Validation of cross section on (n,2n) reactions

Nicola Burianová

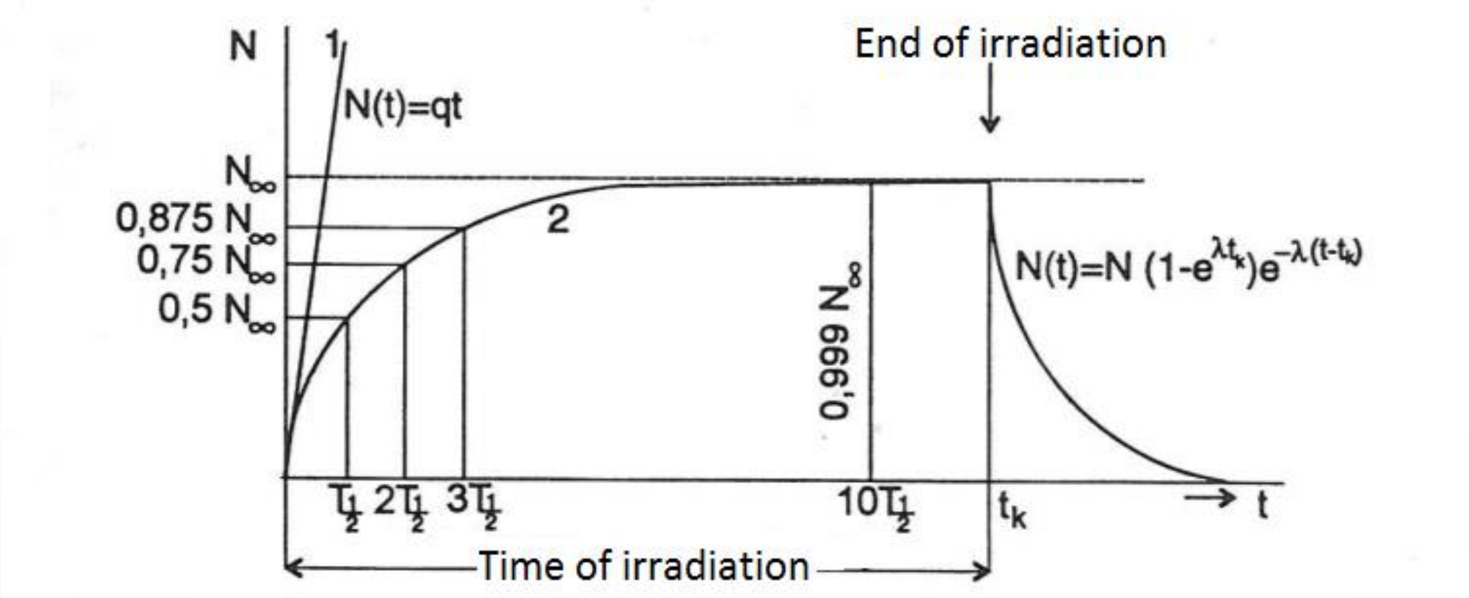
Reasons of validation

- Reactor dosimetry - determining the damage of the reactor vessel (life expectancy of the nuclear power plant)

- Precision of neutron fission spectrum of 235U (in region of the higher neutron energies)

