



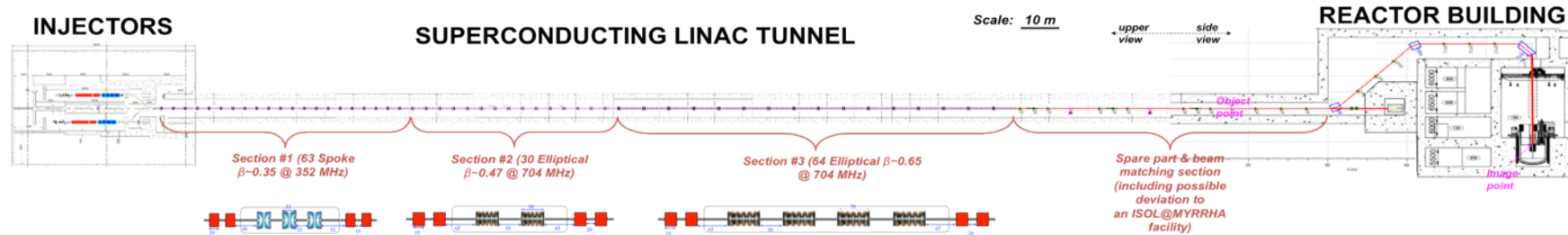
MAX

MYRRHA ACCELERATOR EXPERIMENT
RESEARCH & DEVELOPMENT PROGRAMME



MYRRHA

Multipurpose hYbrid Research Reactor for High-tech Applications



The MYRRHA Linear Accelerator R&D Roadmap

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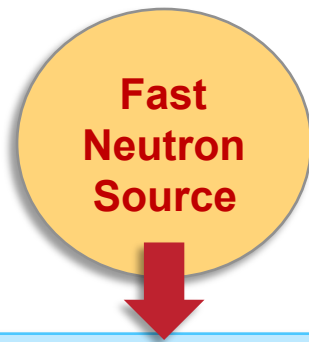
ADT - SCK·CEN



MYRRHA ADS – Technical specifications

Accelerator	
<i>particles</i>	protons
<i>beam energy</i>	600 MeV
<i>beam current</i>	4 mA
<i>mode</i>	CW
<i>MTBF</i>	> 250 h

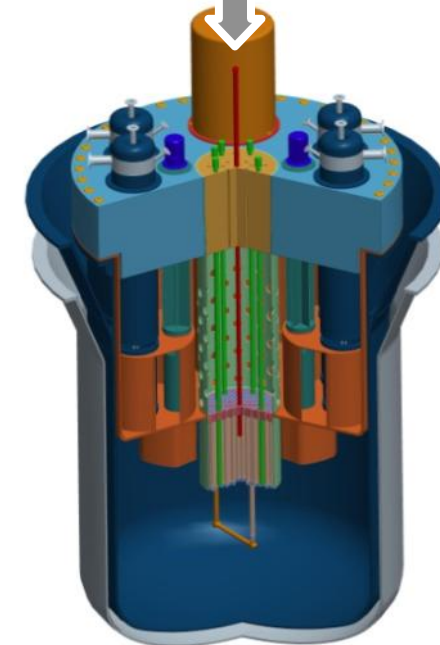
Reactor	
<i>power</i>	~85 MW _{th}
<i>k_{eff}</i>	0.955
<i>spectrum</i>	fast (flexible)
<i>fuel</i>	MOX
<i>coolant</i>	LBE



