Status of the η mass measurement.

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Outline

- world status;
- method;
- selection;
- fits;
- Dalitz cut;
- vertex position systematic;
- linearity response (MC);
- conclusions

η mass present situation

Very good agreement

$M_\eta = (547.311 \pm 0.028 \pm 0.032)$ MeV/c^2

Reaction used: p + d ^{3}He + η

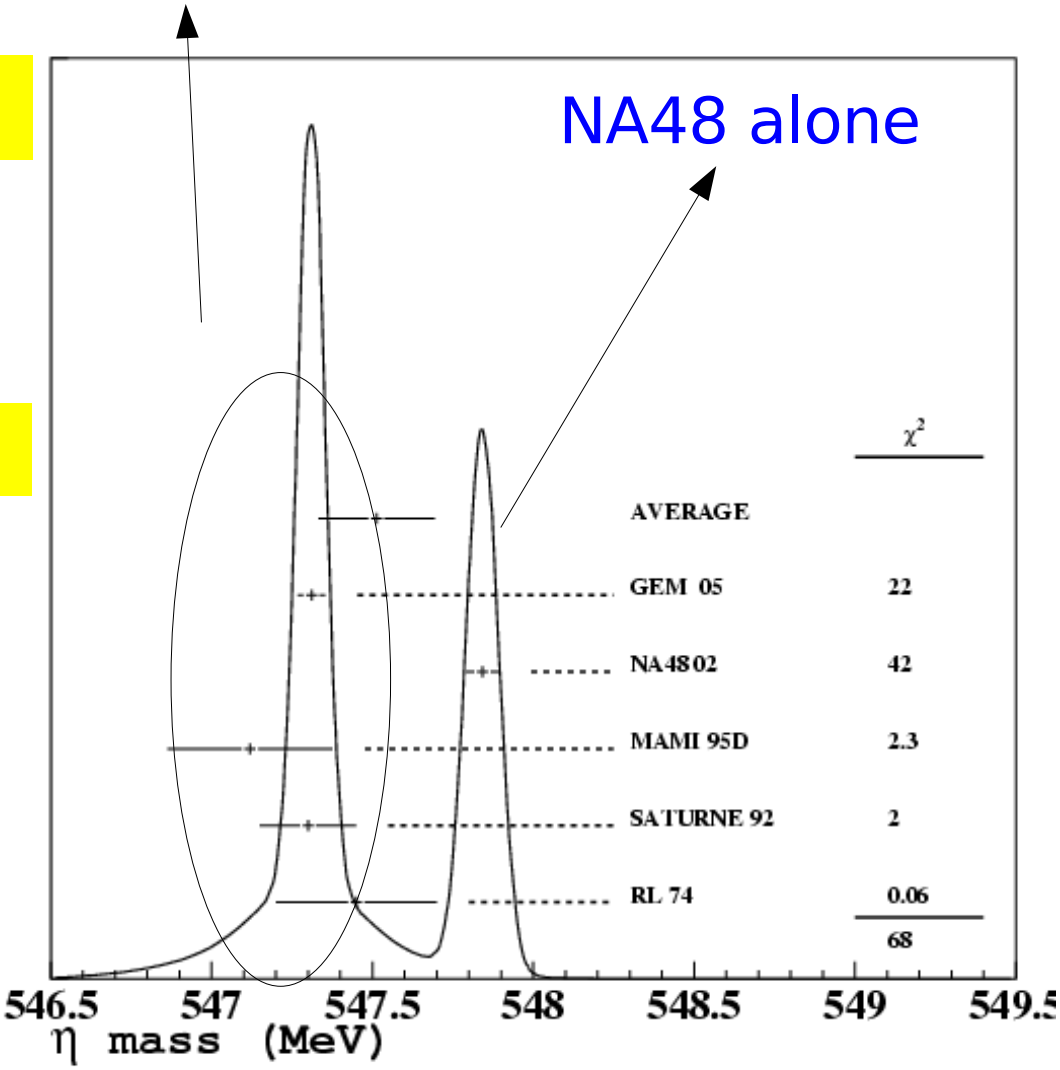
High discrepancy with NA48!

Using η $3\pi^0$ from $\pi^- + p$ η + n :

$M_\eta = (547.843 \pm 0.030 \pm 0.041)$ MeV/c^2

[A, Lai et al., Phys. Lett. B 533 (2002) 196]

New experiments are measuring again the mass:
MAMI with Crystall Ball, expected error 80 KeV



The η mass measurement, experimental techniques.

NA48

The measurement has been done using the $\eta \to 3\pi^0$, it has a small dependence from the absolute energy calibration of the calorimeter;
cross check with $\eta \to \gamma\gamma$ has been performed, very detailed systematic study;
The same method has been successfully applied to the $K_L \to 3\pi^0$.

GEM

Missing mass technique in p + d → ^{3}He + η;
the spectrometer has been calibrated using other 2 reactions. The working point of the apparatus has been changed after the calibration (linear response has been assumed). It was not possible to perform any cross-checks.

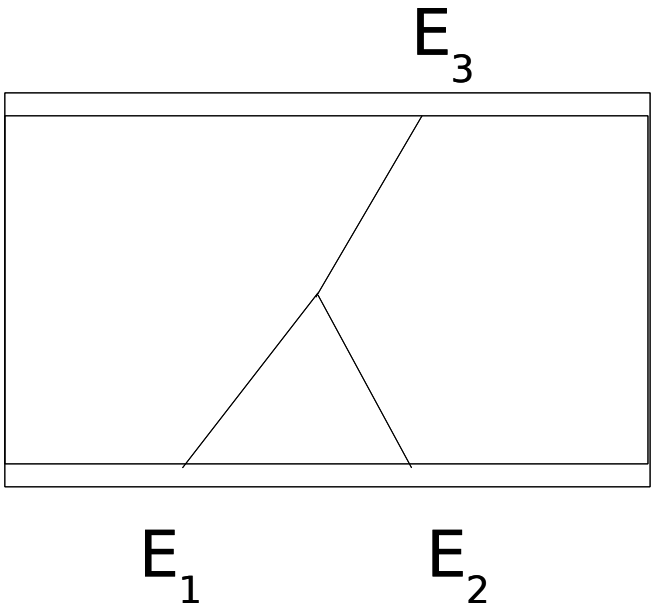
MAMI

Missing mass technique in γ + p → p + η;
Determination of the reaction threshold by counting the number of reaction as a function of the γ energy.

The method.

$\phi \rightarrow \eta, \pi^0 \ \gamma$

$\gamma\gamma$



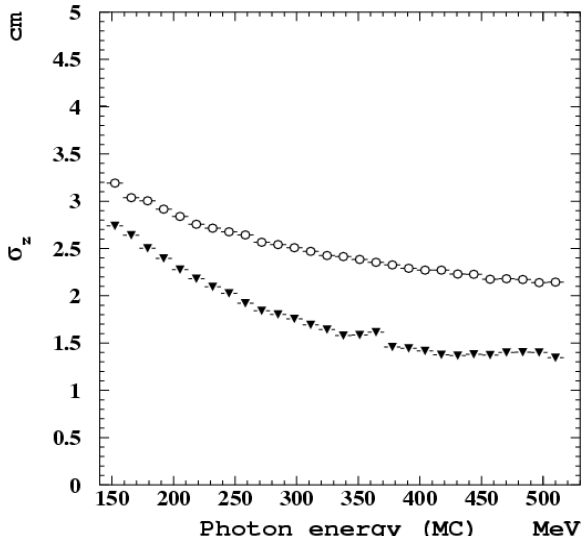
A kinematic fit is performed using the cluster times, energies and positions.

Kinematic fit constraints:

Px,Py,Pz,Etot → constrain the energies to the cluster positions.

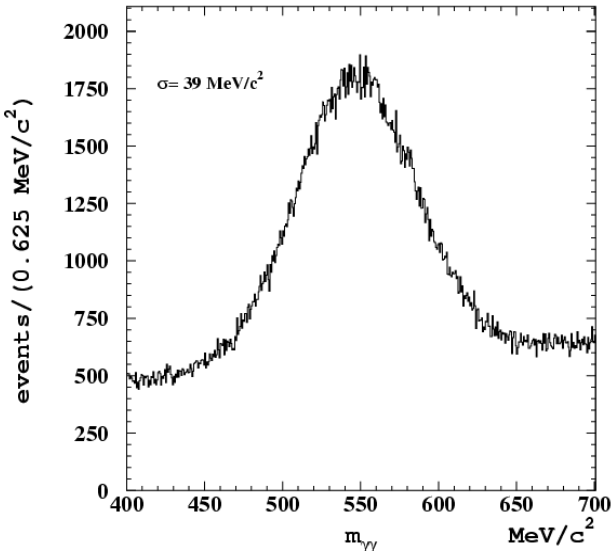
t-r/c of clusters → Improve z resolution.

z resolution improvement (MC study)

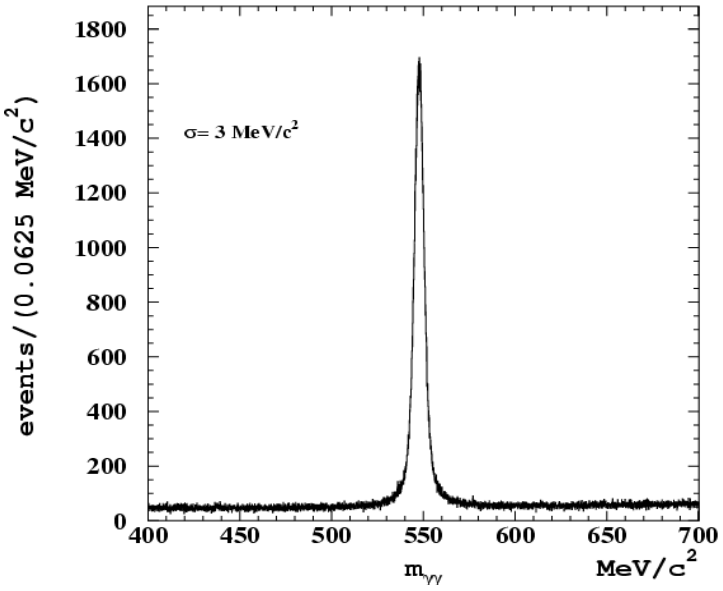


MC RAD04
3γ sample

Obtained comparing the cluster position with the extrapolated photon from the I.P. using the kine direction of the photons.



without fit



with fit

Selection

We are looking for events with 3γ in the final state.

