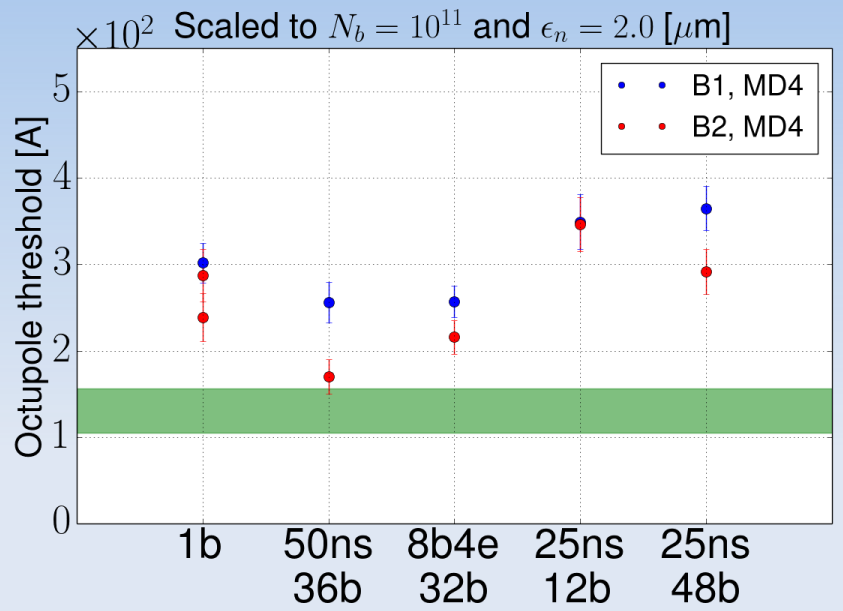
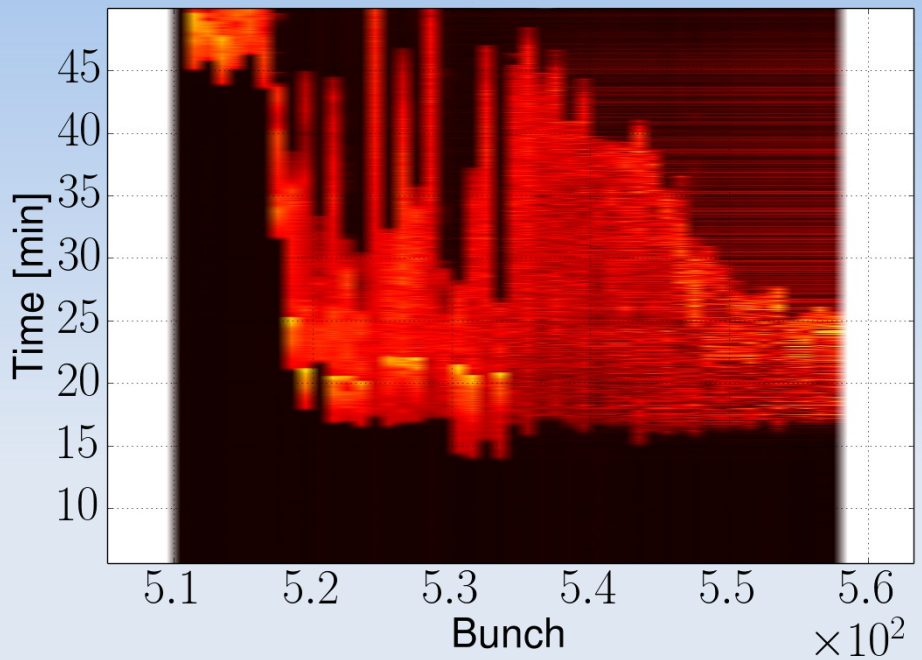
MD 3294 : Train instability threshold and high pile-up test

X. Buffat, D. Amorim, S. Antipov, N. Mounet, T. Levens, B. Salvachua, R. Suykerbuyk, E. Metral, B. Salvant, H. Bartosik, G. Iadarola, S.V. Furuseth



