Nuclear fuel assembly as a material irradiation position at research reactor LVR-15

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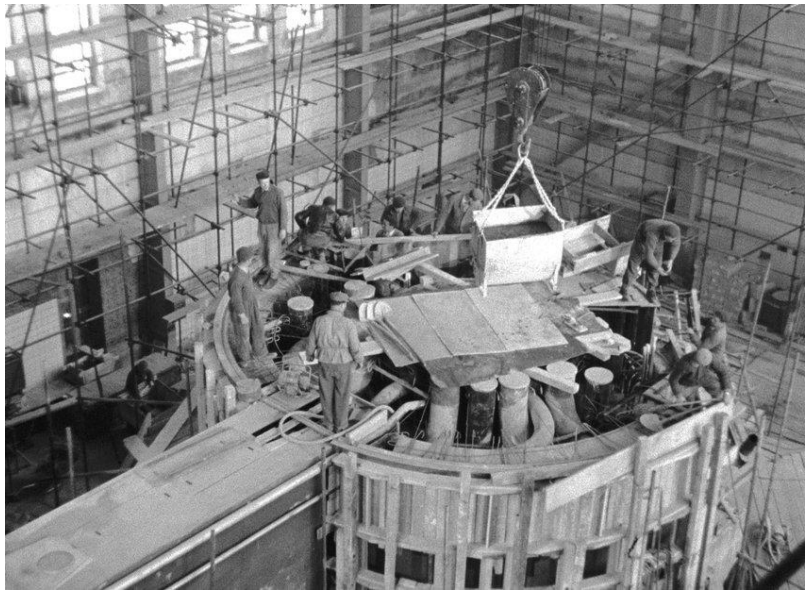
- Purpose and main utilization
- Devices for irradiation

Nuclear fuel assembly as an irradiation position

Summary and future outlooks



History of LVR-15 research reactor

1957: commissioning of the first research reactor in Czechoslovakia – VVR-S (2 MWt) at the Nuclear Physics Institute in Řež.

1964: reactor refurbishment and power uprate up to 4MWt (new fuel EK-10 with 10% enrichment)

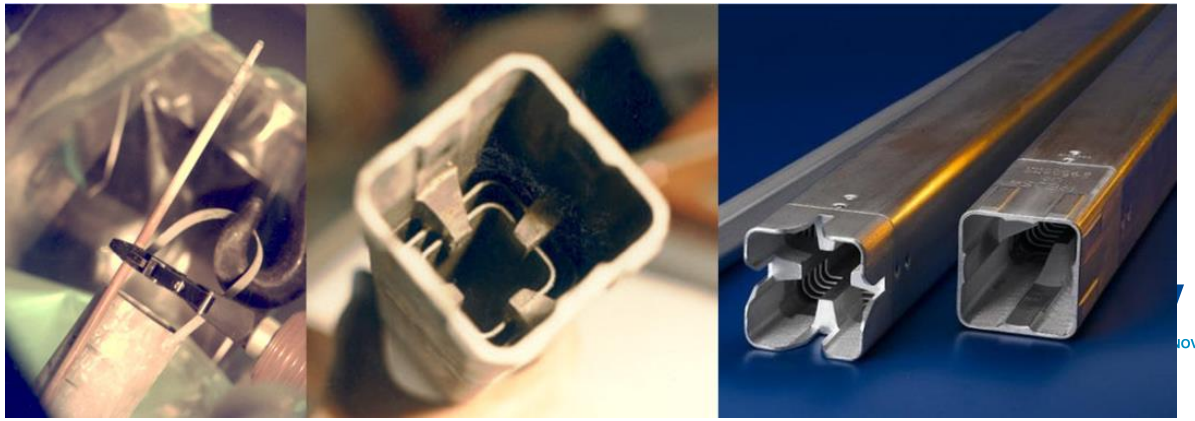
1974: power uprate up to 10MWt (new fuel IRT-2M with 80% enrichment)

1988–1989: Major reconstruction of VVR-S to LVR-15.

