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# TENDL-2019 and the Ni isotopes: what to expect

INDEN - International Nuclear Data Evaluation Network,  
Vienna, IAEA, December 2-5, 2019

- The new TENDL-2019 library
- Ni isotopes in the RRR
- Ni isotopes in the fast range
  - TALYS calculations
  - Optimization based on differential data

# TENDL-2019: new library

- Method: Quality evaluation, production automation, open source



https://tendl.web.psi.ch/tendl\_2019/tendl2019.html

T6 - OneDrive

TENDL-2019 nuclear data li...

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## TALYS-based evaluated nuclear data library

Home Reference & us Citations TALYS

**TENDL-2019**

“ We believe that our great goal can be achieved with systematism and reproducibility. We are so outside the box, that the box is a point”

### How to reference

### Sub-library files

1. Neutron
2. Proton
3. Deuteron
4. Triton
5. He3
6. Alpha
7. Gamma

### tar & Ace files

### Random files

### TENDL-2019: (release date: December 2019)

Last update: 5 November 2019

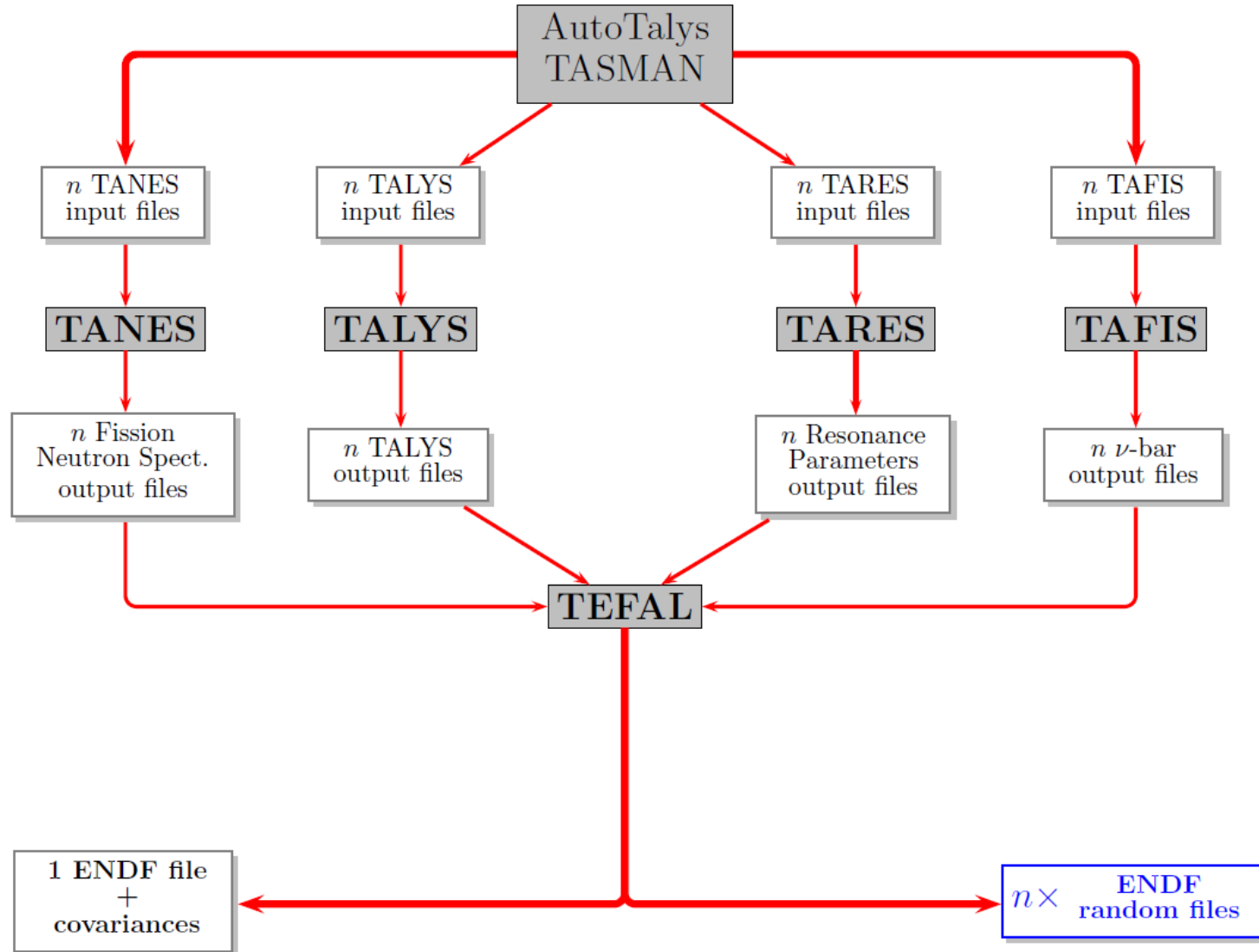
TENDL is a nuclear data library which provides the output of the TALYS nuclear model code system for direct use in both basic physics and applications. The 10<sup>th</sup> version is **TENDL-2019**, which is based on both default and adjusted TALYS calculations and data from other sources (previous releases can be found here: [2008](#), [2009](#), [2010](#), [2011](#), [2012](#), [2013](#), [2014](#), [2015](#), and [2017](#)).

Up to 2014, TENDL was produced at NRG Petten. Since 2015, TENDL is mainly developed at PSI and the IAEA (Nuclear Data Section). Still, many people contributes to TENDL with the testing and processing of the files.

TENDL contains evaluations for seven types of incident particles, for all isotopes living longer than 1 second (about 2800 isotopes), up to 200 MeV, with covariances.

# TENDL-2019: new library

- Method: Quality evaluation, production automation, open source



# TENDL-2019, what is new ?

- To be release at the end of 2019
- Mainly developed between IAEA and PSI
- Beta versions already available  
([https://tendl.web.psi.ch/tendl\\_2019/tendl2019.html](https://tendl.web.psi.ch/tendl_2019/tendl2019.html))
- Similar structure as the previous TENDL
  - 2813 isotopes, 200 MeV, with covariances
  - Neutrons, protons, deuterons, tritons, He3, alphas, and gammas
- New and simplified T6 available “on demand”
- TALYS-1.95 (above resonances)
- TARES-1.4 (resonances)
- NJOY-2016
- PREPRO-2018
- Other codes/tools
- New “library” database (comparisons, import...)

