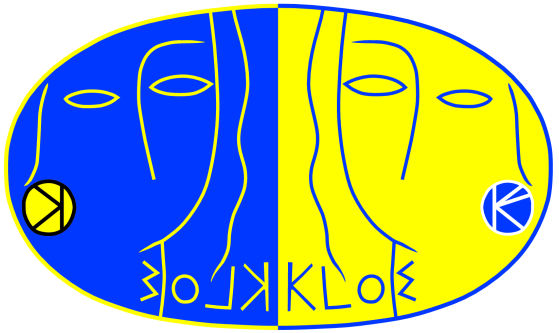


Almost final results on $e^+e^- \to \omega\pi^0$ cross section

A. De Santis & S. Giovannella

RWG meeting

14/05/08

$$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$$

$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$

- Sample selection → 5 clusters
  - neutral (KLOE TCLO km129)
  - in Time Window ($|T_\gamma - R_\gamma/c| < \min(5\sigma_t, 2\text{ ns})$)
  - $E_\gamma < 7$ MeV
  - $\cos(\theta_\gamma) < 0.92$ (~23°)
  - $E\gamma_1 + E\gamma_2 < 900$ MeV

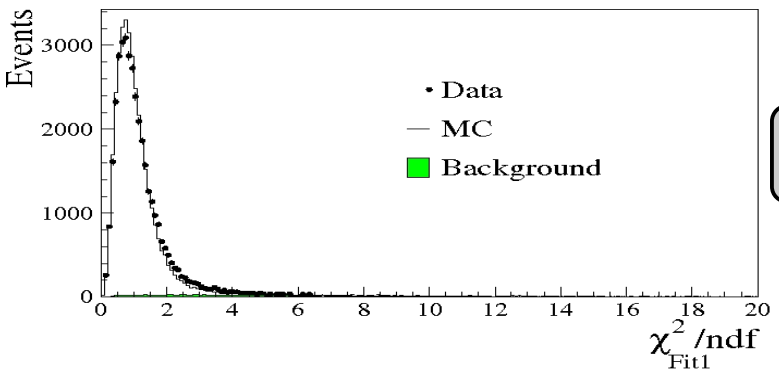
Acceptance (Step1)

- Photons pairing:
  - 1st kinematic fit (ToF and Energy momentum conservation)
  - parametrization of photon energy resolution (MC)
  - photon pairing into π^0 minimizing a χ^2 defined with the previous resolution
- 2nd kinematic fit (ToF, Energy momentum conservation and π^0 masses)

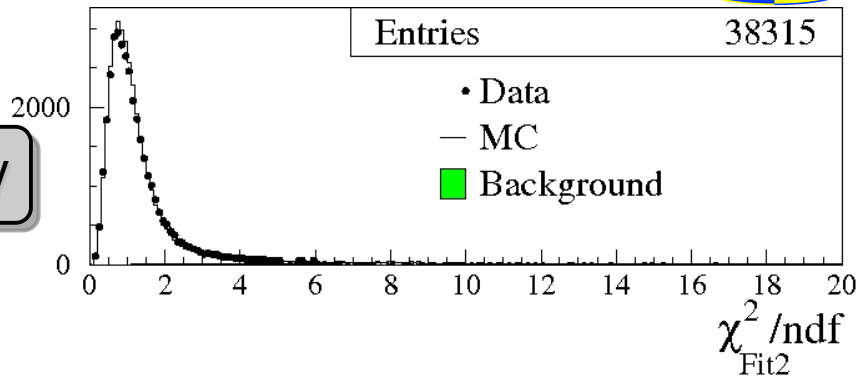
- $\chi^2(2^{nd})/N_{dof} < 5$
- $|\Delta M_{\pi 0}| < 5\sigma_M$

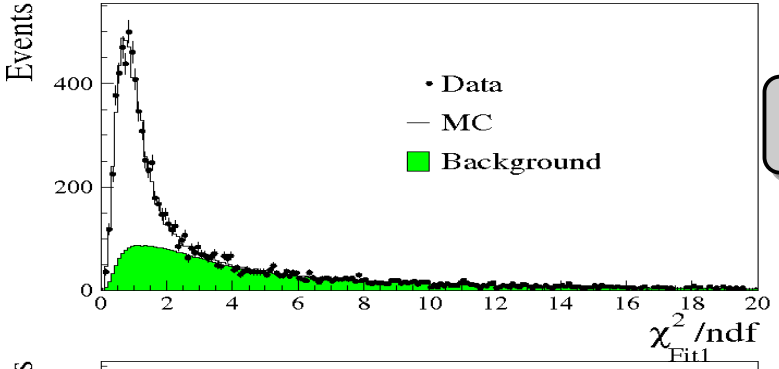
Bkg Rej (Step2)

$\omega\pi^0 \to \pi^0\pi^0\gamma$: Data-MC comparison (Step 1 & 2)

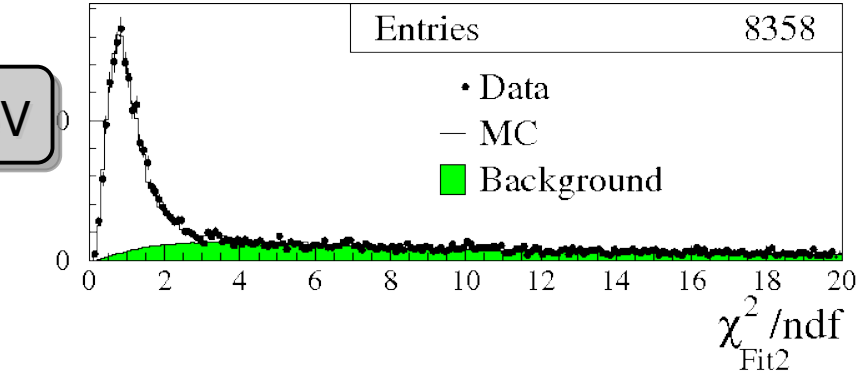


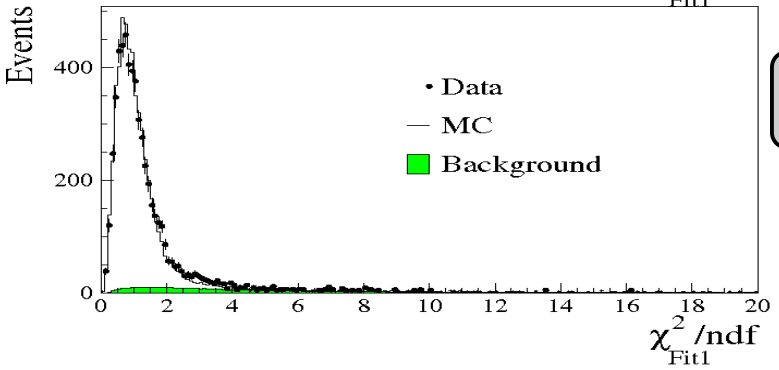
√s = 1000 MeV



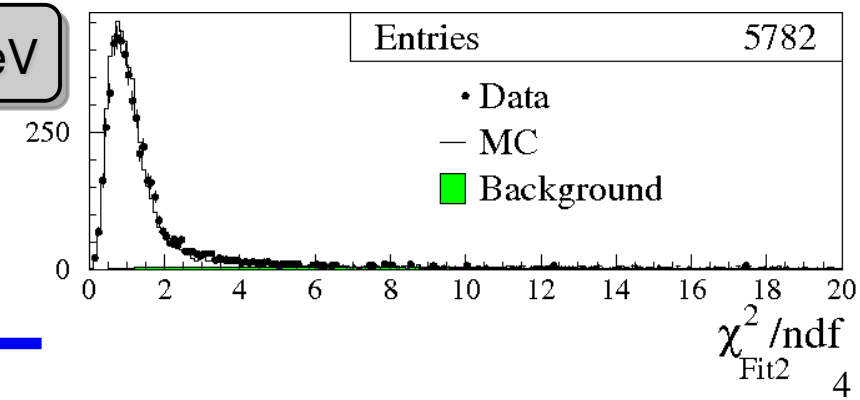


√s = 1018 MeV



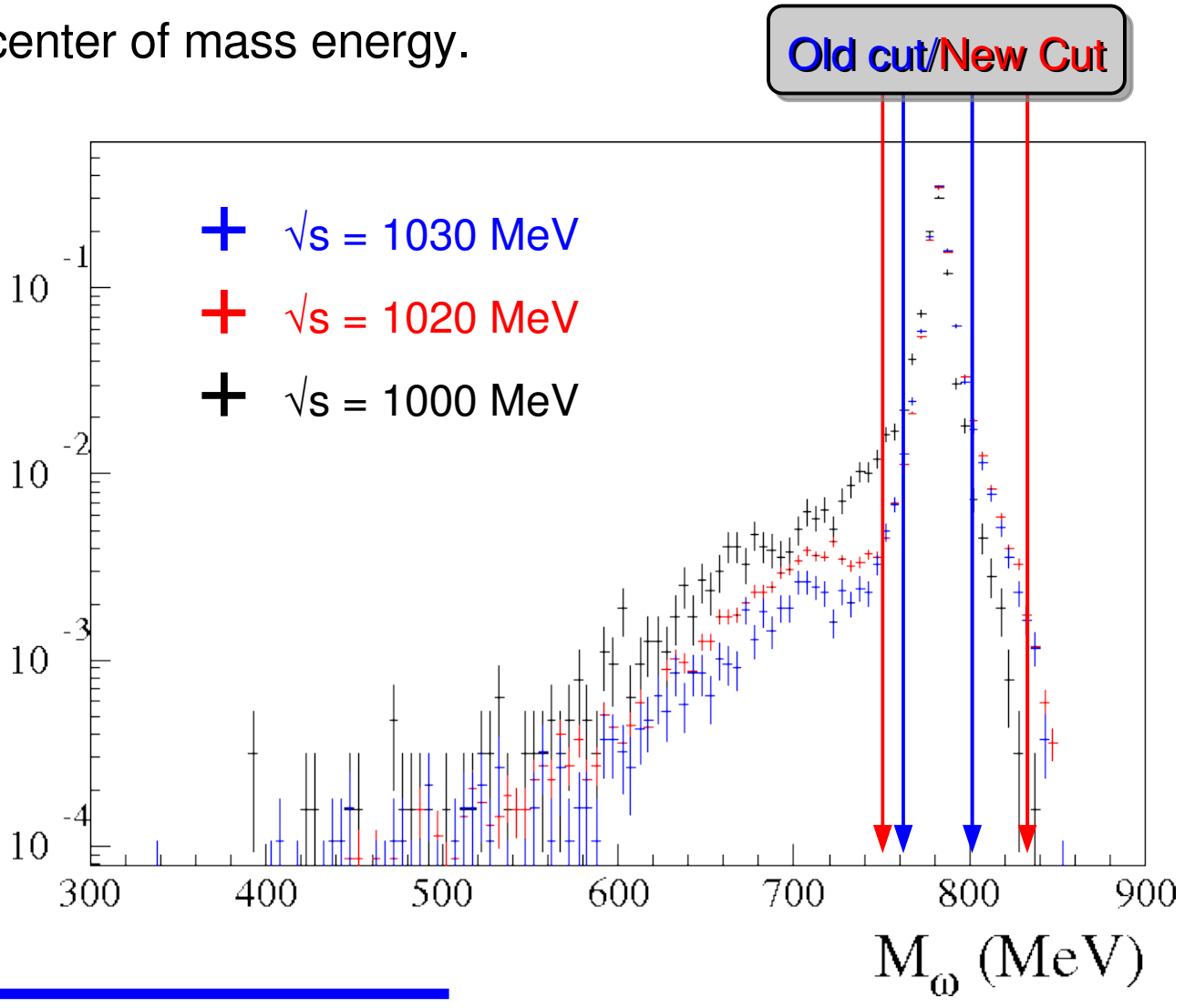


√s = 1030 MeV



$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$

The ω tail depends on the center of mass energy.