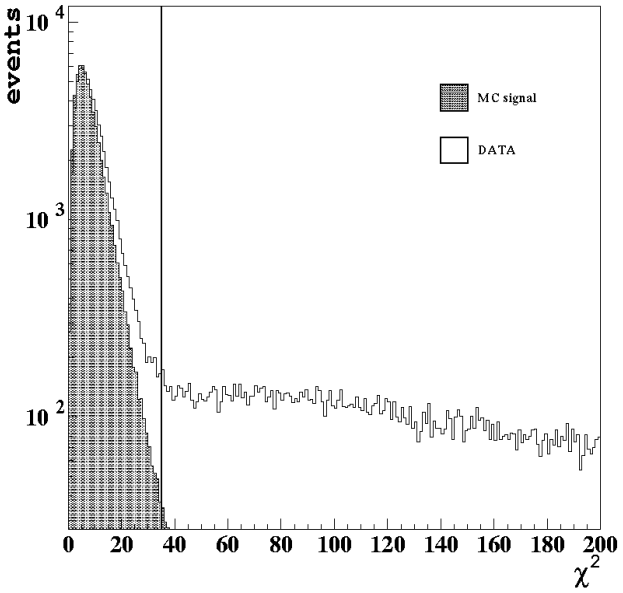
Requirements

- At least 3 clusters in the barrel such that:
  - $50^o < \theta < 150^o$
  - $|t - r/c| < \min(5\sigma_t, 2\ ns)$
  - No association with any charged track found by the "track to cluster" algorithm;

n number of clusters

$\binom{n}{3}$ combinations $\longrightarrow \sum_{i=1}^{3} E_i > 650\ MeV \longrightarrow$ kinematic fit: chose the combination with the smallest χ^2

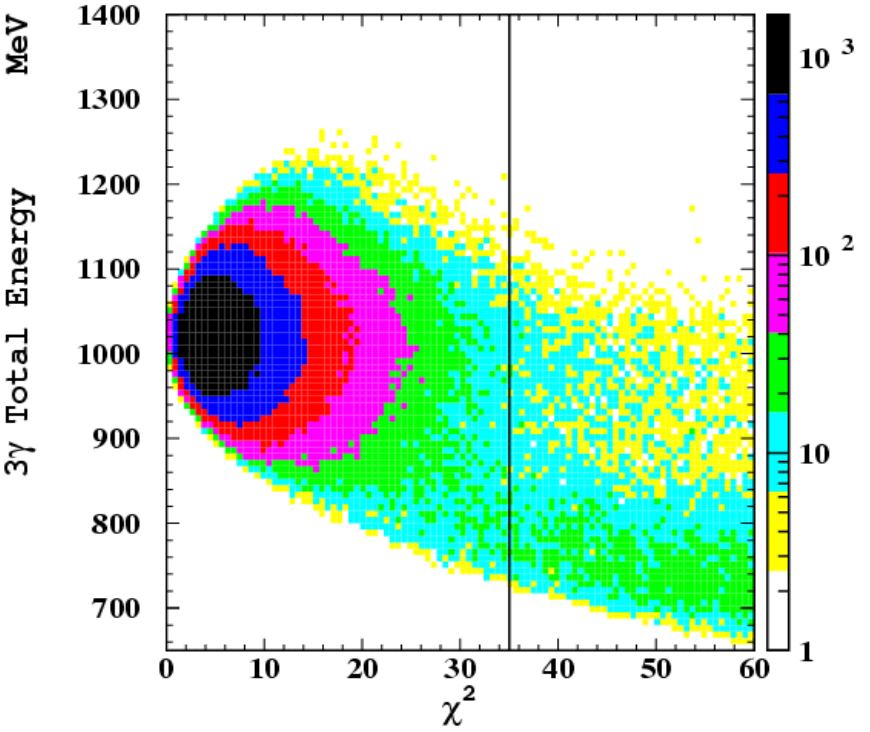
The χ^2 and the energy cut



$\chi^2 < 35$

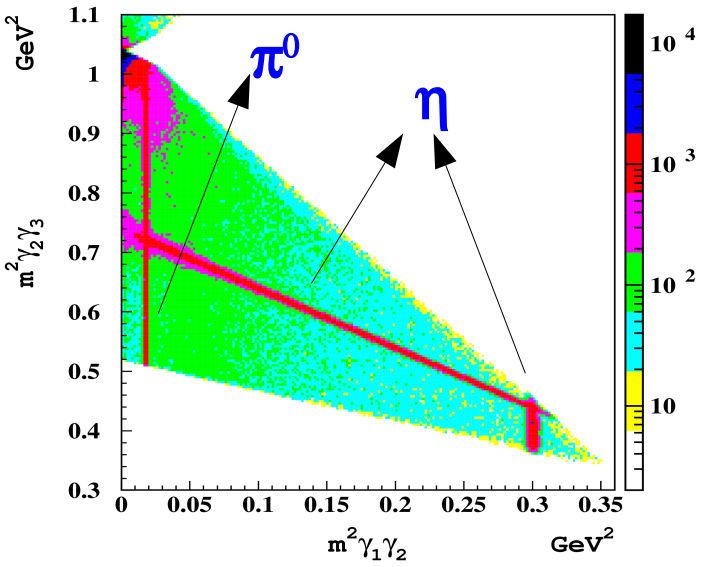
normalized at the peak

With the the chosen cut on χ^2, the total energy cut doesn't have any effect.

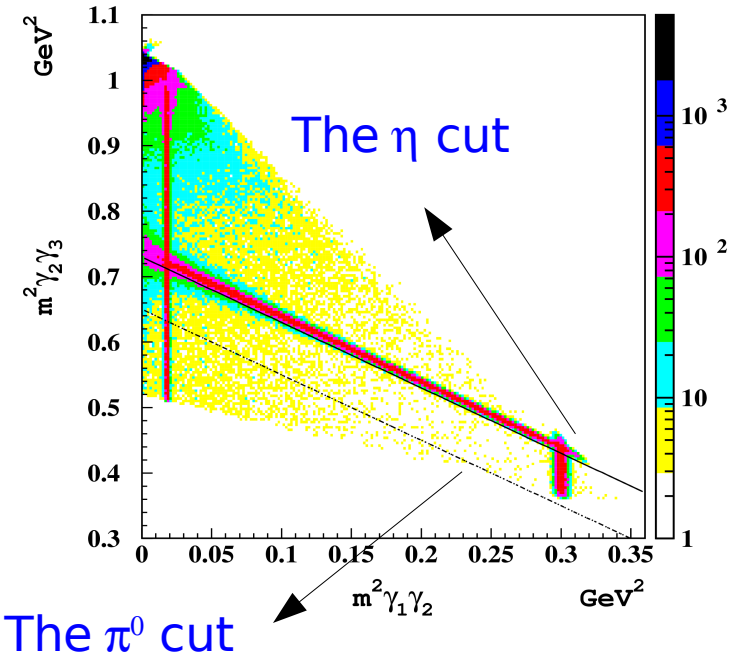


Dalitz plot of the 3γ

It's convenient to use a Dalitz plot of the 3γ, ordering the photons according their energy $E_1 < E_2 < E_3$.

