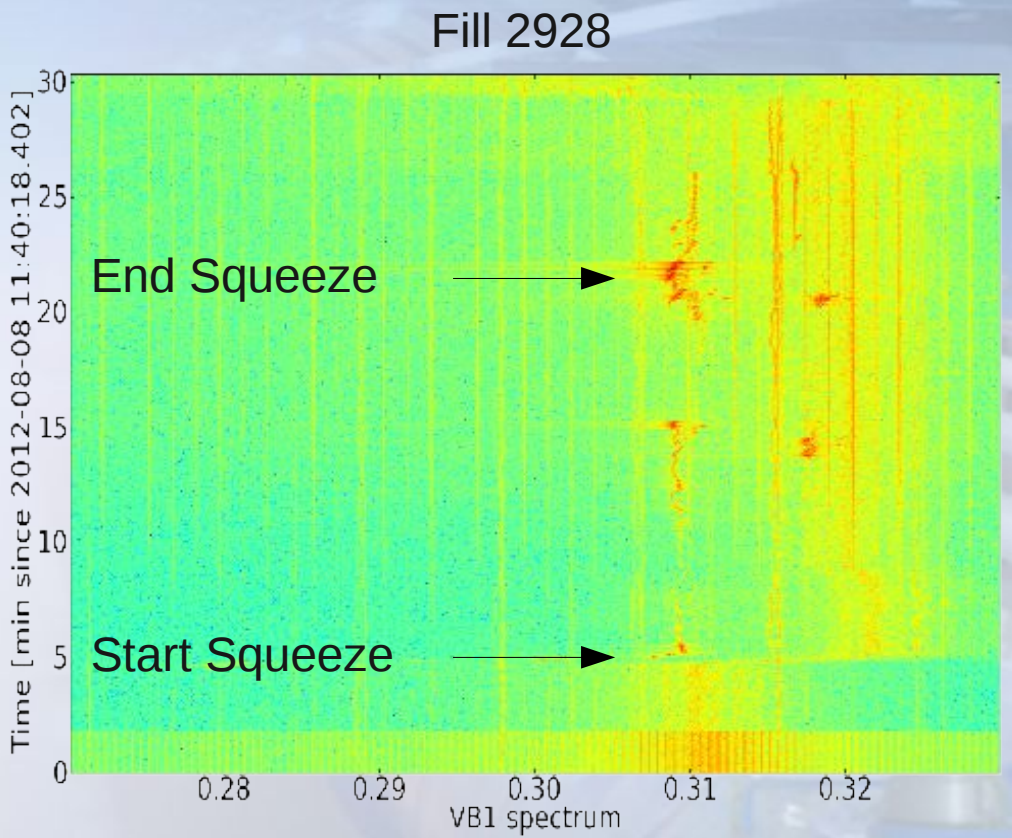
Stability considerations with beam-beam and octupoles

X. Buffat on behalf of the collective effects and beam-beam teams

- Instability observations with new octupole setting
- Stability diagrams
  - Before / after the squeeze
  - Collapse of separation (ADJUST)

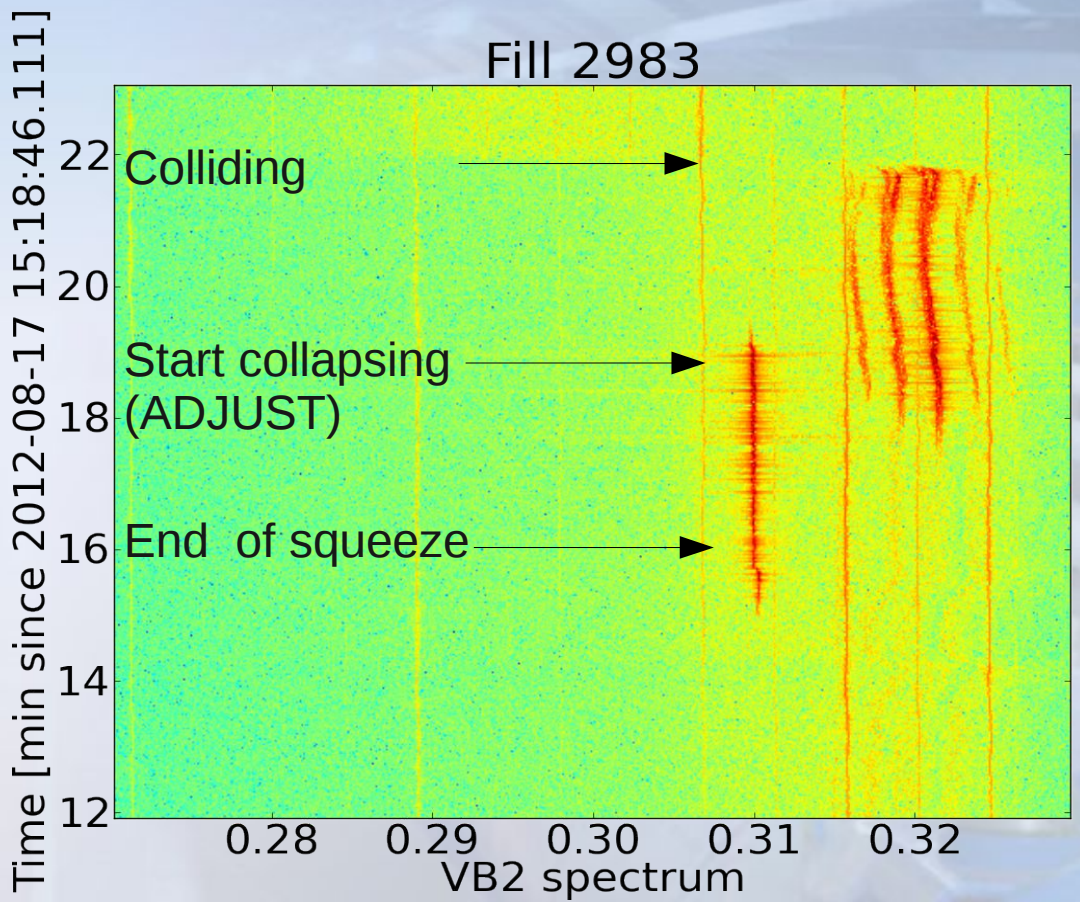
Observations
Flat top / during the squeeze

- Fills 2928, 2932
- Both vertical and horizontal
- No longer observed with high chromaticity and large ADT gain

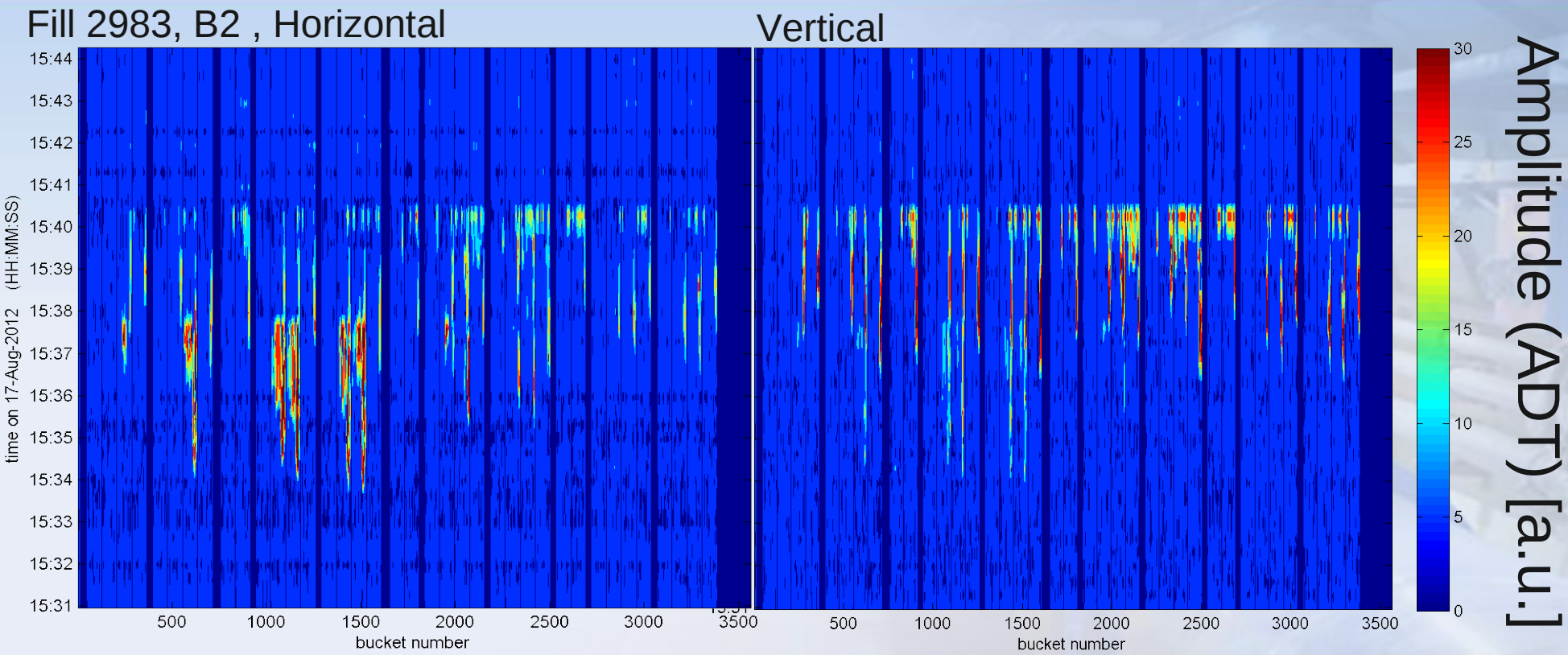


Observations
End of squeeze

- Fills 2927, 2928, 2980, 2981, 2983, 2984, 2987, 2991, 2995, 2997
- Mainly vertical, but not exclusively
- Losses and emittance growth, but no dump
- Note : BBQ is not bunch by bunch → all bunches in one spectrum

