

# Preliminary analysis for E asymmetry on pi-p exclusive reaction from g14 experiment

@CLAS collaboration Meeting,  
Hadron Spectroscopy WG, Nov. 22, 2013

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(On behalf of CLAS collaboration)

# 1. Physics motivation: for missing resonances issue, measure 16 spin observables for neutron (little known)

Sandorfi - CIPANP'12

*Polarization observables in  $\gamma n (p) \rightarrow$  photo-production :*

Photon beam	Target			Recoil			Target - Recoil								
				$x'$	$y'$	$z'$	$x'$	$x'$	$x'$	$y'$	$y'$	$y'$	$z'$	$z'$	$z'$
	$x$	$y$	$z$				$x$	$y$	$z$	$x$	$y$	$z$	$x$	$y$	$z$
unpolarized	$\sigma_0$	$T$			$P$		$T_{x'}$		$L_{x'}$		$\Sigma$		$T_{z'}$		$L_{z'}$
$P_L^Y \sin(2\phi_\gamma)$		$H$	$G$	$O_{x'}$		$O_{z'}$		$C_{z'}$		$E$		$F$		$-C_{x'}$	
$P_L^Y \cos(2\phi_\gamma)$	$-\Sigma$	$-P$			$-T$		$-L_{z'}$		$T_{z'}$		$-\sigma_0$		$L_{x'}$		$-T_{x'}$
circular $P_c^Y$		$F$	$-E$	$C_{x'}$		$C_{z'}$		$-O_{z'}$		$G$		$-H$		$O_{x'}$	

This talk <sup>↑</sup>

**Full set of 16**

status	CLAS run period	beam	target
complete	g13	$\vec{\gamma}_L, \vec{\gamma}_c$	LD <sub>2</sub>
complete	g14	$\vec{\gamma}_L, \vec{\gamma}_c$	HDice (Longitudinally polarized)

Sandorfi, Hoblit, Kumano, Lee, J.PHYS, G38 (2011)053001

# Pseudoscalar meson reactions and observables measured in this experiment

<i>reaction</i>	<i>observable</i>
$\gamma + n(p) \rightarrow \pi^- p(p)$	$\sigma_0, \Sigma, \mathbf{E}, G$
$\gamma + n(p) \rightarrow \pi^+ \pi^- n(p)$	$\sigma_0, I^c(\Sigma), I^s, I^0, P_z, P_z^0(E), P_z^s(G), P_z^c$
$\gamma + n(p) \rightarrow K^0 \Lambda(p)$	$\sigma_0, \Sigma, E, G$ $O_{x'}, O_{z'}, C_{x'}, C_{z'}, P, T=(-O_{y'})$ $L_{x'}, L_{z'}, T_{x'}, T_{z'}$
$\gamma + n(p) \rightarrow K^0 \Sigma^0(p)$	$\sigma_0, \Sigma, P, E, G$
$\gamma + n(p) \rightarrow K^+ \Sigma^-(p)$	$\sigma_0, \Sigma, E, G$

From proposal Eo6-101

## 2. Experimental apparatus

Circularly and linearly polarized photon beams

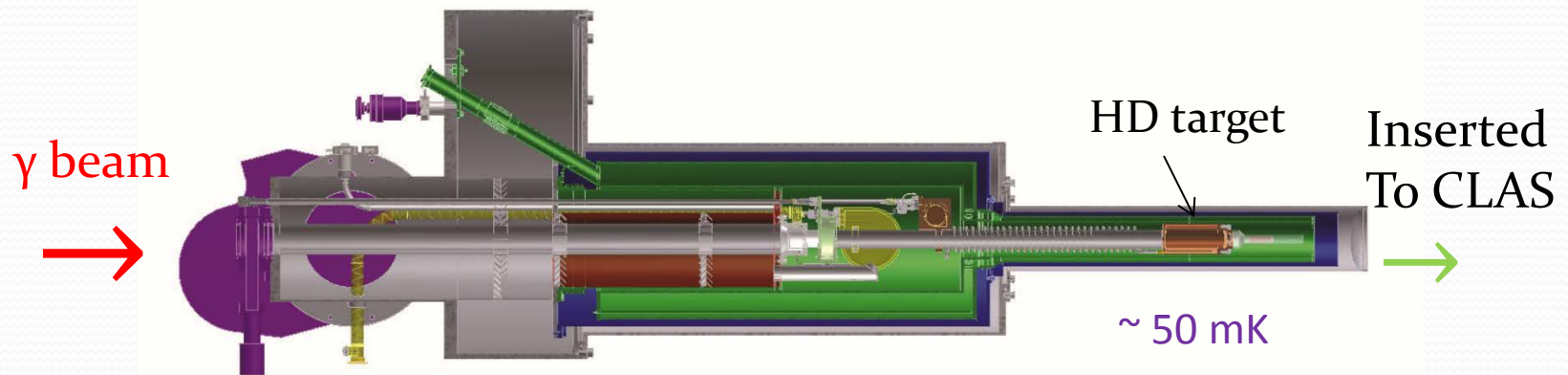
CLAS detectors and electron tagging system

