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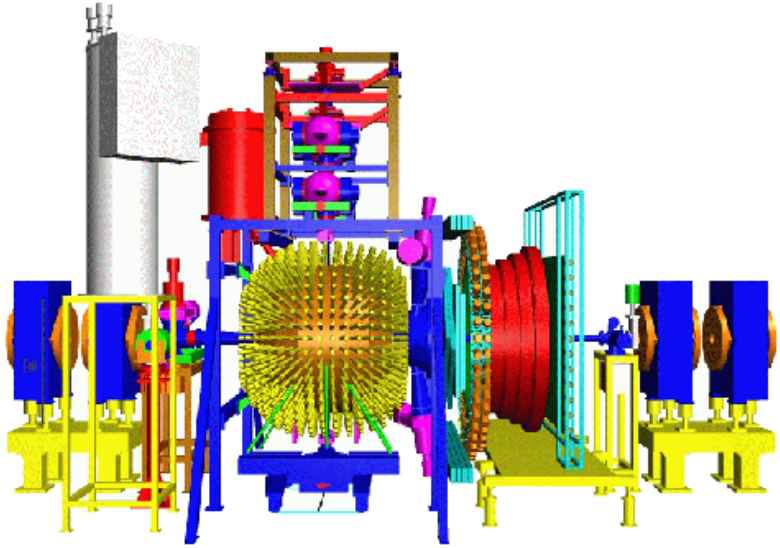

Current status $\eta \to \pi^+\pi^-\pi^0$ decay with WASA at COSY

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$\eta \to 3\pi$ meeting, April 8, 2009

Introduction

η decays to $\pi\pi\pi$ via isospin violating strong interactions proportional to $m_d - m_u$ difference (e.m. effects are small). Many experiments have been made on $\eta \to 3\pi^0$. This talk focuses on $\eta \to \pi^+\pi^-\pi^0$.

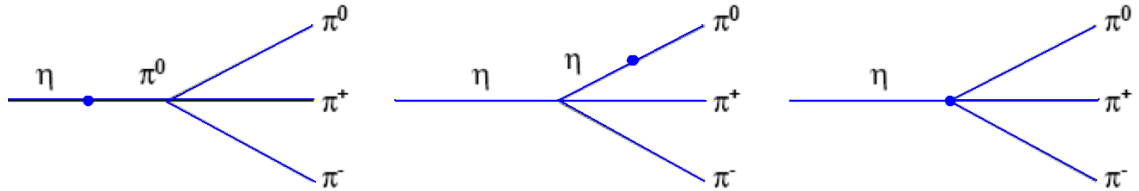


Figure. $\eta \to \pi^+\pi^-\pi^0$ *at tree level (Current Algebra).*

The decay rate is expanded around $X = Y = 0$ in Dalitz plot:

$$\frac{d\Gamma}{dXdY} \propto |A(X,Y)|^2 \propto 1 + aY + bY^2 + cX + dX^2 + eXY + fY^3 + \ldots \quad (1)$$

$$X = \sqrt{3}\frac{T_+ - T_-}{Q_\eta}, \; Y = \frac{3T_0}{Q_\eta} - 1 \quad (2)$$

$$Q_\eta = T_+ + T_- + T_0 \quad (3)$$

The Dalitz plot parameters b and f are thus far difficult to reproduce in any theoretical approach.

