Search for $\phi \rightarrow a_0\gamma \rightarrow \eta\pi^0\gamma \rightarrow 5\ \gamma$ events with the KLOE detector

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5 prompt γ's

- **Data from first period of data taking :**
  $\int L = 2.35\ pb^{-1}$

Process	B.R. $(x\ 10^{-5})$	Exp. evts $(\varepsilon = 1)$
$a_0\gamma \to \eta\pi^0\gamma \to 5\gamma$	3.5	260
$\rho\pi^0 \to \eta\pi^0\gamma \to 5\gamma$	0.3÷0.7	22 ÷50
$\omega\pi^0 \to \eta\pi^0\gamma \to 5\gamma$	$\sigma \approx 6$ pb	15
$f_0\gamma \to \pi^0\pi^0\gamma \to 5\gamma$	10	
$\rho\pi^0 \to \pi^0\pi^0\gamma \to 5\gamma$	3	2500
$\omega\pi^0 \to \pi^0\pi^0\gamma \to 5\gamma$	$\sigma \approx 0.6$ nb	
$\eta\gamma \to 3\gamma$	$\sim 500 \times P_{5\gamma}$	~ 1000*
$\eta\gamma \to 7\gamma$	$\sim 420 \times P_{5\gamma}$	~ 1000*

(* $P_{5\gamma}(3\gamma) \approx P_{5\gamma}(7\gamma) \approx 3\%$ from MC)

The KLOE detector

- **Electromagnetic calorimeter**
  - **Fine sampling Pb/SciFi**
  - **Hermetical coverage**
  - **High efficiency for low energy photons**

$\sigma_E/E = 6\%/\sqrt{E[\mathrm{GeV}]}$ $\sigma_t = 110\ \mathrm{ps}/\sqrt{E[\mathrm{GeV}]}$

$\sigma_{x,y} = 1.2\ \mathrm{cm}$ $\sigma_z = 1.2\ \mathrm{cm}/\sqrt{E[\mathrm{GeV}]}$

- **Central drift chamber**
  - **He based gas mixture**
  - **Large detection volume**

$\sigma_v \sim 1\mathrm{mm}$ $\sigma_{pt}/p_t \sim 0.5\%$

$\sigma_{r\varphi} \sim 200\ \mu\mathrm{m}$ $\sigma_z \sim 2\ \mathrm{mm}$

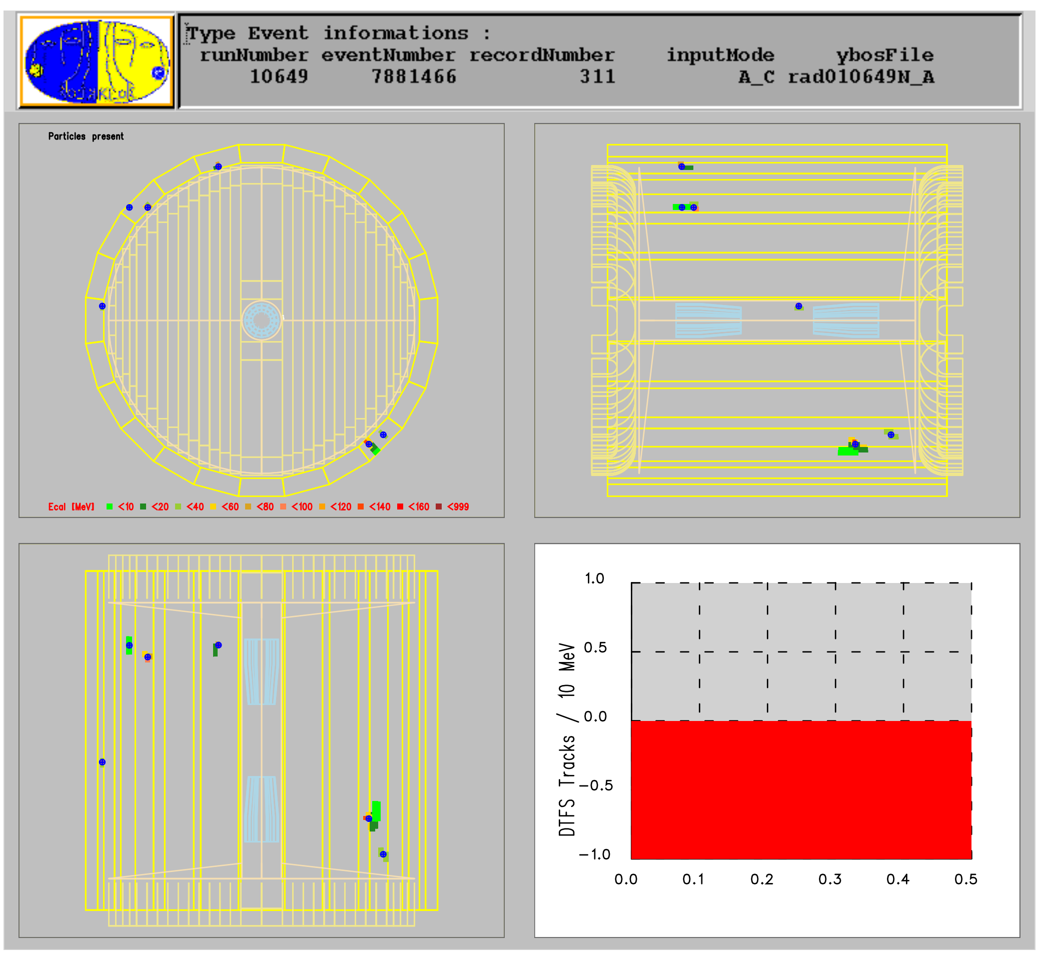
- **Quadrupoles’ calorimeter**
  - **Pb/Sci tile calorimeter covering the quadrupoles inside KLOE**