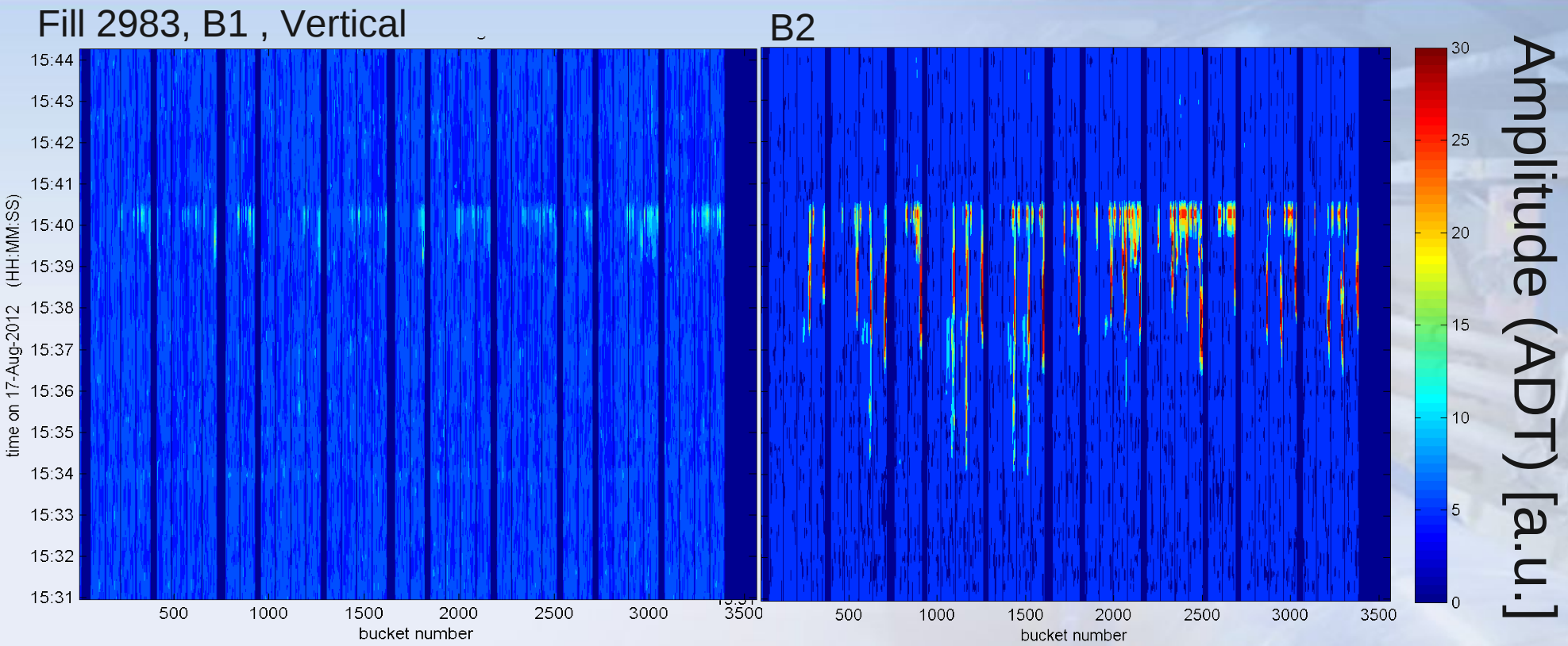


Observations



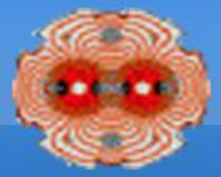
- Horizontally, middle-end of batches are unstable
  (as before the change of octupole polarity)
- Vertically, end of batches are going unstable

Observations



- Only one beam is unstable at a time

Summary of observations

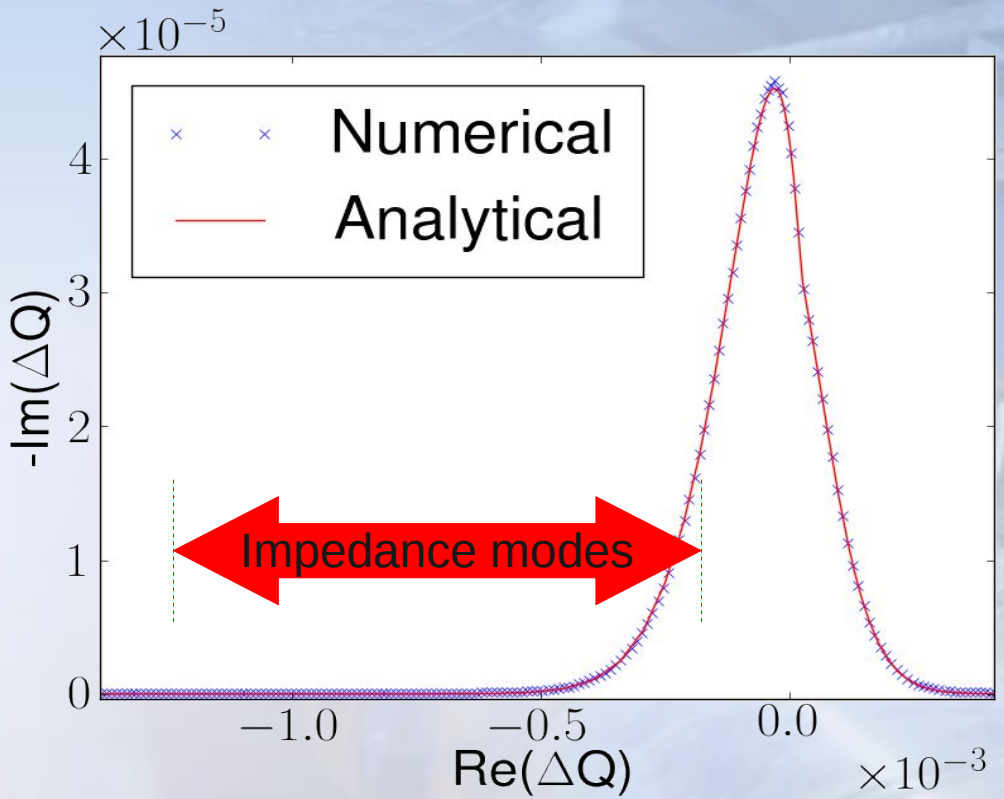


- Less stability at the begining of the squeeze
  - Not an issue with current parameters
- Vertical instabilities are now also observed at the end of the squeeze / while collapsing the separation (ADJUST)
- Different bunches are affected (End of batches)

- Why at the end of the squeeze ?

Numerical evaluation of stability diagrams

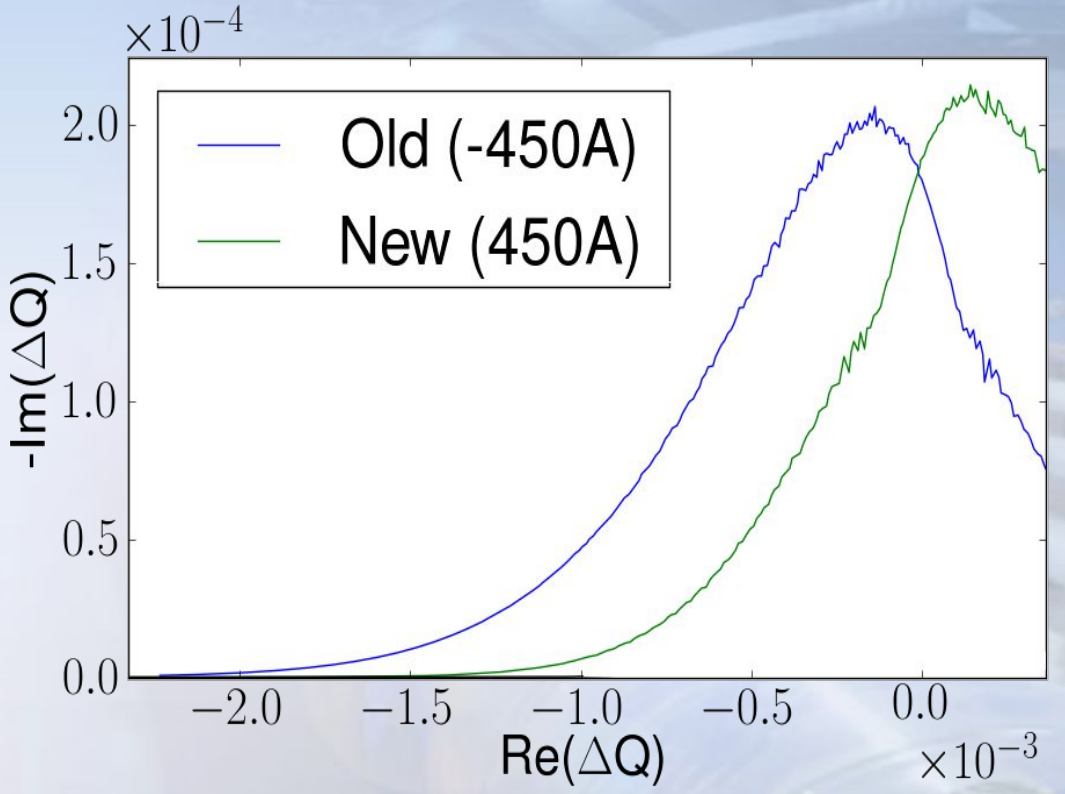
- Tune spread from tracking simulation (MAD-X)
- Numerical evaluation of the dispersion integral



- W. Herr and L. Vos, *Tune distributions and effective tune spread from beam-beam interactions and the consequences for Landau damping in the LHC,* LHC Project Note 316, 2003

