

Experimentally Constrained $^{73}\text{Zn}(n,\gamma)^{74}\text{Zn}$ Reaction Rate

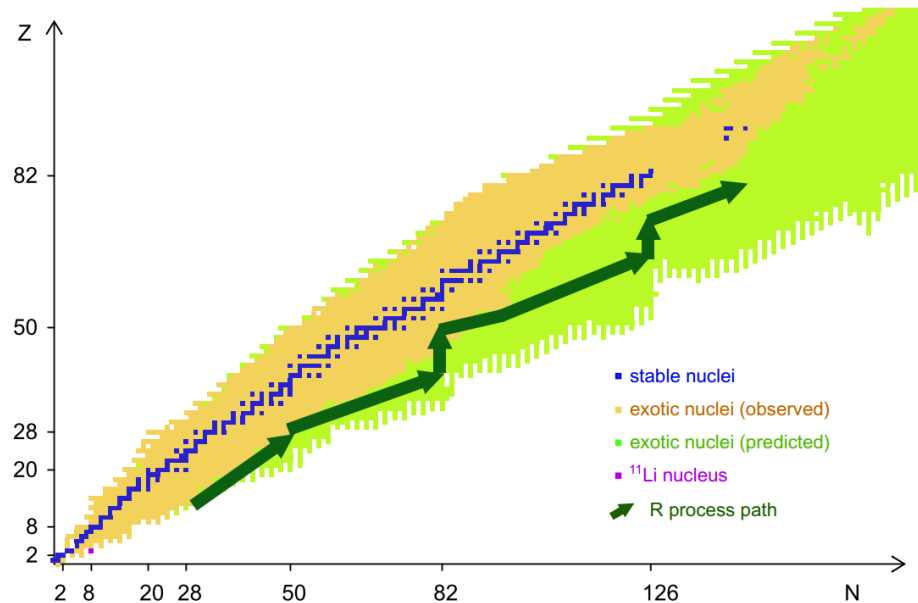
Rebecca Lewis
Oslo Workshop 2017

Outline

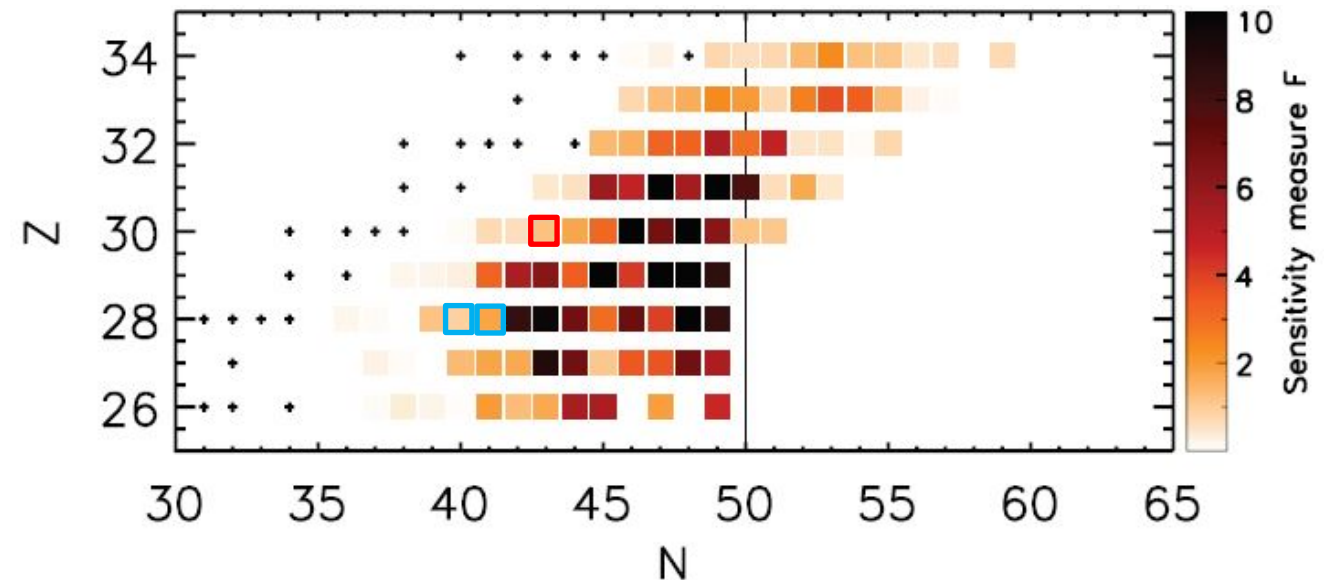
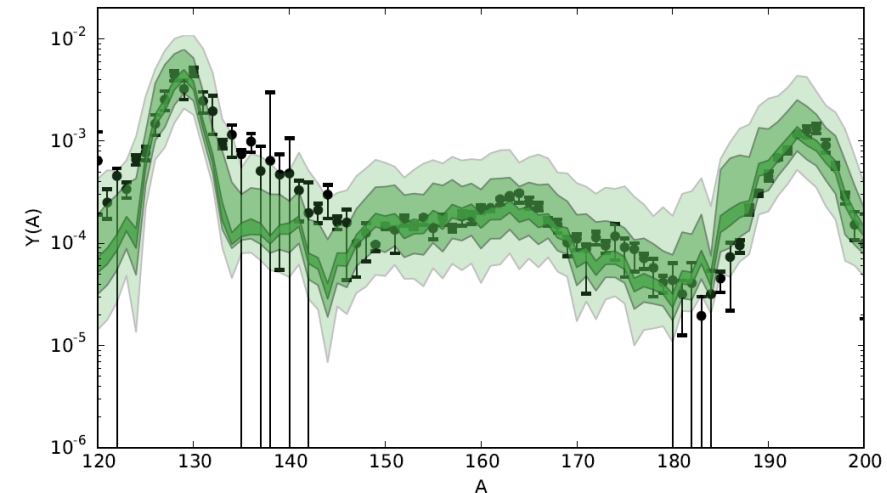
- Neutron capture cross sections in the r-process
- NSCL experiment
- $^{73}\text{Zn}(n,\gamma)^{74}\text{Zn}$ cross section and reaction rate
- Comparison of TALYS and CoH

Neutron capture in the r-process

- Uncertain nuclear physics inputs make modeling r-process abundances uncertain
 - Neutron capture rates not known
- Weak r-process nuclei ($A \sim 80$ peak) important
- Want to investigate changes in rates over whole region



