# A.O.B.:
# Update on the crystal collimation plans

O. Brüning and S. Redaelli

Inputs : G. Arduini, R. Bruce, M. Calviani, M. Di Castro, S. Gilardoni, A. Masi

Acknowledgements: B. Di Girolamo, Y. Papaphilippou, M. Zerlauth

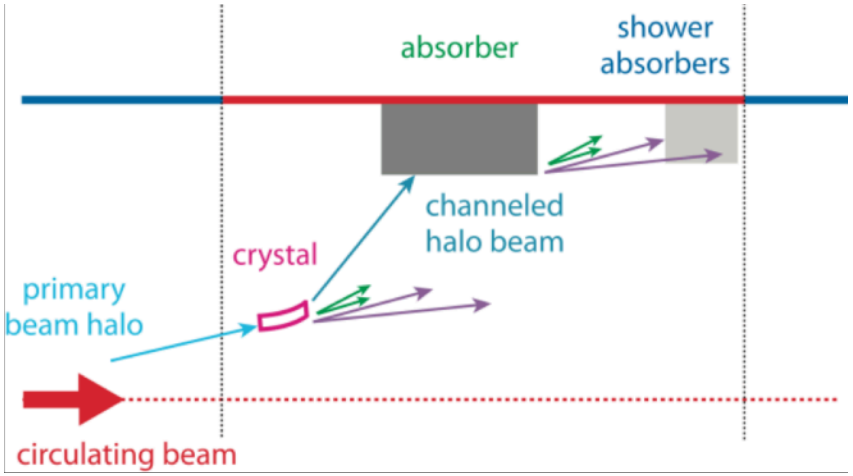
410th LMC meeting, 03/02/2021

# Table of contents

# Introduction

- "Crystal collimation" relies on hadron-beam channeling in bent crystals, used instead of standard primary collimators, to improve halo cleaning.
  - Promising results obtained in Run 2 at 6.5 Z TeV with Pb ion beams
- Part of R&D studies under HL-LHC-WP5, then in 2019 integrated in the baseline upgrade as mitigation to schedule risks with the 11T dipoles
  - "Baseline 4.0" approved by Council in Dec. 2019, following C&S review.

*Crystal collimation scheme*



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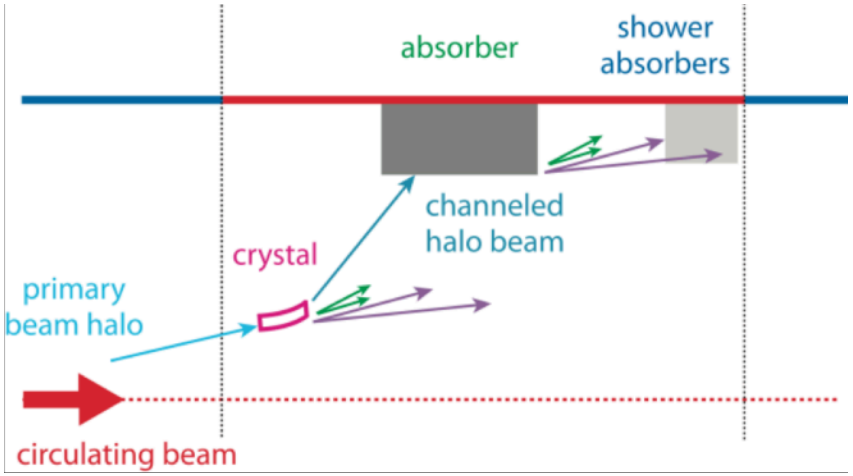


