Status report on

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

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Outline

Data sample

Tracking efficiency

PID using TOF

Cluster veto correction

Procedure review

“Low-θ” background

Data-MC comparison

Non-ϕ backgrounds

Conclusions

Data sample

Statistics increased both for data and MC

79 pb^{-1} data 2002 → As for now, not used

1719 pb^{-1} data 2004/05

Using drc/mrc streams with ETA4C tag

46×10^3 pb^{-1} MC signal only

3479 pb^{-1} MC all_phys(2/3) 2004/05

850 pb^{-1} MC eeg100 2004/05

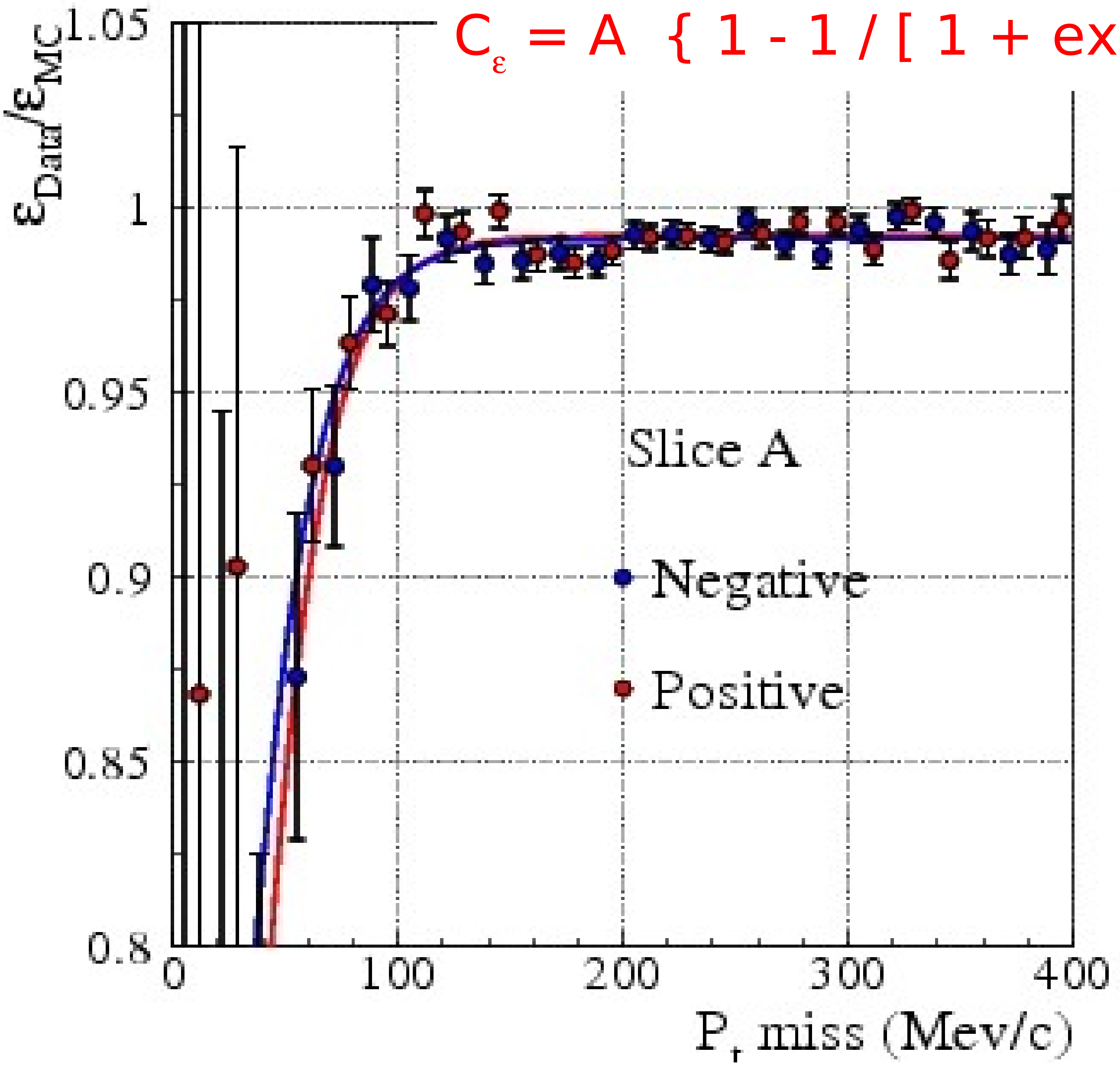
2790 pb^{-1} MC ppgphok5 2004/05 → Private production Thanks to A. De Santis

(on going - LSF=5)

Tracking efficiency

using ρπ sample work done together with A. De Santis

$C_\varepsilon = A \; \{ 1 - 1 / [1 + \exp((X-X_0)/\delta)] \}$



KLOE Memo 343

Code updated:
new ntuples produced applying the efficiency correction

PID using TOF

Asymmetry in Mππee spectrum due to *wrong mass assignment*

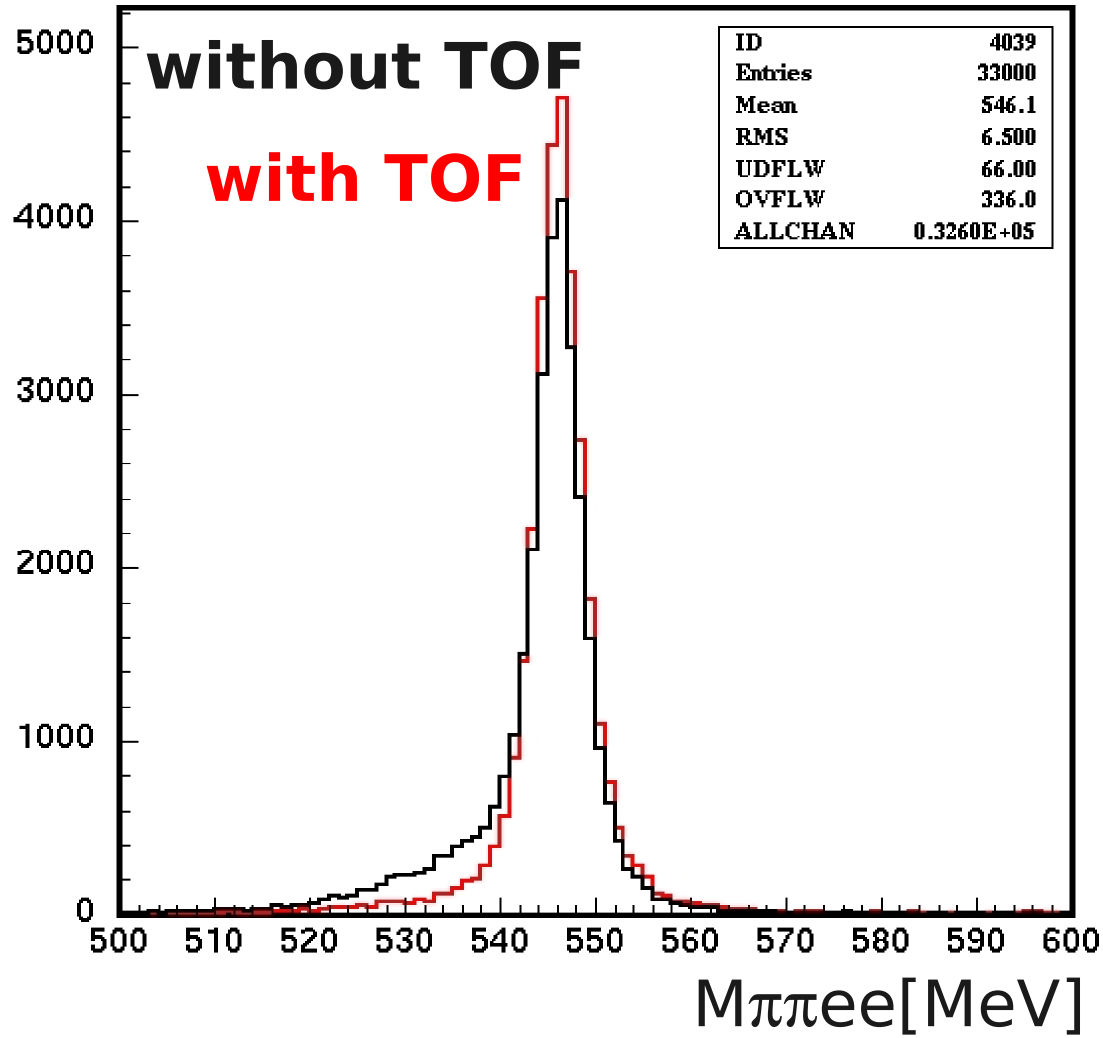
Can be improved using TOF

We evaluate

$\Delta t = t_{track} - t_{cluster}$

in both electron (Δt_e)

and pion (Δt_π) hypothesis



Cluster veto correction

Effect of the veto in ETA4CTAG has been evaluated

Reminder: ETA4CTAG rejects events having neutral clusters in the range $50 < E_{cl} < 250$ MeV

	#events w/ accidental clusters in vetoed range	#events w/o accidental clusters in vetoed range	Ratio
2004	125937	26483346	0.00475(1)
2005	327349	61225992	0.00535(1)
2004⊕2005	453286	87709338	0.00517(1)

Correction to be applies to the branching ratio

Procedure review

Backgrounds normalized using luminosity
instead of fitting (NEW)

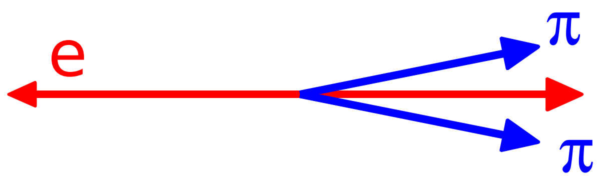
1. EVCL	ETA4CTAG
2. Momenta	450<S4p<600 MeV and 270<S2p<460 MeV
3. χ^2	$\chi^2 < 4000$
4. Conversions	Mee>15 MeV and Dee>2.5 cm (@BP)
5. "QCAL" events	$\langle\cos\theta_+\rangle < 0.85$ and $\langle\cos\theta_-\rangle > -0.85$
6. $M\pi\pi ee$	$535 < M\pi\pi ee < 555$ MeV

Data-MC comparison at each step

Discrepancies can be hint of non-ϕ backgrounds

(i.e. $\pi\pi\gamma$, and $ee\gamma$)

