Pseudoscalar mesons production in γγ interactions

28-04-2009

$e^+ e^- \to \eta e^+ e^-$ process

$$\sigma_{e^+e^-\to e^+e^-X} = \frac{16\alpha^2\Gamma_{X\gamma\gamma}}{m_X^3}\left(\ln\frac{E_b}{m_e}\right)^2\left((y^2+2)^2\,\ln\frac{1}{y}-(1-y^2)\,(3+y^2)\right) \qquad y = m_X/(2E_b)$$

$\sqrt{s}$ (GeV)	1
$\sigma_{e^+e^-\to e^+e^-\eta}$ [pb]	43

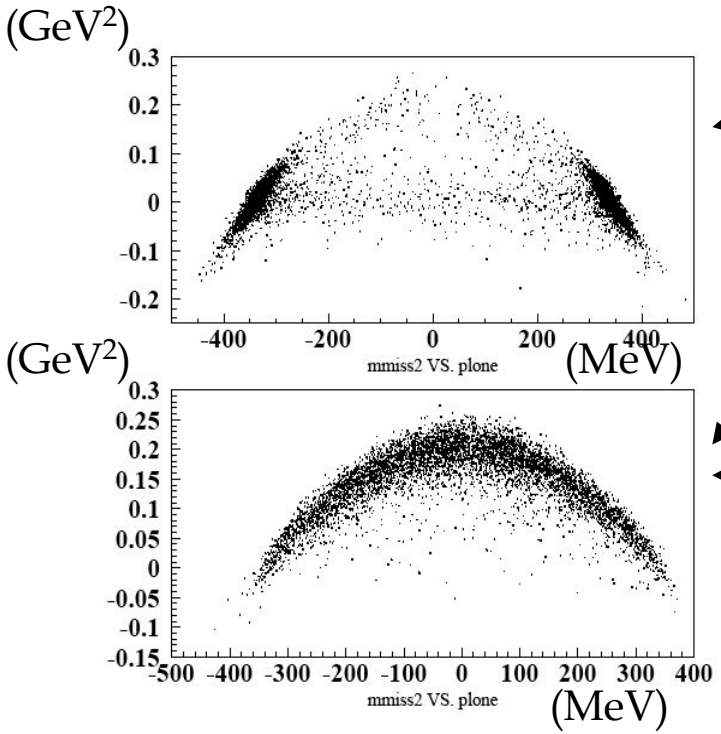
Integrated luminosity L= 240 pb^{-1}

$\eta \to \pi^+ \pi^- \pi^0$

N. expexted events = L σ ($e^+ e^- \to \eta e^+ e^-$) BR ($\eta \to \pi^+ \pi^- \pi^0$) ϵ

process	σ (nb)	
$\eta(\to \pi^+\pi^-\pi^0)\gamma$	0.24	
$\omega(\to \pi^+\pi^-\pi^0)\pi^0$	5.72	
$\pi^+\pi^-\pi^0$	30	
K^+K^-	3	$\mu^\pm\nu\pi^\mp\pi^0$, $\pi^+\pi^-2\pi^0$
K_SK_L	2	$K_S \to 2\pi^0, K_L \to \pi^\mp\ell^\pm\nu$
$\pi^+\pi^-\gamma$	50	γ split or plus 1 acc. γ

kinematics



Unreducible background $\Phi \rightarrow \eta\gamma$

Signal

$$M^2_{miss} = s + m^2_\eta - 2\sqrt{s}\sqrt{p^2_T + m^2_\eta + p^2_L}$$

$$= s + m^2_\eta - 2\sqrt{s}E_T\left(1 - \frac{p^2_L}{E^2_T}\right)^{1/2}$$

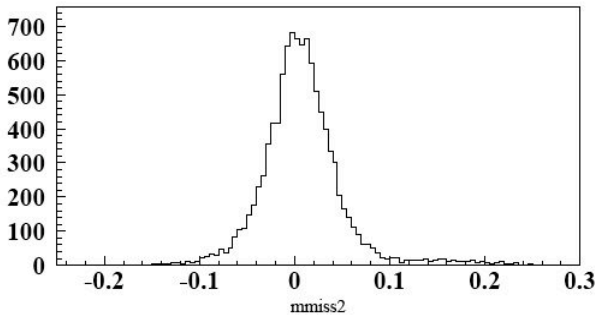
$$\simeq s + m^2_\eta - 2\sqrt{s}E_T - \sqrt{s}\frac{p^2_L}{E_T}$$

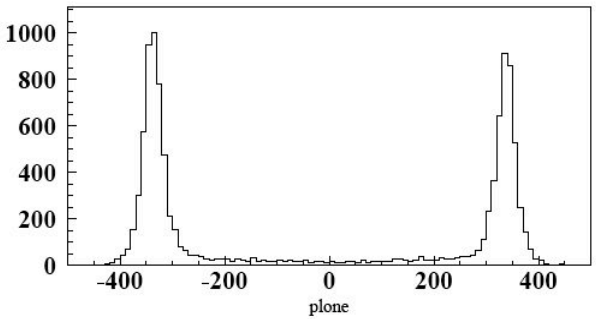
Mmiss^2 vs $\pi^+ \pi^- \pi^0$ longitudinal momentum from MC distributions

