#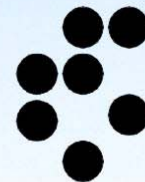 Measurements and calculations of the neutron spectrum in different irradiation channels of the TRIGA Mark II reactor, Slovenia

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Scope

Neutron spectrum characterisation of irradiation channels of TRIGA Mark II reactor

- Al, Au, Th, U, Fe monitors for spectrum determination in the IC-40 channel of carousel facility.
- Al, Au, Th, U, W monitors for spectrum determination in the IC-40 and CC channels of TRIGA reactor.
- Rh-discs with different thicknesses were irradiated in the PT (in reactor core).
- Cd-ratio method was used.
- Full-core model for the MCNP5 Monte Carlo code is used for activation and spectrum calculations (Andrej Trkov).

Q_0 and k_0 for Se-75

- 1000 mg/L of Se (Merck) was used.
- Cd ratio method in the IC-40 was applied.

Proficiency tests

- The efficiency test for calibration of an HPGe detector using: Ba-133, Eu-152, Ra-226 (Zsolt Revay).
- The proficiency test of the SMELS samples Types I, II and III using k0_IAEA ver 4.00 program.
- BCR-320R Channel Sediment for validation purpose (three replicates).

Nuclear research reactor
TRIGA Mark II (250 kW)
(reactor core No. 189, 2006)
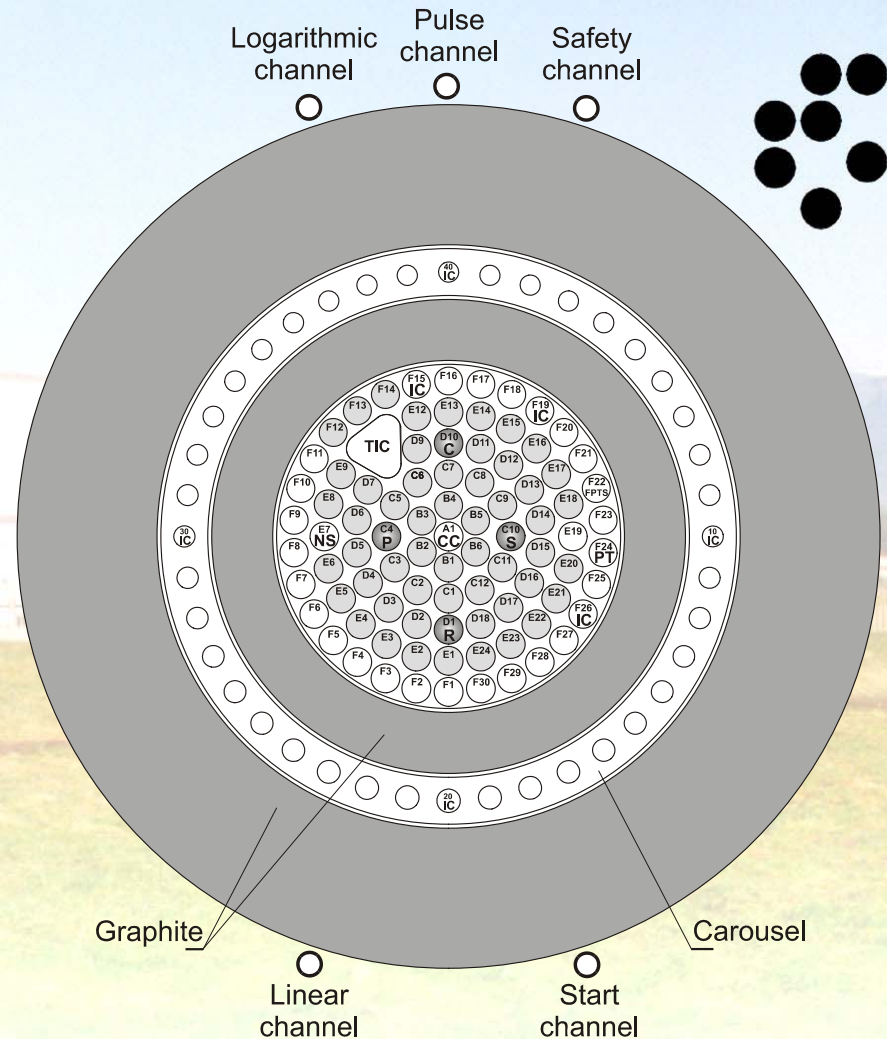
- Short and long irradiation in the CC:

