

Realization of a new research facility in Belgium for nuclear innovation addressing societal challenges

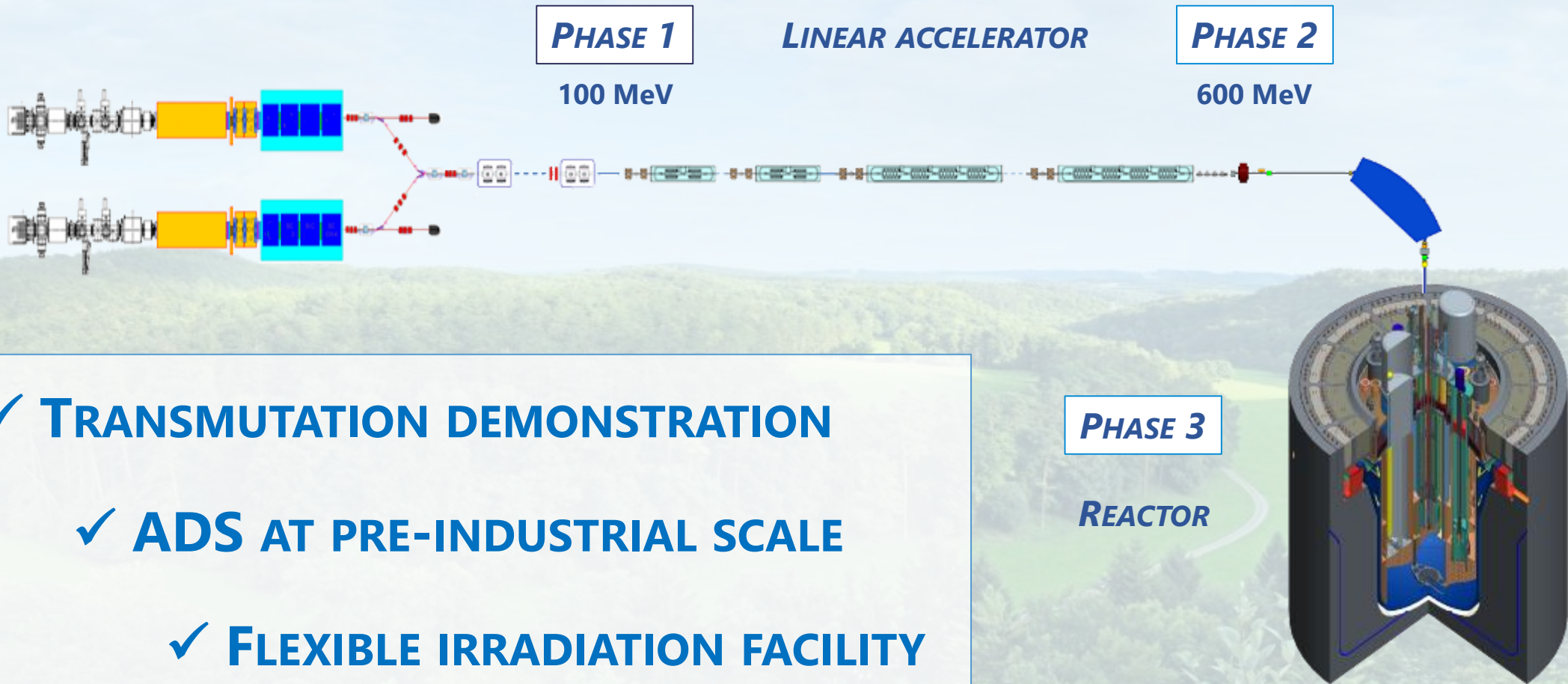
A new milestone reached, creation of :
MYRRHA AISBL/IVZW

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Celebrating 20 years of n_TOF
22 November 2021 - Geneva, Switzerland

MYRRHA: ACCELERATOR DRIVEN SYSTEM



- ✓ **TRANSMUTATION DEMONSTRATION**
- ✓ **ADS AT PRE-INDUSTRIAL SCALE**
- ✓ **FLEXIBLE IRRADIATION FACILITY**

MYRRHA's Application Portfolio



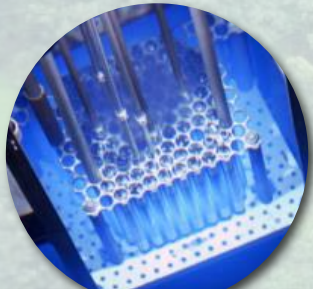
Radio-isotopes



SNF*/ Waste



Fusion



**Mat. & Fuel
GEN IV**

**Multipurpose
hYbrid
Research
Reactor for
High-tech
Applications**



**Fundamental
research**

*SNF = Spent Nuclear Fuel

European Strategy for P&T (2005)



EU P&T Strategy 2005: “The **implementation of P&T** of a large part of the high-level nuclear wastes **in Europe needs the demonstration of its feasibility at an “engineering” level**. The respective **R&D activities could be arranged in four “building blocks”**”:

| P&T building blocks | Description | Name & Location |
|---------------------|---|----------------------|
| 1 Partitioning | ▪ Demonstrate capability to process a sizable amount of spent fuel from commercial Light Water Reactors to separate plutonium, uranium and minor actinides | ▪ Atalante (FR) |
| 2 Fuel production | ▪ Demonstrate the capability to fabricate at a semi-industrial level the dedicated fuel needed to load in a dedicated transmuter | ▪ JRC-ITU (EU) |
| 3 Transmutation | ▪ Design and construct one or more dedicated transmuters | ▪ MYRRHA (BE) |
| 4 Fuel unloading | ▪ Specific installation to process fuel unloaded from transmuter ▪ Not necessarily the same as type to process original spent fuel unloaded from commercial power plants | |

