MYRRHA
An innovative and unique irradiation research facility

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Overview

- The MYRRHA Project
- The Belgian Approval Process
- MYRRHA in a European and World Context
- Conclusions

MYRRHA Genesis & History

Post BR2

1994

ADONIS

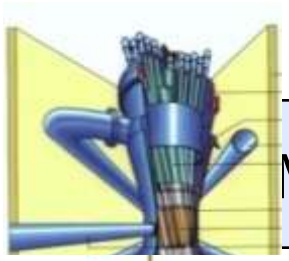
1994-96

Transmutation

1995

Non Energy Applications

1994 RI
1995 H_2



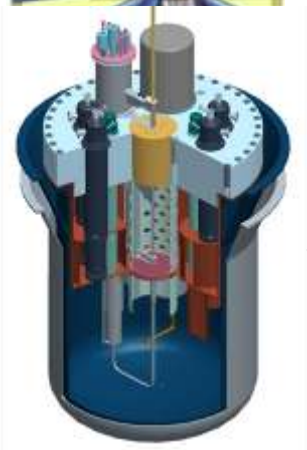
MYRRHA Project (1998-2004)

Gen.IV LFR

2002 GIF

from 2005

XT-ADS in EUROTRANS



current MYRRHA Project (2010)

MYRRHA International Reviewing

2001: International Strategic Guidance Committee

2002: International Technical Guidance Committee

2003: Review by Russian Lead Reactor Technology Experts (ISTC#2552p project)

2005: Conclusions of the European Commission FP5 Project PDS-XADS (2001-2004)

2006: European Commission FP6 Project EUROTRANS (2005-2009): Conclusions of Review and Justification of the main options of XT-ADS starting from MYRRHA

2007: International Assessment Meeting of the Advanced Nuclear Systems Institute

2008: European Commission FP7 Project Central Design Team (CDT) at Mol for MYRRHA detailed design

2009: MIRT of OECD/NEA on request of Belgian Government *(see further)*

MIRT: «Summary of the main findings»

MYRRHA is an innovative and exciting project and the facility would be unique in the world

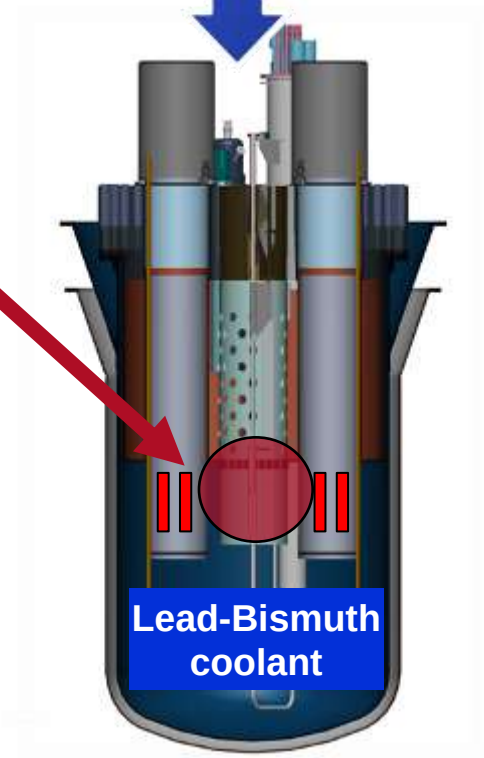
MYRRHA could play a role :

- in decisions related to and the development of the technology of the transmutation of nuclear waste
- in the development of advanced nuclear reactors, especially lead-cooled reactors
- as a fast neutron irradiation facility for materials and component testing for fission and fusion reactors
- as serving the needs of accelerator-based scientific communities (radioactive beams, proton therapy, proton-based isotope production, accelerator science,…)
- as a neutron irradiation facility for silicon crystal doping and manufacturing of radioactive isotopes for medical and industrial sources

MYRRHA

Accelerator
(600 MeV – 2.5 mA proton)

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



Spallation source

Fast neutron source

Multipurpose fast spectrum irradiation facility

Meeting long term needs of society

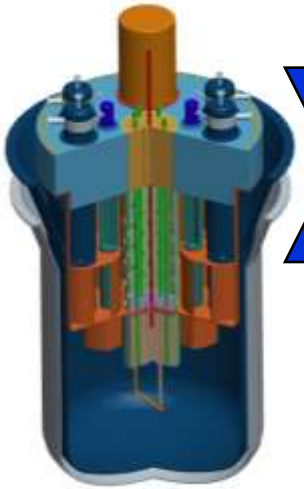
	Challenge	Solution	MYRRHA contribution
Fission	High radiotoxic level waste	Transmutation	ADS demo
Fission GEN IV	Demonstrate concept	Build demonstrators	LFR technology demo Fast spectrum irradiation facility
Fusion	Extreme operating conditions	Material testing & development	Fast spectrum irradiation facility
Fundamental research	Pushing the limits of knowledge	Access to proton beam	Long term experiments with radioactive ion beams (RIB)
Renewable energies	Efficient power electronics	High efficiency transistors (NTD-Si)	Securing NTD-Silicon production
Healthcare	Ageing population	A long term source of medical radioisotopes	Securing radioisotopes production (existing and new ones)

Objective

1962

BR2

- Material Testing Reactor (fission)
- Fuel testing For LWR & GEN II/GEN III
- Irradiation Services:
  - Medical RI
  - Silicium doping
  - Others



2023

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)

Rationale

Objectives	Requirements	Choices

Flexible
Fast Spectrum
Irradiation
facility
	• 1.10^{15} n/cm².s (>0.75 MeV) in large volumes (3 l)	• small target
		  • windowless design with an off-centre SL
		  • loopless window design
		• LM cooling

	• availabilty (65%) • flexibility	• HLM cooling • pool-type • in-vessel storage • FA manipulation beneath core • in-vessel inspection & repair • IPS manipulation above core • replaceability
	• no high temperatures required	• LBE cooling

Rationale

Objectives	Requirements	Choices
ADS demonstration	• high power accelerator • reliability • target	• LINAC (600 MeV, 4 mA)
LFR demo	• HLM technology & components • *Critical mode operation*	• *MYRRHA/FASTEF*
Operational in 2023	• Use of mature technology where possible • Innovation where needed	• FR MOX 30-35% fuel • 15-15-Ti AS → T91 MS • LBE

