TRIGA
Reactor

THE ENEA-CASACCIA RESEARCH REACTORS
CURRENT STATUS

R. Rosa

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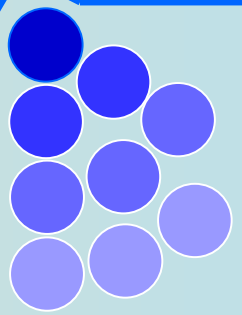
Presentation Outline



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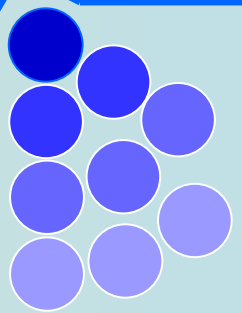
- ENEA Casaccia Research Center
- TRIGA RC-1 reactor
- TAPIRO reactor
- Statistics

ENEA-Casaccia Research Center

ENEA-Casaccia Research Center



TRIGA
Reactor

- Main research center in Italy (~100 ha surface)
- 1500 employees (of 3500 whole ENEA)
- Developed in the 60th for nuclear research
- Re-designed in the 90th for **N**ew technologies, **E**nergy and the environment (**A**mbiente)
- Main facilities:
  - 2 research reactors
  - 1 gamma irradiation plant
  - 2 seismic test stations
  - EMC facility
  - renewable energies demonstration plants

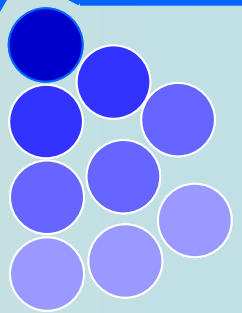
TRIGA RC-1 Reactor

- General Atomic Mark II
- 1960: 1st start-up @ 100 kW
- 1967: upgrade 1 MW

TRIGA
Reactor

TRIGA RC-1 Main Features - 1

Reactor Type	Triga Mark II
Reactor Name	ENEA RC-1
Site	C.R. Casaccia – Rome - Italy
Power	1 MW
Fuel	Uranium – ZrH alloy (8.5% Wt U)
Enrichment	20 % ^{235}U
Moderator	ZrH, H_2O
Coolant	Demineralized water in natural convection



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TRIGA RC-1 Main Features - 2

Reflector	Graphite
Control rods	#4 B_4C Fuel Follower #1 B_4C Regulating Rod
Fuel Clad	SS - Clad (0.5 mm thickness)
U – 235 per fuel element	~ 38 g (fresh fuel)
U – 235 loaded	~ 3400 g
Max burn-up allowed	35%
Max Neutron Flux (Central Thimble)	~ $2.7*10^{13}$ n/cm^2*s
Operating cycle	6 hours/d – 5 days/w – 10 months/y

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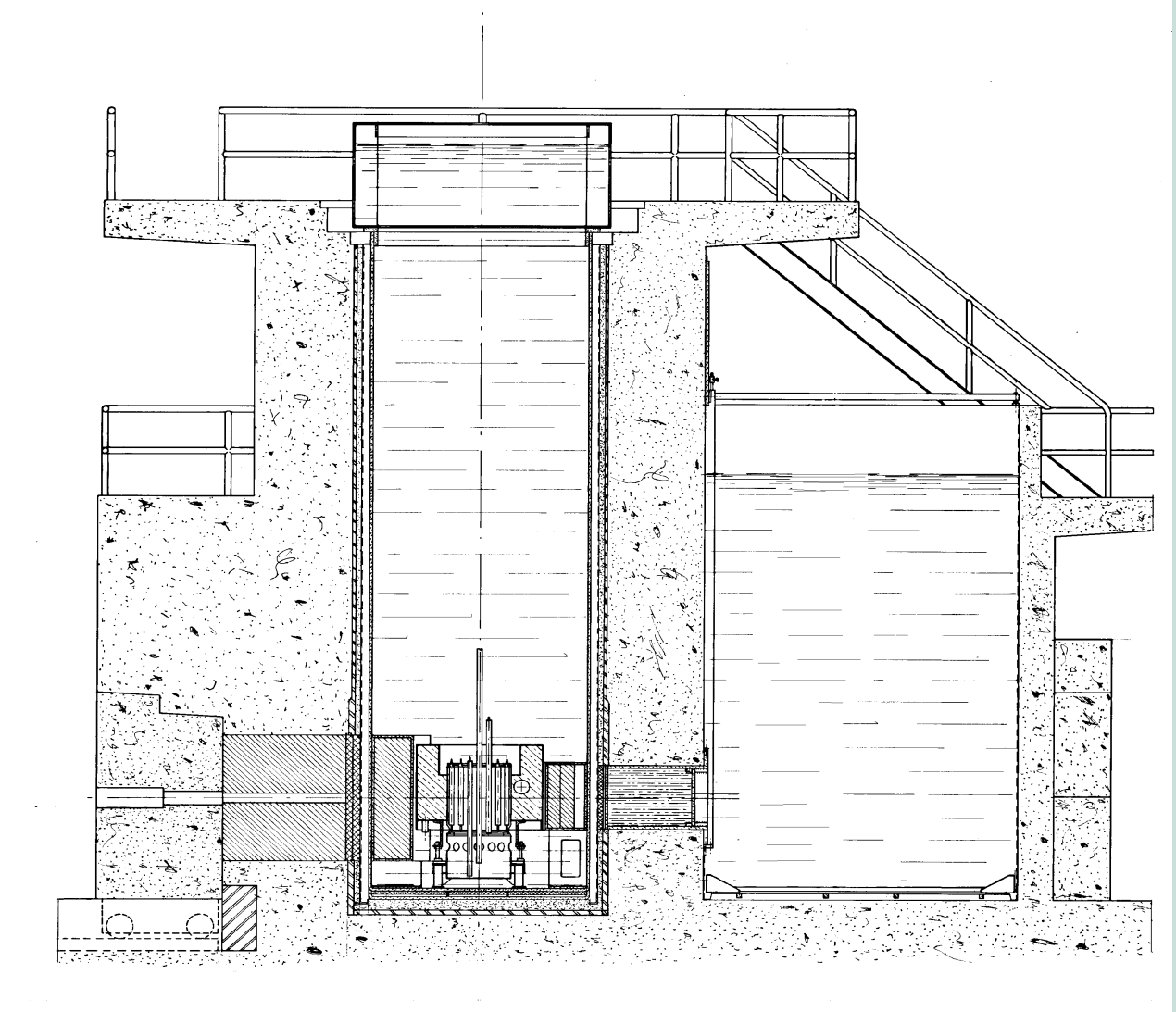
TRIGA RC-1



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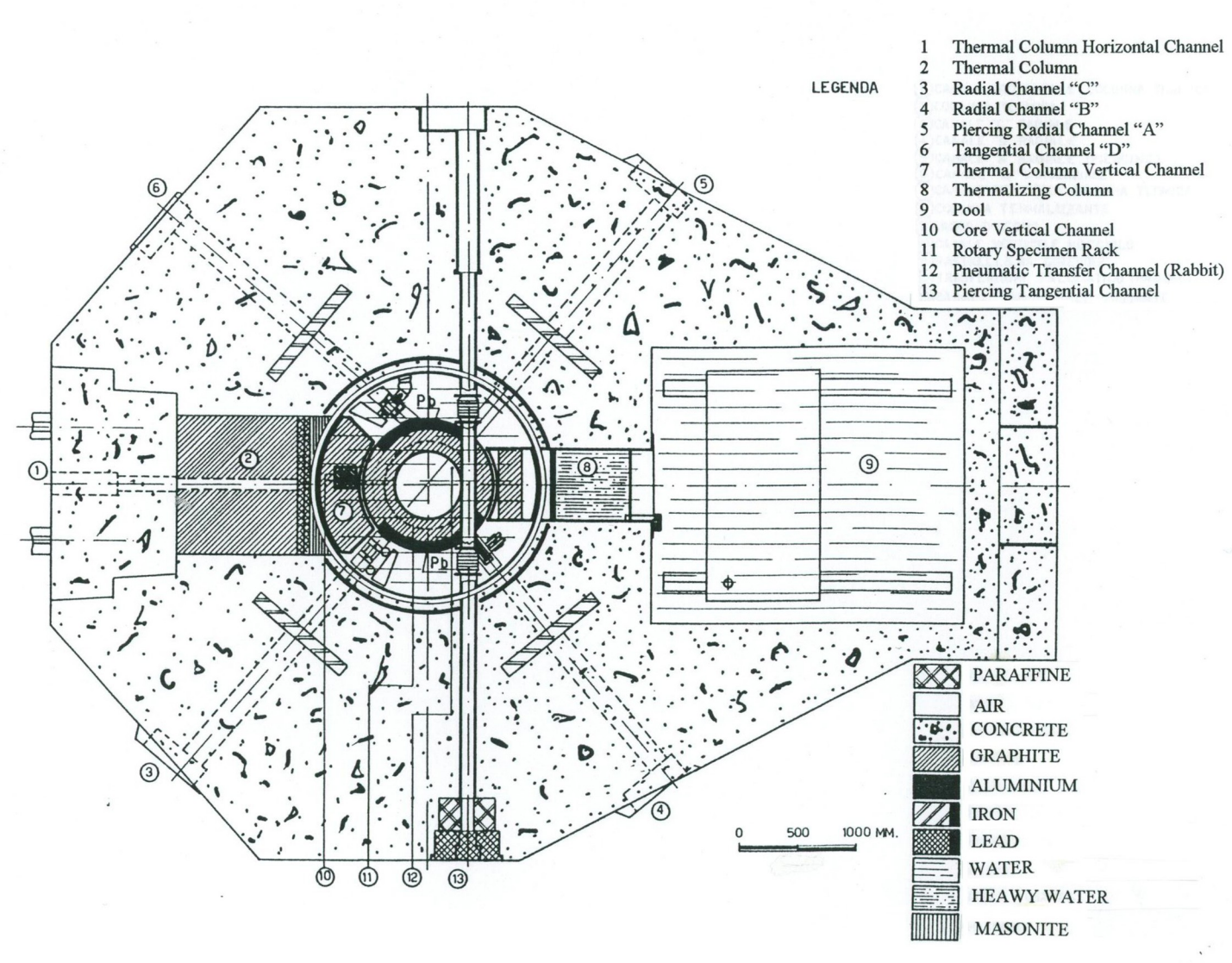
TRIGA RC-1



