

# Exploring beam production schemes for LHC type beams

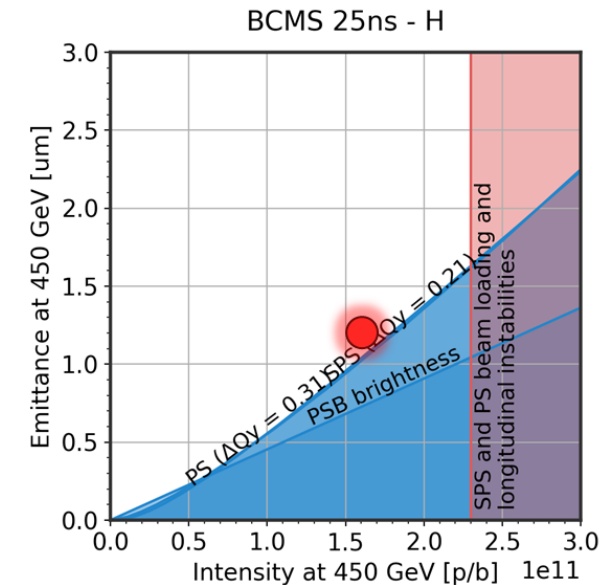
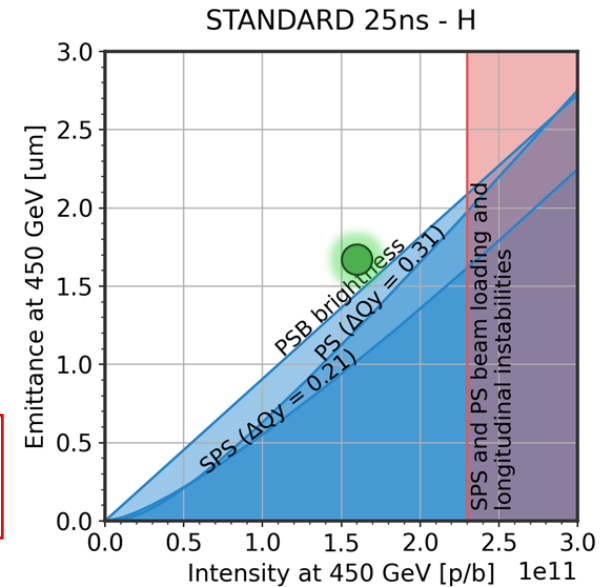
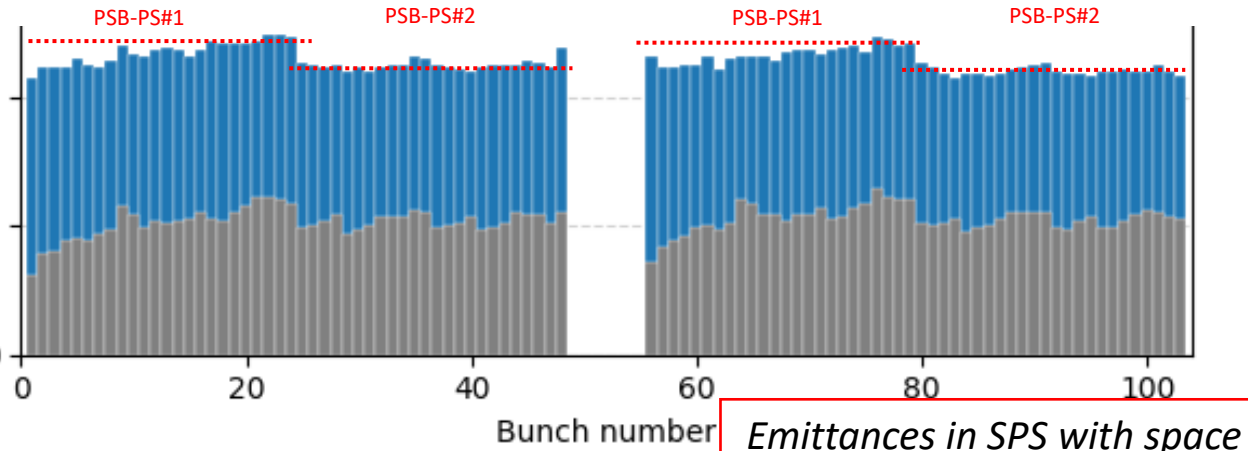
*IPP MD Days  
03-05/02/2025*

