

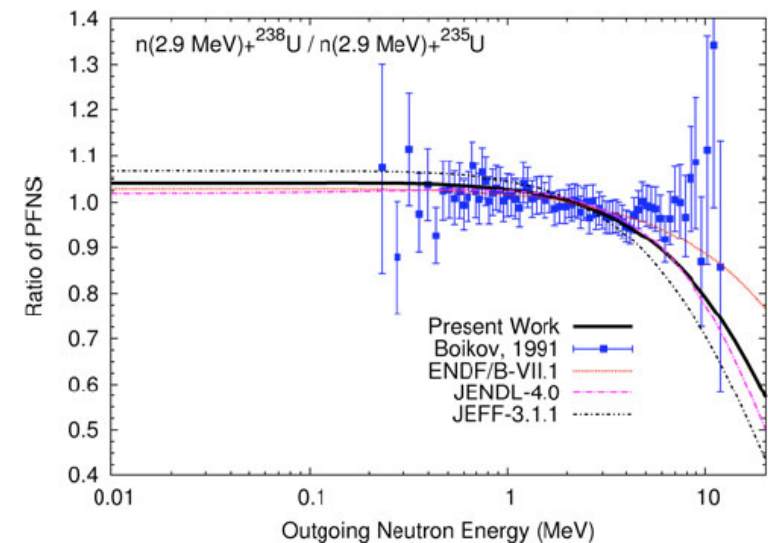
# $^{235}\text{U}$ – PFNS & PFGS

**Patrick Talou**

Los Alamos, April 11, 2016

# Prompt Fission Neutron Spectrum

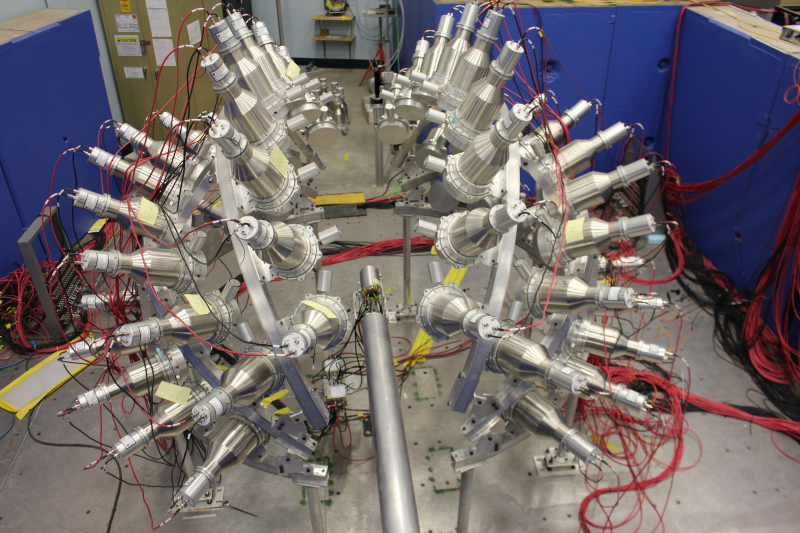
- **Preliminary file:**
  - Thermal GMA analysis (Trkov-Capote)
  - 0.5-5.0 MeV: Madland-Nix model calculations, Rising-Talou
  - Above 5.0 MeV, ENDF/B-VII.1
- **By Nov. 2016,**
  - New high-energy calculations, Neudecker
- **Validation against**
  - Preliminary Chi-Nu data below 1 MeV  $E_{\text{out}}$
  - Lestone NUEX data at 1.5 MeV  $E_{\text{inc}}$



