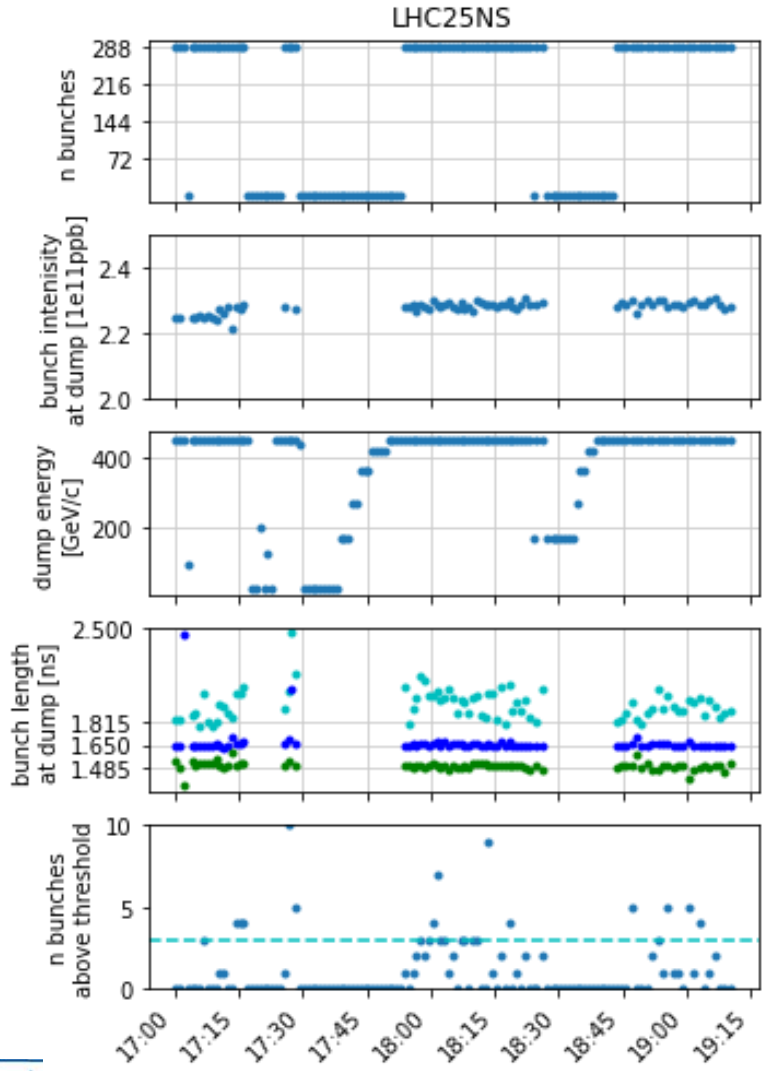
Pushing intensity with LHC-type beams the longitudinal side

Giulia Papotti for SPS RF

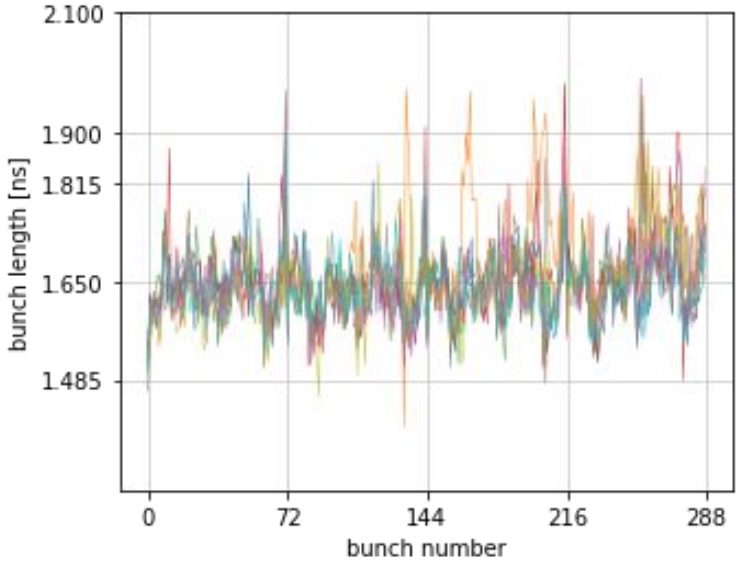
acks: F. Ten Broeke, R. Calaga, S. Calvo, G. Cipolla, H. Damerau, F. Killing, L. Intelisano, I. Karpov, E. Montesinos, S. Pitman

+ all colleagues in the transverse plane!

2024 achievements with beam



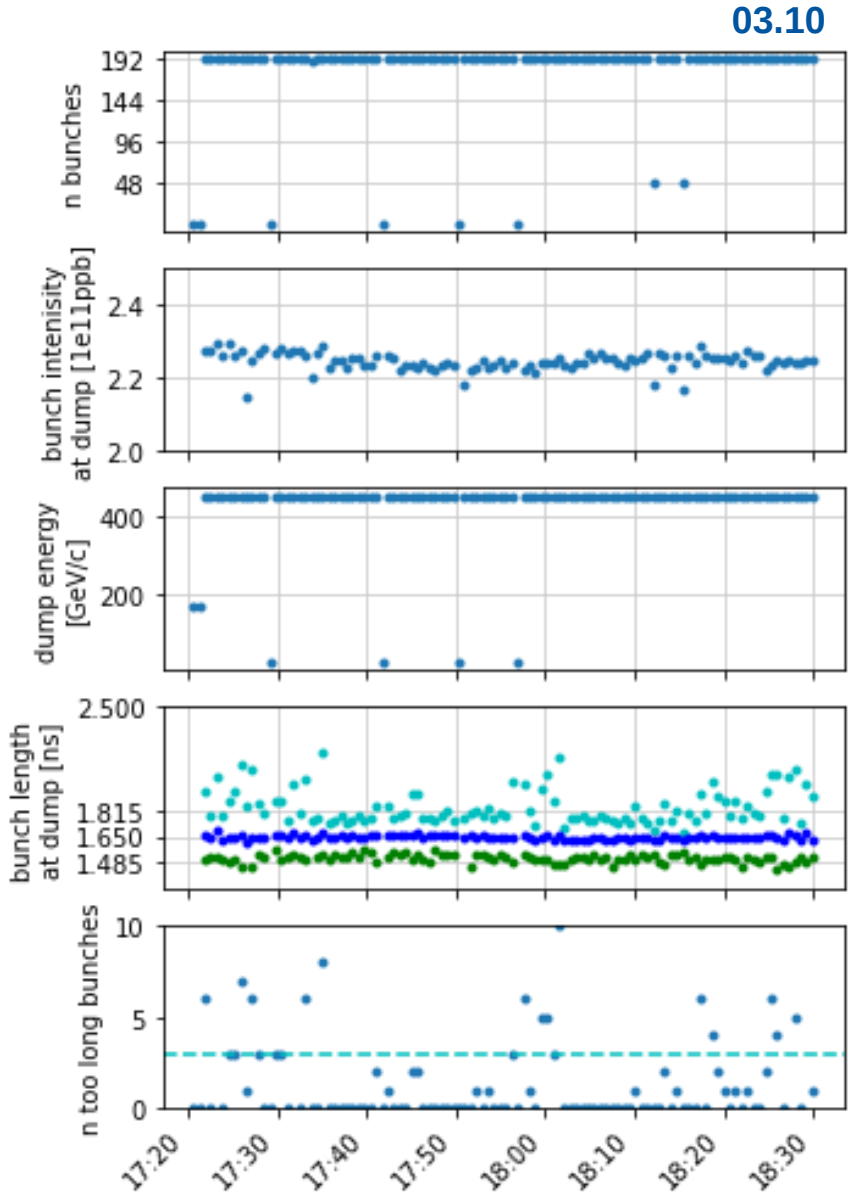
- 28.03, LIU parameters demonstrated
  - 4x72b 2.3e11 ppb in 1.65 ns +/-10%
  - V200 = 9 MV



I.K. at SPS MPC on 09.04, G.P. at SPS MPC on 24.09

2024 recap

- hardware performance shaped the longitudinal developments
  - slow progress during scrubbing due to abundant vacuum activity, mostly in cavity 3
  - reduced power from August (HOM coupler failure in cavity 3, Thales amplifier spare availability)
- nevertheless, reduced power allowed
  - long trains with reduced intensity
    - 12.09: 4x72b 2.0e11 ppb ok, 2.2e11 ppb ~ok
  - shorter trains at nominal intensity
    - 03.10: 4x48b 2.25-2.3e11 ppb ~ok
    - 15.10: 1x56b 2.4e11 ppb 8b4e ok
  - i.e. we have some margins



plans for 2025

- main focus: repeatability and operability
  - achieve specs on longer timescales
  - ideally with operational margin on intensity
  - moving towards less expert support (see LIU Reliability Run)

- on the hardware side
  - sufficient spares for Thales amplifiers available for 2025 and 2026 operation
    - also moving to ceramic transistors
    - see G. Cipolla at IPP on 19.07
  - during YETS: overdrive protection upgrade, new loads, revise matching step of cavity 3, new gain/phase adjustment, added measurement capability to 938 MHz couplers
  - during HWC: cavity conditioning via LSA function
    - should reduce vacuum activity during scrubbing
    - mostly during nights, both SFTPRO and LHC-type