$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$

$\phi \rightarrow S\gamma$ and $\phi \rightarrow \omega\pi^0$ are assumed uncorrelated (int ~2% KN212)

Signal identification performed requiring $750 < M\pi\gamma < 830$ MeV

(enlarged with respect to the original analysis $|M_{\pi\gamma} - M_{\omega}| < 3\sigma_M$)

Sig ID (Step3)

Background contribution estimated from MC distribution normalized with scale factor calculated using the MC/Data luminosity ratio (tested on different background enriched distribution) .

check number

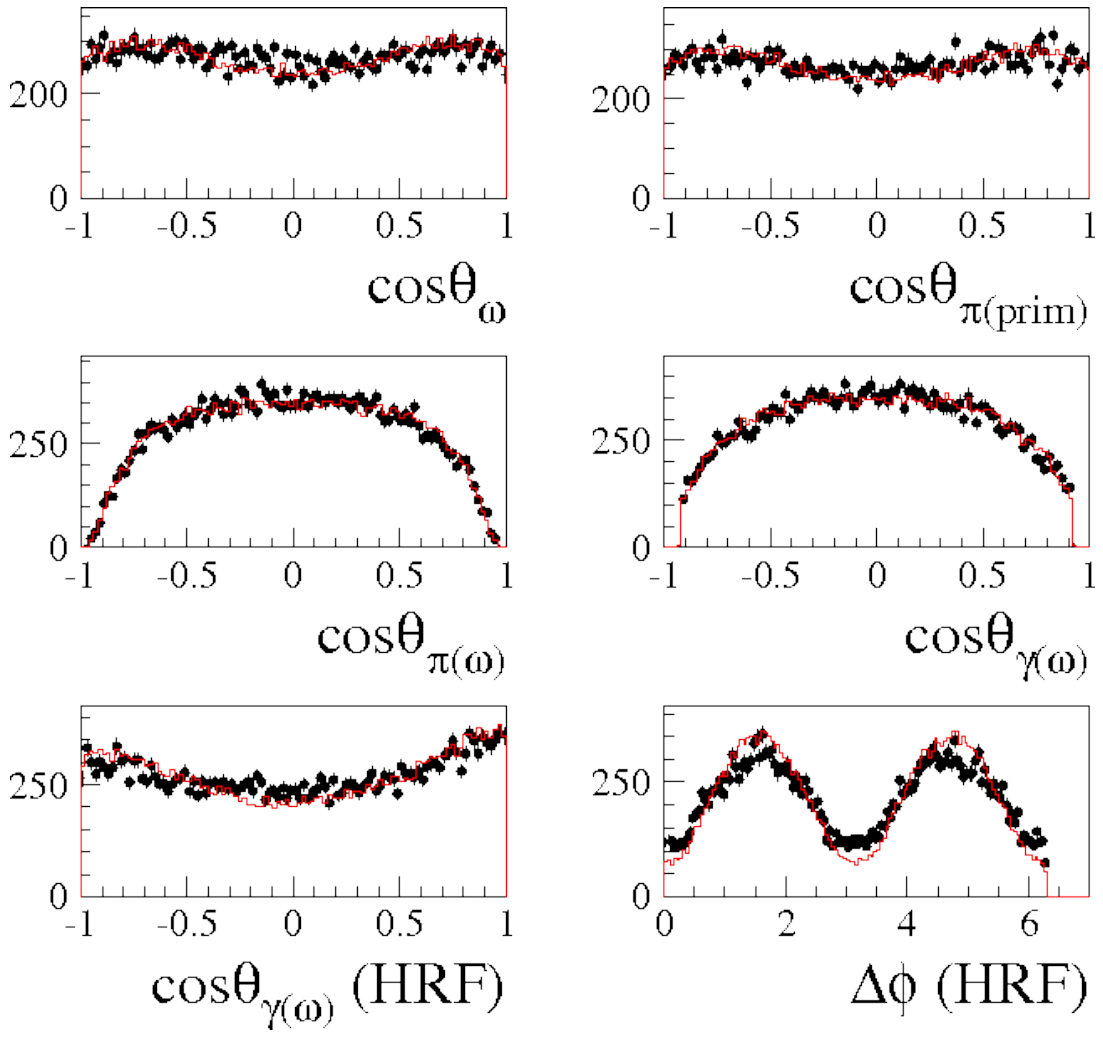
Dominant Background sources

Background	S/B (no cuts)	S/B (selection)	S/B (bkg rej)
$\eta\pi 0\gamma$	8.5	8.8	18.9
$\eta\gamma \rightarrow \pi 0\pi 0\pi 0\gamma$	0.1	0.5	3.9
$\eta\gamma \rightarrow \gamma\gamma\gamma$	0.1	18.8	32.3

$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$: Data-MC comparison (Step 4)

Data-MC comparison after ω identification and residual background subtraction.

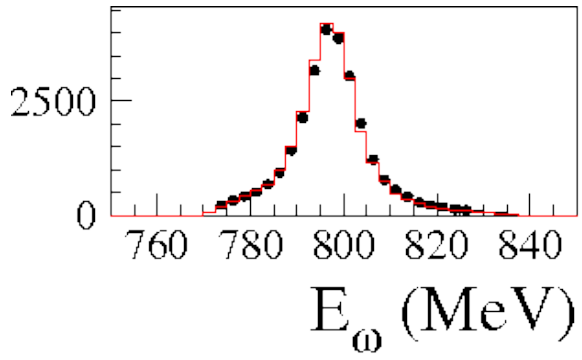
Angular distributions

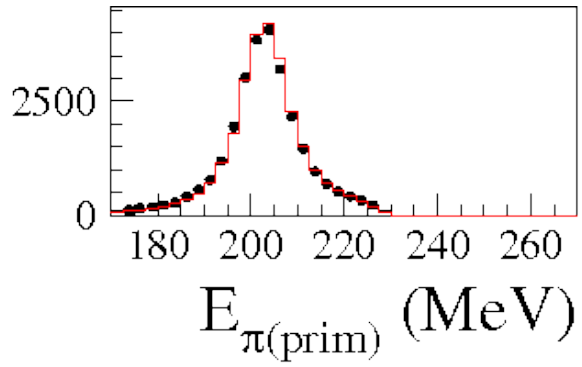


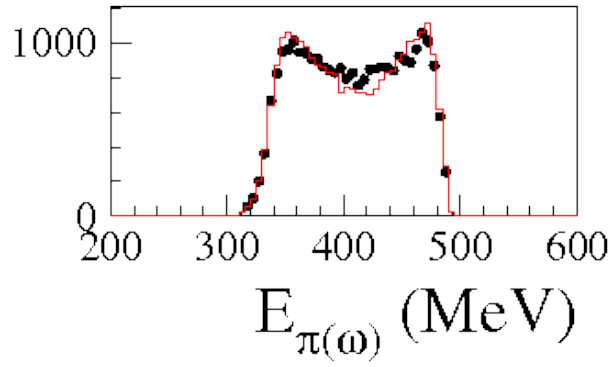
$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$: Data-MC comparison (Step 4)

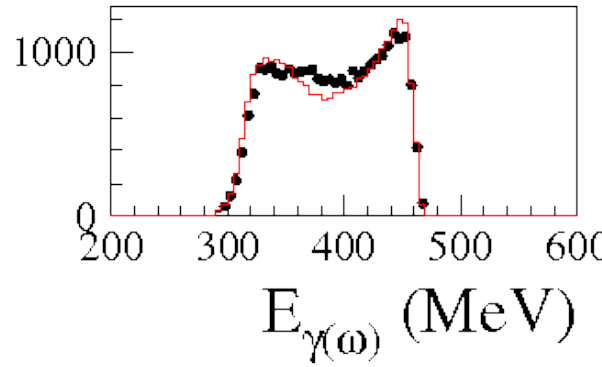
Data-MC comparison after ω identification and residual background subtraction.