$$E_T = \sqrt{p^2_T + m^2_\eta} \sim m_\eta$$

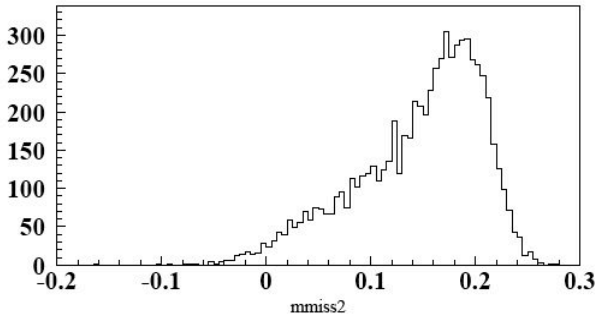
kinematics

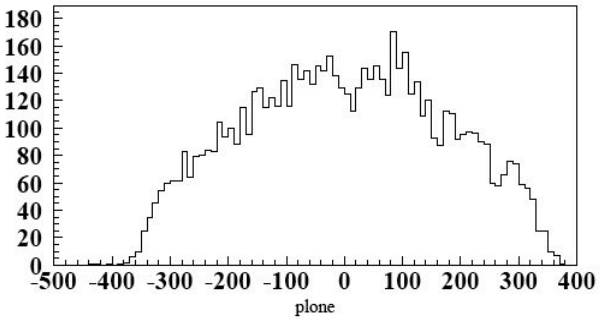
Mmiss^2 and $\pi^+\pi^-\pi^0$ longitudinal momentum from MC distributions





$\Phi \rightarrow \eta\gamma$

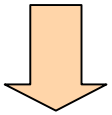




Signal

(GeV^2) (MeV)

Analysis criteria



- TRIGGER, FILFO
- γγ filter (see KLOE Memo n.346), in detail:
  - at least 2 neutral prompt clusters
  - 100 MeV < Σ E_γ < 900 MeV
  - $E_{\gamma 1}$ > 50 MeV
- 2 tracks with opposite charge from a cylinder with $\rho_{PCA} < 8$ cm, $|z_{PCA}| < 7$ cm, $\rho_{first\text{-}hit} < 50$ cm

Event selection

- Only 2 neutral prompt clusters
- Xγγ-pairing < 8
- Cut on X_η
- "Electron likelihood" cut
- Cuts to reduce "pathological" background:
  - "Split track" cut
  - $E_{\gamma 1} < 225$ MeV
  - $\sin\theta_{\gamma 1} > 0.462$
- Kinematic cut

Xγγ pairing:

$$\chi^2_{pair} = \left(\frac{M_{ij} - m_{\pi 0}}{\sigma(E_i, E_j)} \right)^2$$

$$\frac{\sigma(E_i, E_j)}{M_{ij}} = \frac{1}{2} \left(\frac{\sigma_{E_i}}{E_i} \oplus \frac{\sigma_{E_j}}{E_j} \right)$$

$$M_{ij}^2 = 2 E_i E_j (1 - \cos\theta_{ij})$$

Resolution energy

$$\frac{\sigma_E}{E} \sim \frac{0.06}{\sqrt{E(GeV)}}$$

Xη:

Kinematic fit using Lagrange multipliers method

- **10 γ variables**
- **4 constraints**

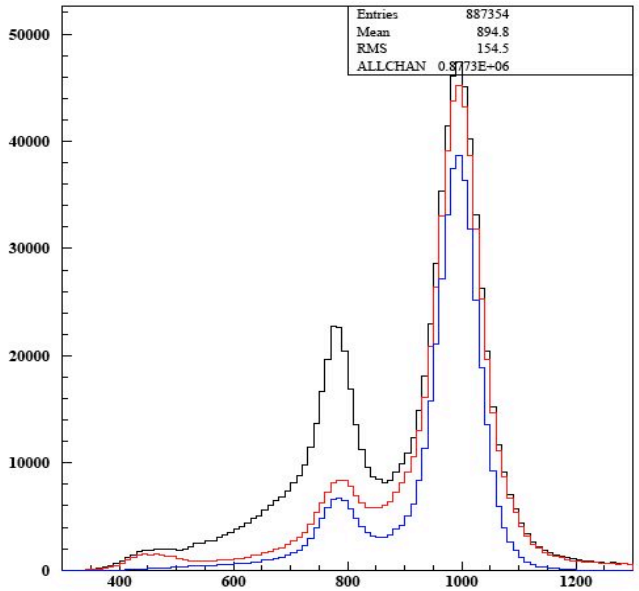
$m^2_{\gamma\gamma} = m^2_{\pi 0}$

$m^2_{\pi+\pi-\gamma\gamma} = m^2_{\eta}$

$t_\gamma - |\underline{r}_\gamma| / c = 0$ for 2γ

Mη ≈ 550 MeV

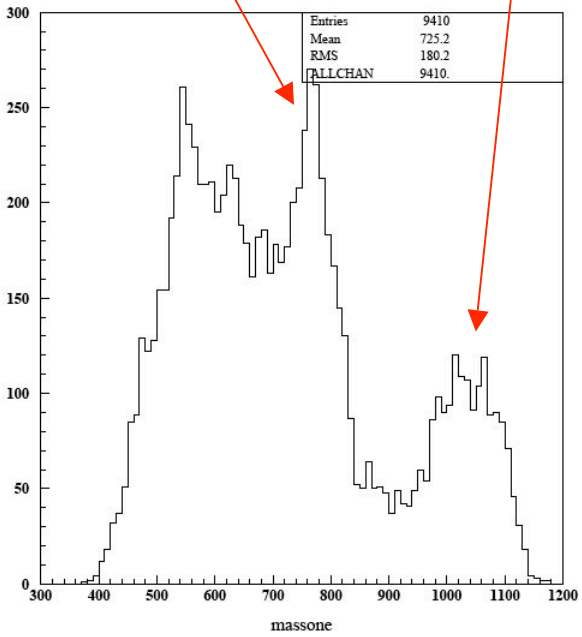
Mω ≈ 780 MeV



- $\pi^+\pi^-\gamma\gamma$ invariant mass distribution (MeV): A) all data events (black); B) npro=2 (red); C) X^2pair < 8 (blue)

