Luminosity, Emittance Evolution & OP Scans

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Evian, 2015-12-15

outline

OP scans: technique, parameters

- estimate beam spot size by displacing beams at the IP and recording the luminosity change
  - fit Gaussian to relative luminosity vs beam separation
  - only dependences: knob accuracy and lumi linearity
- latest parameters & strategy
  - scan at the start, after 10h and before dump
  - IP 5 only, earlier IP 1 & 5
    - IP 1: instabilities, luminosity monitor non-linearities
    - IP 5: appreciated by CMS, bunch-by-bunch data available
  - 7 steps per plane, 10 s per step, $\pm 3\sigma$ displacement
    - cost: ~40 seconds at low luminosity per scan
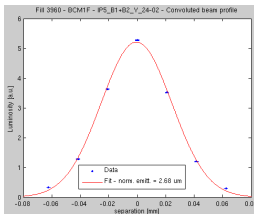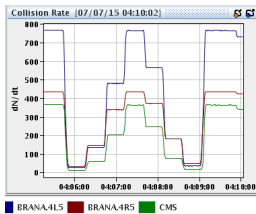
errors, comparison to other instruments

- **errors: ~6% in the separation plane, ~20% in the crossing plane**
  - luminosity non-linearity (~5%), β^* (~3%), dynamic β^* (~2%), beam-beam kick (~2%)
  - crossing plane only: crossing angle (~15%), bunch shape (~10%)
  - bunch-to-bunch relative differences: only non-linearity
  - evolution in a fill: non-linearity and bunch shape

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- OP scan emittance in ATLAS and CMS compared during μ-scan fill
  - near perfect relative bunch-by-bunch agreement
  - absolute values very sensitive to crossing angle, agree within error bars
    - extra information about geometric factors in ATLAS and CMS

emittance at start of stable beams

- convoluted emittances at the "start" of stable beams
  - OP scans done up to ~2 h into stable beams
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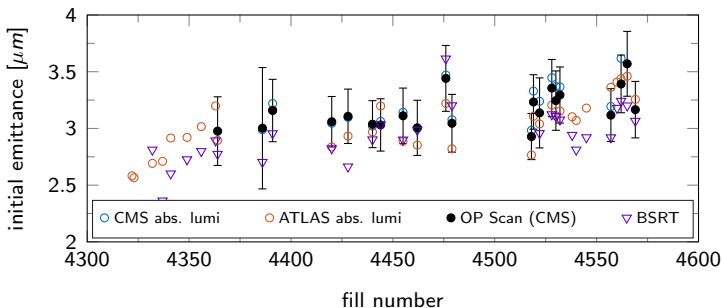
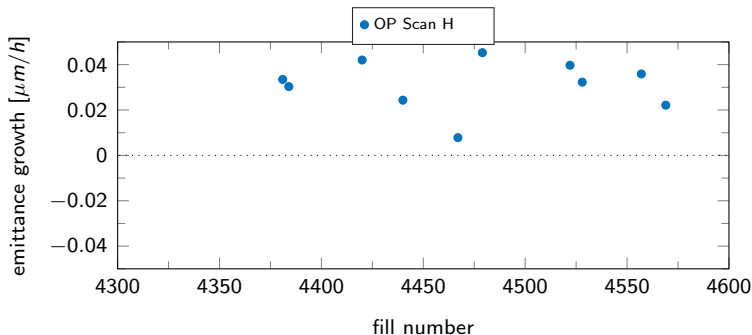* excluded CMS points for fills with magnet off or ramping

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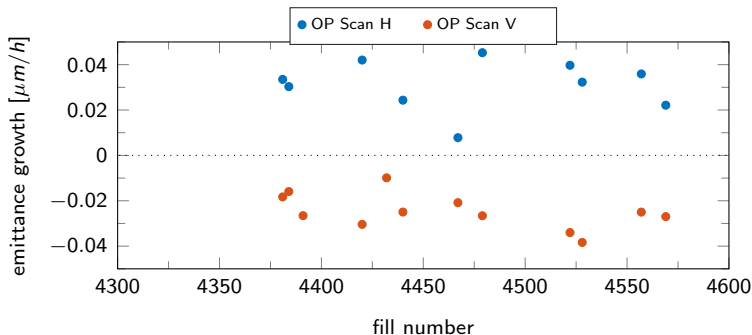
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- horizontal emittance growth, ~0.03 μm/h (crossing plane uncertainty)
- vertical emittance shrinkage, ~0.02 μm/h
- convoluted emittance: constant within error bars
  - BSRT sees small shinkage, difference in horizontal plane
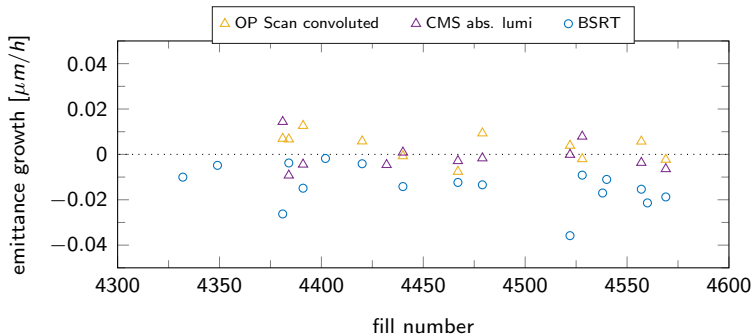
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- mean emittances in stable beams
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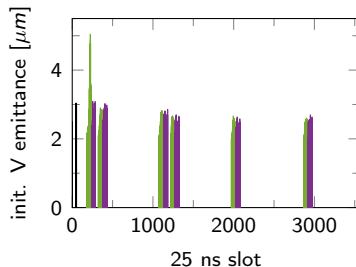 - horizontal growth, vertical constant

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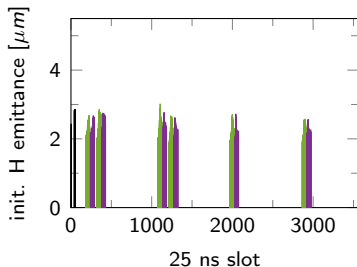   - horizontal growth, vertical constant

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    - large spread in emittances over trains, ~1 μm
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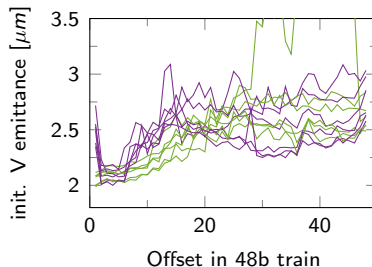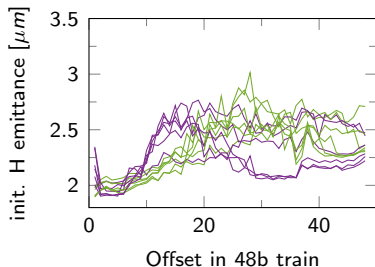
luminosity & luminosity lifetime in 2015

- luminosity lifetime very good w.r.t. 2012
  - 2015: $30 - 60$ h, peak ~5000 Hz/μb
  - 2012: $5 - 10$ h, peak ~7500 Hz/μb
- 6.5 TeV: synch light damping, emittance shrinking
- 25 ns: lower initial brightness, intensity and luminosity per bunch
- luminosity decay strongly dominated by intensity decay
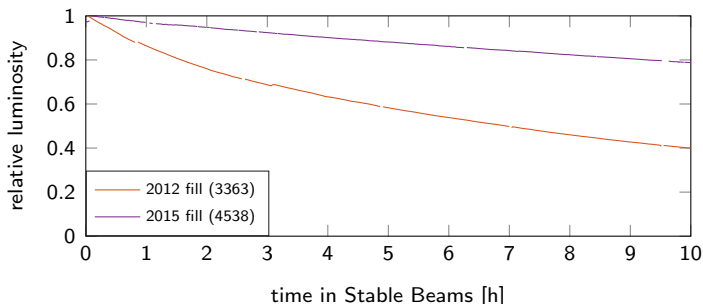
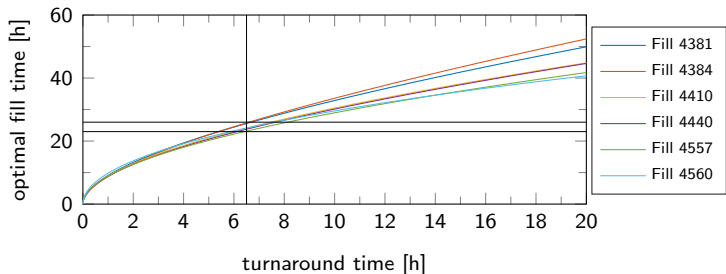# optimum fill length (from 2015 lumi data)

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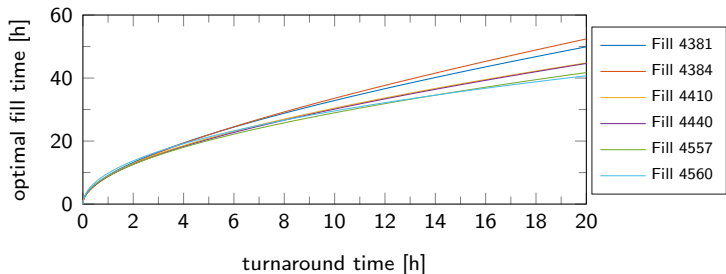
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    - optimum fill length: ~25 h

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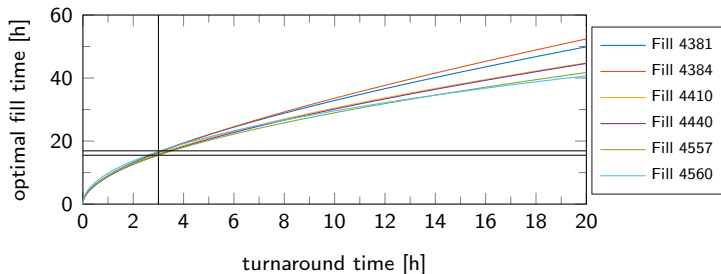
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  - optimistic case: ~3 h
    - optimum fill length: ~16 h

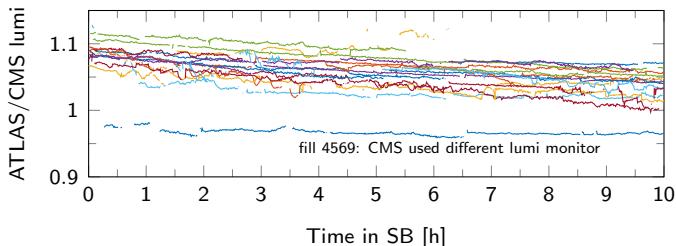* long (> 12 h) fills with > 1000 bunches

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  - ~9% at the start of stable beams, ~4% in the end
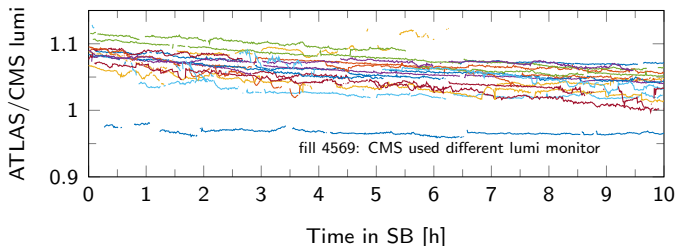
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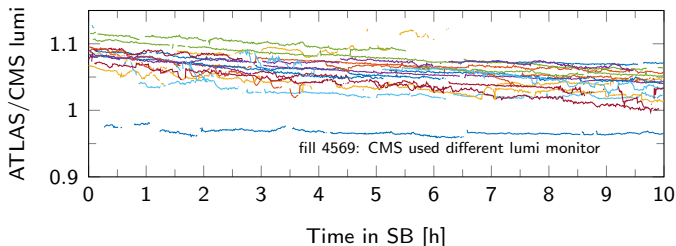   - indication from μ scan fill: luminous area ~2% bigger in CMS

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  - ATLAS high by 3.3%, residual error on calibration 5% (*W. Kozanecki*)
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fill 4569: CMS used different lumi monitor

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  - luminosity imbalance down to ~1%

conclusions & outlook
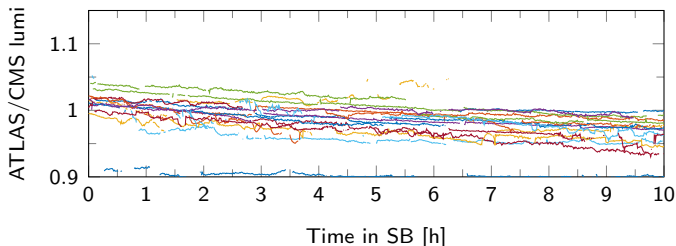
- luminosity & luminosity lifetime
  - peak ~5000 Hz/μb, lifetime $30 - 60$ h
  - 25 h optimal fill length for 6.5 h turnaround time
- emittance in stable beams
  - nominal beams:
    - start of stable beams: ~3 μm
    - horizontal growth, vertical shrinking, convoluted constant
  - BCMS beams (only one fill!)
    - start of stable beams: ~2.5 μm, bunch-by-bunch spread
    - horizontal growth, vertical constant, convoluted growth
- OP scans
  - complementary emittance measurements in 2015
    - self-consistent and in agreement with wire scanners & BSRT
  - proposal for 2016:
    - IP5 only, end-of-2015 parameters (7 steps, 10 seconds per step)
    - scan before programmed beam dumps or after ~15 h
    - scan at the start of stable beams: frequency to be discussed with CMS
    - dedicated tab and online analysis in the new lumi scan application