Collimation settings for the ion run

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Crystal collimation for Pb ions

Challenges of future ion collimation:

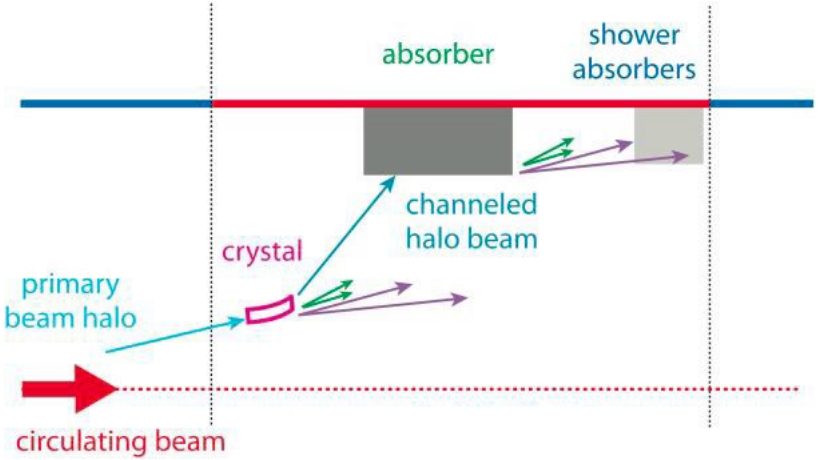
- Ion fragmentation which changes mass-to-charge ratio.
- Higher stored beam energy.
- Delayed installation of the 11T dipoles.

Advantages of crystal collimation:

- Reduced fragmentation.
- Ability to handle the target stored beam energy.
- Better collimation performance.

Crystal collimation operation:

- Bent crystal is the primary collimator.
- Crystalline planes can “channel” the incoming halo particles.
- The bend provides a significant angular kick.
- The channeled halo is intercepted by a downstream absorber.



Proposed changes in ion collimation

Crystal scheme for ion collimation

Baseline is to use the standard collimation system with the same settings as in the proton run, but with a few changes discussed in the following

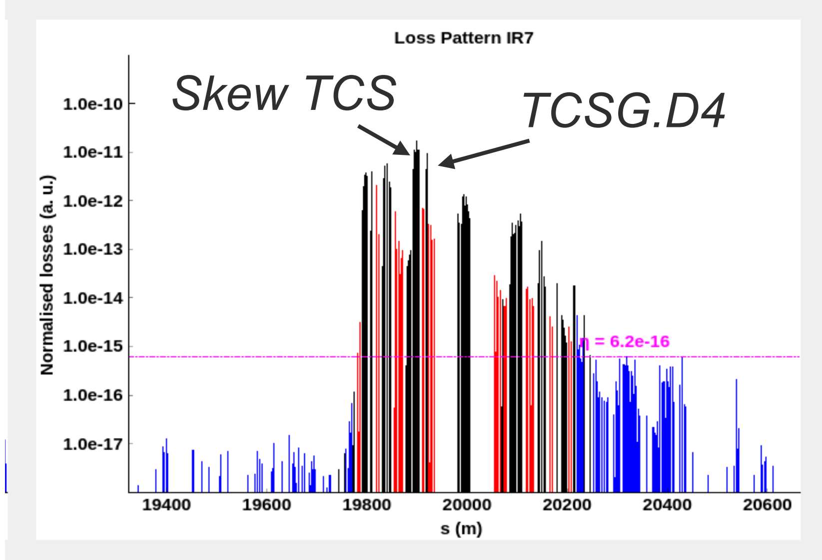
- **Crystals inserted as primaries at 5 σ:**
  - Previous MDs explored even tighter settings (4.5 to 4.75 σ).
  - However, larger primary opening improves beam lifetime and decreases sensitivity to 10Hz losses.
  - Smaller aperture difference between crystal and absorber to allow deeper hits into the absorber and higher number of absorbed particles.

- **Standard secondary collimators used as absorbers**
  - TCSG.D4L7.B1, TCSPM.B4L7.B1, TCSG.D4R7.B2, TCSPM.B4R7.B2: kept at standard setting of 6.5 σ.
  - kept at standard setting of 6.5 σ.

