Linac4 3 MeV Run – August 2019

G Bellodi for the whole Linac4 team

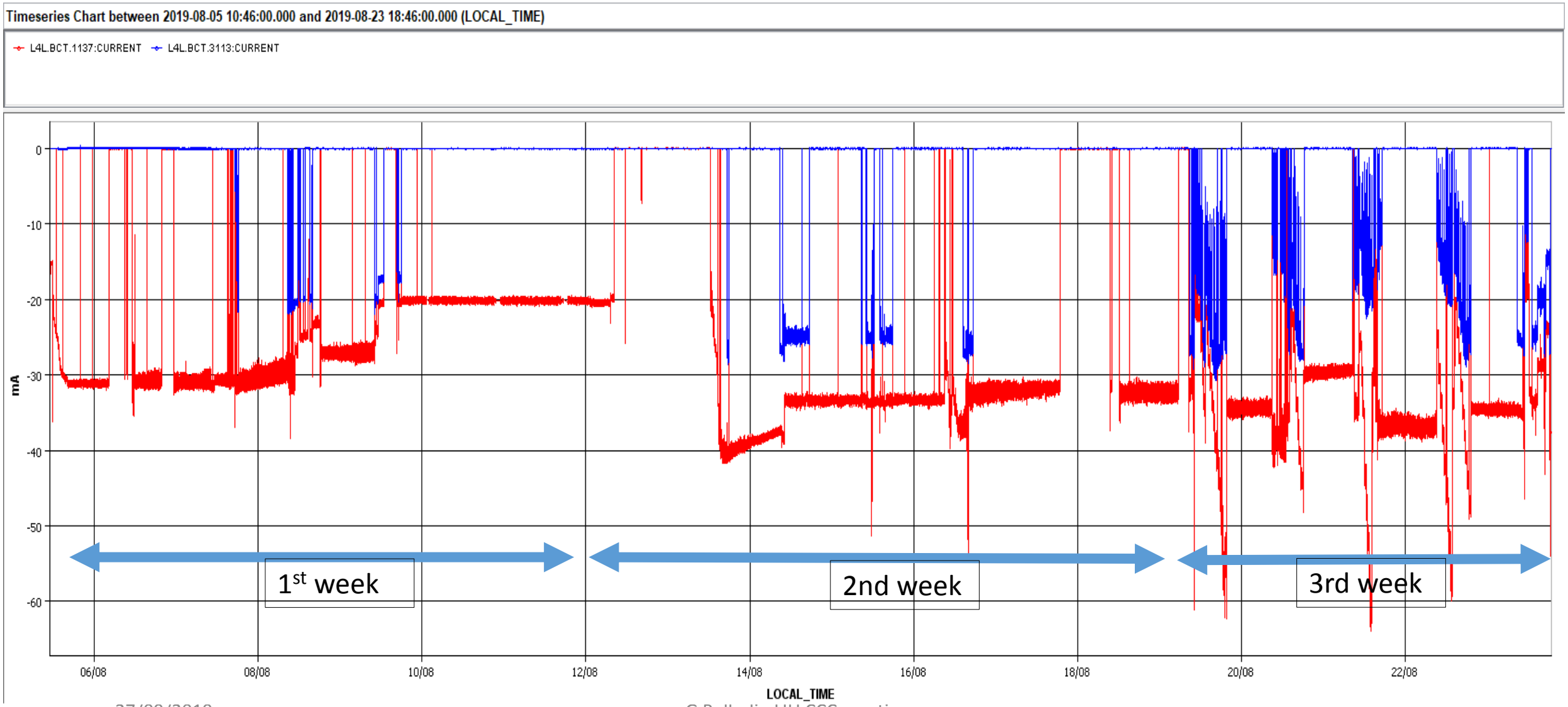
Plans for 3 MeV summer run (5-23 August)

AL at Linac4 HW and BC WG meeting–10/07/2019

- Autopilot
  - Debugging
  - Regulation of power
- 2MHz amplifier
  - Verifications and tests
- Cesiation system (discrete and continuous)
  - Verifications and tests
- Steering studies including
  - Solenoid polarity (4 combinations)
  - Steerers (asked EPC to lift the software veto)

Beam currents at 45keV and 3MeV

- on average beam after the RFQ was available ~50% of the time during working hours
- availability increase with time



Issues I

LN4→ PSB Timing migration:
"The PSB injection timing FEC as well as the LN4 main trigger FEC were completely refactored during the June 2-week stop for the LN4-PSB connection. Modules and devices were added, removed, reordered. The LTIM FESA class is also producing OR signals between adjacent outputs of a CTR, by directing the counter outputs to various module outputs. Unfortunately the LTIM persistency files were not updated to correspond to the new required configuration, resulting in, for instance, signals like the tail-clipper were not received, even if the working-sets were showing an acquisition (the device output being redirected to the wrong module output). The whole configuration was corrected today.
No cabling errors observed." (ikozsar, 07/08)

Control samplers not working and no logging of signals in Timber : new XenericSampler version installed during the weekend 10-11/08 with wrong Linac4 description files, eventually fixed by BE-CO – we were blind to source operation, and no cesiation possible in these conditions!

Source:
Discrete cesiation done on 13/08, top-up after a few days
HT bias power supply problem, circuit breaker reset (09/08)
Source RF amplifier tube failed and needed replacing with a spare (12/08)

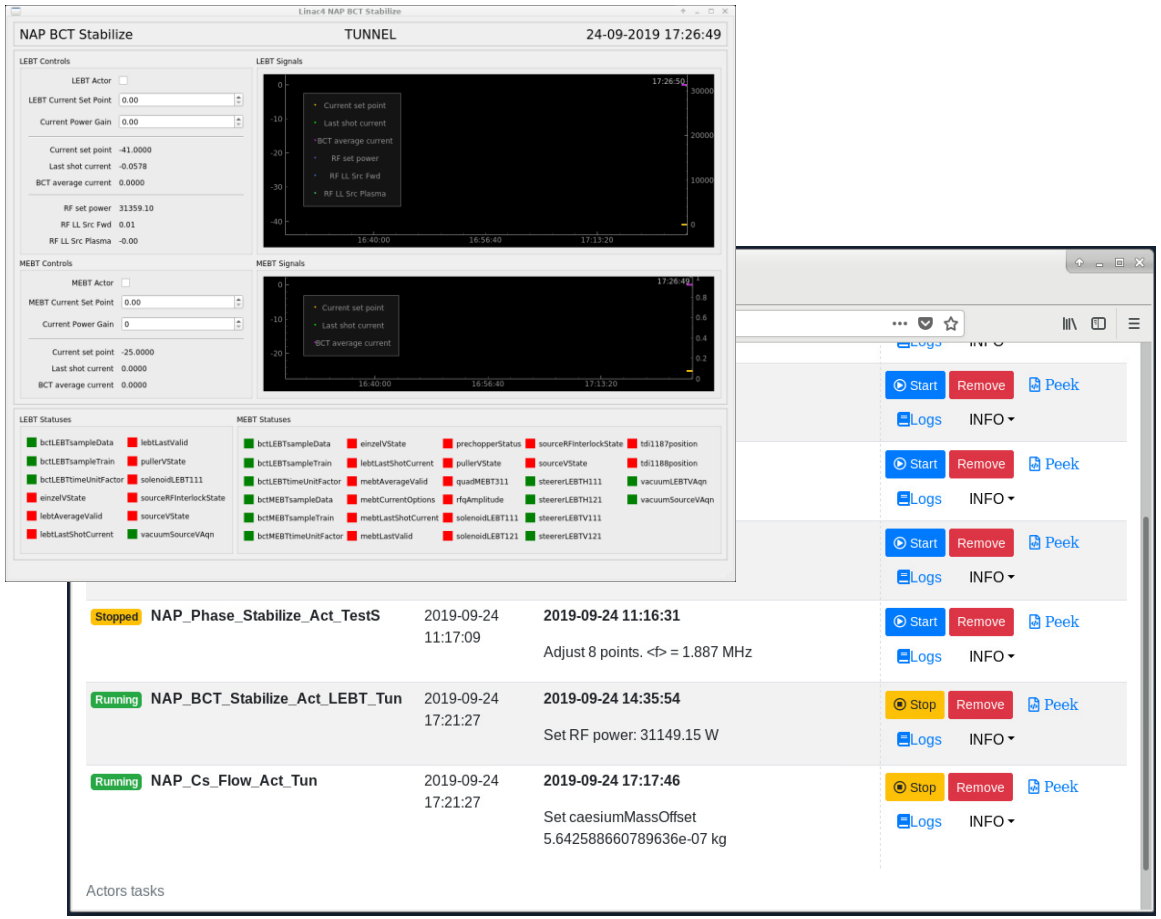
Issues II

Chopper:
Driver unit replaced with spare.
Tail monitoring problem on plates 3-4: 8 us jitter observed on L4X.STOPCHOPPER timing, sometimes falling after amplifier timeout- Timing advanced by specialist by 10us as temporary fix to allow operation. To be followed up.

BI L4L wire scanners : L4L.BWS3712 motorization problem fixed during an access. OP GUI recompiled. Scan settings and ranges to be re-tested.

FGCs not ready exceptions:
L4L steerers/solenoids electronics upgrade to allow for automatic polarity control : HW validation and cycling tests carried out during the August run. Migration took place on Monday August 26th

Beam tests: Autopilot



- Hosting environment for Python scripts developed by BE-CO
- Graphical interface in preparation (BE-CO)
- Regulation modules written by BE-ABP
- Modules split into two parts:
  - Monitors provide data verification and logging
  - Actors use information provided by monitor to stabilize source

Autopilot

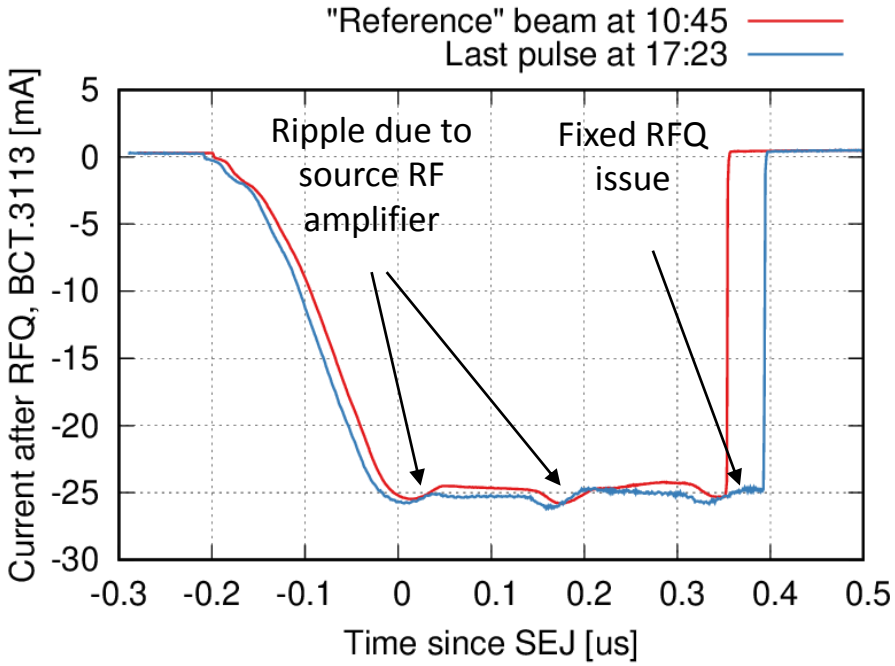
Autopilot GUI snapshot (work ongoing)

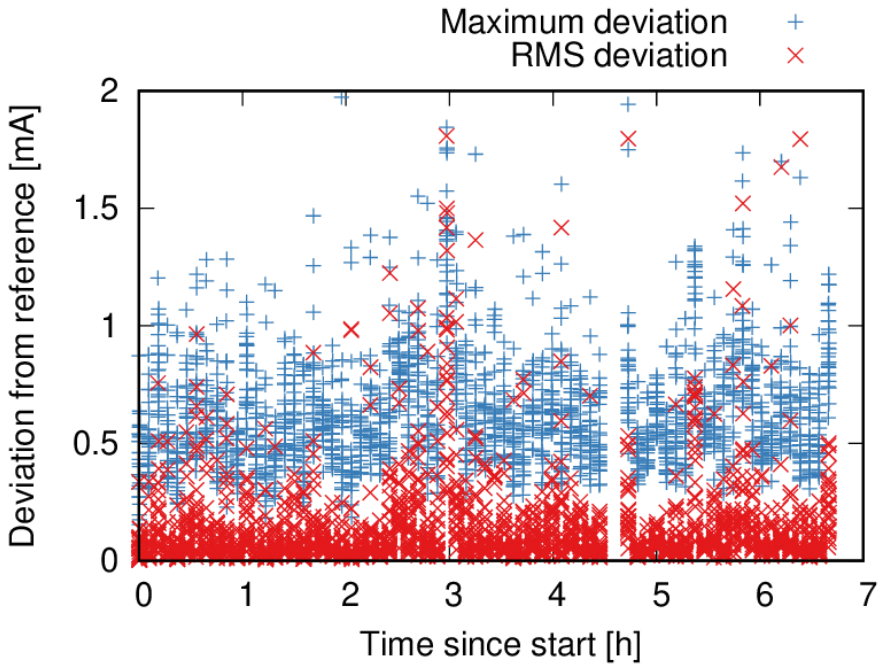
- Modules in preparation for the LBE run:
  - HV_Reset: Automatic reset of the source high voltage supplies
  - BCT_Stabilize: Regulate beam current to fixed value*
  - eH_Mon: Monitoring of e/H ratio

*= LEBT current regulation acting on sourceRF power , MEBT current regulation acting on source current

Autopilot: BCT_Stabilize verification

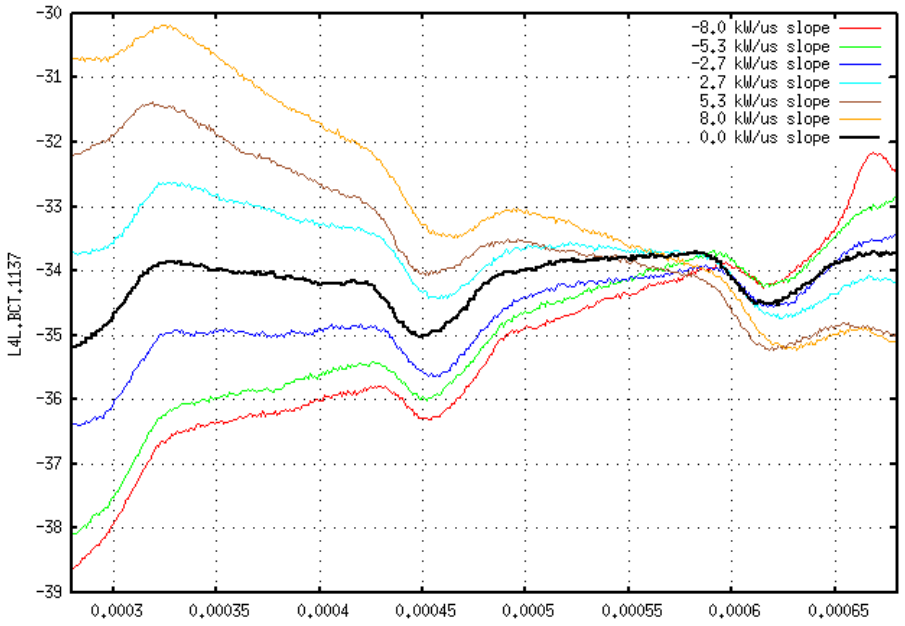
- Light cesiation on 2019/08/13
  - Goal: **reproduce drift** typically seen in timespan of 1 week over a day.
  - **No (manual) retuning** over the day.
- Test performed from 10:45 to 17:30
  - Shorter pulse (350 us) than hoped due to too short/early RFQ RF pulse
  - e/H drift from 5 to 6: less than expected, test should have been directly after cesiation
- Over ~6.5 h
  - Maximum deviation: < ~1 mA
  - RMS deviation < ~0.5 mA





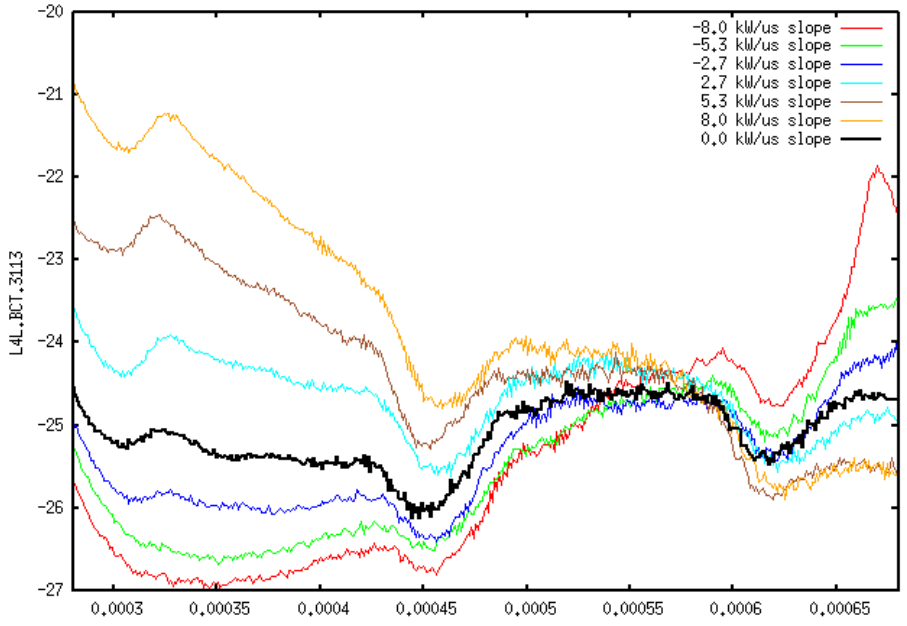
Autopilot: Slope correction on the RFQ

LEBT BCT (BCT.1137)



Time [ms]

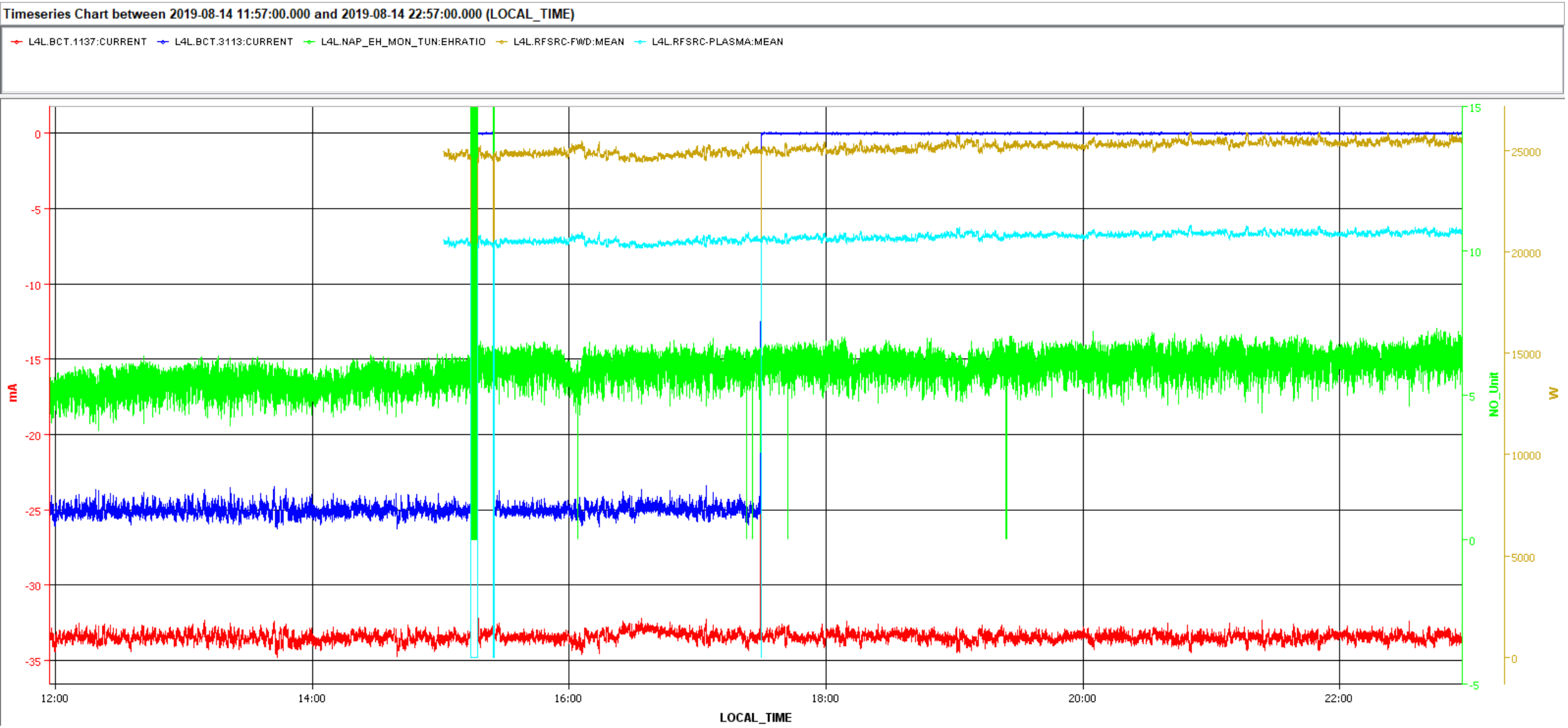
BCT after RFQ (BCT.3113)



Time [ms]

- Basis of an slope correction algorithm after the RFQ:
  correct **beam current slope after RFQ** with **slope of beam current in the LEBT**
- Preliminary implementation (insufficient data validation) tested and works:
  long-term test required

Example of Autopilot regulation after source cesiation on 14/08 (concurrent Timber logging problem)

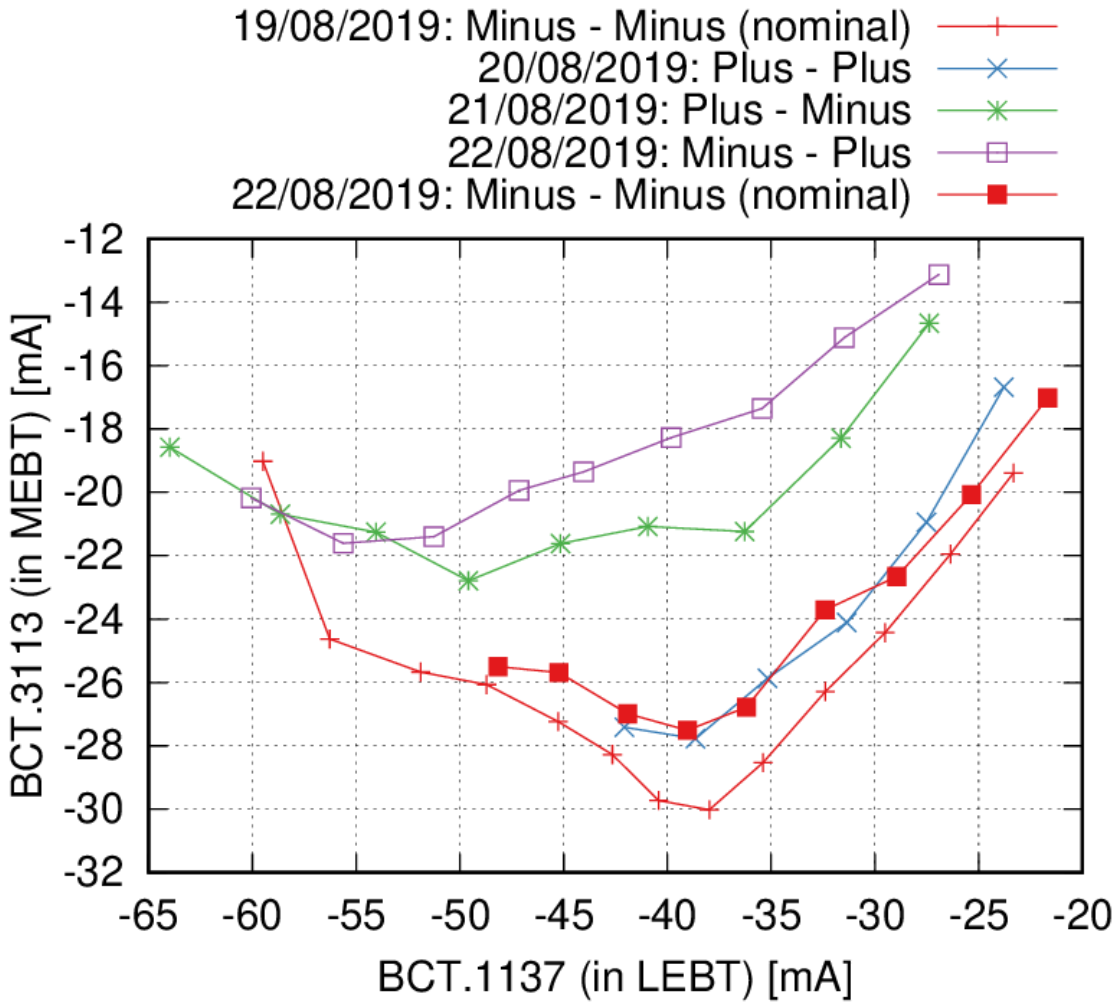


Beam measurements

- Quantification of 2 MHz noise from source RF at 45keV and 3 MeV: taken logs of L4L.BCT.1137 and L4L.BCT.3113 traces at 56ns and 94 ns resolution for different source RF power points to study current stability and frequency spectra.

- Steering studies for all four solenoid polarity configurations at different source RF power points to study transmission through RFQ.

Solenoid polarity scan

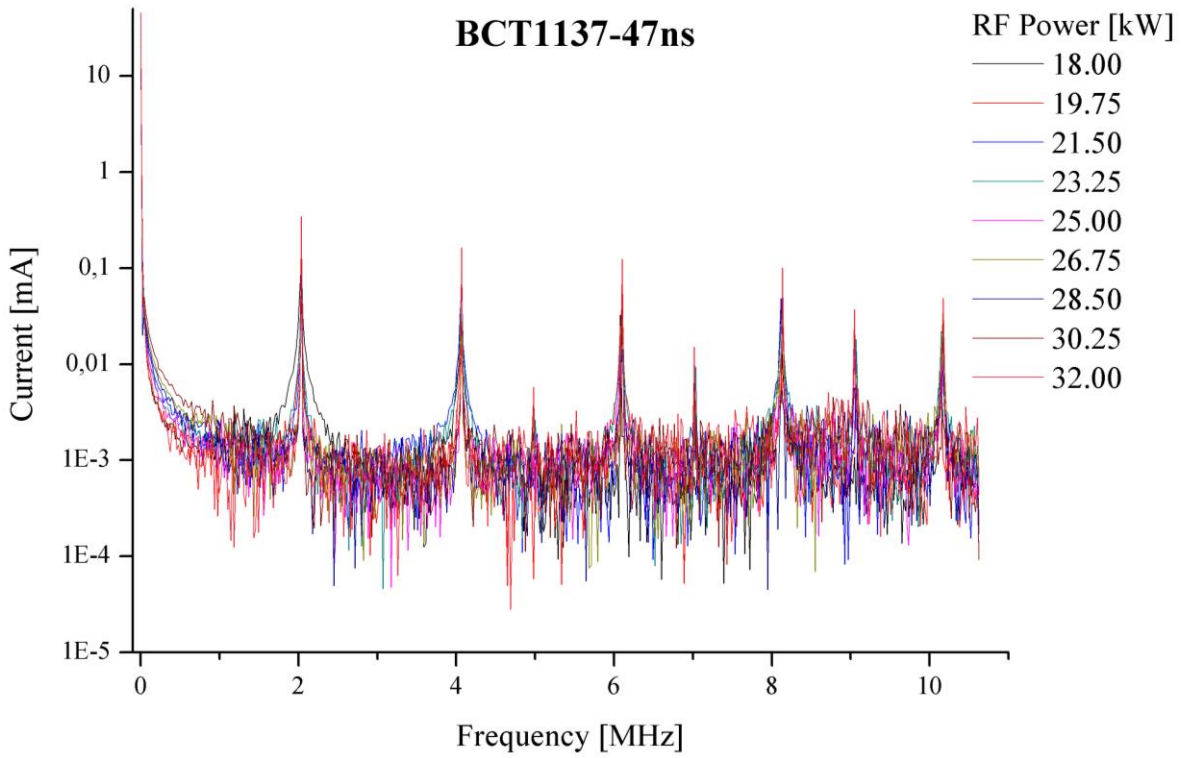


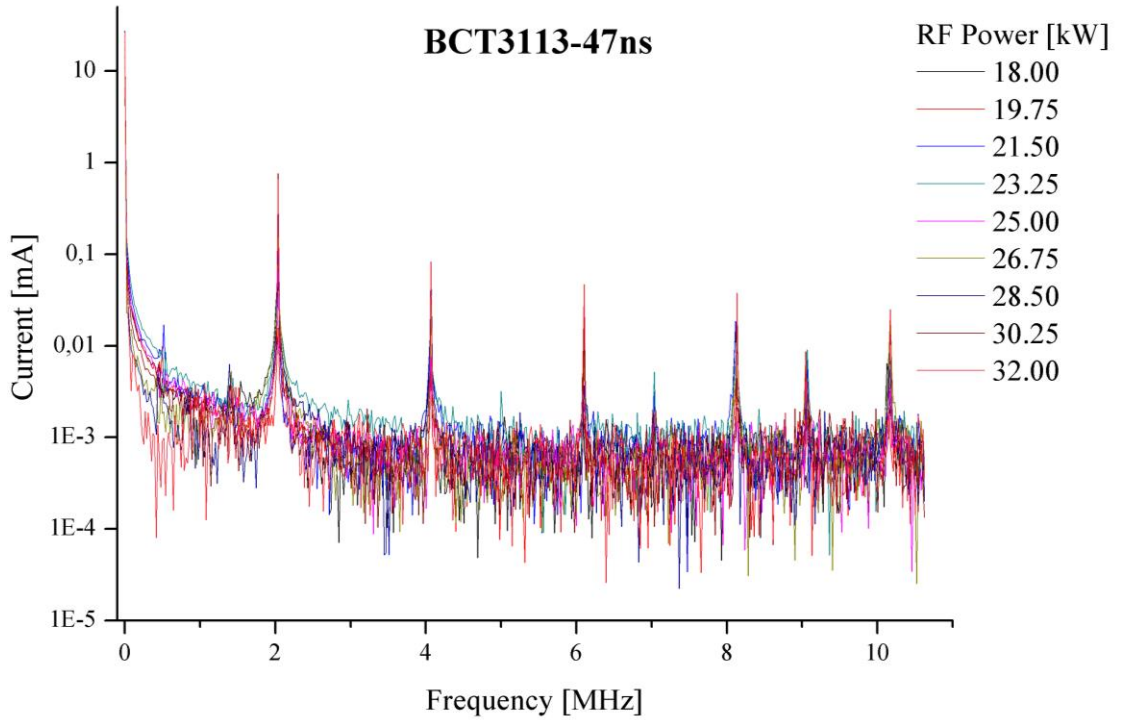
- Measurement procedure
  - Flip solenoid polarity (manual)
  - Scan source RF (beam current)
  - Rematch beam for maximum transmission at each current (solenoids and steerers)
- NB
  - Decreasing level of source cesiation (19/08: e/H = 2 to 22/08: e/H = 5)
  - Sudden drop of RFQ voltage during first scan
- Results
  - Configurations with parallel field alignment roughly equivalent
  - Significantly reduced transmission for anti-parallel configuration

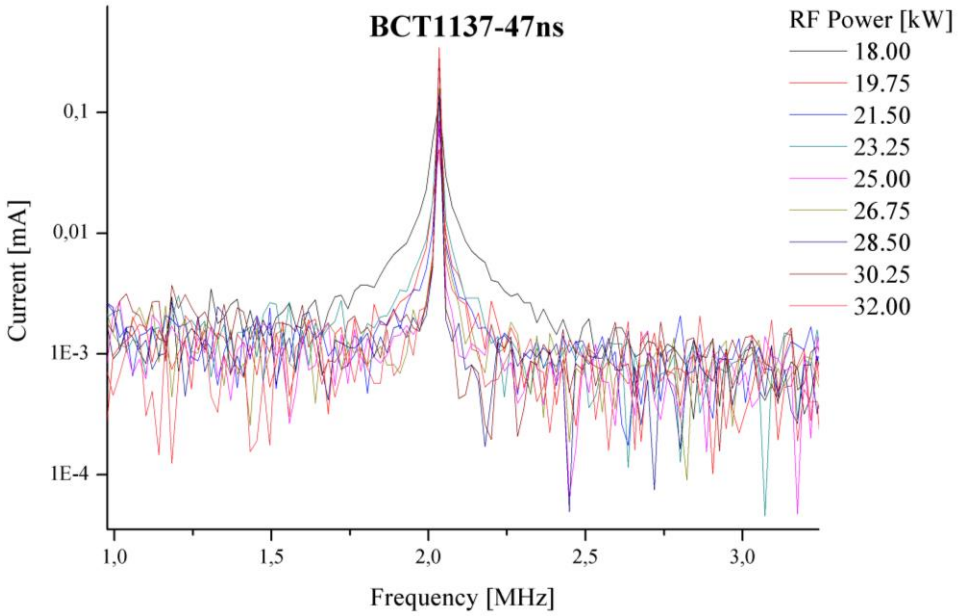
→ <u>confirms initial beam offset and asymmetry</u>

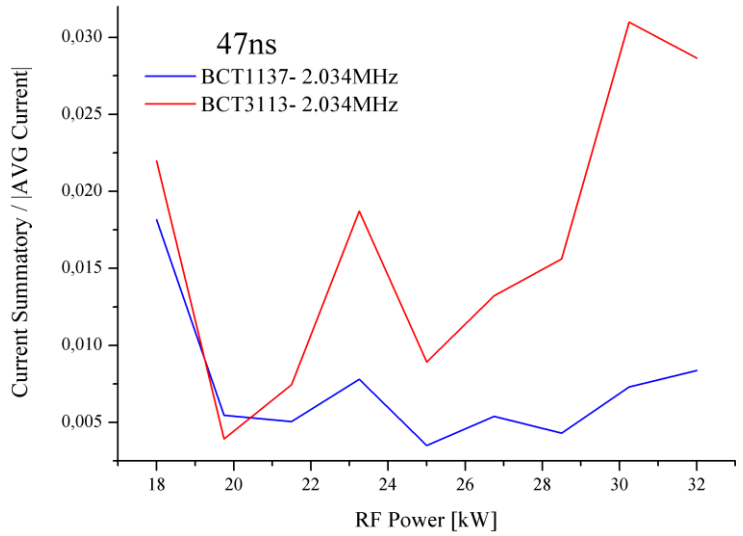
2 MHz noise evaluation

- The plasma in the ion source is driven by a 2 MHz RF through an antenna.
- Record BCT.1137 and BCT.3113 for different source RF power levels (200 µs after SEJ, 47.05 ns and 94.1 ns sampling times)



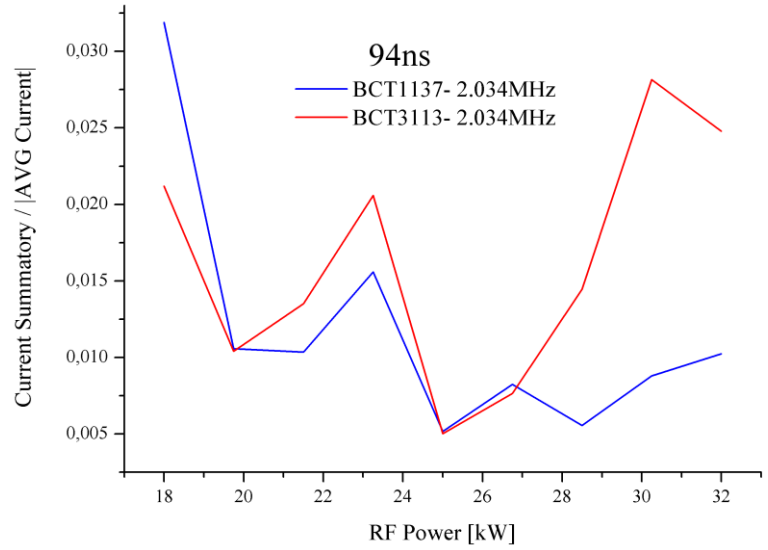






Results:

- ≈ 0.5% beam ripple 2 MHz after the source
- < 3 % beam ripple 2 MHz after the RFQ
- Higher frequency ripple in the per-mille level
- RFQ does not seem to damp oscillations
- Statistics may be too low to draw conclusions on the dependence on power



Summary of August 3 MeV run

- 3 weeks of testing dedicated to Autopilot and RFQ transmission studies.
- Test of solenoid polarity revealed issues with beam steering or asymmetry in the LEBT.
- Approx. 2 % of 2 MHz beam ripple after the RFQ observed.
- Tests of Autopilot:
  - Test of monitor and actor for BCT_Stabilize:
    different current averaging methods, data validation in PPM operation with different pulse lengths, stability tests
  - Preliminary modules for pulse flatness and source RF frequency stabilisation tested

Ion Source and Caesiation

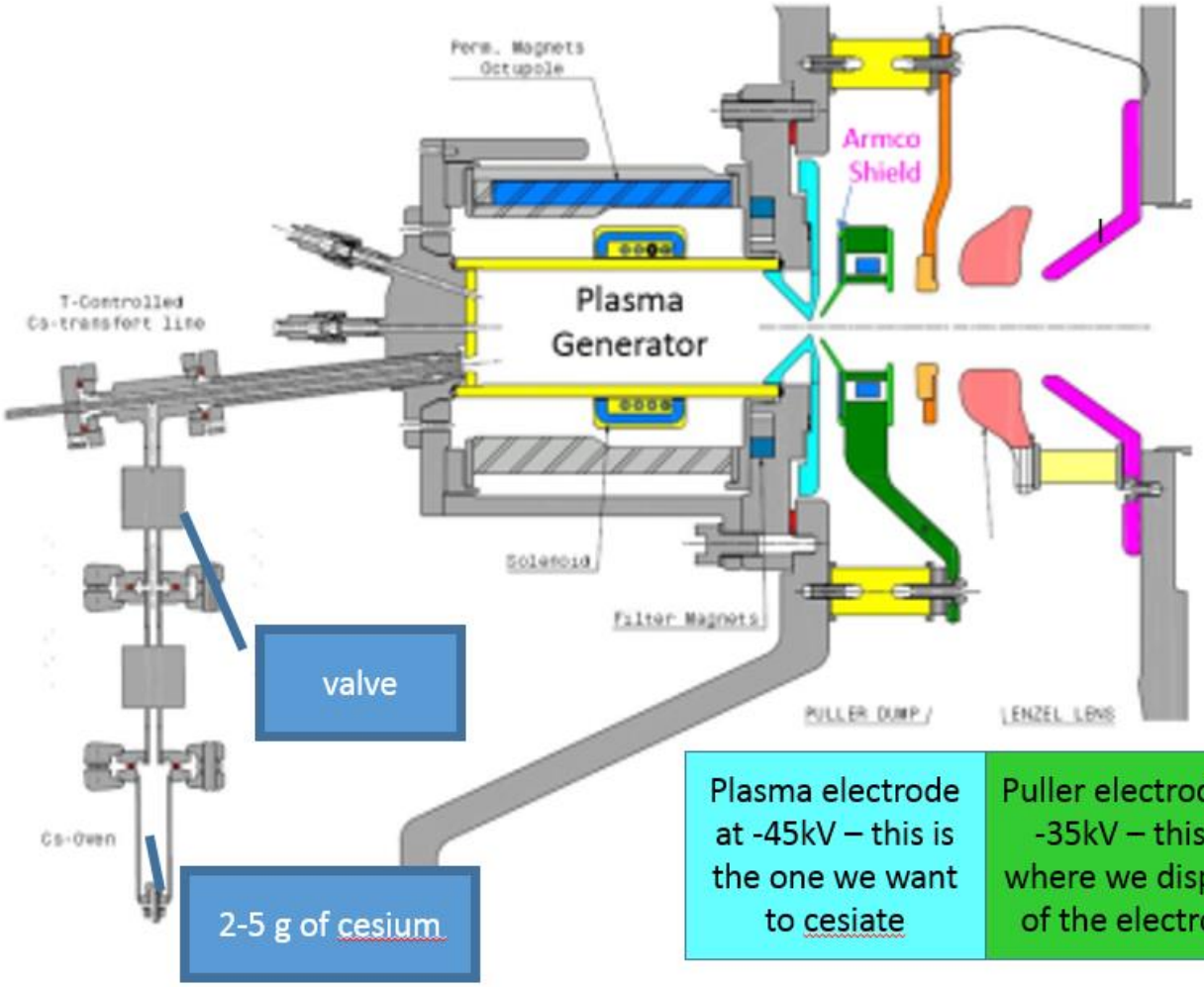
Continuous caesiation has been tested on the 3MeV test stand since May 2019.

Special MPP panel meeting scheduled before deployment at Linac4 could go ahead.
Positive recommendation received end of August :

- first tests at Linac4 since 09/09 with the sector valve closed for performance validation
- if no issues encountered (which is the case so far..), plan to carry on through the LBE run with continuous caesiation and sector valve to RFQ in open state

Thank you for your attention

Ion Source and Caesiation



One-shot caesiation : we segregate the source and part of the LEBT from the rest of linac4 when the caesium valve is open and the oven hot (INTERLOCKED)

Continous cesiation : we evaporate caesium during beam operation, i.e. the oven is hot and all the valves are open

Plasma electrode at -45kV – this is the one we want to cesiate	Puller electrode at -35kV – this is where we dispose of the electrons	Ground electrode	Lens at +-30kV	Ground electrode

A.Lombardi

One-Shot vs. Continuous Caesiation

- Advantages of Continuous Caesiation
  - Avoid down time of 3-4 hours every 2-3 weeks
  - Provide a more stable beam (notice long-term stability not shot-to-shot)
  - Reduce load on the electron dump – opens possibility to new source design
- Lay-out
  - Sector valve separating Source from RFQ
- One-shot → valve closed
- Continuous → valve open, possibly exposing RFQ to Caesium
  - concerns of performance degradation of the RFQ