Sample selection

- **No tracks in the drift chamber**

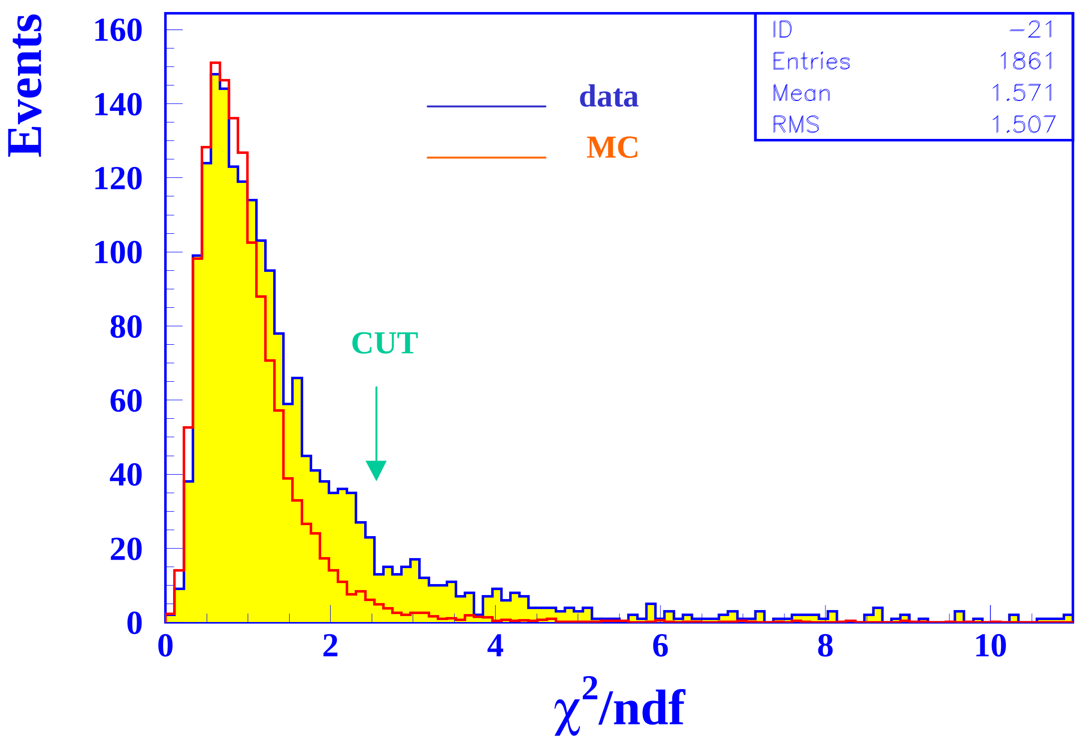
- **5 prompt photons in the calorimeter ($|t-r/c| < 5\ \sigma_t$) , with $\vartheta > 21^o$**

- **total energy E > 900 MeV**



Constrained fit

- **30 parameter fit:** **E, x, y, z and t for each photon + X, Y, Z of the I.P. + the beam energies E_+, E_-**
- **9 constraints :** **t-r/c=0 for each photon + the four-momentum conservation**



- **Cut: χ^2/ndf < 2.5**

Background rejection

- Look for the best photon pairing (min. χ^2) in the 3 hypotheses:

1) $\eta\pi^0\gamma$ hypothesis:

$$\chi^2_{\eta\pi 0} = \frac{(M_{12} - M_{\pi 0})^2}{\sigma^2_{\pi 0}} + \frac{(M_{34} - M_{\eta})^2}{\sigma^2_{\eta}}$$

2) $\pi^0\pi^0\gamma$ hypothesis:

$$\chi^2_{\pi 0\pi 0} = \frac{(M_{12} - M_{\pi 0})^2}{\sigma^2_{\pi 0}} + \frac{(M_{34} - M_{\pi 0})^2}{\sigma^2_{\pi 0}}$$

3) $\eta\gamma\to 3\gamma$ hypothesis:

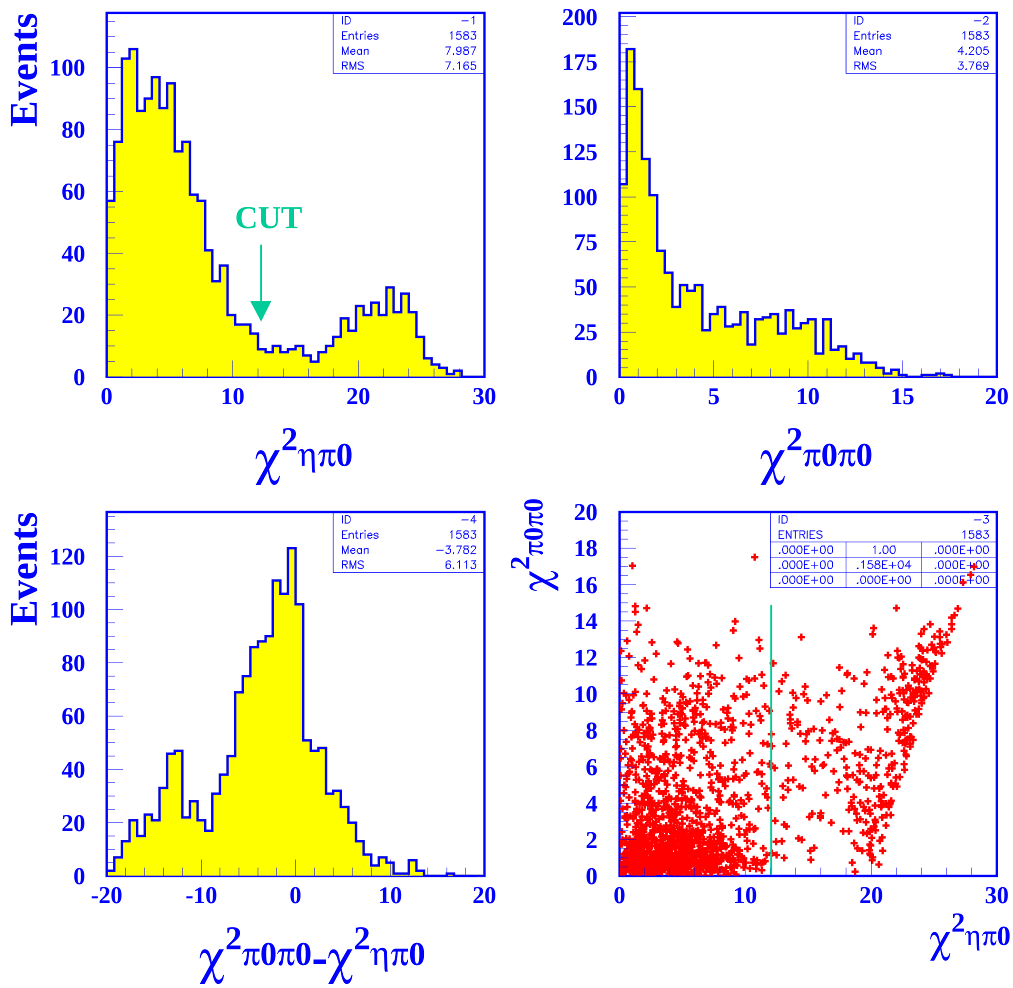
$$\chi^2_{\eta\gamma} = \frac{(M_{12} - M_{\eta})^2}{\sigma^2_{\eta}} + \frac{(E_3 - E_{rad})^2}{\sigma^2_{rad}}$$