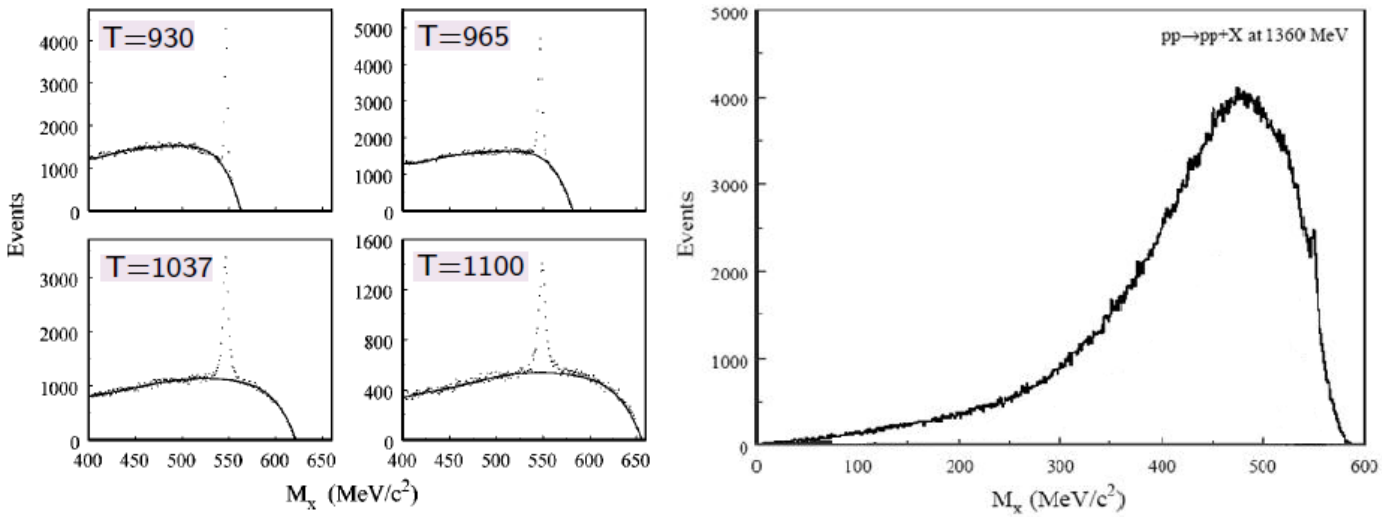
KLOE- result	Current Algebra
$a = 1.090 \pm 0.005^{+0.008}_{-0.019}$	$a \approx 1$
$b = 0.124 \pm 0.006 \pm 0.010$	$b=a^2/4$
$d = 0.057 \pm 0.006^{+0.007}_{-0.016}$	$d=0$
$f = 0.14 \pm 0.01 \pm 0.02$	$f=0$

Table: *Dalitz plot parameters for KLOE cf. CA result*

$\eta \to \pi^+\pi^-\pi^0$ with WASA-at-COSY

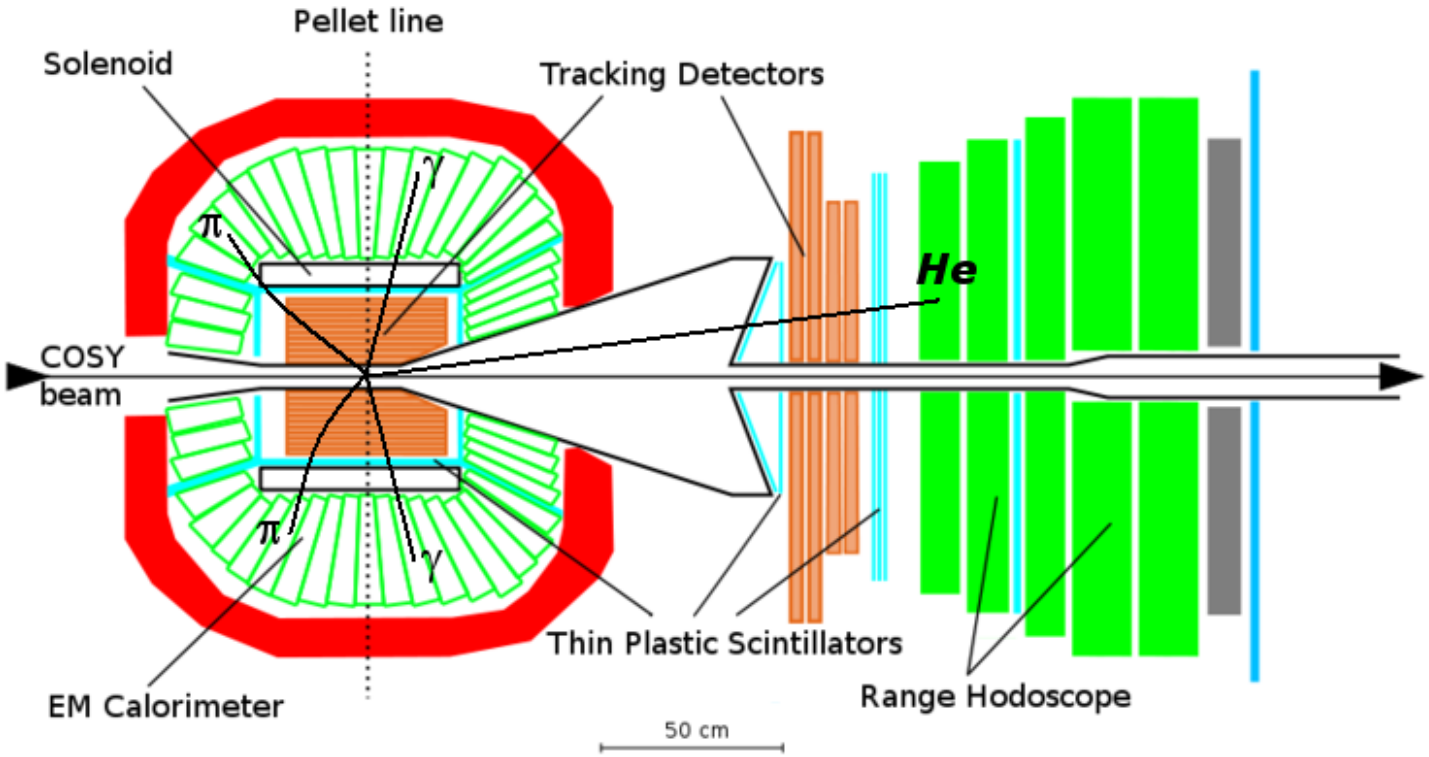
$pd \to {}^3He\eta$ at beam energy 1.0 GeV. 4 weeks run in fall 2008. Next data taking 8 weeks in summer 2009.

