



## MYRRHA

**M**ultipurpose **hY**brid **R**esearch **R**eactor for **H**igh-tech **A**pplications

Katrien VAN TICHELEN

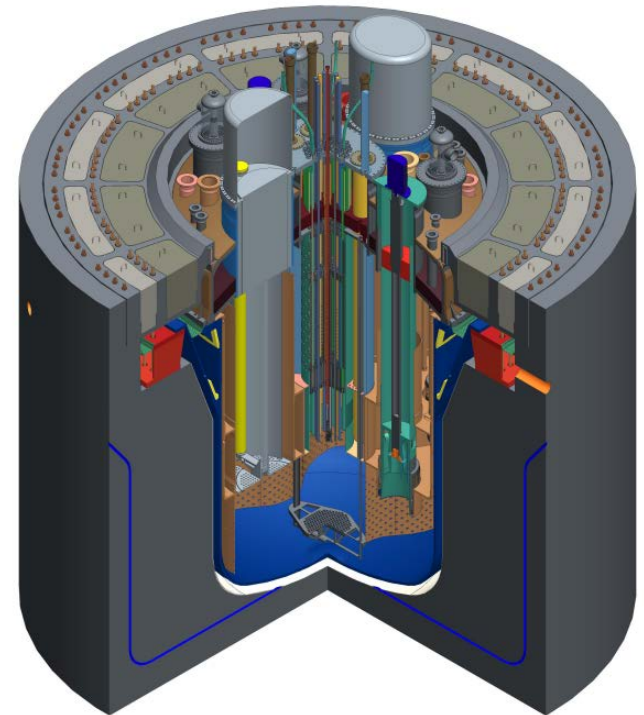
SCK•CEN / Institute for Advanced Nuclear Systems

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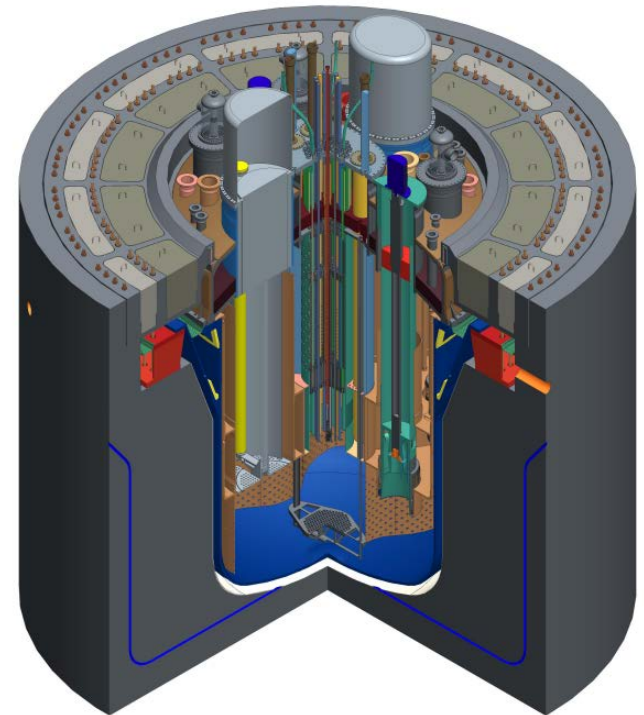
**46. Kraftwerkstechnisches Kolloquium 2014: Kernenergetisches Symposium  
Dresden, Germany, 14-15 October, 2014**



- Why MYRRHA (in Belgium) ?
- What is MYRRHA ?
  - Concept – Design - Performance
- Present status
  - Licensing - Support R&D - Consortium
- Conclusion



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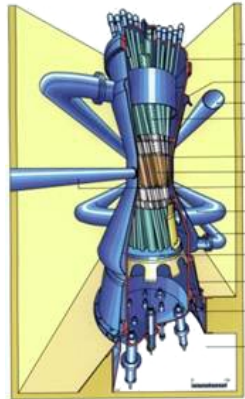


# Challenges for nuclear R&D in EU

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- **Attract new talents** and **educate and train** them
- Keep **high level of competency** in nuclear technology
- Continue to **address the nuclear safety** through highly instrumented experiments
- Come with **acceptable solution for nuclear waste**
- Develop **new nuclear fission energy technologies**: more **sustainable** and **compatible** with future energy environment
- Prepare the path for the nuclear **fusion for energy** production
- Guarantee **welfare of the population** via nuclear medicine

# MYRRHA in Belgium to replace BR2 reactor



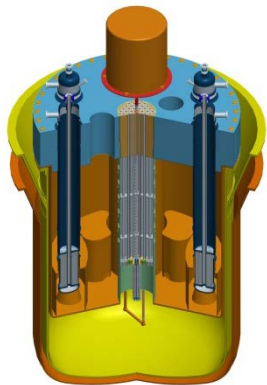
1962

BR2

Material Testing Reactor (fission)

Fuel testing for LWR & GEN II/GEN III

Irradiation Services:  
- Medical RI  
- Silicon Doping  
- Others



2026

MYRRHA

**Fast** Neutron Material Testing Reactor (fission + **fusion**)

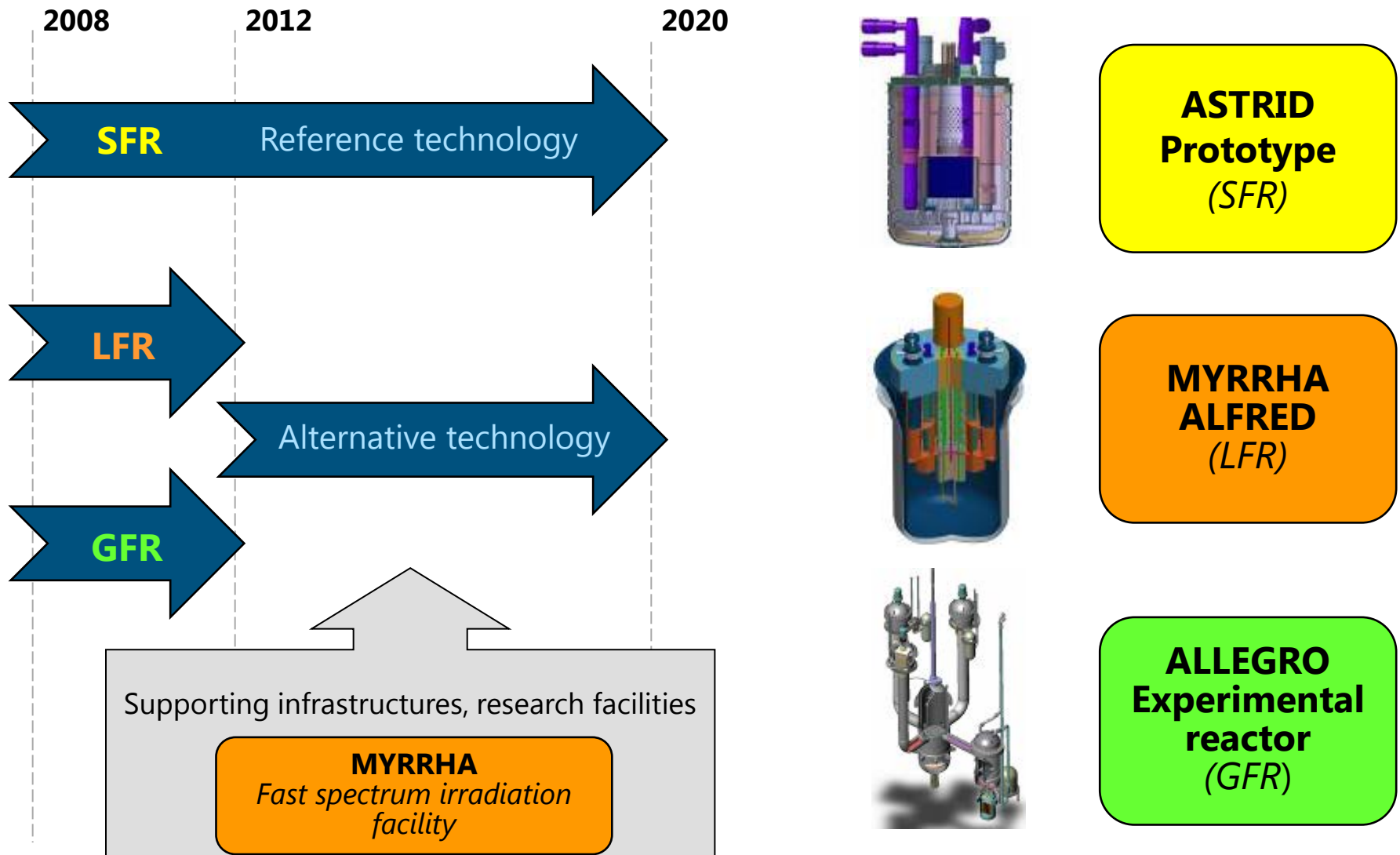
**ADS-Demo** + **P&T Testing**  
(Partitioning & Transmutation)

Irradiation Services:  
- Medical RI  
- Silicon Doping  
- Others

Fuel testing for **LFR GEN IV**

LFR European Technology Pilot Plant (ETPP)

# MYRRHA as part of the ESNII European Sustainable Nuclear Industrial Initiative

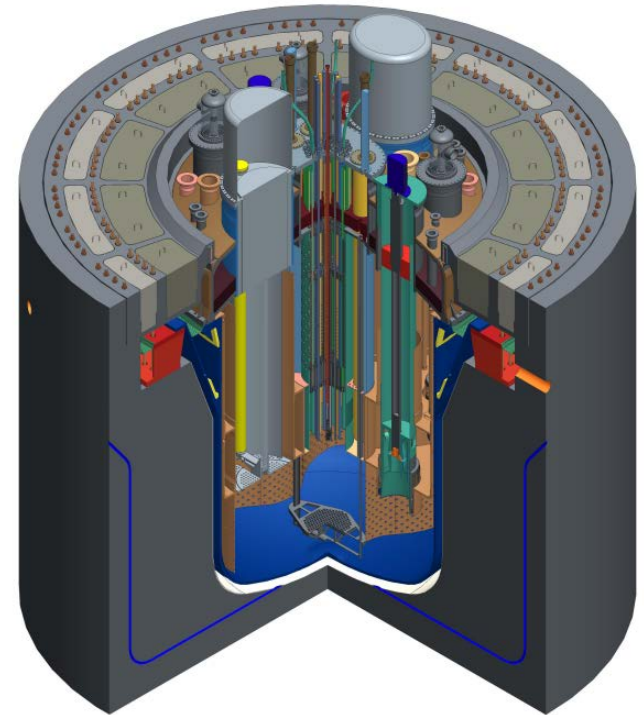


# MYRRHA contributes to the European strategy for P&T

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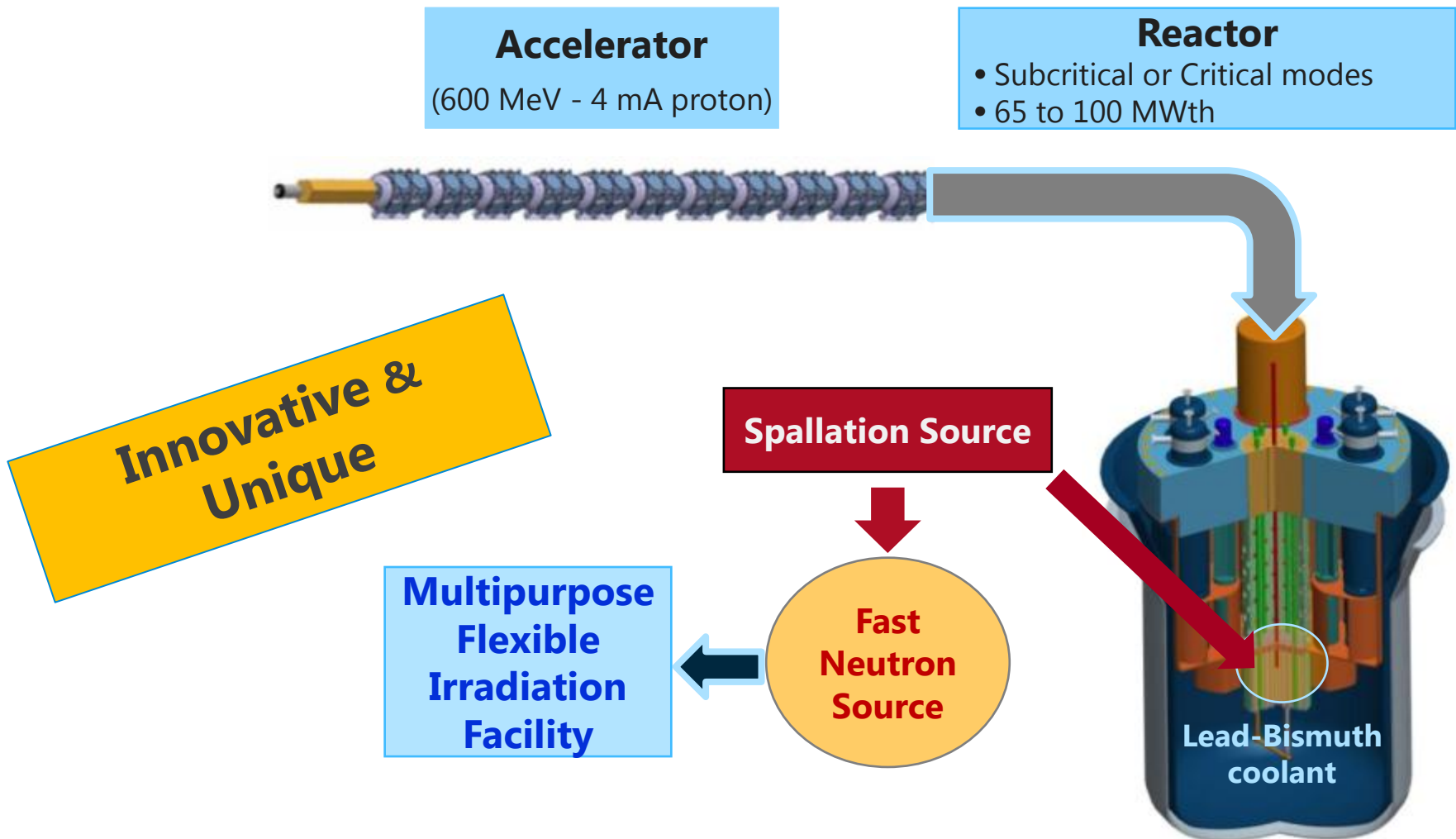
- The implementation of P&T of a large part of the high-level nuclear waste in Europe needs the **demonstration of its feasibility at an “engineering” level**. The respective R&D activities could be arranged in four “building blocks”:
  1. Demonstration of the capability to process a sizable amount of spent fuel from commercial LWRs in order to separate plutonium (Pu), uranium (U) and minor actinides (MA)
  2. **Demonstration of the capability to fabricate at a semi-industrial level the dedicated fuel needed to load in a dedicated transmuter**
  3. **Design and construction of one or more dedicated transmutors**
  4. Provision of a specific installation for processing of the dedicated fuel unloaded from the transmuter, which can be of a different type than the one used to process the original spent fuel unloaded from the commercial power plants, together with the fabrication of new dedicated fuel

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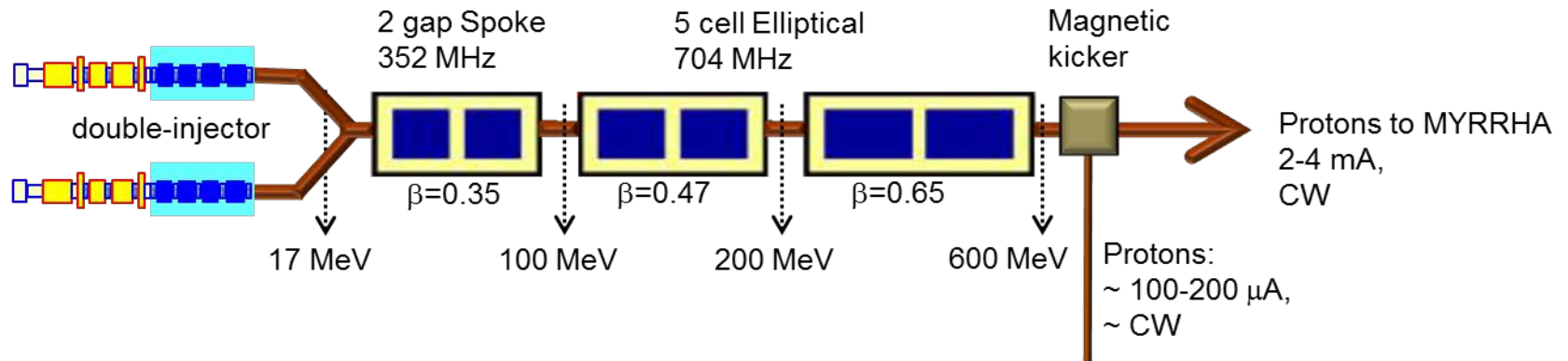




# MYRRHA - Accelerator Driven System



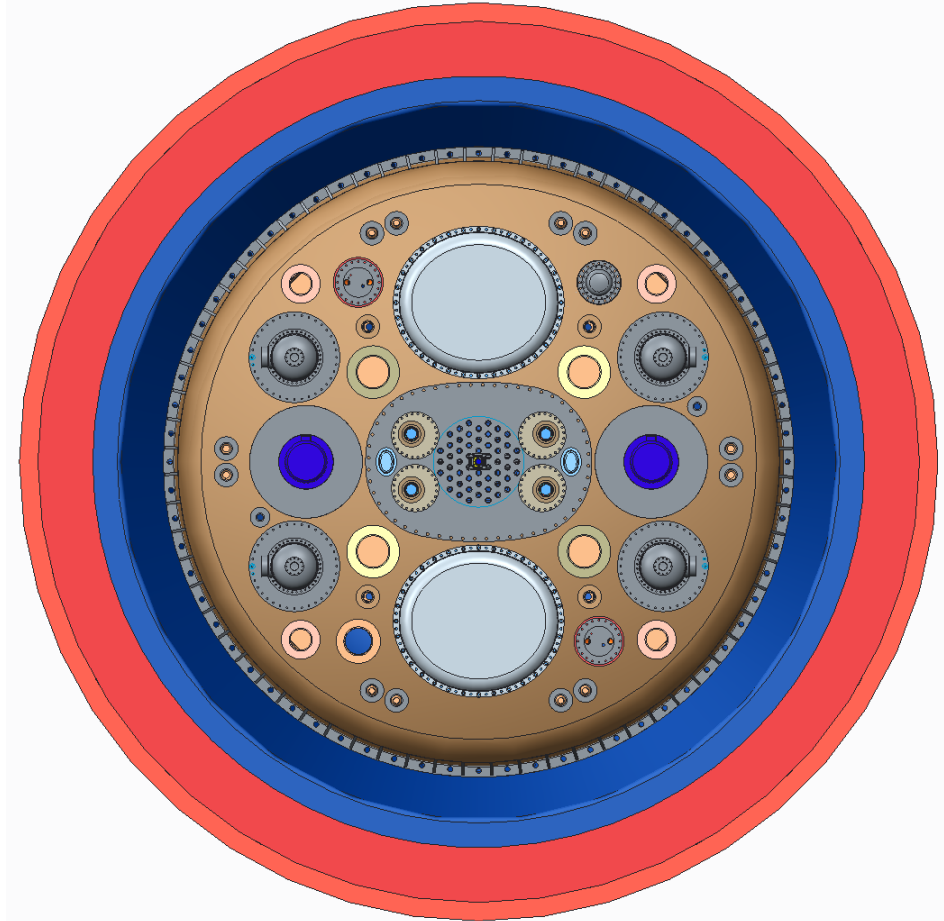
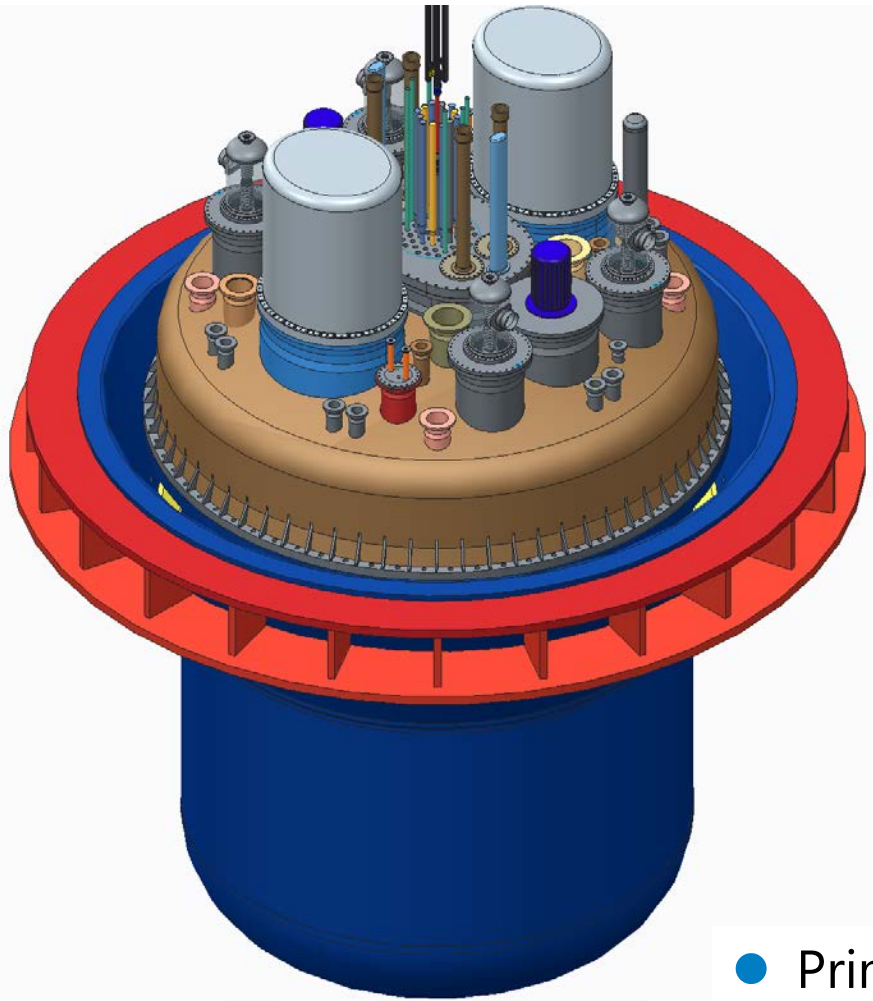
# MYRRHA High-power proton accelerator



# of allowed beam trips on reactor longer than 3 sec	10 maximum per 3-month operation period
# of allowed beam trips on reactor longer than 0.1 sec	100 maximum per day
# of allowed beam trips on reactor shorter than 0.1 sec	unlimited

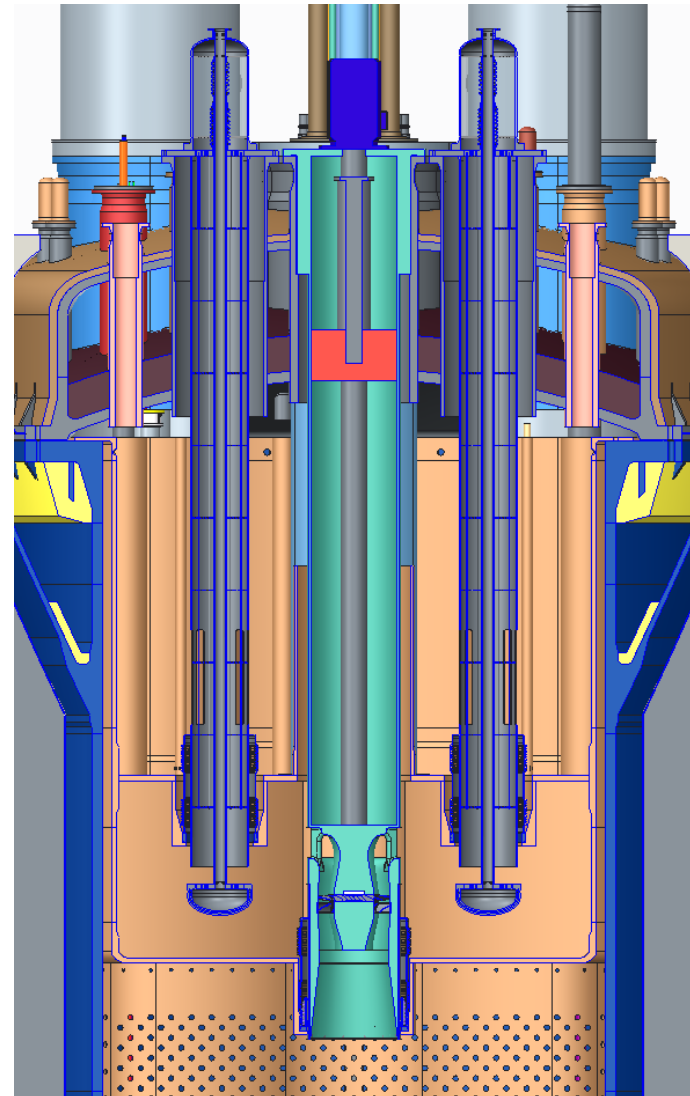
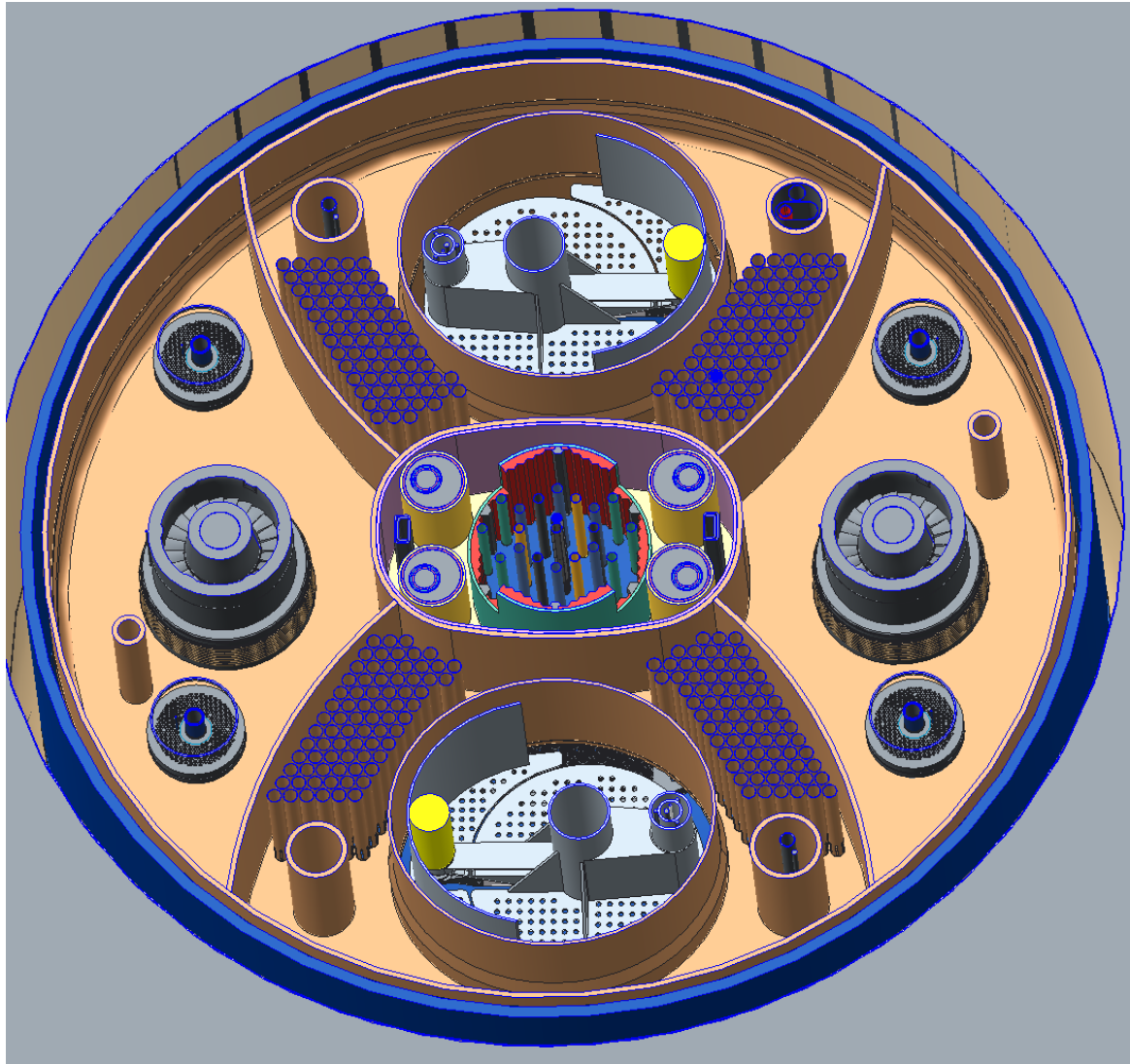
- **Extreme reliability level:** solid design, redundancy, reparability

