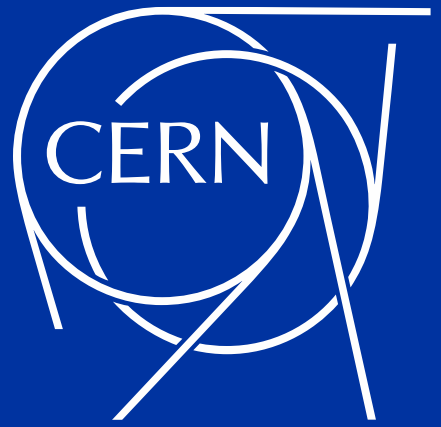


# Beam-beam and luminosity studies

G. Sterbini on behalf BB and Luminosity team and the HL-WP2

Acknowledgment to the MD coordinators, H. Bartosik, P. Belanger, X. Buffat, C. Droin, I. Efthymiopoulos, S. Fartoukh, A. Fornara, M. Giovannozzi, P. Hermes, M. Hostettler, S. Kostoglou, E. Lamb, T. Levens, N. Mounet, Y. Papaphilippou, M. Solfaroli, S. Redaelli, J. Wenninger, R. Tomas, G. Trad.

# Beam-beam and luminosity studies (+IBS, +crabbing, +noise, +VdM)

## At 450 GeV

- **MD11663: Emittance BU at injection for for the HL-LHC single bunches** → IBS focused, 4 h
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## During the ramp

- **MD6983: Emittance BU for the HL-LHC single bunches** → Measure and localize the BU, 6 h

## At 6.8 TeV

- **MD9603: BB limit at the EoL** → optimization of Run3 (nominal vs BCMS), 10 h, EoF MD (?)
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**Legend → MD1/2 or before, MD3/4, MD5**

# Studies of IBS at injection (4 h)

- **AIM:** Study **IBS for various distributions** and detect additional sources of **emittance blowup at injection** to:
  - benchmark our **IBS models**
  - study impact of **non-Gaussian tails** on IBS emittance growth
  - identifying **additional sources of emittance blowup** during injection beyond IBS
- **PROCEDURE:**
  1. Inject from SPS a few high-intensity single bunches (**2.3e11 ppb**) per SPS injection and control their tails with scraping in the SPS: 1st class “nominal emittance/nominal tails”, 2nd class “larger emittance, nominal tails”, 3rd class “large tails”. Inject also few pilots to disentangle emittance BU not intensity driven.
  2. Stay **at injection** in the LHC and perform regular wire scanner measurements (→ **WS intensive MD**).
  3. (if time allows) check effect with reduce **bunch length**, test positive/negative **octupoles** and cycle them before dumping.

# Crabbing in the LHC via HOBB (5 h)

**AIM**: measure HOBB induced **crabbing** in the LHC and test the head-tail monitor [1]

**PROCEDURE:**

- Inject 1 or 2 bunch/beam (**2.3**× $\mathbf{10^{11}}$ ppb at 2.5 um, $\sigma_z$ = 12 cm),
- Stay at injection energy and colliding in IP1 (separated in IP5);
- **dynamical change in the IP1 vertical crossing angle** from -170 to 170 $\mu$rad.

We expect to have 20 $\mu m$ peak-to-peak signal at 1$\sigma_z$ at the HT monitor, deemed in the sensitivity range of this device.

