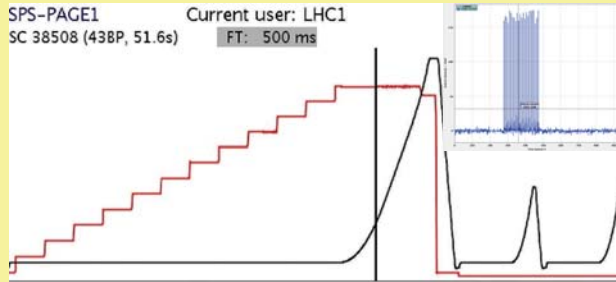




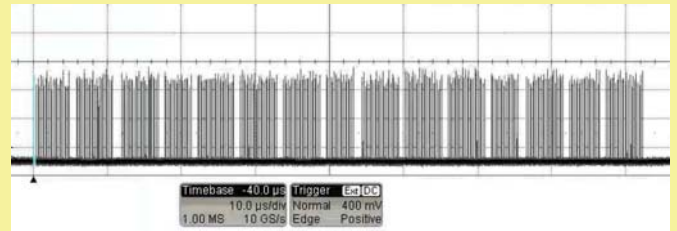
MOTIVATION

Heavy ion collisions were included in the design of the LHC from an early stage, and the first collisions between beams of fully stripped lead took place in Autumn 2010, immediately after the end of the first proton run. The success of the first two Pb-Pb runs, which respectively accumulated 10 and 160 μb^{-1} of integrated luminosity in 2010 and 2011, led the experiments to request a proton-ion run, as a first extension to the LHC design, for the last exploitation period before the long shutdown. A pilot run, using single bunches, was performed in September 2012. The actual physics run, originally planned for autumn 2012, eventually took place in January-February 2013, after the LHC programme had been prolonged to increase the p-p integrated luminosity at a beam energy of 4 TeV. [See MOODB201](#)

Filling one LHC ring with protons

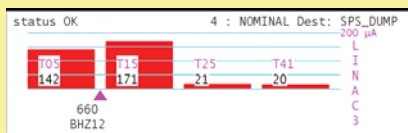


SPS supercycle and bunch distribution

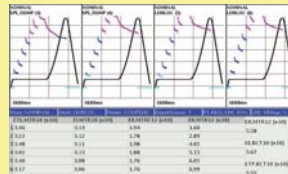


LHC bunch train distribution

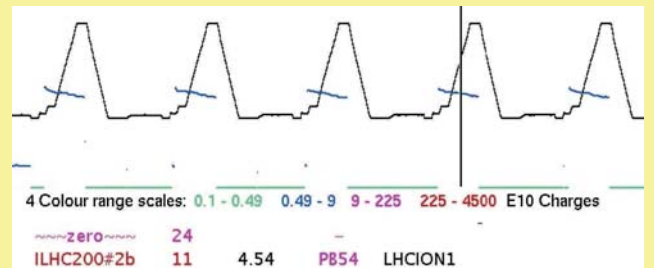
Filling the other LHC ring with Pb⁸²⁺ ions



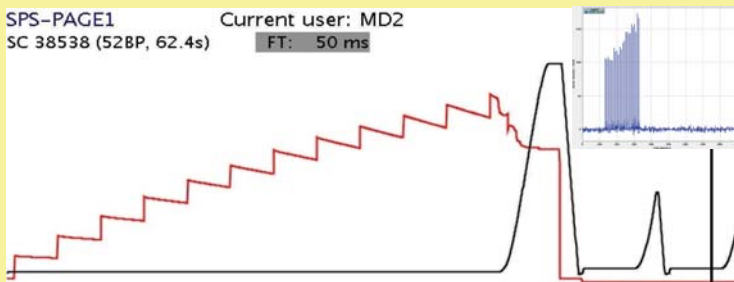
Linac3 intensity histogram (µA)



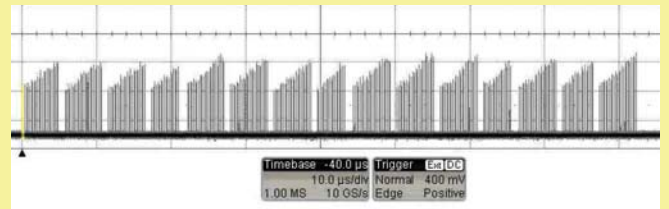
Part of LEIR supercycle



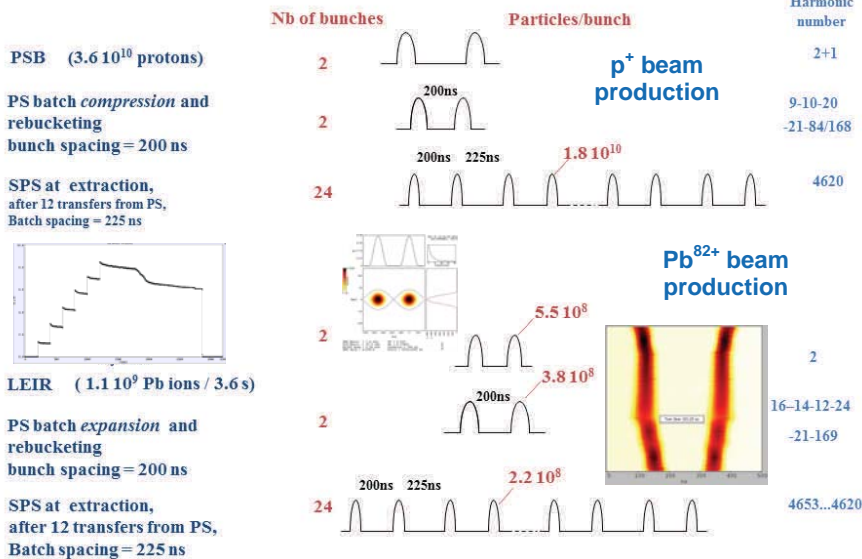
Part of PS supercycle



SPS supercycle and bunch distribution



LHC bunch train distribution



Improvements in 2013:

- Linac3 RF phase optimisation
- LEIR now over design intensity of 4.5×10^8 ions/bunch
- PS vacuum (no high intensity proton cycle)
- SPS Q20 optics [See TUPME046](#)
- SPS hunt for RF Noise

	p ⁺ 2013	Pb ⁸²⁺ 2013	Pb ⁸²⁺ design	
N _B	1.8×10^{10}	2.2×10^8	9×10^7	Particles/bunch
ε _H	0.73	1.1	1.2	µm (norm. RMS)
ε _V	0.45	0.9	1.2	µm (norm. RMS)
N _B /ε	3140	22.1	7.5	10 ⁷ Particles/µm

Proton and Pb⁸²⁺ ion beam properties at SPS extraction.

CONCLUSIONS and OUTLOOK

- The contribution of the injector chain was essential to the success of the first extension to the LHC programme, proton-ion collisions.
- The achieved beam quality allowed the collider to reach a peak luminosity 40% higher (1.1×10^{29} w.r.t. $8.3 \times 10^{28} \text{ cm}^{-2} \cdot \text{s}^{-1}$), and to deliver 40% more integrated luminosity (31 w.r.t. 22.3 nb^{-1}), than expected at the time of planning the run. [See MOODB201](#)
- Overall, the performance of the ion beam now gives good indications for the Pb-Pb collisions after future upgrades. [See WEPEA060](#)