

Ion Source and LEBT Commissioning Results + Current Status

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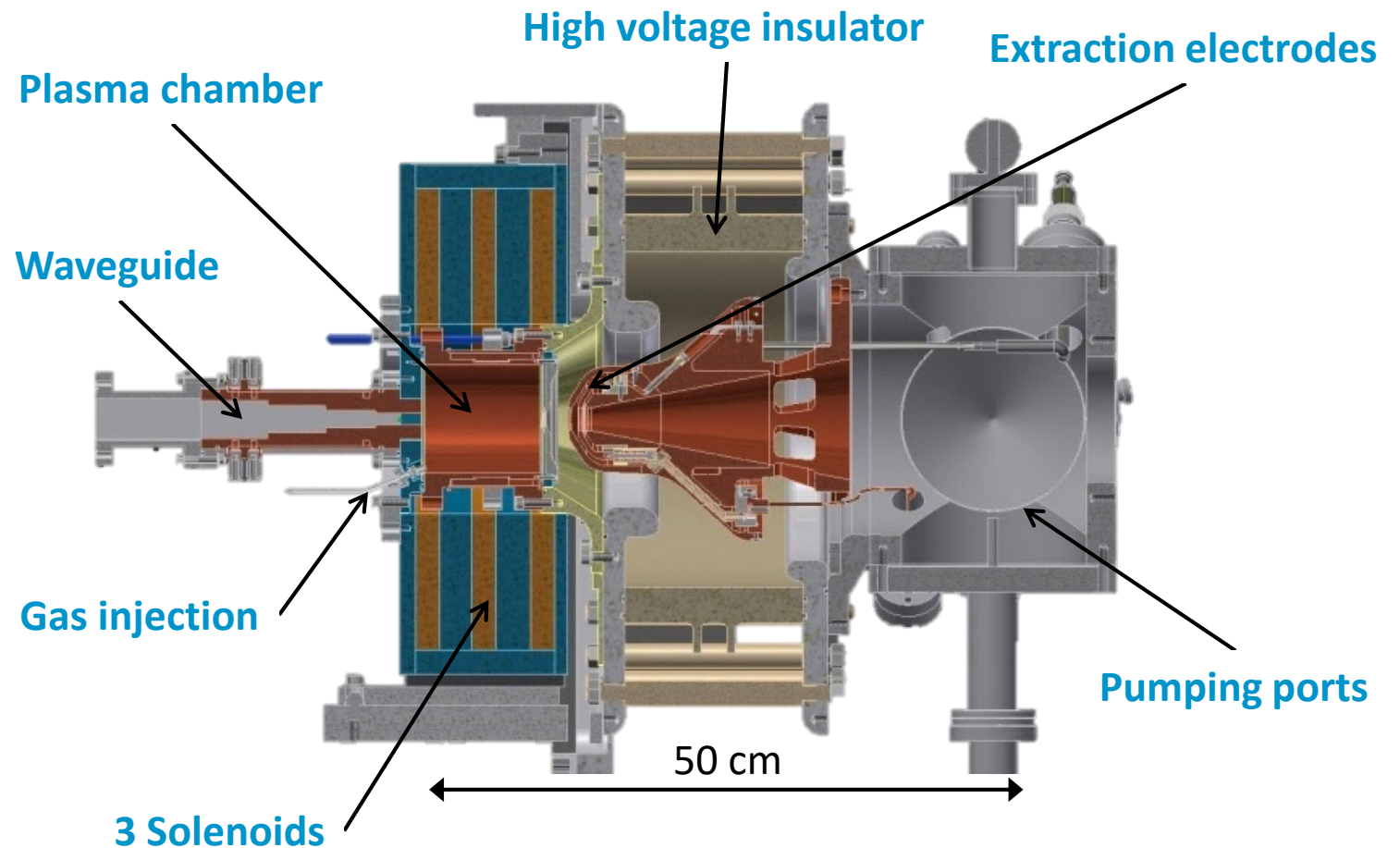
European Spallation Source

- Introduction
- Commissioning Results
- Current Status
- Conclusions

Ion Source

Microwave Discharge Ion Source (MDIS)

Requirement	Value
Beam energy	75±5 keV
Proton beam current	74 mA
Proton fraction	>75%
Pulse length	6 ms
Pulse flat top	3 ms
Repetition rate	14 Hz
Pulse to pulse stability	±3.5 %
Flat top stability	±2 %
Transverse emittance (99%)	1.8 pi.mm.mrad
Beam divergence (99%)	<80 mrad
Start-up after maintenance	32 hours



The ISrc sits inside a 75 kV DC high voltage platform

Magnetron head

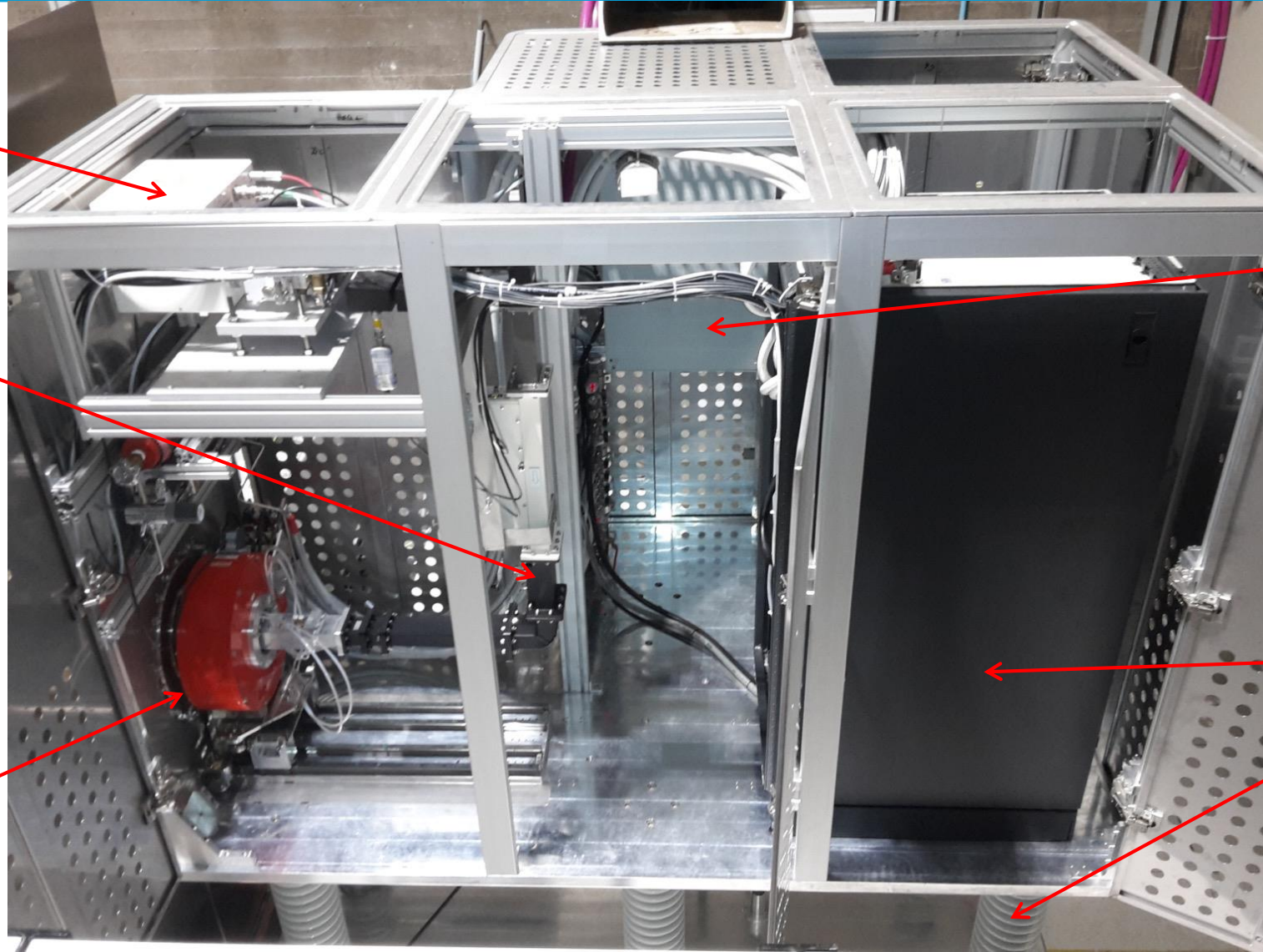
Waveguide

3 Solenoids

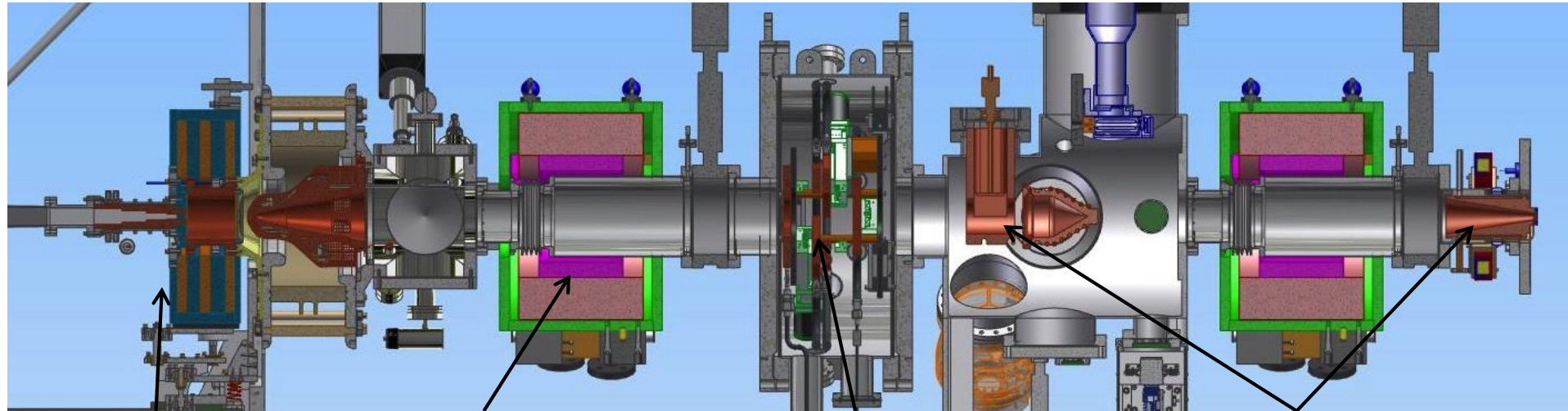
Electrical panel

Electronics rack

Ceramic insulators



The Low Energy Beam Transport (LEBT) matches the beam to the RFQ input

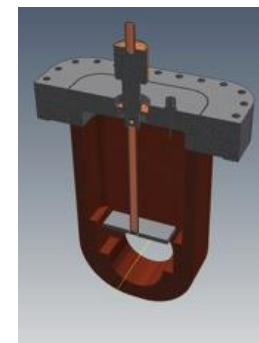
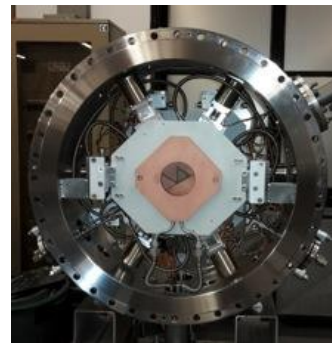
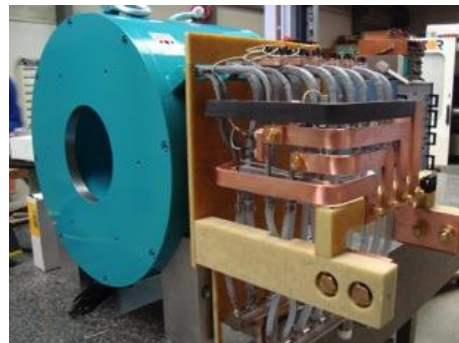


Ion Source
– creates the H^+ beam

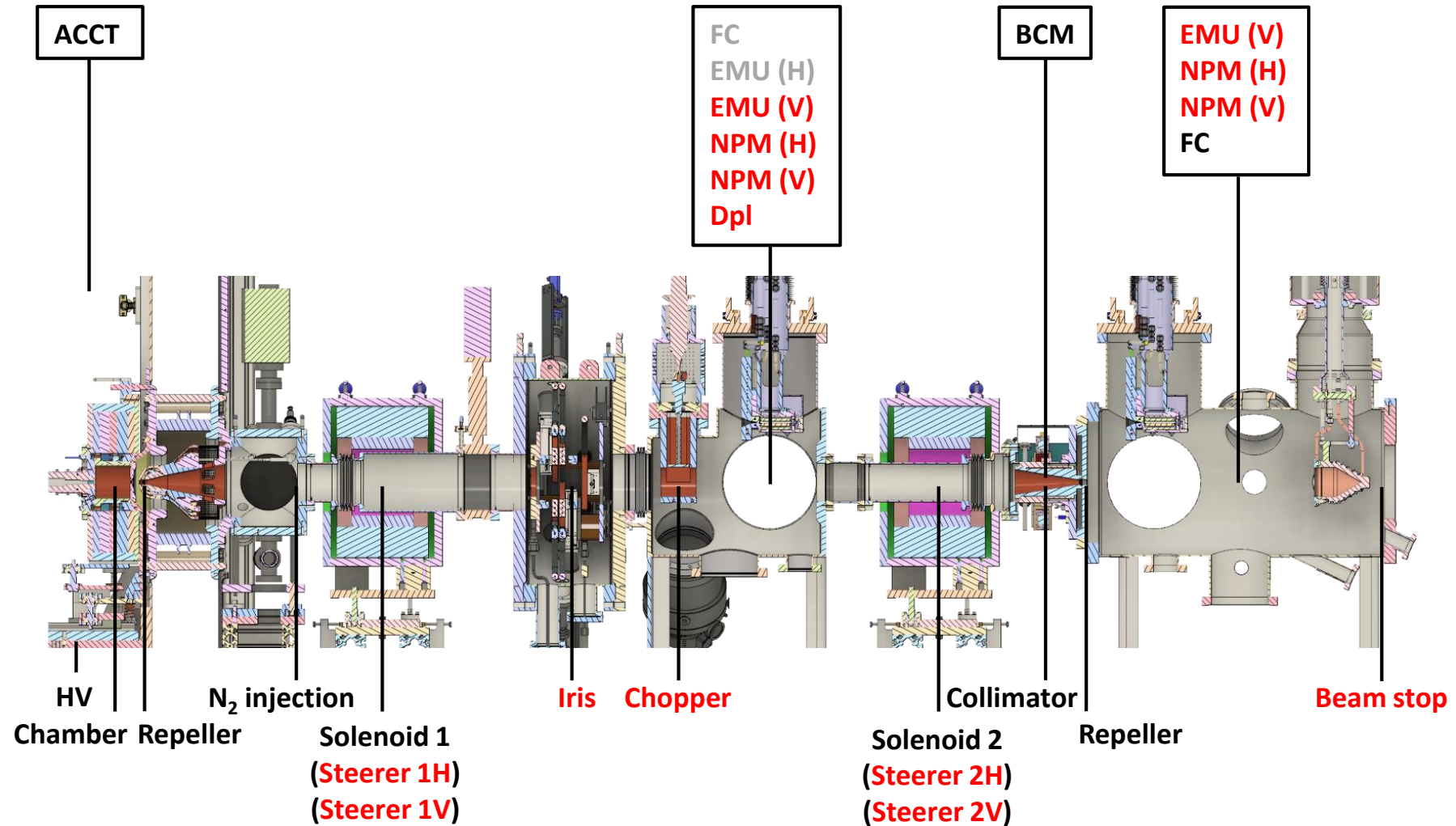
Solenoid
– focuses the beam

Iris
– controls the current

Chopper and collimator
– controls the pulse length



LEBT at the start of commissioning



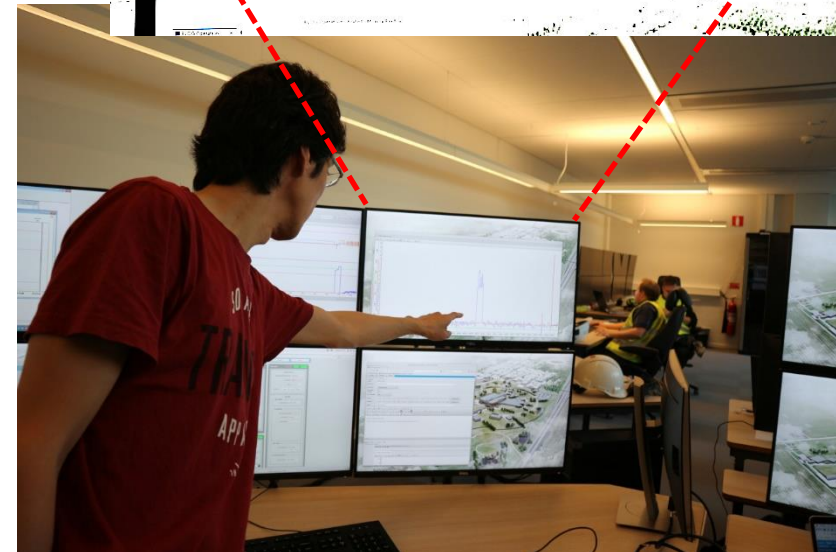
First beam at ESS, 2018-09-19



Logbook message ID 69, 2018-09-19 10:31

Ryoichi on behalf of ISrc team.

*"THE" screenshot of the first beam! Blue trace is the integrated charge per pulse in micro-C. **12 micro-C and 2 ms gives 6 mA. We had the beam for about 10 s.***

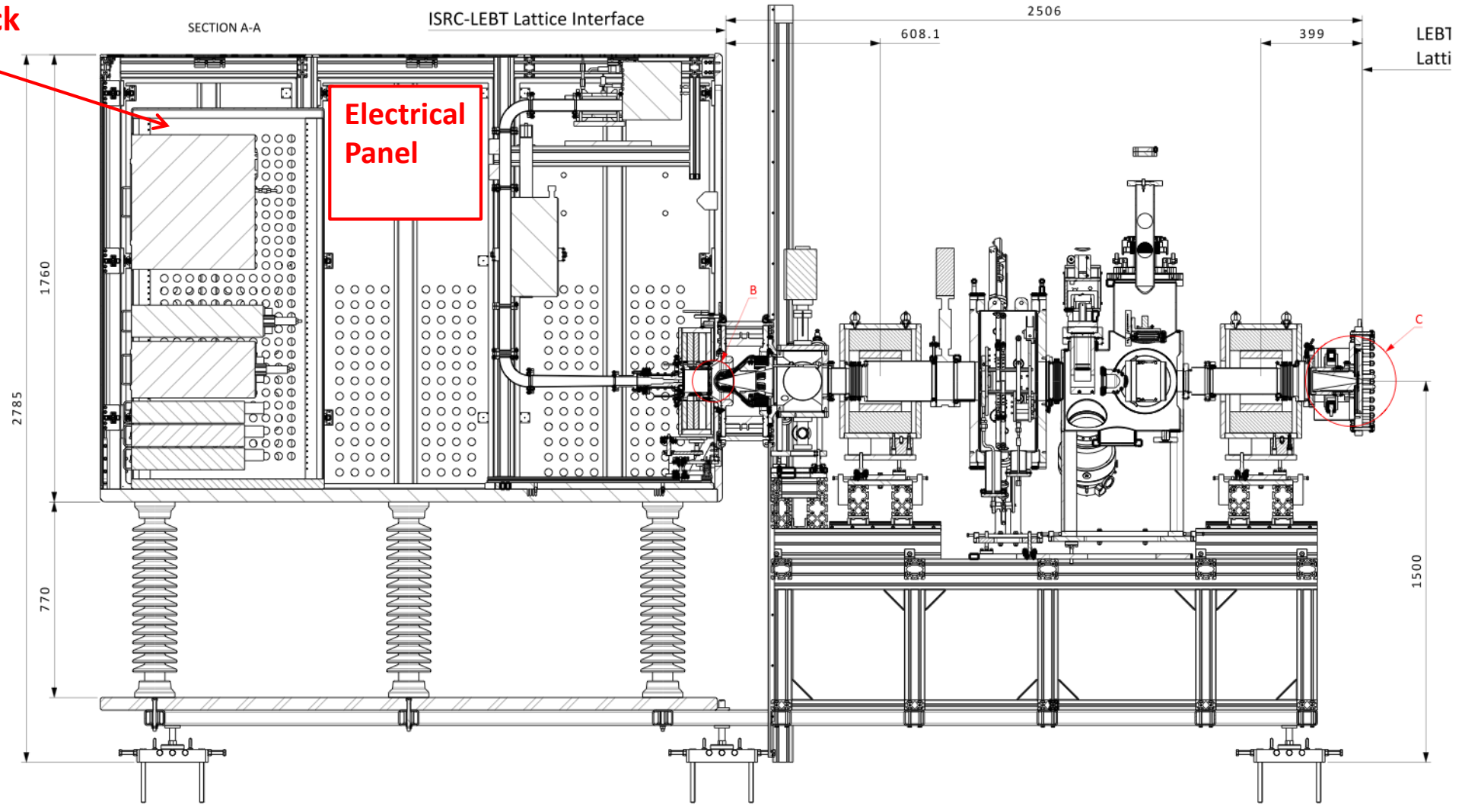


Commissioning Timeline

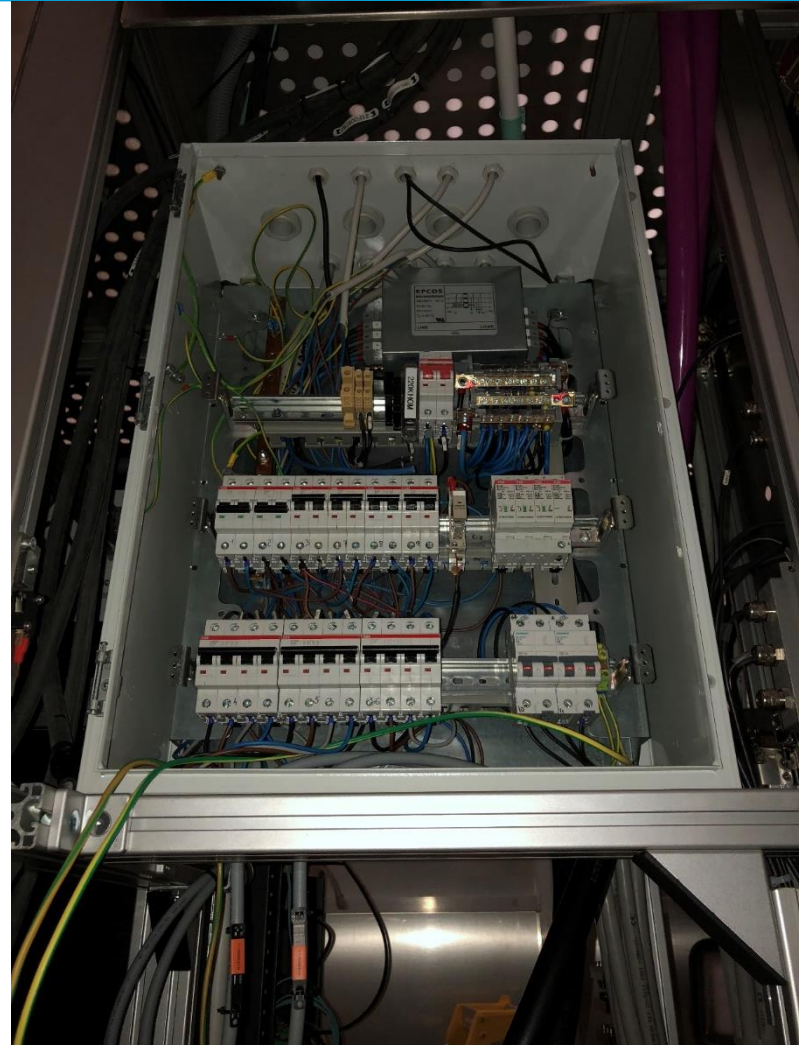
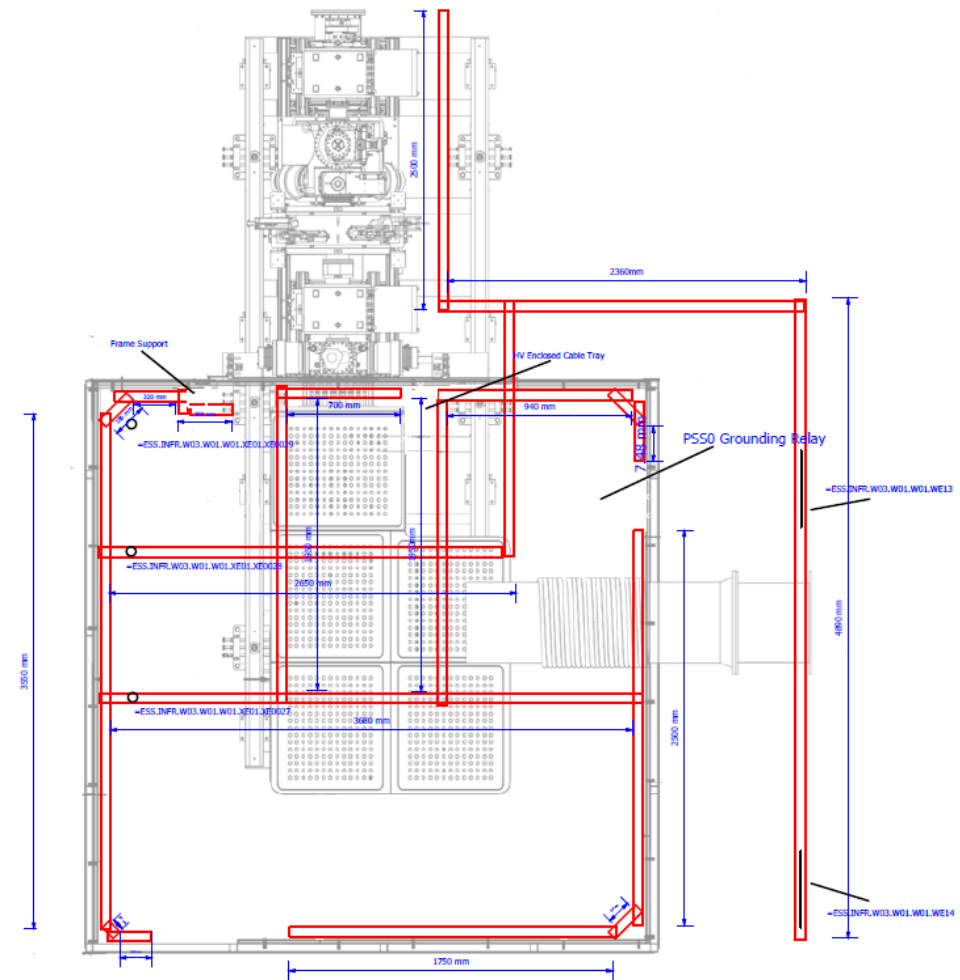
Date	Event
2017-12-14	Source and LEBT delivered to ESS.
2018-07-18	Safety readiness review completed.
2018-09-19	Started beam commissioning and had 1 st beam.
2018-10-02	Started the source repeller repair and 1 st round of EMC grounding work.
2018-11-28	Solenoid 1 power supply damaged (PS from Sol 2 switched to Sol 1).
2018-12-11	Extracted beam for ~2 min and damaged power supplies of 3 coils.
2018-12-12	Started 2 nd round of EMC grounding work.
2019-02-08	Effectively started beam commissioning (with just 1 solenoid).
2019-03-08	Both solenoids became available.
2019-03-19	Started to cover longer hours.
2019-04-05	Chopper became available.
2019-04-25	EMU became available.
2019-04-26	Planned last day of source and LEBT commissioning.
2019-04-29	Started the scheduled water pickling works for NC linac installation.
2019-06-11	Started the extended period (back to normal hours).
2019-07-03	Source and LEBT commissioning ended.

Issues: Grounding

Electronics rack



Issues: Grounding



ISrc+LEBT beam commissioning

From 2018-Sep-19 to 2019-Jul-03



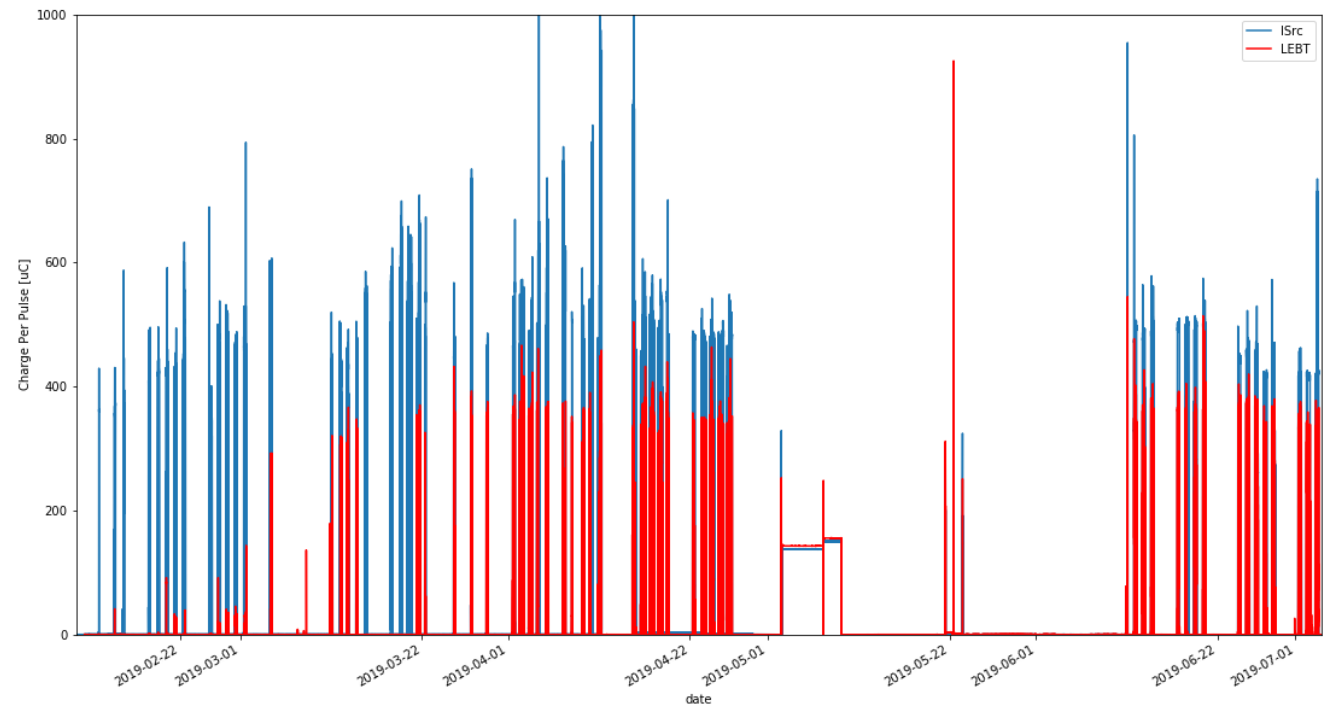
- Most of LEPT was then disassembled for
 - RFQ bead-pull
 - Repairs and upgrades: Repeller (RFQ interface), iris, chopper, diagnostics...

ISrc and LEBT commissioning activities (In Lund)

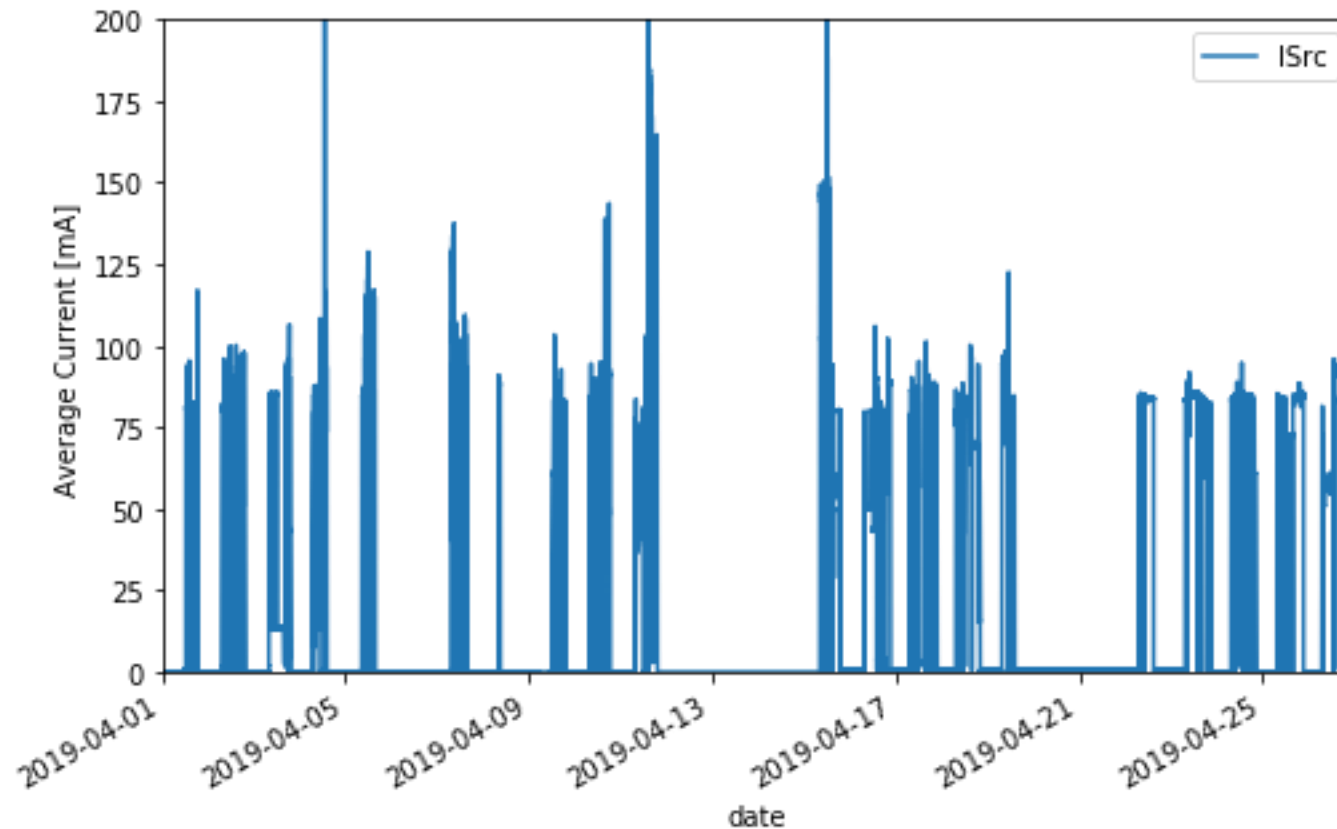
- Commission systems with beam.
 - Establish stable operation of source.
 - ... (diagnostics, control, ...)
- Study source behavior (against 5 knobs).
- Correct beam trajectory.
- Study matching to RFQ.
 - Matching to the RFQ is ultimately optimized by scanning the 2 solenoids and maximizing the transmission through the RFQ.
- Prepare "candidates" for the nominal setting.
 - We don't know beam loss and matching condition of the RFQ.
- Establish adjustment capabilities of pulse length and current with the chopper and iris.
- (Check stabilities.)
- (Transfer expertise to the operation team.)

Beam time achieved from Feb-8 to Jul-3, 2019

- Stable operation achieved after the grounding issue was solved
- 435 h of total beam time
- 88 shifts
- Double shifts March and April
- Gap due to water pickling activities in the tunnel pipes

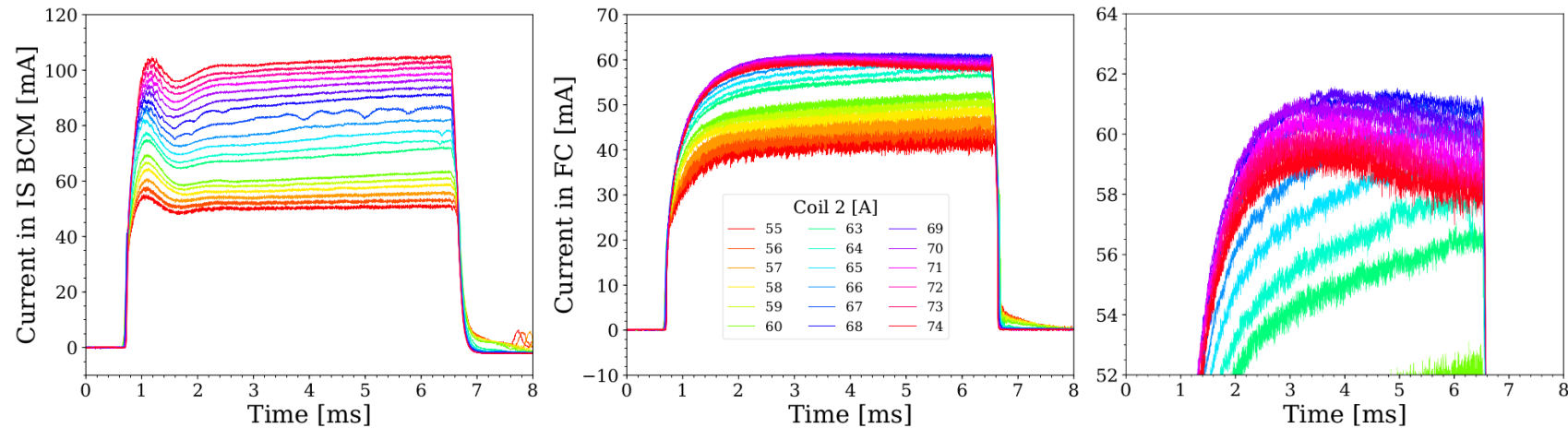


Stable source operation achieved after EMI issue was fixed

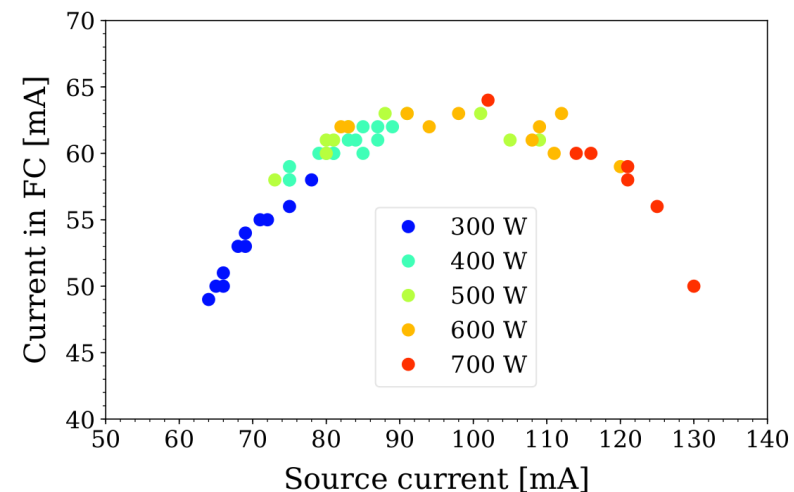


- ~174 hours of beam time in April.
 - "Shifted working hours" to cover 08:00 to 24:00.

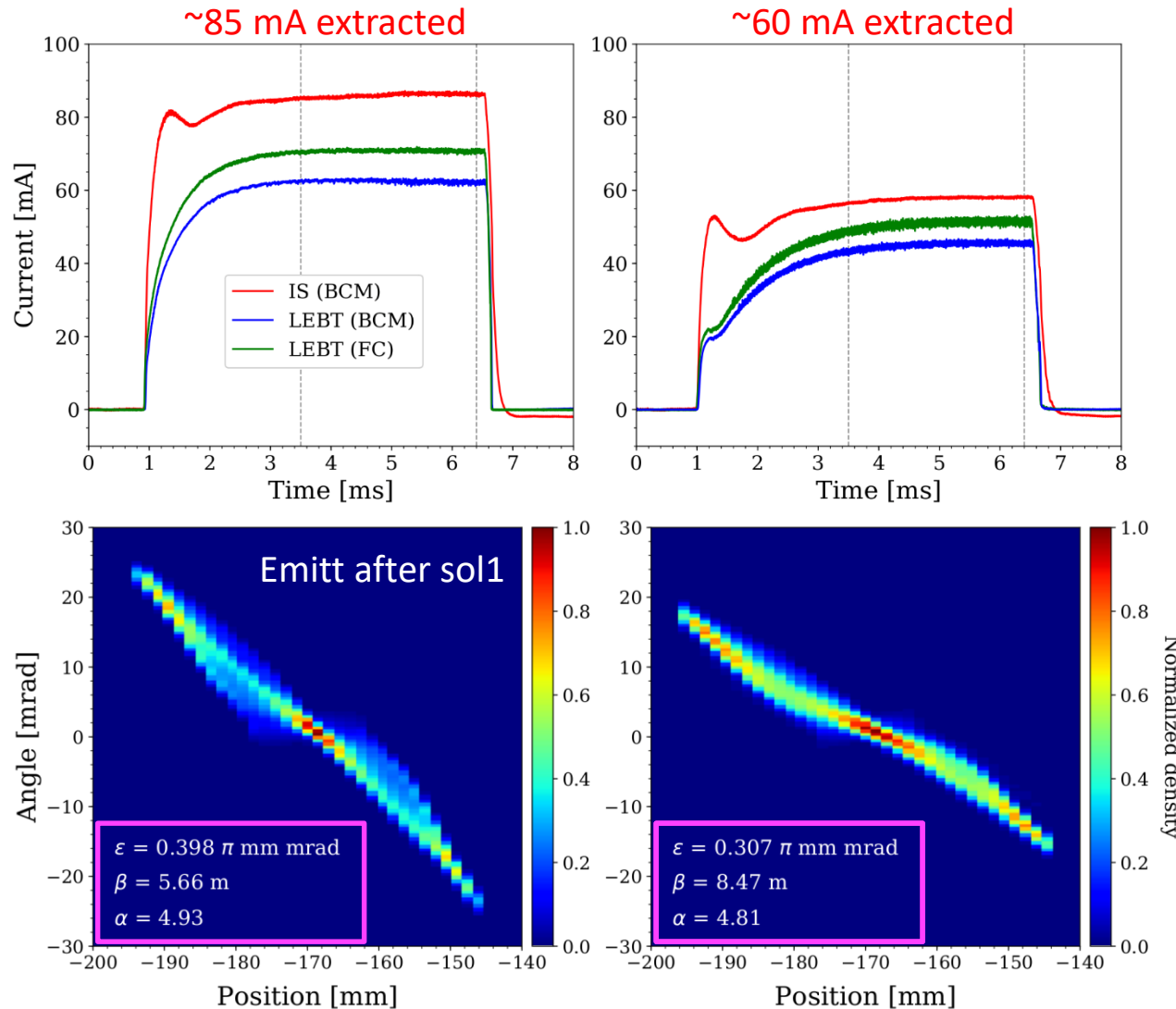
Source characterization



- The source proved to be very flexible and provided a wide operation range.
- We can easily establish a new set point in a systematic manner (coil2 scan).
- The source beam characteristic is dictated by the extracted current.
 - Seems no special source configuration with a high brightness.

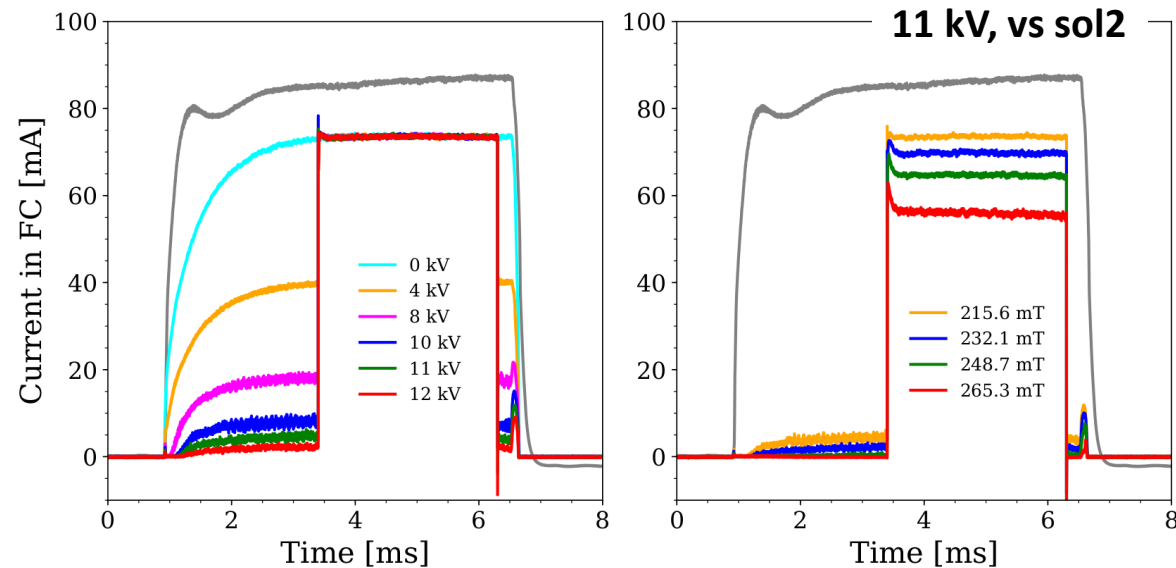


Ranges of current and emittance



- Off site commissioning had 0.2-0.3 π mm mrad for ~85 mA extraction ???
- No positive impact seen by N₂ injection.
- Large initial divergence?
- Large discrepancy between the FC and BCM (even with good transmission).

Chopper and iris issues



- We couldn't move the iris blades before the commissioning was over.
- Chopper electrode was originally designed for positive bias, but the bias was swapped.
 - To avoid drawing electrons which would affect space charge neutralization.
 - Because the field is nonlinear, the swap degraded the efficiency.
 - **Chopper and iris have to be tested from scratch in the beginning of the next phase.**
 - Less straightforward with the RFQ connected.

Commissioning Results

- Commissioning and Validation of FC, NPMs, BCMs and EMU
- Emittance meas:
 - Quad Scan (NPM)
 - Single shot of beam waist (NPM)
 - EMU
- Chopper Tests
- Transported the beam successfully to the end of the LEBT with 85% transmission in some configurations.
- Beam trajectory studies.
 - Estimate for divergence and Solenoid error
- ISRC Characterization

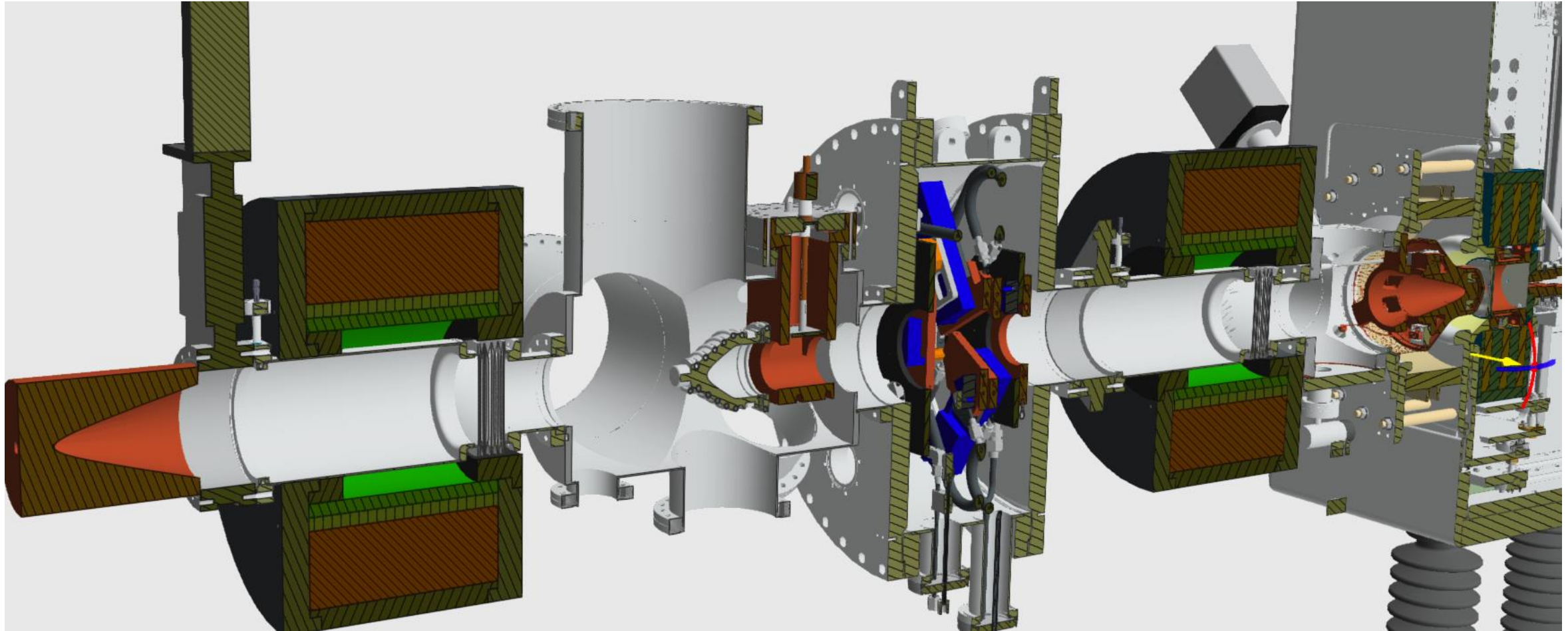
- IRIS Repair
- Fiducialization of Diagnostics Tank and associated devices (FC, EMU2, Doppler...)
- Designing new fence around the HV Platform.
- Installing permanent H2 monitor in the platform.
- Reassembly to start next week.

Issues: IRIS

- Fixing connectors and pins
- Geo Brick → EtherCAT
- Thermocouple wires



LEBT Reassembly



- Overall
 - A lot of progress in all areas of the accelerator.
 - NC linac commissioning is planned for this year.
- Ion source and LEBT
 - Spent nearly 5 months to overcome the EMI issue. Afterwards, stable operation was achieved for the source.
 - Understanding of the ion source behavior has improved a lot.
 - Issues present with beam quality and trajectory.
 - Couldn't establish adjustments of the pulse width and current with the chopper and iris.
 - Resource limitation of the controls team was and will be a major issue. Already talking about the bare minimum configuration for the next phase.

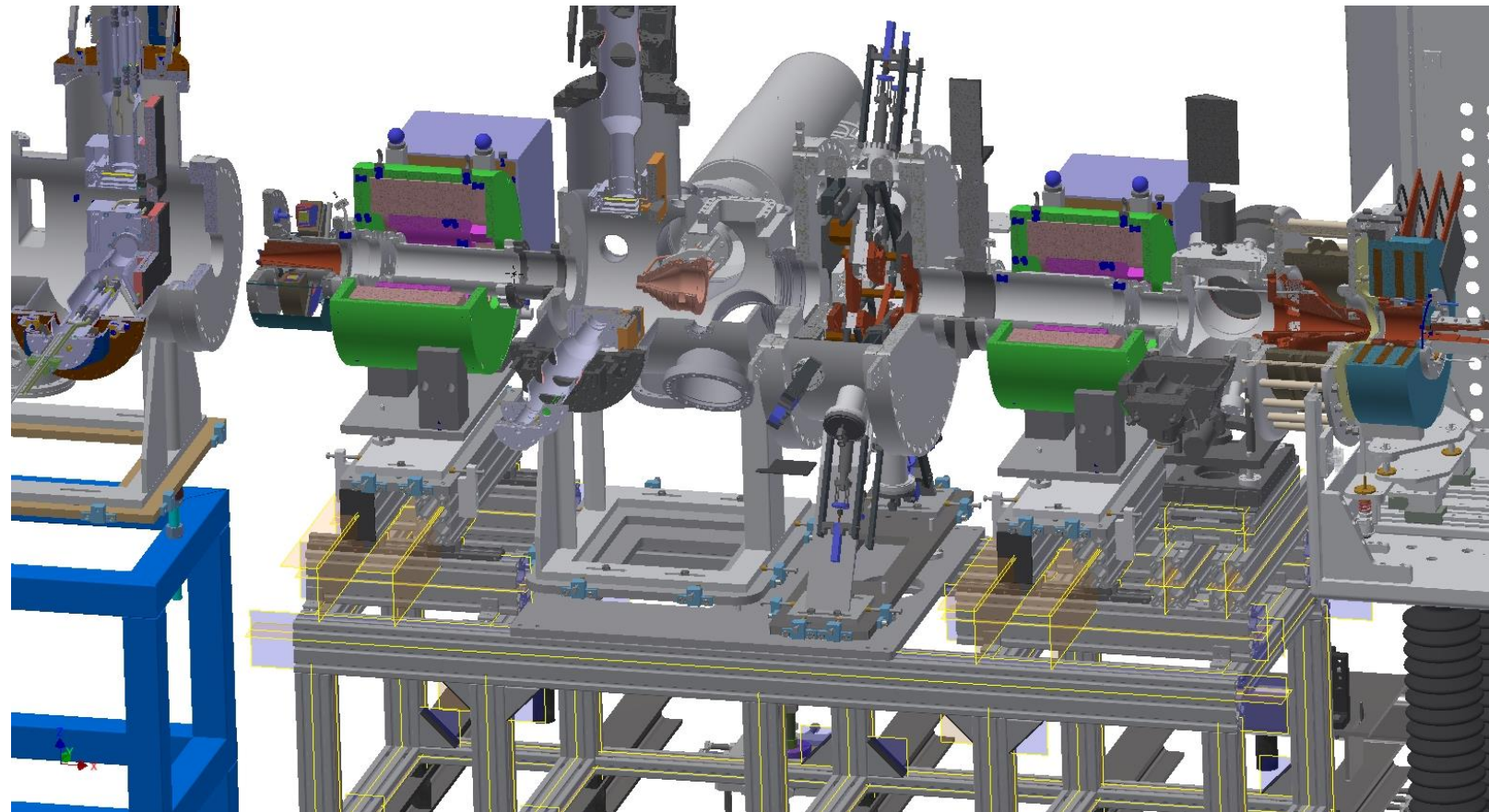
- Beam commissioning leader:
 - Ryoichi Miyamoto
- Beam Physics section:
 - Mamad Eshraqi
 - Natalia Milas
 - Yngve Levinsen
 - Ciprian Plostinar
 - Emelie Nilsson
 - Björn Gålander
- Operations section:
 - Lali Tchelidze
 - Marc Muñoz
- Beam Instrumentation Section:
 - Cyrille Thomas
 - Elena Donegani
 - Clement Derrez
 - Roxana Tarkeshian
 - Rafael Baron
 - Slava Grishin
 - Edvard Bergman
- Integrated Control System:
 - Saeed Haghtalab
 - Antoni Simelio
 - Joao Paulo Martins
 - Thomas Fay
 - Emanuele Laface
 - Juan F. Esteban Müller

Thank you!

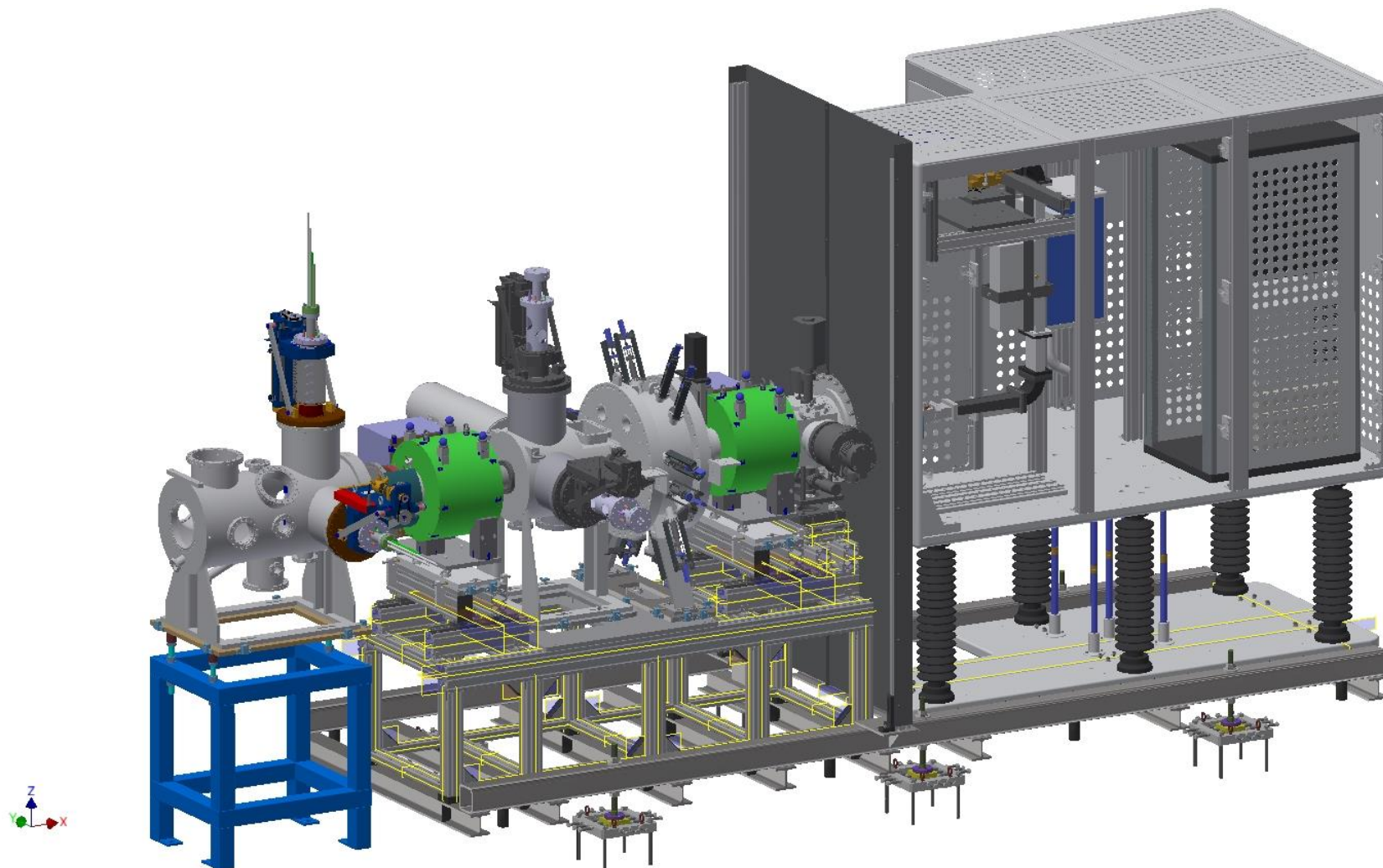
Questions?

BACKUP SLIDES

3D Model



3D Model



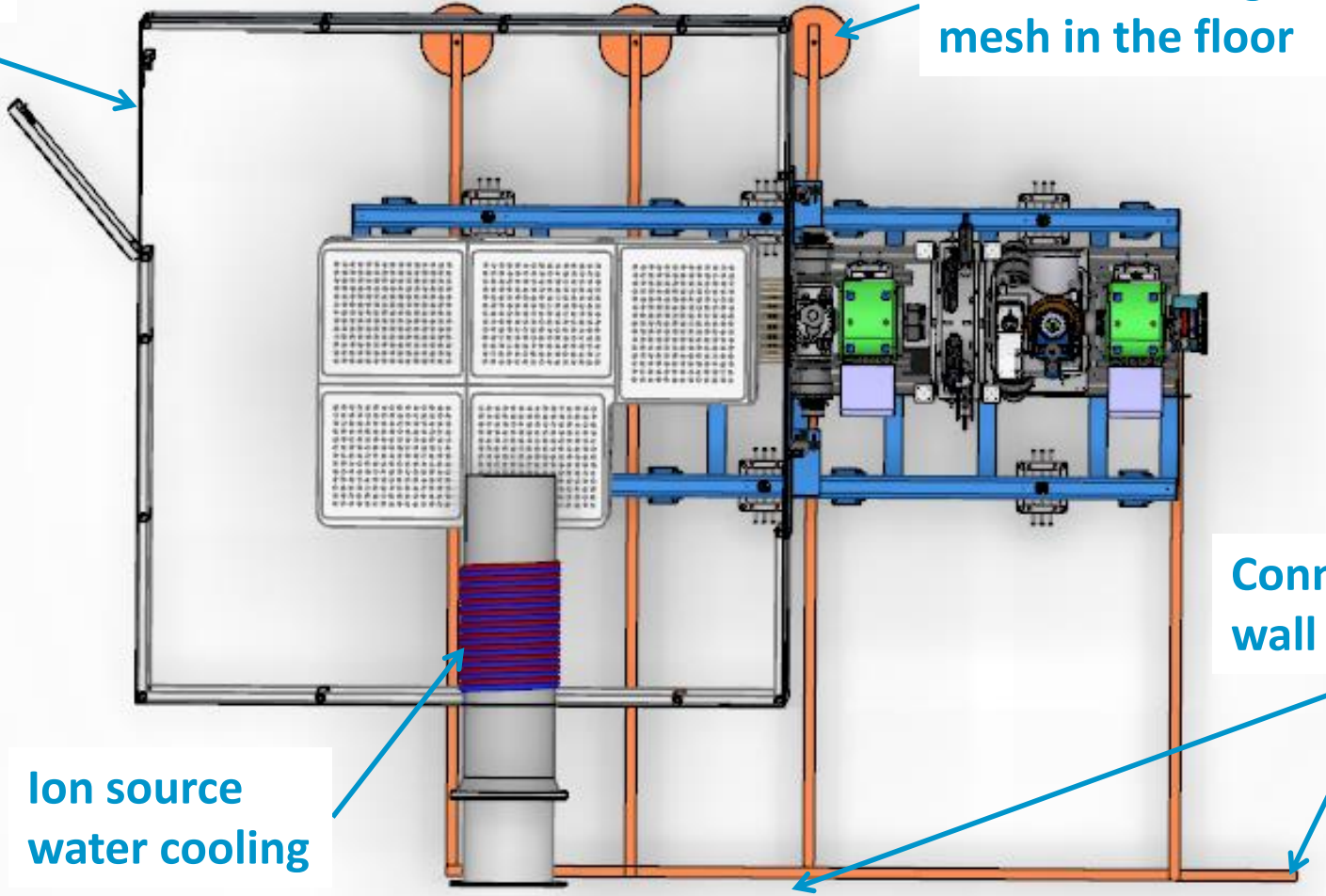
Top view of ISRC & LEBT

PSS0 Entry

Connection to grounding
mesh in the floor

Ion source
water cooling

Connection to
wall grounding



Ion Source + LEBT

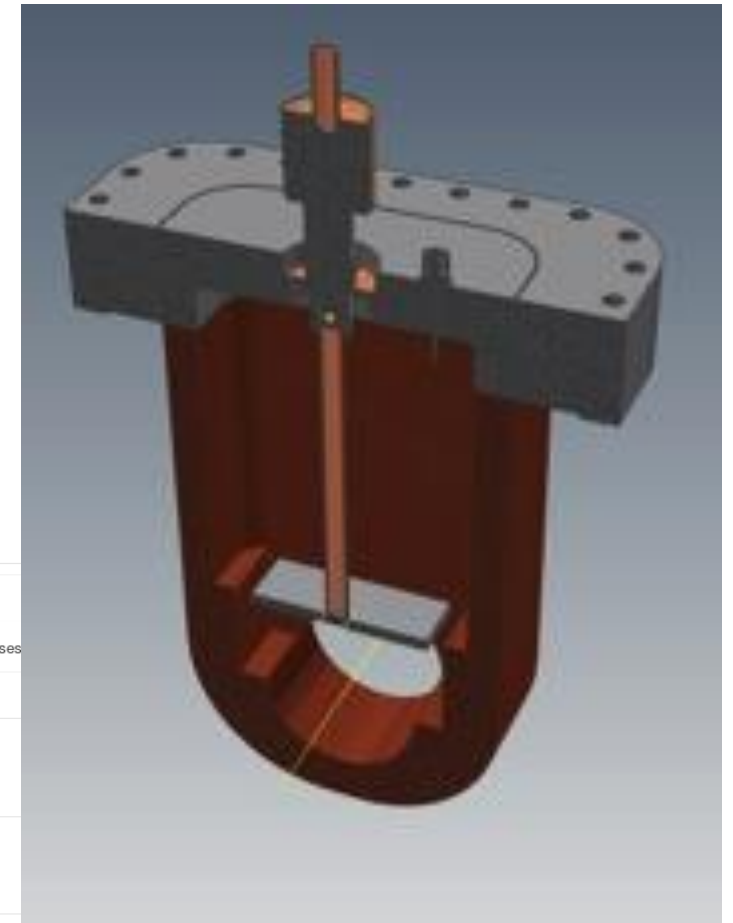
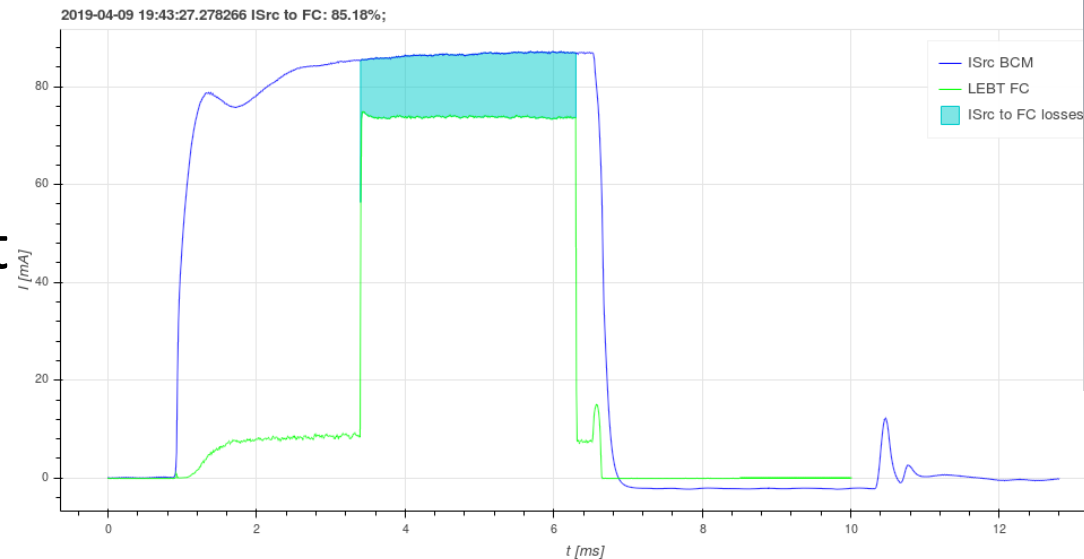
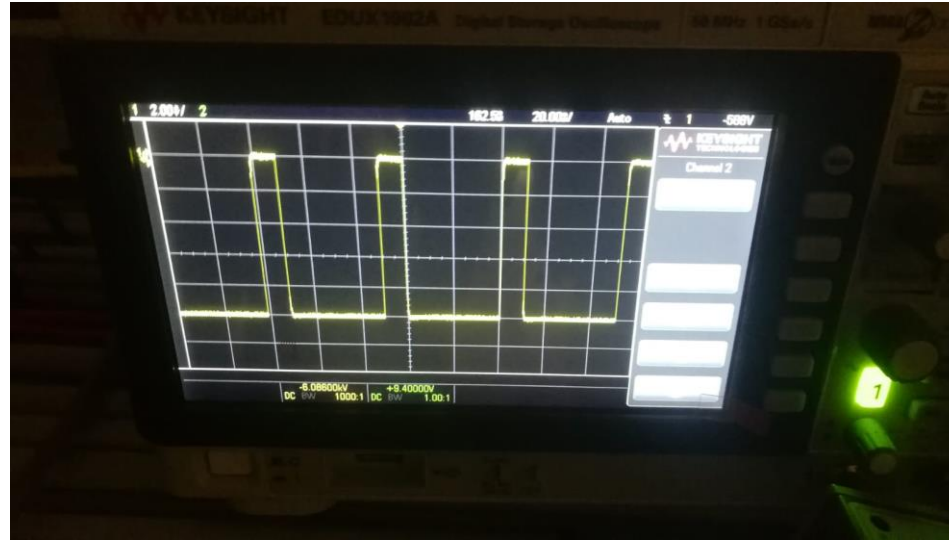
Installation and Commissioning timeline



- December 2017 – LEBT and source shipped from Catania to Lund
- January 2018 to May 2018 – Installations in the tunnel
- July 2018 – Safety Readiness Review
- September 2018 – Start of commissioning
- November 2018 to January 2019 – Sparks from the High Voltage cause damages to a few power supplies, new work with grounding required
- February 2019 – Commissioning restarts
- April 2019 – End of commissioning and start of RFQ installations

Issues: LEBT Chopper

- Commissioning of the chopper started on March 5
- Issues reaching the nominal voltage during testing
- Debugging the system
- Local test successful!
- Remote control test ongoing





HV Power Supply
ML12N25 Glassman

