Status of the $\phi \to f_o\gamma \to \pi^o\pi^o\gamma$ analysis

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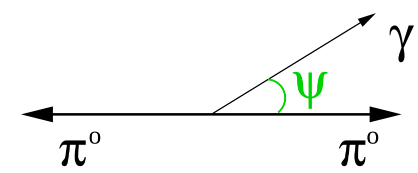
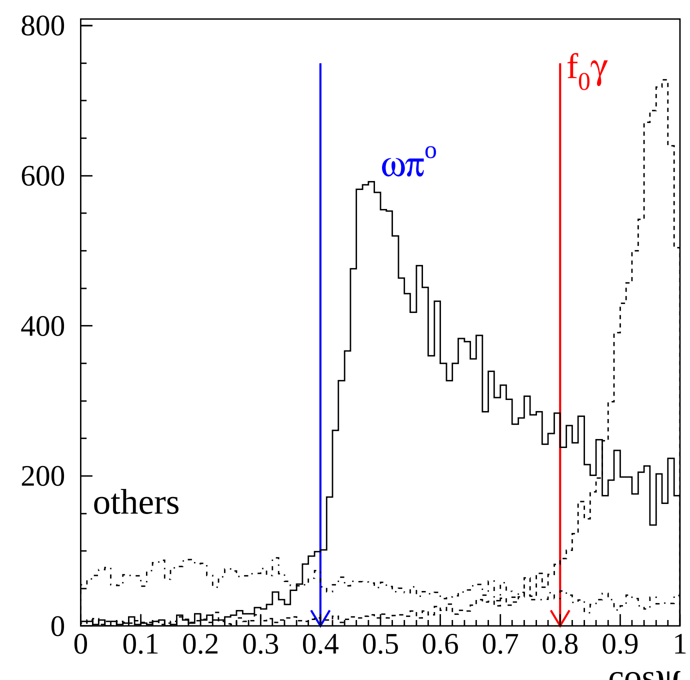
- The 1999 analysis scheme
- Comparison of different f_o models
- The new analysis scheme
- Fit procedure for BR evaluation
- Analysis of 2000 data

The 1999 analysis scheme

Analysis steps of 1999 KLOE data analysis (f_o and a_o treated as $q\bar{q}$ states):

1. Time Window cut: 5 EMC clusters with $E_\gamma > 7$ MeV and $|\mathrm{T} - \mathrm{R}/c| < 5\,\sigma_\mathrm{T}$
2. Acceptance: $21^\circ < \theta_\mathrm{EMC} < 159^\circ$
3. First kinematic fit requiring the 4-momentum conservation and the "promptness" constraint $(\mathrm{T} - \mathrm{R}/c = 0)$
4. Photons' pairing in both the $f_o\gamma$ (two neutral pions with $M_{\pi\pi} > 600$ MeV) and $\omega\pi^o$ (two neutral pions and $M_{\pi\gamma} = M_\omega$) hypotheses
5. Second kinematic fit for both photons pairings, requiring also constraints on pion masses of the assigned $\gamma\gamma$ pairs
6. $e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma$ selection:
   - $\chi^2_{\omega\pi}/\mathrm{ndof} < 20$
   - $0.4 < \cos\psi_{\omega\pi} < 0.8$
7. $\phi \to f_o\gamma \to \pi^o\pi^o\gamma$ selection:
   - ${\chi^2}_{f_o\gamma}/\mathrm{ndof} < 10$
   - $\cos\psi_{\omega\pi} > 0.8$
   - $M_{\pi\pi} > 700$ MeV



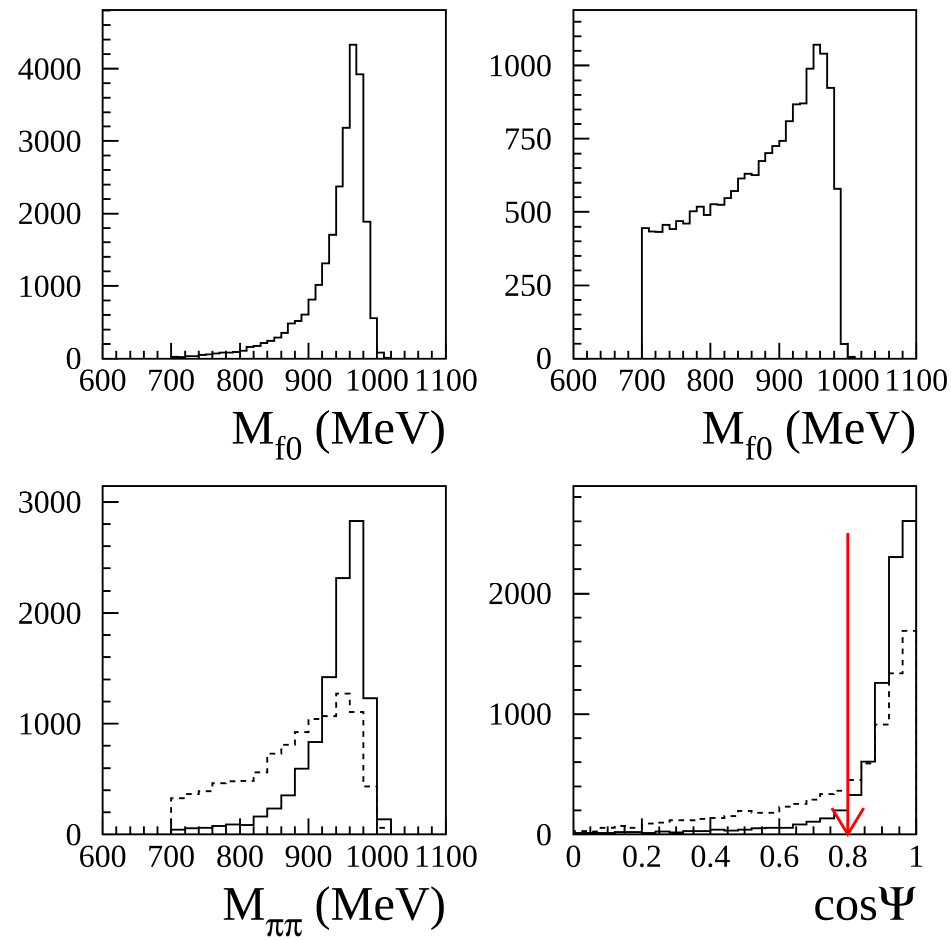


A new f_o model

The f_o invariant mass shape is strongly dependent on the meson nature

A new f_o model ($q\bar{q}q\bar{q}$), with an higher contribution from low masses, studied

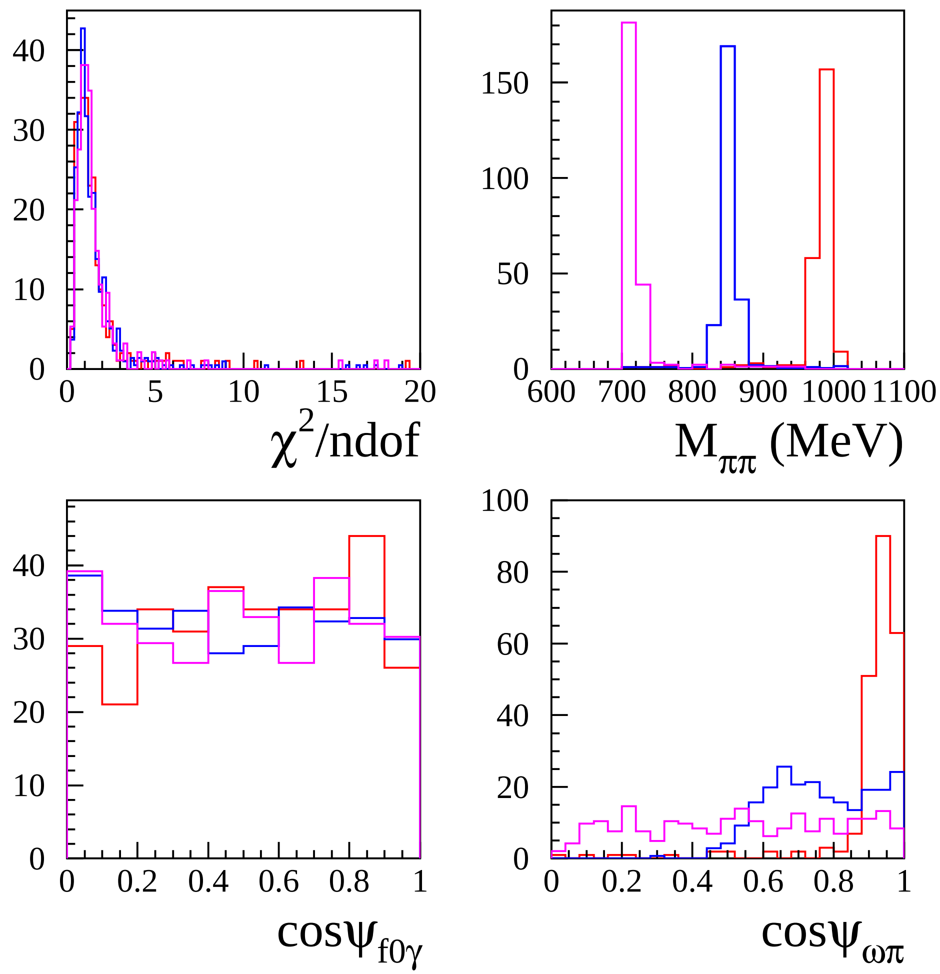
Only events with $M_{\pi\pi} > 700$ MeV considered



The $\cos\psi_{\omega\pi}$ cut is strongly dependent on $M_{\pi\pi}$ shape!

