Status of the HIE-ISOLDE linac

W. Venturini Delsolaro

on behalf of the HIE-ISOLDE teams

CERN, Geneva, Switzerland

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  - Alignment and Monitoring
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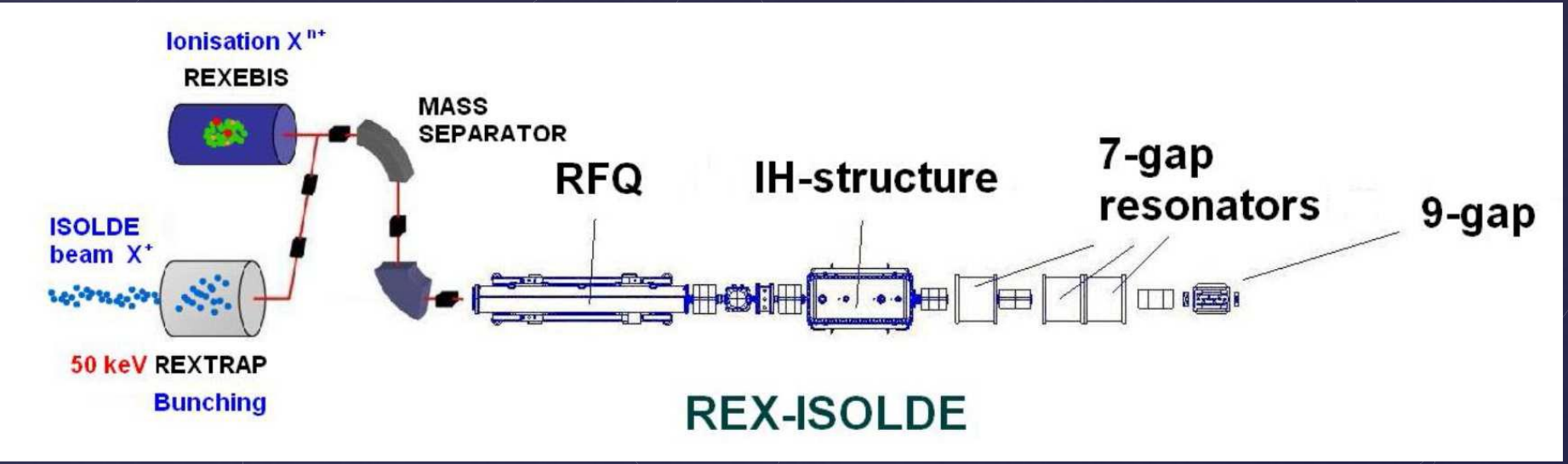
- Schedules
- Summary

REX-ISOLDE

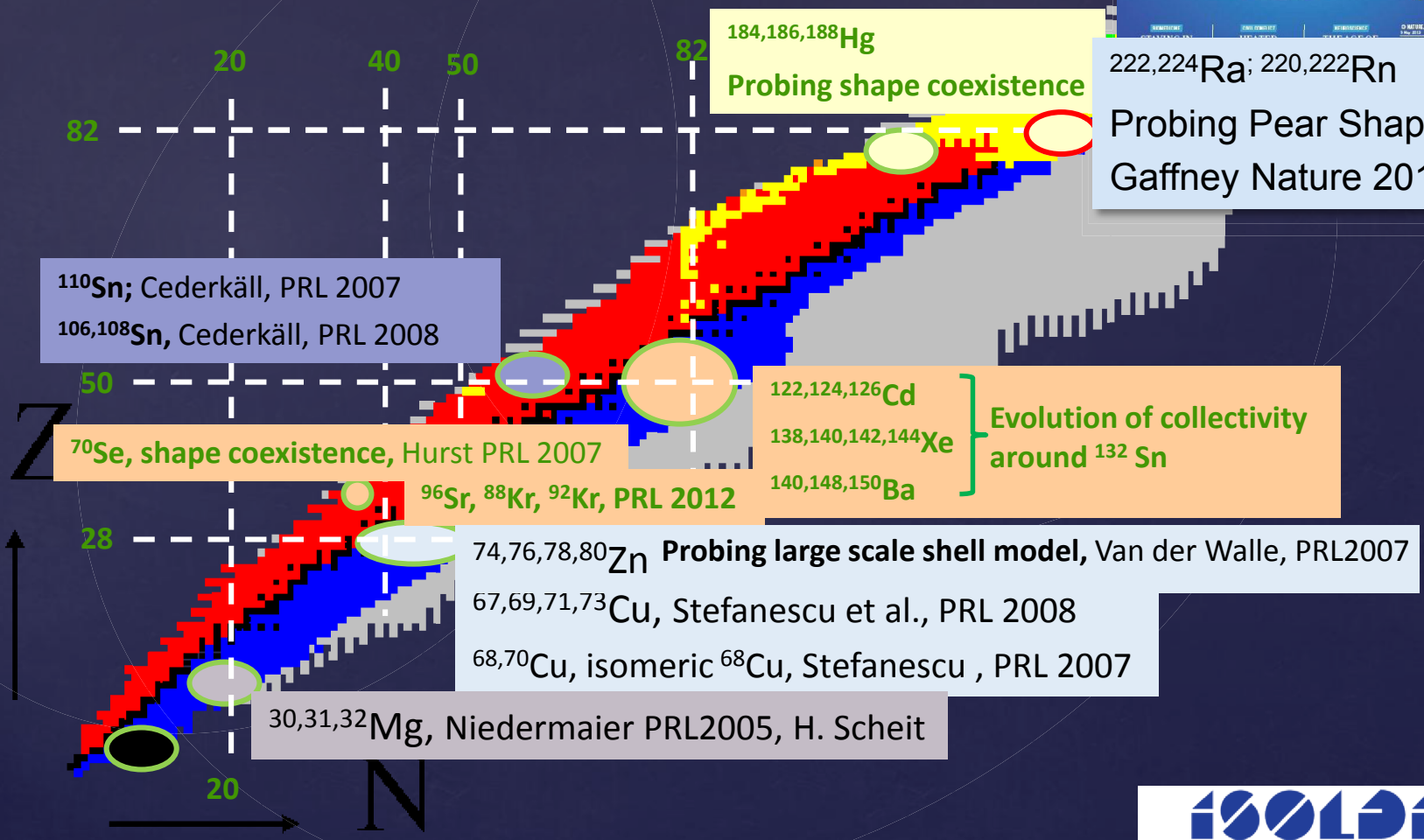


NC linac for post acceleration of ISOLDE RIBs up to 3 MeV/u

Started in 2001: 72 different beams already used
of > 700 available at ISOLDE

Physics program @ REX

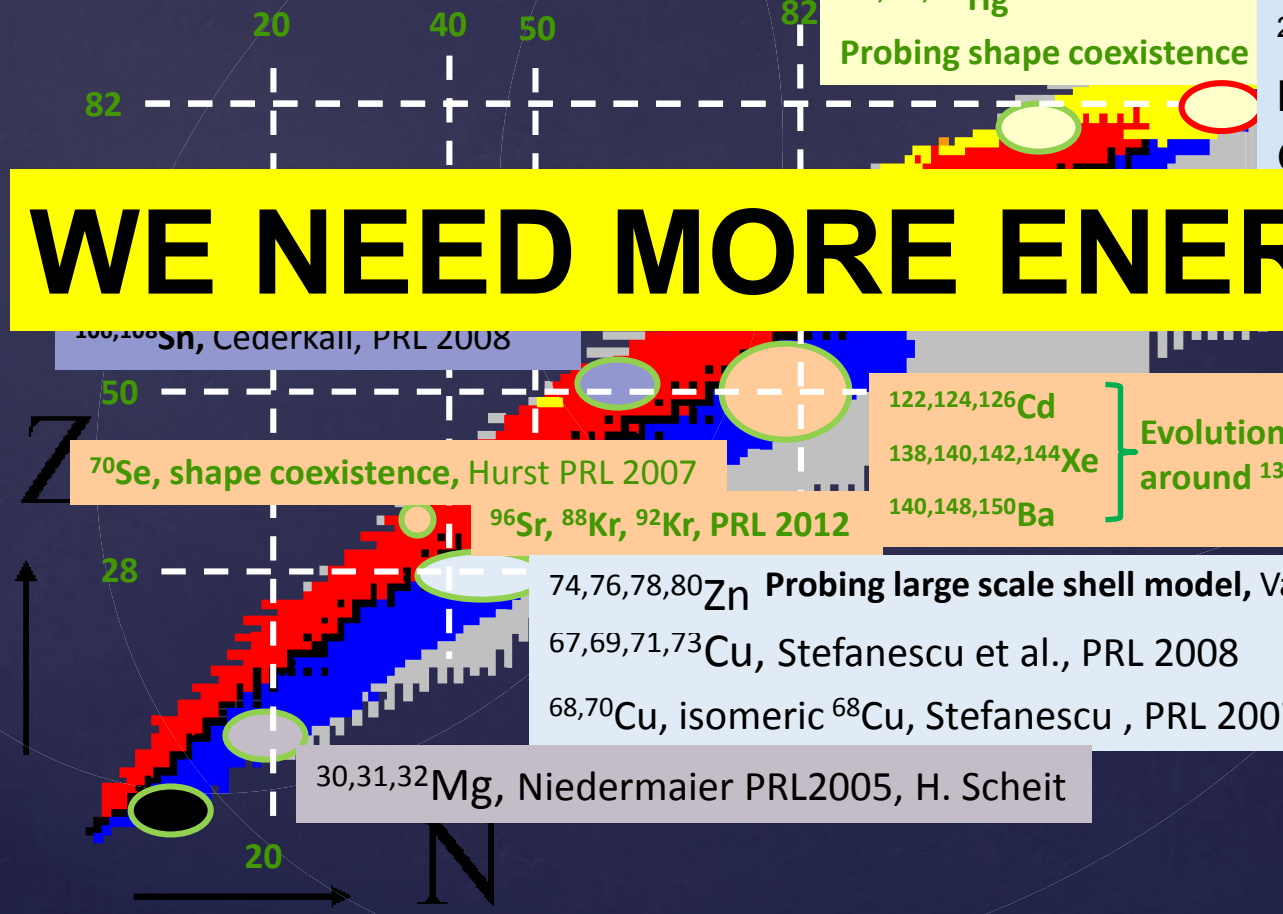
Coulomb excitation with Miniball: collective versus individual nucleon behaviour



ISOLDE

Physics program @ REX

Coulomb excitation with Miniball: collective versus individual nucleon behaviour



^{184,186,188}Hg
Probing shape coexistence

^{222,224}Ra; ^{220,222}Rn
Probing Pear Shape
Gaffney Nature 2013

WE NEED MORE ENERGY!

^{100,108}**Sn,** Cederkall, PRL 2008

^{122,124,126}Cd
^{138,140,142,144}Xe
^{140,148,150}Ba
Evolution of collectivity around ^{132} Sn

^{70}**Se, shape coexistence,** Hurst PRL 2007

^{96}**Sr,** ^{88}**Kr,** ^{92}**Kr, PRL 2012**

^{74,76,78,80}Zn **Probing large scale shell model,** Van der Walle, PRL2007

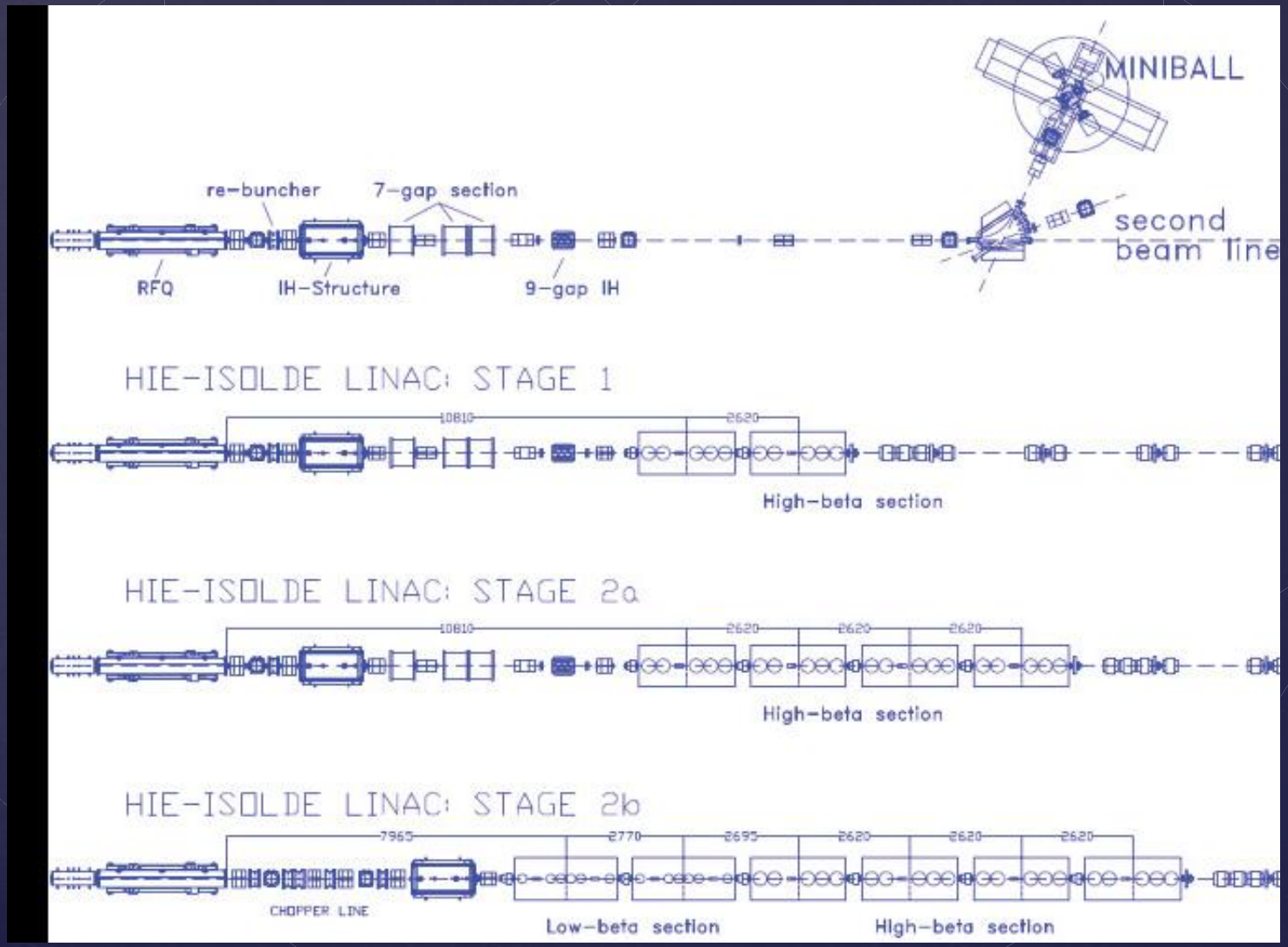
^{67,69,71,73}Cu, Stefanescu et al., PRL 2008

^{68,70}Cu, isomeric ^{68}Cu, Stefanescu , PRL 2007

^{30,31,32}Mg, Niedermaier PRL2005, H. Scheit

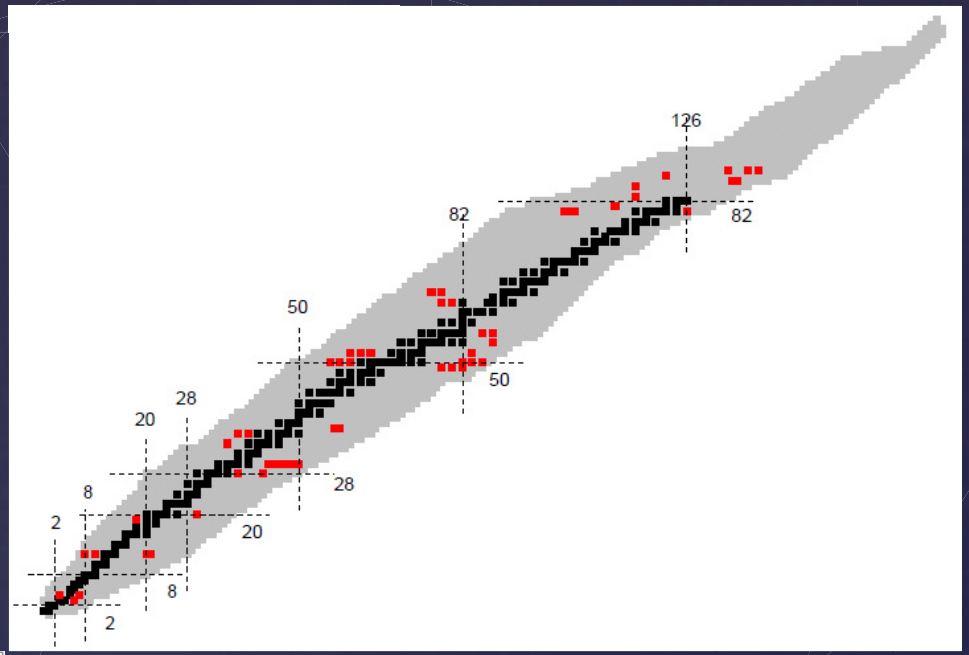
ISOLDE

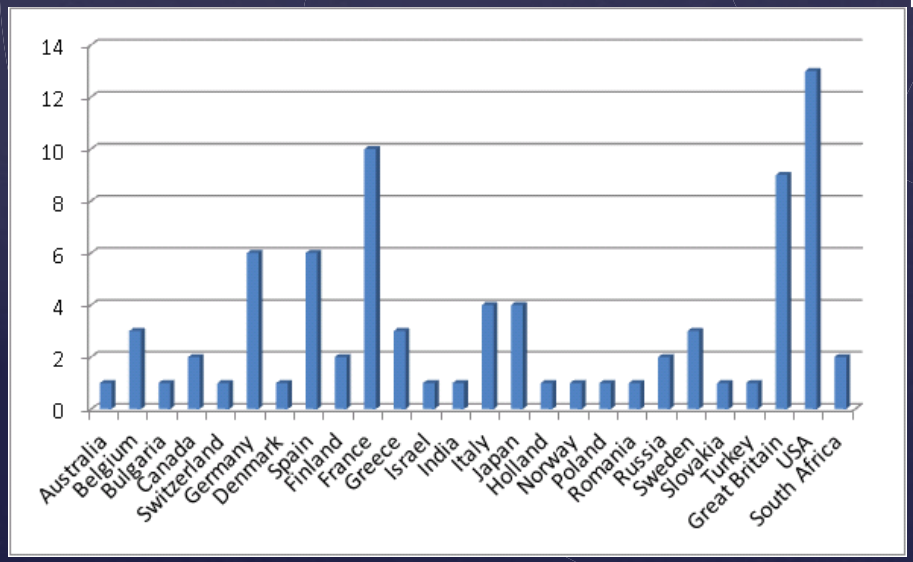
HIE-ISOLDE phases



Physics scope at HIE-ISOLDE

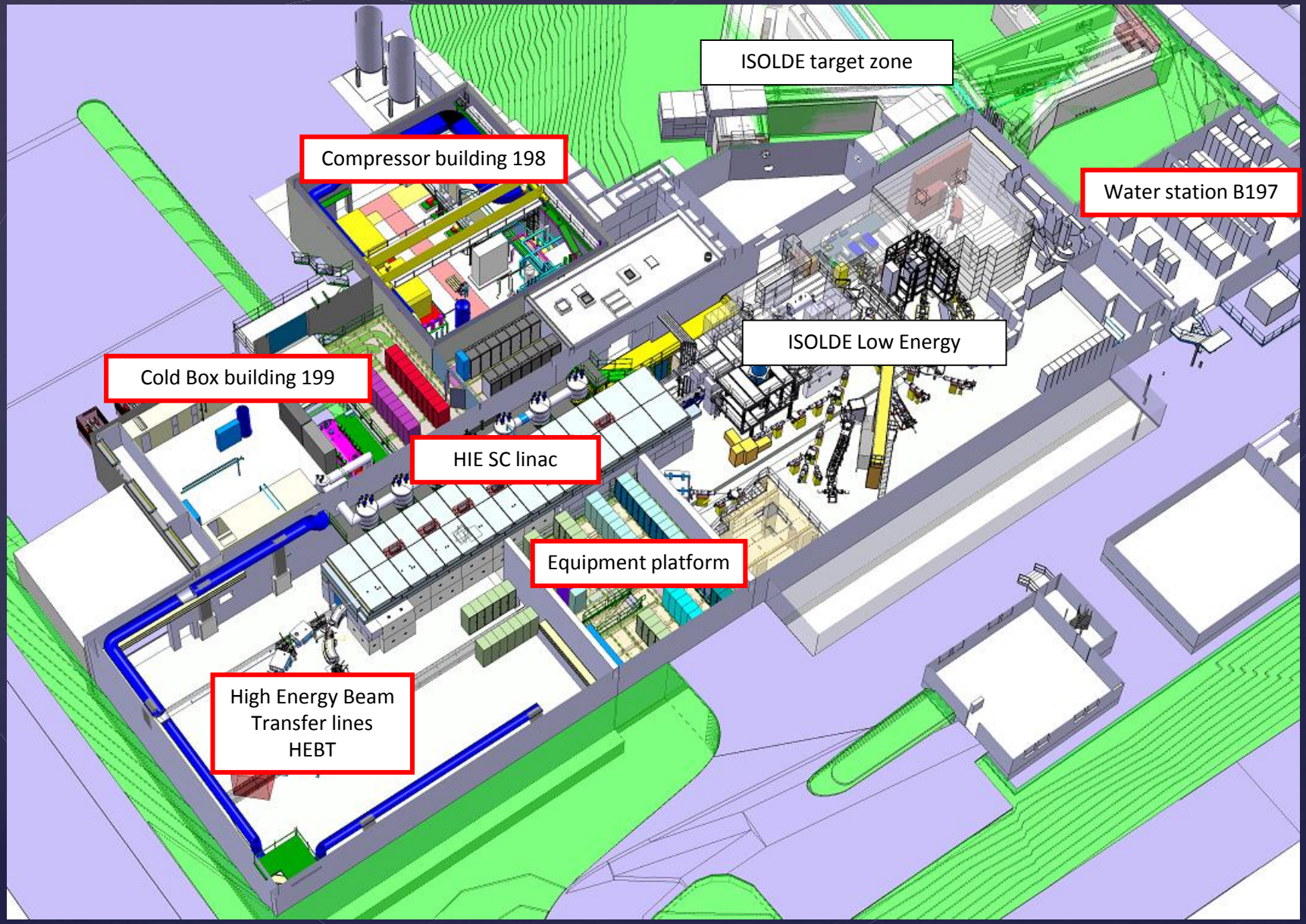
- May 2010: 34 LoI submitted
- 1 Nov 2012: INTC endorsed the increase of 2 GeV-proton energy for ISOLDE
- 27 experiments already approved
- 600 shifts already allocated for physics