# MYRRHA Primary System - rev. 1.6



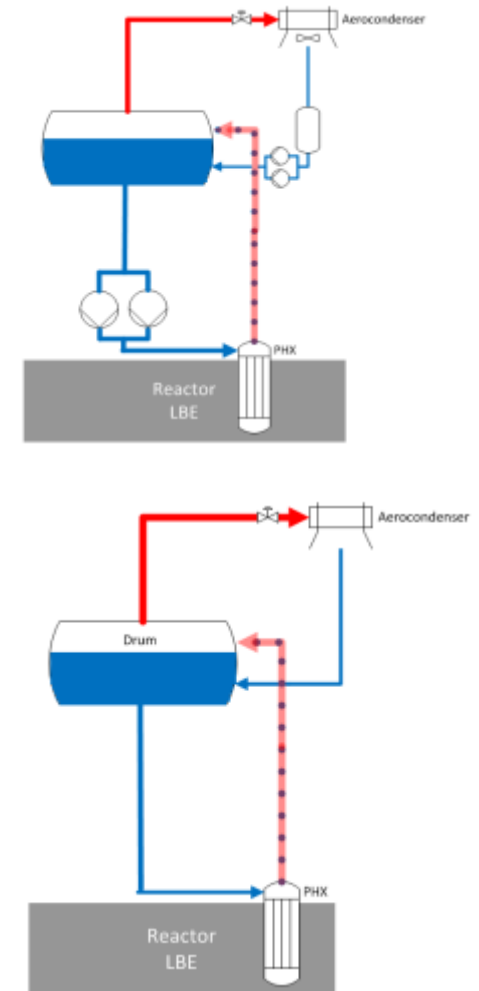
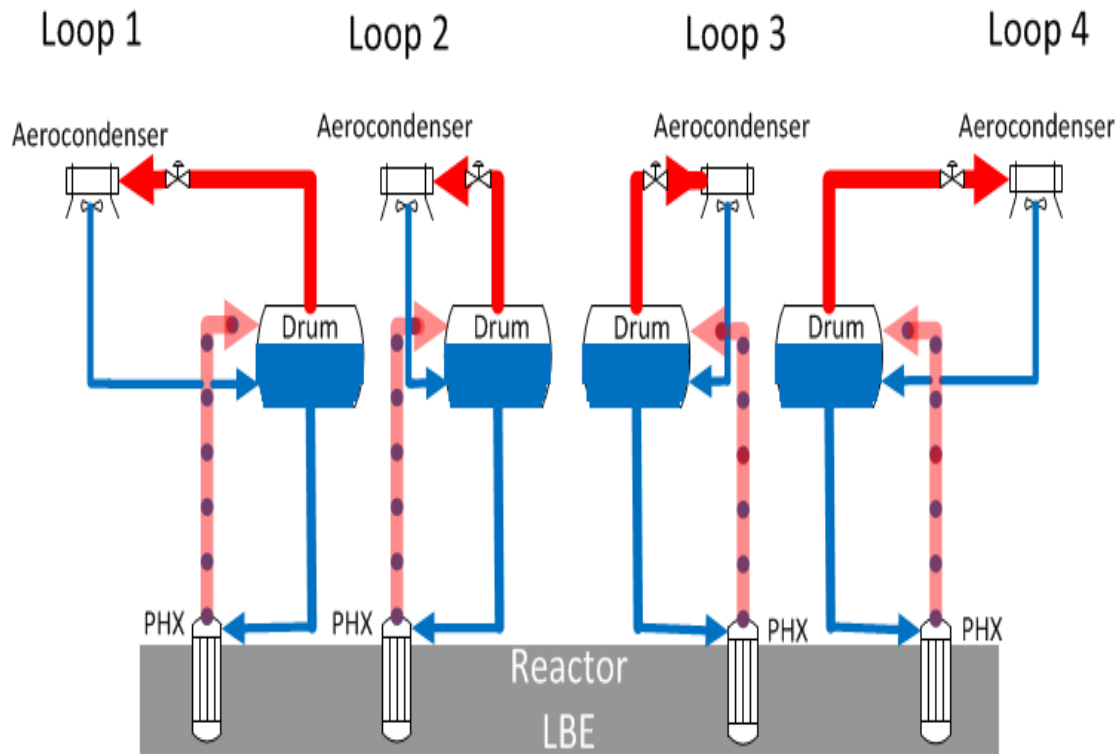
- Primary coolant: **Lead-Bismuth Eutectic**

# MYRRHA Primary System - rev. 1.6



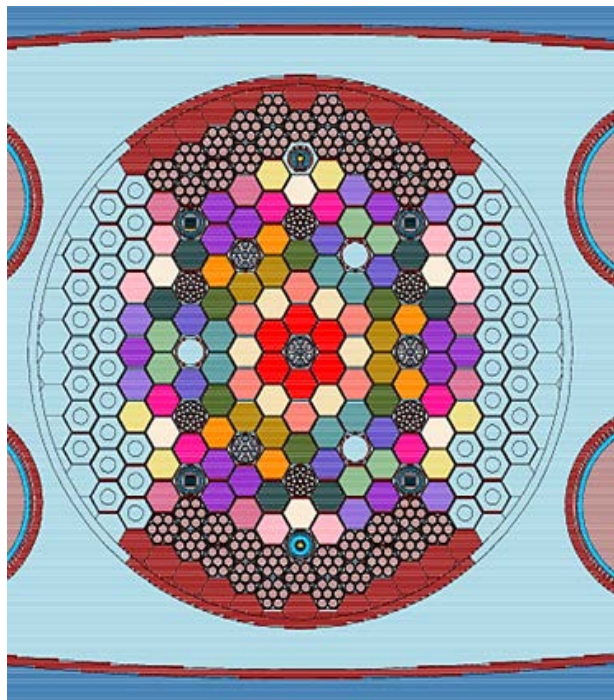
# Secondary and tertiary cooling systems

## Passive decay heat removal

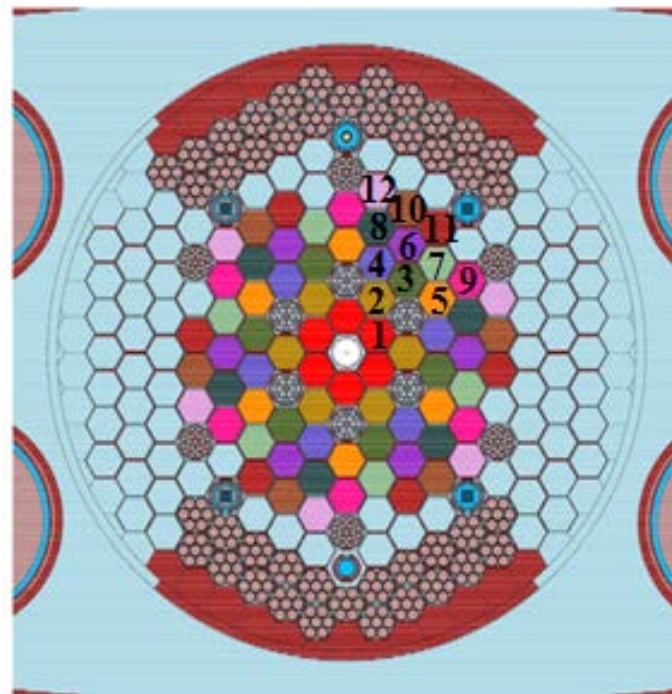


- Secondary coolant: **Water**
- Tertiary coolant: **Air**

# Reference core design



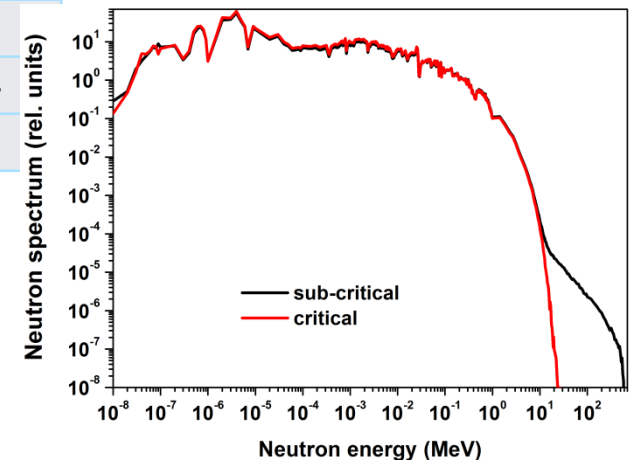
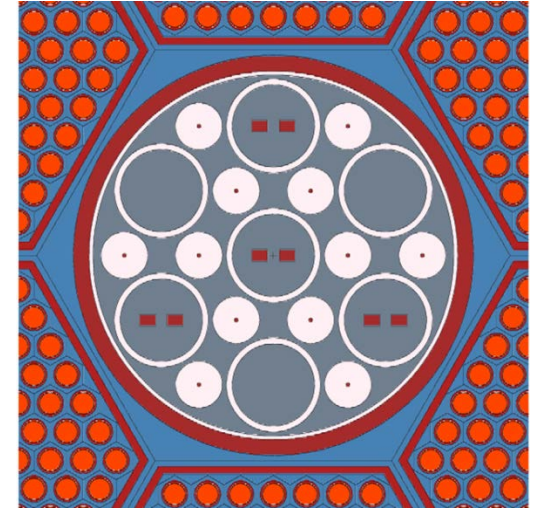
Critical BoC (108 FAs)  
18 batches of 6 FAs  
Max BU: 57 MWd/kgHM



Subcritical BoC (72 FAs)  
12 batches of 6 FAs  
Max BU: 59 MWd/kgHM

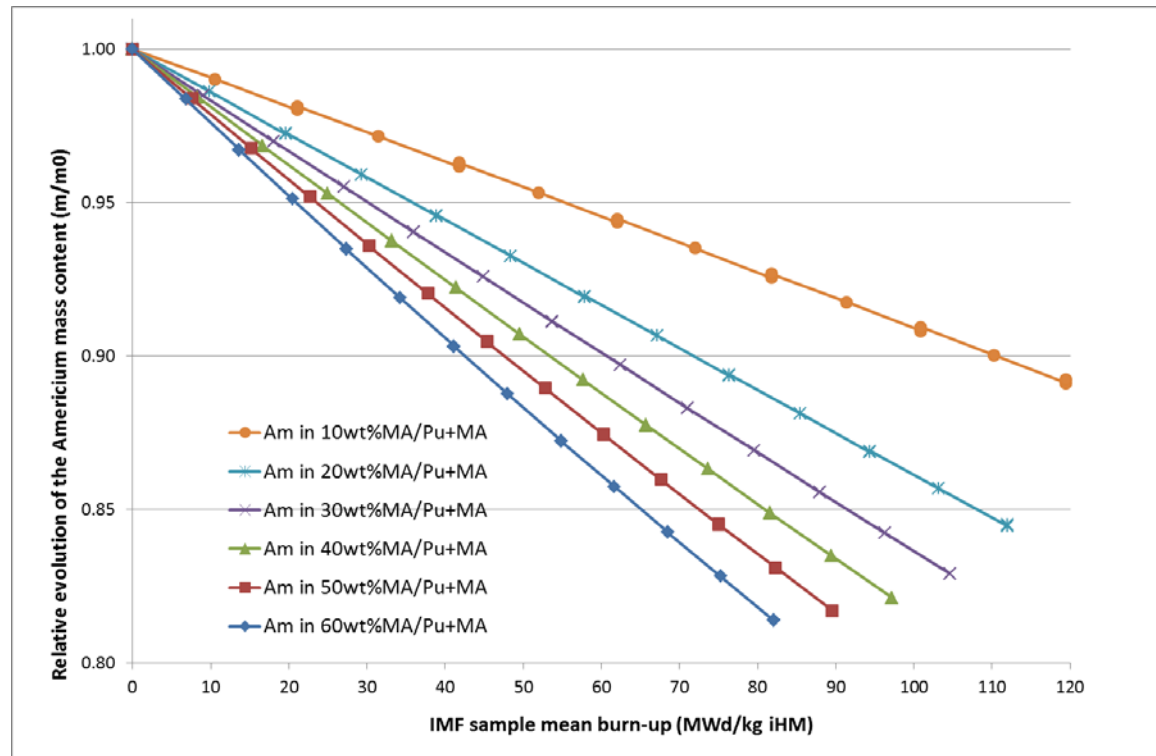
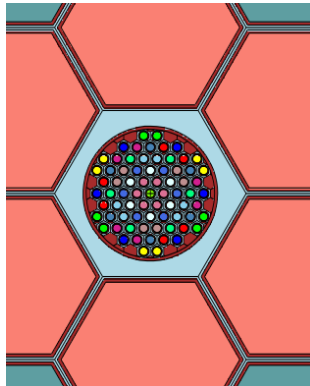
# Irradiation performances

