



Dedicated MDs: PSB, Linac4 and source MDs

MD Days 2025, 03.02.2025

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Very draft dedicated schedule for 2024

- April 17: Linac4/PSB + PS2SPS collimation studies
- April 24: SY-ABT
- May 8: BE-CSS hysteresis compensation
- May 22 (IPAC): SY-ABT
- May 29: Linac4/PSB + COLDEX 1 (+4 weeks ideally for COLDEX 2), needs 15' for motion + local interlock
- June 19: BE-CSS hysteresis compensation
- June 26: BE-ABP vertical instabilities with LHC beam
- July 10: SPARE
- July 17: Linac4/PSB + COLDEX 2, needs 15' for motion + local interlock in BA4
- July 24: SY-RF
- Aug 21: SY-ABT
- Aug 28: SY-ABT
- Sep 25: SY-ABT Shadowing controller for x2 loss reduction (should be late in the year)
- Oct 2 (pp run): Ions emittance measurements at flat bottom
- Oct 16 (LHC ion): SPARE

1/29/2025

F. Asvesta & B. Salvant

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F. Asvesta, *“Outcome and follow-up from IPP MD Days”*

Dedicated Linac4-PSB MDs in 2024

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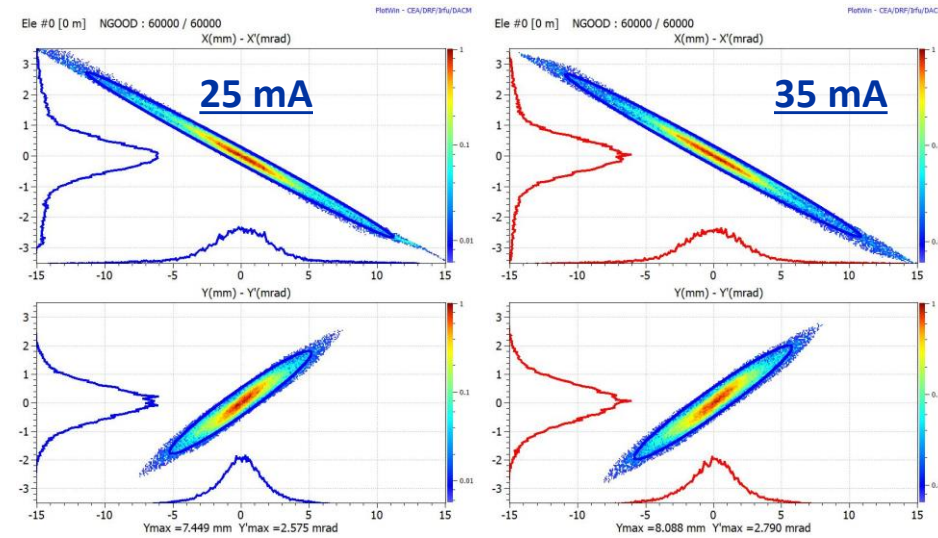
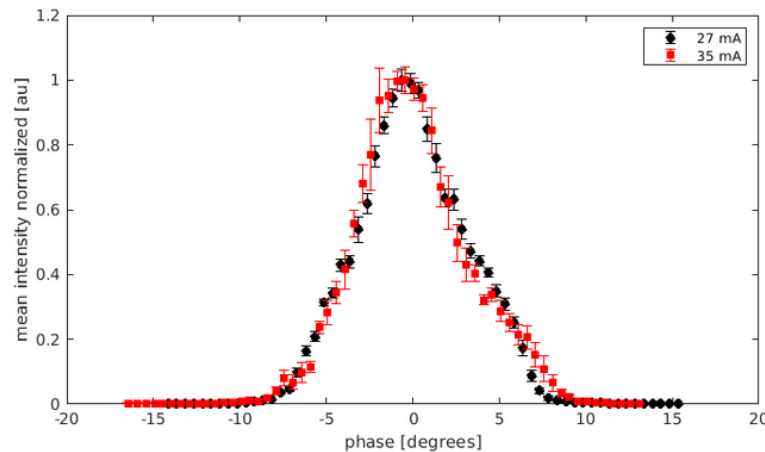
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- Originally, **3 slots allocated** for the high current L4-PSB
- **Assumption that the MD would not be dedicated:**
 - In 2023, L4-PSB proved that **operational beams could be produced**, while delivering high current.
 - **30m-1h** allocated for the **source configuration switch**, both at the start and at the end of the MD.
- **The second slot was postponed to June 19th not to interfere with the COLDEX run.**
- **The third slot was dropped as it was not needed and...**
- In the Fall, we started **pondering about the option to run high current for the last 1-2 weeks of the year** (more later).

So Where Were We?

- **Details** in the presentation from **P. Skowronski's** ([here](#)) and **M. Marchi's** last year talks ([here](#))
- **L4: Detailed transverse and longitudinal characterization of 35 mA beam to the LBE**
 - Current to **25 mA after chopping (35 mA out of RFQ with chopping factor of 0.7)**, which is **maximum average current that the L4 RF klystron-modulator system can handle due to power limitations in the LEP klystrons** with comparable performance of the current operational setting.



Conclusions

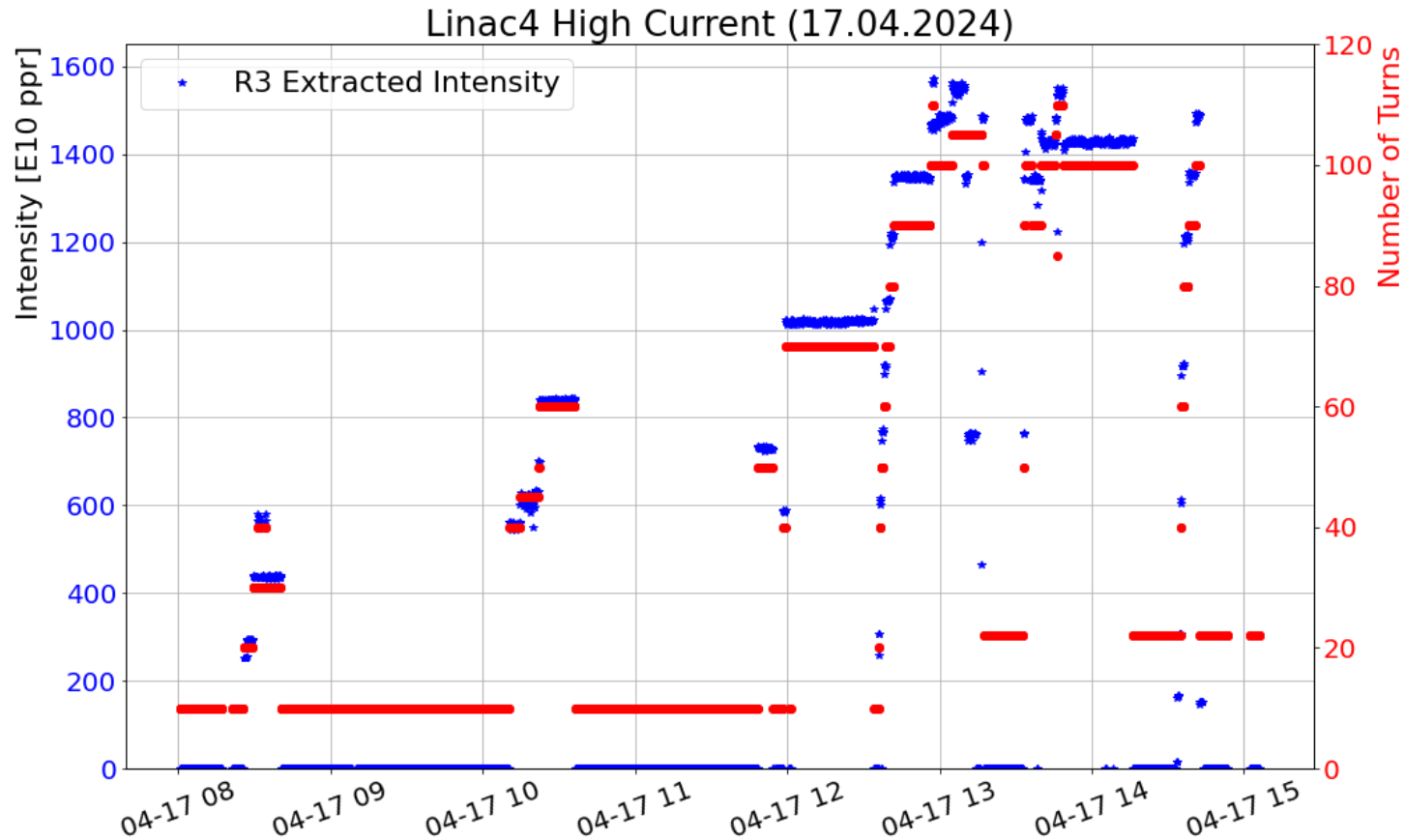
- No significant increase to amplifier current demand with 23 kV at the start of the cycle, 23 kV not operationally maintainable (yet?) **2024 PSB intensity increase campaign showed that more systematic studies are needed to operate reliably beyond 1.2-1.3e13 ppr.**
- Increasing total voltage to 23 kV and extending the triple harmonic improved the transmission at high intensity (1.58×10^{13} ppb.)
Intensity reach attained in R2,R3, R4. No time for testing R1.
- **High-current appears to be beneficial for brightness of BCMS**
- Phase shift measurements at injection show clear effect of bunch length on $h = 2$, further study required in simulation and with nominal current
- Direct injection of two bunches allows more than 6×10^{12} ppb to be extracted, transmission and beam quality to be studied
- Very promising results with longitudinal painting, which exceeded initial expectations
- High-intensity instability studies ongoing to investigate servoloops behavior and impedance

Plan 2024
Semi-dedicated
high-current MDs
for follow-up

Thank you for your attention!



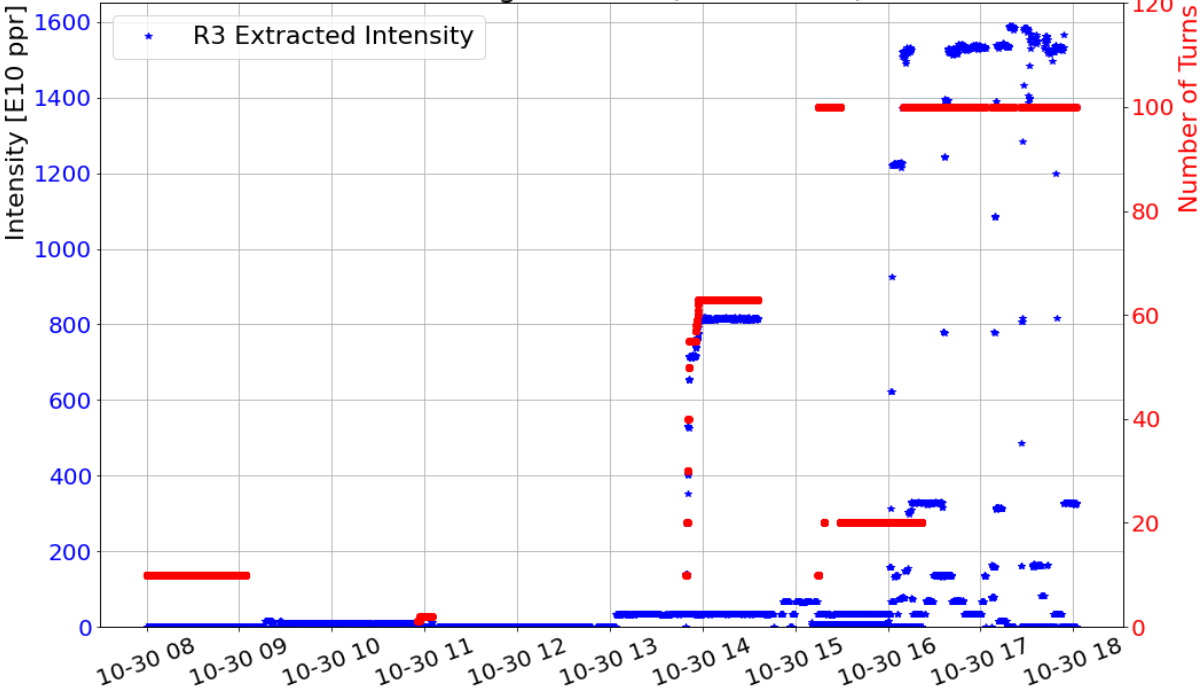
MD Results (I)



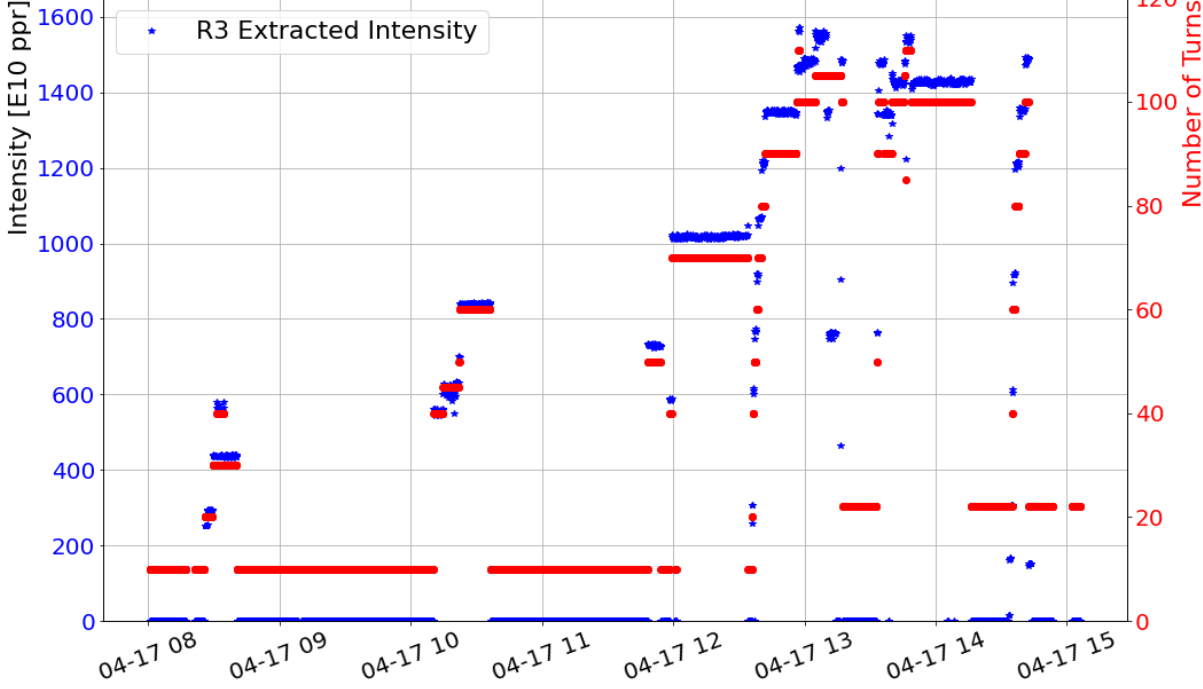
- **All operational beams could be produced with L4 High Current!**
- Operational beams produced rescaling the number of turns.
 - Important to show that it was repeatable.
- Reached **close to 1.6e13 ppr**
- Higher-than-last year number of turns (**110 vs 100**)

Comparison with 2023

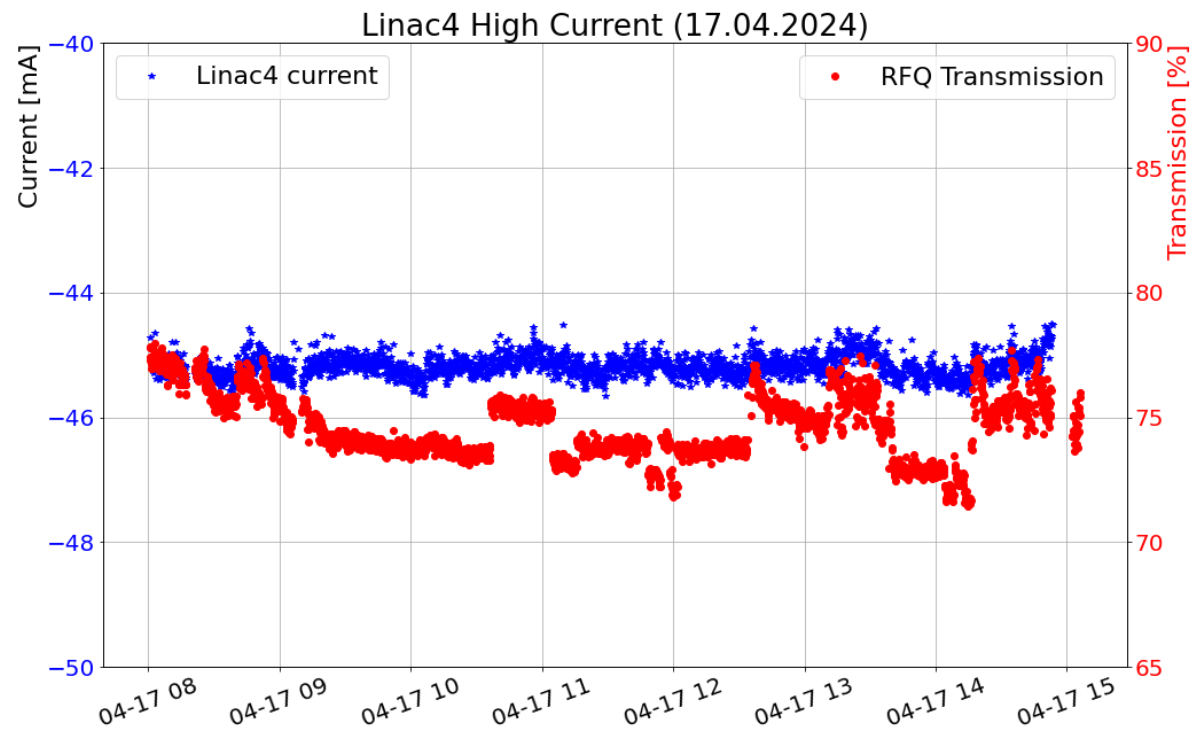
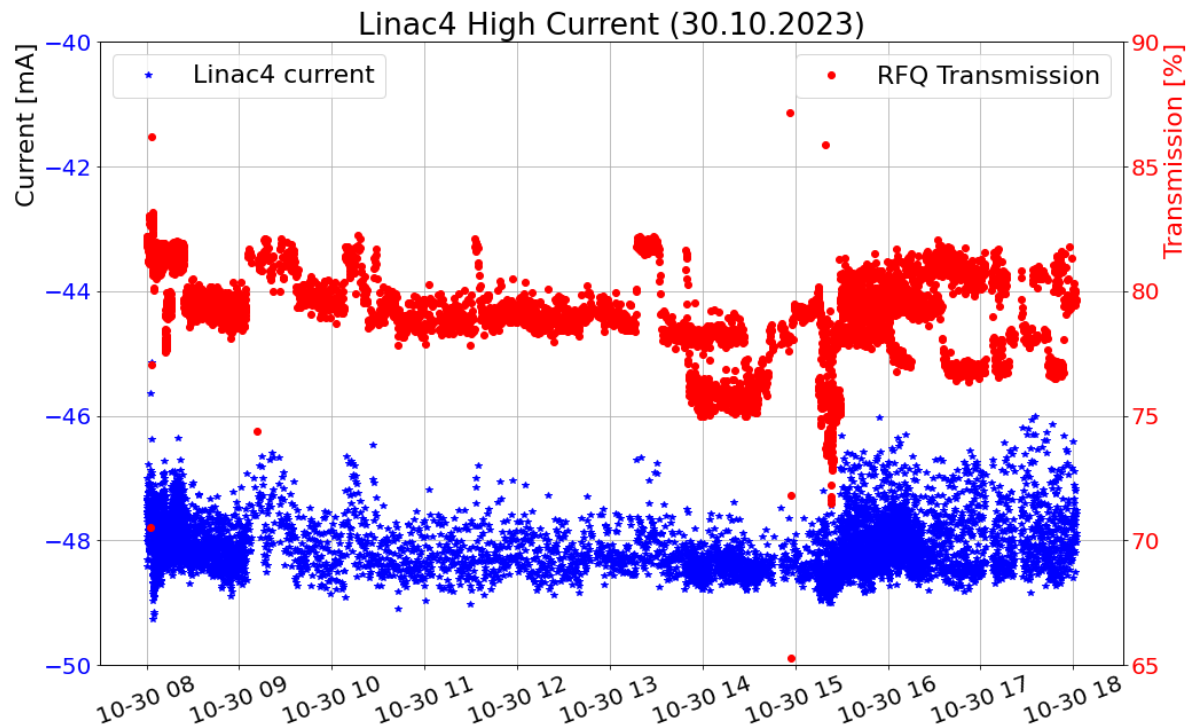
Linac4 High Current (30.10.2023)



Linac4 High Current (17.04.2024)



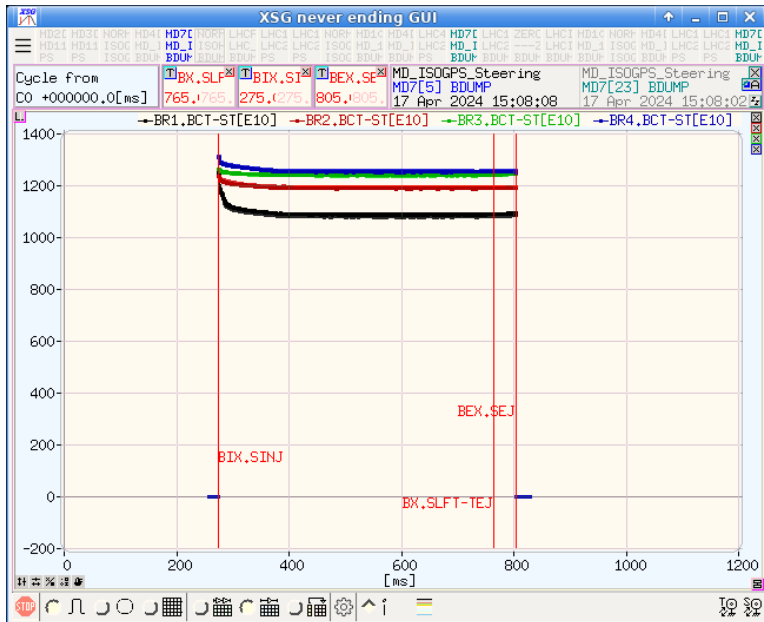
Source Performance in a Glance



- Switching to higher current mode (from the nominal -35 mA) possible.
- Source performance can slightly vary each year, i.e. in 2024 we attained ~-45 mA, but with better stability.

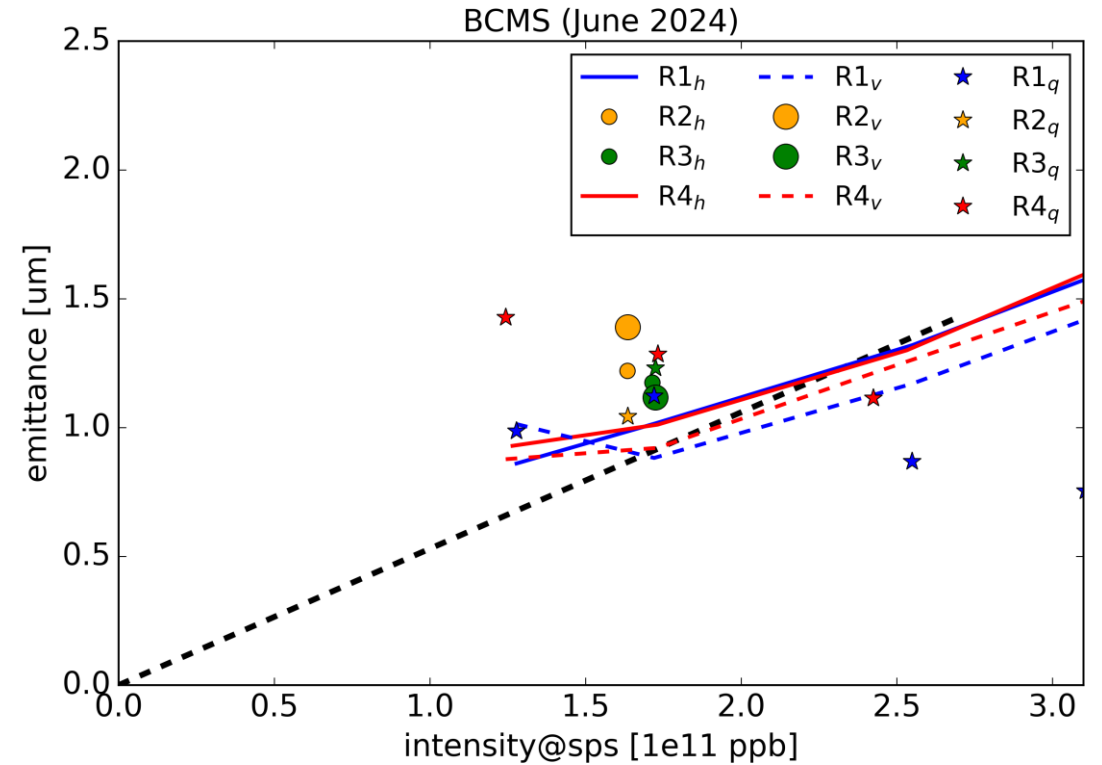
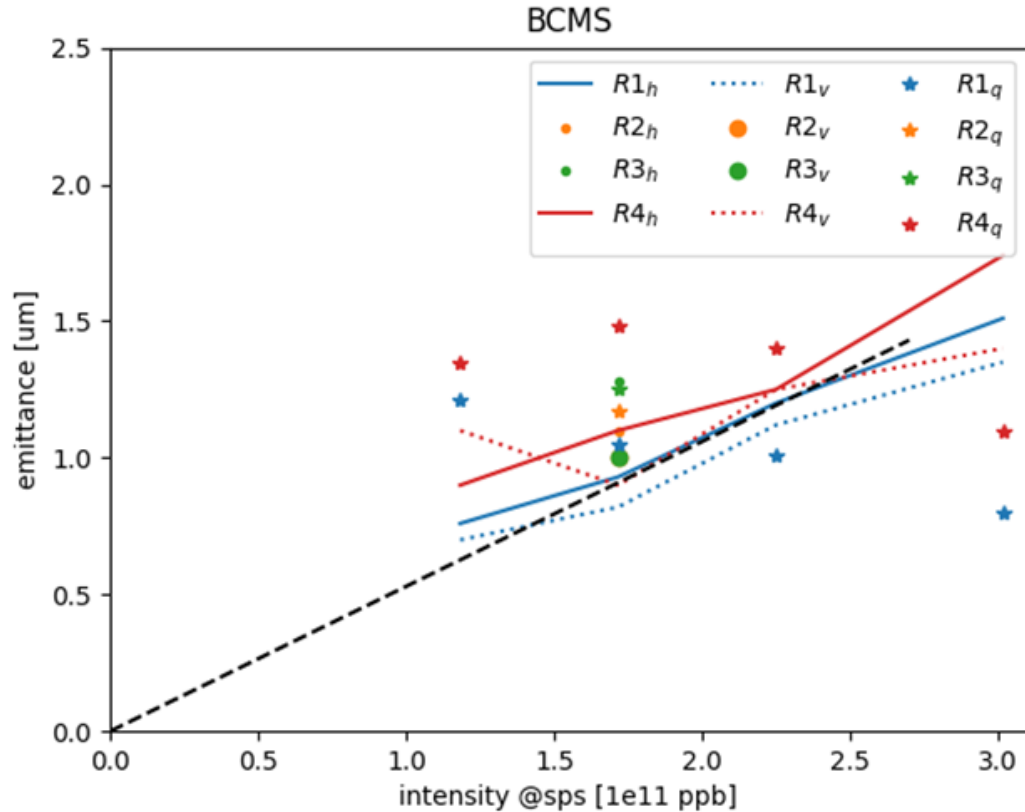
MD Results (III)

- PSB RF voltage limits increased to 23 kV (not viable in operation)
- R1 seemed to suffer from more losses along the cycle initially, fixed later on in MD block #2.
- Usual **interplay between longitudinal and transverse** plane to deal with:
 - Losses at extraction which required either **TFB adjustment or reworking the pos/angle**.
 - **B_Er.DHZ4/11L1 correctors setting affects the TFB performance** → Missing TFB expert to involve in the studies
 - Important **distortion in a few equipment, e.g. radial loops PU**.

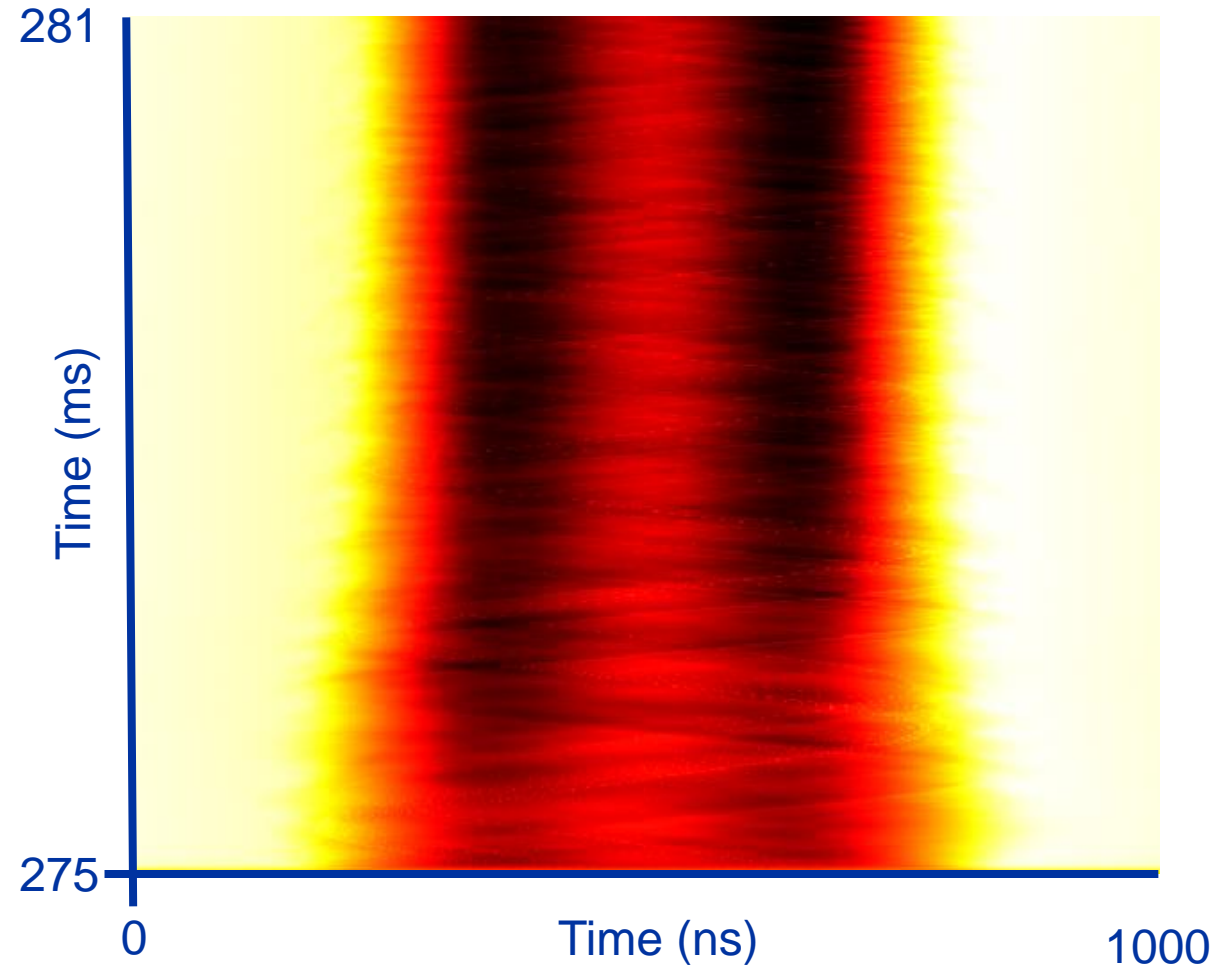
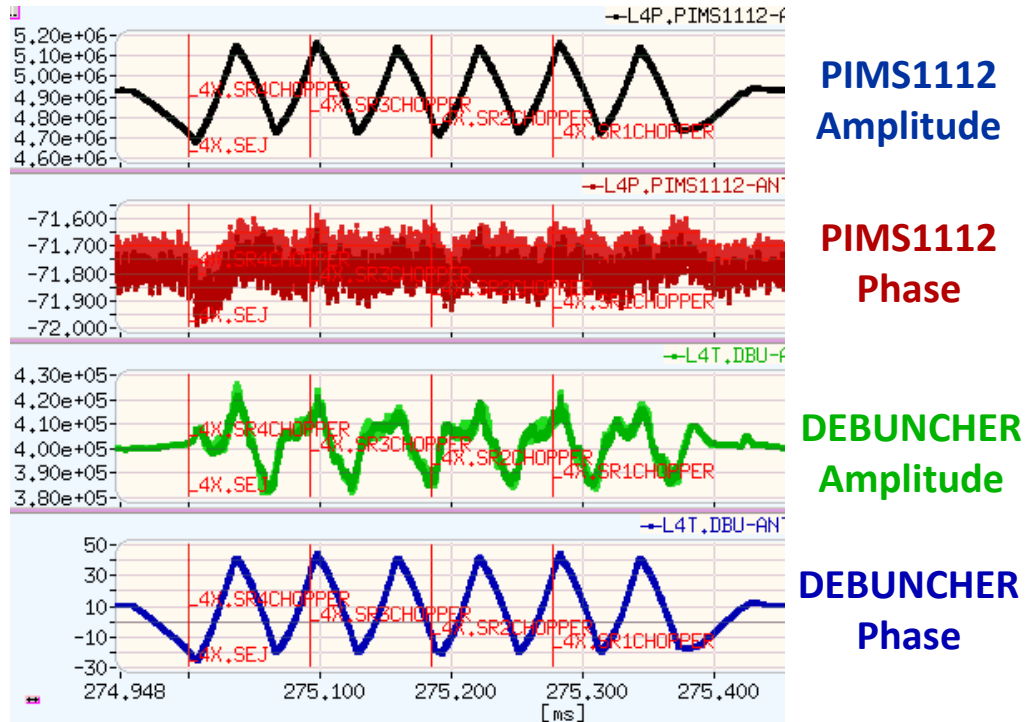


Brightness Results

- Confirmed that the LHC performance are compatible with both configurations.



Longitudinal Painting



- **Proof-of-principle for longitudinal painting** with high-current.
- Linac4 **DEBUNCHER power limitation** more apparent, required reduced setpoint amplitude.
- No significant impact on regulation of the Linac4 PIMS1112 RF line.

Conclusions

- **2024 studies were pivotal for reproducibility purposes:**
 - **Confirm** the observation from 2023.
 - Show that the **L4-PSB accelerators could be operated with the high current mode.**
- **Completed the push for intensity in all rings at 1.4 GeV and confirmed the observation on the LHC brightness:**
 - While **from the beam dynamic standpoint the PSB should be able to attain $1.6e13$ ppr**, this currently requires operating the **RF at 23 kV eating all the RF margins and endangering the lifetime of the RF Finemet amplifiers.**
 - **Systematic studies** needed at different energies to understand better limitations and device possible mitigations.
 - **Expert supports is crucial.**
 - A critical point is the current lack of **TFB experts**, as the TFB tuning is critical for the stability of intensities
- After the Fall, and following discussions with the experts, **we proposed to take a leap forward and perform a high current Linac4 run (source at -45 mA, nominal is -35 mA) for the last 2 weeks of the year:**
 - Detailed presentation at the [IEFC #358](#)
 - Decision taken **to not proceed with the test, to minimize any endangering of the last 2 weeks of the AD run.**

Proposed Plan for 2025

- Following the rejected proposal for high current run at the end of 2024 and discussing with the Linac4 experts, particularly keeping in mind that there will be limited maintenance in the short YETS 2025-2026, **we propose:**
 - Perform the **Linac4 BC with the source at -40 mA**.
 - At the end of the BC period, **decision point to either keep the -40 mA or go to the -35 mA configuration.**
 - **If all goes well, we will run at -40 mA.**
 - In case of **increased** (wrt nominal operation) **RFQ breakdown rate** or any **other issues** which could tracked down to the increased current, the Linac4 will **revert to the -35 mA**.
- Because of the increased current, there is **no need to push the current further for higher intensity/brightness studies.**
- To **validate the klystron-modulator systems performance** and to **detect degradations in good precision**, the RF team is requesting a **MD slot toward the end of each Run / year of 2h to 4h** (ppm user to L4Z dump) in which the beam current will be ramped-up until the first klystrons start to saturate.

Closing Remarks

Intensity reach: *ISOLDE – PSB*

- Intensities equivalent of $\sim 6800e10$ ppp at 1.4 GeV (in MDs)
 - $\sim 1700e10$ ppr in R4 (<7% losses)
 - $\sim 1600e10$ ppr in R4 (<2% losses)
 - Interlock on amplifiers for FineMet cavities had to be adjusted



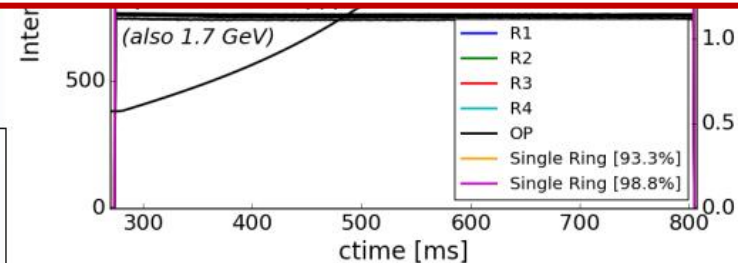
Do we need to push the Linac4 current? Explorations done with the experts indicate marginal gain for equipment lifetime (by reducing the max pulse length) while the intensity reach can be done with more turns.

Limitations might be different for higher energy (1.7 & 2 GeV)



**Intensities considered are INDEPENDENT from
Linac 4 Source Current Configuration**

These Intensities can be reached both with low & high current





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