Some essential features of the TAPIRO Fast-Neutron Source Reactor located at ENEA-CR Casaccia (Rome)

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The Casaccia Research Center

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History

- **Fast source reactor**
- **Based on the concept of AFSR (Argonne Fast Source Reactor - Idaho Falls)**
- **Designed by ENEA's staff**
- **Start-up: 1971**
- **First Activities: fast reactor shielding experiments**
  biological effects of fast neutrons

Reactor: Main Components

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CORE	Cylindrical: diameter 125.8 mm height 109.5 mm (2/3 fixed – 1/3 mobile)
FUEL	Uranium-molybdenum alloy (98.5% U – 1.5% Mo) Density: 18.5 g cm^{-3} Enrichment: 93.5% U^{235} Operative mass: 22107.42 g/U^{235}
CLADDING	Stainless steel: thick 0.5 mm
REFLECTOR	Cylindrical Inner Reflector: diameter 348 mm Outer Reflector: diameter 800 mm Overall Height: 700 mm Material: Copper Weight: 2600 kg

Reactor: Auxiliary and Irradiation Systems

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COOLING SYSTEM	Forced He: 100 g/sec @ 7.5 ata Heat Exchanger + Refrigerator Inlet core temp: 35° C - Outlet 25° C
BIOLOGICAL SHIELD	Shape: near spherical Thickness: 1.75 m Material: high density borate concrete Density: 3.7 kg dm^{-3}
IRRADIATION CHANNELS	3 channels at the reactor midplane 1 tangential (to the top edge of the core)
THERMAL COLUMN	Max Volume: 1.6 m3 2 piercing channels

The Big Concrete *Sphere*

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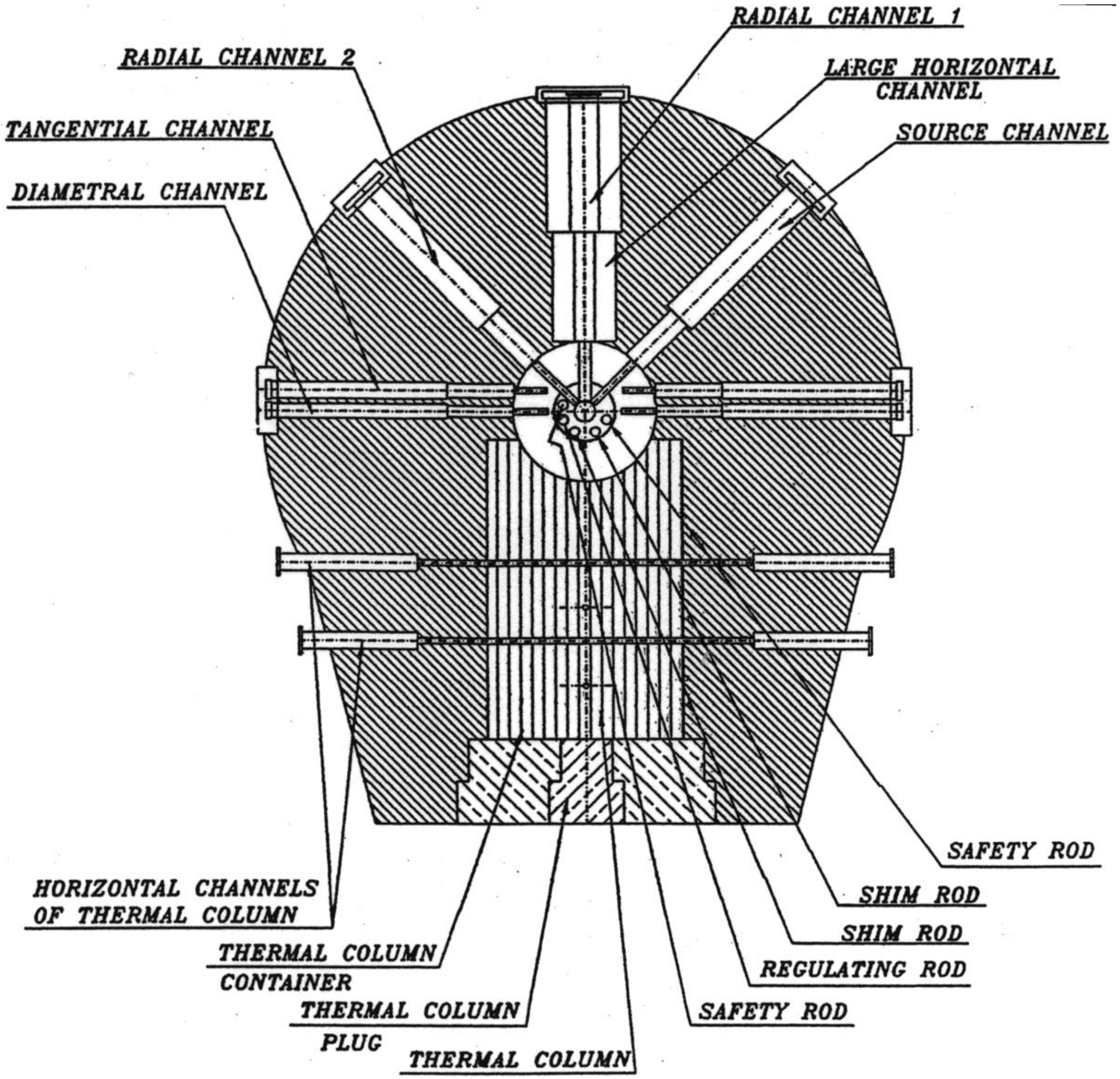
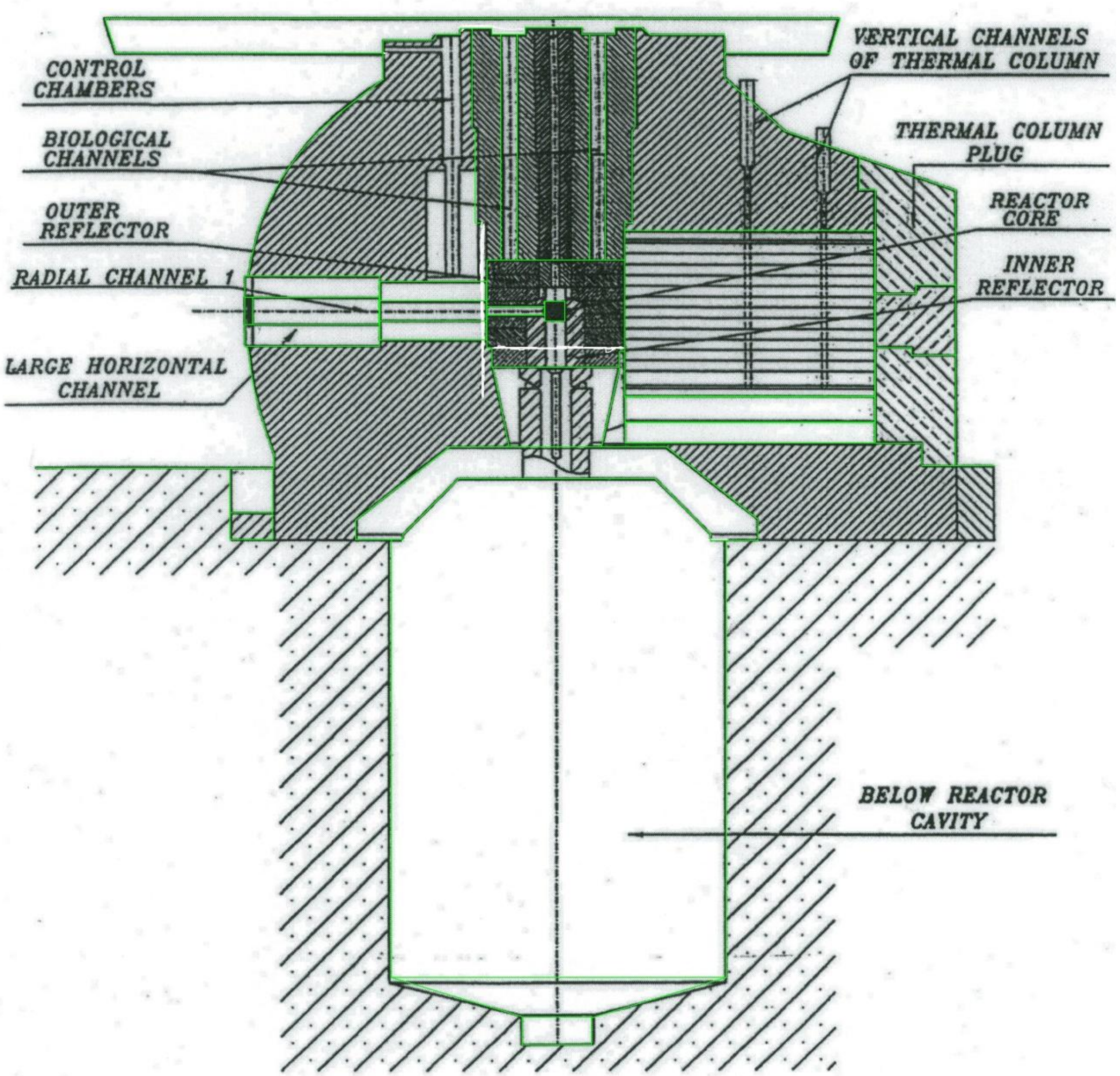
TAPIRO: Horizontal Section