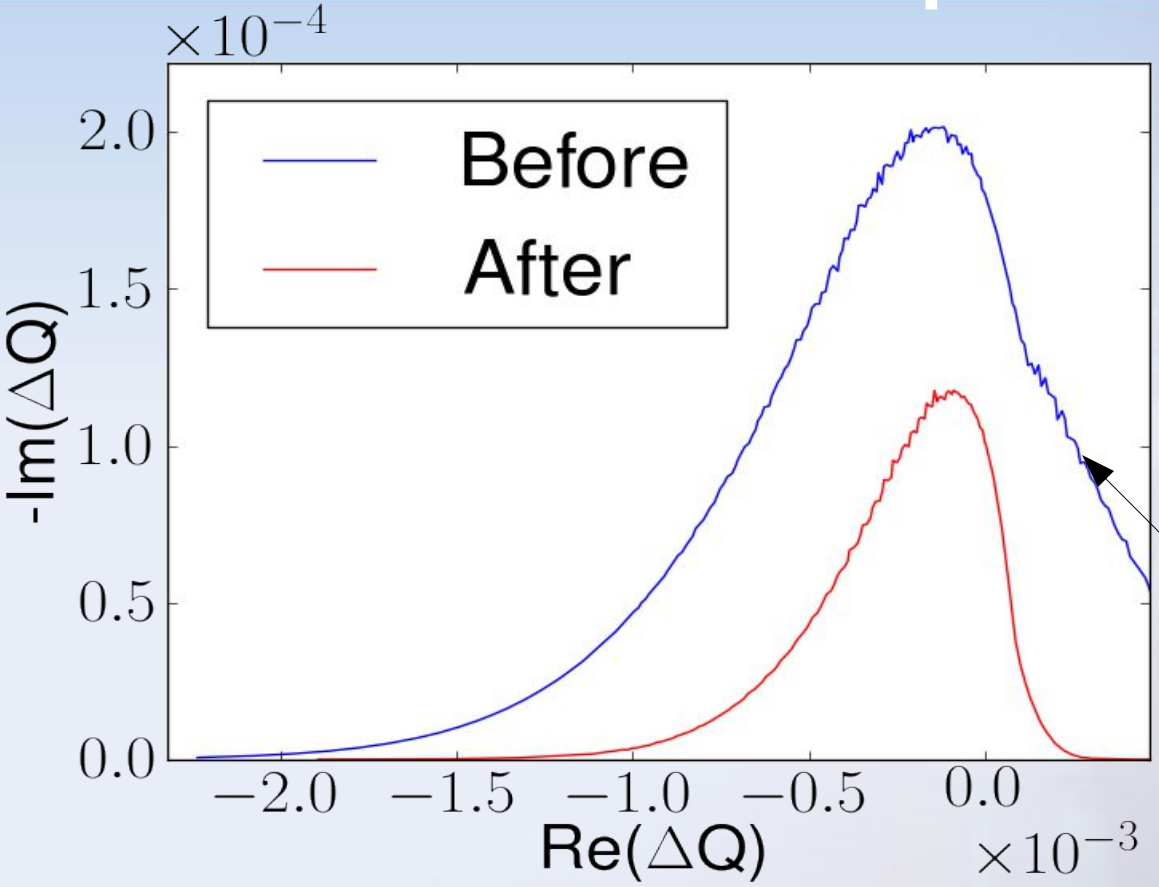
Before the squeeze

- Stability diagram smaller than with old polarity
  - As already mentioned by the impedance team [1]
- Stabilized by
  - high current in the octupole
  - high chromaticity
  - high damper gain



[1] E. Métral and A. Verdier, Stability Diagram For Landau Damping With A Beam Collimated At An Arbitrary Number Of Sigmas, CERN-AB-2004-019 -ABP

After the squeeze
Old polarity

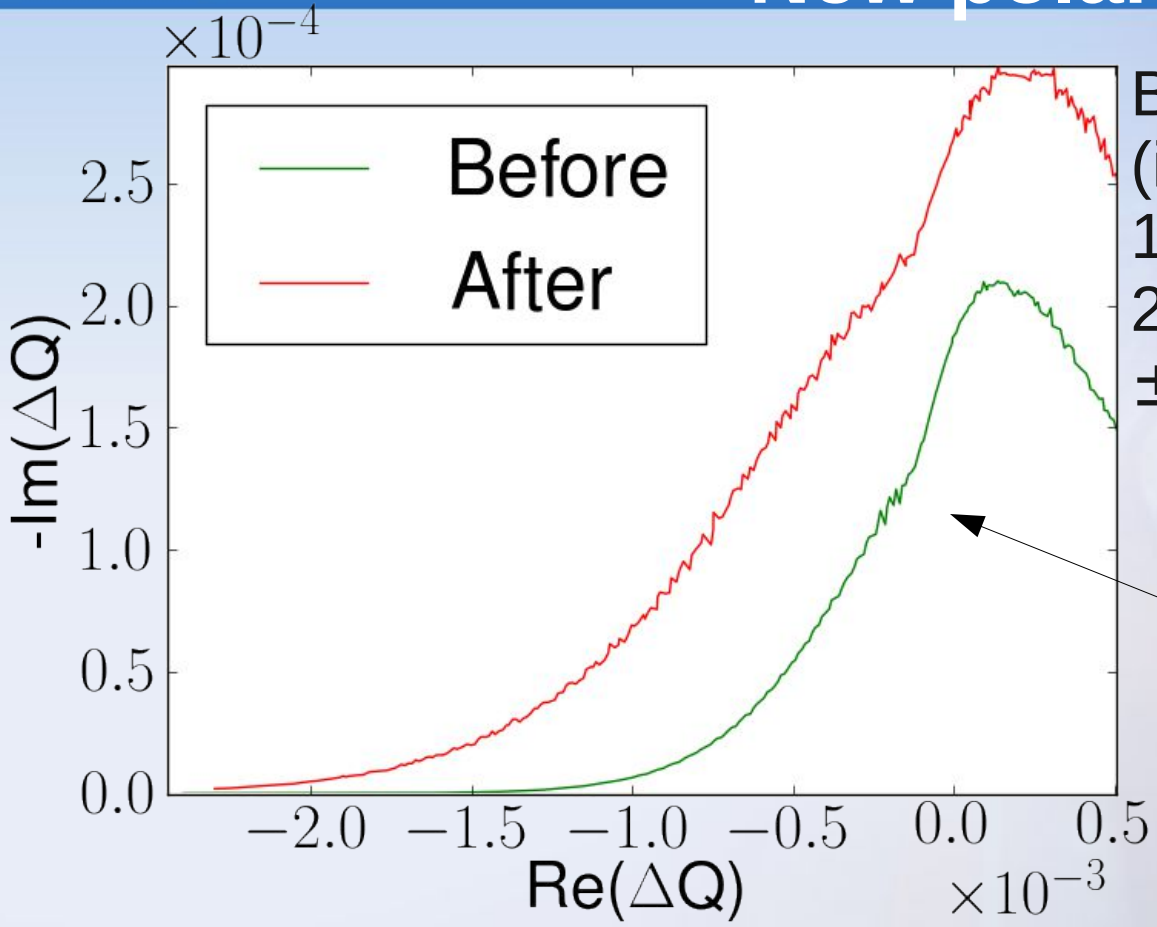


Beam 1, bunch 85
(i.e. Nominal bunch)
1.4E11
2E-6 µm
±450A

Stable before the squeeze

- The compensation of LR and octupole tune spread could explain the instability

After the squeeze
New polarity



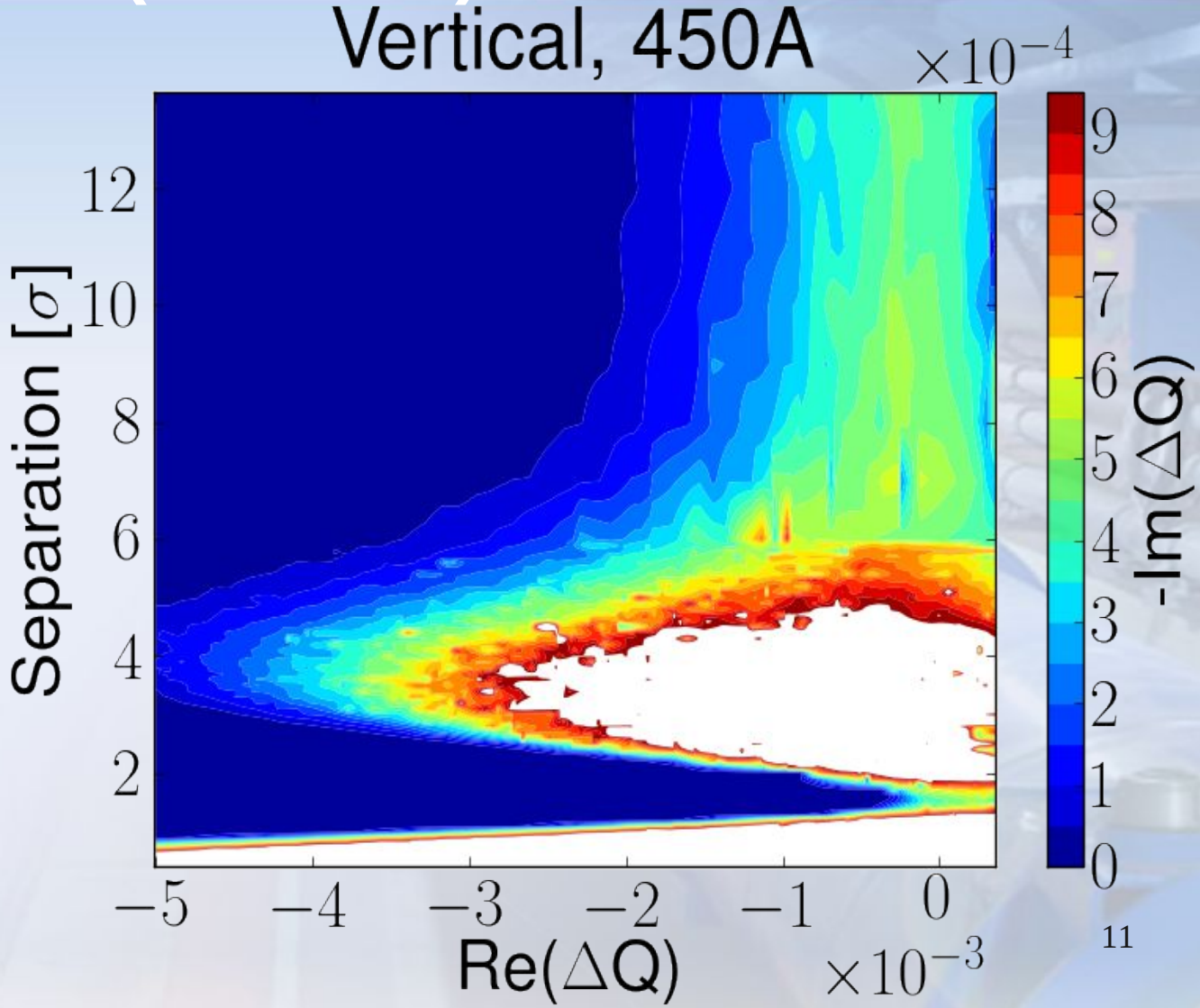
Beam 1, bunch 85
(i.e. Nominal bunch)
1.4E11
2E-6 µm
±450A

