Minutes of 127th Collimation Upgrade Specification Meeting

Participants: C. Accettura (CA), A. Bertarelli (AB), E. Belli (EB) (scientific secretary), N. Biancacci (NB), F. Carra (FC), J. Daricou (JD), M. d’Andrea (MdA), M. Gasior (MG), J. Guardia Valenzuela (JGV), A. Kurtulus (AK), I. Lamas (IL), A. Lechner (AL), A. Mereghetti (AM), E. Metral (EM), M. Migliorati (MM), D. Mirarchi (DM), N. Mounet (NM), J. Oliveira (JO), A. Perillo Marcone (APM), JB. Potoine (JBP), D. Quartullo (DQ), S. Redaelli (SR) (chairman), B. Salvant (BS). A. Waets (AW).

Indico link.

Actions from this meeting

• Provide the model of strip crystal, holder and support (IL) for simulations with the most critical beam-crystal distance of 2 mm (DQ).

• Assess needs for checking V3 and possible improvements.

• Evaluate needs for resistivity measurements at GSI at lower DPAs than what achieved in the first run.

1 Recent progress of impedance simulation for crystal goniometers (D. Quartullo) [slides]

Summary of the presentation

DQ gave an update on the longitudinal impedance of the LHC V2 crystal goniometer, which is the one currently installed in LHC. The model used for simulations is the one provided by EN department (except for the bellows which were simplified), containing the characterization of all components’ materials (see presentation by IL at this link). For these studies, 4 different beam-crystal distances have been taken into account. For each configuration wakefield simulations have been performed and the longitudinal impedance table has been provided, with an accurate analysis of the corresponding resonant modes. These simulations have been compared with 2017 and 2019 RF measurements, showing much larger Q factor and shunt impedance and a partial agreement in the resonance frequency. DQ also showed an estimation of the power loss for both proton and ion beams. Different operational scenarios have been considered, with the goniometer operational for ion beams. A perturbative analysis was performed to take into account variations in impedance and beam power-spectrum and the power loss was estimated for all the configurations, showing that the power loss for proton beams is about 2 orders of magnitude larger than the one estimated for ions, mainly due to the beam intensity. Power-loss densities showed the modes with the largest contribution to the dissipated power.

Discussion

• DM asked if simulations for strip crystals are foreseen, because they are the most promising to be used in HL-LHC and the highest impedance peak comes from the holder which is very different between quasi mosaic and strip crystals. DQ replied that results will not be significantly different, but it is better to simulate the case.
• BS commented that the results shown do not account for the EM properties of the crystal that were measured, and therefore the power loss to the crystal itself and the change of mode frequencies due to the crystal are not known yet.

• SR commented that there is a huge difference between the direct computation of power loss and the estimated maximum power and asked if this approach is not too conservative. DQ replied that the maximum power loss is computed by considering the worst case scenario where modes are hitting the beam spectral lines. NB commented that the maximum power loss is very unlikely and it should come with a probability function, as done in the past. BS commented that the fact that the system moves will cause the frequencies to sweep, and therefore it is much more likely that the worst beam spectrum lines are hit at one point compared to devices that do not move. He therefore recommends to perform the statistical analysis mentioned by NB, but to keep the maximum power loss as reference for the case of moving devices. An engineering design should account for an additional safety factor to these numbers.

• SR recalled that a different version - V3 - will be build by the Russian collaborators. SR asked if V3 of the crystal goniometer can be improved for operation with ions before the construction of the prototype. IL replied that a thermal study can be done to define the components with the maximum temperature and that one possible improvement for the new design could involve the thermal characteristics of the materials. BS commented that thermocouples should be installed closer to the crystal.

2 Resistivity change from DPA estimates for IR7 collimators (C. Accettura) [slides]

Summary of the presentation
CA presented some studies about the resistivity degradation observed in IR7 collimators as a function of peak DPA, where data obtained from experiments have been compared with estimated DPAs. First results refer to the GSI irradiation tests done in 2019 with Ca ions: the beam was uniform over the sample surface and the resistivity of the irradiated layer was computed by applying a parallel resistance model that has been improved for these studies. The present model takes into account the precise penetration depth of the ion computed by FLUKA which changes significantly with the density of the sample material. Each sample has been irradiated at 4 different fluences (corresponding to different DPAs), showing a resistivity increasing with the peak DPA for CFC FS140. Other irradiation tests have been done in the past at Kurchatov institute on CFC AC150K to study its resistivity change with DPAs by using a proton beam at 25-30 MeV. All these data have been compared to the DPAs estimated for IR collimators, showing that the lower DPA observed in the irradiation tests is 1-2 order of magnitude higher than peak DPAs expected in IR collimators. Since simulations data are not available for all the IR7 secondary collimators, the DPAs are approximated by considering the estimated energy depositions (see presentation by AW at this link). This approximation allows a first estimate of the change in resistivity for the different collimators.

Discussion
• SR commented that with an estimated peak DPA 2 orders of magnitude below the first measurement point no effects are expected. EM replied that on the other hand if the
resistivity is increased by a factor 2 then tune shift will change by a factor $\sqrt{2}$, which means 40% for these collimators.

- NM asked why the first value of DPA is already a factor 2 higher in resistivity. CA replied that for low fluences the uncertainty is about 30% and the value is probably lower. The possibility to measure at lower doses is also being considered.

### 3 Orbit at collimators during impedance MDs in 2018 (A. Mereghetti) [slides]

**Summary of the presentation**

AM presented measured orbit at the collimators during MDs devoted to impedance measurements in 2017 and 2018 performed with TCSPM.D4R7.B2 (three-stripes HL-LHC prototype) and the companion TCSG.D4R7.B2. While in 2017 there was a reasonable agreement between measurements and simulations for all materials (except Mo-stripe), in 2018 measurements showed a larger tune shift. Local orbit errors were considered as a possible cause for this observation. In 2017, the BLM-based alignment for TCSG was not always performed and the BPM-based alignment for TCSPM was not ideal because of the large gap. Thus the missing alignment before impedance measurements is likely not the reason for the discrepancy between measurements and simulations in 2018. The only difference in 2018 was the beam orbit at measured collimators which was degrading with time.

**Discussion**

- NM commented that according to studies of Sergey Antipov an orbit offset of 100 µm was enough to increase the tune shift by 10-20%.

- NB commented that the TCSPM tune shift measured in July 2017 and September 2017 was very similar despite the different values of misalignment and this would confirm that alignment has a small effect on the discrepancy.