TAPIRO



TAPIRO: Vertical Section

TAPIRO



Accessing the Thermal Column

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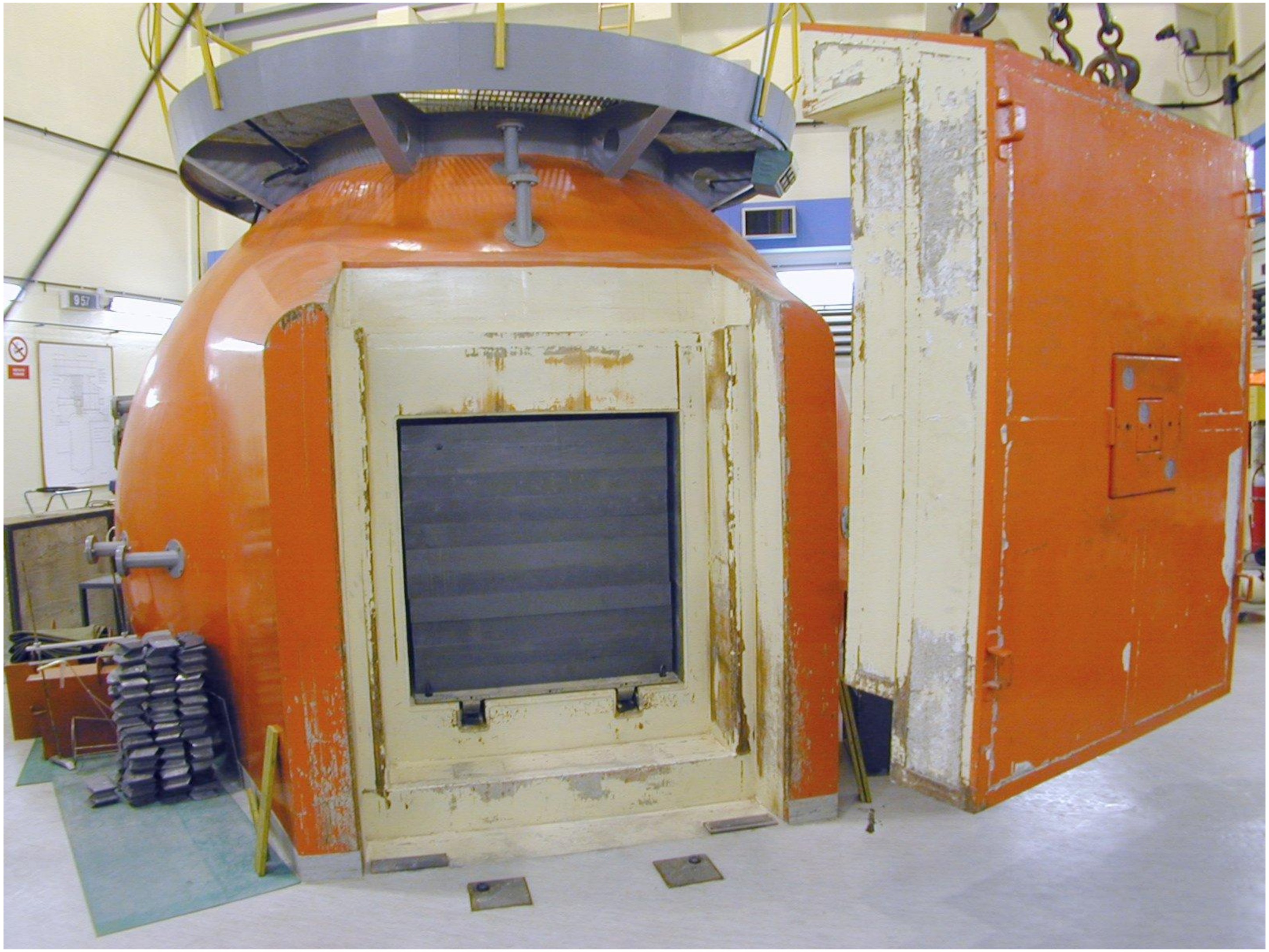
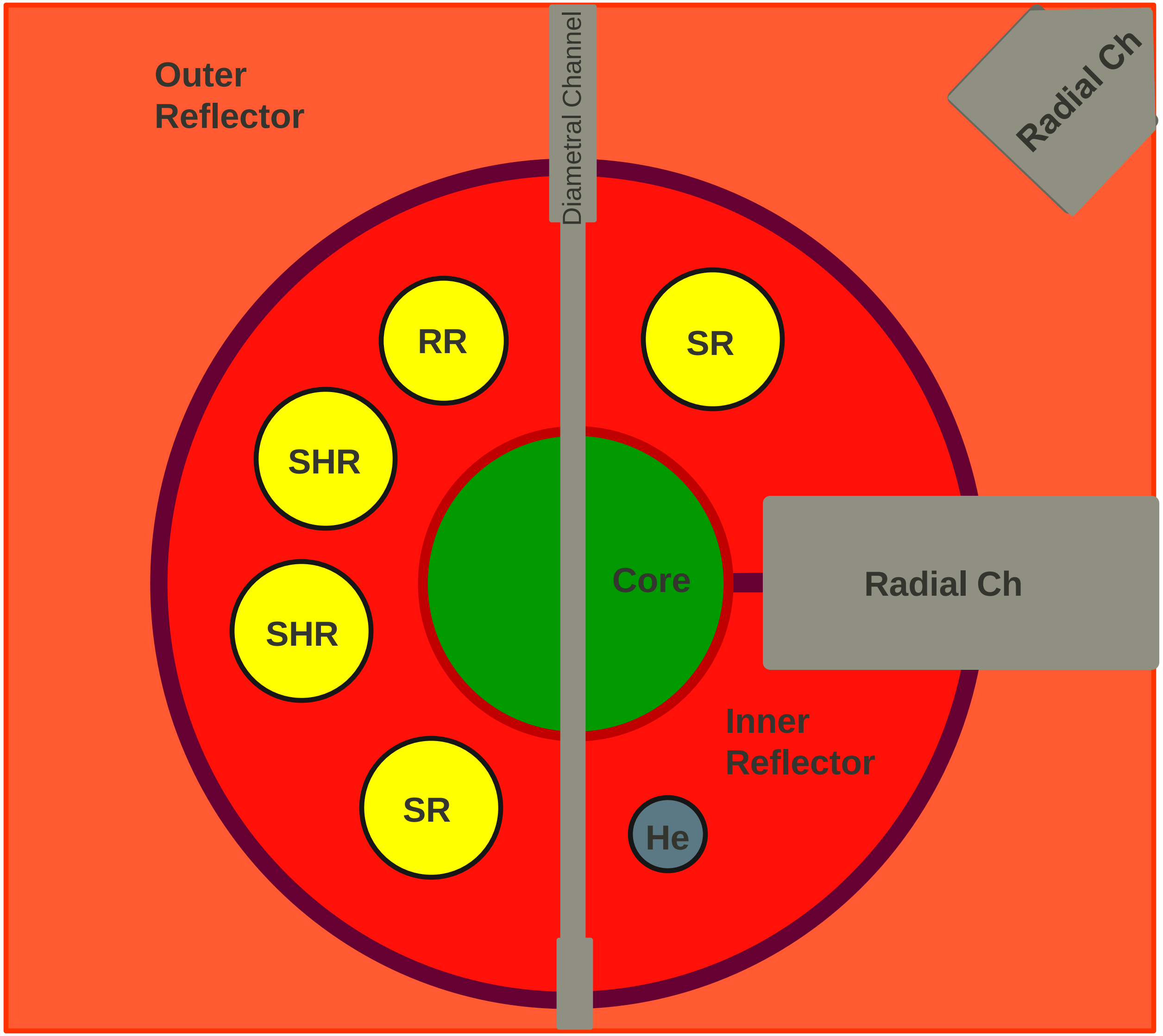


