MEASURING THE QF OF GERMANIUM USING AN ^{88}Y/BE PHOTONEUTRON SOURCE

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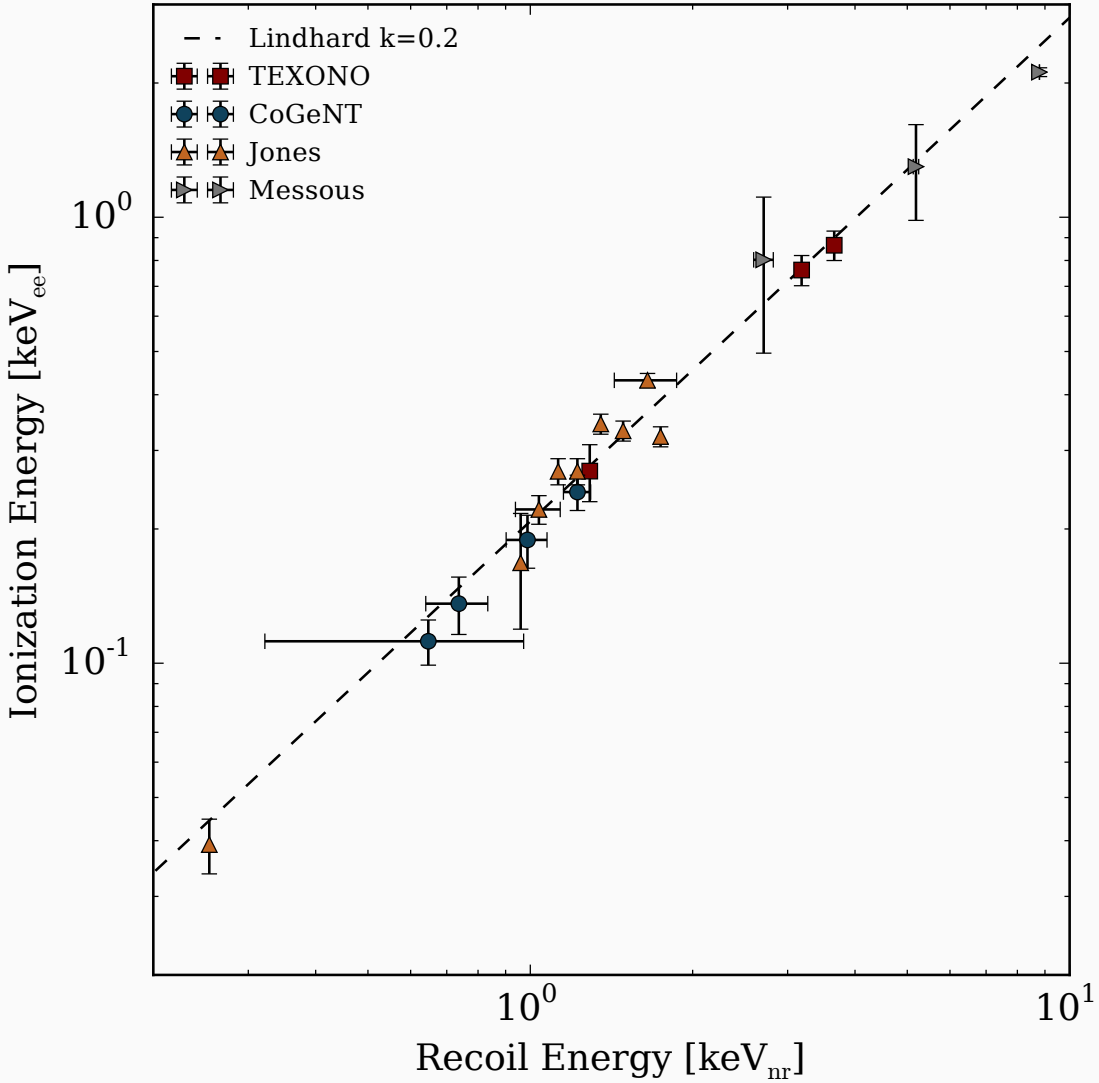
QF OF GERMANIUM EXTREMELY WELL MEASURED

