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Overview of the dissemination of n_TOF experimental data and resonance parameters

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IAEA
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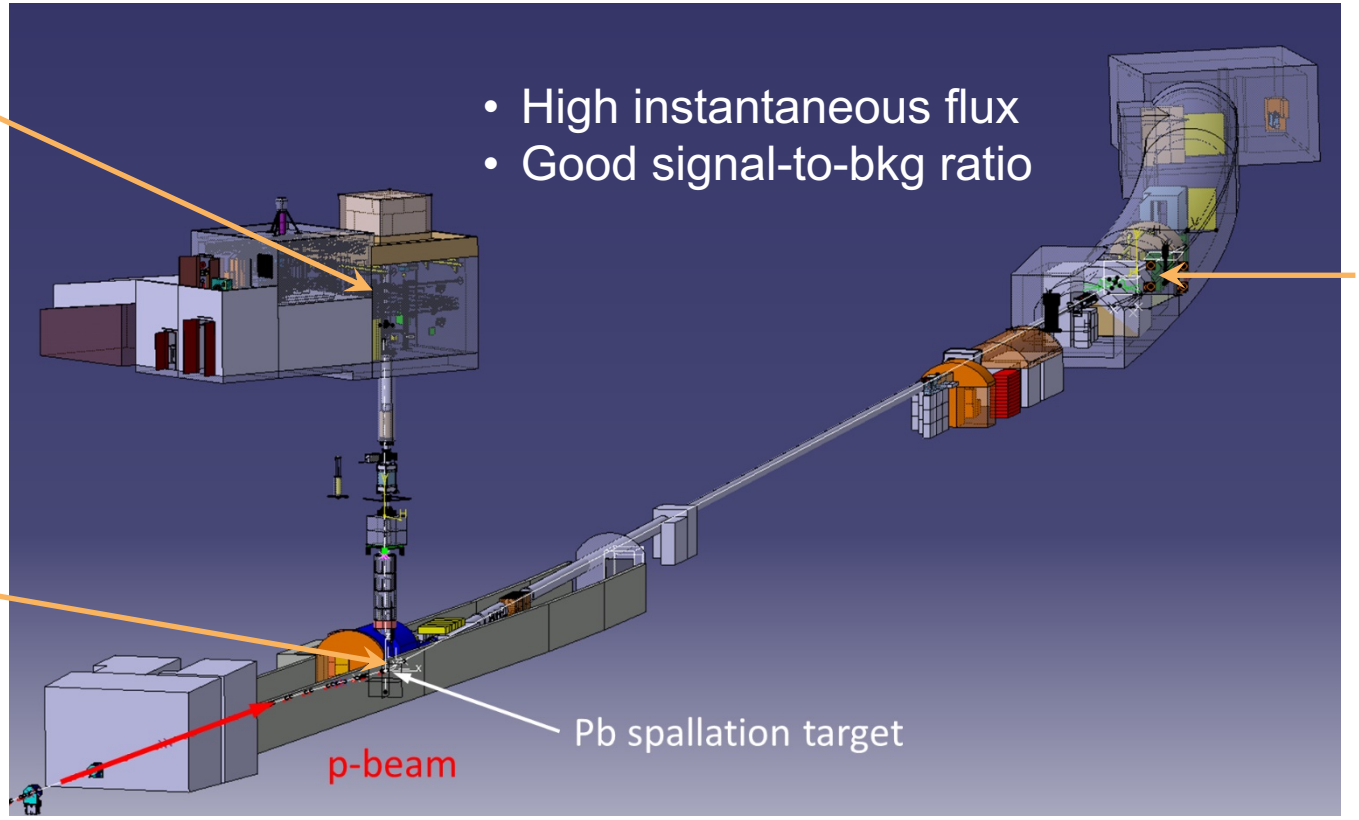
PSI

Irfu

n_TOF facility

EAR 2
Since 2014
~18 m
~10^7 n/cm^2 (/pulse)
$\Delta E/E$ ~10^{-2} (1keV)