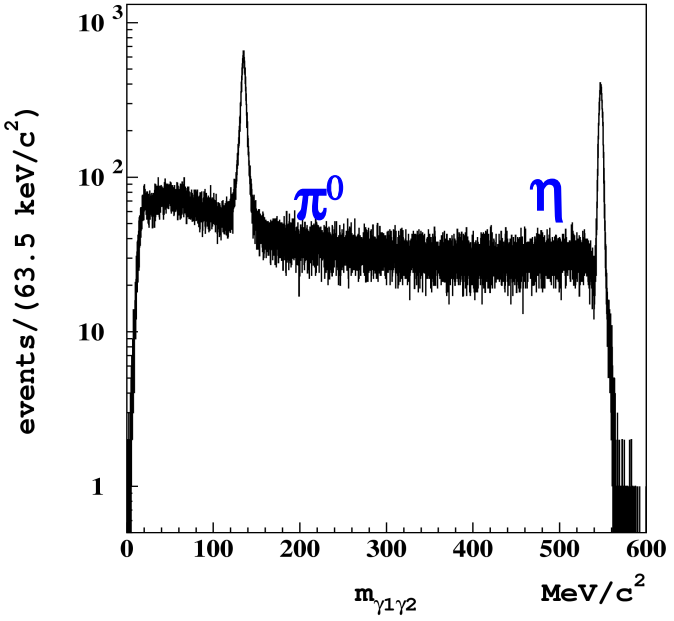


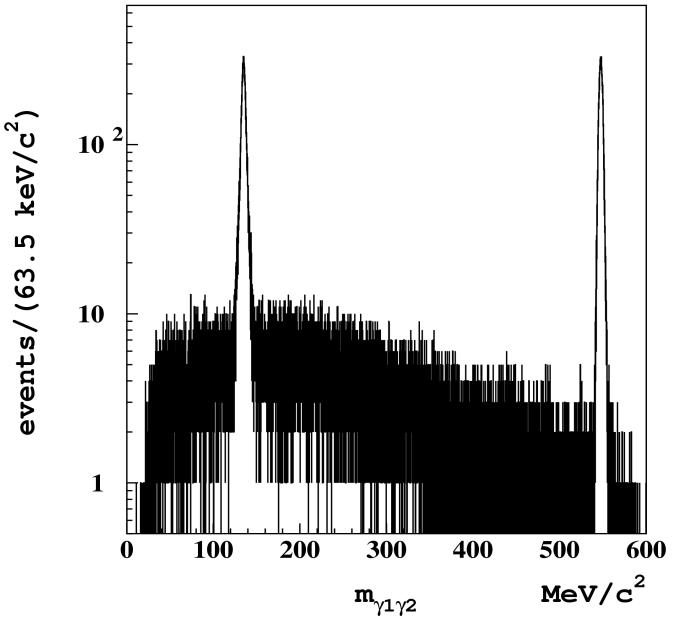
$\chi^2 < 35$



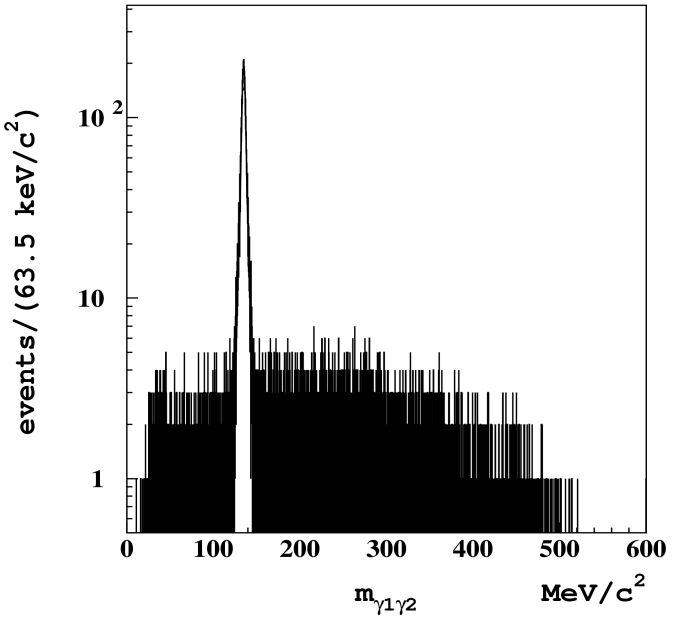
It is important to reduce the background under the peaks because the background shape uncertainity can spoil the precision of the measurement.

Mass distribution





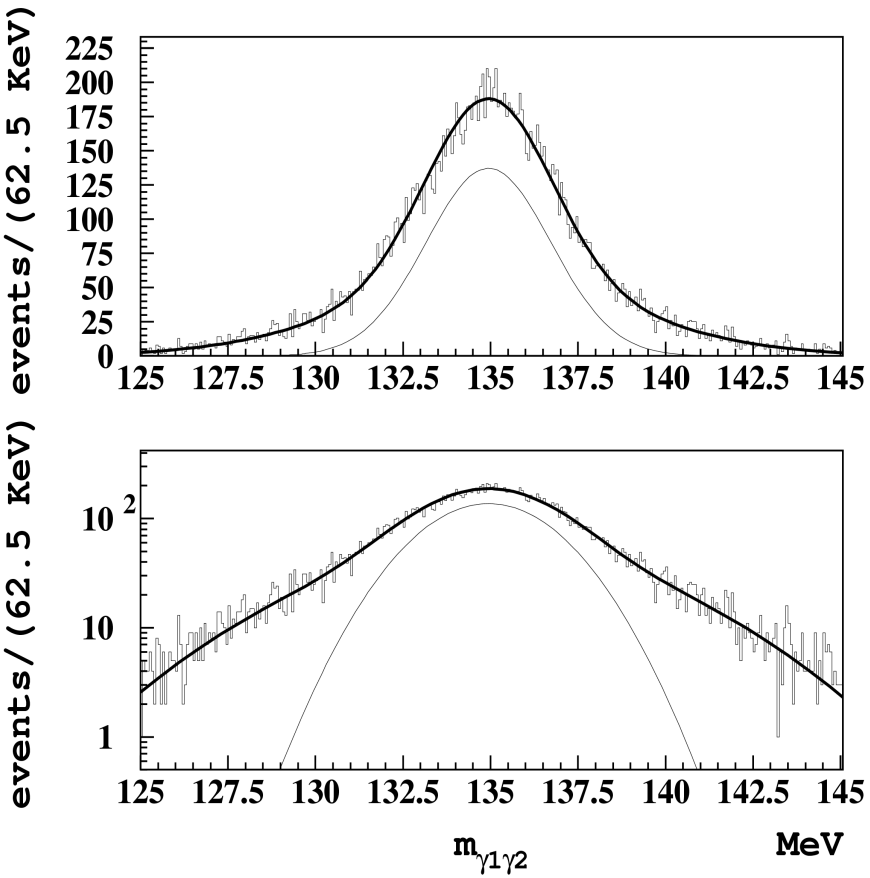
$\eta\gamma$ selection.



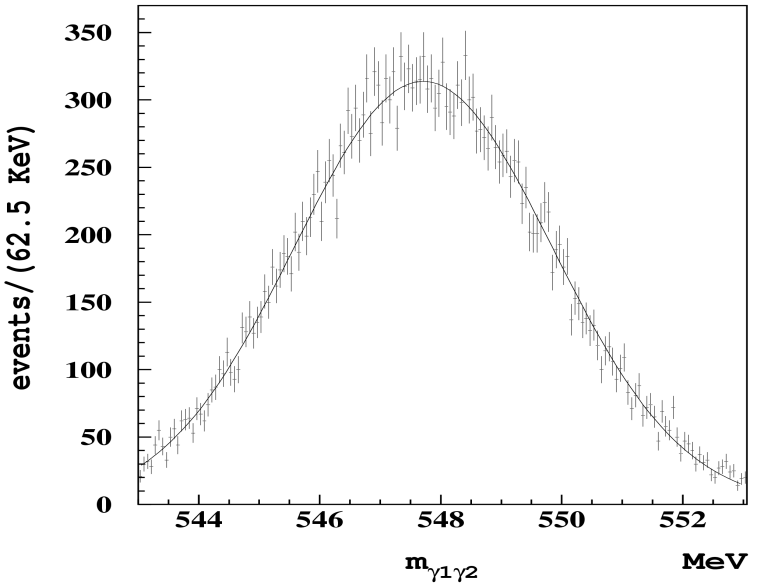
$\pi^0\gamma$ selection.

Fit

DATA 50 pb^{-1}



single gaussian



χ^2 = 0.98 Prob = 57%

σ = 2.14 MeV, σ_{mean} 14 keV

two gaussians with the same mean.