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Acknowledgements:

CPS operators, MD coordinators

# Introduction



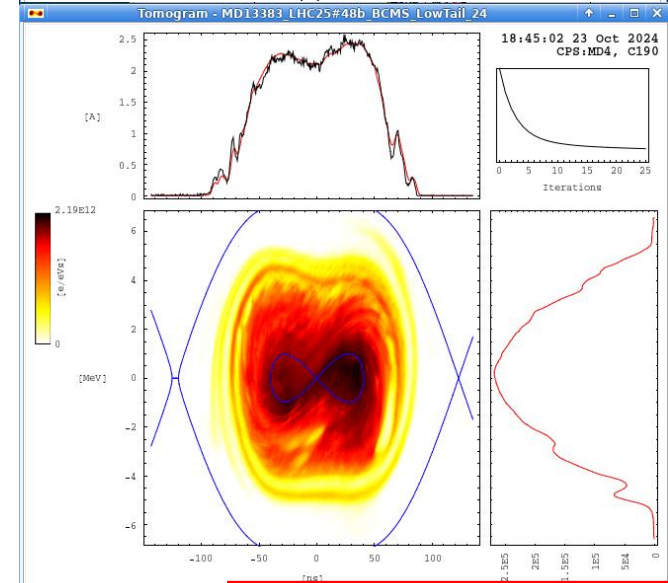
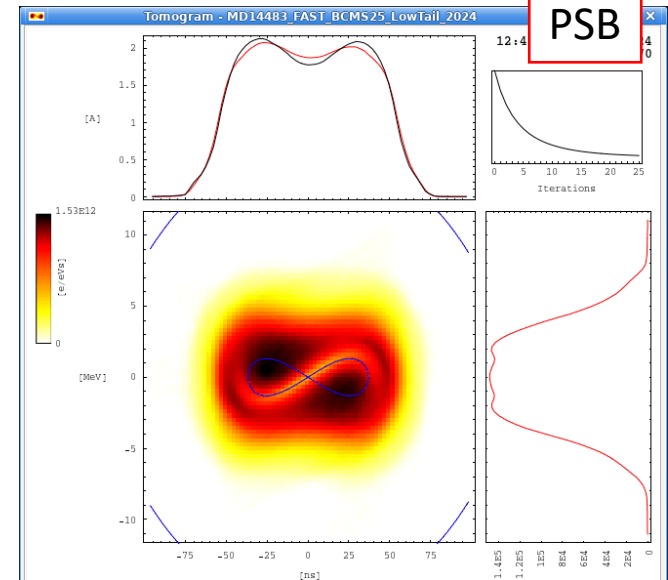
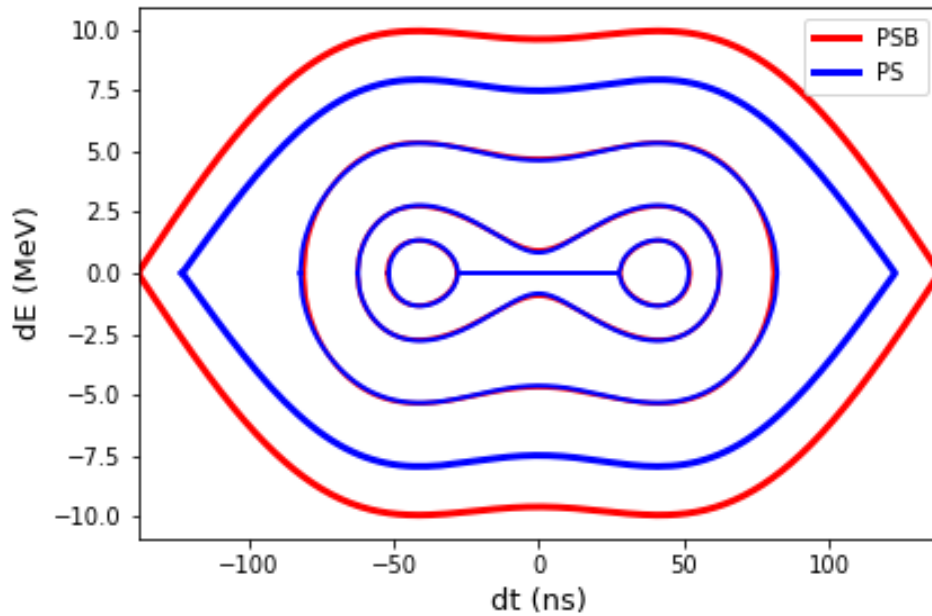
## ■ The objectives