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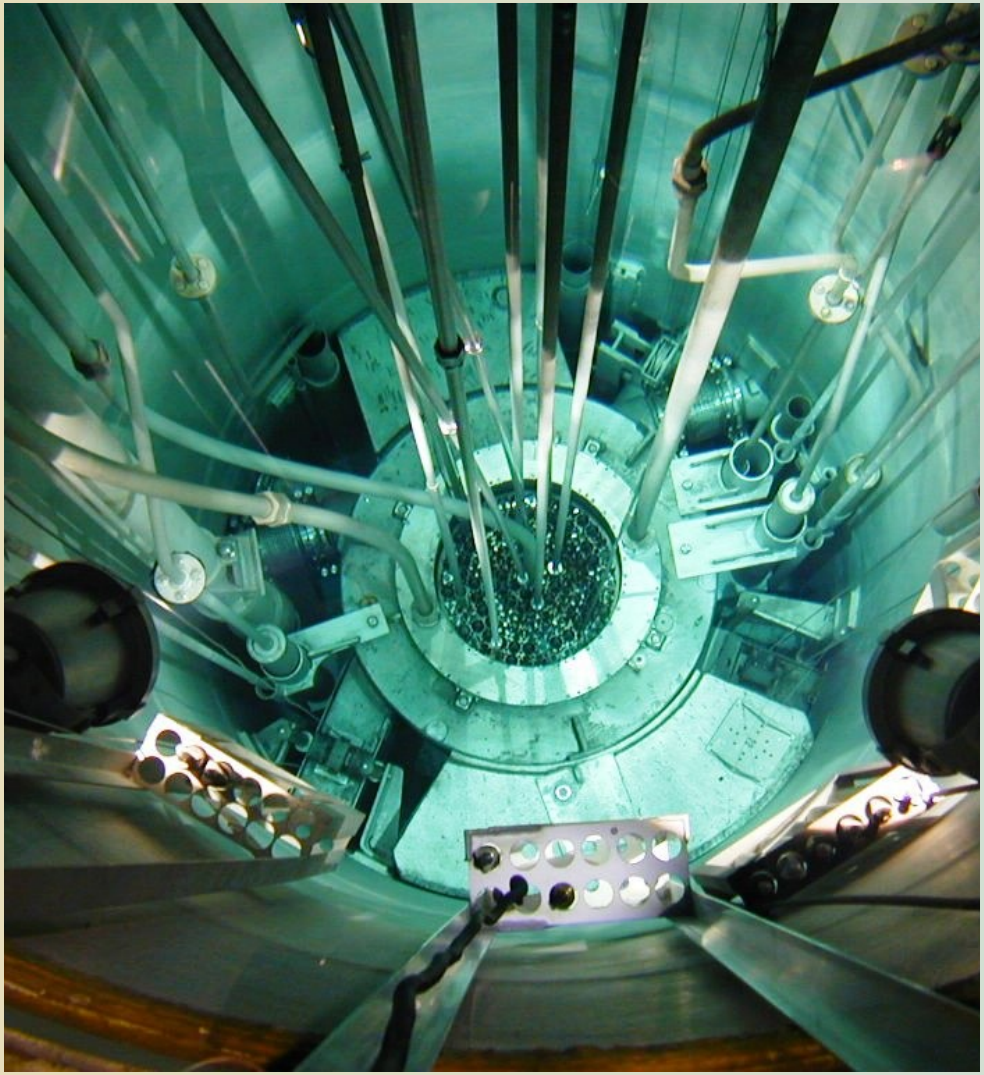
TRIGA RC-1



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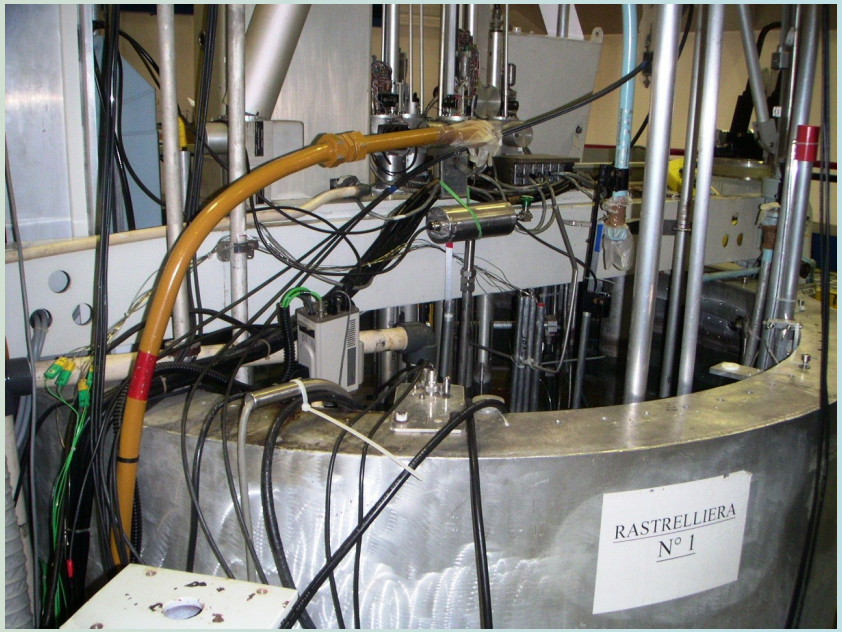
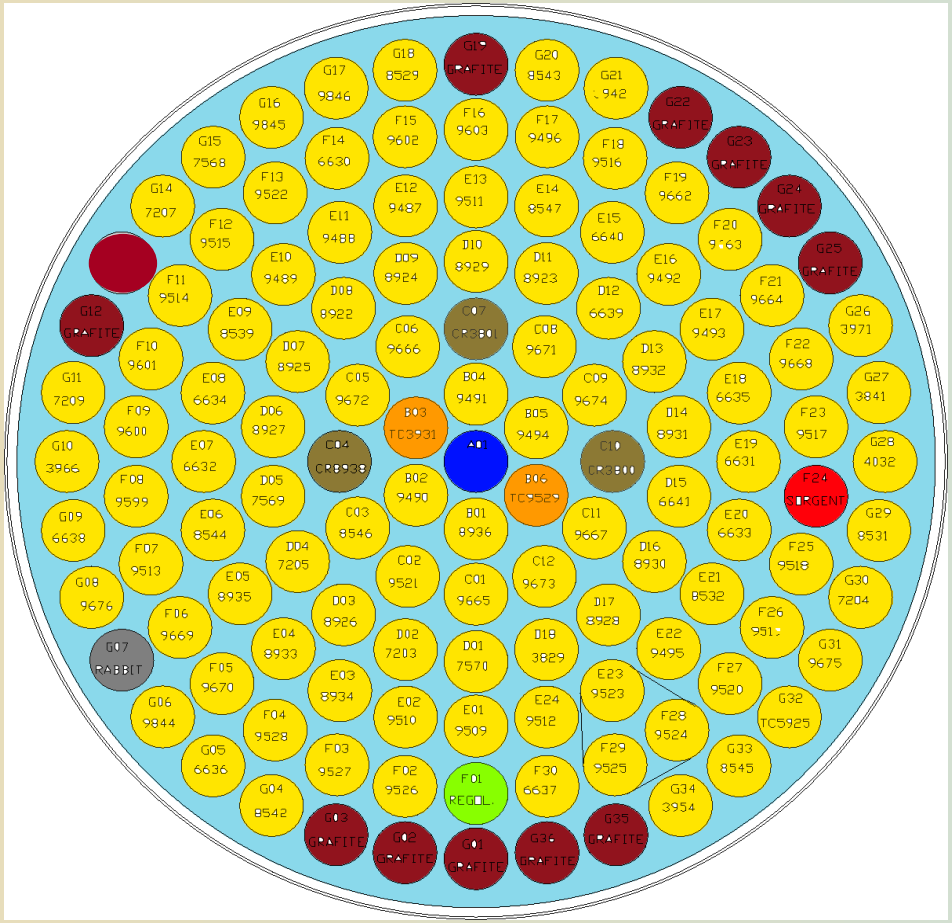


TRIGA RC-1: Standard Core Loading



- Standard Fuel Elements (N=111)
- Fuel Follower Control Rod (N=3)
- Boron Carbide Control Rod (N=1)
- Instrumented Elements (N=2)
- Graphite (N=11)
- Neutron Source (N=1)
- Central Thimble (Air or Water)
- Rabbit

