HIE-ISOLDE Linac: Status of the R&D activities

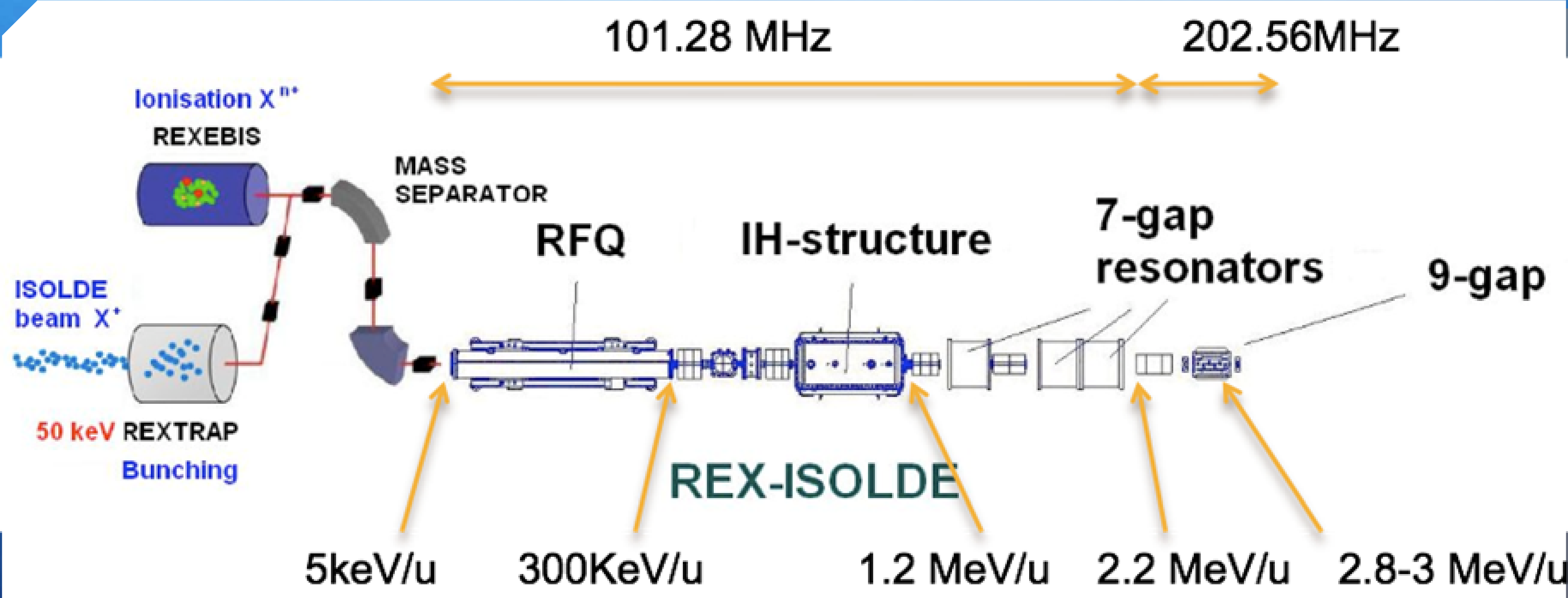
M. Pasini, CERN BE-RF and
Instituut voor Kern- en Stralingsfysica, K.U.Leuven
On behalf of the HIE-ISOLDE team

Overview

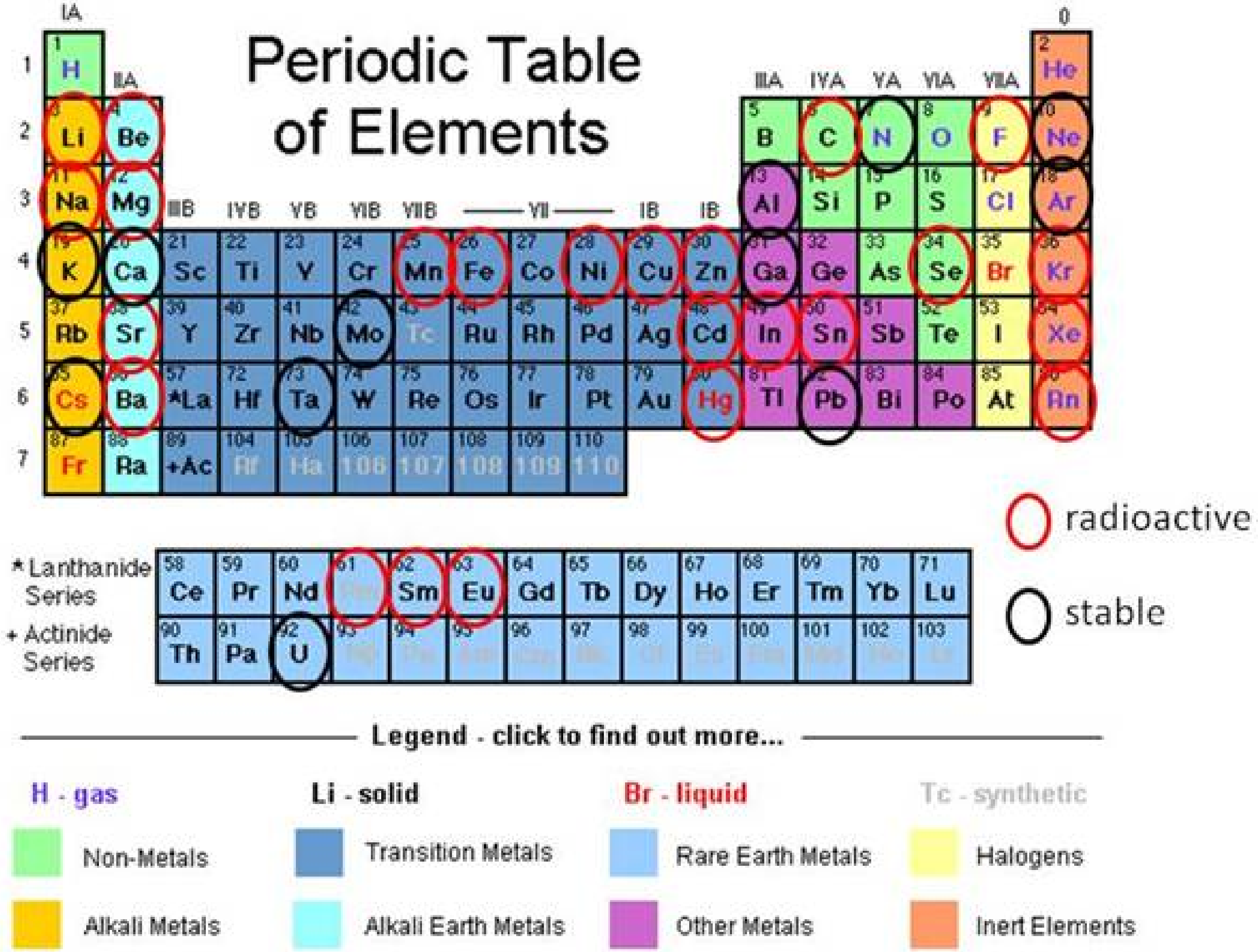
- The ISOLDE Facility- status
- HIE-ISOLDE project
- R&D activities
- Summary

The ISOLDE facility

REX-ISOLDE Post accelerator



Accelerated elements
(Talk of F. Wenander Mo12)



Users next requirements:

- Higher energy for the post-accelerated beam
- More beams (Intensity wise and different species)
- Better beams (High purity beams, low emittances, more flexibility in the beam parameters)

HIE-ISOLDE activity

- ✓ REX energy upgrade and increase of current capacity
  - Energy upgrade in 3 stages: 5.5 MeV and 8 MeV/u or higher and lower energy capacity
  - REX trap and charge breeder upgrade
- ✓ ISOLDE proton driver beam intensity upgrade - strongly linked to PS Booster improvements including linac4
  - Faster cycling of the booster
  - New target stations for ISOLDE
  - New targets
  - New target handling system
- ✓ ISOLDE radioactive ion beam quality – more than half already financed through the ISOLDE collaboration
  - Smaller longitudinal and transverse emittance
  - Higher charge state for selected users
  - Better mass resolution
  - Target and ion source development e.g. RILIS

HIE-ISOLDE 1 project

+ Energy upgrade up to 8 MeV/u with a superconducting linac based on Nb sputtered QWRs and the design study of the intensity upgrade

R&D activity funded

HIE-ISOLDE 2 project

- Higher Linac energies and Intensity upgrade: targets and charge breeder

R&D activities for the linac (started in 2008)

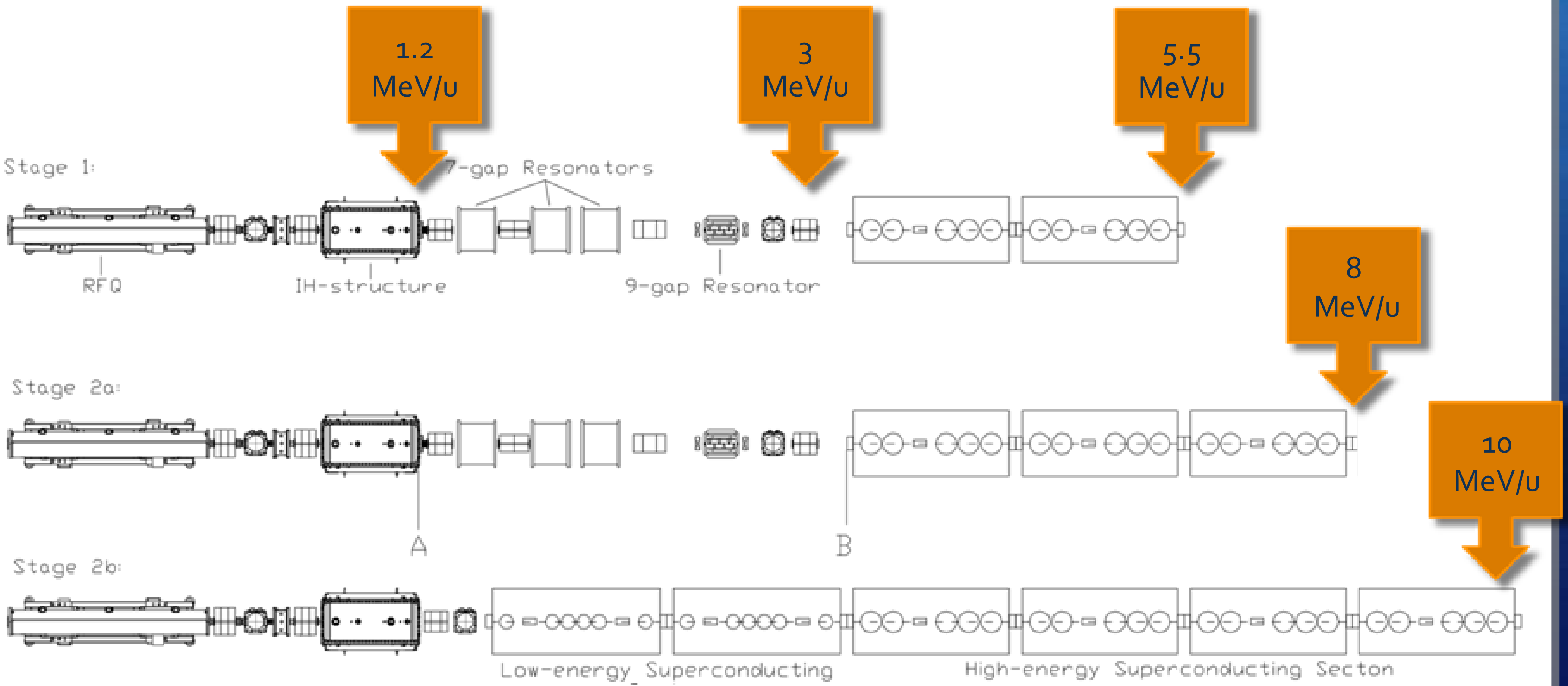
- Beam dynamics studies
- High beta cavity prototype development (Nb bias sputtering technique)
  - Tuners, coupler, RF system
- Cryomodule design
- Solenoid studies
- Infrastructure and integration

HIE-ISOLDE SC-linac

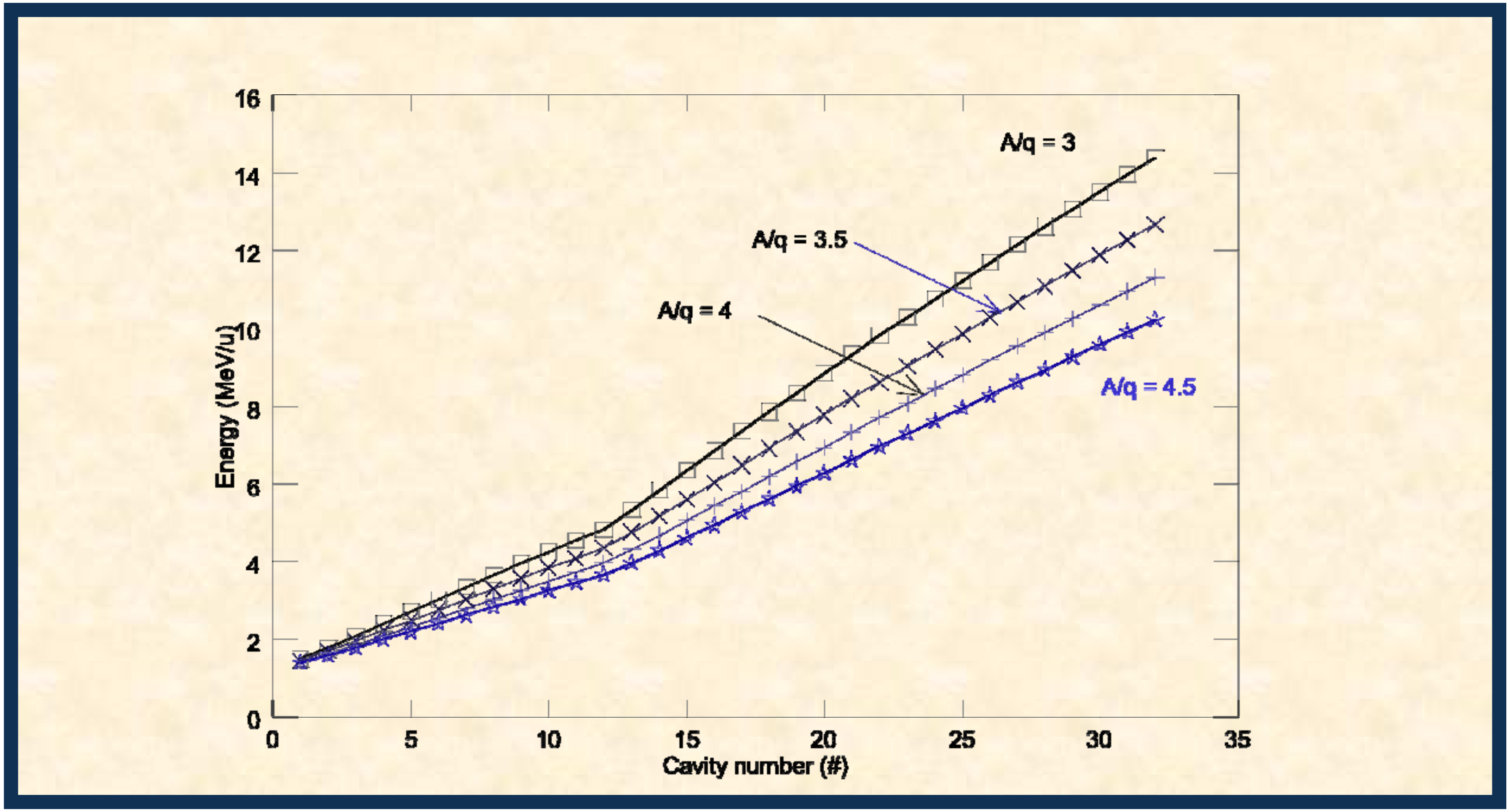
- SC-linac between 1.2 and 8 MeV/u (possibility to further extend to 10 MeV/u).
- Energy fully variable; energy spread and bunch length are tunable. Average synchronous phase ϕ_s= -20 deg
- 2.5<A/q<4.5 limited by the room temperature cavity
- 16.02 m length (without matching section)
- No ad-hoc longitudinal matching section (included in the lattice)

HIE-ISOLDE LINAC - layout

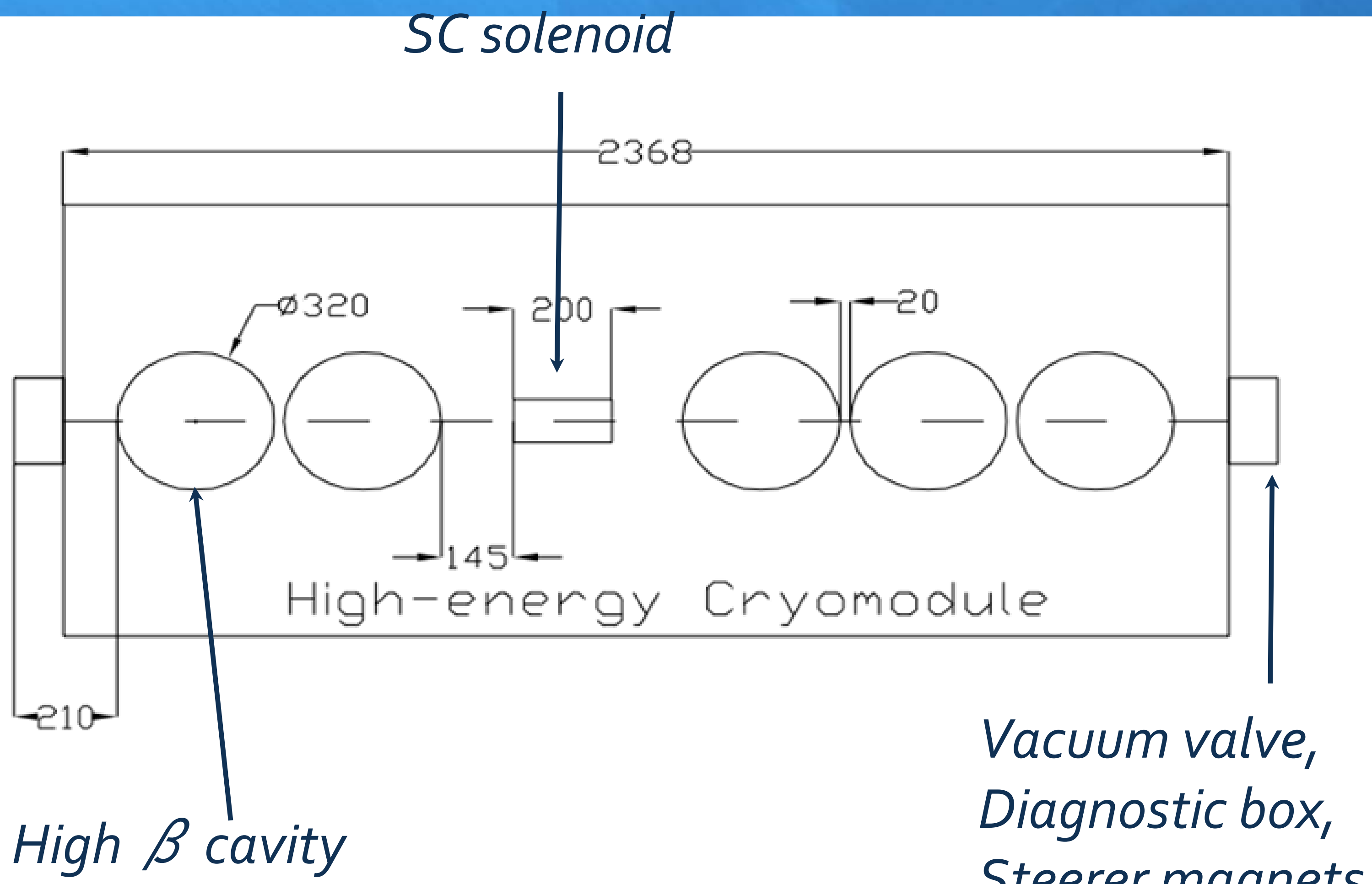
3 stages installation



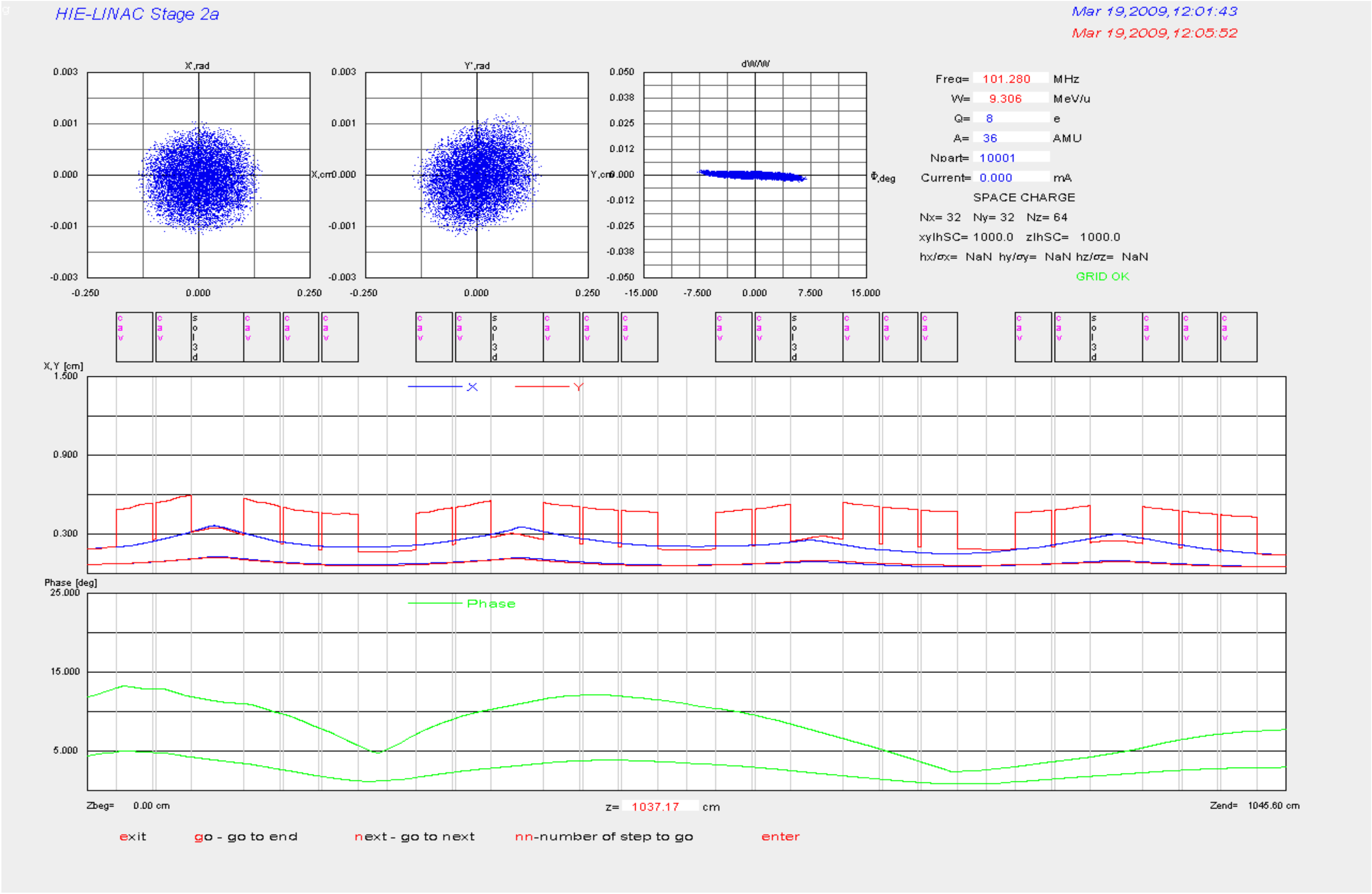
Final Beam Energies



LINAC lattice



Beam Dynamics



Beam dynamics choices

- Solenoid focusing
  - Shorter inter cryomodule distance → increased longitudinal acceptance
  - Minimum number of tuning knobs
  - High tolerance to mismatch beam.
- Transverse Phase advance for zero space charge set to 90 deg. → Avoid parametric resonance and maintain the beam emittance.
- Longitudinal matching within the lattice.

