Measurement of low-charged electron beam with a scintillator screen

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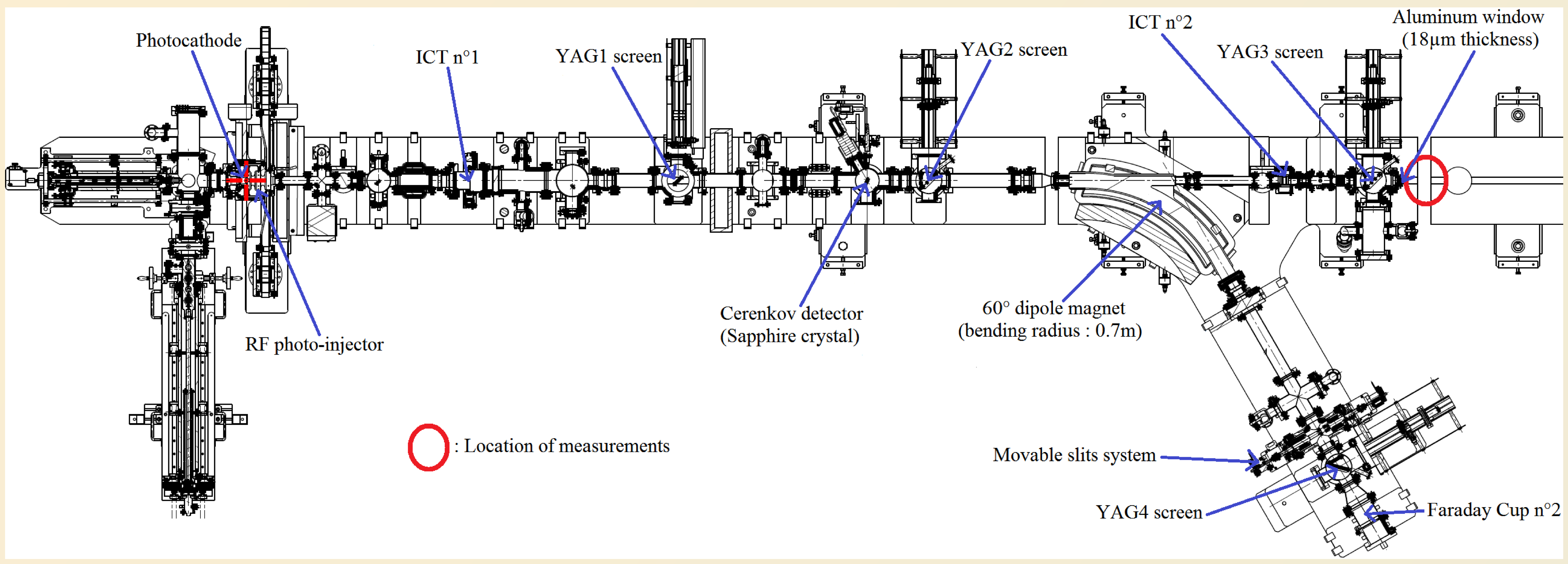
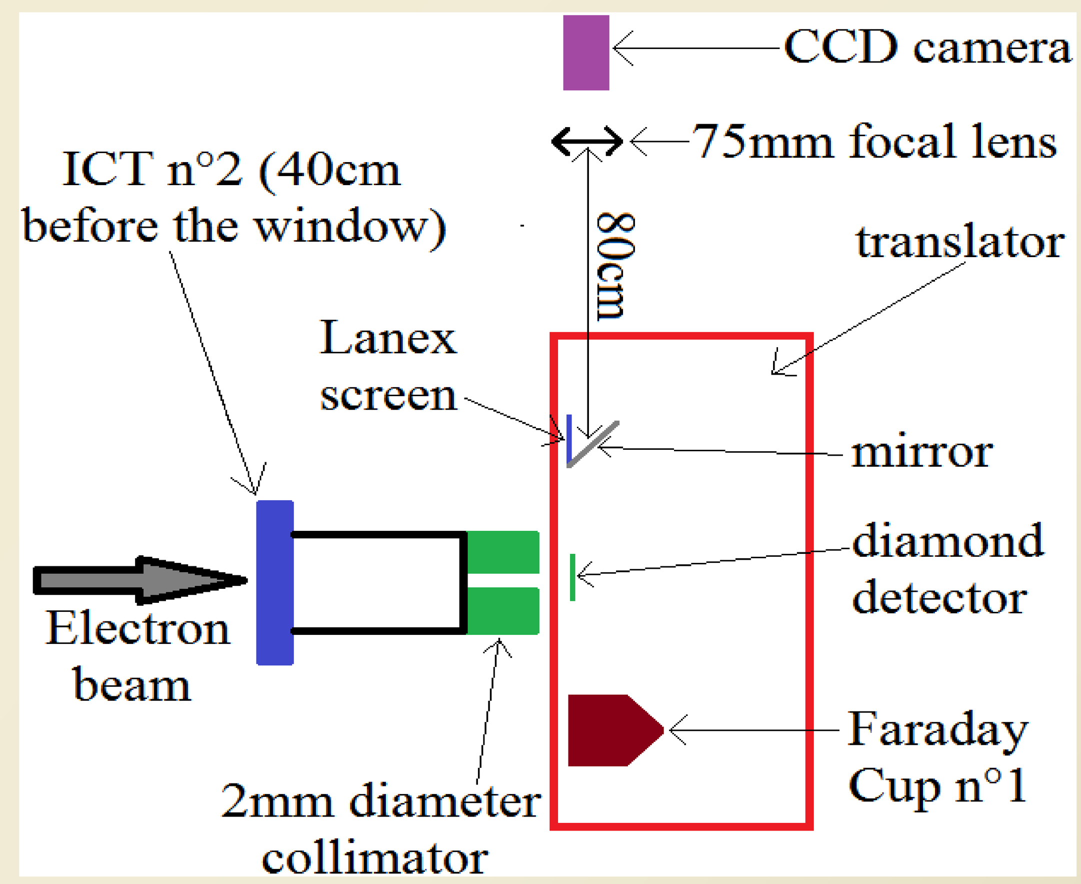
Motivations

