Short Recap of BPM Interlocks in Run 2 and LS2 Collimation Upgrades

A. Mereghetti, on behalf of the LHC Collimation Team
In-Jaw BPMs

- **In-jaw BPMs are relevant for:**
  - Collimator alignment:
    - Faster than BLM-based procedure;
    - Beam is not touched $\rightarrow$ no losses;
    - Measure beam angle (by design);
  - Monitoring of closed orbit at collimators:
    - Check of collimator centering;
    - Fill-to-fill reproducibility;
    - Possibility to implement interlocks on closed orbit;
  - Collimators with in-jaw BPMs as of end of Run 2:
    - All TCTs – IR1/2/5/8; 16
    - IR6 TCSPs; 2
    - IR7 TCP.C6L7.B1 (HL-LHC prototype); 1
    - IR7 TCSPM.D4R7.B2 (HL-LHC prototype), with third BPM mounted on the tank; 1
    - Wire TCLs (not TCTs), i.e. TCL.4L5.B2 (IR5) and TCLVW.A5L1.B2 (IR1); 2
In-Jaw BPM Interlocks

History

- 2016: analysis of BPM readouts (pp run) with proposal of settings (G. Valentino, 211th LHC Coll WG meeting);
- 2017:
  - Interlocks deemed necessary to push $\beta^*$ down to 30 cm (from 40 cm, after TS2 – R. Bruce, 6th Evian Workshop);
  - Testing + fixes (A. Gorzawski, 221st LHC Coll WG meeting);
  - Deployment (un-masked interlock) started after TS2;

Settings

- The interlock settings consist of:
  - A table of $\beta^*$ versus collimator $\beta$ and interlock tolerance in $\sigma$.
  - A reference emittance (3.5 $\mu$m) to define the beam size.
- SIS logic:
  - Reads back the appropriate $\beta^*$ and the energy,
  - Interpolates the collimator $\beta$ and tolerance for that $\beta^*$,
  - Calculates the beam size at the BPM,
  - Normalizes the two BPM readings by the beam size,
  - Finally applies the tolerance $\Rightarrow$ interlock if both BPMs are out of tolerance
- The interlock limits are currently set to 4$\sigma$ except for:
  - 1$\sigma$ in IR1 and IR5 at $\beta^*$= 40 cm,
  - 1.5$\sigma$ in IR6 at $\beta^*$= 40 cm (linked to IR5 $\beta^*$),
  - 2.5$\sigma$ in IR8 at $\beta^*$= 3 m.

J. Wenninger, 127th MPH Meeting;
In-Jaw BPM Interlocks (II)

- Aim of in-jaw BPM interlock in Run 2: to ensure that operational margins between TCTs and IR6 protection devices are in place (asynchronous beam dump);
  - Reduction in margins necessary to accommodate pushed values of $\beta^*$;
  - Interlock on TCTs and IR6 TCSGs BPM readouts;
- No spurious dump from interlock once activated (2017 TS2 – A. Mereghetti, 8th Evian Workshop, and N. Fuster Martinez, 9th Evian Workshop);
- Orbit excursions at TCTs well below interlock settings (A. Mereghetti, 238th LHC Coll WG meeting for 2018 data);
  - It could be good to have a final overview report for the entire Run 2…
- Tank BPM useful for monitoring beam orbit on the non-cleaning plane;
  - Useful verifications in case the 5th axis is deployed;
LS2 Collimation Upgrades involving new BPMs:

- **4 TCSPMs per beam (LHC-TC-EC-0014):**
  - Mo-coated MoGr jaws;
  - In-jaw BPMs + tank BPM;
- **2 TCPM per beam (LHC-TC-EC-0016):**
  - MoGr jaws (no Mo coating);
  - In-jaw BPMs + tank BPM;
- **1 TCLD in-between 11 T dipoles per beam (LHC-TC-EC-0013):**
  - In-jaw BPMs only;
- **1 TCLD in empty cryostat per beam (LHC-TC-EC-0012):**
  - In-jaw BPMs only;

NB: relocation of wire collimators (LHC-TC-EC-0019) does not imply new BPMs!

32 new in-jaw BPMs + 12 new BPMs on tank; → Interlock strategies?
Conclusions

• In-jaw BPMs have proven to be precious tools for collimation for fast and clean jaw alignment, and for beam monitoring and interlocking;
  • At the basis of tight operational margins between TCTs and IR6, allowing to push $\beta^*$ in Run 2 to 30 cm;
• New collimation hardware planned for installation in LS2 comes with new in-jaw BPMs and tank BPMs;
  • Increase beam monitoring, especially in IR7;
  • Potential to establish new interlocks for safe operation:
    • IR7 TCPM(s): to avoid large excursions on beam closed orbit;
    • IR7 TSPMs: to avoid un-wanted scraping of the coated surfaces;
    • IR7 TCLDs: to assure correct beam position wrt collimator jaws (e.g. bump for mitigation of losses);
• Open question by A. Gorzawski (221st LHC Coll WG meeting):
  • Can we deploy smoother functions on interlock settings?
Thanks for your attention