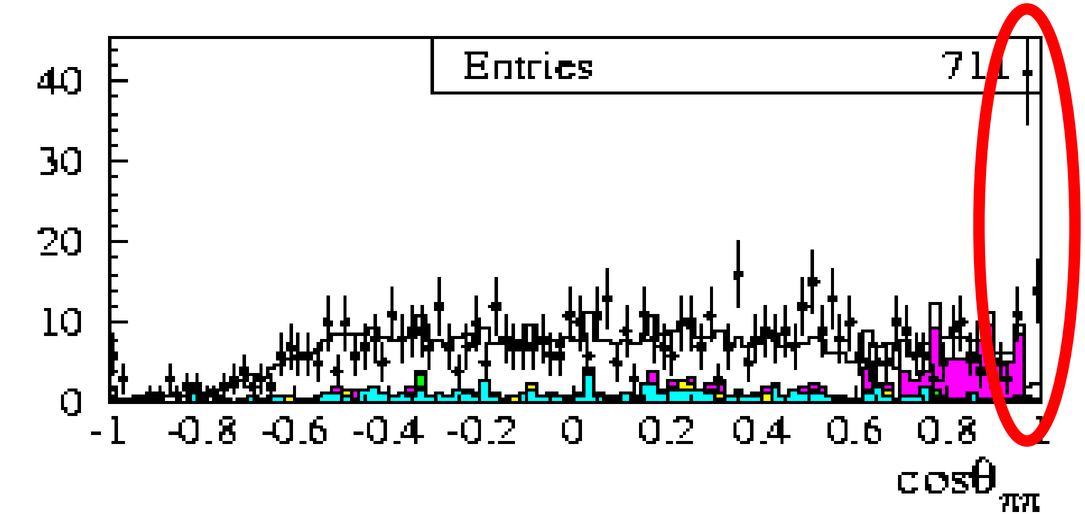
Low-θ background

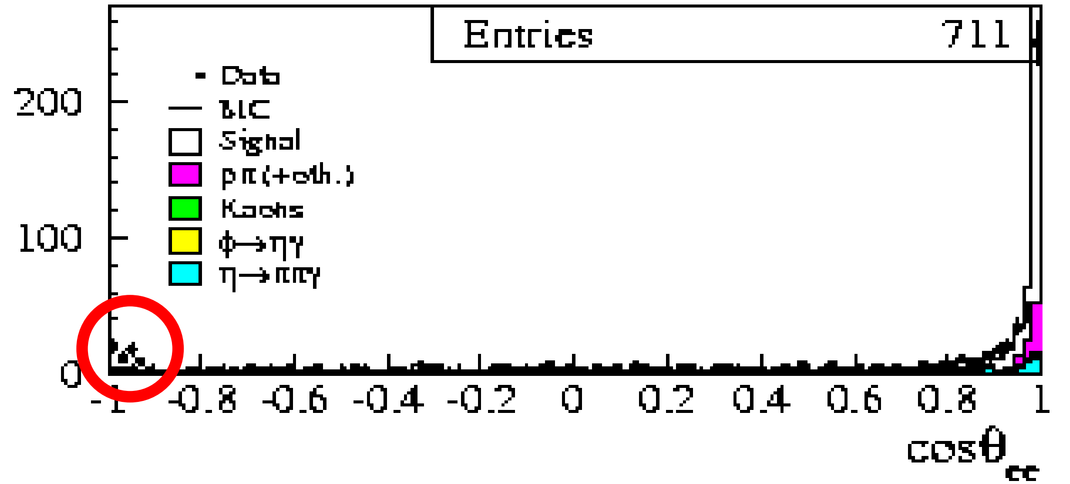


We had seen on data events not simulated in MC

TOF of “pions” (i.e. particles with higher momenta), compatible with electrons TOF

