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

MYRRHA

Multipurpose h**Y**brid **R**esearch **R**eactor for **H**igh-tech **A**pplications

A flexible and fast spectrum irradiation facility

Eucard2-MAX ADS Workshop, CERN, Geneva (CH)

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MYRRHA

Multipurpose h**Y**brid **R**esearch **R**eactor for **H**igh-tech **A**pplications

A flexible and fast spectrum irradiation facility

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MYRRHA - Accelerator Driven System

Accelerator

(600 MeV - 4 mA proton)

Reactor

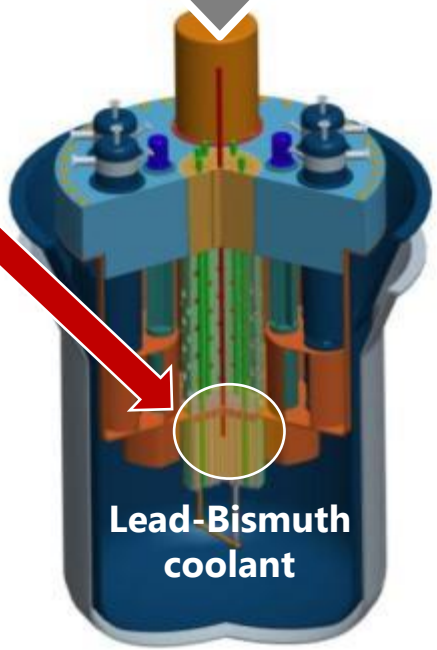
- Subcritical or Critical modes
- 65 to 100 MWth

Innovative & Unique

Spallation Source

Fast Neutron Source

Multipurpose Flexible Irradiation Facility



MYRRHA Accelerator Challenge

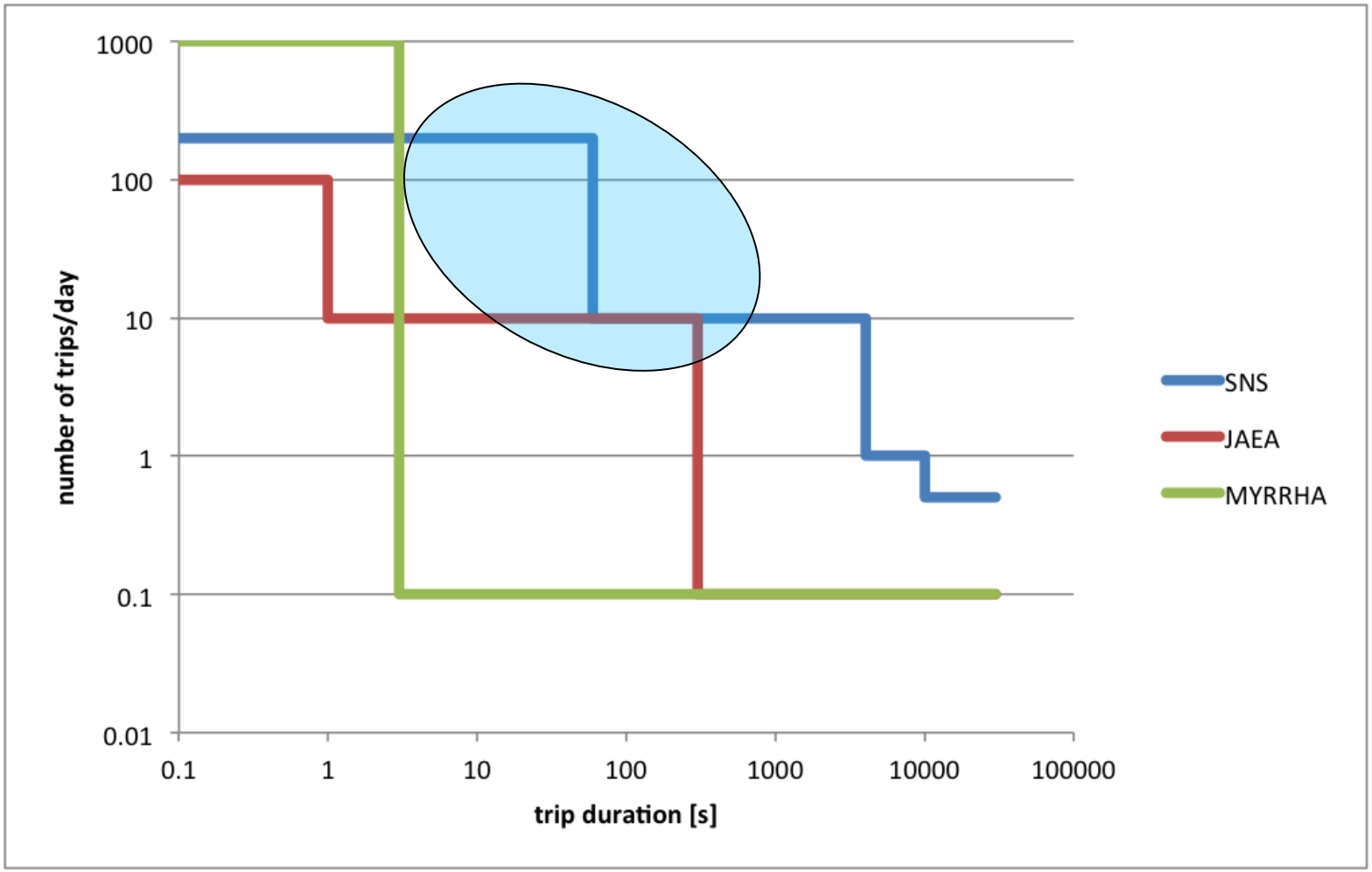
fundamental parameters (ADS)	
particle	p
beam energy	600 MeV
beam current	4 mA
mode	CW
MTBF	> 250 h

challenge !