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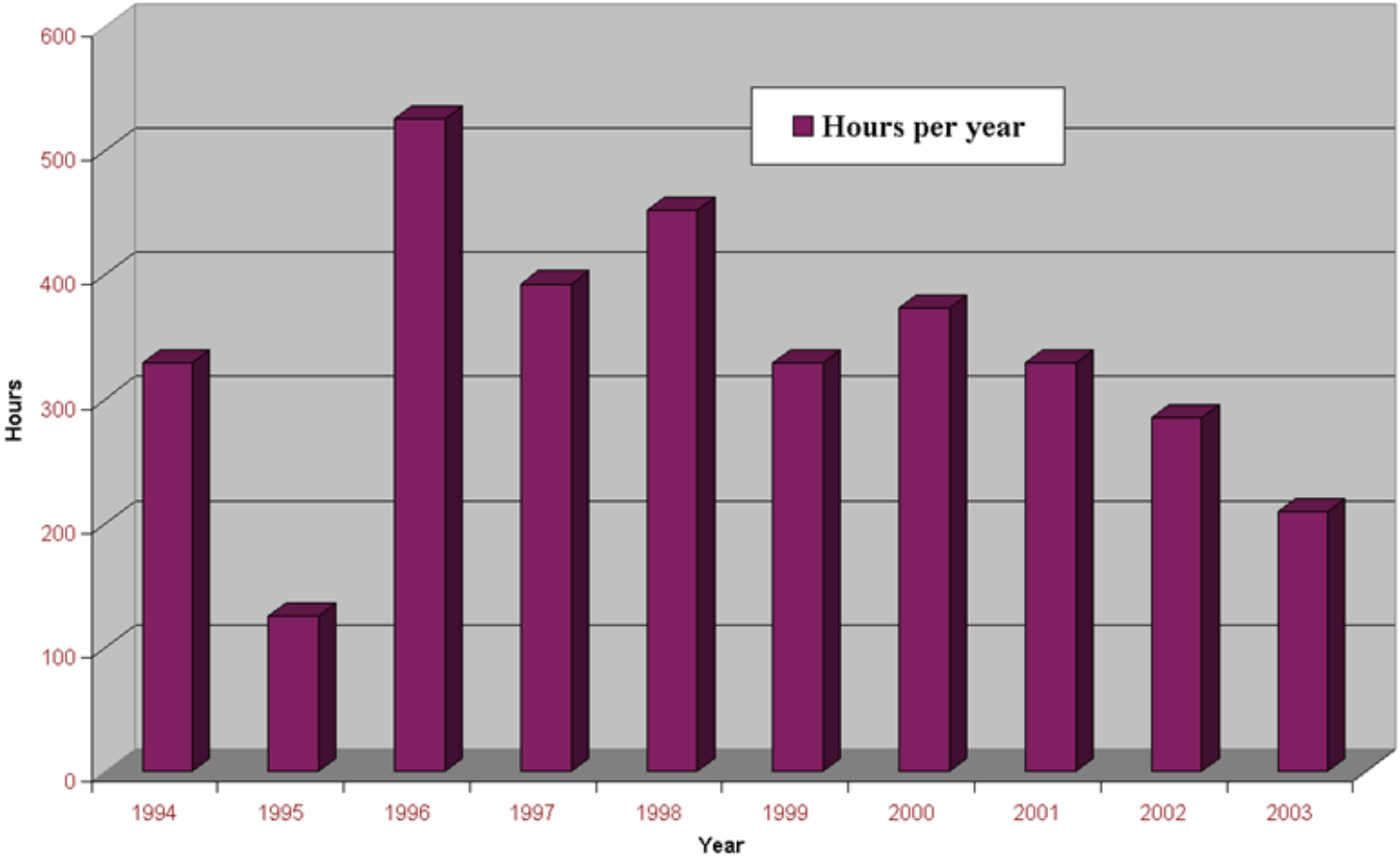
TRIGA RC-1: Past Activity



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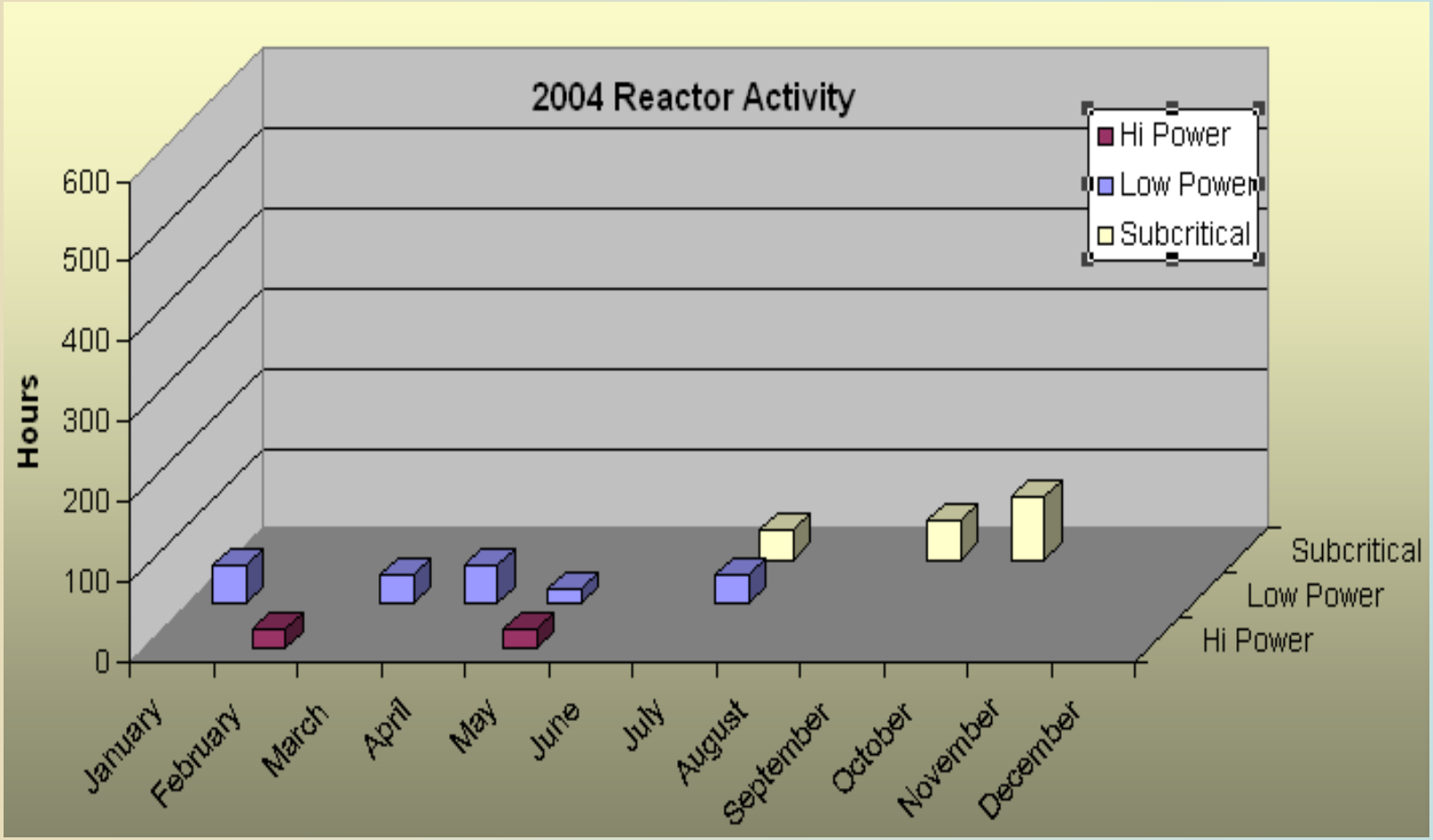
TRIGA RC-1: 2004 Activity



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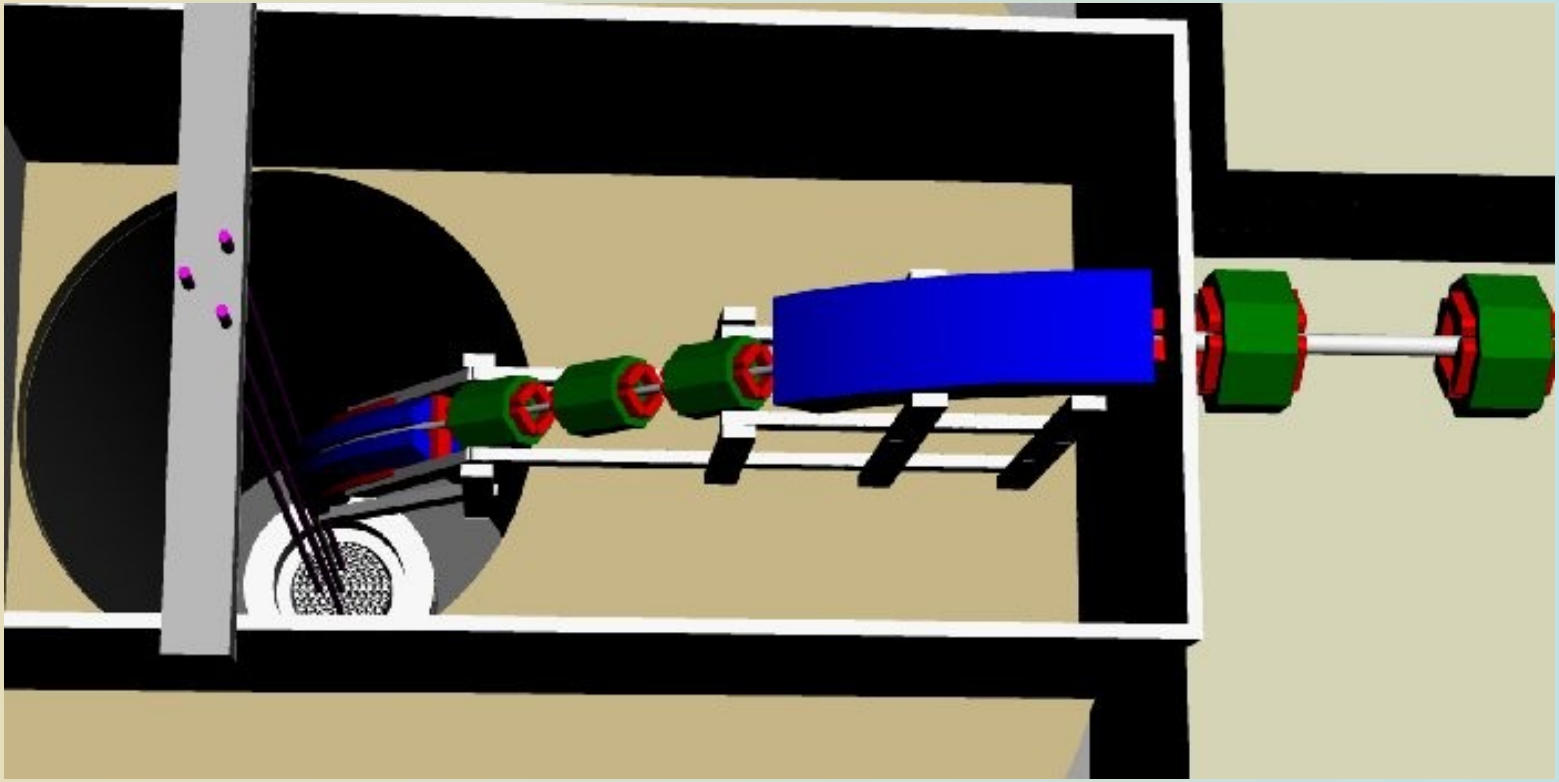
TRADE: TRiga Accelerator Driven Experiment