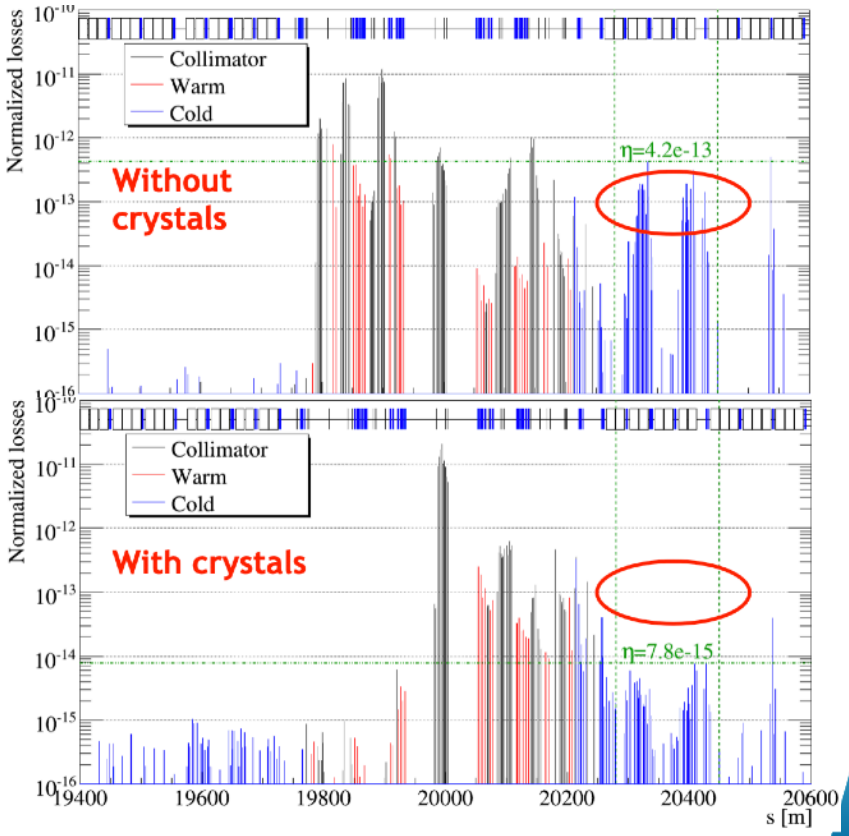

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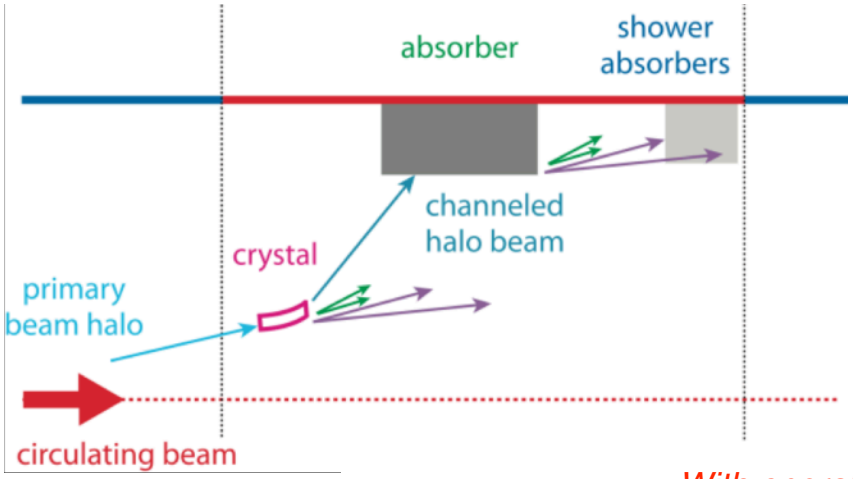