QWR cavities (Nb sputtered)

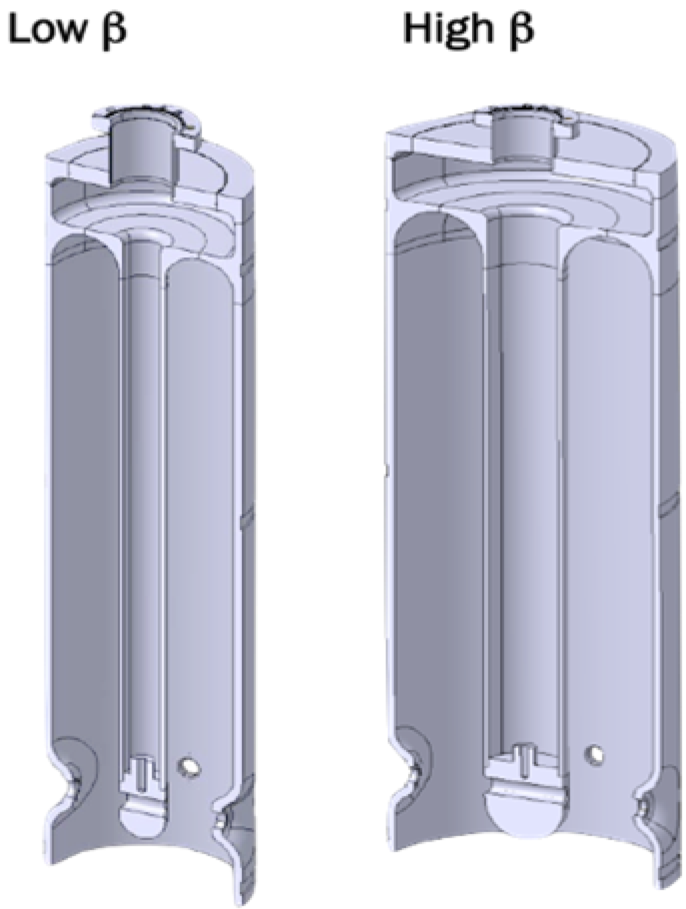
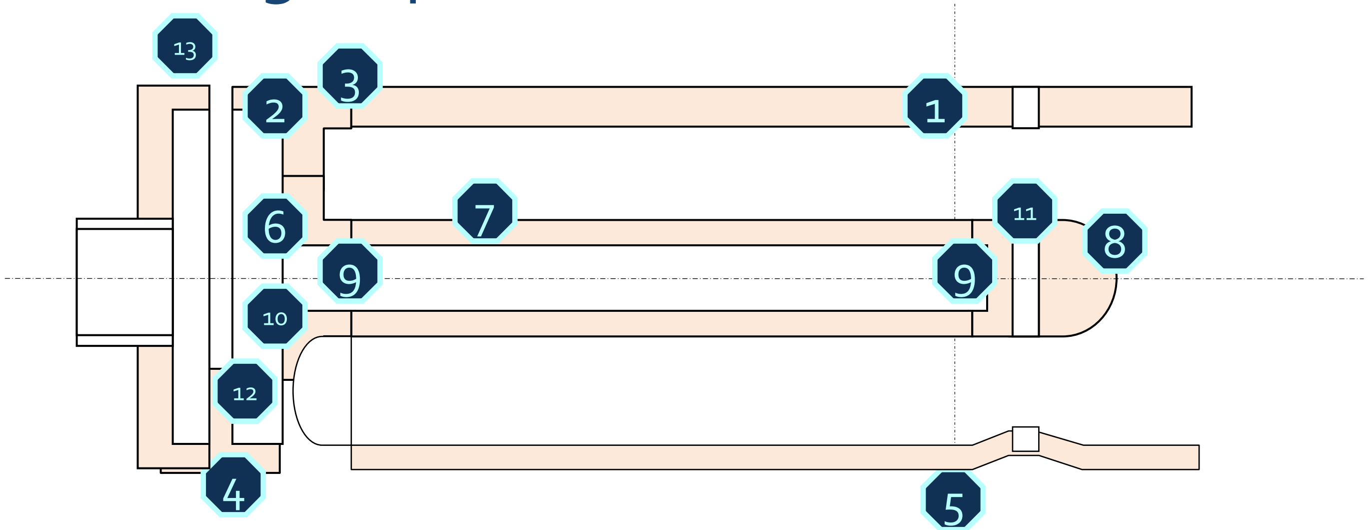


Table 1: Cavity design parameters

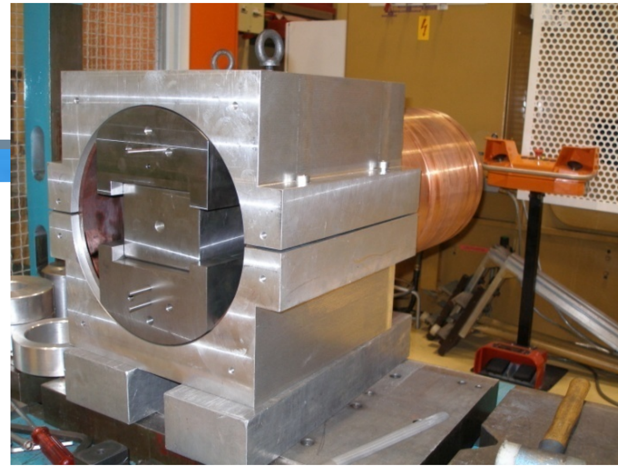
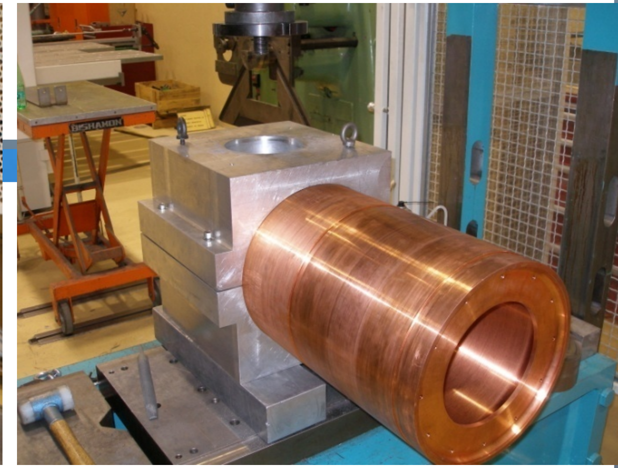
Cavity	**Low β**	**highβ**
No. of Cells	2	2
f (MHz)	101.28	101.28
β_0 (%)	6.3	10.3
Design gradient E_{acc}(MV/m)	6	6
Active length (mm)	195	300
Inner conductor diameter (mm)	50	90
Mechanical length (mm)	215	320
Gap length (mm)	50	85
Beam aperture diameter (mm)	20	20
$U/E_{acc}{}^2$ (mJ/(MV/m)^2	73	207
E_{pk}/E_{acc}	5.4	5.6
H_{pk}/E_{acc} (Oe/MV/m)	80	100.7
R_{sh}/Q (Ω)	564	548
$\Gamma = R_S \cdot Q_0$ (Ω)	23	30.6
Q_0 for 6MV/m at 7W	$3.2 \cdot 10^8$	$5 \cdot 10^8$
TTF max	0.85	0.9
No. of cavities	12	20

Manufacturing sequence

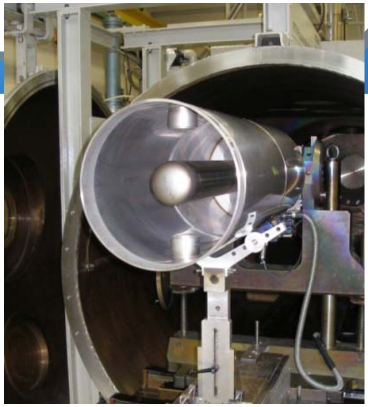


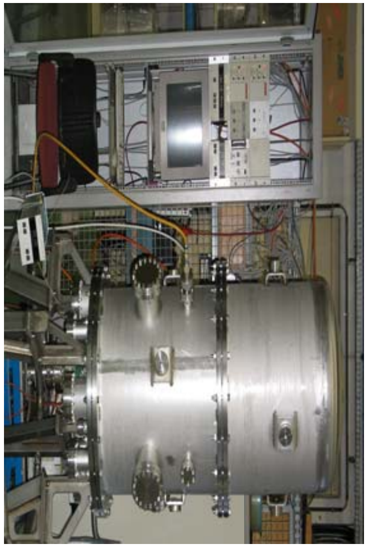
- Rolling of half tubes, longitudinal welding, rough machining
- Machining of end piece
- E-beam welding
- Fine machining of inner surface
- “Bossage” and machining of beam ports
- Manufacturing of baseplate of inner conductor
- Manufacturing of central tube
- Manufacturing of head
- E-beam welding of the 3 parts of inner conductor
- Fine machining of inner conductor
- Drilling of beam line
- Final long-distance e-beam welding
- E-beam welding of top flange ensemble