Polarized neutron target (Solid HD) : newly installed

# New longitudinally polarized target for this experiment

Frozen Spin Polarized solid HD target

Relaxation time  $> 1$  year @  $\sim 50$  mK and 0.9 Tesla

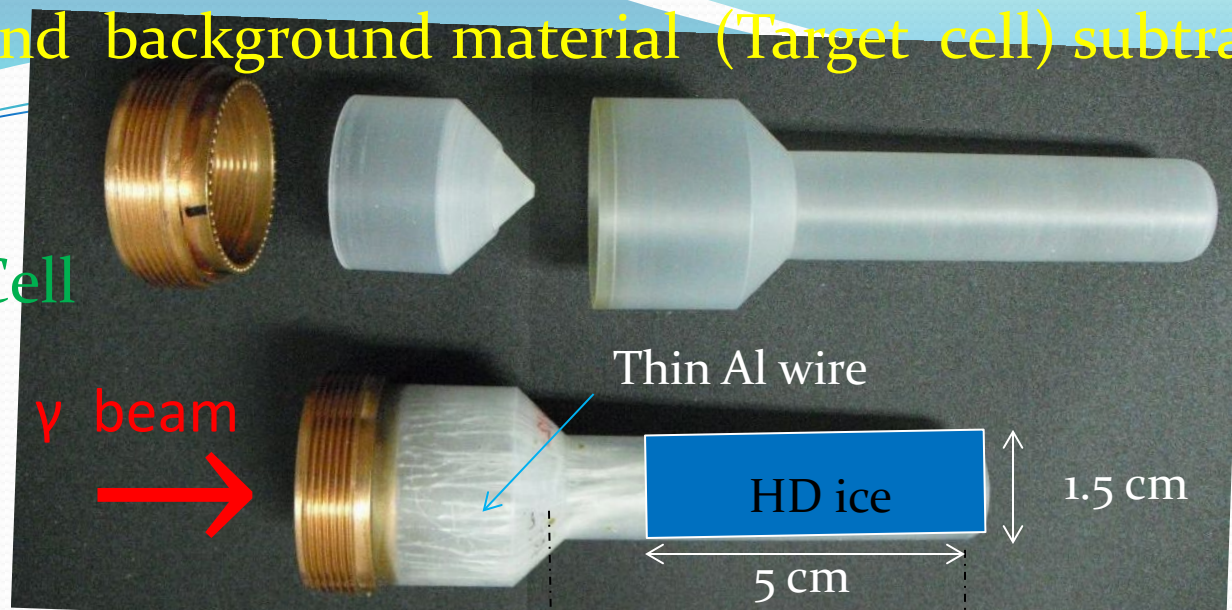


(Thanks to Mike Lowry for drawing)

- \* Horizontal Dilution Fridge (designed and constructed by HDice group at Jlab)
- \* 1 Tesla main Solenoid for longitudinal holding field
- \* Transverse field of 750 Gauss for field rotation (spin flip)
- \* NMR coil: polarization monitor during the run and spin transfer and H-spin flip, Birdcage coil

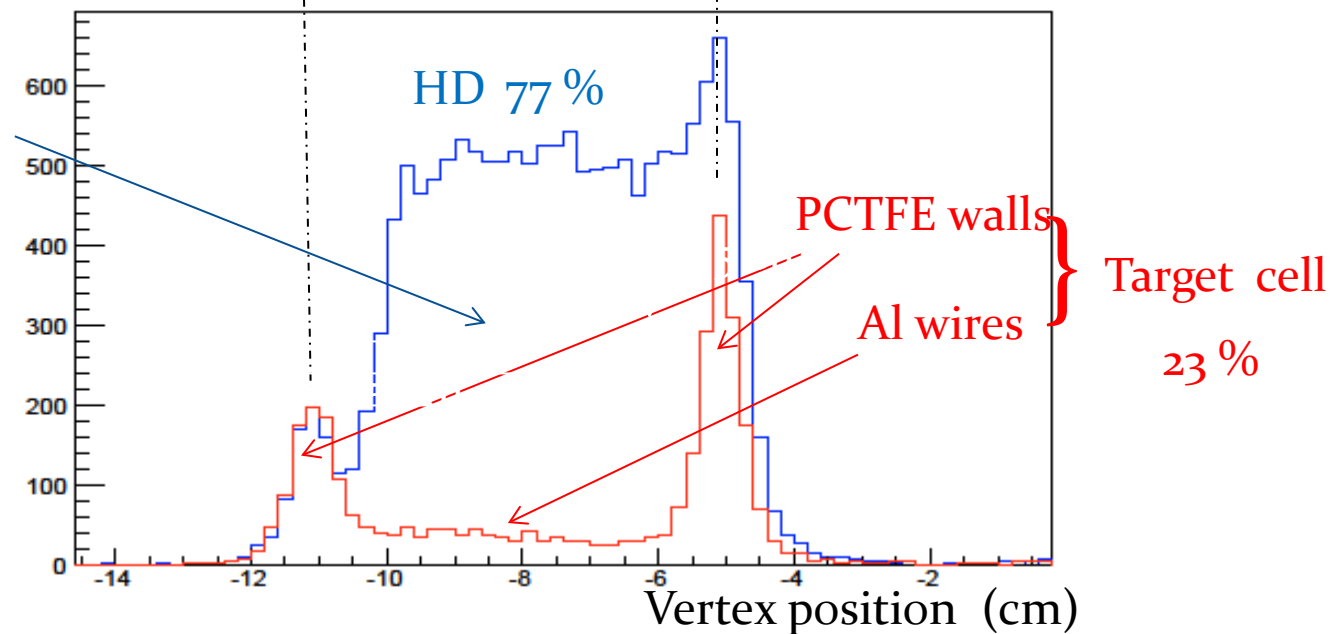
# Target and background material (Target cell) subtraction

Target Cell



Reconstructed vertex (beam direction) for  $\pi^-$  and proton

HD and target cell





### 3. Running conditions and Preliminary results

## Triggers

\* 1 charged:  $\gamma + p \rightarrow \pi^+ + X$

$$\gamma + n(p) \rightarrow \pi^- + X$$

\* 2 charged:  $\gamma + n(p) \rightarrow \pi^- + p + X$

## g14 experiments: Dec. 2011 – May. 2012

\* Circularly polarized photon beams:  $0.85 < E_\gamma < 2.4$  GeV

$\vec{D}$  : 27 days  $\rightarrow$  4.5 B events (Dpol.  $\sim +25\%$ )

$\overleftarrow{D}$  : 37 days  $\rightarrow$  6.1 B events (Dpol.  $\sim -17\%$ )

Dpol : Preliminary

\* Linearly polarized photon beams:  $1.6 < E_\gamma < 2.2$  GeV

$\vec{D}$  : 21 days  $\rightarrow$  2.5 B events (Dpol.  $\sim +25\%$ )

$\overleftarrow{D}$  : 9 days  $\rightarrow$  1.2 B events (Dpol.  $\sim -17\%$ )

