Updates on the η mass .

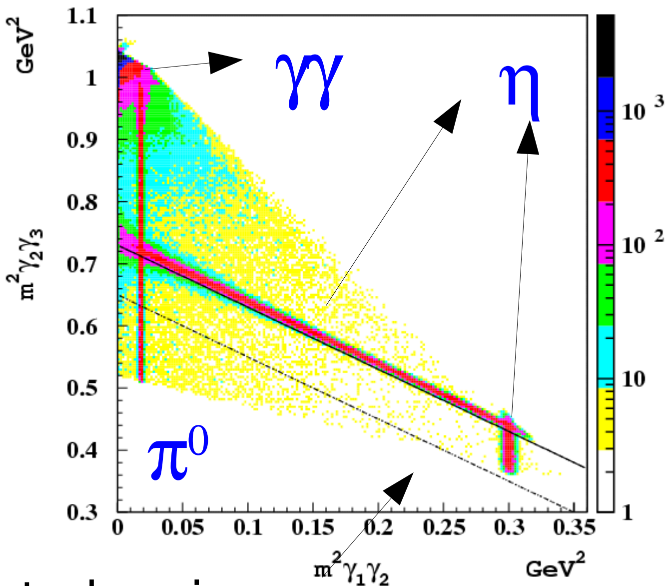
B. Di Micco

General comments from the referees:

- Measurement ok, systematic ok, but:

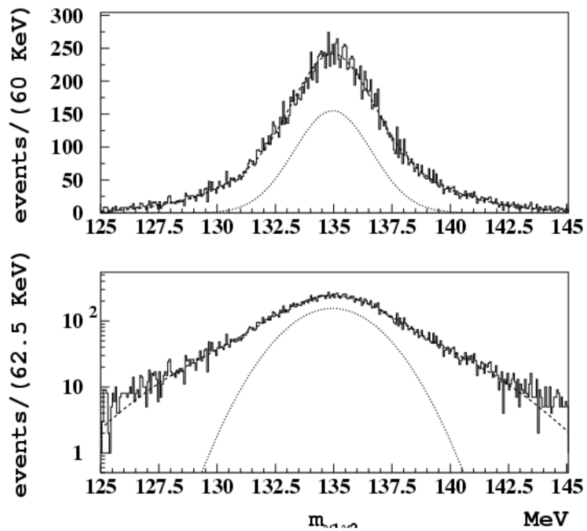
1) Need to understand MC correction;
2) Further check on systematic above all on the azimuthal dependence.

Dalitz plot and invariant mass distribution

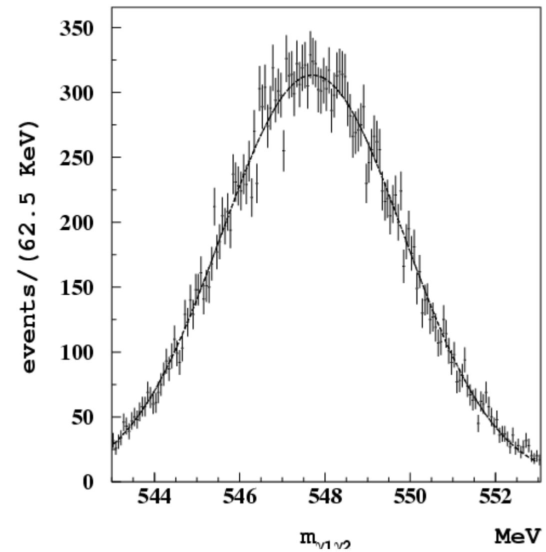


Accepted region

double gaussian for π^0

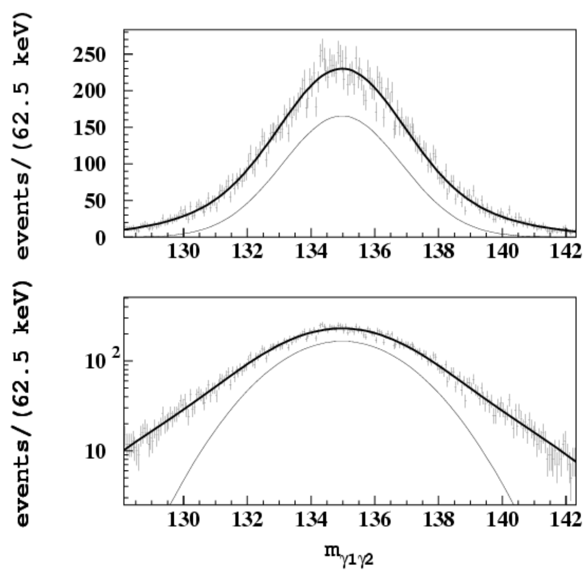


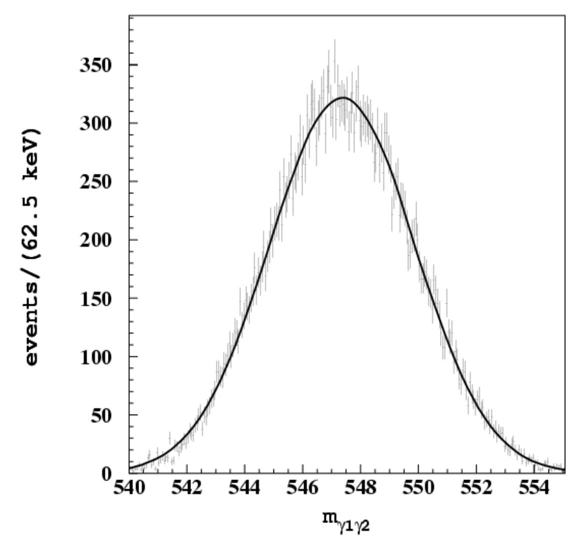
single gaussian for η



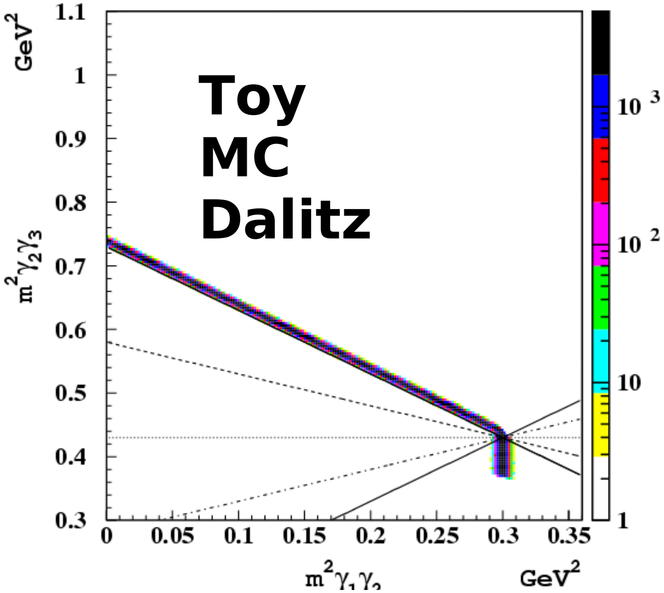
RAD 04 MC distribution

MeV	DATA	RAD 04	ALLPHYS 05
$\sigma\, m_\eta$	2.137 ±0.012	2.514 ± 0.012	2.502± 0.022
a_1/a_2	2.70	2.57	8.7
$\sigma_1\, m_\pi$	1.78±0.05	1.86 ± 0.10	2.09 ± 0.20
$\sigma_2\, m_\pi$	4.07±0.19	3.53 ± 0.34	4 ± 3

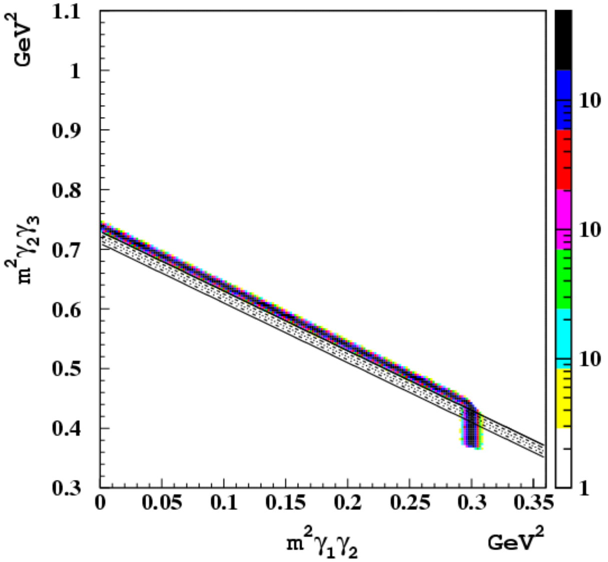


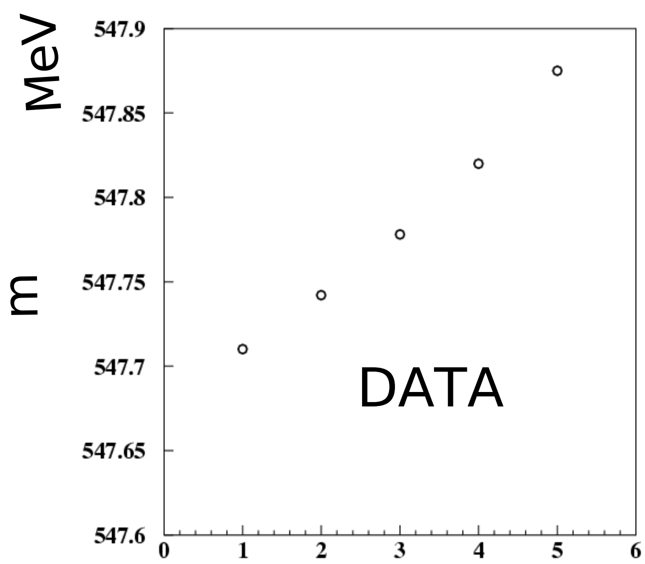


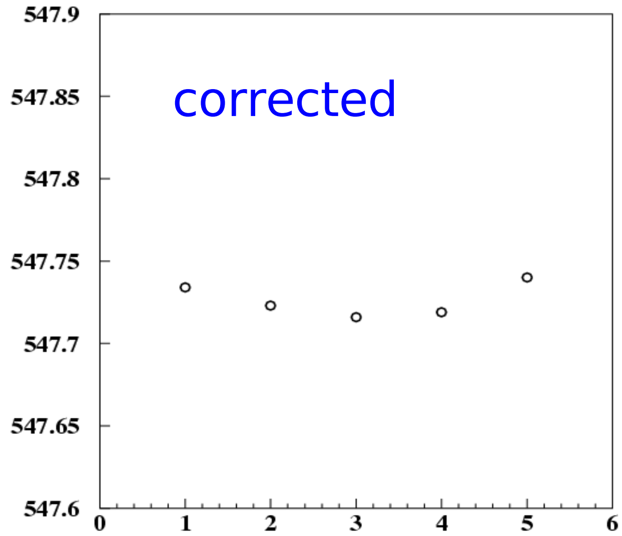
Dalitz cut

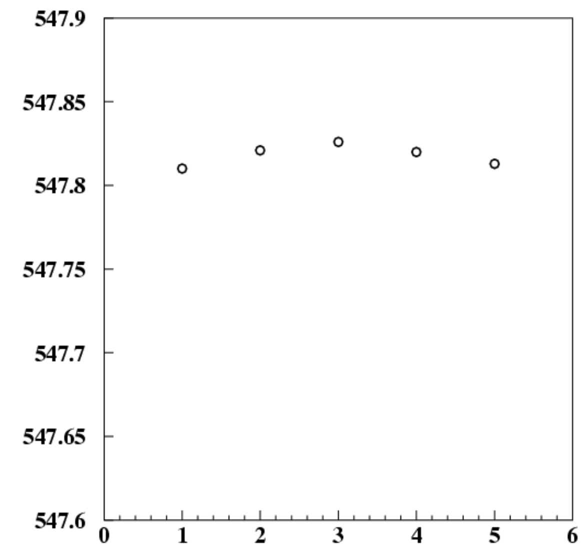


The cut on the Dalitz plot produces a distortion on the distribution that shifts the mass.
The effect is determined with a toy MC and used to evaluate a correction.

