Update on correlation between DA and Lifetime with Beam-Beam

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G. Iadarola, N. Karastathis, G. Sterbini

HI-LUMI WP2 – 07/11/2017

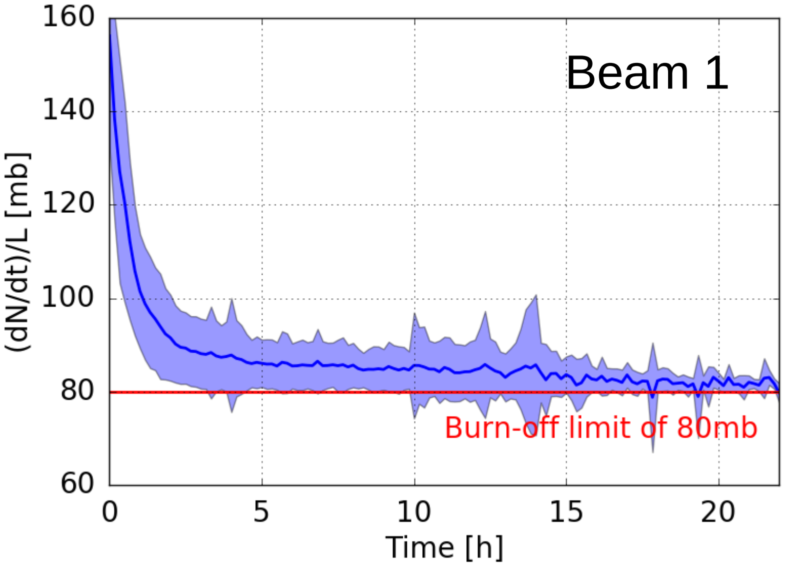
A foreword on DA

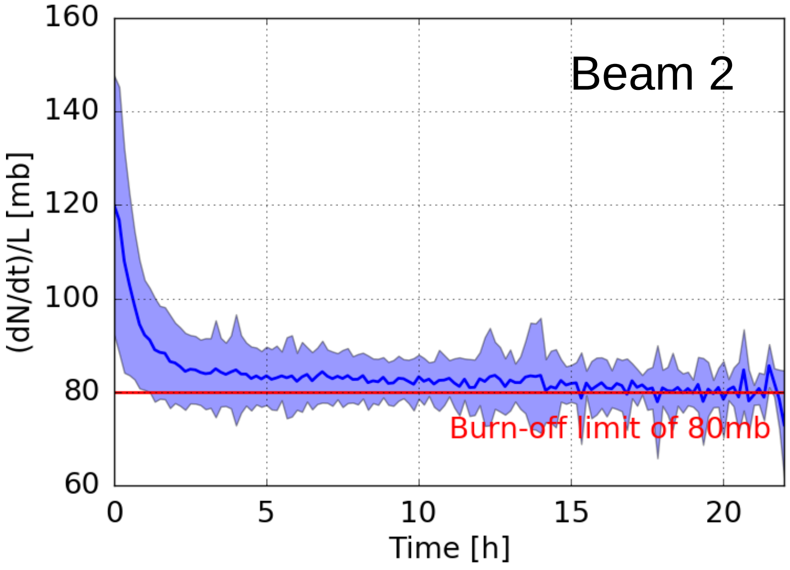
- The DA obtained from tracking simulations depends on several **conventions**:
  - Number of turns: 1M = 90 s of beam time
  - Choice of initial momentum: 27e-5 ~ ¾ of the bucket height (see also D. Pellegrini, 81st WP2)
  - Number of angles for min DA: 5
  - Specific machine realisation (typically without errors)
  - LHCb normally in the good polarity, levelled by separation at 2e32 Hz/cm²
- We use them as a **reference** for the DA vs lifetime comparison (i.e. different considerations can lead to different DA vs lifetime correlation).