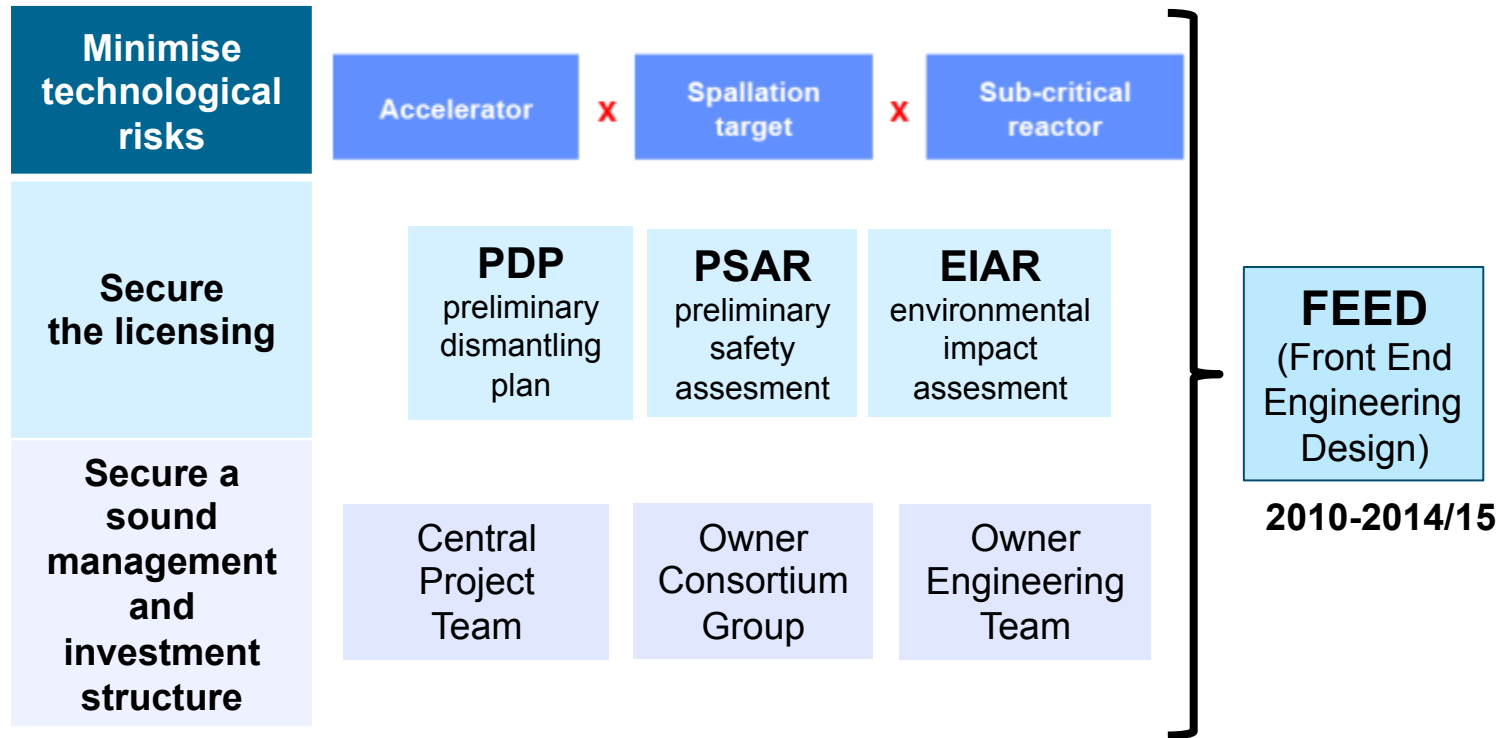
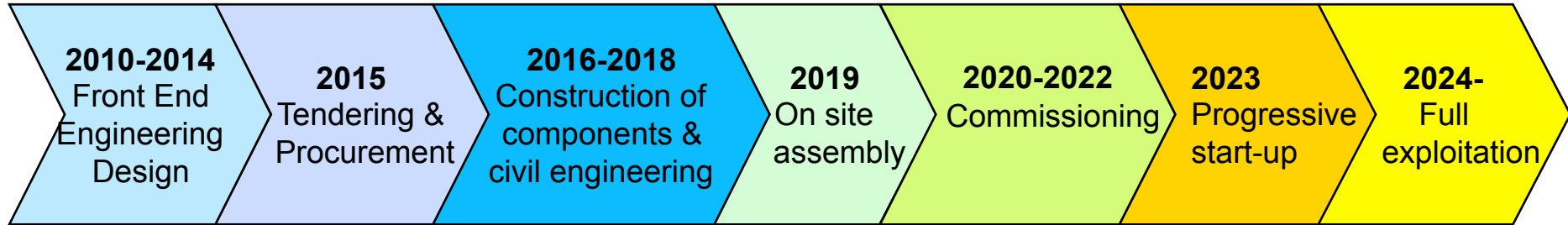
**Multipurpose
Flexible
Irradiation
Facility**

Target	
<i>main reaction</i>	spallation
<i>output</i>	2·10 ¹⁷ n/s
<i>material</i>	LBE (coolant)
<i>power</i>	2.4 MW

