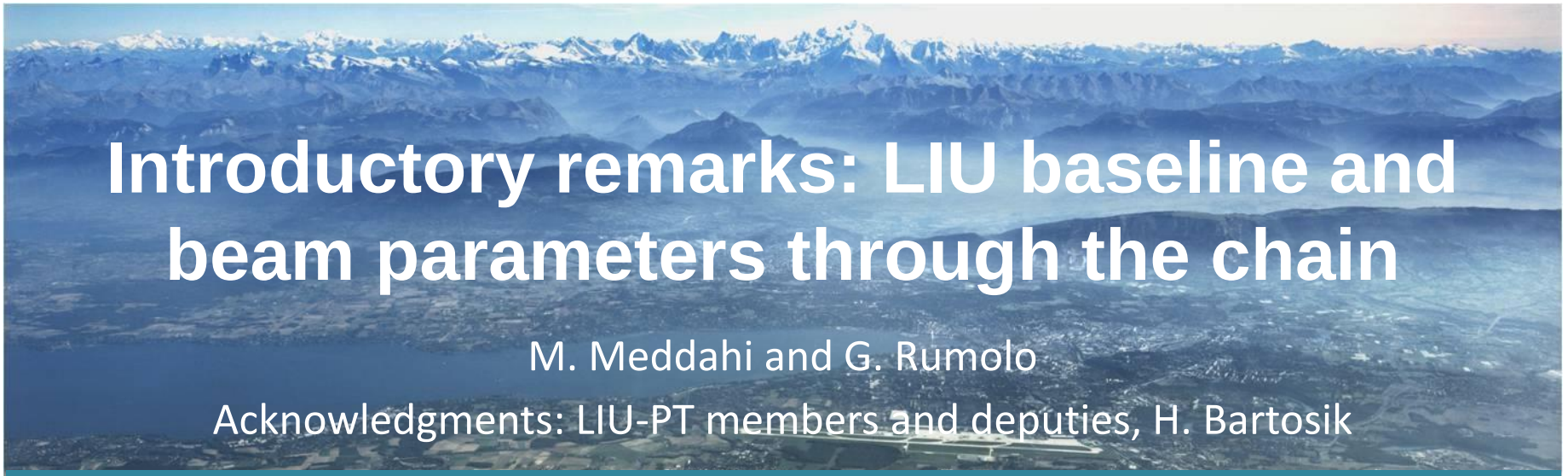

LHC Injectors Upgrade

Introductory remarks: LIU baseline and beam parameters through the chain

M. Meddahi and G. Rumolo

Acknowledgments: LIU-PT members and deputies, H. Bartosik

Outline:

- LIU baseline
- Proton beam parameters
- Pb ion beam parameters

CERN

LIU baseline as of 1/1/16
(Compact → details in the talks during LIU session)

- **PSB**
  - New H^- charge exchange injection at 160 MeV from Linac4 to double brightness
  - Acceleration to 2 GeV with replacement of C02-C04-C16 RF systems by Finemet cavity based RF system, and new main power supply
- **Linac3 + LEIR**
  - 100 ms injection rate into LEIR to allow larger accumulated ion current
- **PS**
  - New injection at 2 GeV for protons to mitigate space charge
  - Newly installed and upgraded longitudinal feedbacks (impedance reduction and against CBI)
- **SPS**
  - Power upgrade of the main 200 MHz RF system, double available 800 MHz voltage, new LL RF system including slip stacking capability
  - Electron cloud mitigation through beam induced scrubbing + a-C coating of QFs and one arc – keep option of full a-C coating staged to LS3, if proved necessary by Run 3 operation
  - New beam dump system in LSS5 and new design of protection devices to comply with the target HL-LHC beam parameter values
  - Longitudinal impedance reduction through QF-type flange shielding and improvement of HOM damping in 200 MHz cavities

LIU baseline as of 1/1/16
(Compact → details in the talks during LIU session)

- **PSB** → **Talk by K. Hanke**
  - New H^- charge exchange injection at 160 MeV from Linac4 to double brightness
  - Acceleration to 2 GeV with replacement of C02-C04-C16 RF systems by Finemet cavity based RF system, and new main power supply

- **Linac3 + LEIR** → **Talk by R. Scrivens**
  - 100 ms injection rate into LEIR to allow larger accumulated ion current

- **PS** → **Talk by K. Hanke**
  - New injection at 2 GeV for protons to mitigate space charge
  - Newly installed and upgraded longitudinal feedbacks (impedance reduction and against CBI)

