Instability observations in the LHC in special high-β* runs

Typical beam conditions in the high-β* runs done for
IP1 ATLAS/ALFA **and IP5** TOTEM/CMS

- **IP1 and IP5 : β* = 90m, .. 1000m, no crossing angle, colliding head-on**
- **Injection / end of ramp optics (including crossing angles, parallel separation on) in the rest of the machine**
- **small number of bunches**
- **absence of parasitic crossings**
- **very tight collimator settings**

one more general slide on : high β* = 1000 m

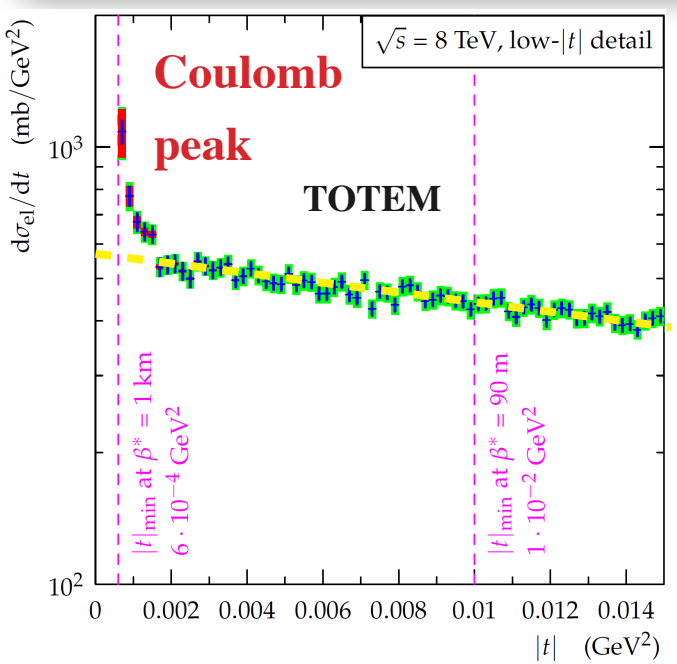
De-squeeze to β* = 1000 m to get very parallel beams.

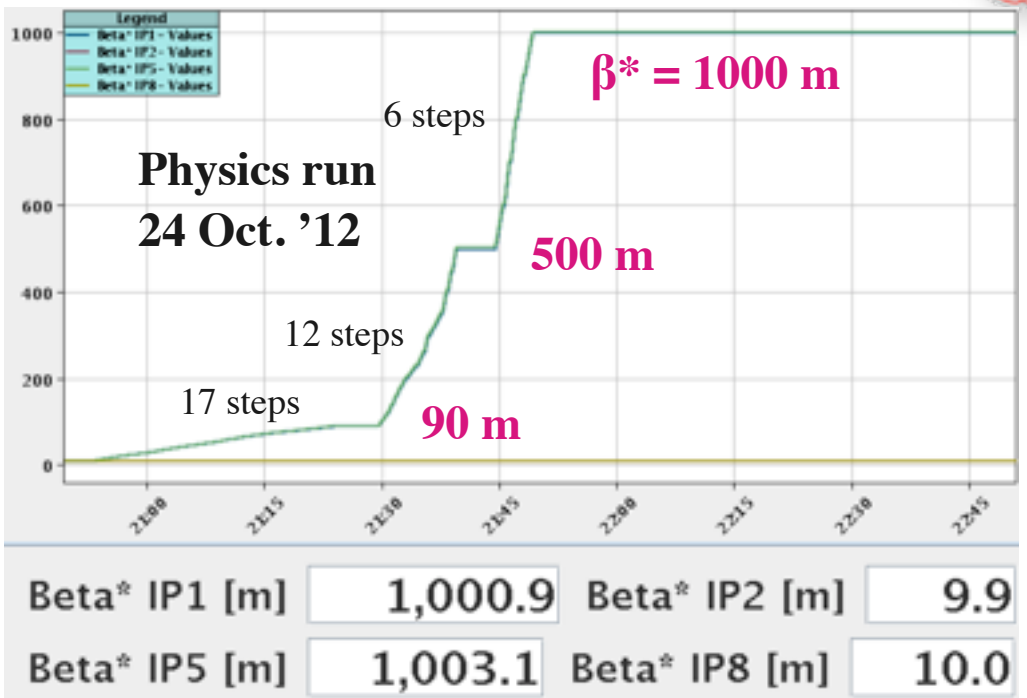
Beam-divergence at IP1&5 reduced 40× compared to normal physics to