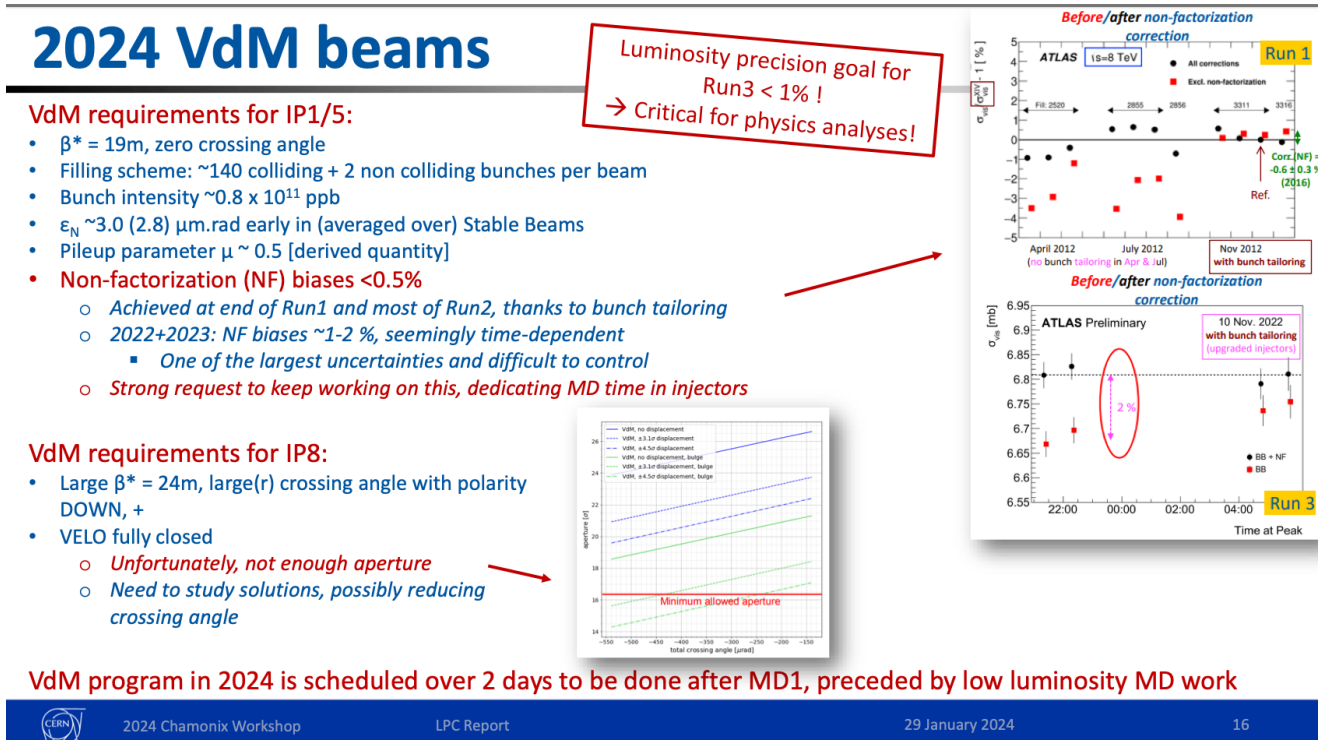
→ **Strong synergies with the HT monitor studies (T. Levens)** and possible parasitic preparation with the collision at injection (e.g., 18 March). Several SPS injections required to have fresh bunches/statistics.

[1] https://indico.cern.ch/event/1350057/

# Non-factorizable transverse distribution (4 h)

**AIM:** Inject and observe **non-factorizable (NF) transverse distributions in LHC** (see Elleanor's presentation in JAP2023).

NF start to be the dominating contributor of the luminosity calibration error and **situation degraded in Run3** → clear request from LPC to dedicate MD time on the problem. The proposal is to stage it in the different machines (PSB → PS → SPS).




Courtesy of F. Alessio

## PROCEDURE:

1. Prepare VdM like flavor in the PSB (NF and F) and after qualification in the PS and SPS, inject them in LHC (mimic part of the filling scheme of the recent VdM scans).
2. Stay at injection and using consecutive **V/H scraping** and/or **WS measurement** (→ WS intensive MD), observe and quantify if the NF feature is preserved.