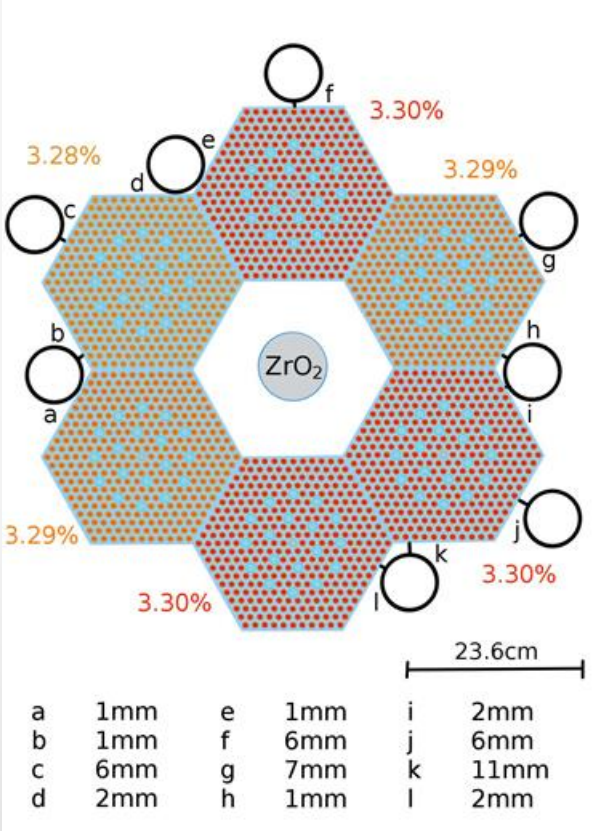
Irradiation

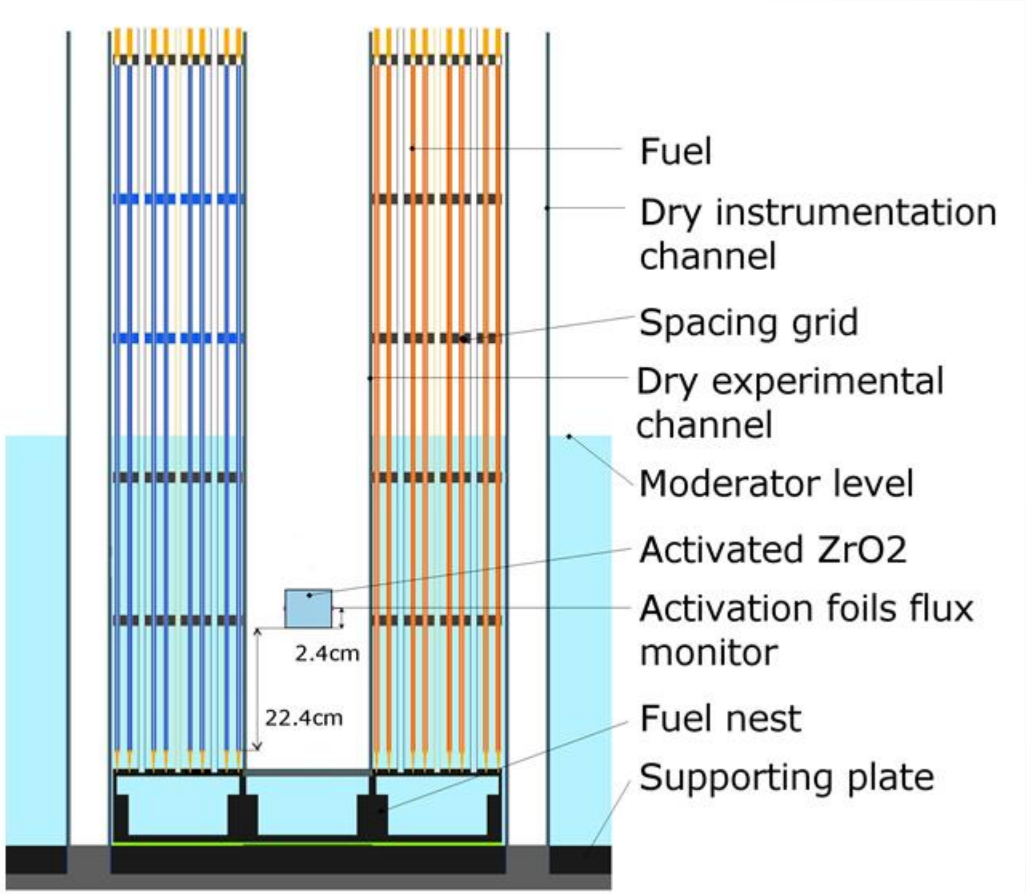
- Chosen sample is irradiated in reactor LR-0
- Irradiation time is dependent on half-life of generated radioisotope