0.7 µrad (0.7 mm spread in 1 km)

Primary Collimators down to 2σ and Roman Pot detectors very close to the beam (0.87 mm, 3σ)

$$\sigma_{TOT}^2 = \frac{16\pi(\hbar c)^2}{1+\rho^2} \cdot \left.\frac{d\sigma_{EL}}{dt}\right|_{t=0}$$ Optical theorem



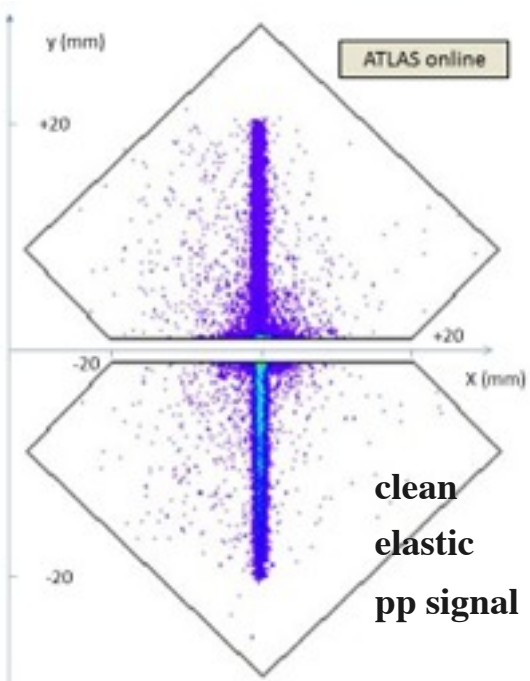


measure pp scattering down to ~ 5 µrad, reaching the Coulomb interference region

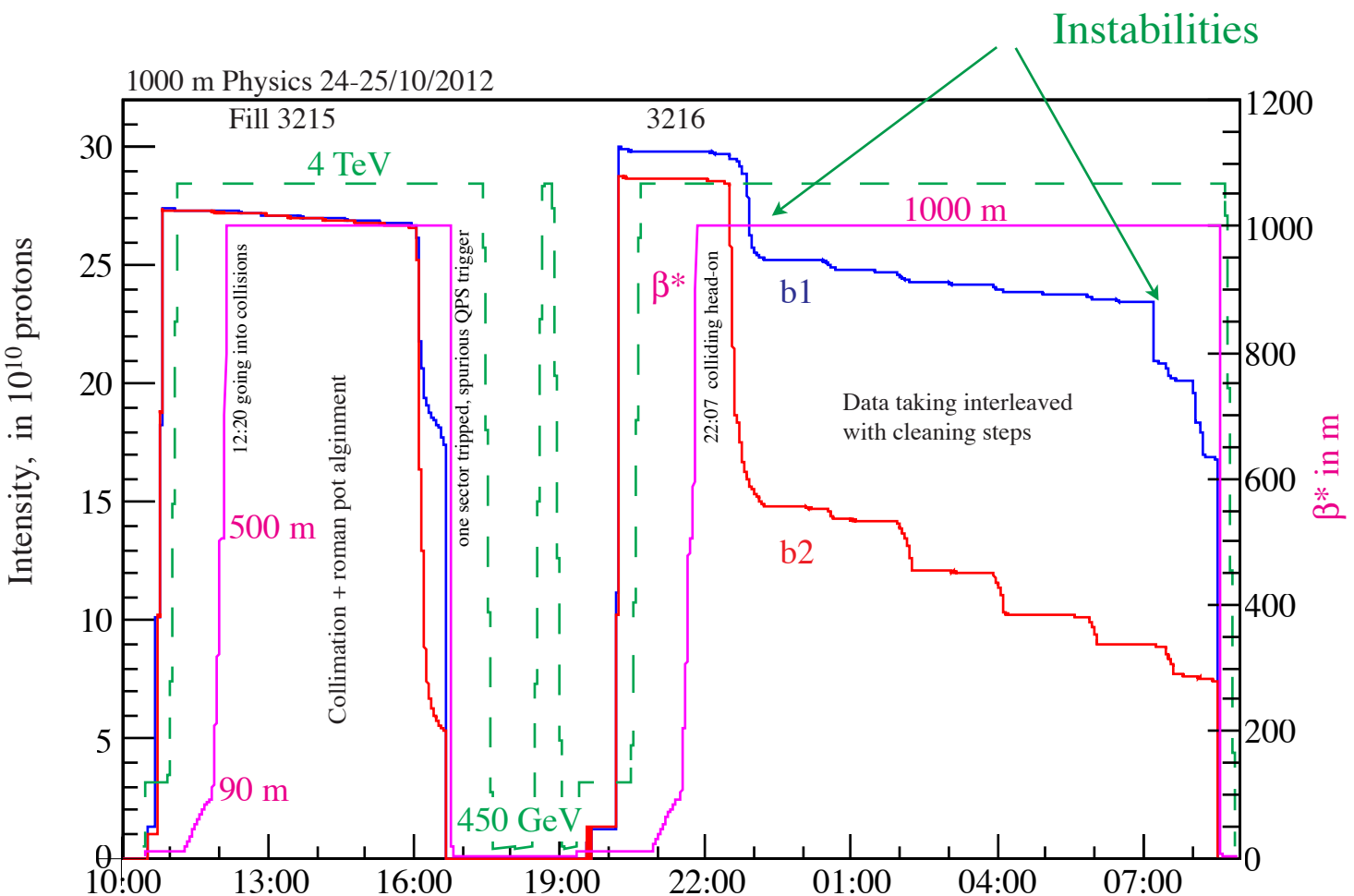
(120 µrad in UA4 SPS)

Fundamental measurements with major consequences

$\sigma_{in} \approx 85$ mb (not 60 mb) at 7 TeV



1000 m physics run Wed-Thu 24-25 /10/2012



21:50
ε_N meas. in μm
B1H = 1.83
B1V = 1.3
B2H = 3.31
B2V = 2.24
beam 2 much larger

