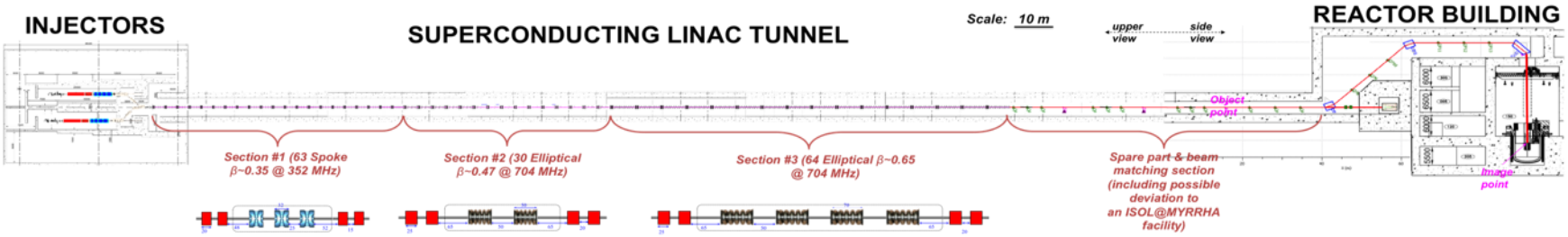
MYRRHA

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



MYRRHA: a polyvalent research project around an ADS nuclear reactor

The MYRRHA project and its broad spectrum of applications

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

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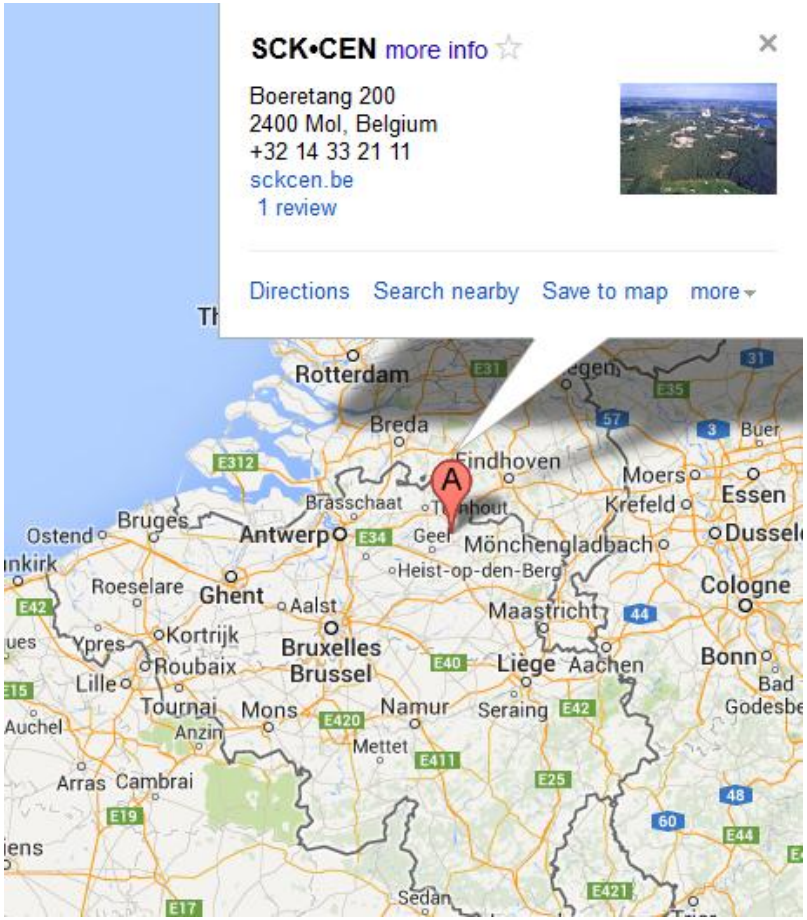
SCK•CEN: background

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



1st pressurized water reactor (PWR) outside USA (BR3)

Innovative nuclear fuel (MOX fuel)

Highest performing material testing reactor in Europe (BR2)