A new analysis scheme

$M_{f_o} = 700 \div 720$ MeV
$M_{f_o} = 860 \div 880$ MeV
$M_{f_o} = 980 \div 1000$ MeV



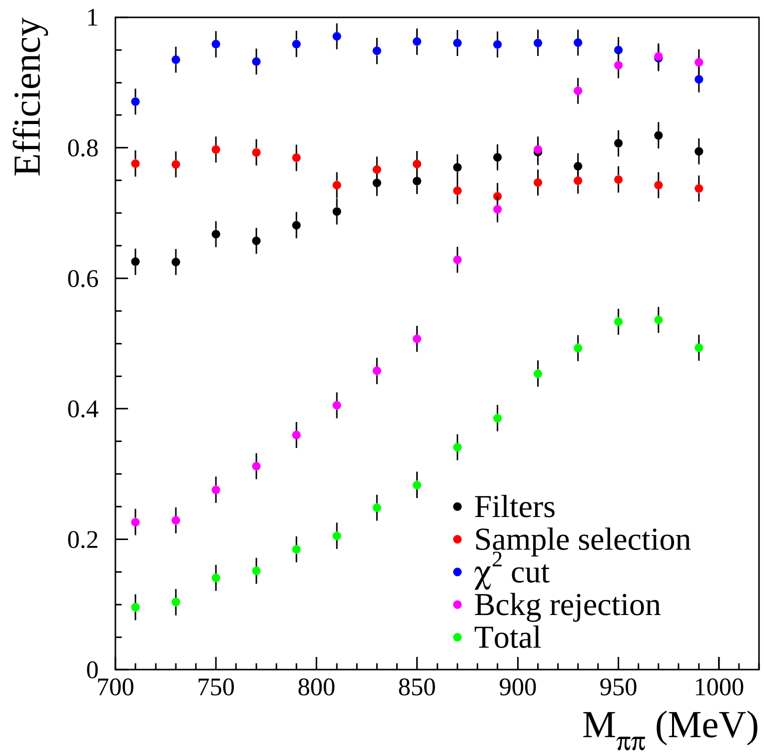
New cuts to select f_o events:

1. $\chi^2{}_{f_o\gamma}/\mathrm{ndof} < 5$
2. $\cos\psi_{\omega\pi} > 0.4$
3. $\omega\pi^o$ **veto**:

   rejection of events with $\chi^2/\mathrm{ndof}_{\omega\pi} < 3$ and $|M_{\pi\gamma} - M_\omega| < 3 \cdot \sigma_\omega$

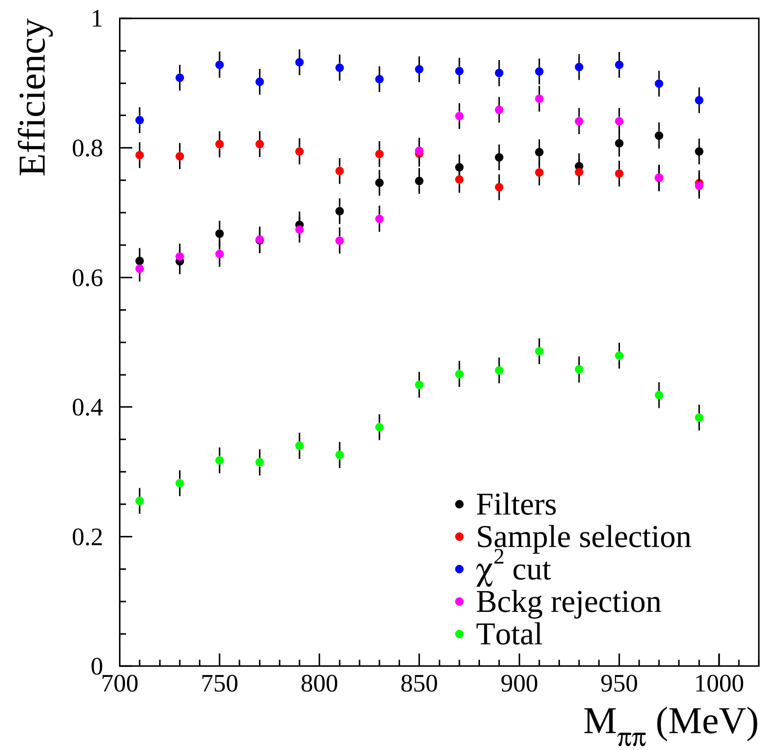
Efficiency comparison

Old analysis



Factor 4 of total variation

New analysis



Total variation of $\sim 30\%$

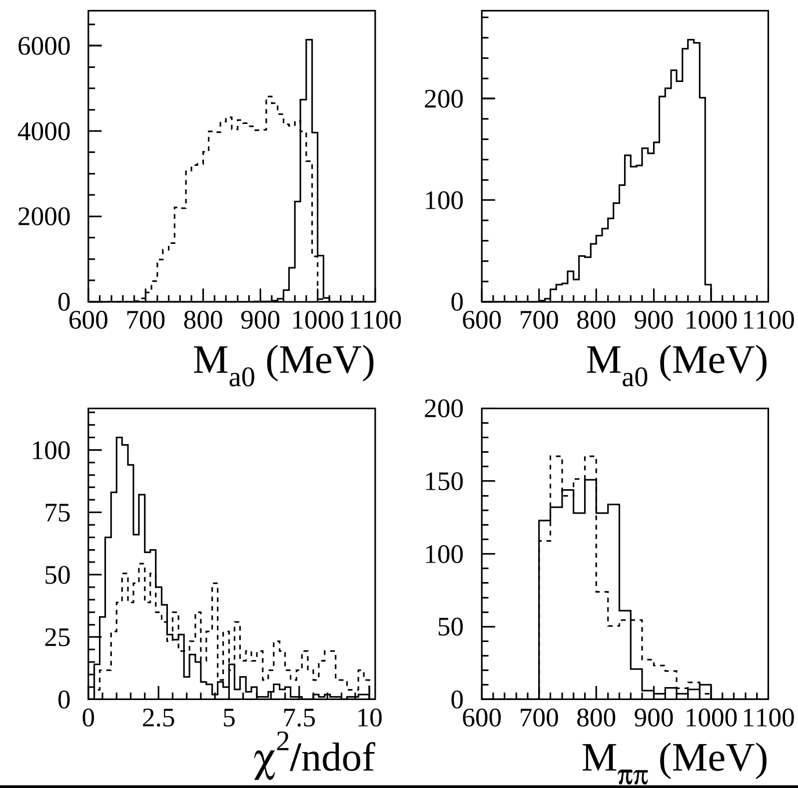
Effect of the new analysis on the background (1)

Background decay	Natural S/B	Analysis eff.	Final S/B
$e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma$	0.7	2.1%	13.2
$\phi \to \rho\pi^o \to \pi^o\pi^o\gamma$	2.7	6.5%	17.1
$\phi \to a_o\gamma \to \eta\pi^o\gamma \to \gamma\gamma\pi^o\gamma$	2.5	3.8%	27.7
$\phi \to \eta\gamma \to \pi^o\pi^o\pi^o\gamma$	0.02	0.1%	8.4