Reactor layout

Inner vessel

Cover

Core structure

Spallation window

Heat exchangers

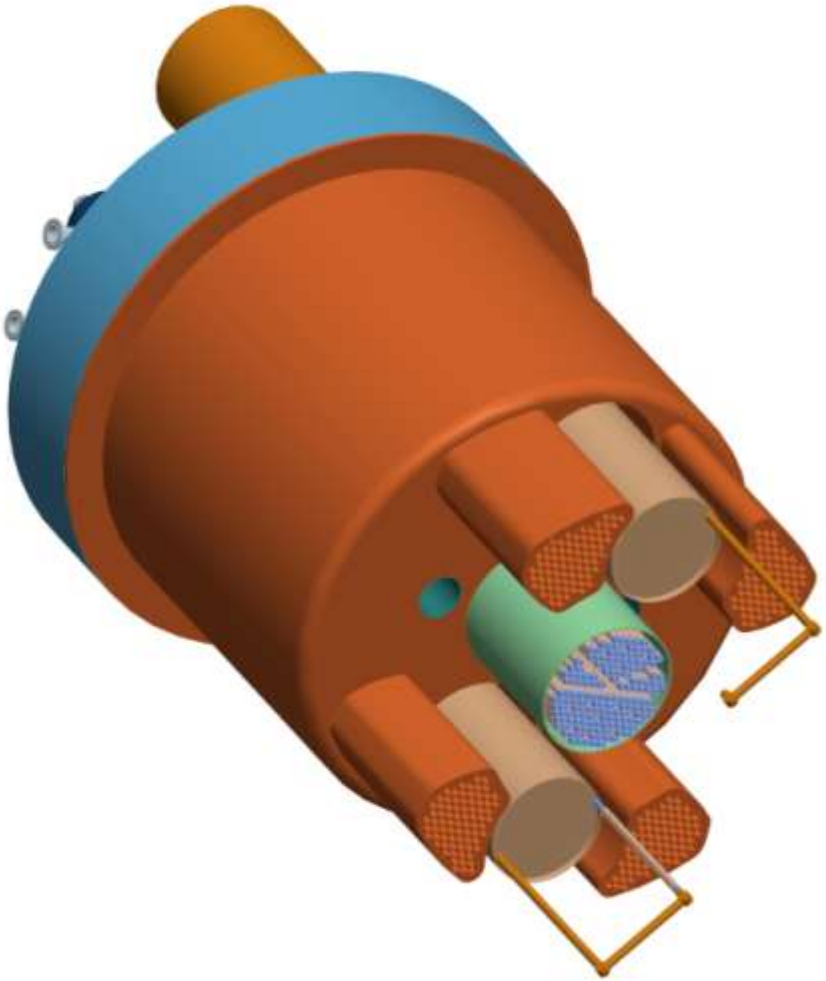
Pumps

Diaphragm

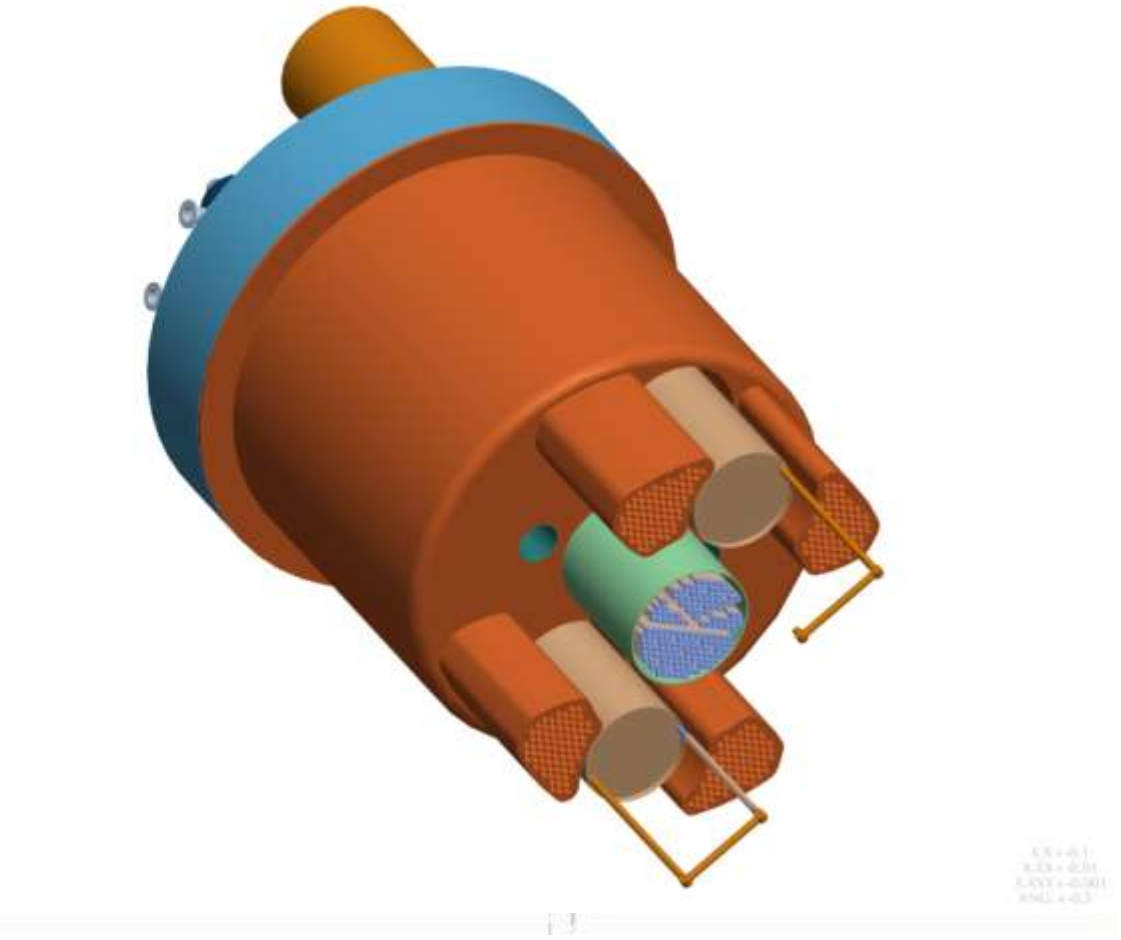
Fuel manipulators

Guard vessel

Fuel storage

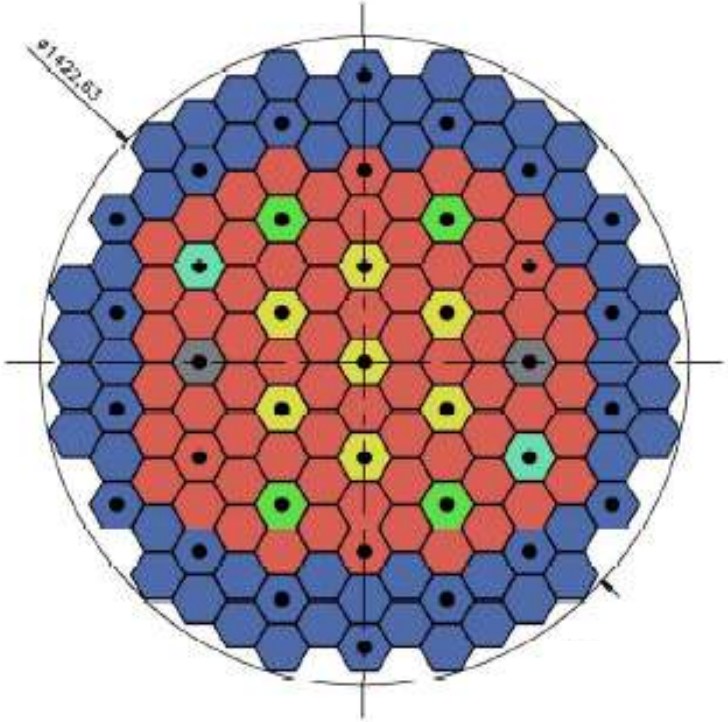


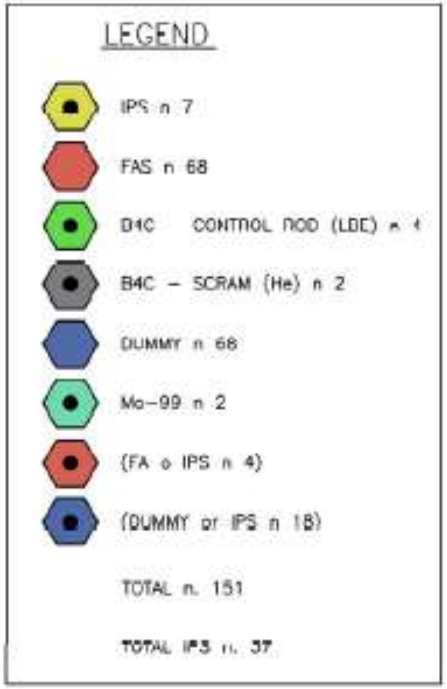
Reactor layout – In-vessel fuel manipulation

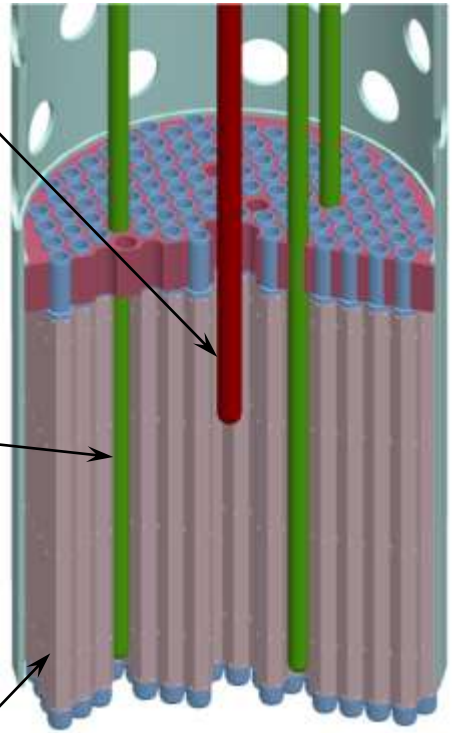


Reactor layout - Core

- k_{eff}≈0.95 (ADS mode)
- 30-35 % MOX fuel
- 7 IPS positions





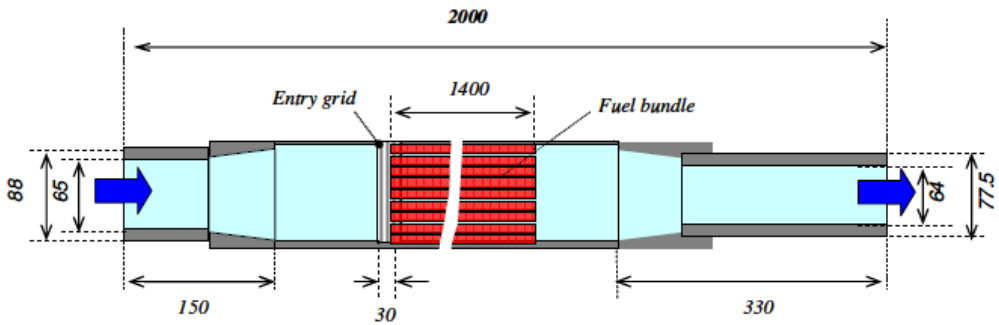


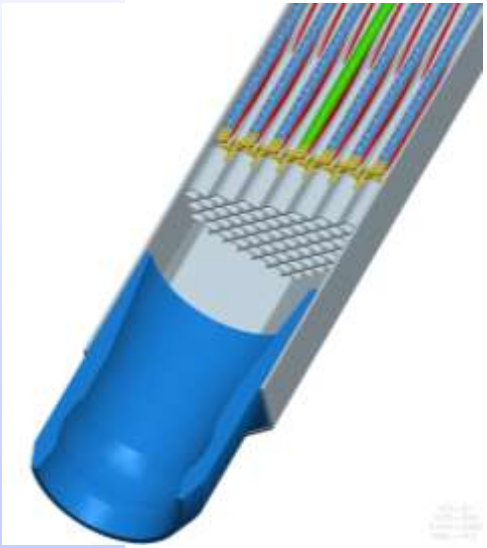
Reactor layout - Fuel and fuel procurement

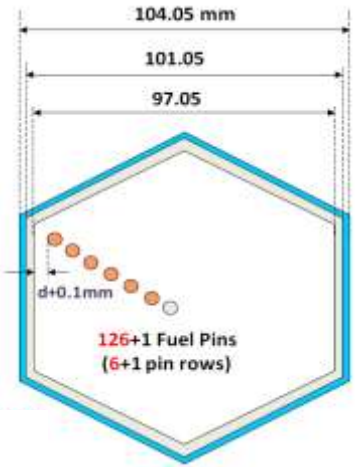
- Reference option for the first cores
  - 30% – 35% MOX fuel
  - Phenix fuel pin
    - 15-15 Ti cladding
    - OD 6.55mm, 0.45mm wall thickness
    - Wire wrap
    - Solid pellet
    - Known experience (BN, Phenix)
    - Large existing database
  - Possible fuel providers
    - France, UK, Japan, ..

