Simulations and measurements of collisional losses with Pb beams at the LHC

Alessandro Frasca, Andrey Abramov, Roderik Bruce, Rongrong Cai, Francesco Cerutti,
Luigi Salvatore Esposito, Bjorn Lindström, Frederik Van der Veken, Filippo Ziliotto, Marcin Patecki

LHC heavy ion program

- LHC operated as heavy ion collider with fully-stripped $^{208}Pb^{+82}$ ions
- Pb-Pb or p-Pb collisions at the experiments ATLAS, CMS, ALICE and LHCb
- it will continue during Run 3 and Run 4
- collisional losses from ions fragmenting introduce performance limitations

Main interactions

- bound-free pair production (BFPP): produces lead ions with one or more bound electrons, dominates in Pb-Pb
- electromagnetic dissociation (EMD): original $^{208}Pb^{+82}$ ions emit one or more nucleons
- inelastic interactions: dominate in p-Pb

Performance limitations

- BFPP and EMD generate secondary beams with slightly modified charge-to-mass ratio
- localised losses leading to beam dumps or magnet quenches
- upper limit on luminosity

Simulation of collisional losses

- this work aims at setting up a reliable simulation model to predict collisional losses in future runs
- simulation tool: SixTrack-FLUKA coupling
- FLUKA generates the collision products at each IP
- SixTrack tracks the generated collision products along the LHC lattice until they are lost

Benchmark

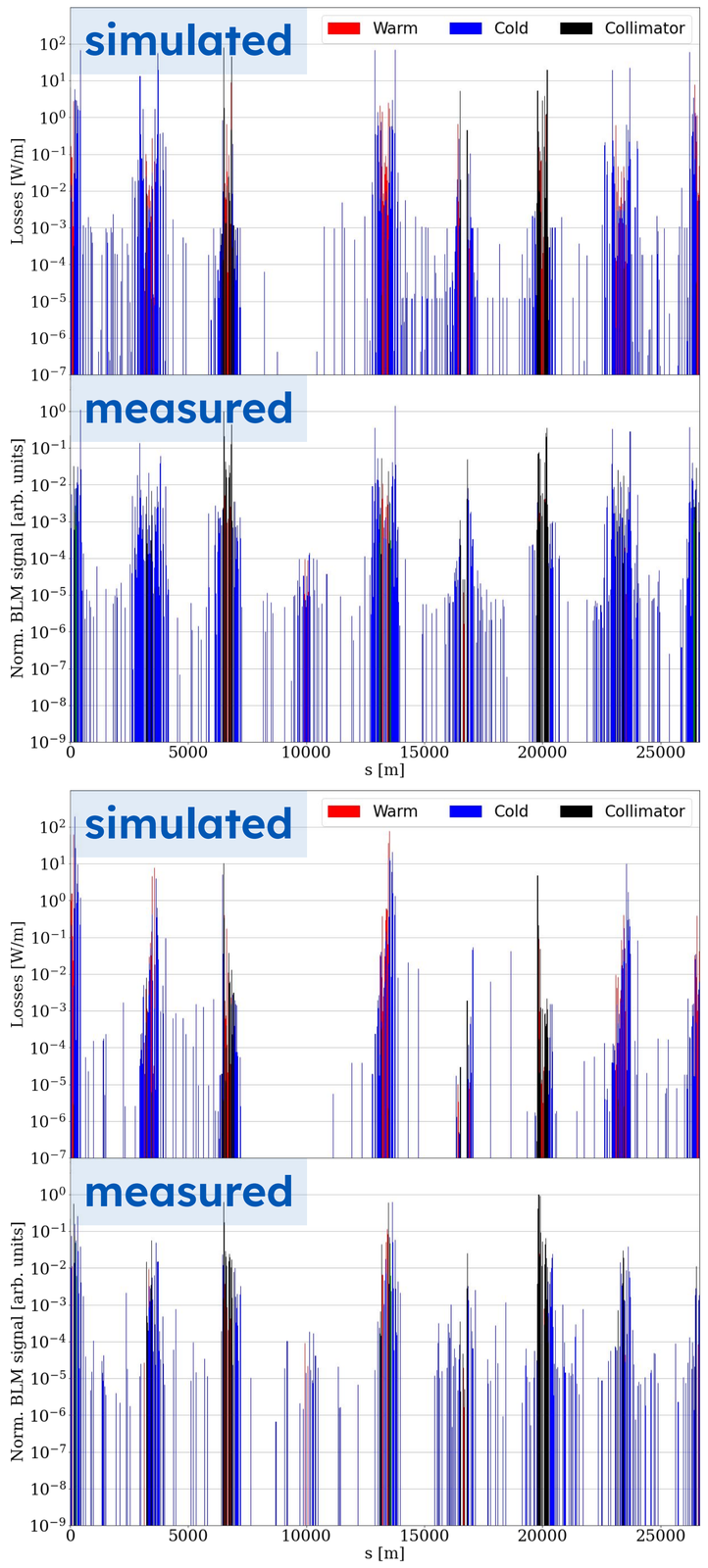
- simulations of 2018 Pb-Pb and 2016 p-Pb lossmaps
- compared to measured BLM signals

2018 Pb-Pb run

- 6.37 Z TeV
- BFPP, EMD and inelastic interactions
- good qualitative agreement

2016 p-Pb run

- 6.5 Z TeV
- BFPP neglected
- EMD and inelastic interactions
- losses measured at the collimation regions are underestimated by a factor 10^1–10^2 (betatron losses)



- very good agreement for collisional losses: valid tool to estimate collisional losses in future runs

Prediction for future Pb-Pb and p-Pb runs

- simulations including future beam, hardware and optics changes envisaged for Run 3-4
- higher beam energies (7 Z TeV) and luminosities
- almost all cold losses below the conservative quench limit of 9 W/m
- the few peaks above are either mitigated BFPP losses or simulation artifacts due to the binning
- FLUKA full-energy deposition studies required to verify