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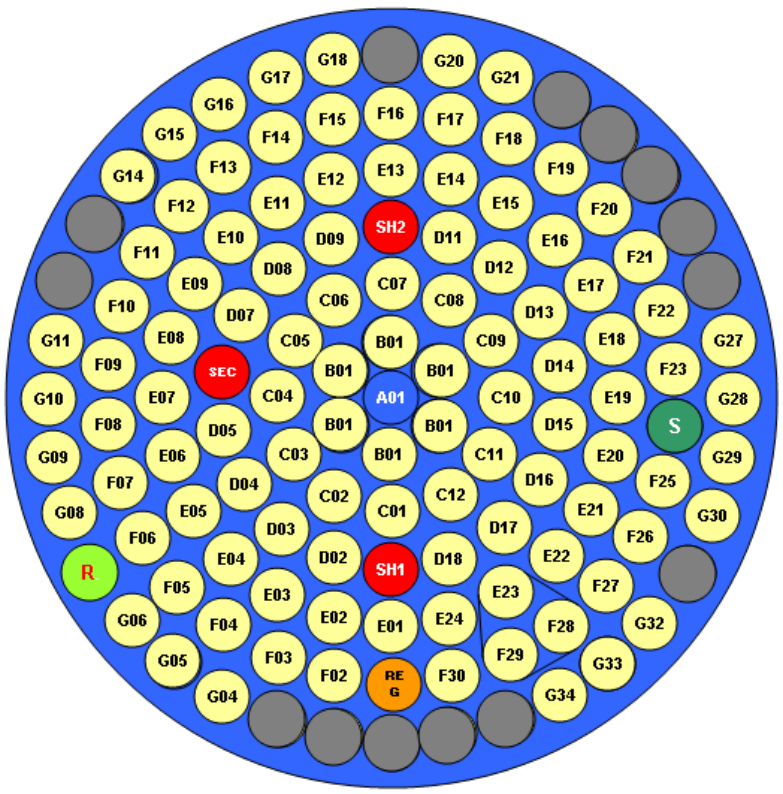
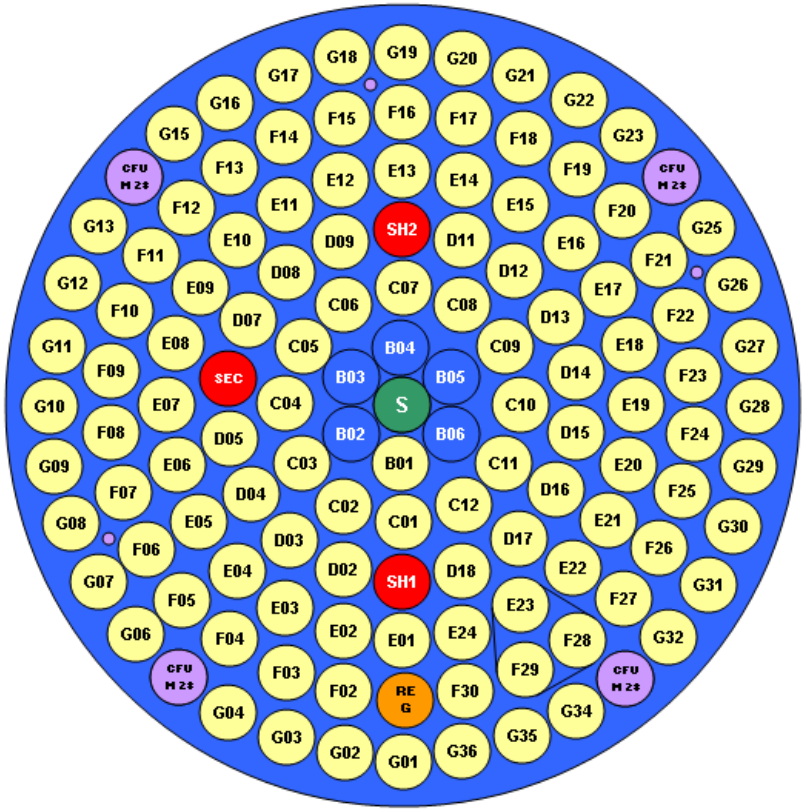
TRIGA RC-1: Core Loading



TRADE 1 MW



TRADE Subcritical

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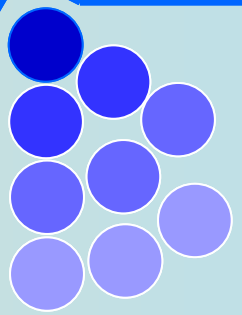

New experimental equipments for pre-TRADE:

- Special Instrumented Fuel
- Spallation Source Dummy
- DT and DT neutron generators
- Cf-252 neutron source
- Fast-Rabbit mapping device
- Source harmonic oscillator

TRIGA RC-1: SIFE - Special Instrumented Fuel Element - 1

- **A special element was procured by CERCA – F with a central channel of 4 mm internal diameter in order to host a fission chamber and investigate the fission rate inside the fuel;**
- **The special element was delivered on December 2003 and the experimental campaign started on January 2004.**

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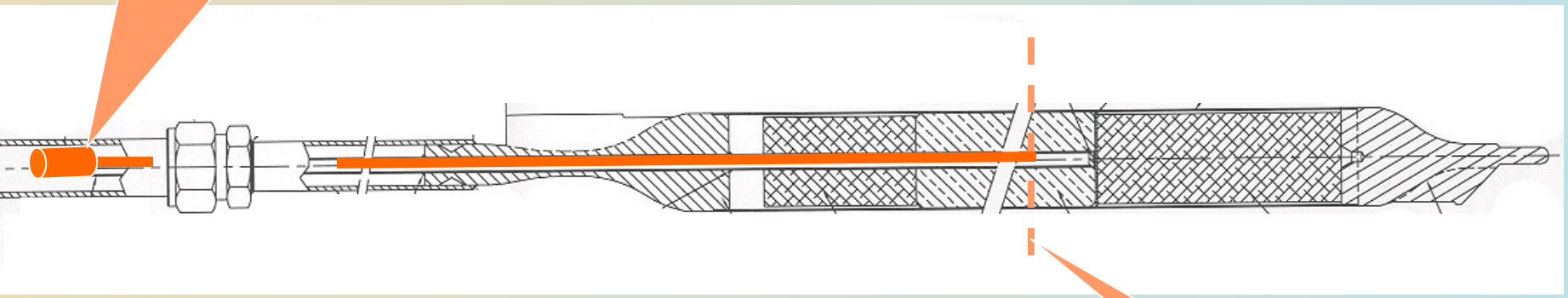
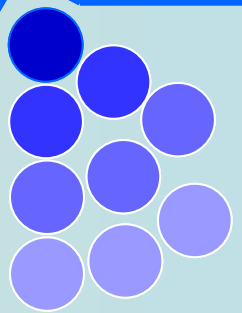
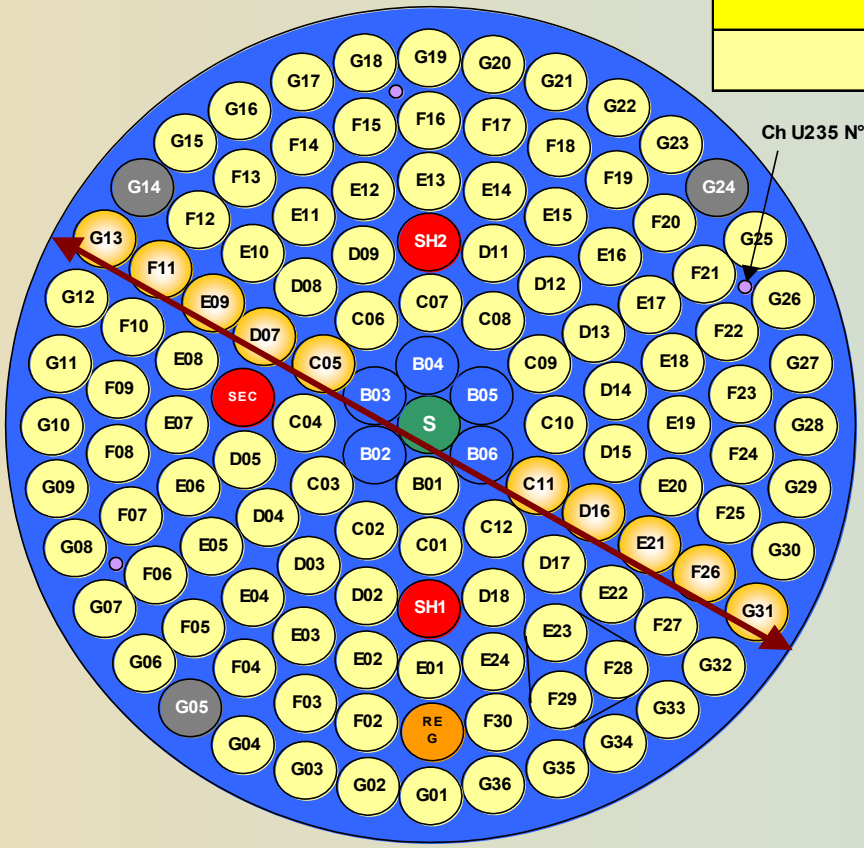


