Production of Medical Isotopes at the FRM II Research Reactor

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IGORR 2017, Sydney

FRM II: Key Parameters

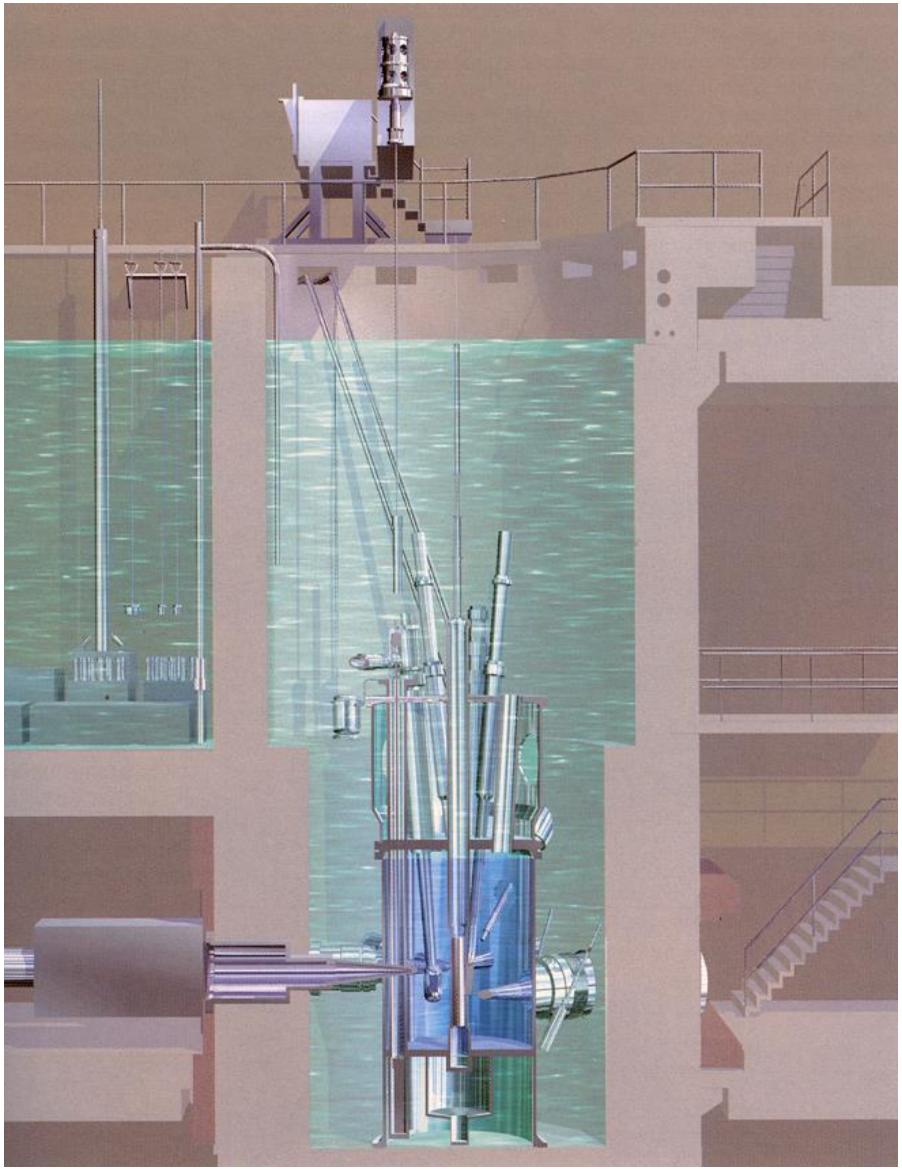
- power: 20 MW
- cycle length: 60 d
- 240 operational days / year

Mission of FRM II

- basic research by n-beams

but as an add-on also

- Si doping
- Production of medical isotopes
- Cancer therapy
- Production of tracer isotopes
- Neutron Radiography
- Neutron tomography,
- …



Lu-177:

$T_{1/2}$ = 6.7 d

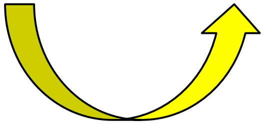
$E(ß)_{max}$ = 498 keV

Eγ = 208 keV (11%)