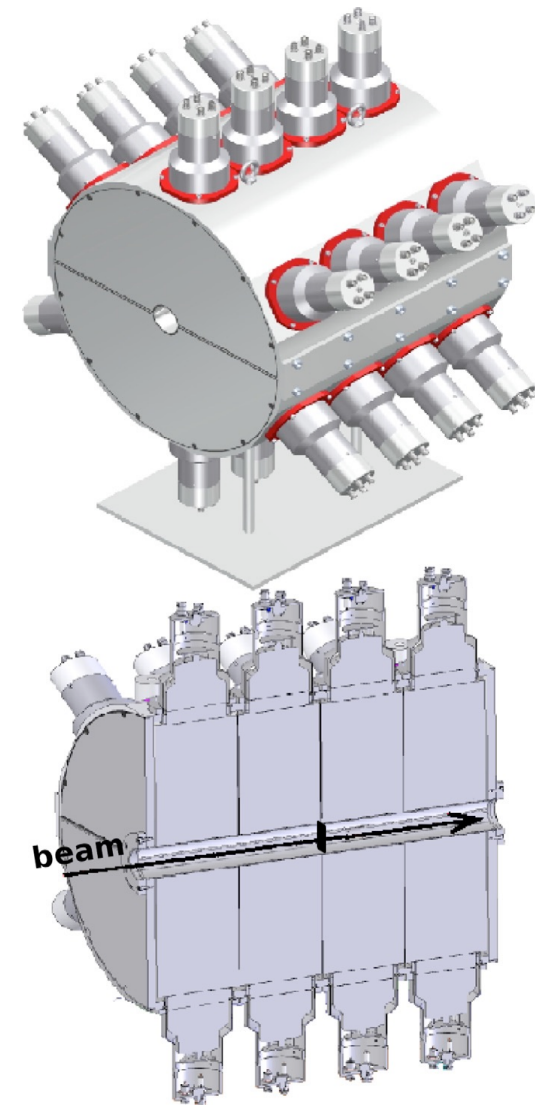
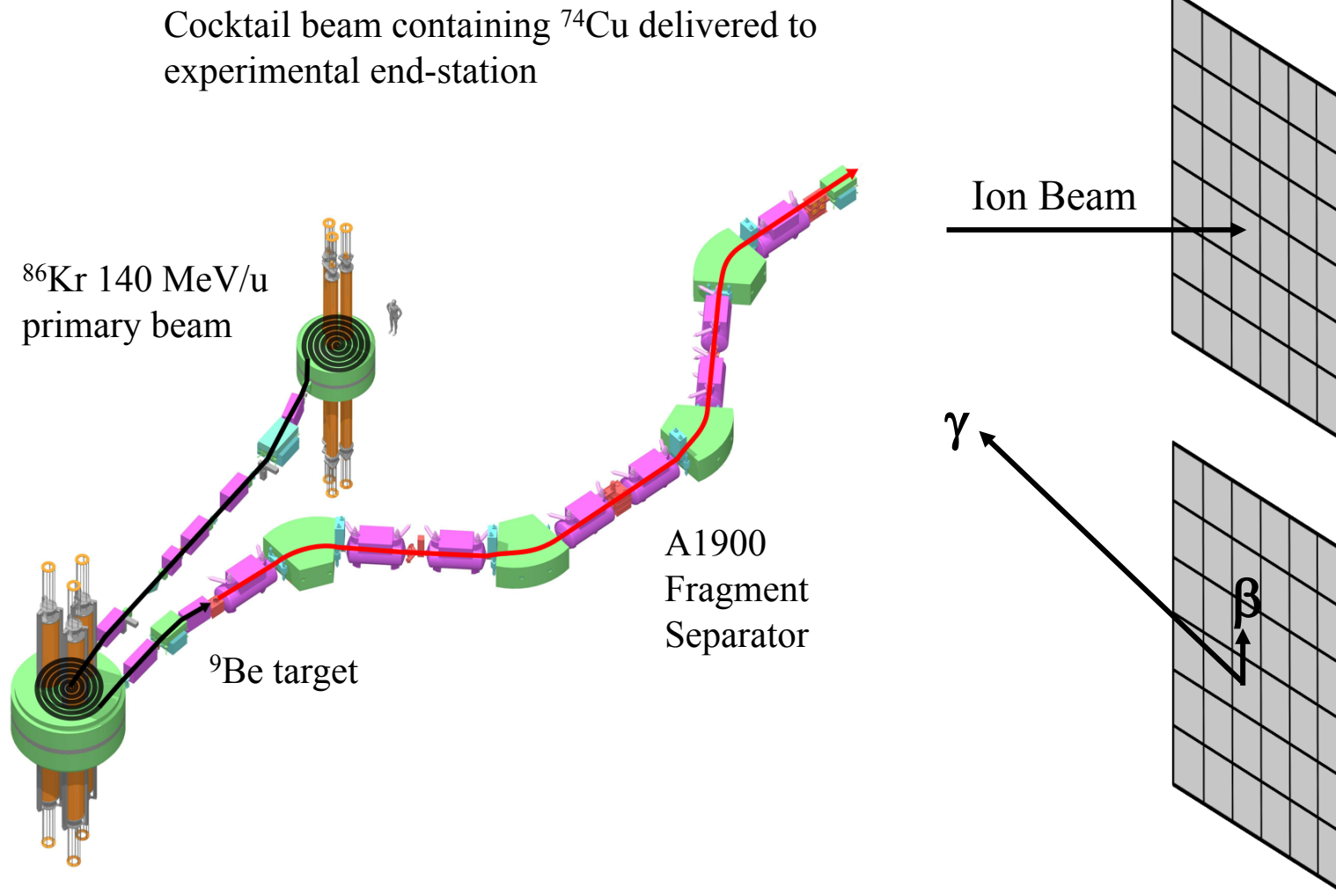
T. Otsuka, Phys. Scr. **T152**, 014007 (2013).



Liddick et. al., PRL **116**, 242502 (2016).