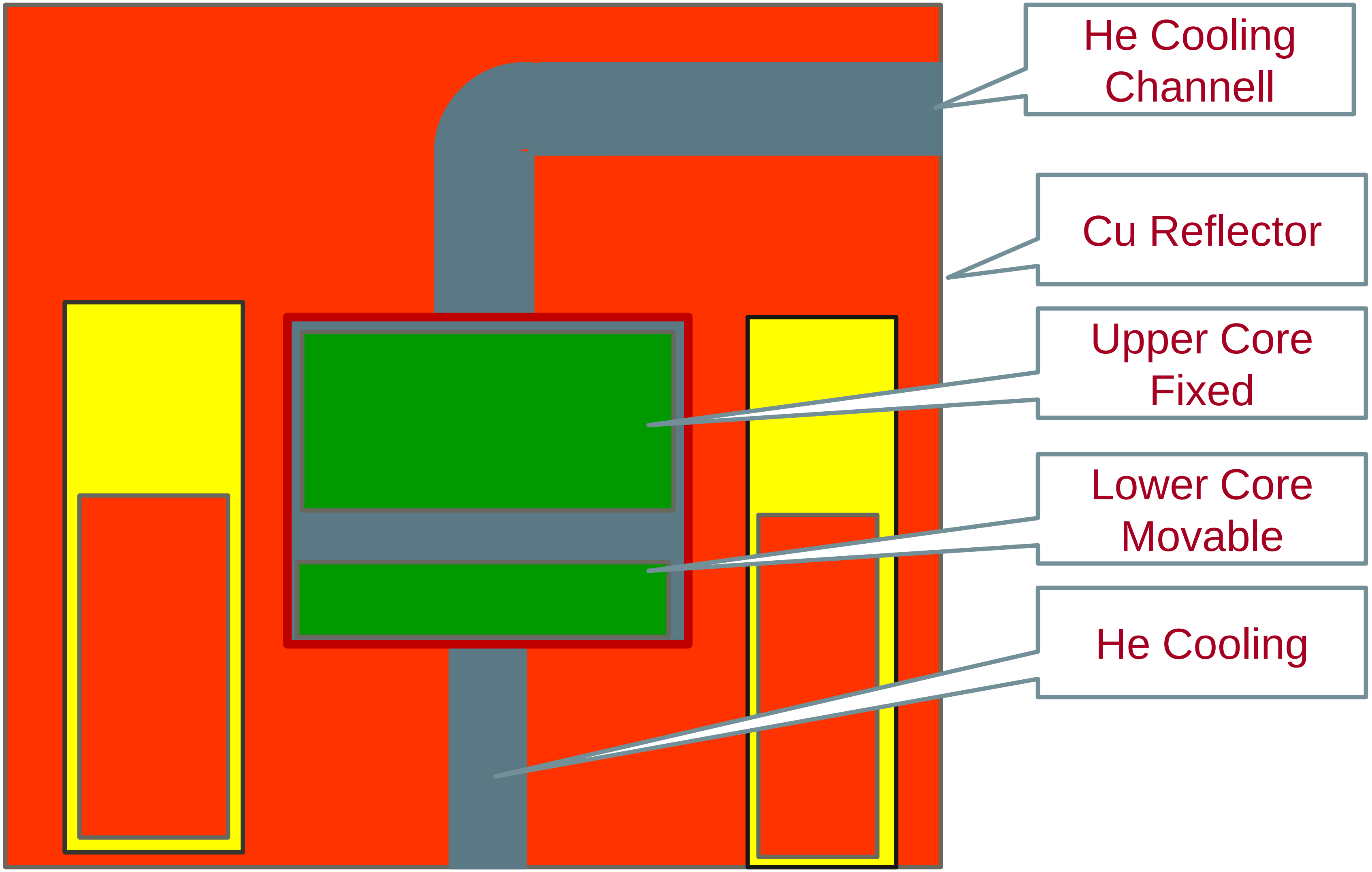
Schematic Horizontal Cut at Reactor Midplane