Irradiation

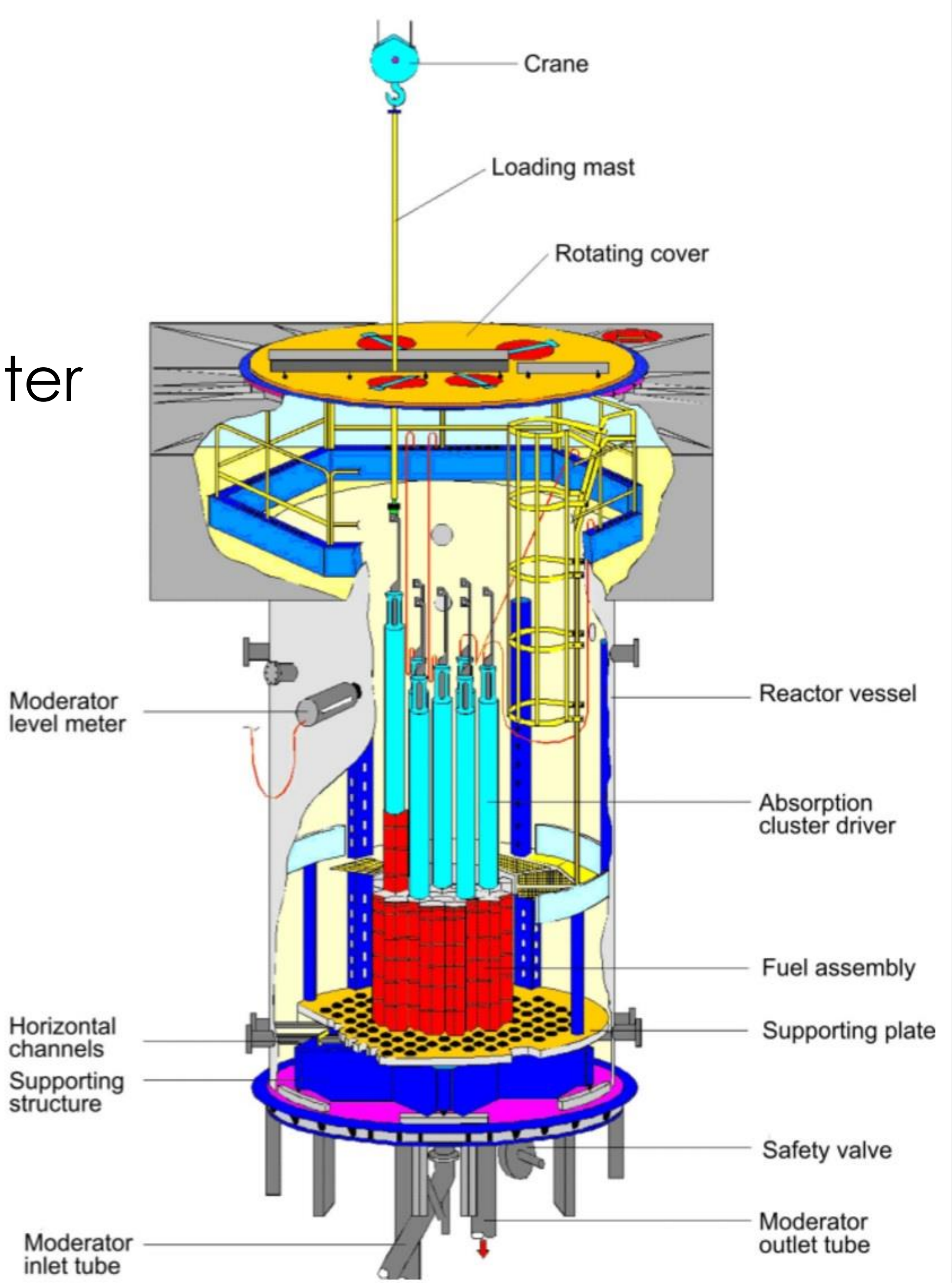
- Example of ZrO2 irradiation





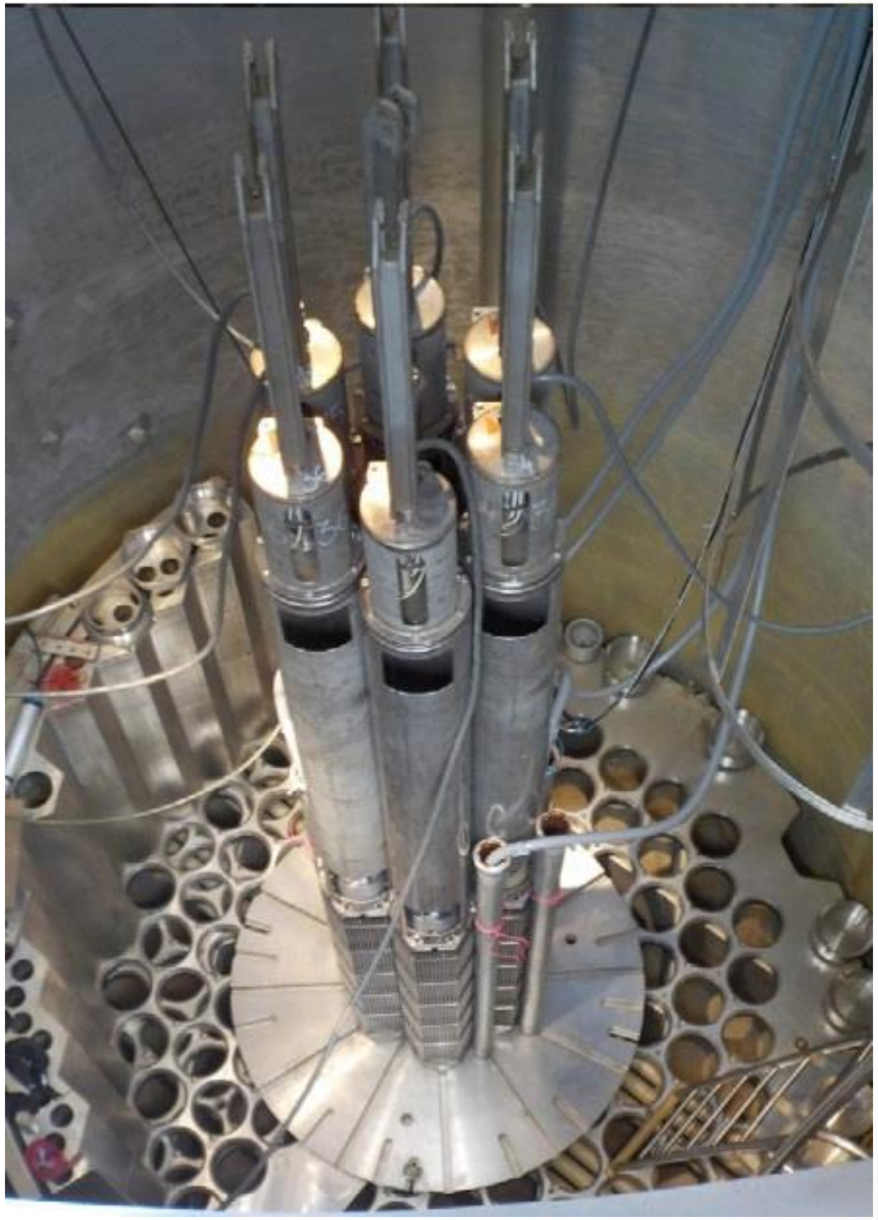
LR-0 reactor

- Moderator - De-mineralized water with boric acid
- Fuel - UO2
- Enrichment - 1.6 - 4.4% U235
- Absorption Clusters - 18 rods - solid B4C
- Maximum output - 1kW