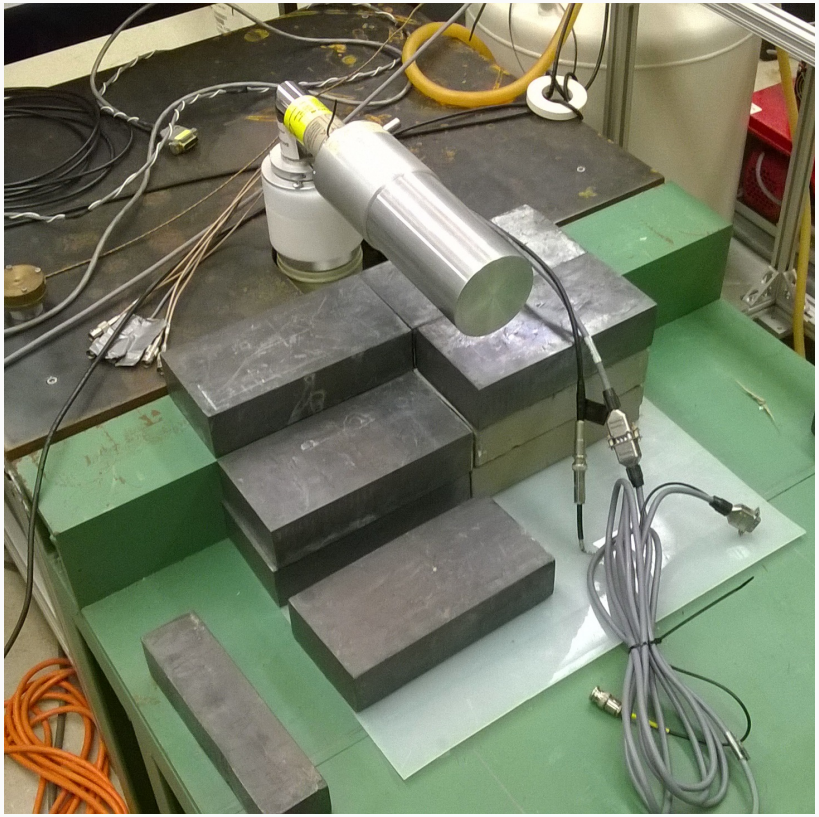


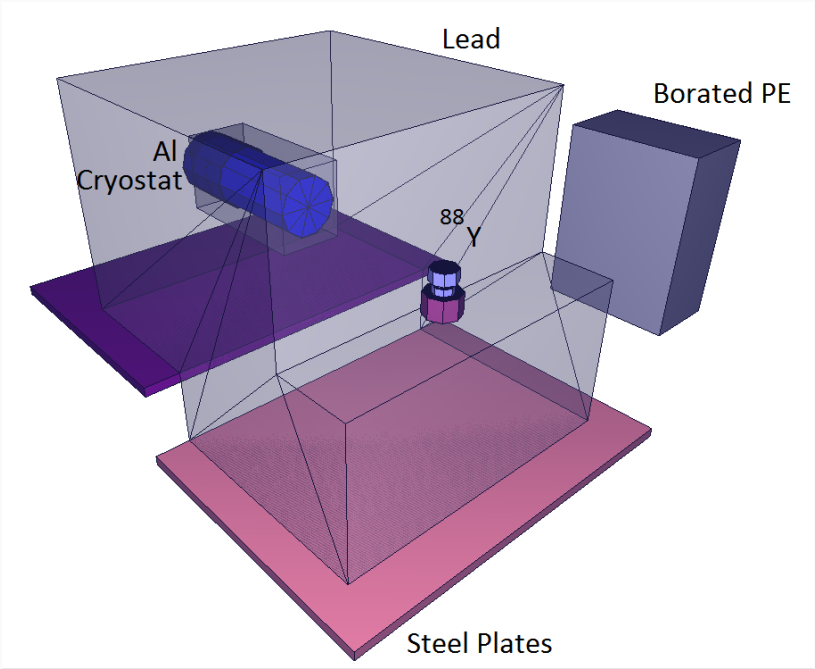
DETERMINE QF USING ^{88}Y

J. I. COLLAR, PRL110 (2013), 211101

- Use an ^{88}Y source with a beryllium encapsulation to produce mostly monochromatic neutrons
  - $E_{\gamma,1}$ = 1.836 MeV ($\sim$ 99 %) $\rightarrow E_n$ = 152 keV
  - $E_{\gamma,2}$ = 2.734 MeV ($\sim$ 0.5 %) $\rightarrow E_n$ = 963 keV
- Replace beryllium encapsulation by aluminum as total γ attenuation closely matches for energies of interest and is inert of neutron emission