Studied with Didone

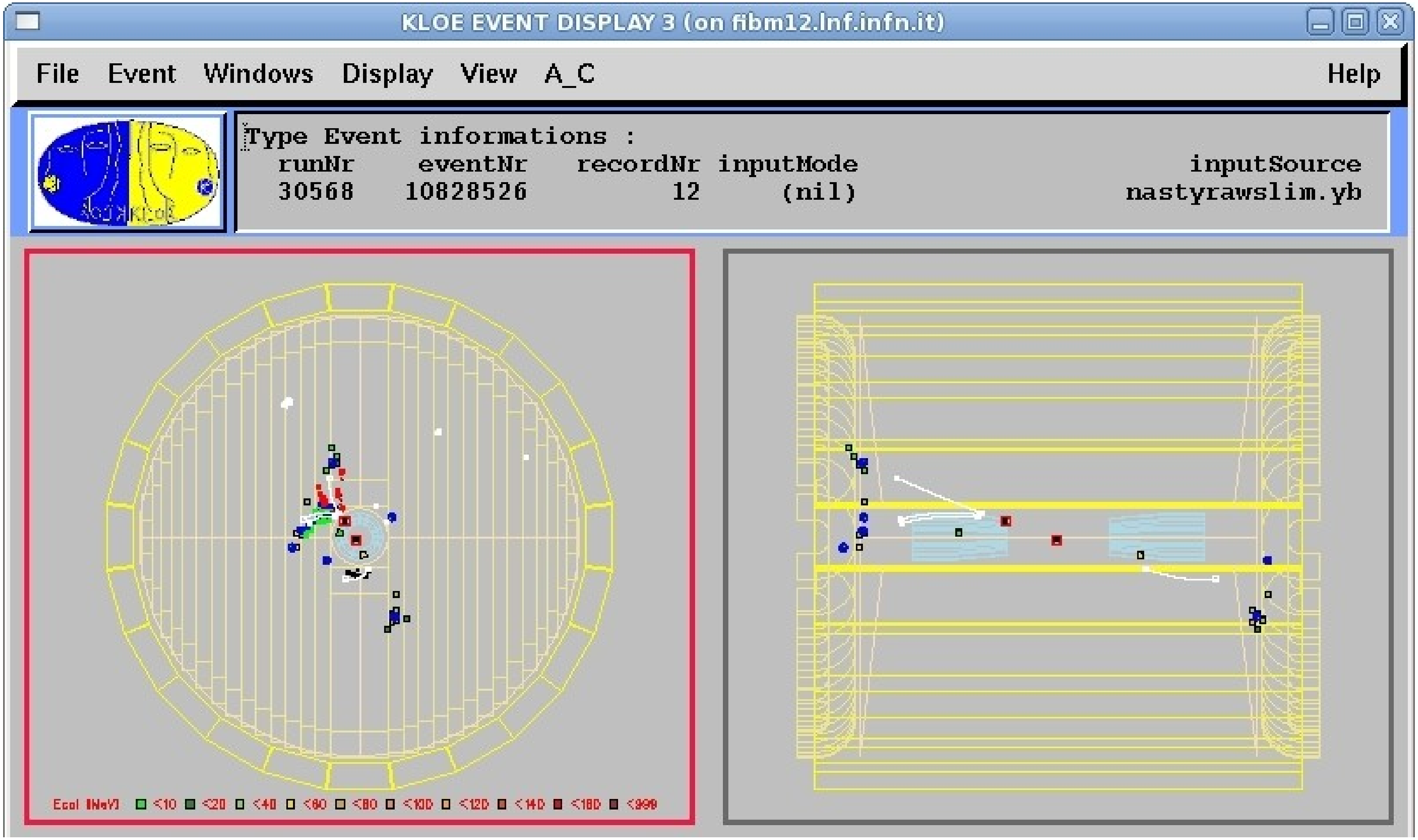




Low-θ background

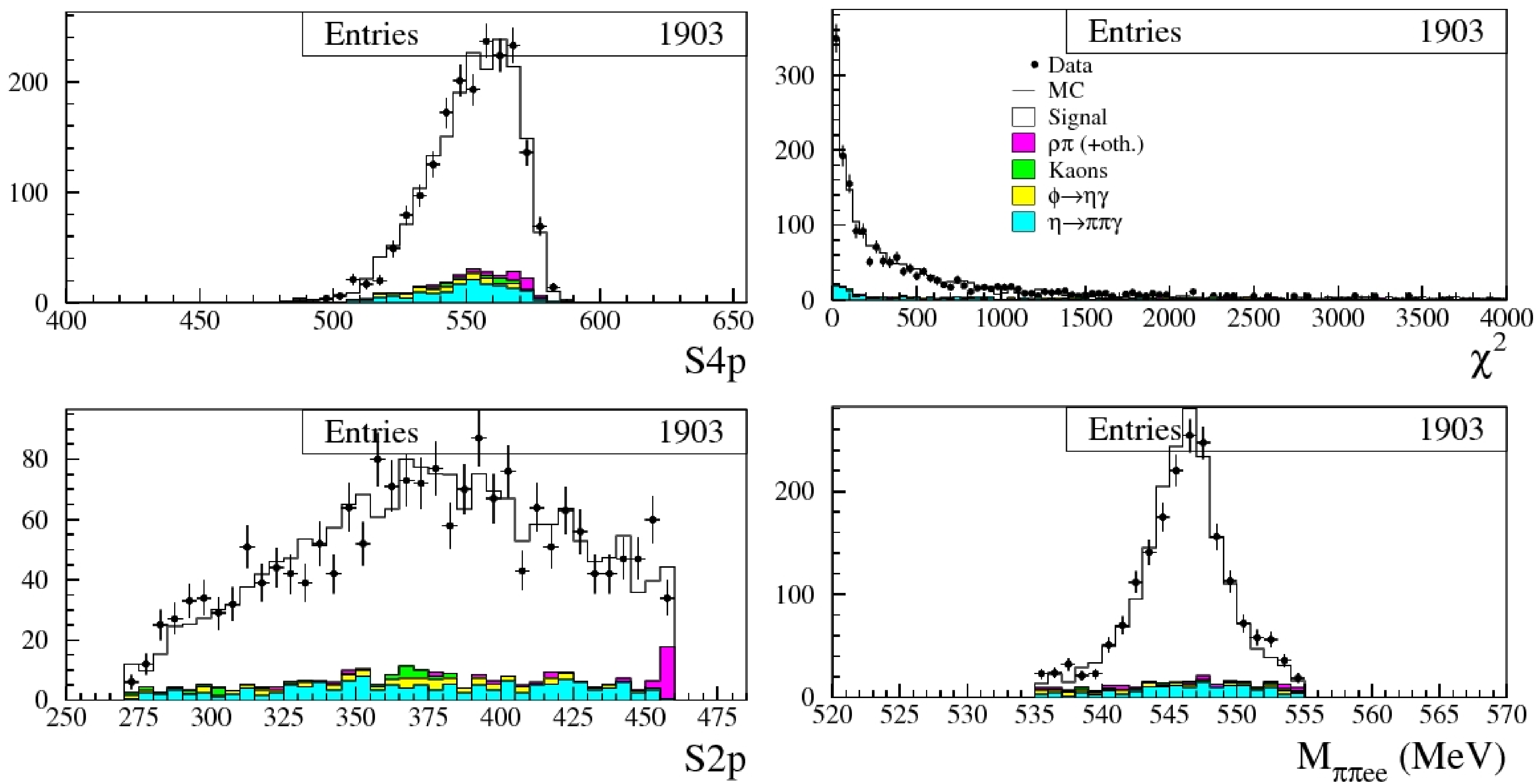
Small angle tracks

A particle hits something in the BP producing two more particles



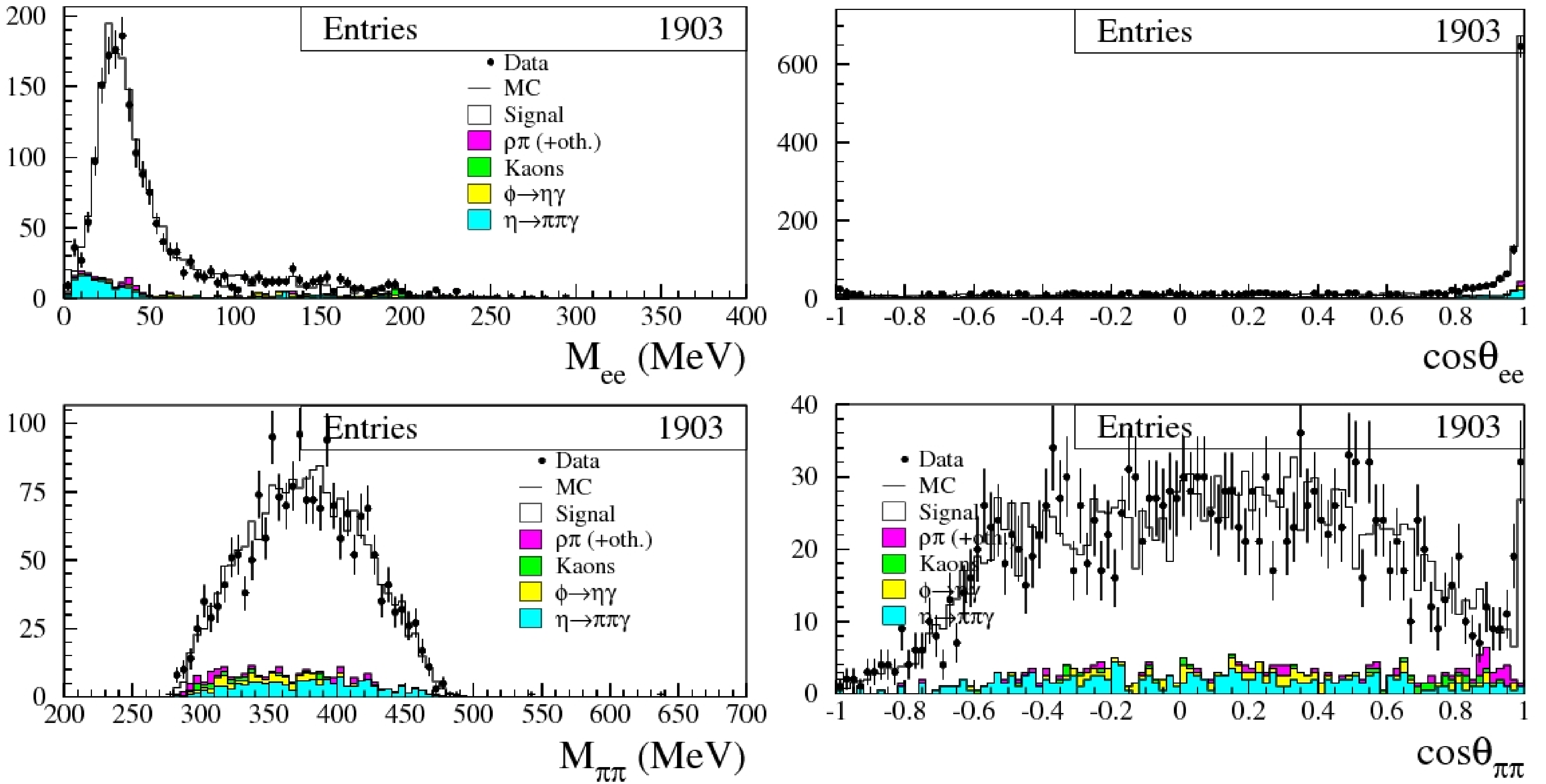
Data-MC comparison

Very good agreement



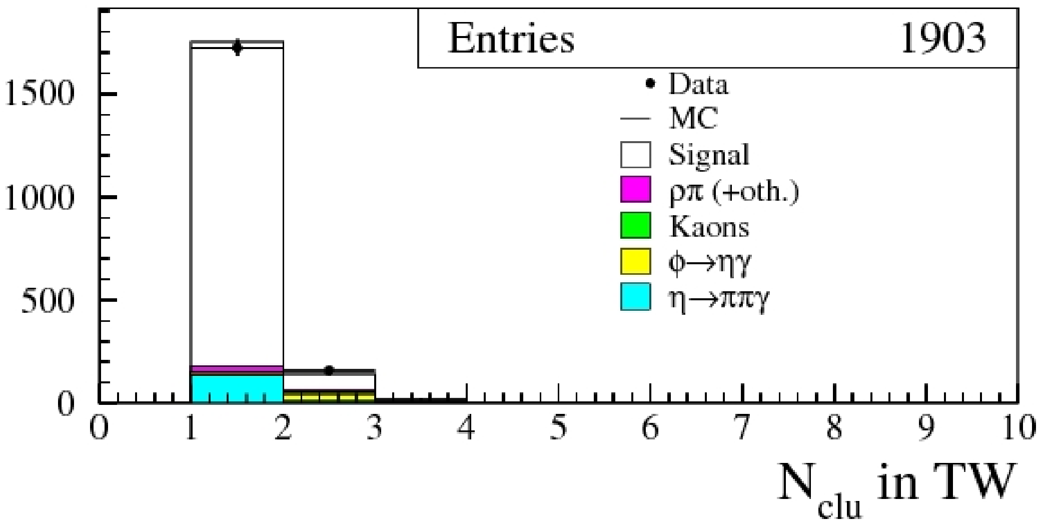
Data-MC comparison

