Non-intersecting beam diagnostics - Beam Induced Fluorescence Monitor

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Due to the high beam power expected for FAIR, novel methods for non-intersecting beam diagnostics for the High Energy Beam Transport Lines must be considered. We investigate the detection of fluorescence photons from the excited states of the residual gas N_2 with a **B**eam **I**nduced **F**luorescence (**BIF**) Monitor [1]. This method was successfully applied for high current measurements at UNILAC [2]. Photons in the wavelength range 390 nm < λ < 470 nm are generated by transitions in N_2^+ with about 60 ns lifetime [3]. 'Single-photon counting' is performed with an image intensifier [4], equipped with a double MCP for 10^6-fold photo-electron amplification. The light from the fast P46 phosphor screen with 300 ns decay time is taper-coupled to a digital CCD camera with a FireWire interface (Basler 311f).

The setup was installed behind SIS close to the beam dump HTP and tested with different ions (Xe, Ta, U) and varying energies (from 60 to 750 MeV/u) for fast and slow extraction. An example of such a measurement is shown in Fig. 1: The spots within the area of the vacuum window are created by single optical photons, their projection along the beam axis yield the horizontal profile. The correspondence to a SEM-Grid measurement proves the applicability. But the BIF method offers a higher spatial resolution (here 300 µm/pixel), which can be matched easily to other requirements by the choice of an appropriated lens/taper system, e.g. In addition, a BIF Monitor can be realized within a short insertion length.

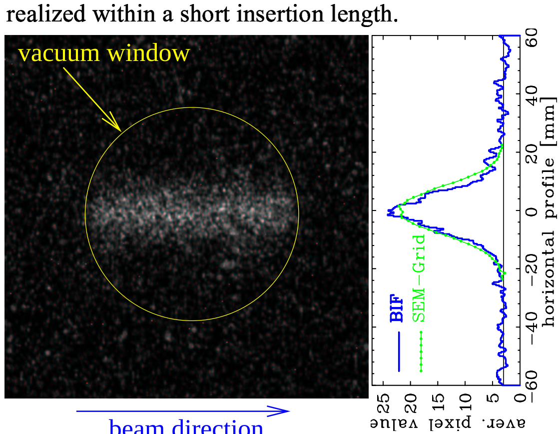

Figure 1: Acquired image: 1.5 µs fast extraction of $2x10^9$ Xe 48+ at 200 MeV/u and the projected horizontal profile compared to a SEM-Grid-signal. The BIF data was acquired at $1x10^{-3}$ mbar and averaged over 20 shots.

The critical demand for a BIF Monitor is the amount of background caused by neutrons hitting the photo-cathode (Na2KSb)Cs of the image intensifier. It leads to a uniform distribution even outside the optical path, as shown in Fig. 1. Due to the energy-dependence of neutron production and the location close to the dump the background is higher than for UNILAC beam parameters. For the U73+ beam with 5 energy-steps between 60 and 550 MeV/u noise increases by a factor of ~30. For fast extraction, a background decay time of 1.6(4) ms was determined by gating the photo-cathode of the image intensifier and independently by a plastic scintillator system. This long decay time can be understood qualitatively by the neutron moderation inside the beam dump and the surrounding concrete walls [5]. With an appropriate short gating of the image amplifier during the 1 µs beam delivery, this background can be reduced.

For sufficient signal strength on a single shot basis, a relatively large pressure bump of typically 10^{-3} mbar was required for the investigated beam currents. These currents are two to three orders of magnitude lower than expected for FAIR. To legitimate the necessary extrapolation for FAIR, the vacuum pressure was varied over 4 orders of magnitude to larger pressures. Fig. 2 confirms the pressure independence of the determined profile-width σ and the linearity of the total signal strength. This proves that the fluorescence is dominated by the above-mentioned N_2^+ transitions.

The described and further systematic investigations [6] demonstrate the general applicability of BIF for the FAIR in fast and slow extraction mode. In particular for the final-focus adjustments at the S-FRS, anti-proton or Plasma-Physics targets. A local vacuum bump might still be necessary, but is probably tolerable close to these targets. A careful shielding of the image intensifier against neutrons is required. To enlarge the distance to the beam pipe, a commercially available 'Fibre Optics Image Bundle' might be a solution.

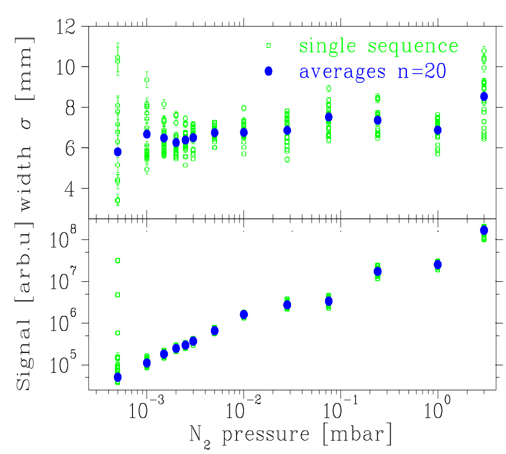

Figure 2: The horizontal profile width σ and the total signal strength as function vacuum pressure function determined by the BIF Monitor (beam parameters see Fig. 1)

References

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