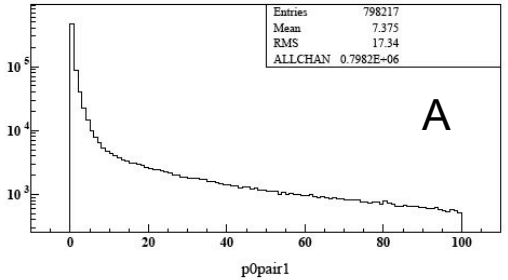
$\Phi \rightarrow \pi^+\pi^-\pi^0$ &
e+e-→e+e-(γ)

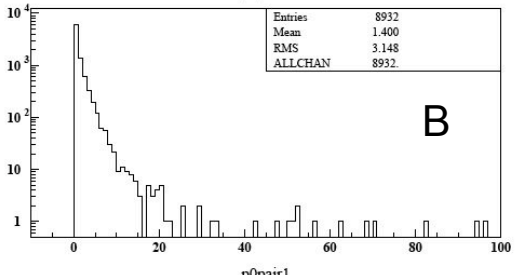
$\Phi \rightarrow \omega\pi^0$

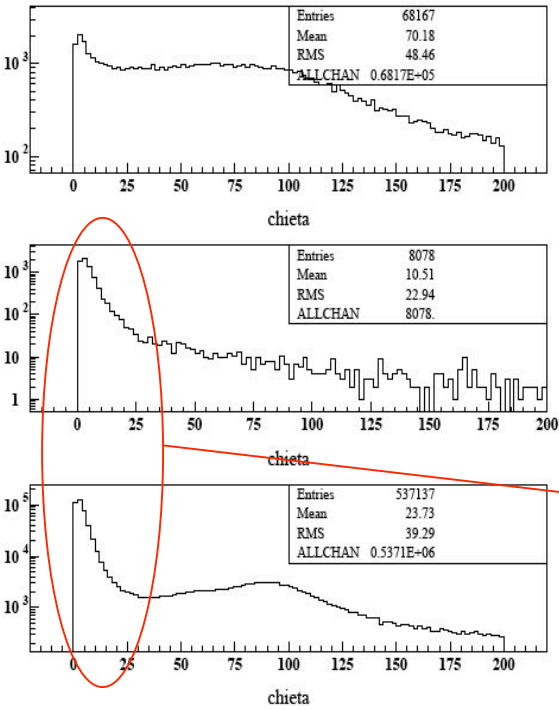


- $\pi^+\pi^-\gamma\gamma$ invariant mass distribution (MeV) after the cut Xη < 1000

X^2pair distribution A) data; B) MC signal

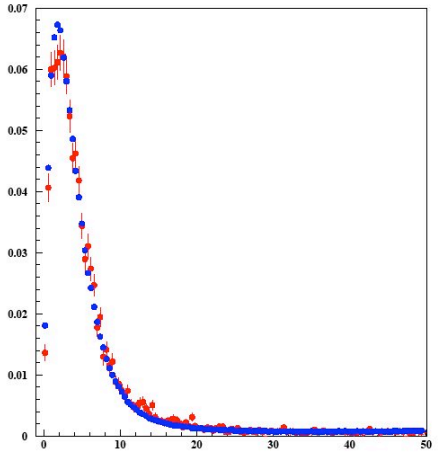






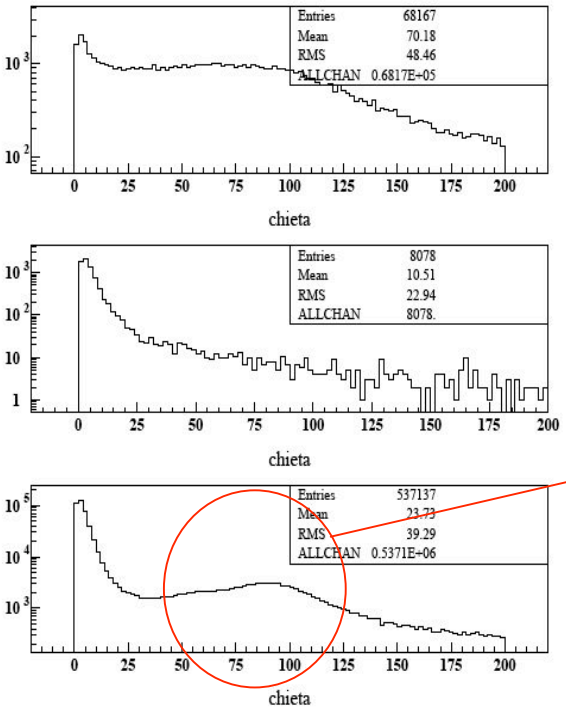
$X^2\eta$ distribution A) data; B) MC signal; C) MC $\eta\gamma$

$X^2\eta$ distribution for low values of $X^2\eta$: MC signal (red) and MC $\eta\gamma$ (blue)