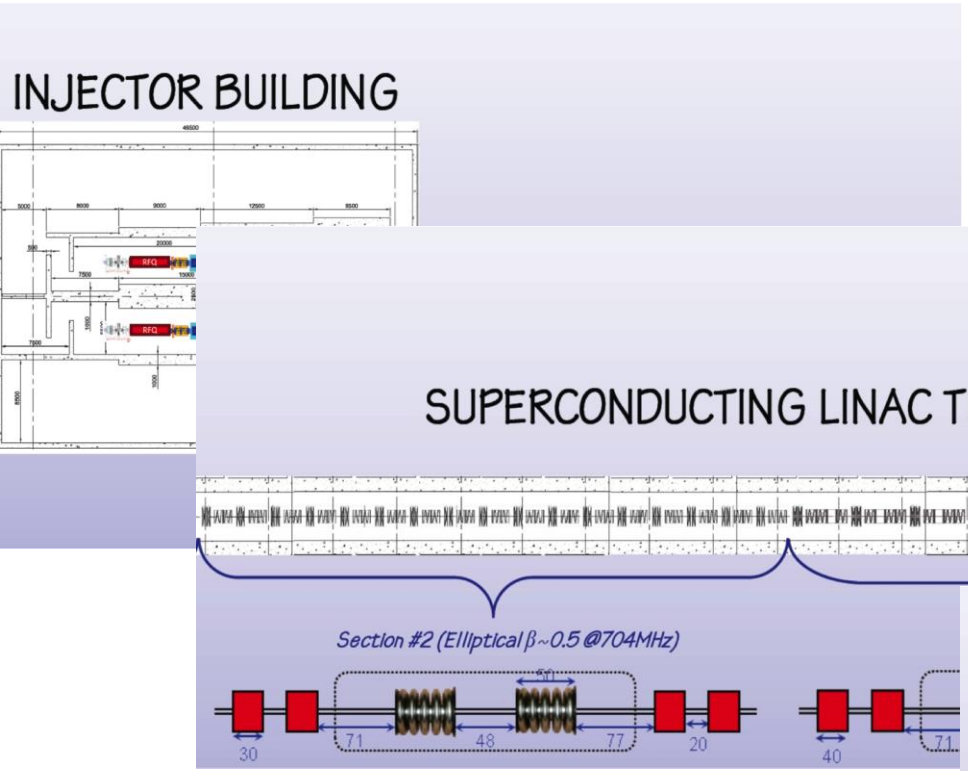
failure = beam trip > 3 s

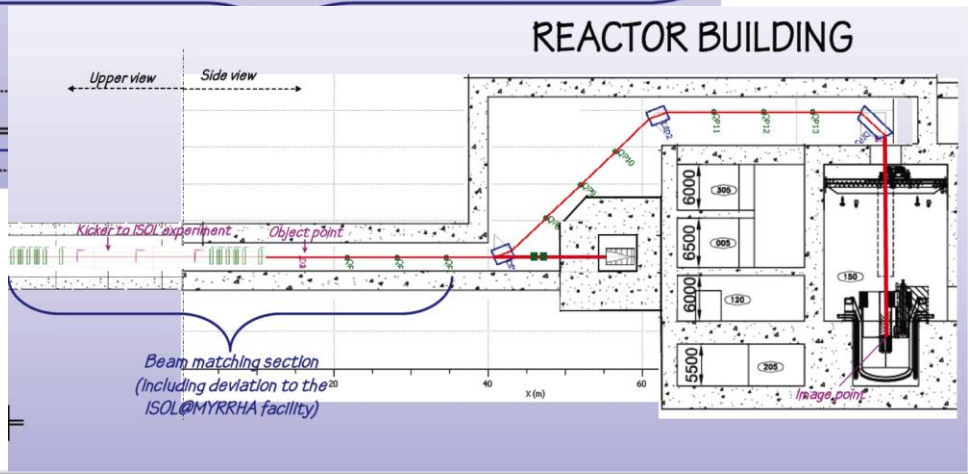
implementation	
superconducting linac	
frequency	176.1 / 352.2 / 704.4 MHz
reliability = redundancy	double injector
	“fault tolerant” scheme