  - $\lambda_{\mathrm{BeO}}(1\,\mathrm{MeV}) = 0.06112\,\mathrm{cm}^2\,\mathrm{g}^{-1}$ and $\lambda_{\mathrm{Al}}(1\,\mathrm{MeV}) = 0.06146\,\mathrm{cm}^2\,\mathrm{g}^{-1}$
- Subtract aluminum (γ only) spectrum from beryllium spectrum (γ and neutron content) to obtain a residual neutron spectrum
- Fit simulated spectrum to data using preferred QF model

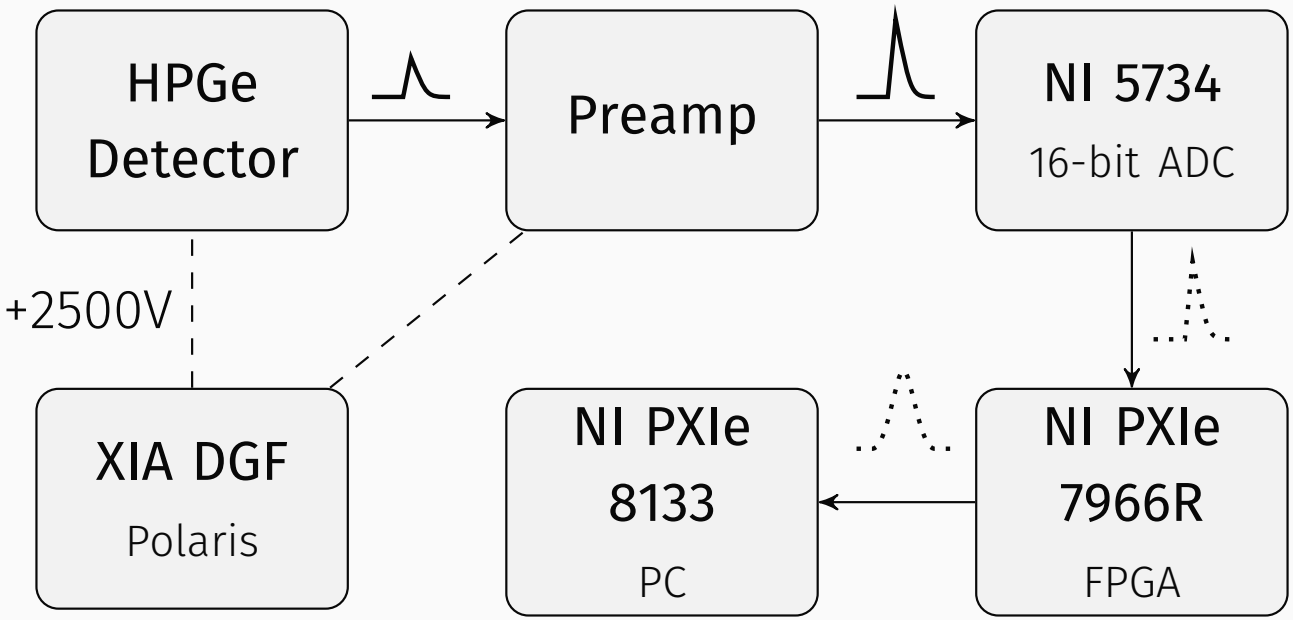
TAKING ^{88}Y DATA USING A PPC GE DETECTOR





