Packing Fraction update
8/24/16

Melissa's Method (PF technote on wiki)

$$Y_{production} = Y_{He}^{outside} + (1 - pf) Y_{He}^{inside} + pf Y_{NH3}$$

$$Y_{dummy} \approx Y_{He}^{outside} + Y_{He}^{inside}$$

Assumes dummy yield is approximately equal to the empty yield.

$$Y_x \propto \frac{\rho_x L_x}{M_x} \sigma_x$$

Using these three relations the pf can be expressed in the form:

$$pf = \left(\frac{L_{total}}{L_{tg}} \right) \left(\frac{Y_{production}}{Y_{dummy}} - 1 \right) \left(\frac{\frac{\rho_N}{M_N} \sigma_N + \frac{\rho_H}{M_H} \sigma_H}{\frac{\rho_{He}}{M_{He}} \sigma_{He}} - 1 \right)^{-1}$$

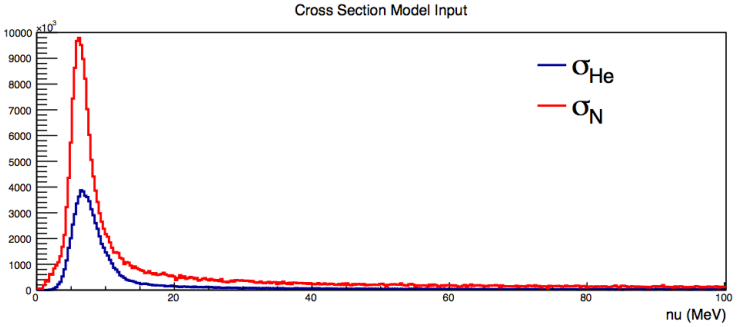
From data

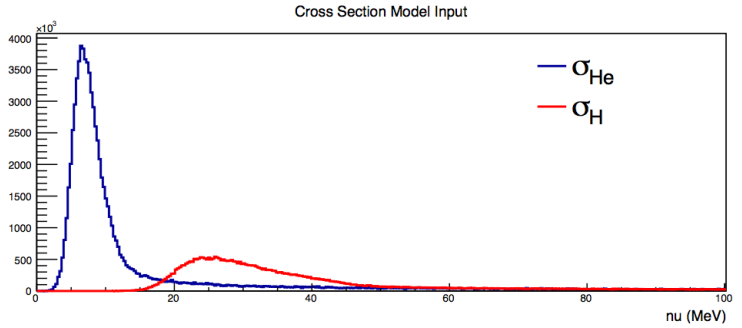
Ratios from simulation

Important!! Absolute XS wasn't used.

Melissa's Method (PF technote on wiki)

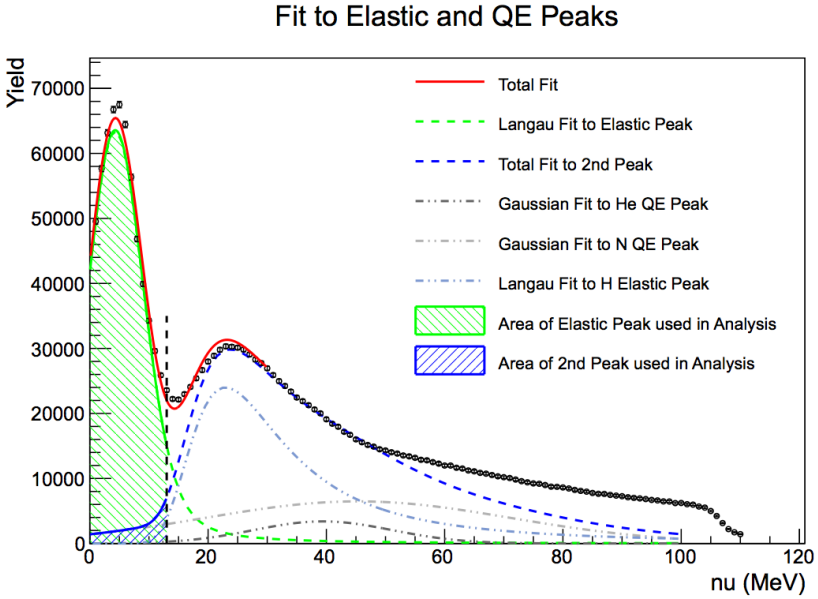
- Ratios taken between XS model output (right)
  - Note: XS units are arbitrary(?) so only ratios can be used.
- Since absolute elastic XS can't be (wasn't?) determined, it can't be combined with inelastic model from QFS or Bosted.
- Fitting method to data used to isolate elastic peak to match model.



