# Beam induced fluorescence monitor development: Comparison of image intensified CCD and electron multiplying CCD cameras*

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Beam Induced Fluorescence (BIF) monitors offer the possibility for non-interceptive beam profile diagnostics and are therefore highly relevant for the future FAIR facility. Several BIF monitors are already in operation at the UNILAC accelerator [1] and are based on Image Intensified CCD (ICCD) cameras. However, recent technological developments of electron multiplying CCD (emCCD) cameras offer an alternative to the ICCD.

During the GSI beam time in 2014 profile measurements have been performed both with an ICCD (Proxivison/Basler) [2] and an emCCD (Princeton Instruments ProEM512B) camera [3]. These two cameras have different working principles: the ICCD camera uses electron multiplication within a microchannel plate (MCP) due to the high voltage applied between photocathode and phosphor screen. The emCCD camera achieves signal amplification by avalanche diode-like electronics in the extended portion of the serial readout register [3].

The goal of the experiments was to compare the performance of the two cameras under similar conditions. A typical experimental set-up is shown in Figure 1.

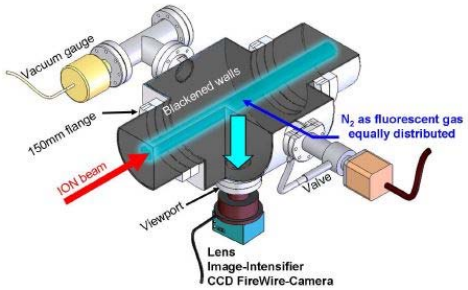


Figure 1: Typical set-up of a BIF profile monitor [2].

The measurements have been performed with 300 MeV/u $^{238}$U ion beams in slow extraction mode, pulse duration 500 ms, beam widths 7.2 and 10.7 mm for ICCD and emCCD measurements, respectively. Nitrogen has been used as working gas at pressures of $5\cdot10^{-3}$, $10^{-2}$, $2\cdot10^{-2}$ (ICCD) and $3.5\cdot10^{-2}$(emCCD) mbar. To increase the S/N ratio, averages over a few hundred acquisitions have been computed both for background and beam images. Figure 2 and Figure 3 show the transverse profiles obtained with the ICCD and emCCD cameras and also for comparison the profiles from a scintillating screen placed 1 m downstream of the BIF diagnostic chamber.

The magnitude of the ICCD profiles is basically proportional to the $N_2$ pressure (p). This is not the case for the emCCD. The profile taken at $3.5\cdot10^{-2}$ mbar shows a not expectable stronger increase in magnitude than at $5\cdot10^{-3}$ and $10^{-2}$ mbar. The proportionality of the intensity of the $N_2$ emission at 337 nm to $p^2$ may cause this behaviour.

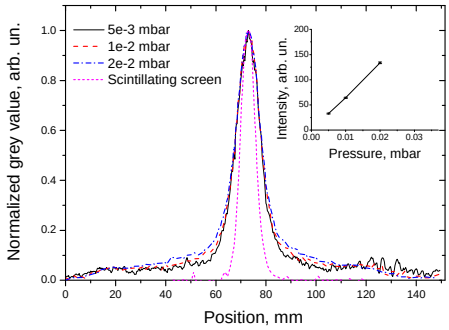


Figure 2: ICCD transverse profiles at different pressures.

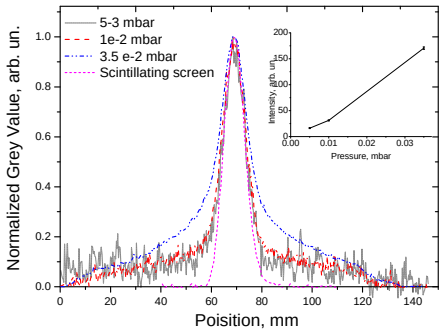


Figure 3: emCCD transverse profiles at different pressures.

The central part of the emCCD low pressure profiles is comparable to the one from the scintillating screen, while the ICCD profiles are systematically broadened. This behaviour can be explained by the fact that single photons produce wide spots in the ICCD acquired image. The effect can be mitigated by proper image processing. The tails of the BIF profiles and the strongly increased width at $3.5\cdot10^{-2}$ mbar are most probably due to the $N_2$ emission at 337 nm, known to give rise to wide profiles, which also are pressure dependent [4]. Filtering this line out should help to improve the profile width accuracy.

## References

[1] C.A. Andre et al., DIPAC2011 proc., p.185
[2] P. Forck et al., HB2010 proc., p. 497
[3] David Dussault, Paul Hoess, Proceedings of SPIE Vol. 5563, pp.195-204 (2004)
[4] P. Forck et al., OPAC Workshop 2014

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