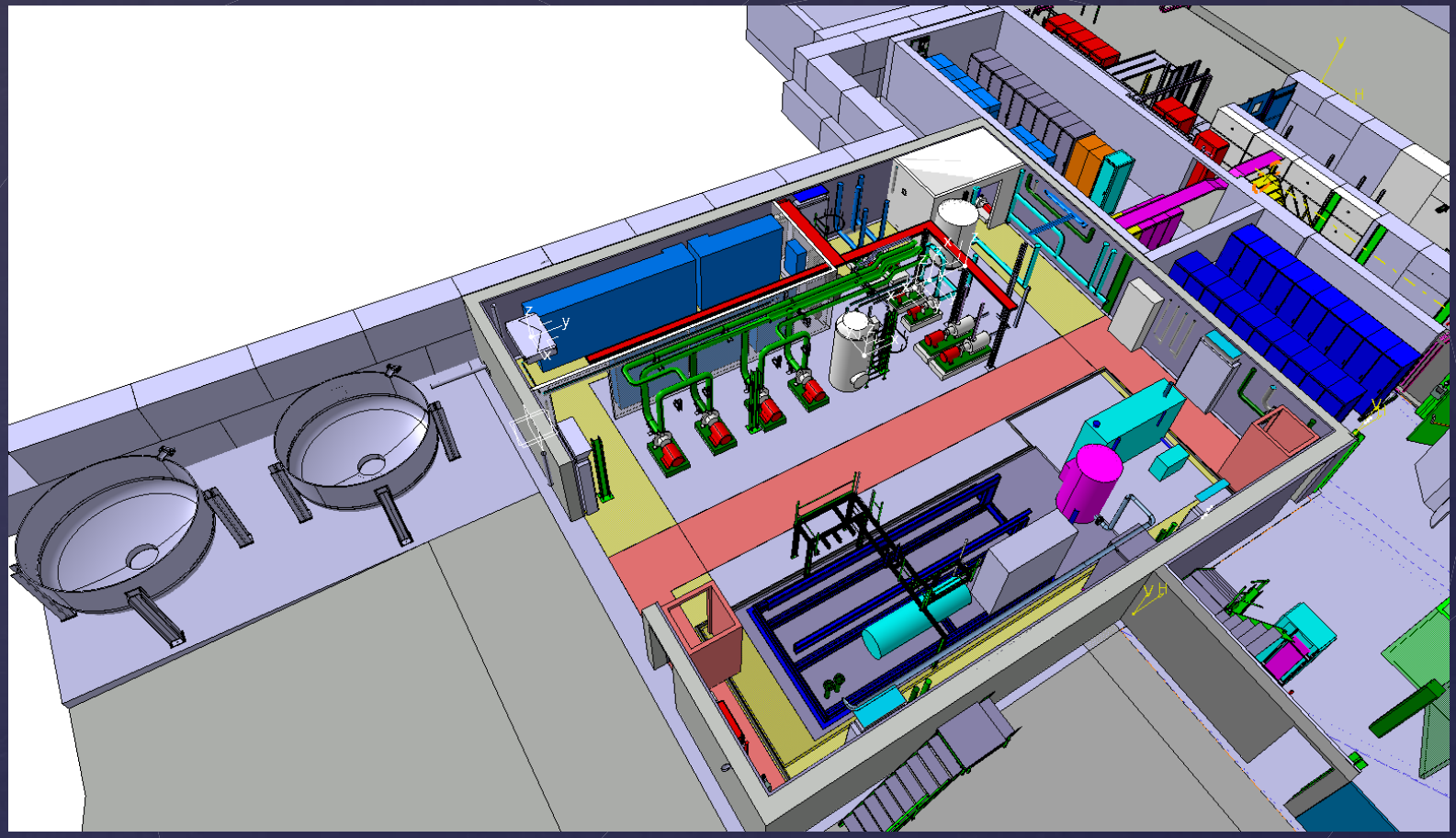
Number of institutes (82) per country involved in HIE-ISOLDE
Proposals submitted in October 2012

HIE ISOLDE installation progress



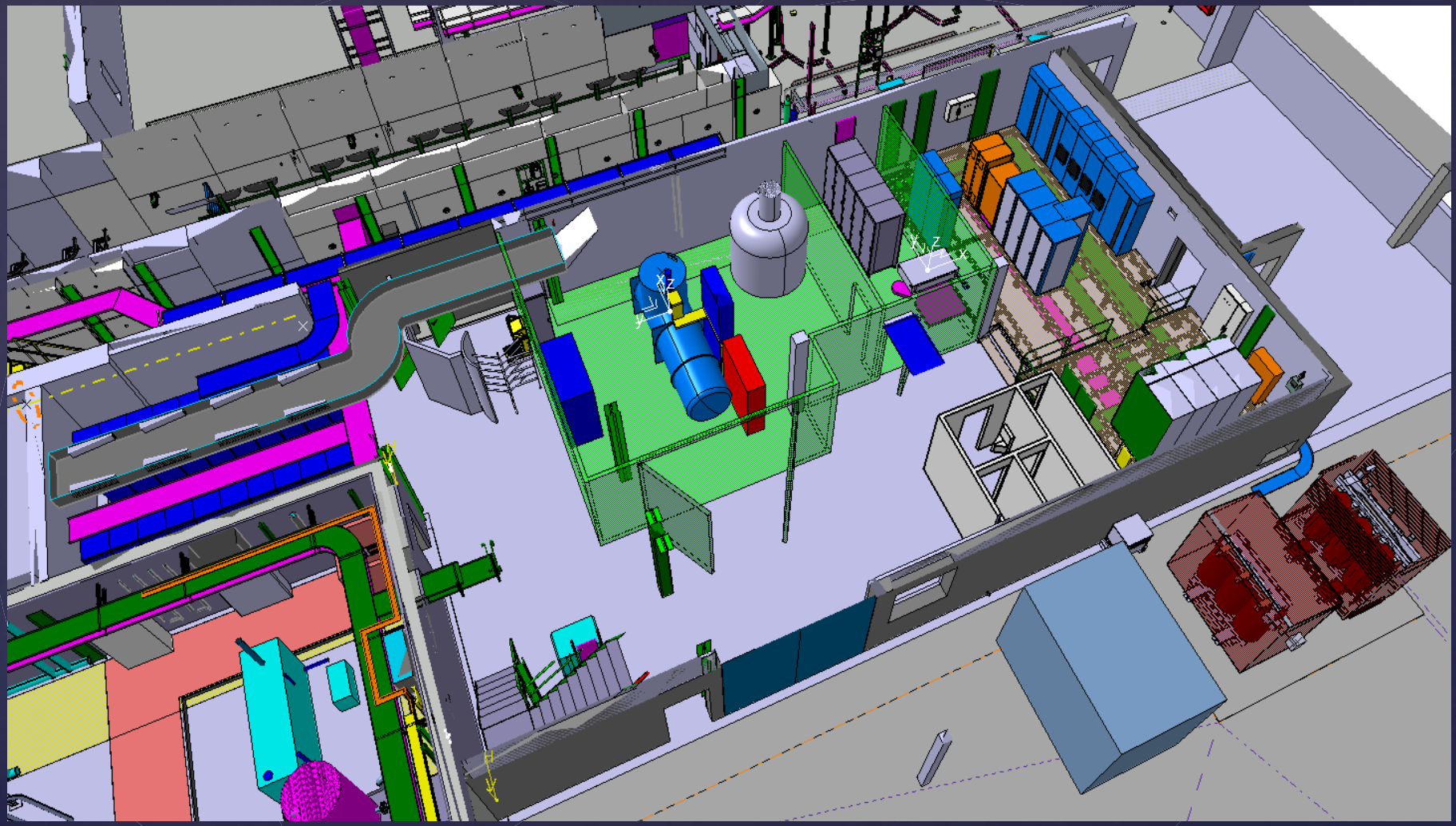

BOLDE

Compressor building 198



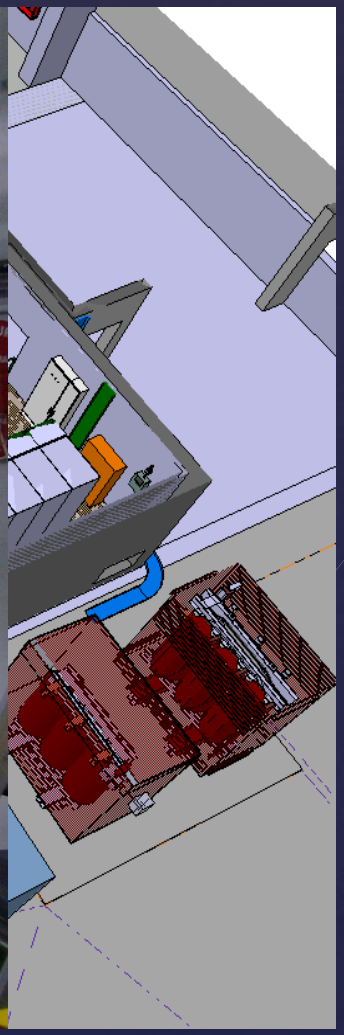
Compressor building 198

Cold Box building 199



RF, cryogenics, solenoid racks, and CV systems installed.

Cold Box building 199



RF, cryogenics, solenoid racks, and CV systems installed.

Cold Box building 199

RF, cryogenics, solenoid racks, and CV systems installed.

Cold Box building 199

RF, cryogenics, solenoid racks, and CV systems installed.

Linac Hall

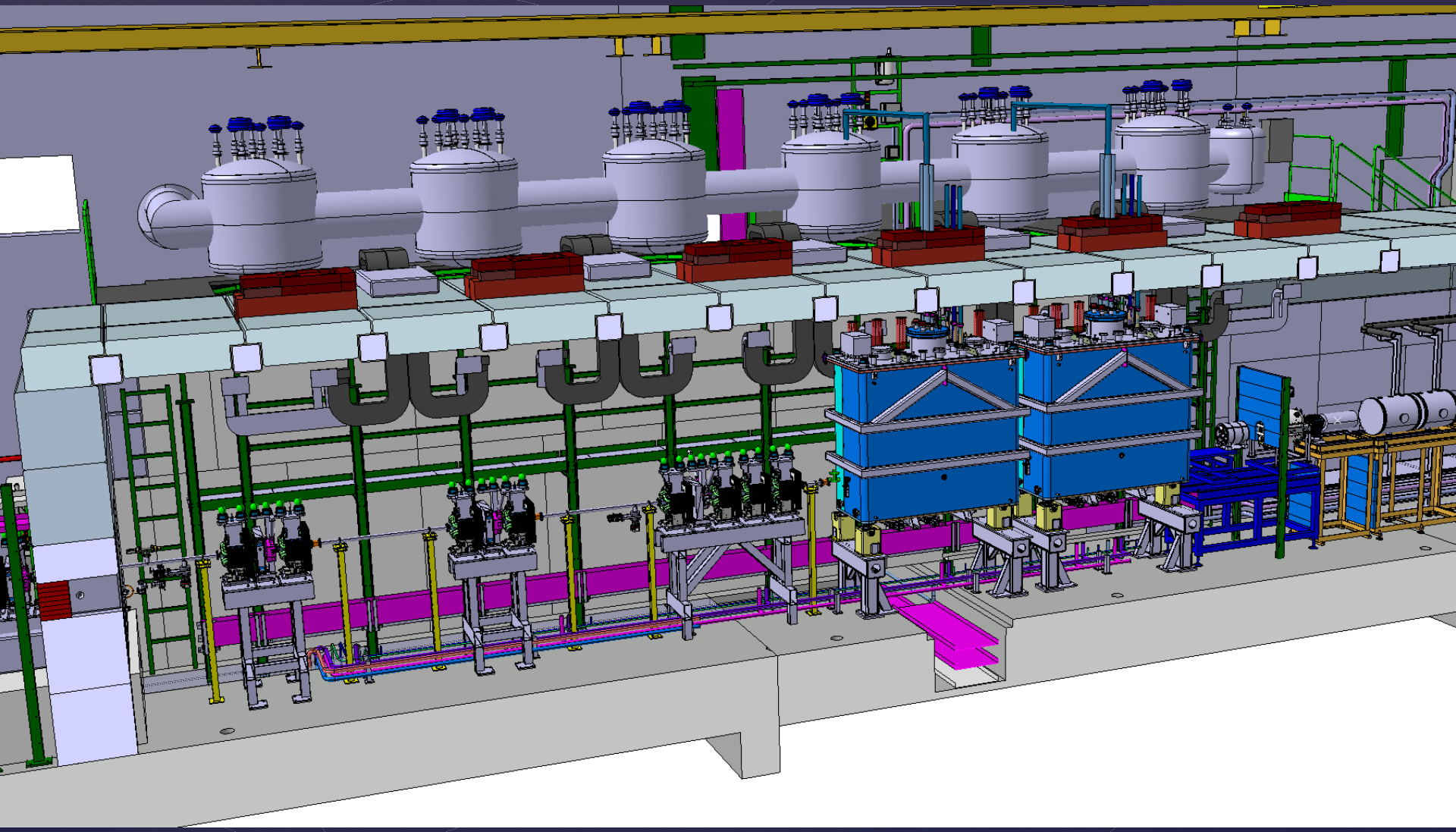
Linac shielding

Linac Hall

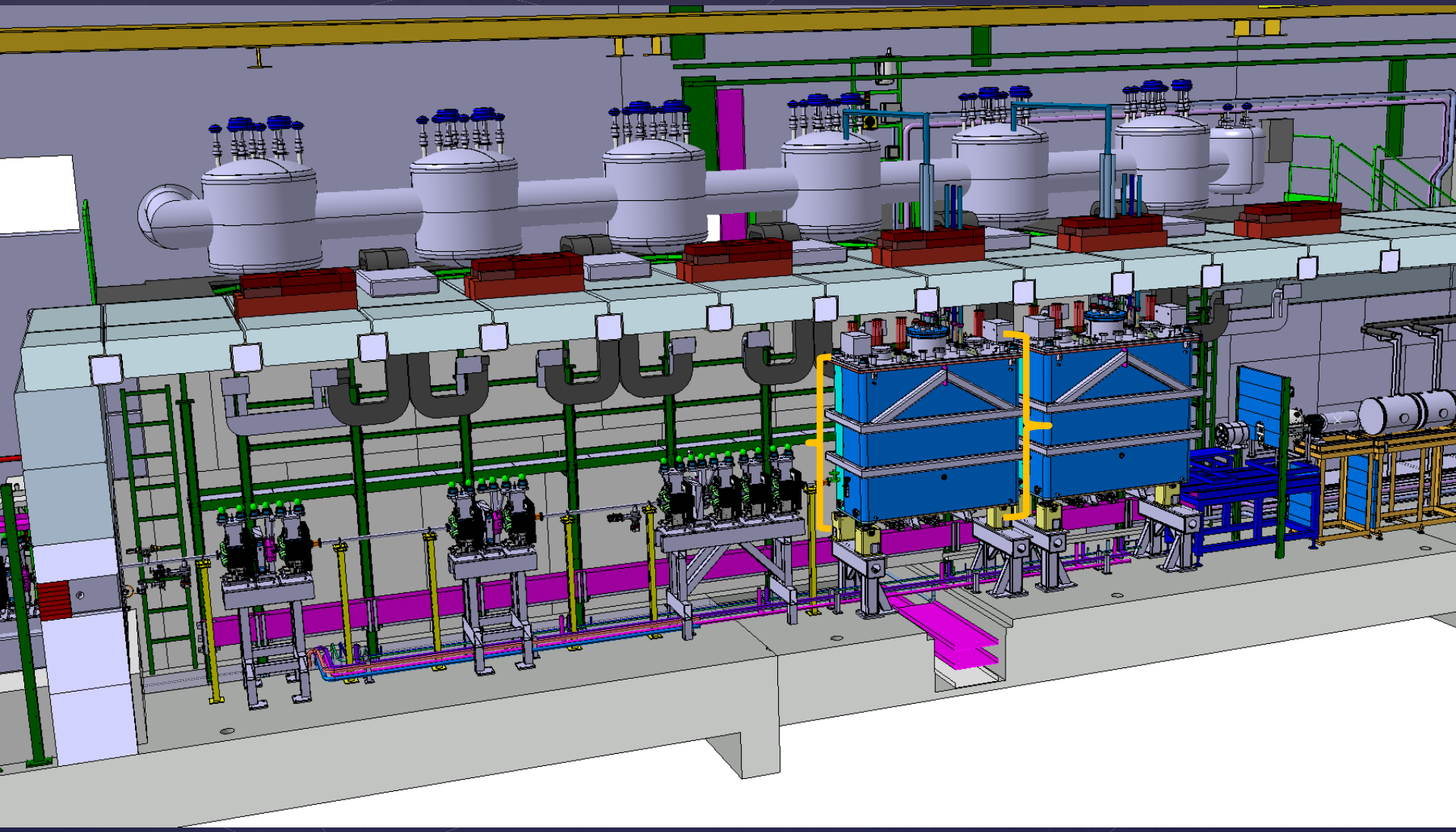
Linac shielding

HEBT magnet supports and piping

HIE LINAC (phase I)

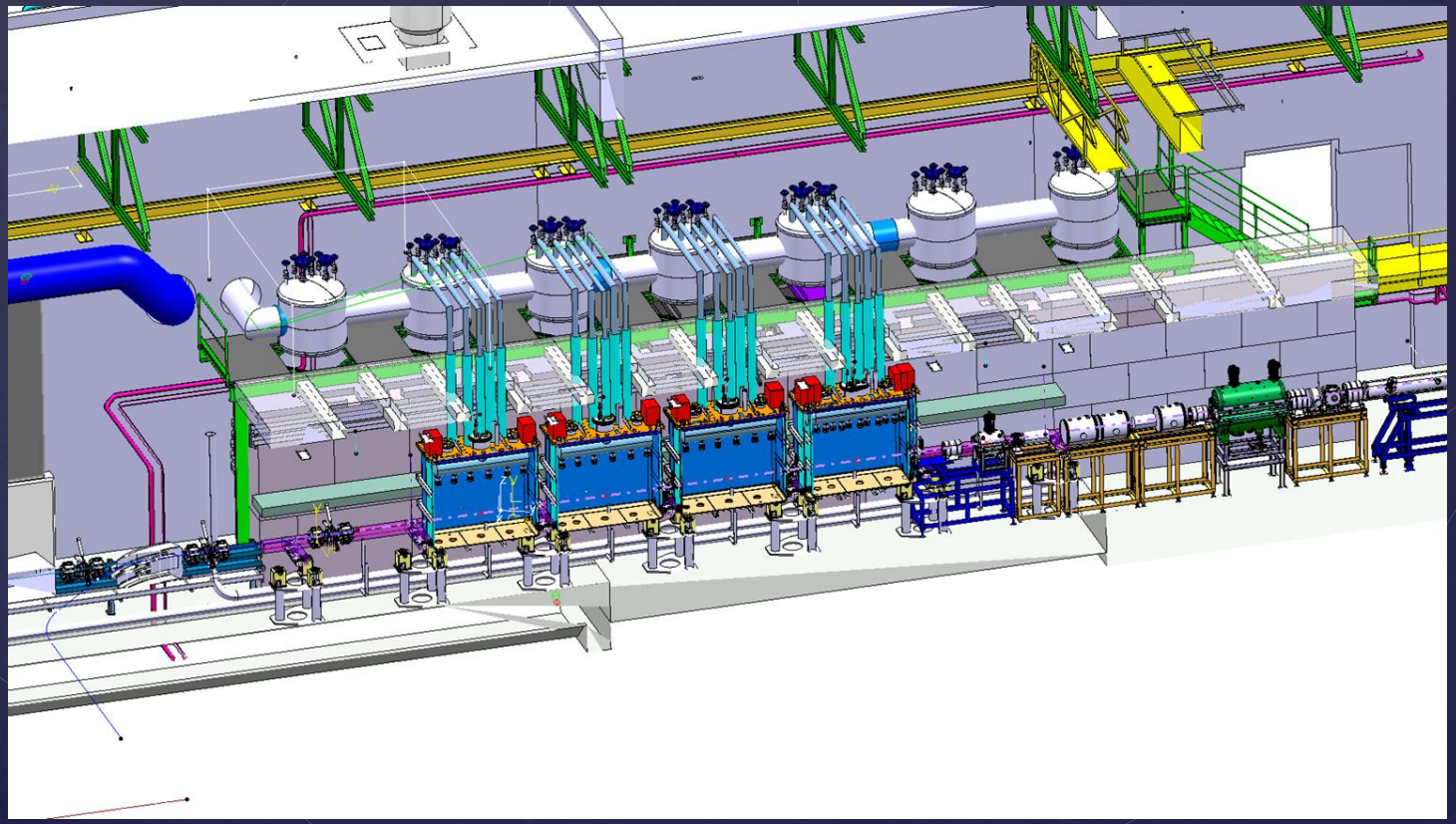


HIE LINAC (phase I)

