

LHRS Analysis for d_2^n

Experimental ^3He Cross Sections and Systematic Errors for Selected Cuts

D. Flay

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Experimental ^3He Cross Sections (1)

Definition

- To determine the **experimental cross section**, we calculate the following:

$$\frac{d^2\sigma_{\text{exp}}}{d\Omega dE'} = \frac{d^2\sigma_{\text{raw}}}{d\Omega dE'} - \frac{d^2\sigma_{\text{dil}}}{d\Omega dE'} - \frac{d^2\sigma_{e^+}}{d\Omega dE'}$$

where:

$$\frac{d^2\sigma_{\text{dil}}}{d\Omega dE'} = \frac{\rho_{\text{N}}}{\rho_{\text{N}} + \rho_{^3\text{He}}} \frac{d^2\sigma_{\text{N}}}{d\Omega dE'}$$

$$\frac{d^2\sigma_{e^+}}{d\Omega dE'} = \text{positron cross section}$$

$$\rho_i = \text{Filling densities of N or } ^3\text{He (prod. cell)}$$

Experimental ^3He Cross Sections (2)

Method

- To determine the the nitrogen and positron cross sections, we use the **same cuts** that were used on the negative polarity production data
- The only difference in the nitrogen data case is that the nitrogen density (in the reference cell) is used in the denominator of the cross section

Experimental ^3He Cross Sections (3)

Nitrogen Dilution: 4-pass

Nitrogen Cross Sections: $E_b = 4730$ MeV					
p (MeV)	$\frac{d^2\sigma_N}{d\Omega dE'}$	$\frac{\text{pb}}{(\text{MeV}\cdot\text{sr})}$	$\frac{d^2\sigma_{\text{dil}}}{d\Omega dE'}$	$\frac{\text{pb}}{(\text{MeV}\cdot\text{sr})}$	
600	85.4393 ± 2.3880		0.8835 ± 0.0247		
1120	10.8095 ± 0.5024		0.1115 ± 0.0052		
1190	8.3155 ± 0.3719		0.0863 ± 0.0039		
1420	4.6185 ± 0.3516		0.0480 ± 0.0037		
1510	3.5672 ± 0.1920		0.0368 ± 0.0020		
1600	2.1575 ± 0.1625		0.0223 ± 0.0017		

Experimental ^3He Cross Sections (4)

Nitrogen Dilution: 5-pass

Nitrogen Cross Sections: $E_b = 5890 \text{ MeV}$				
$p \text{ (MeV)}$	$\frac{d^2\sigma_N}{d\Omega dE'}$	$\frac{\text{pb}}{(\text{MeV}\cdot\text{sr})}$	$\frac{d^2\sigma_{\text{dil}}}{d\Omega dE'}$	$\frac{\text{pb}}{(\text{MeV}\cdot\text{sr})}$
600	86.5426 ± 3.4471		0.8975 ± 0.0357	
700	49.8612 ± 1.9565		0.5137 ± 0.0202	
900	19.4339 ± 1.2741		0.2020 ± 0.0132	
1130	8.0841 ± 0.4349		0.0835 ± 0.0045	
1200	5.8520 ± 0.3481		0.0607 ± 0.0036	
1270	5.4415 ± 0.2893		0.0561 ± 0.0030	
1420	3.4430 ± 0.2242		0.0355 ± 0.0023	
1600	0.9887 ± 0.1092		0.0103 ± 0.0011	

Experimental ^3He Cross Sections (5)

Positron Background: 4- and 5-pass

Positron Cross Sections: $E_b = 4730 \text{ MeV}$	
$p \text{ (MeV)}$	$\frac{d^2\sigma_{e^+}}{d\Omega dE'} \left[\frac{\text{pb}}{(\text{MeV}\cdot\text{sr})} \right]$
600	3.1191 ± 0.0823
800	0.6966 ± 0.0331
1120	0.0990 ± 0.0104
1420	0.0070 ± 0.0031