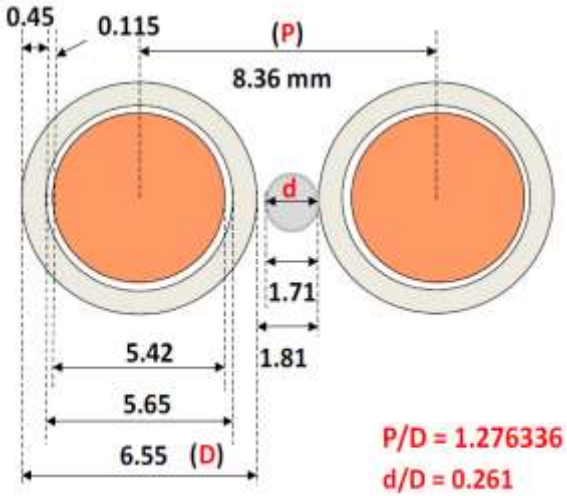
Reactor layout – Fuel assembly

- Phenix fuel
  - Cladding in 15-15 Ti
  - Wire wrap

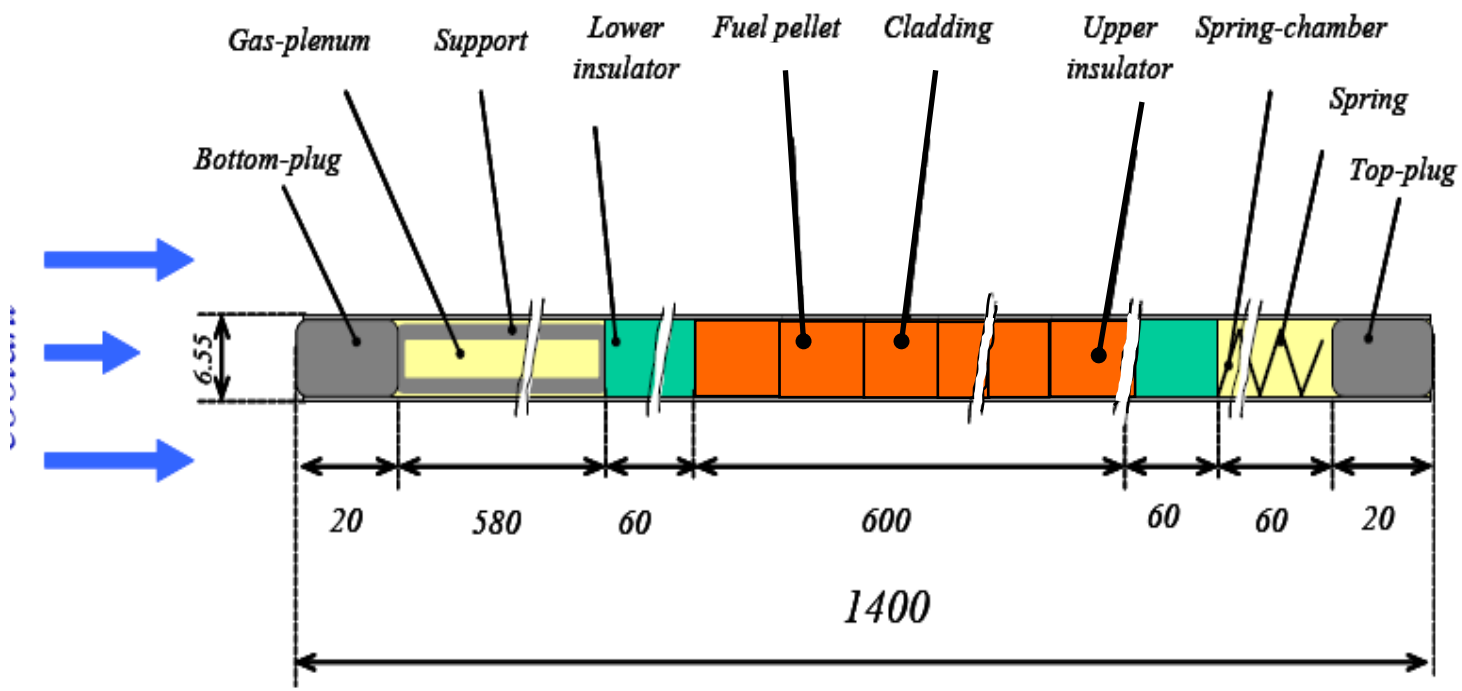






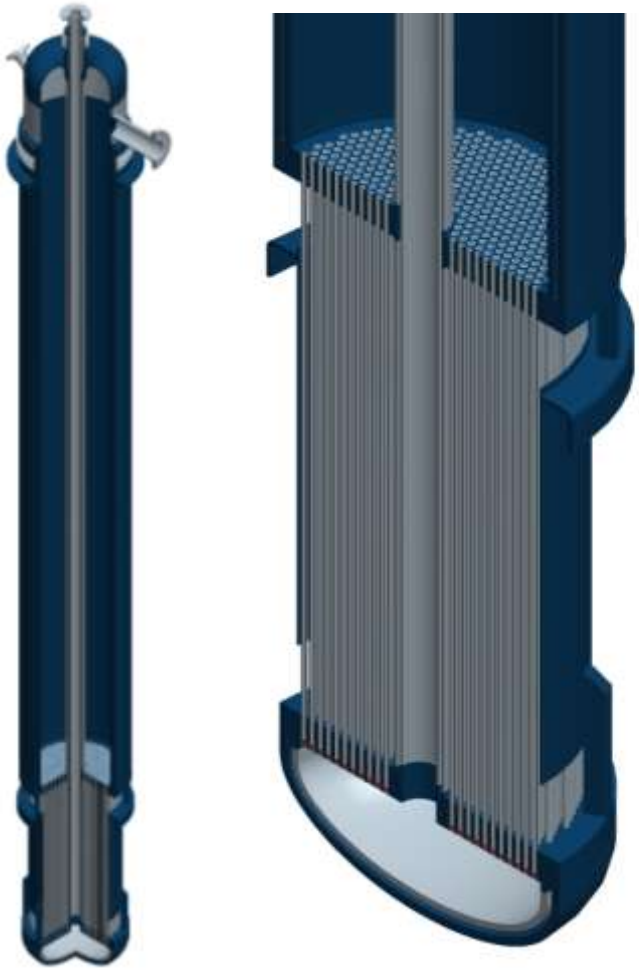


Reactor layout – Fuel pin



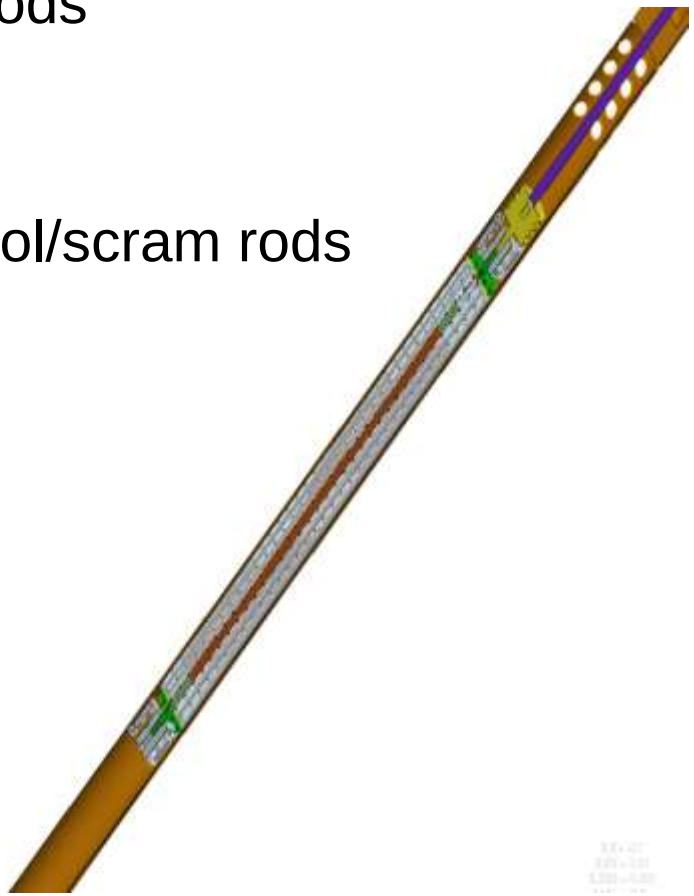
Reactor layout – The heat exchanger

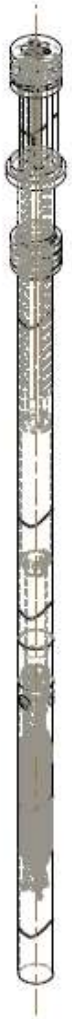
- Primary Heat Exchanger
  - Shell and Tube
  - Double walled design
  - Length of tubes: 1.5m
  - Diameter of tubes: 16mm
  - 700 tubes
  - Shroud: 850mm
  - Total length: about 8m
  - Internal pressure: 16bar