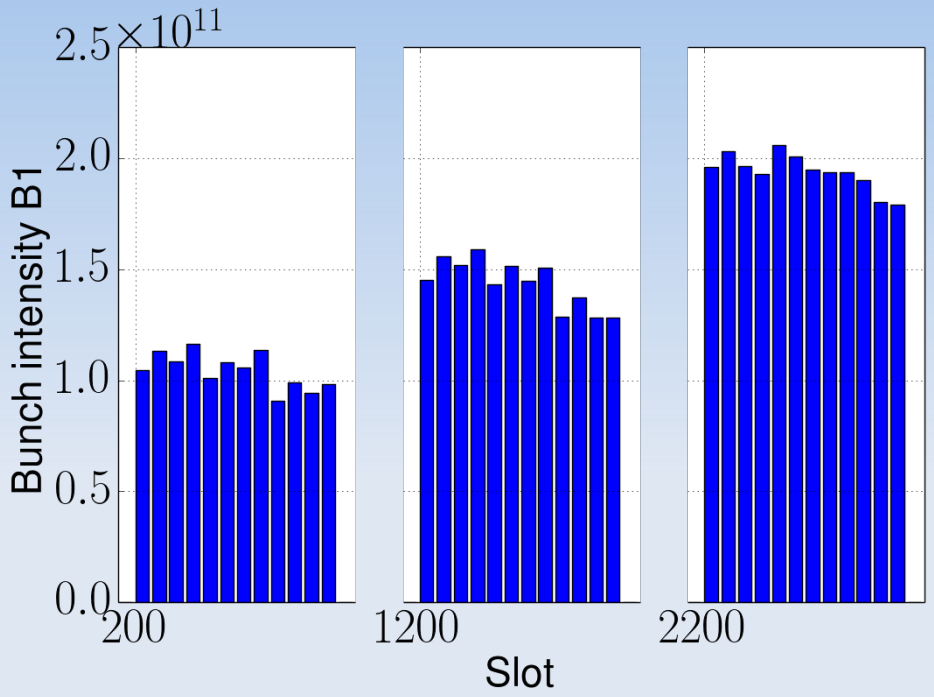


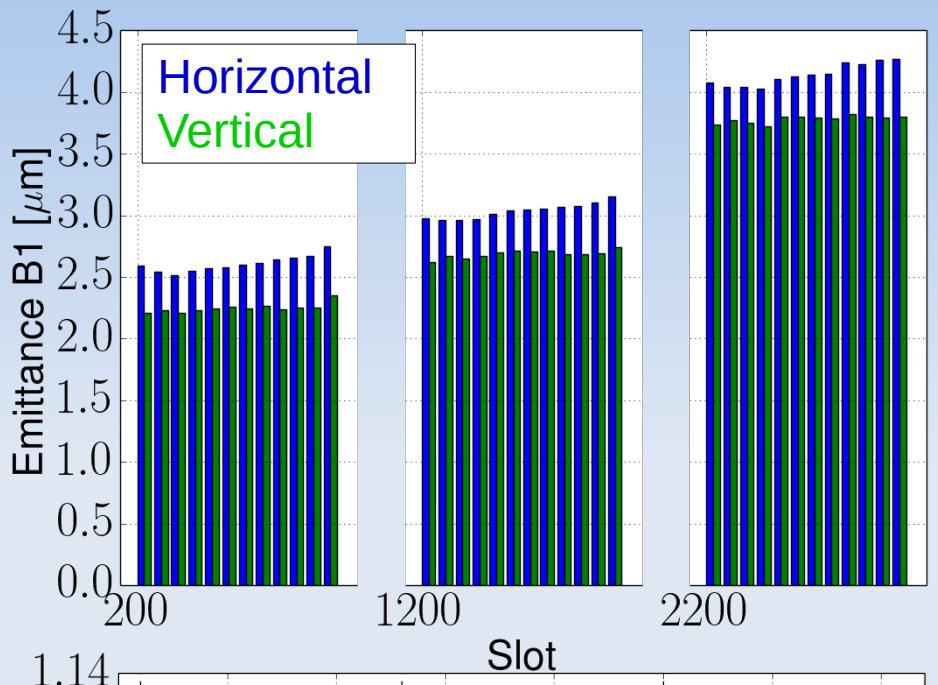
- In 2017 (MD2936), the threshold of 25ns bunch trains (12b and 48b) was measured higher than other beams
- The bunch pattern suggests a contribution from electron cloud

→ Measure the intensity dependence towards HL-LHC intensities with 12b trains of various intensities

→ Profit of the effort from the injectors to obtain high intensity bunch train to perform a high-pile up test with 25ns train