Positron Cross Sections: $E_b = 5890 \text{ MeV}$	
$p \text{ (MeV)}$	$\frac{d^2\sigma_{e^+}}{d\Omega dE'} \left[\frac{\text{pb}}{(\text{MeV}\cdot\text{sr})} \right]$
600	3.8986 ± 0.1262
900	0.5104 ± 0.0280
1130	0.0955 ± 0.0083

Experimental ^3He Cross Sections (6)

Results: 4-pass

Cross Sections: $E_b = 4730$ MeV [units: pb/(MeV·sr)]				
p (MeV)	σ_{raw}	σ_{dil}	σ_{e^+}	σ_{exp}
600	11.7034 ± 0.1106	0.8835 ± 0.0247	3.1191 ± 0.0823	7.7008 ± 0.1363
800	4.4761 ± 0.0625	0.0000 ± 0.0000	0.6966 ± 0.0331	3.7795 ± 0.0680
1120	1.3912 ± 0.0182	0.1115 ± 0.0052	0.0990 ± 0.0104	1.1807 ± 0.0198
1190	1.1264 ± 0.0150	0.0863 ± 0.0039	0.0000 ± 0.0000	1.0401 ± 0.0156
1260	0.8668 ± 0.0120	0.0000 ± 0.0000	0.0000 ± 0.0000	0.8668 ± 0.0120
1420	0.4669 ± 0.0082	0.0480 ± 0.0037	0.0070 ± 0.0031	0.4119 ± 0.0087
1510	0.3125 ± 0.0050	0.0368 ± 0.0020	0.0000 ± 0.0000	0.2757 ± 0.0053
1600	0.1962 ± 0.0037	0.0223 ± 0.0017	0.0000 ± 0.0000	0.1739 ± 0.0039

Experimental ^3He Cross Sections (7)

Results: 5-pass

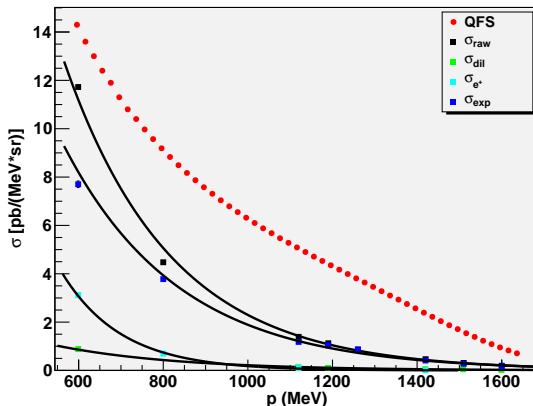
Cross Sections: $E_b = 5890$ MeV [units: pb/(MeV·sr)]

p (MeV)	σ_{raw}	σ_{dil}	σ_{e^+}	σ_{exp}
600	11.5570 ± 0.0631	0.8975 ± 0.0357	3.8986 ± 0.1262	6.7609 ± 0.0825
700	6.4020 ± 0.0515	0.5137 ± 0.0202	0.0000 ± 0.0000	5.8883 ± 0.0537
900	2.2953 ± 0.0253	0.2020 ± 0.0132	0.5104 ± 0.0280	1.5829 ± 0.0305
1130	0.9672 ± 0.0128	0.0835 ± 0.0045	0.0955 ± 0.0083	0.7882 ± 0.0142
1200	0.7287 ± 0.0130	0.0607 ± 0.0036	0.0000 ± 0.0000	0.6680 ± 0.0136
1270	0.5798 ± 0.0078	0.0561 ± 0.0030	0.0000 ± 0.0000	0.5237 ± 0.0082
1340	0.4436 ± 0.0096	0.0000 ± 0.0000	0.0000 ± 0.0000	0.4436 ± 0.0096
1420	0.3331 ± 0.0050	0.0355 ± 0.0023	0.0000 ± 0.0000	0.2976 ± 0.0053
1510	0.2252 ± 0.0045	0.0000 ± 0.0000	0.0000 ± 0.0000	0.2252 ± 0.0045
1600	0.1508 ± 0.0031	0.0103 ± 0.0011	0.0000 ± 0.0000	0.1405 ± 0.0032
1700	0.0929 ± 0.0028	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0929 ± 0.0028