NEAR
(> 2021)
~3 m
~10^8 n/cm^2 (/pulse)



EAR 1
Since 2001
~182 m
~10^5 n/cm^2 (/pulse)
$\Delta E/E$ ~10^{-4} (1keV)

p-beam: 0.8 Hz – 20 GeV/c – 7 ns RMS – 7.10^{12} p/pulse – 2.10^{15} n/pulse (300 n/p)

n_TOF measurements

(n,f) measurements

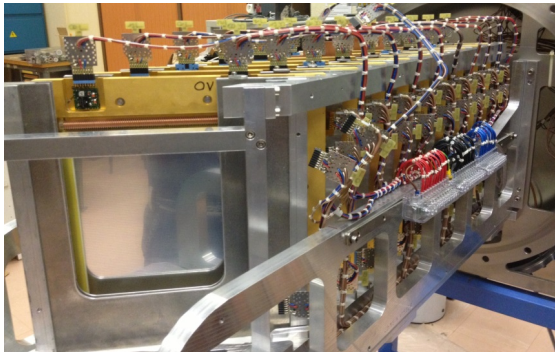
- FIC (Fast Ionization Chamber)
- PPAC (Parallel Plate Avalanche Counters)
- MicroMegas (MicroMesh Gaseous detector)

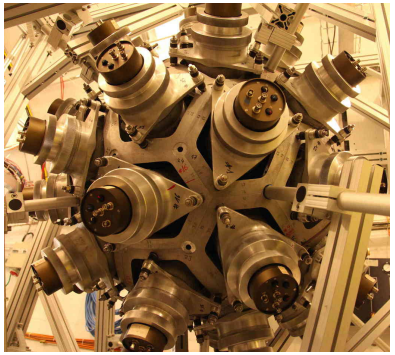
(n,γ) measurements

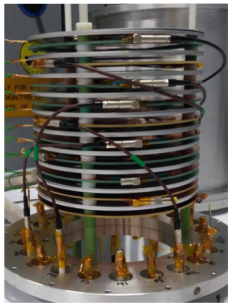
- C_6D_6 scintillators
- TAC (Total Absorption Calorimeter)

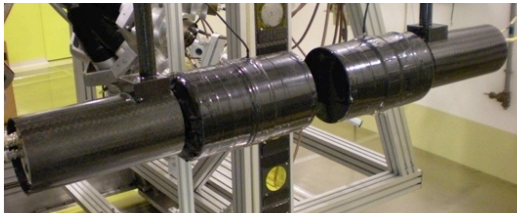
(n,cp) measurements

- Si telescope for (n,p) and (n,α)
- MicroMegas for (n,α)









n_TOF measurements

	(n,γ)	(n,f)	(n,cp)
Ph-I	27	18	0
Ph-II	16	4	3
Ph-III	30	9	9

- Phase-I (2001-2004)
  - Detector developments: TAC, FIC, PPAC
  - Numerous (n,γ) and (n,f) measurements
- Phase-II (2009-2012)
  - New spallation target and type-A area
  - Essentially (n,γ) measurements
  - Additional (n,f) measurements, incl. FFAD
- Phase-III (2014-2018)
  - New experimental area: EAR-2
  - Highly radioactive targets, low xs
  - (n,cp) measurements
- Phase-IV (2021-…) ongoing
  - New experimental area: NEAR
  - Activation measurements

n_TOF data in EXFOR

- n_TOF yields and cross sections are disseminated through EXFOR
  - Significant progress since ND2016 and now on track
  - 92% of all final data have been released
    See http://twiki.cern.ch/NTOFPublic
- n_TOF resonance parameters (RP) from SAMMY analyses are also available in EXFOR (and in Mughabghab's Atlas)
- Some of these RP already found their way to evaluated files ☺