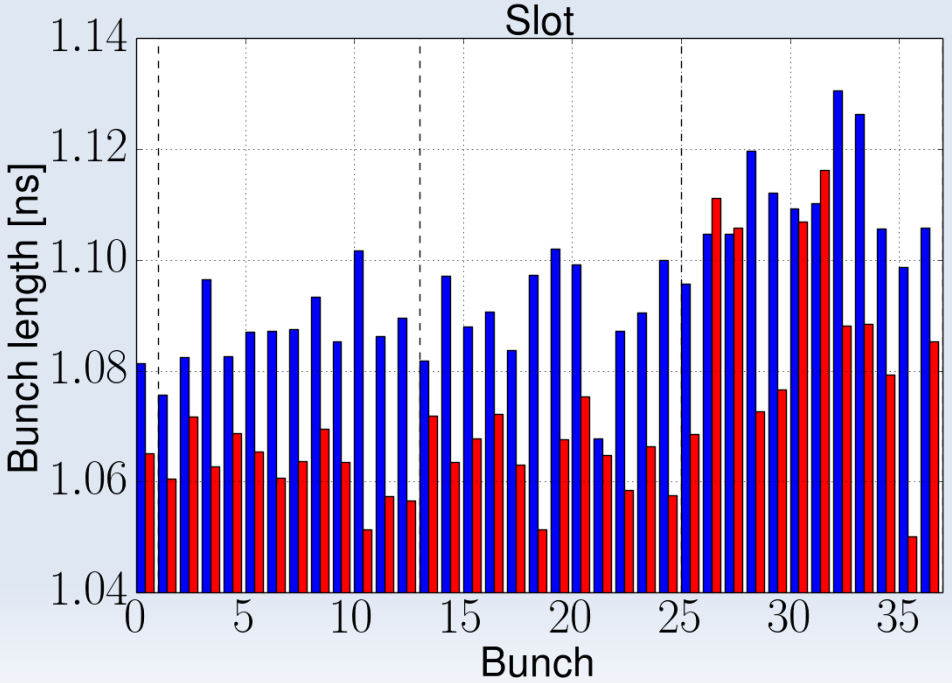
Bunch parameters at flat top





- 3 12b trains of different intensities (1.0, 1.5 and 2E11)
  - The beam emittance follows the beam intensity (expecting constant brightness from injectors)
  - High intensity bunches are a few percent longer than others

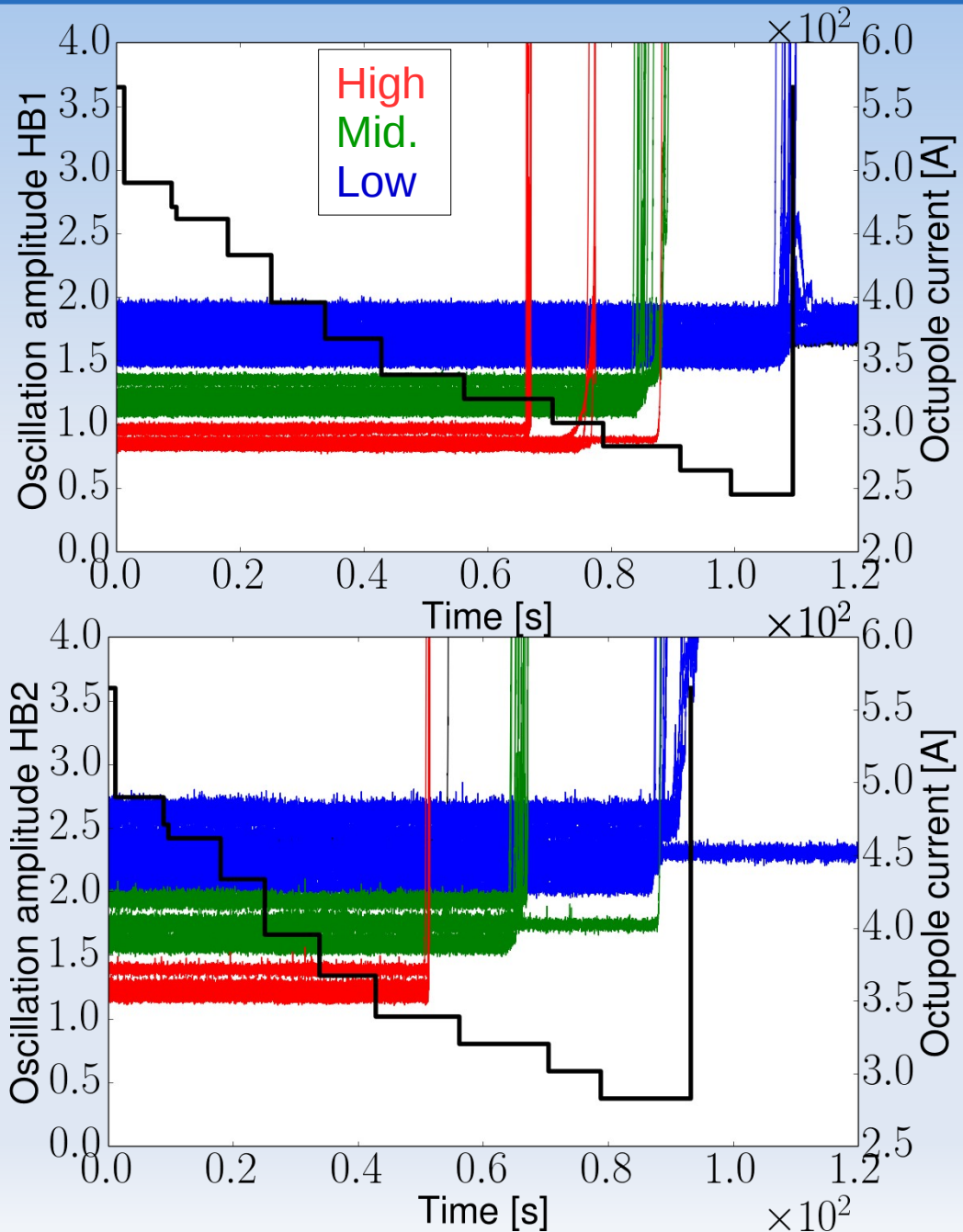
→ Good conditions to probe the intensity dependence, **many thanks to injectors'OP!**



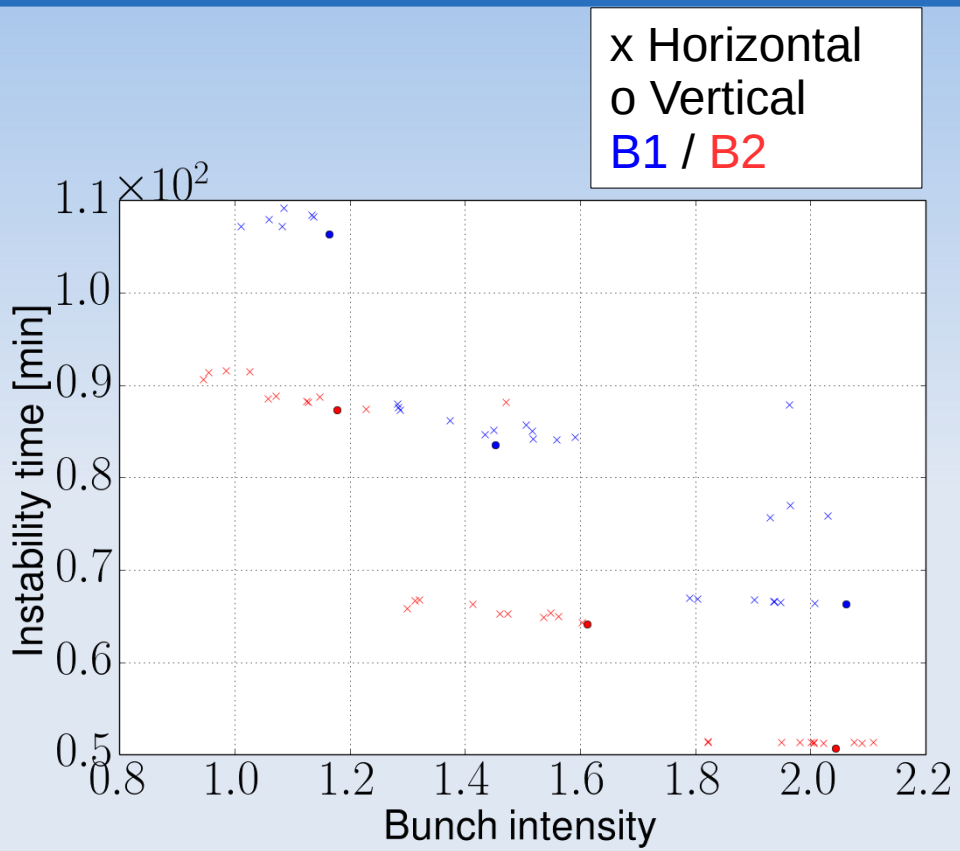
Instability threshold

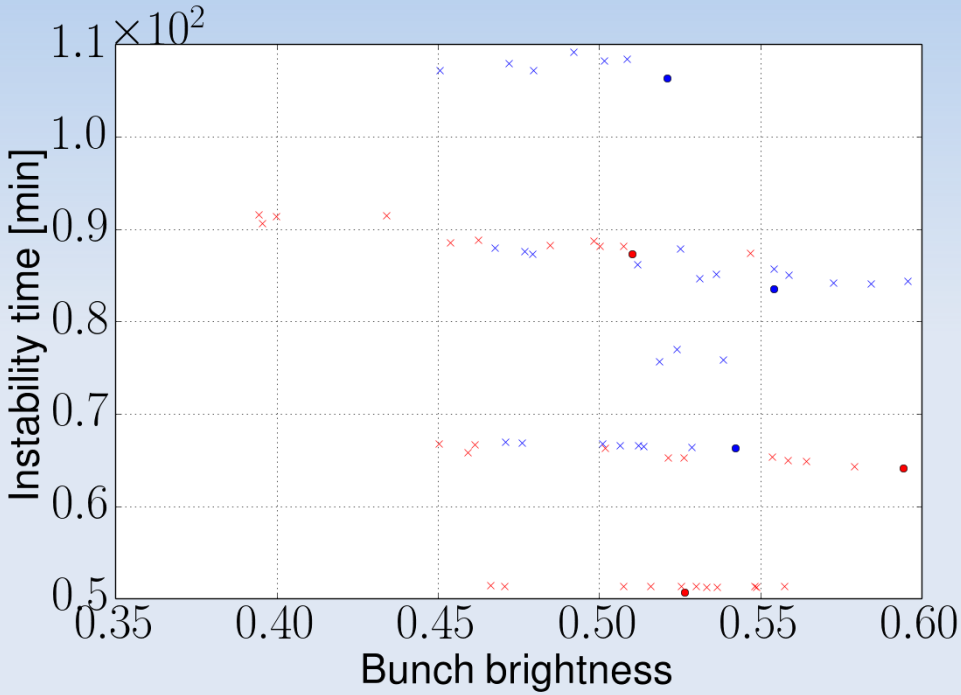
- In both beams the highest intensity train became unstable first, then the intermediate and finally the low intensity 12b train
- The ADT attenuators were optimised for 2E11, the noise floor is higher for low intensity trains

  → Noise effect cannot explain the observed behaviour



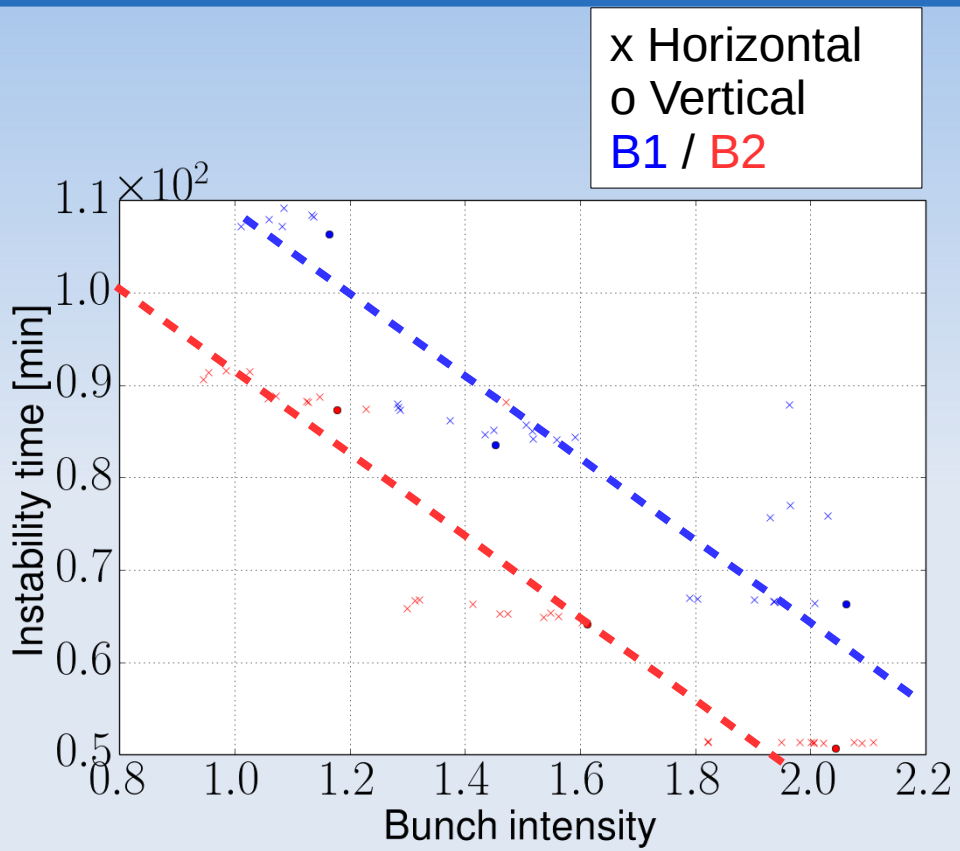
Intensity dependence

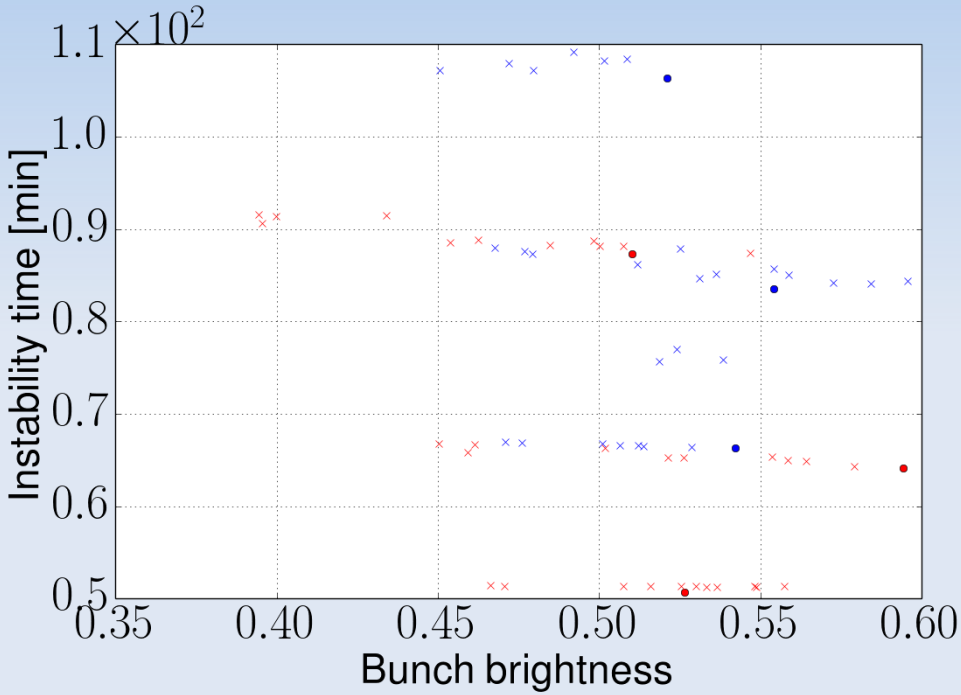




- A dependence on bunch brightness is expected, but a dependence on bunch intensity is observed !

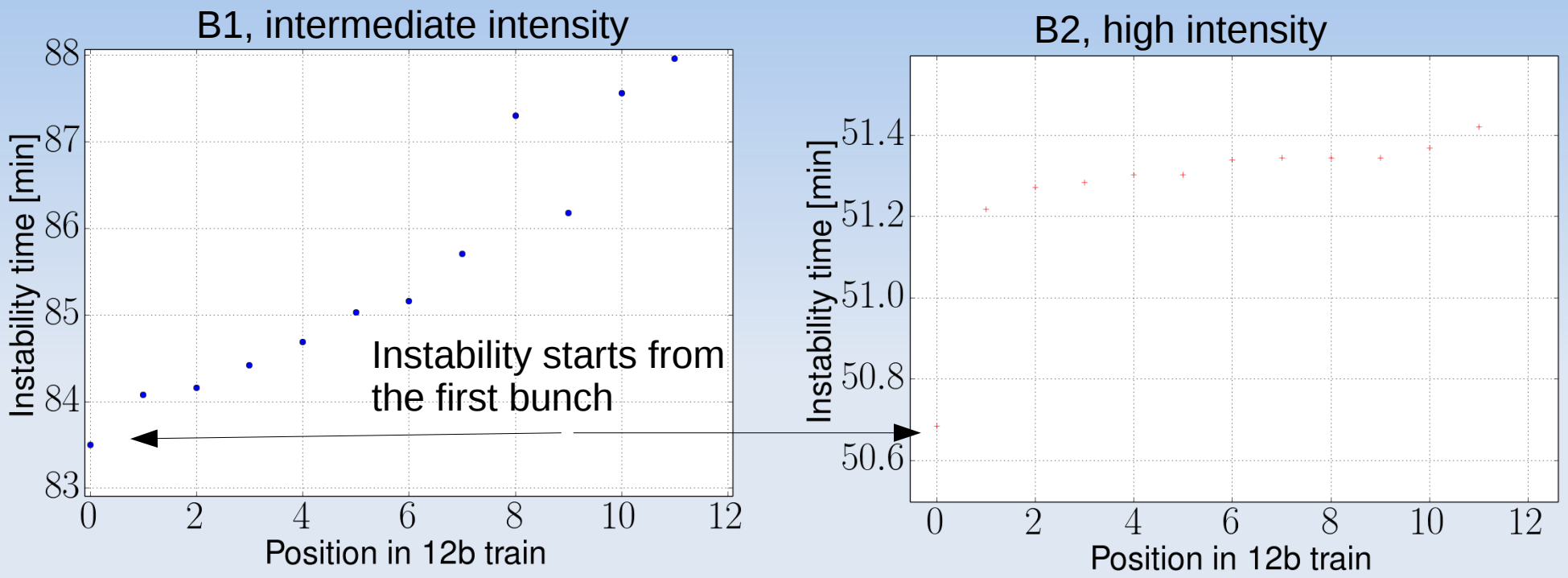
Intensity dependence





- A dependence on bunch brightness is expected, but a dependence on bunch intensity is observed !

Bunch position in the train

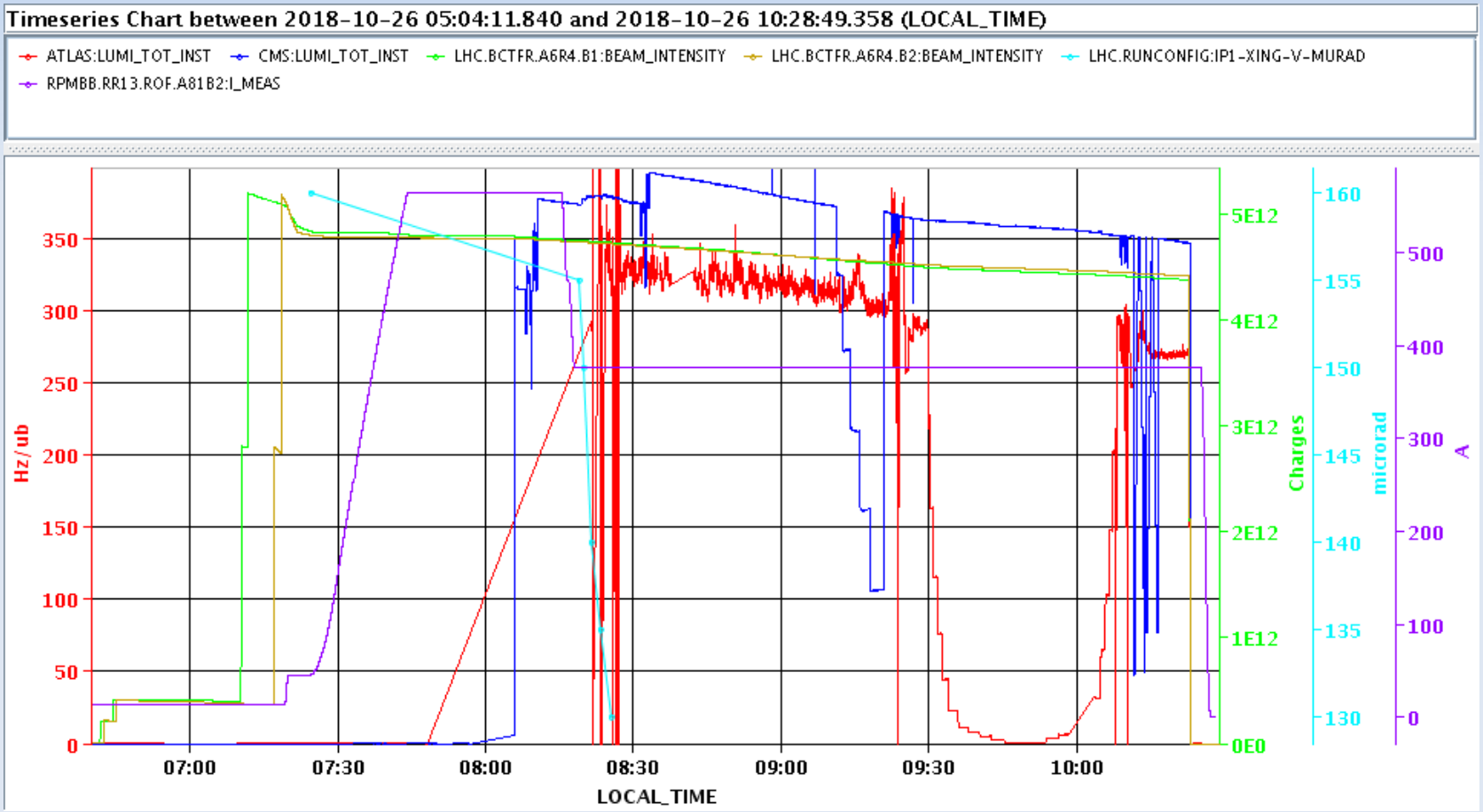


- The bunch pattern is significantly different w.r.t. the 2017 observation (first bunches are most critical)
- This feature was already observed in 2017

  → This 'Ghost Train Instability' remains unexplained, in particular the bunch pattern is puzzling

High-pile up test

- Executed standard cycle with 2 high intensity 12b trains per beam, providing collisions in all IPs
  - Maintained lifetime with octupole and chromaticity reduction, allowing for Xing angle levelling. β* levelling was within reach lifetime wise, but not allowed by rMPP



- Pile-up about 130 (i.e. ~ HL-LHC design) were reached with 25ns beams

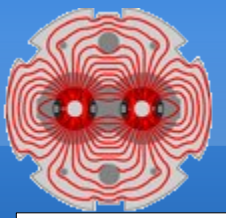
Conclusion

- At constant brightness the instability threshold of bunch trains depends on the bunch intensity, which is unexpected
  - The bunch pattern does not match electron cloud expectation
  - The dependence does not match the expectation for ADT driven noise
  - Requires further studies
- The high-pile up test when smoothly (at least from the machine side), reaching HL-LHC pile-up with 25ns bunch trains

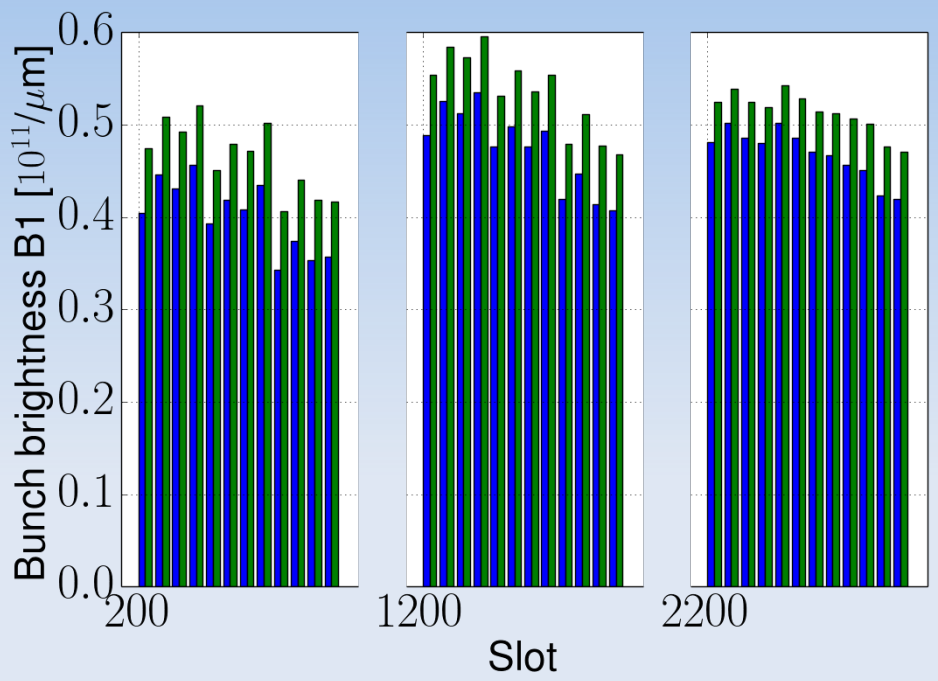
→ Many thanks to the injectors for preparing this very interesting beam!

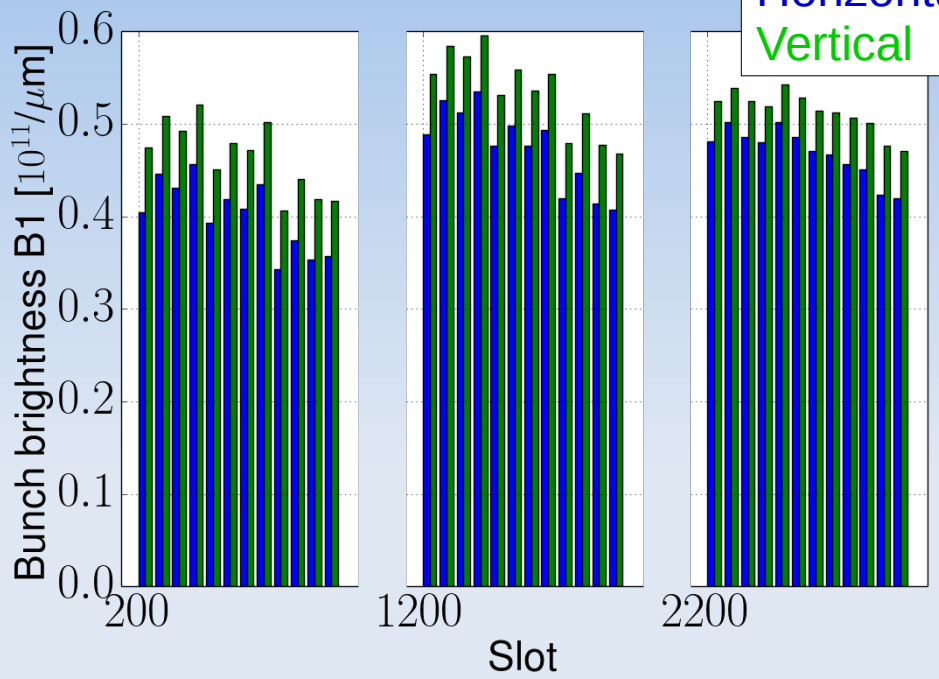
Backup

Bunch brightness at flat top



Horizontal
Vertical

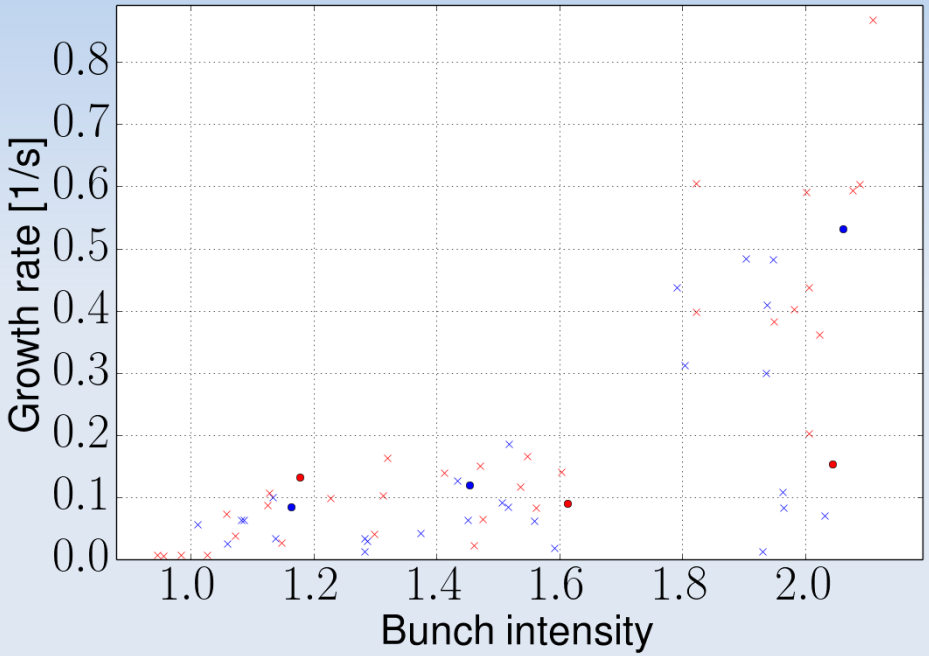




Vertical (avg ; max): (-10%;-4%) (+4%;+10%) (-12%;-2%) (+0%;-6%)

- On average the lowest intensity trains are less bright, the brightest bunch is only few percent lower

Backup
Growth rate



- The growth rates do follow the expected intensity dependence