Packing Fraction

M. Cummings

8/27/14

Old Method

$$Y_{pf} = Y_N + Y_{H_3} + Y_{He} + Y_{Al}$$

Includes contributions from aluminum end cap and NMR coil

$$\downarrow$$

$$Y_{pf} = Y_N + Y_{H_3} + Y'_{He} + Y_{dummy}$$

$$\downarrow$$

$$\frac{Y_{pf} - Y_{dummy}}{Y_{empty}} = \frac{Y_N + Y_{H_3} + Y'_{He}}{Y_{empty}}$$

$$Y_{He} = \overbrace{Y_{He}^{out}}^{\text{He outside the target cup}} + \overbrace{Y_{He}^{in}}^{\text{He inside the target cup}}(1 - pf)$$

Want to use cross section ratios: normalize by total counts with only helium

Old Method

$$\frac{Y_{pf} - Y_{dummy}}{Y_{empty}} = \frac{Y_N + Y_{H_3} + Y'_{He}}{Y_{empty}}$$

$$Y_x = \frac{\rho_x}{e} \frac{\sigma_x}{\Delta\Omega \Delta E' \Delta Z}$$

$$\rho_x = \frac{\rho_{mass}\, l_{tg}\, N_A}{M_{molar}}$$

$$\frac{Y_{pf} - Y_{dummy}}{Y_{empty}} = \frac{pf}{\rho_{He}\sigma_{He}} (\rho_N \sigma_N A_N + \rho_{H_3}\sigma_{H_3} A_{H_3} - \rho_{He}\sigma_{He} A_{He})$$

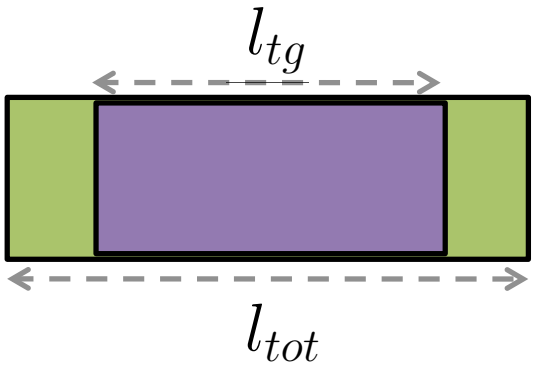
Cross sections obtained from g2psim

$$A_x = \frac{\#\text{ of counts in cut}}{\text{total }\#\text{ of counts in fit}}$$

Suggestion from last time – simplify method to use ONLY data (no input from simulations)

Updated Method

$$Y_{prod} = Y_{He}^{out} + (1 - p_f) Y_{He}^{in} + p_f Y_N + p_f Y_H$$



$$Y_{tg} = Y_{prod} - Y_{He}^{out}$$

Yield from materials within the target cell

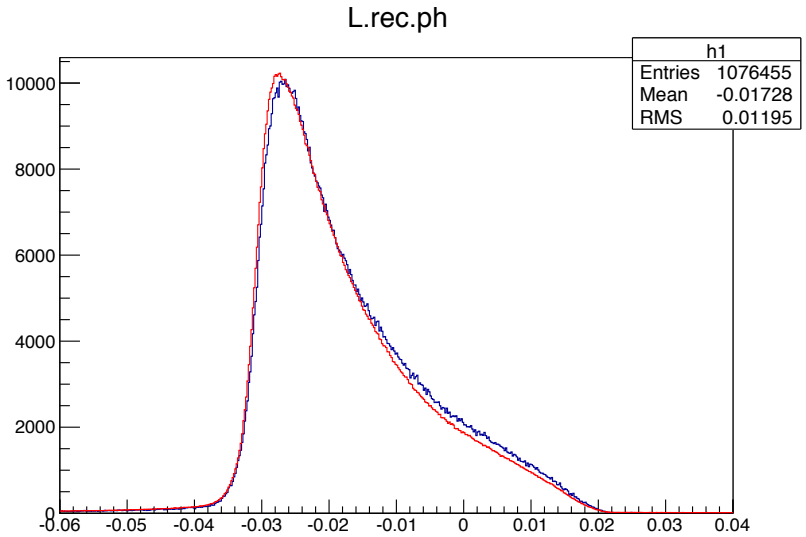
$$Y_{He}^{out} = \frac{(l_{tot} - l_{tg})}{l_{tot}} Y_{dummy}$$