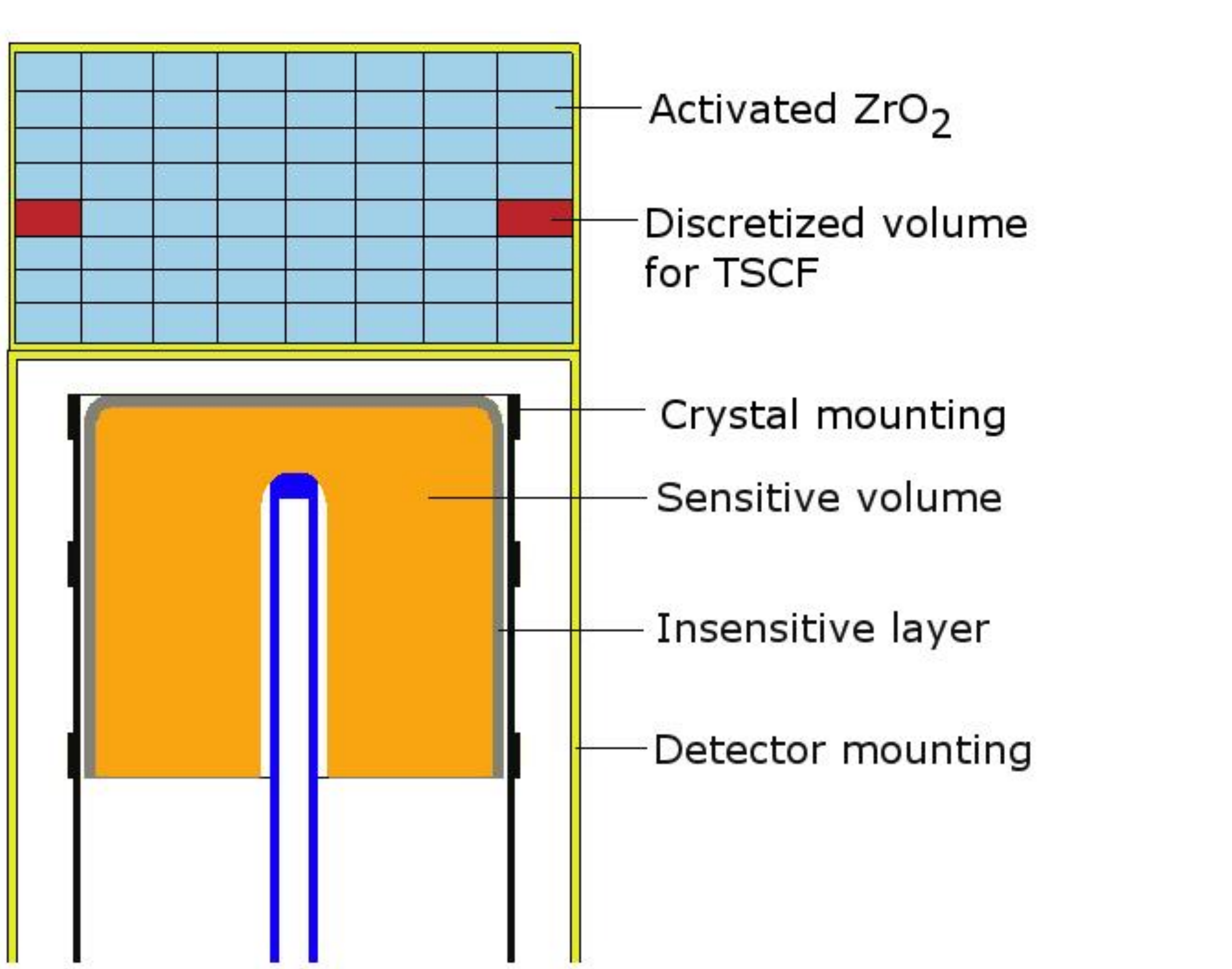
LR-0 reactor

Overhead view inside the LR-0 reactor with special core without moderator



Measurement after irradiation

- ▶HPGe spectrometry
- ▶Measurement of activation foils (Au, Ni)
- ▶Measurement of irradiated capsule (ZrO2, …)



Measurement after irradiation

It is needed to have well-defined detector, because we measure large-volume sample (for efficiency calibration).

