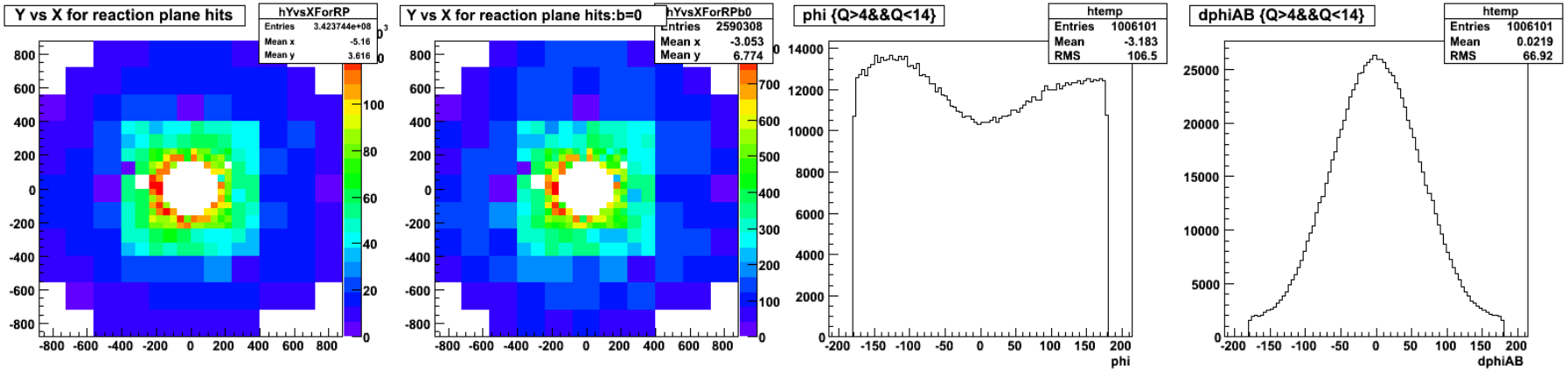


(0<R<1000)mm, no center of gravity shift in (X,Y), 4<|Q|<14

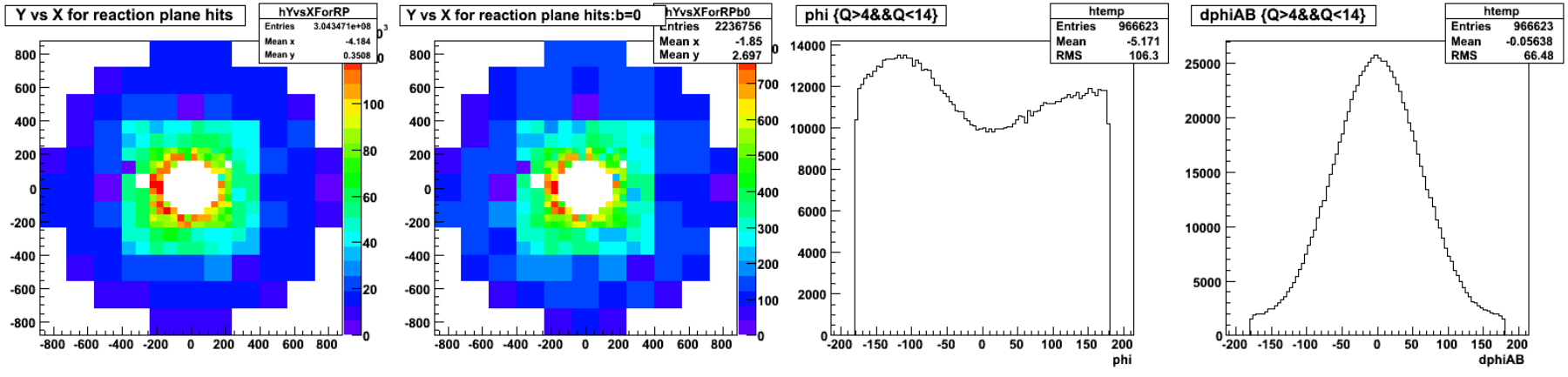


(120<R<1000)mm, no center of gravity shift in (X,Y), 4<|Q|<14

Last day (231) files between 00:00-00:59 approaching center of gravity

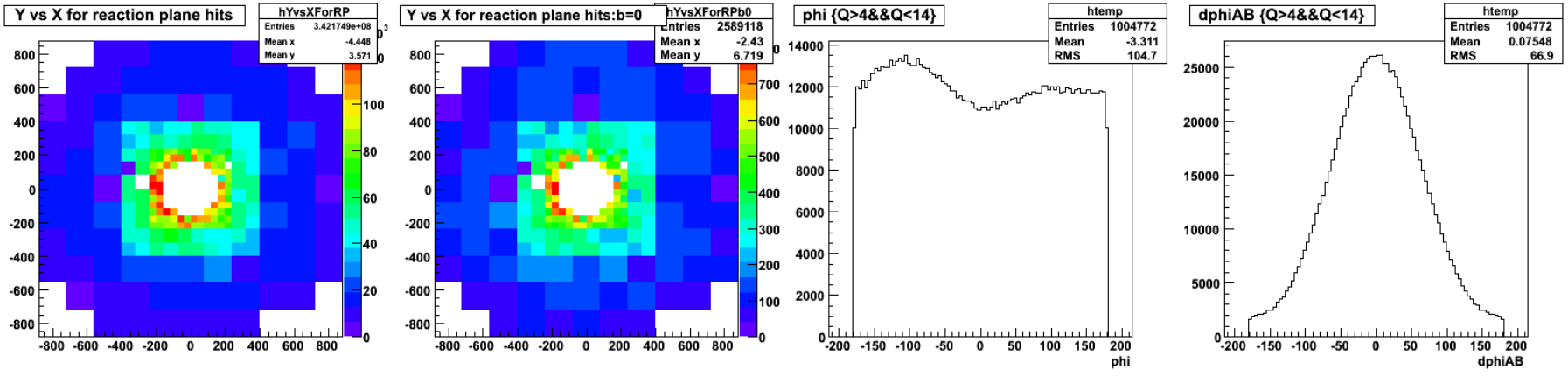


(170<R<1000)mm, no center of gravity shift in (X,Y), 4<|Q|<14

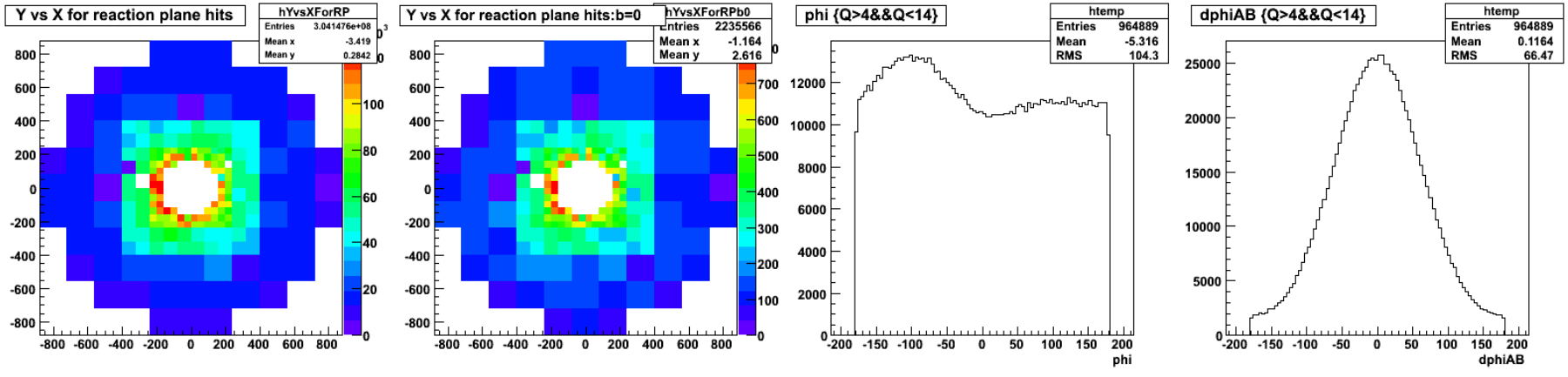


(170<R<820)mm, no center of gravity shift in (X,Y), 4<|Q|<14

Last day (231) files between 00:00-00:59 approaching center of gravity

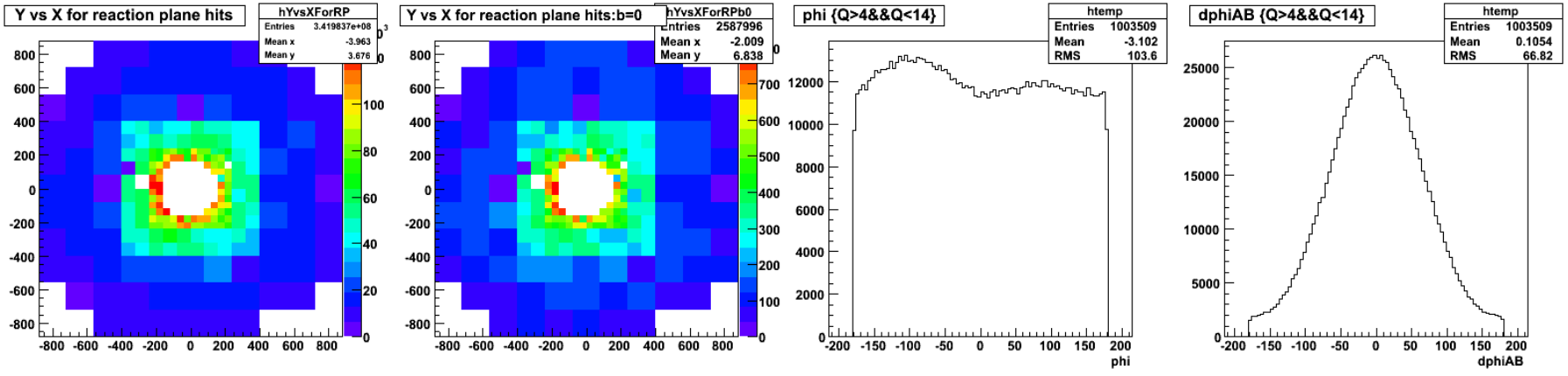


(170<R<1000)mm, center of gravity shift in (X=X-3.0, Y=Y+0.0), 4<|Q|<14