About beam trips



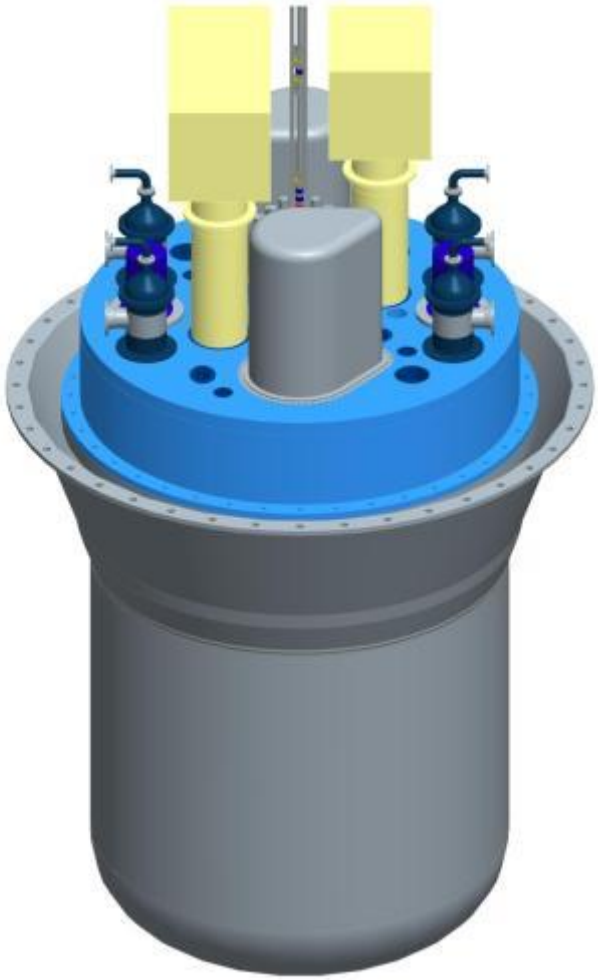
MYRRHA linac





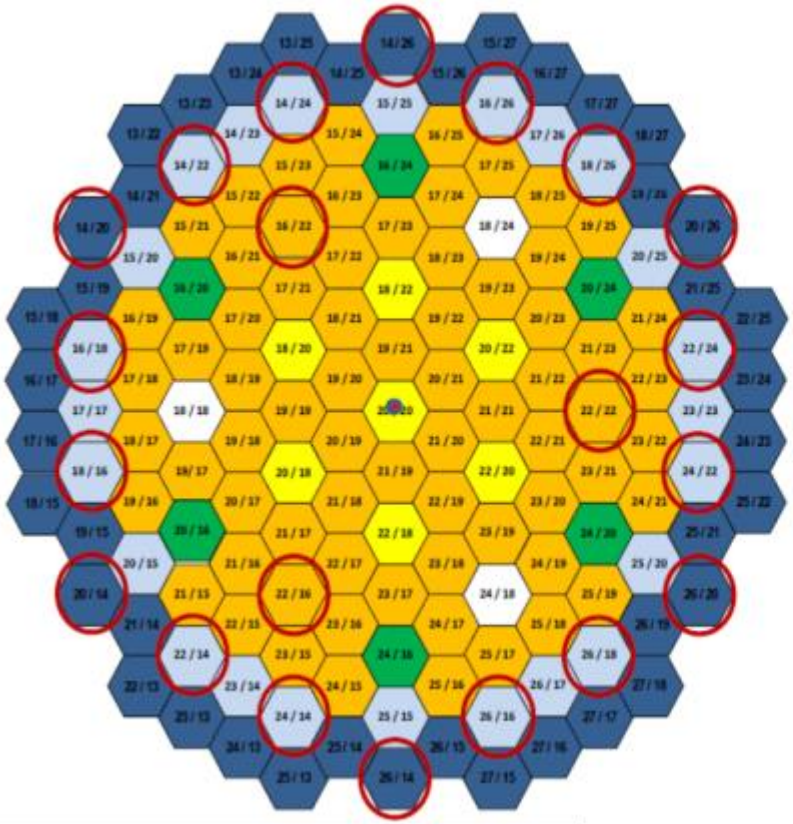
Reactor layout

- 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
- IVFHS
  - IVFHM



Core and Fuel Assemblies

- 151 positions
- 37 multifunctional plugs

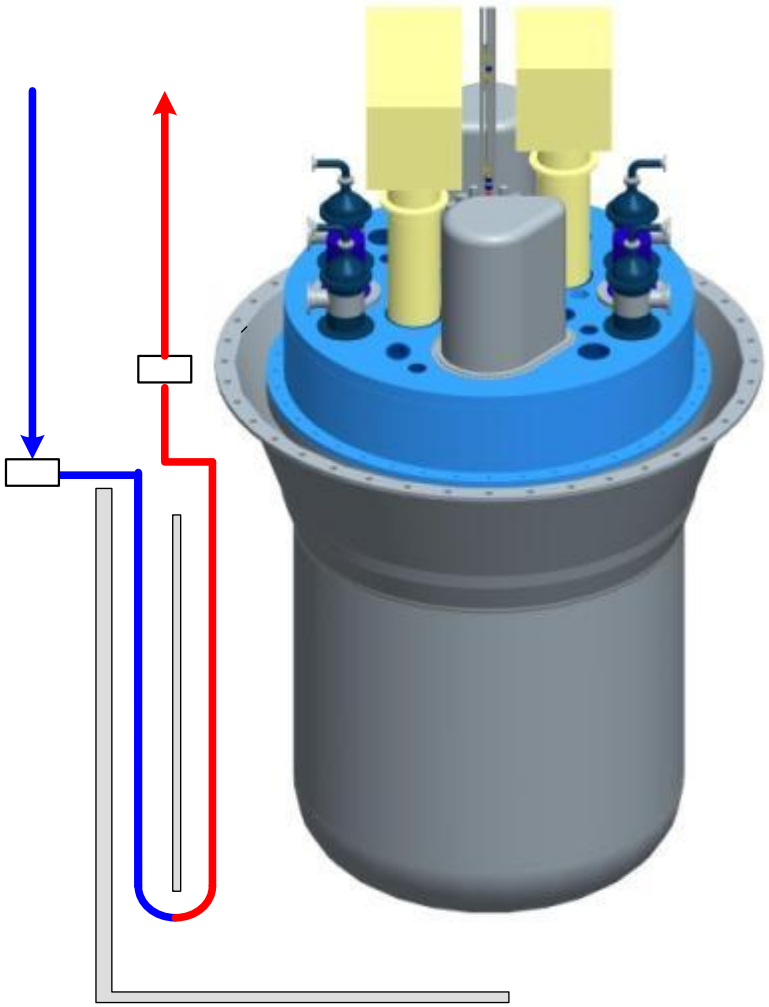


69 FAs
7 (central) IPS
6 CR (buoyancy)
3 SR (gravity)
24 "inner" Dummy (LBE)
42 "outer" Dummy (YZrO)
151 S/As

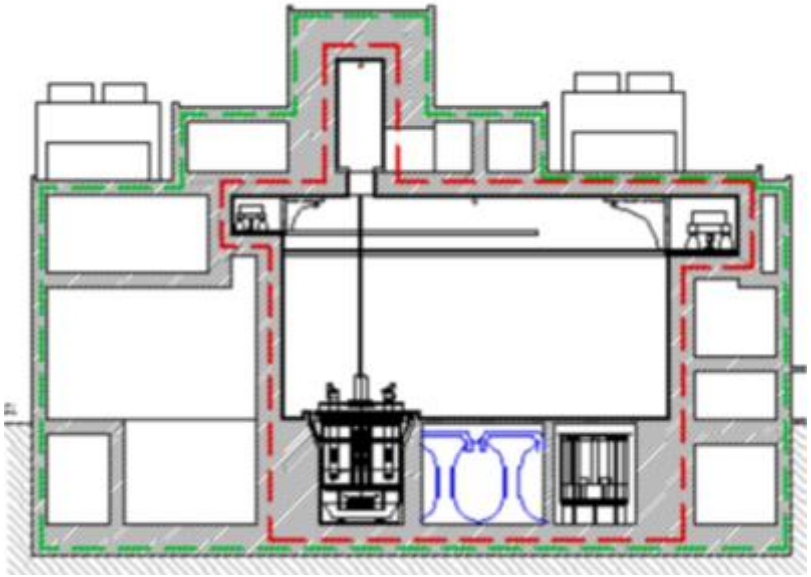
Additional positions available for inserts from the top (21/37)

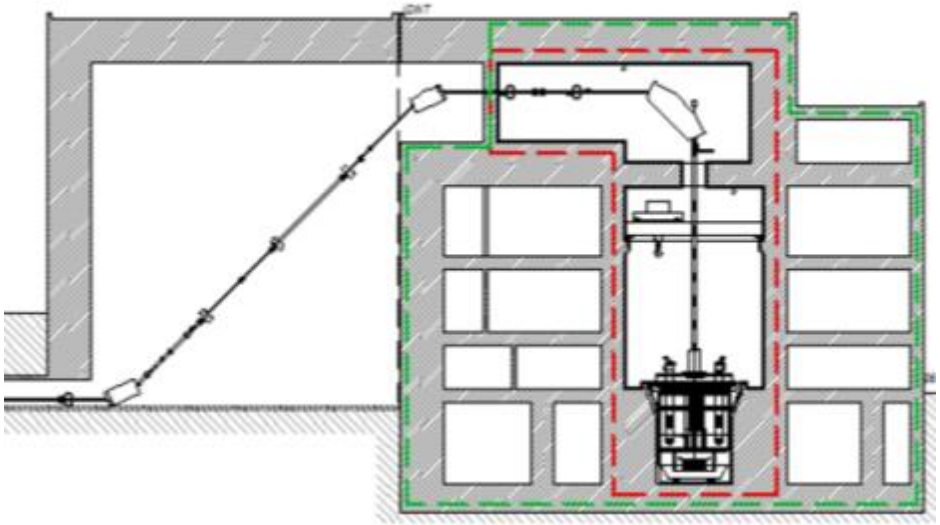
Cooling systems

- Decay heat removal (DHR) through secondary loops
  - 4 independent loops
  - redundancy (each loop has 100% capability)
  - passive operation (natural convection in primary, secondary and tertiary loop)
- Ultimate DHR through RVCS (natural convection)



