

f- decays working group report

P.Gauzzi

- **Papers in preparation**
- **Update of published analyses**
- **New analyses**
- **Conclusions**

Papers in preparation

- $f \otimes p^+ p^- p^0$

(C.Bini)

- $f \otimes h \otimes p^+ p^- 7g$

(C.Di Donato)

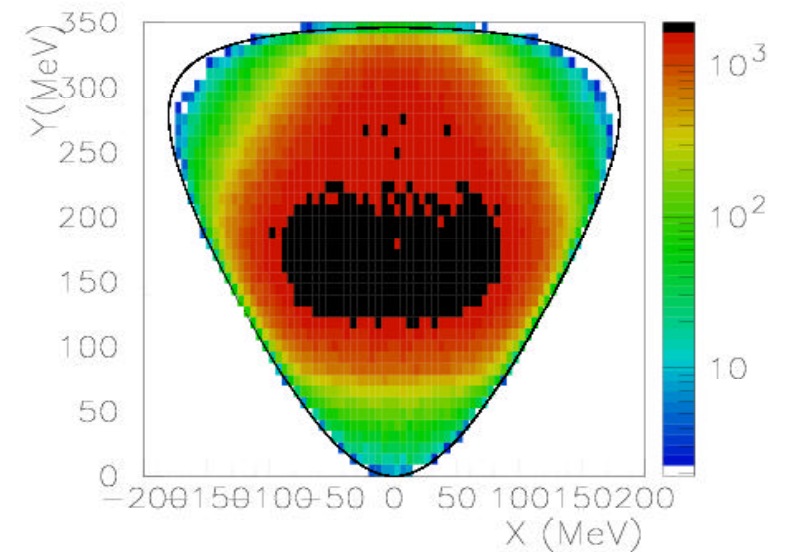
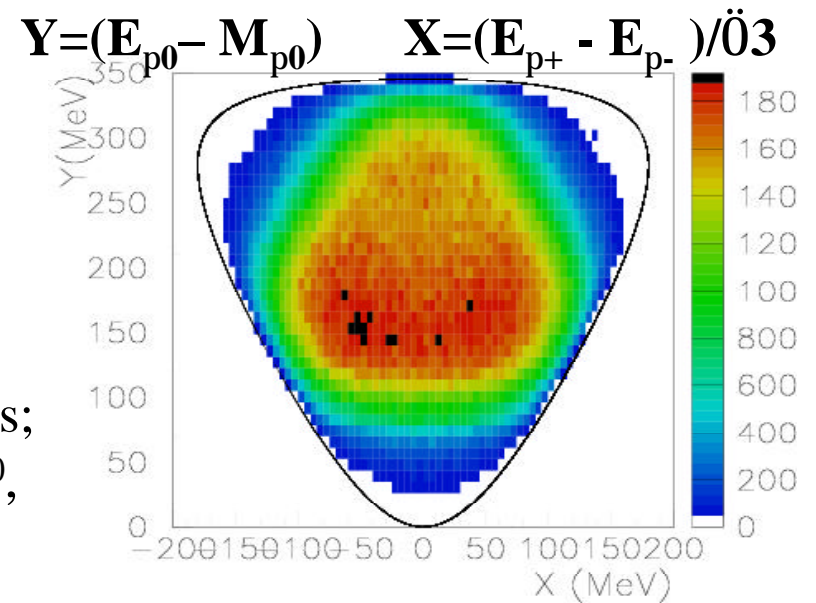
Status of the paper "f → rp" (C.Bini -19/12/2002)

- 27/11: **Draft 0** (*Phys.Lett. style*) submitted to referees M.Antonelli & L.Passalacqua.

"Study of the decay $f \rightarrow p^+p^-p^0$ with the KLOE experiment"

Reactions of the referees:

- refine momentum measurement corrections;
 - improve fit (more free parameters $\Gamma^+ \Gamma^- \Gamma^0$, effect of $\rho(1450)$);
 - minor corrections to the text.
- 1-10/12: Work done by M.Antonelli (with help of C.Bini): a further DC miscalibration is found affecting M(miss) measurement.
 - new correction (p vs θ dependence)
 - systematic at 200 keV level.
 - Work in Progress:
 - new results after momentum corrections;
 - try fit with different set of parameters.
 - ~15/1/2003: **Draft 1** (Draft 0 + minor corrections + "final" numbers) for second round with referees → submit to the collaboration.



Summary of results and comparison with KLOE and outer world (results are not “final”)

Measured quantity	Result	PDG	KLOE hadr. (G-S fit)
$M(r^0)$	$775.9 \pm 0.6 \pm 0.5$	771.1 ± 0.9 776.1 (CMD-2)	775.1 ± 0.1
$M(r^0)-M(r^\pm)$	$-0.5 \pm 0.3 \pm 0.5$	0.4 ± 0.8	-
$M(r^+)-M(r^-)$	$0.4 \pm 0.4 \pm 0.5$	-	-
$G(r)$	$145.2 \pm 1.2 \pm 0.8$	149.2 ± 0.7 144.5 (CMD-2)	147.0 ± 0.8
$BR(f \rightarrow p^+p^-p^0)_{\text{direct}}$	$(1.4 \pm 0.2) \times 10^{-3}$ (*)	$<0.6 \times 10^{-3}$ 90%CL (SND) $<5 \times 10^{-3}$ 90%CL (CMD2)	-
$s(e^+e^- \rightarrow wp^0, w \rightarrow p^+p^-)$ $BR(w \rightarrow p^0g) / BR(w \rightarrow p^+p^-)$	69 ± 7 pb (**) 6.6 ± 0.8	5.1 ± 0.9	-

(*) Evaluated using $BR(f \rightarrow p^+p^-p^0)$ from PDG

(**) Evaluated using $s(e^+e^- \rightarrow p^+p^-p^0)$ from KLOE

$$BR(j \rightarrow p^+p^-p^0)_{\text{direct}} = \frac{\int |A_{\text{direct}}|^2 dXdY}{\int |A_{\text{total}}|^2 dXdY} \times BR(j \rightarrow p^+p^-p^0)$$

$$s(e^+e^- \rightarrow wp^0 \rightarrow p^+p^-p^0) = \frac{\int |A_{\text{wp}}|^2 dXdY}{\int |A_{\text{total}}|^2 dXdY} \times s(e^+e^- \rightarrow p^+p^-p^0)$$

$f \rightarrow h g \rightarrow p^+ p^- \gamma$

C.Di Donato: KLOE Memo no.268

$f \rightarrow h g, h \rightarrow h p^+ p^-, h \rightarrow p^0 p^0 p^0$
 $h \rightarrow h p^0 p^0, h \rightarrow p^+ p^- p^0$

- **Status of the paper:**

- 10^7 MC evts. analyzed for $f \rightarrow K_S K_L, K_S \rightarrow p^+ p^-$ and $K_L \rightarrow 3p^0, \bar{P}$ no event selected \bar{P} upper limit @ 90% CL reduced from 18 to 0.5 events (statistics of year 2000)
- study of systematics in progress
- analysis of 2001 and 2002 data started

