Development of advanced reactor systems : the MYRRHA project

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SNETP Forum 2021

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Belgian Government decision of 7 September 2018

Decision to build MYRRHA as large new research infrastructure in Mol, Belgium

Belgium **allocates** € 558 m for 2019-2038

- € 287 m for 2019-2026: construction of MINERVA (linac 100 MeV + PTF & FTS)
- € 115 m for 2019-2026: design, R&D and licensing for Phases 2 (extended linac 600 MeV) & 3 (reactor)
- € 156 m for 2027-2038: MINERVA operations (linac 100 MeV)

Establishment of **international non-profit organisation**

MYRRHA AISBL/IVZW

Government support for establishing MYRRHA partnerships

Belgium appoints cabinet ministers to promote and negotiate international partnerships

Source: Belgian minister of Energy, Environment & Sustainable Development

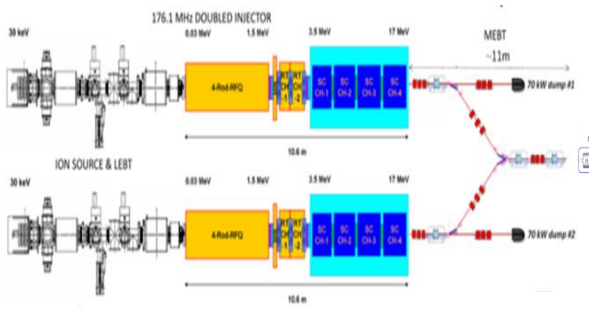
MYRRHA = Accelerator Driven System (ADS)

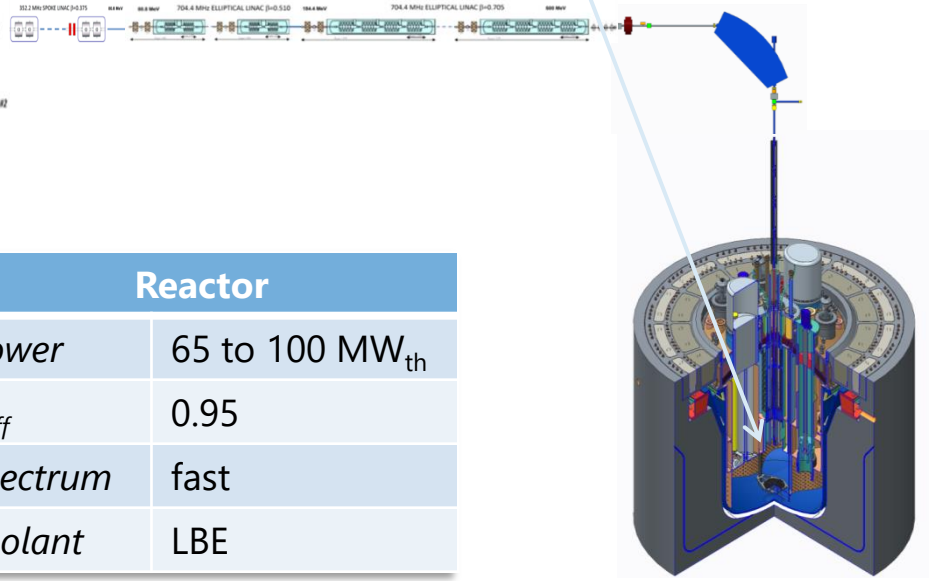
Construction of Accelerator-Driven System (ADS) consisting of

- A 600 MeV – 2,5 mA to 4,0 mA proton linear accelerator
- A spallation target/source
- A Lead-Bismuth Eutectic (LBE) cooled reactor able to operate in subcritical & critical mode

Accelerator	
particles	protons
beam energy	600 MeV
beam current	2.4 to 4 mA

Target	
main reaction	spallation
output	$2 \cdot 10^{17}$ n/s
material	LBE (coolant)

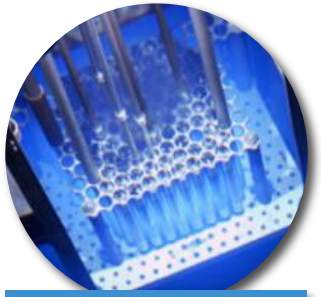




Reactor	
power	65 to 100 MW_{th}
k_{eff}	0.95
spectrum	fast
coolant	LBE

Source: SCK CEN MYRRHA Project Team

MYRRHA application portfolio



Fission GEN IV

Fusion

Multipurpose h**Y**brid **R**esearch **R**eactor for **H**igh-tech **A**pplications