Experimental ^3He Cross Sections (8)

Results: 4-pass

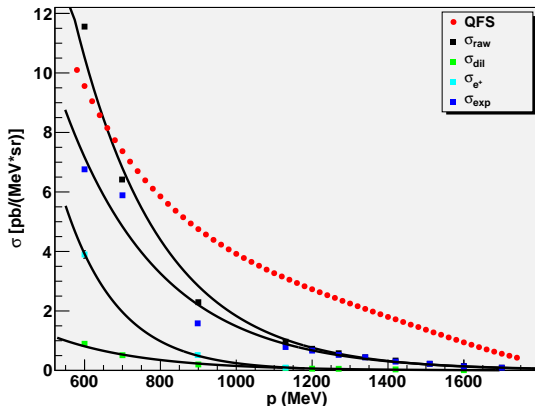
^3He Cross Section (4-pass, $\theta = 45^\circ$)



Experimental ^3He Cross Sections (9)

Results: 5-pass

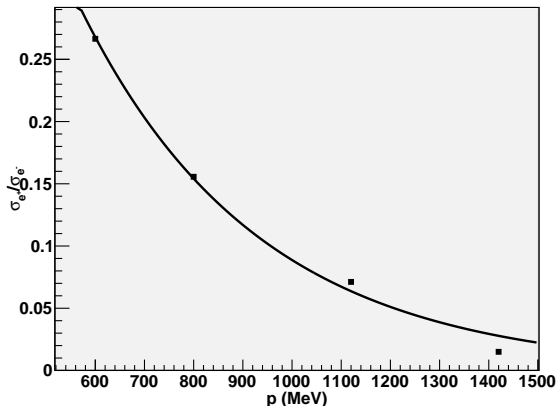
^3He Cross Section (5-pass, $\theta = 45^\circ$)



Experimental ^3He Cross Sections (10)

Cross Section Ratios: 4-pass

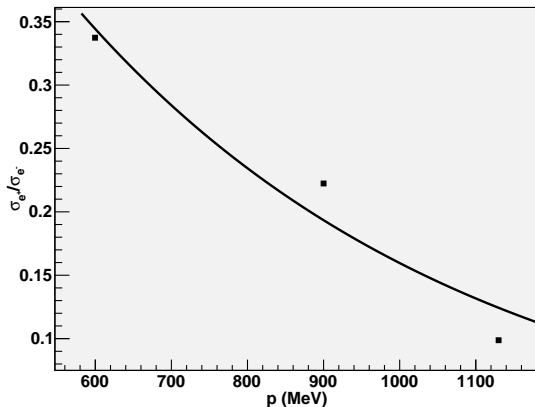
^3He $\sigma_{e^+}/\sigma_{e^-}$ (4-pass, $\theta = 45^\circ$)



Experimental ^3He Cross Sections (11)

Cross Section Ratios: 5-pass

^3He σ_e/σ_e (5-pass, $\theta = 45^\circ$)



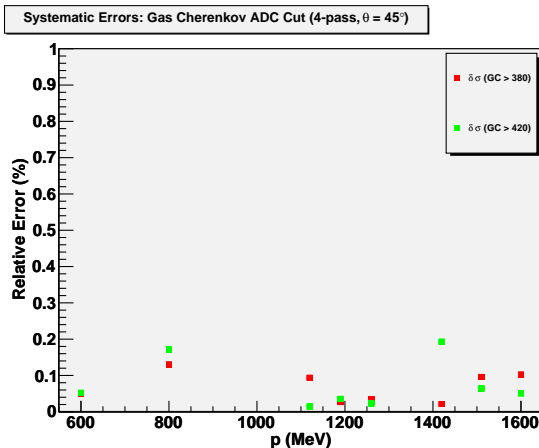
Systematic Errors (1)

Method

- To determine the systematic error for a given quantity (e.g., the gas Čerenkov ADC cut):
 - 1 Vary the cut by a **reasonable** amount and see what the resulting σ_{raw} is (implementing the appropriate cut efficiency as well)
 - 2 Compare this to the **original** σ_{raw} and determine the **relative error**
- We carry this procedure through for the GC, E/p and β cuts (the study is also needed for the target cuts)