- Good signal to background ratio
- Simple unbiased trigger (${}^3He$ in FD, max $\theta_{He} \approx 10^\circ$), absolute br. ratios.
- Previous experience from CELSIUS/WASA.



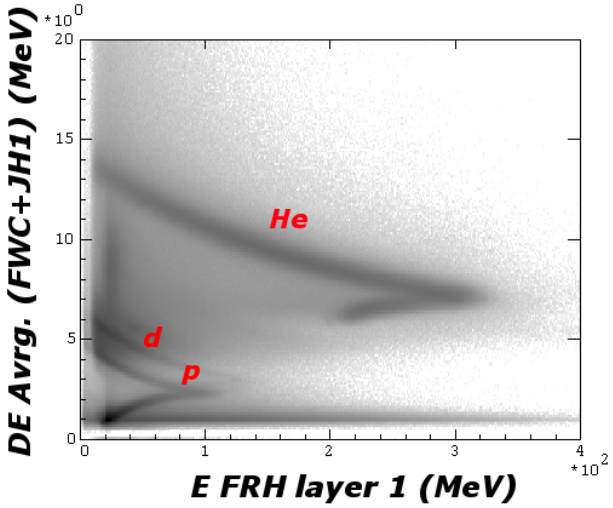
Bilger et al., Ph. Rev. C, 65, 044608 (left picture)

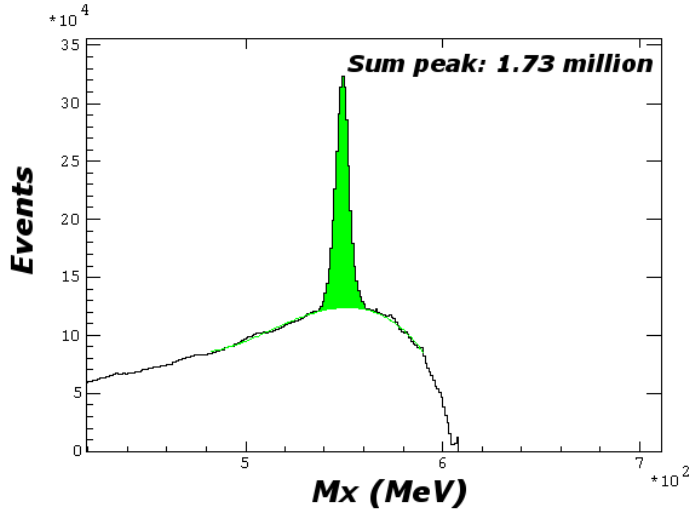
WASA-at-COSY detector setup



Estimation of η events.