TAPIRO



Schematic Vertical Cut with Control Rods

TAPIRO



Schematic Vertical Cut with Control Rods

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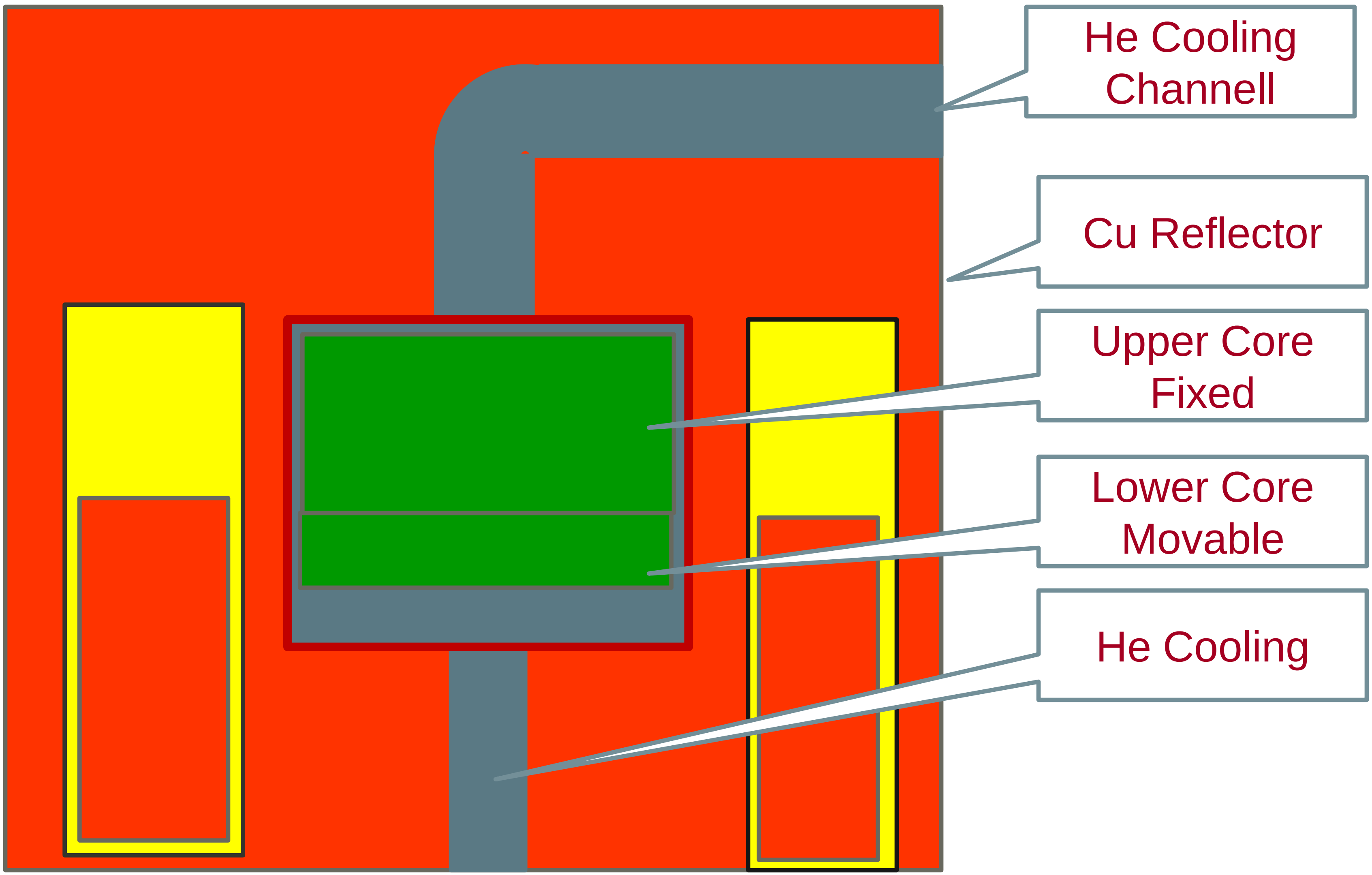
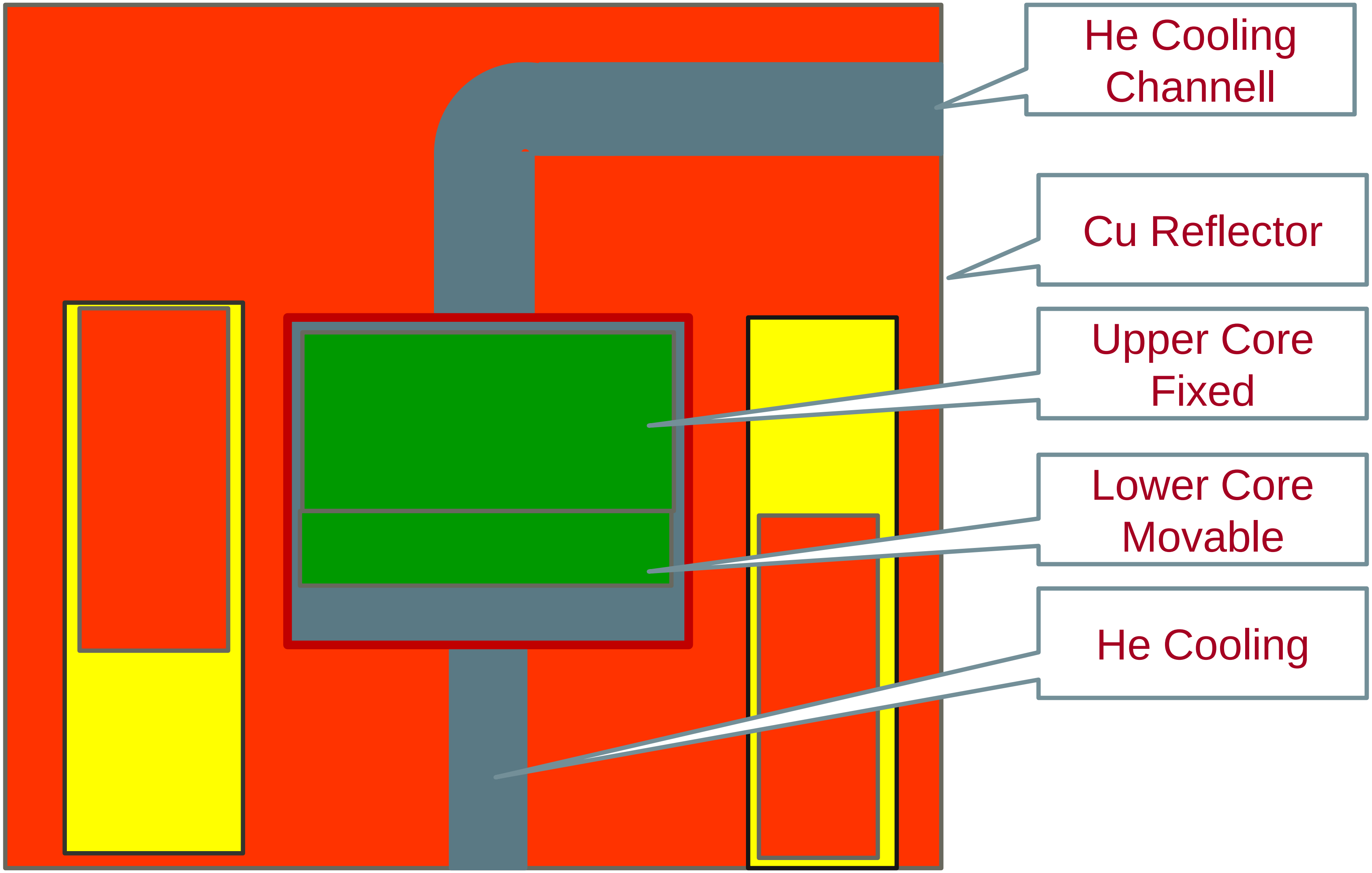