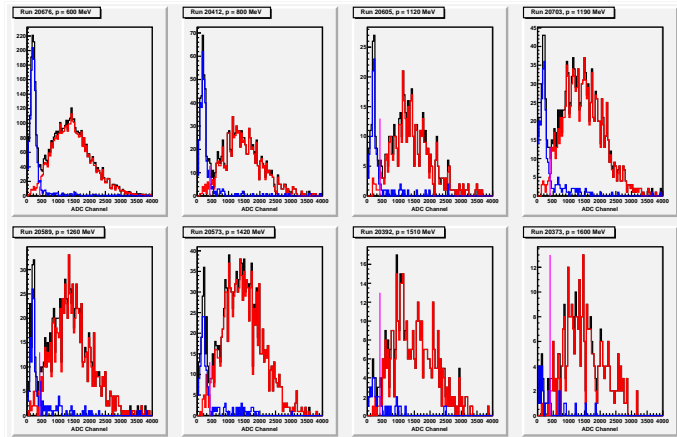
Systematic Errors (2)

Gas Čerenkov Cut: 4-pass



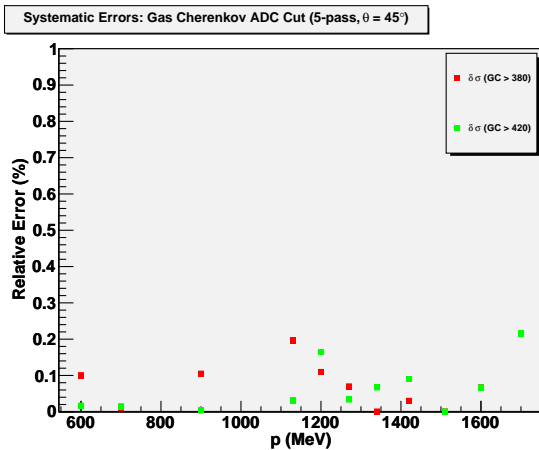
Systematic Errors (3)

Gas Čerenkov Spectra: 4-pass



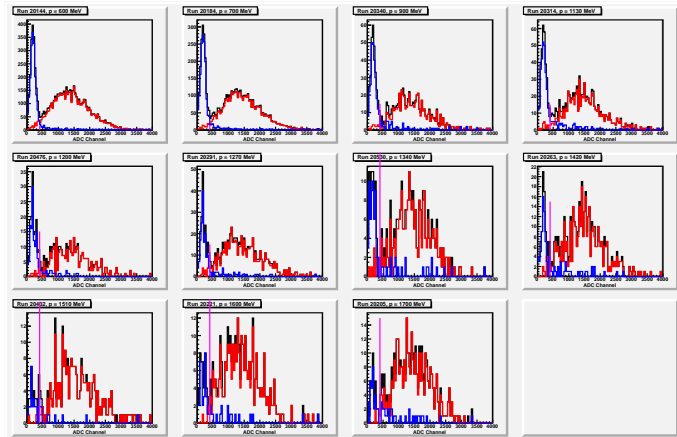
Systematic Errors (4)

Gas Čerenkov Cut: 5-pass



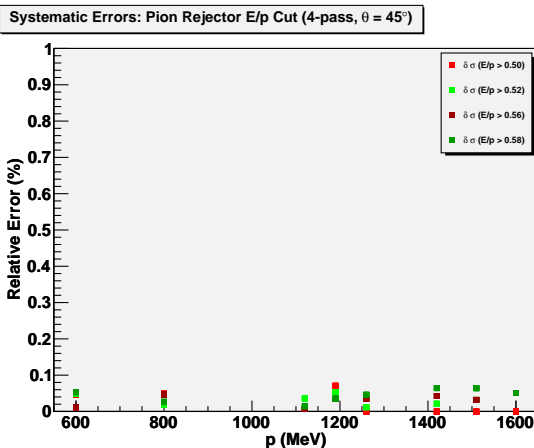
Systematic Errors (5)