Approximately 10 million η on disk. Here some preliminary analysis from approximately 70 hours of data taking or 92 runs is shown.





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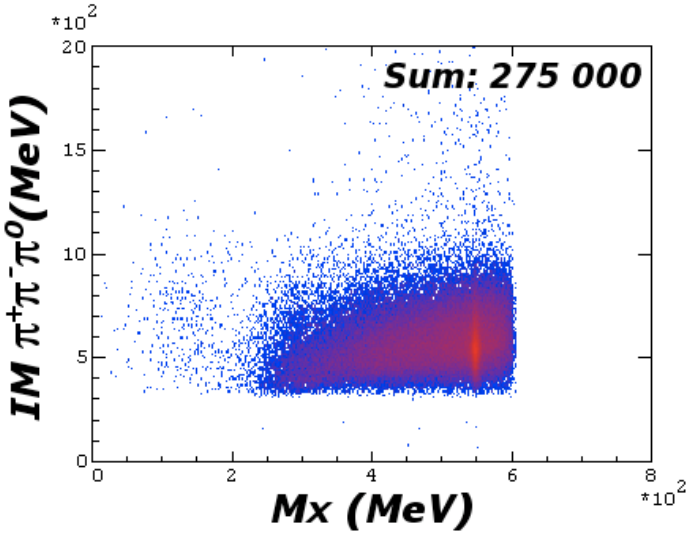
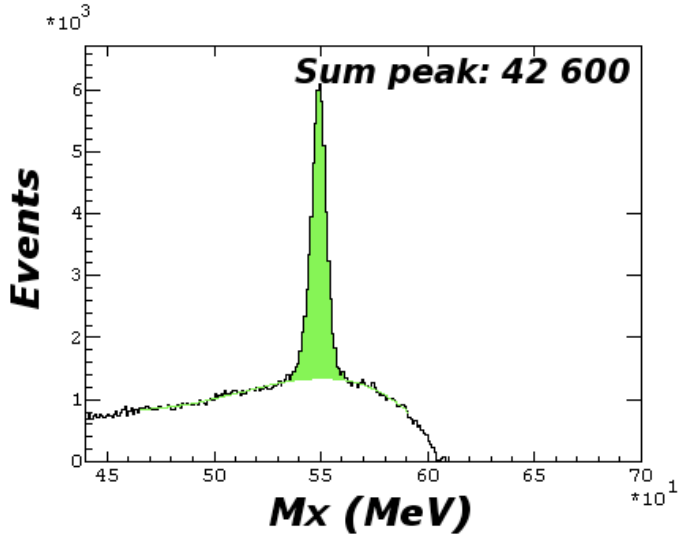
Correction tables have been applied. Events have been rejected which do not fulfill these criteria:

- $30.5° \leq \theta_{\pi^\pm} \leq 150°$, $24° \leq MDC_\theta \leq 159°$
- $22.5° \leq \theta_\gamma \leq 166°$, $20° \leq SEC_\theta \leq 169°$
- $p_{corr,\pi^\pm} \leq 450$ MeV/c

MM v IM plots

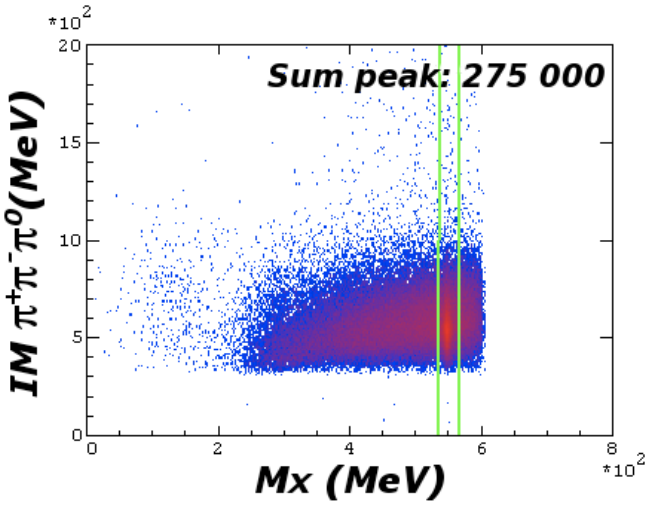
MM(^3He) versus IM($\pi^+\pi^-\pi^0$) with projection on MM-axis.