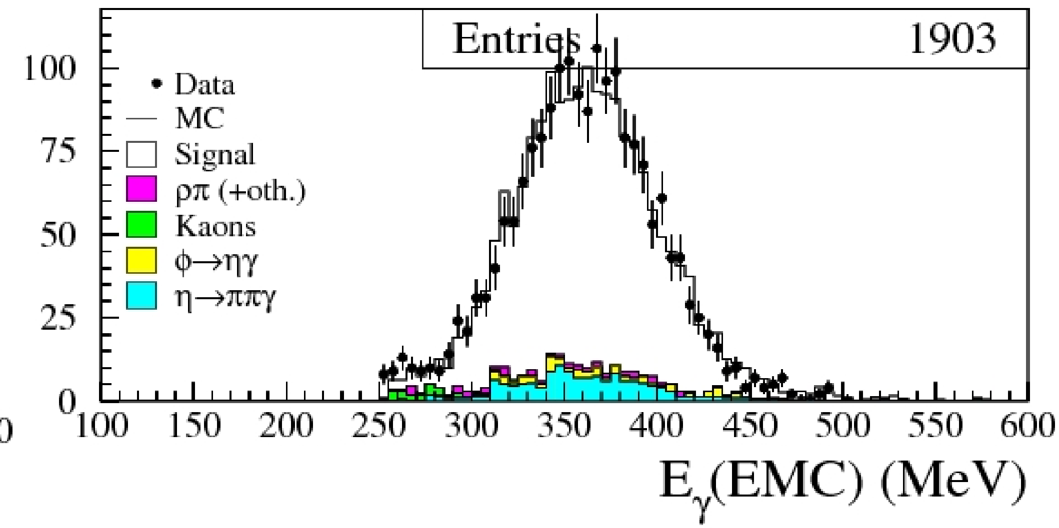
Very good agreement

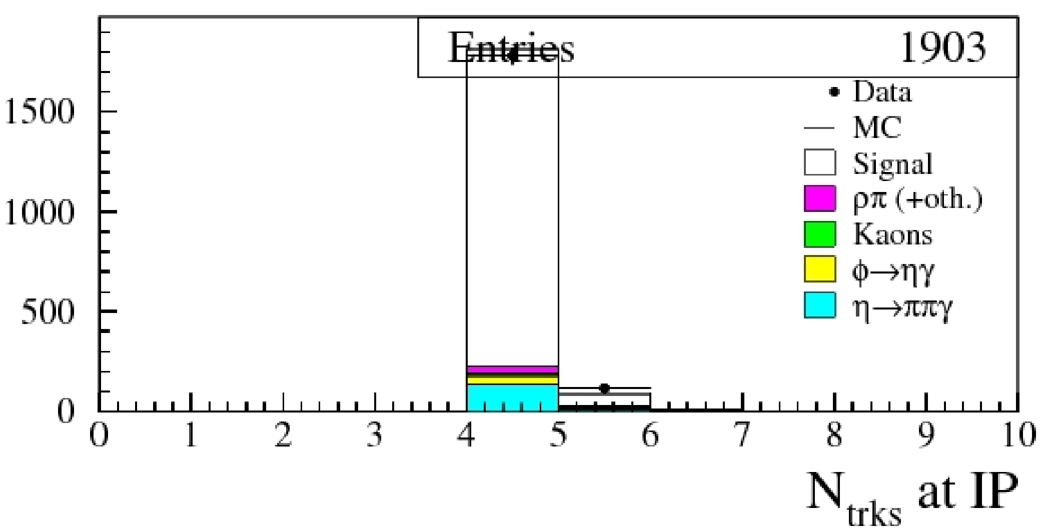


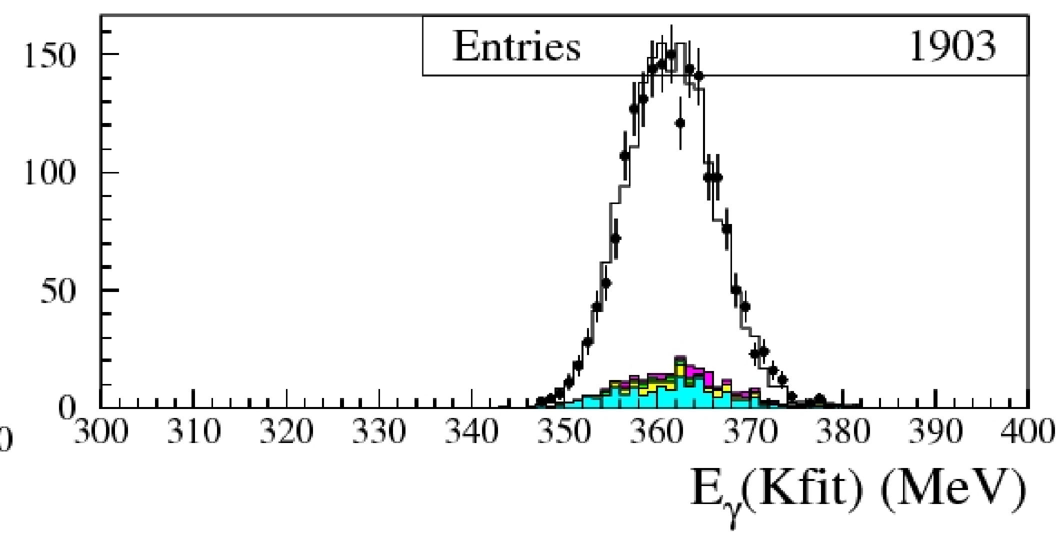
Data-MC comparison

Very good agreement



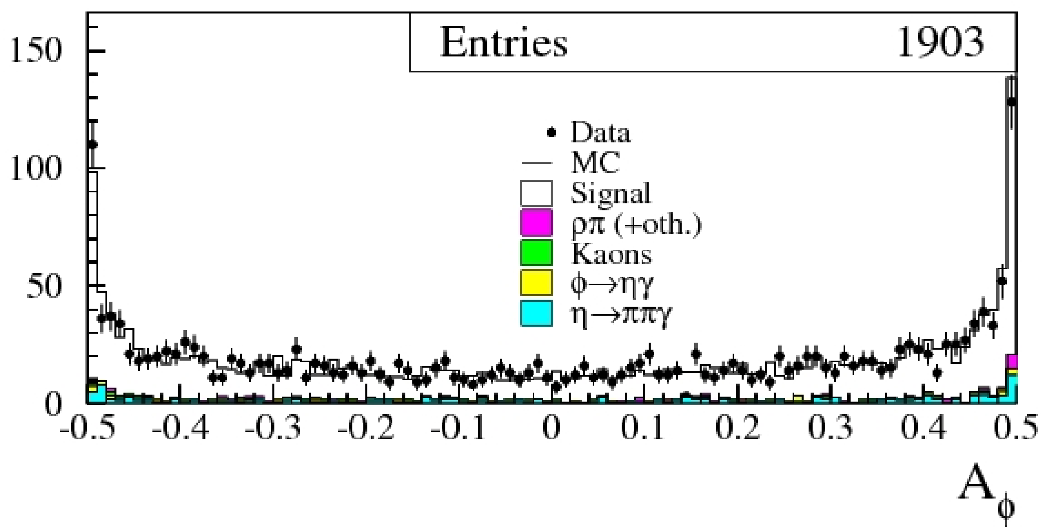


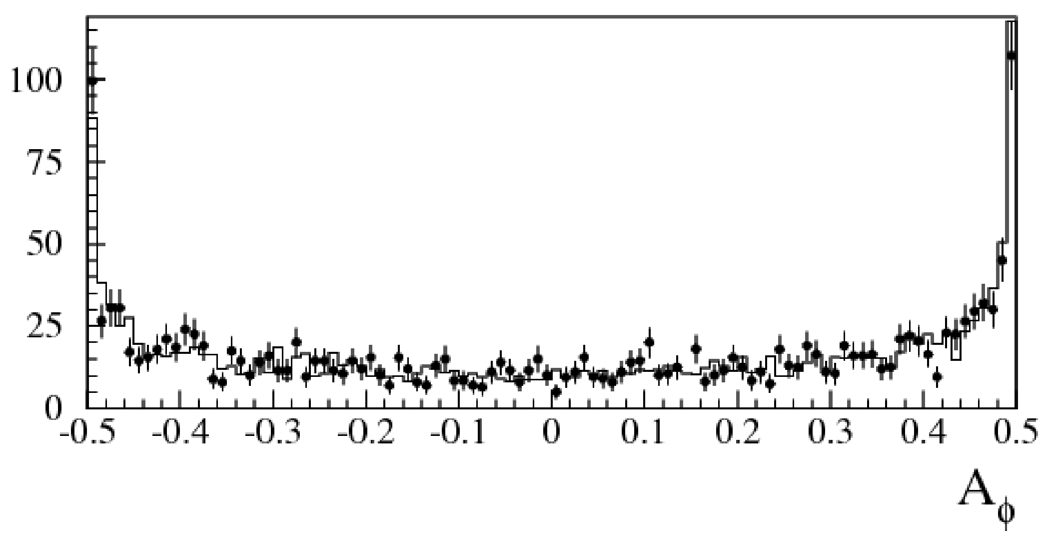




Data-MC comparison

Very good agreement (even in the asymmetry!)

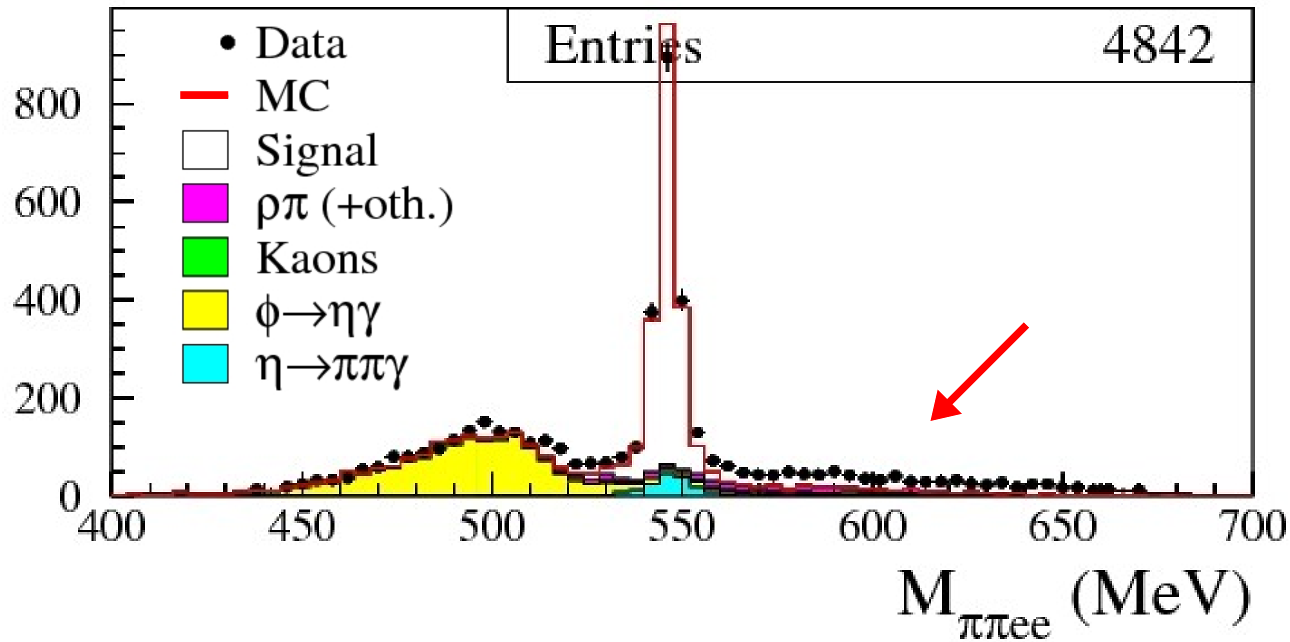




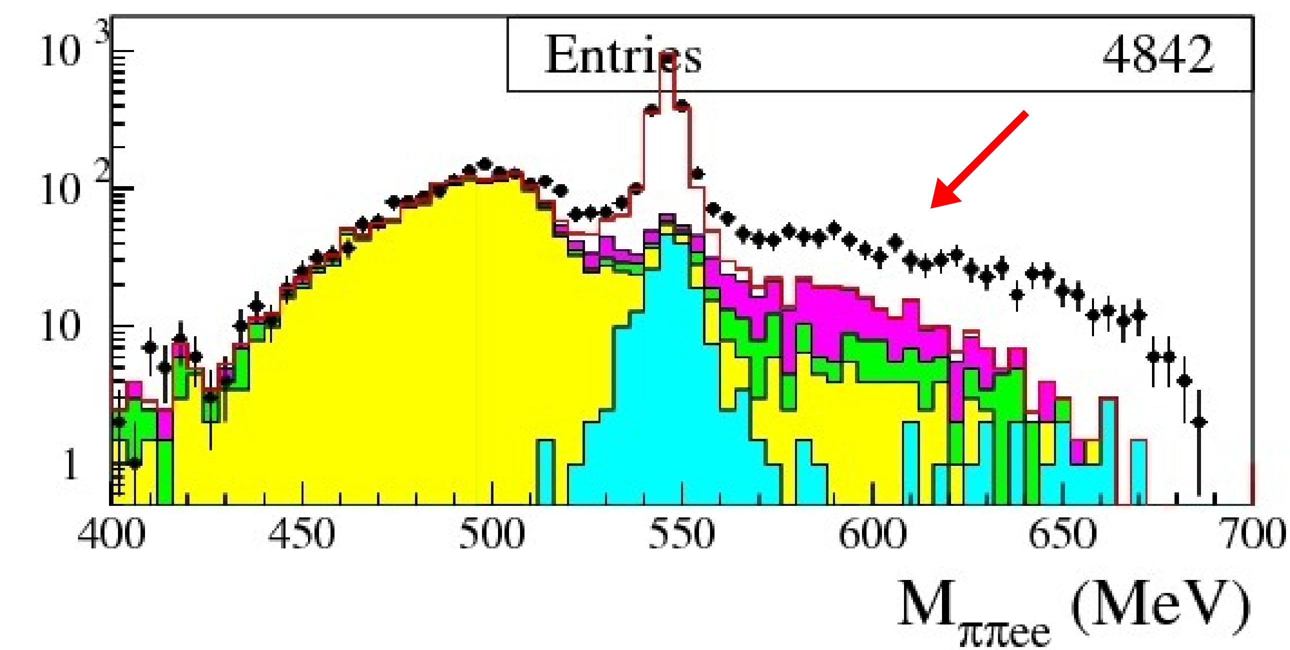
After background subtraction

Data-MC comparison

Something is rotten in the state of ~~Denmark~~ etappee



Data-MC disagreement for $M_{\pi\pi ee} > M_\eta$



Could come from continuum processes, not in all_phys MC

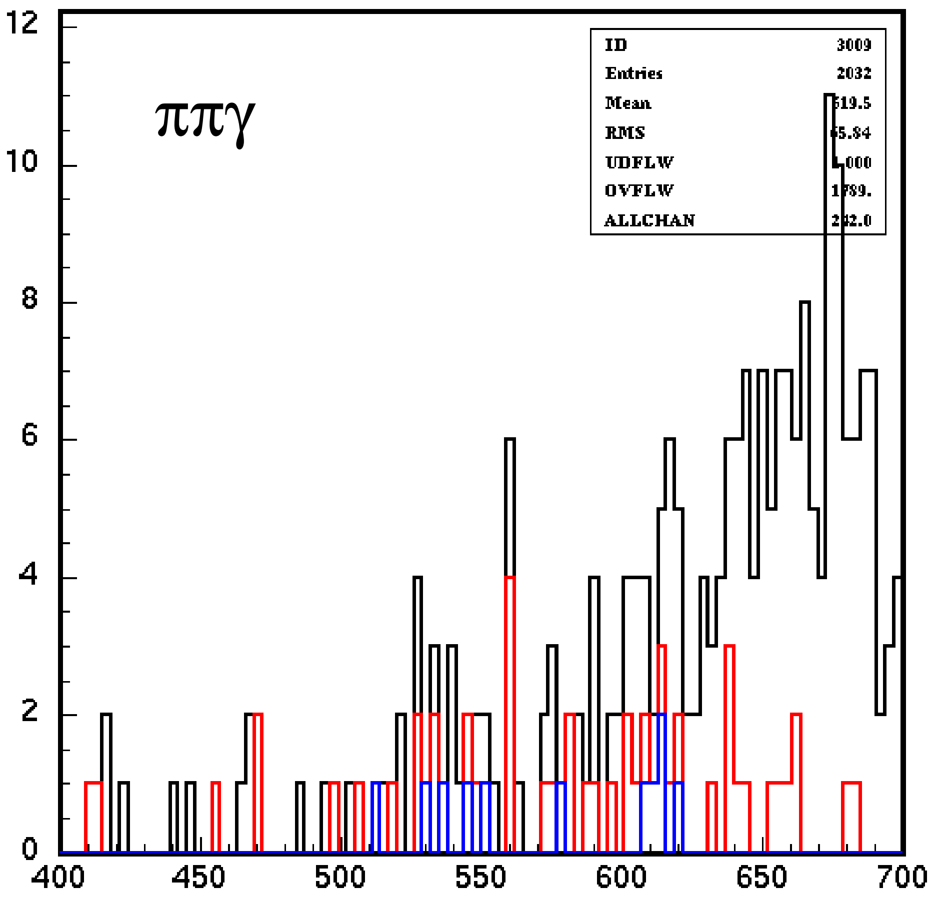
ππγ and eeγ backgrounds

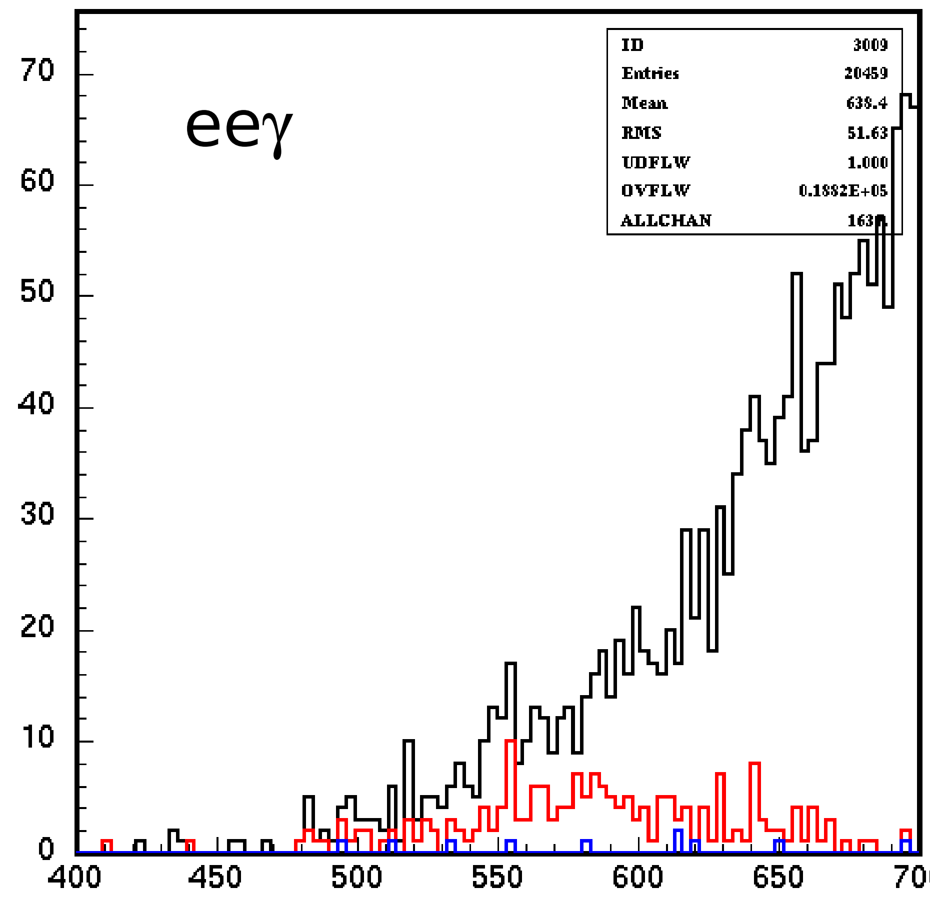
Present after EVCL

Reduced by momenta and χ^2 cuts

Very few MC statistics left

Work in progress





$\pi\pi\gamma$ and eeγ backgrounds

Present after EVCL

Reduced by momenta and χ^2 cuts

Very few MC statistics left

Work in progress

$\pi\pi\gamma$

We are producing $\pi\pi\gamma$ MC using ppgphok5 card for 2004-05 data with LSF=5

Seems that $\pi\pi\gamma$ contribution to mysterious background is negligible

eeγ

Studied using eeg100 production (LSF=0.5) for 2004-05 data

We don't have MC for events having Eγ<100 MeV

Cross section is too big for private MC production

Smart solution is needed

Conclusions

- ☺ Tracking efficiency
- ☺ PID with TOF
- ☺ Whole 2004-2005 statistics available and used
- ☺ Whole MC all_phys (1/2/3) statistics available and used
- ☺ Accidental cluster veto correction
- ☺ Low-θ background
- ☺ Good Data-MC agreement

- ☹ Background from continuum processes

Backup slides

Motivations

η structure, using virtual photon

Model comparison (VMD, χPT)

Test of CP violation: Gao model

Mod.PhysLett.A17 1583-1588.2002

Angular asymmetry between ee and $\pi\pi$ planes, A_{CP},

can be due to unconventional CPV mechanism

described by a $T\times V$ 4 quarks operator with $\Delta s=0$.

Within SM constrained by BR($\eta\rightarrow\pi\pi$),

using the experimental upper limit: $A_{CP} < 10^{-4}$

using theoretical prediction: $A_{CP} \sim 10^{-15}$

CPV model predicts an upper bound of 10^{-2}

BR: theory & experiment

Jarlskog, Pilkuhn 1967	$0.0065 \times BR(\eta \to \pi^+\pi^-\gamma)$
Using PDG06 $(30.5 \pm 0.7) \times 10^{-5}$	$(25.7 \pm 1.3) \times 10^{-5}$ Using CLEO '07
Picciotto, Richardson 1993	$(32 \pm 3) \times 10^{-5}$
Faessler et al. 2000	36×10^{-5}
Borasoy, Nissler 2007	$(29.9^{+0.6}_{-0.9}) \times 10^{-5}$
CMD-2 (4 events)	$(37\ ^{+25}_{-18\ stat} \pm 3_{syst}) \times 10^{-5}$
CELSIUS-WASA (16 events)	$(43 \pm 13_{stat} \pm 4_{syst}) \times 10^{-5}$

Tracking efficiency

using $\rho\pi$ sample work done together with A. De Santis

Sample selection

#tracks from IP = 1 or 2

tagging tracks checked for flips

One and only one cluster pair such that:

$t_{cl} - r_{cl}/c < \min(2\text{ ns}, 3\sigma_t)$

$0.65 < \cos(\gamma\gamma) < 0.85$

$300 < E_{\gamma\gamma} < 600$ MeV

w/o associated tracks (Official TCLO)

self-triggering (on the barrel and $E_{cl} > 70$ MeV)

