HIE-ISOLDE Commissioning report

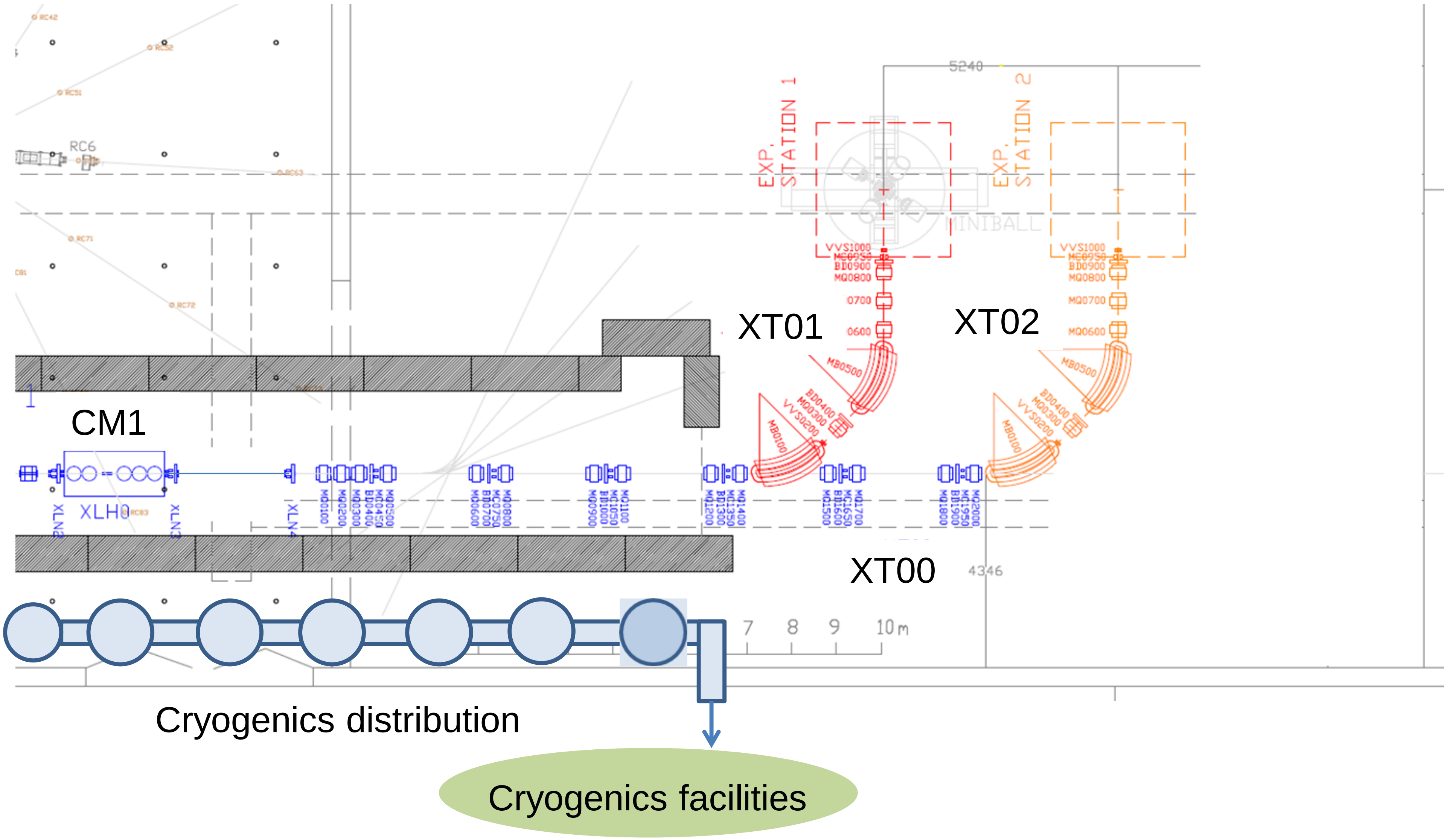
Walter Venturini Delsolaro
on behalf of the HIE ISOLDE Commissioning team

HIE ISOLDE Workshop and Users meeting, November 2-4, 2015

Outline

- HIE ISOLDE roadmap for 2015
- Commissioning organization, goals and procedures
- HEBT commissioning results
- CM1 commissioning results
- Report on cryogenics incident
- Main pending issues (Non Conformities)

Systems to be commissioned



HIE ISOLDE roadmap 2015

	Jan-15	February	March	April	May	June	July	August	September	October	Novembe
											w46
CM1 Assembly											
CM1 Installation & Test											
XT00 Installation&Tests											
XT001 Installation&Tests											
XT002 Installation&Tests											
Cryogenics Facilities											
Machine Checkout											
REX-ISOLDE											
Beam Commissioning											
Physics at 4.3 MeV/u											Run e

DONE

Hardware Commissioning

- Goals of HC work:
  - define the envelope of parameters within which the machine could be operated by BE-OP during the physics run
  - Validate software and controls
  - Identify, investigate and document the weak points and limitations preventing hardware to reach nominal performance
- HIMAC Working group gathering all equipment owners with strong involvement of BE-OP
- Accurate preparation work→ written procedures
- For HEBT circuits, we used well oiled LHC methods
- Cryomodule commissioning procedure was a good Anzaz, it will be retrofitted with experience of CM1

HEBT commissioning results

- All XT00, XT01 and XT02 circuits released for operation
- Operational currents set for the needs of 2015 physics run
- B field control for dipoles validated

CM 1 main commissioning steps

CERN
CH1211 Geneva 23
Switzerland

EDMS NO.	REV.	VALIDITY
1511269	**0.0**	**DRAFT**

REFERENCE
HIE-O-HCP-0001

Date : 2015-01-14

Hardware Commissioning Procedure

Hardware Commissioning Procedure for the HIE-ISOLDE cryomodules

This document describes the sequence of tests and the parameters to be recorded for the hardware commissioning of the HIE-ISOLDE cryomodules.

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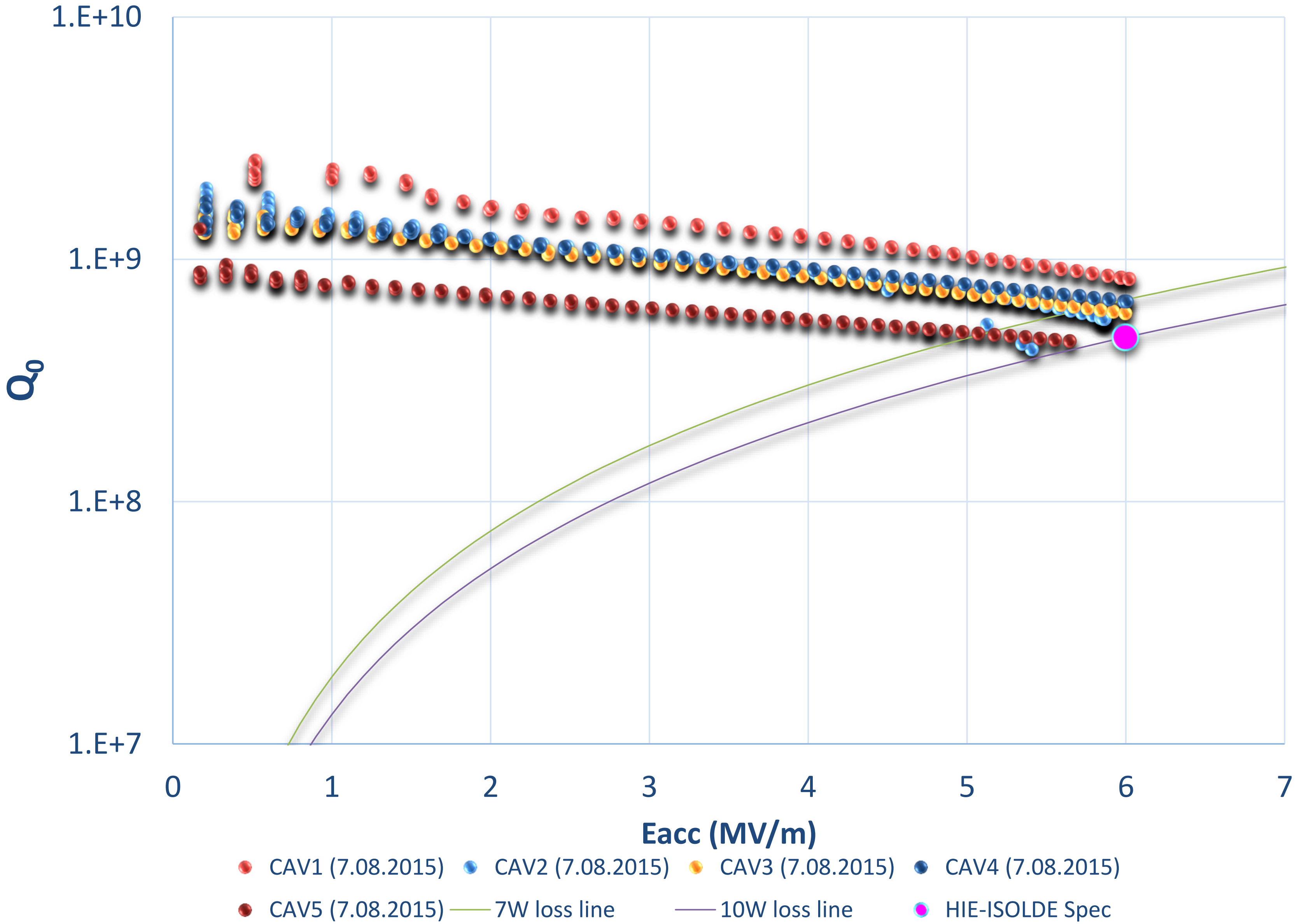
P. Zhang		

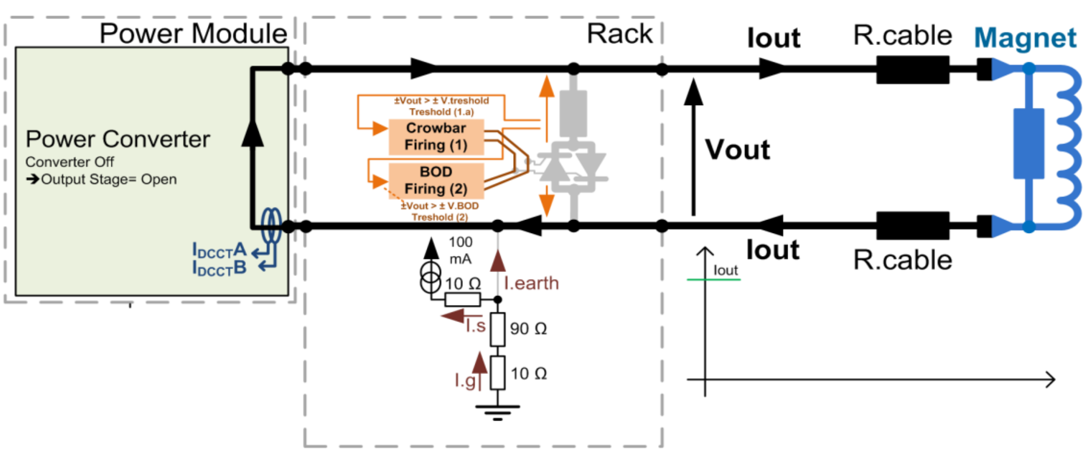
1. Interlock tests
2. Slow pump down
3. RF, Instrumentation, ELQA tests before cool down
4. Low Level RF tests
5. Cool down
6. RF conditioning above Tc
7. RF tests at 4.5 K
8. SC solenoid test
9. Survey and Alignment
10. Heat load measurements
11. Thermal cycles

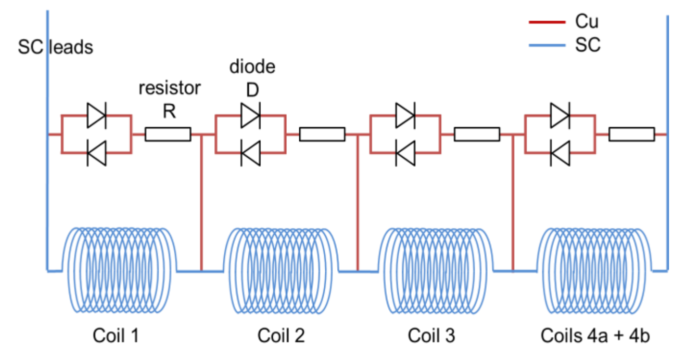
CM1 cavity test results



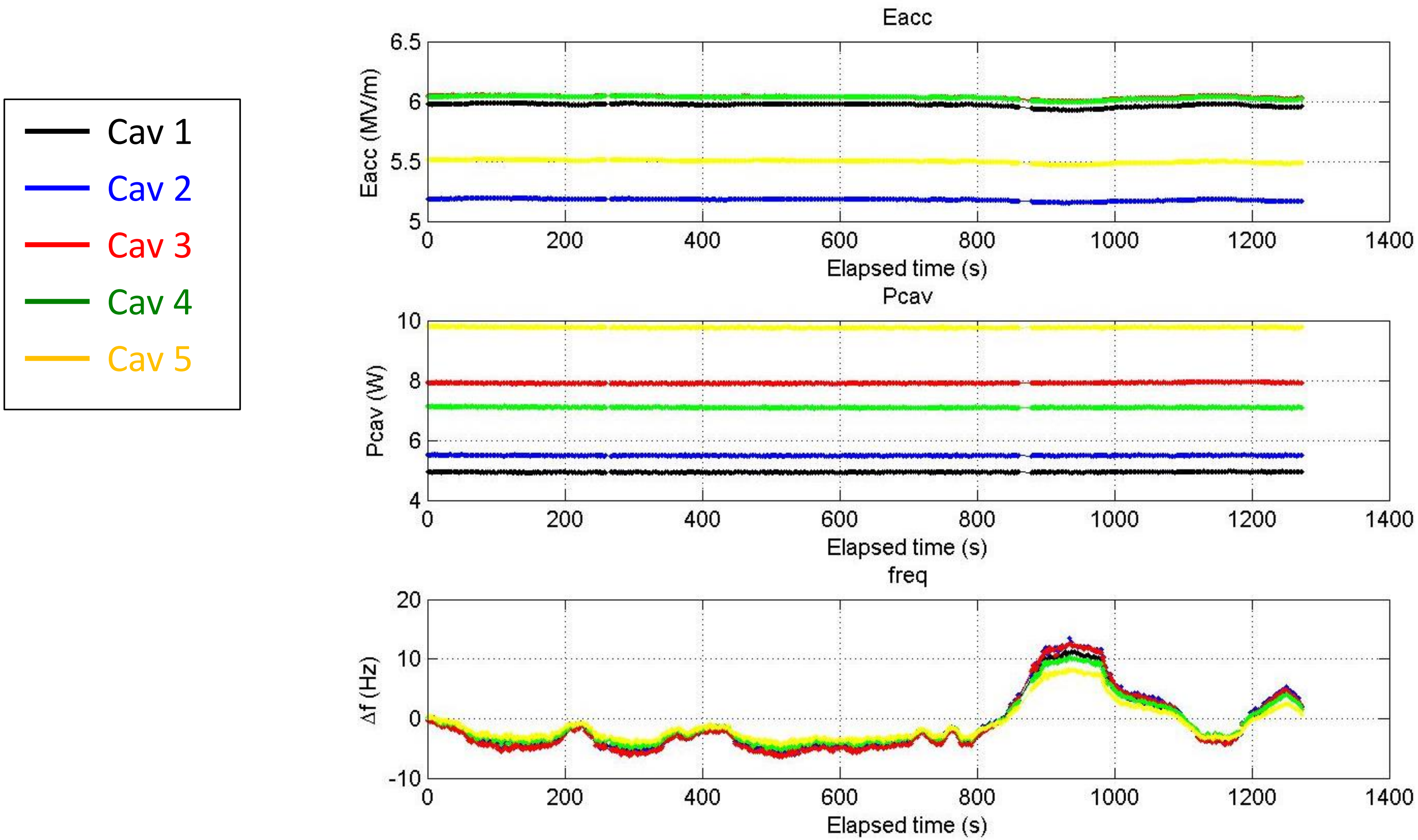
Solenoid test results

- Nominal current set conservatively for operation: (115.5 A→ 100 A, need 90 A)
- Insulation at cold tested up to 500 V (checked to be sufficient in case of quench)
- Vapour cooled current leads set at 0.5 g/s
- Fast power abort from nominal triggered quench (as expected): good reaction of the cryogenics system
- No spontaneous quenches, continuous operation at ~ 60% of I_{NOM}
- Small issue: power converter trips (in current mode) when changing polarity…traced back to repolarization of the parallel diodes
- Need to verify for future solenoids if this events are not signs of a defect in the protection scheme





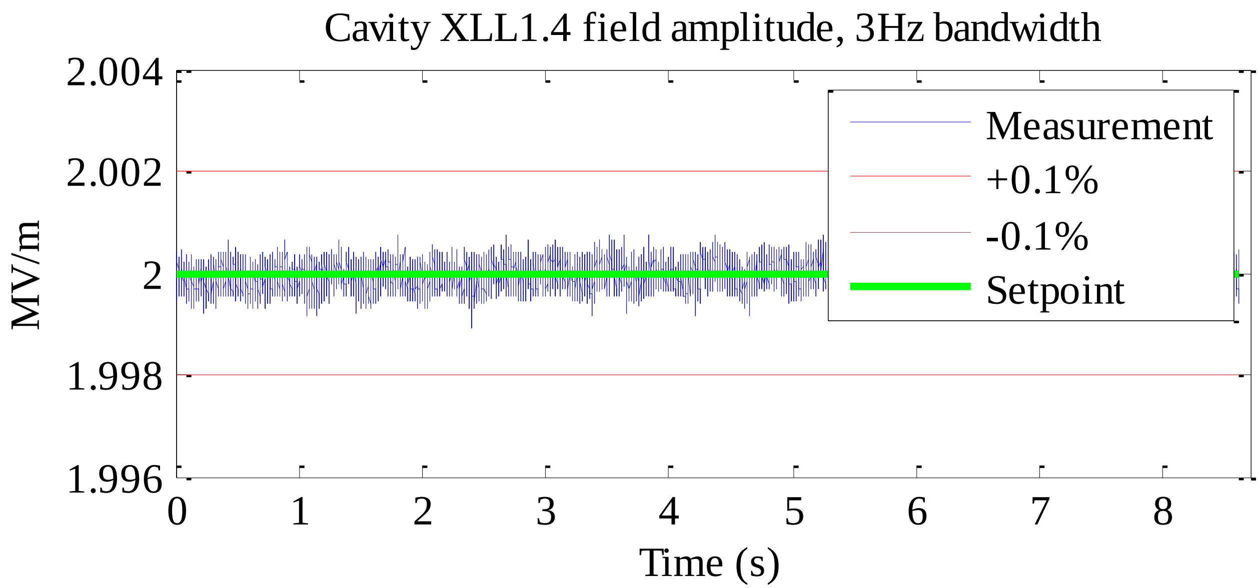
Combined powering of cavities and solenoid

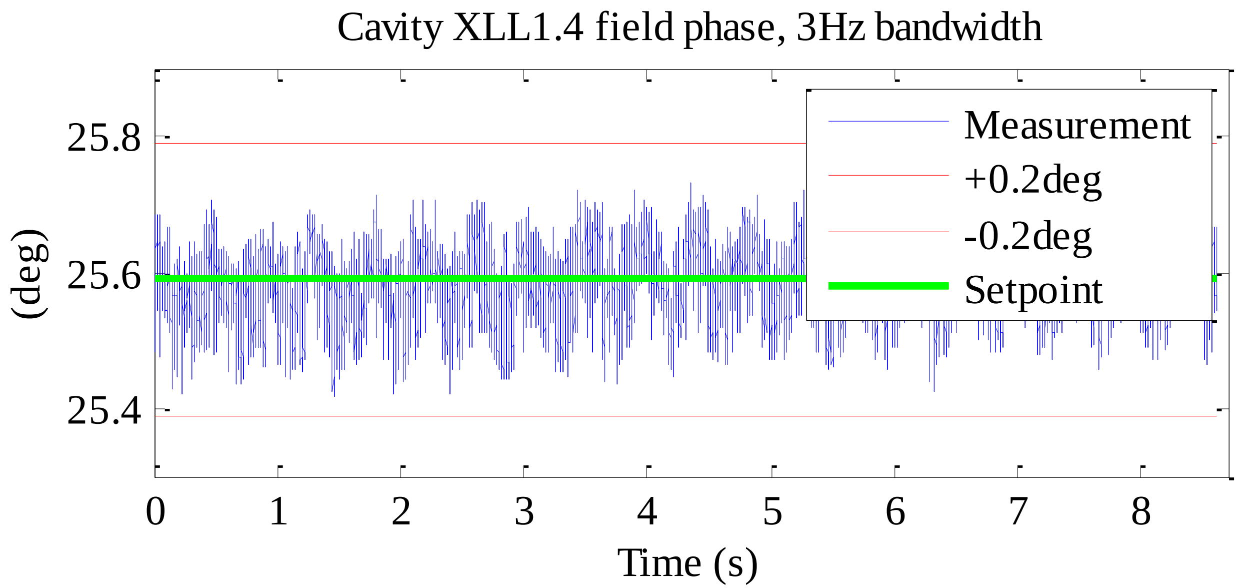


Solenoid current: 0A → 100A → 0A

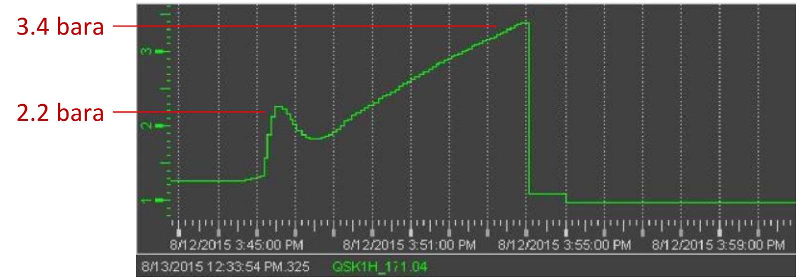
Pei Zhang

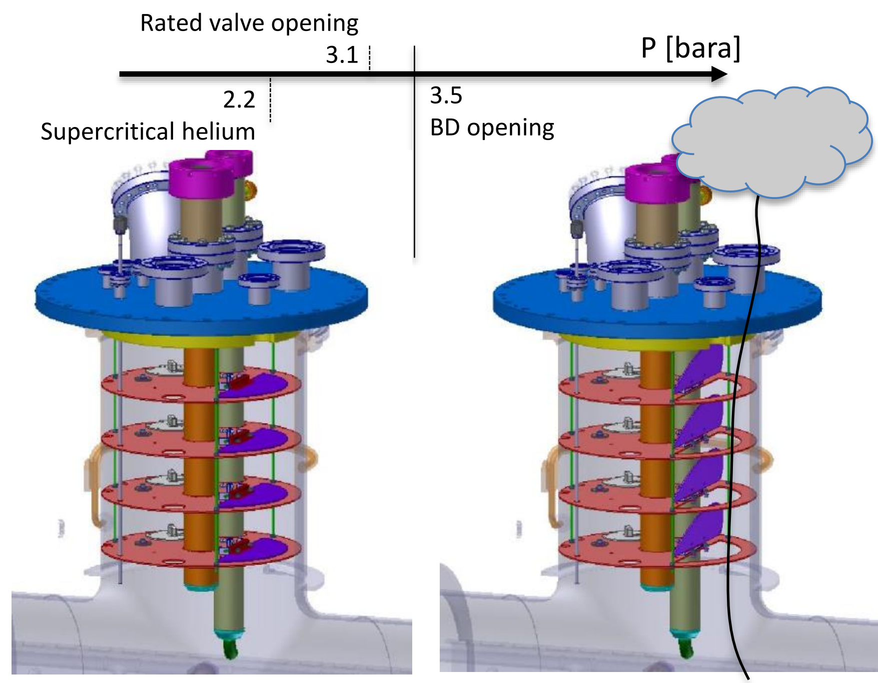
Performance of the LLRF system





Cryogenics incident 12.8.2015





Reconstructed chain of events

- Initial pressure fluctuation in the low pressure circuit (15:47:33)
- Stop of warm compressor and of the cold box
- Faulty logic of valve opening and closure to protect cryomodule
- Cryomodule helium circuits are pressurized by the cold box transient
- The safety valve which should have protected the rupture disk does not open: calibration was too close to disk limit
- Rupture disk burst open, helium is released in the hall (15:53:59)
- Hall evacuated by fire brigade
- First analysis
- First crisis meeting (16:50)
- Rupture disk is replaced in situ, preventing air in-leak (~ 19:30)

all details at:

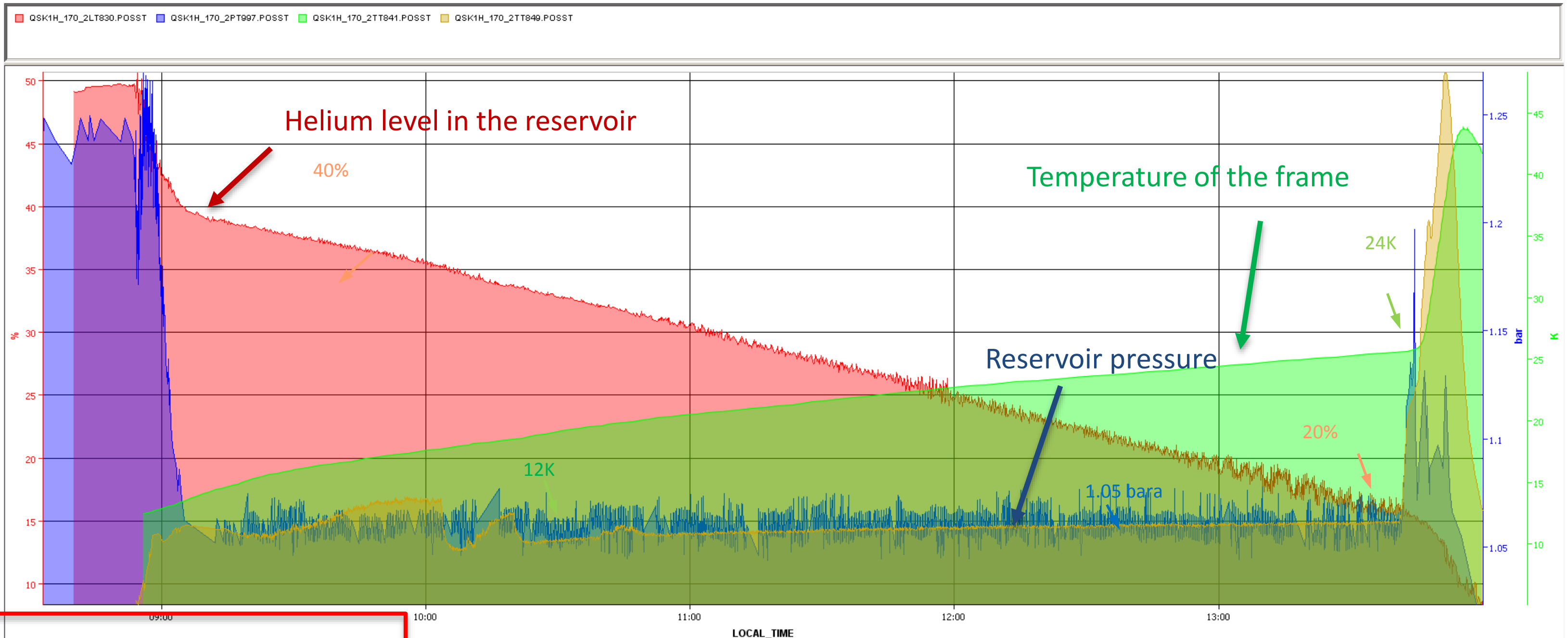
- https://edms.cern.ch/document/1535758/1
- https://edms.cern.ch/document/1535759/1
- https://edms.cern.ch/document/1536156/1
- https://edms.cern.ch/document/1536524/1

Static heat load measurement at 4.5 K

Distribution of heat into boil-off of liquid and structure warm-up;

Limitation: no flow meter for mass flow monitoring;

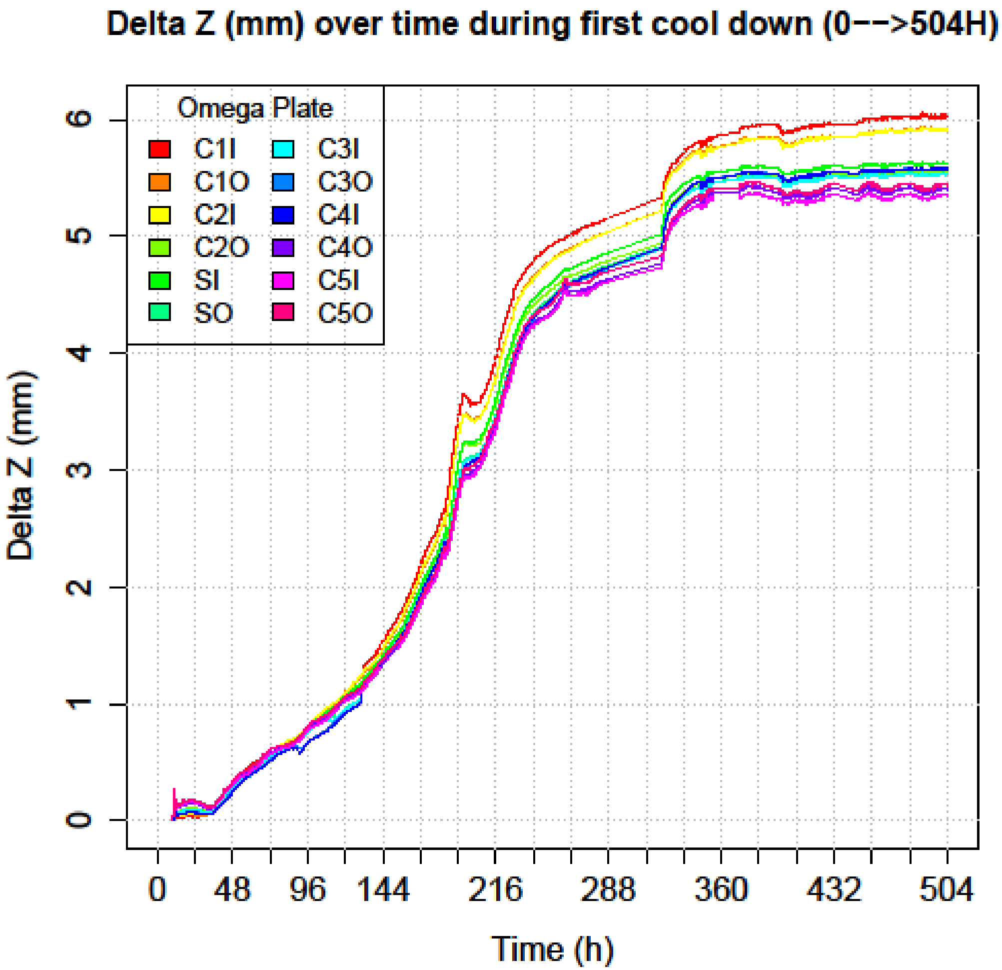
Temperatures on Thermal Shield, Cavities/Solenoid, etc. constant during the test;

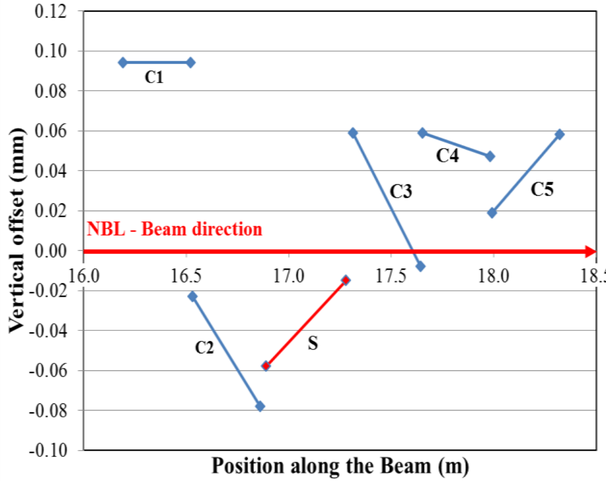


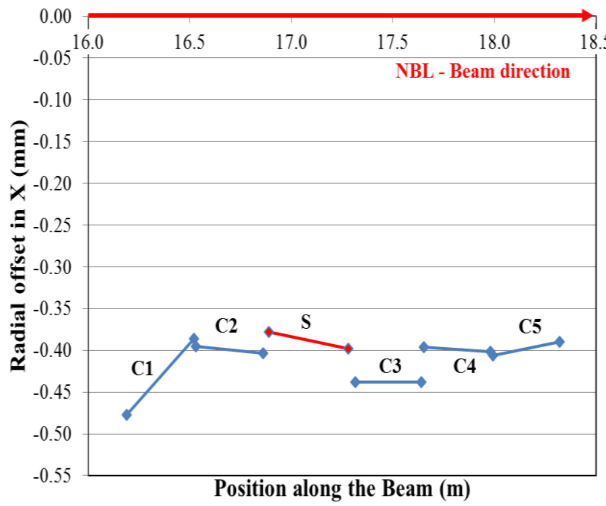
Measurement results:

STATIC HEAT LOAD WITHIN EXPECTATIONS; NO ANOMALY. CRYOSTAT DESIGN QUALIFIED

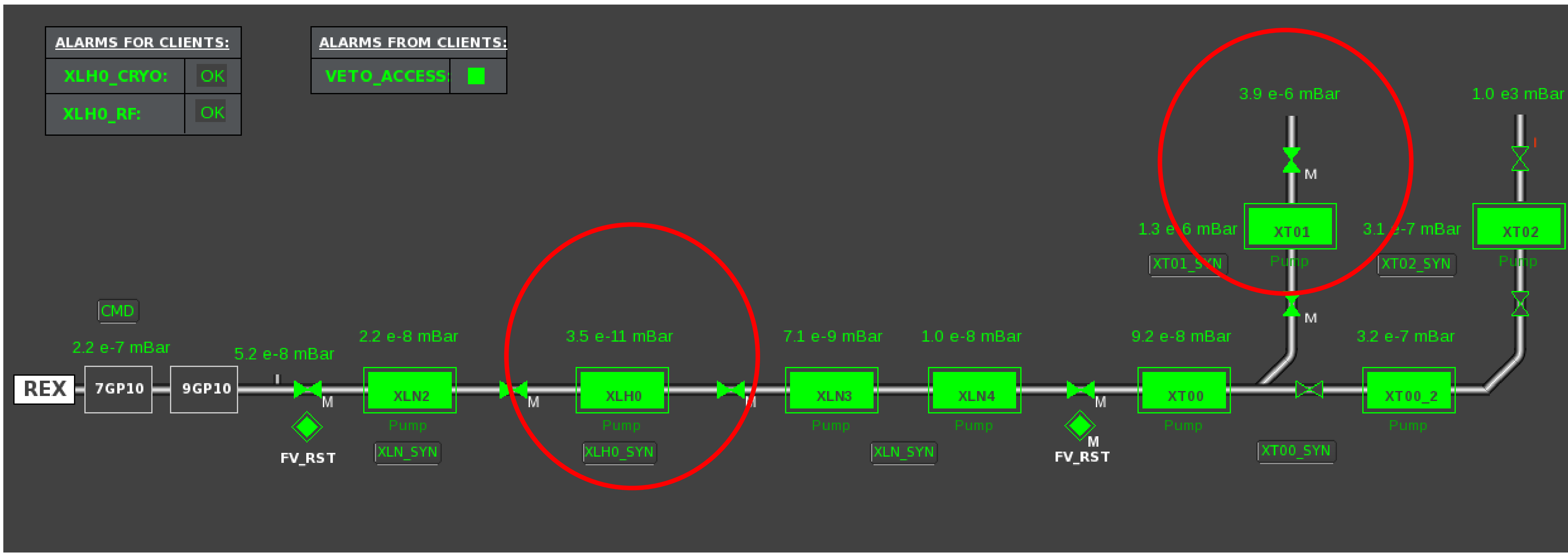
Survey and alignment



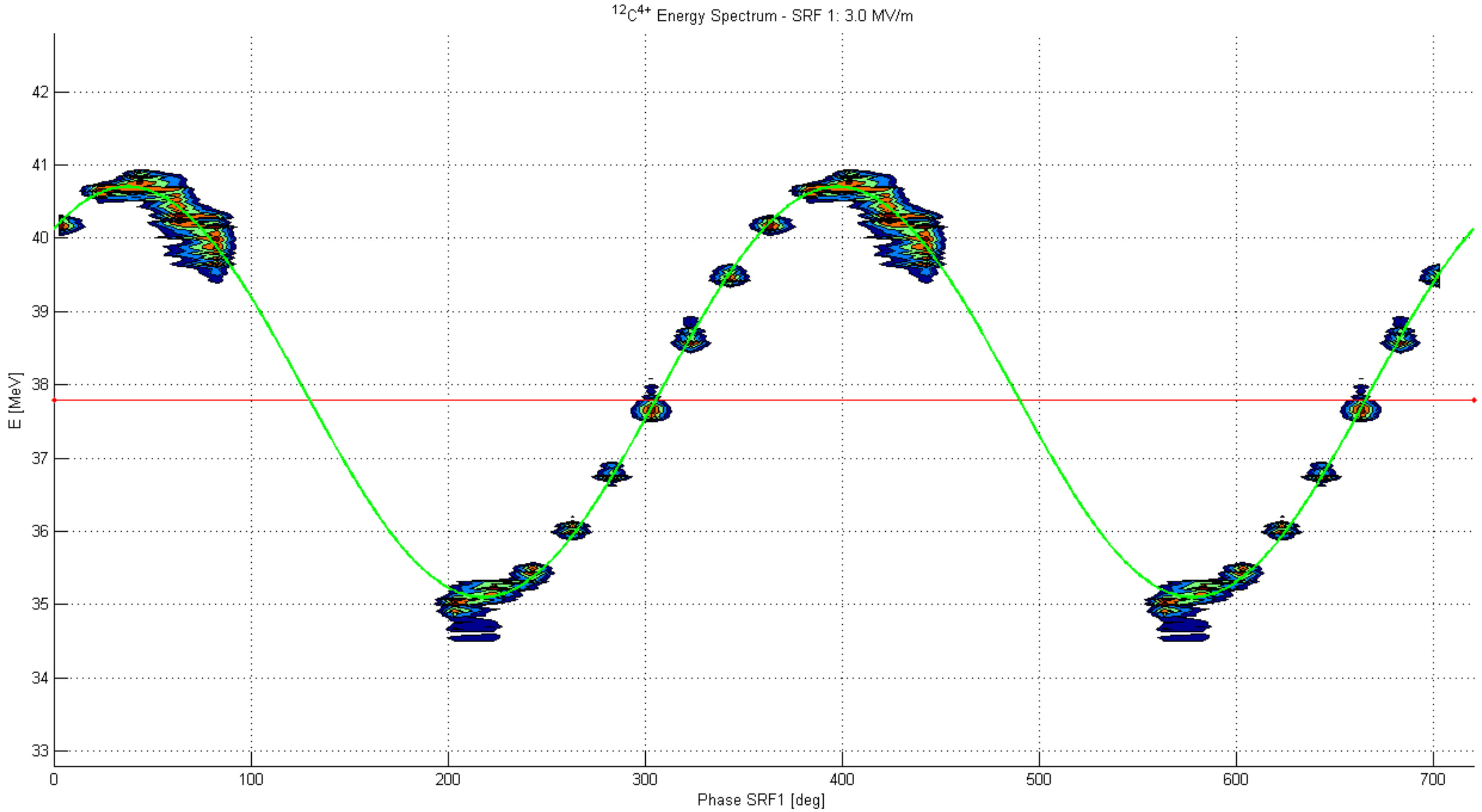




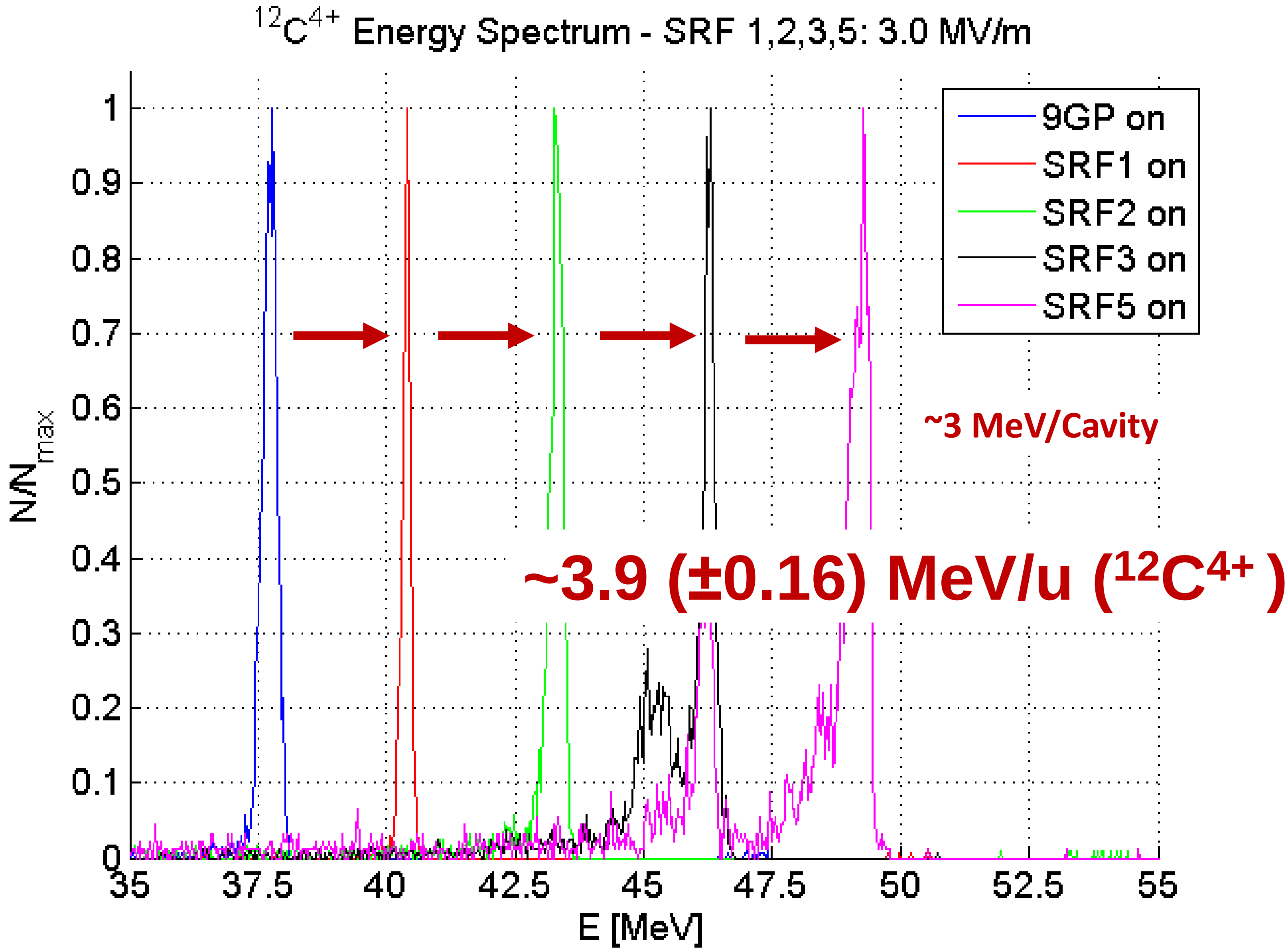
Beam vacuum from REX to the experimental stations



First beam acceleration with a HIE ISOLDE superconducting QWR



Cavity phasing with 4 cavities: first try



PENDING ISSUE(S)

Non Conformities

CERN CH-1211 Geneva 23 Switzerland

EDMS NO.	REV.	VALIDITY
XXXXXXX	0.1	DRAFT

REFERENCE
HIE-EQCOD-NC-XXXX

Date: 2013-09-23

Nonconformity Report

IDENTIFICATION	
1. Originator's Name: W. Venturini Delsolaro	6. Date: 30.11.2015
2. Contractor/Supplier: CERN	7. Part description: Mechanical drive system of RF coupler
3. Contract No:	8. Qty:1
4. Project Engineer: V. Parma	9. Dwg No: ISLACSC_0577
5. Quality Manager: W. Venturini Delsolaro	

10. Found during what activity:	
☐ Incoming inspection	☐ Final inspection
☐ In-process inspection	X☐ Other: commissioning

11. Description of nonconformity (use continuation page if necessary)

Anomalous friction on the mechanical drive axis of cavity #5 RF coupler

12. Action taken to prevent misuse (use continuation page if necessary)

The coupler was adjusted manually for each stage of the commissioning (RF conditioning at warm, RF measurements, operation with beam), and the motor controls were disabled.

IMPORTANCE		
13.	X ☐ Non critical	☐ Critical

DISPOSITION					
14.	☐ Use-as-is	☐ Repair	☐ Reject	X☐ Rework	☐ Return to supplier

Description of proposed action (use continuation page if necessary)
With the measures described above, the coupler could be used for the first physics run, with some limitations. Since the cryomodule is taken out of the machine, it is suggested to ascertain the cause of the friction and remove it.

CORRECTIVE/PREVENTIVE ACTION

15. Description of proposed action (use continuation page if necessary)

1) Check friction after warm up
2) Check friction after transport
3) Check friction after venting
4) Visually inspect the axis after opening

APPROVAL OF NON CRITICAL NONCONFORMITIES		
16	Project Engineer:	Date:

APPROVAL OF CRITICAL NONCONFORMITIES		
17	Project Management:	Date:

1. Anomalous friction on CAV5 coupler axis
2. Impedance change in solenoid circuit
3. Overheating of the couplers
4. Blocked horizontal degree of freedom of frame adjustment system
5. A few survey targets lost
6. Condensation on the top flange

RF couplers issue: recap

- First observations in CM1: RF shifts → thermal expansion hypothesis
- Near-failure in CM1
- Cold test1 at SM18 (failure at 200 W)
- Looking for source of heat in the coupler
- Comparative survey of LNL and TRIUMF solutions
- Failure tests of antennas in oven to find limit temperature
- Cold test2 at SM18: copper braid thermalization on coupler OK
- Vacuum calculations + warm test bench (plasma hypothesis challenged)
- DC current measurements (plasma hypothesis revived)
- Thermal + RF models (ANSYS + CST)
- Cold test3 at SM18 (60 W): incipient failure
- Cold test at Cryo-lab reproducing CM1 thermalization
- Benchmarking thermal simulations
- Cold test 4 at SM18: modified coupler (Bz4→ Cu-Be, Macor→ Shapal, holes)
- New detailed RF simulations of antenna tip fields
- Improved system prototype under test

HIE ISOLDE RF coupler task force

Taskforce members:

A. Boucherie, J. Bremer, L. Dufay Chanat, T. Koettig, Y. Leclercq, E. Montesinos, A. Miyazaki, V. Parma, S. Teixeira, M. Therasse, L. Valdarno, D. Valuch, G. Vandoni, W. Venturini Delsolaro, P. Zhang.

Taskforce meetings (minutes and slides):

https://edms.cern.ch/document/1536619/1

https://edms.cern.ch/document/1539539/1

https://edms.cern.ch/document/1539542/1

https://edms.cern.ch/document/1541497/1

https://edms.cern.ch/document/1543024/1

https://edms.cern.ch/document/1551204/1

https://edms.cern.ch/document/1551205/1

https://edms.cern.ch/document/1555124/1

https://edms.cern.ch/document/1556843/1

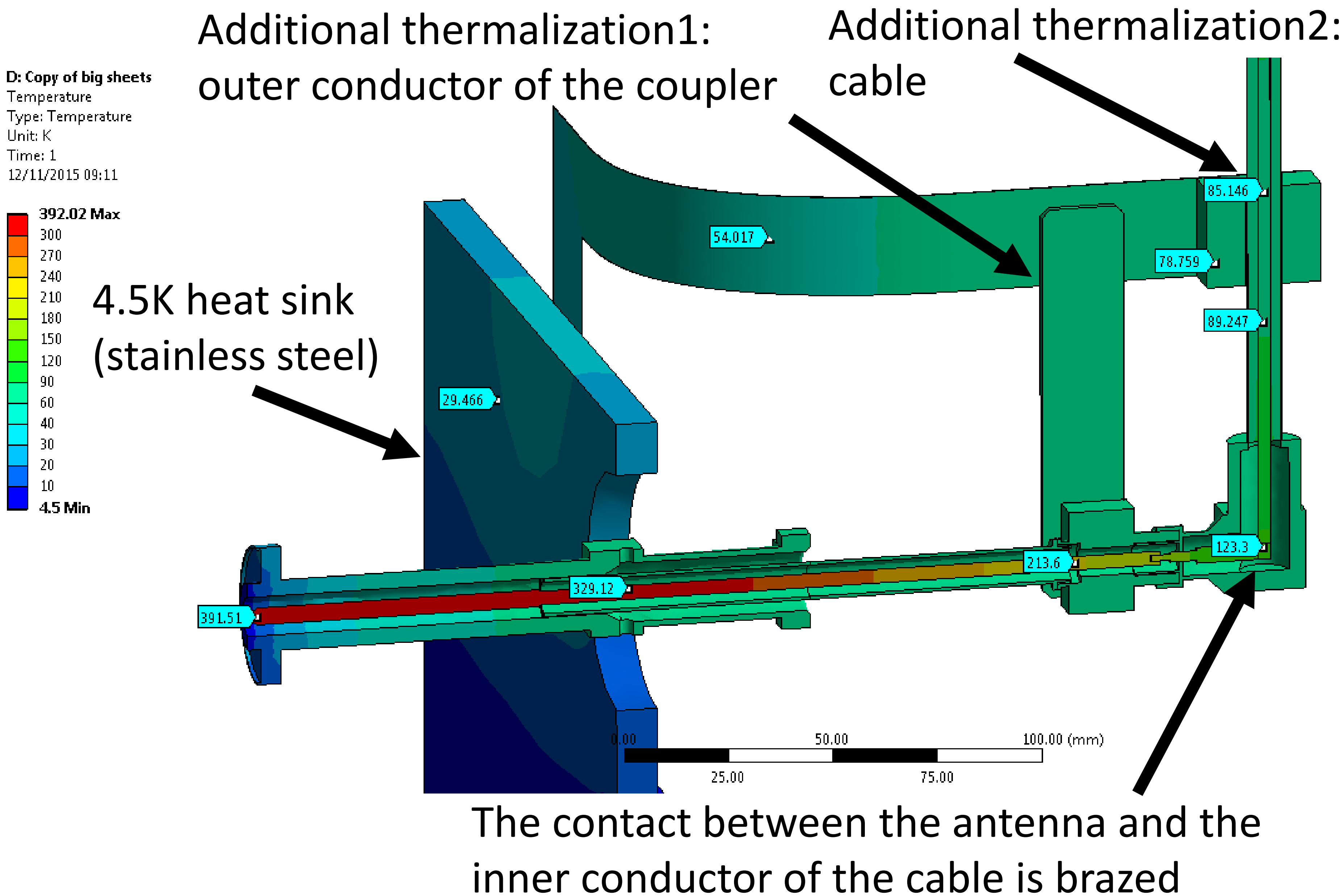
https://edms.cern.ch/document/1558989/1

https://edms.cern.ch/document/1560717/1

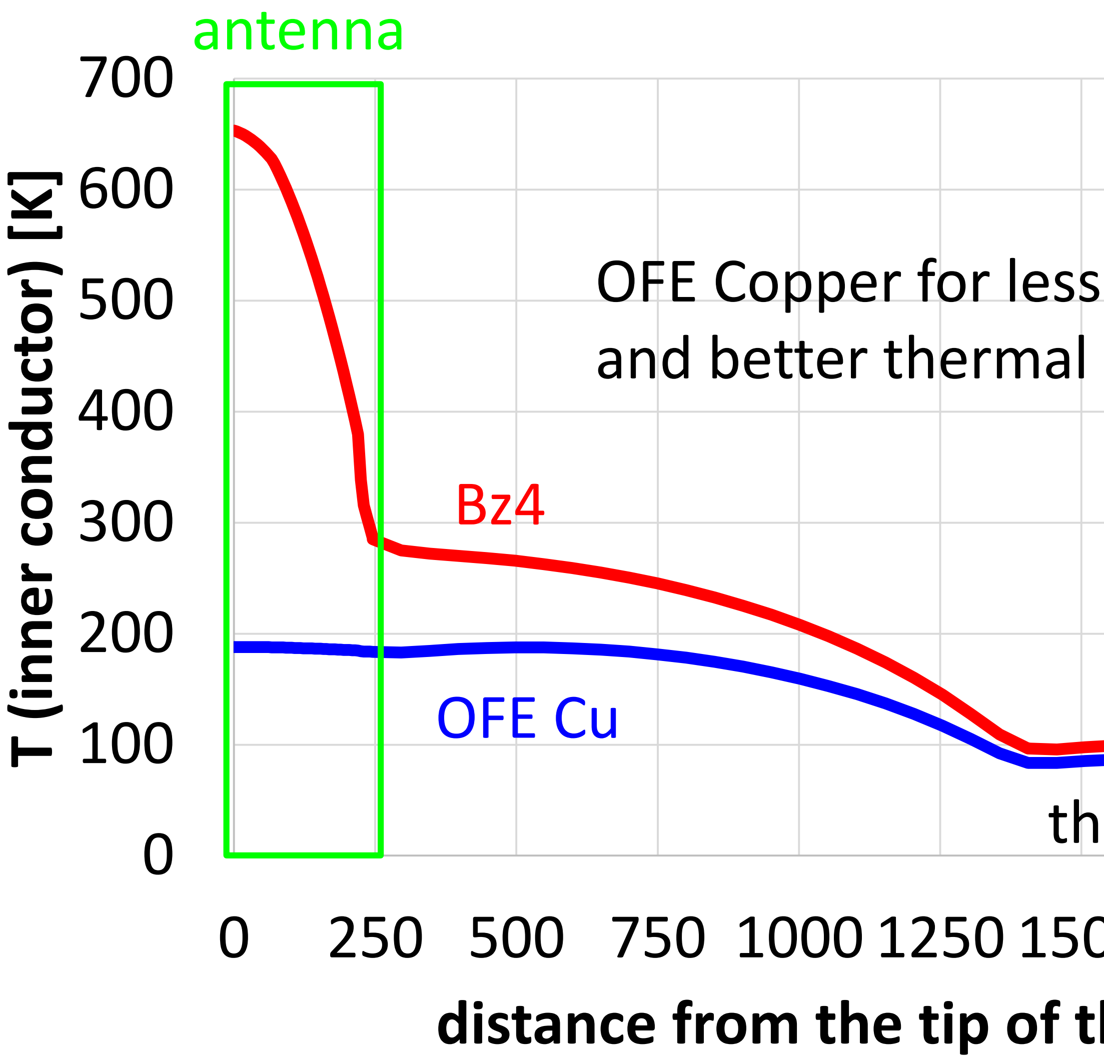
Preliminary conclusions and actions taken

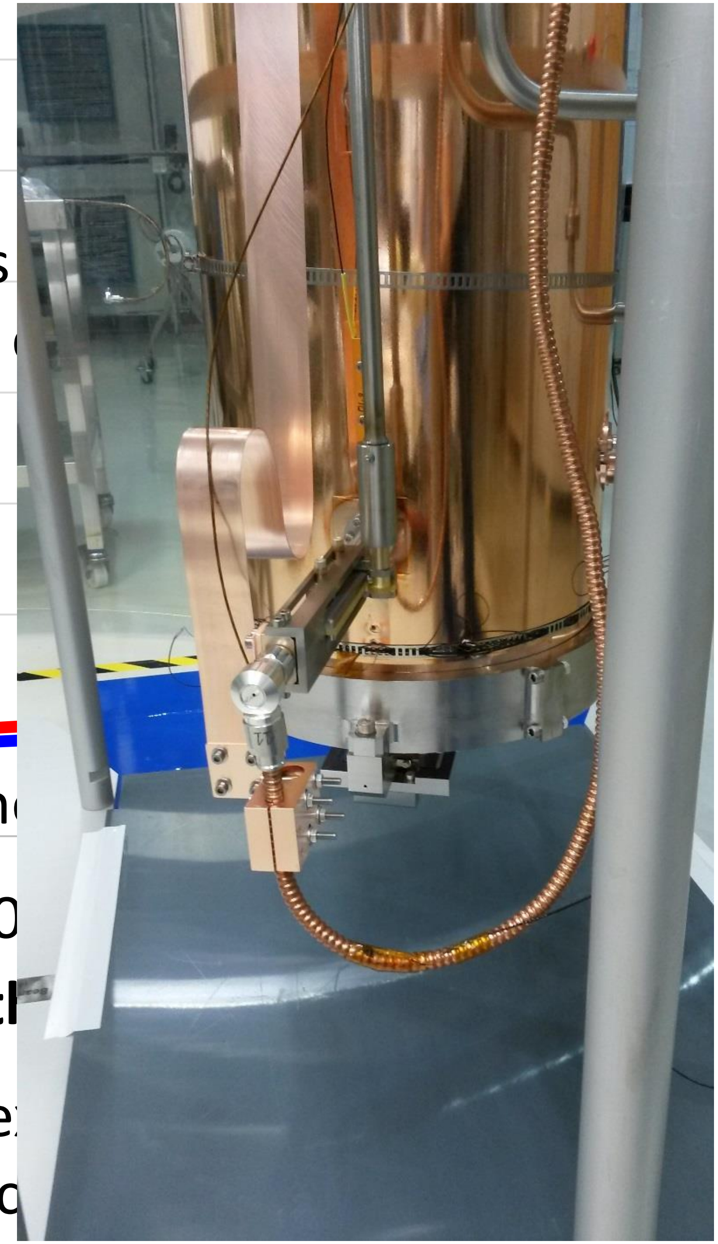
- Triggering phenomenon is pure RF heating
- Glow discharge, if present was due to consequent outgassing
- Key is cooling of the coupler antenna
- New thermalization of copper and cable
- New couplers with Cu OFE antennas soldered to the cables

Additional thermalization



Bz4 → OFE Cu (250W)





The simulation has *not yet quantitatively* e

→ A more conservative modification is nec

Conclusions

- The 2015 Hardware Commissioning campaign achieved its goals:
  - Envelopes for OP defined
  - Software & Controls operational
  - Weaknesses and limits identified and investigated
- CM design choices validated:
  - Cavity cleanliness preserved during assembly
  - Heat loads according to specs.
  - Alignment specifications fulfilled
- SC cavities field measurements confirmed with beam
- A prompt reaction to cryogenics incident saved the physics run
- RF input lines/coupler problem identified, being addressed
- Few more small issues (axis of coupler #5, horizontal alignment, diodes…)
- Next steps→ Yacine's talk

Still to be understood: