156th Meeting of the Machine Protection Panel

Participants: O. Bjorkqvist, A. Boccardi, C. Bracco, D. Lazic, Y. Nie, J. Pospisil, C. Schwick, J. Uythoven, M. Valette, M. Wendt, J. Wenninger, C. Wiesner, D. Wollmann, M. Zerlauth.

The slides of all presentations can be found on the website of the Machine Protection Panel:
http://lhc-mpwg.web.cern.ch/lhc-mpwg/

1.1 Approval of MPP#155's minutes

- No actions from the 155th MPP.

1.2 New design of interlocked BPMs in IR6 - design goals and first experience with a prototype system (M. Wendt, J. Pospisil)

- Manfred and Jan presented the status of developments for the interlocked BPMs in point 6.
- The interlocked BPMs system (BPMS) protects the beam dump elements and IR6 collimators by monitoring the turn by turn, bunch by bunch position of the beam in IR6. The current system has limitations for doublets, as for reliable readings the bunch spacing must be ≥ 25 ns, probably due to aging of components, as well as position offsets for low bunch intensity which can lead to undesired beam dumps.
- An upgrade is therefore foreseen with the following requirements:
    - Bunch by bunch measurement.
    - Position resolution <100 µm, position range ± 7.5 mm.
    - Intensity range from 1.5e9 to 3e11 protons per bunch (ppb) and from 1e9 to 5e10 charges per bunch for ions. In a given gain range the sensitivity covers bunches with 20 times less intensity than the maximum.
        - Jan asked what happens if one injects at 2.2e11 ppb (as expected after the LIU upgrade). The mentioned range means factor 20 on intensity with a sliding range, so if one injects at 2.2e11 the range will go down to 1.1e10 and pilots with 1e10 would be invisible.
        - Manfred added the gain switching is very fast and could be done in 20 ns if needed, but synchronisation will be complicated.
- Regarding implementation of the new system, the signal from both pickups is delayed and combined and after a set of attenuation and amplification all the processing is done in the FPGA. There are very few settings for this system and it features a new calibration and heartbeat signal periodically checking for the status of the sensor.
- Once the signal is in the UA, the signal is copied and delayed three times to have more samples in the ADC and the full 25 ns between bunches is filled.

For doublets, the signal would only be copied once which would still yield 10 points per electrode and allow calculation of the position.

  - Jan asked how the switching to that mode would be done because both cannot be done at the same time. Manfred proposed it would be instructed from operators. Jorg observed that the doublets are already a problem for the standard system so in parallel there might well be normal bunches in the machine to assure the correct orbit.

- The performances of the system were estimated with simulation and the resolution target of 100 µm would be achieved for intensities above 1.6e10 ppb. The sigma of the error would then go down with intensity while the mean is always zero. There are also some non-linearites of the reading to be expected at low intensities.
- A test was performed in SPS point 4 with the prototype system. The orbit of the 450 GeV beam was measured for 200 turns. The measured position fits the expected values with a slight offset which is larger on the first bunch. This is due to the bunch to bunch residual signal leaking into the next 25 ns which is absent for the first bunch. This effect will be corrected in the second prototype. The data was also compared to the operational BPM system in the SPS and shows good agreement. The results of this test also fit the previously mentioned simulation even though some of the requested intensities were not obtained from the injectors.
- The comb filter in the prototype was hand-made at CERN and showed successful tests, but it will be difficult to reproduce reliably and will have too low power handling capacity. The second version was done in PCB design, it includes power dividers and shows no leakage of the ringing into the next bunch when tested with an impulse.
- In conclusion, the system is single channel with direct digitalisation and provides bunch by bunch, single pass position with the expected resolution. The measurements of doublets remain to be done, a lower resolution is to be expected.
- Manfred requested confirmation from MPP that a centred beam signal was OK for the calibration and heartbeat signal, which is the case. The prototype tests in 2018 have to be defined.
  - Jorg brought up the problem of injecting a nominal after a probe in the LHC when the probe bunch can be seen after the gain change. Manfred answered one can implement an analog threshold not to see it which would be decided by MPP. The interlocking could be made energy dependant but the BPMS would have to subscribe to the SMP.
  - Markus asked where the factor 20 comes from. The signal from proton bunches is 6-7 V and the ADC range is 700 mV so attenuation is needed which defines the signal to noise. The switch to a different gain can be done in 20 ns but should be avoided. The range is also defined to +/- 7 mm with a 12-bit ADC, which is the best one can use at such frequencies, some 14-bit ADC could exist but are not available on commercial boards compatible with VFC. Markus asked whether it could be envisaged to split the signals and send them to different hardware using different fixed gains – the interlocks signals could

then be combined and cover the full intensity range. Daniel suggested it would be good to have overlapping ranges then. Andrea answered that the cost of this would not be negligible, as there are 8 systems worth 10k CHF already and this would imply doubling most of the system.
    - Daniel commented that with the LIU upgrade some injected bunches might go higher than 2e11 and asked how would one proceed in such a case. Manfred proposed that some attenuation can be added for the nominal mode, similar to doublets.
    - Manfred asked whether it is possible to define a lower bound of bunch intensities at the end of physics fills. Jorg answered that it should be 4e10 ppb depending on the turnaround and ultimately on optimal fill length. There is enough margin to avoid unwanted dumps from BPMS.
    - Markus observed that if one bunch becomes unstable and loses intensity fast one would dump from it when the machine is actually safe. A review of the use cases might be necessary.
- Regarding tests in 2018, the analog part of the prototype is ready. Manfred asked how and when it will be performed and in which machine, he proposed close to the strip line BPMs in SPS point 5. Jorg was against doing the test in point 5 as this BPM is crucial for the luminosity in IP5. For the LHC, IP 1 and 5 would allow easier access to the UA, moreover the end of the run is not ideal as operation with ions is foreseen. Jorg proposed that the signal from the triplet BPM is redirected for a 12h MD in stable beams, October was mentioned as a tentative timeslot. The hardware should be ready by the end of the summer. A second test with ions could also be done.
- The goal is to install the system in LS2 in parallel to the existing one in order to avoid jumping from one to the other.
    - Andrea asked how the interlocking logic would be done as the current one implies two windows but the shorter one is useless as the thresholds are defined now and the longer one always dumps.
    - Manfred asked what the threshold should be and if keeping +/- 3 mm was desired as well in the future. Jorg answered that with a bunch by bunch measurements one might relax the threshold.

Action (OP, MPP): Define operational scenarios and bunch intensities/types to be considered for the new BPM electronics for IR6.

AOB - Intensity Cruise checklist 2017 (D. Wollmann)

- A checklist with all high intensity fills was uploaded to social.cern.ch. The experts and responsible people should comment of the relevant dump and investigate when the cause of dump is still not understood and mitigated. The goal is to document the problems we had in 2017.
- Jorg commented it is now too late in the year to remember details. Daniel answered the goal would be to perform it step by step during the year in the future to avoid having to comment 300 dumps in December.

- Chiara commented the proposed deadline of the Christmas break is too difficult as the planning is quite packed with Evian. Daniel answered the goal is not to write an extensive summary but to fill the table, a proposed new goal is to have it ready for Chamonix in January for people having trouble meeting the end of year deadline.

AOB - all

- This was the last MPP of the year, please enjoy the winter break and thank you all for your collaboration in 2017 to keep the LHC running safely.