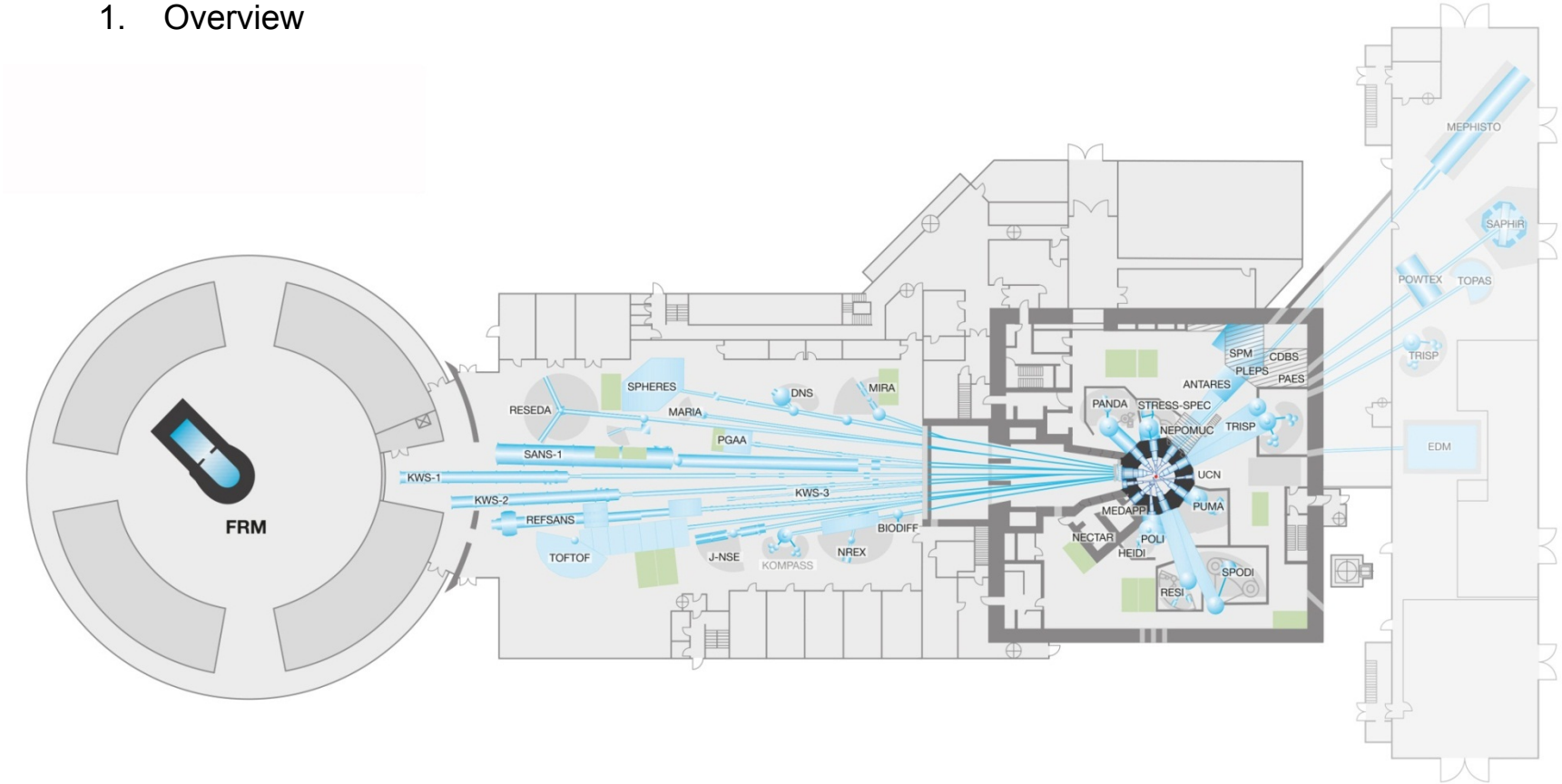
The Forschungs-Neutronenquelle Heinz-Meier-Leibnitz (FRM II)

Christoph Morkel

I. Overview
II. Technical Concept
III. The Fuel Element
IV. Cold Source / Hot Source
V. Conclusion

I. The Neutron Source FRM II

1. Overview



FRM **Neutron Guide Hall** **FRM II** **Hall East**

The Forschungs-Neutronenquelle FRM II

I. Overview

International Neutron Sources						
	High flux reactor (HFR) Grenoble (FR)	Pulsed reactor IBR-IT Dubna IRL - II	Spallation source ISIS Chilton (UK)	ESS W -Target H2O Moderator	FRM II (D_2O) Munich	Opal (D_2O; 20%) Aus
$\hat{\Phi}\left[cm^{-2}s^{-1}\right]$	10^{15}	$2\cdot10^{16}$	$4.5\cdot10^{15}$	$1.4\cdot10^{17}$	$6.8\cdot10^{14}$	$1.8\cdot10^{14}$
$\overline{\Phi}\left[u\ cm^{-2}s^{-1}\right]$	10^{15}	$2\cdot10^{13}$	$7\cdot10^{12}$	$0.6\cdot10^{15}$	$6.8\cdot10^{14}$	$1.8\cdot10^{14}$
Pulse repetition rate $\nu\left[s^{-1}\right]$	—	5	50	14	—	—
Pulse duration $\left[10^{-6}s\right]$	—	250	30	165	—	—
P $[MW]$	57	2	0.2	5	20	20

