LBOC, 22.05.2012

Observations on luminosity curves
or
"the beam never forgets"

Giulia Papotti (BE-OP-LHC)

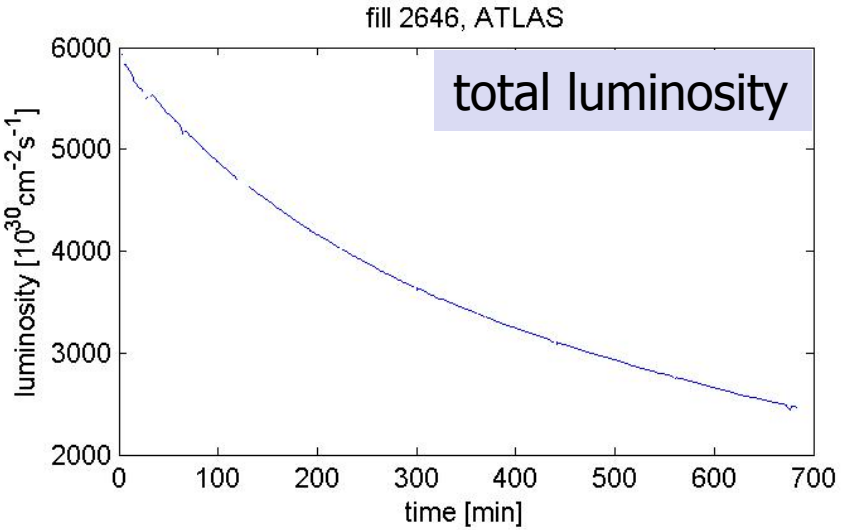
and after fruitful discussions with W. Herr,
G. Arduini, J. Wenninger, G. Rumolo,
S. Gilardoni, K. Cornelis, B. Mikulec, …

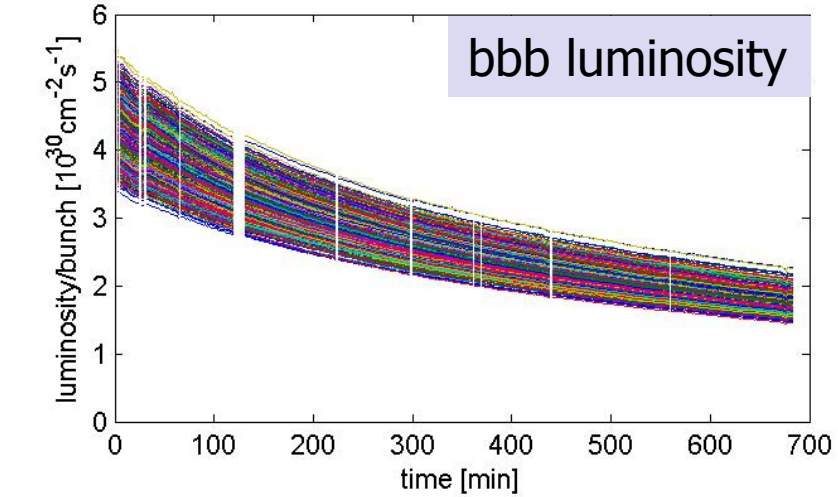
outline

- bunch-by-bunch (bbb) luminosity curves
  - IBS and injectors
- emittances at start of fill
  - IBS and injectors
- burn-off

- present one recent fill (2646), but looked at many others

bunch-by-bunch luminosities





- wide spread among bunches in luminosity production
  - up to a factor 2

lumi curves parametrization

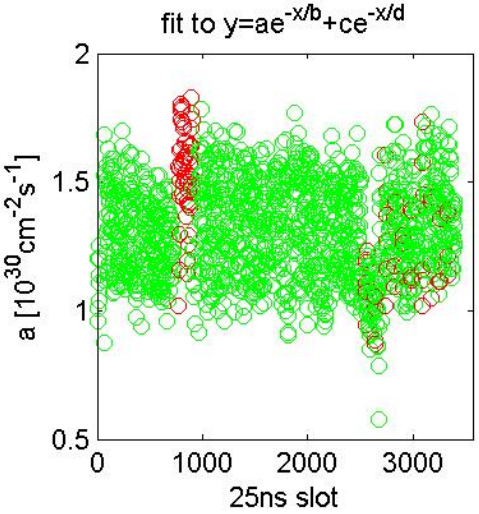
- double exponential: $L(t) = a\, e^{-t/b} + c\, e^{-t/d}$
  - $y = a\, e^{-x/b} + c\, e^{-x/d}$
  - not a physical model, but a good empirical description that allows parametrization
    - a+c = L(t=0)
    - b, d time constants for the luminosity decay

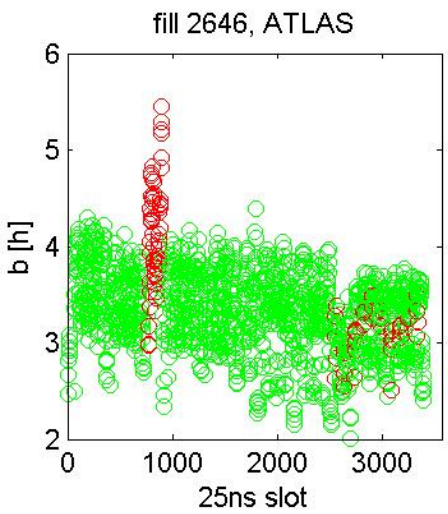
- fit the double exponential to bunch-by-bunch curves