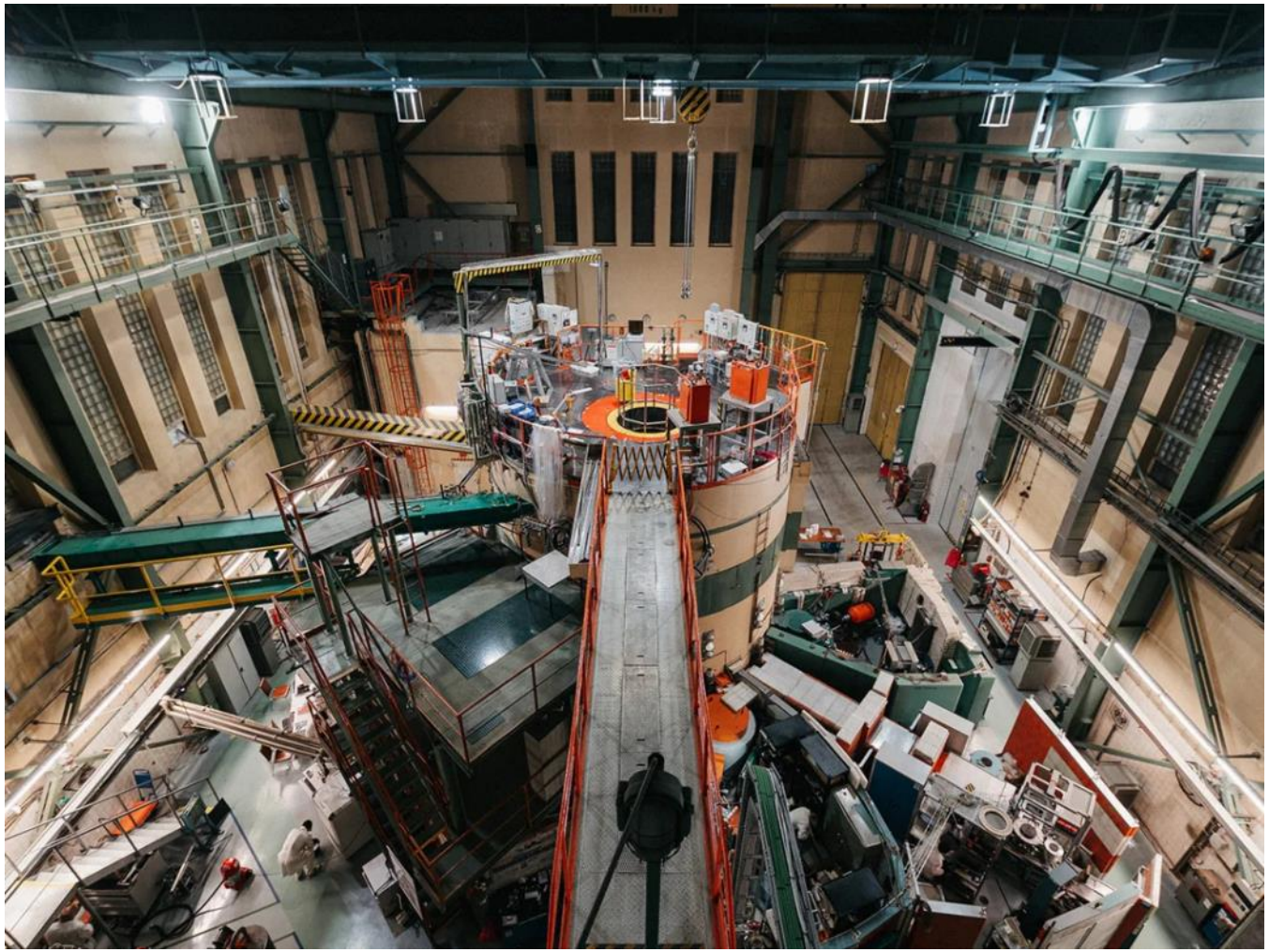
- Reactor vessel extraction, full system modernization to enhance operational safety.

1995-1998: new fuel IRT-2M with 36% of enrichment, and transition to permanent operation

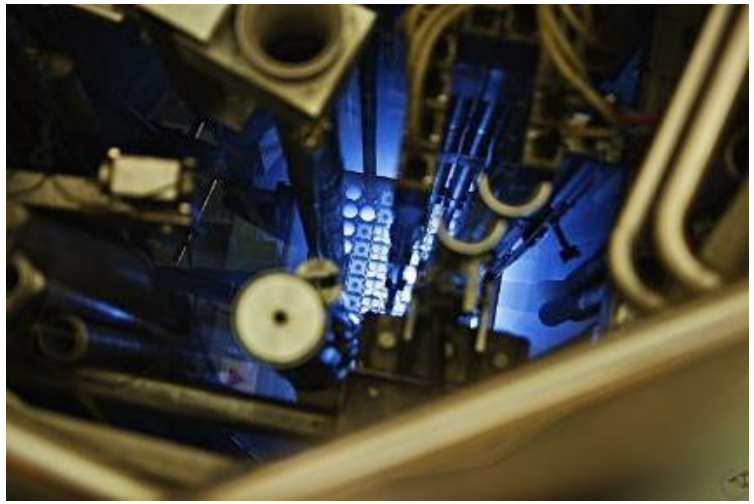
2011: new fuel IRT-4M with 19,7% enrichment



Research reactor LVR-15



Reactor type	tank
Pressure	atmospheric
Average temperature	45 °C
Coolant	demineralized water
Reflector	beryllium
Nominal power	10 MWt
Thermal flux	1.5 x 10^{14} n/cm^{2}s
Fast flux	2.5 x 10^{14} n/cm^{2}s