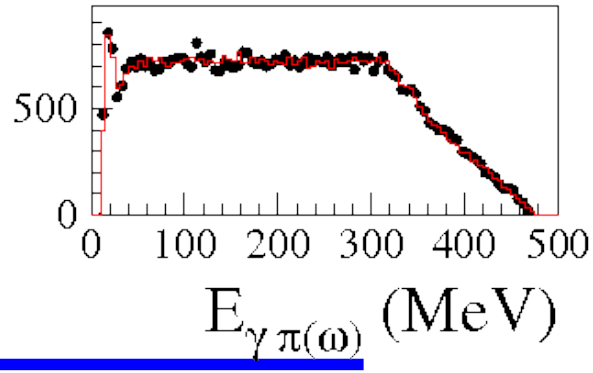
Energy distributions

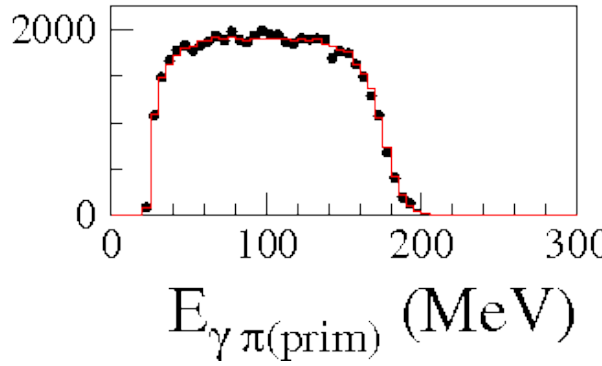






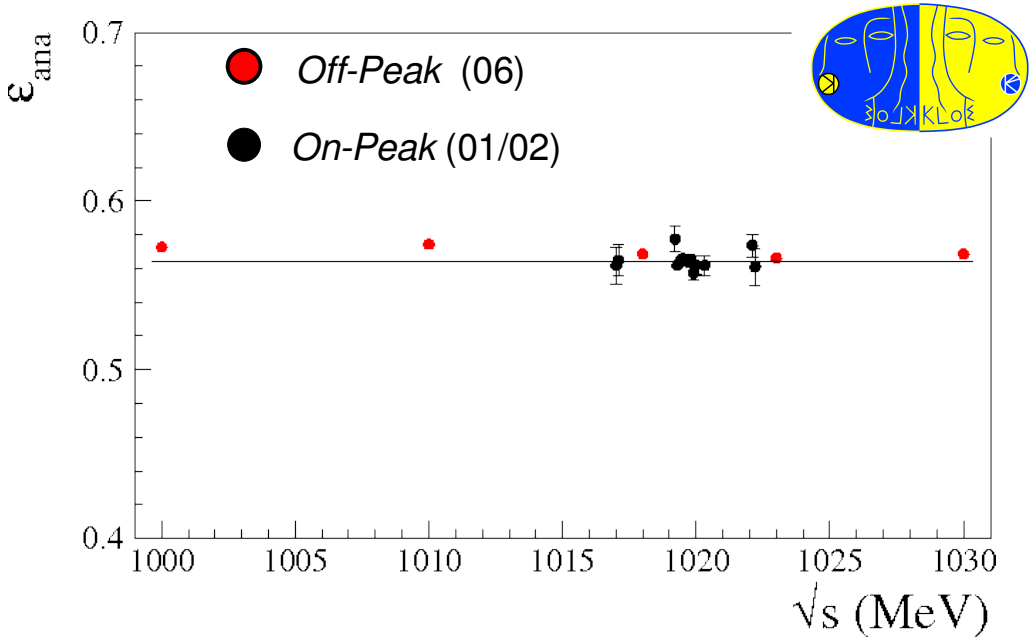




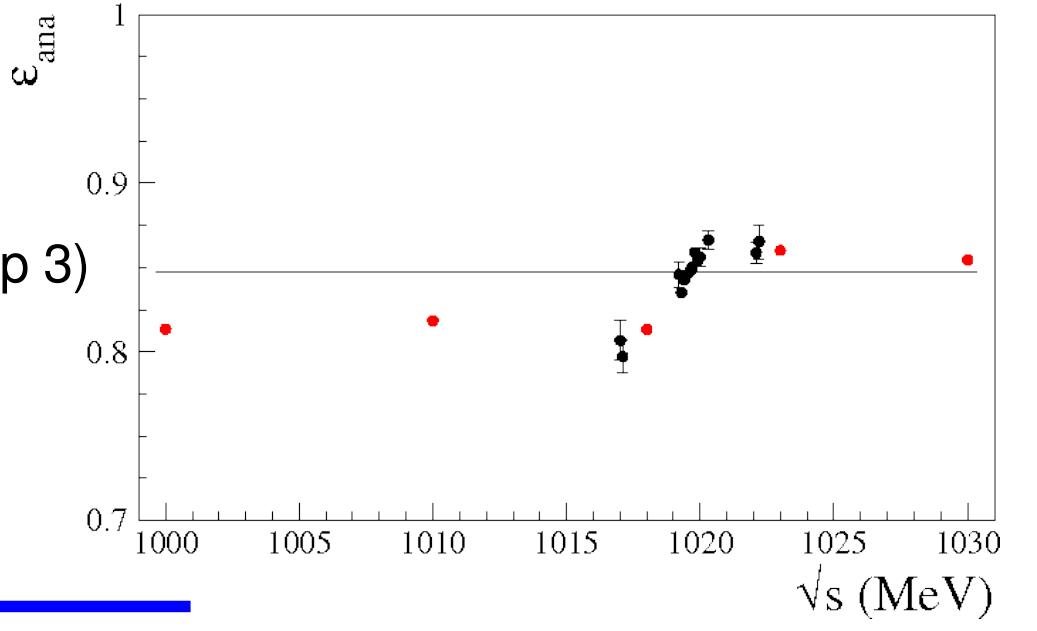


$\omega\pi^0 \to \pi^0\pi^0\gamma$: Efficiency

Analysis efficiency after the preselection and background rejection (Step1+2)



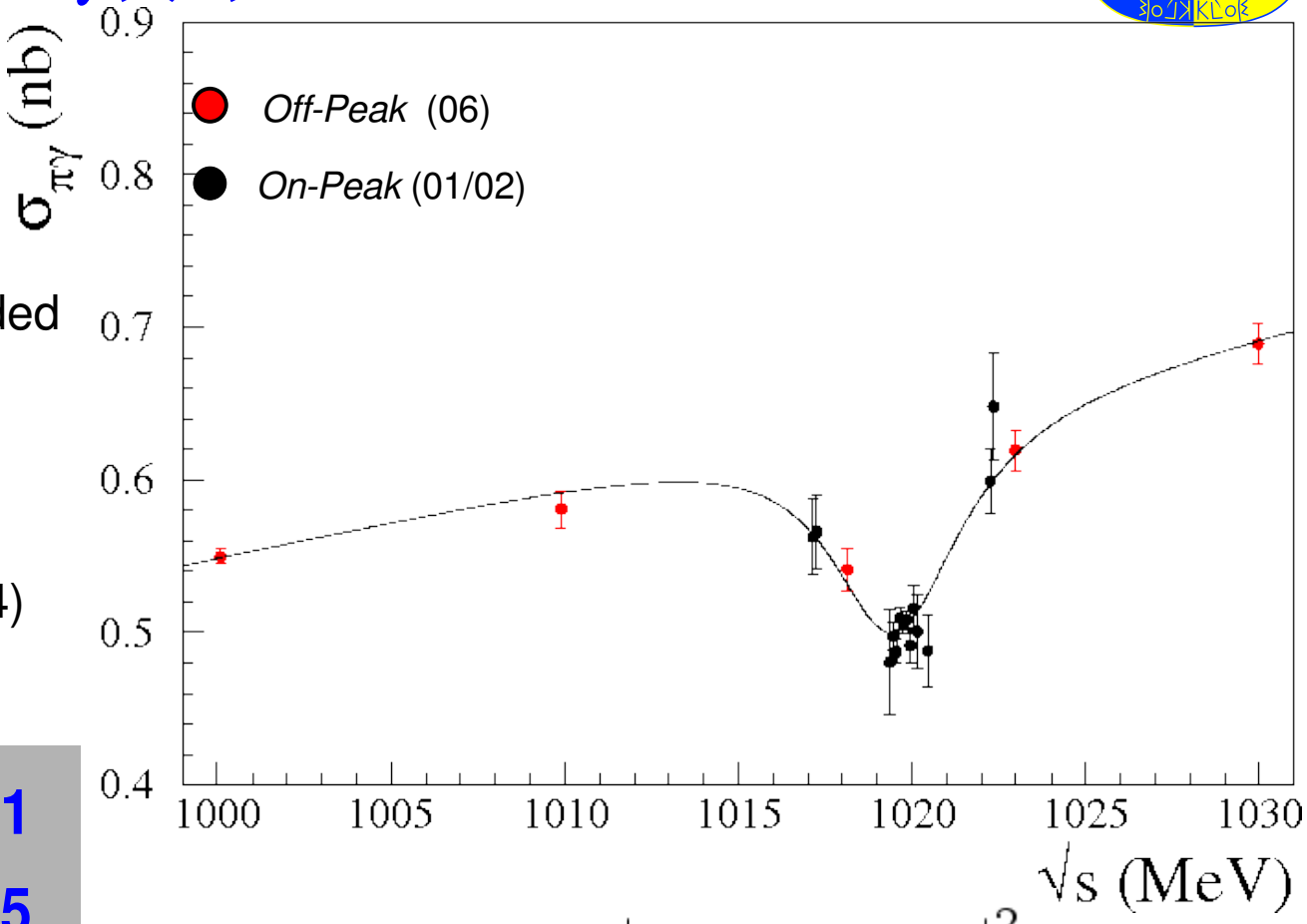
Analysis efficiency after the Mω cut (step 3)



$\sigma(e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma)(E)$

- Efficiency and vlabha luminosity as function of sqrt(s)
- Radiative correction included
- BES included
- Preselection efficiency correction (1.022 +- 0.004)
- ISR tail correction

σ_0	0.724 ± 0.011
$\Re e(Z)$	0.011 ± 0.015
$\Im m(Z)$	-0.154 ± 0.007
s'	0.0053 ± 0.0005



$$\sigma(E) = \sigma_0(E)\left|1 - Z\frac{m_\phi \Gamma_\phi}{D_\phi}\right|^2$$

$\omega\pi^0 \to \pi^0\pi^0\gamma$: Systematics

	σ_0 (nb)	$\Re(Z)$	$\Im(Z)$	σ' (nb/MeV)	χ^2 / Ndof
Default	**0.724(11)**	**0.011(15)**	**-0.154(7)**	**0.0053(5)**	**13.1/15**
χ^2	0.720(11)	0.004(15)	-0.155(7)	0.0054(5)	9.9/15
Mω	0.730(11)	0.005(15)	-0.156(7)	0.0059(5)	8.2/15
Eg	0.727(10)	0.010(15)	-0.155(7)	0.0055(5)	11.0/15
E scale	0.722(10)	0.004(14)	-0.155(7)	0.0054(5)	9.7/15
Bkg	0.724(11)	0.012(14)	-0.157(7)	0.0053(5)	13.9/15
√s scale	0.723(11)	0.022(15)	-0.151(7)	0.0052(5)	12.3/15
ISR tail	0.728(11)	0.010(15)	-0.158(7)	0.0052(5)	12.5/15
Mππ	0.728(10)	0.006(14)	-0.153(7)	0.0053(5)	11.3/15
Interf	0.724(11)	0.019(18)	-0.158(7)	0.0053(6)	13.0/15
All	**±0.003**	**±0.006**	**±0.004**	**±0.0002**	

$$\omega\pi^0 \rightarrow \pi^+\pi^-\pi^0\pi^0$$

$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Dataset

Integrated luminosity *onpeak* 450 pb^{-1}

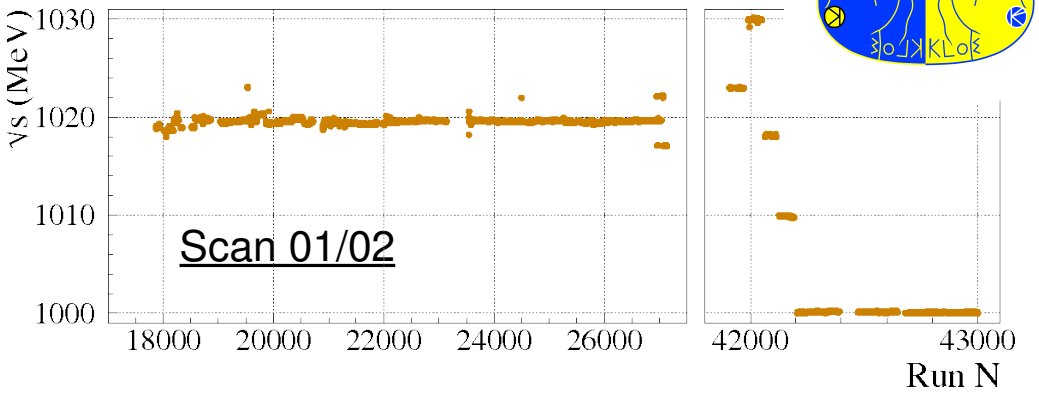
Integrated luminosity *offpeak* 150 pb^{-1}

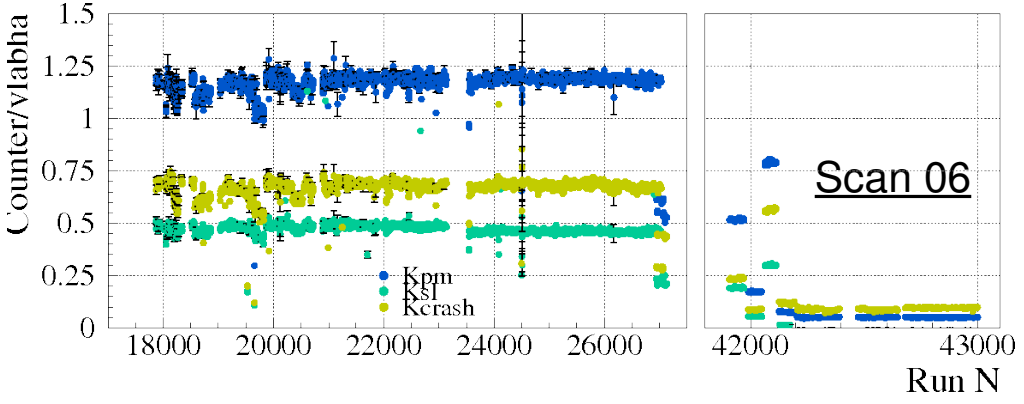
Data:

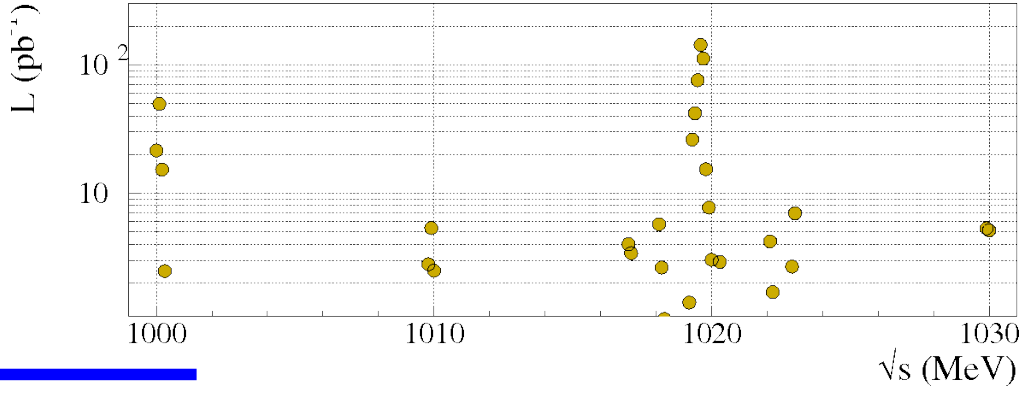
- drc (DBV-13/14) 01/02
- drc (DBV-24/25) 06

MC sample:

- Signal (DBV-26 LSF=1) 01/02
- mrc (DBV-18 all_phys LSF=0.2) 01/02
- mrc (DVB-26 all_phys LSF=1(2)) 06







$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Luminosity

In order to use the correct luminosity for the energy outside the ϕ resonance peak we have used directly vlabha entries.