Reactor layout – The control/scram rods

- Gravity driven scram rods
  - Ballasted
  - Forced injection
- Buoyancy driven control/scram rods

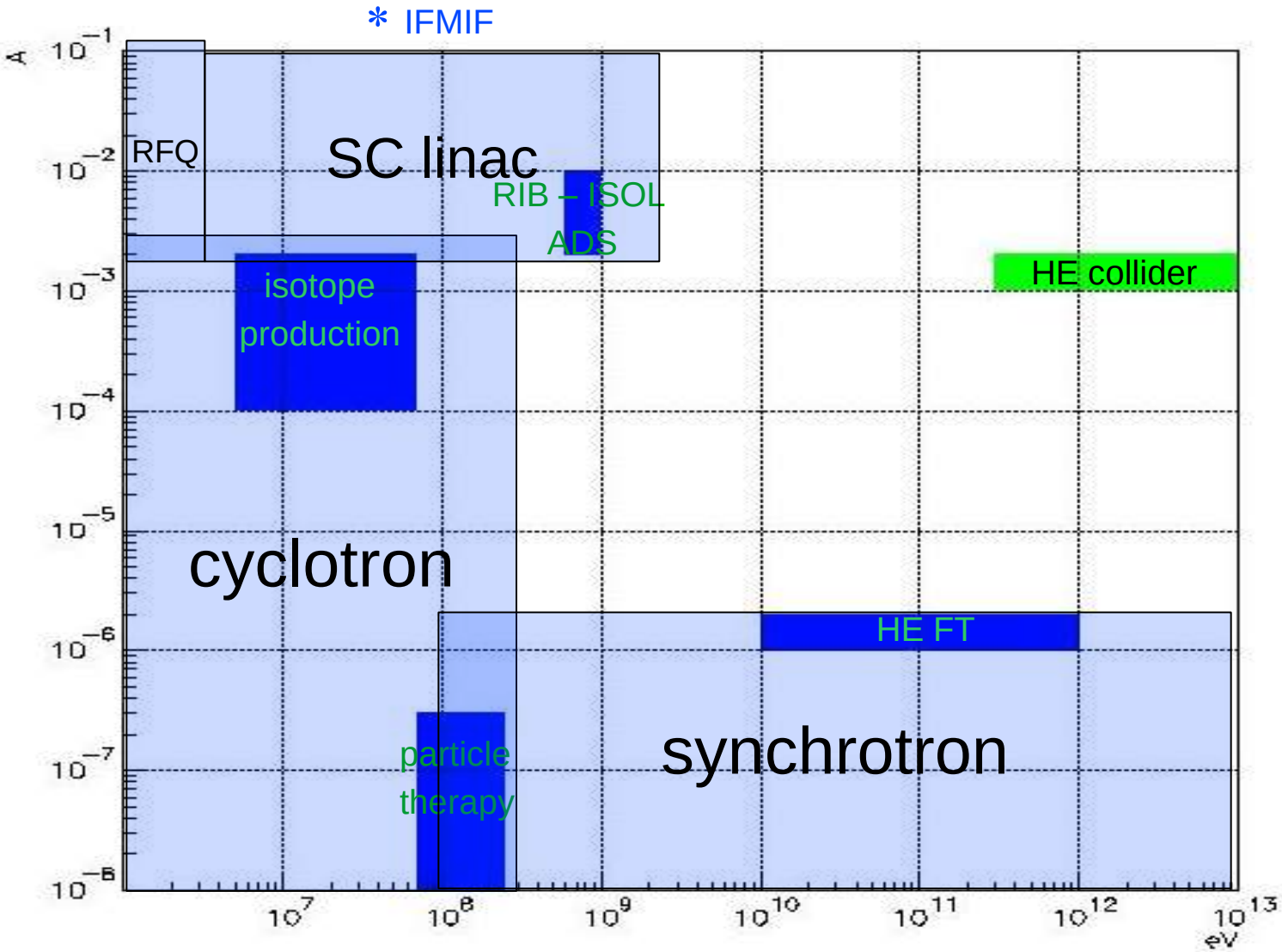




Accelerator

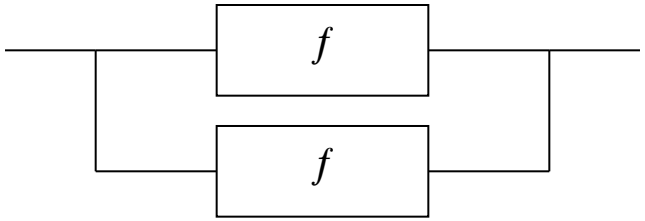
Proton energy	600 MeV
Beam intensity (CW)	Max 4 mA
Beam entry	vertically from above
Beam stability	energy ±1% intensity ±2%, size ±10%
Footprint on target	“donut”-shaped, r_{in} 25 mm r_{out} 50 mm
Reliability	Trips > 3s = max 10 per cycle
Time structure	CW, I=0 holes 200 μs, 1 Hz pulsed mode capable (50 Hz)

Accelerator

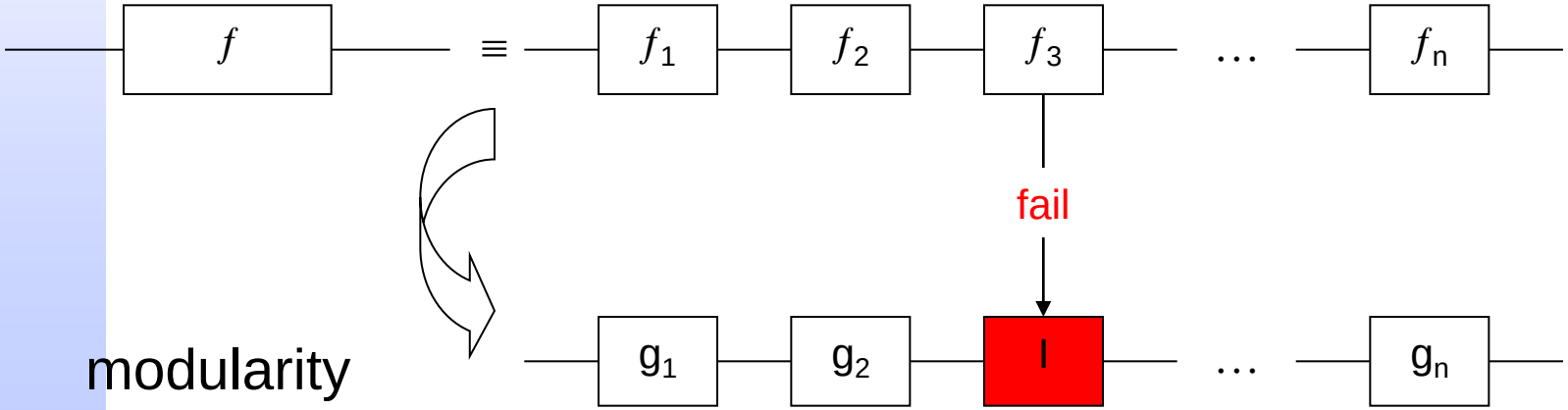


Accelerator - Reliability

parallel scheme (redundancy)