- **SPS** → **Talk by B. Goddard**
  - Power upgrade of the main 200 MHz RF system, double available 800 MHz voltage, new LL RF system including slip stacking capability
  - Electron cloud mitigation through beam induced scrubbing + a-C coating of QFs and one arc – keep option of full a-C coating staged to LS3, if proved necessary by Run 3 operation
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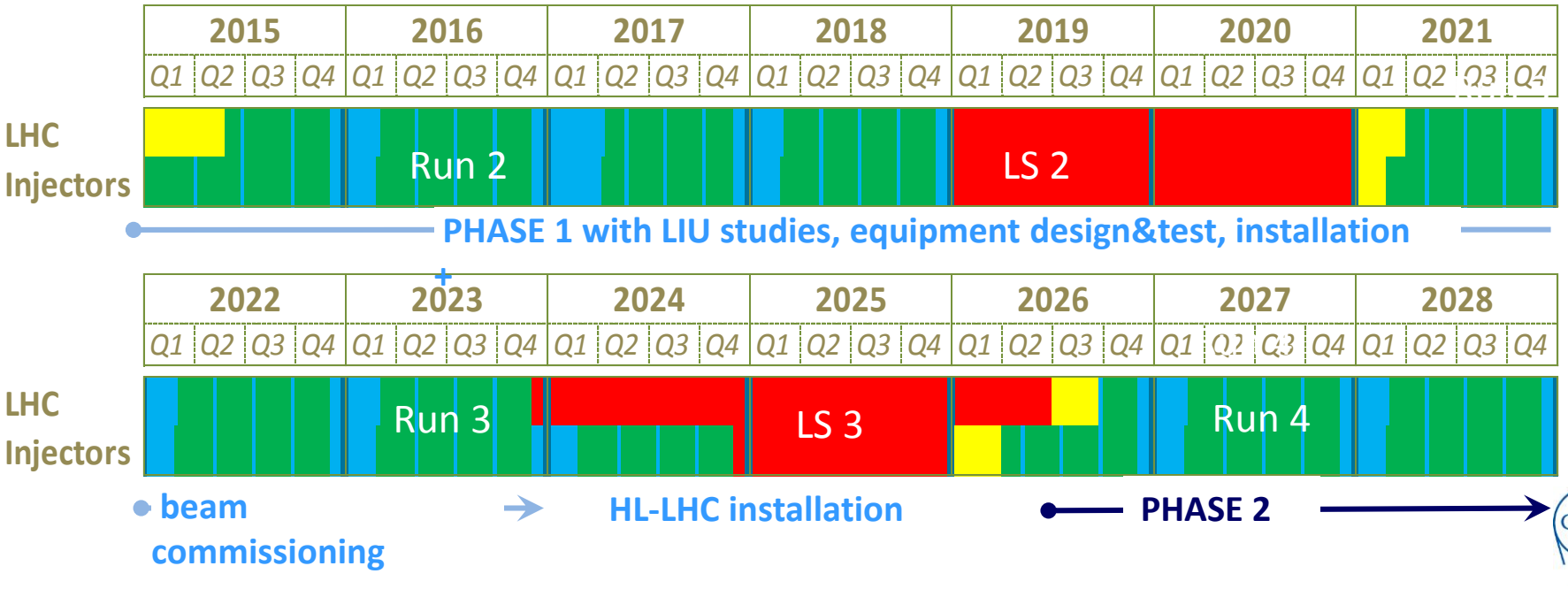
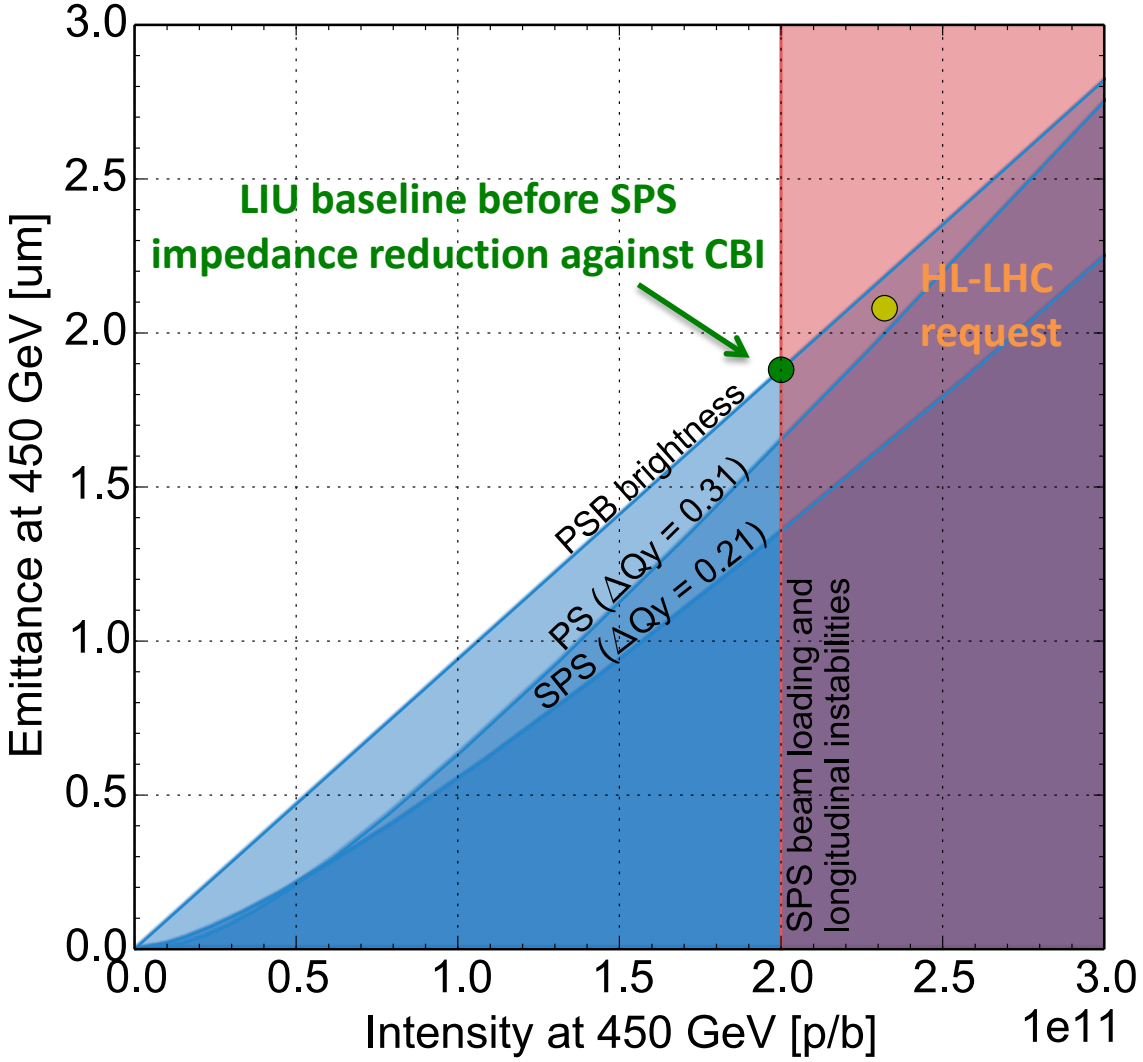
General → **RF talk by H. Damerau**
→ **Transverse feedback talk by W. Höfle**