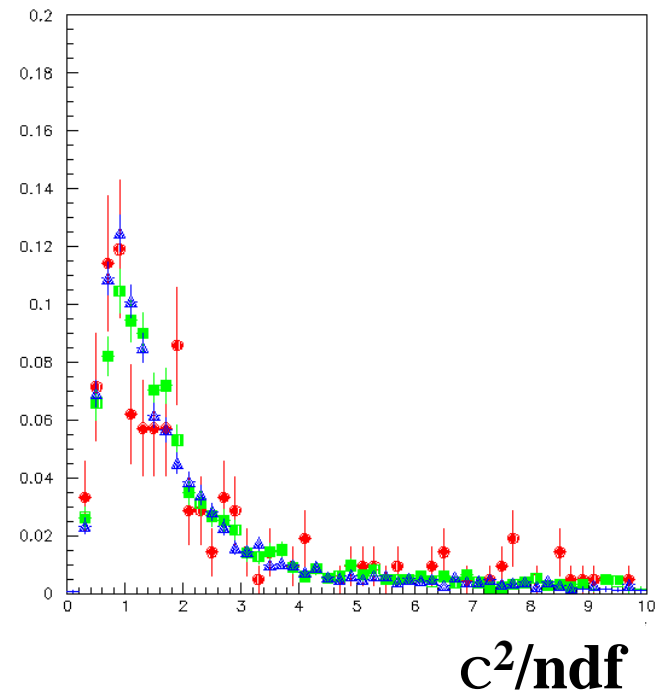
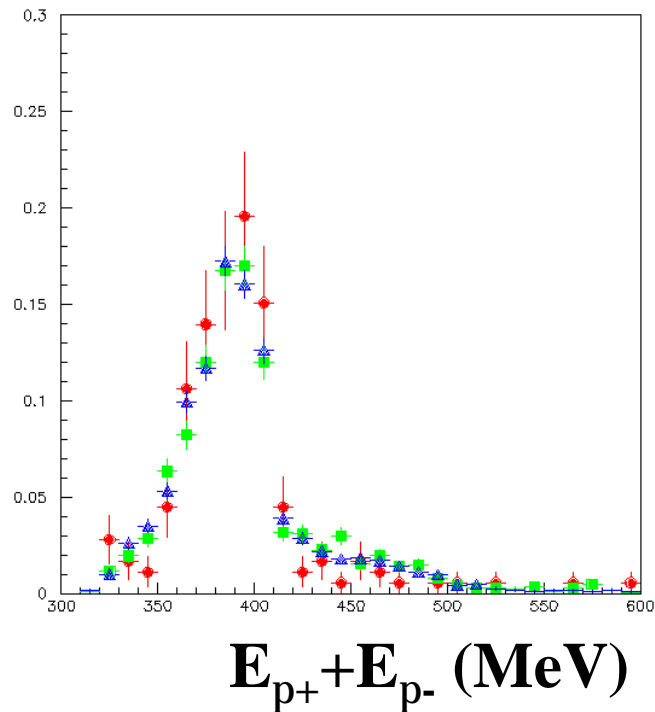
$f \rightarrow h g \rightarrow p^+ p^- \gamma$

- Comparison:

2000: 16.3 pb⁻¹ \rightarrow 179 evts. \rightarrow 11.0 ev./pb⁻¹

2001: 118 pb⁻¹ \rightarrow 1645 evts. \rightarrow 13.9 ev./pb⁻¹

2002: 223 pb⁻¹ \rightarrow 3008 evts. \rightarrow 13.4 ev./pb⁻¹



$f \otimes h \otimes g \otimes p^+ p^- \gamma$


- **Schedule:**

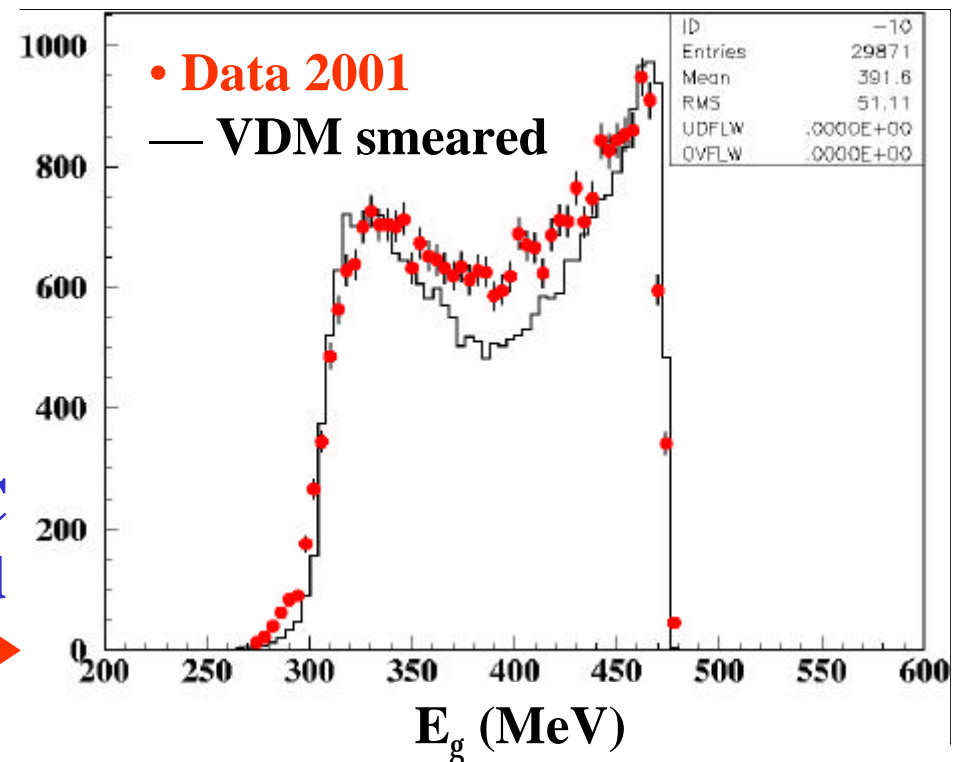
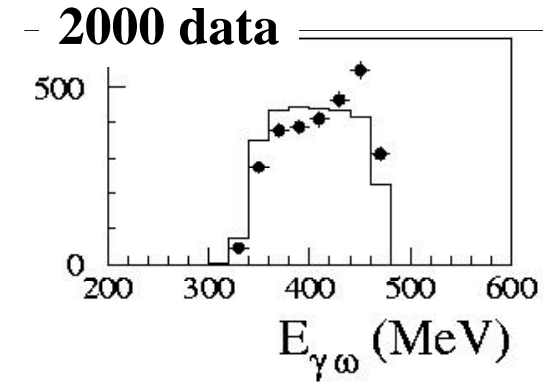
- **end of February 2003 : update of Memo 268 (2000 data)**
- **study of systematics for 2001/2002 (ntuples are ready)**
- **first draft of paper**

Update of previous analyses

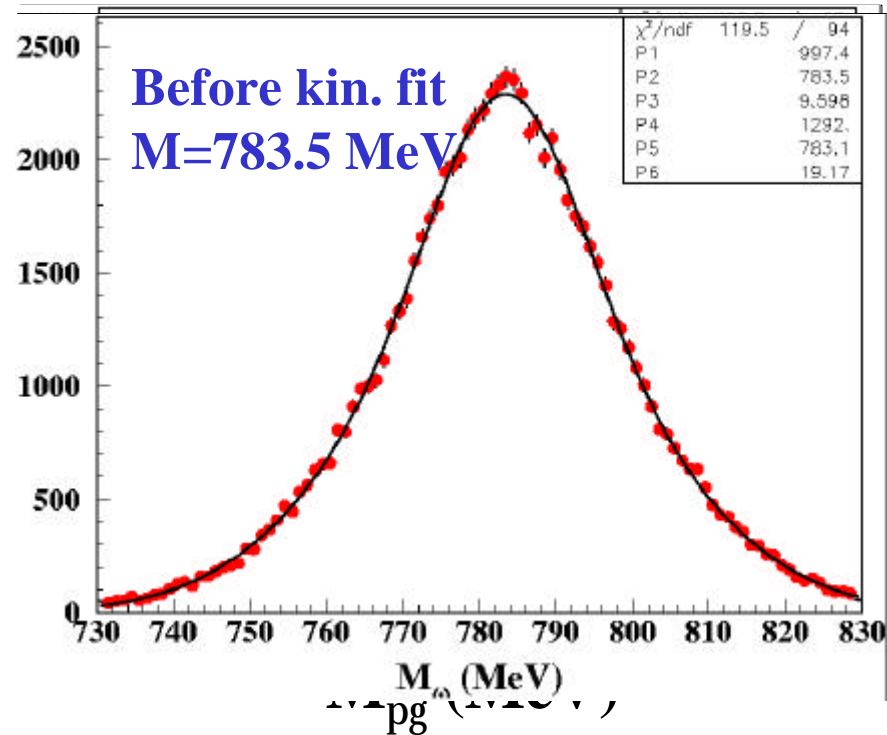
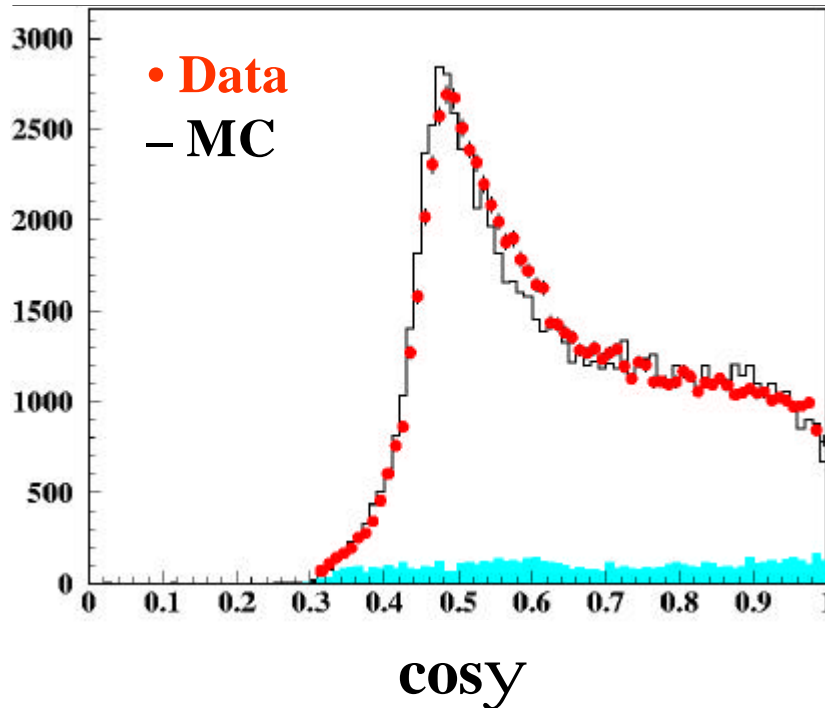
- 5 photon final state: $a_0 g / f_0 g$ (wp^0) (P.G.)
- $f \rightarrow h(h^0)g \rightarrow p^+ p^- 3g$ (F.Ambrosino)