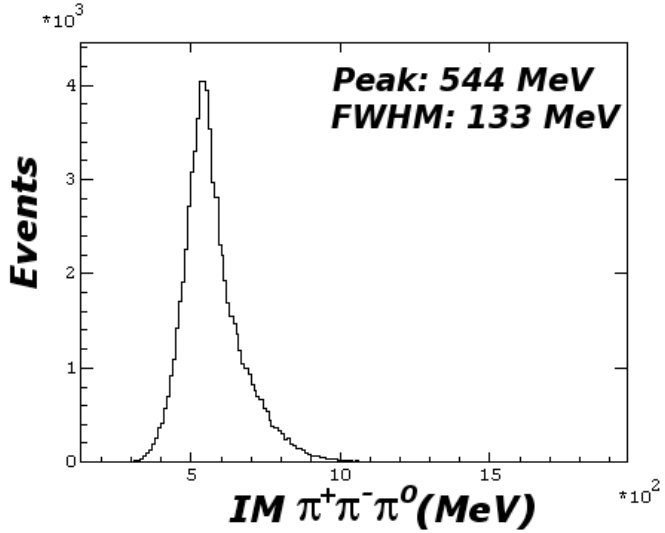




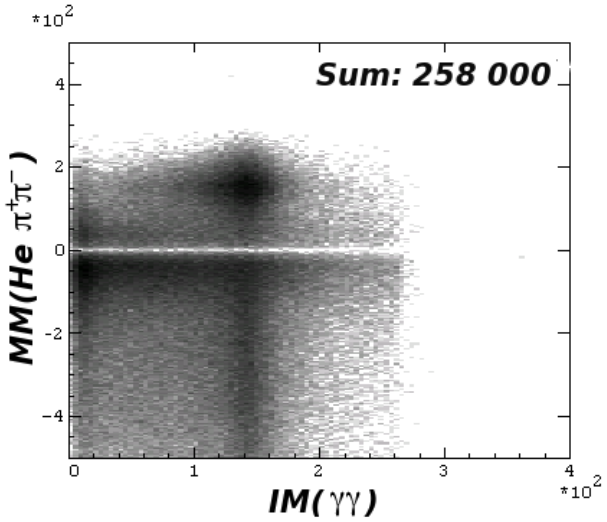
MM v IM plots

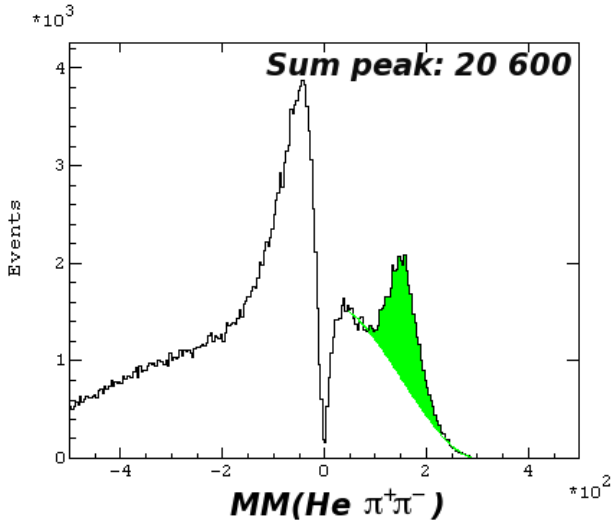
MM(^3He) versus IM($\pi^+\pi^-\pi^0$) with projection on IM-axis.





A cut that may be used to separate chance coincidences from true events: MM($^3He\pi^+\pi^-$) vs IM($\gamma\gamma$)