χ^2 = 1.01 Prob = 43%

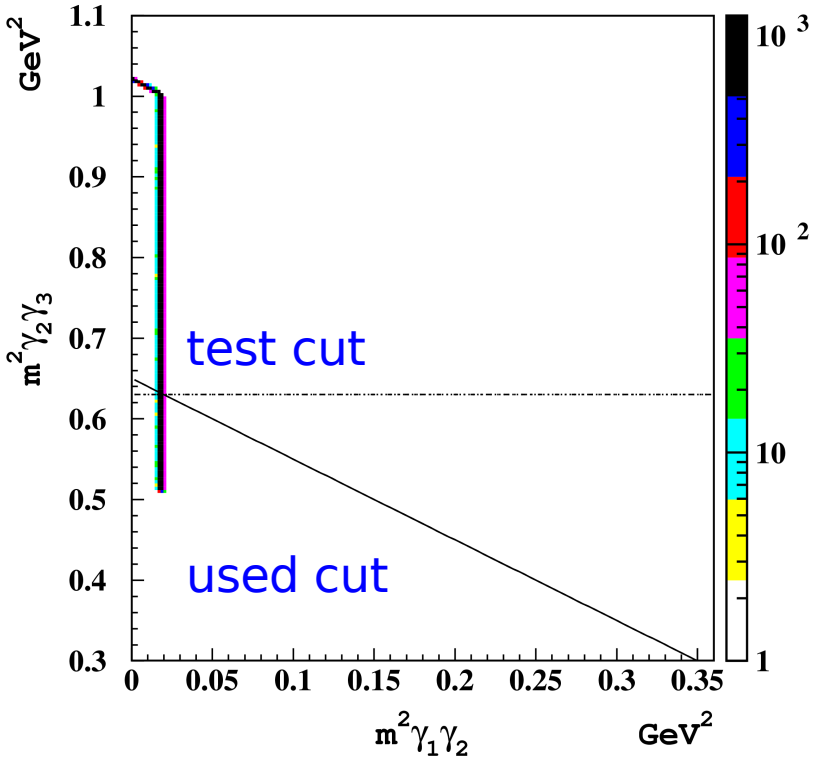
σ_{core} = 1.78 MeV, σ_{broad} = 4 MeV

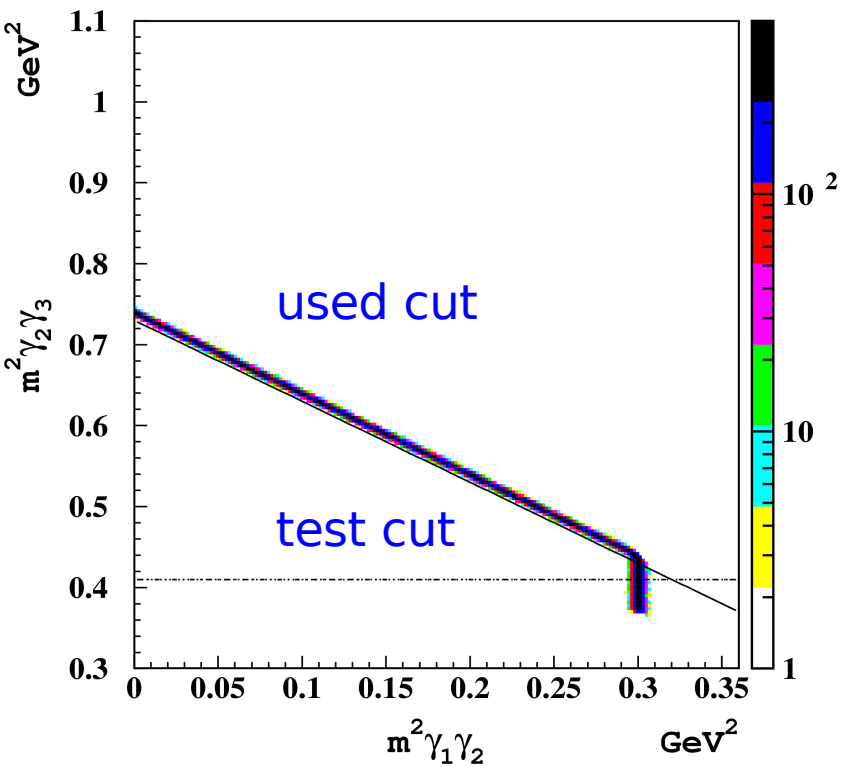
σ_{mean} = 21 keV

Why this cut choice?

The cut in the Dalitz plot, if not well chosen can produce significant shifts on the value of the measured mass.

To study the effect we generate with a toy montecarlo events $\phi \to \pi^0 \gamma$, and $\phi \to \eta\gamma$. The mass values are generated with a gaussian shape.





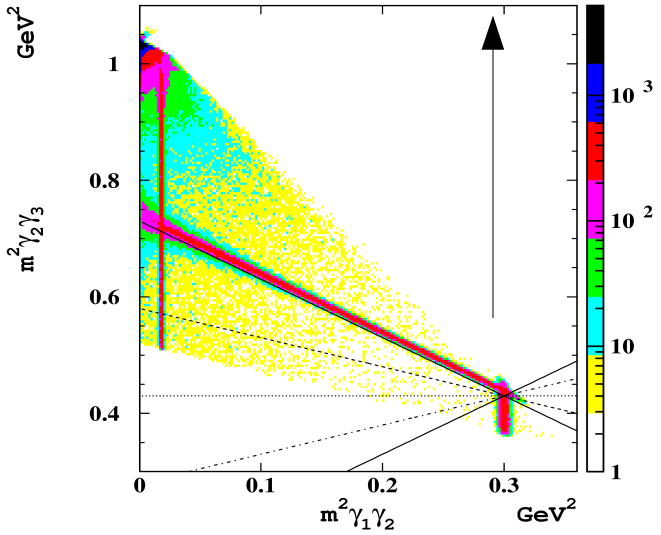
Mass shifts

		input	used cut	test cut
π^0	mass	134.930	134.937 ± 0.012	134.959 ± 0.012
	σ	3.0	2.962 ± 0.008	2.960 ± 0.008
η	mass	547.780	547.777 ± 0.016	547.856 ± 0.019
	σ	2.0	1.941 ± 0.012	134.94 ± 0.016

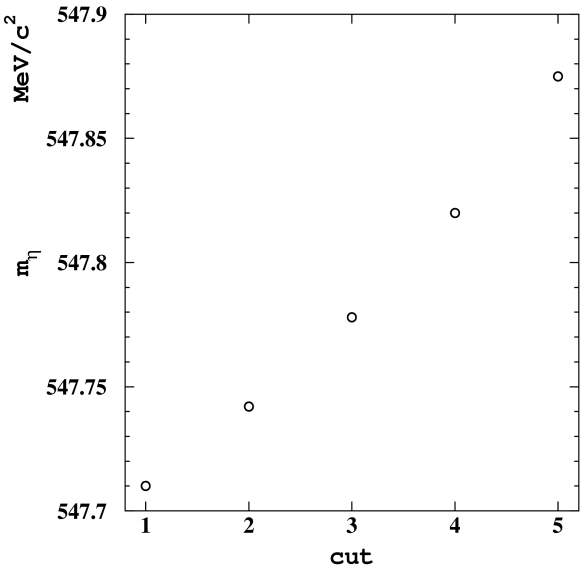
Systematic due to this cut has to be avaluated by correcting with the montecarlo the value of the mass and checking the stability.

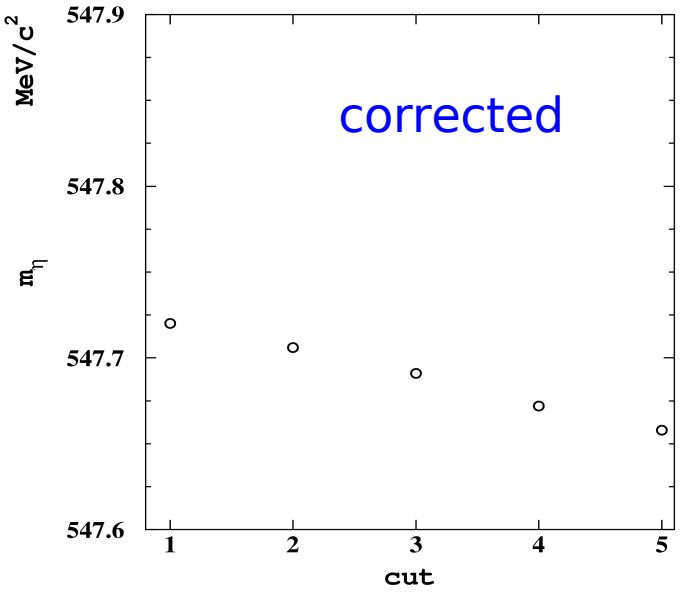
Dalitz cut systematic evaluation

different cut choices



cut	MC(547.3)	DATA	DATA corr
0.73-x	547.290	547.710	547.720
0.58-0.5x	547.336	547.742	547.706
0.43	547.387	547.778	547.691
0.28+0.5x	547.448	547.820	547.672
0.13+x	547.520	547.875	547.658