TRIGA RC-1: Fission Rate Mapping with SIFE - 1



- 3 different loaded fission chambers:
  - ^{235}U for thermal fission rates
  - ^{237}Np for intermediate spectrum range
  - ^{238}U for the fast energy range
- 50 measures with SIFE displacement along a core traverse
- Reactor power:
  - 10 W (50 W for ^{238}U)
- Measurement duration:
  - 1000 s

TRIGA RC-1: Fission Rate Mapping with SIFE - 2



TRADE Exp Week 03-2004

STATE 3

Ch U235 N° 2092

- Fuel
- Graphite
- Water Hole
- FC — Fission chamber
- S — Source
- RE G — Regulating Rod
- S. — Shim Rod 1 and 2 and Safety Rod

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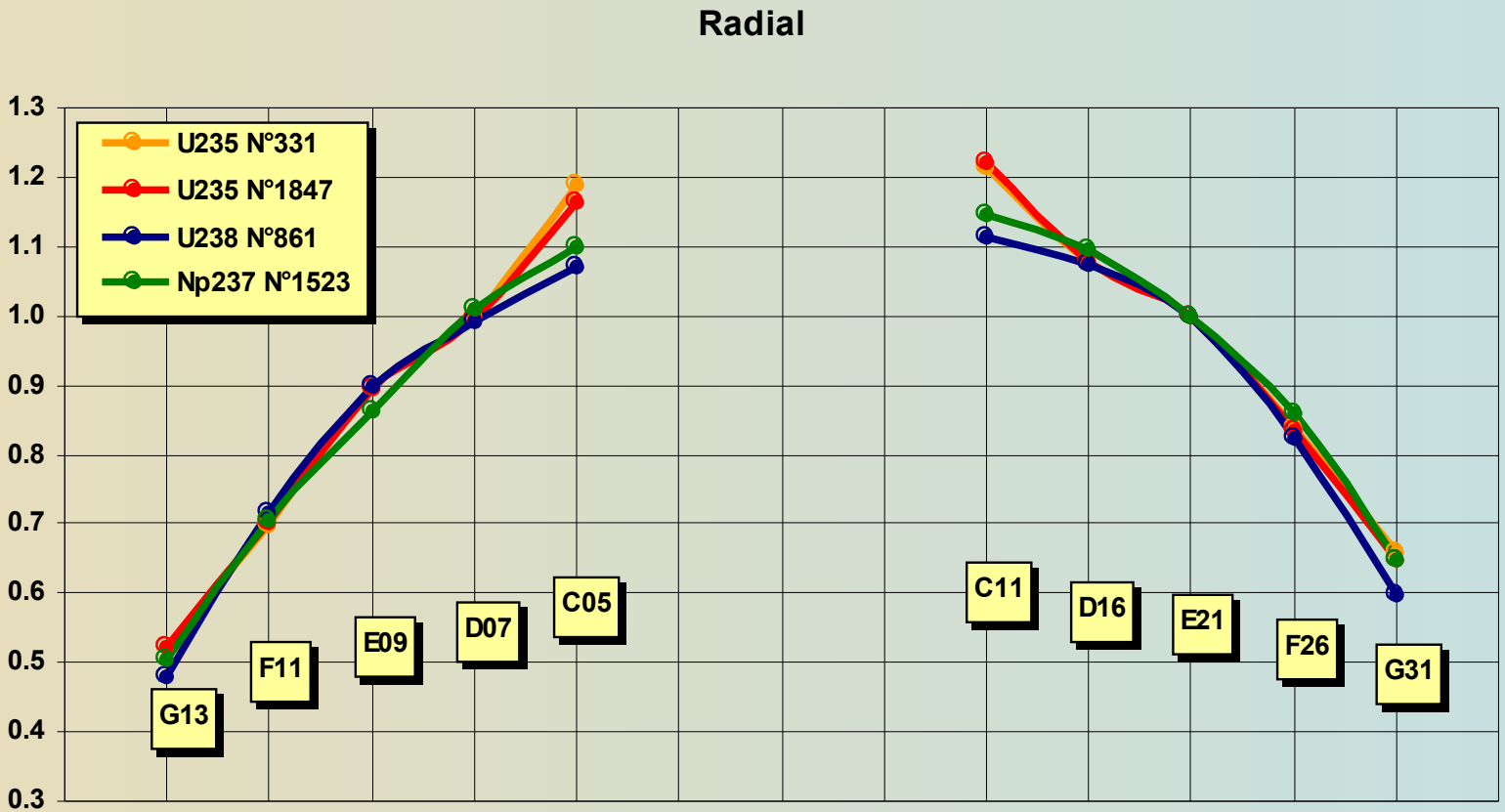
TRIGA RC-1: Fission Rate Mapping with SIFE - 3



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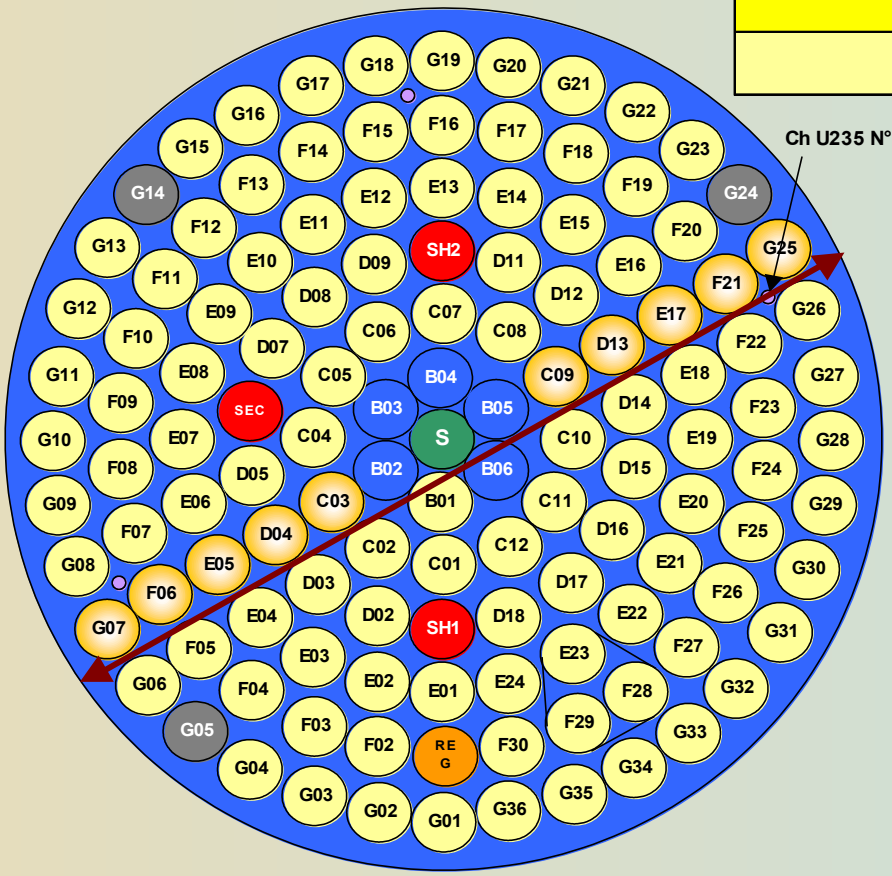
TRIGA RC-1: Fission Rate Mapping with SIFE: - Asymmetry 1



