Optical layout for the measurement of Short Living Baryon Magnetic Moment using Bent Crystals at LHC.

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Concept & past experience

Magnetic moment of channeled particles should precess in a bent crystal

$$J_{spin} = \frac{g-2}{2} g J_{crystal}$$

See V.G. Baryshevskii, Pis'ma Zh. Tekh. Fiz.5, 182 (1979) and PLB 757 (2016) 426-9.

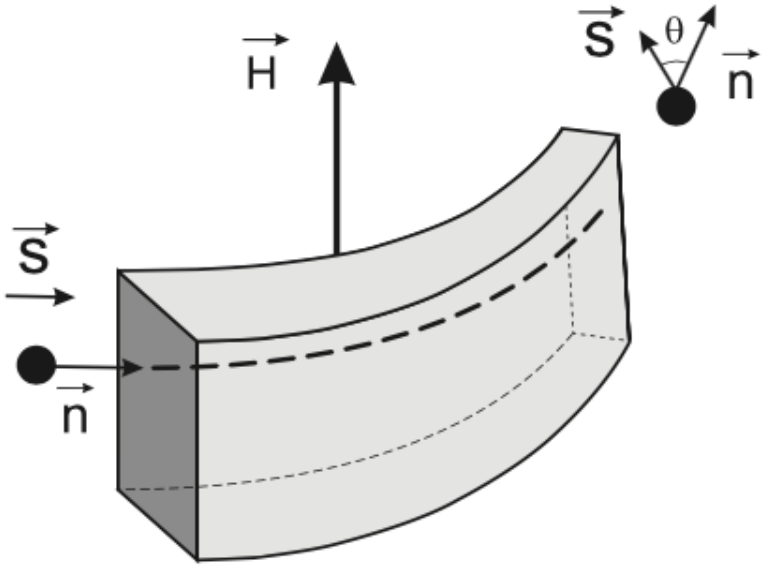


Figure 1. Spin rotation in a bent crystal

Experiment E 751 at FNAL
PhysRevLett 69.3286 (1992)

