# HIE-ISOLDE Status Report

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On behalf of HIE-ISOLDE Project Team

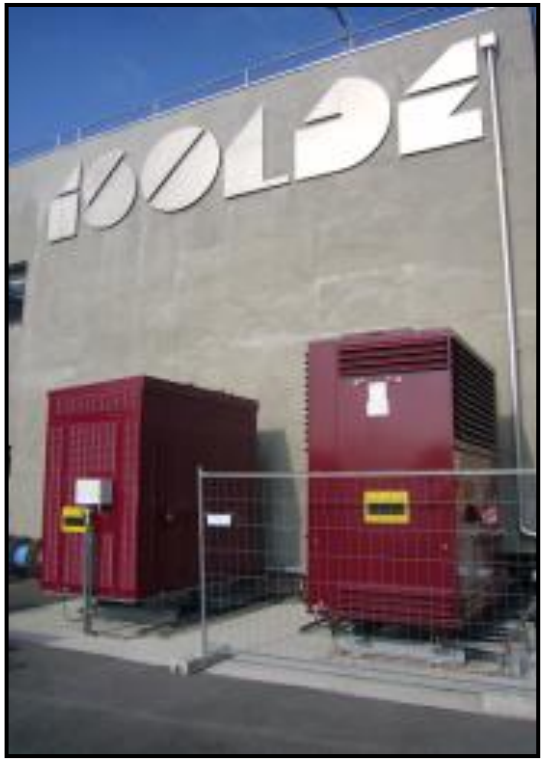
**48th Meeting of the INTC, CERN, 5-6 November 2014**

# Outline

- Status of the technical systems
- Financial situation
- Schedule
- Conclusions

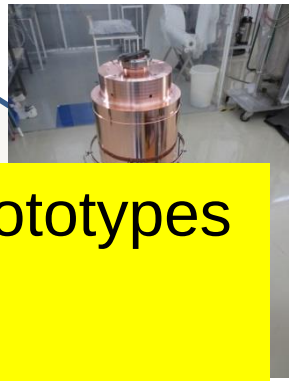
# Status of the infrastructure

In summary: **very good**. Infrastructure is in place




Visit and see for yourself!

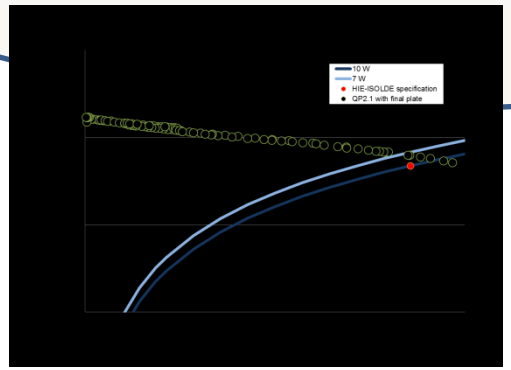
# Nb sputtered cavities



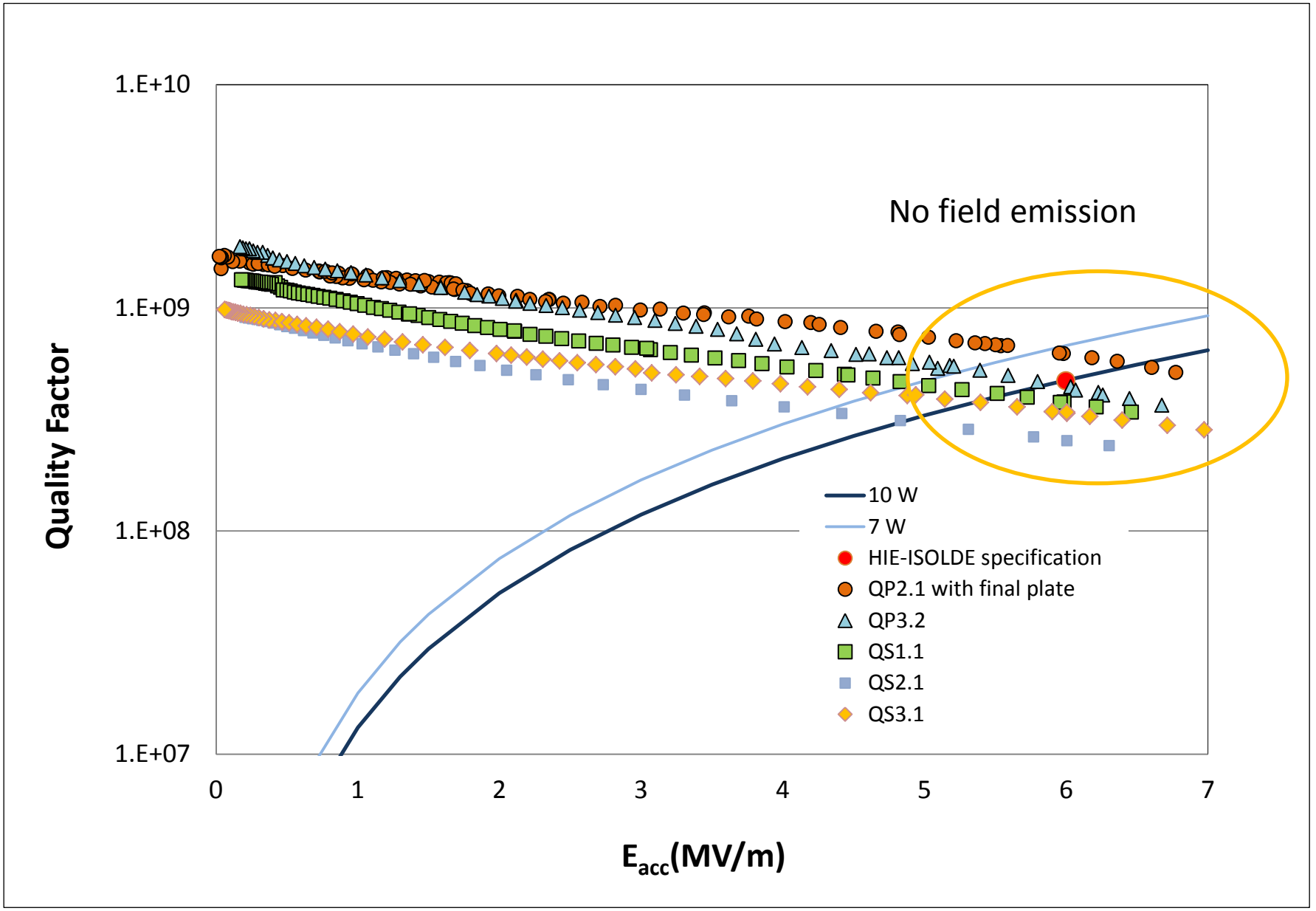
Cavity tuning → Surface treatment → Rinsing cleanroom → Niobium

Cavity production protocols validated on CERN prototypes
Series copper substrates from industry
Some teething problems: delays, non conformities

Cavity closure → Test cryostat preparation → RF test → End: Cavity storage




# Series cavity performance



# CM 1 operational scenarios

| cavity | Eacc (MV/m) | Q0 | Voltage (MV) | Pcav (W) |
|---|---|---|---|---|
| QP2.1 | 5.98 | [illegible] | [illegible]79 | 7.6 |
| QP3.2 | 6.01 | 4.91E+08 | 1.80 | 9.7 |
| QS1.1 | 5.99 | 3.78E+08 | 1.80 | 12.5 |
| QS2.1 | 6.00 | 2.63E+08 | 1.80 | 18.1 |
| QS3.1 | 6.00 | 3.22E+08 | 1.80 | 14.8 |
| **Total** | | | **8.99** | **62.7** |