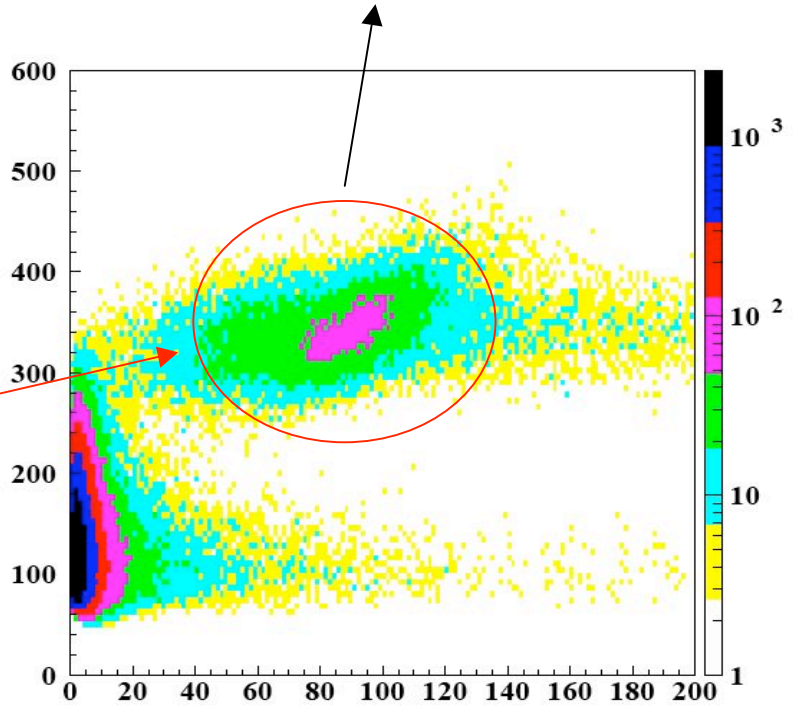


Very good agreement between official ALLRAD and private e+e- → e+e- eta MC productions

Pairing with the monochromatic γ!



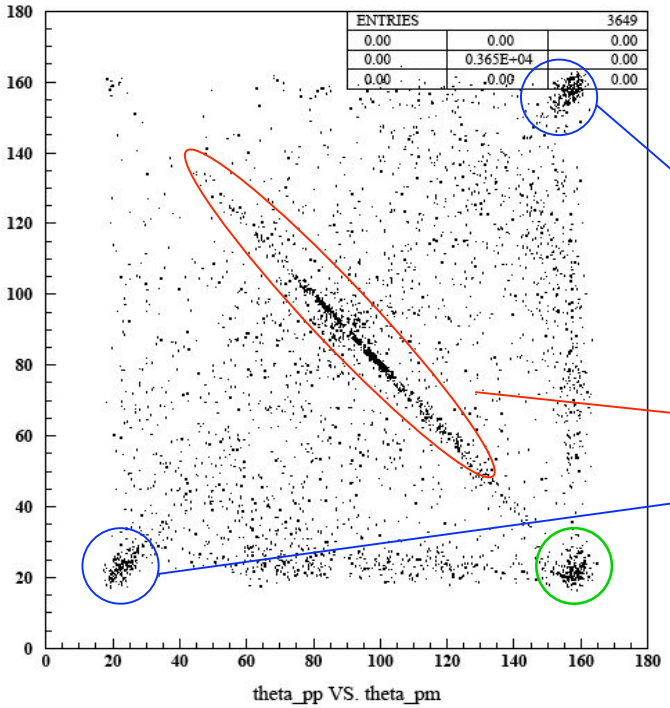
$X^2\eta$ distribution A) data; B) MC signal; C) MC $\eta\gamma$



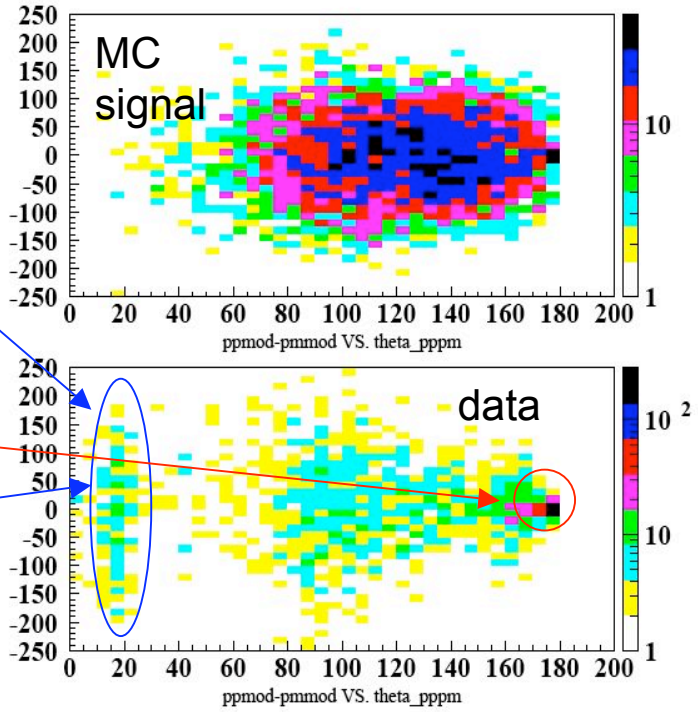
Energy of the most energetic photon (MeV) vs $X^2\eta$ for MC $\eta\gamma$

