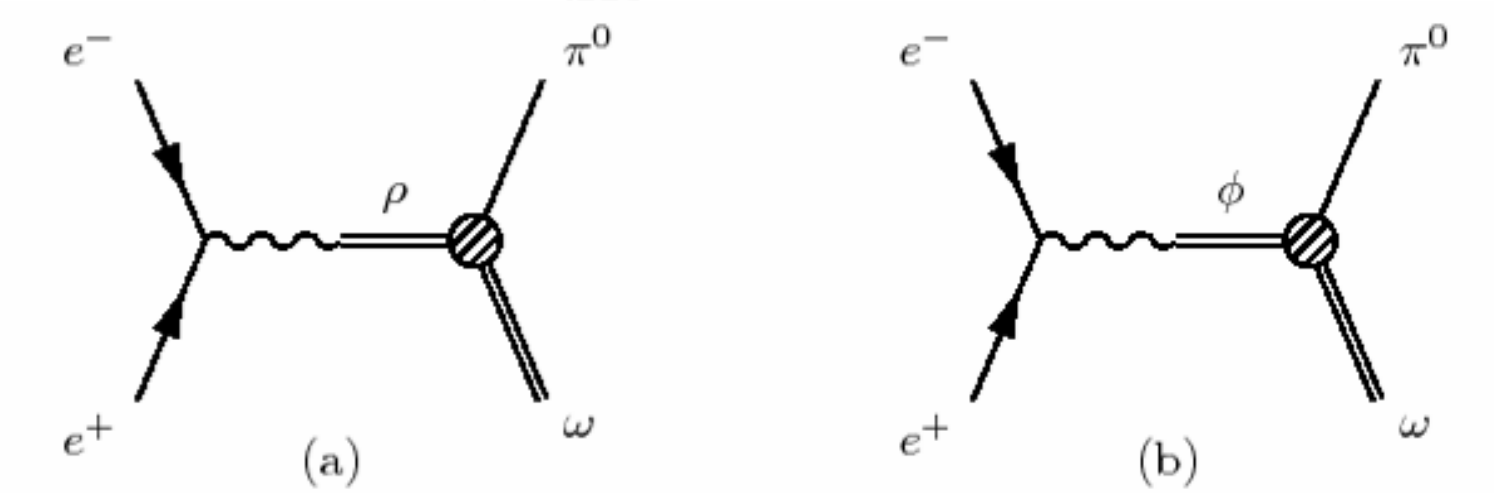
Cross section $e^+e^- \rightarrow \omega\pi^0 \rightarrow \pi^0\pi^+\pi^-\pi^0$

Antonio De Santis

Simona Giovannella

Amplitude



ϕ contribution in cross section (b) could be represented as interference with continuum process $\rho -> \omega\pi^0$ (a).
Interference is parametrized by term (Z) at ϕ-resonace peak.

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

Data sample

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

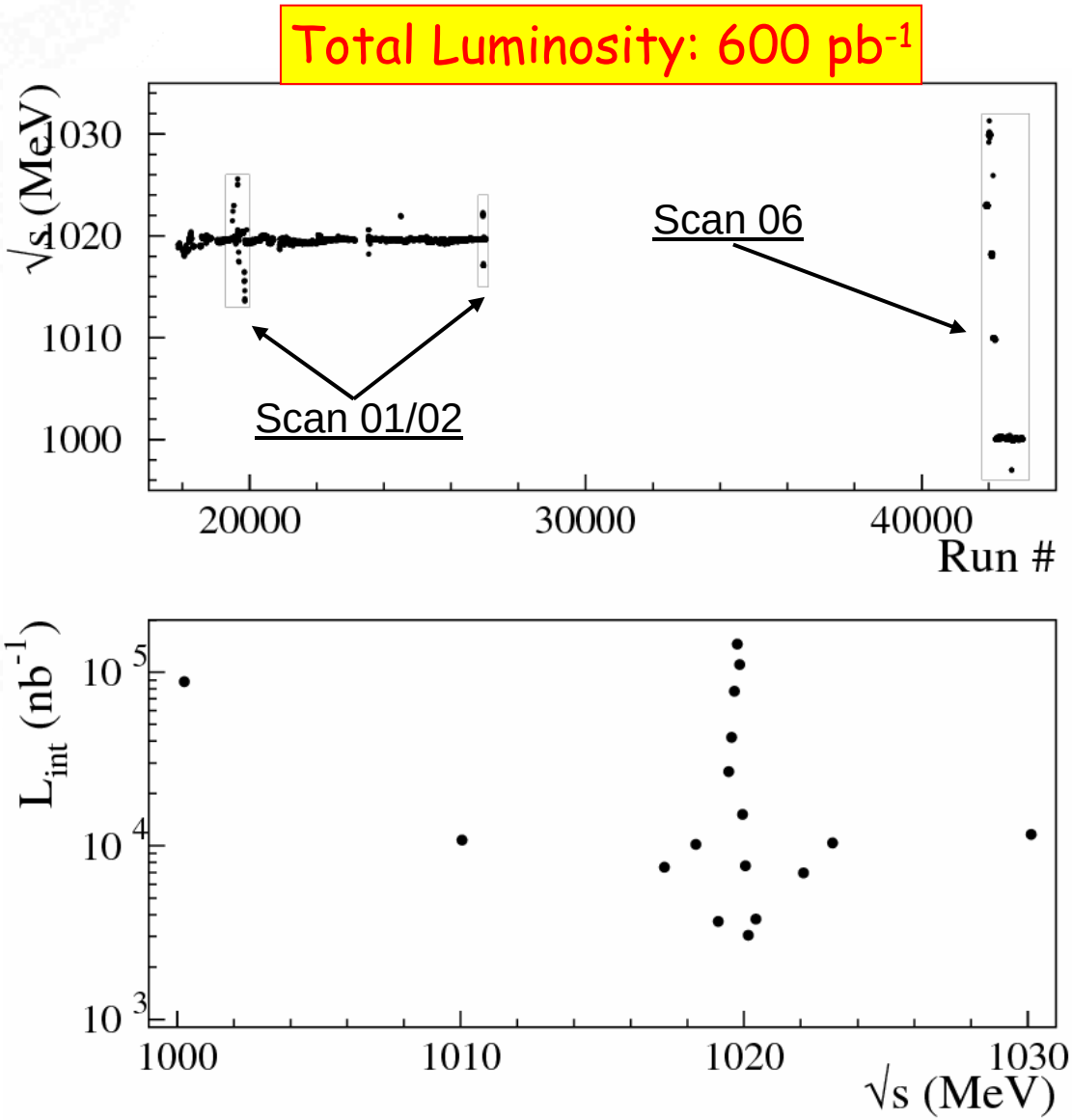
Integrated luminosity *offpeak* 150 pb^{-1}

Data:

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

MC sample:

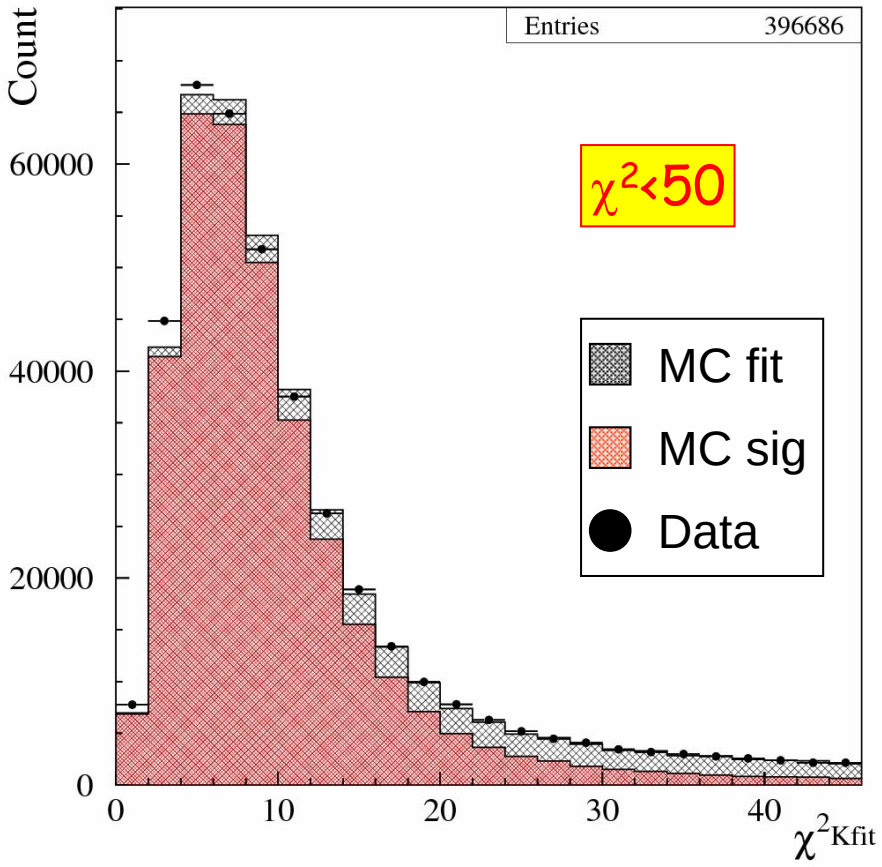
- Signal (DBV-26 LSF=1) 01/02 (?)
- mrc (DBV-18 all_phys LSF=0.2) 01/02
- mrc (DVB-26 all_phys LSF=1(2)) 06

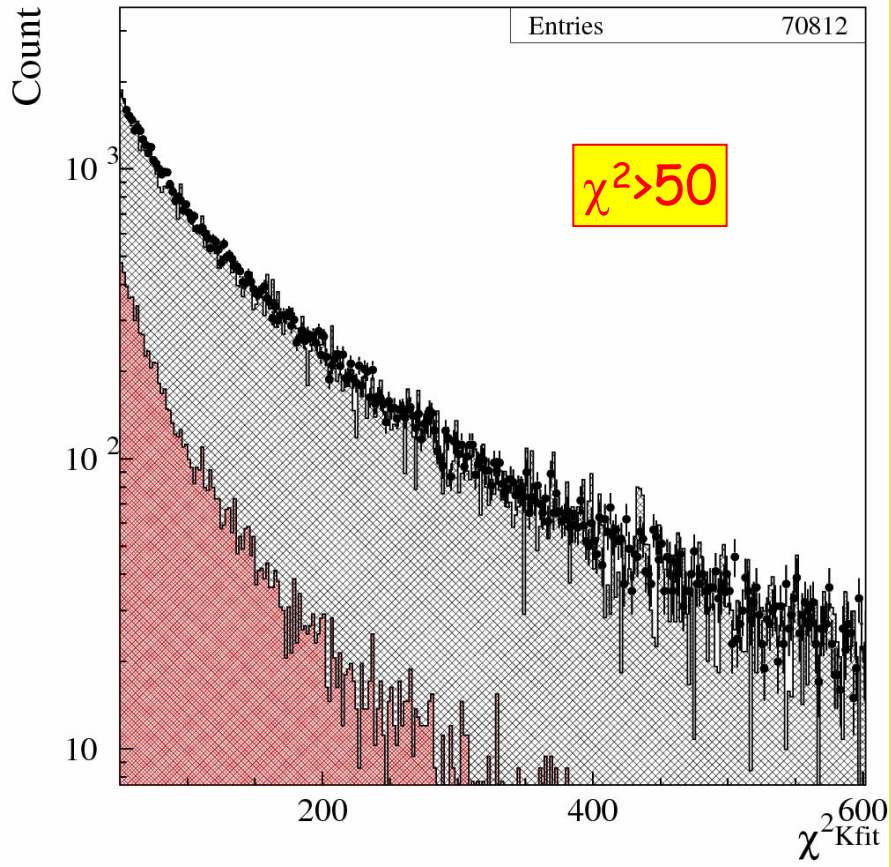


Analisys strategy

- Acceptance
  - 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
    - $|\cos(\theta)| < 0.93$
- Kinematic Fit (33 input parameters, 8 constraints) (?)
- Fine selection:
  - $\chi^2 < 50$
  - $\Delta m_\pi / m_\pi < 3\sigma$
- Slice dataset in function of E_{CM} (100 Kev Bin)
- Signal events counting (fit via HMCMLL)
- Cross section fit

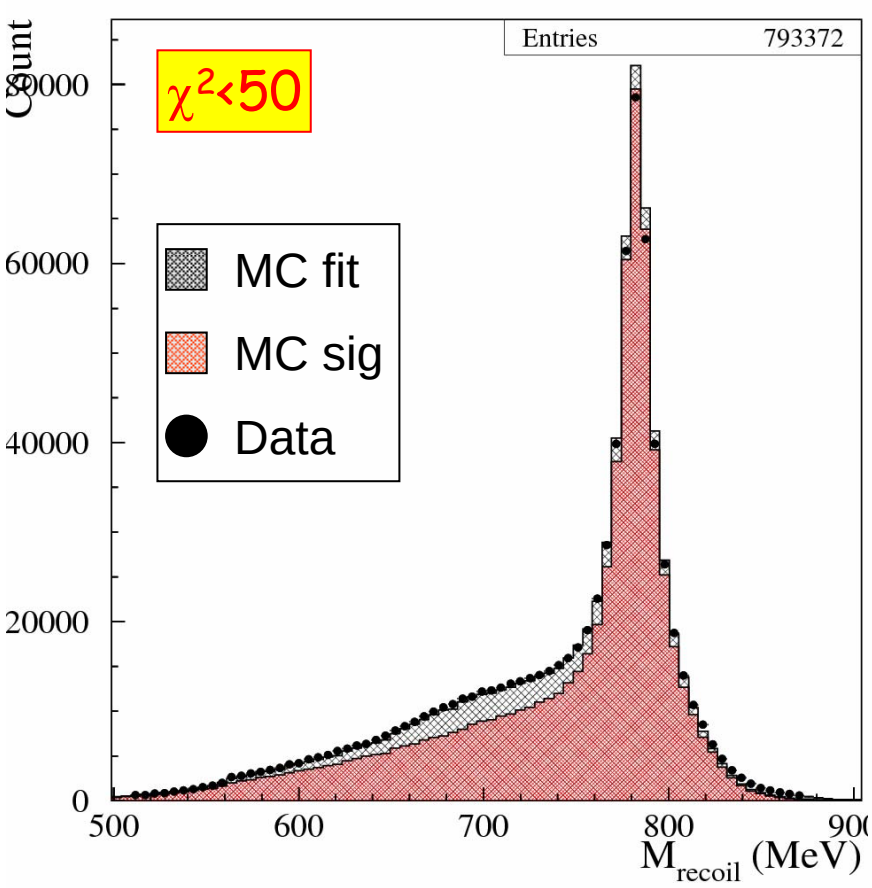
Data vs MC: $\cos(\theta)_{\pi^0}$

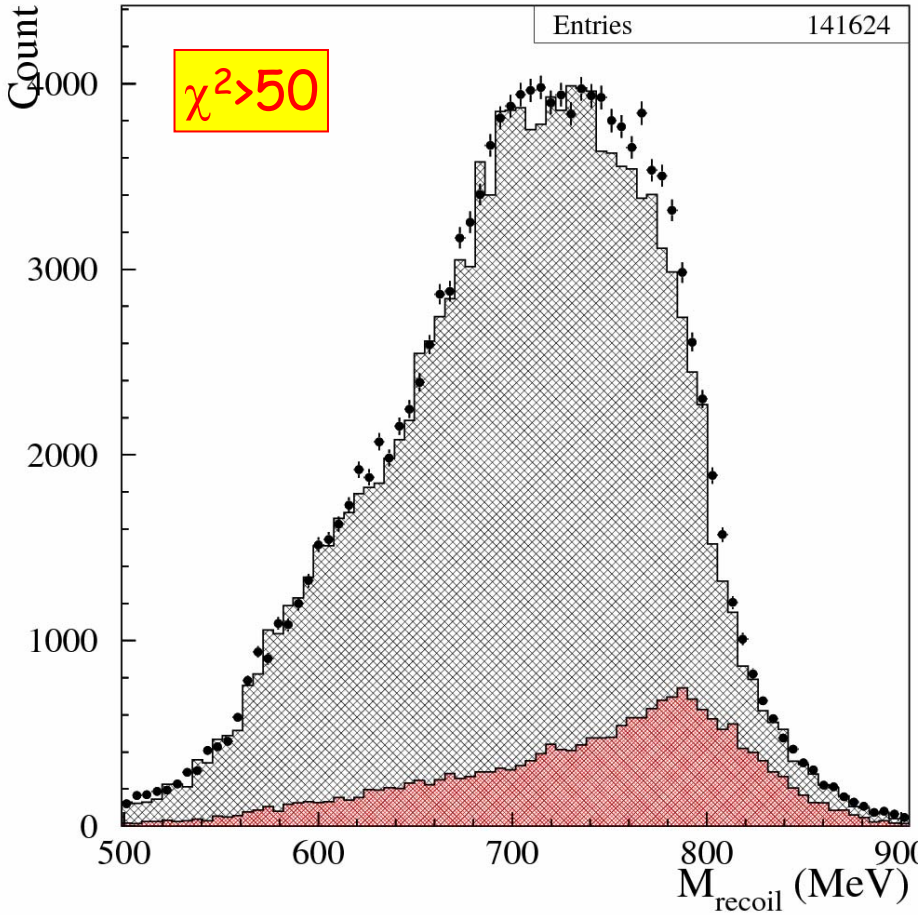




Same scale factors are used to normalize MC distributions in both selections

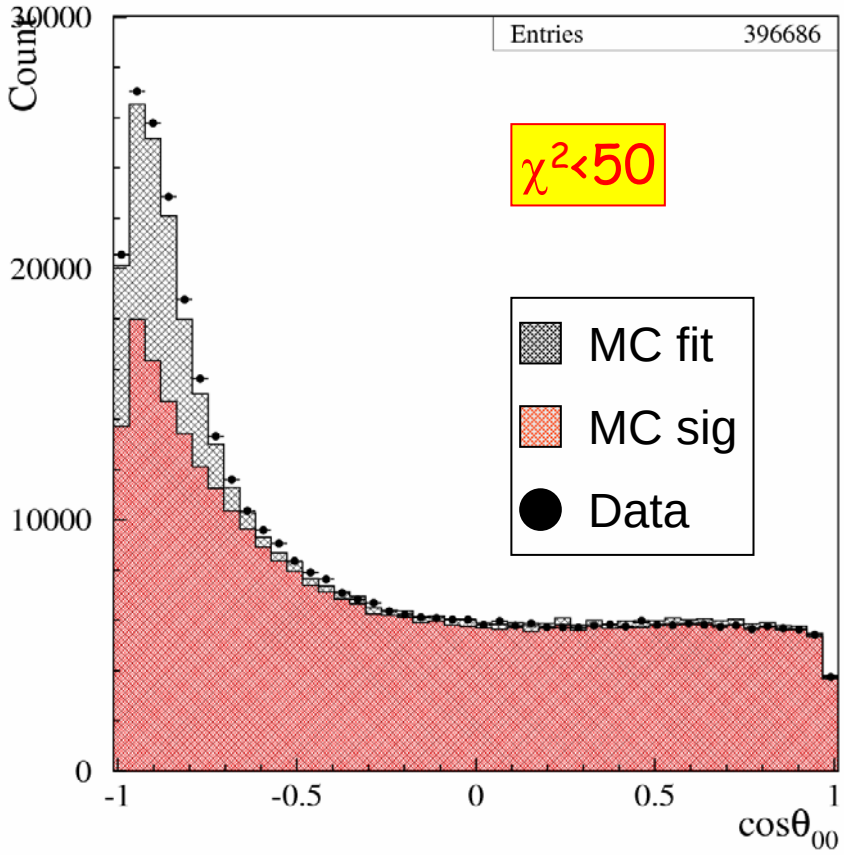
Data vs MC

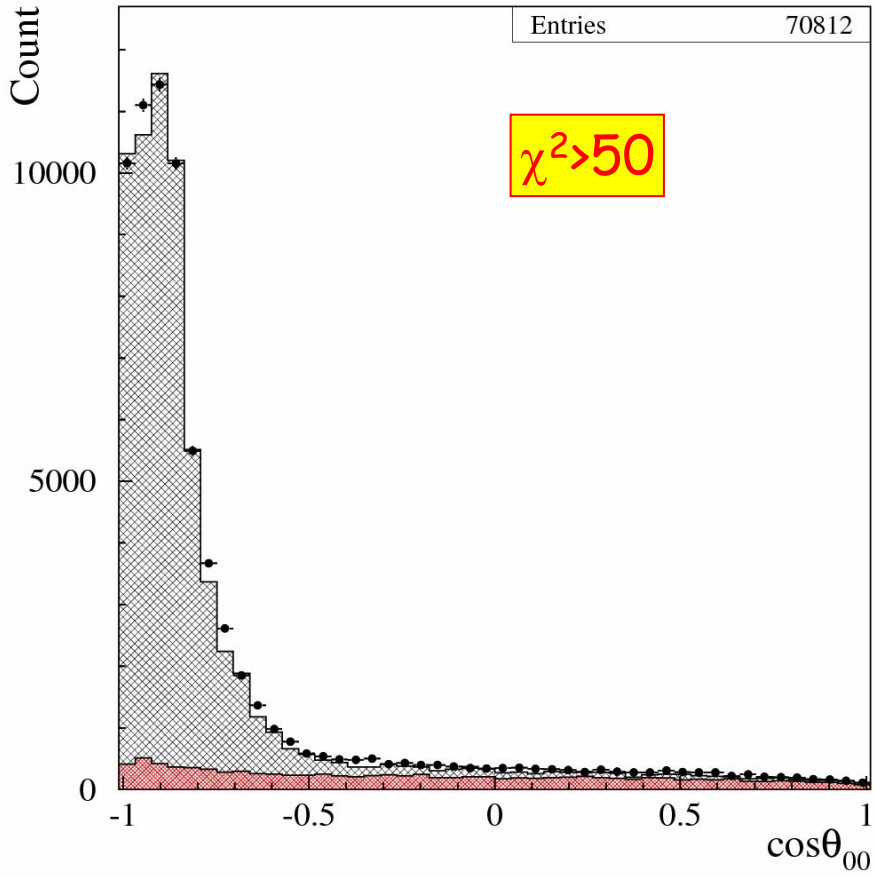




Same scale factors are used to normalize MC distributions in both selections

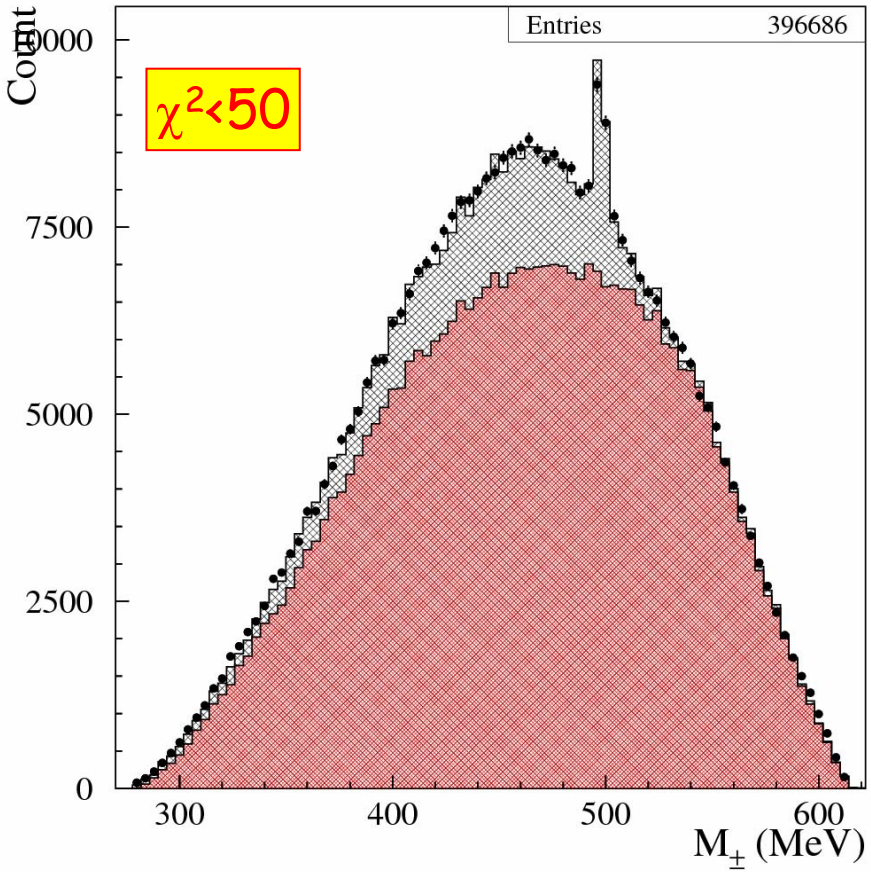
Data vs MC

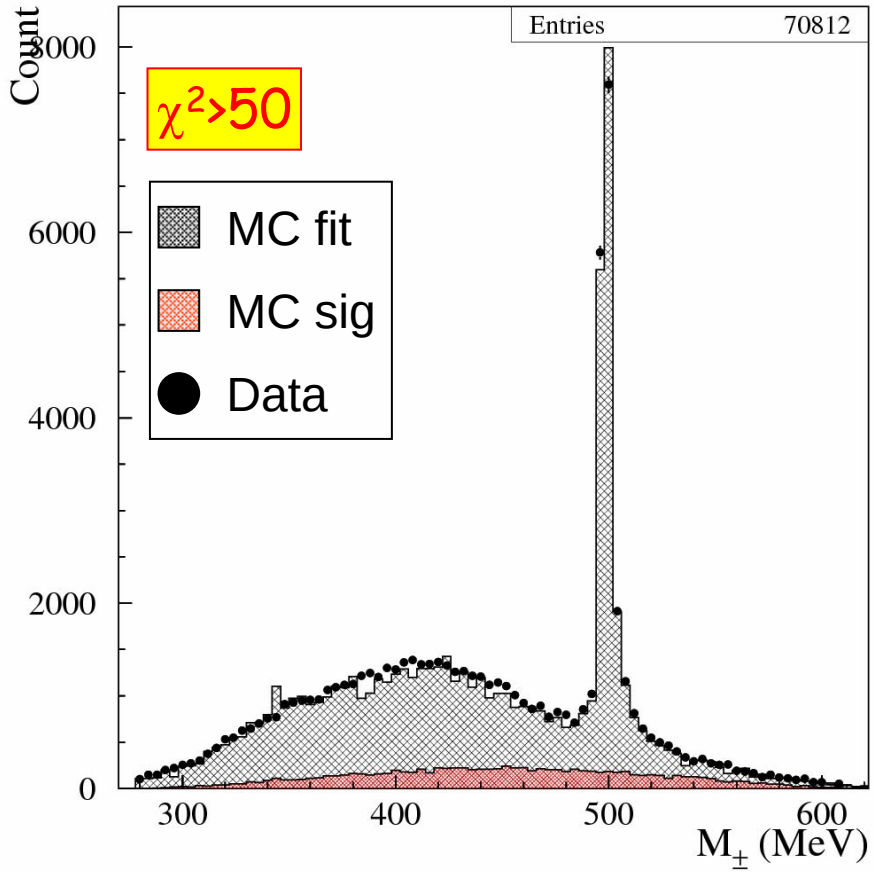




Same scale factors are used to normalize MC distributions in both selections

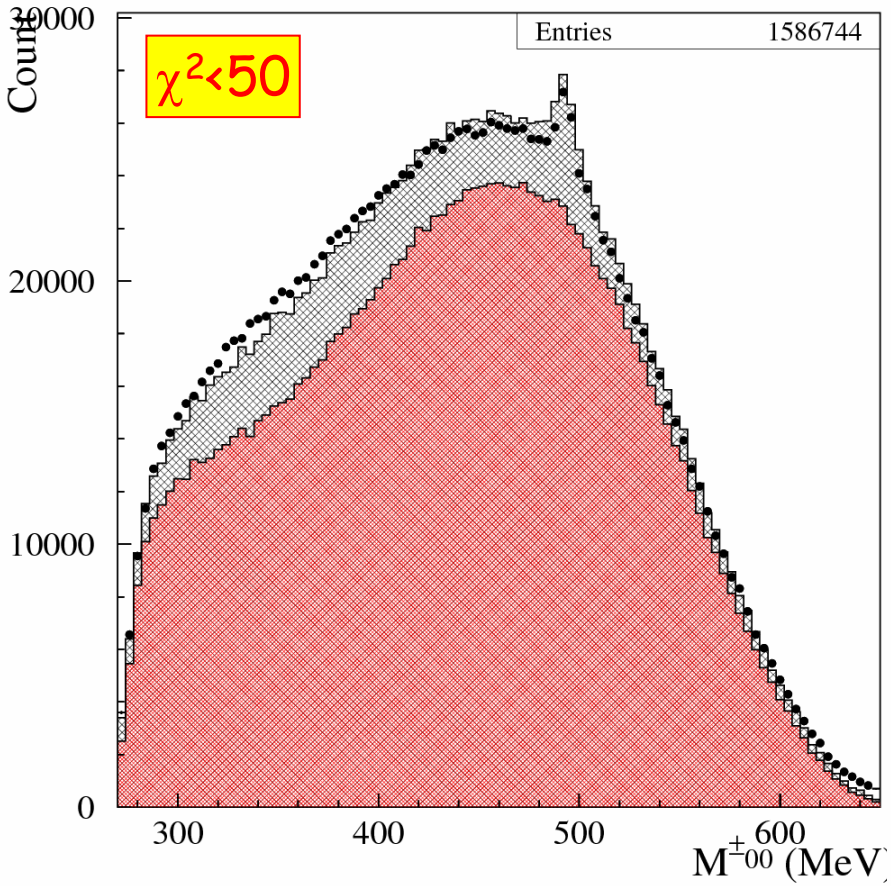
Data vs MC

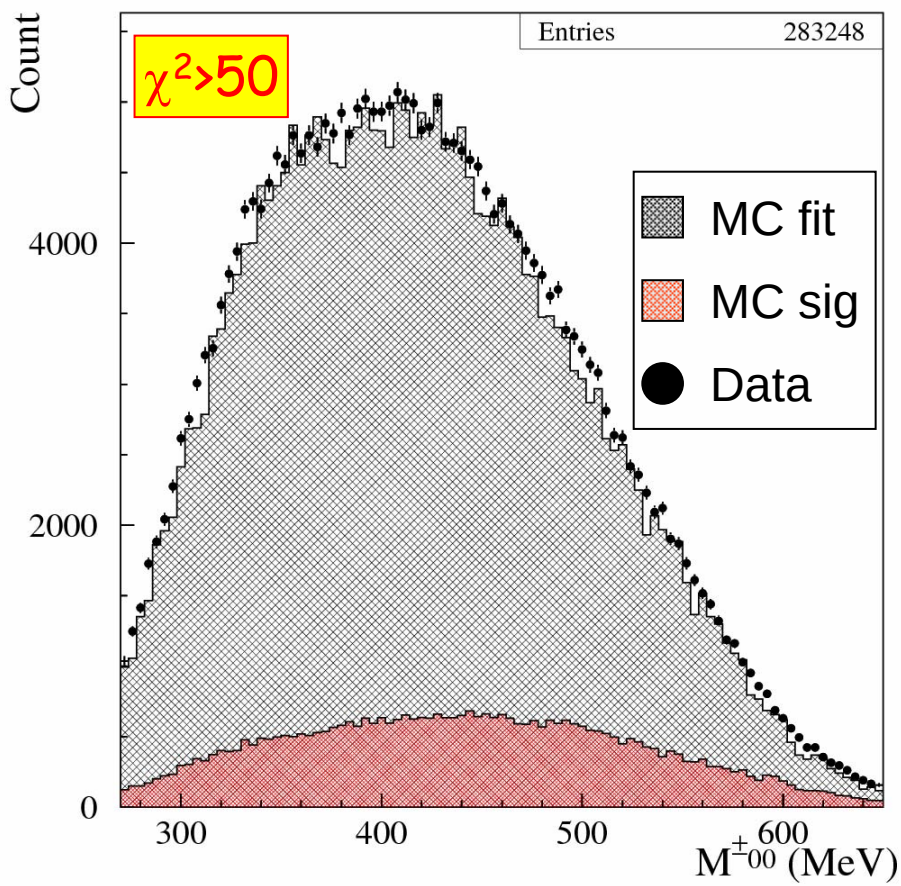




Same scale factors are used to normalize MC distributions in both selections

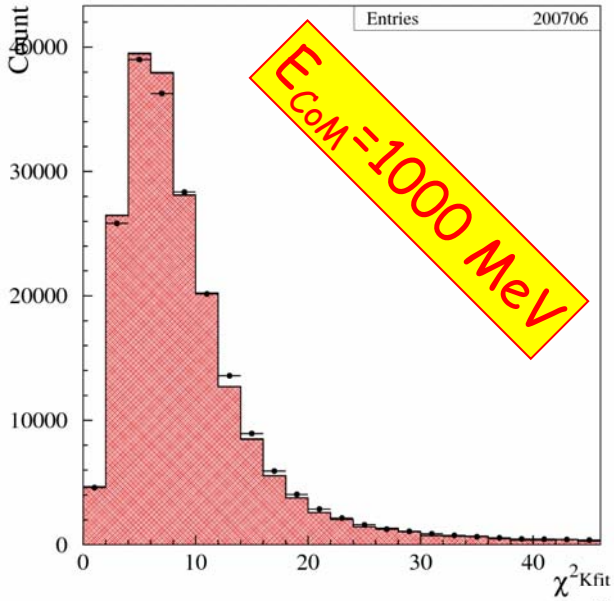
Data vs MC

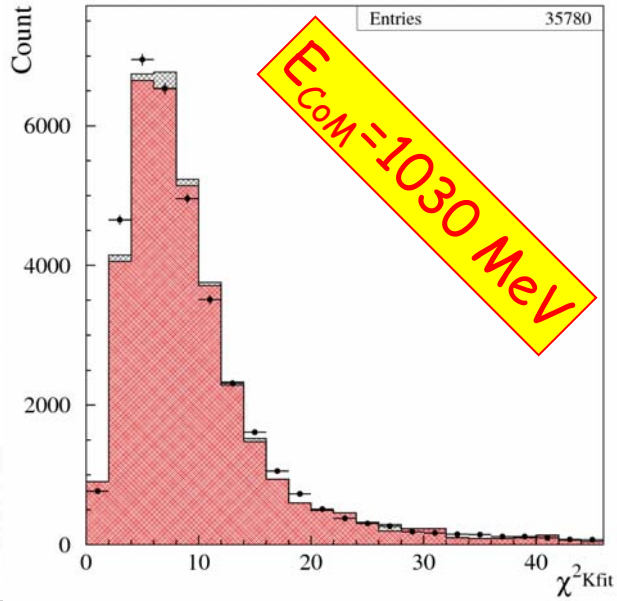


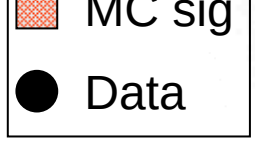


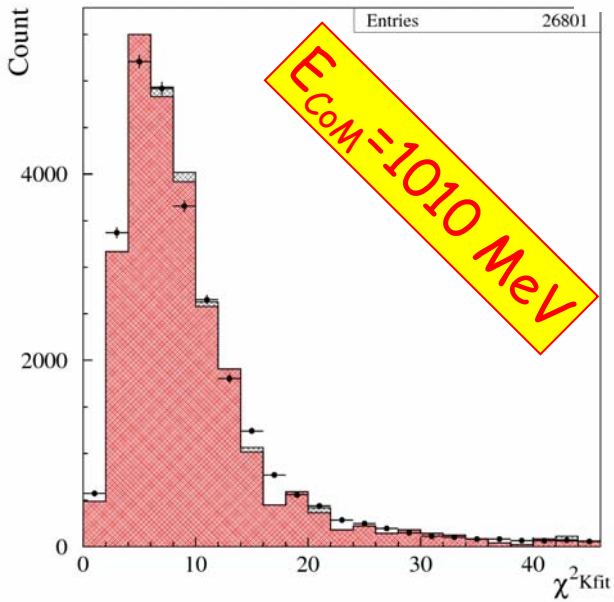
Same scale factors are used to normalize MC distributions in both selections

Data vs MC


Entries 200706
Count
χ^2Kfit
E_{CoM}=1000 MeV


Entries 35780
Count
χ^2Kfit
E_{CoM}=1030 MeV

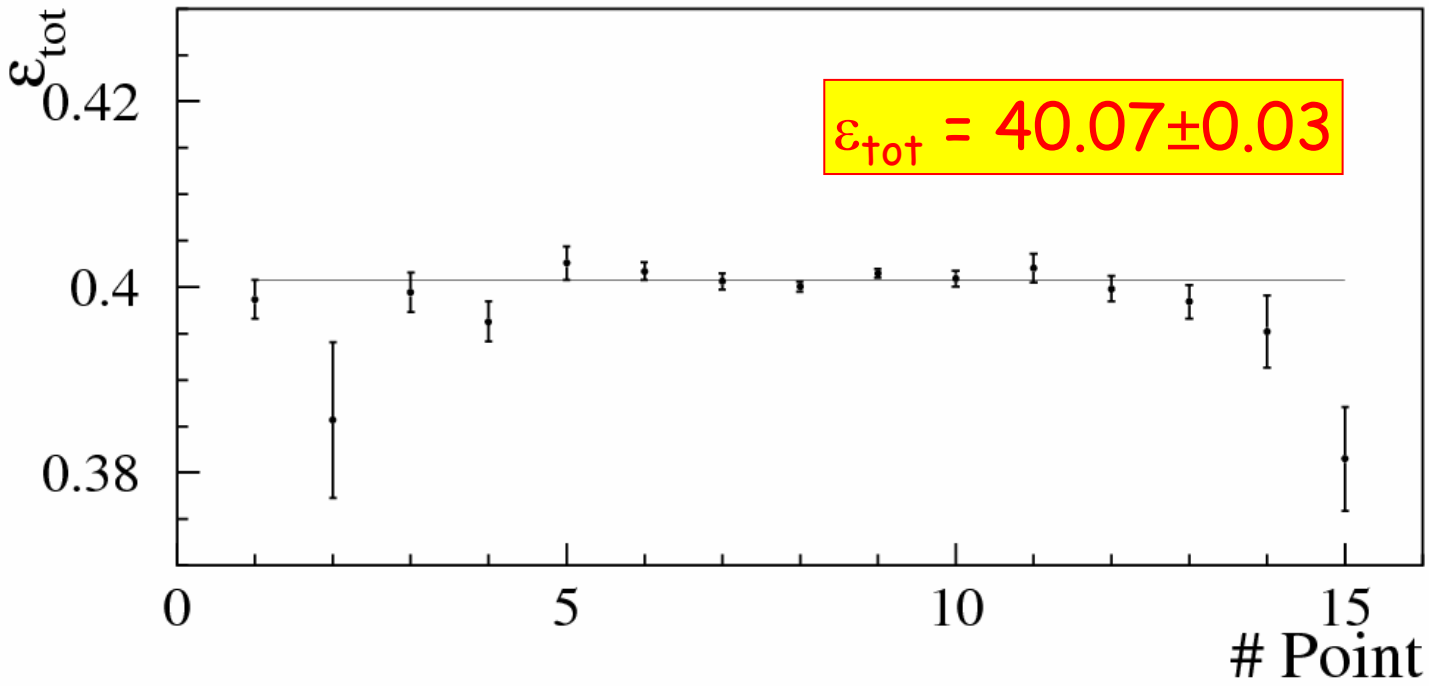

MC fit
MC sig
Data


Entries 26801
Count
χ^2Kfit
E_{CoM}=1010 MeV

Efficiency

Conditional efficiency:

Cut	$\varepsilon_{cut}(\%)$
Acceptance	48.05 ± 0.05
Rejection-box + Bhaha-cut	94.11 ± 0.02
$\chi^2_{K\,fit}$	97.84 ± 0.03
ECL	91.65 ± 0.04



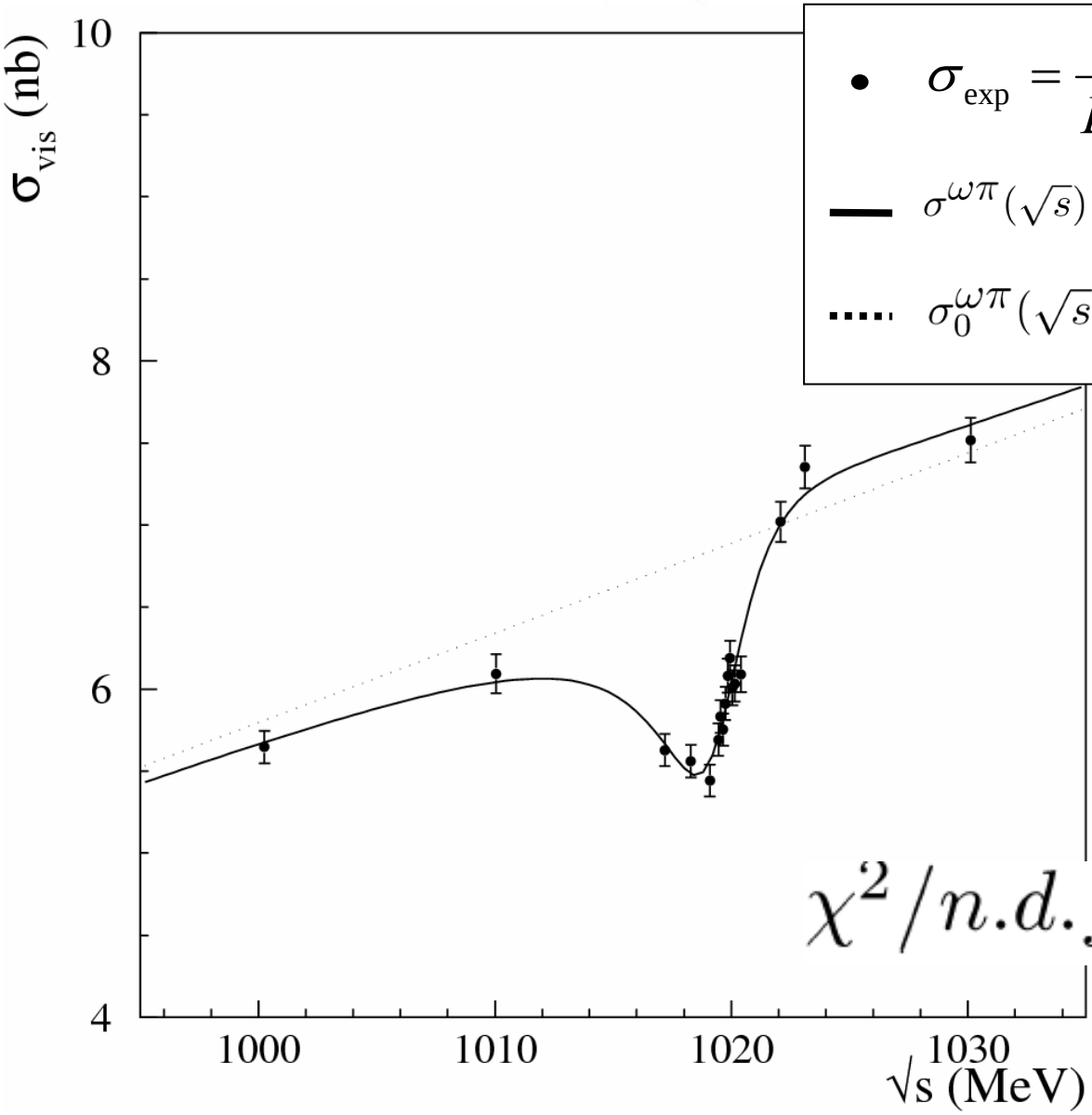
Systematic errors I

Source	$\delta_\varepsilon/\varepsilon$
Tracking	1 %
Vertexing	1 %
Clustering	7‰
Trigger	10^{-4}
Cosmic Veto	3‰
Acceptance	3‰
Analysis cuts	3‰
Luminosity	5‰
Total	1.7 %

Different source of systematic errors are taken into account.

All of them are summed in quadrature with statistic error of the counting fit to get the final error on the visible cross section

Cross section fit



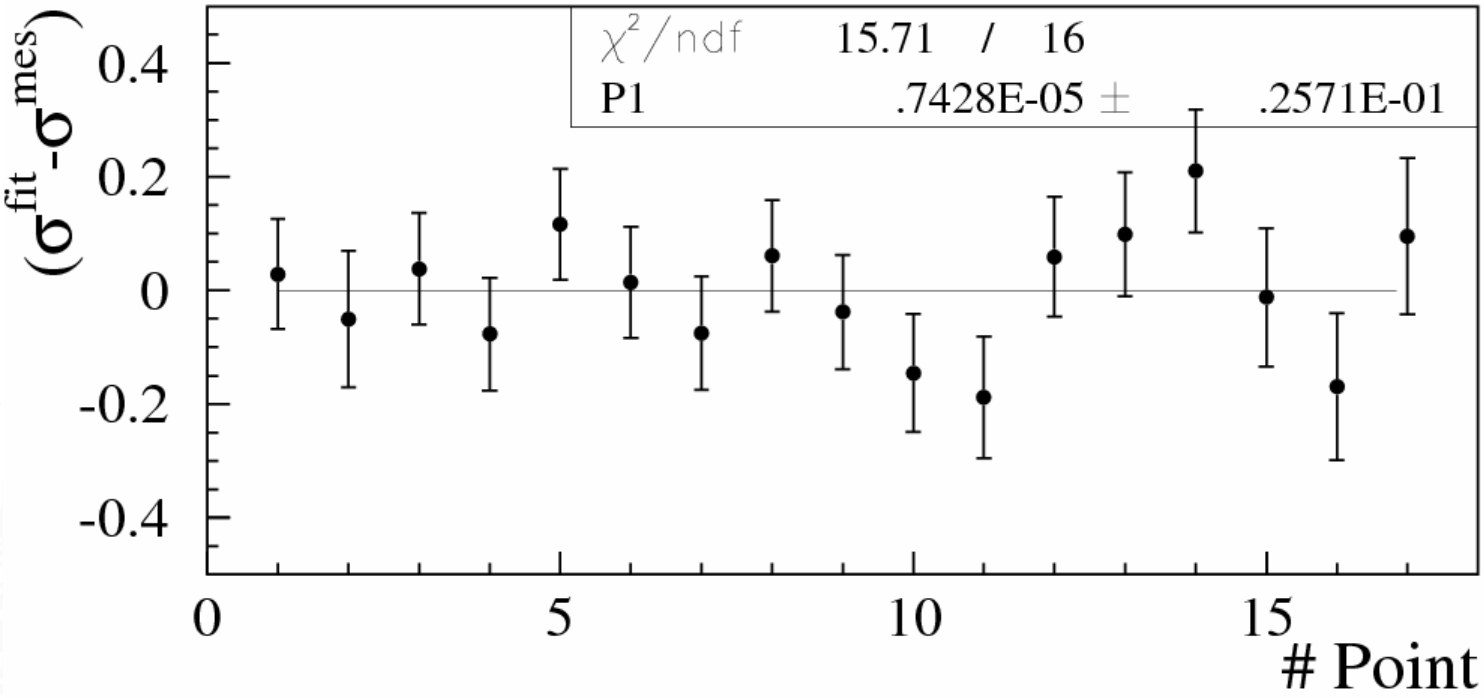
$$\bullet \quad \sigma_{\exp} = \frac{N_{count}}{L_{\text{int}} \cdot \varepsilon_{tot}}$$

$$\sigma^{\omega\pi}(\sqrt{s}) = \sigma_0^{\omega\pi}(\sqrt{s}) \cdot \left|1 - Z_{\pm}\frac{M_\phi \Gamma_\phi}{D_\phi}\right|$$

$$\sigma_0^{\omega\pi}(\sqrt{s}) = \sigma_0^{\omega\pi^0} + \sigma'(\sqrt{s} - M_\phi)$$

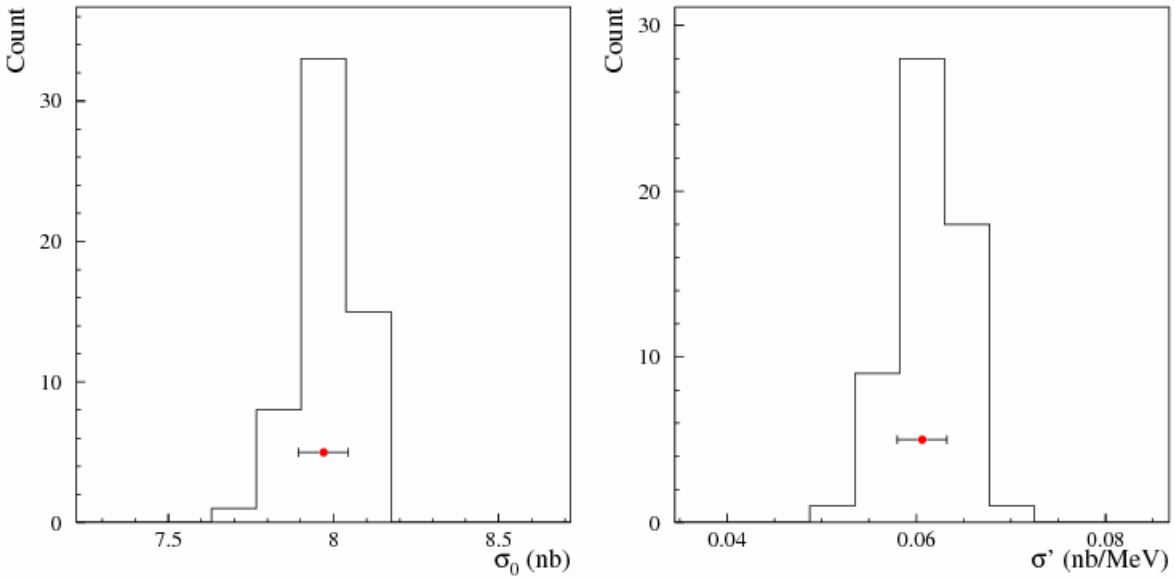
$$\chi^2/n.d.f. = 15.7/13$$

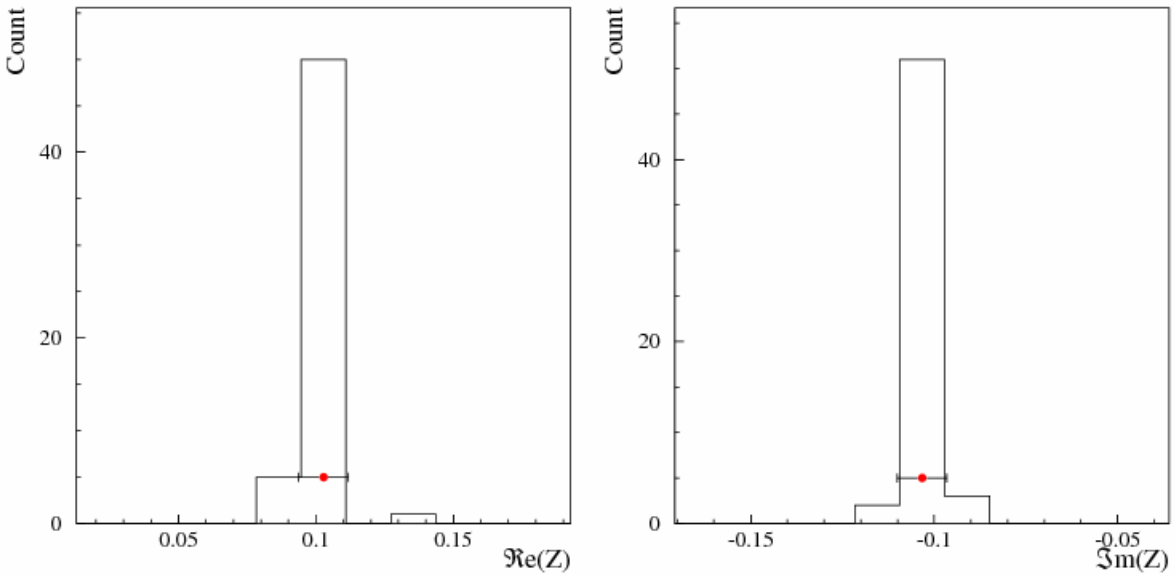
Fit result



$\sigma_0^{\pm}$ (nb)	7.970	$\pm$	0.074
$\Re(Z)$	0.1028	$\pm$	0.0090
$\Im(Z)$	-0.1033	$\pm$	0.0067
σ' (nb/MeV)	0.0606	$\pm$	0.0026

Systematic errors II





Systematic errors on the fit parameters are evaluated as r.m.s. of the distributions obtained varying cuts and fitted distribution (counting).

Cross section stability as been checked for each CoM energy.

Final results

KLOE results:

$\sigma_0^{\pm}$ (nb)	7.970	$\pm$	0.074	$\pm$	0.080
$\Re(Z)$	0.1028	$\pm$	0.0090	$\pm$	0.0061
$\Im(Z)$	-0.1033	$\pm$	0.0067	$\pm$	0.0033
σ' (nb/MeV)	0.0606	$\pm$	0.0026	$\pm$	0.0033

$$\mathrm{BR}_{eff}(\phi \to \omega\pi^0) = (3.57 \pm 0.47)\, 10^{-5}$$

SND results:

$\sigma_0^{\pm}$ (nb)	7.32	$\pm$	0.14	$\pm$	0.38
$\Re(Z)$	0.110	$\pm$	0.019	$\pm$	0.003
$\Im(Z)$	-0.127	$\pm$	0.025	$\pm$	0.005
$\mathrm{BR}(\phi \to \omega\pi^0) \times 10^{-5}$	$5.5^{+1.6}_{-1.4} \pm 0.3$				

KLOE Memo xxx

Study of the $e^+e^- \to \omega\pi^0 \to \pi^+\pi^-\pi^0\pi^0$ process using 2001/2002 data

A. De Santis[1], S. Giovannella[2]

[1] *University of Rome "La Sapienza" and sezione INFN Roma1*

[2] *INFN - Laboratori Nazionali di Frascati*

Abstract

We report the measurement of the visible cross section for the $e^+e^- \to \omega\pi^0$ process performed using 450 pb^{-1} of e^+e^- collisions collected in the 2001−2002 data-taking period and the off-peak data collected at the end of KLOE data-taking. We use the final state $\pi^-\pi^+\pi^0\pi^0$ studying the dependence of the cross sections on the center of mass energy, $\sqrt{s}$, from 1000.0 to 1030.0 MeV and fit them to extract the relevant parameters of the $\omega\pi^0$ process.

Referees at work

Conclusions

Cross section parameters accuracy better than SND results.

Agreement between results due to large errors in SND measurements.

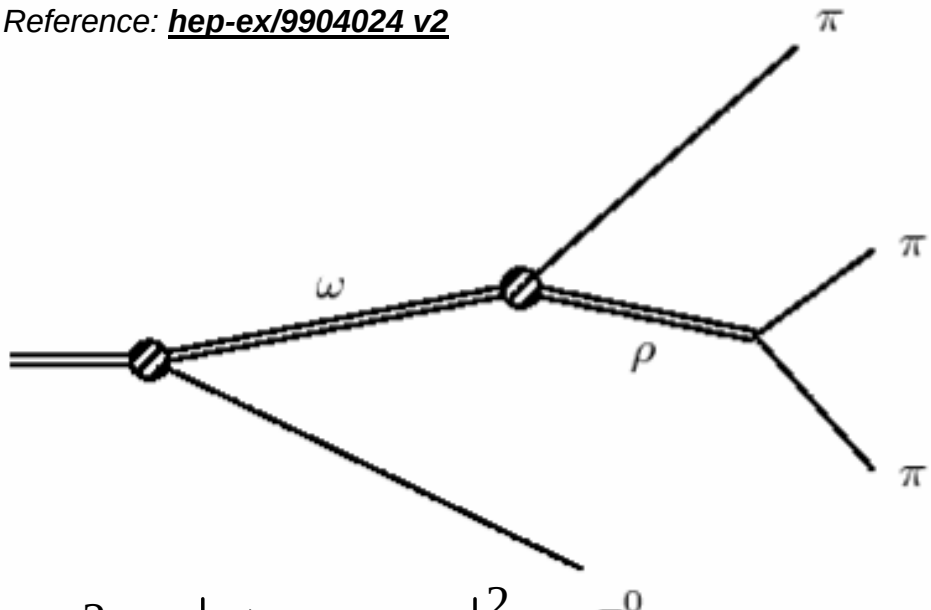
Yesterday was my birthday and Today is exactly one months after my wedding and this work is completed…

…Life is Beautiful

Spare

Amplitude: MC generator

Reference: ***hep-ex/9904024 v2***



All term which differs for exchange between two π^0's or different ρ charge must be summed. Resulting matrix element (M) could be expressed as modulus squared of current composed by two term(π^0's permutation) each composed by tree terms (ρ charge)

$$|\mathrm{M}|^2 = \left|\vec{J}_{\omega\pi^0}^{\,+-00}\right|^2$$

$$\vec{J}_{\omega\pi^0}^{\,+-00} = G_\omega\left[\vec{t}_\omega(p_2,p_4,p_1,p_3) - \vec{t}_\omega(p_2,p_1,p_4,p_3) - \vec{t}_\omega(p_2,p_3,p_1,p_4)\right] + (p_2 \leftrightarrow p_3)$$

$$\vec{t}_\omega(p_1,p_2,p_3,p_4) = \frac{F_\omega^2(P-p_1)}{D_\omega(P-p_1)D_\rho(p_3+p_4)}$$

$$\{(\varepsilon_4\vec{p}_3 - \varepsilon_3\vec{p}_4)(\vec{p}_1\cdot\vec{p}_2) - \vec{p}_2(\varepsilon_4\vec{p}_1\cdot\vec{p}_3 - \varepsilon_3\vec{p}_1\cdot\vec{p}_4) - \varepsilon_2\left[\vec{p}_3(\vec{p}_1\cdot\vec{p}_4) - \vec{p}_4(\vec{p}_1\cdot\vec{p}_3)\right]\}$$

Amplitude current term

Form factor

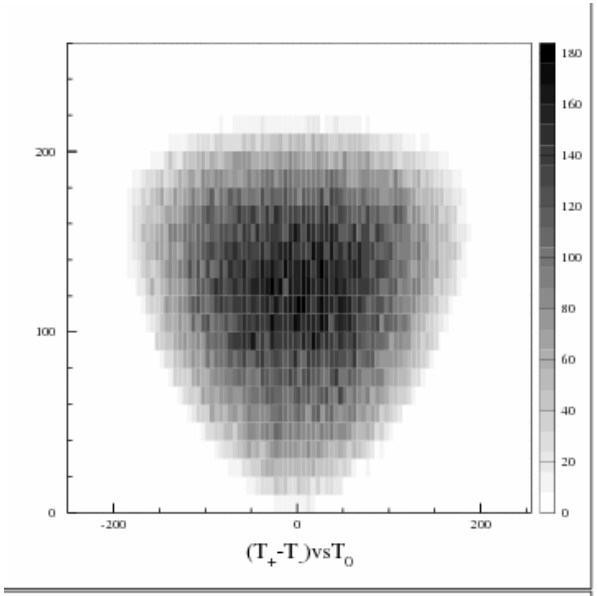
$$\vec{t}_\omega(p_1,p_2,p_3,p_4) = \frac{F_\omega^2(P-p_1)}{D_\omega(P-p_1)D_\rho(p_3+p_4)}$$

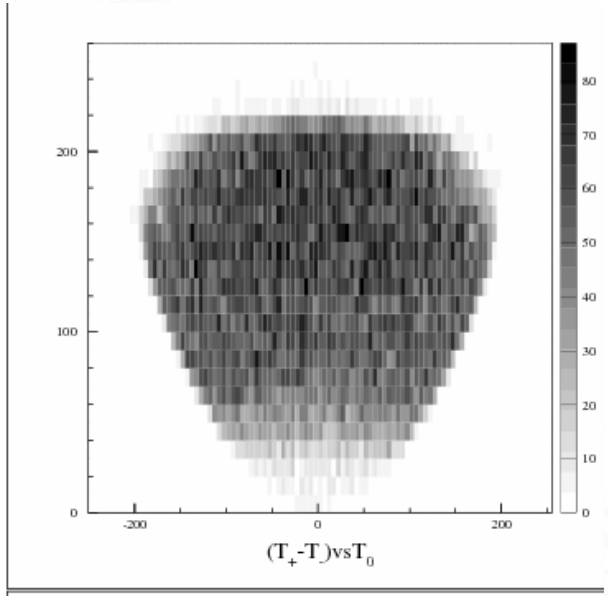
$$\{(\varepsilon_4\vec{p}_3-\varepsilon_3\vec{p}_4)(\vec{p}_1\cdot\vec{p}_2)-\vec{p}_2(\varepsilon_4\vec{p}_1\cdot\vec{p}_3-\varepsilon_3\vec{p}_1\cdot\vec{p}_4)$$

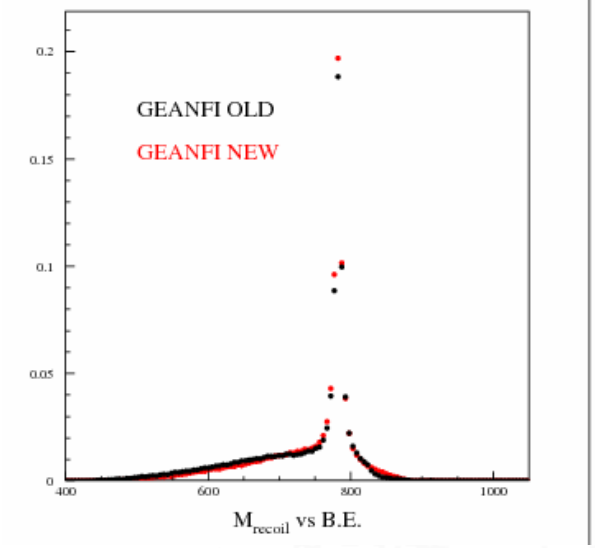
$$-\varepsilon_2[\vec{p}_3(\vec{p}_1\cdot\vec{p}_4)-\vec{p}_4(\vec{p}_1\cdot\vec{p}_3)]\}$$

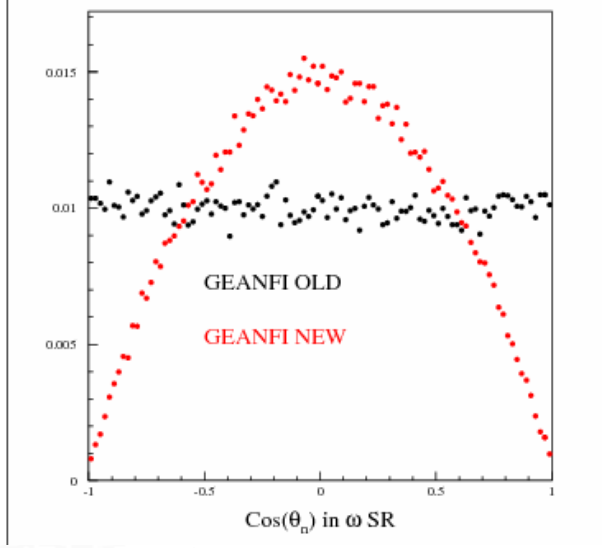
Inverse propagator

Major change in GEANFI









Kinematic fit

Input parameters:

Cluster energy (E_{clu})	$\Delta E_{clu} = \frac{0.06}{\sqrt{E_{clu}(\mathrm{GeV})}}$ MeV
Cluster position ($\vec{R}_{clu}$)	$\Delta \vec{R}_{clu} = 1.2$ cm
Cluster time (T_{clu})	$\Delta T_{clu}(\frac{0.057}{\sqrt{E_{clu}(GeV)}} \oplus (0.140))$ ns
Track curvature ($\mathcal{C}_{trk}$)	$\Delta \mathcal{C}_{trk} \sigma_{trkfit}(\mathcal{C}_{trk}))$
Polar angle of the track ($\cot(\vartheta_{trk})$)	$\Delta \cot(\vartheta_{trk}) \sigma_{trkfit}(\cot(\vartheta_{trk}))$
Azimuthal angle of the track (φ_{trk})	$\Delta \varphi_{trk} \sigma_{trkfit}(\varphi_{trk})$
Vertex position ($\vec{R}_{vtx}$)	$\Delta \vec{R}_{vtx} \sigma_{vtxfit}(\vec{R}_{vtx})$
Four-momentum of the ϕ (P_ϕ)	$\Delta E_\phi = 0.3$ MeV; $\Delta P_x(\phi) = 0.005$ MeV

Constraints:

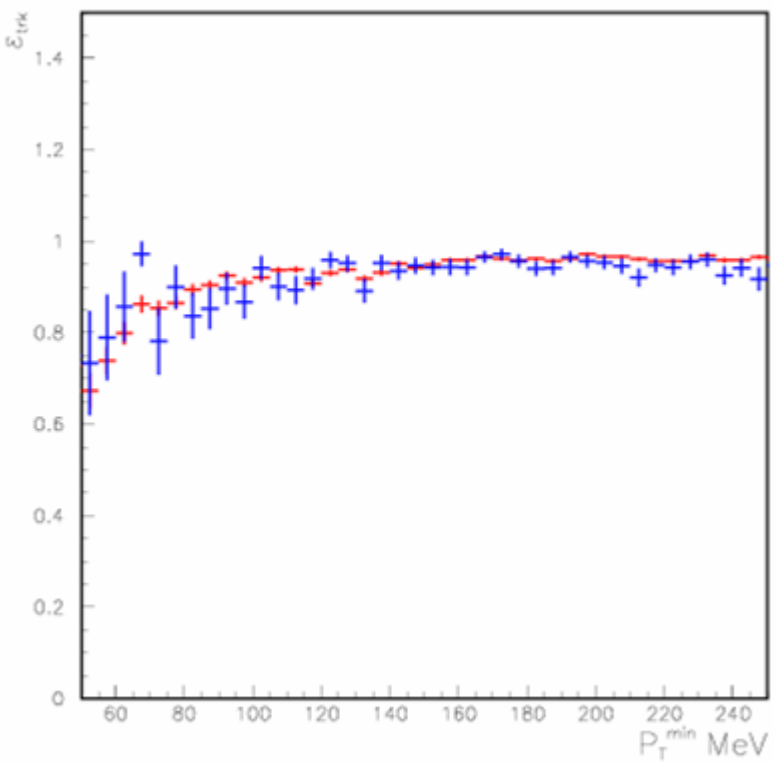
$$T_\gamma - R_\gamma / c = 0 \qquad P_\varphi - p_{\pi^+} - p_{\pi^+} - \sum_\gamma p_\gamma = 0$$

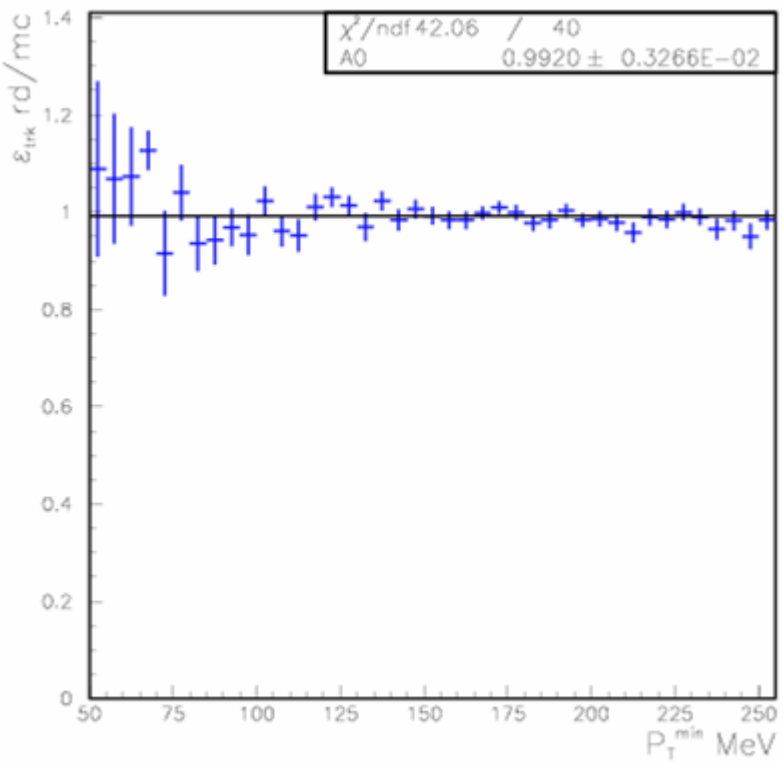
Measured visible cross section

$$\sigma_{\exp} = \frac{N_{count}}{L_{\text{int}} \cdot \varepsilon_{tot}}$$

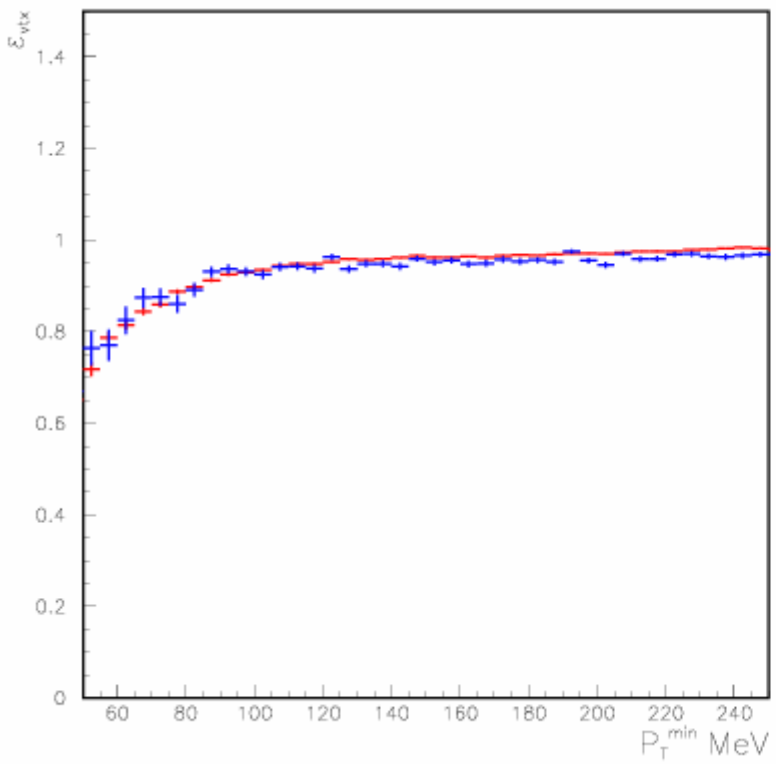
$\sqrt{s}$									
1000.25	5.65	$\pm$	0.10	1019.55	5.83	$\pm$	0.10	1020.15	6.03	$\pm$	0.11
1010.05	6.09	$\pm$	0.12	1019.65	5.75	$\pm$	0.10	1020.41	6.09	$\pm$	0.11
1017.19	5.63	$\pm$	0.10	1019.75	5.91	$\pm$	0.10	1022.09	7.02	$\pm$	0.12
1018.29	5.56	$\pm$	0.10	1019.85	6.08	$\pm$	0.10	1023.12	7.35	$\pm$	0.13
1019.09	5.44	$\pm$	0.10	1019.95	6.19	$\pm$	0.11	1030.12	7.52	$\pm$	0.14
1019.45	5.69	$\pm$	0.10	1020.05	6.01	$\pm$	0.11				

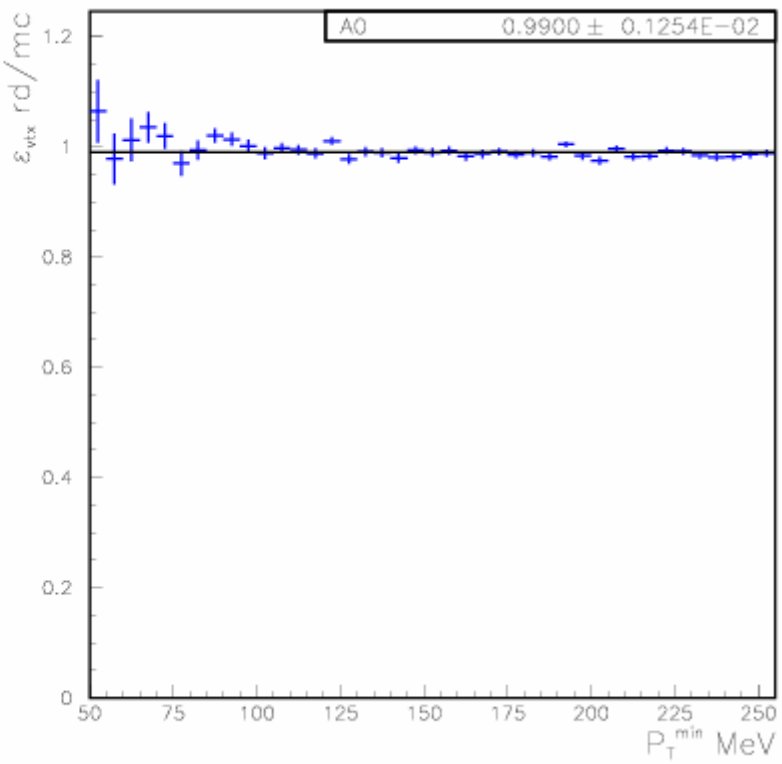
Tracking efficiency





Vertex efficiency





Eta filter and Bhabha filter