Stable before the squeeze

- The compensation of LR and octupole tune spread do not explain the instability

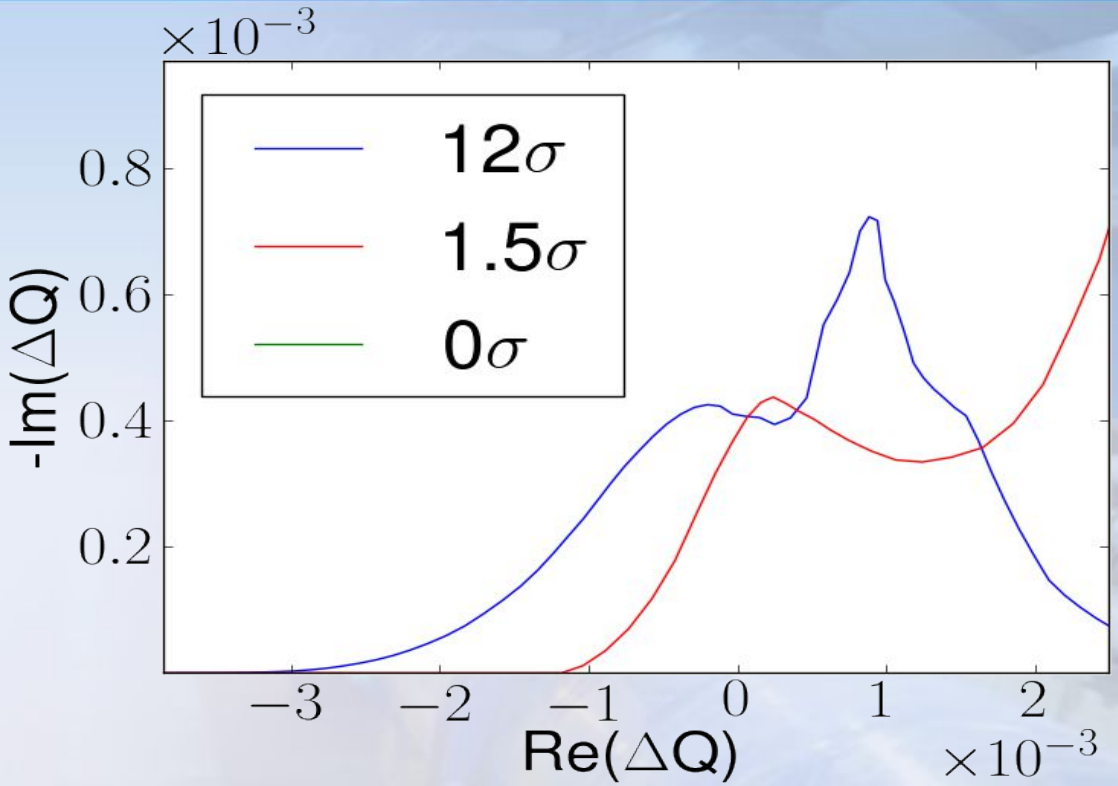
Collapse of separation (ADJUST)

- Parameters :
  - 1.5E11
  - 2E-6 µm
  - 450A (new)
  - Full LR in all IPs
- All IPs collapsed synchronously
- No offset in the Xing plane



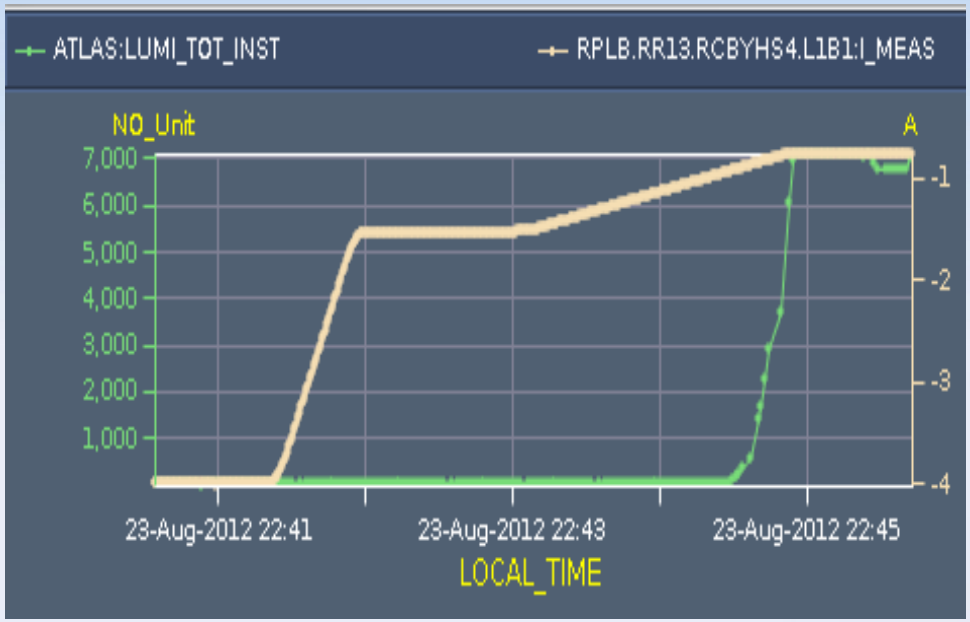
Minimum of stability

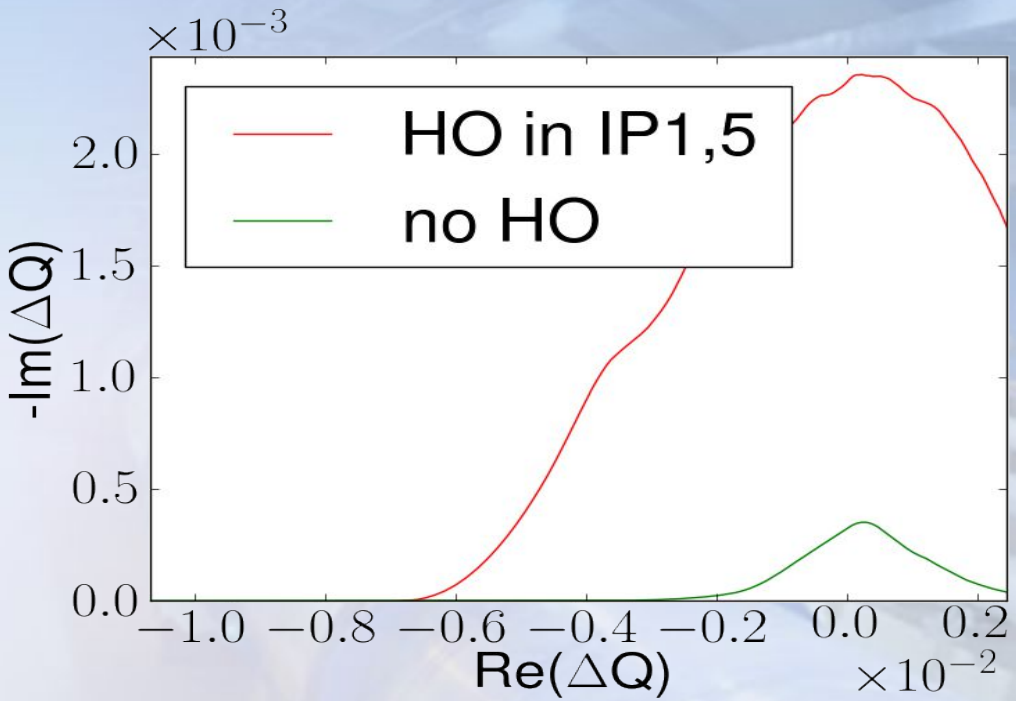
- New polarity provides better stability during the collapse of the separation
- Still there is minimum of stability to go through
- Difficult to predict, depends on :
  - Collision schedule
  - Intensity
  - Emittance
  - Octupole setting
  - Transverse offsets at the IPs



- We have been going through this minimum all last year ! but faster...

Rise time / Collapse time



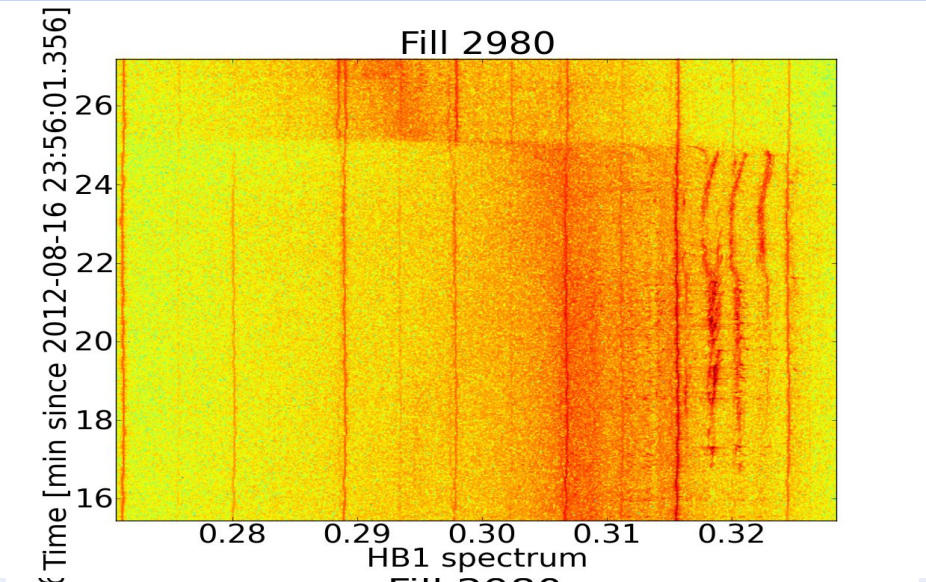


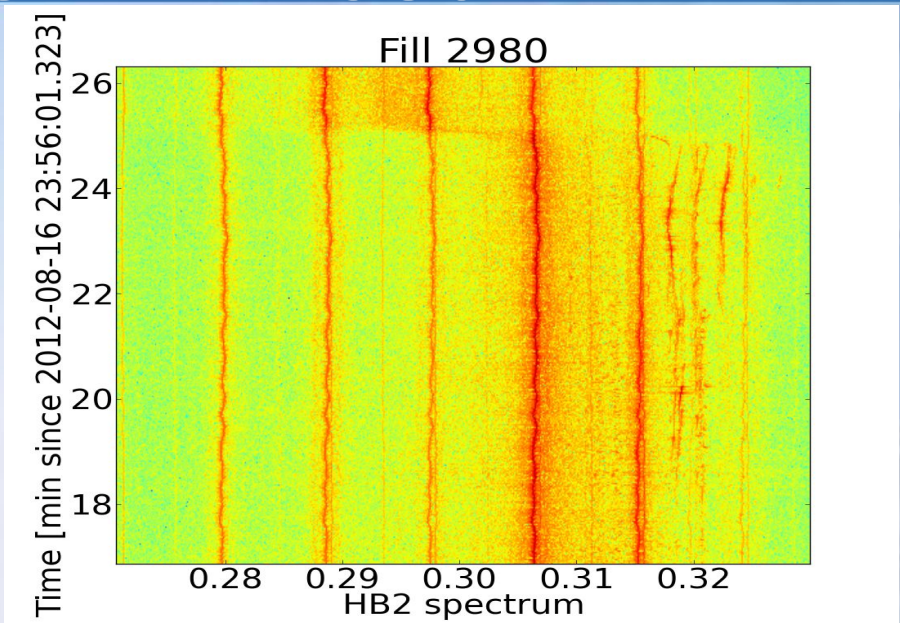
- Instabilities take time to develope (few seconds)
- The process takes 220s instead 56s because of IP8 tilting
  → One could do IP8 tilting after colliding in IP1 and 5

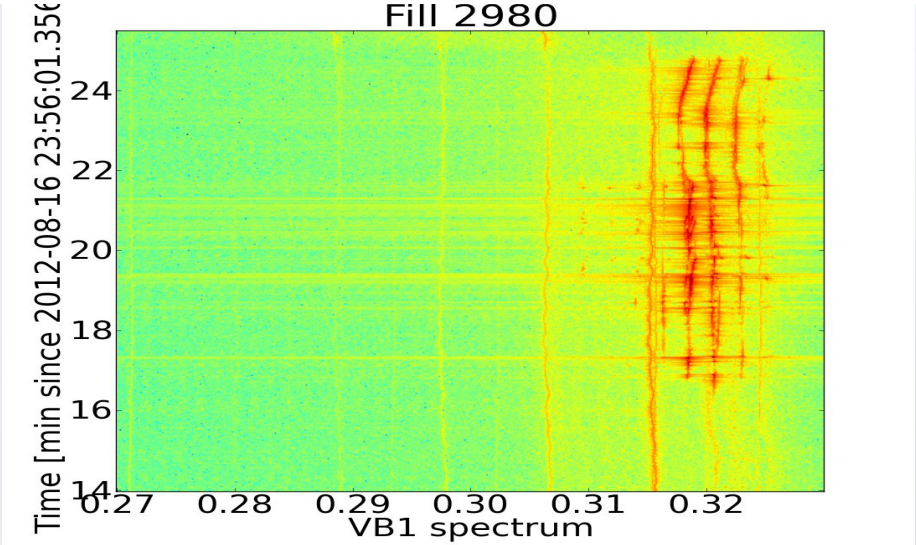
Conclusion

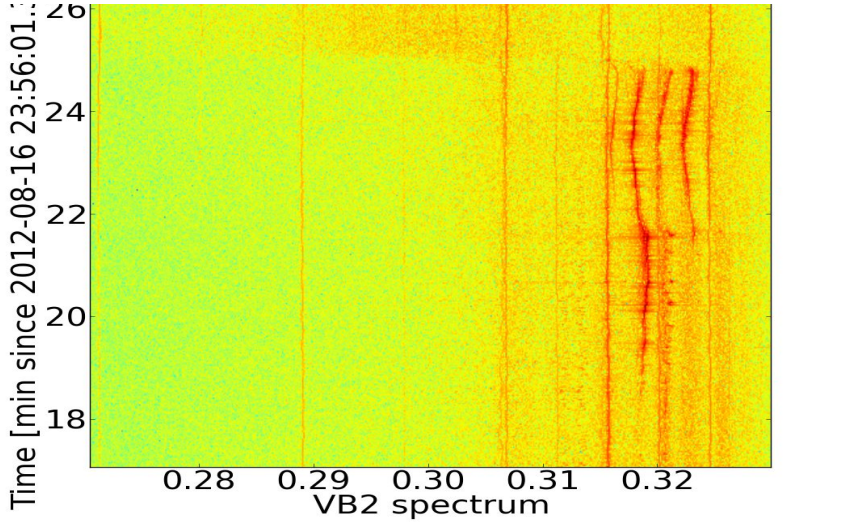
- New octupole polarity should provide a better stability at the end of the squeeze, but worse at the beginning
- Instability before / during / after the squeeze cannot be explained by the reduction of tune spread due to LRs (especially with the new polarity of the octupole)
  - The source of the instability must be understood
  - Possible solution : Stability region due to head-on is huge
- It is difficult to ensure sufficient stability during the collapse of the separation
  - May be avoidable by going faster through the process (e.g. Colliding IP1 and 5 before IP8 tilting)