European Landscape of Neutron User Facilities

ESS
Sweden

PIK
Russia

JINR
Russia

BER II
Germany

ISIS
UK

- **FRM II**
  Germany

ORPHÉE
France

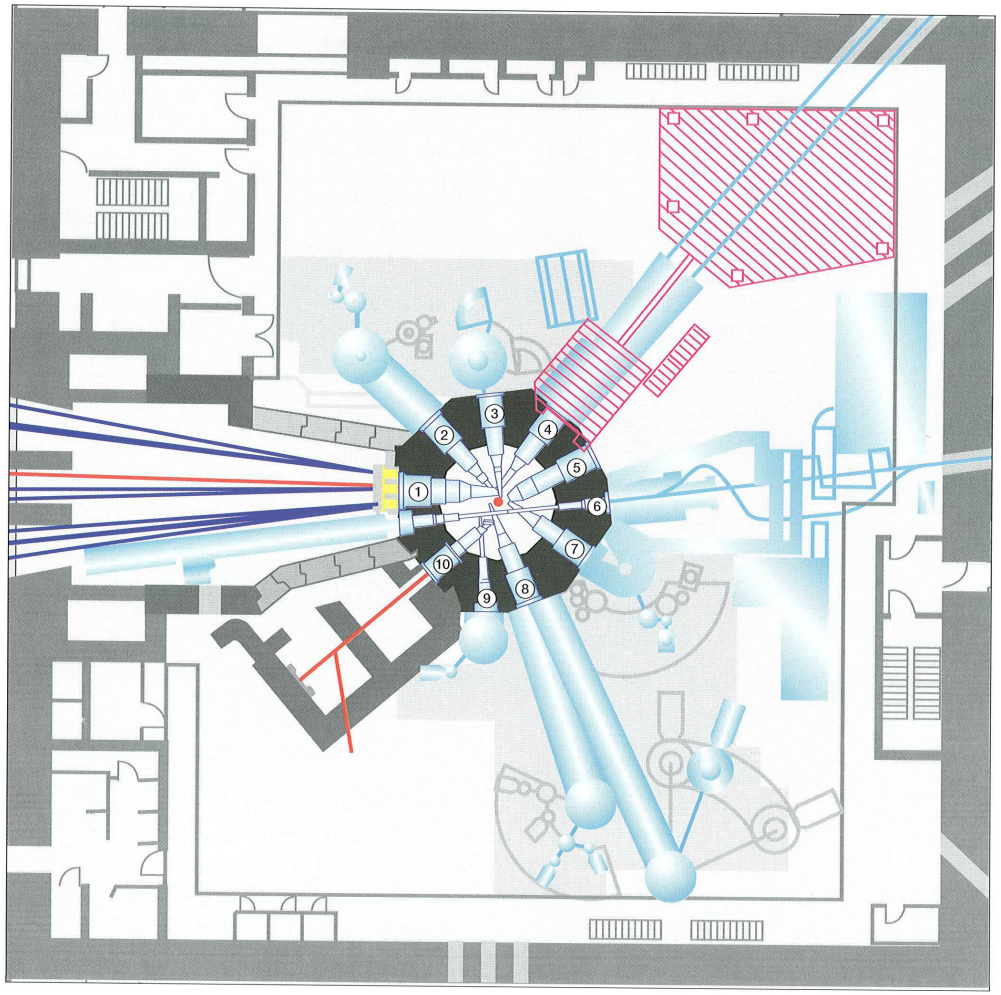
ILL
France

SINQ
Switzerland

The Forschungs-Neutronenquelle FRM II

I. Overview

Experimental Hall
with Reactor pool



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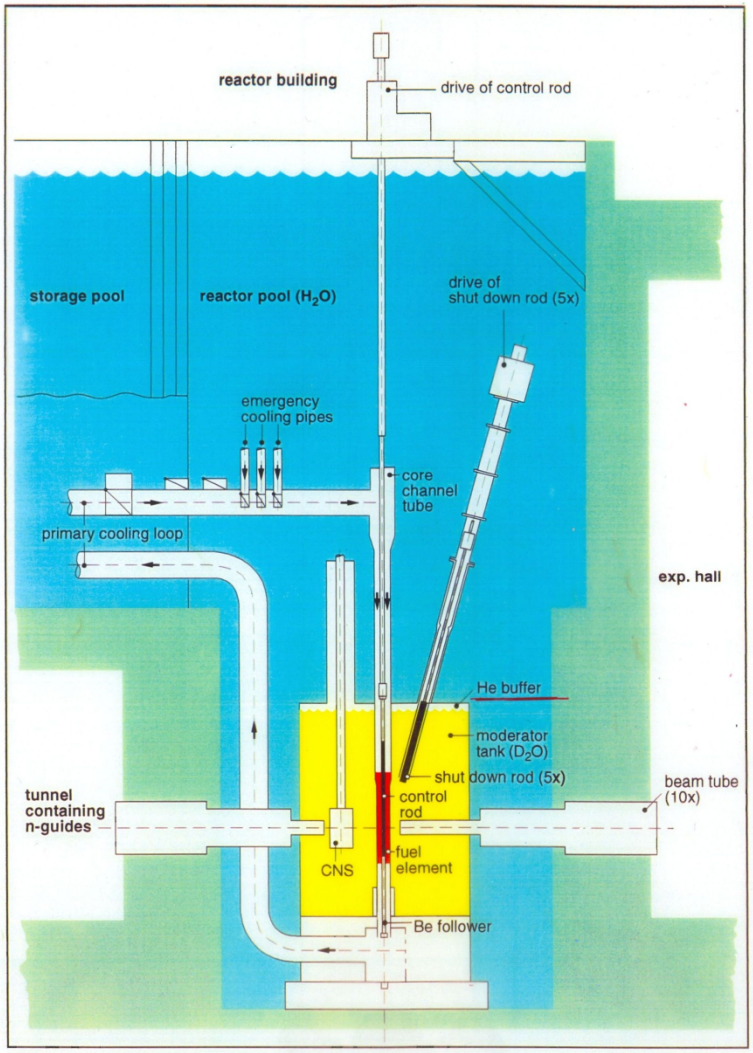
II. Technical Concept