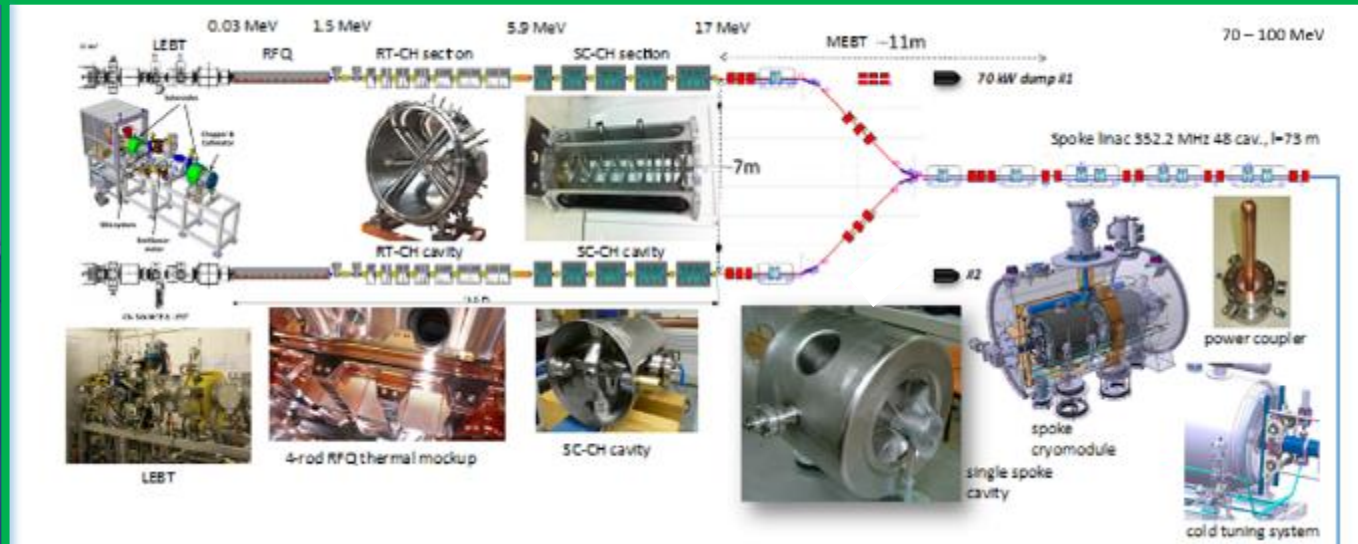
The European Commission contributes to the 4 building blocks and fosters the national programmes towards this strategy for **demonstration at engineering level**.

MYRRHA'S PHASED IMPLEMENTATION STRATEGY

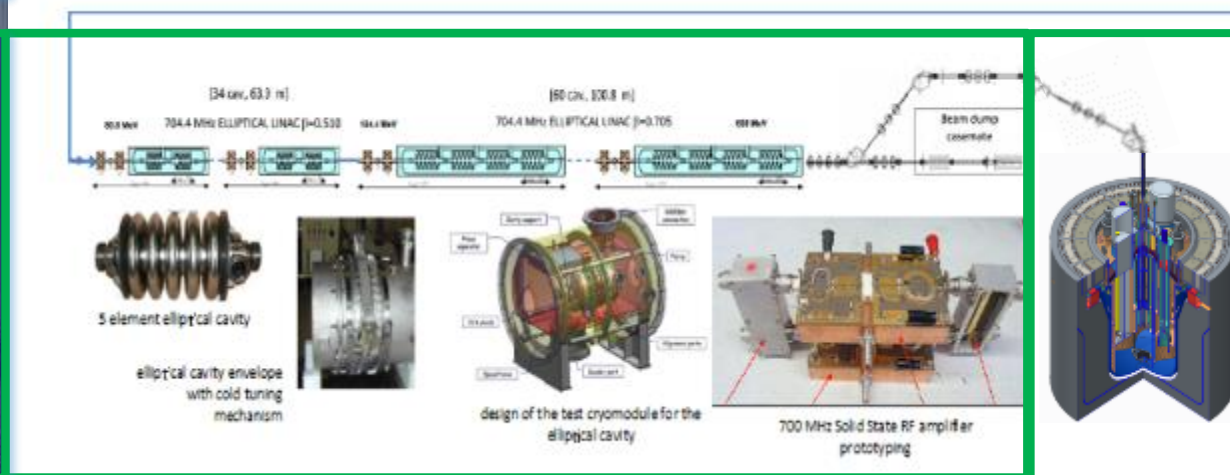
Benefits of the phased approach:

- already a first operational facility available in Mol at **end of 2026**
- spreading the investment costs
- successful milestone then next step >> reducing technical & financial risks