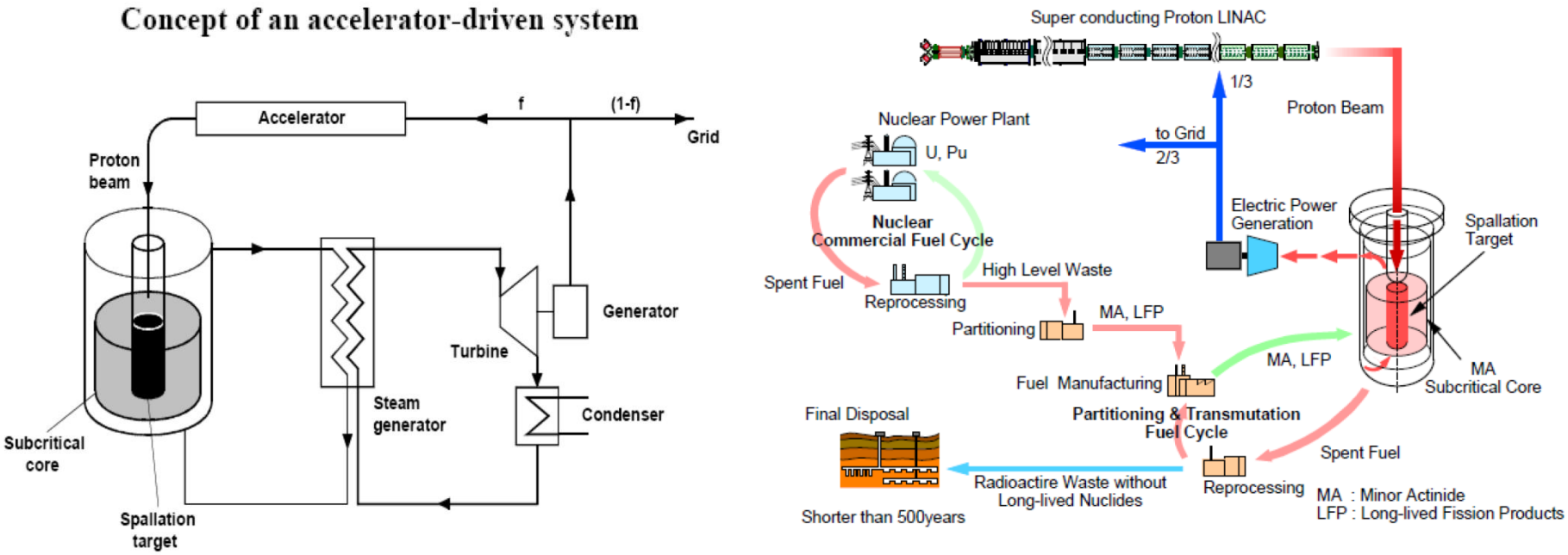
World first underground lab for R&D on HL waste disposal (HADES)

World first lead based ADS (GUINEVERE)

MYRRHA

World premiere project for transmutation of nuclear waste

What is an ADS?



An **Accelerator-Driven-System** is:

- a subcritical neutron multiplication assembly (nuclear reactor, $k_{eff}<1$),
- driven by an external neutron source,
- obtained through the spallation mechanism with high energy (~ 1GeV) protons,
- impinging on massive (high Z) target nuclei (Pb, W).

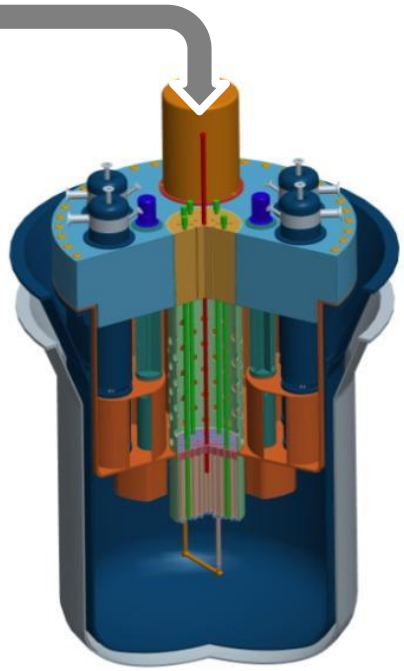
MYRRHA - Accelerator Driven System

Accelerator	
particles	protons
beam energy	600 MeV
beam current	2.4 to 4 mA
mode	CW
MTBF	> 250 h

