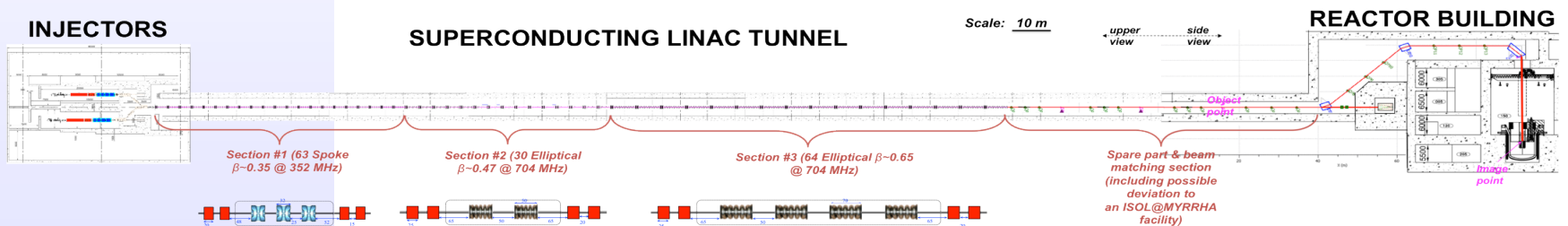


MYRRHA Accelerator R&D Program

Multipurpose hYbrid Research Reactor for High-tech Applications



Dirk Vandeplassche
Luis Medeiros Romão

- MYRRHA Project
 - General context
 - Project Schedule and budget
 - Guinevere ADS
- MYRRHA Linear Accelerator R&D Program
 - Global R&D Program
 - Accelerator Group
 - Collaborations
- MYRRHA Facility

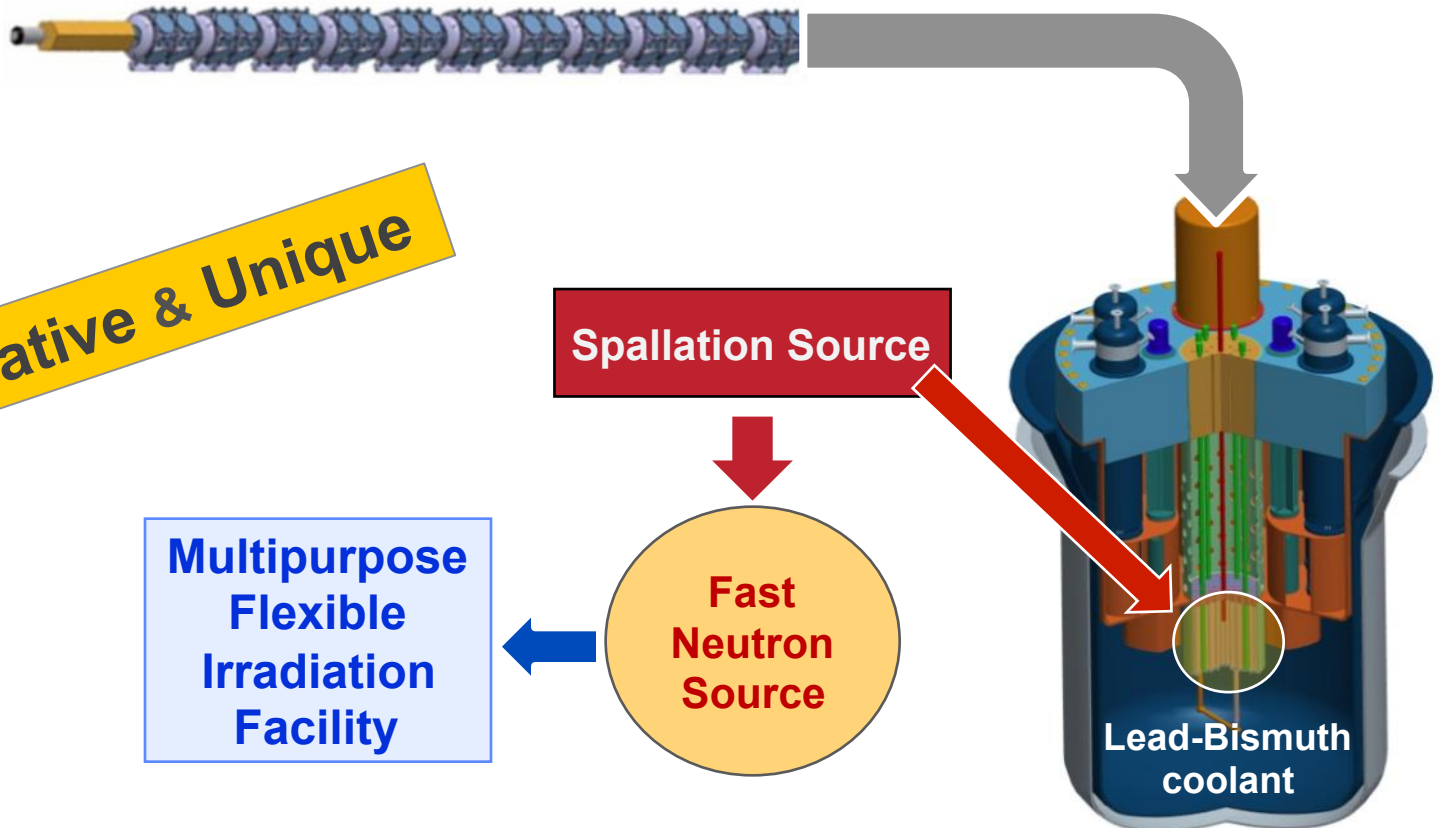
MYRRHA Accelerator Driven System

Accelerator

600 MeV
4 mA proton CW

Reactor

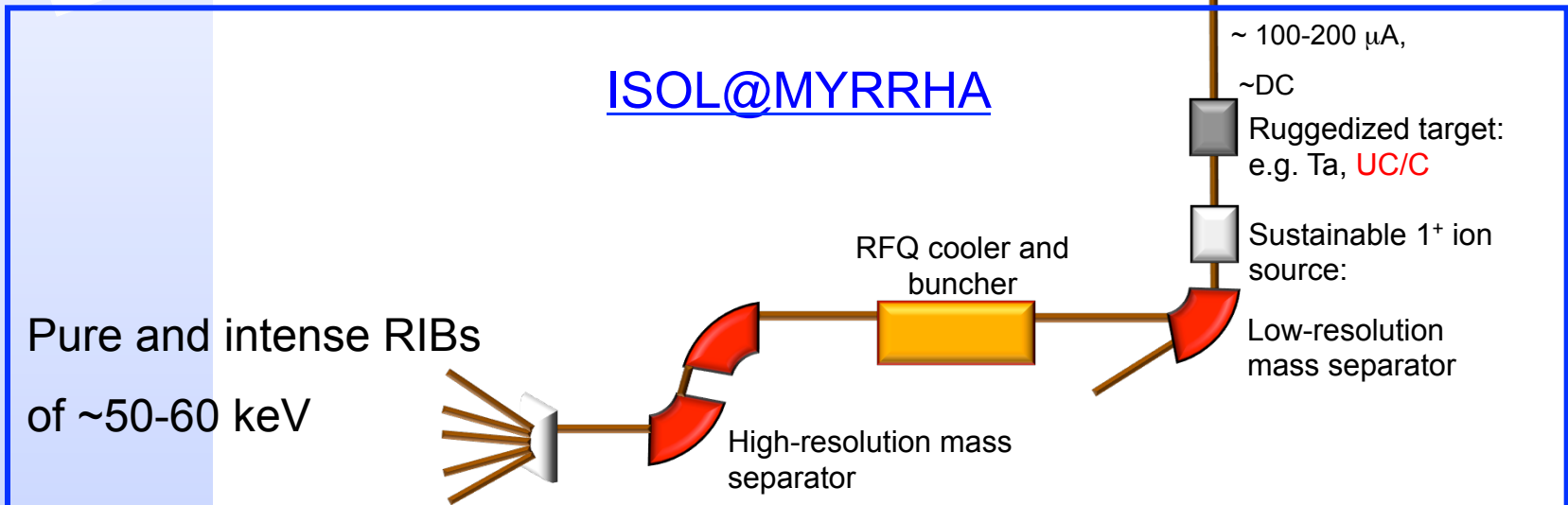
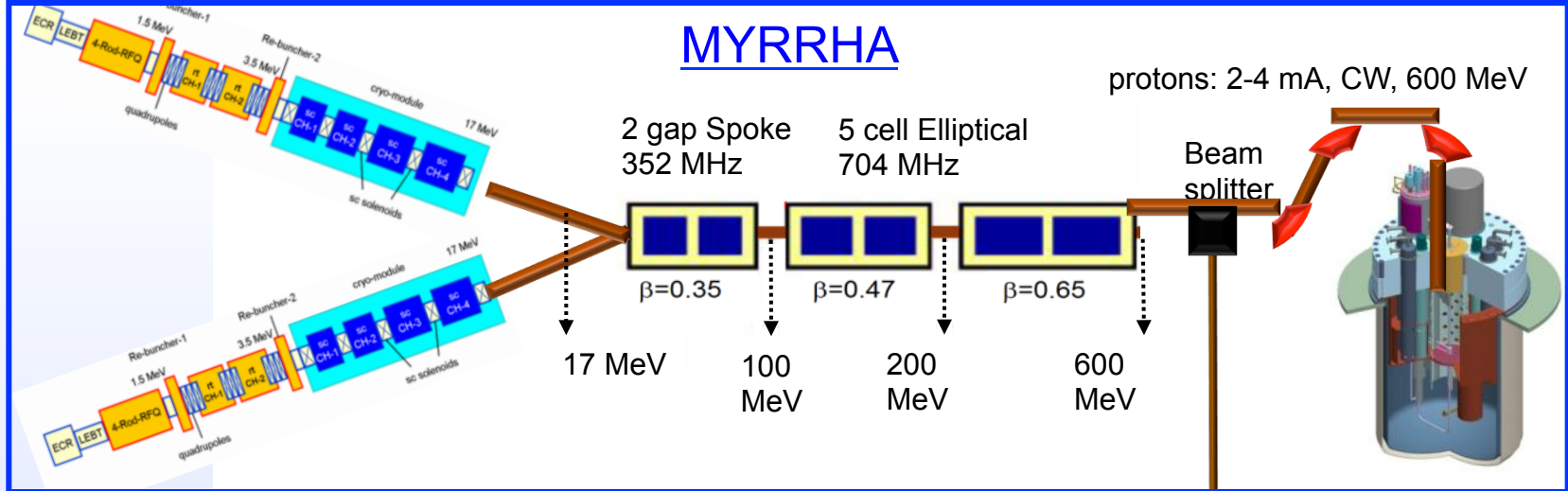
Subcritical or Critical modes
65 to 100 MWth