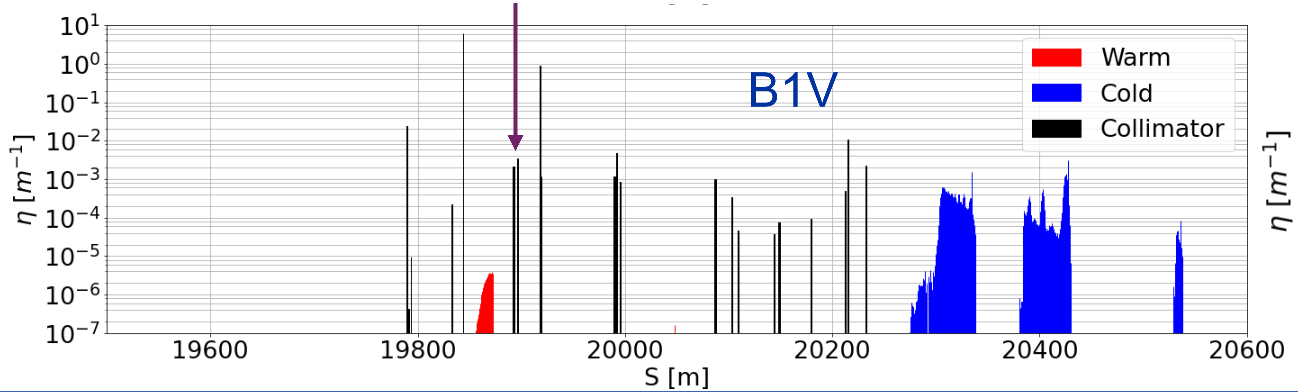
- **TCPs at 6 σ instead of 5 σ :**
  - The losing of hierarchy was observed in the 2023 beam tests.
  - Increases distance from TCPC to ensure to always have TCPC as primary collimator.

Skew TCSGs

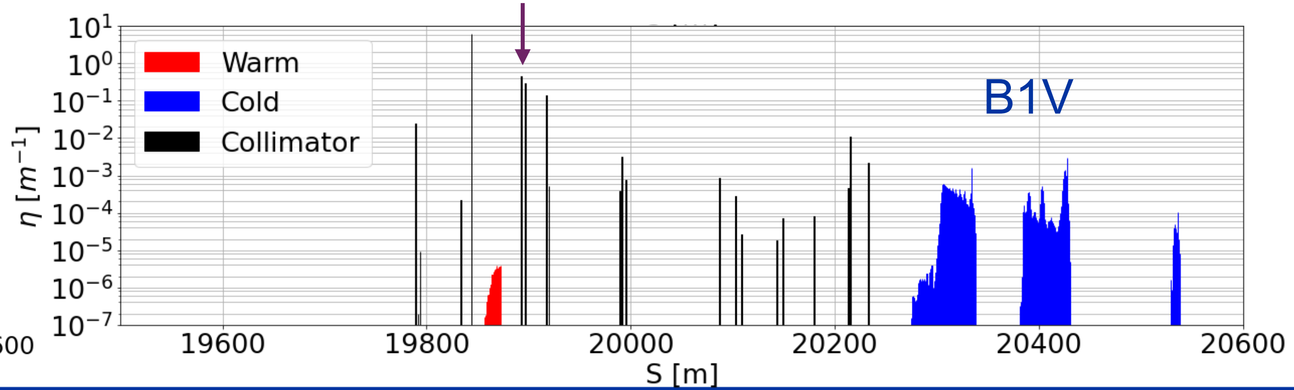
- **In the vertical plane, there are two skew collimators between the crystal and the absorber.**
- **Grazing impacts of the channeled halo on these collimators have been observed in measurements and simulations**.
  - Grazing beam may deteriorate cleaning due to shorter active length and potential higher out-scattering.
  - However, simulations show no difference in cleaning efficiency in DS with different settings. -> Experimental data needed.
- **Keep tentatively the skew TCSGs at 6.5 σ**.