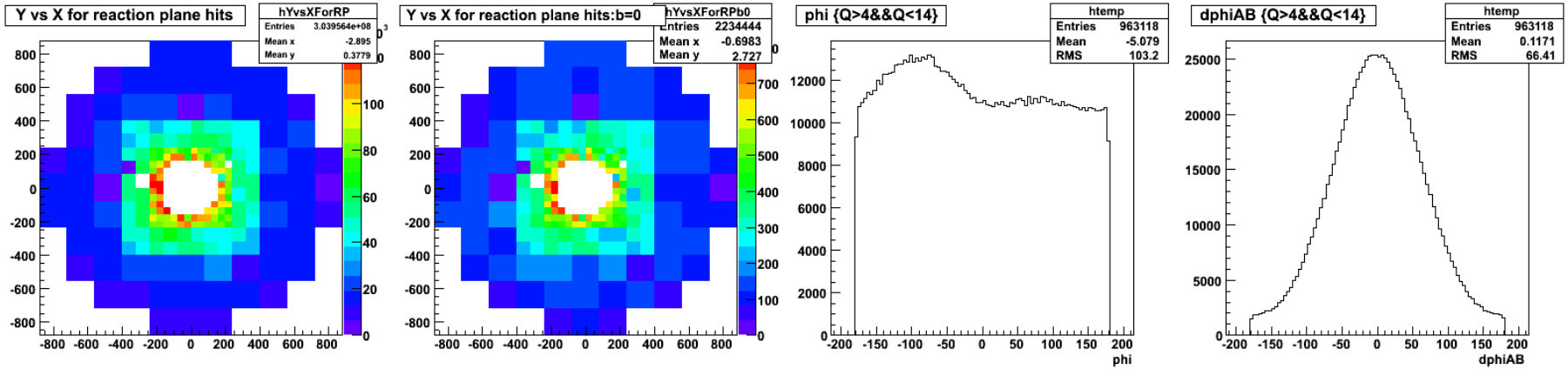


(170<R<820)mm, no center of gravity shift in (X=X-3.0, Y=Y+0.0), 4<|Q|<14

Last day (231) files between 00:00-00:59 approaching center of gravity

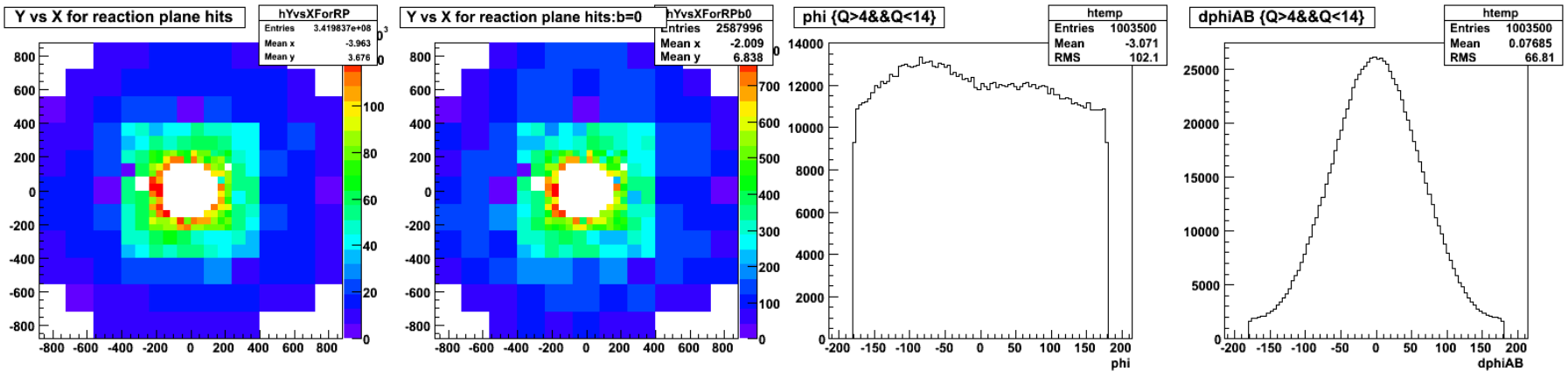


(170<R<1000)mm, center of gravity shift in (X=X-4.5, Y=Y+0.0), 4<|Q|<14

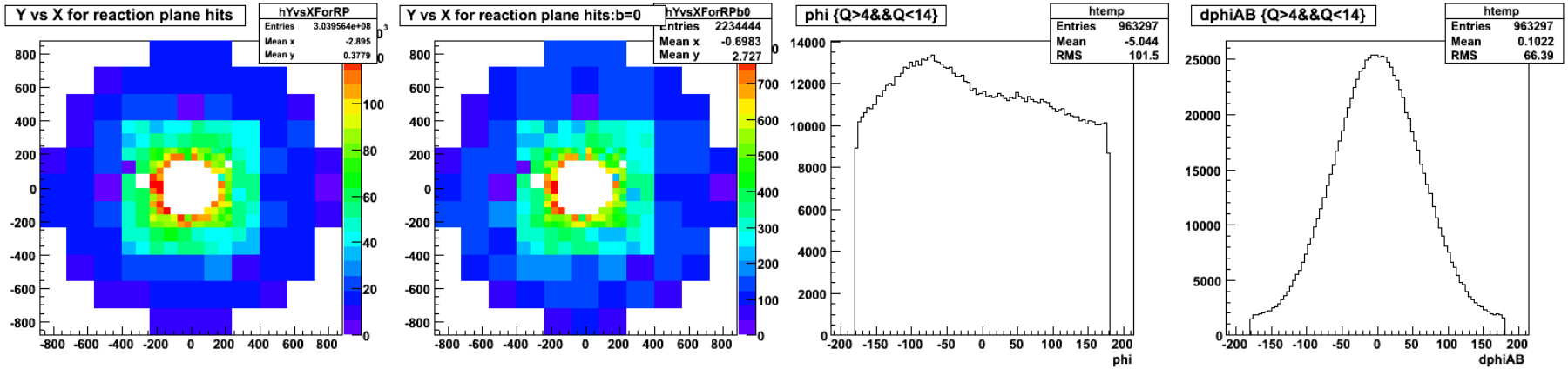


(170<R<820)mm, no center of gravity shift in (X=X-4.5, Y=Y+0.0), 4<|Q|<14

Last day (231) files between 00:00-00:59 approaching center of gravity

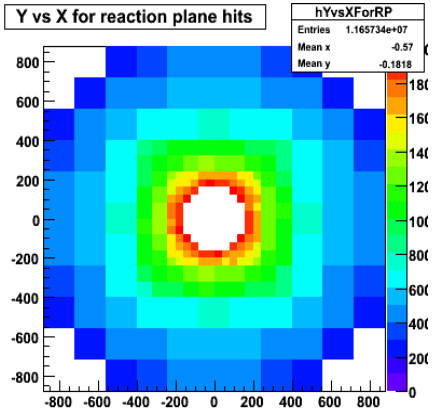


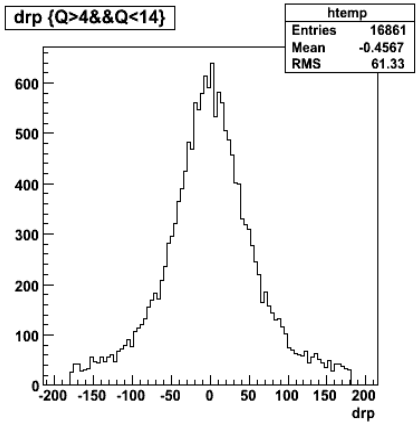
(170<R<1000)mm, center of gravity shift in (X=X-9.5, Y=Y+0.0), 4<|Q|<14

