The Belgian Government will support in a progressive way the MYRRHA project or any equivalent project at SCK•CEN aiming to continue the needed research for innovative solutions for High level waste, qualification of materials for fusion, the production of radioisotopes for medical applications in our country and fundamental nuclear research in collaboration with the universities and sister organisation of SCK•CEN.
Key objective of the MYRRHA-programme

Construction of an Accelerator-Driven System (ADS) as a Large Research Facility consisting of

- A 600 MeV – 2.5 mA proton linear accelerator
- A spallation target/source
- A lead-Bismuth Eutectic (LBE) cooled reactor able to operate in subcritical & critical mode

Accelerator (600 MeV – 2.5 mA proton)

Fast neutron source

Spallation source

Multipurpose flexible Irradiation facility

Reactor
- subcritical mode (50-100 MWth)
- critical mode (~100 MWth)

Lead-Bismuth coolant
MYRRHA multipurpose facility: application portfolio 2014

- Radio-isotopes: Priority
- Fission GEN IV
- Fusion
- Multipurpose Hybrid Research Reactor for High-tech Applications
- Waste: Primary goal
- Fundamental research
- LFR European Technology Pilot Plant (ETPP)
- Silicon doping

Source: MYRRHA ad hoc Group (MAHG), SCK•CEN MYRRHA Project Team, MYRRHA Business Plan
MYRRHA application portfolio 2016: Silicon doping is not economically attractive for MYRRHA

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

**Waste:** Primary goal

**Radio-isotopes:** Priority

**Fission GEN IV**

**Fusion**

**SMR LFR:** Valorisation only

**Fundamental research**

Source: SCK•CEN MYRRHA Project Team, MYRRHA Business Plan
In 2015, SCK•CEN investigated three scenarios for the implementation of MYRRHA:

- SC1: Accelerator first + Reactor later
- SC2: Reactor first + Accelerator later
- SC3: Accelerator and Reactor all together

In December 2015, SCK•CEN Board selected Scenario one (SC1) as the most appropriate approach for the realisation of MYRRHA. This scenario consists of a phased approach (Phase 1 = 2016-2024)

- Eliminating the technical risks
- Spreading the investment cost
- Allowing first R&D facility available by 2024

Source: SCK•CEN MYRRHA Project Team
Global high-level planning MYRRHA Project (2016-2030)

Source: SCK•CEN MYRRHA Project Team
MYRRHA accelerator design

- 0 – 100 MeV section

- 70 kW dump #1

- Spoke linac 352.2 MHz cav., I=73 m

- Power coupler

- Single spoke cryomodule

- Cold tuning system

- 704.4 MHz ELLIPTICAL LINAC β=0.510

- 704.4 MHz ELLIPTICAL LINAC β=0.705

- 5 element elliptical cavity

- Elliptical cavity envelope with cold tuning mechanism

- Design of the test cryomodule for the elliptical cavity

- 700 MHz Solid State RF amplifier prototyping

- Beam dump casemate

- Reactor target
Based on design of ISOL@MYRRHA target station by Pierre Bricault et al. 2013-2014
Fuel Assembly and Core

- Core
  - 211 positions
    - 108 FA in critical core
  - 55 MFC
  - Mass flow rate
    - 13800 kg/s
    - Ti: 270°C
    - To: 325°C
Confirmation innovative design components

- **Mechanical design of the primary pump**
  - Mechanical architecture defined
  - Bearing types identified
  - Mechanical analysis in progress

- **Innovative double wall heat-exchanger**
  - Test module for COMPLOT is designed
  - Design under review by the industrial partner
  - Construction of module in 2017

Source: MYRRHA ad hoc Group (MAHG), SCK•CEN MYRRHA Project Team
Confirmation innovative design components

- **In-Vessel Fuel Handling Machine with an additional articulation**
  - Concept development of the additional articulation in a second revision
  - Engineering design of gripper on-going
  - Start of manufacturing of gripper components in 2017

- **Diaphragm**
  - Analysis lay-out on-going
  - New conceptual design in development
  - Concept review planned in January 2017

- **Reactor vessel**
  - Reactor Vessel with integrated Safety Vessel designed
  - Mechanical analysis being finalised
  - Start of licensability analysis in January 2017

Source: MYRRHA ad hoc Group (MAHG), SCK•CEN MYRRHA Project Team
Elements of the Pre-Licensing Phase

- There are two main elements that form part of the pre-licensing phase process:
  - Focus Points
  - The Design Options and Provisions File (DOPF)

- Focus Points address specific issues/topics that are considered important to be addressed in the pre-licensing phase. These are the fundamental important points that can influence the licensability of the project.

- The DOPF works on a slightly higher level, though it will finally incorporate many of the aspects of the focus points. The document outlines the safety approach of the facility as well as the options and provisions taken to meet the safety objectives.
Focus Points Overview

- Focus Points address specific topics of importance that meet the three following conditions:
  - New or not mature enough
  - Specific to MYRRHA
  - Has an impact on the safety of the facility

- Focus Points are defined by FANC/Bel V

- Focus Points may be added or removed as the project progresses, however this has to be done with approval from FANC

- Focus Points are grouped into Focus Point Themes, each theme can have several specific Focus Points associated with it
Focus Point Themes

- External Hazards
- LBE Issues
- Criticality
- Fuel Qualification Program
- Decay Heat Removal
- Confinement
- I&C
- Management of gases
- In-Vessel Fuel Storage
- In-Vessel fuel manipulation and recovery
- Radiological safety
- Licensing of codes, standards and methodologies
- Accident analysis
- Severe accidents
- Experimental devices
- Accelerator
LBE R&D programme

- LiLiPuTTeR-II
- HELIOS 3
- Heavy Liquid Metal Lab
- MEXICO
- CRAFT
- LIMETS 3
- RHAP'TER
- COMPLOTT
- ESCAPE
- US lab

LBE conditionning

- Democritos (VKI) + European platforms (ENEA, KIT, KTH) + JAEA
VENUS-LFR critical facility (2010-2018)

- First licensing of lead reactor outside Russia (2007-2010...2013)
- Core design consolidation - Code validation
- Subcritical approach procedures
### Technical deliverables

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technical Design Report (TDR) for <strong>full accelerator</strong></td>
</tr>
<tr>
<td>2</td>
<td>Conceptual design of 100 MeV <strong>accelerator building</strong></td>
</tr>
<tr>
<td>3</td>
<td>Prototyping of all 100 MeV <strong>accelerator components</strong></td>
</tr>
<tr>
<td>4</td>
<td>Confirmation of innovative <strong>reactor design components</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>Licensibility statement</strong> on MYRRHA from FANC/AFCN</td>
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</tbody>
</table>

### Non-technical deliverables

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Total <strong>budget</strong> consolidation for <strong>Phase 1</strong>: Investment (±25%), OPEX &amp; revenues</td>
</tr>
<tr>
<td>7</td>
<td><strong>A fuel cycle scenario</strong> study including transmutation and impact on the geological disposal for the Belgian scenario</td>
</tr>
<tr>
<td>8</td>
<td>Consolidation of the SC1 implementation plan &amp; associated <strong>financing plan</strong></td>
</tr>
<tr>
<td>9</td>
<td><strong>Risk</strong> assessment &amp; mitigation <strong>methodology</strong></td>
</tr>
<tr>
<td>10</td>
<td><strong>Commitment</strong> of major <strong>stakeholders</strong> for <strong>Phase 1</strong> (investors, scientific &amp; technological users)</td>
</tr>
<tr>
<td>11</td>
<td>Update of 2010 MYRRHA <strong>socio-economic study</strong> in Belgium and its regions (incl. broader EU dimension)</td>
</tr>
</tbody>
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Source: MYRRHA ad hoc Group (MAHG), SCK-CEN MYRRHA Project Team
MYRRHA
A pan-European, innovative and unique facility at Mol (BE)