$$\varphi_{th} \sim 10 \cdot 10^{12} \text{ cm}^{-2} \text{ s}^{-1}$$

-Short irradiation in the PT and in the FPTS
(up-to 30 min.)

$$\varphi_{th} \sim 3.5 \cdot 10^{12} \text{ cm}^{-2} \text{ s}^{-1}$$

- Long irradiation in the IC-40 (typically 20 hours)

$$\varphi_{th} \sim 1.1 \cdot 10^{12} \text{ cm}^{-2} \text{ s}^{-1}$$

Logarithmic channel   Pulse channel   Safety channel

Graphite   Carousel

Linear channel   Start channel

Fuel elements 20 % U-235   FPTS Fast pneumatic transfer system

Control rods   PT Pneumatic transport tube channel

NS Neutron source   CC Central channel

IC Irradiation channels   TIC Triangular channel

# Experimental
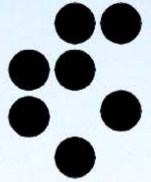
Experimental equipment

- 250 kW light-water moderated nuclear research reactor TRIGA Mark II with graphite reflector.
- Semiconductor coaxial HPGe detector (Canberra, 45% relative efficiency).
- Semiconductor coaxial HPGe detector (Ortec, 40% relative efficiency).
- Analytic weight METTLER AE 163 (accuracy ± 0.00001 g)
- Al-Au discs (Al(99.9%)-Au(0.1%)) 5 mm in diameter and 0.2 mm high.
- Polyethylene containers
- Al and polyethylene rabbits.

Sample preparation

- Aliquot of a sample into SPRONK ampoule (pure polyethylene)
- Pellets 5 and 10 mm in diameter prepared using hydraulic press (SPECAC, UK).
- Sample and standard are prepared in sandwich form and irradiated in the carousel facility and PT of the TRIGA Mark II reactor
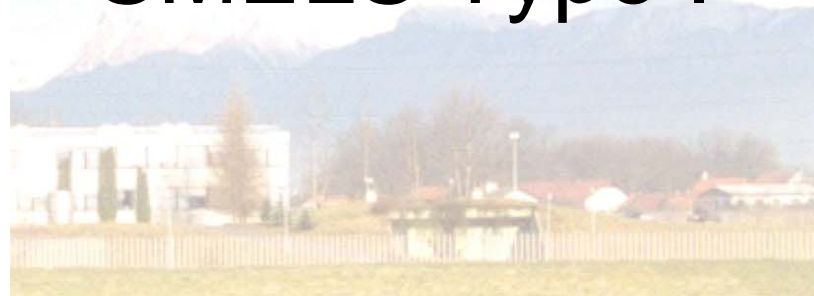
Evaluation of data

