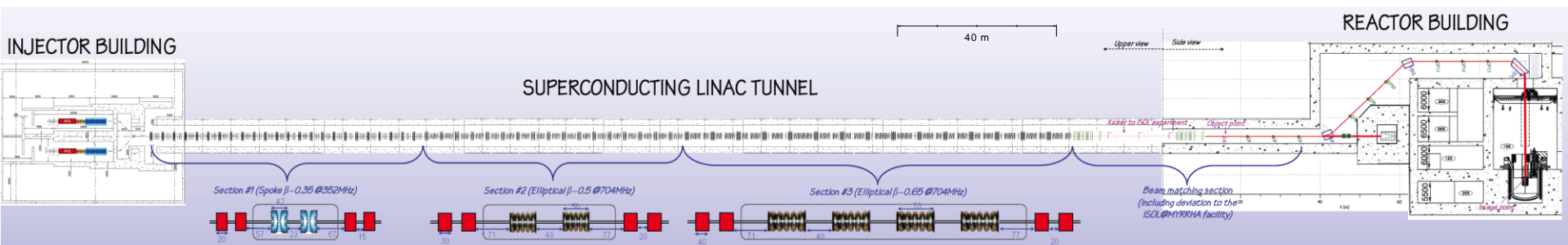


Prototyping activities in view of realising the phase 1 accelerator for MYRRHA



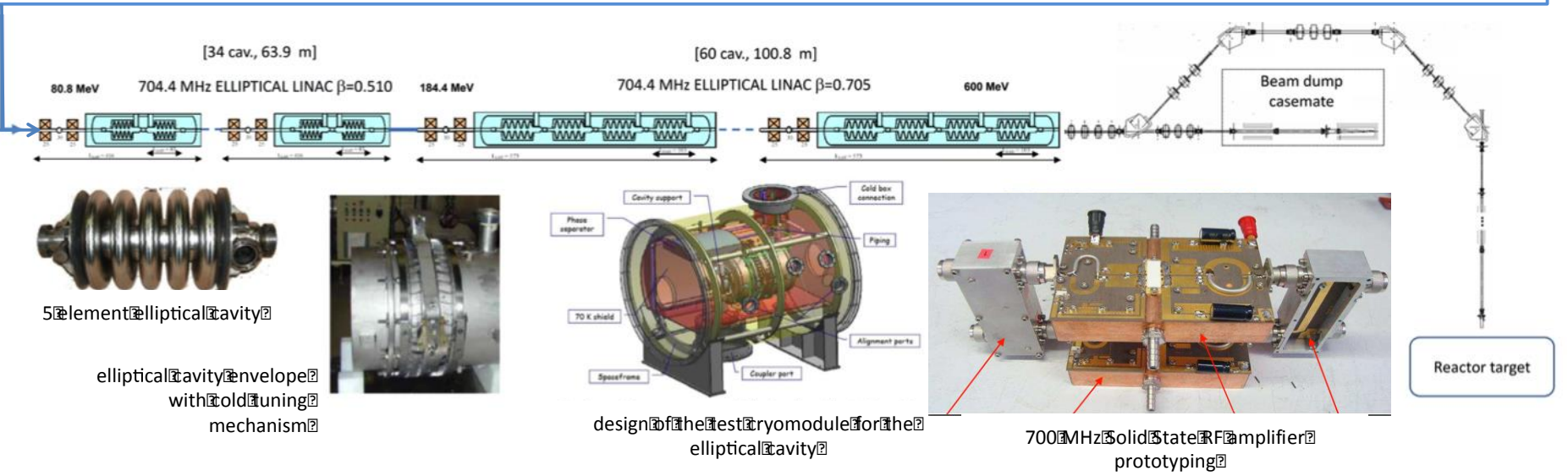
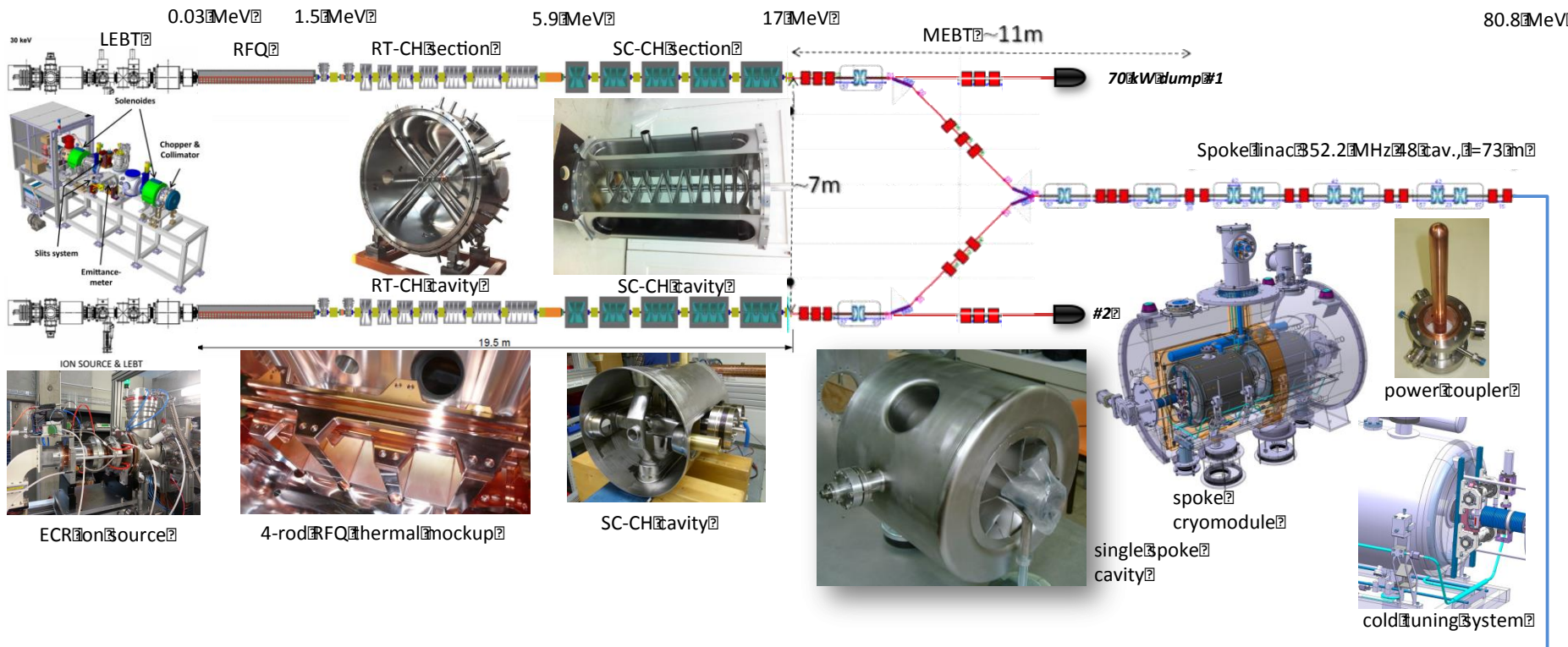
Dirk Vandeplassche (SCK•CEN)