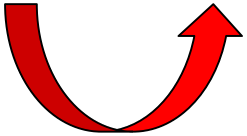
Range in human tissue: 2 mm

Applications:
prostate cancer
NED tumours

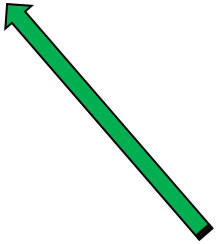
Different production routes to Lu-177



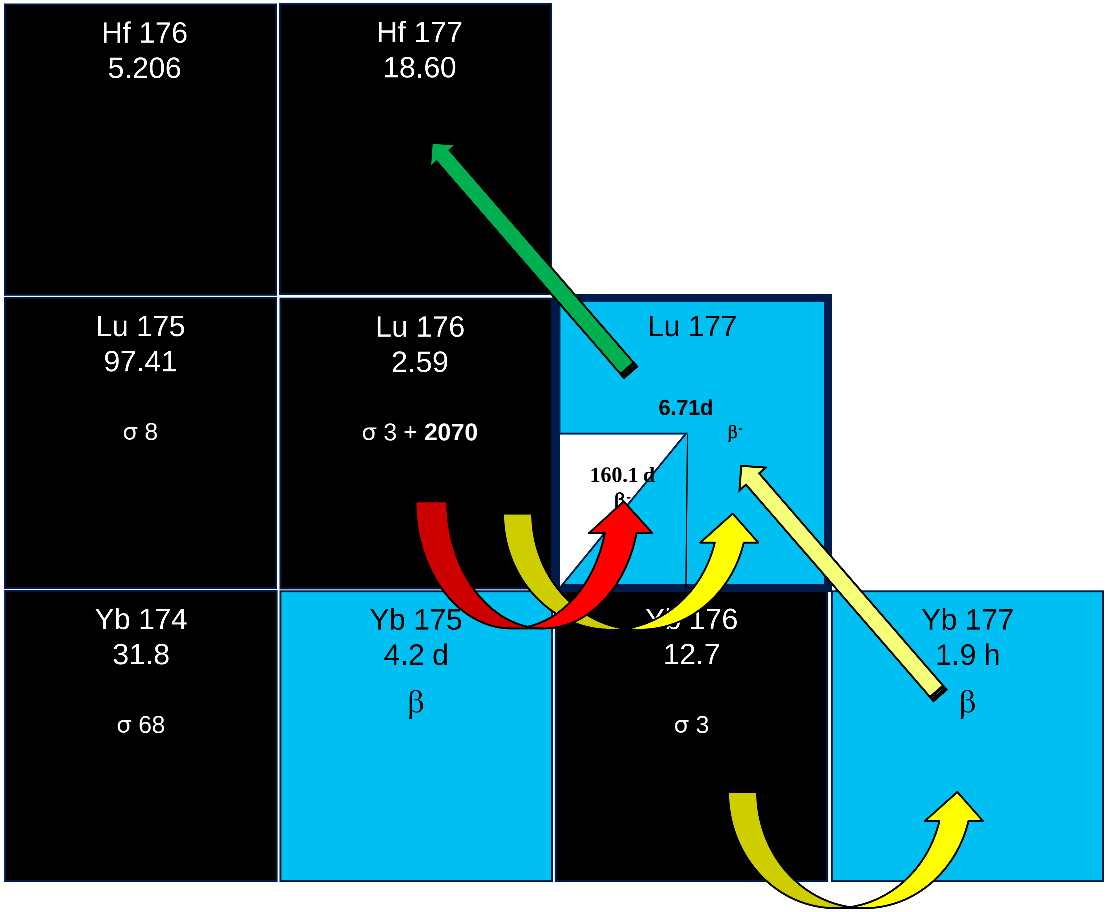
Production



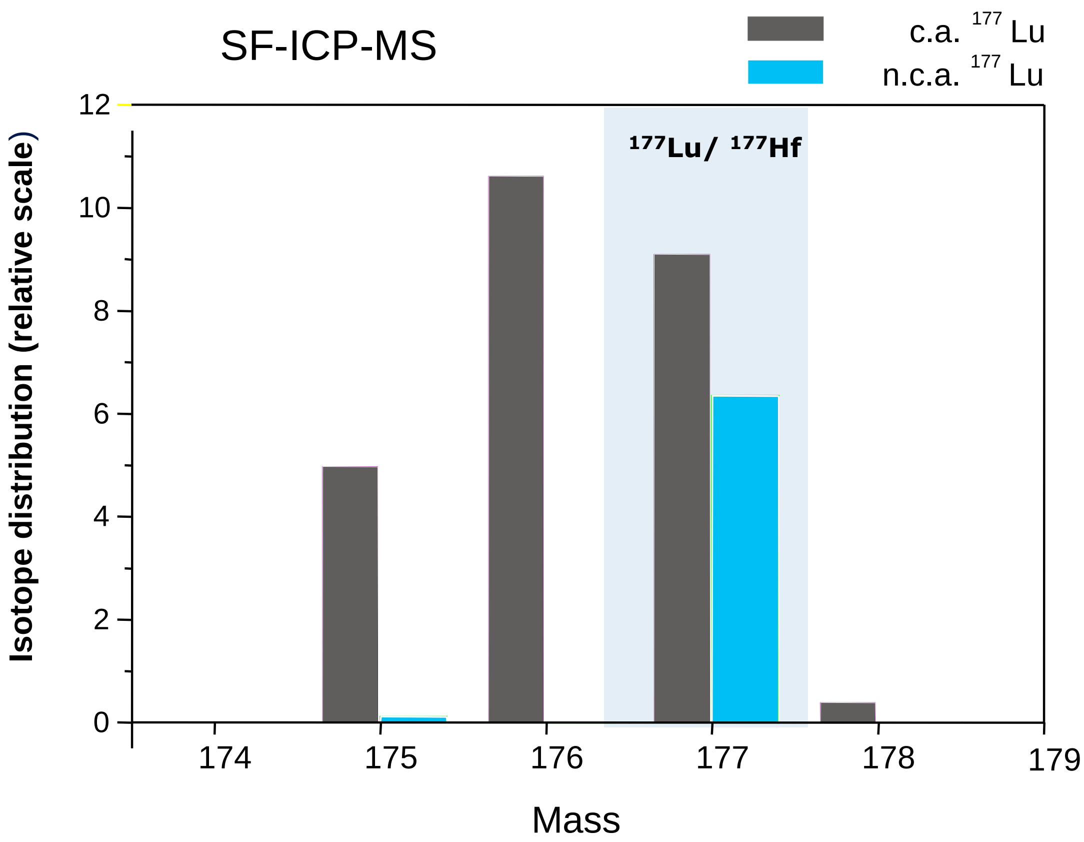
Undesirable
side reaction



Therapy

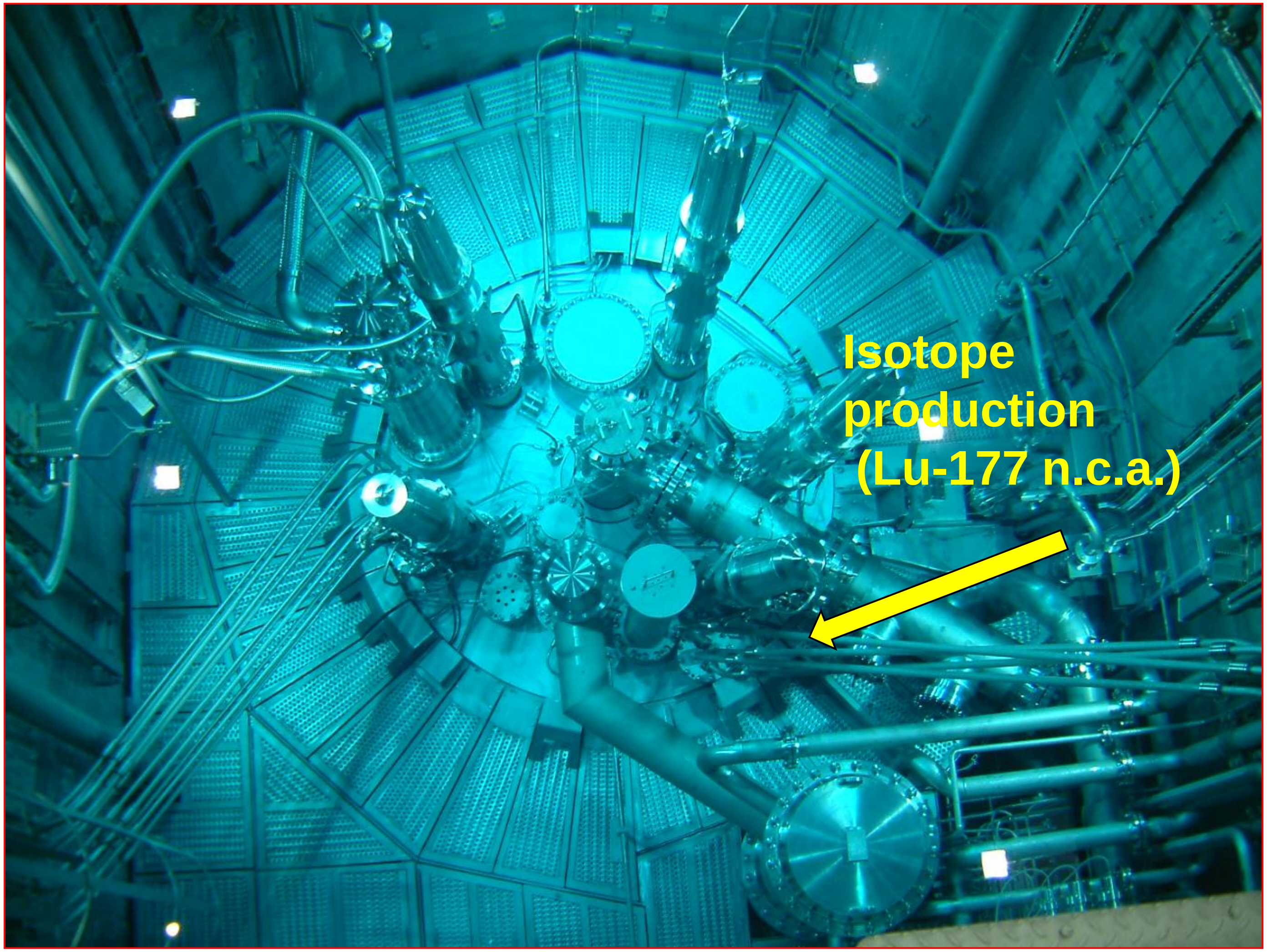


Isotopic contents in Lu-177 and Lu-177 n.c.a.



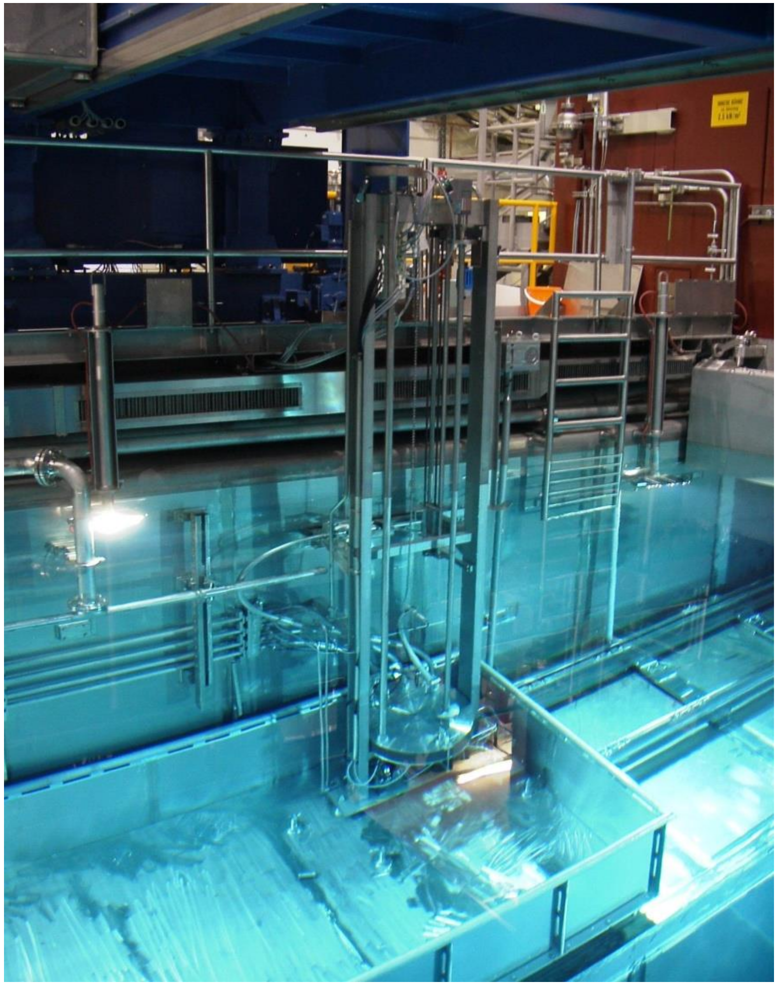
Zhernosekov et al.; 2011 DGN Bregenz

Top view into the reactor pool

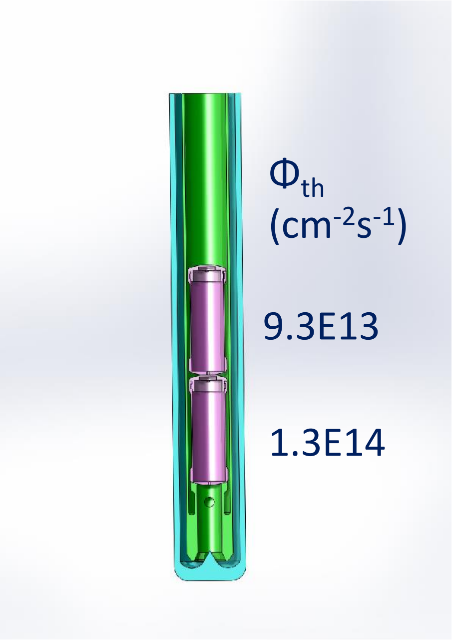


Hydraulic Irradiation Facility for Isotope Production

Canning of Yb_2O_3

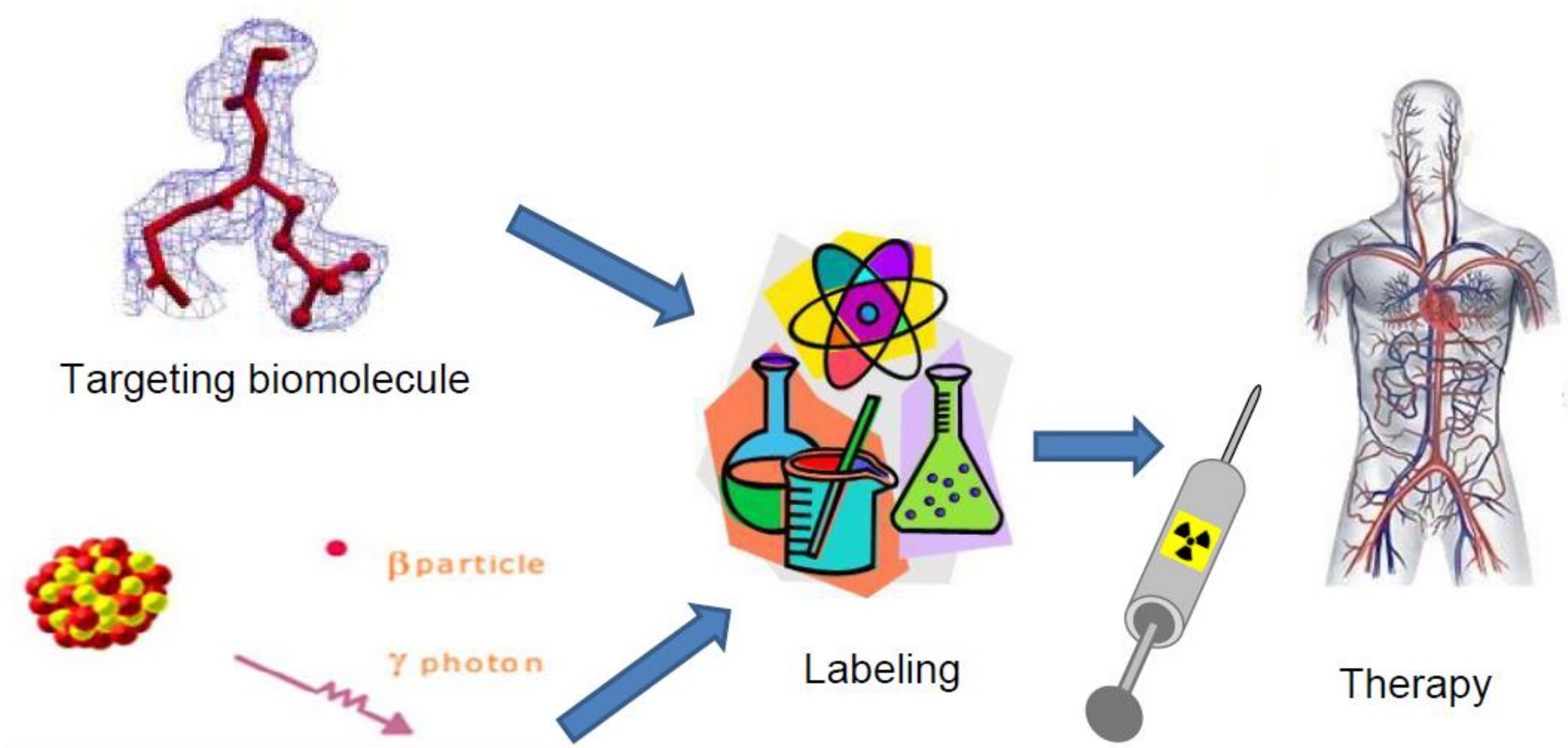


Loading / Unloading device



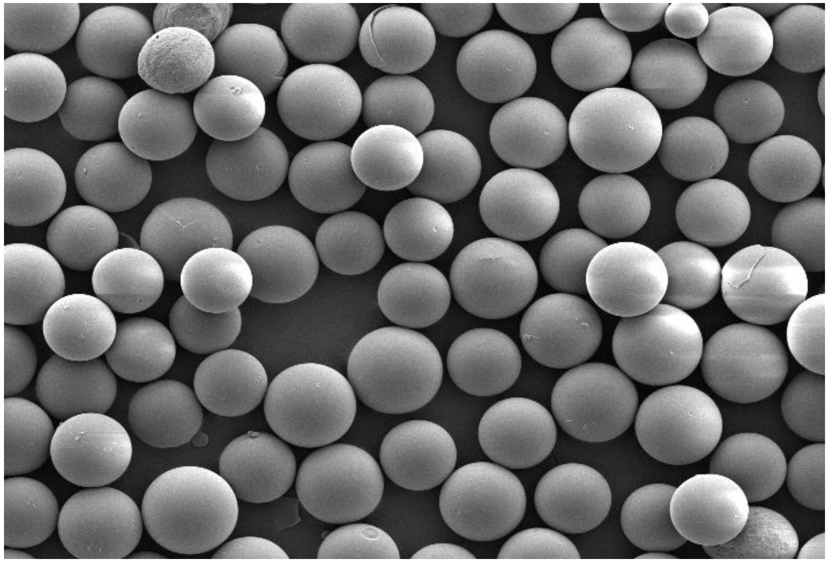
Stack of irradiation capsules

Idea of Peptide Receptor Radionuclide Therapy of Neuroendocrine Tumors



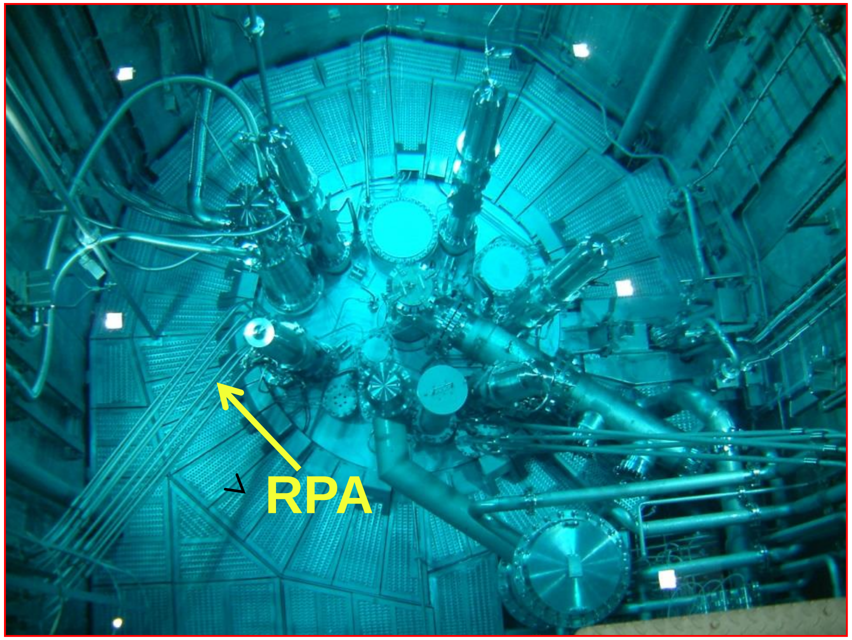
Ho-166 microspheres for the radioembolization of liver tumors

Production route	Ho-165 (n,γ) Ho-166
Material	PLLA microspheres with holmium-166
Mean diameter (μm)	30
Therapeutic β-emission	1850 keV (50.0%) 1770 keV (48.7%)
Half-life (h)	26.8
Patient dose (GBq)	2-12



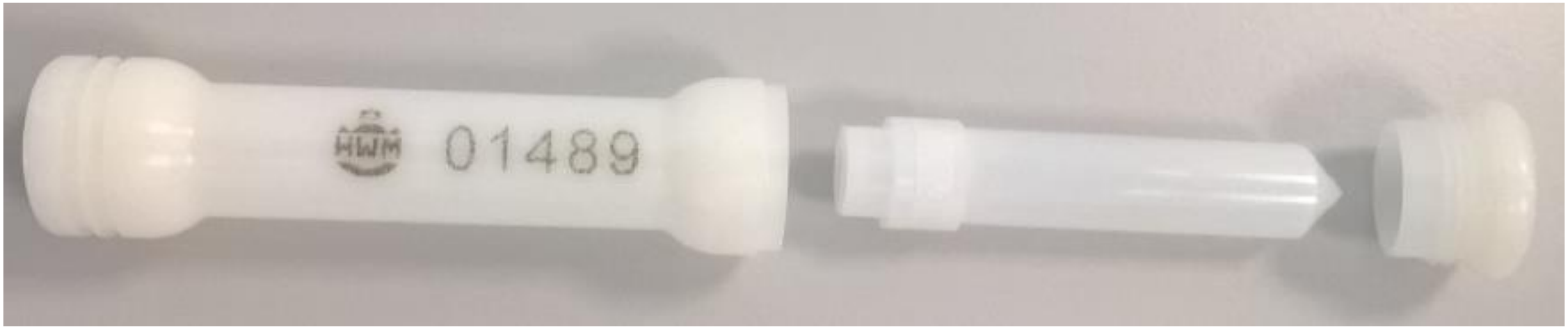
courtesy of Quirem

Irradiation using the Pneumatic Rabbit System (RPA)

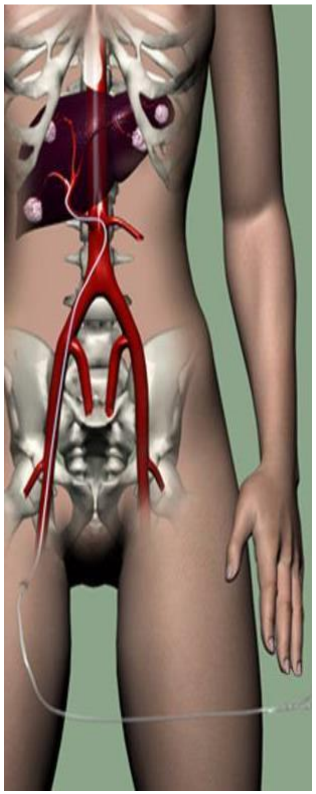


Requirements to be met:

- High accuracy with respect to Ho-166 target activity
- Low heat load to microspheres
- Low fast neutron flux density to guarantee mechanical integrity of microspheres.



Unique

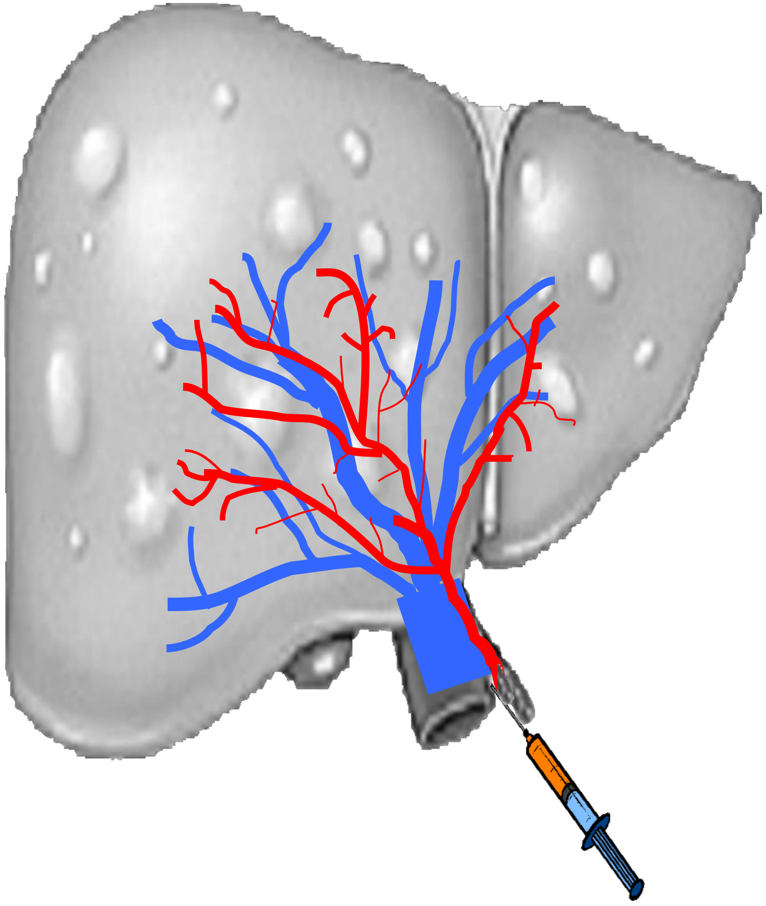


Blood source for liver:

- 70% portal vein
- 30% hepatic artery

Blood source for tumor:

- 99% hepatic artery



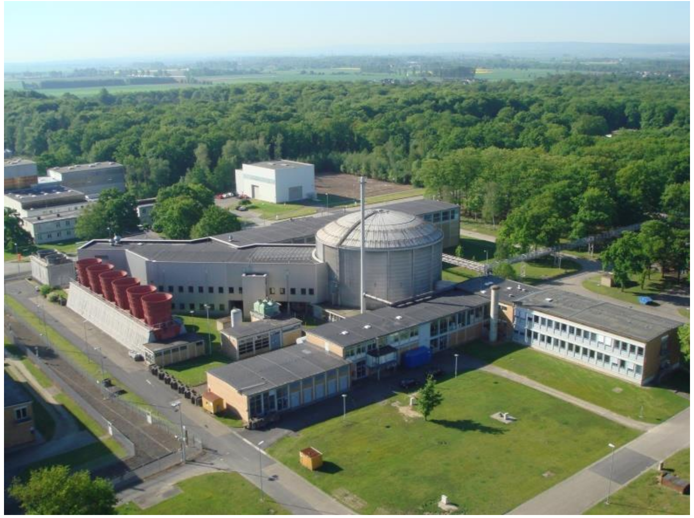
courtesy of Quirem

Status of Mo-99/Tc-99m in Germany:

Highest consumption in Europe; No present contribution to supply

Rossendorfer Forschungsreaktor (until 1989)

Research Reactor DIDO, FZJülich (until 2006)



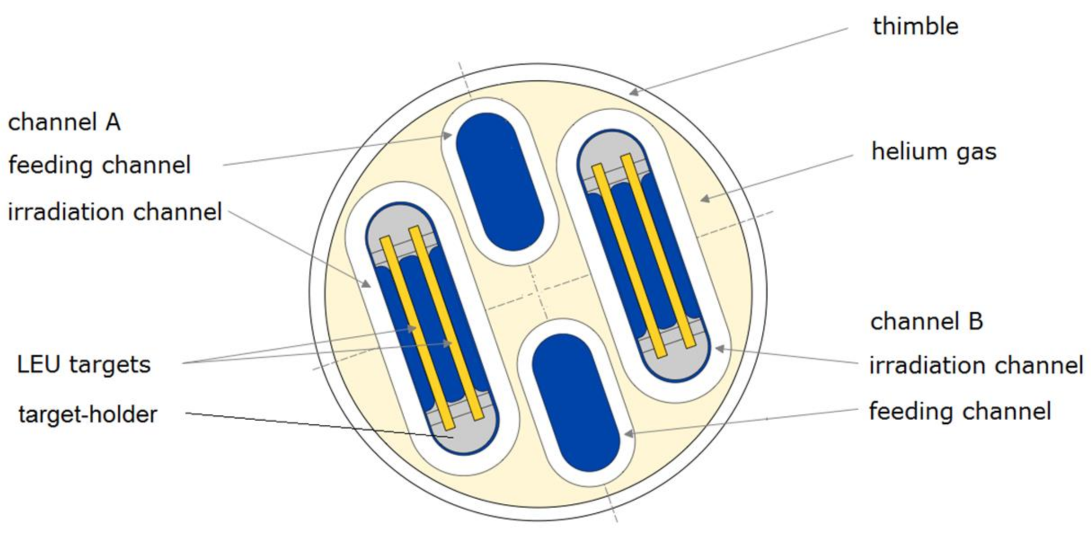
Challenges to be met in Mo-99 Production at FRM II

- Simultaneous irradiation of 16 (at least 12) targets
- Neutron flux density in target postion > 1E14 (1/cm²s)
- Heat release from targets during irradiation: ≈400 kW
- Loading and unloading of targets during reactor operation
- Integration into reactor safety instrumentation
- Evaluation of possible interference with scientific intruments
- Development of handling tools
- Loading of freshly irradiated targets into transport casks
- Adaption of infrastructure (elevator, radioprotection equipment,..)
- Staff, cost, time schedule

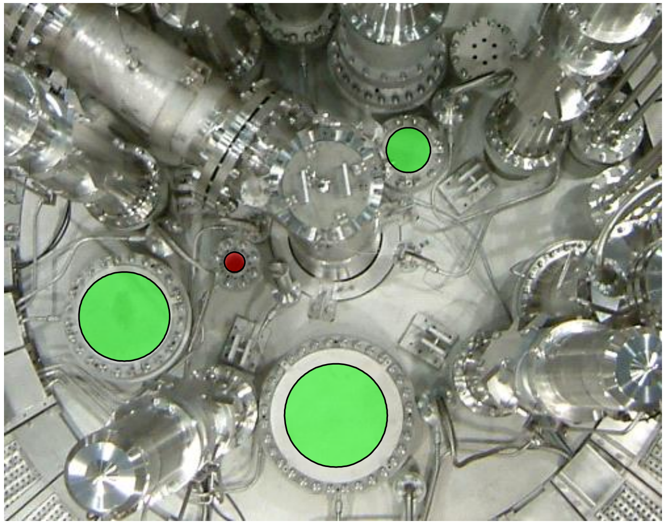
Licensing Procedure according to German Atomic Law

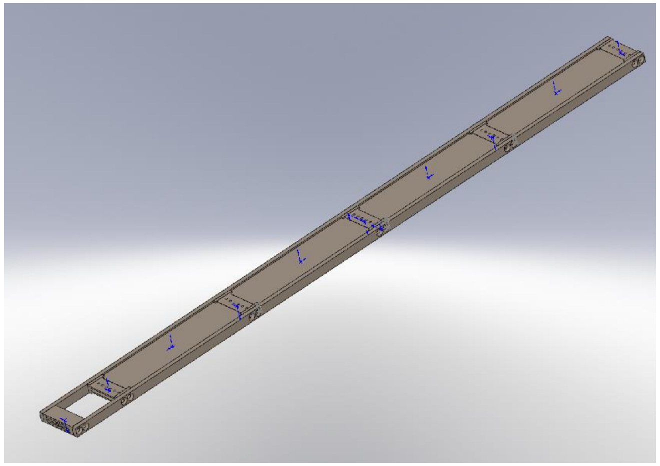
Design of the Irradiation Rig

Top view of irradiation rig



● **Irradiation position**

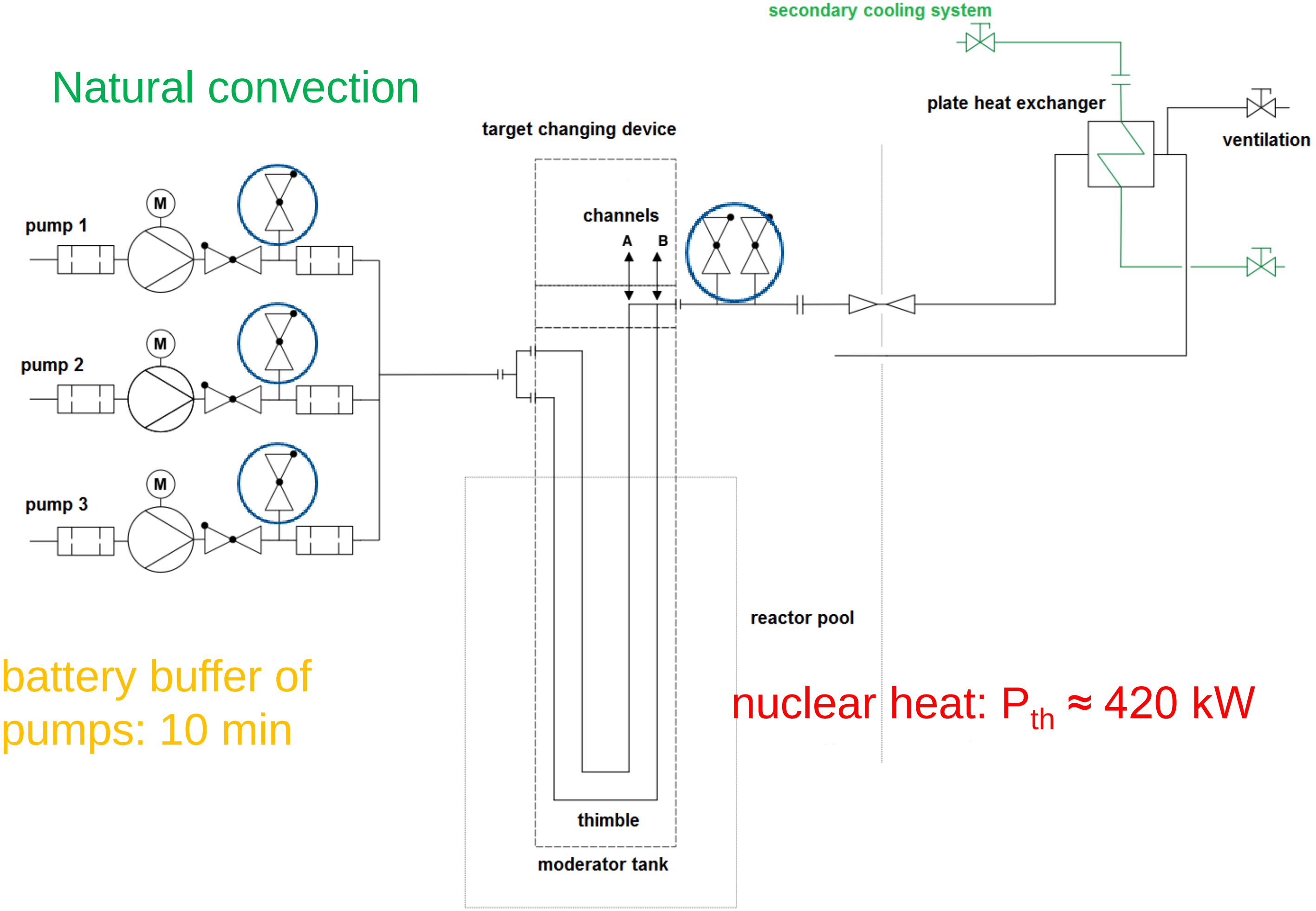




holder for up to 4 targets

Design of the cooling unit

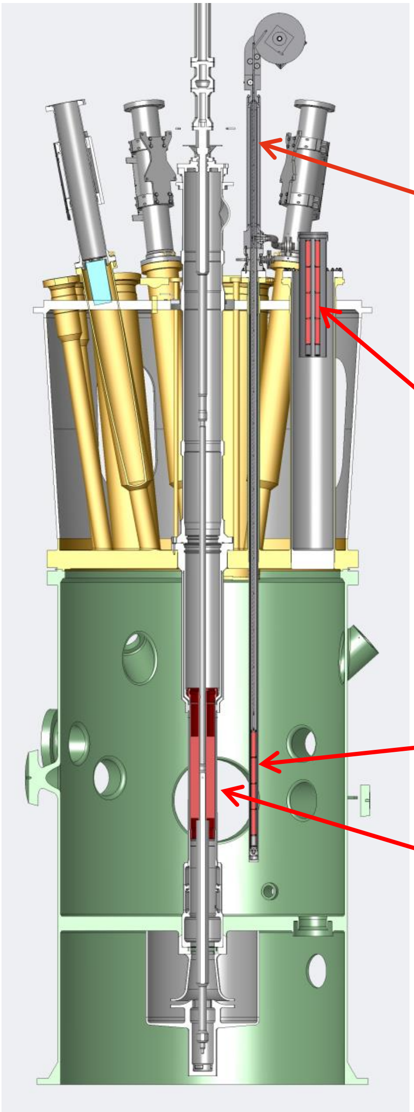
Natural convection



battery buffer of pumps: 10 min

nuclear heat: $P_{th} \approx 420$ kW

Integration of Mo-99 facility into FRM II reactor pool

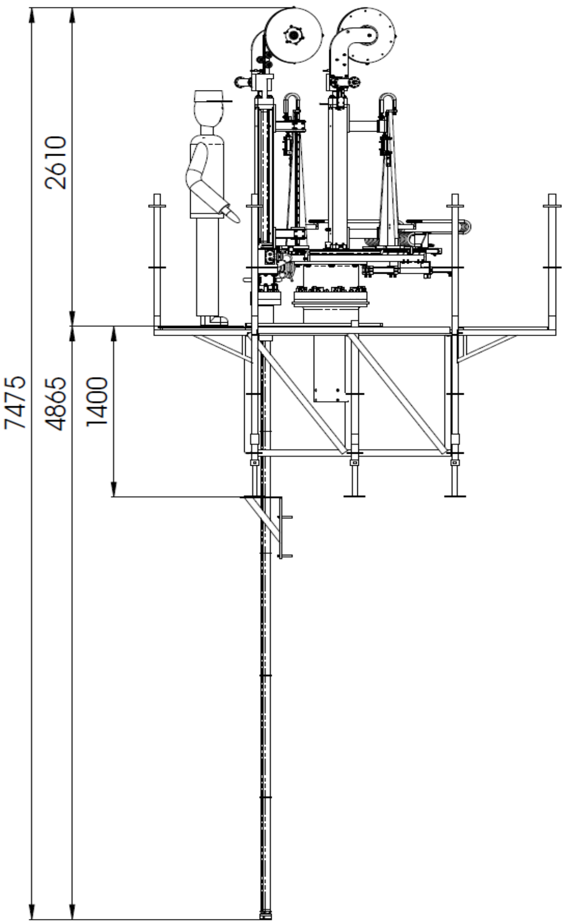


Loading and Unloading

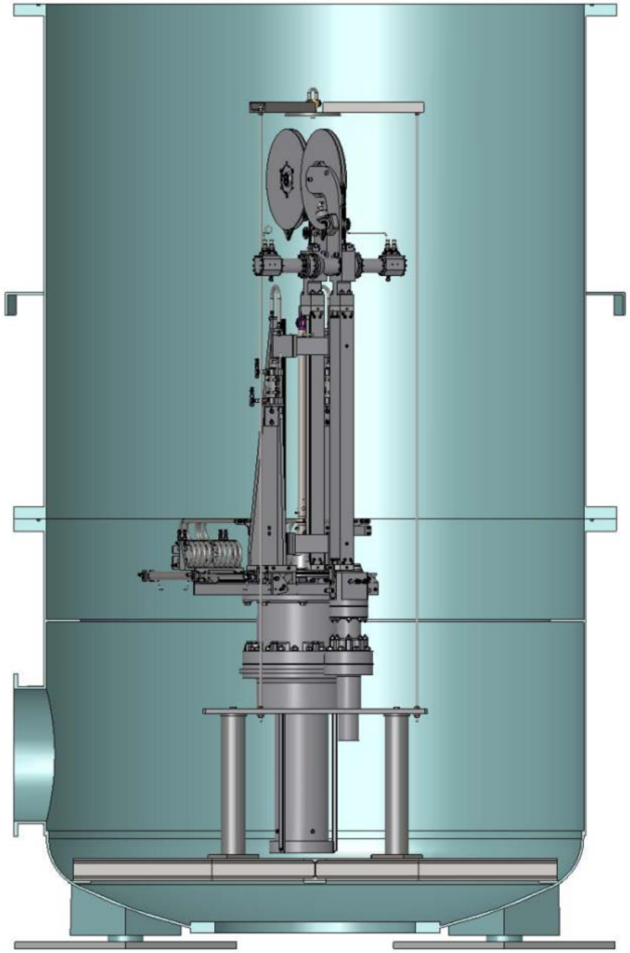
Transfer into in-pile part

Targets in Irradiation position

Fuel assembly



Full size mockup of changing unit



Under-water test using a mock-up:

Test of mechanical function:
Handling of the transport unit
Loading and unloading of targets
Trouble shooting

Test of electrical function:
Sensors, motor and cable

Some Data of the water tank:

Height 3,5 m
Water 17 m^3
Weight ca. 23,2 to

Summary of important parameters

LEU target irradiationIrradiation positons: 2 channels

Max. number of targets 2 * 8 LEU targets

Average thermal flux within meat of target: $1.7 * 10^{14}$ n $cm^{-2}s^{-1}$

Anticipated Mo-99 production: 32 weeks/year

Max. Mo-99 activity after 156 h of irradiation (EOI): 16 700 Ci

Expected available capacity per week (6-day Ci): ~ 2 100 Ci

Anticipated start of production: 2019


Thank you !
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