Spent Nuclear Fuel

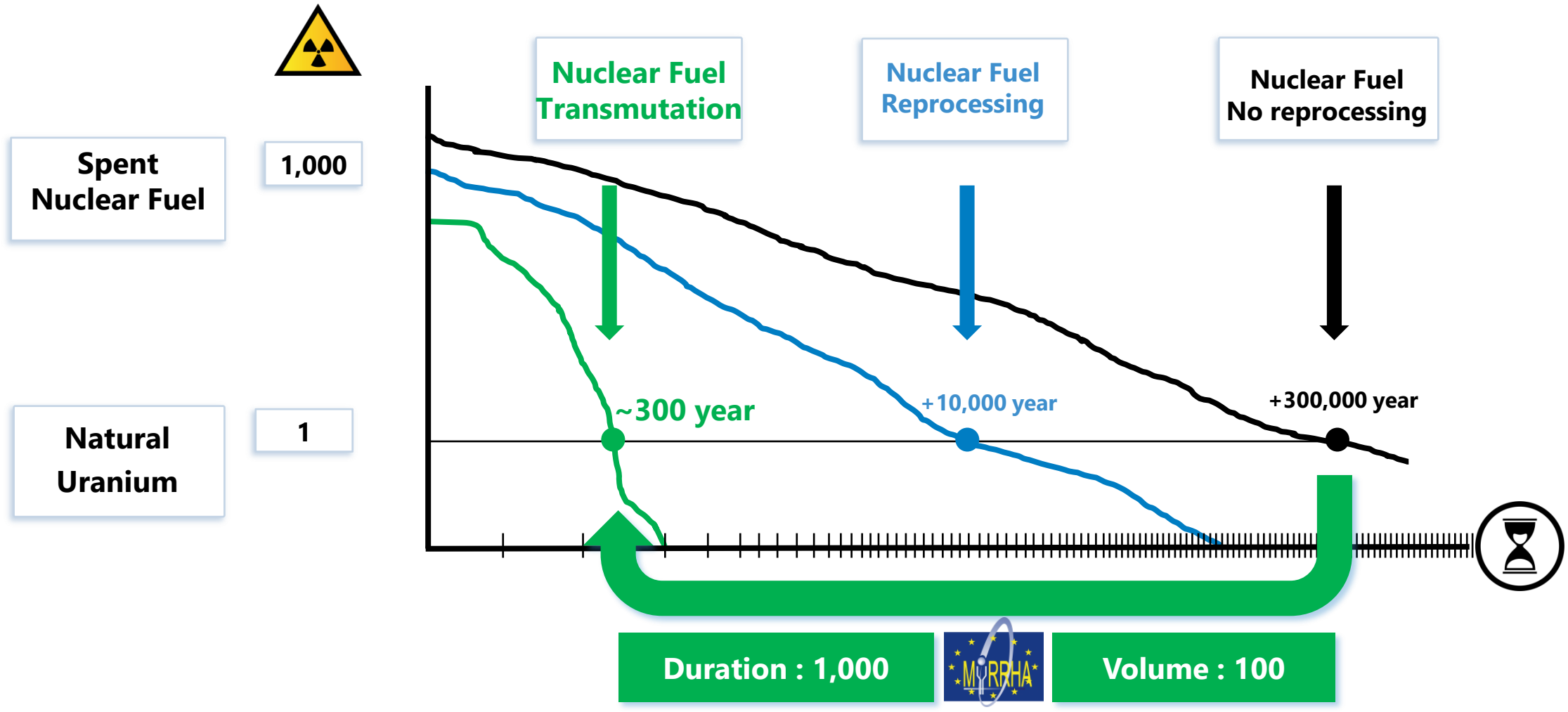
Fundamental research

Radio-isotopes

Small Modular Reactor

Source: SCK CEN MYRRHA Project Team

Transmutation: Spent Nuclear Fuel solution

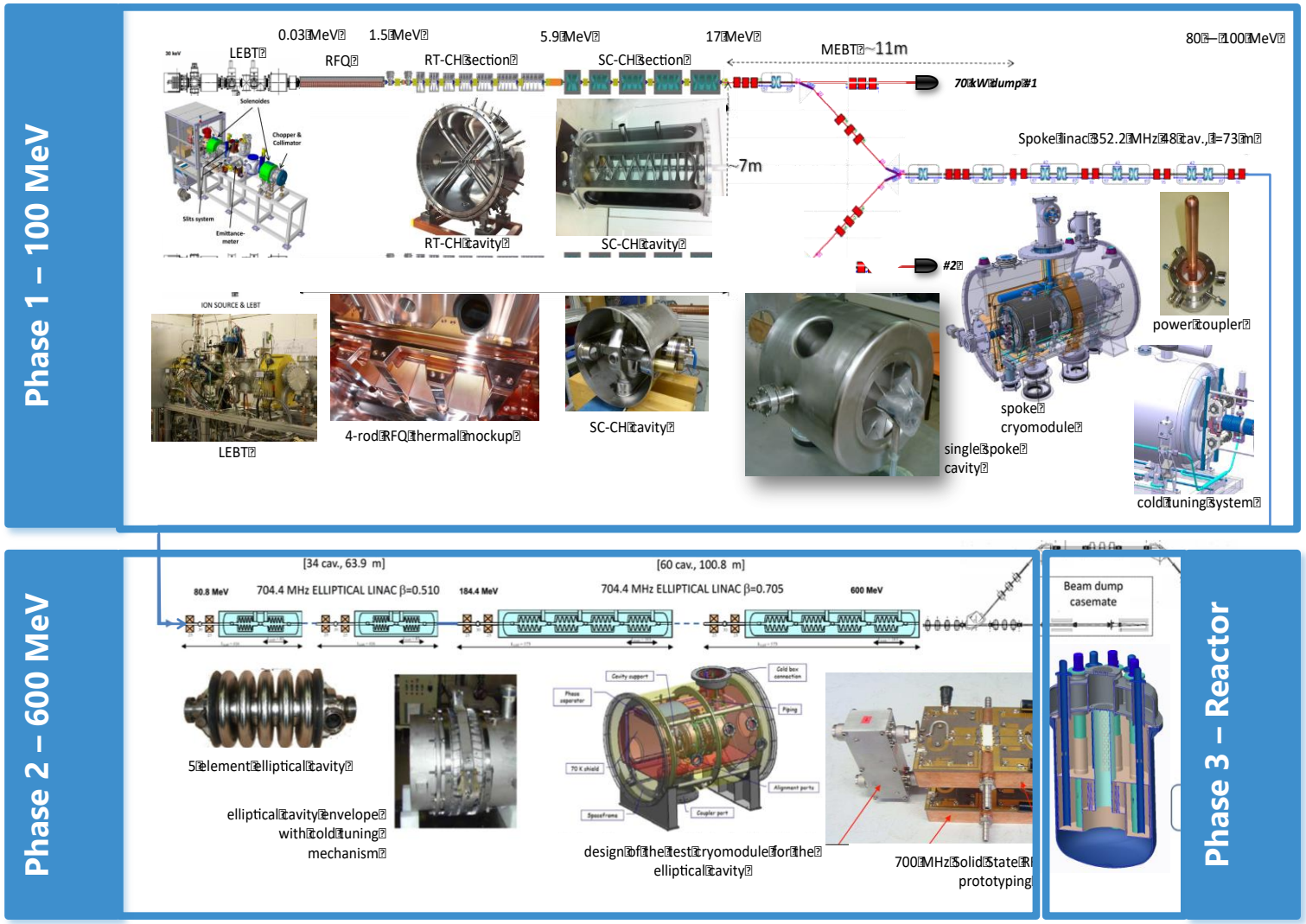


Source: European Commission Strategy Paper on Partitioning & Transmutation (2005), SCK CEN MYRRHA Project Team

MYRRHA's phased implementation strategy

Phased approach benefits:

- Reduced technical risk
- Spreading investment cost
- First R&D facility available in Mol end of 2026