# TENDL-2019, what is new ?

- TALYS-1.95
  - Improved photon strength function: Simplified Modified Lorentzian (better estimated of neutron capture c.s.)
  - (Again) solution of the remaining 30 MeV discontinuities (found by KIT and JAEA)
  - Improvement of specific nuclides (esp. Ni isotopes)

# TENDL-2019, what is new ?

- TARES-1.4: resonance formatting and analyzing tool
- Measured/compiled/evaluated resonances:
  - Based on latest JENDL-4.0, ENDF/B-VIII.0 and JEFF-3.3
  - Based on the latest Atlas, 6<sup>th</sup> edition (2018)
- Statistical resonances:
  - Based on CALENDF
  - Translating the unresolved range from TALYS into statistically resolved range
  - Consistency between the RRR, URR and fast range
- Covariances in MF32 and MF33
  - Consistency between both format
  - Consistent with the random files (using the ENDSAM from IJS)



# Ni isotopes in the RRR

- For stable Ni 58, 60, 61, 62 and 64, and unstable Ni59 and Ni63:
  - For thermal elastic

	Origin RRR	This work (barns)	END RRR (keV)	Atlas-2018 (barns)	ENDF/B- VIII.0 (barns)	JEFF-3.3 (barns)	JENDL- 4.0 (barns)
Ni58	JENDL-4.0	$24.8 \pm 3.3$	812	$25.3 \pm 0.4$	25.0	25.0	25.0
Ni60	JENDL-4.0	$1.4 \pm 0.5$	456	$1.0 \pm 0.1$	1.1	1.0	1.4
Ni61	Atlas-2018	$10.1 \pm 0.6$	69	$8.2 \pm 1.0$	8.8	8.8	8.8
Ni62	Atlas-2018	$9.6 \pm 3.4$	601	$9.6 \pm 0.4$	9.7	9.6	9.6
Ni64	Altas-2018	$0.01 \pm 0.01$	583	$0.014 \pm 0.005$	0.3	0.3	0.03
Ni-nat		$17.7 \pm 2.2$		$17.8 \pm 0.4$	17.8	17.7	17.8
Ni59	Atlas-2018	1.8	15	-	2.3	6.7	2.3
Ni63	HFR	4.6	30	-	5.7	5.7	-



# Ni isotopes in the RRR

- For stable Ni 58, 60, 61, 62 and 64, and unstable Ni59 and Ni63:
  - For thermal capture

	Origin RRR	This work (barns)		Atlas-2018 (barns)	ENDF/B- VIII.0 (barns)	JEFF-3.3 (barns)	JENDL- 4.0 (barns)
Ni58	JENDL-4.0	$4.6 \pm 0.4$		$4.4 \pm 0.1$	4.2	4.6	4.6
Ni60	JENDL-4.0	$2.9 \pm 0.4$		$2.4 \pm 0.1$	2.4	2.8	2.9
Ni61	Atlas-2018	$2.1 \pm 0.5$		$2.1 \pm 0.4$	2.5	2.5	2.5
Ni62	Atlas-2018	$14.9 \pm 1.6$		$14.9 \pm 0.3$	14.9	14.3	14.3
Ni64	Altas-2018	$1.6 \pm 0.1$		$1.63 \pm 0.02$	1.5	1.5	1.5
Ni-nat		$4.47 \pm 0.29$		$4.49 \pm 0.16$	4.07	4.43	4.45
Ni59	Atlas-2018	$73.9 \pm 1.7$		$73.7 \pm 1.8$	75.8	73.4	75.6
Ni63	HFR	$24.2 \pm 12$		$24.4 \pm 3.0$	24.4	24.3	-

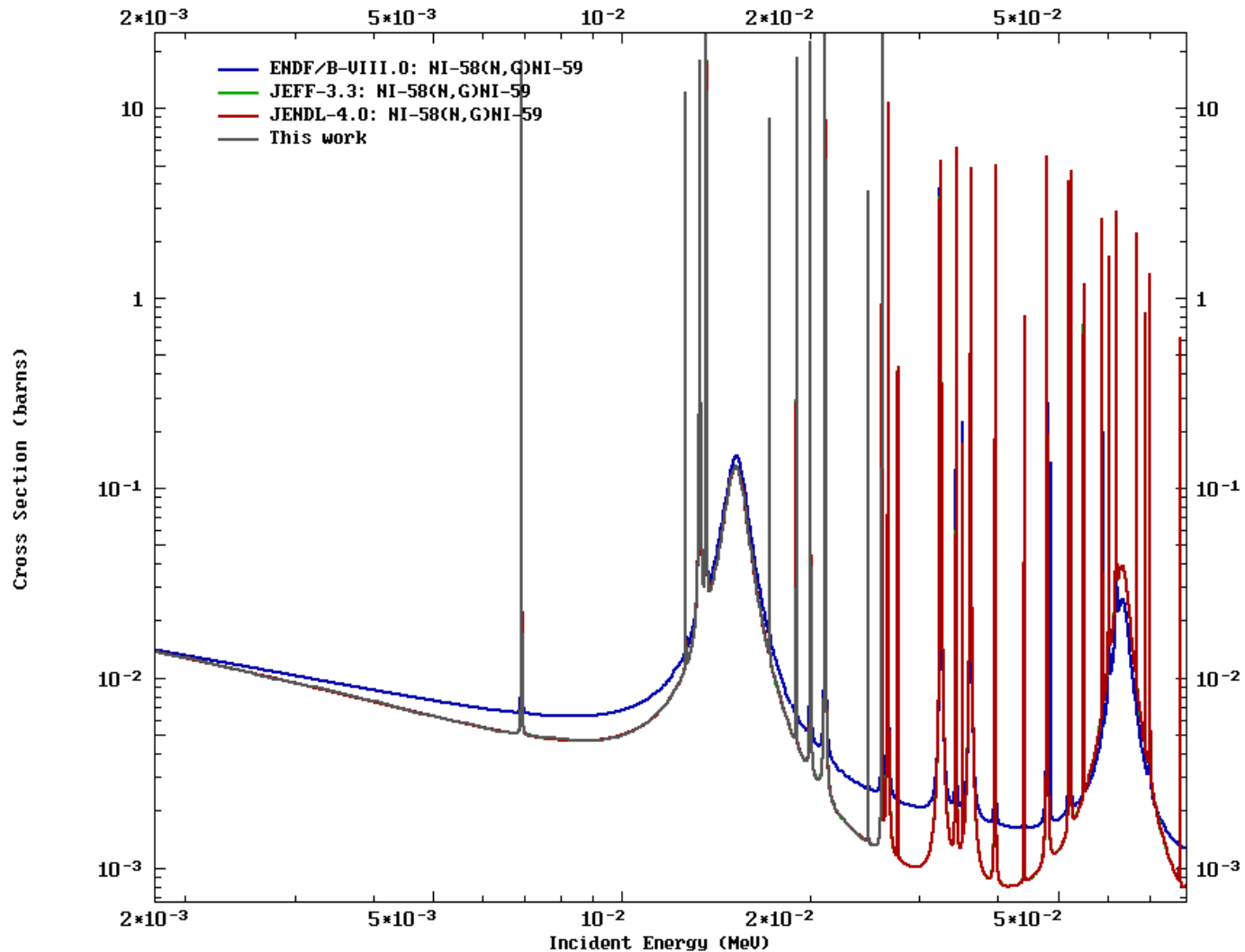
# Ni isotopes in the RRR

- For stable Ni 58, 60, 61, 62 and 64, and unstable Ni59 and Ni63:
  - For resonance integral