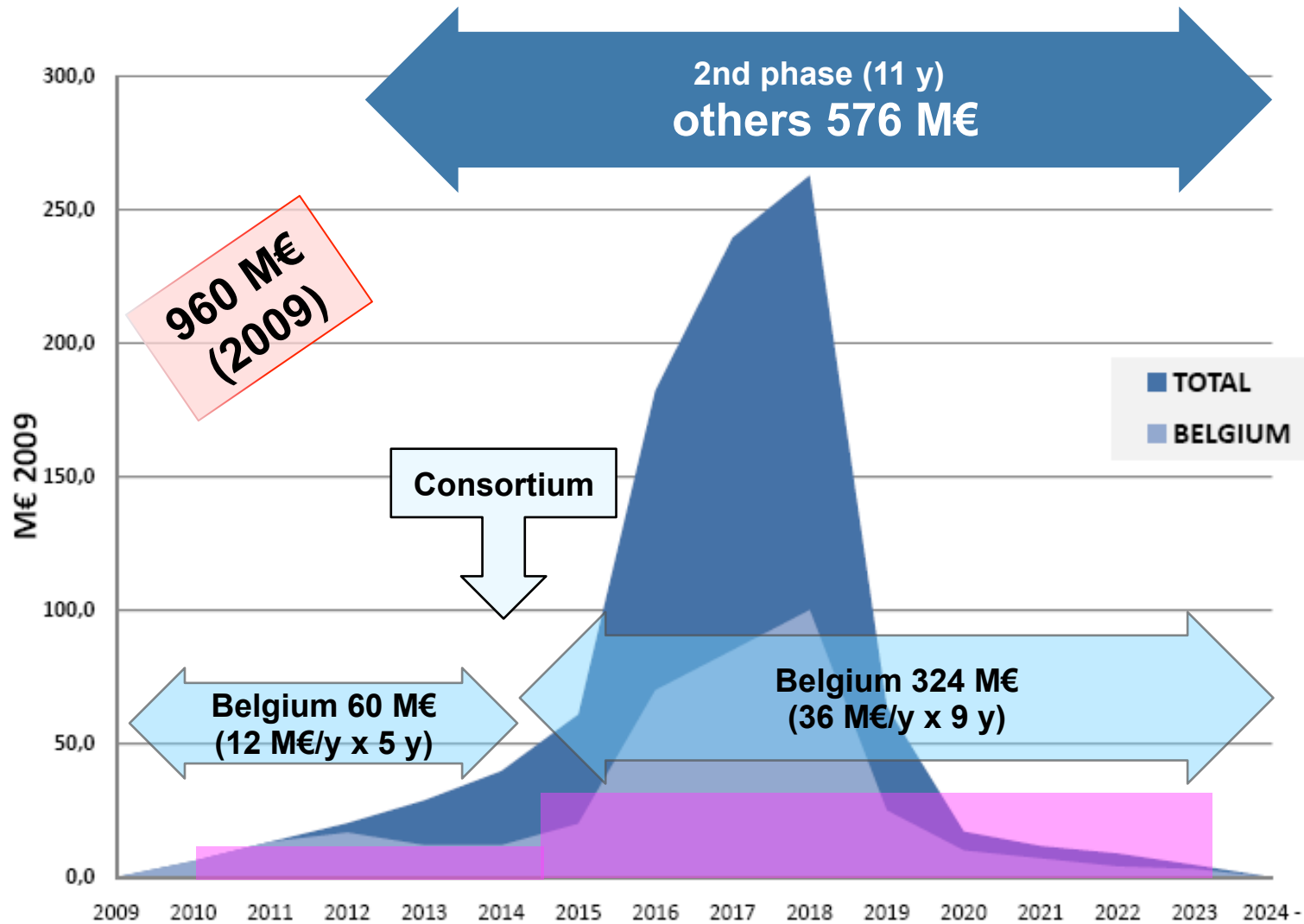
- Transmutation concept
- Irradiation facility for GEN-IV materials
- Neutron irradiated silicon
- Radioisotopes for nuclear medicine
- Fundamental research



MYRRHA ADS – Schedule



MYRRHA ADS – Budget



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.

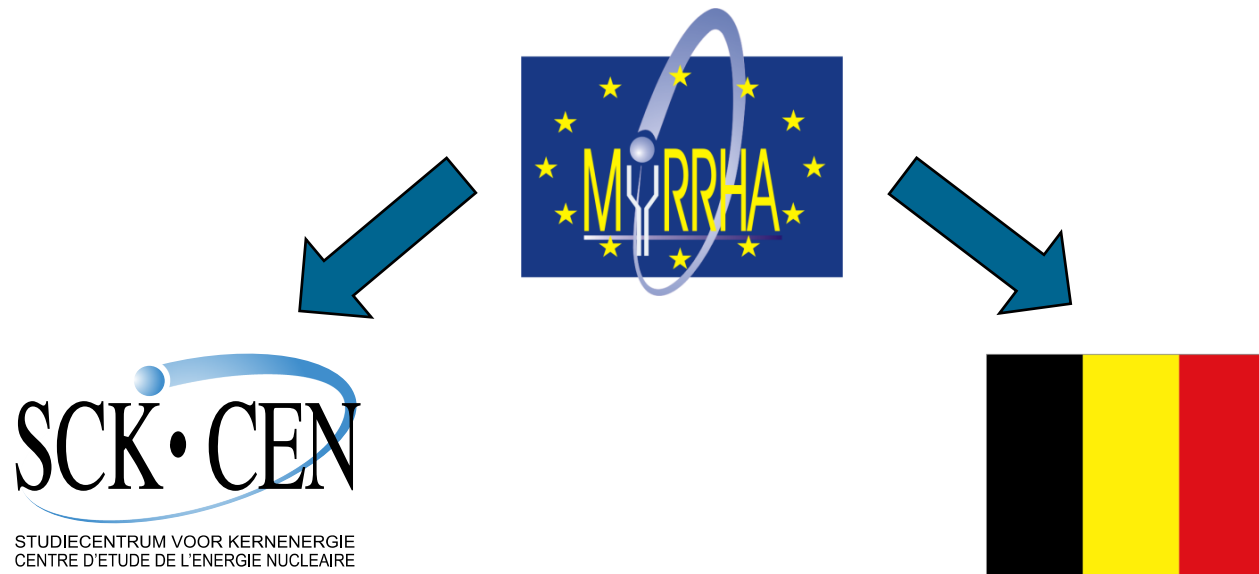
ROYAUME DE BELGIQUE

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**

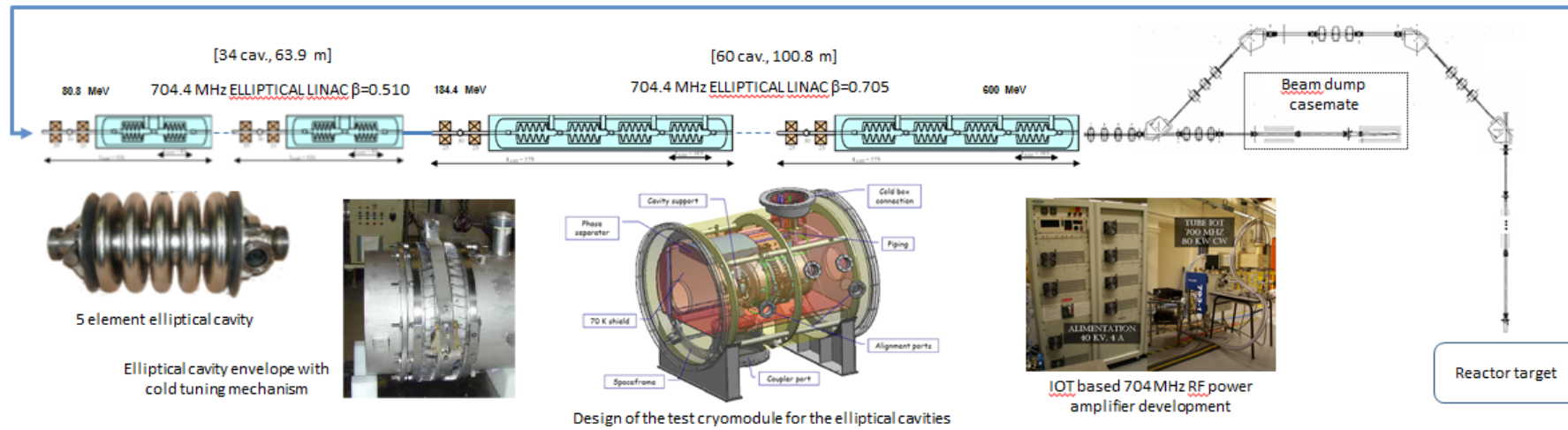
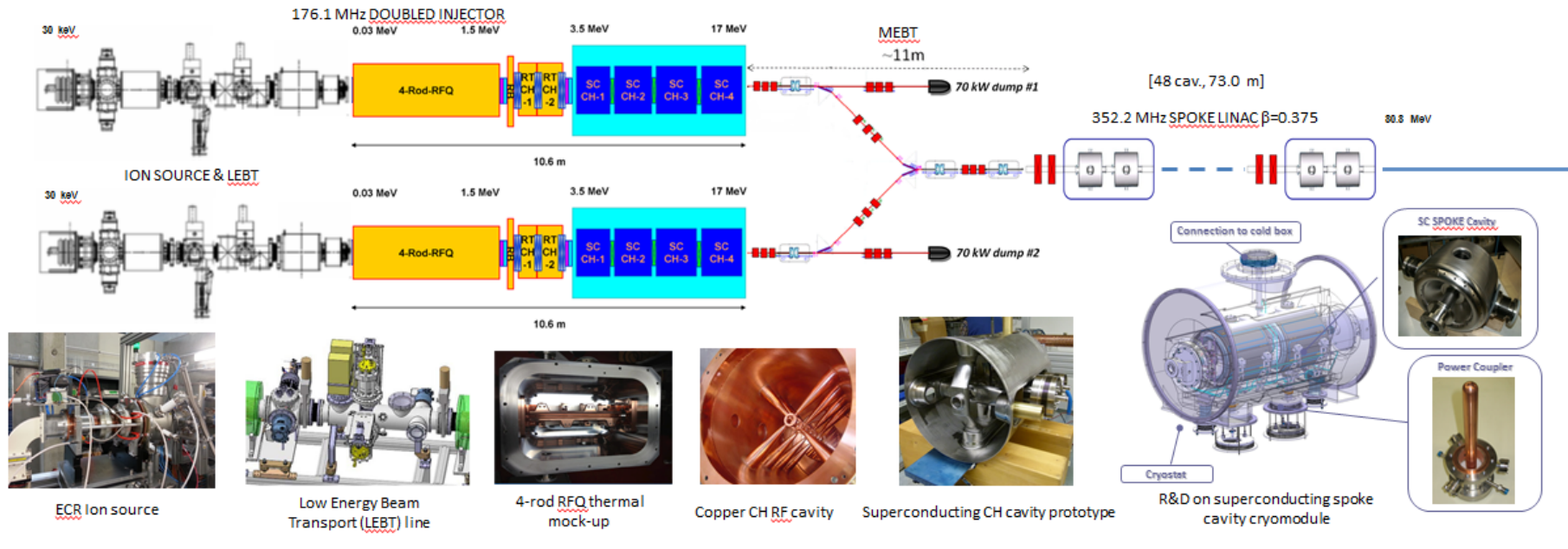
MYRRHA ADS – Accelerator “home context”