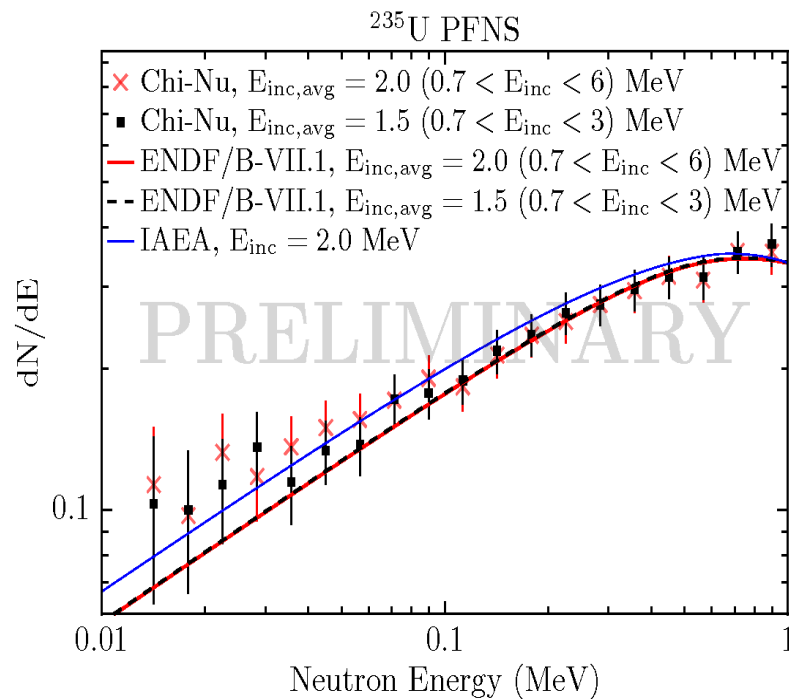
Should we include the other U isotopes? Would need to extend up to 20 MeV...

# The LANL/LLNL Program to Measure Prompt Fission Neutron Spectra at LANSCE

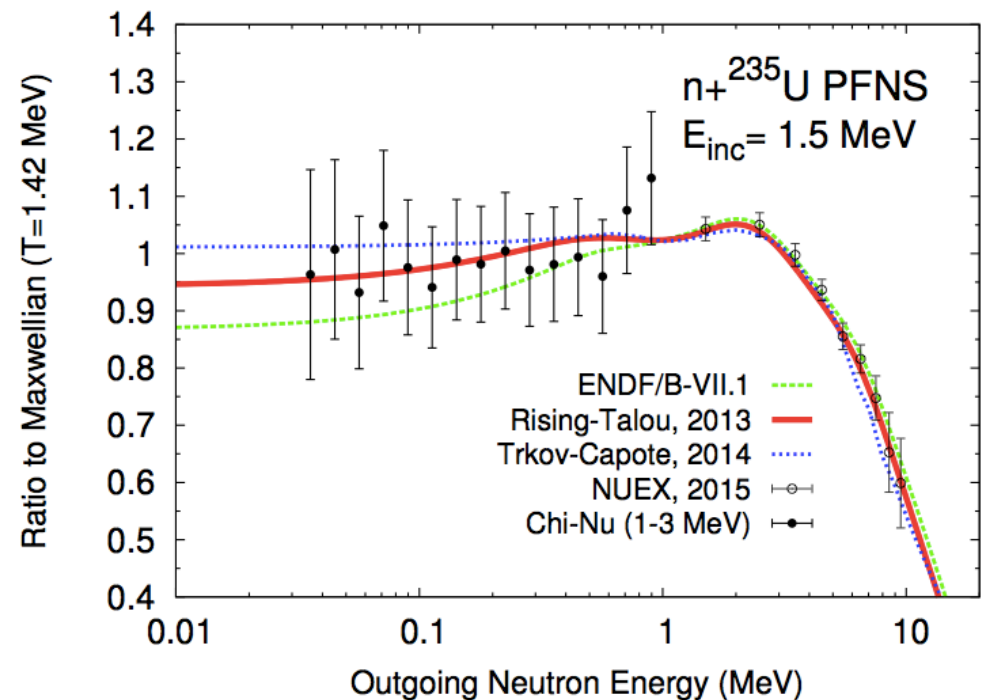
## 2015-16 LANSCE Run Cycle

- 100Hz accelerator operation
  - Digital data acquisition upgrade completed and operational (even with  $^{239}\text{Pu}$ )
  - $^{235}\text{U}$  PFNS data taken below 1 MeV outgoing taken, enabling us to reduce uncertainties
  - $^{235}\text{U}$  PFNS data above 1 MeV also taken in early 2016
  - Some  $^{239}\text{Pu}$  data taken, with a new PPAC from LLNL with better fission/alpha discrimination
- 
- Preliminary results from last run cycle have been circulated
  - Draft of results from the new data will be shared with evaluators soon!