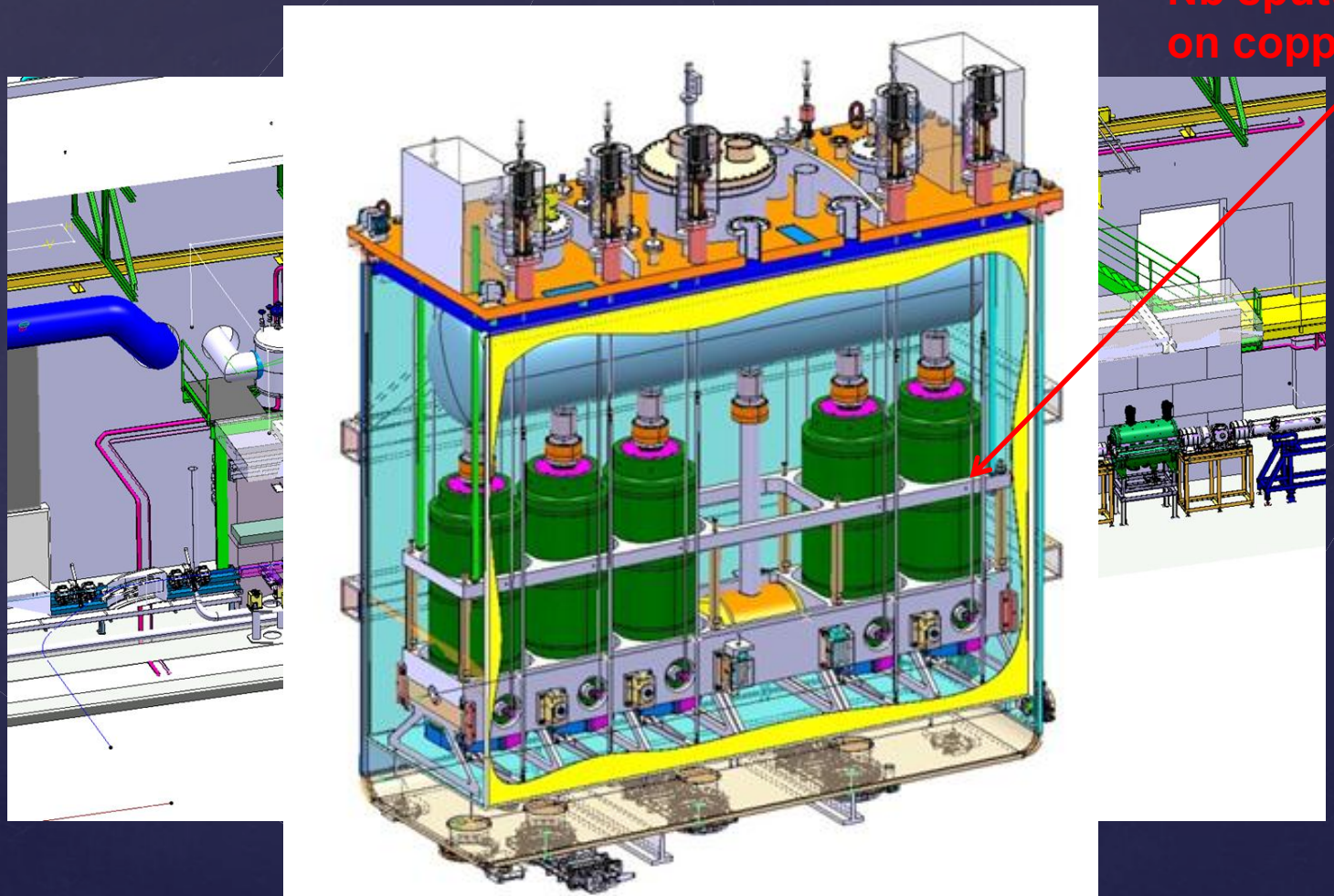


Cryo Module 2 installation: Shutdown 2015/16: Jan – March 2016
Scenario: 2nd commissioning at 5.5Mev/u with 2 CM‘s as of May 2016

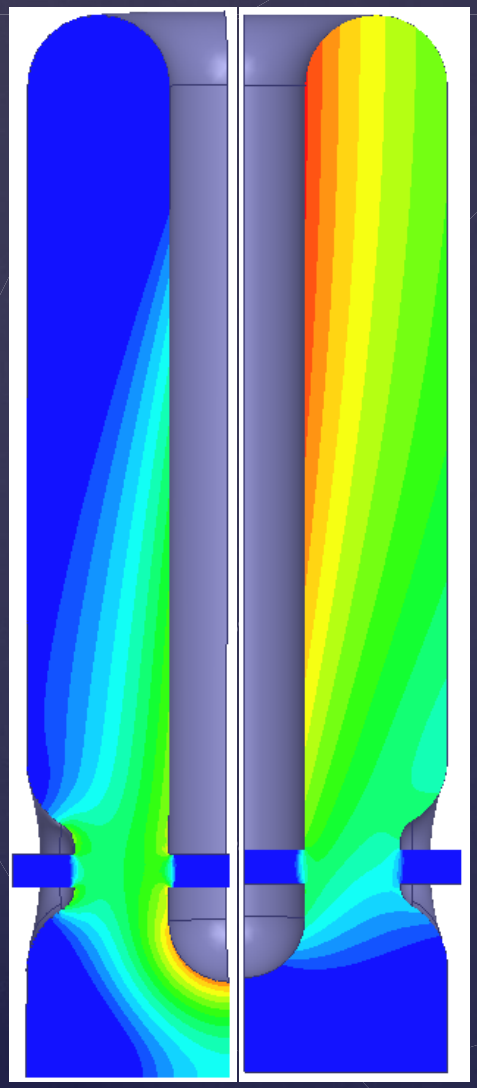
High beta cryomodules (phase II)



High beta cryomodules (phase II)



High beta QWR



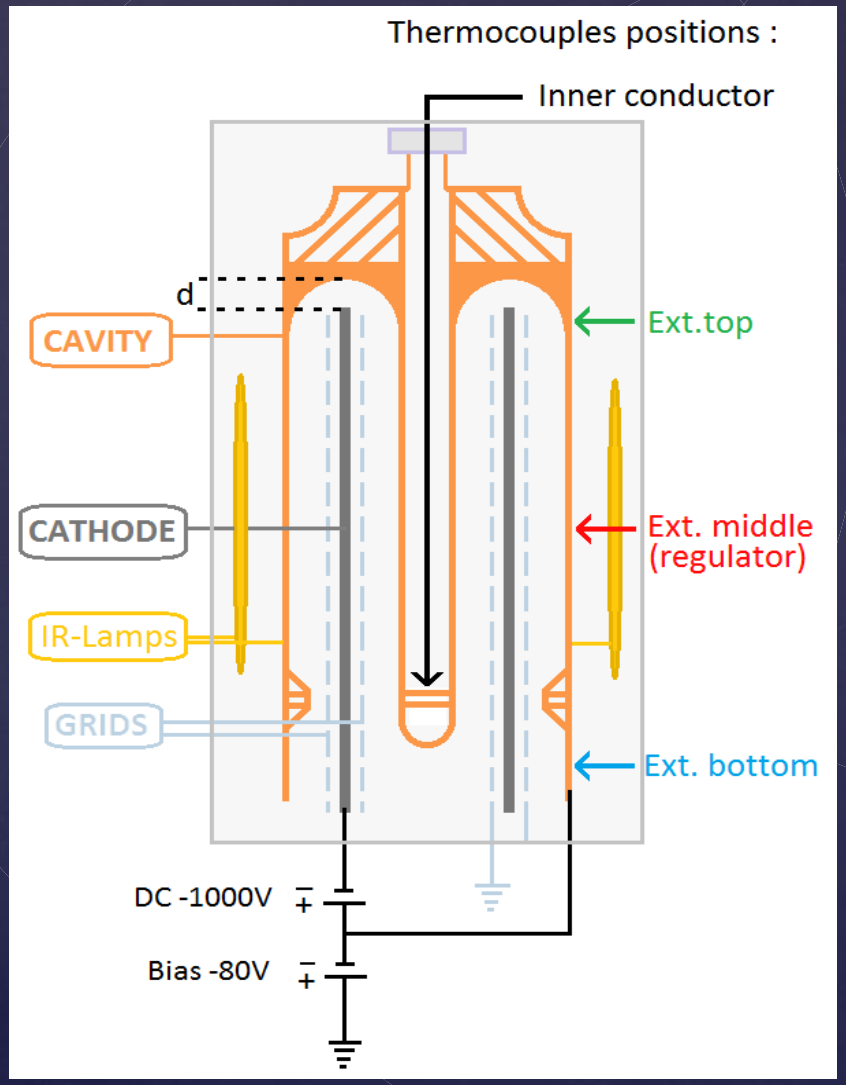
HIE ISOLDE	Baseline†	New*
f_0 at 4.5K [MHz]	101.28	101.28
β_{opt} [%]	10.86	10.88
TTF at β_{opt}	0.9	0.9
R/Q [Ω] (incl. TTF)	554	556
E_p/E_{acc}	**5.5**	**5.0**
H_p/E_{acc} [G/(MV/m)]	95.4	95.3
U/E^2_{acc} [mJ/(MV/m)^2]	208	207
$G=R_sQ$ [Ω]	30.7	30.8
P_{diss} @ 6 MV/m [W]	**10**	**10**
P_{diss} on bottom plate [W]	**0.0035**	**0.0018**

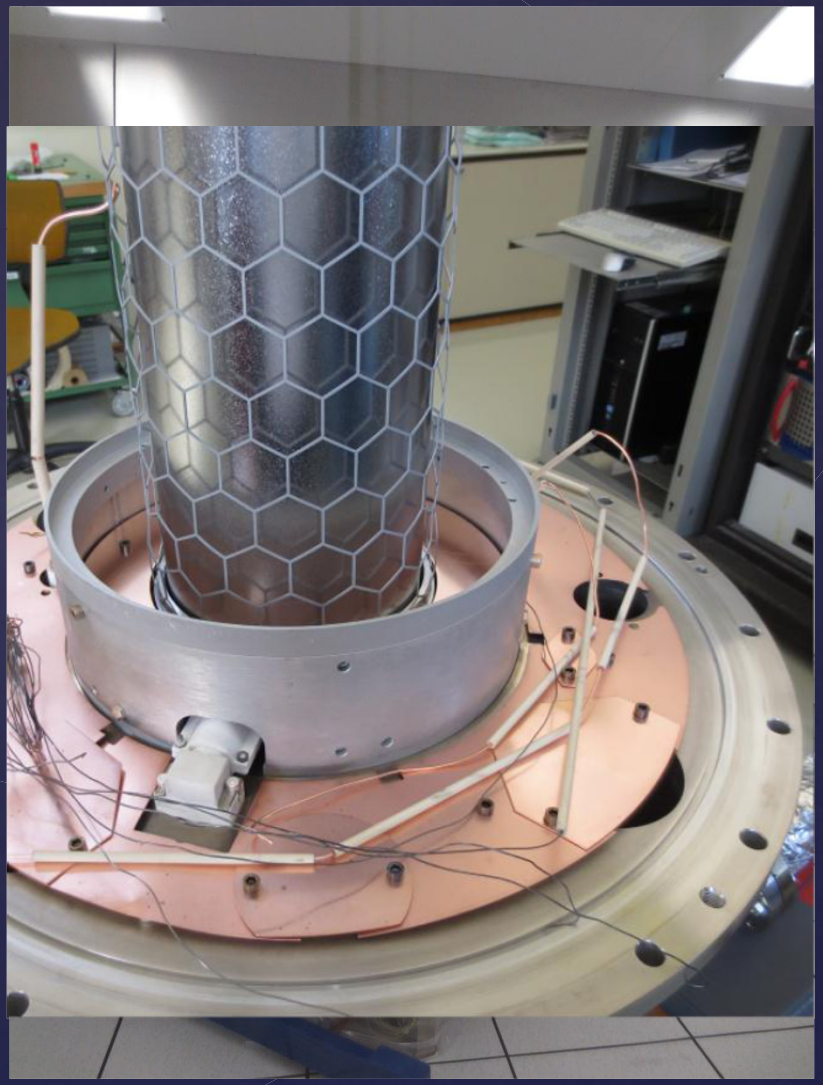
†Original tuning plate *Simplified tuning plate

Ref. Proceedings of SRF2009, p. 609

Bias diode sputtering system at CERN

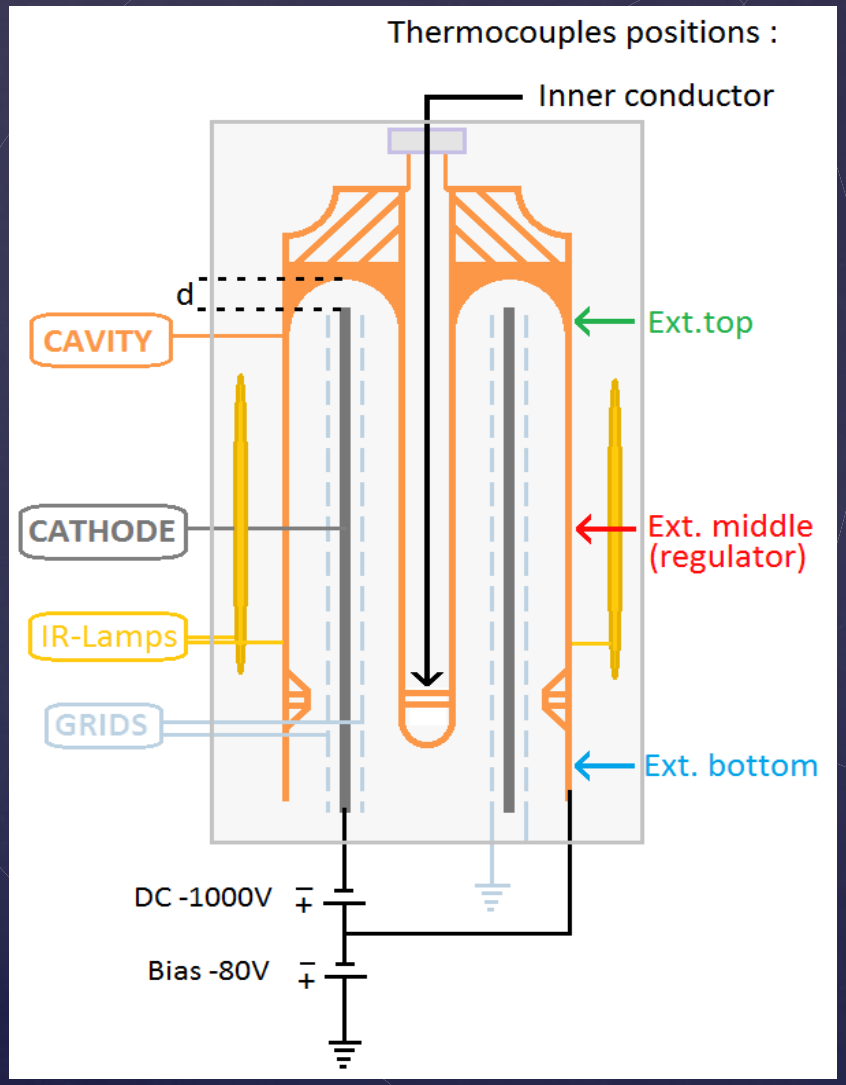
Schematics





Bias diode sputtering system at CERN

Schematics



System assembly in clean room

Surface quality of the inner conductor tip

Central electrode: 20 mm diameter, at earth potential

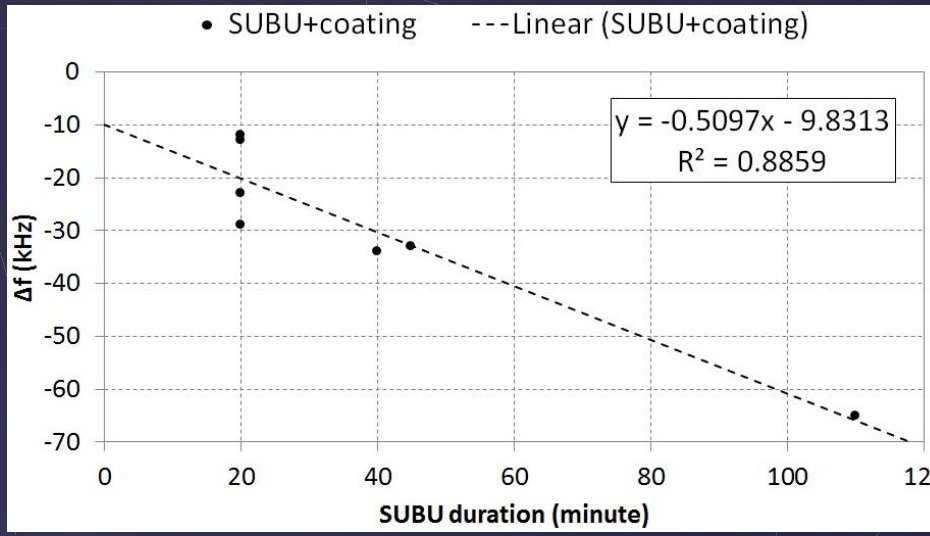
Surface quality of the inner conductor tip

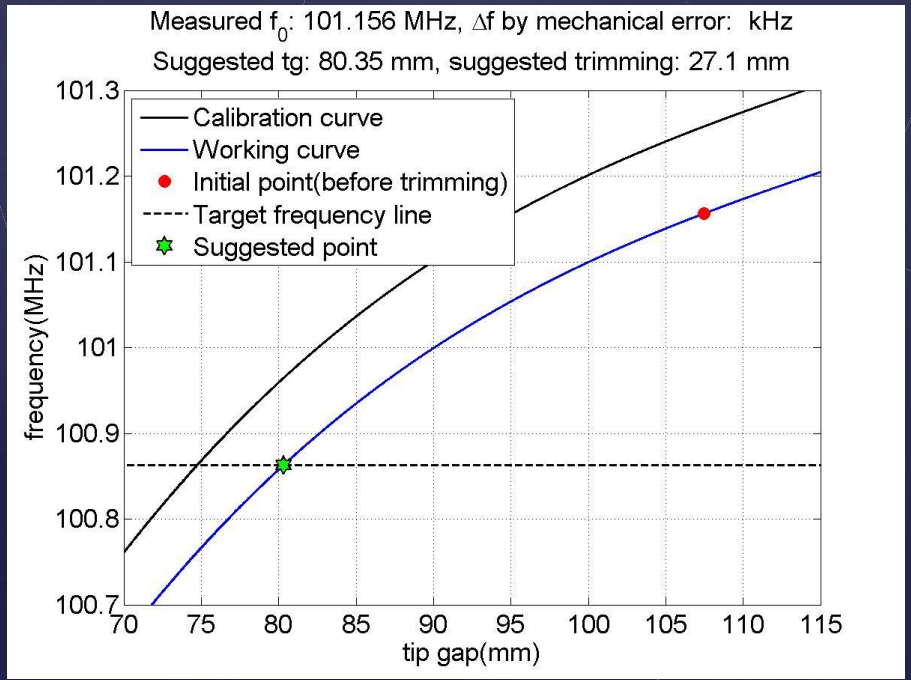
Central electrode: 20 mm diameter, at earth potential

