$^{19}F(\gamma,\alpha)^{15}N$ Systematic Studies

Seamus Riordan
seamus@anl.gov

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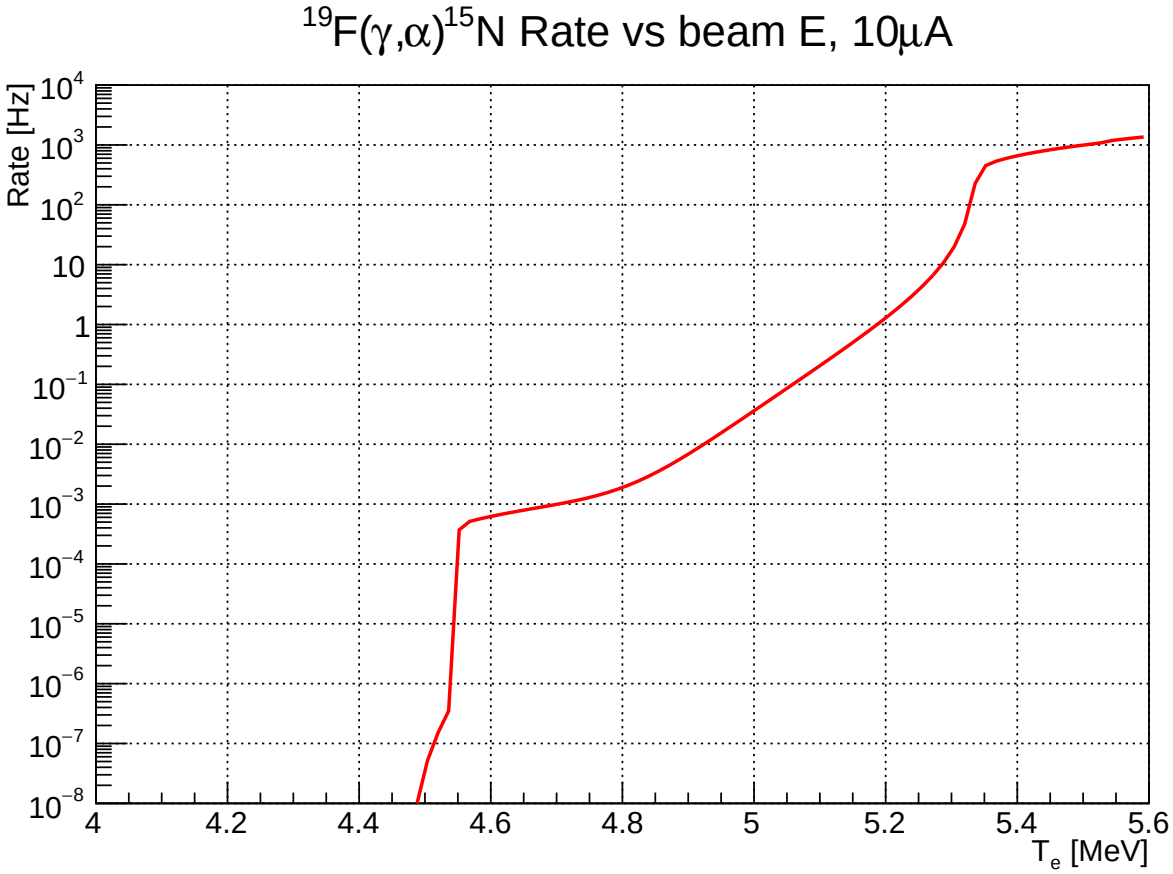
Summary

- Started evaluation of systematics
- Energy variations in agreement with previous analysis
- Geant4 simulations for position and resolution underway
    - Statistics necessary are limiting factor

