Transverse beam shape measurements of intense Uranium beams using optical transition radiation

B. Walasek-Höhne[1], *C. Andre*[1], *H. Bräuning*[1], *C. Dorn*[1], *R. Fischer*[1], *P. Forck*[1], *H. Graf*[1], *F. Hagenbuck*[1], *R. Haseitl*[1], *K. Höhne*[2], *A. Lumpkin*[3], *R. Lonsing*[1], *A. Reiter*[1], *C. Schmidt*[1], *M. Schwickert*[1], and *R. Singh*[1]

[1]GSI, Darmstadt, Germany; [2]FAIR, Darmstadt, Germany; [3]FermiLab, Batavia, USA

Particle-beam diagnostic techniques based on Optical Transition Radiation (OTR) have been demonstrated at a number of facilities with relativistic electron and proton beams [1]. Optical transition radiation is generated when an ion of charge q and velocity β crosses the interface between two media with different dielectric constants. This radiation is emitted over the visible spectrum and standard optical imaging techniques can be used to acquire the OTR signal and then reconstruct beam size and position. Since OTR is a surface phenomenon, thin foils can be used as the converter to reduce beam scattering and minimize heat deposition. The OTR method can be used to measure beam properties as transverse profiles and 2-D shape, transverse position, divergence, emittance and intensity.

The OTR signal of a non-relativistic ion beam has been shown for the first time in 2011 with a pilot OTR experiment at the UNILAC [2]. During the 2014 beam time, usability of the OTR method to obtain profiles of high energetic ion beams was successfully demonstrated and first images were taken. Measurements were performed with 600 MeV/u Uranium beams from SIS18 of intensities up to around 2×10^8 particles per pulse (ppp) and 300 ms pulse length on a stainless steel target. In order to detect the low number of photons a standard CCD Camera (Prosilica GC650) with additional image intensifier (Lambert Instruments I187) was used.

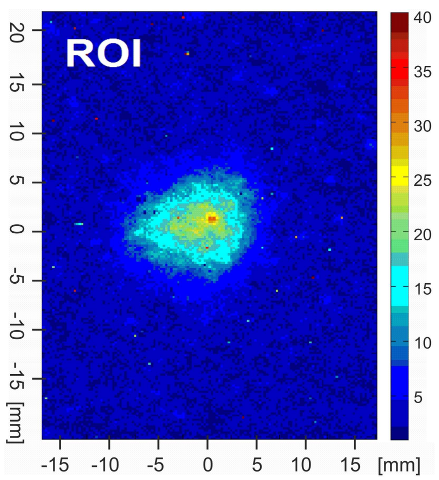

Figure 1: False colour OTR images of beam cross-section during irradiation with 1.5×10^8 U^{92+} ions. The beam energy was 600 MeV/u (pulse length 300 ms).

Various experiments have been performed to estimate the signal strength, to determine the imaging qualities and to evaluate the working regime of the OTR technique. Figure 1 shows a false colour OTR image from 1.5×10^8 U^{92+} ions impinging on the target.

For beam imaging OTR has the advantage that it is expected to show perfect linearity to the number of incident particles without the risk of saturation. In Figure 2 the integral OTR signal is displayed for different particle numbers per pulse. The beam current was measured with a Secondary Electron Monitor (SEM). In our studies the OTR signal shows a linear behaviour with respect to the incident particle number. For U^{92+} ions reasonable beam distributions were acquired down to 2×10^7 ppp.

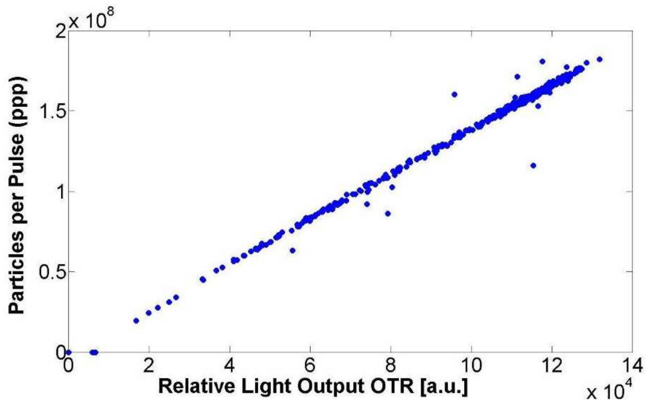

Figure 2: The OTR signal strength as a function of the particle number for the U^{92+} beam.

To determine the imaging qualities of the OTR method, additional profile measurements with a MWPC have been made. The beam profiles obtained with MWPC and OTR are in good agreement. OTR has an advantage of directly obtaining two dimensional beam shape.

The usage of OTR monitoring as a minimally intercepting method can be considered as an alternative to scintillators or BIF monitors.

References

[1] V. E. Scarpine et al., "OTR imaging of intense 120 GeV protons in the NuMI beamline at FNAL" PAC 2007 `http://www.JACoW.org/`

[2] B.Walasek–Höhne et al., "Optical Transition Radiation for non-relativistic ion beams" HB 2012 `http://www.JACoW.org/`

DOI:10.15120/GR-2015-1-FG-GENERAL-48