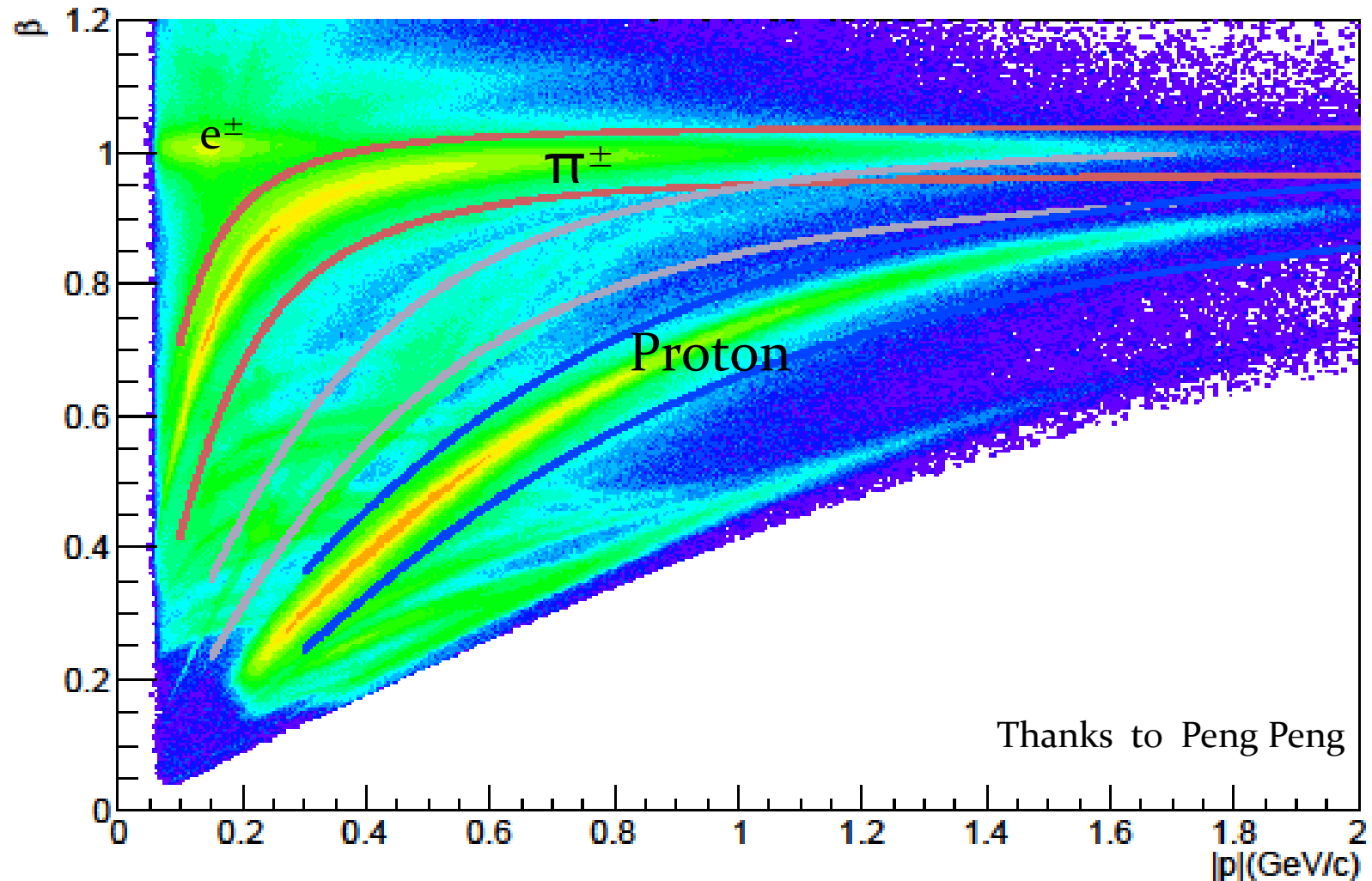


# Data reductions for $\gamma + n(p) \rightarrow \pi^- + p(p)$

- (a) Only  $\pi^-$  and Proton detected in CLAS
- (b) Coplanarity cut
- (c) Cut for Missing mass squared
- (d) Missing momentum cut
- (e) Target Cell subtraction and vertex cut

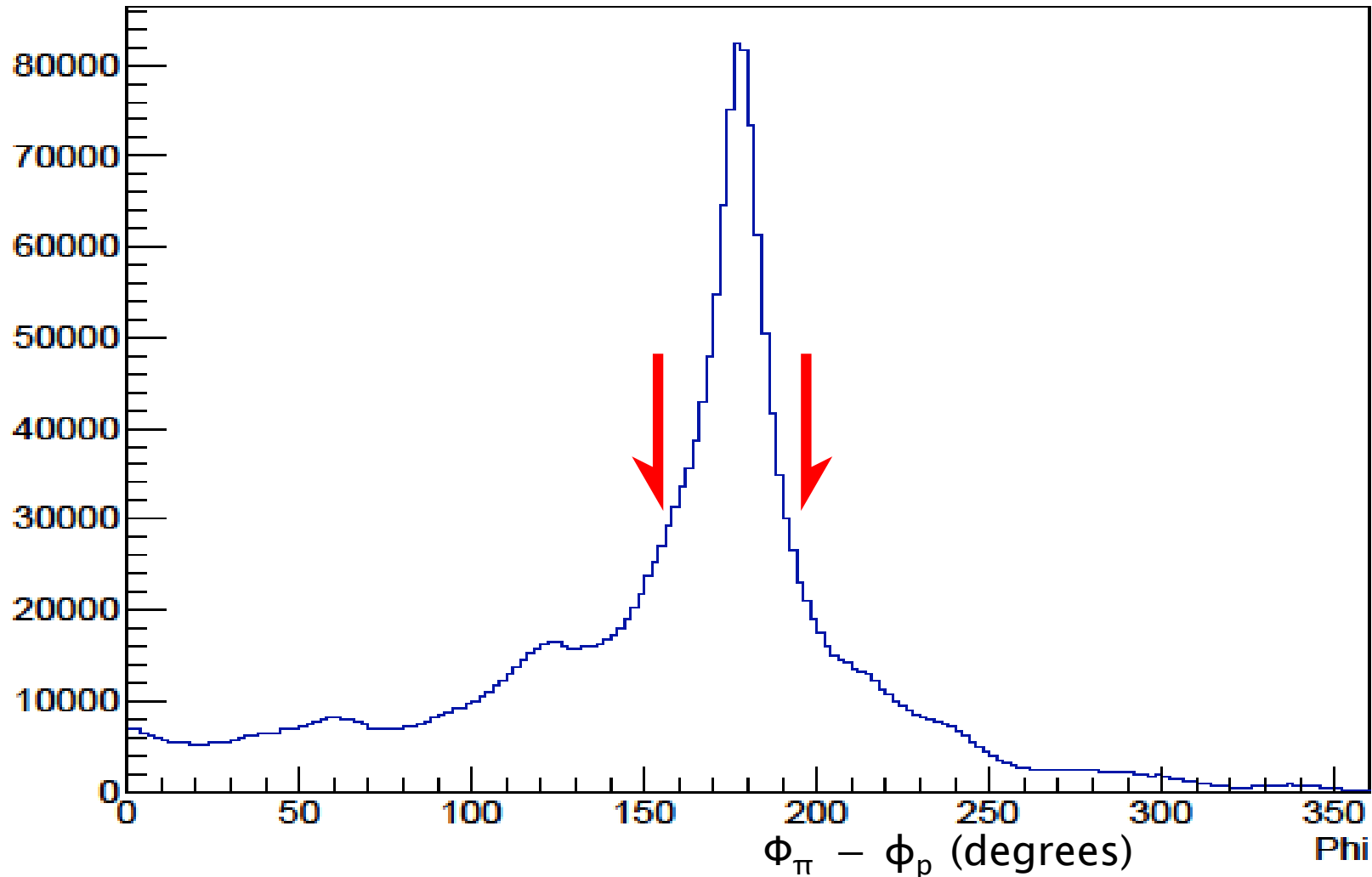
# (a) Select events; only $\pi^-$ and Proton detected in CLAS