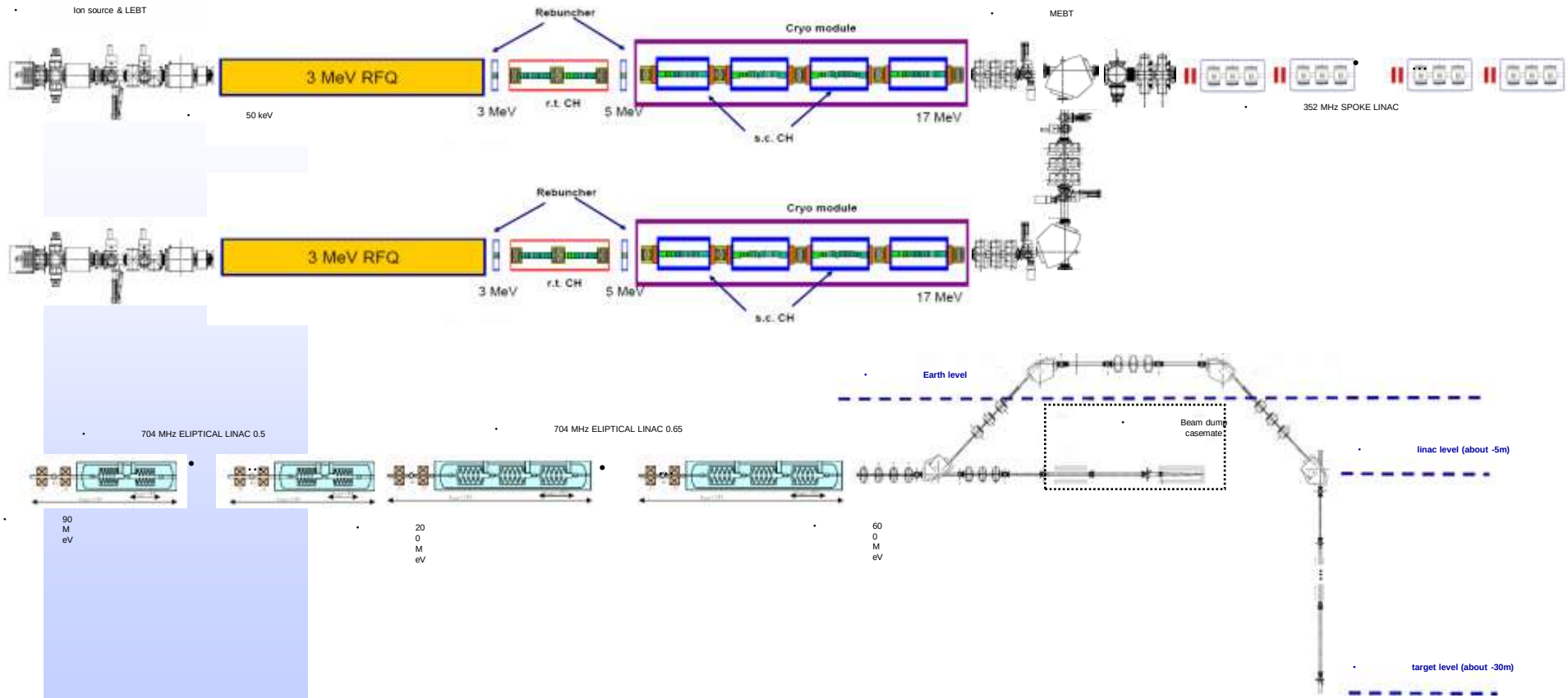


serial scheme: IF



modularity

Accelerator - layout



Accelerator components

Section of RFQ has been brazed in July 2009 at Annecy

2 Spoke resonators @352 MHz (β 0.15 & 0.35) fabricated and tested

CH cavity tested sucessfully

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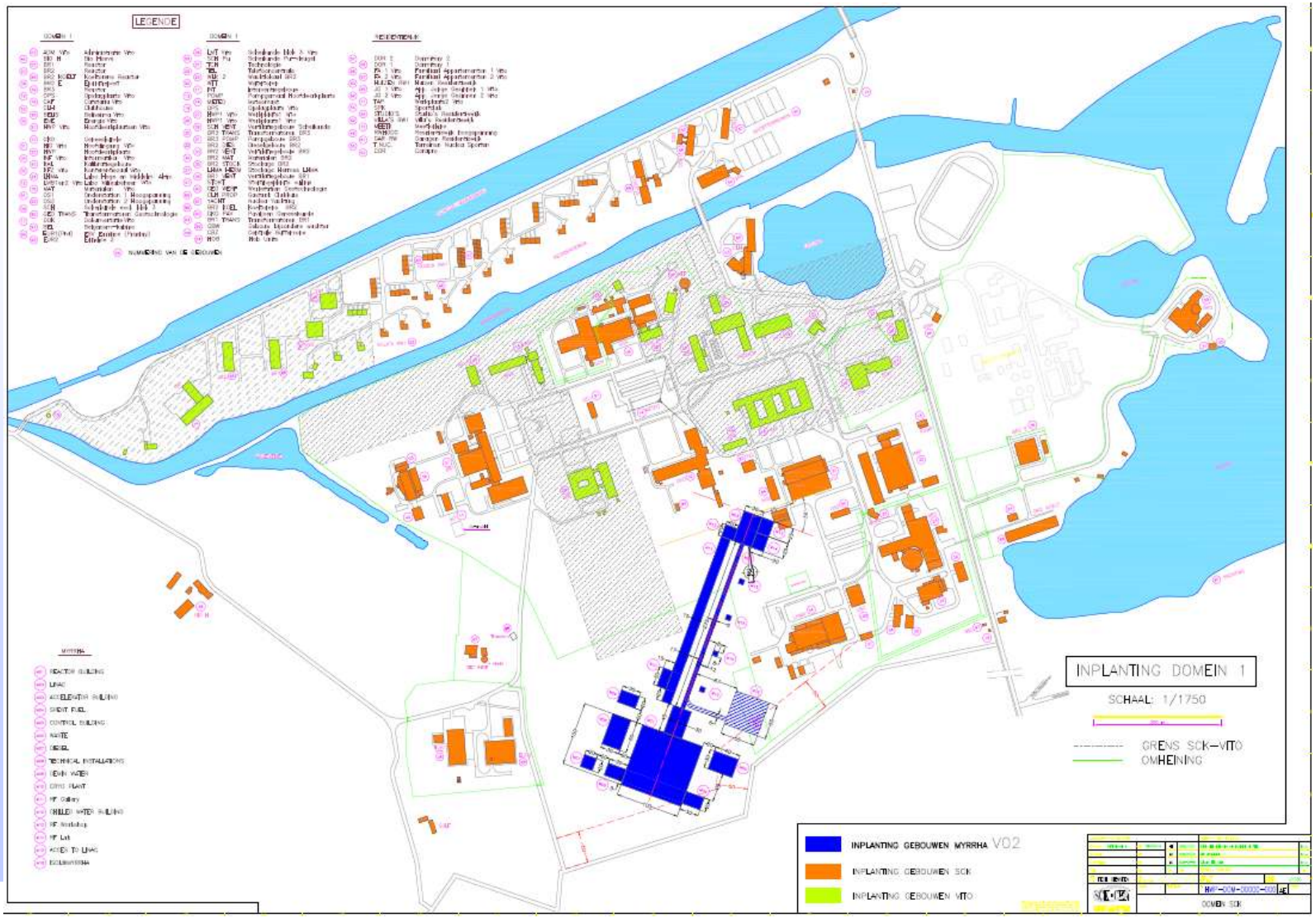
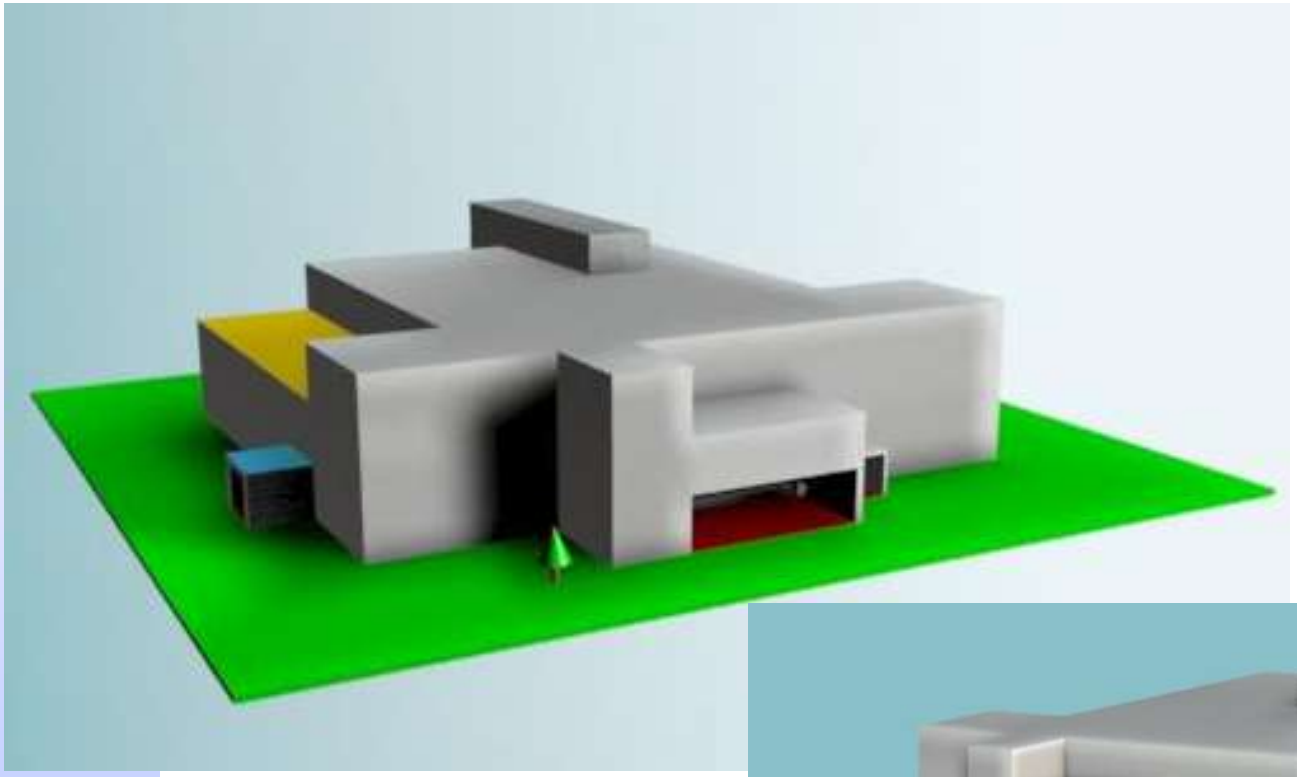
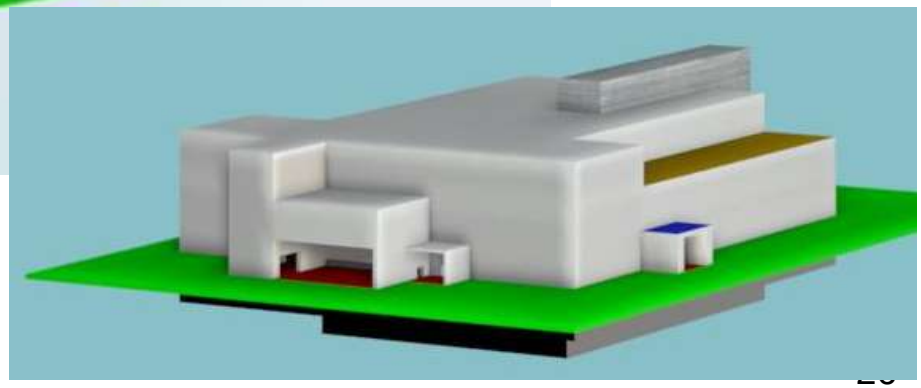
Building layout and reactor hall