Integration into building





Multipurpose facility
ADS demonstration & P&T Research

Material research
Φ_{Fast} = 1 to 5.10^{14} n/cm².s
(En>1 MeV) in large volumes

Fuel research
Φ_{tot} = 0.5 to 1.10^{15} n/cm².s

Fission GEN IV

Φ = 1 to 5.10^{14} n/cm².s
(ppm He/dpa ~ 10)
in medium-large volumes

Fusion

50 to 100 MWth
Φ_{Fast} = ~10^{15} n/cm².s
(En>0.75 MeV)

Waste

Multipurpose
h**Y**brid
Research
Reactor for
High-tech
Applications

High energy LINAC
600 MeV – 1 GeV
Long irradiation time

Fundamental research

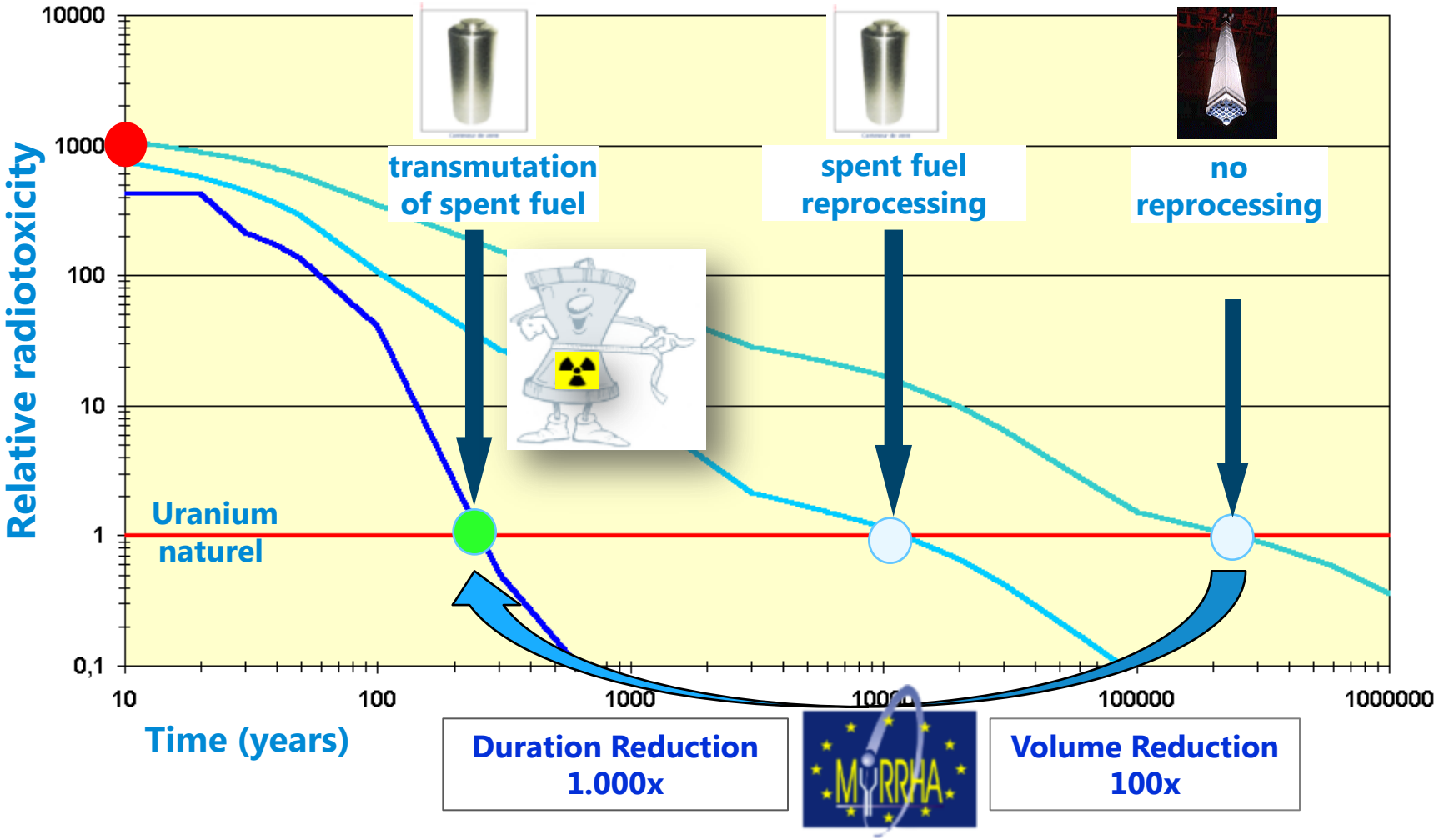
Φ_{th} = 0.5 to 2.10^{15} n/cm².s
(En<0.4 eV)

Radio-isotopes

Silicon doping

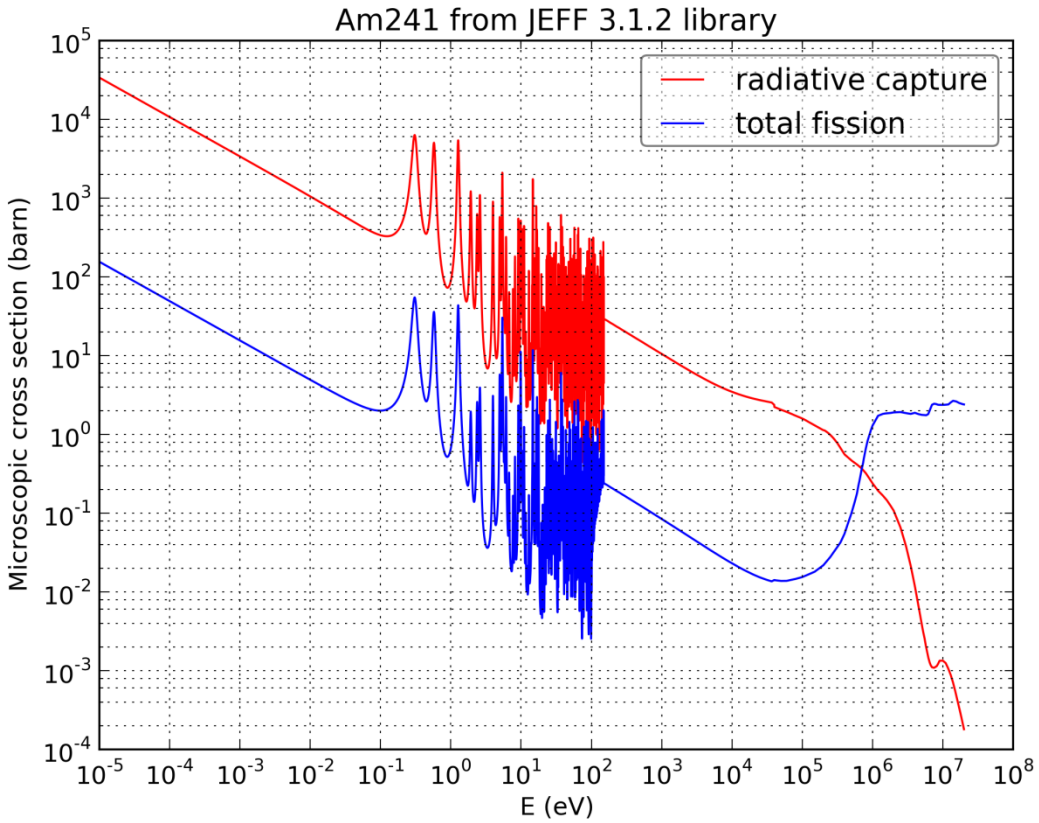
Φ_{th} = 0.1 to 1.10^{14} n/cm².s
(En<0.4 eV)