No counter electrode

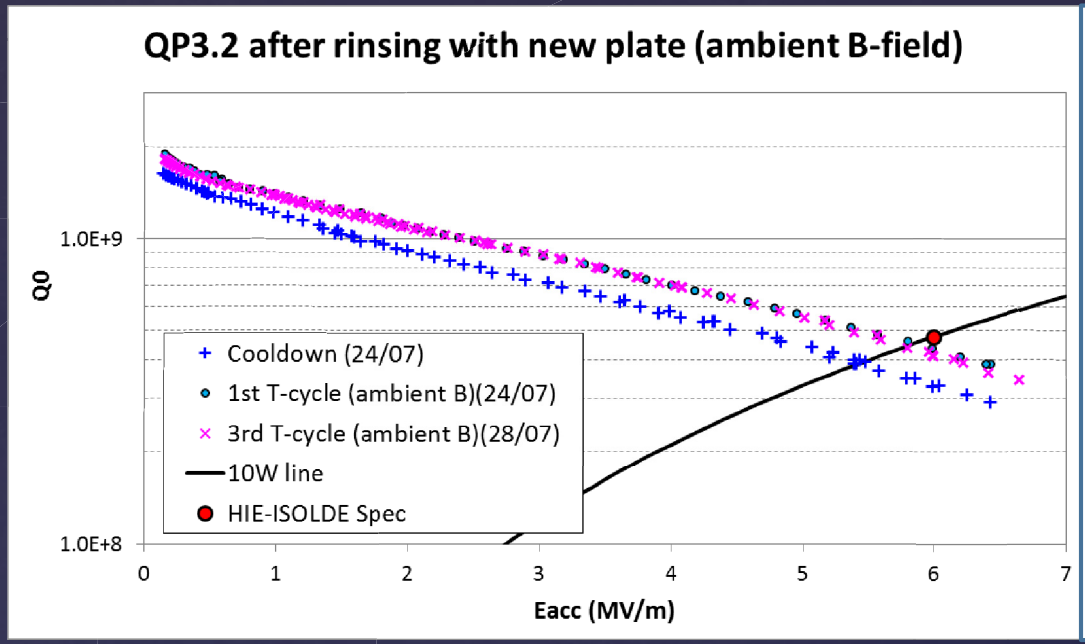
Cavity Tuning

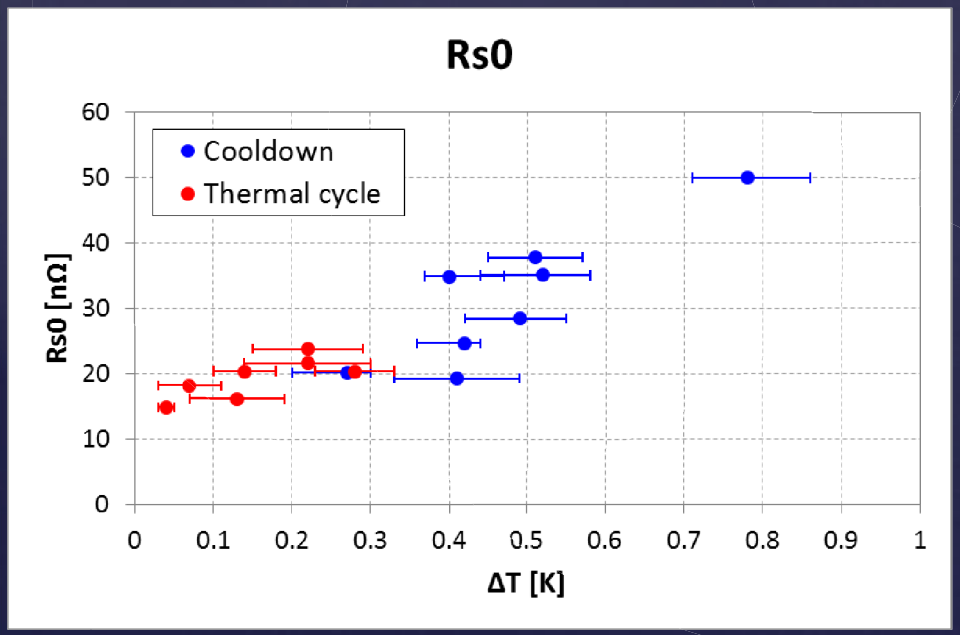
influence variables	frequency shift (kHz)
295 K to 4.5 K and air to vacuum	+371 +/- 5
chemical etching 40’	-27 +/- 3
Nb coating	-7 +/- 5

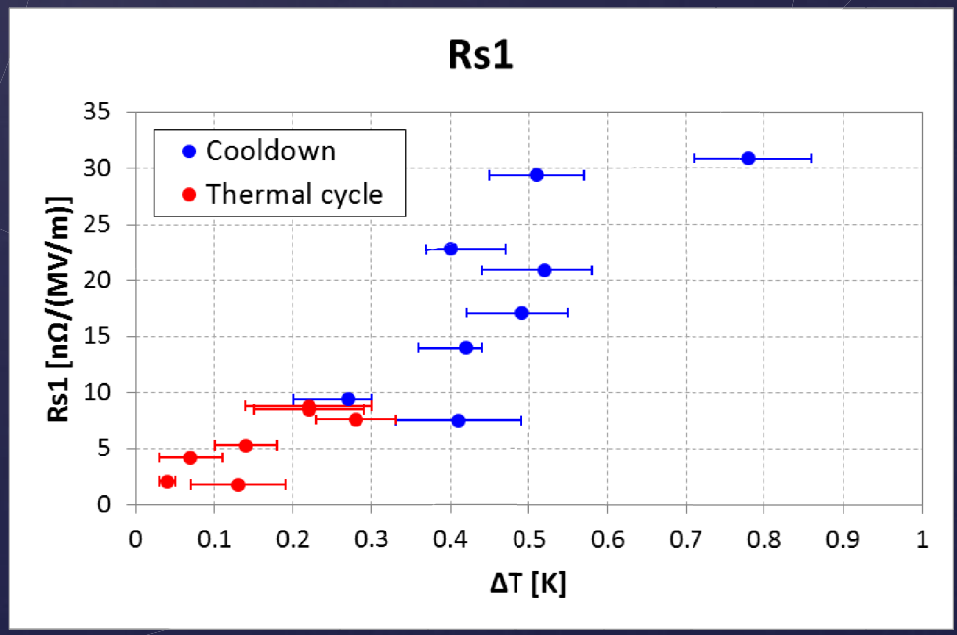




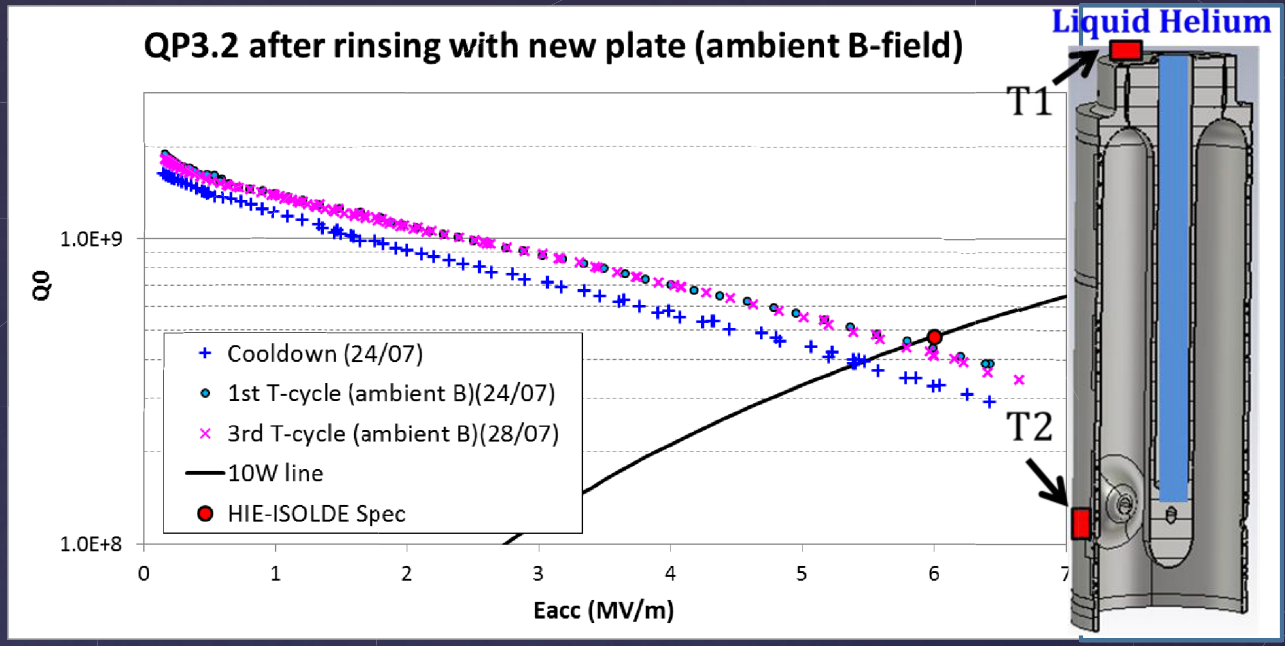
Surface resistance vs. thermal gradient across T_c



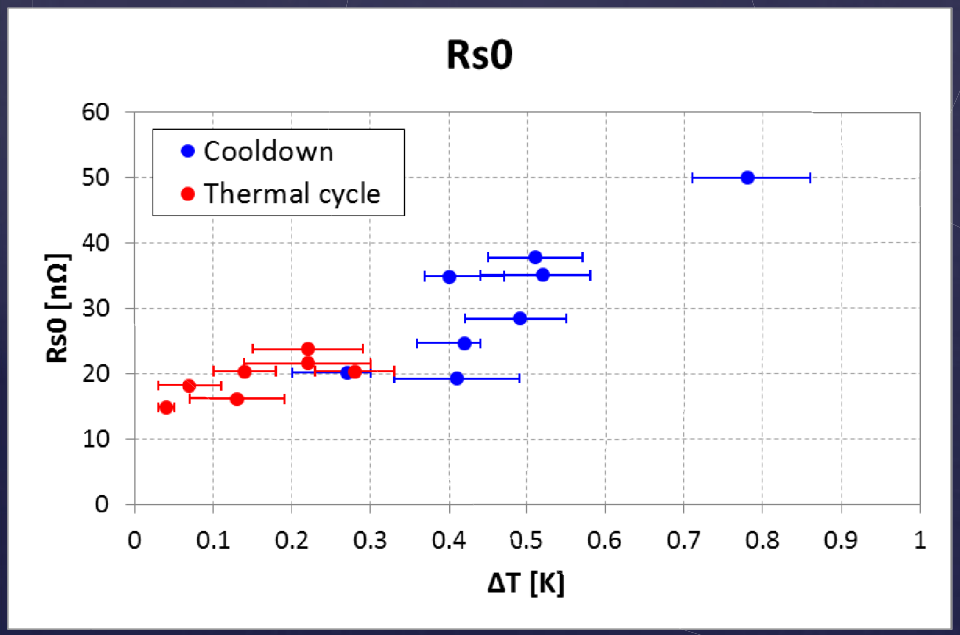


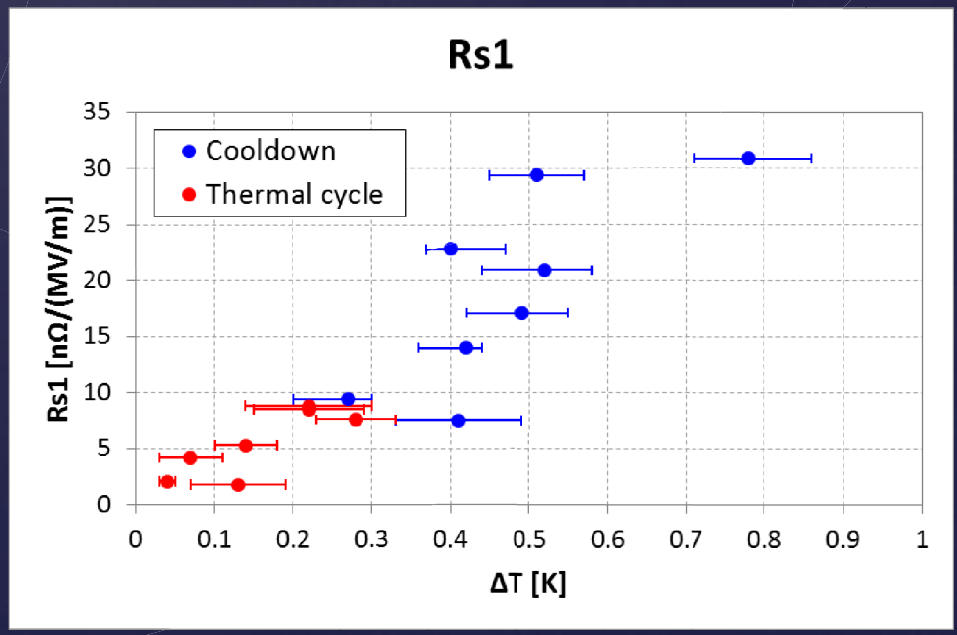


Surface resistance vs. thermal gradient across T_c

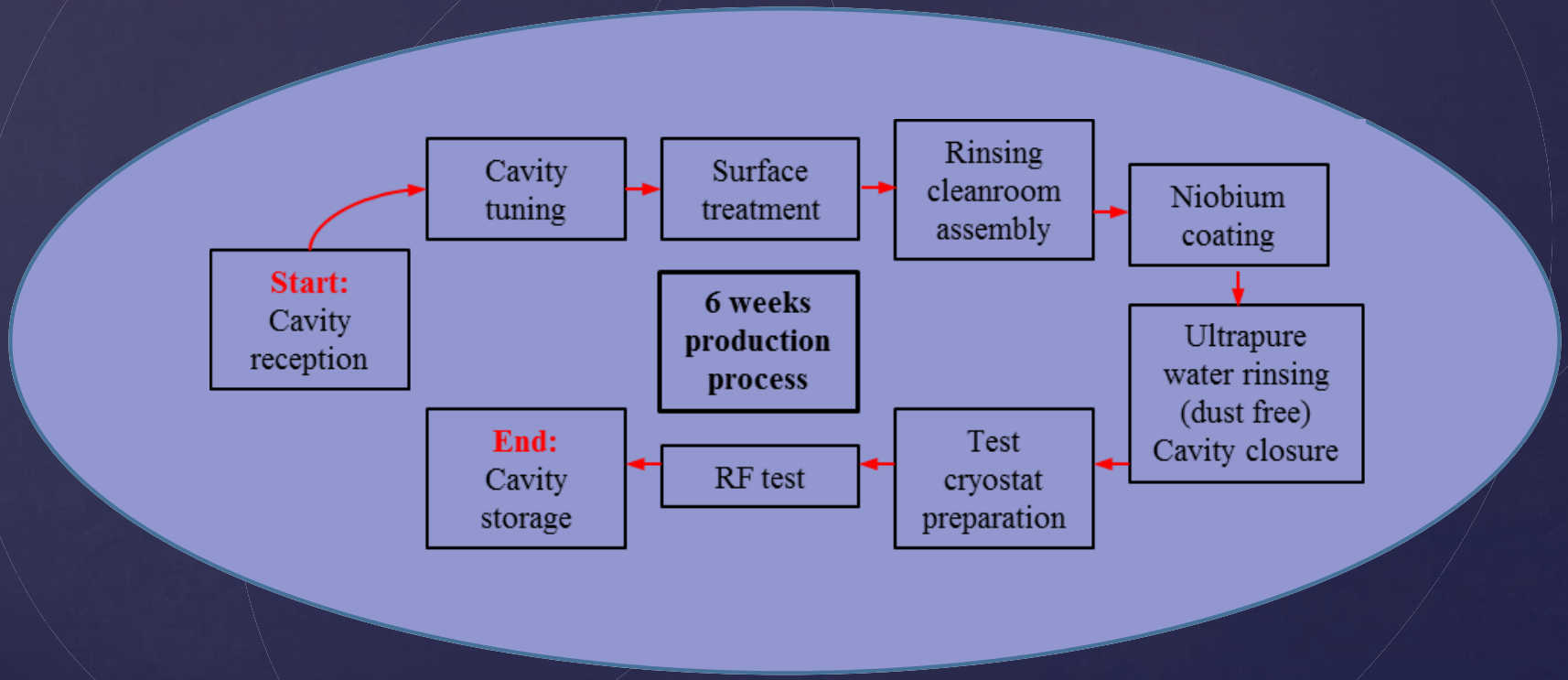


Thermal gradient: $\Delta T = T2 - T1$



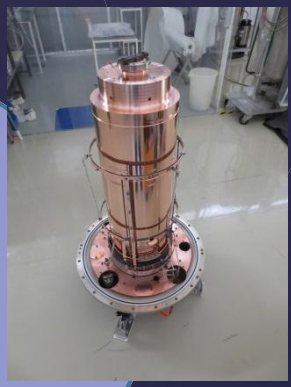


Cavity production workflow



Cavity production workflow

Poster THPP131



Start: Cavity reception

Cavity tuning

Surface treatment

Rinsing cleanroom assembly

Niobium coating

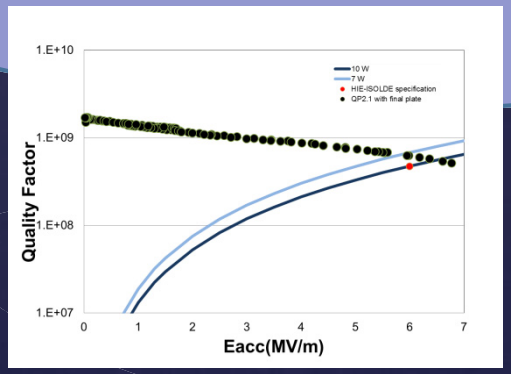
Ultrapure water rinsing (dust free) Cavity closure