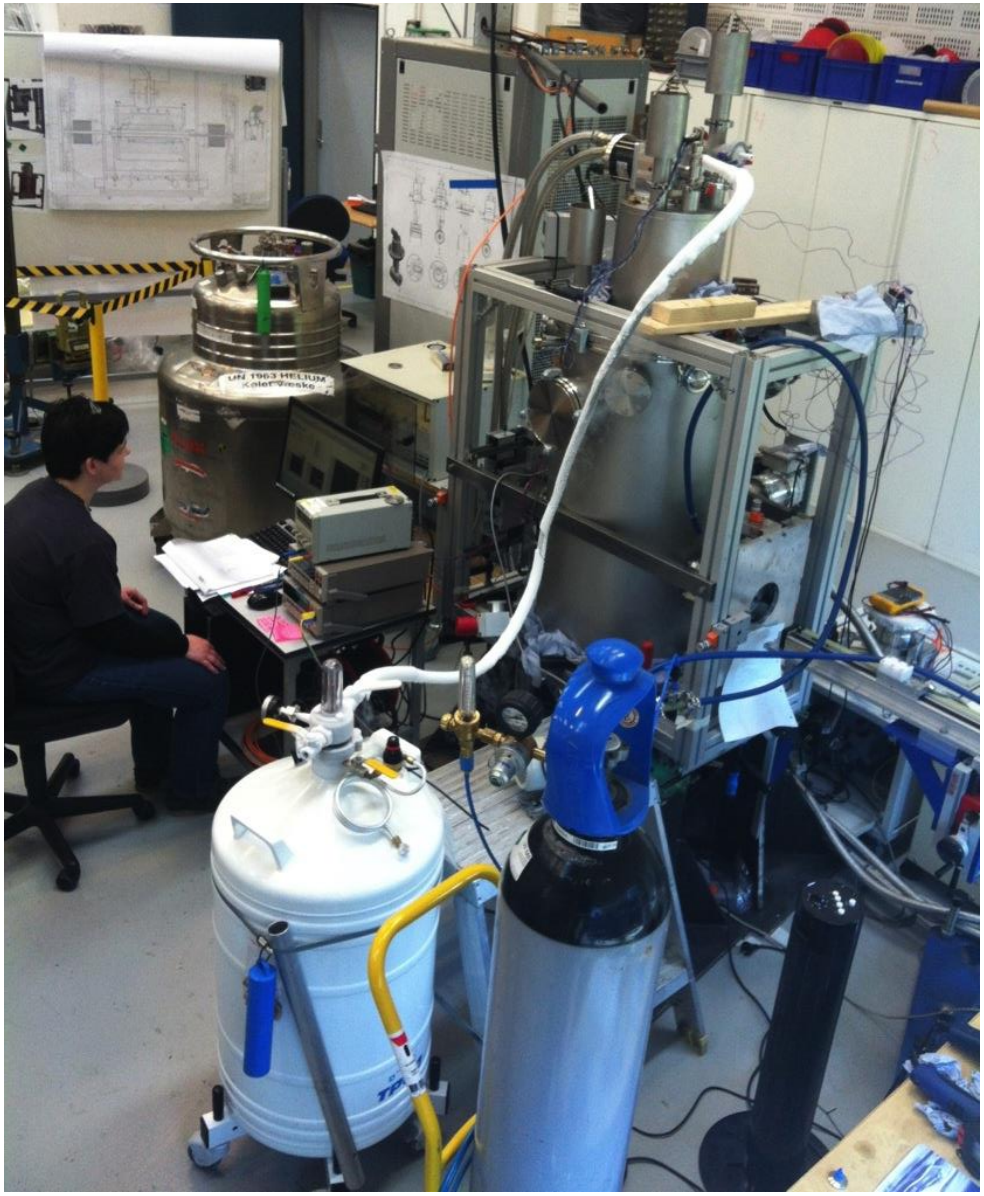
uniform field option

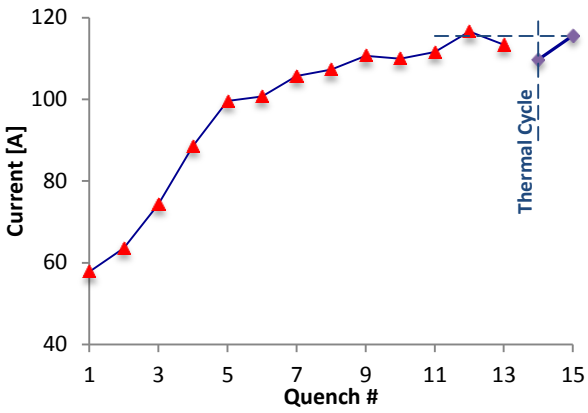
This is already within the cryogenics margin

| cavity | Eacc (MV/m) | Q0 | Voltage (MV) | Pcav (W) |
|---|---|---|---|---|
| QP2.1 | 6.61 | 5.40E+08 | 1.98 | 10.6 |
| QP3.2 | 6.15 | 4.64 | [illegible] | 10.7 |
| QS1.1 | 5.73 | 3.97E+08 | 1.72 | 10.9 |
| QS2.1 | 4.99 | 3.14E+08 | 1.50 | 10.5 |
| QS3.1 | 5.29 | 3.62E+08 | 1.59 | 10.2 |
| **Total** | | | **8.63** | **53** |

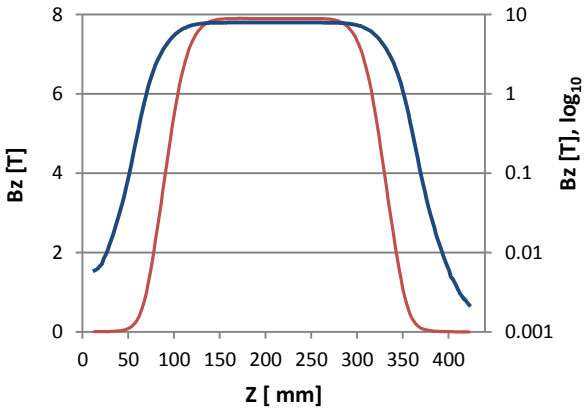
uniform power option

# Superconducting Solenoid






Training performance



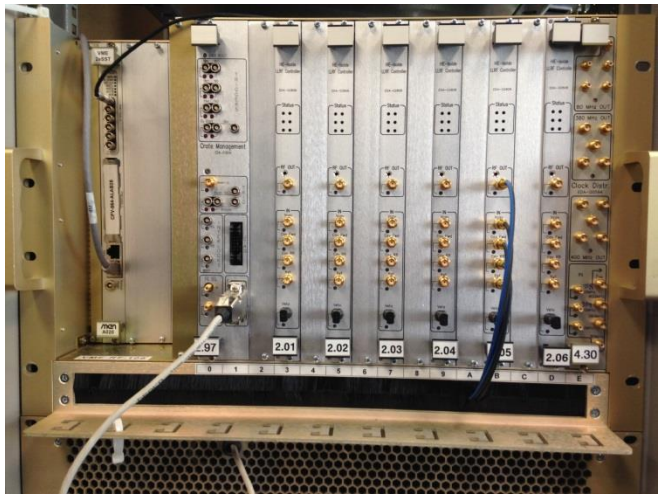

Magnetic field measurements

# RF systems (Power and LLRF)

- Low microphonics; low sensitivity to He pressure, 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
  - Direct RF generation by DAC
  - 1 LLRF controller card per cavity

LLRF controller for one cavity


LLRF system for a complete cryomodule (6 cavities)

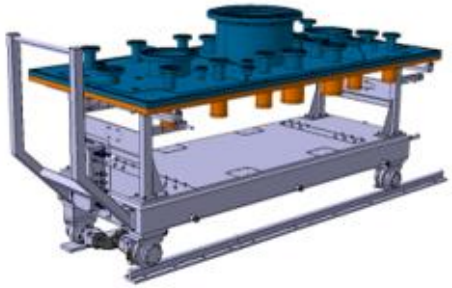



**Main deliverables in time, no showstopper so far**

- LLRF: on track
- Power RF: power amplifiers delivered
- RF controls software: catching up delays, RF group committed on essential functionalities for Day 1

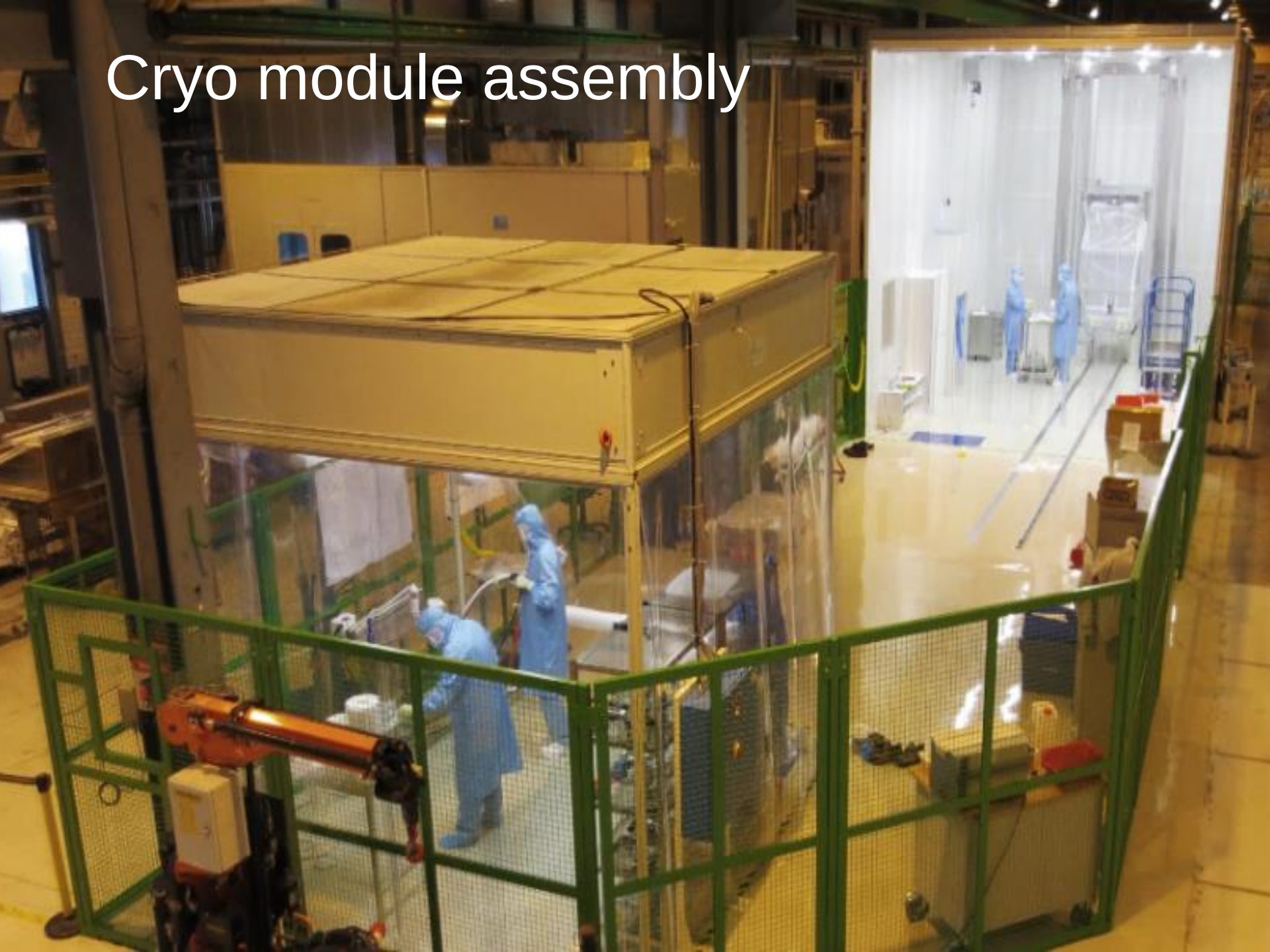
# Cryomodules: all main components at CERN

# All CM assembly infrastructure and tooling is available

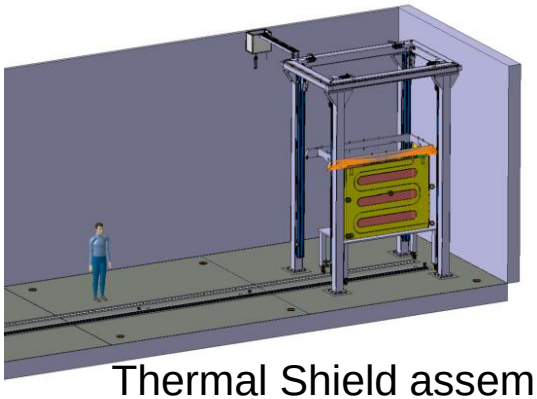




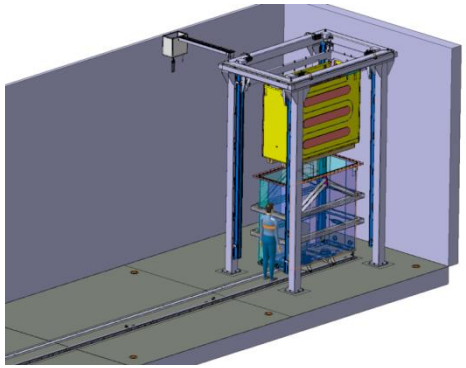
# Cryo module assembly



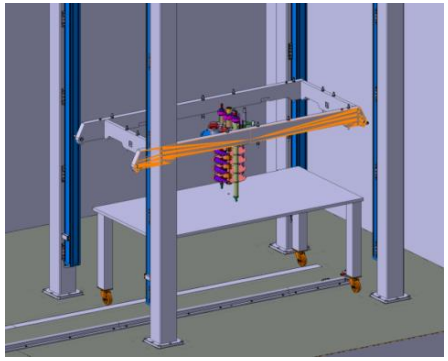
# CM assembly process (1/2)