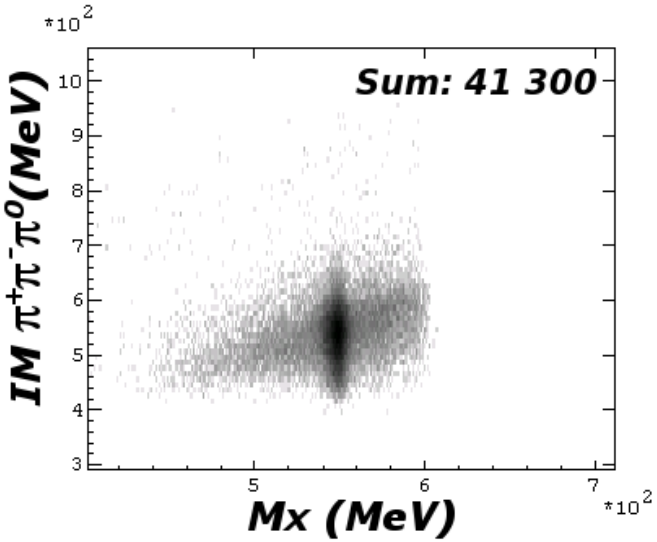


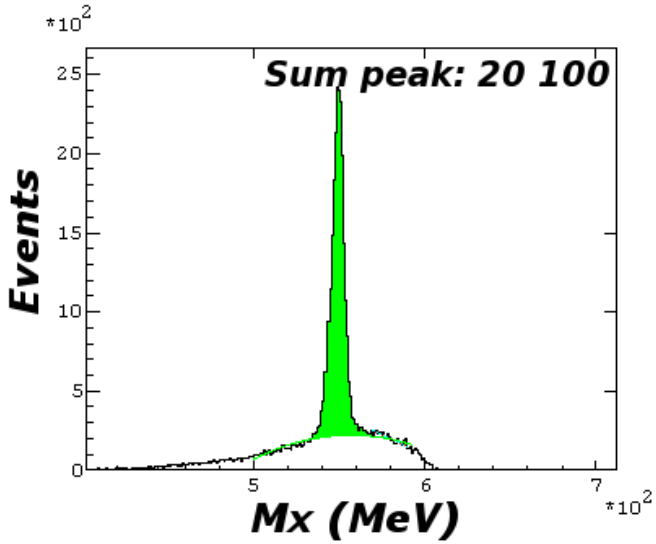


The cut:
$50 \leq MM(^3He\pi^+\pi^-) \leq 250$ and
$100 \leq IM(\gamma\gamma) \leq 200$

MM(^3He) v IM($\pi^+\pi^-\pi^0$) after cut

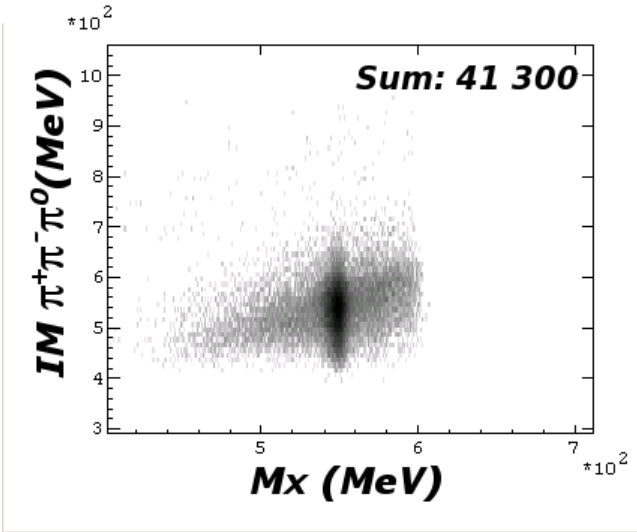
This gives the result in the MM(^3He) versus IM($\pi^+\pi^-\pi^0$) sc. plot:

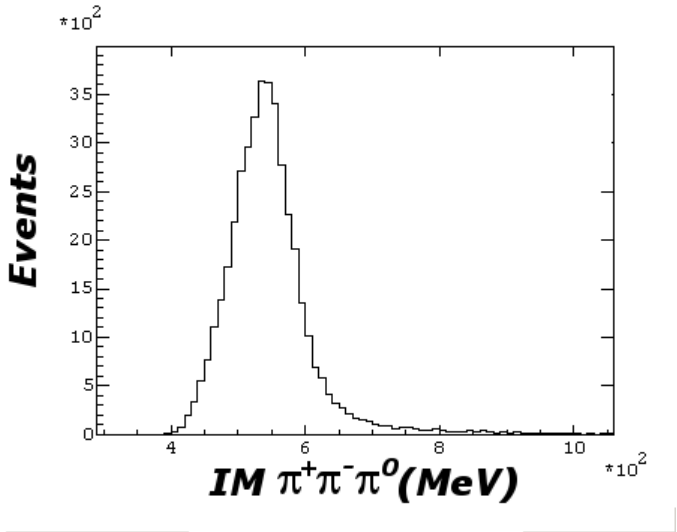




MM(^3He) v IM($\pi^+\pi^-\pi^0$) after cut

This gives the result in the MM(^3He) versus IM($\pi^+\pi^-\pi^0$) sc. plot:





MC studies from 10^6 $pd \to {}^3He\eta$ events

Type	nr of events	Br. ratio (%)	Acc. (%)
He detected	694 000	-	69.4
$\eta \to \gamma\gamma$	189 000	39.3	48.1
$\eta \to \pi^+\pi^-\pi^0$	46 800	23.0	20.3
$\eta \to \pi^+\pi^-\pi^0$ w. MM($He\pi^+\pi^-$) v IM($\gamma\gamma$)- cut	36 300	23.0	15.8

Table: *Number of events from MC studies including acceptance and branching ratios.*

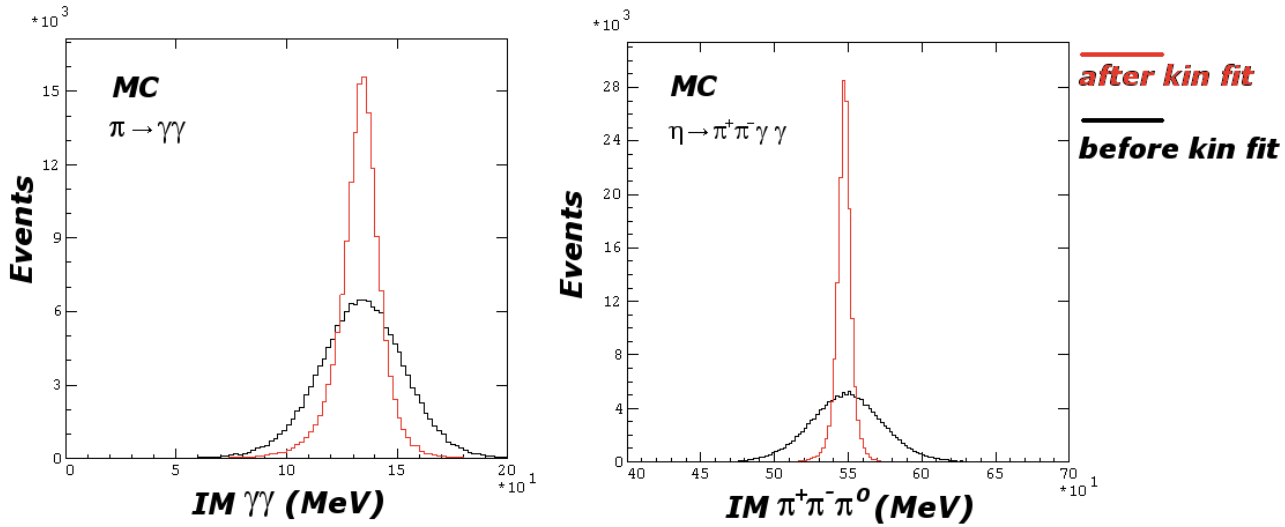
Experimental results in comparison with expected from MC estimates

Type of distribution	nr of events	nr of expected events from MC
MM calculated for He	$1.73 \cdot 10^6$	-
$\eta \rightarrow \gamma\gamma$	374 000	472 000
$\eta \rightarrow \pi^+\pi^-\pi^0$ candidates	42 600	116 400
$\eta \rightarrow \pi^+\pi^-\pi^0$ w. MM($He\pi^+\pi^-$) v IM($\gamma\gamma$)- cut	20 300	90 600

Table: *Number of events in experimental plot in comparison with expected number from MC estimates.*