	Origin RRR	RI (barns)		Atlas-2018 (barns)	ENDF/B- VIII.0 (barns)	JEFF-3.3 (barns)	JENDL- 4.0 (barns)
Ni58	JENDL-4.0	2.1 ± 0.2		2.1 ± 0.2	1.9	2.1	2.1
Ni60	JENDL-4.0	1.4 ± 0.1		1.2 ± 0.1	1.2	1.3	1.4
Ni61	Atlas-2018	1.7 ± 0.1		1.8 ± 0.3	2.4	2.4	2.4
Ni62	Atlas-2018	6.8 ± 0.7		7.4 ± 0.4	7.0	6.6	6.6
Ni64	Altas-2018	0.9 ± 0.1		0.8 ± 0.1	0.8	0.8	0.8
Ni-nat		2.1		-	1.9	2.0	2.1
Ni59	Atlas-2018	116 ± 2		114 ± 8	118	108	118
Ni63	HFR	17.8		-	18.8	18.8	-

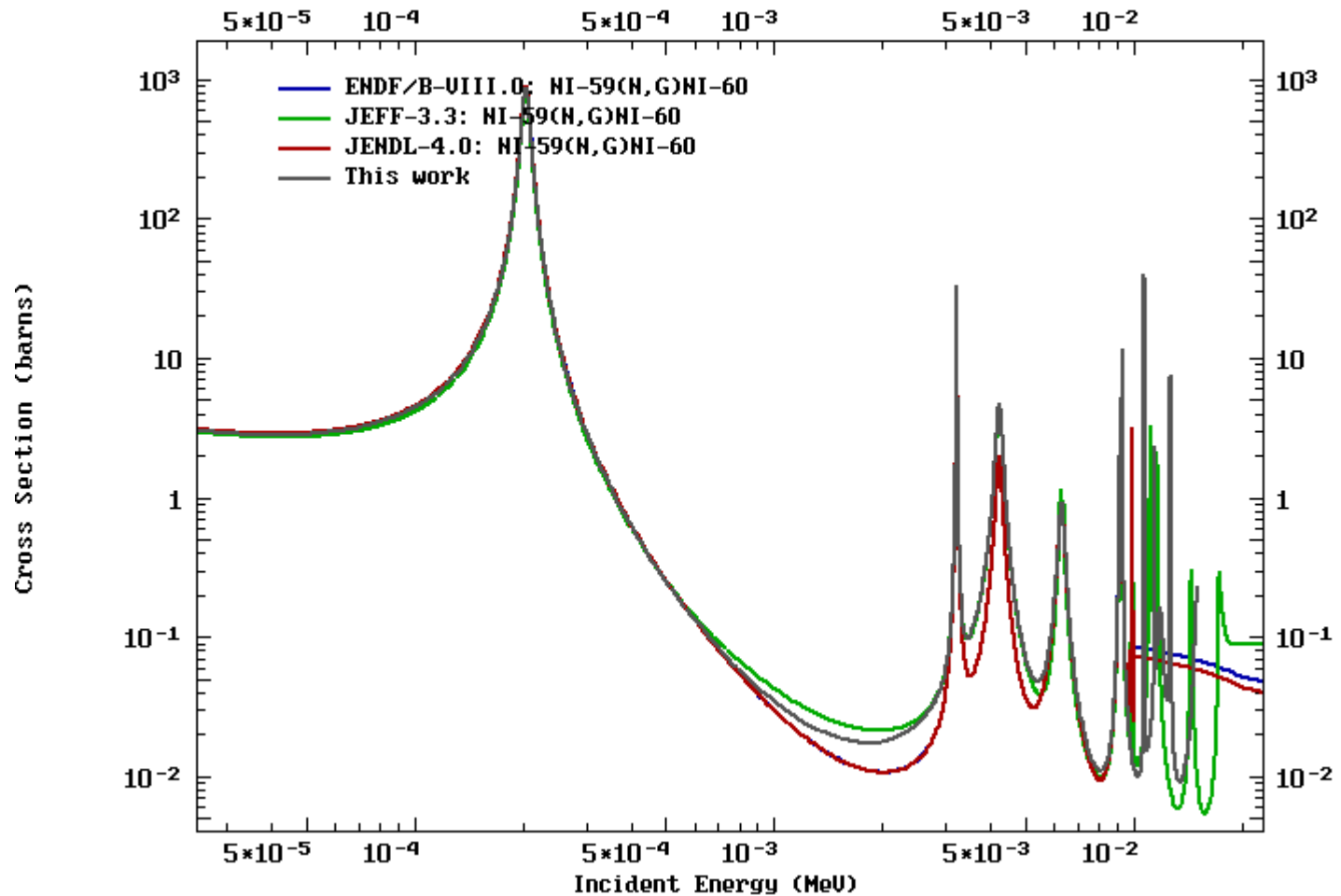
# Ni isotopes in the RRR

- Plot of  $^{58}\text{Ni}$  isotopes (n,g) in the RRR



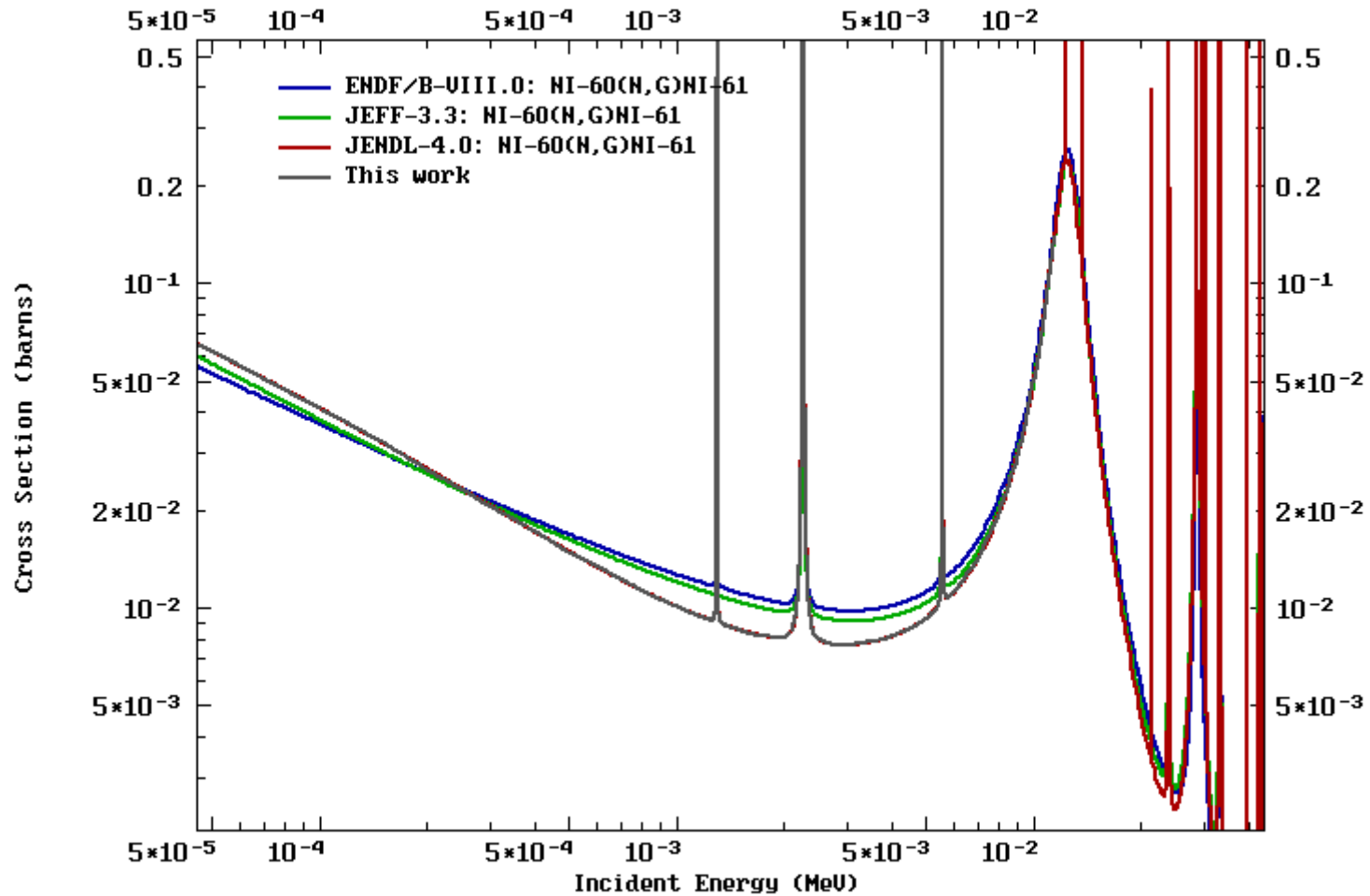
# Ni isotopes in the RRR

- Plot of  $^{59}\text{Ni}$  isotopes (n,g) in the RRR



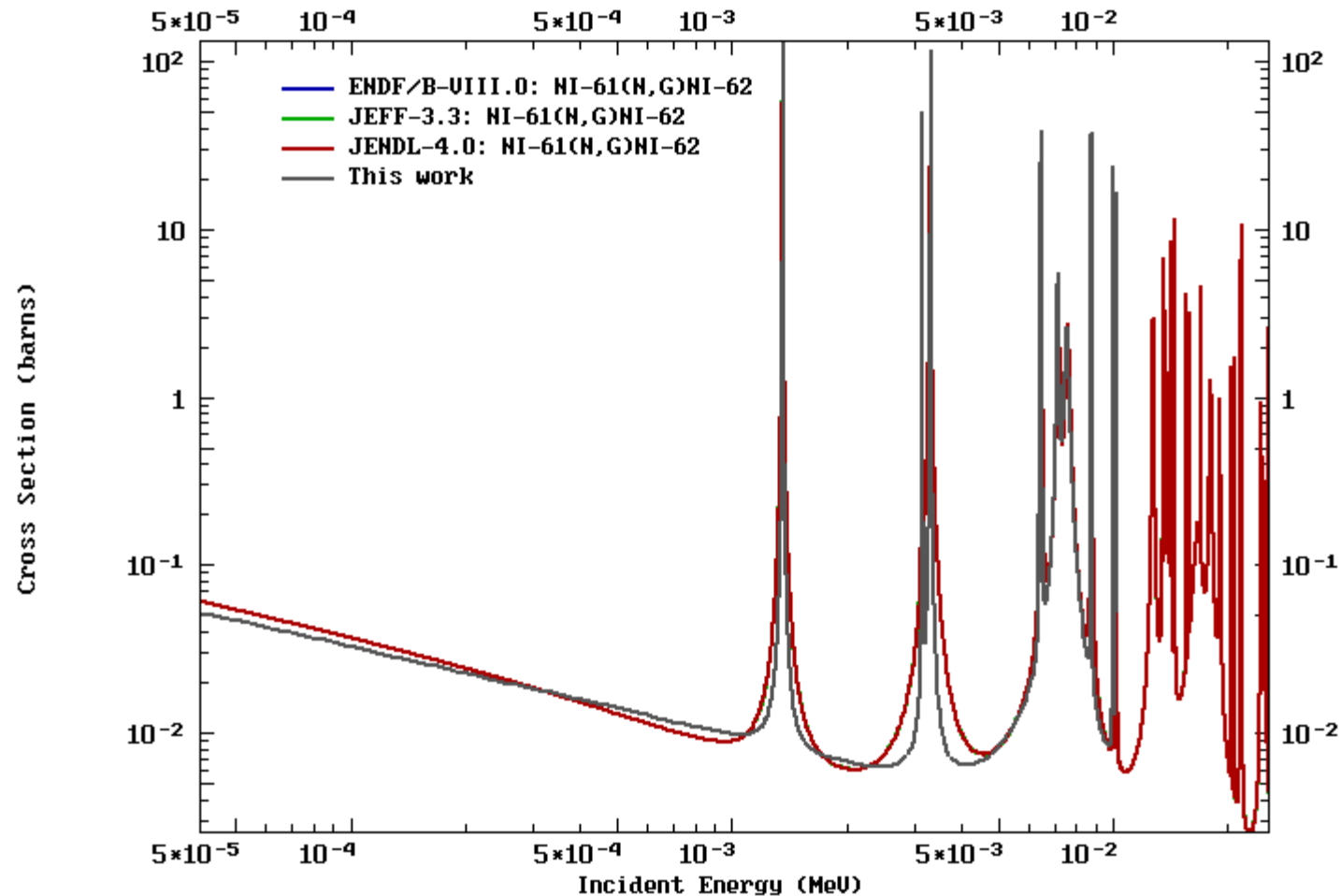