- MYRRHA
- Phase 1 rationale and needs
- MAX and updates
- 100 MeV linac
- prototyping activities
- planning
- conclusion

- ADS
- Pb-Bi cooled reactor $\sim 100 \text{ MW}_{\text{th}}$
- linear accelerator

basic specifications

particle	p
beam energy	600 MeV
beam current	4 mA
mode	CW
cycle length	3 months
beam MTBF	> 250 h



From an accelerator perspective:

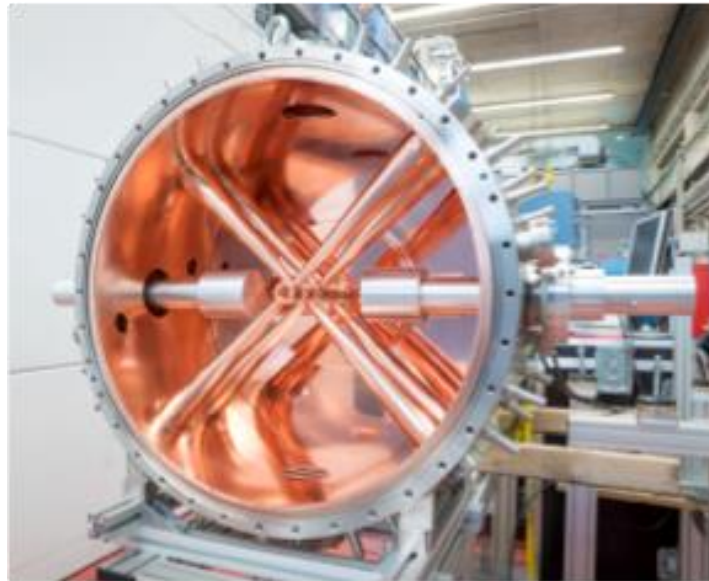
- cost spreading
- the Pb-Bi reactor may profit from getting more R&D time
- *reliability* being the main challenge of the accelerator (MTBF 250h), it is useful to
 - realise a significant fraction only
 - insert a decisional hold point in the global schedule
 - evaluate the adequateness of technological choices