		Critical	Sub-critical
Flux and DPA values normalised to	MWth	96	72
Beam current	mA	-	1.74 – 2.52
DPA damage in IPS			
IPS in central channel	DPA/Y	21.7	-
IPSs in off-central channel	DPA/Y	13.9	31
Neutron Flux in IPS			
IPS in central channel / target			
$\Phi_{\geq 0.75 \text{ MeV}}$	n/cm <sup>2</sup> s	<b>4.05E+14</b>	<b>1.01E+15</b>
$\Phi_{\text{tot}}$	n/cm <sup>2</sup> s	<b>2.61E+15</b>	<b>3.75E+15</b>
IPSs in off-central channel			
$\Phi_{\geq 0.75 \text{ MeV}}$	n/cm <sup>2</sup> s	<b>2.56E+14</b>	<b>4.2E+14</b>
$\Phi_{\text{tot}}$	n/cm <sup>2</sup> s	<b>1.75E+15</b>	<b>2.6E+15</b>



# Minor actinide transmutation studies

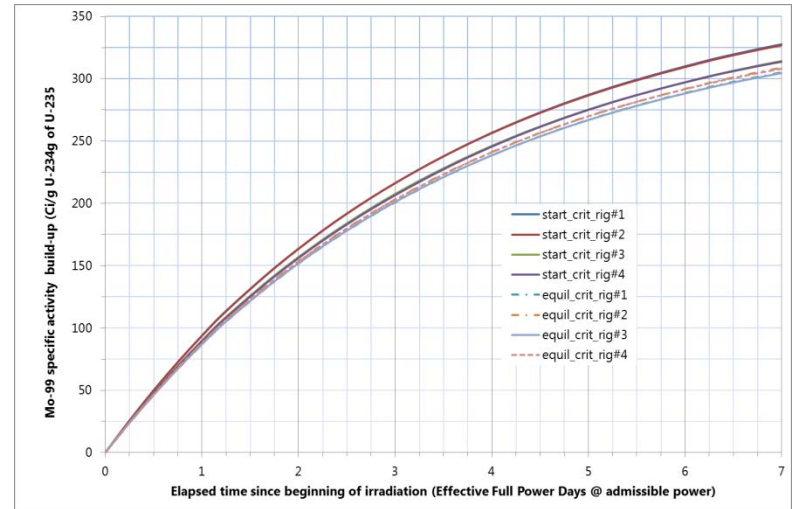
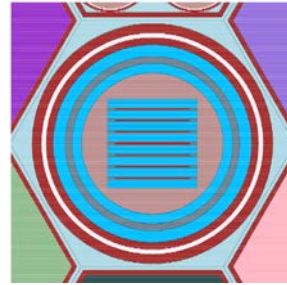
- Minor Actinide loaded device
  - IMF fuel (MgO matrix)
  - Different MA loading factors
  - Loss of Am, Np
  - Build-up of Cm
  - Loss or build-up of Pu



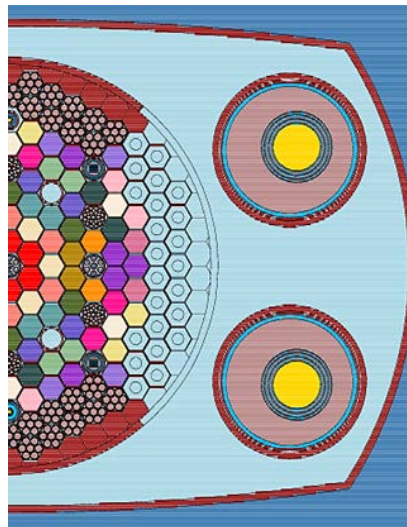


# Radioisotope production & Si doping

- Mo-99 production
  - Fission of U targets
  - Moderation needed:
    - ⇒ H<sub>2</sub>O device
  - High specific activities

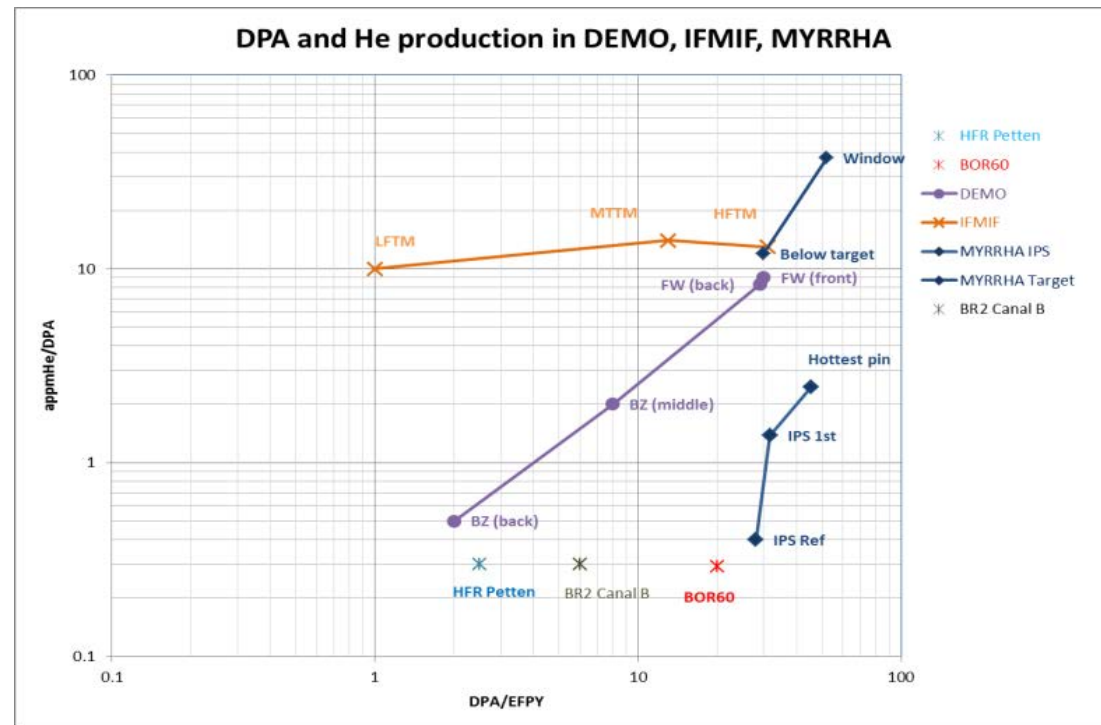
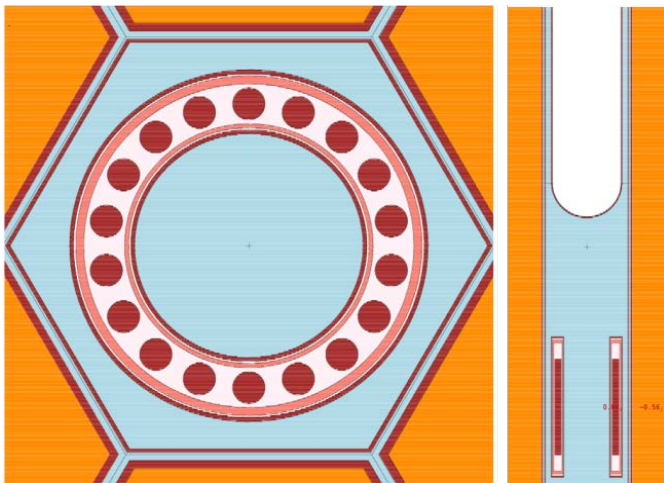


