Lawrence Livermore National Laboratory

Capture Gamma-ray Modeling

Neil Summers

Collaborators

Brad Sleaford, Aaron Hurst LLNL, Rick Firestone, Shamsu Basunia LBNL, Hee dong Choi LBNL/Seoul Nat. Uni.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

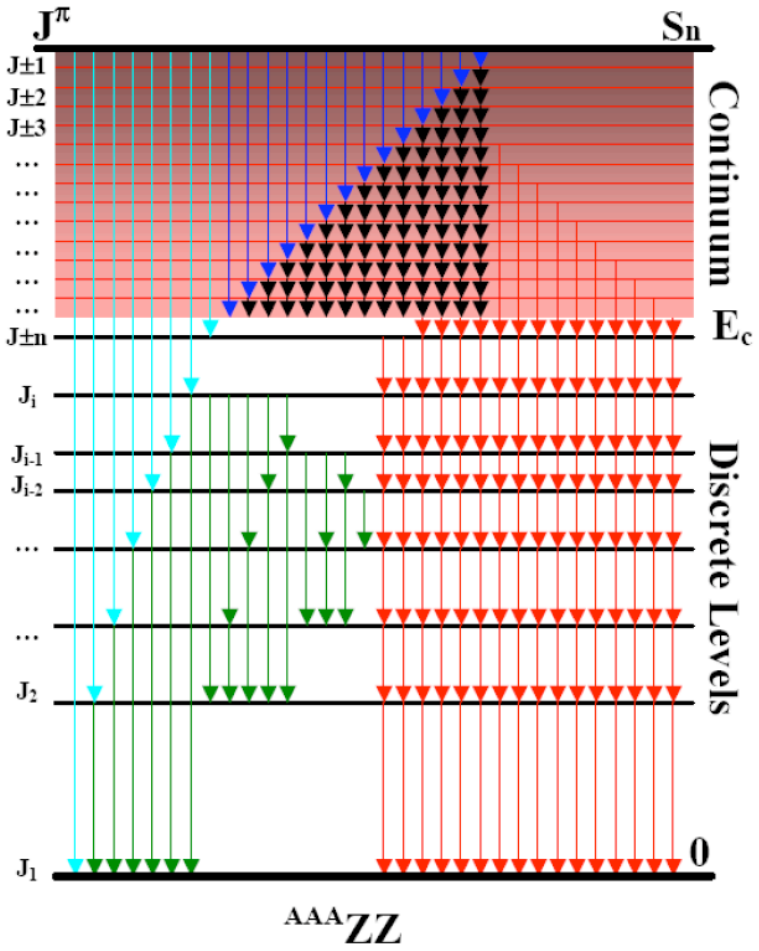
Improved Capture Gamma Spectra Needed in Non-Proliferation Programs

- Goal
  - Improved capture gamma spectra needed in transport codes for national security interests
- Method
  - Use statistical decay code DICEBOX to model capture gamma cascade and tune input parameters to experimental data from EGAF project
- Final Products
  - Improved RIPL level schemes
  - ENDF evaluations with primary gammas, improved gamma spectra, improved thermal cross sections

Simulation of gamma cascade for thermal neutrons

DICEBOX Monte Carlo Code

Becvar & Krticka



DICEBOX generates (n,γ) level scheme simulations (nuclear realizations) based on statistical model level densities $\rho(E_i, J^\pi_i)$ and γ-ray transition probabilities Γ_{if} where

a) All levels and γ-rays below E_{crit} are taken from experiment.

