



MYRRHA

Multipurpose hYbrid Research Reactor for High-tech Applications
&
Its role in the European Strategy for P&T

Marc DIERCKX on behalf of Prof. Dr. Hamid AÏT ABDERRAHIM
SCK•CEN / MYRRHA

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MEGAPIE Technical Review Meeting, October 23 2014, Bregenz



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

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- Why MYRRHA?
- What is MYRRHA?
- R&D and Design partners network of MYRRHA
- Present status: Design, Licensing, support R&D and Consortium
- MYRRHA project planning
- Conclusion

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SCK•CEN: background

Studiecentrum voor Kernenergie
Centre d'Étude de l'énergie Nucléaire

SCK•CEN more info ☆

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2400 Mol, Belgium
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sckcen.be
1 review



Directions Search nearby Save to map more ▾



BR3

1st PWR
outside USA



MOX

Innovative
nuclear fuel



BR2

#1 performing
MTR in Europe



HADES

1st underground
lab for R&D on HL
waste disposal



GUINEVERE

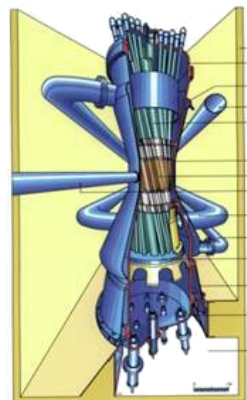
1st lead based
ADS



MYRRHA

1st project for
transmutation of
nuclear waste

MYRRHA in Belgium to replace BR2



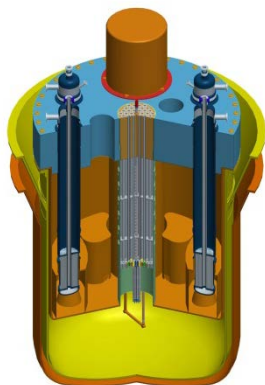
1962

BR2

Material
Testing Reactor
(fission)

Fuel testing
for LWR &
GEN II/GEN III

Irradiation
Services:
- Medical RI
- Silicium Doping
- Others



2026

MYRRHA

Fast Neutron
Material
Testing Reactor
(fission + fusion)

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

Irradiation
Services:
- Medical RI
- Silicium Doping
- Others

Fuel testing for
LFR GEN IV

LFR European Technology Pilot Plant (ETPP)

What are the challenges for Nuclear R&D in EU?

- Attract new talents and Educate & Train them,
- Keep high level of competency in nuclear technology in Belgium,
- 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 the European scene

Knowledge
Economy



27.11.2010
Confirmed on ESFRI
priority list projects

10.12.2010
Included in NuPECC
Long Range Plan

NuPECC: The Nuclear
Physics European
Collaboration
Committee

ESFRI: European Strategic
Forum for Research
Infrastructure

Energy
Independence

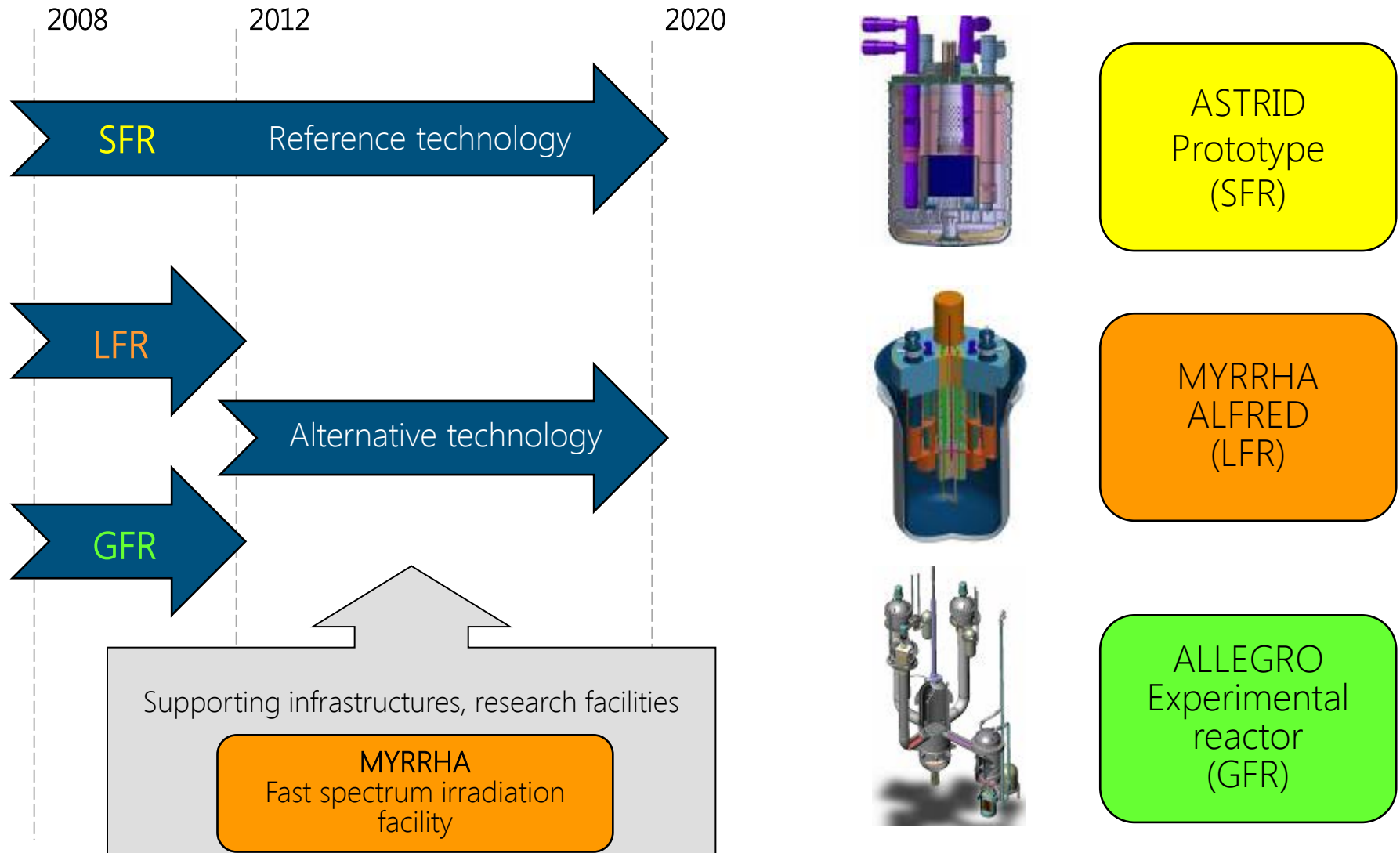


15.11.2010
in ESNI
(SNETP goals)

ESNI: European Sustainable Nuclear Industrial Initiative
SNETP: Sustainable Nuclear Energy Technology Platform

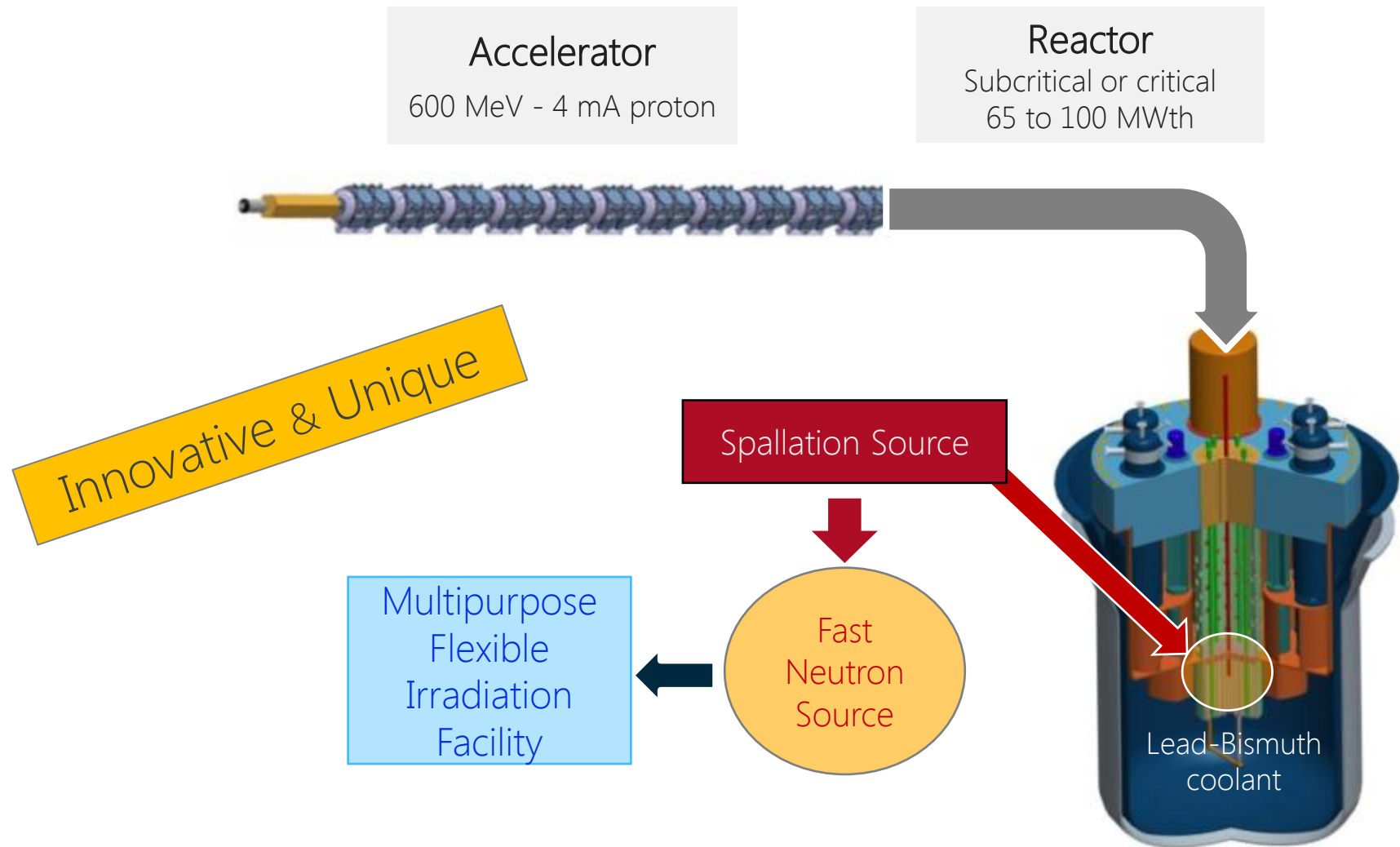
MYRRHA as part of the ESNII

ESNII: European Sustainable Nuclear Industrial Initiative



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MYRRHA - Accelerator Driven System



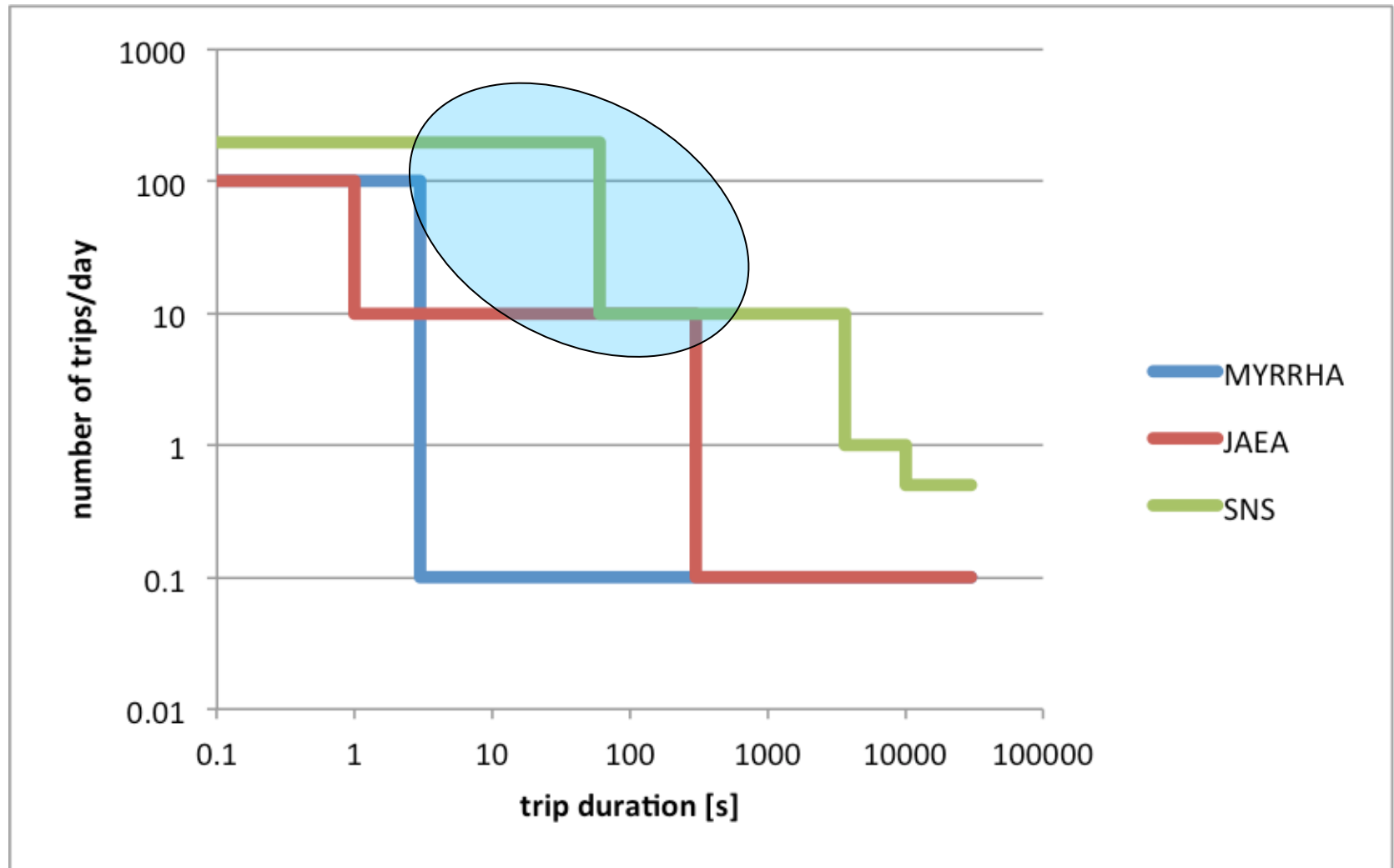
MYRRHA Accelerator: beam characteristics

→ High power proton beam (up to 2.4 MW)

Proton energy	600 MeV
Beam current	0.1 to 4.0 mA
Repetition rate	CW, 250 Hz
Beam power stability	< $\pm 2\%$ on a time scale of 100ms
Beam footprint on reactor window	Circular $\varnothing 85\text{mm}$
Beam footprint stability	< $\pm 10\%$ on a time scale of 1s
allowed beam trips longer than 3 sec	< 10 trips per 3 month operation
allowed beam trips longer than 0.1 sec	< 100 trips per day
allowed beam trips shorter than 0.1 sec	unlimited

→ Extreme reliability level: MTBF > 250 hrs

About beam trips



MYRRHA Accelerator: design key-points



WANTED
Dead or Alive

- **Reliable**: extremely high Mean Time Between Failures (MTBF) > 250 hrs
- **Continuous**: CW beam delivery
- **Powerful**: 1 to 4 mA beam current, high power

"It's not that I'm so smart, it's just that I stay with problems longer."

A. Einstein

● **Superconductivity**:

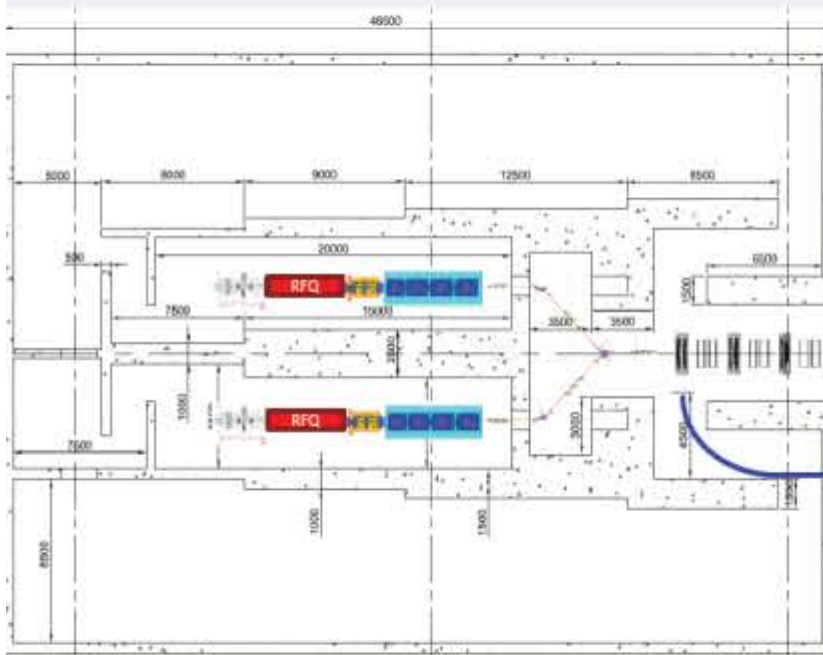
- access to large accelerating gradients (operation margins)
- large beam apertures with small losses
- lower power consumption in CW
- high beam current handling
- compact machine

● **Fault Tolerance**:

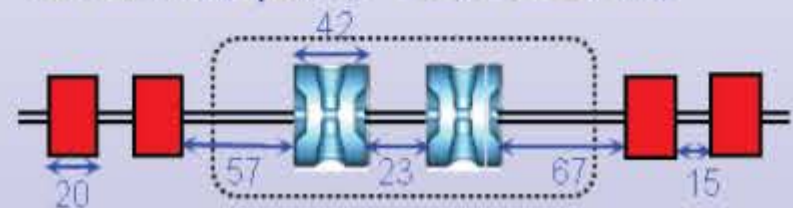
- **Solid design**: robust optics, use components far from their technological limits, modularity
 - Solid State (SS) RF amplifiers
 - Modular DC power supplies
 - Digital Low Level RF (LLRF) control
- **Redundancy**, with
 - Parallel scheme in the injector: frozen optics
 - Serial scheme in the High Energy LINAC: modular structures
- **Repairability** (short MTTR) to guarantee high availability

D. Vandeplasseche, Proc. IPAC 2011

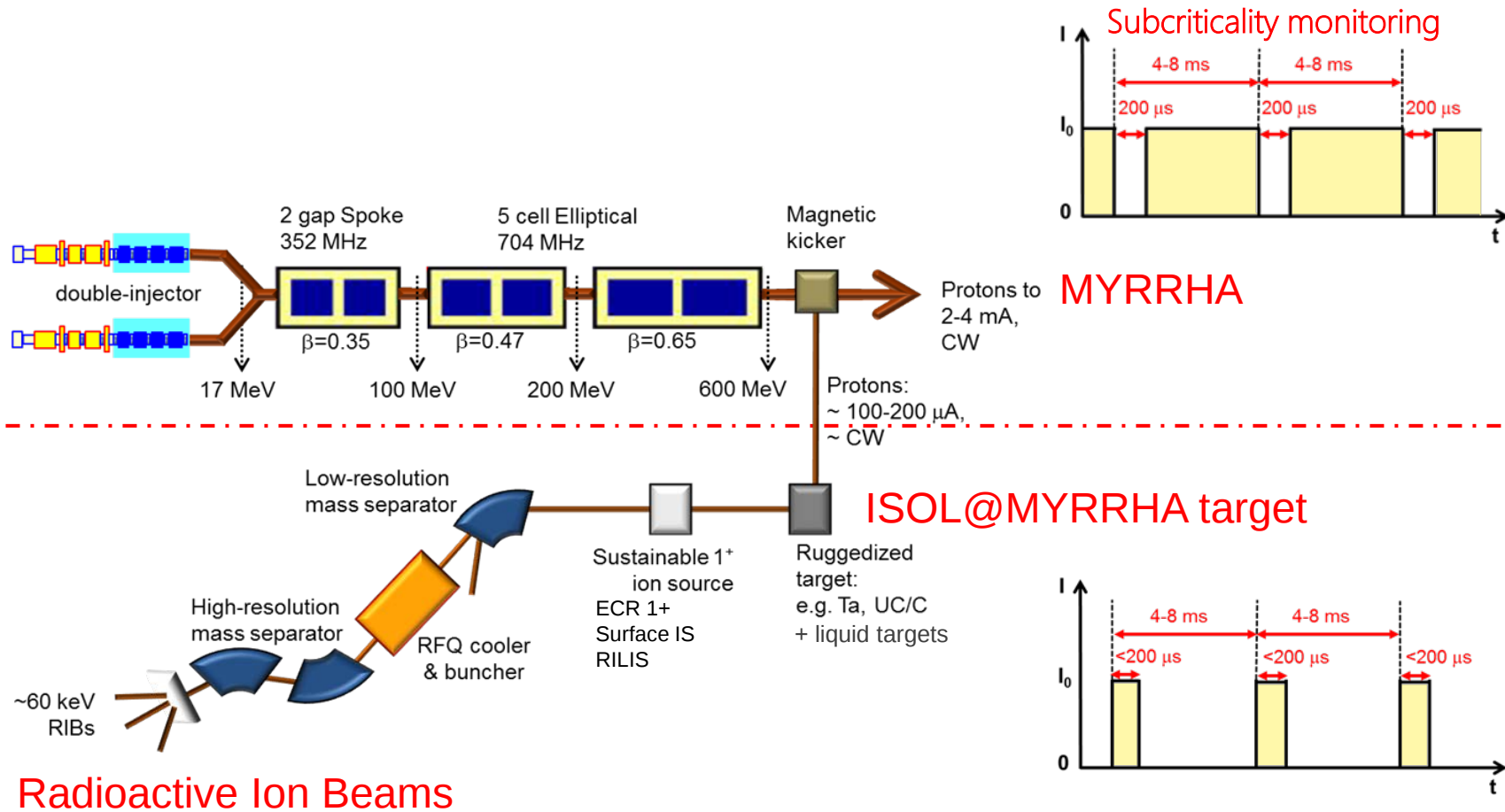
INJECTOR BUILDING



Section #1 (Spoke $\beta \sim 0.35$ @ 352 MHz)

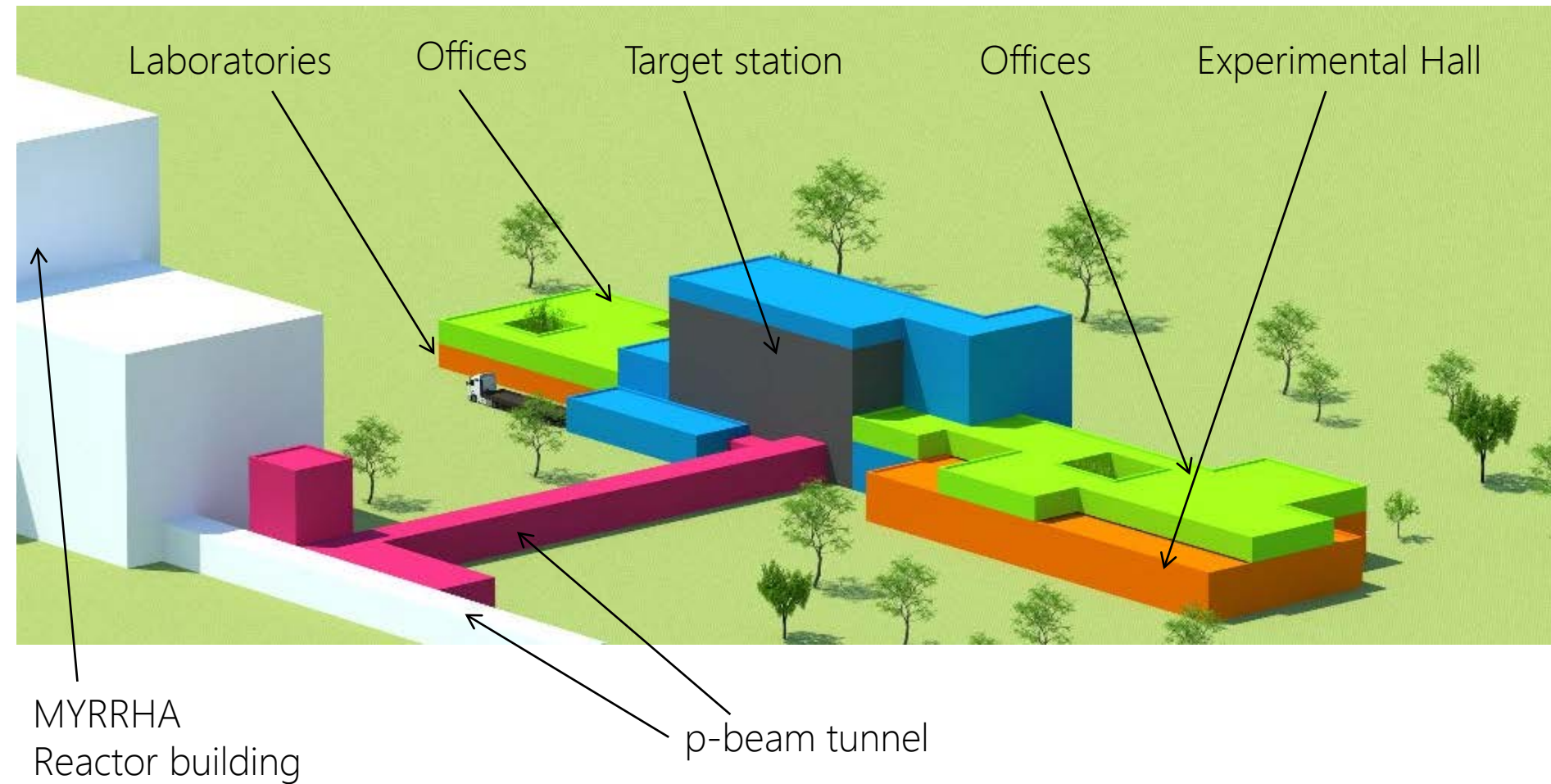


ISOL@MYRRHA - Concept

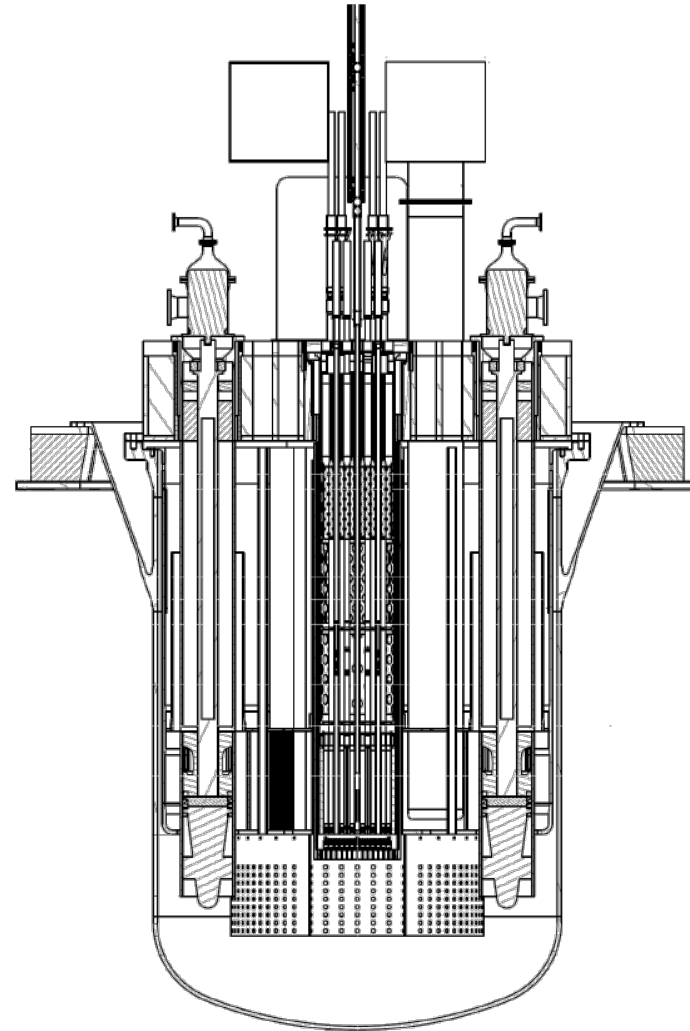
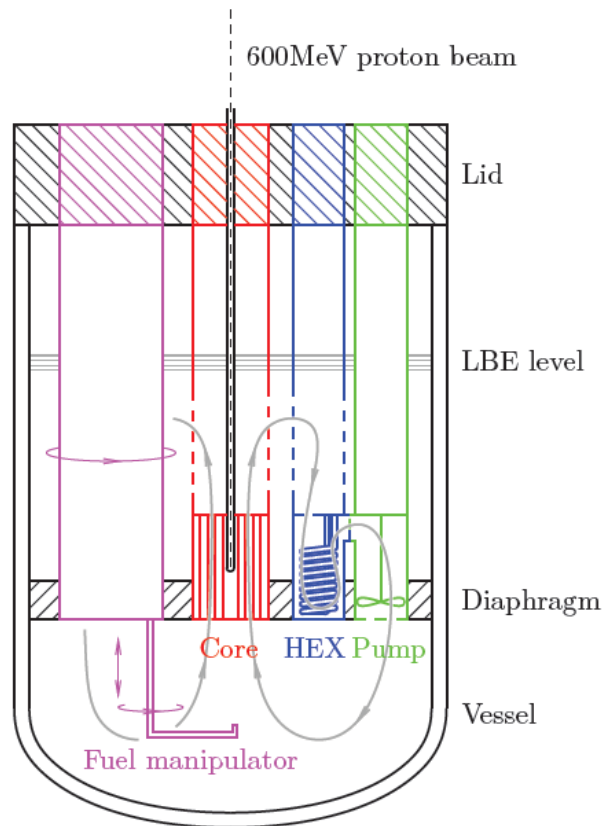


Radioactive Ion Beams

ISOL@MYRRHA - 3D view



MYRRHA Reactor layout

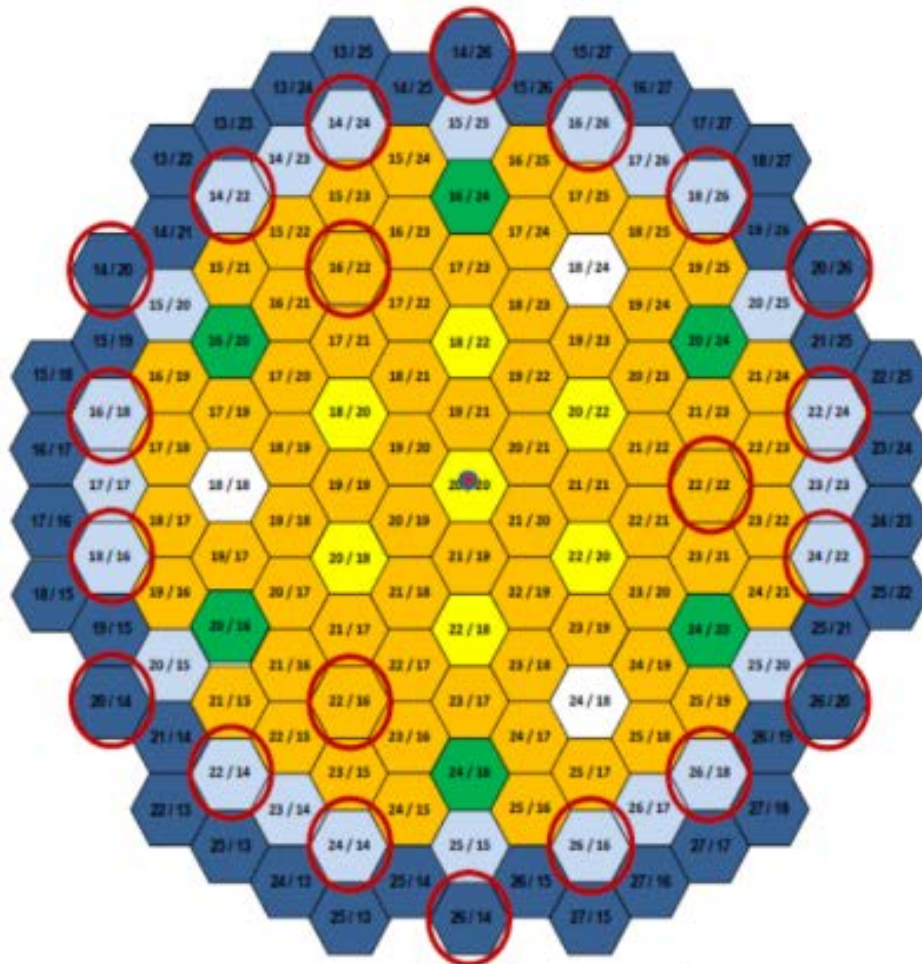


MYRRHA Reactor layout

- Reactor vessel
- Reactor cover
- Core support structure
 - Core Barrel
 - Core Support Plate
 - Jacket
- Core
 - Reflector assemblies
 - Dummy assemblies
 - Fuel assemblies
- Spallation target assembly and beam line
- Above core structure
 - Core plug
 - Multifunctional channels
 - Core restraint system
- Control rods, Safety rods, Mo-99 production units
- Primary heat exchangers
- Primary pumps
- Si-doping facility
- Diaphragm
 - IVFS (in-vessel fuel storage)
- In-vessel fuel handling system
 - IVFHM (in-vessel fuel handling machine)



MYRRHA Core and Fuel Assemblies

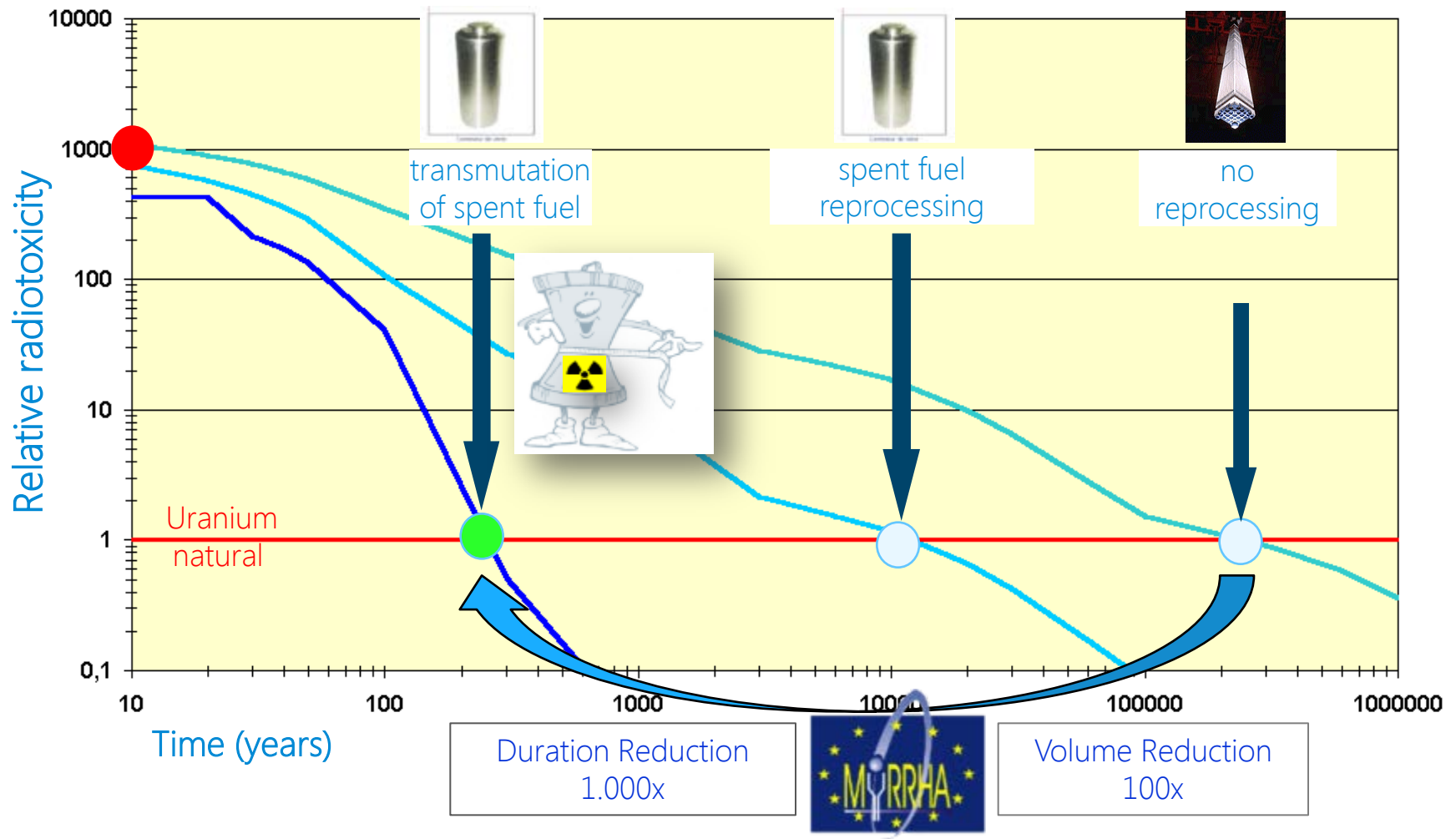


-  69 FAs
 -  7 (central) IPS
 -  6 CR (buoyancy)
 -  3 SR (gravity)
 -  24 "inner" Dummy (LBE)
 -  42 "outer" Dummy (YZrO)
- 151 S/As

 Additional positions available for inserts from the top (21/37)

Come with acceptable solutions for HLW

Motivation for transmutation



MYRRHA contributes to the European Strategy for P&T

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”:

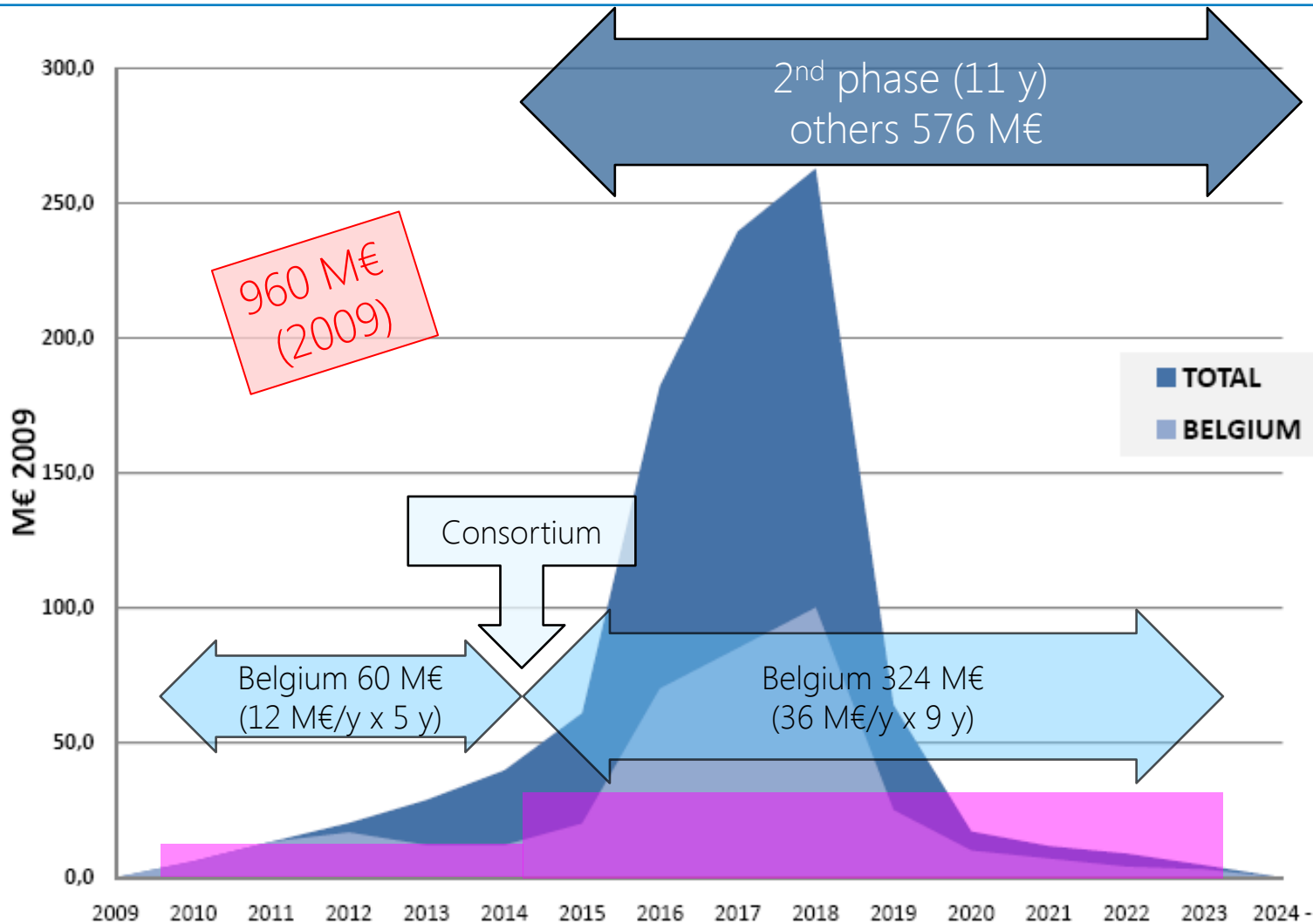
1. Demonstration of the capability to process a sizable amount of spent fuel from commercial LWRs in order to separate plutonium (Pu), uranium (U) and minor actinides (MA)
2. Demonstration of the capability to fabricate at a semi-industrial level the dedicated fuel needed to load in a dedicated transmuter, (JRC-ITU)
3. Design and construction of one or more dedicated transmuters
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: R&D international network



Belgian commitment: secured International consortium: under construction



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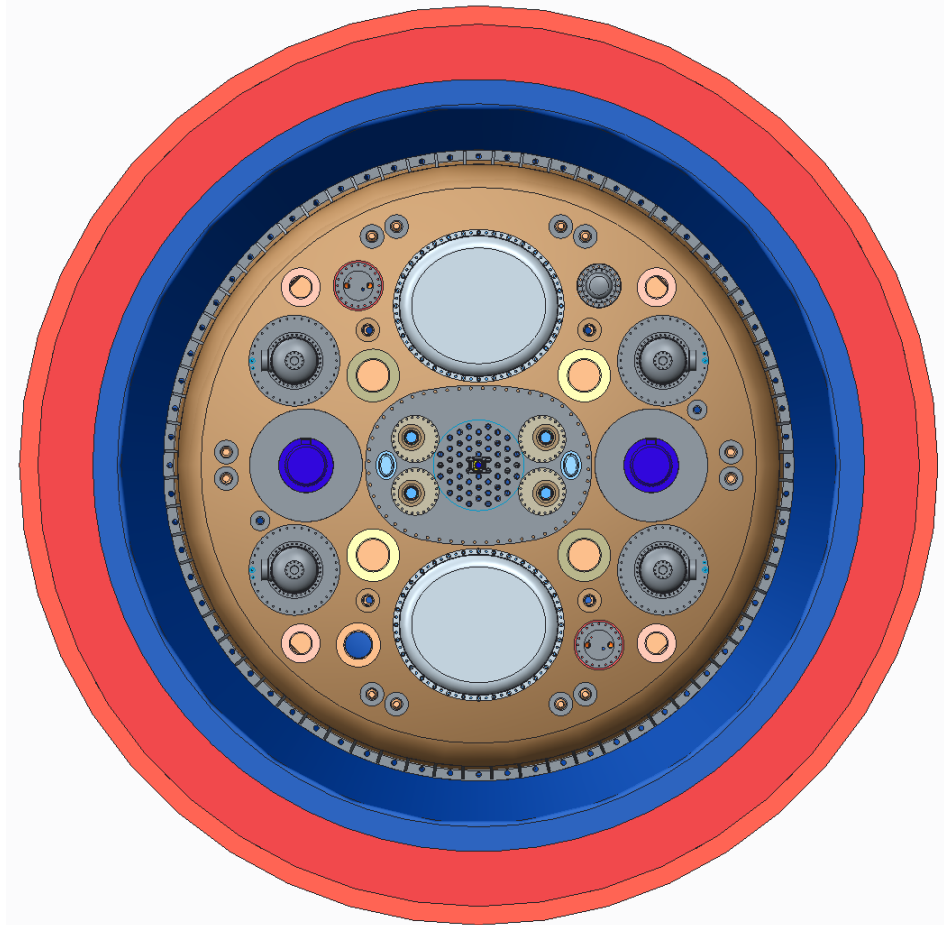
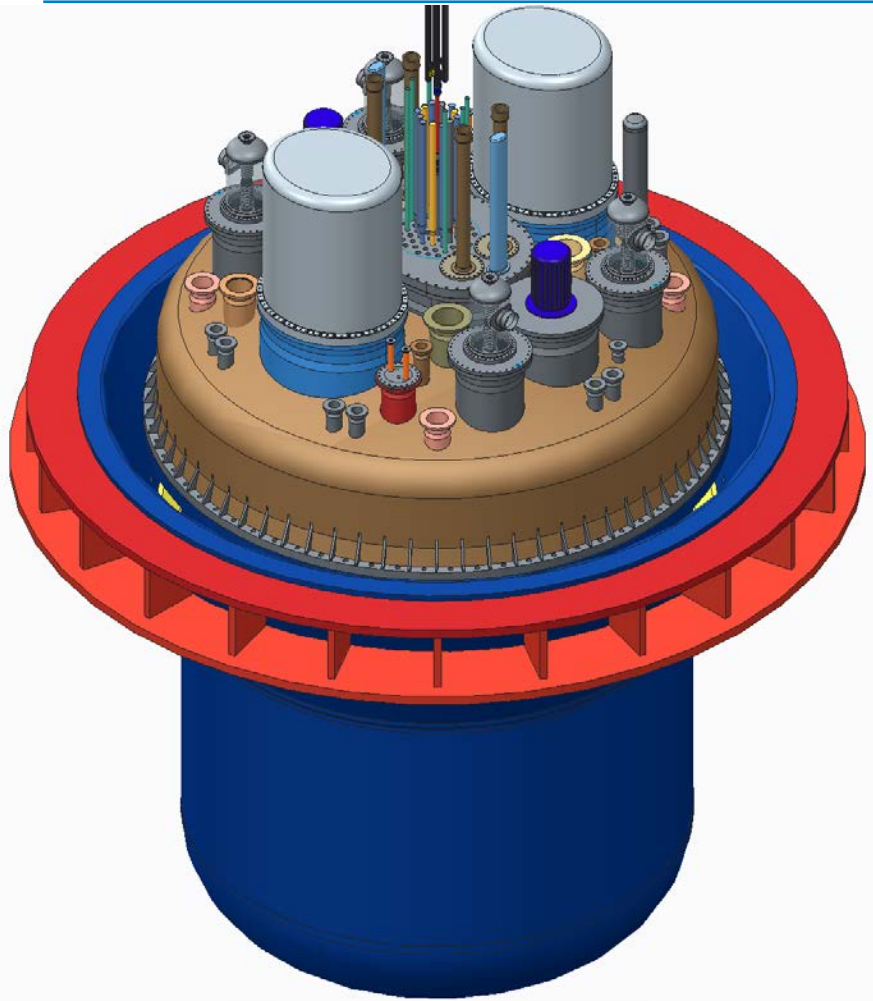


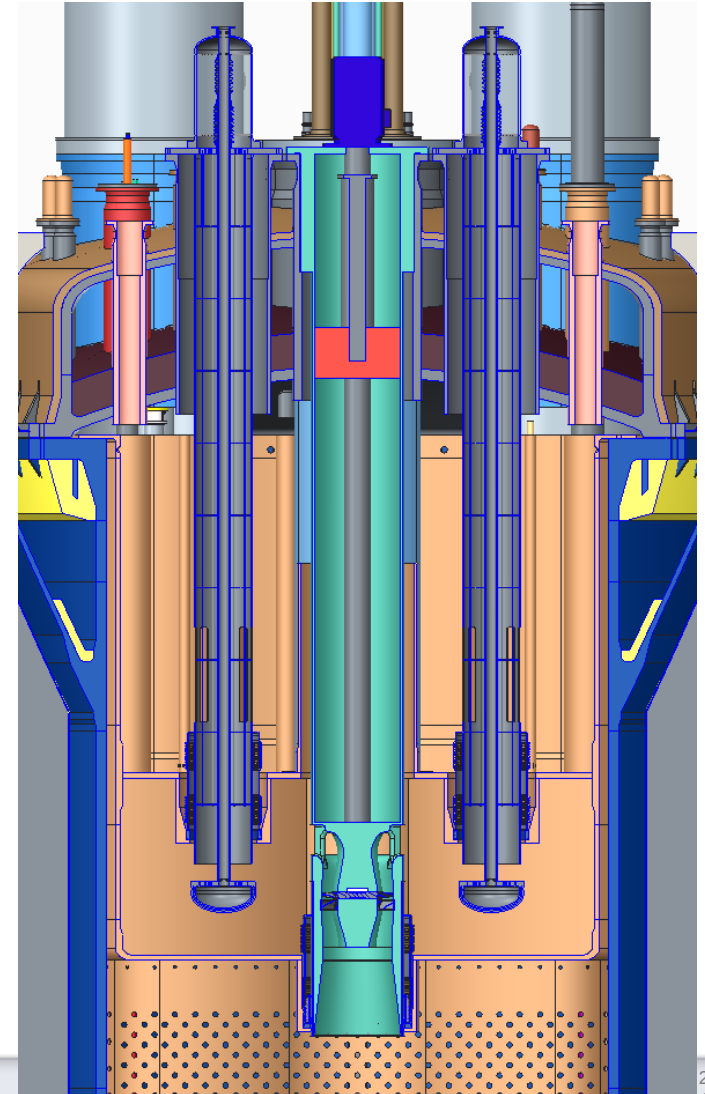
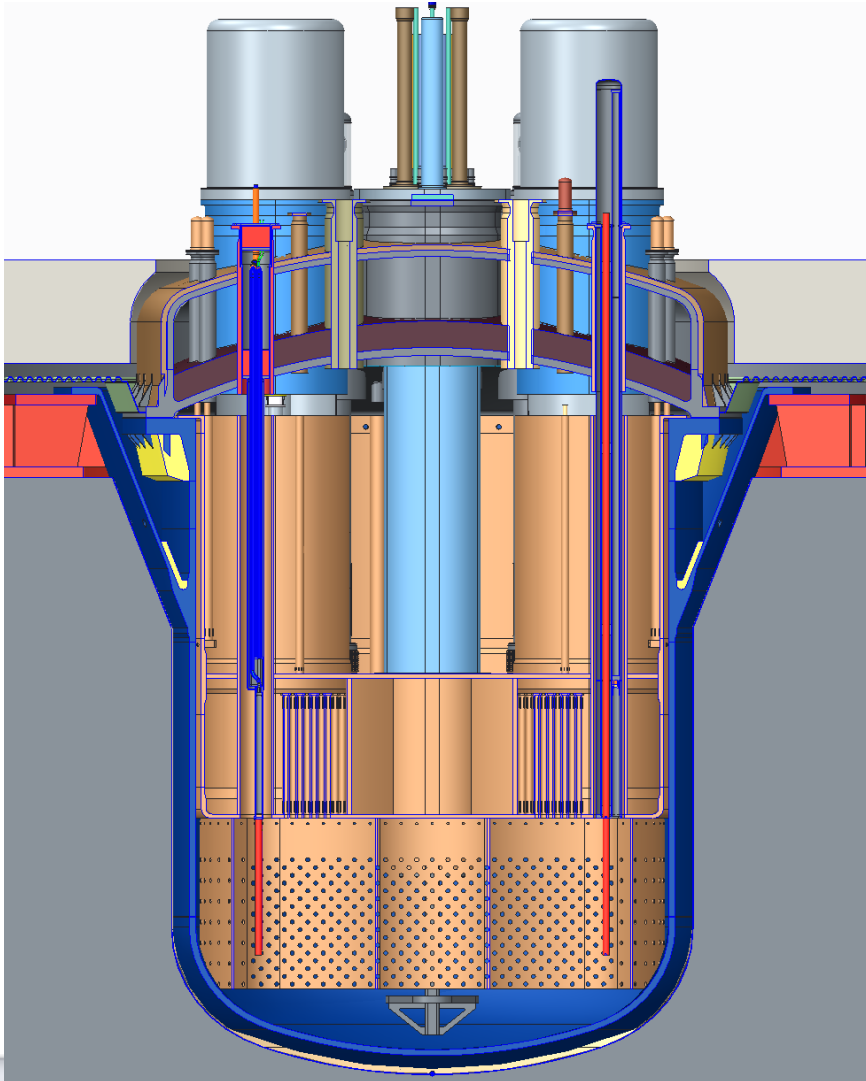
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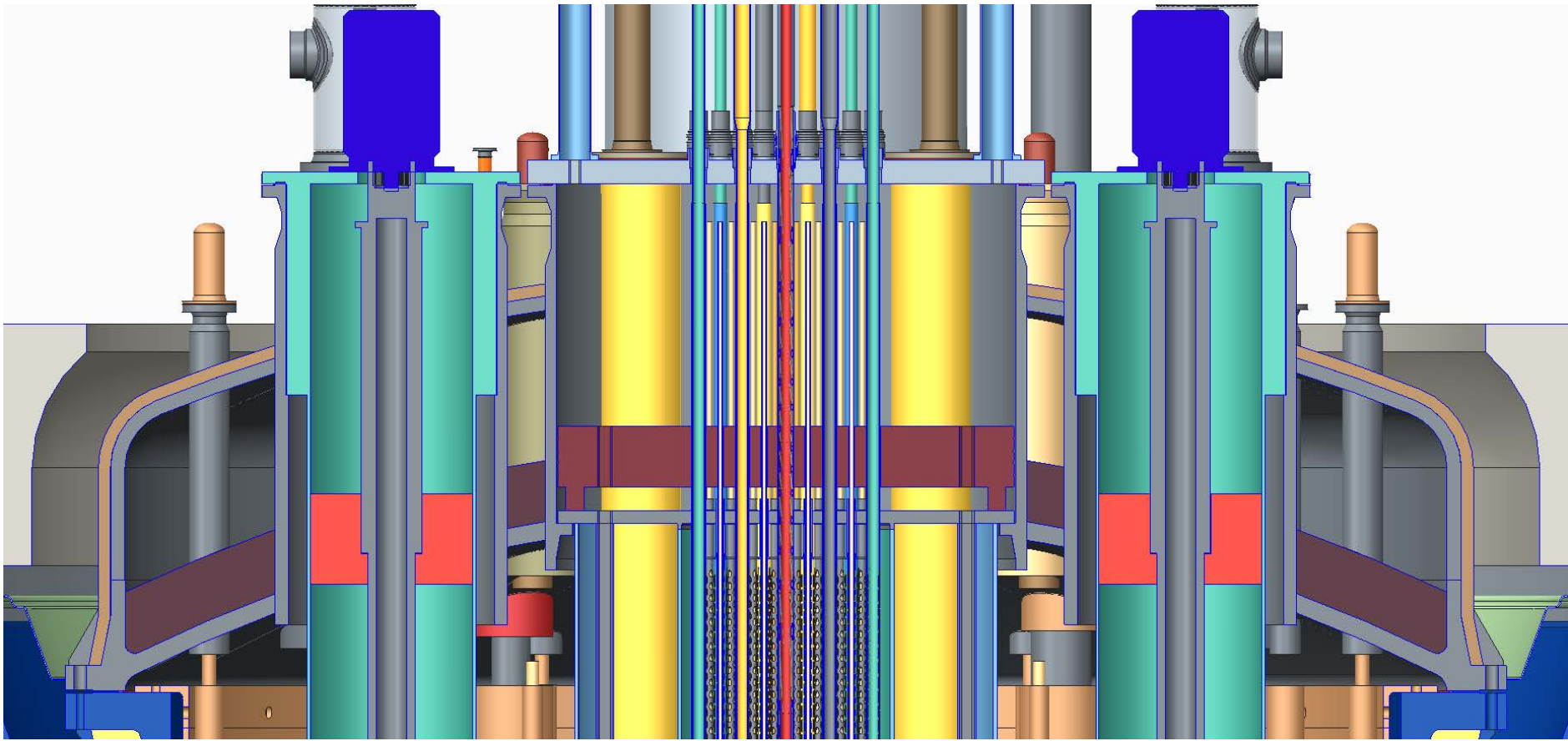
Current status