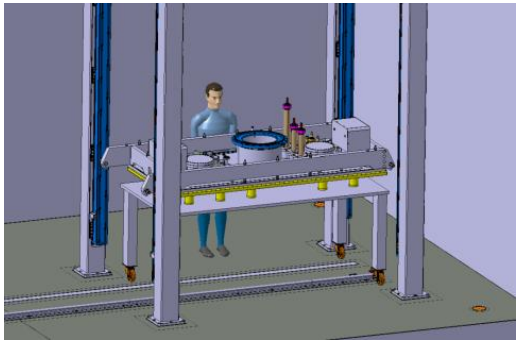
Thermal Shield assembly



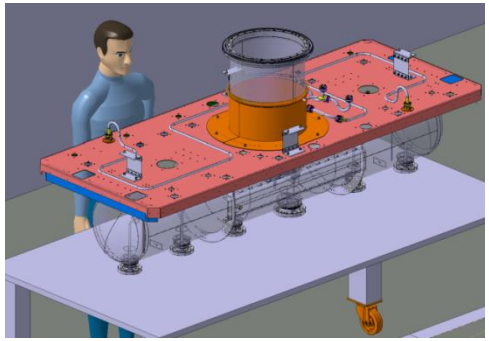
TS introduction in VV



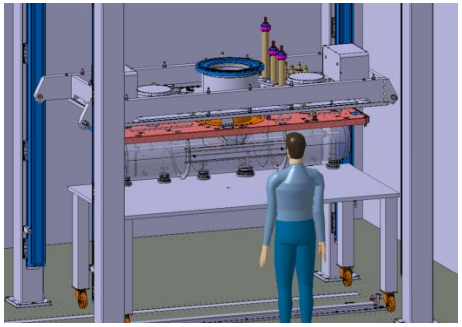
Chimney positioning



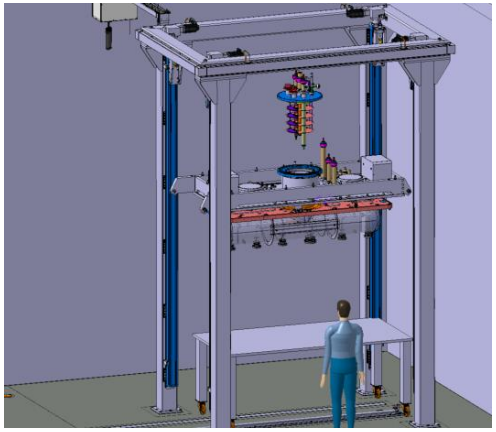
Equip top plate and leak test



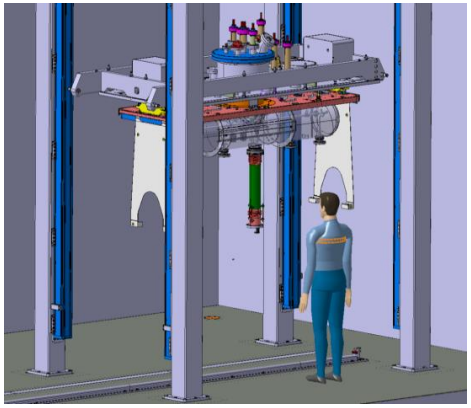
He Vessel + Top Shield



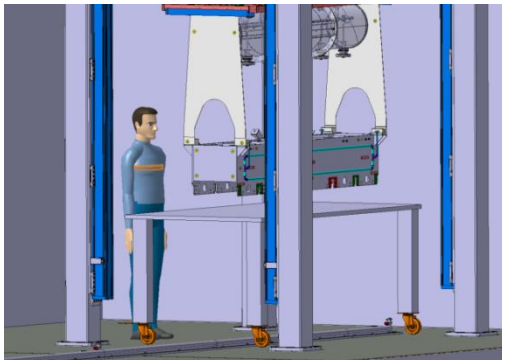
He Vessel mounting



Chimney insertion

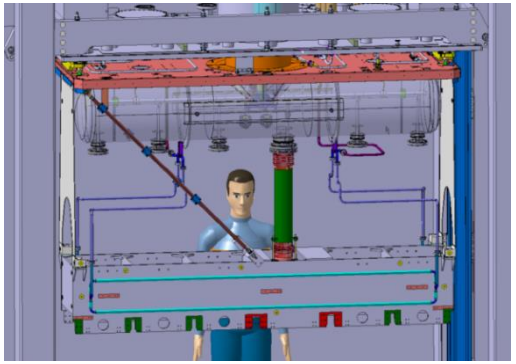


Bayonets + leads + supports

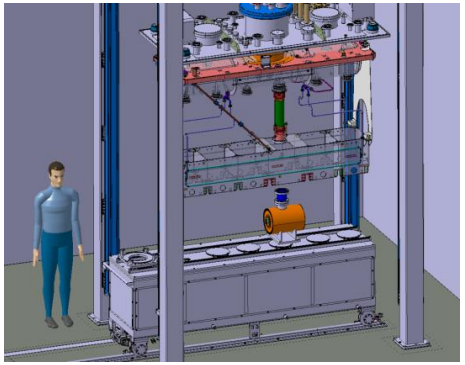


Cav./Sol. Frame mounting

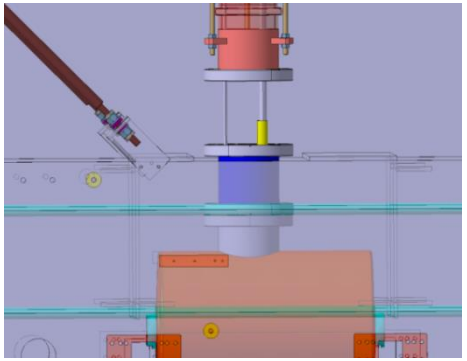
# CM assembly process (2/2)