- Si doping
  - Out-of-core
  - Cd ratio
  - Resistivity

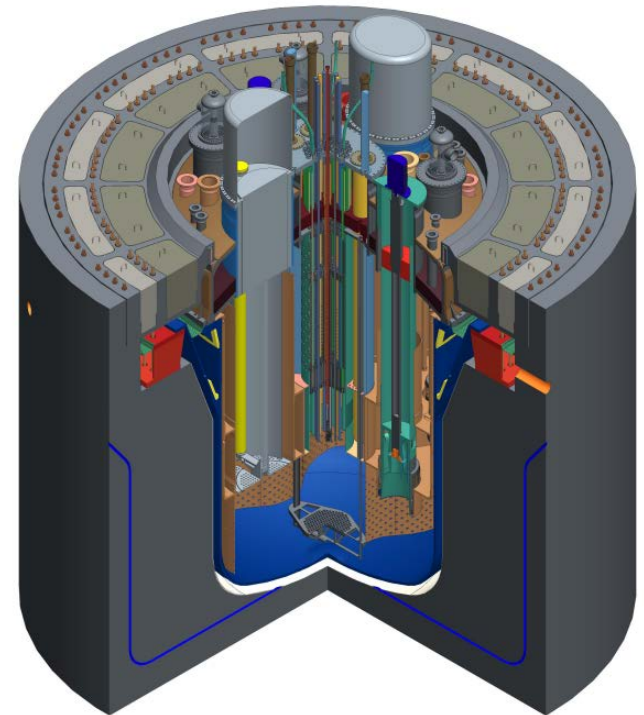


# Irradiation for fusion-like conditions

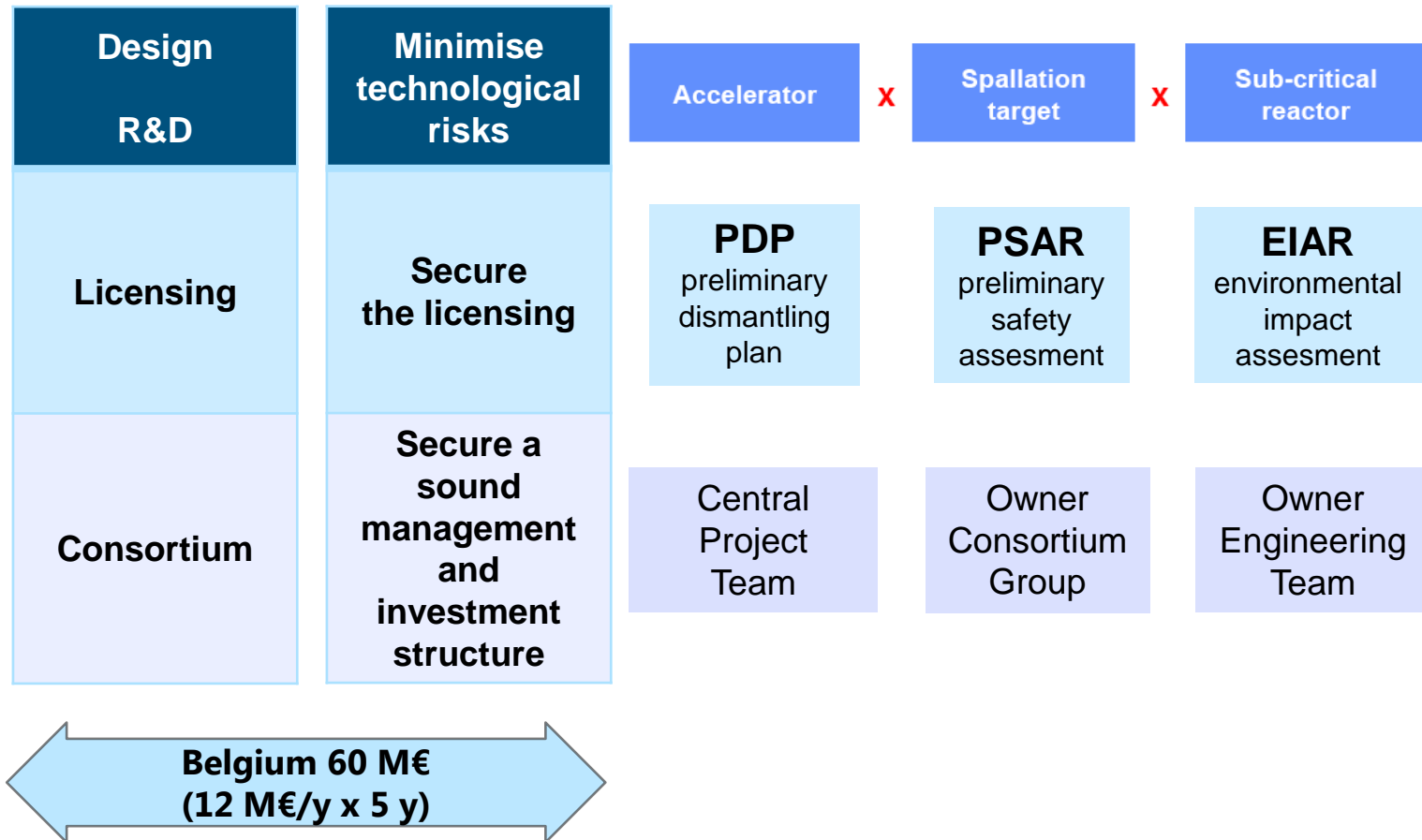
- Below spallation target
  - Very high + hard neutron flux
  - Proton flux
- Irradiation of samples
  - High dpa's & dpa rates
  - High appmHe/dpa rates



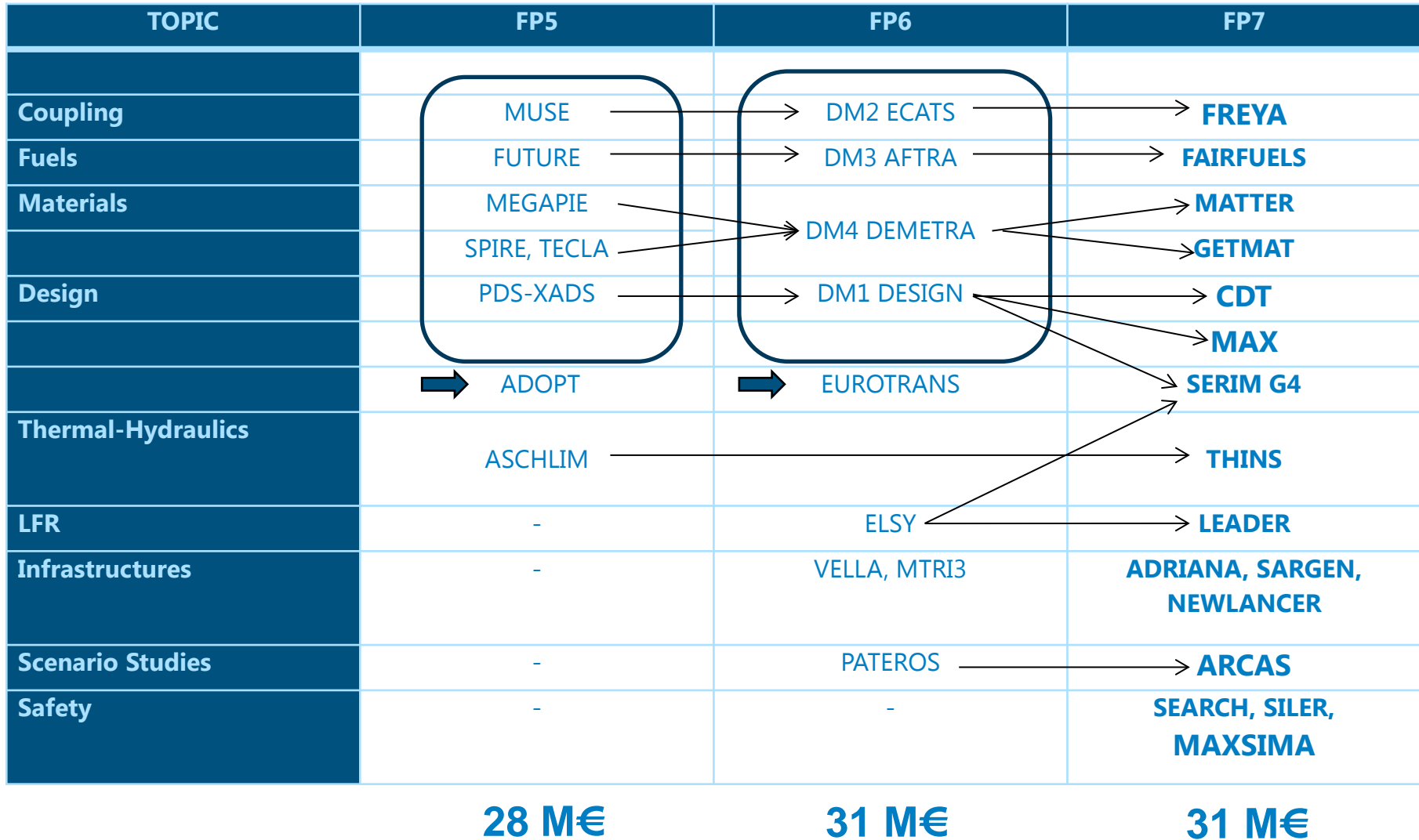
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# Present phase: Pre-Licensing 2010-2014



# P&T inspired many EU FP projects beneficial to MYRRHA



# LBE R&D program

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- LiLiPuTTeR-II
- HELIOS 3
- Heavy Liquid Metal Lab
- MEXICO
- CRAFT
- LIMETS 3
- RHAPTER
- COMPLOT
- ESCAPE
- US lab