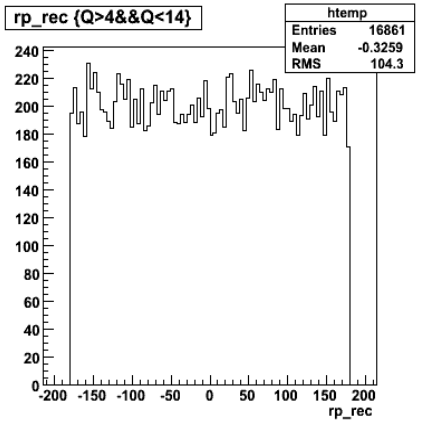


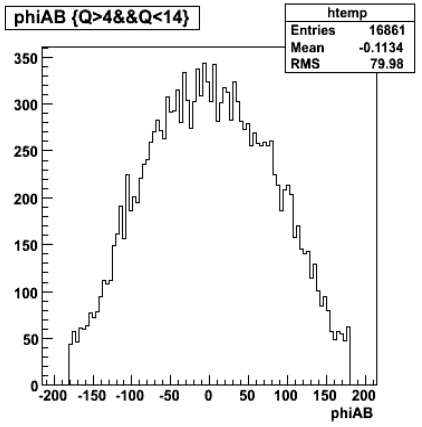
(170<R<820)mm, no center of gravity shift in (X=X-9.5, Y=Y+0.0), 4<|Q|<14

Comparison with simulation w/o X-shift

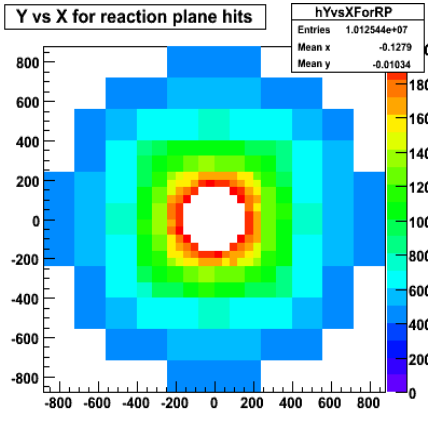


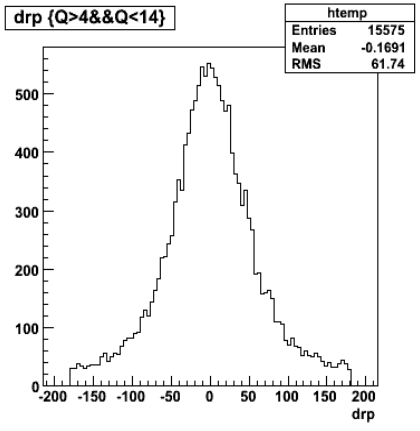


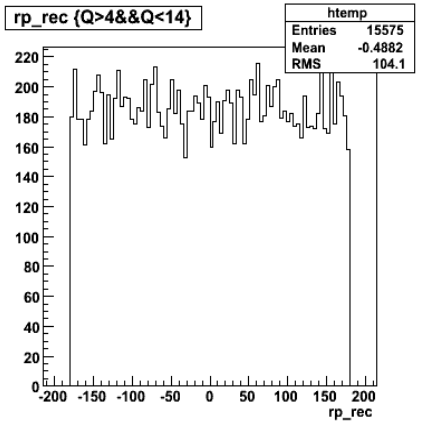


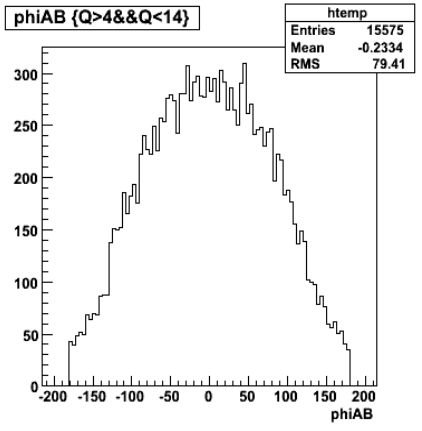


(170<R<1000)mm, center of gravity shift in (X=X+0.0, Y=Y+0.0), 4<|Q|<14



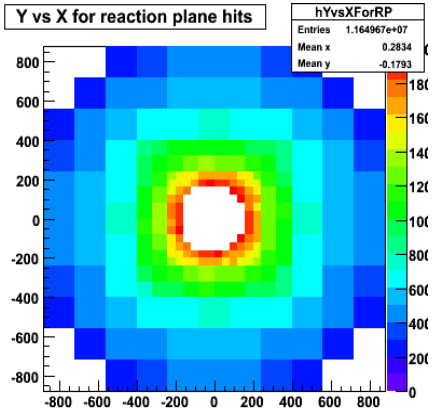


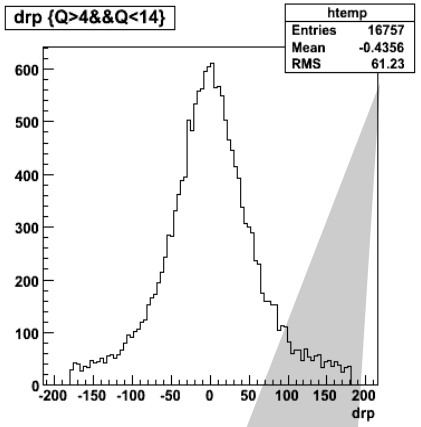


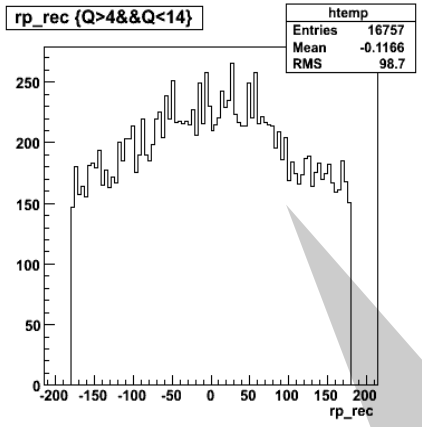


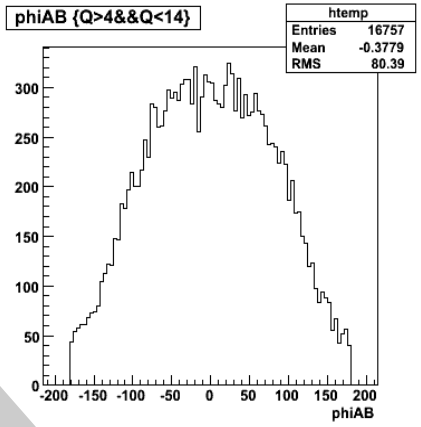
(170<R<820)mm, no center of gravity shift in (X=X+0.0, Y=Y+0.0), 4<|Q|<14

Comparison with simulation with -9.5mm X-shift





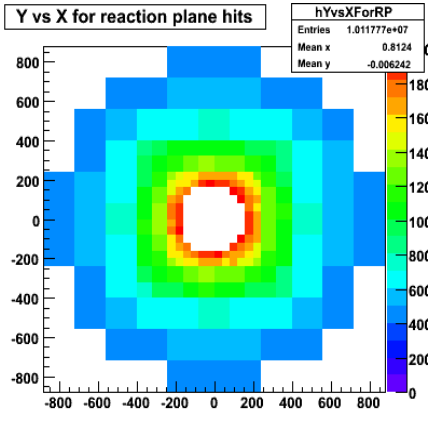


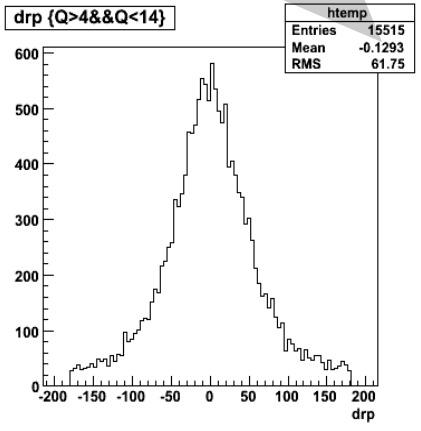


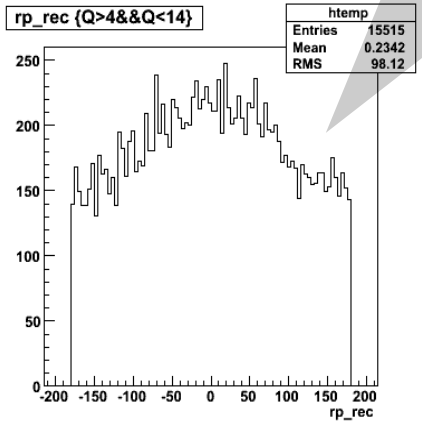
(170<R<1000)mm, center of gravity shift in (X=X-9.5, Y=Y+0.0), 4<|Q|<14