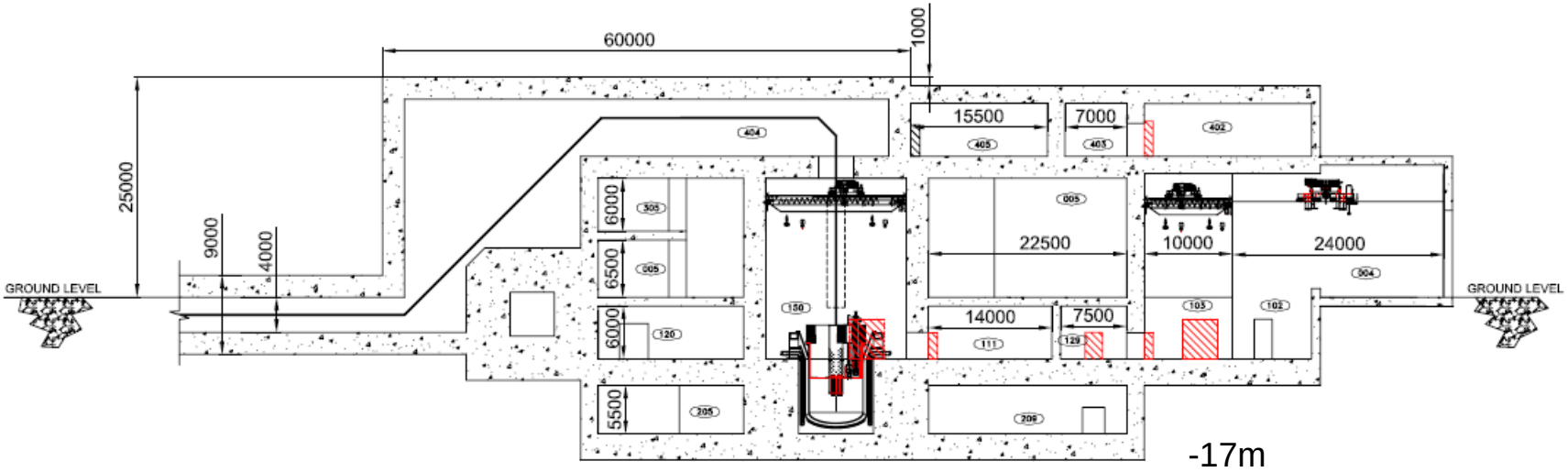


Building layout and reactor hall – the reactor building

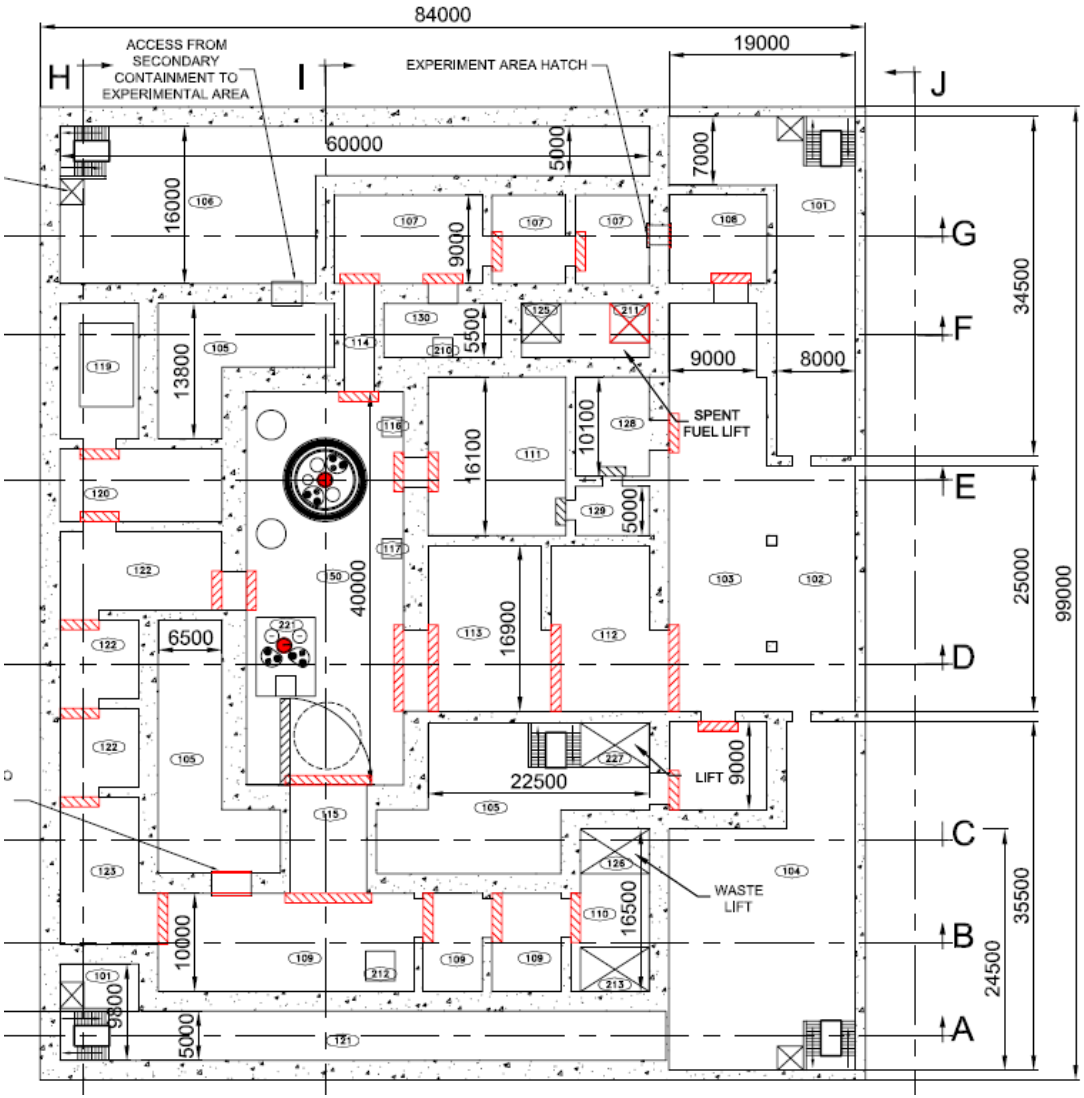




Building layout and reactor hall – the reactor building



Building layout and reactor hall – the reactor building



Detailed budget: balancing costs & revenues

2010 - 2023

Investment 960 M€

Building 196 M€	Equipment 370 M€	Engineering 202 M€

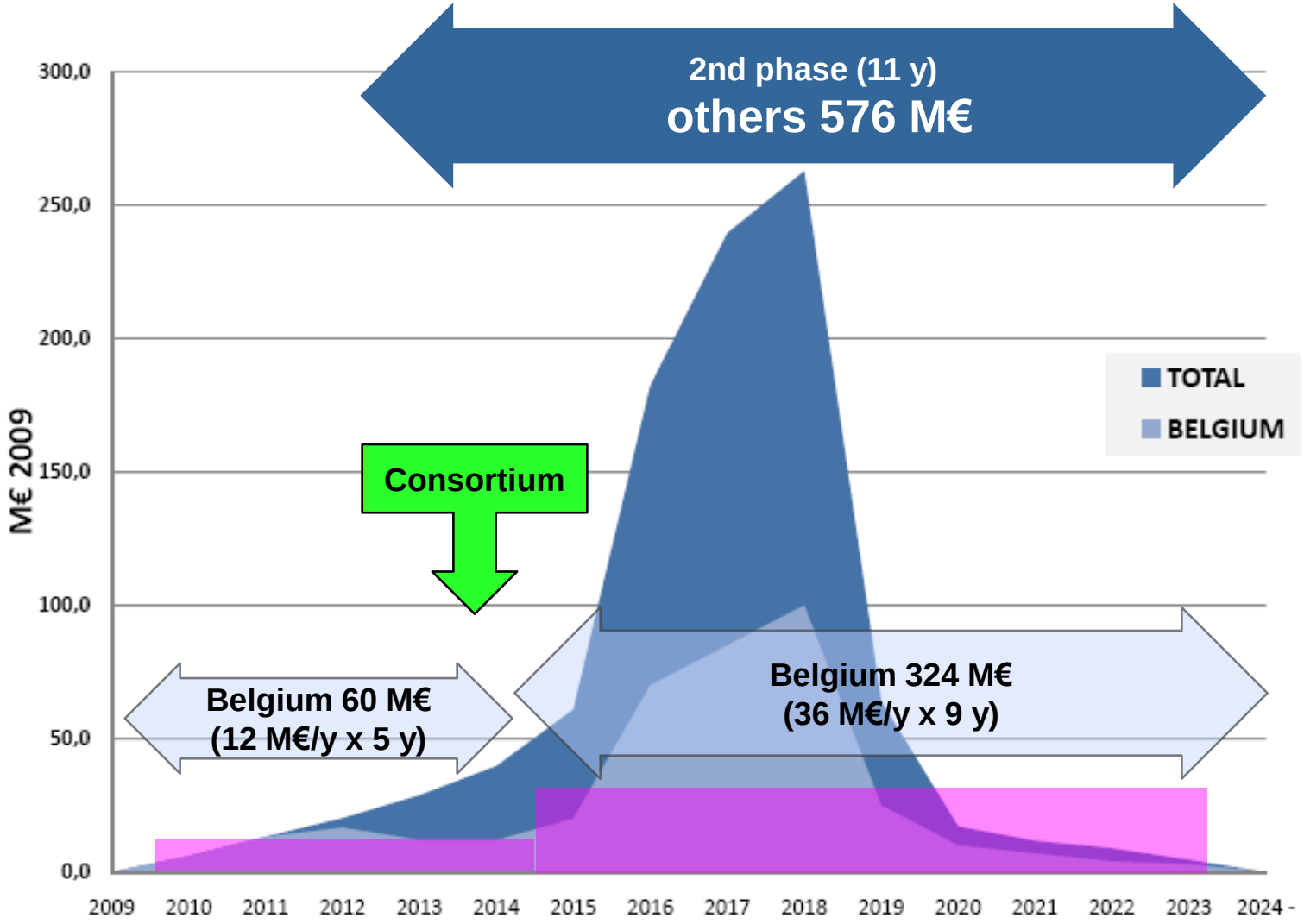
Contingencies 192 M€

2024 ~ 2054

Operational Budget

Costs	Revenues
Operational costs 46.6 M€/y	Consortium endowment 25.2 M€/y
	Science & **T**ech. revenues 17.1 M€/y
Organisation reinforcement 14.6 M€/y	**S**ervices revenues >18.8 M€/y