Gas Čerenkov Spectra: 5-pass



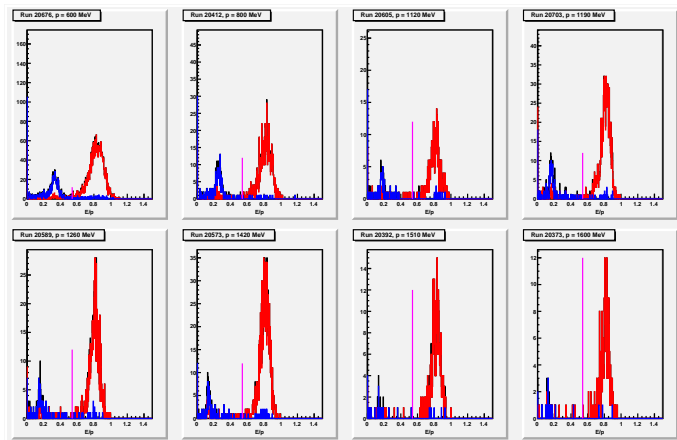
Systematic Errors (6)

E/p Cut: 4-pass



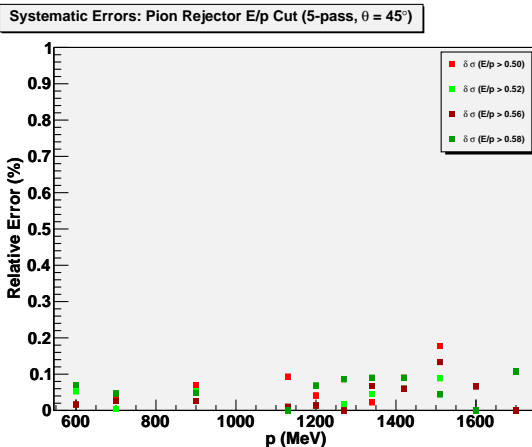
Systematic Errors (7)

E/p Spectra: 4-pass



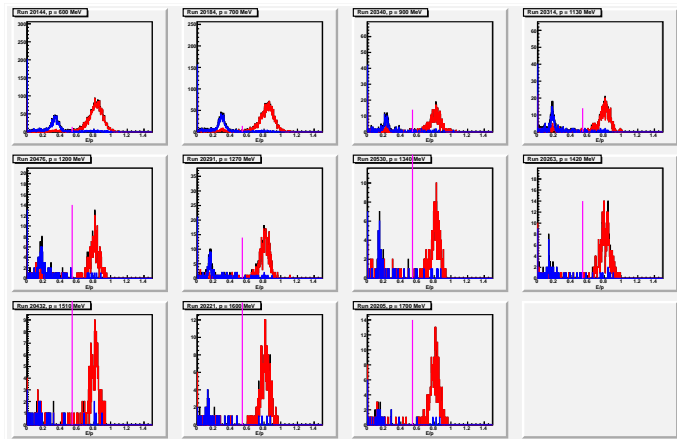
Systematic Errors (8)

E/p Cut: 5-pass



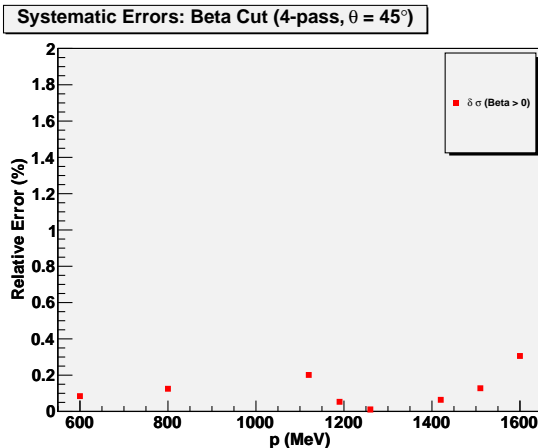
Systematic Errors (9)