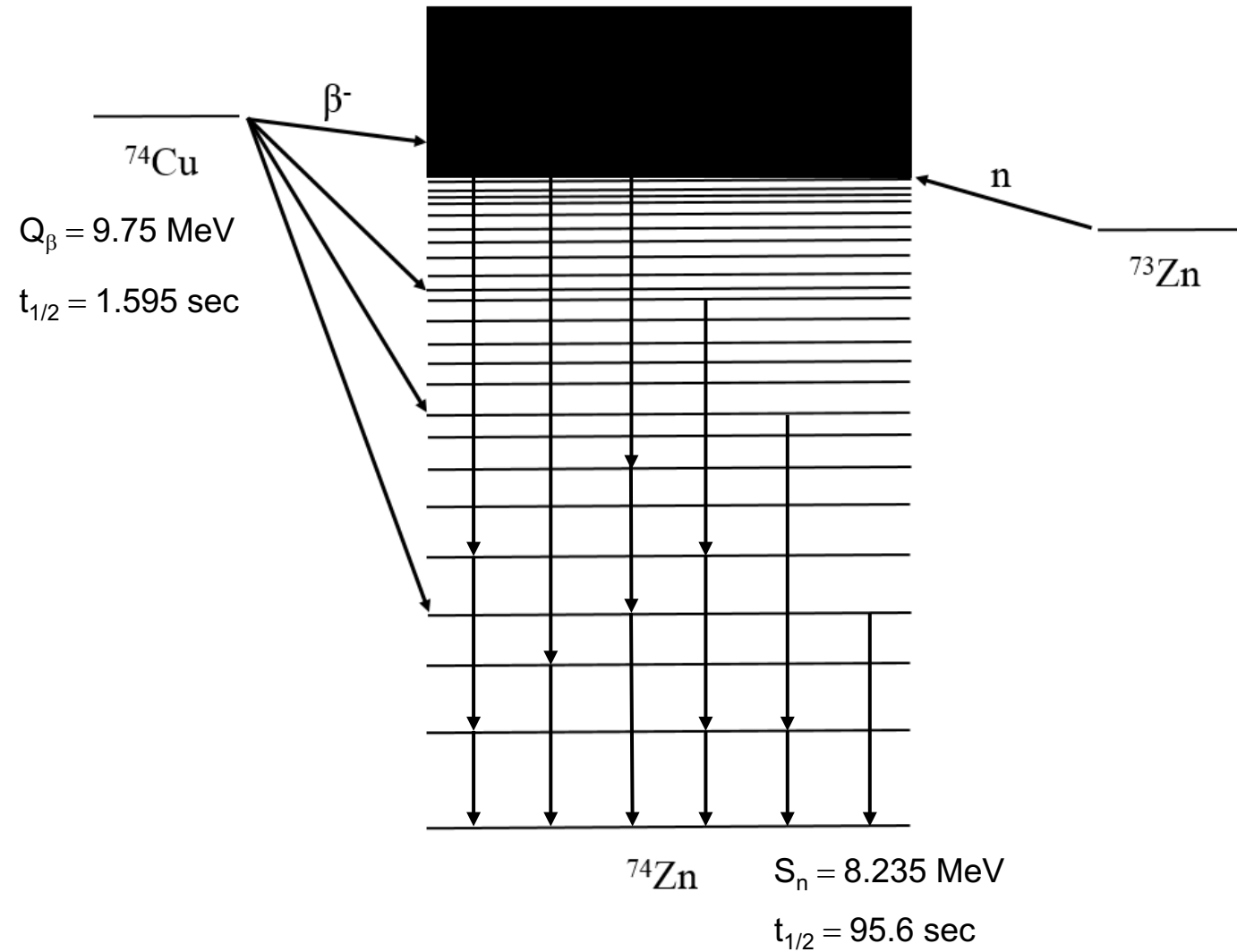
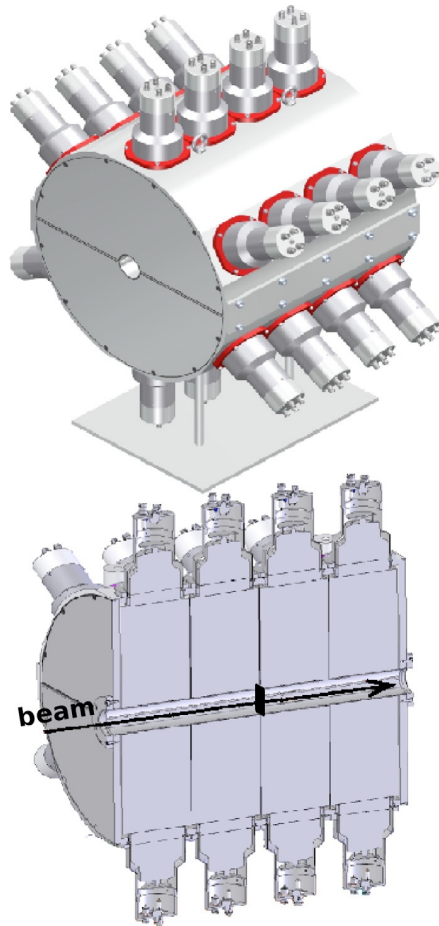
Surman et. al. AIP Adv. **4**, 041008 (2014)

NSCL Experiment



Simon et. al. Nucl. Inst. Meth. A. **703**, 16 (2013)