Phase 1 accelerator needs

- "significant fraction":
 - able to feed a reliability model with predictive power
 - 1 injector only → evaluate
 - main linac with 1 family of cryomodules only
 - applicable final beam energy
- Phase 1 : linac 100 MeV = injector + full spoke section
- needs :
 - limited R&D : well established concepts
 - extensive prototyping

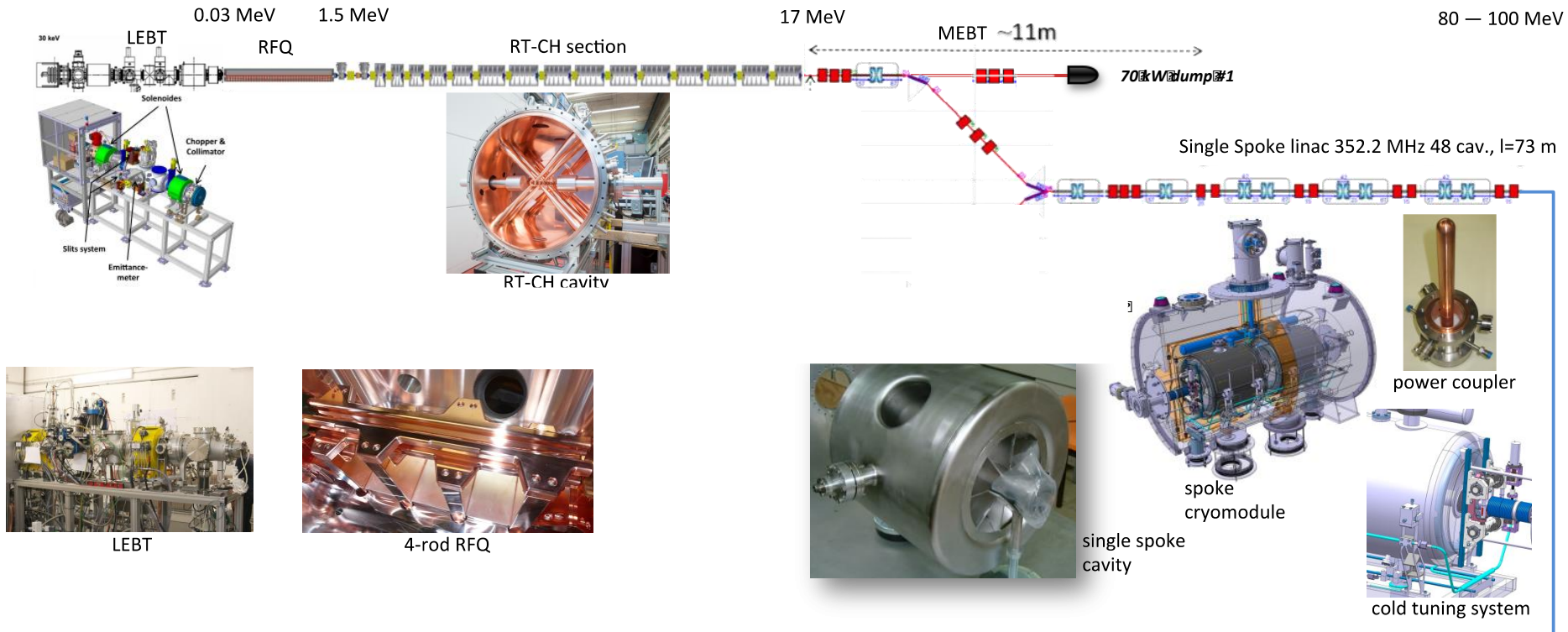
- FP7 2011–2014 object : accelerator only
- main achievements:
 - formalisation of fault tolerance schemes
 - start-to-end beam simulations
 - error studies
 - reliability model
 - engineering files "ready for construction"
 - selected R&D topics
- international design review
 - globally positive feedback on technological choices
 - suggestions for change :
 - injector optics
 - (cavity choice for low β elliptical section)

- further updates :
 - phase 1 risk reduction
 - allow for somewhat more aggressive planning
 - full NC injector (copper CH-type cavities)



- this freezes the 100 MeV conceptual design

100 MeV phase 1 linac



LPSC+SCK

IAP

IPNO

+ many others ...