Kinematical Fit MC studies

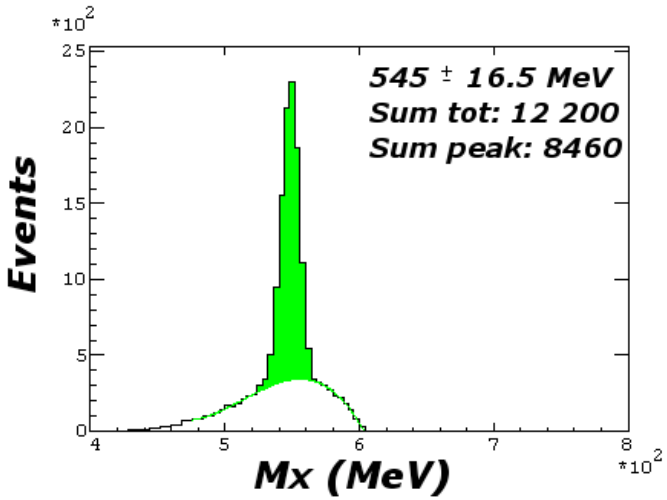
Kinematical fit after simulation of detector resolution.
Only 4-momentum constraints.

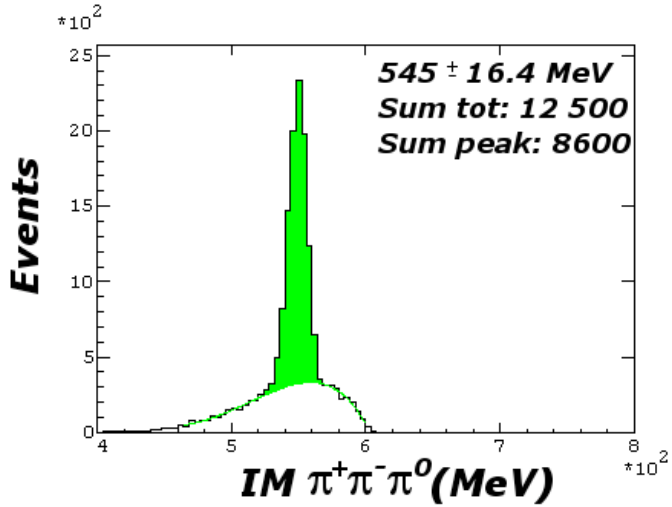


Resolution on $IM\gamma\gamma$ improved from 43.4 to 16.2 MeV FWHM.
Resolution on $IM3\pi$ improved from 54.0 to 8.9 MeV FWHM.

Kinematical fit on experimental data:

- errors are not the same as MC $\Rightarrow$ crude estimates:
  - Momentum Errors: $\pi^{\pm}_{exp}, \gamma_{exp} = 2 \cdot \pi^{\pm}_{MC}, 2 \cdot \gamma_{MC}$
  - $\theta_\gamma, \phi_\gamma = 4^\circ$
- cut on pdf ≤ 1 %





Conclusion: Errors need to be known better.

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Outlook

- 4 weeks of data taking with 10 million η on disk
- Work to improve resolutions and efficiency
- Work to understand the errors better
- Additional statistics from 8 weeks of data taking, summer 2009.

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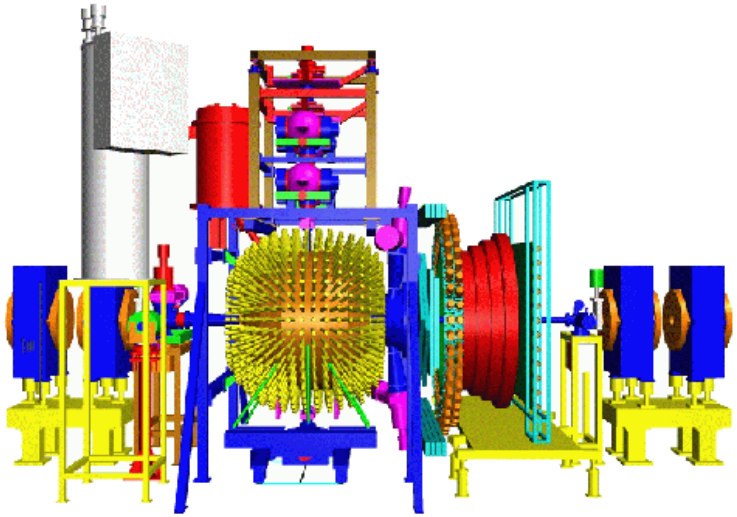

Thank You for your attention.