Motivation for transmutation



Fast Neutron are unavoidable for transmutation

- To transmute MAs, we need to fission them
- The ratio Fission/Capture is more favorable with fast neutrons

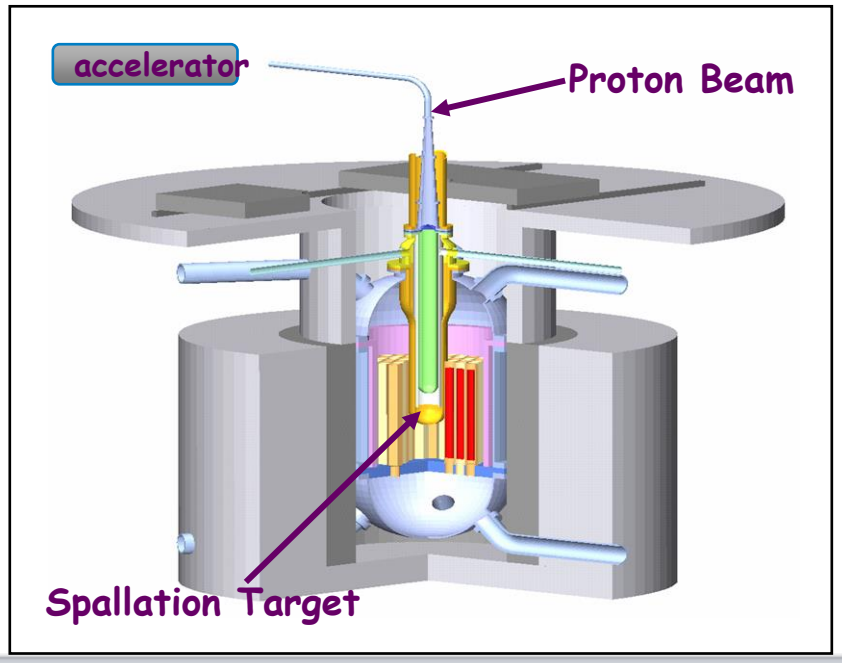


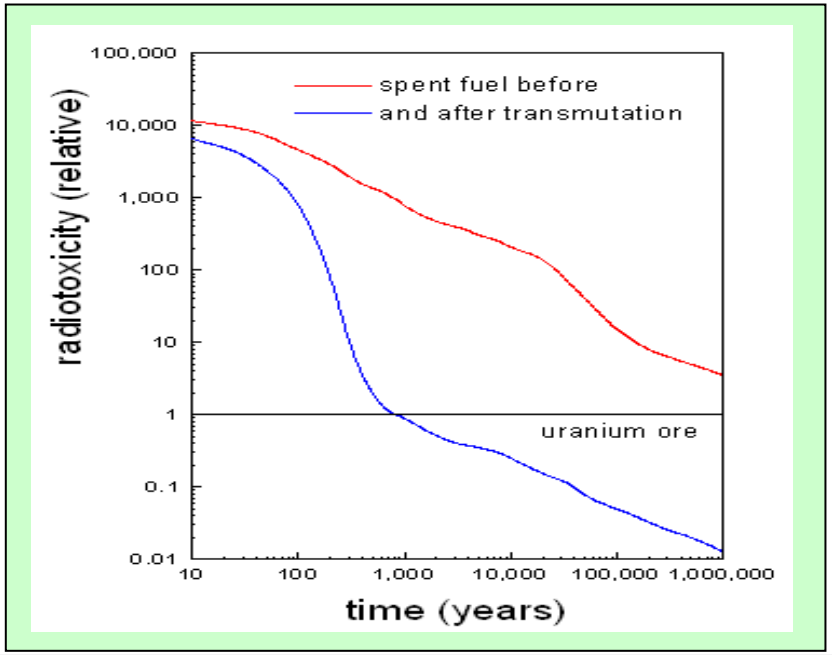
Is sub-criticality a luxury?

Both Critical reactors as well as ADS can be used as MAs transmuters

Nevertheless, critical reactors, heavily loaded with MAs, can experience severe safety issue due to reactivity effect induced by a smaller fraction of delayed neutrons.

ADS can operate in a more flexible and safer manner even if heavily loaded with MAs hence leading to efficient transmutation. Therefore we say that **sub-criticality is not a luxury but a necessity.**