Test cryostat preparation

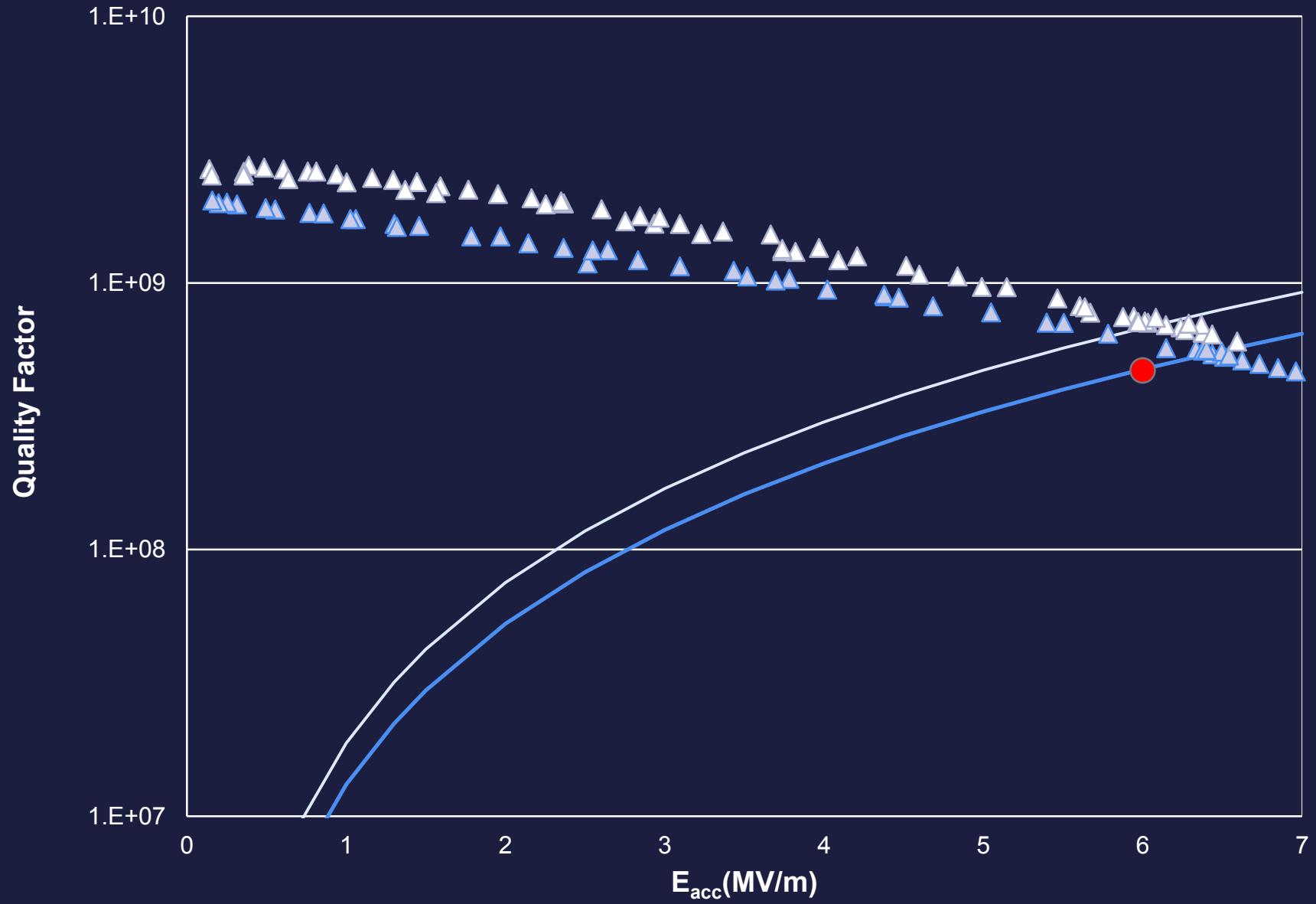
RF test

End: Cavity storage

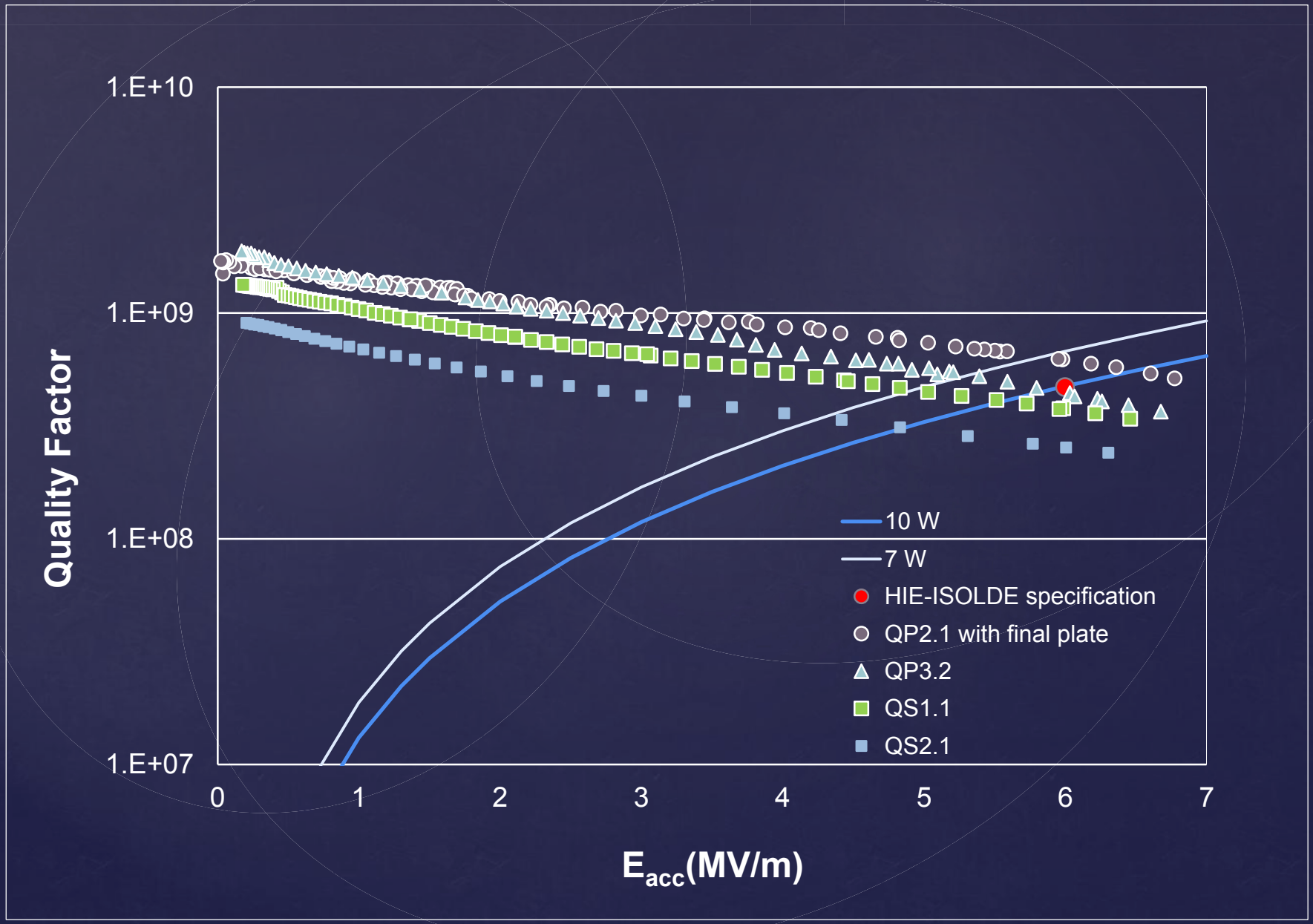
6 weeks production process



Prototype cavities performance



Performance of the first 4 series cavities



Series cavities stored

...

RF systems (Power and LLRF)

- Low microphonics; sensitivity to He pressure ~ 0.01 Hz/mbar, no beam loading → high Q_L in operation
- → Eased design for the input coupler
- → 700 W solid state RF amplifiers

- State of the art digital LLRF system
  - Direct RF sampling
  - Digital quadrature demodulation
  - Direct RF generation by DAC
  - VME form factor, 1 LLRF controller card per cavity

- LLRF system installed in 14 shielded racks

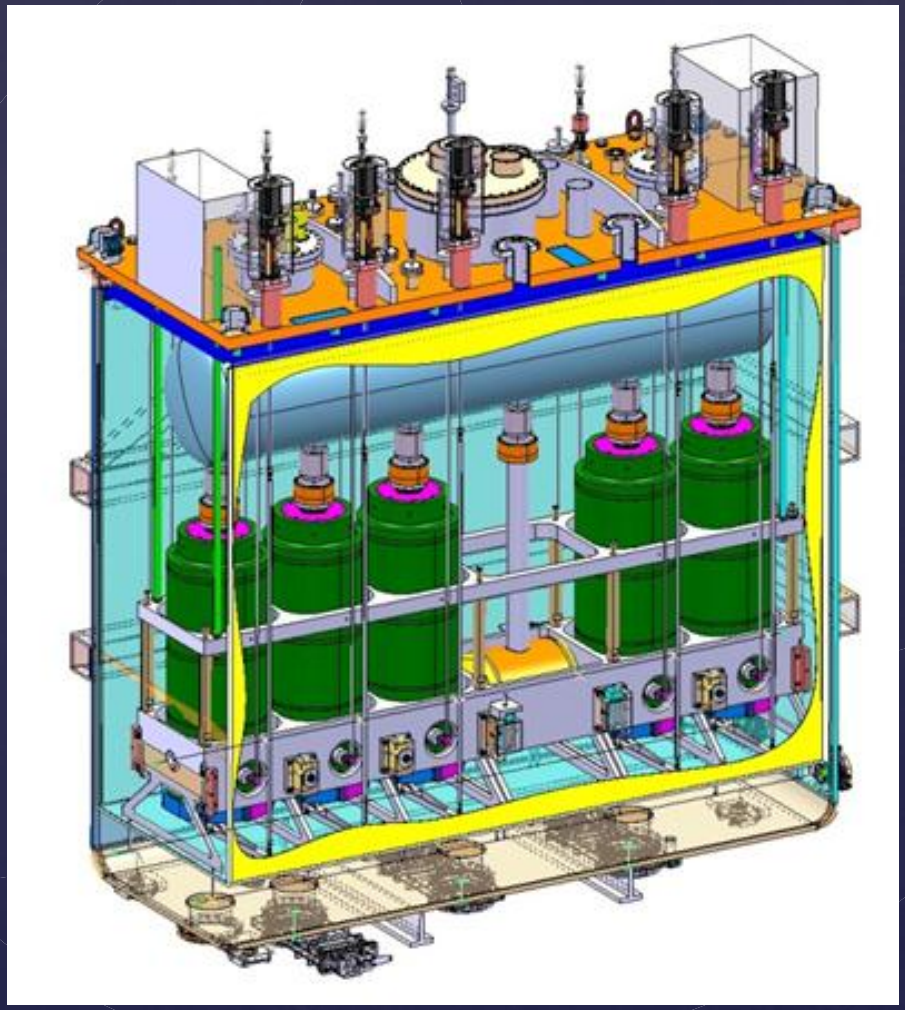
- Reference RF phase distributed over the length of linac to allow automatic cavity phasing for different species

Paper TUPP031

LLRF controller for one cavity

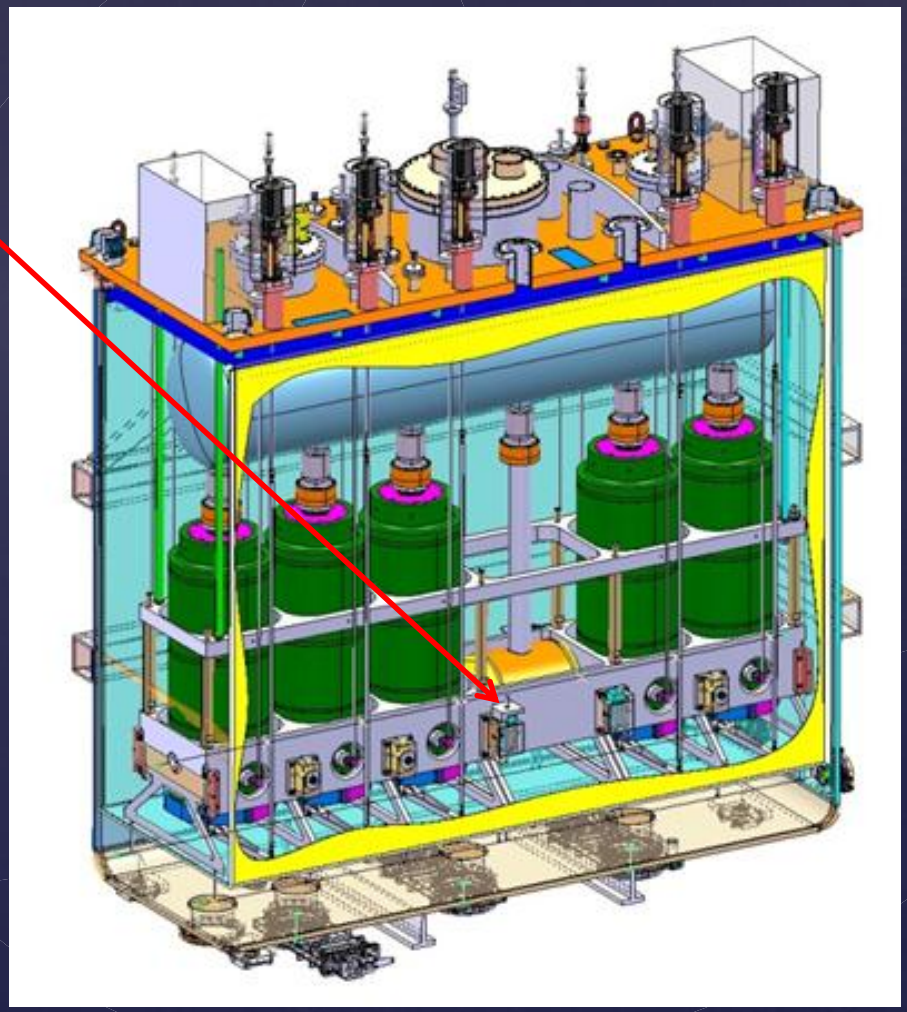
LLRF system for a complete cryomodule (6 cavities)

High beta cryomodules

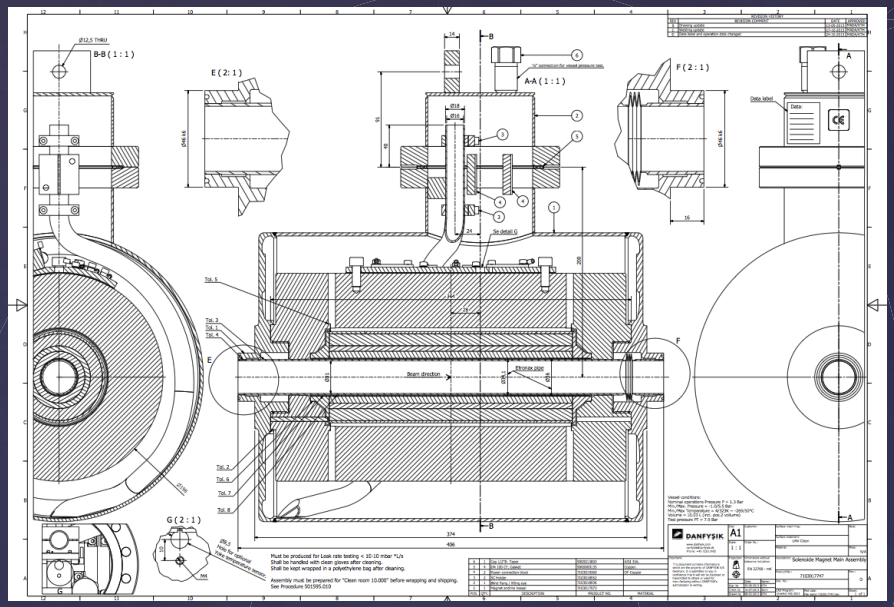


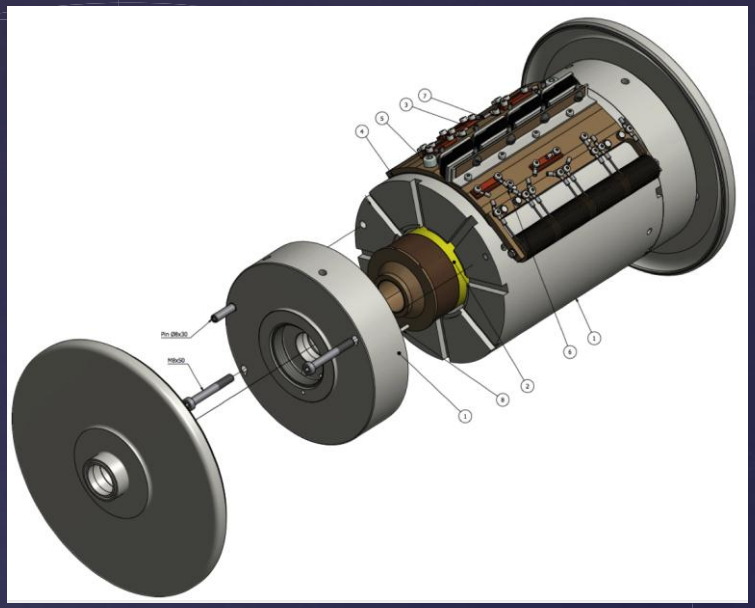
High beta cryomodules

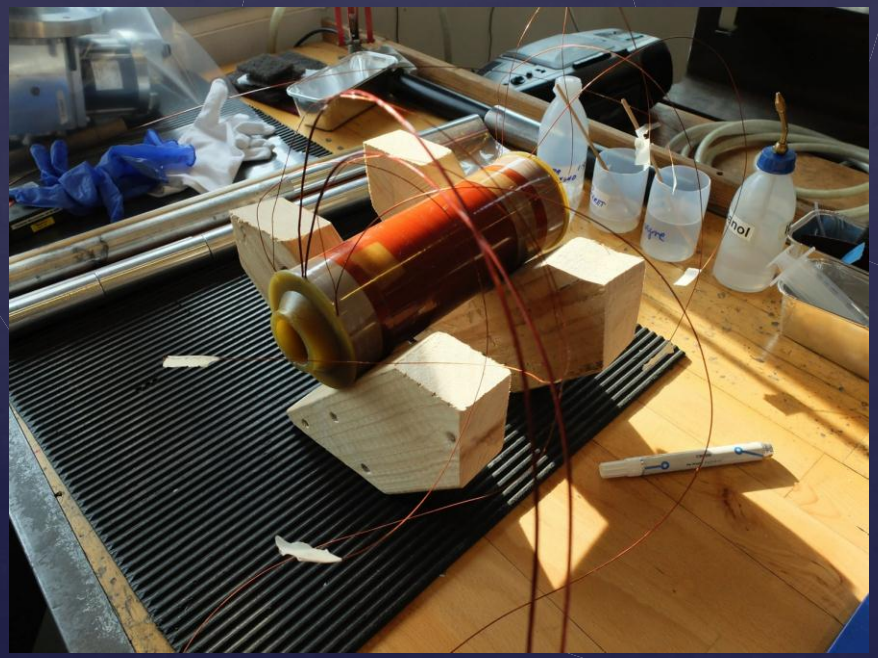
Nb-Ti
SC solenoid

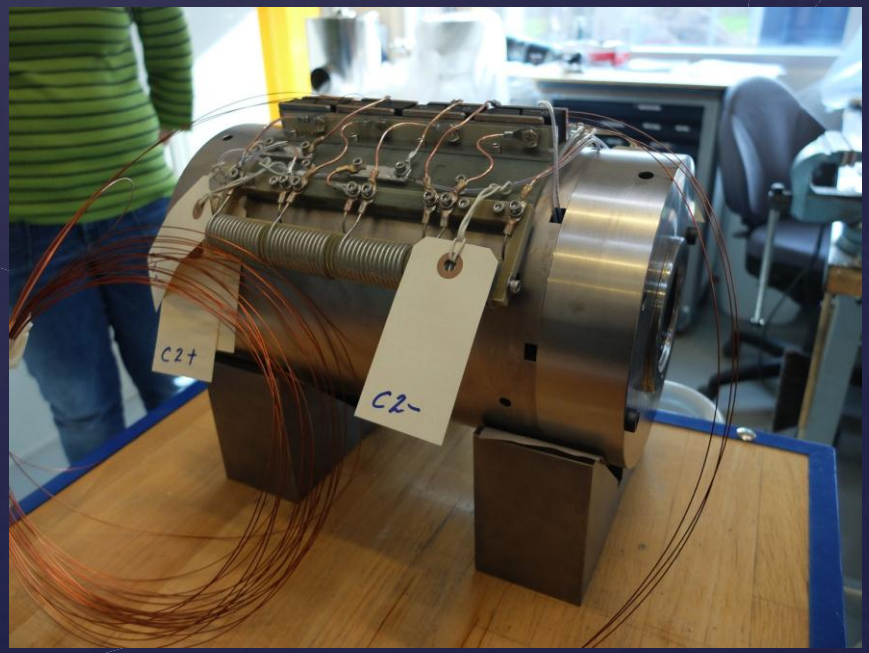


SC solenoid

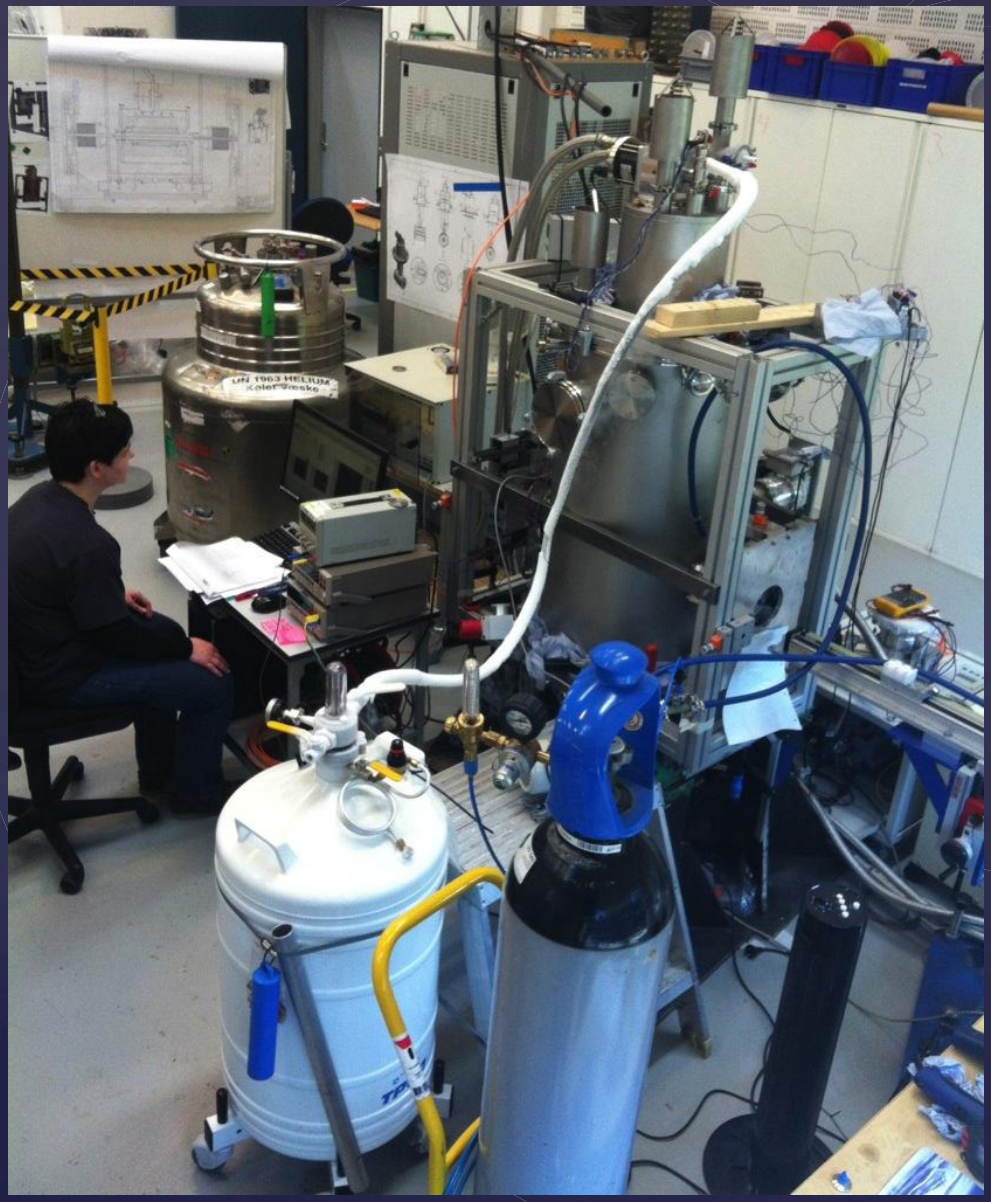

B-B (1 : 1)
E (2 : 1)
A-A (1 : 1)
F (2 : 1)
G (2 : 1)
Beam direction
Flange plate
DANFYSIK
A1

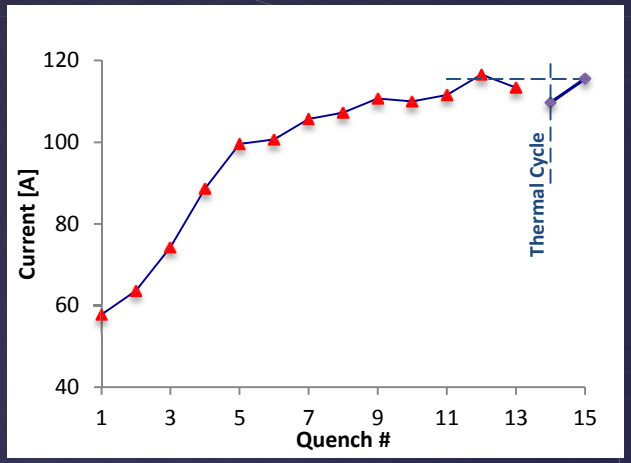

Pin Ø8x30
M8x50



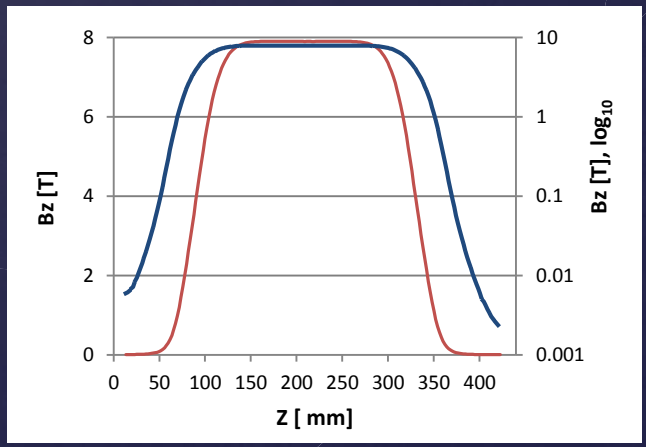

C2+
C2-

Qualification test results solenoid1



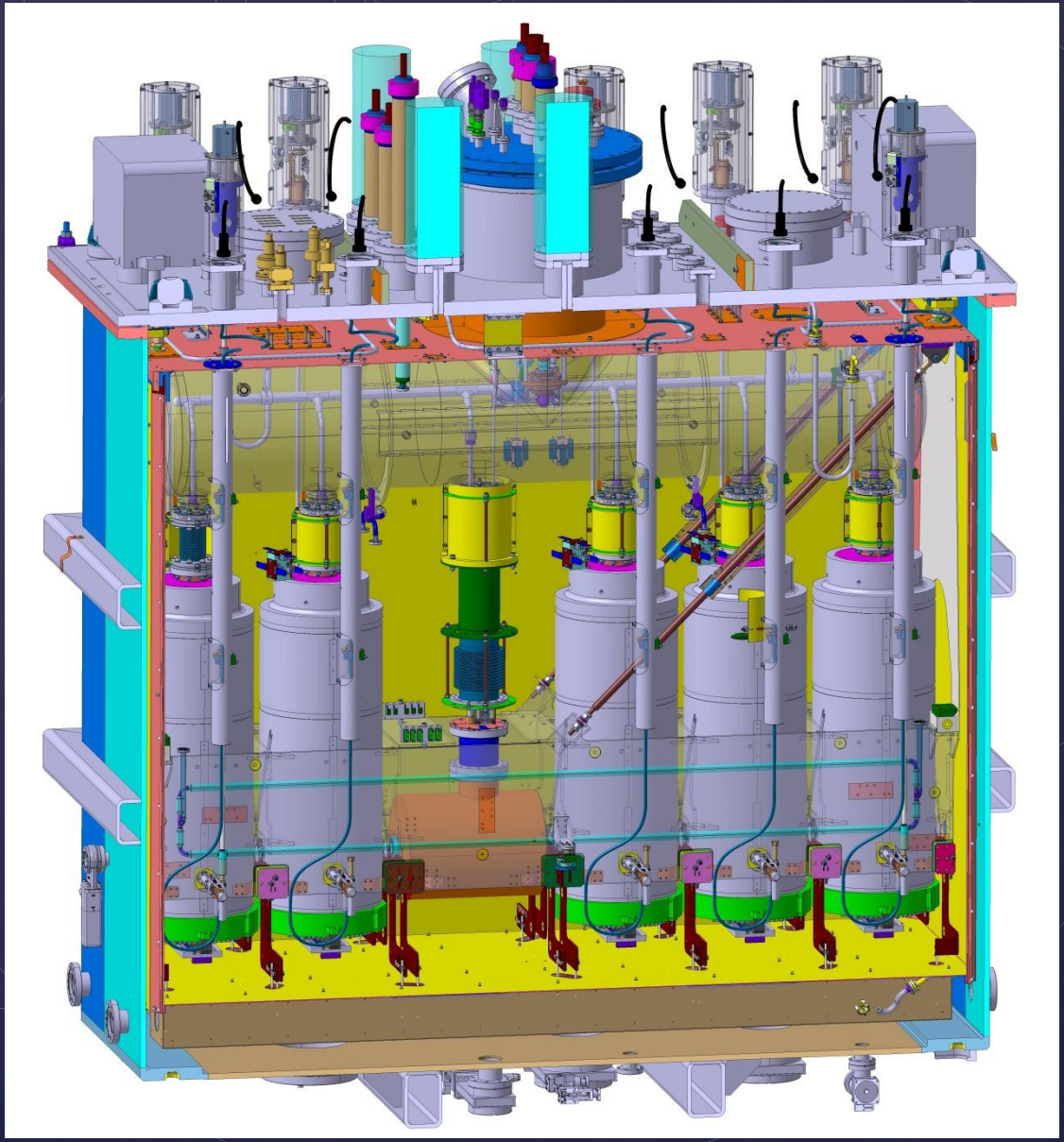


Training performance

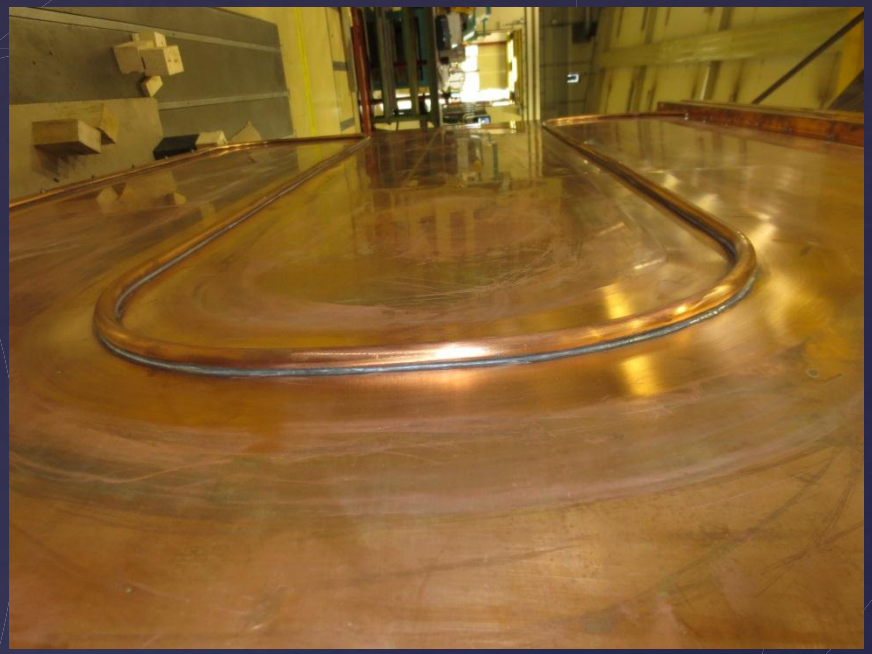


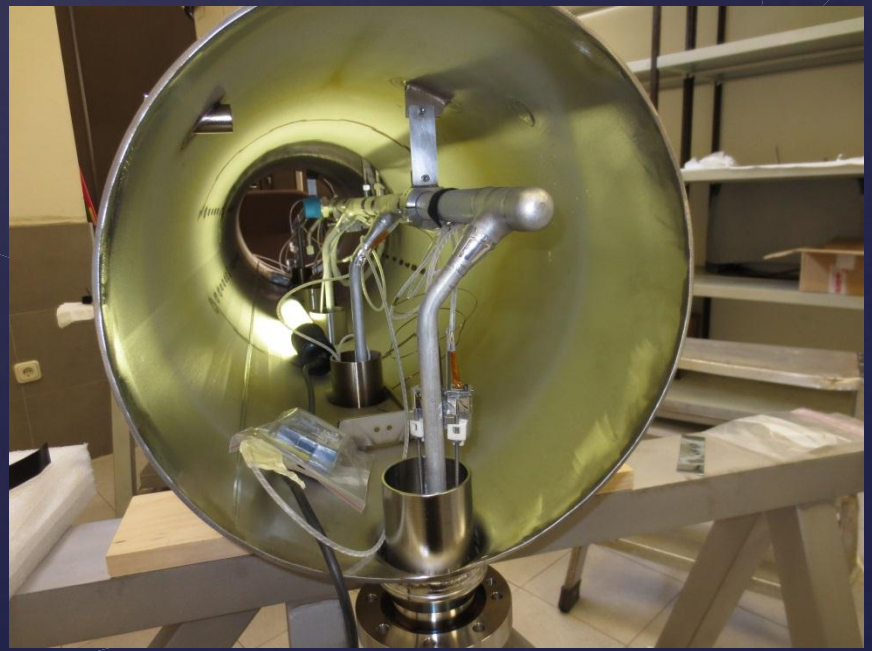
Magnetic field measurements

Cryo-module assembly



Cryo-module elements

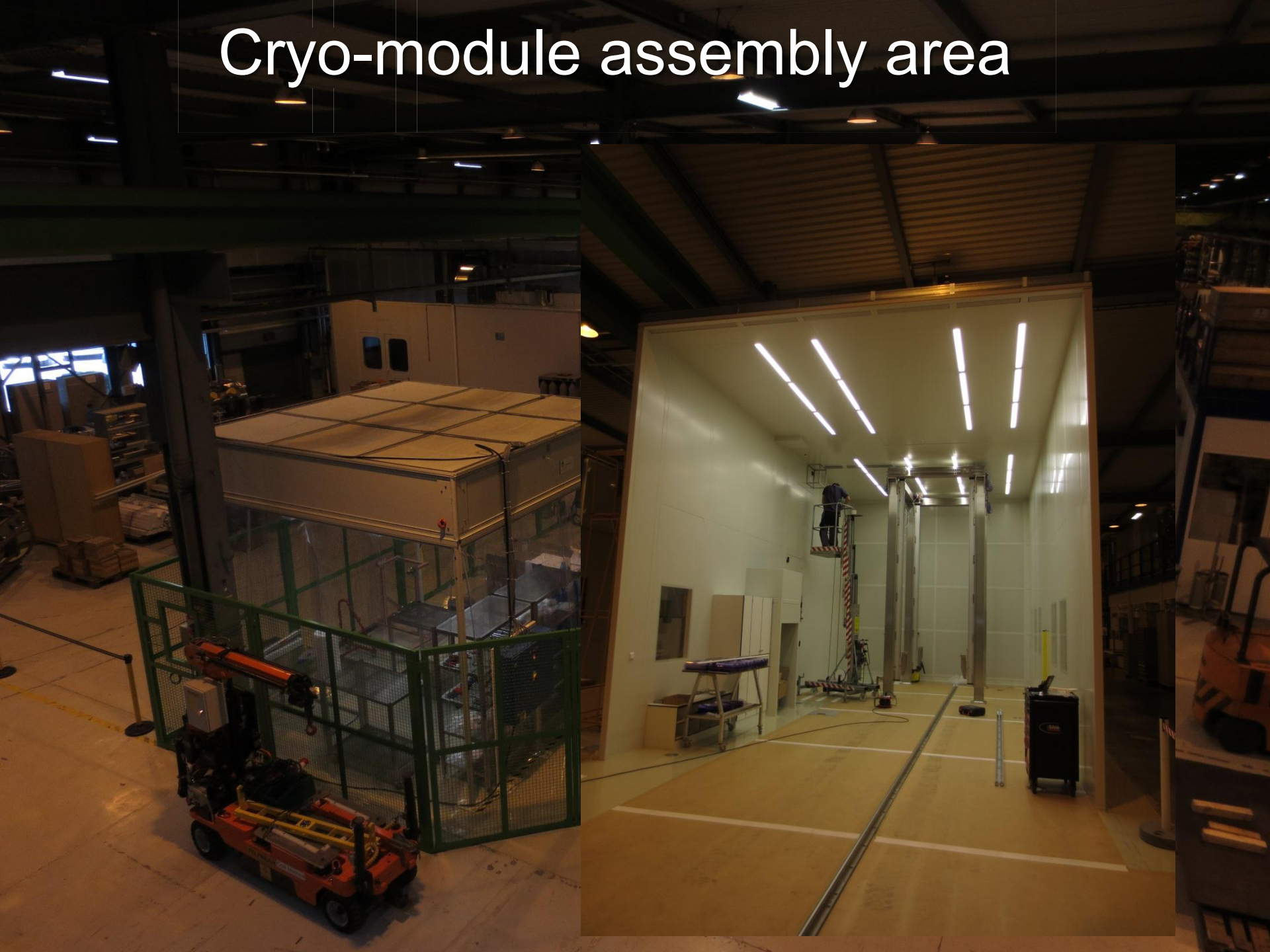




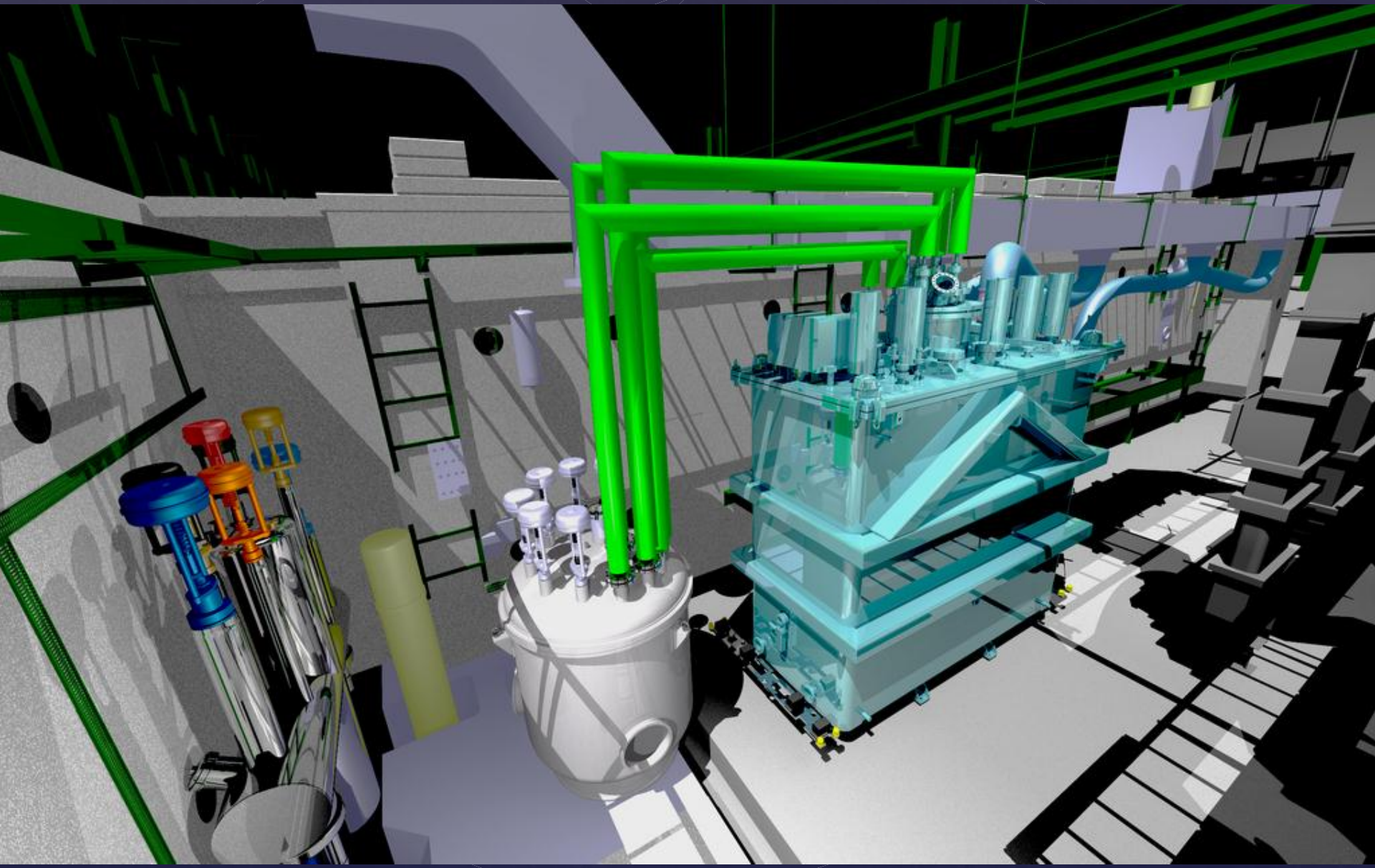
Cryo-module reception and logistics area

Cryo-module assembly area

Cryo-module assembly area



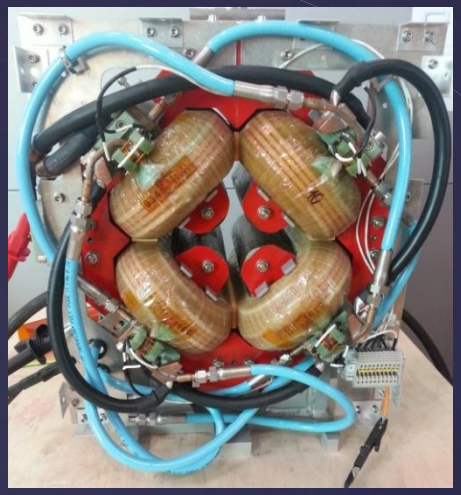
Integration of Cryo-module cold test stand