Particle Identification using  $\beta = v/c$  vs  $P$  ( $v$ : from TOF)



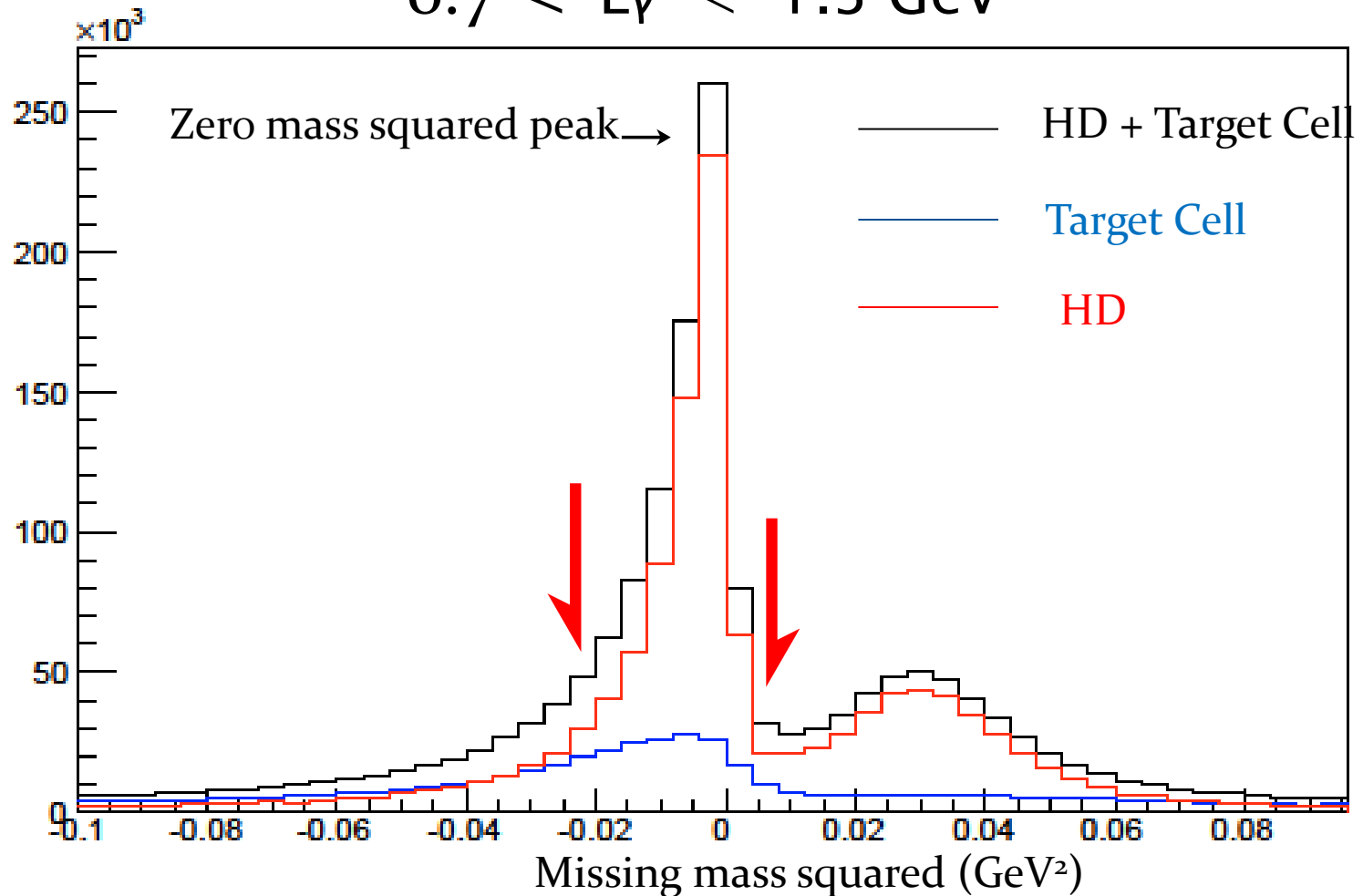
## (b) $\phi_{\pi^-} - \phi_p$ distribution and coplanarity cut for $\pi^-$ and proton