## Chi-Nu (preliminary) data

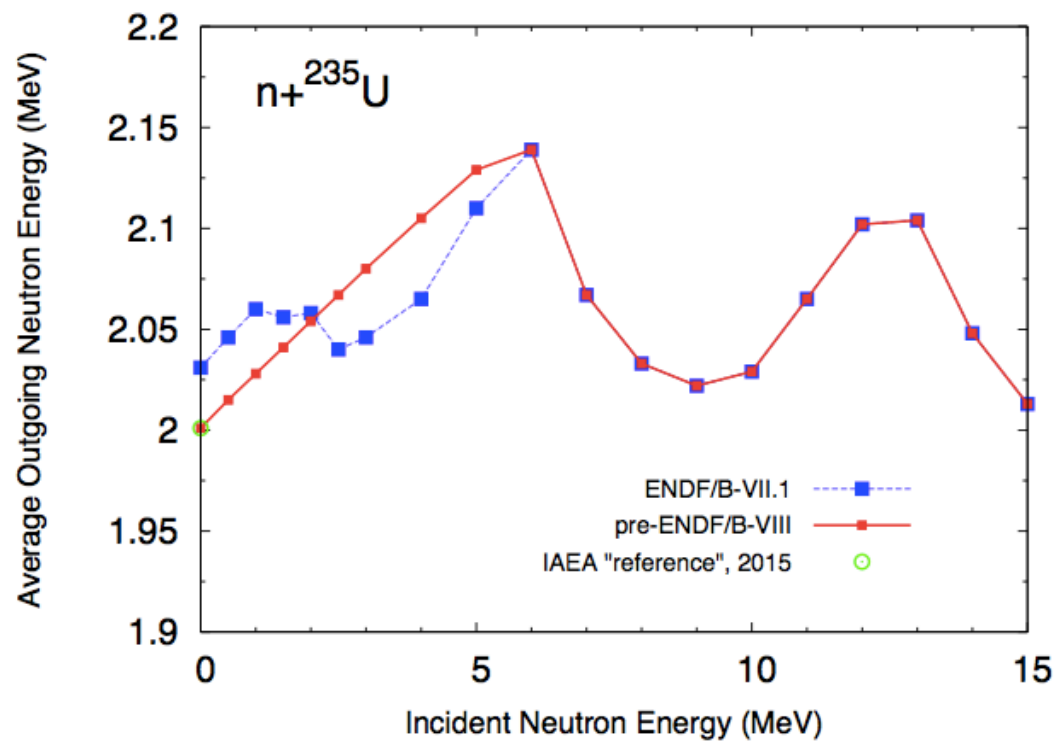


## NUEX data (Lestone)



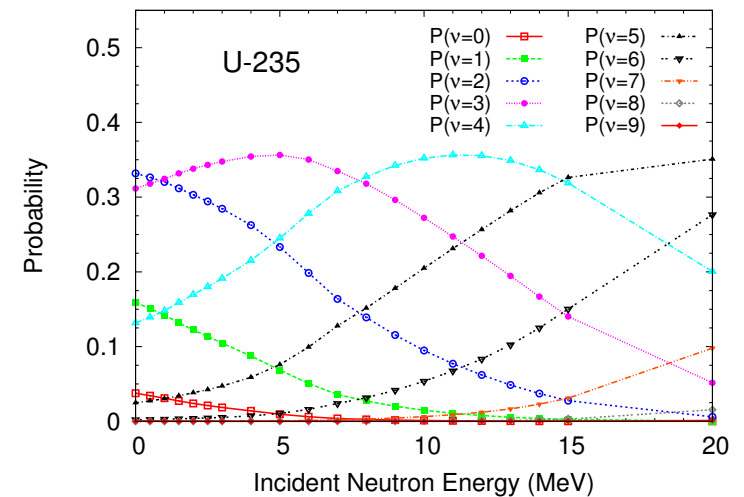
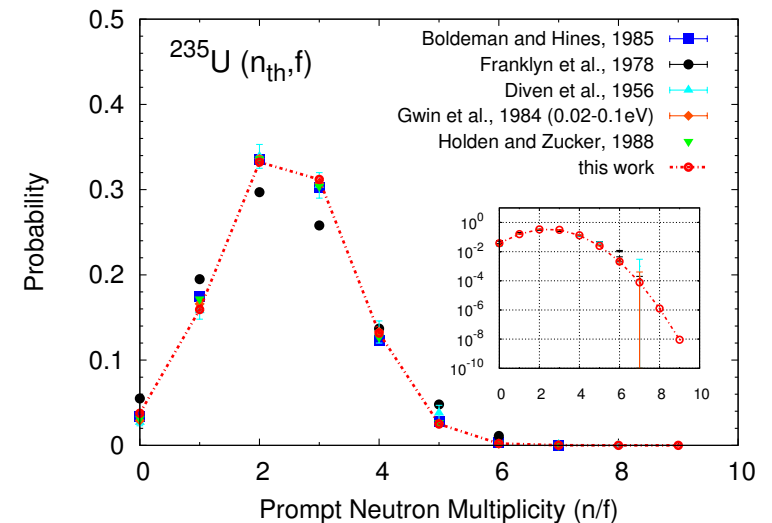
## $\langle E_{\text{out}} \rangle$ vs. $E_{\text{inc}}$