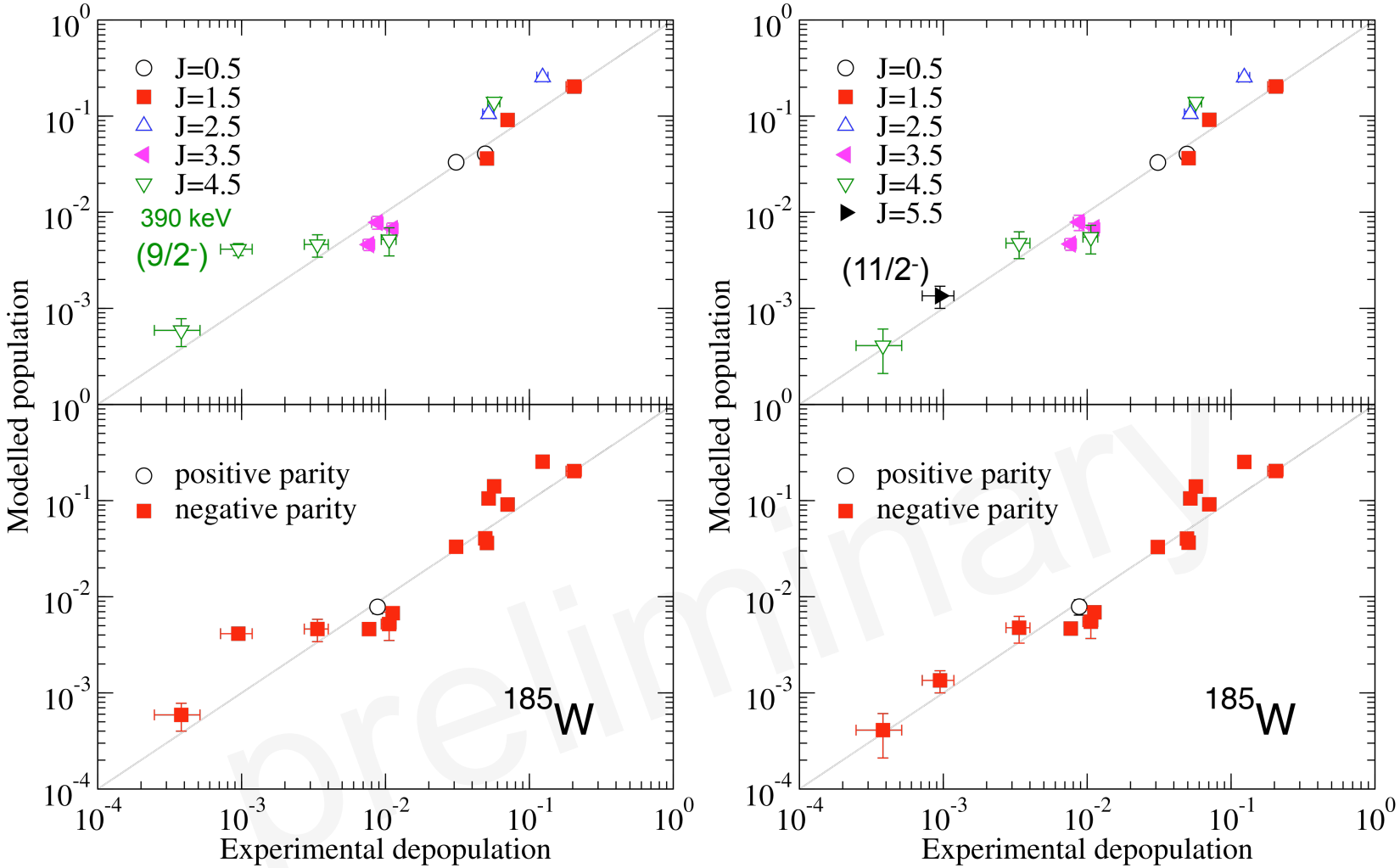
b) All levels and γ-rays above E_{crit} are generated randomly from level density and PSF models

c) Primary γ-ray cross sections are taken from experiment when known.

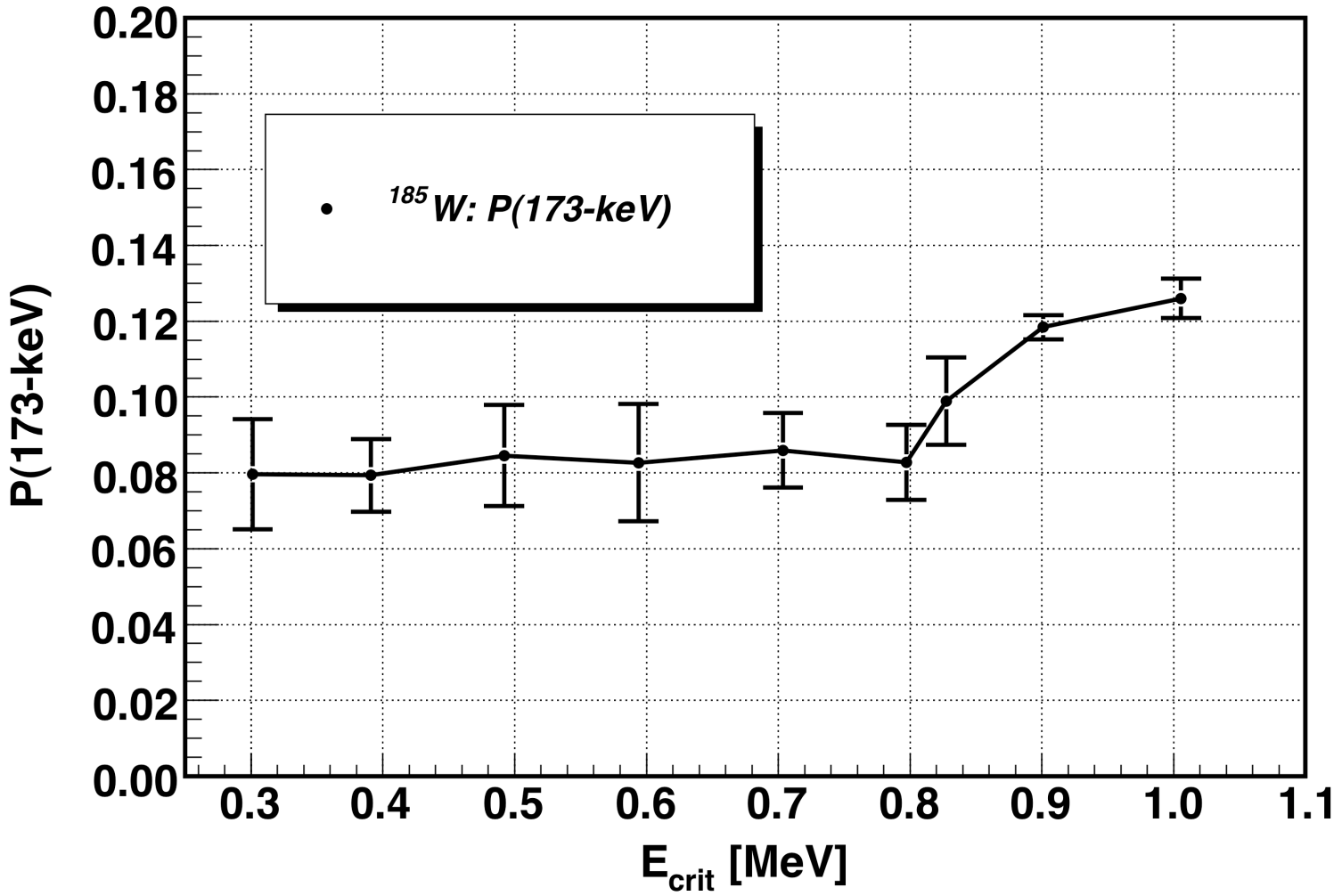
Typically 30,000 capture state γ-ray decay cascades are randomly generated for each nuclear realization.

