

Realization of a new Research Infrastructure : MYRRHA

at SCK CEN in Belgium for nuclear innovation for Europe

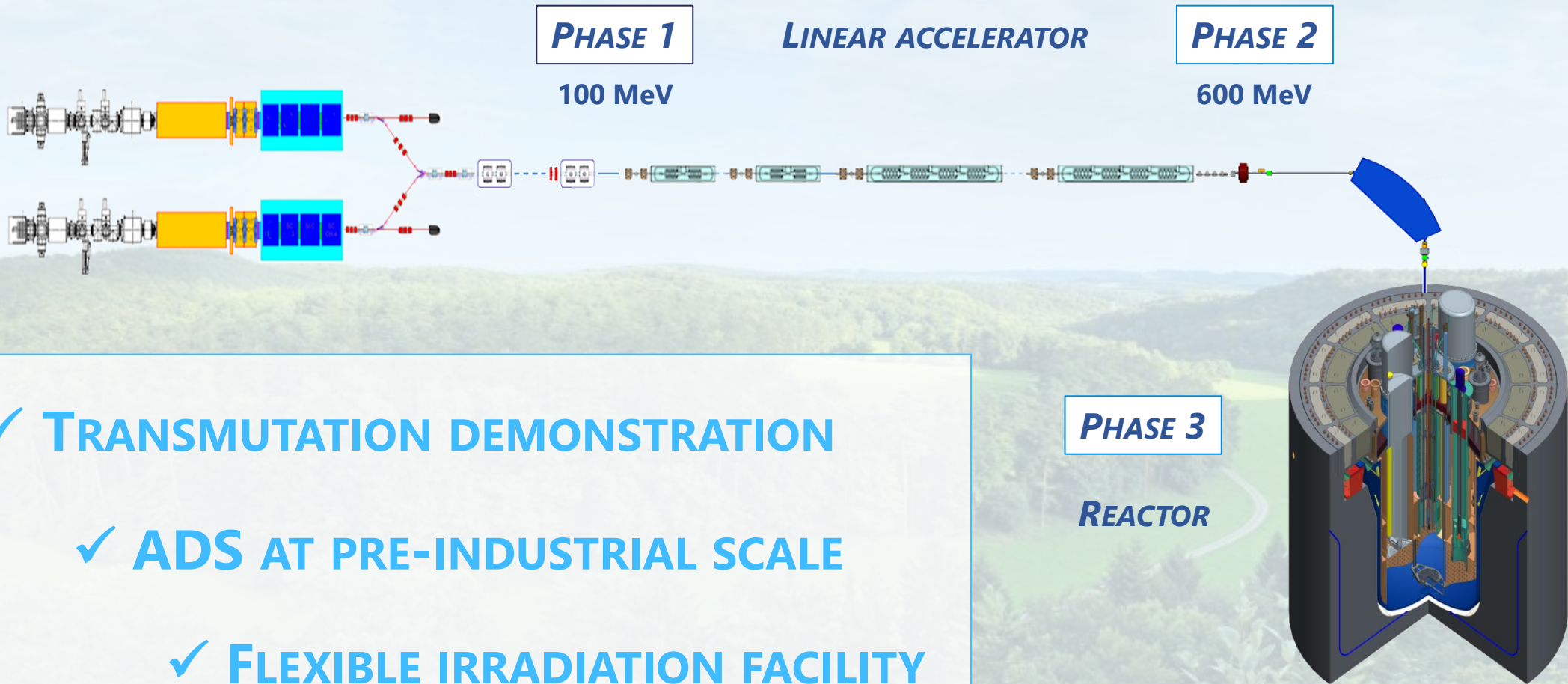
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BSBF'2022

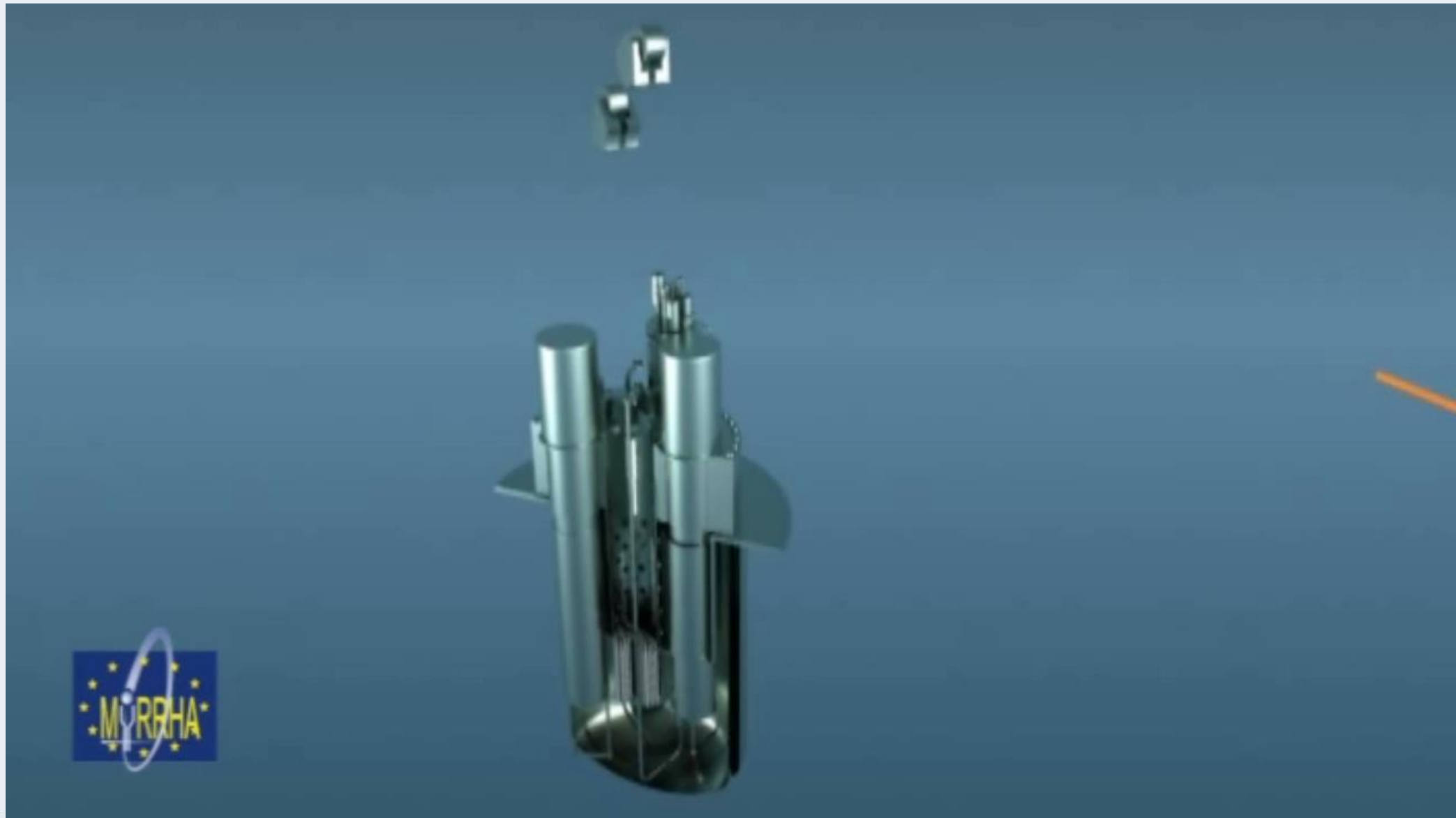
Big Science Business Forum, 4-7 October 2022, Granada (SP)