Cavity fabrication

Surface treatments ready

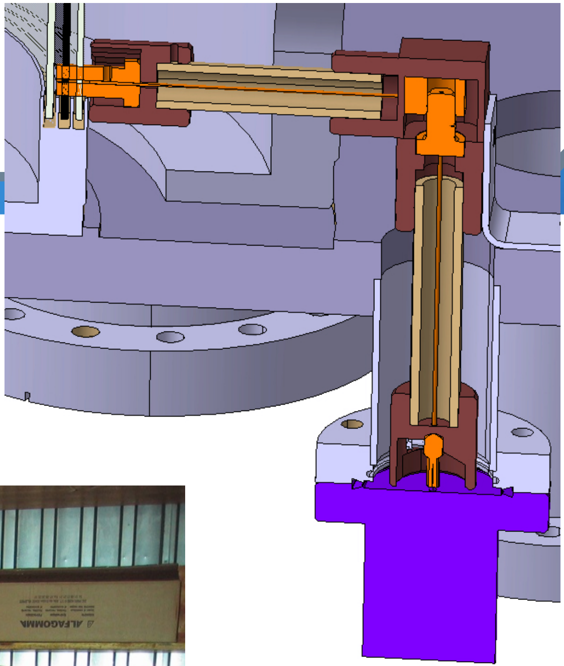




Coating system

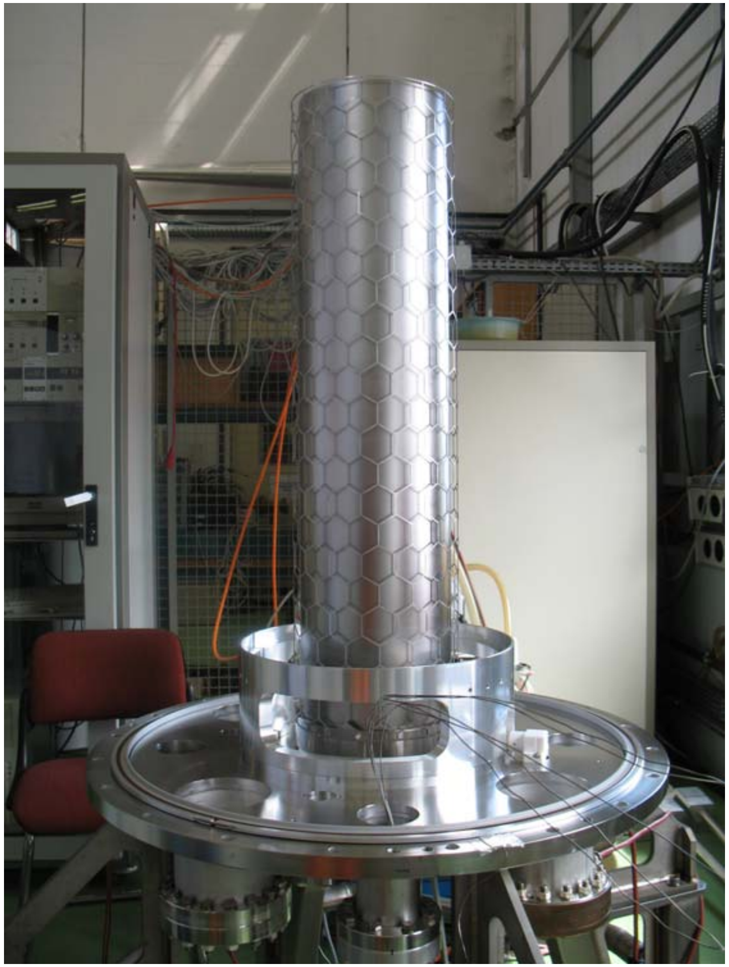
Bias grid by water jet cutting

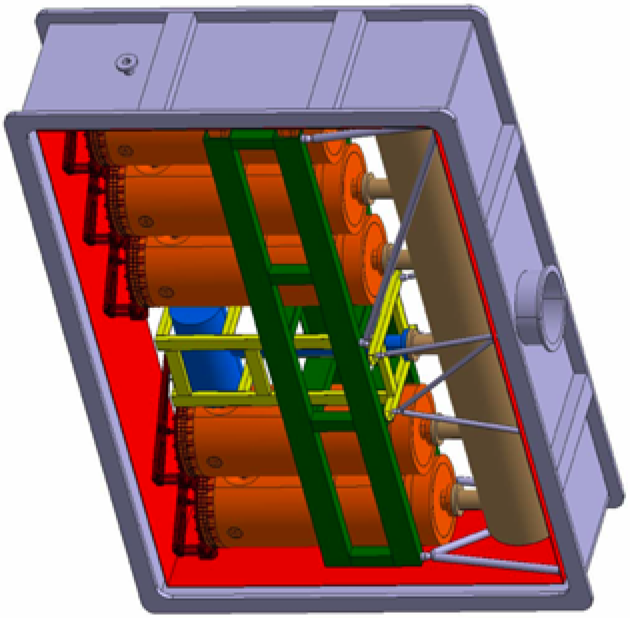
Coating vacuum system



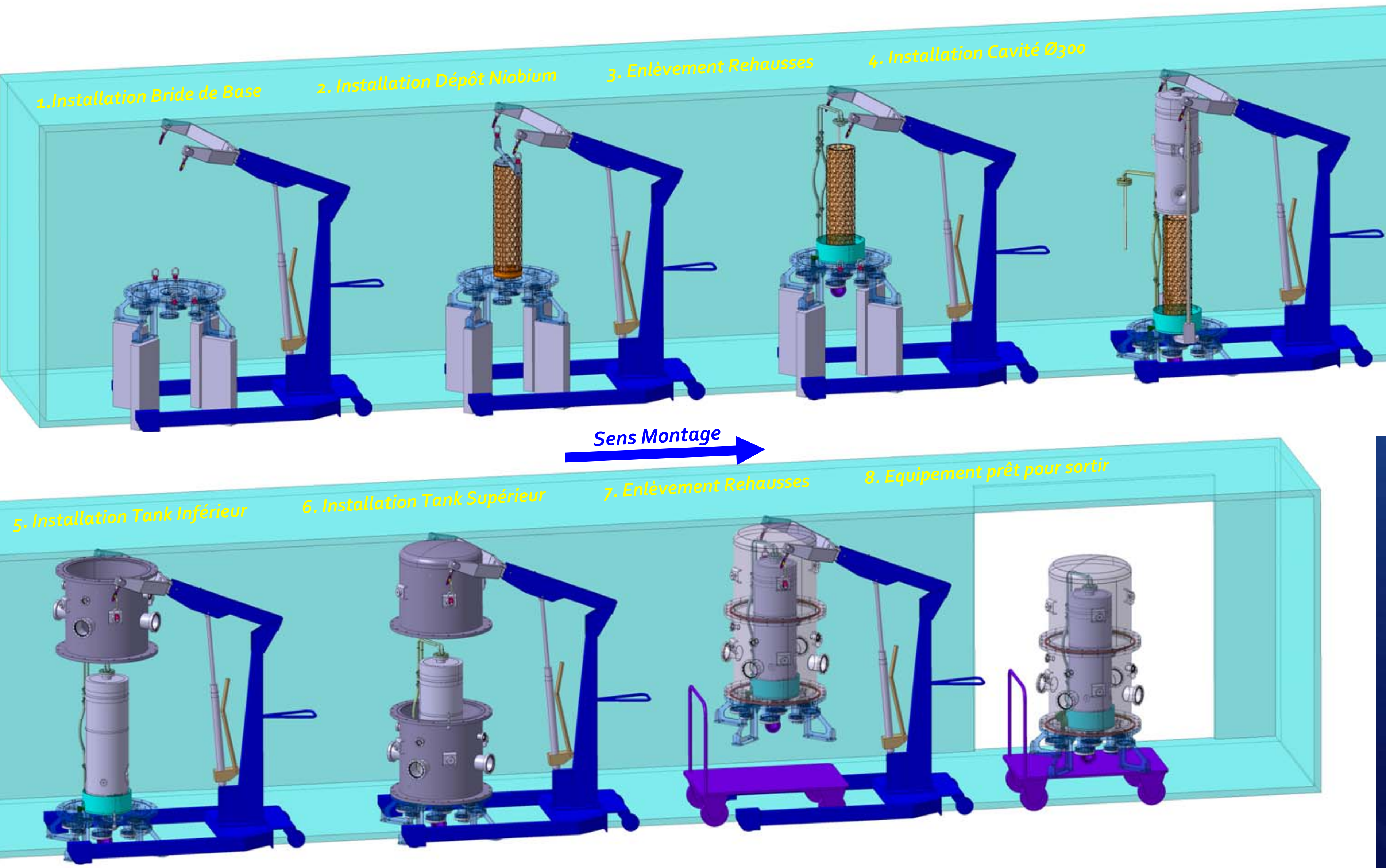
Shielded electrical feedthrough

Sputtering chamber





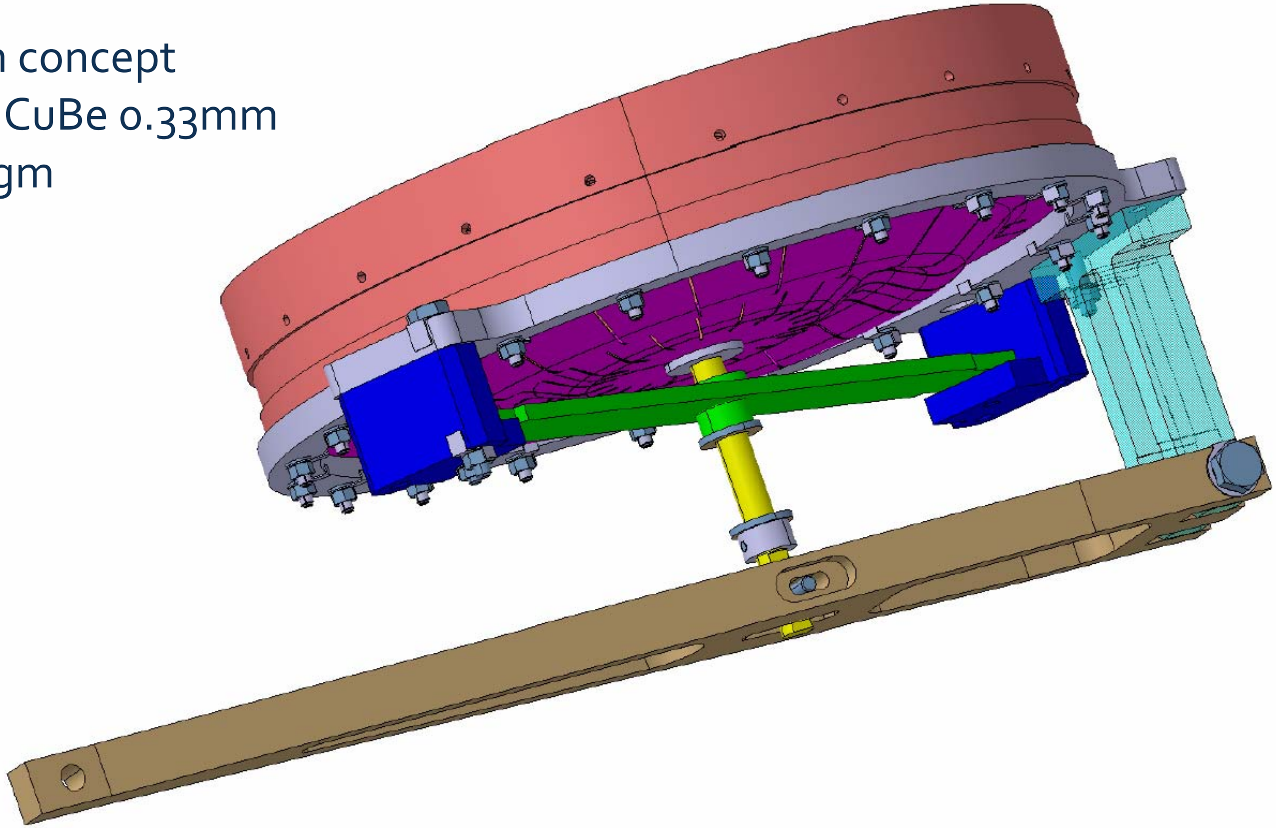
Assembly sequence for clean room operations



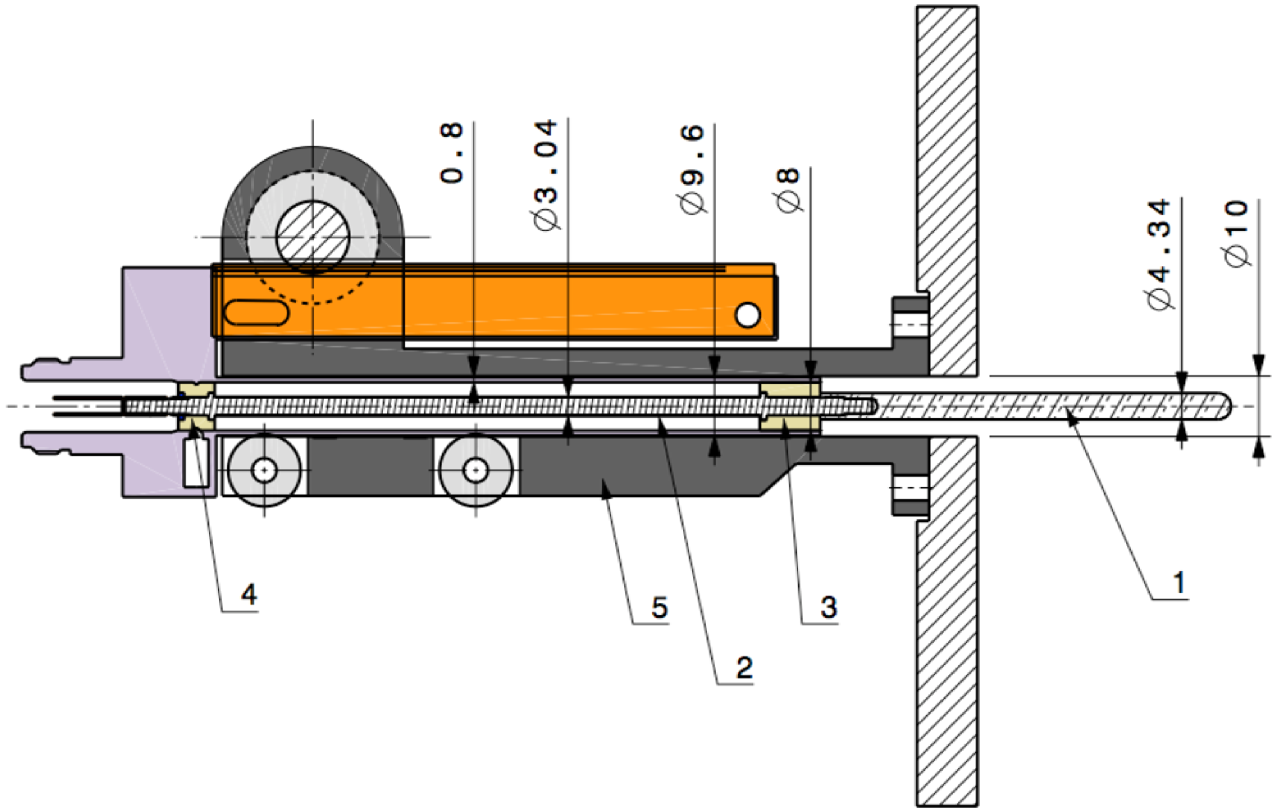
Gilles VILLIGER TS/MME

Tuning plate (in construction)

Zero backlash concept
hydroformed CuBe 0.33mm
thick diaphragm



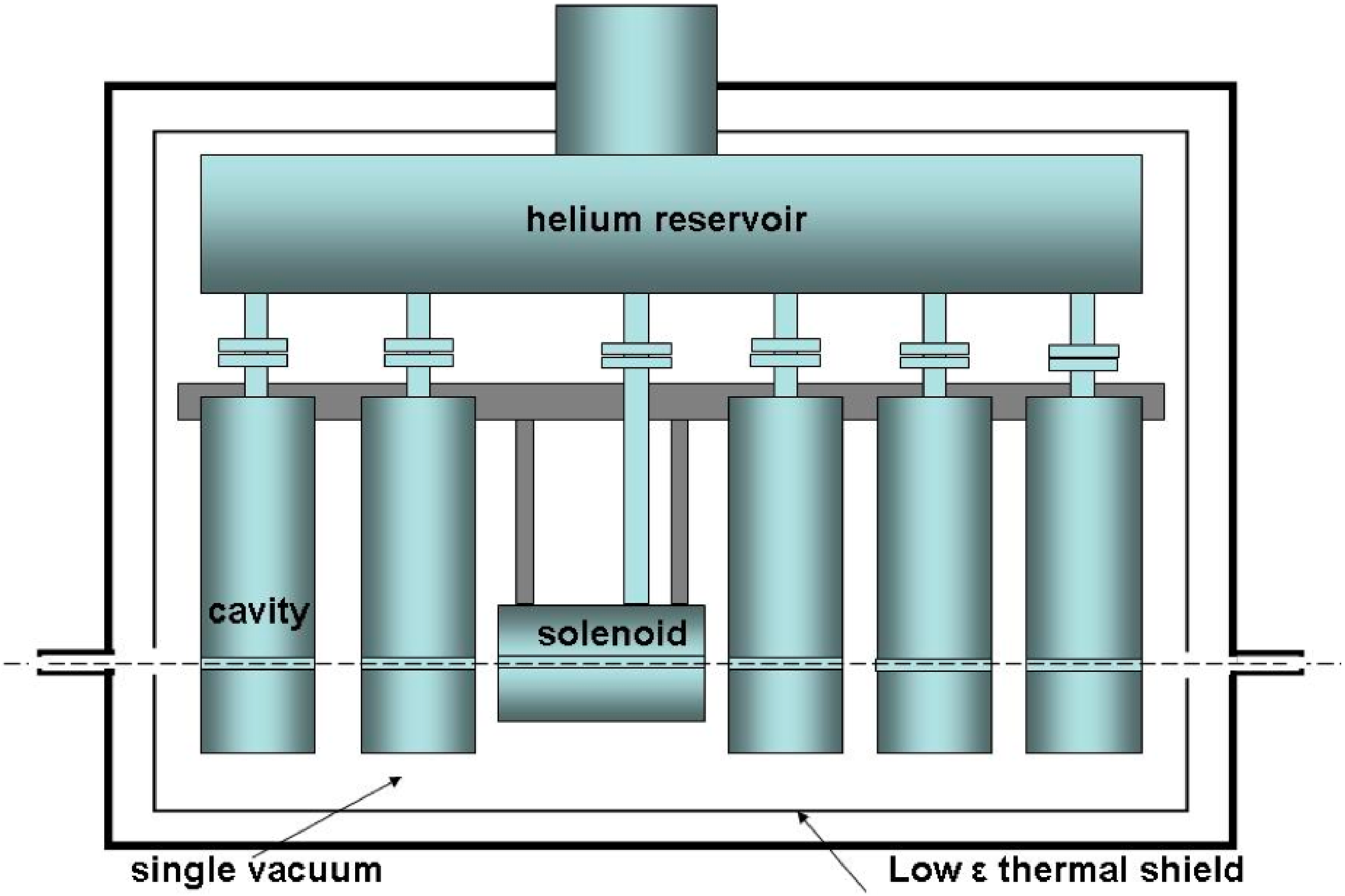
RF Coupler



Main Parameters of the high β cryomodule

Parameter	Value
No. cavities	5
Mechanical length of cavity	320 mm
Beam aperture diameter	20 mm
No. of SC solenoids	1
Solenoid max field, current	9 T, 600 A
Vacuum vessel (approximate dimensions)	Length: 2.5 m; width: 1 m; height: 2 m
Cavity/solenoid operating temperature	4.5 K
Helium vessel volume (preliminary)	150 l
Thermal shield temperature	50 K (gaseous helium)

Common vacuum



Evaluation points (1/2)

- Heat loads
- Risk of cavity pollution
- On-site cryomod. intervention
- Size of clean room infrastructure
- Disassembly cav. for maintenance
- Design/construction/ assembly complexity
- Cryostat cleanliness requirements
- Alignment at assembly

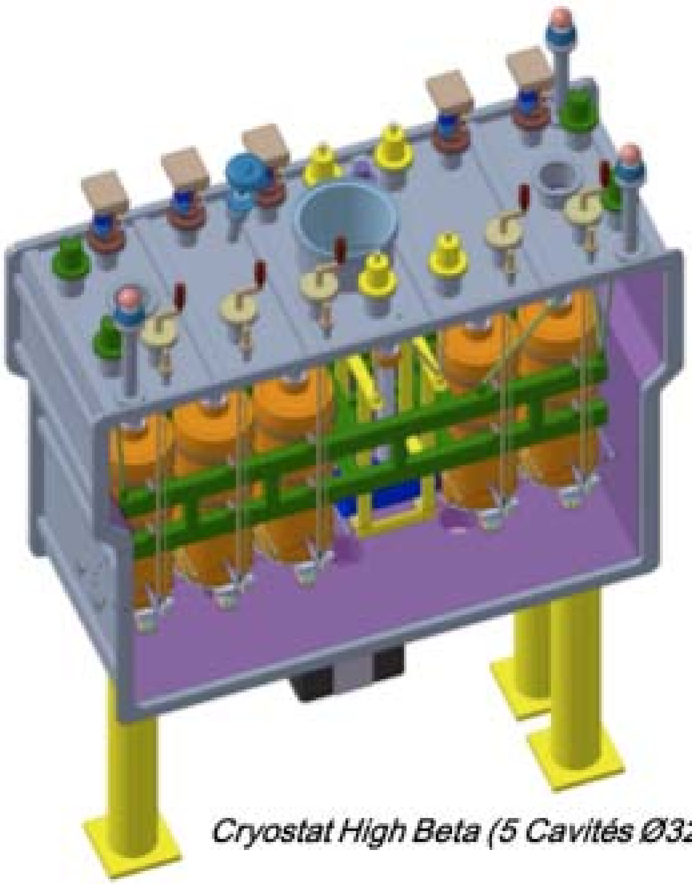
Evaluation point (2/2)

- Longitudinal space requirements
- Capital cost
- Development
- Learning curve and construction time

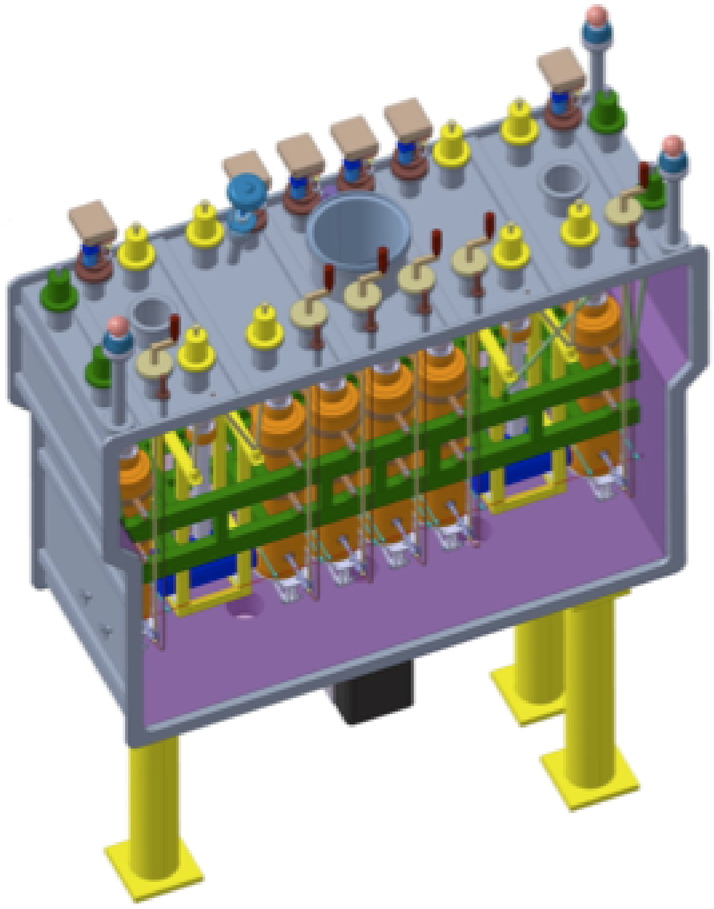
Some more specifications

- Alignment – adjusting position of the solenoid from outside
- Vacuum – no worm leaks are tolerated, cold leaks (He gas) can be tolerated up to 10e-7 mbar
- Assembly should be compliant with CERN infrastructure (important for maintenance)