n_TOF data in evaluated files

Nuclide	JEFF			ENDF/B			JENDL		
	3.1.1 (2009)	3.2 (2014)	3.3 (2017)	VII.0 (2006)	VII.1 (2011)	VIII.0 (2018)	3.3 (2002)	4.0u (2010+)	5.0 (2021)
Be7									X
Fe54						X			X
Fe57						X			X
Ni63									X
Zr90								X,Tag08	X
Zr91								X,Tag08	X
Zr92									X
Zr93									X
Zr94									X
Zr96									X
La139								X	
Sm151				X	X	X		X	X
Tm171									X
Au197		X	X		Led11	X			
Pb204								X,Dom07	X
Pb206			X					X,Dom07	
Pb207			X					X,Dom06	X
Bi209			X					X,Dom06	
Th232		X	X	X,Aer06	X	X		X	X
U233									Cal09,Bel11
U234								X,Dri06	X
U235			Par16			Par16,Bal17			Ama19
U238						Min17,Wri17			Par15
Pu240									Sta20
Pu242									X
Am241									X
Am243									X

The "X" indicates a match of a grep command on the evaluated files with one of the following patterns: nTOF, n_TOF, n-TOF, n TOF, CERN, <name-of-first-author>

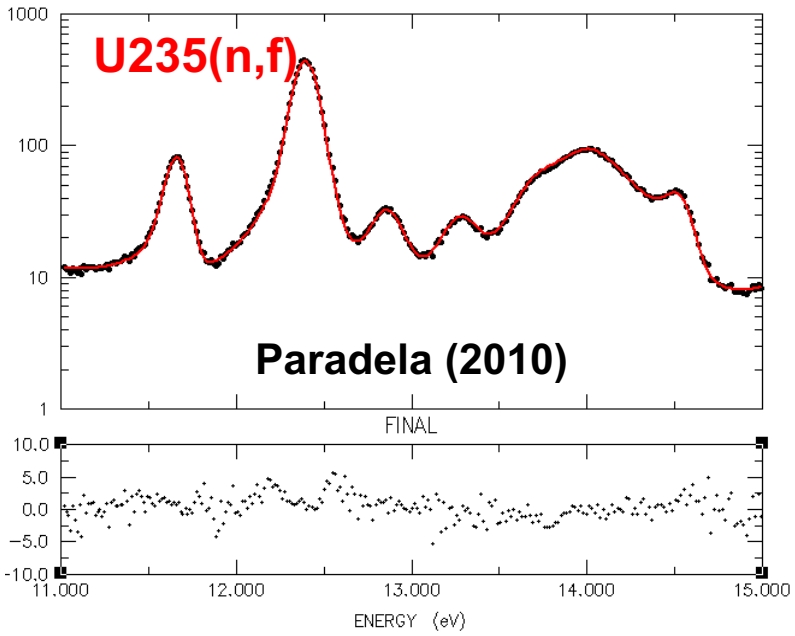
The reference "NameYear" indicates citation of the corresponding data in the library-release Big Papers

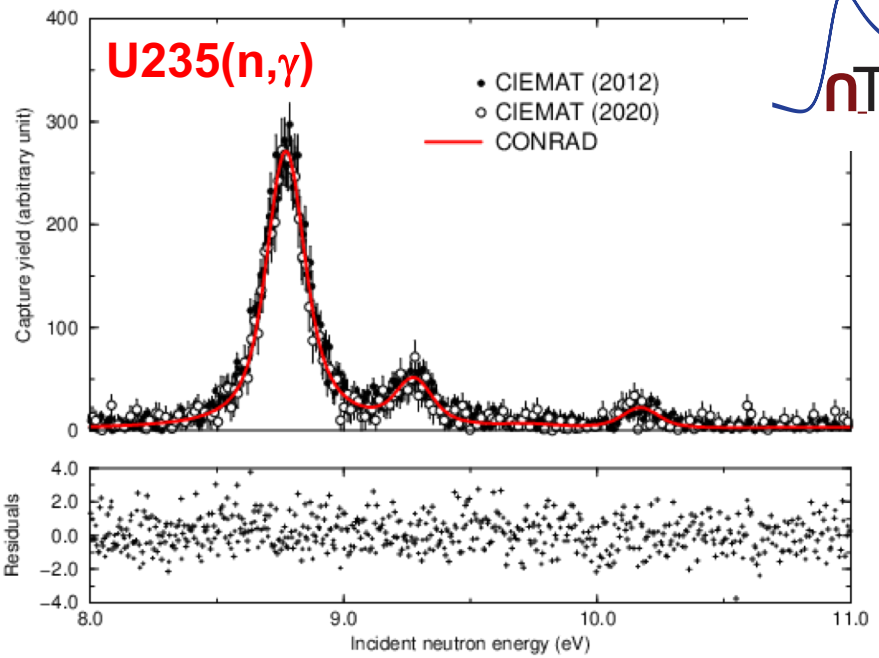
⚠ This list doesn't include the n_TOF RP adopted from the Atlas of Neutron Resonances