$0.7 < E_\gamma < 1.3 \text{ GeV}$



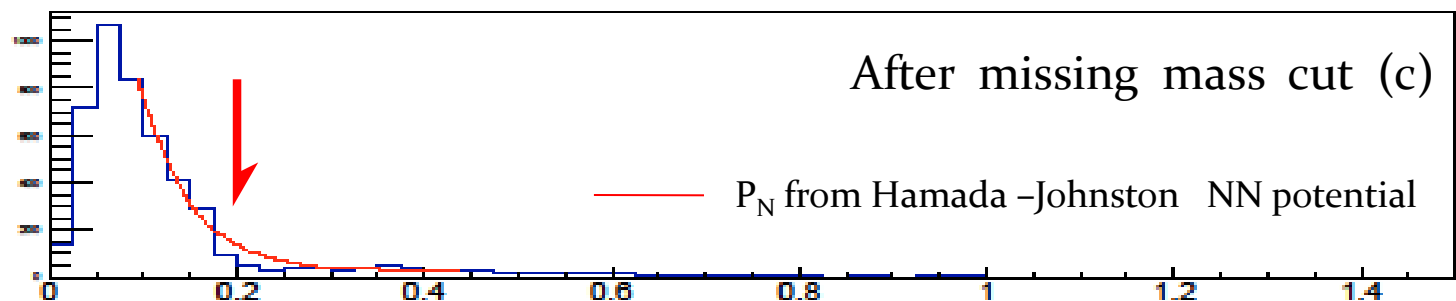
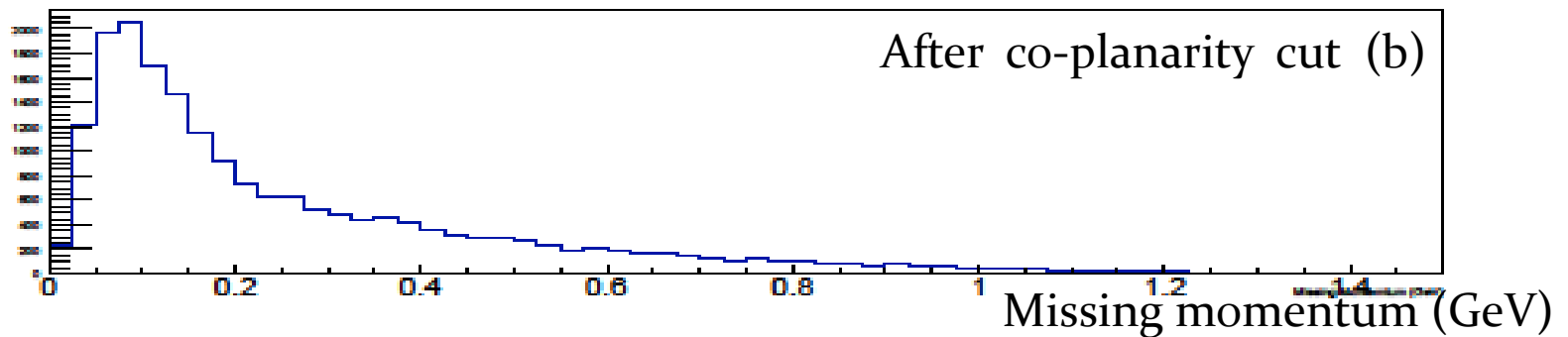
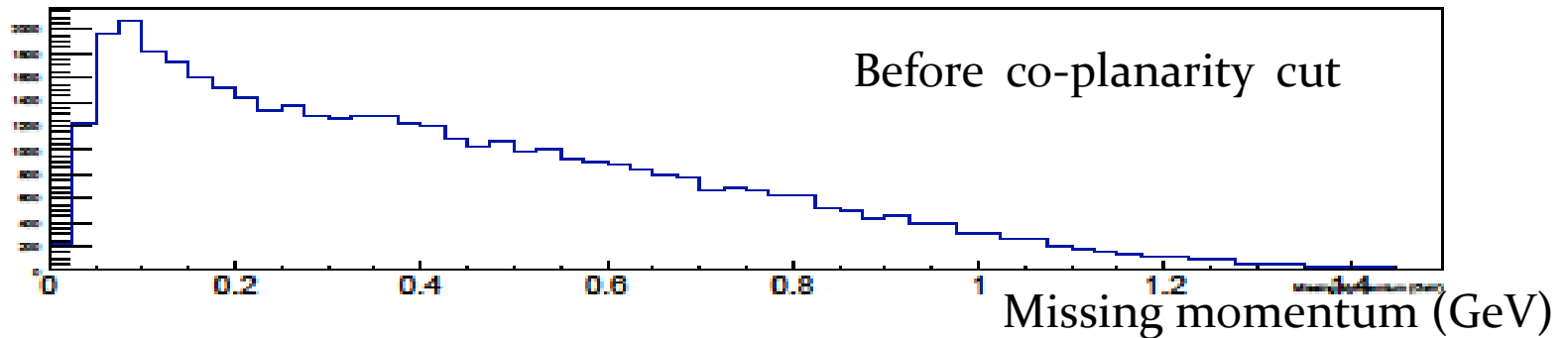
(c) Missing mass squared distribution for  
 $\gamma + n(p) \rightarrow \pi^- + p + X$  and cut; selection of quasi-free