(E_{rad} = 363 MeV)

$\pi^0\pi^0\gamma$ rejection

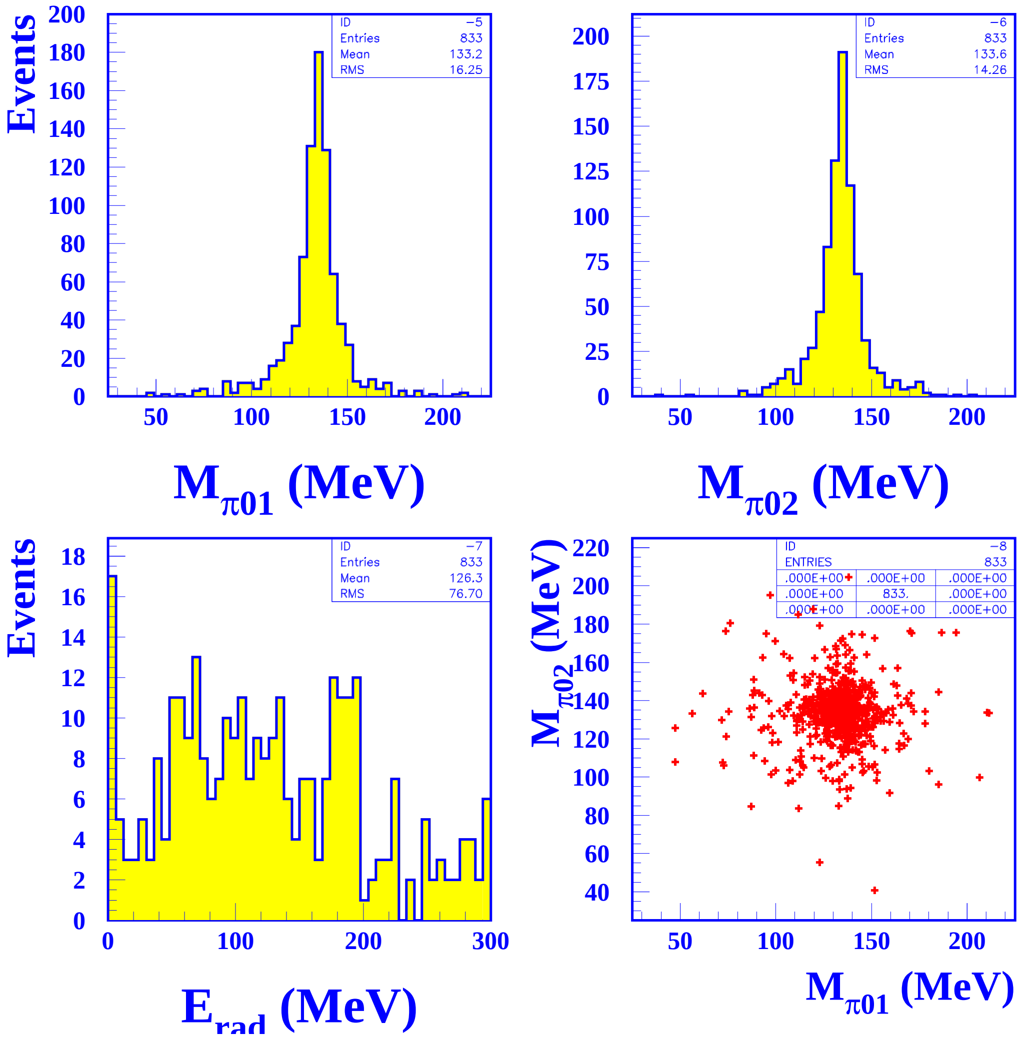
- $\chi^2_{\eta\pi 0} < 12$

- $\chi^2_{\eta\pi 0} < \chi^2_{\pi 0\,\pi 0}$



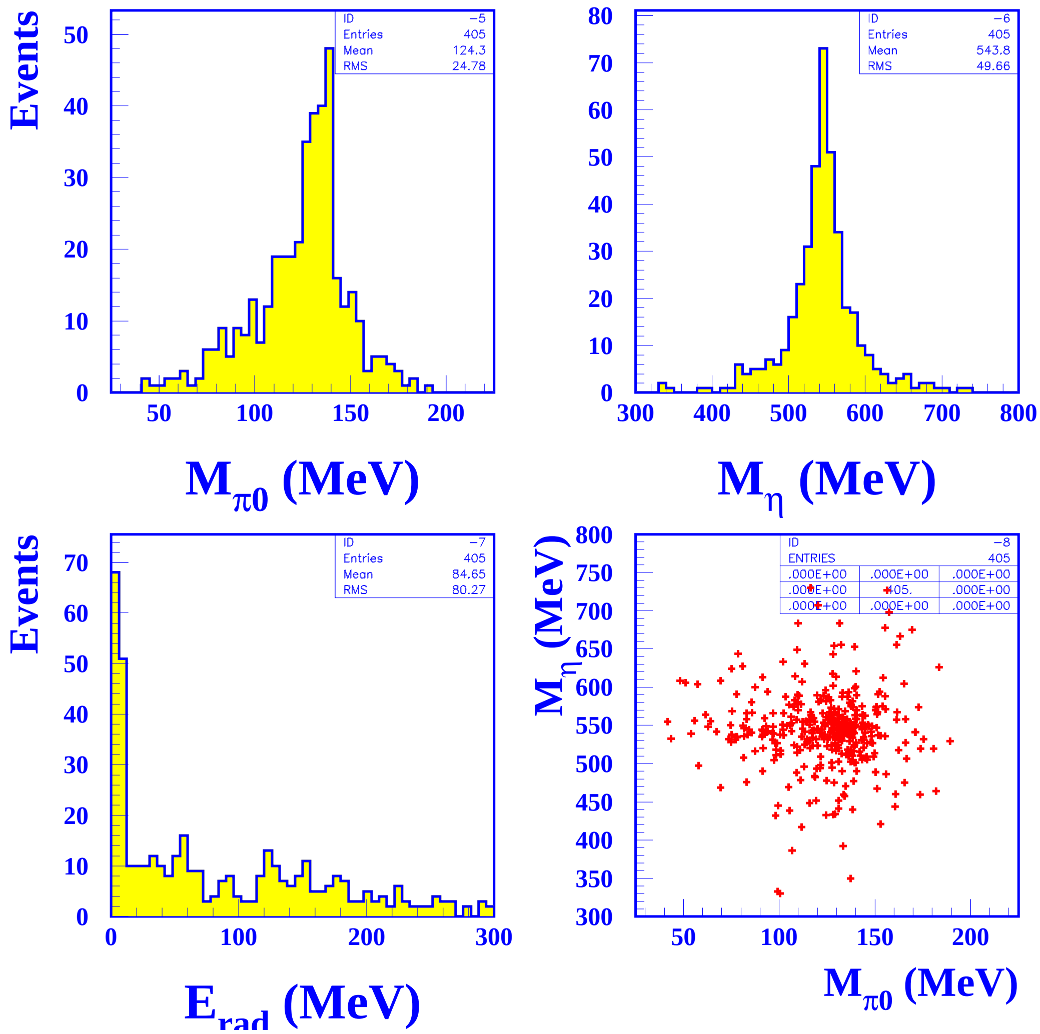
$\pi^0\pi^0\gamma$ sample