$e^+e^- \rightarrow w p^0 ; w \rightarrow p^0 g$

- Bckg. for a_0 and f_0
- Data-MC discrepancy:
process simulated as a sequence
of two body decays without any
correlation between g and w
- VDM calculation of
 $e^+e^- \rightarrow w p^0 \rightarrow p^0 p^0 g$
(Achasov-Gubin PRD63 (2001)
by replacing r with w)
- After weighting the existing MC
with the ratio between VDM and
“wrong” E_g distributions 



$e^+e^- \rightarrow \omega p^0$; $\omega \rightarrow p^0 g$



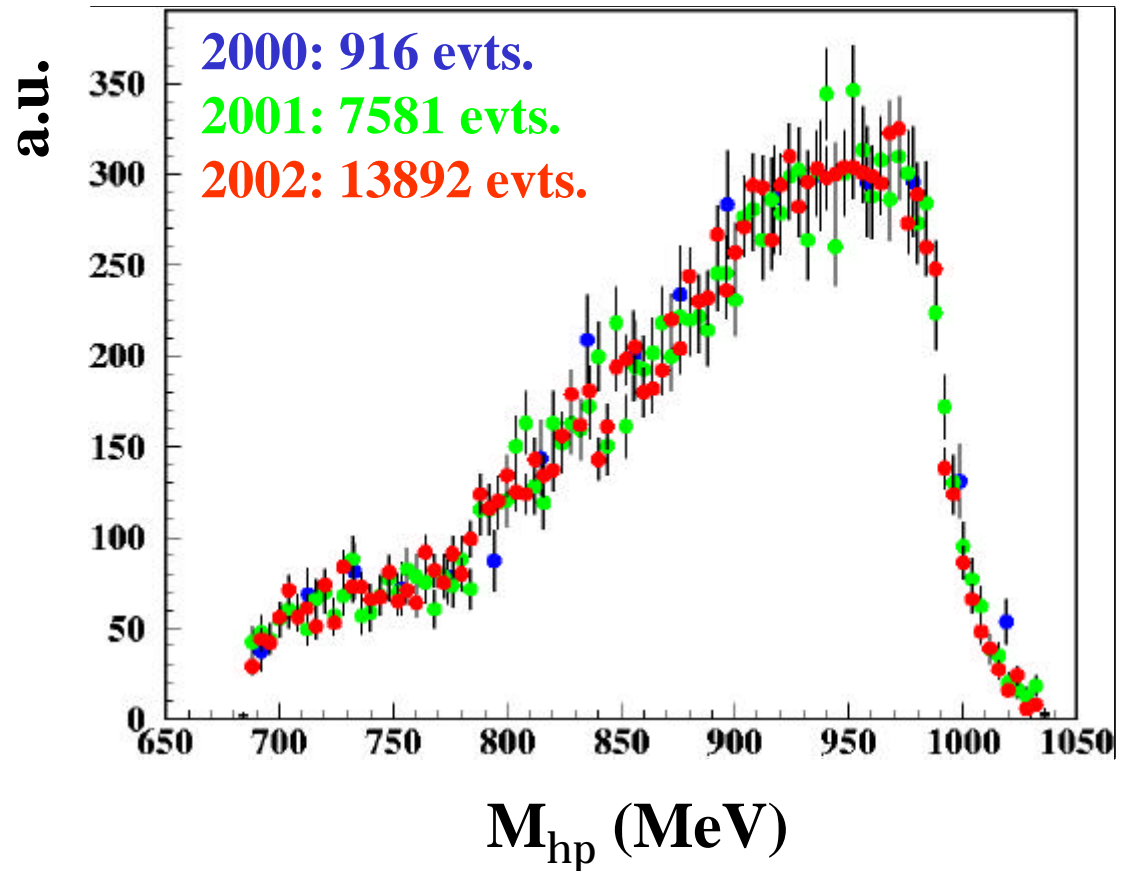
- 2001+2002 data: 86500 events

- $M_\omega = 785.4 \text{ MeV} (+0.4\%)$
effect of the kinematic fit

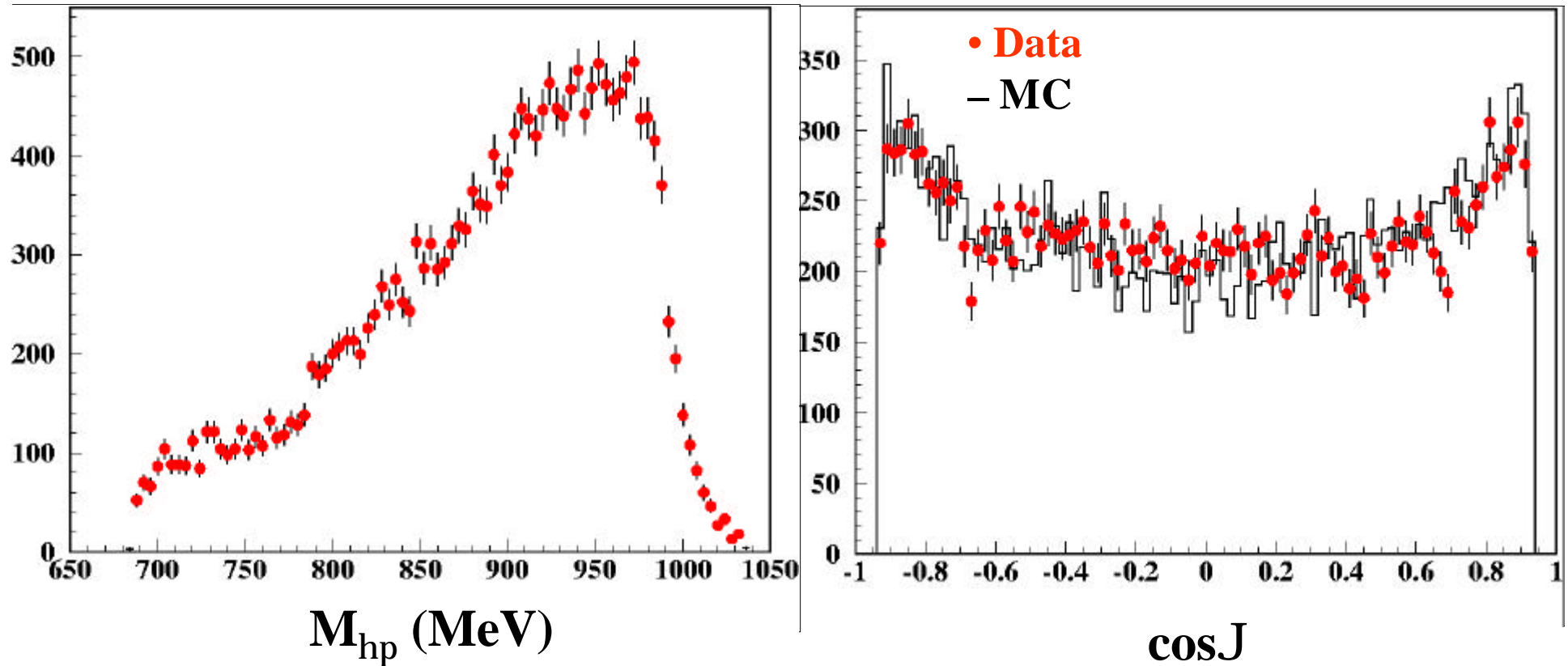
- Preliminary evaluation: $\sigma(e^+e^- \rightarrow \omega p^0 \rightarrow p^0 p^0 g) = 0.43 \text{ nb}$
($0.46 \pm 0.01 \pm 0.03 \text{ nb}$ – KLOE Note 178), but full simulation needed

f[Ⓜ]hp⁰g

- Same analysis of 2000
- Integr. luminosity:
 - 2000: 16.3 pb⁻¹
 - 2001: 140 pb⁻¹
 - 2002: 260 pb⁻¹
- Event numbers
 - 2000: 56 evts./pb⁻¹
 - 2001: 54 evts./pb⁻¹
 - 2002: 53 evts./pb⁻¹



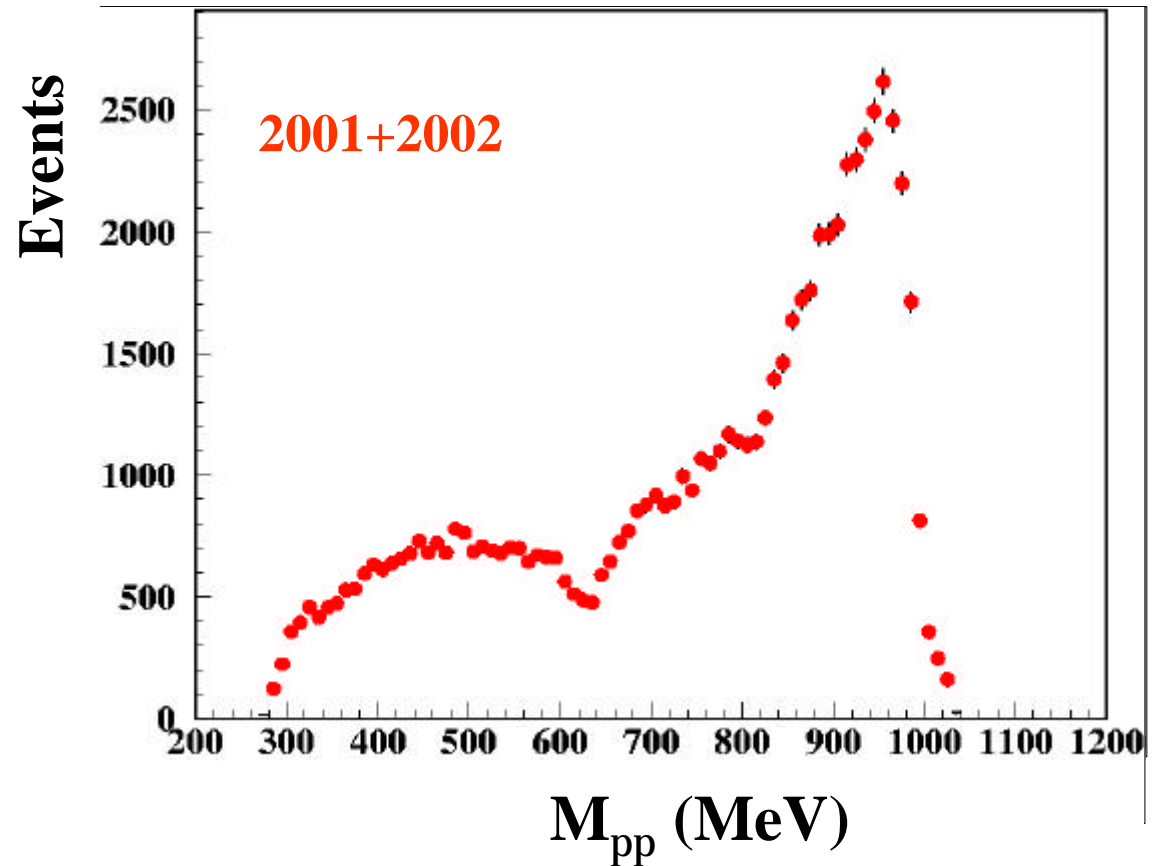
f⁰ hp⁰g



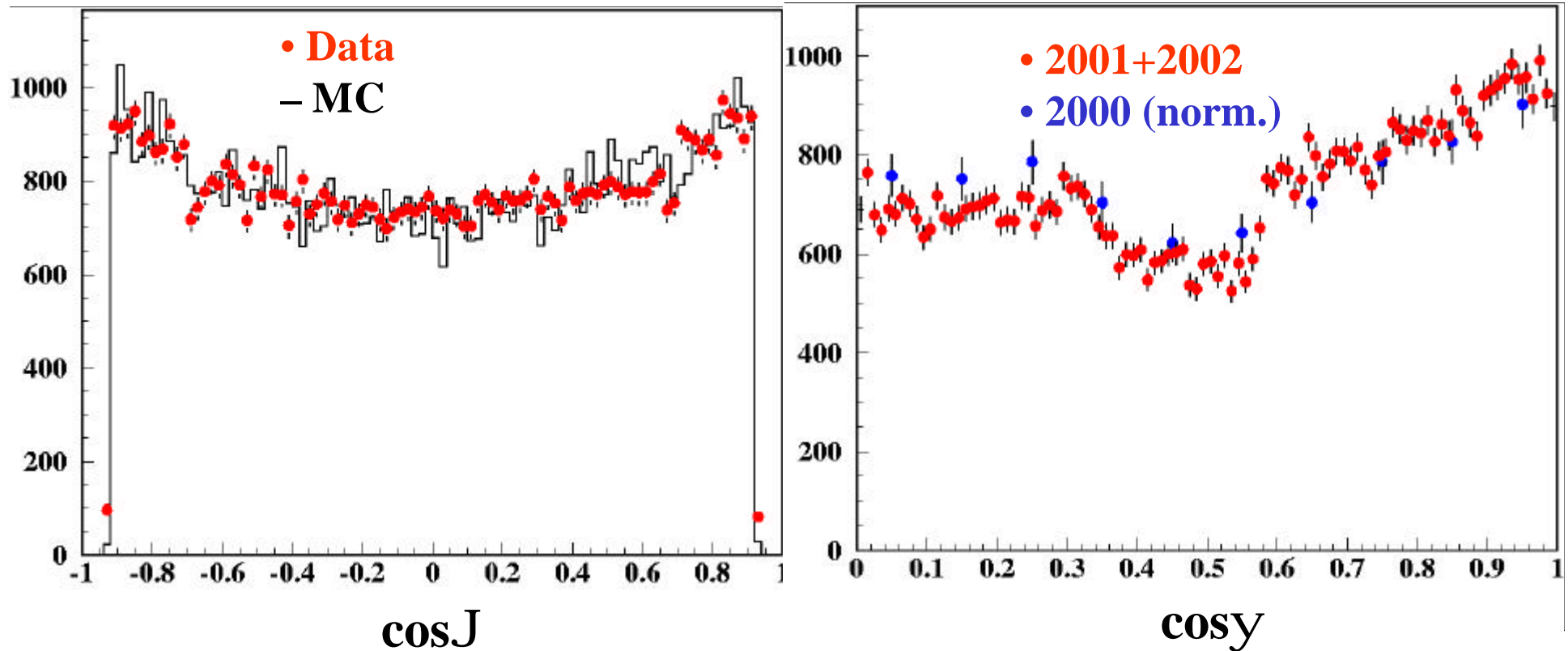
- 2001+2002: 21743 events

$f^{\circledast} p^0 p^0 g$

- Same analysis of 2000
- Integr. luminosity:
 - 2000: 16.3 pb⁻¹
 - 2001: 140 pb⁻¹
 - 2002: 260 pb⁻¹
- Event numbers:
 - 2000 : 190 evts./pb⁻¹
 - 2001 : 182 evts./pb⁻¹
 - 2002 : 183 evts./pb⁻¹
 - ↳ ~4% less events
- 2001+2002: 73142 events



$f^0 p^0 p^0 g$

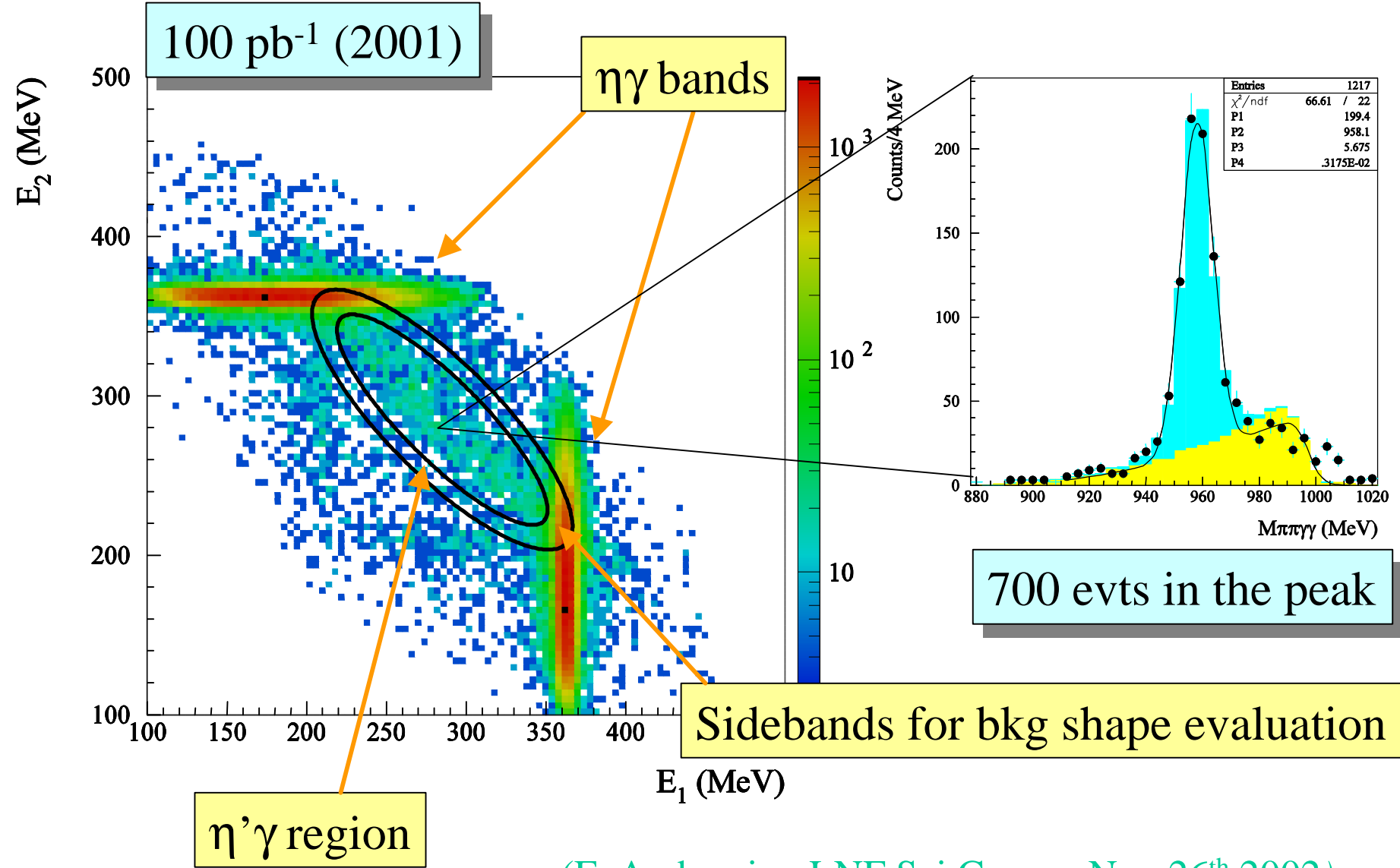
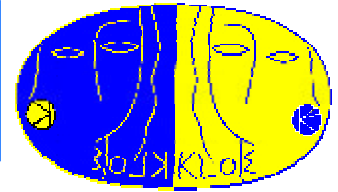


- $\cos y$ shape slightly different, but this shape depends on the analysis cuts \mathcal{P} differences in the w_{p^0} rejection

a_0/f_0 analysis

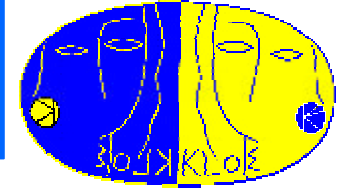
- 2001, 2002 data are in reasonable agreement with 2000 ones
- small differences for the f_0 to be understood
- Background subtraction:
 - need full wp^0 simulation (Achasov parametrization in GEANFI)
 - need better $f \otimes hg \otimes p^0 p^0 p^0 g$ understanding
- After that fit the new spectra:
 - a_0 : combined fit of $5g$ and $p^+ p^- 5g$ spectra (with a_0 mass free)
 - f_0 : fit to different models $P \ S(500)$?

f⁰h(h')g⁰p⁺p⁻ggg update

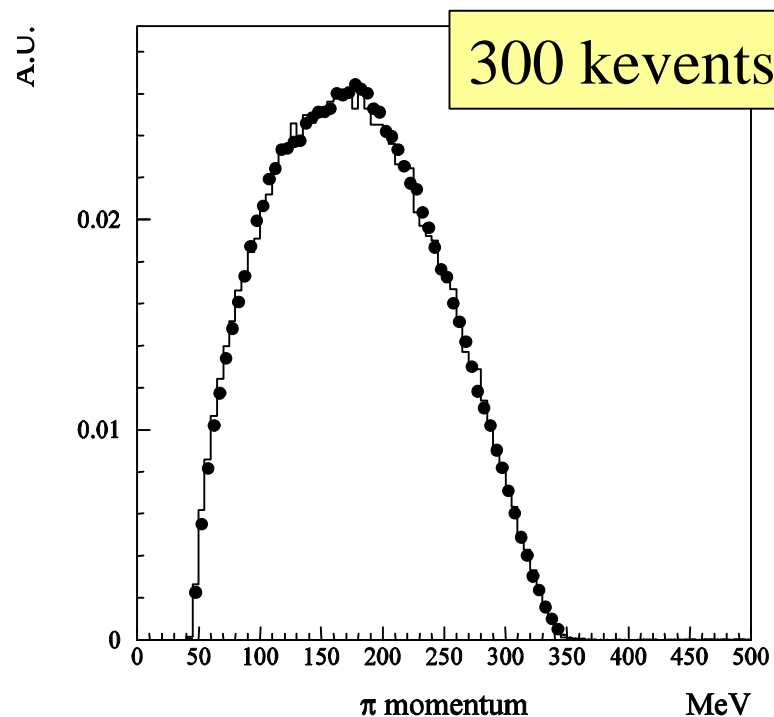


(F. Ambrosino LNF Sci.Comm. Nov 26th 2002)

h- h' ratio



The selected number of $\eta\gamma$ events scales with luminosity within errors as expected. Events are very clean with background $<1\%$



Year 2000 (16.3 pb⁻¹):

$$N_{\eta'\gamma}/N_{\eta\gamma} = (2.4 \pm 0.24_{\text{stat}} \pm 0.1_{\text{bkg}}) \cdot 10^{-3}$$

Year 2001 (preliminary) (100 pb⁻¹):

$$N_{\eta'\gamma}/N_{\eta\gamma} = (2.2 \pm 0.09_{\text{stat}} \pm 0.05_{\text{bkg}}) \cdot 10^{-3}$$

(F. Ambrosino LNF Sci.Comm. Nov 26th 2002)

New analyses

• $f_0 \textcircled{R} p^+ p^-$

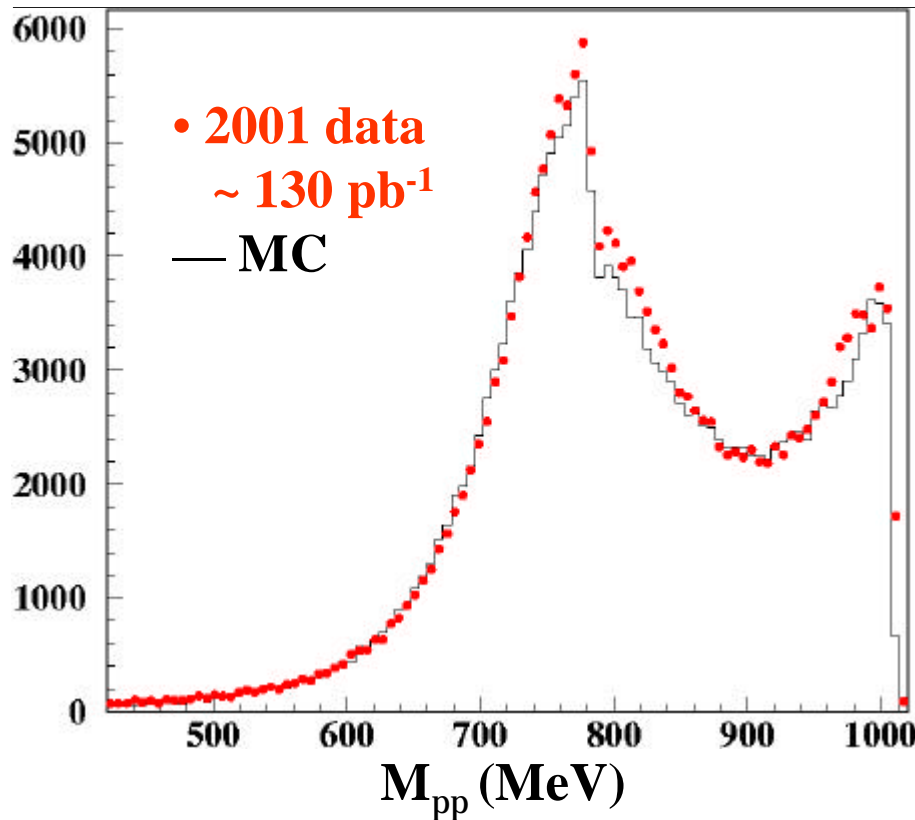
(C.Bini – S.Ventura)

• $h \textcircled{R} p^0 gg$

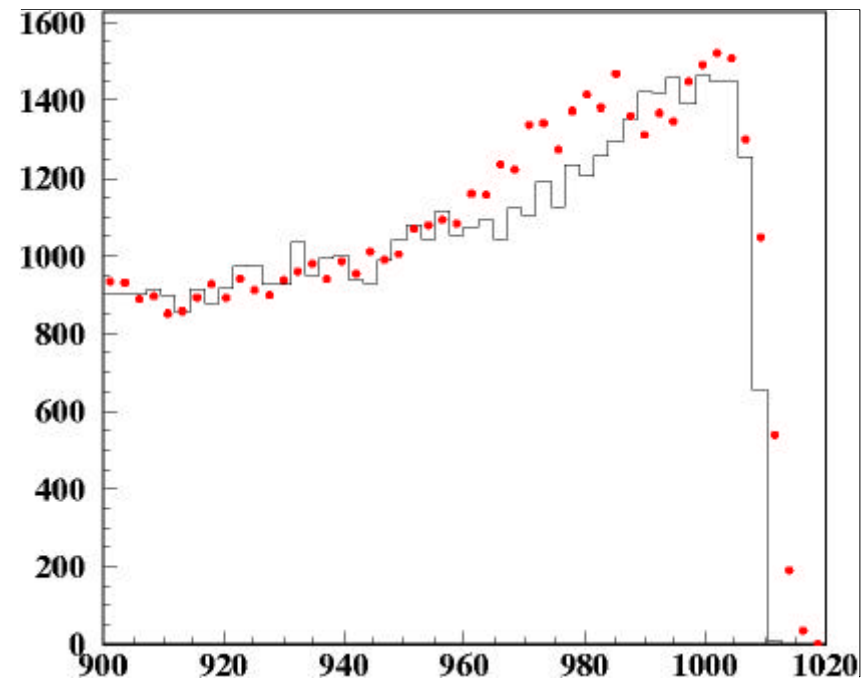
(P.G.)

$f \textcircled{R} f_0 g ; f_0 \textcircled{R} p^+ p^-$

- $p^+ p^- g$ final state selected: f_0 signal expected in the region between 900 and 1020 MeV; interference with FSR expected
- MC sample used: ppphvlag stream (no f_0 signal)
- Absolute normalization data-MC: s from EVA, L from VLAB

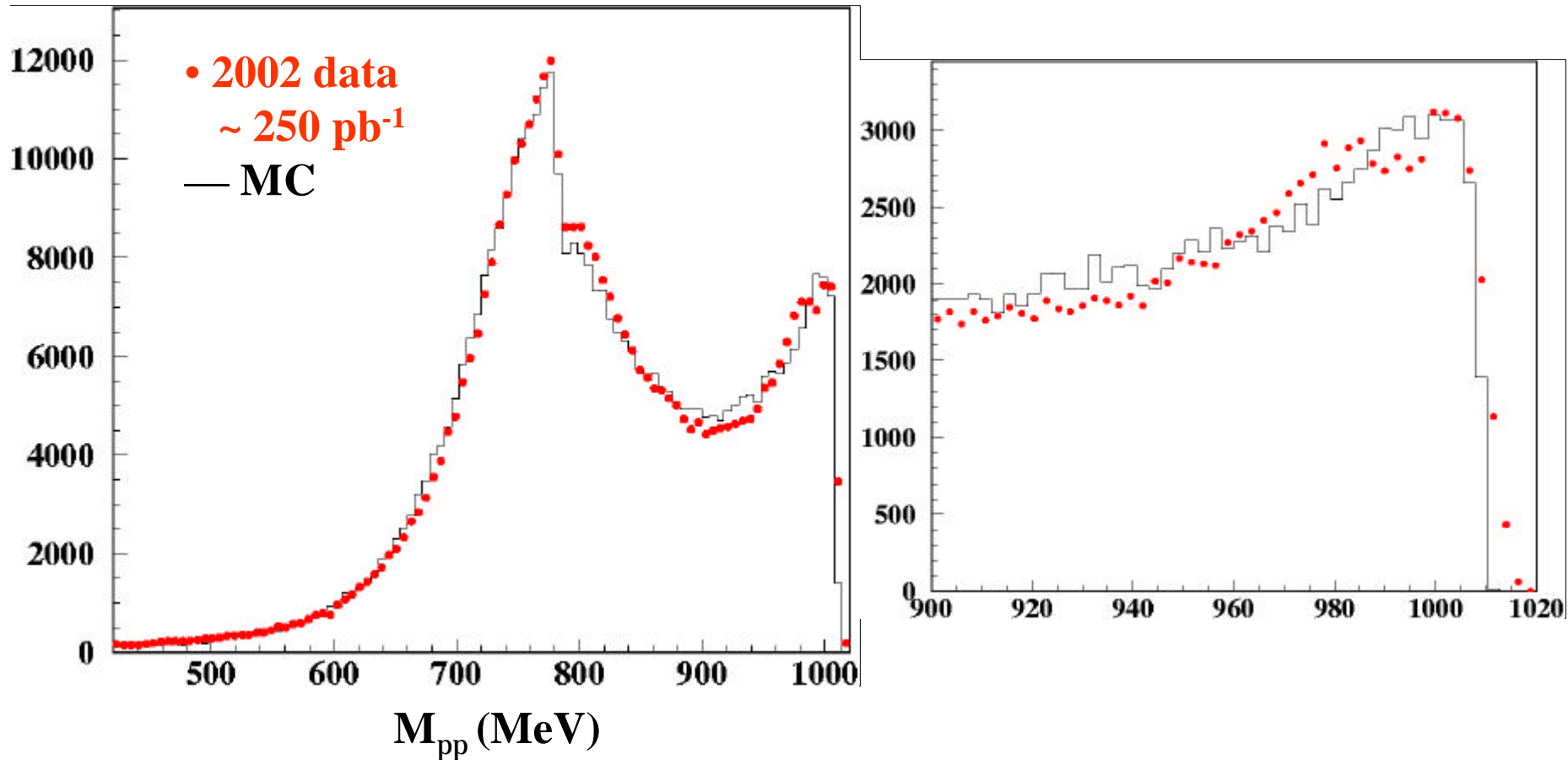


- Differences in the r peak
- Evidence of the f_0 signal



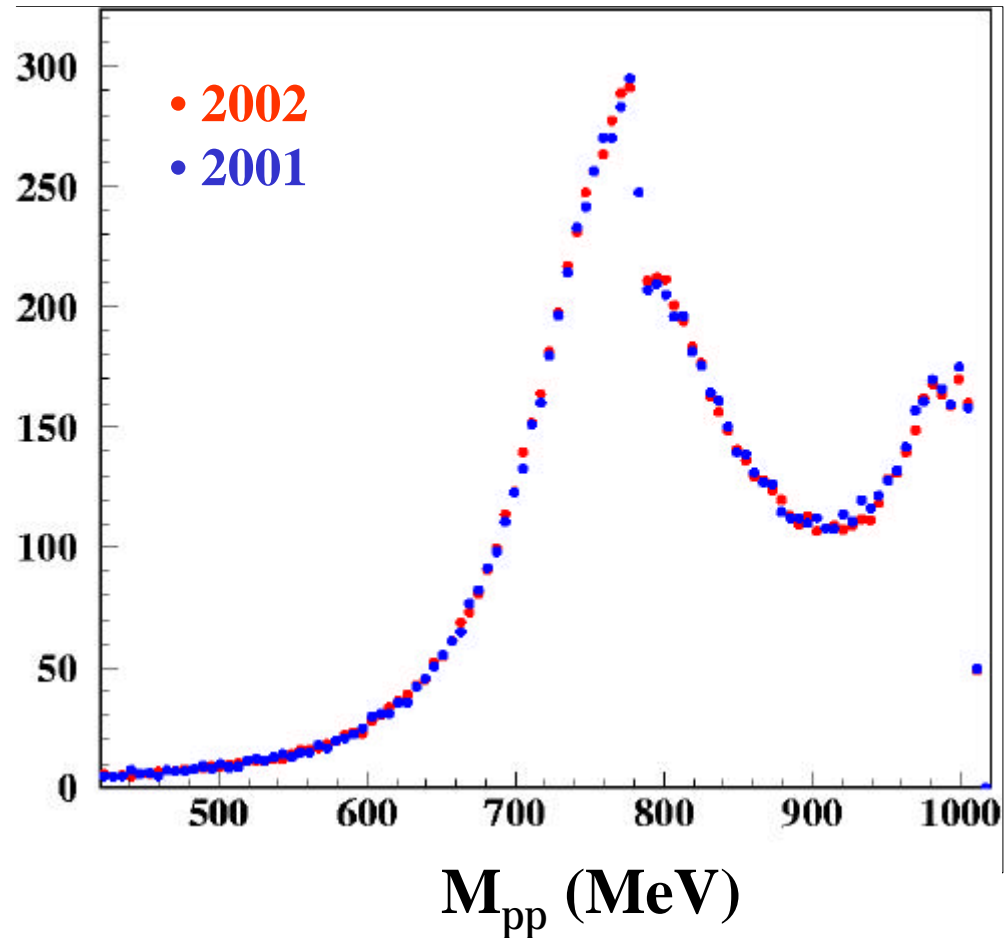
$$f \otimes f_0 g ; f_0 \otimes p^+ p^-$$

- 2002: the whole spectrum seems moved down
↳ normalization problem ?
can depend on luminosity calculation
or efficiency variation from 2001 to 2002



$$f \otimes f_0 g ; f_0 \otimes p^+ p^-$$

- The two spectra are well compatible
- Checks to be done:
 - luminosity
 - photon efficiency
 - tracking efficiency
 - effect of accidentals
 - r parametrization in the MC
- Fit to some model



$h \rightarrow p^0 gg$

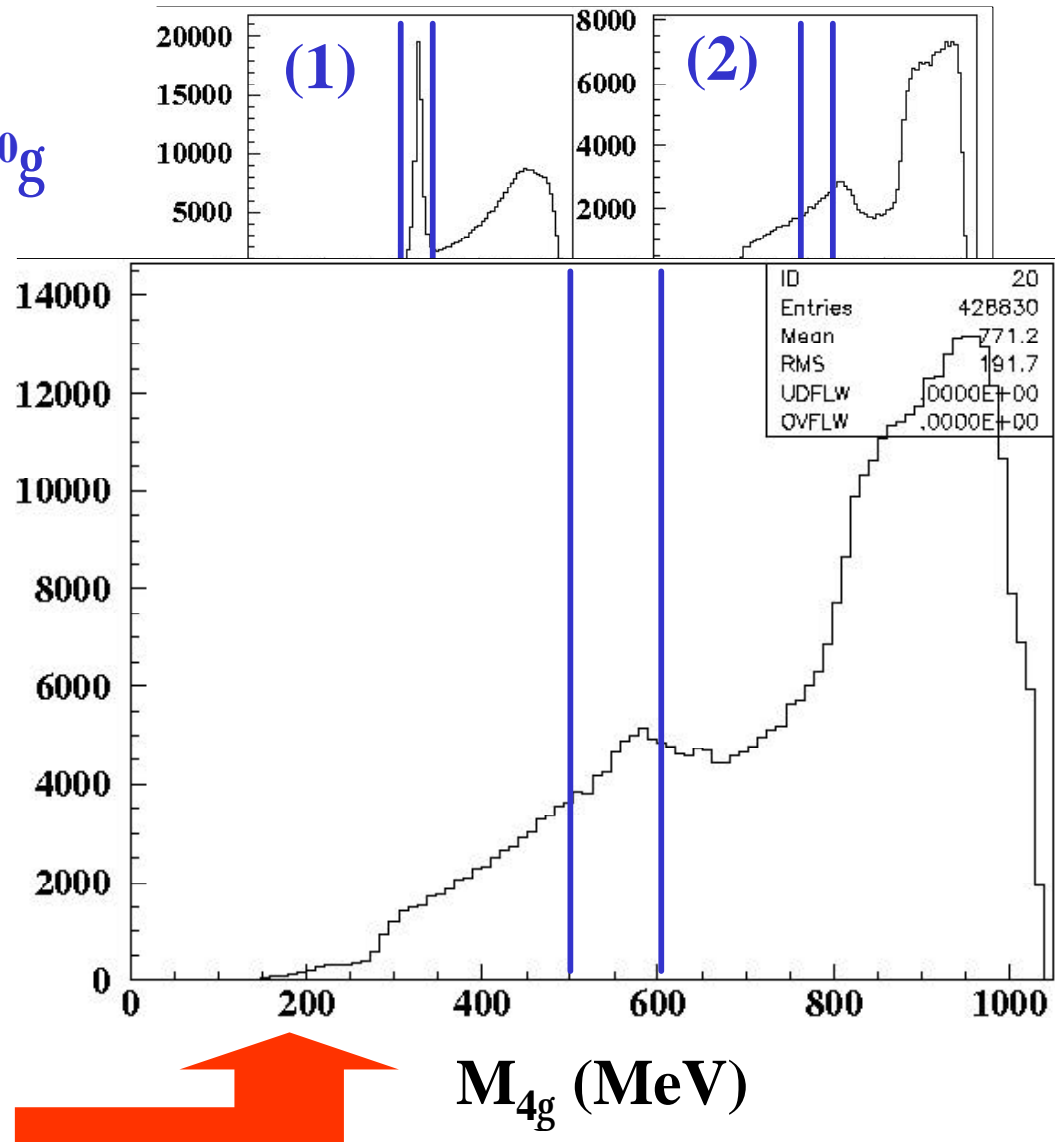
- For cPT it is a unique test of $O(p^6)$ terms
- Previous measurements:
 - GAMS-2000 (1981): ($p\bar{p} \rightarrow h n$) 6×10^5 h produced ; 38 evts.
 $Br(h \rightarrow p^0 gg) = (9.5 \pm 2.3) \times 10^{-4}$
 - GAMS-2000 reanalysis (1984): $Br(h \rightarrow p^0 gg) = (7.1 \pm 1.4) \times 10^{-4}$
 - SND (2001): $f \rightarrow hg$; 2.6×10^5 h produced; 7 signal evts/170 found
 $Br(f \rightarrow p^0 ??) = (2.1_{-1.9}^{+3.8}) \times 10^{-4} \Rightarrow Br(h \rightarrow p^0 gg) < 8.4 \times 10^{-4} @ 90\% \text{ C.L.}$
 - Crystal Ball (preliminary-2001) : 2×10^7 h produced
~ 500 evts. found $Br(h \rightarrow p^0 gg) = (3.2 \pm 0.9) \times 10^{-4}$
- KLOE: with 2001 + 2002 statistics $\Rightarrow \sim 2 \times 10^7$ h produced
(same as Crystal Ball)
- First look at $\sim 400 \text{ pb}^{-1}$ of the 2001-2002 data $\Rightarrow \sim 1.7 \times 10^7$ h
 - same program for the $5g$ final state
 - kinematic fit for $f \rightarrow hg \rightarrow p^0 ggg$ hypothesis added

$f \textcircled{R} hg \textcircled{R} p^0 ggg$

- MC: (1) $f \textcircled{R} hg \textcircled{R} p^0 ggg$
- (2) $e^+e^- \textcircled{R} wp^0 ; w \textcircled{R} p^0 g$
- (3) $f \textcircled{R} f_0 g$ “flat”
- (4) $f \textcircled{R} a_0 g$ “flat”
- (5) $f \textcircled{R} hg \textcircled{R} ggg$
- (6) $f \textcircled{R} hg \textcircled{R} p^0 p^0 p^0 g$

- All 4g combinations:
at least one with the h
mass within 50 MeV

- Data after standard
5 prompt g selection
and 3g bckg (hg, $p^0 g$, ggg)
reduction



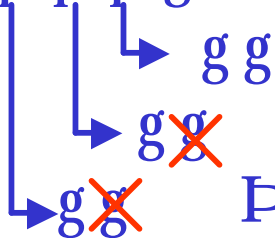
f[Ⓡ] hg[Ⓡ] p⁰ ggg

After p⁰p⁰g and hp⁰g rejection:

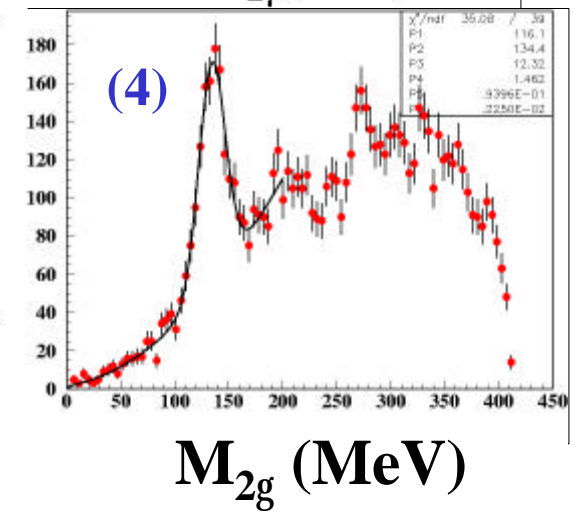
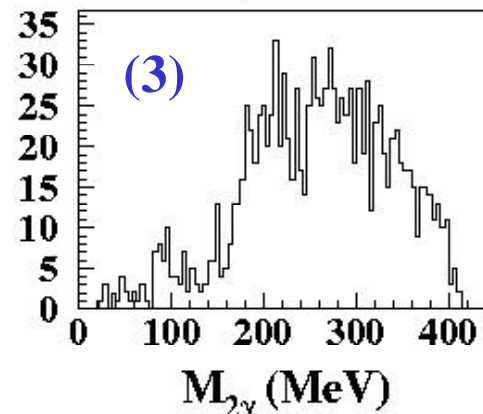
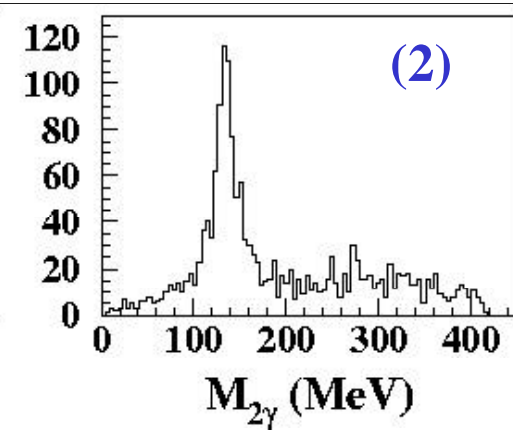
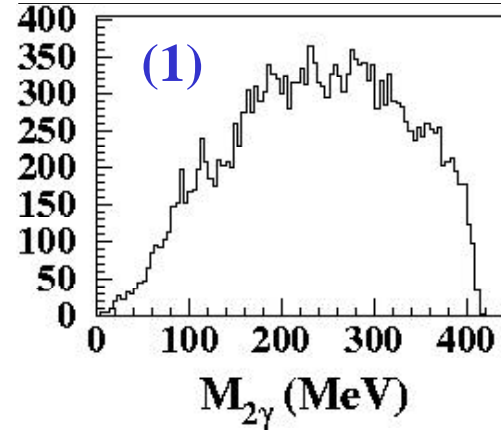
- (1) Signal (MC)
- (2) Residual p⁰p⁰g (MC)
- (3) hg[Ⓡ] p⁰p⁰p⁰g (MC)
- (4) Data

Cutting the p⁰ peak does not help with (3)

f[Ⓡ] hg[Ⓡ] p⁰p⁰p⁰g

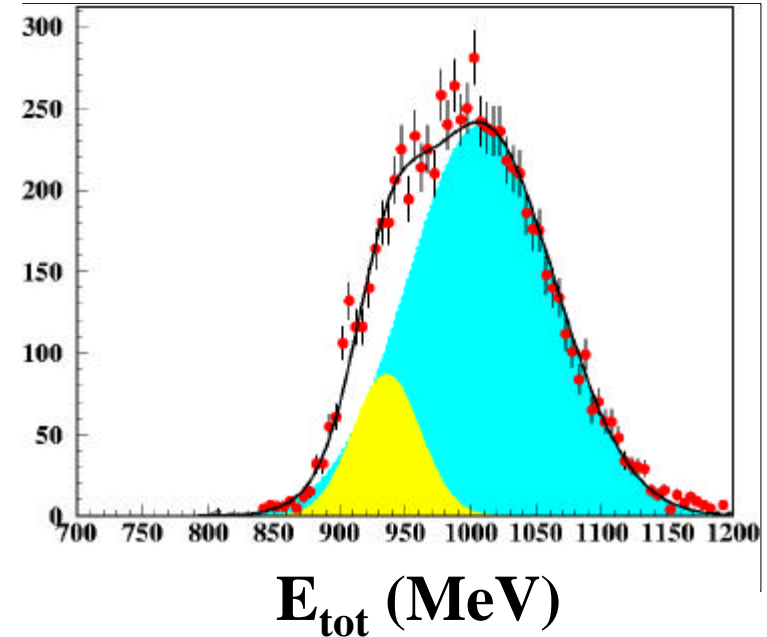


↳ only one p⁰ is reconstructed



$f \textcircled{R} hg \textcircled{R} p^0 ggg$

- After cut on the p^0 peak:
3900 events selected ($\epsilon \gg 15\%$)
 $S/B \gg 0.3 - 0.5$
- Background: $f \textcircled{R} hg \textcircled{R} p^0 p^0 p^0 g$
 - 1) with photons lost \bar{P} asymmetric total energy
 - 2) with merged clusters
- Still no clear signal of $h \textcircled{R} p^0 gg$
It is crucial to improve $f \textcircled{R} hg \textcircled{R} p^0 p^0 p^0 g$ rejection both using QCAL (g lost) and shower shape variables (merging)



Other studies in progress

- $h^{\otimes} p^+ p^- p^0$ (T.Capussela, F.Perfetto)
- $h^{\otimes} ggg$ (B.Di Micco)
- $f^{\otimes} hp^0g ; h^{\otimes} p^+ p^- p^0$ (C.Bini, D.Leone)

Conclusions

- **Papers:** -- “rp” almost completed
 - $f_0 \rightarrow h_0 \rightarrow p^+ p^- \gamma$: analysis of 2001/2002 data in progress
- **Next WG meeting (end of January): review of the 2001/2002 results to decide on possible presentation to EURIDICE meeting (6-7/2/2003) and to winter conferences**
 - a_0/f_0 neutral and charged final states (with fits ?)
 - h/h_0 update
 - Slope of Dalitz plot of $h \rightarrow p^+ p^- p^0$