Skews at 8 σ



Skews at 6.5 σ

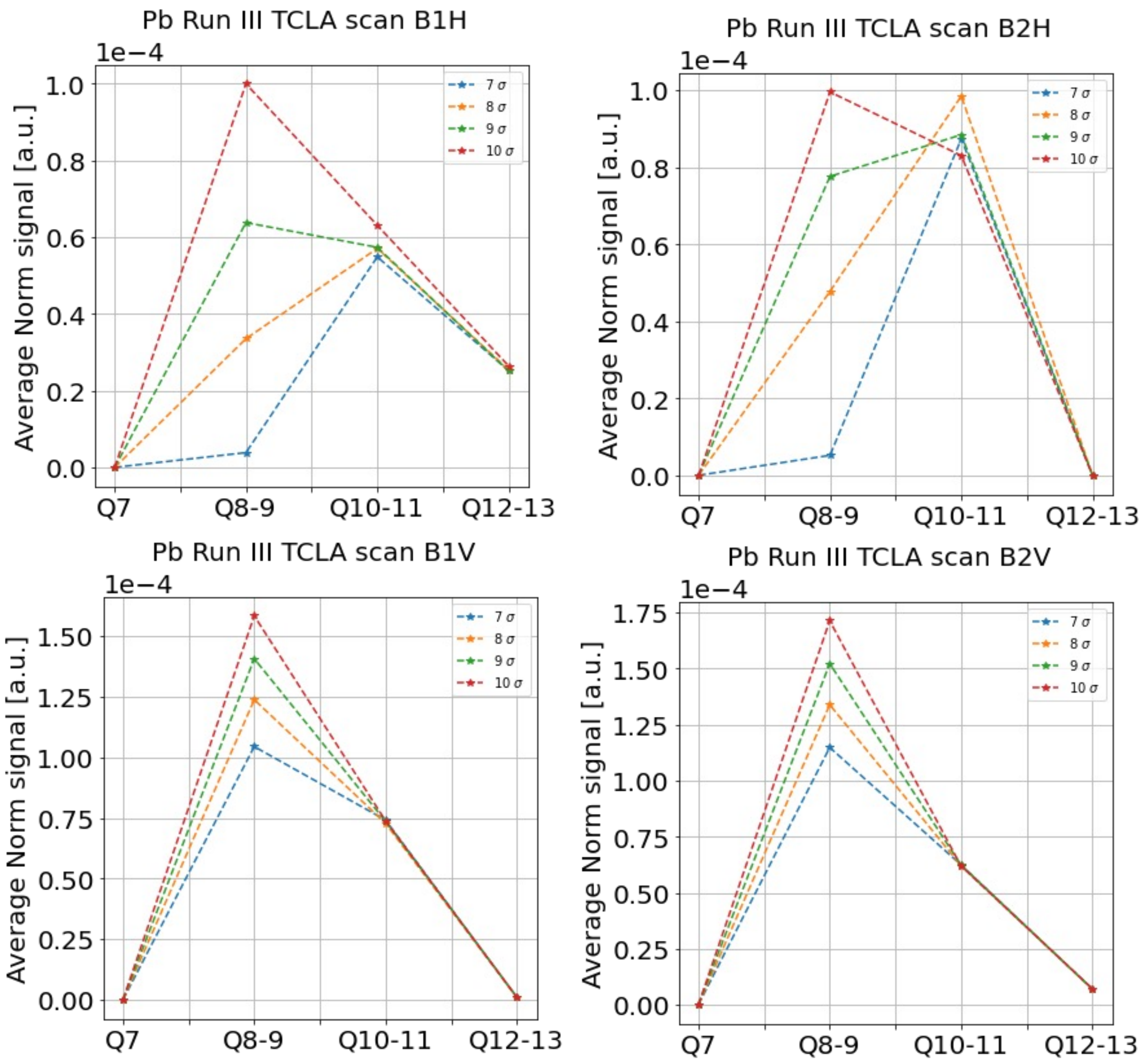


Standard secondary absorber collimators

- **The collimators used as absorbers are:**
  - At injection: TCSG.D4L7.B1, TCSG.B4L7.B1, TCSG.D4R7.B2, TCSG.B4R7.B2.
  - At flat top: TCSG.D4L7.B1, TCSPM.B4L7.B1, TCSG.D4R7.B2, TCSPM.B4R7.B2.
- **During ramp in the horizontal planes:**
  - TCSG is gradually retracted.
  - TCSPM is gradually inserted from a 0.5 σ retraction.
  - This poses risks of grazing beams -> **proposal to have only one absorber** during the entire ramp.
- **Flat top settings kept at the standard 6.5 σ.**