“Pathological” background

θπ + vs θπ - (deg), data

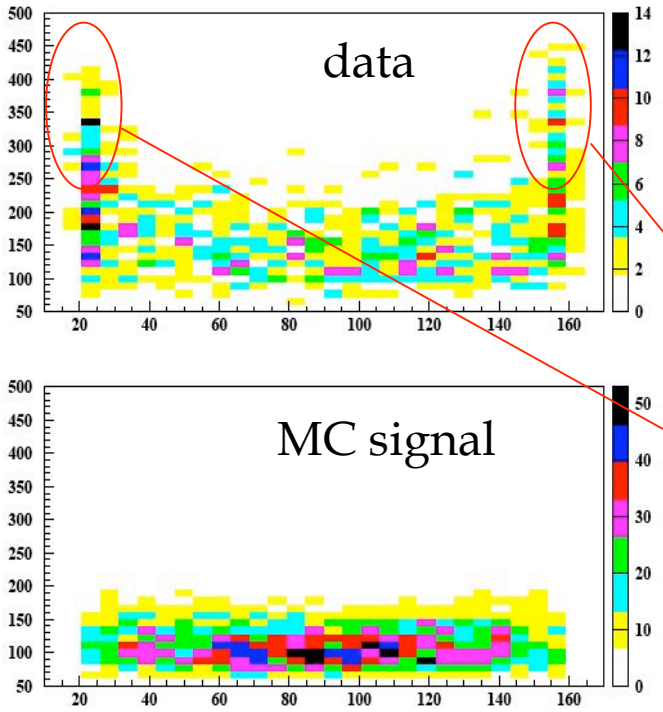


|p(π +)|-|p(π -)| (MeV) vs θπ+π- (deg)



γ → e+e- e+e- → e+e- (γ) Split tracks

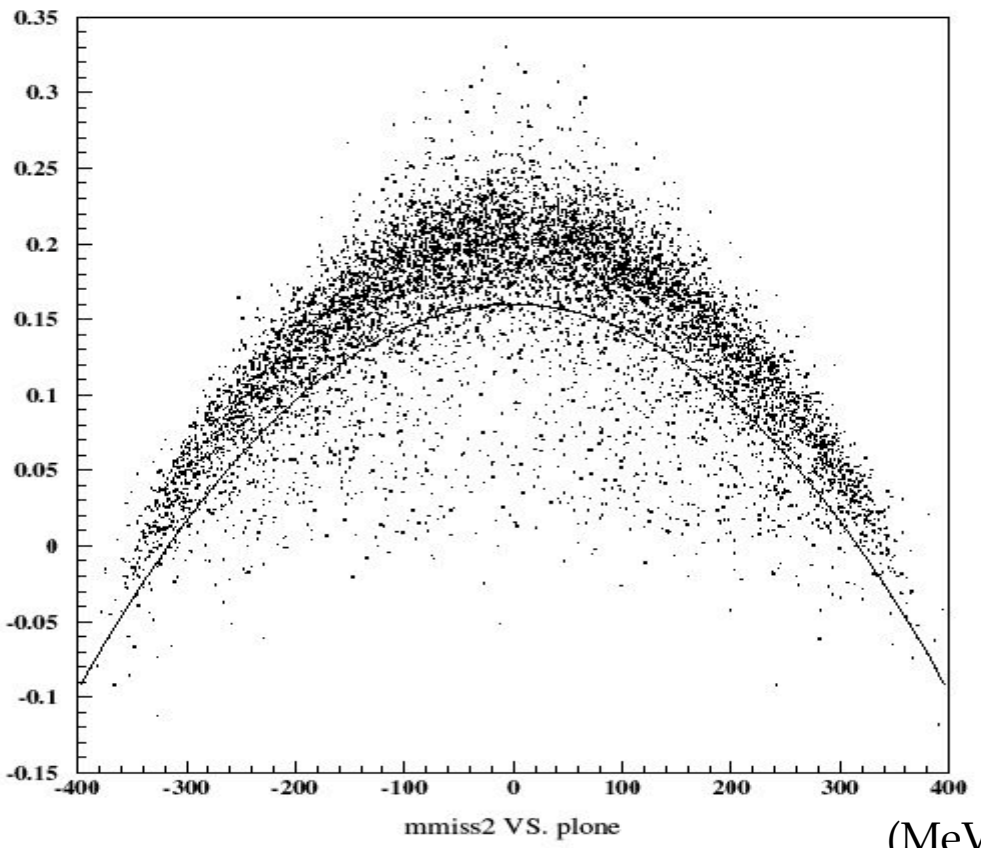
“Pathological” background (2)



- Electrons cut out with the “electron likelihood” cut
- Split tracks cut out with the “split” cut