50 separate realizations are usually averaged to get the statistical variation in the simulated level feedings.

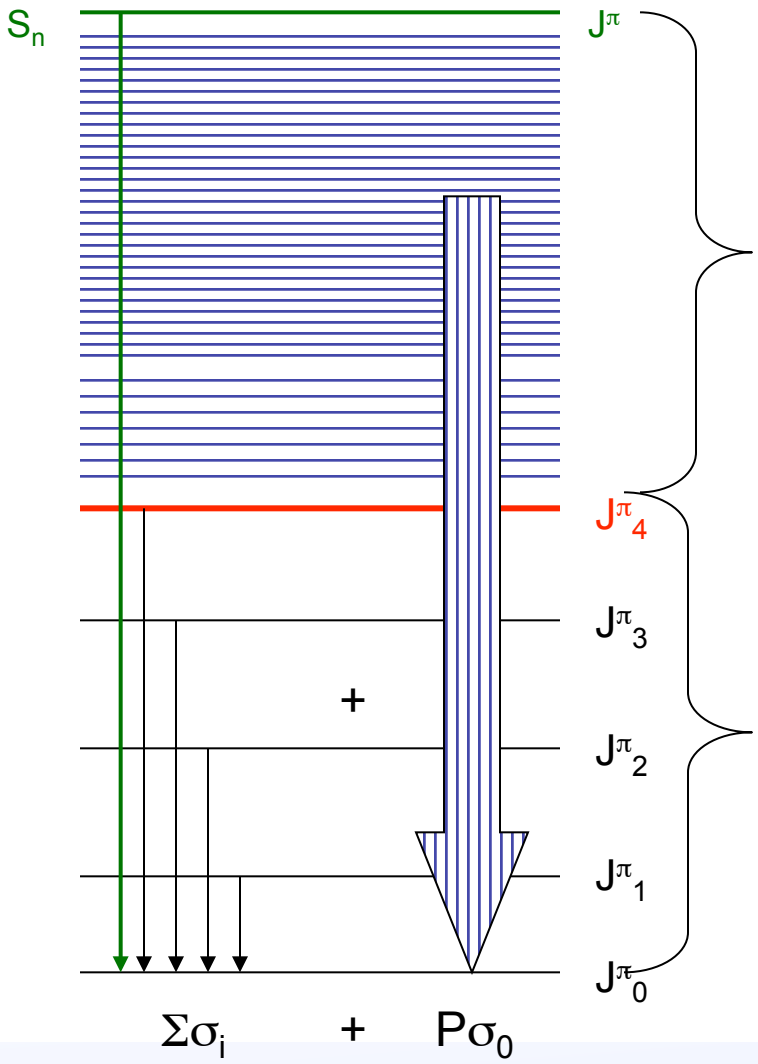
Determining uncertain spins



Determining critical energy below which the level scheme is complete



Total capture cross section



- New thermal neutron capture cross sections
- Sum of
  - Measured experimental gamma cross sections which feed the ground state (primary+feeding below E_{crit}) ($\Sigma\sigma_i$)
  - Modeled population feeding from continuum to ground state (P)
- $\sigma_0 = \Sigma\sigma_i + P\sigma_0$ ➔ $\sigma_0 = \Sigma\sigma_i / (1-P)$

Making ENDF libraries

- Tune input parameters to fit thermal neutron capture data
- Experimental data for discrete lines from thermal neutron capture combined with model calculations of unresolved quasi-continuum
- Model calculations for incident neutrons with higher energies
  - CASINO, sister code which can model gamma cascade for energies up to resonance region.
  - EMPIRE/TALYS being modified to include primary gammas
  - Can use surrogate data (where available) to check if model calculations consistent at higher energies
- Ideal situation
  - Work with evaluators to produce new evaluation based on
    - updated RIPL file of level scheme
    - primary gamma data from EGAF
    - New thermal capture cross sections
    - photon strength function and level density tuned parameters