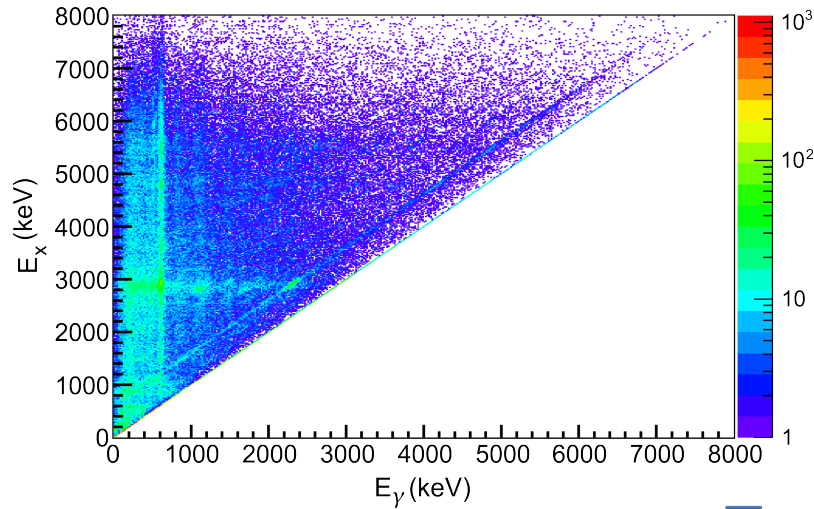
Total Absorption Spectroscopy



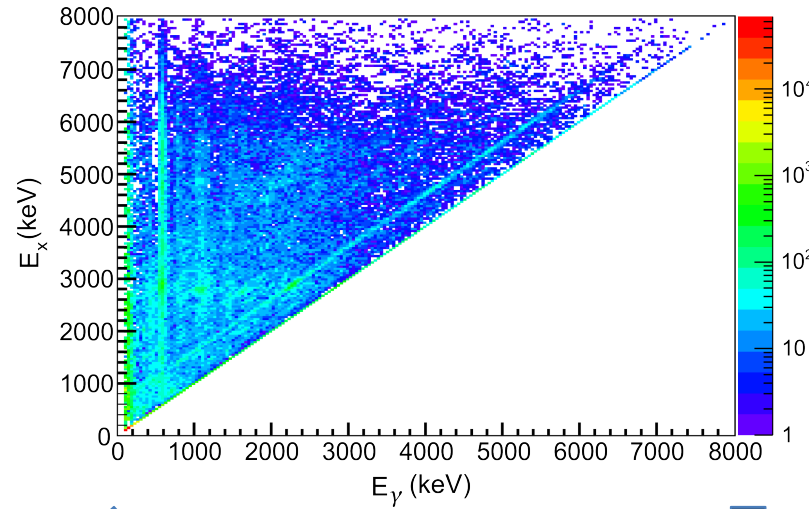
Simon et. al. Nucl. Inst. Meth. A. **703**, 16 (2013)

β -Oslo method

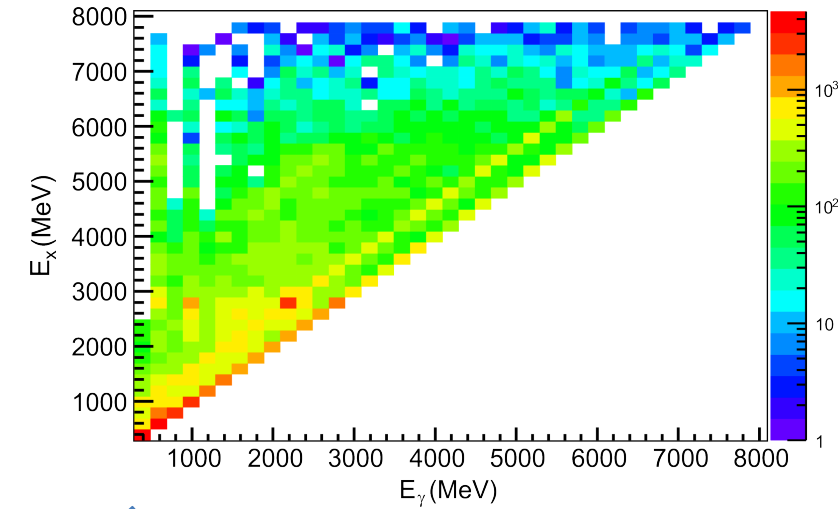
Raw



Unfolded



Primary



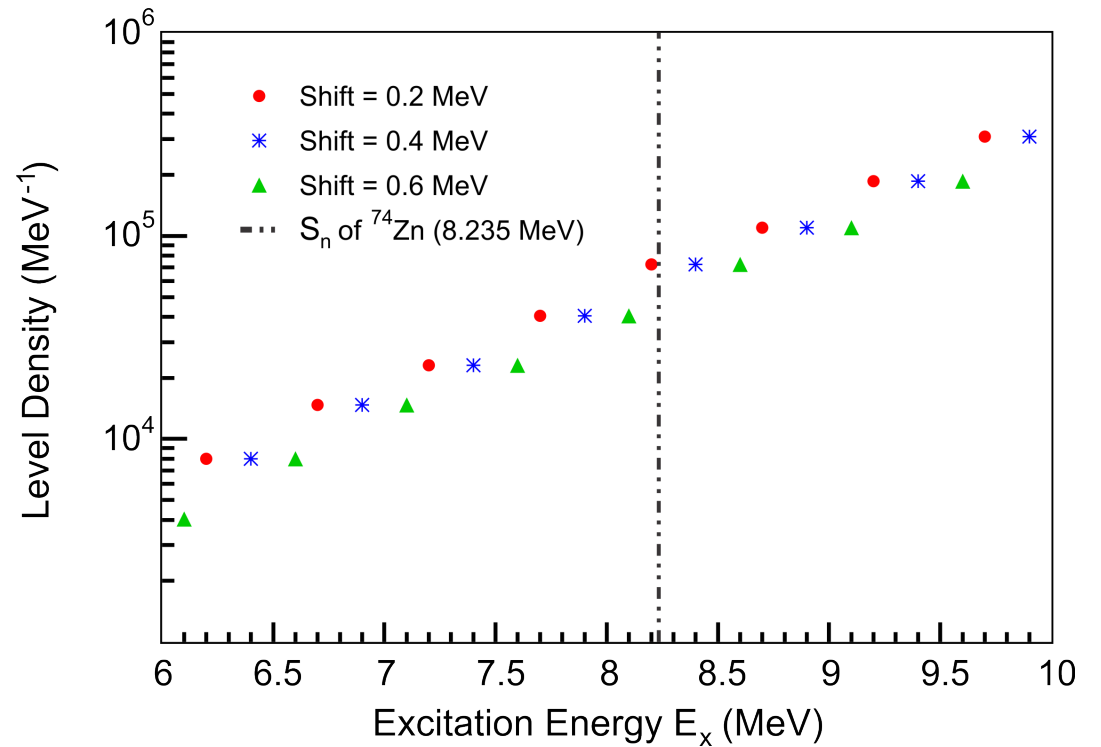
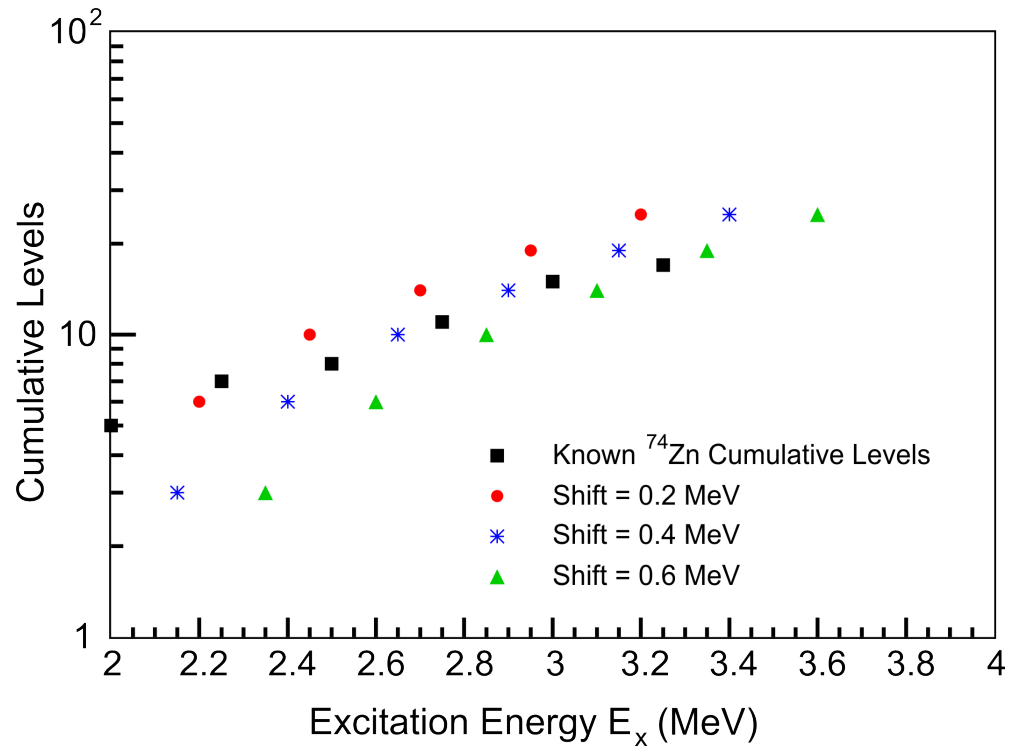
Nuclear Level Density (NLD)
Gamma Strength Function (γ SF)