BACKUP
observations – fill 2980

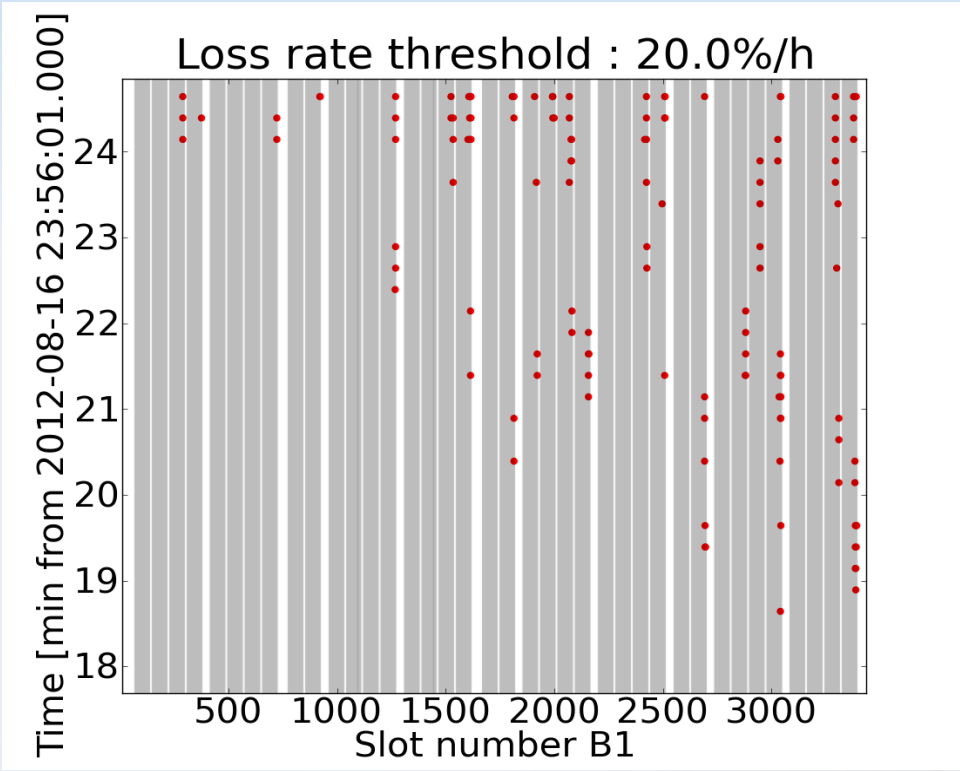


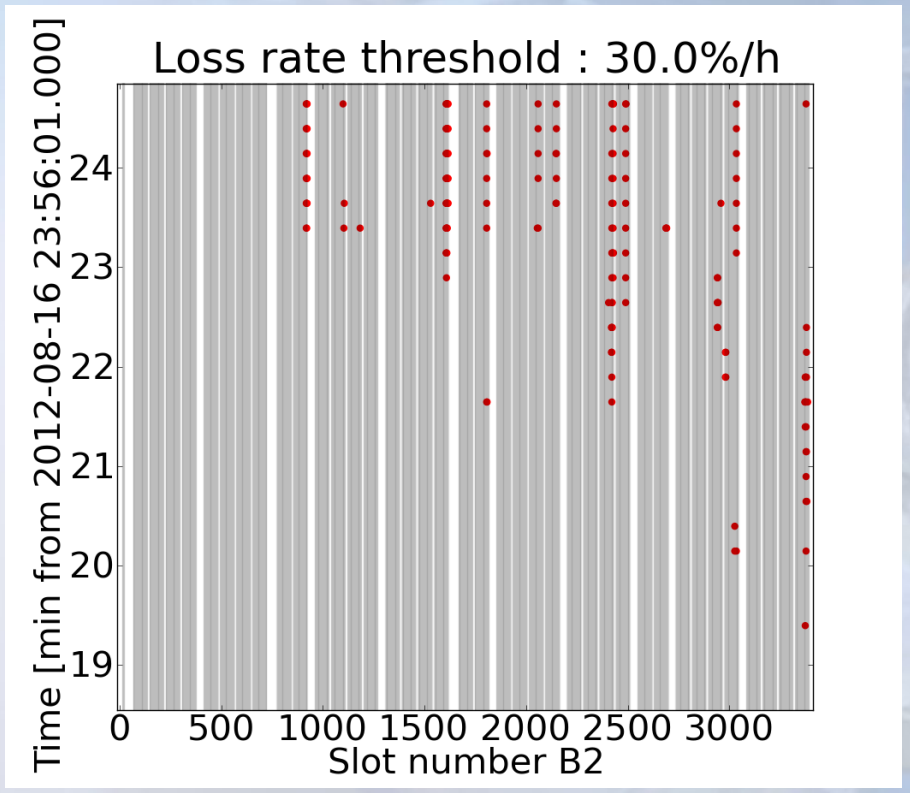




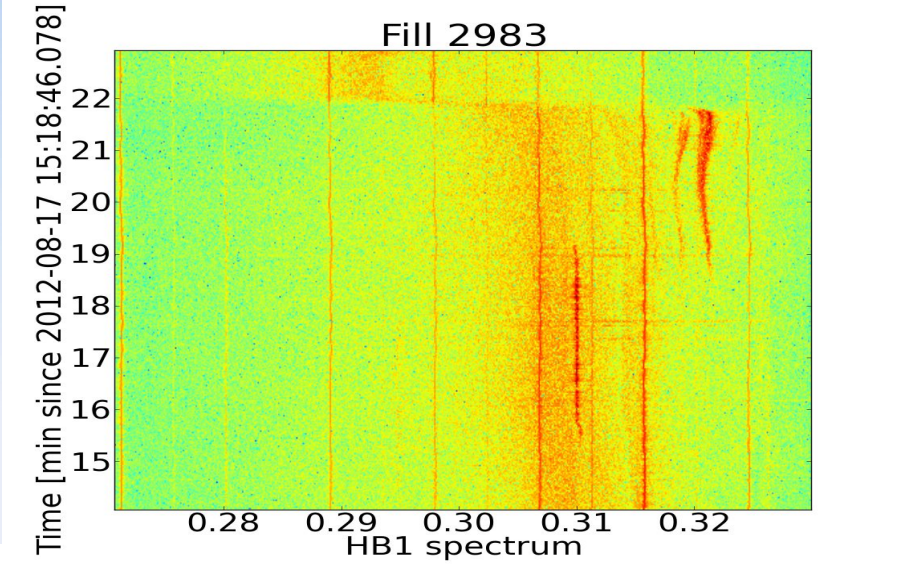


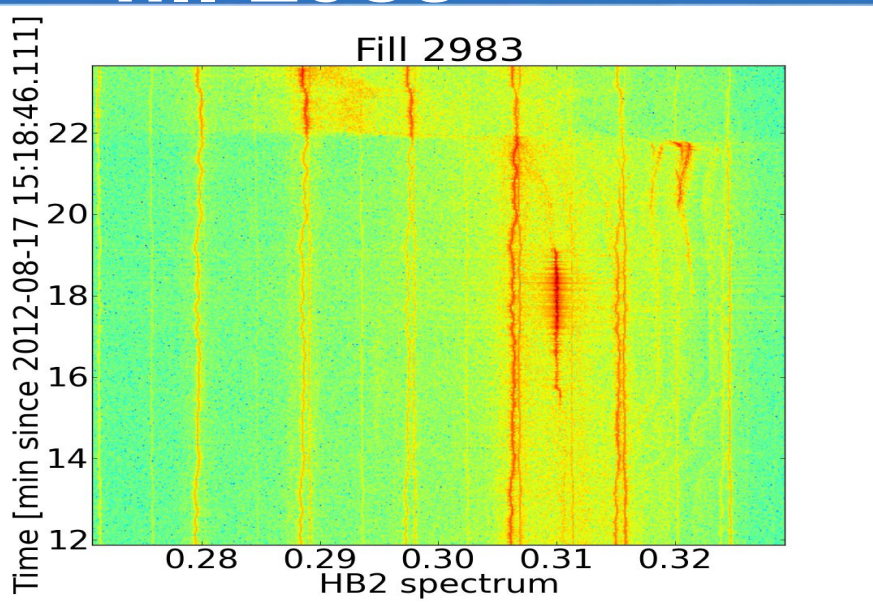
BACKUP observations – fill 2980

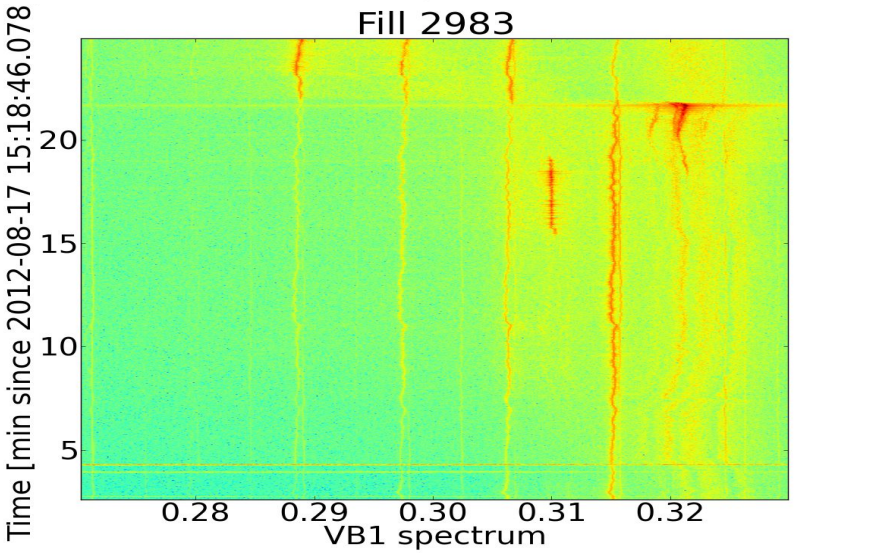


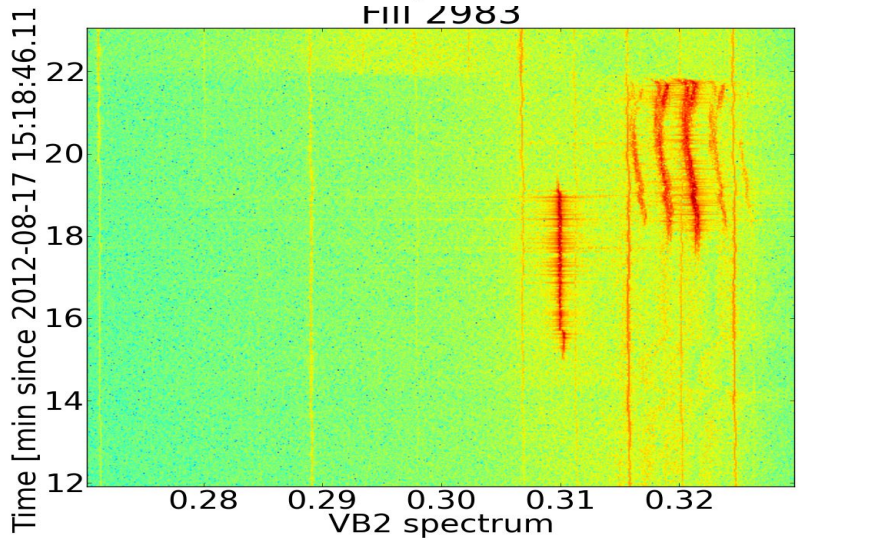


BACKUP
observations – fill 2983

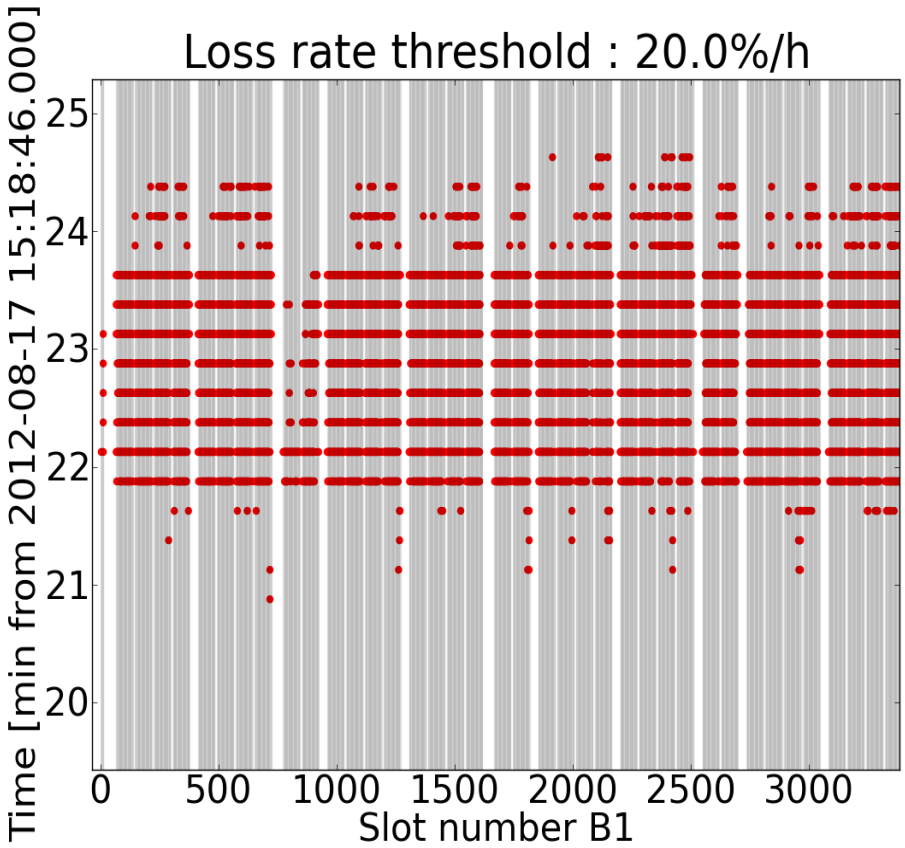


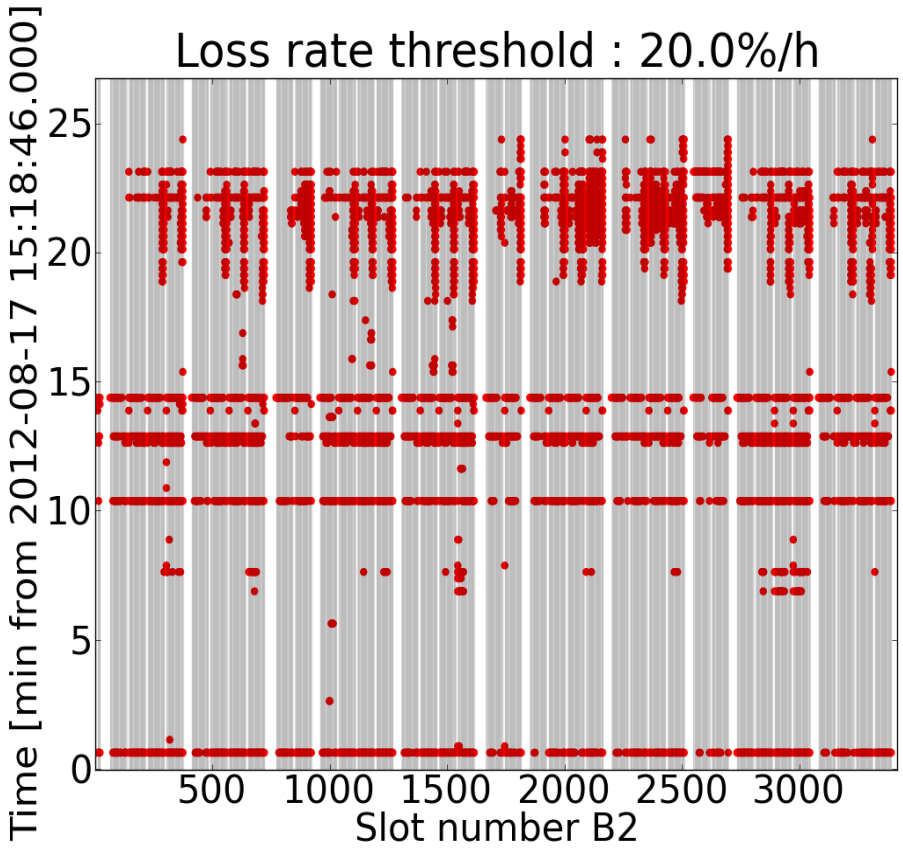




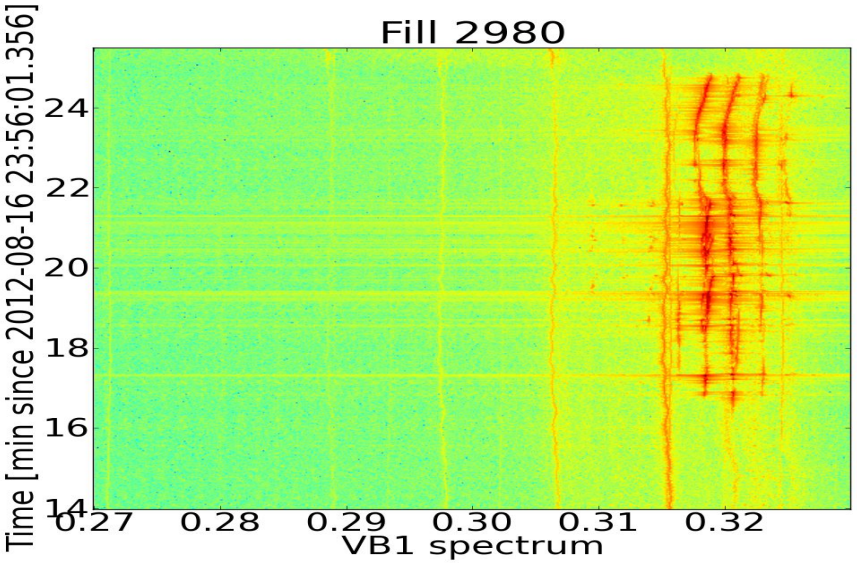


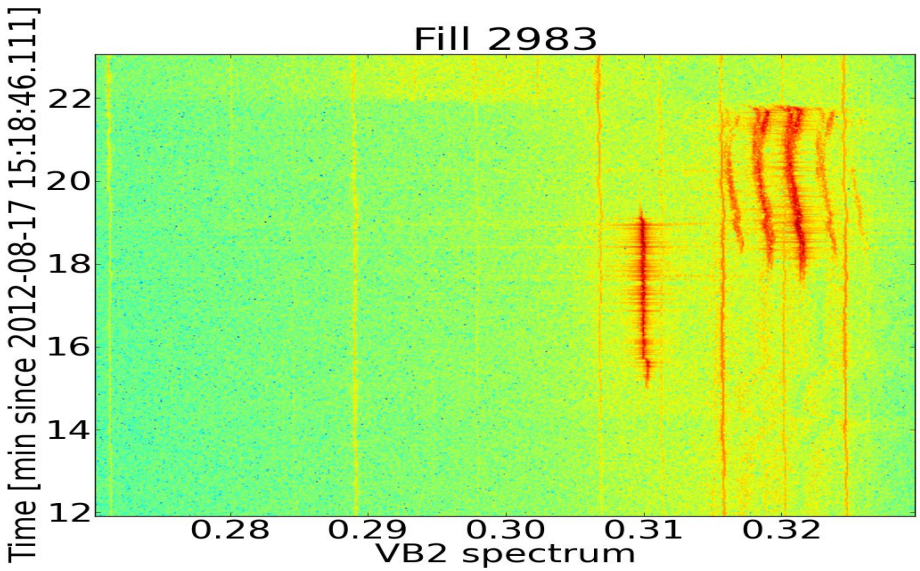
BACKUP observations – fill 2983

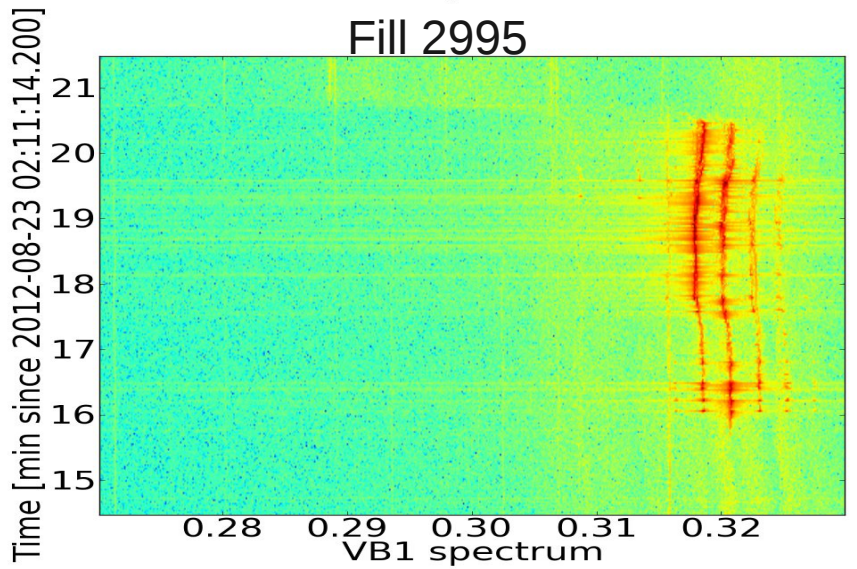


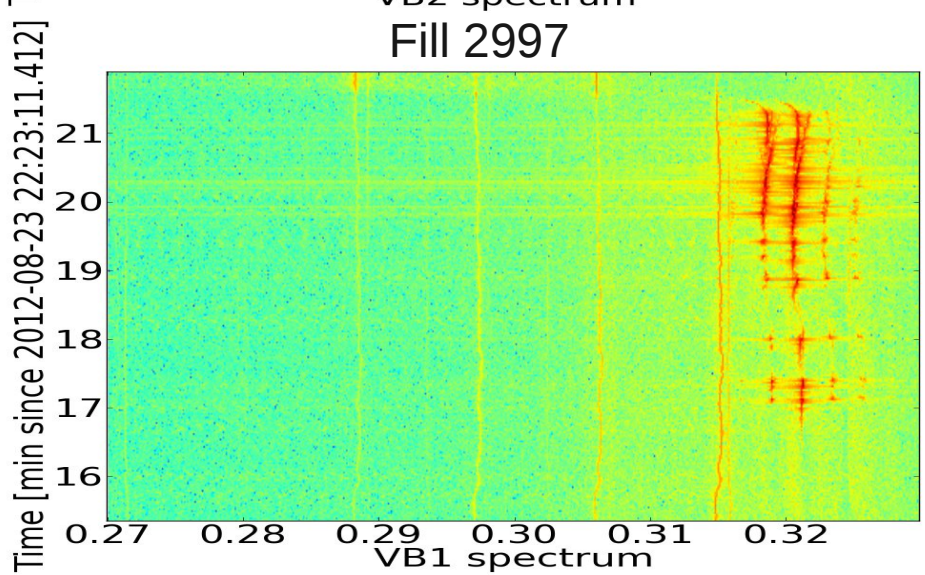


BACKUP
reproducibility

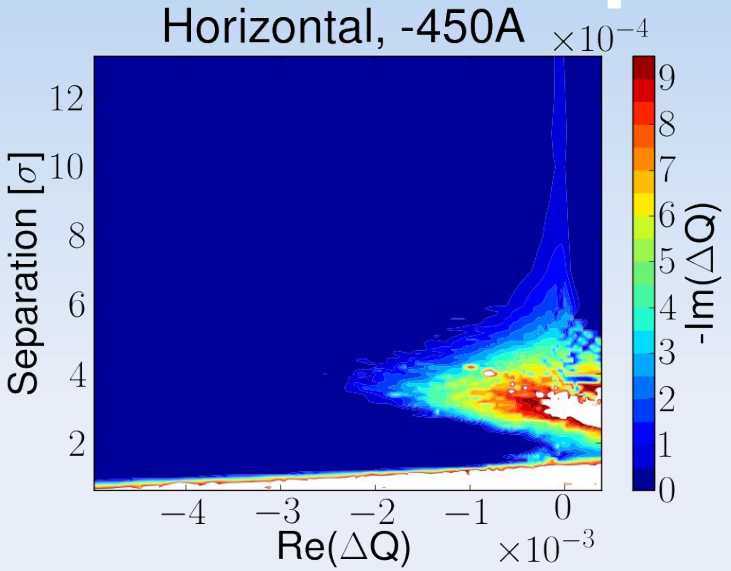


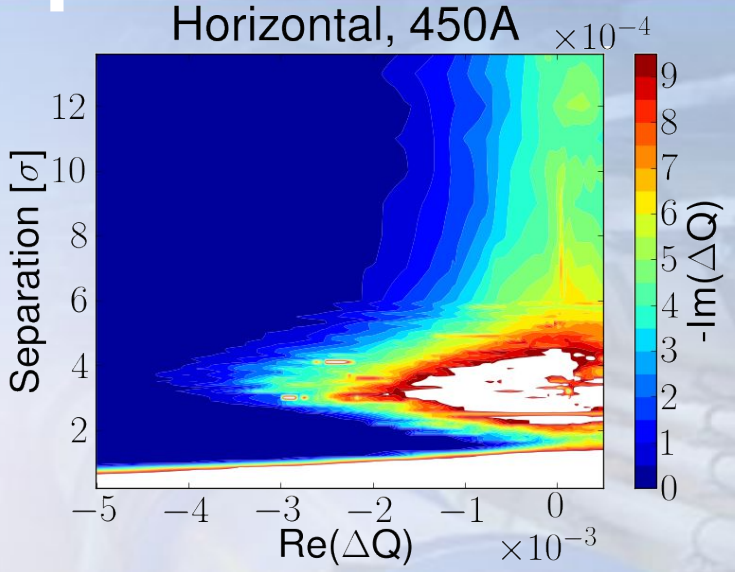


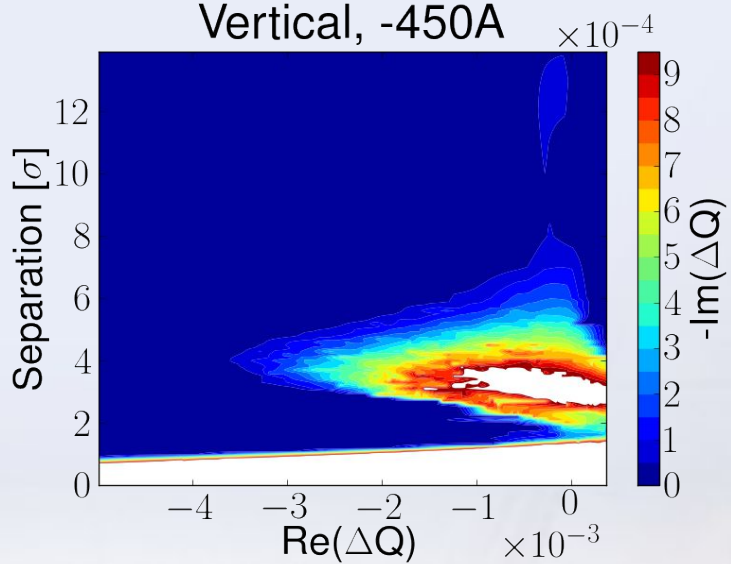


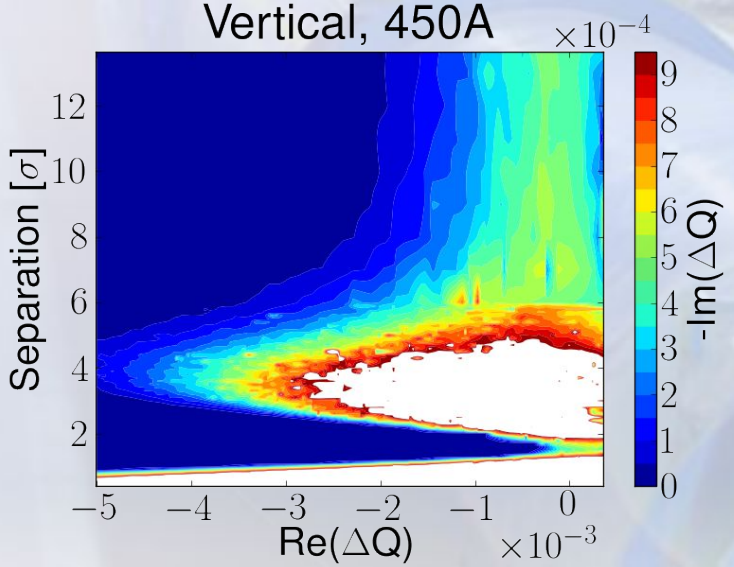


BACKUP
collapse of separation

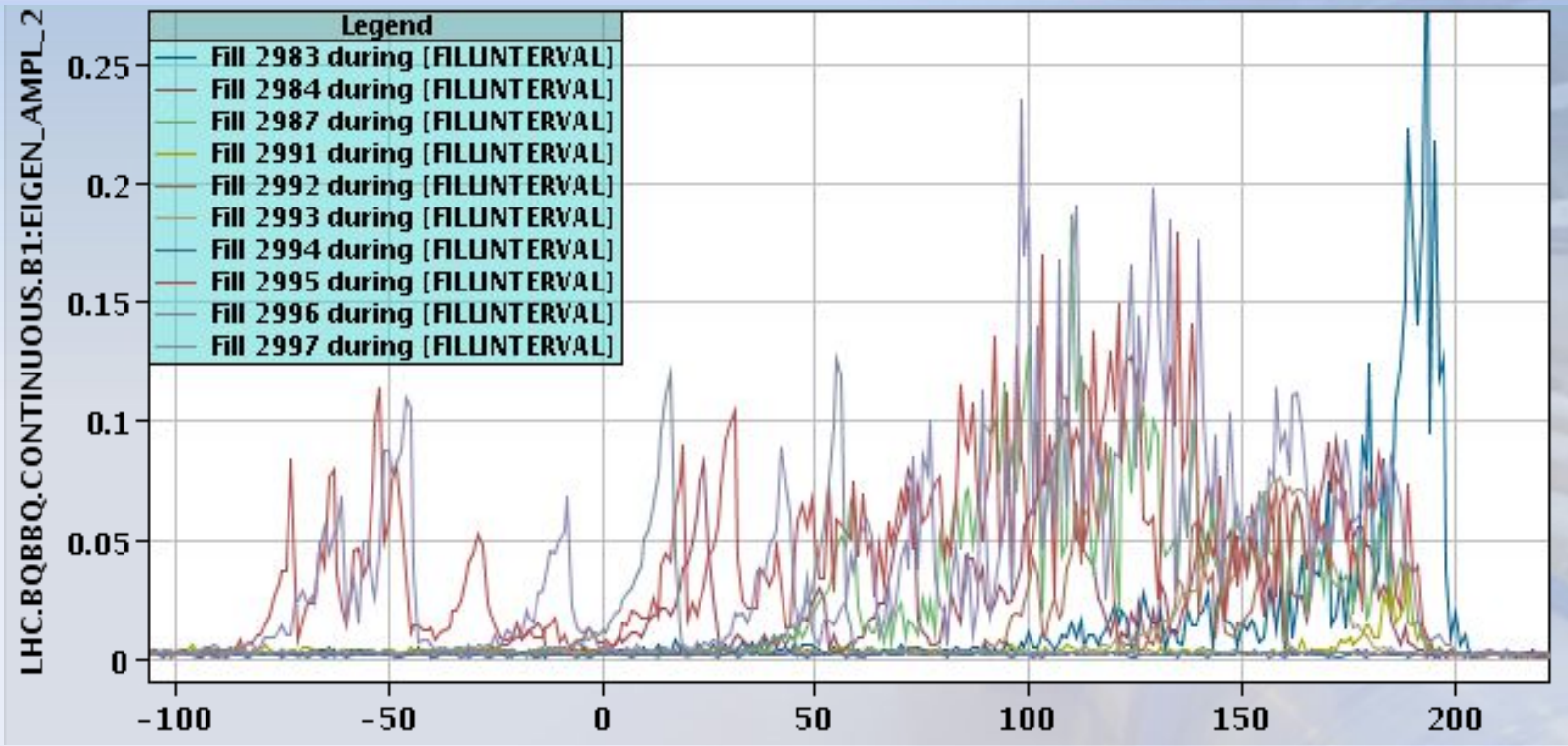








BACKUP – BBQ amplitude



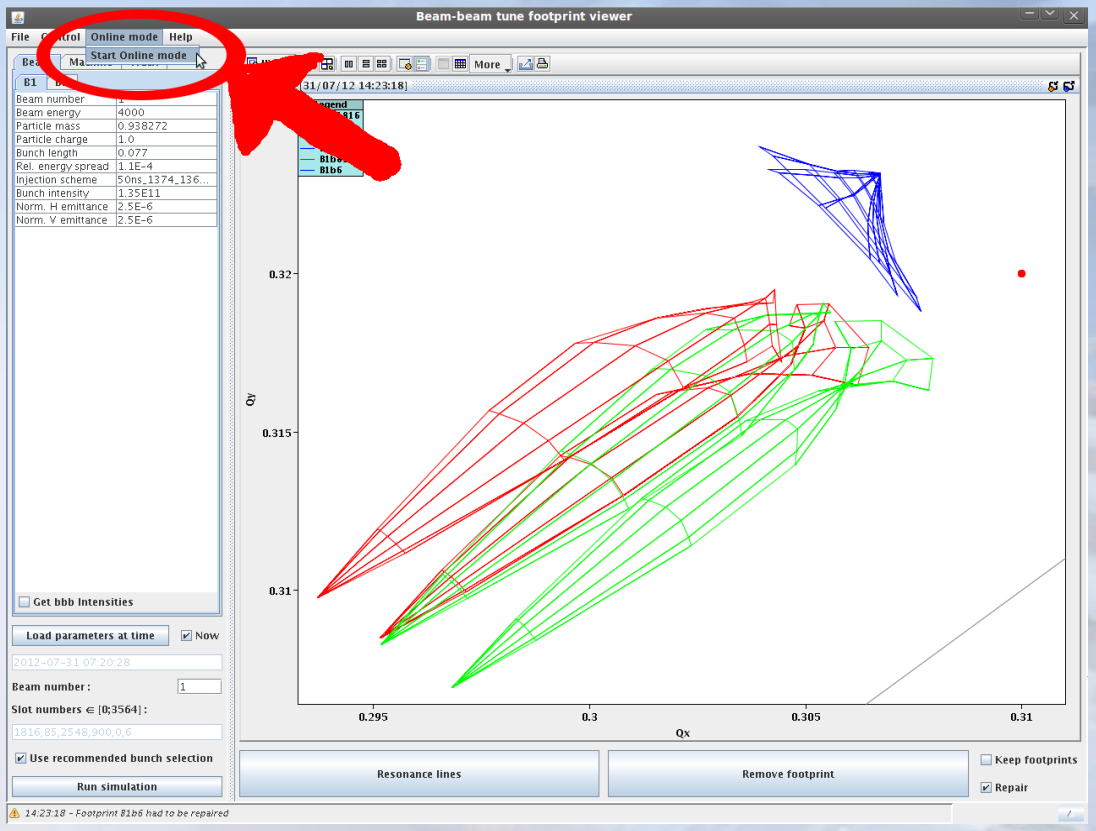
Time [s since start of PHYSICS beam process]

- Instabilities do not start at the same time in the process
- Sometime during the collapse of separation, but not exclusively

BACKUP

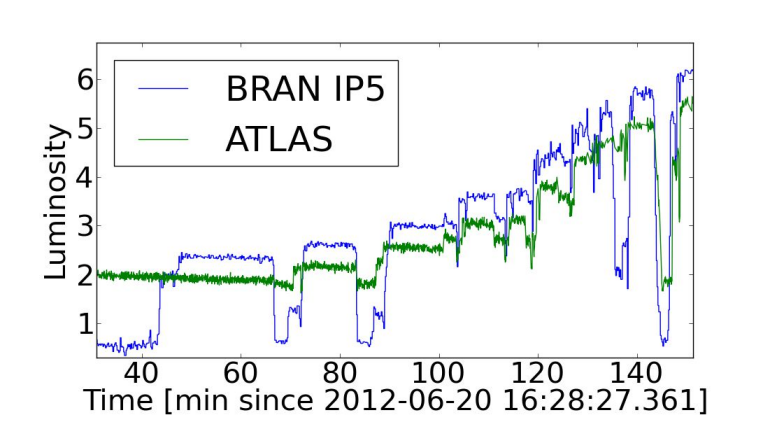
Online footprint viewer

- Online footprint viewer fully operationnal
- Automatically
  - Select interesting bunches
  - Load beam/machine parameters
  - Actualize as fast as possible (Running tracking jobs on a remote machine)

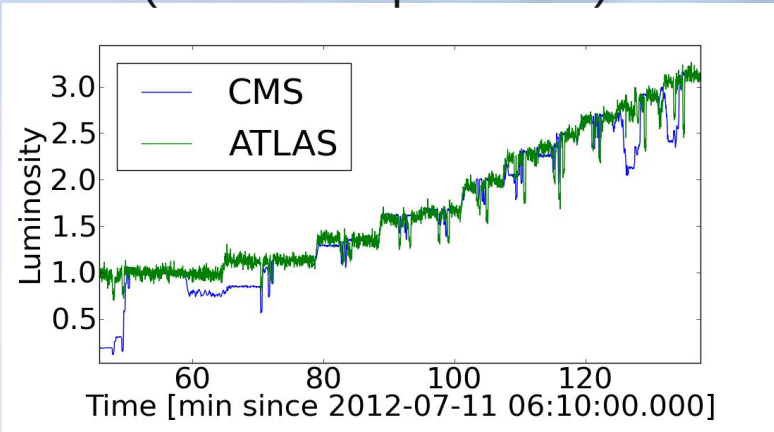


BACKUP
β* leveling MD

2748 (2 bunches per beam)



2828 (2 bunches per beam)



2829 (1 train of 48 bunches per beam)