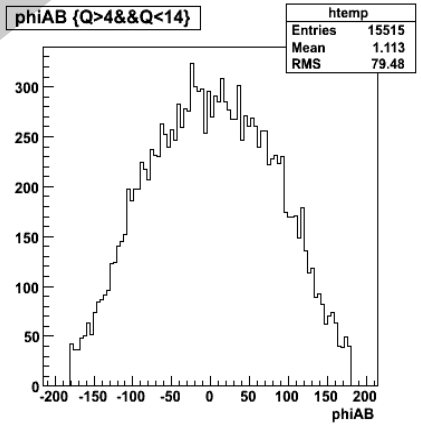
Almost no change!?

Strong anisotropy



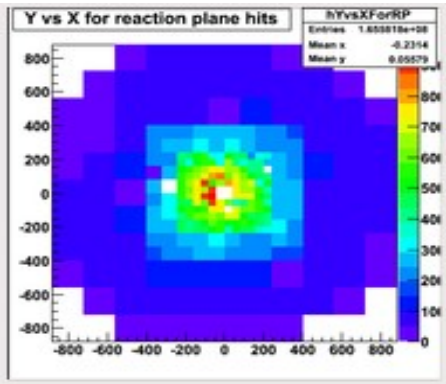


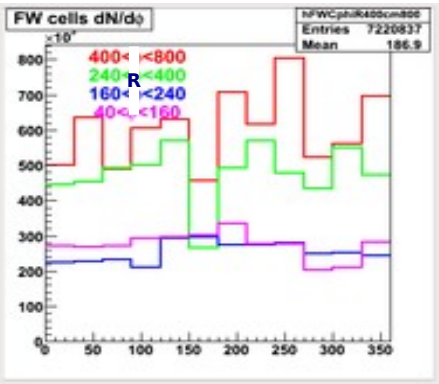


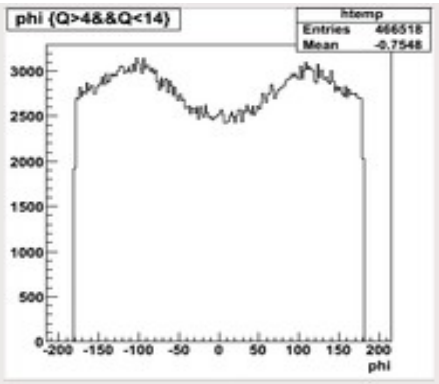


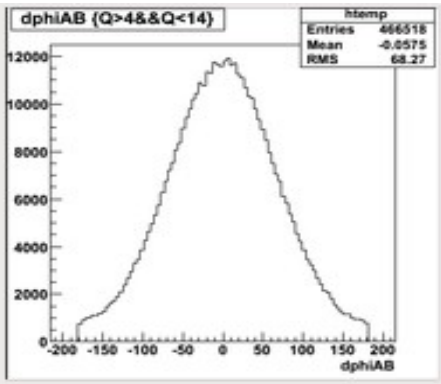
(170<R<820)mm, no center of gravity shift in (X=X-9.5, Y=Y+0.0), 4<|Q|<14

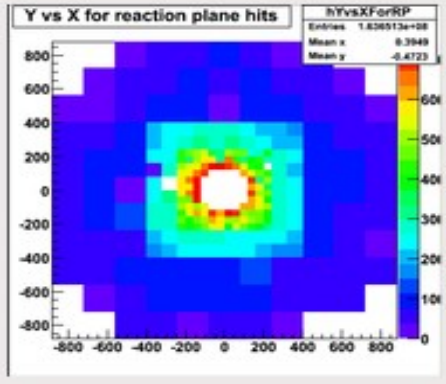
(Au@1.25AGeV)+Au HADES 2011 test beam
FW azimuthal anisotropy (day 227 be1122718423*)

