Status of the TSL activities at CEA/Cadarache in the framework of the Nausicaa collaboration

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Outlines

- H2O and UO2 measurements and Monte-Carlo analysis
- Generation of TSL covariances
- Future TSL activities for SG48

H2O measurements and Monte-Carlo analysis

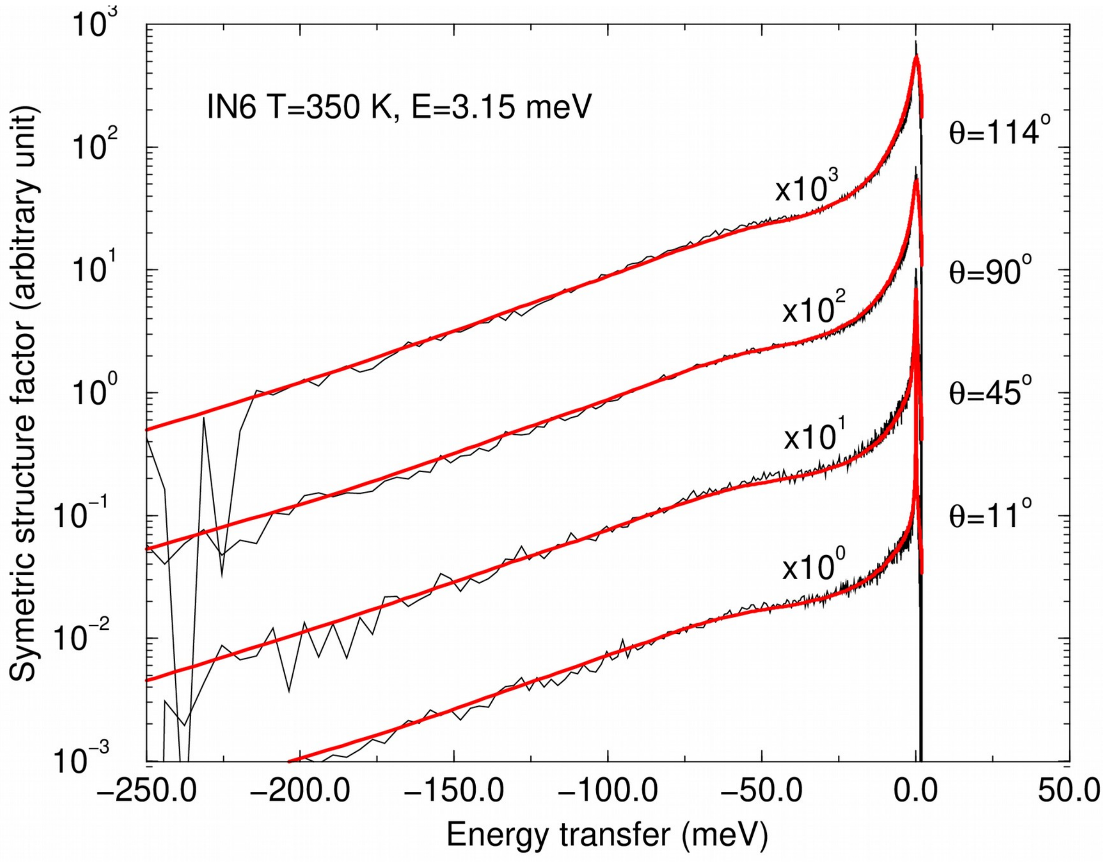
Inelastic neutron scattering measurements on IN5, IN4 and IN6 time-of-flight spectrometers

TOF	Author	Ref.	H_2O sample	λ	E	Temperature	Pressure
IN4	Farhi et al.	[34]	hollow cylinder	1.1 Å	67.6 meV	294, 311, 323 K	1 bar
	Farhi et al.	[34]	hollow cylinder	2.2 Å	16.9 meV	294 K	1 bar
	Jaiswal et al.	[35]	cylinder	2.4 Å	14.2 meV	300, 350, 430, 494 K	1, 42, 94, 115, 147, 176, 185 bar
IN5	Farhi et al.	[34]	hollow cylinder	2.0 Å	20.5 meV	286, 293, 302 K	1 bar
	Farhi et al.	[34]	hollow cylinder	5.0 Å	3.27 meV	291, 302, 311 K	1 bar
	Qvist et al.	[36]	capilaries	5.0 Å	3.27 meV	283, 293 K	1 bar
	Qvist et al.	[36]	capilaries	8.0 Å	1.28 meV	283, 293 K	1 bar
	Qvist et al.	[36]	capilaries	12.0 Å	0.57 meV	283 K	1 bar
IN6	Jaiswal et al.	[35]	cylinder	5.1 Å	3.15 meV	350, 494 K	1, 70, 470 bar