Table provided

Electron Parameter	Desired Beam Control	Desired Beam Knowledge	Measurement or example for reference	Possible action to improve or achieve desired Beam Control
Energy Range	4.5-5.5 MeV	0.1% (~5 keV)	2.0% (worst case – orbit unknown) 0.3% (best case – orbit/stray included)	Improve PS (5mA FS ~ 0.18%), evaluate w/ new Hall probe
Energy Step	0.1 MeV	0.02% (~1 keV)	<0.15% (0.06% PS regulation + 0.13% BPM resolution for angle)	Evaluate process and w/ new Hall probe
Energy Spread	<0.06%	<0.06% (~3 keV)	9-14 keV (2K/4K test using 2D harp and 0L02 Twiss)	Implement harp to measure beam size and min. energy spread w/ 0L02
Beam Current	1 nA – 100 uA	?	BCM (1% >1 uA cal'd FC2)	Implement isolated dump + picoammeter for low/all currents
RMS sigma at radiator	1 mm	?	a) Use viewer/camera b) Meas. 0L02, propagate	Implement harp to measure beam twiss, set/know spot size w/ 0L02
RMS diverg. at radiator	Not specified	?	Not done	Implement harp to measure beam twiss, set/know divergence w/ 0L02
Position at radiator	Photons centered on collimator	0.1 mm	Used x-ray screen to center beam on radiator, and recorded BPM's in 5D line,	Procedure to transfer radiator centering to electron beam positions between each energy/configuration

Rate vs. T



- Points to remember for energy systematics with current σ
  - Slope for 4.75 MeV is relatively shallow

Energy Systematics

- Reminder - statistical uncertainty $\sim 3 - 5\%$
- Varied energy for independent points and collectively

Max % change in σ reconstruction -
Relative 4×10^{-4} energy change ($\sim$2 keV)
Yield and derivative for 10μA, 0.05 MeV lower than endpoint

T MeV	Y s^{-1}	dY/dT $(s\ MeV)^{-1}$	Max σ_{recon} % change
4.75	1.0×10^{-3}	4.6×10^{-3}	1.7
4.85	1.9×10^{-3}	1.8×10^{-2}	6.3
4.95	6.8×10^{-3}	1.1×10^{-1}	5.0
5.05	3.6×10^{-2}	6.3×10^{-1}	4.9
5.15	2.0×10^{-1}	3.6×10^{0}	5.3
5.25	1.3×10^{0}	2.6×10^{1}	6.7

- All energies changed relative 10^{-3} (5 keV) - nominal change of 10% in reconstruction

Energy Systematic Error

- For absolute beam energy uncertainty of δE (= 0.1%) and zero relative beam energy uncertainty:

$$\frac{dy_i}{y_i} = \frac{y_i(E_i + \delta E) - y_i(E_i)}{y_i(E_i)} \qquad \frac{dN_{ij}}{N_{ij}} = \frac{N_{ij}(E_i + \delta E) - N_{ij}(E_i)}{N_{ij}(E_i)}$$

$$E_0 = 4.75 \pm \delta E$$

$$E_i = E_0 + i\Delta$$

E_i (MeV)	dy_i/y_i (%)	$d\sigma_i/\sigma_i$ (%)
4.75	11.1	11.7
4.85	9.8	10.1
4.95	8.8	9.2
5.05	8.4	9.0
5.15	8.7	9.6
5.25	11.7	12.7

This is the cross section dependence on energy

- Accounted for dN_{ij} due to energy error when calculating dy_i

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- 10% reconstruction variation for 0.1% in agreement with prior study

G4 Analysis

Nominal Conditions

Directory: `simulations/nominal`

Parameter	Nominal Value	Notes
Energy	4.5-5.5 MeV	
Energy RMS Spread	3 keV	
Beam Position	(0 mm, 0 mm)	
Position RMS spread	(1 mm, 1 mm)	