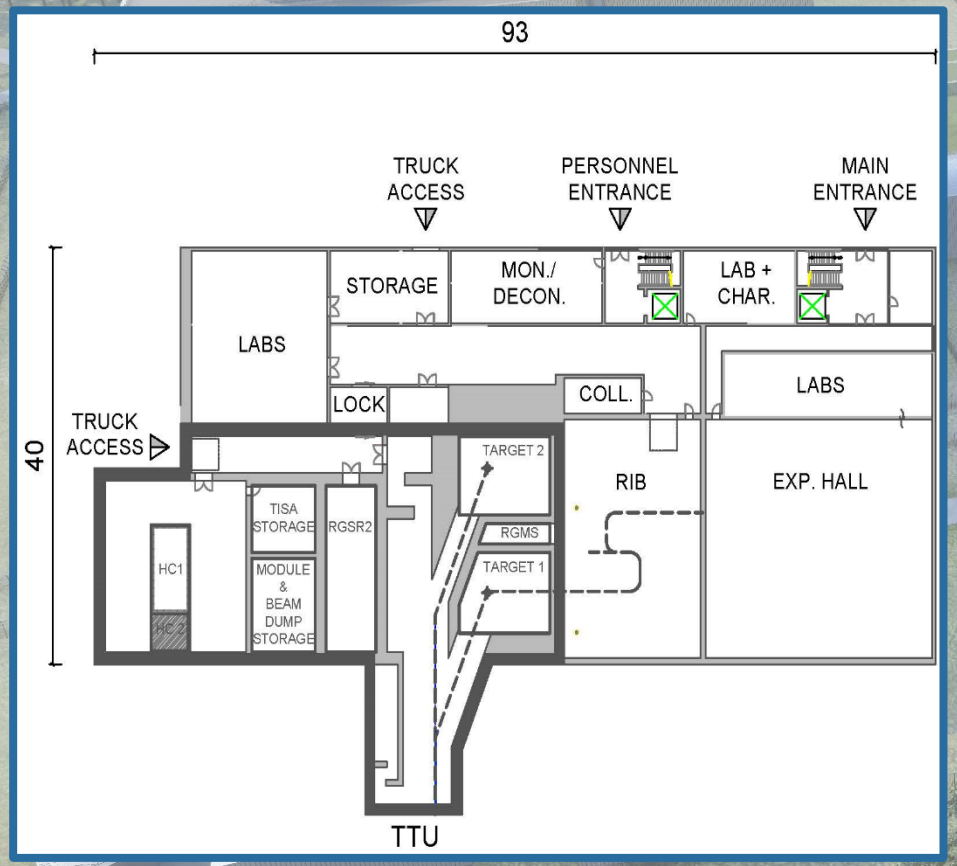
Source: SCK CEN MYRRHA Project Team

Applications	Description	MYRRHA phase 1 2026	MYRRHA phase 2 2032	MYRRHA phase 3 2036
	**Spent fuel transmutation** >> Reduce radio-toxicity: • in volume (factor 100) • in duration (factor 1,000 from 300,000 years to 300 years)	✗	✗	✓
	**Innovative radioisotopes** Produce new diagnostic and therapeutic medical isotopes for research and clinical use	✓	✓	✓
	**Fundamental research** A landmark project on the ESFRI high priority list contributing a.o. to fundamental research in nuclear physics science and nuclear medicine	✓	✓	✓
	**Fusion energy** Conducting advanced materials research, qualification and testing for fusion energy	✓	✓	✓

