# Preparation for the 2018 start-up

Schedule update and first ideas for start-up

Configuration and parameters in 2018

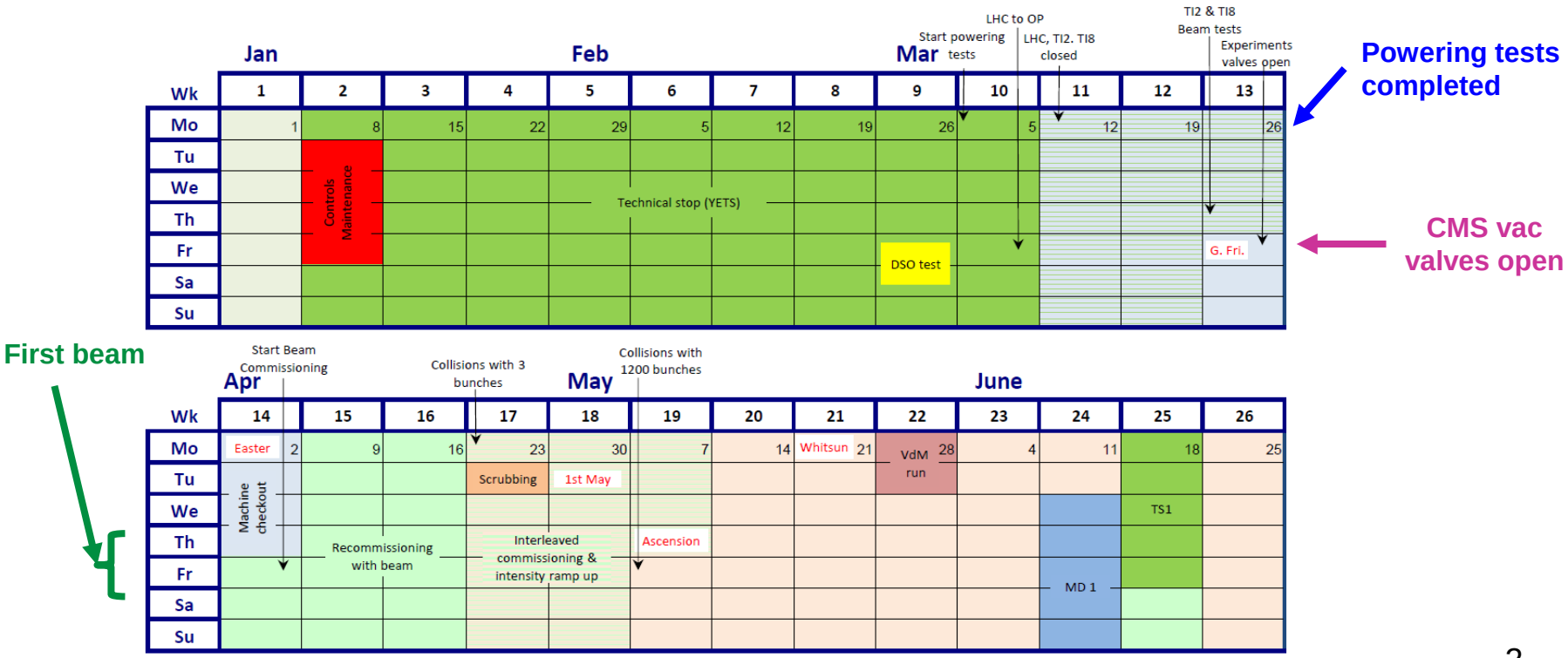
Performance estimates for 2018 (from Chamonix)

Crossing levelling in IR8?

J. Wenninger

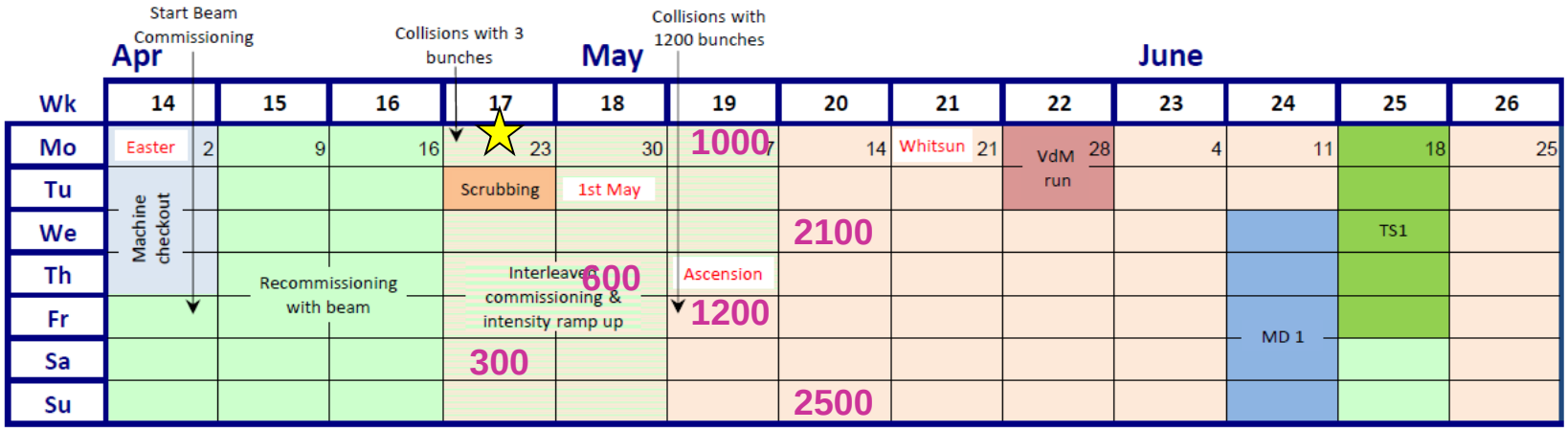
# 2018 start-up schedule update

- **Powering tests** should be completed at the beginning of week 13.
- **Checkout** starts week 13, **opening of CMS vacuum valves is delayed** from Mo 26th March to Fri 30th March.
  - No BIS and full LBDS tests possible as long as CMS valves closed.
  - **TI2/8 test** maintained middle of week 13. To be confirmed (SPS crab cavity installation).
- **First beam** postponed by 4 days to second half of week 14.
- The new schedule proposal will be discussed tomorrow at the LMC.