E/p Spectra: 5-pass



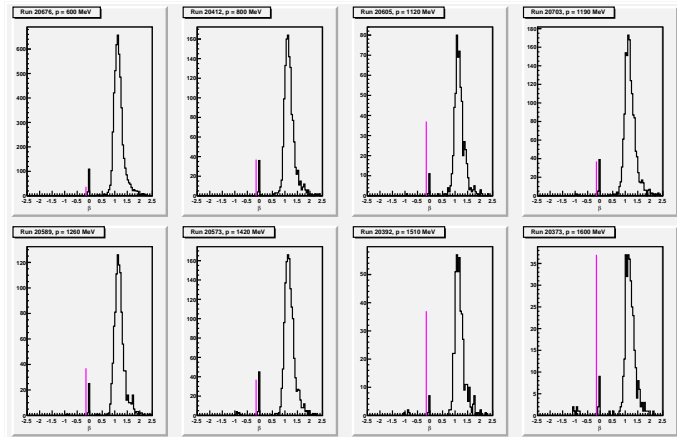
Systematic Errors (10)

β Cut: 4-pass



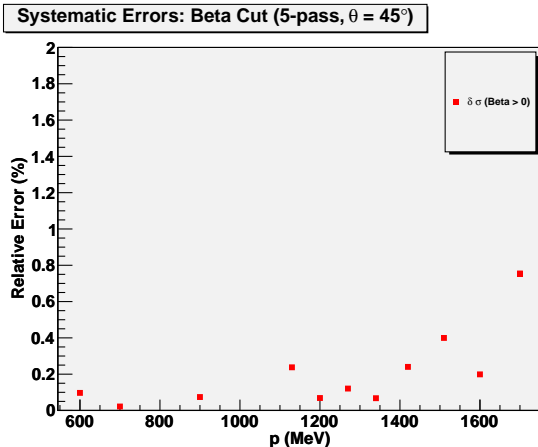
Systematic Errors (11)

β Spectra: 4-pass



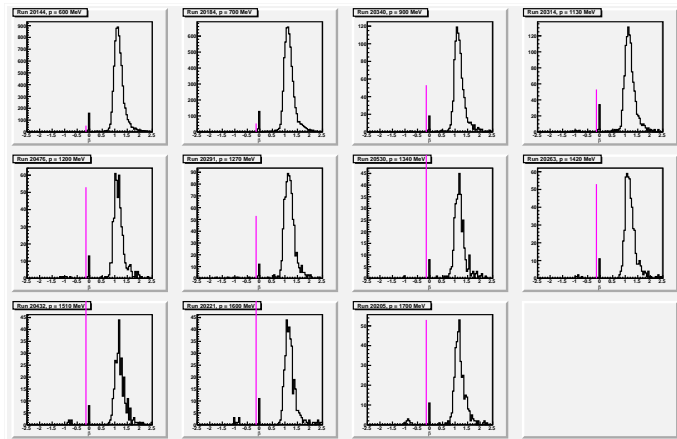
Systematic Errors (12)

β Cut: 5-pass



Systematic Errors (13)

β Spectra: 5-pass



Systematic Errors (14)

Results: 4-pass

Systematic Errors: $E_b = 4730$ MeV				
p (MeV)	GC (%)	E/p (%)	β (%)	Total (%)
600	0.10	0.10	0.20	0.24
800	0.20	0.10	0.20	0.29
1120	0.15	0.10	0.22	0.28
1190	0.08	0.10	0.18	0.22
1260	0.08	0.10	0.15	0.19
1420	0.22	0.10	0.18	0.30
1510	0.15	0.10	0.20	0.27
1600	0.15	0.10	0.38	0.42

Systematic Errors (14)

Results: 5-pass

Systematic Errors: $E_b = 5890$ MeV				
p (MeV)	GC (%)	E/p (%)	β (%)	Total (%)
600	0.12	0.10	0.20	0.25
700	0.02	0.10	0.12	0.16
900	0.12	0.10	0.18	0.24
1130	0.22	0.12	0.25	0.35
1200	0.20	0.10	0.18	0.29
1270	0.10	0.11	0.18	0.23
1340	0.10	0.12	0.20	0.25
1420	0.12	0.12	0.25	0.30
1510	0.02	0.22	0.42	0.47
1600	0.08	0.10	0.22	0.25
1700	0.22	0.12	0.80	0.84

