SCINTILLATING SCREEN STUDIES FOR LOW ENERGY, LOW INTENSITY BEAMS

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Introduction

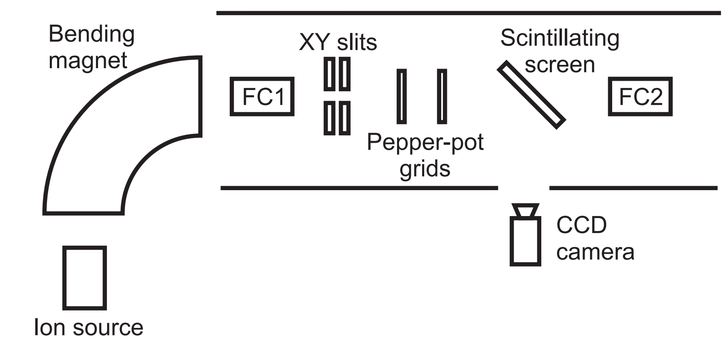
Future atomic and nuclear physics experiments put challenging demands on the required beam instrumentation. Low energy (<1 MeV), low intensity (<10^7 pps) beams will require highly sensitive monitors. In order to investigate the limits of scintillating screens for beam profile monitoring in the low energy, low intensity regime, a systematic analysis of CsI:Tl and a scintillating fibre optic plate (SFOP) was done under different irradiation conditions with keV proton beams.

Screens

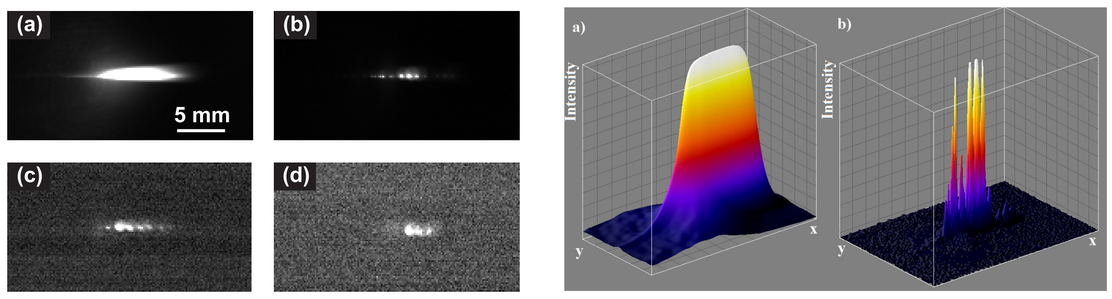
- Cesium Iodide doped with Thallium (CsI:Tl):
  - 50 × 50 × 1 mm^3
- Terbium-doped glass Scintillating Fiber Optic Plate (SFOP):
  - 25 × 25 × 2 mm^3
  - Single fiber diameter: 10 μm

Experimental Setup

- 450 kV pre-injector at INFN-LNS, Catania, Italy.
- Proton beams: 200 keV and 50 keV
- Beam currents: from a few pA down to the sub-fA region with additional pepper-pot grids.

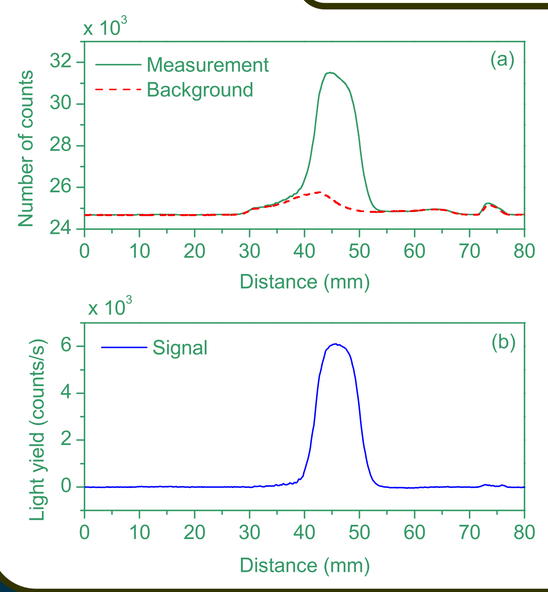


Proton Beam Images



Beam images taken with CsI:Tl for 200 keV protons and (a) no pepper-pot grids, (b) first grid only, (c) second grid only, (d) both grids. Acquisition time was 1 s for images a-c and 20 s for image d. Note the different contrast/brightness window settings.