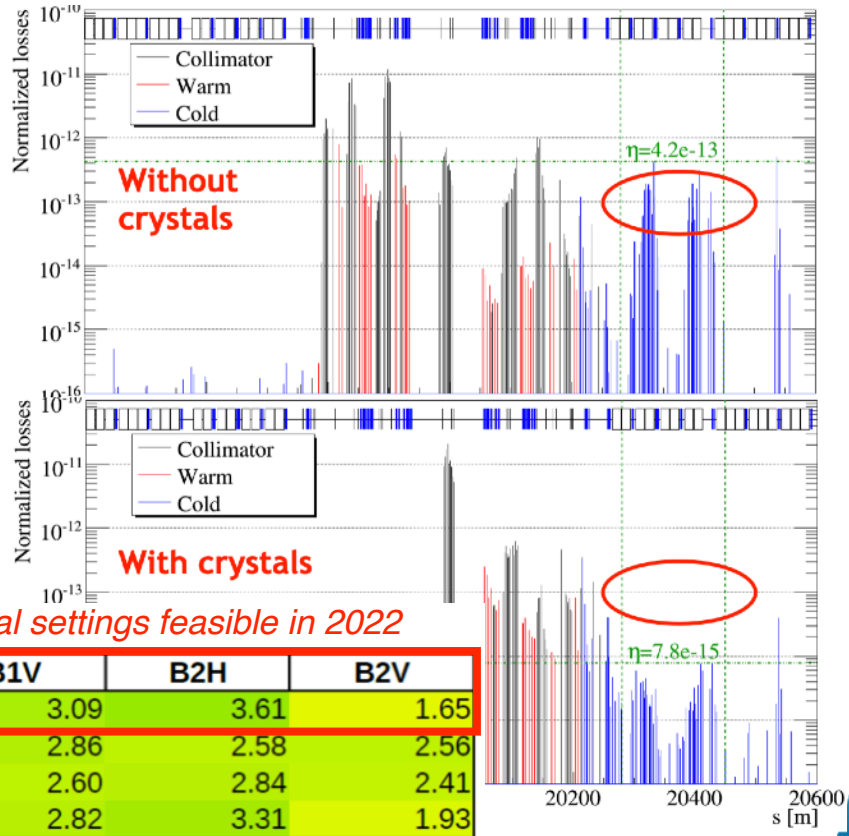


*With operational settings feasible in 2022*

**OP**

| | B1H | B1V | B2H | B2V |
|---|---|---|---|---|
| cry w/ TCLAs @ 10 | 7.50 | 3.09 | 3.61 | 1.65 |
| cry w/ TCLAs @ 9 | 6.16 | 2.86 | 2.58 | 2.56 |
| cry w/ TCLAs @ 8 | 5.71 | 2.60 | 2.84 | 2.41 |
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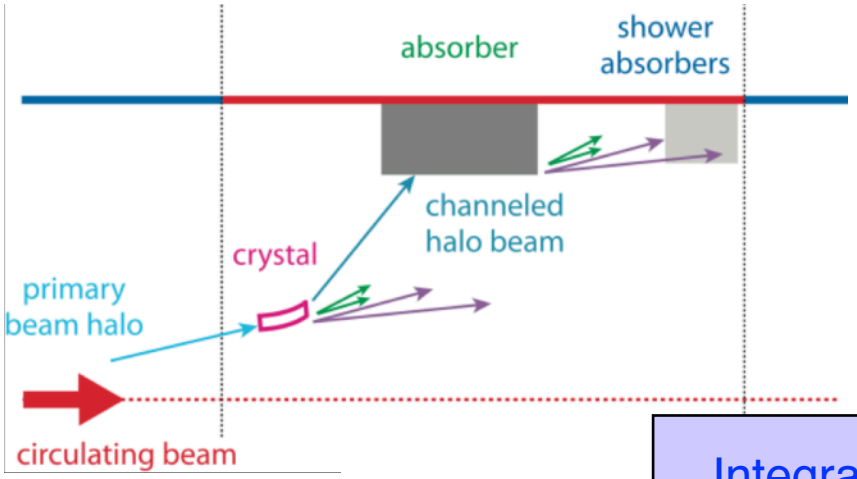


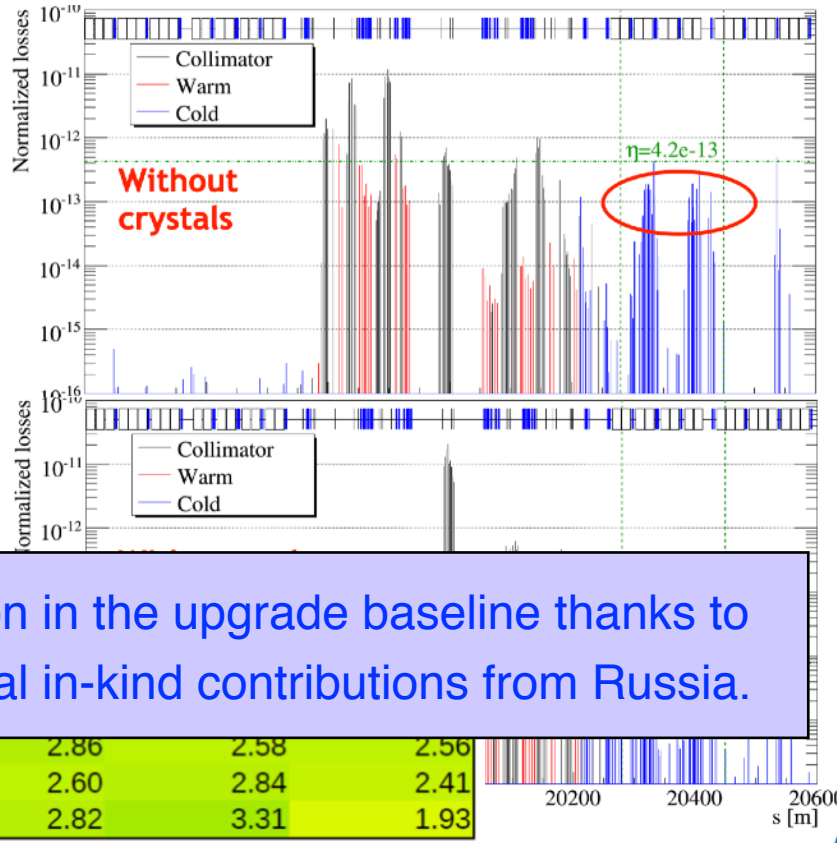


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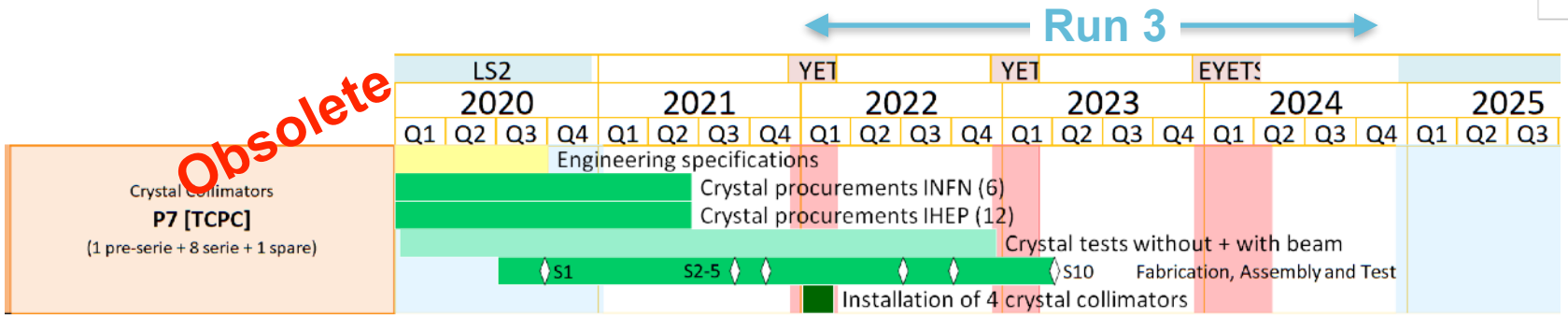
Integration in the upgrade baseline thanks to substantial in-kind contributions from Russia.

# In-kind scope and initial timeline




— Goal: crystal collimation system operational in 2022 for the first Pb ion run

— Russian institutes PNPI and IHEP to provide the mechanics of the "Crystal Primary Collimators", called TCPC, to replace the presently-installed test devices.

— *Mechatronics and controls components come from CERN: schedule under control*

— Initial in-kind schedule based on the plan that in-kind funding could start in 2020. It then turned out that it can **not start before spring 2021**.

— LHC schedule changed as well, with first physics run now planned in 2022.

*See also plans presented to the 398th LMC* S. Redaelli, LMC 03/02/2021

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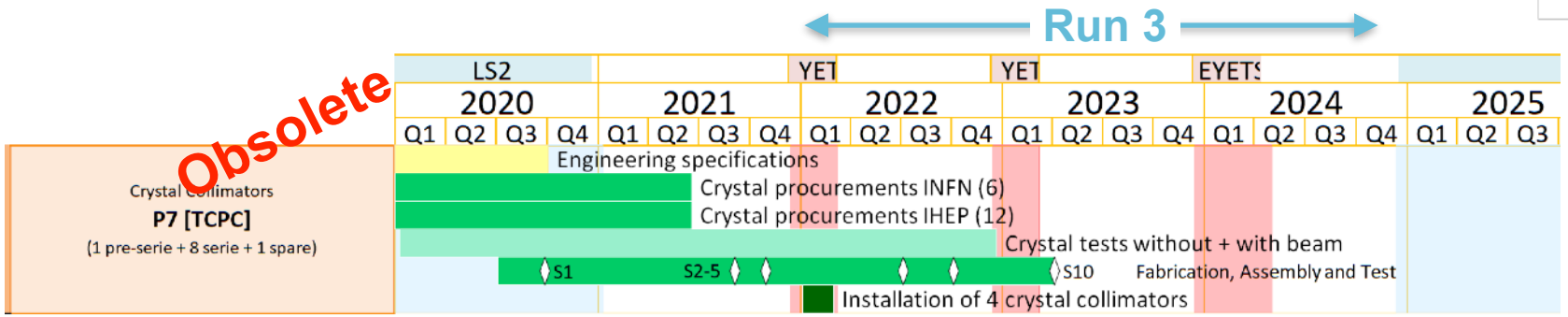


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— LHC schedule changed as well, with first physics run now planned in 2022.

In the second half of 2020, it became clear that it would be too risky to rely only on the in-kind support to make any intervention before the LHC startup in 2022. Confirmed at the end of 2020 when the decision on 11T dipoles was taken.

*See also plans presented to the 398th LMC* S. Redaelli, LMC 03/02/2021

# Project approach

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- In light of the decision (Nov. 2020) not to install the 11T dipoles around IR7 during LS2, the HL-LHC project decided to support the deployment in the LHC of **crystal collimation** as “Plan A” for the **ion runs in Run 3**.
  - Ahead of the kick-off of hardware activities in Russia, the project undertakes the construction of **2 TCPC units** for installation before the 2022 run.
    - Can replace the 2 most critical test devices in IR7 (out of 4 used in Run 2) Present proposal: replace the vertical TCPCs in 6L7-B1 and 6R7-B2.
  - Design and construction are done at CERN with in-kind support, which will also help the subsequent production in Russia
    - In-kind support remains instrumental to complete to rest of units & spares
  - Discussions with relevant CERN teams indicate that **schedule is tight but feasible** for completing two units by **early November 2021**.