Energy (MeV)	$\sigma(e^+e^- \to e^+e^-)_{(vla)}$ (nb)
1000	448.40
1010	439.95
1020	431.51
1030	423.06

From babayaga

We have sliced dataset in bins of 100 keV width.

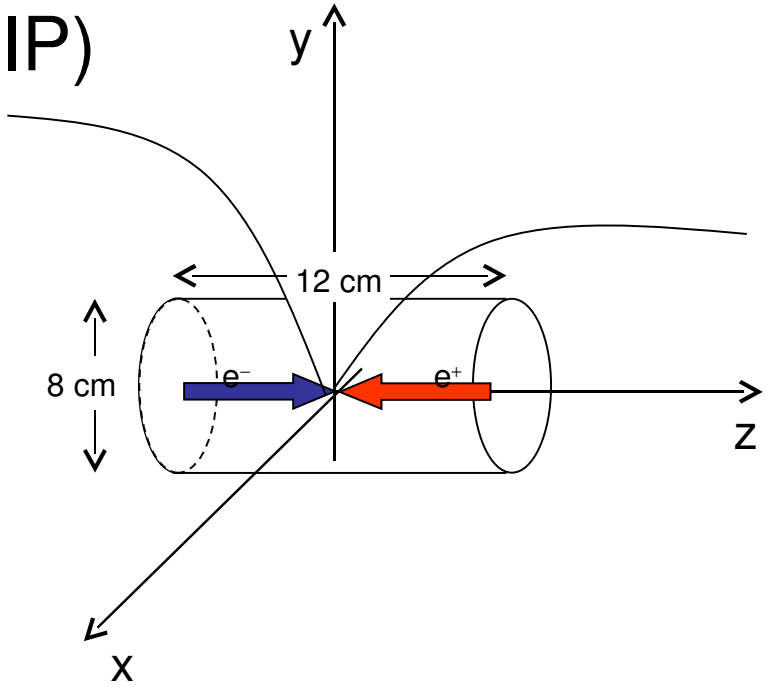
In the region around the ϕ *peak* we have used these bins.

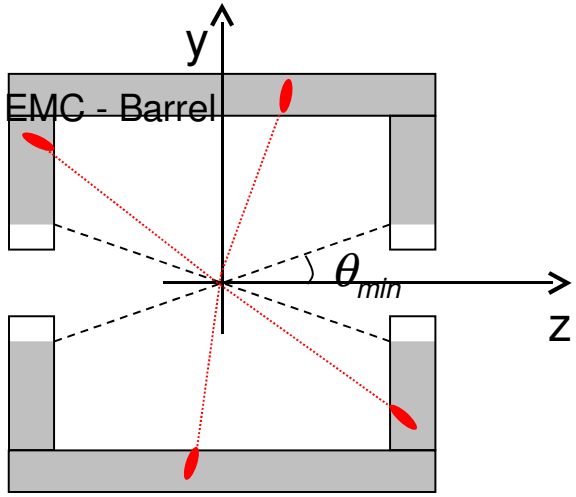
For the *off-peak* data we have packed them using the luminosity weighted energy.

$$E_k = \frac{\sum_j E_{jk} L_{jk}}{\sum_j L_{jk}}$$

$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Sample selection

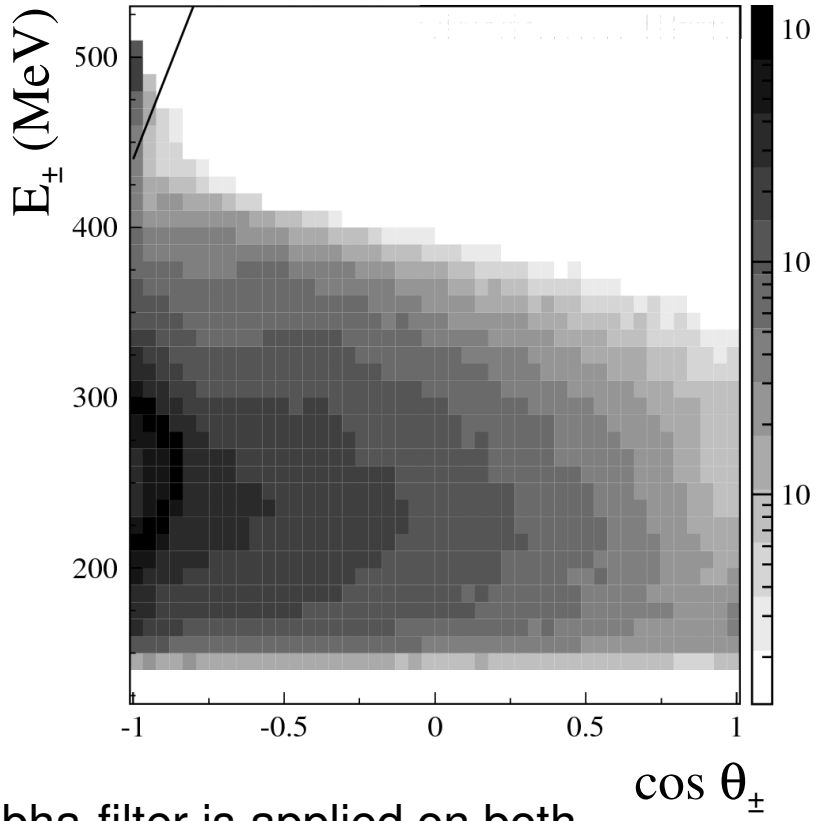
- One vertex at Interaction Point (IP)
- Two tracks connected at vertex
- Four neutral cluster with:
  - E_{clu} grater than 10 *MeV*
  - *ToF* compatible with prompt γ
  - $|\cos(\theta)| < 0.93$

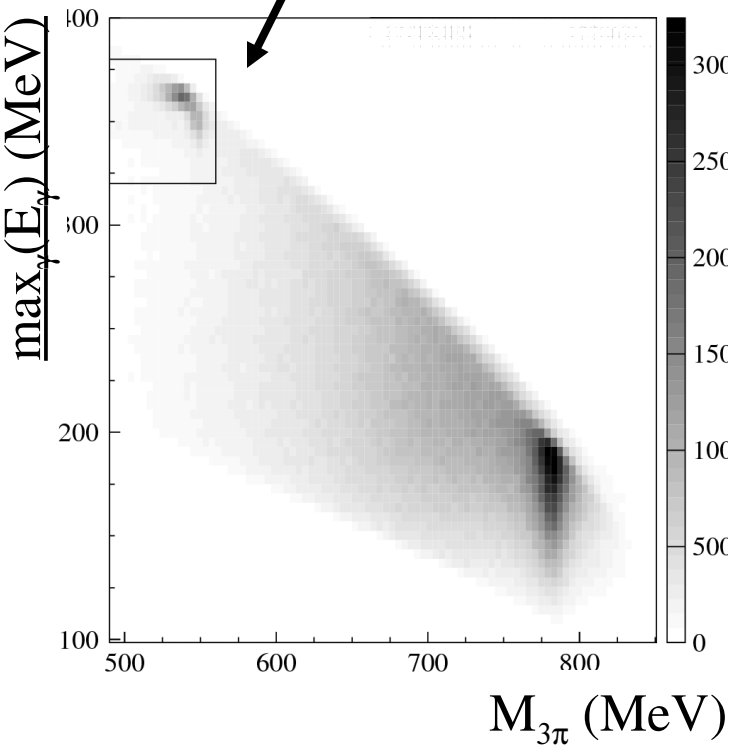




$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Background rejection

- $\Delta m_\pi/m_\pi < 3\sigma$
- bhabha-filter
- η-filter





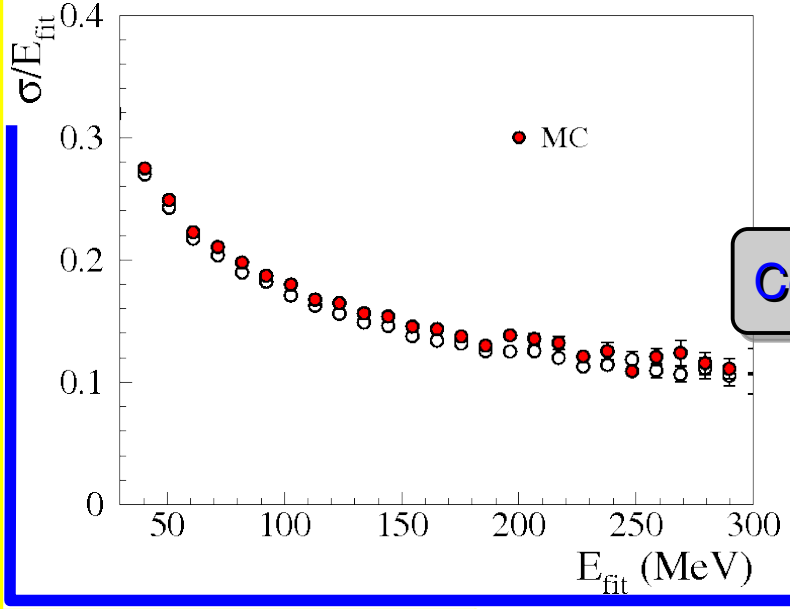
Bhabha-filter is applied on both tracks.

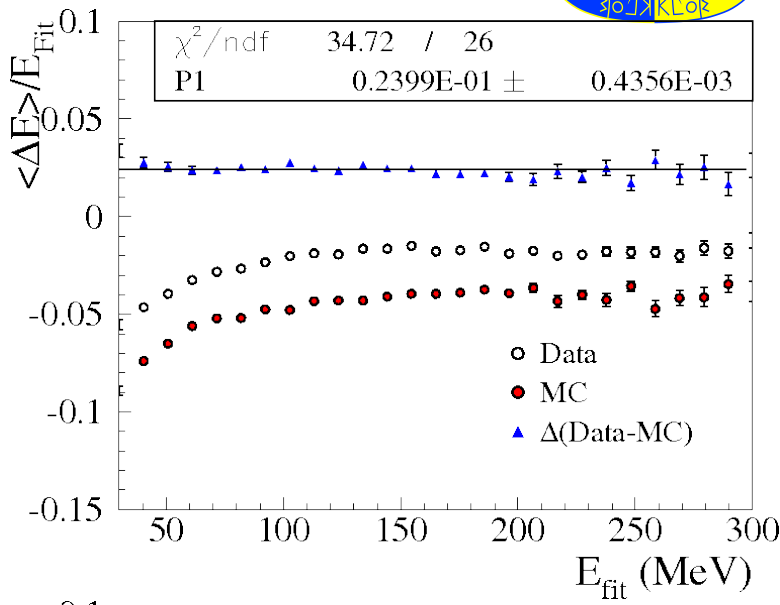
η-filter as been implemented to reject events due to cluster splitting/machine background.

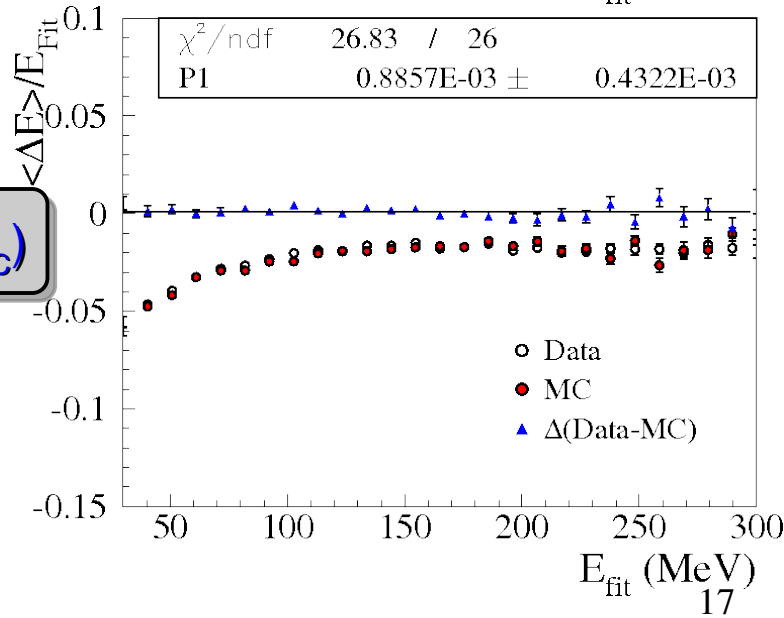
$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: MC energy scale

To analyse the MC energy scale for EMC we have fitted the kinematic fit pulls ($E_{rec} - E_{fit}$) with simple gaussian for different value of fitted energy

A difference in the scale calibration of 2.4% has been found





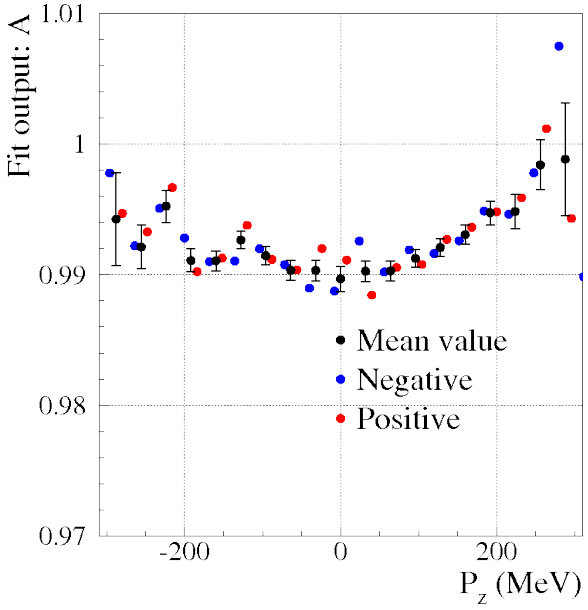


Corrected (+2.4% E_{MC})

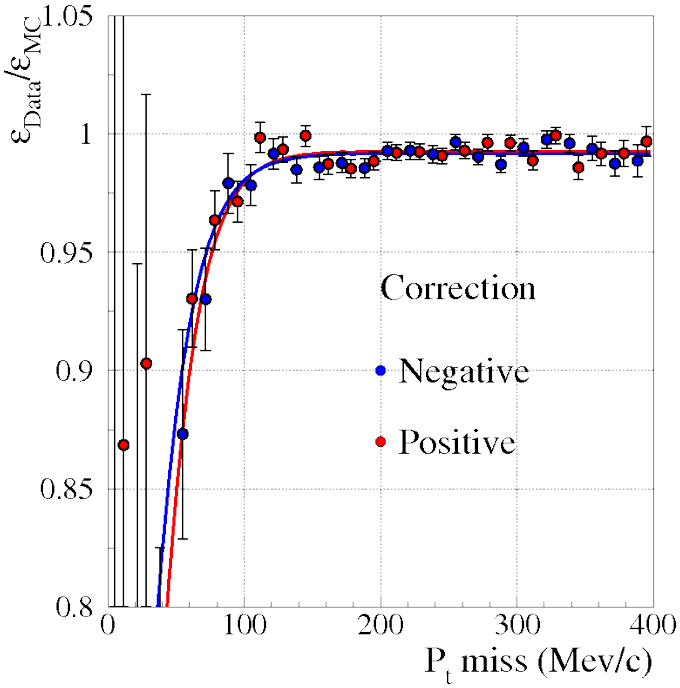
$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Data/MC tracking efficiency

Tracking efficiency (KM343) has been determined both for on-peak and off-peak data using UFO stream

For on-peak the resulting correction is smaller



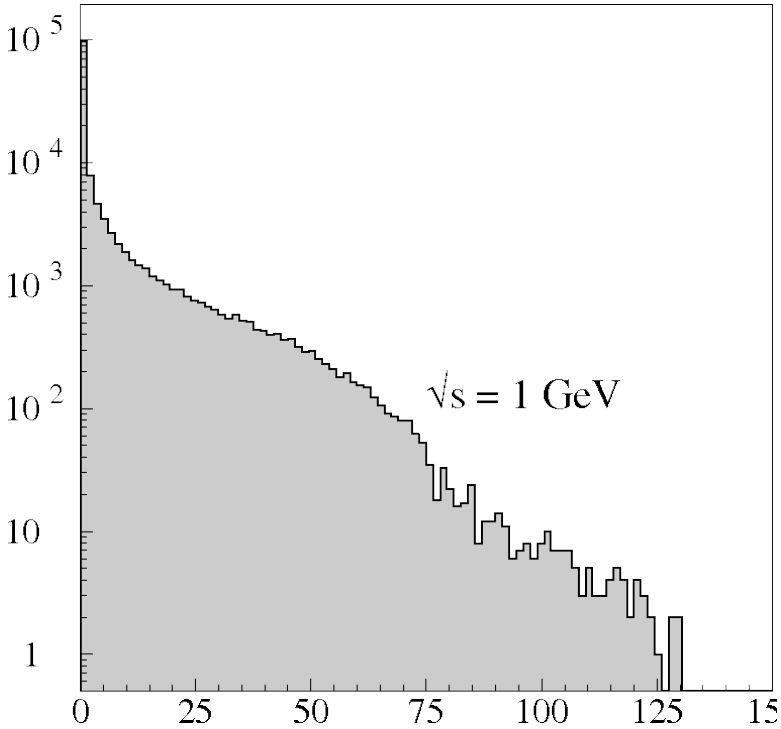
Fit result for plateau value as a function of Pz component

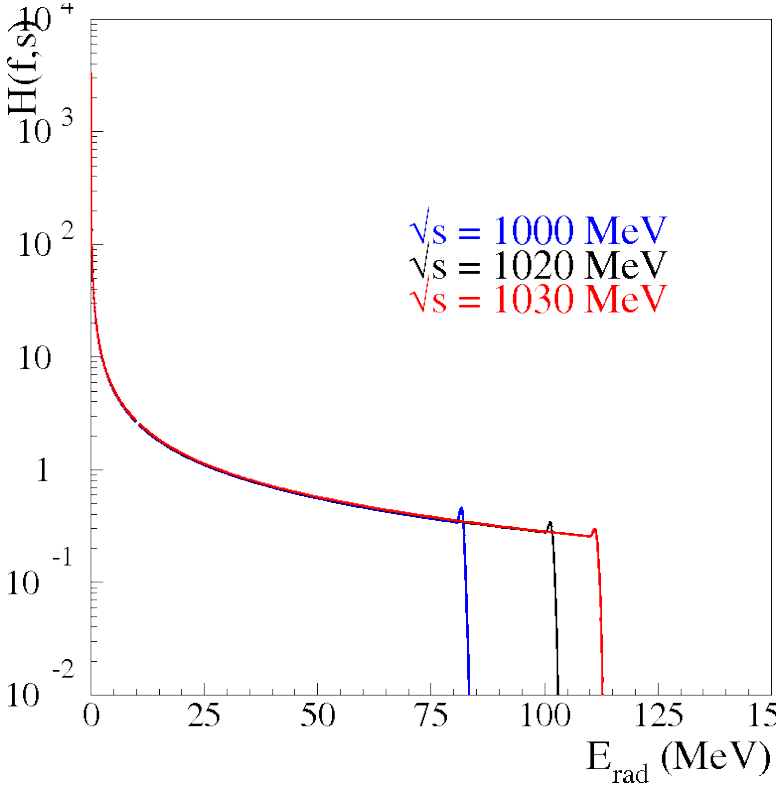


Each slice in Pz of the distribution for Pt-Pz has been fitted with:

$$C_\epsilon = A\left(1 - \frac{1}{1+e^{(X-X_0)/\delta}}\right)$$

$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: ISR Tail

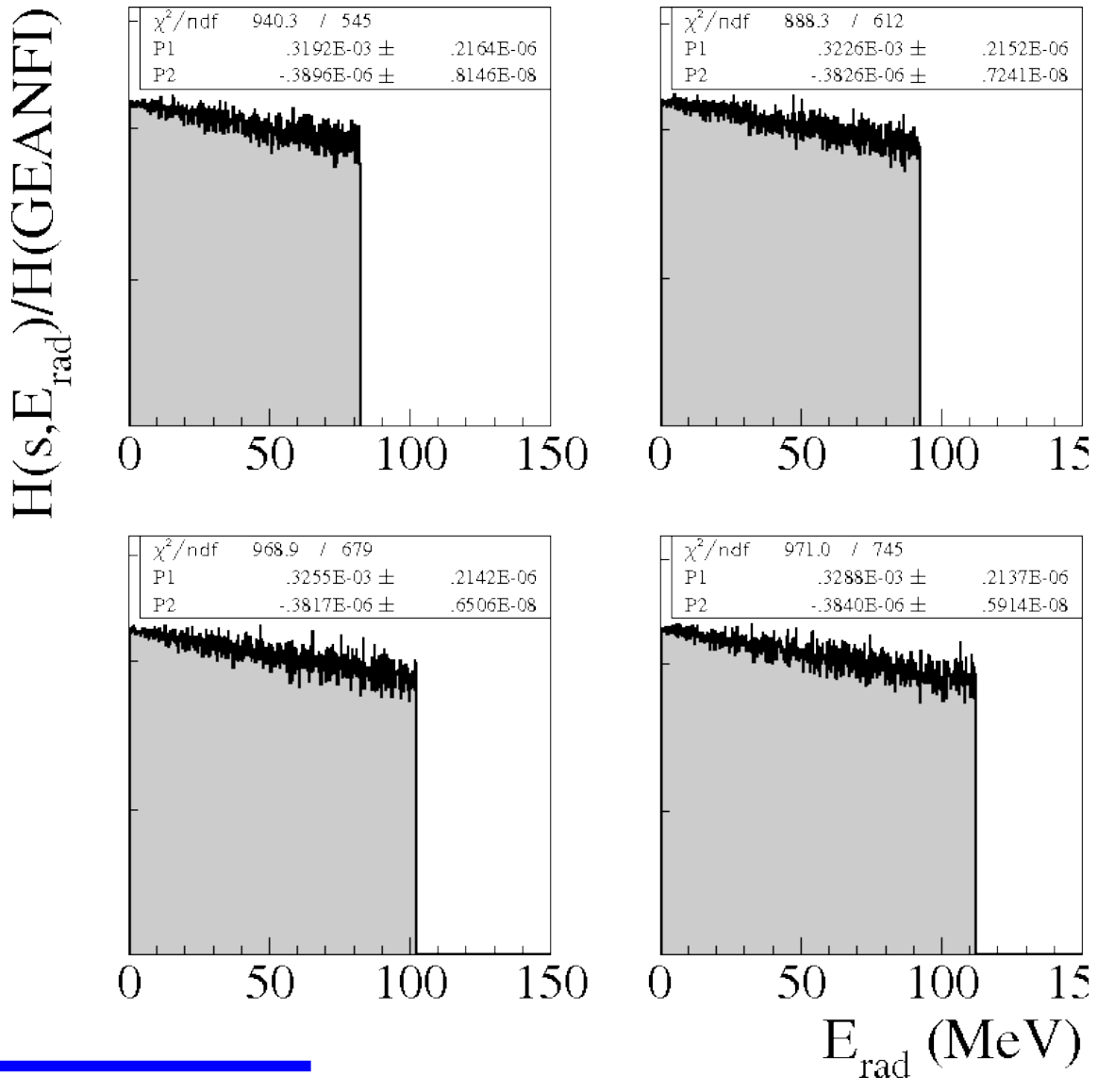




In GEANFI (Official release) the radiative correction is fixed with respect to the Center of Mass energy and has a bad shape.