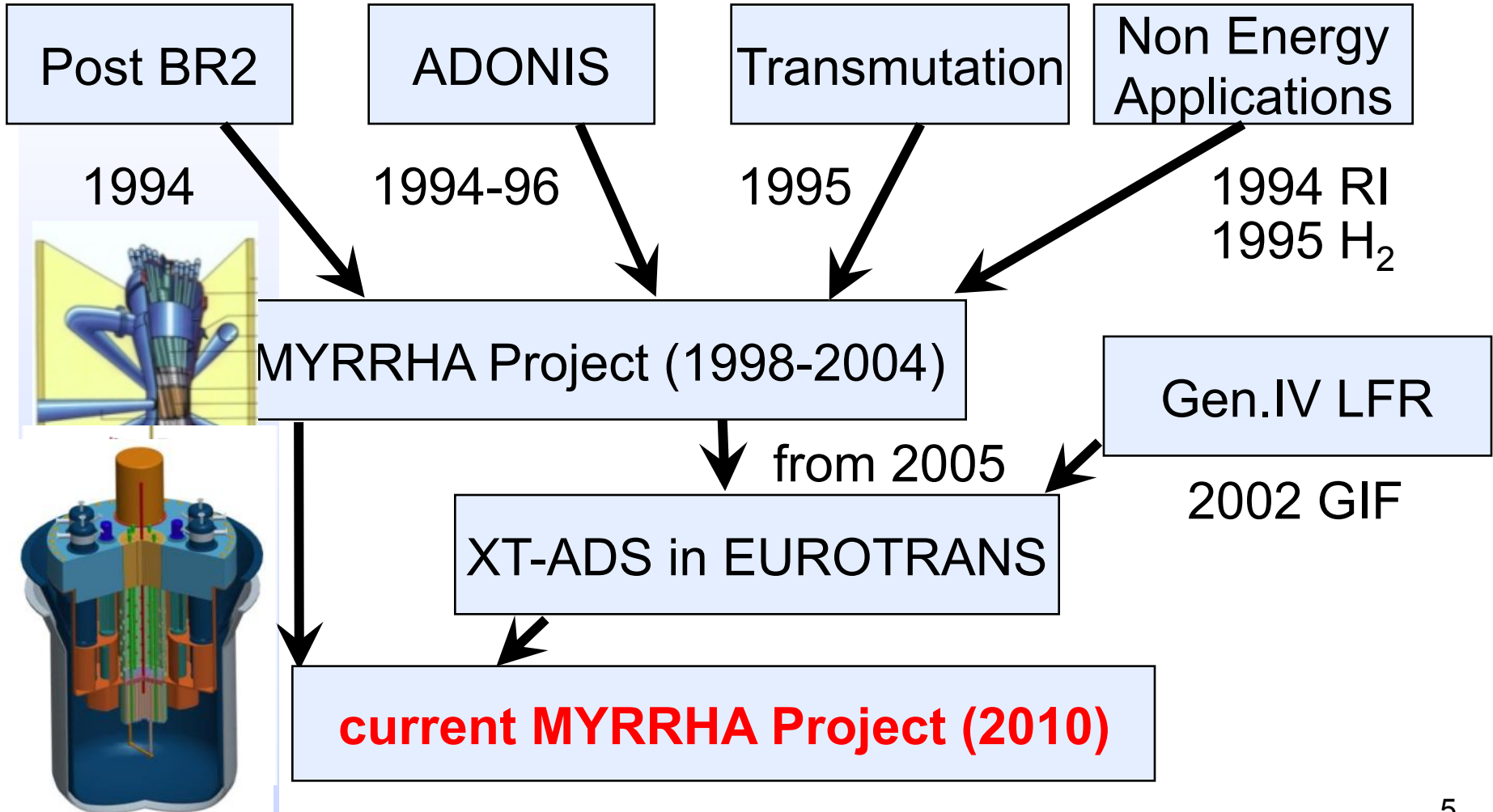
Innovative & Unique

**Multipurpose
Flexible
Irradiation
Facility**

ISOL@MYRRHA fundamental research



MYRRHA Genesis & History



Decision of Belgian Government 05.03.2010

KONINKRIJK BELGIË

FEDERALE OVERHEIDSDIENST ECONOMIE,
K.M.O., MIDDENSTAND
& ENERGIE

Koninklijk besluit tot toekenning van een aanvullende subsidie aan het Studiecentrum voor Kernenergie voor de verwezenlijking van het MYRRHA-project.

ROYAUME DE BELGIQUE

SERVICE PUBLIC FÉDÉRAL ÉCONOMIE,
P.M.E., CLASSES MOYENNES
& ÉNERGIE

Arrêté royal attribuant une subvention complémentaire au Centre d'Etude de l'Energie nucléaire pour la réalisation du projet MYRRHA.

- Strongly supporting the project
- Special endowment of 60 MEUR for 2010-2014
- Milestones to reach in 2014 for continuation of the project
 - 1) **Completion of the engineering design**
 - 2) **Obtaining licencing permit**
 - 3) **International consortium formed (additional 40% financing)**
- Govt follow-up committee: **MYRRHA Ad Hoc Group**

European context: At the crossroads of ESFRI and SET Plan

ESFRI
European
Strategic
Forum for
Research
Infrastructure

SET Plan
European
Strategic
Energy
Plan

**Knowledge
Economy**



**Energy
Independence**



**The only
ESFRI project
for Belgium**

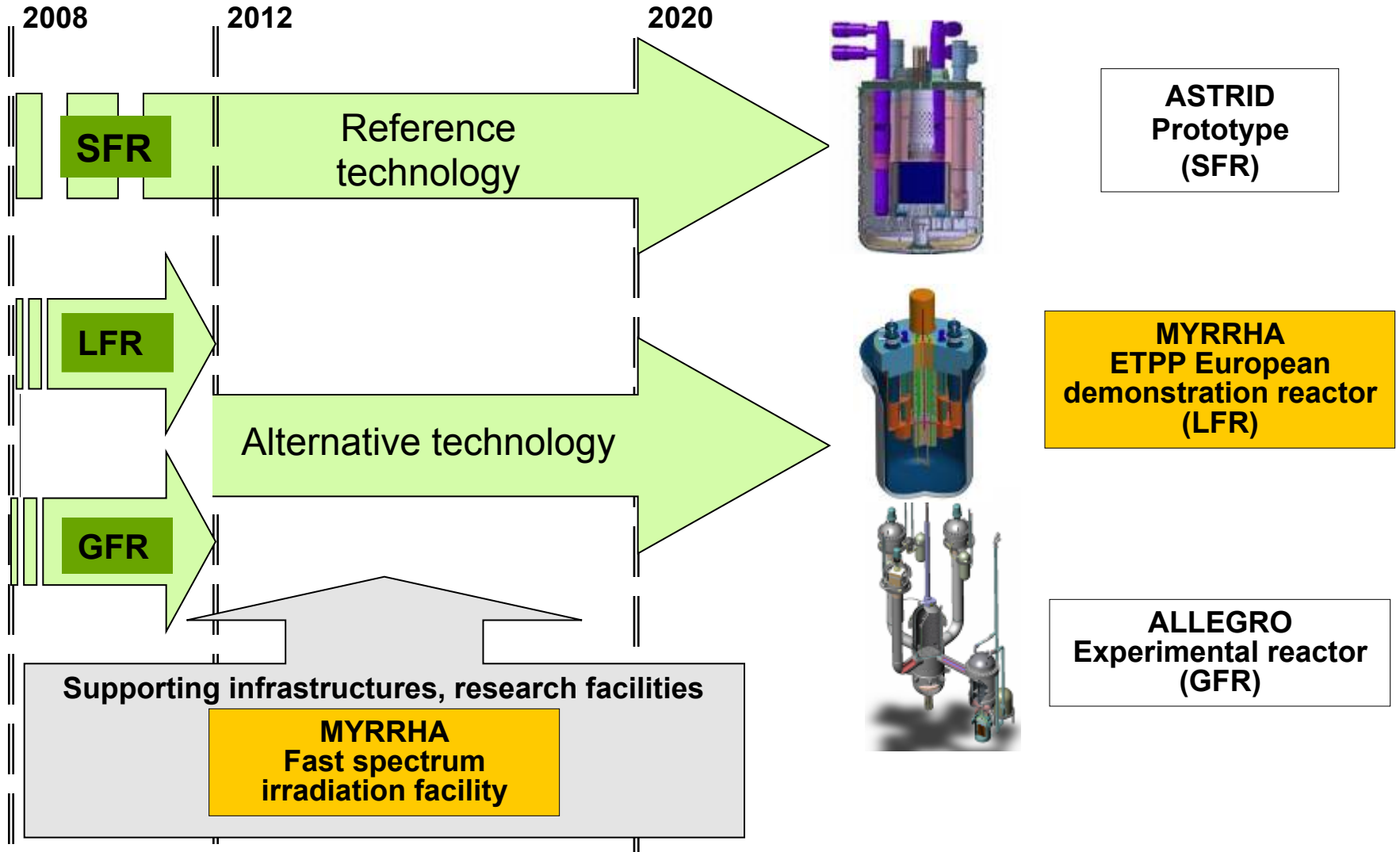
**MYRRHA key
milestones achieved
in 2010**