Cryomodule pre-study concept

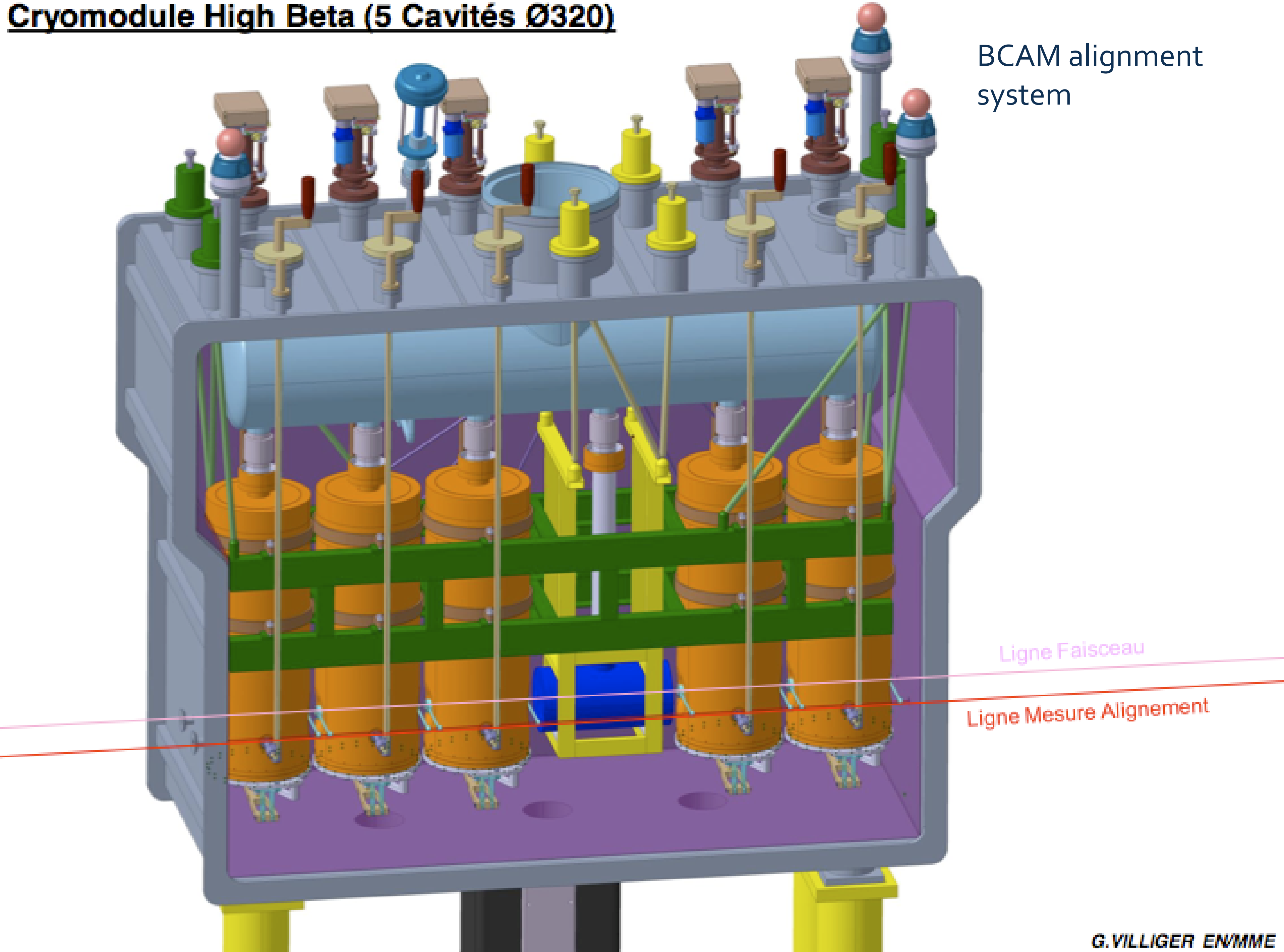


Cryostat High Beta (5 Cavités Ø320)



Cryomodule High Beta (5 Cavités Ø320)

BCAM alignment system



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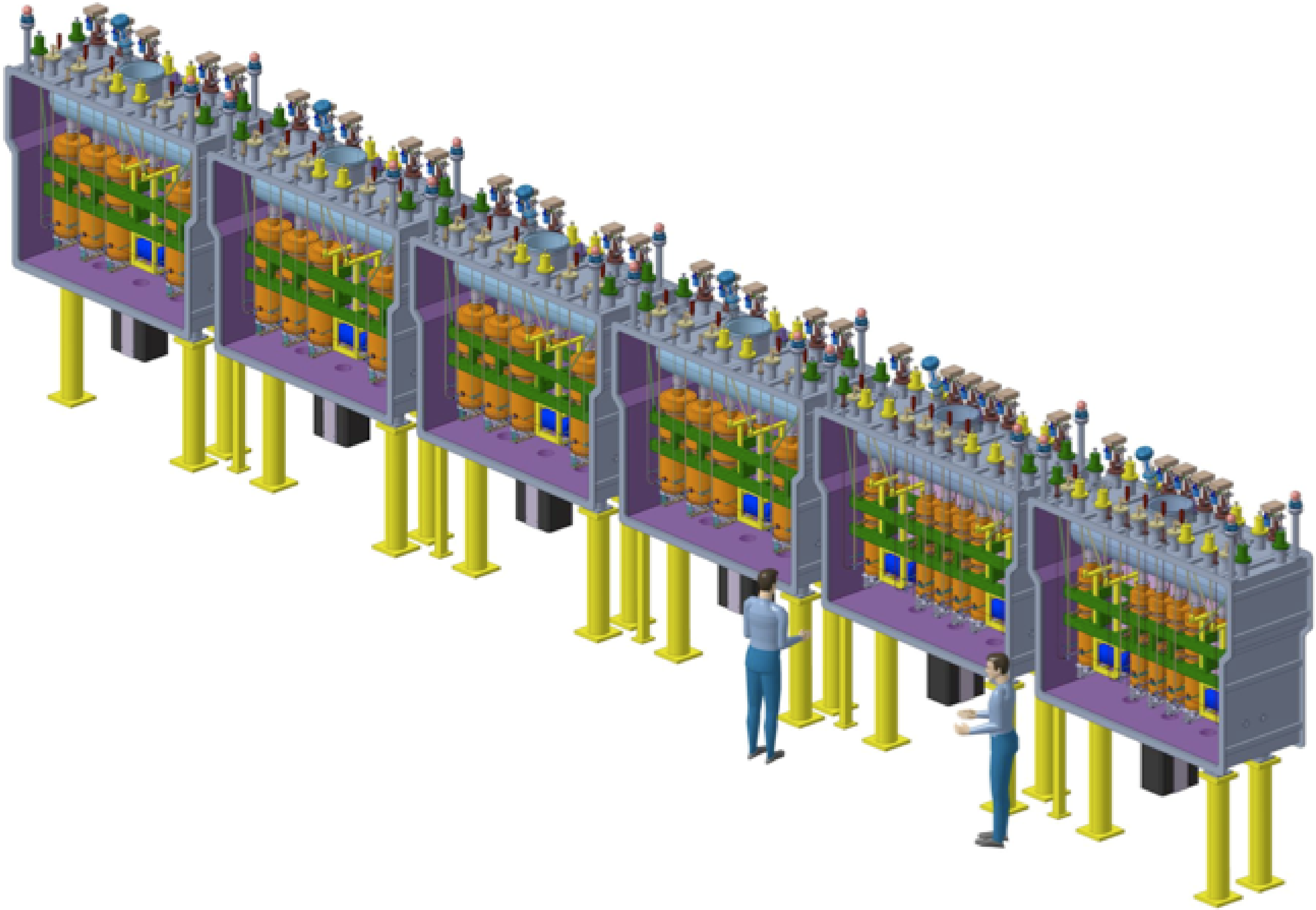
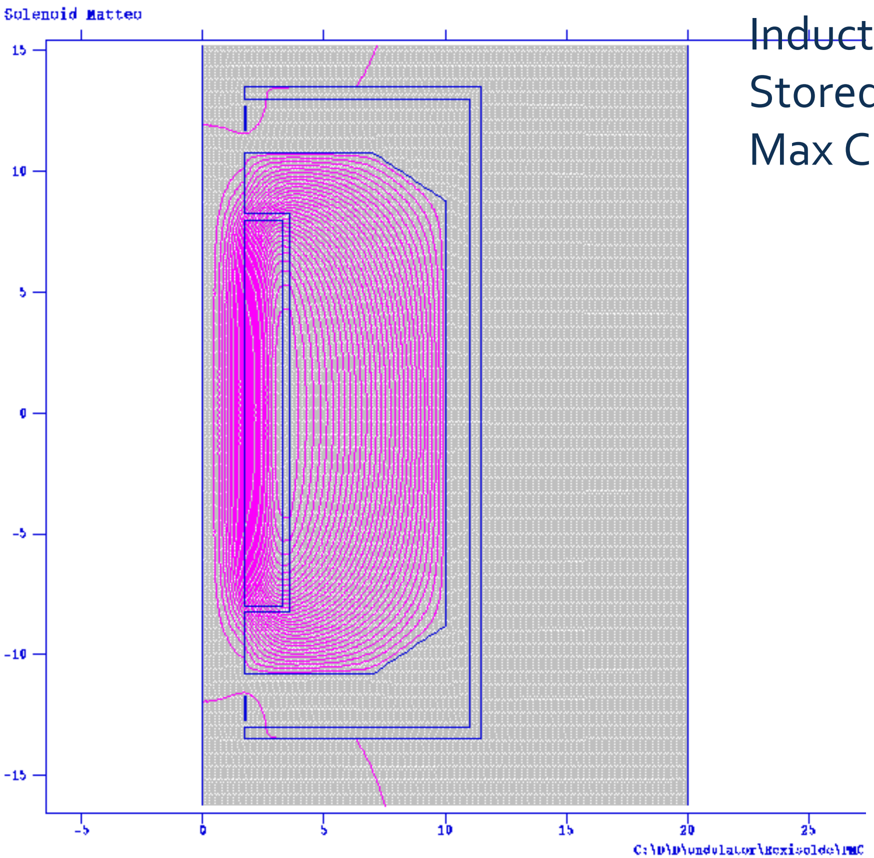
Ligne Cryomodules



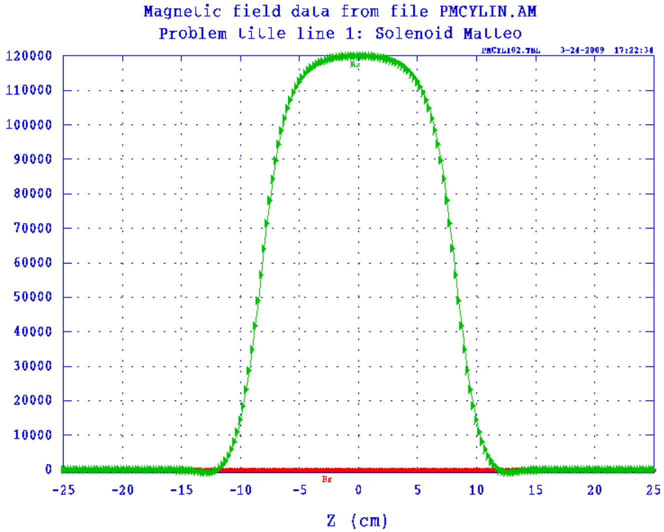
Solenoid R&D – Parameters table

Magnetic length	0.16	m
$\int B\,dz$	>1.8	Tm
B residual at 0.25m from mid	<0.2	Gauss
Max dimensions	<0.4	m
Operating temperature	4.2	K