- Evaluation of the spectrum by HyperLab program
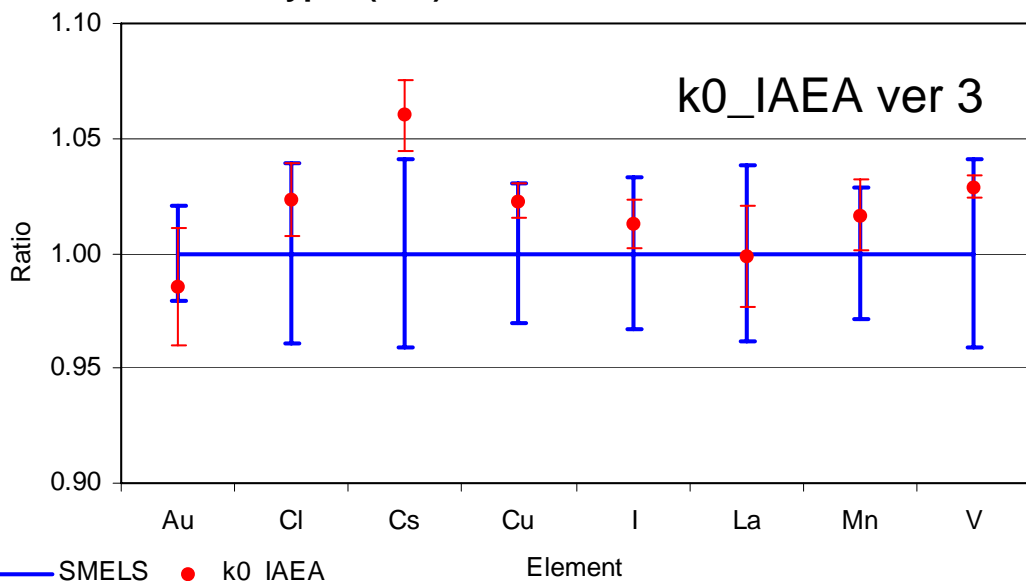- Calculation of element concentration by k0_IAEA program
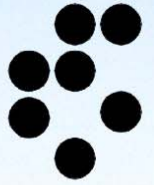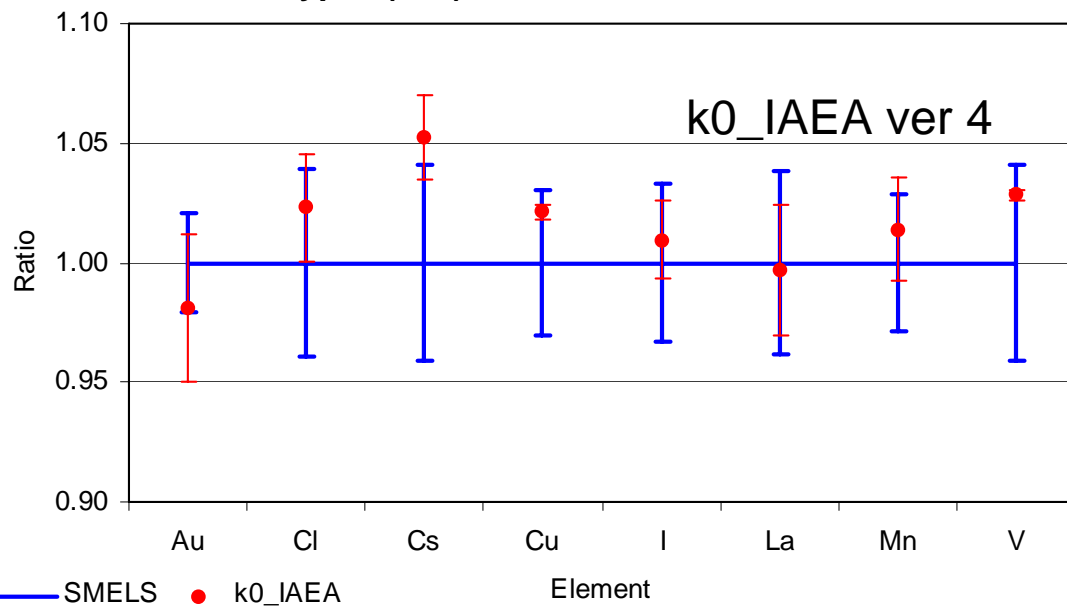
Re-evaluation of the SMELS samples via k0_IAEA ver 4
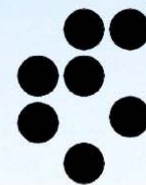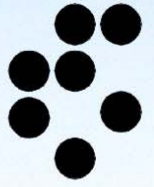
SMELS Type I (n=3) in the PT of the TRIGA reactor