**27.11.2010
Confirmed on ESFRI
priority list projects**

**15.11.2010
in ESNI
(SNETP goals)**

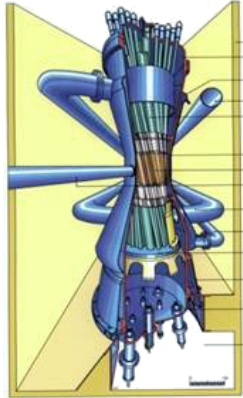
SNETP Gen. IV Systems

European Sustainable Nuclear Industrial Initiative



SCK·CEN Context

MYRRHA replaces BR2



1962

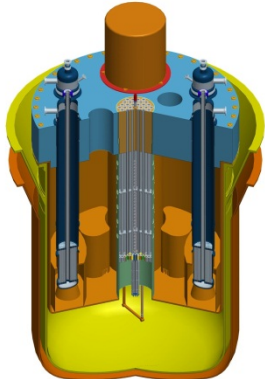
BR2

Material
Testing Reactor
(fission)

Fuel testing
for LWR &
GEN II/GEN III

Irradiation
Services:

- Medical RI
- Silicon Doping
- Others



2023

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
LFT GEN IV

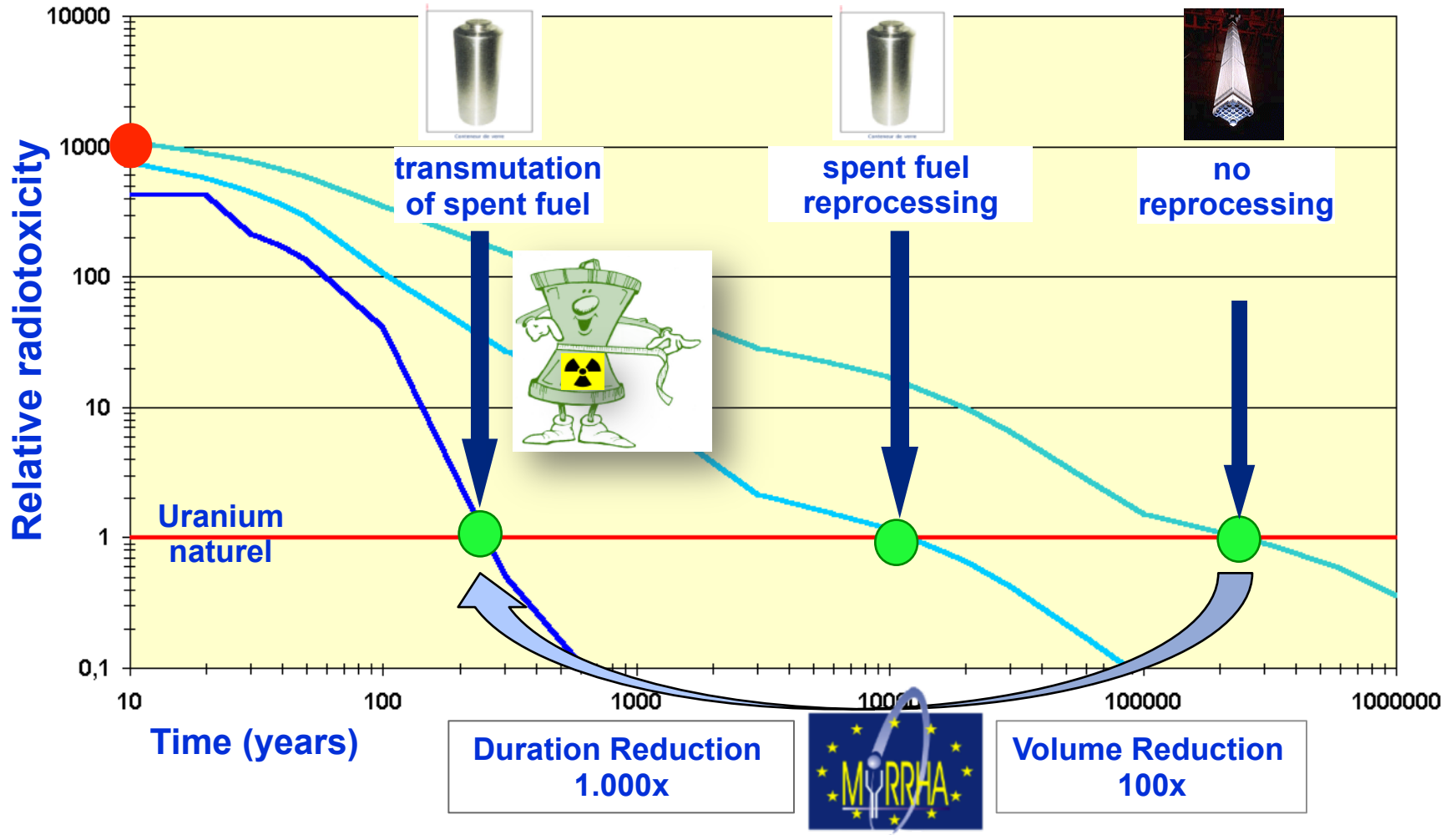
LFR European Technology Pilot Plant (ETPP)

MYRRHA's contribution

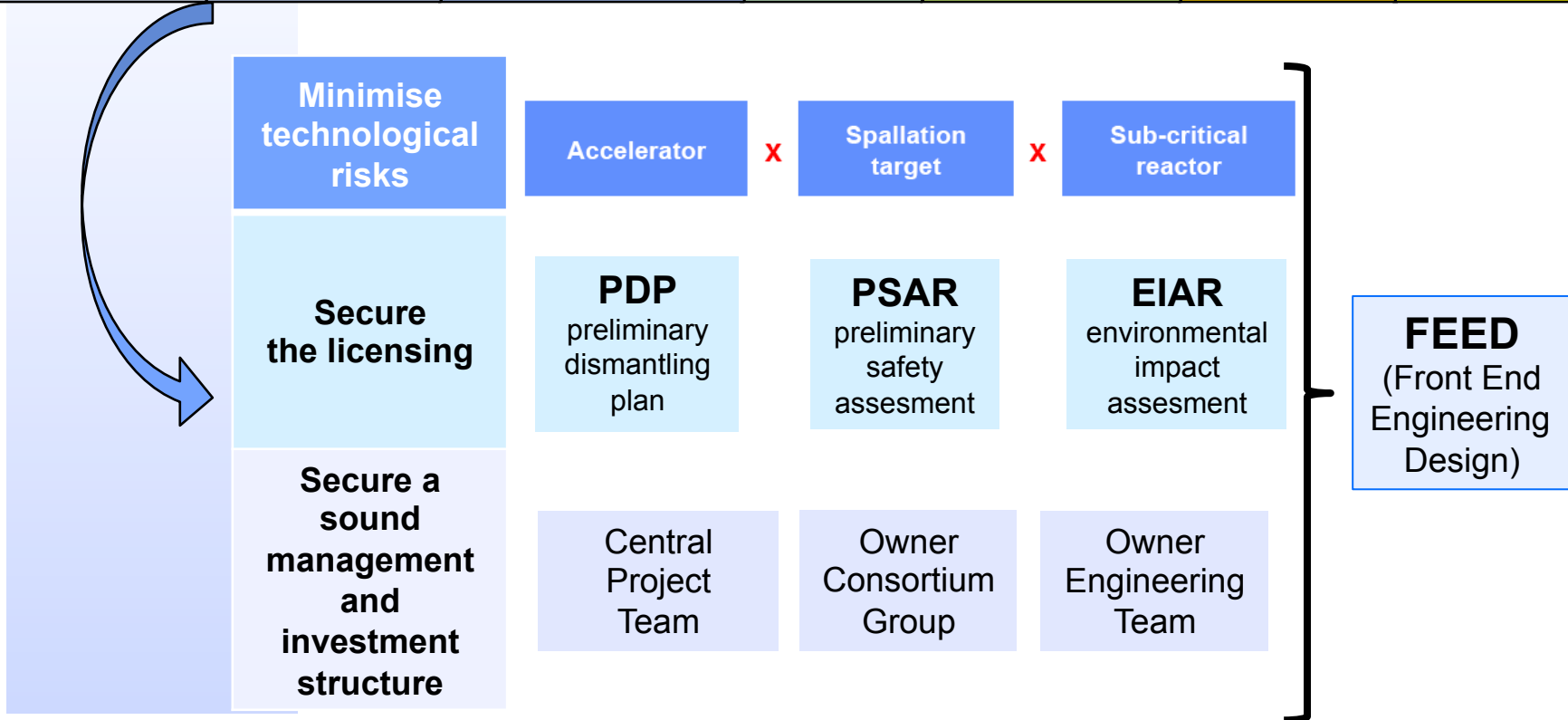
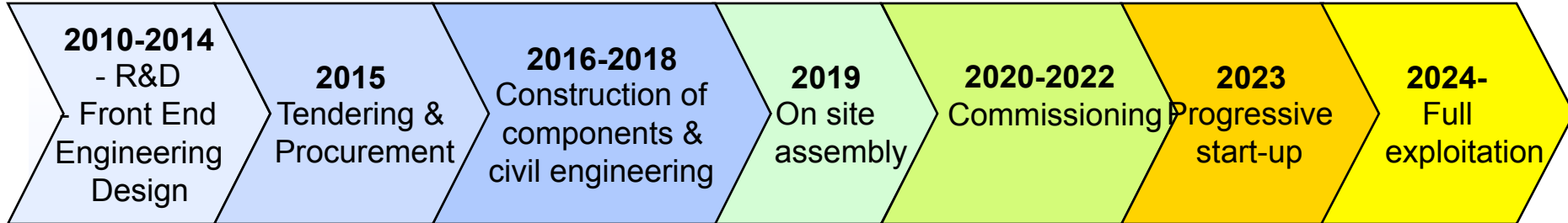
Multipurpose
hYbrid
Research
Reactor for
High-tech
Applications

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

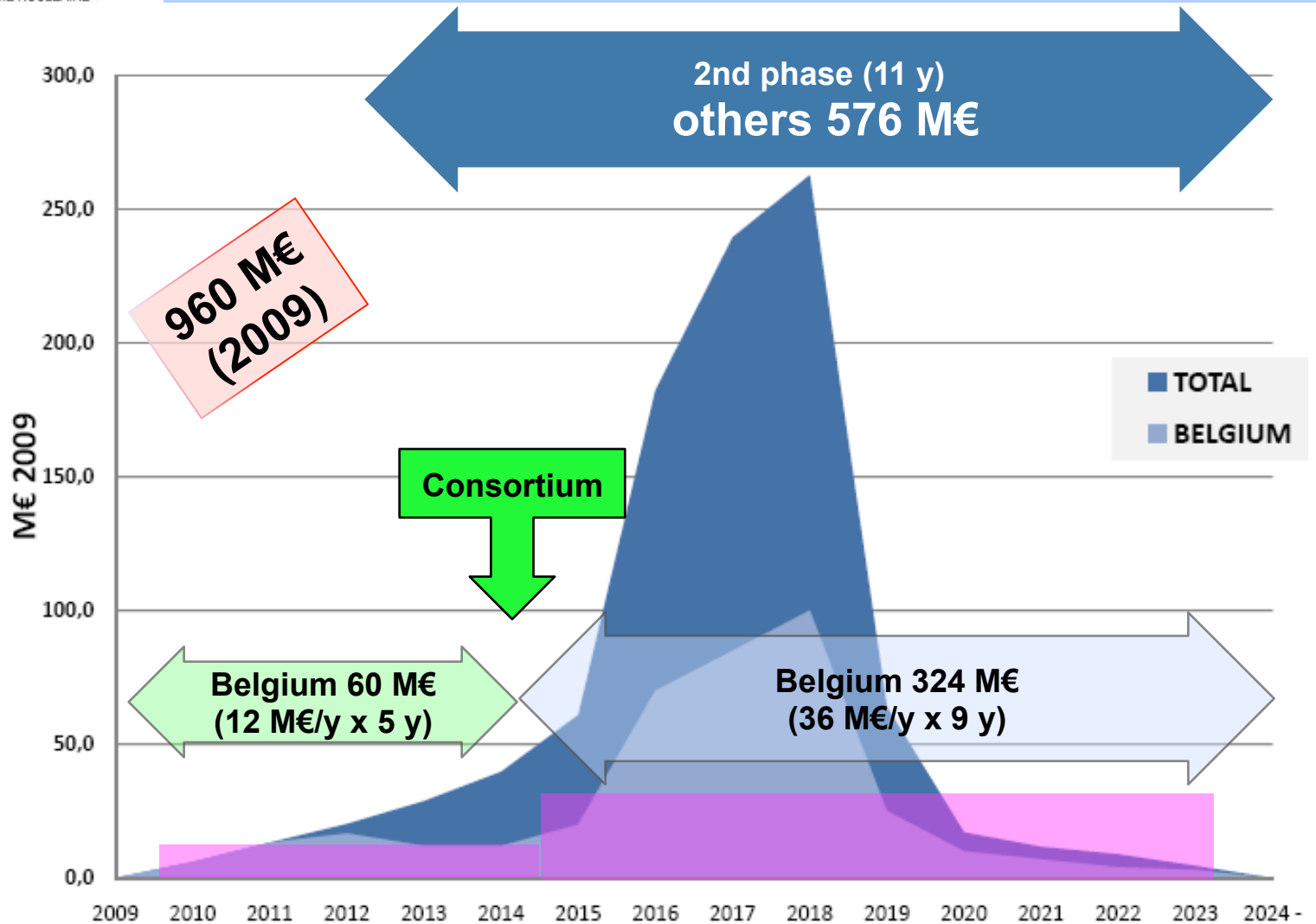
Motivation for transmutation



Program Timeline

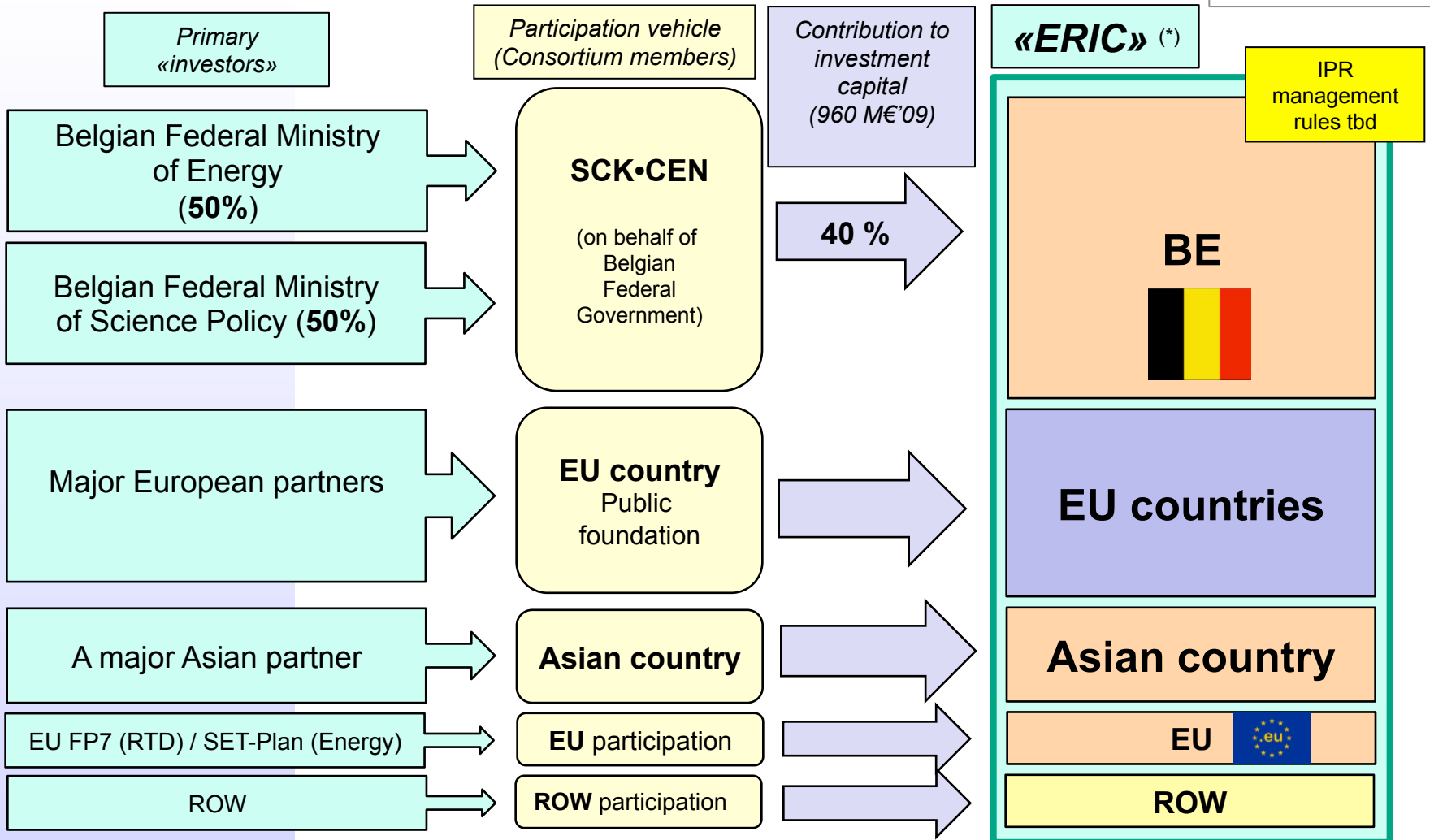


Program Budget

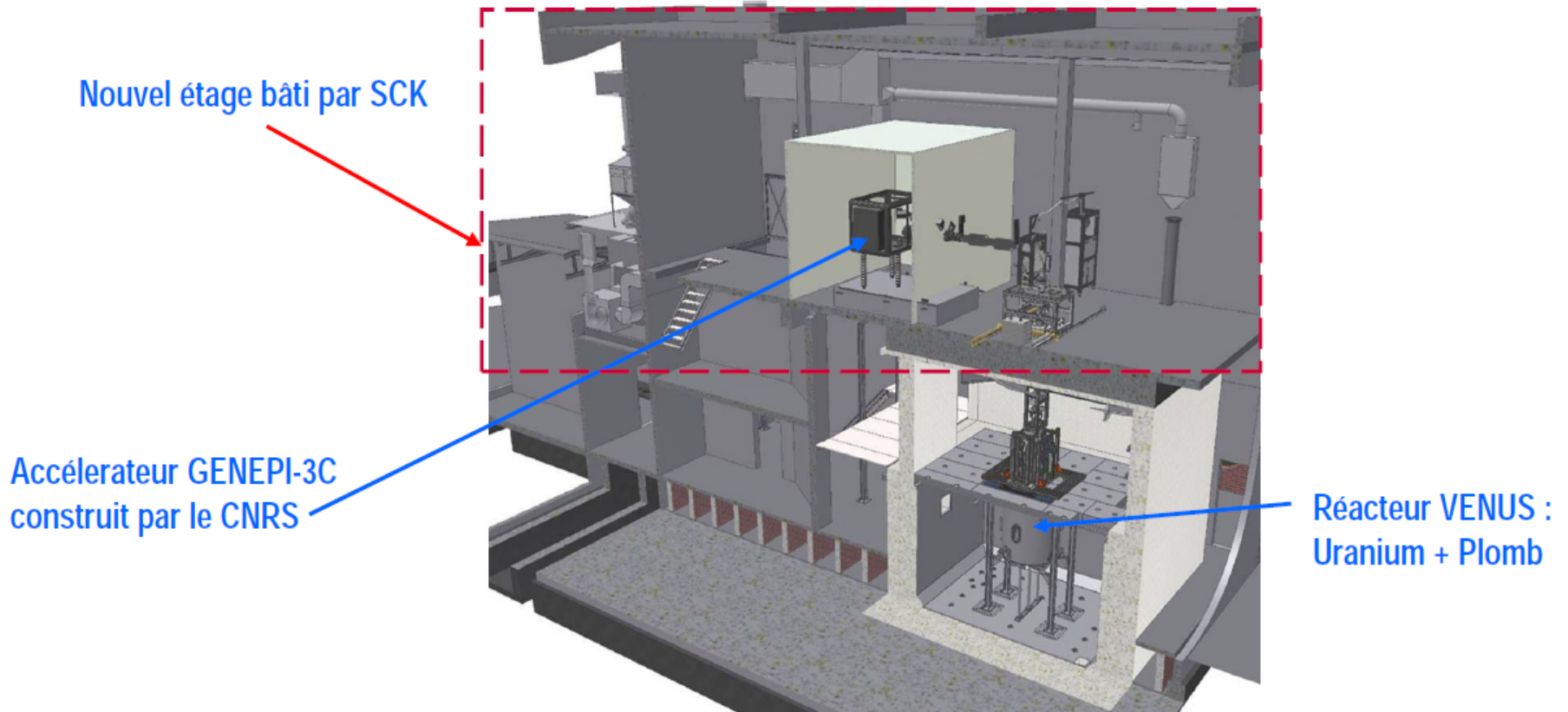


International Members Consortium

(*) *European Research Infrastructure Consortium*



First ADS – GUINEVERE



MLA Specifications

fundamental characteristics (ADS)

beam energy	600 MeV
beam current	4 mA
mode	CW
MTBF	> 250 h

challenge !

failure = beam trip > 3 s

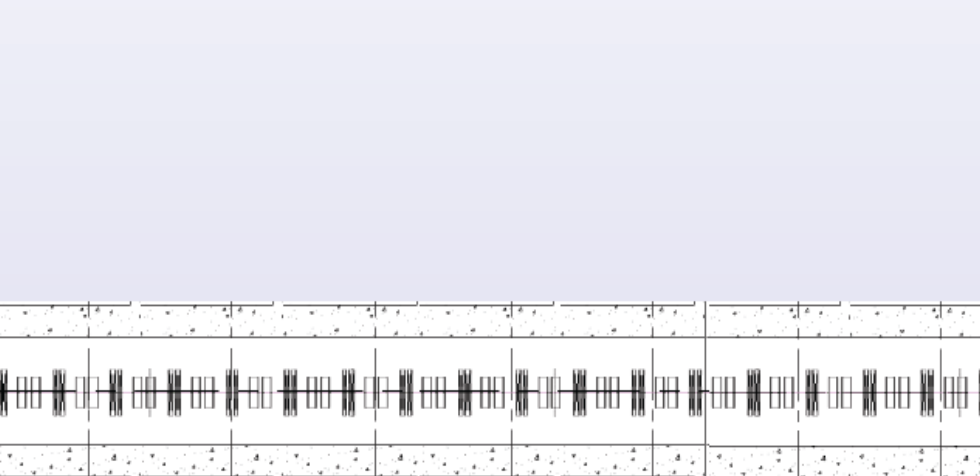
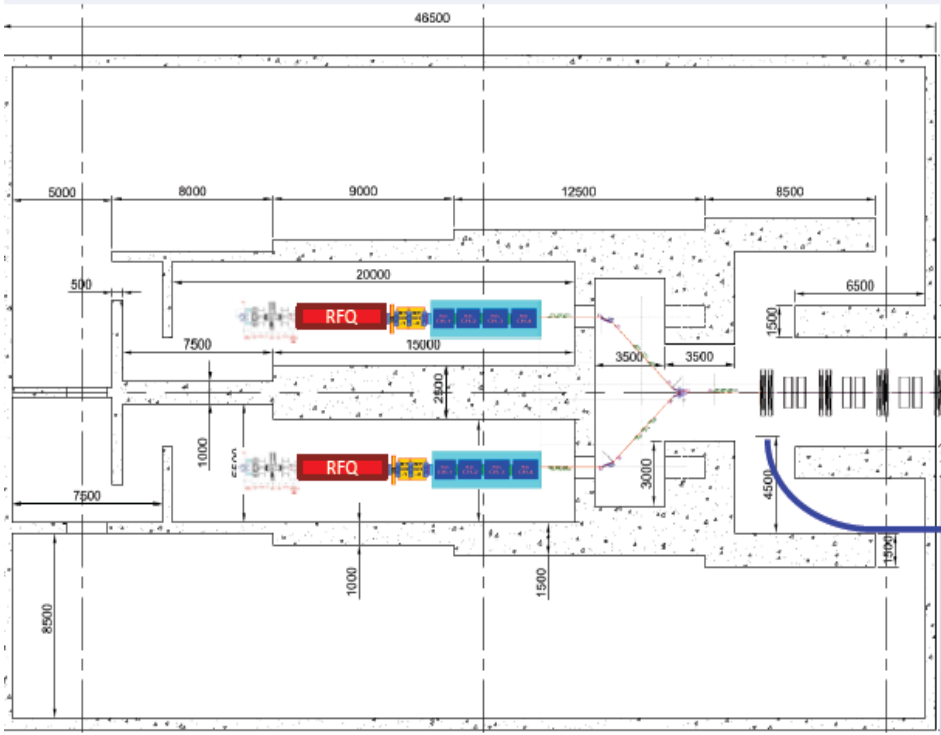
implementation and design guidelines

SC Linac

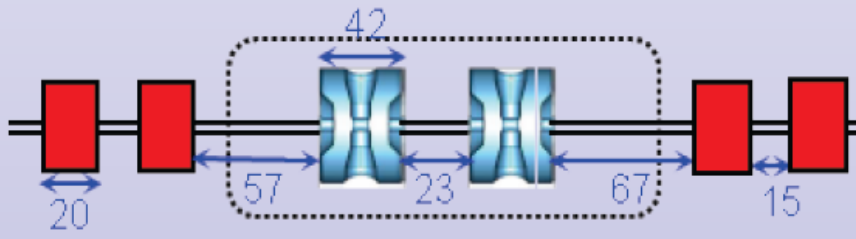
frequency	176.1 / 352.2 / 704.4 MHz
reliability = redundancy	dual injector
	fault tolerance

Layout of the MYRRHA linac

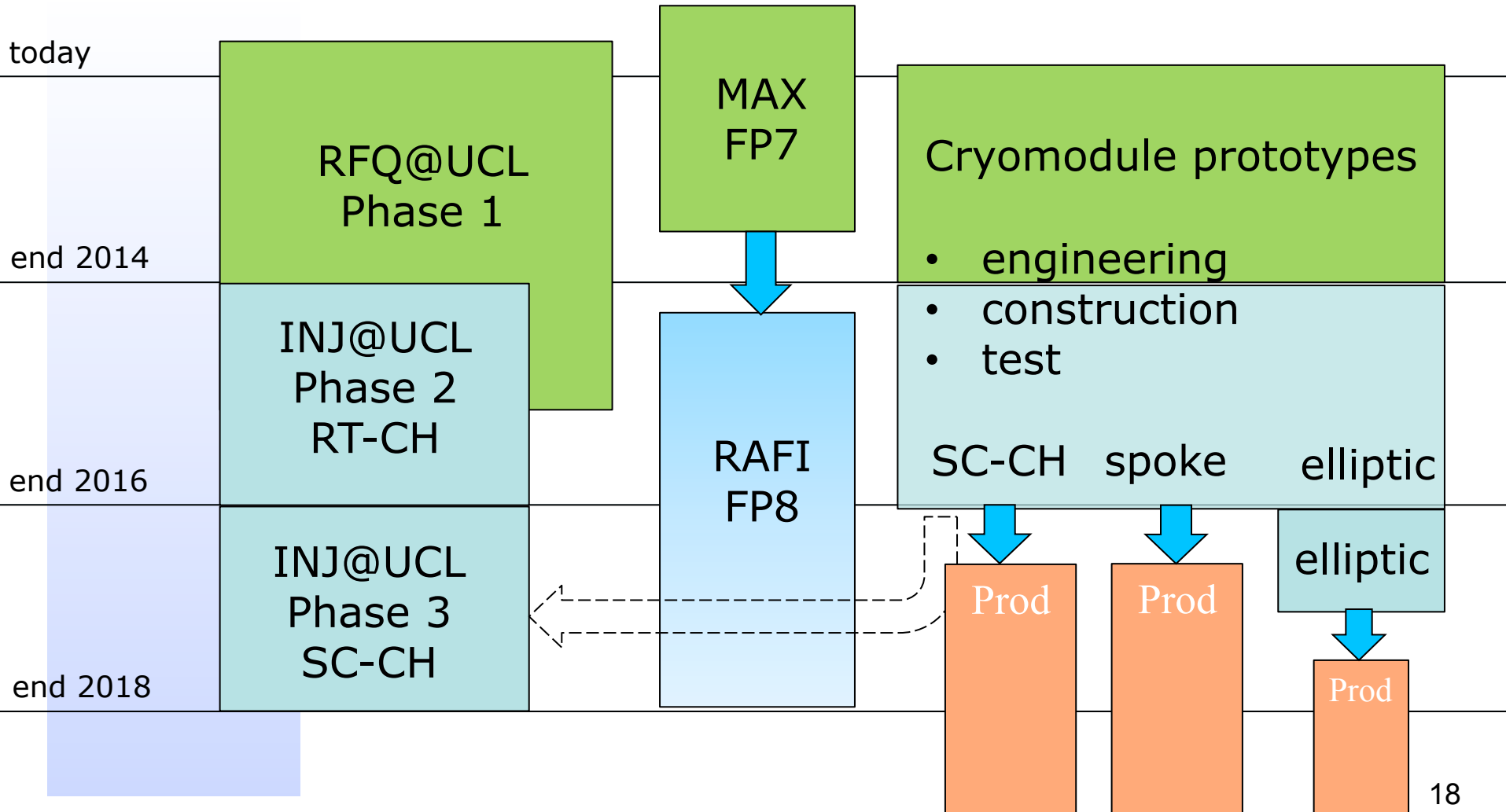
INJECTOR BUILDING



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



R&D Program

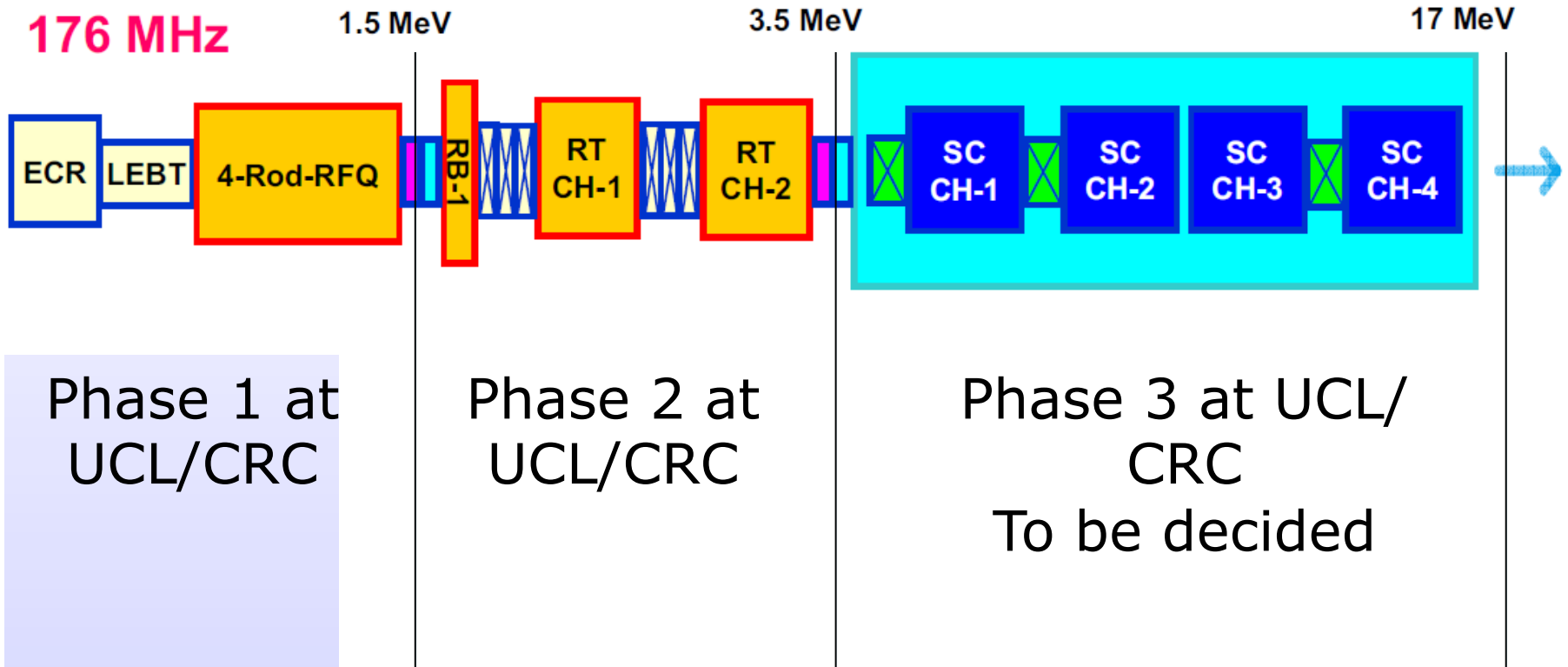


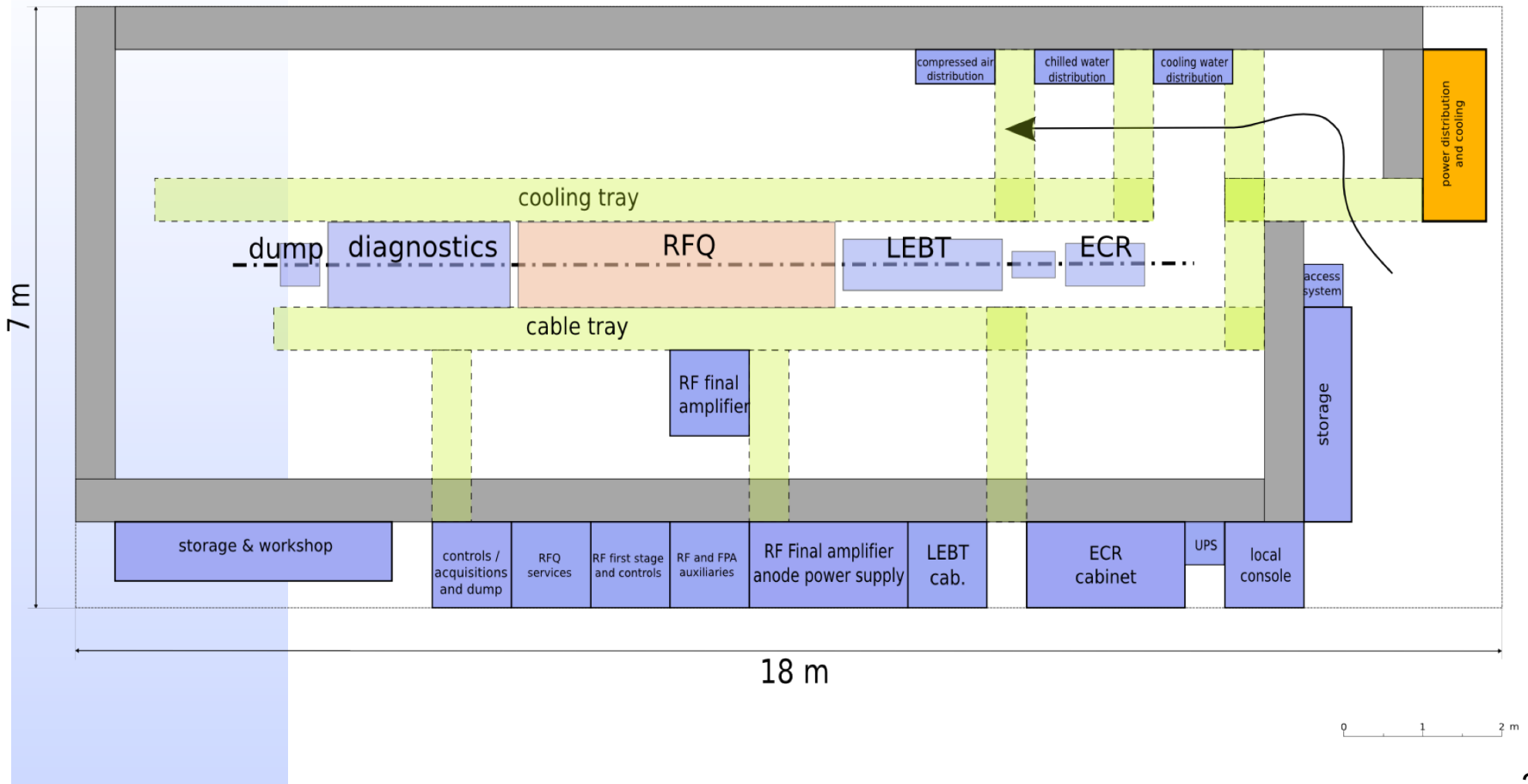
FP7 - MAX

3 years	coordinated by IPNO
Goal	coherent concept of the Myrrha accelerator
Technical WP's	<ol style="list-style-type: none"> 1. Global coherence 2. Injector 3. Main linac 4. System optimisation
<p>Outstanding topics:</p> <ul style="list-style-type: none"> • simulations (beam and reliability) • injector • design of spoke cryomodule • tests with legacy elliptical cryomodule • perspectives for 704 MHz SS ampl. 	<p>Principal partners:</p> <ul style="list-style-type: none"> • IN2P3 - IPN Orsay • IAP Frankfurt • INFN Milano • CEA • SCK•CEN

RFQ@UCL

Up to 2014 and beyond	led by SCK•CEN
Goals	<ul style="list-style-type: none"> • address 4-rod RFQ • tool for relevant reliability oriented experiments • experience – education
Outstanding topics: <ul style="list-style-type: none"> • source, LEBT, RFQ • RF amplifier • diagnostics • relevant control system • possible extension (CH) 	Principal present partners: <ul style="list-style-type: none"> • IAP Frankfurt • IN2P3 • UCL/CRC







Present Status

item	actor	concept	design	engineering	construction	installation	acceptance
bunker	SCK•CEN	✓	-	-	III-12	-	
elec	SCK•CEN	✓	✓	III-12	IV-12	I-13	
cooling	SCK•CEN	✓	✓	III-12	IV-12	-	
ECR	Pantchnik	✓	✓	II-12	IV-12	I-13	I-13
ε-meter	Pantchnik	✓	✓	III-12	IV-12	-	
LEBT + diag	LPSC, IPN, SCK•CEN	✓	III-12	III-13		IV-13	I-14
chopper	LPSC, IPN, SCK•CEN	✓	III-13	IV-13	II-14	III-14	
RFQ	IAP → NTG	✓	✓	II-13	I-14	III-14	IV-14
diag after RFQ	LPSC?, LPC?, IPN, SCK	✓	IV-13	III-14		IV-14	
dump 35 kW	SCK•CEN	✓	III-13	IV-13	II-14	III-14	
RF	tbd	✓	(✓)	III-12	I-13	II-13	
LLRF	tbd	✓	(✓)	III-12	I-13	II-13	
controls	tbd	✓	III-12	continuous → IV-14			

Cryomodules

Up to 2014 and beyond	coordinated by SCK•CEN executed by "principal architects"
Goals	3 prototype cryomodules <ul style="list-style-type: none"> • engineering design • construction • tests • feedback to design
Outstanding topics: <ul style="list-style-type: none"> • innovation • reduction of He consumption • industry mindedness 	Principal potential partners: <ul style="list-style-type: none"> • IPNO • JLab • AMOS

Vision

Where are we going?

Vision 2014

RFQ@UCL delivering “some” 1.5MeV protons

Vision 2023

MLA@SCK•CEN delivering reliably 600MeV protons to
MYRRHA facility

Mission

Why are we here?

Mission 2014

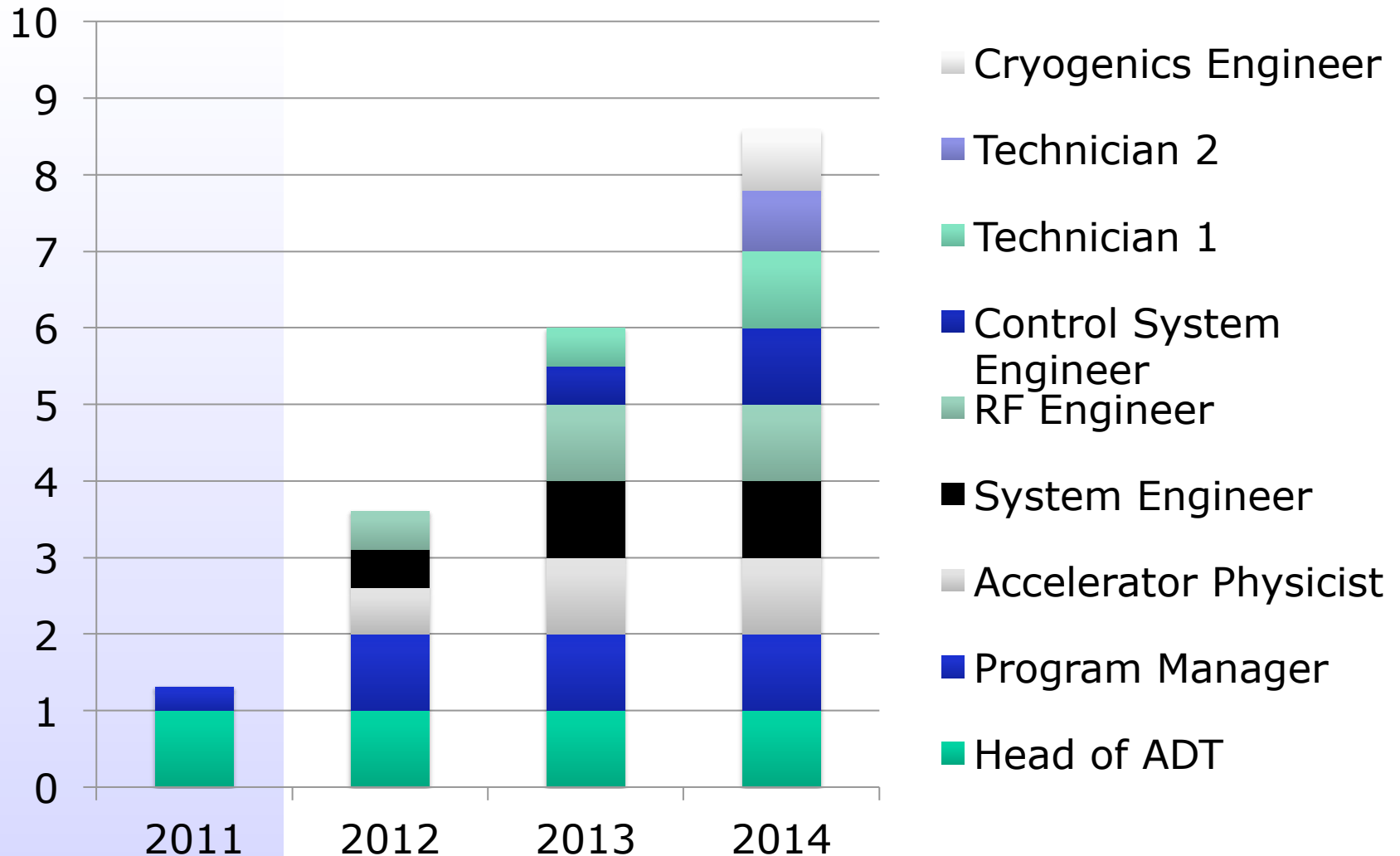
Build Accelerator Know-How for SCK•CEN
Resolve technological issues
Create a platform for improvement and education
Convince that we can do it

Mission 2023

ACCELERATOR Driven System

Build a highly skilled Operations, Maintenance and Training
Accelerator Team to ensure reliable beam delivery and
continuous improvement

Accelerator Group 2011 - 2014



Signed Collaboration agreement CNRS – IN2P3

Institute	Foreseen projects	Estimated Period
IPN Orsay	Spoke cryomodules (engin., manufac. and tests)	2012 – 2016
Subatech Nantes	Full power beam-dump (design)	2012 – 2013
LPSC Grenoble	LEBT (engin., manufac. and tests)	2012 – 2014
IPHC Strasbourg	High power Emittancemeter (engin., manufac. and tests)	2013 – 2014

Collaboration agreements in preparation

- **CERN**
 - Various accelerator topics and RIB targets
- **Ganil / SPIRAL2**
 - Accelerator development and building needs
- **JLAB**
 - Several interesting subjects around SCRF
 - Outstanding topic: High Q cavities

- **ESS**

- Cryomodule co-developments
- Control system

- **SNS**

- Machine operation and optimization (reliability)
- Auto retune

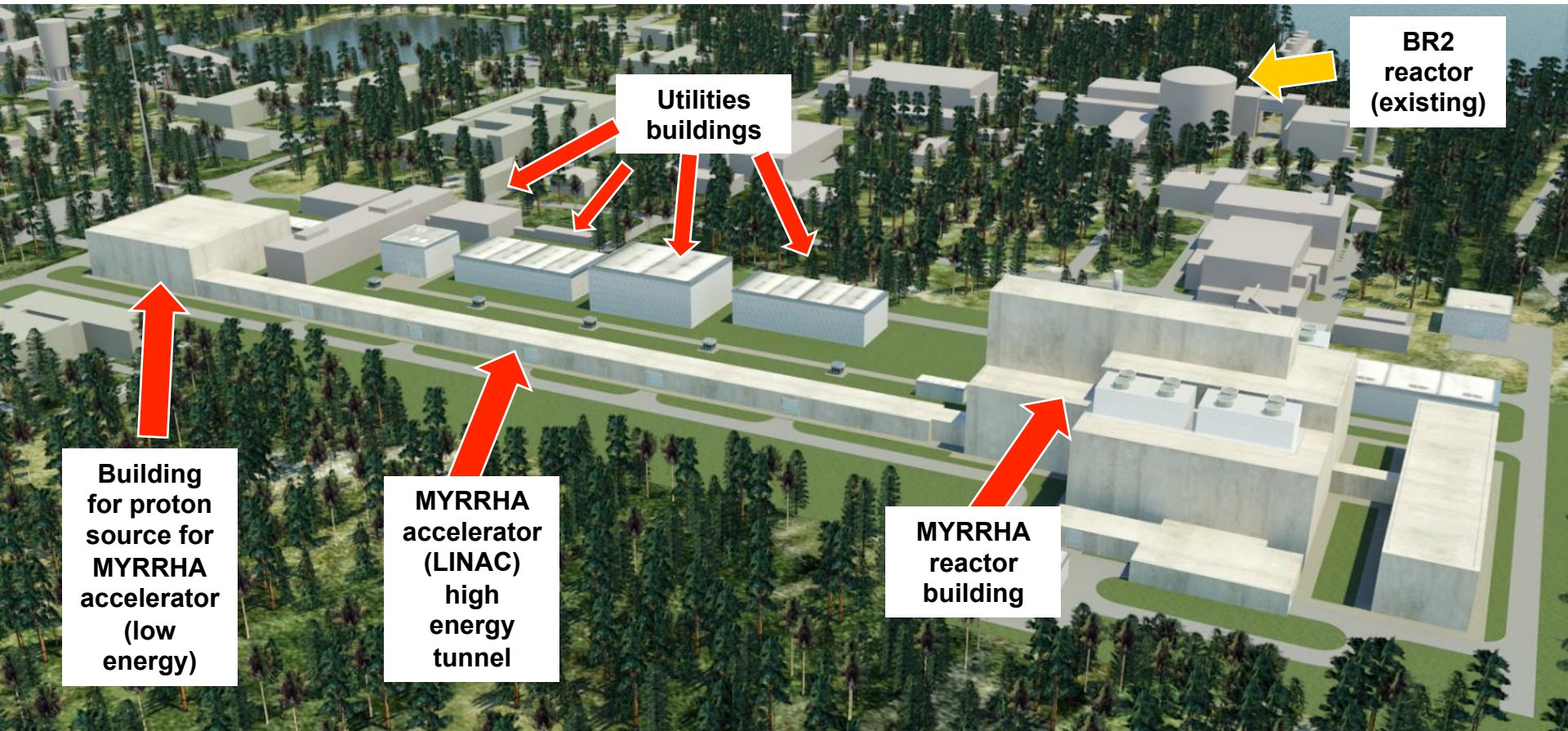
- **PSI**

- Machine protection
- HP beam-dump
- Beam Window
- HP CW beam handling

Belgian Industries Collaborations in discussion

- **AMOS**
 - Cryomodule design, engineering and manufacturing
- **IBA**
 - General accelerator engineering
 - RFQ@UCL

MYRRHA @SCK·CEN, Mol

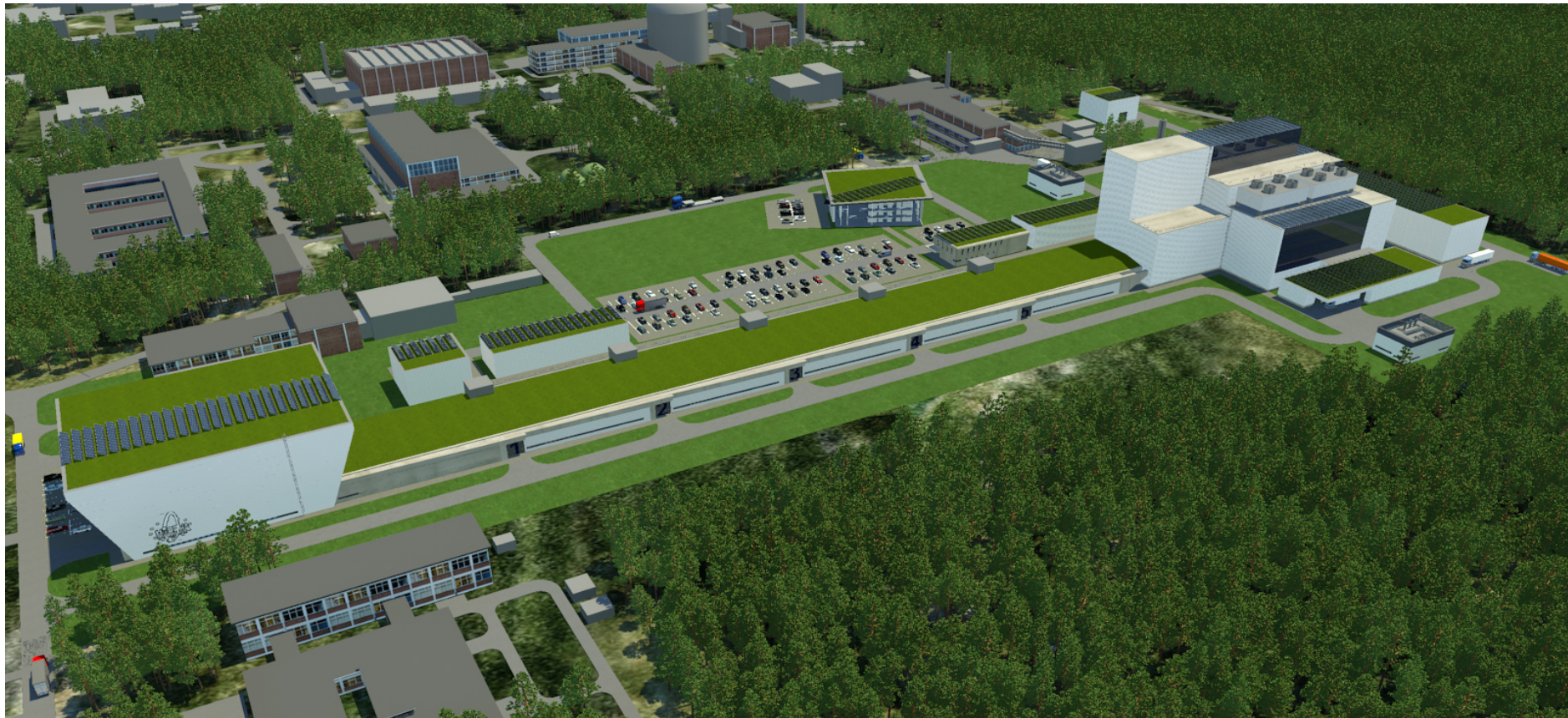




STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

MYRRHA

Look into the future...



SLHiPP-2

MYRRHA Accelerator talks

- **Spoke Cryomodule conceptual design for ESS and MYRRHA**, Hervé Sagnac
- **Cryogenic installation for MYRRHA**, Nicolas Chevalier
- **Reliability oriented activities around the 700MHz horizontal cryomodule**, Frédéric Bouly
- **MYRRHA injector design and related R&D**, Holger Podlech
- **Design of the MYRRHA superconducting linac and beam delivery**, Jean-Luc Biarrotte

MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM

A pan-European, innovative and unique facility

- Time horizon: full operation ~ 2023
- Costs: ~ EUR 960 million



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SCK•CEN

Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire

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

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