- Events with $\chi^2_{\pi 0\ \pi 0} < \chi^2_{\eta\pi 0}$



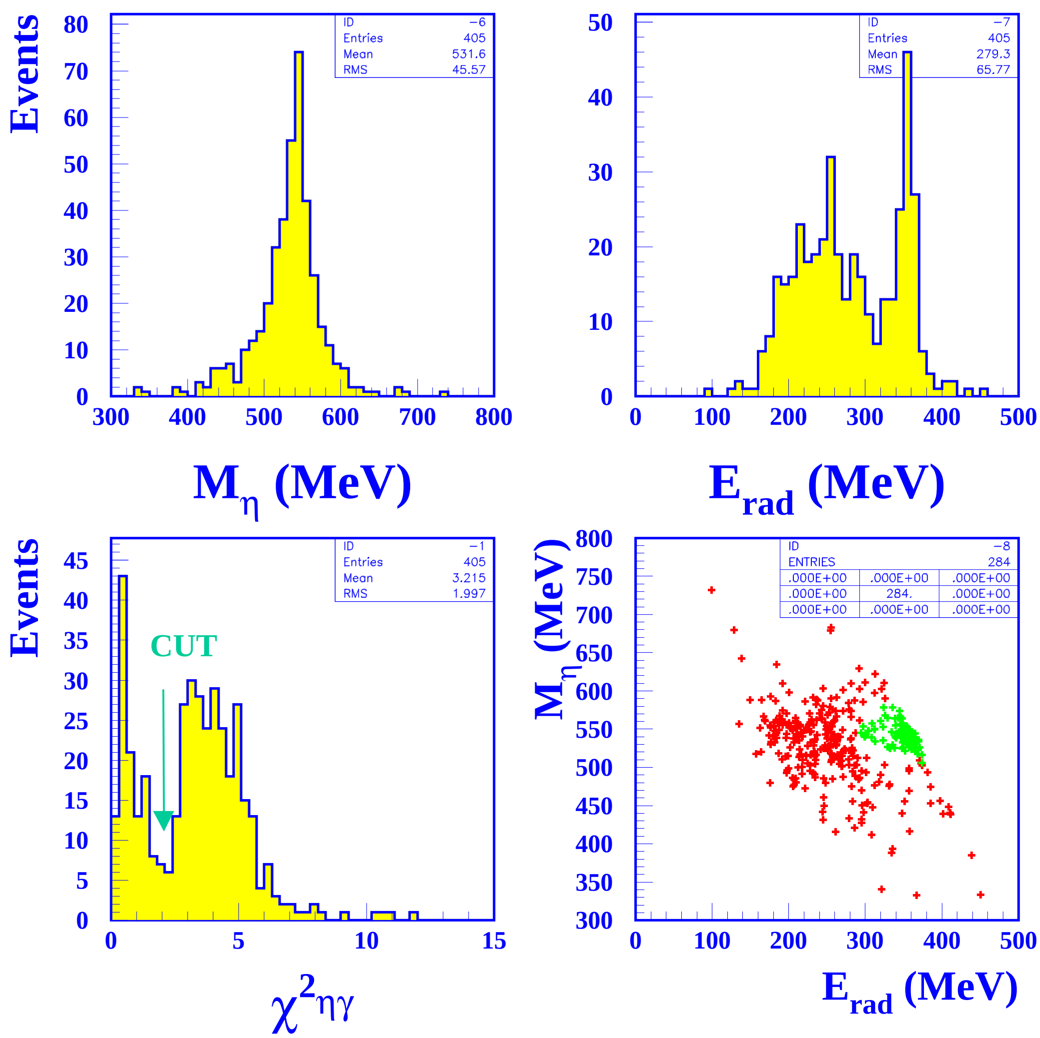
$\eta\pi^0\gamma$ sample

- 405 events



- Still some contamination

$\eta\gamma$ rejection

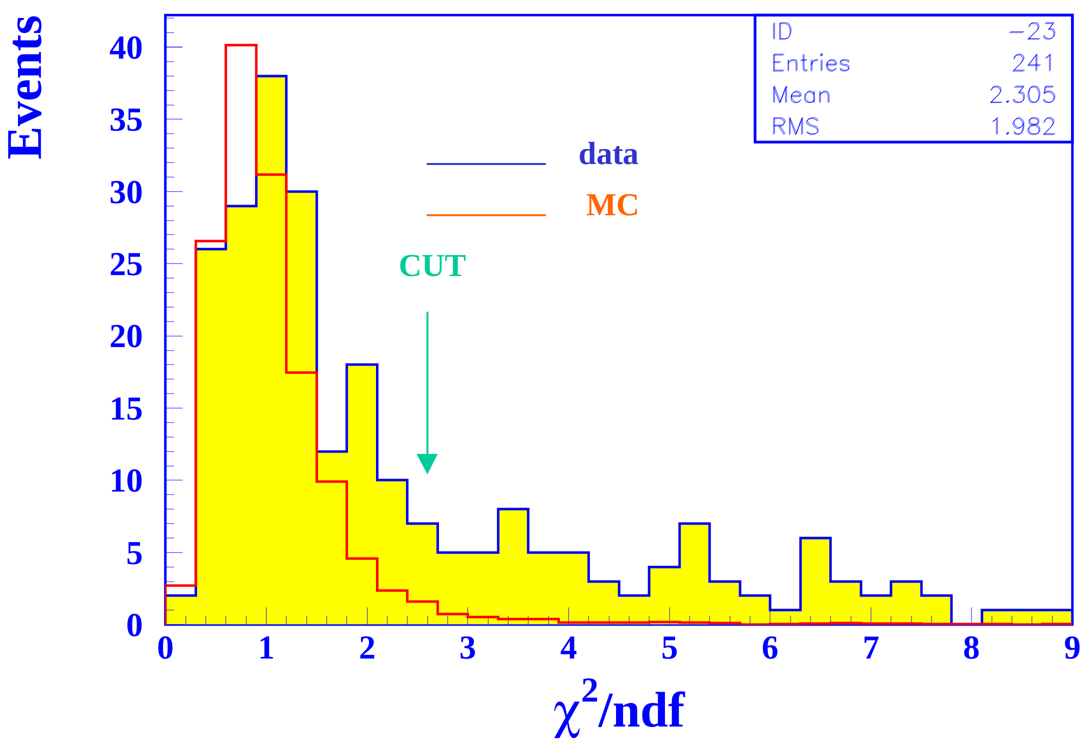