MYRRHA Phase 1 *(MINERVA)*: implementation in 2026

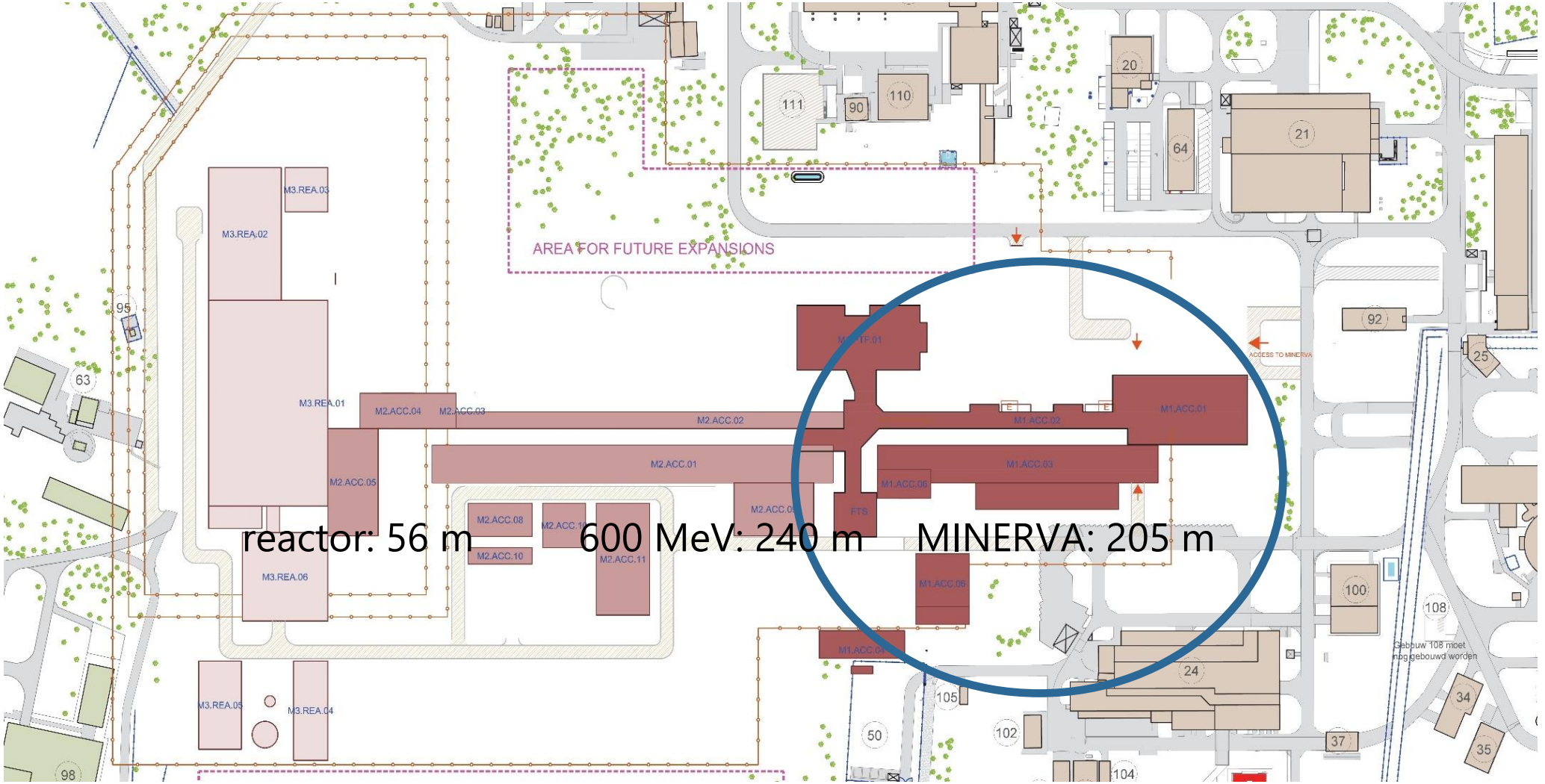
MINERVA = Linac 100 MeV + Proton Target Facility

Objectives = accelerator reliability + radioisotopes + ISOL physics + fusion material R&D



Source:

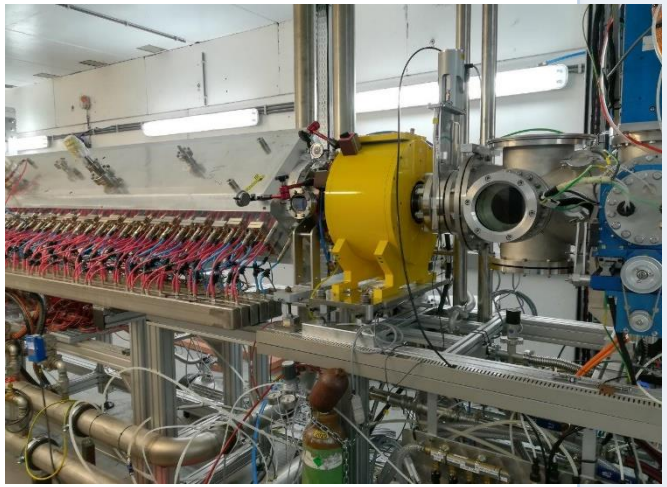
MYRRHA masterplan



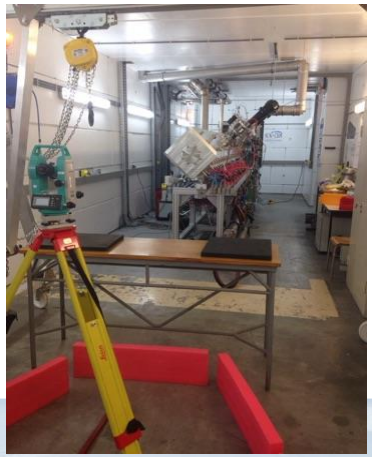
Source:

Accelerator at LLN: Injector Test Stand

- Status
  - Proton source and low-energy transfer line tested (spring 2019)
  - RFQ conditioned (summer 2019)
  - **RFQ has reached 1.5 MeV in June 2020**
  - Staged increase to 5.9 MeV until 2022

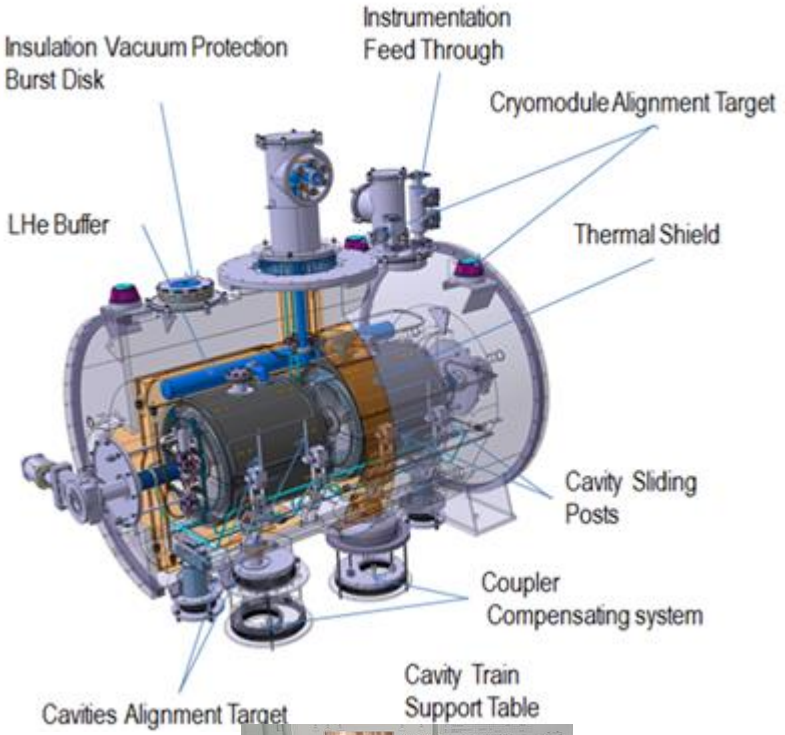


- Impacted by COVID-19 crisis
  - UCL closed for 3 months



Source:

CRYOMODULE prototype – not just a drawing, but becoming reality



MYRRHA Reactor: implementation in 2036

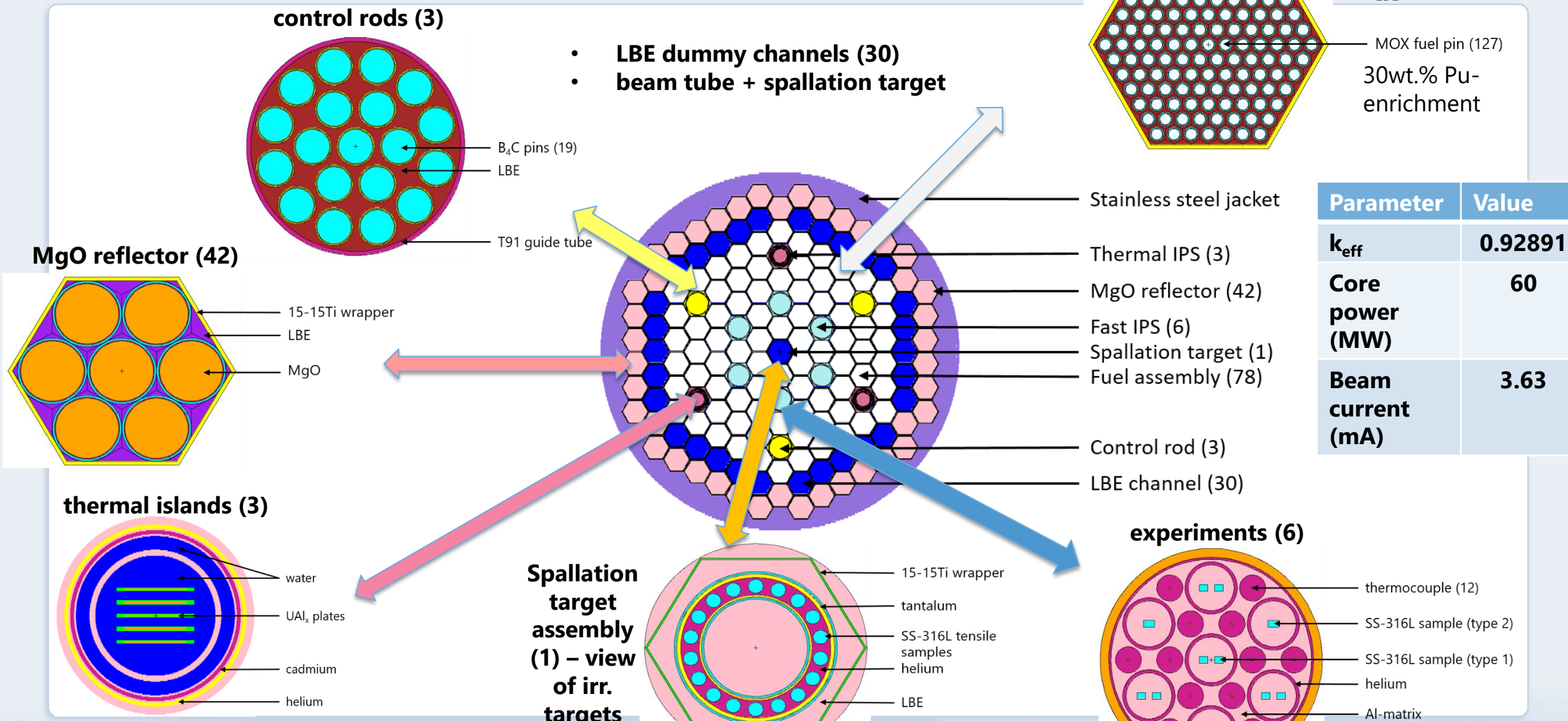
Objectives = transmutation + radioisotopes + fusion material R&D + technology platform