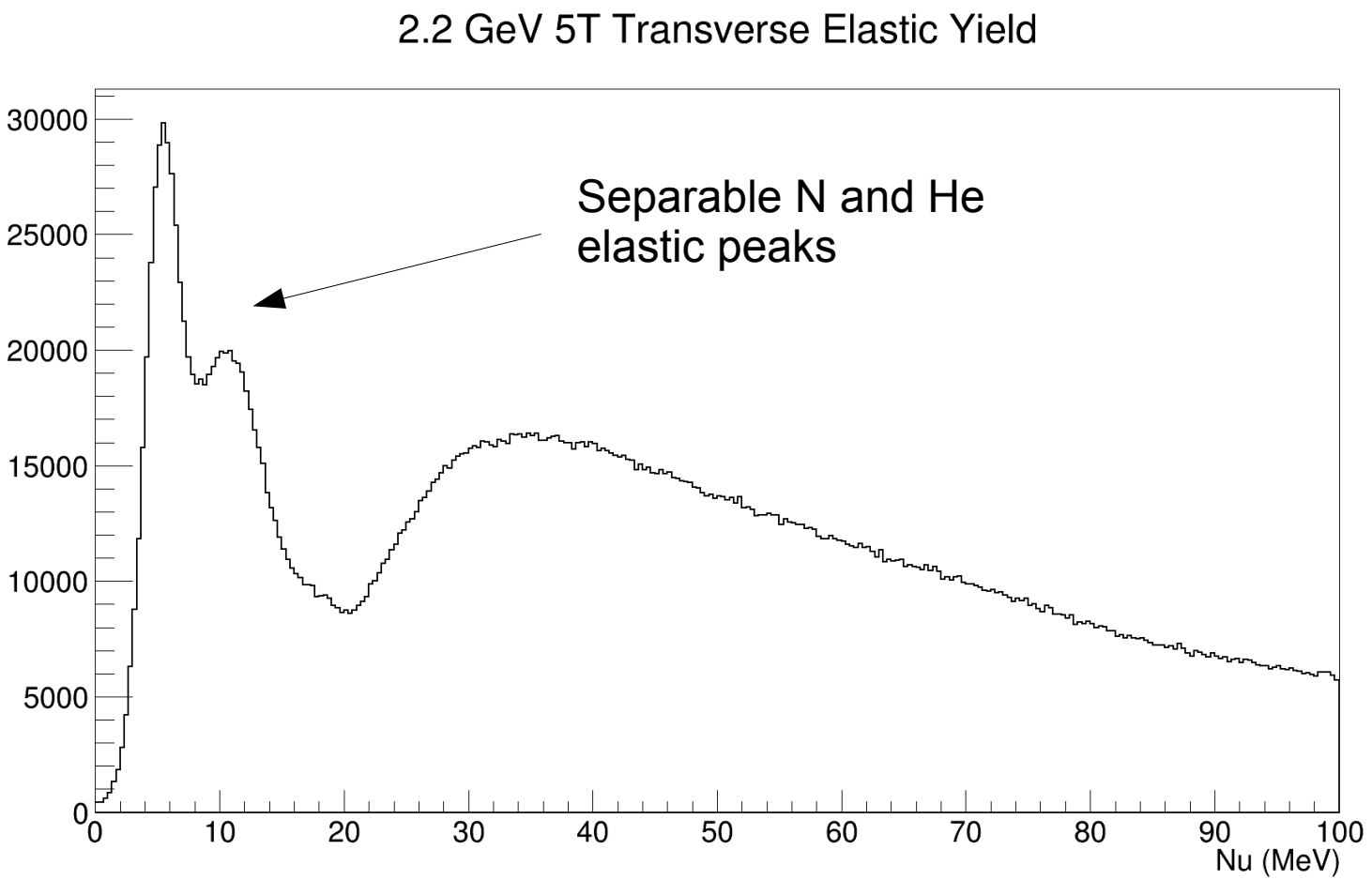


Fitting method:

- Fit gaussian to elastic.
- Output fit parameters (mean, width, area) used as starting parameters for gaussian-landau convolution fit to elastic.
- Fit gaussian to quasi-elastic
- Output fit parameters (mean, width, area) used in conjunction with parameters from QFS to fit a gaussian+gaussian+landau fit to quasi-elastic.
- Output parameters from both elastic and quasi-elastic fits used in total spectrum fit.
- Final fit has 13 parameters.



Using this method with updated data...

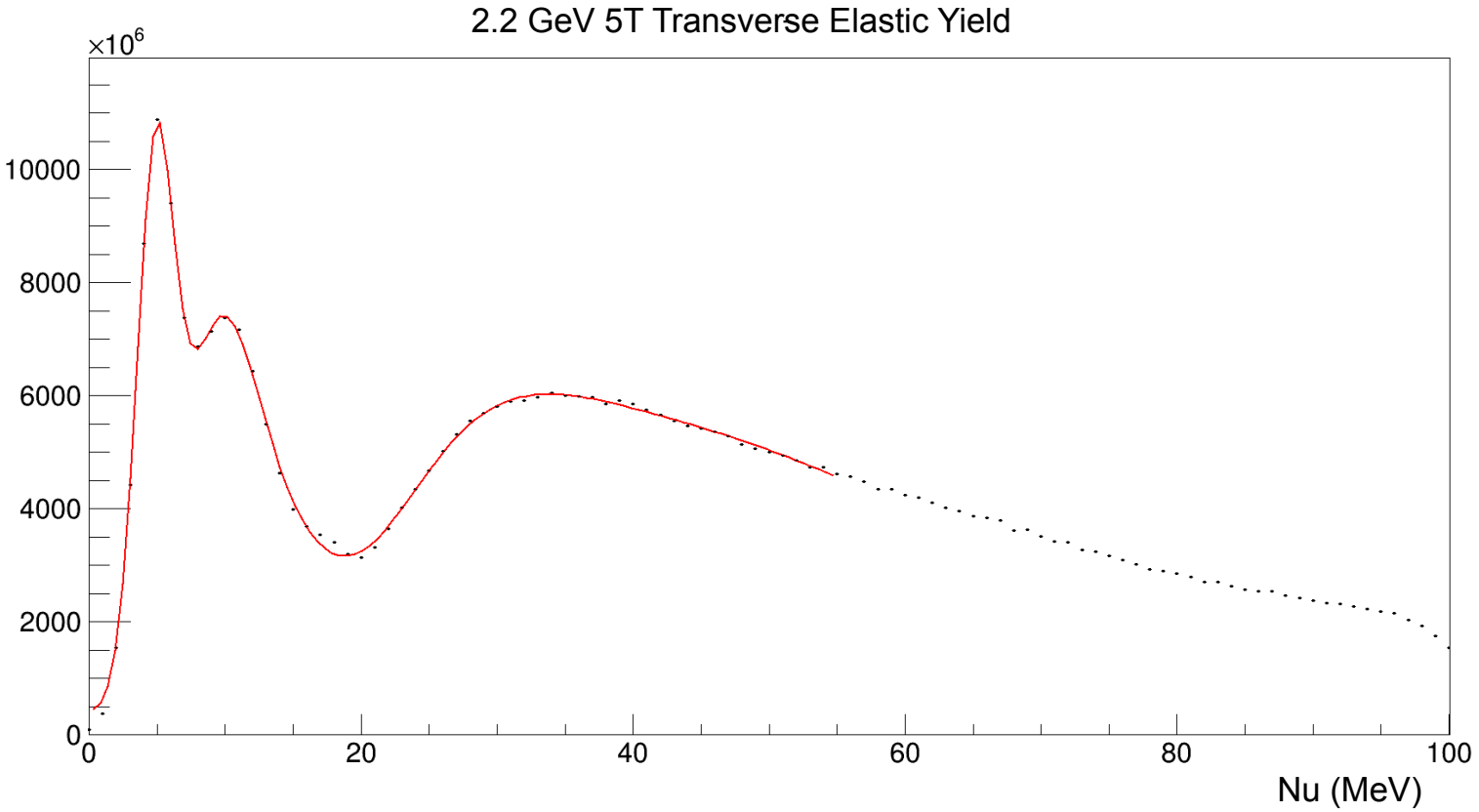


Elastic fitting method needs to be updated to account for two elastic peaks...

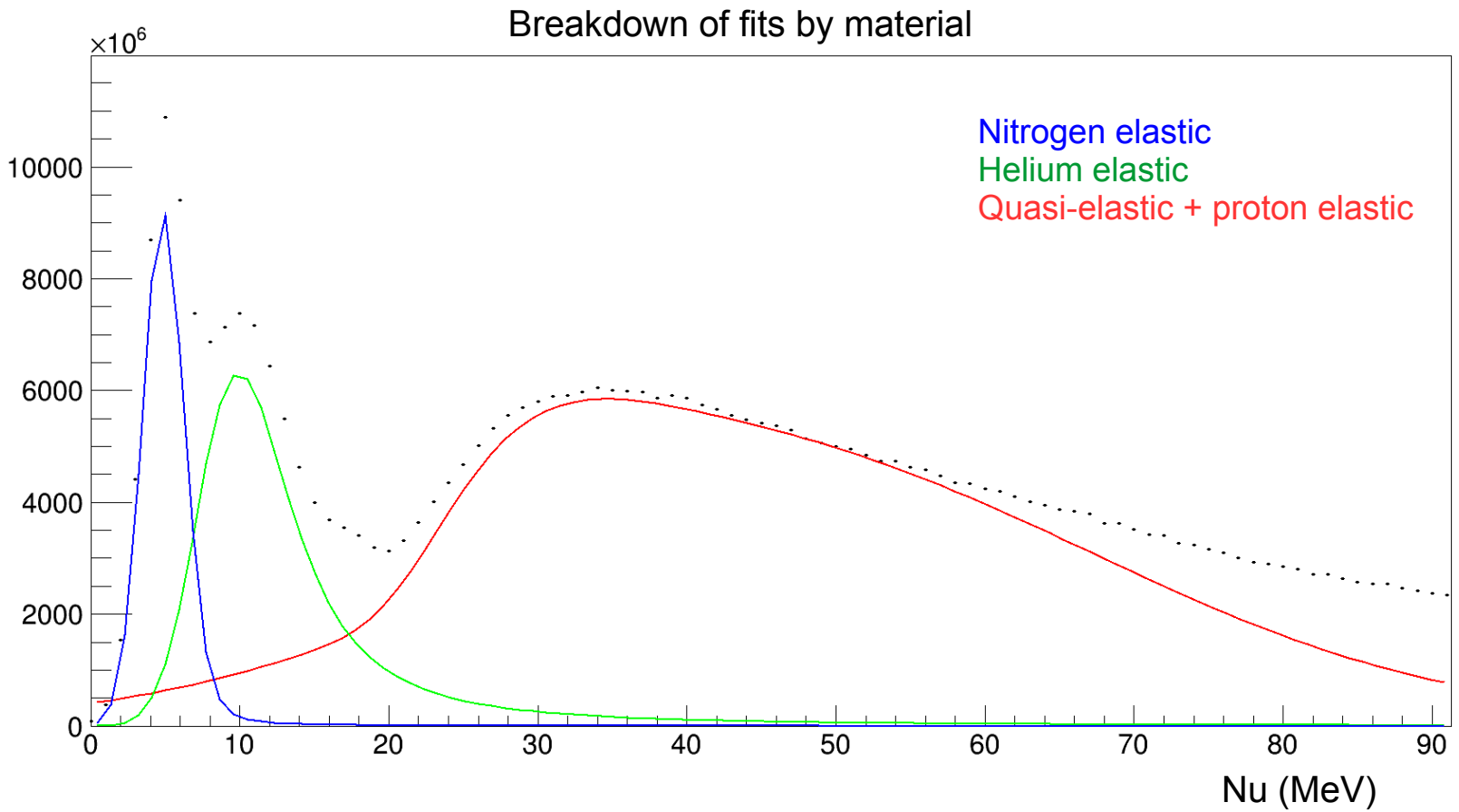
Using this method with updated data...