Energy RMS Spread scan

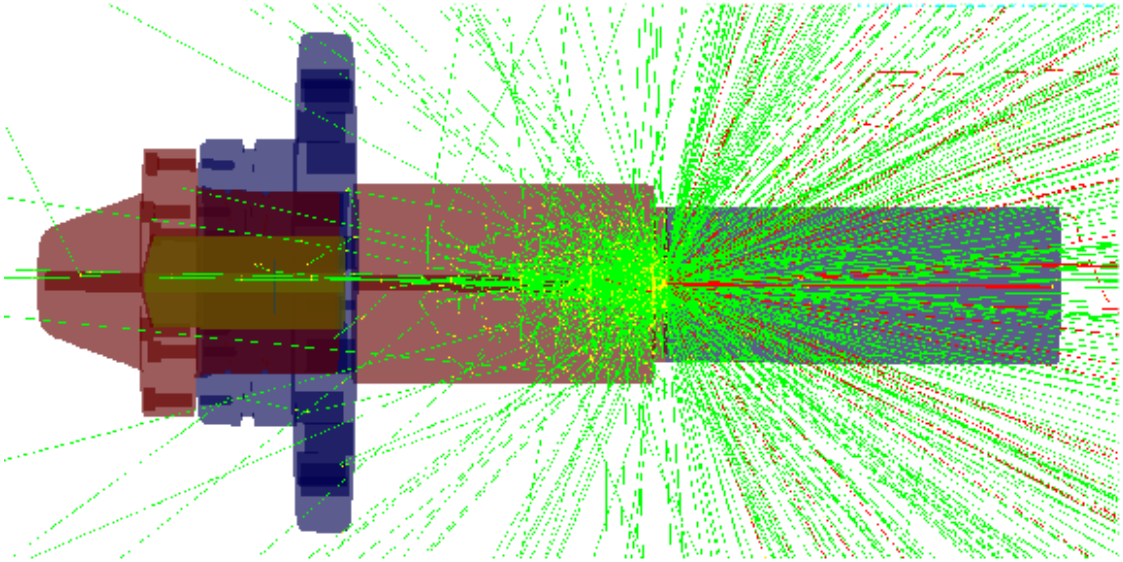
Directory Name	RMS Energy spread	Notes
`energy_rms1`	20 keV	Nominal settings otherwise
`energy_rms2`	50 keV	Nominal settings otherwise
`energy_rms3`	10 keV	Nominal settings otherwise

Position Offset

Directory Name	Position Offset	Notes
`position_offset1`	(1 mm, 0 mm)	Nominal settings otherwise
`position_offset2`	(2 mm, 0 mm)	Nominal settings otherwise
`position_offset3`	(3 mm, 0 mm)	Nominal settings otherwise

Position RMS Spread

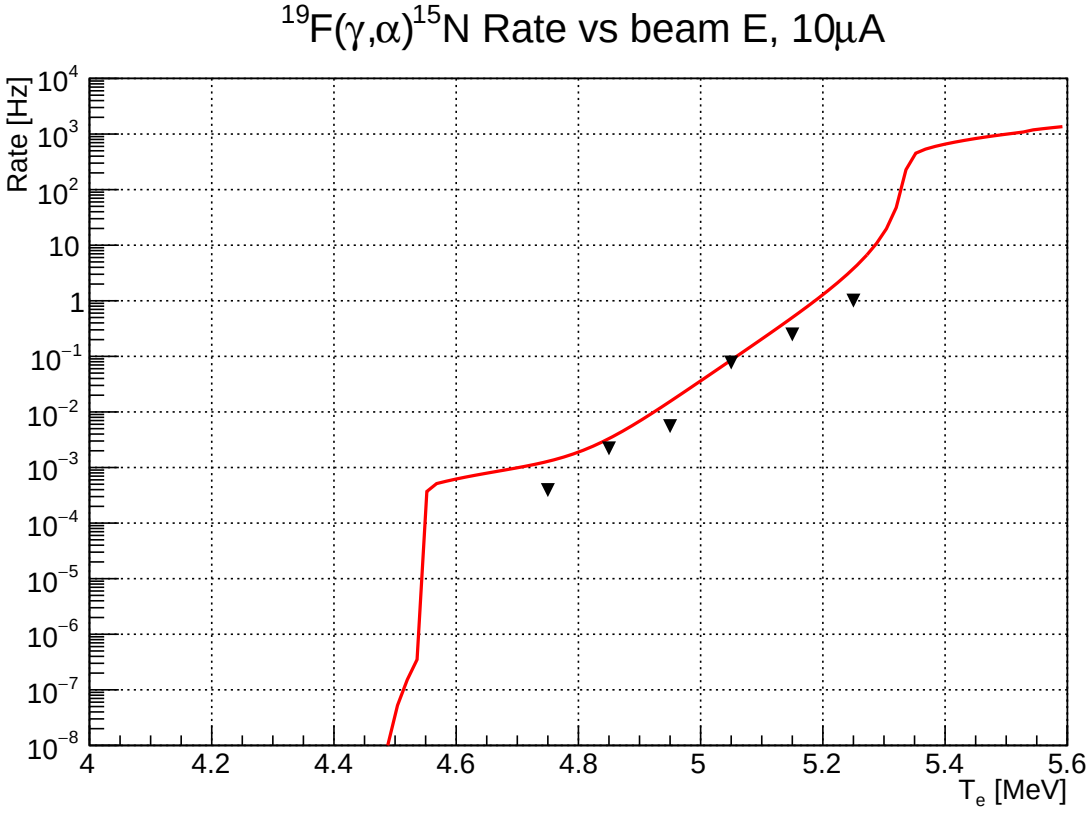
Directory Name	Position RMS spread	Notes
`position_rms0`	(0.5 mm, 0.5 mm)	Nominal settings otherwise
`position_rms1`	(2 mm, 2 mm)	Nominal settings otherwise
`position_rms2`	(3 mm, 3 mm)	Nominal settings otherwise
`position_rms3`	(4 mm, 4 mm)	Nominal settings otherwise