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LVR-15 reactor operation

Neutron flux and DPA depend on core setup, fuel depletion and cycle setup

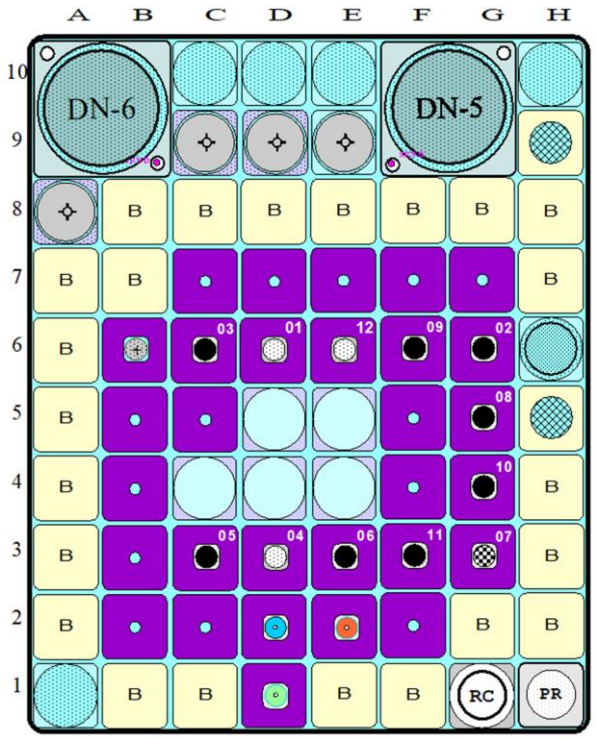
- Can slightly changed cycle by cycle

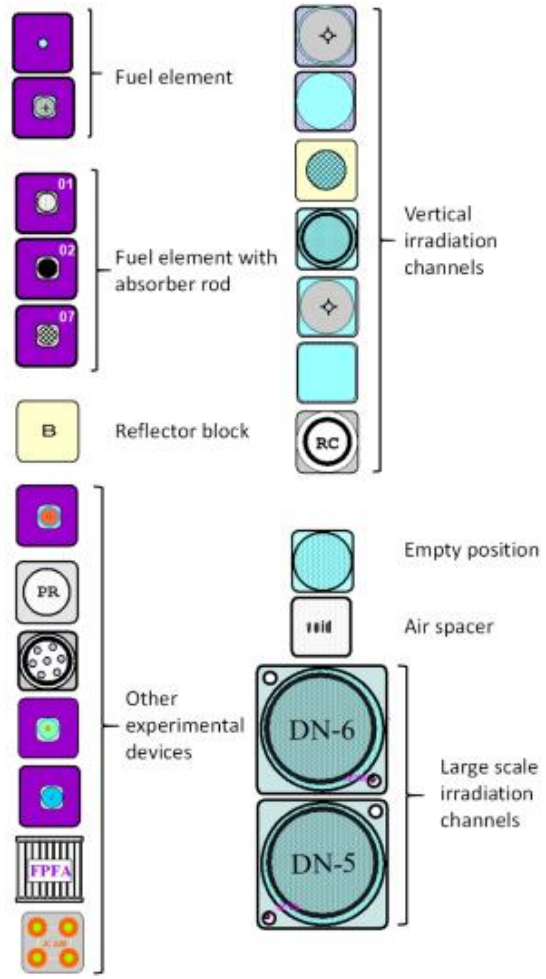
Typical usability: **200 EFPD**

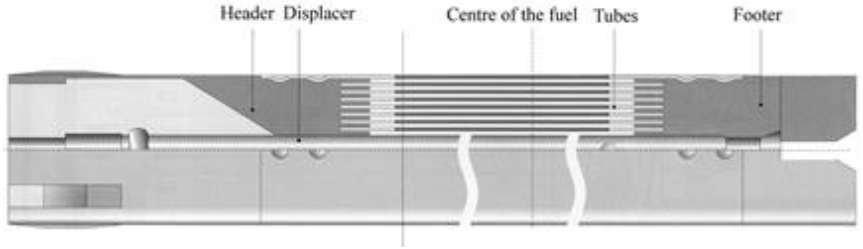
- 25-33 days of irradiation cycle, 14-20 days of outage
- Approx. 6-7 cycles per year

Fuel

- U235 Type IRT-4M
- Enrichment 19,75 %







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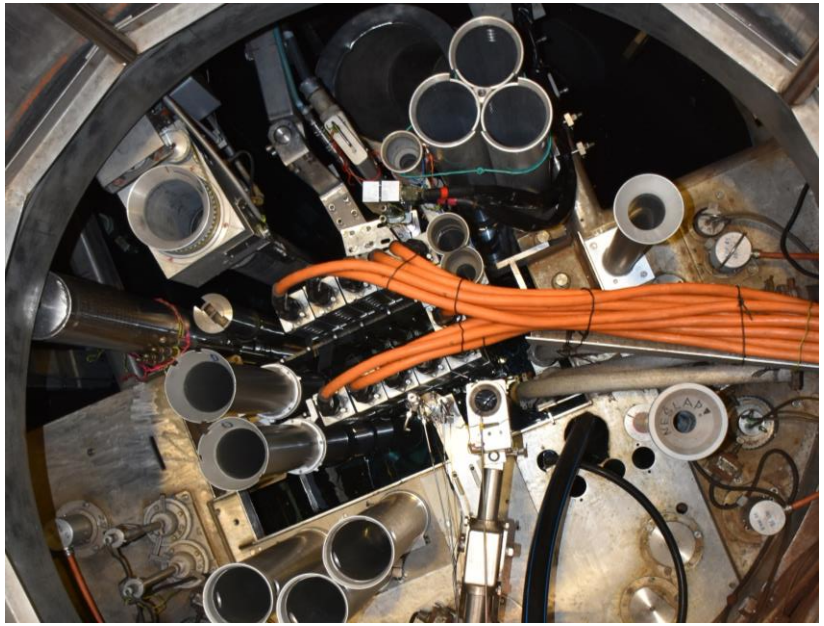
LVR-15 reactor utilization

Material research, *no fuel irradiation*

- Irradiation rigs: standardized, special purpose rigs
- Past experience with in-pile water loops: BWR, PWR
- Currently in operation out-of-pile loops: SCWL, HTHL