- **Cut: $\chi^2{}_{\eta\gamma} > 2$ $\Rightarrow$ 241 events survive**

Second fit

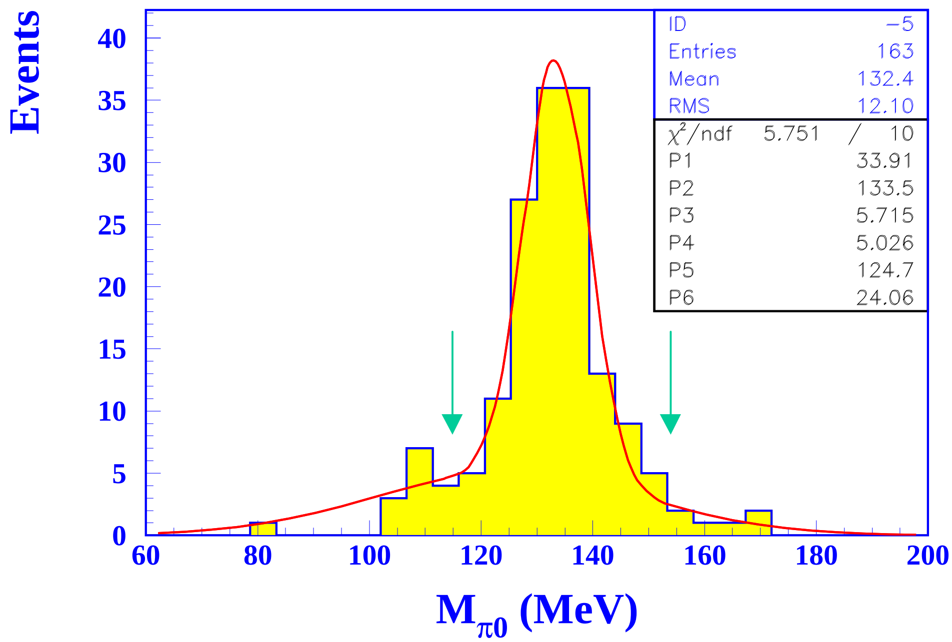
- 30 parameters

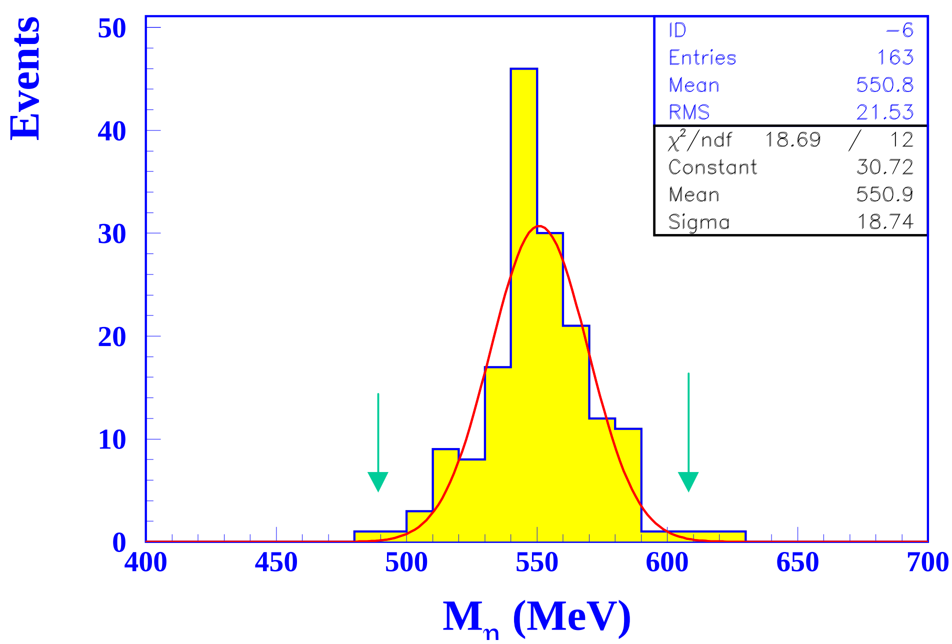
- 11 constraints : 9 as before + 2 invariant masses of η and π^0