$0.7 < E_\gamma < 1.3 \text{ GeV}$



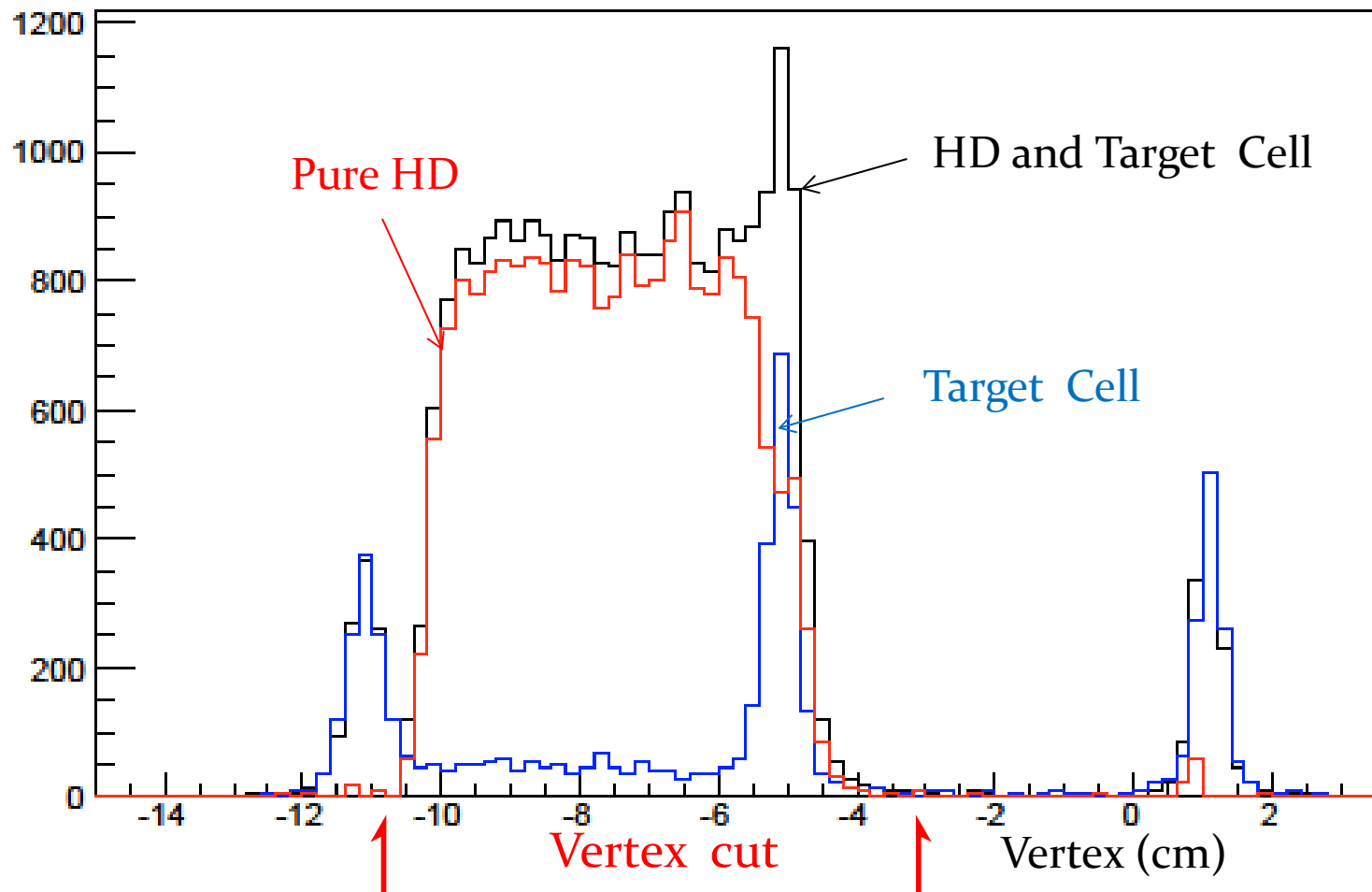
(d) Missing momentum distribution for  $\gamma + n(p) \rightarrow \pi^- + p + X$ ; selection of quasi-free neutrons

$$0.7 < E_\gamma < 1.3 \text{ GeV}$$



## (e) Target Cell subtraction and vertex cut

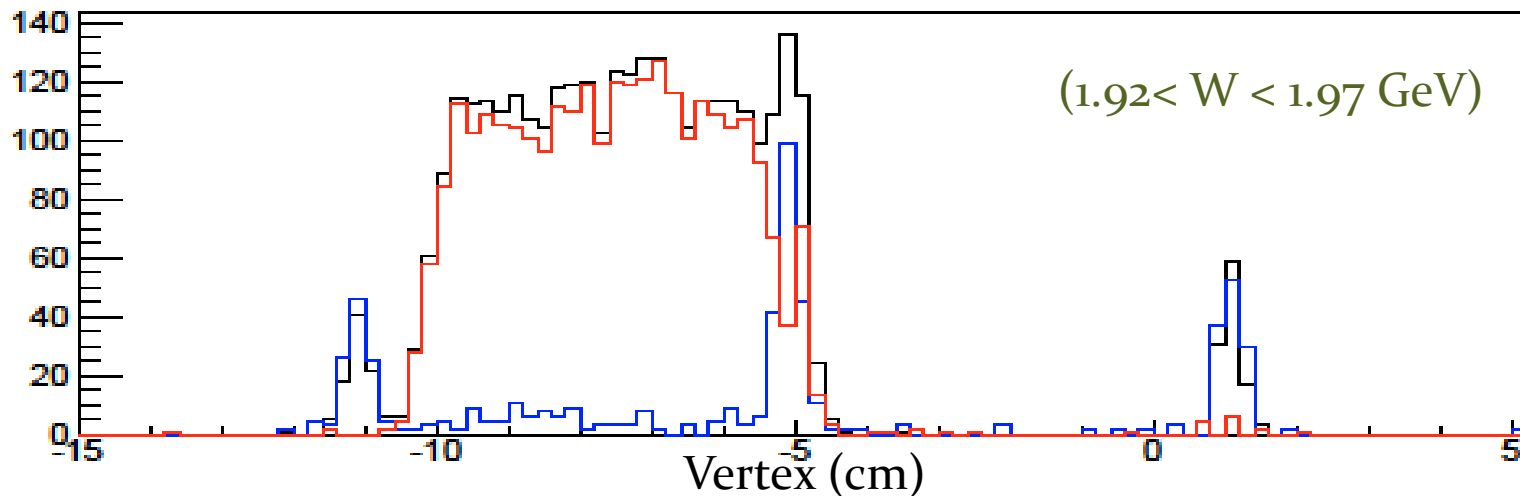
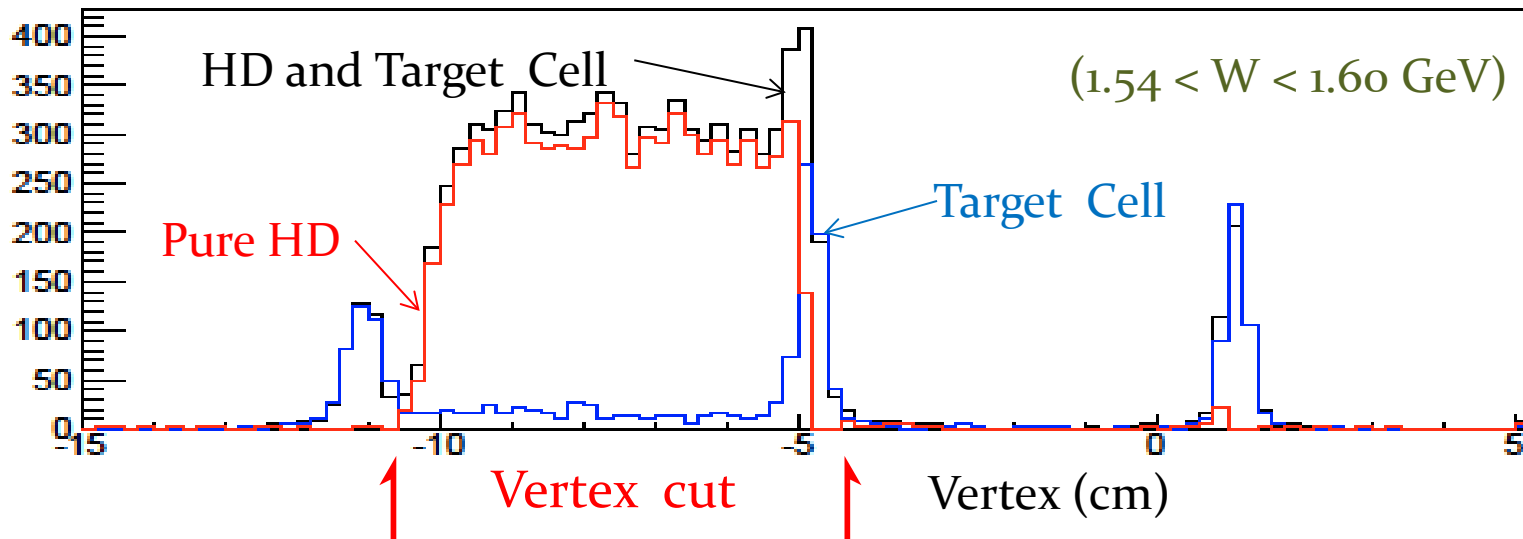
Reconstructed vertex along beam axis for spin parallel