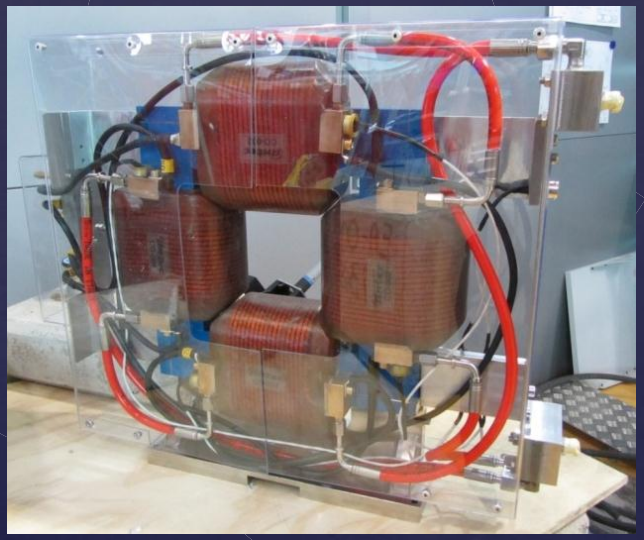
Beam Transport and beam instrumentation

NC magnets

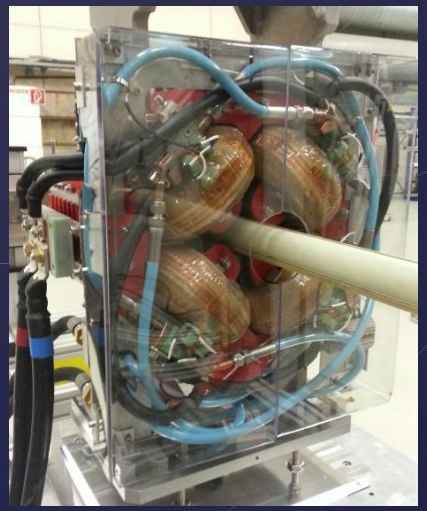
Pre-series dipole yoke stacking



Series Quad #2

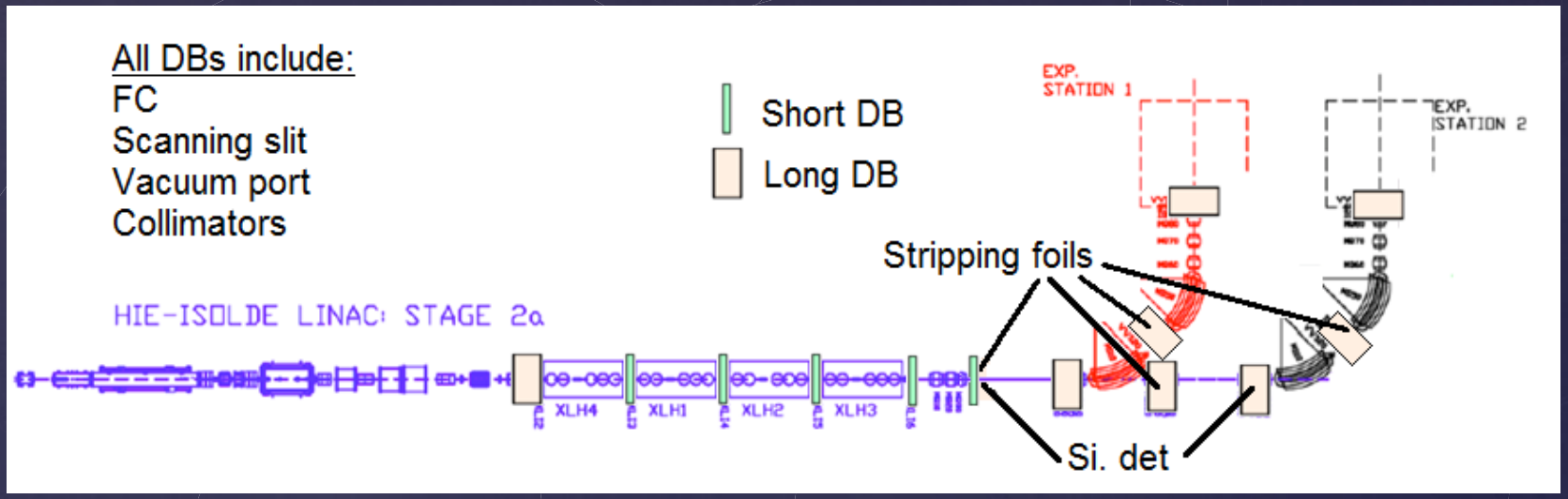


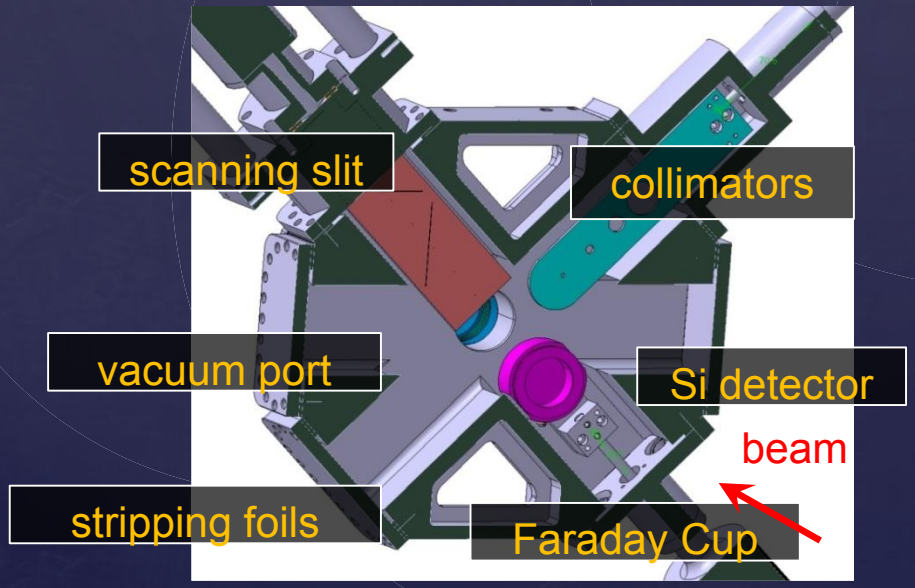
Pre-series steerer delivered June 2014

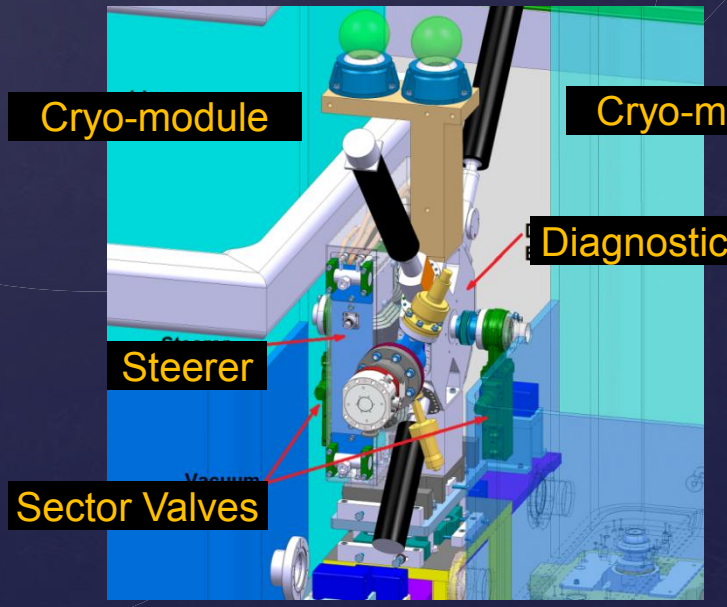


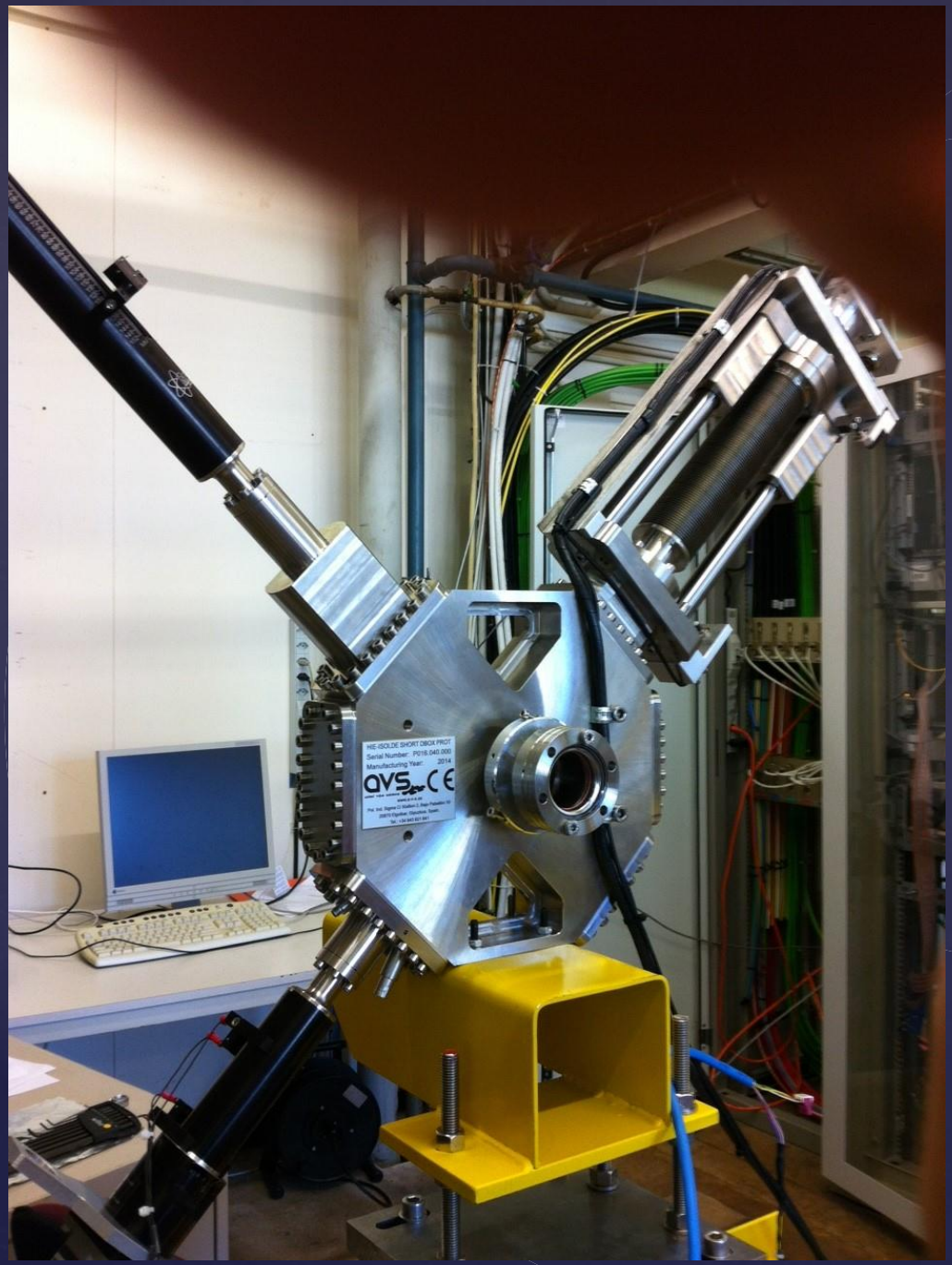
Series Quad #3

Beam Instrumentation (D-boxes)





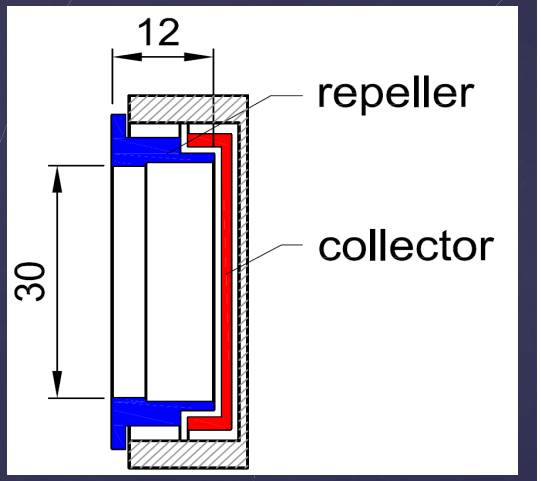


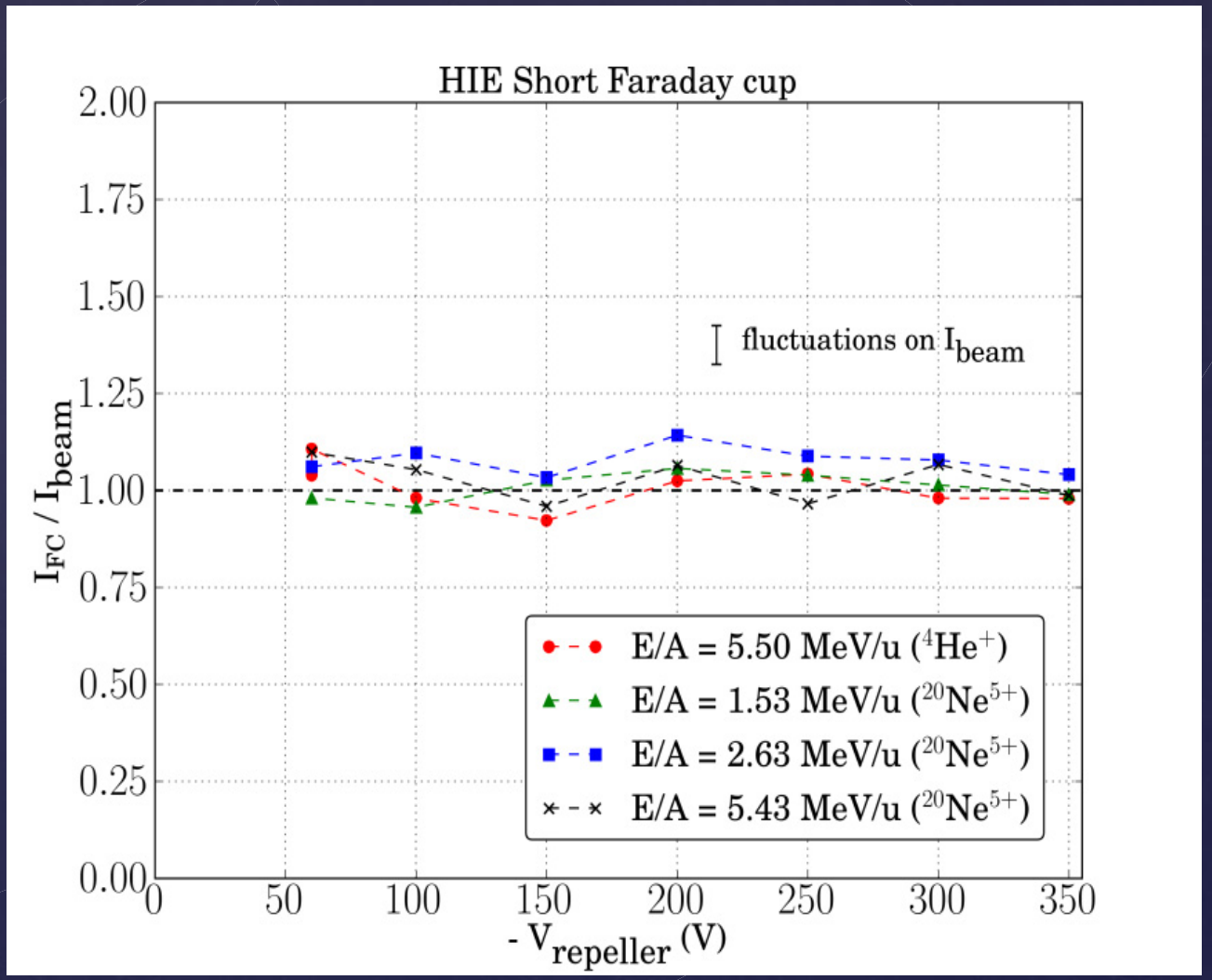


Diagnostic box prototype validated

Short Faraday cup qualification tests

HIE linac FC





MATHILDE (Monitoring and Alignment Tracking for Hie IsoLDE)

Requirements:
- 0.3mm (Cavities) and 0.15mm (Solenoids) at 1σ with respect to the nominal beam line

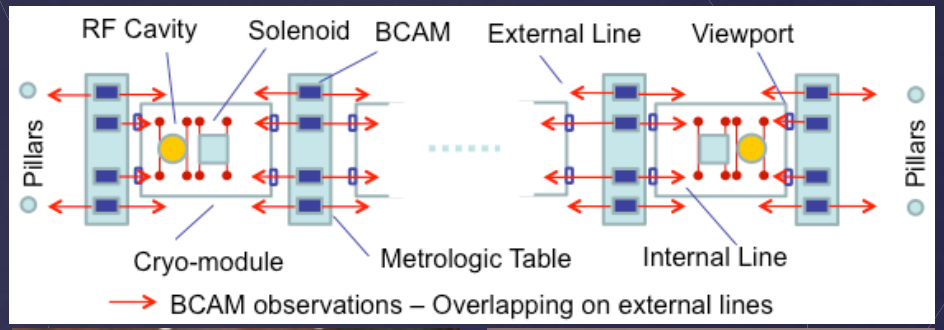
H-BCAM cameras and electronics
- Manufactured
- Calibrated
- Delivered at CERN

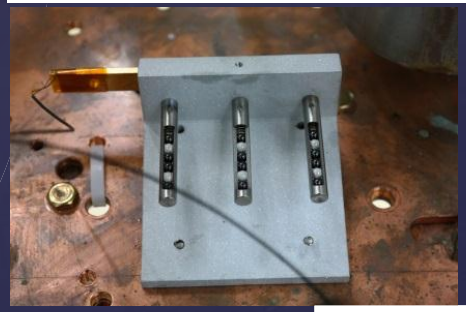
High-index glass ball targets:
- Tested precision : 10 micro-rad at 1σ
- Tested in vacuum and at 5 K
- Targets under price inquiry

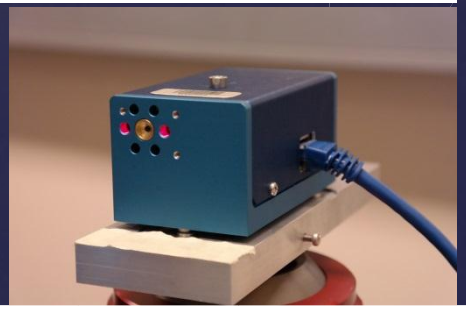
Viewports with 5 deg. tilt:
- Effects on measurement studied and verified
- Quantity for 2 CM delivered at CERN
  → Under Reception Tests

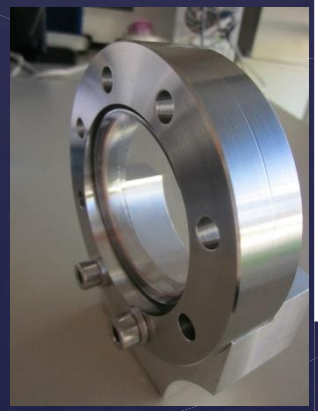
Metrologic plate toward final design

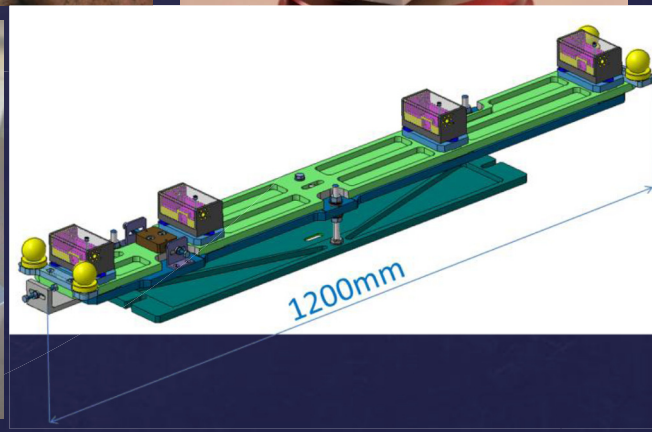
Software development on-going











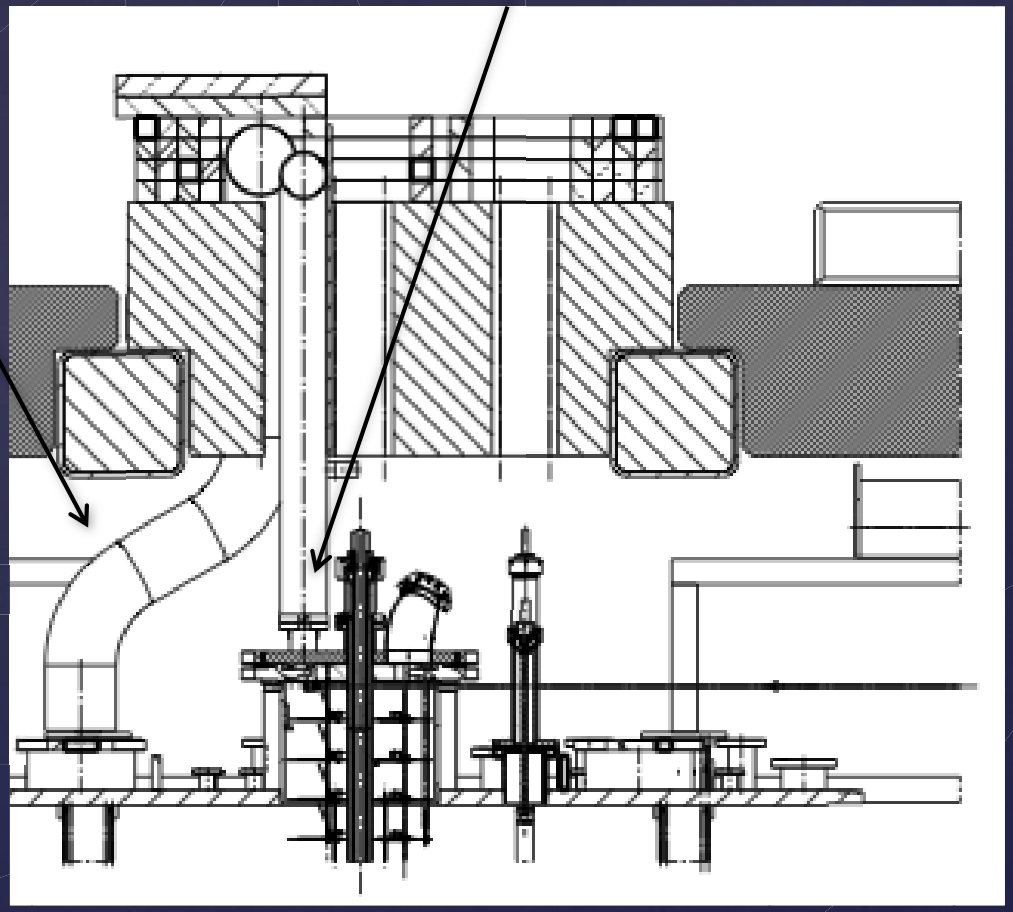
Safety

Cryogenic Hazard

Safety pressure device on insulation vacuum routed outside

Safety pressure device on LHe tank routed outside

Port for instrumentation re-assigned to rupture disk



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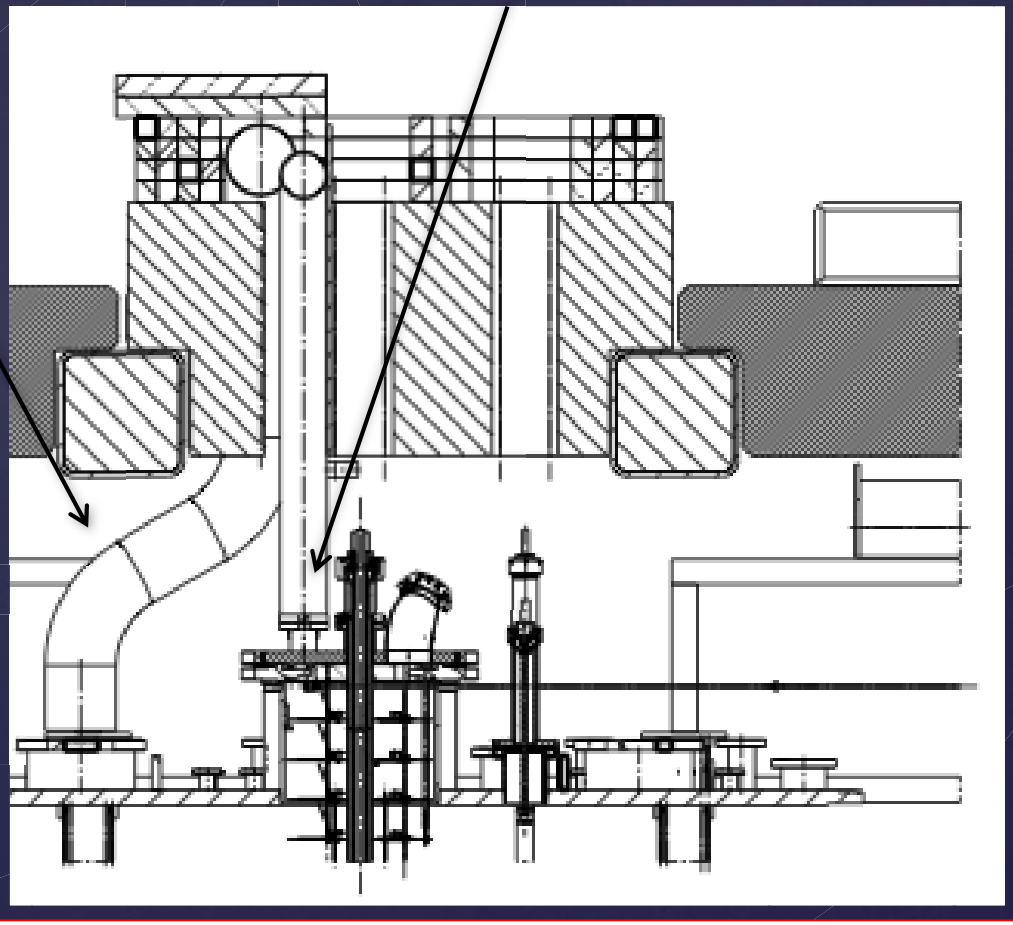
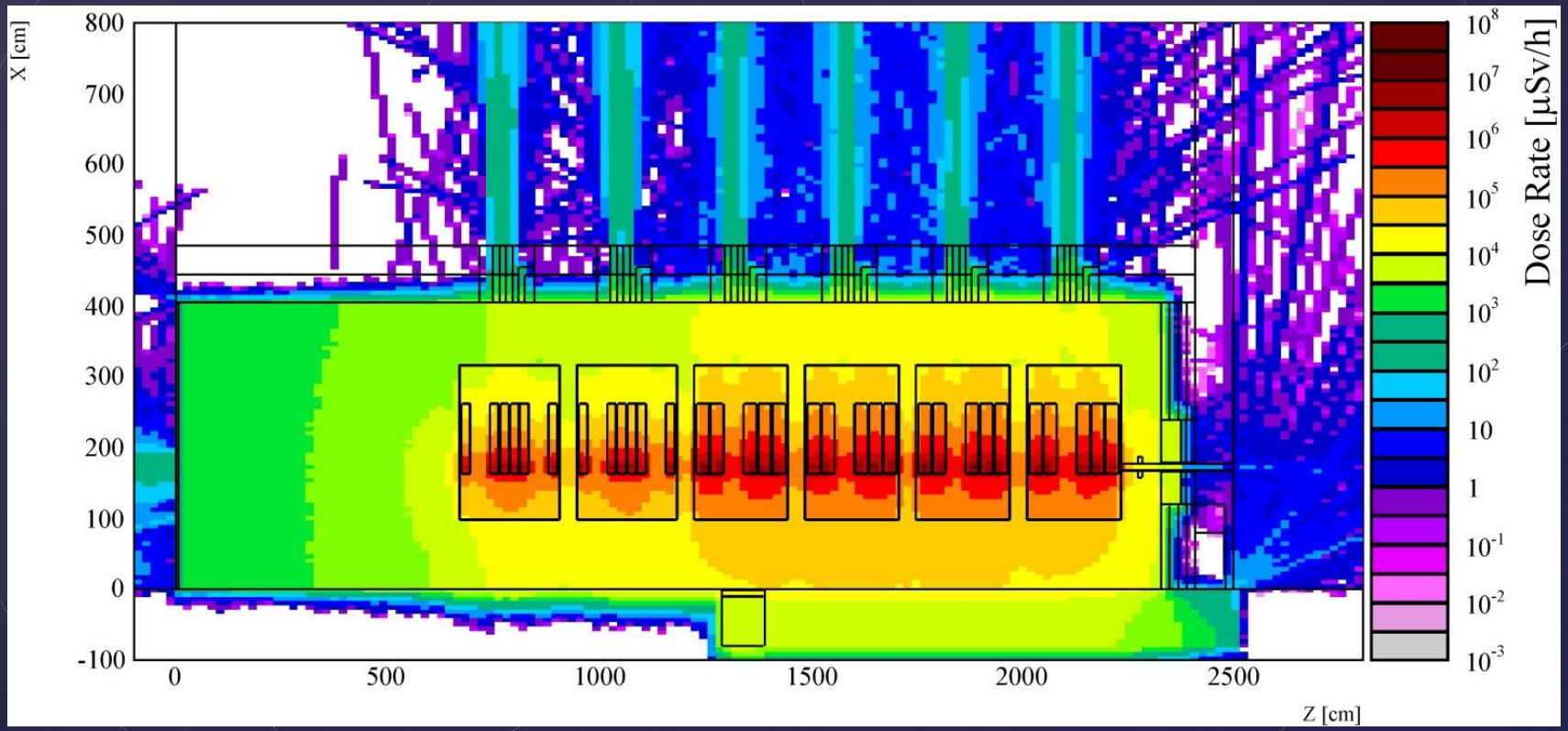


Access to the tunnel possible while cryo-modules are cold

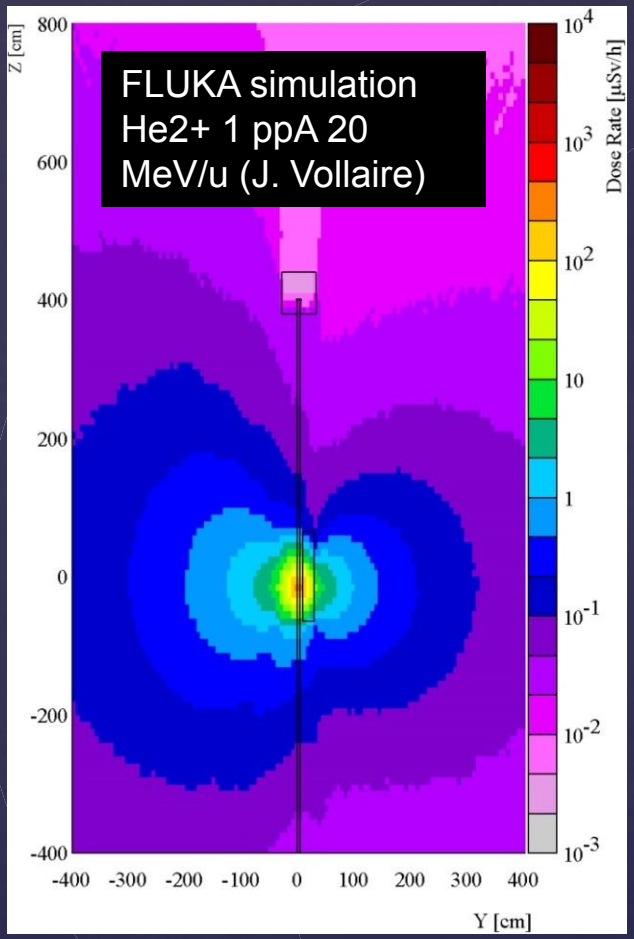
Radioprotection (I)

X-Ray doses: Locally hundreds of μSv/h on the roof during He processing

BASELINE : NO ACCESS TO THE ROOF



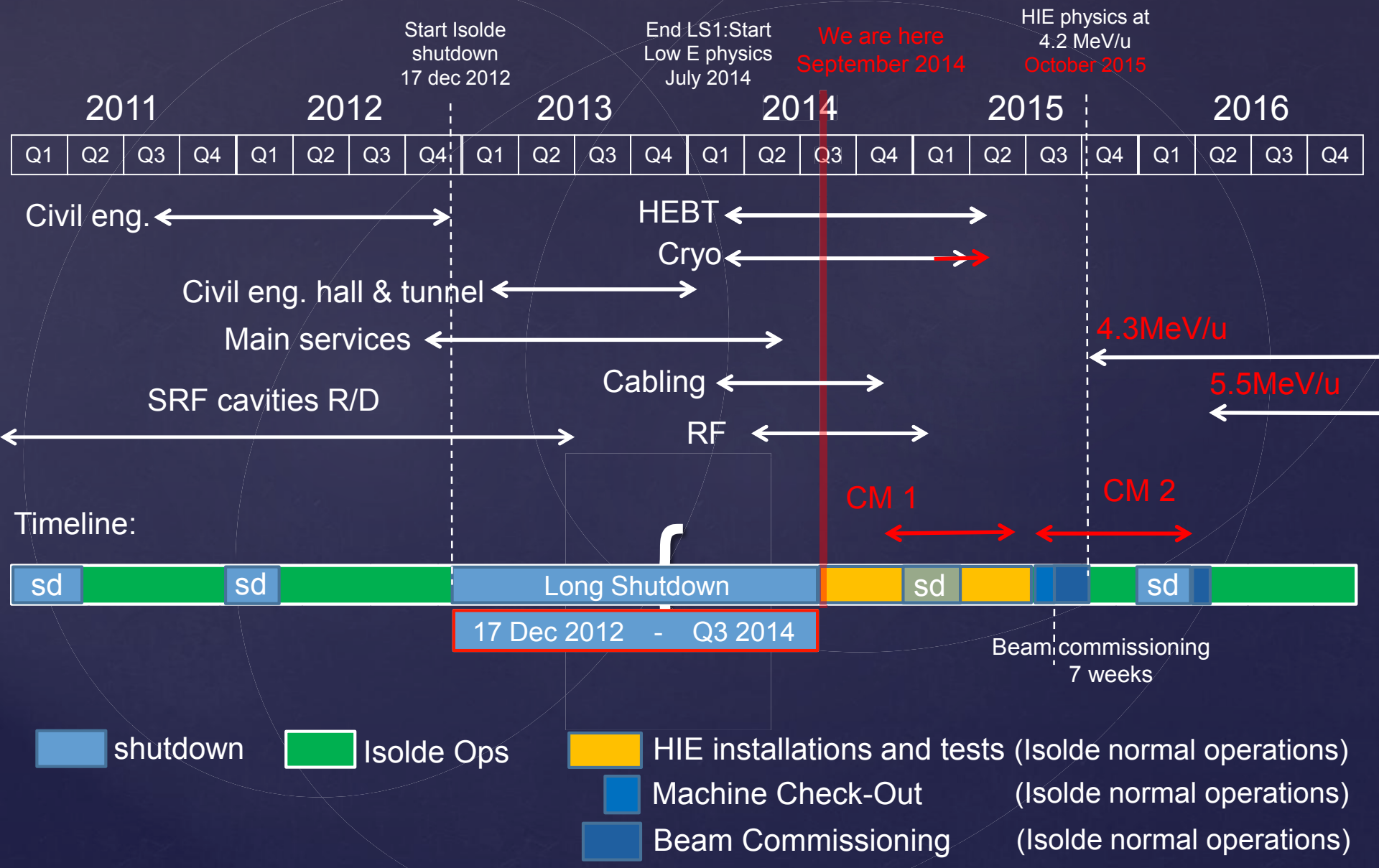
Radioprotection (III)



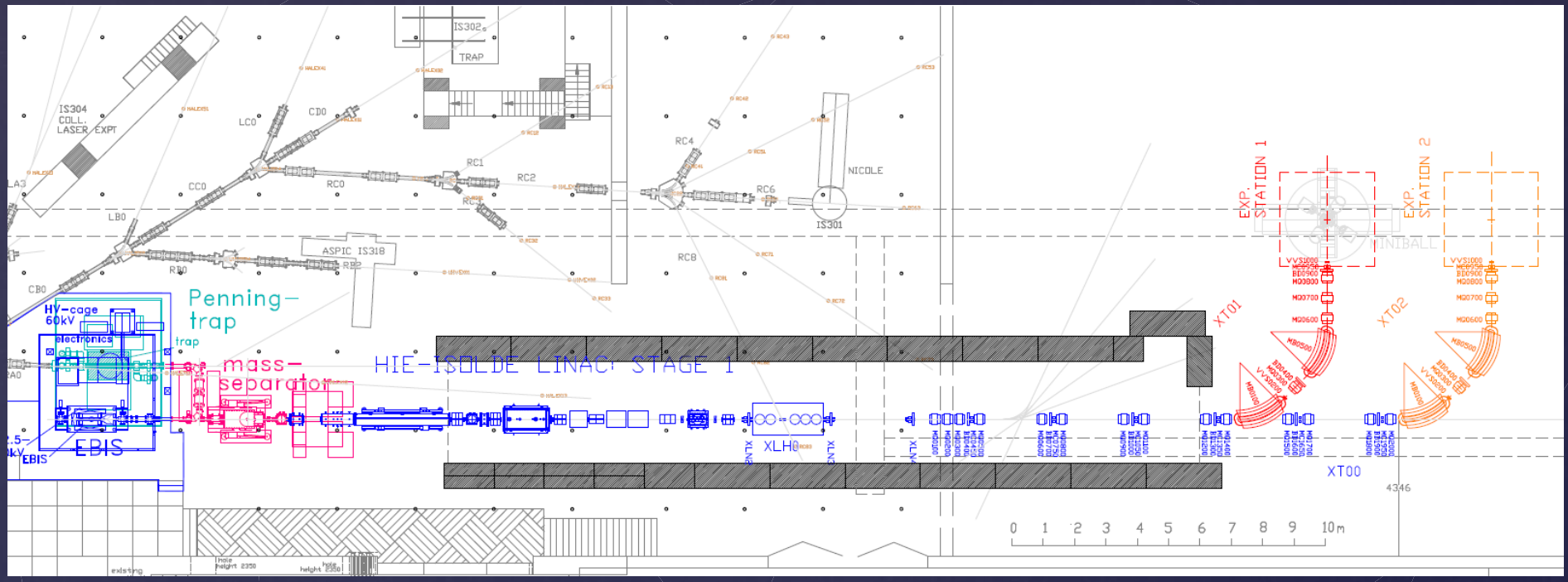
	A	Z	q	A/q	MeV/u Stage1	MeV/u Stage2	MeV/u Stage3	20.0 epA Sv/h at 1 m Stage1	20.0 epA Sv/h at 1 m Stage2	20.0 epA Sv/h at 1 m Stage3
He	4	2	1	4	6.47	10.20	11.45	3.8E-07	3.3E-06	5.0E-06
	4	2	2	2	10.19	16.90	20.05	1.6E-06	6.6E-06	9.0E-06
C	12	6	3	4	6.47	10.20	11.45	1.3E-07	1.1E-06	1.7E-06
	12	6	4	3	7.73	12.54	14.54	2.3E-07	1.6E-06	2.4E-06
	12	6	5	2.4	8.97	14.77	17.38	3.8E-07	2.0E-06	2.8E-06
	12	6	6	2	10.19	16.90	20.05	5.4E-07	2.2E-06	3.0E-06
N	14	7	4	3.5	7.01	11.22	12.81	1.4E-07	1.2E-06	1.7E-06
	14	7	5	2.8	8.09	13.19	15.37	2.3E-07	1.5E-06	2.2E-06
	14	7	6	2.333333333	9.15	15.08	17.77	3.5E-07	1.7E-06	2.4E-06
	14	7	7	2	10.19	16.90	20.05	4.7E-07	1.9E-06	2.6E-06
O	16	8	4	4	6.47	10.20	11.45	9.6E-08	8.2E-07	1.2E-06
	16	8	5	3.2	7.42	11.97	13.79	1.5E-07	1.1E-06	1.7E-06
	16	8	6	2.666666667	8.36	13.67	15.98	2.3E-07	1.4E-06	2.0E-06
	16	8	7	2.285714286	9.28	15.31	18.07	3.2E-07	1.5E-06	2.1E-06
	16	8	8	2	10.19	16.90	20.05	4.1E-07	1.6E-06	2.2E-06
Ne	20	10	5	4	6.47	10.20	11.45	7.7E-08	6.6E-07	9.9E-07
	20	10	6	3.333333333	7.23	11.62	13.33	1.1E-07	8.7E-07	1.3E-06
	20	10	7	2.857142857	7.98	13.00	15.12	1.5E-07	1.0E-06	1.5E-06
	20	10	8	2.5	8.73	14.33	16.83	2.1E-07	1.2E-06	1.6E-06
	20	10	9	2.222222222	9.46	15.64	18.47	2.7E-07	1.2E-06	1.7E-06
	20	10	10	2	10.19	16.90	20.05	3.3E-07	1.3E-06	1.8E-06
	22	10	5	4.4	6.12	9.54	10.55	5.9E-08	5.0E-07	7.5E-07
	22	10	6	3.666666667	6.81	10.85	12.32	8.2E-08	6.9E-07	1.0E-06
	22	10	7	3.142857143	5.07	7.50	13.99	1.9E-08	1.1E-07	1.2E-06
	22	10	8	2.75	8.19	13.37	15.59	1.5E-07	9.7E-07	1.4E-06
	22	10	9	2.444444444	8.86	14.57	17.13	2.0E-07	1.1E-06	1.5E-06
	22	10	10	2.2	9.53	15.75	18.62	2.5E-07	1.1E-06	1.6E-06
Ar	40	18	9	4.444444444	6.08	9.47	10.46	3.2E-08	2.7E-07	4.0E-07
	40	18	10	4	6.47	10.20	11.45	3.8E-08	3.3E-07	5.0E-07
	40	18	11	3.636363636	6.85	10.92	12.40	4.6E-08	3.8E-07	5.8E-07
	40	18	12	3.333333333	7.23	11.62	13.33	5.5E-08	4.3E-07	6.4E-07
	40	18	13	3.076923077	7.60	12.31	14.24	6.5E-08	4.8E-07	7.0E-07
	40	18	14	2.857142857	7.23	11.62	13.33	4.7E-08	3.7E-07	5.5E-07
	40	18	15	2.666666667	8.36	13.67	15.98	9.1E-08	5.5E-07	7.8E-07
	40	18	16	2.5	8.73	14.33	16.83	1.0E-07	5.8E-07	8.2E-07
	40	18	17	2.352941176	9.10	14.99	17.66	1.2E-07	6.0E-07	8.4E-07
	40	18	18	2.222222222	9.46	15.64	18.47	1.3E-07	6.2E-07	8.6E-07

L. Moritz, "ISAC II Safety Report", TRIUMF, 2006

HIE simplified planning



To be Commissioned in 2015



REX Low energy part (charge breeder)

NC linac

SC linac (1 cryomodule/5 cavities)

HEBT : 2 beamlines

- Re-commissioning of REX nc linac
- 1 cryomodule / cavities (including cryo plant and infrastructure)
- 2 experimental beam lines

KH

Status summary

HIE-ISOLDE is much awaited for by the nuclear physics community

We are aiming at delivering the first beams at the end of 2015, with one cryomodule, physics programme was adjusted accordingly

- General infrastructure progressing well
- Cavity workflow at CERN optimized, throughput ~ 1 cavity/month
- 3 cavities accepted, fourth cavity on hold
- Copper substrates non conformities being handled
- SC solenoids: first conforming item being delivered at CERN
- Cryomodule assembly infrastructure in place
- Cryomodule elements being received from industry, also with strong engagement of the CERN workshops
- Cryomodule assembly in clean room starting
- Beam instrumentation, alignment and monitoring equipment validated and being procured
- Safety issues addressed, safety file to be approved by end 2014
- Staggered dry runs of the installed equipment, software and controls starting at the end of this year.

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CERN technical staff

All the HIE ISOLDE Working Groups at CERN

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The HIE ISOLDE International Advisory Panel

CERN management

Thanks for the attention….