Reactor pool
(schematic)



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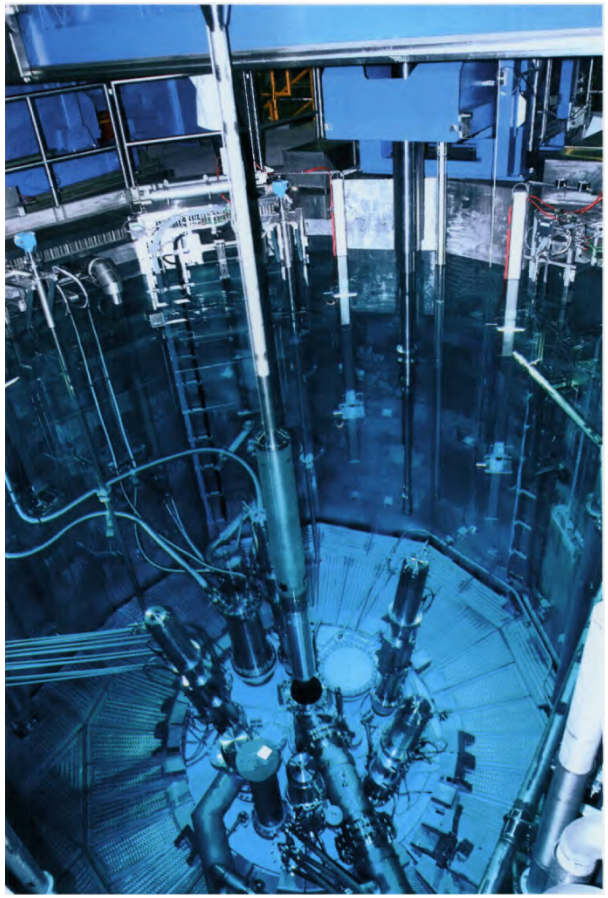
II. Technical Concept

Insertion of a fuel element



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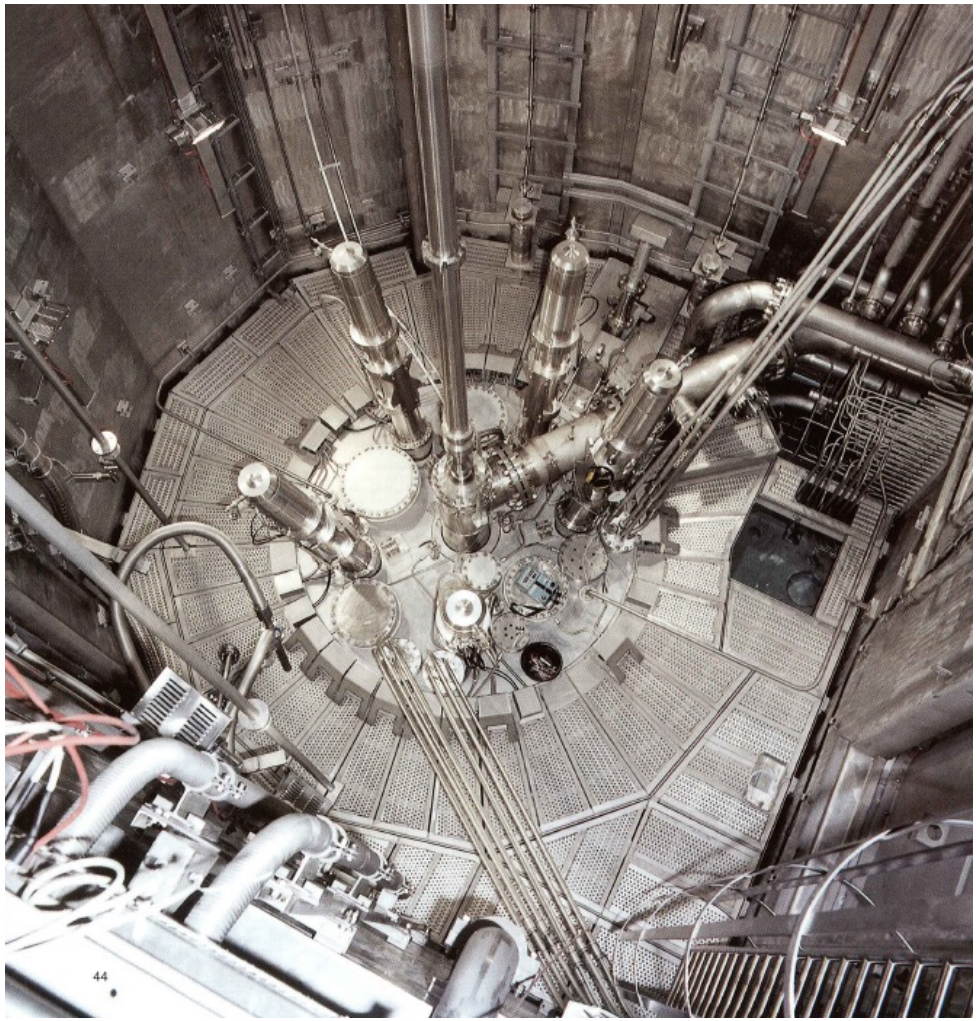
II. Technical Concept

View into the pool



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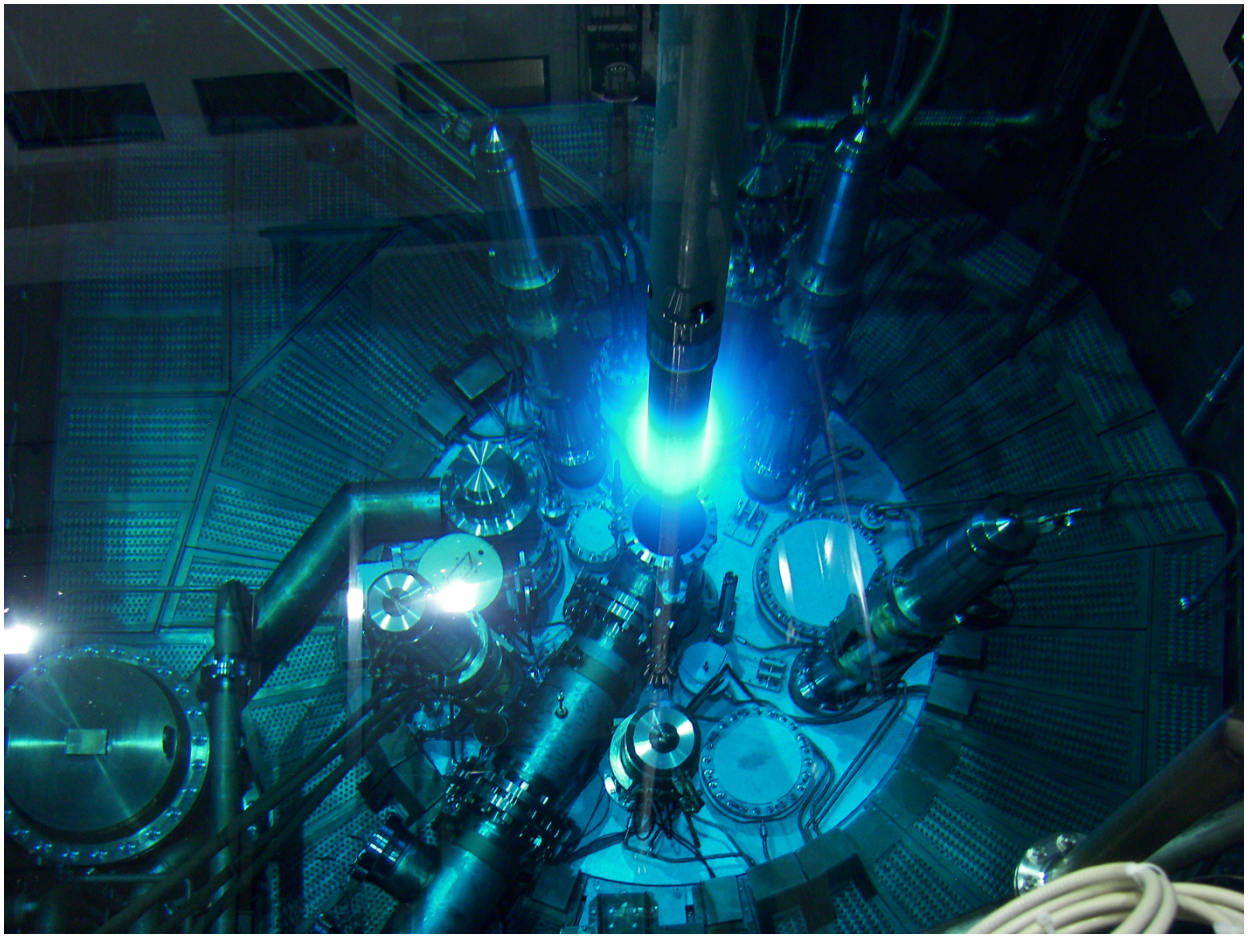
II. Technical Concept

Discharge of a spent fuel element



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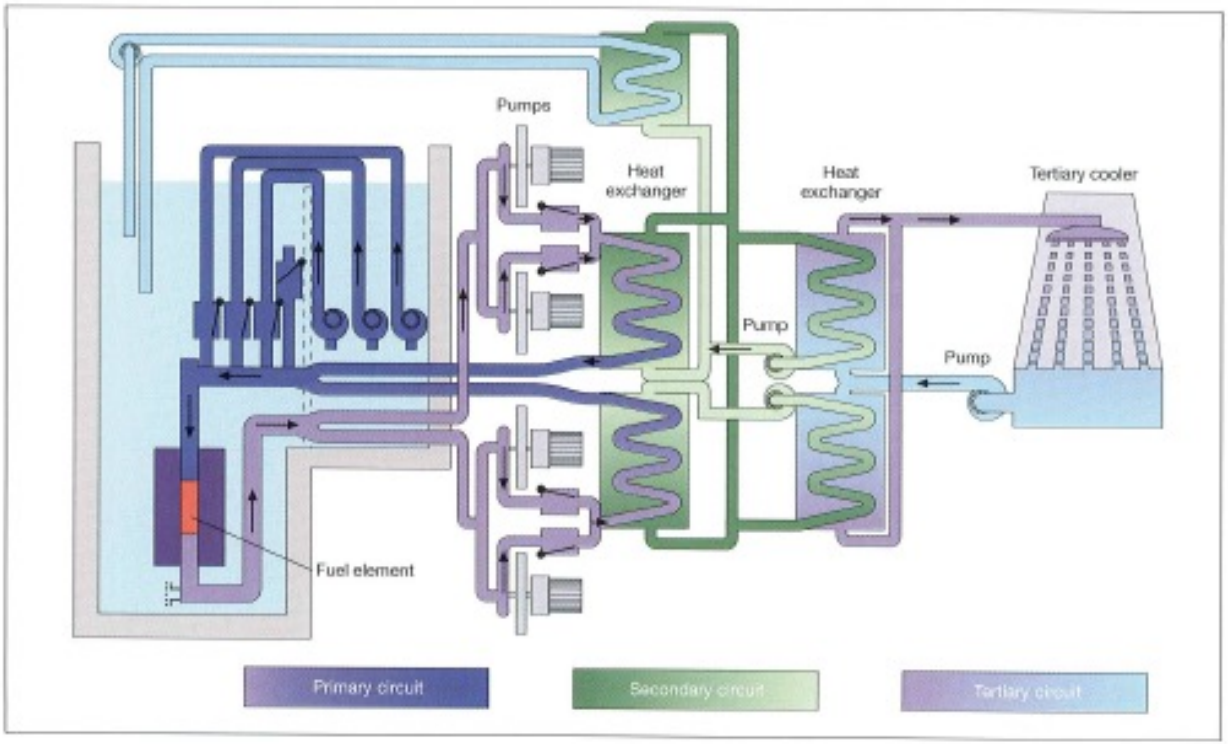
II. Technical Concept

