Optimizing Pb beam losses at the LHCb for maximum luminosity

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LHC heavy ion operation

- fully-stripped lead ions $^{208}Pb^{+82}$
- up to 7 Z TeV beam energy
- Pb-Pb collisions at the four experiments ATLAS, CMS, ALICE and LHCb
- electromagnetic interactions dominate over nuclear inelastic ones

Bound-free pair production (BFPP)

$$^{208}Pb^{+82} + {}^{208}Pb^{+82} \rightarrow {}^{208}Pb^{+82} + {}^{208}Pb^{+81} + e^{+}$$

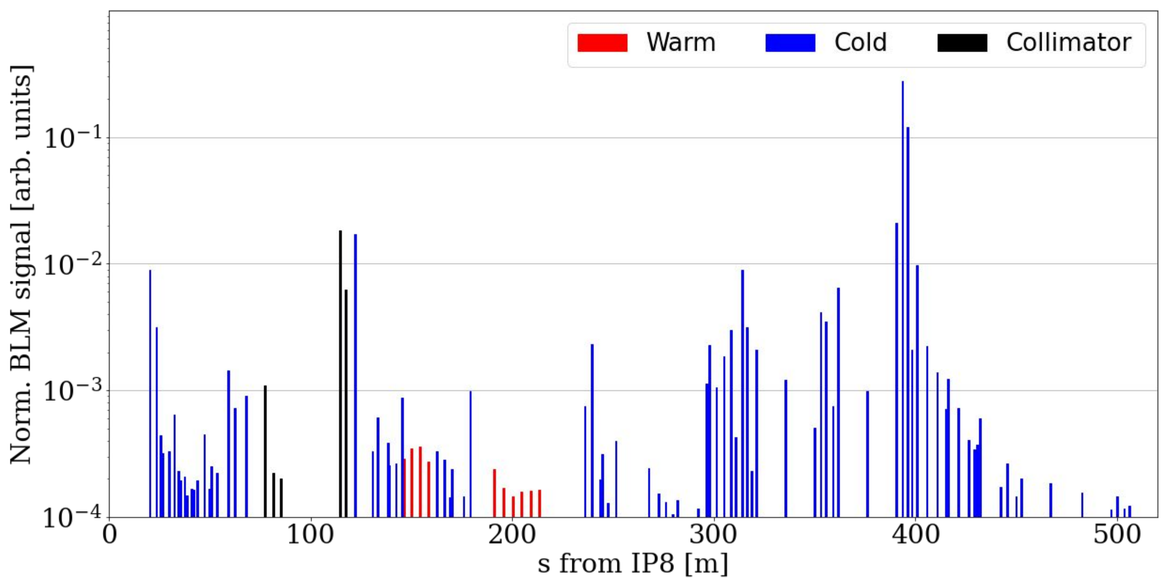
- highest cross section
- small transverse momentum recoil
- secondary beams with well-defined magnetic rigidity change
- localised power deposition downstream the IP

$$P_p = \mathcal{L}\sigma_p E_b$$

- risk of beam dumps or magnet quenches
- luminosity limitations

BFPP at LHCb

- so far luminosity levelling to a safe value of $10^{27}cm^{-2}s^{-1}$
- recent request for an higher integrated luminosity until the end of LHC Run 4
- mitigation strategy for BFPP to increase LHCb peak luminosity
- TCLD collimators, as adopted for ALICE, presently not foreseen



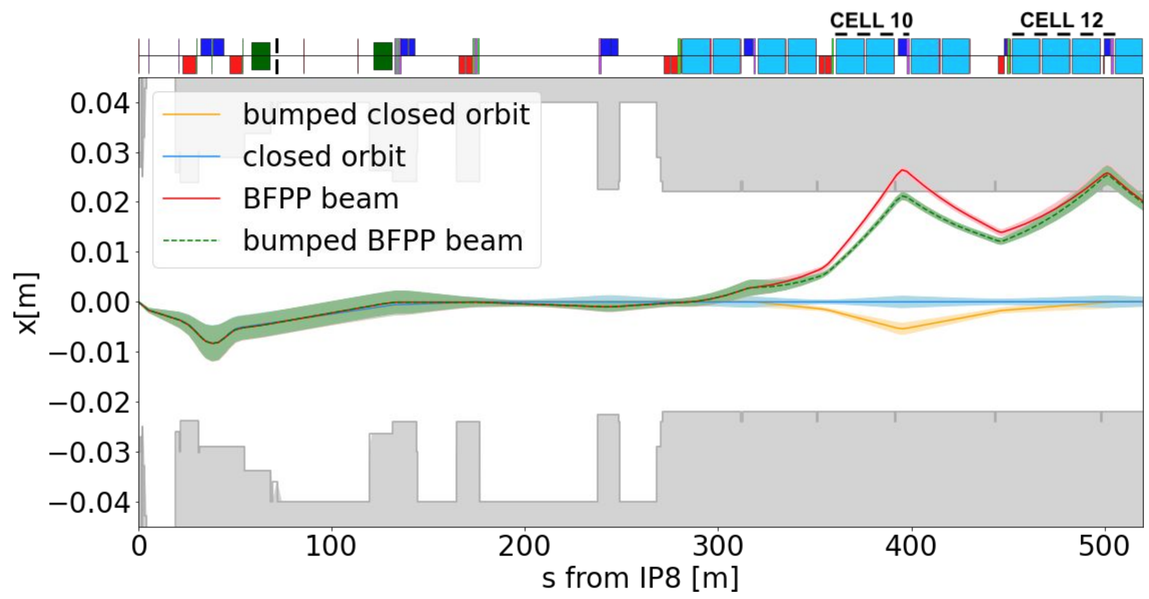
- B1 BFPP peak loss at LHCb measured by beam loss monitors
- physics operation in 2018

SixTrack simulation goals

- tracking of BFPP particles from LHCb
- study of loss patterns
- investigation of orbit bumps as mitigation strategy

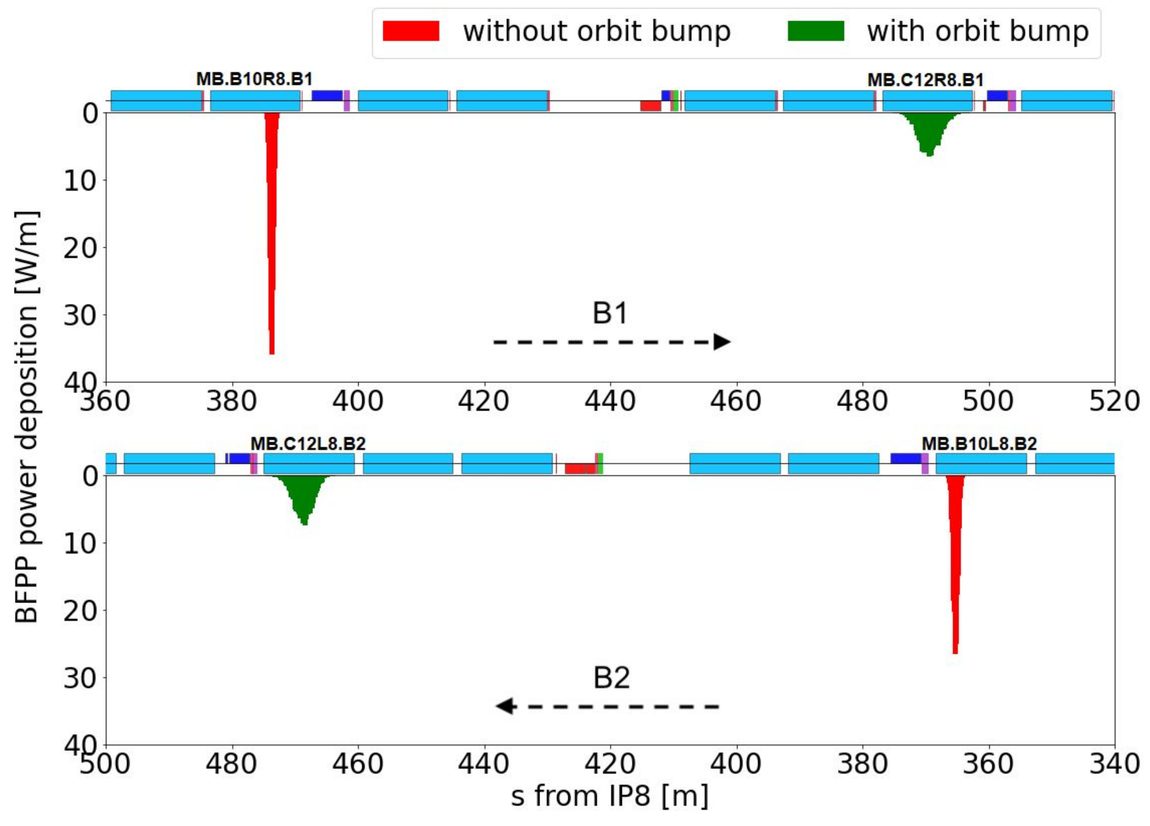
BFPP beam tracking from LHCb

- 2018 LHC heavy-ion optics
- both 2018 and design beam parameters
- dispersive trajectory of $^{208}Pb^{+81}$ ions mimicked by tracking $^{208}Pb^{+82}$ ions with a fractional momentum offset δ=1/81
- initially distributed as the colliding ions
- BFPP beams hit the superconductive dipoles in cell 10 MB.B10R8.B1 and MB.B10L8.B2



Orbit bumps as alleviation strategy for LHCb

- horizontal orbit bumps of -5.3 mm on MQML.10R8.B1 and +5 mm on MQML.10L8.B2
- BFPP losses shifted from cell 10 to cell 12
- simulation of new loss patterns show new impact locations on superconductive dipoles MB.C12R8.B1 and MB.C12L8.B2
- in cell 12 larger β-function and hence larger BFPP beam transverse size
- BFPP power deposition more spread out



- a full energy deposition study with FLUKA using these results as input predicts a peak power load lower by a factor of 4 in cell 12
- the levelled luminosity at LHCb could be safely increased by a factor 2-3 in future Pb-Pb runs