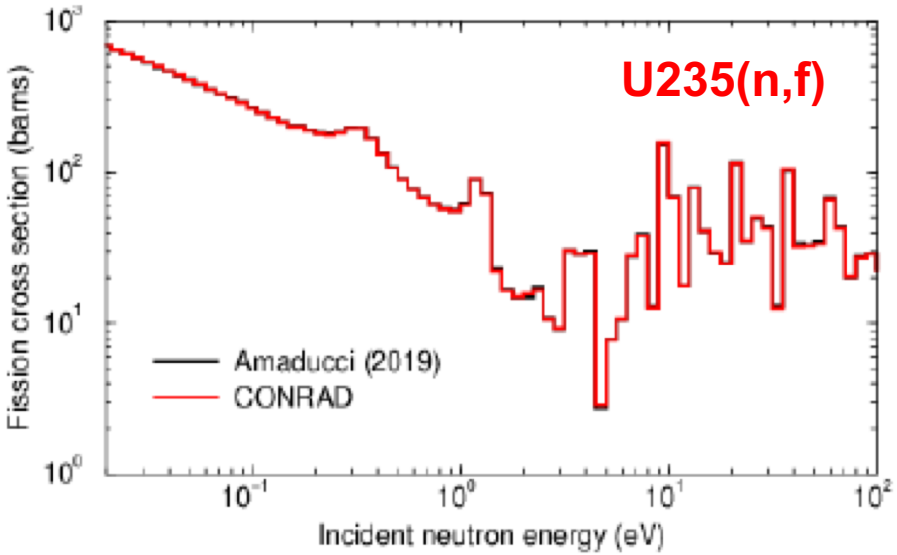
n_TOF data in evaluated files

- About half of the published n_TOF data (for ~50 nuclides) are cited by evaluation projects
- JENDL-5 is the first library built after n_TOF data have been made widely available in EXFOR (23 n_TOF “citations” in JENDL-5) ☺
- The n_TOF Collaboration is now releasing RP from SAMMY analyses in ENDF-6 format for further use by evaluation projects
- Ongoing efforts to integrate n_TOF data in TENDL and JEFF files
  - using yields and cross sections
  - using resonance parameters

n_TOF data in evaluated files







- CONRAD evaluations for JEFF-4
- n_TOF data for U-234,235, Pu-242 and Am-243
- Example for U-235 datasets

n_TOF RP for evaluation projects

Rationale for the use of n_TOF RP in evaluated files

1. Adoption of RP (either from n_TOF or Mughabghab's Atlas) is not straightforward for major isotopes
2. Priority should be given to actual evaluation work using all available measurements, e.g. Gd-155,157, U-238, etc.
3. n_TOF RP could be adopted on a case-by-case basis

Different sources for n_TOF RP

A. Tabulated RP and sometimes resonance kernels (RK) in publications
B. Additional information from the authors (including SAMMY files)