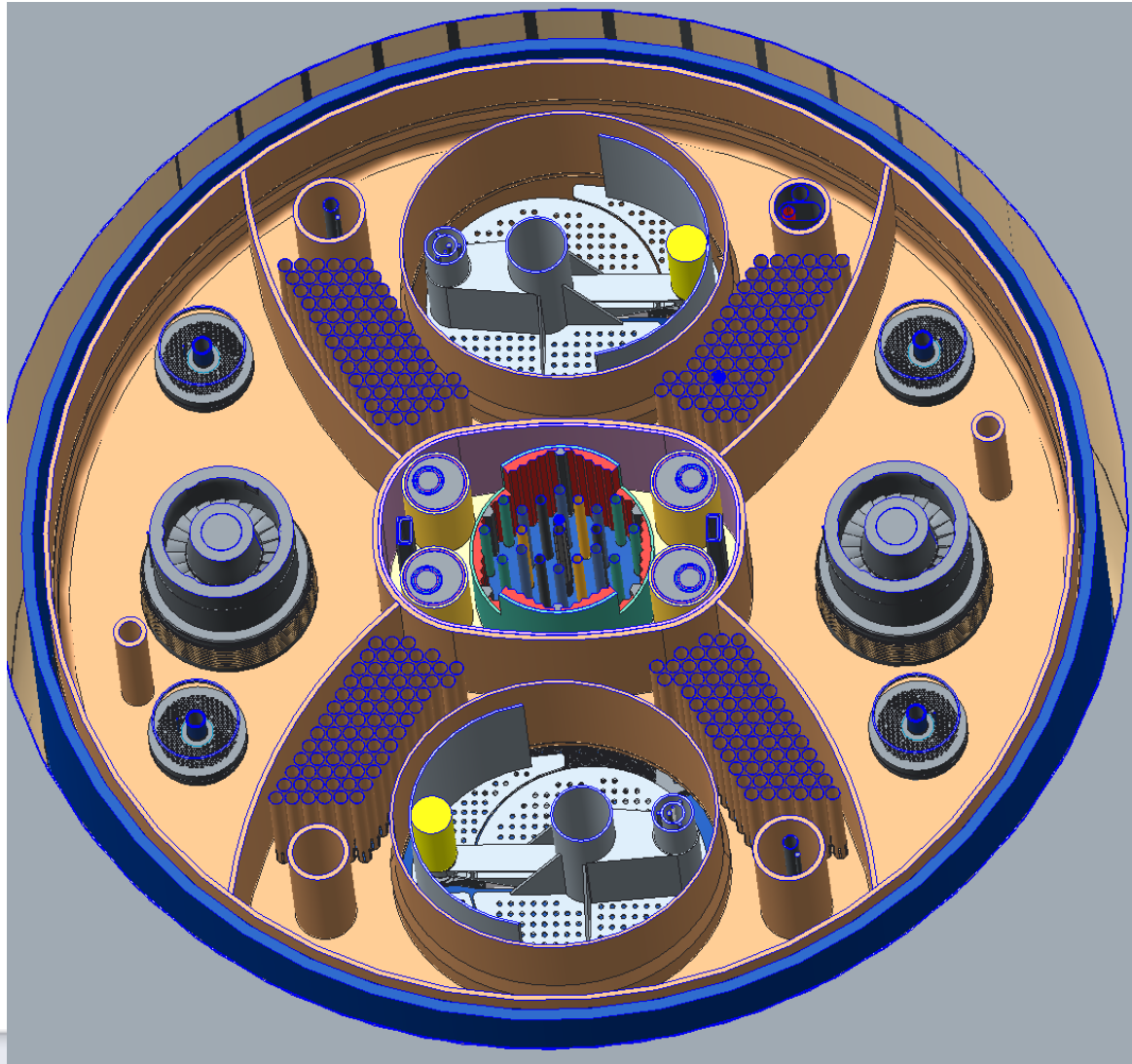
MYRRHA

Primary System Design
revision 1.6



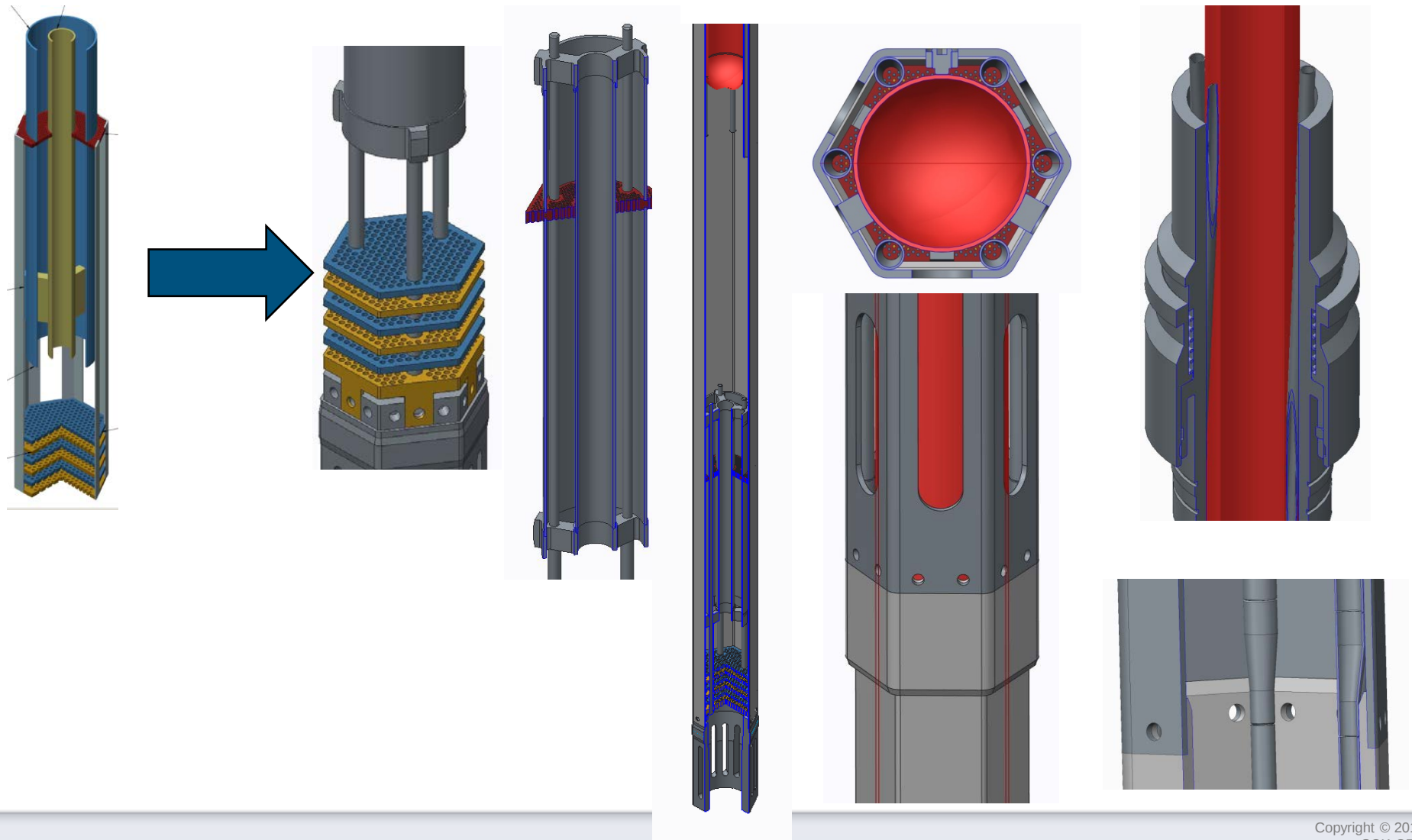






MYRRHA rev. 1.6

Spallation target





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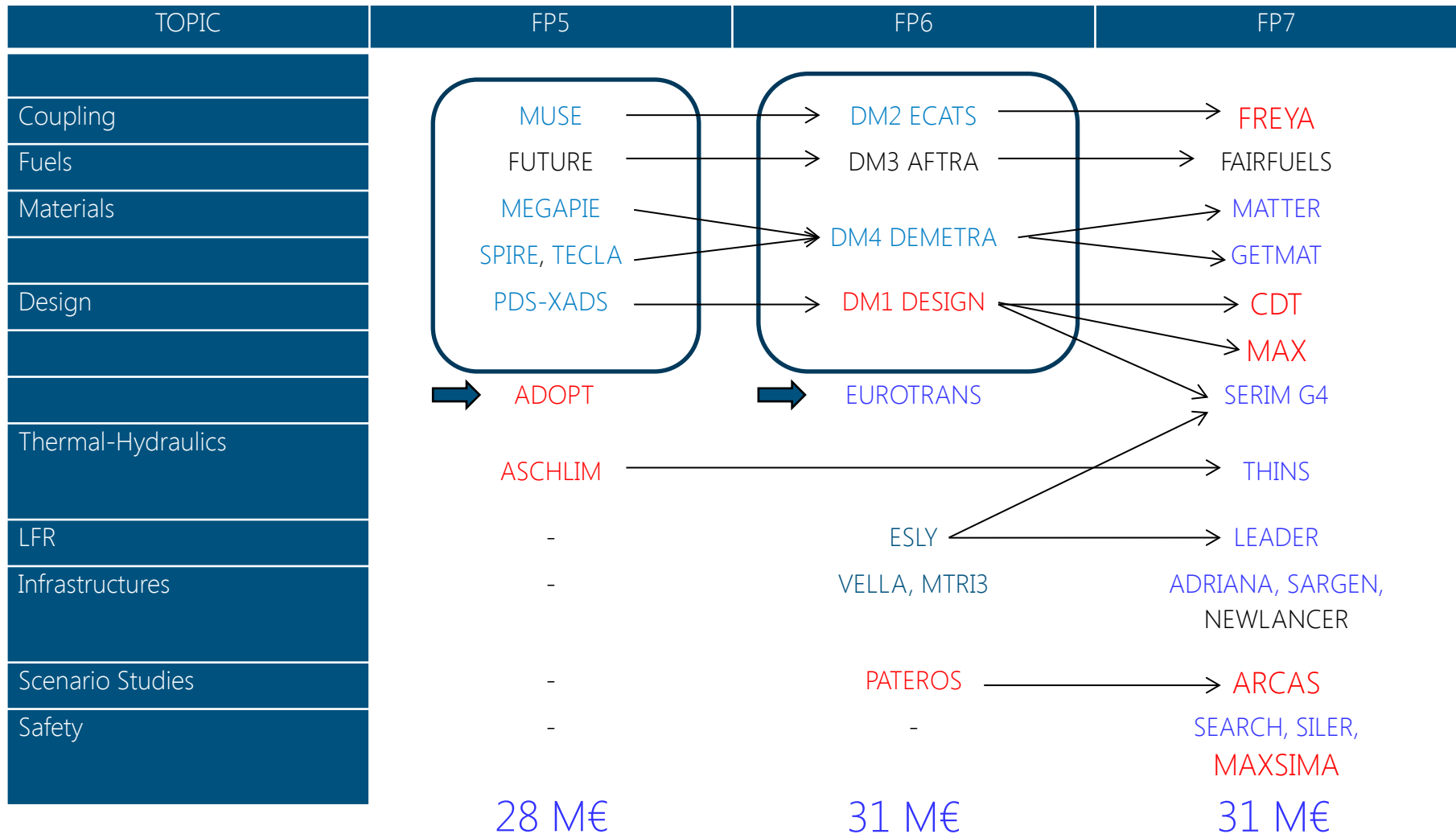
Current status

MYRRHA R&D Support Programme

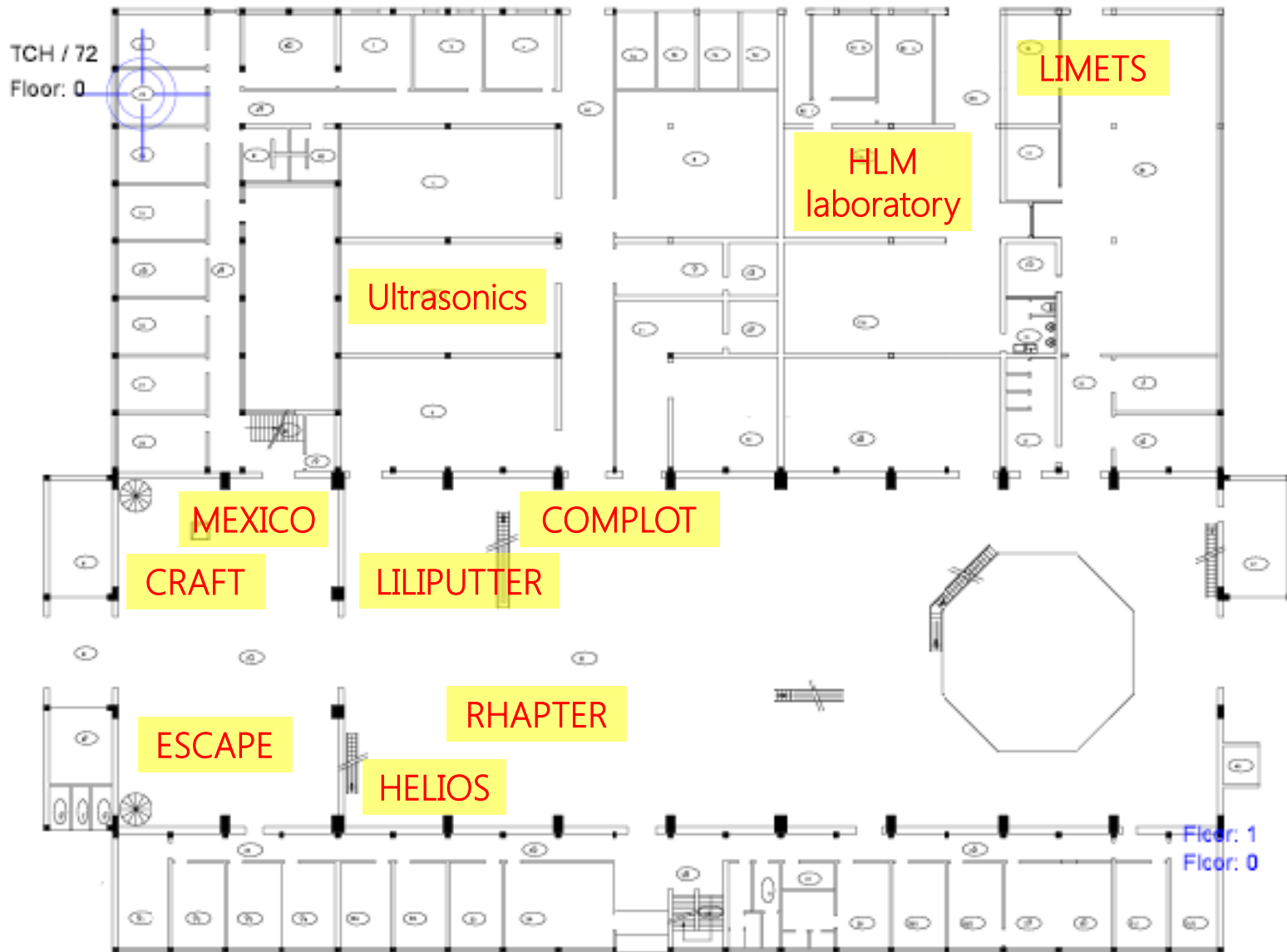
MYRRHA R&D support Programme

- At European Commission level
 - FP (5, 6, 7) projects & H2020 (WP2014-15: NFRP-9)
- At international bilateral level
 - France (CNRS, CEA), Germany (KIT, FZR, FZJ, IAP-FU),
 - Italy (ENEA, ANSALDO Nuc, INFN), Spain (CIEMAT),
 - Japan (JAEA), Korea (NUTRECK-SNU),
 - Kazakhstan(NNC, Kazatomprom), ...
- At Belgian level
 - Federal Government (BELSPO)
 - Regional (VL, WL, BXL) R&D funding organisations
 - FWO, IWT, FNRS
 - Bilateral agreements with universities

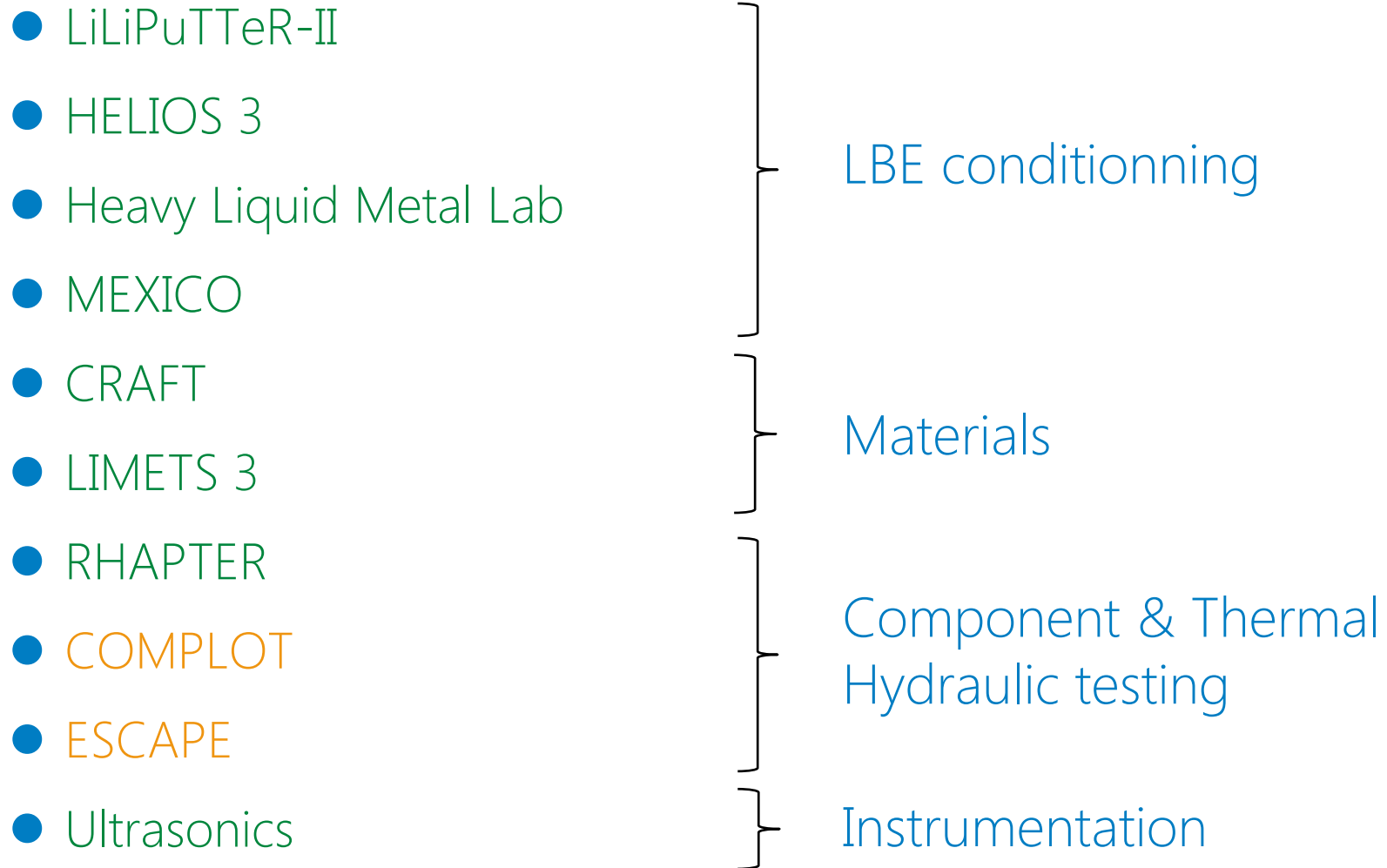
P&T inspired many Euratom FP projects that were/are beneficial to MYRRHA



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



R&D subjects related HLM technology



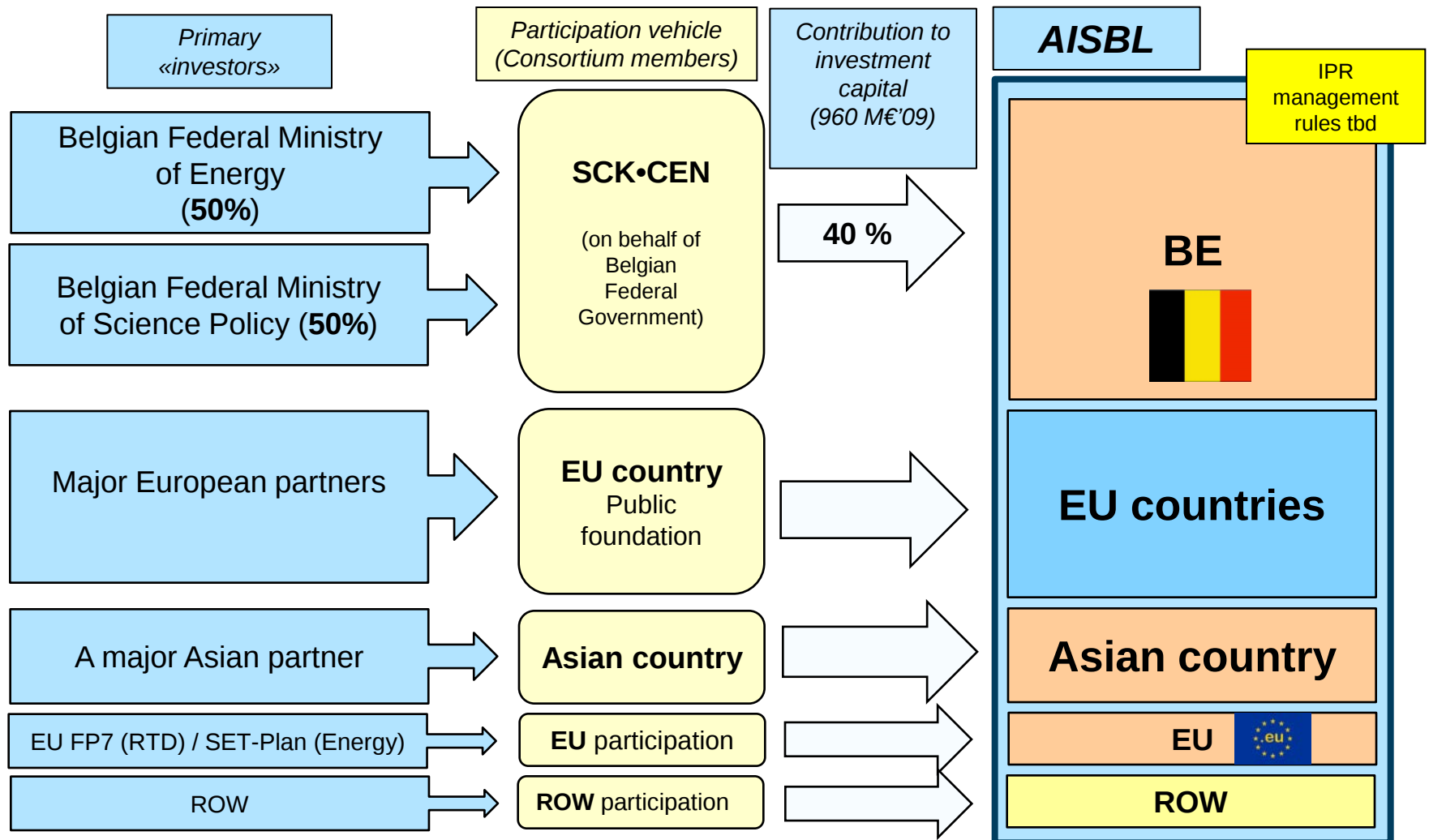


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CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Current status

MYRRHA
International Consortium

International Members Consortium



MYRRHA Consortium status update

European Commission



GÜNTHER H. OETTINGER
MEMBER OF THE EUROPEAN COMMISSION

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 New College!*

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.

As you know MYRRHA has been included in the European Strategy Forum on Research Infrastructures (ESFRI) 2010 Roadmap. The Commission has supported MYRRHA so far through the Euratom Framework Programme with around 6 Million Euro. As regards future

European Commission

➤ 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



European Commission

- Funding of the FP7 project **MARISA**
 - Bring the MYRRHA project to the degree of maturity needed to start construction
 - Establishing of MYRRHA consortium, development of a legal and financial framework, integration and coordination of scientific and technical work, deployment of instruments for the management of the MYRRHA project during construction
 - Financial support: € 3.260.000 at full cost (3 years)
- Dedicated call published in the framework of the Horizon-2020 programme
 - Anticipated budget of € 7.000.000 to € 9.000.000.
- Access for MYRRHA to the Risk-sharing the Horizon 2020 EURATOM programme
 - Discussed at CE Fission Committee meeting of 22 May 2014
 - Project financing through a loan provided by the European Investment Bank (EIB)

EURATOM – WORK PROGRAMME 2014-2015

NFRP 9 – 2015: Transmutation of minor actinides (Towards industrial application)

Specific Challenge: The elimination or transmutation of minor actinides is a key to the sustainability of the back-end of the fuel cycle. Further research is needed in order to demonstrate the feasibility of transmutation of high-level waste at industrial scale. Advanced experimental tests as well as numerical simulation tools will be required to conduct this interdisciplinary research encompassing basic as well as applied sciences. The technological and economic performance of transmutation in a fast neutron facility should also take into account the other possible uses of the equipment, e.g. for the production of radioisotopes or material testing for nuclear fission and fusion applications.