Data taken from PhD thesis of Qvist (2011), Ferran (2014), Scotta (2016), Jaiswal (2017)

H2O measurements and Monte-Carlo analysis

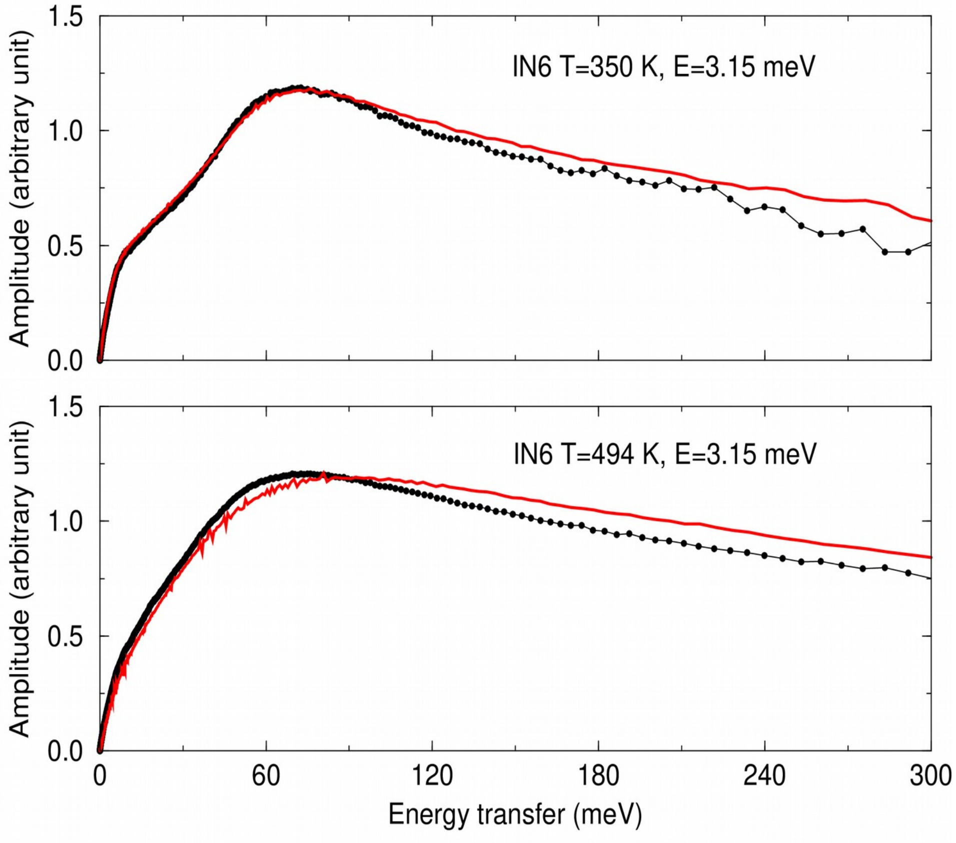
Symmetric form of the water dynamic structure factor T=350



Analysis performed with the Monte-Carlo neutron transport code **TRIPOLI4** by using the **CAB model** for H in H_2O (=ENDF\B-VIII)