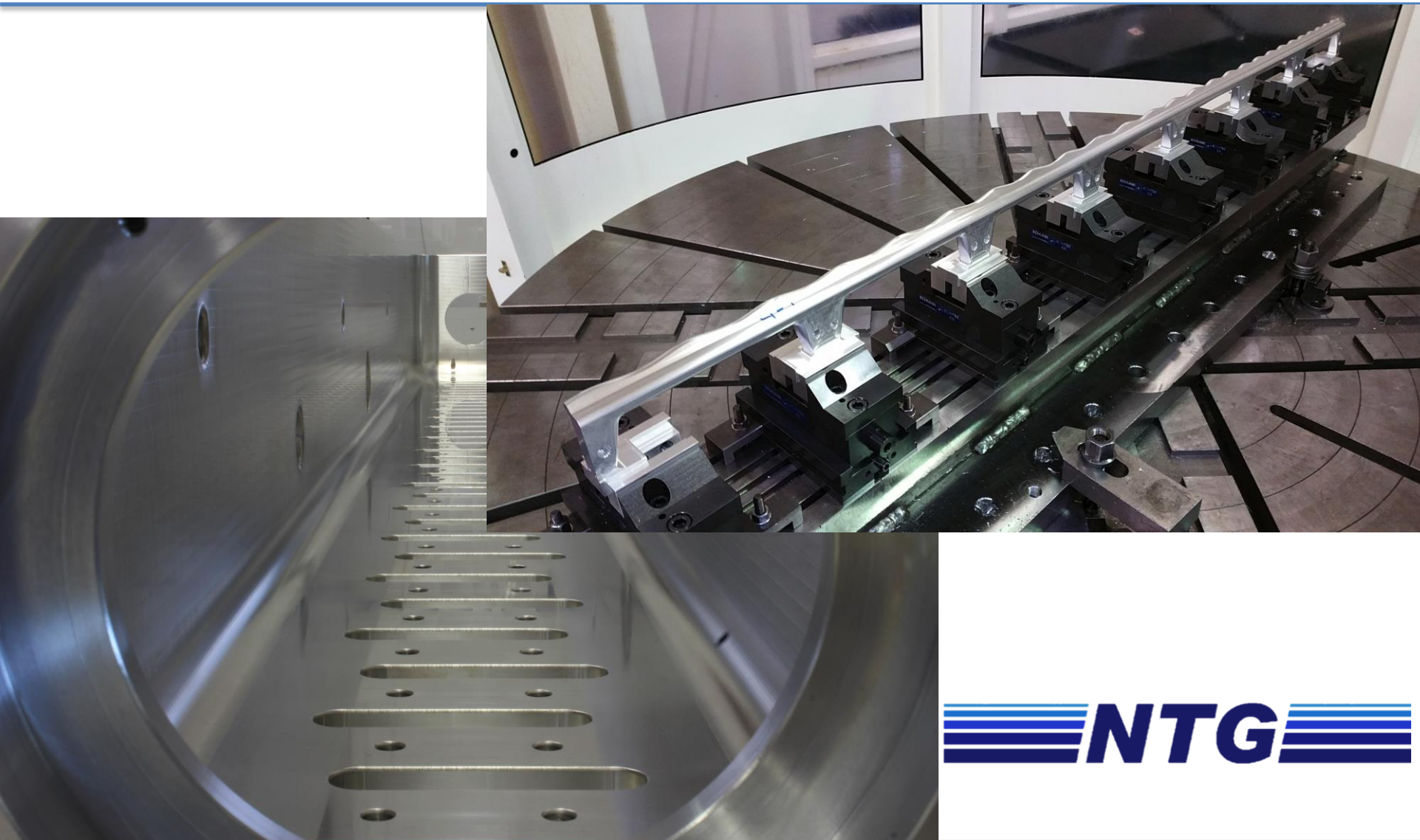
In the MYRRHA context we need to prototype :

- first of a kind items and MTBF-sensitive items
 - fully operational injector (5.9 MeV)
 - ECR-IS
 - LEBT (solenoids and PC's, diagnostics)
 - 4-rod RFQ + LLRF + 160 kW SS RF amplifier (176 MHz)
 - series of 7 copper CH cavities + LLRF + SS RF amplifiers
 - magnets + PC's, diagnostics
 - diagnostic line and beam dump
 - vacuum, cooling
 - 3-tier control system (EPICS-based)