Measuring electron beam charge lower than 1pC in an accelerator is very challenging since the traditional diagnostics, like Faraday Cup and ICT, are limited in resolution to a few pC because of electronic noise. A way to simply measure lower charge would be then to use the linear relation, existing before saturation regime, between the incident charge on a scintillating screen and the total light emitted in response by this screen.

Such powerful and simple measurement may thereafter be used as a single-shot charge diagnostic for electron beam generated and accelerated by laser-plasma interaction, for which there is no repeatability from one shot to another. It will for instance be used in the context of the DACTOMUS project.



Layout of PHIL accelerator at LAL, Orsay, France

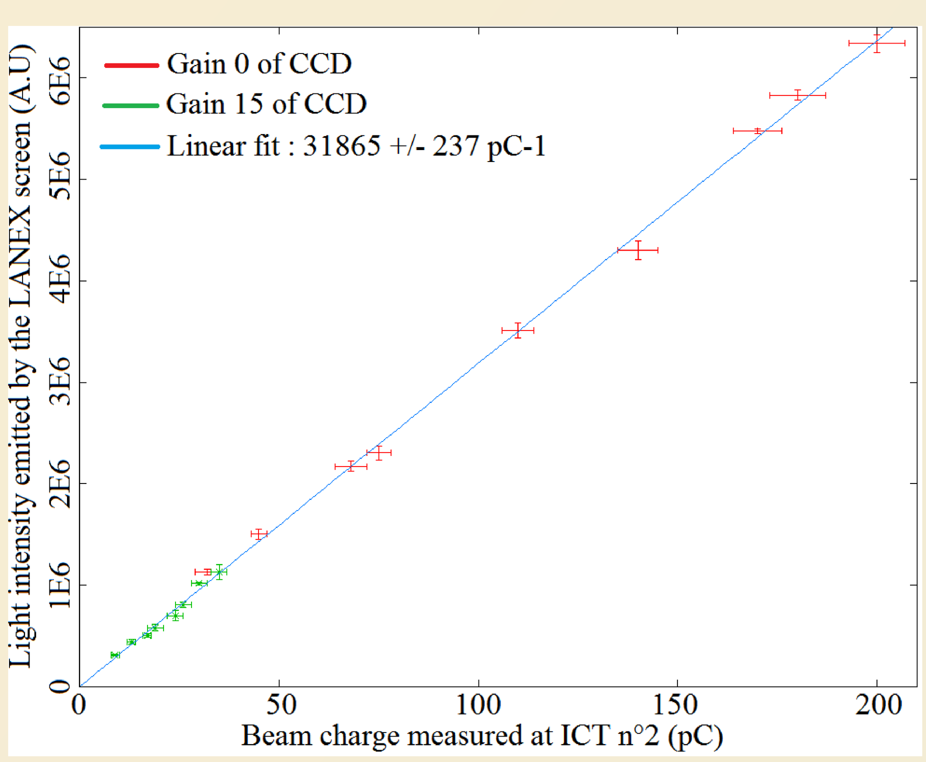


Schematic of the experimental layout

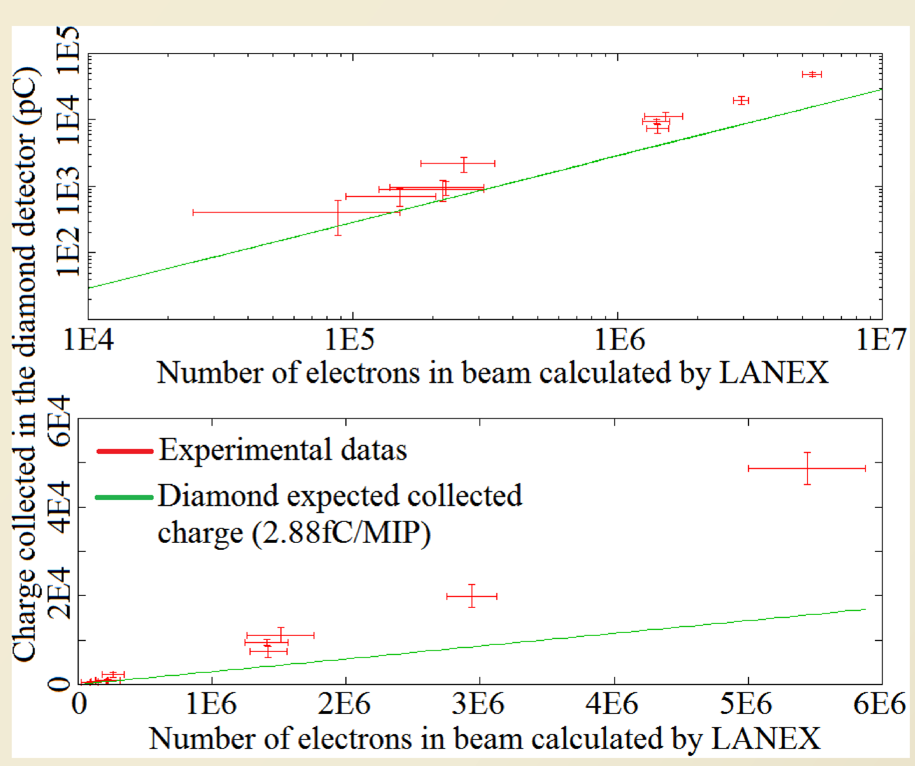
Experimental procedure

The LANEX screen has first to be calibrated. This is done by measuring the light intensity emitted by the LANEX screen in response to the electron beam impact, by integrating the luminous signal on the CCD camera, for several beam charge between 200pC and 3pC measured with ICT n°2 (down to 10pC) and Faraday Cup n°1 (down to 3pC).