Guttormsen et. al. Nucl. Inst. Meth. A. **374**, 371 (1996)

Guttormsen et. al. Nucl. Inst. Meth. A. **255**, 518 (1987)

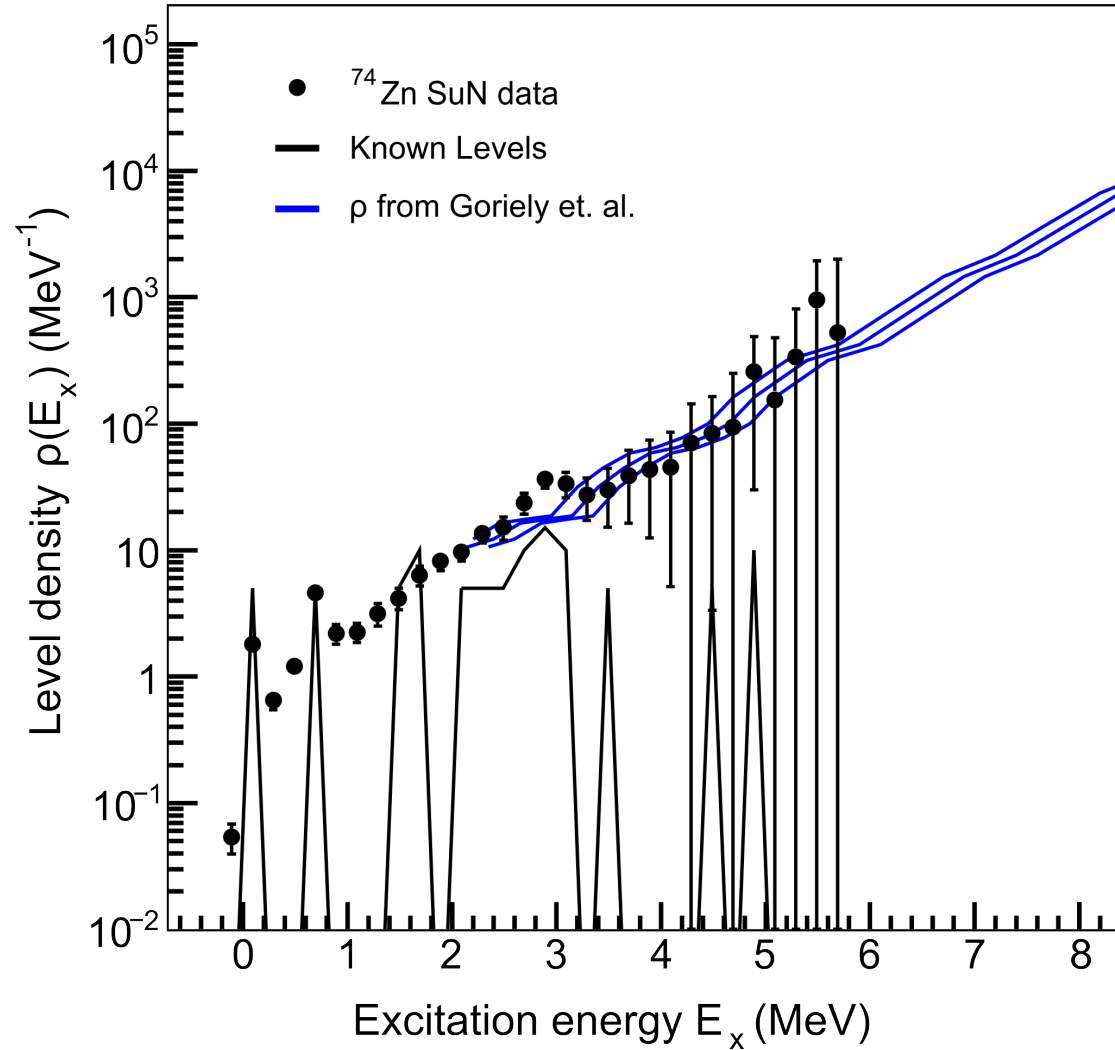
Schiller et. al. Nucl. Inst. Meth. A. **447**, 498 (2000)

NLD Normalization



Goriely et. al. PRC **78**, 064307 (2008)

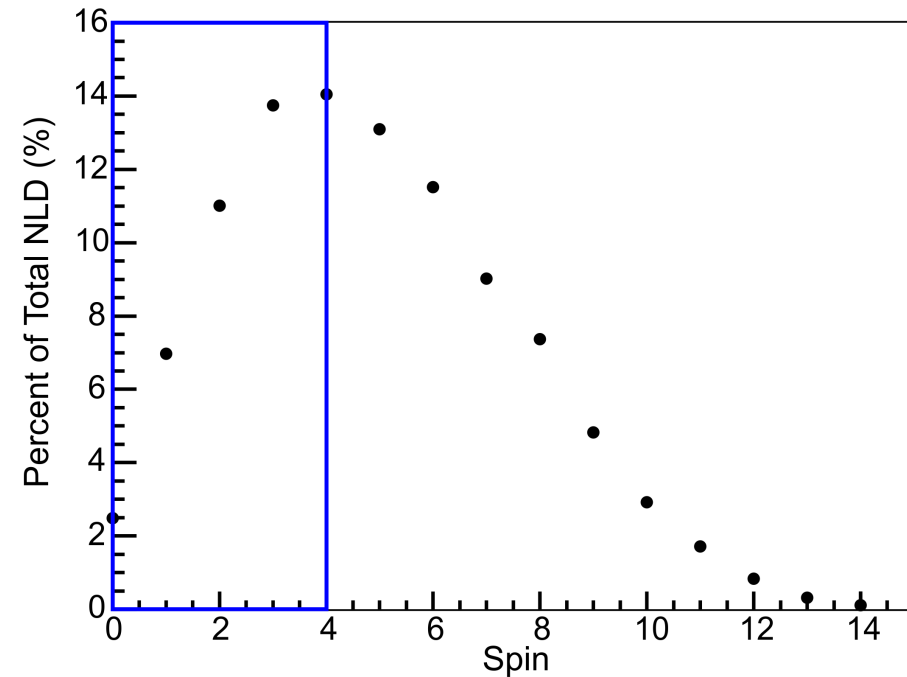
Full Normalized NLD



Goriely et. al. PRC **78**, 064307 (2008)