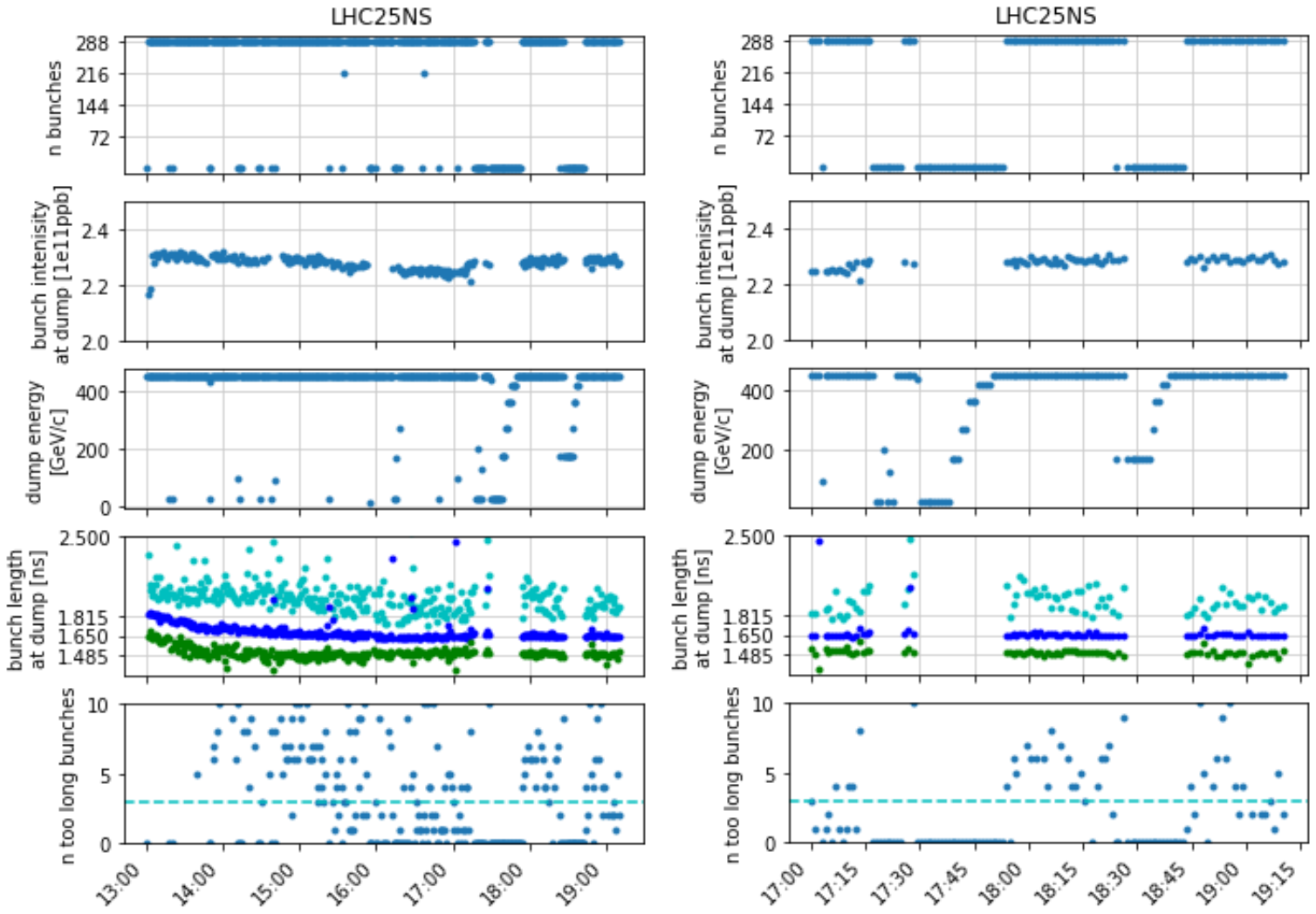
extras

2024 timeline

- 13 March (during scrubbing): TWC200 C3 vacuum spike
  - and about 20 SSPA modules broken
- 28 March: LIU intensity and bunch length demonstrated
- 18 May: TWC200 C1 elbow arcing
  - see F. Killing at SPS MPC on 30.07
- 15 June: TWC200 C6 loads breakage
  - and about 100 SSPA modules broken over several weeks
  - see S. Pitman at JAP24
- 11 July: TWC200 C3 HOM coupler burnt
  - and about 15 SSPA modules broken
  - see G. Papotti at IPP on 19.07
  - followed by “summer MD pause” to prioritize LHC luminosity production
  - one more discovered during YETS inspection
- 13 August: TWC200 C3 combiner load failure (see next slide)
  - had been arcing
  - then replaced 5 out of 36
- 12 and 19 September: LIU MDs resumed, but with limited RF power in C3
  - amplifier module failures throughout the year (see G. Cipolla at IPP on 19.07)

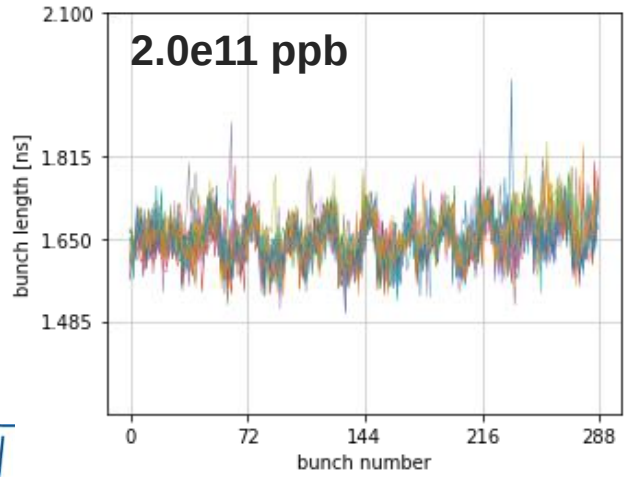
LIU parameters demonstrated (28 March)

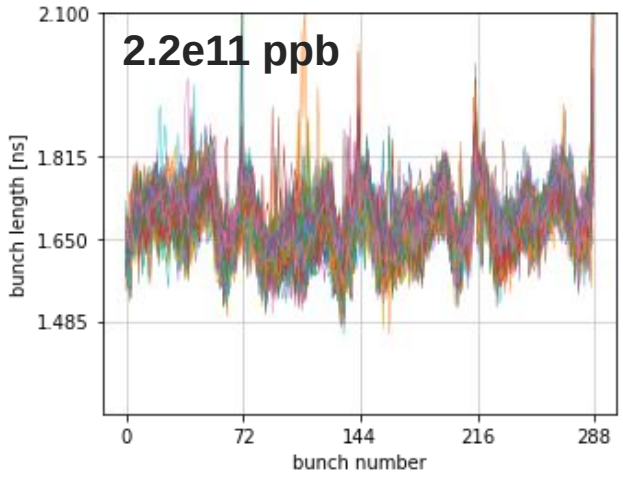
- 4x72b 2.3e11 ppb in 1.65 ns +/-10%
  - see also I.K. at SPS MPC #59
- on the RF system settings
  - TWC200 up to 9.2 MV
  - TWC800 < 10% at the flat bottom
  - sensitivity to blow up frequency band
- within BQMSPS acceptance (loose) thresholds
  - with non-rigid dipole oscillations to be investigated, and ideally solved
- focus then to move to repeatability and operability