Also the a_o mass shape is not perfectly known

Different shapes bring to a different analysis efficiency

A MC flat distribution corrected to resemble the SND shape

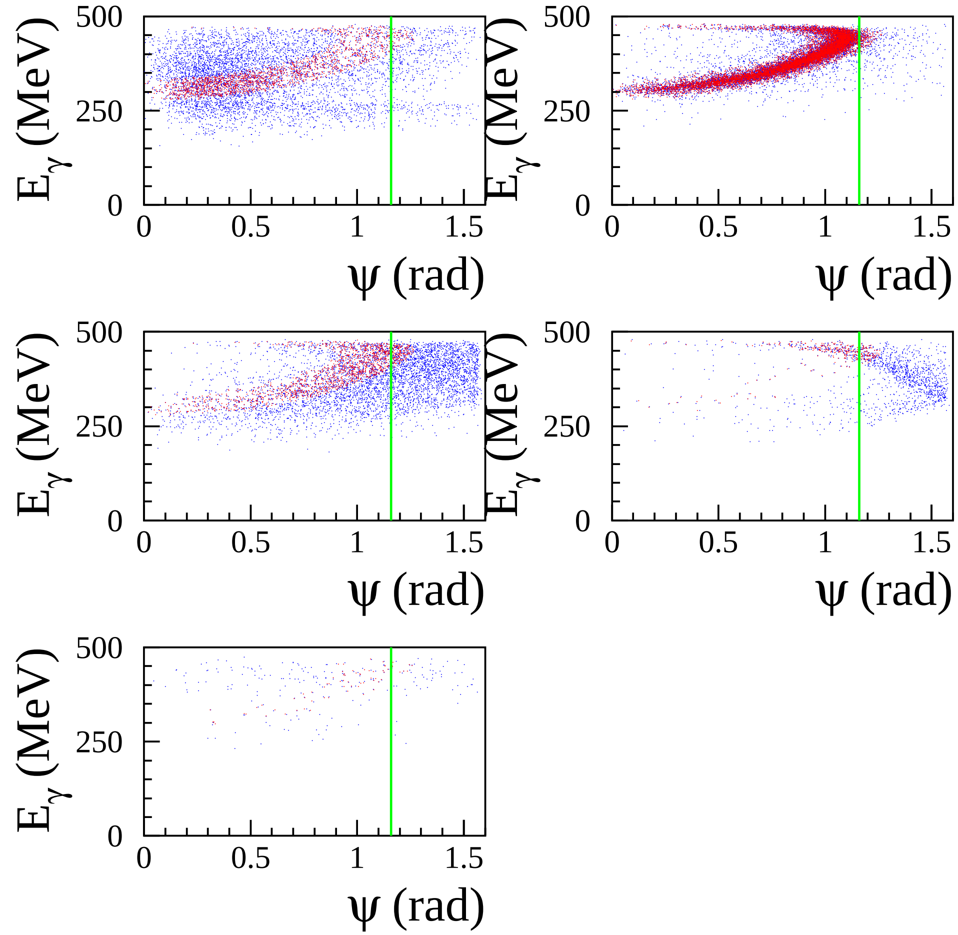


Effect of the new analysis on the background (2)

The effects of the new analysis cuts can be observed in the scatter plot of ω-photon energy *vs* the ψ angle

The red region is rejected by the $\omega\pi^o$ veto

The green line corresponds to the $\cos\psi_{\omega\pi}$ cut

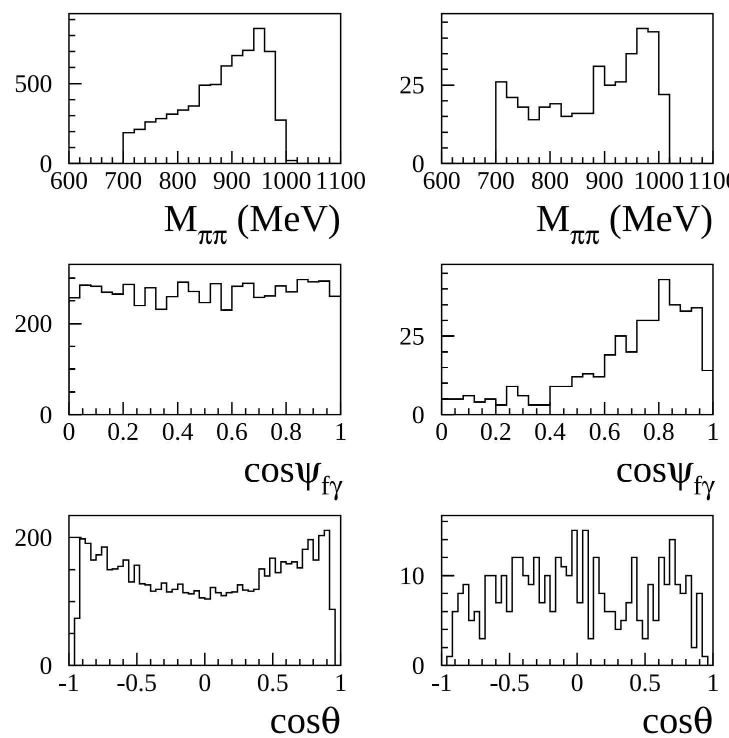


Technique for BR evaluation

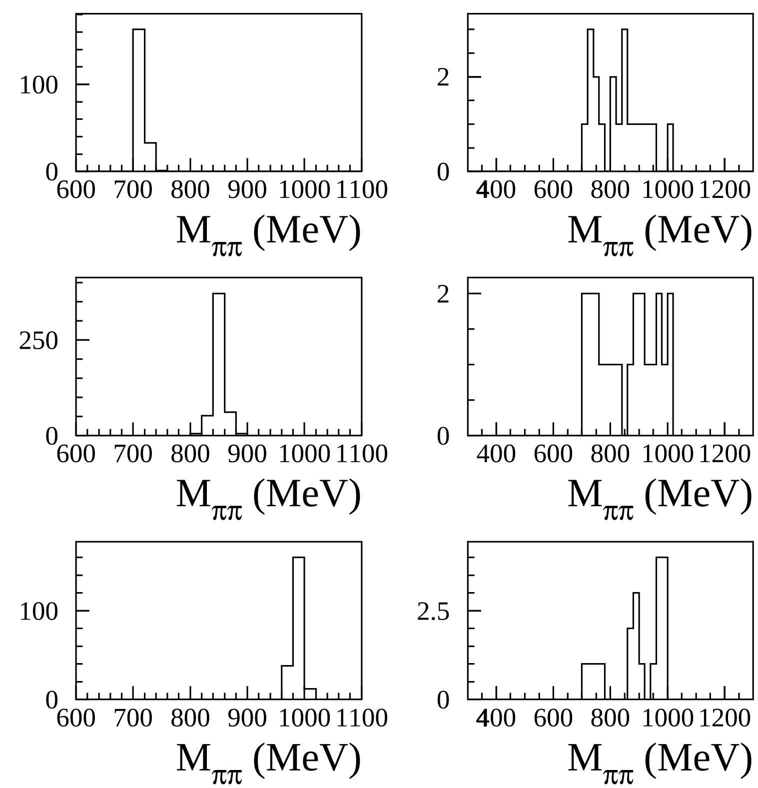
- Even assuming a perfect knowledge of the background, the observed spectrum can be corrected for the analysis efficiency on bin by bin basis only if the reconstruction effects do not modify the shape significantly
- In well reconstructed events the gaussian smearing is ~ 6 MeV
- A wrong photons' combination happens in 6% of the cases, giving rise to a different shape for the various quantities
- Also wrong clustering $(4 \div 5\%)$ give rise to distorted shapes
- To take into account these effects, a fit procedure that convolutes any theoretical dN/dM shape with the expected gaussian smearing and the wrong pairing distribution has been developed. These smearing effects have been applyed to one of the analytic function used for the EVA generator. The reconstructed $M_{\pi\pi}$ shape was successfully fitted with a smeared fit function
- Same fit procedure applyed on $q\bar{q}q\bar{q}$ MC production
- Once the procedure will be completed, it will be applied on data. BR will be evaluated directly from fit results and the new parameters will be used to reproduce the new shape in MC events