- Further increasing the brightness by reducing the transverse emittance
- Avoid space charge effects on PS flat bottom and large deviation from first/second batch transferred from PSB to PS

## ■ Two approaches

- Mitigate space charge with longer bunches longitudinally with fixed intensity/longitudinal emittance
- Find alternative schemes to play with intensity/longitudinal emittance at flat bottom, and recombination on the plateau

# Flat bunches from the PSB, to the PS

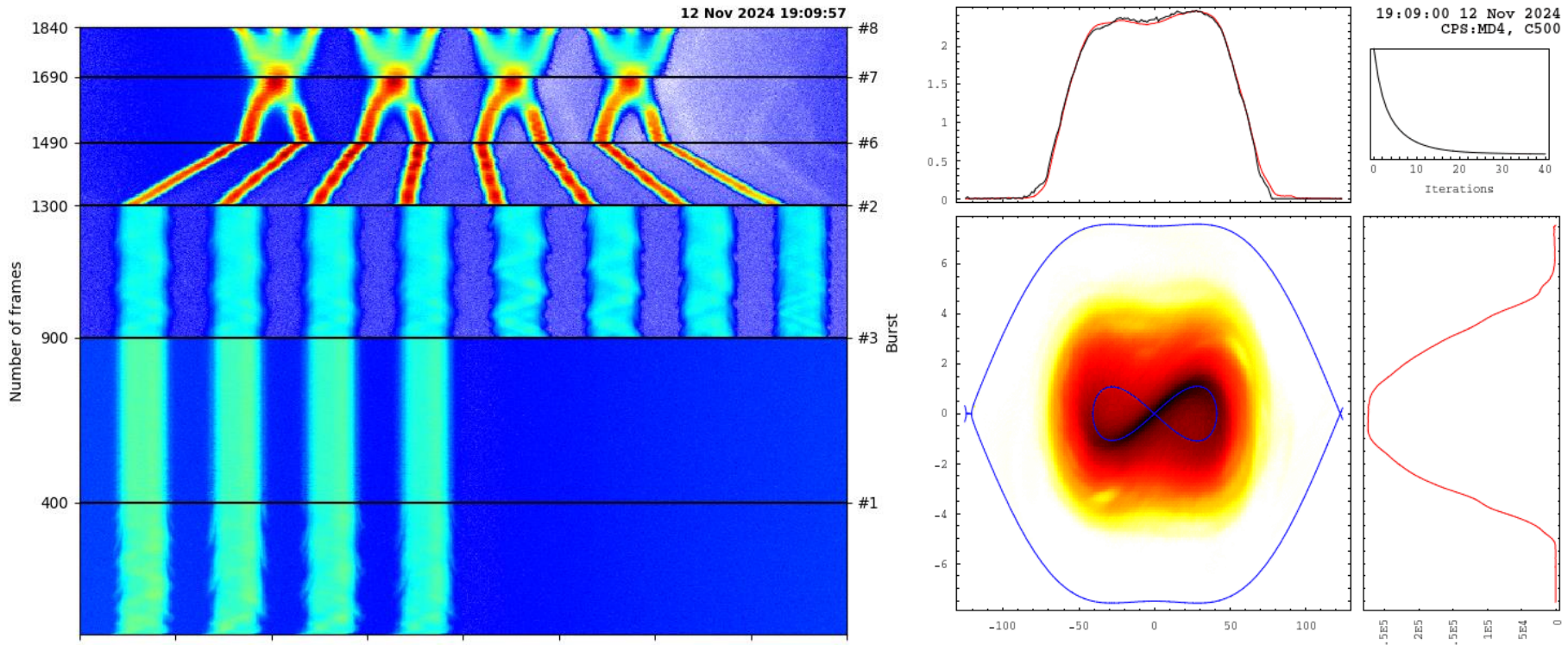


RMS Emitt. = 0.289 eVs  
90% Emitt. = 1.16 eVs  
Mchd Area = 1.3 eVs  
RMS dp/p = 8.99E-4

PS, first tests in 2024...