Cooling loops of FRM II



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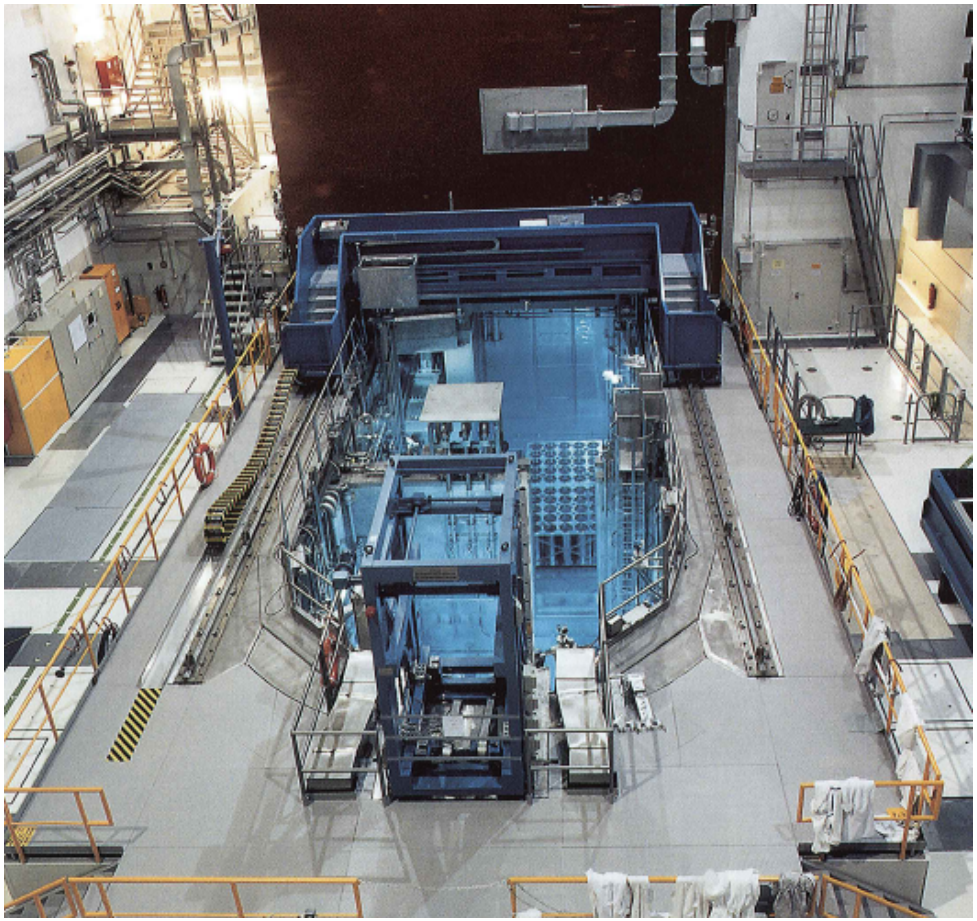
II. Technical Concept

Reactor hall with pool



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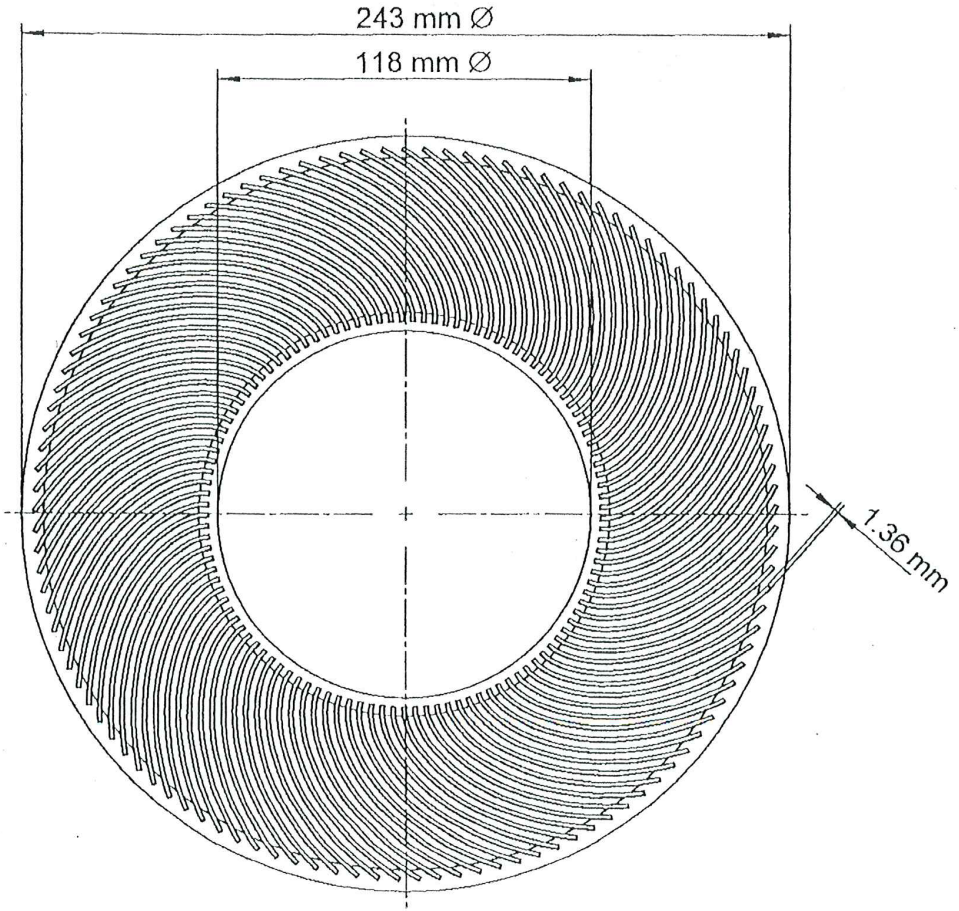
II. Technical Concept