k0_IAEA ver 3

Ratio / Element

— SMELS ● k0_IAEA

SMELS Type I

SMELS Type I (n=3) in the PT of the TRIGA reactor

k0_IAEA ver 4

Ratio / Element

Note:
the same gamma spectra for input

3rd RC —— SMELS ● k0_IAEA

SMELS Type II (n=3) in the IC40 of the TRIGA reactor

k0_IAEA ver 3

SMELS Type II
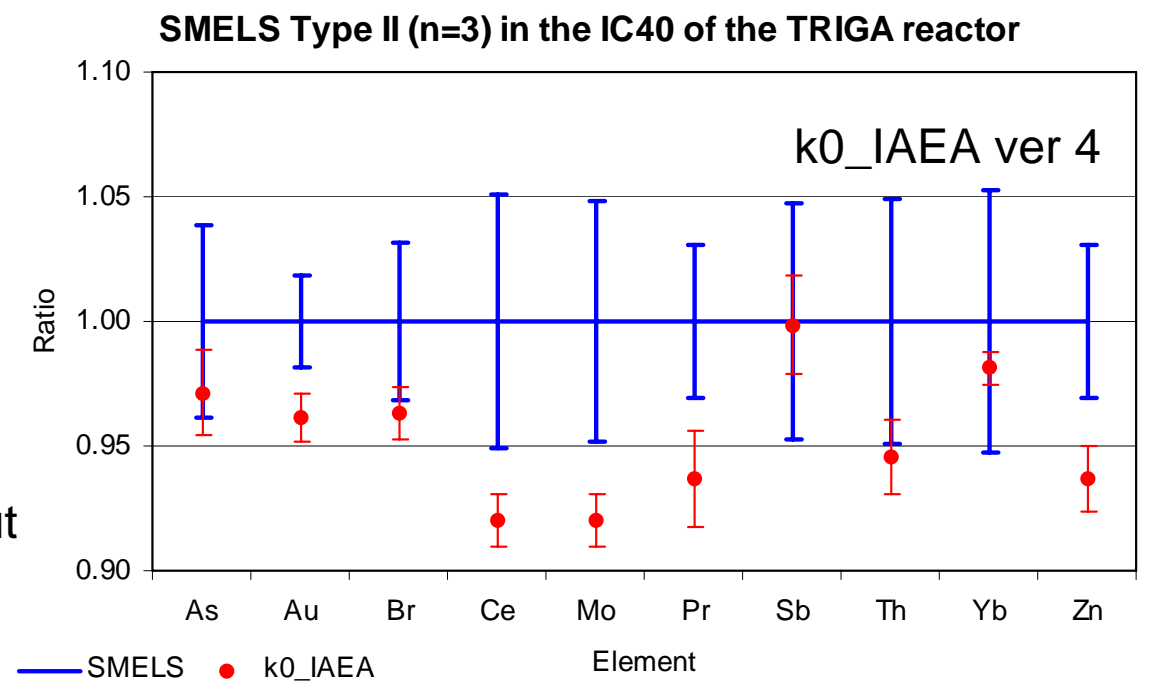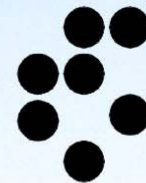
k0_IAEA ver 4
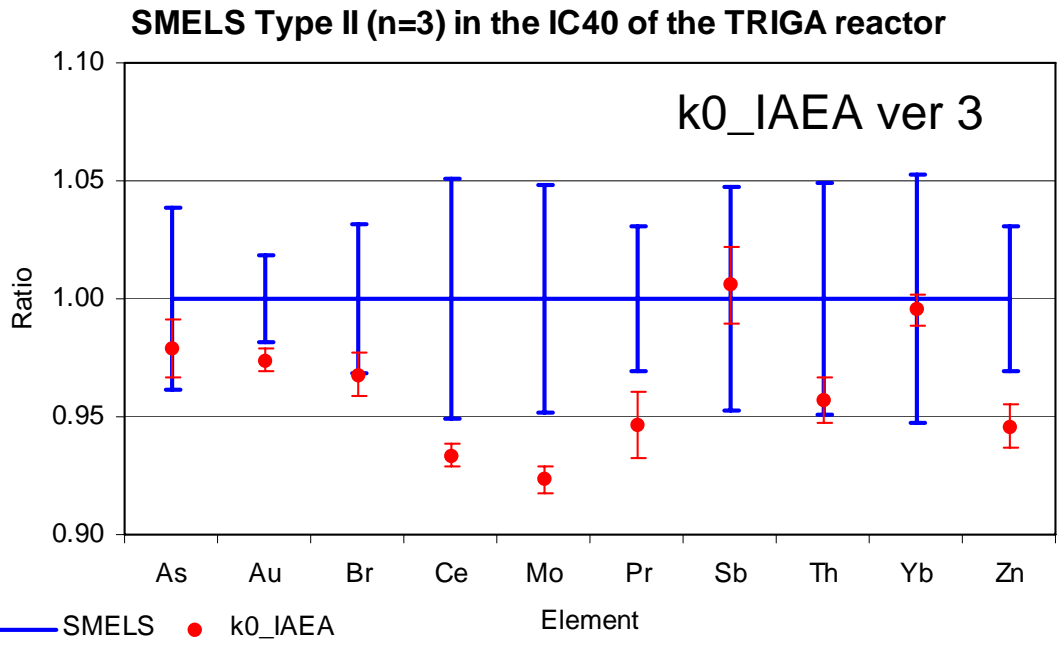
Note:
the same gamma spectra for input