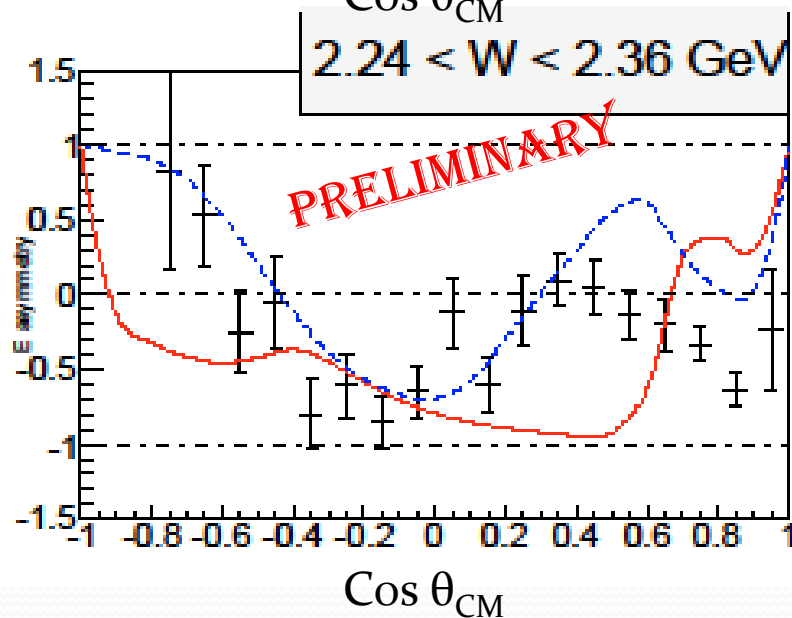
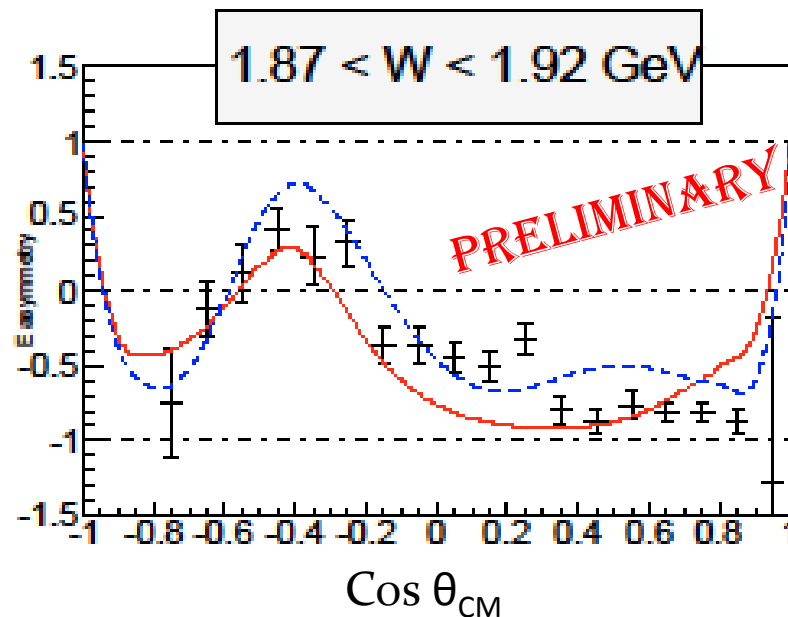
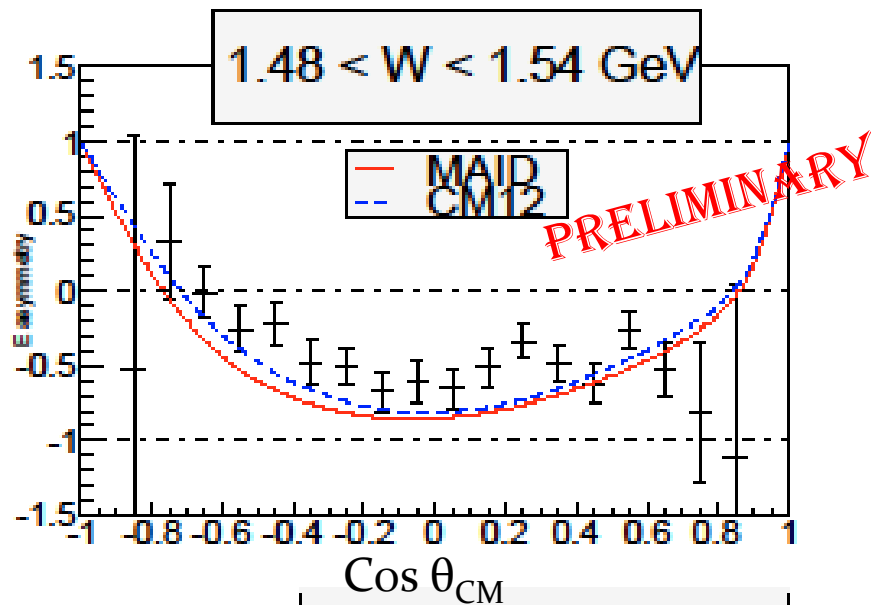