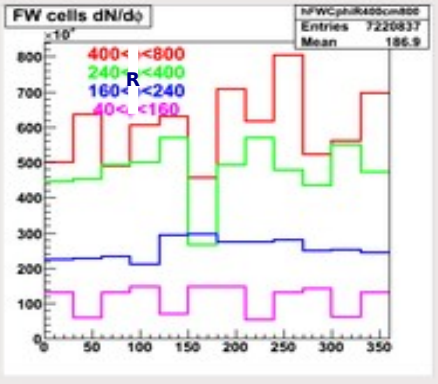


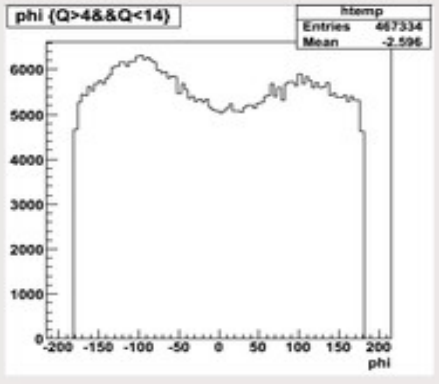


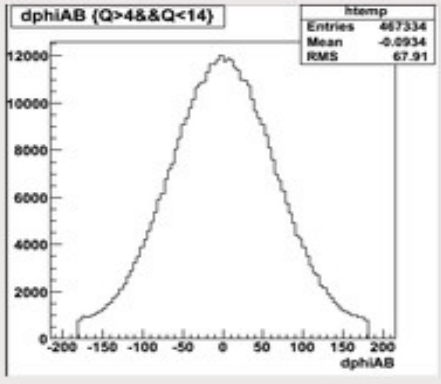


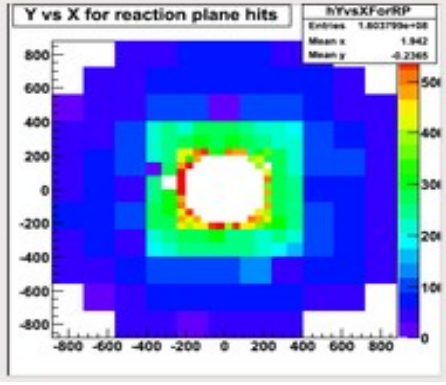


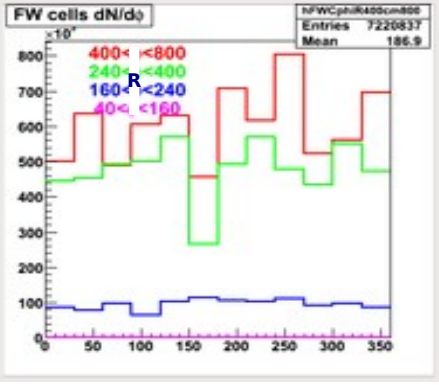


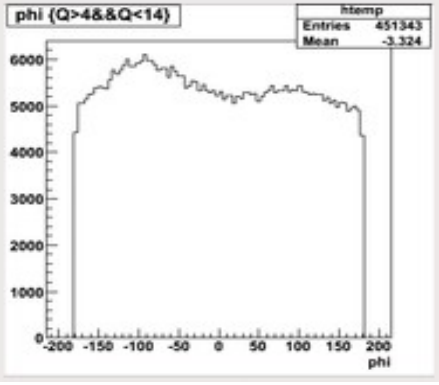


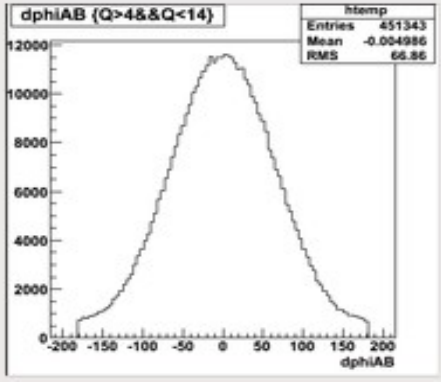




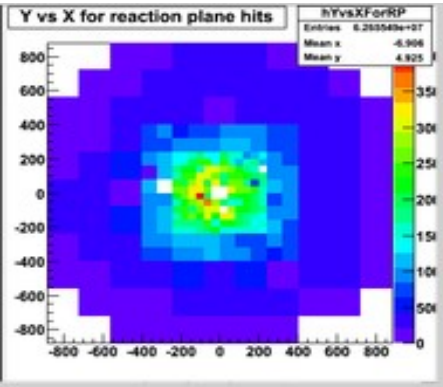


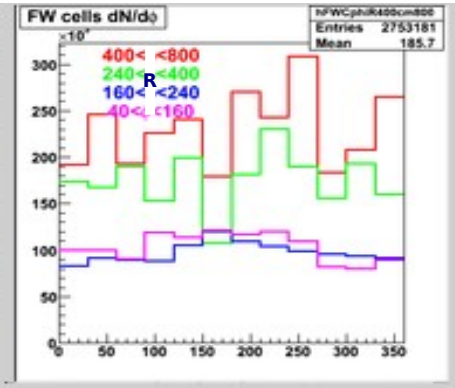


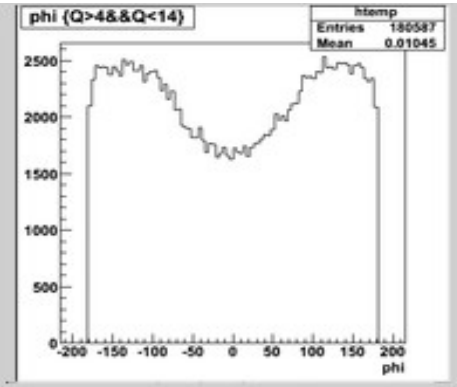


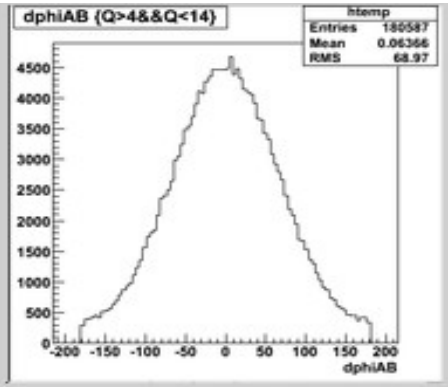


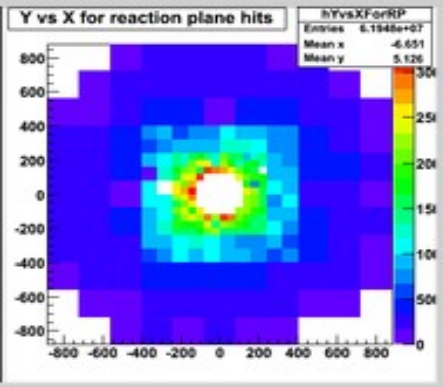
(Au@1.25AGeV)+Au HADES 2011 test beam
FW azimuthal anisotropy (day 229 be1122901465*)

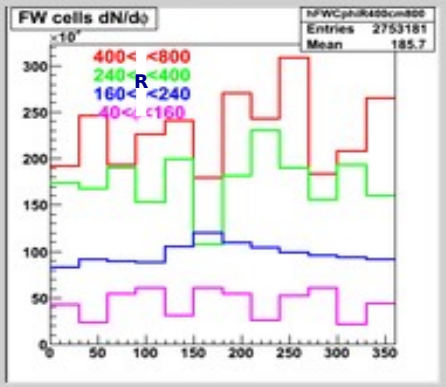


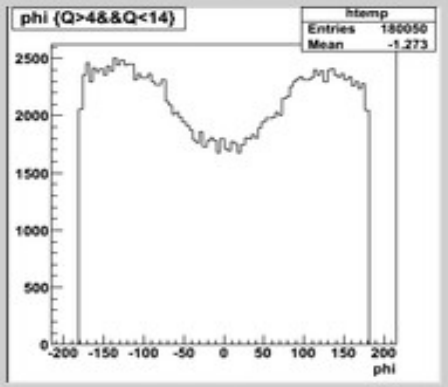


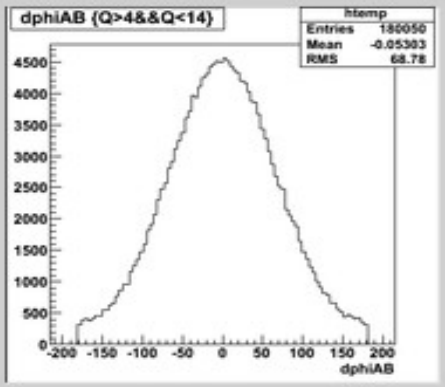


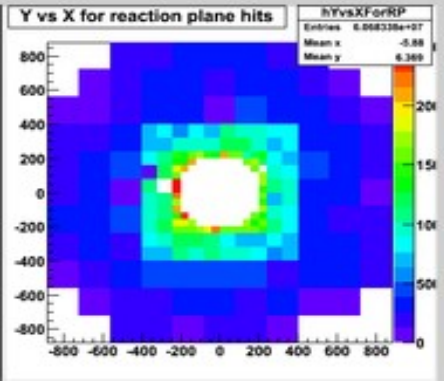


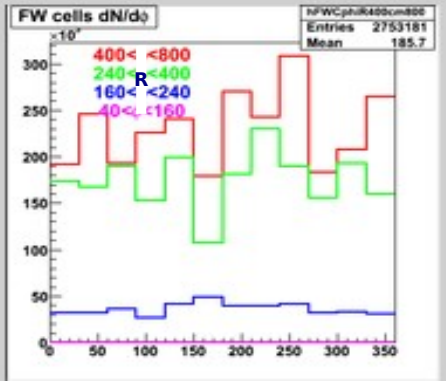


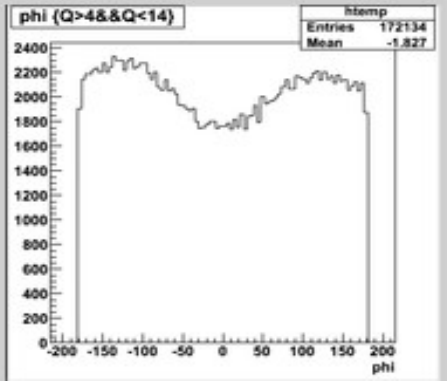


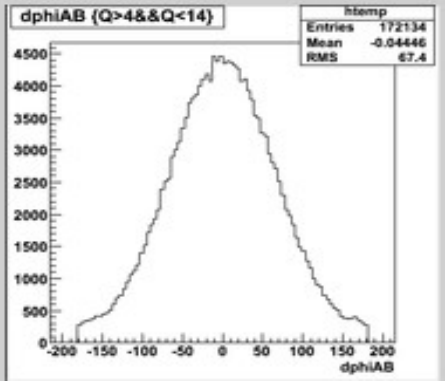




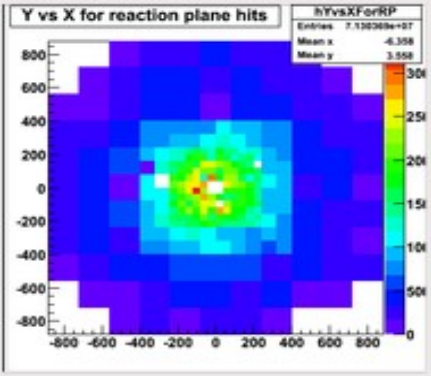


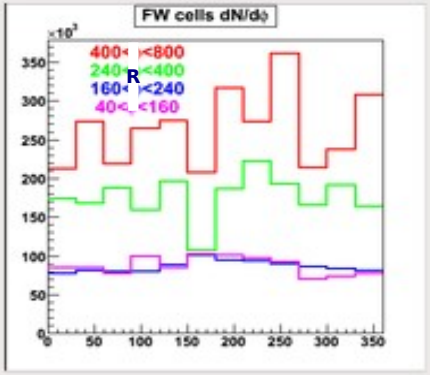


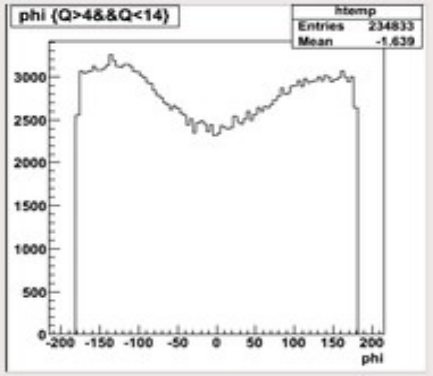


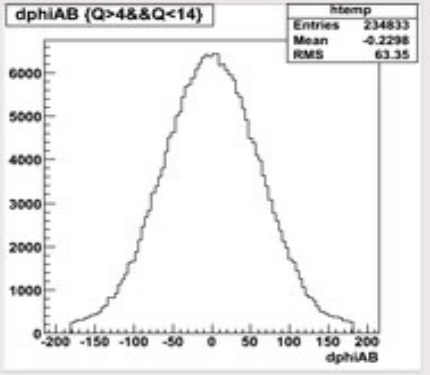


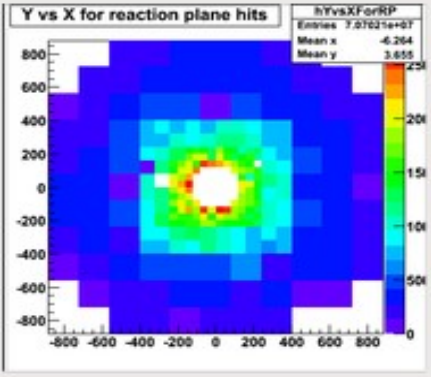
(Au@1.25AGeV)+Au HADES 2011 test beam
FW azimuthal anisotropy (day 230 be11230233*)

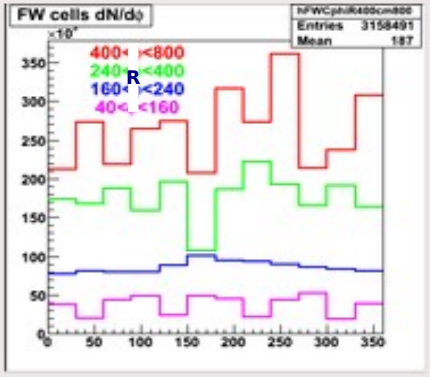


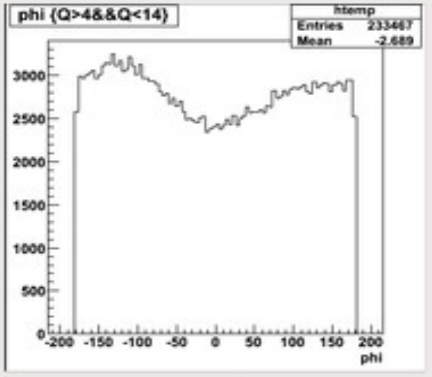


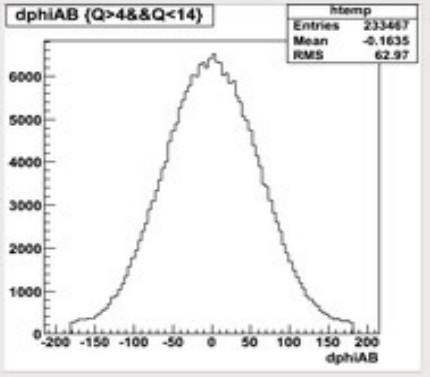


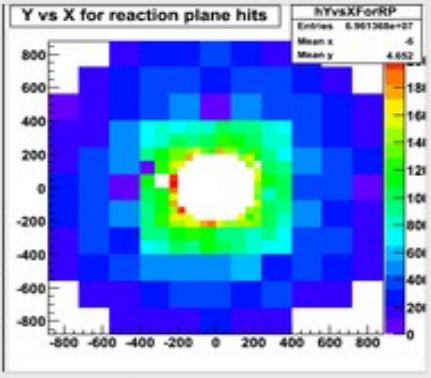


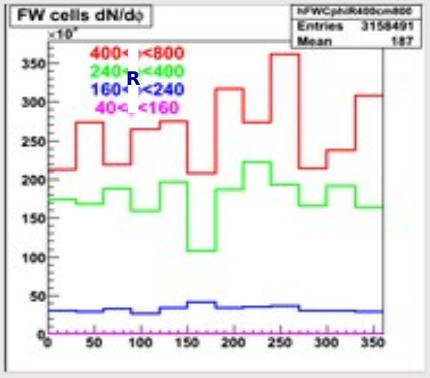


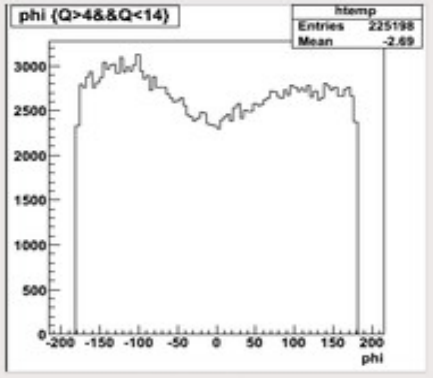


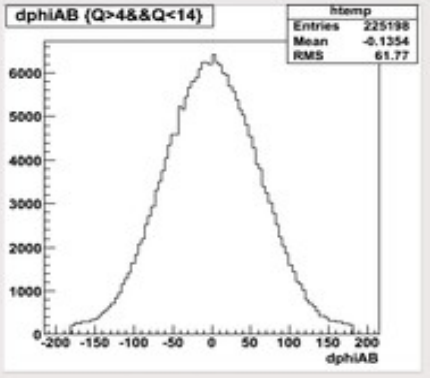




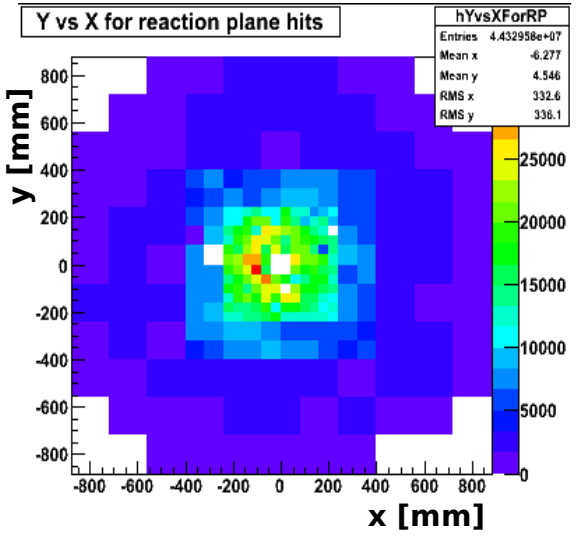


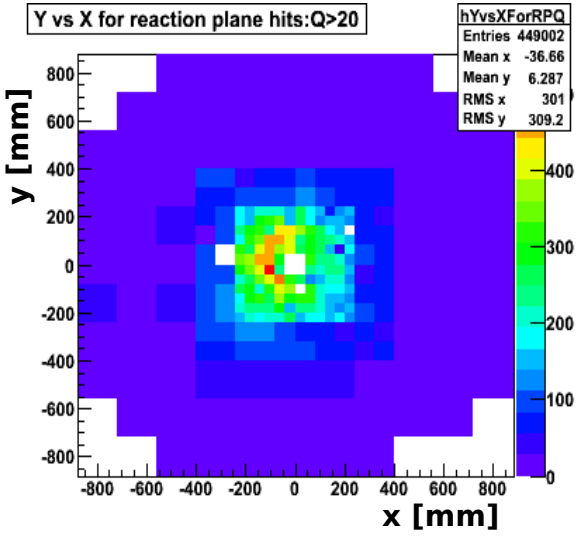


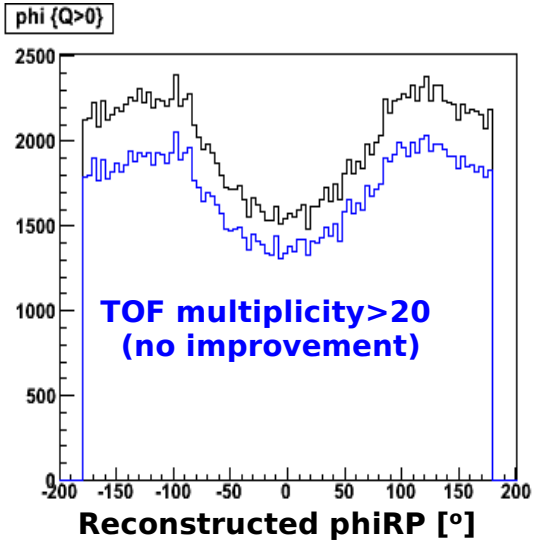




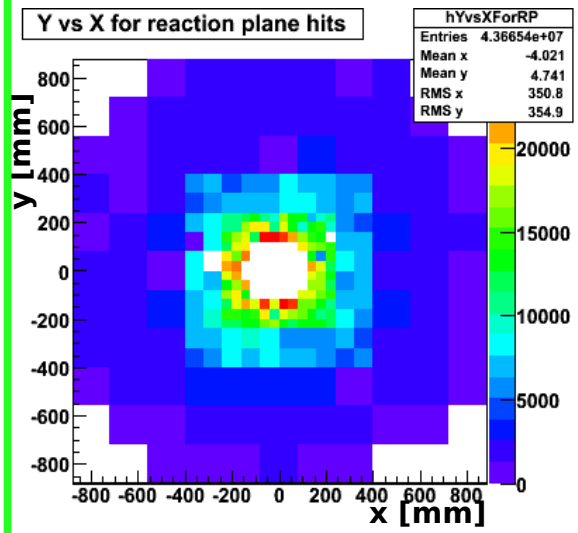
(Au@1.24AGeV)+Au HADES 2011 test beam FW azimuthal anisotropy (day 229)

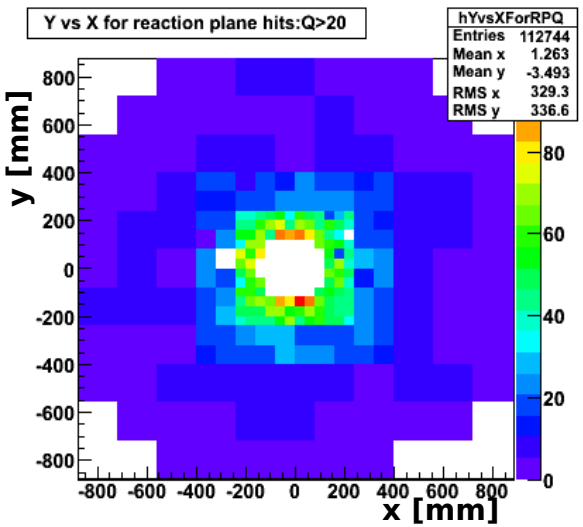


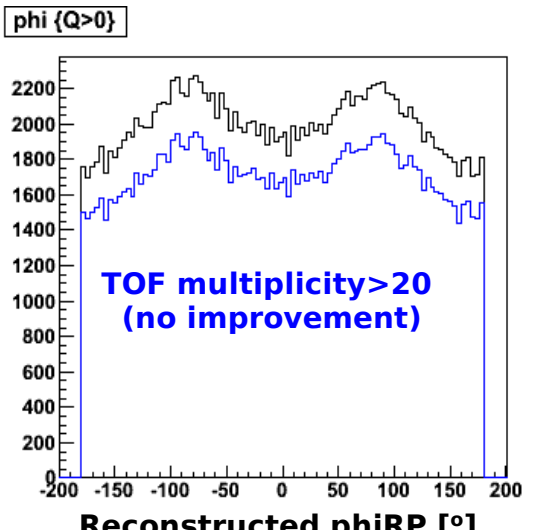




Adjusting for beam shift x=x-(-7.2mm) y=y-(-1mm); and Rmin = 138mm (to gain isotropy)

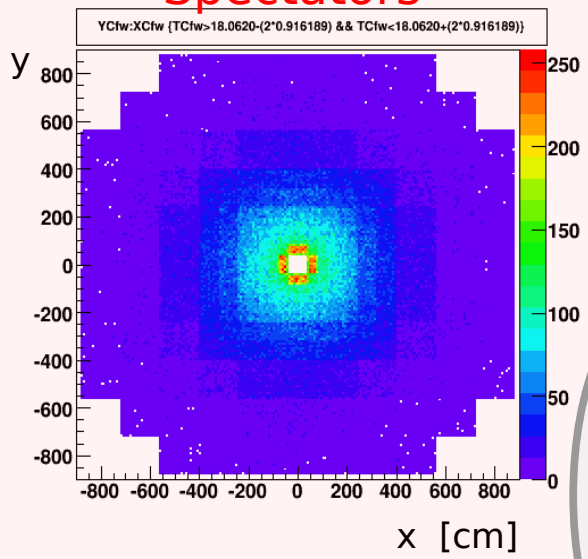


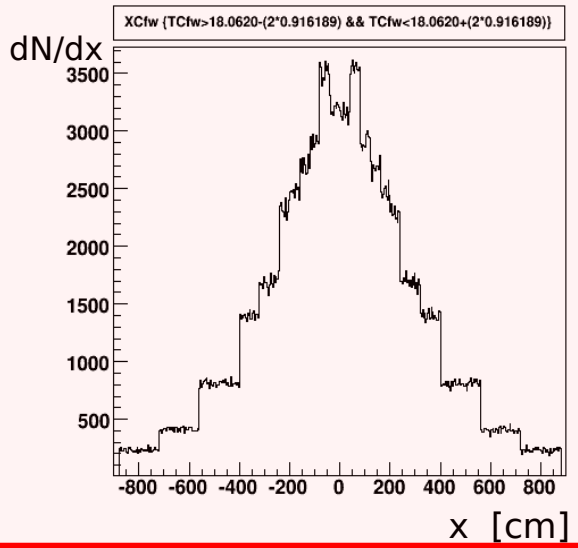




Simulation: FW fired cells distribution Au+Au@1.25AGeV (selection of spectators in FW)

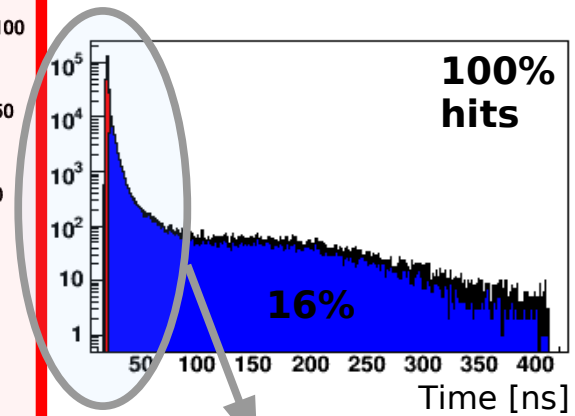
Spectators

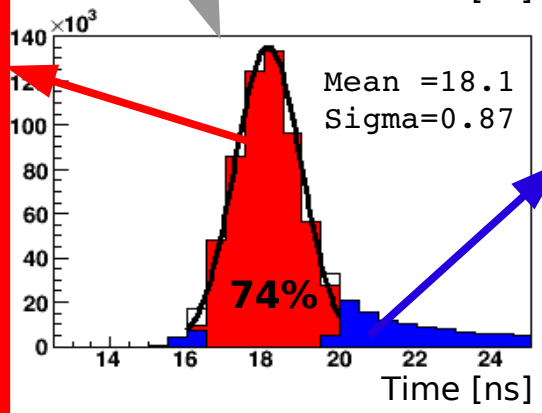




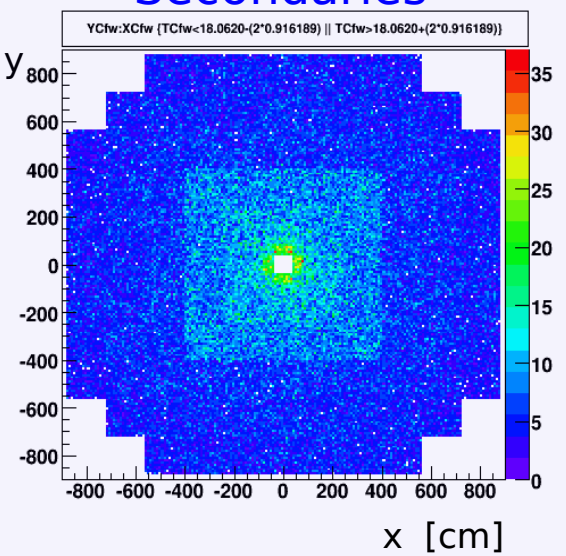
Selecting spectators by peak at time-of-flight distrib. in FW cells

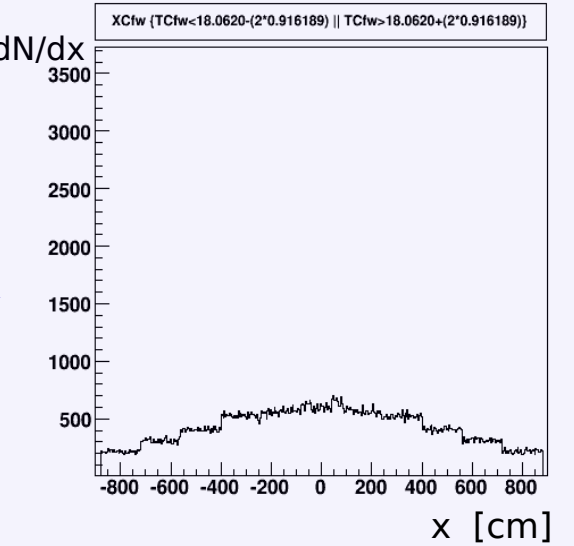
(left): inside 2sigma
(right): outside2sigma





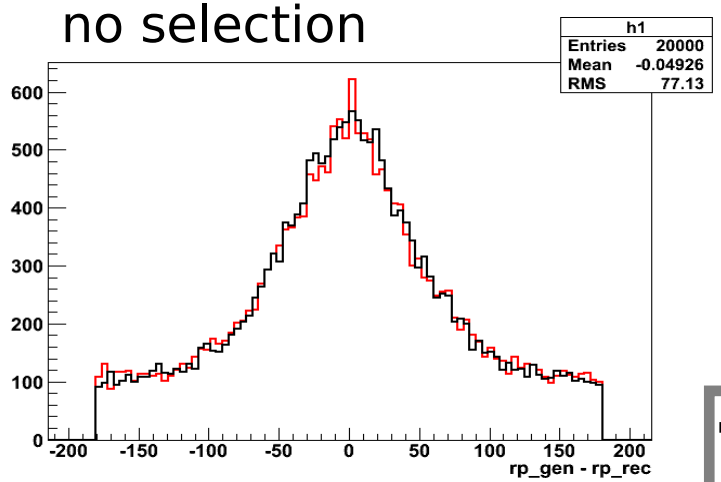
Secondaries



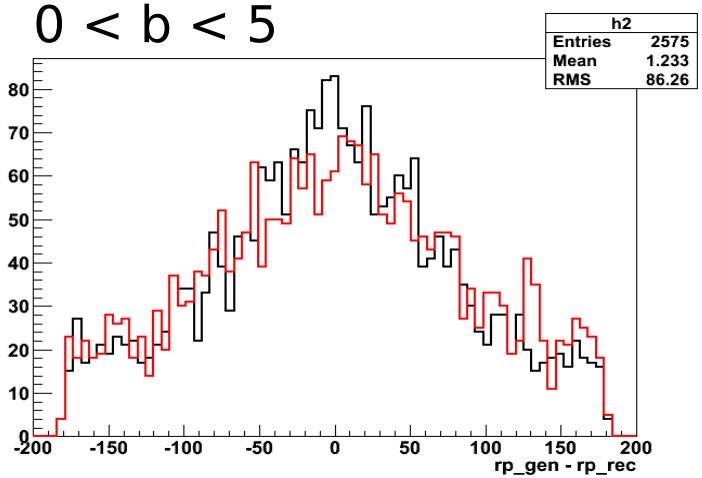


Reaction plane reconstr.: Au+Au@1.25GeV/u

no selection

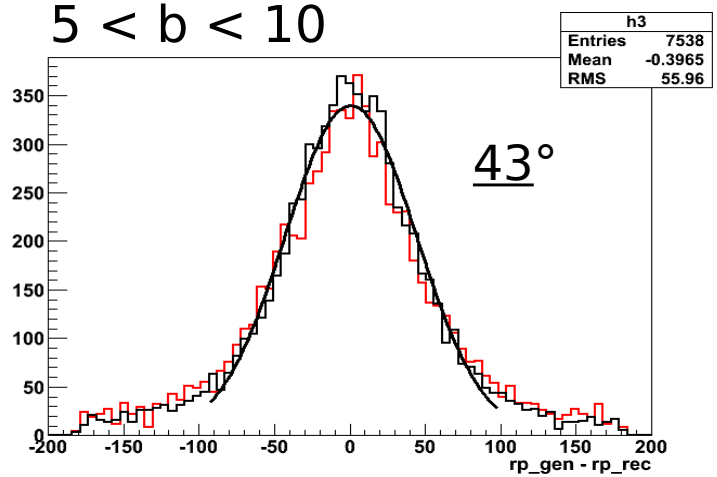


0 < b < 5

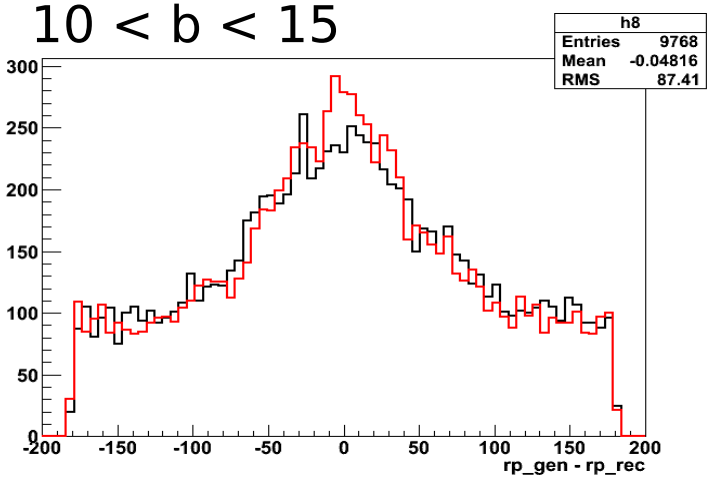


no weight
Z weight

5 < b < 10



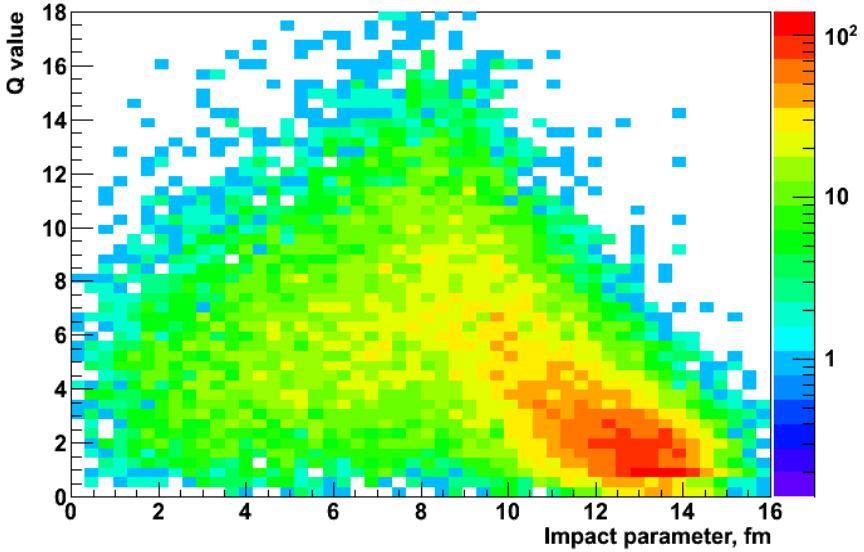
10 < b < 15

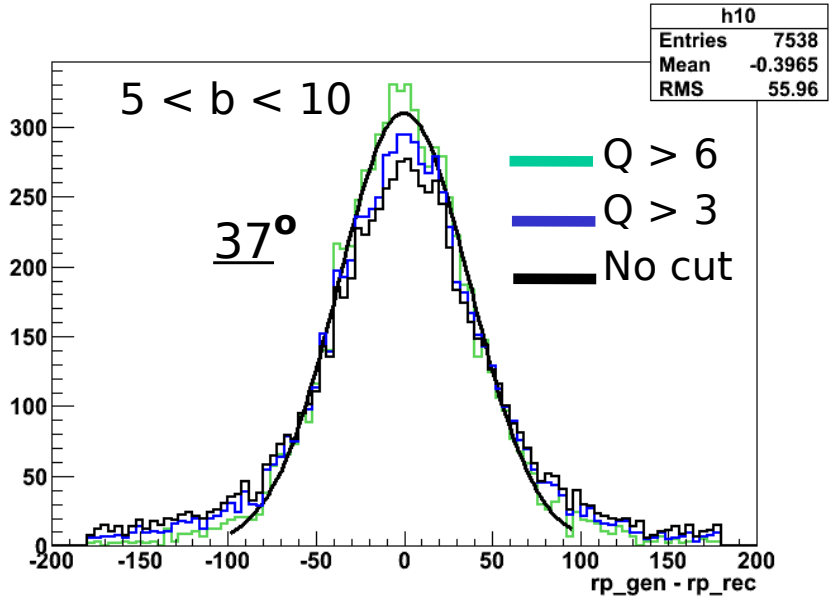


⇉ K.Lapidus (HADES coll.meet 2010, GSI)

Reaction plane recons. : Au+Au@1.25GeV/u

Cut on Q value helps in
suppression of tails and
improves the resolution





Simulations with FW
located at 5-7m from target

⇉ K.Lapidus (HADES coll.meet. 2010, GSI)