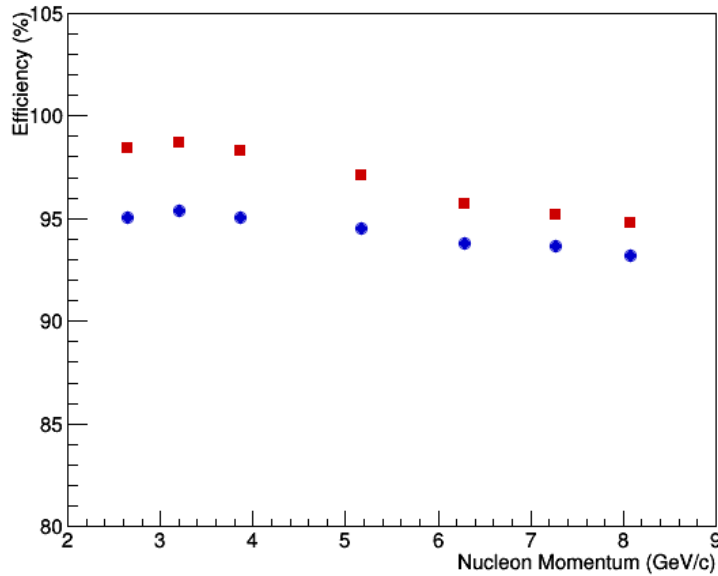
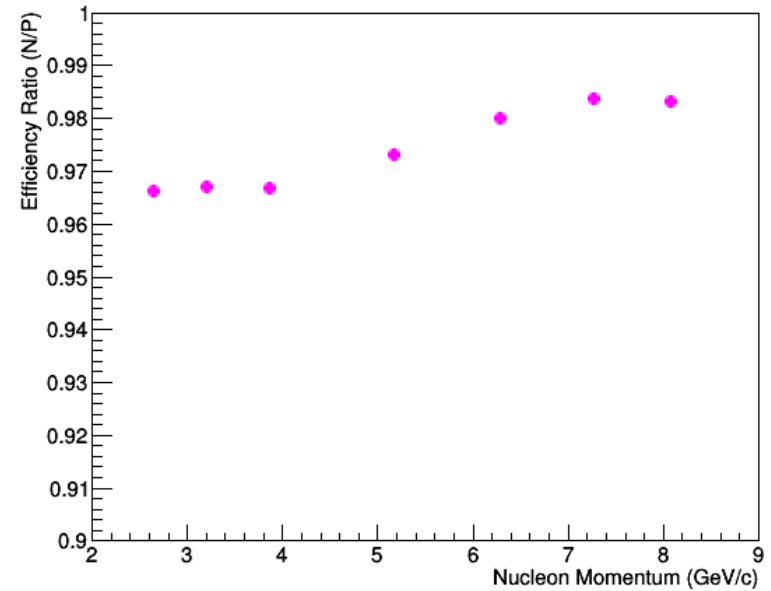


5c) Calibration of HCal n & p efficiency

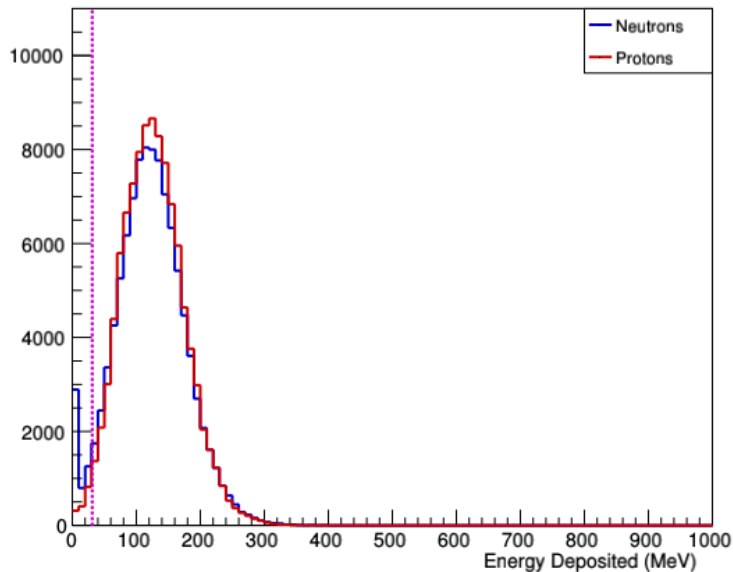
HCAL Efficiency ($E_T=1/4E_{\text{peak}}$) (3x3 cluster)



