A double-crystal experiment in the LHC: what is the best layout and location?

MOPL/048
IPAC23

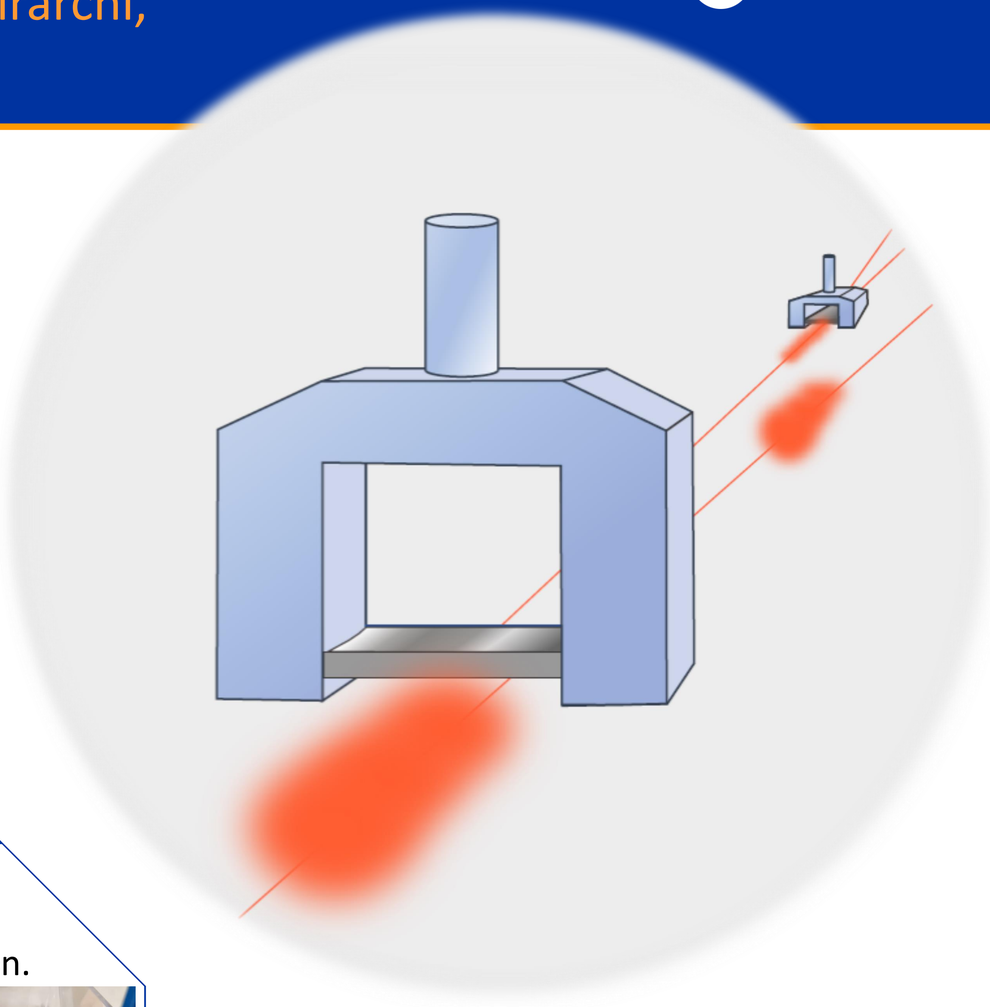
Kay A. Dewhurst*, Marco D'Andrea, Pascal D. Hermes, Danielle Mirarchi, Stefano Redaelli, Marcin Patecki

Introduction

The Physics Beyond Colliders (PBC) studies at CERN investigate using the Large Hadron Collider (LHC) for fixed-target experiments beyond the colliding-beam physics. As part of PBC, a double-crystal experiment is considered for the off-momentum region of the LHC; IR3. Bent silicon crystals will be used to channel particles from the halo of the main proton beam and deflect them onto a target, second crystal, and detector. The experiment is planned in two stages:

- A Proof-of-Principle (PoP) test stand
- A final PBC experiment

We consider which layout of components is best for these double-crystal experiments.



Experiment aims

Proof-of-Principle (PoP) test stand

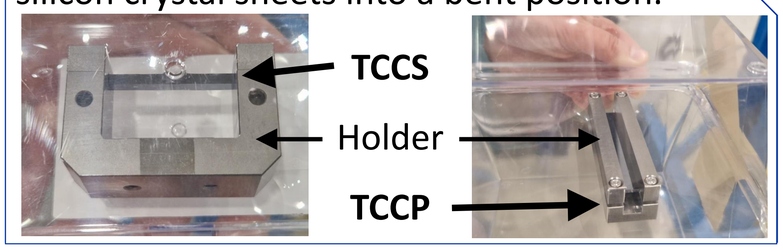
- Characterise the new silicon crystals at TeV energies (up to 7 mrad bending)
- Provide technical experience for other PBC studies

Final PBC experiment

- Measure the electric and magnetic dipole moments of short-lived baryons (Λ_c)

Crystals TCCS and TCCP

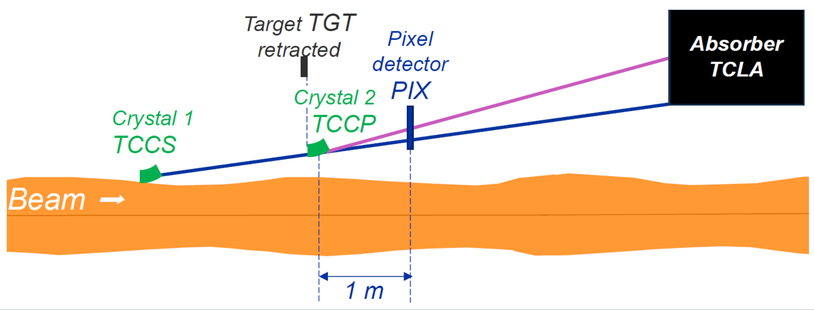
Protons follow the lattice structure of the silicon crystal. Holders clamp the silicon crystal sheets into a bent position.



Scan for the paper: https://tinyurl.com/DoubleCrystal

PoP test stand

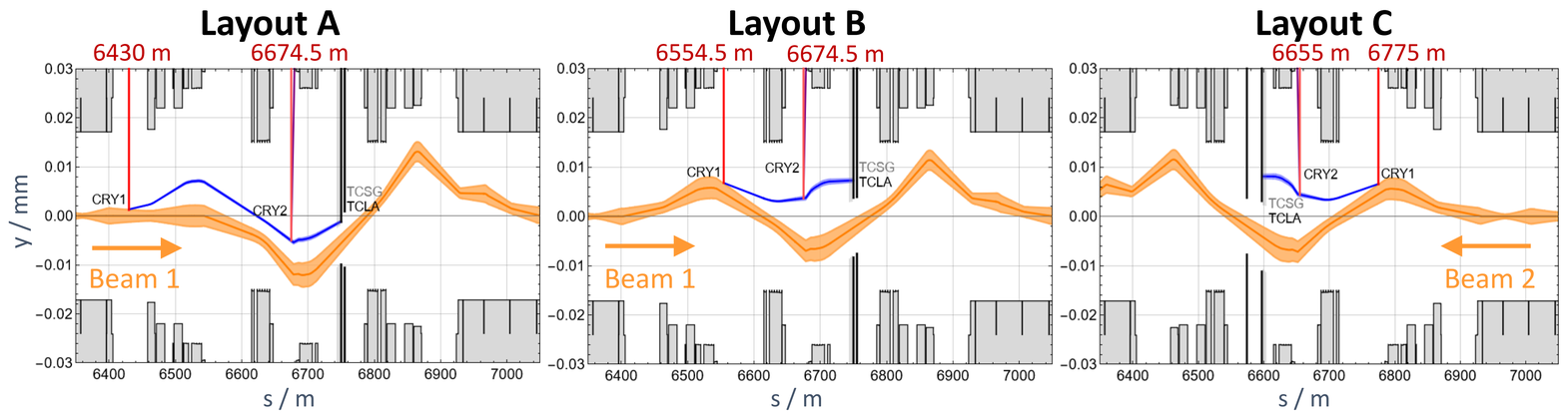
A first crystal (TCCS) channels halo-protons onto the second crystal (TCCP). Some protons are channelled again in the TCCP: forming single- and double-channelled spots on the pixel detector. The channelling efficiency of the TCCP is measured using the relative intensities of these spots.



We investigated 3 layouts for the test stand in IR3; A, B and C. All 3 were feasible, but layout A showed some disadvantages: the crystals could not be aligned at injection energy (0.45 TeV) and the pixel detector would need to be very close to the main beam to capture the single-channelled spot.

Final PBC experiment

In the final PBC double-crystal experiment, we insert the target, add a 4 Tm spectrometer, and add new vertical collimators (TCSGs and TCLA). Protons impact the target producing rare baryons that precess and form decay products in the TCCP. The spectrometer measures these decay products. The addition of a spectrometer magnet causes an orbit bump in the main beam, which must be compensated by corrector magnets in the local region (IR3). This was done for all 3 layouts in MADX.



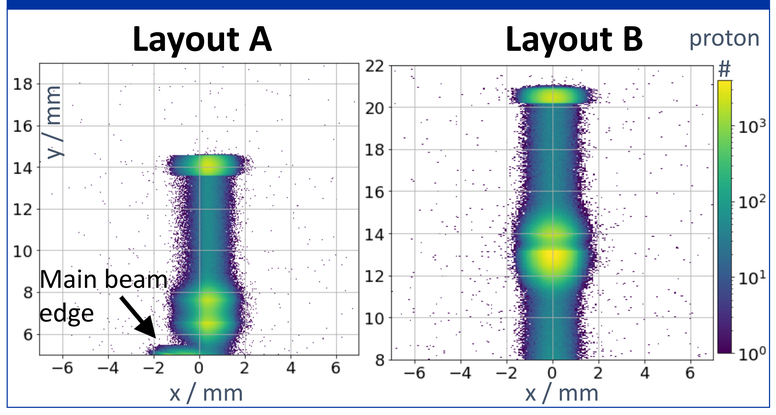
The number of Protons impacting on the Target (PoT) will determine the yield of rare baryons in the final PBC experiment. Particle tracking was performed for each layout and collimation setting (primary TCP at either 6.7σ or 8.5σ) to calculate the integrated PoT over 10 h.

$$PoT(t) = \frac{1}{2}\frac{I(t)}{\tau}\exp\left(-\frac{1}{\tau}\right)\frac{N_{imp}^{TCCS}}{N_{sim}}\varepsilon_{ch}^{TCCS}$$

Protons-on-Target (PoT)

Layout (Beam)	TCP y[σ]	TCCS s[m]	TCCP s[m]	Proportion Channelled	PoT [×10^{10}]
A (1)	8.5	6430	6674.5	0.17	0.11
B (1)	8.5	6554.5	6674.5	0.35	1.40
C (2)	8.5	6755	6655	0.58	1.19
A (1)	6.7	6430	6674.5	0.39	0.52
B (1)	6.7	6554.5	6674.5	0.30	1.55
C (2)	6.7	6755	6655	0.57	1.26

PoP: Spots on the pixel detector



Conclusion

We recommend work to install the double-crystal experiment in IR3 of the LHC moves forward using layout B. This layout uses beam 1, with TCCS at 6554.5m and TCCP at 6674.5 m

Positives of layout B:

- PoP and final PBC: Favourable trajectories
- PoP: Crystal alignment possible at injection energy (0.45 TeV)
- PoP: detector far from the main beam edge
- PoP: local TCLA can be used as the absorber
- Final PBC: bump least-close to the aperture
- Final PBC: greatest number of PoT

cern.ch
CERN BE-ABP-NDC
*kay.dewhurst@cern.ch