Effects of the wrong photons' combination

Complete $M_{\pi\pi}$ spectrum



Different slices of $M_{\pi\pi}$

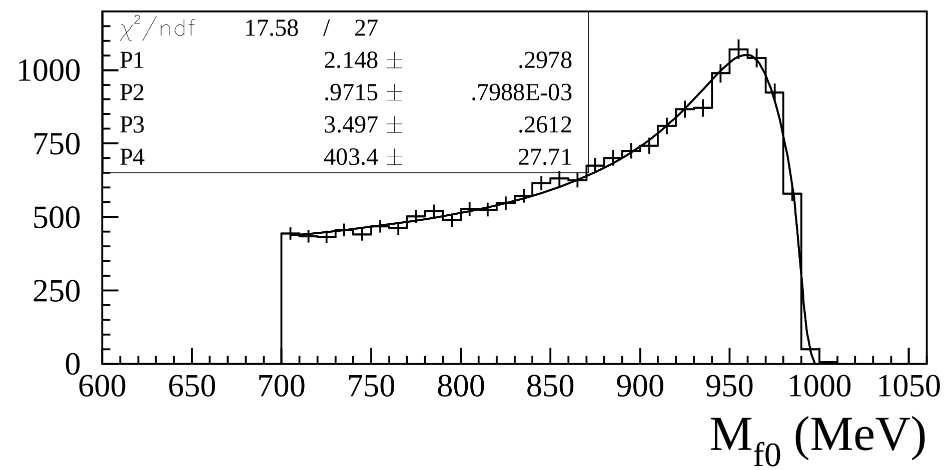


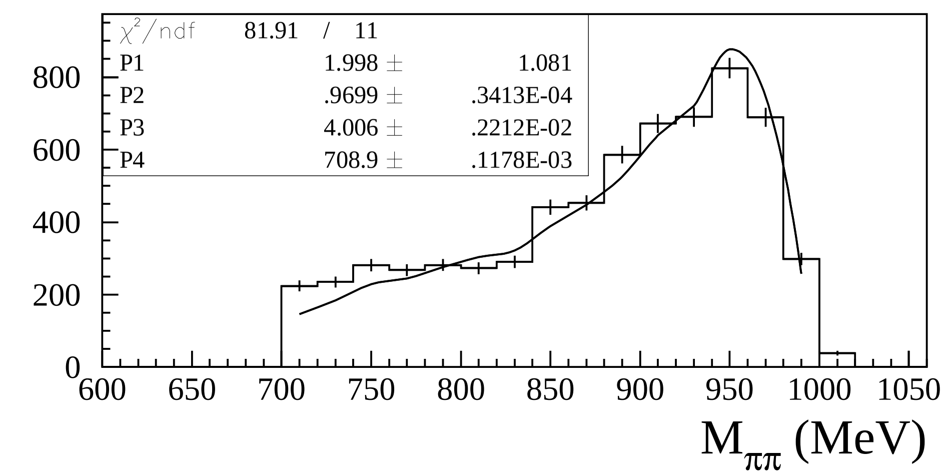
Fit to $q\bar{q}q\bar{q}$ GEANFI data

MC generated mass fitted with the analytic form

Same curve used to fit reconstructed mass using:

1. bin by bin analysis efficiency
2. 6 MeV gaussian smearing
3. bin by bin pairing efficiency, using a flat bad pairing distribution
4. no clustering effects taken into account



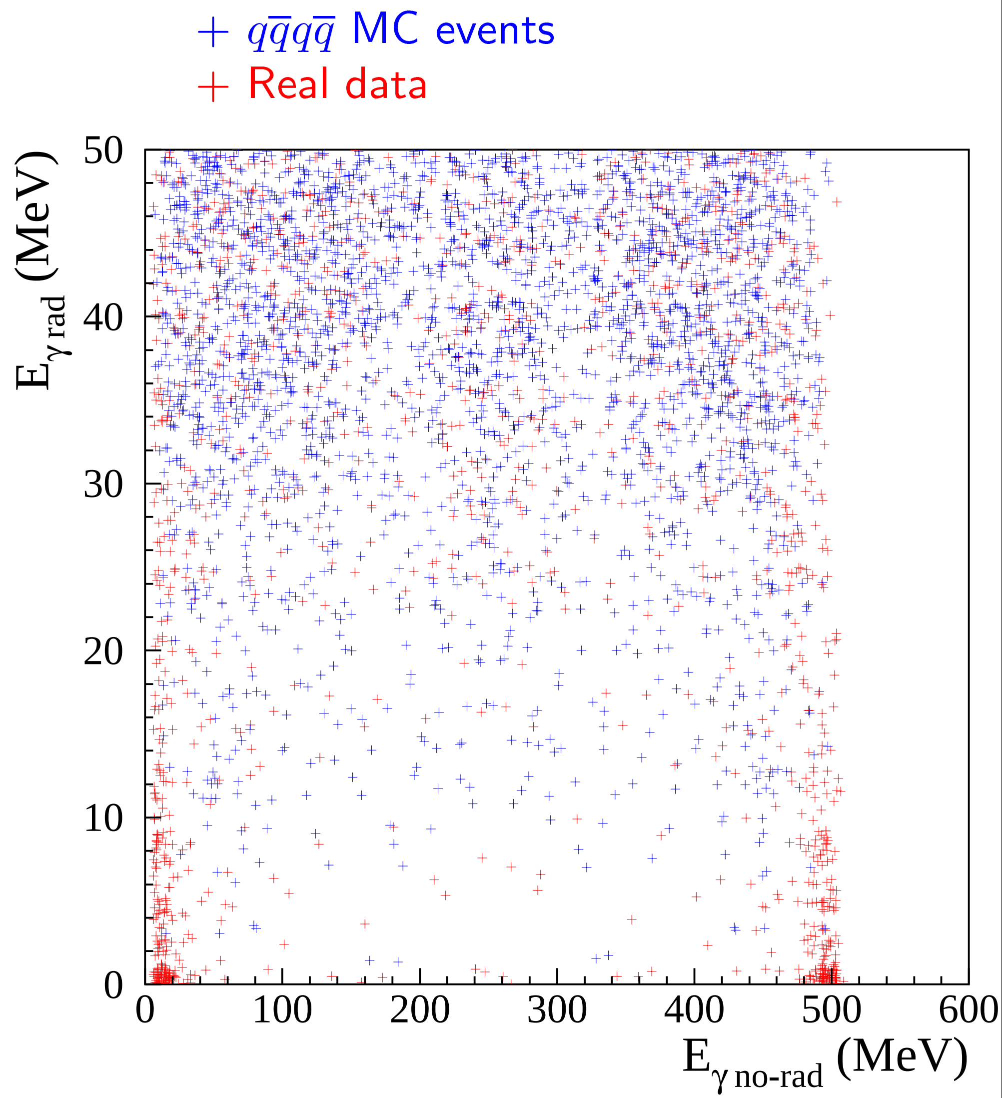


Analysis of 2000 data

New analysis scheme applied to 16970 nb^{-1} of the October-December 2000 KLOE data taking (runs $15174 \div 17330$)

Some contamination from 3 photons final state can be seen

A cut $E_{\gamma\ rad} > 10$ MeV reduces this background

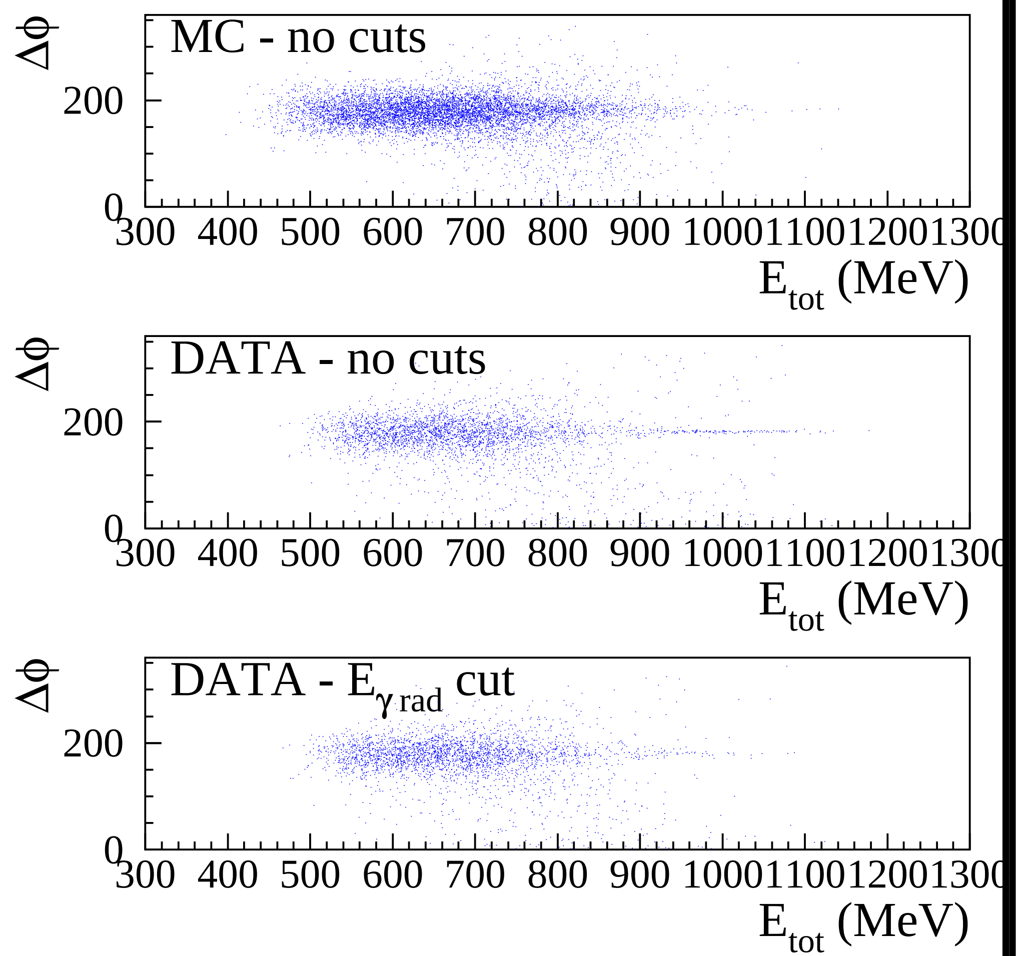


The $\gamma\gamma(\gamma)$ background rejection

- $\gamma\gamma(\gamma)$ background contamination can be observed studying the azimuthal angle difference ($\Delta\phi$) *vs* the sum of the energy of the two most energetic clusters ($E_{\rm tot}$) of the event