MYRRHA: ACCELERATOR DRIVEN SYSTEM



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

Accelerator Driven System: intrinsic safety



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

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

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's Application Portfolio



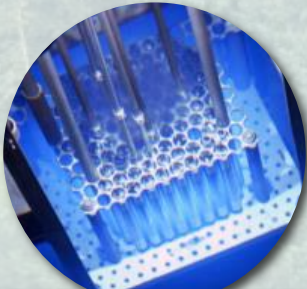
Radio-isotopes



SNF*/ Waste



Fusion



**Mat.& Fuel
GEN IV**

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

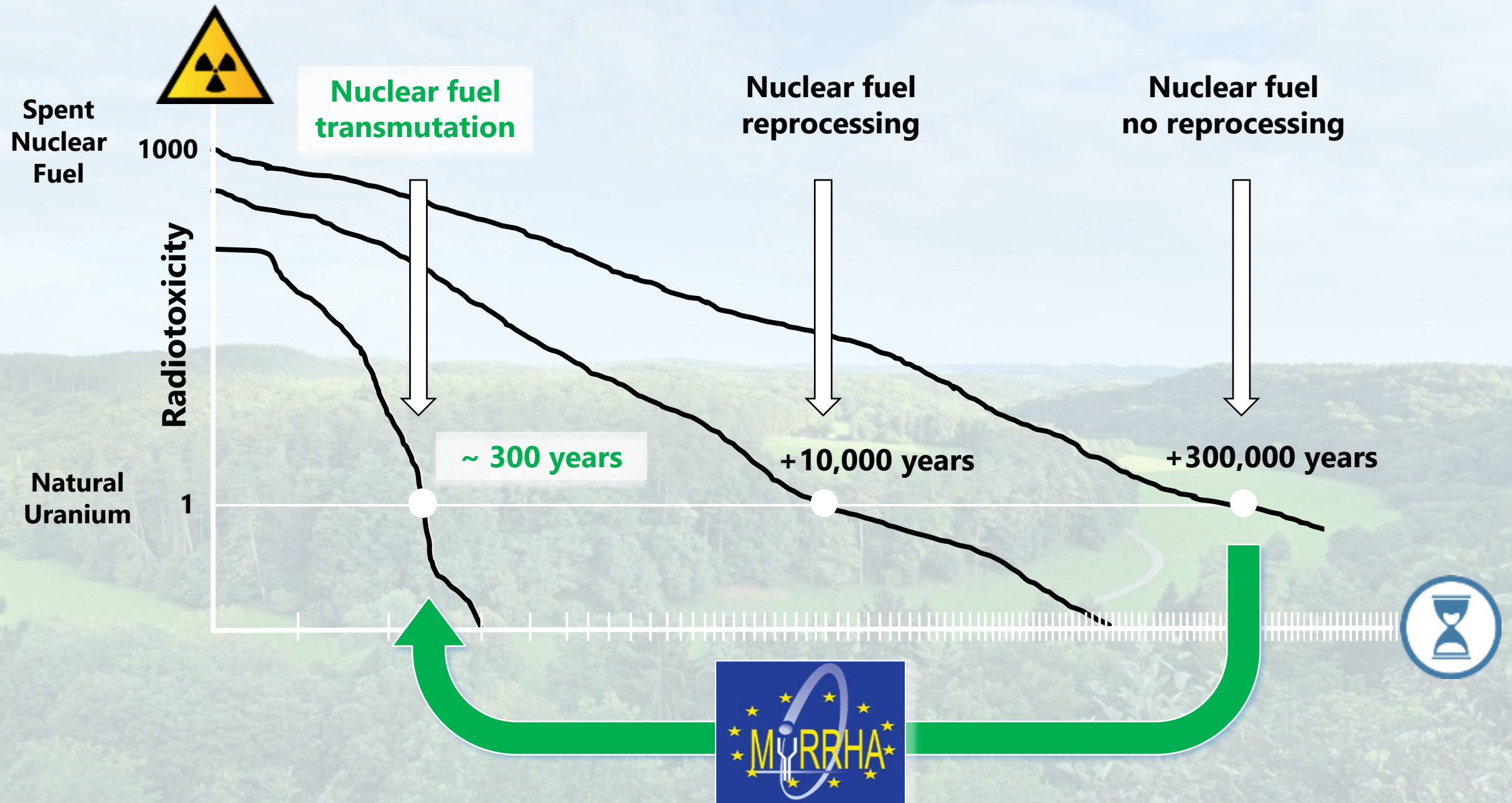


**Fundamental
research**



**Support to
SMR LFR**

*SNF = Spent Nuclear Fuel



MYRRHA Scope

- MYRRHA is a **large pan-European research infrastructure** based on ADS concept aiming at:
 - Meeting the objective of **SCK CEN** of having a **large research facility** for taking over the role of BR2 but enlarging its portfolio in the field of materials for **fusion**, offering capabilities for the development of **Gen IV** reactors and contributing to nuclear medicine and **fundamental science**;
 - Meeting **European** and **international** objective in the field of **HLW** mgt via advanced options,
 - Meeting the primary objective of **Belgium**; maintaining the high level of **nuclear competences** and expertise in the country, preserving a leading role in **medical radio-isotope** innovation and production, and **enabling innovative solutions**;