- Pool tank reactor
- Compact Core
- U_3Si_2-Al – dispersion fuel with highly enriched uranium (93%)
- Light water (H_2O) cooling
- Heavy water (D_2O) moderation
- Cold source / hot source
- 10 beam tubes

⇒ **High thermal neutron flux (ca. 8 x 10^{14} $cm^{-2}s^{-1}$) at low thermal power (20 MW)**

The Forschungs-Neutronenquelle FRM II

III. The Fuel Element



Cross section of the fuel element with 113 curved fuel plates

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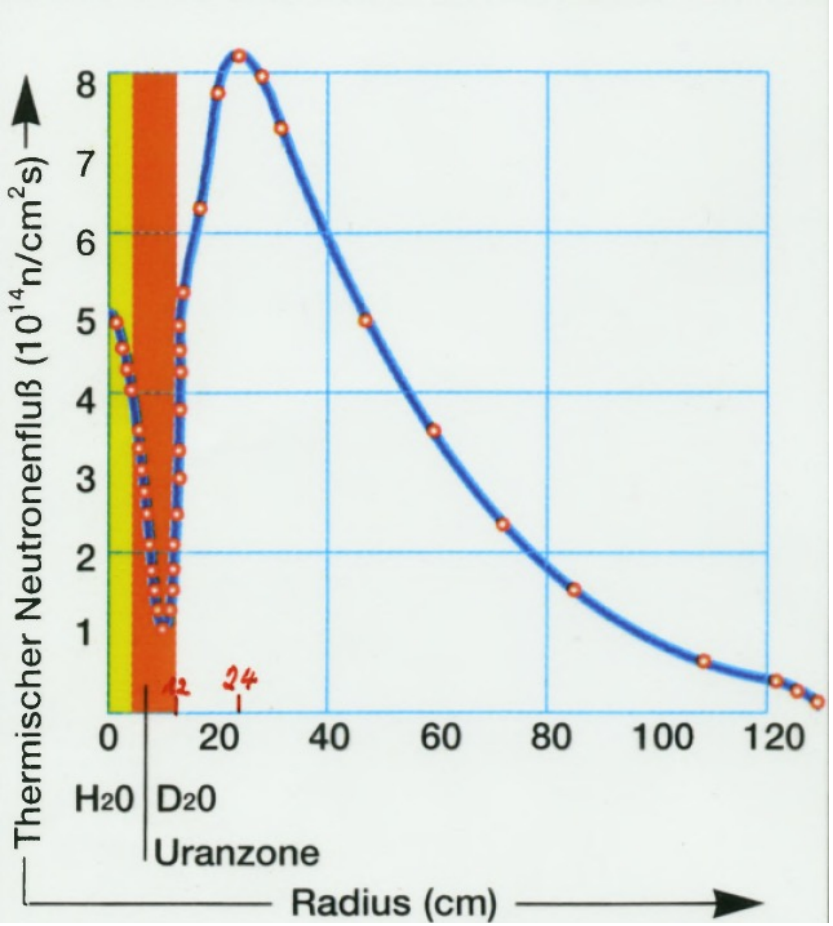
III. The Fuel Element



Thermal neutron flux over radius R in the mid-plane of the fuel element.

The flux - maximum is at R = 12 cm outside the fuel element in the moderator tank (D_2O)