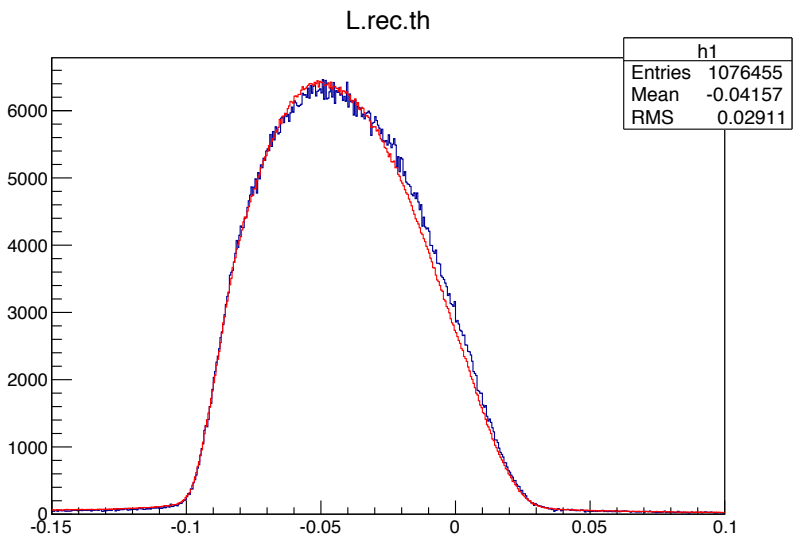
$$Y_{He}^{in} = \frac{l_{tg}}{l_{tot}} Y_{dummy}$$

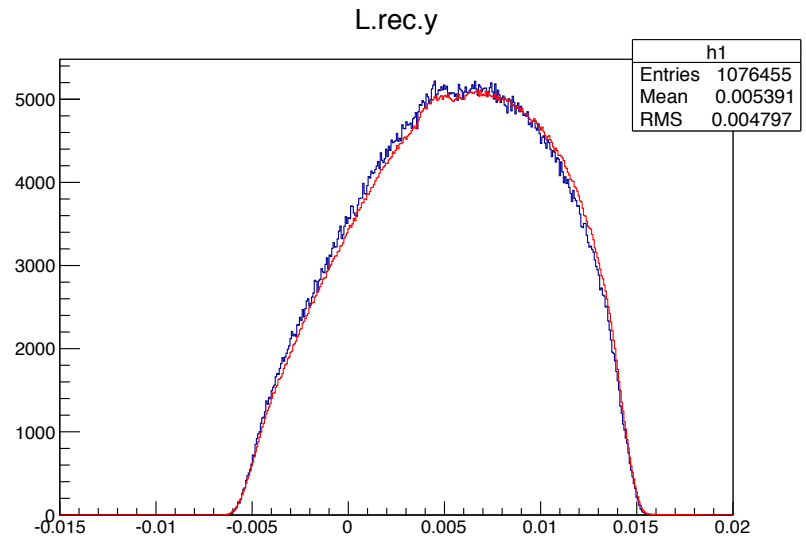
Assumes uniform acceptance throughout

$$(1 - p_f) = \frac{Y_{He}^{in}}{Y_{tg}}$$

Acceptance Variables



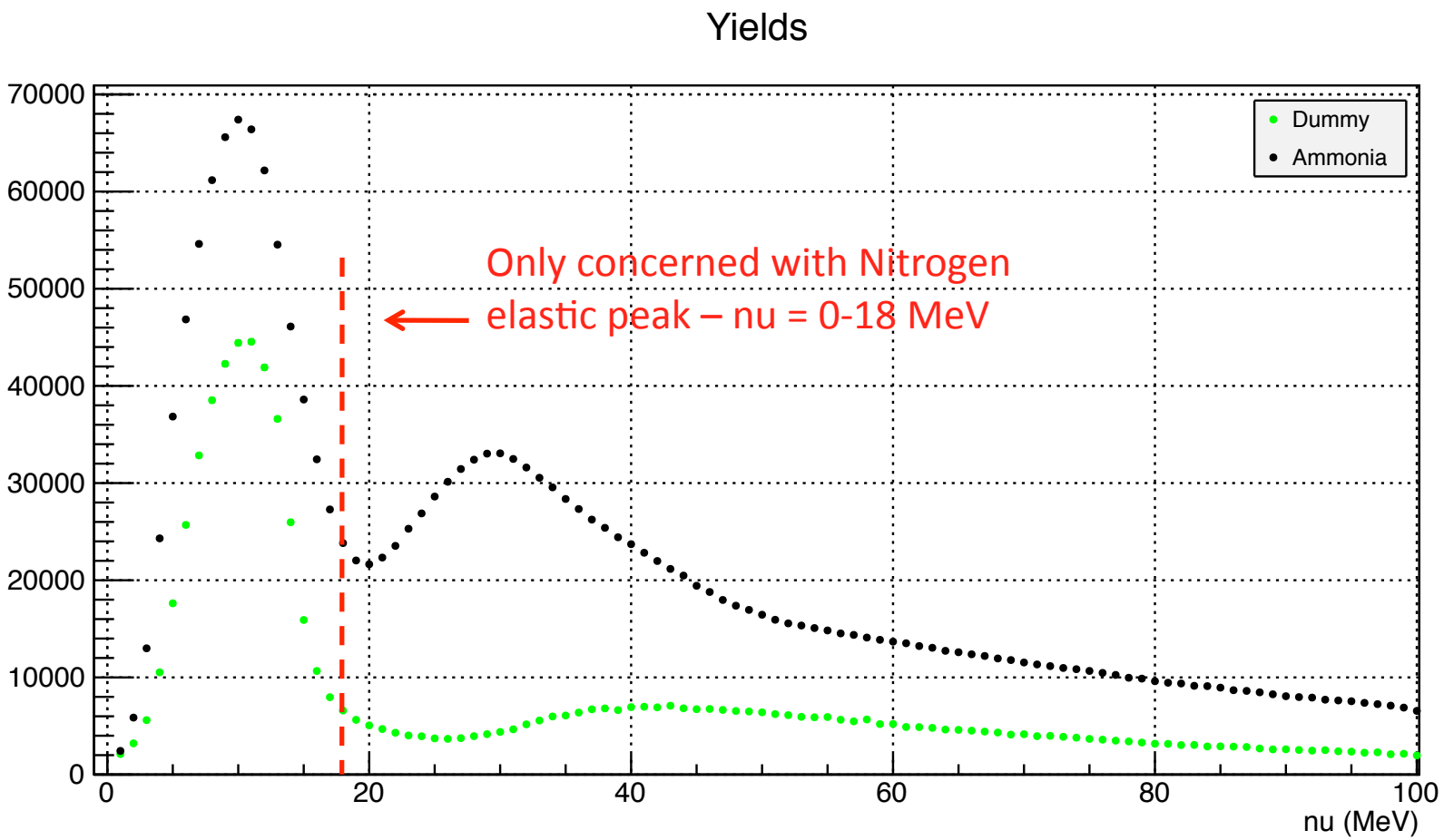




Run 3446 (Production)

Run 3448 (Dummy)

Yields for Production/Dummy Run



Uncertainty

$$(1 - p_f) = \frac{Y_{He}^{in}}{Y_{tg}} = \frac{\frac{l_{tg}}{l_{tot}} Y_{dummy}}{Y_{prod} - \frac{l_{tot} - l_{tg}}{l_{tot}} Y_{dummy}}$$