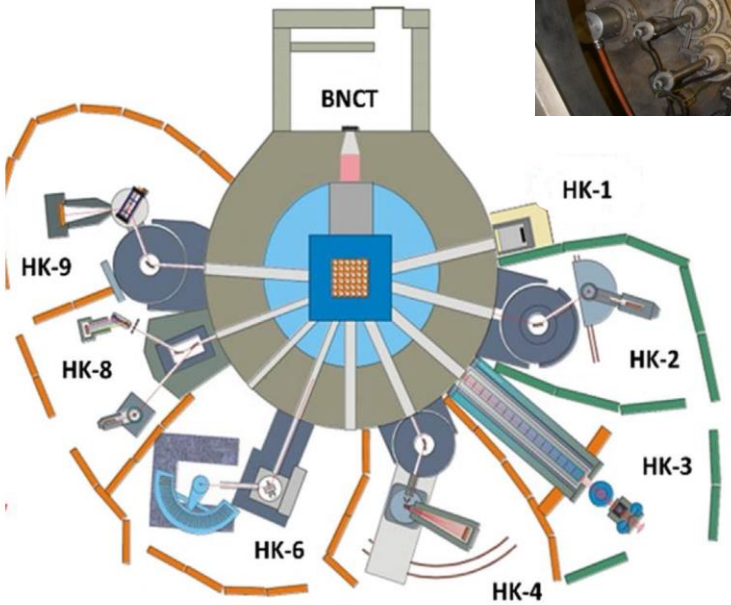
Isotope production (medical, industrial)

Neutron Transmutation Doping

- Rotating rigs for Si crystal ingots

Neutron beams channels

- 9 horizontal channels



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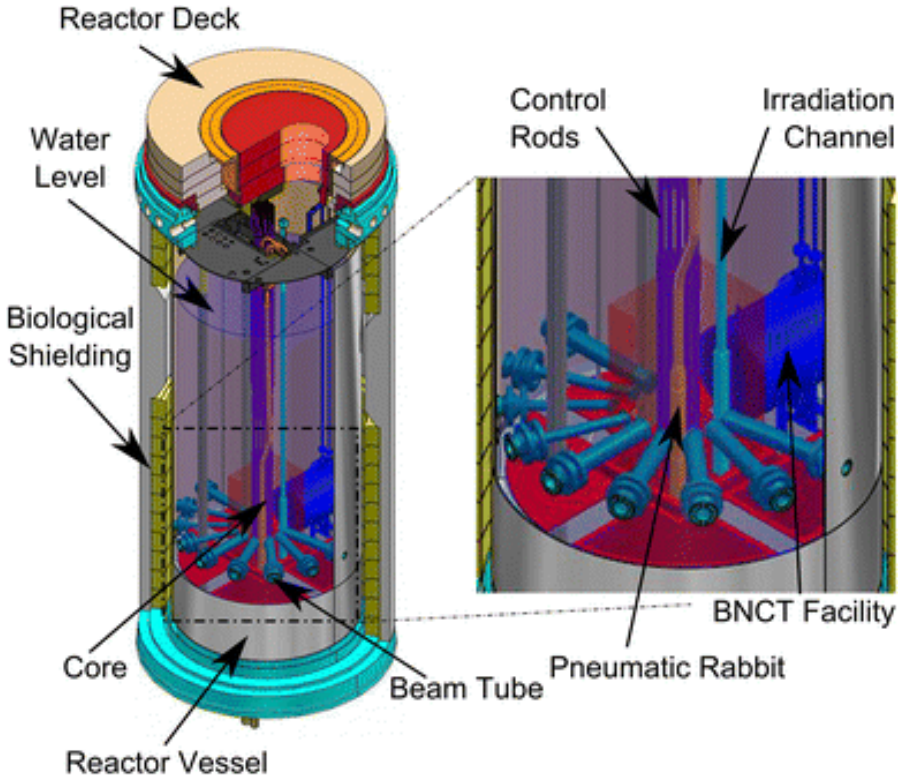
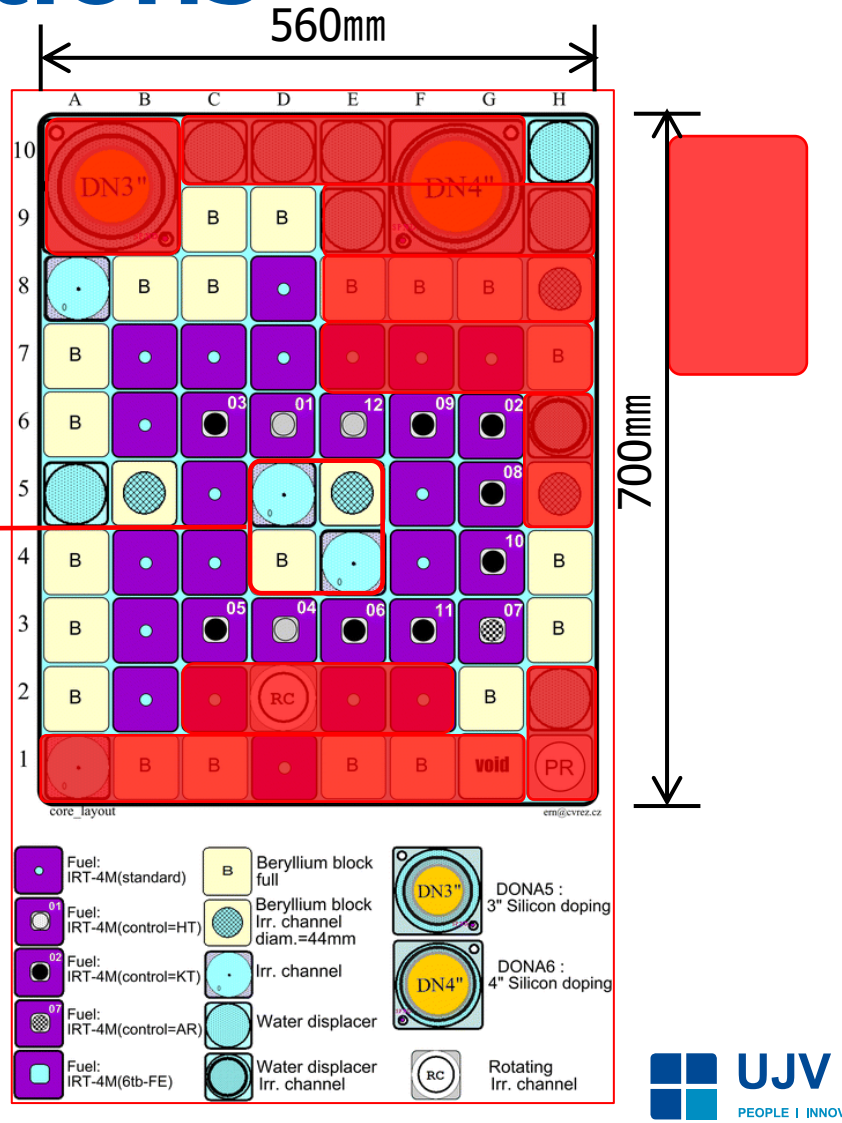
LVR-15 irradiation positions



