Minutes of 145th Collimation Upgrade Specification Meeting
Minutes for 145th meeting (30 August 2021)

Present: AZZOPARDI Gabriella (GA), BRUCE Roderik (RB), CAI Rongrong (RC), CALVIANI Marco (MC), CERUTTI Francesco (FC), DI CASTRO Mario (MDC), GAVRIKOV Yury (YG), GALLUCCIO Francesca (FG), GILARDONI Simone (SG), LECHNER Anton (AL), LINDSTRÖM Björn (BL), MASI Alessandro (AM), MATHESON Eloise (EM), MIRARCHI Daniele (DM), MOLSON James (JM), OLIVEIRA Joao (JO), PATECKI Marcin (MP), POTOINE Jean-Baptiste (JBP), REDAELLI Stefano (SR), ROSSI Roberto (RR), ESPOSITO Luigi Salvatore (LSE), SCANDALE Walter (WS), SOLIS PAIVA Santiago Andres (SASP), VAN DER VEKEN Frederik (FvdV)

Agenda

1 Actions from this meeting
   • Once the thermal cycle tests of the remaining three INFN crystals are done, before the H8 beam tests, a preranking of the crystals, as well as a list of priorities for the beam tests is to be decided (SR, MDC to organize a dedicated discussion).
   • Ask INFN to present the status from their side concerning crystal production (SR).

2 Recap of actions from previous meetings - S. Redaelli
   The minutes of the previous CoIUSM were approved without comments. SR recalled the recent joint meeting with WP2 (available at this link) that addressed some of the actions on the work by BL and the updated Run 4 configuration. The minutes are under preparation.
   The minutes from the last meeting were approved without comments.

3 LHC crystal goniometers: crystal x-ray measurements - E. Matheson [slides]

   Summary of the presentation
   Following up on a previous action from CoIUSM#141, EM presented results of the crystal x-ray measurements. The validation process of the crystals is composed of several steps:

   • x-ray characterization of miscut, torsion and bending angle and visual inspection under microscope upon reception.
   • thermal cycle tests to 250 deg.
   • x-ray characterization to be repeated after thermal cycle to check the stability of miscut, torsion and bending angle.
• Bake out and RCG tests - performed by vacuum group.
• H8 beam tests - channeling efficiency and bending angles assessed with hadron beams.

The six crystals from PNPI have been measured and the reports completed. The bake out and RCG reports are currently under approval. There was a non-conformity in two of the crystals, B04-C04 and B05-C05. The former had a broken package on arrival. It is believed to have received a shock during shipping, leading to a smaller bending angle than the specification (48 µrad). This can possibly be repaired at CERN.

The second crystal has a small chip on one of the edges. Discussion is ongoing whether to attempt repair at CERN by PNPI experts or to send back to PNPI.

As for the four crystals from INFN, the acceptance and nonconformity documents are under preparation. One crystal (STF-129) has been measured with x-rays, and the report is being finalized. The bake out and RCG tests of this crystal will commence on September 1st. Bake out tests of the remaining three crystals will be done after the beam tests. The other three crystals were received recently and it is expected that they can undergo the first x-ray measurements in time for the preparation of H8 tests.

The timeline is very strict:
• September 16th: Installation of initial crystal in tanks
• September 15th–20th: H8 beam tests
• October 15th: Swap and installation of final crystals in the final TCPC assemblies
• November 24th: Installation slot opens
• January 21st: Installation slot closes

Discussion

• WS asked for a confirmation that 15th of October is the deadline for the choice of the crystals to be installed. EM confirmed this. SR asked for a clarification, if this is the date that the assembly has to be given to the vacuum team, with the crystals already mounted. EM replied that this is the final day to receive the crystals and start installing them in the TCPC assembly. LSE confirmed that this is the final date to decide on which crystal to install.

• WS emphasized that this is a very strict timeline and that it is difficult to predict whether or not all crystals will be fully measured and analyzed. YG commented that preliminary H8 results will be available online, which can help produce a short list of crystals/data to be prioritized for more detailed analysis.

• SR asked about the impedance measurements, whether or not these will be repeated after the beam tests, as long as there are no issues. EM replied that they will not have to be repeated.

• SR pointed out that the crystals are of high quality, with a miscut of the Russian ones well within specifications and with an excellent miscut for the first INFN crystal. He continued that the non-conformities are unfortunate, but if the tests of the final crystals from INFN can be finished, there will be four plus four crystals to test with beam. SR asked what the schedule for these measurements is. EM replied that the first measurements are currently being done, with thermal cycle tests, taking one week, to be done next week. This leaves enough time to perform the second x-ray measurements, but not the bake out and RCG tests. MDC added that the remaining INFN crystals could be measured after the beam tests, which SR agreed would be good.

• SR suggested to follow up offline before the H8 tests.