Source:

From design Rev. 1.6 to Rev. 1.8

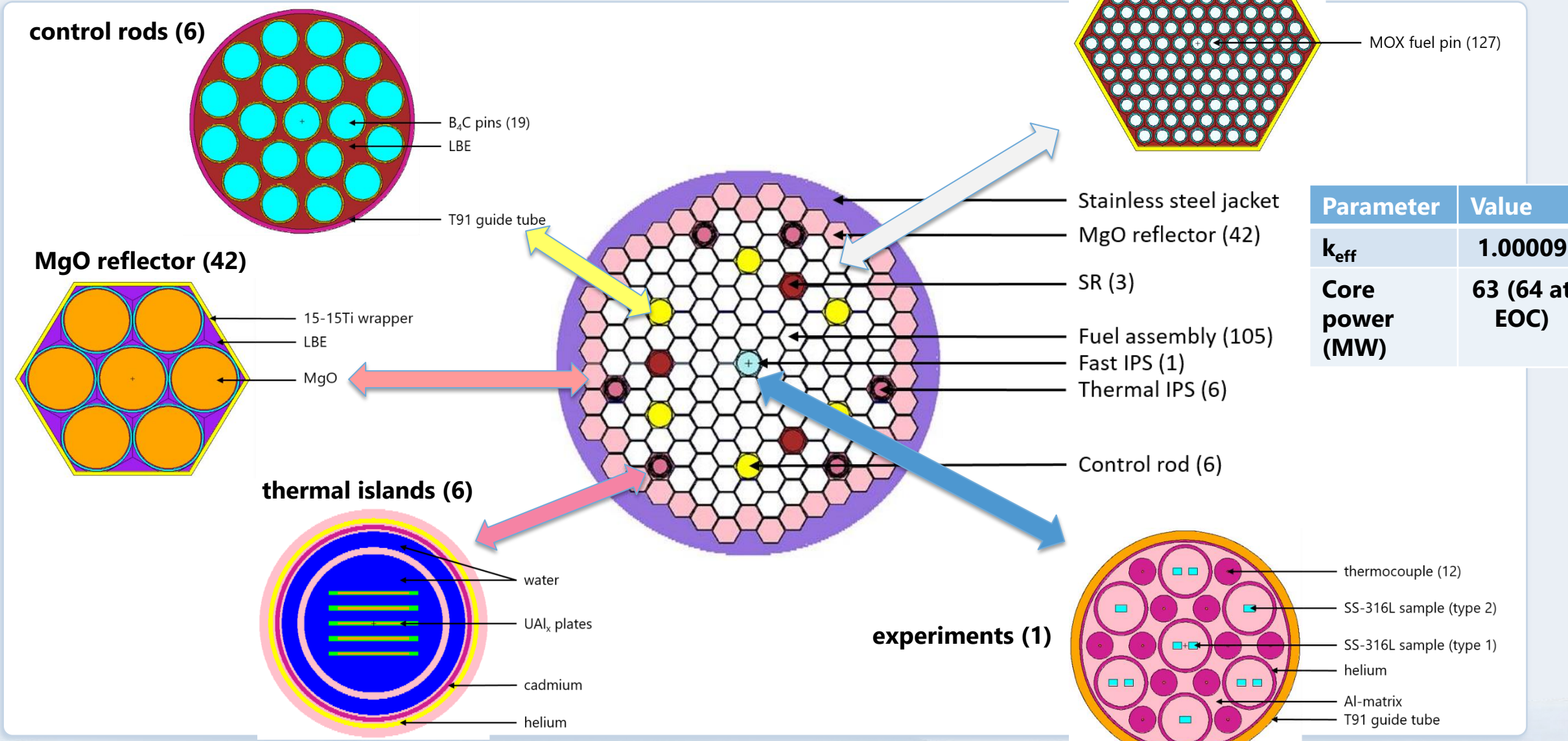
- Objective of the Revision 1.8 design :
- Address the technical issues identified in Rev. 1.6
  - Reduce the size and cost (transport limitations)
  - Po-H_20 interaction (increased Po-volatility)
  - Corrosion in LBE at high temperatures
  - Reactor cavity leak tightness and integrity
- Satisfy the application catalogue and top-level technical requirements