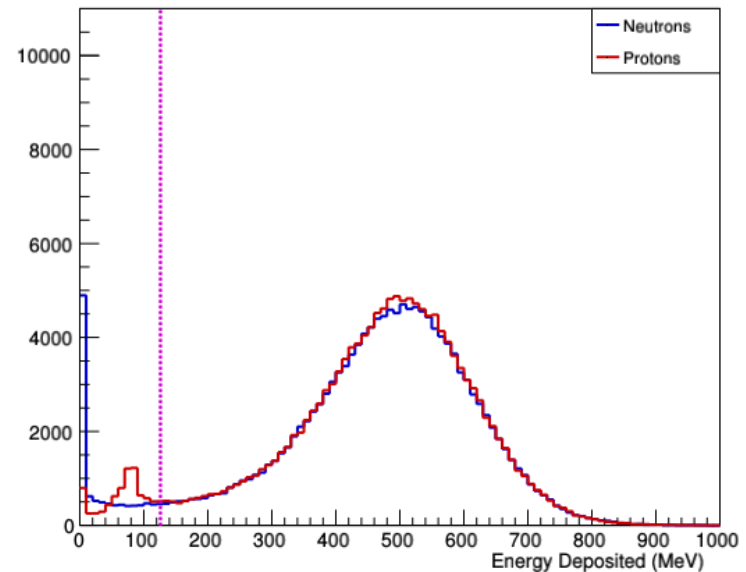
HCAL Efficiency Ratio (N/P) ($E_T=1/4E_{\text{peak}}$) (3x3 cluster)



P=2.64 GeV/c Energy Deposited (3x3 cluster, GMn acceptance)



P=8.08 GeV/c Energy Deposited (3x3 cluster, GMn acceptance)



p(e,e')p

Used to cleanly calibrate HCal efficiency with elastic protons near center of QE distribution at all 7 kinematics (CDet tag)

- With 48D48 on, calibrates efficiency as well as position of center of QE proton distribution
- With 48D48 off, calibrates position of center of QE neutron distribution

configuration	Q^2 (GeV/c) ²	E_{Beam} (GeV)	θ_{BB} (deg.)	$d\sigma/d\Omega$ (fb/sr)	\mathcal{L} (10 ³⁸ /cm ² /s)	rate	statistics	
						Hz	hours	
1	3.5	4.4	32.5	109000.0	0.7	249	6.3	5.6E+06
2	4.5	4.4	41.9	17300.0	1.4	102	7.8	2.9E+06
3	5.7	4.4	58.4	2090.0	2.8	29	25	2.6E+06
4	8.1	6.6	43.0	794.0	2.8	9.5	5	1.7E+05
5	10.2	8.8	34.0	459.0	1.4	2.1	5	3.8E+04
6	12.0	8.8	44.2	82.5	2.8	1.0	5	1.7E+04
7	13.5	11.0	33.0	103.0	2.8	1.1	6	2.3E+04

$p(\gamma, \pi^+)n$

Used to cleanly calibrate HCal efficiency with neutrons
near center of QE distribution at 2 kinematics

E	Theta pi	Q2	$p' \pi^+(n)$	$p' \pi^+ (N\pi)$	$\Delta p'$	$\Delta p'/p'$	
GeV	deg	GeV	GeV	GeV	GeV	%	
4.4	40.5	4.36	2.07	2.003	0.069	3.31	(Treating π^+ as massless)
4.4	64.3	6.00	1.20	1.16	0.04	3.31	
4.4	40.5	4.37	2.06	1.995	0.069	3.35	(Including π^+ mass)
4.4	64.3	6.00	1.19	1.15	0.04	3.38	

π has momentum expected for elastic electron scattering, but at positive spectrometer setting. Expect very low background. Shower, gas Cherenkov distinguish from e^+

Top $\sim 3.3\%$ ($\Delta p_\pi/p_\pi$) of bremsstrahlung spectrum cleanly tags (near elastic) neutrons. Elastic protons also cut. Easily resolved by HRS.

Really 2 HRS pos near 40.5° and 4 near 64.3° (3° apart)

Cross Section

Based on SLAC measurements

(Anderson et al., PRD 14 (1976) 649)

$$\frac{d\sigma}{dt} \text{ vs. } \cos(\theta^*) \quad \text{at } E_\gamma = 4.0, 5.0, \text{ and } 7.5 \text{ GeV}$$

