Minutes of the informal Linac4 Diagnostics Working Group Meeting focused on profile measurements with 160 MeV H- held on 13 July 2009

Present: C.Dutriat, B.Cheymol, E. Bravin, T.Hermanns, B.Mikulec.

Agenda:

1. Introduction (B.Mikulec)

2. Three monitors emittance measurement (T.Hermanns)

3. Multiple scattering simulations (B.Cheymol)

4. Discussion (all)

1. Introduction

B.Mikulec explained that the aim of this meeting was to identify possible technical solutions for an appropriate profile measurement to determine the emittance of the Linac4 160 MeV beam in the Linac4 dump line and before PSB injection.

2. Three monitors emittance measurement

T.Hermanns presented a short overview of the simulations that have been carried out by B.Mikulec and himself for an emittance measurement using 3 profile monitors in the Linac4 dump line (3MonitorsEmittanceMeasurement.pdf). The optics of the line have to be altered such that a beam waist of the beta function is produced at the central monitor position and that the beam ellipse turns by approximately 60 degrees between each position to obtain most efficient phase space sampling of the plane to be studied. The principal problem is that in order to reach small error values for the determination of the emittance, the beam size at the central monitor position gets very small (O(0.6 mm 1 sigma)). This implies that solutions should be found to be able to measure the beam size with an device with internal resolution around 10 um.

3. Multiple scattering simulations

The original idea was to use SEMgrid monitors with best obtainable resolution as profile detectors. The smallest technically feasible wire pitch is currently 300 um with 40 um thick tungsten wires, but C.Dutriat mentioned that this was challenging. Moreover with H- particles stripping will occur corresponding to the geometrical factor of the wire-to-spacing (15.4%). The particles that undergo stripping in the wire will moreover be scattered. B.Cheymol has simulated the effect of multiple scattering of 100k 160 MeV particles using FLUKA. 160-xy.bmp shows the distribution of the beam arriving at a 40 um thick tungsten foil (red) and the distribution 1 m later. The 1-dimensional deviation of the particle positions 1 m after the foil are also shown in this histogram (160-x.bmp). It can be seen that the average deviation 1 m after the foil is around 1 mm. This excludes an emittance measurement with the desired resolution with 3 SEMgrids in one shot.

4. Discussion

- Rule of thumb: 3 measurements per sigma; with >3 samples/sigma one can expect a resolution on the order of 1% for a perfectly Gaussian distribution.
- SEMgrids can be excluded for our purpose as the reachable resolution is insufficient
- The highest resolution can be obtained with wire scanners, but many measurements would be needed (~5 measurements/sigma and sample ~8 sigma). Besides the long integrated measurement time (~3x50 s) the beam needs to be very stable.
- Scintillation screens: this seems to be the preferred solution. Time-resolved measurements are not possible, but this is acceptable. The screen itself can be made of ceramics, where the grain size of the

order of 10 um limits the resolution. Other materials should be checked as well as the thermal load with the Linac4 beam. The final resolution depends on the camera; non-radiation hard versions have no problem to resolve 10 um, but radiation hard versions have worse resolution. In principle only one screen+camera could be used with a quadrupole scan, but it is still proposed to keep the 3 positions (3 subsequent measurements) because the camera resolution can be adapted to the one required for that special measurement. The design cost for a screen system has been estimated by E.Bravin to be on the order of 30-50 kCHF and the production cost per screen set to ~15-20 kCHF per set (this solution might also be reused for the LBE line emittance measurement; T.Hermanns will nevertheless check first if the current emittance measurement procedure could still be applied with modifications for Linac4 emittance measurements). B.Mikulec will try to find out the total annual dose at the 3 camera positions (suppose 30 cm distance from beam line at same beam height) with and without shielding; this will define the type of camera that has to be used.

- C.Dutriat brought up the point that it would be worth to think of another location of the emittance measurement at Linac4 exit in order to reuse it for SPL operation. B.Mikulec replied that it has been accepted by the Linac4 Collaboration that the setup will have to be dismantled for SPL operation. With the current 3-monitor method it is not possible to squeeze everything in front of the horizontal bending magnet; neither it seems realistic budget-wise to consider constructing a special emittance measurement line. A.Lombardi confirmed in an email that it seems to be understood by everybody that there will be no emittance measurement with SPL in place. Another possibility would be a laser-based emittance measurement installed before the bending magnet. After E.Bravin the APL proposal seems to be dead, but there are ongoing discussions with the Royal Holloway University London. The group there seems very open for a collaboration with CERN on this subject. E.Bravin is part of the people following up this subject.

-- BettinaMikulec - 14 Jul 2009

- 3MonitorsEmittanceMeasurement.pdf: Introduction into the 3 monitors emittance measurement in the Linac4 dump line.
- 160-x.bmp: Particle deviation of a 160 MeV beam 1 m after a 40 um thick tungsten foil.
- 160-xy.bmp: 2D particle distributions of a 160 MeV beam before and 1 m after a 40 um thick tungsten foil.

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