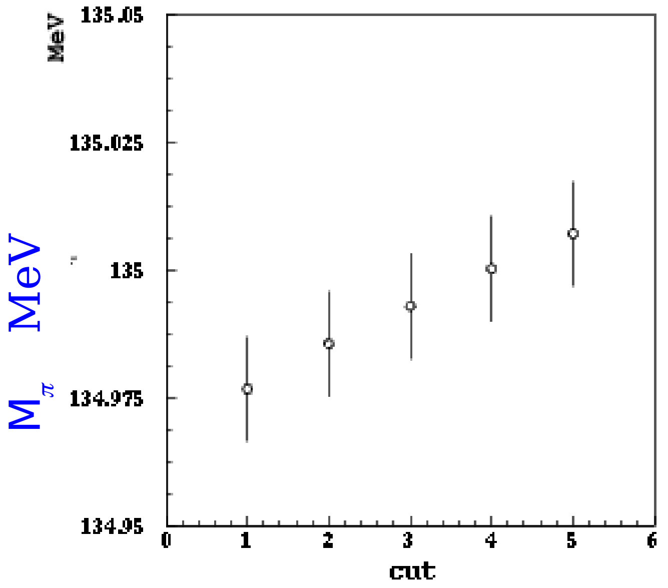


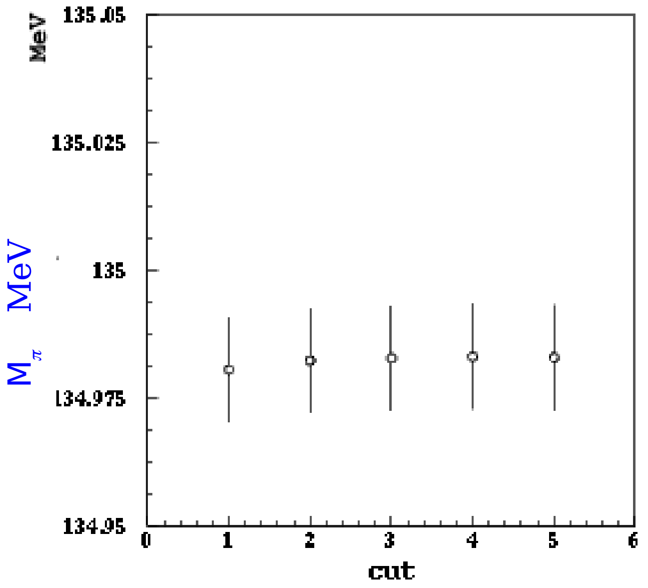




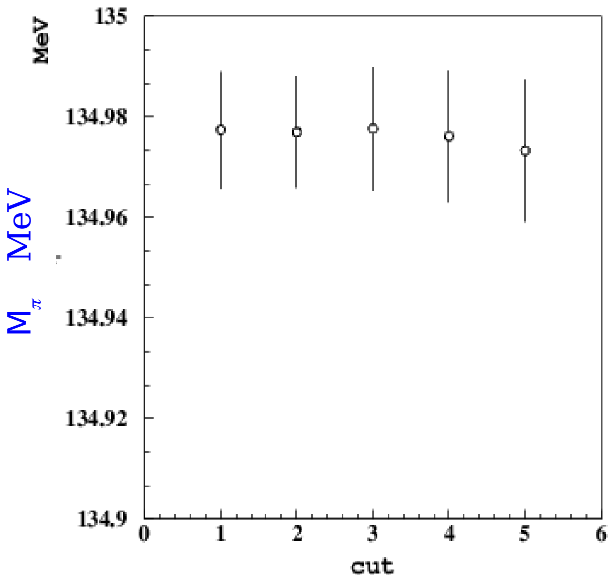


π^0 case





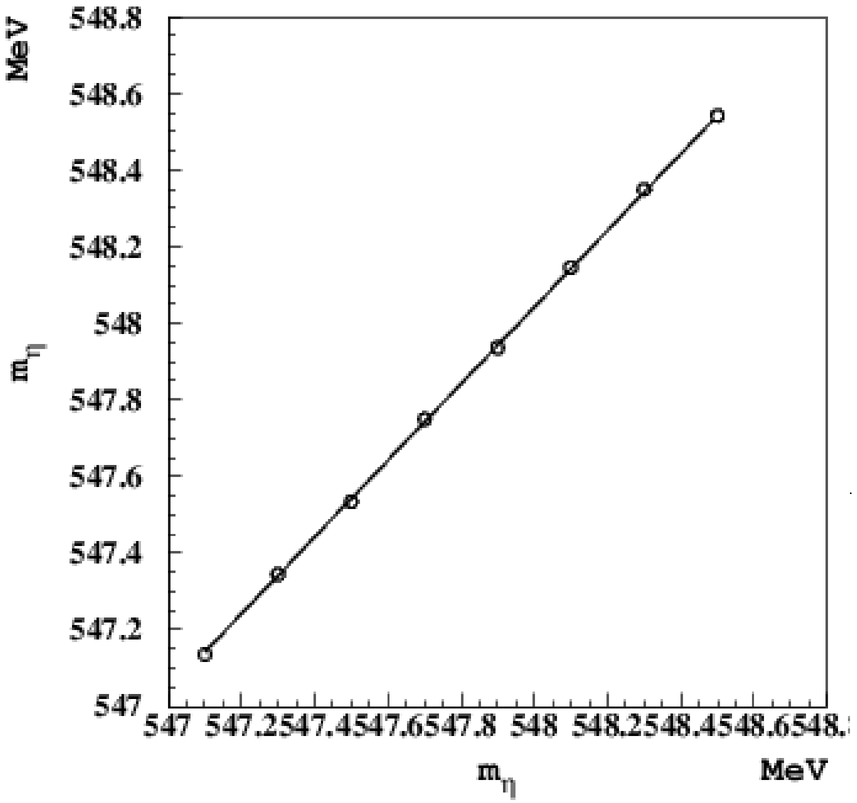
Slope cut



Constant cut

Global check of the fit

To evaluate corrections to the measured value, the GEANFI MC has been generated with different value of the input mass and the response curve has been determined.

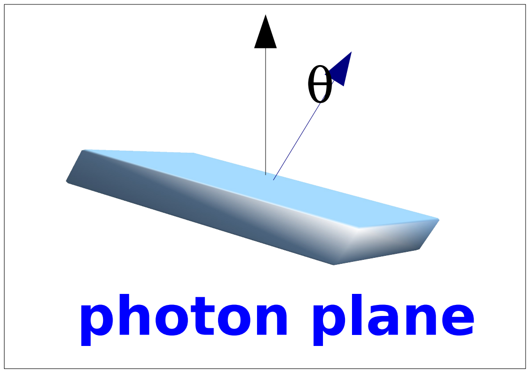


	$M_{rec} - M_{input}$		
	MC GEANFI (Δ_1)	TOY MC PAR (Δ_{dalmc})	TOY DATA PAR (Δ_{dalDATA})
m_η	41 keV	-47 keV	-36.4 keV
m_{π^0}	65 keV	-6 keV	-3.8 keV

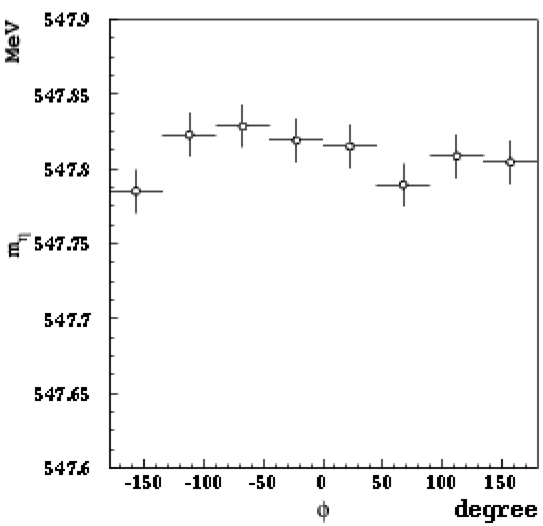
The correction due to the slope cut on the Dalitz is different for DATA and MC, so we have to take into account the difference in estimating the final shift..

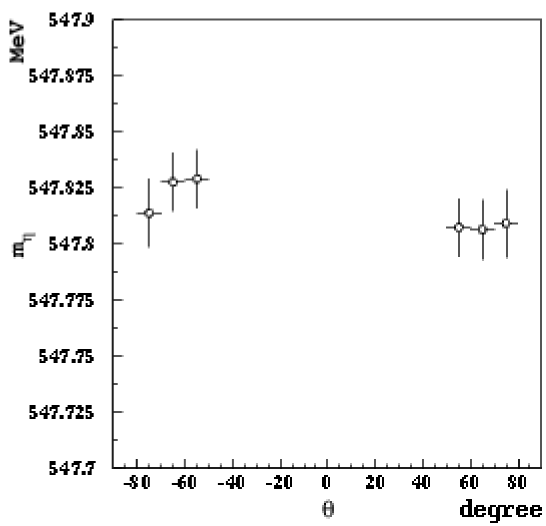
$$M_\eta = M_{\eta\text{mes}} - (\Delta_1 - \Delta_{\text{dalmc}} + \Delta_{\text{dalDATA}}) =$$
$$M_{\eta\text{mes}} - 41keV - 47keV + 36.4 = M_{\eta\text{mes}} - 52keV$$
$$M_{\pi^0} = M_{\pi 0\text{mes}} - 65 - 6 + 3.8keV = M_{\pi^0} - 67keV$$

½ of the correction taken as systematic error.



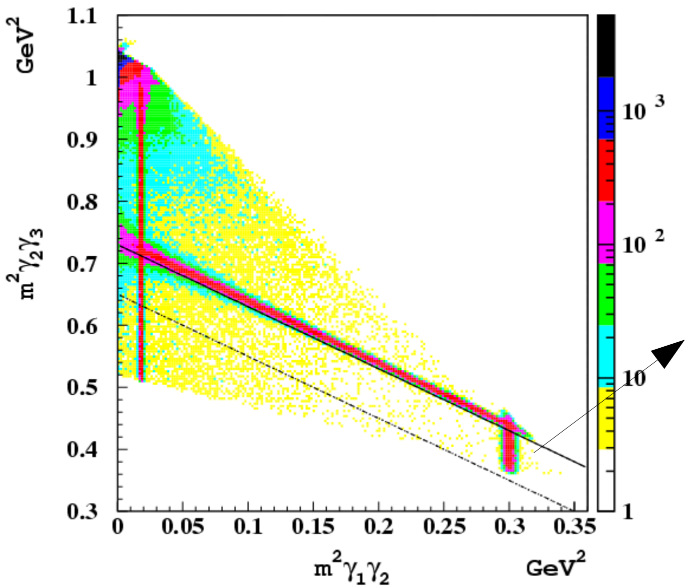
The isotropy in the response is evaluated using the rotation of the 3 photons plane in the space.