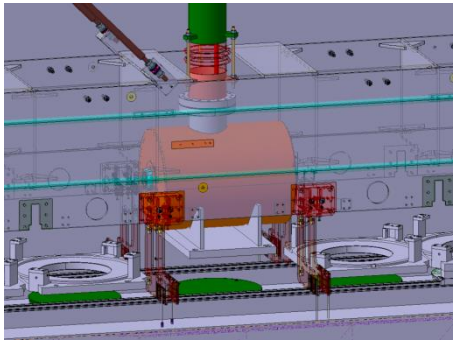
Diagonal rods + cryo circuit



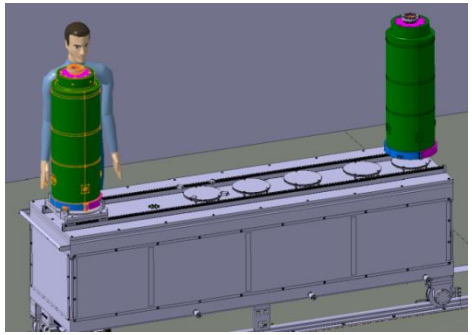
Solenoid



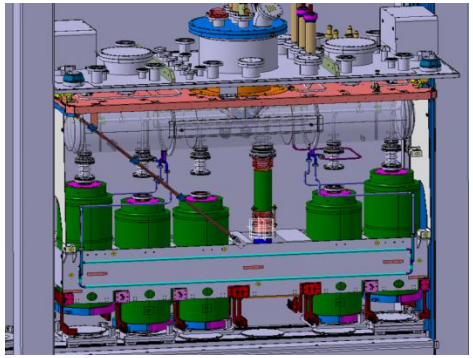
Solenoid connection



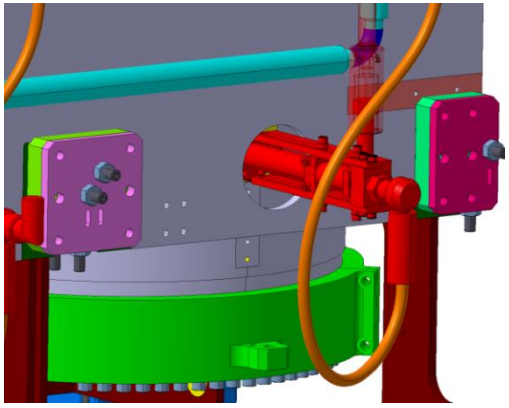
Solenoid alignment



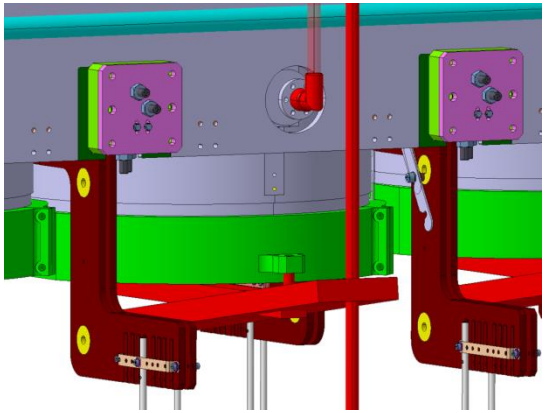
Cavities



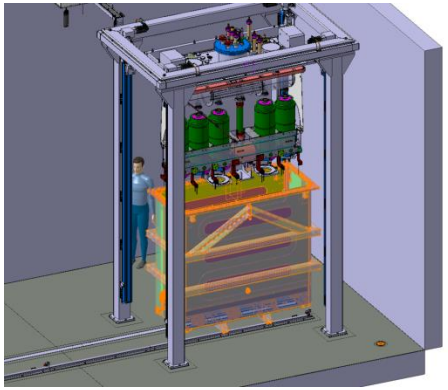
Cavities connection



RF couplers and lines

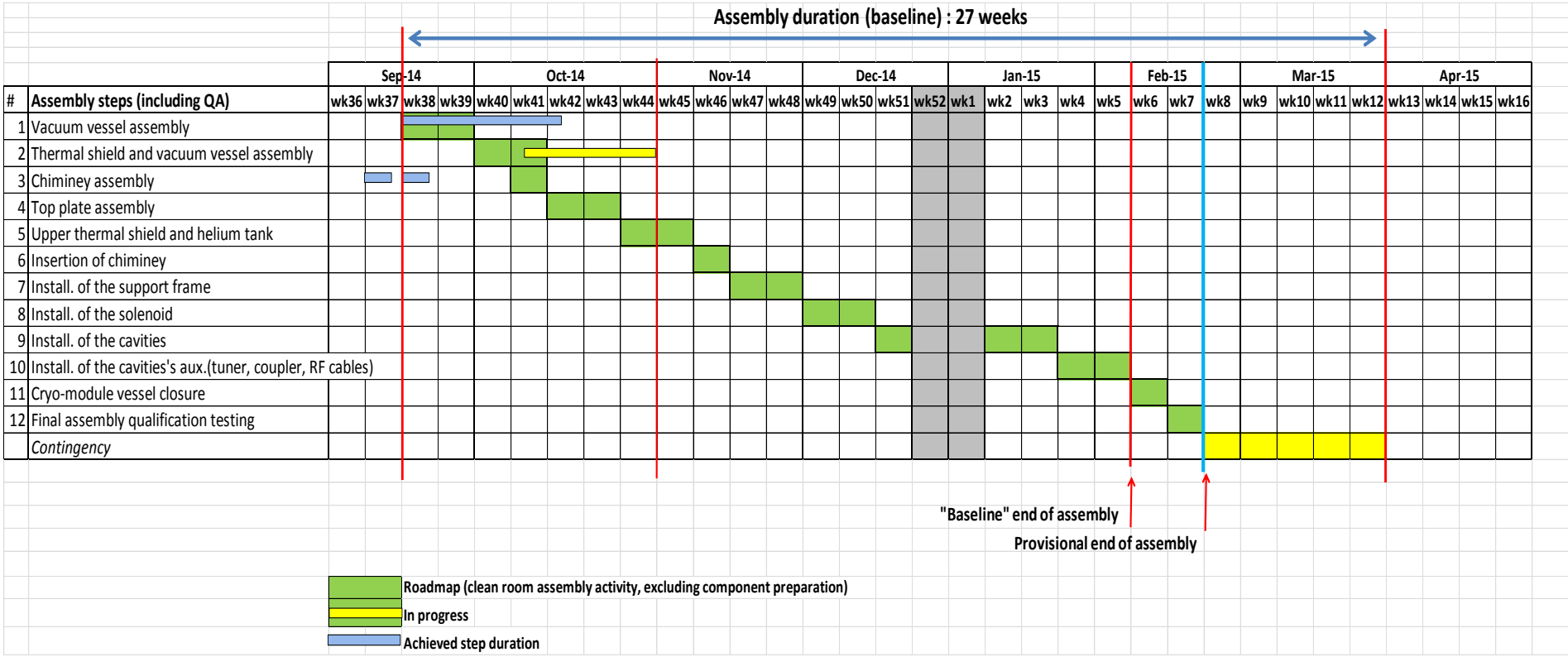


Tuning system



Final insertion inside vessel

# CM assembly schedule: progress tracking




**Assembly started 9 weeks late w.r.t. baseline plan established in Spring 2014**

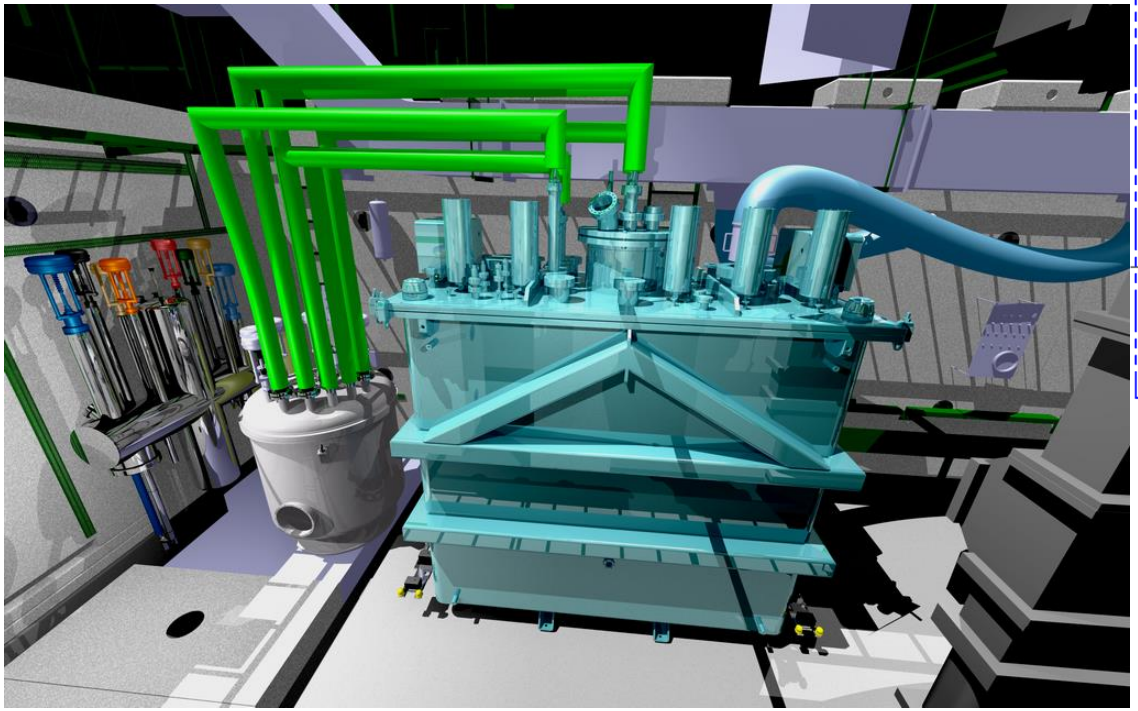
**Status, after 7 (out of 27) weeks of assembly:**