$|m_{\pi 0} - m_{\gamma\gamma}| < 40$ MeV

Efficiency on $\rho\pi$ stream ~ 0.09

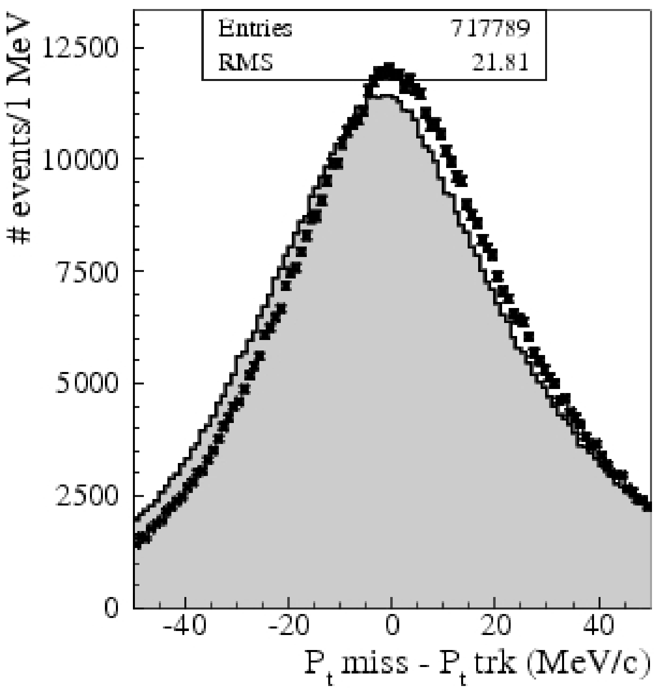
Sample purity ~ 0.994

Tracking efficiency

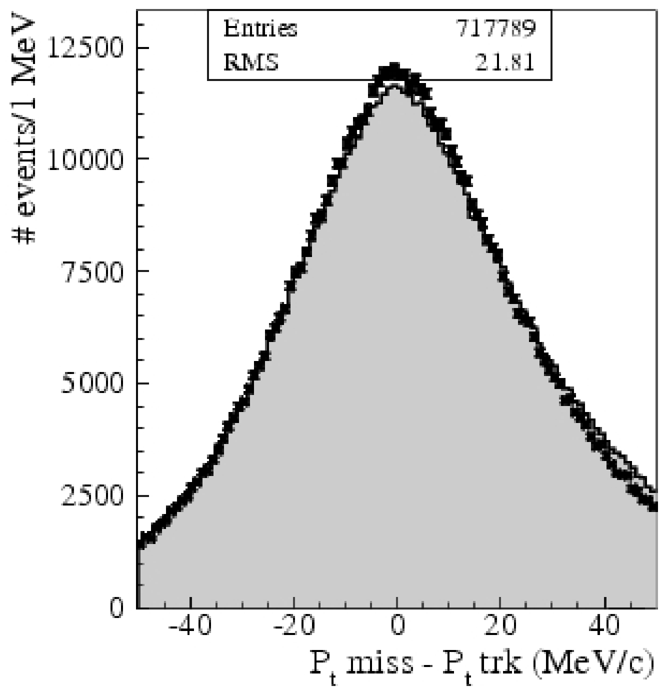
After $\gamma\gamma$ selection, kinematic fit to π^0 mass is applied

It improves the knowledge of the missing momentum

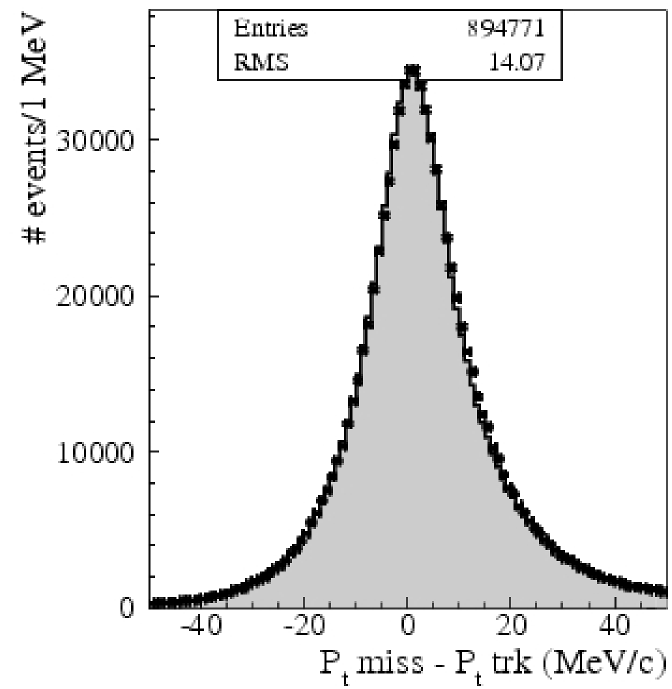
Cluster energy correction applied $E_{eff}=1.014\times E_{rec}$ (KM342)



Raw



Linearization



Linear. & Fit

Dots: data Filled: MC

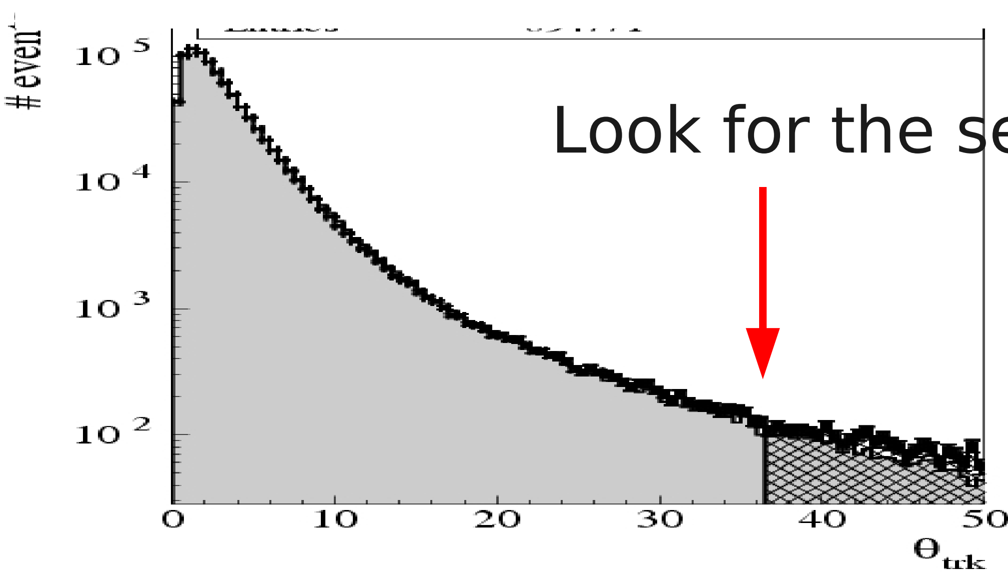
Tracking efficiency

Multiplicity has to be considered in efficiency evaluation

$$\varepsilon_{obs} = \frac{2N_2P(C_2)}{2N_2P(C_2)+N_1P(C_1)} = \frac{2\varepsilon_1^2}{2\varepsilon_1^2+2\varepsilon_1(1-\varepsilon_1)} = \varepsilon_1$$

Efficiency can be evaluated separately per charge

$$\varepsilon_{obs}^{\pm} = \frac{n(\pm\,track|\mp\ tag)}{n(\mp\,tag)} = \frac{P(C_2)}{P(C_2)+P(C_1^{\mp})} = \frac{\varepsilon_{1\pm}^2}{\varepsilon_{1\pm}^2+\varepsilon_{1\pm}(1-\varepsilon_{1\pm})} = \varepsilon_{1\pm}$$

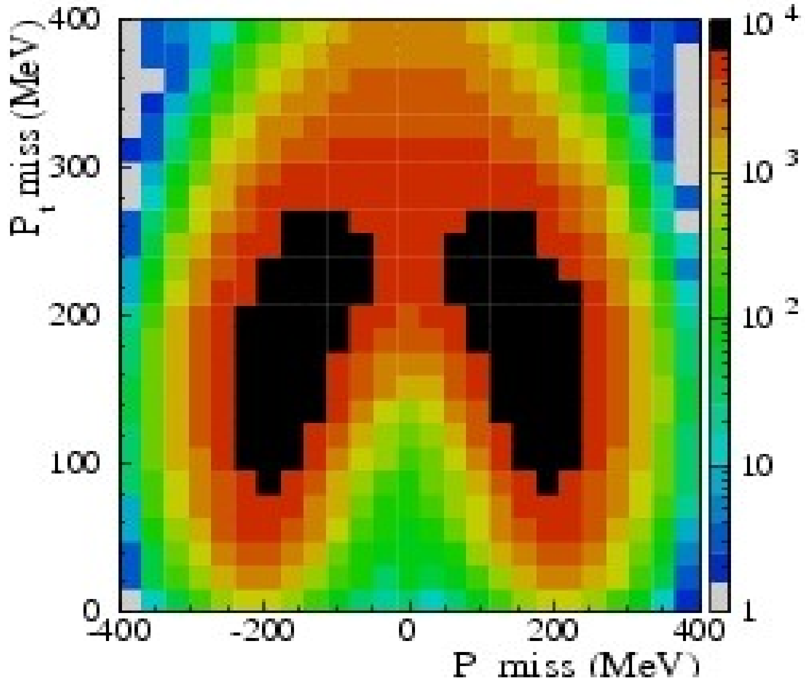


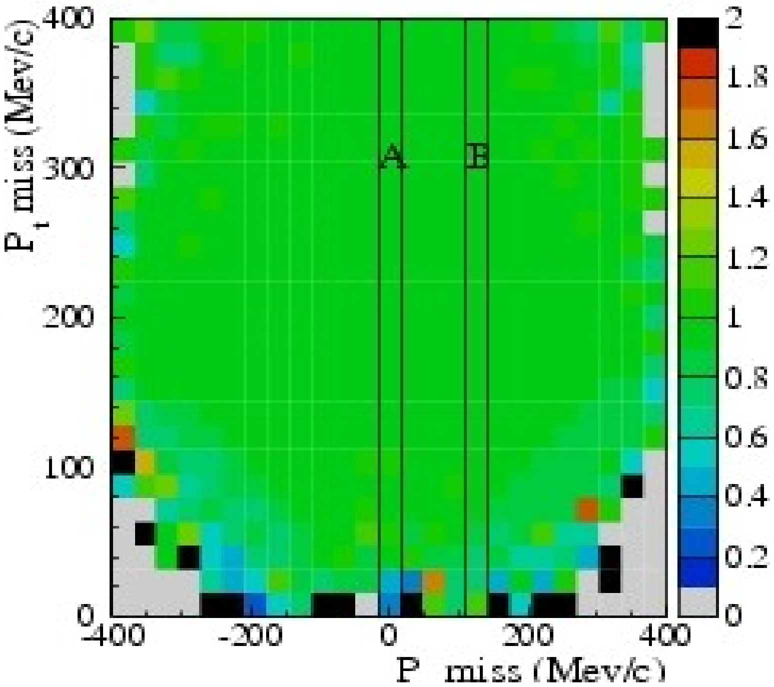
Look for the second track around the pointer