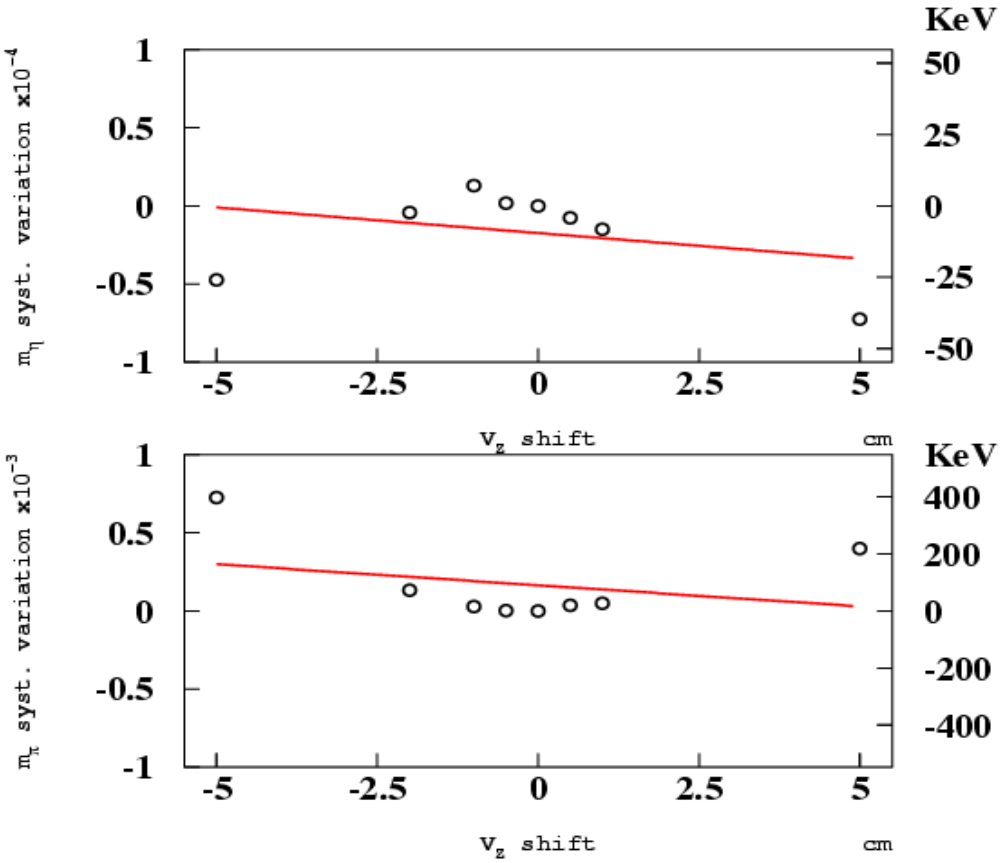




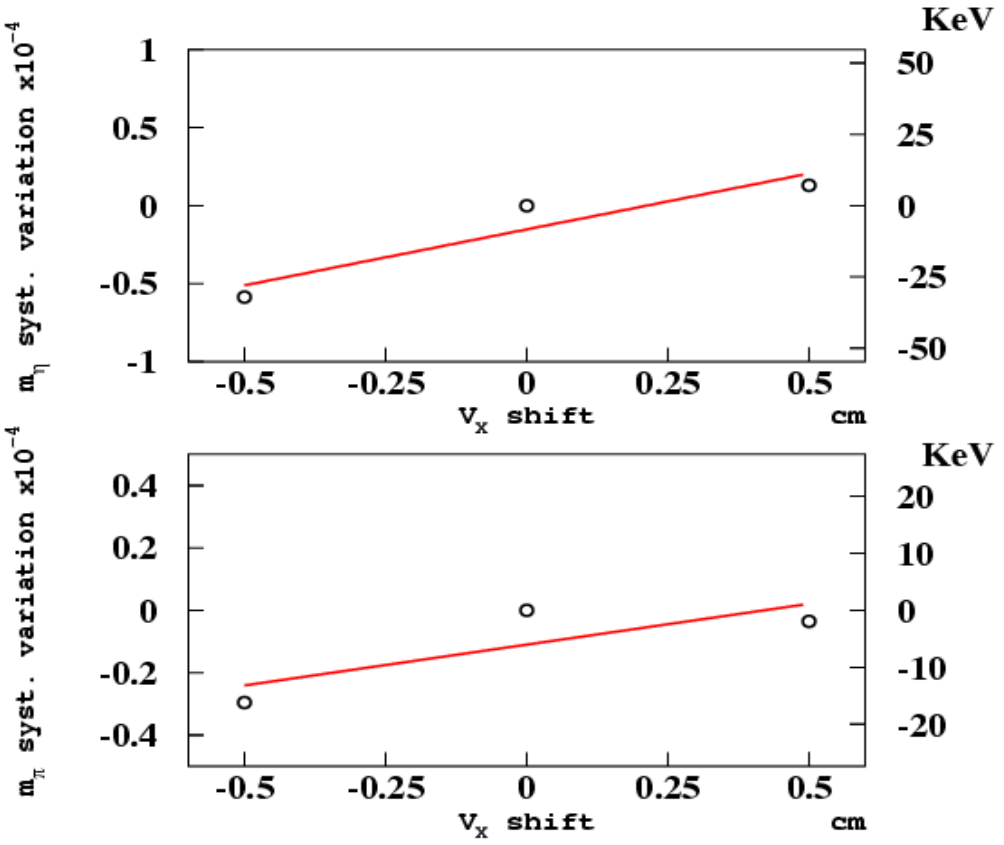
30 keV residual systematic

Vertex position systematic

z



x

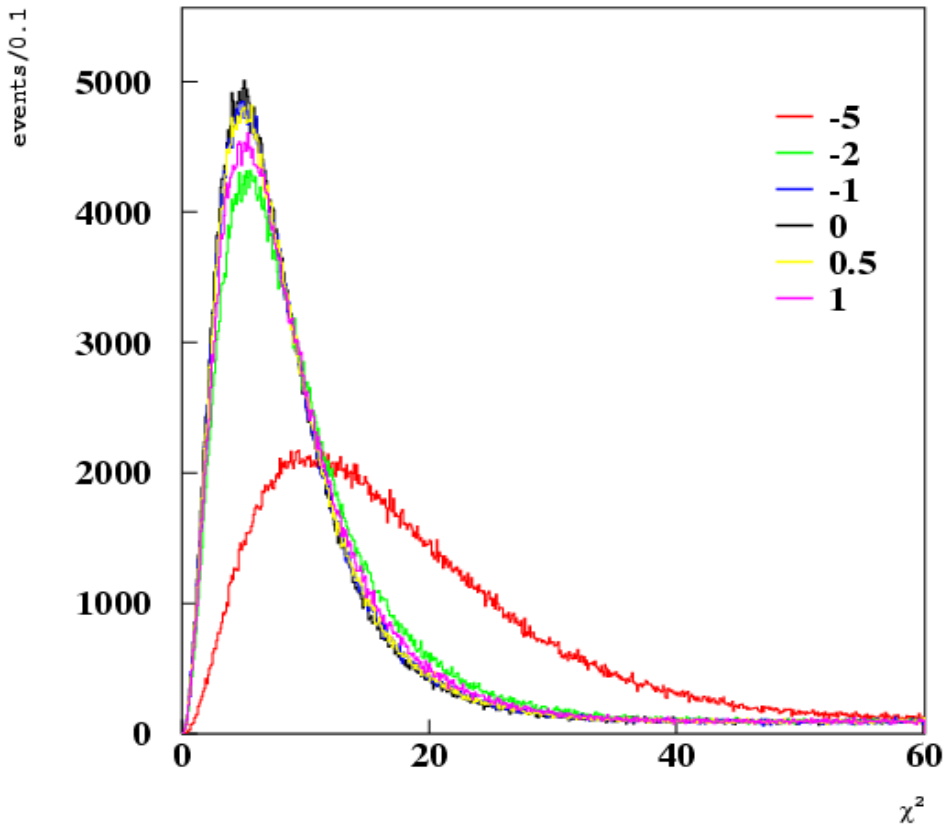


-1 < Z vertex position syst. < 0.5 cm assumed (checking the χ^2)

-0.5 < x vertex position syst. < 0.5 cm

Vertex position systematic

z

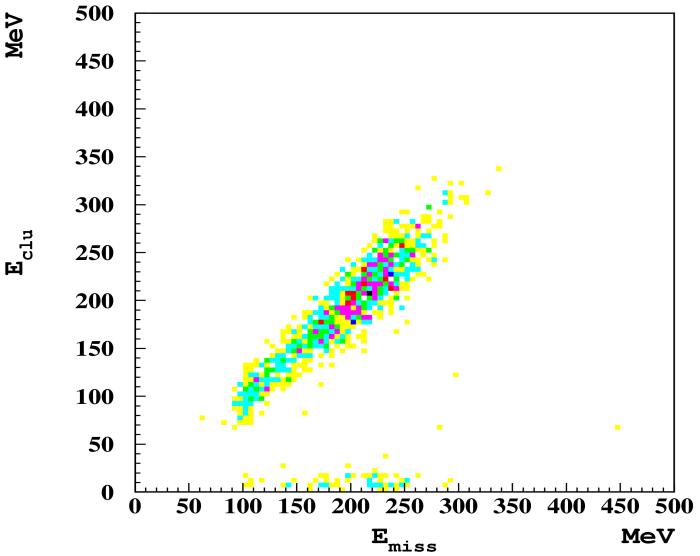


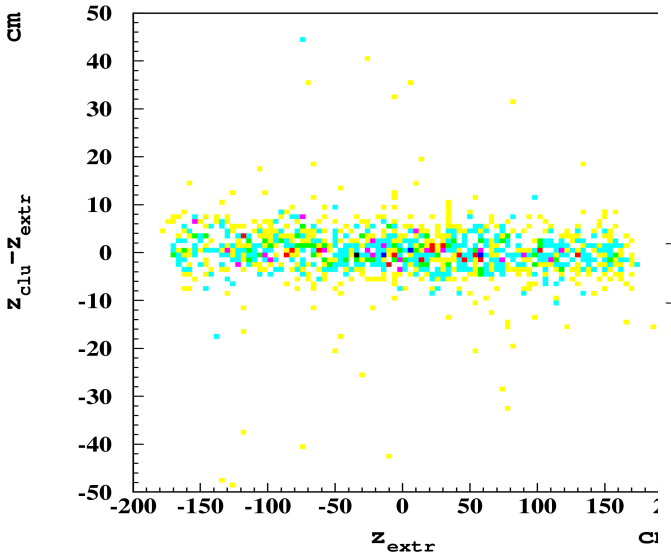
Systematic evaluation using $\pi^+\pi^-\gamma$ L.A.

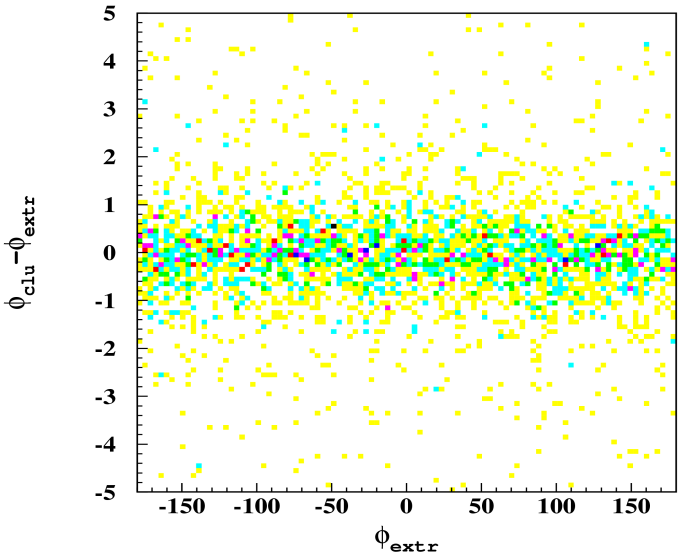
- linearity in energy and position response;
- I.P. position systematic using the charged vertex position distribution;
- relative DC-EMC postion using extrapolated tracks in the calorimeter.