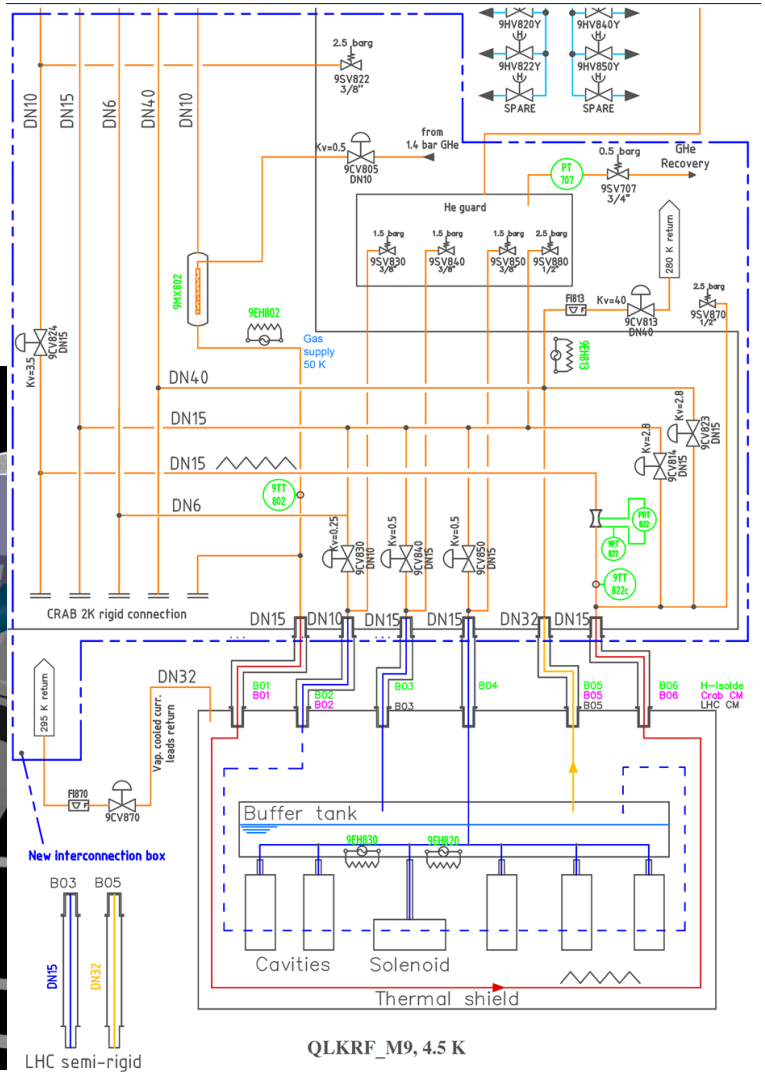
- Step
- Step
- Step

Initial progress is slower than planned: learning curve effect to be assessed

# SM18 CM test infrastructure

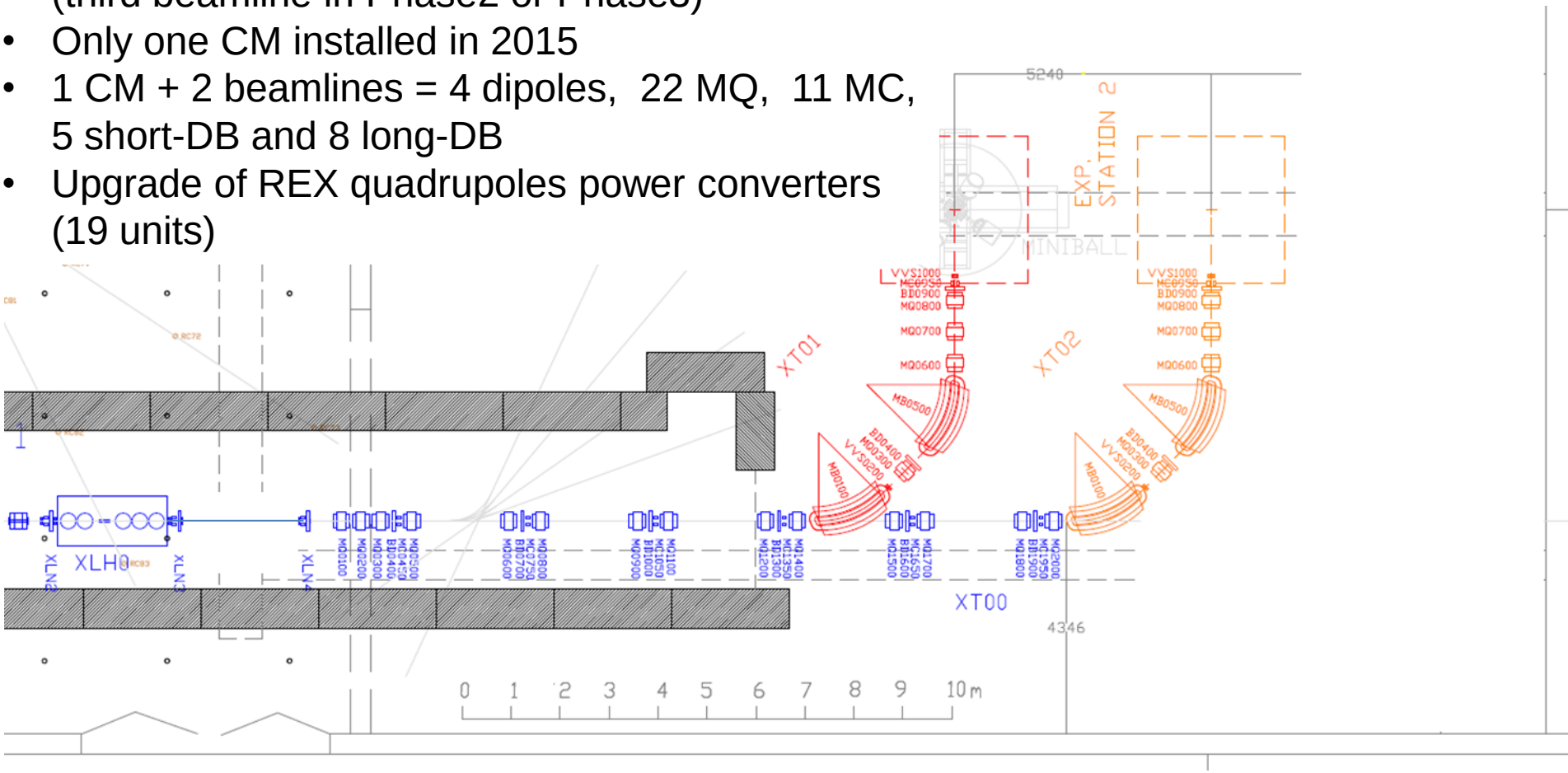
- Integration study done
- Reshuffling M9 bunker roof: October 2014
- Racks installation and RF cabling by end 2014
- Cryogenics valve box installation and commissioning: January 2015





# HEBT – 2015 (phase ½)

- Two  beam lines built and operational in 2015 (third beamline in Phase2 or Phase3)
- Only one CM installed in 2015
- 1 CM + 2 beamlines = 4 dipoles,  22 MQ,  11 MC, 5 short-DB and 8 long-DB
- Upgrade of REX quadrupoles power converters (19 units)




**Full infrastructure installed directly for the 3-phases**

# HEBT equipment

**Magnets (MB, MQ, MC):**

- Procurements now on-track
- 3 months delay for MB and MQ compared to original delivery dates, 1 month for MC
- Need close follow-up for the MQ contract

**Power converters:**

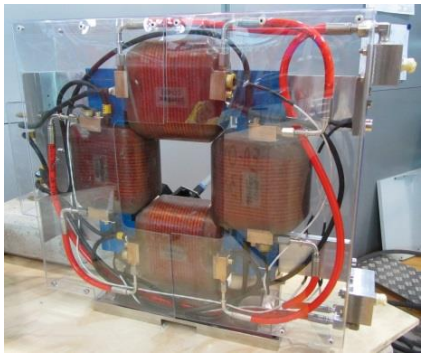
- **MB and MC on time**
- **MQ: 3.5 months delay: potential impact on the start of dry runs**

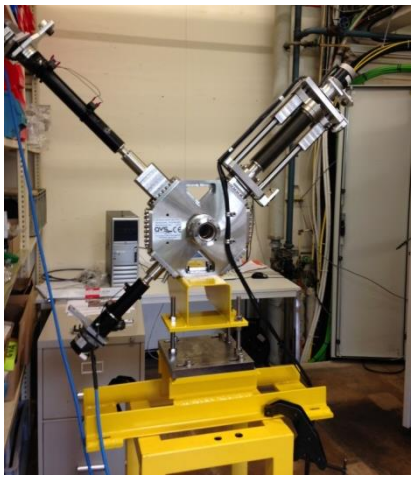
**Beam instrumentation**

- SDB delivered
- LDB: 1 month delay, no impact

**Vacuum system**

- Procurements on-track
- Need to finalise integration





# Financial Situation (EDMS **1422826**)

**Infrastructure**

"The Cost to Completion of the infrastructure part of the HIE-ISOLDE project, entirely funded by CERN, is **21.2 MCHF**.

The revised estimate of the infrastructure part shows that the **total cost remains unchanged**."

**Machine**

"The Cost to Completion of the machine part of the HIE-ISOLDE project was revised in November 2013 in the EDMS document "*HIE-ISOLDE Project Financial Situation 2013 – Machine Part*". The new Cost to Completion for the machine part was announced at **21.95 MCHF**.

The actual accounting of Phase 1 and the revised estimate for Phases 2 & 3 show that the **total cost remains unchanged"**

# Financial Situation (EDMS **1422826**)

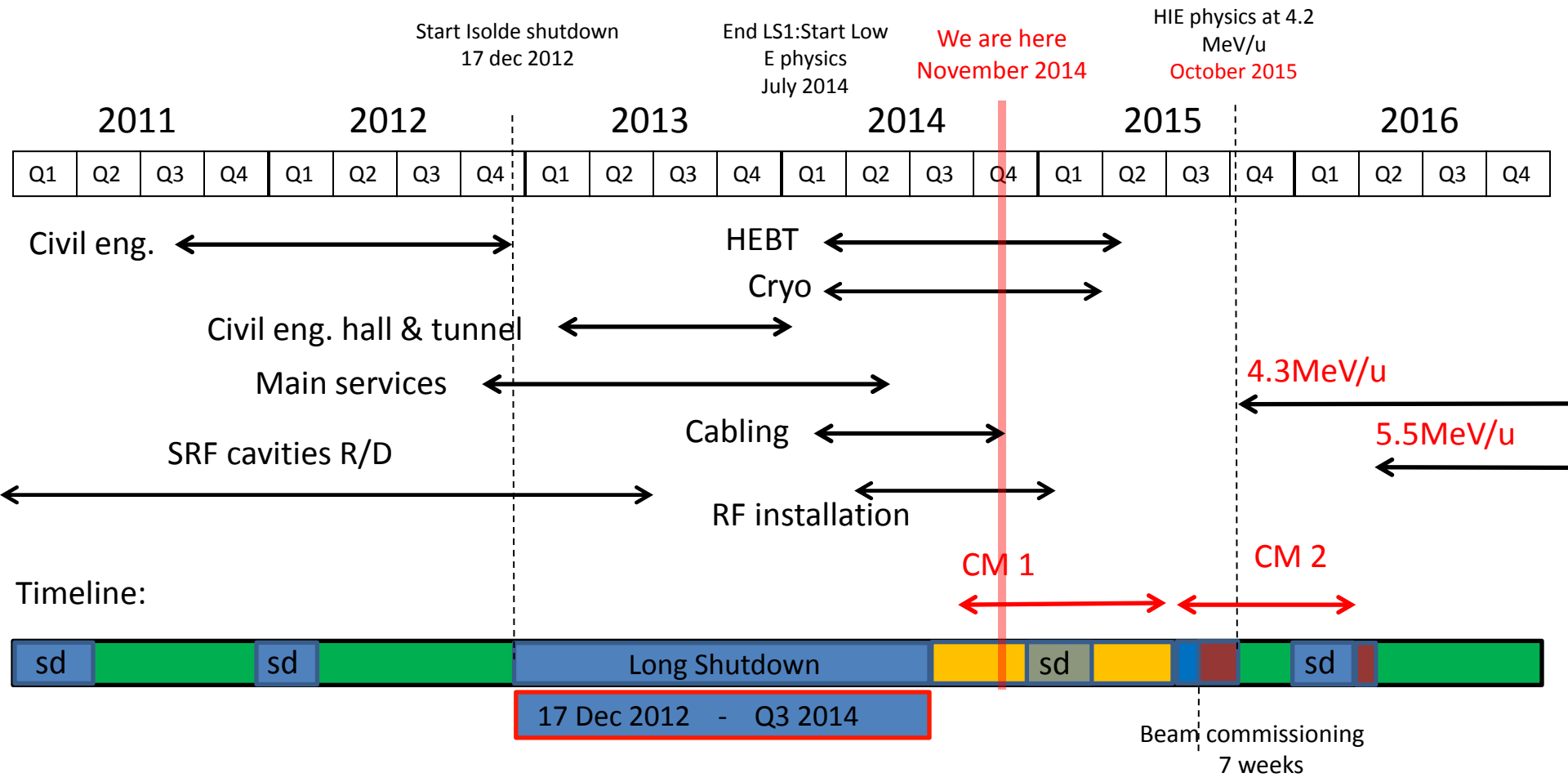
**“Funding and Cash Flow for the Machine Part**

Based on the income secured so far by the collaboration, the CERN loan granted and special contribution from CERN, the cash balance of the machine part of the HIE-ISOLDE project shows that:

**the Phase 1 is funded,**
**0.7 MCHF are missing for the Phase 2**
and **5.6 MCHF are missing for the Phase 3.”**

Cash flow shortage for Phase 2 (transient effect due to collaboration rate of contribution) does not seem to be a showstopper

# HIE simplified planning




shutdown

Isolde Ops

HIE installations and tests (Isolde normal operations)

Machine Check-Out (Isolde normal operations)

Beam Commissioning (Isolde normal operations)

# Conclusions

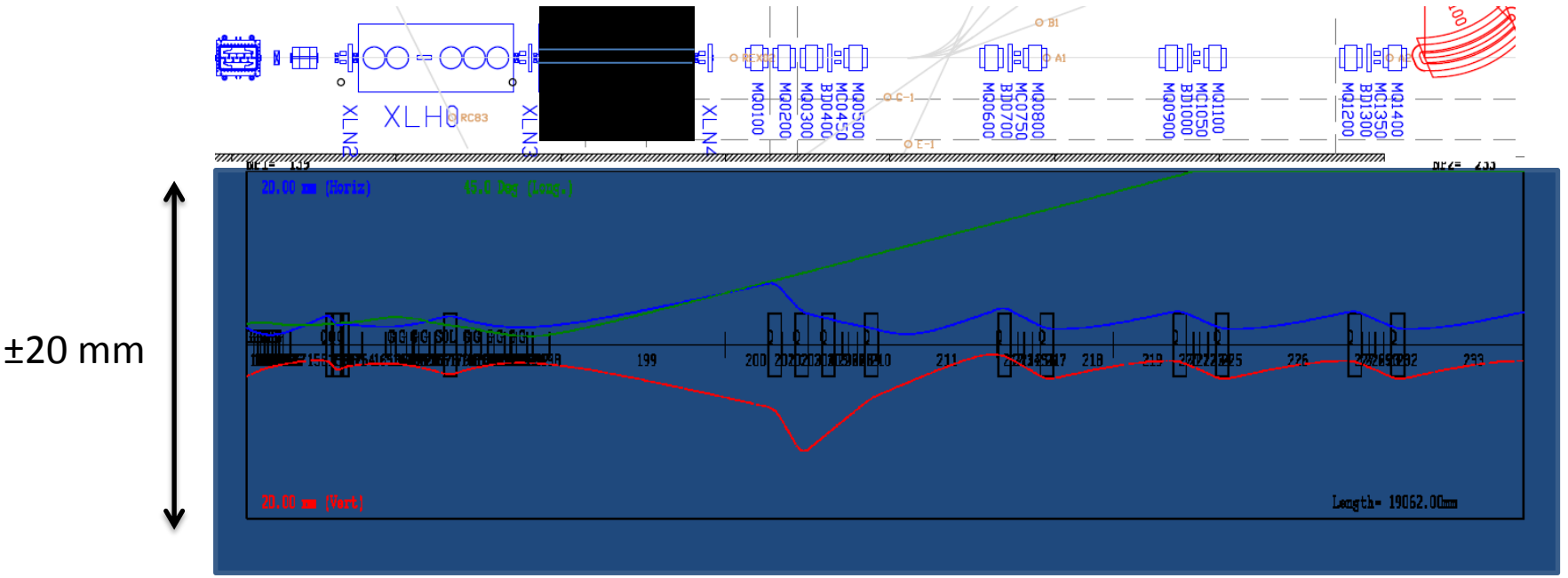
- Good progress on infrastructure
- Minimal set of active components (SC cavities and solenoid) already available for installation in CM1
- Cryomodule assembly in clean room started
- HEBT elements mostly on time (with some criticalities)
- **Cost and schedule reviewed by CERN on 27.10.2014**
- **Outcome:**
  - Project monitoring tools found adequate
  - Financial situation under control
  - Schedule risk for physics deadline in 2015 highlighted
  - Cryomodule assembly time is the schedule driver
  - Re assessment and mitigation plan requested in 1 month
  - **Phase II: go-ahead** with procurement of remaining components
  - Spare parts policy to be evaluated (for funding)
  - Phase III: not for now, focus on high beta section (4 cryomodules)

# backup slides

# Operation with one cryomodule

Between October 2015 and 2015/16 shutdown, only one cryomodule (5 cavities) will be available. Can we run with a missing cryomodule?

- The beam blows up but remains well inside +/- 20 mm aperture
- The beam can be matched into the transport channel with the matching quadruplet without losses



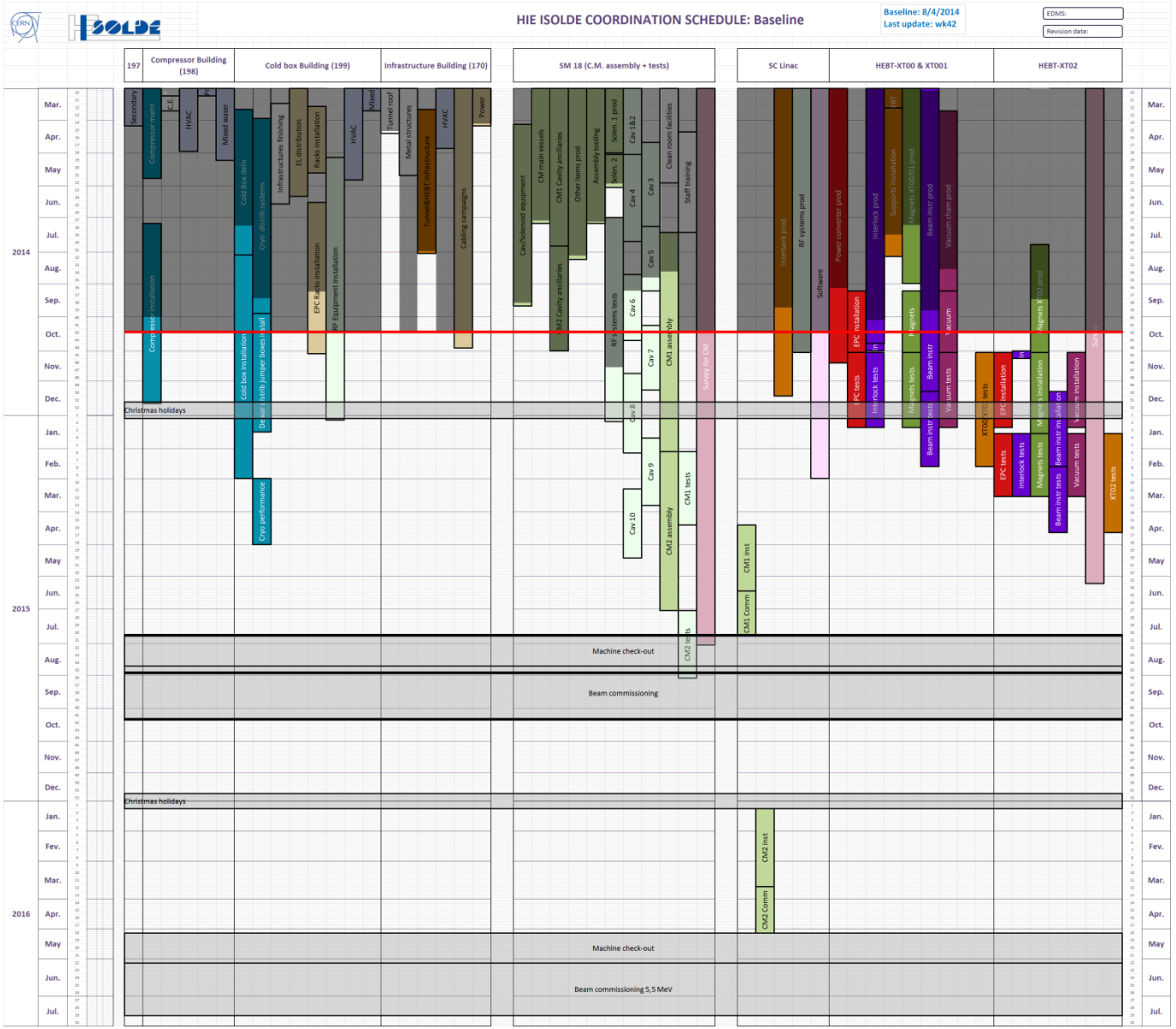
# HIE-ISOLDE global planning progress (Phase1)

08/4

24/6

26/8

24/10



# Industry contract for high $\beta$ cavity cavities

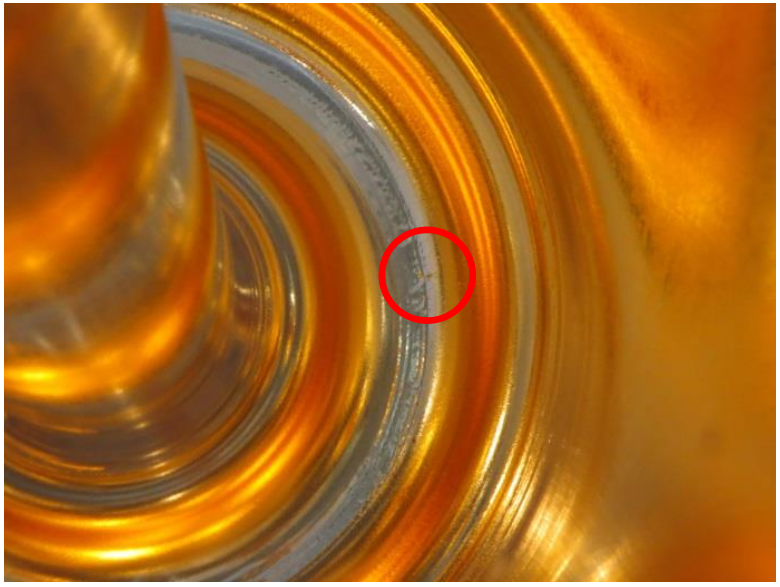
- **15** cavities ordered on 25.05.2013 (with +**5** in option)
- QS1 delivered in June 2014: **7 months delay on contract**
- QS1 **non conform**, coated, almost on specs
- QS2 delivered July 2014, **non conform, coated, low performance**
- **QS3** delivered August 2014 (5th substrate, including QP2/QP3) **severe non conformities. Repaired at CERN, coated, performance slightly below specs**
- **QS4** delivered in October 2014, **substrate conform to specifications,** to be coated now
- Two more cavities expected before end of the year

# QS3.1 history

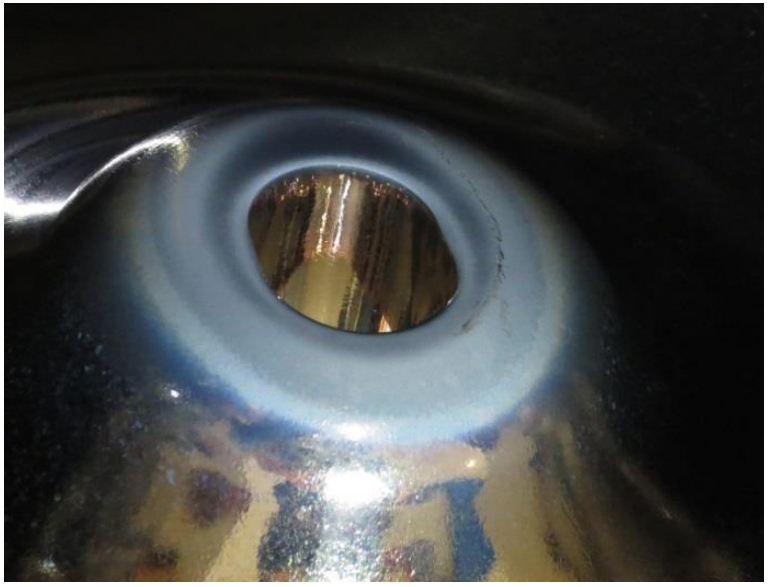
Features spotted after 3rd SUBU

After 2 CERN welds

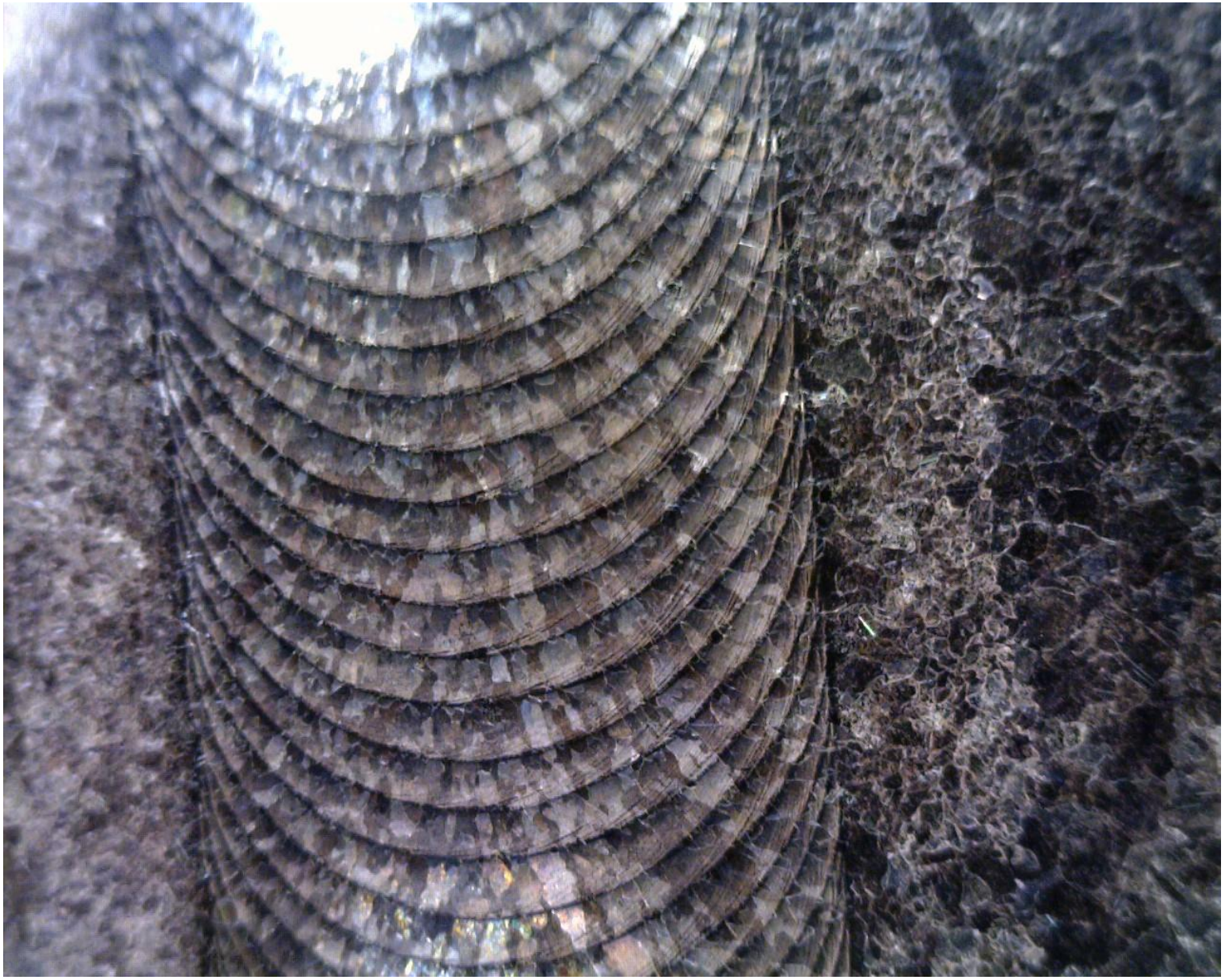
After 4th SUBU



After coating (incident)

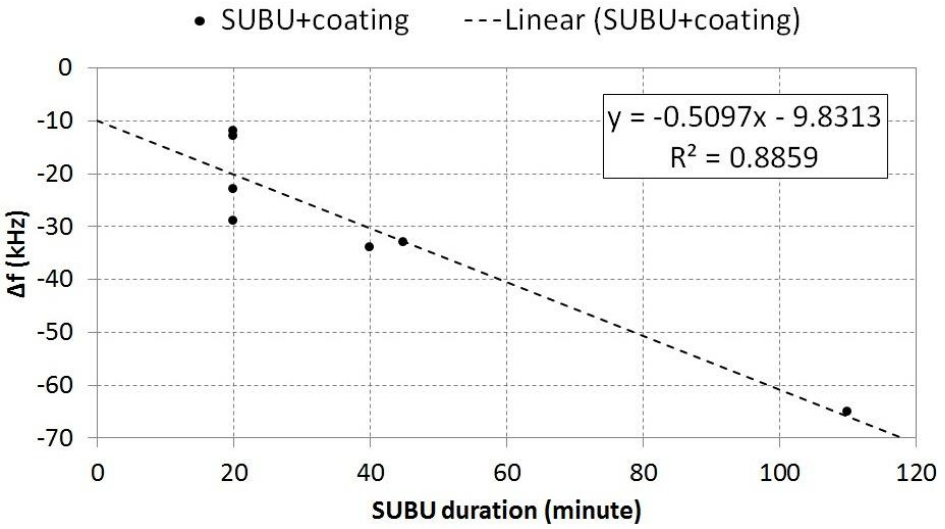


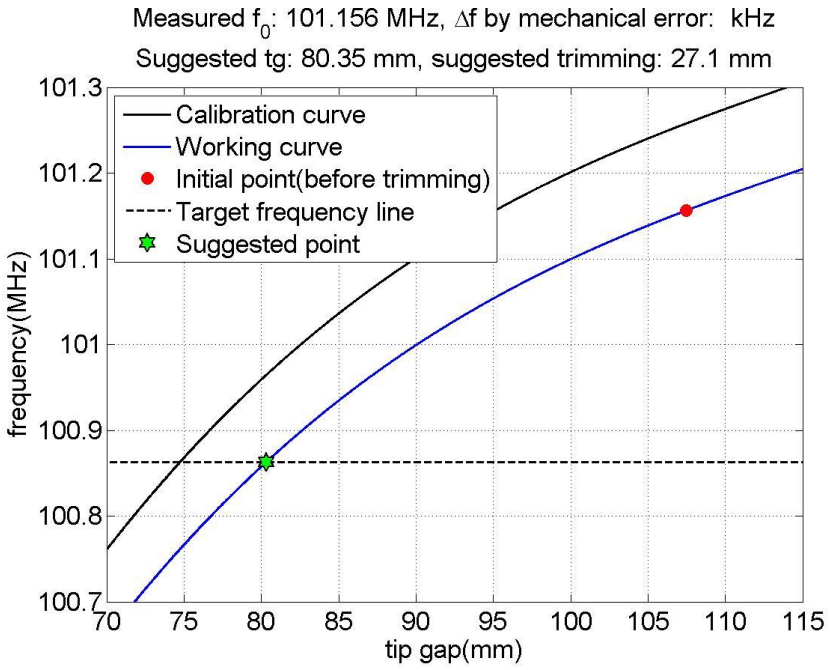
# QS4: substrate problems solved?



# Cavity tuning, mystery solved

| 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 |



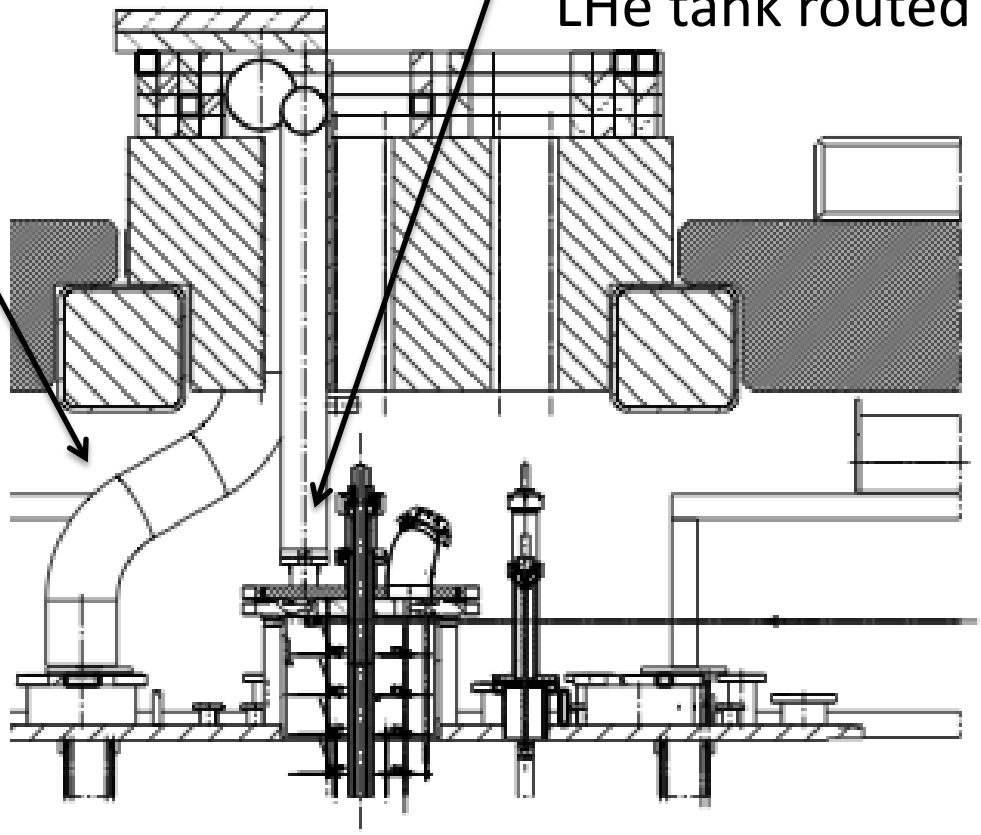




# Cryogenic Hazard

Safety pressure device on insulation vacuum routed outside

Safety pressure device on LHe tank routed outside

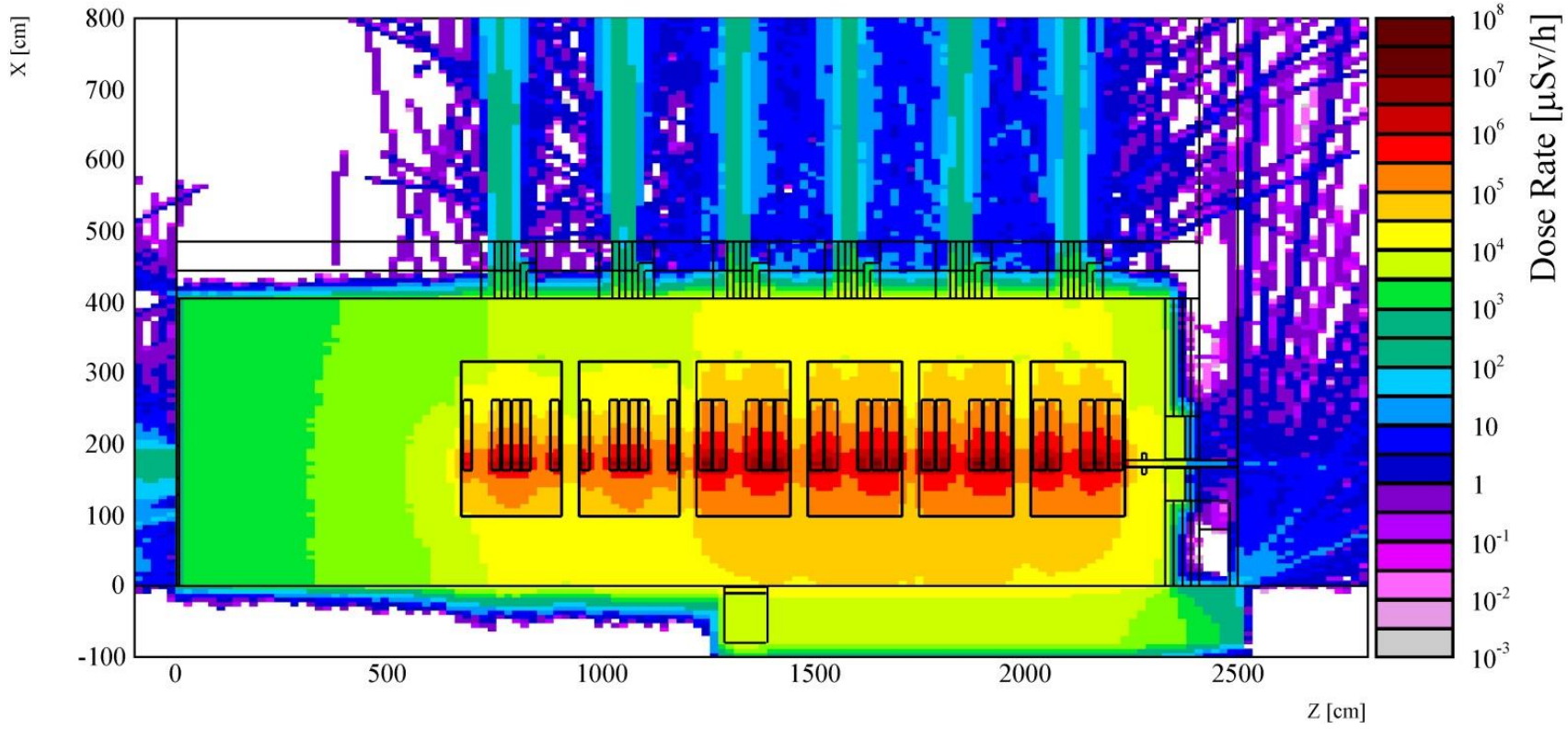
Port for instrumentation re-assigned to rupture disk



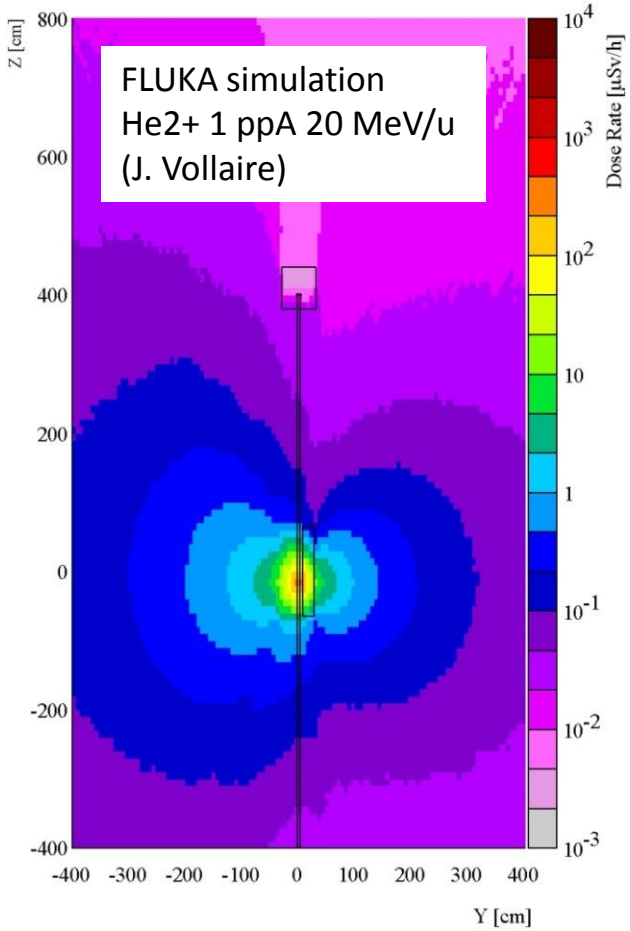
# Radioprotection (X-rays)

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

BASELINE : NO ACCESS TO THE ROOF



# Radioprotection (neutron production)



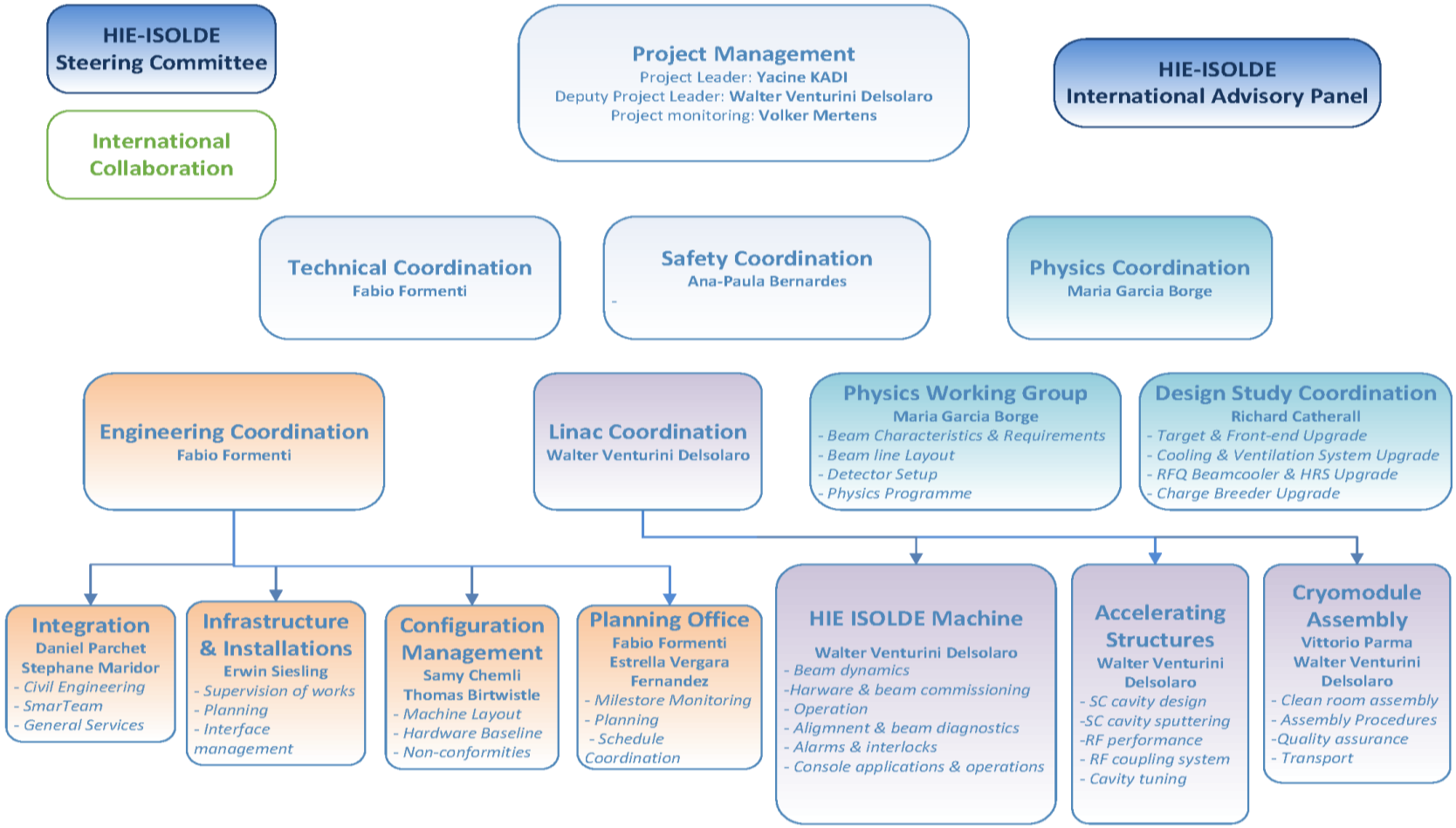


| | A | Z | q | A/q | MeV/u Stage1 | MeV/u Stage2 | MeV/u Stage3 | 20.0 epA Sv/h at 1 m Stage1 | 20.0 epA Sv/h at 1 m Stage2 | 20.0 epA Sv/h at 1 m Stage3 |
|---|---|---|---|---|---|---|---|---|---|---|
| He | 4 | 2 | 1 | 4 | 6.47 | 10.20 | 11.45 | 3.8E-07 | 3.3E-06 | 5.0E-06 |
| | 4 | 2 | 2 | 2 | 10.19 | 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

# Situation in Oct. 2014

- Project Structure was re-organized



# What is needed for Phase 2

- Additional Infrastructure
  - Jumper boxes x 2 ✔
  - Solenoid power converters x 2 ✔
  - Cryomodule supports x 2 ✔
  - Vacuum chambers
- SC Linac components:
  - Cavity substrates x 10 ✔ 3 add. options needed from RI
  - Coupler system x 10 ✔ 5 add. Units
  - Tuner system x 10
  - Solenoids x 2 ✔
  - Cryostats x 2
  - Intertanks x 2 ✔
  - RF systems (LLRF, RF amplifiers) x 2