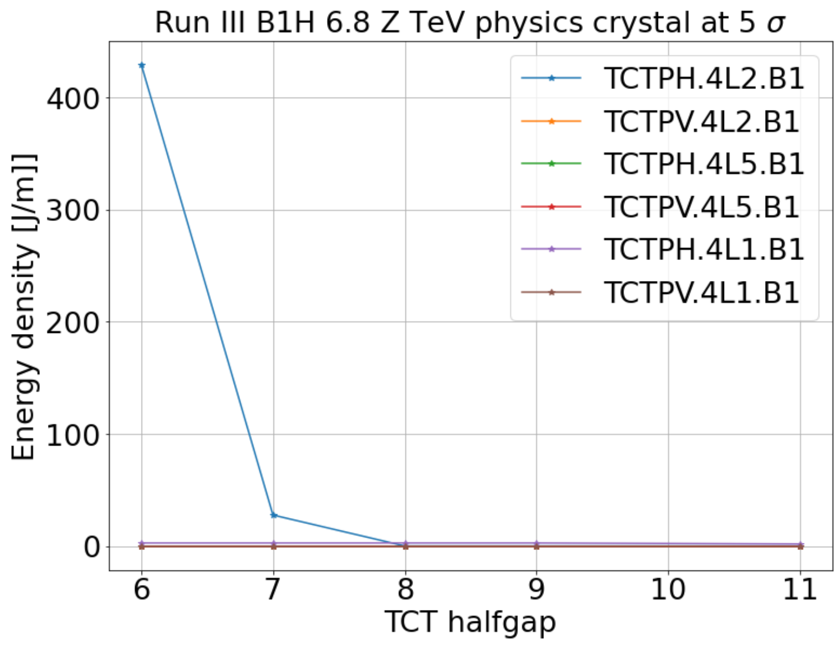
TCLAs

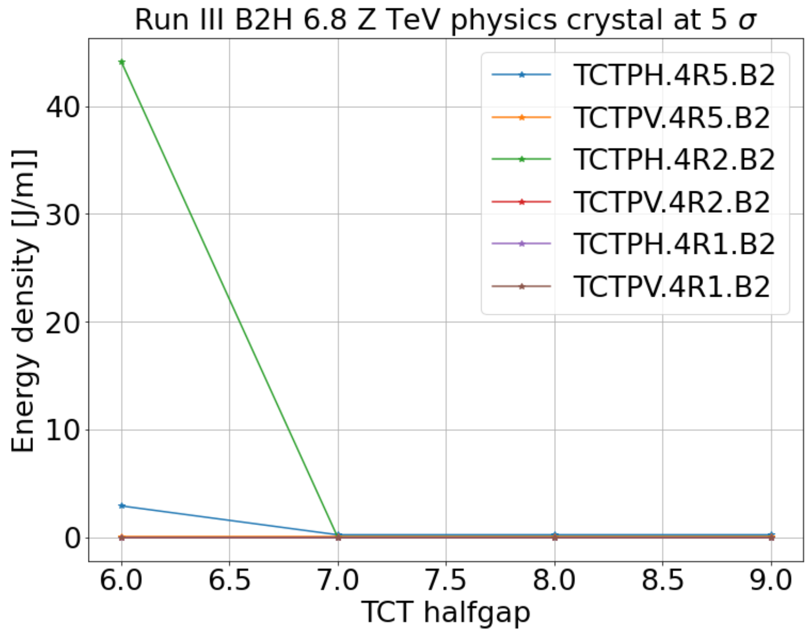
- **Previous crystal studies have shown a reduction of the Q8-9 loss cluster with tighter TCLA settings.**
- **Main inner limit from risk of hitting TCLAs with mis-kicked beam during asynchronous dump**
  - TCLAs made of tungsten -> same damage limit as for TCTs
  - Onset of plastic deformation at about 5×10^9 protons at 7 TeV (about 5.6 kJ impacting energy)
  - Simulations show that even at the 7 σ, the highest summed energy density (~300 J/m) is significantly below the limit.
- **Proposal to tighten the TCLAs to 8 σ from 10 σ.**



TCTs

- **In previous ion runs, high experimental background observed occasionally, originating from showers from TCTs.**
- **Dumps on TCTs observed during high beam losses (10 Hz events).**
- **Both issues could be mitigated by a more open TCT setting.**
- **Proposal to open the TCT setting as much as possible without jeopardizing aperture protection**
  - final setting can be decided based on the aperture measurements in the commissioning - position TCTs 1 σ inside the measured aperture
  - Tentatively assuming a 9.5 σ TCT setting
- **Checking also risks of damaging TCTs during an asynchronous dump - simulated impacts over a range of TCT settings for single-module pre-fire type 2:**
  - Energy density far below damage limit even with TCT at 6 σ.
  - Not limited by asynchronous dump with current optics.





Conclusions

Proposals

- **Baseline for collimation in 2023 ion run: use standard collimation system with same settings as for protons with a few changes.**
- **TCPs opened from 5 to 6 σ to guarantee hierarchy and safe operations.**
- **TCLA tightened to 8 σ from 10 σ to reduce the losses in Q8-9.**
- **Asynchronous dump scenario does not pose any restrictions on TCLAs and TCTs.**

Action points

- **Collect experimental data to finalize skew collimator settings**
- **Collect aperture measurements to finalize TCT settings**
- **Finalize one absorber collimator for the horizontal planes**

Collimator	Proposed
TCP	6 σ
TCPC	5 σ
TCSG.B5L/R7.B1/2, TCSG.A5L/R7.B1/2	6.5 σ (TBF)
TCLA	8 σ
TCT	9.5 σ (TBF)

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