- Fixes “peculiar” behavior near 3 MeV
- Still need update at higher energies (Neudecker)

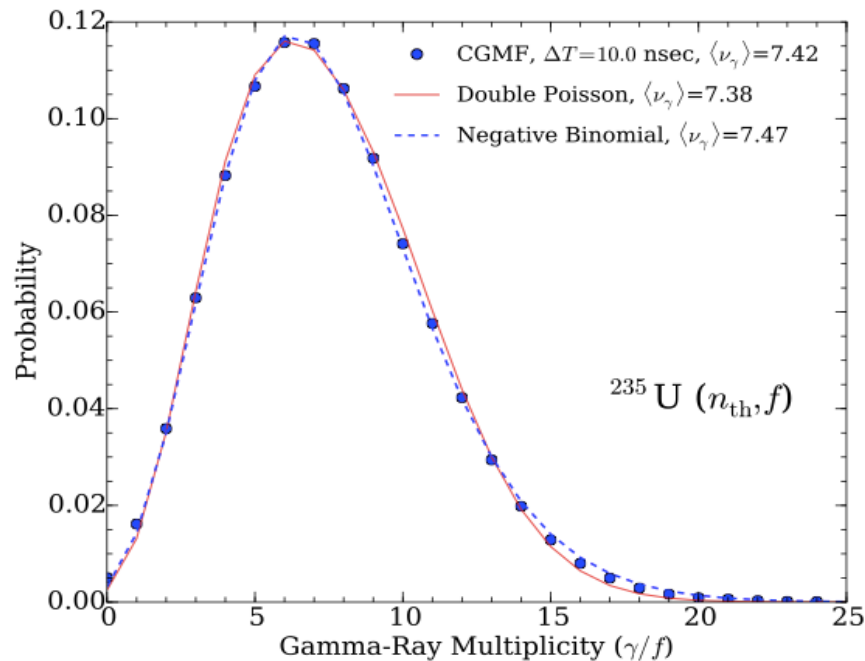


## $P(\nu)$ , $\chi(\nu)$

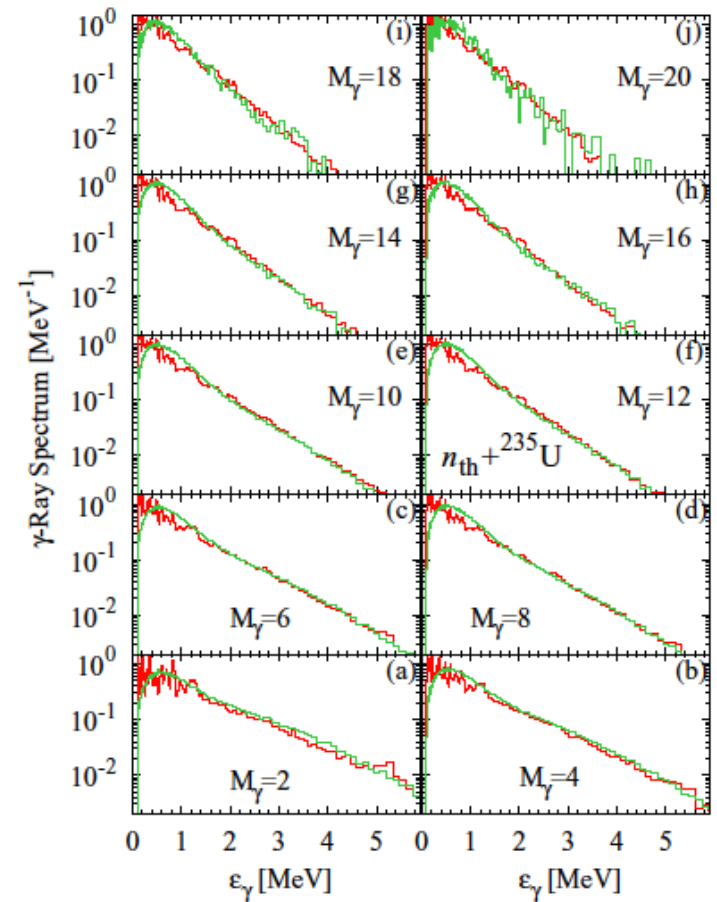
- New ENDF format accepted for  $P(\nu)$  and  $\chi(\nu)$
- $P(\nu)$  calculated using Terrell's formula, and compared to limited data by Frehaut
- CGMF calculations for  $\chi(\nu)$  – no easy “re-normalization” to ENDF-evaluated average PFNS; done at thermal energy only for now
- Will attempt to include new data into Nov. 2016 file