ξ range
0.0020 - 0.0094

for
5e10, 3 μm
to
1.0e11, 1.3 μm

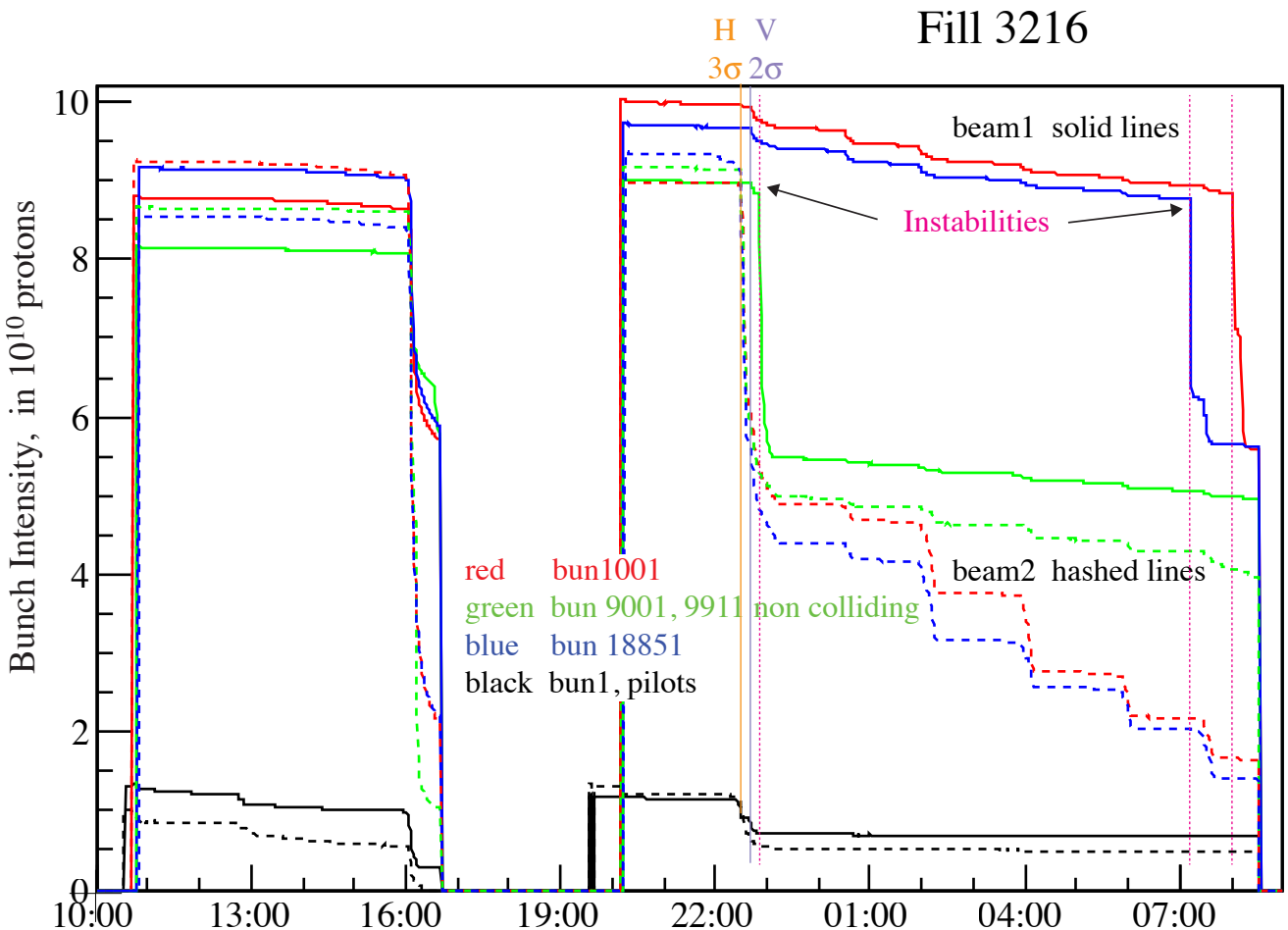
Single_3b_2_2_2_wp_nLR
nLR means no long range

1	1	pilot
1001	1001	
9001	9911	non colliding
18851	18851	

Beam 1, 2 intensities, energy and β* as a function of time over 23 h for the 1000 m runs on the 24 to 25 October.

3 bunches + 1 pilot each beam, one pair not colliding
Evidence for instabilities : look at single bunch intensities

1000 m physics run 24-25 /10/2012

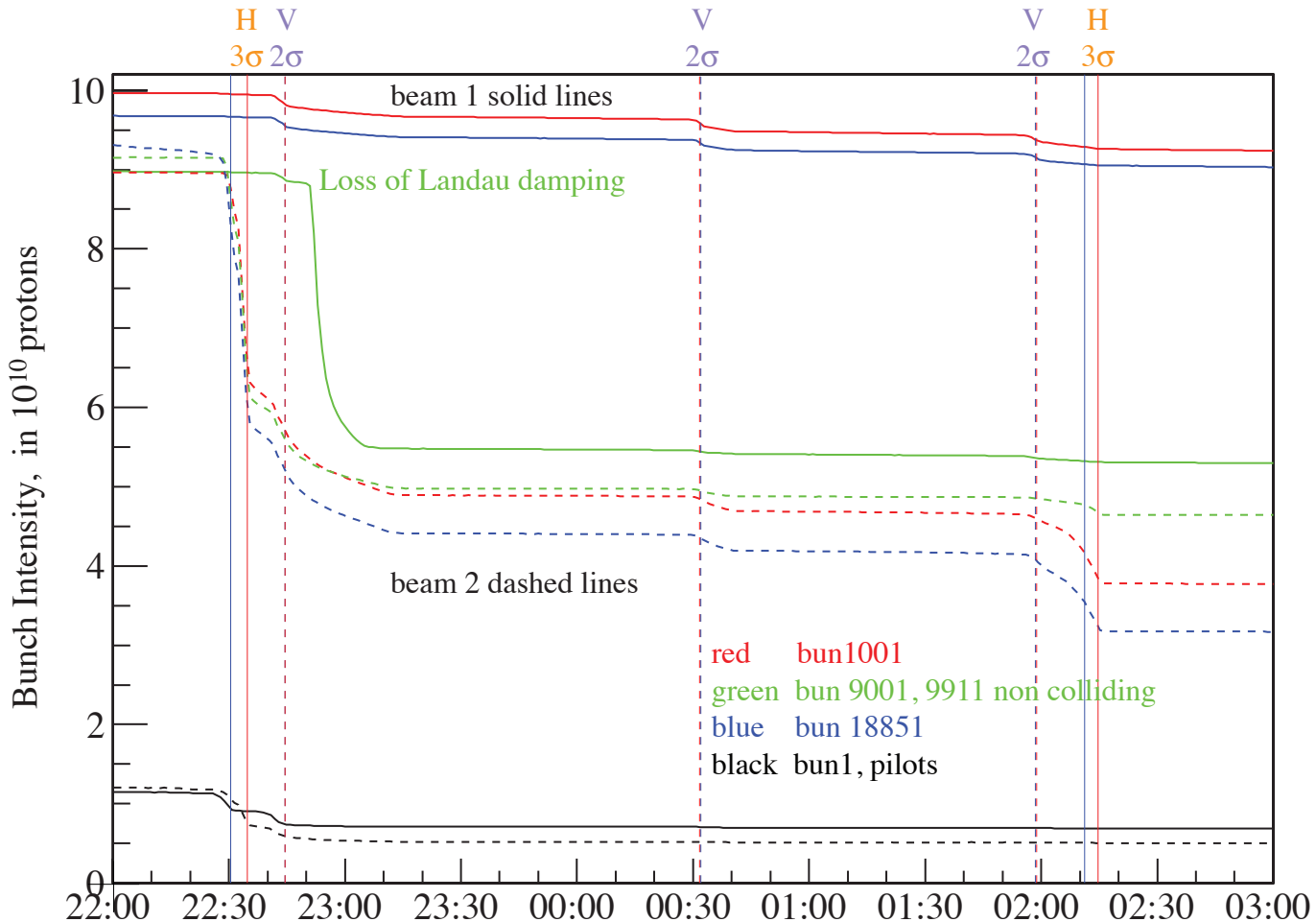


Beam (solid lines) and beam 2 (dashed lines) bunch intensities

beam sizes in σ in collimation convention, for ε_N = 3.5 μm normalized emittance

octupoles at 208 Amps

bunch intensities, zoomed 22:00 to 3:00

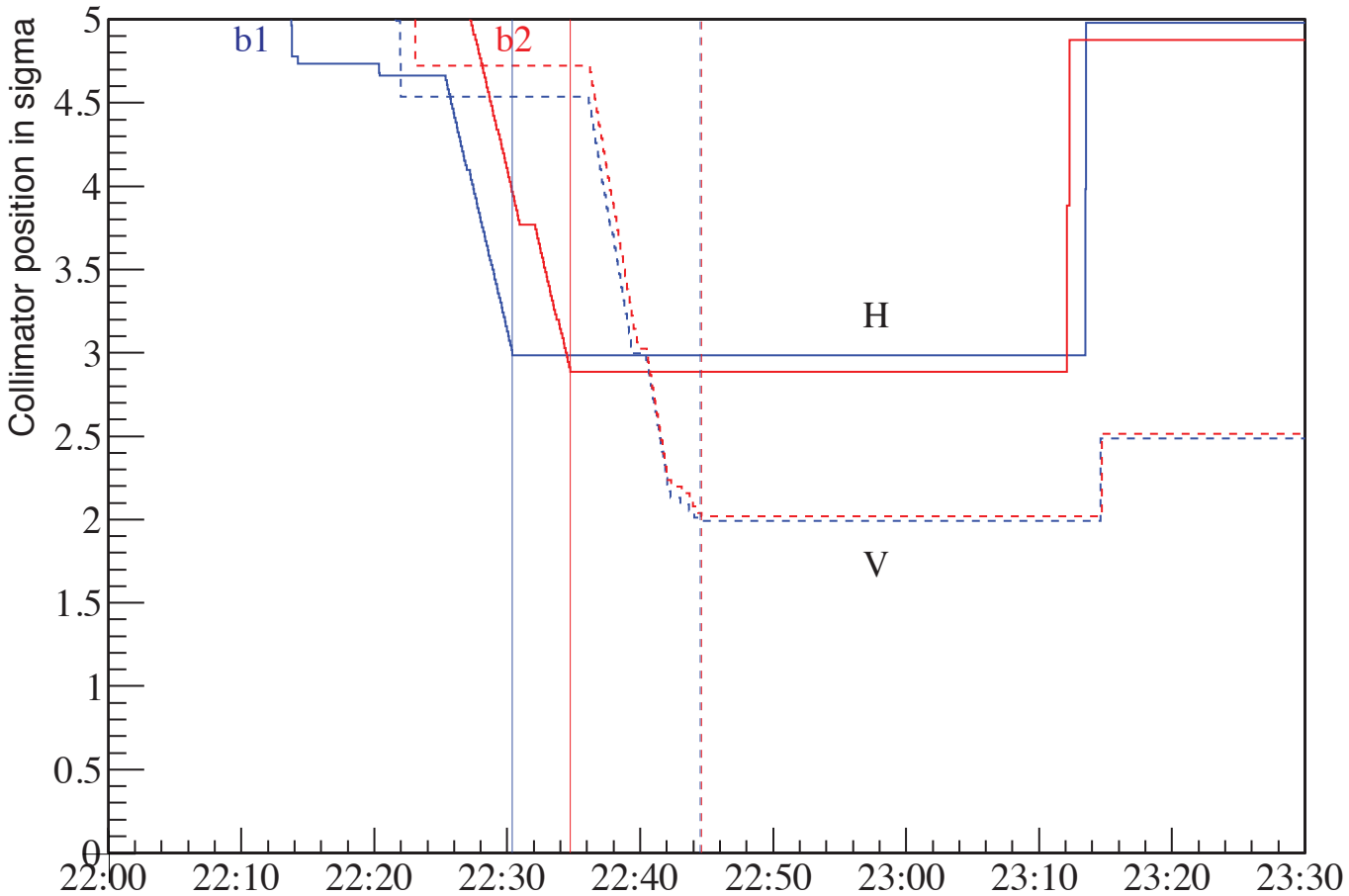


Instability : seen on strongest non-colliding bunch (lack of Landau damping) shortly after moving the primary collimator to 2σ

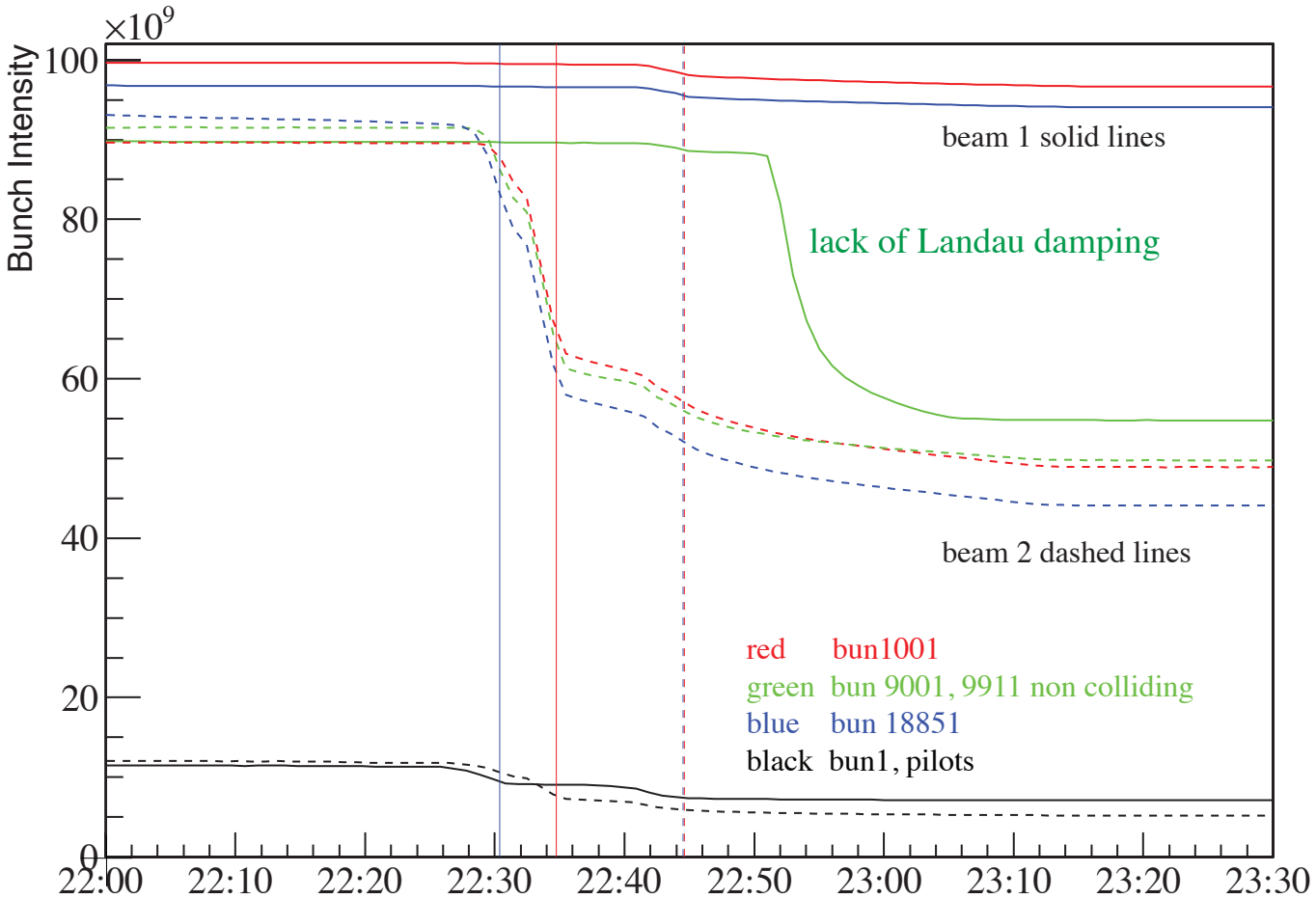
and again at the end of the fill when beam2 was weak so that the damping from beam-beam head-on became insignificant

Other losses from scraping transverse tails

primary collimators, further zoomed 22:00 to 23:30



bunch intensities, further zoomed 22:00 to 23:30



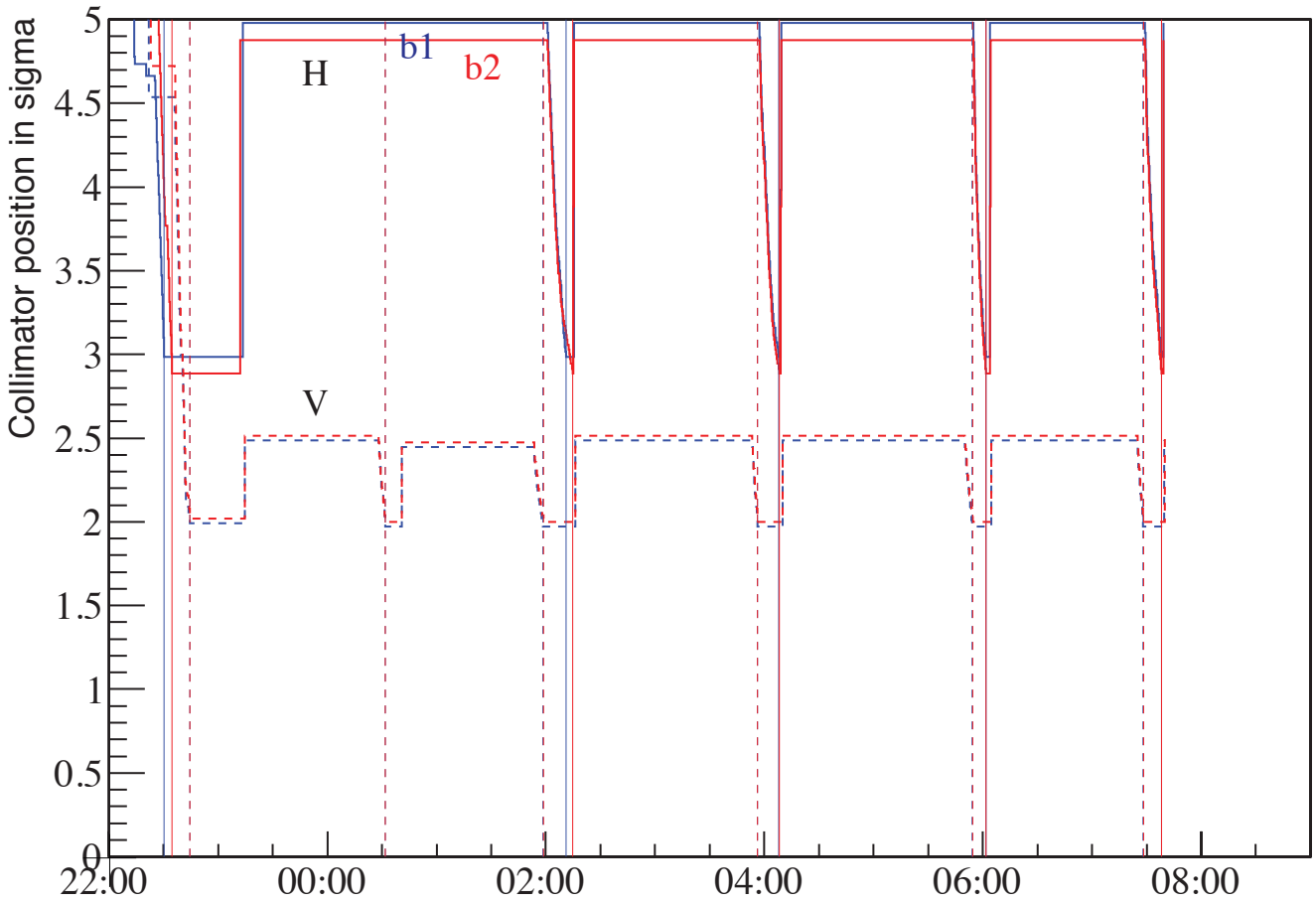
Backup

Observation of beam instabilities with very tight collimation

Authors : H. Burkhardt, Nicolas Mounet, Tatiana Pieloni Presenter Tatiana Pieloni

Abstract : We report about the observation of instabilities in the LHC in special runs with high beta* and very tight collimation down to 2 sigma which increases the transverse impedance significantly. The losses appeared primarily on the highest intensity, non-colliding bunches which can be interpreted as evidence for insufficient Landau damping. We describe the beam conditions, observations and possible explanations for the observed effects.

Primary collimators 22:00 to 9:00



Beam intensities 22:00 to 9:00