Center



Current LVR-15 irradiation devices

Capsule type

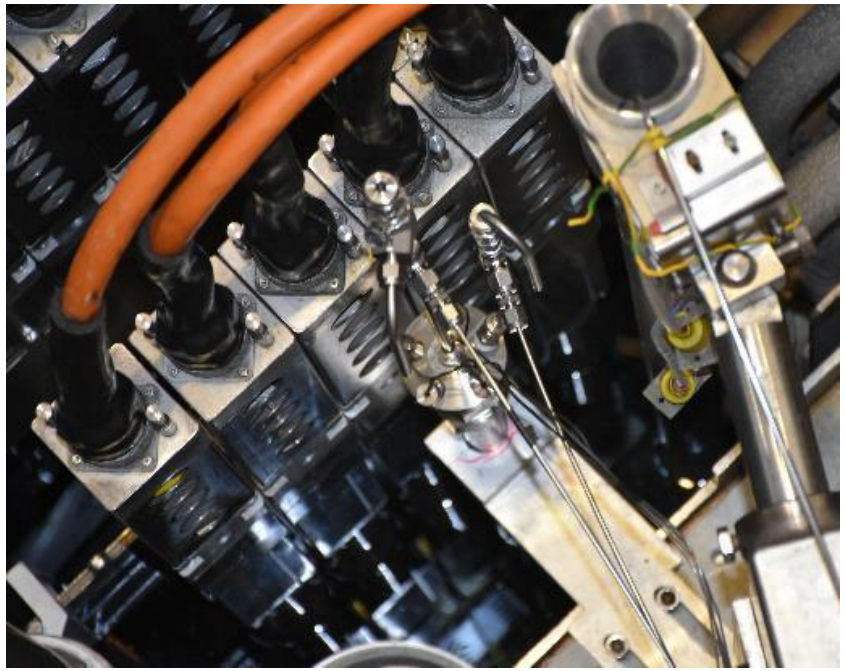
- For isotope production or low fluence requirements material irradiation
- Dry or wet (depend on requested spectra)
- Static or rotation during irradiation
- No TCs, only passive monitors

CHOUCA type rig

- For standardized tests
- Inert gas, electrical heaters
- Unique sample holder for each irradiation

Single purpose rigs

- Nonstandardized unique designs
- Gen IV. and fusion applications
- Low fluence rigs (concrete, aggregates)
  - Inert gas, temperature controlled by gas gap setup and gas mixture control, placed at the core edge or out-of-core



New material irradiation needs

Original utilization of LVR-15 reactor was for basic neutronic studies and RPV steel studies -> no need for extra high fluences

Production of radioisotopes came out as a worldwide need -> requirements for higher fluxes and constant access