- Radiograms of detector – pictures of detector geometry
- Measurement of insensitive layer

Evaluation of measurement

$$RR = \frac{NPA}{T_m} \times \frac{\lambda}{\varepsilon \times \eta \times N} \times \frac{1}{\left(1 - e^{-\lambda . T_m}\right)} \times \frac{1}{e^{-\lambda . \Delta T}}$$

Where:

RR is the reaction rate of activation during power density $\overline{P}$ (power in first day of irradiation experiment);

T_m is time of measurement by HPGe;

ΔT is the time between the end of irradiation and the start of HPGe measurement;

ε is the gamma branching ratio;

η is the detector efficiency (the result of MCNP6 calculation);

N is the number of target isotope nuclei;

Evaluation of measurement

RR = Φ*σ

Where Φ is neutron flux and σ is cross-section. Neutron flux is determined from measurement of activation foils (Au for thermal neutrons and Ni for fast neutrons)

$$\phi = \frac{K_{Au} + K_{Ni}}{2};\ K_{Au} = \sum_{i=1}^{N} \frac{RR^{i}_{Au}(1\text{ nps})_{Calculated}}{RR^{i}_{Au}(\overline{P})_{Measured}},\ K_{Ni} = \sum_{i=1}^{N} \frac{RR^{i}_{Ni}(1\text{ nps})_{Calculated}}{RR^{i}_{Ni}(\overline{P})_{Measured}}$$

Evaluation of measurement

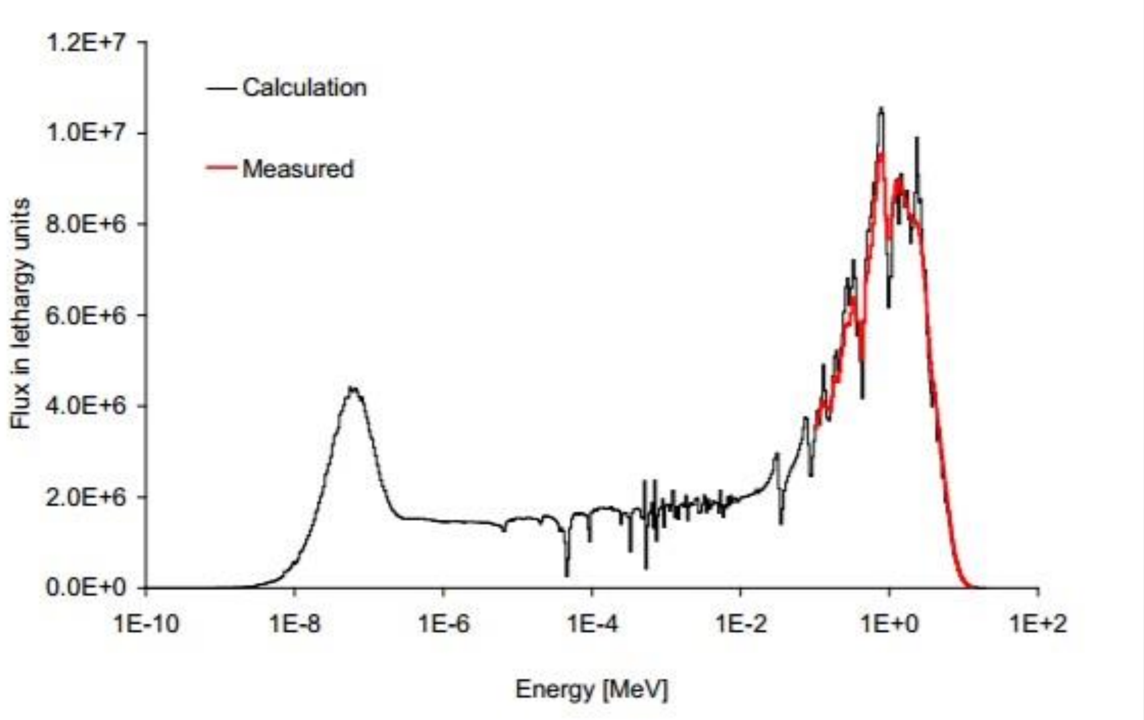
$$RR_{Calculated} = \frac{\int_E \sigma(E) \times \phi(E) \times dE}{k_{eff}^{calculated}}$$

$$\overline{\sigma} = \frac{RR}{\int_{E > 10\ MeV} \phi(E) \times dE} \times C$$

RR is the reaction rate;
$\sigma(E)$ is the cross section;
$\phi(E)$ is the calculated neutron spectrum;
C is the correction factor to the spectral shift effect (C = 0.985).

Acquired spectral average cross-section is compared with spectral average cross-section in databases.

Neutron spectrum is calculated by MCNP method



Thank you for your attention!