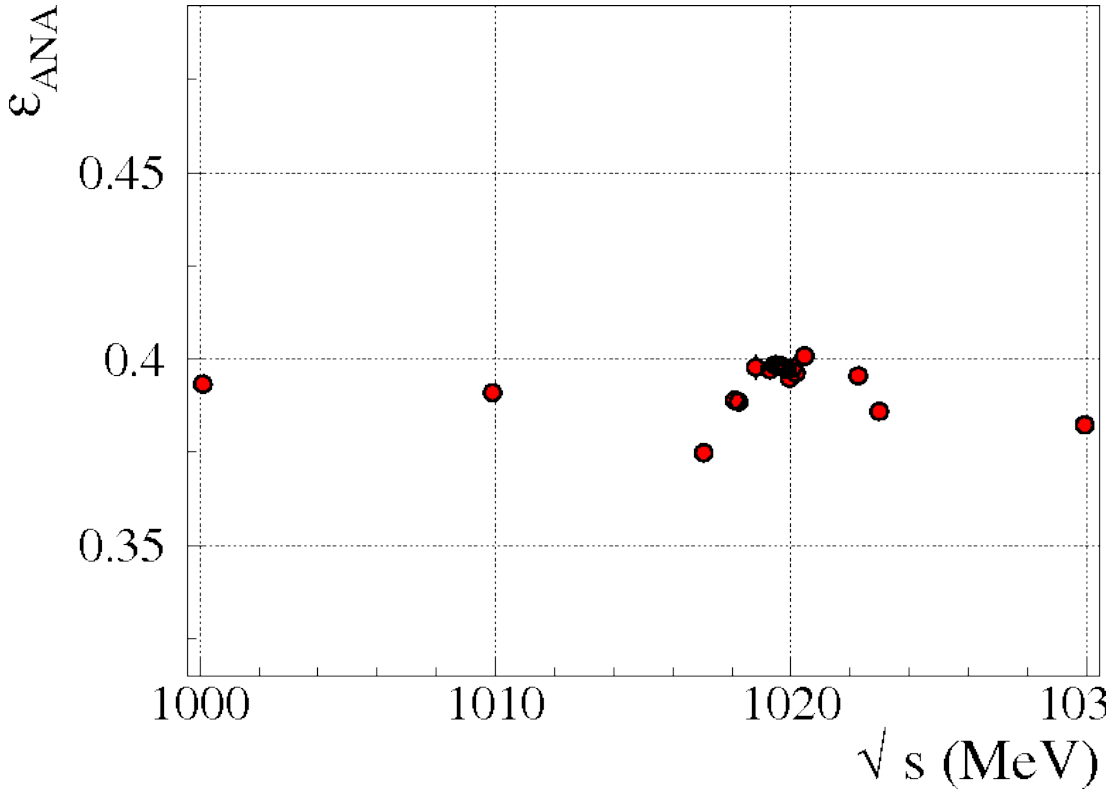
$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: ISR Tail

To correct this effect (~5% of the total number of events) we use the ratio of the GEANFI shape and the radiator used in the cross section fit



$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Efficiency

- Tracking and vertexing efficiency correction included
- Clustering efficiency correction curves included
- ISR reshape included
- FILFO and CV negligible

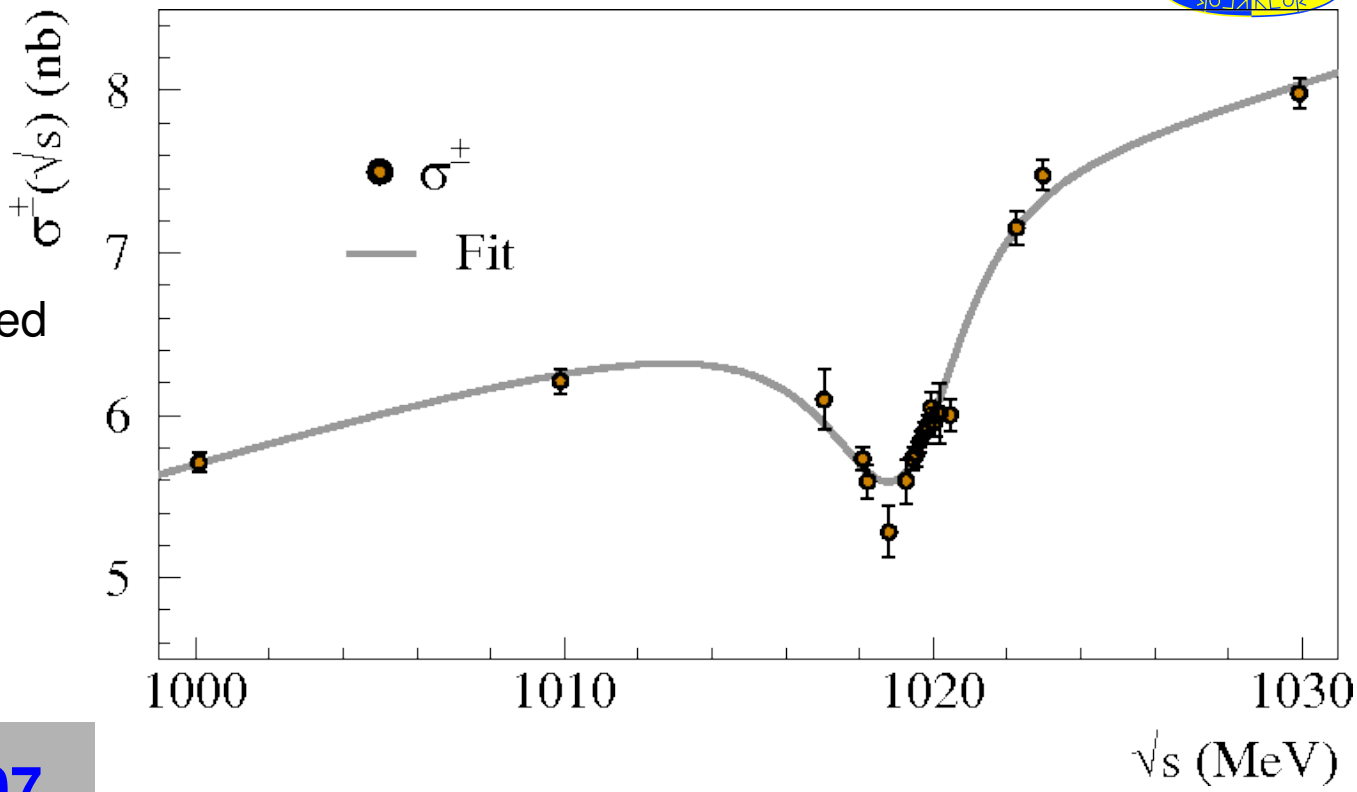


$\sigma(e^+e^- \to \omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0)(E)$

Efficiency and vlabha luminosity as function of sqrt(s) included

Radiative correction included

BES included



σ_0	8.13 ± 0.07
$\Re e(Z)$	0.077 ± 0.008
$\Im m(Z)$	-0.130 ± 0.005
s'	0.077 ± 0.004

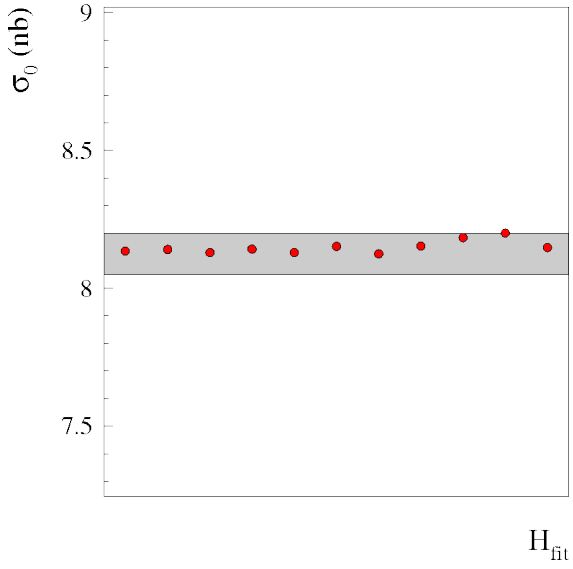
$$\sigma(E) = \sigma_0(E)\left|1 - Z\frac{m_\phi \Gamma_\phi}{D_\phi}\right|^2$$

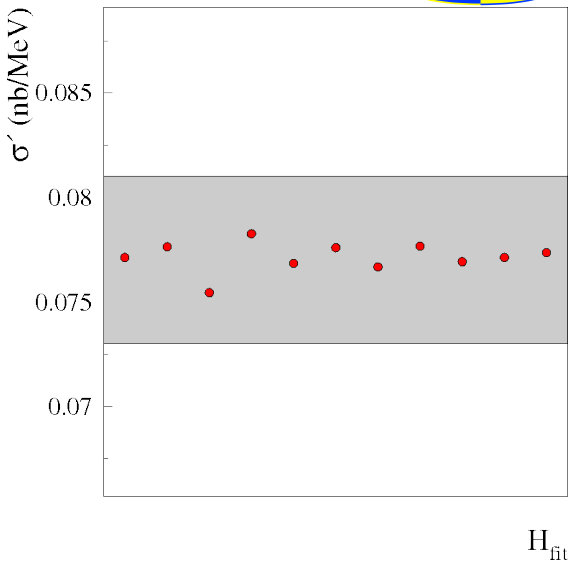
$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Cross section systematics

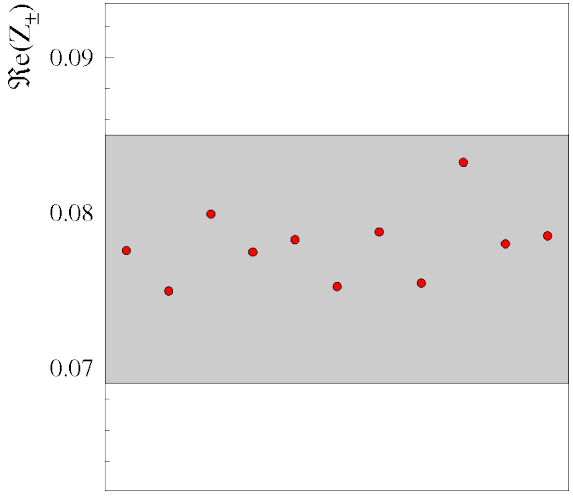
Cross section parameters variation as a function of distribution used in the counting fit