National context evolution (3)

2015 -> Today (National Program on waste management)

In **2014** the national policy for the management of spent fuel from commercial nuclear power plants is the safe storage of spent fuel followed by its reprocessing & disposal or direct disposal



2017: Prospective study on the strategies for the management of Belgian nuclear spent fuel

6 different strategies are assessed:

Direct disposal

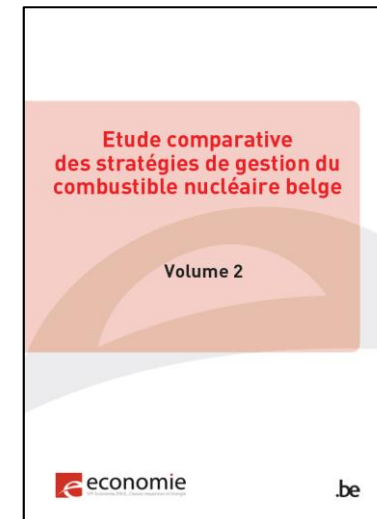
Classical reprocessing of full inventory & disposal

Partial reprocessing

Advanced separation (P&C)

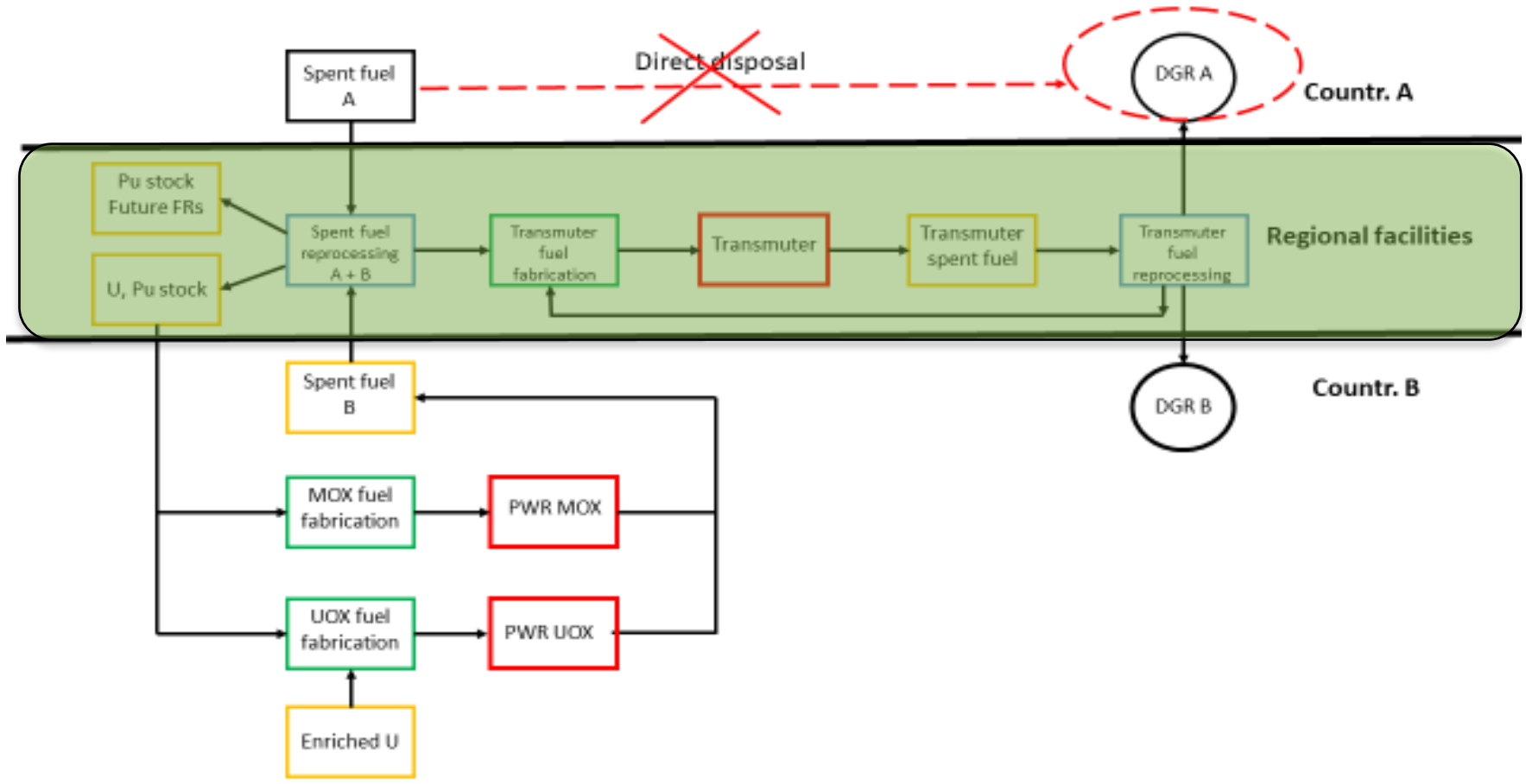
Partitioning & Transmutation (P&T)

Additional research





Even with completely different national NE policies European solution for HLW works with ADS