H2O measurements and Monte-Carlo analysis

Experimental density of states at 350 and 494 K

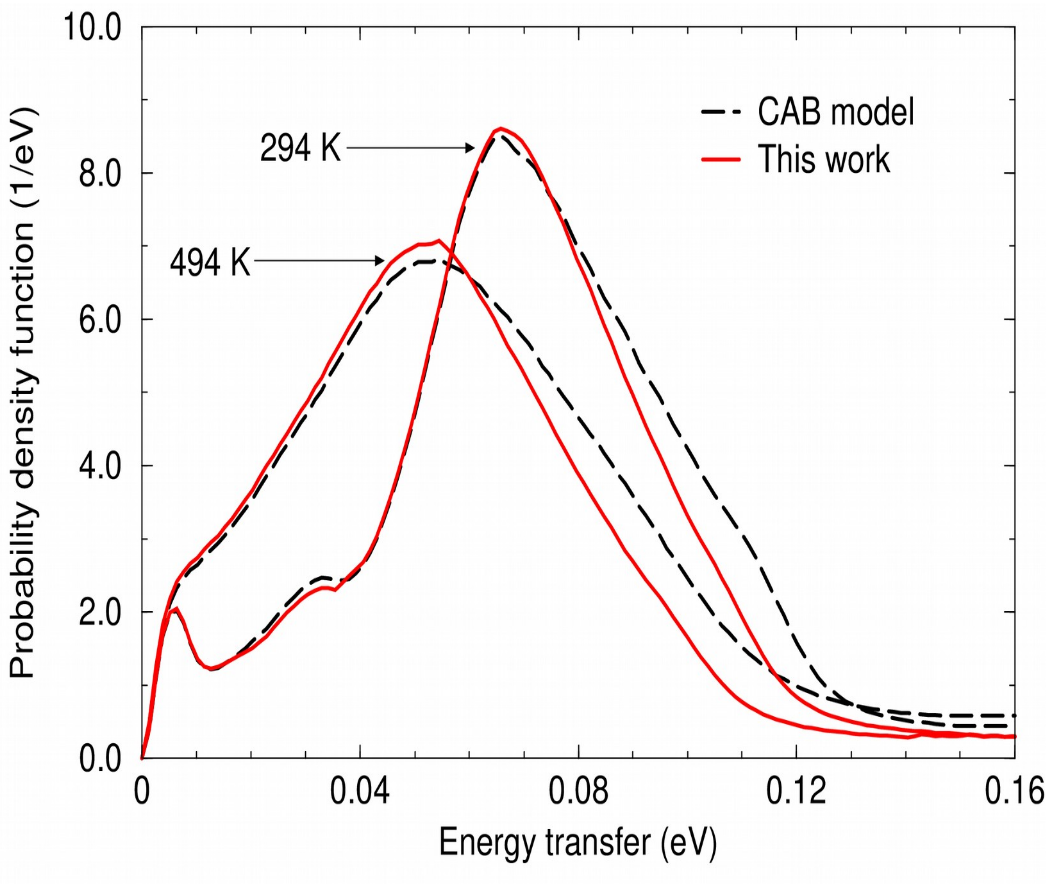


Water Librational mode:

- Reasonable agreement between the data and the TRIPOLI4 simulations (CAB model)
- Slight improvement is needed (frequency shift is overestimated at elevated temperature)