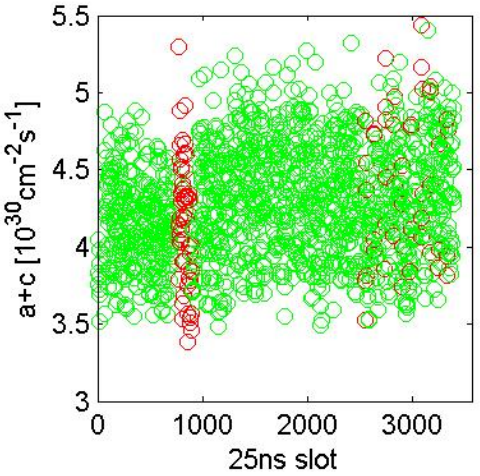
$$L_{tot}(t) = \sum_{i=1}^{N_b} L_i(t) = \sum_{i=1}^{N_b} \left(a_i e^{-t/b_i} + c_i e^{-t/d_i} \right)$$

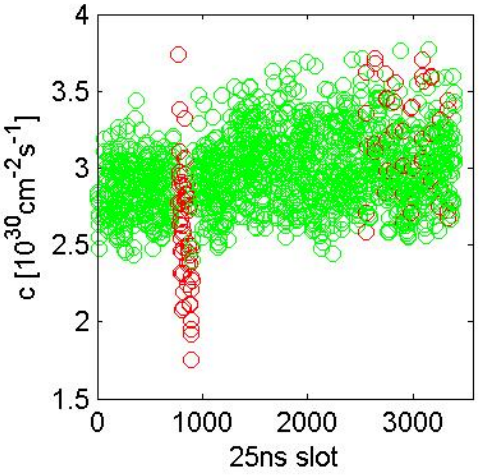
- and look at a_i, b_i, c_i, d_i for all bunches in that fill

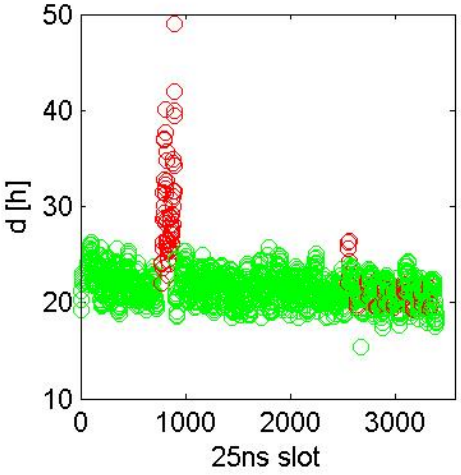
bbb lumi parameterization







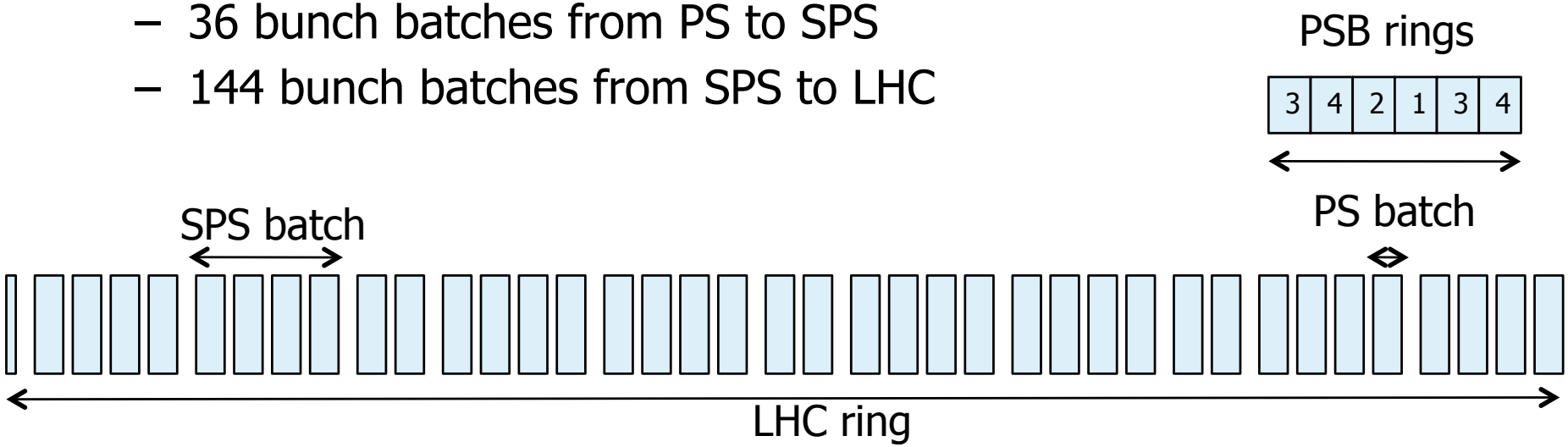




- later injections have higher peak but shorter lifetimes
  - probably IBS
    - Δ=~2-3% in integrated luminosity over 10 h
    - M. Schaumann (BE-ABP) verifying with simulations
- overall spread much bigger!

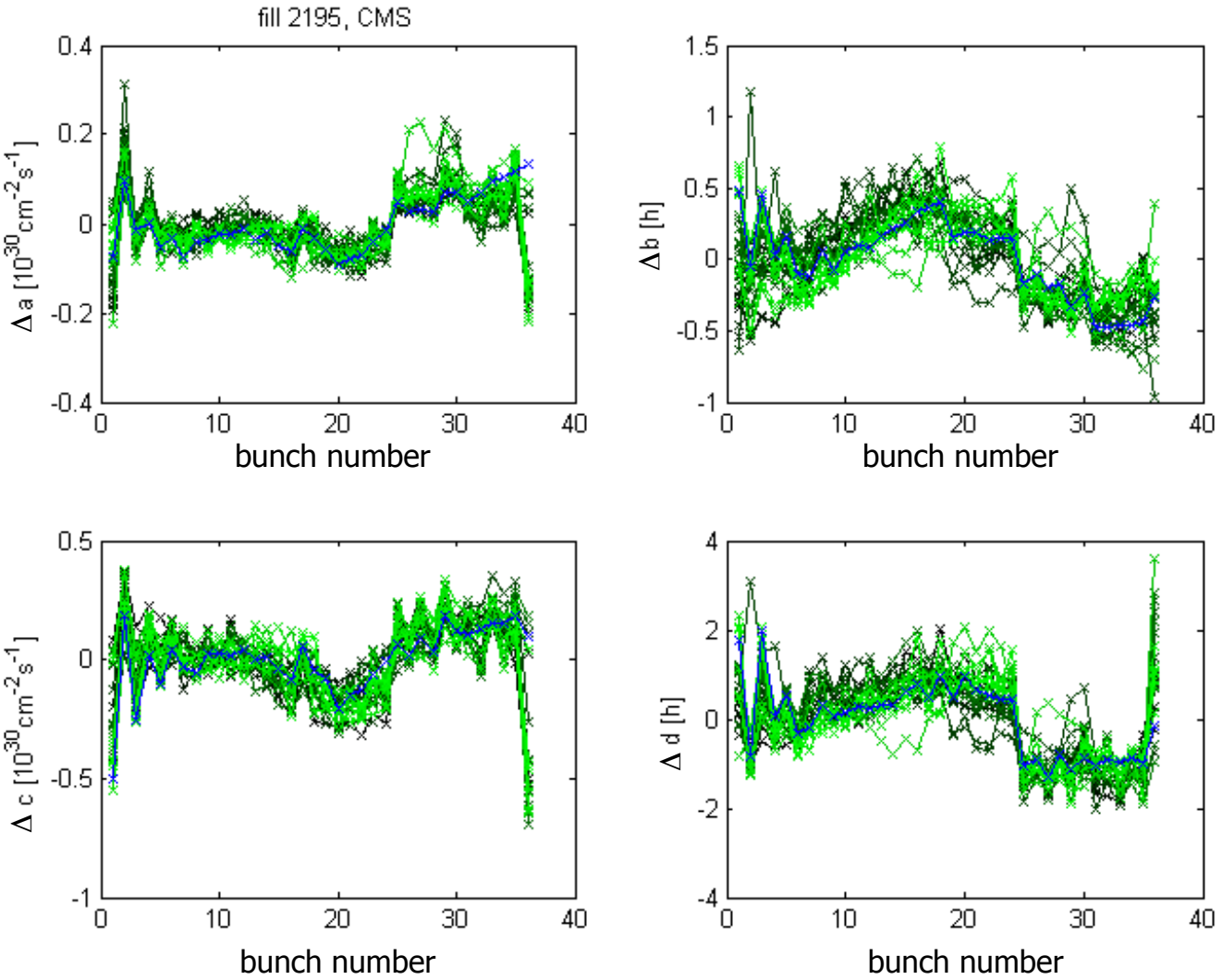
traces of the injectors

- overlap according to structure according to beam production at injectors
  - 36 bunch batches from PS to SPS
  - 144 bunch batches from SPS to LHC



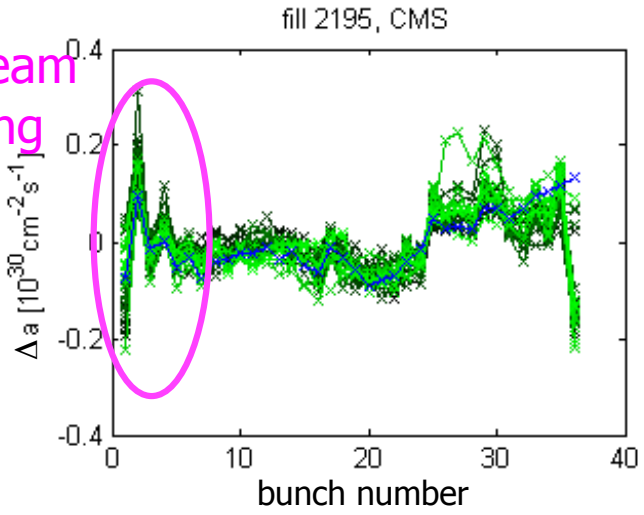
- can see structures from injectors in bbb lumi curves!
  - SPS injection kicker (especially on 225 ns batch spacing)
  - PS splittings and transient beam loading
  - PSB rings differences (6 bunch structure)

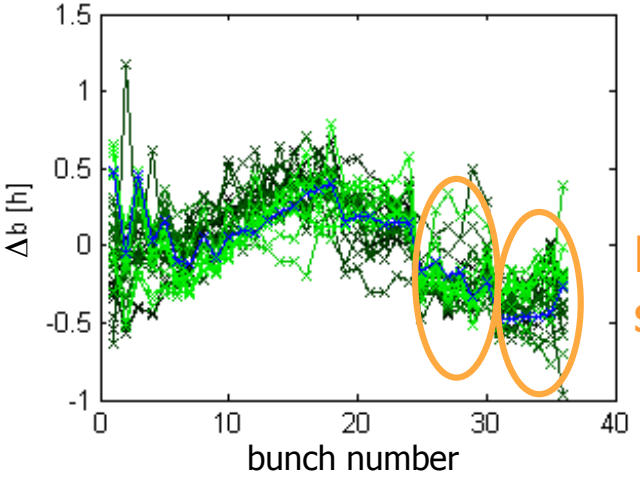
example (2011)



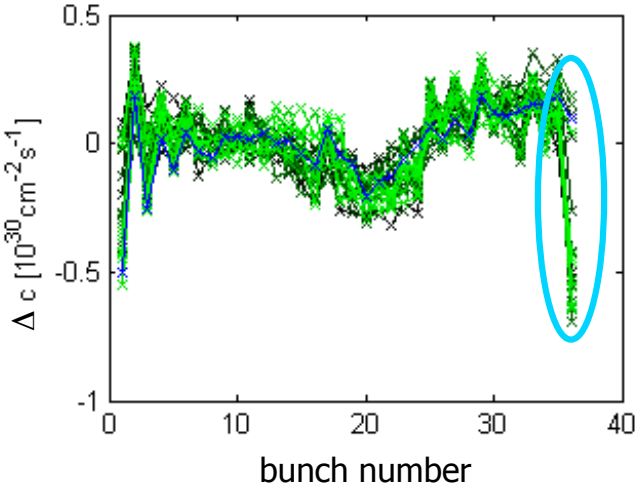
example (2011)