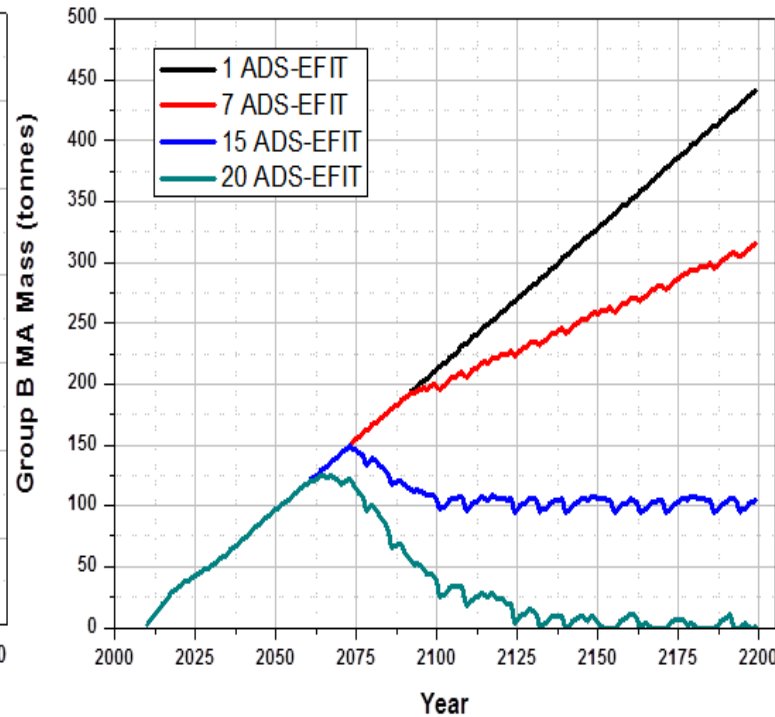
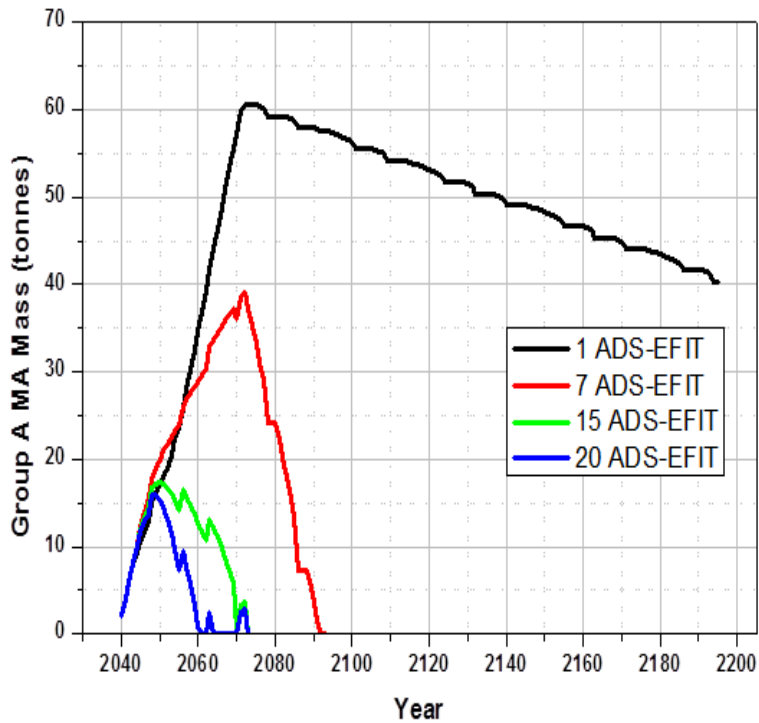
- Advantages for A**
 - ADS shared with B
 - ADS burn A's Pu& MA
 - Smaller Fu-Cycle units & shared

- Advantages for B**
 - ADS shared with B
 - ADS burn B's MA
 - A's uses B's Pu (part) as resource in FR
 - FR fleet not contam with MA's
 - Smaller Fu-Cycle units & shared

FP6 PATEROS project: Scenario 1 objective: elimination of A's spent fuel by 2100
A = Countries Phasing Out, B = Countries Continuing

Shared & efficient solution for Minor Actinides management EU case with 144 power reactors using EFIT 400 MWth

- **Europe should go for a regional approach** (see PATEROS, ARCAS)
- **Countries with different nuclear energy policies to collaborate together**
 - Countries willing to continue Nuclear Energy
 - Countries willing to develop fast reactor systems
 - Countries in nuclear phase out, interested in Partitioning & Transmutation (P&T)



**15 EFIT * 400 MWth = 6000 MWth
For all EU HLW treatment**

Doel (BE) = 9000 MWth

Tihange (BE) = 9000 MWth

Gravelines (FR) = 17118 MWth

Zaporizhzhya (UA) = 18000 MWth

Bruce (CND) = 18702 MWth

Kashiwazaki-Kariwa = 23895 MWth

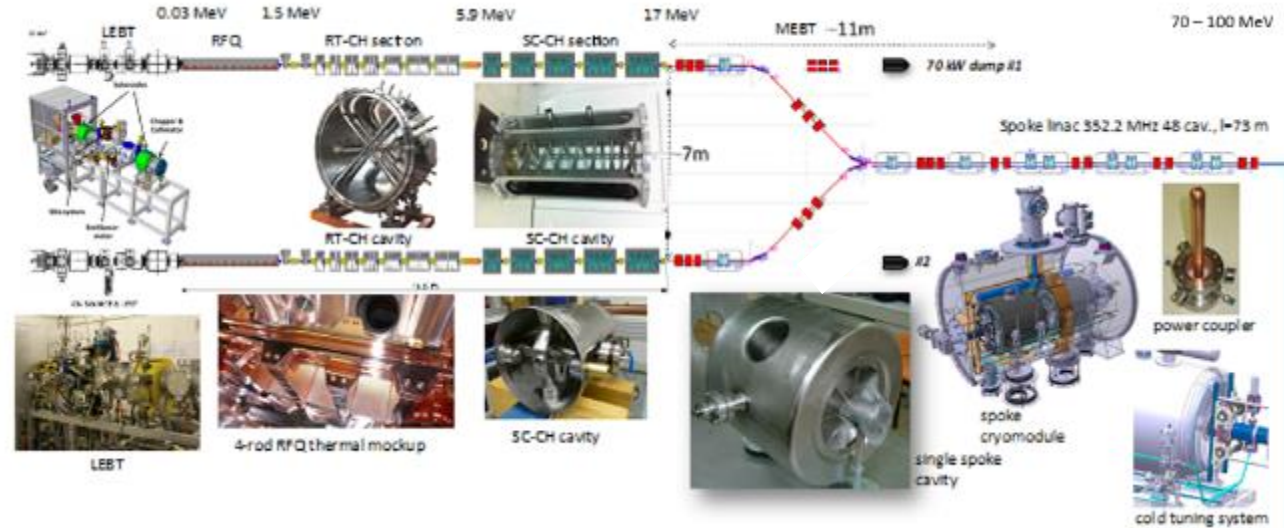
MYRRHA'S PHASED IMPLEMENTATION STRATEGY

UNDER CONSTRUCTION

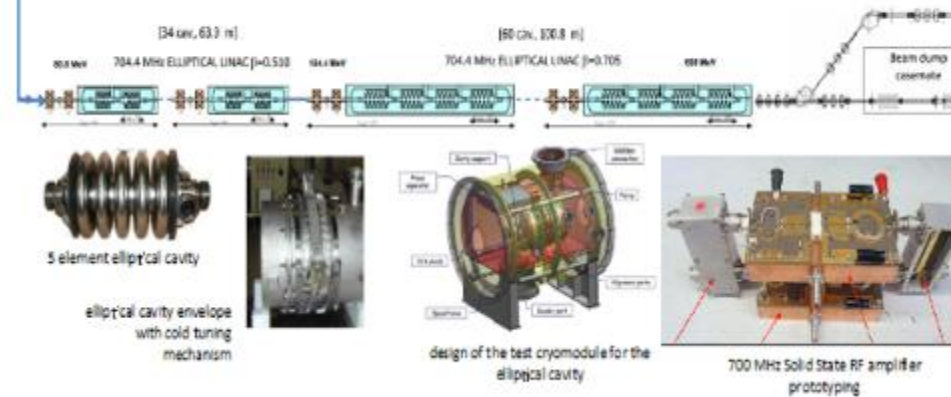
Benefits of the phased approach:

- 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



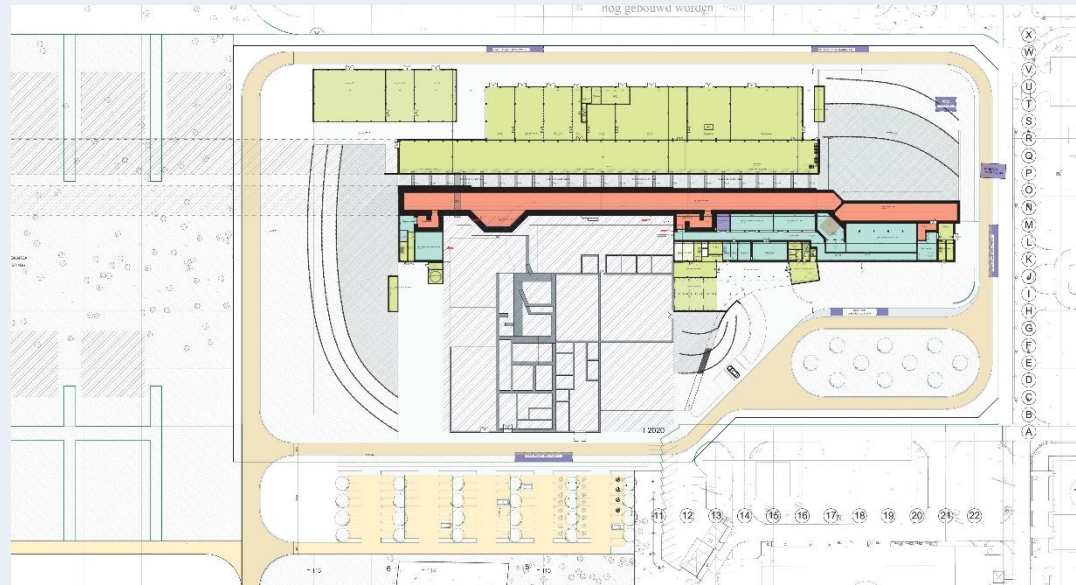
Phase 2 – 600 MeV



Phase 3 – Reactor

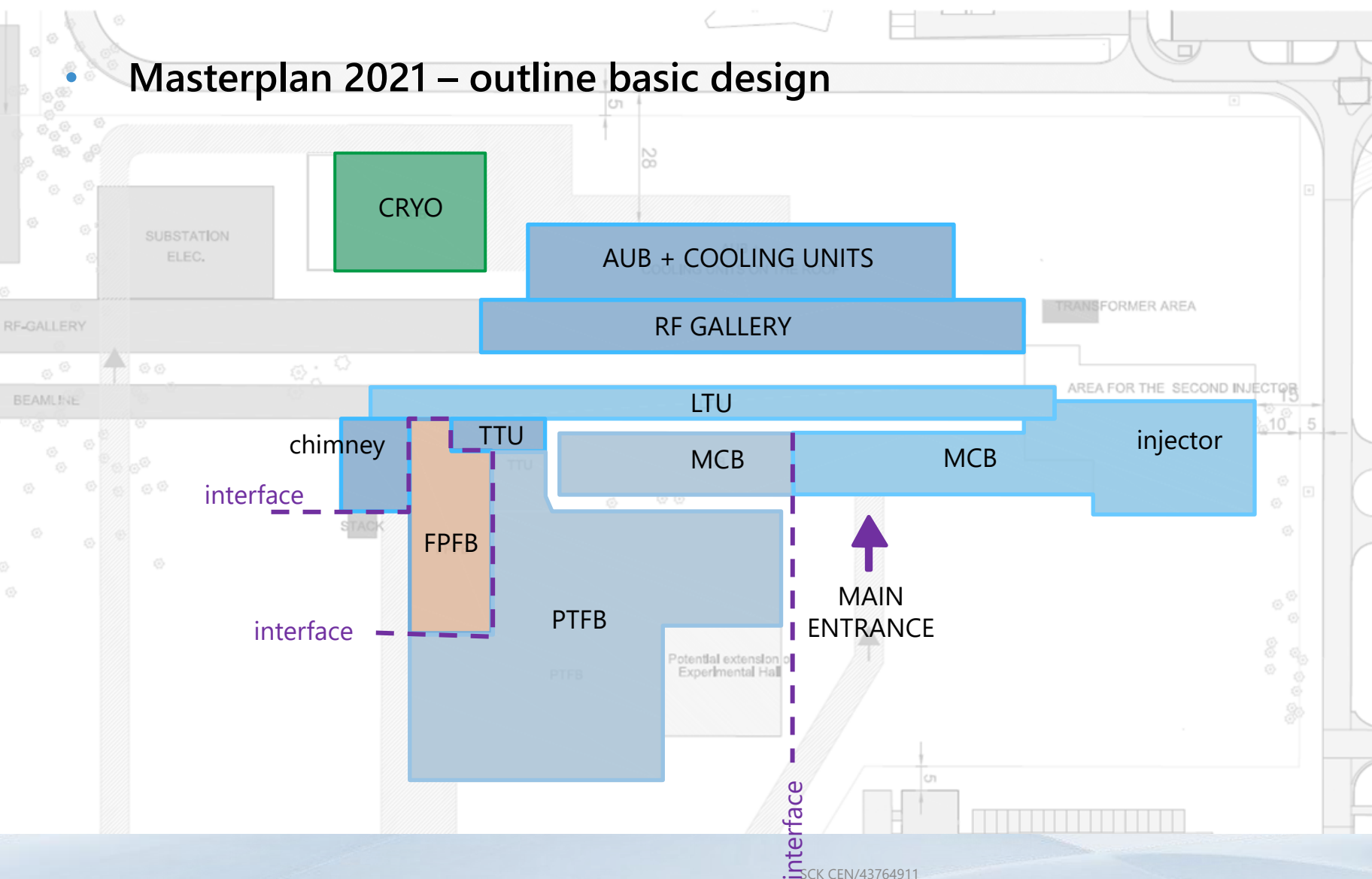
MINERVA implementation by 2027

- Overall architecture frozen, main internal floor plan decisions taken
- PTF design close to level of ACC, FPF catching up