3rd

SMELS Type III (n=3) in the IC40 of the TRIGA reactor
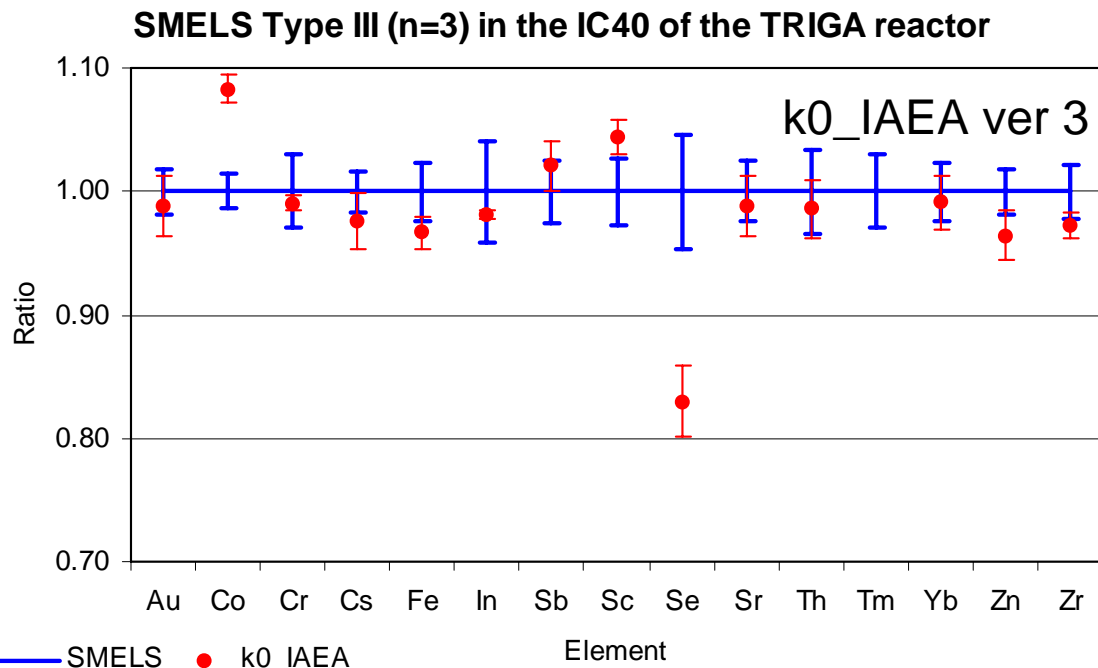
k0_IAEA ver 3