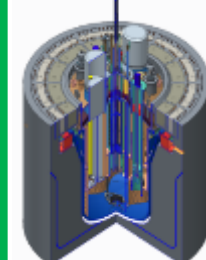
Phase 1 – 100 MeV + Proton Target Facility



Phase 2 – 600 MeV



Phase 3 – Reactor



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

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

Establishment of **international non-profit organisation**

**MYRRHA
AISBL/IVZW**

Government support for establishing MYRRHA partnerships

Belgium appoints tutorship ministers to promote and negotiate international partnerships

Belgian Government decision of 7 September 2018

Confirmed on 23 July 2021 (+ creation of MYRRHA NPO)



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

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Establishment of **international non-profit organisation**

MYRRHA AISBL/IVZW

Decided 23.07.2021

Created 17.09.2021

Government support for establishing MYRRHA partnerships

Belgium appoints tutorship ministers to promote and negotiate international partnerships



MYRRHA

International nonprofit organisation

MYRRHA AISBL: separate legal entity needed to find external partners/investors

Responsability:

- SCK CEN
 - Design & build MINERVA
 - Conduct R&D for phases 2 ACC-600 & 3 MYRRHA Reactor
 - Obtain licenses for Phase 1 and later on for Phases 2 & 3
 - Being the nuclear operator of MYRRHA/MINERVA
- MYRRHA AISBL
 - Establish the MYRRHA International Consortium
 - Guarding the overall scope of MYRRHA programme

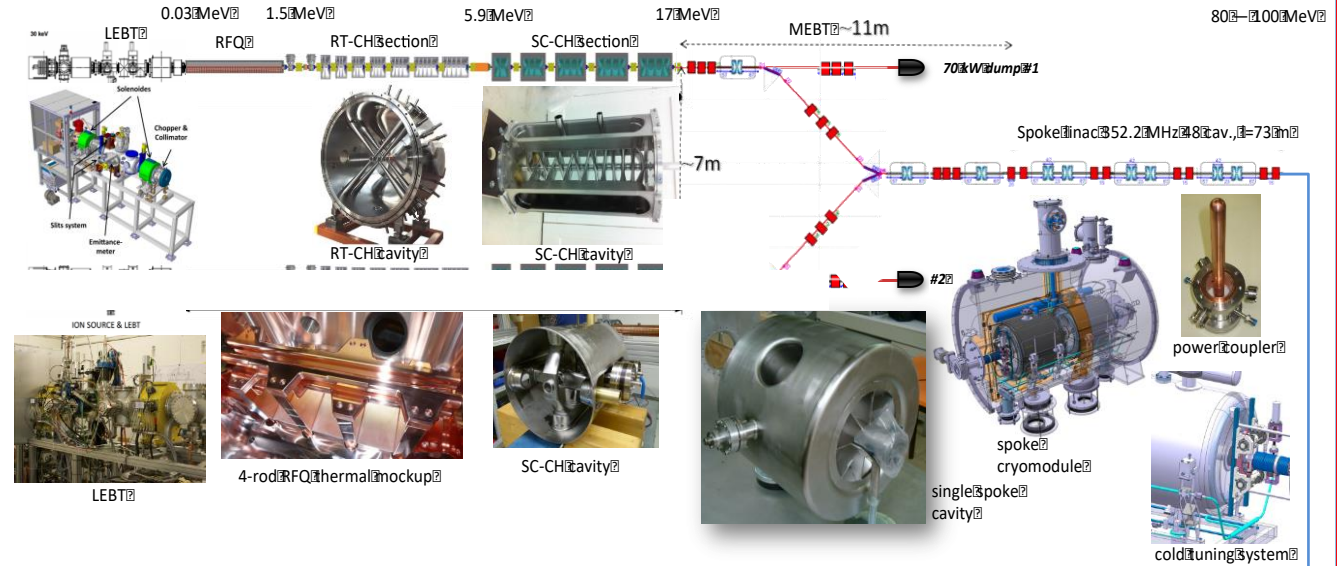
MYRRHA's phased implementation strategy

UNDER CONSTRUCTION

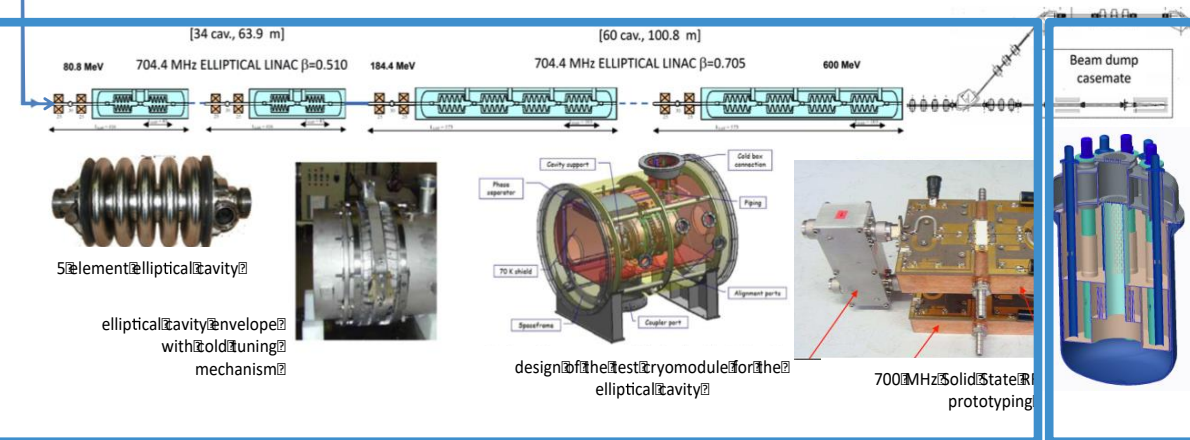
Phased approach benefits:

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

Phase 1 – 100 MeV



Phase 2 – 600 MeV

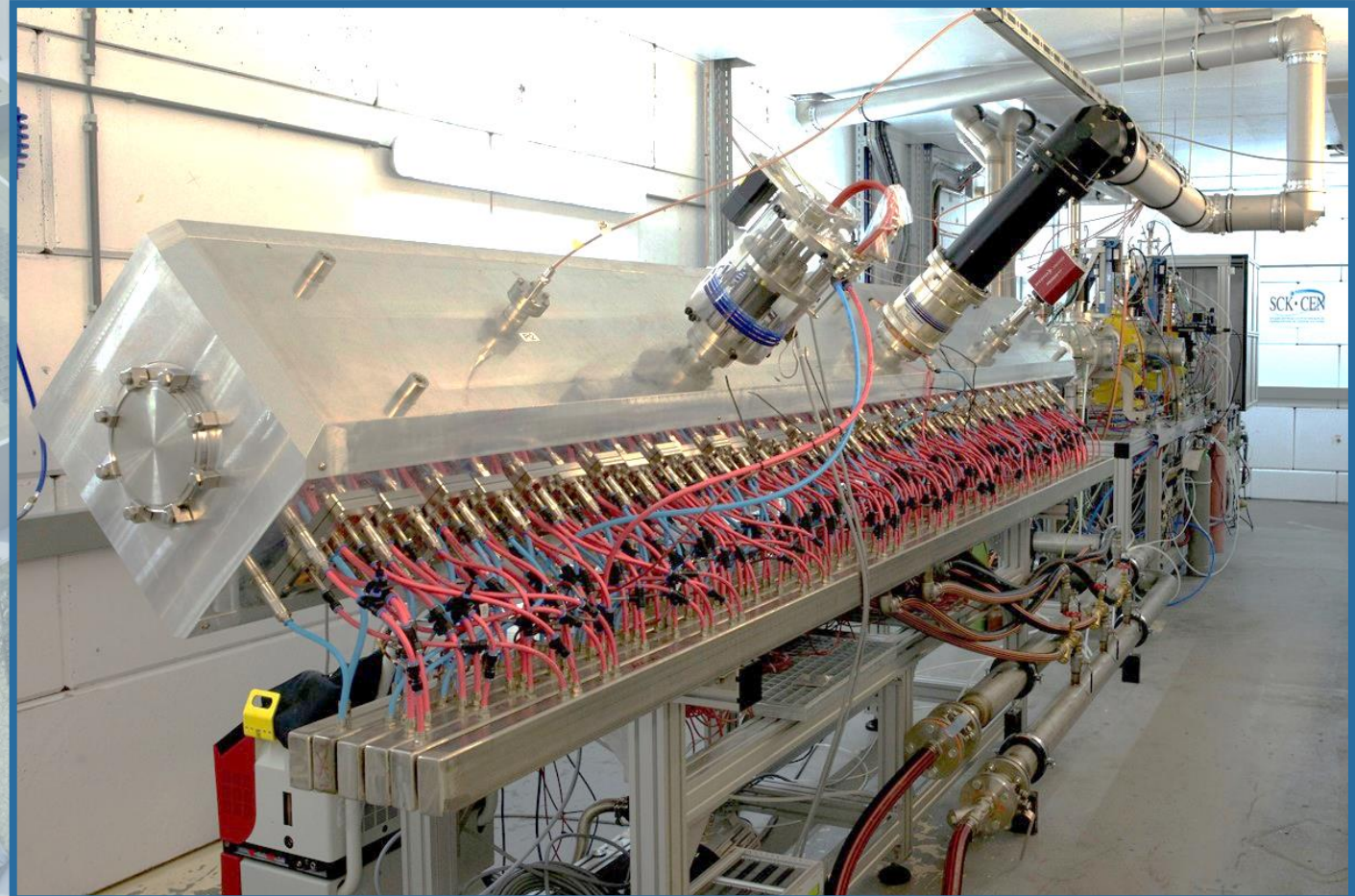


Phase 3 – Reactor

The MYRRHA accelerator takes shape in LLN

MYRRHA protons accelerated successfully

★ 30 June 2020



The cryomodule prototype of MYRRHA ready for testing

Superconductivity and French prototype: a crucial milestone coming up for MYRRHA