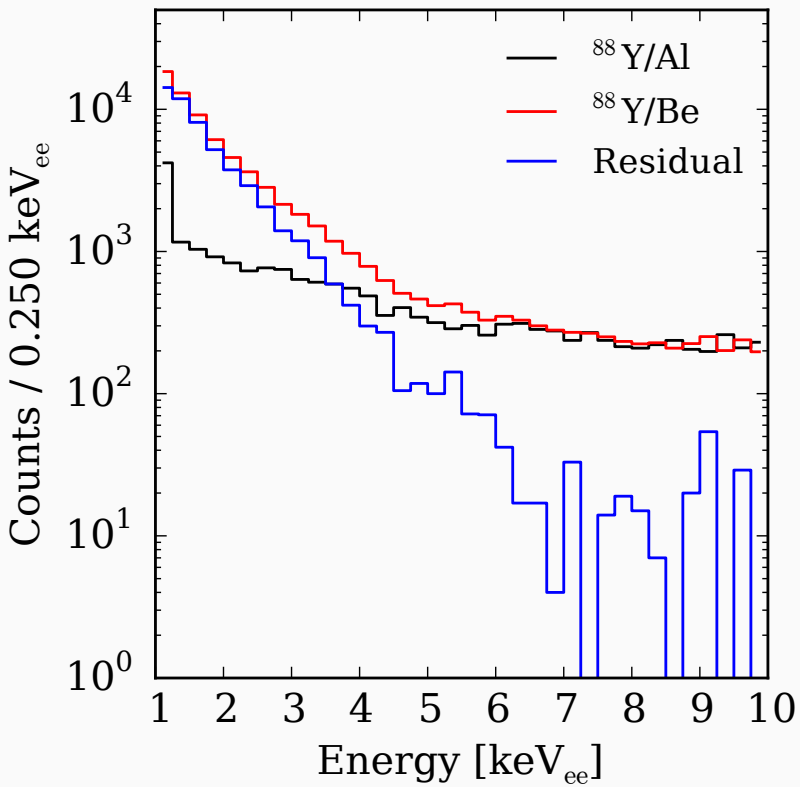
- 0.475 kg of germanium (50.7 mm × 43 mm)
- Activity: 0.68 mCi , 670 neutrons/s
- Runtime: 20 hours for each source configuration
- 20 cm of lead reduced gamma flux to manageable levels