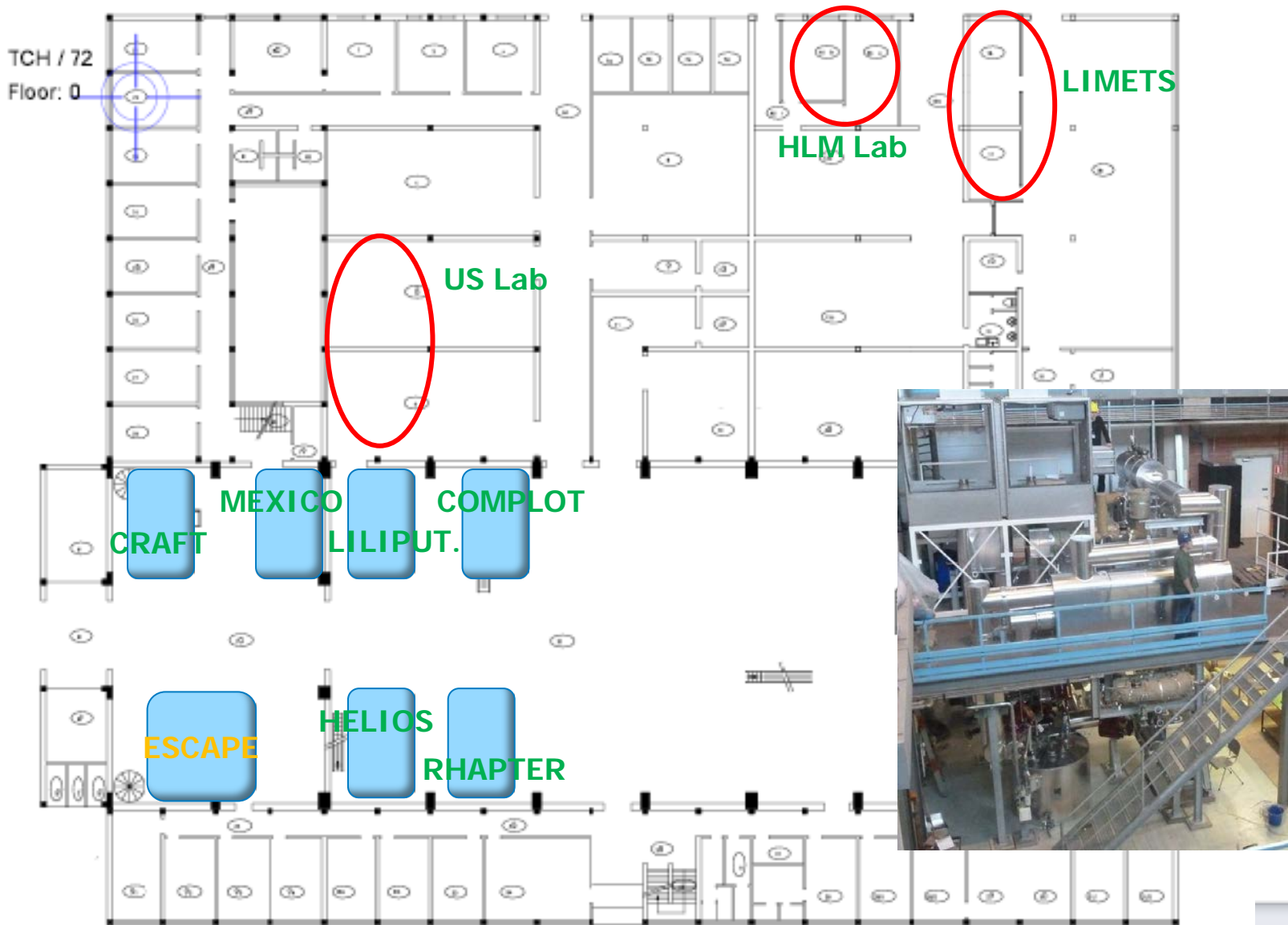
LBE conditioning

Materials

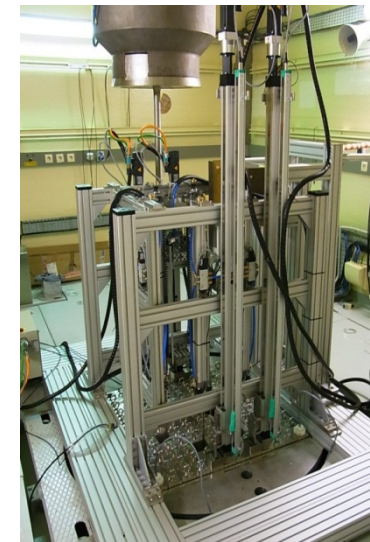
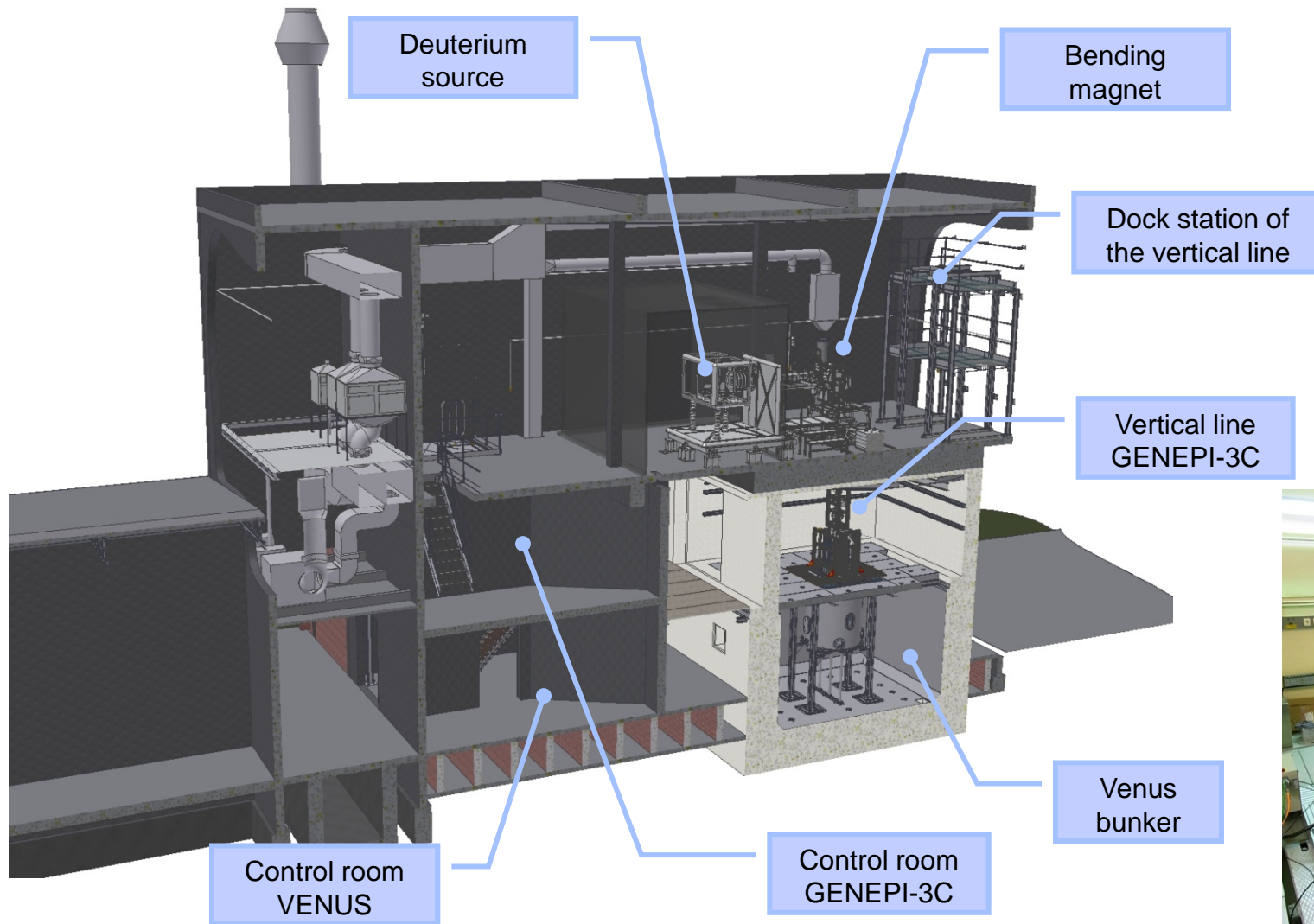
Component testing & TH

Instrumentation

# MYRRHA R&D facilities at SCK•CEN in TCH Building

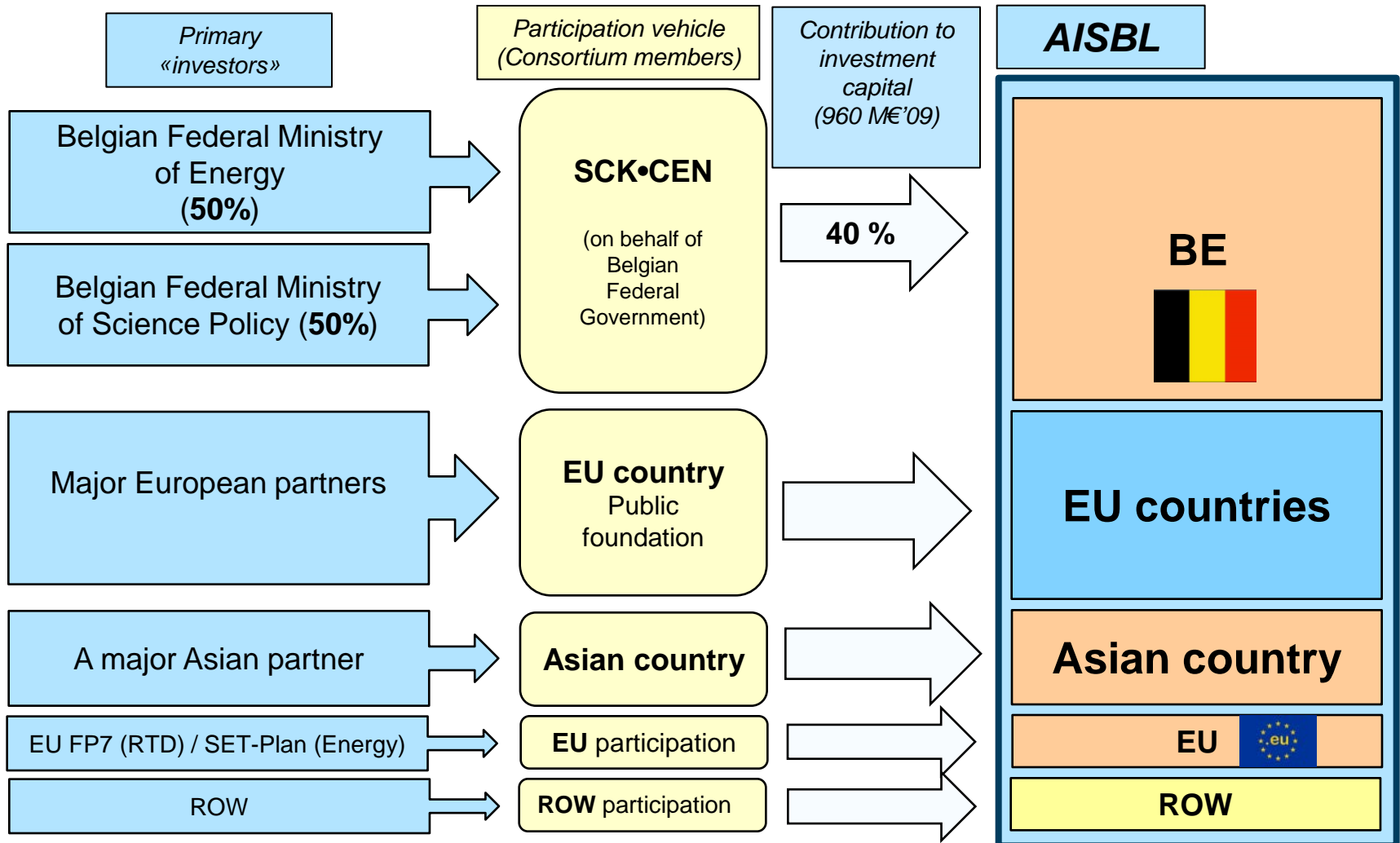


# GUINEVERE @ VENUS Zero-power facility





# International Members Consortium





# European Commission

GÜNTHER H. OETTINGER  
MEMBER OF THE EUROPEAN COMMISSION

Ref. Ares(2014)1045194 - 03/04/2014

Brussels, 03.04.2014  
MvS/cg Ares (2014)593729

Mr Melchior Wathelet  
Secretary of State  
for the Environment, Energy and Mobility  
51, rue de la Loi

1040 Brussels

Dear Mr Wathelet, *verwelkom naar Kollonge!*

It was a great pleasure to meet you again during our visit to the Belgian Nuclear Research Centre of Mol on 18 February last. Please allow me to extend my gratitude to the Belgian delegation for the excellent hospitality and for giving us the opportunity to visit the GUINEVERE installation.

I reconfirm that the European Commission fully recognises the importance of the MYRRHA project, its EU added value and the contribution it will make to ensure that fission continues to play a key role in addressing today's societal challenges in energy and other fields. This state-of-the-art large nuclear research infrastructure will provide European researchers with an excellent instrument to carry out cutting-edge research of relevance to a wide range of applications.



## May 2013

Submission of the report "The MYRRHA ESFRI Project, Excellence in Science Towards Sustainability to tackle societal challenges".

## November 2013

Working meeting between European Commissioner G. Oettinger and Secretary of State M. Wathelet

## 18 February 2014

Visit of European Commissioner of Energy Günther Oettinger and State-Secretaries Melchior Wathelet and Servais Verherstraeten to SCK•CEN

## 3 April 2014

**Letter of European Commissioner of Energy Oettinger expressing support of the EC to MYRRHA**



Japan Atomic Energy Agency (JAEA)

Tokai-mura, Ibaraki 319-1184, JAPAN

### Expression of Interest

Prof. Dr. Hamid Alt Abderrahim  
Deputy Director General SCK-CEN and  
Director MYRRHA Project  
SCK-CEN  
Boeretang 200-2400 Mol  
Belgium  
Phone: + 32 14 33 25 92  
Fax: + 32 14 31 89 36  
E-mail: haitabde@sckcen.be

Dear Prof. Dr. Hamid Alt Abderrahim:

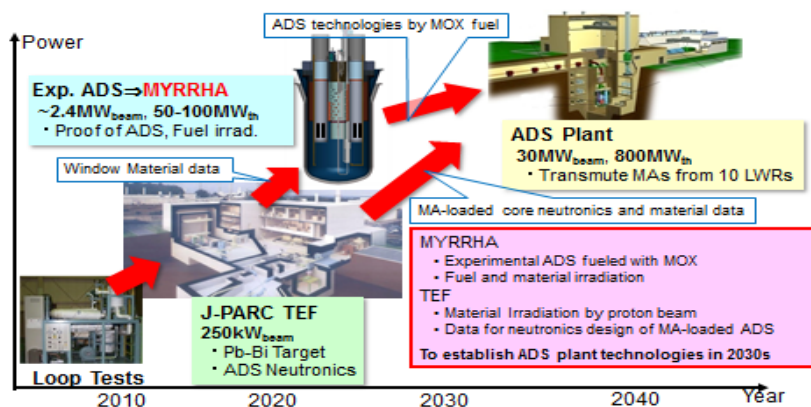
As a response to your letter, dated on January 14, 2013, calling for our participation in the MYRRHA Project, we, the Japan Atomic Energy Agency, would like to express our interest in the project.

According to the "Terms and Conditions of the MYRRHA Offer of SCK-CEN to Candidate Partners", we would like to start the negotiation about the "Commitment Letter" with SCK-CEN. Please be noted, however, that we should start the discussion in parallel with the Japanese Government about the budget plan. It will, therefore, take long time such as more than one year to confirm our contribution level.

We also have a plan to construct the Transmutation Experimental Facility (TEF) as a

Date	Topic
22 Feb. 2013	Submission of a <b>"Letter of Intent"</b> by JAEA for the participation of Japan in MYRRHA
2013	Mutual visits
21-23 Jan. 2014	Visit of to Japan for negotiation with MEXT & JAEA representatives of participation in MYRRHA: <ul style="list-style-type: none"> <li>✓ Form of participation (in-cash/in-kind)</li> <li>✓ Calendar</li> <li>✓ Needed input for MEXT</li> </ul>
19 May 2014	MYRRHA Workshop at the Belgian Embassy in Tokyo <ul style="list-style-type: none"> <li>✓ Attended by more than forty high-level Japanese guests (MEXT, JAEA, Mitsubishi HI, Hitachi Corp. Toshiba-GE, Fuji Electric Comp,, Kyoto University, Tokyo University , Rikken Cyclotron Res. Centre)</li> <li>✓ <b>MYRRHA on JAEA P&amp;T Roadmap</b></li> <li>✓ <b>Negotiation on-going on definition of level of participation</b></li> </ul>

## International Collaboration with MYRRHA





## Partitionierung und Transmutation

> Forschung – Entwicklung – Gesellschaftliche Implikationen

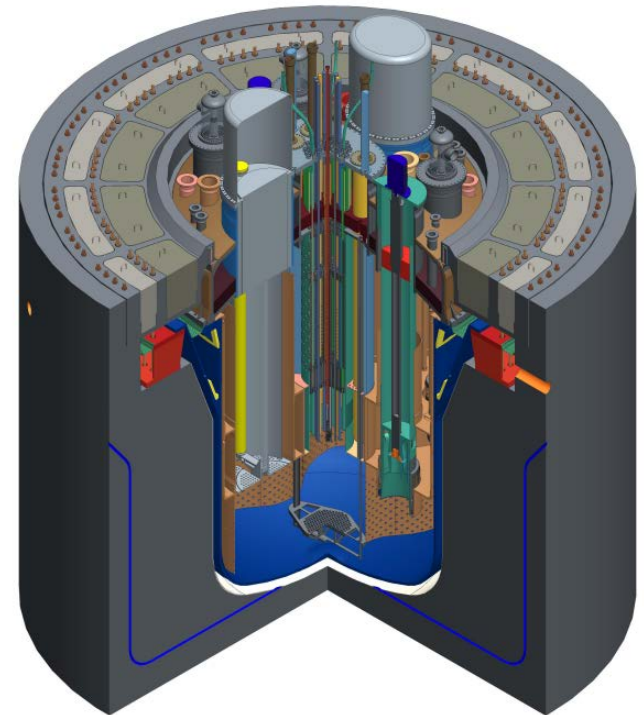
Ortwin Renn (Hrsg.)

> Vorläufiger Projektbericht

Stand: 22. Oktober 2013

- National Committee established to evaluate Partitioning & Transmutation (P&T) as part of the German policy for high level nuclear waste management (with emphasis on the Accelerator-driven systems route)
  - Evaluation panel composed of nuclear scientists, experts in human sciences complemented with three international experts
  - Assessment of added value of participation by Germany in MYRRHA
- Evaluation report published under the leadership of the “*Deutsche Akademie der Technikwissenschaften*” (ACATECH). The report:
  - Expresses support to P&T as a technology for HLW management;
  - Proposes to continue research in Germany in an international context
  - Expresses preference for the ADS option at R&D level
- **Decision by Federal Ministry of Education and Research (“Bundesministerium für Bildung und Forschung”, BMBF) anticipated by end of 2014**

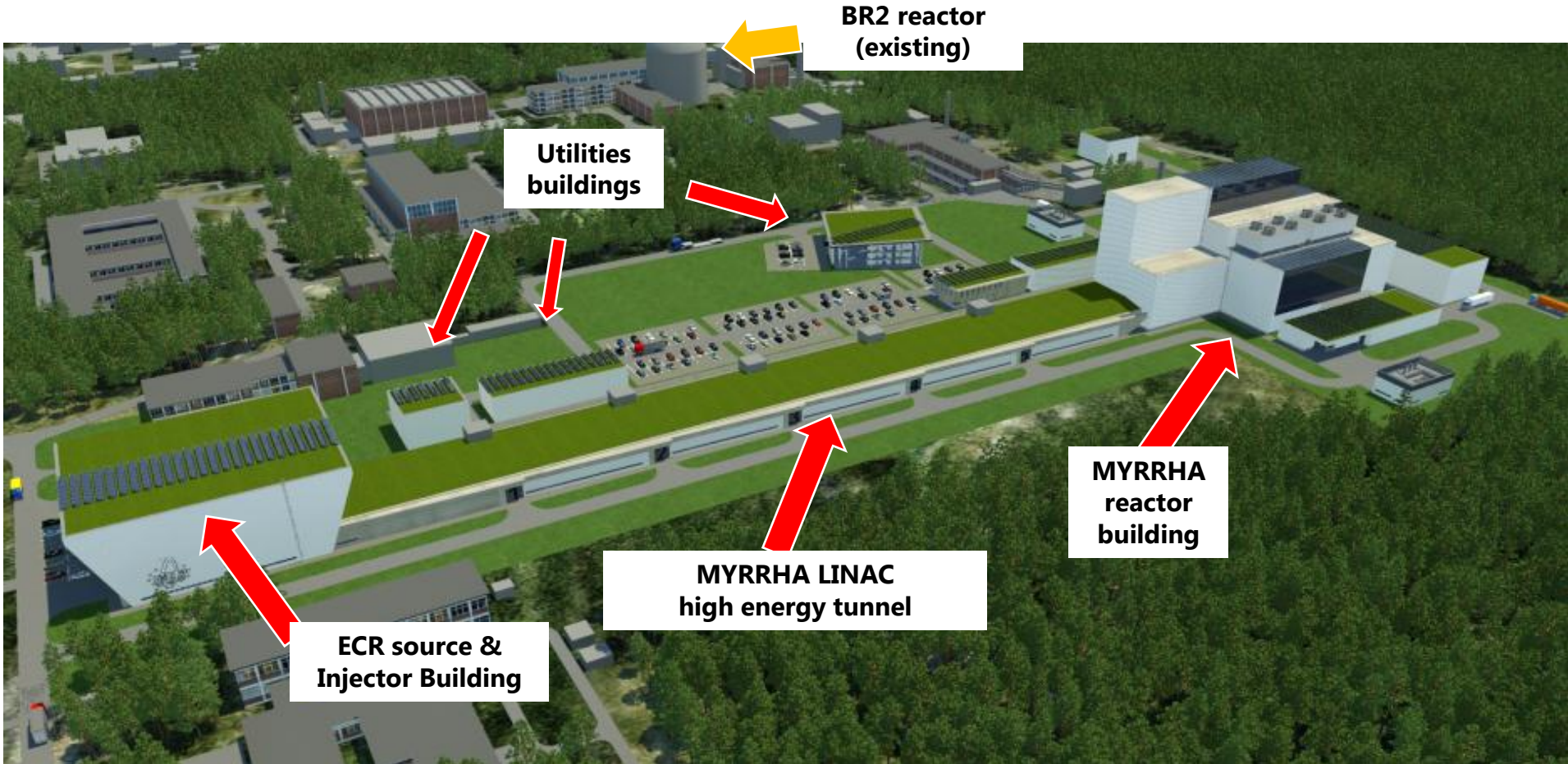
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# MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM

An international, innovative and unique facility at Mol (BE)

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Centre d'Etude de l'Energie Nucléaire  
Belgian Nuclear Research Centre

Stichting van Openbaar Nut  
Fondation d'Utilité Publique  
Foundation of Public Utility

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STUDIECENTRUM VOOR KERNENERGIE  
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE