LHC Luminosity Lifetime

Measurement, Comparison between fills, high-bandwidth ADT effects

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Outline

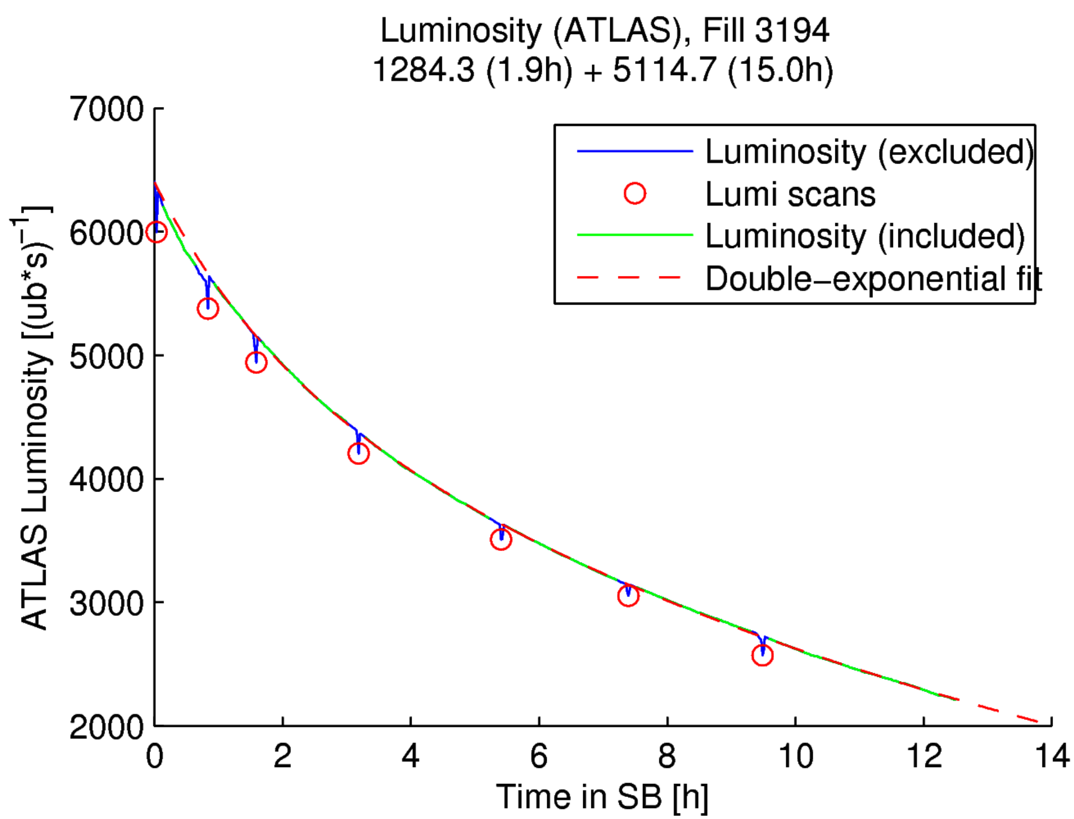
- Luminosity decay
  - Empirical description
  - Lifetime, Lifetime evolution
  - Supertable plugin
- Comparison of different fills
  - Optimum fill length
  - Effects of the high-bandwith ADT

Luminosity decay

- Empirically described by double-exponential:

$$L(t) = L_{0,1} \exp\left(-\frac{1}{\tau_1} t\right) + L_{0,2} \exp\left(-\frac{1}{\tau_2} t\right)$$

- Interpretation: fast- and slow-decaying part
  - Typical values:
    $L_{0,1}$: ~20% peak
    τ_1 : ~2h
    $L_{0,2}$: ~80% peak
    τ_2 : ~15h

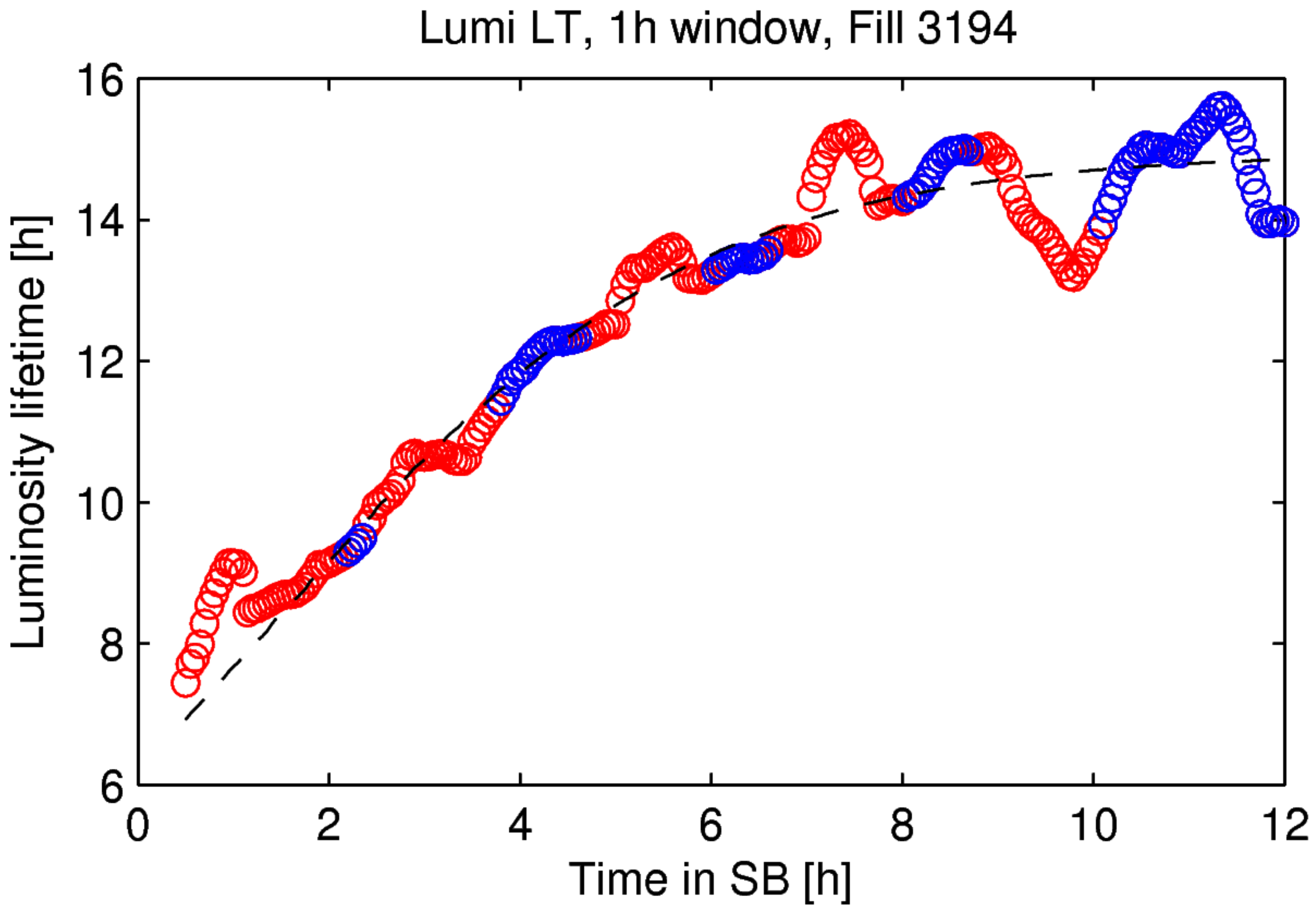


Instantaneous Luminosity Lifetime

- Single-exponential fit over a limited time frame

  $$L_0 \exp\left(-\frac{1}{\tau} t\right)$$

  - ➔ Reasonable fits over ~2h
- Parameters from fit:
  - ➔ τ = (Instantaneous) Luminosity lifetime
- Sliding window
  - ➔ $\tau(t)$ – Luminosity lifetime evolution over the fill
  - ➔ ~7h at start of SB, ~15h at the end
  - ➔ Agrees with double-exponential fits

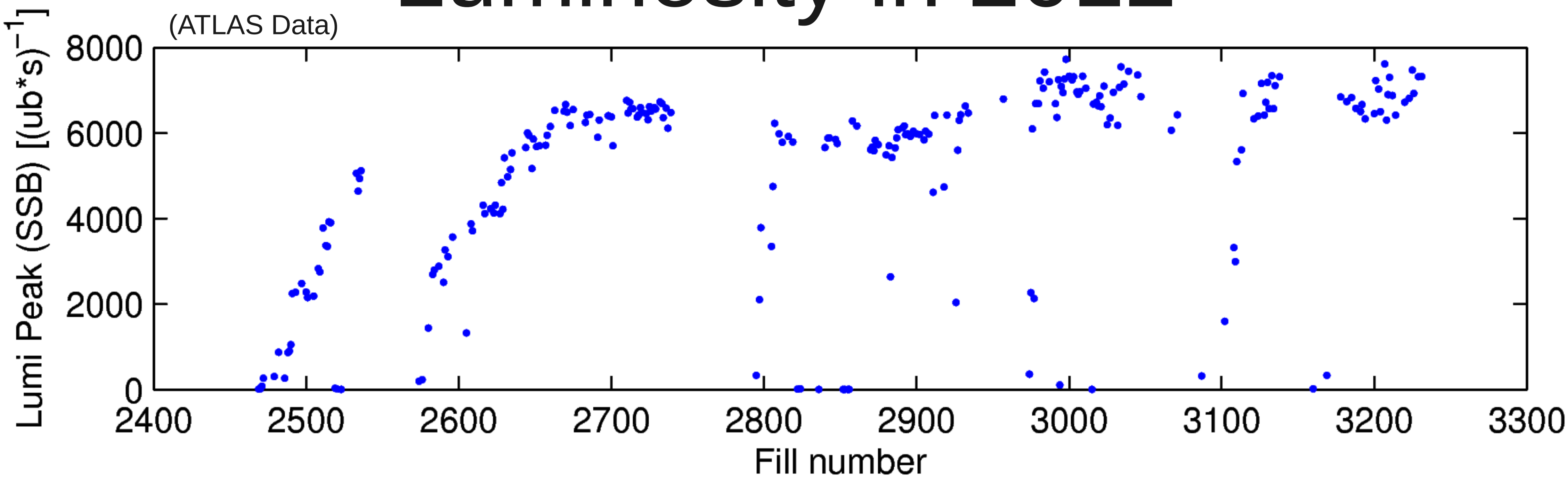


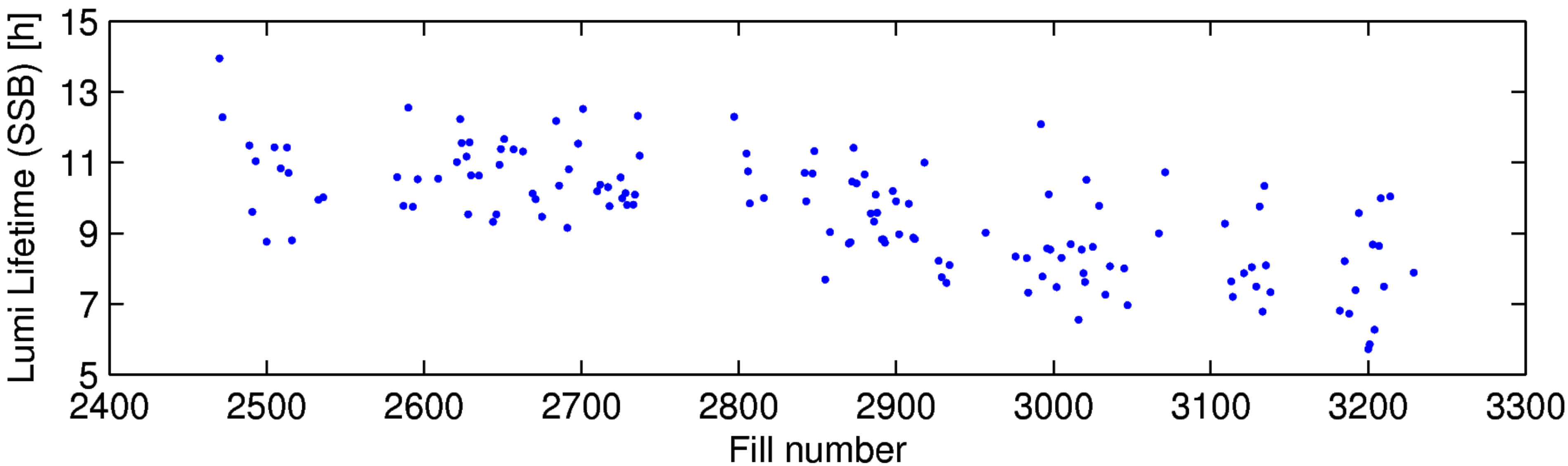
- Blue: Lifetime from sliding window fit
  - ➔ Red: sliding over luminosity scans
- Black: lifetime from double-exponential fit

Luminosity Lifetime in the Supertable

- Instantaneous lifetime (single-exponential fits) at specific points in time
  - Double-exponential fitting is not robust; only works for long (~8h SB) fills
  - TEVATRON approximation fit does not provide easy to interpret parameters (e.g. a plain lifetime)
- Values chosen for the supertable
  - Lifetime at start of stable beams (0.5h-2.5h)
  - Lifetime at end of stable beams (last 2h)
- Ongoing with A. Macpherson

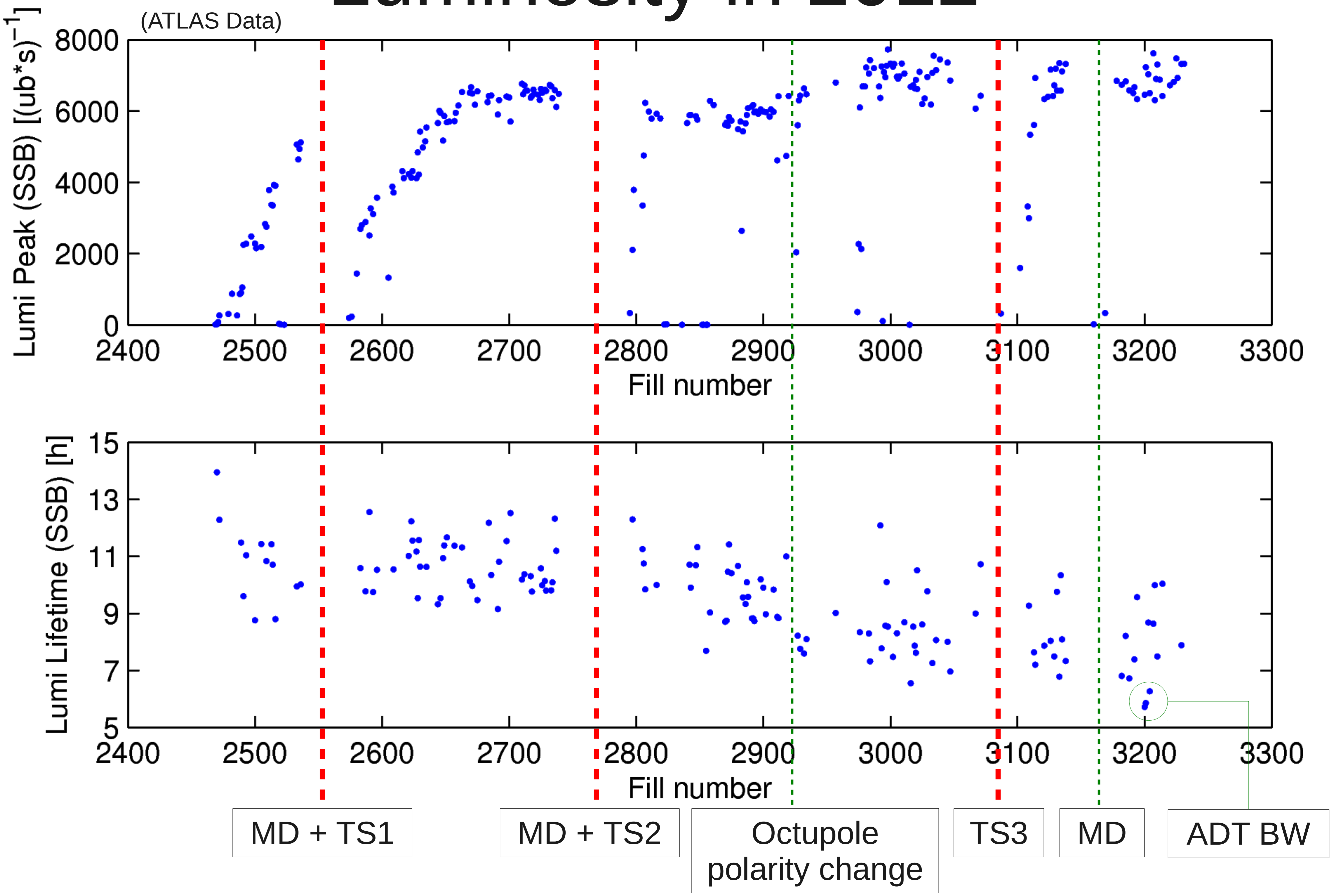
Luminosity in 2012





- Lifetime for all fills of 2012 with at least 3h in SB

Luminosity in 2012



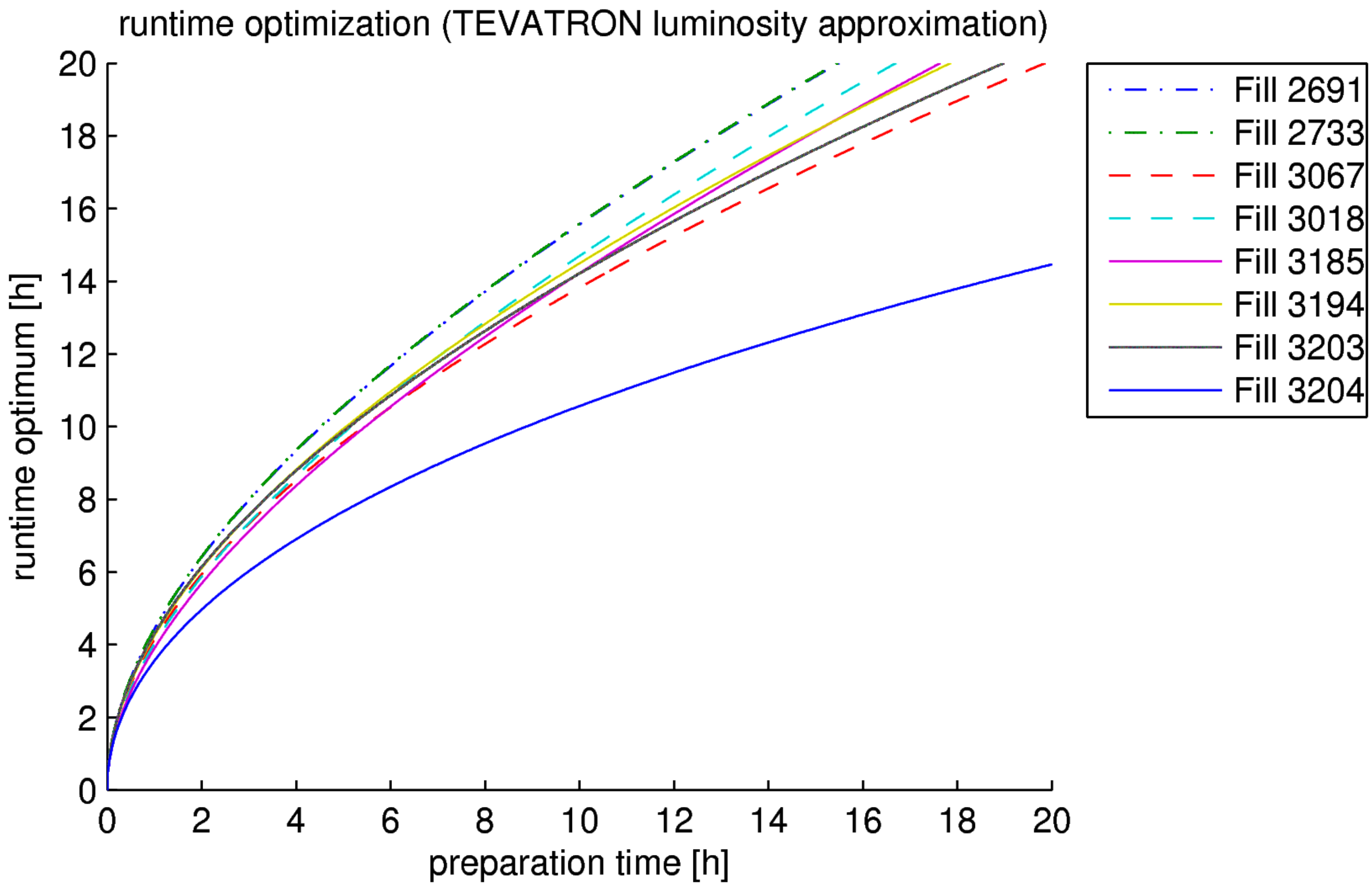
Optimum fill length/runtime

- Depends on
  - luminosity evolution *L(t)*; in particular: luminosity lifetime
  - fill length (runtime) t_r – *our free parameter*
  - turn-around (machine preparation) time t_p
- Maximize integrated luminosity, based on the TEVATRON approximation fits

$$\langle L \rangle = \frac{\int_0^{t_r} L_T(t)\, dt}{t_r + t_p} \qquad \text{with} \qquad L_T(t) = \frac{L_{0,T}}{\left(1 + \frac{t\, b}{\tau_T}\right)^b}$$

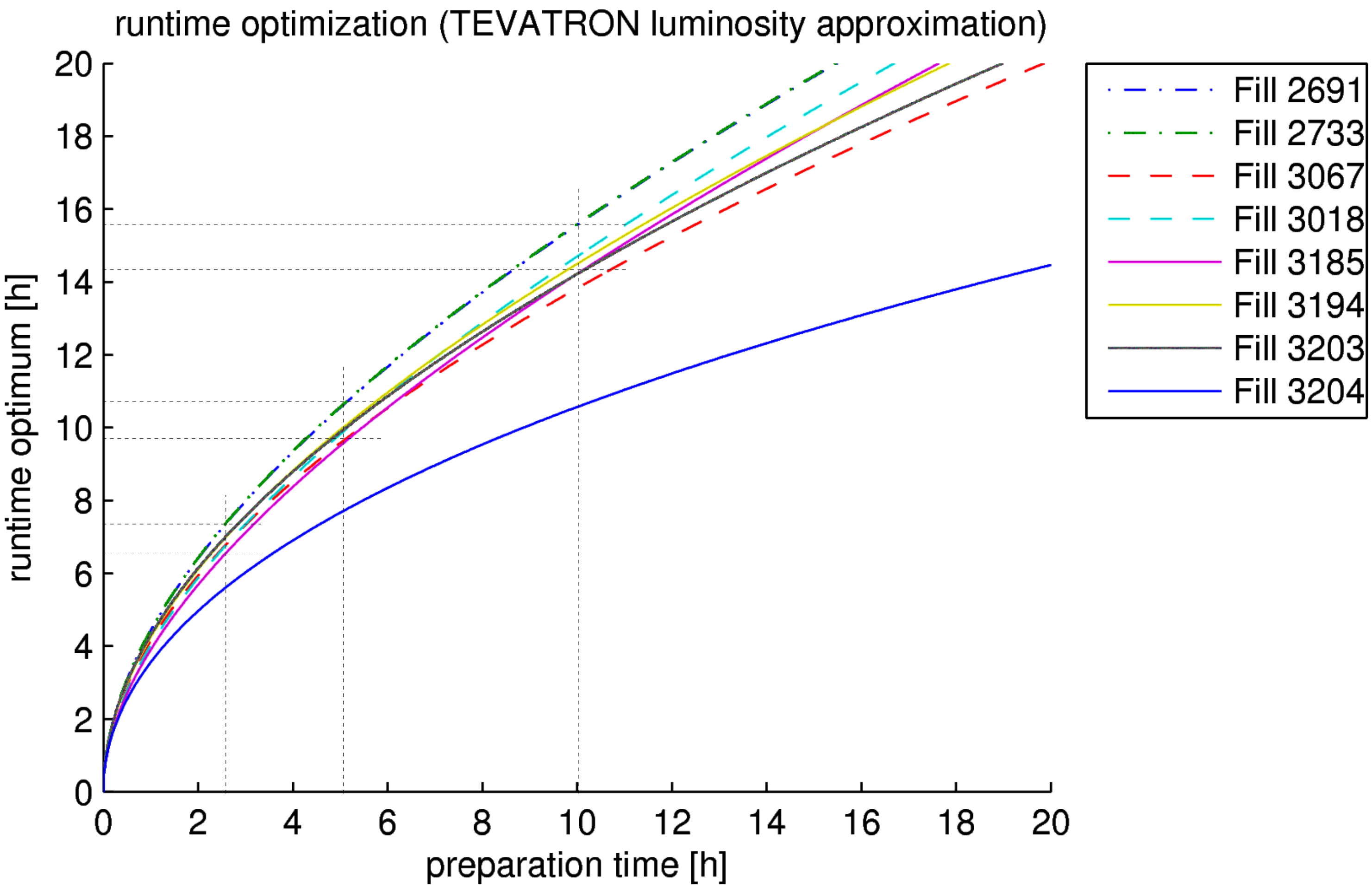
- Symbolic integration, division and derivation, then solve numerically for roots for given *b*, $L_{0,T}$, τ_T from fit

Optimum fill length/runtime



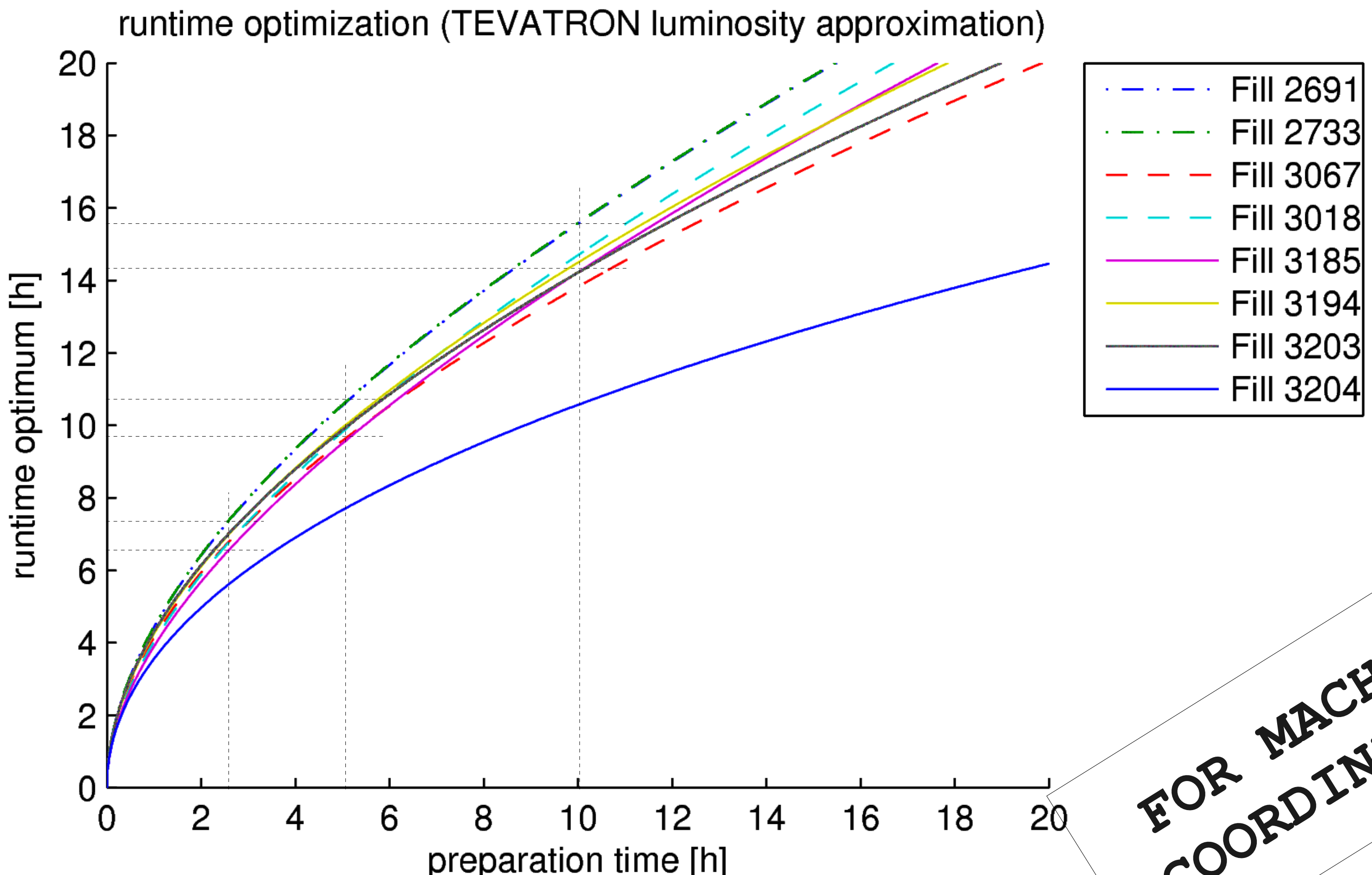
- Dash-dotted lines: before TS2 (June 2012)
- Dashed lines: before TS3 (September 2012)
- Solid lines: recent fills, after TS3

Optimum fill length/runtime



- Typical optimum fill length:
  - 7h with 2.5h preparation; 10h with 5h preparation; 15h with 10h preparation
- Recent fills (lower lifetime, higher initial value) demand lower fill length

Optimum fill length/runtime



FOR MACHINE COORDINATORS

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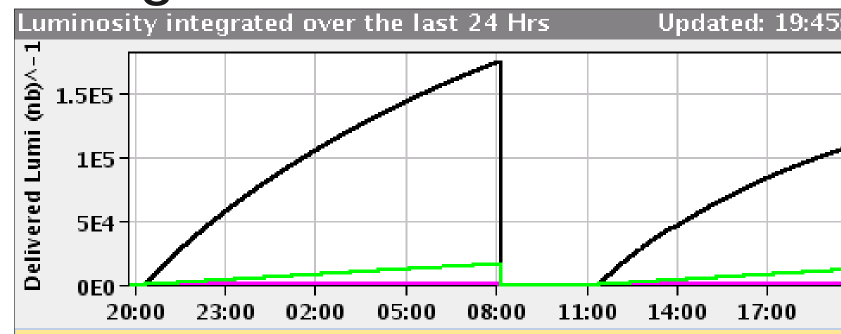
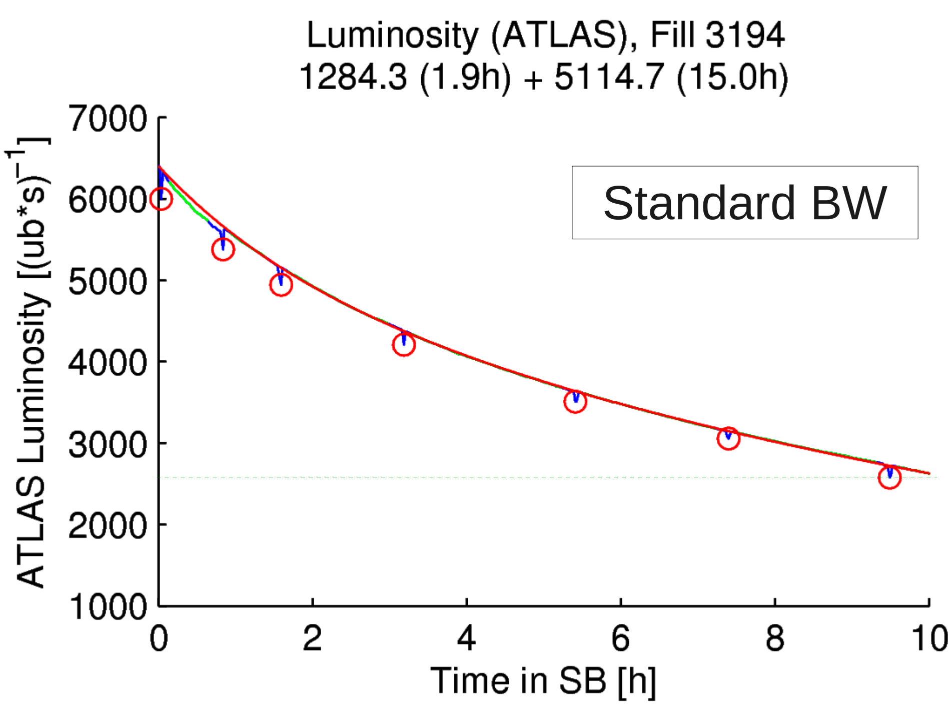
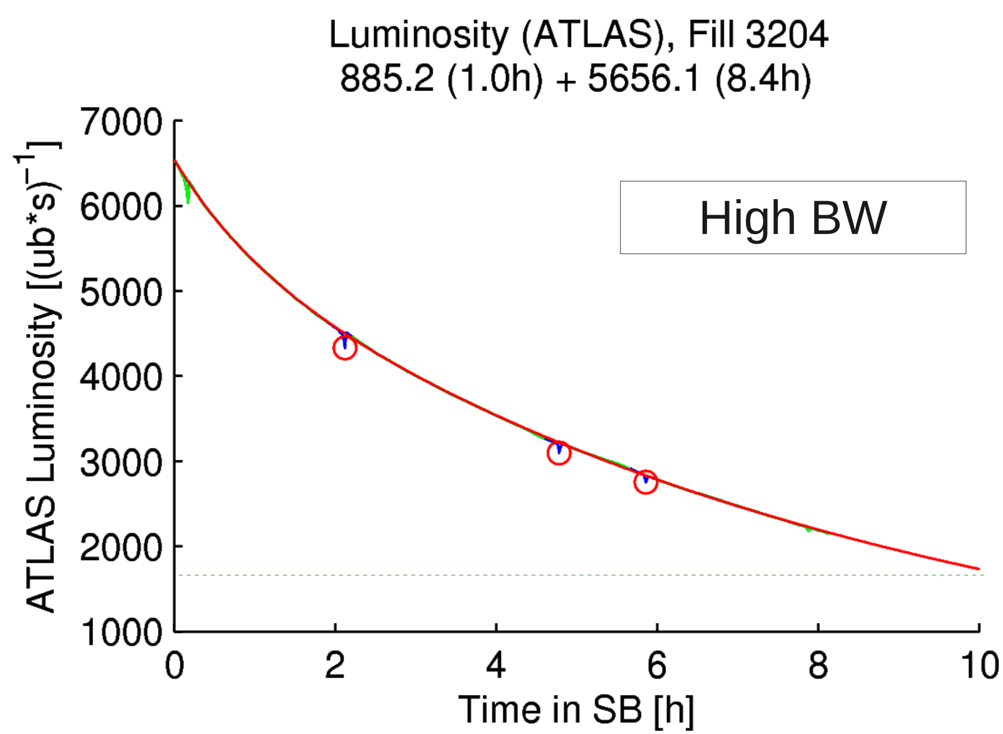
Effects of the high-bandwidth ADT

- For fills 3200, 3201, 3204 the ADT had high bandwidth in SB
  - Comparable peak luminosity
  - Luminosity lifetime ~40% smaller
  - Integrated luminosity ~20% smaller after 10h in SB

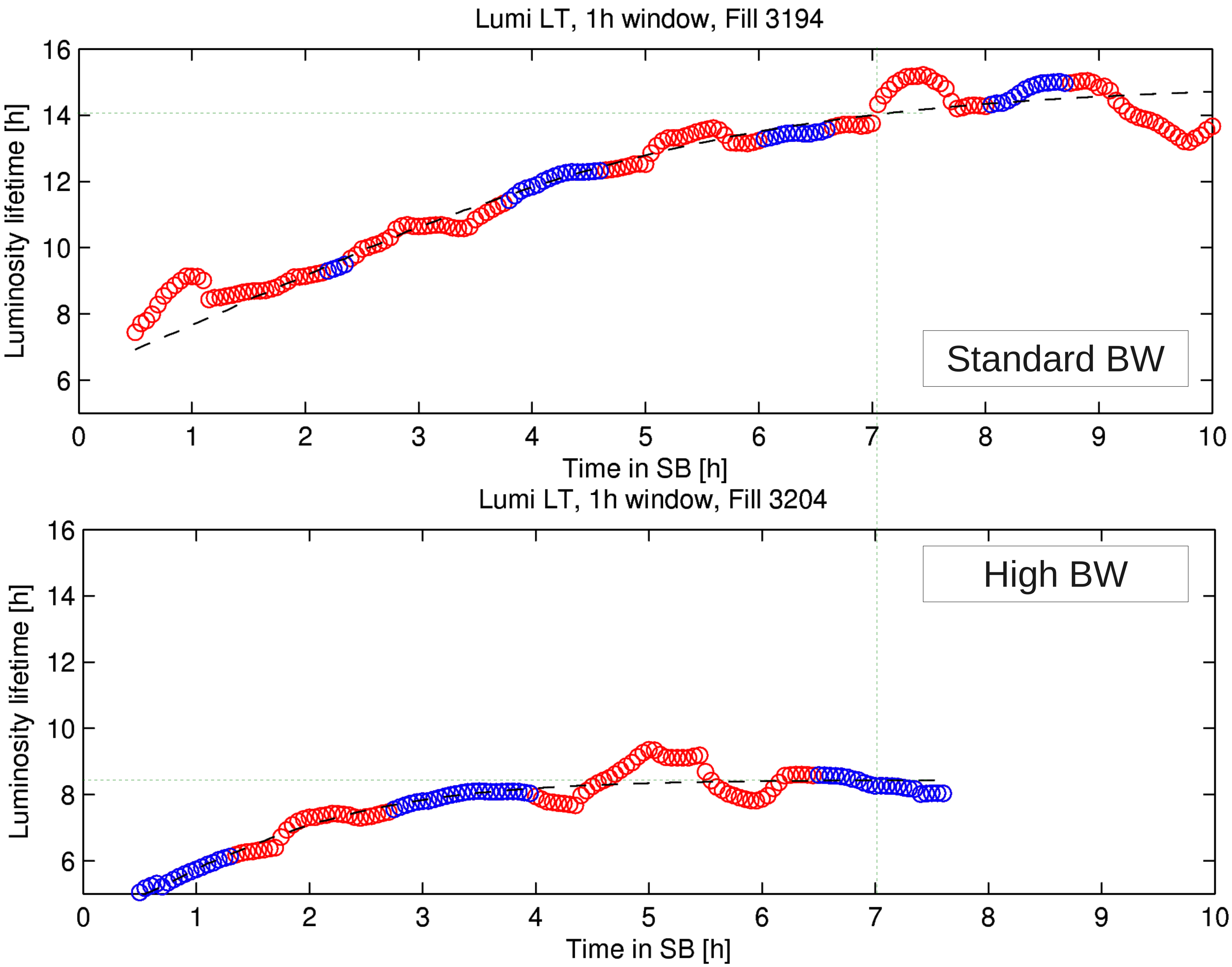


Source: LHC Luminosity VISTAR

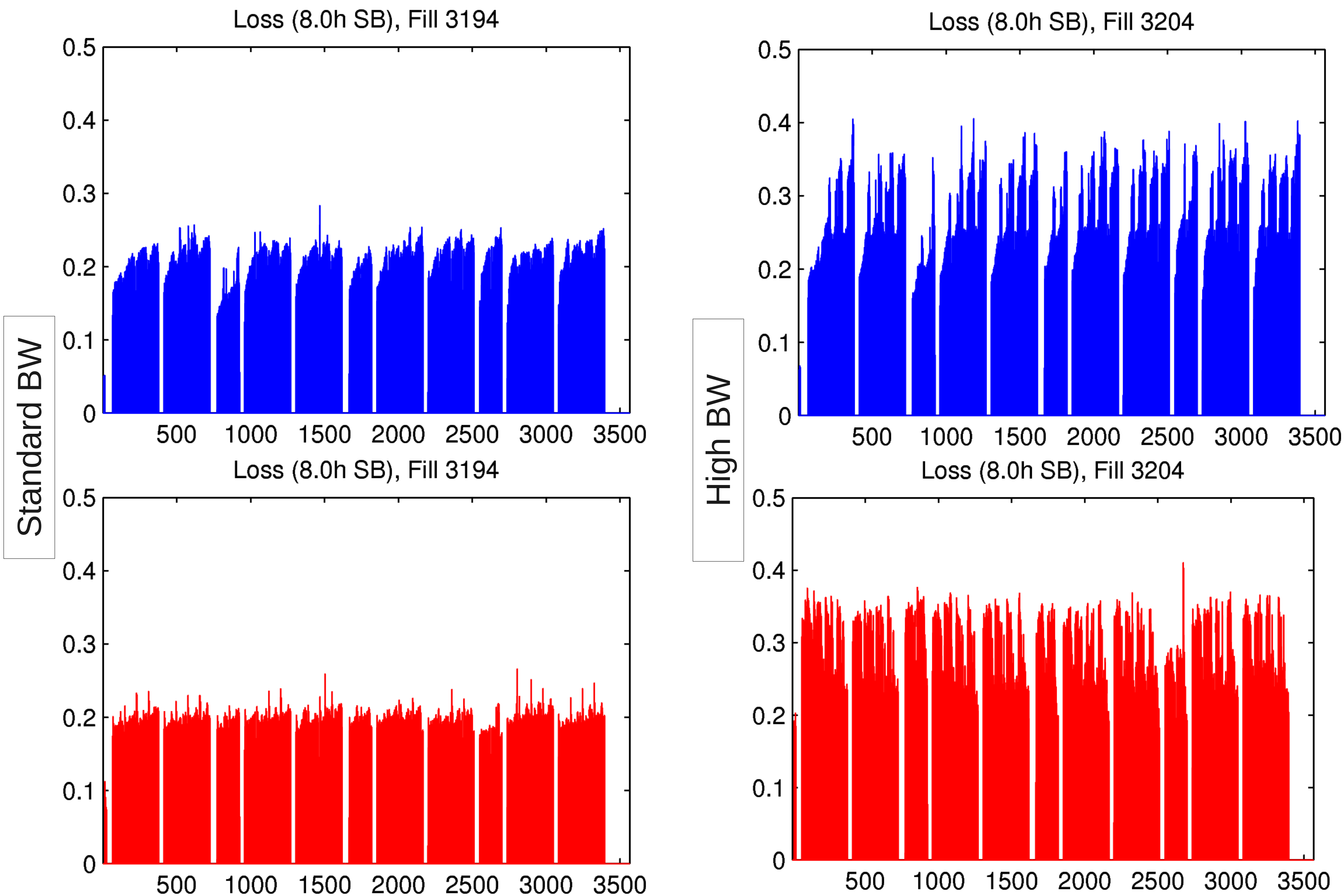




Sliding window lifetime comparison

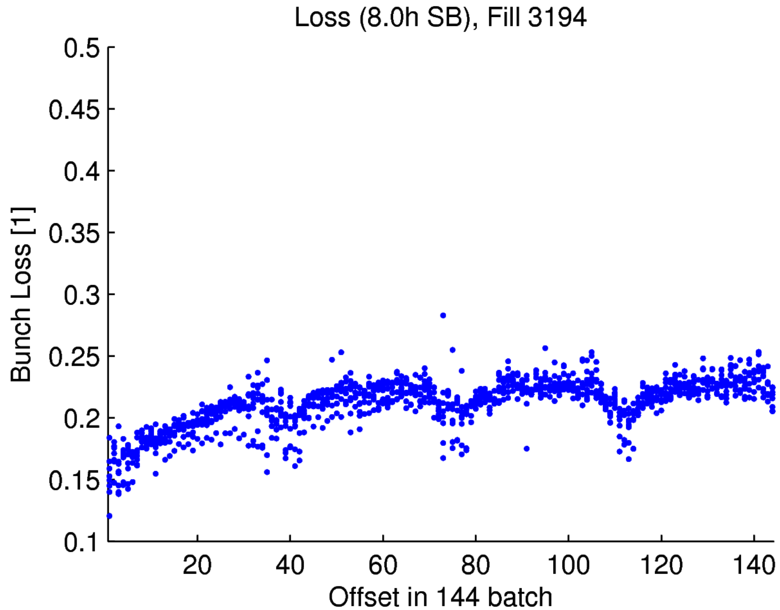


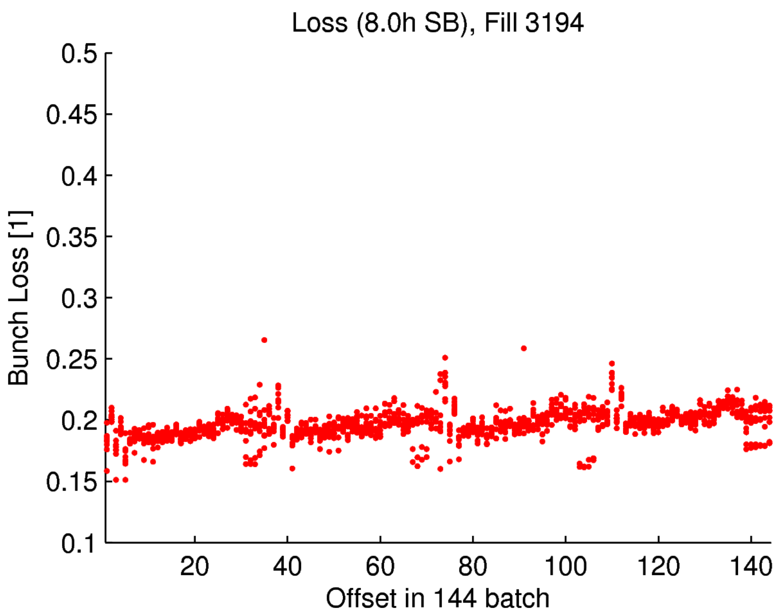
Overall Loss comparison



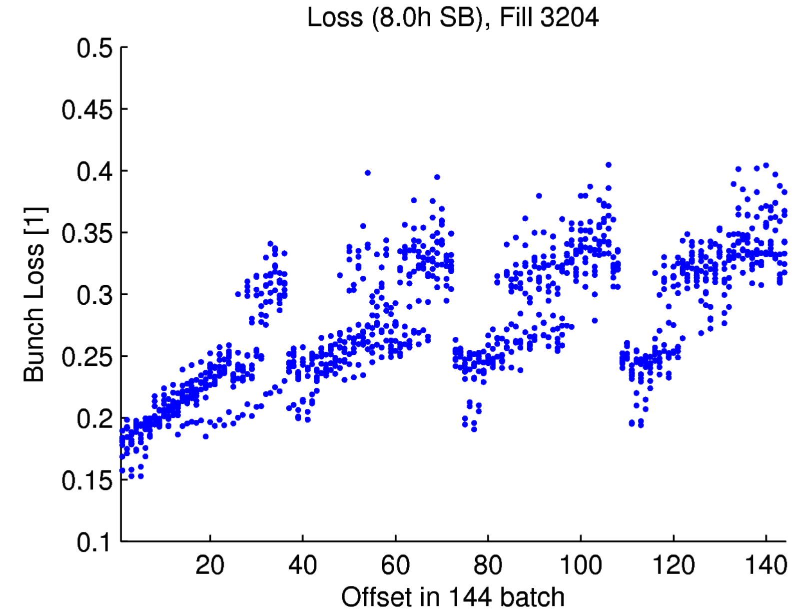
Loss comparison by 144 batch

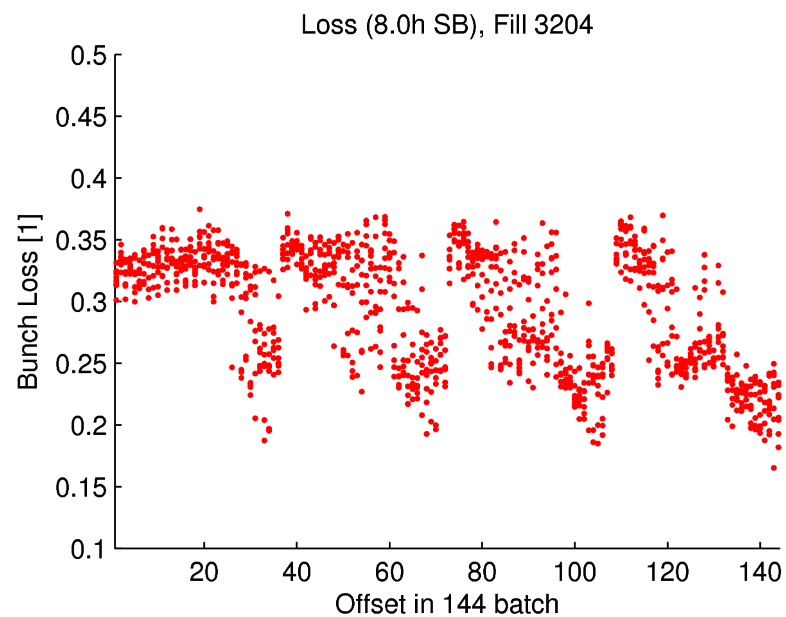
Standard BW





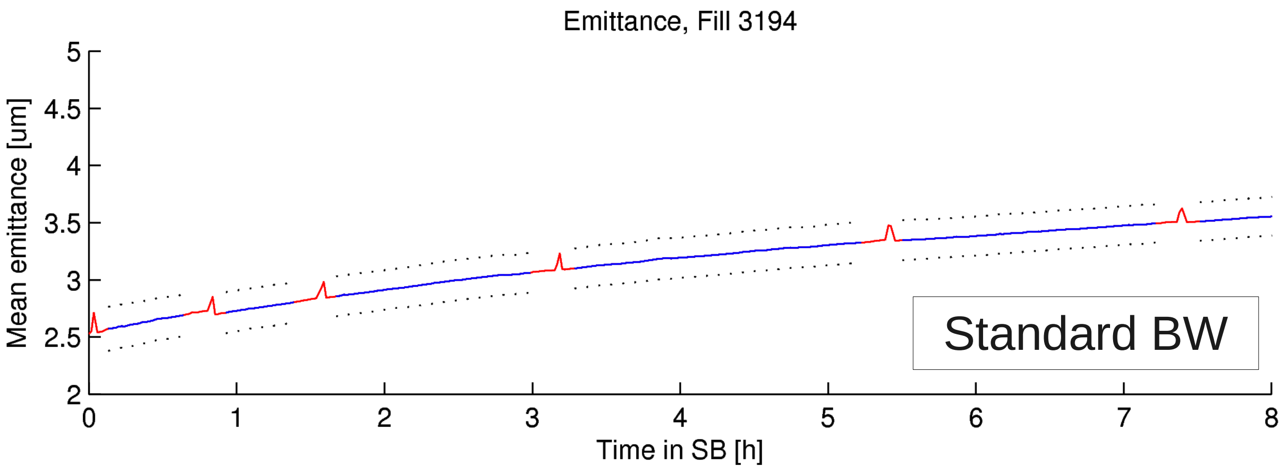
High BW

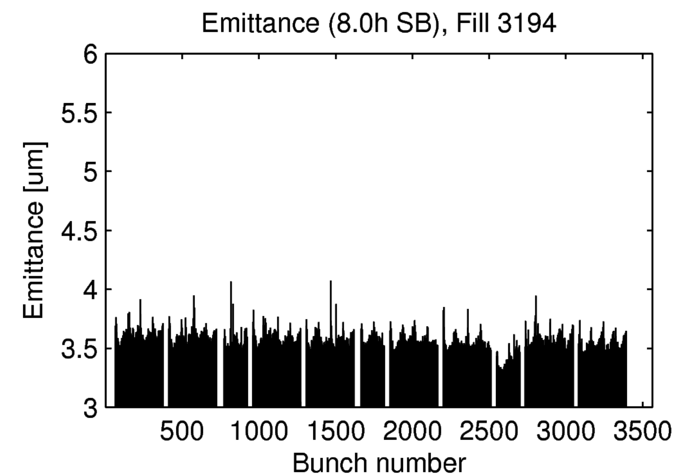


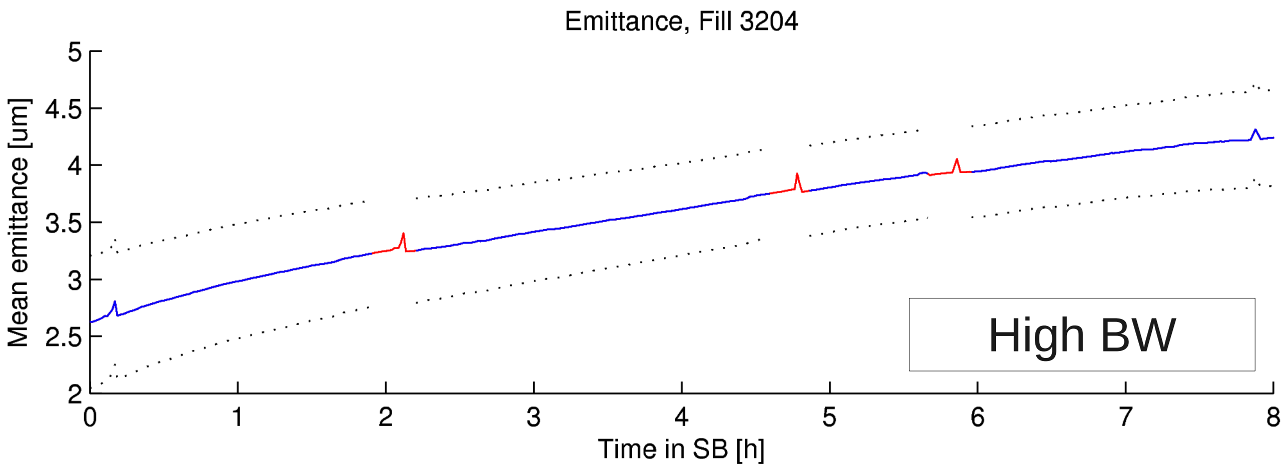


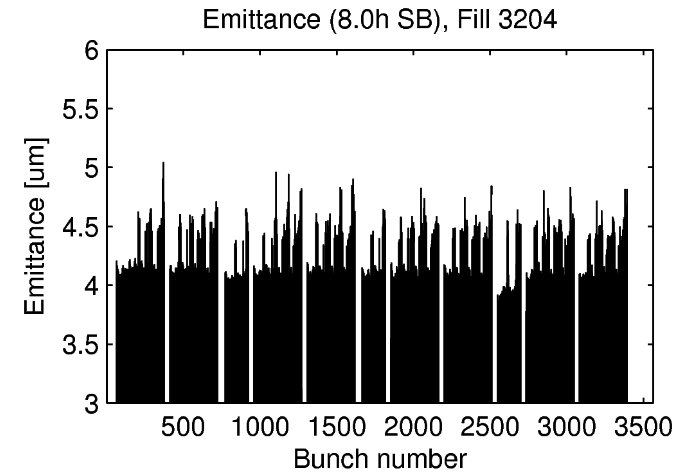
Emittance comparison

- Convoluted emittance from Luminosity
  - ➔ Assuming round and equal beams
  - ➔ No emittance measurement available for recent fills









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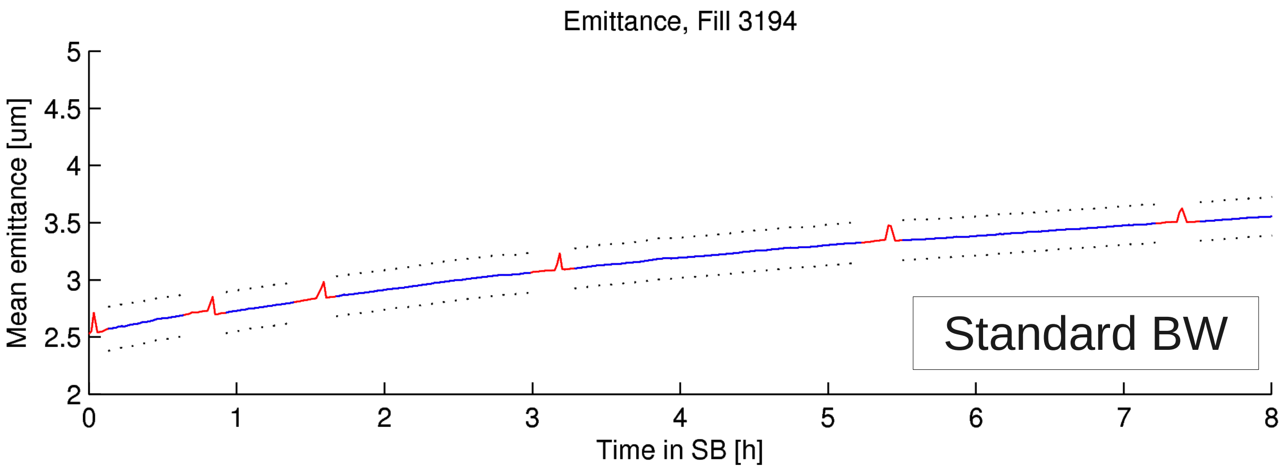

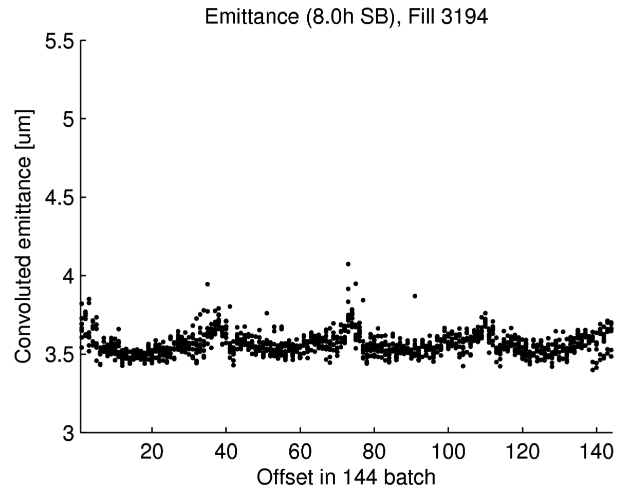

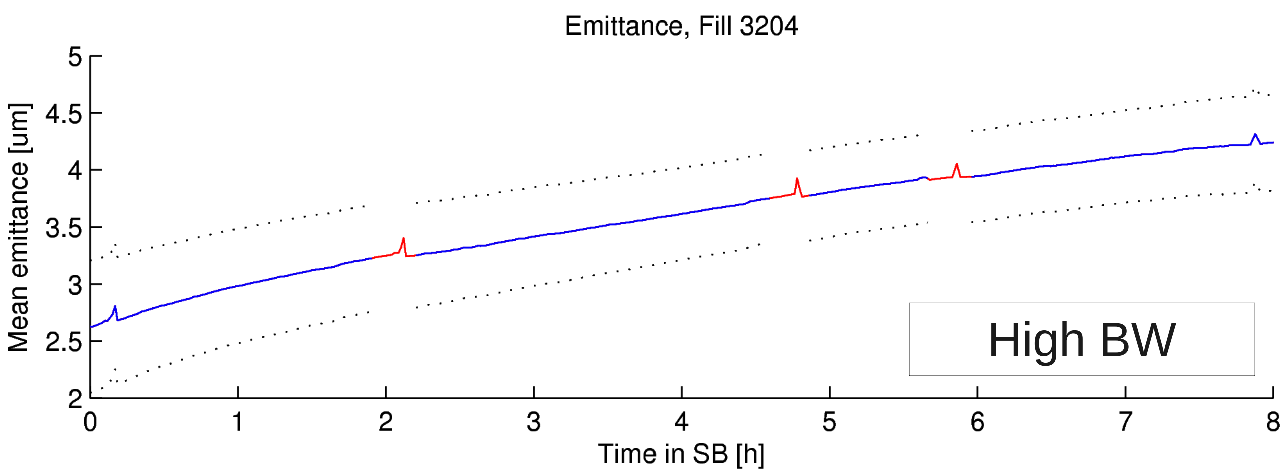

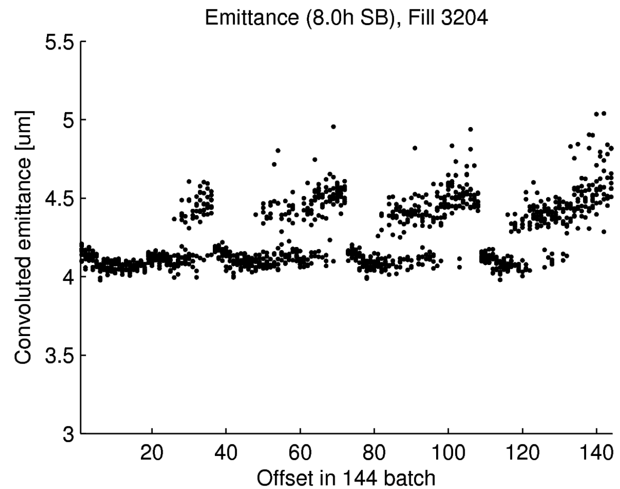

Conclusions

- Luminosity lifetime
  - Increasing with time: Start: ~7h; after 10h: ~15h
  - Lifetime at SSB and EOF: In Supertable soon
- Optimum fill length
  - 7h with 2.5h preparation; 10h with 5h preparation; 15h with 10h preparation
- High-bandwidth ADT during SB
  - Higher emittance growth, higher losses
  - Lower luminosity lifetime and integrated luminosity
  - Preliminary results do not show the same effects for recent fills (high-bandwidth ADT till collisions, standard bandwidth ADT in SB)

Questions?

Backup slides

High BW ADT: Losses