- The $E_{\gamma\ \rm rad}$ cut considerably reduce it

- Residual contamination is done rejecting the events with $E_{\rm tot} > 900$ MeV and $175° < \Delta\phi < 185°$



The $e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma$ decay

Analysis efficiencies (from MC):

Background decay	Natural S/B	Analysis eff.	Final S/B
$e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma$	—	53.7%	—
$\phi \to f_o\gamma \to \pi^o\pi^o\gamma$	1.5	9.8%	8.4
$\phi \to \rho\pi^o \to \pi^o\pi^o\gamma$	4.1	9.5%	23.0
$\phi \to a_o\gamma \to \eta\pi^o\gamma \to \gamma\gamma\pi^o\gamma$	3.8	3.8%	54.8
$\phi \to \eta\gamma \to \pi^o\pi^o\pi^o\gamma$	0.03	0.04%	47.1

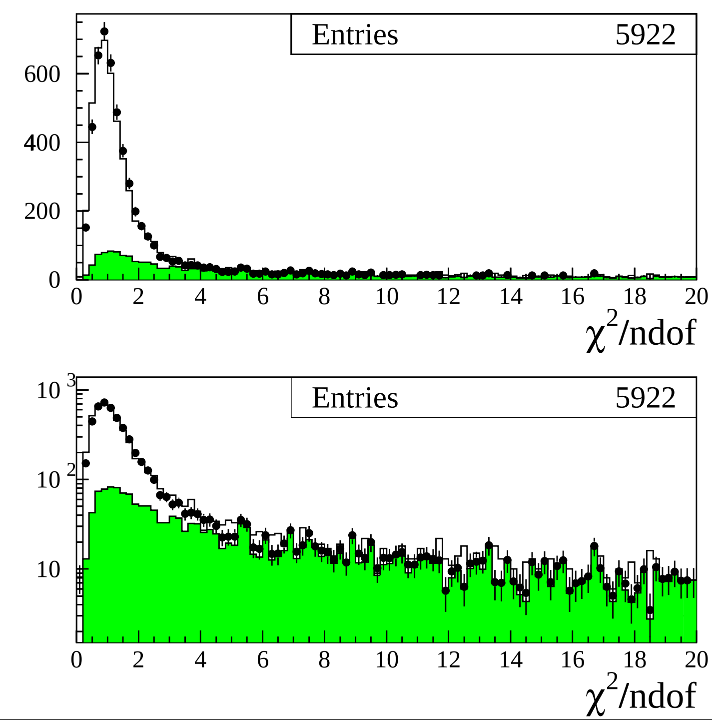
Number of events surviving analysis cuts:

$N(\text{TW cut}) = 24797$

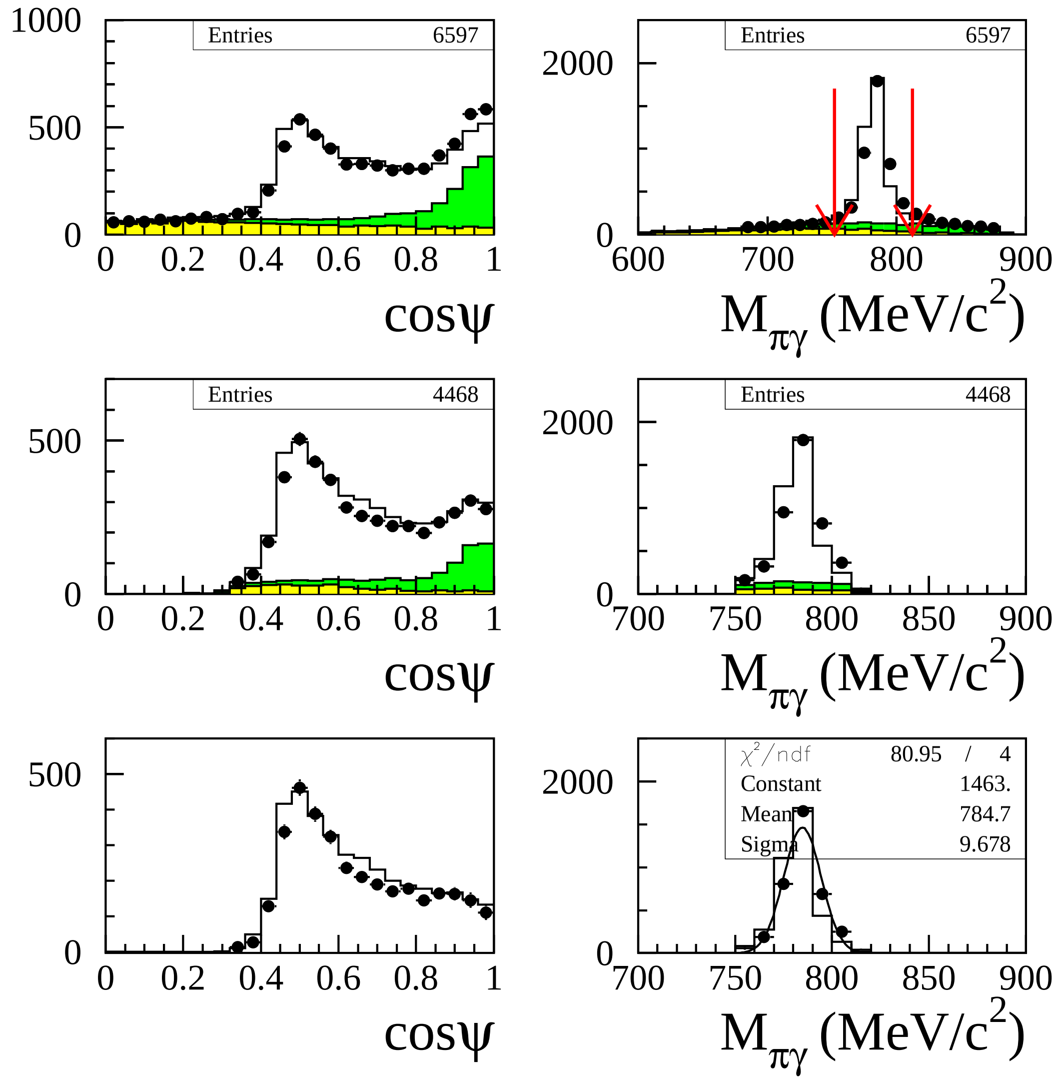
$N(\text{acc. cut}) = 17876$

$N(\chi^2\text{ cut}) = 6597$

$N(M_\omega\text{ cut}) = 4468$



The $e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma$ decay: final distributions



Expected background events:

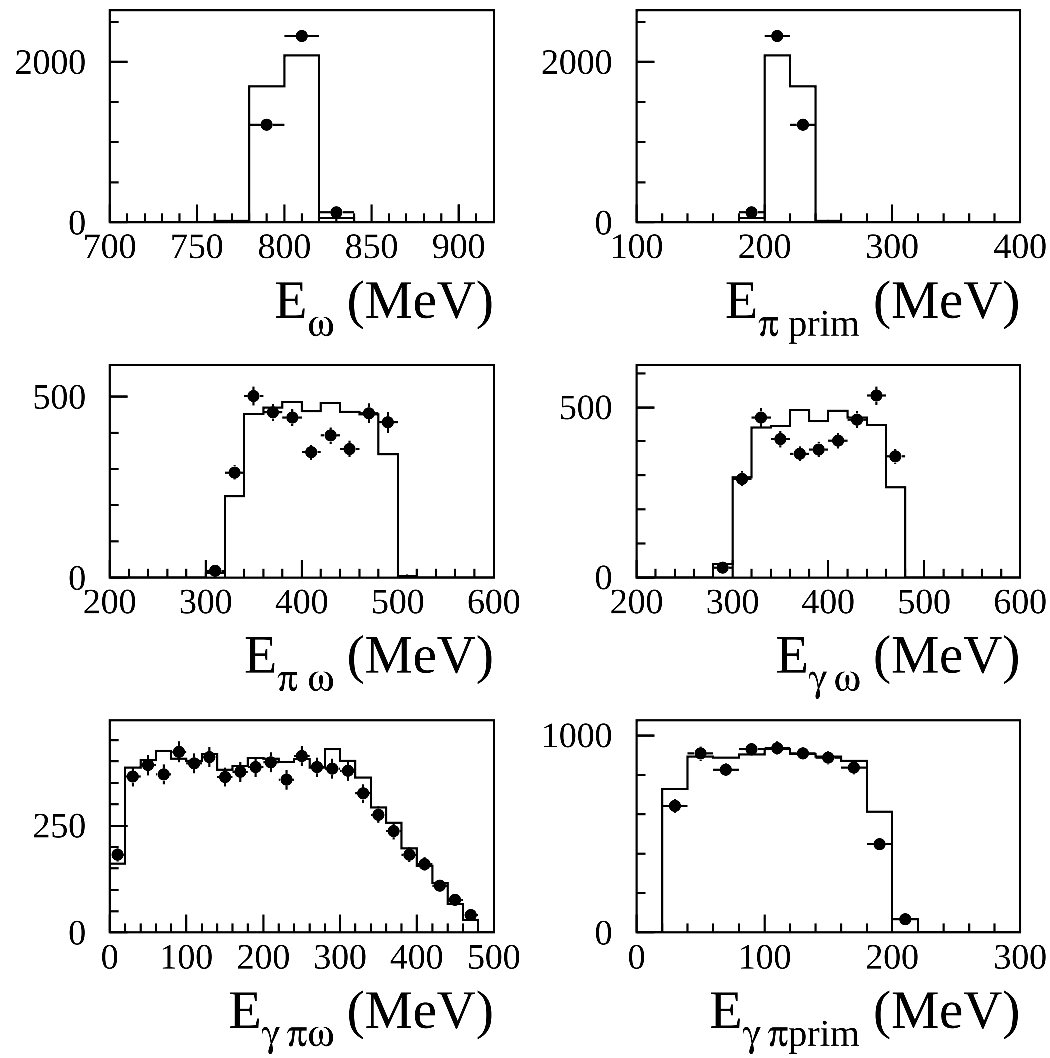
$N_{\rm bckg} = 776 \pm 28$

Final events counting:

$N_{\omega\pi} = 3692 \pm 72$

$\sigma(e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma) = (\, 0.405 \pm 0.008\,(\mathrm{stat.})\,)\ \mathrm{nb}$

The $e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma$ decay: energy distributions



The $\phi \to f_o\gamma \to \pi^o\pi^o\gamma$ decay

Number of events surviving analysis cuts:

$N(\text{TW cut}) = 24797$

$N(\text{acc. cut}) = 17876$

$N(\chi^2\ \text{cut}) = 4999$

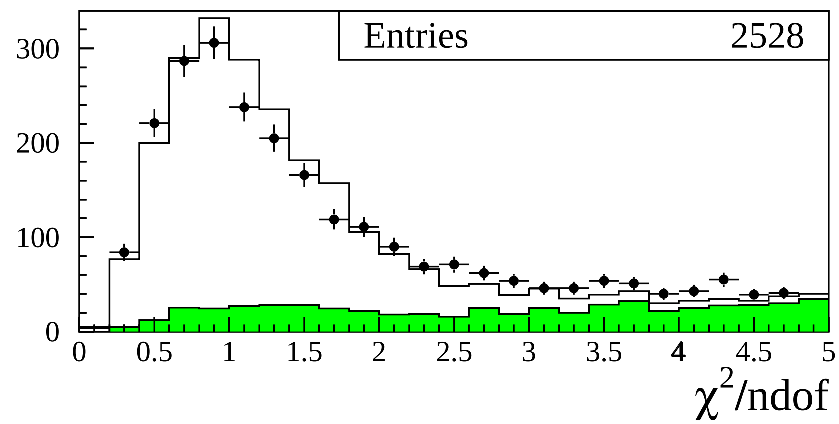
$N(\text{Bckg rej.}) = 2528$

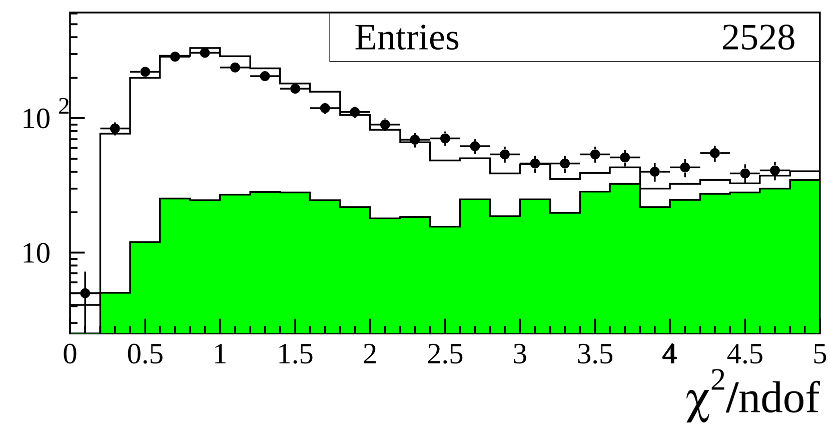
Expected background events:

$N_{\text{bckg}} = 568 \pm 24$

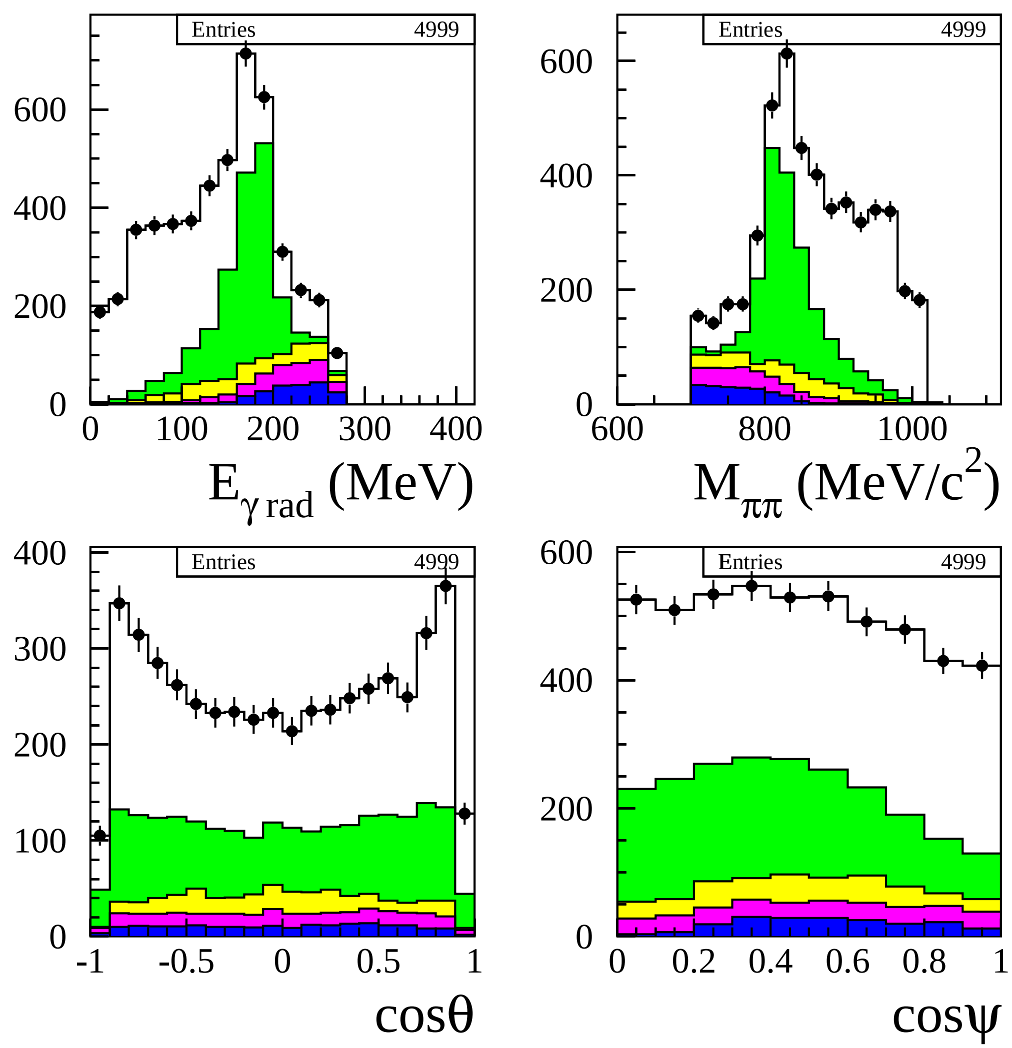
Final events counting:

$N_{f_o\gamma} = 1960 \pm 56$





The $\phi \to f_o\gamma \to \pi^o\pi^o\gamma$ decay: χ^2 cut

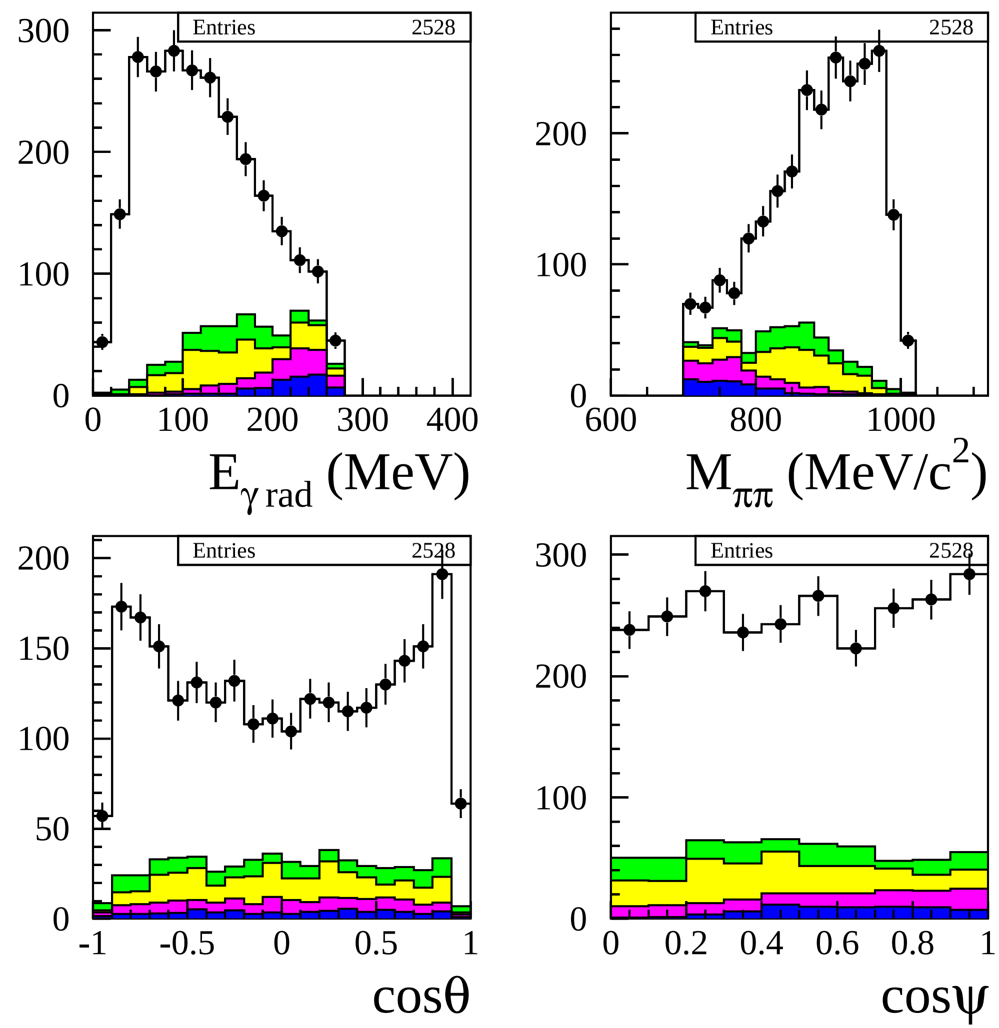


The $\phi \rightarrow f_o\gamma \rightarrow \pi^o\pi^o\gamma$ decay: background rejection

BR evaluated using:

- σ_ϕ from 3 γ's final states (KM234)
- Bin by bin analysis efficiency (wrong clustering and pairing not considered!)

For $M_{\pi\pi} > 700$ MeV:



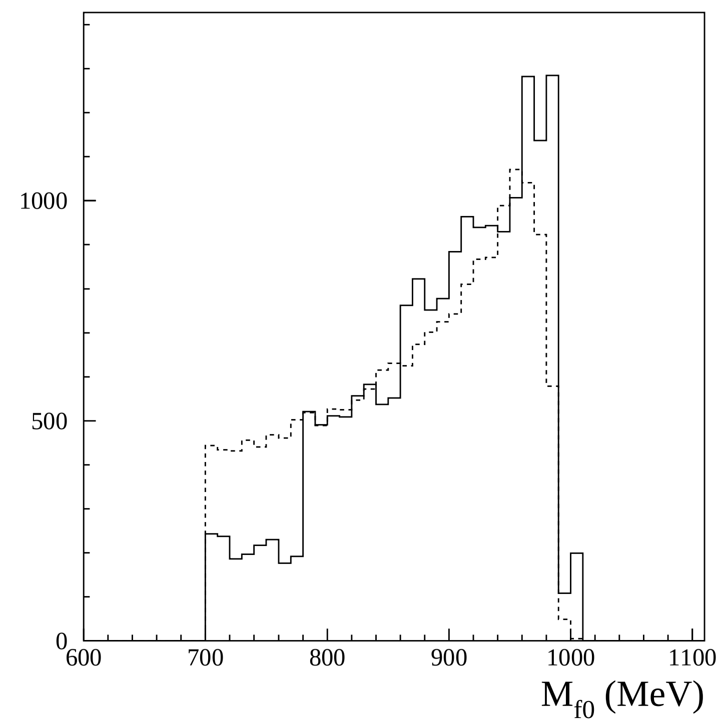
$$\mathbf{BR}(\phi \rightarrow f_o\gamma \rightarrow \pi^o\pi^o\gamma) = (\,\mathbf{0.87} \pm \mathbf{0.03}\,(\mathbf{stat.})\,) \cdot \mathbf{10^{-4}}$$

The $\phi \to f_o\gamma \to \pi^o\pi^o\gamma$ decay: Data–MC comparison

Fit procedure not complete & MC f_o mass shape arbitrarly choosen. The comparison is done in 4 steps:

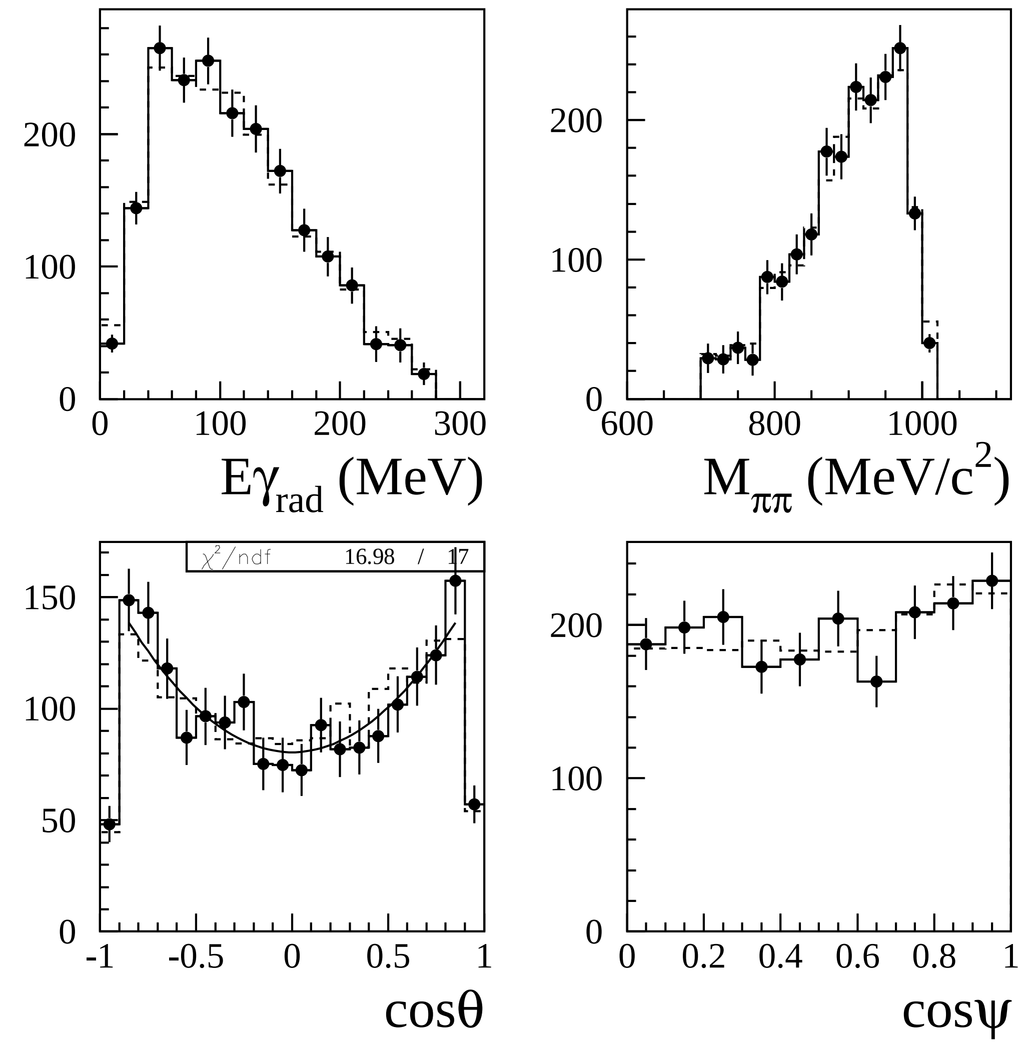
1. $f_o\gamma$ MC events analyzed in slices of $M_{\pi\pi}$ to obtain the various histograms shapes, for both $f_o\gamma$ and $\omega\pi^o$ events
2. For each mass bin, determination of the scale factor (ScF) that applied on the MC $M_{\pi\pi}$ shape reproduces data
3. ScF applied to all MC "sliced" histograms to reproduce all the spectra
4. Data–MC distributions compared