- Cut: χ^2/ndf < 2.5

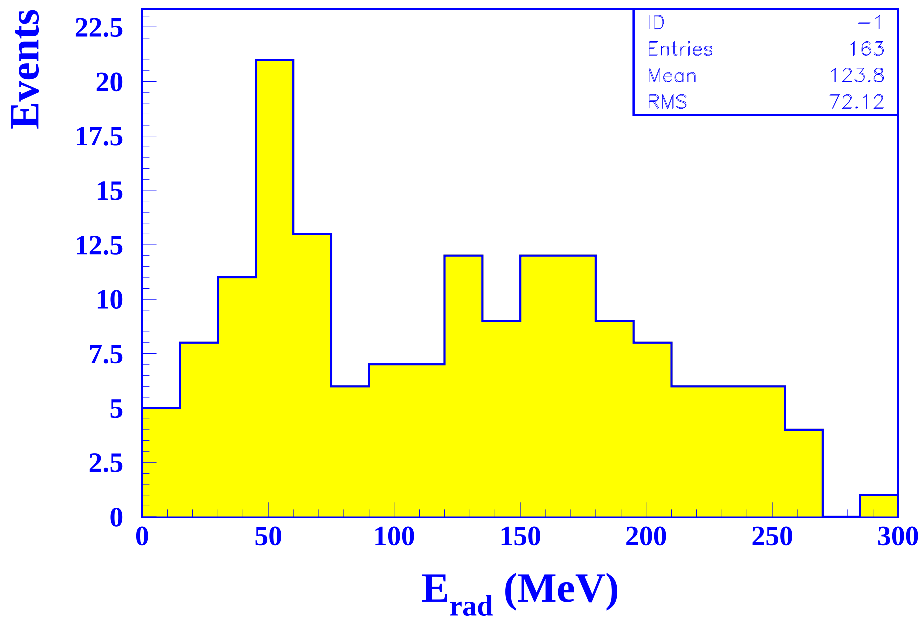
Second fit

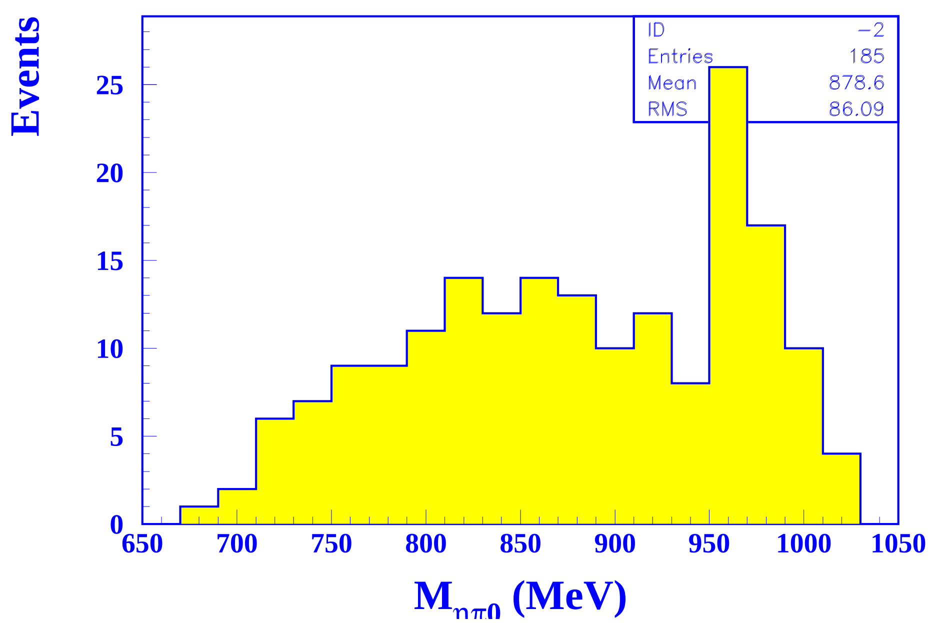




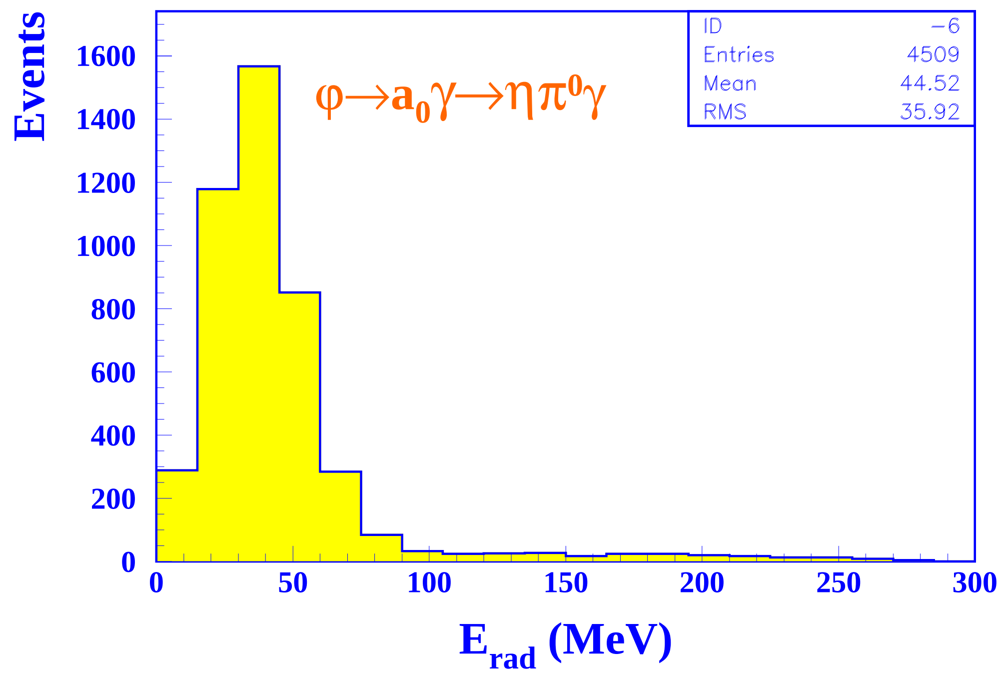
- 3 σ cut on M_η and $M_{\pi 0}$ ⇒153 events