# Target Cell subtraction and vertex cut

Reconstructed vertex along beam axis for spin parallel

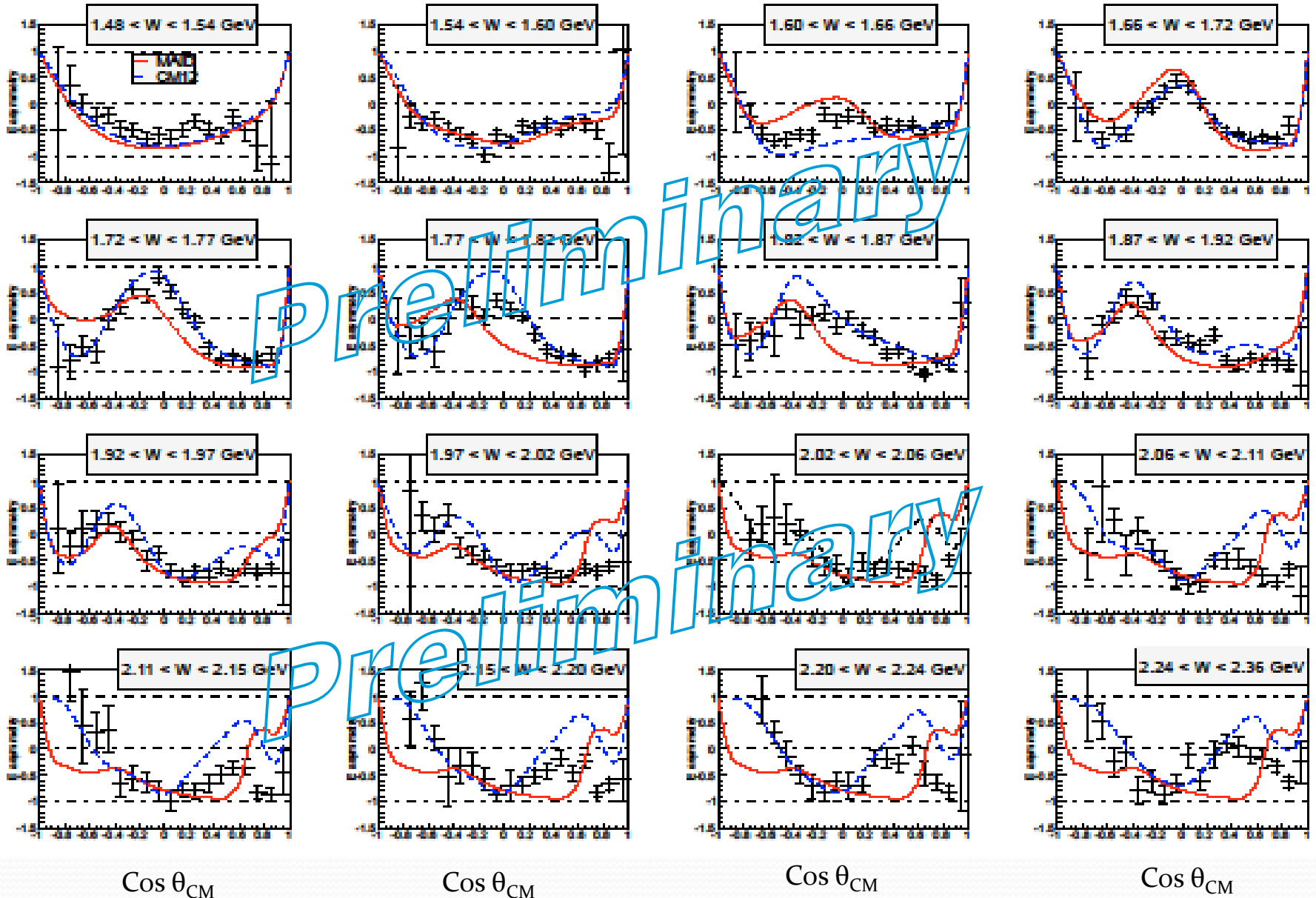


# Preliminary E asymmetries for $\gamma + n(p) \rightarrow \pi^- + p(p)$



- All cuts applied
- Use ~ 20 % of Data
- $P_D \sim 26 \%$

# Preliminary E asymmetries for $\gamma+n(p) \rightarrow \pi^- + p + (p)$ (20 % of data)



## 4. Summary

- a. Completed experiments for pseudoscalar-meson photo-production from longitudinally polarized HD at CLAS.
- b. The experiment was done for 64 days of circularly and 30 days of linearly polarized photon beams.
- c. Average target D polarization during the experiments have been estimated to be  $\sim 20\%$ .
- d. Analyses for target polarizations have been ongoing.

## 4. Summary

e. Calibrations for experimental data have been carried out.

Tagger: Natalie Walford (CUA)

TOF: Haiyun Lu (CMU)

ST: Jamie Fleming (The University of Edinburgh)

DC: Dao Ho (CMU)

EC: Irene Zonta (Universita' di Tor Vergata)

Energy loss corrections: Eugene Pasyuk, Andy Sandorfi (Jlab)

Target Pol.: Alex Deur (Jlab), Vivien Laine (Universite Blaise Pascal, Jlab), Peng Peng (UVA)

Photon beam Pol.: Franz Klein (CUA)

Flux calculation: Peng Peng (UVA)

f. Analyses for other channels, like  $\gamma + n(p) \rightarrow n \pi^+ \pi^- (p)$ ,  $K^0 \Lambda$ , and  $K^+ \Sigma^-$  are in progress. Events with linearly polarized photon beams have been studied.

# Preliminary E asymmetries for $\gamma+n(p) \rightarrow \pi^- + p + (p)$ (20 % of data)

