

Injectors: MD beams in Run3 and planning

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Using input from LIU workshop (Montreux 2020)

LHC MD day 2020

Outline

- **Introduction to LIU upgrades and expected injectors performance**
- **Beam commissioning in 2021 and performance ramp-up in Run 3**
- **Feed-back on LHC MDs in 2018 and proposals for improvements**
- **Summary and conclusions**

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Overview of new systems and injector upgrades during LS2

○ PSB

- Connection to Linac4 → New H⁻ charge exchange injection at 160 MeV from Linac4 to double brightness of LHC beams
- Acceleration to 2 GeV with new main power supply POPS-B and replacement of C02-C04-C16 RF systems by Finemet based RF system

○ PS

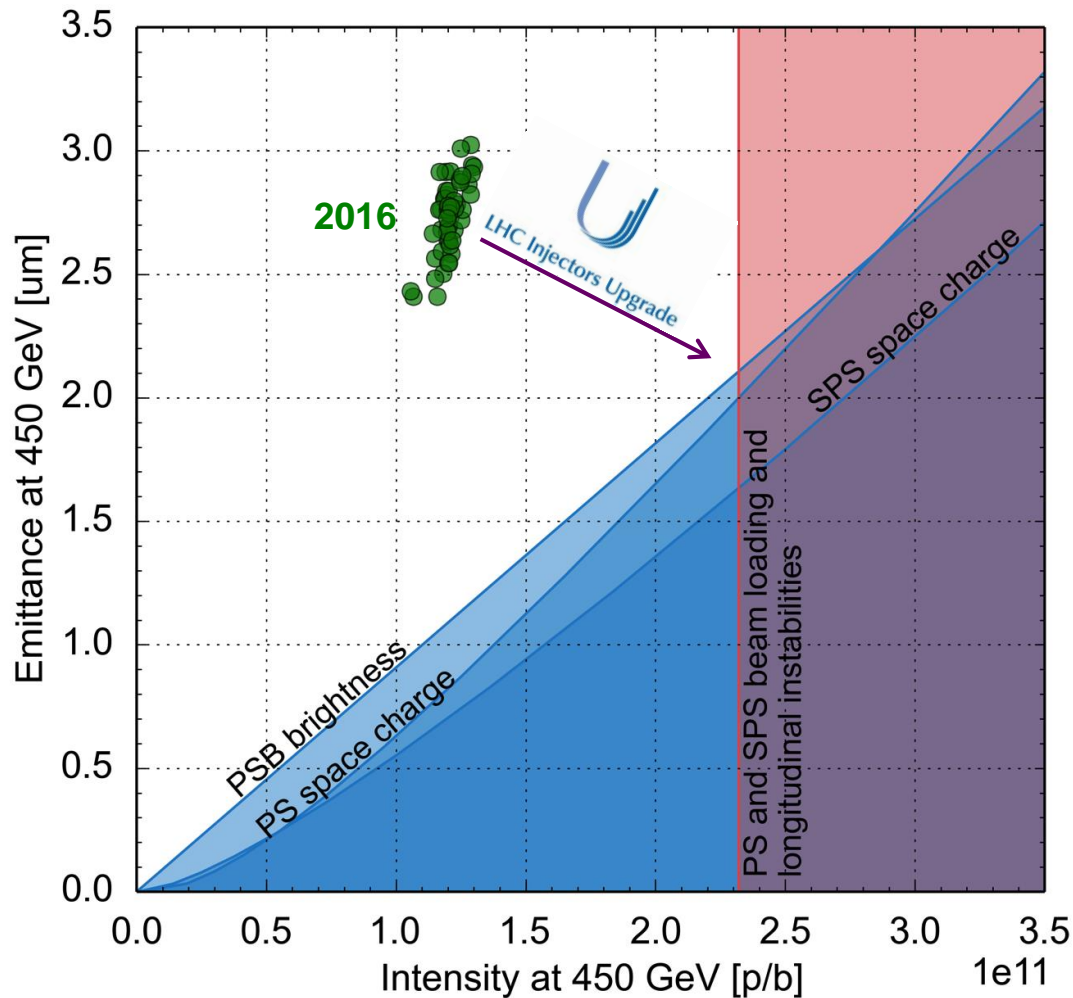
- New injection at 2 GeV for protons to mitigate space charge
- RF improvements (impedance reduction and new longitudinal feedback) to improve beam quality and increase longitudinal coupled bunch instability threshold
- Operational deployment of transverse feedback system

○ SPS

- 200 MHz RF system upgrade (rearrangement of cavities, power upgrade, new LLRF)
- Electron cloud mitigation and impedance reduction to increase intensity reach
- New beam dump system in LSS5 and new design of protection devices to comply with the target HL-LHC beam parameter values

LHC Injectors Upgrade

Expected performance limits after LIU upgrades



- Connection of Linac4 and PSB H- injection at 160 MeV to allow for higher brightness
- PSB-to-PS transfer at 2 GeV instead of 1.4 GeV to allow for higher brightness
- PS RF upgrades to reduce impedance and cure coupled bunch instabilities with feedback (Finemet cavity)
- SPS RF upgrades to increase RF power including impedance reduction and new LLRF + new beam dump and protection devices to cope with higher brightness

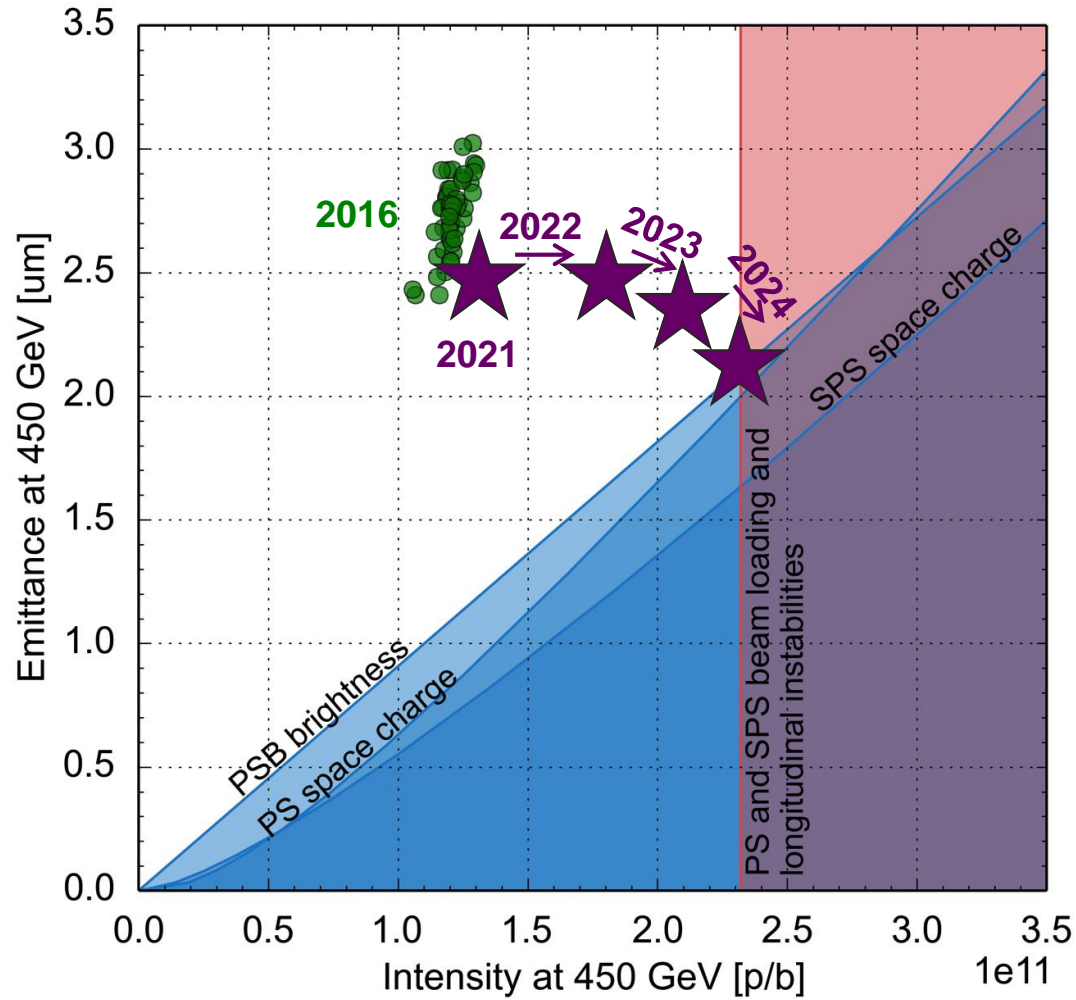
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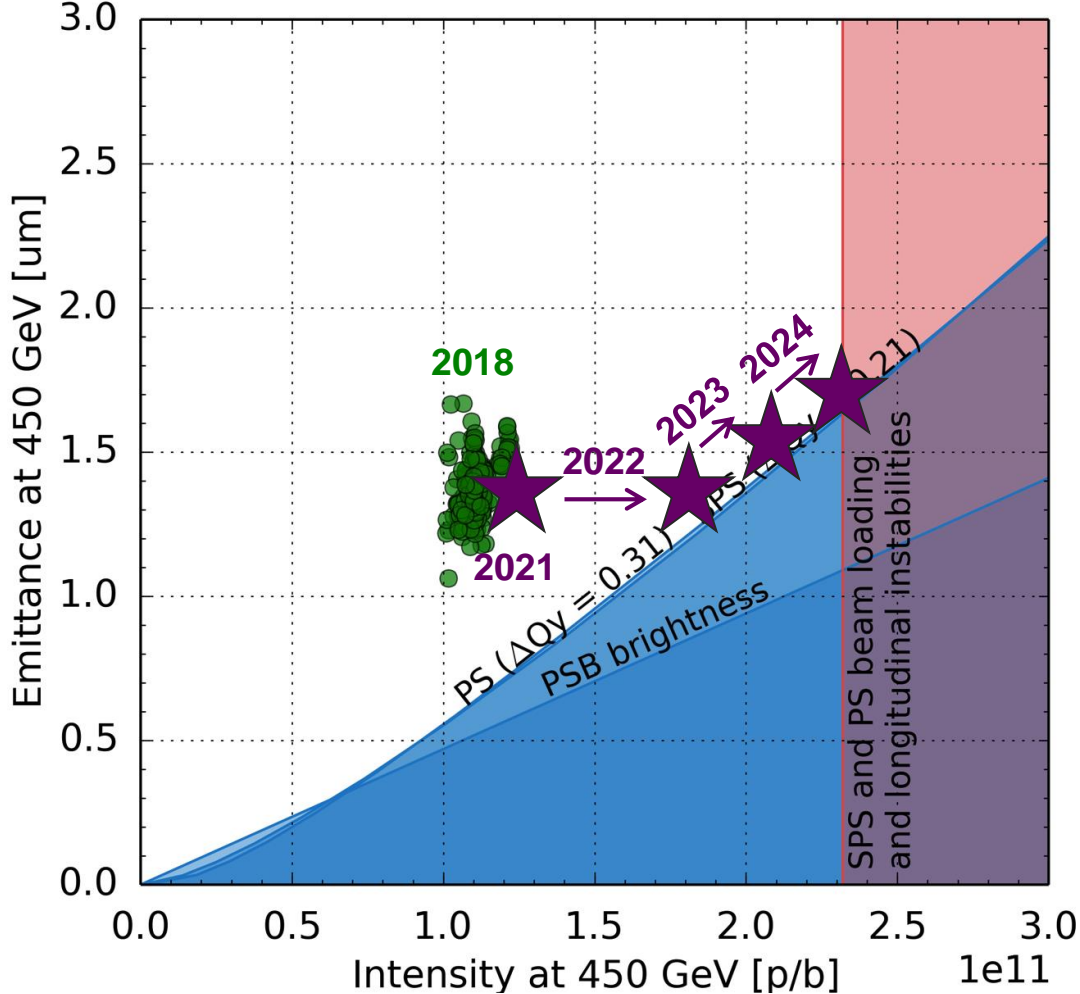
Projected performance ramp-up during Run 3

- **2021 will be devoted to recover the pre-LS2 performance with the new LIU equipment + commissioning of slip stacking with ions in SPS**
- **2022-2024 will be devoted to gradual beam performance ramp-up**
 - LIU proton intensity should be already available from the PSB/PS
 - Intensity ramp-up in SPS
 - Brightness ramp-up in the PSB and PS
- **Critical beam dynamics challenges to be addressed**
 - Emittance preservation at PSB-to-PS transfer and along the chain
 - Losses at PS-to-SPS transfer and at SPS start of ramp
 - SPS longitudinal stability throughout the cycle
 - SPS transverse stability at injection up to LIU intensities
 - Beam degradation from electron cloud in SPS

Performance ramp-up: standard beam at LHC injection



Performance ramp-up: BCMS beam at LHC injection



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Injectors experience with LHC MDs in 2018 (and before)

- **LHC MD period is stressful for the injectors**
 - Usually many non-operational beams to be prepared (lots of additional work)
- **Beam requests not always fully clear**
 - In some cases the beam requirements had to be reconstructed by the MD coordination team together with injectors team
 - Injectors need all beam parameters for preparation (intensity, emittances, number of bunches, batch spacing, bunch length, ...)
 - Also the injectors LSA cycles need to be defined (up to now done by injectors)
 - In addition: last minute changes, sometimes even on the day of the MD ...
- **Distribution of information could be improved**
 - In addition to the MD schedule in ASM, beam preparation was done based on EXCEL sheets – not clear when changes have been made and therefore sometimes different versions used for beam preparation
- **Clearly there is room for improvement of the efficiency of LHC MDs**

Proposals to improve LHC MD beam preparation in Run 3

- **All information should be centralized in MD tool**
 - including detailed beam description, LSA cycles in injectors, ...
 - as was the original idea of the MD tool!
- **Prepare option in MD tool for MD users to select pre-defined beams**
 - LHC pilot
 - LHC indiv (single bunch, operational characteristics)
 - LHC 25 ns beam (operational characteristics)
- **For MDs that require characteristics other than pre-defined beams**
 - Should organize a meeting with concerned MD users, MD coordinators and 1 representative per machine at latest 2 weeks before MD block
 - All necessary beam information (including LSA cycles) to be defined together and inserted into MD tool (after feasibility is clarified)
 - Indicate also which beam parameters are critical for each MD and which are less critical (maybe through separate option in MD tool?)
- **Beam requests need to be finalized 2 weeks before LHC MD block**

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Summary

- **2021 will be devoted to recovery pre-LS2 beam performance with new hardware and LIU upgrades**
- **2022-2024 it is planned to ramp up the performance with focus on standard and BCMS beams:**

Year	Intensity	Emittance standard	Emittance BCMS
2021	1.3e11 p/b	2.50 um	1.30 um
2022	1.3e11 → 1.8e11 p/b	2.50 um	1.30 um
2023	1.8e11 → 2.1e11 p/b	2.50 → 2.30 um	1.30 → 1.55 um
2024	2.1e11 → 2.3e11 p/b	2.30 → 2.10 um	1.55 → 1.7 um

- **Provided proposals on how to improve the LHC MD beam preparation in Run 3**

**Thank you for your
attention**