ScF can be applied to the original MC f_o mass distribution to check the new shape:

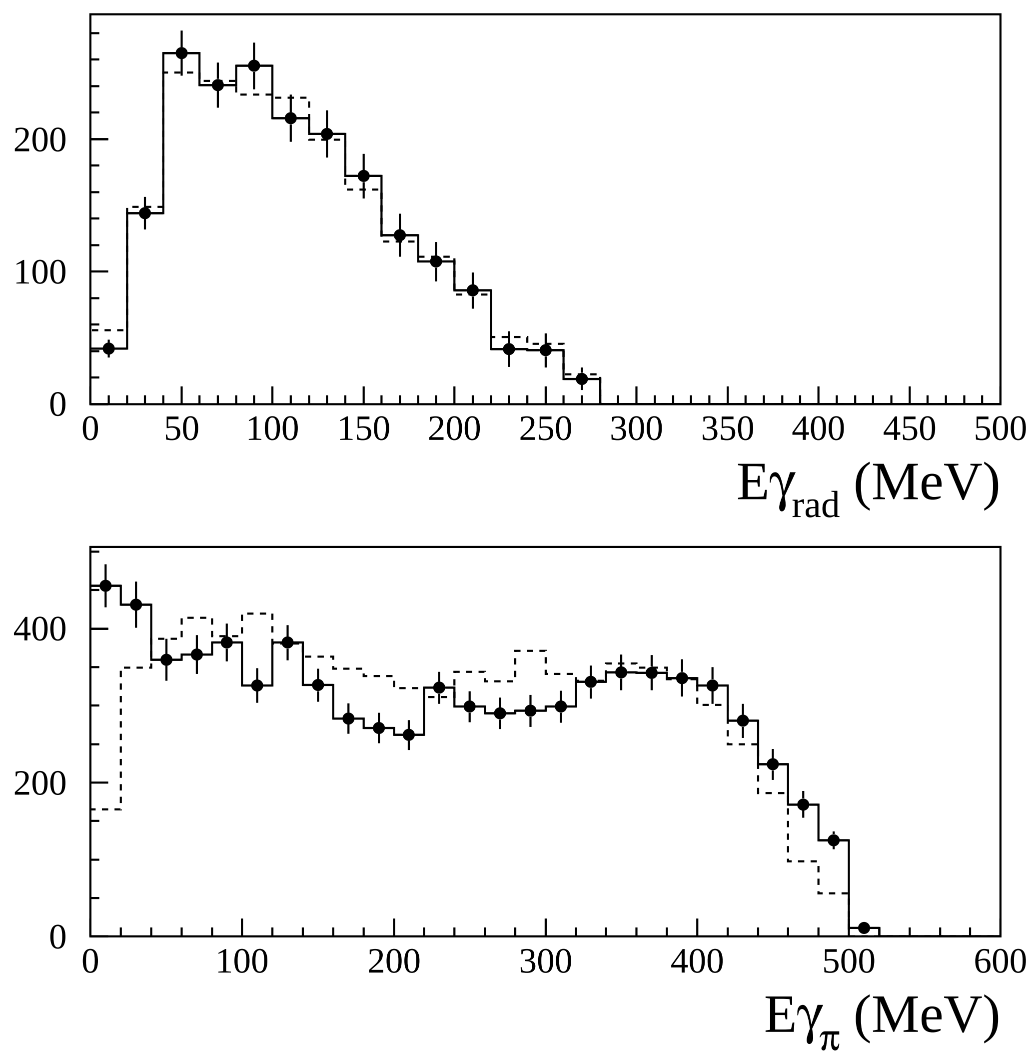


Using the ScF, the overall analysis efficency for the signal is $\varepsilon_{\mathrm{tot}} \sim 42\%$

The $\phi \rightarrow f_o\gamma \rightarrow \pi^o\pi^o\gamma$ decay: final distributions

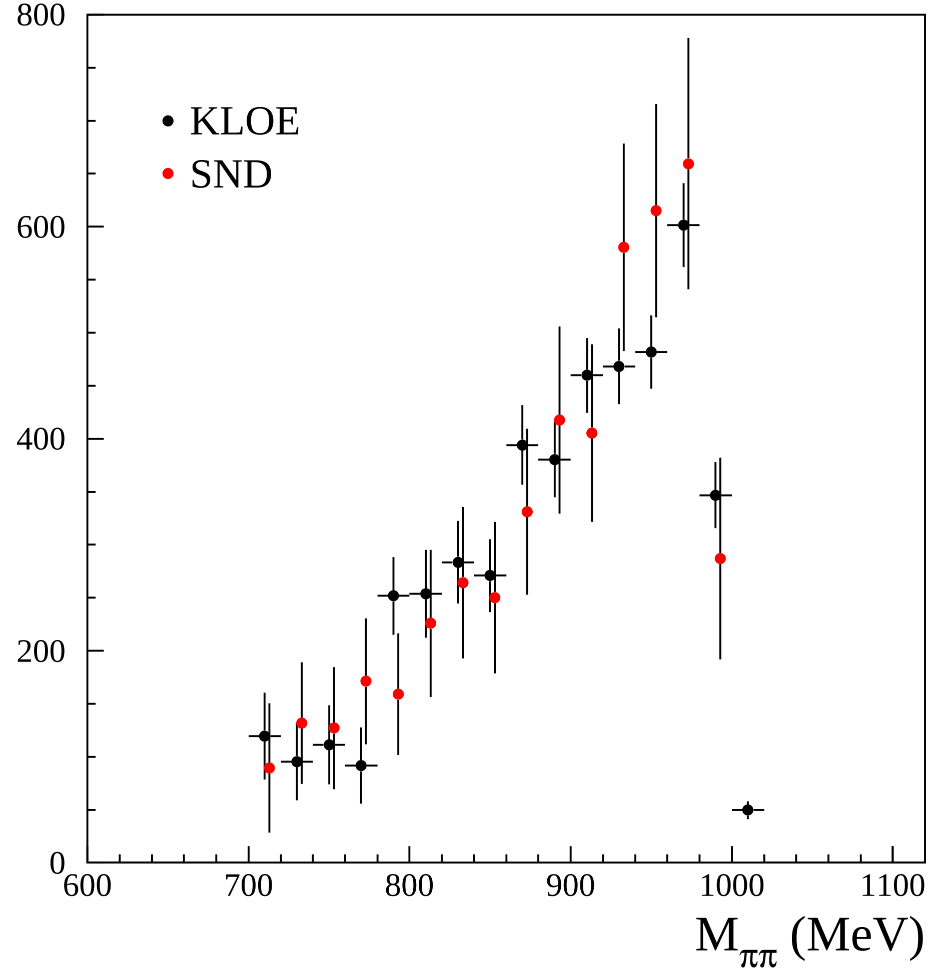


The $\phi \to f_o\gamma \to \pi^o\pi^o\gamma$ decay: energy distributions



The $\phi \longrightarrow f_o\gamma \longrightarrow \pi^o\pi^o\gamma$ decay: KLOE/SND comparison

- KLOE final distribution corrected for bin by bin analysis efficiency
- SND experimental values arbitrarly normalized



Conclusions

- **Analysis scheme modified in order to be less dependent on the f_o mass shape**
- **Fit technique developed to evaluate BR value indipendently from the model**
- **Search of $\phi \to \pi^o\pi^o\gamma$ decay performed using $\sim 17\ \mathrm{pb}^{-1}$ collected @ KLOE in year 2000**
- **Preliminary measurements, using bin by bin analysis efficiency, give:**

$$\mathrm{BR}(\phi \to f_o\gamma \to \pi^o\pi^o\gamma) = (\,0.87 \pm 0.03\,(\mathrm{stat.})\,) \cdot 10^{-4}$$

$$\sigma(e^+e^- \to \omega\pi^o \to \pi^o\pi^o\gamma) = (\,0.405 \pm 0.008\,(\mathrm{stat.})\,)\ \mathrm{nb}$$