Reactor	
power	~85 MW_{th}
k_{eff}	0.955
spectrum	fast (flexible)
fuel	high-enriched MOX
coolant	LBE

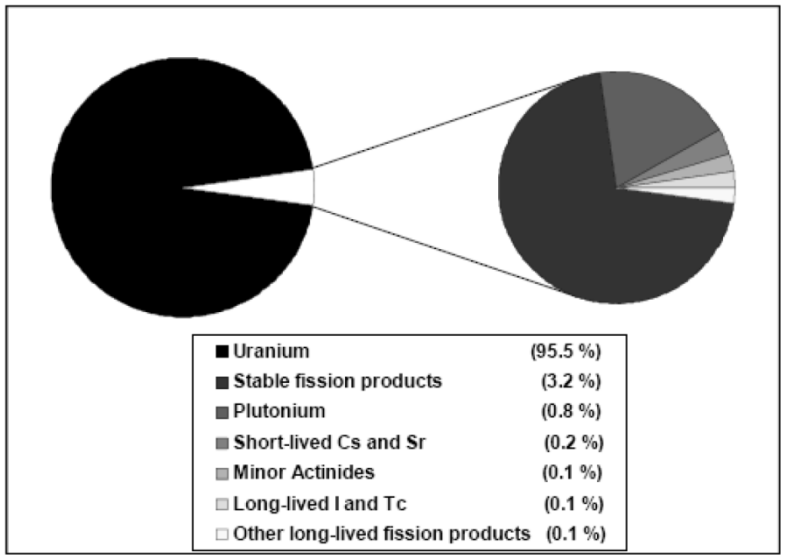
- Demonstrate the **ADS concept** (coupling accelerator + spallation source + power reactor)
- Demonstrate **Transmutation** (experimental fuel assemblies)
- Fast neutron source: **Multipurpose and flexible Irradiaton facility**

Target	
main reaction	spallation
output	$2 \cdot 10^{17}$ n/s
material	LBE (coolant)
power	2.4 MW



Partitioning & Transmutation

Composition of spent nuclear fuel (standard PWR 33 GW/t, 10-year cooling)



1 tonne of SNF contains:
955.4 kg U
8.5 kg Pu

Minor actinides (MAs)
0.5 kg ^{237}Np
0.6 kg Am
0.02 kg Cm

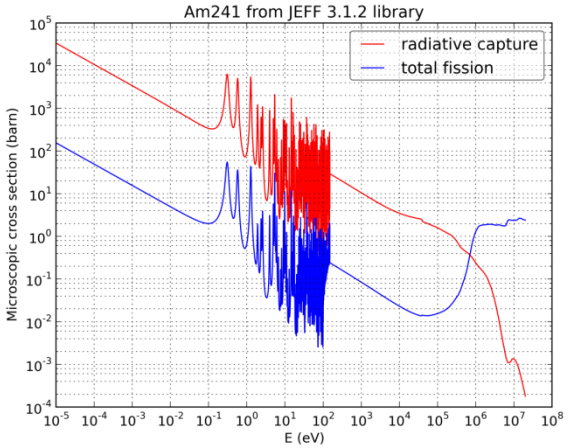
Long-lived fission products (LLFPs)
0.2 kg ^{129}I
0.8 kg ^{99}Tc
0.7 kg ^{93}Zr
0.3 kg ^{135}Cs

Short-lived fission products (SLFPs)
1 kg ^{137}Cs
0.7 kg ^{90}Sr

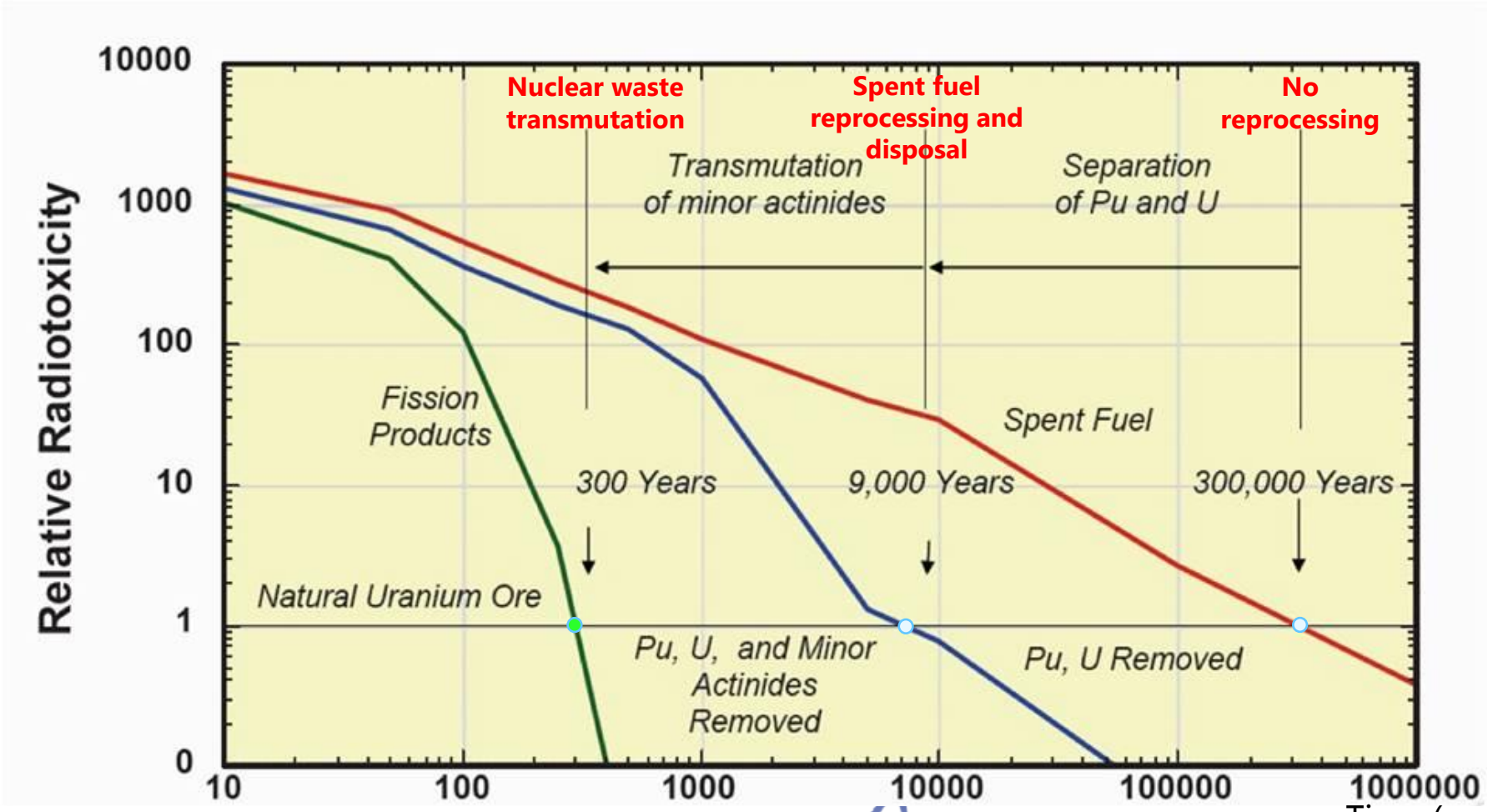
Stable isotopes
10.1 kg lanthanides
21.8 kg other stable

- Spent nuclear fuel current EU strategy is:
  - Onsite in-pool cooling (up to 10yrs)
  - Reprocessing in (few) centralized and dedicated plants (1yr): here U&Pu is removed from the spent fuel
  - Disposal:
    - Superficial for LLW and ILW (half lives ~10^3 yrs)
    - Geological for HLW (half lives ~ 10^6 yrs)

- Storage (*"to wait"*) vs. treatment (*"to use nature against nature"*):
  - To reduce radiotoxicity of MAs, we can to fission them
  - The ratio Fission/Capture is more favorable with fast neutrons
  - To reduce radiotoxicity of LLFPs, they should undergo several neutron captures



Nuclear waste: transmutation impact



US DOE exstimation, LWR fuel, burn-up: 50 GWd/MT, 5 years in-pool cooling

Duration Reduction: 1000x

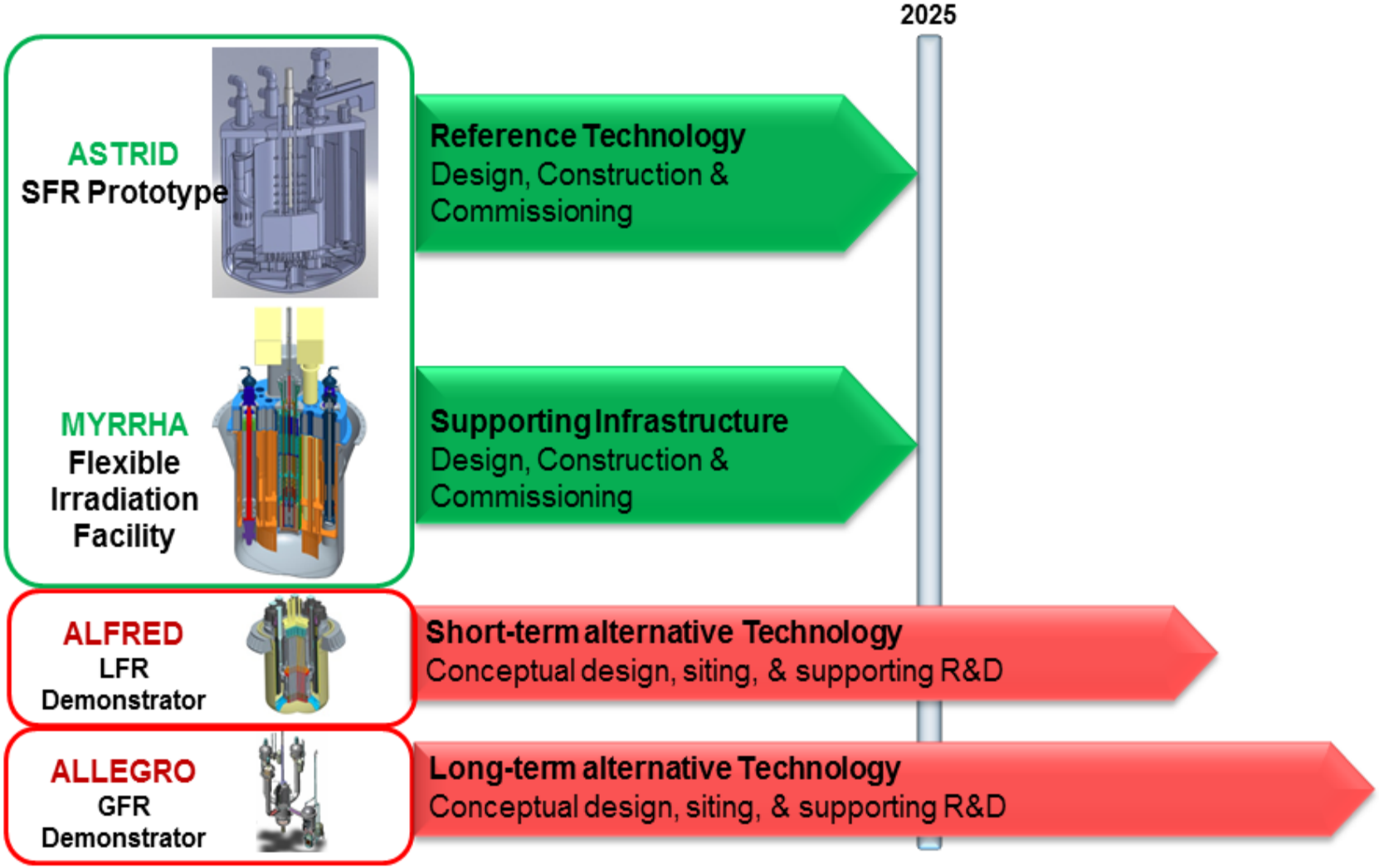
Volume Reduction: 100x

MYRRHA: applications

	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 (Neutron Transmutation Doped NTD-Si)	Securing NTD-Silicon production