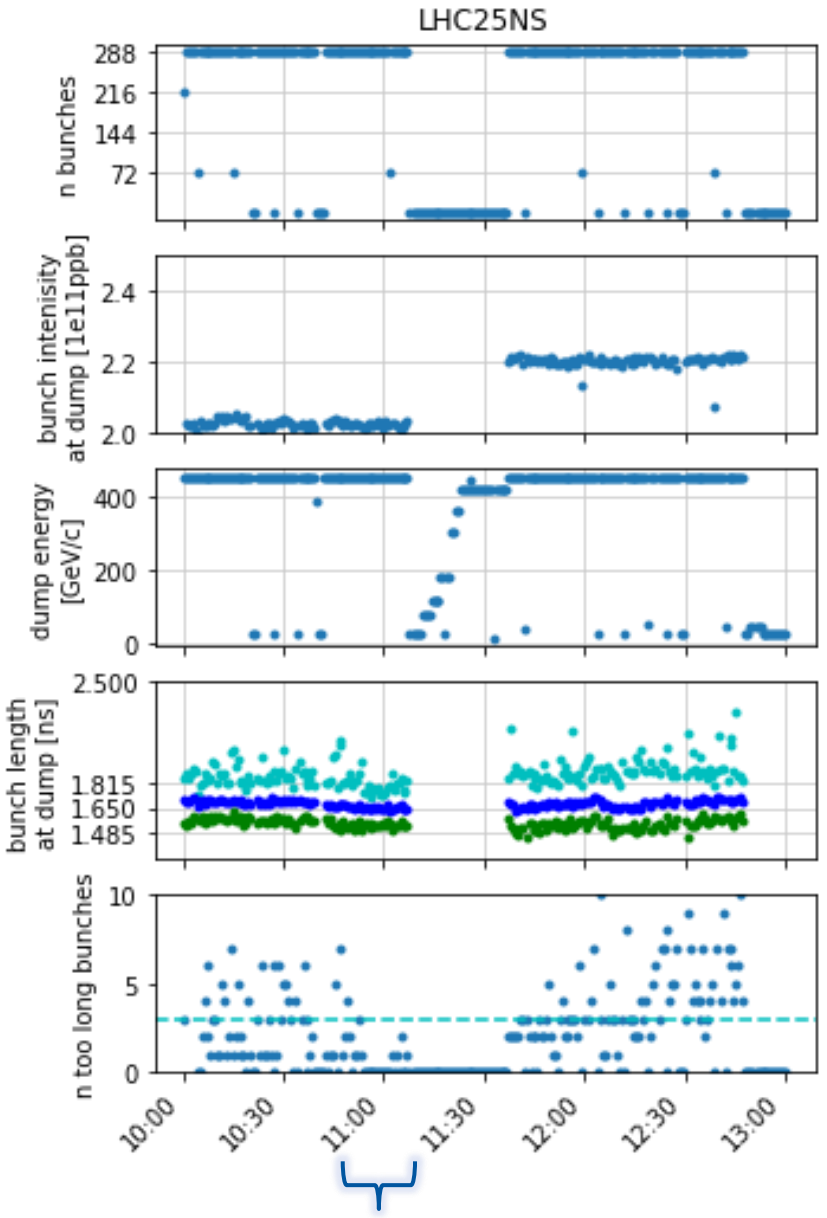


pMD of 12 Sept

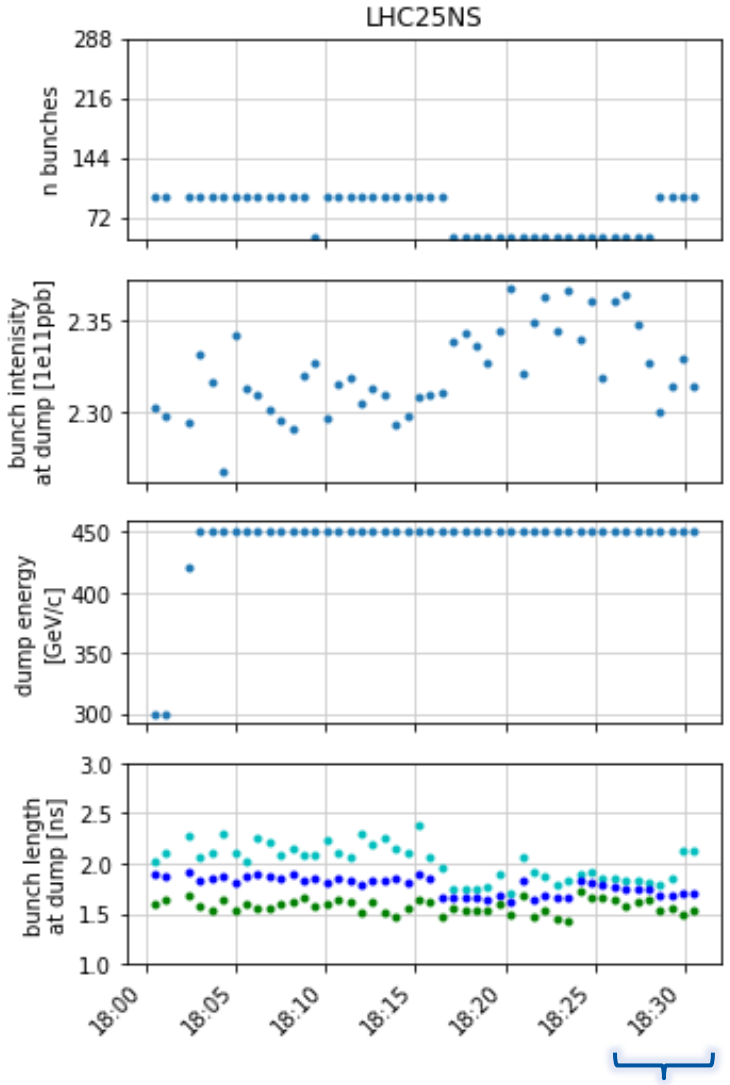
- 4x72b 2.0e11ppb decent, out of the box
  - 25 cycles
  - no settings changed since before the summer!
- 4x72b 2.2e11ppb mostly ok
  - only shift down of blow-up frequency band by 2%
  - last bunch of trains at times unstable
  - V200 = 7.5 MV
- 4x72b 2.4e11ppb: could not stabilize
  - often last bunches of trains unstable (but not only)
  - missing power: max ~7.5 MV
    - with abundant clamping by LLRF
  - in addition, 4 vacuum spikes at TWC200 C1, likely needs (more gentle) conditioning



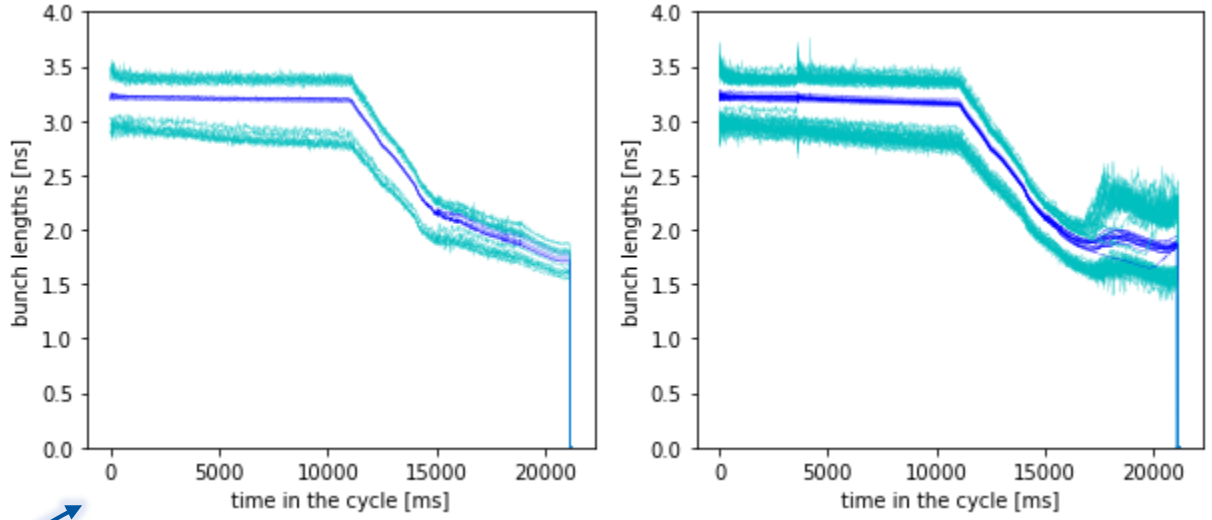




pMD of 19 Sept

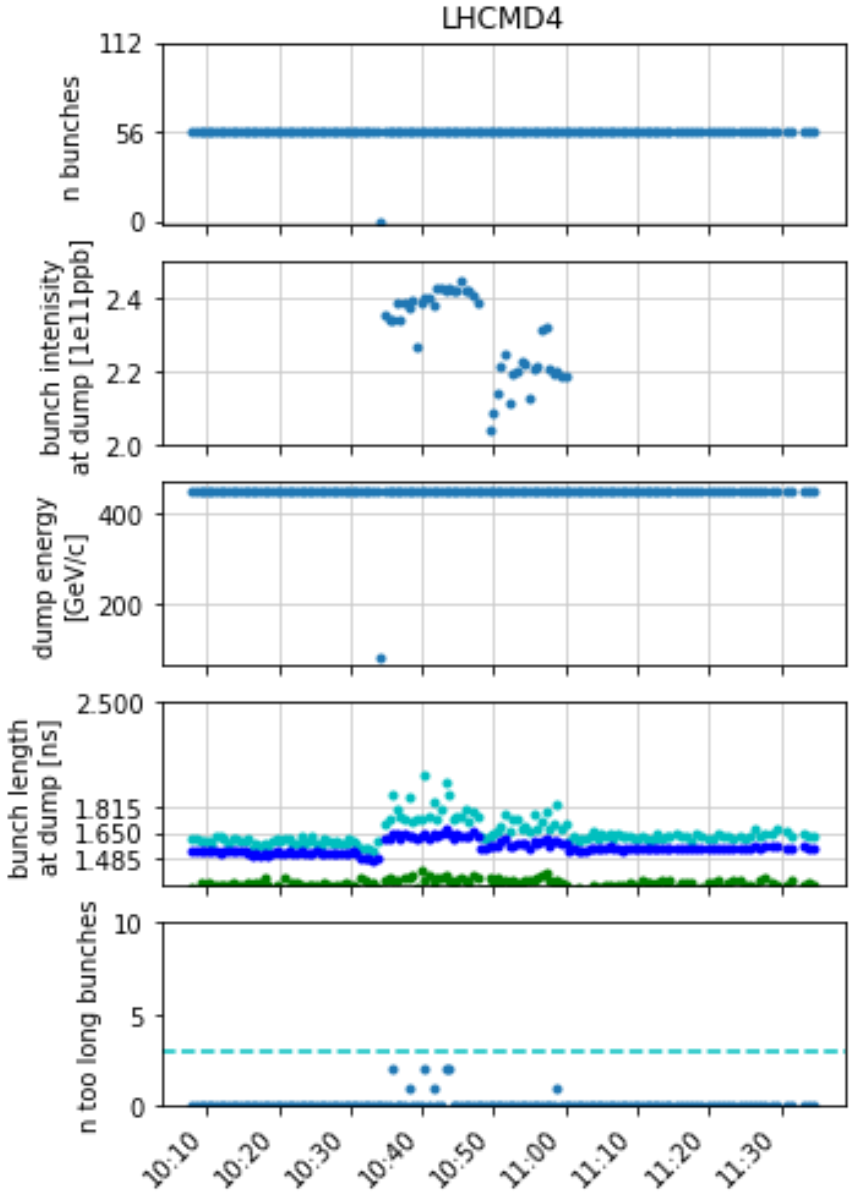


- only a short time with 2x48b 2.3e11 ppb at 450 GeV/c
- clear evidence that 1 batch is stable, 2 batches not
  - with the same settings
- for re-obtaining LIU parameters, need the extra power

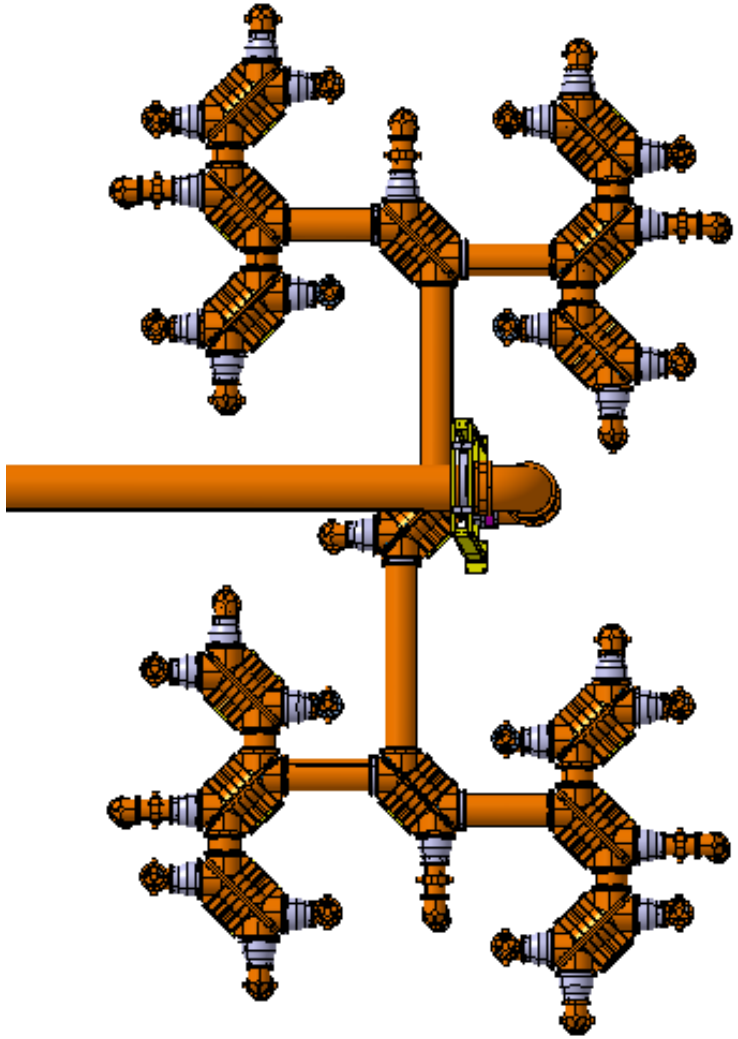


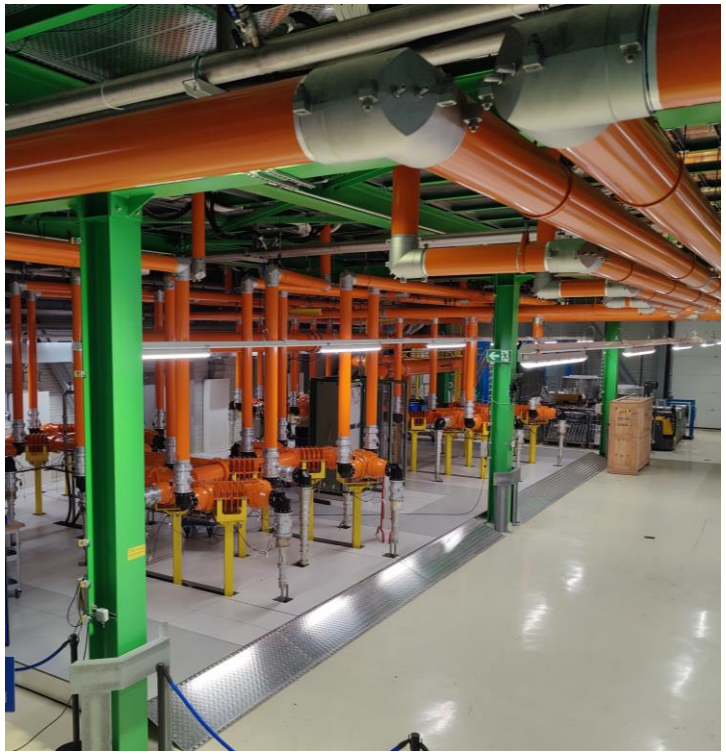
15 October, 8b4e

- one batch only



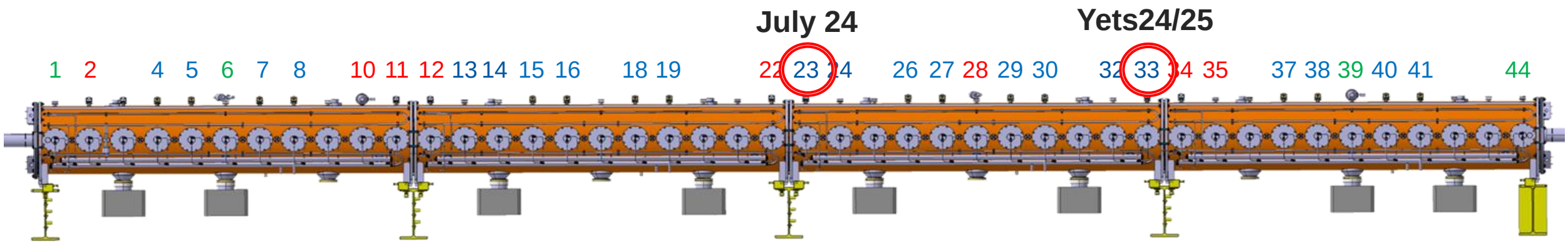
combiner load failure (13 Aug)





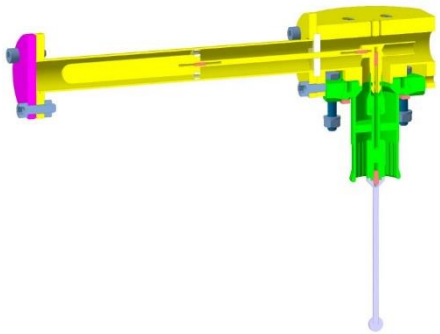
courtesy F. Ten Broeke, SY-RF-AC

- load between T14 and T12 failed, signs of arcing
  - T14 had high failure rate before (even at low power), after load exchange SSPA module breakages reduced
- ongoing campaign to replace loads and reduce failures
  - status of loads is difficult to determine in situ

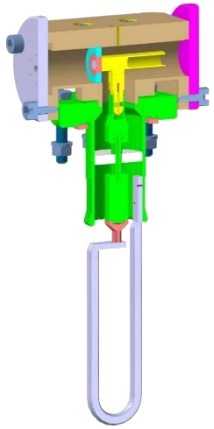


8 x 628 MHz version B (forks)
16 x 628 MHz
6 x 938 MHz
Vacuum Gauges 1 – 6 – 39 – 44

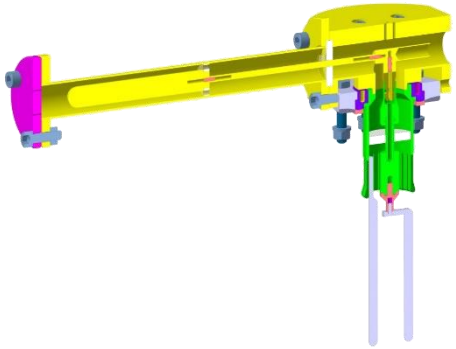
628 MHz HOM coupleur bride Fixe/tourante

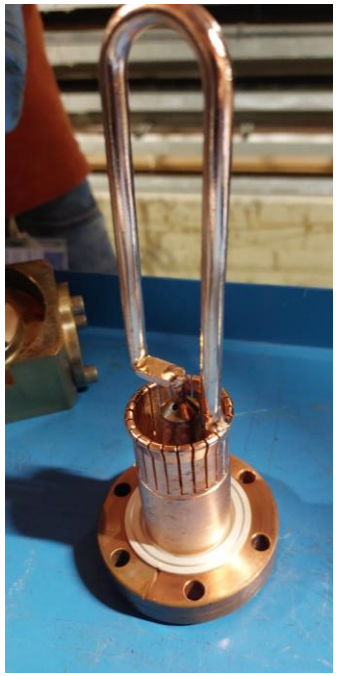


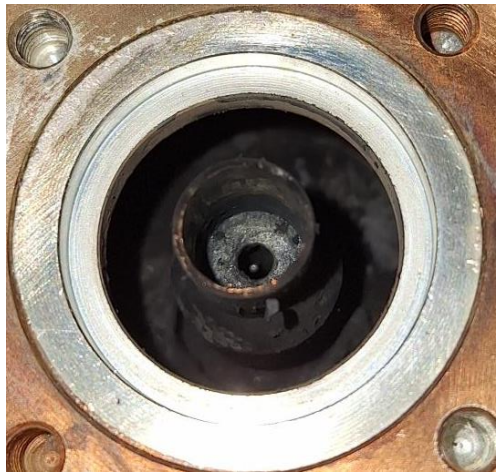
938 MHz HOM coupleur bride Fixe



8 x 628 MHz version B (forks)