Reduced $\rho(S_n)$

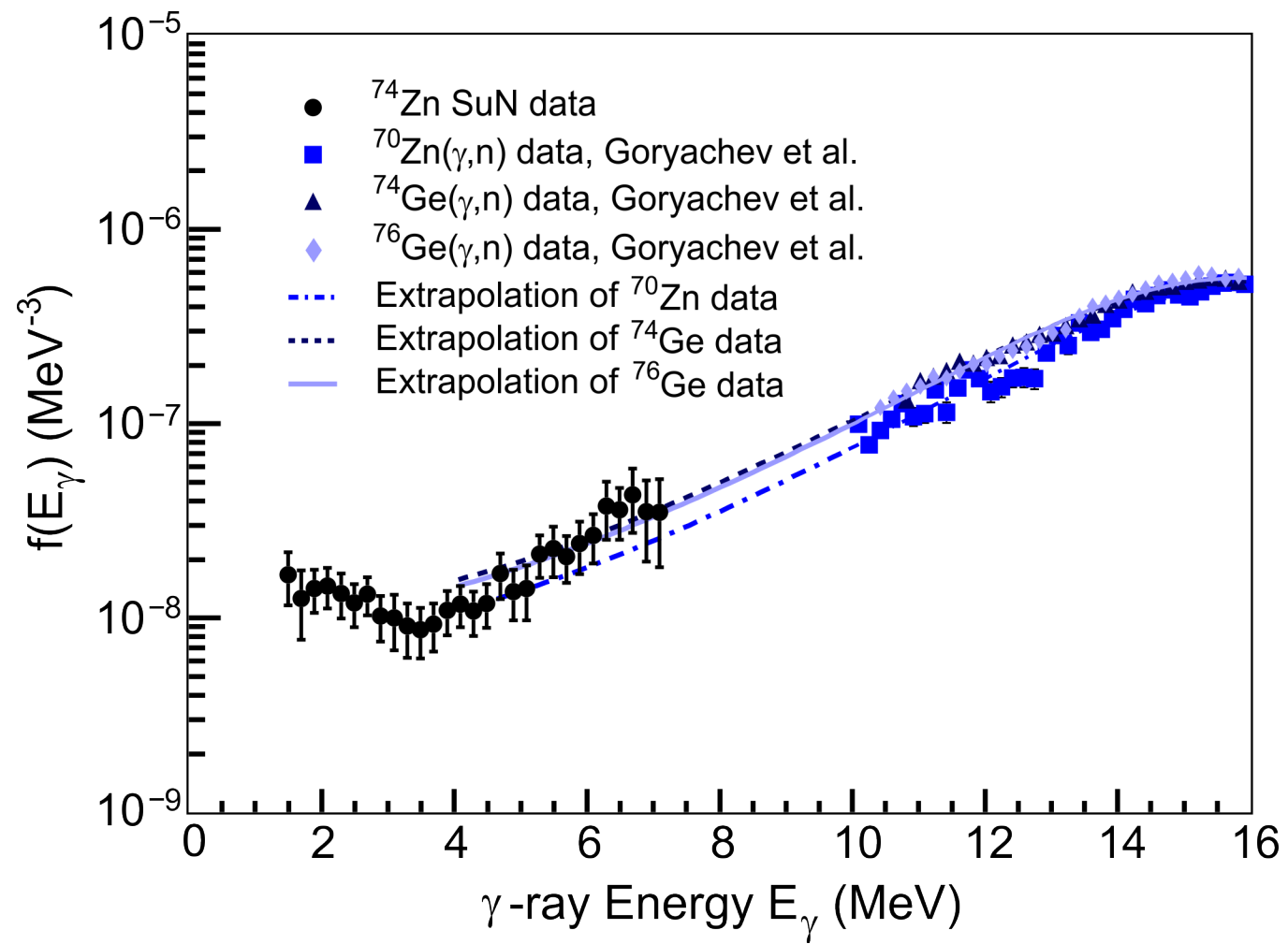
- ^{74}Cu ground state: 2^-
- After β decay: 1^- , 2^- , 3^-
- After one γ transition: $0^{+/-}$, $1^{+/-}$, $2^{+/-}$, $3^{+/-}$, $4^{+/-}$
- Final spin population at S_n :
48% of total NLD



	Full $\rho(S_n)$ (MeV ⁻¹)	2^- $\rho(S_n)$ (MeV ⁻¹)
0.2 MeV (upper limit)	6360	3070
0.4 MeV shift (central value)	5200	2510
0.6 MeV shift (lower limit)	4230	2040

