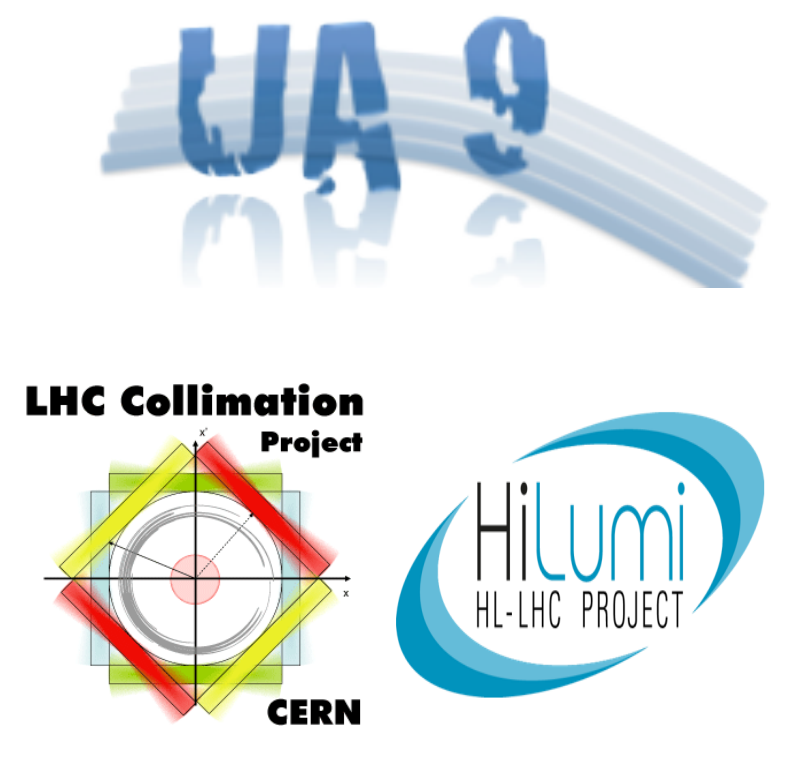




Observation of channeling in bent crystals at the CERN LHC



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Abstract:

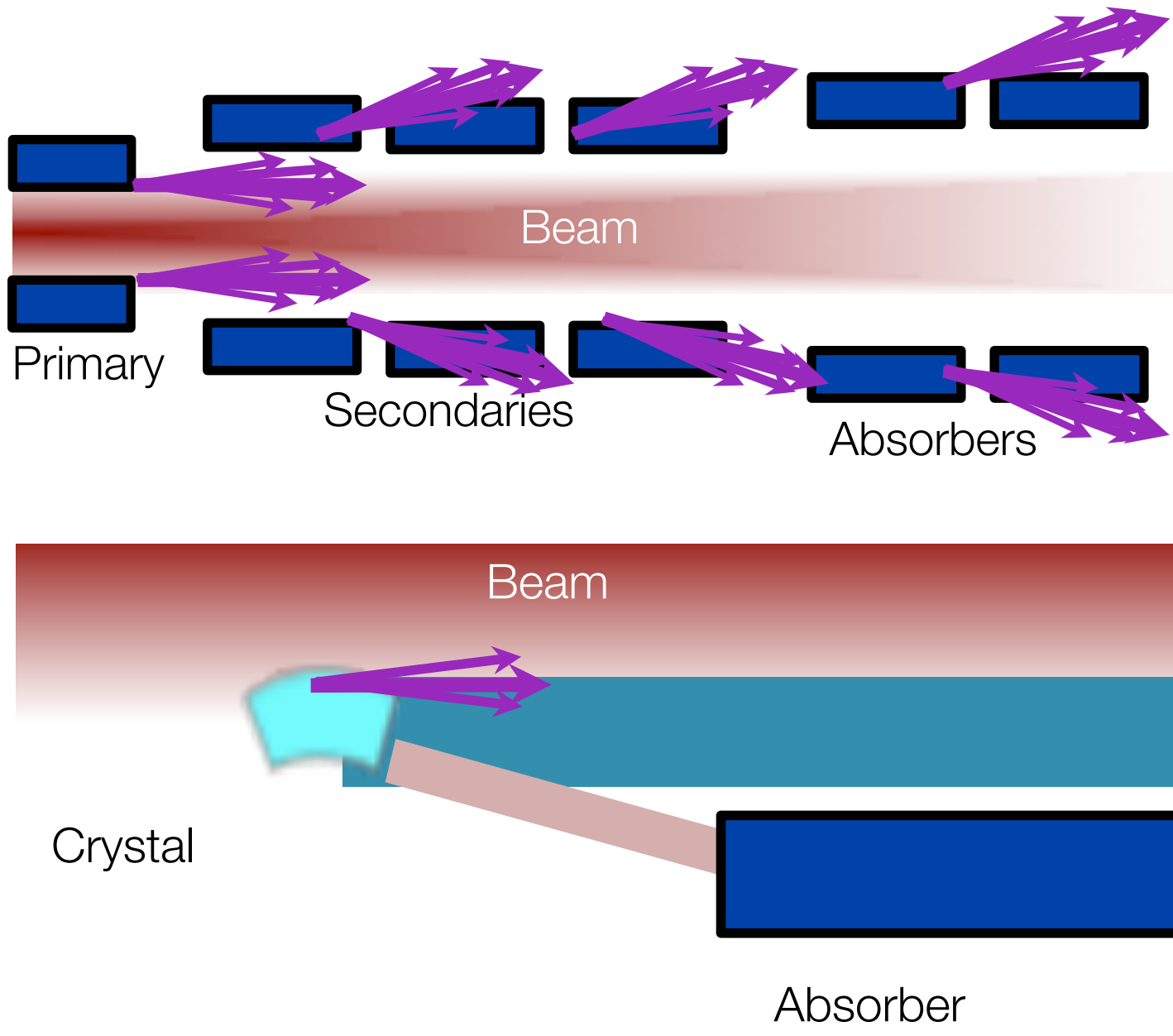
The UA9 collaboration is investigating the feasibility of crystal-assisted collimation for the future high luminosity upgrade of the CERN LHC (HL-LHC). During dedicated tests in 2015, bent crystals were approached to the circulating the beams to test their usage as first stage in a crystal-based system. Proton and Pb ion beams were used. Two high-accuracy goniometers, each equipped with one bent silicon crystal, were installed in the betatron cleaning insertion of the LHC in 2014. Tests were performed with protons at injection energy (450 GeV/c) and at flat top (6.5 TeV/c), and with ions at injection energy (450 Z GeV/c). A reduction of losses immediately downstream of the crystals were observed in optimum channeling orientation, demonstrating for the first time channeling of 6.5TeV protons. Halo cleaning efficiency of the crystal-based collimation system was also measured.

introduction

High-energy particles interacting with a mono-crystalline material can be trapped by the electromagnetic potential generated by atomic planes in the lattice. This condition is achieved within a small angular acceptance (critical angle). This technology is being considered as a possible path to improve the ion beam collimation for the HL-LHC. Before relying on it, one must demonstrated that channeling works reliably at the LHC design energy and that it improves the performance of the present system. Bent crystals have been installed in the LHC betatron cleaning insertion to address these open points. First results from beam tests in 2015 demonstrated for the first time channeling of 6.5TeV proton beams.

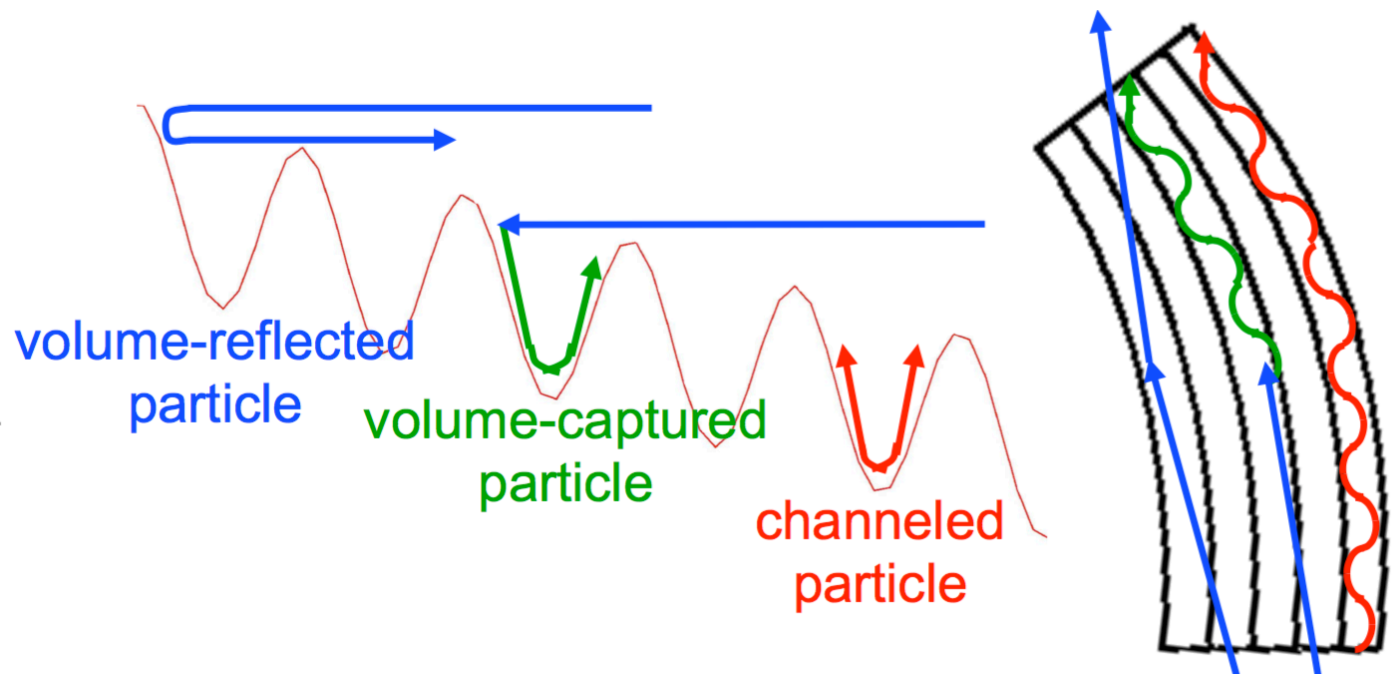
basic idea

Bending to large angles can be used as a perfect primary collimator



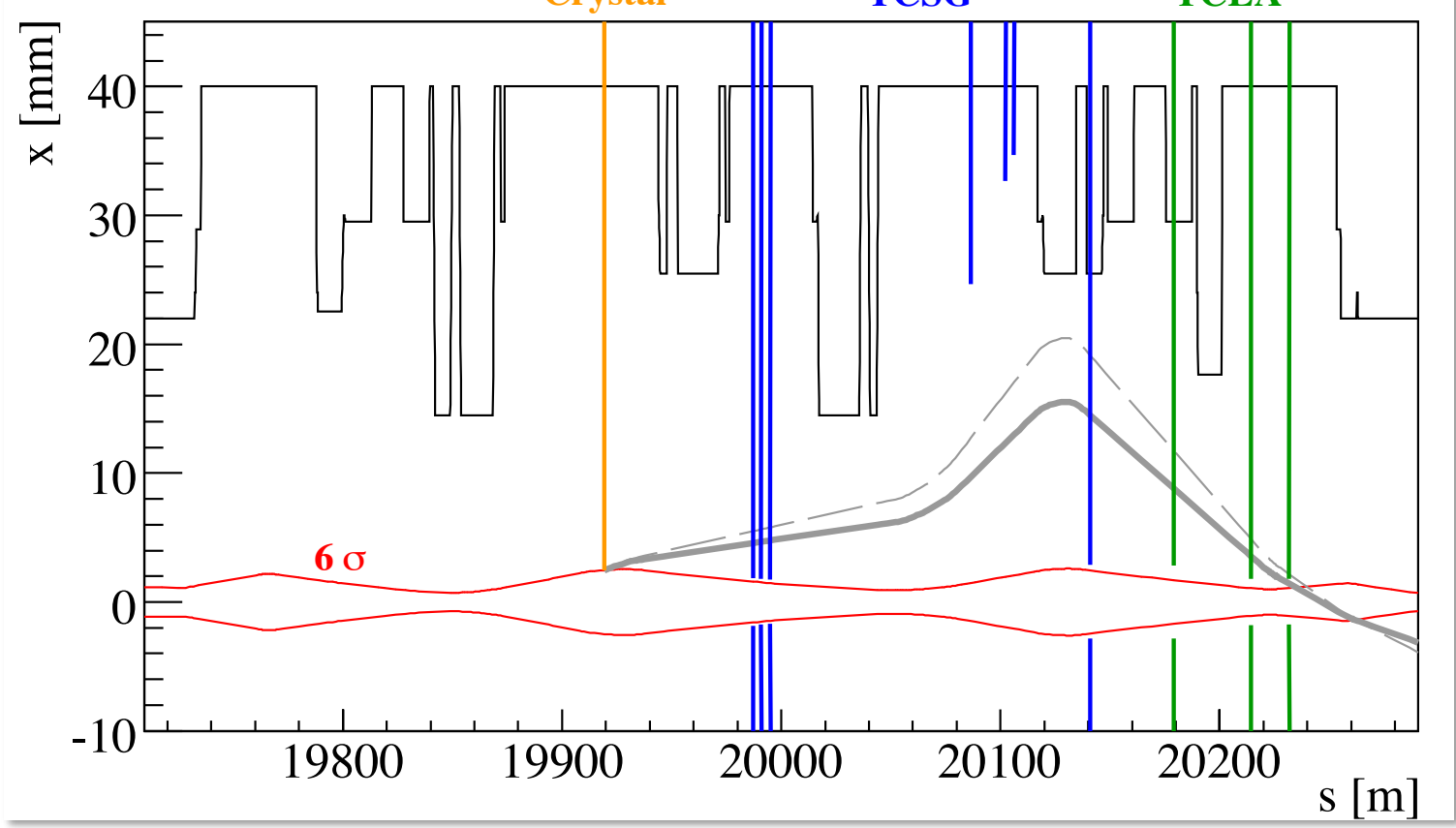
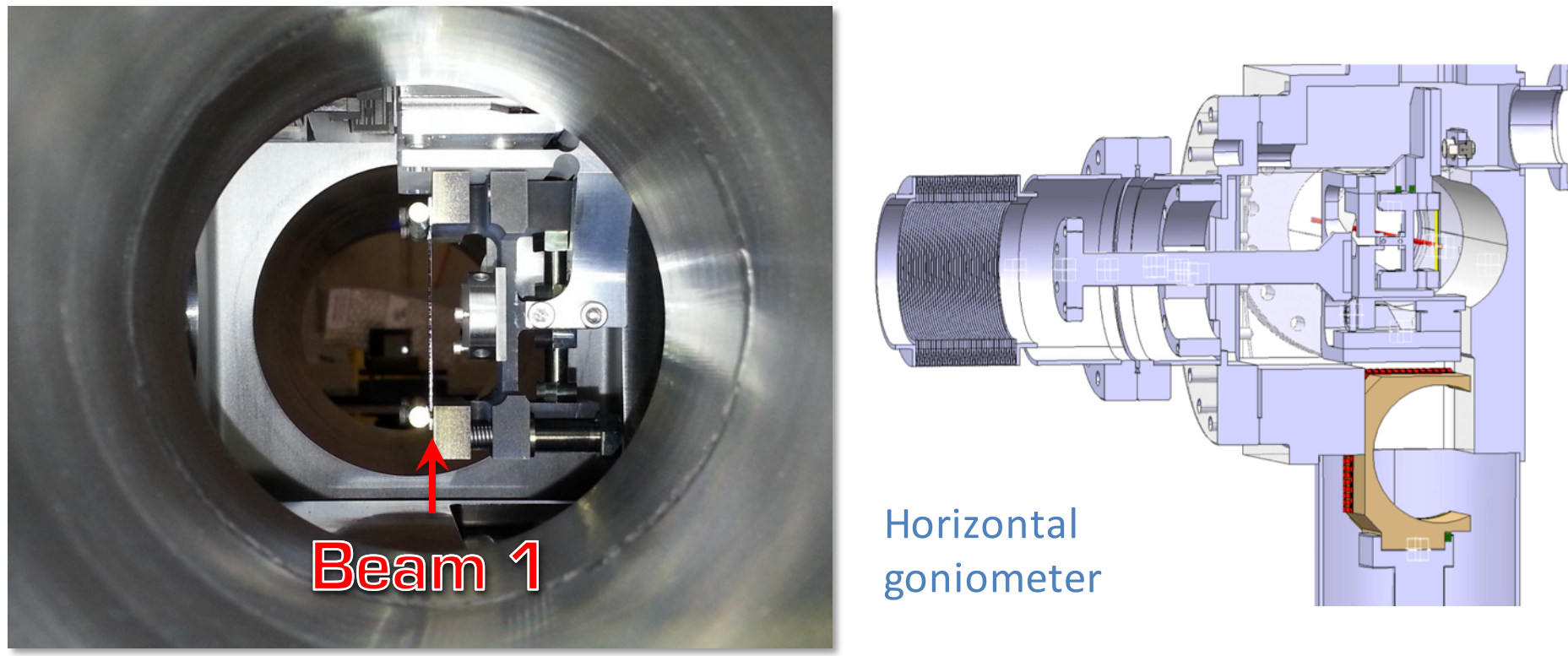
Present collimation system is based on multi-stages solid collimators. Crystal-assisted collimation is based on a two stages setup.

Existing collimators are used to absorb the extracted halo particles.



layout

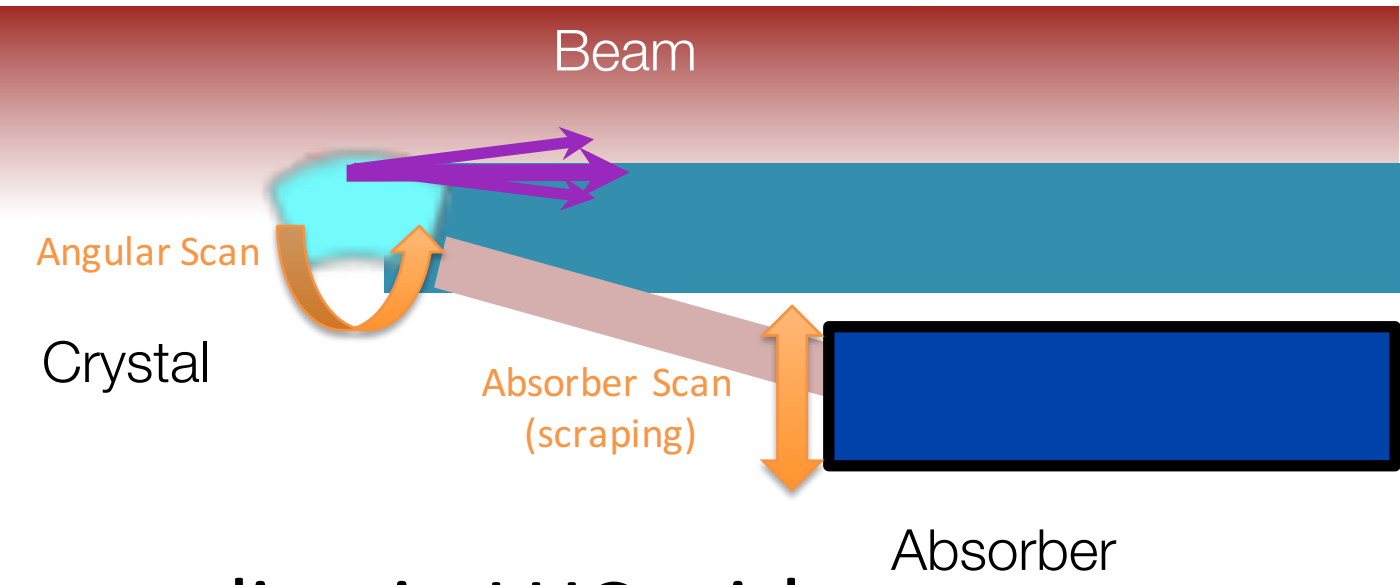
Two goniometers are installed in the H & V planes of the LHC Beam 1. They are designed to be transparent to LHC standard operation. A 0.1 μ rad resolution is achieved using a piezoelectric actuator to orient the crystals on the beam envelope.



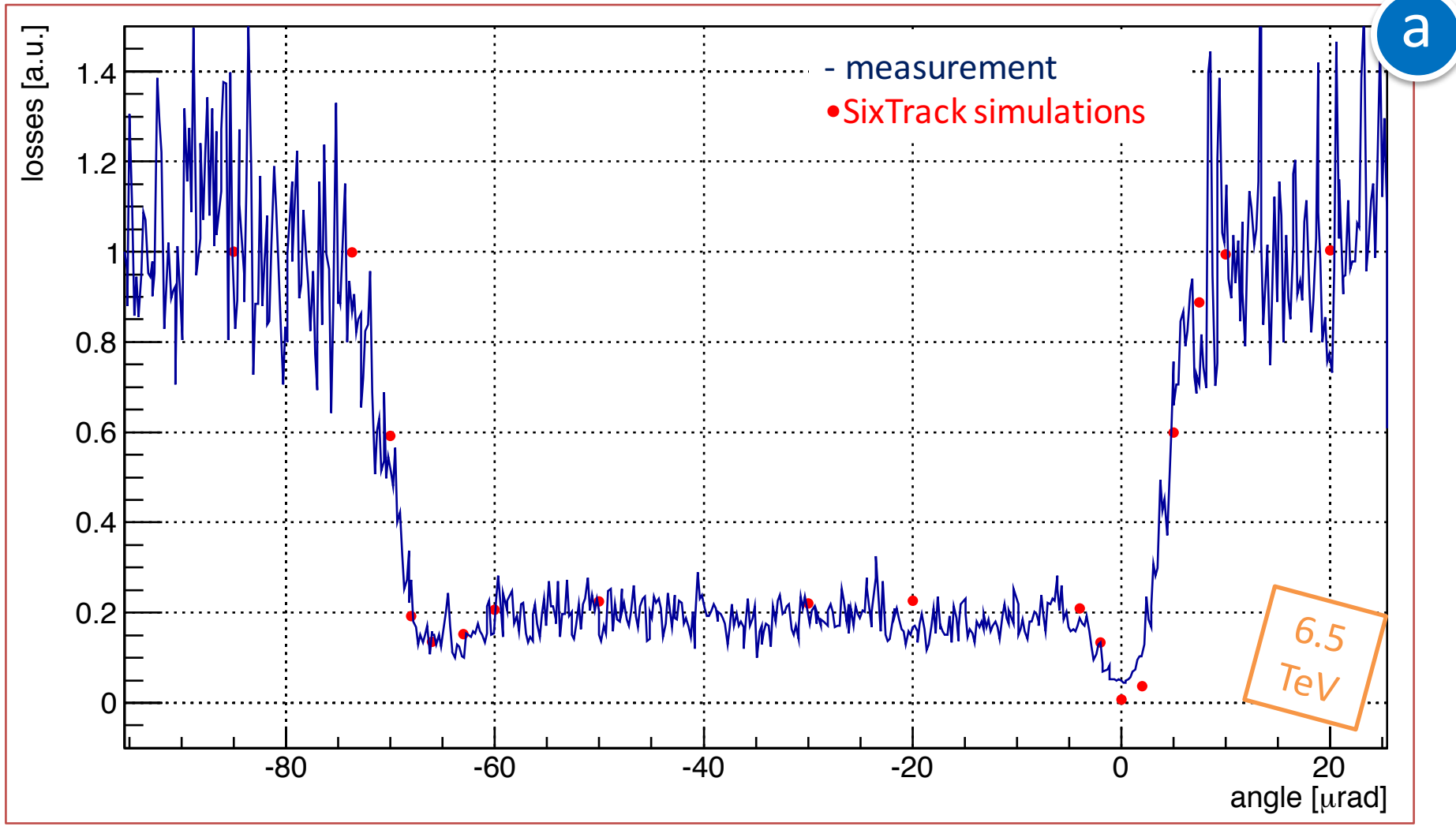
The system is optimized to measure the cleaning performance at 6.5 TeV/c [2]

Results of the LHC MDs with protons in 2015

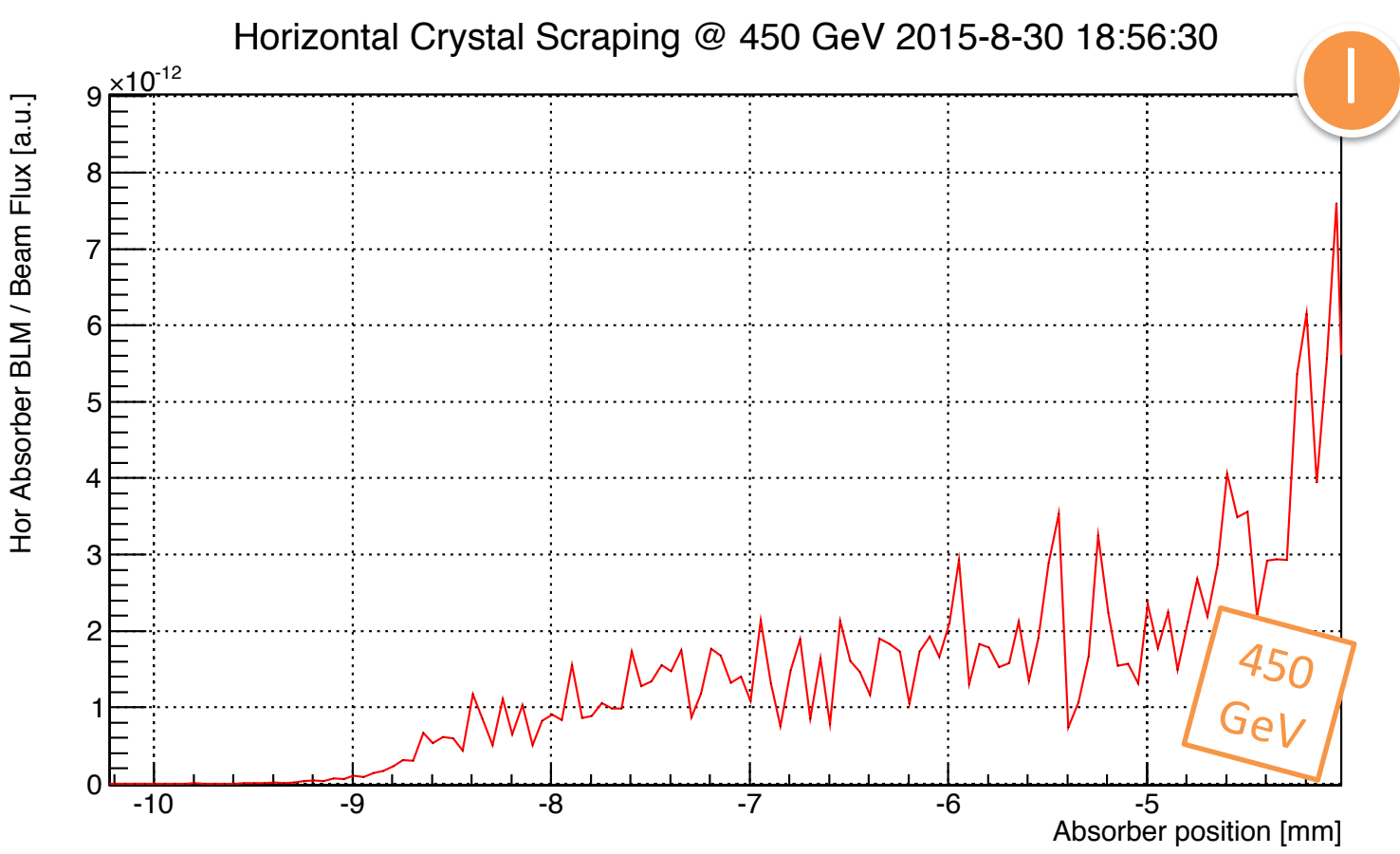
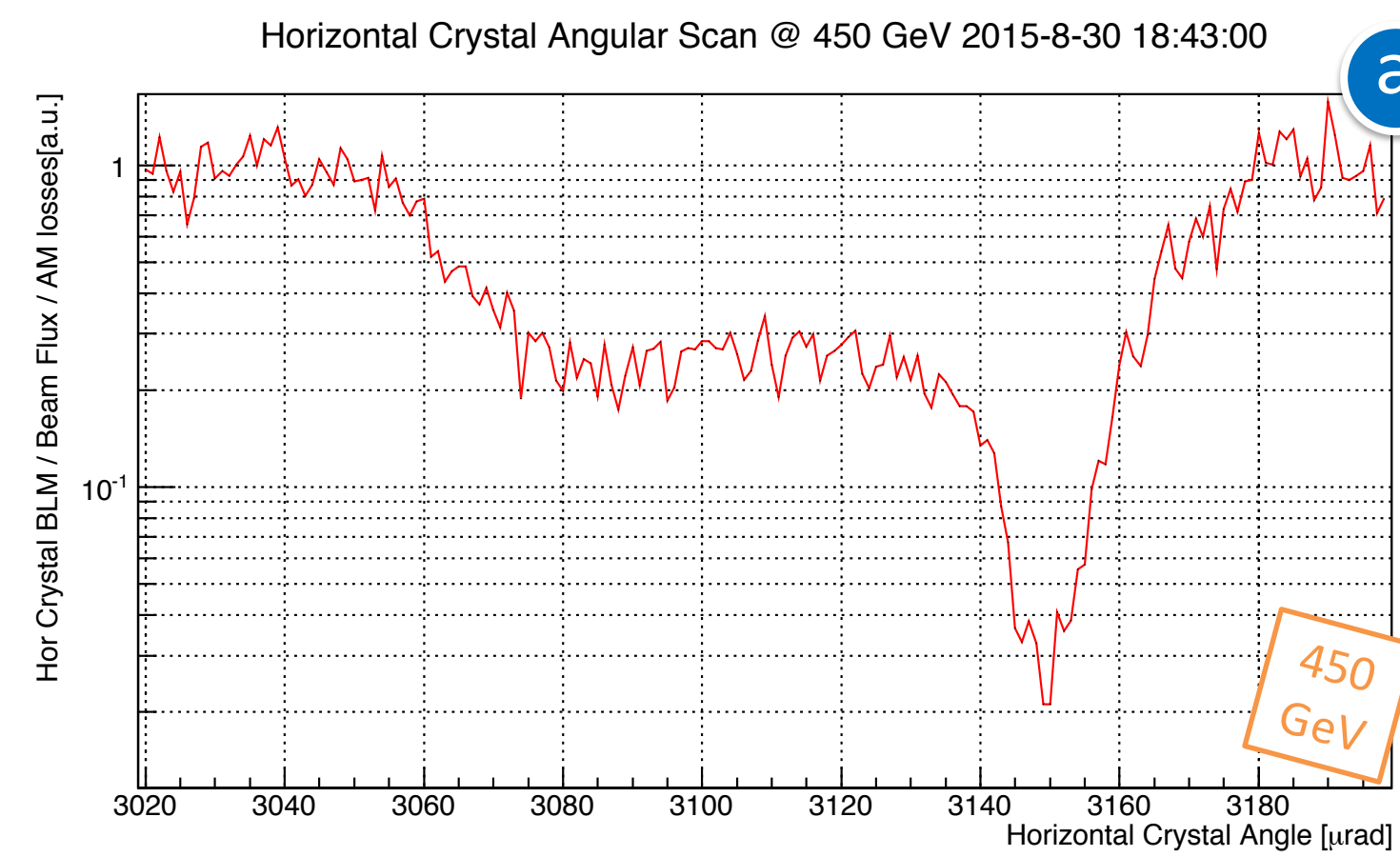
Channeling is observed as local reduction of losses when crystal is parallel to beam envelope **a** (angular scans); presence of channeled beam separated from main beam at absorber **i** (linear scan) [3].



First observation of channeling in LHC with protons at record energy of 6.5 TeV

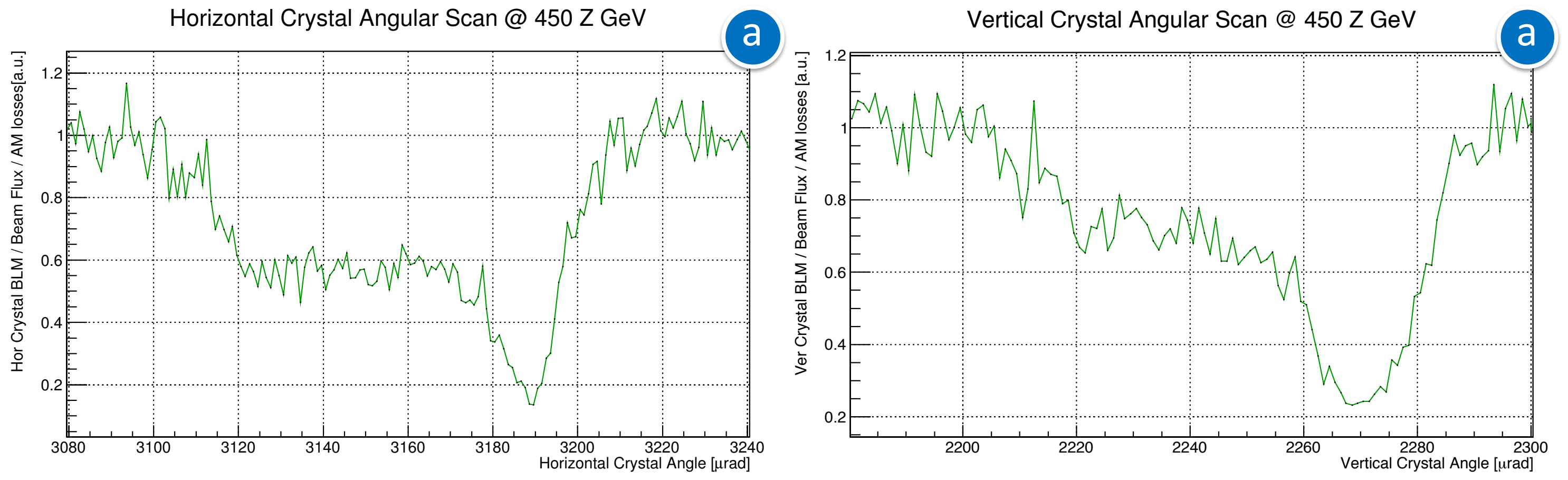


Horizontal crystal measurements at injection energy



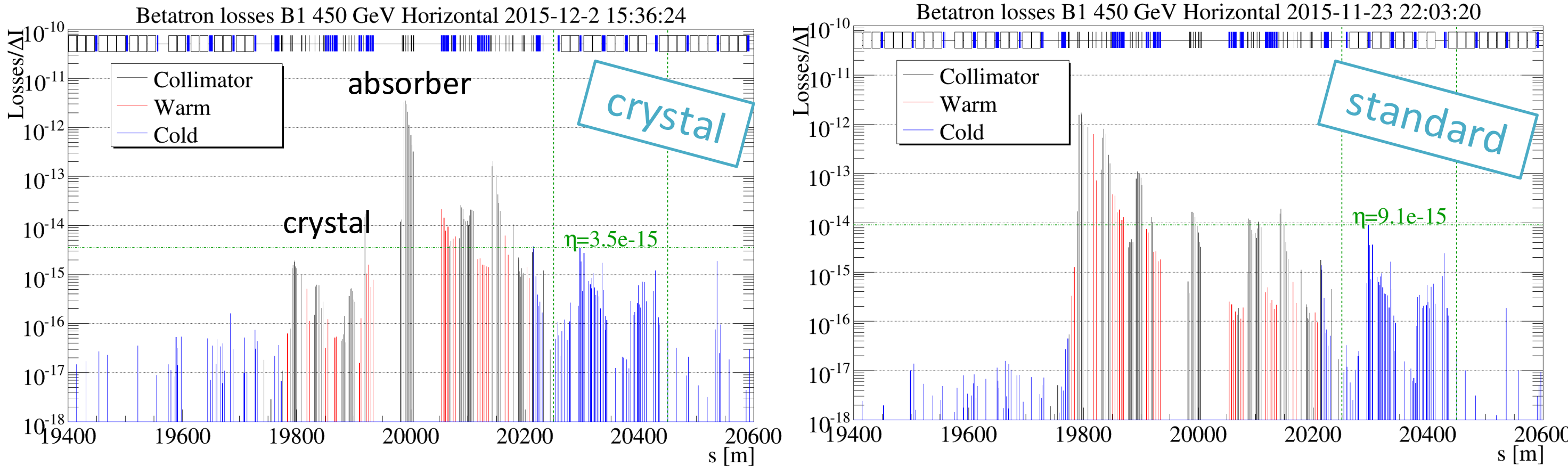
Results of the LHC MD with ions in 2015

Channeling was observed also for Pb ion beams with horizontal and vertical crystals at record energy of 450 Z GeV.



Ion collimation cleaning at injection energy (preliminary)

Losses are concentrated on the absorber and reduced in the dispersion suppressor (DS) by a factor 2.6. This represents a very promising result



Conclusions:

Presented results of first beam tests on crystal collimation at the LHC. Channeling was observed at record energies of 6.5 TeV/c for protons and 450 Z GeV/c for Pb ions. First important results towards the demonstration of this technology for HL-LHC. Further tests are foreseen in 2016. Main goals: assess channeling and collimation cleaning at 6.5TeV.

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