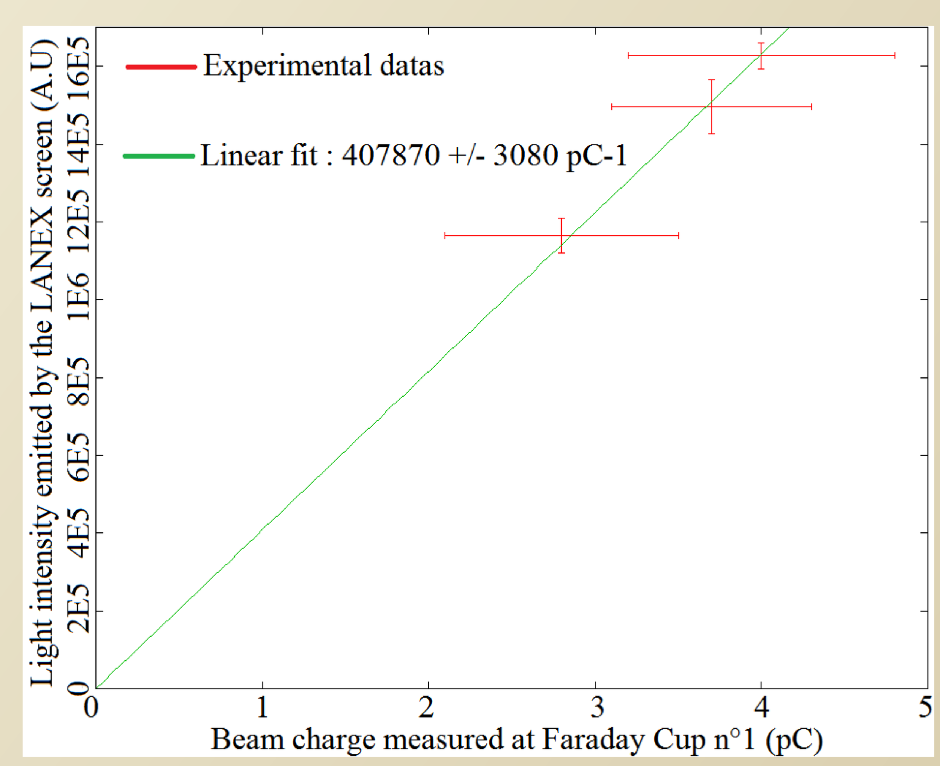
The linear fits obtained are then used to perform lower beam charge measurements by a simple integration of the luminous signal on the CCD camera. The measurements has been compared to those coming from a CVD single-crystalline diamond detector produced by Cividec.



LANEX high-charge calibration



Comparison between LANEX and diamond



LANEX low-charge calibration

Results analysis and prospects

The LANEX screen has a perfectly linear luminous response to the beam charge from 3pC up to 200pC and probably beyond. Since the uncertainties on the fits are very low (<1%), the uncertainty on the charge measured with LANEX mainly comes from the fluctuations of the CCD signal.

The values obtained with the LANEX screen were unable to be confirmed by the measure with the CVD diamond detector for a beam charge higher than $3*10^5$ electrons, showing that either the diamond detector response or the LANEX luminous response is not yet well understood. Under vacuum measurements are intended with a new detector and different types of scintillating screen to find the origin of the discrepancy.

The lower beam charge measured via the LANEX screen, and confirmed by the diamond detector, is of 15 +/- 10fC. The 10fC ultimate resolution limit is mainly due to the noise on the CCD camera signal (X-rays and thermal noise). Proposed solutions to lower the resolution limite are to shield the CCD against X-rays and to cool it in order to reduce thermal noise.