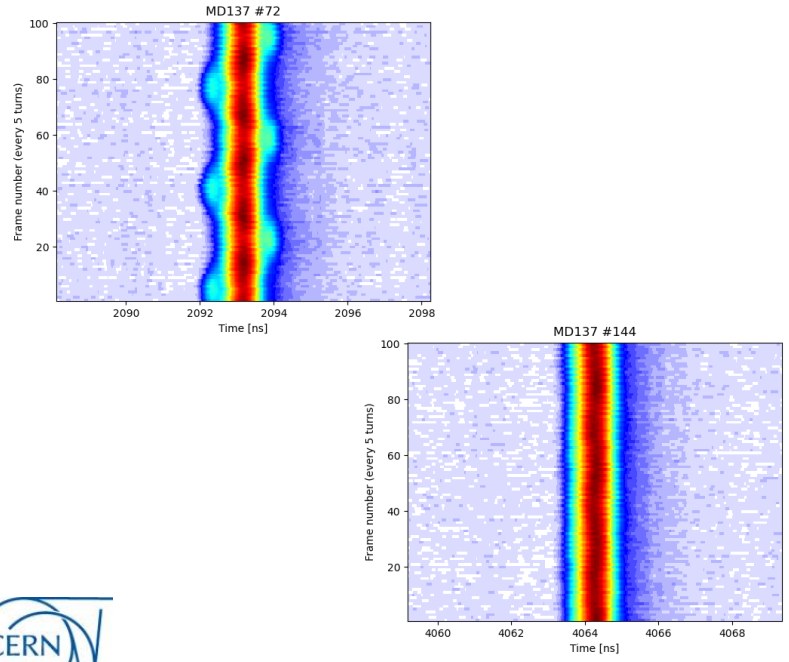




SY-RF-AC

non-rigid dipole oscillations and op. measurements

- op measurements improvement: addition of fwhm 20% cut?
  - can easily be added to ABWLM, at system renovation
  - for BQM, need to verify impact on evaluation duration
    - 15-20 ms max from measurement to dump/not decision
- for BQM, can use existing stability detection algorithms



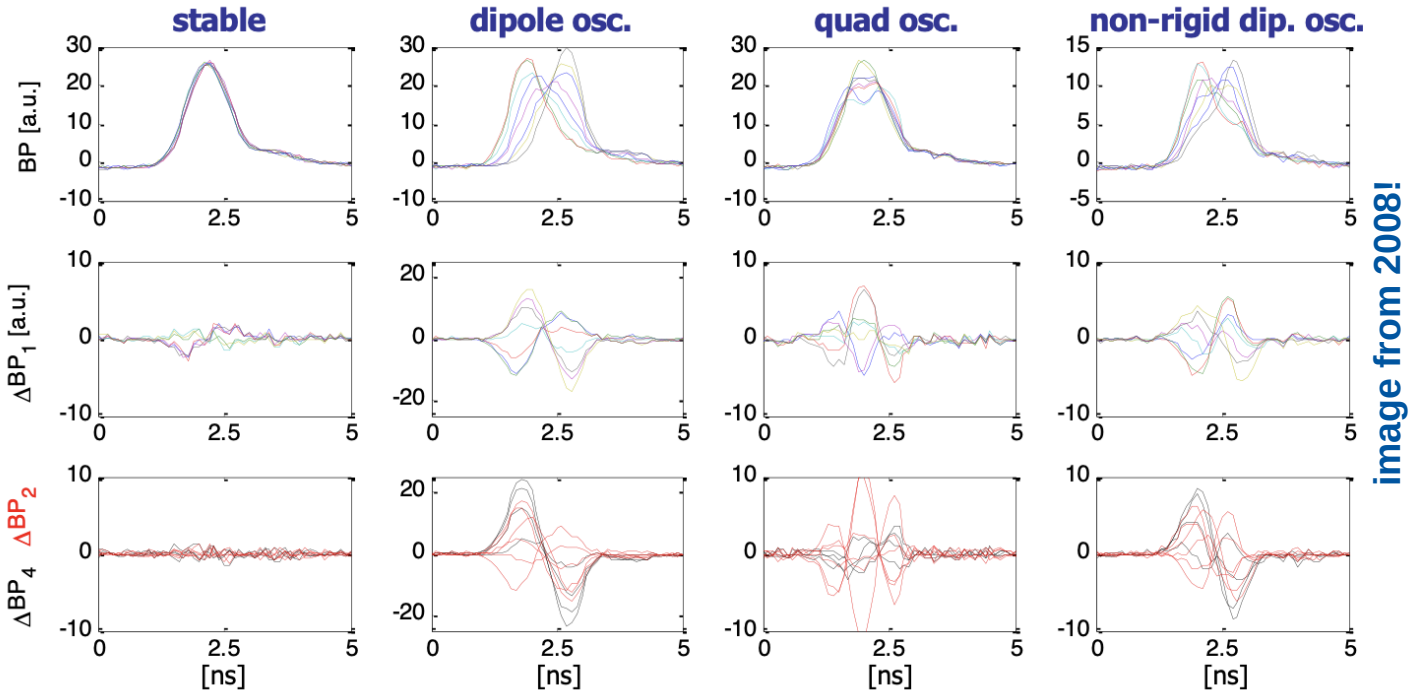


image from 2008!