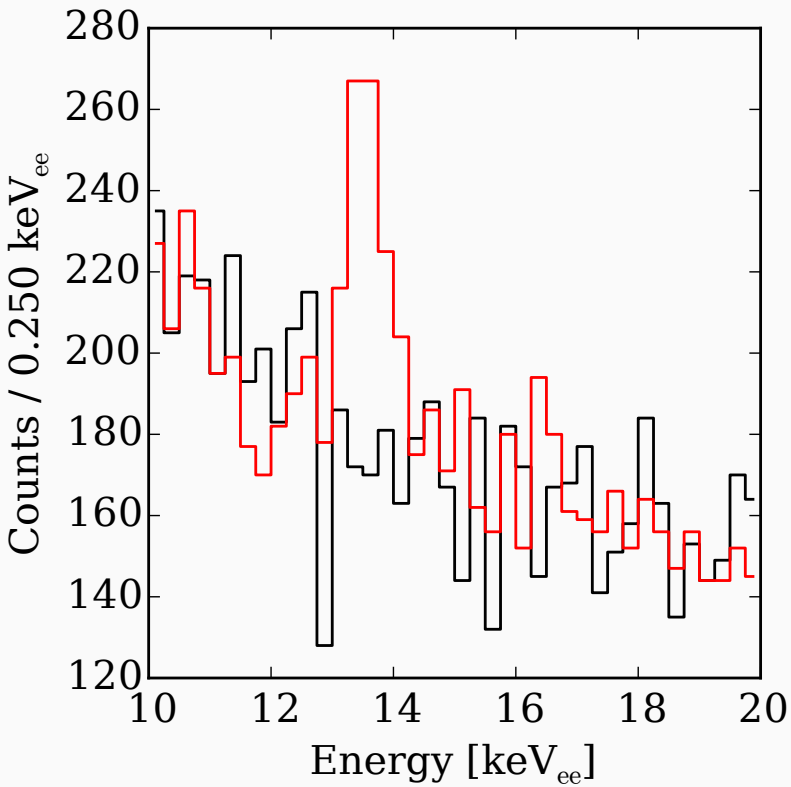
SETUP USED W.I.P. VERSION OF NEW C4 DAQ



- Sampling rate: 40 MS/s
- Trace length: 400 µs

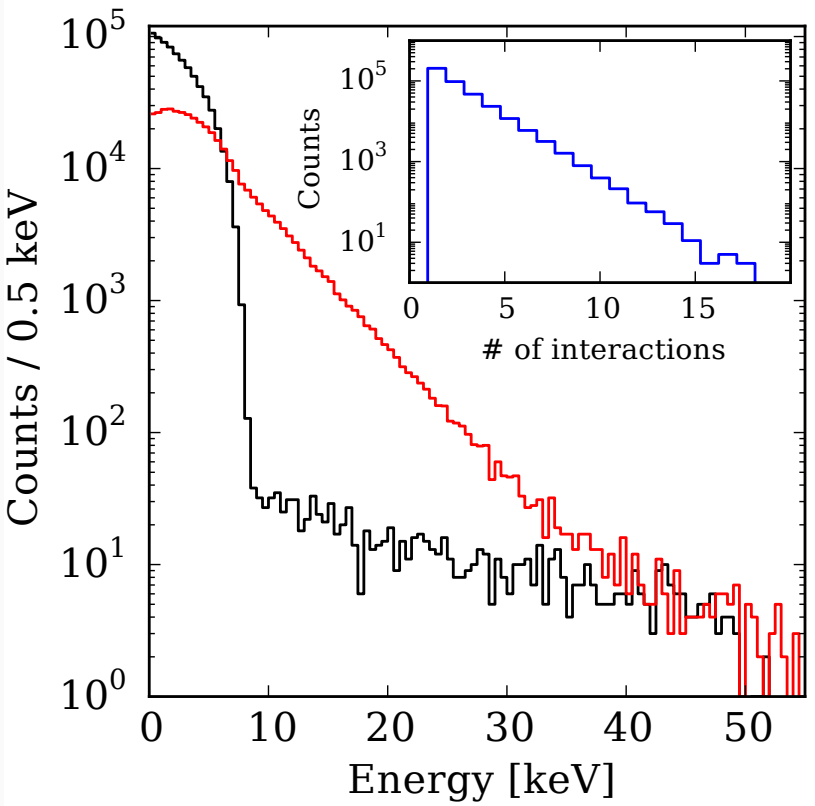
EXPERIMENTAL SPECTRA SHOW A CLEAR NEUTRON EXCESS





NO SURPRISE BY MCNP SIMULATION OF EXPERIMENTAL SETUP

- MCNP-Polimi V 2.0
- Simulations for both standard and revised (A.E.Robinson, Phys.C89 (2014),032801) lead neutron cross section libraries



FITTING MCNP SIMULATION TO THE RESIDUE SPECTRUM USING MCMC

- Ge QF well described by Lindhard theory in the low E region:

$$QF = \frac{k\,g(\epsilon)}{1 + k\,g(\epsilon)} \tag{1}$$

$$g(\epsilon) = 3\,\epsilon^{0.15} + 0.7\,\epsilon^{0.6} + \epsilon \tag{2}$$

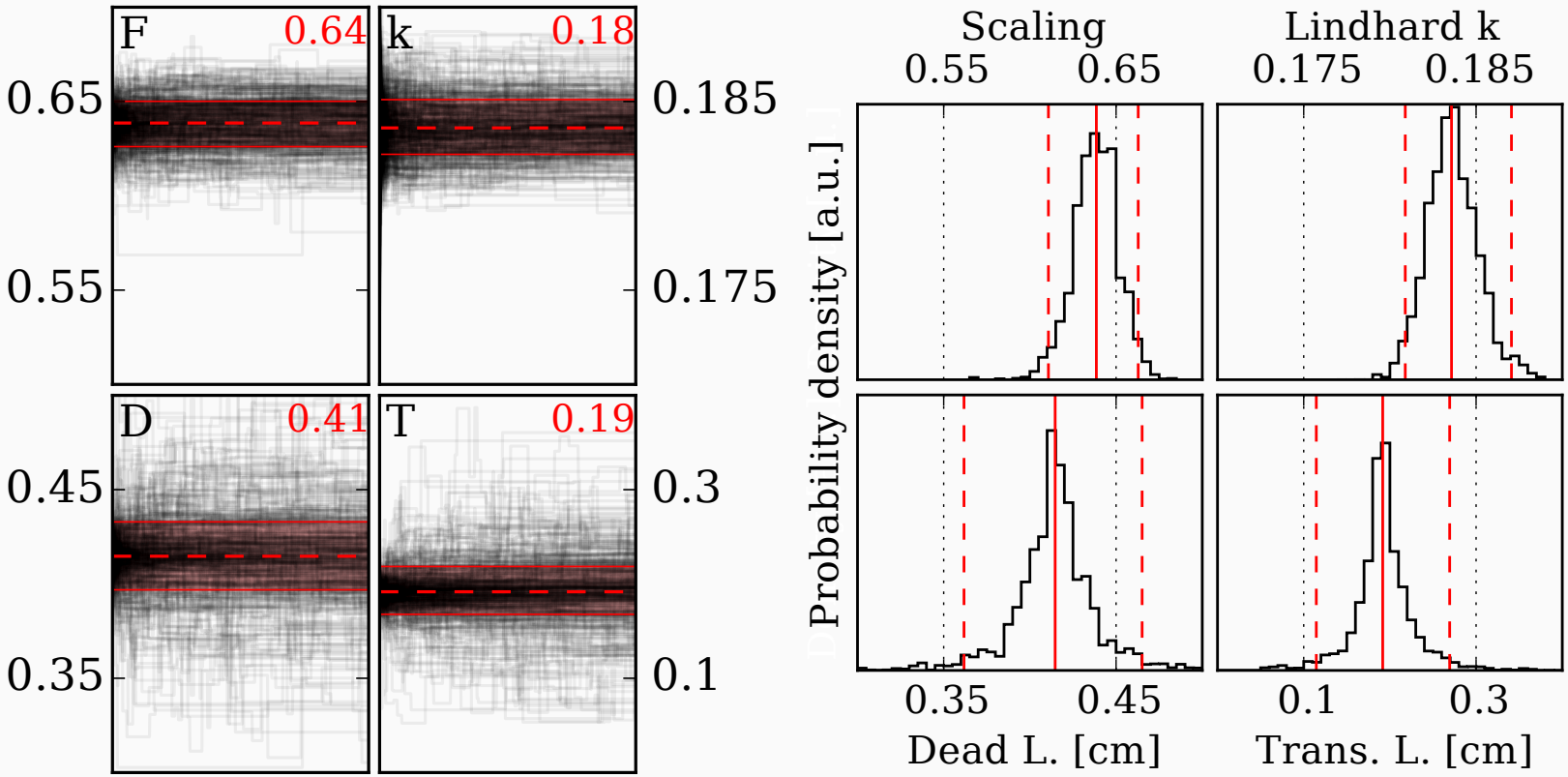
$$\epsilon = 11.5\,E_{\mathrm{nr}} Z^{-7/3} \tag{3}$$

- Detector dead layer (D) and transition layer (T) modeled by sigmoid shaped charge collection efficiency
- Overall scaling (F)

→ One fit parameter (k), three nuisance parameters (F,D,T)