Final sample

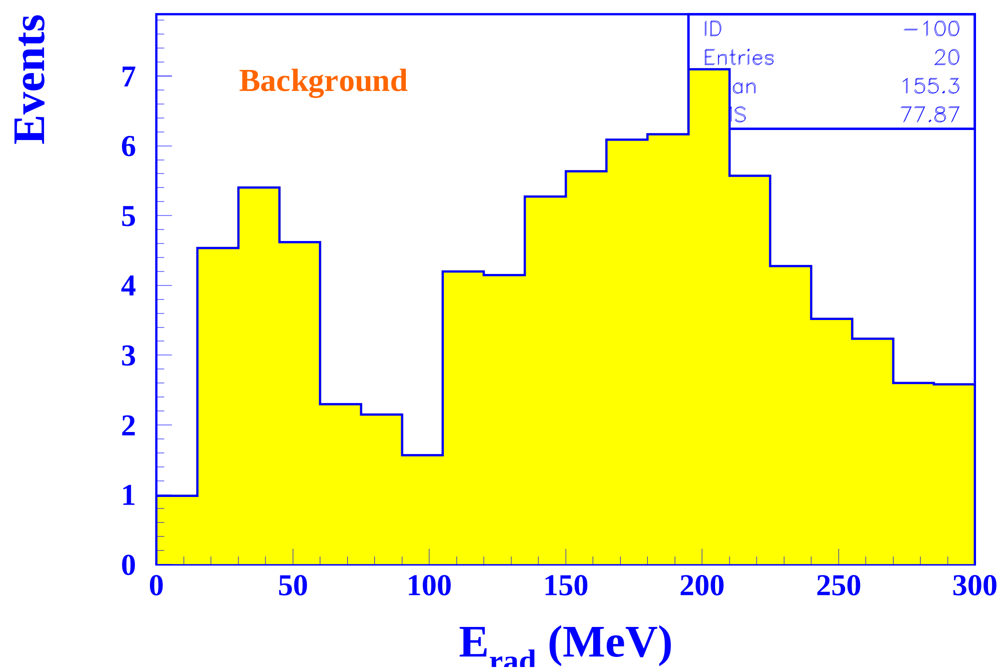




MC spectra



Events
$\varphi \to a_0\gamma \to \eta\pi^0\gamma$
ID -6
Entries 4509
Mean 44.52
RMS 35.92
0 200 400 600 800 1000 1200 1400 1600
0 50 100 150 200 250 300
E_{rad} (MeV)



Events
Background
ID -100
Entries 20
155.3
77.87
0 1 2 3 4 5 6 7
0 50 100 150 200 250 300
E_{rad} (MeV)

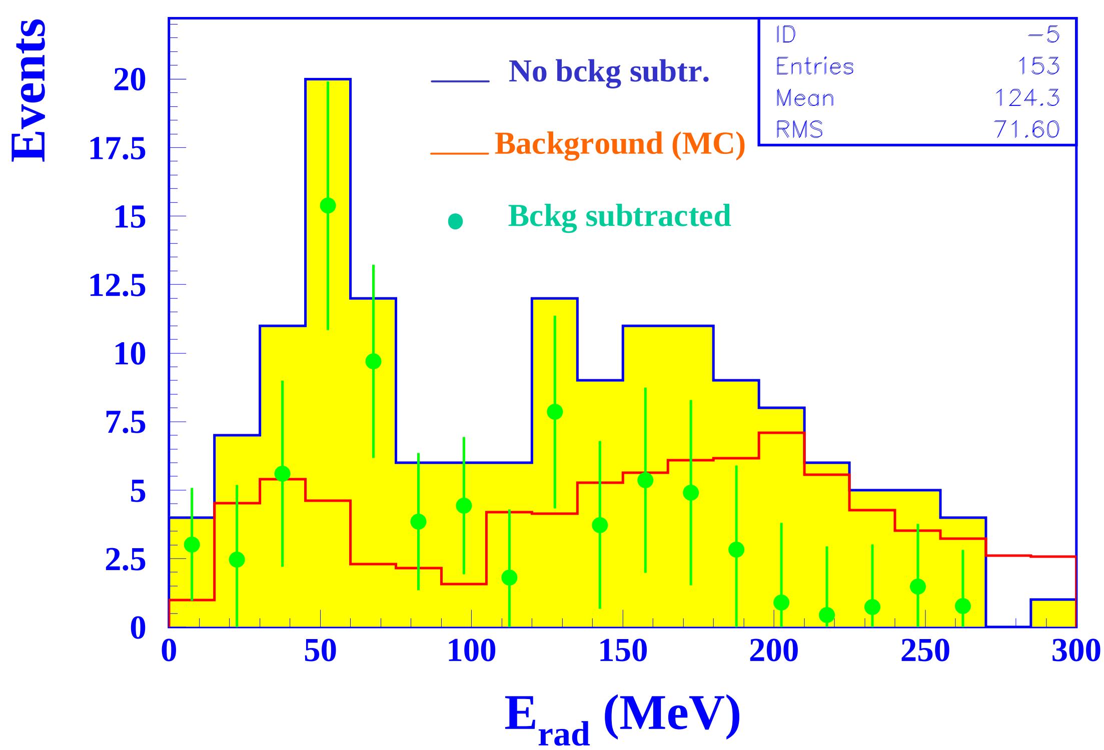
Efficiencies (from MC)

	Trig. + filters	5 pr.γs	Sel. +fits	total
$a_0\gamma \to \eta\pi^0\gamma$	0.81	0.70	0.54	0.30
$\rho\pi^0 \to \eta\pi^0\gamma$	0.77	0.70	0.58	0.32
$f_0\gamma \to \pi^0\pi^0\gamma$	0.80	0.70	0.01	$6\cdot10^{-3}$
$\rho\pi^0 \to \pi^0\pi^0\gamma$	0.80	0.70	0.06	0.03
$\omega\pi^0 \to \pi^0\pi^0\gamma$	0.82	0.70	0.04	0.02
$\eta\gamma \to 3\gamma$	0.78	0.03	-	$<5\cdot10^{-4}$
$\eta\gamma \to 7\gamma$	0.80	0.03	0.05	10^{-3}