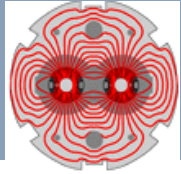


# Commissioning activities

- Collecting commissioning activities is ongoing.
  - Requests for ADT, RF, ABT, BI, collimation & aperture have been received (no surprises).
  - OMC → next presentation.
- With the current input and educated guesses for missing items, **2 ½ weeks** seems to be a reasonable estimate for the time needed to first stable beams.
  - ~ 2 weeks at 100% availability.
  - +2 days for vdm setup.
- Since S12 was not brought to room temperature, the **time for scrubbing** was reduced to ~ **24 hours** based on the experience of the previous years.

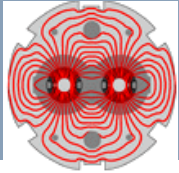


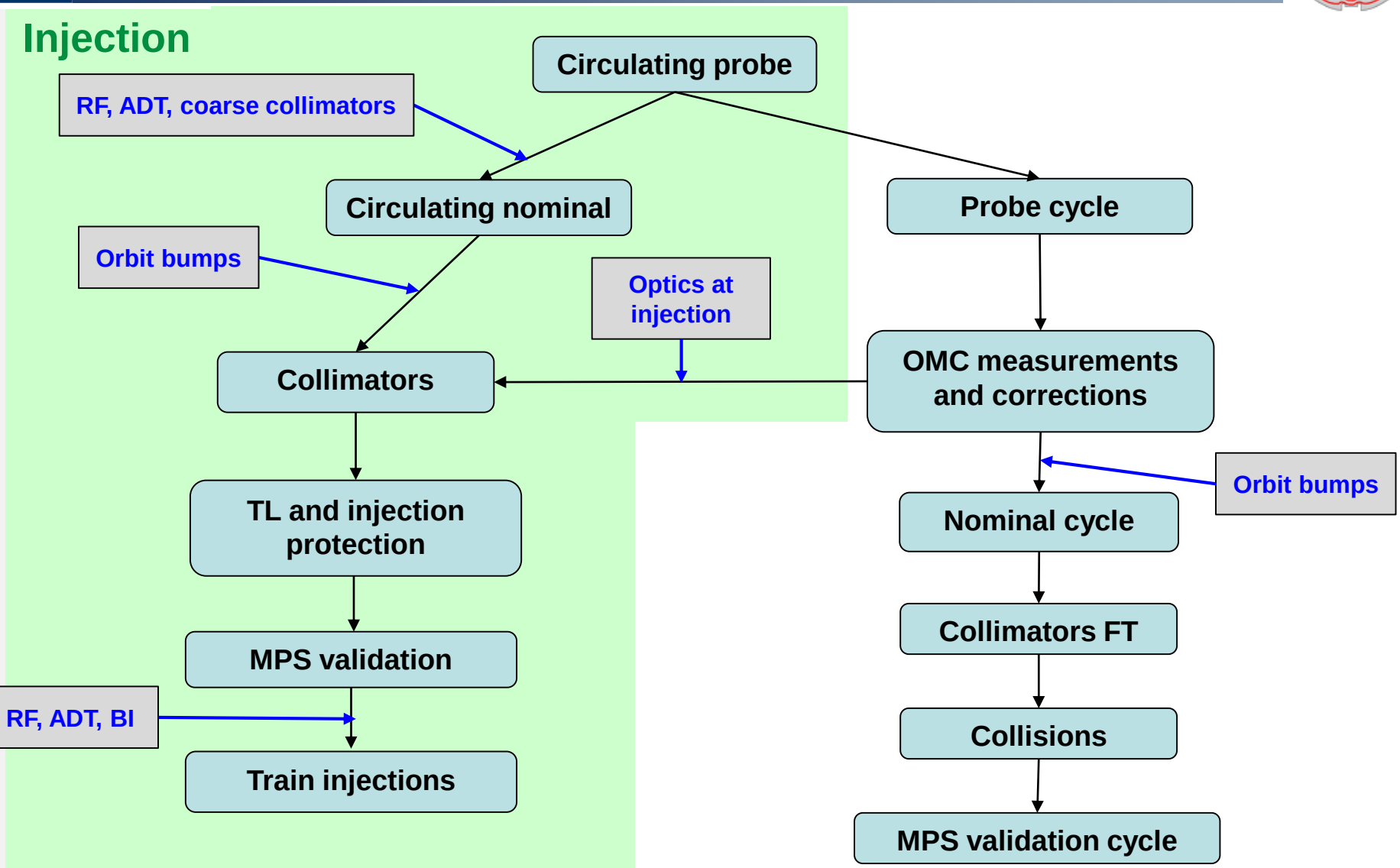
# Start-up plan – rough outline



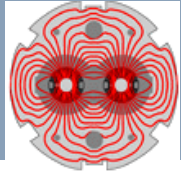
- On day 1 we will start with a flat machine for the first injections.
- As soon as the beams circulate, we should put in place coarse collimator settings to prepare for the **injection of a nominal bunch**.
  - Reference orbit – aim to correct towards 2017 flat reference orbit.
  - Once reference orbit is defined we can start collimator and absorber setup activities for the ring and the TLs.
  - In 2017 the nominal bunch came only the 5$^{th}$ day, this year we should get it earlier – aim for day ~2-3.
- Question: should we operate for a few days with **flat machine**?
  - Possible consumers: orbit and optics correction. To be evaluated.
- In 2017 the 30cm commissioning came late(r) because we did not plan to use 30cm right away. This year we must commission the squeeze to 25 cm from the start to allow $\beta^*$ levelling test to start asap.