Subcritical (BOC) core layout



Parameter	Value
k_{eff}	0.92891
Core power (MW)	60
Beam current (mA)	3.63

Critical (BOC) core layout



Parameter	Value
k_{eff}	1.00009
Core power (MW)	63 (64 at EOC)

Rev. 1.7 in numbers

Parameter	Unit	Rev. 1.6	Rev. 1.7
Max. Core Power	MW_{th}	100	64
Design power	MW_{th}	110	70
Vessel diameter	m	10.2	8.3
Vessel height	m	15.9	11.9
Total reactor height	m	20.2	16.3
Longest component length (Pump)	m		14
LBE inventory	m^3	725	525[1]
Total mass	ton	10000	6682[2]

- [1] 2000 ton reduction in LBE coolant equates to 30 million EURO less investment cost for the LBE coolant compared to Rev. 1.6
- [2] 1300 ton reduction in steel mass

MYRRHA contributes to EU strategic objectives

ESFRI
European Strategic Forum for Research Infrastructure

Knowledge Economy

MYRRHA

Energy Independence

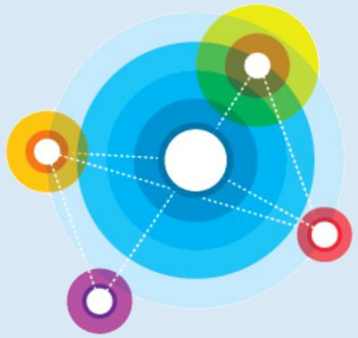
SET Plan
European Strategic Energy Technologies Plan

EIB InnovFin	MYRRHA selected by **European Investment Bank (EIB)** as potential project for EIB financing **procedure underway**
Juncker Plan	MYRRHA is on **European Fund for Strategic Investments** (**EFSI** - **"Juncker Plan"**) candidate project list for financing

Source: European Strategy Forum on Research Infrastructures (ESFRI), European Strategic Energy Plan (SET), EIB InnovFi
SCK CEN MYRRHA Project Team

MYRRHA contributes to Belgian strategic objectives

Knowledge Economy



(Visie-Vision 2030)

Nationaal Pact voor Strategische Investeringen

Pacte National pour les Investissements Stratégiques

Energy Independence

(2021-2030)

Geïntegreerd Nationaal Energie- en Klimaatplan

Plan National intégré Energie Climat

International R&D network - 1

Universities

Research

Source: SCK CEN MYRRHA Project Team
** Acquired by Veolia*

International R&D network - 2

Private Sector

Authorities

Source: SCK CEN MYRRHA Project Team
** Acquired by Veolia*

- Link to the MYRRHA 3D movie
- https://youtu.be/FSon1FQBxJo

SCK CEN
Belgian Nuclear Research Centre

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Fondation d'Utilité Publique
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