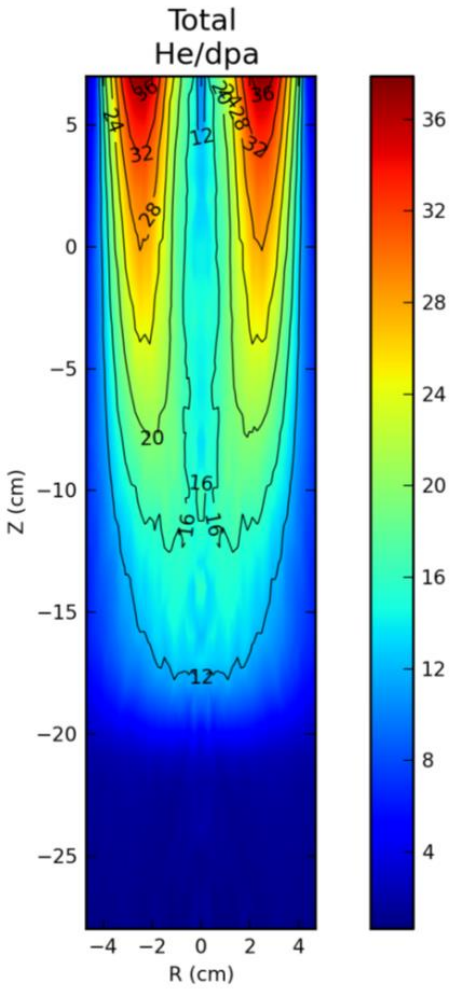


European Strategy for P&T

- **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.**

MYRRHA-IMIFF for fusion material



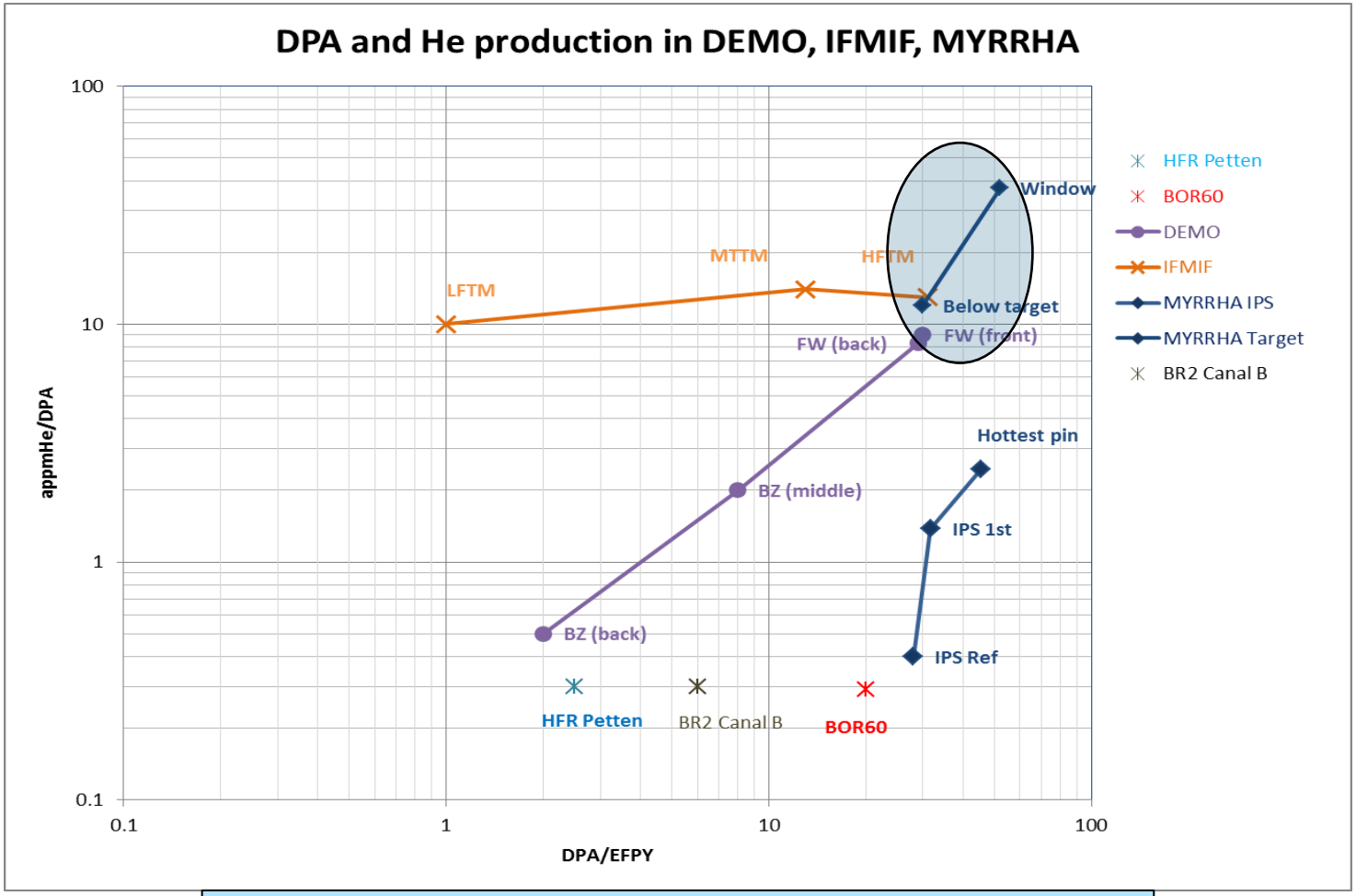
- In sub-critical ADS-mode , a high appmHe/dpa ratio is reached, especially in the region of the window of spallation source
- Volume of 1 lt with appmHe/dpa ~ 12 close to spallation target

➔ Useful volume

30 lt with range from 5 to 20 appmHe/dpa

➔ (Pre-)selection of materials for fusion application

MYRRHA for fusion irradiations



Estimated damage induced in DEMO and proposed irradiation conditions in IFMIF and MYRRHA-IMIFF