Ch U235 N° 2092

TRADE Exp Week 03-2004

STATE 3

TRIGA
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- Fuel
- Graphite
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- FC — Fission chamber
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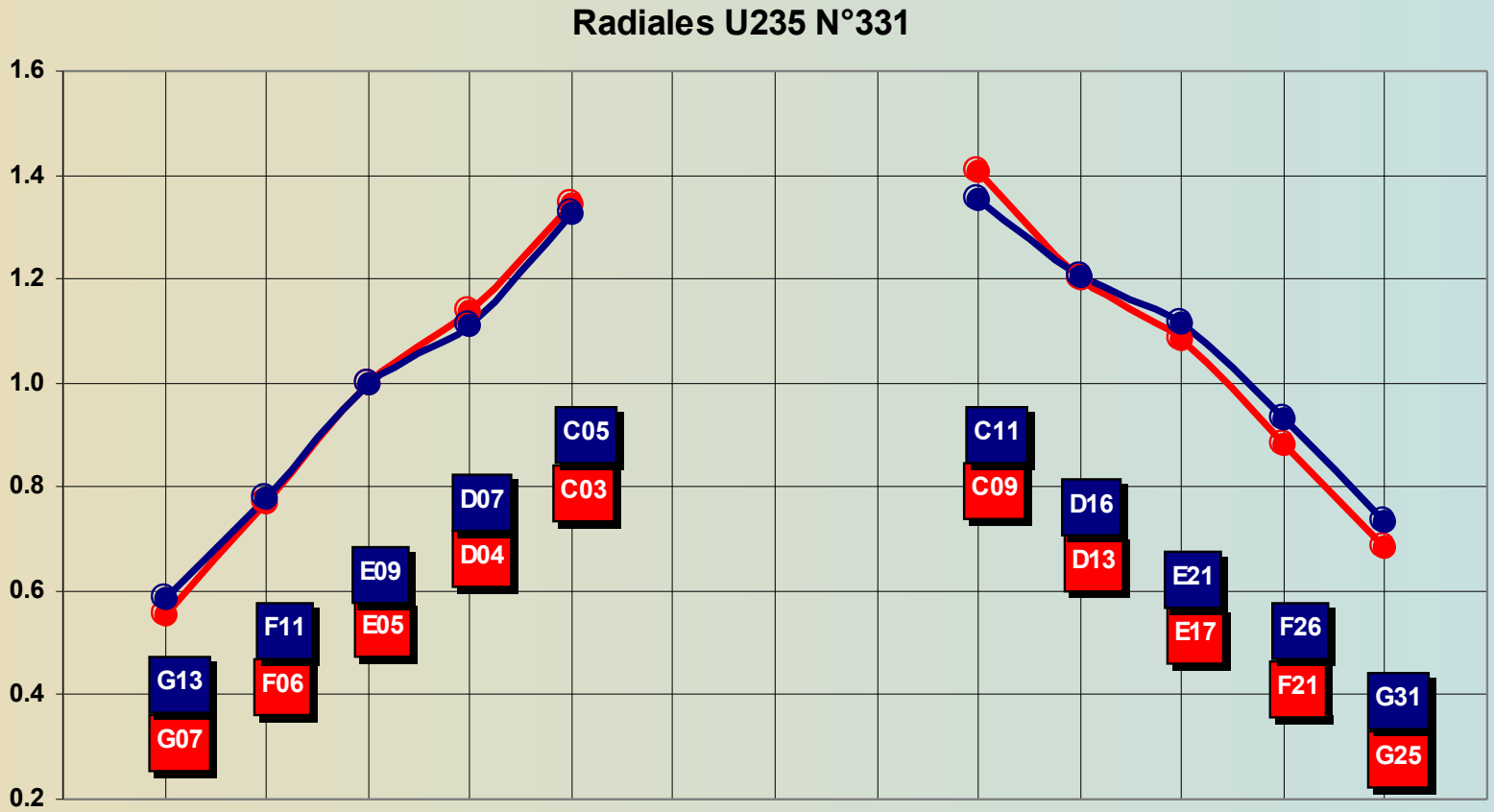
- RE G — Regulating Rod
- S. — Shim Rod 1 and 2 and Safety Rod

TRIGA RC-1: Fission Rate Mapping with SIFE: - Asymmetry 2



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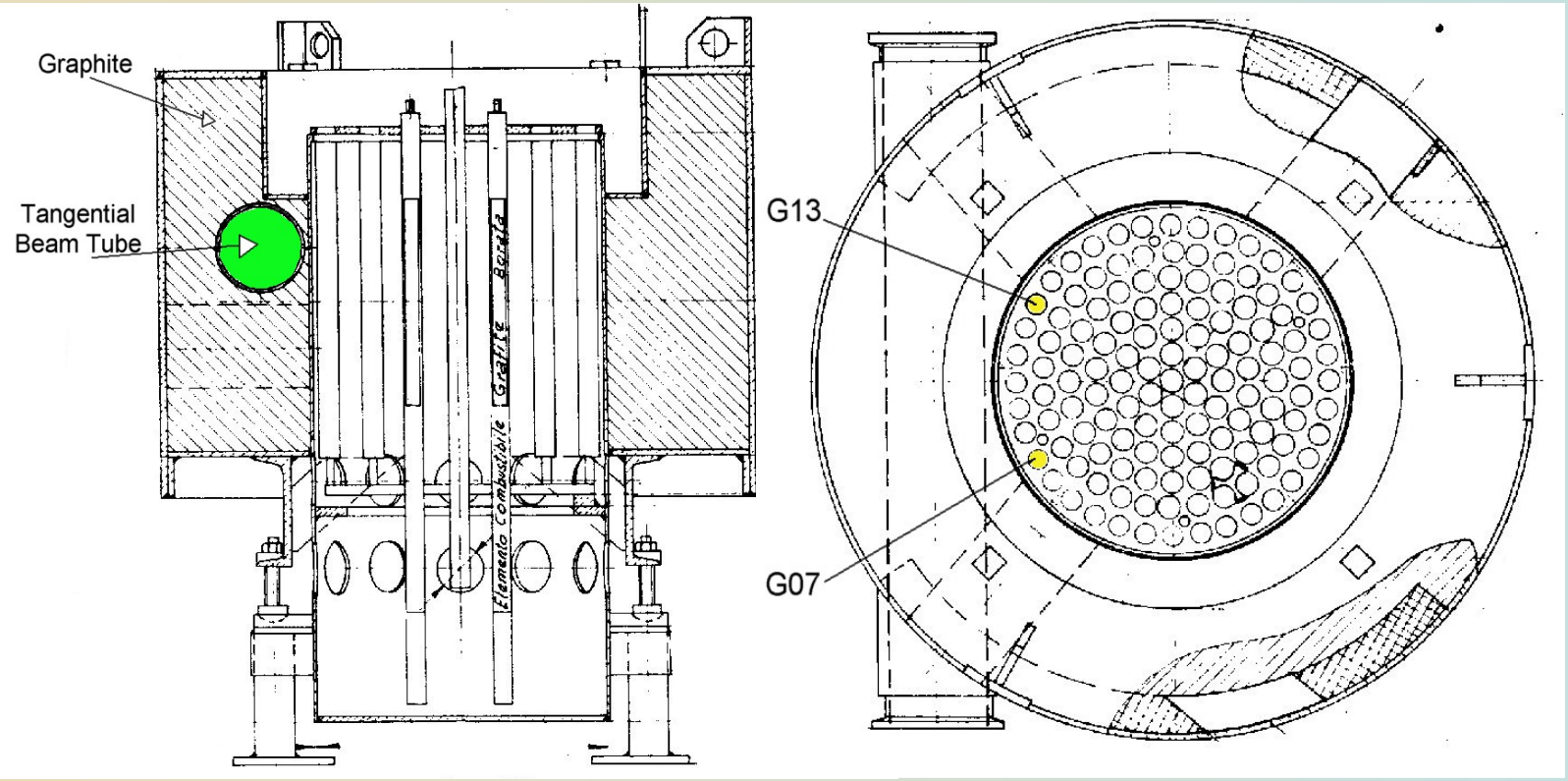
TRIGA RC-1: Fission Rate Mapping with SIFE: - Asymmetry 3



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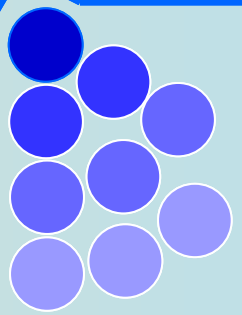
TRIGA RC-1: Future Activities



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2005: Conclusion of the ADS experimental campaign

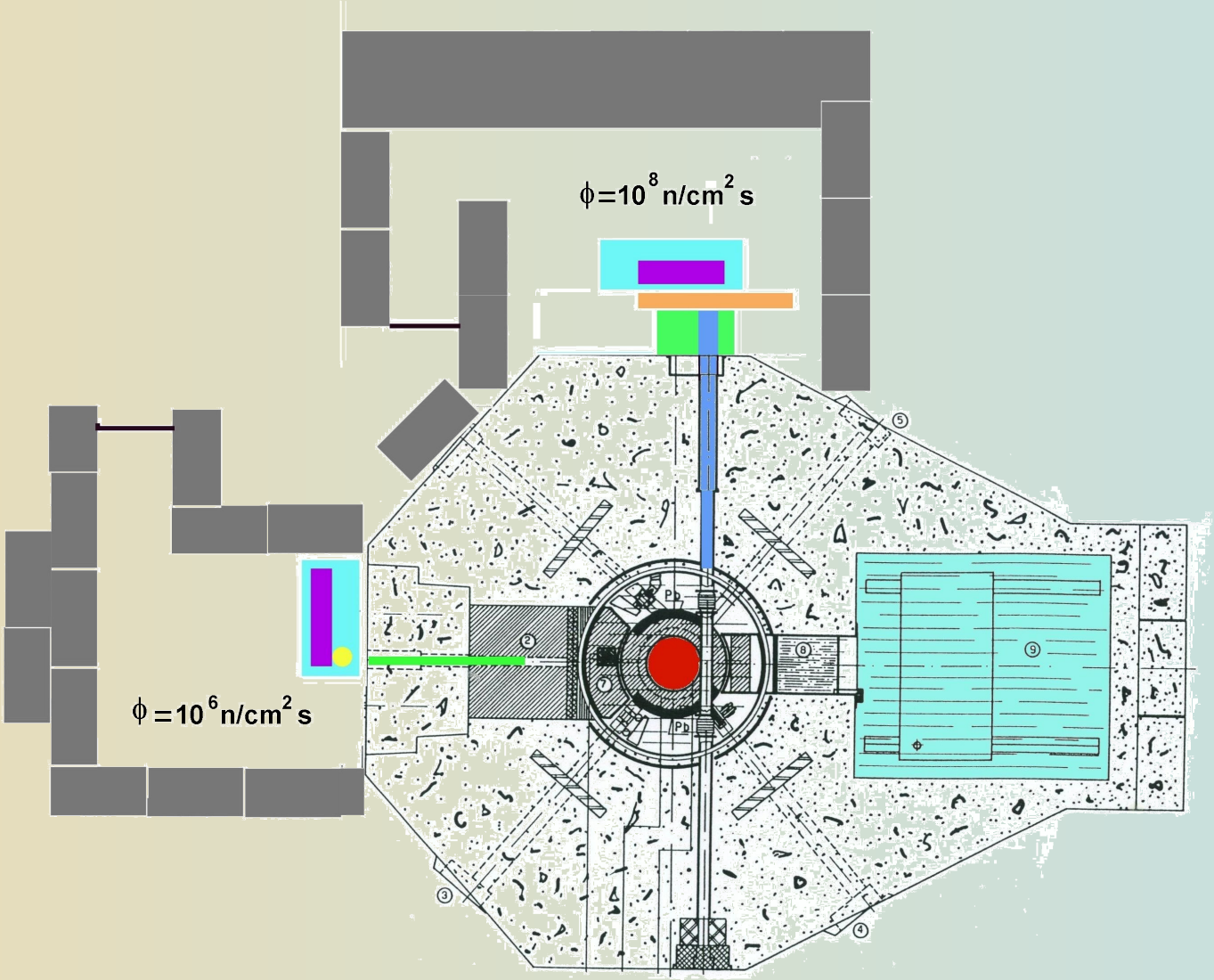
2006: full 1 MW core:

- **Neutron Radiography**
- **Medical Isotopes Production**

Irradiation on demand

- **Training**

TRIGA RC-1: Neutron Radiography Stations



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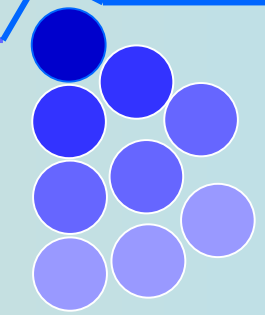
TAPIRO Reactor

- Fast source reactor
- Based on the concept of AFSR (Argonne Fast Source Reactor - Idaho Falls)
- Designed by ENEA's staff
- Start-up: 1971

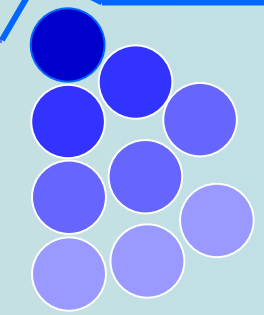
TAPIRO
Reactor

TAPIRO: Main Features



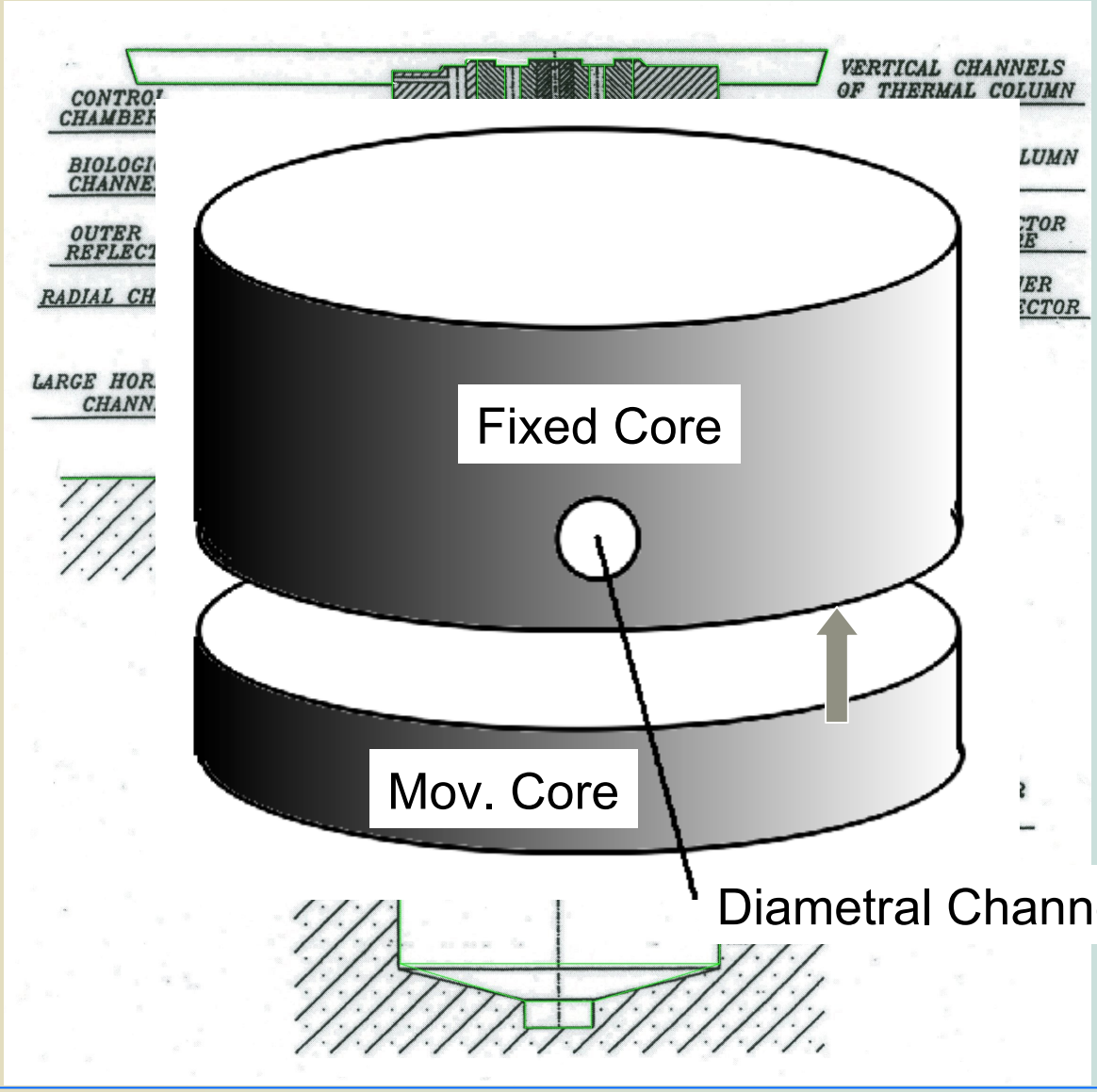
CORE	Cylindrical: diameter 125.8 mm height 109.5 mm (2/3 fixed – 1/3 mobile)	
FUEL	Uranium-molybdenum alloy (98.5% U – 1.5% Mo)	
	Density:	18.5 g cm^{-3}
	Enrichment:	93.5% U^{235}
	Operative mass:	22107.42 g/U^{235}
CLADDING	Stainless steel:	thick 0.5 mm
REFLECTOR	Cylindrical Inner Reflector:	diameter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

TAPIRO: Main Features



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 concrete Density: 3.7 kg dm^{-3}
NUCLEAR DATA	Neutron Spectrum: fast Maximum Neutron Flux: $5.0 \cdot 10^{12}$ $n \cdot cm^{-2} \cdot s^{-1}$ @ 5kW
THERMAL COLUMN	Max Volume: 1.6 m^3