$E = 4.4 \text{ GeV}$

θ	θ^*	$\cos(\theta^*)$
40.5	99.85	-0.17
64.3	127.4	-0.61

$$\frac{d\sigma}{dt} \propto s^{-7} \text{ at fixed } \cos(\theta^*)$$

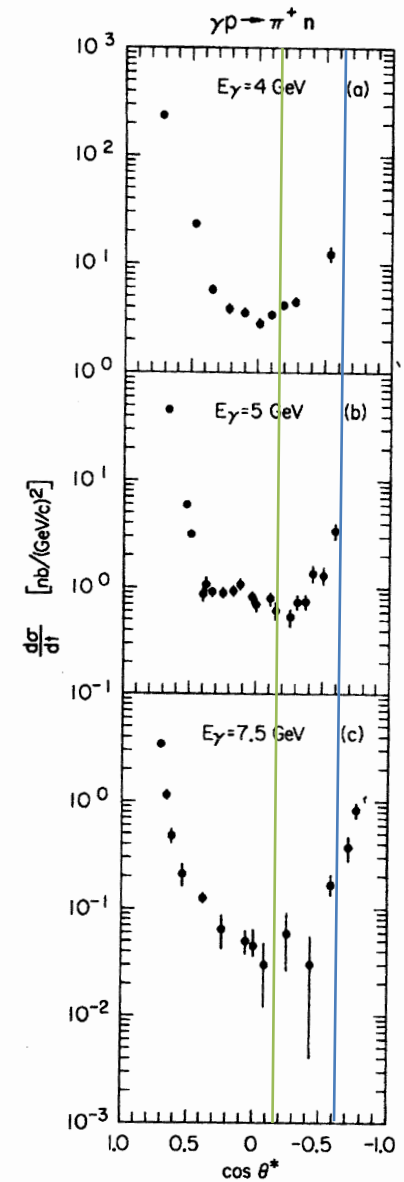
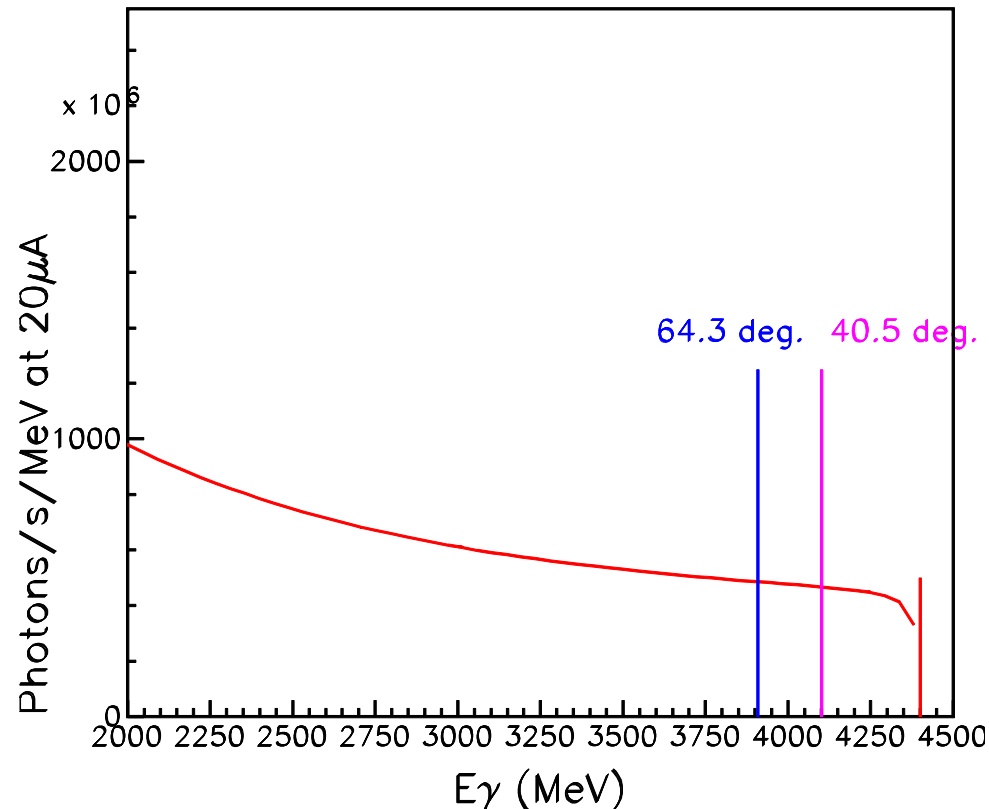


FIG. 5. $d\sigma/dt$ versus $\cos\theta^*$ for the reaction $\gamma p \rightarrow \pi^+ n$ at (a) $E_\gamma = 4.0 \text{ GeV}$, (b) $E_\gamma = 5.0 \text{ GeV}$, and (c) $E_\gamma = 7.5 \text{ GeV}$.

Bremsstrahlung Spectrum

(From Matthews and Owens NIM 111 (1973) 157)

Usable flux from endpoint to $E\gamma_{\text{cut}}$ which gives p_π (from $\gamma(p,n)\pi^+$)
below max p_π of $\gamma(p,N\pi)\pi^+$ with endpoint photon



Rates and Statistics

	40.5°	64.3°	
$\frac{d\sigma}{d\Omega^*}$	0.9	3.35	nb/sr
$\frac{d\Omega^*}{d\Omega}$	2.3	0.776	
$\frac{d\sigma}{d\Omega}$	2.08	2.60	nb/sr
Usable Flux	1.24	2.16	$\times 10^{11}$ / s (@20 uA)
$\rho LN / A$	6.41×10^{23}		/ cm ²
Accept.	5.3×10^{-3}		sr
Rate	0.88	1.91	/ s
Hours	24	12	hr
HRS pos.	2	4	
	37.9	20.6	k event per HRS position

Summary

- $p(e,e')p$
- >17 k calibration events at each kinematic (much more at low Q^2 , where most important)
 - Covering center of region used for QE for that kinematic
- $p(\gamma,\pi^+)n$
- >20 k calibration neutrons over small adjacent HMS images. (2 near 40.5° , 4 near 64.3°)
 - Calibration for neutron momenta ~ 3 GeV/c and ~ 4 GeV/c
 - Small area covered on HCal, but clean neutron ID because of HRS.