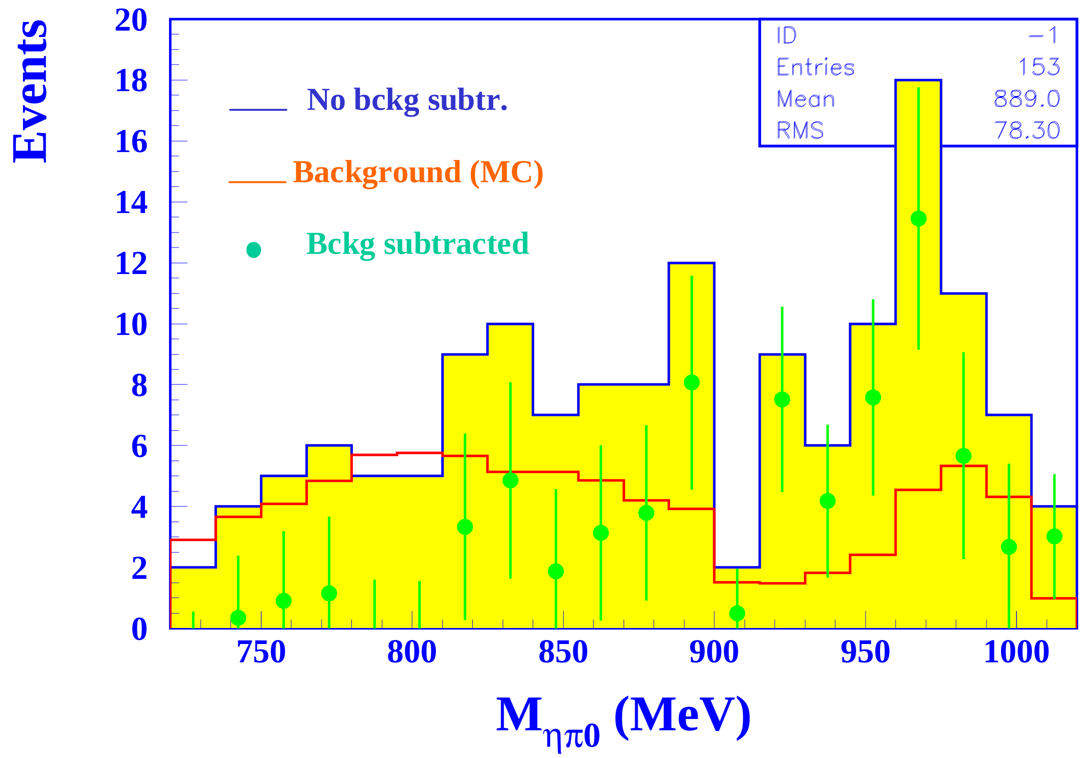
Photon spectrum

Background subtraction: use MC spectra and efficiencies for the bckg processes

(assume same spectrum for $\rho\pi^0$ and $\omega\pi^0 \rightarrow \eta\pi^0\gamma$)

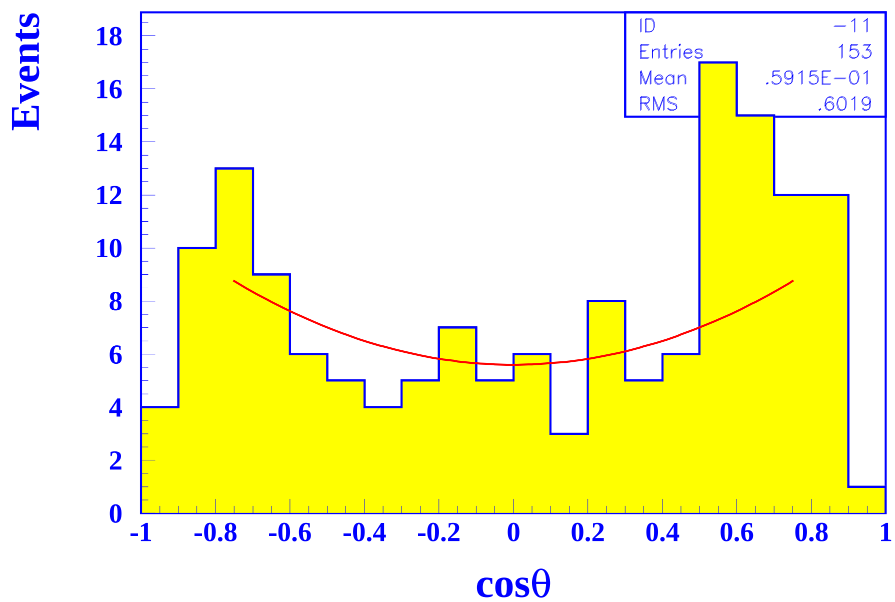


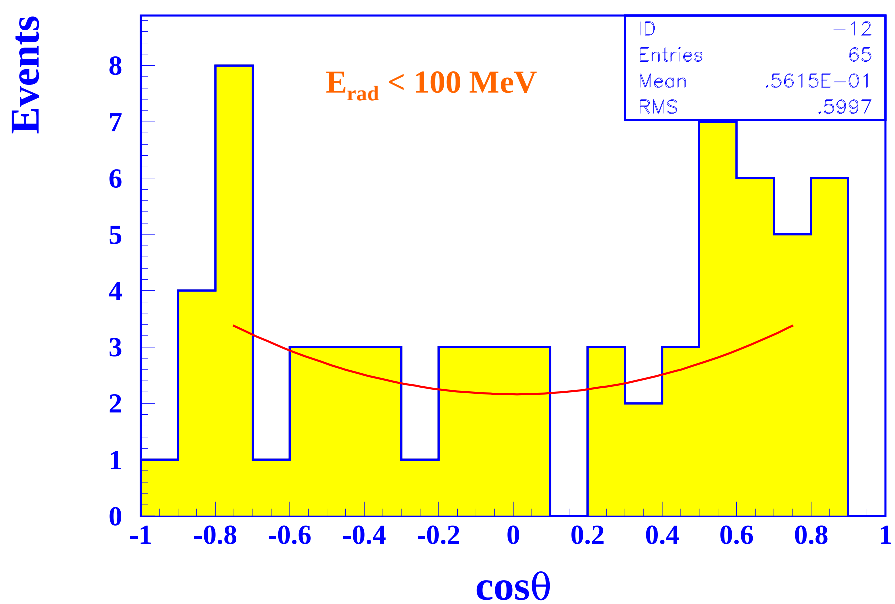
$\eta\pi^0$ invariant mass



Angular distribution

Rad. photon $\Rightarrow 1 + \cos^2 \vartheta$





$Br(\varphi \to a_0 \gamma)$

- $Br(\varphi \to a_0\gamma) = (N - B) / (\varepsilon L \sigma_\varphi Br(\eta \to \gamma\gamma))$

1) from the spectrum with background subtraction

- $N - B = 153 - 84 = 69$ events
- Integrated $L = 2.35\ pb^{-1}$ (Bhabha sc.)
- $Br(\eta \to \gamma\gamma) = 39.2\ \%$ (from PDG)

$$Br(\varphi \to a_0\gamma) = (0.78 \pm 0.15_{stat}) \cdot 10^{-4}$$

2) No bckg subtr. and $E_{rad} < 100$ MeV

- $N = 65$ events
- $\varepsilon = 28\%$ for the signal

$$Br(\varphi \to a_0\gamma) = (0.79 \pm 0.10_{stat}) \cdot 10^{-4}$$

SND : $Br(\varphi \to a_0\gamma) = (0.89 \pm 0.14 \pm 0.06) \cdot 10^{-4}$

(DAΦNE '99)

Conclusions

- $\varphi \to \eta\pi^0\gamma \to 5\gamma$ **events have been observed in the first KLOE data**

- **The energy spectrum of the radiated photon shows an excess of events in the region expected for the a_0 signal**

- **$Br(\varphi \to a_0\gamma) = (0.78 \pm 0.15_{stat}) \cdot 10^{-4}$**

- **Work is in progress to:**
  - **better understand the background**
  - **evaluate the systematics**
  - **fit the energy spectrum**