
CERN

Joint Accelerator Performance Workshop

5-8 December 2022

https://indico.cern.ch/event/1194548/

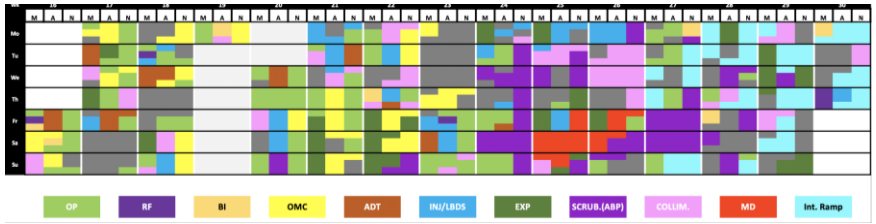
JAPW – session 4
Accelerator performance: LHC

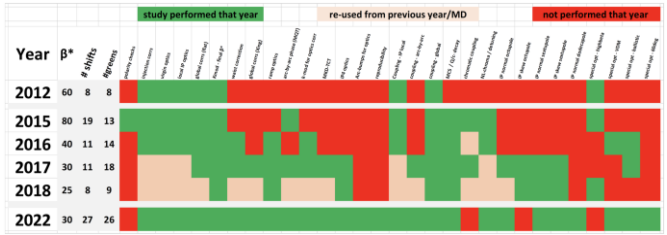
Roderik Bruce, Matteo Solfaroli

Many thanks to:
G.Trad, E.Maclean, F.Van der Veken, C.Bracco, D.Jacquet,
M.Hostettler, N.Mounet, S.Kostoglou and P.Hermes

Looking back at 2022

- It was a **successful year**!
  - **Effective and complex** commissioning after LS
    - Amazing experts' availability and strong commitment
  - **NO limitation** on commissioning
  - **40 fb^{-1}** despite all problems encountered (at the price of postponing IONS and high-beta runs)
  - Reached **L=2.4x10^{34} HZ cm^{-2}**, ~2.5 times beyond design value
- **Complex commissioning** coming out of an LS, including new HW, SW and systems
  - Extensive system commissioning, including **all steps** from scratch, several challenges during commissioning, with consequent impact on the extra-time, consuming contingency
  - Next year a **reduced commissioning** is to be expected





Where are the limits?

- Tighten collimator settings and/or Xing angle to **gain in beta* reach** (margin in octupoles available)?
  - Shall we push now or postpone aggressive (and more complex) scenarios to second part of Run3?
- Limitation on IT cooling indicates that LHC could stably operate at **2.4×10^{34} Hz cm^{-2}**
  - What is **acceptable pile-up** for experiments?
- **Filling schemes** studies
  - **Pure BCMS** limited by heat load and dump kicker (is conditioning possible?)
  - **Mixed scheme** high performance, while generating larger workload for injectors
  - **Pure 8b4e**
    - Does it allow cryogenic system in economy mode? How many plants? How much saving?
    - HW limitation?? Observed vacuum spikes on 800 MHz cavity in SPS
  - Shall we define a **new performance indicator** as integrated luminosity per MW/h?
- **1.8×10^{11} p/b** is it ready for LHC production?
  - When will it be available from injectors (besides test and MDs)? Are there HW limitations in SPS?

Where should we put our attention?

- **Machine validation** in presence of strong non linearities
  - High losses on TDIS at injection (steady state losses may be problematic for HW)
  - Strategy to be reviewed to ensure coherent validation
- **AC-DIPOLE**
  - Performance and reliability vital for optics studies - **NO limitation** on 2022 commissioning
  - Significant interest in potential for **further improvements** in AC-dipole capability
- **TCLIA setting** strategy defined for proton and ions (device alignment in the tunnel not foreseen before EYETS 23/24)
- Strategy for **improving losses** during injection
  - **MKE6 flatness** improvement possible (device is within specification)?
  - **Relax openings** of critical collimators by 0.5 σ -> Check ring collimator hierarchy
  - Is large effort on **tail cleaning** justified?

What's the vision for the future?

- **Building on experience**, procedure and knowledge, OP can perform tasks previously done by system experts
  - **OP resource reduction** had limited impact on operational performance (also thanks to increased automation)
  - **Improved automation** is key (i.e. loss maps application, FMCM, K-modulation,…)
  - Result in **increase flexibility** of commissioning (OP present 24h) and in **pressure release** on system experts (often involved in commissioning/operation across the complex)
  - **Closer collaboration** between system experts and OP on tool development mandatory
  - **Continuous effort** in development of methods and tools is fundamental
- Improve **injection process** (significant spread cycle by cycle)
  - Transfer line **drifts & steering**
    - Steering cost in term of time is not negligible (dedicated sessions needed)
    - 12 bunches trajectory is not representative of trains
    - ➔ **2023 strategy**: steering during fill (>12 b) if corrections within FEI limits (automatic steering under study)
  - Missed injections and beam quality: **earlier setup** of LHC beams?
  - **Dedicated filling** (potential increase ~15% in filling time + less blow-up) ➔ Proposal to use it for some time (1 week?)

Actions for follow up

- Review of **strategy for machine validation** in presence of non-linearities (MPP, COLL)
- Clarify if **need for AC-DIPOLE upgrade**? (OMC, ABT)
- Follow-up on **steady-state losses** on TDIS (ABT, ABP, OP) to ensure limiting impact on HW
- Tackle the **losses during injection** to avoid future limitation (ABT, COLL, OP)

www.cern.ch