→ Strong synergy with the halo/tail MD program and the LHC Luminosity Calibration and Monitoring Working Group

# Beam-beam and luminosity studies (+IBS, +crabbing, +noise, +VdM)

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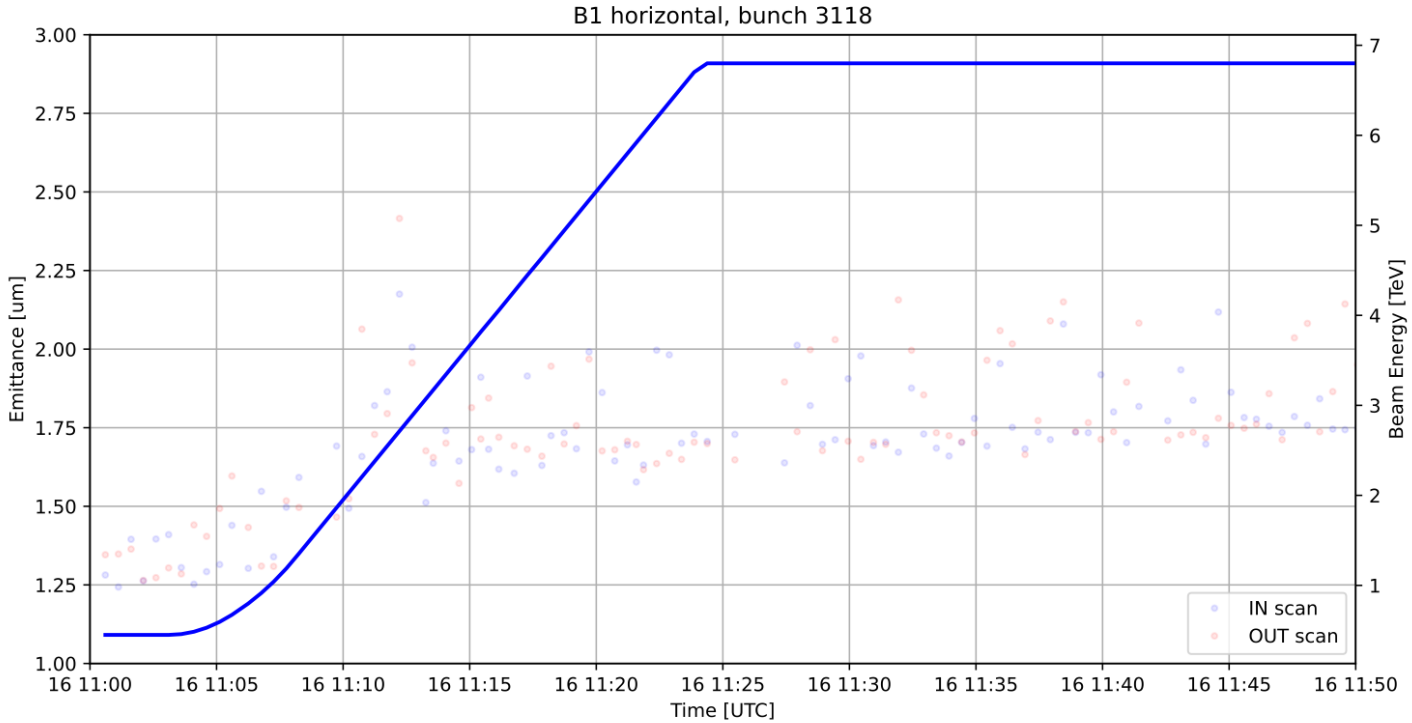
# Emittance BU of HL single bunches (RAMP)  6 h

**AIM:**
Quantify the the HL-LHC single bunch emittance blow-up during the ramp.

**PROCEDURE:**
Very similar approach of the BSRT calibration but with the bunches having **2.3e11 ppb** and emittance injected in range of **1.5-2.5 urad**. (1.3e12 p was the integral for BSRT calibration, FILL8778). In principle we could consider **5 HL-LHC  bunches** per beam (TBC).

Once ramped, we could test the **end-of-collapse** and stay in collision for 30 min.
→ Partial synergy with the BSRT calibration
→ WS intensive MD

BSRT Calibration in 2023 (courtesy of G. Trad)




Depending on the result:
- test bunches with different scraping from the SPS to see the tail evolution.
- test a single bunch (SETUP beam) with relaxed collimators.)

# Beam-beam and luminosity studies (+IBS, +crabbing, +noise, +VdM)

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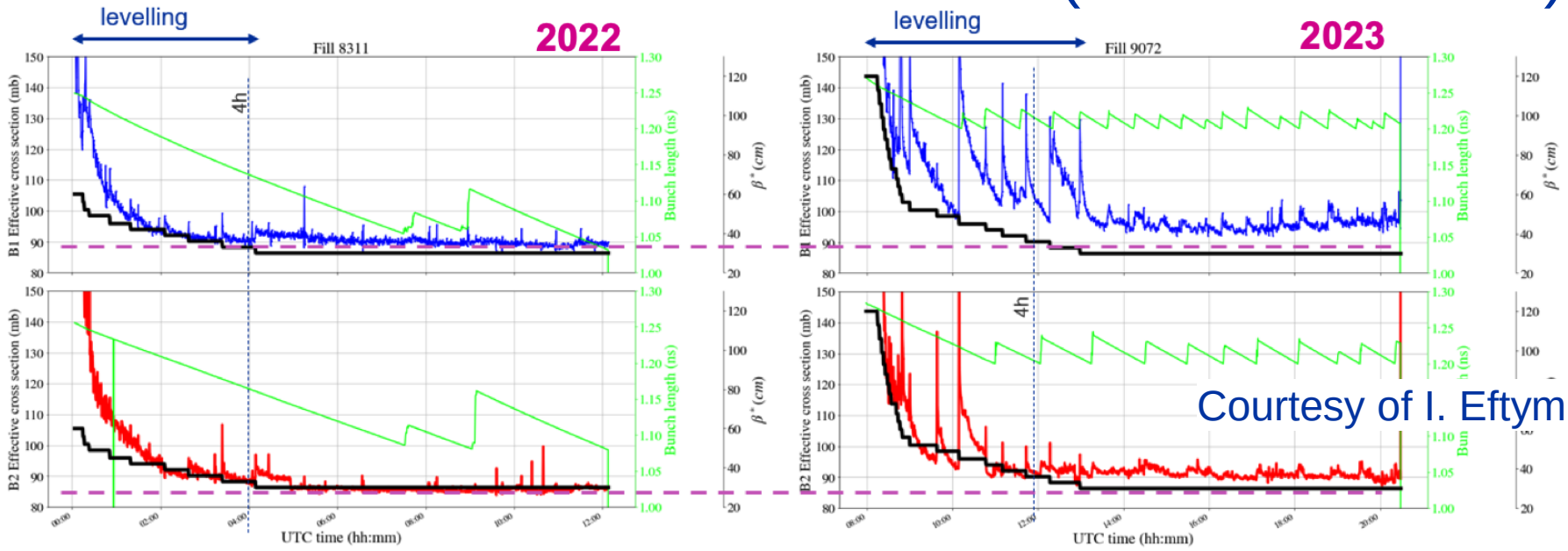
# **Explore the BB limit for nominal and BCMS** (EoF MD or 10 h)




Courtesy of I. Eftymiopoulous

**AIM:** Interest to see the BB limit at the EoL. Observations during 2023 show extra-losses during the levelling step. Chamonix → to validate the performance Nominal vs BCMS. As commented by Stéphane: performance should be evaluated at constant BB limit (BCMS could **work at lower crossing**

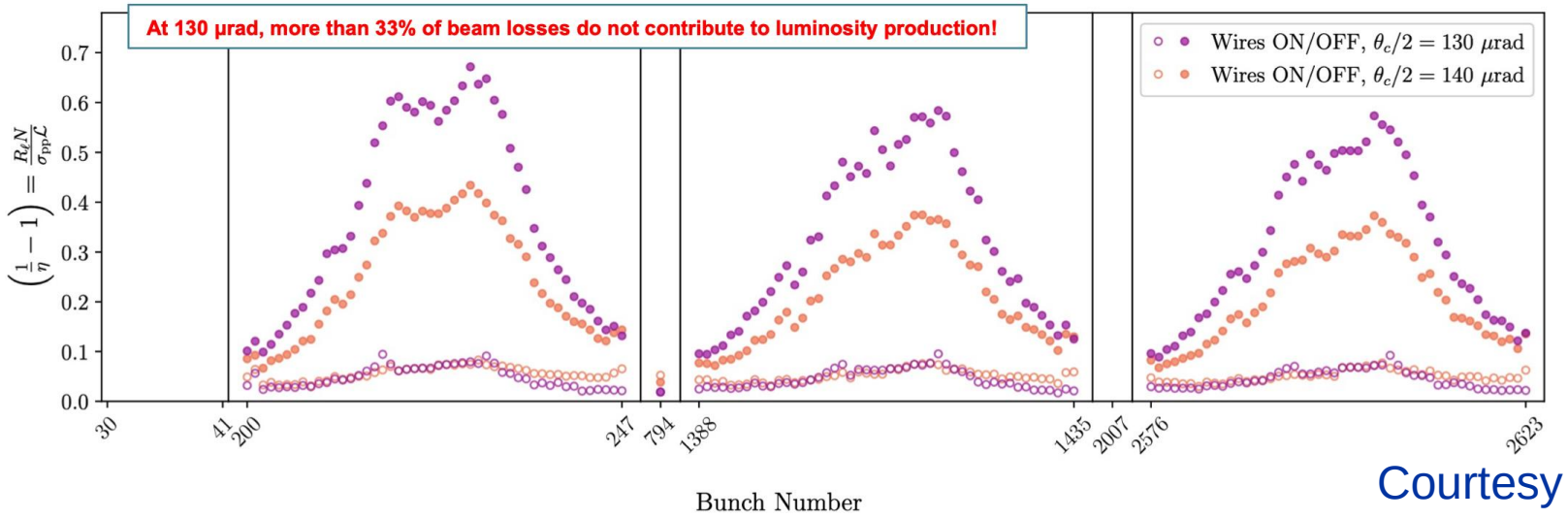
**PROCEDURE:** Explore BB limit for nominal/BCMS bunches at EoL (e.g. reduce Xing angle 160 → 120 urad).
We assume $\beta* = 30$ cm and >4 trains at top energy .
Ideally we would like to profit of the **octupole reversal polarity** (from the start of SB).
We would like also to use the **wires compensators**.

**Can it be and EoF MD?**

# Extra losses during collisions

- **AIM:** To study the impact of distributions with different tails from the injectors to the extra losses observed  at the start and during collisions.
- **PROCEDURE:**
  - During intensity ramp up, SPS injections with nominal and aggressive scraping
  - Compare effective cross section during the L-levelling for the different scraping flavor
  - **Can it be included in the intensity ramp-up?**

# Wire compensation and β* leveling (8 h)




Courtesy P. Belanger

**AIM**: In 2022 we tested the wire compensation during crossing angle anti-leveling at constant β*. We propose to explore the **compensation varying β*.**
The segment **20<β*<30 cm** range is interesting for us: pushed BBLR and potential to extend the L-level time (e.g. Run4 perspective).