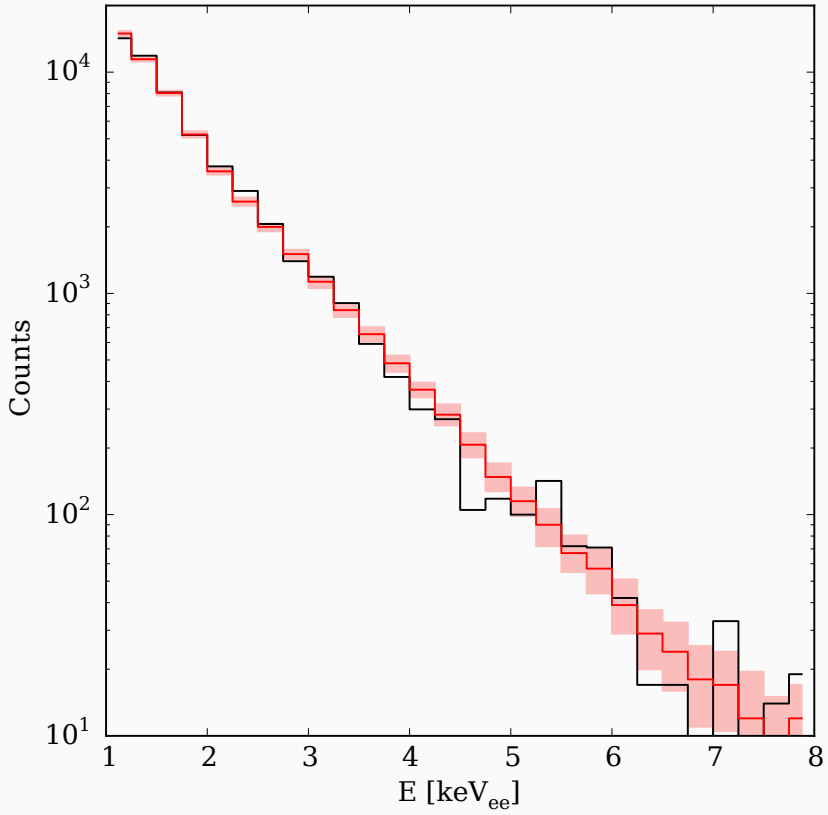
- Sample phase space using Goodman & Weare ensemble sampler (emcee)

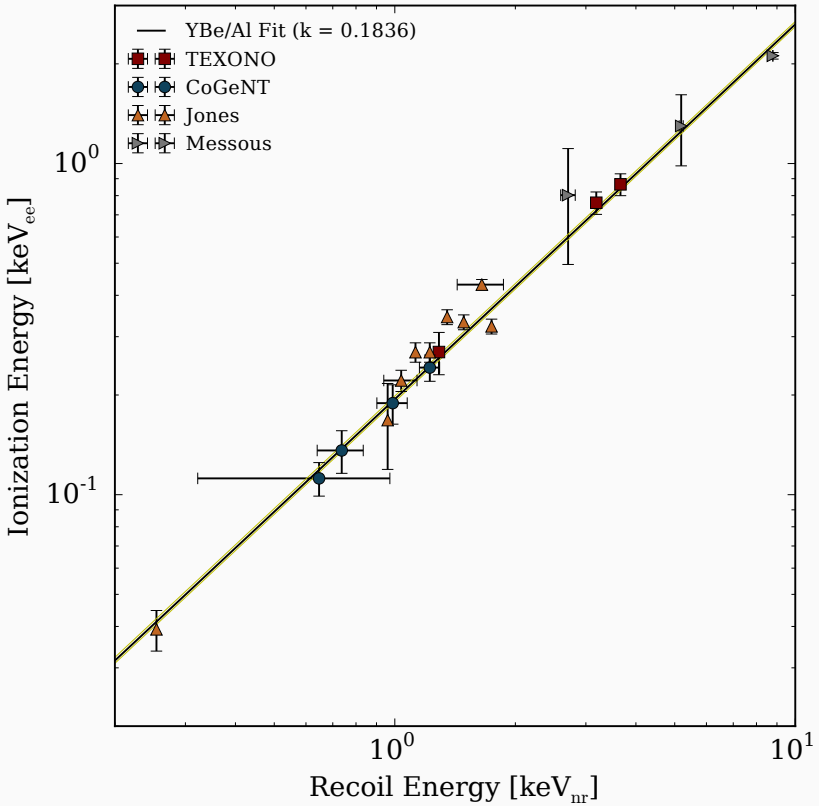
WALKERS SAMPLED POSTERIOR DISTRIBUTIONS WELL



- Rubin-Gelman: $R_{\mathrm{RG}} - 1 \approx 0.05$ for all parameters

OBTAINED LINDHARD K FOLLOWS PREVIOUS MEASUREMENTS





- χ^2/d.o.f = 47/28