Results: RP in MF2/MT151 with LRU=1 (i.e., RRR)
RP uncertainties in free format

n_TOF RP for evaluation projects

Isotopes for which n_TOF RP (+uncertainties) are available

- From capture measurements: ^{24,25,26}Mg, ^{54,57}Fe, ^{90,91}Zr, ^{139}La, ^{151}Sm, ^{155,157}Gd, ^{171}Tm, ^{186,187,188}Os, ^{197}Au, ^{206,207}Pb, ^{209}Bi, ^{234}U , ^{238}U, ^{237}Np, ^{242}Pu, ^{241}Am, ^{243}Am
- From fission measurements: ^{236}U, ^{240}Pu

Isotopes for which kernels (or RP and RK) are available (additional evaluation work is required to convert RK to RP)

- From capture measurements: ^{58,62,63}Ni, ^{70,73,76}Ge, ^{93}Zr, ^{92,94,96}Zr, ^{204}Pb
- From fission measurement: ^{235}U

RP already available in ENDF-6 format are highlighted in green

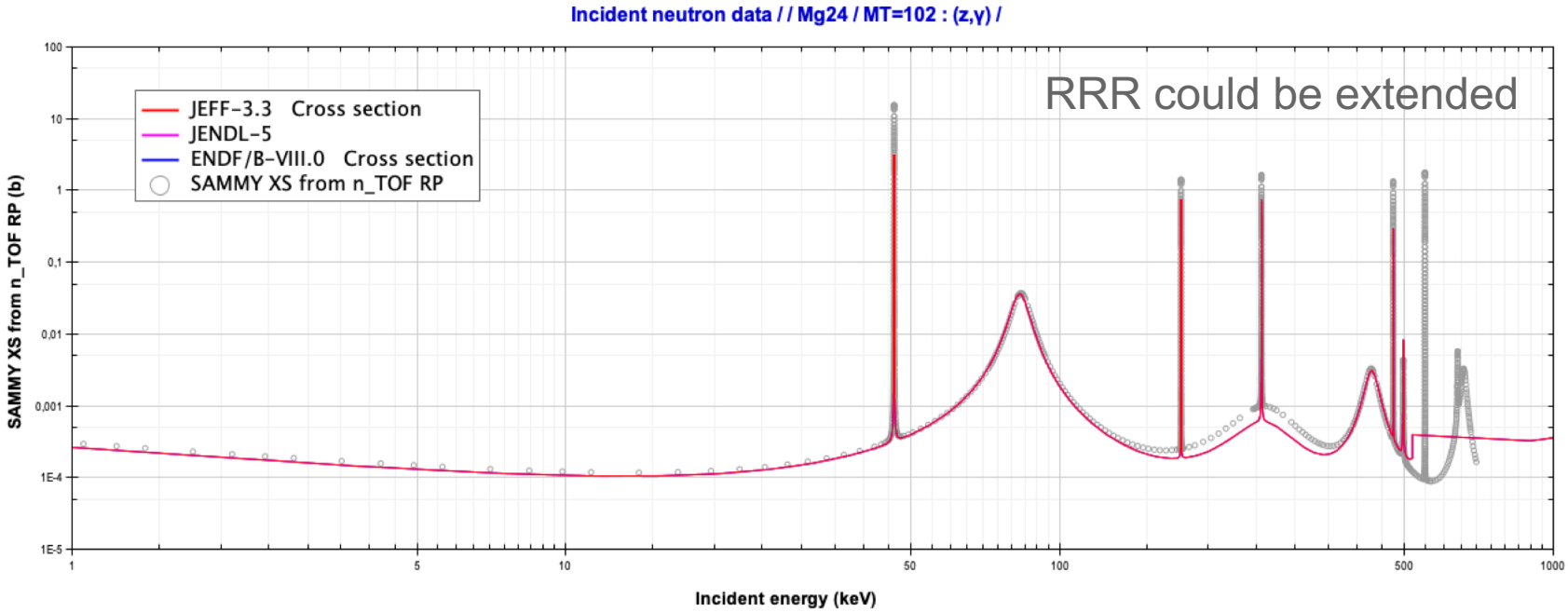
Examples are given in the following slides, where the n_TOF cross section is reconstructed with the SAMMY code (for checking purpose)