- Scan of parameters for six beam energies underway
- Sufficient statistics requires significant farm time
- Machinery in place to use output spectra in existing rate calculations

G4 Brem Rate Comparison

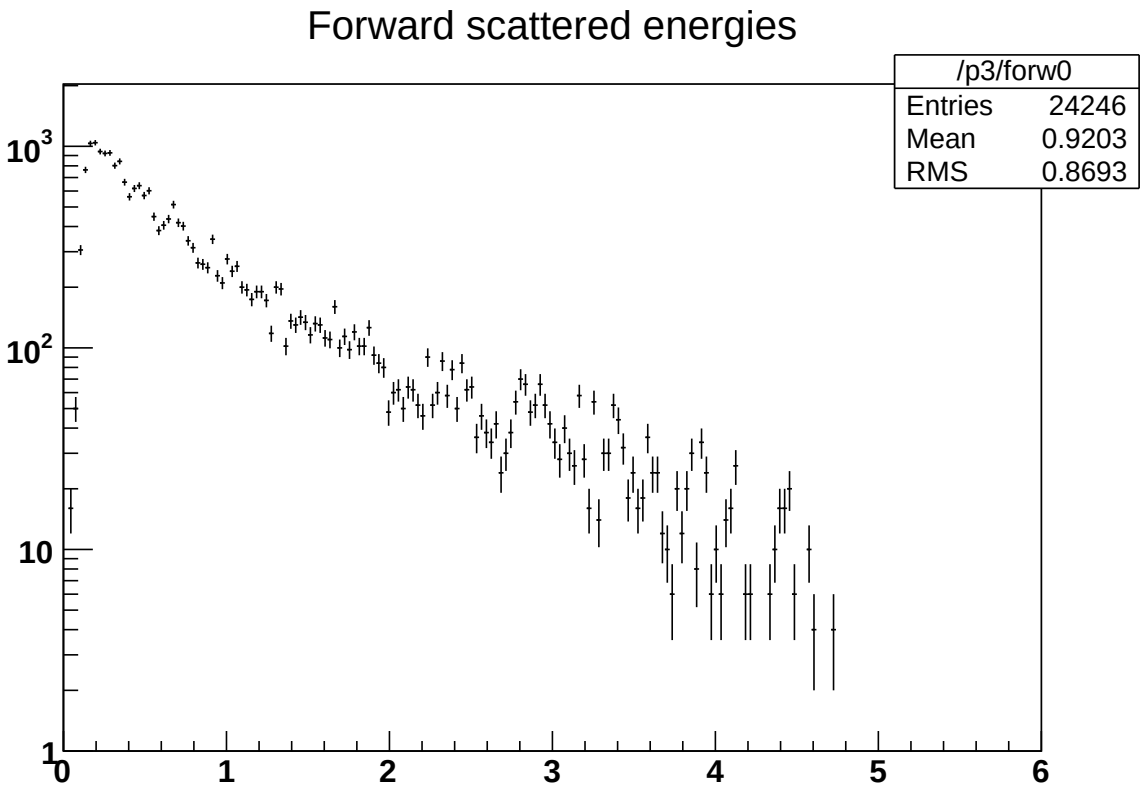
Limited Statistics



- Just taking brem spectrum after final insert
- New simulation uses all collimator and material definitions
- Rates nominally lower by about factor of 2

Statistics

Spectrum for $T = 4.75$ MeV, 100M incident e^-



- Unfolding requires sampling on step-size level near end points
- Statistics to achieve requires serious computation - running now