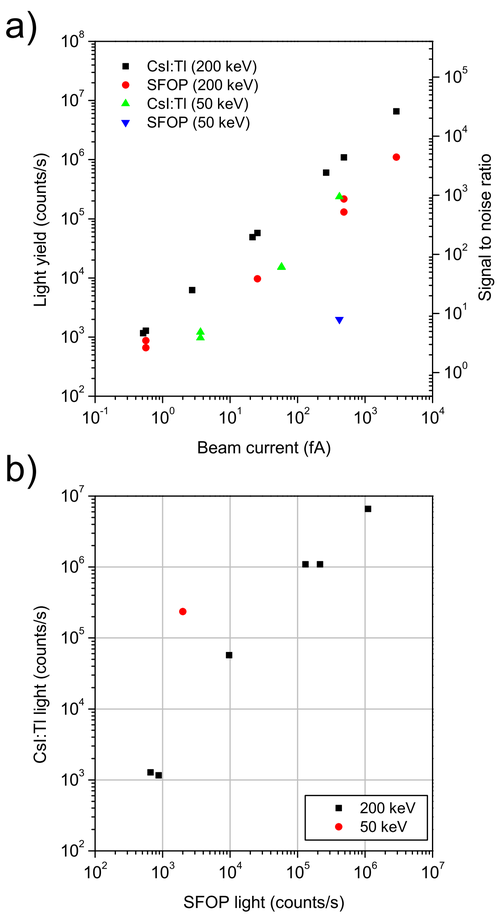
Background Subtraction



- Dark image was subtracted automatically by the CCD;
- ROI was selected and projected onto the X-axis (Fig. a);
- A region outside ROI was selected and projected onto the same axis (Fig. a);
- Signal was extracted (Fig. b).

Sensitivity

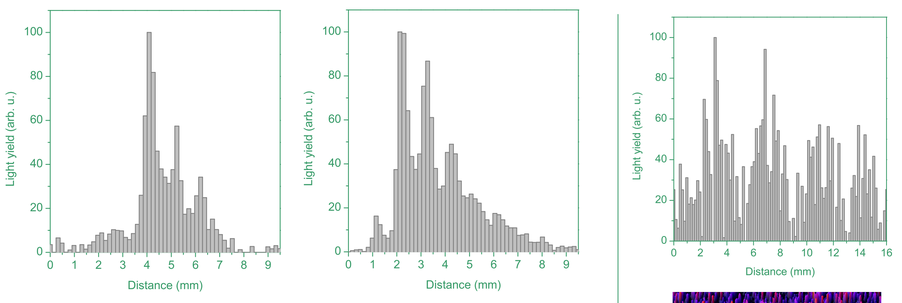
Sub-fA currents measured!



(a) Calibrated light output and signal-to-noise ratio as a function of beam current for CsI:Tl and SFOP, irradiated with 200 keV and 50 keV proton beams. Note that the beam current was estimated, thus the results may shift "left" or "right" within the uncertainty of one order of magnitude.

(b) Light emitted by the SFOP as compared to CSI:Tl for 200 keV and 50 keV proton beams.

Resolution



Intensity modulation caused by the pepper-pot grids for CsI:Tl (left) and the SFOP (right). A resolution down to 0.3 mm was observed, but can be improved.

2D intensity maps can reveal complex structures present in images produced with pepper-pot grids, thus a simple projection onto one axis may not give sufficient information on the response of the system and degrade the resolution.

Extension to Antiproton Beams

- Different range of protons and antiprotons in matter (Barkas effect), but below 5 μm for both types of particles at <300 keV.
- Annihilation products: mainly weakly ionising high-velocity pions and recoiling, heavily ionising nuclear fragments.
- The screens are expected to be too sensitive to the secondary particles.

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