Cut out with the cuts on Eγ1 and θγ1

Kinematic cut



Mmiss^2 vs $\pi^+ \pi^-$ π^0 longitudinal momentum for MC signal

Mmiss^2>0.16-1.6 10^{-6} $p_L{}^2$

$$M^2_{miss} \simeq s + m^2_\eta - 2\sqrt{s}E_T - \sqrt{s}\frac{p^2_L}{E_T}$$

Efficiencies

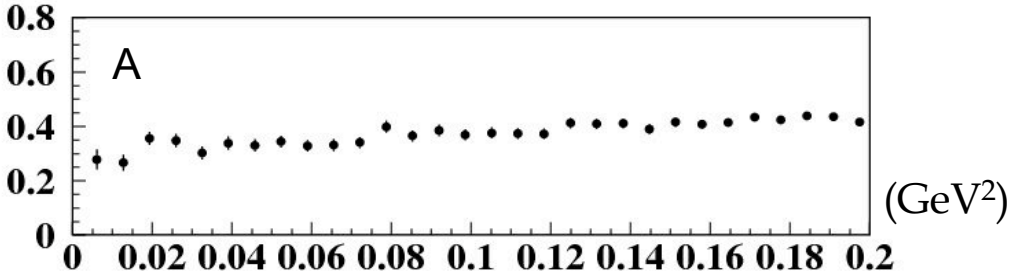
	LSF:	10	1	1	1	1	6
	MC signal	$\eta\gamma$	$\omega\pi^0$	$\pi^+\pi^-\pi^0$	K^+K^-	K_SK_L	$\pi^+\pi^-\gamma$
n.events	22538	5555116	9298930	9022080	29487300	19872200	36066300
trg, filfo	8950	3118867	5733480	4095760	232911	238308	307692
psum<700, 2≤npro≤4	8940	3089986	5560538	3906808	226534	188351	289795
npro=2	8487	1060838	180895	3594437	191825	30446	272933
X^2pairing<8	8357	286906	100613	3501870	186157	22697	141476
$X^2\eta$<24	7036	106564	3910	1566	10310	5900	439
electron likelihood	5989	95366	3230	1377	9200	4759	418
split tracks	5895	93595	3035	893	8127	4394	387
$E\gamma1$<225 MeV	5820	88148	2806	702	7315	4035	366
$\sin(\theta\gamma1)$>0.462	5428	78038	2696	592	6986	3837	352
kinematic cut	4927	67364	1041	259	2584	2220	55
ε	0,219	0,012	$1{,}12\ 10^{-4}$	$2{,}87\ 10^{-5}$	$8{,}76\ 10^{-5}$	$1{,}12\ 10^{-4}$	$1{,}52\ 10^{-6}$

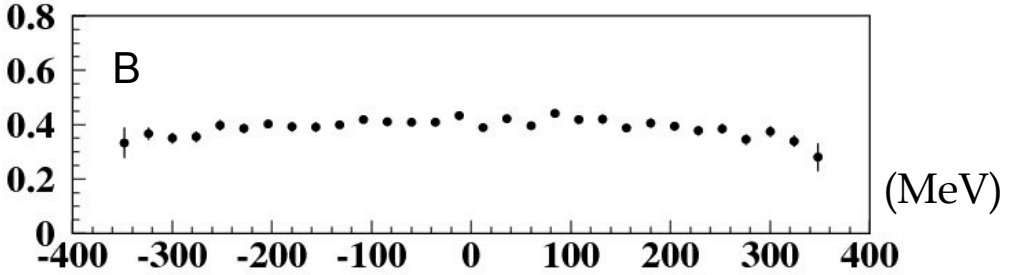
Trigger, filfo, data filter and track requirements efficiencies