H2O measurements and Monte-Carlo analysis

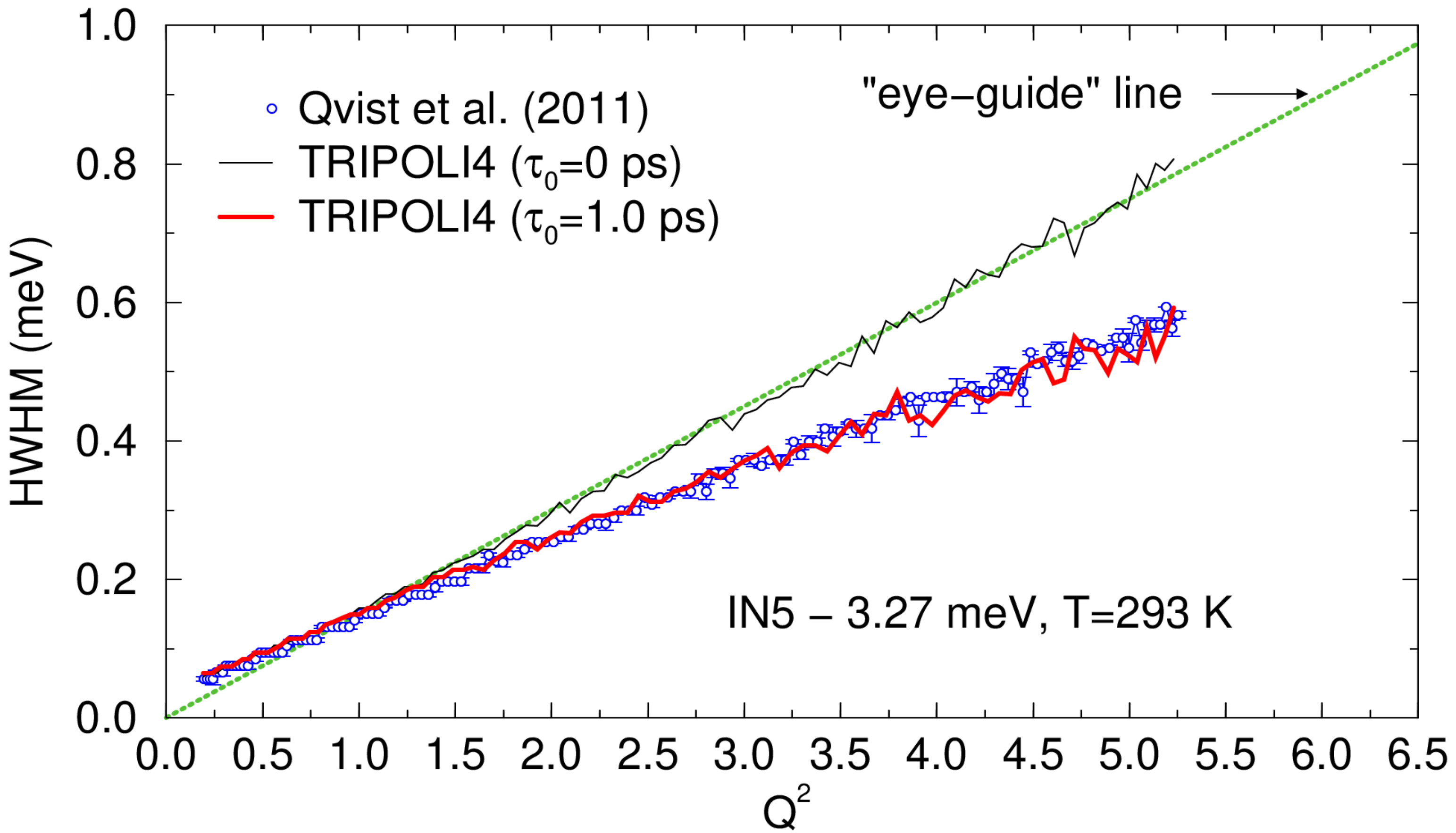
Iterative Bayessian least-squares fitting procedure implemented in the nuclear data code CONRAD



ILL data provide a narrower water librational band than predicted by MD simulations