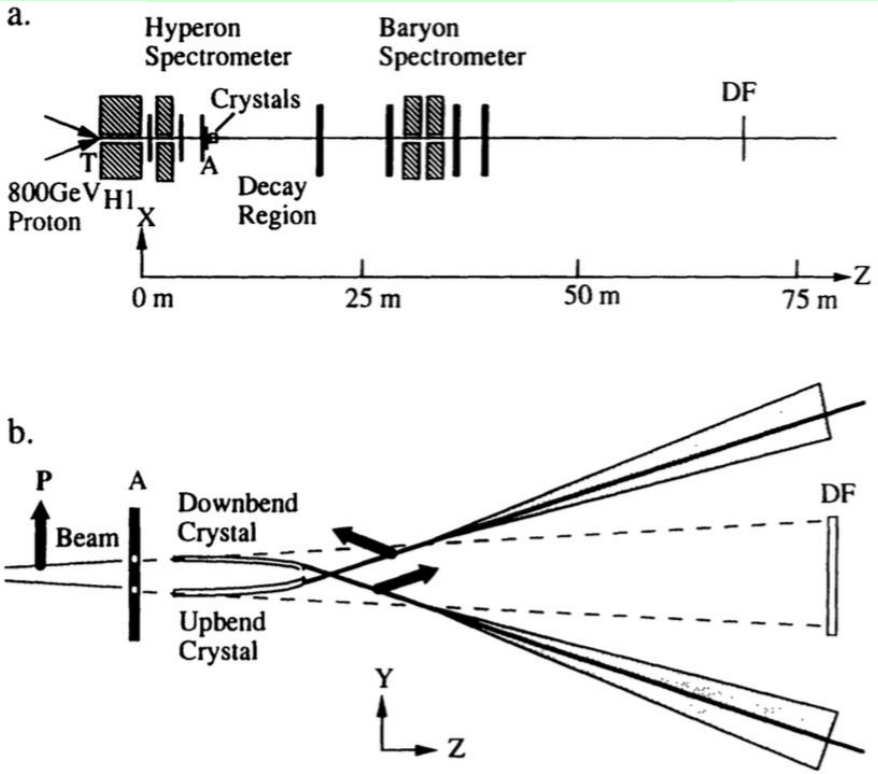


FIG. 1. (a) Plan view of the incident proton beam and spectrometer system. The horizontal scale (z) correctly illustrates the length of the apparatus, the vertical scale (x) is schematic only. (b) Elevation view of the channeling apparatus (not to scale). The arrows illustrate the spin precession in the crystals. Shaded areas depict the Σ^+ decay cone. The scintillation counters A and DF are part of the trigger and are described in the text.