## What about $P(\nu_\gamma)$ and $\chi(\nu_\gamma)$ ?



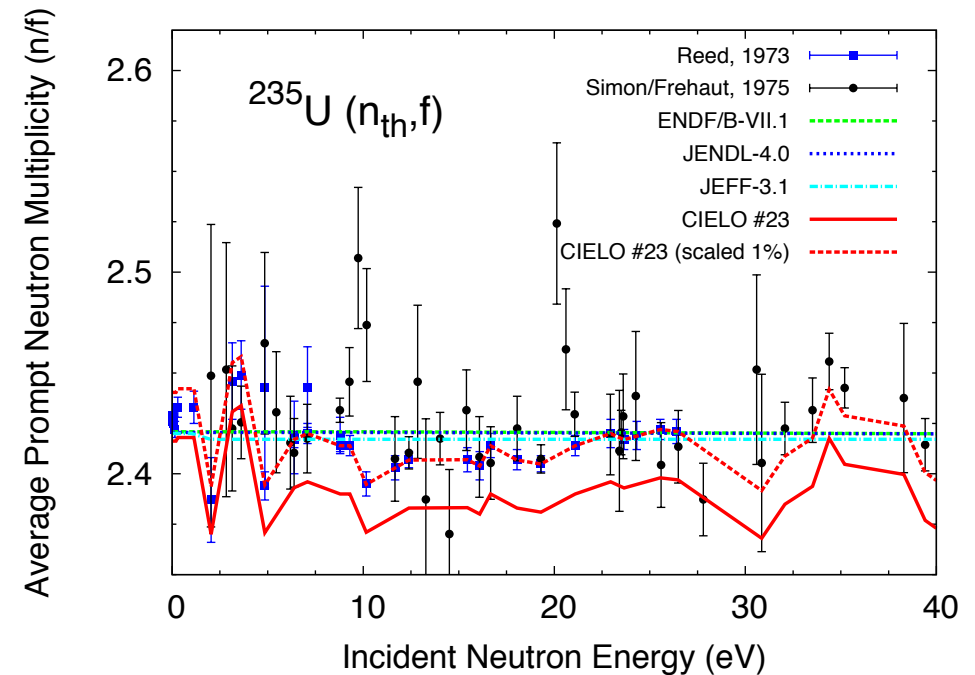
- Include new data into Nov. 2016 file? Would require ENDF format extension



Comparison of CGMF calculations with parameterized model of Jandel representing DANCE data

# Prompt Neutron Multiplicity

- **From IAEA's latest file:**
  - “Prompt nu-bar evaluated by V. Pronyaev, based on Reed data from C00-3058-39, normalized to thermal value of 2,41161. Simon data were measured rel. to  $^{252}\text{Cf(sf)}$  normalized at 10-27 eV on Reed's data (10-Jan-2016). The dip in the data around 30 eV was suppressed. Thermal value was increased by 0.0046 below 0.2 eV.”