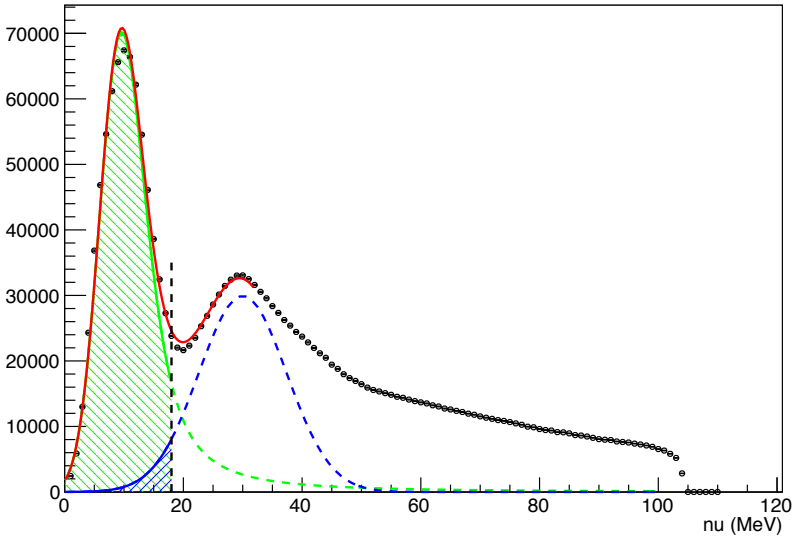
σ_{l_tg} = 1 mm
σ_{l_tg} = 1 mm
σ_{Y_prod} = 2468.6
σ_{Y_dummy} = 1048.4

Propagation of Uncertainty: σ_{p_f} = 0.011

Uncertainty

Uncertainty due to contamination:

Run 3446 (Production)



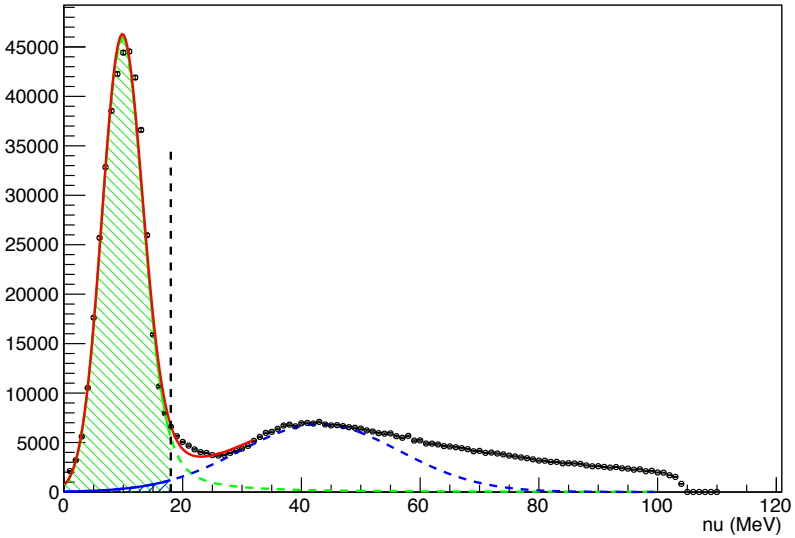
Production Run:

Area of Nitrogen Elastic = 708487

Area of Contamination = 29228.5

3.96% of total counts

Run 3448 (Dummy)



Dummy Run:

Area of Helium Elastic = 402348

Area of Contamination = 6992.57

1.71% of total counts

Uncertainty

Uncertainty due to difference between fit and sum:

Production Run:
Area from Sum = 751493.36
Area from Fit = 737715.50 → 1.85% difference

Dummy Run:
Area from Sum = 418644.69
Area from Fit = 409340.57 → 2.25% difference

Results

Using Run 3446 (material 8)

$p_f = 0.542 \pm 0.053$

To Do:

- Include acceptance (when ready)
- Repeat procedure for other target materials/settings
- Suggestions from this meeting?