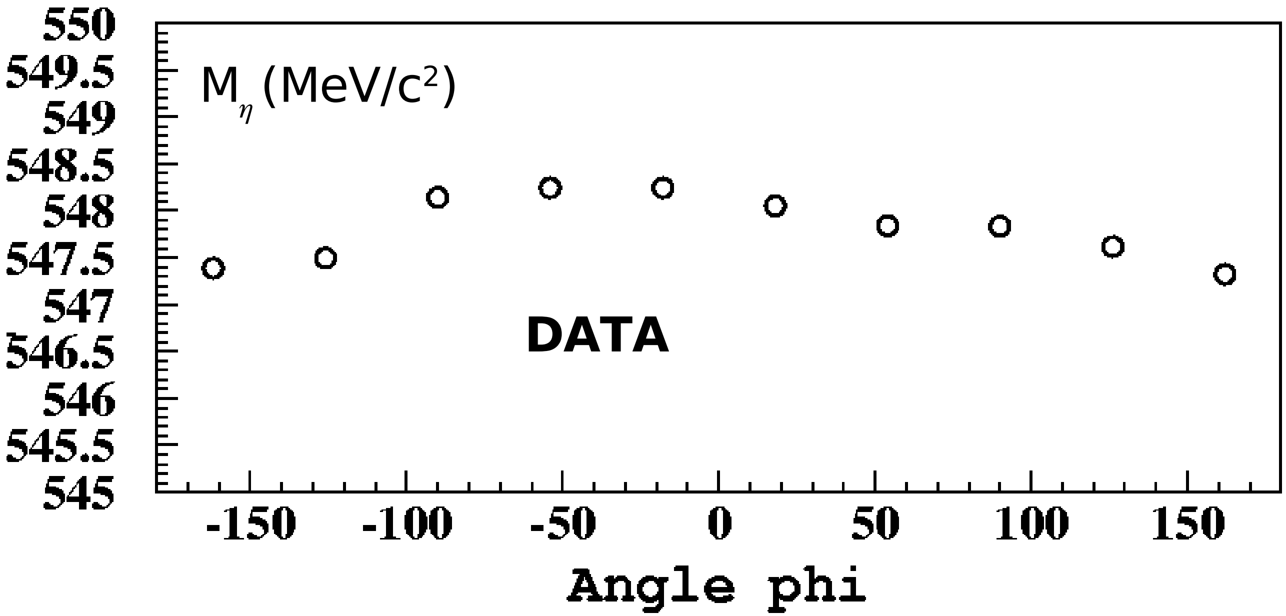
	m_η (keV)	m_π (keV)	m_η/m_π
azhimutal uniformity	15	12	3.7×10^{-4}
polar uniformity	10	44	1.2×10^{-3}

What about the photon coming from the ϕ

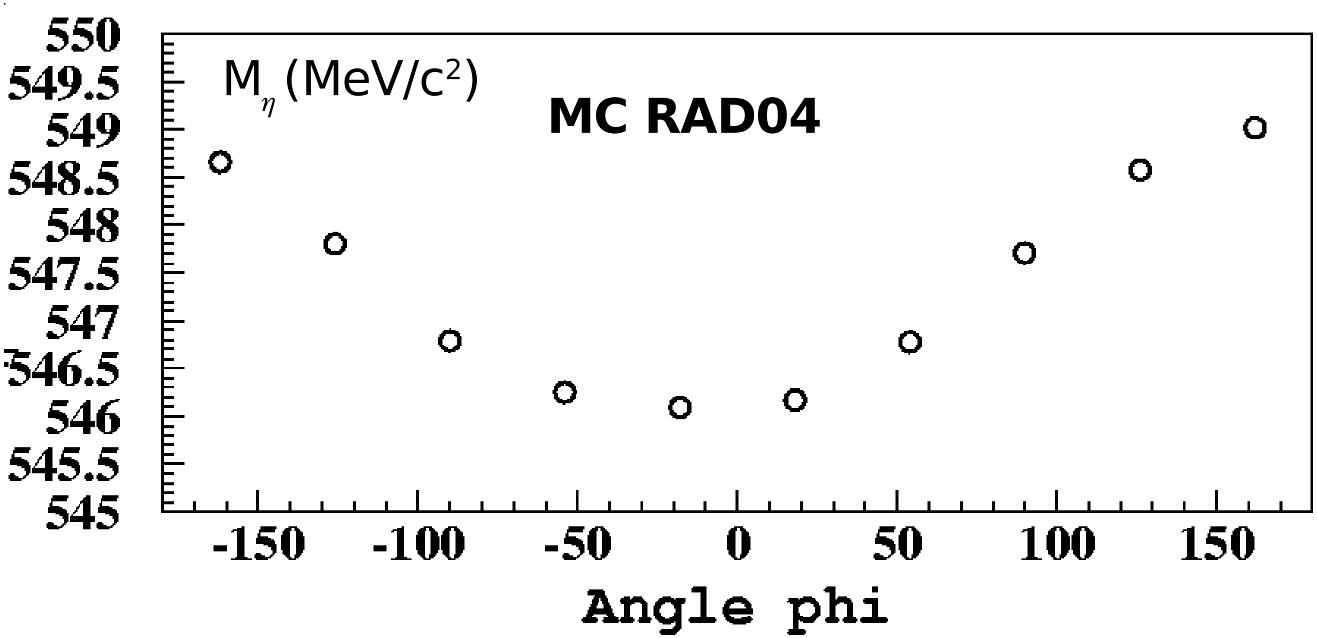


η decay photons
the most energetic is the one coming from the ϕ decay

I always preferred to not look exclusively to a single photon (the kinematic fit build strong correlation among variables, better to avoid to look at systematic because what you see can be just an effect of these correlations, that usually cancels when you integrate over the kinematic variables.



Small variation on DATA, huge variation on MC.



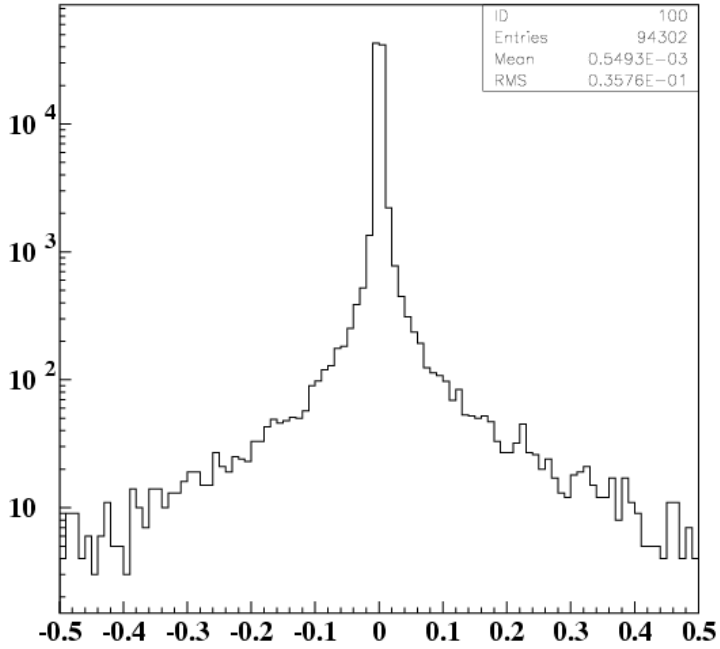
Can we trust MC to estimate the correction?

Let's try to understand why this happens.

An angular variation can be due to a wrong ϕ momentum estimate.

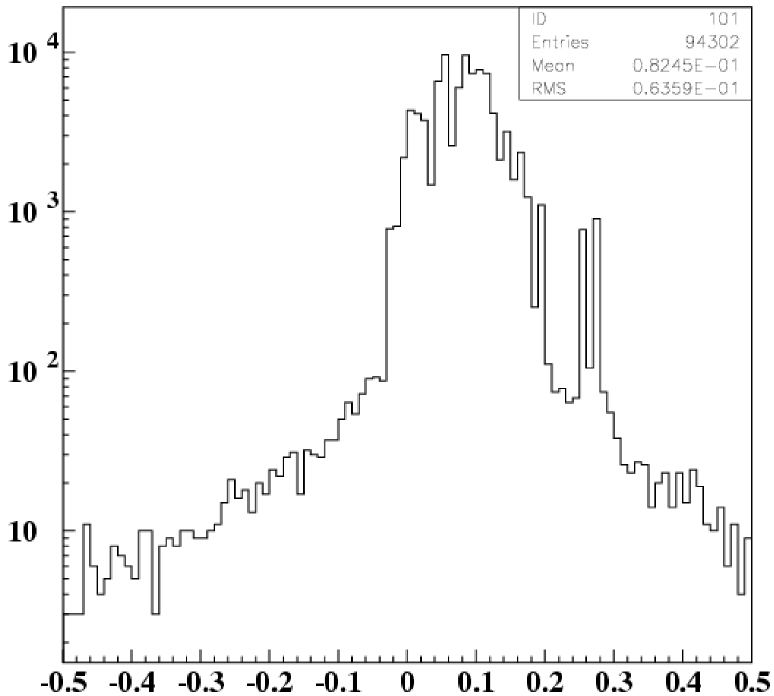
By naïve calculation on energy momentum conservation, 2 degree error on the momentum brings to a sinusoidal effect of some MeV.

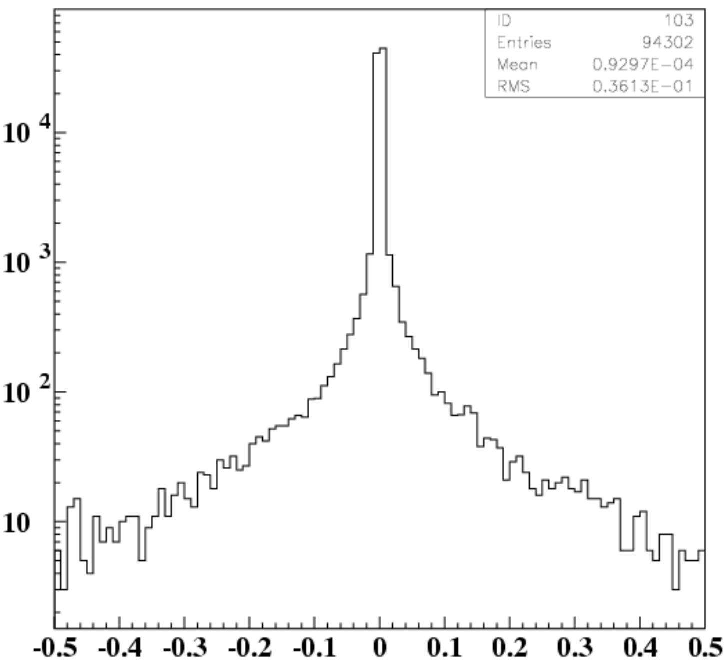
Let's check the beam momentum simulated respect the beam momentum used in the fit (BMOM).



$P_{x\,MC}$-$BMOM_x$ MeV/c

In the MC we select only event $\phi \to \eta\gamma$, $\eta \to \gamma\gamma$, γ without an ISR photons in the final state. The spread is due to infra-red – collinear photons below the transportation cut.



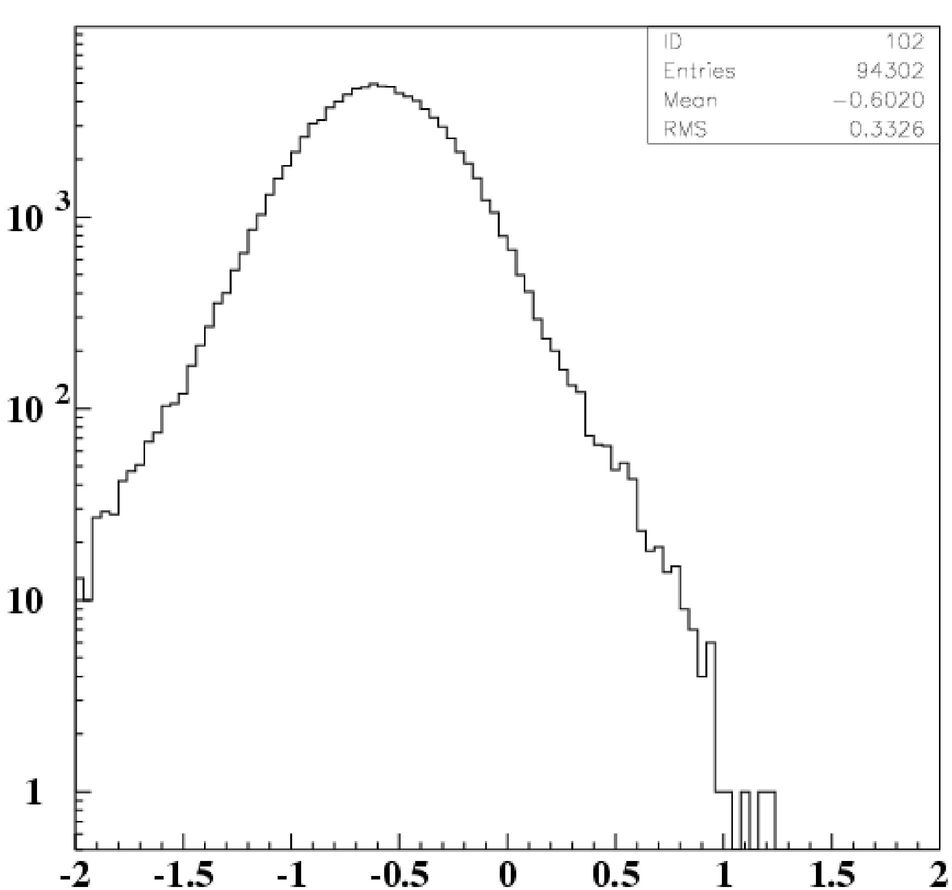


$P_{y\ MC}$-$BMOM_y$ MeV/c

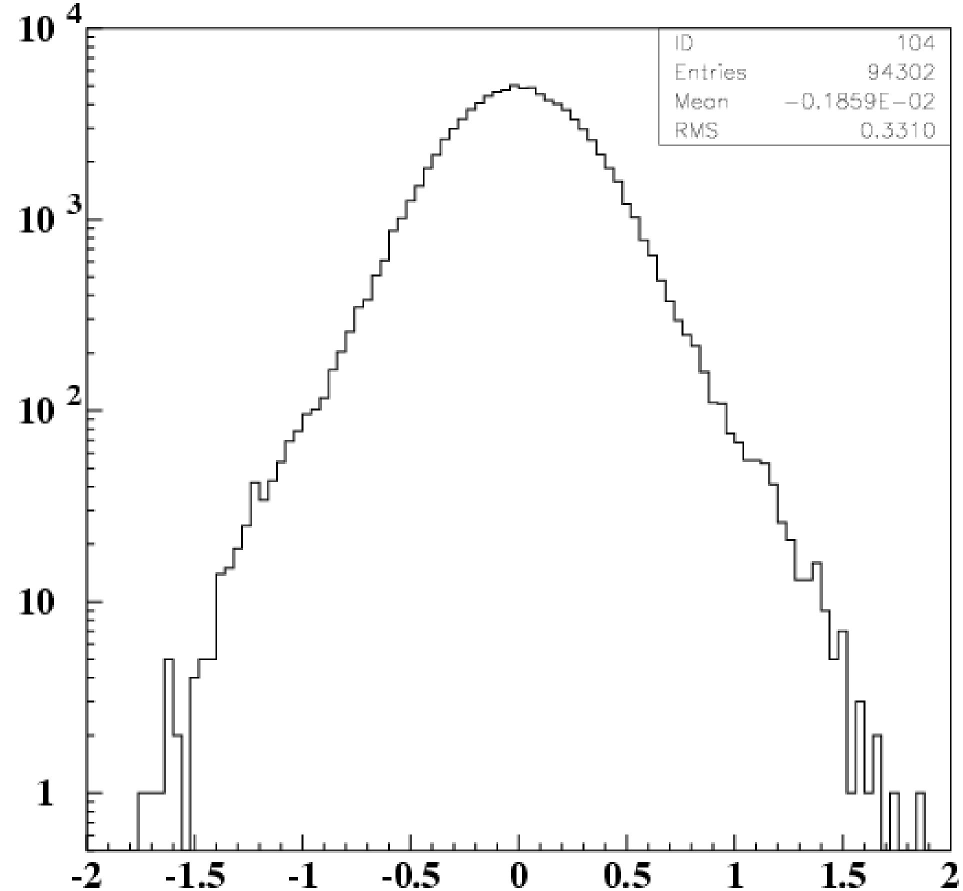
$P_{y\ MC}$ MeV/c

In the MC P_y is always 0!!

We have to check with Caterina if this is wished or not.



$P_{z\,MC}$-$BMOM_z$ MeV/c

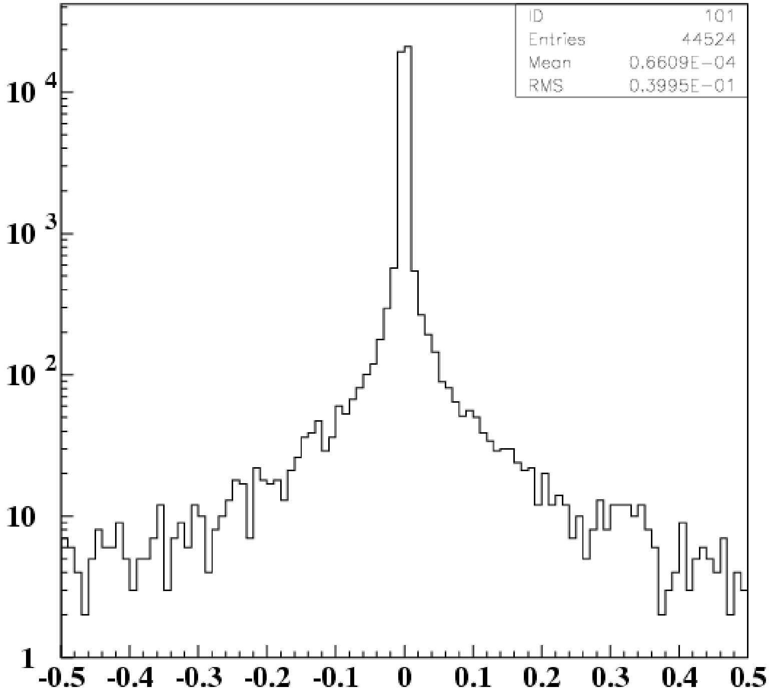


$P_{z\,MC}$ MeV/c

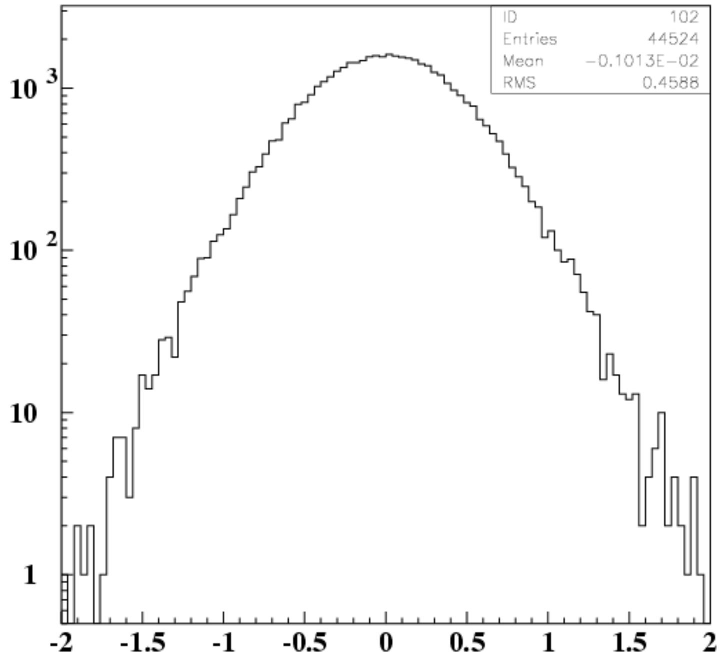
In the MC P_z is always 0!!

Interesting, we have find something unexpected, but does it solve the problem?

Let's generate from scratch using geanfi and imposing BPX = -12.5,
BPY = 0, BPZ = 0

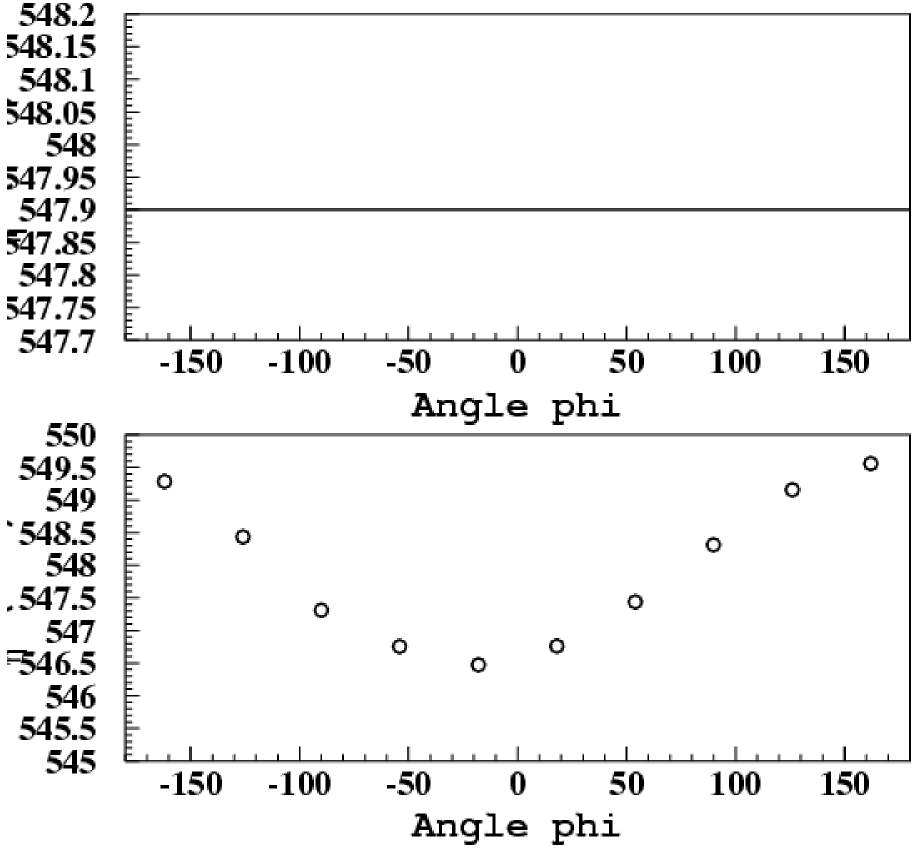


$P_{y\ MC}$-$BMOM_y$ MeV/c



$P_{z\ MC}$-$BMOM_z$ MeV/c

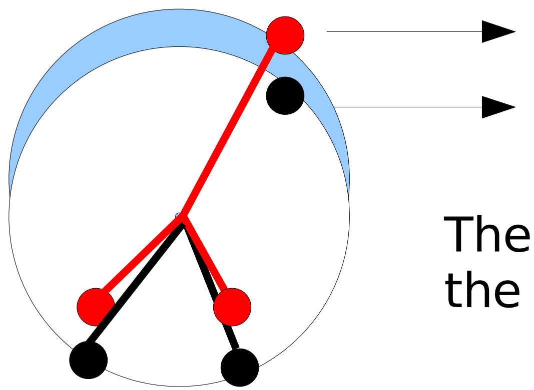
M_η (MeV/c²)



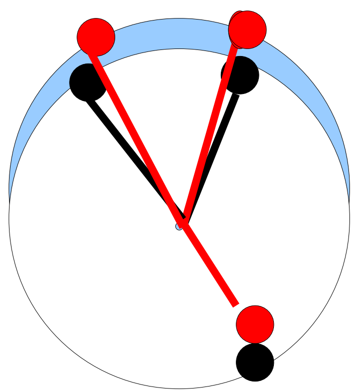
The problem is still there.

The bad momentum is not the reason for that.

2° possibility: in the MC there is a shift between the reconstructed position of the photons and the real centroid.

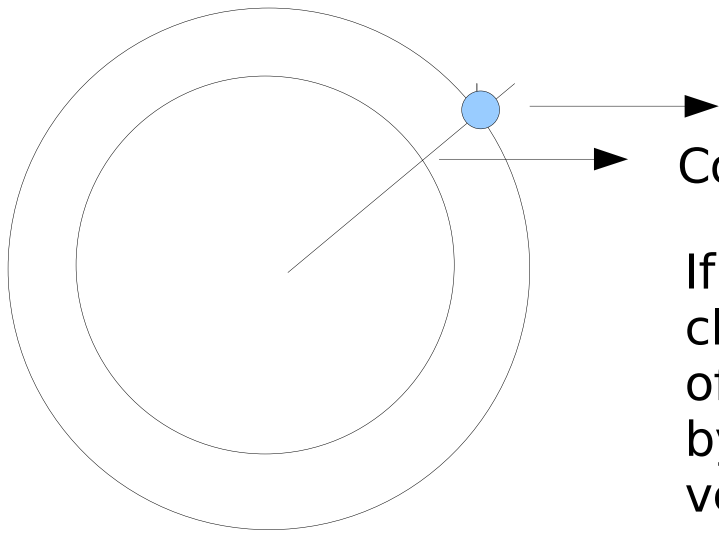


The angle between the photons change and also the estimated mass.