European Context

ESFRI
European
Strategic
Forum for
Research
Infrastructure

SET Plan
European
Strategic
Energy Plan

Knowledge Economy

MYRRHA

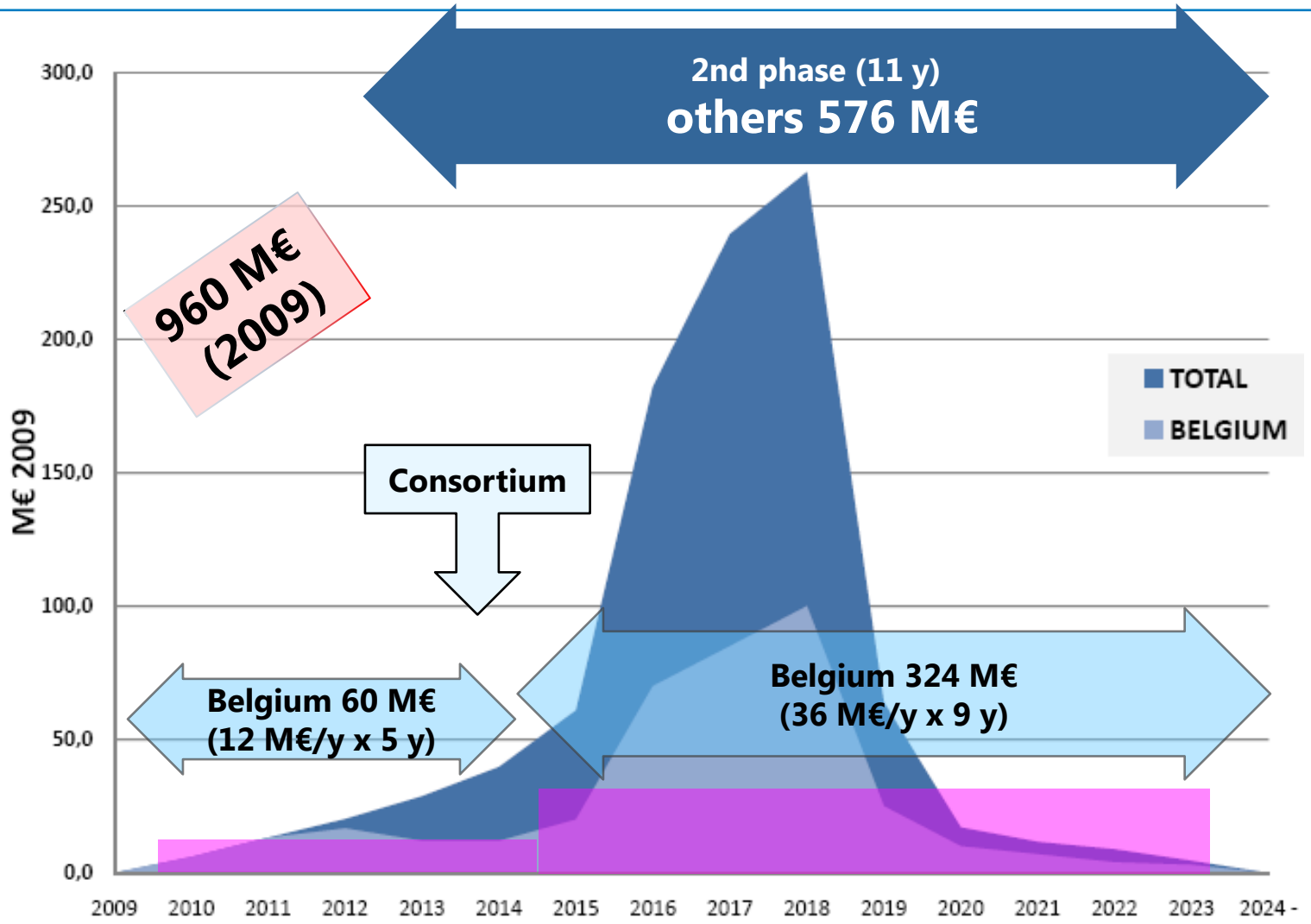
Energy Independence

27.11.2010
Confirmed on ESFRI priority list projects

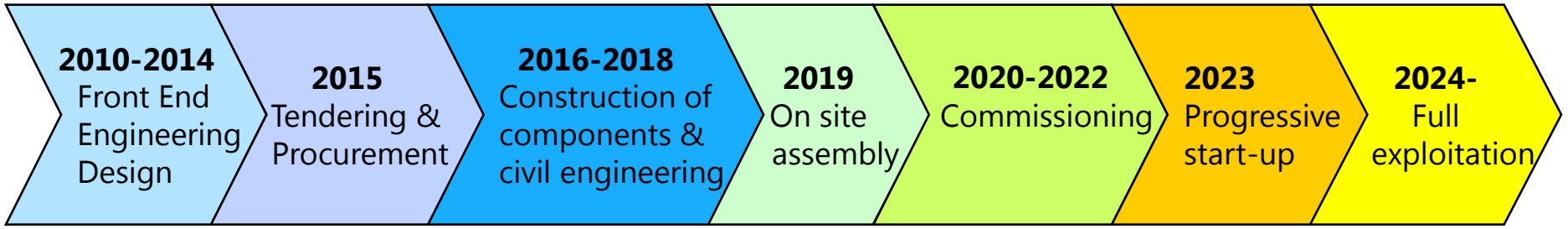
15.11.2010
in ESNII
(SNETP goals)

MYRRHA: an international network

Belgian commitment: secured
International consortium: under construction



The project schedule
Executing presently the FEED Phase: 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

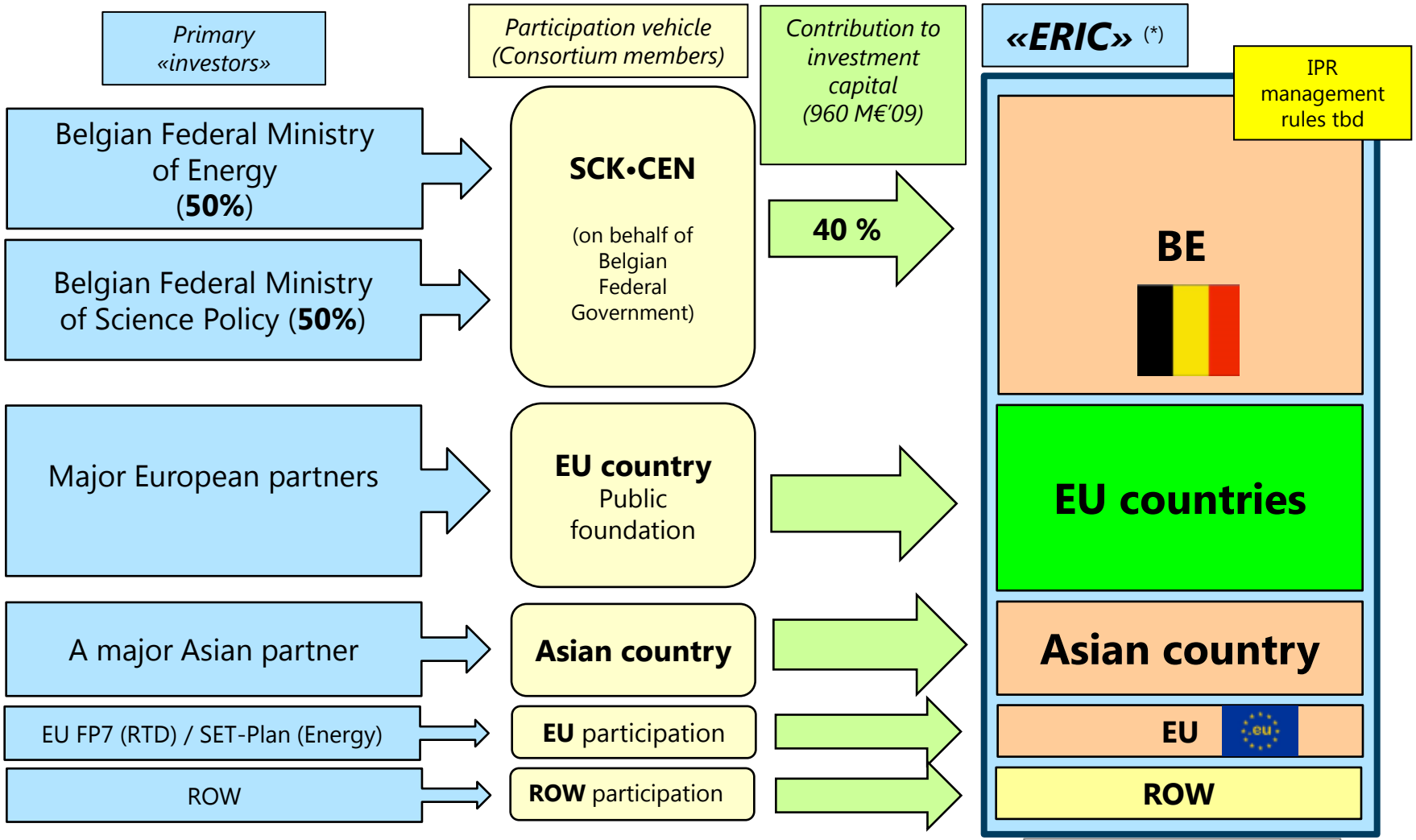
Owner Consortium Group

Owner Engineering Team

FEED (Front End Engineering Design)