# Start-up plan – rough outline





# Commissioning plan

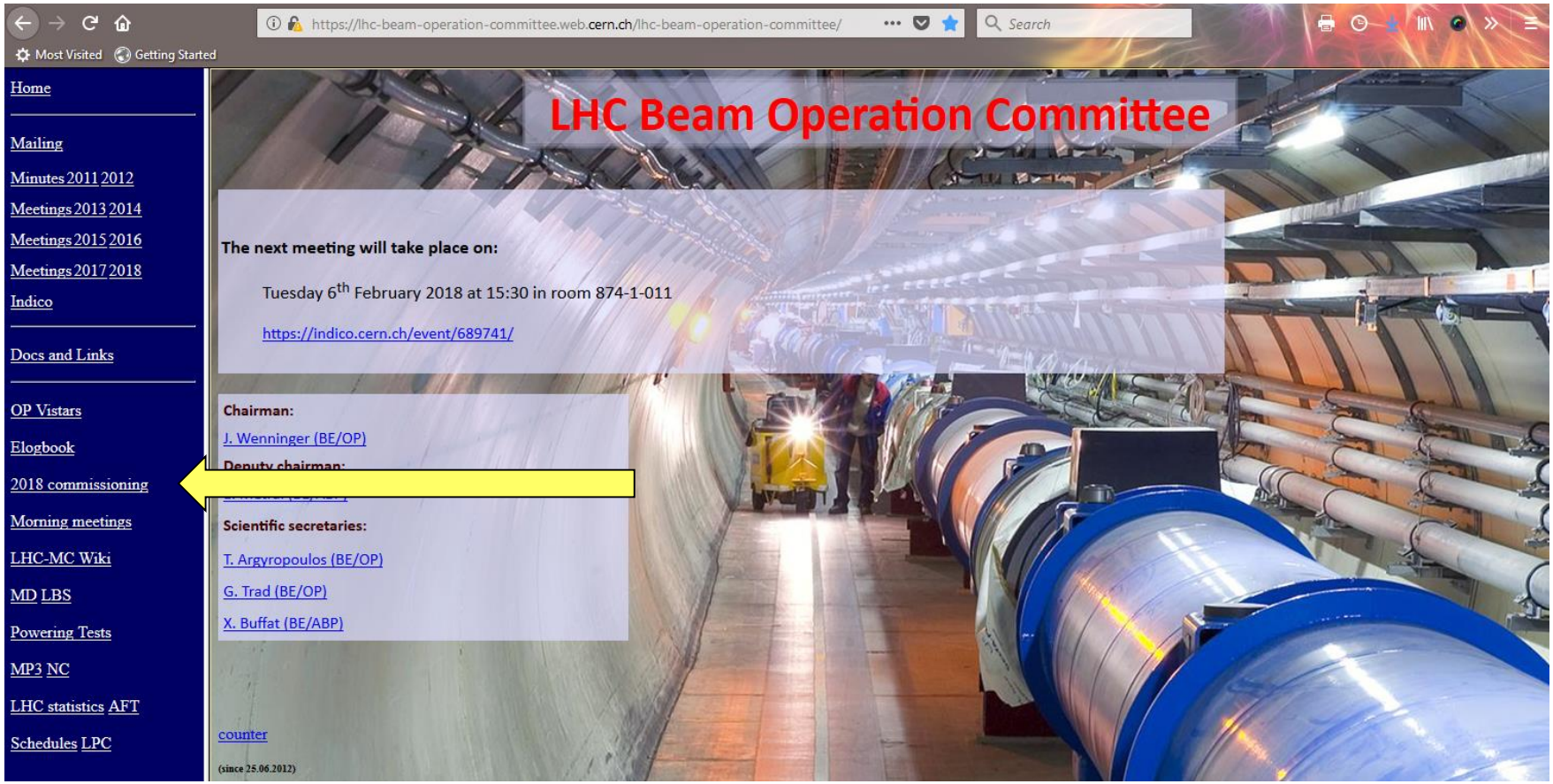


- Shift-by-shift commissioning plan in preparation based on the 2017 effective plan – under construction.
- Google spreadsheet to plan & track:
  - https://docs.google.com/spreadsheets/d/1nnEb3f15L3NwxJ0RAnh-WkG_eiUUfJ9WGh2yxaT5Kjo/edit?usp=sharing
  - The 2017 realized plan is available in another tab of the same spreadsheet.

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | Commissioning plan 2018 shift by shift | | | | | | |
| 2 | | | | | | | |
| 3 | **Date** | **Shift** | **Time** | **Faults** | **Team** | **Status** | **Activity** |
| 4 | **02/04/2018** | | | | | | **Monday** |
| 5 | | **M** | **4** | | **ABT** | | MKI interlock and synchronization tests with beams to TEDs |
| 6 | | **M** | **4** | | **ABT** | | MKI interlock and synchronization tests with beams to TEDs |
| 7 | **Beam !** | **A** | **4** | | **OP/RF** | | Injection, first turn, RF capture B1&B2 - closed orbit |
| 8 | | **A** | **4** | | **OP/BI** | | BI work: BPM phasing, BCT checks, multi-turn & AC dipole |
| 9 | | **N** | **4** | | **OP/BI** | | BI work: BPM phasing, BCT checks, multi-turn & AC dipole |
| 10 | | **N** | **4** | | **OP** | | New optics, cycle to 6.5TeV, then Q, Q' at injection |
| 11 | **03/04/2018** | | | | | | **Tuesday** |
| 12 | | **M** | **4** | | **OMC** | | Optics measurements at 450GeV / feedback preparation for R&S / BI checks |
| 13 | | **M** | **4** | | **OMC** | | Optics measurements at 450GeV / feedback preparation for R&S / BI checks |
| 14 | | **A** | **4** | | **COLL** | | Coarse collimator set-up and loss map in preparation for ramp & ULO check |
| 15 | | **A** | **4** | | **OP** | | Ramp and squeeze to 1m, optics at flat top |
| 16 | | **N** | **4** | | **OP/OMC** | | Repeat ramp and squeeze to 1m (coupling and FF) |
| 17 | | **N** | **4** | | **OP** | | |
| 18 | **04/04/2018** | | | | | | **Wednesday** |
| 19 | | **M** | **4** | | **OP/BI** | | FIDEL measurements, BPM and BI checks |
| 20 | | **M** | **4** | | | | No beam from SPS |
| 21 | | **A** | **4** | | **OP** | | Ramp and squeeze to 1m |
| 22 | | **A** | **4** | | **OP/OMC** | | Squeeze to 40 cm in steps, optics measurements |
| 23 | | **N** | **4** | | **OMC** | | Squeeze to 40 cm in steps, optics measurements and corrections |
| 24 | | **N** | **4** | | **MPS** | | MPS tests of BLM system at injection |
| 25 | **05/04/2018** | | | | | | **Thursday** |

# Commissioning plan

- The commissioning plan is accessible from the LBOC home page



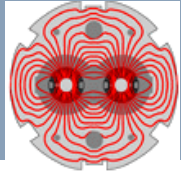
# Parameters for 2018

- As presented in Chamonix:

| Parameter | Value |
|---|---|
| Optics | 2017 ATS |
| Cycle | **PPLP** ramp with squeeze to 1m |
| Beam type | BCMS |
| Bunch intensity | 1.15 - **1.3** x $10^{11}$ p/bunch |
| #bunches per train | 144 |
| Total number of bunches | 2556 |
| Initial/baseline β* | 30 cm |
| Final β* (by leveling) | **27/25 cm** |
| ½ xing angles(**) | **160**/200/**160**/-250 |
| CMS bump | **-1.8 mm** |

(**) : same ATLAS xing angle polarity as in 2017.

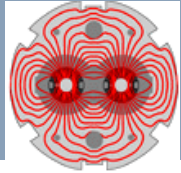
# Collimation



- Presentation by R. Bruce in Chamonix.
- Configuration for **2018** almost identical to 2017 except for **IR1/5 aperture and TCTs** that will be **1σ** tighter.
- Assumptions:
  - Same quality of orbit & optics than in 2017.
  - Phase advance dump-TCT remains < 30°.
  - 2017 aperture measurements confirmed in 2018, no impact of the slightly larger CMS IP shift.

| Collimator | 2017 | 2018 |
|---|---|---|
| TCP IR7 | 5.0 | 5.0 |
| TCSG IR7 | 6.5 | 6.5 |
| TCLA IR7 | 10.0 | 10.0 |
| TCP IR3 | 15.0 | 15.0 |
| TCSG IR3 | 18.0 | 18.0 |
| TCLA IR3 | 20.0 | 20.0 |
| TCSG IR6 | 7.3 | 7.3 |
| TCDQ IR6 | 7.3 | 7.3 |
| TCT IR1/5 | 8.5 | 7.5 |
| *Aperture 1/5* | *9.5+0.5* | *8.5+0.5* |
| TCT IR2 | 37.0 | 37.0 |
| TCT IR8 | 15.0 | 15.0 |

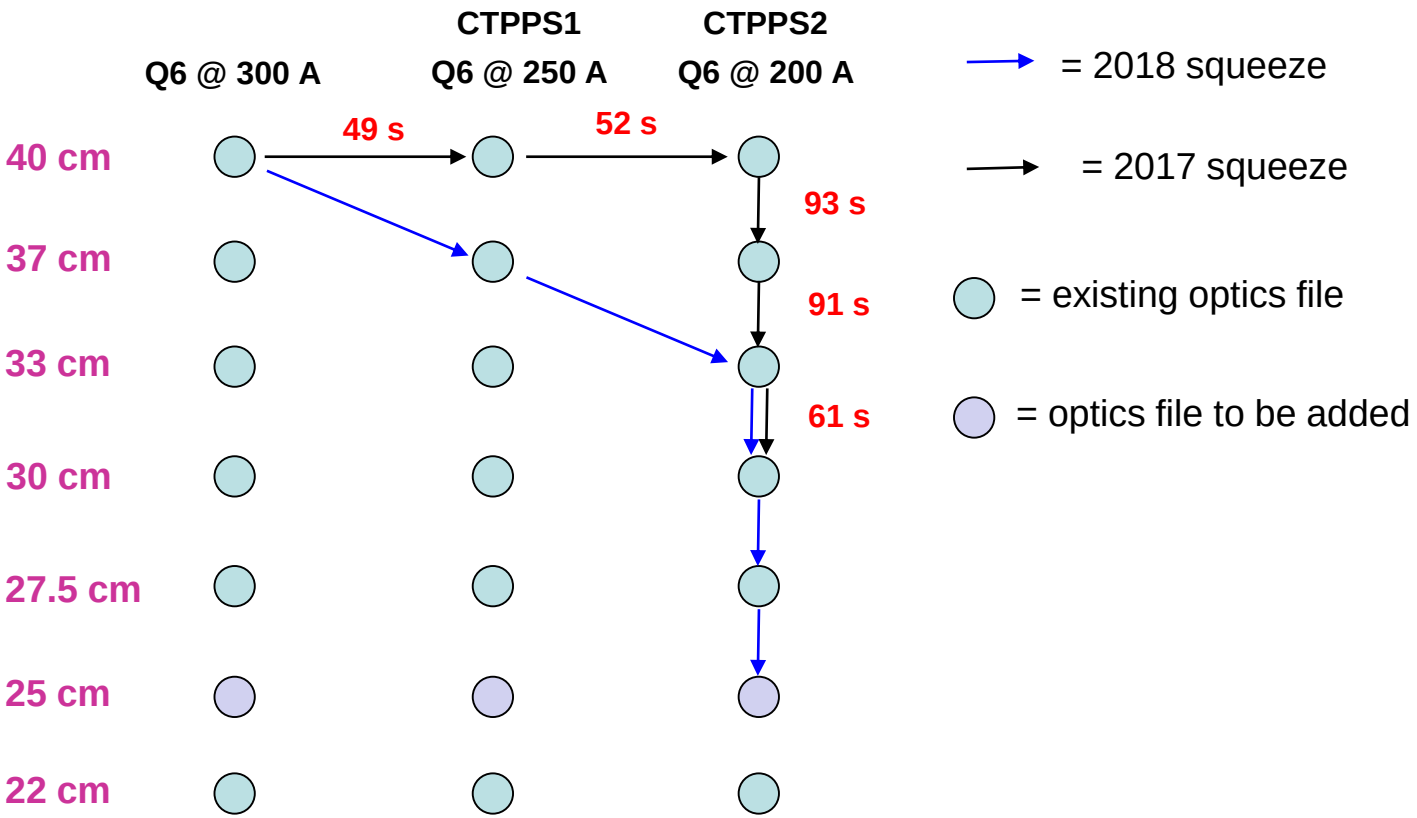
# Cycle configuration



- **Ramp**: we will use the faster PPLP ramp in 2018.
  - The settings established during the 2017 MD will be used for bootstrapping.
- **Tune change**:
  - No change wrt 2017.
- **Squeeze**:
  - Merge squeeze segments 1m-40cm and 40cm-30cm,
  - Take a short cut to the CTTPS2 version (Q6 @ 200 A) – see next slide,
  - Reuse the 2017 settings for bootstrapping as much as possible.
- **Collisions**:
  - No change wrt 2017.
- **Squeeze for β* levelling**:
  - Add a new squeeze segment to 25 cm with stop ~27.5 cm.
    - Note that the β* information in the timing is truncated to the **cm**.
  - Must be setup eventually with colliding beams.
  - **Detailed scenario to be defined.**

# Optics 40-25 cm

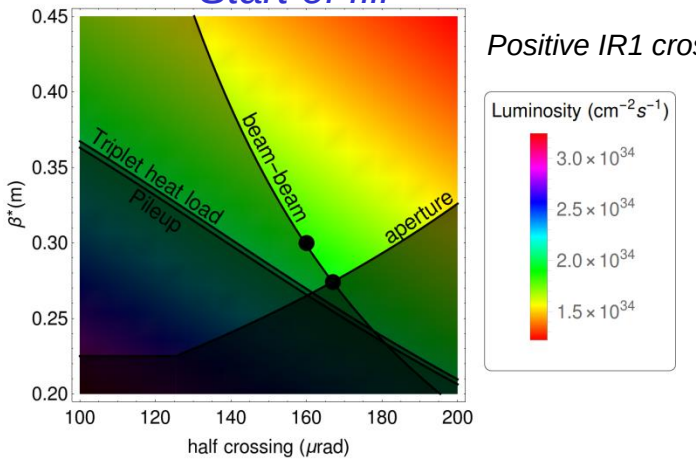
- The 40cm-30cm squeeze segment will be merged with the 1m-40cm segment to form a single squeeze beam process.
- The end of the squeeze to 30 cm can be rebuild by taking a short cut towards the CTTP2 variant. This could save some ~100 s of squeeze time.



# β*-leveling – where can we go?

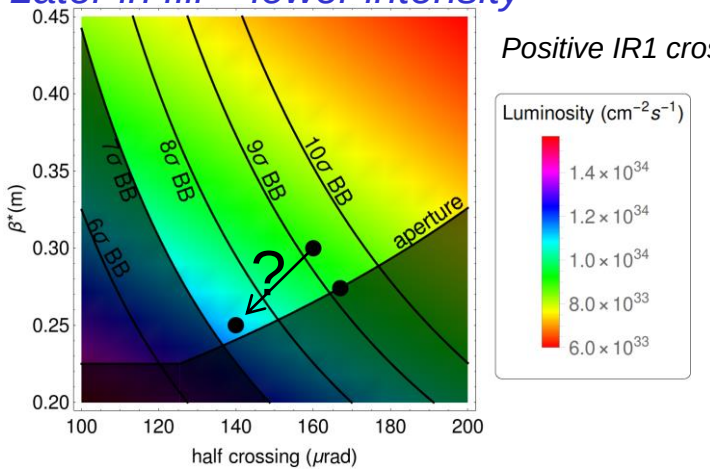
- Better reach in β* as limits from beam-beam, triplet heat load, and pileup are relaxed at smaller bunch intensities. Limit depends on bunch intensity
- Could reach 25 cm later in fill staying above 7 σ beam-beam separation
- **Exact path of leveling still to be defined (β* -values and crossing angles)**
  - Work on leveling scenarios by OP and Y. Papaphilippou + team

*Start of fill*




*Positive IR1 crossing*

*Later in fill – lower intensity*



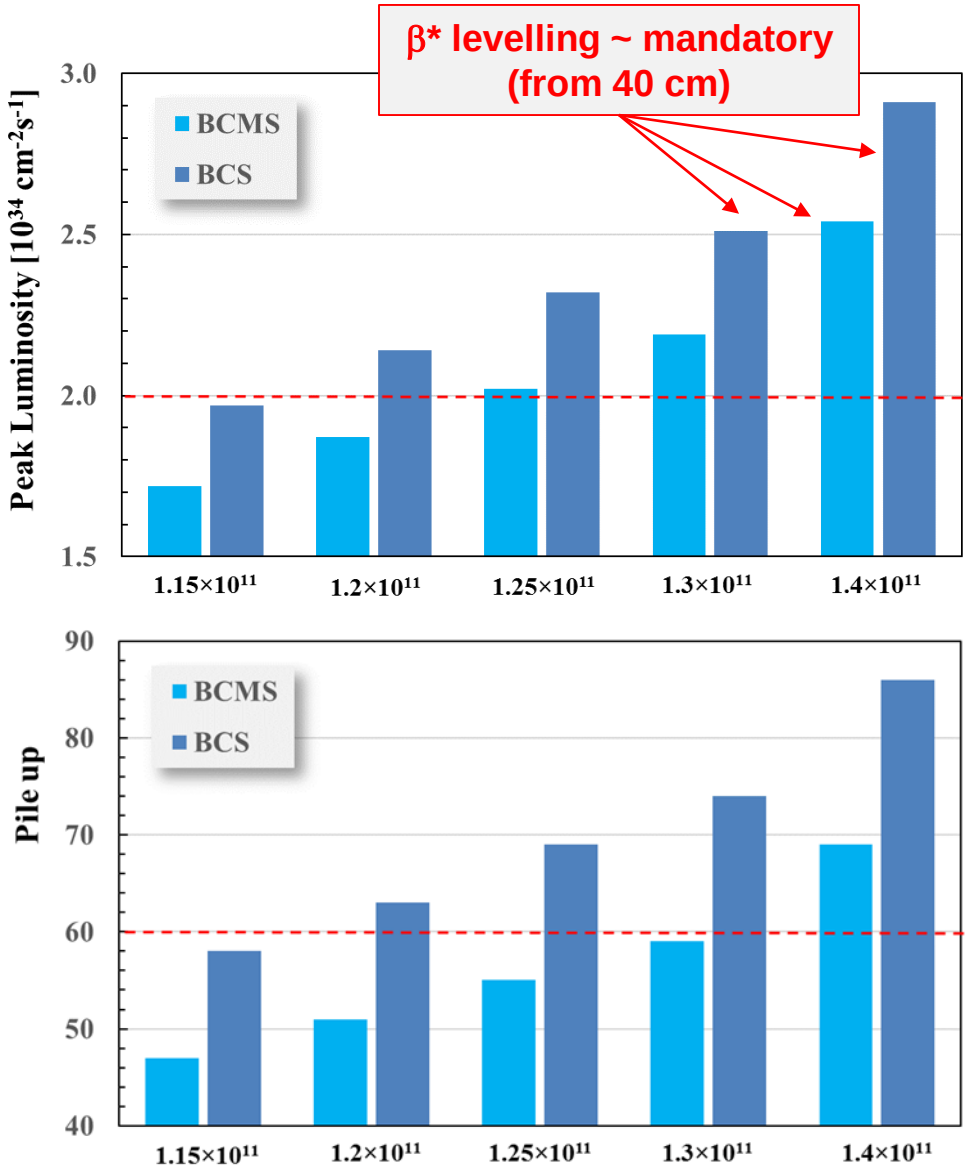

*Positive IR1 crossing*

# 2-stage β* levelling

- Introducing β* levelling in stable beams implies that we schedule calibration runs for CTPPS/AFP at all (max 3) β* values.
- To decouple the commissioning of β* levelling and the CTPPS calibration runs, we could re-use the 2017 crossing levelling strategy:
  - In the initial commissioning we only perform the CTTPS/AFP calibration at 30 cm for the extreme 30cm crossing angles: 160 – 120 μrad.
  - During the running period until TS1 we test β* levelling at the end of fills first in ADJUST and later in STABLE BEAMS to gain some experience with the technique and refine the strategy.
  - After TS1, during the re-validation phase, we perform the CTTPS/AFP calibrations at lower β*.

# Peak luminosity and pile-up

- Parameters:
  - β* 30 cm.
  - ½ xing angle 160 μrad.
  - 8.3 cm rms bunch length (1.1 ns)
  - Emittance (slightly pessimistic for lower $I_b$):
    - BCMS : 2.5 μm
    - BCS : 1.8 μm
- BCMS pile-up remains ≤ 60 up to $1.3\times10^{11}$ ppb.
- β* levelling may become mandatory for peak L above $2.5\times10^{34}$ $cm^{-2}s^{-1}$ !

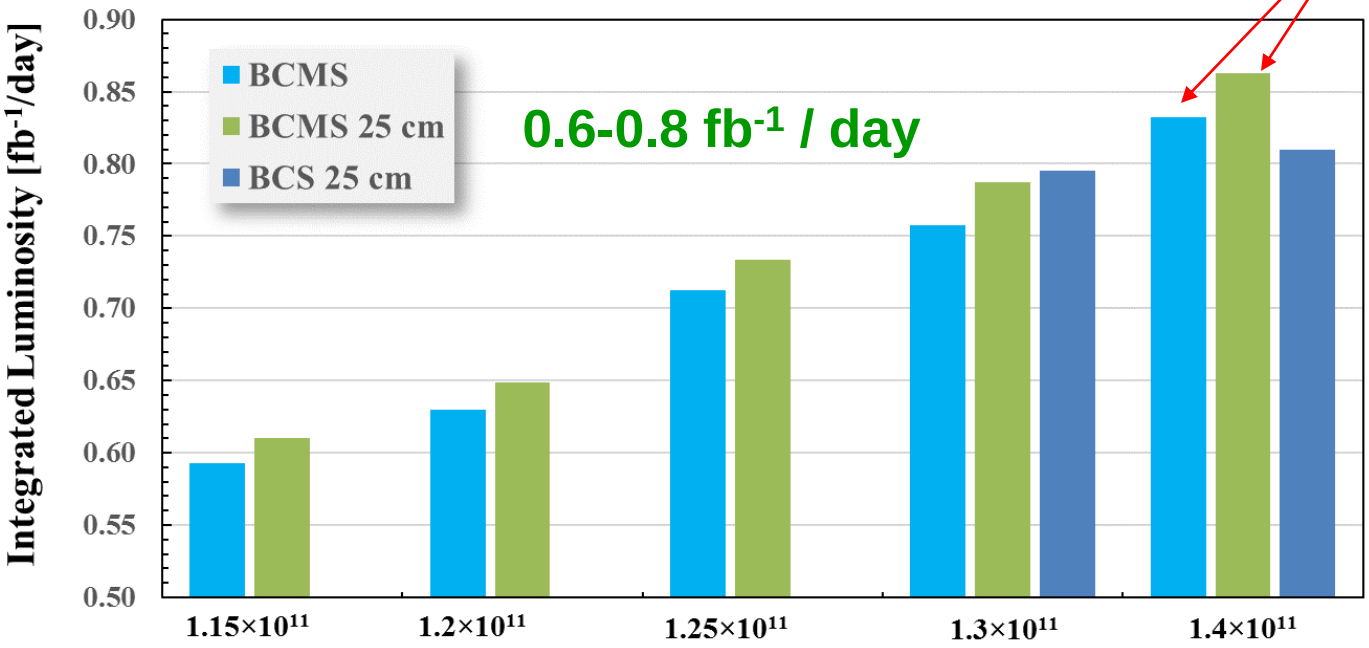


# Performance by fill

- Integrated luminosity per day estimates for 12 hour long fills scaled to **50% efficiency for stable beams**.
  - Emittance growth and levelling scenarios are included.
  - For β* < 30 cm: first β* levelling, then crossing angle levelling (not exactly initial plan) – **gain from β* levelling ~3-4%** – depends on scenario.
  - BCS assumes offset levelling to pile-up of 60 !

*Y. Papaphilippou et al*

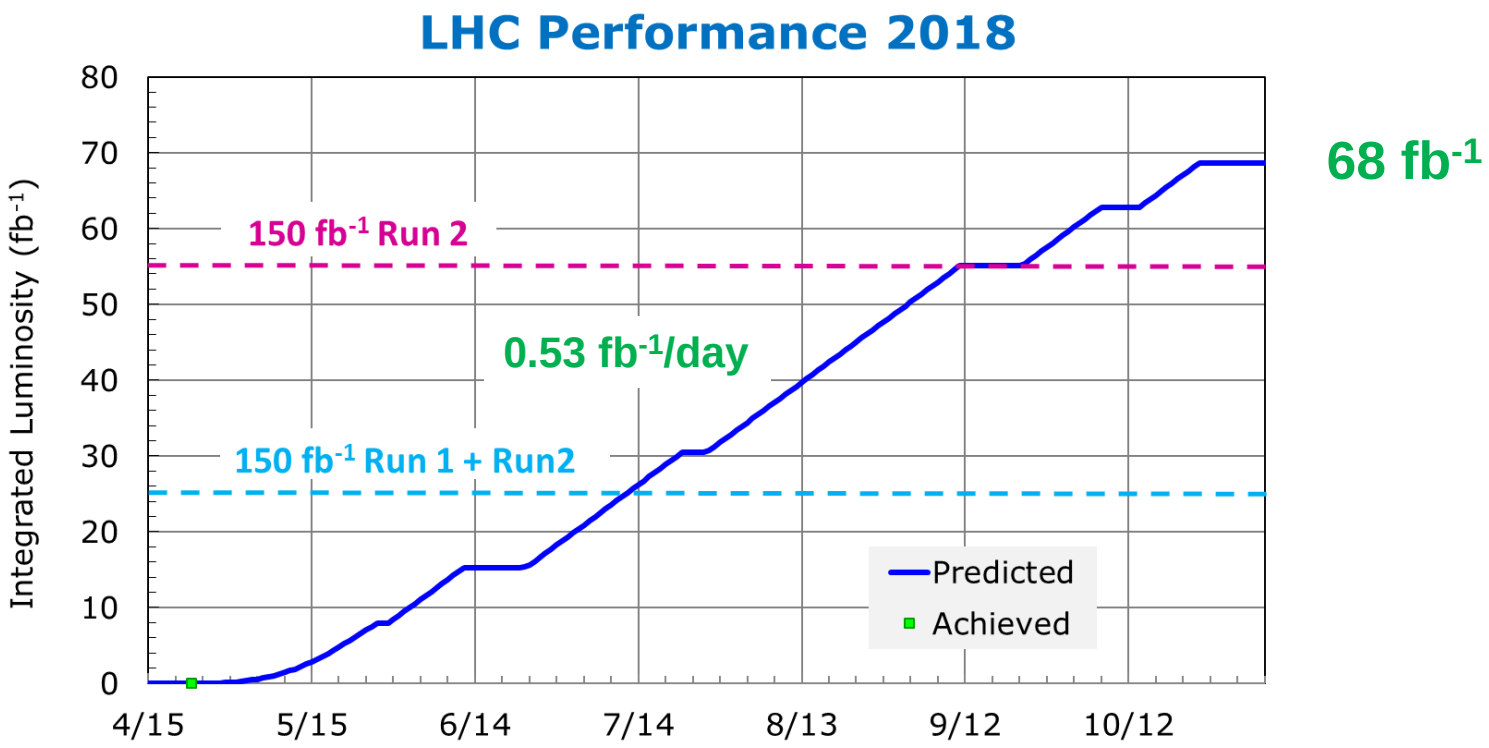
*Injection kickers !*
*Heat load !*
*Injectors (SPS) !*



# Performance ATLAS & CMS

- Model of the 2018 performance for BCMS beams.
  - **$1.15\times10^{11}$ ppb** (achieved in 2017),
  - **45% stable beams efficiency**,
  - half crossing angle of **160 μrad**,
  - without added value of β* levelling.

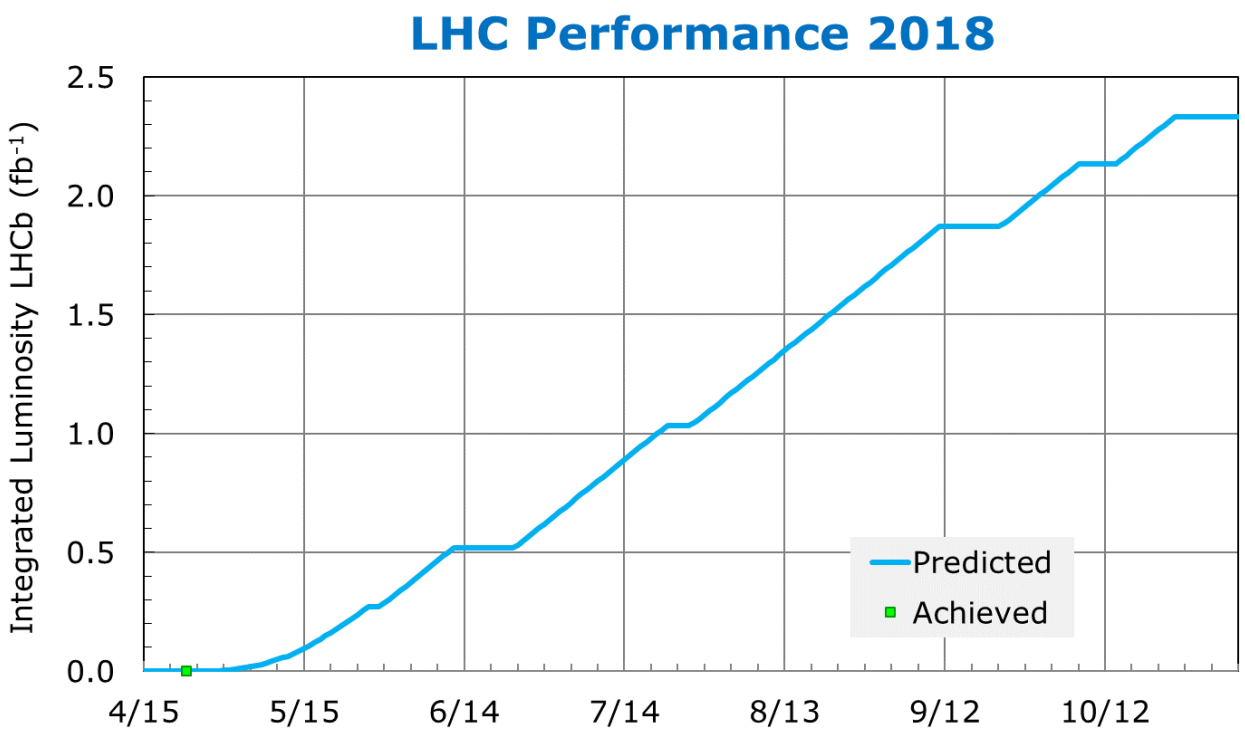
| Margins |
|---|
| >5% |
| 10% |
| ~5% |
| few % |




**68 fb$^{-1}$**

# Performance LHCb

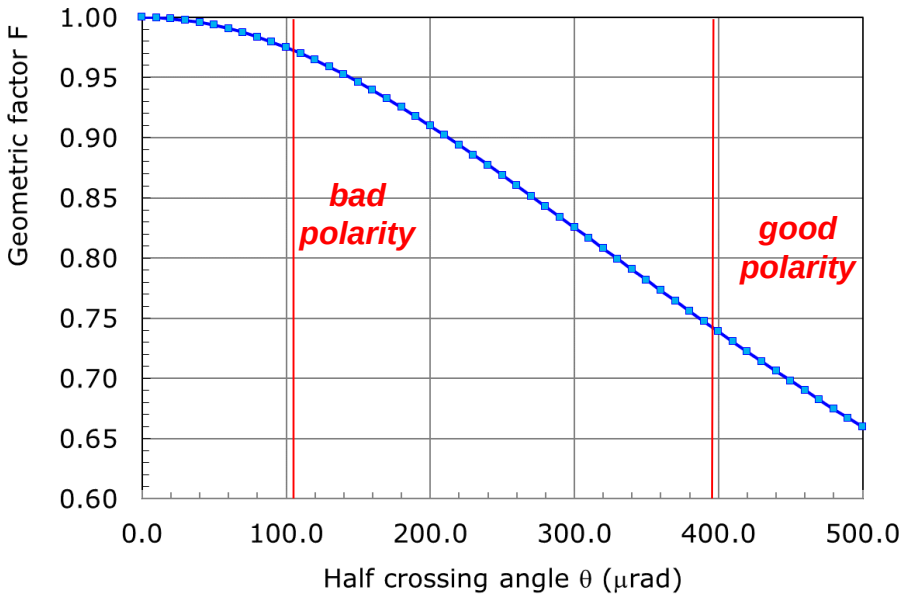
- Model based on levelling at a peak luminosity of **$4.6\times10^{32}$ $cm^{-2}s^{-1}$** for the **BCMS beam** (2332 colliding pairs) – 2017-like.
  - Integrated luminosity given purely by time in stable beams (and number of colliding pairs).
  - LHCb does not gain from higher bunch charges, smaller xing angles (in 1 & 5) and β* levelling, only availability and beam type matter.




**~ 2.3 $fb^{-1}$**

# IR8 crossing angle levelling?

- In Chamonix S. Fartoukh suggested to replace the bunch length blow up performed for LHCb for the good polarity with a crossing angle reduction.
- Crossing angles at IP8:
  - The external ½ crossing angle is -250 μrad,
  - The internal ½ crossing angle is ± 145 μrad (spectrometer bump),
  - With **good** polarity (PC polarity +) the full ½ crossing is -395 μrad,
  - With **bad** polarity (PC polarity -) the full ½ crossing is -105 μrad.
- The geometric factor F for β* = 3 m:




- The longitudinal size of the interaction region is reduced by ~25% in good polarity.
  - Size ~ F.
- To gain the equivalent of 10% bunch length blow up, the external angle should be **reduced to -150 μrad** (or less) with good polarity.

# IR8 crossing reduction

- Option 1: reduce crossing angle at the start of the fill.
  - Collide,
  - Optimize IR1 & IR5,
  - Optimize IR2 & 8 in crossing plane, levelling in IR2,
  - Reduce crossing angle in IR1 and IR5 (if applicable),
  - Reduce crossing angle in IR8 in steps,
  - Levelling in IR8.


- Option 2: reduce during the fill.
  - Switch off levelling and apply a step in crossing angle (≤ 20 μrad),
    - Lumi change ~ within the levelling tolerances.
  - Repeat 5 times at some interval.
- Option 1 delays the start of data taking / levelling for IR8, while option 2 implies that LHCb will operate with a number of distinct crossing angle configurations (issues for data analysis?).