Belgian commitment: secured
International consortium: under construction

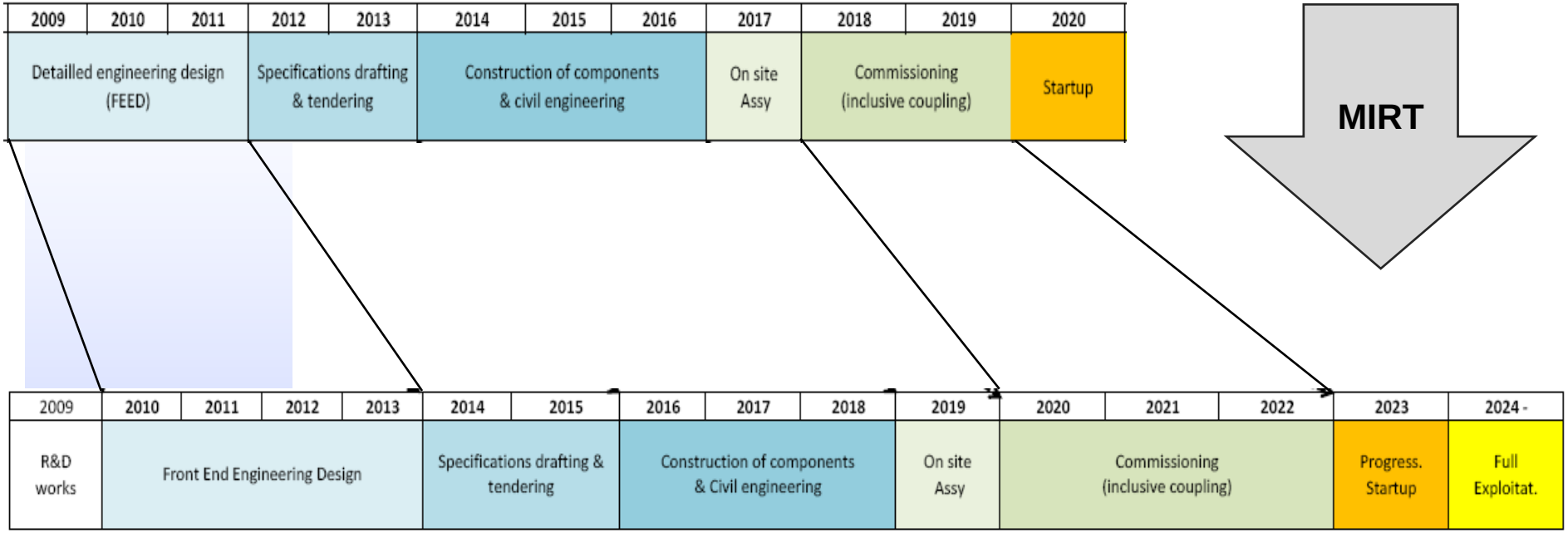


The next phase of work: 2010-2014

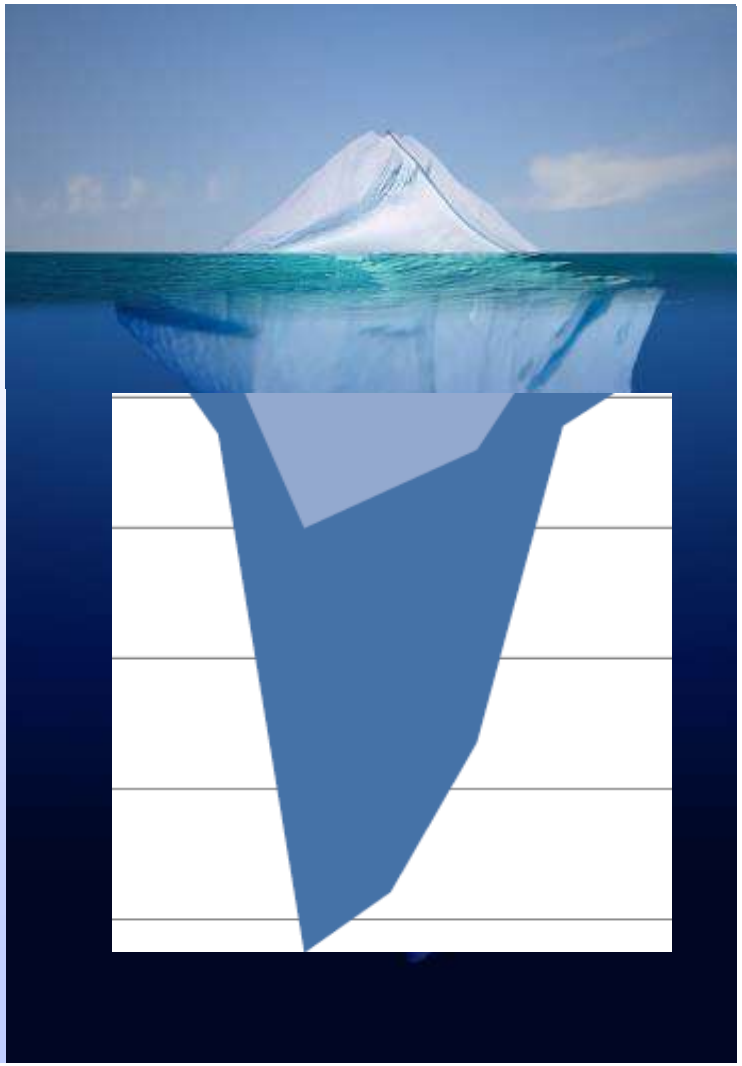
Minimise technological risks	Accelerator x	Spallation target x	Sub-critical reactor
Secure the licensing	**PDP** preliminary dismantling plan	**PSAR** preliminary safety assesment	**EIAR** environmental impact assesment
Secure a sound management and investment structure	Central Project Team	Owner Consortium Group	Owner Engineering Team

FEED (Front End Engineering Design)

Updated project schedule 2010 - 2024



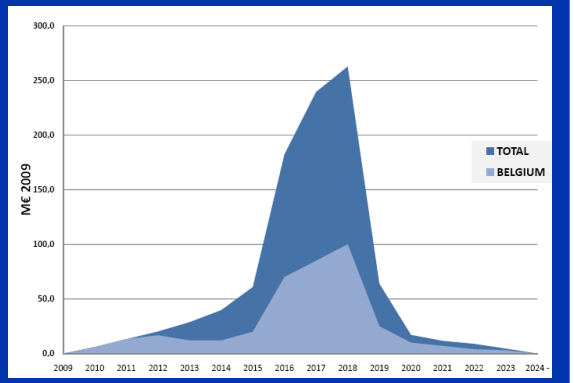
What is left to do?