just a prompt cluster is required

$|t - r/c| < \min(5\sigma_t, 2\ ns)$

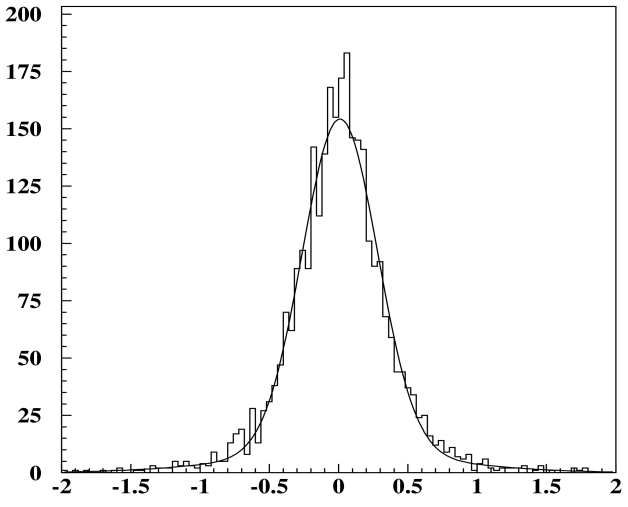




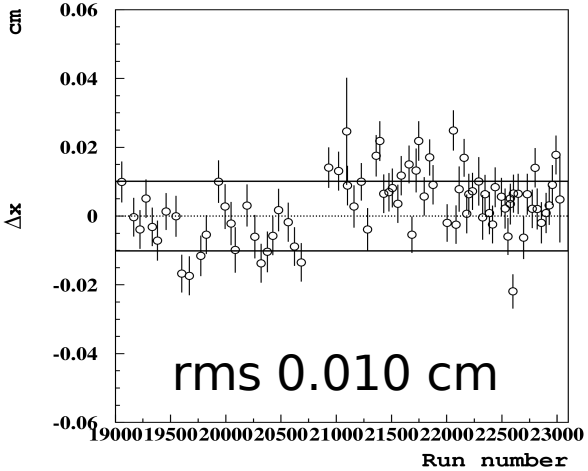


Vertex position systematic

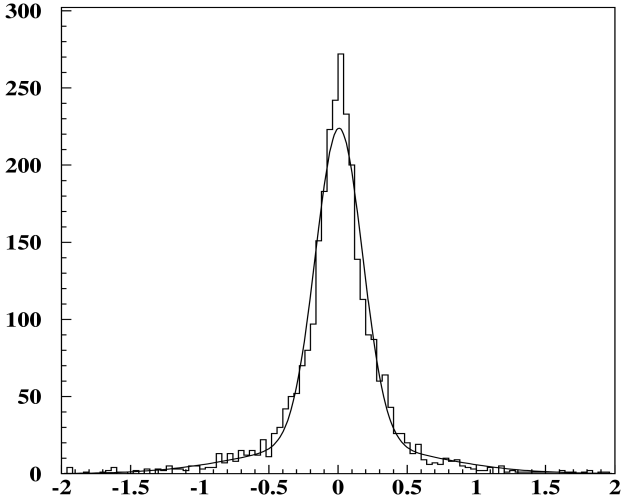
X



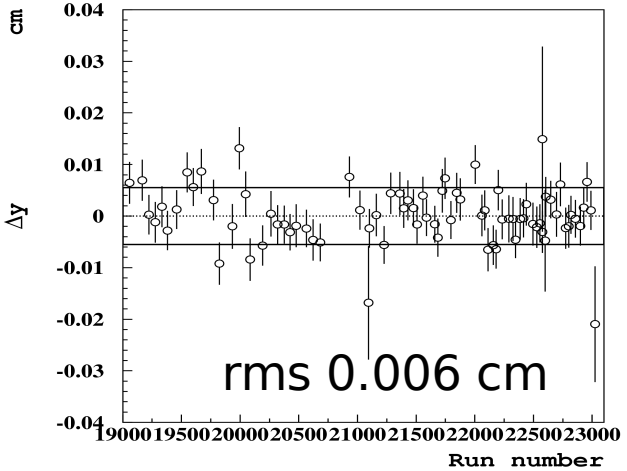
$x_{\pi\pi\gamma} - x_{BPOS}$



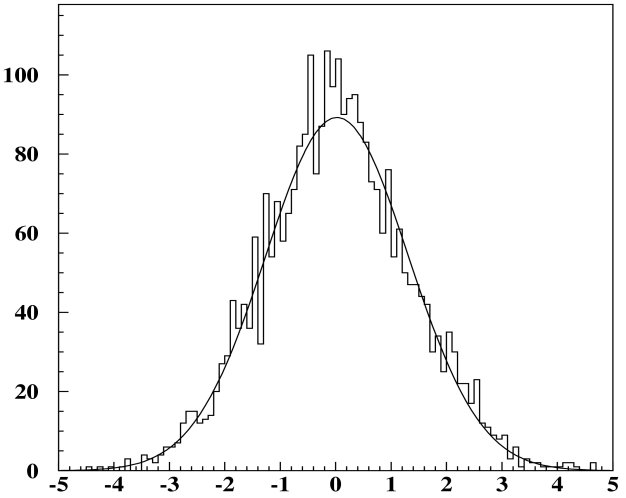
y



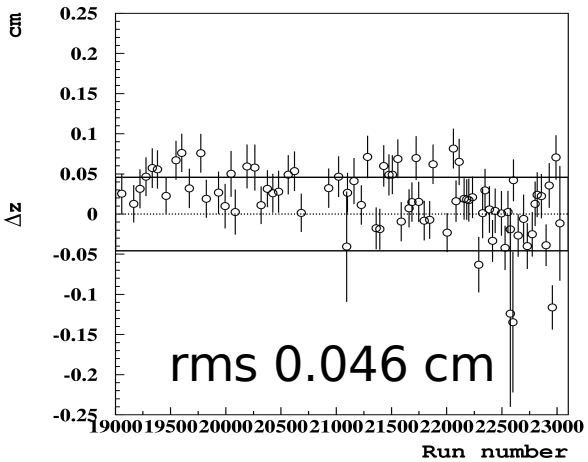
$y_{\pi\pi\gamma} - y_{BPOS}$



z

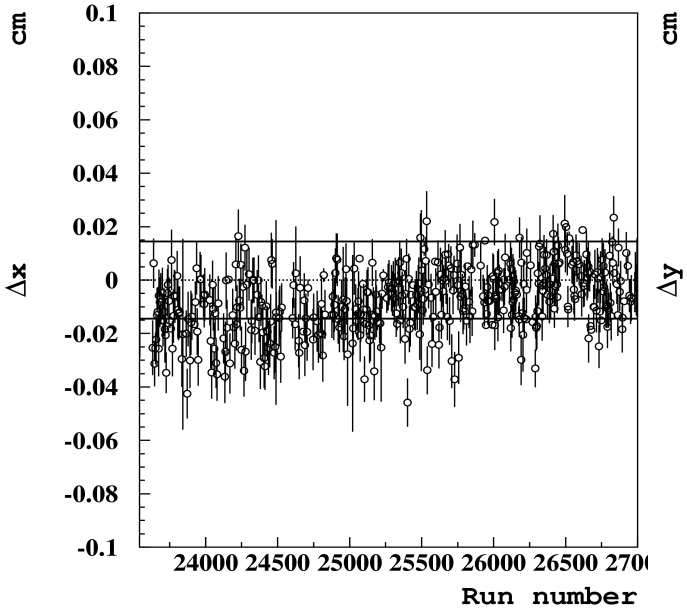


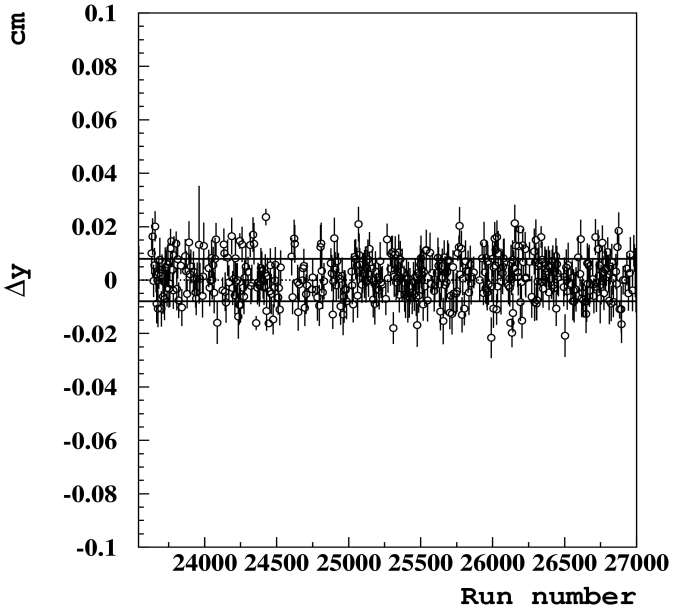
$z_{\pi\pi\gamma} - z_{BPOS}$