• EM asked whether or not there will be time to test eight crystals in H8, to which SR replied that LSE will discuss in the next presentation.
Update after the meeting

The bake out test of the first INFN crystal, initially planned for September 1st, has been postponed. It will be done together with the other three crystals after the H8 beam tests, if necessary.

4 Plans for crystal validation in H8 - L.S. Esposito [slides]

Summary of the presentation

LSE presented the plan for the beam tests in H8. The allocated time is from Wednesday 15th September until the 29th, although due to a technical stop the first beam will be on the morning of September 17th. During the first week the crystal tests are the main user, but the second week will be parasitic on TOTEM. The collaboration with them is good. It could be possible to extend by a third week, but given the time constraints it is uncertain whether or not this is helpful.

The beam will consist of mostly protons and pions of 180 GeV/c, with a spread of a few millimeters and 30 µrad. The ranking of the crystals will look at channeling efficiency, bending angle and torsion, as well as INI signals if available. The setup is the same as during RunII. Crystals and detectors will be in air, surrounded by vacuum pipes to reduce background scattering.

The goniometers and crystal alignment systems are operational. One crystal holder is missing, to be found or rebuilt in September. The scintillator trigger used during RunII is to be tested before use. A backup solution for the trigger can be provided by BI.

System will be in commissioning during the first week, starting Wednesday the 15th. Up to five days are expected for the setup. Detectors will then be tested with old crystals to compare the data. For the LHC crystals, at least four hours are necessary to collect high statistics. In three days all eight crystals can be measured, barring any unforeseen issues.

Online analysis will provide a preliminary estimate of the bending angle. Reconstruction can only be done after the beam tests, and partially during the Wednesday breaks when there is no beam to NA. This involves the same people and requires the usage of the same PC dedicated to the data taking, so resources are limited. It is under investigating whether or not a new PC dedicated to the reconstruction can be added, but this could be tricky since the system is based on an old framework.

Once the first data is reconstructed, completing the analysis of the full data set will take at least two to three weeks. Each crystal will be independently analysed by at least two separate teams (in STI and ABP).

The final installation slot in the TCPC (goniometers) is on October 15th.

Discussion

• WS commented that the scenario does not take into account that the second week might be dedicated to UA9 measurements that rely on the same people.

• WS also commented that it might be misleading to base an initial ranking on small statistics. It might help with the timeline, but one has to decide whether to base the ranking on a complete analysis, or to give emphasis to a forecast based on a short sample per crystal. SR commented that the first selection of crystals will also be based on the measurements done before the beam tests, which should be accurate for angle, geometry and torsion. WS replied that, based upon what has been presented, there is only one clear outlier, so there is no good criterium for excluding crystals. He added that one could e.g. exclude the one with the highest miscut, but that it is not clear if this is the correct choice.

• WS emphasized that the effort of ranking the crystals must find a compromise with the other goals of the UA9 collaboration. SR asked WS about the second week, when people will be involved in the measurements. WS replied that they have prepared different things to measure. One is to investigate crystals with a trapezoidal shape that are focusing/defocusing. These could provide fundamental information on the dependence of multiple scattering in the channeling mode for the path length of the particle into the crystal. A second point is to prepare the investigation into emittance cooling. WS
stressed that these are two major activities that are important to fit in, and that if the measurements are going slower it is possible to prolong the beam slot.

- SR suggested to continue offline and stressed that a clear list of priorities should be drawn up, based on the measurements that are already available. He added that a meeting after the measurements of the remaining three crystals have been done would be useful. WS agreed that a preranking of the crystals should be decided some days in advance of the beam tests. He added that, aside from the limited manpower, the main difficulty is the beam availability, which can be as low as 50%. SR concluded that the first milestone is to resume discussion once the thermal cycle measurements of the remaining three crystals are done, and then to draw up a list of the measurements to be done.

- WS asked if it is known why the INFN crystal are much more stable after thermal cycles than in the past. SR and MDC recalled that the previous batch of INFN crystals tested by UA9 in 2018 were already very stable, but they had an issue with torsion out of specifications. This aspect is much improved. MDC added that there were no big changes according to A. Mazzolari. WS remarked that the crystals in the LHC have been changing angle during measurements. MDC clarified that he referred to the ones that have been measured by x-rays, and SR added that it was the LS1 crystals that had issues. DM mentioned that the situation changed when they changed the style of the holder. WS asked if this means that they are no longer using pre-compression, but instead impart the torsion through spacers. MDC confirmed that optically they can see that there are spacers being added.

- SR suggested to ask A. Mazzolari or someone from INFN to present the status from their side, in the form of a report to the ColUSM. WS emphasized that it is important that issues in the past that have been corrected are also well documented and presented to the community, in order to avoid repetition. SR added that it would be interesting to know why there is no issue with the torsion anymore. SR added that for the first batch in 2018, they also used different components and alloys than what was expected.