Schematic Vertical Cut with Control Rods



Schematic Vertical Cut with Control Rods

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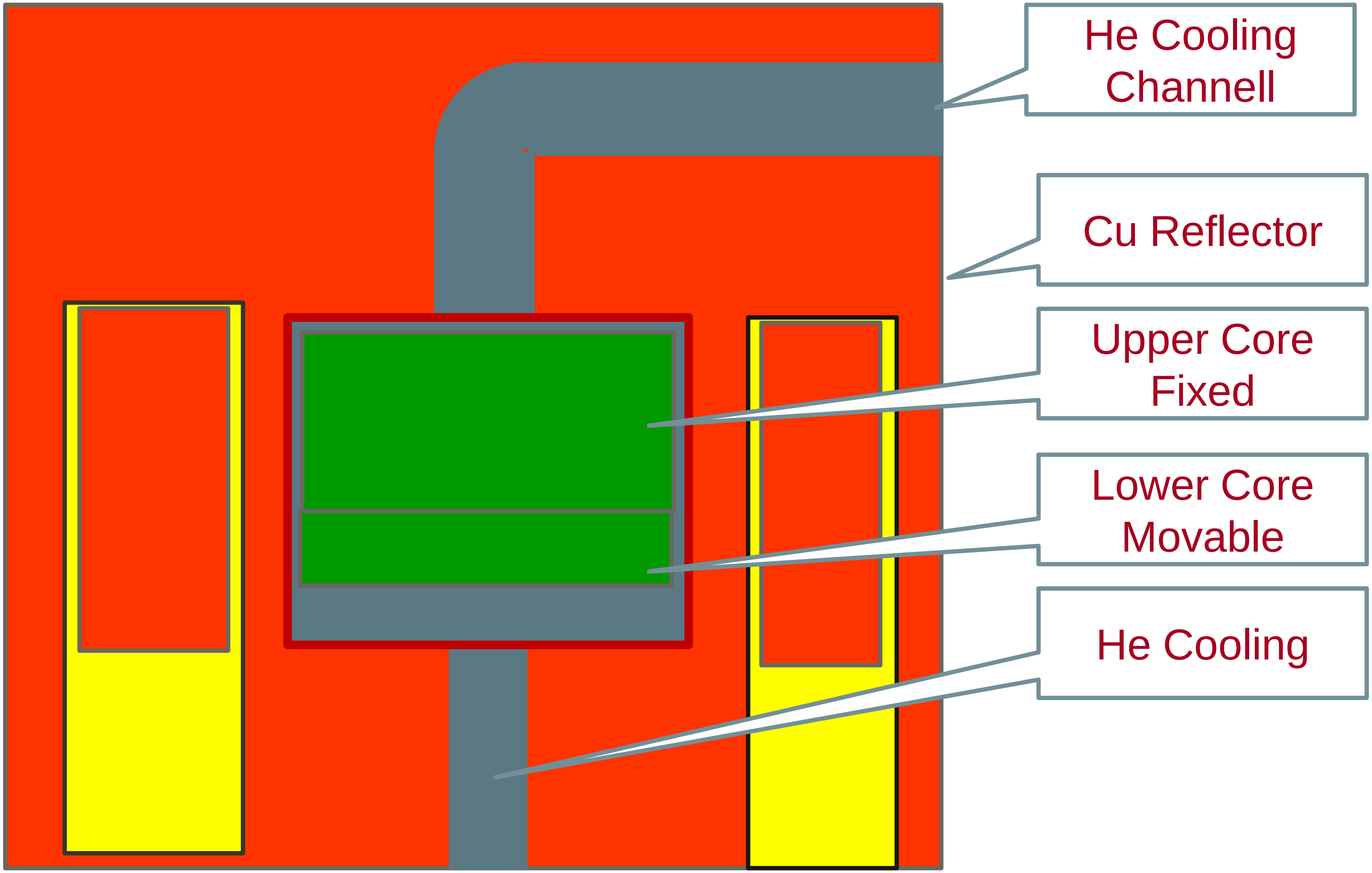
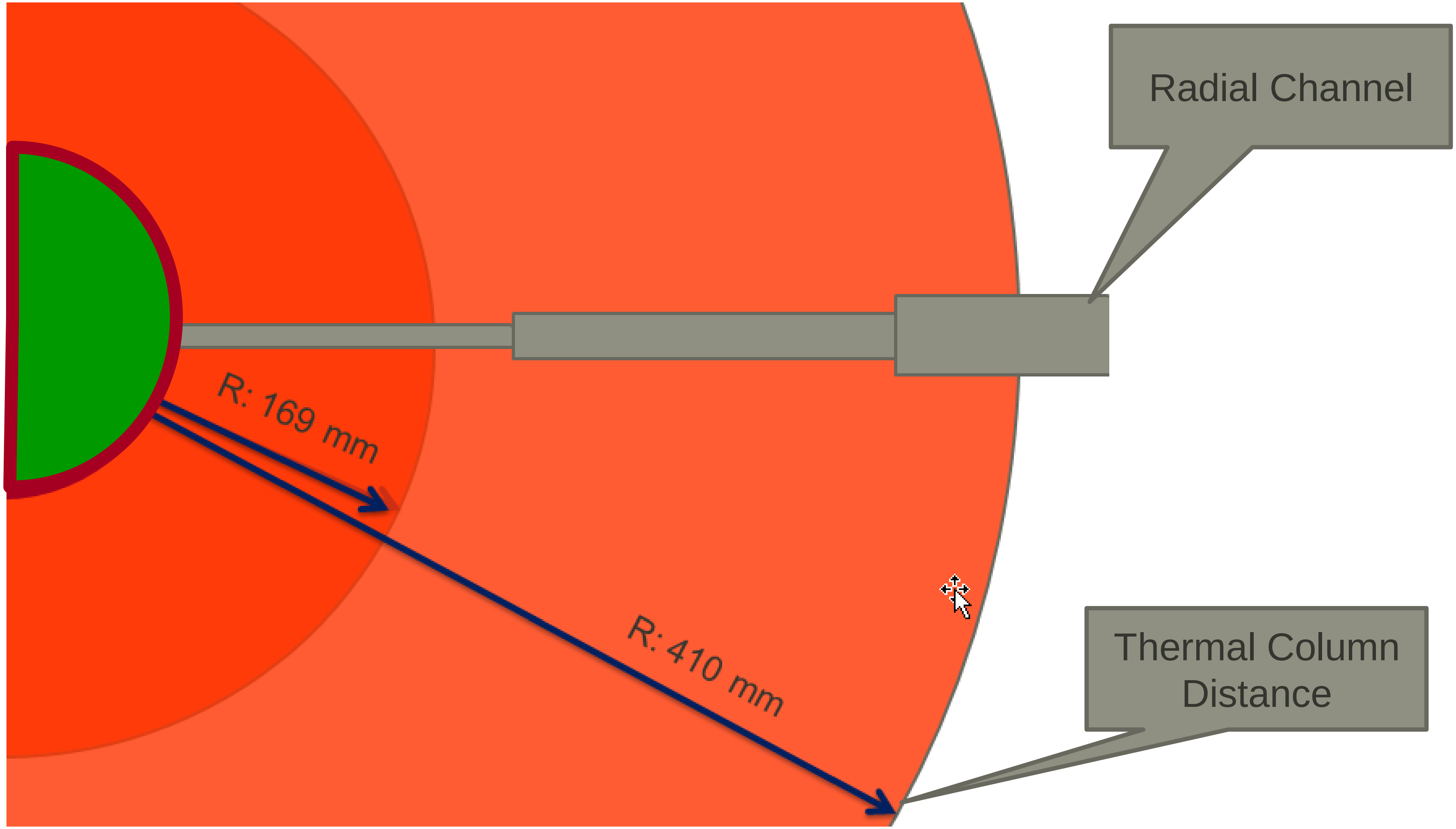