Design status

- Masterplan 2021 – outline basic design

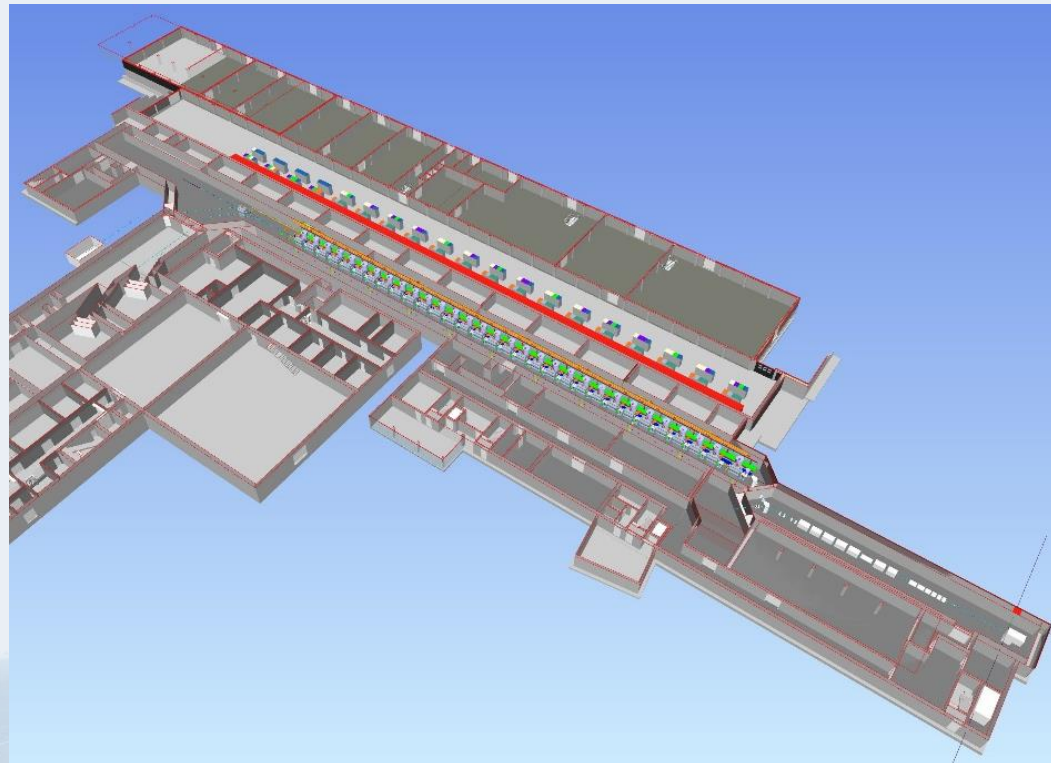
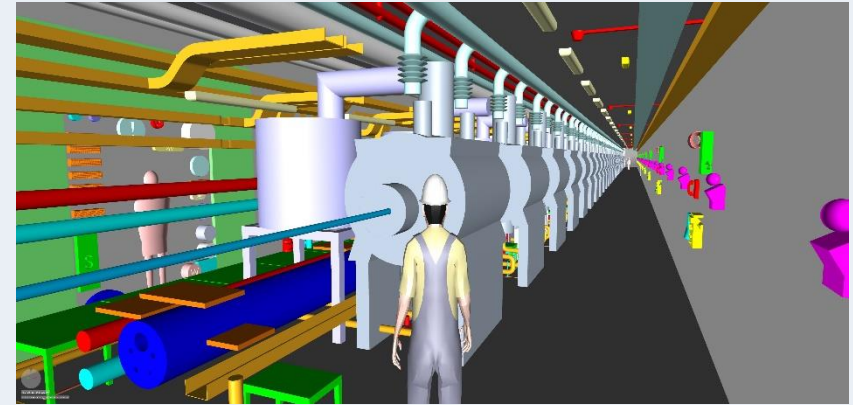


- = ACC
- = PTF
- = FPF
- = AUXILIARY

- PTFB: PTF Building
- FPFB: FPF Building
- TTU: Transfer TUnnel
- MCB: MINERVA Central Building
- FEB: Front-End Building
- LTU: LINAC TUnnel
- CRYO: Cryo-plant
- AUB: Accelerator Utilities Building

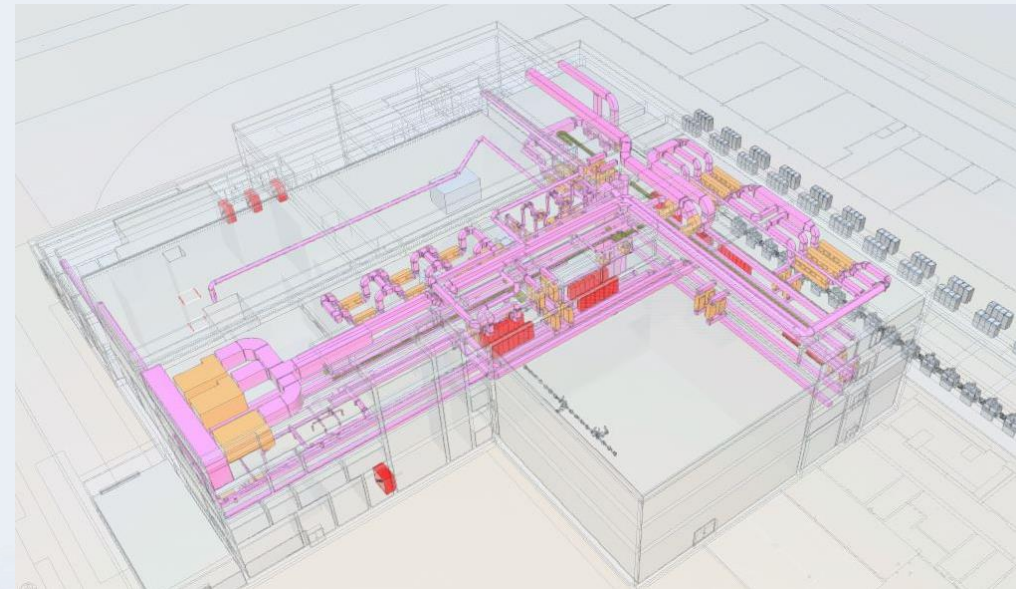
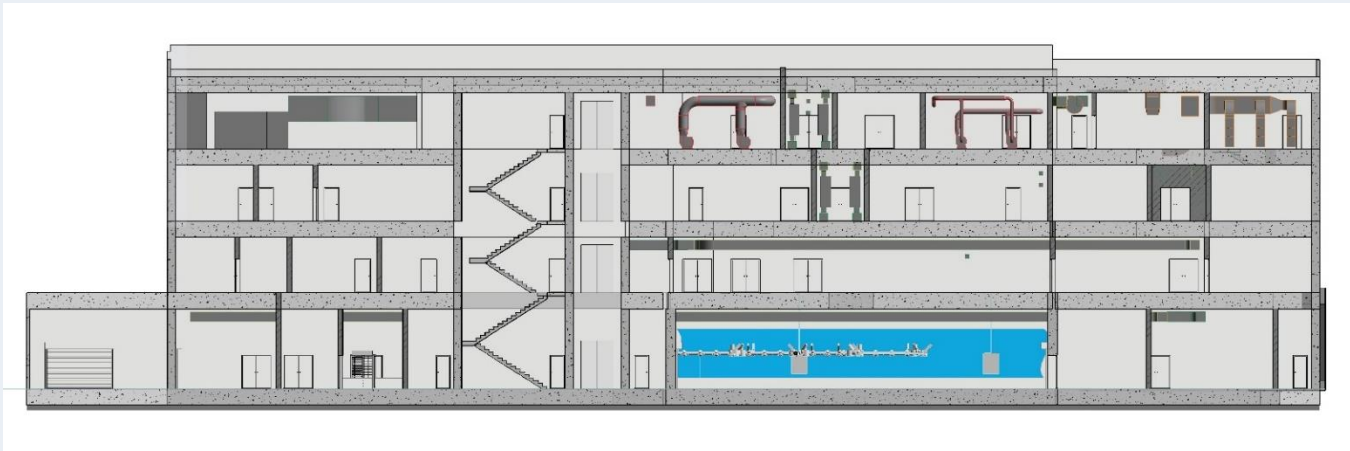
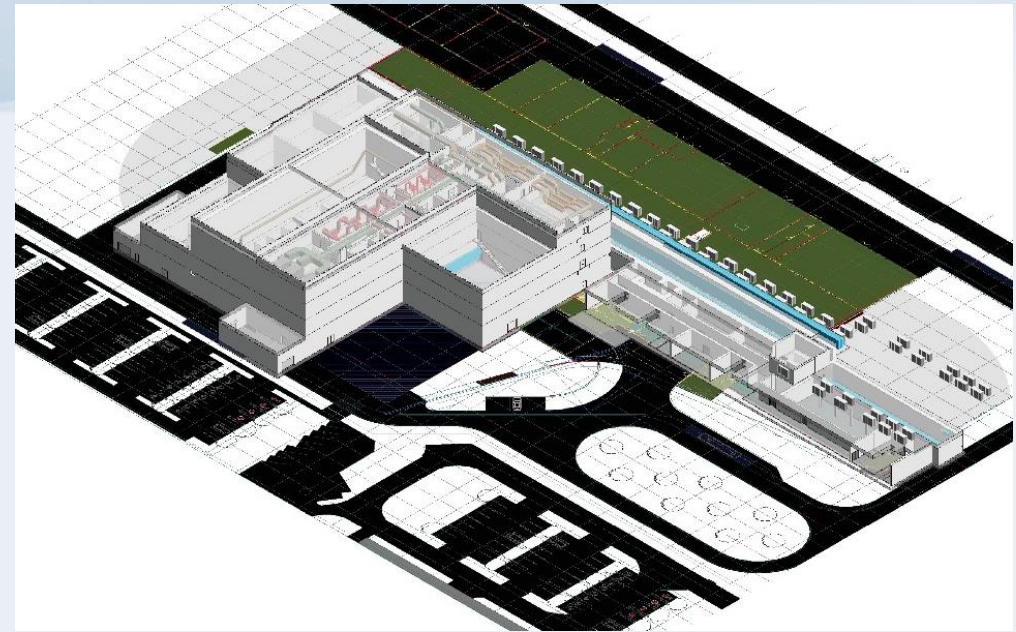
NF ACC

- **Outline Basic Design phase**
 - 3D data model
 - determines minimum level of detail (LOD 100) of all SSC
 - links 'all' information
 - tool for integration of SSC



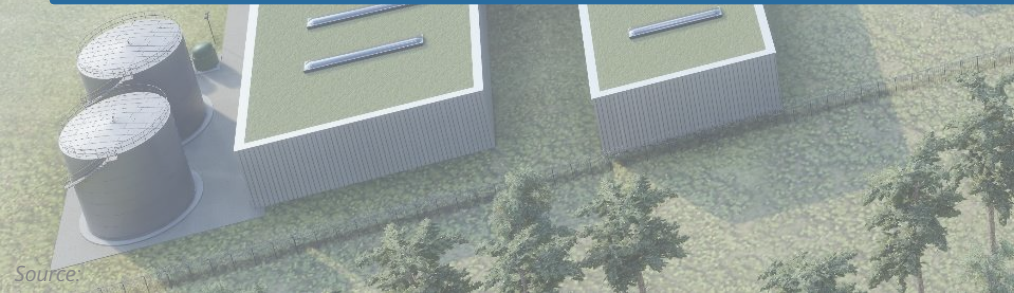
NF PTF

- **Conceptual Design phase**
 - 3D data model
 - minimum LOD 100, higher level reached
 - primary systems included



MYRRHA REACTOR: IMPLEMENTATION IN 2036

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



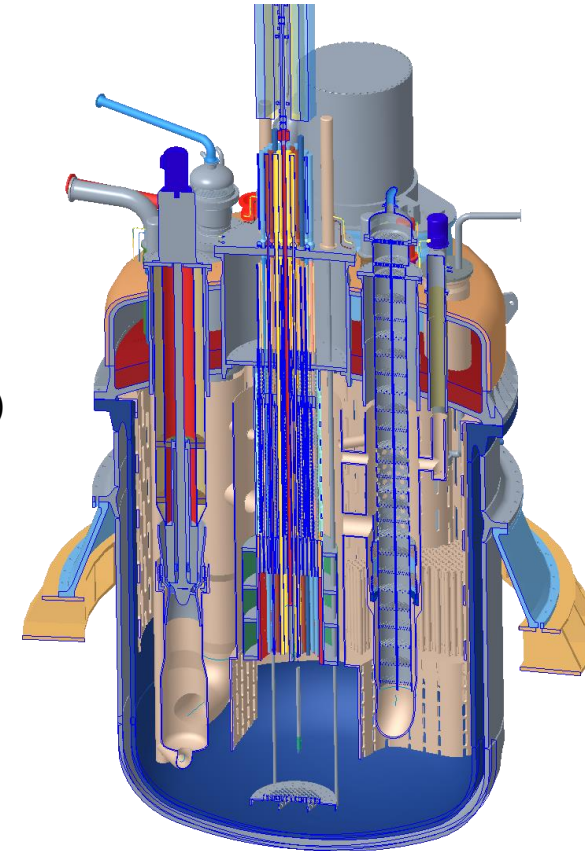
MYRRHA REACTOR HIGHLIGHTS



MYRRHA reactor primary design Rev. 1.8, frozen end 2020

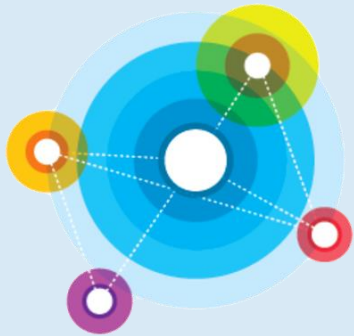
- Integrated Pool-type concept with LBE coolant
- Fuel assemblies: hexagonal bundles of cylindrical wire-spaced fuel pins (MOX fuel 30wt.% Pu)
- 4x heat exchangers: double-walled with leak detection; water/steam on secondary side
- 2x primary pumps: vertical shaft mixed-flow design
- Bottom core loading: single in-vessel fuel handling machine (IVFHM)
- Safety vessel integrated into the primary vessel

<u>Parameter</u>	<u>Unit</u>	<u>Value</u>
Maximum core power	MW _{th}	64
Maximum heat sink rated power	MW _{th}	70
Shutdown state LBE temperature	°C	200
Maximum core inlet LBE temperature	°C	220
Maximum average hot plenum LBE temperature	°C	270



MYRRHA contributes to Belgian strategic objectives

Knowledge Economy



(Visie-Vision 2030)

**Nationaal Pact
voor
Strategische
Investeringsen**

**Pacte National
pour les
Investissements
Stratégiques**



Energy Independence

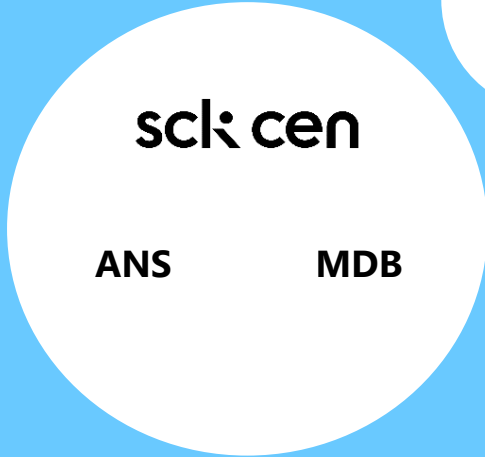


(2021-2030)

**Geïntegreerd
Nationaal
Energie- en
Klimaatplan**

**Plan National
intégré
Energie
Climat**

How to participate in MYRRHA



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 AISBL/IVZW: Membership

- Member categories :
 - a) **Founding members** : Belgian State and SCK CEN
 - b) **Contributing members** open for :
 - Countries
 - **National Research Organisations, industries of a country**
 - International Institutions or Associations
- Rights & Obligations
 - Contribution in-cash or in-kind to become contributing member
 - from 40 M€ contribution :
 - 1 Director in the Board of Directors (overall maximum of 4)
 - 1 Voting right in the General Assembly per 40 M€ contribution
 - Annual membership fee <100 k€ on proposal of BoD (right of nomination of a representative in the International Scientific and Technical Advisory Board (ISTAB))

MYRRHA phase 1 Implementation – Supply and Service contracts

- Civil Engineering (building)
 - Process systems (HVAC, cooling plants)
 - Cryogenic system (plant, distribution)
 - Solid state amplifiers
 - High power RF transfer lines, RF cavities, cryomodules
 - Accelerator beamline elements (magnets, fast magnets, beam diagnostics, interception devices)
 - IT systems, I&C components
-
- Public tendering, staged from 2021 until 2024
 - execution until 2027
 - Total 300 MEuro

Contacts for MYRRHA

- **Becoming member of the MYRRHA AISBL/IVZW**
 - Hamid AÏT ABDERRAHIM
 - +32 476 719113
 - haitabde@sckcen.be
- **Providing services or components to MYRRHA, contacts:**
 - **MYRRHA Phase 1 Implementation (MINERVA)**
 - Adrian Fabich
 - Mobile +32 470 90 32 77
 - adrian.fabich@sckcen.be
 - **MYRRHA Reactor**
 - Marc Schyns
 - Mobile +32 473 53 36 76
 - mschyns@sckcen.be
- **General contact information & procurement conditions**
 - **General contact information :** www.myrrha.be and myrrha@sckcen.be
 - **Purchase office :** aanbestedingen@sckcen.be (procurement office)

Conclusions

Belgium sends a strong signal about its ambitions:

- Maintaining a high level of **know-how** in the nuclear field
- Becoming an **international pole of attraction** for young talents in nuclear applications
- Convert innovations into **solutions** for **societal challenges** (nuclear waste, nuclear medicine, sustainability)
- Encourage and welcome **international cooperation and partnership**



2018
Positive decision



Ground breaking
Q2 2023

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SCK CEN

Belgian Nuclear Research Centre

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