Update to fitting method:

- Fit two gaussians with offset ranges.
- Use output parameters as starting parameters for two gaussian-landau fits.
- Quasi-elastic fit remains unchanged.
- Final fit with quasi-elastic and both elastic fits to total spectrum.
- 17 fit parameters total.



Using this method with updated data...



Being able to isolate the Helium elastic peak in production actually allows for a potential cross-check:

- Integrate the Helium elastic peak in the production and empty runs (easy to isolate He elastic in the empty run)
- The ratio between the two integrals should be directly proportional to the packing fraction. Can ignore nitrogen, quasi-elastic contamination, models, etc..!

Alternative method check

$$Y_{production,\,He\,isolated} = Y_{He}^{outside} + (1 - pf)\,Y_{He}^{inside} + pfY_{NH3}$$

Isolate Helium elastic peak

$$Y_{Empty} = Y_{He}^{outside} + Y_{He}^{inside}$$

Using the relation $Y_x \propto \frac{\rho_x L_x}{M_x}\sigma_x$

$$PF = \frac{L_{total}}{L_{tg}}\left(1 - \frac{Y_{production,\,He\,isolated}}{Y_{empty}}\right)$$

Test with 2.2 GeV 5T Transverse:

Production run 6063
He elastic integral: 6.25e10

Empty run 5947
He elastic integral: 8.8e10

Packing Fraction = 0.389
Previous result = 0.479

Initial thought:
Problem with alternate method?
But...

Using this method with updated data...

$$pf = \left(\frac{L_{total}}{L_{tg}}\right)\left(\frac{Y_{production}}{Y_{dummy}} - 1\right)\left(\frac{\frac{\rho_N}{M_N}\sigma_N + \frac{\rho_H}{M_H}\sigma_H}{\frac{\rho_{He}}{M_{He}}\sigma_{He}} - 1\right)^{-1}$$

- Returning to original method from PF technote
- Production and Dummy yields integrated over elastic after quasi-elastic contamination subtracted out (from updated fitting results)
- XS ratios from Melissa's technote. (Will recalculate result with updated ratios soon)

PF = 0.358
PF (alternate method) = 0.389
PF (Melissa's note) = 0.479

Possible that the Helium elastic peak shift has changed the result when using this method? (Shouldn't, method integrates over entire elastic region)

Removing fit dependance

$$Y_{production} = Y_{He}^{outside} + (1 - pf) Y_{He}^{inside} + pf Y_{NH3} + Y_{Al}$$

$$Y_{Empty} = Y_{He}^{outside} + Y_{He}^{inside}$$

$$Y_{dummy} = Y_{He}^{outside} + Y_{He}^{inside} + Y_{Al}$$

Again using the relation $Y_x \propto \frac{\rho_x L_x}{M_x} \sigma_x$

$$pf = (Y_{production} - Y_{dummy}) \left(\frac{AN_o}{e} \frac{\rho_{NH_3} L_{tg}}{M_{NH_3}} (\sigma_N + 3\sigma_H) - \frac{L_{tg}}{L_{total}} Y_{Empty} \right)^{-1}$$

Where $\frac{AN_o}{e}$ is the constant of proportionality

- This method removes the need to subtract the quasi-elastic, since its true everywhere.
- Issue is that an absolute Nitrogen and Helium XS (at both elastic and inelastic) are needed.
- I can produce an inelastic XS with P.Bosted model, but still unsure how to get the absolute elastic XS from g2psim.
- Removing the 17 parameter fit might help!

To do:

- Recalculate the elastic XS ratios since they have likely changed.
- Error analysis on both methods (helium peak isolation and original method).
- If I can get an absolute elastic simulated XS I will also try the third method (the no fit method), along with error analysis.
- Suggestions?