Healthcare	Ageing population	A long term source of medical radioisotopes	Securing radioisotopes production (existing and new ones)

MYRRHA as part of the ESNII

European Sustainable Nuclear Industrial Initiative



MYRRHA within EURATOM: 2010-2014

CDT

Reactor design

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MARISA

Support action

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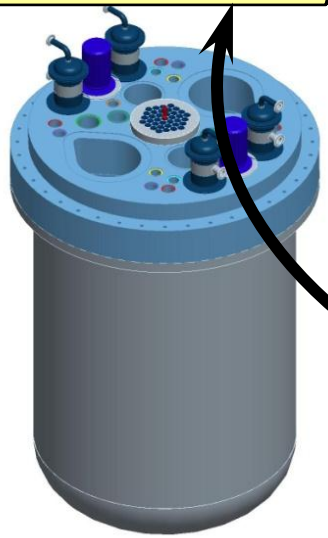
FREYA

GUINEVERE experiment

SCK•CEN



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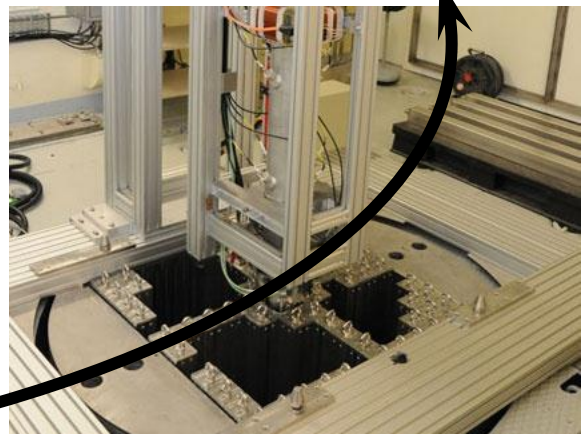
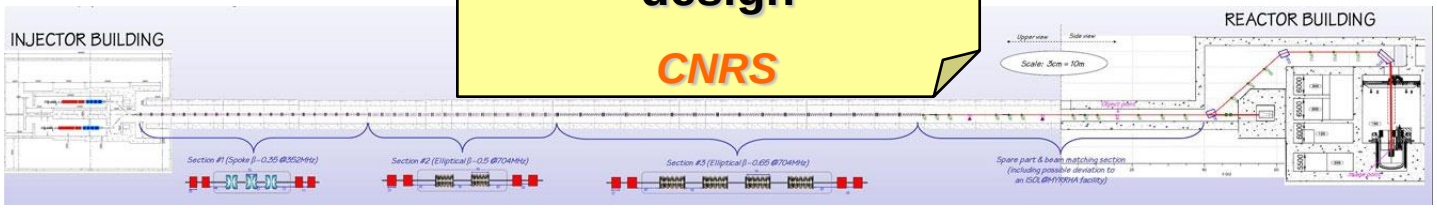


MAX

Accelerator design

CNRS



Project Timeline

2010-2014 R&D & Front End Engineering Design → **2015** Tendering & Procurement → **2016-2018** Construction of components & civil engineering → **2019** On site assembly → **2020-2022** Commissioning → **2023** Progressive start-up → **2024-** Full exploitation

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)