# Ni isotopes in the RRR

- Plot of  $^{60}\text{Ni}$  isotopes (n,g) in the RRR



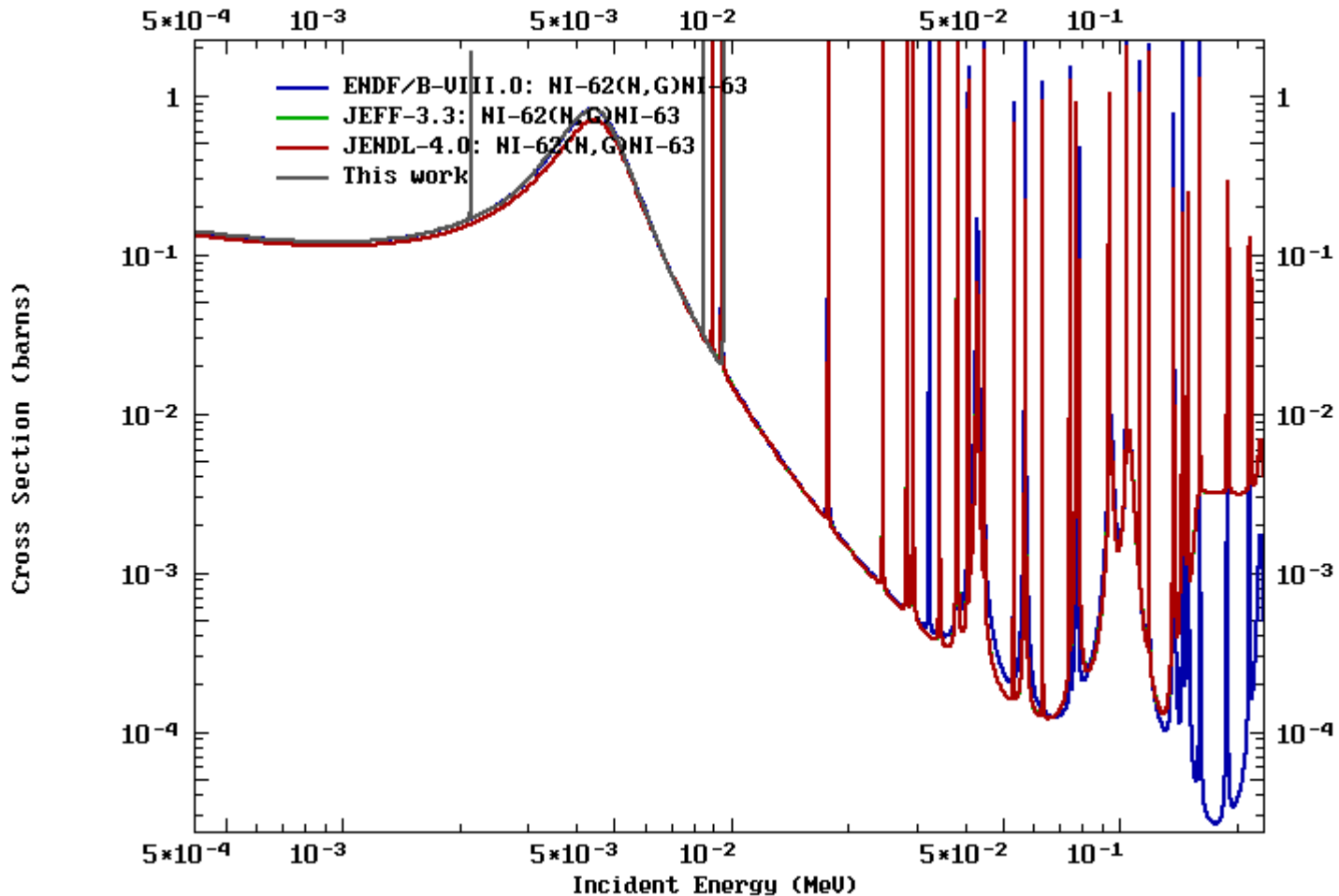
# Ni isotopes in the RRR

- Plot of  $^{61}\text{Ni}$  isotopes (n,g) in the RRR (new resonance parameters)



# Ni isotopes in the RRR

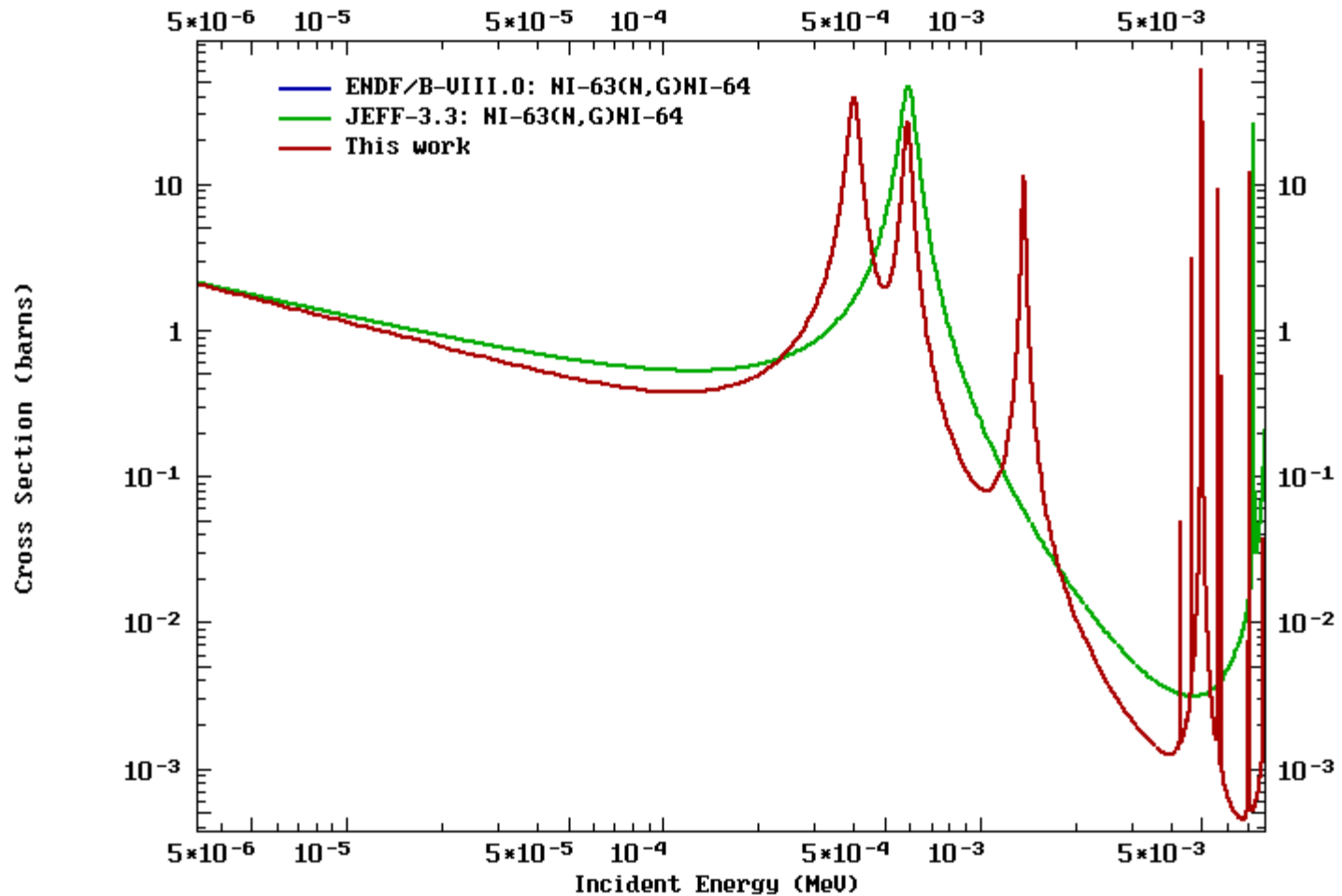
- Plot of  $^{62}\text{Ni}$  isotopes (n,g) in the RRR