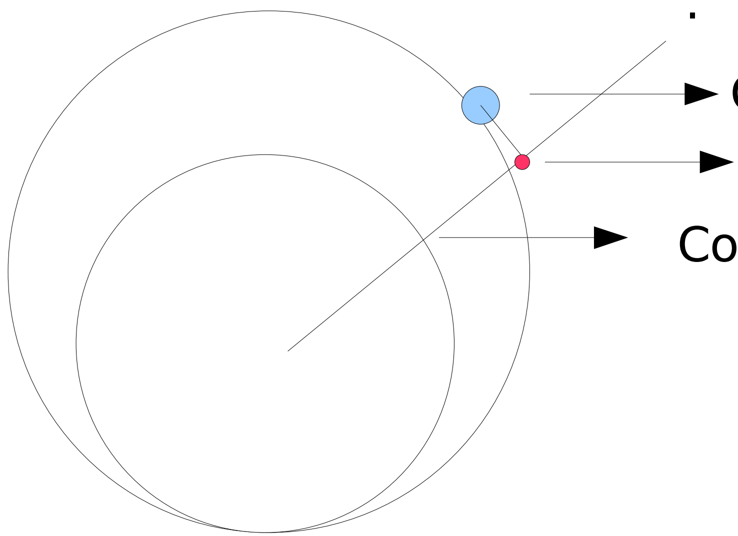


The reconstructed mass acquires a ϕ behaviour. This behaviour is systematic safe because it cancels out (the systematic due to a displacement in the vertex has been evaluated and it is by far negligible).

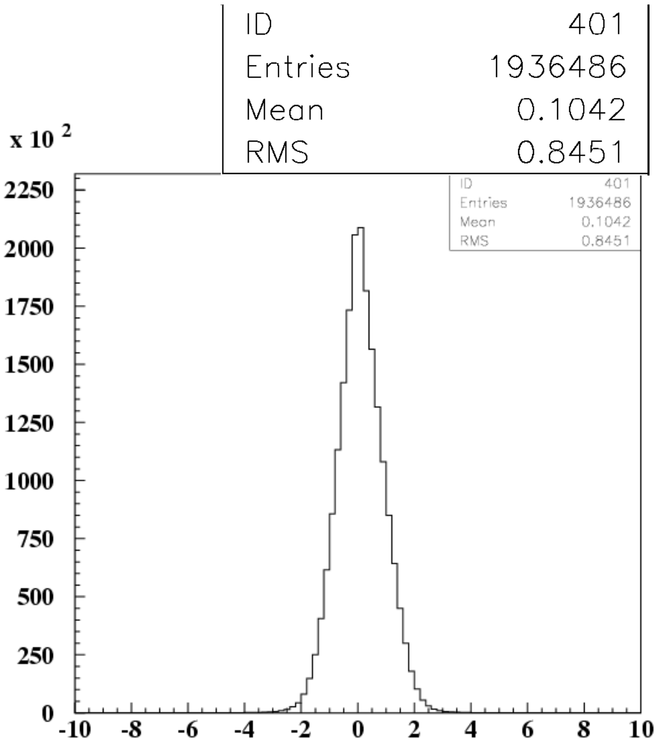
How can we check it?
We have the position of the first convertion point in the calorimeter.



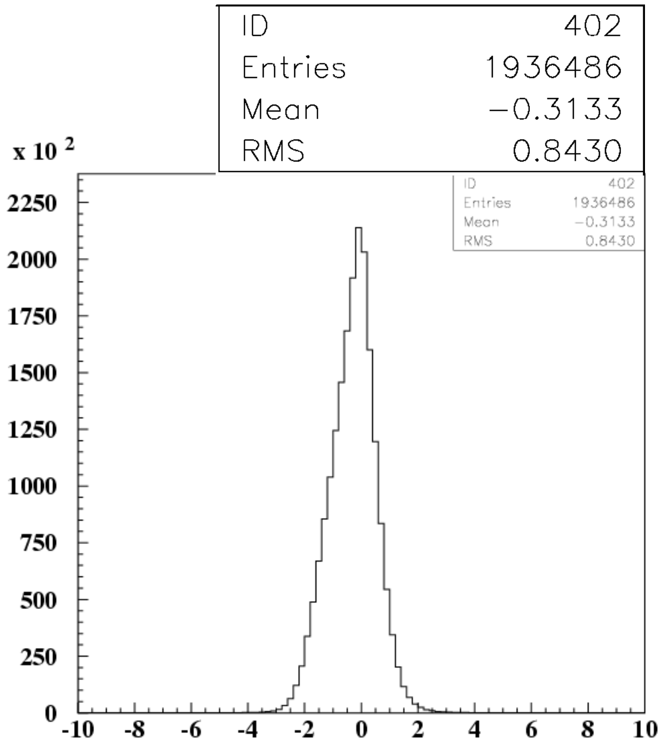
If everything is aligned the cluster has to be on the line of flight of the photons, given by the straight line from the vertex to the conversion point
.



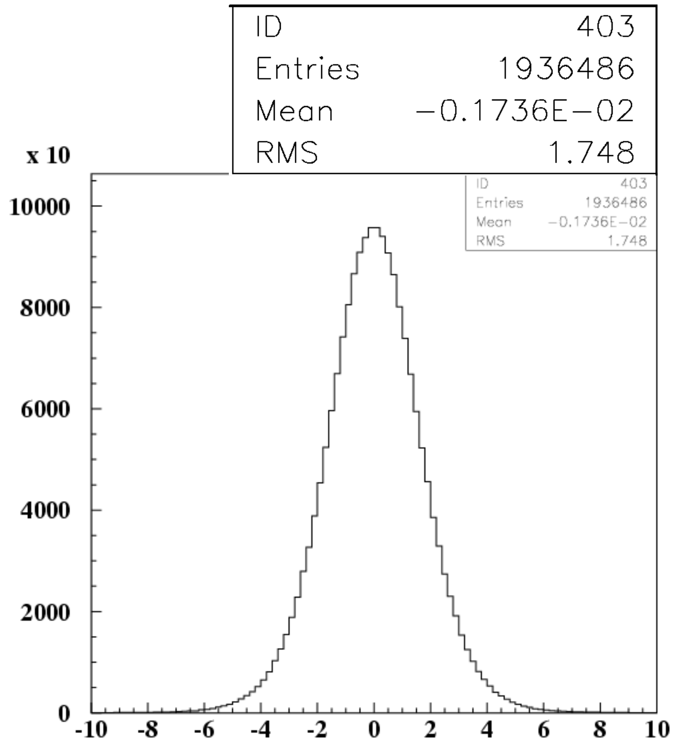
We can check the alignment by plotting the variables $x_{clu} - x_{proj}$, $y_{clu} - y_{proj}$, $z_{clu} - z_{proj}$



$x_{clu} - x_{proj}$ cm

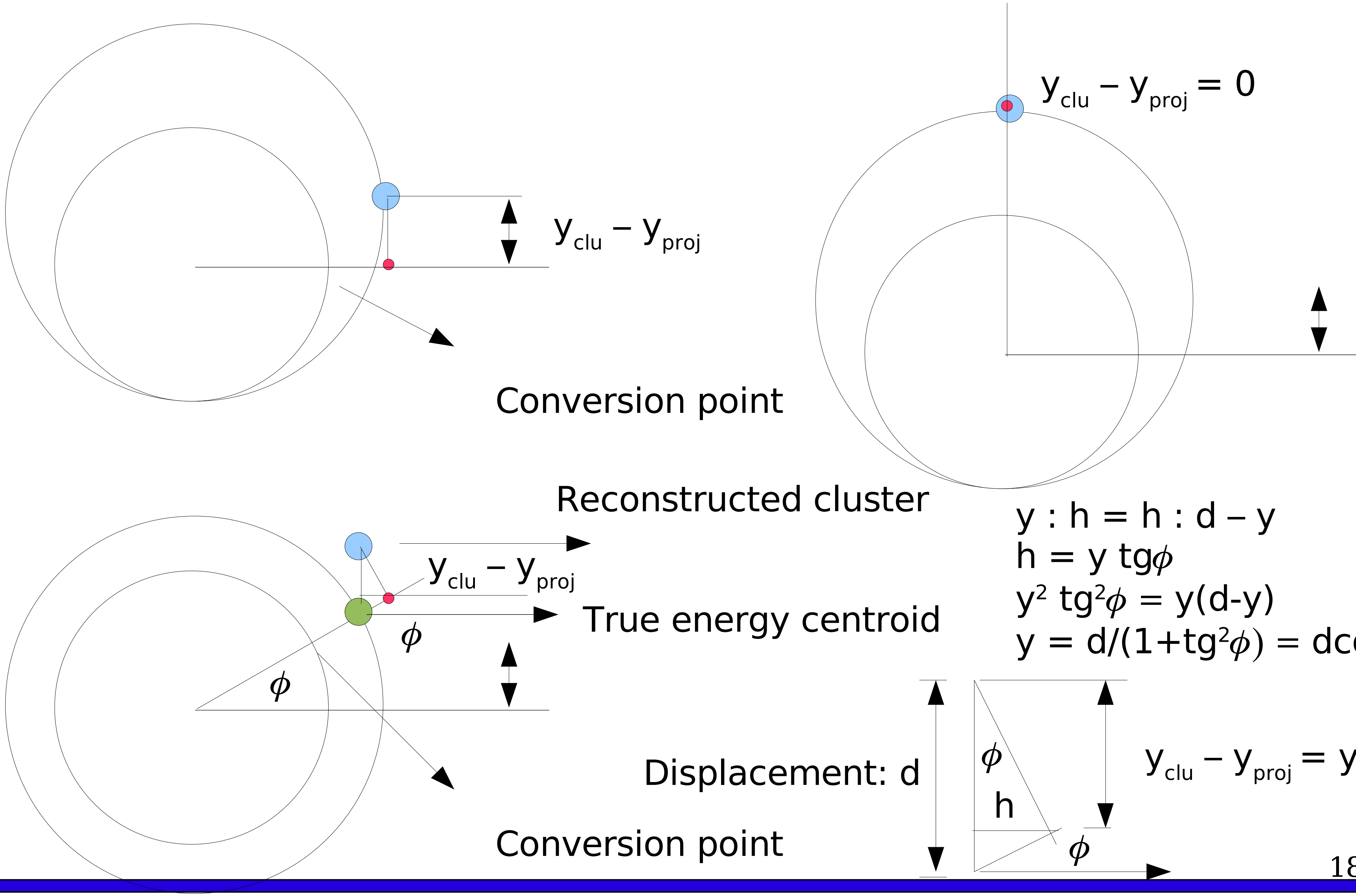


$y_{clu} - y_{proj}$, cm



$z_{clu} - z_{proj}$ cm

This is just the average value, what is the ϕ behaviour?