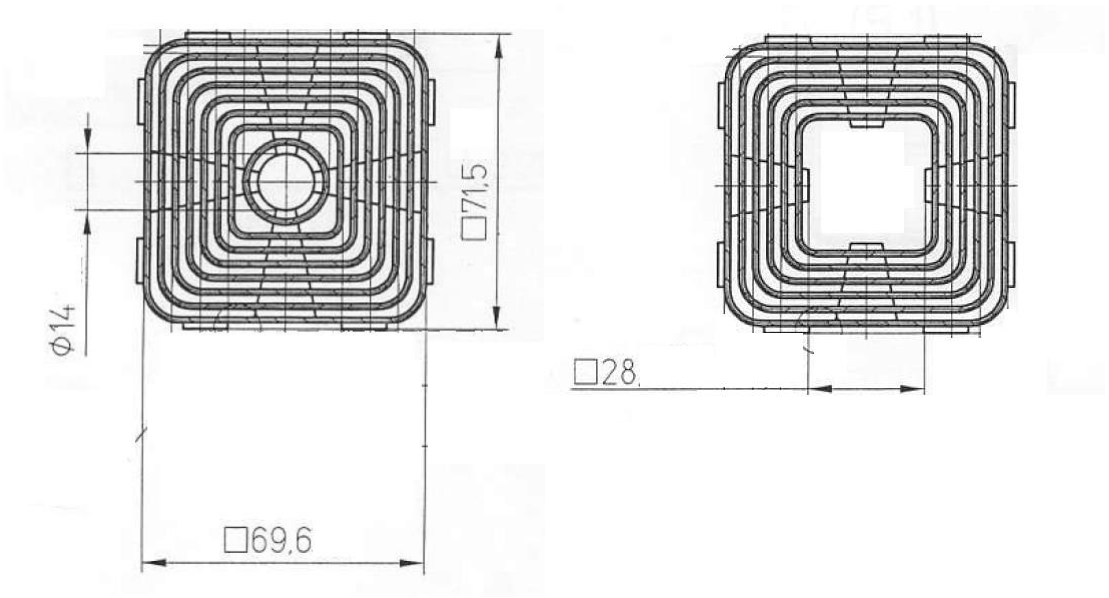
- Not original purpose of the reactor -> need for core load redesign -> central trap was designed, and currently is used for Mo-99 production

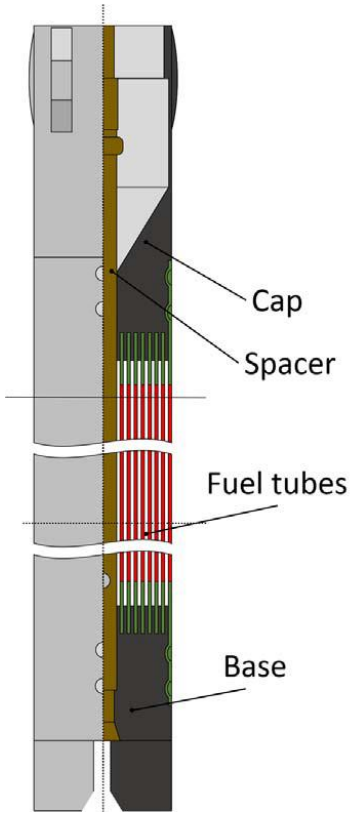
After F1NPP accident and HBWR (Norway) closure, a need for Accident Tolerant Fuel cladding material development came out

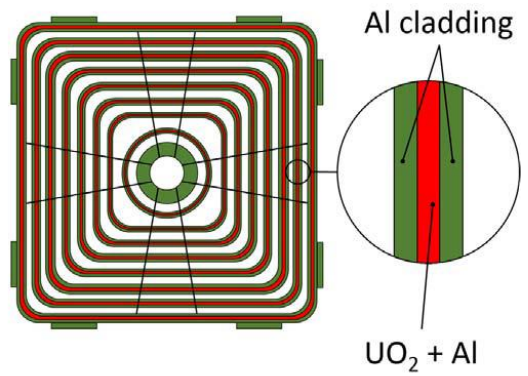
- LVR-15: central trap was already occupied. Therefore CVR find a position with higher fluxes -> nuclear fuel assembly IRT-4M

IRT-4M nuclear fuel assembly

- Plate type tube assembly with UO_2-Al composition
- 19.7 % U235 enrichment, active high 60 cm
- Eight-tube fuel assembly – 300 g U235
- Six-tube fuel assembly – 263.8 g U235







High dpa rig – material irradiation

Rig placed inside the LVR-15 fuel assembly (positions: D1, D2, E1, E2)

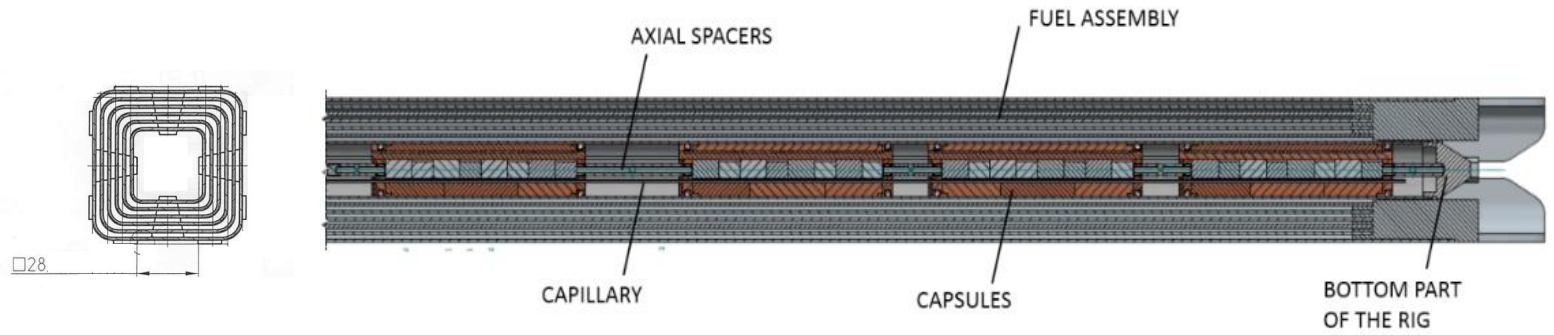
- Aluminum tube with 28 mm outer diameter

