Minutes of the Booster Commissioning Working Group held on 18th of November 2010

Present: G. Bellodi, J. Borburgh, C. Carli, K. Hanke, L. Hein, T. Hermanns, A. Lombardi, B. Mikulec, A. Newborough, D. Nisbet, U. Raich, F. Regis, T. Zickler

Agenda:

1. Communications
2. Follow-up of open actions
3. Alternative for Linac4 Beam Energy Measurement (T. Hermanns)
4. AOB

1. Communications

The last minutes have been approved.

2. Follow-up of open actions

B. Mikulec informs that the list of open actions has been cleaned up. Some of the open actions overlap with actions of the Linac4 BCC. Please consult the open actions twiki page to follow up the remaining points.

3. Alternative for Linac4 Beam Energy Measurement (download presentation)

This work is a follow up of a discussion at the Linac10 conference, where D. Raparia from BNL suggested that their beam energy measurement principle (see TUPSM011_BNL.pdf) could also be applied to Linac4.

At the moment it is planned to upgrade the LBS line (about 50 m upstream of the PS Booster injection) for operation with the Linac4 beam according to the present concept for Linac2 operation. This foresees to use a slit to select a beam slice, which is then analysed by a spectrometer magnet, recorded by a SEM grid and finally dumped in an installation inside the concrete ceiling of the experimental area. While a concept to install a beam dump at ceiling height is already available, first discussions on a new slit show that its production could become more complex than expected (refer to slide 3 of the presentation for details).

Therefore, even if this original proposal is by no means ruled out, T. Hermanns presented an alternative for Linac4 beam energy measurement. This is based on the BNL Linac energy measurement, which is expected to be applicable for Linac4 energy measurements because the BNL beam parameters resemble those of Linac4 (200 MeV Hminus ions, 30 mA beam current):

When Hminus ions interact with atoms of the rest gas inside the vacuum pipe and they strip off their electrons. Due to the kinematics of this reaction - initially electrons and Hminus ions have the same velocity - there exists a correlation between Hminus and electron energy. Hence, a bending magnet deflects the electrons into an analysis line being perpendicular to the beam line. In this analysis line a variable voltage slows down/stops them and only those, which escape from this field region, are measured by a Faraday cup. Over several Linac4 pulses the integrated electron current is sampled as a function of the retarding voltage. Finally, one differentiates the resulting curve to determine the mean energy and the energy spread of the electron distribution and so of the Hminus ions.

As the precision of the measurement depends on the step width, with which the voltage is varied, the reconstructed values for mean energy and energy spread are compared with their input values as a function of different voltage steps. A range from 50 V to 300 V has been tested. The general conclusion is that the reconstruction is better the finer the voltage steps are. For the mean energy the absolute deviation is still below 1% even for the greatest voltage steps, but for the energy spread it is indispensable to sample the electron energy distribution with steps at the order of half the energy spread. Otherwise the reconstructed value deviates by several 10% from the input value. For a sufficient precision of the measurement 10 to 20 data points must be taken, i.e. the number of Linac4 pulses are required.

As data-sample PathManager data at LTB.BHZ40 have been used. The energy distribution follows a second order polynomial with mean energy 159.204 MeV and energy spread 150 keV. Electromagnetic interactions are respected as well. However, it can be shown that self-generated Gaussian distributions of non-interacting particles with the same input values as previously cited qualitatively and quantitatively give similar results. With this knowledge energy distributions with different input parameters could be tested.

Concerning the electron current a first estimation predicted an electron current of about 4nA, while Faraday cups can measure currents as low as a few tenths of pico-Amps. As the electron current is mainly determined by the vacuum level, any small signal can be easily increase by artificially worsen the vacuum level. However, U. Raich noted that the estimation is not correct, as it does not take the beam cross section into account. A new estimate will be soon available.

In summary, the advantages of this alternative are

- LBS line remains untouched if system will be installed in LBE line)
- No new slit design required
- No beam dump to be installed at ceiling
- No sophisticated spectrometer magnet required
- Installation of equipment close(r) to Linac4 exit?
- Less expensive?

The challenges are:

- High voltage installation to retard electrons
- Amplify electron signal by artificial gas injection system

The disadvantages are:

- Linac4 energy measurement not in one shot
- Time-differentiated measurement not possible

During the discussion the following questions have been raised:

- C. Carli: Does the space-charge destroy the signal for energy spread measurements as the relative energy spread for electrons is high in bunched beams.
- D. Nisbet: The resolution for the voltage ramping is not a problem, but the absolute calibration must be seriously addressed. For the latter item Etienne Carlier should be contacted.
- C. Carli: A method to measure the energy painting must be maintained. However, an ultimate precision is not necessary because after injection into the PS Booster empirical adjustments of the B-field can be performed.
- L. Hein: it should be taken into account that stray fields (of the PS for instance) could influence the electron deviation. However a local shielding seems to be feasible.

4. AOB

No AOB.

-- ThomasHermanns - 18-Nov-2010

- TUPSM011_BNL.pdf: Paper on beam energy and laser beam profile monitor at the BNL Linac
- 1011_L4Commissioning_ThHermanns.pdf: Alternative for L4 Energy Measurement via Electron Spectrum

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