★ *27 November 2020*

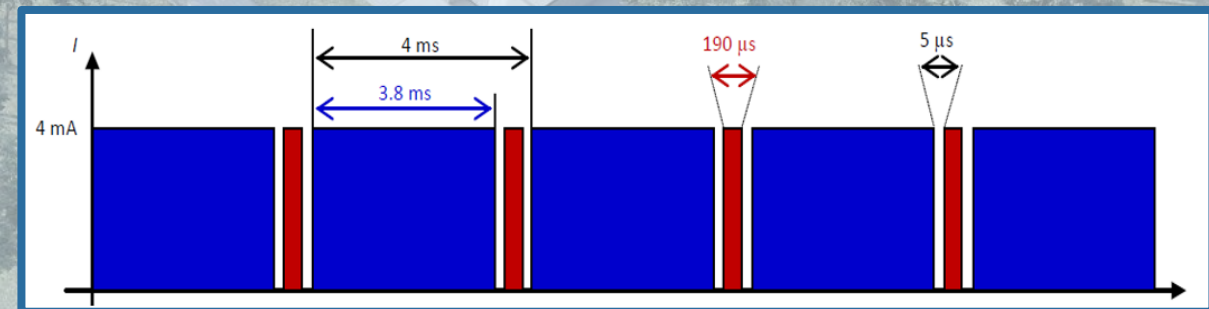
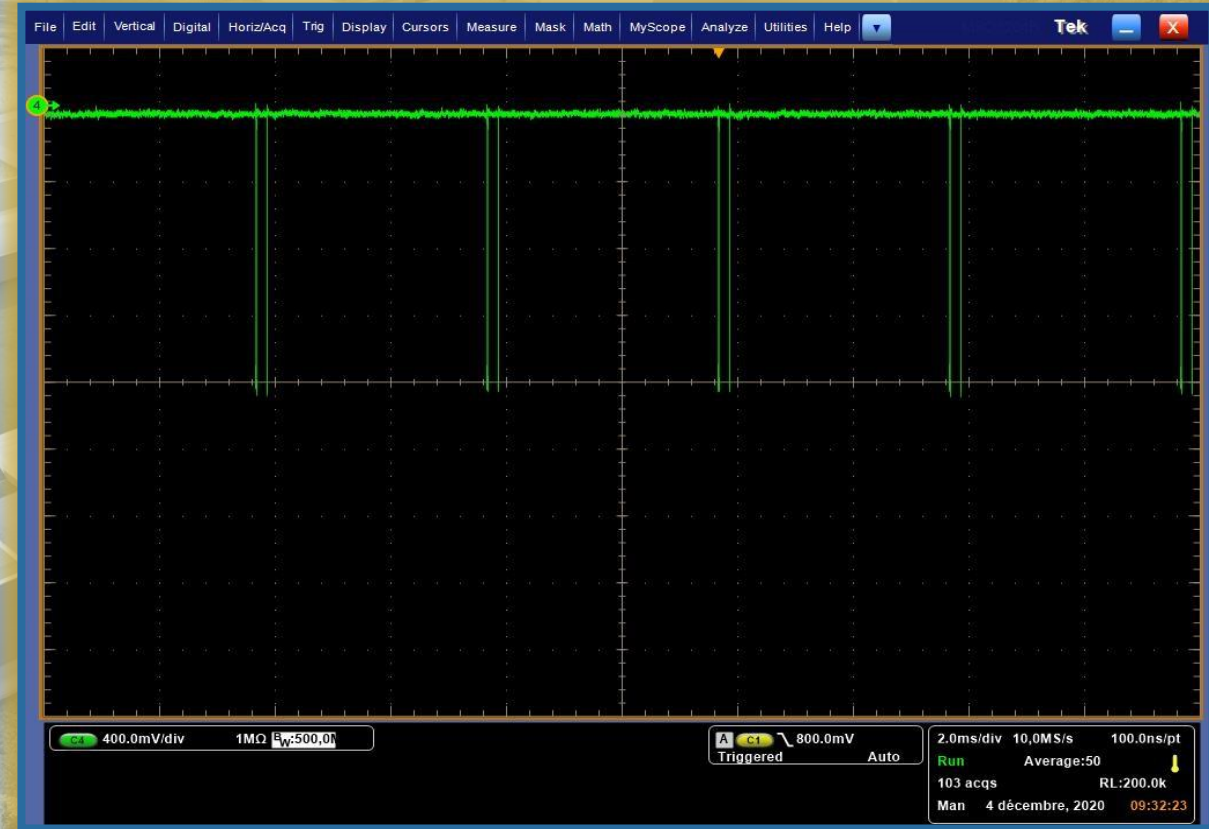


The 4-rod RFQ shines in LLN

The MYRRHA 4-rod RFQ reach its first success:
nominal proton beam delivered intensity of 4
mA and energy of 1,5 MeV

- Transmission through RFQ 98%
- Beam holes ✓, Duty cycle (99,75%: 95%
MYRRHA Reactor + 4,75% PTF

★ 4 December 2020



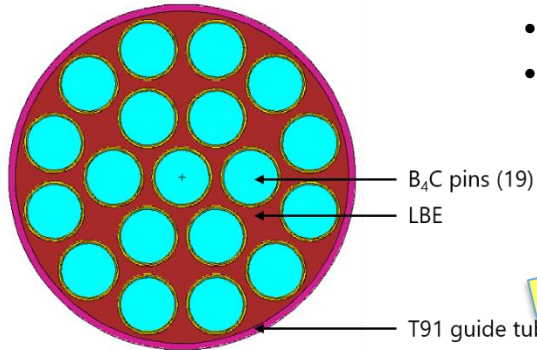
MYRRHA REACTOR: IMPLEMENTATION IN 2036

OBJECTIVES = TRANSMUTATION + RADIOISOTOPES + FUSION MATERIAL R&D + FISSION TECHNOLOGY PLATFORM



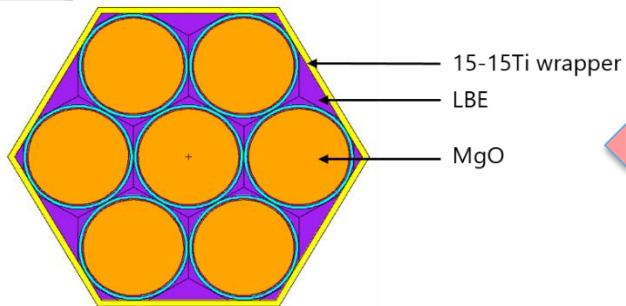
Subcritical (BOC) core layout

control rods (3)

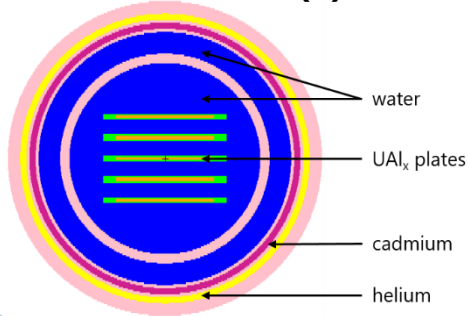


- **LBE dummy channels (30)**
- **beam tube + spallation target**

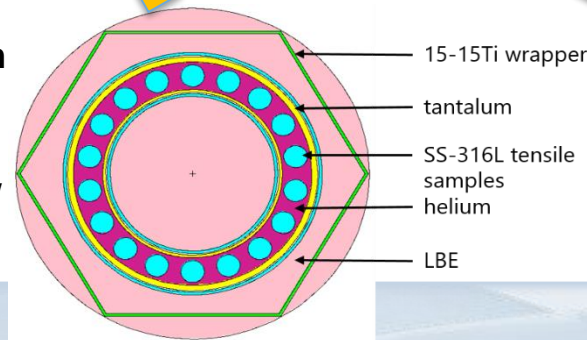
MgO reflector (42)



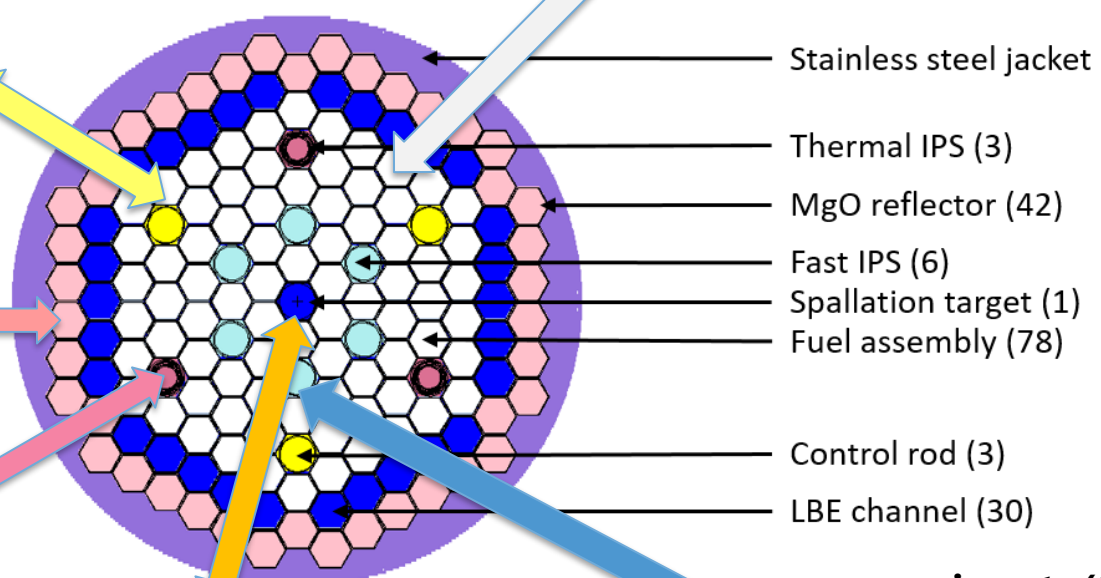
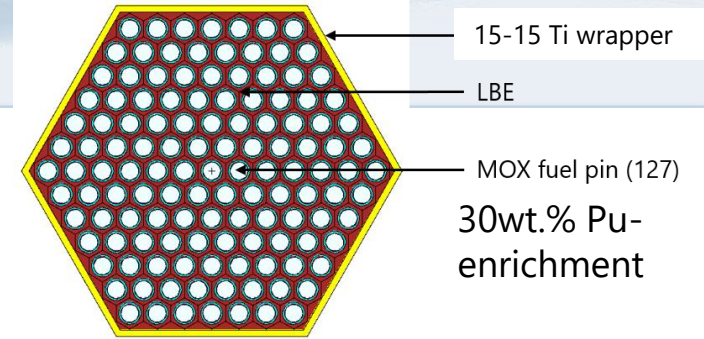
thermal islands (3)