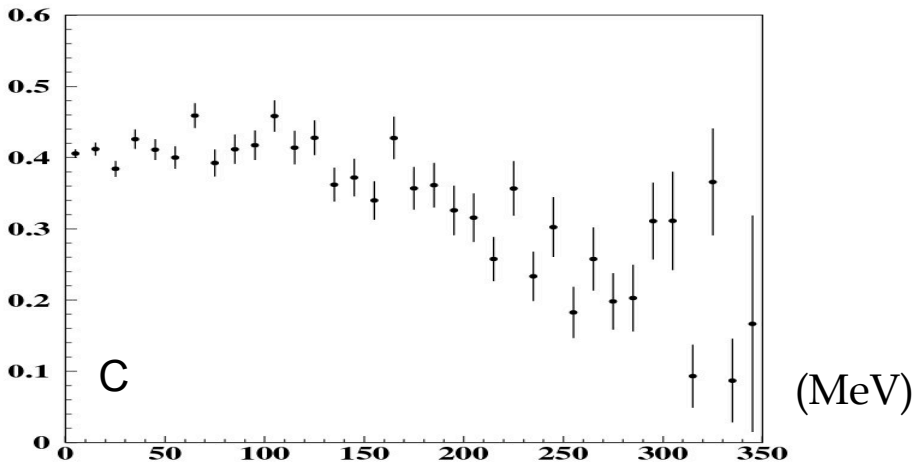
A. Squared missing mass

B. Longitudinal momentum of $\pi^+\pi^-\pi^0$

C. Transverse momentum of $\pi^+\pi^-\pi^0$

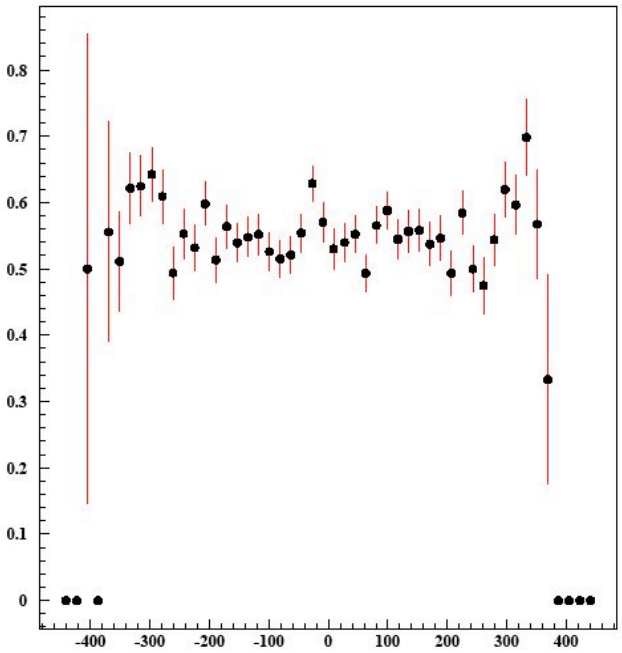






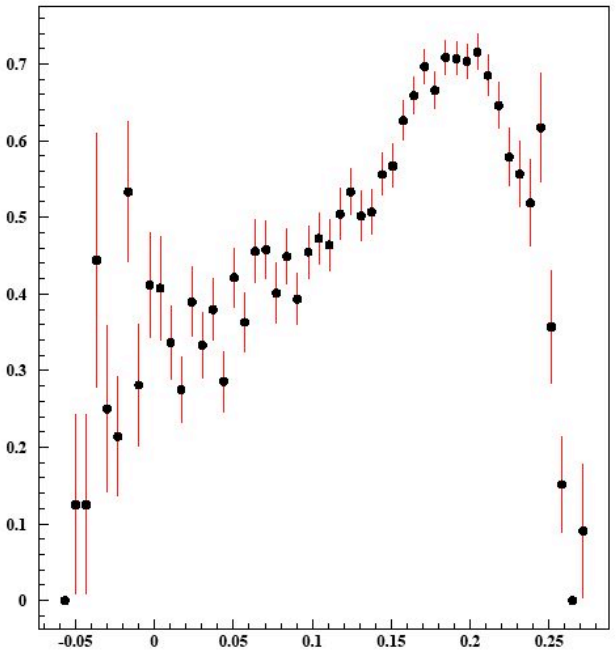
Analysis cuts efficiencies

Longitudinal momentum of $\pi^+\pi^-\pi^0$



(MeV)

Squared missing mass



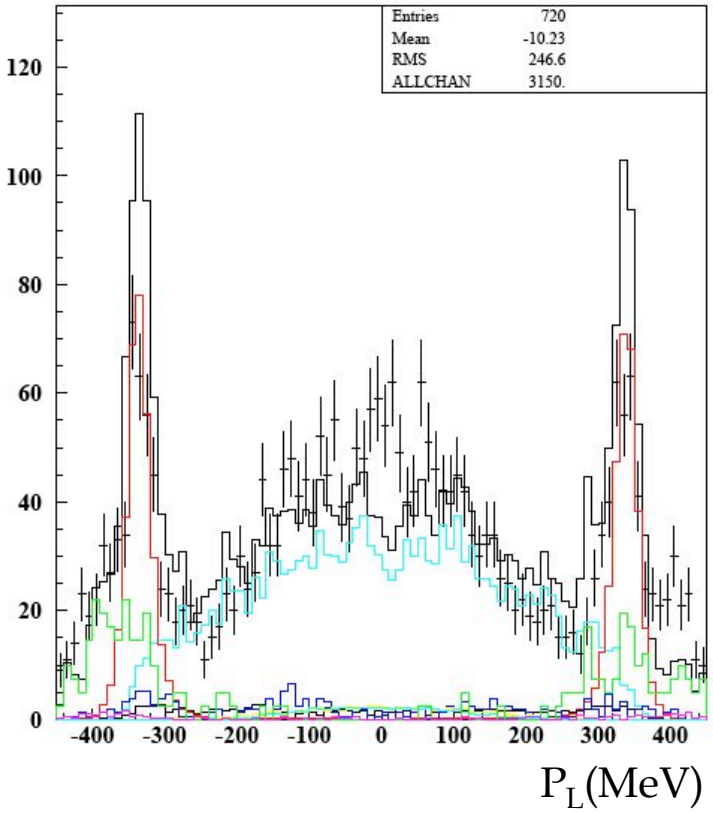
(GeV^2)

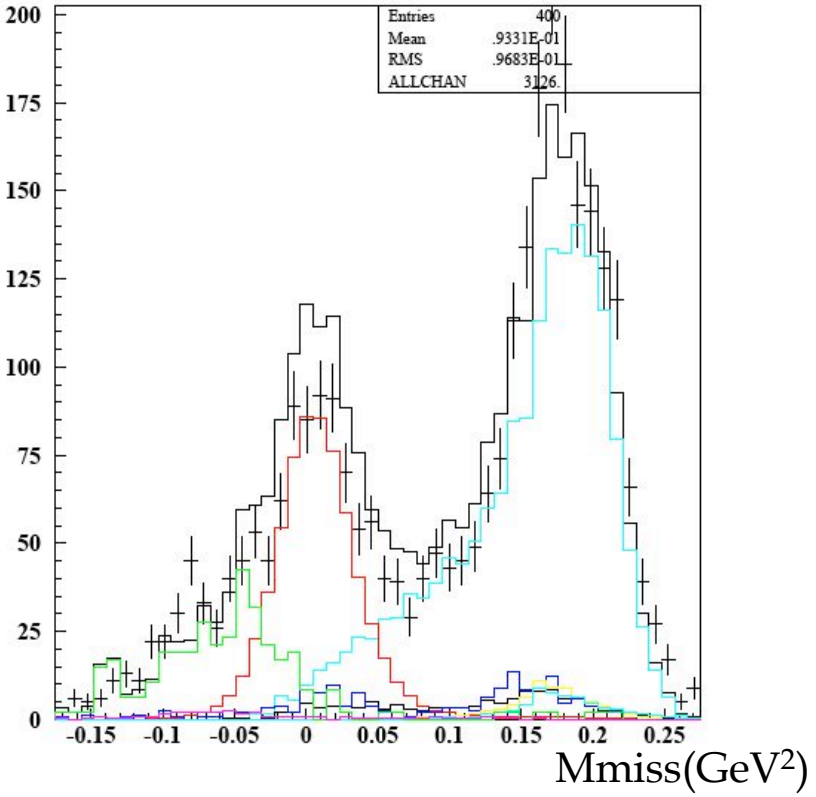
Fractions

$$w = \sigma L N(MC)/N(data)N_0$$

	N_0	σ (nb)	$N(MC)_F$	fraction
MC signal	22538	0,04	4927	0,694
$\eta\gamma$	5555116	0,28	67364	0,269
$\omega\pi^0$	9208930	5,72	1041	0,051
$\pi^+\pi^-\pi^0$	9022080	30	259	0,068
K^+K^-	29487300	3	2584	0,021
K_SK_L	19872200	2	2220	0,018