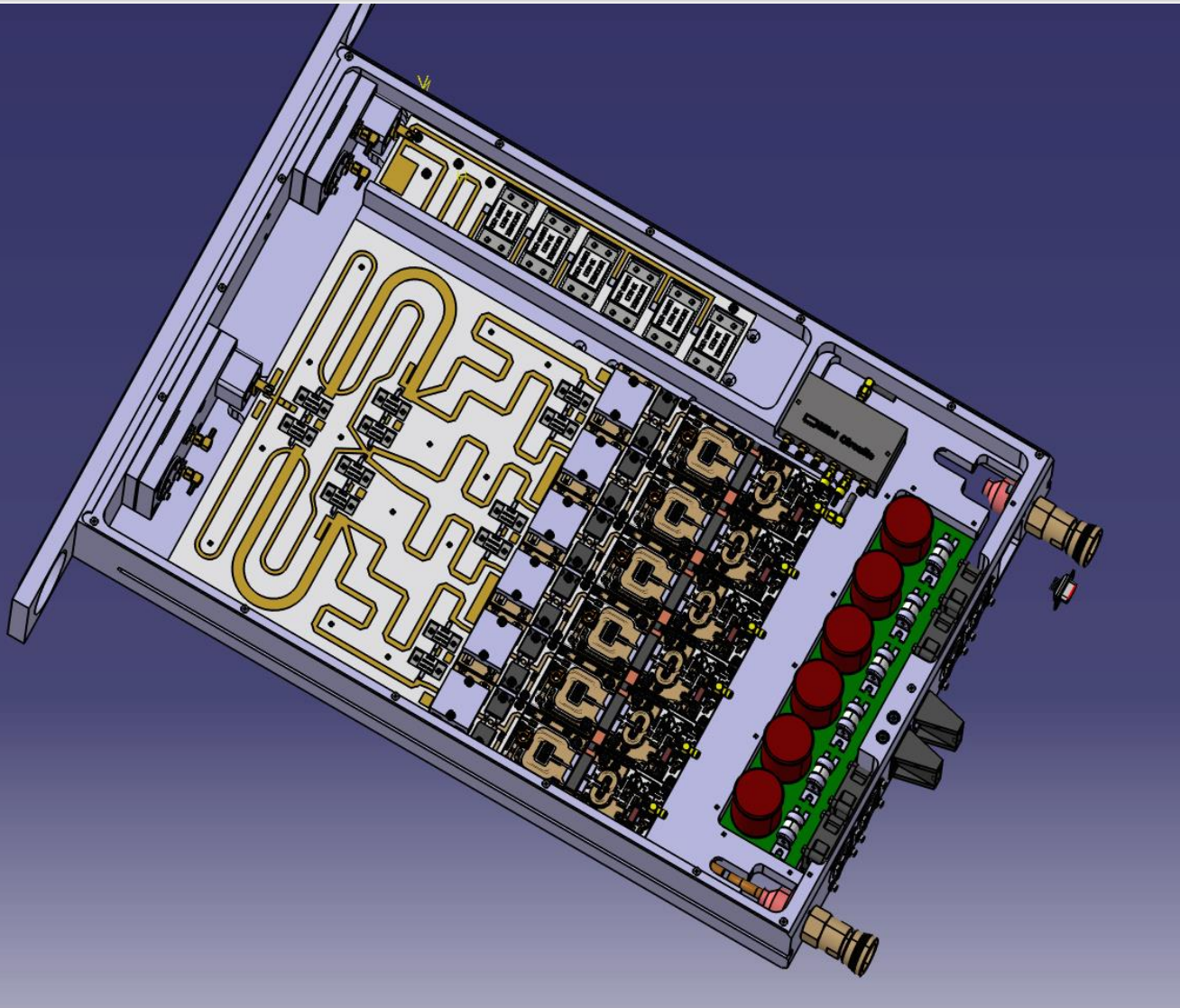
- MEBT-3 : fast switching dipole
- first of innovative series, MYRRHA specific
 - copper CH cavity 17 MeV
 - spoke section : cryomodule (with 2 single spoke SC cavities), cold tuning, power coupler
 - digital LLRF compatible with fault recovery
 - 352 MHz SS RF amplifier
 - selected beam diagnostic devices
 - elements of MPS

- H2020 2015–2019
- accelerator : WP2 13 part. 12 tasks 5+ M€
- activities / goals
 1. operational MYRRHA RFQ
 2. general linac support
 - beam dynamics
 - reliability
 - diagnostics
 - space charge experiments

- prototyping
 - 4-rod RFQ, 30 keV – 1.5 MeV, 176 MHz, CW
 - detailed conceptual design : IAP Frankfurt
 - detailed mechanical design : NTG
 - manufacturing : NTG
 - associated RF amplifier : 160 kW CW, Solid State with 1 kW elementary LDMOS transistors
 - concept, design and assembly : IBA
 - LLRF for all the injector cavities
 - concept and design : IPN Orsay
 - controls
 - implementation : Cosylab