H2O measurements and Monte-Carlo analysis

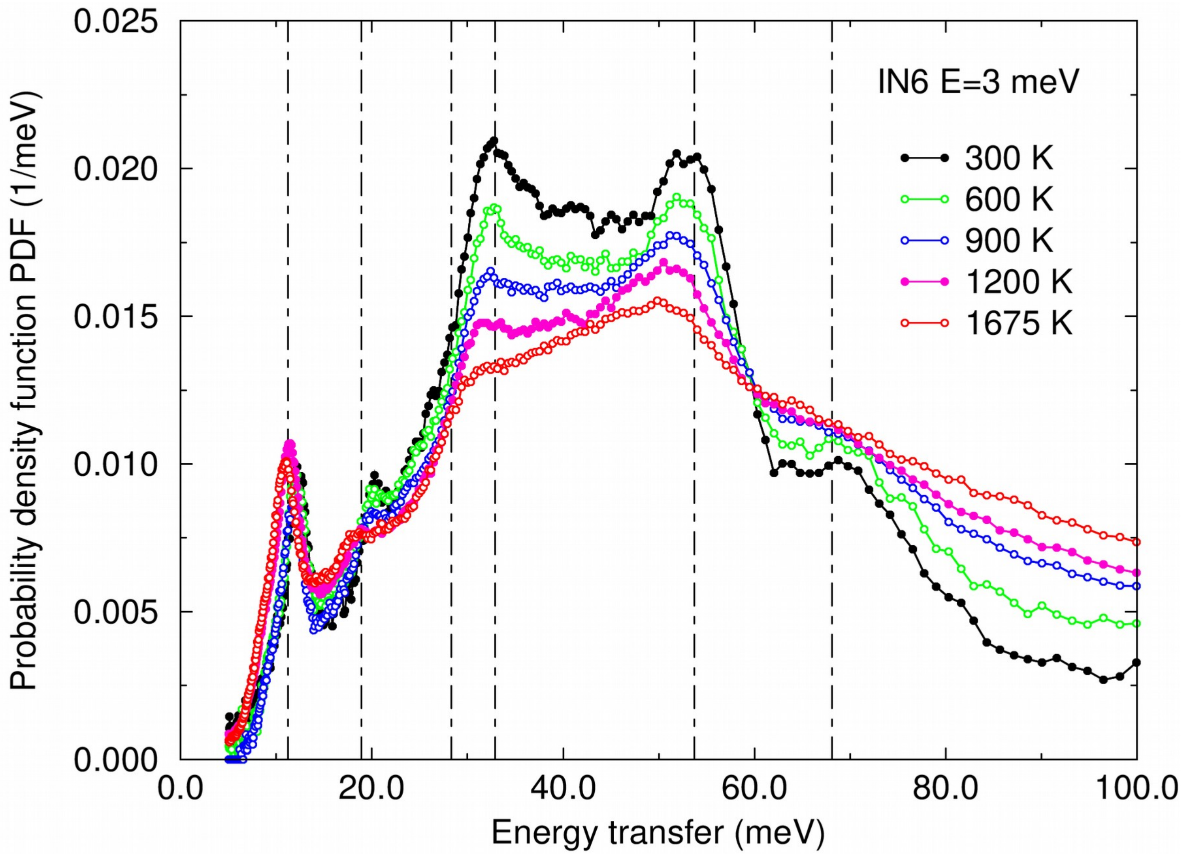
QENS data analysis



Translational diffusion part : Egelstaff-Schofield diffusion model with a Singwi-Sjolander residence time correction

UO2 measurements and Monte-Carlo analysis

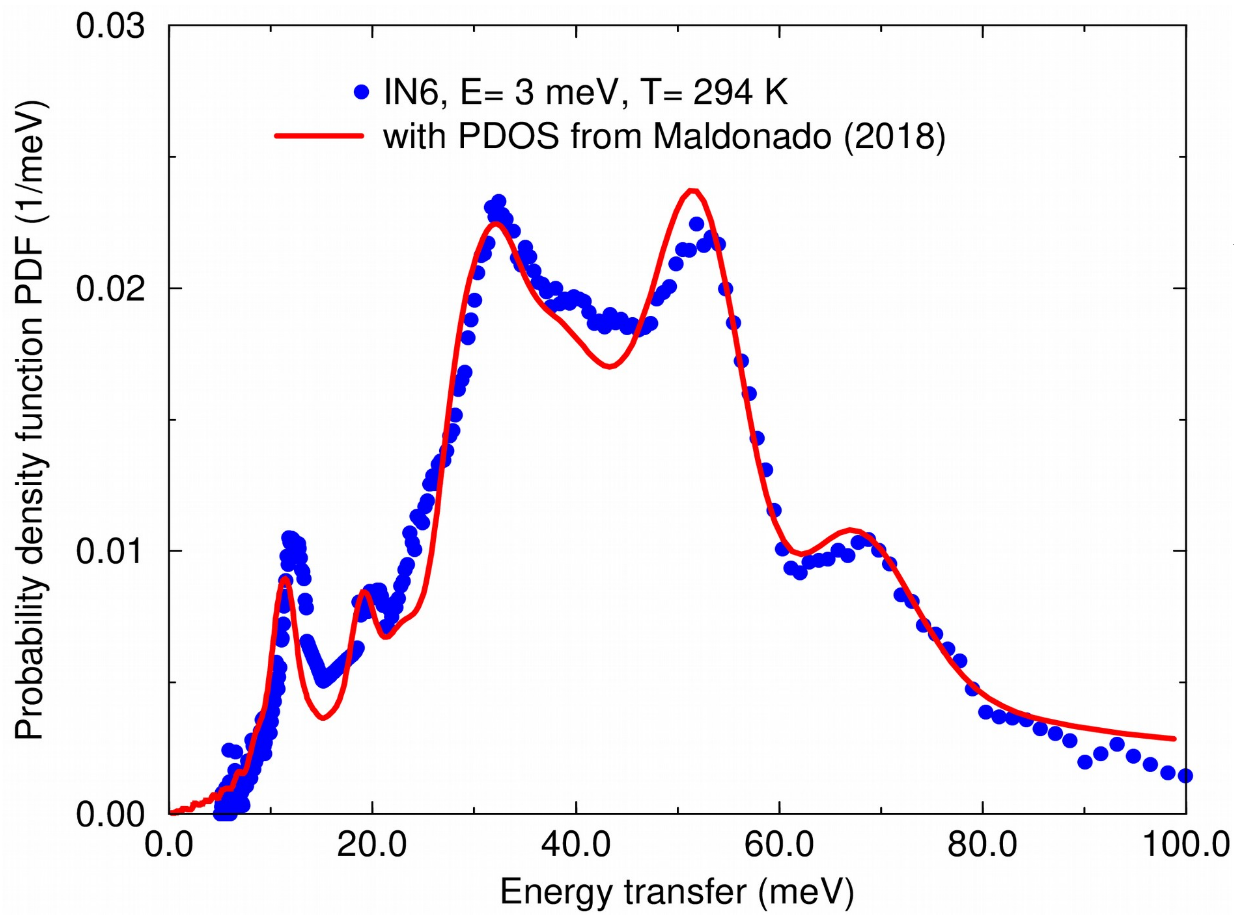
Inelastic neutron scattering measurements on IN6 time-of-flight spectrometer (T=294 to 1675 K)



