What is the problem

- At LLNL we were comparing our Monte Carlo code Mercury results to MCNP results
- Energy deposition agreed well when transporting neutrons only
- Energy deposition did not agree well at low neutron (projectile) energy when gammas were added to transporting
- I concluded that the difference was due to the fact that FUDGE was implementing the formula for the primary gamma energy as specified in Chapters 12 and 13 in the ENDF manual and NJOY was not.
- I also was concluded that the formula in the ENDF manual is incorrect, and speculated that NJOY developers realized this and had implemented a more correct formula
- Basically, the formula in the ENDF manual ignores the recoil of the residual

Gamma energy?

- What in chapters 12 and 13 of the ENDF manual is calls the primary gamma energy is really the total available "kinetic energy" for the gamma and the "residual" in the center-of-mass frame

  - Kinetic energy for a photon is its energy (in my lingo)

  - In chapters 12 and 13, the gamma is either a primary or a discrete gamma
    - primary gamma via capture reaction

      projectile + target → primary_gamma + residual (e.g., n + O16 → γ + O17_e5)

    - Discrete gamma

      residual → discrete_gamma + residual (e.g., O17_e5 → γ + O17_e2)

      residual → discrete_gamma + residual (e.g., O17_e2 → γ + O17_e1)

My recommendation, in chapters 12 and 13

- replace

LP=2 for primary photons where the photon energy EG'$_k$ is given by

$$\mathrm{EG}'_k = \mathrm{EG}_k + \frac{\mathrm{AWR}}{\mathrm{AWR}+1}\, E_n .$$

- with

LP=2 for primary photons where the sum of the photon energy EG'$_k$ and kinetic energy of the residual K_r is

$$\mathrm{EG}'_k + \mathrm{K}_r = \mathrm{EG}_k + \frac{\mathrm{AWR}}{\mathrm{AWR}+1}\, E_n$$

and the photon energy EG'$_k$ is given by

$$\begin{aligned}\mathrm{EG}'_k &= \left(1 - \frac{\mathrm{EG}_k/(\mathrm{m}_n c^2)}{2\,(\mathrm{AWR}+1)} - \frac{\mathrm{AWR}\; E_n/(\mathrm{m}_n c^2)}{(\mathrm{AWR}+1)^2}\right) \mathrm{EG}_k \\ &+ \left(1 - \frac{\mathrm{AWR}\; E_n/(\mathrm{m}_n c^2)}{(\mathrm{AWR}+1)^2}\right) \frac{\mathrm{AWR}}{\mathrm{AWR}+1}\, E_n .\end{aligned}$$