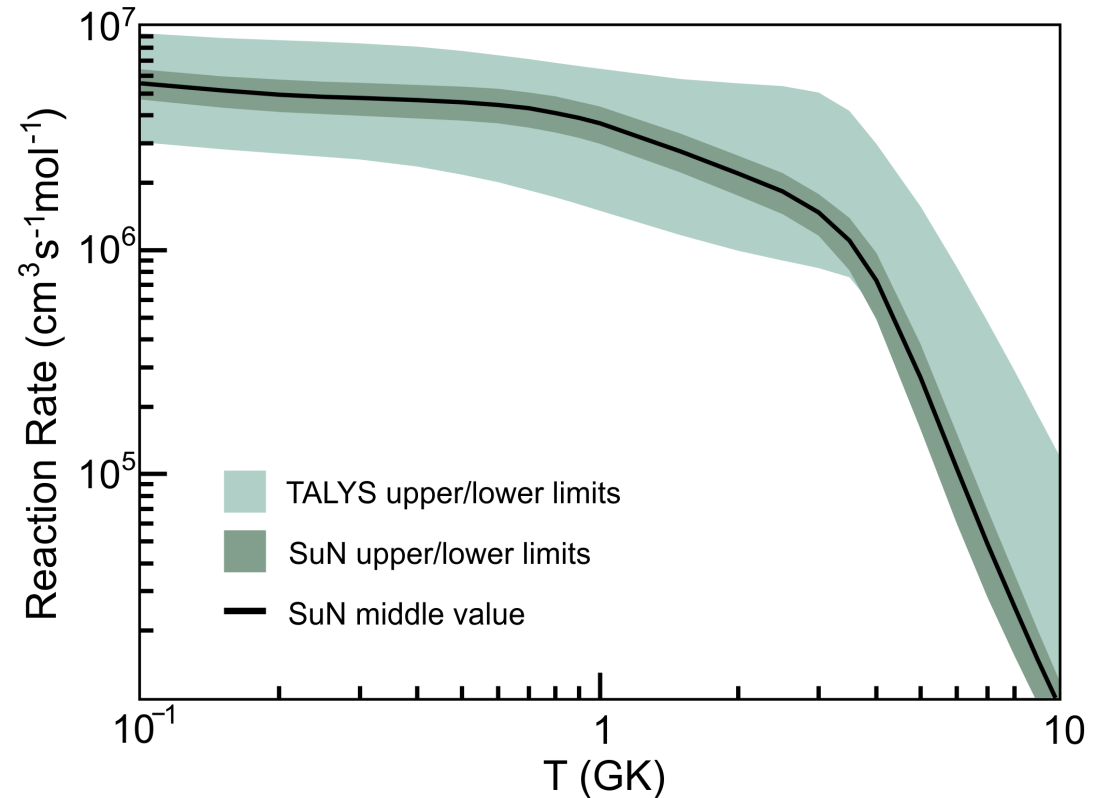
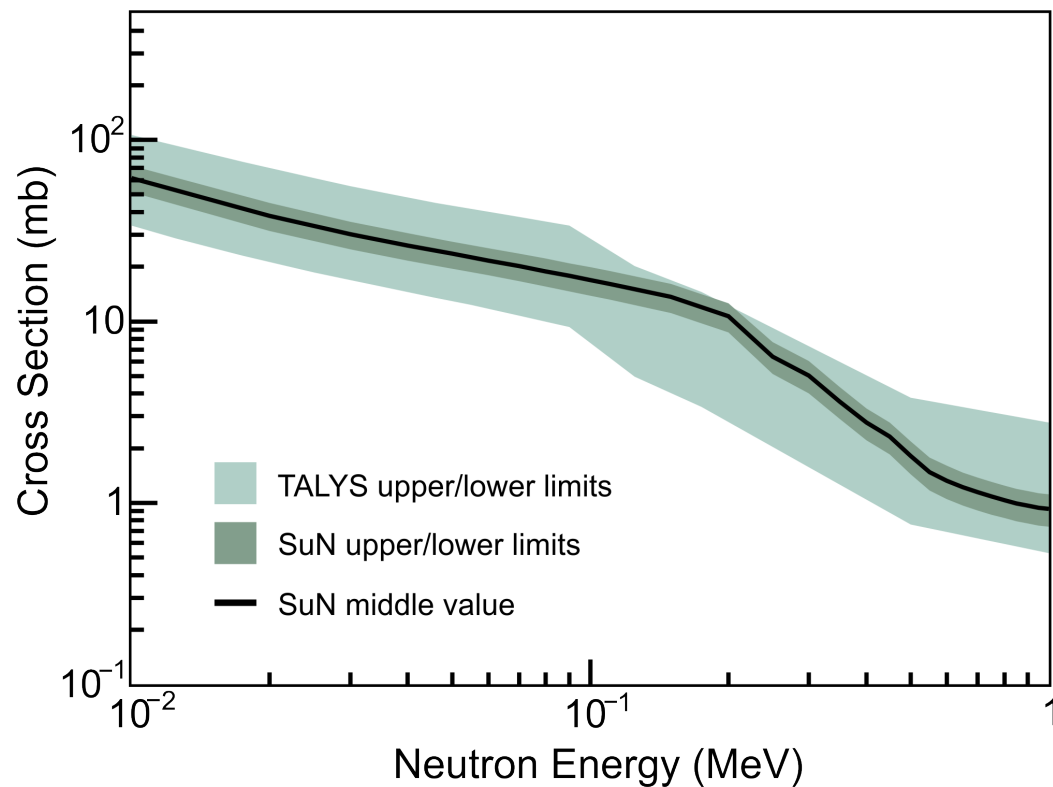
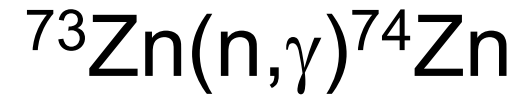
Goriely et. al. PRC **78**, 064307 (2008)

Normalized γ SF



Goryachev et. al. Vopr. Teor. I Yad. Fiz. **8**, 121 (1982)

Constrained Cross Section and Reaction Rate

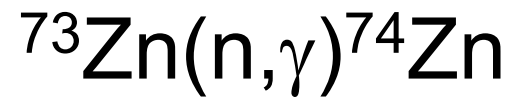


Koning et. al. Proceedings of the Int. Conf. on Nucl. Data for Science and Tech., EDP Sciences, 211 (2008)