Data taken from PhD thesis of Scotta (2016) and Xu (ongoing)

UO2 measurements and Monte-Carlo analysis

Experimental density of states at 294 K



Analysis of the data with the neutron transport code TRIPOLI4 by using the abinitio density of states of Maldonado (Uppsala University)

Generation of TSL covariances

Different strategies were investigated:

- Covariance matrix between MD parameters
- Covariance matrix between LEAPR parameters
- Covariance matrix between S(alpha,beta)

Propagation of TSL uncertainties to integral parameters via direct perturbation method, Iterative Fission Probability and TMC

Generation of TSL covariances

Table 6. Example of uncertainties on the reactivity (UOX configuration at room temperature) in pcm due to the nuclear data. The contribution of ^1H in H_2O comes from the present work. The other contributions were calculated with the covariance data base COMAC [32] developed at the CEA of Cadarache.

Isotopes	(n,f)	Capture	(n,n)	(n,n′)	(n,xn)	ν_{tot}	χ_{fast}	χ_{th}	Total
^1H in H_2O		150	71						166
^{10}B		26							26
^{16}O		97	14	2					98
^{90}Zr		11	72	4					72
^{91}Zr		27	30	2					40
^{92}Zr		27	20	2					33
^{94}Zr		2	8	2					8
^{96}Zr		2	6						6
^{234}U	1	6	2						6
^{235}U	104	174	13			276		142	371
^{236}U		1							1
^{238}U	29	165	83	38	18	32	9		195
Total	108	303	137	39	18	277	9	142	470

Generation of TSL covariances

Table 7. Example of uncertainties on the reactivity (MOX configuration at room temperature) in pcm due to the nuclear data. The contribution of ^{1}H in H_2O comes from the present work. The other contributions were calculated with the covariance data base COMAC [32] developed at the CEA of Cadarache.

Isotopes	(n,f)	Capture	(n,n)	(n,n′)	(n,xn)	ν_{tot}	χ_{fast}	χ_{th}	Total
^{1}H in H_2O		46	110						119
^{10}B		8							8
^{16}O		114	24	4					117
^{90}Zr		11	24	7					27
^{91}Zr		13	16	4					21
^{92}Zr		8	22	4					24
^{94}Zr		2	59	3					59
^{96}Zr		2	13	1					14
^{235}U	2	6	3	1		5		4	9
^{238}U	114	88	80	−60	25	35	12		160
^{238}Pu	1	70	−20	1		9	1		67
^{239}Pu	278	371	26	5		57	0	126	484
^{240}Pu	42	178	−16	−5	1	2	9		182
^{241}Pu	108	96	8			88	58		179
^{242}Pu	3	131	10	2		2	1		131
^{241}Am	−3	47	2	29		1			47
Total	322	475	156	−59	25	111	60	126	619

Future TSL activities for SG48

Future experimental program:

- Actinide oxides:ThO2, NpO2
- Low enriched fuels: U3Si2, UMo, UZrH
- Structural materials: ZrY4, Nb

New processing code:

- CINEL (from Shuqi Xu) in replacement of LEAPR+NCRYSTAL developed in Python with GPU acceleration