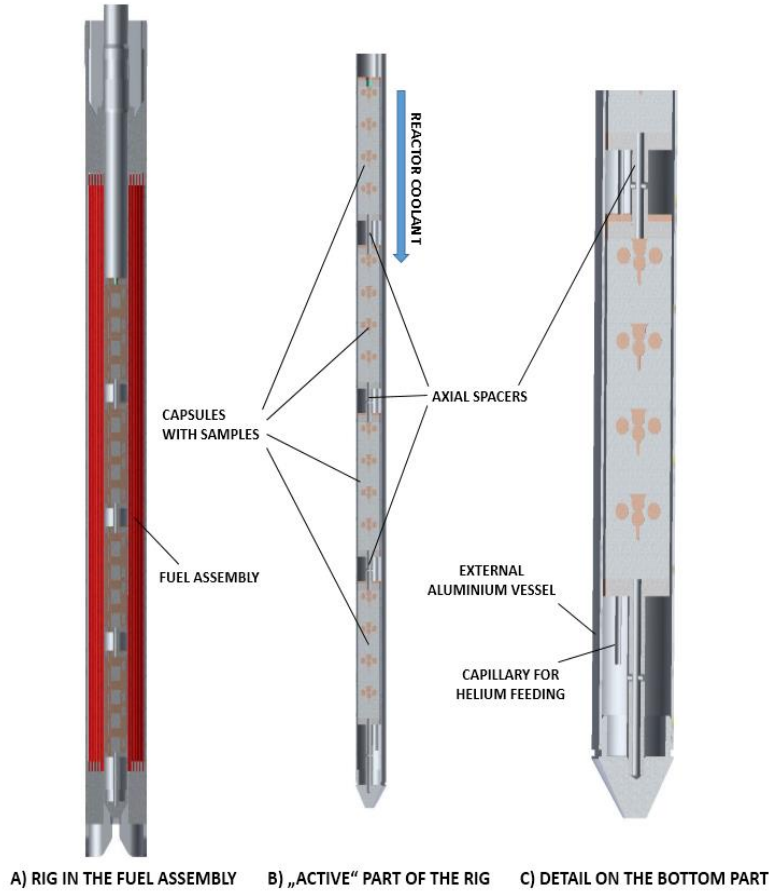
Heated by gamma and neutron interaction

- Temperature control by gas mixture composition (He-N2)
- Up to 370 °C

Specially design to achieve higher neutron fluences

- ~1.0 dpa / year

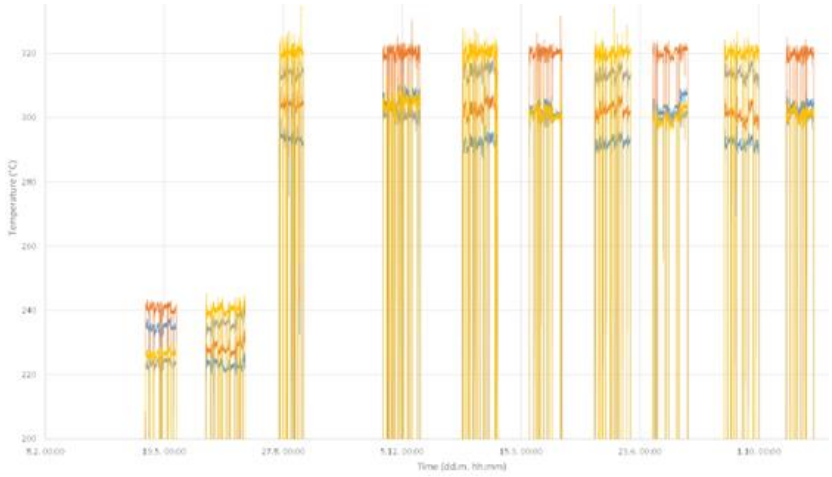


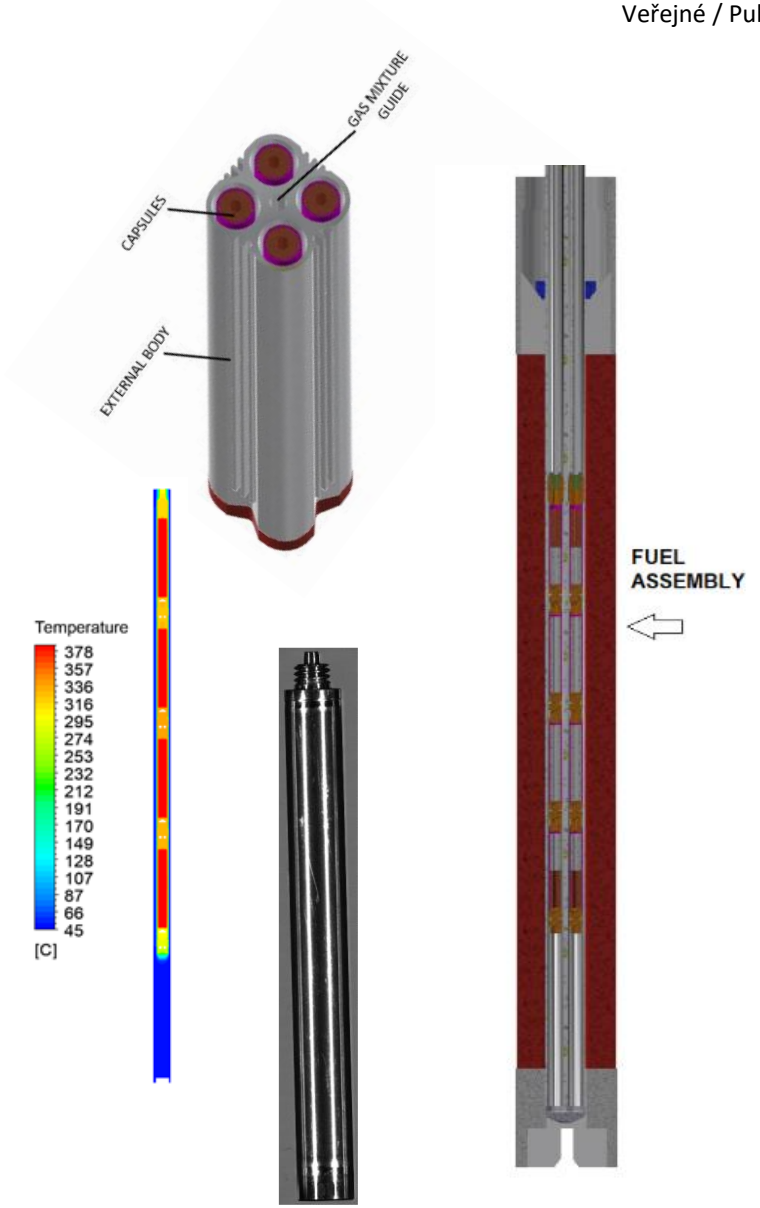


ATF cladding creep rig

Developed for INCA project within FIDES-II framework

- OKaP irradiation rig
- 16 sample positions (75 mm clad tube segments)
- Up to 12 pressurized samples
- Temperature achieved by internal copper heaters, controlled by gas gap and gas mixture/flow
- On-line temperature monitoring at upper level (4TCs)





[1] https://www.oecd-nea.org/jcms/pl_70363/in-pile-creep-studies-of-atf-cladding-inca-fides-ii-joint-experimental-programme-jeep
[2] RRFM-2024, ISBN 978-92-95064-40-9, T. Melichar, J. Soltes, M. Miklos, J. Milcak

Conclusion

Lots of development and updates were done since 1955

- commissioning of VVR-S -> refurbishment a power uprate, LVR-15 -> several fuel types implemented -> reactor utilization changed due to isotopes production needs and material testing requirements