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- Key reference documents: HL-LHC “decision management reports” (DMRs)
  - LHC-LBH-ED-0001 (EDMS 2441244): non-installation of 11 T dipoles
  - LHC-TCPC-ED-0001 (EDMS 2455213): in-house production of 2 TCPCs

# Conclusions

- Following the decision not to install in LS2 11 T dipoles around IR7 during LS2, we are working on deploying the crystal collimation scheme for ion operation in Run 3
  - Focus on lead ion beams, following the LIU intensity upgrade
- Important delays in 2020: the lack of funds in Russia prevents relying fully on in-kind contributions, as initial planned.
- The HL-LHC project decided to advance resources to prepare at least two “crystal primary collimators” that are expected to be available for installation at the end of 2021
  - Hybrid system in 2022, still relying on some of the test devices used in Run 2
  - In-kind contribution will follow to complete the construction of additional units that should be installed in the YETS2022-23
- Next steps:
  - Final assessment of resources and planning
  - Update of the ECR LHC-TC-EC-0015 (July 2018) for crystal installation in LS2
  - To be presented to the LMC for approval: request to install new TCPC after beam tests in fall 2021.

# Reserve slides

# Recap. from CSR2019

## Project approach to crystal collimation

- Crystal collimation: ion-beam cleaning (or low intensity proton beams)
  - *IR7 cannot easily be upgraded to sustain high losses from proton beams*
  - *Satisfactory cleaning performance for proton after upgrade*
- Crystal Collimation as a backup plan for late installation of 11T dipole
  - *But after the new DS upgrade are not strictly needed*
  - *With essentially no additional cost, **we are buying a backup plan, in case of delay**.*
  - *We increase the robustness of cleaning upgrade also in presence of 11T*
- The experience in 2018 demonstrated important applications of crystal collimation beyond high-intensity beam cleaning (e.g. special runs).
- HL-LHC also contributes to a new technology demonstration for the future machine!
  - *First time usage in collider's operation!*
- Opportunity for a new partner to participate in HL-LHC.



*Presented to the Cost & Review 2019*

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Approval made possible thanks to substantial in-kind contributions by Russia (PNPI/IHEP)

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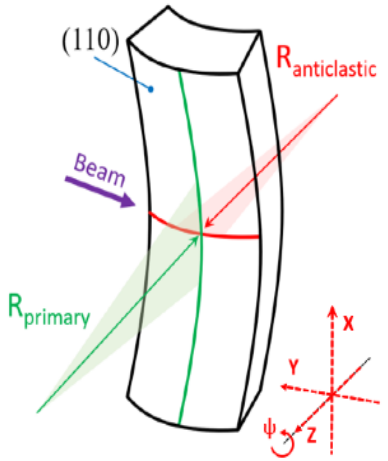
# References to recent material

- Presentation to the 398th LMC, Jul. 8th (S. Redaelli)
  - Scenarios for different 11T installation plans.
- Presentation to the 405th LMC, Nov. 11 (D. Mirarchi)
  - Pb ion losses in 2018 and extrapolations to Run 3.
- 120th HL-TCC meeting, Nov. 12 (three presentations)
  - Review of Pd ion cleaning performance, hardware status and production plans.
- First look at in-house production schedule of TCPC by EN/STI (I. Lamas)
  - Collimation upgrade manag. meting, ColUMM, Nov. 19
- Dec. 2020 - Jan. 2021: decision management reports
  - See links above for reports from WP11 and WP5.
- Next LMC: report on controls plans for 2022 (M. Di Castro)

# Plans for crystal procurement

See http://cds.cern.ch/record/2730428 for details on procedure


X-Ray machine setup



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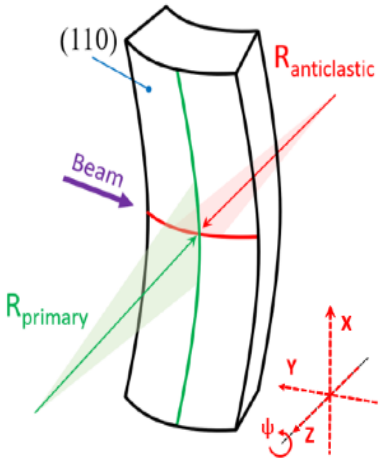