The Forschungs-Neutronenquelle FRM II

III. The Fuel Element : Compact Core

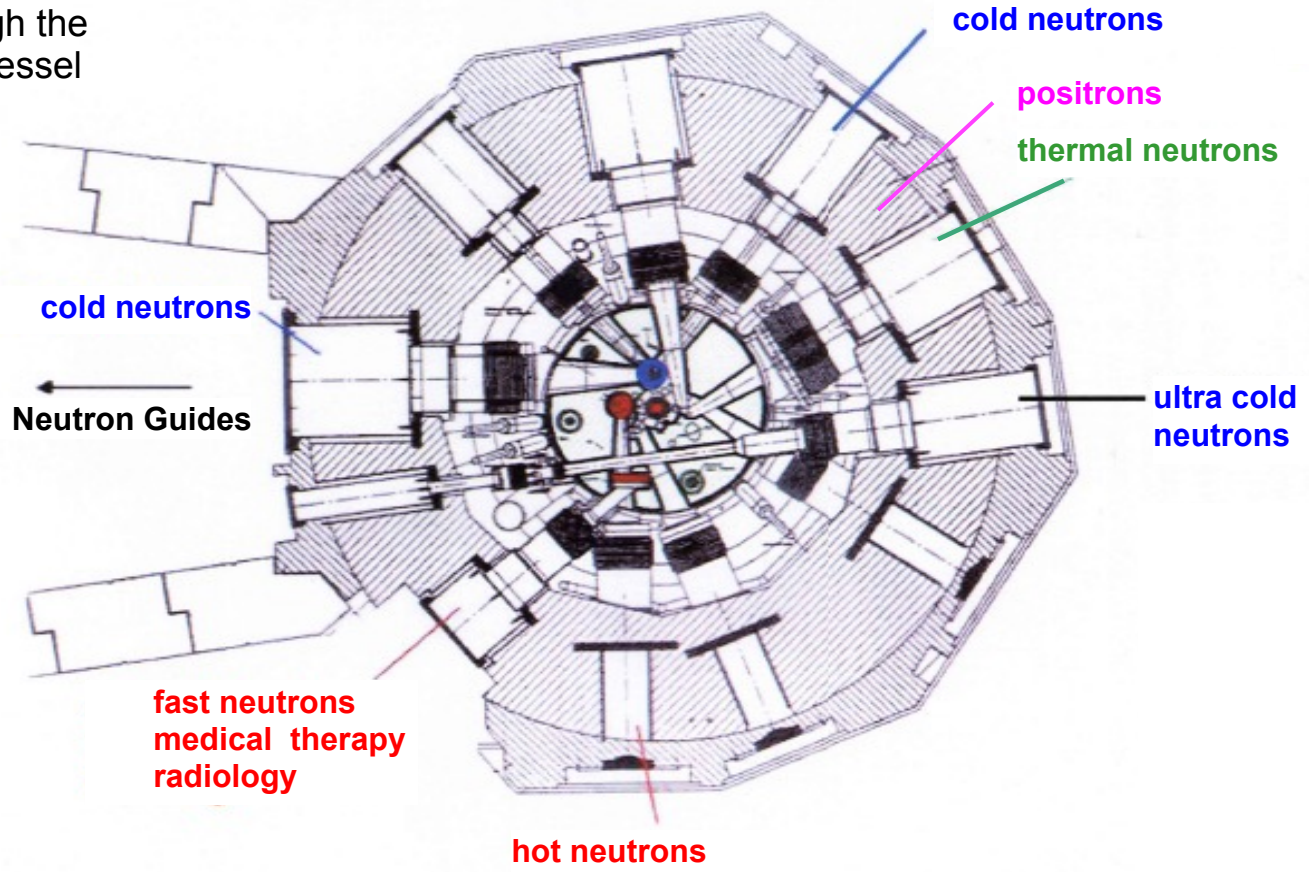
Technical Data

Radius / hight [cm]	:	24,3 / 70
Power [MW]	:	20
Cycle [d]	:	60
^{235}Uran-enrichment (nominal) [%]	:	93.0
Fuel mass ^{235}U al B0C [g]	:	7537
U-density [gU/cm³]	:	3.0 / 1.5
Max. therm. neutron flux [$cm^{-2}s^{-1}$]	:	7.8×10^{14}
Average power density [MWl^{-1}]	:	1.06
Max. power density [MWl^{-1}]	:	2.43