Magnetic design

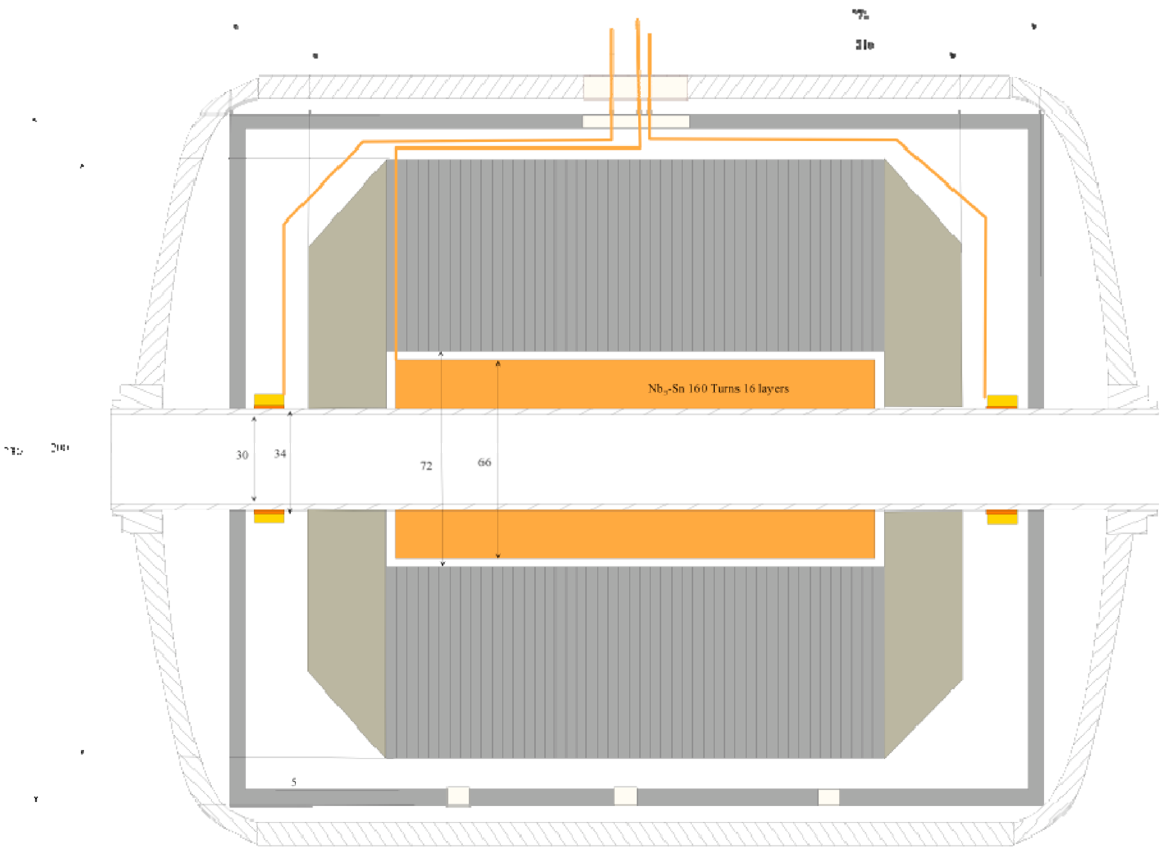


Inductance	=	78 mH
Stored energy (600 A)	=	14 kJ
Max Current	=	600A

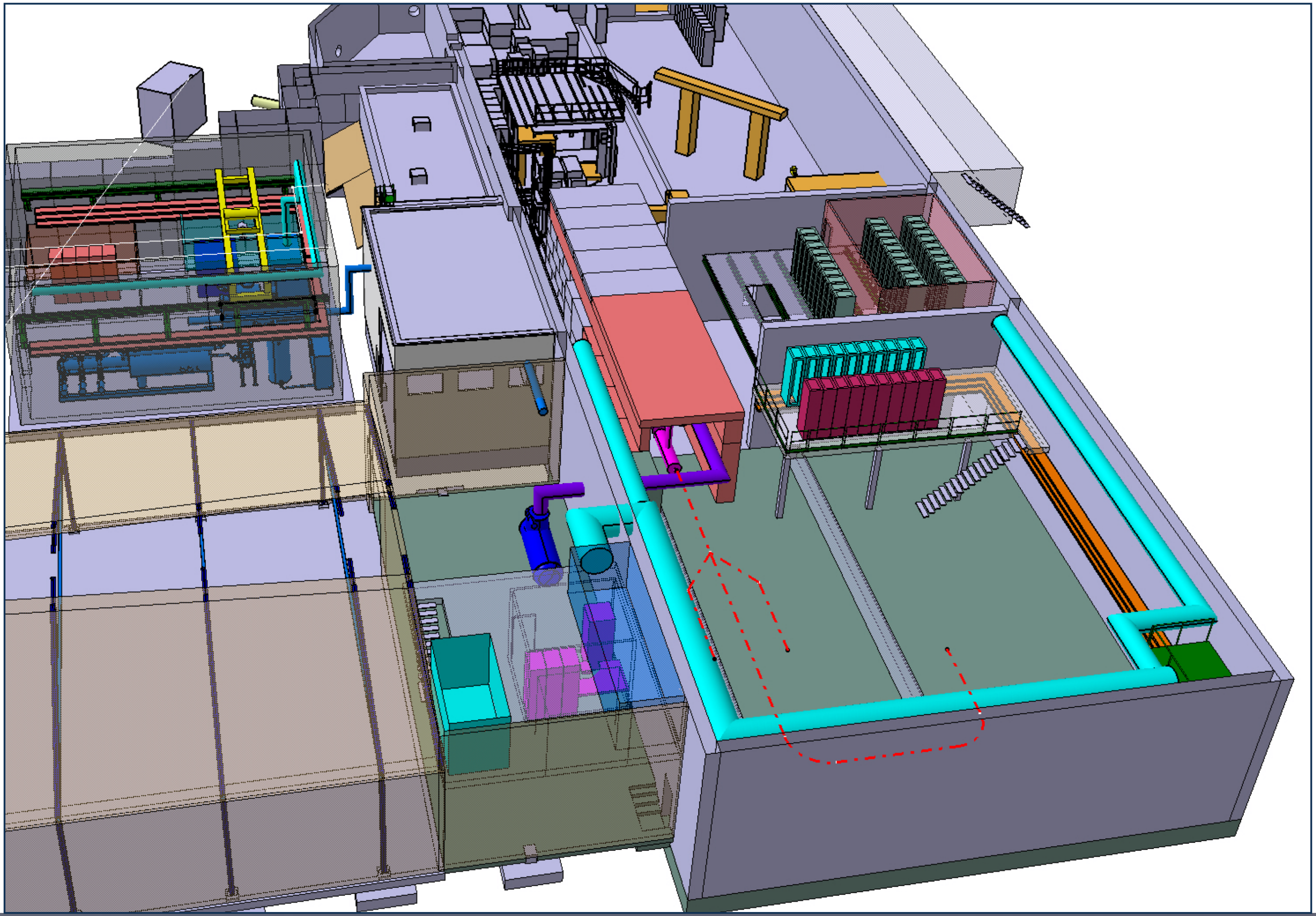


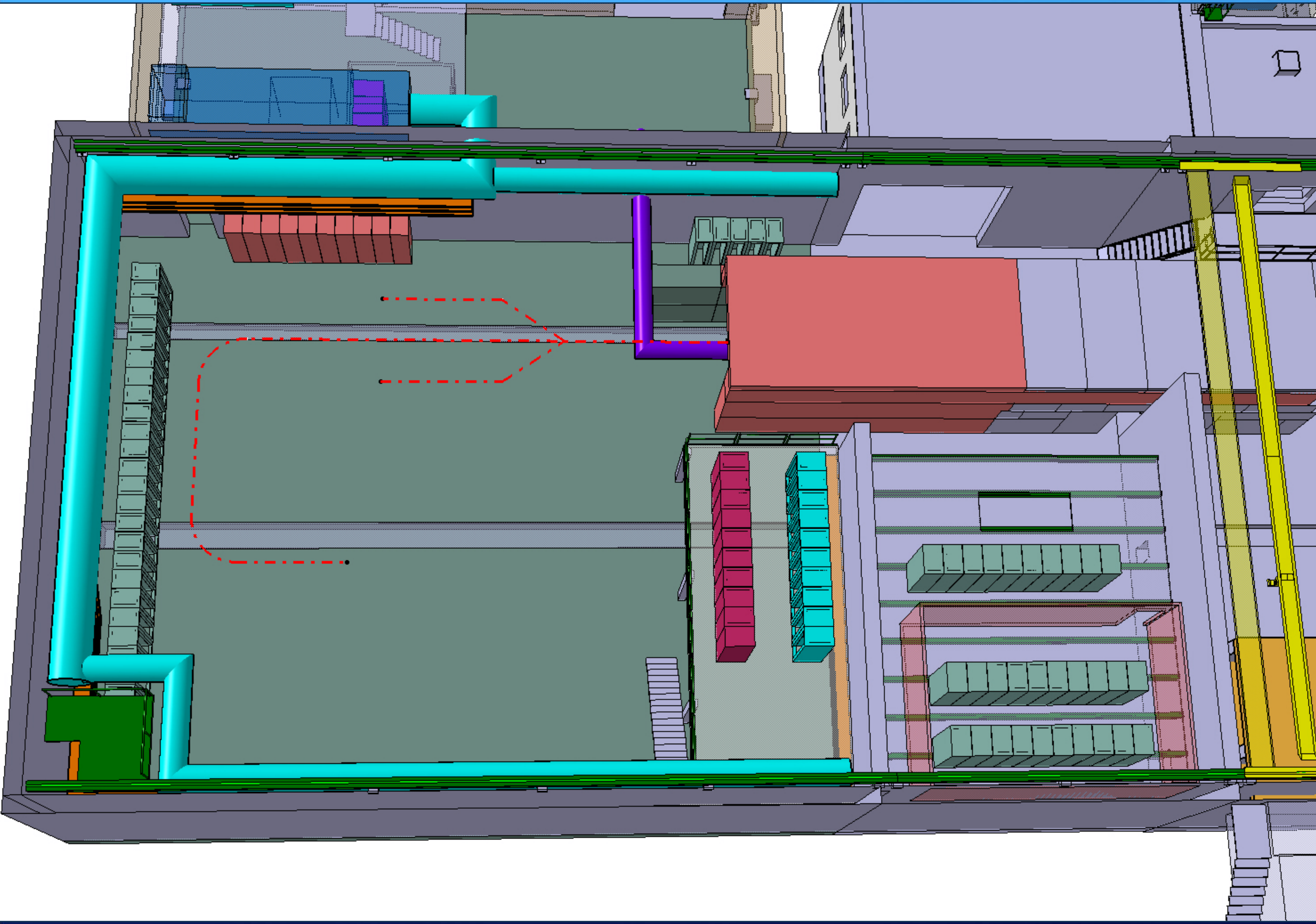
Nb3Sn

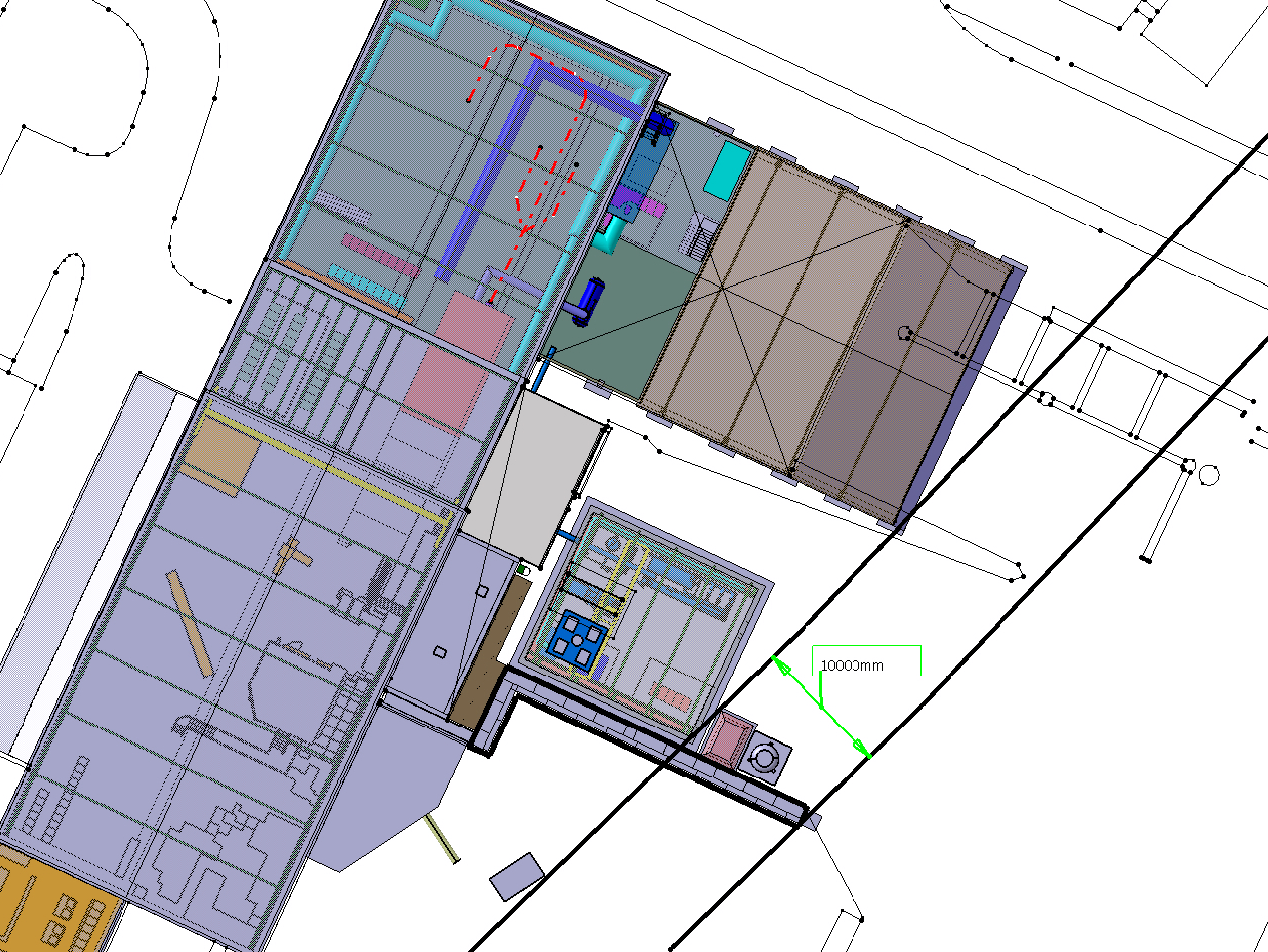
Solenoid R&D

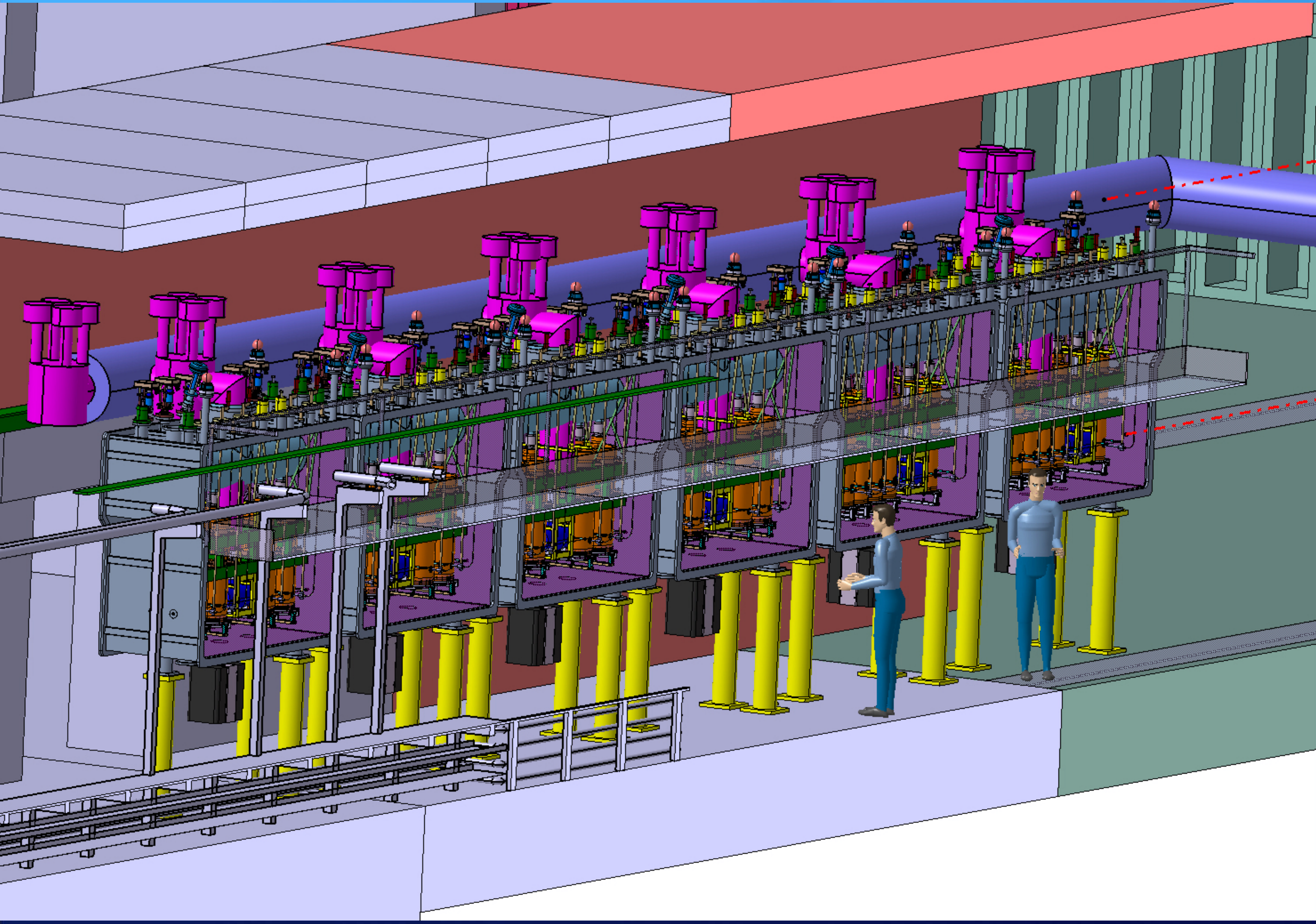


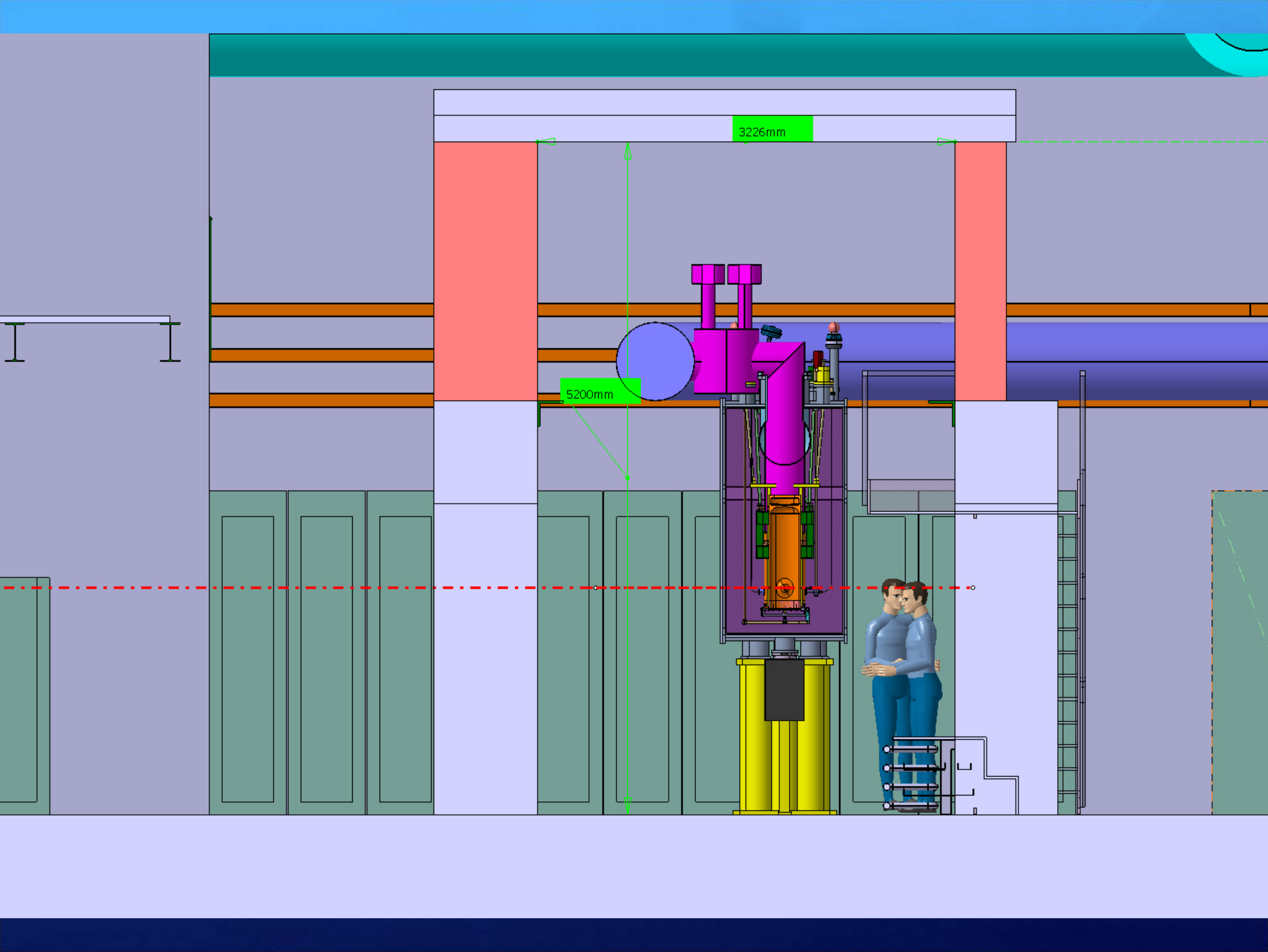
Buildings and infrastructures






10000mm




3226mm
5200mm

Summary

- HIE ISOLDE R&D activity is in good health and ongoing
- Test of the first cavity are expected in August (t.b.c.)
- The construction phase is depending now on the CERN management; hopefully a decision will be taken at the council meeting in September. If it is positivite we can foresee to have installed and commissioned the first 2 cryomodules by 2013.

People

- HIE-ISOLDE design group
- ISOLDE physics and operation group
- LNL-INFN and TRIUMF
- Cockcroft Institute, Liverpool and Manchester University

Thanks for your attention!