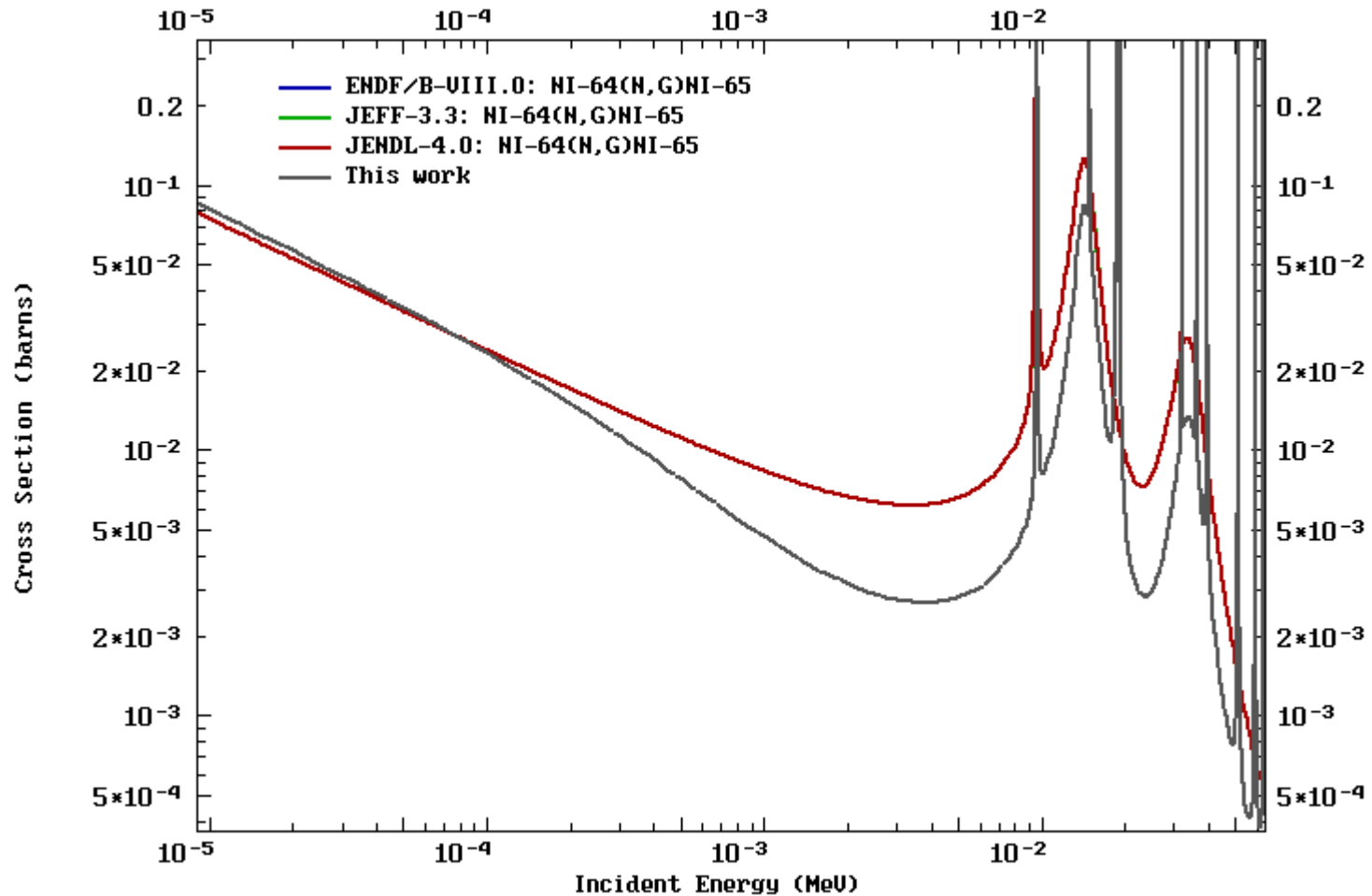
# Ni isotopes in the RRR

- Plot of  $^{63}\text{Ni}$  isotopes (n,g) in the RRR



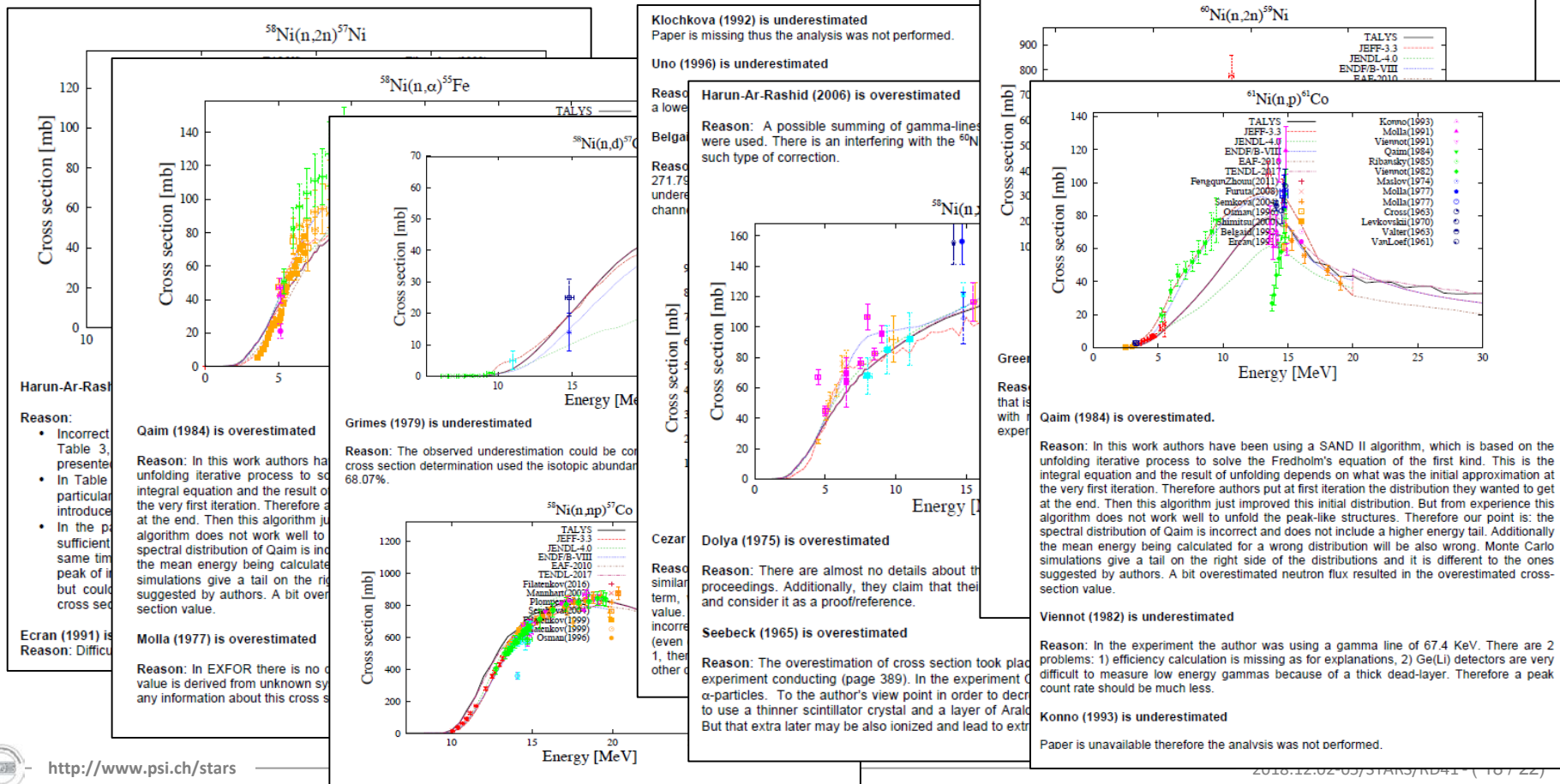
# Ni isotopes in the RRR

- Plot of  $^{63}\text{Ni}$  isotopes (n,g) in the RRR



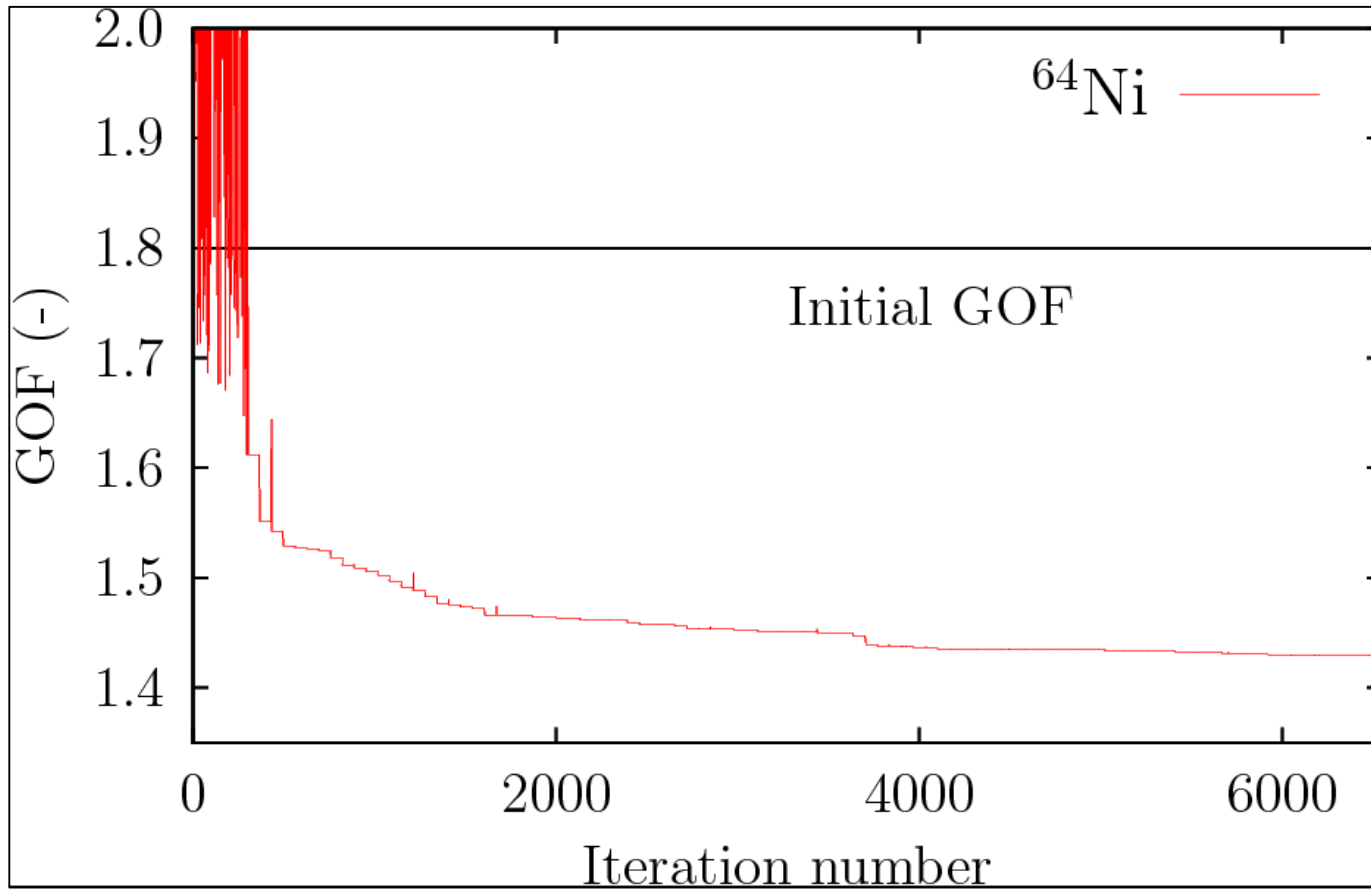
# Ni isotopes in the fast range

- Performed with TALYS-1.9 and the latest T6
- Analyze EXFOR data
- Search of the model parameters to fit a selection of EXFOR data, and
- Search of the model parameters to fit ENDF/B-VIII.0 for other channels.
- Full ENDF-6 files produced from MF1 to MF40



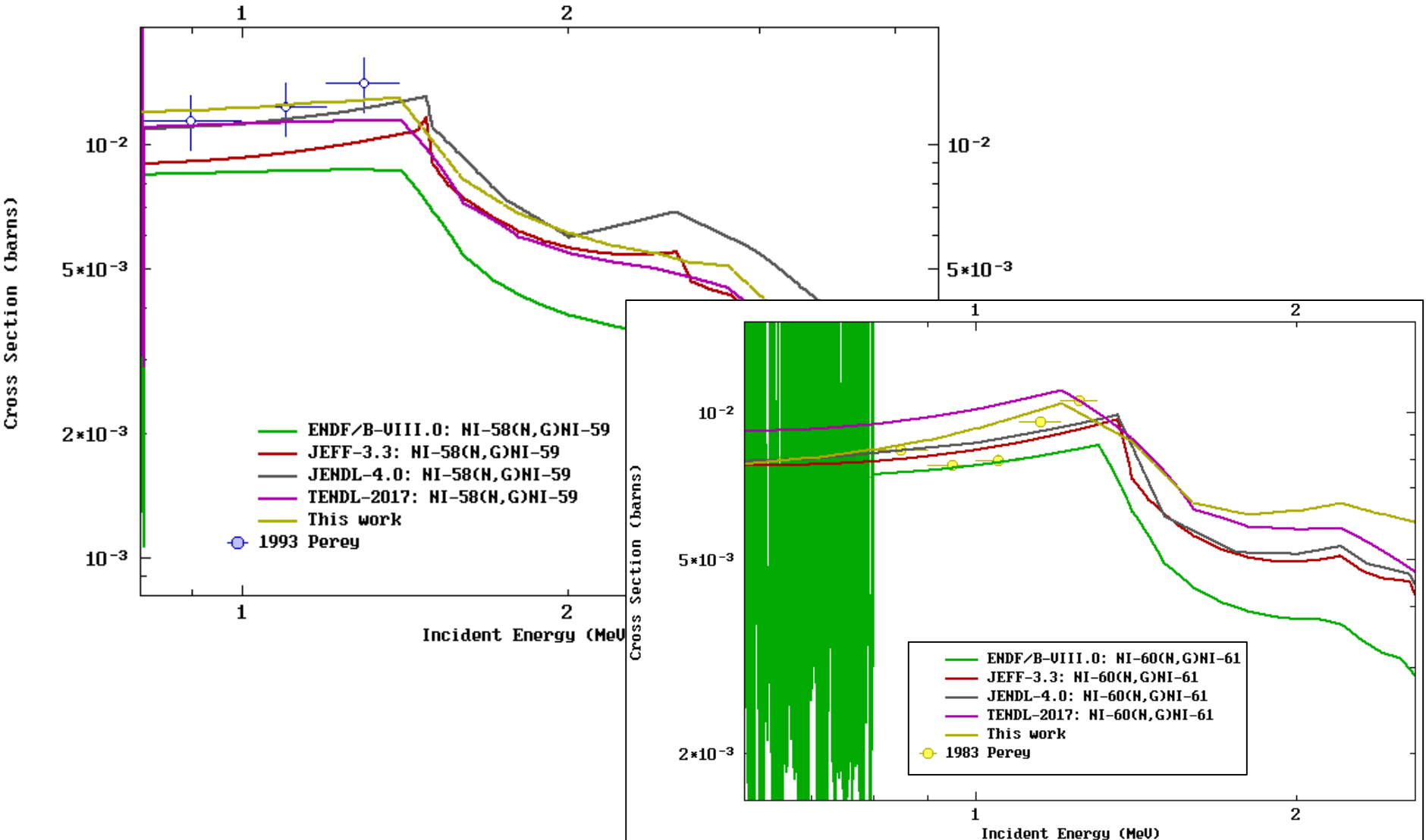
# Ni isotopes in the fast range

- Example for GOF (goodness of fit estimator) for  $^{64}\text{Ni}$  compared to ENDF/B-VIII.0:



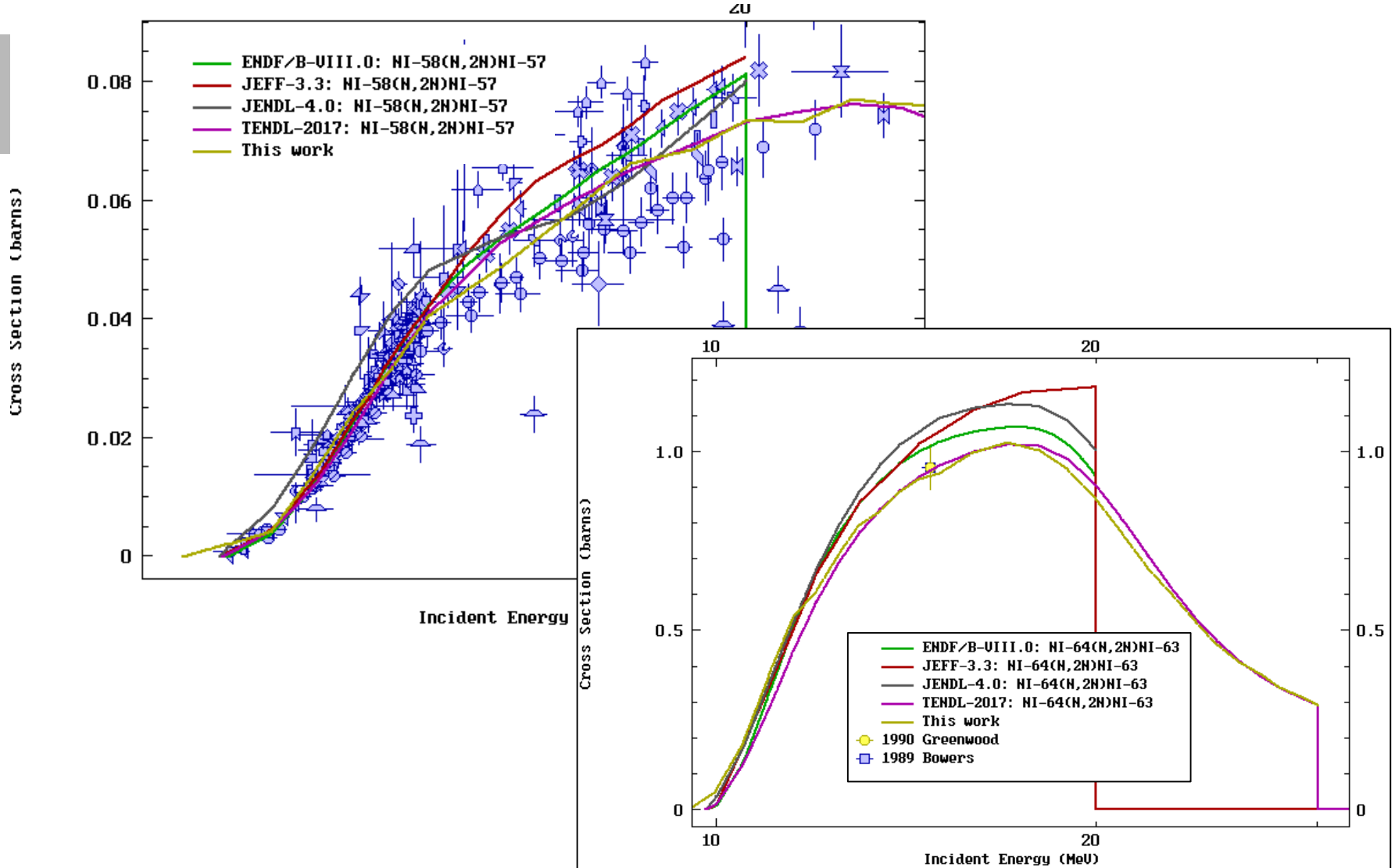
# Ni isotopes in the fast range

- Example capture on Ni58 and Ni60:



# Ni isotopes in the fast range

- Example for (n,2n) on Ni58 and Ni64:



# Conclusions

- Latest T6 package as used in TENDL-2019
- Evaluation of the Ni still in progress with T6
- New resonance data
- Analysis of the EXFOR data in the fast range
- Parameter optimization for TALYS using a selection of EXFOR data
- Methods and results to be implemented in the next TENDL release



# Wir schaffen Wissen – heute für morgen