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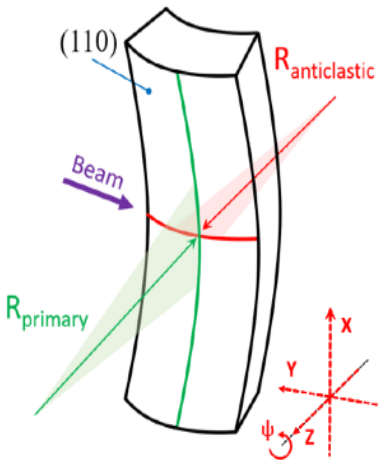

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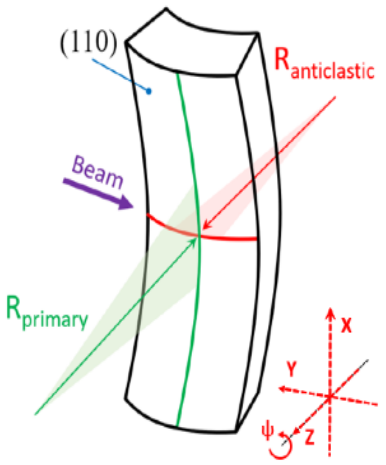

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- Validation with hadron beams in H8 is being discussed (time request for North Area brought forward by SY/STI).
  - Dates for tests to be finalised once delivery dates known