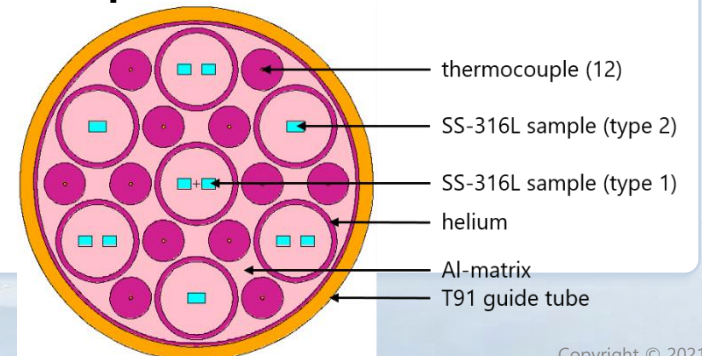
Spallation target assembly (1) – view of irr. targets



fuel assembly (78)



experiments (6)



| Parameter | Value |
|--------------------------|----------------|
| k_{eff} | 0.92891 |
| Core power (MW) | 70 |
| Beam current (mA) | 3.6 |

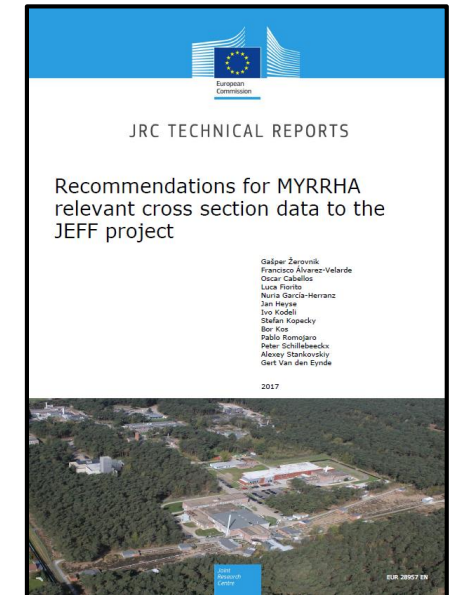
Core calculations need good nuclear data

- FP7 CHANDA project



- Identification of key nuclides and reactions using sensitivity studies

| Nuclide | Quantity/Reaction | Nuclide | Quantity/Reaction |
|-------------------|--------------------|-------------------|--------------------|
| ^{16}O | $\sigma(n,n)$ | ^{235}U | $\bar{\nu}$ |
| ^{56}Fe | $\sigma(n,n)$ | | $\sigma(n,f)$ |
| | $\sigma(n,n')$ | | $\sigma(n,\gamma)$ |
| ^{208}Pb | $\sigma(n,\gamma)$ | ^{238}U | $\sigma(n,n)$ |
| | $\sigma(n,n')$ | | $\sigma(n,n')$ |
| ^{209}Bi | $\sigma(n,n')$ | ^{238}Pu | $\sigma(n,\gamma)$ |
| | $\sigma(n,\gamma)$ | ^{239}Pu | $\sigma(n,f)$ |
| | | ^{239}Pu | $\bar{\nu}$ |
| | | | χ |
| | | | $\sigma(n,f)$ |
| | | ^{240}Pu | $\sigma(n,\gamma)$ |
| | | ^{241}Pu | $\bar{\nu}$ |
| | | ^{242}Pu | $\sigma(n,f)$ |
| | | ^{242}Pu | $\sigma(n,f)$ |

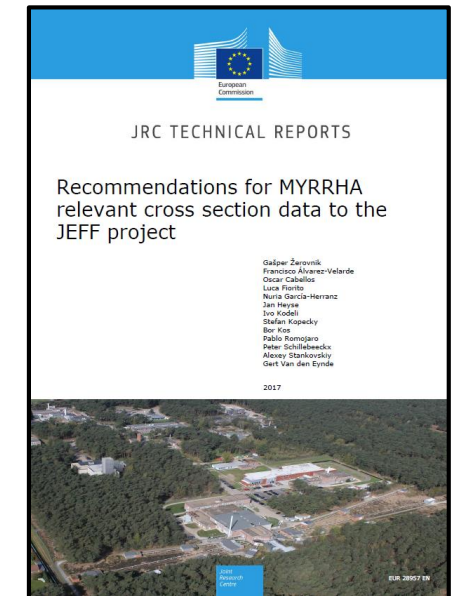


Core calculations need good nuclear data

- FP7 CHANDA project



- Identification of key nuclides and reactions using sensitivity studies
- Improve evaluated data
 - Improved experimental data
 - n_TOF: (n,f) and (n, γ) (see presentations D. Cano Ott)
 - Actinides: capture on fissile nuclides:
 - $^{233, 235}\text{U}(n, \gamma)$
 - ^{239}Pu , planned
 - Lead, Bismuth
 - Recommendations to the JEFF project
- Continuation in SANDA



Example: ^{209}Bi

- Budapest Neutron Centre (Research Reactor)

- $\sigma_{g+m}(n,\gamma)$, $\sigma_g(n,\gamma)$, $\sigma_m(n,\gamma)$ at 0.025 eV

- n_TOF

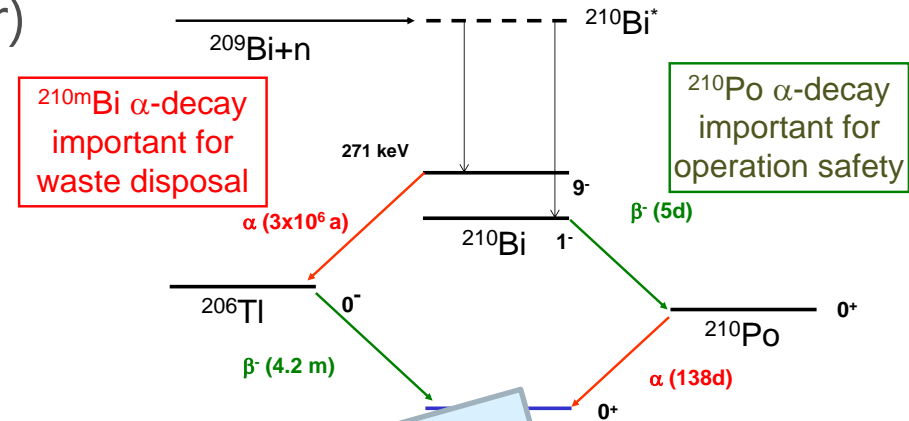
- $\sigma_{g+m}(n,\gamma)(E_n)$

- GELINA

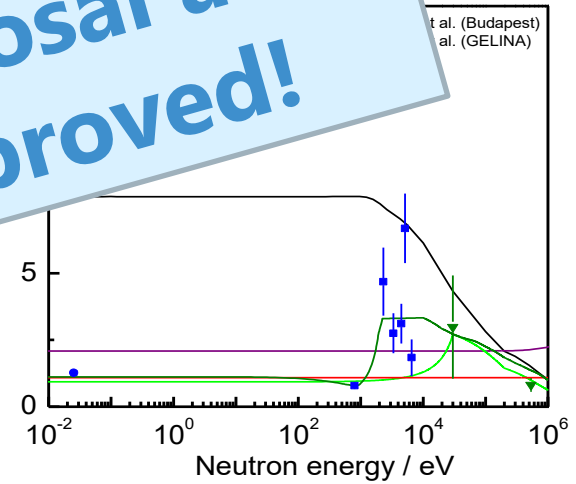
- $\sigma(n,\text{tot})(E_n)$
 - $\sigma_{g+m}(n,\gamma)$, $\sigma_g(n,\gamma)$, $\sigma_m(n,\gamma)(E_n)$

- JPARC (SCK)

- $\sigma_{g+m}(n,\gamma)$, σ_g



New EUFRAT proposal at GELINA for Pb approved!



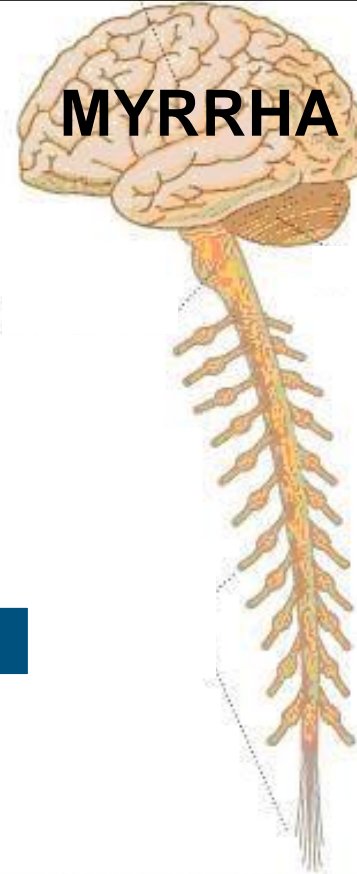
MYRRHA REACTOR HIGHLIGHTS



“Mystery creates wonder, and wonder is the basis of man’s desire to understand” said Neil Armstrong

MYRRHA is a wonderful project full of mysteries

MYRRHA: a backbone of innovation inspired by Belgium



1

Radio-chemistry

- Separation for Partitioning of HLW¹
- Alpha – therapy radio-isotopes
- Separation of radio-isotopes for Space Power

2

Material development

- New fission reactors
- Fusion materials
- But can serve beyond Nuc.En (JPNM)

3

Fundamental Physics

- RIB² physics
- Rare decays
- Extreme precisions experiments

Accelerator technology (reliability ADS)

4

- Improve availability of accelerator facilities
- Brilliance
- Performance
- Economy

HLM³ technology

5

- Fusion technology
- New reactor technology (LFR/SMR)
- Heat storage for solar power

Beyond U fuel cycle & Electricity

6

- Thorium => ADTR⁴, Molten Salt ADS/Reac.
- Cogen : Elec+Heat, Elec+H₂

¹ HLW = High-Level Radio-active Waste

² RIB = Radio-active Ion Beam facility

³ HLM = Heavy Liquid Metal technology (as coolant for reactors)

⁴ ADTR = Accelerator Driven Thorium Reactor

As Newton said

"If I have seen further it is by standing on the shoulders of giants."

- Science can only progress in a cooperative
- Each small or big endeavor builds on what has been done in the past

- This project would not have been active without your near data measurements ...

- ... without you we would not



Thank you and happy birthday!

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Belgian Nuclear Research Centre

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Foundation of Public Utility

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