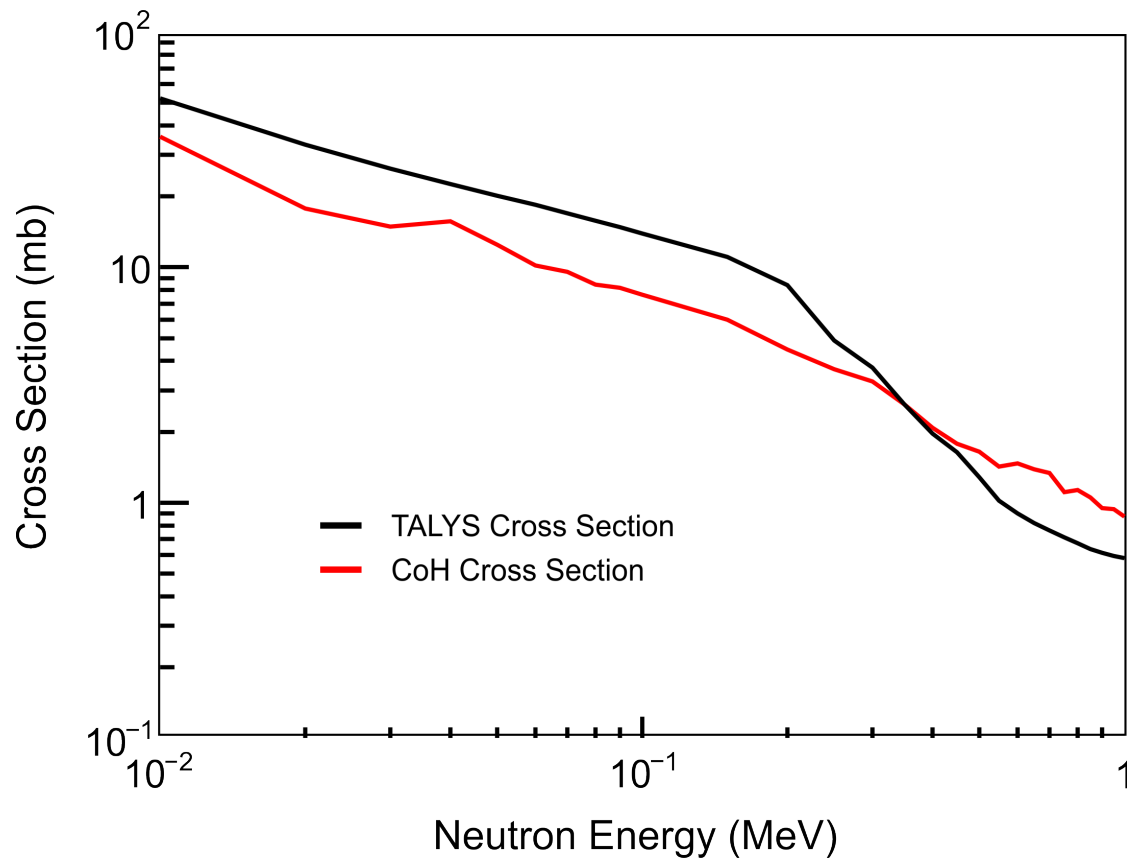
Comparing Hauser-Feshbach Codes

	TALYS	CoH
Level density file	Total spin-dependent LD, assumes equal parity distribution (can be read from a tabulated file)	Parity- and spin-dependent LD (can be read from a tabulated file)
Gamma strength function	GLO for E1 and SLO for M1, can provide GDR parameters but their values are limited	GLO for E1 and SLO for M1, can provide GDR parameters that are not limited
Normalization	SF norm can be turned off with flag	SF norm uses Γ_γ value, can only be turned off in source code
Known levels, spins, parities	Assigns spin/parity to unknowns using statistical spin rules (don't always match suggested values), default is to create theoretical levels above known until N=100	Doesn't use levels with unknown spin/parity unless told to do so, no default theoretical levels
Neutron energies	Provided in a file, can handle small binning (eg. 10 keV above 100 keV)	Provided in input, needs larger binning (eg. min 50 keV above 100 keV)
Preequilibrium	Adds an exciton model by default (can be turned off)	Separate calculation, slightly different parameterization of exciton model

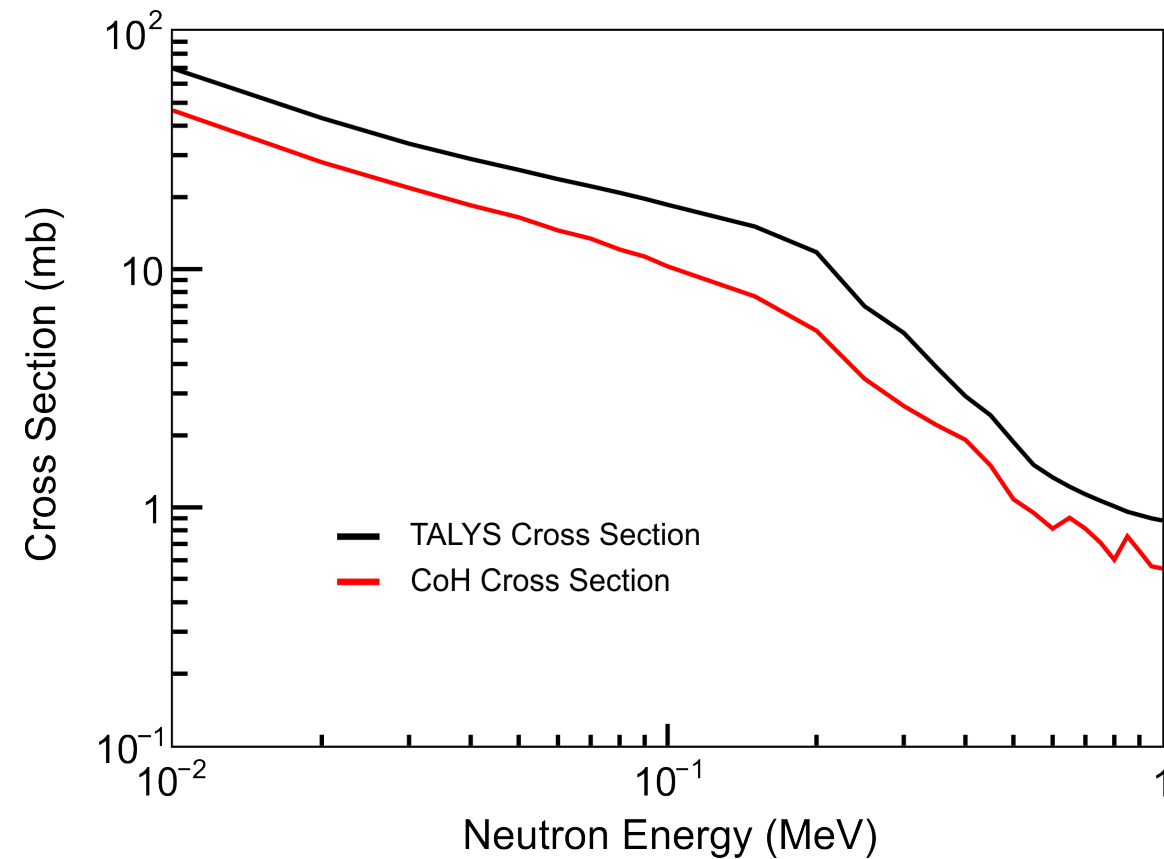
Cross Section Comparison



Using Defaults



Final Results



Conclusions

- $^{73}\text{Zn}(n,\gamma)^{74}\text{Zn}$ cross section and reaction rate experimentally constrained for the first time
- Ensuring the same input in different reactions codes can be difficult
- Reaction codes can produce different cross sections even with the same input



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