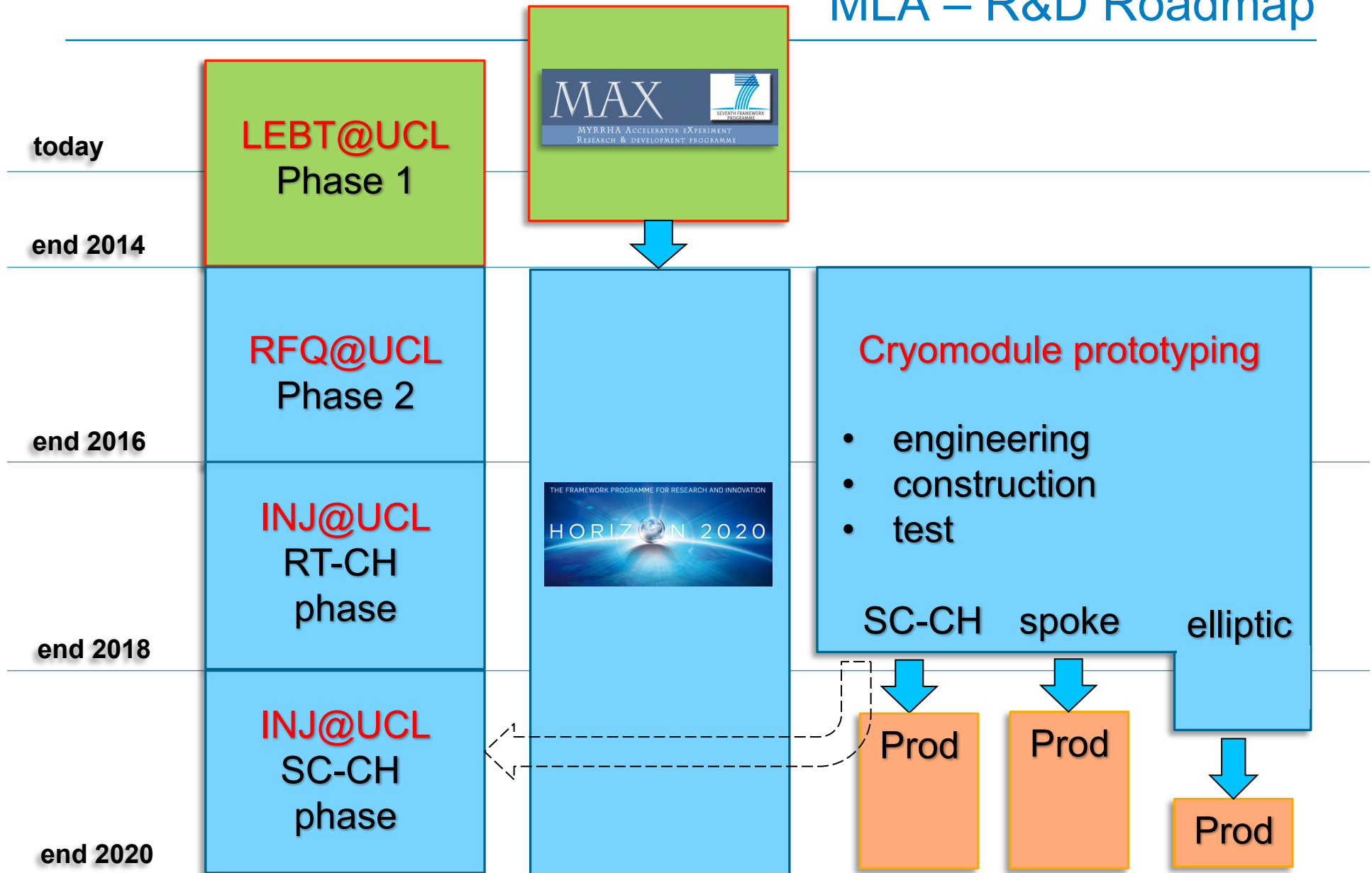
- Nuclear reactor research center
- No accelerator history
- Very limited internal accelerator resources

- Supporting MYRRHA
- No “in house” accelerator research tradition
- Limited accelerator research capabilities


MYRRHA Linac – Scope



MLA – R&D Roadmap



R&D – MYRRHA Accelerator eXperiment

 <p>MYRRHA ACCELERATOR EXPERIMENT RESEARCH & DEVELOPMENT PROGRAMME</p>	<h2>FP7 - MAX</h2>
<p>3 years- coordinated by IPNO</p>	
<p>Goal</p>	<p>coherent concept of the Myrrha accelerator</p>
<p>Technical Work Packages (WPs)</p>	<ol style="list-style-type: none"> 1. <u>Global design coherence</u> 2. <u>Injector design</u> 3. <u>Main linac design</u> 4. <u>System optimisation</u>
<p>Main topics:</p> <ul style="list-style-type: none"> • Simulations (beam and reliability) • Injector consolidated design • Design of spoke cryomodule • Tests with 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



MAX International Design Review (11/2012)

2.1 May the adopted general philosophy and methodology lead to the design of a highly reliable accelerator?

2.2 Are the different design choices appropriate for such a machine?

2.3 Is the R&D programme coherent, adequately focused and efficient at this stage of the project?

2.4 In a more global view, what should be the essential points of concern for the MYRRHA project team in the two following years (2013-2014) to prepare for the accelerator construction?

- ◆ **Construction of a cryomodule prototype for each type (foreseen in the R&D Program)**
- ◆ **Complete the R&D program especially in terms of prototyping**
- ◆ **Overall MYRRHA schedule is too aggressive**
- ◆ **Lack of an adequate accelerator core team**

INJ@UCL

Up to 2014 and beyond - led by SCK•CEN

Goals

- Test platform: experimentally address the injector design through prototyping
- tool for relevant reliability minded experience

Main topics:

- Beam characterization
- Chopper
- CW operation of the 4-rod RFQ
- SS RF amplifiers
- Diagnostics for high current beams
- 3-tier Control System
- Long reliability runs

Principal partners:

- MAX Collaboration (especially WP1 and WP2)
- research institutes: IPNO, LPSC, IAP, CRC
- industries: Panttechnik, Cosylab

Cryomodules

After 2014 - coordinated by SCK•CEN
executed by “principal architects”

Goals

Cryomodules prototyping for spoke, CH (RT & SC), elliptical

- engineering design
- construction
- tests
- feedback to design

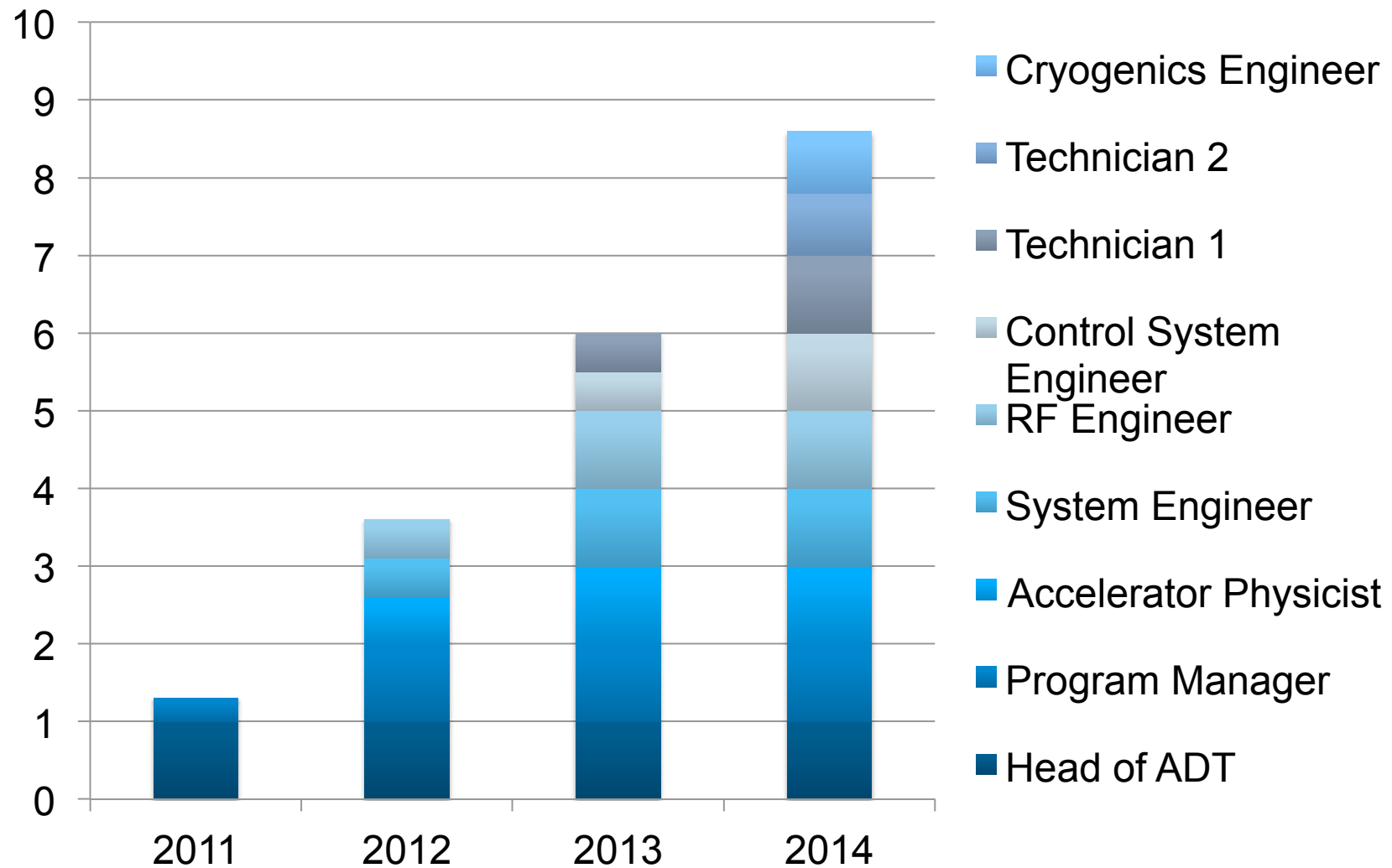
Main topics:

- Architectures and design choices
- Data for reliability models
- Prototypes before industrial series production

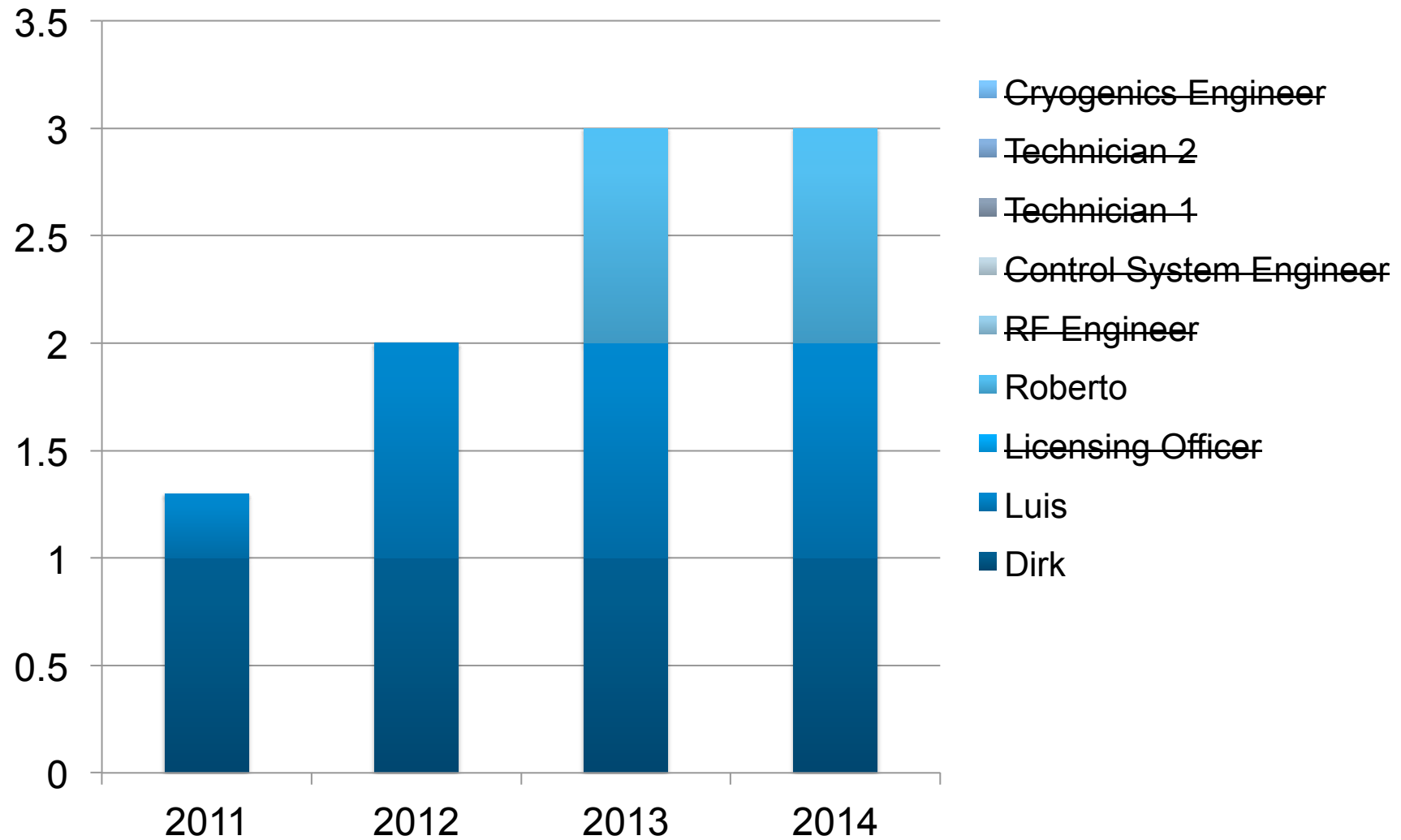
Principal potential partners:

- IPNO
- CERN
- CEA
- JLAB

Accelerator Group – Baseline 2012



Accelerator Group – Status since 02/2013



MLA – Key collaborations

Institution	Laboratory	Projects	Status
CNRS/IN2P3	IPN Orsay	MAX	End 7/2014
		Spoke Cryomodule	Stand-by
		LLRF	Stand-by
	LPSC Grenoble	LEBT	Mid 2015
	Subatech Nantes	Full power beam-dump	Stand-by
	IPHC Strasbourg	High power emittancemeter	Stand-by
Ganil/SPIRAL2		Beam diagnostics Facility design	On going
IAP		RFQ	Stand-by (H2020 ?)
		CH cryomodules	Stand-by

MLA – Key collaborations

Institution	Laboratory	Projects	Status
CEA	IRFU	MAX	On going
UCL	CRC	Experimental facility Design resources Technicians Machining hall	On going
	RF Engineering	Antenna EM field solver applied to RFQ based on moments (PhD thesis)	On going
CERN		still to be defined within the signed framework	MoU signed
SLHiPP		HPPA community	Active member

MLA – Possible key collaborations

Institution	Laboratory	Projects	Status
CEA	IRFU	Elliptical cryomodules Virtual accelerator	Only within the European frameworks
ESS		Reliability Cryomodule design & engineering Beam diagnostics Control system Accelerator facility	Blocked (political level)
TTC		Superconducting RF	Application accepted but on stand-by

MLA – Possible key collaborations

Institution	Laboratory	Projects	Status
PSI		HP beam handling HP beam diagnostics HP beam dump	No formal contacts
JLAB		Elliptical cryomodules High Q cavities Production capacity	On stand-by
SNS		Experience feed-back (reliability) Operations	No formal contacts (except within MAX)

MLA – Present key industrial partners

Company	Projects	Status
ACS	Cryogenic system preliminary design including facility	Delivered
	Cryogenic system preliminary engineering and budgetisation	Stand-by
Pantechnik	Ion source	Delivered
	2 x Allison emittancemeter	1x Delivered
Cosylab	Control system study	Delivered
	LEBT EPICS Based control system	January 2015
Sigmaphi	LEBT solenoids	October 2014
Linac Dynamics	Consultancy: Beam dynamics Error studies HEBT optimization	On going

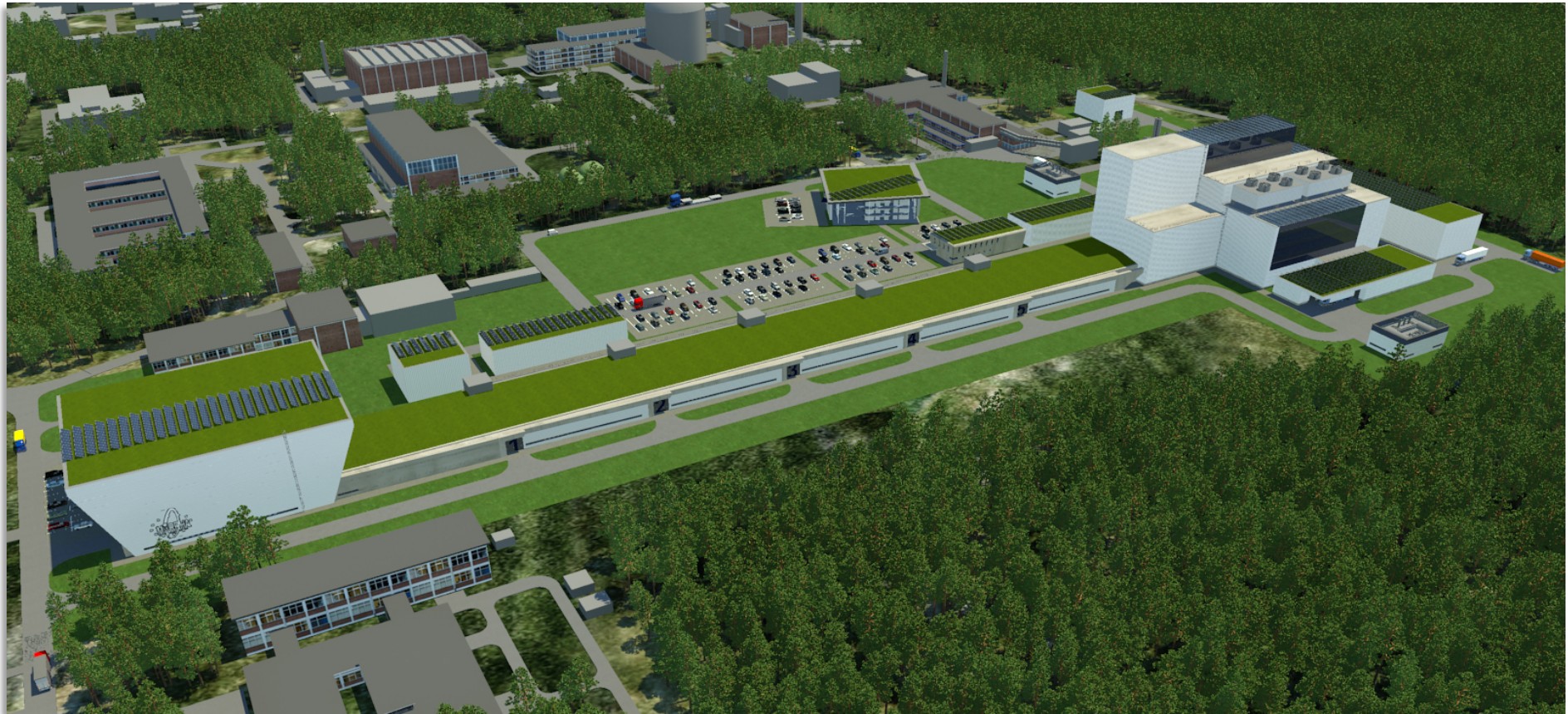
MLA – Present key industrial partners

Company	Projects	Status
IBA	Technical consultancy (ex: RF, general engineering)	On going
FEED Consortium (led by AREVA)	Accelerator facility and ancillary systems (excluding cryogenic system)	On going

Concluding thoughts...

- Present situation: **budget restrictions** (very slow progress on prototyping)
- Future is pending on **funding scheme** (consortium set-up)
- Present MYRRHA **planning** has not yet been reviewed (aggressive)
- Accelerator strategy = in kind contribution (excluding buildings and ancillary systems) → **high external dependency**
- We still need a strong **internal** core team:
 - Coordinating design, engineering, procurement, installation, commissioning
 - Take on operations, maintenance, upgrades, etc...
- No realistic plan exists for a full Linac production
- Nevertheless, we have many ingredients but lack the most important one to fully deploy the recipe!

The future...



Thank you for your kind attention and support!



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