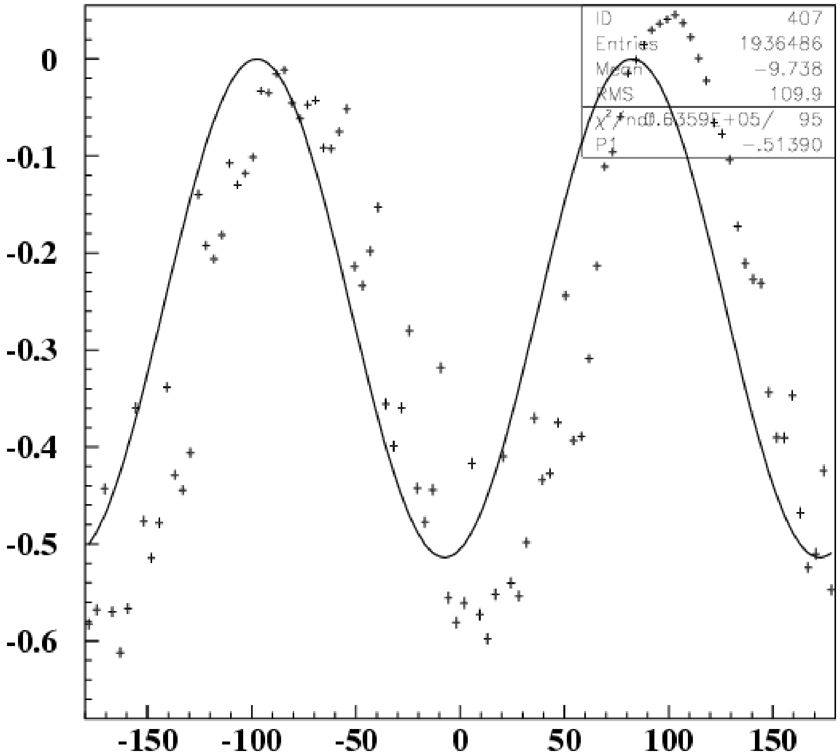
$y : h = h : d - y$

$h = y \, tg\phi$

$y^2 \, tg^2\phi = y(d-y)$

$y = d/(1+tg^2\phi) = d\cos^2\phi$

y

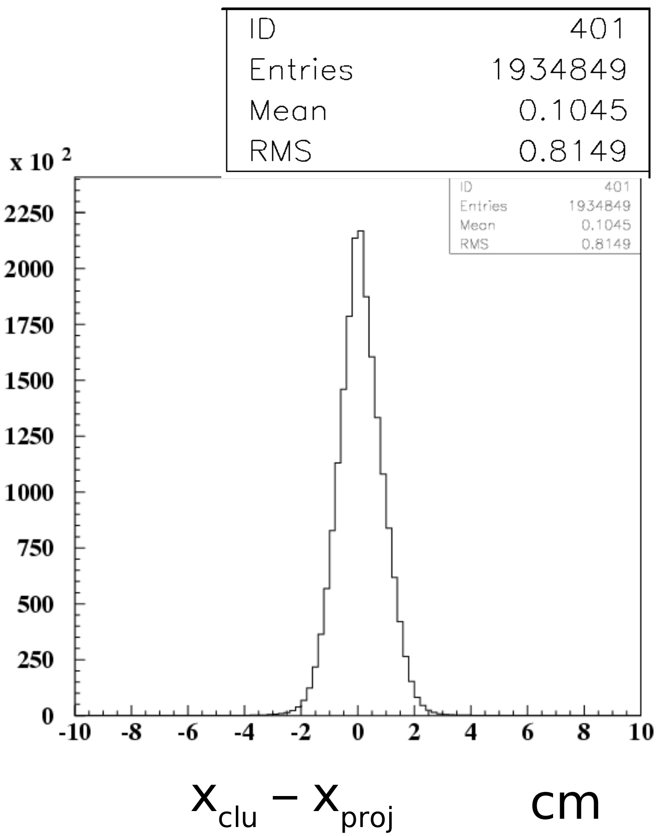


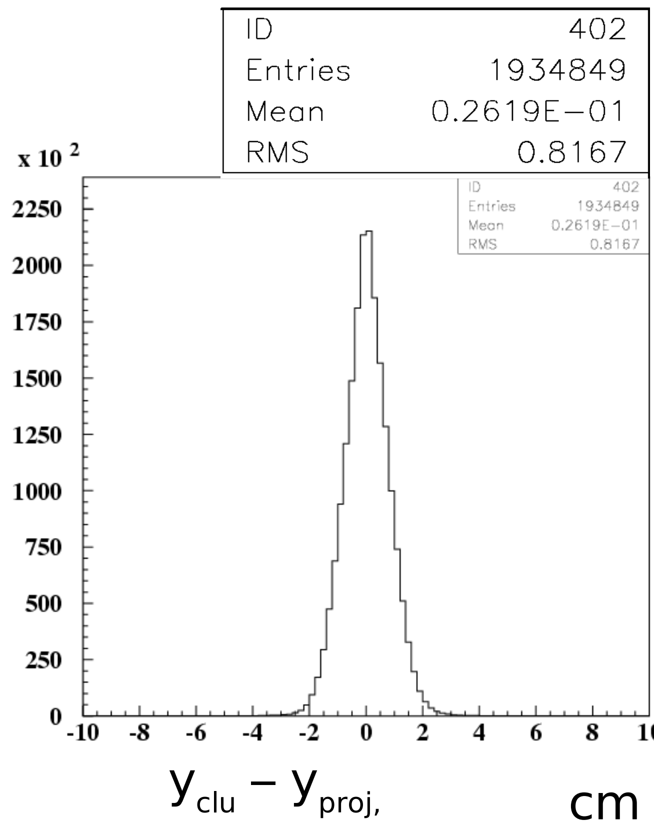
ϕ

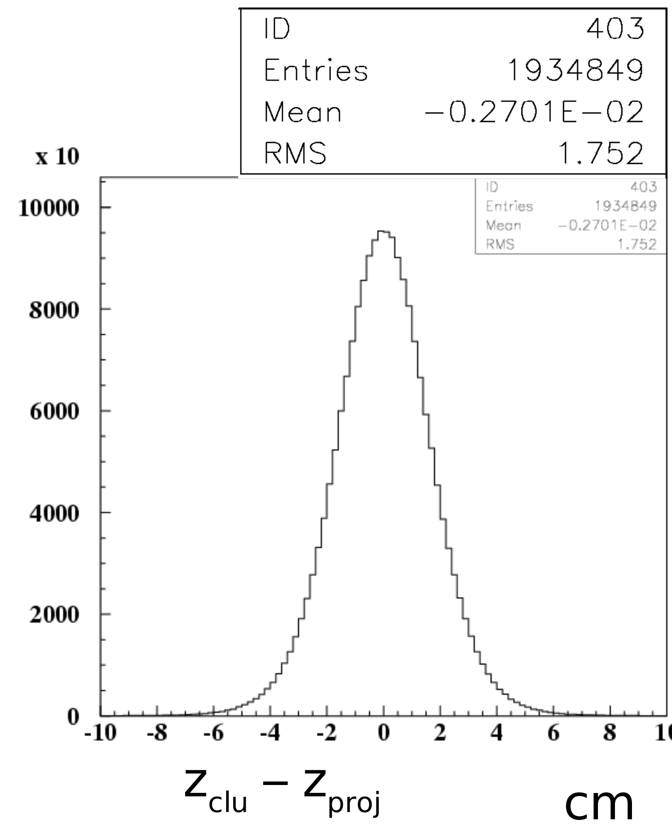
The main behaviour is reproduced, but it seems a bit shifted (x dispacement). Anyhow we find a displacement of about 5 mm between cluster position and true energy deposition.

We can apply this correction and rerun the machinery.

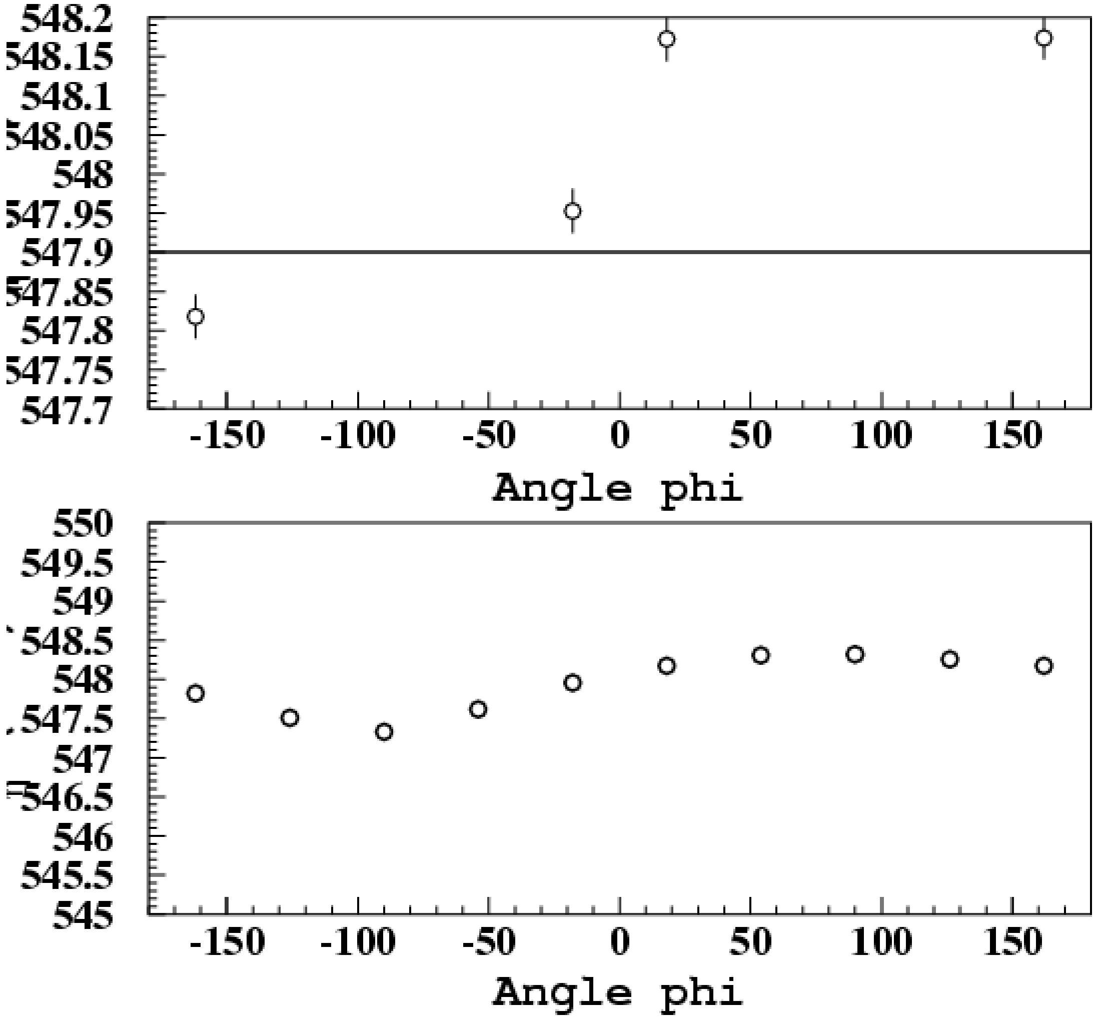
Distributions after the alignment in y.





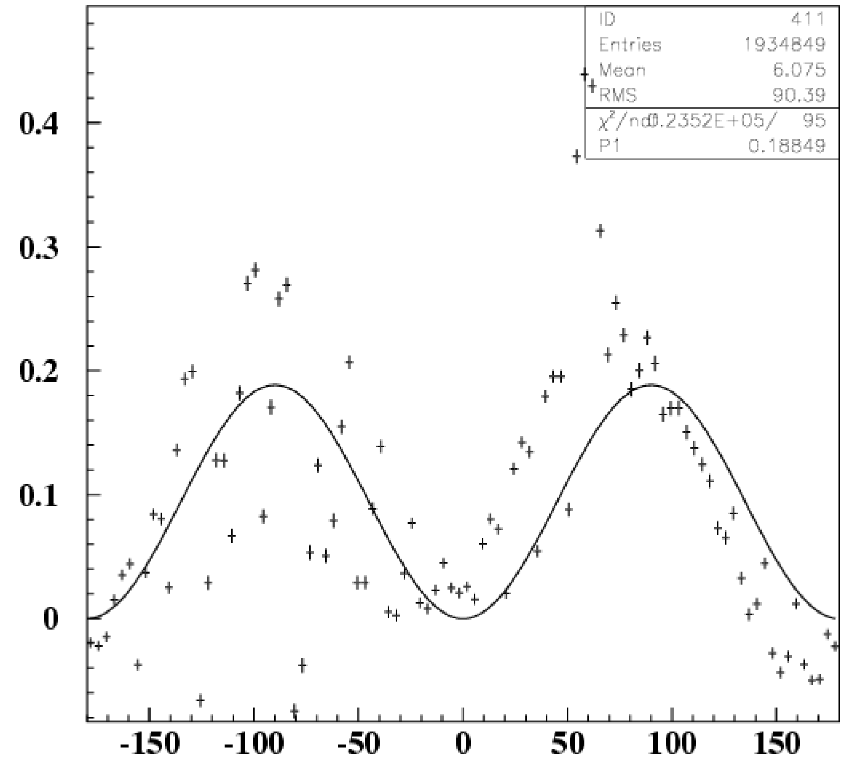


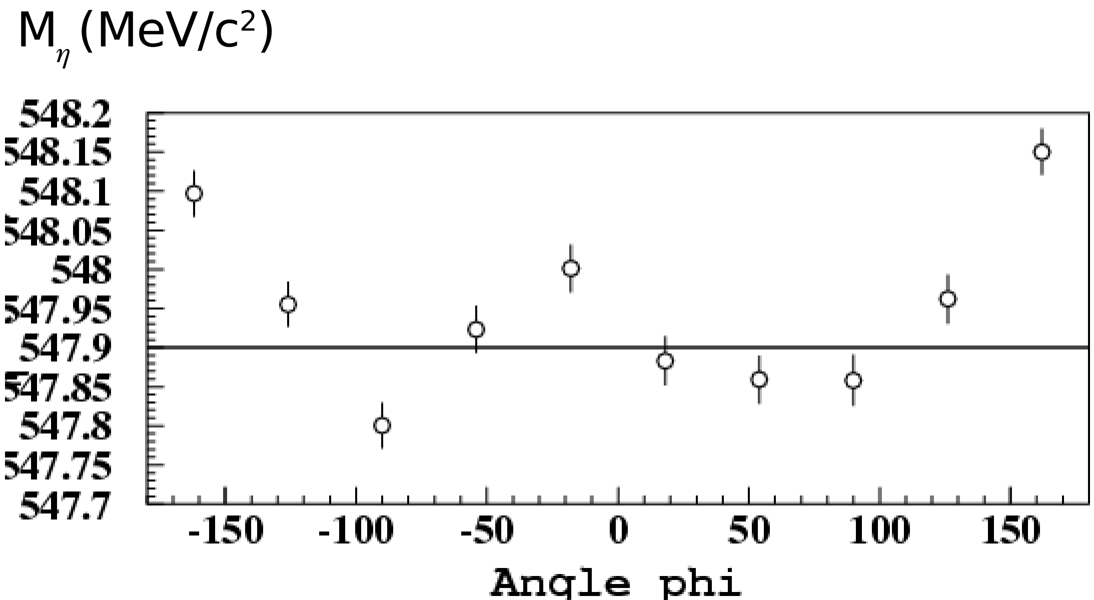
M_η (MeV/c²)



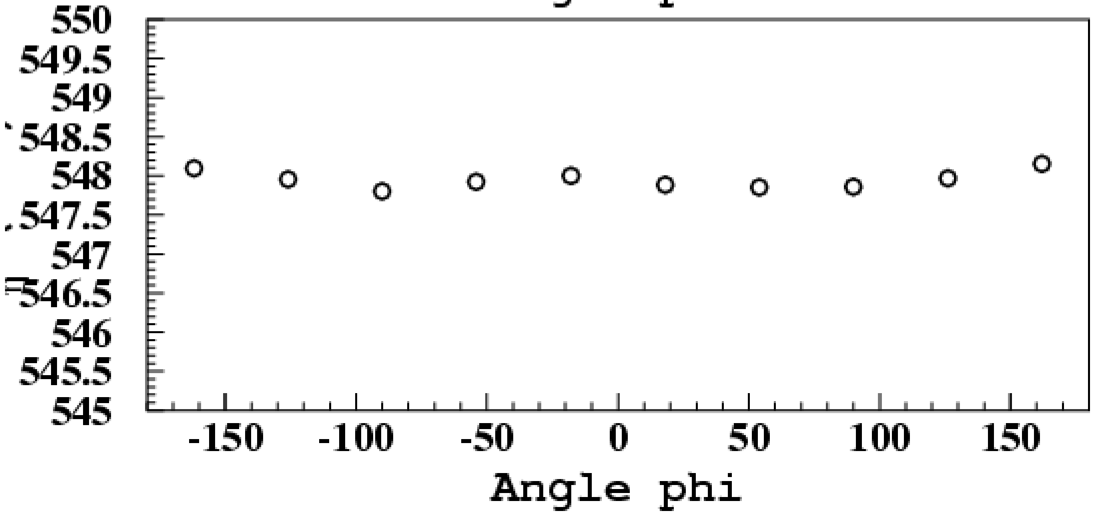
$x = d_x \sin^2\phi$

Δx

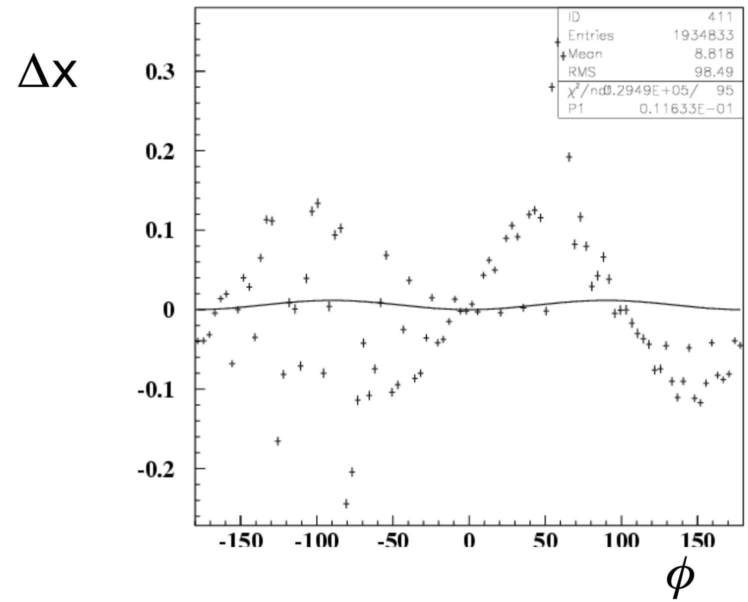




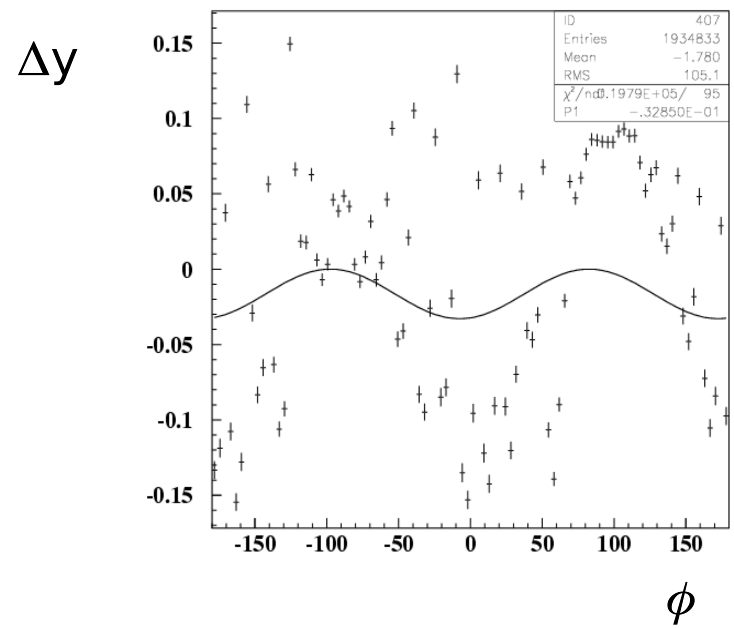
M_η (MeV/c²)
Angle phi



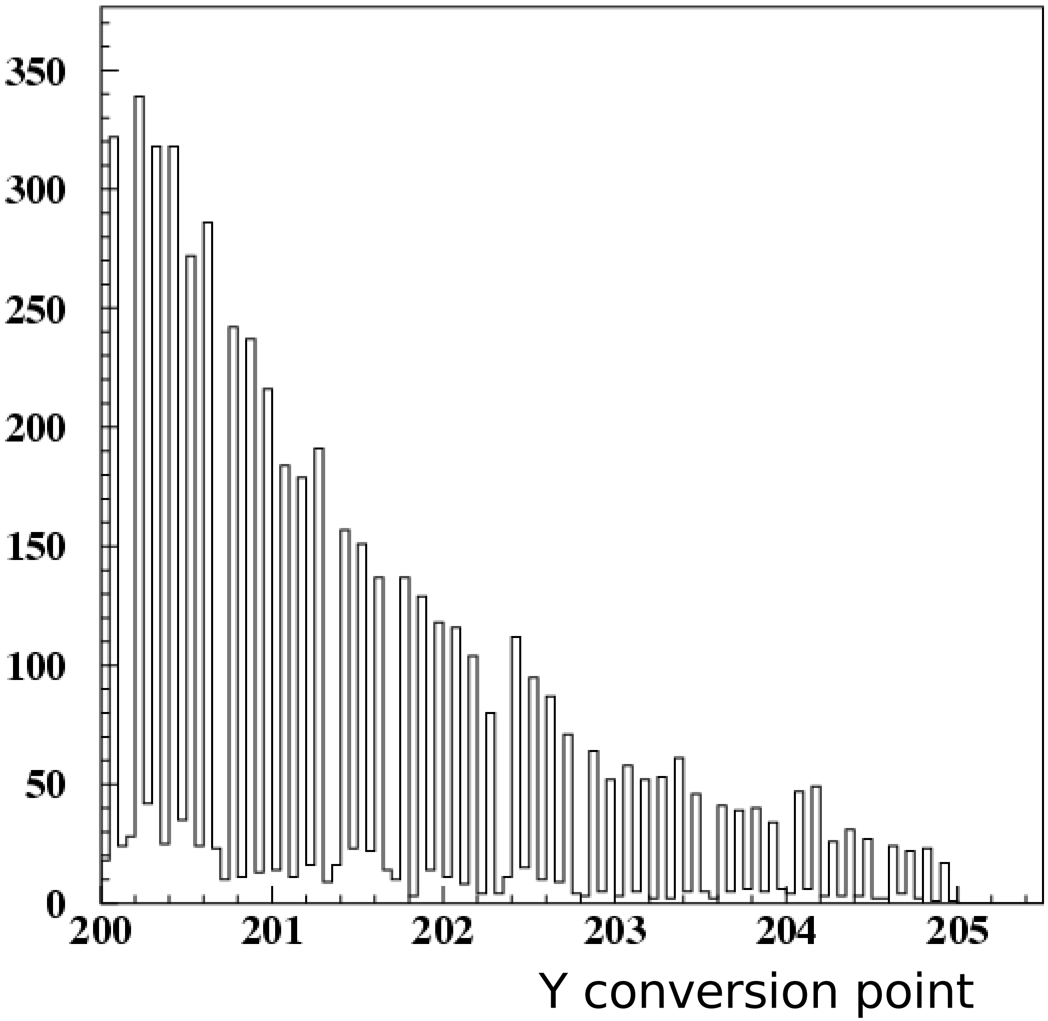
Angle phi



Δx
ID 411
Entries 1934833
Mean 8.818
RMS 98.49
χ²/ndf 0.2949E+05/ 95
P1 0.11633E-01
ϕ



Δy
ID 407
Entries 1934833
Mean -1.780
RMS 105.1
χ²/ndf 0.1979E+05/ 95
P1 -.32850E-01
ϕ



We cannot pretend so much at 1 mm level.

the MC suggest a correction of Δ_1 = 46 ± 10 keV

Nothing changes (a bit expected, we just applied global shifts...)

To understand if the problem is in the shower description or in the kinematic fit itself, we proceed in this way: from the truth we take xcv, ycv, zcv, tcv, ephot and then apply a smearing according known energy, time and position resolution:

$$\frac{\sigma E}{E}=\frac{0.057}{\sqrt{E\,GeV}} \qquad \sigma_t=\sqrt{\frac{(54\,ps)^2}{E(GeV)}+(50\,ps)^2} \qquad \sigma_z=\frac{1\,cm}{\sqrt{E(GeV)}}$$