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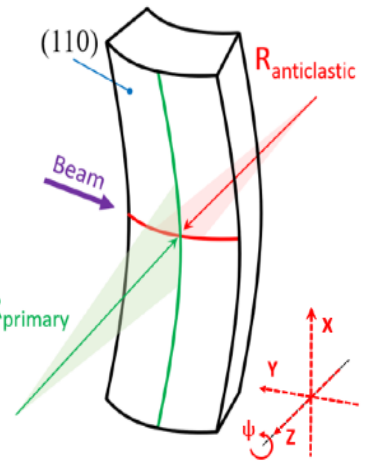
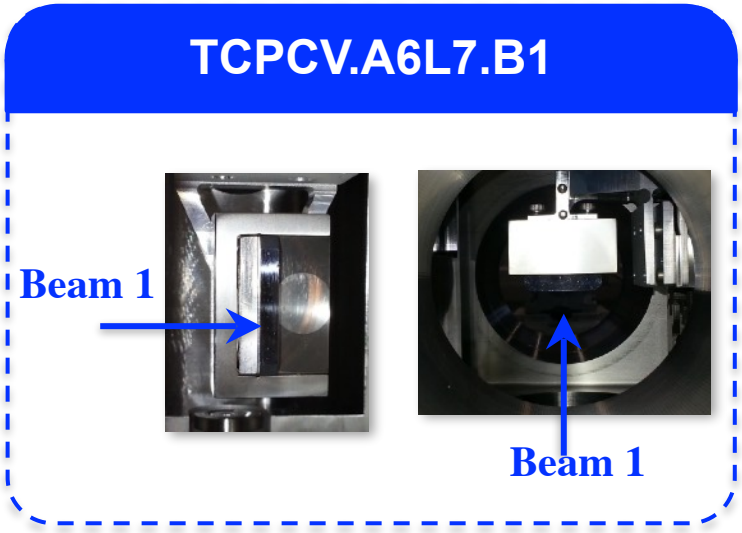
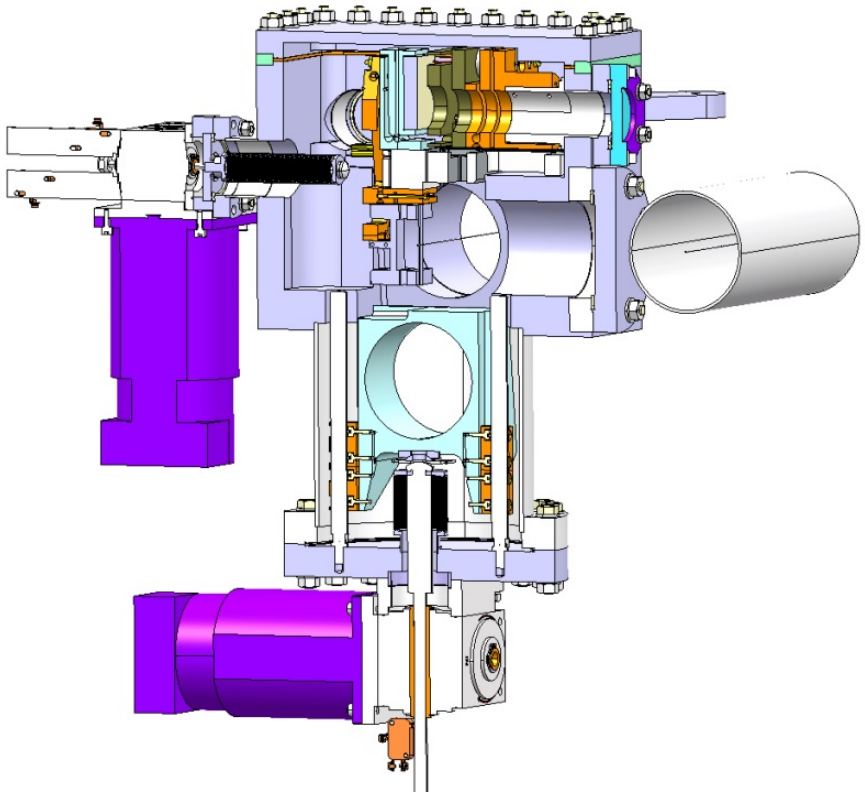
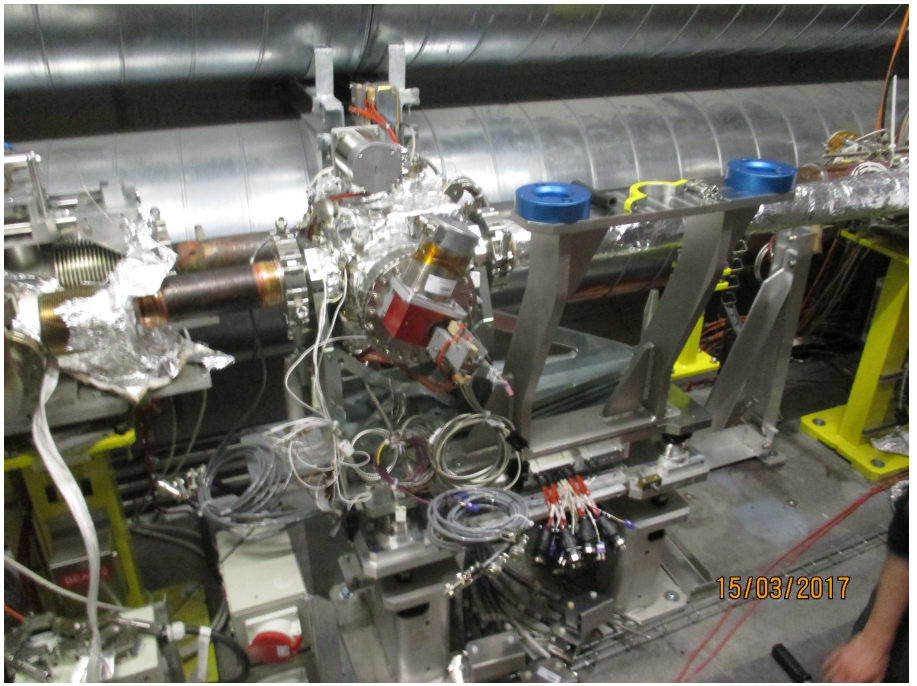


# The bent crystal for LHC collimation




# TCPC assembly






**TCPCV.A6R7 B2 Vertical**