Reactor Component Distances from Core

TAPIRO



Calculated Neutron Fluence Rate per Energy Groups

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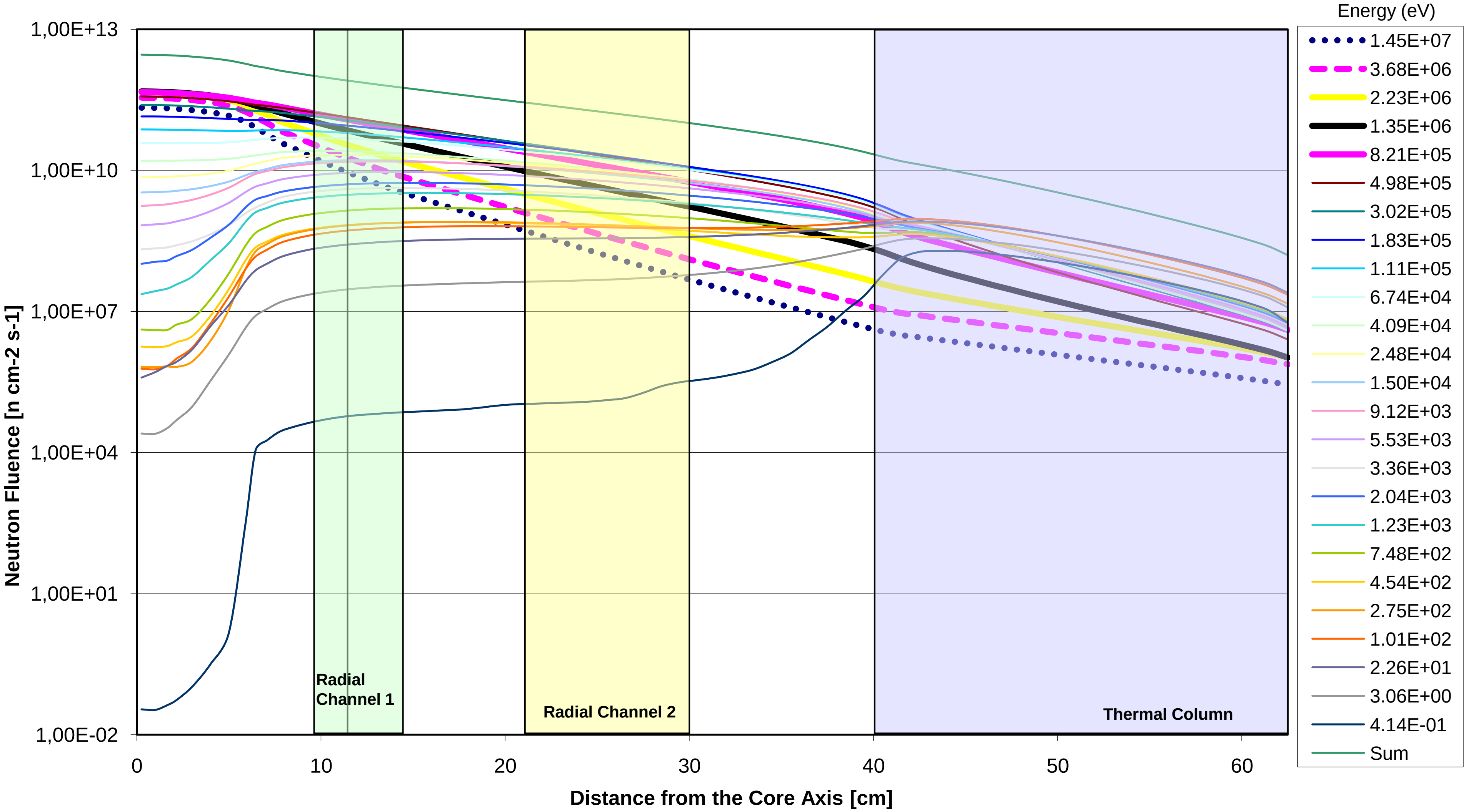

Activities up to now

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- Characterization of N-16 counters devoted to monitoring
- Neutron radiation damage on components for the electromagnetic calorimeter (ECAL CERN LHC- Project)
- BNCT and neutron radiation effects on cancerous cells

At full reactor power [5 kW]

- Core center
  - Total core integrated neutron source strength: 3×10^{14} n/s
  - Total neutron fluence rate: 4×10^{12} n · cm^{-2} · s^{-1}

    8×10^{11} n · cm^{-2} · s^{-1} > 1.35 Me V
- Entrance of the thermal column
  - Total neutron fluence rate: 1.5×10^{10} n · cm^{-2} · s^{-1}

    4×10^{7} n · cm^{-2} · s^{-1} > 1.35 MeV

BNCT Thermal Column Modification

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Thermal Column Scheme for BNCT