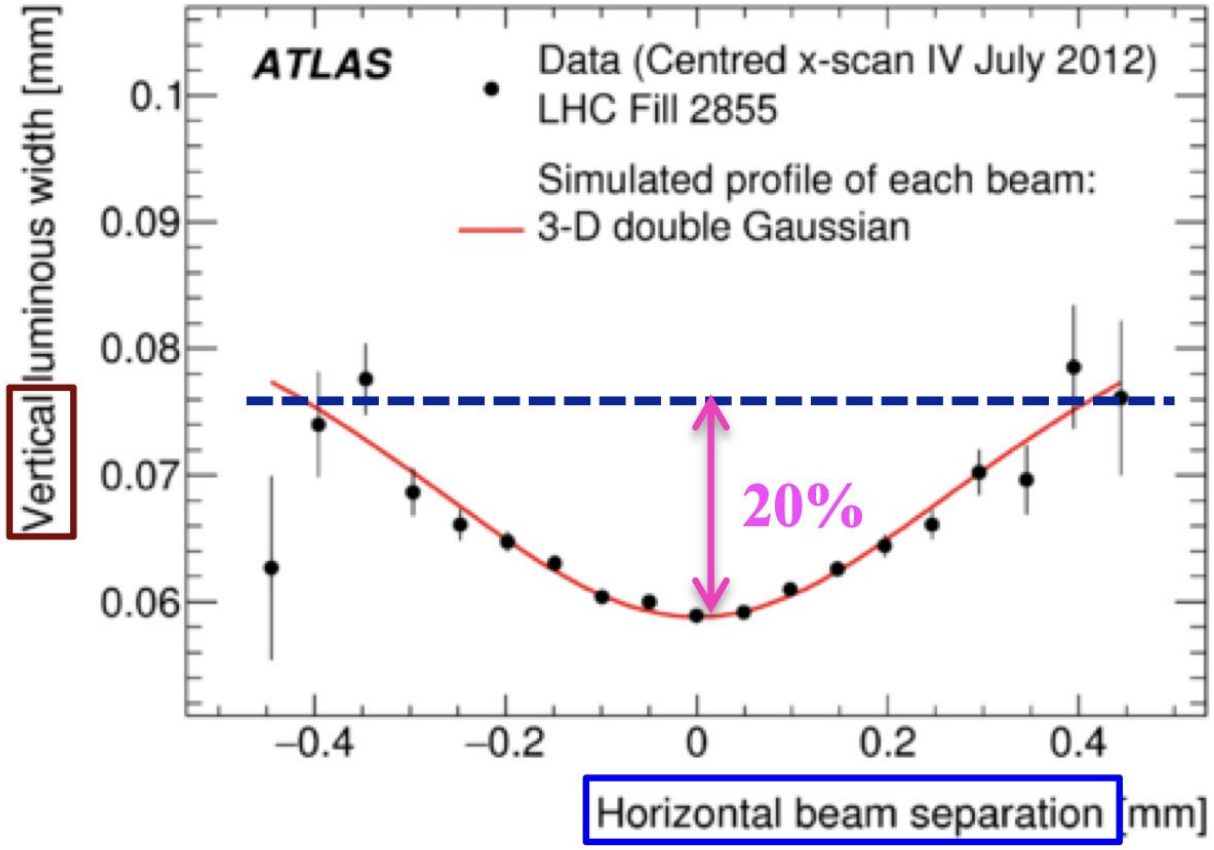
**PROCEDURE**: Collide 3 or 4 trains of nominal and BCMS. Inject the trains to have several super-PACMAN bunches (see plot of BB signature above). Power ON-OFF the wire at different beta* (e.g. 20<β*<30 cm range + at β*=20 cm, reduce the xing.

# VdM bunches and non-factorization (8 h)

**Preliminary: we need to further discuss with the experiments on the feasibility of such study!**

**AIM**: Verify if NF distributions, if measured at 450 GeV, are transported and L-visible at 6.8 TeV → if confirmed this is an important ingredient in the understanding the NF of the VdM scans.

**PROCEDURE**: Use the VdM cycle and filling scheme but interleaving NF and F bunches. Accelerate to FT and perform **luminosity scans (TBC)** and **scraping tests** to verify if and how much the NF is transported from FB to FT.




Courtesy of W. Kozanecki

→ Strong synergy with the halo/tail MD program and the LHC Luminosity Calibration and Monitoring Working Group

# Noise from the dipole converters (6 h, HL cycle)

- **AIM**: Understanding if 8 kHz cluster is related to main bends power converters leveraging on the **HL optics high-tele index**, switching **ON and OFF the active filters** of MB power converters (as done in MD4147 but using the ADT obs-box for b-by-b and t-by-t measurements). → Important reference measurement before the **MB PC upgrade next EYETS** (ECR LHC-R-EC-0002).

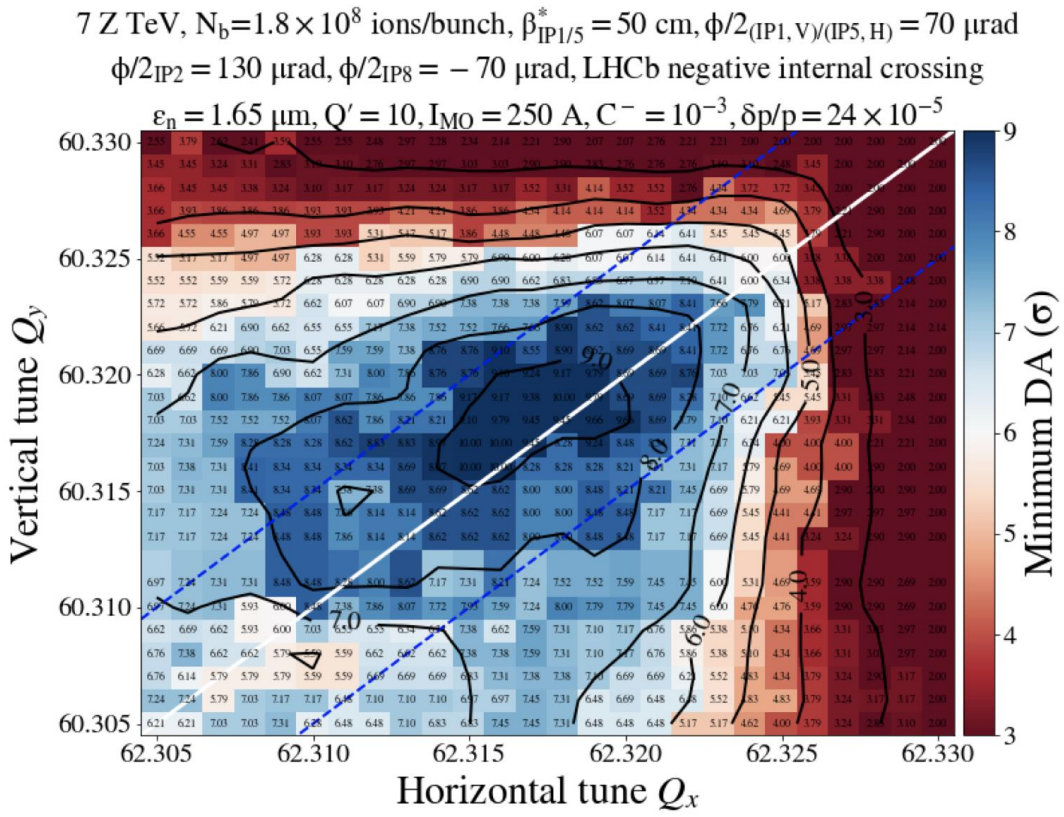
- PROCEDURE:
  1. Inject 20 PILOTs regularly distributed in the machine
  2. Ramp-up and **HL** squeeze (see Riccardo's presentation) with **maximum tele-index**.
  3. Observe the 8 kHz spectrum while switching **ON/OFF the MB active filters**.

# Ions and BB 2025 configuration (8 h)

**AIM**: test a new optics and **reduced crossing configuration for the 2025 ions** run. Potential performance gain (especially in IP8 thanks to reduced β*).

**PROCEDURE:**
After validation of the smaller β* optics in IP8.
$\theta_x$-scan in IP1/2/5/8 with β*=50/50/50/? cm (4 trains at top energy).
Procedure is to be finalized.

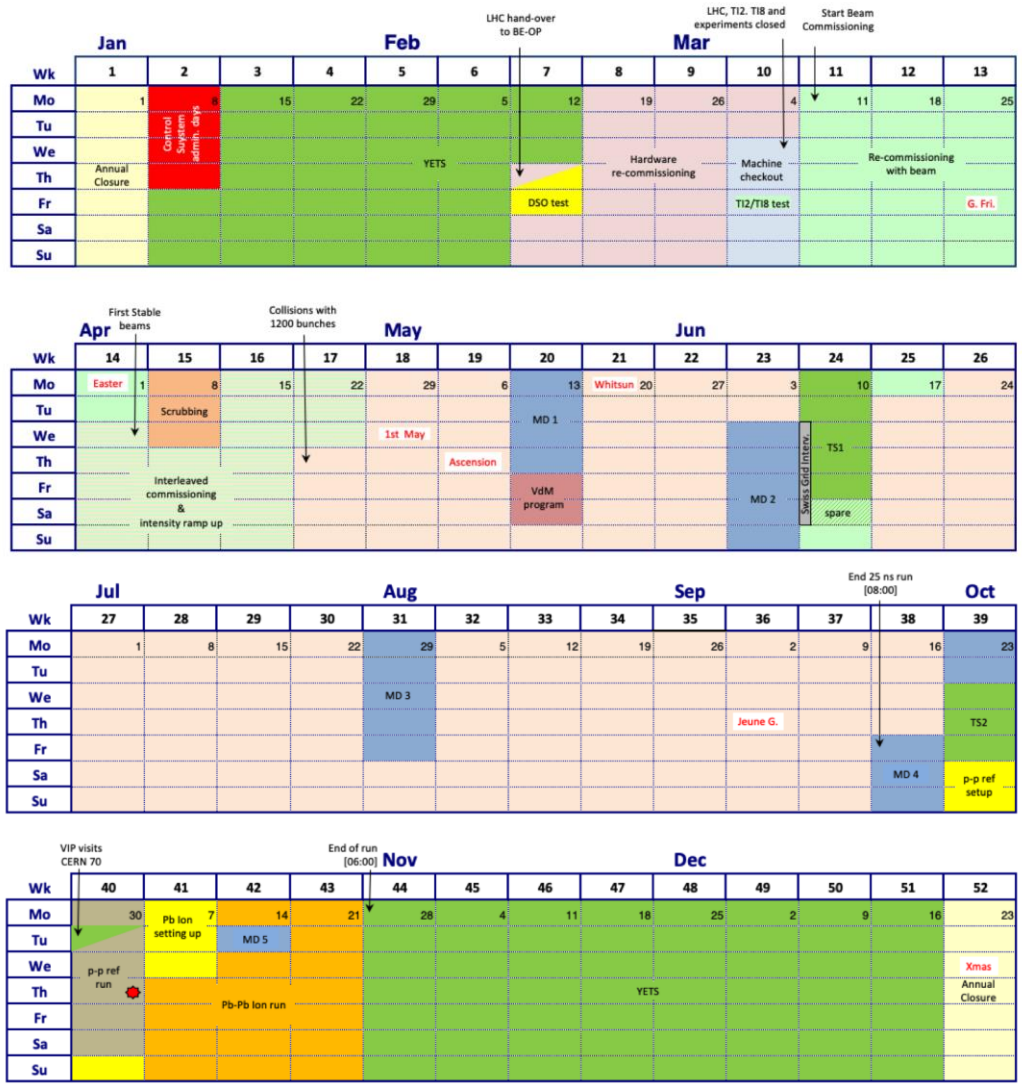
Ions DA simulations with reduced $\theta_x$



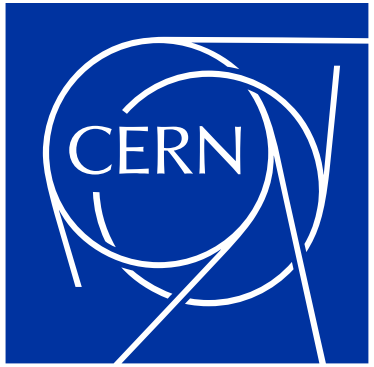

Courtesy of S. Kostoglou

**Thank you for your attention.**

# 20 days of MDs




https://edms.cern.ch/document/2872429/1.0

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