SMELS Type III

SMELS Type III (n=3) in the IC40 of the TRIGA reactor

k0_IAEA ver 4
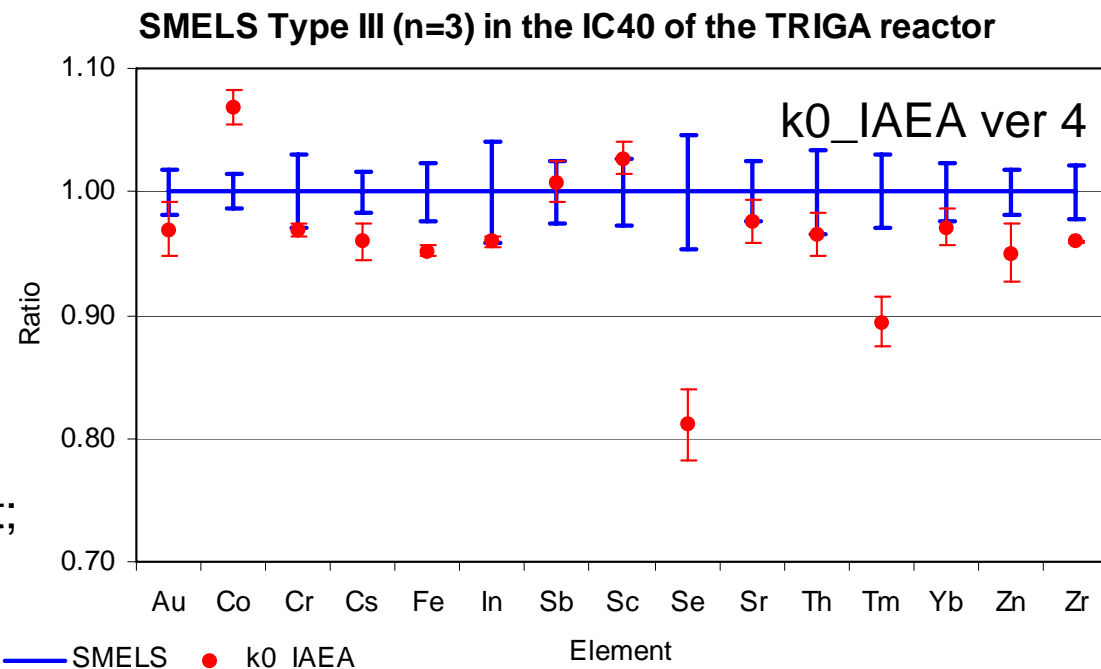
Note:

-the same gamma spectra for input;

-Cr subscripted manually

3rd F
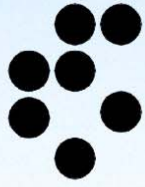
E, keV	k0_recomm	Q0	k0_IAEA	Q0_IAEA	Ratio Q0	Ratio k0
96.7	4.18E-04	10.8	4.27E-04	11.5	0.939	0.979
121.1	1.94E-03		1.98E-03			0.980
136	6.76E-03		6.89E-03			0.981
198.6	1.76E-04		1.80E-04			0.978
264.7	7.11E-03		7.25E-03			0.981
279.5	3.00E-03		3.06E-03			0.980
303.9	1.61E-04		1.64E-04			0.982
400.7	1.43E-03		1.45E-03			0.986

E, keV	gamma (%), k0_IAEA	gamma (%) F. De Corte	Ratio (FDC/k0_IAEA)
96.7	**4.127**	**3.440**	**0.834**
121.1	**20.52**	**15.967**	**0.778**
136	**69.98**	**55.638**	**0.795**
198.6	**1.817**	**1.449**	**0.797**
264.7	**70.12**	**58.519**	**0.835**
279.5	**29.54**	**24.691**	**0.836**
303.9	**1.281**	**1.325**	**1.034**
400.7	**13.70**	**11.770**	**0.859**