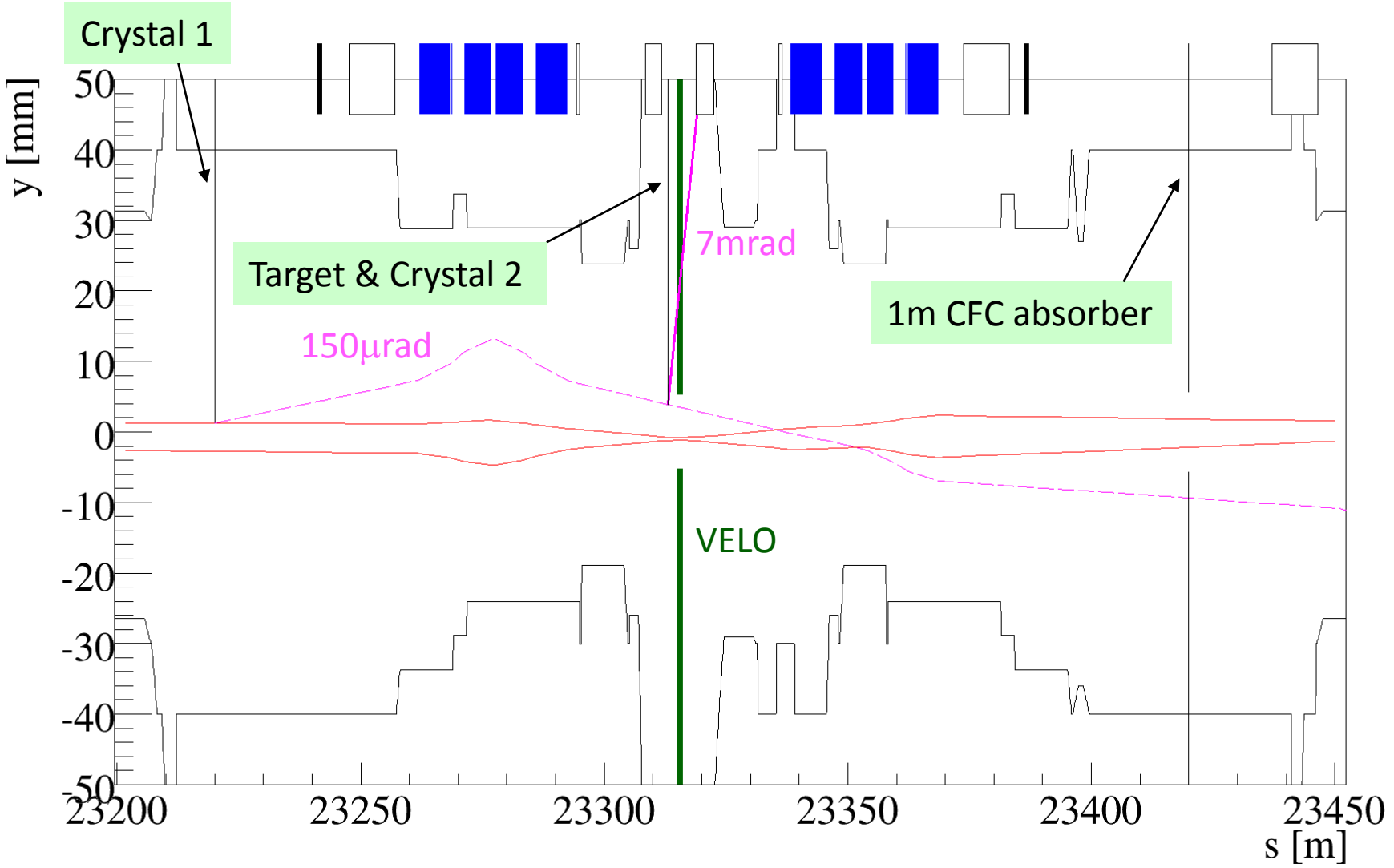
The proposal for LHC

- We propose to measure the **magnetic moment of the Λ_c** and other charmed charged baryons at LHC top energies (see the talk of A. Stocchi).
- The preferred scenario requires four new elements in LHC:
  - A **first bent crystal** deflects the halo particles upstream of an interaction region of LHC, in our case the LHCb one, in order to separate them from the circulating beam.
  - A **target inserted in the pipe** intercepting the deflected halo, producing short-living baryons.
  - A **second bent crystal** to channel part of the baryons and deflect them into the LHCb detector, where the spin orientation is measured from the analysis of the decaying fragments.
  - An additional **absorber** to intercept the halo particles non-interacting with the target, thereby allowing the possibility of fixed-target operation in parasitic mode.
- *An alternative scenario may consists in extracting protons in the LHC dump area and in measuring the short-living baryons polarization WITH A NEW DETECTOR.*
- The experiment should be based on the **UA9** technology to steer with bent silicon crystals the diffusive halo surrounding the circulating beam in LHC, up to 6.5 TeV energy.
- Such a technology can be applied also to produce **non-resonant or resonant extraction of beams** in SPS and in LHC *(for our alternative scenario)*.

Layout upstream of LHCb

All devices placed in available slots in IR8

The crystal 1 is at 5.0 σ from the center-line, whilst the collimation system has the 2016 nominal settings, with the primary TCP at 5.5 σ.



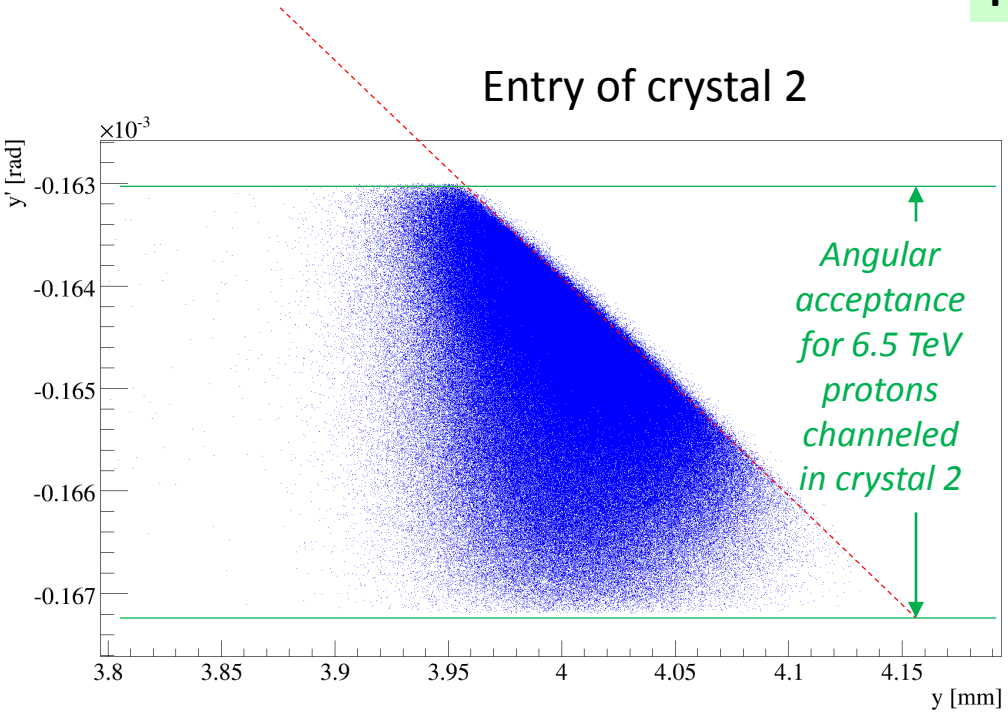
phase space at second cry.

Coordinates in the machine reference frame

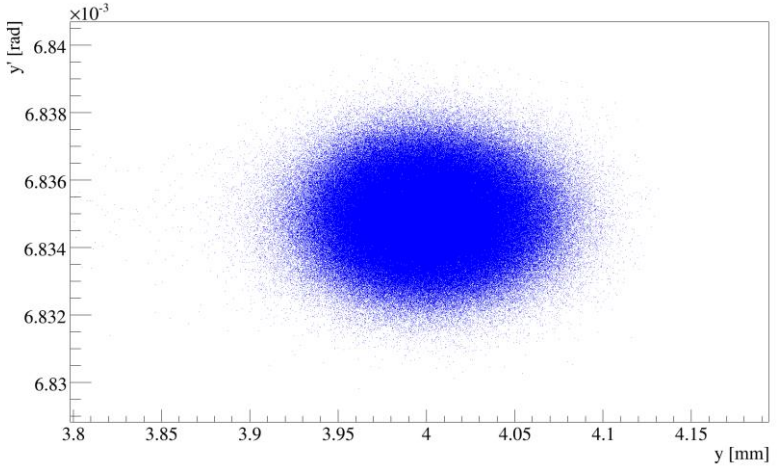
Short-living baryons are produced with an energy smaller than that of the incident protons. **Their angular acceptance and the phase space portrait are increased as 1/√E**

Cut performed by crystal 1

Entry of crystal 2

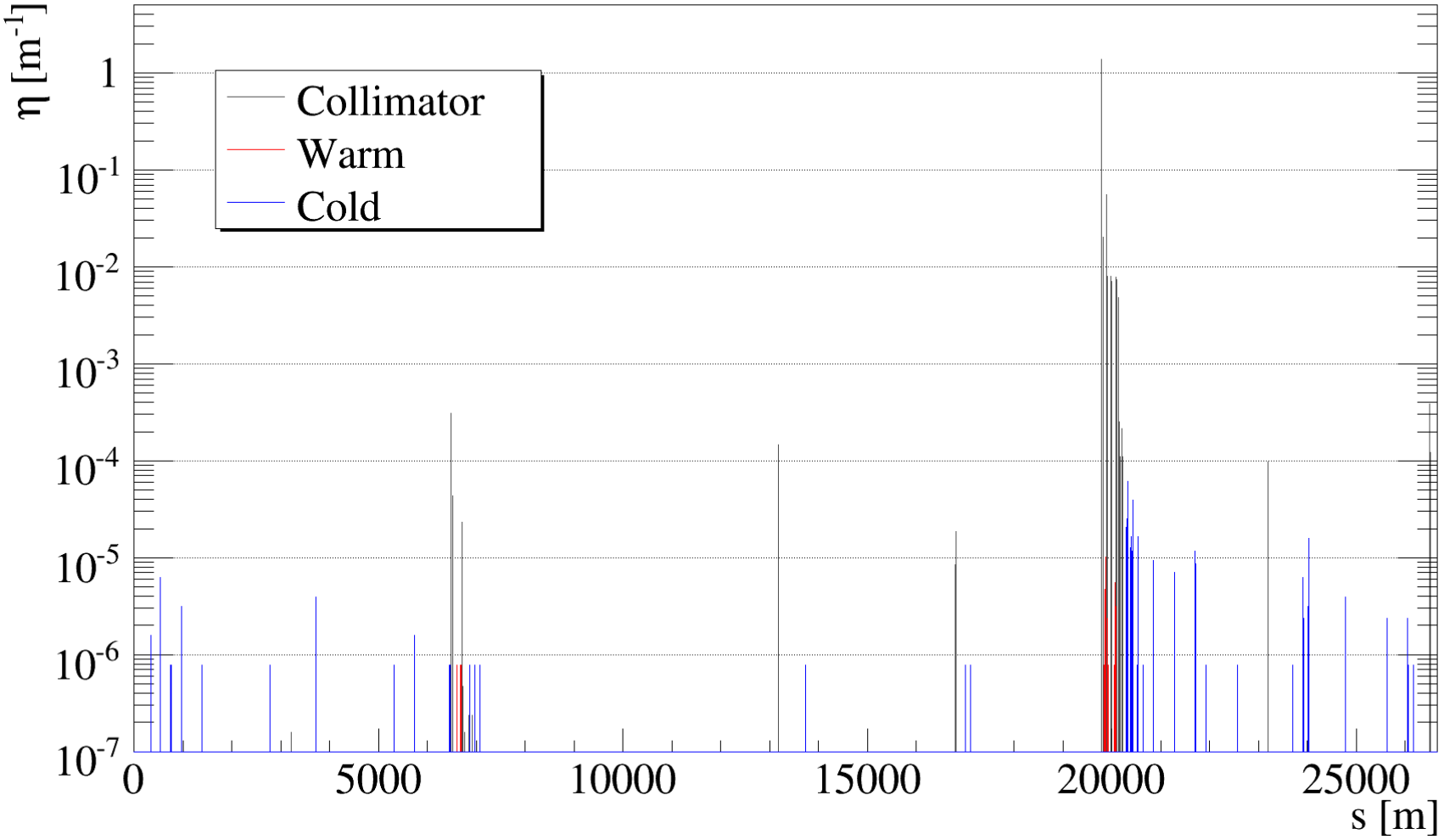


Exit of crystal 2



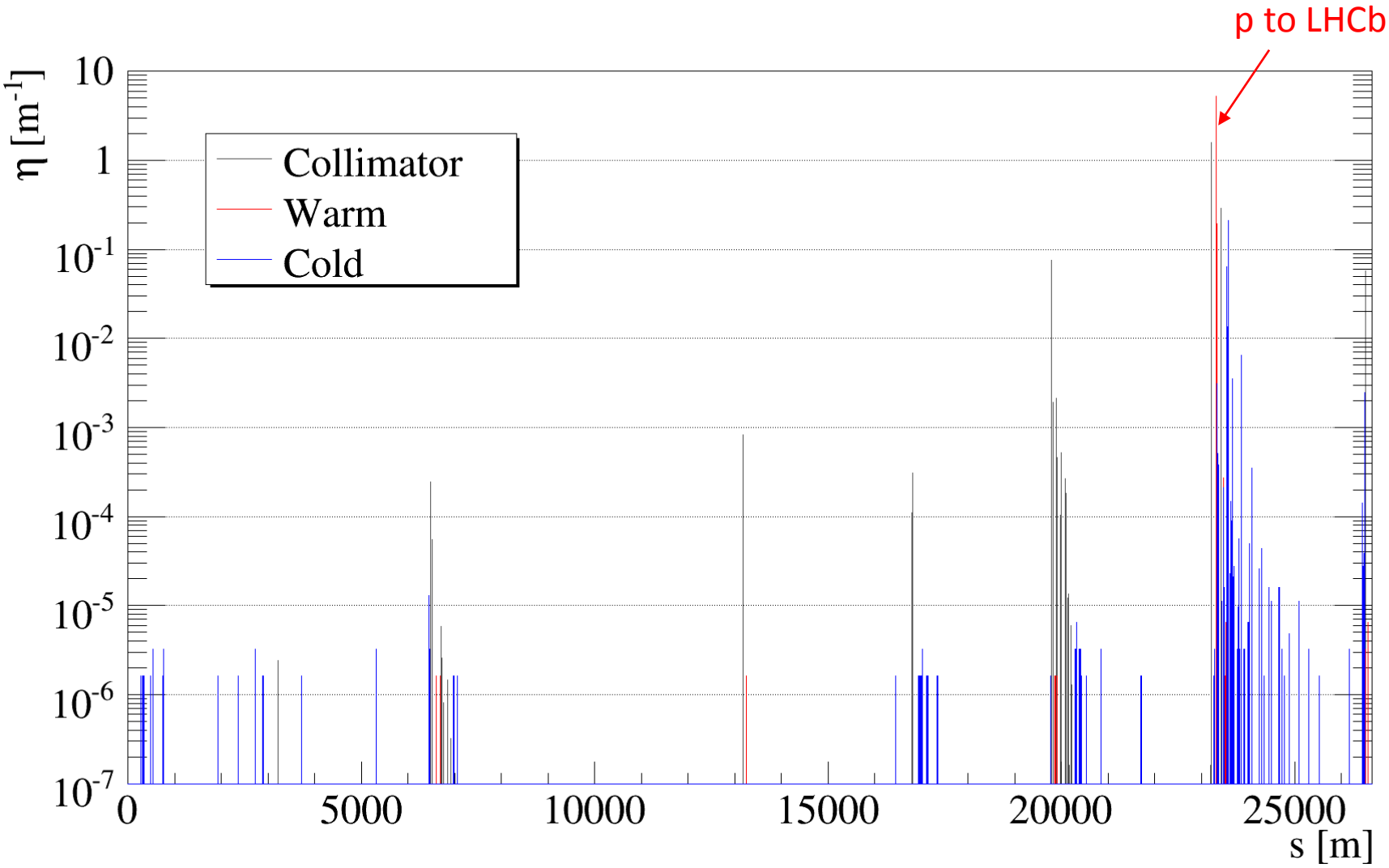
LHC reference loss map

2016 machine (squeezed beams) with 2016 collimator settings

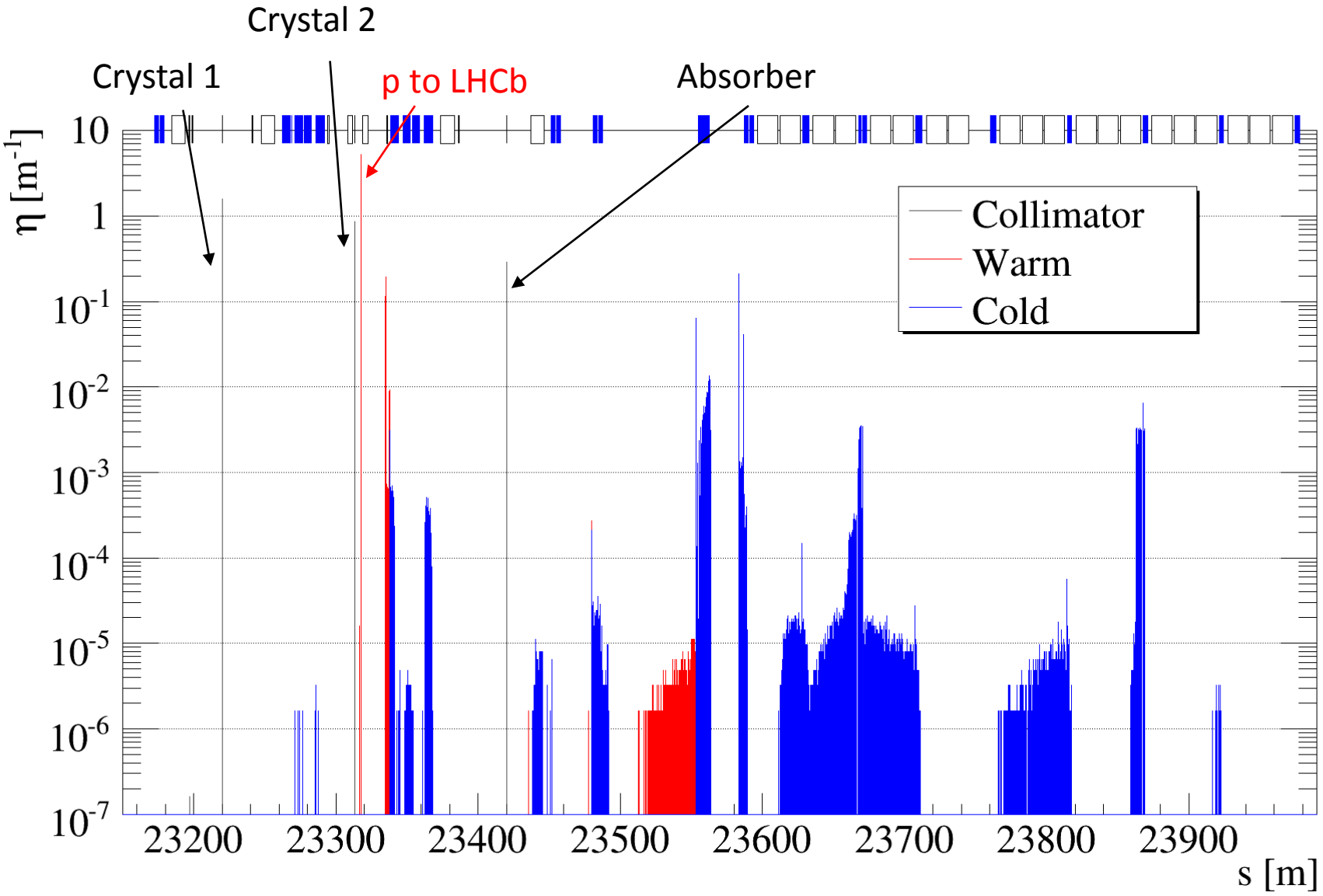


Loss map during “double channeling”

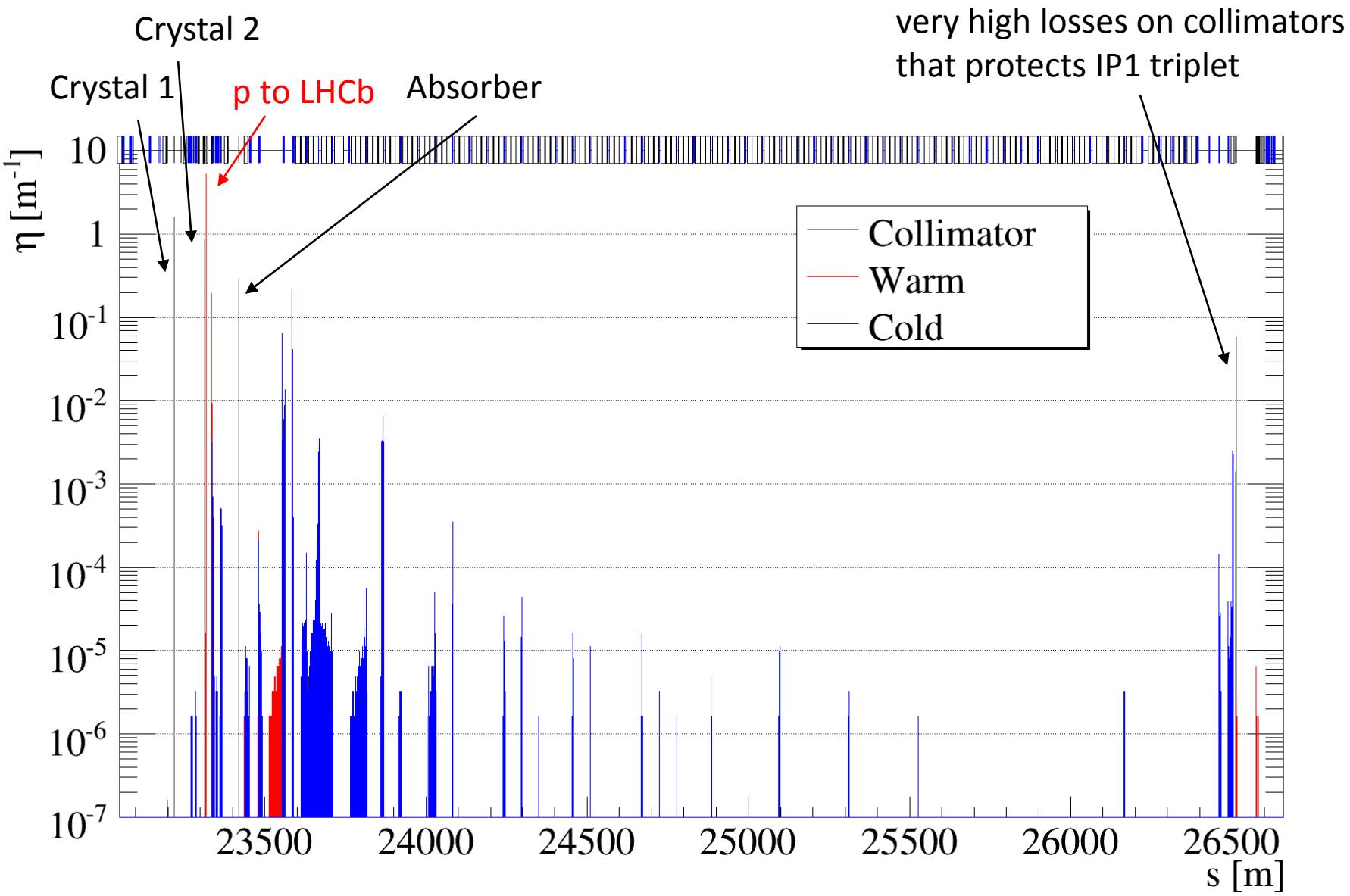
First crystal as primary restriction at 5σ



Loss map (ZOOM IP8) “double channeling”



Loss map (ZOOM IP8-IP1) “double channeling”



Conclusions

- Possible to design and integrate such system in the present LHC layout
  - ✓ “double channeling” (i.e. channeled halo by the first crystal intercepted and channeled again by the second crystal)is compatible with the LHCb geometry and acceptance (with short-living baryons traversing well the LHCb VELO).
  - ✓ Still a long way for a fully effective scenario

- Loss maps simulations show that a substantial reduction of the induced halo should be obtained to allow parasitic operation.
  - ✓ Simulations with 5mm long W target in place and at the same aperture of the second crystal show a negligible impact expected on losses generated in the ring.
  - ✓ Simulations performed using absorber made of 1 m of W (present TCLA/TCT) instead of 1m of CFC show a small improvements of losses between IP8 and IP1
  - ✓ Comparisons between Flat top and Squeeze optics do not show relevant differences in terms of loss maps

Simulations will be improved soon to take into account the energy spectrum of the short-leaving baryons produced into the target.

Next steps

- Ask the necessary support to CERN, LAL,… and LHCB in order to formulate a proposal to the LHCC
- A CDR should investigate:
  - Full layout
  - Compatibility with the LHC collimation system and with the LHCb detector
  - Optimize
    - The beam energy
    - The target and the crystal length to maximize the production of Λ_c and their channeling efficiency
    - The crystal bending angle for an optimal acceptance of the Λ_c fragments into LHCb
  - Investigate the alternative option of an experiment with an extracted beam (SPS or LHC)
- Propose tests in the SPS and H8 in the North Area to investigate
  - The optimal assembly Target&Crystal2
  - The efficiency of the double crystal scenario
  - The compatibility with the crystal collimation scenario
- Propose scenarios in LHC to evaluate
  - the compatibility with LHCb and with the collimation system
  - The parasitic mode operation
  - The background and the data taking rates.