$\cos\theta_{trk} < 0.8$

Tracking efficiency

Data pointer

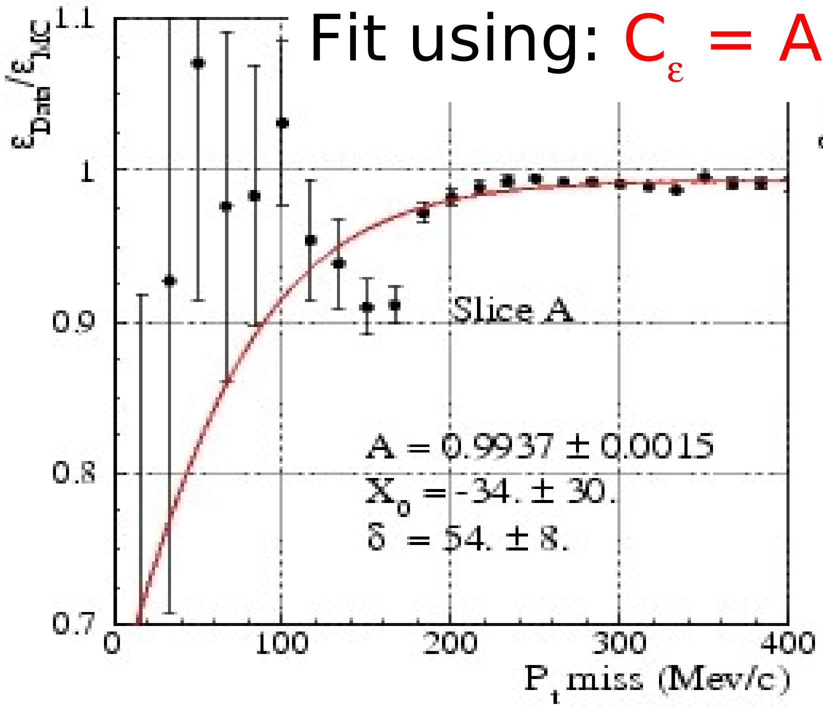


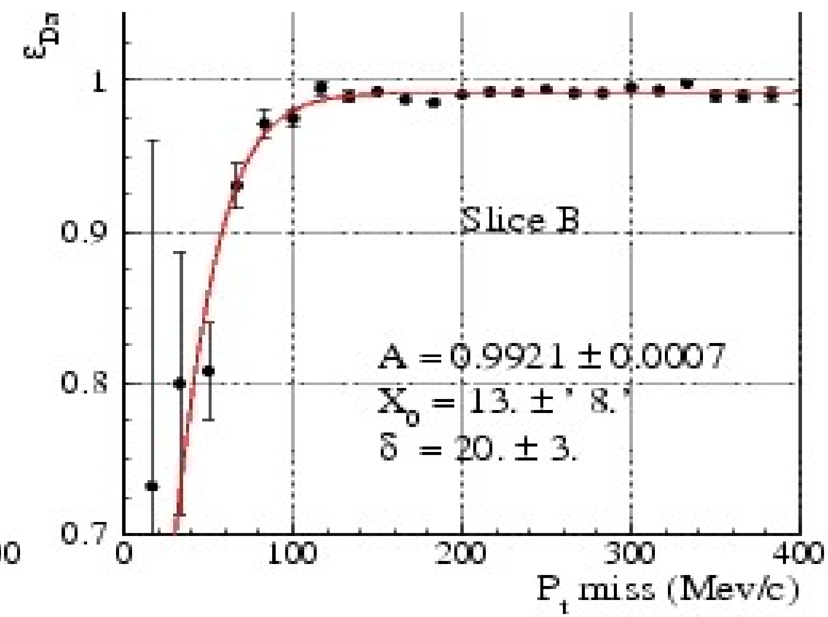


$$\frac{\varepsilon_{Data}}{\varepsilon_{MC}}$$

Fit using: $C_\varepsilon = A \ \{ 1 - 1 / [1 + \exp((X-X_0)/\delta)] \}$

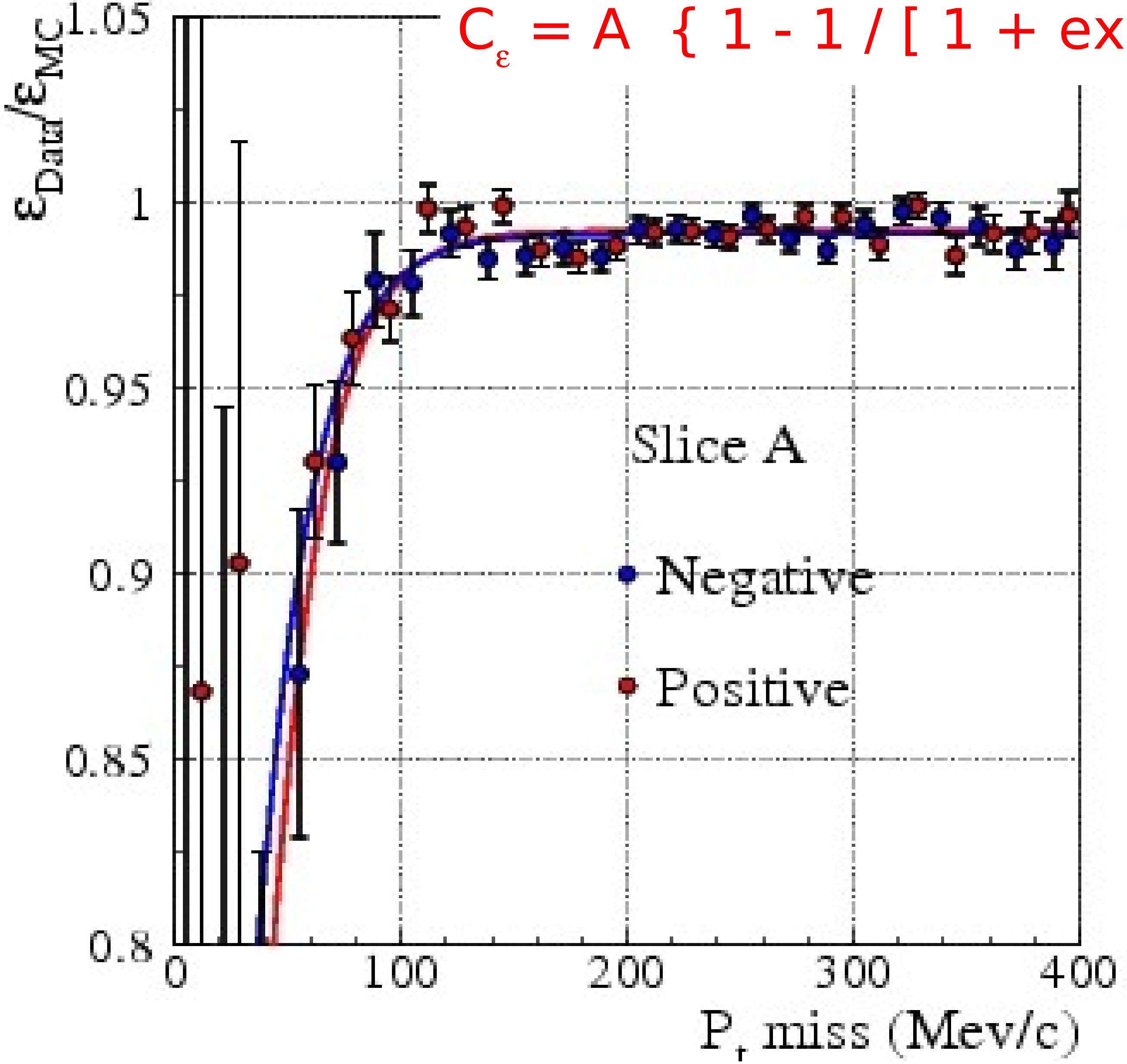
$$\frac{\varepsilon_{Data}}{\varepsilon_{MC}}$$





$$\frac{\varepsilon_{Data}}{\varepsilon_{MC}}$$

Tracking efficiency



$C_\varepsilon = A \{ 1 - 1 / [1 + \exp((X-X_0)/\delta)] \}$

Work finished

KLOE Memo 343

Code updated:

new ntuples already produced

PID using TOF

Asymmetry in Mππee spectrum due to *wrong mass assignment*

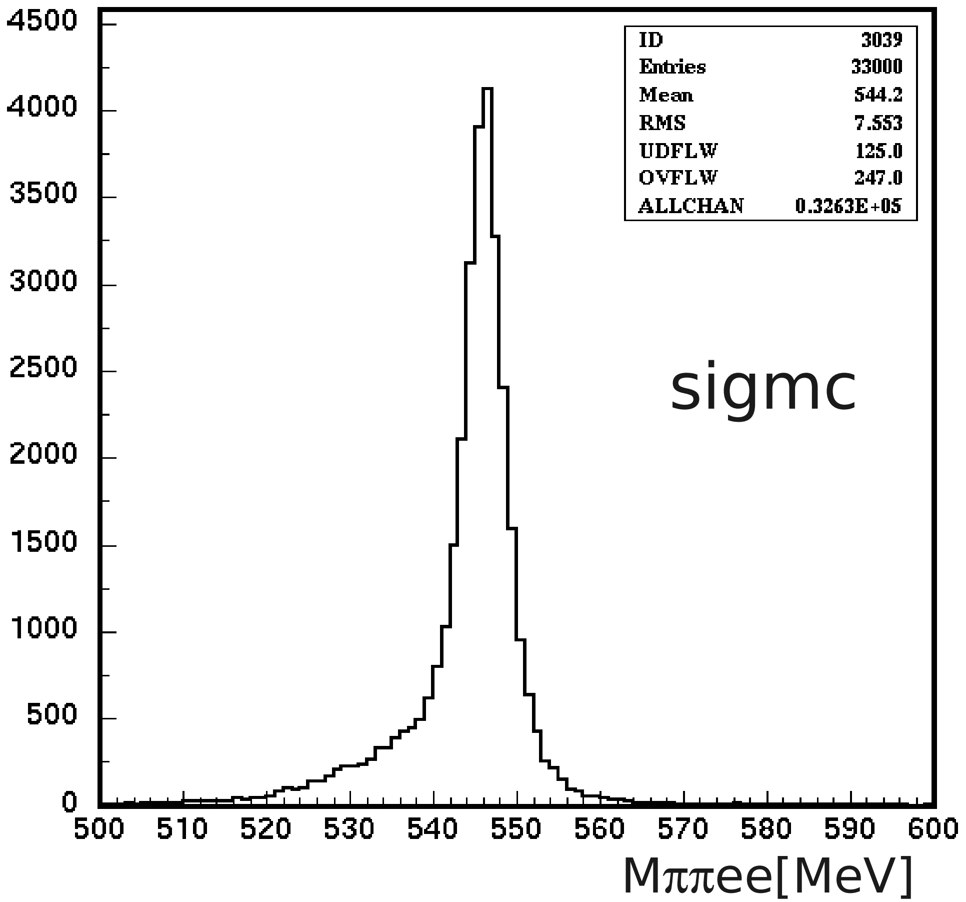
Can be improved using TOF

We evaluate $\Delta t = t_{track} - t_{cluster}$

in both electron (Δt_e)