Timelines of LIU

- **Activities until LS2**
  - Beam and simulation studies (e.g. space charge, electron cloud, impedance) to validate beam performance
  - Design, procurement and test of equipment (e.g. protection devices)
  - Installation/cabling work during **(E)YETS's** when possible
  - Civil engineering work on surface (e.g. new MPS building for PSB)
- **Main LIU installations and hardware work during LS2**
- **Beam commissioning of LIU beams after LS2**
  - **Ion beams** to be ready by **end 2021**
  - **Proton beams** during **Run 3** to be ready for LHC physics after **LS3**

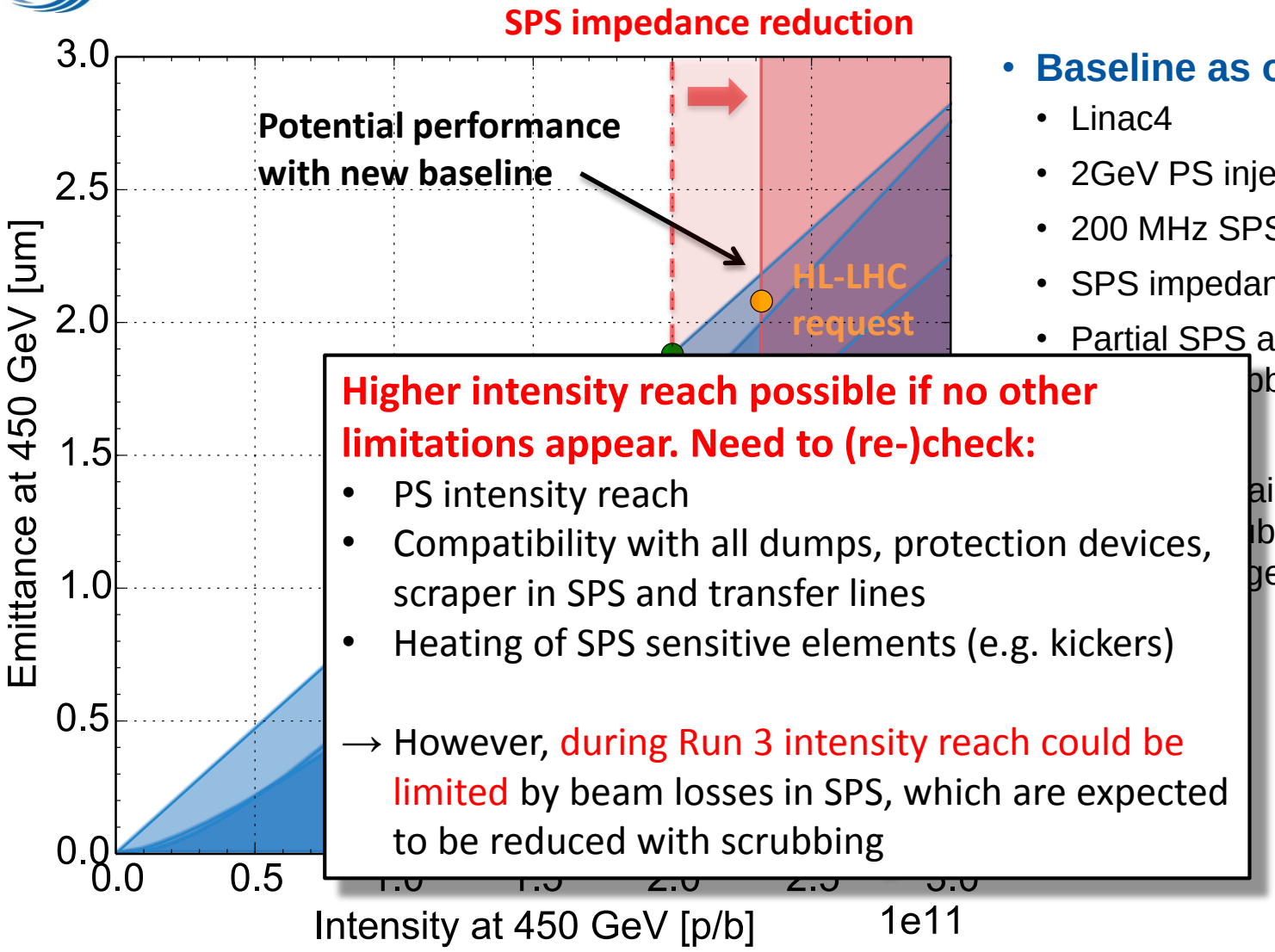


LIU performance reach for protons (25 ns)



	$\mathcal{N}$ (x 10^{11} p/b)	ε (μm)
LIU Baseline	2.0	1.9
LIU BCMS	2.0	1.4
HL-LHC	2.3	2.1

LIU performance reach for protons (25 ns)



- **Baseline as of 1/1/2016**
  - Linac4
  - 2GeV PS injection energy
  - 200 MHz SPS RF upgrade
  - SPS impedance reduction (LS2)
  - Partial SPS aC coating (LS2) + bbing (Run3)

+/-

aining aC coating
bbing not sufficient
get parameters

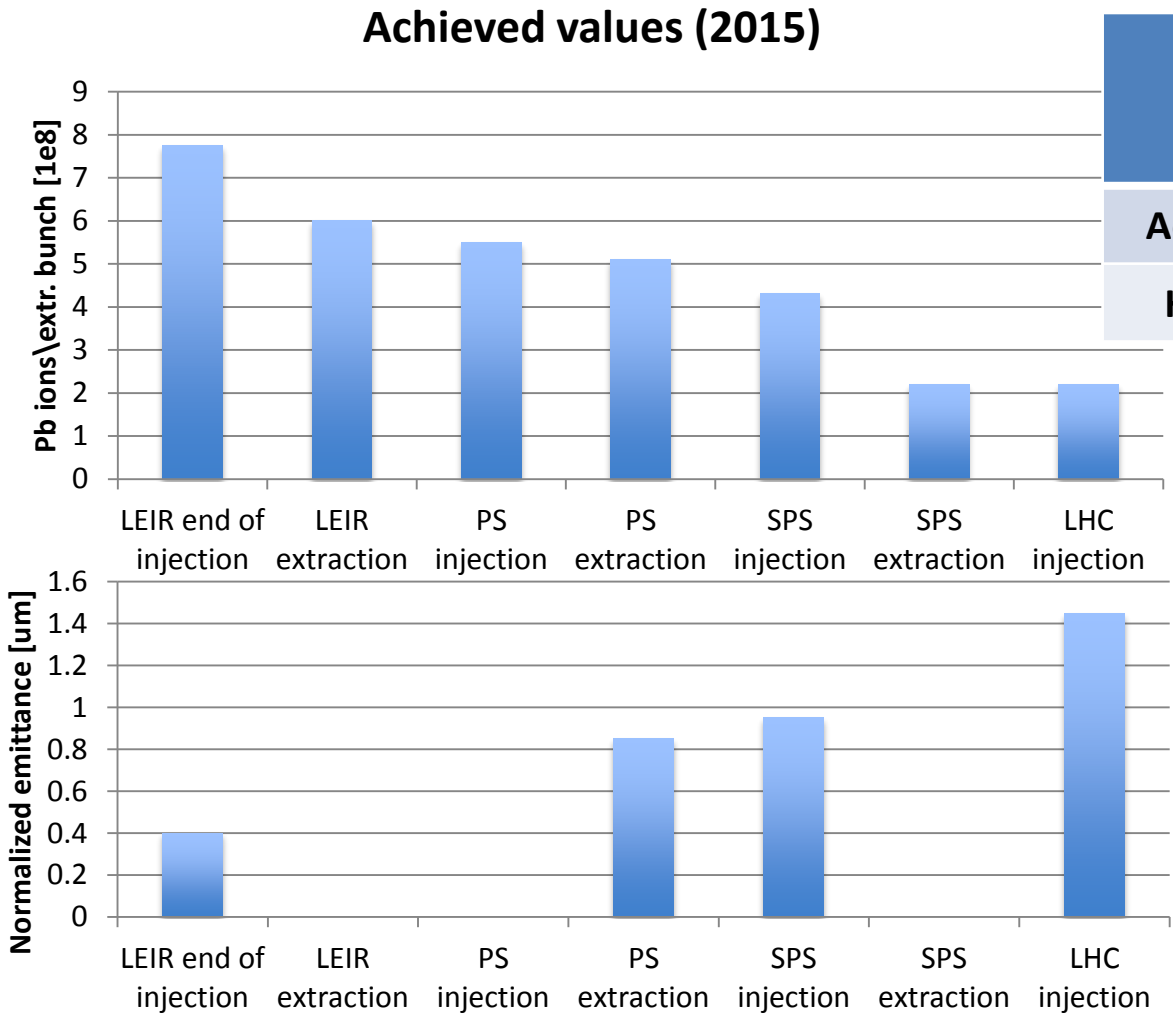
Higher intensity reach possible if no other limitations appear. Need to (re-)check:

- PS intensity reach
- Compatibility with all dumps, protection devices, scraper in SPS and transfer lines
- Heating of SPS sensitive elements (e.g. kickers)

→ However, during Run 3 intensity reach could be limited by beam losses in SPS, which are expected to be reduced with scrubbing

LIU performance reach for Pb ions (50 ns)

- **Intensive study program at the end of 2015 to push injector performance and systematically identify bottlenecks and loss/emittance growth distribution**

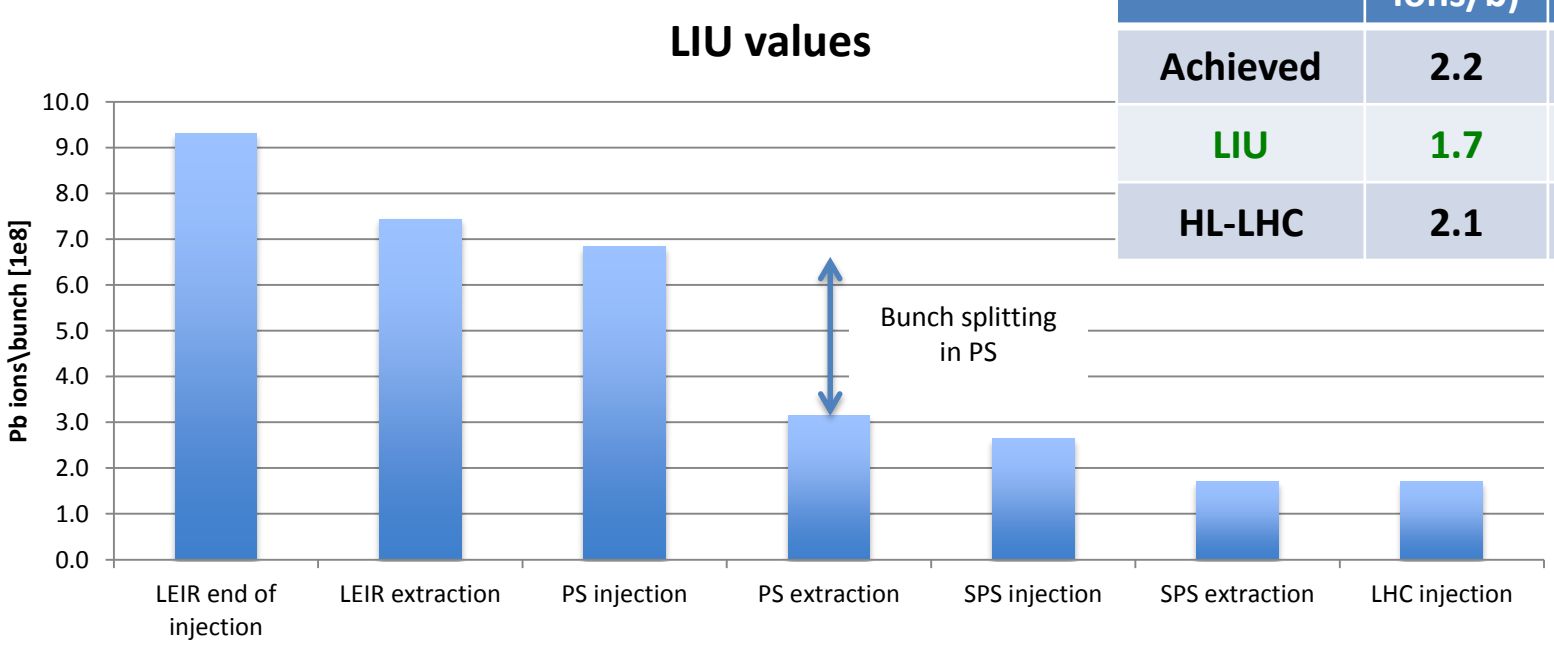


	$\mathcal{N}$ (x 10^8 ions/b)	ε (μm)	# of bunches
Achieved	**2.2**	**1.45**	**518**
HL-LHC	**2.1**	**1.3**	**1248**

LIU performance reach for Pb ions (50 ns)

- **Intensive study program at the end of 2015 to push injector performance and systematically identify bottlenecks and loss/emittance growth distribution**
- **LIU achievable table obtained by combining**
  - Extrapolation from information collected in 2015 (transmission, emittance growth)
  - Baseline upgrades, i.e. increase of accumulated intensity in LEIR and slip stacking in SPS

	$\mathcal{N}$ (x 10^8 ions/b)	ε (μm)	# of bunches
Achieved	**2.2**	**1.45**	**518**
LIU	**1.7**	**1.3**	**1152**
HL-LHC	**2.1**	**1.3**	**1248**



LIU performance reach for Pb ions (50 ns)

- **Intensive study program at the end of 2015 to push injector performance and systematically identify bottlenecks and loss/emittance growth distribution**
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→ **2016 machine studies with Pb ion beams are crucial to validate predictions, understand losses (in rings and transfers) and explore scenarios**

- Full functionality of the systems and availability of resources expected

→ **Options under consideration/study to push Pb ion beam performance. E.g.**

- Push the present LHC injection and extraction (MKI/MKD) kicker gaps to (realistic) limits
- Consider different filling schemes in PS (e.g. with 50 ns spacing resulting in **25 ns in LHC**)
- 100 ns upgrade of the SPS injection kicker system
- Reduce LEIR cycling rate

More in the next LIU talks