Experience from 2016

Recap from 93rd WP2

Losses during the fill

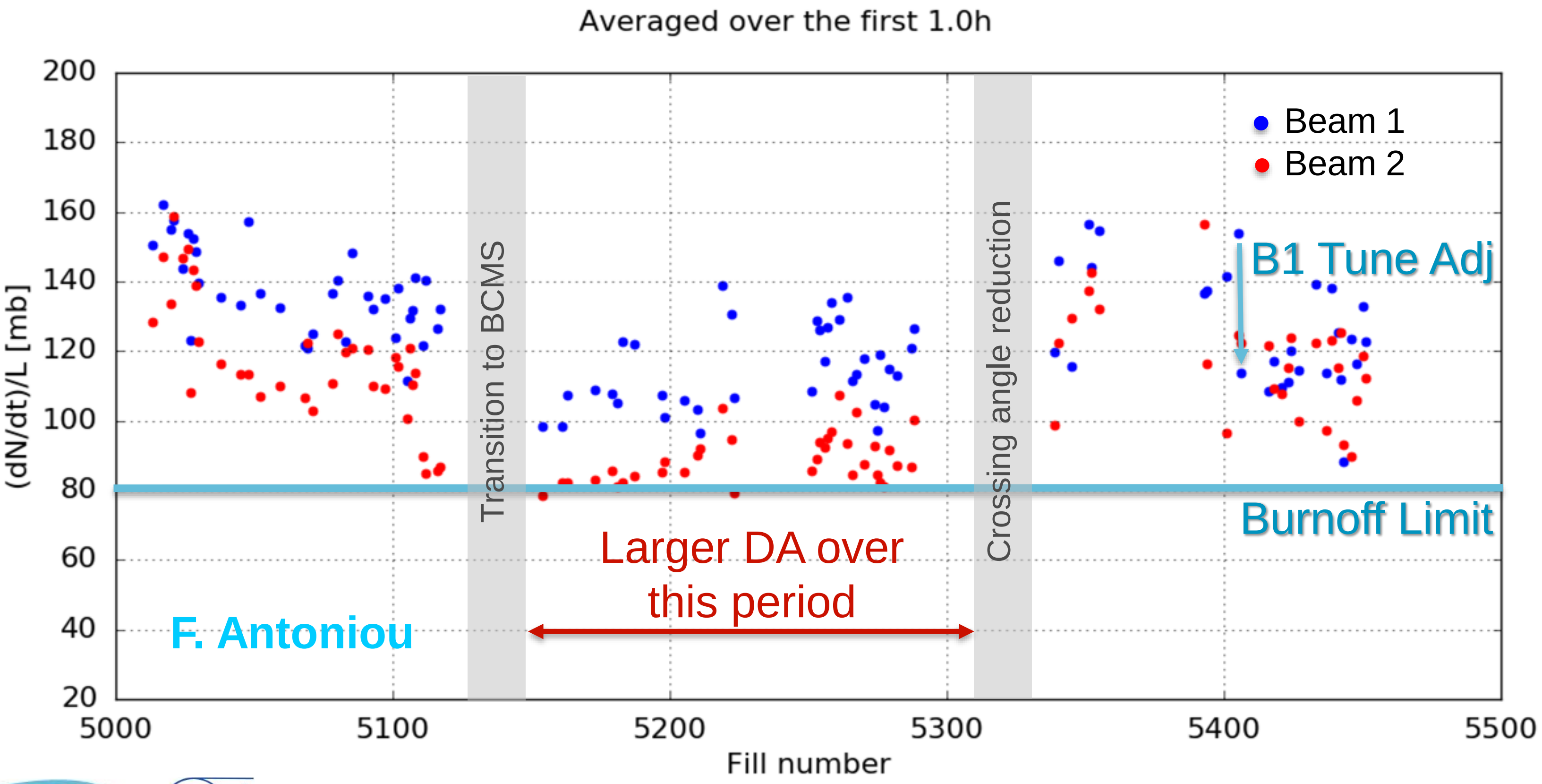




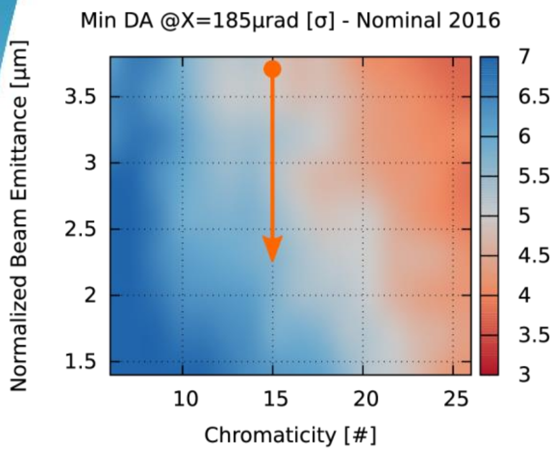
F. Antoniou

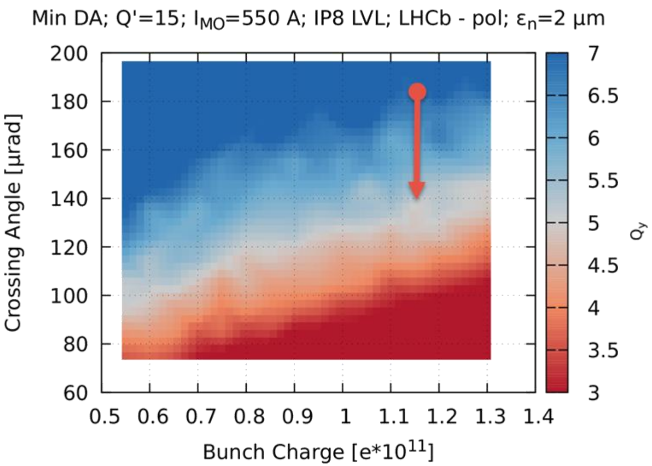
- Normalised loss-rate, approaches burn-off limit within first **2-3h**.
- These early losses appear to be **correlated** with DA.

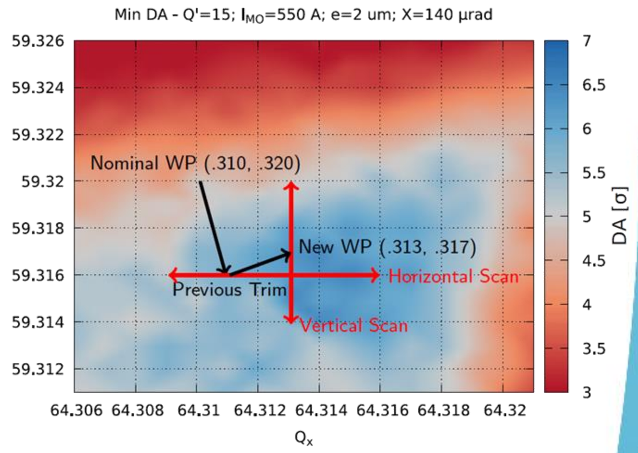
1st hour losses along the year



DA follow up along 2016 Run



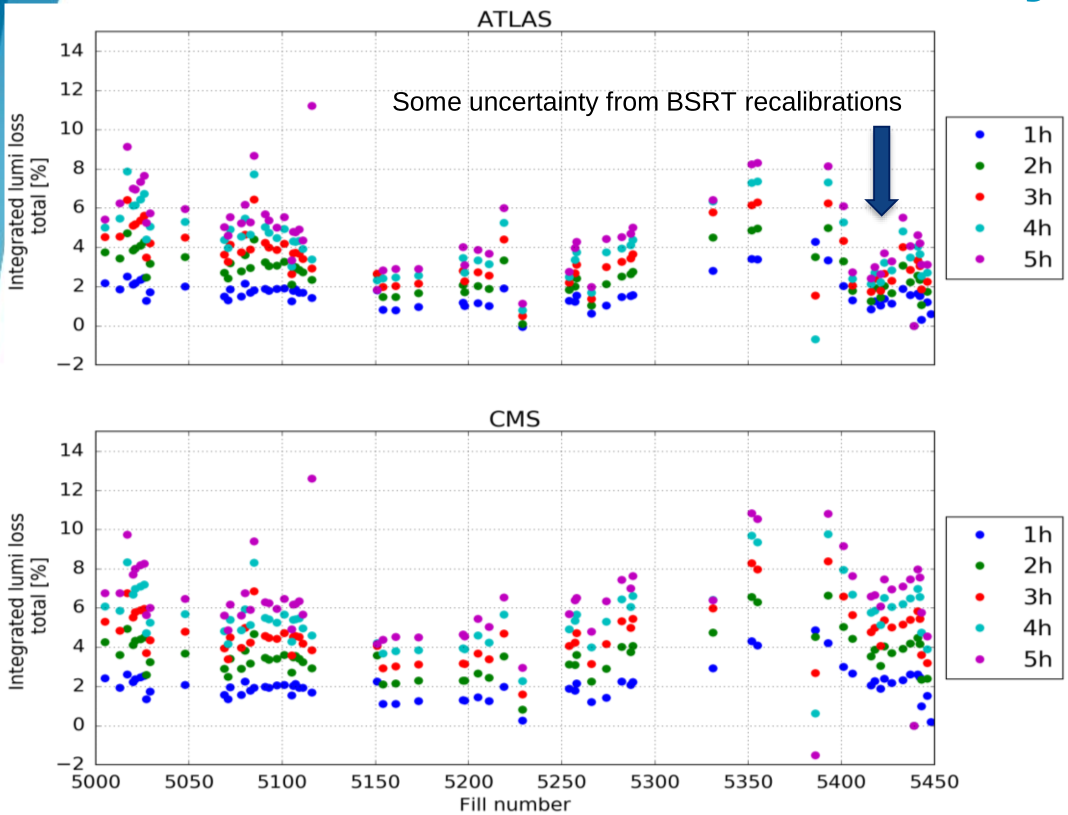




- Reduction of emittance, increasing the DA from **5 to 6 σ**
- Reduction of crossing angle, reducing the DA from **6 to 5 σ**
- Tune adjustment bringing restoring the DA from **5 to 6 σ**

What is the impact on the integrated luminosity?

Luminosity loss



The integrated **luminosity loss** along the fills from:

- emittance blow-up (compared to the expected evolution), extending for the entire fill duration.
- beam losses localised in the **first few hours**.

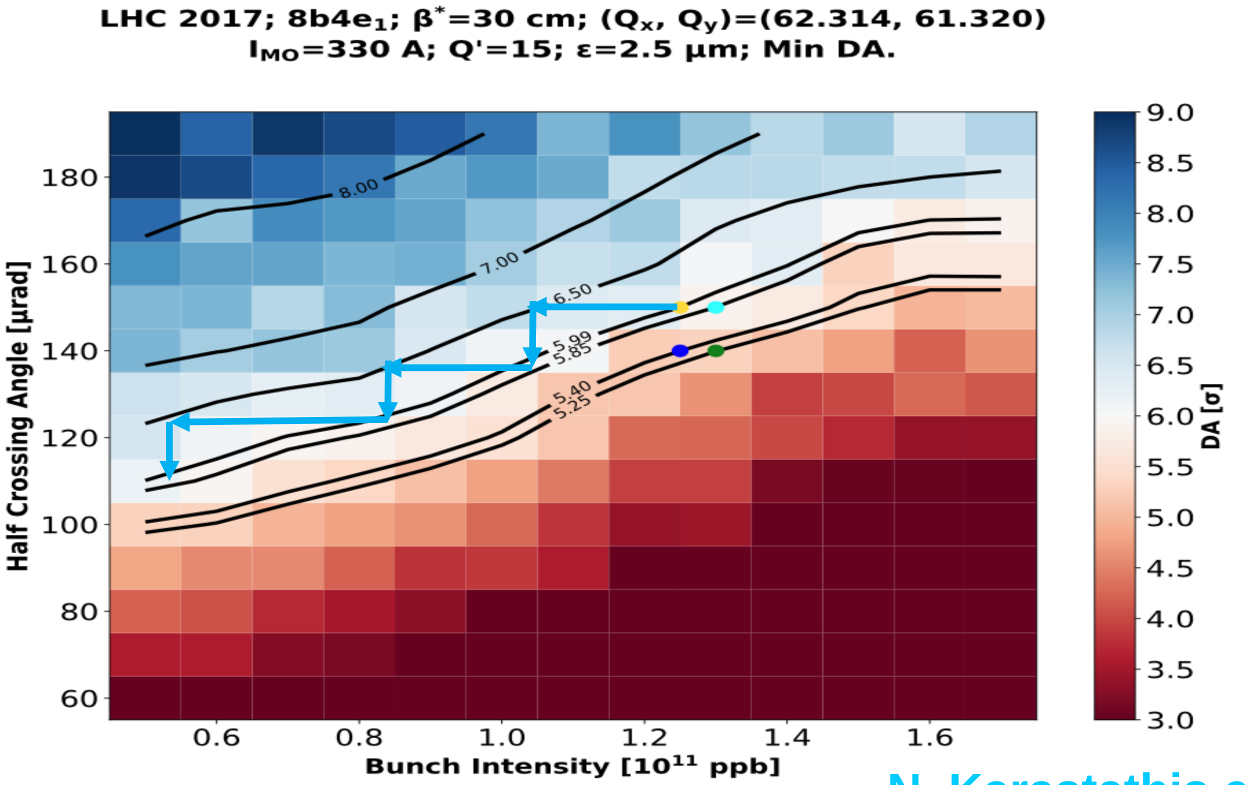
The contribution of losses is up to **2~3 %**, while the crossing reduction came with a **10 %** increase.

Trading DA for performances can be worth the losses.

F. Antoniou

Improvements in 2017

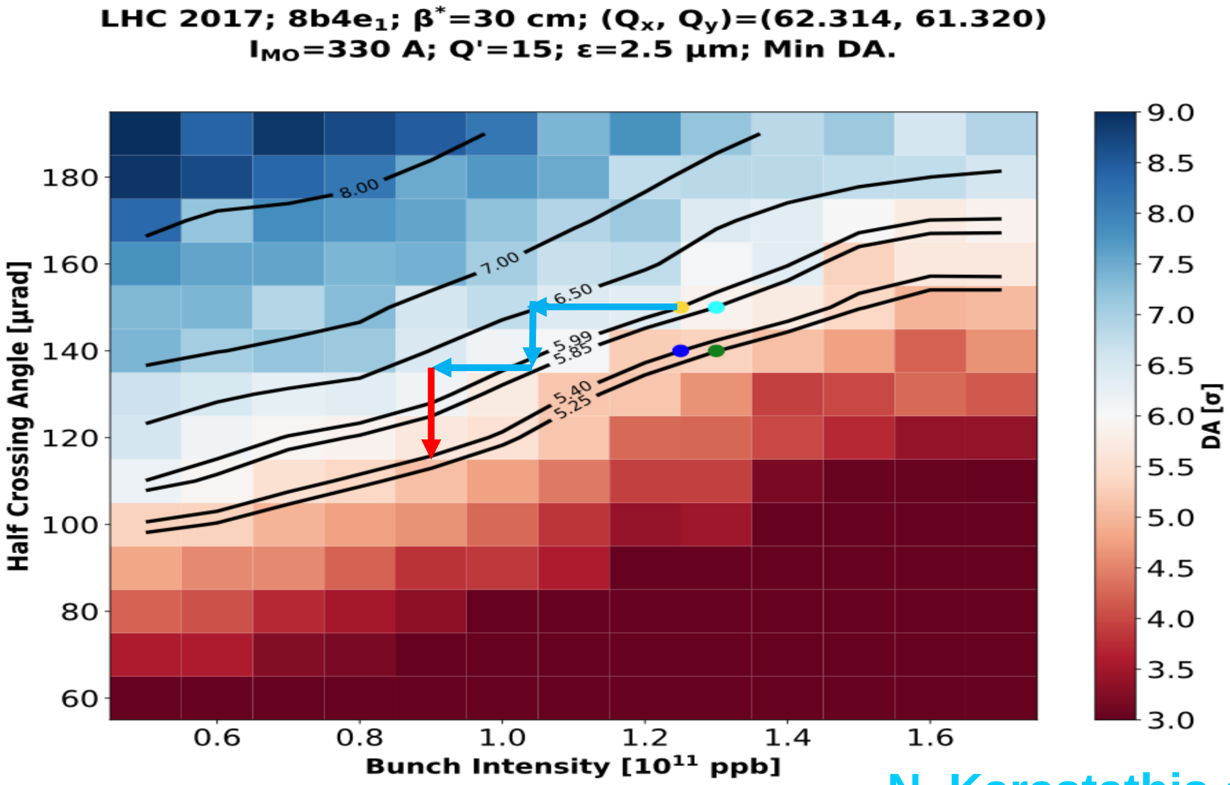
Crossing angle anti-leveling: a test for DA



- Each intensity allows for a specific crossing angle in terms of DA
- Steps for crossing angle reduction based on DA simulations
- Steps translated into time for OP…

N. Karastathis et al.

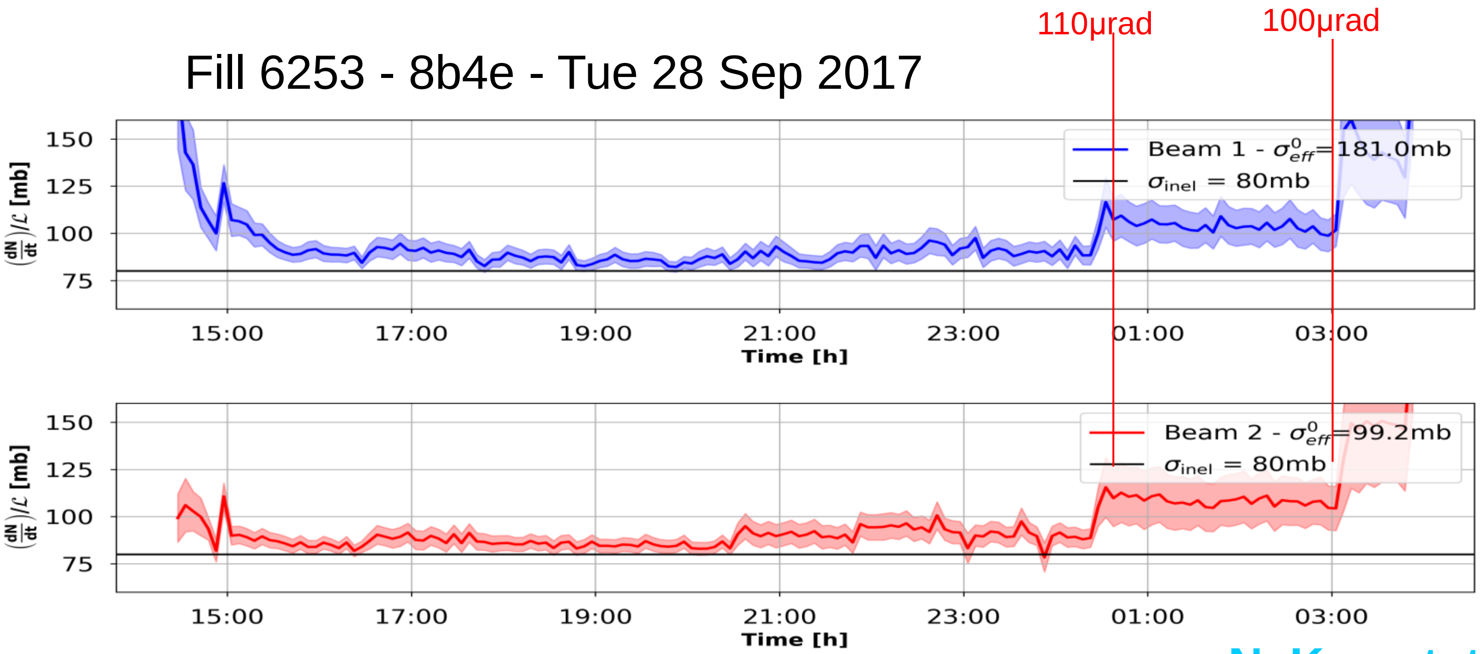
Crossing angle anti-leveling: a test for DA



- Reduction steps not always applied at the right intensity
- Sometimes resulting in aggressive settings

N. Karastathis et al.

Crossing angle anti-leveling: a test for DA

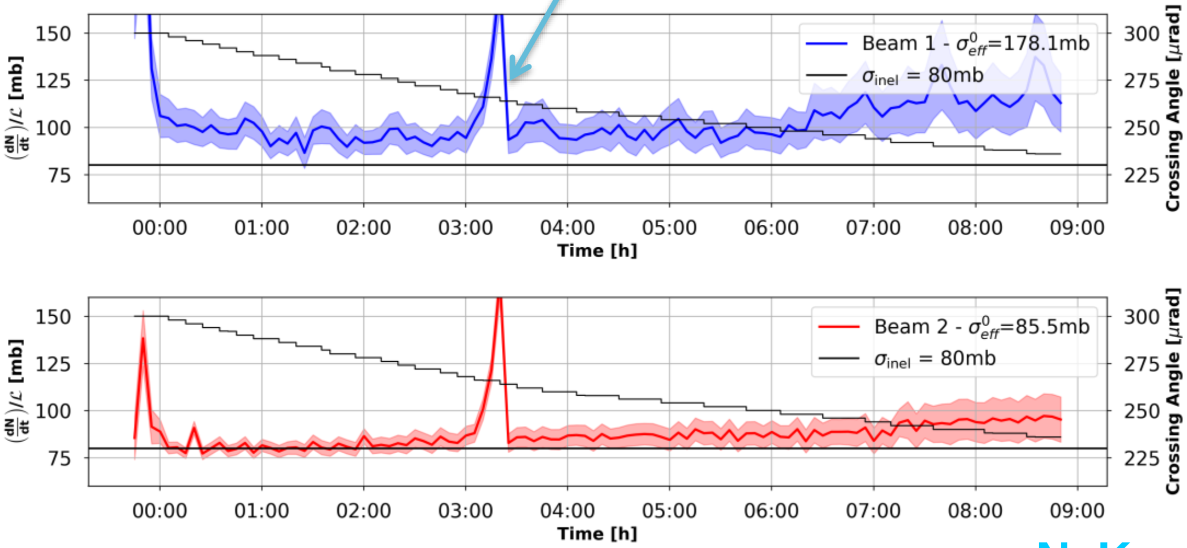


N. Karastathis

- Lifetime approaches the burnoff limit very quickly.
- Aggressive settings are seen on the beam lifetime and cross section.

Fill 6061: Continuous variation of crossing angle

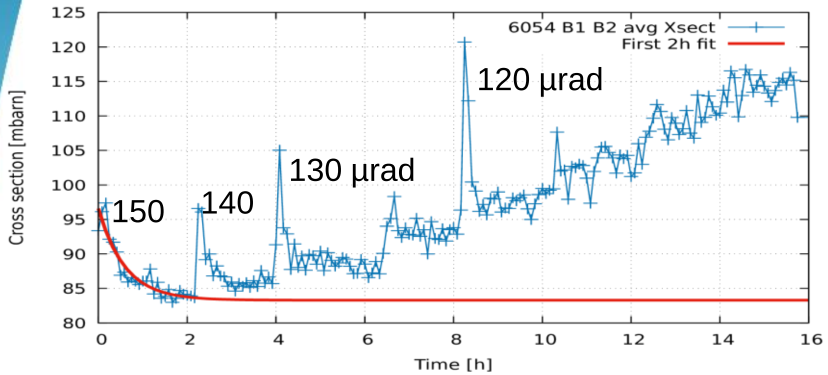
Atlas lumi issue



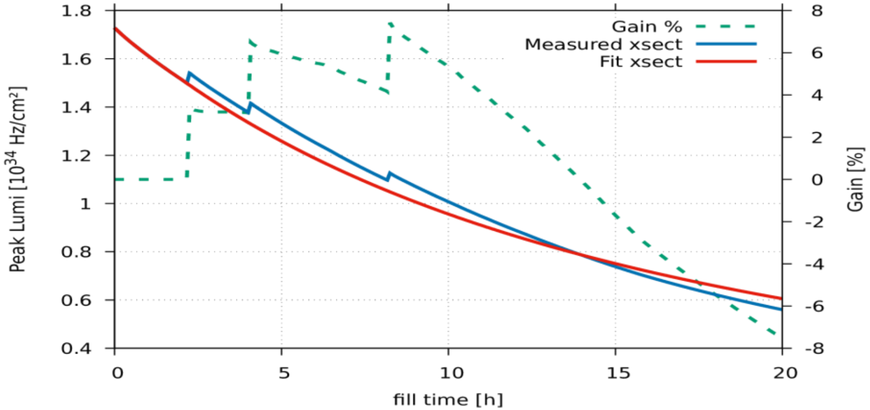
N. Karastathis

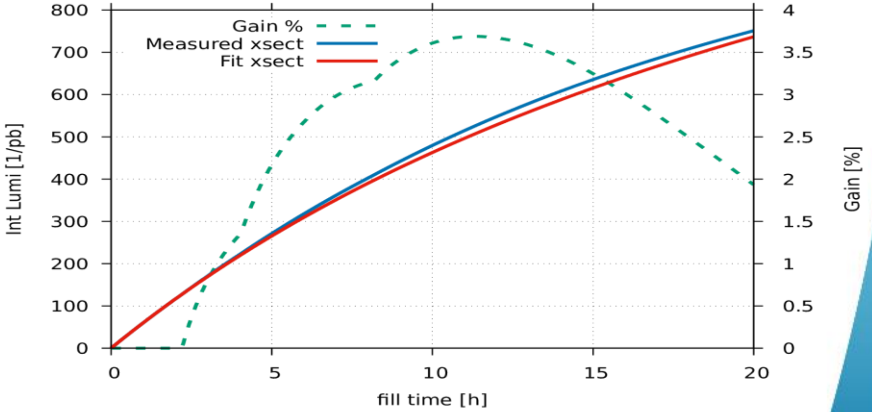
- Smooth losses without large dips
- Proposed for HL-LHC

A word on performance



- Perform integration with:
  - Measured (fill 6054) cross section and realistic crossing angle steps,
  - Cross section fitted on the first 2h and fixed crossing angle.
- Aggressive crossing steps, still ~3% gain of integrated luminosity.

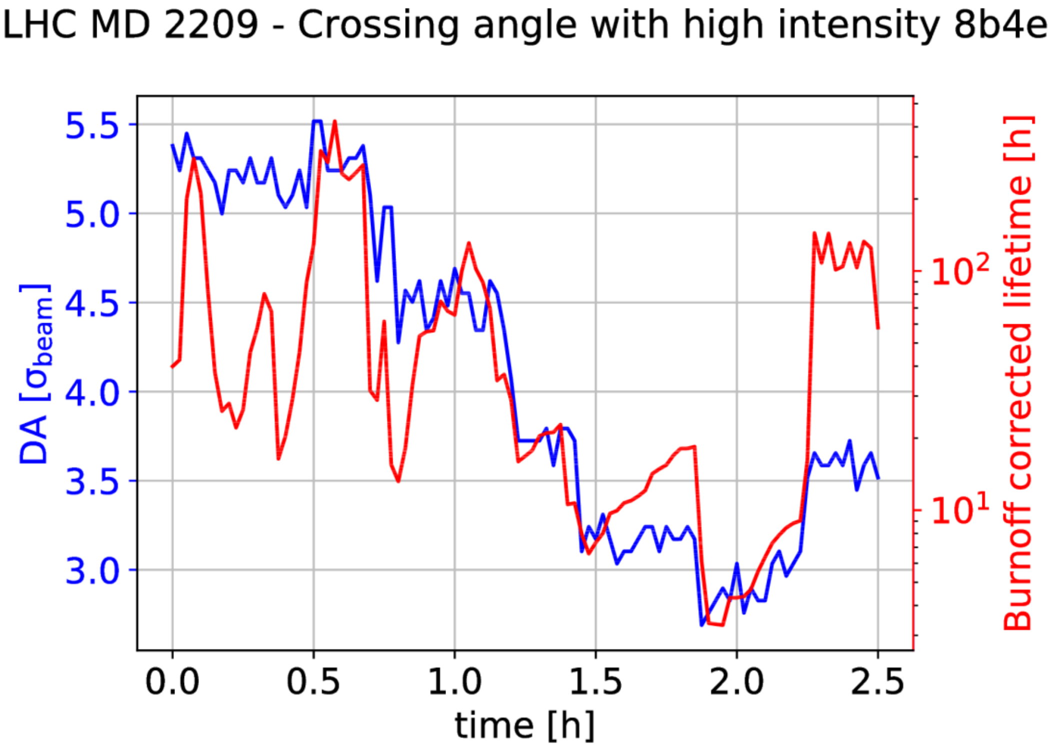




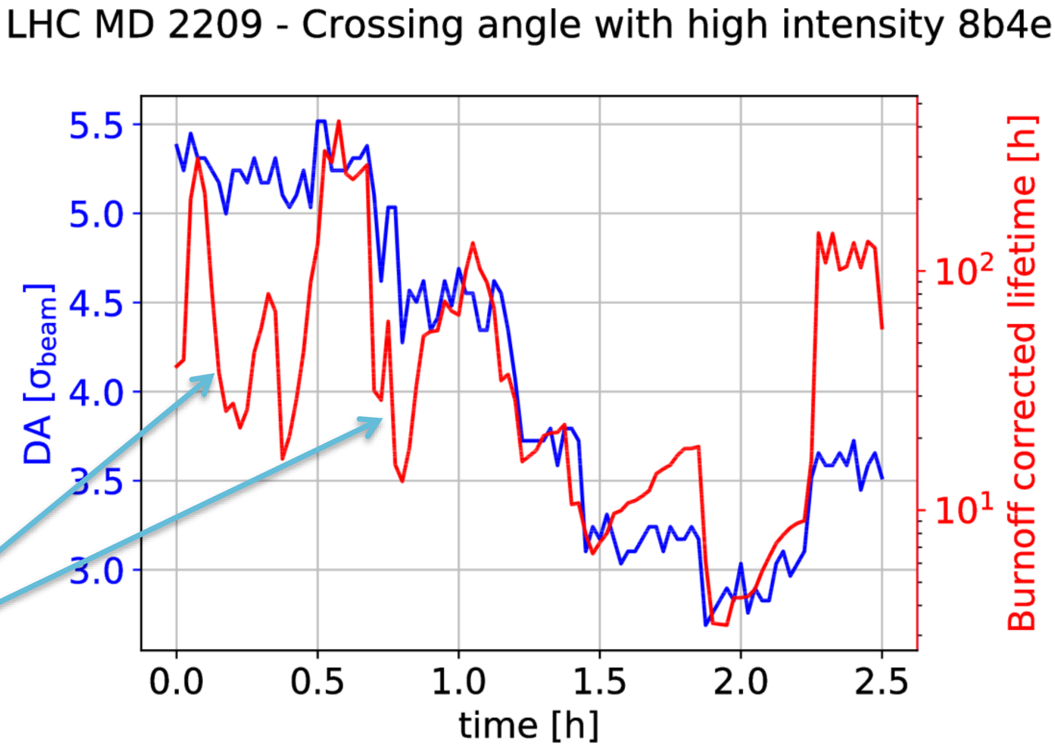
Putting all together

- **Feed** all the machine settings and beam measurements to DA simulations and **benchmark** with lifetime.
- **MD2209** (G. Iadarola, D. Pellegrini et al.) Crossing angle with high intensity 8b4e bunches chosen:
  - Reduction of the crossing angle in steps;
  - Very good tune and lumi control along the fill;
  - Attempt to recover lifetime at the smallest crossing by reducing octupoles and chroma.

Lifetime vs DA

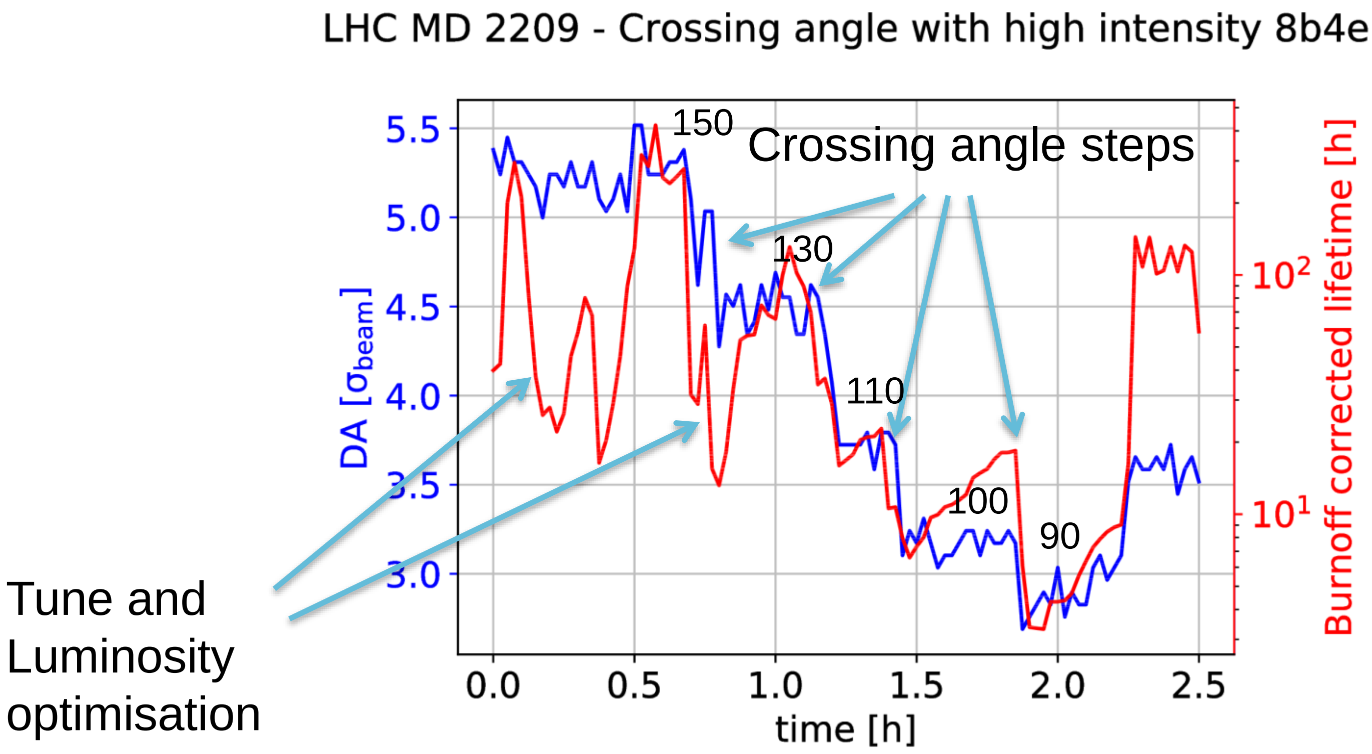


Lifetime vs DA

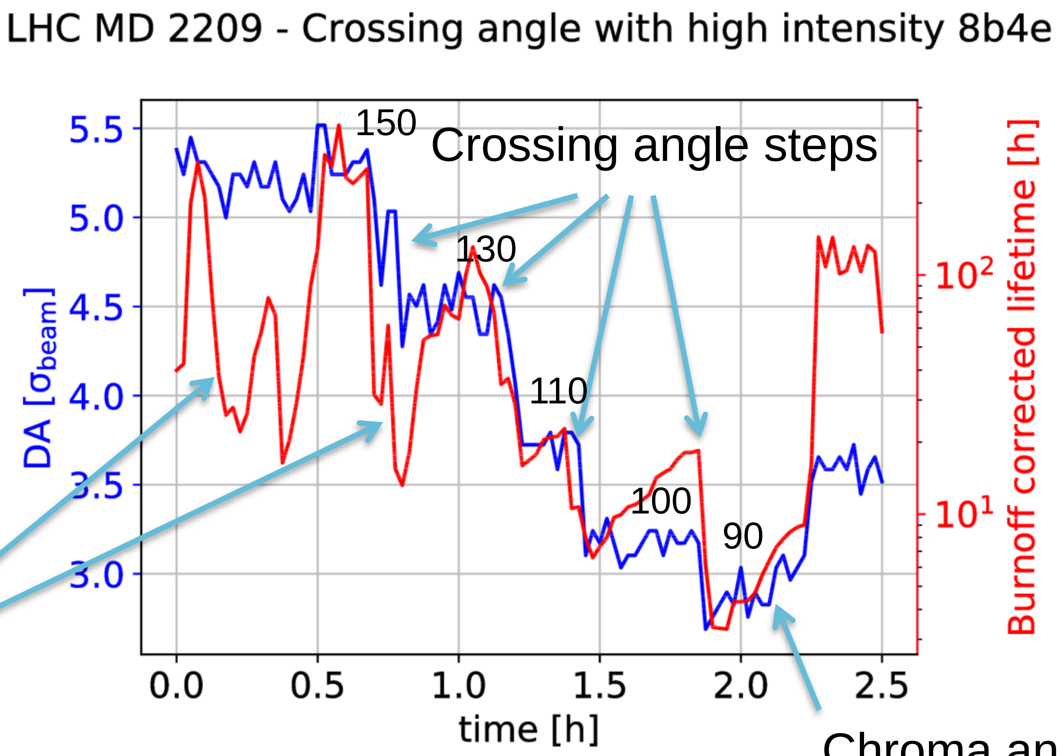


Tune and Luminosity optimisation

Lifetime vs DA



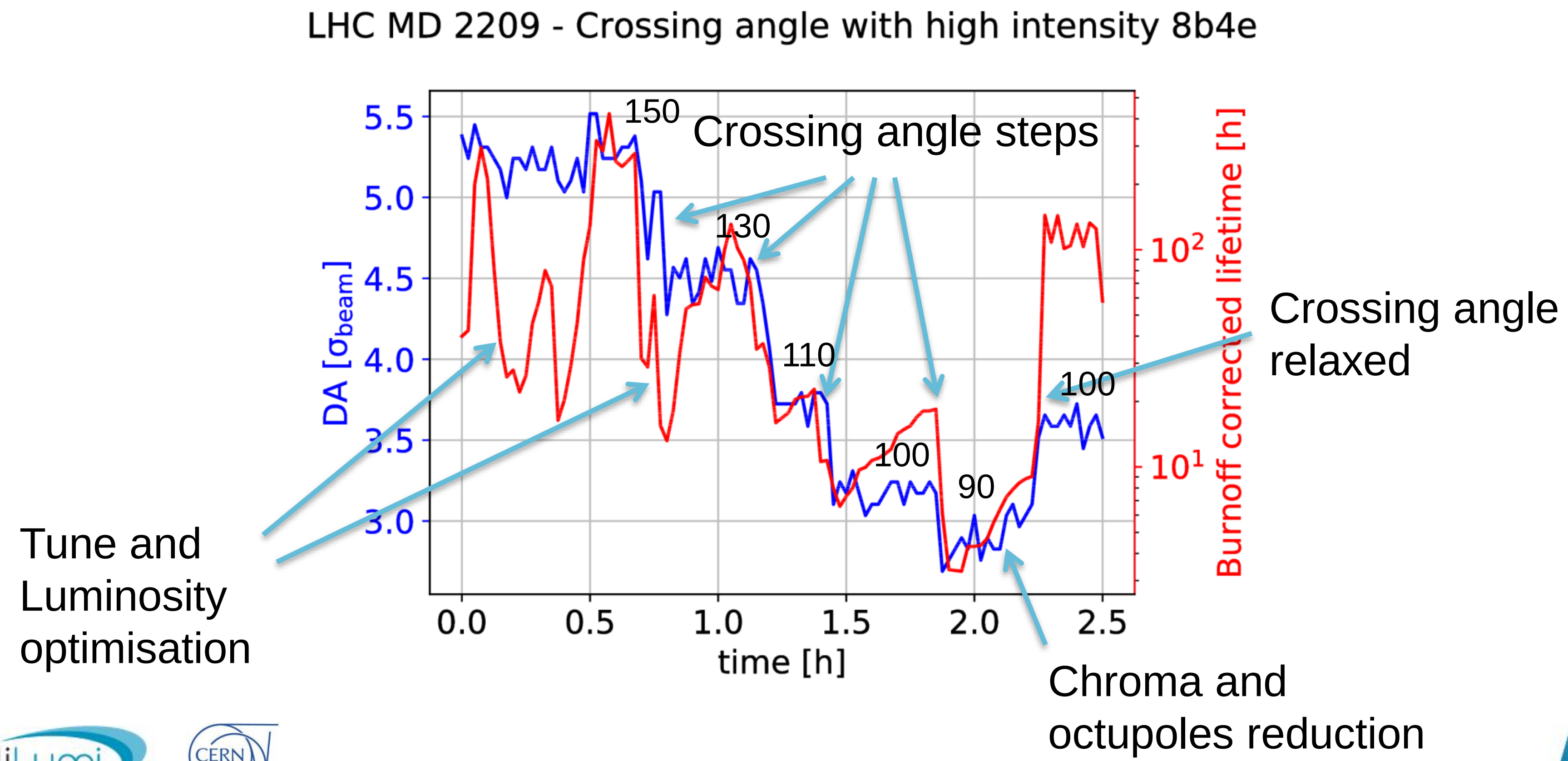
Lifetime vs DA



Tune and Luminosity optimisation

Chroma and octupoles reduction

Lifetime vs DA



Conclusions

- Flexible crossing angle operation **extremely useful**, also in MDs!
- First-of-the-kind exercise of **feeding** of both beam and machine parameters along the fill to DA simulations.
- Remarkable **agreement** between the steps in burnoff-corrected lifetime and DA.
- DA can be affected by **systematics**.
- Cannot reproduce the **raise** of lifetime after aggressive steps or when relaxing the crossing angle:
  - Intensity and emittance variations are **not enough** to explain.

Outlook

- Move to **lifetime** simulations, taking into account the particles already lost in the previous tracking intervals to understand the quick gain of lifetime after the perturbations.
- Extend the analysis to additional fills to improve the **statistics**.
- Possibly **identify** more lifetime-affecting settings in order to improve the general understanding.
- Initiate **beam 2** simulations with beam-beam.

HiLumi HL-LHC PROJECT

Backup