2010-2014/15

International Members Consortium – Phase 1
As of early 2012



(*) European Research Infrastructure Consortium

International Members Consortium - Phase 2

CLOSED/ SHARED INFORMATION
for MoC

OPEN INFORMATION

SHARED INFORMATION
for participants

CLOSED INFORMATION
for participants

«ERIC» (*)

Members of Consortium — ~25%
- Individual research of a member of Consortium
- Collaborative research amongst members of Consortium
- 3 years program commitment

Open User Facility — ~25%
- Governments funding
- Criteria of research excellence
- Independant program access committee (PAC)

Collaborative research — ~25%
- Distribution of information to participants

Contract research Commercial services — ~25%
- RI
- NTD Silicon

BENEFITS for Members of Consortium
- Board position to control overal operation
- Priority of access
- Potential benefit of low price (compensation profit from commercial revenues)
- Capacity transfer flexibility (rules tbd)

SCK•CEN
as qualified and licenced operator of the MYRRHA infrastructure under contractual arrangement with ERIC

(*) European Research Infrastructure Consortium

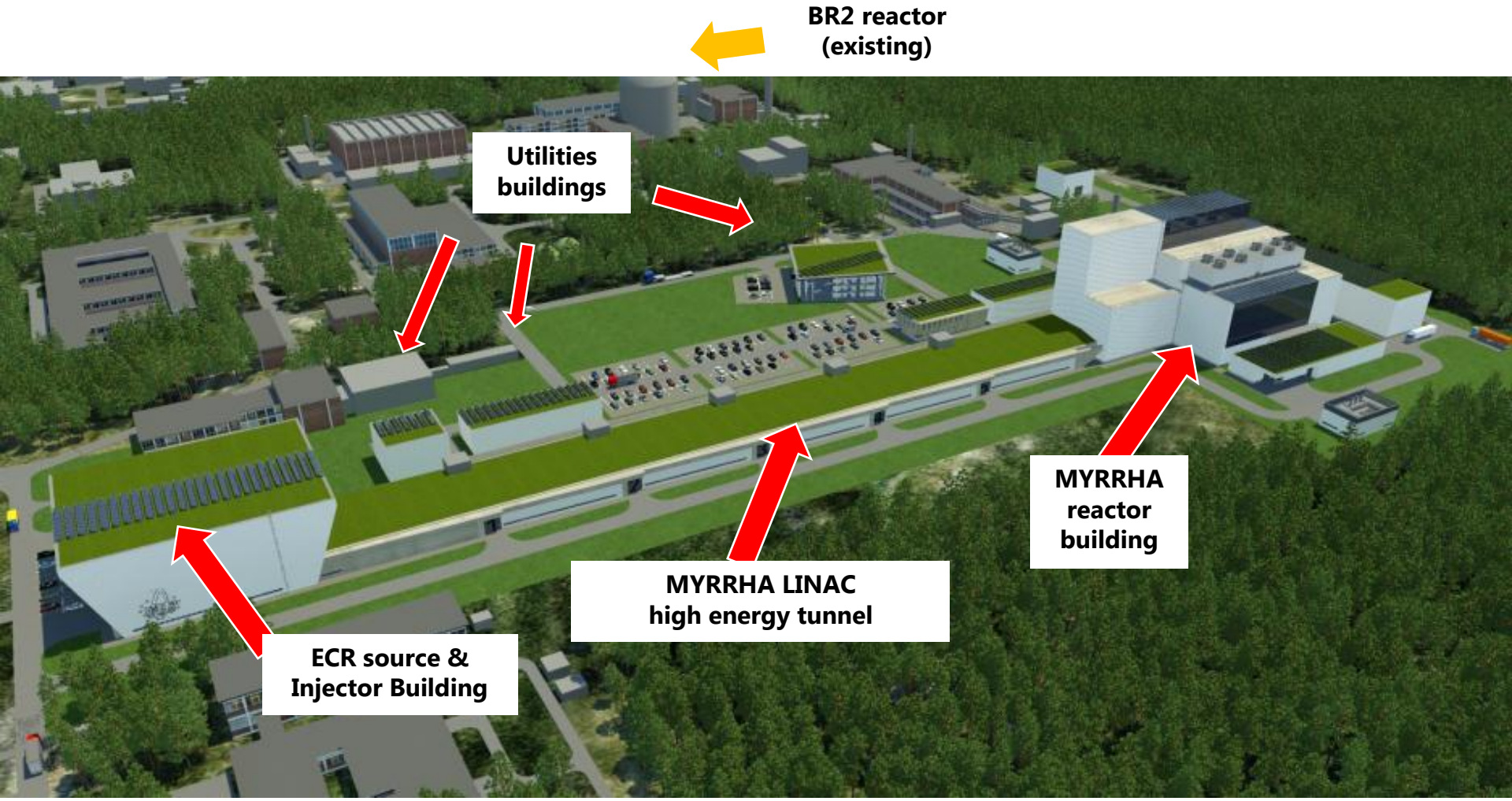
Conclusions

- **MYRRHA As a Multipurpose Fast Spectrum irradiation facility selected by ESFRI, is responding to:**
  - The issue of addressing the nuclear waste legacy of present reactor technology through advanced options (**ADS, P&T**)
  - The SNETP need for a **multipurpose research infrastructure** expressed in its Strategic Research Agenda whatever the considered technology for Gen.IV systems
  - The Objective of Belgium and SCK•CEN to **maintain a high level expertise in the country** in the nuclear safety, nuclear technology and nuclear competencies independently of the future of NE
  - The objective of the European Commission to make available a series of **relevant irradiation facilities for the fusion materia**l research community towards the DEMO construction
  - **Secure society needs** for RI for medical applications and Doped-Si for renewable Energy

MYRRHA & CERN

- **SCK•CEN signed last year a collaboration agreement with CERN on MYRRHA, in particular related to the development of its accelerator :**
  - **Linac4:** injector developments and tests
  - **Linac4:** building definition and integration
  - **Linac4:** normal conducting RF cavities
  - **Cryogenics:** system definition and optimisation
  - **Cryogenics:** interactions with industrial providers and test procedures
  - **Fast Pulsing Magnets:** long flat top kicker magnet
  - **Low Level Controls:** data acquisition, timing
  - **SPL:** elliptical cavity cryomodule design and prototyping
  - **Accelerator Reliability**

MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM
A pan-European, innovative and unique facility at Mol (BE)



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Belgian Nuclear Research Centre

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Fondation d'Utilité Publique
Foundation of Public Utility

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