Irradiation devices needed to be adjusted according to the needs

- Capsules, single purpose rigs, experimental corrosion loops, standard chouca-type rigs

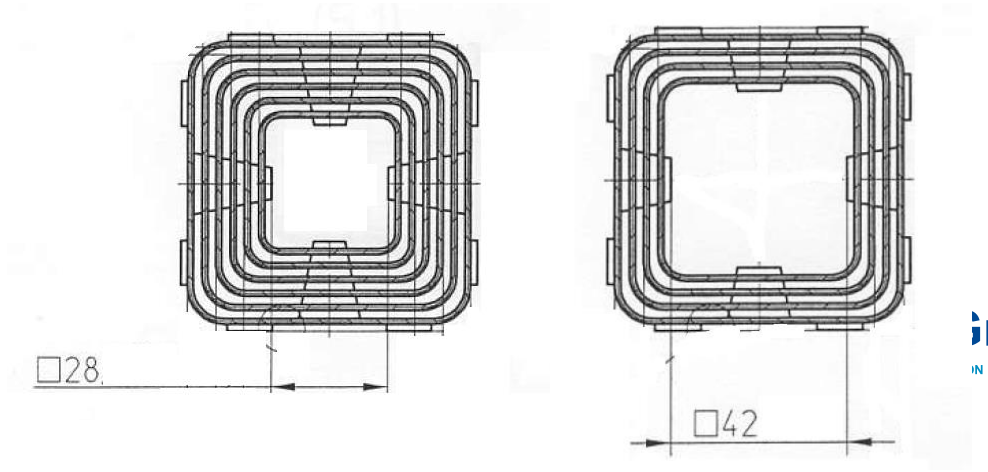
ATF cladding demands required new irradiation approach at LVR-15

- OKaP-type rig placed into the LVR-15 fuel assembly was developed, for reaching higher fluxes

Next development

OKaP type rig update

- Combination of TCs and SiC passive monitors
- ROKaP – 7 TCs including 9 pressurized samples
  - Irradiation started on 6th of June 2025
- SOKaP – 8TCs with tube samples with different dimensions
  - Irradiation started on 18th of August 2024
- Calorimetry measurement for better understanding of gamma heating
  - Irradiation test planed in 12/2026-02/2027
- New design for 4-plate assembly
  - 15% lower fluxes, however more space
  - Better temperature control



Thank you
ありがとうございました

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