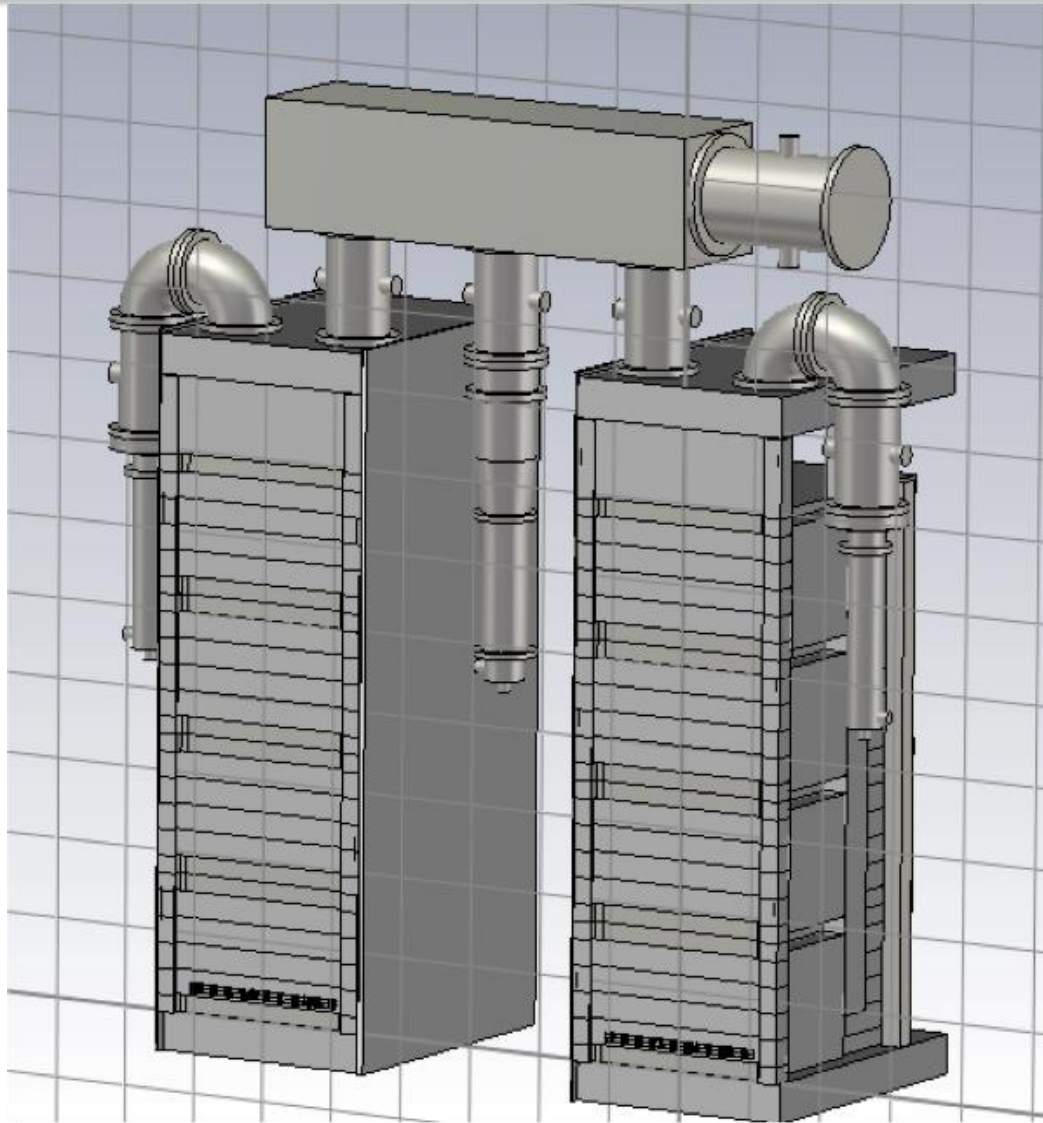


SS amplifier for RFQ





iba

SS amplifier for RFQ



Iba

- research institute partners : collaborative model
 - contracts : Collaboration Agreements with technical addenda
 - principal players = principal architects of linac subsections
 - injector : IAP Frankfurt 
 - spoke section : IN2P3 / IPN Orsay 
 - further players are obviously needed for covering all aspects of the linac

- industrial *partners*
 - contracts : commercial, typically after public tendering
 - principal "métiers" (skills)
 - manufacturing (NC & SC cavities, mechanical components)
 - magnets
 - electronics (DC, RF)
 - cryogenics
 - controls
 - connections
 - construction

- interfacing partners
 - deliverables : documents
 - contracts : commercial and/or collaboration agr.
 - principal skills
 - engineering design
 - engineering specifications
 - follow-up
 - special case : integration
 - 3D modeling
 - data base(s)

Prototyping for phase 1

WP	R&D lots (APS act.)	MYRTE	env. partner	pres. status
IS	charact., ctrl. integr.		Pantechnik, SCK	OP
LEBT	chopper, SCC studies, PLC	*	LPSC, SCK	partly OP
RFQ	cavity, SSA, PLC	*	IAP, NTG, IBA, SCK	CONSTRUCT
CH sect.	optics, cav., magnets, SSA, diag., PLC		IAP, Bevatech, IBA	partly DESIGN
MEBT	optics, magnets, switch, rebunchers, dump, SSA, PLC		IPHC, LPSC, CERN, Industry, IBA	CONCEPT
Spoke	cryomodule, RF couplers, magnets, SSA, PLC	-	IPNO, LPSC, LAL, Industry	partly DESIGN
Cryogenics	design, valve box		ACS, Industry, ?	CONCEPT
Diagnostics	global layout, BPM, BLM, FE electronics	-	CEA, IN2P3, Industry	initial CONCEPT
Controls	LLRF, timing, EPICS, virtual acc., GUI, user pgms, data bases, MPS	-	IPNO, Cosylab, CEA, Spiral2, SCK	CONCEPT, embryonic OP
Reliability	modeling, beam dynamics, tuning	-	EA, SCK, CEA, IN2P3	partly DESIGN
Integration	data base, 3D model, BOP		FEED, SCK, all	0
Test platform 5.9 MeV	installation, exploitation	-	SCK, all	embryonic OP

The MYRRHA spoke resonator : the delivery

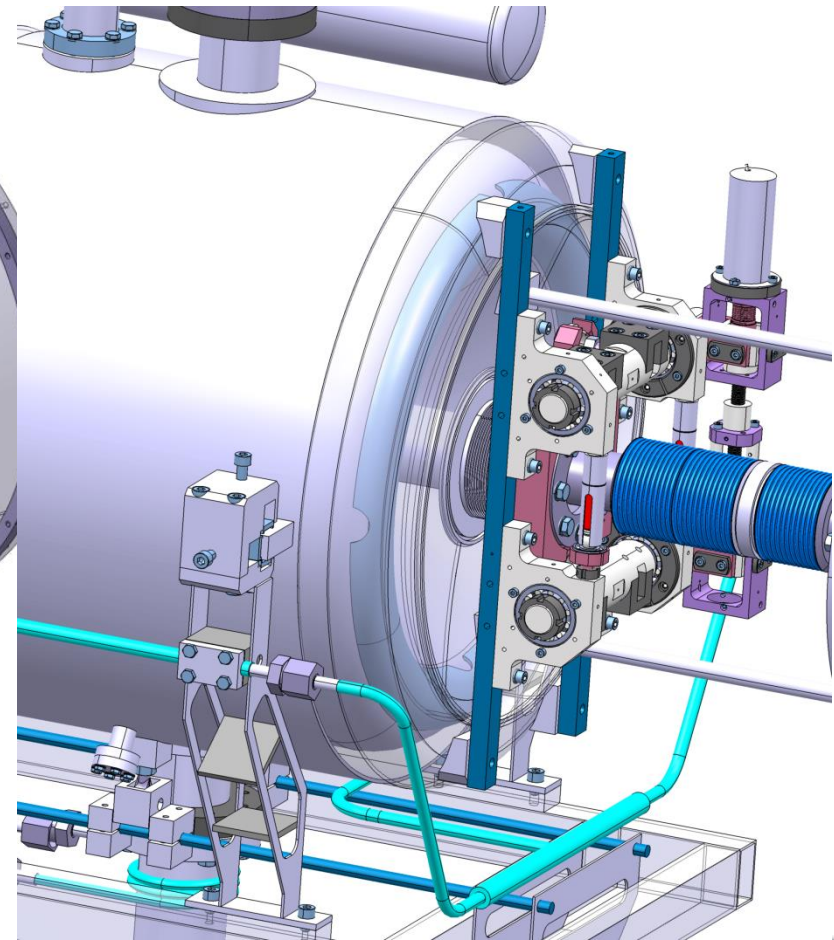
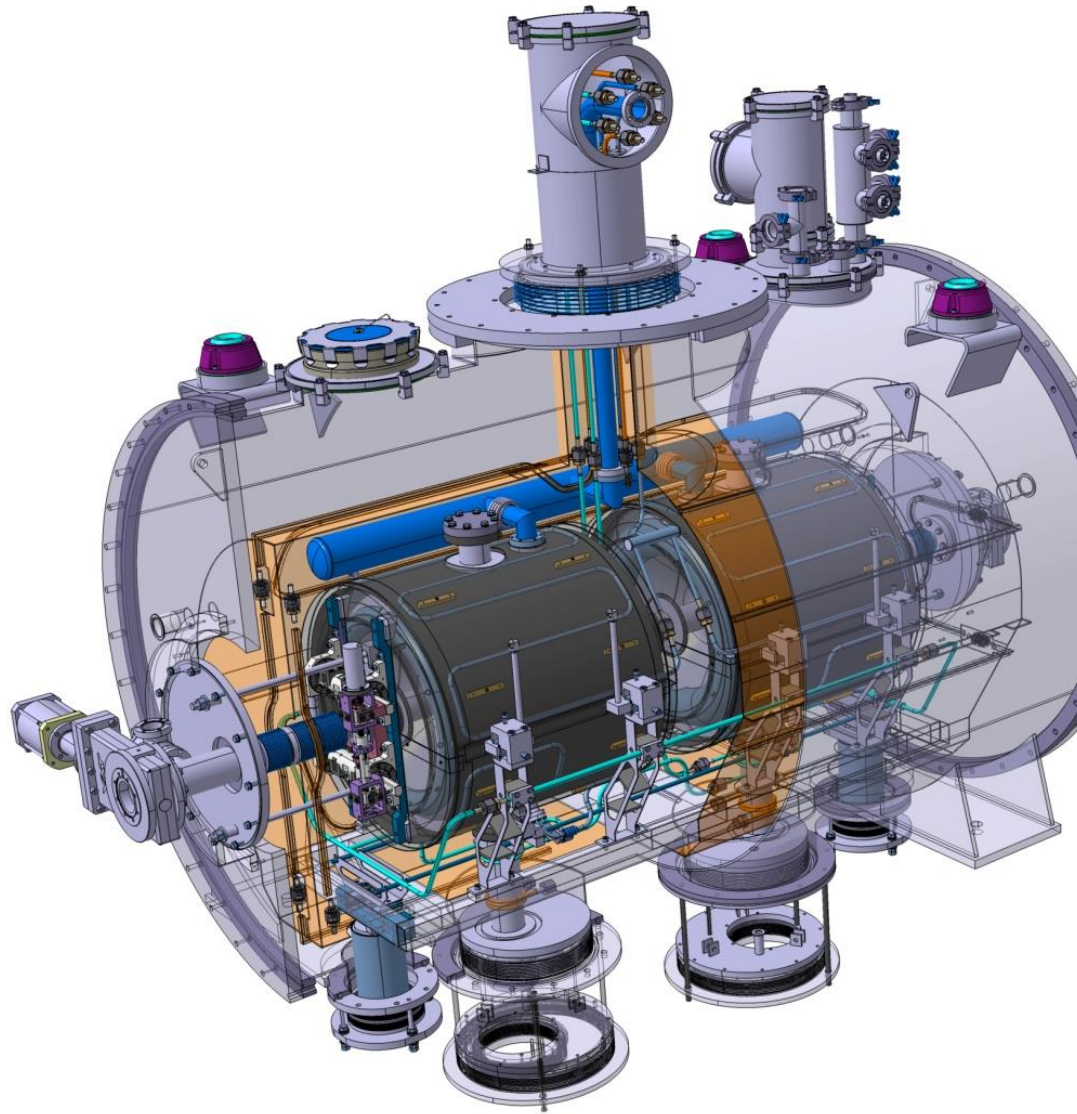


**AMELIA
(ZA01)**

**VIRGINIA
(ZA02)**



Prototyping for phase 1

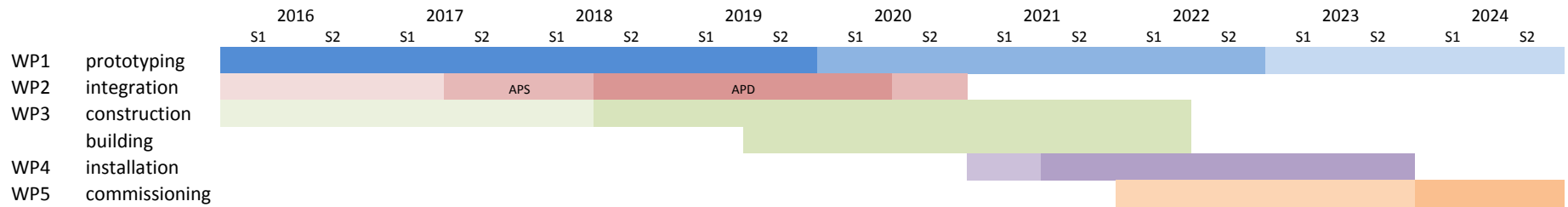


- hold point for decision taking = 2024

milestone	date
ground breaking	2018
very first beam	2021
hold point	2024
nominal beam	2025

- phase 2 prototyping within phase 1
 - 100–200 MeV section cryomodule (double spoke ?)
 - 200–600 MeV section : elliptical cryomodule
 - 704 MHz SS RF power amplifier

100 MeV planning



- the phased approach is the correct way to handle the challenge set by the fault tolerance requirement
- we know from reliability modeling that both MTBF and MTTR of individual components are crucial → optimisation through
 - prototyping (e.g. spoke cryomodule)
 - small scale operations, fully representative (e.g. 5.9 MeV)
- a broad and powerful network of partnerships historically exists and is being formalized