TAPIRO: Vertical Section



TAPIRO
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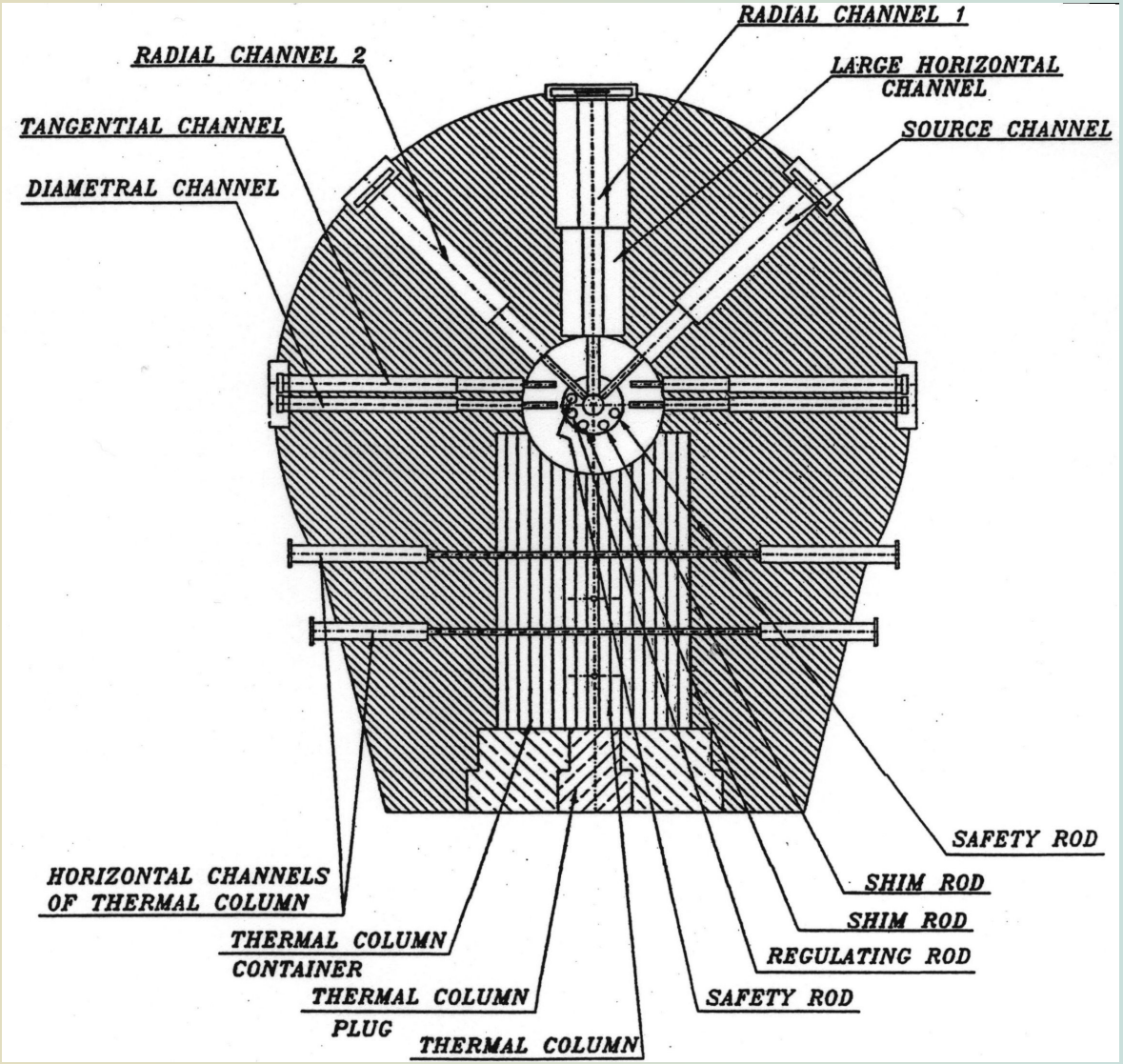
TAPIRO: Horizontal Section



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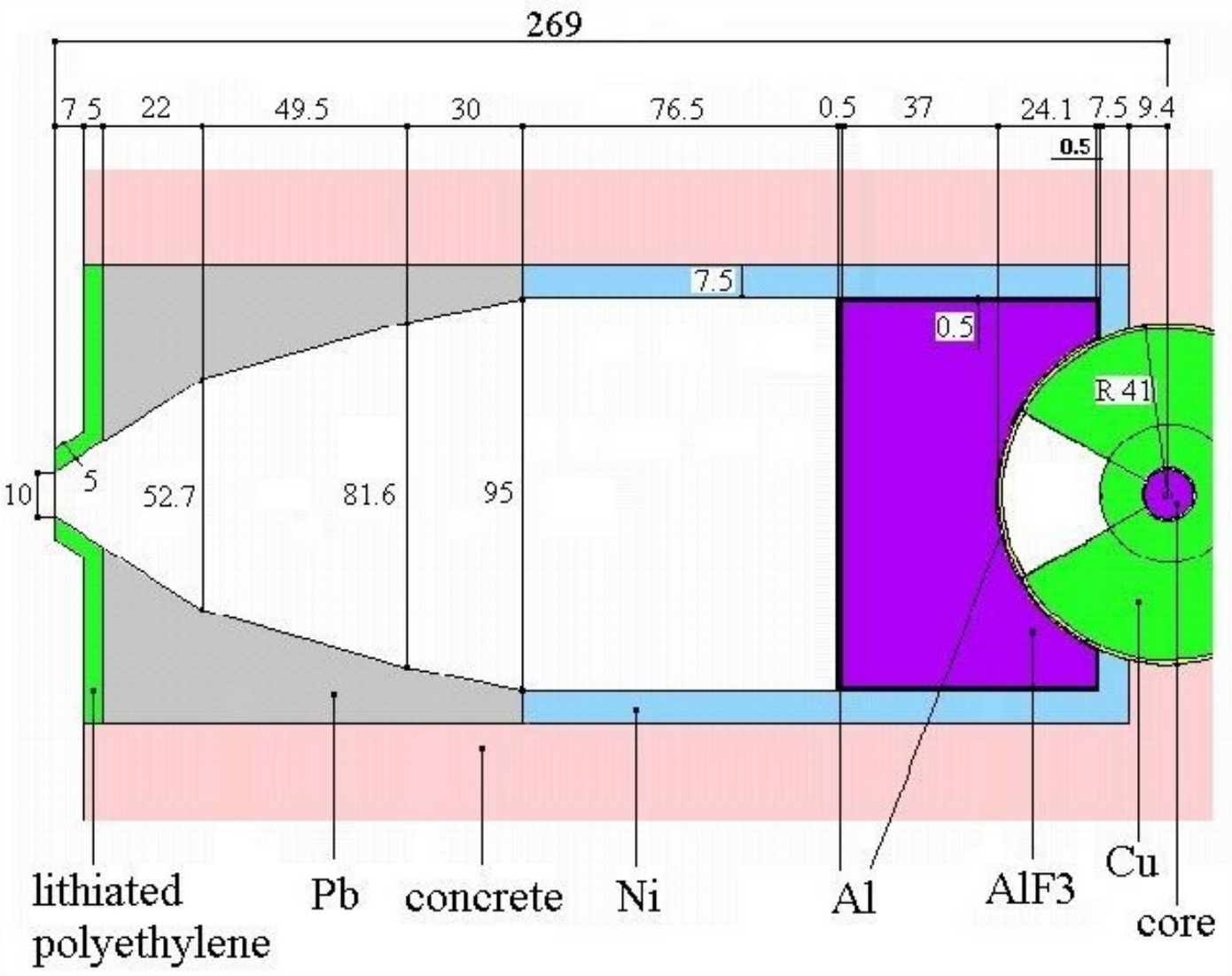
TAPIRO: Thermal Column

TAPIRO
Reactor

Thermal Column Modification for BNCT



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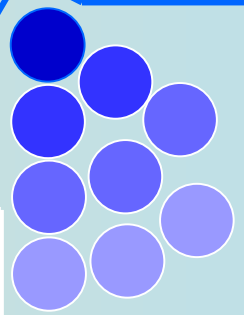
Thermal Column MCNP Calculated free beam parameter



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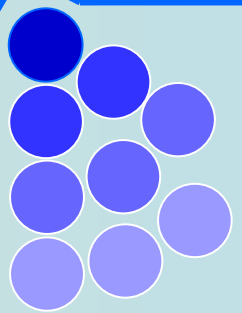
Epithermal neutron flux (0.4 eV – 10 keV)	8×10^{8} n cm^{-2} s^{-1}
Neutron dose in water (> 10 keV)	3.4×10^{-13} Gy cm^{2}
γ whole body dose	4.1×10^{-13} Gy cm^{2}
Epithermal neutron current	0.73

(mean values over 100 cm^2 aperture)

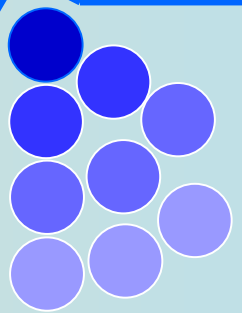
BNCT therapeutic parameters

	calculated in ADAM phantom		measured in water phantom
	TAPIRO (10/35 µg/g ^{10}B)	TAPIRO (18/65 µg/g ^{10}B)	MITR (18/65 µg/g ^{10}B)
Advantage Depth Dose Rate (ADDR) (GyEq/min)	0.25	0.32	1.72
Treatment time (min)	50	39	7.3
Peak Therapeutic Ratio (PTR)	4.3	5.6	6.3
Advantage Depth (AD) (mm in cranium)	86	94	97
Therapeutic Depth (TD) (mm in cranium)	66	74	75



TAPIRO
Reactor

TAPIRO: Future Activities



TRIGA
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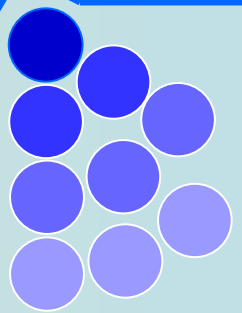
- BNCT
  - Experimental Assessment MCNP Estimations
  - Trials in cooperation with Hospitals
- Neutron Irradiation Service
  - Electronics components for aerospace and High Energy Physics

Statistics: Reactor Staff

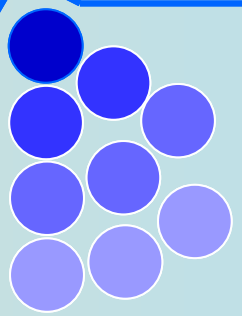
	TRIGA	TAPIRO
Director	1	1
Technical Directors	2	-
Supervisors	3	1
Operators	2 ½	1
Technician	1	1
Technical Secretary	½	-
Total	10	4
Researchers	4	-
Health Physics	5	

Statistics: Radioactive Doses

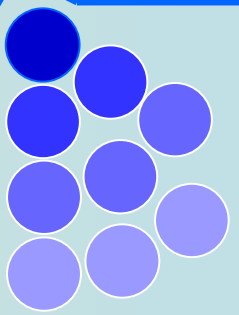
	TRIGA	TAPIRO
Annual Dose	**mSv**	**mSv**
Reactor Staff	14.3	5.3
Research Staff	4.1	-
Maximum Personal Dose		
Reactor Staff	1.8	1.5
Research Staff	1.2	-



Statistics: Radioactive Doses



Annual Dose	mSv
Reactor Staff	14.3
Research Staff	4.1
Maximum Personal Dose	
Reactor Staff (10)	1.8
Research Staff (4)	1.2



Thank-You!