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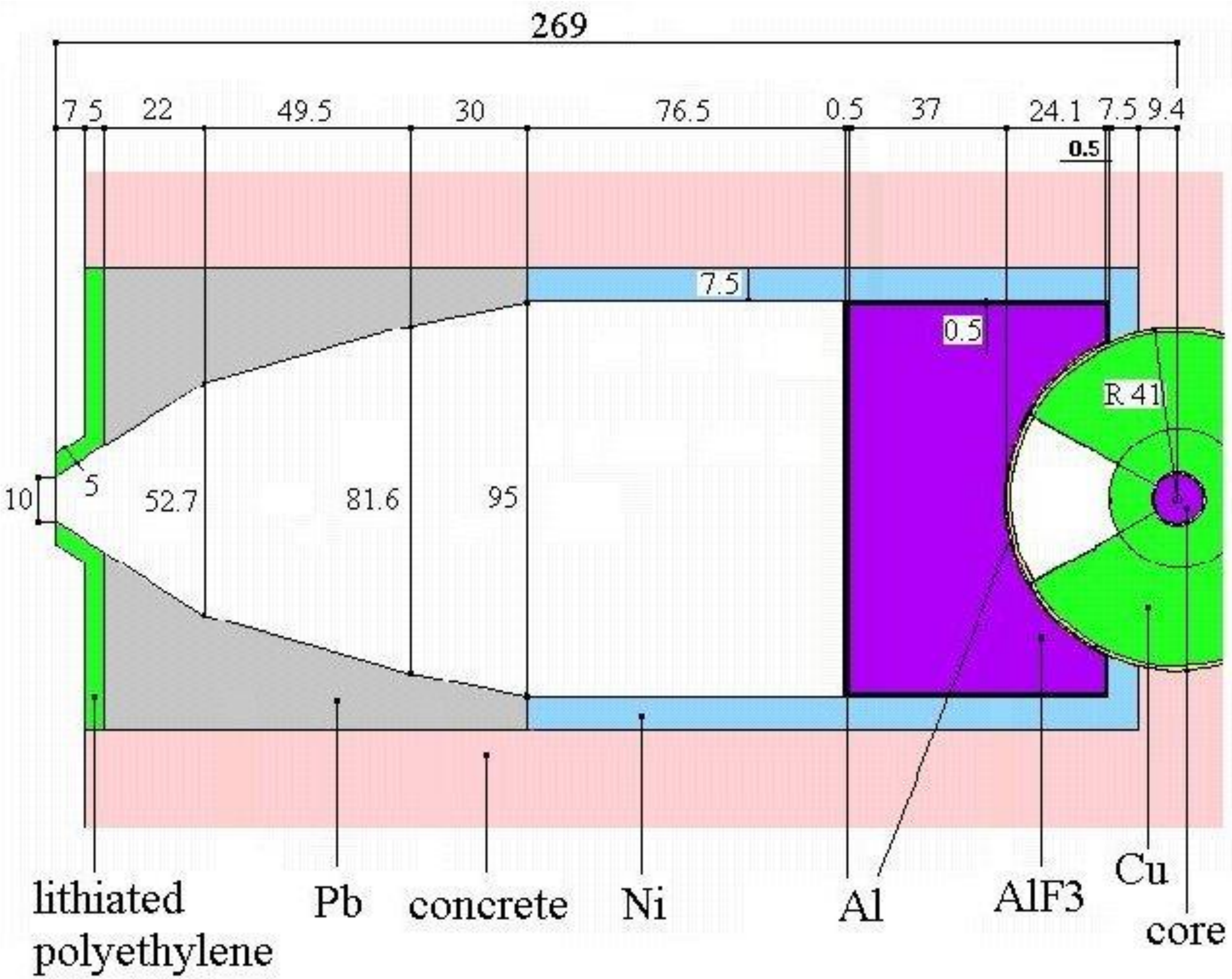

BNCT Shielding

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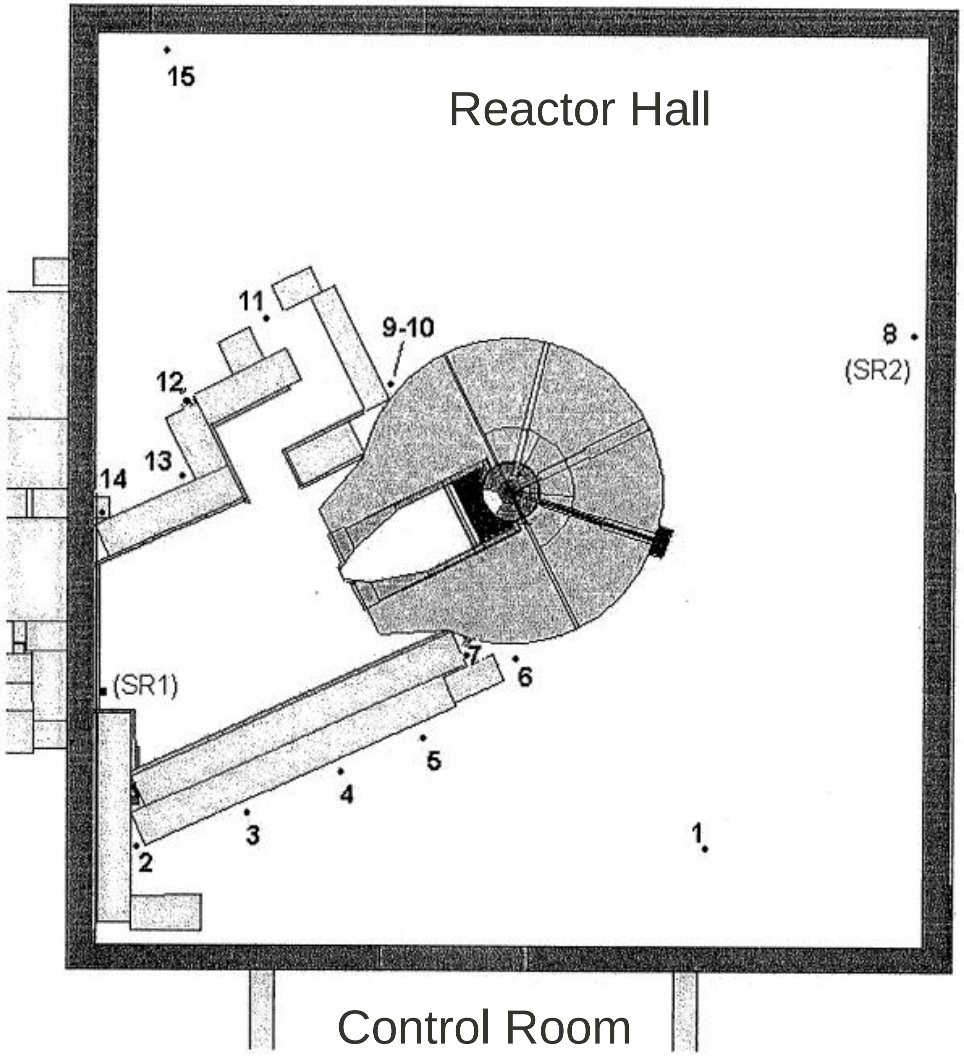