Systematic Errors (14)

Results: Comparison to Statistical Errors

$E_b = 4730 \text{ MeV}$		
$p \text{ (MeV)}$	$\delta_{\text{syst}} \text{ (\%)} $	$\delta_{\text{stat}} \text{ (\%)} $
600	0.24	0.95
800	0.29	1.39
1120	0.28	1.61
1190	0.22	1.33
1260	0.19	1.38
1420	0.30	1.76
1510	0.27	1.60
1600	0.42	1.89

$E_b = 5890 \text{ MeV}$		
$p \text{ (MeV)}$	$\delta_{\text{syst}} \text{ (\%)} $	$\delta_{\text{stat}} \text{ (\%)} $
600	0.25	0.55
700	0.16	0.80
900	0.24	1.10
1130	0.35	1.32
1200	0.29	1.78
1270	0.23	1.35
1340	0.25	2.16
1420	0.30	1.50
1510	0.47	1.99
1600	0.25	2.06
1700	0.84	3.01

Summary

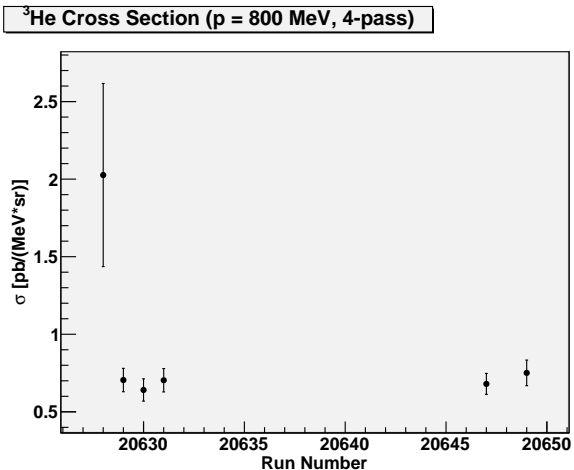
- Cross Sections:
 - Diluted nitrogen and positron cross sections have been computed and subtracted to form σ_{exp}
 - Shape of σ_{exp} is a little smoother now, especially at low p
 - Some kinematic bins missing for both nitrogen and positron data. In the former case, we're missing the reference cell pressure for those runs; in the latter case, we do not have all the kinematic bins – what we see here is all we have.
 - All cross sections (and $\sigma_{e^+}/\sigma_{e^-}$) follow exponential curves quite well
- Systematic Errors:
 - All systematic errors for the shown cuts are below 1% and are dominated by the statistical errors

What's Next?

- SAMC:
 - Debug, debug, debug
- Cross Sections:
 - Determine proper way to fold in positron background into the statistical error on σ_{raw} (errors shown only incorporate the correction due to the nitrogen contribution)
 - Take a closer look at the positron data (see appendix)
- Systematic Errors:
 - Target cut studies
 - VDC one-track and trigger cut studies (?)
 - Deadtime (livetime) and charge

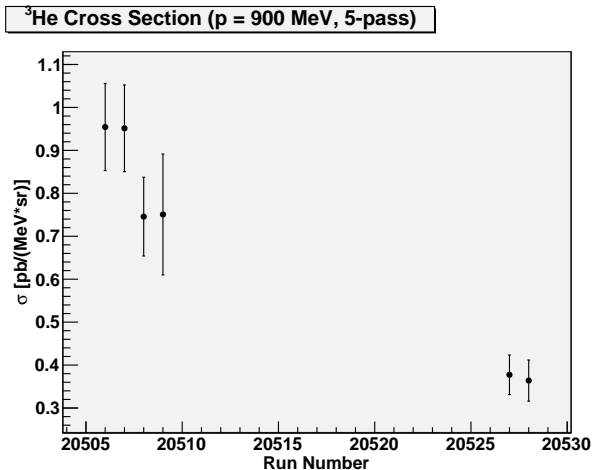
Appendix (1)

Suspect Positron Cross Sections



Appendix (2)

Suspect Positron Cross Sections



Appendix (3)

Suspect Positron Cross Sections