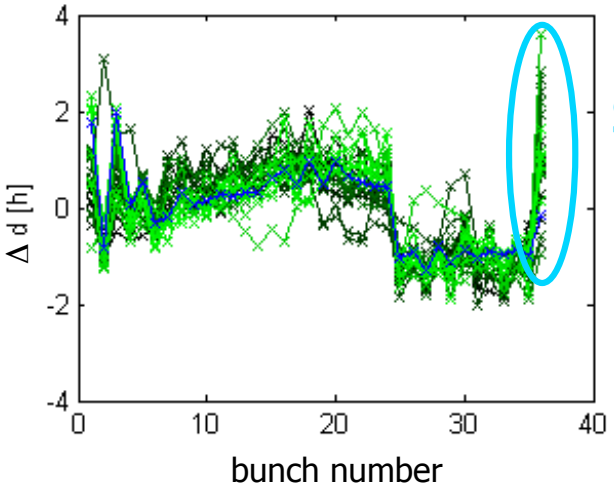
PS beam loading





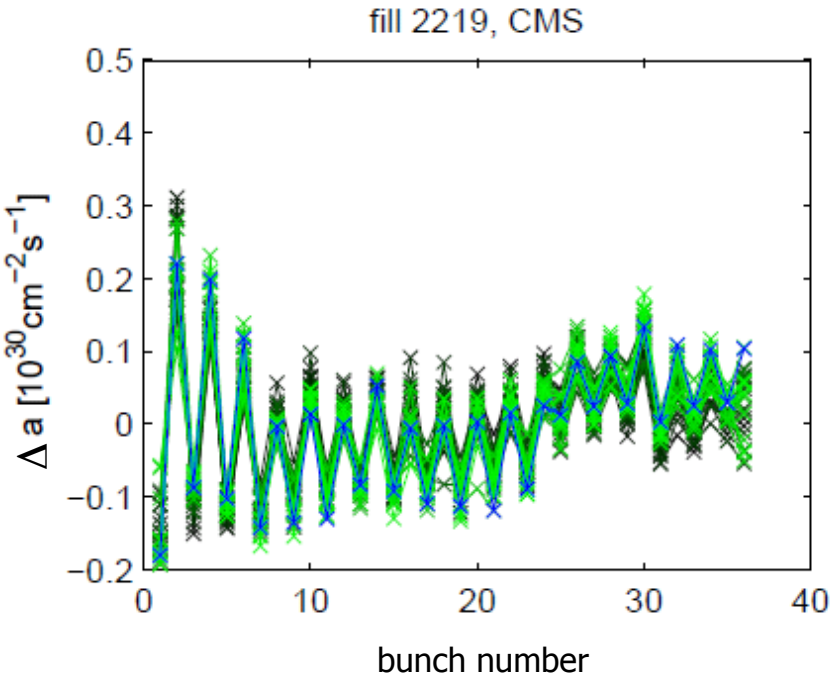
PSB structure





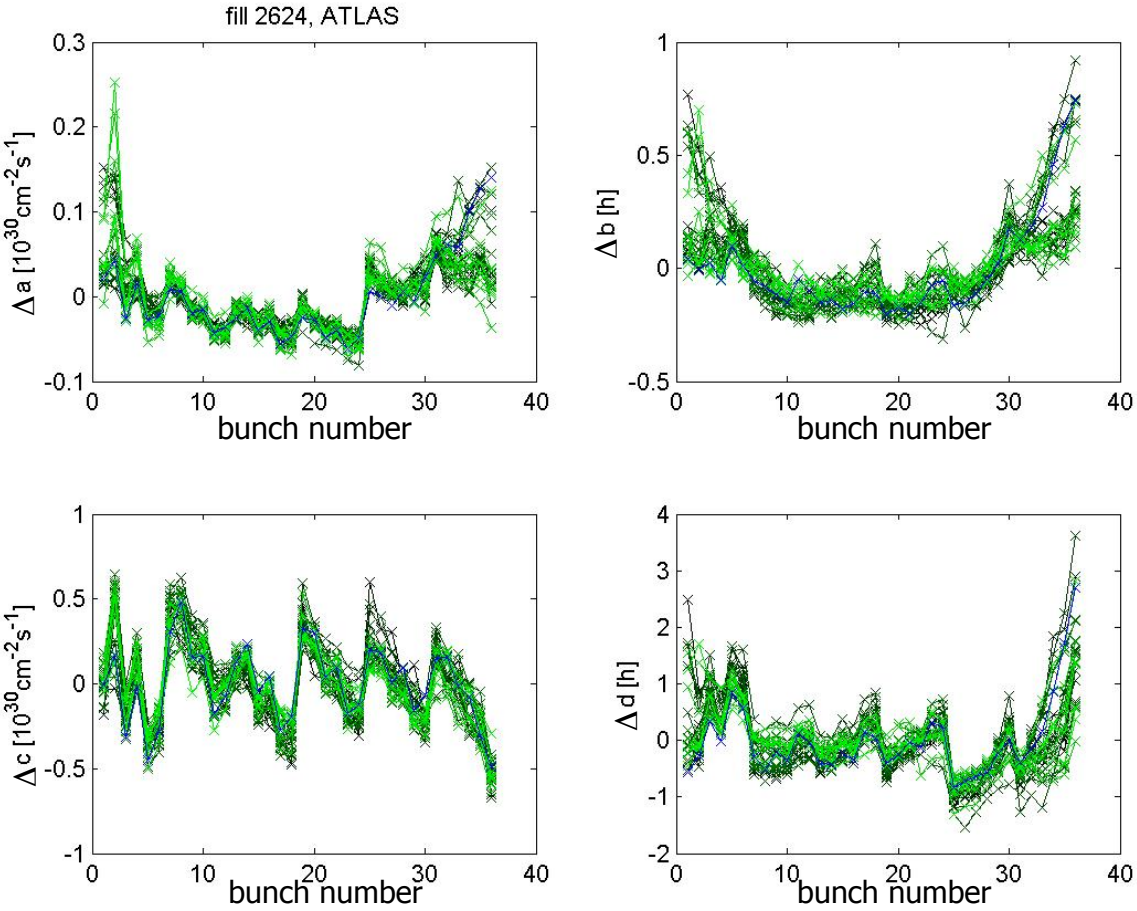
SPS injection kicker

example (2011) -2-



PS splittings not optimized

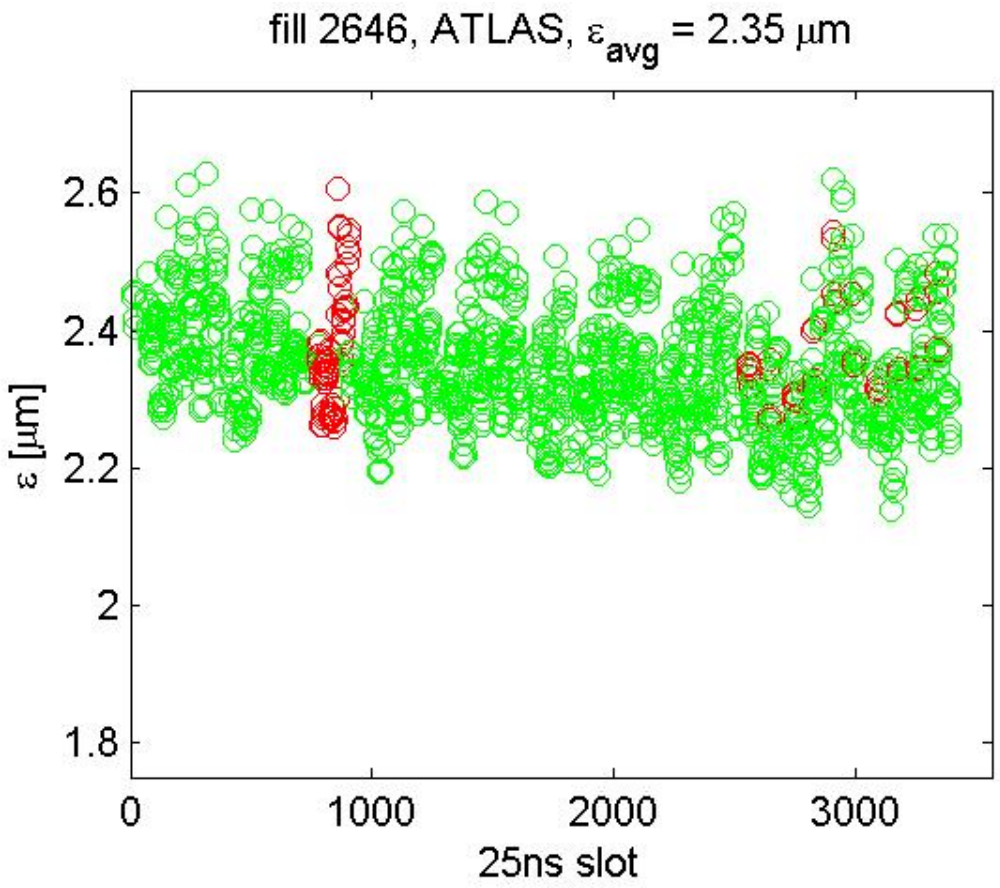
example (2012)



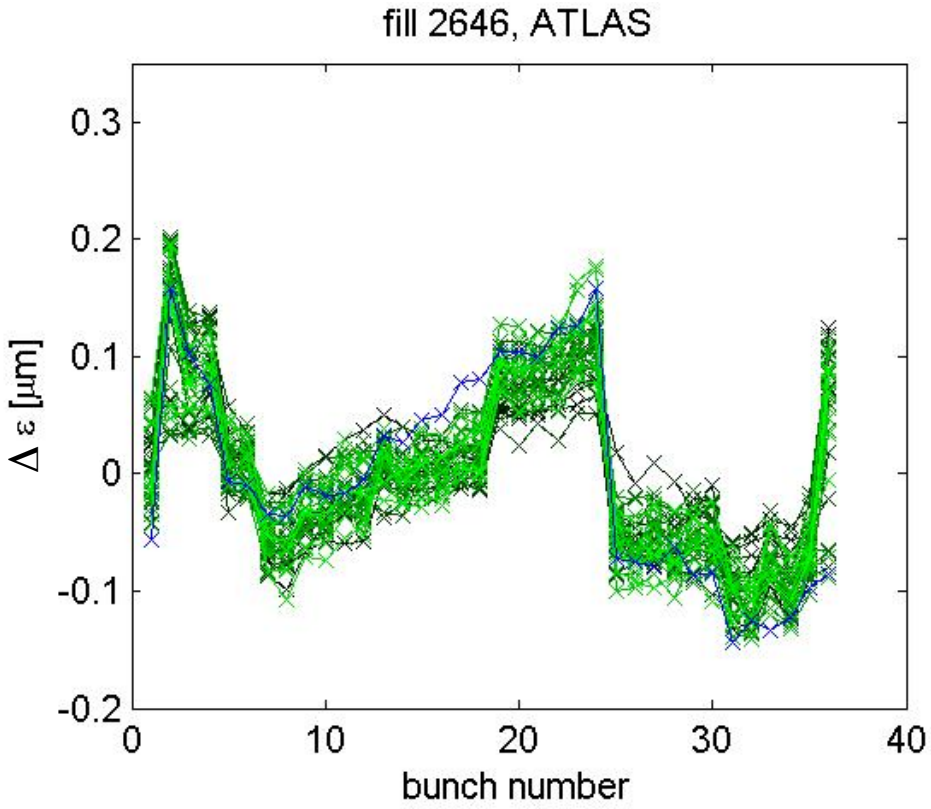
- ongoing collaboration with injectors supervisors and operators for optimization
  - S. Cettour Cave, K. Cornelis, S. Gilardoni, G. Metral, B. Mikulec, …

ε at start of stable beams

- emittance from fBCT and a_i+c_i
  - IBS… ~0.1um over filling



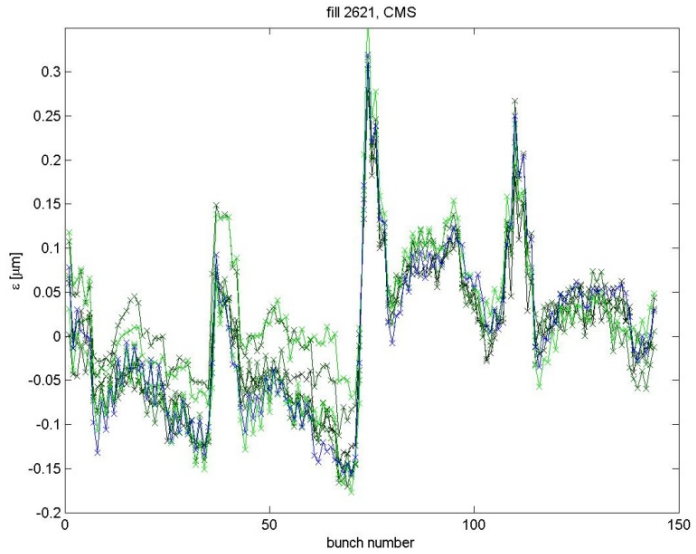
$\Delta\varepsilon$ from injectors

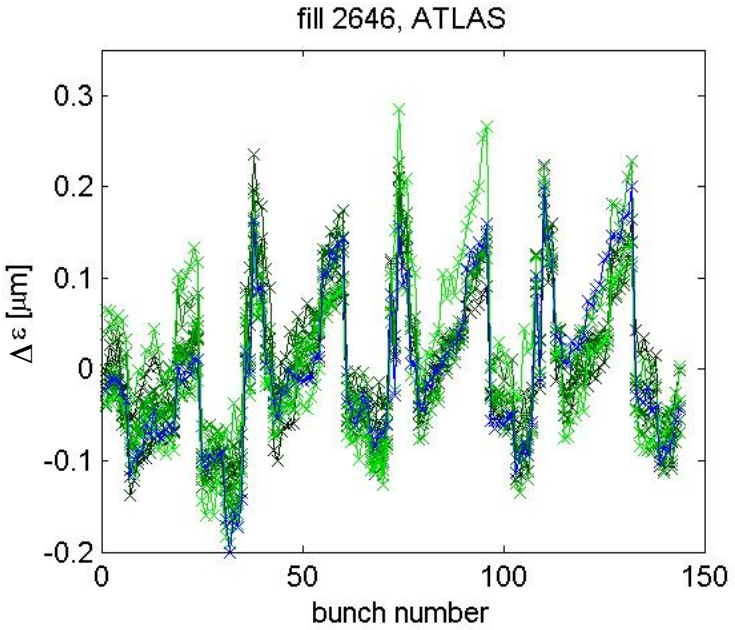


- feedback to PS and PSB:
  - e.g. PSB ring 1? if reproduced over few fills!
  - e.g. PS-SPS transfer optimization (action this morning!)

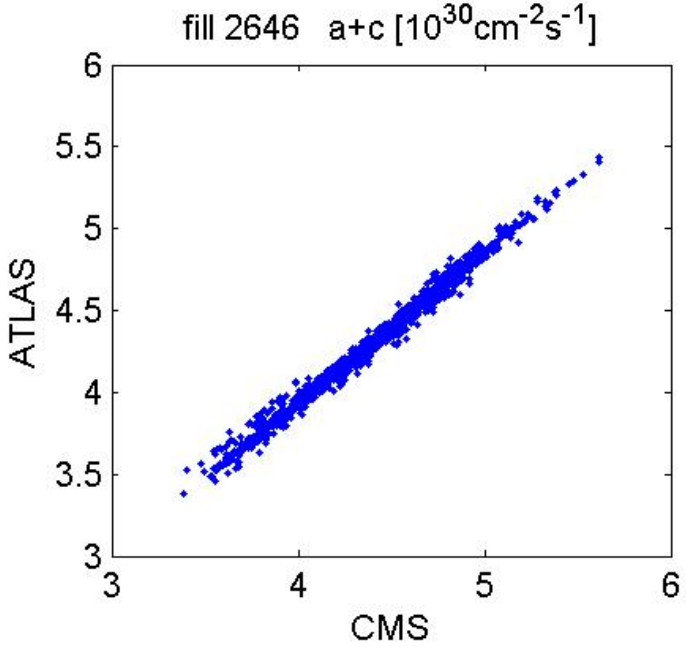
$\Delta\varepsilon$ from injectors

- highlighted emittance problem last week (w19/20)
  - after specific lumi indication
  - requires BSRT support for distinguishing H or V



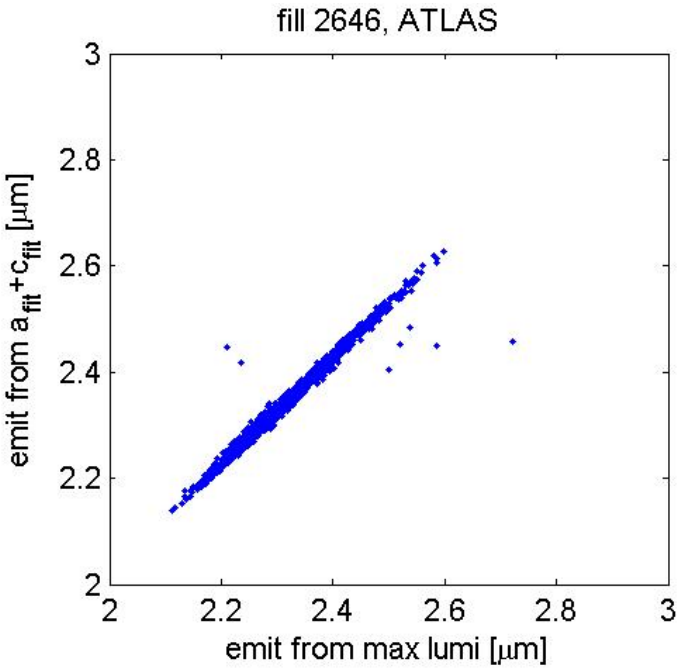


sanity checks



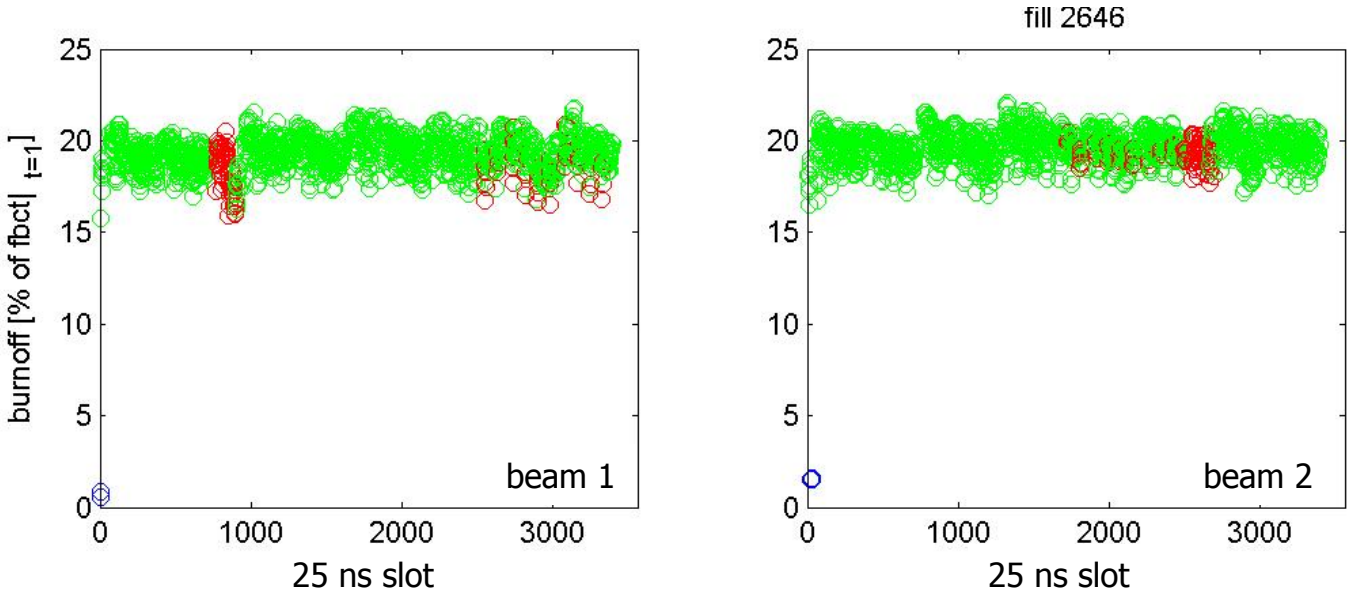
- good agreement between ATLAS and CMS data

- good agreement in emittance from a+c and from max lumi



burn off

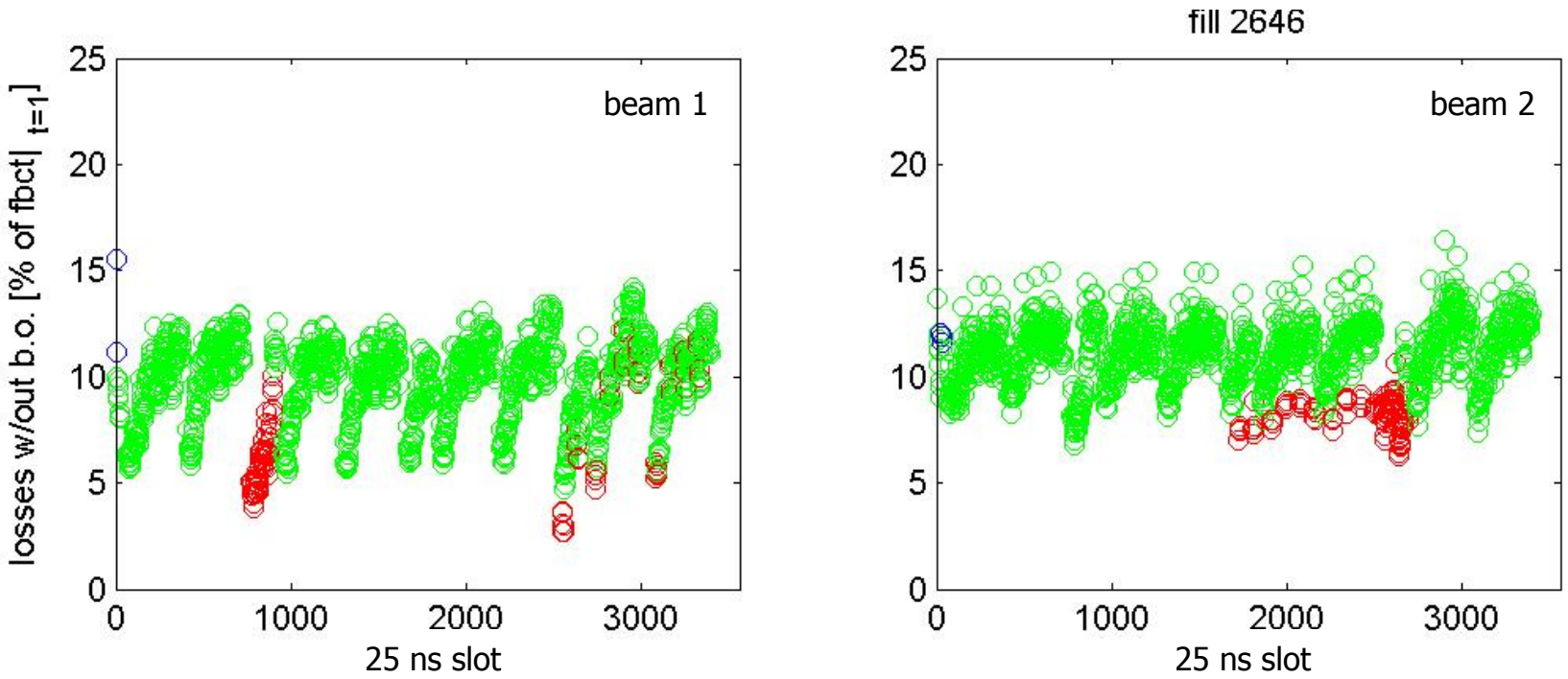
- use IP1, IP5 and IP8 lumi curves
  - neglect IP2
- total cross section (from LPC): 101 mb



- e.g. 16h fill last Saturday
  - 20% percent of protons used for luminosity
    - snapshot at end of fill (16 h fill)
  - colliding in IP8 only much lower burn off

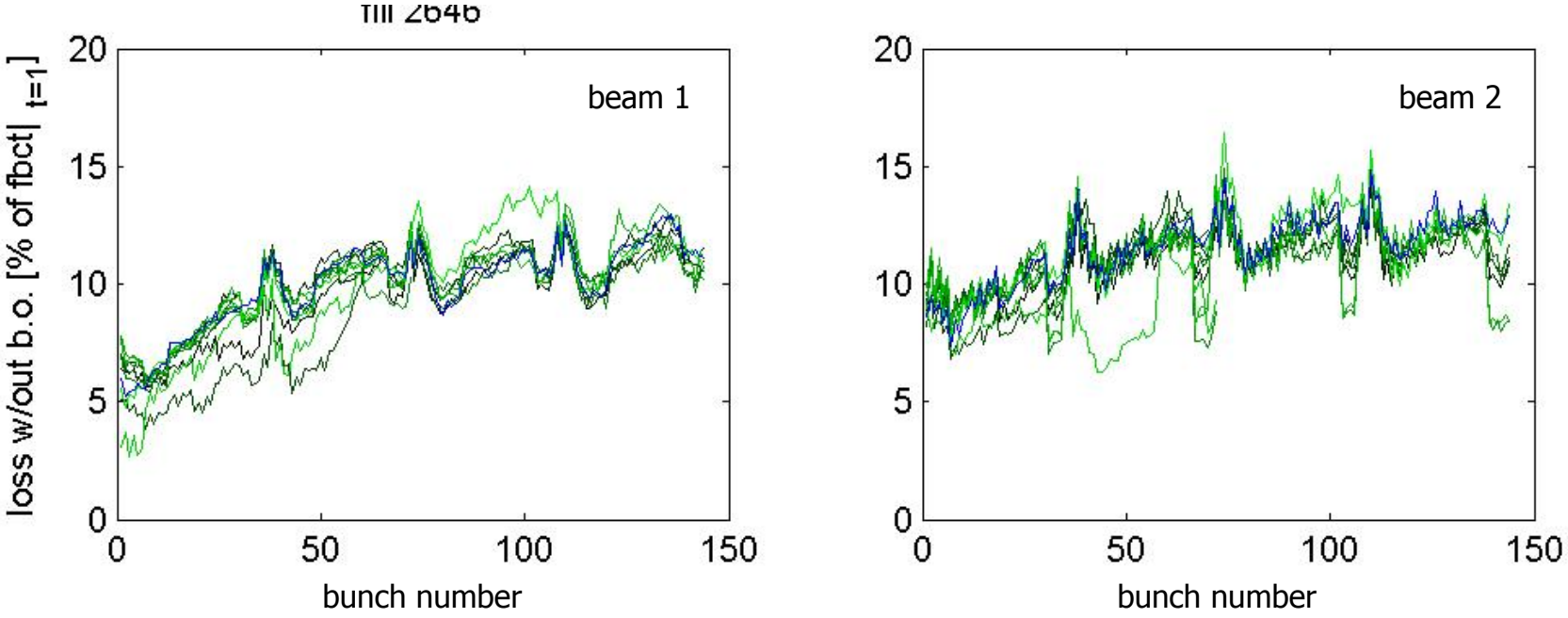
other losses -1-

- losses that are not burn off: ~10% of total intensity
  - snapshot at end of fill (16 h fill)
  - very similar despite head-on collision pattern



other losses -2-

- 'SPS transfer' pattern, cause not clear
  - GR: SPS e-cloud?



conclusions

- big spread in bunch pair luminosity production
  - injector variations seem to dominate
  - IBS less important
- fit to luminosity curves allow parametrization
  - see memory of the beam of production scheme
    - see PSB, PS, SPS traces
- emittance at start of collisions can be studied and possibly improved
  - collaboration ongoing across injector complex
- burn off important part of losses
  - structure on remaining losses visible and to be understood