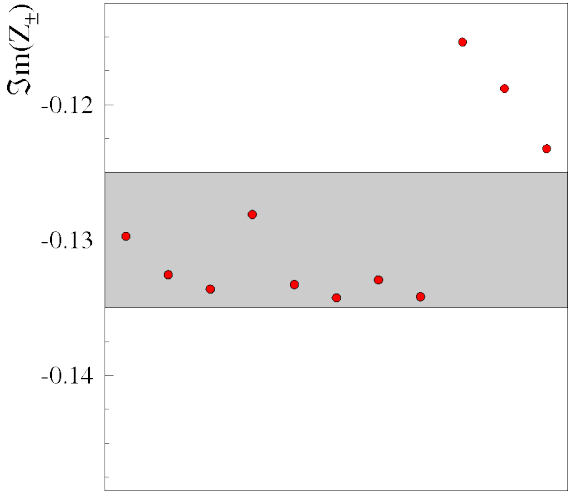
Numerical outputs

8.13	0.078	-0.130	0.077
8.14	0.075	-0.133	0.078
8.13	0.080	-0.134	0.075
8.14	0.077	-0.128	0.078
8.13	0.078	-0.133	0.077
8.15	0.075	-0.134	0.078
8.12	0.079	-0.133	0.077
8.15	0.075	-0.134	0.078
8.18	0.083	-0.115	0.077
8.20	0.078	-0.119	0.077
8.14	0.079	-0.123	0.077









$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Cross section systematics

Cross section parameters variation as a function of distribution used in the counting fit

energy cut (10/20/50)

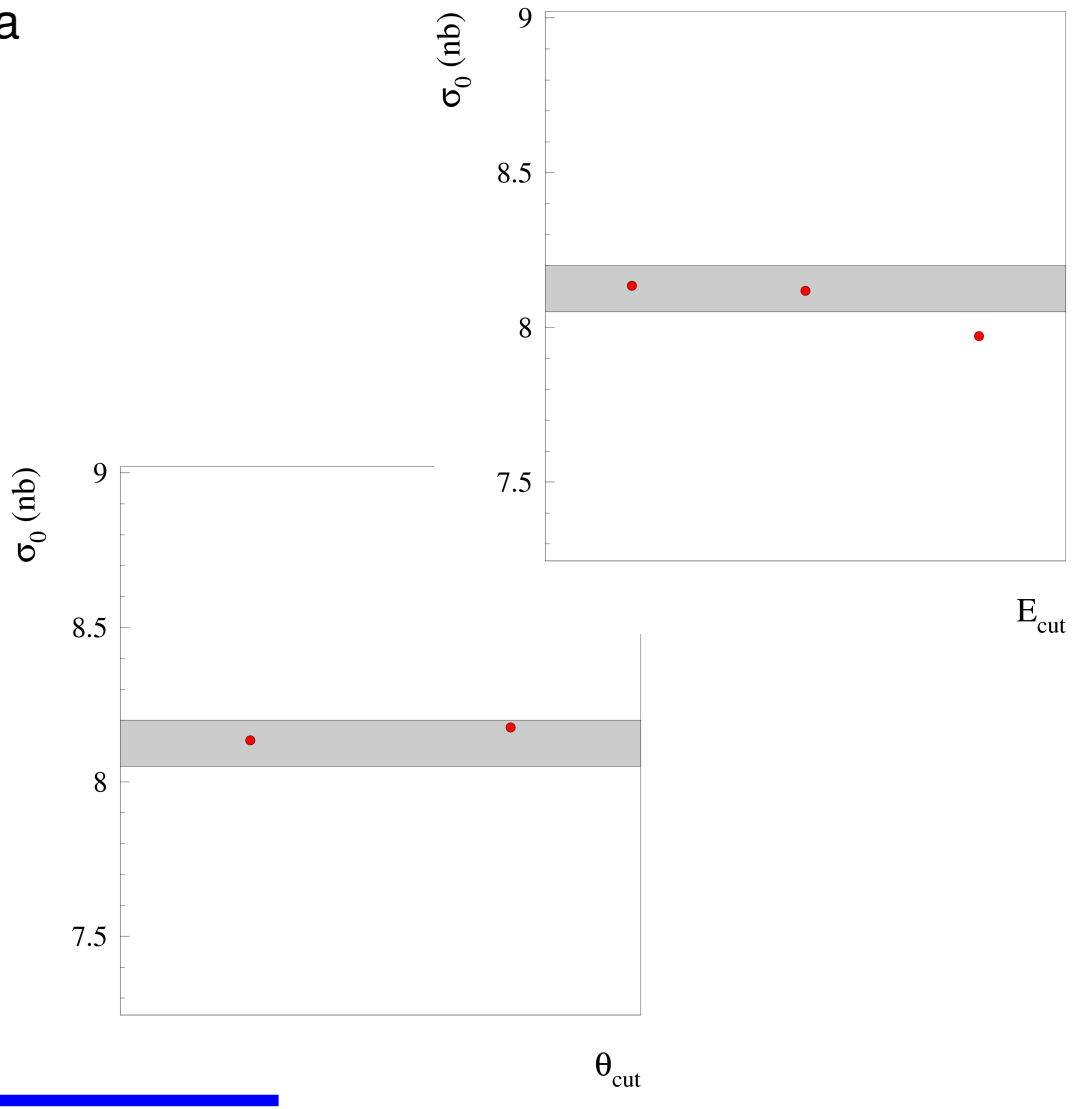
8.13	0.078	-0.130	0.077
8.12	0.082	-0.129	0.077
7.97	0.089	-0.123	0.078

angular cut (0.93/0.90)

8.13	0.078	-0.130	0.077
8.18	0.077	-0.132	0.076

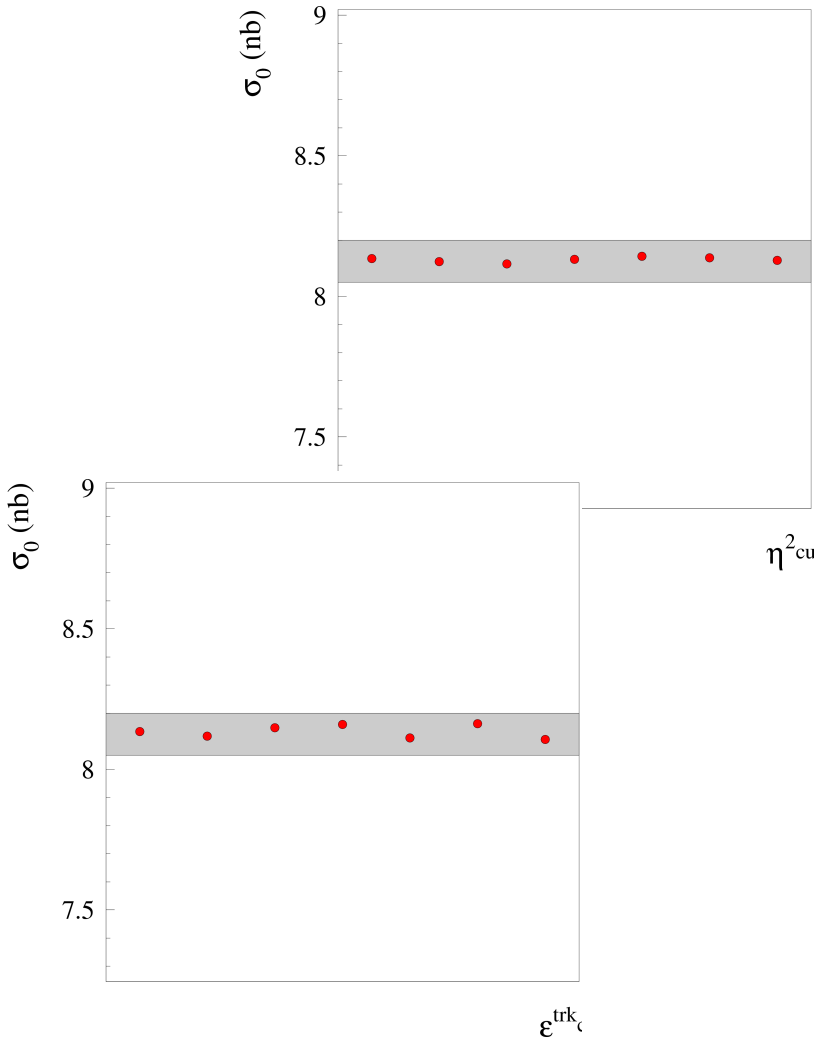
energy and angle (10,0.93/20,0.90)

8.13	0.078	-0.130	0.077
8.15	0.082	-0.130	0.076



$\omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$: Cross section systematics

# chi2 (50/10/20/30/40/60/70)			
8.13	0.078	-0.130	0.077
8.12	0.064	-0.138	0.081
8.12	0.075	-0.129	0.078
8.13	0.076	-0.128	0.077
8.14	0.079	-0.129	0.077
8.14	0.078	-0.131	0.077
8.13	0.078	-0.130	0.078
# tracking efficiency (000/100/-100/010/0-10/001/00-1)			
8.13	0.078	-0.130	0.077
8.12	0.077	-0.130	0.077
8.15	0.078	-0.129	0.077
8.16	0.077	-0.131	0.077
8.11	0.078	-0.129	0.077
8.16	0.077	-0.131	0.077
8.11	0.078	-0.128	0.077

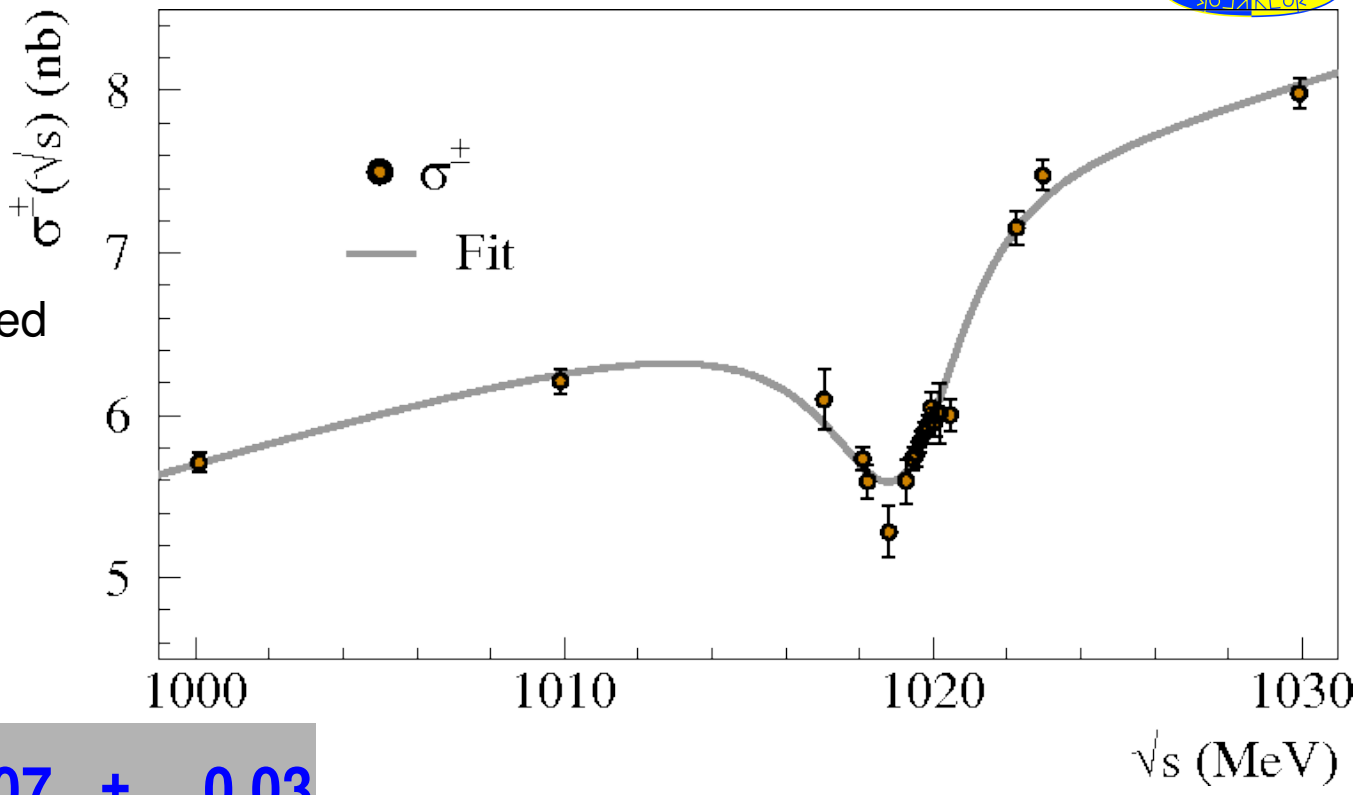


$\sigma(e^+e^- \to \omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0)(E)$