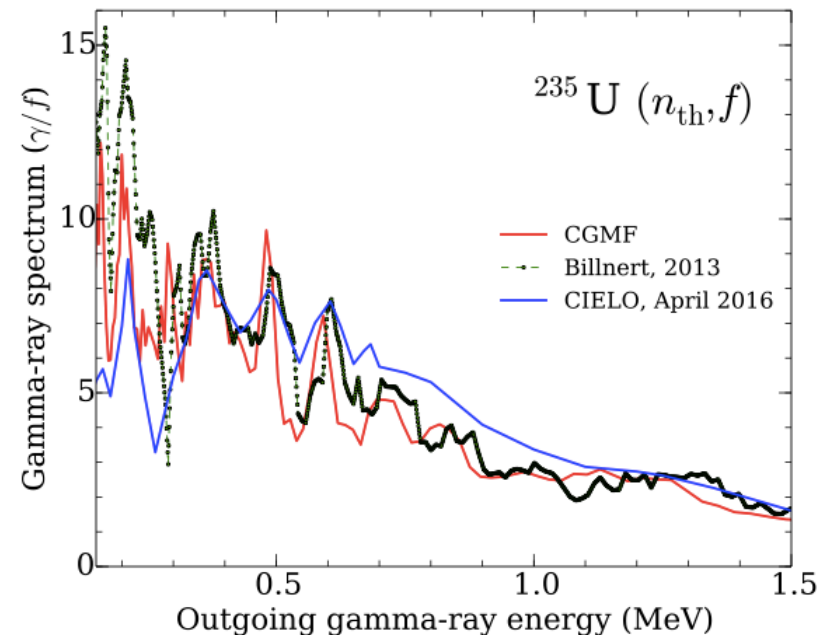
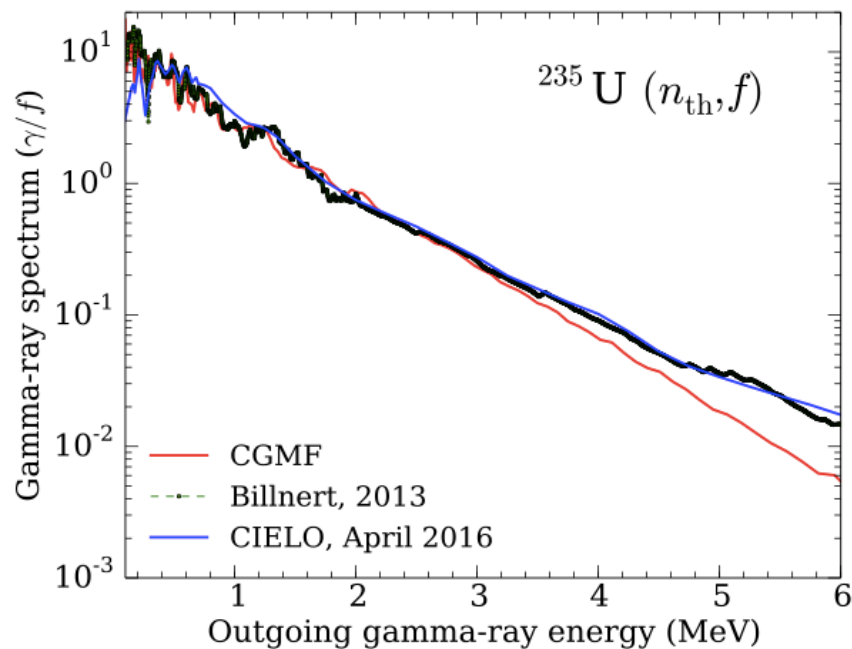


## Prompt Fission Gamma-Ray Spectrum (PFGS)

- **Current CIELO file:**
  - PFGS based on Verbinski data (1970) at thermal
  - Reproduced identically at 20 MeV
- **New model capability**
  - CGMF, Monte Carlo Hauser-Feshbach applied to the decay of fission fragments → PFGS can be obtained for the first time
- **New experiments**
  - Billnert et al., IRMM, Geel, 2013 (thermal)
  - Chyzh et al., DANCE, LANL-LLNL, 2013 (thermal)
  - Lebois et al., LICORNE, IPN Orsay, 2015 (fast) – preliminary – almost no change in the fast range compared to thermal

## Proposed PFGS for B-VIII.β0:

- Thermal from Billnert et al.
- CGMF calculations up to 20 MeV (still working on higher-energy calculations)
- Fix double-counting below 1.09 MeV



## Time-Dependent PFG Spectrum and Multiplicity

- “Late prompt”  $\gamma$ -rays emitted from isomeric states in fission fragments
- No format to handle this physics in ENDF right now