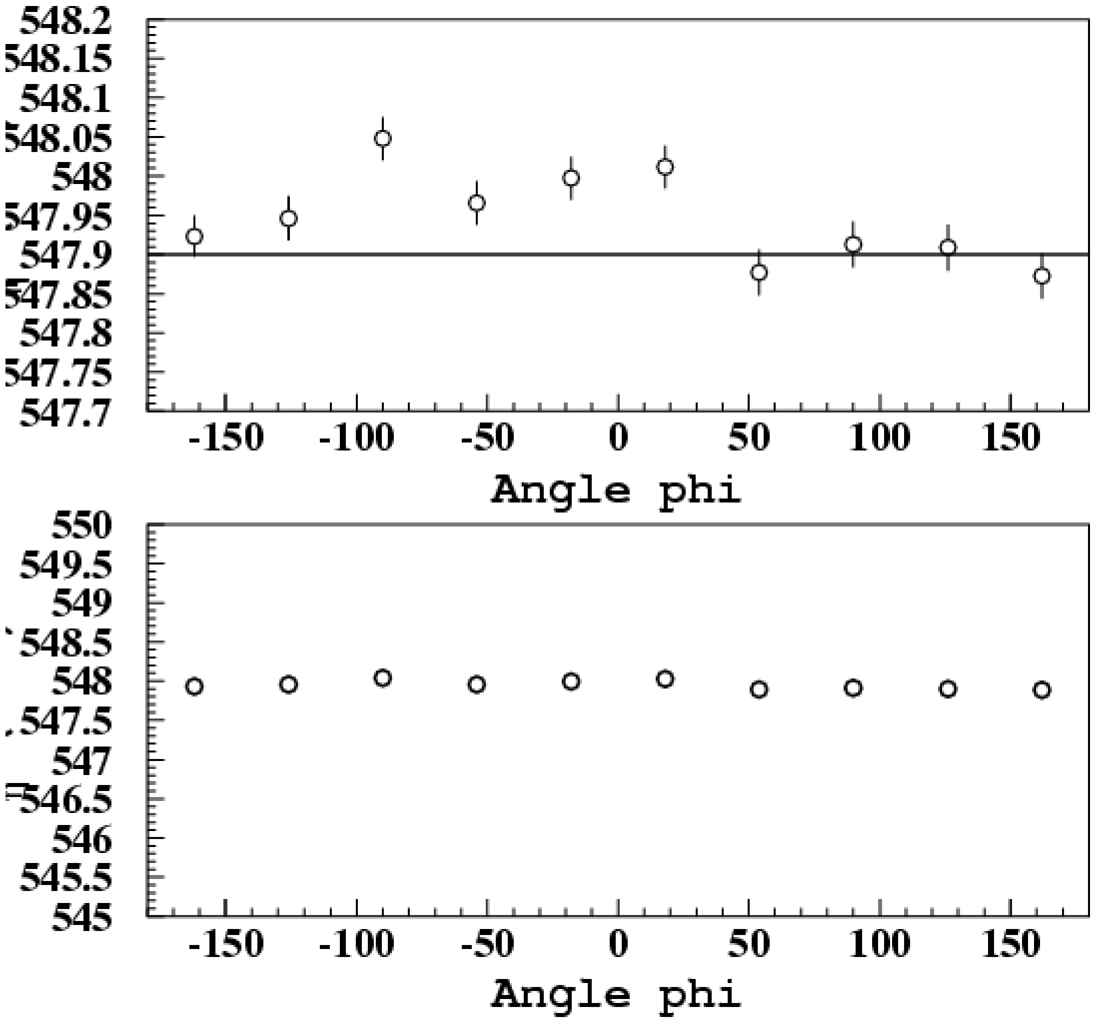
$$\sigma_x=\sigma_y=2.81\frac{cm}{\sqrt{12}}$$

Tuned to obtain σm_η MC = σm_η DATA = 2.14 MeV/c²

Using 4.4/sqrt(12) we obtain 3 MeV/c²

Again we obtain as correction: 57 ± 10 keV to compare with 52 keV of the global correction (in this case the correction due to the Dalitz is the same for data and mc)

M_η (MeV/c^2)

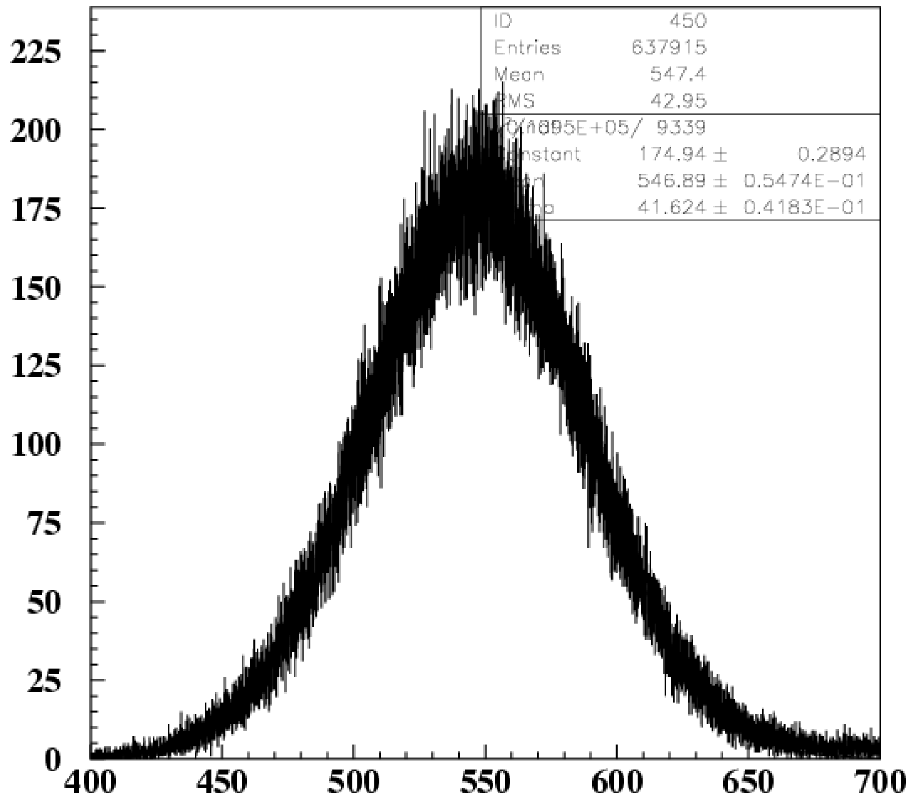


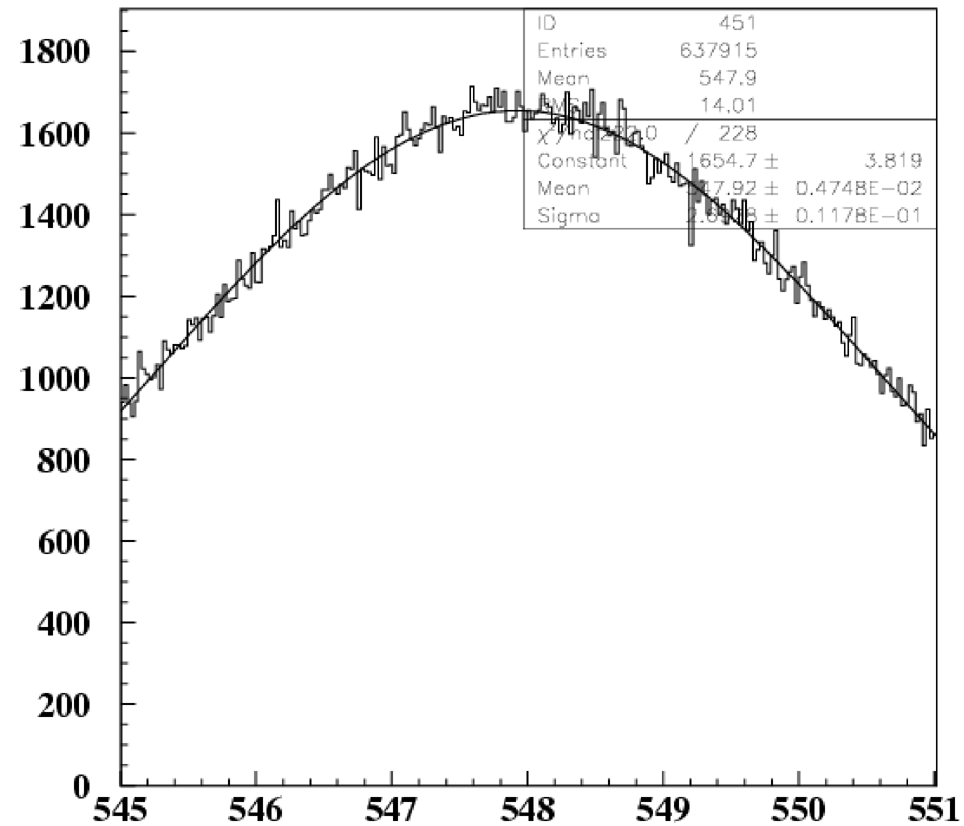
548.2
548.15
548.1
548.05
548
547.95
547.9
547.85
547.8
547.75
547.7
-150
-100
-50
0
50
100
150
Angle phi
550
549.5
549
548.5
548
547.5
547
546.5
546
545.5
545
-150
-100
-50
0
50
100
150
Angle phi

A further investigation

Invariant mass before kinematic fit
1 MeV shift.

Invariant mass after kinematic fit
20 keV shift.



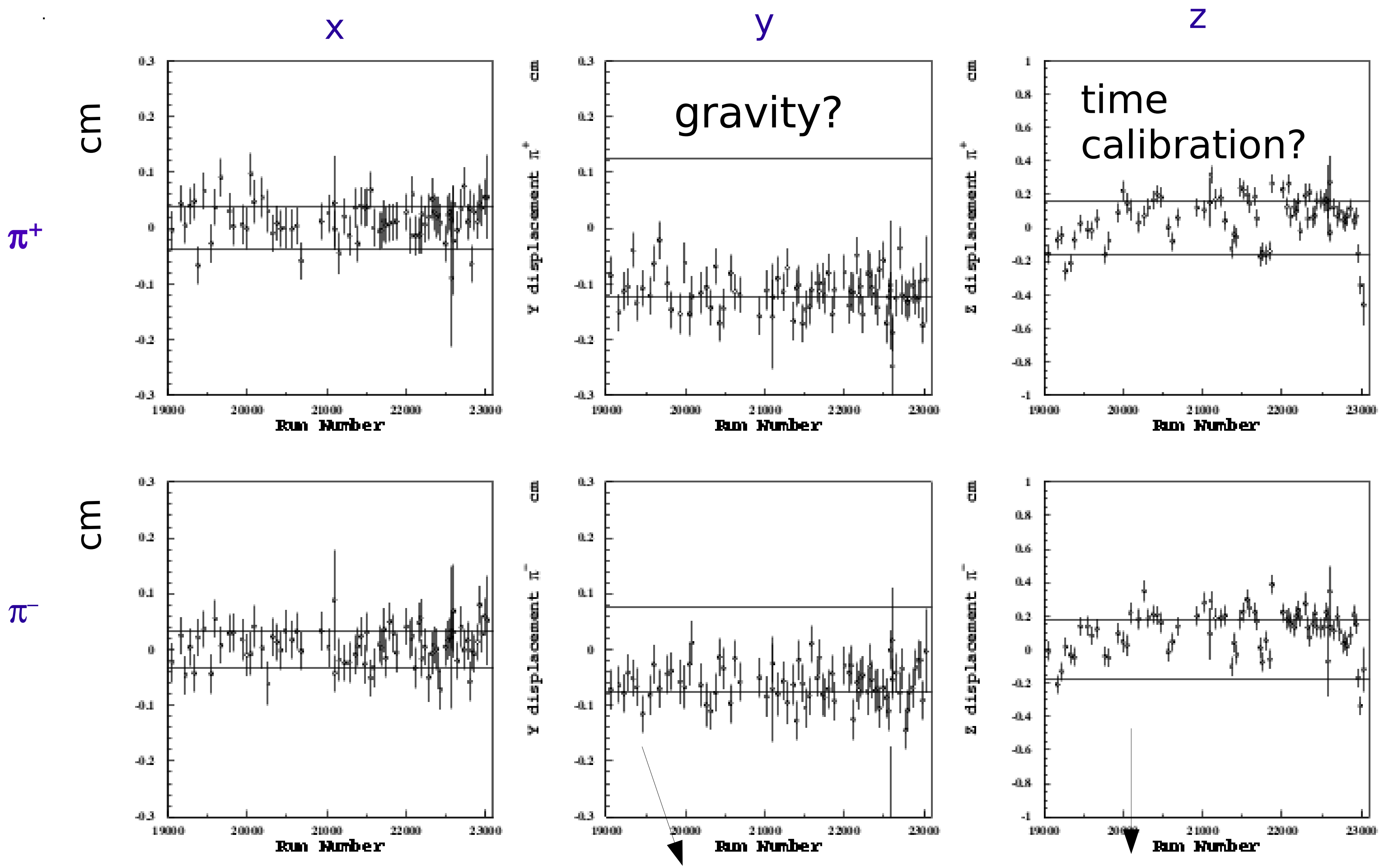


The invariant mass is built using the photons from the η without requiring any cut or selection.

- The MC correction besides the several discrepancy we have found, is still the same (the isotropy of the configuration dumps down a lot all these effects, this correction has to be mainly assigned to the procedure itself (the invariant mass is a non linear combination of the measured quantities so small – predictable deviation have to be expected).

- The correction is well understood, it is confirmed also in the dummy smearing approach, that means it has not to be assigned to MC reconstruction simulation problem.

- My statement is, **let's apply this correction and get ½ of it as systematic error** (difficult to understand how well MC is able to predict the distortion).



the emc is 1 mm down.

fluctuation probably due to the time cal.