Backup

Recall: Run Selection

2.2 GeV, 2.5T, Elastic

	Run	Tgt x	Tgt y	Tgt theta	Tgt phi
prod.	3446	4.57	3.38	0.0636	0.0042
dummy	3448	4.62	3.30	0.0635	0.0042
empty	3449	5.89	1.69	0.0619	0.0056
packing fraction	3503	2.09	1.05	0.0608	0.0033
	3574	2.00	0.49	0.0601	0.0009
	3727	4.75	2.30	0.0633	0.0049
	3864	0.84	0.69	0.0608	0.0007

- Use “dummy” run in place of “empty” run

- Use production run in place of “packing fraction” run

Extracting the p_f (from last time)

$$\frac{Y_{pf} - Y_{dummy}}{Y_{empty}} = \frac{pf}{\rho_{He}\sigma_{He}}(\rho_N\sigma_N A_N + \rho_{H_3}\sigma_{H_3}A_{H_3} - \rho_{He}\sigma_{He}A_{He})$$

Yields	
pf (3446)	614310
dummy (3448)	388513

A	
A_N	0.849
A_H	0.048
A_{He}	0.937

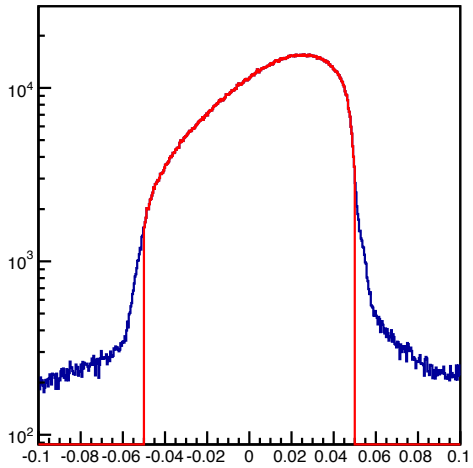
σ (μB)	
σ_N	28.25
σ_H	32.38
σ_{He}	34.79

pf = 0.492

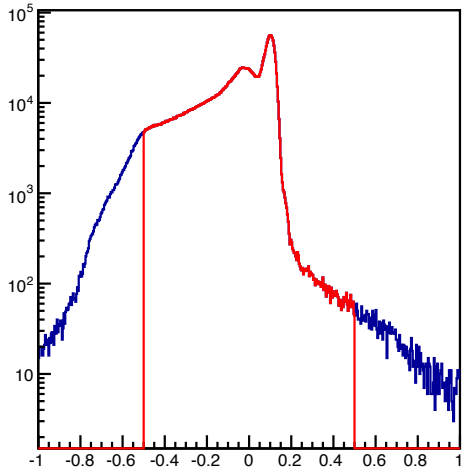
Loose Acceptance Cuts

PF Run 3727

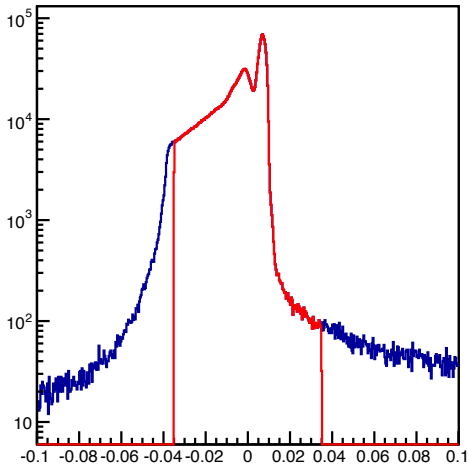
Y Cut: +/- 0.05



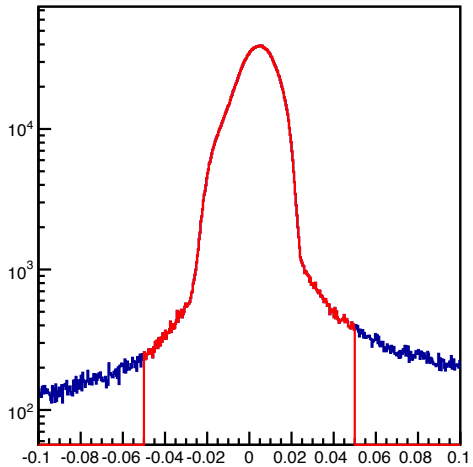
X Cut: +/- 0.5



dp Cut:+/- 0.035



Theta Cut: +/- 0.05



Phi Cut: +/- 0.05