and pion (Δt_π) hypothesis

#tracks	4	0.04
associated	>3	0.29
to cluster	>2	0.74
and fraction	>1	0.99

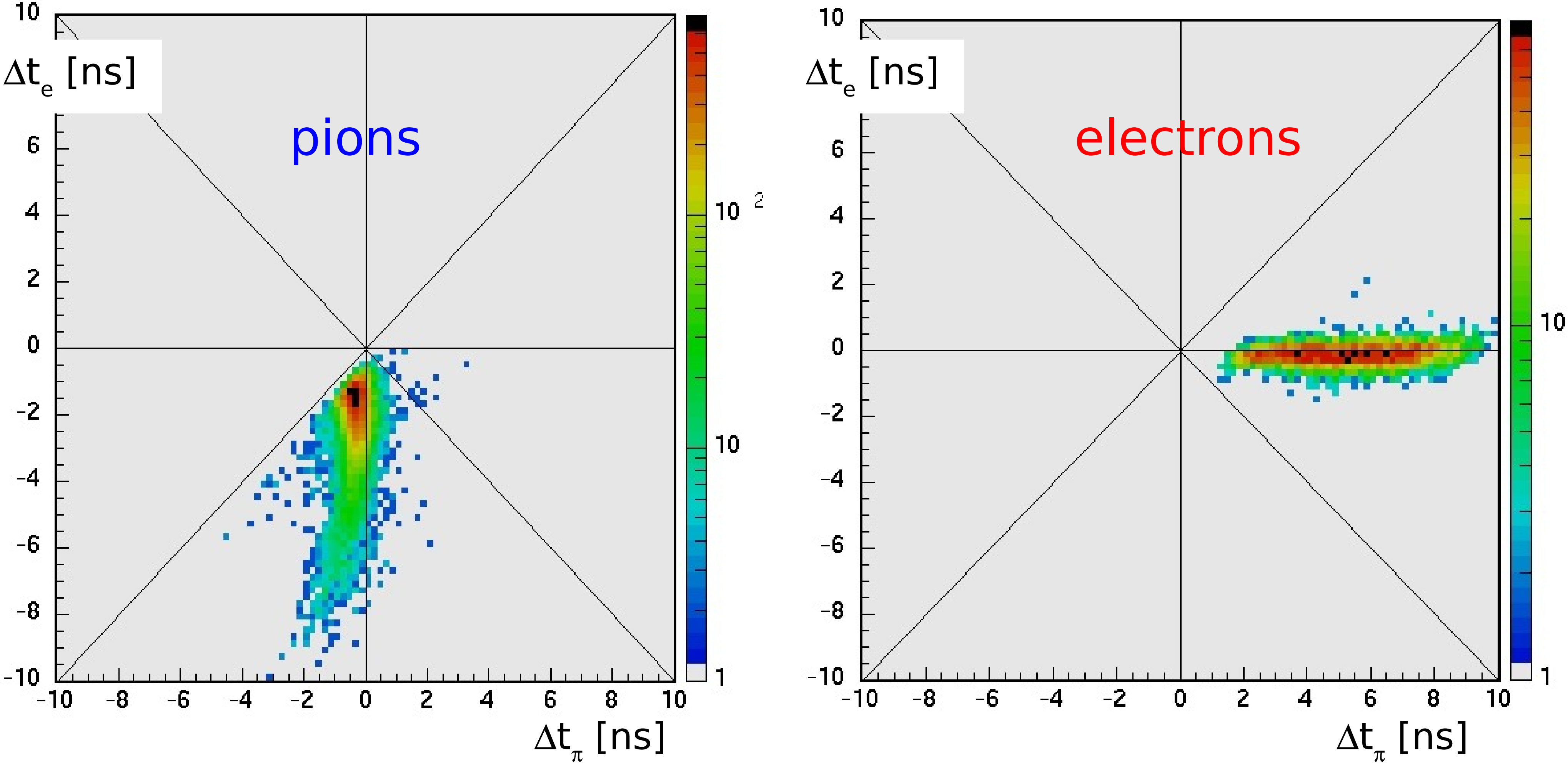


Also look for kink (i.e. decay)

Extrapolation to EMC using Spadaro's libraries

PID using TOF

Cool! Hm.... I mean.... powerful!



PID using TOF

Algorithm for mass assignment

T#1 = Track #1 T#2 = Track #2

1-Look for track pair having the same charge and extrapolation to the calorimeter (both tracks)

T#1 with kink
T#2 without kink $\Longrightarrow$ T#1=π
T#2=e

2-For all other tracks use Δt_e vs Δt_π to assign mass

3-Use pair's charge to solve ambiguities

PID using TOF

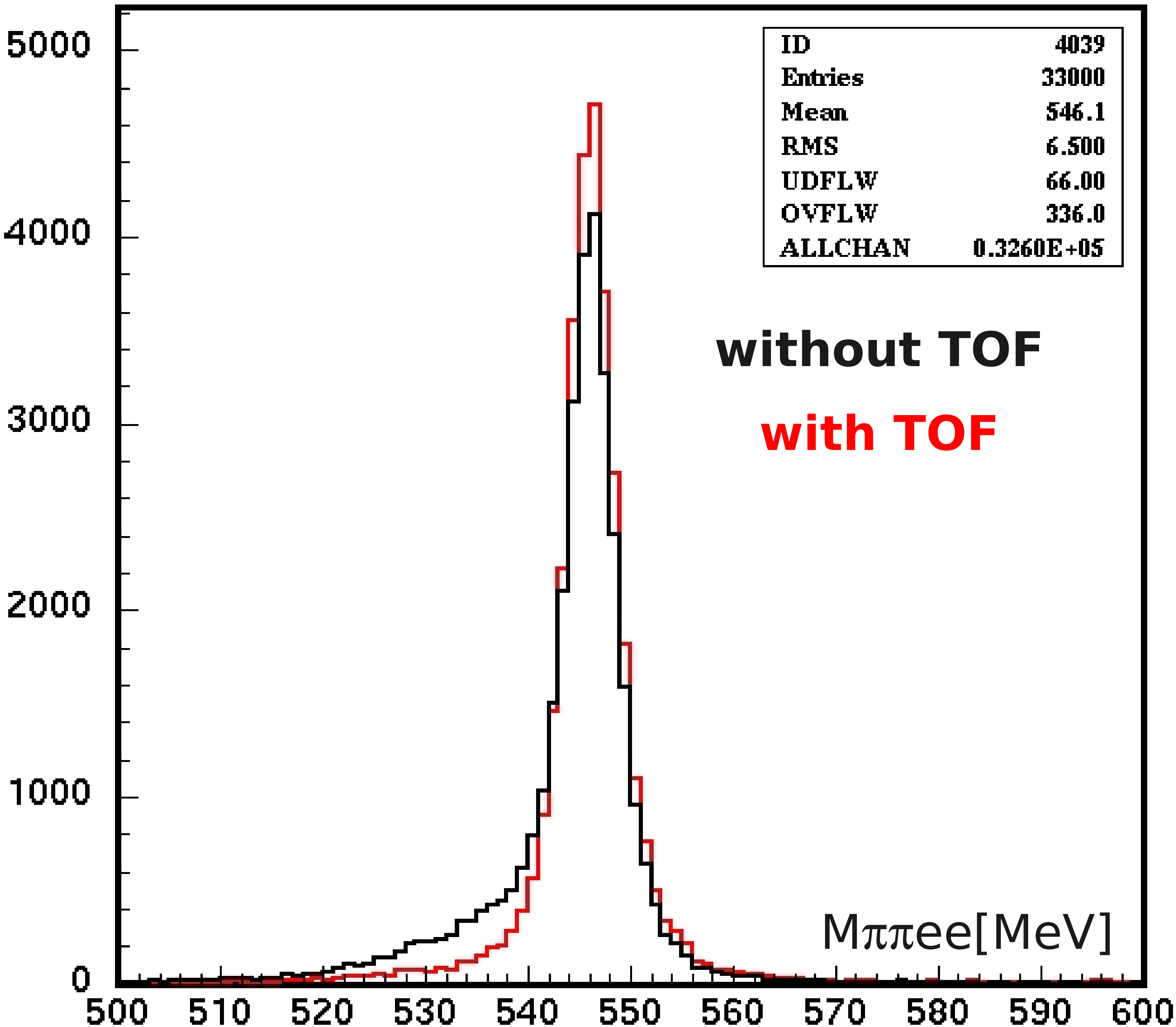
Algorithm for mass assignment

3-Use pair's charge to solve ambiguities

T#1	T#2	
e	e	min(Δt_e) $\Rightarrow$ e
e	π	ok
e	?	T#2 = π
π	e	ok
π	π	min(Δt_e) $\Rightarrow$ e
π	?	T#2 = e
?	e	T#1 = π
?	π	T#1 = e
?	?	if T#1 w/ kink and T#2 w/o kink $\Rightarrow$ T#1=π & T#2=e (and vice versa)

Ordered momenta are used for remaining assignment ambiguities

PID using TOF



Background studies

Anyway good MC-Data agreement after all cuts

(χ^2, momenta, conv@BP, Mππee, angular cuts)