Scope: This research should contribute to the further development of state-of-the-art critical or sub-critical fast neutron installations for transmutation. Due consideration should be given to the actual effectiveness of the transmutation process, as for example by using accelerator driven systems, as well as the safety and reliability of the facility and the demonstration of the industrial feasibility of the process. The development of innovative fuel and targets for the

MYRRHA Consortium status Japan



Japan Atomic Energy Agency (JAEA)
Tokai-mura, Ibaraki 319-1184, JAPAN

Expression of Interest

Prof. Dr. Hamid Ait Abderrahim
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Director MYRRHA Project
SCK•CEN
Boeretang 200-2400 Mol
Belgium
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Fax: + 32 14 31 89 36
E-mail: haitabde@sckcen.be

Dear Prof. Dr. Hamid Ait 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 Phase-2 program of J-PARC. We wish both projects, MYRRHA and TEF, can collaborate to lead the worldwide research activities on the transmutation technology to reduce the burden of radioactive waste management.

Best regards,

February 22, 2013
Atsuyuki Suzuki

President
Japan Atomic Energy Agency
Tokai-mura, Ibaraki 319-1184
JAPAN
Phone : +81-29-282-1122

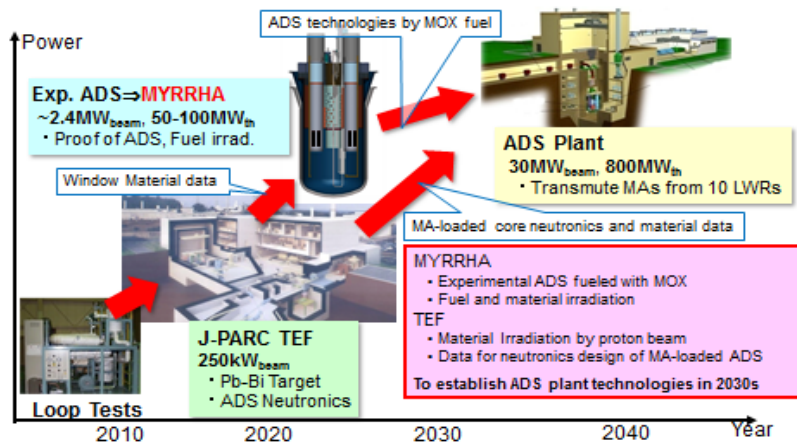
Date	Topic
22 Feb. 2013	Submission of a "Letter of Intent" by JAEA for the participation of Japan in MYRRHA
21-24 Apr. 2013	Meeting between MEXT and SPF Economy
21-22 May 2013	Visit of Dr Hideaki YOKOMIZO (Exec. Director of JAEA) to SCK•CEN
26-29 Nov. 2013	Visit of SCK•CEN to Japan for negotiation of participation in MYRRHA

MYRRHA Consortium status Japan



Date	Topic
21-23 Jan. 2014	Visit of HAA to Japan for negotiation with MEXT & JAEA representatives of participation in MYRRHA: ✓ Form of participation (in-cash/in-kind) ✓ Calendar ✓ Needed input for MEXT
19 May 2014	MYRRHA Workshop at the Belgian Embassy in Tokyo ✓ 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) ✓ MYRRHA on JAEA P&T Roadmap ✓ Negotiation on-going on definition of level of participation

International Collaboration with MYRRHA



MYRRHA Consortium status Germany



- 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

 **acatech**
DEUTSCHE AKADEMIE DER
TECHNIKWISSENSCHAFTEN

Partitionierung und Transmutation

> Forschung – Entwicklung – Gesellschaftliche Implikationen

Ortwin Renn (Hrsg.)

> Vorläufiger Projektbericht

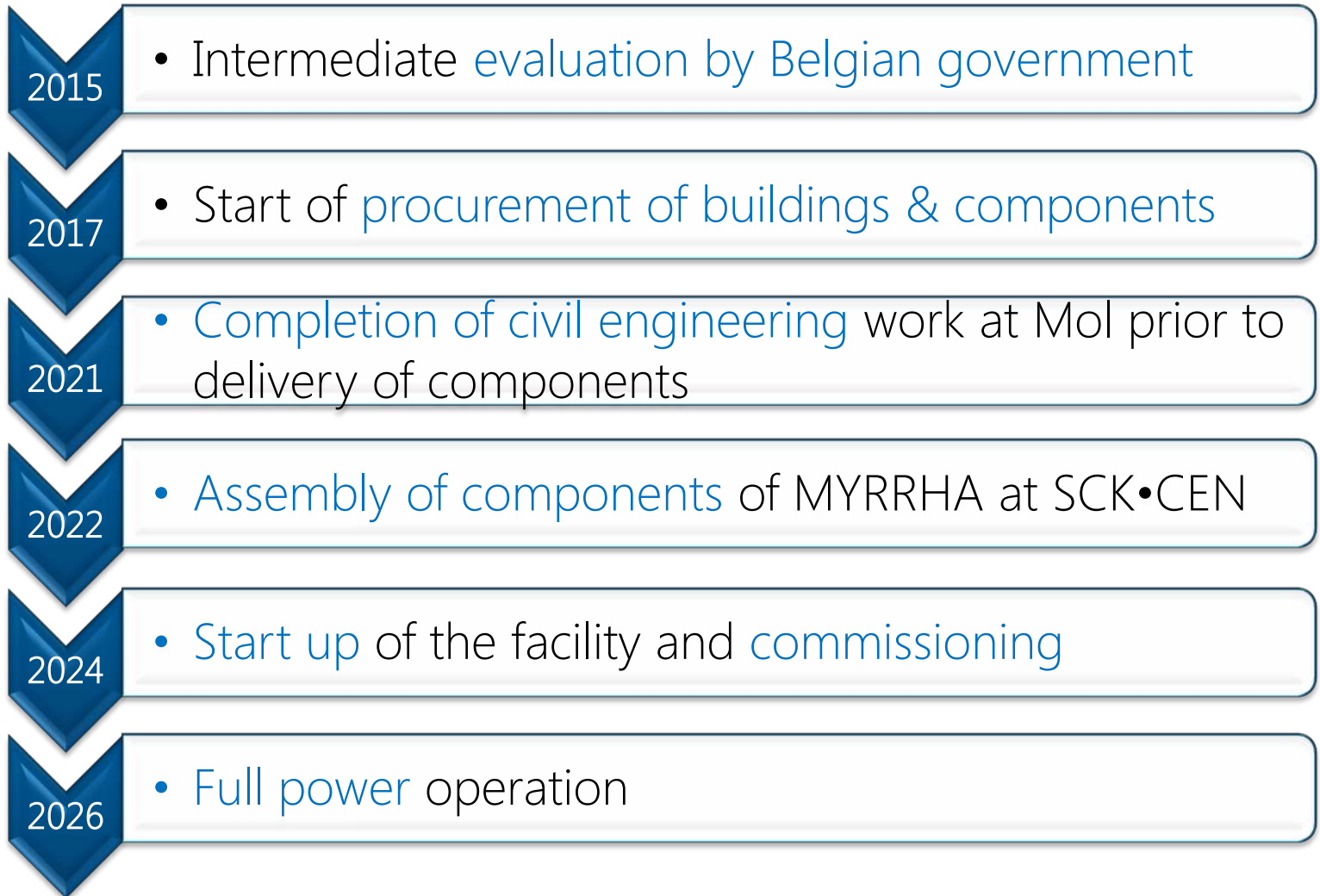
Stand: 22. Oktober 2013

Next steps for Consortium

- Finalise support/commitments from the following partners :
 - EC (3 meetings between BE Gov./EC), visit of Commissioner G. Oettinger with BE State Secretary of Energy to SCK•CEN on 18.2.2014
 - Japan (EoI received Feb. 2013, negotiations on-going with MEXT/JAEA)
 - Germany (Evaluation report published, decision expected mid-2014)
- Continue negotiations with :
 - China (EoI sent on Aug. 2012, negotiations on-going at CAS level)
 - South Korea (EoI since 2010, negotiations with MEST & MKE)
 - France (negotiation with major R&D actors and Ministry of Research)
 - UK (negotiation with DECC & major R&D and industrial actors)
- Potential: Italy, Poland, Romania, Sweden, **USA**
- Finalise the AISBL statutes with the help of the EU legal services and EIB assistance

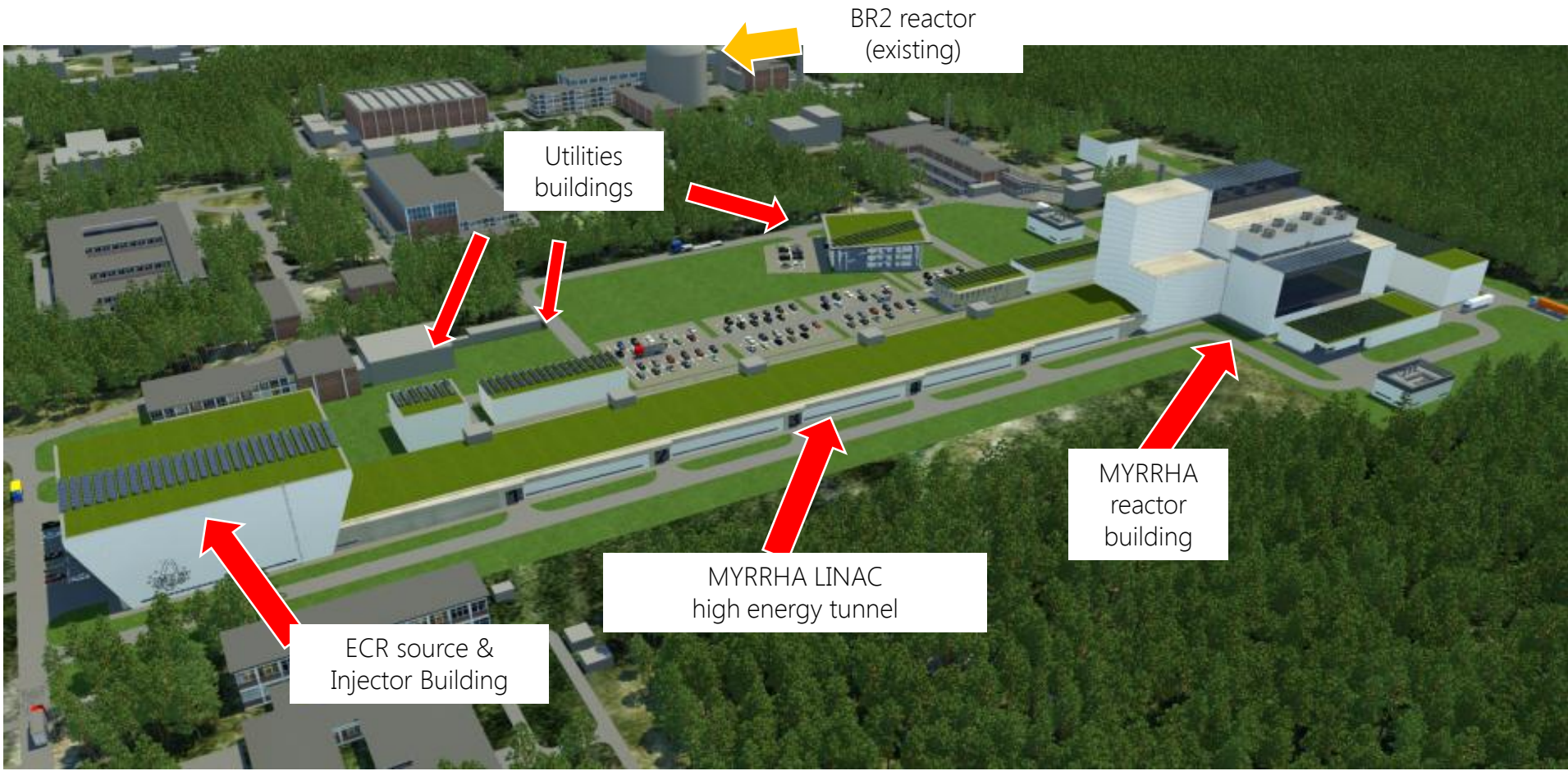
MYRRHA project planning

Under re-evaluation with FANC and Belgian government



MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM

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



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Belgian Nuclear Research Centre

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