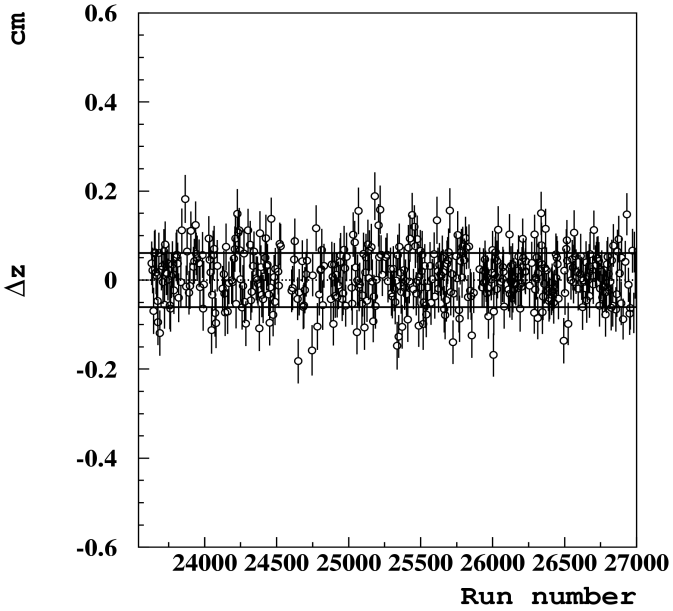


Vertex position systematic

X y z







rms 0.014 cm

rms 0.008cm

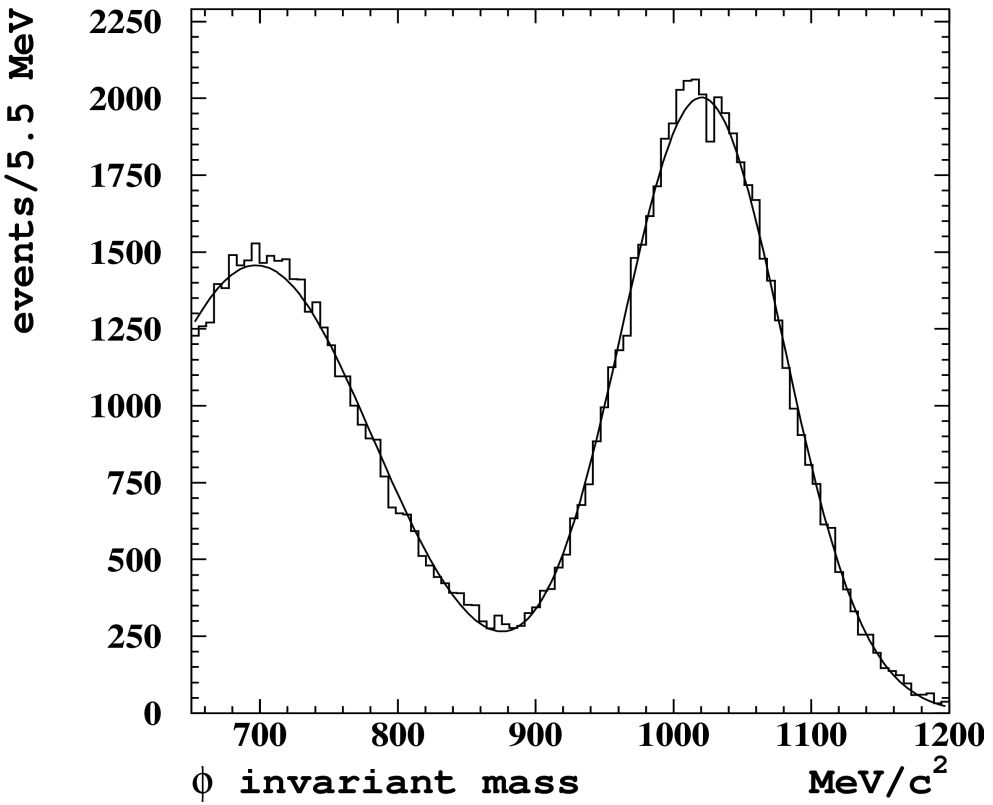
rms 0.061 cm

The uncertainty on the vertex position is much lower than the previous estimate.

Energy calibration

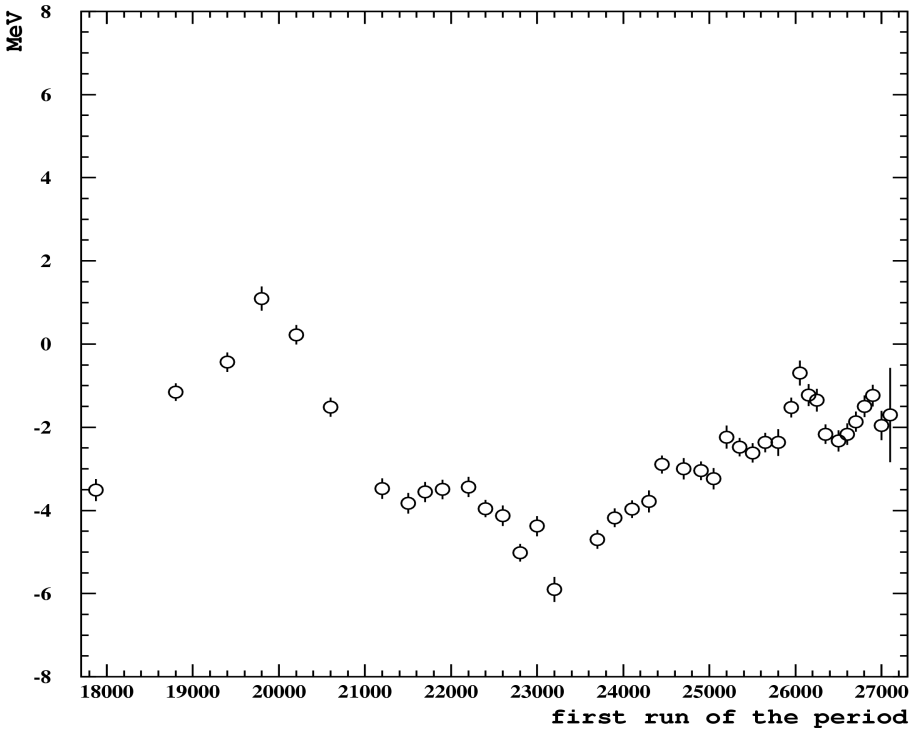
Constant term systematic evaluated using 3γ total energy.

10 pb^{-1}

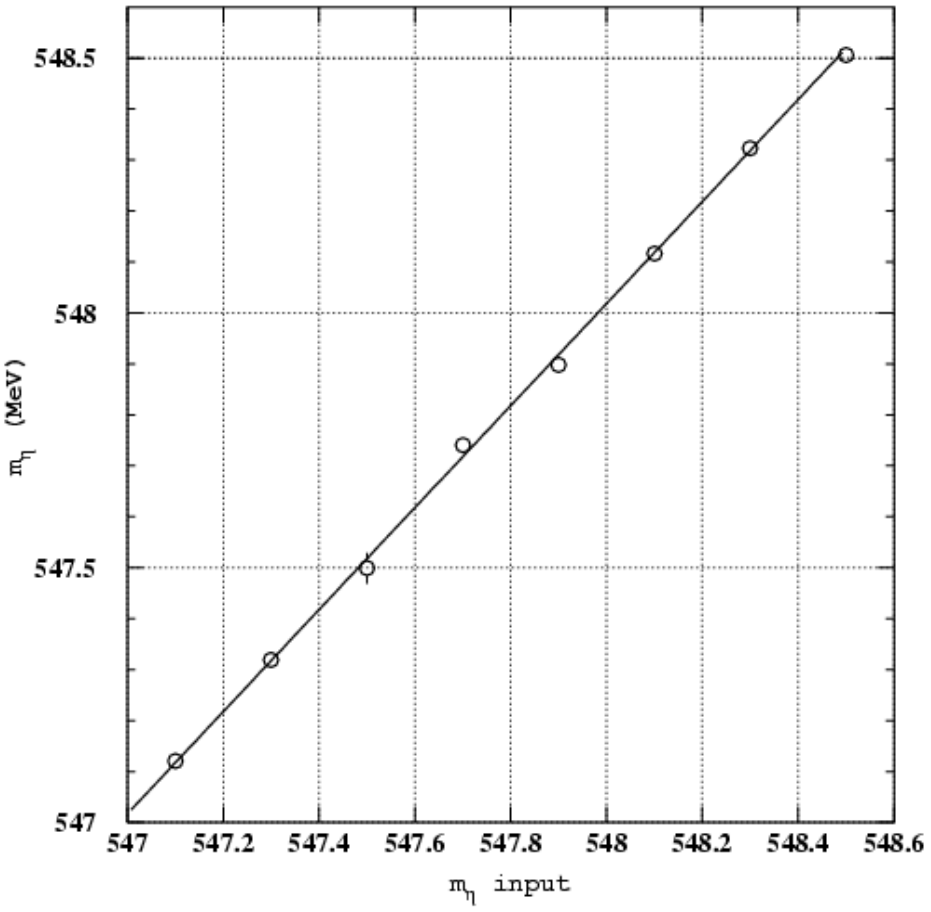


2001 + 2002

error = 7/(3x2) MeV = 1.2 MeV



MC study of linearity response



Modified geanfi version to set η mass via data card.

$M_{fit} = M_{true} + (0.017 \pm 0.005)$ MeV/c^2

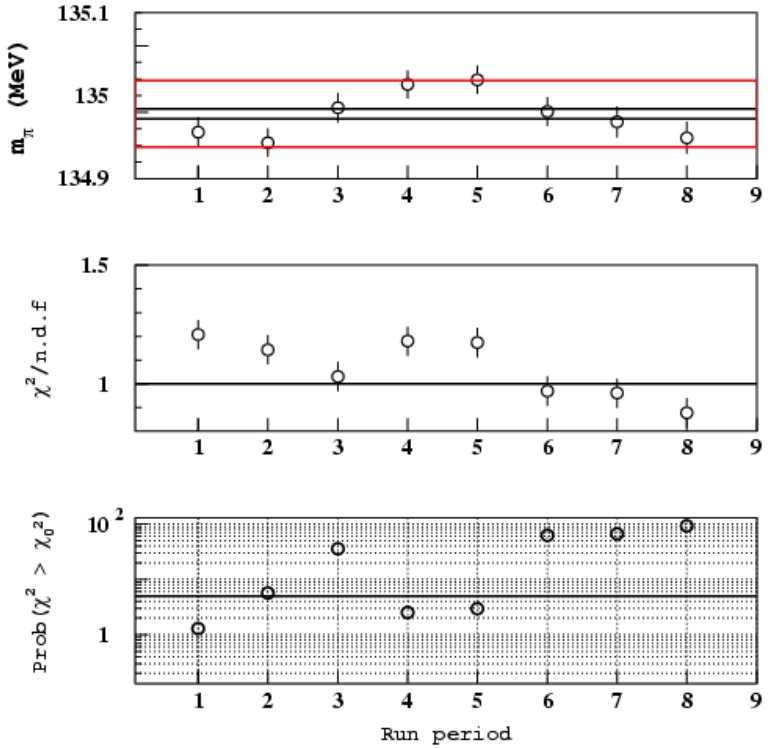
$\chi^2/7 = 1.1$ Pb = 36%

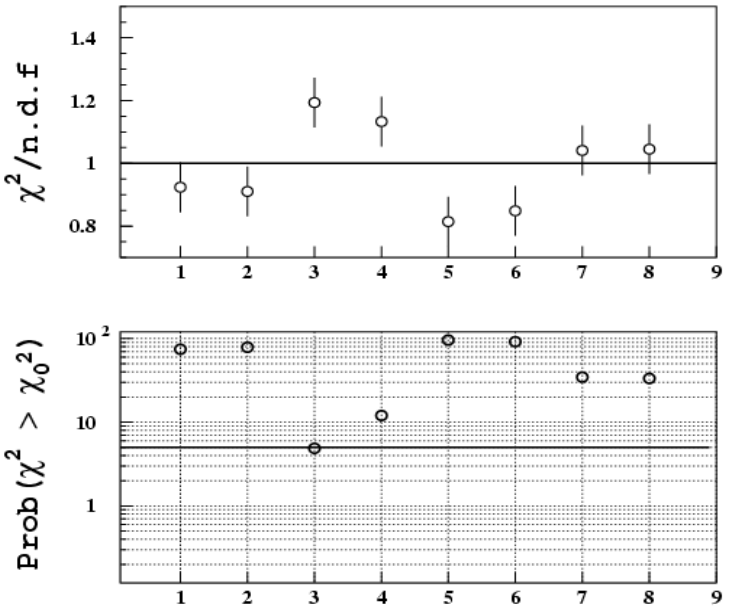
50pb^{-1} for each point

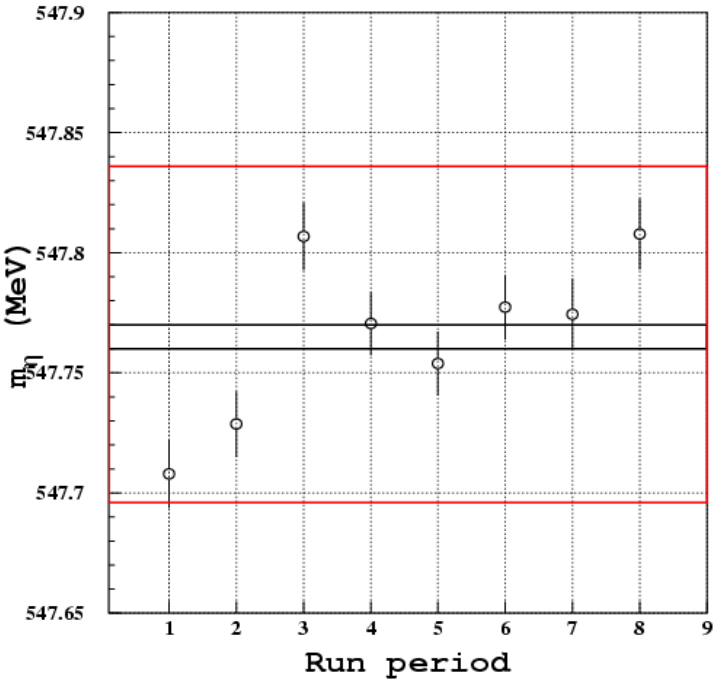
linearity is perfect. Small correction for the constant term is probably needed.

Preliminary mass measurement

Data-set divided in 8 periods







$m(\pi^0) = 134990 \pm 6_{stat} \pm 30_{syst}$ KeV

$m(\pi^0)_{PDG} = 134976.6 \pm 0.6$ KeV

$m(\eta) = 547822 \pm 5_{stat} \pm 69_{syst}$ KeV

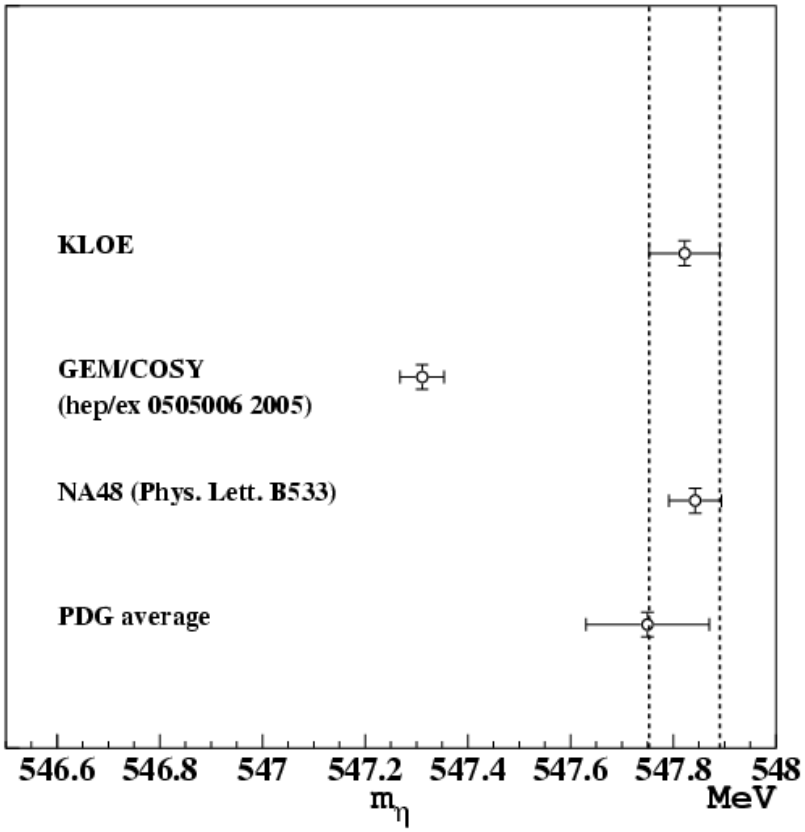
Syst from sqrt(s), vertex position

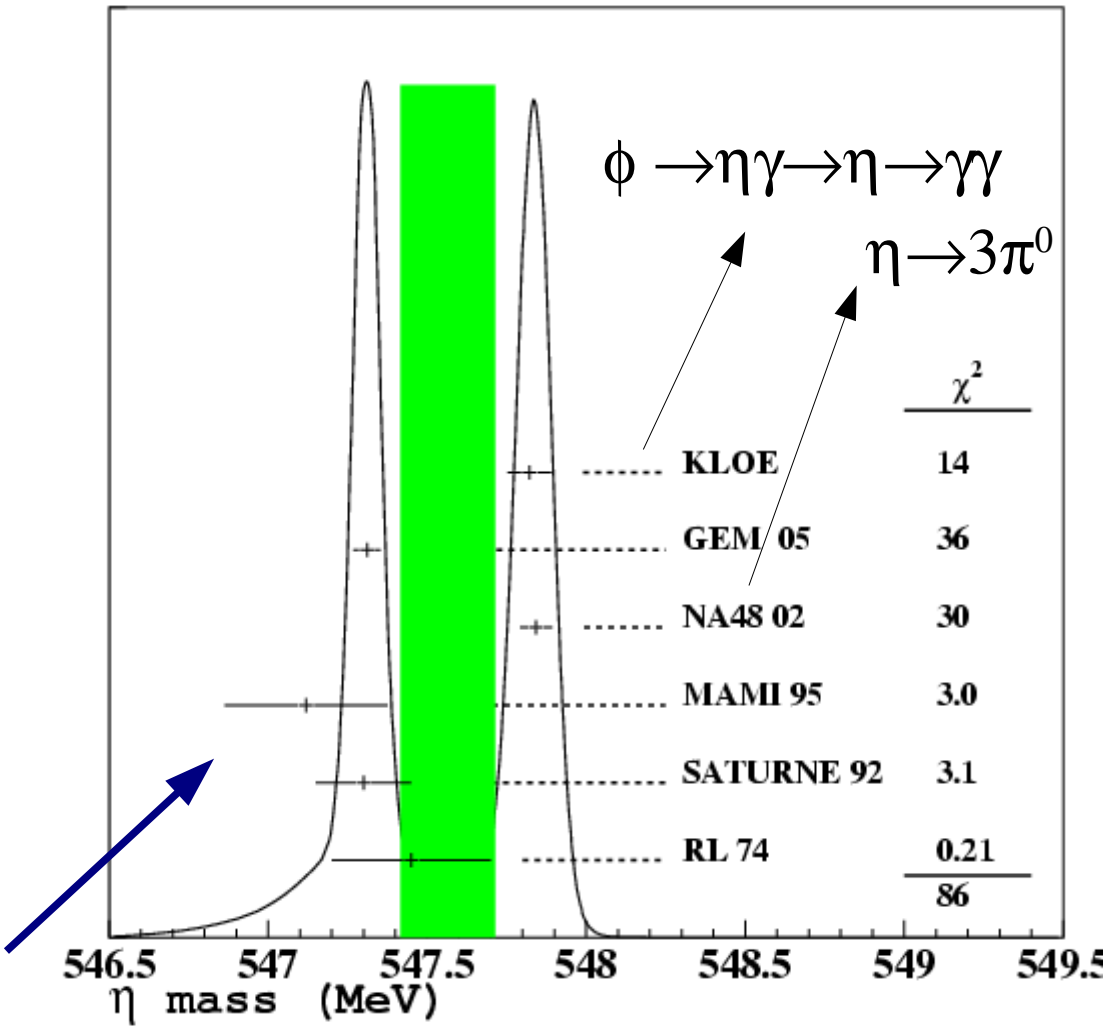
110 keV ± 110 keV correction

New situation with KLOE

KLOE PRELIMINARY

NA48 compatibility
0.24 σ





Produced at threshold on nuclear target.

?

Conclusions

- Memo in preparation;
- Tools for systematic determination of all the main effects are ready, the final systematic evaluation will be ready soon;
- from the (still not complete) systematic evaluation seems that the systematic error of the preliminary result is overestimated (as I wished);
- Memo with all systematic studies ready hopefully in less than one month.

Preliminary result: $547.822 \pm 0.005_{stat} \pm 0.069_{syst}$