- Bunch flattening with higher RF systems in PSB used routinely. Experience up to triple harmonics.
- Original tests with double RF in PS switched after injection showed limited benefits.
- Promising matching conditions found using h2+h4 in PSB, with h9+h18 in PS.

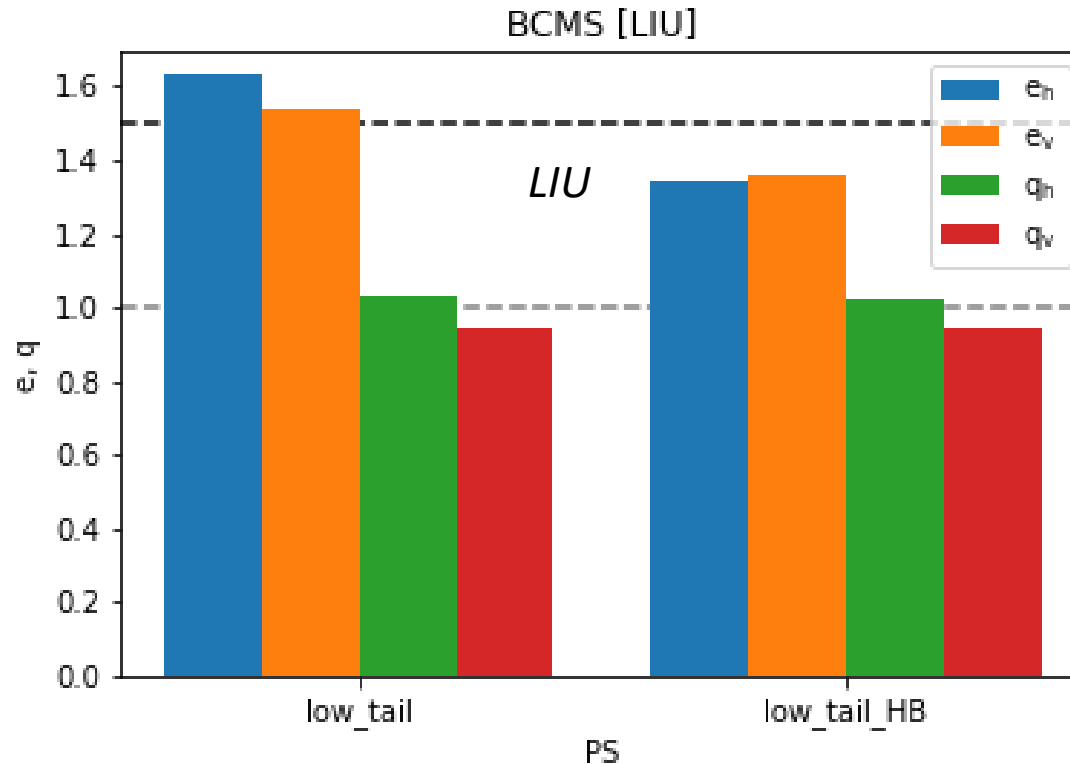
# Double RF harmonic at transfer and acceleration



## ■ Excellent matching conditions found after important modifications

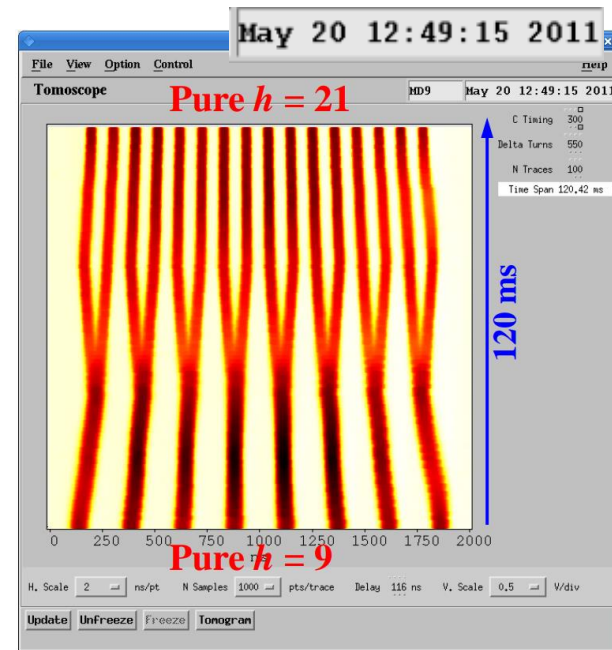
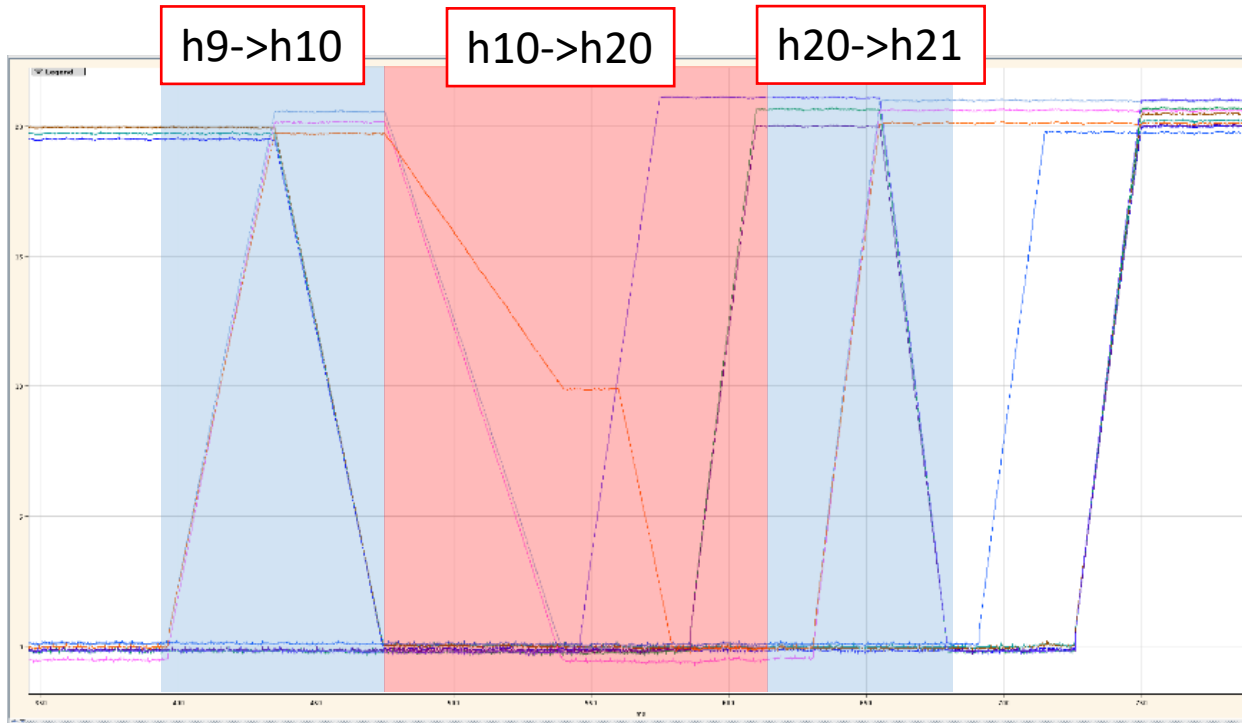
- in settings (settings overhaul in PS to have double RF harmonic up to mid-ramp towards intermediate plateau),
- some tweaks (PSB running effectively with h1+h2+h4 for synchronization, see Simon's talk),
- and fine adjustments (voltages, loop gains, transfer is quite sensitive)...

# First benefits in beam brightness



- Applying double RF allowed to reduce the transverse emittance in MD by 10%
- Together with further tune optimization (at flat bottom, intermediate plateau, transition crossing) allows to reach LIU requirements with gaussian tails.
- Reliability and operability of the scheme to be checked in 2025, including SPS.

# Setting-up of the renewed BCS cycle

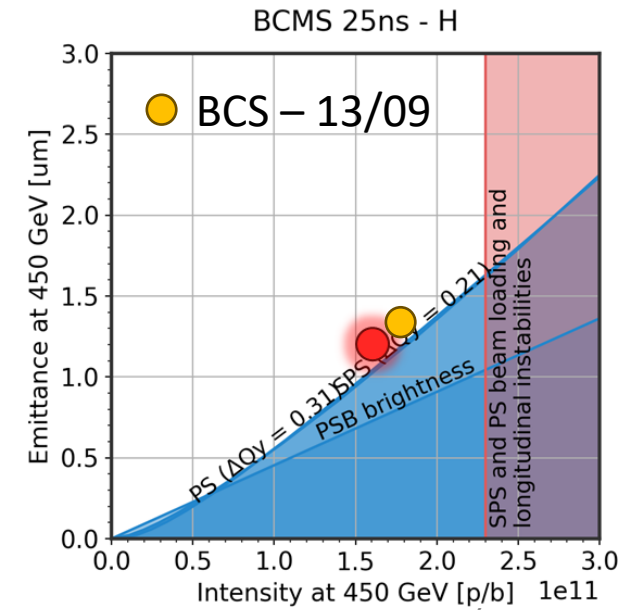
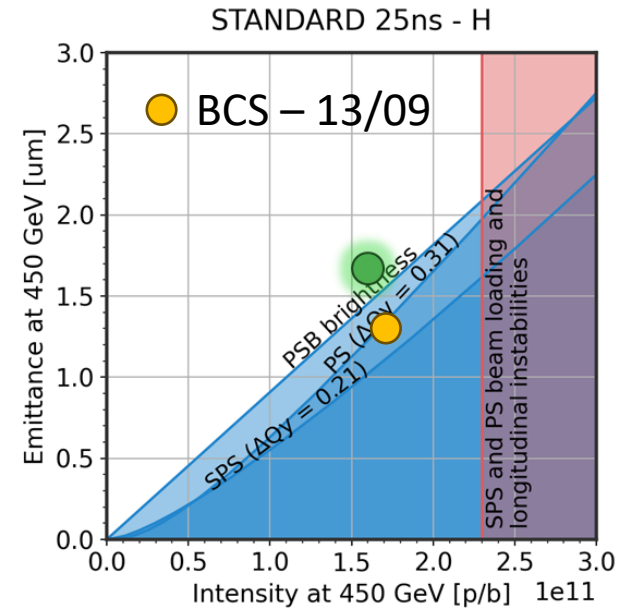
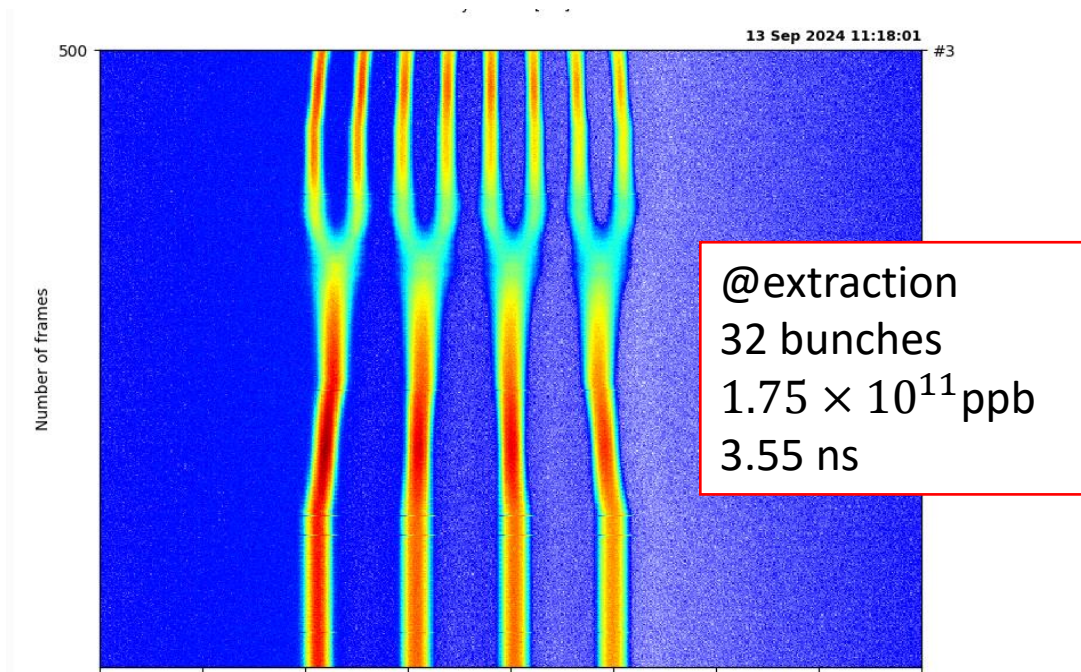


*H. Damerau, LIU-PS Working  
Group Meeting, 22/05/2012*

- Idea to revive the “Batch Compression and Splitting” cycle, yielding
  - **32 bunches in 2 basic period** (vs. 36 bunches in 3 basic period for BCMS)
  - expected brightness similar as the 8b4e variant (i.e. better than nominal, slightly worse than BCMS)
- Major settings overhaul, new timing tree. Base settings adjusted empirically, based on the experience from the other LHC beam variants (no deep consideration of bucket area, adiabaticity...)

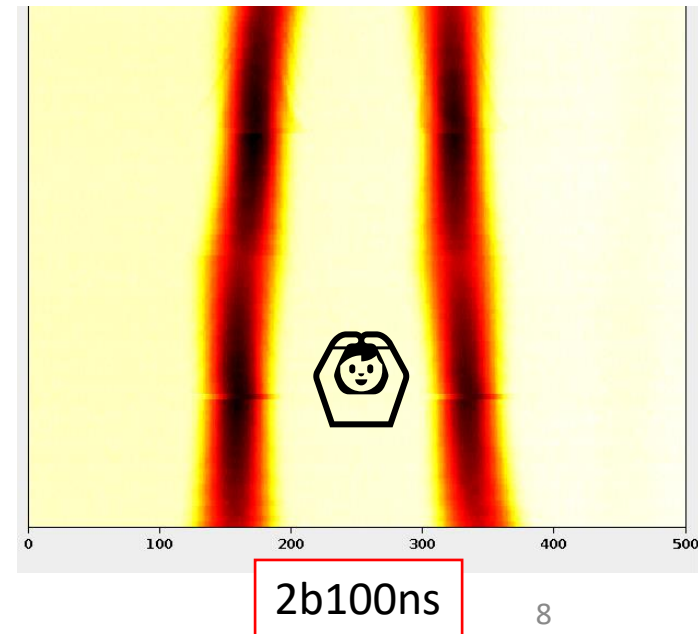
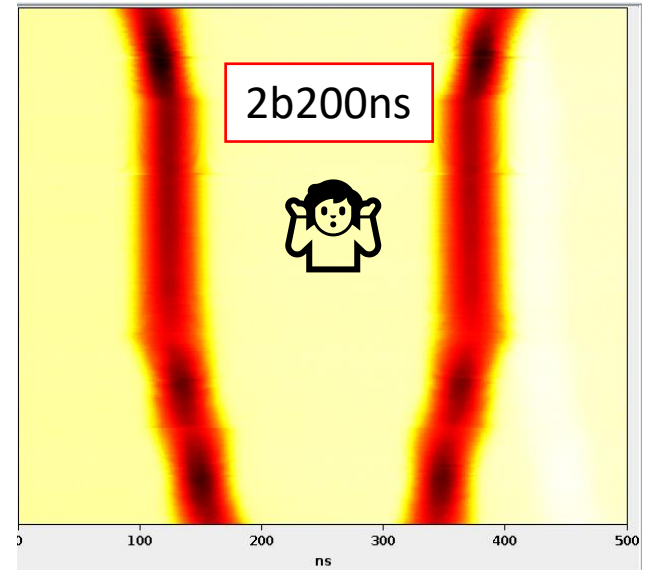
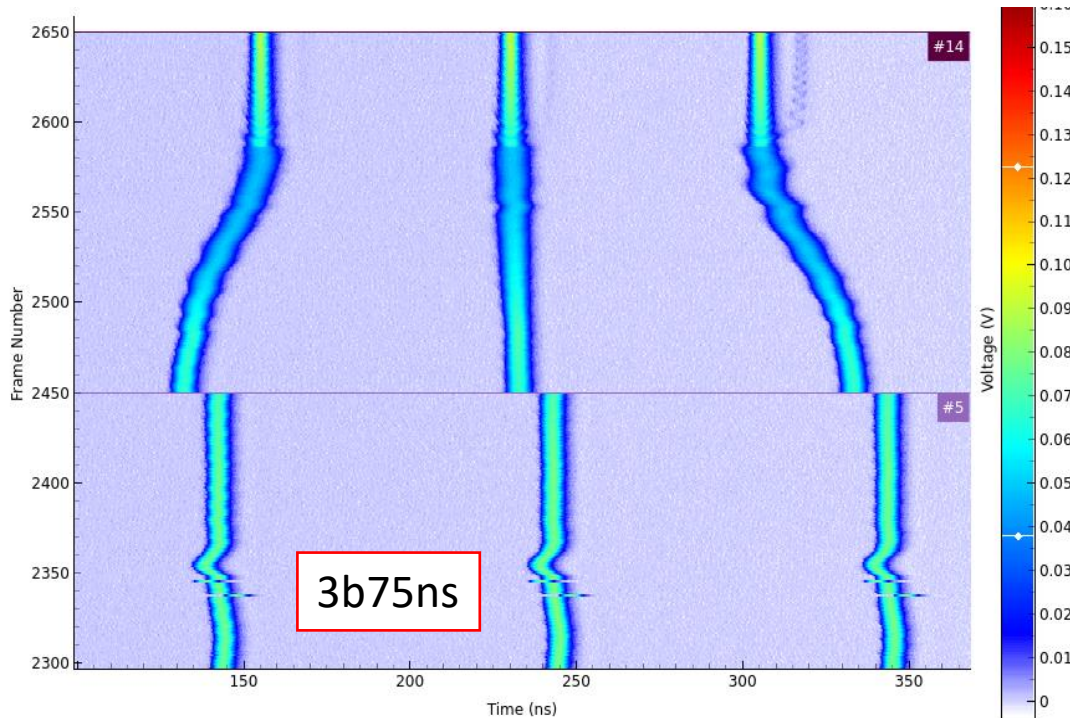


# Preliminary results with the BCS cycle



- **Excellent longitudinal behavior of the beam during the manipulation.** MD reached its purpose, but future needs to be established based on:
  - Benefits (cycle time, ease of optimization without triple splitting).
  - Drawback is 32 bunches instead of 36 bunches.
- **No optimization done in transverse plane, single WS acquisition shows acceptable transverse emittance.**

# RF Manipulations for ion beams



- Many beam variants prepared for tests for ion beams.
- No luck for the ILHC MD session in 2024, but can be re-used in 2025.
- Variants with 50ns spacing at PS extraction to be looked in more details!



# Plans in 2025

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- Successfully re-created many beam variants for proton and ion beams. The main bottleneck is the complex setup for settings management.
- Continuation of MDs in 2024 with the following objectives
  - Confirm effective benefit in brightness of double RF transfer and evaluate operability of the scheme (long term stability/drifts?)
  - Investigate ideas for RF manipulations in PS to produce 36b in 2BP
  - Further develop tools to simplify cycle setting up and help specify future scheme for settings management post-LS3, with PS RF upgrades.
  - Investigate production of ion beam with 50 ns spacing from PS.
- No major trouble or special request expected in 2025.