Efficiency and vlabha luminosity as function of sqrt(s) included

Radiative correction included

BES included



σ_0	8.13	± 0.07	±	0.03
$\Re e(Z)$	0.077	± 0.008	±	0.004
$\Im m(Z)$	-0.130	± 0.005	±	0.006
s'	0.077	± 0.004	±	0.002

$$\sigma(E) = \sigma_0(E)\left|1 - Z\frac{m_\phi \Gamma_\phi}{D_\phi}\right|^2$$

Combined

ω's BR

Parameter $(e^+e^- \to \pi^+\pi^-\pi^0\pi^0)$	
$\sigma_0^{\pm}$ (nb)	8.13 ± 0.08
$\Re(Z_{\pm})$	0.077 ± 0.009
$\Im(Z_{\pm})$	$-0.130 \pm 0.0.008$
$\sigma'_{\pm}$ (nb/MeV)	0.077 ± 0.004

Parameter $(e^+e^- \to \pi^0\pi^0\gamma)$	
$\sigma_0^{\pi\pi\gamma}$ (nb)	0.724 ± 0.011
$\Re(Z_{\pi\pi\gamma})$	0.011 ± 0.016
$\Im(Z_{\pi\pi\gamma})$	-0.154 ± 0.004
$\sigma'_{\pi\pi\gamma}$ (nb/MeV)	$0.0053 \pm 0.0.0005$

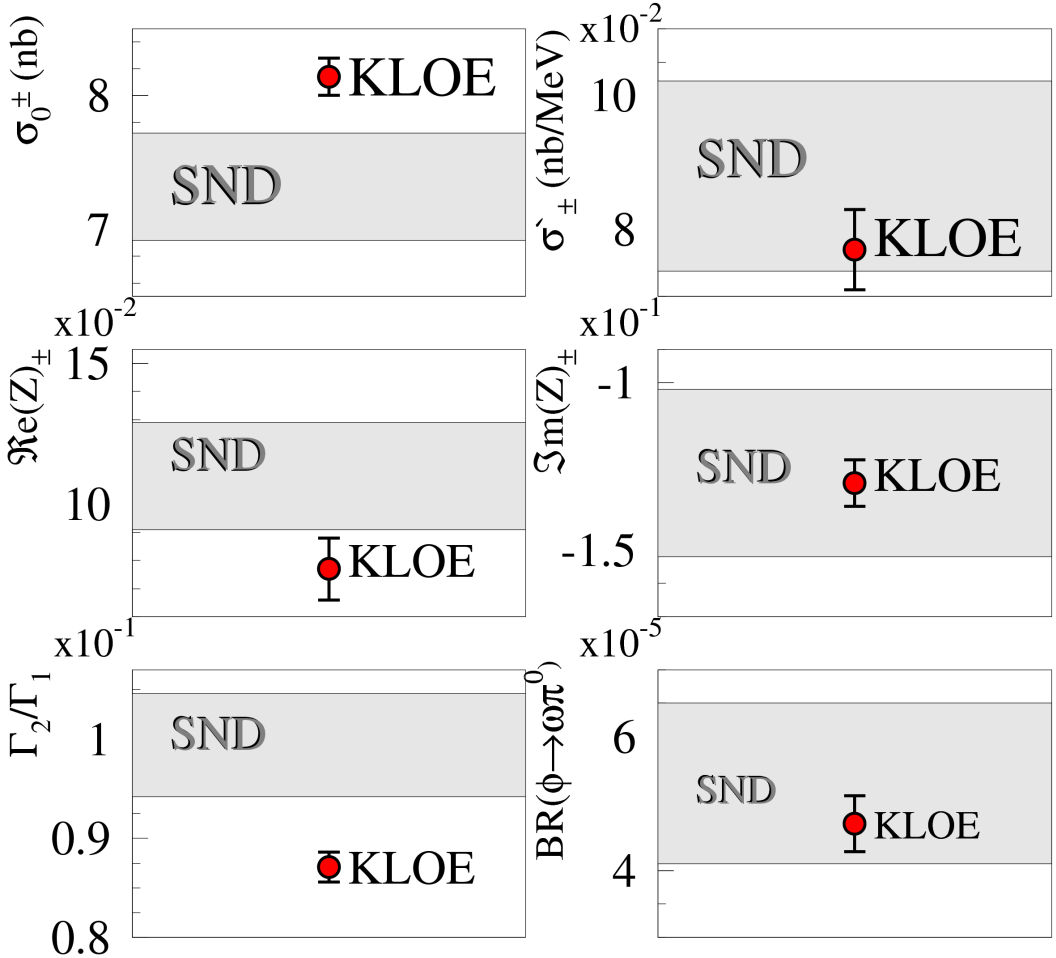
$$\frac{\sigma_0(\omega \to \pi^0\gamma)}{\sigma_0(\omega \to \pi^+\pi^-\pi^0)} = 0.0890 \pm 0.0016$$

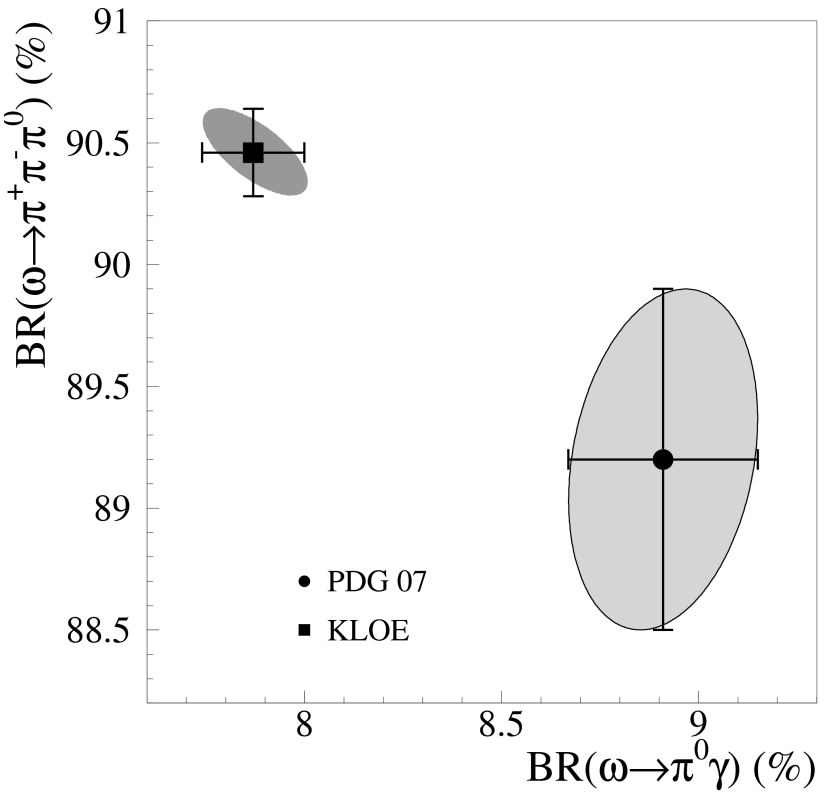
$$\frac{\Gamma(\omega \to \pi^0\gamma)}{\Gamma(\omega \to \pi^+\pi^-\pi^0)} = 0.0871 \pm 0.0.0015$$

$$BR(\omega \to \pi^+\pi^-\pi^0) = (90.46 \pm 0.18)\%$$

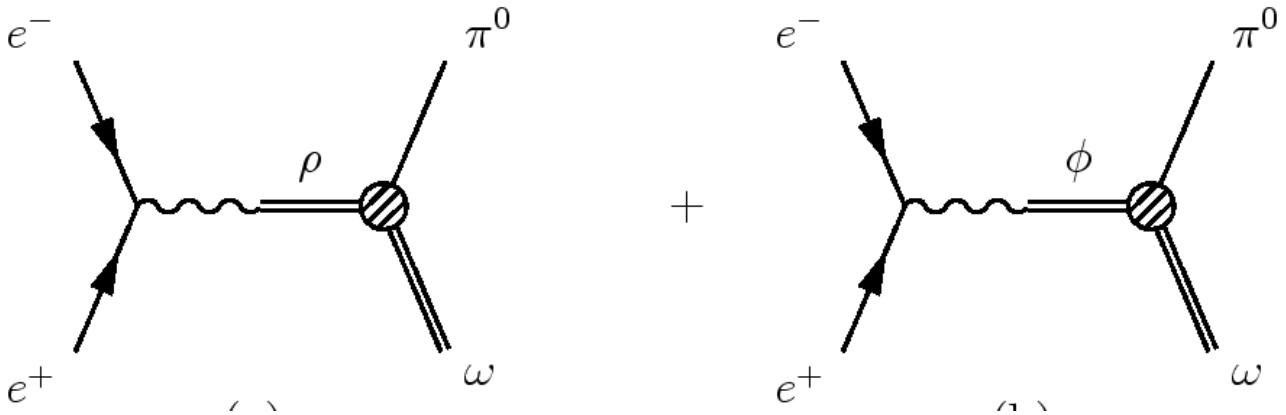
$$BR(\omega \to \pi^0\gamma) = (\ 7.87 \pm 0.13)\%$$

ω's BR


$\sigma_{0^+}^{\pm}$ (nb)
8
7
KLOE
SND
$\sigma'^{\pm}$ (nb/MeV)
x10^{-2}
10
8
SND
KLOE
$\Re e(Z)_{\pm}$
x10^{-2}
15
10
SND
KLOE
$\Im m(Z)_{\pm}$
x10^{-1}
-1
-1.5
SND
KLOE
Γ_2/Γ_1
x10^{-1}
1
0.9
0.8
SND
KLOE
BR($\phi\to\omega\pi^0$)
x10^{-5}
6
4
SND
KLOE


BR($\omega\to\pi^+\pi^-\pi^0$) (%)
91
90.5
90
89.5
89
88.5
PDG 07
KLOE
8
8.5
9
BR($\omega\to\pi^0\gamma$) (%)

$BR(\phi \to \omega\pi^0)$



$$BR(\phi \to \omega\pi^0) = \frac{\sigma_0(m_\phi)|Z|^2}{\sigma_\phi}$$

$$BR(\phi \to \omega\pi^0) = (4.70 \pm 0.42) \times 10^{-5}$$

SPARE

$\omega\pi^0 \rightarrow \pi^0\pi^0\gamma$: Data-MC comparison (Step 3)