Fit





Intervals for the fractions: ± 20% (except for the signal, ηγ converted and γγ converted)

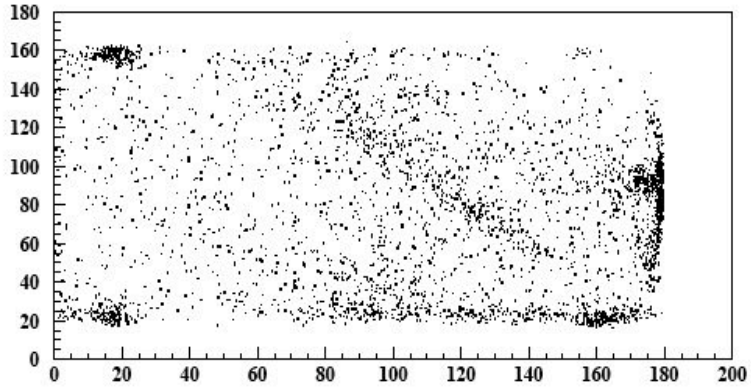
Light blue: signal

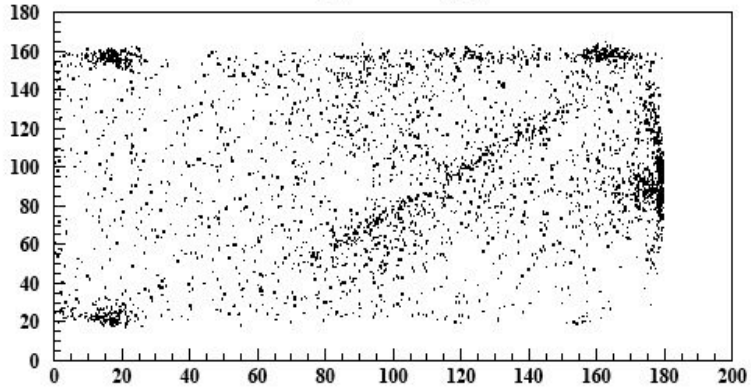
Red: ηγ (η → charged decays)

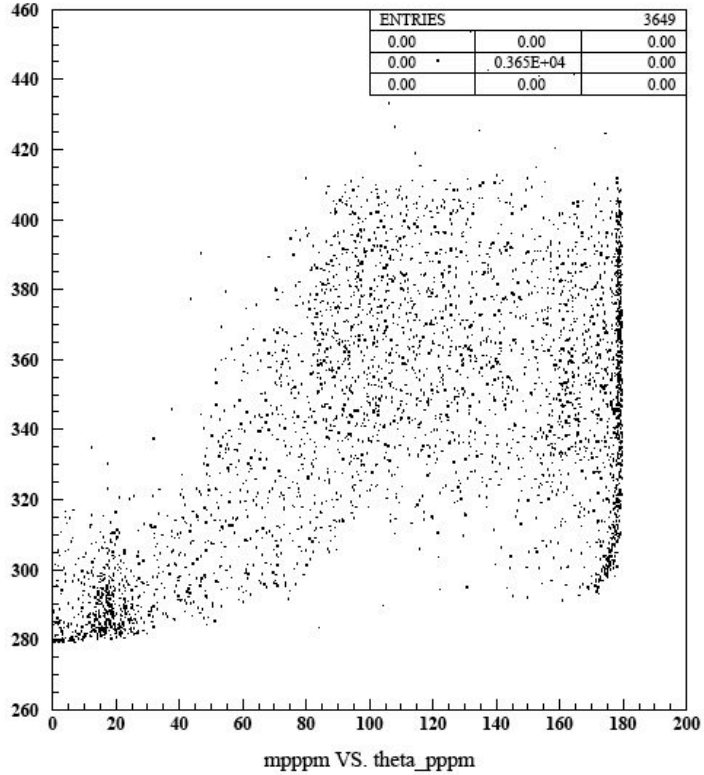
Green: ηγ converted (η → neutral decays→$3\pi^0$)

Outlook

- Improve the tracks requirement (check with the vertex requirement?)
- Optimize some cuts
- With a better background classification, ask for dedicated high stat. MC productions (eeg, gg with conversions?)


theta_pp VS. theta_pppm


theta_pm VS. theta_pppm


ENTRIES 3649
0.00 0.00 0.00
0.00 0.365E+04 0.00
0.00 0.00 0.00
mpppm VS. theta_pppm

Efficiencies

	MC signal	_ _	_ π^0	$\pi^+\pi^-\pi^0$	K^+K^-	K_SK_L	$\pi^+\pi^-$ _	_ _ conv.	__ conv.
n.events	22538	5555116	9298930	9022080	29487300	19872200	36066300	14215235	82410400
trg, filfo	8950	3118867	5733480	4095760	232911	238308	307692	87890	6527
psum<700, 2≤npro≤4	8940	3089986	5560538	3906808	226534	188351	289795	37953	6361
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X^2_ <24	7036	106564	3910	1566	10310	5900	439	183	143
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sin(__1)>0.462	5428	78038	2696	592	6986	3837	352		
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