today

action plan
2010 - 2014

2015 - 2023

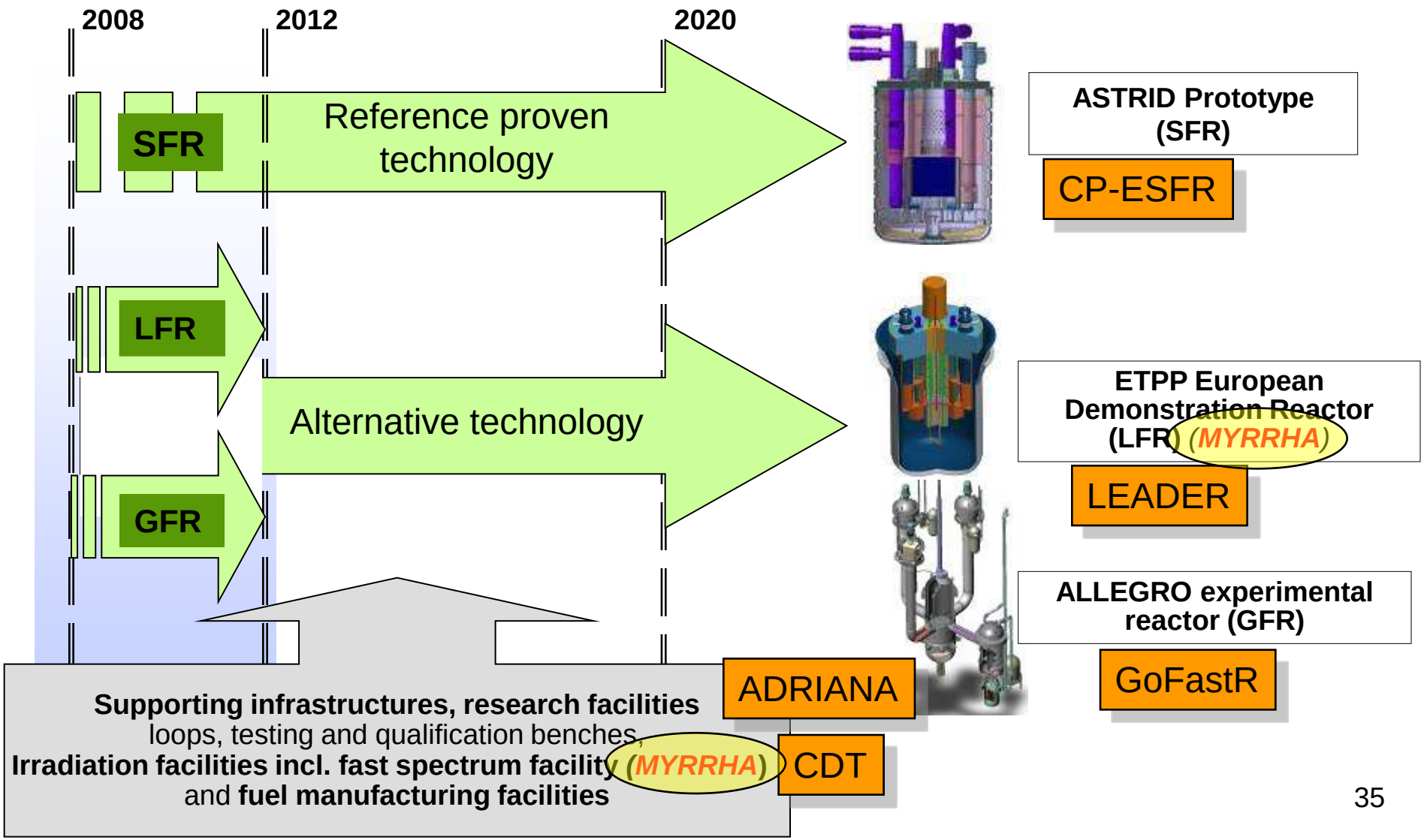


Forging strong partnerships and alliances in Europe and worldwide

In-cash In-kind FP7 EII	Belgium: 40% (05.03.2010)	Engineering
	EU Member States	Building
	EU	
	ROW	Equipment
loan	EIB	

Owners' Consortium Group	• Co-sharing investment cost • Co-sharing exploitation cost • Privileged access conditions
Alliances	• Securing revenues from Users' Group

MYRRHA in ESNII & FP7 to reach the SNETP goals for Gen.IV FR



MYRRHA has strong relations to European and worldwide institutions

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in der Helmholtz-Gemeinschaft

Forschungszentrum Rossendorf

INFN
Istituto Nazionale di Fisica Nucleare

CR54

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AGH

The final sprint

Joining the MYRRHA project

- Belgium is welcoming international participation in the MYRRHA consortium
- Membership eligibility for the international MYRRHA consortium is based on a balanced in-cash/in-kind contribution

- Until end 2014, our objectives are:
  - to collect **Letters of Intent** for participation in the MYRRHA International Consortium (deadline end 2011)
  - to sign **Memoranda of Understanding** for collaboration in MYRRHA with international partners (deadline end 2013)
  - To finalise the **Consortium legal framework** (deadline mid 2014)

Implementation of P&T Strategy

- **Implementation of P&T of a large part of the high level nuclear wastes in Europe needs demonstration of the feasibility of several installations at an "engineering" level leading to arrangement of R&D activities in four "building blocks", so as:**
  1. **To process a sizable amount of spent fuel from commercial power plants (i.e. LWR) in order to separate Pu and MA,**
  2. **To fabricate at semi-industrial level the dedicated fuel needed to load a dedicated transmuter,**
  3. **To make available one or more dedicated transmuters,**
  4. **To process the dedicated fuel unloaded from the transmuter and fabrication of new dedicated fuel.**

Conclusion

- International Collaboration is a must in P&T
- National motivated initiatives are paramount triggers
- Belgium is contributing through MYRRHA to the 3rd Building Block of the European Vision on P&T

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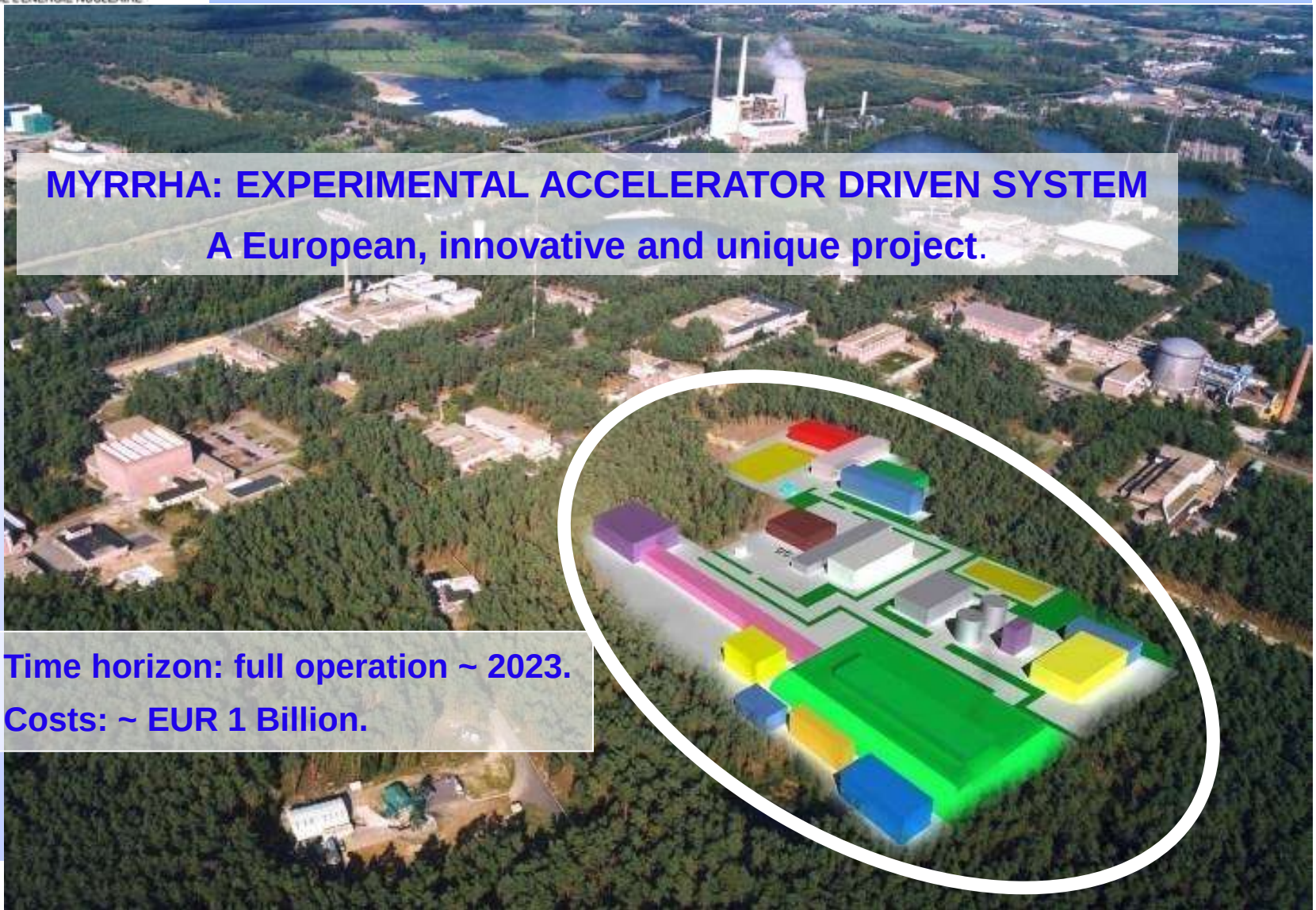
Thank you !



MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM

A European, innovative and unique project.

Time horizon: full operation ~ 2023.

Costs: ~ EUR 1 Billion.

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