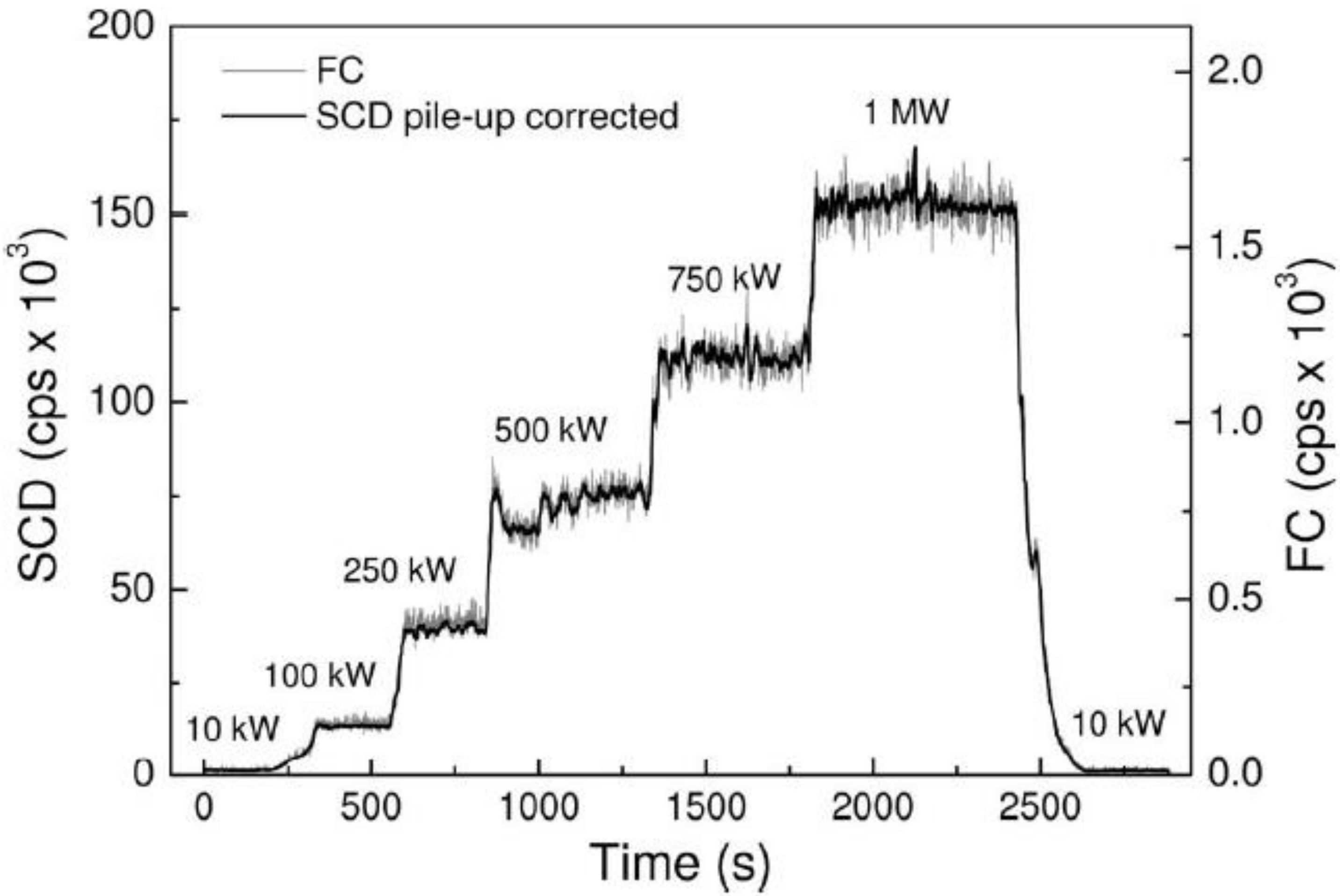
Planned Activities

- Dismantling the BNCT Shielding and Thermal Column Internals
- Return to the Original Reflector
- Thermal Column Reshape
- Revision of the MCNP Model of the Reactor (Cooperation with La Sapienza University – Rome)
- Experimental Assessment of the MCNP Neutron Fluence Estimations
- Single Crystal Diamond Detectors Test

- Chemical vapor deposited single crystal diamond in a p-type/intrinsic/metal/^{6}Li layered structure
- First test in thermal field in TRIGA at 1 MW (10^9 neutrons/cm^2/s)
- Excellent linearity observed
- Test in fast field is required

M. Marinelli, E. Milani, G. Prestopino, A. Tucciarone, C. Verona-Rinati, M. Angelone, D. Lattanzi, M. Pillon, R. Rosa, E. Santoro - Synthetic single crystal diamond as a fission reactor neutron flux monitormg - **Applied Physics Letters 90**, 183509 (2007)

Linearity 10 kW – 1 MW



Small Fission Chambers

Ref. #	Loading	Content [μg]
1880	U-235	10
1995	U-235	50
2019	U-238	132
1997	Pu-239	30
1998	Np-237	30

Wide Activation Foils Availability

SUPPORT TO ADS R&D

- Different patterns of neutron field
  - investigations of selected phenomena radiation damage
- Static and dynamic regimes:
  - parametric studies on ADS prototypical fuel in thermal column, eventually with a converter zone.
- Steady conditions
  - influence of fuel/Pb ratio on neutronic behavior of fuel-lead matrices.
- Dynamic conditions
  - absolute reactivity measurement conditions relative to source-jerk techniques

BLANKET EXPERIMENTS 1/2

TAPIRO

- Benchmark for validate neutronic codes for systems with significant spectral changes within the core (HTGR and Fast Systems)
- Traverses in graphite and lead columns,
  - Possible removal of a sector of the outer copper for a very hard neutron spectrum.
  - graphite column where spectrum gradually softens up to thermal
  - lead column where the spectrum softens from hard to epithermal
- Different materials interposed (U-nat, Pb, Fe, etc.): spectrum transition conditions at interface points between regions with different compositions.
- Activation foils: threshold energies in the fast, intermediate and epithermal regions.
- Quantitative gamma spectrometry
- Fission Chambers based Techniques

BLANKET EXPERIMENTS 2/2

Analogous experiments on TAPIRO performed in the early 70's:

- Studies of the propagation of neutrons along the axis of a large sodium tank inserted in place of the graphite column.
- Measurement campaign in collaboration with CEA Cadarache for the fast reactor program

Similar purpose: testing the ability of neutronic codes to reproduce the measured quantities.

The experimental data are now included in the NEA documentation (International Reactor Physics Experiment Evaluation Project -IRPhEP)

Main Targets of the Future Activities

- Enhance the Reactor Activity in connection with the new Italian Way towards NPP
- Cooperate with Universities and Research Centers for the next Generation of Nuclear Experts
- …. Outcomes of the present TM

Thank you for your attention!