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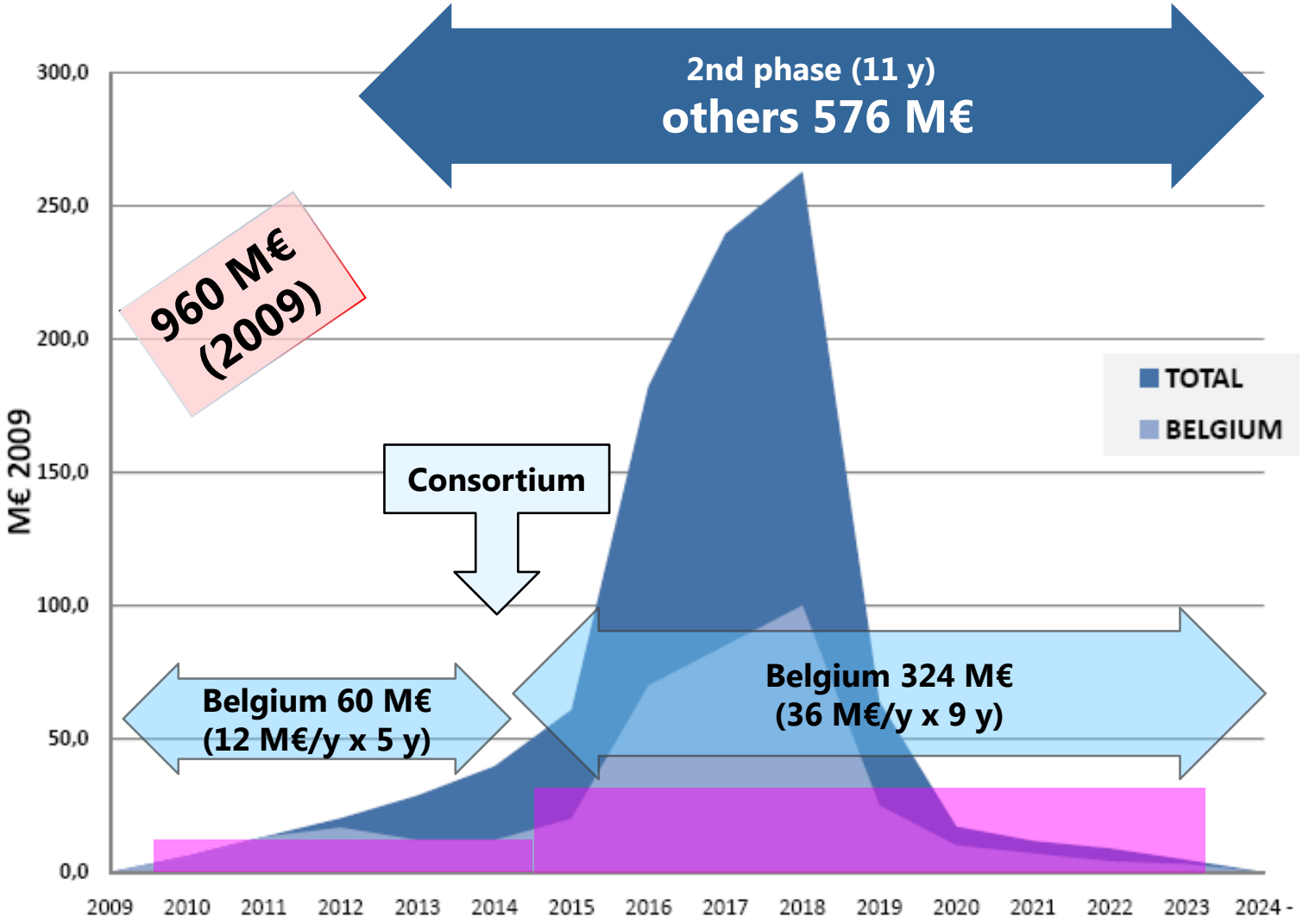
Myrrha accelerates towards realisation

15 October 2013

Belgium's SCK-CEN has awarded a €24 million ($32 million) contract for front-end engineering design for the Myrrha accelerator-driven research reactor to a multinational consortium led by Areva.

Project budget



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