Status of the HIE-ISOLDE linac

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on behalf of the HIE-ISOLDE project

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Contributors

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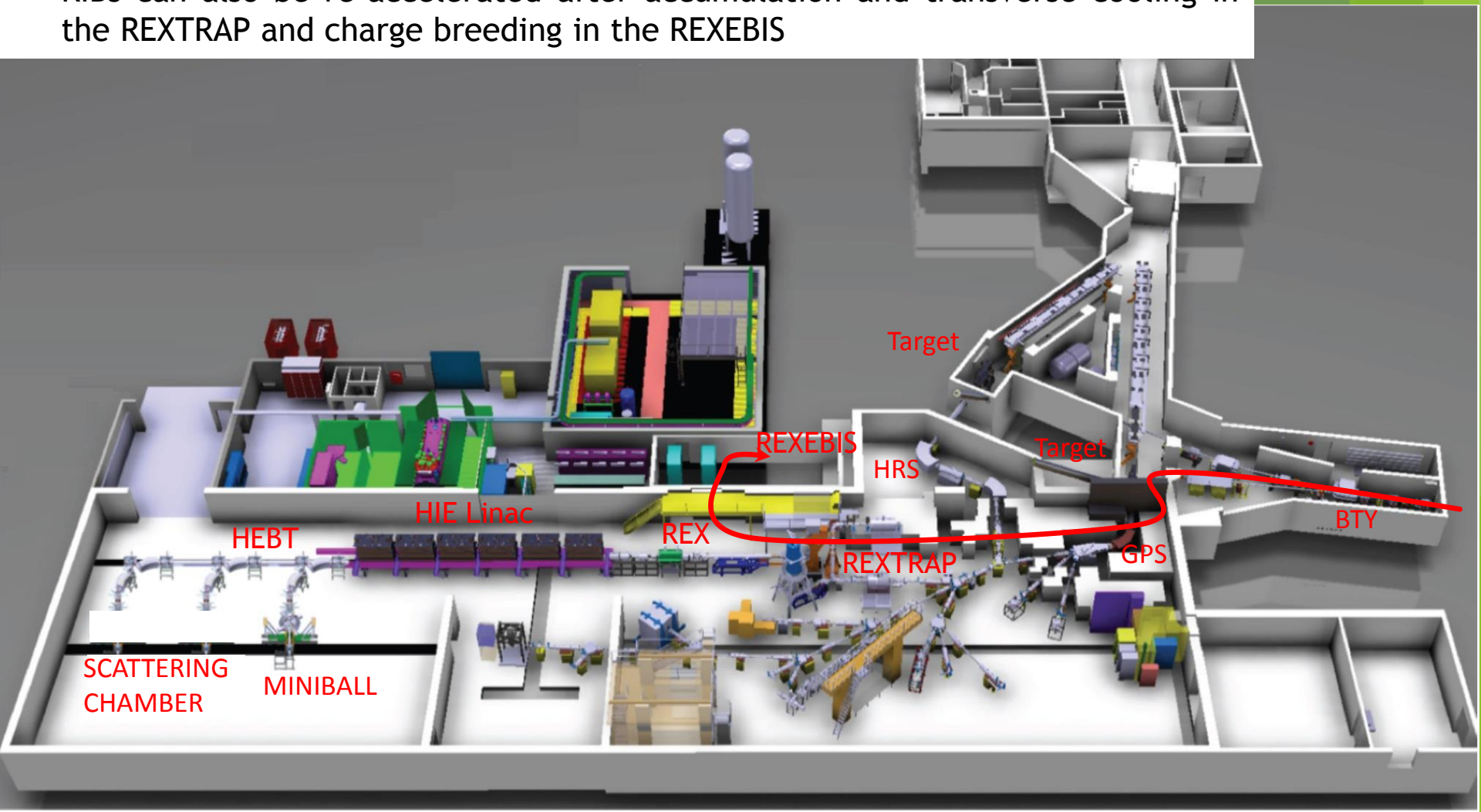
Outline

- HIE ISOLDE project phases
- Highlights from Phase 1a and 2015 physics run
- Addressing RF coupler issues
- Refurbishing/overhauling over the winter stop
- Commissioning campaign of 2016, Phase 1b
- Conclusions and outlook

ISOLDE Complex

- RIBs produced by impinging 1-1.4 GeV protons on ISOL targets
- RIBs are selected in either the General Purpose or High resolution Separators (GPS, HRS) and transported to a low energy experimental station
- RIBs can also be re-accelerated after accumulation and transverse cooling in the REXTRAP and charge breeding in the REXEBIS



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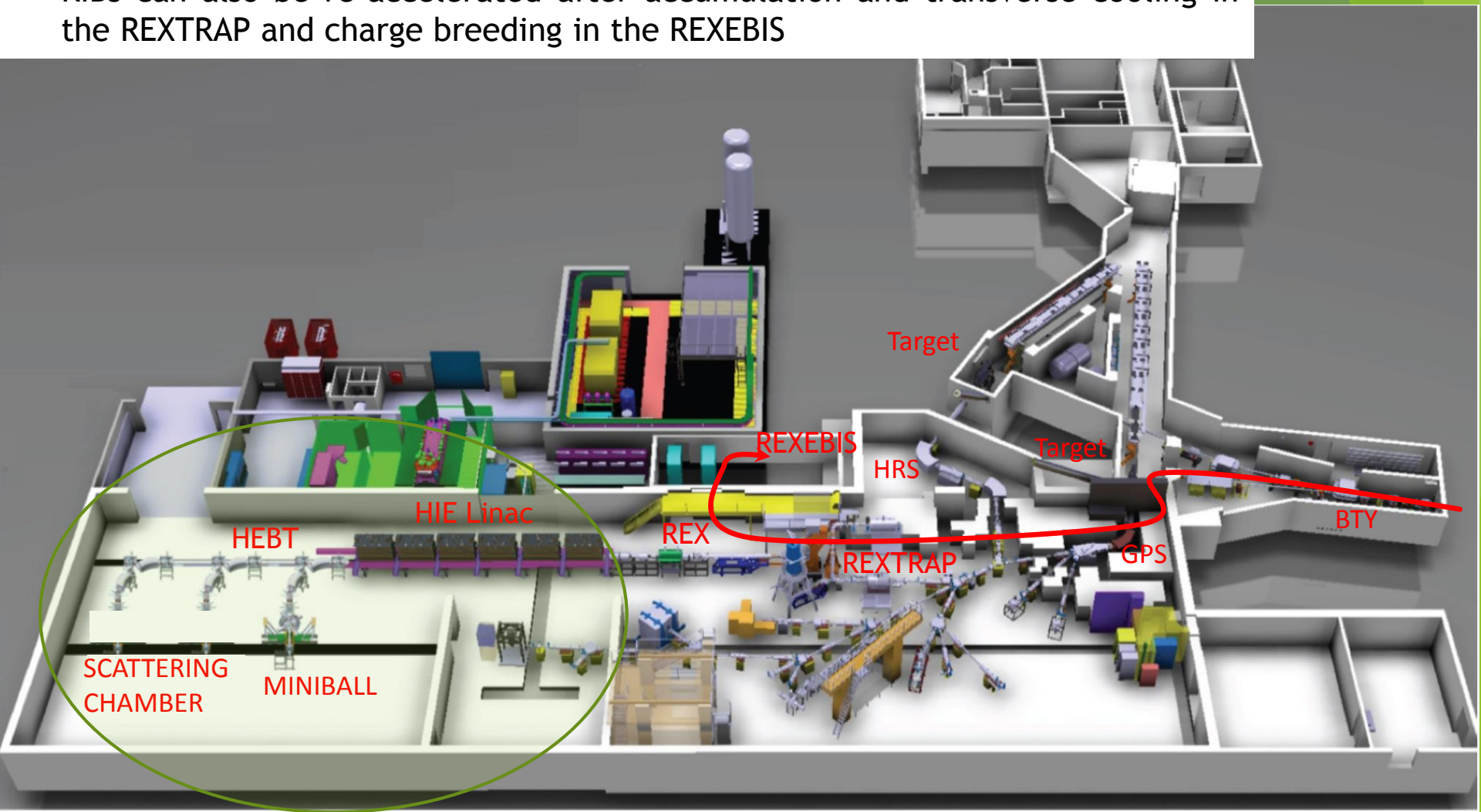
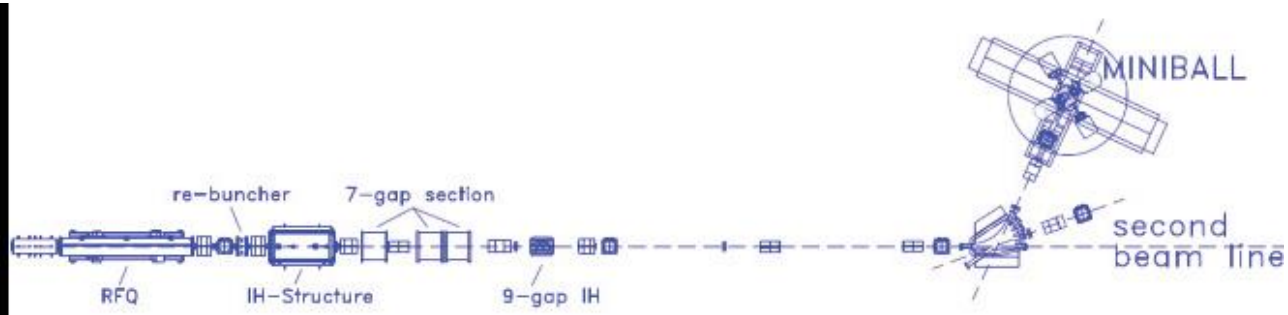
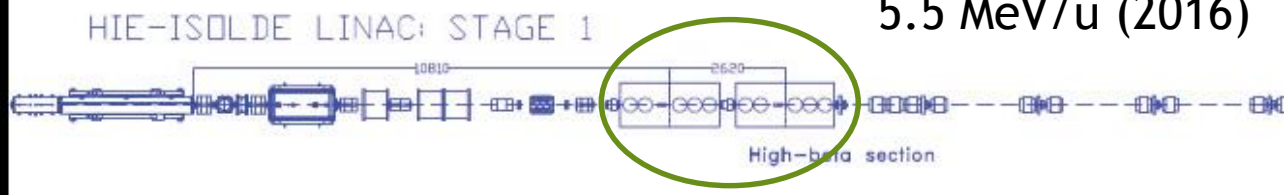
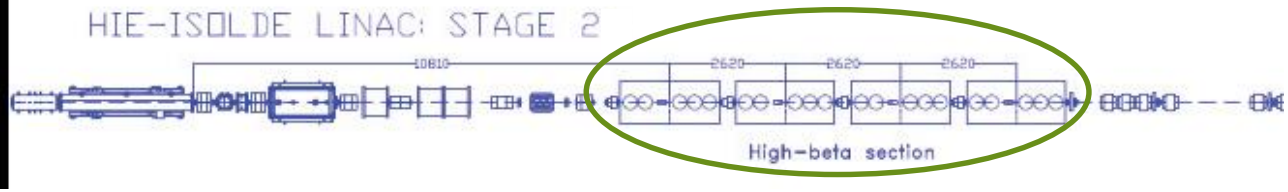


HIE-ISOLDE phases



5.5 MeV/u (2016)



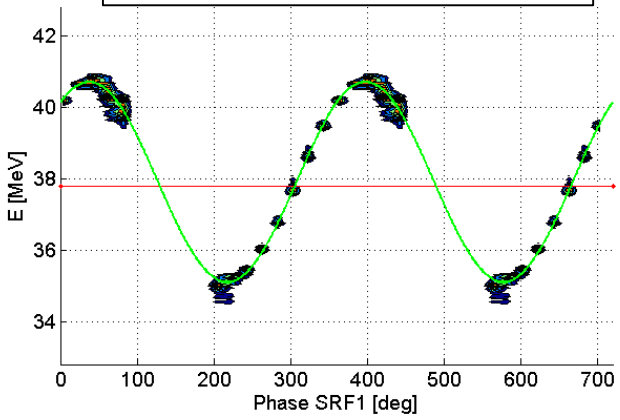


10 MeV/u (2018)

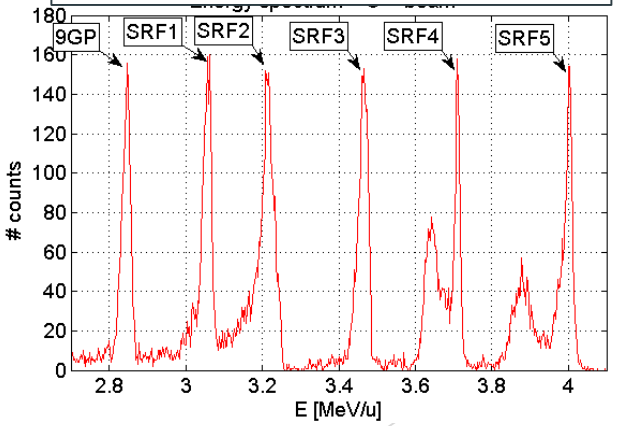
HIE-ISOLDE phase1a (2015)

- Commissioning of 1 (prototype) cryomodule and 2 HEBT lines
- Validation of cryogenics heat loads, vacuum performance, cleanliness (assembly procedures), RF performance, omission of magnetic shielding OK, solenoid stray fields, LLRF, alignment during cool down, etc.
- Main (serious!) non conformity: overheating of RF power couplers
- Managed to save a minimal physics run

Phasing the first SRF cavity



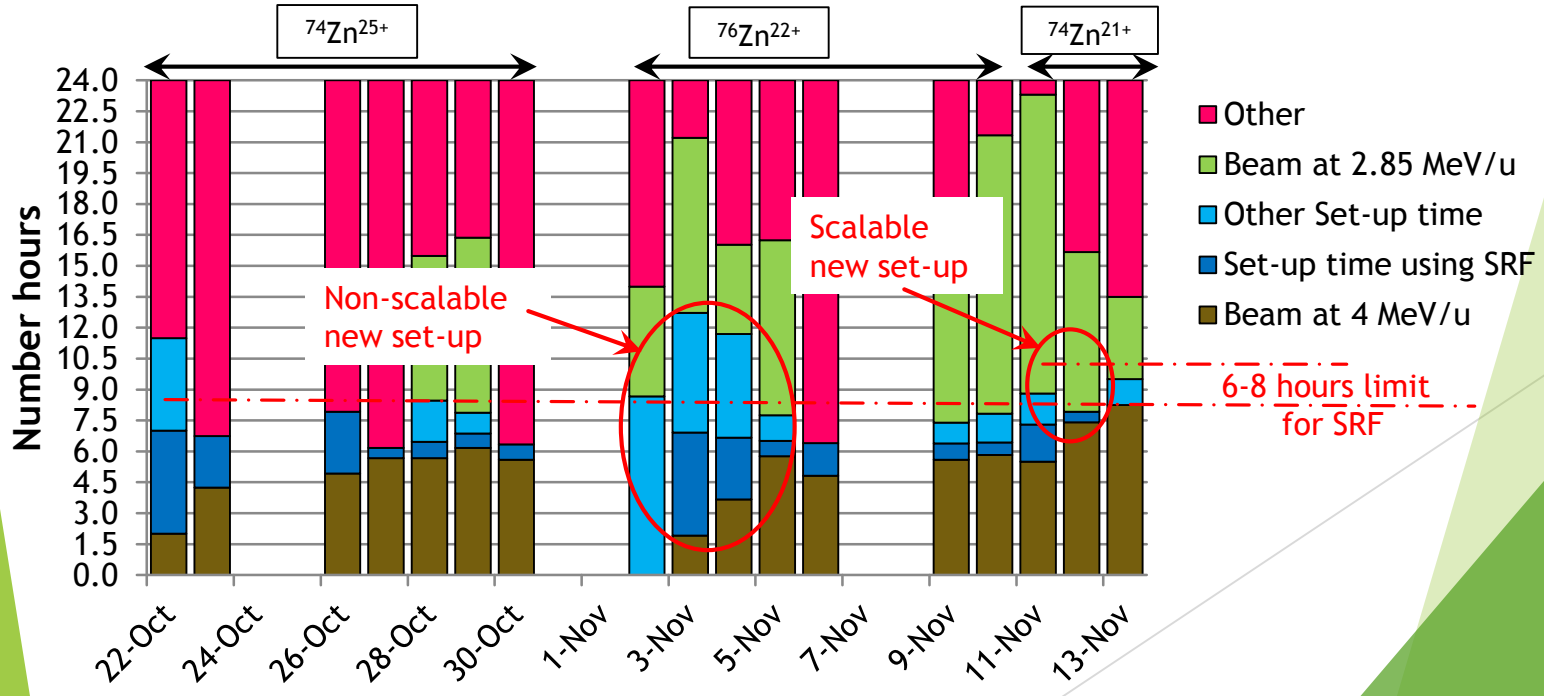
Energy spectrum of $^{12}C^{4+}$ beam turning off one SRF cavity at a time



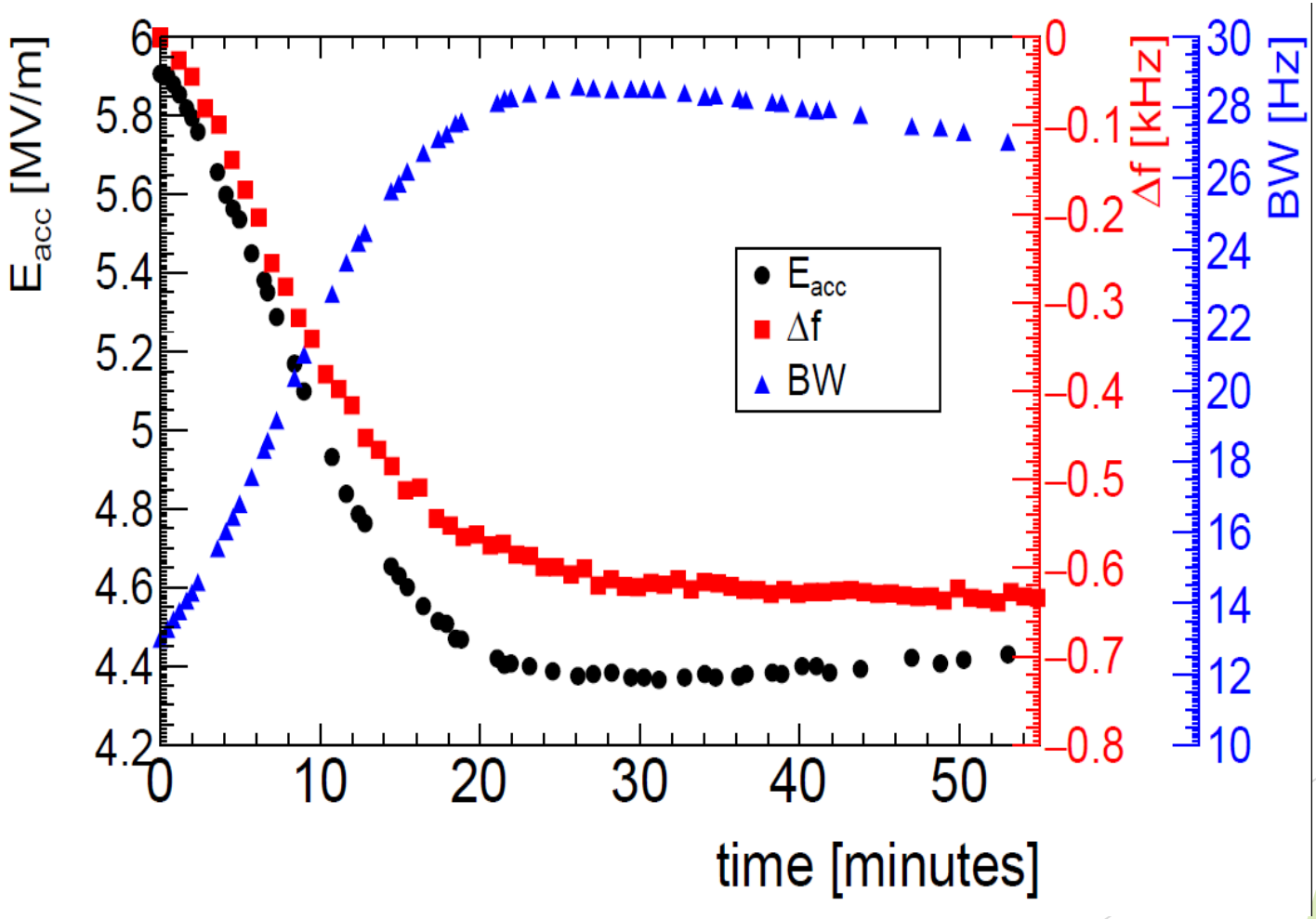
2015 Physics run

- Short (5 weeks) but useful…
- Two RIBs (^{74}Zn, ^{76}Zn) to the MINIBALL experimental station
- Two energies: 4 MeV/u - 2.85 MeV/u (while SRF off due to the problem of the RF couplers)

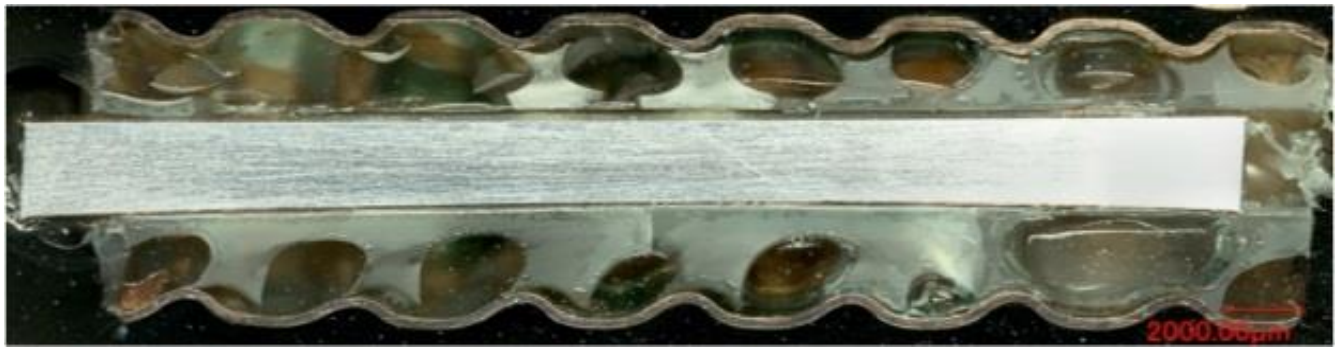
Beam	To:	Energy [MeV/u]	Time [hours]
$^{22}Ne^{7+}$	Miniball	2.85	~ 60
$^{74}Zn^{25+,21+}$	**Miniball**	**2.85 / 4**	**~ 90**
$^{76}Zn^{22+}$	**Miniball**	**2.85 / 4**	**~ 90**
$^{14}N^{4+}$	Scat. Ch.	2.85 / 4	~ 2
$^{12}C^{4+}$	Scat. Ch.	4	~ 2
$^{133}Cs^{39+}$	SPEDE	2.85 / 4	~ 110



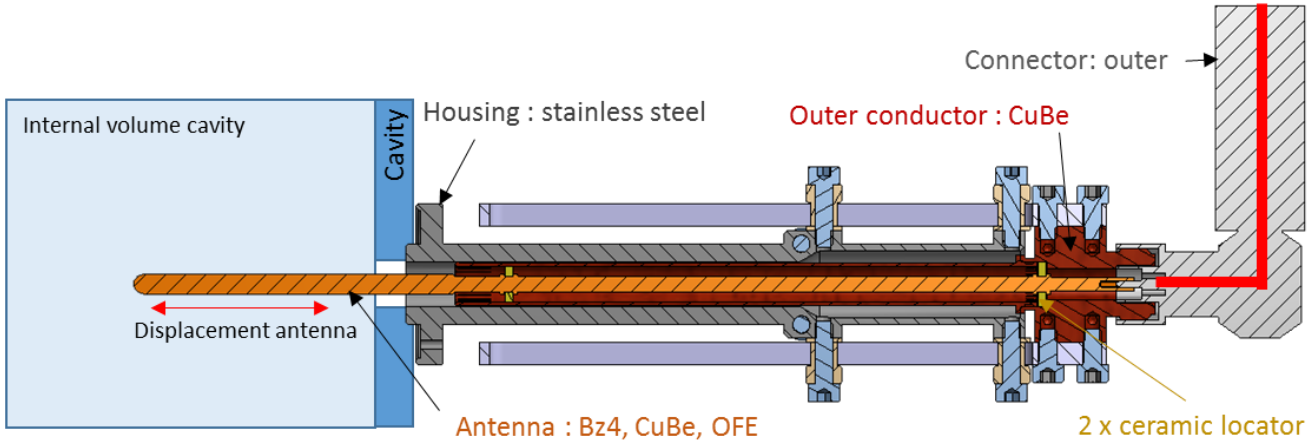
RF coupler overheating symptoms

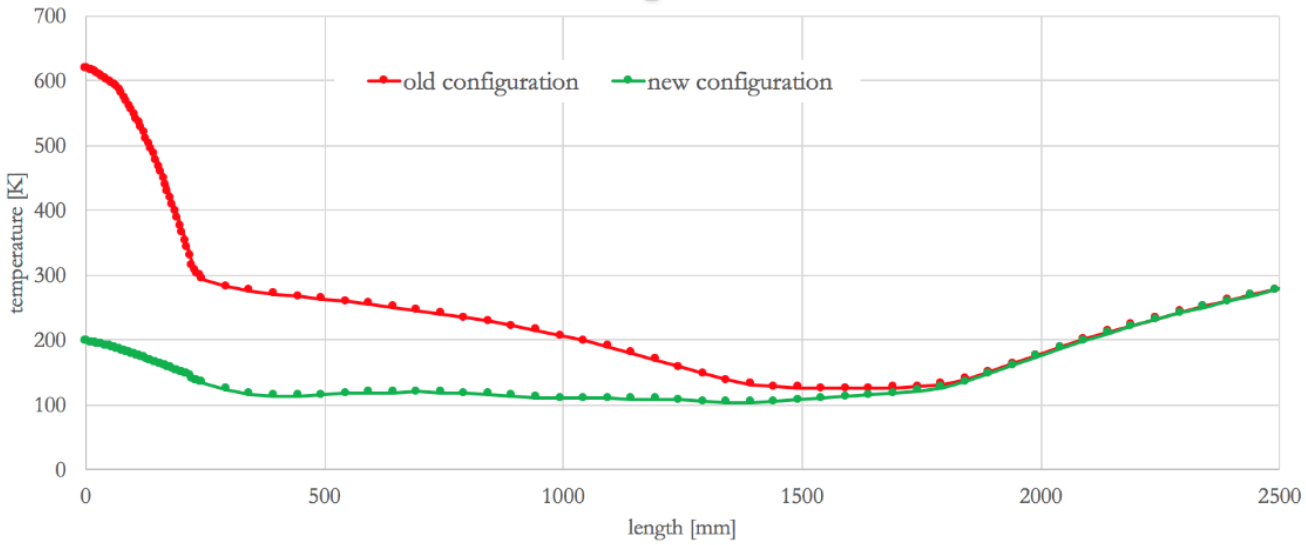


RF coupler post mortem (off line stress test, 200 W)



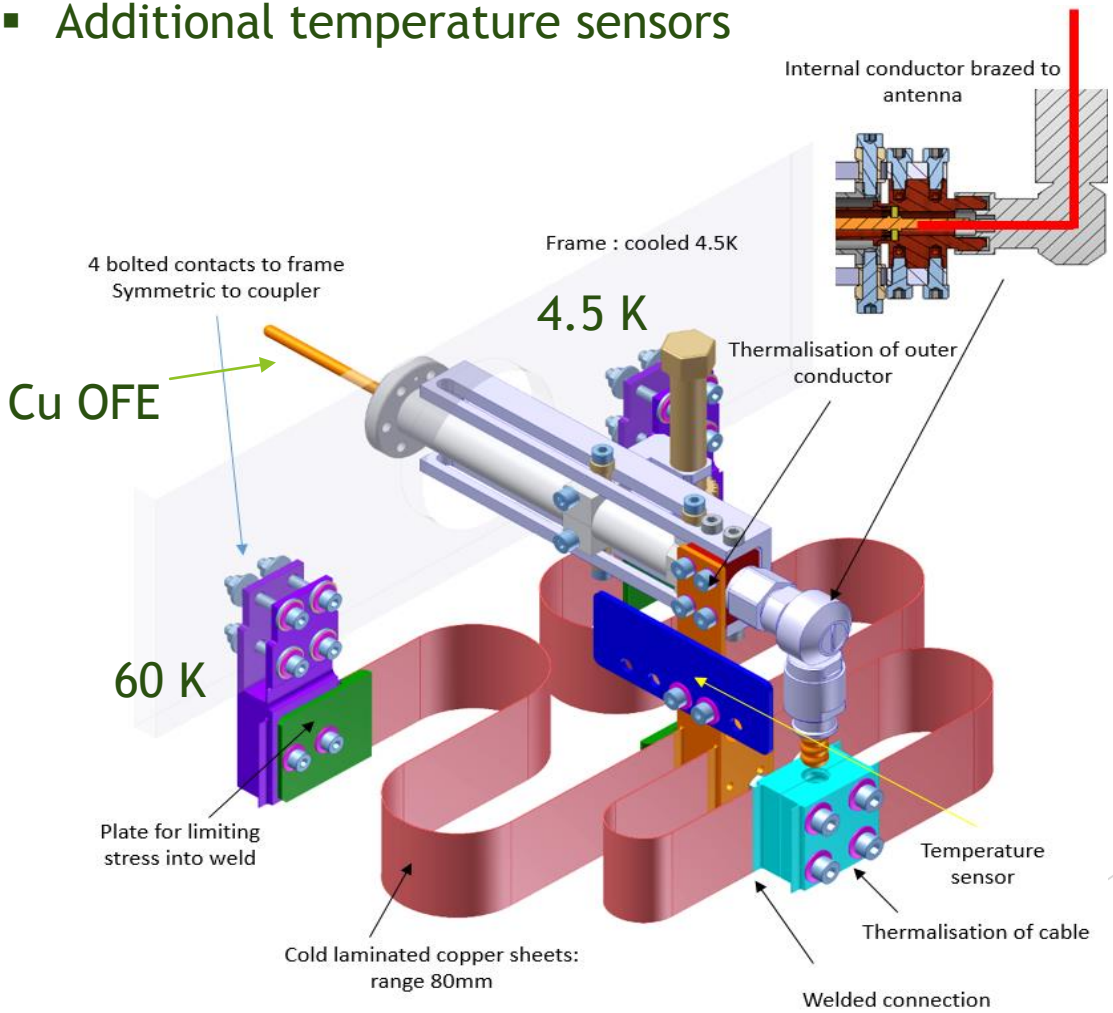
RF and thermal simulations



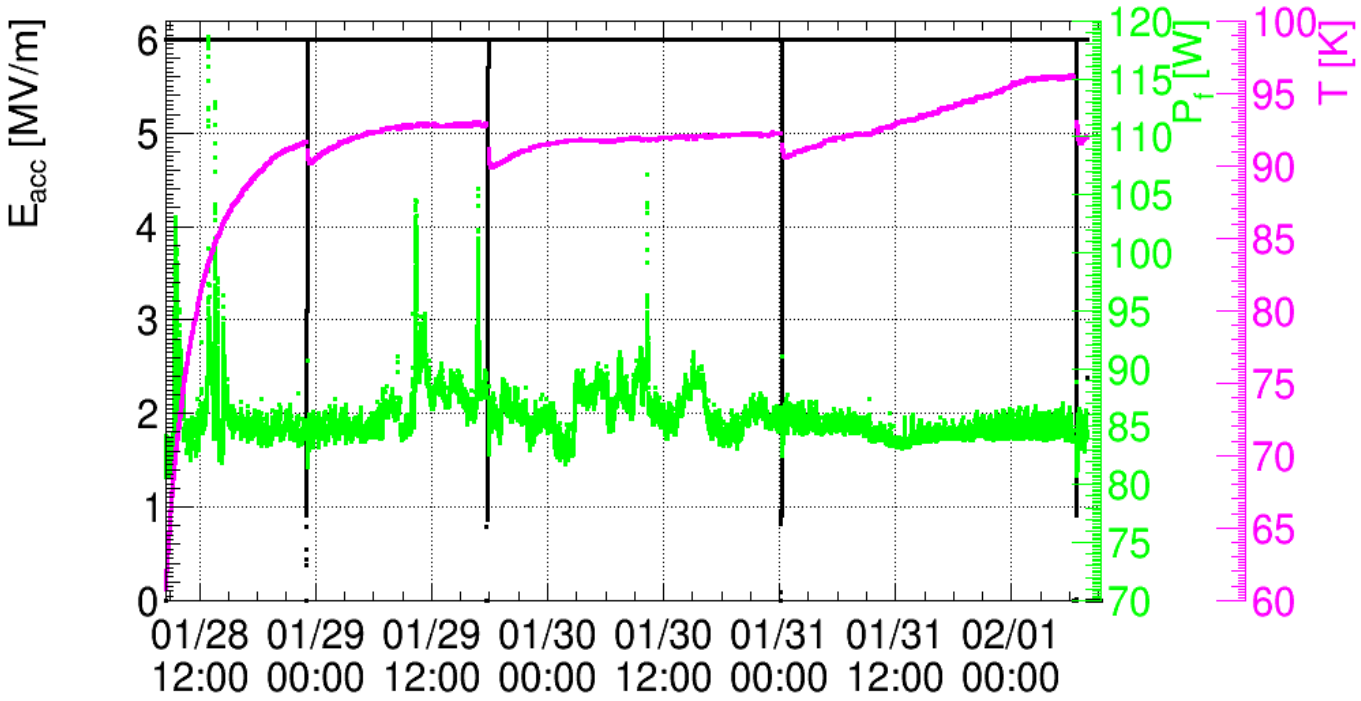


New coupler design

- OFE copper for antenna
- Antenna brazed to RF cable inner conductor
- Reworked thermalization of the RF cable and coupler
- Additional temperature sensors



Prototype validation



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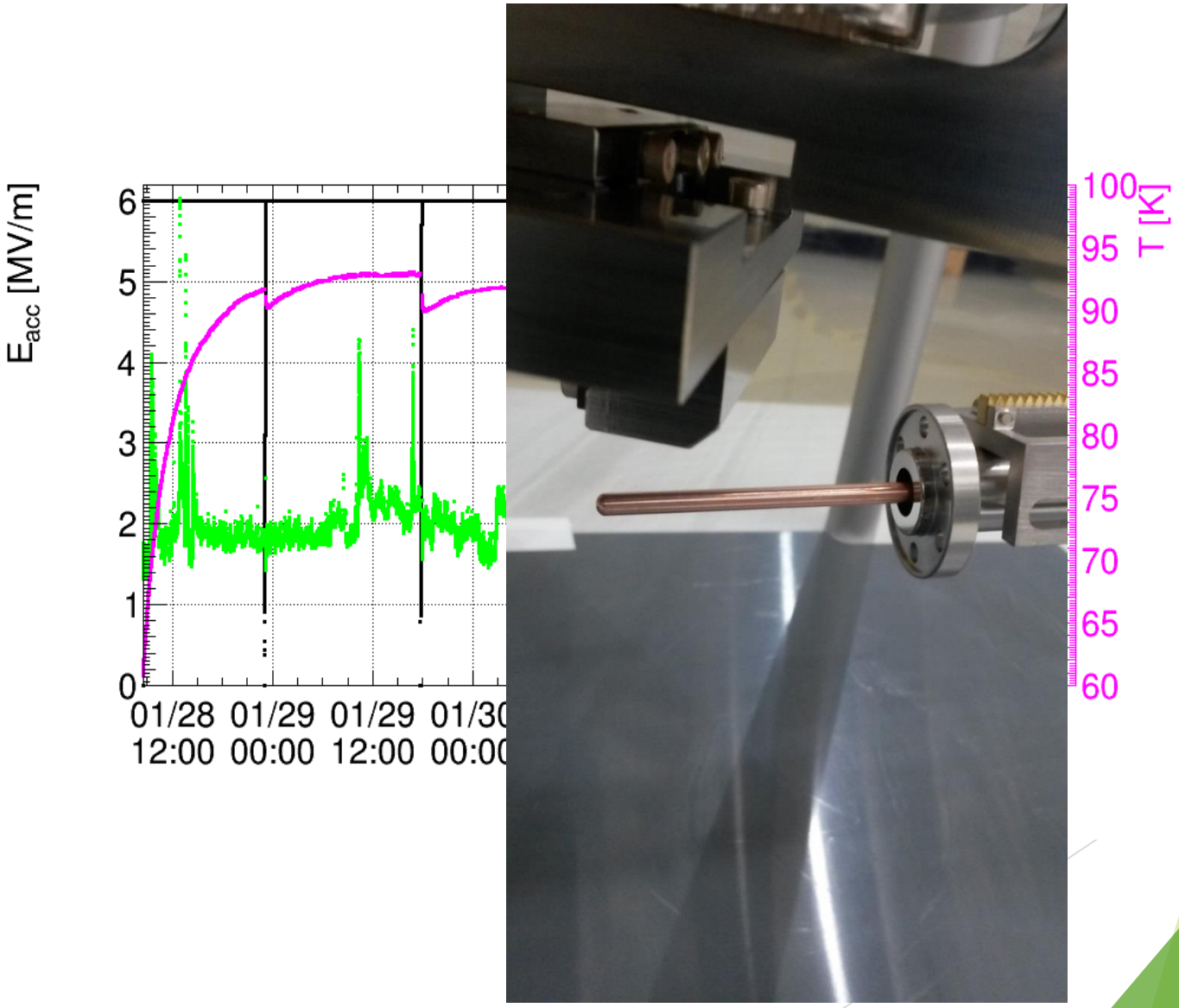
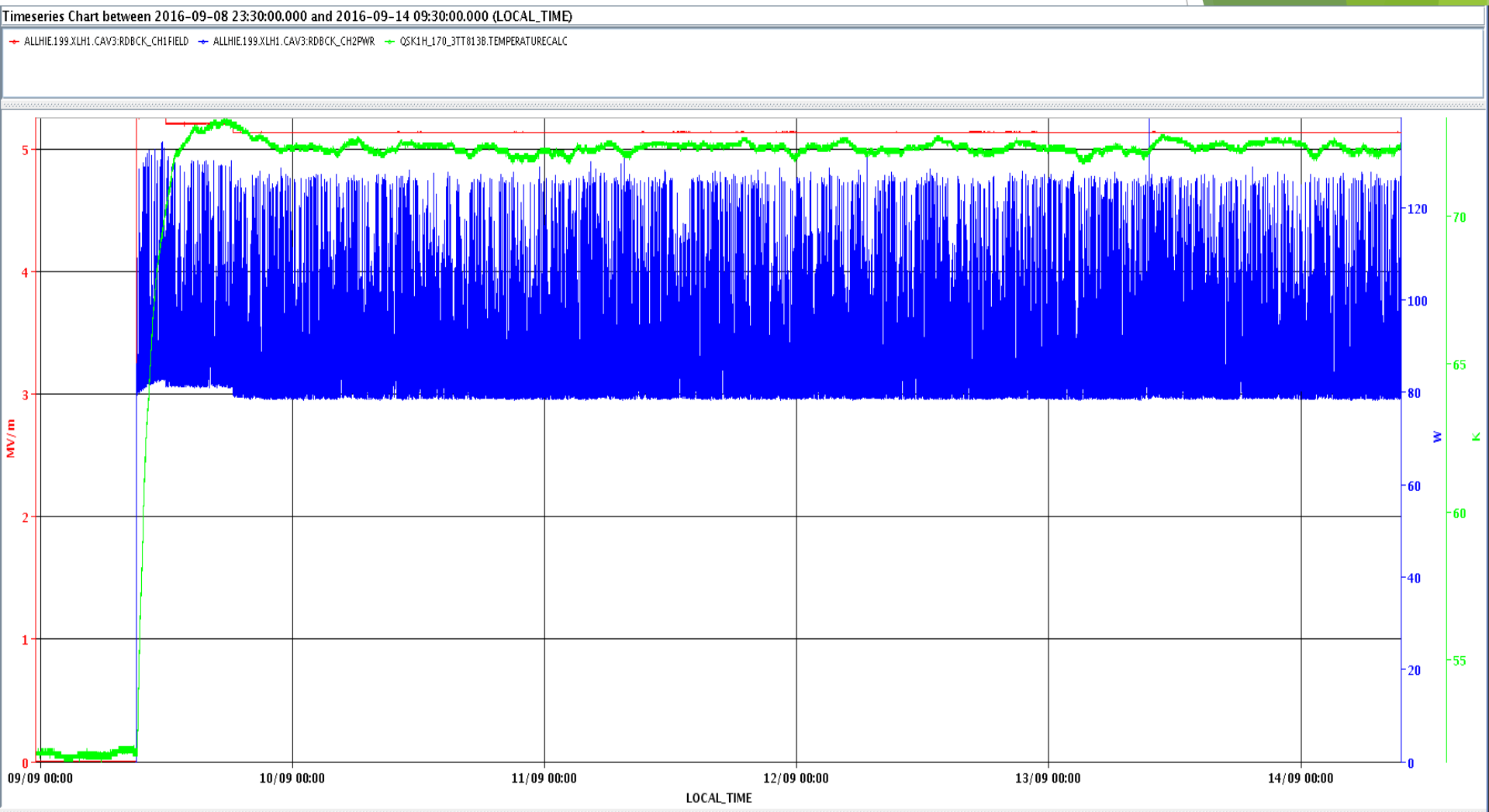
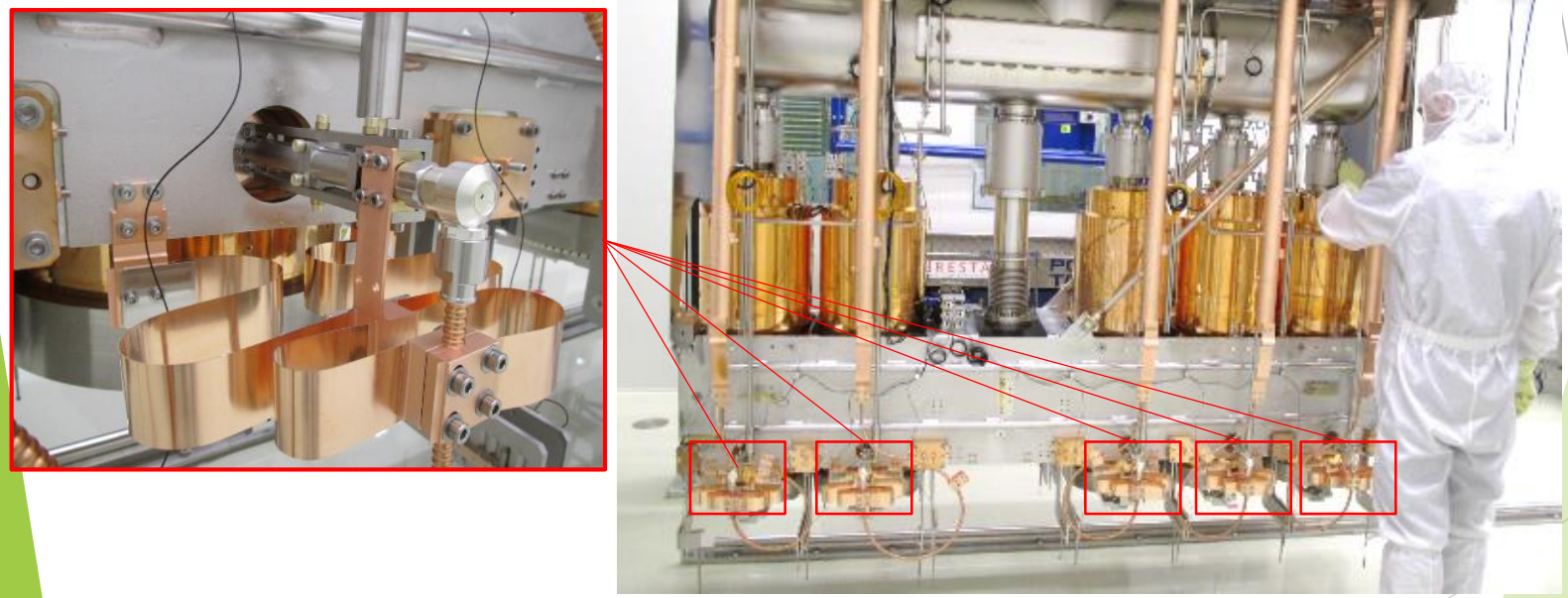


Behaviour in the linac



CM1 leaving the tunnel

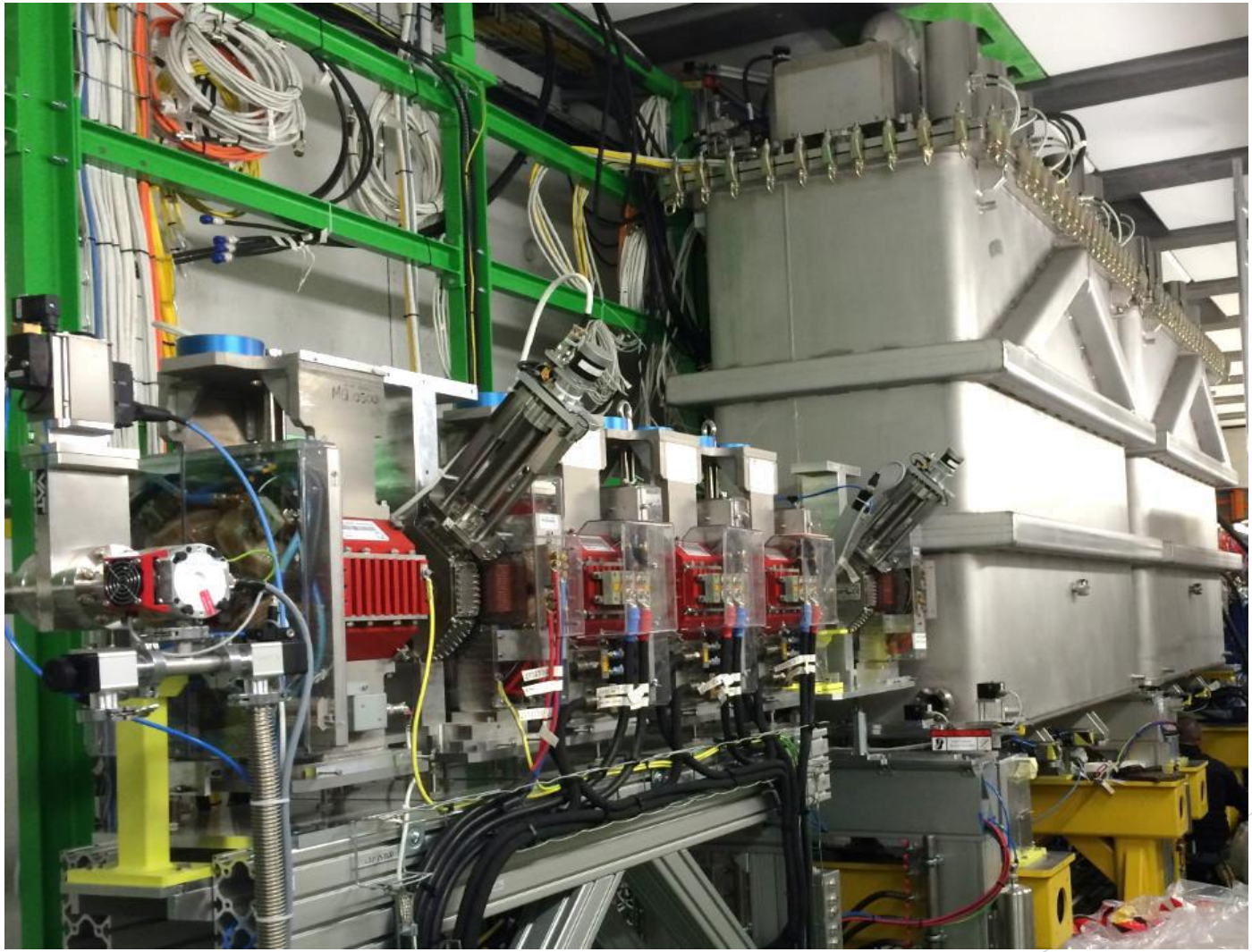
Assembly of new couplers in CM2



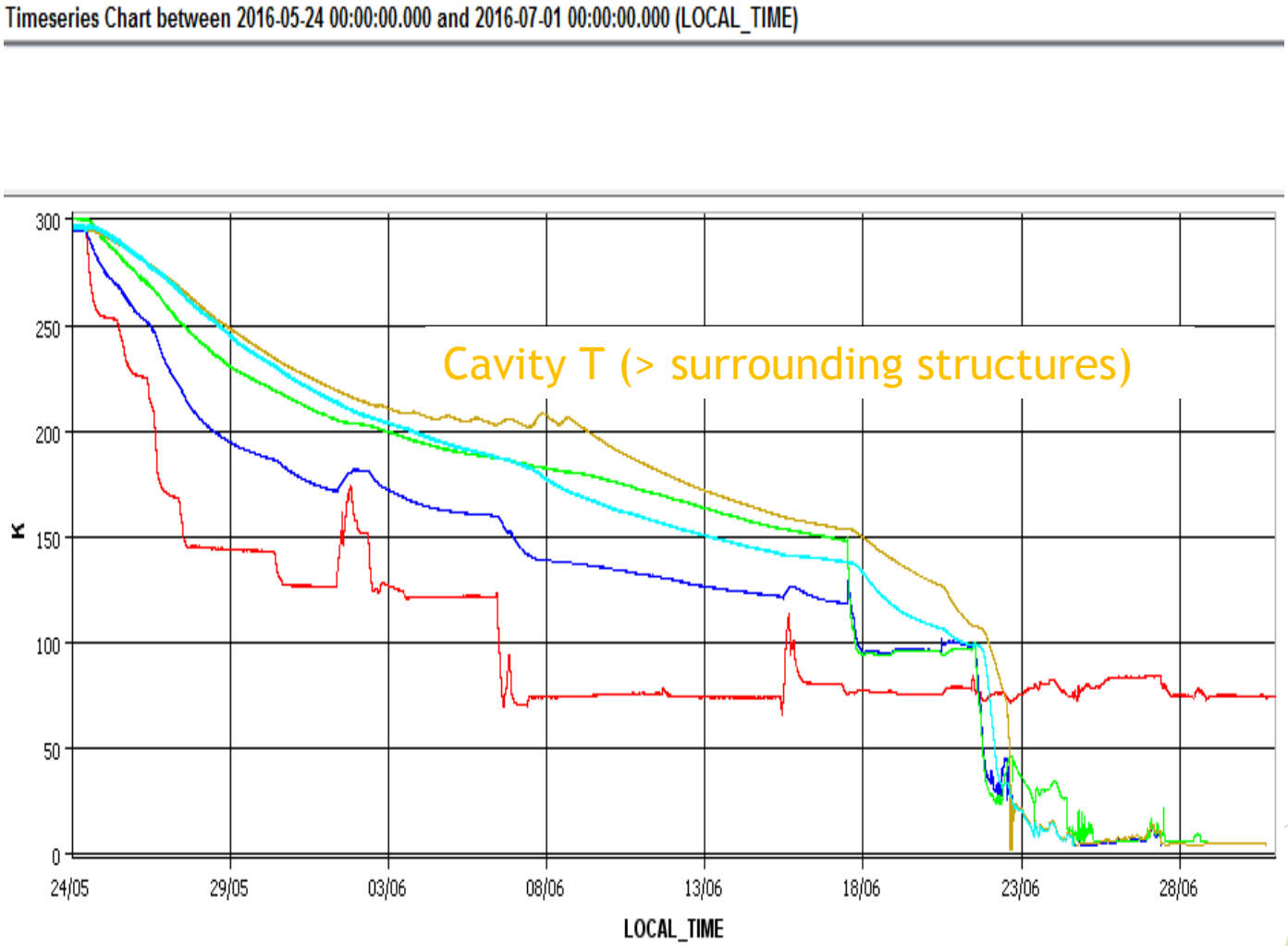
CM1 going to be refurbished

CM1 back to the tunnel

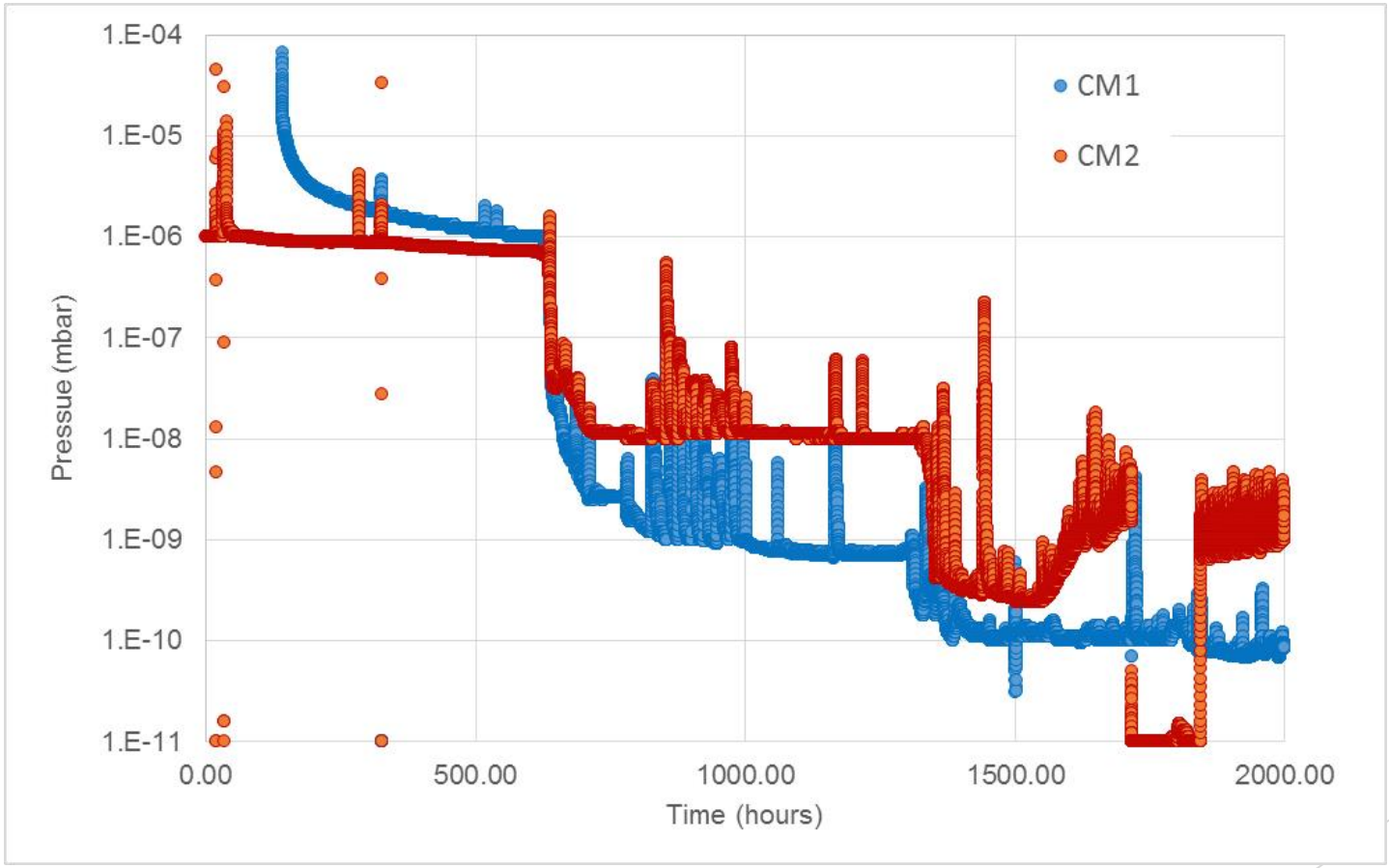
HIE ISOLDE linac complete (Phase 1)



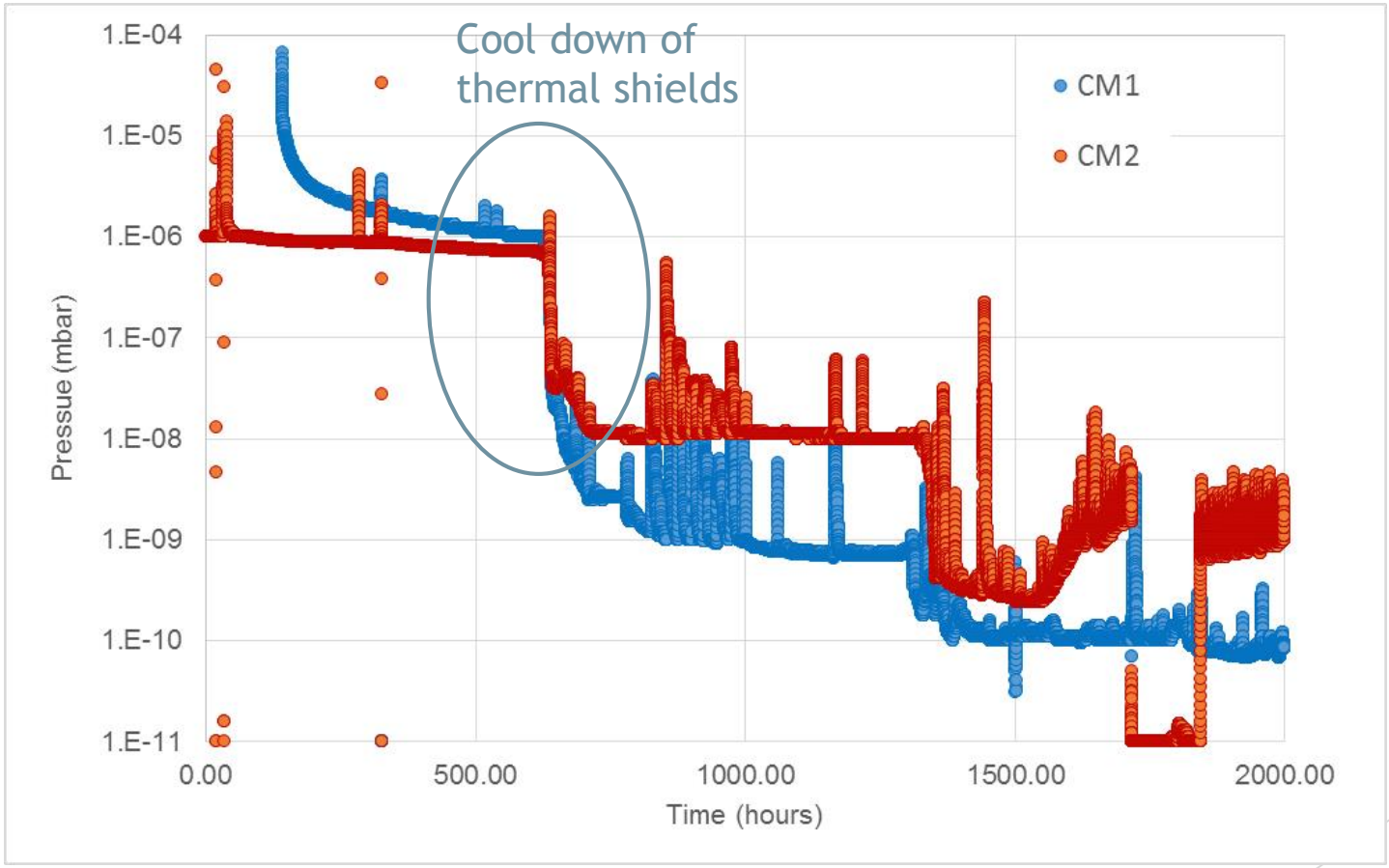
Cool down of CM1 and CM2



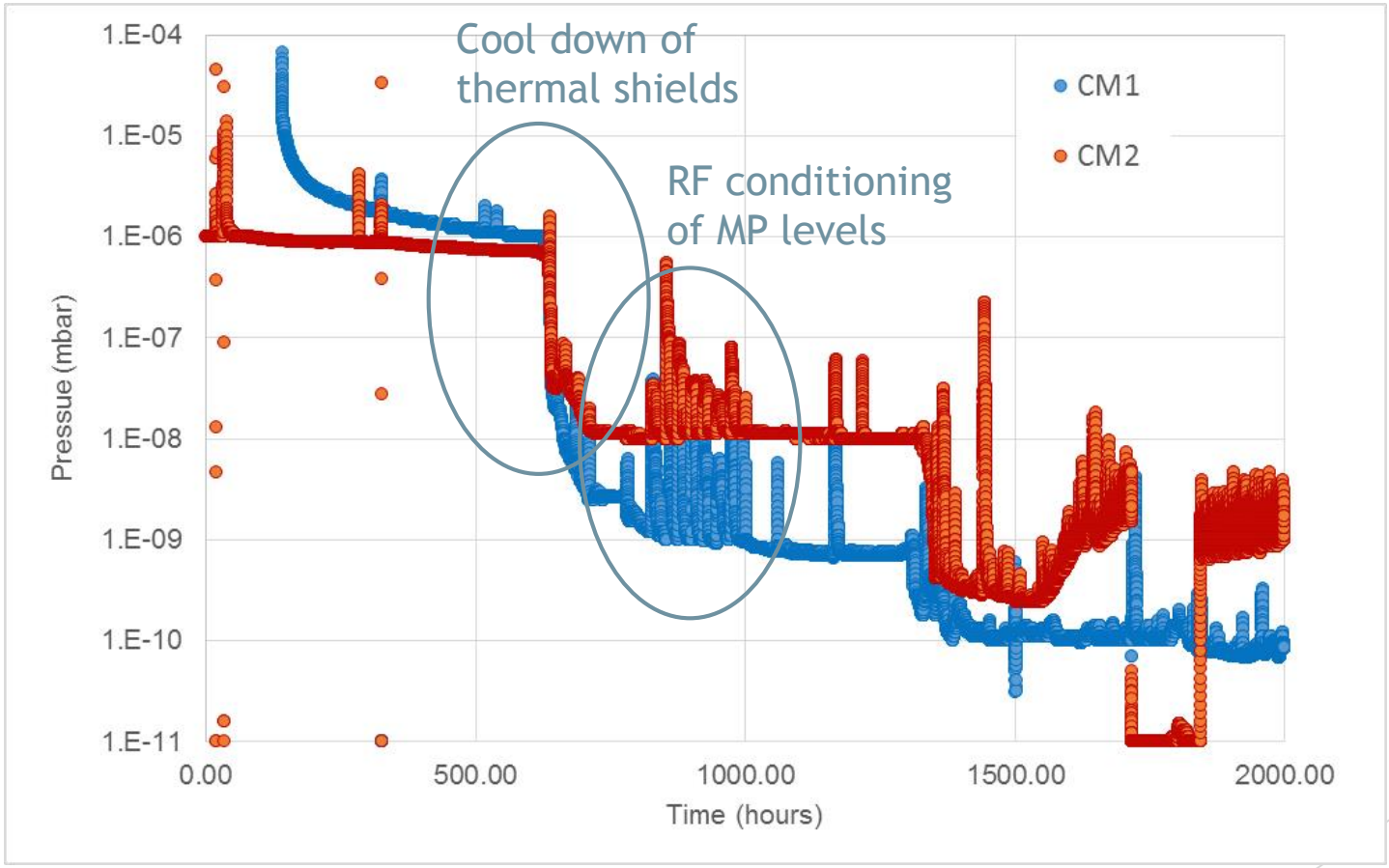
Beam vacuum


1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
Pressue (mbar)
0.00
500.00
1000.00
1500.00
2000.00
Time (hours)
CM1
CM2

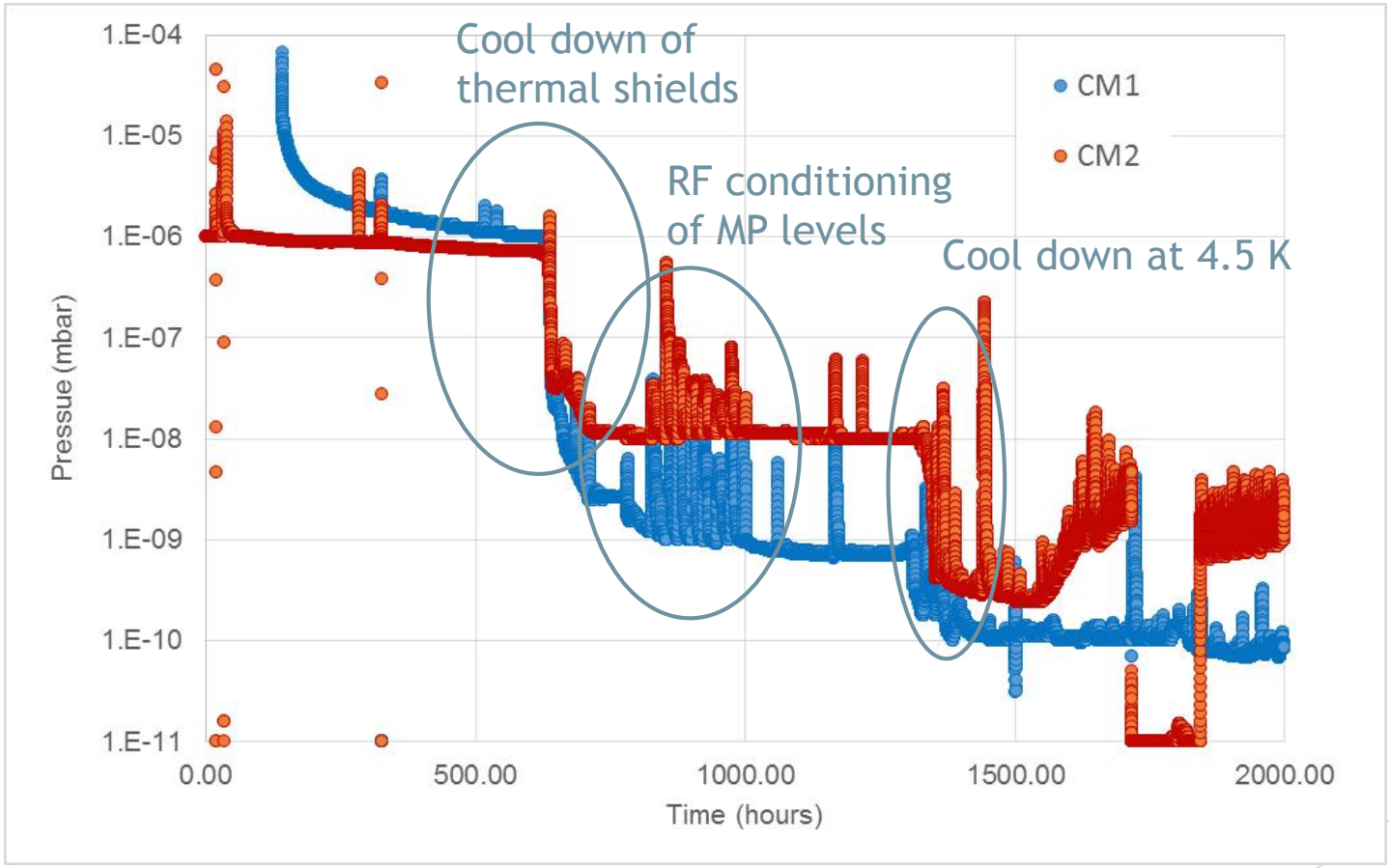
Beam vacuum


Cool down of thermal shields
CM1
CM2
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
Pressue (mbar)
0.00
500.00
1000.00
1500.00
2000.00
Time (hours)

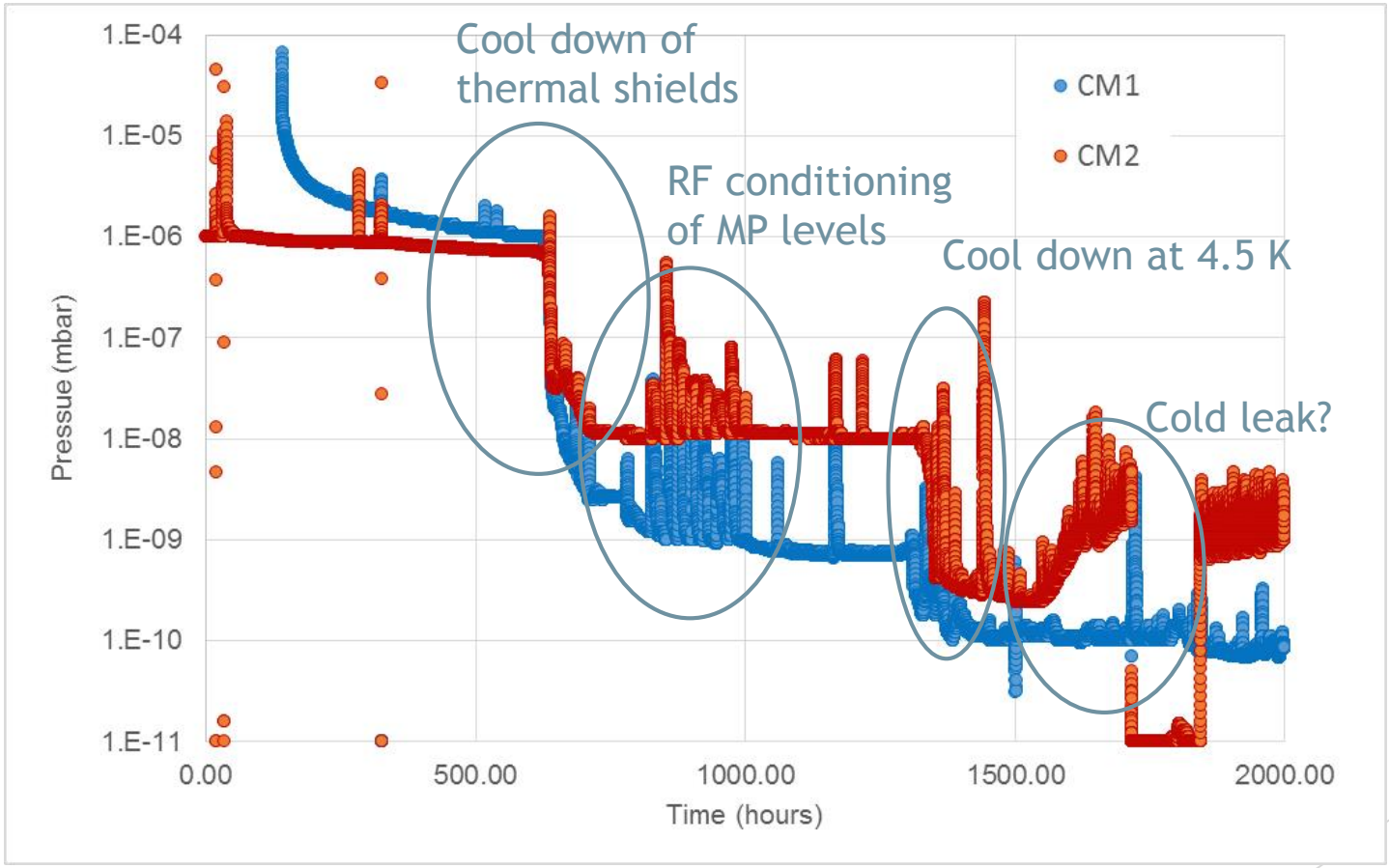
Beam vacuum


Cool down of thermal shields
RF conditioning of MP levels
CM1
CM2
Pressue (mbar)
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
0.00
500.00
1000.00
1500.00
2000.00
Time (hours)

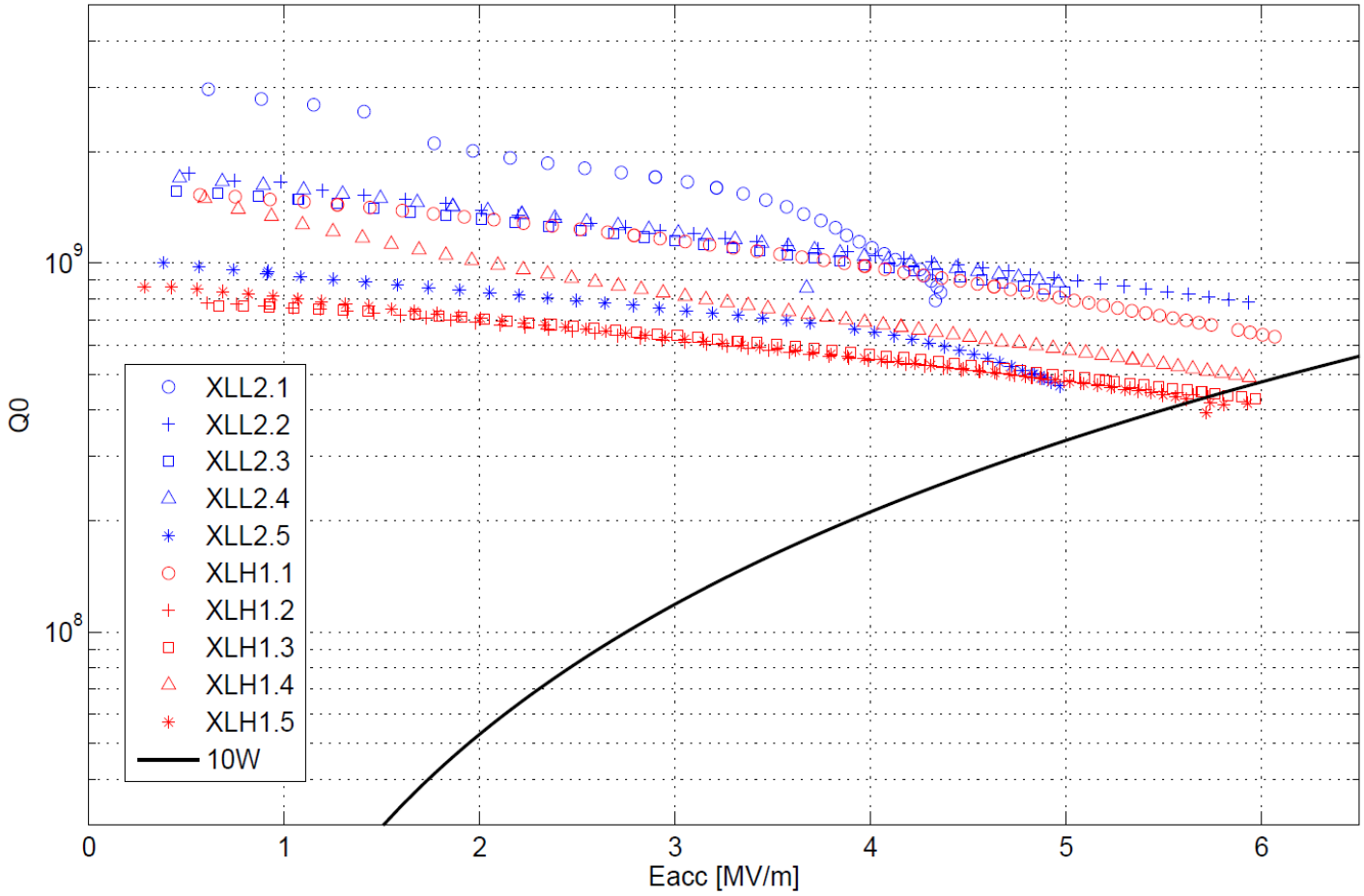
Beam vacuum


Cool down of thermal shields
RF conditioning of MP levels
Cool down at 4.5 K
CM1
CM2
Pressue (mbar)
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
0.00
500.00
1000.00
1500.00
2000.00
Time (hours)

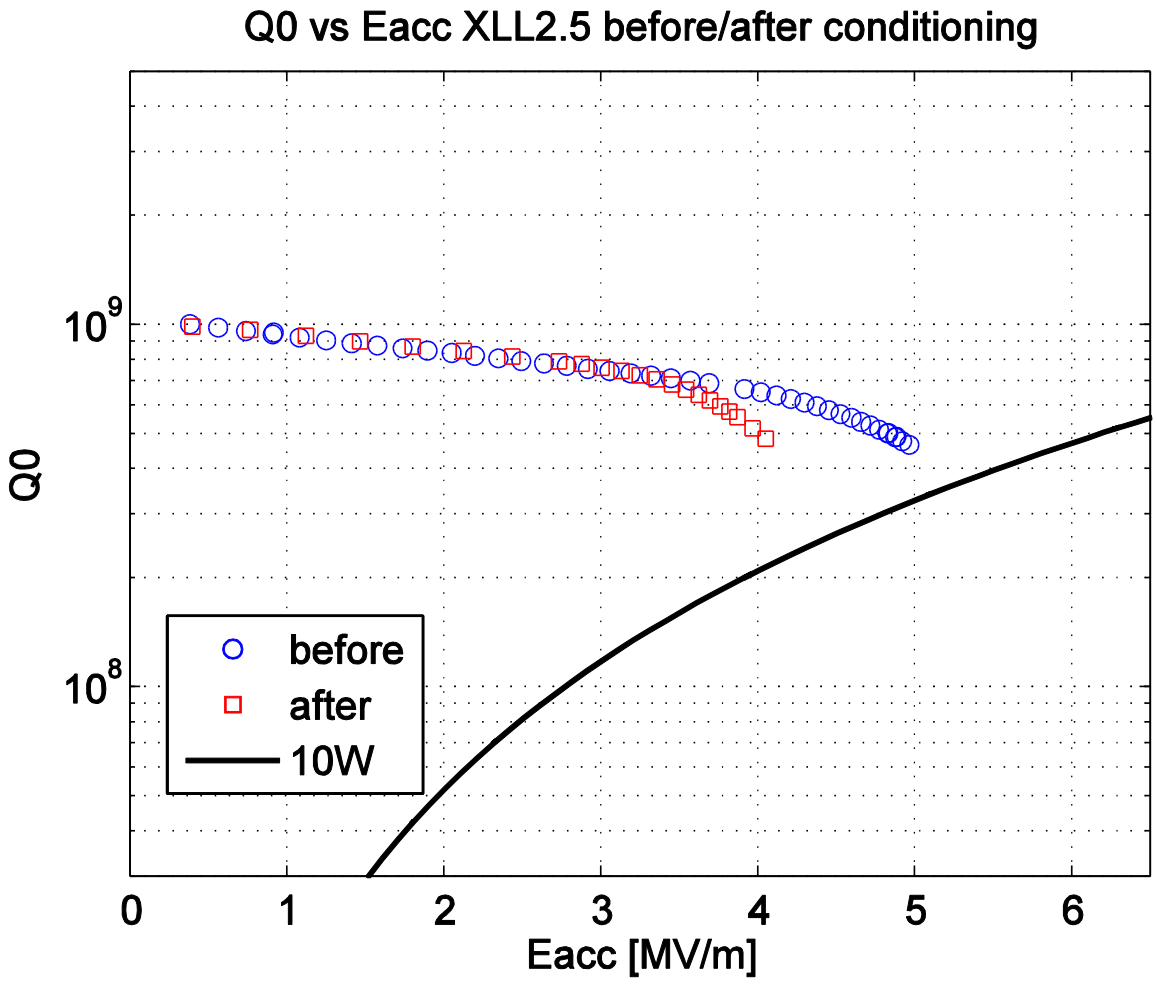
Beam vacuum


Cool down of thermal shields
RF conditioning of MP levels
Cool down at 4.5 K
Cold leak?
CM1
CM2
Pressue (mbar)
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
0.00
500.00
1000.00
1500.00
2000.00
Time (hours)

SRF cavity performance

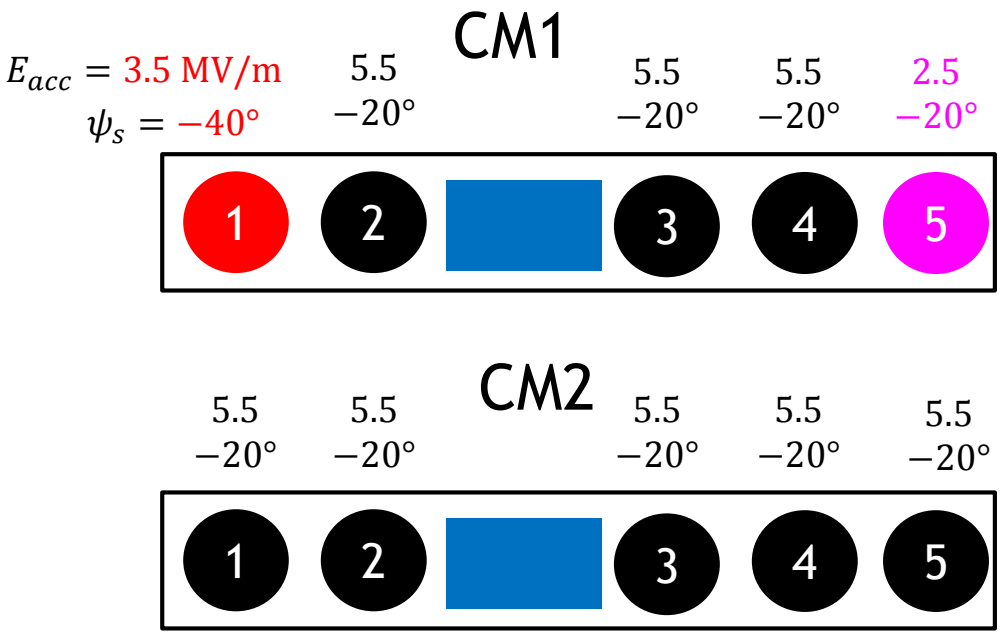


A timid conditioning attempt

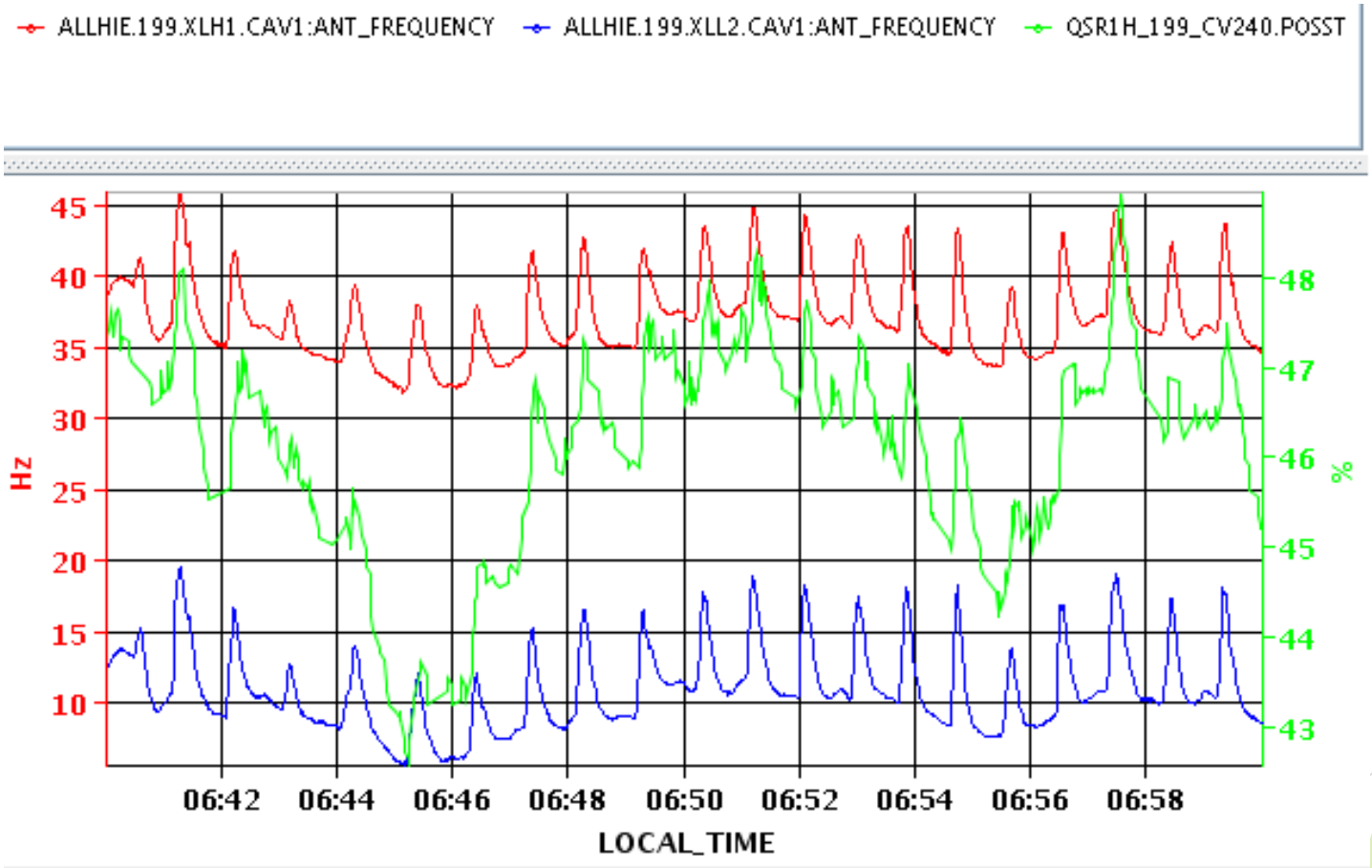


Settings for 2016 physics run

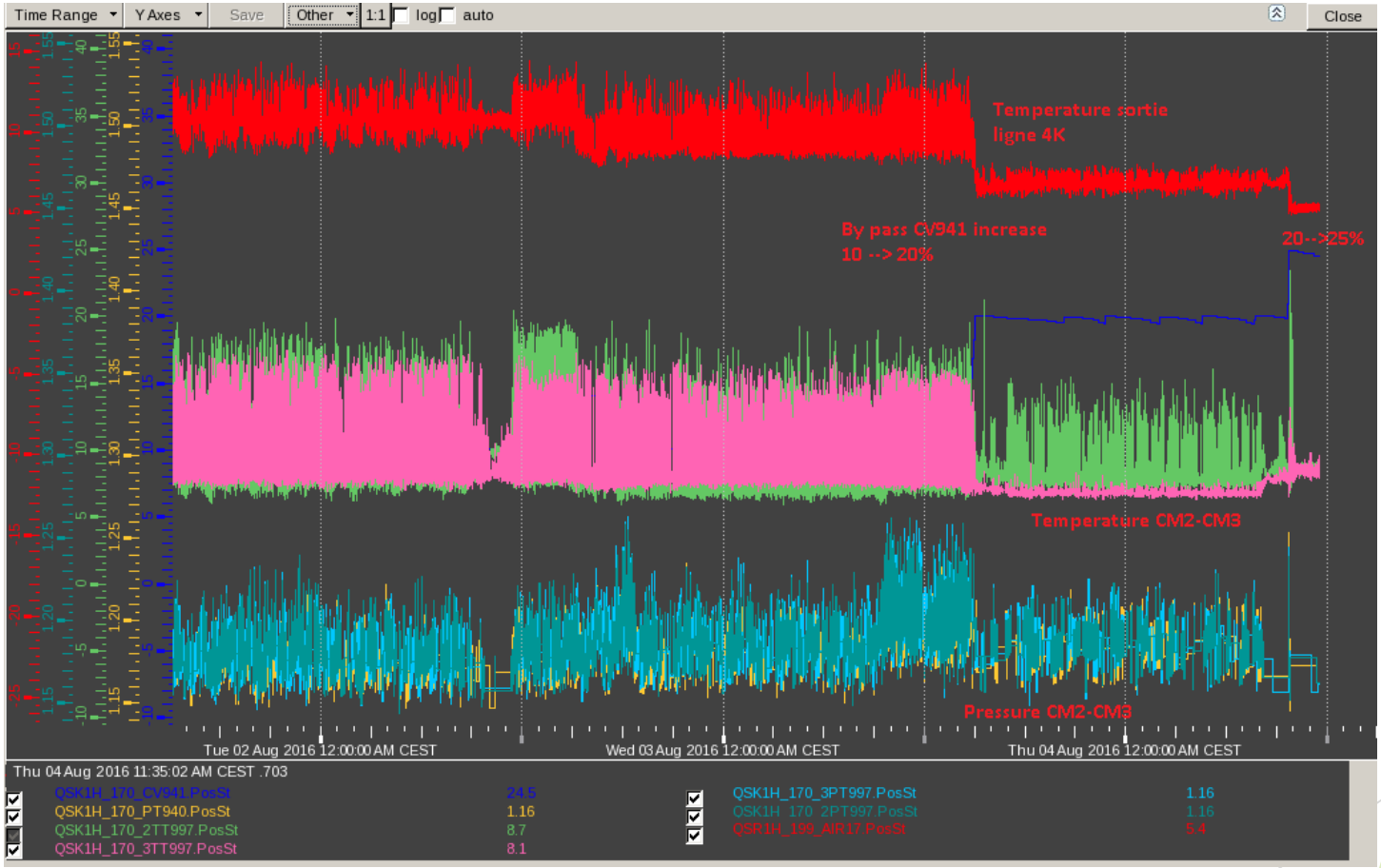
- Keep XLL2.1 and XLL2.5 at ***3.5 MV/m*** and ***2.5 MV/m*** compensate the accelerating voltage by other cavities
- Bunching efficiency compensated by increase the synchronous phase in XLL2.1 from ***-20 to -40 deg***.



Cavity detuning and… cryogenics control valves



Improving cryogenics process stability



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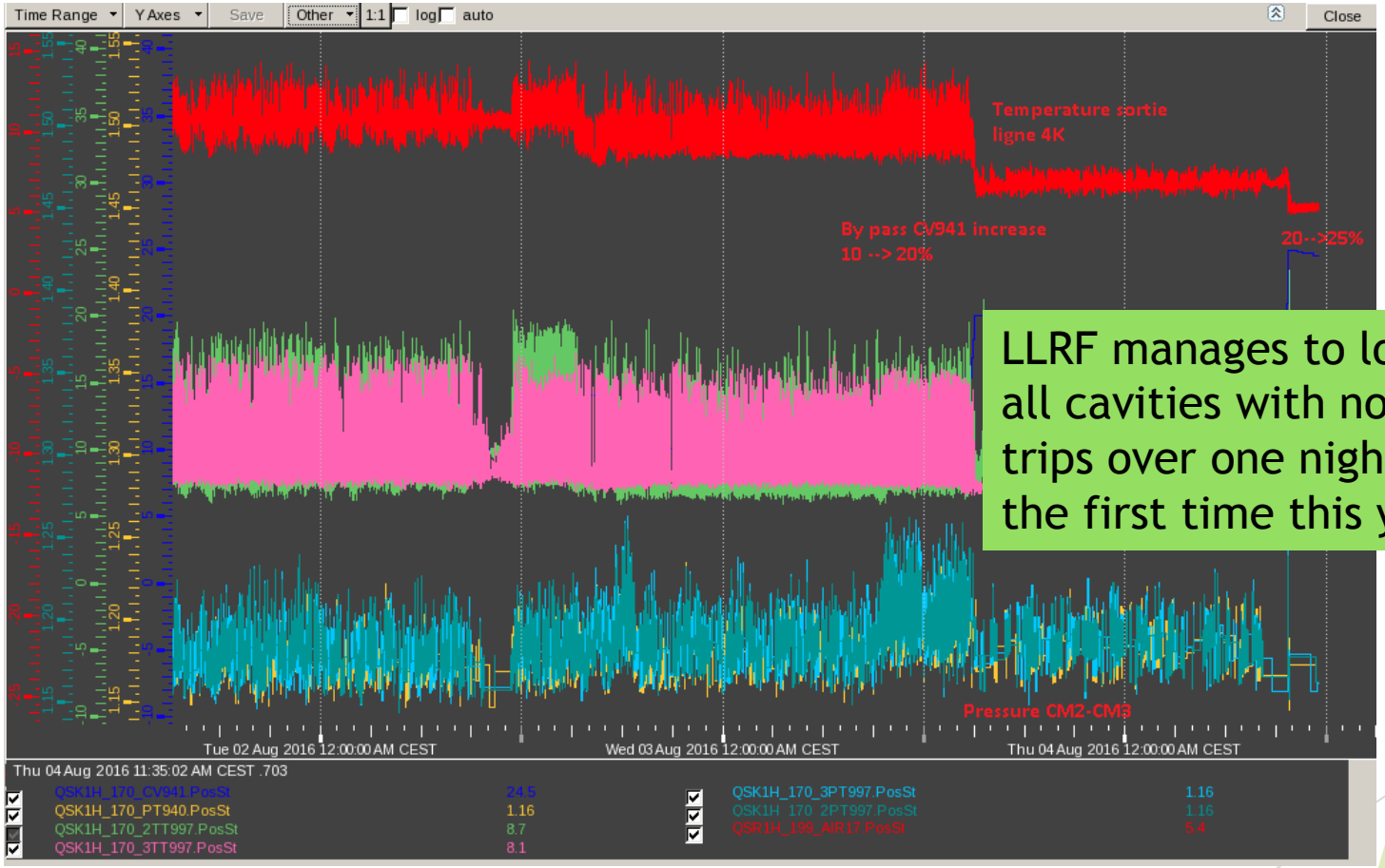


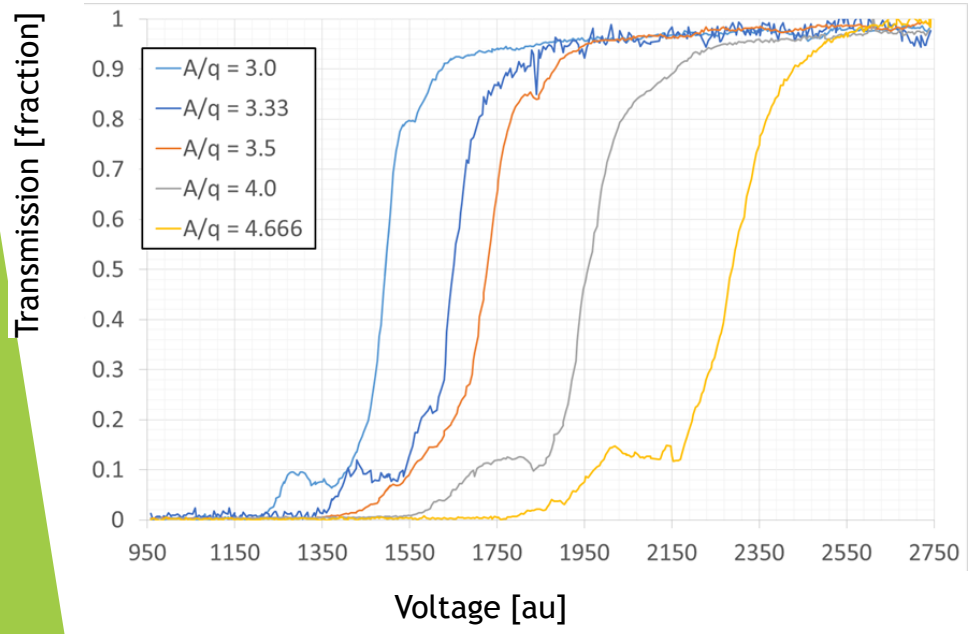
LLRF manages to lock all cavities with no trips over one night for the first time this year

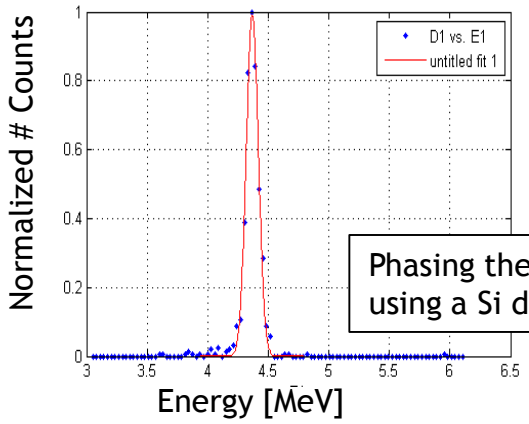
Beam commissioning (I)

Operational settings for the REX linac accelerating structures:

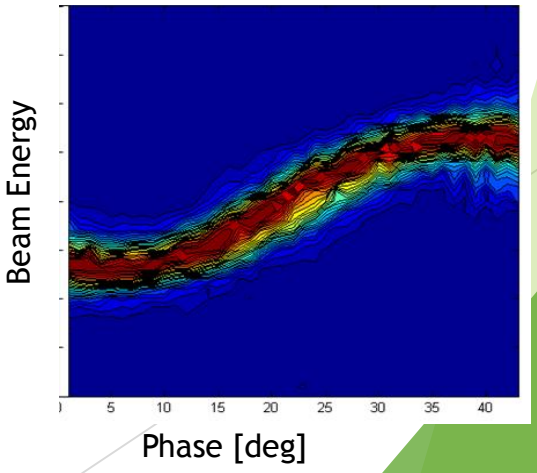
- Beam transmission through the RFQ for different A/q
- Used silicon detectors before cryomodules to phase the other six normal conducting cavities

RFQ transmission





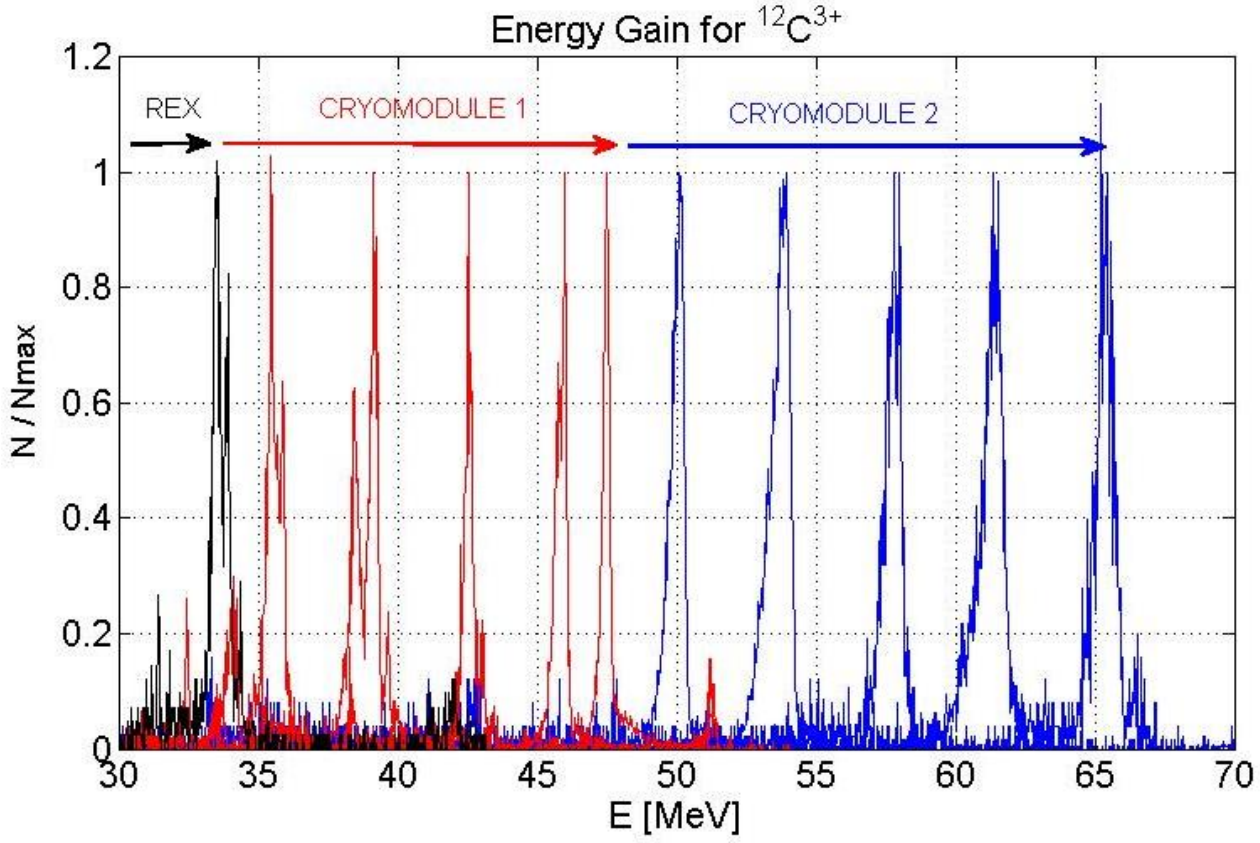
Phasing the Buncher using a Si detector



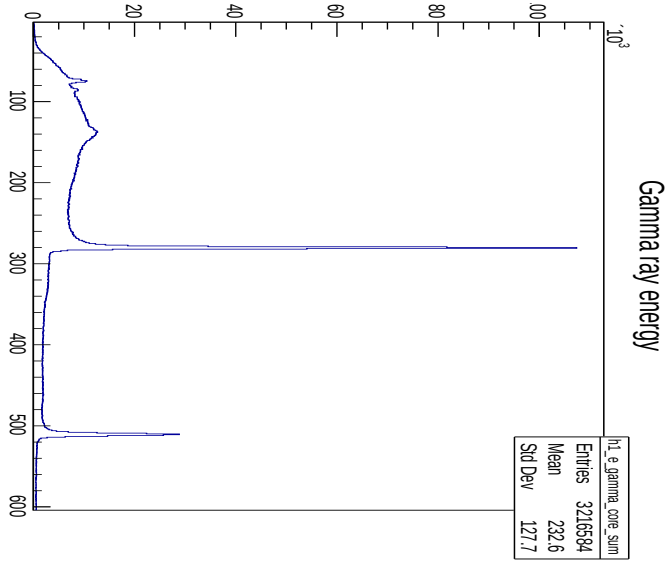
Beam commissioning (II)

Phasing the SRF cavities:

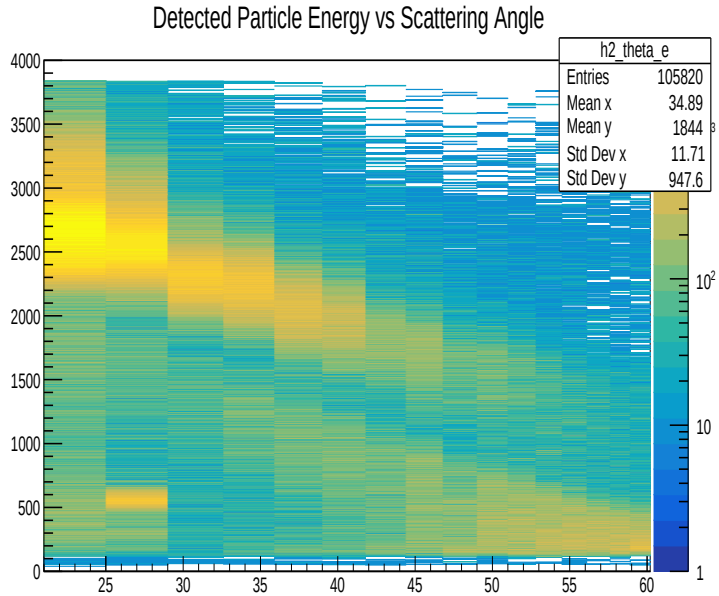
- A cocktail of beams with A/q=4.0 ($^{4}He^{+}$, $^{12}C^{3+}$, $^{16}O^{4+}$, $^{20}Ne^{5+}$, $^{40}Ar^{10+}$) was used to phase the SRF cavities
- Energy changes of the beam were measured using silicon detectors and the dipole magnet in the first HEBT line



2016 Physics run: September 9, 2016 at 19:30
First exotic beam to Miniball $^{110}Sn^{26+}$ at 4.5 MeV/u



Gamma-ray line at 280 keV shows that ^{110}Sn was accelerated



Detected particle energy vs scattering angle shows that beam energy is at 4.5 MeV/u.

Summary

- Phase 1 of the HIE-ISOLDE project is now complete
- Acceleration up to 5.5 MeV/u for all nuclei from ISOLDE
- The RF couplers have been re-engineered for improved thermal stability, they seem to work well
- Two cavities have been contaminated during the refurbishing of CM1, were set below FE onset for the
- Physics run 2, ongoing until middle November
- Conditioning of 2 cavities with He will follow
- CM3 will be ready at the end of the year, and installed during the winter stop
- Baseline plan: Physics run with 3 CMs in 2017

Acknowledgments

CERN technical staff

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The HIE ISOLDE International Advisory Panel

The CERN management

Thanks for your attention