More at http://twiki.cern.ch/NTOFPublic

n_TOF RP for evaluation projects

^{24}Mg

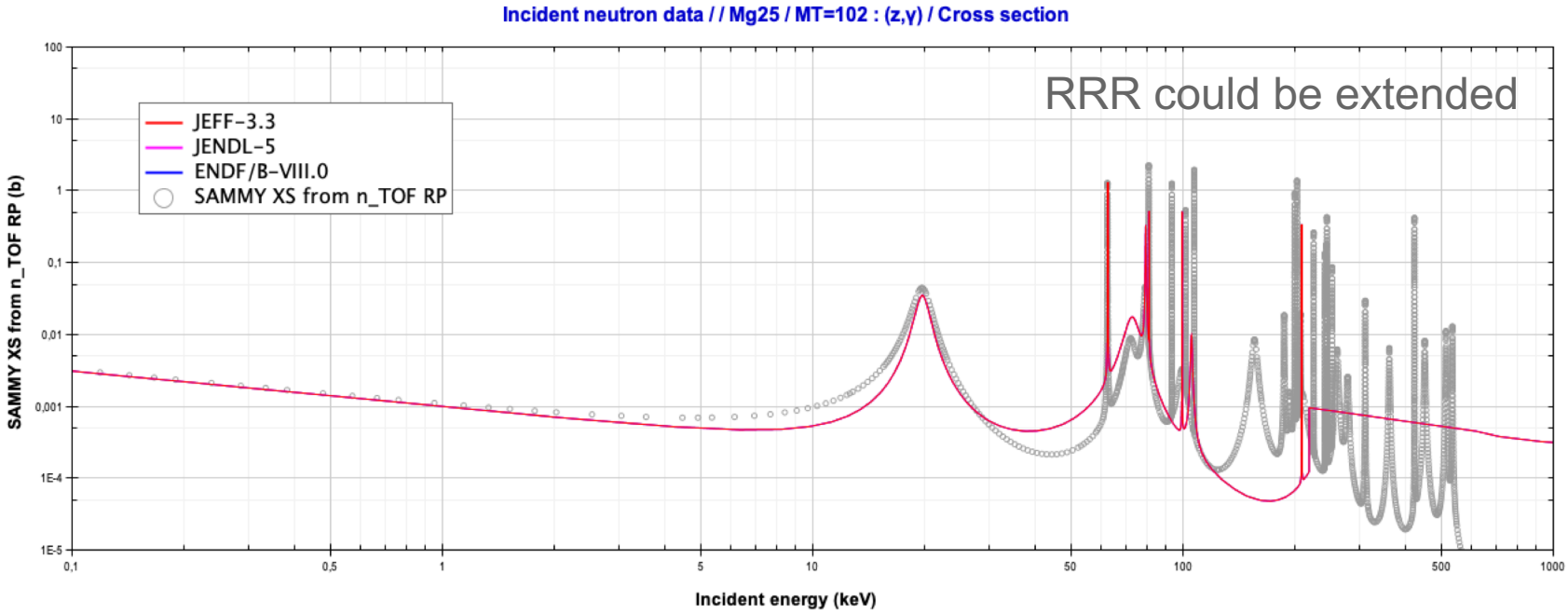
- C. Massimi et al. (n_TOF Collaboration), PRC 85 (2012) 044615
- Reich-Moore analysis up to to 700 keV (incl. Mg-nat transmission)
- A bound-state is added to reproduce the thermal capture of Walkiewicz [PRC 45 (1992) 1597]



n_TOF RP for evaluation projects

^{25}Mg

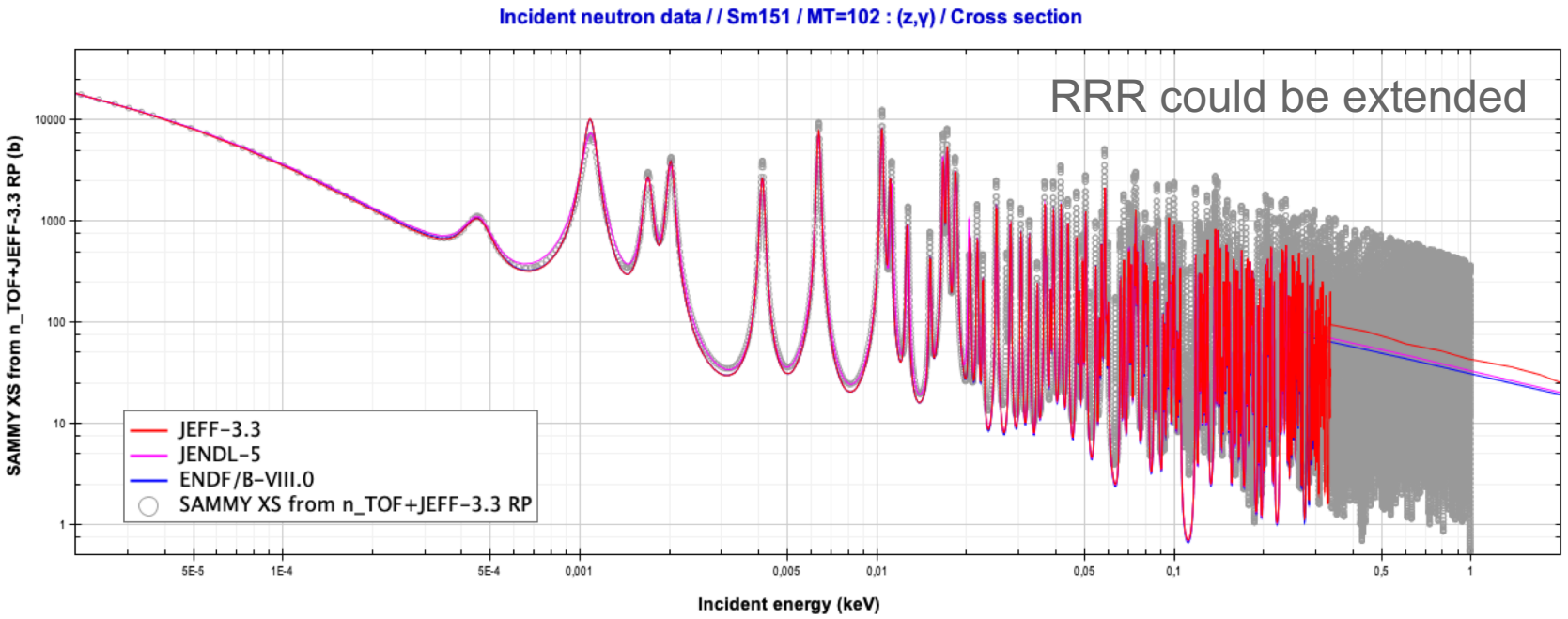
- C. Massimi et al. (n_TOF Collaboration), PRC 85 (2012) 044615
- Reich-Moore analysis up to to 700 keV (incl. Mg-nat transmission)
- A bound-state is added to reproduce the thermal capture of Walkiewicz [PRC 45 (1992) 1597]



n_TOF RP for evaluation projects

^{151}Sm

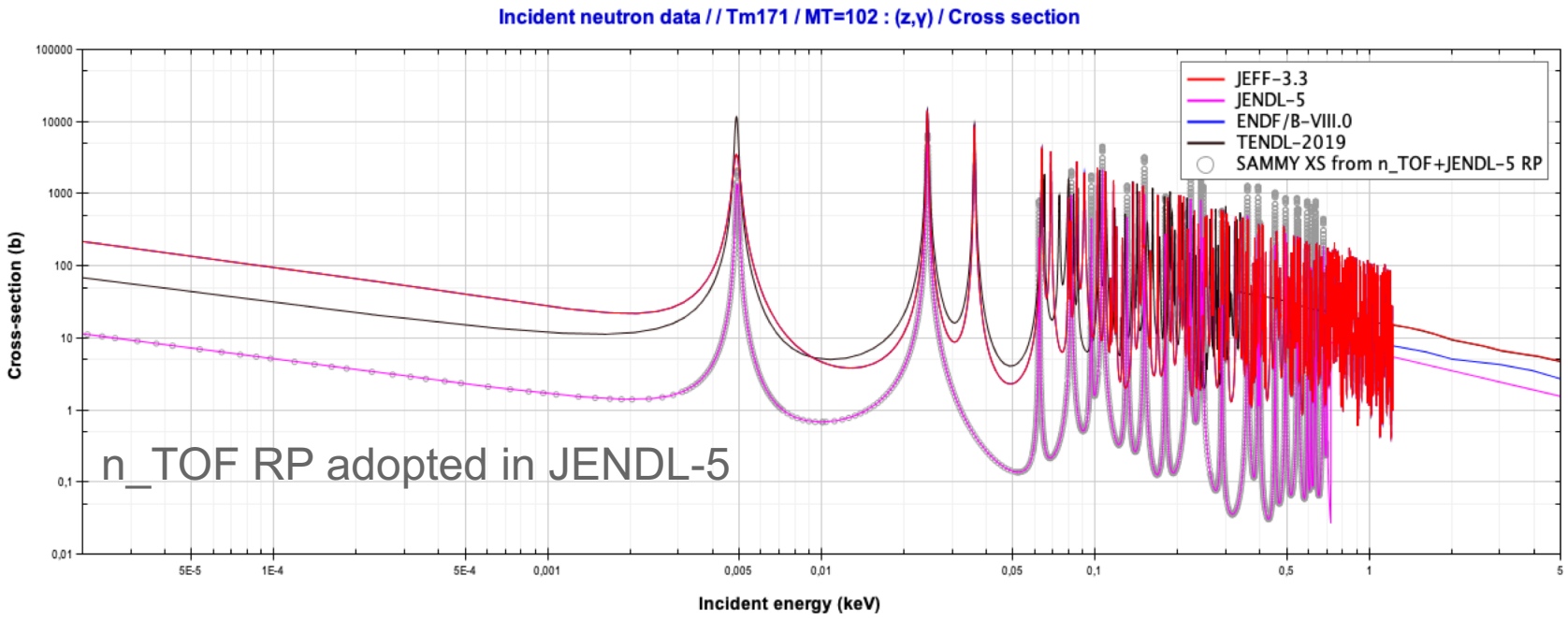
- S. Marrone et al. (n_TOF Collaboration), PRC 73 (2006) 034604
- Reich-Moore analysis between 0.6 eV and 1 keV
- The resonances below 0.6 eV are from JEFF-3.3 in the plot below



n_TOF RP for evaluation projects

^{171}Tm

- C. Guerrero et al. (n_TOF Collaboration), PRL 125 (2020) 142701
- Reich-Moore analysis between 1 eV and 700 eV
- The negative level is borrowed from JENDL-5 in the plot below



n_TOF data dissemination

Outlook

- n_TOF yields and cross sections are available in EXFOR
- n_TOF resonance parameters (RP) are also available in EXFOR (and in Mughabghab's Atlas), and many have been adopted in evaluations
- RP are now systematically translated to ENDF-6 format for further use by evaluation projects
- All data (yields, cross sections, RP) are available from the n_TOF data dissemination webpage at https://twiki.cern.ch/NTOFPublic
- New TENDL and JEFF-4 test files are being produced using n_TOF datasets (U-234,235, Pu-242, Am-243…) and also n_TOF RP (Mg-24,25,26, Fe-54,57, La-139, Sm-151, Tm-171, Os-186,187,188…)

Thank you for your attention!

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