I. The Forschungs-Neutronenquelle FRM II

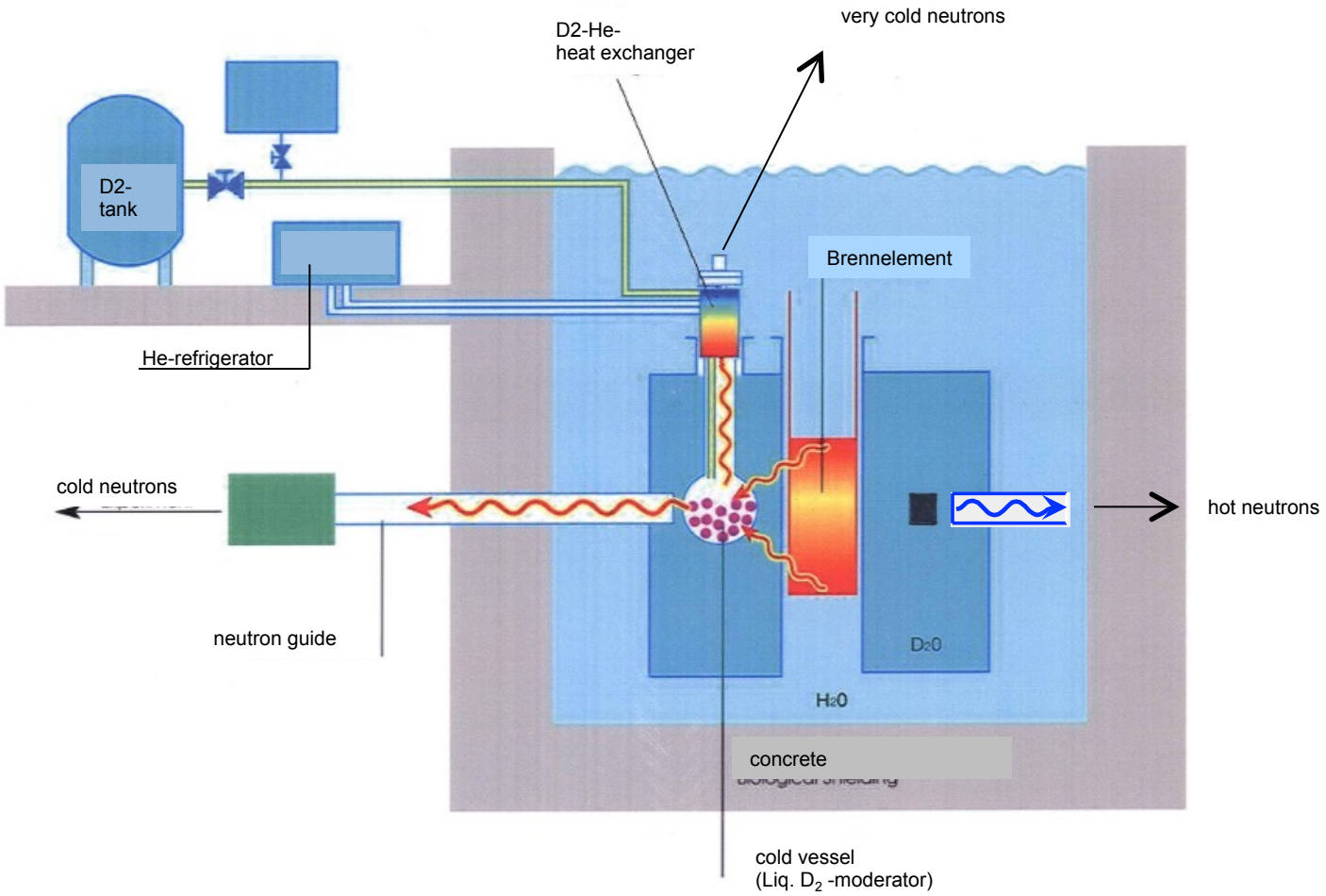
IV. Cold Source, Hot Source

Cut through the
Reactor Vessel



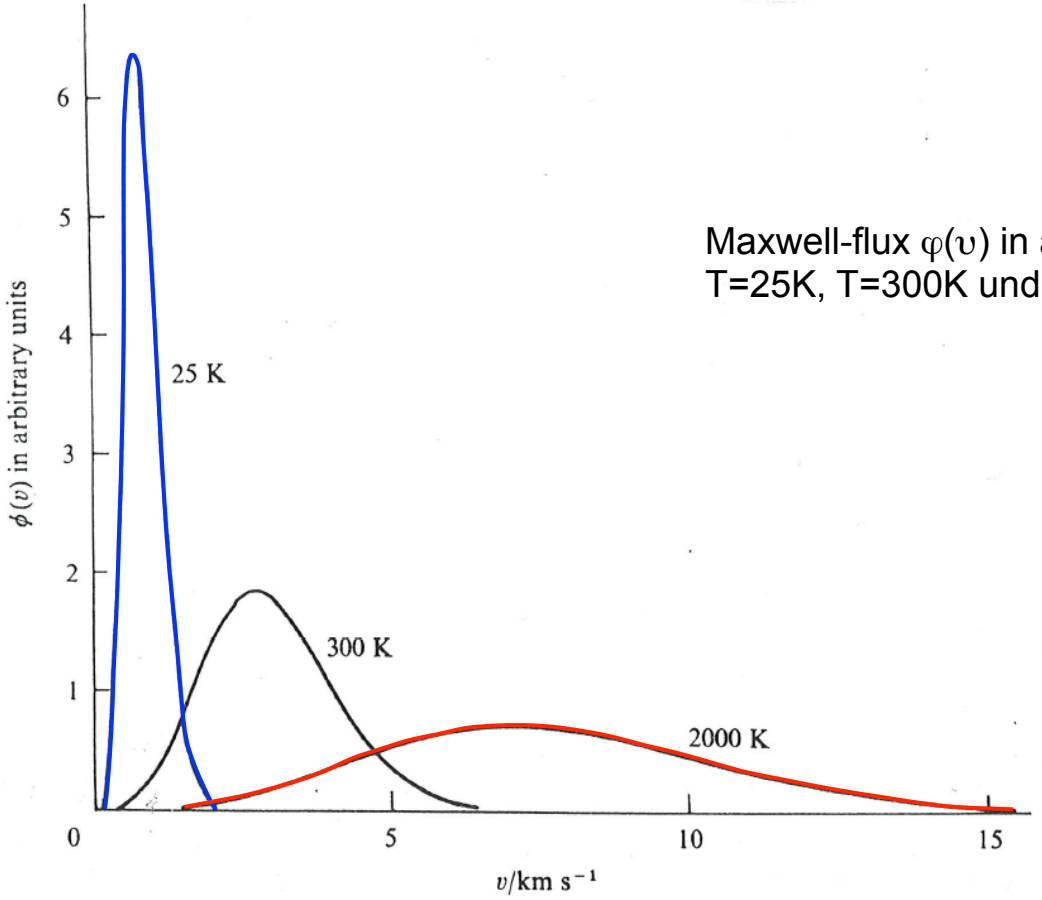
The Forschungs-Neutronenquelle FRM II

IV. Cold Source, Hot Source



The Forschungs-Neutronenquelle FRM II

IV. Cold Source, Hot Source



Maxwell-flux $\varphi(\upsilon)$ in a moderator at T=25K, T=300K und T=2000K.

The Forschungs-Neutronenquelle FRM II

V. Conclusion

- Research reactor, optimized für neutron scattering experiments, medical therapy and industrial applications
- Construction: Siemens – Framatome and TUM
- Key features of FRM II::
  - 20 MW thermal power
  - Compact Core (cylindr.), 8 kg U (93%)
    - U_3Si_2-Al – dispersion fuel
  - 60 d cycle lenght, 4 cycles per year
  - H_2O-cooling, D_2O-moderation
  - thermal neutron flux: max. 8 x 10^{14} n/cm²s (with tank-installations 6,8 x 10^{14} n/cm²s)
- First criticality: March, 2nd, 2004