A NEW SYSTEM FOR MONITORING TRANSVERSE BEAM PROFILES

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Abstract

The beam profile is one of the crucial parameters in the field of charged-particle acceleration. Besides a sufficiently high spatial resolution also information about the absolute current distribution is of great interest. While detectors based on scintillation/luminescence effects show a great spatial resolution their durability is strongly limited. Also no precise information about the absolute current distribution can be gained due to nonlinearities in the light yield. Wire-based detectors are well-suited for Gaussian-like distributed beam profiles but they may fail at asymmetrical particle arrangements. To meet the requirement of high spatial resolution measured in absolute current values we have developed for our LEBT a beam-profile imaging system based on an array of tiny Faraday Cups (FC). It provides a spatial resolution of 22×20 measurements/cm^2 and an adaptable current range. It interferes with the beam only during data aquisition and shows a comparatively high durability [1].

BASIC CONCEPT

To achieve a high spatial resolution it is beneficial to chose the size of one single pixel to be small and the pixel density to be high. For that reason we decided to arrange 44 tiny FCs in a pattern that offers a good compromise between high density and the height of the resulting array as the height of this array defines the height of the resulting sensitive area. During operation the array is driven through the beam at a right angle. It records the currents measured by the 44 micro-FCs at high time resolution. Because the position of the array is known at all times, this allows us to measure the beam profile with a high spatial resolution.

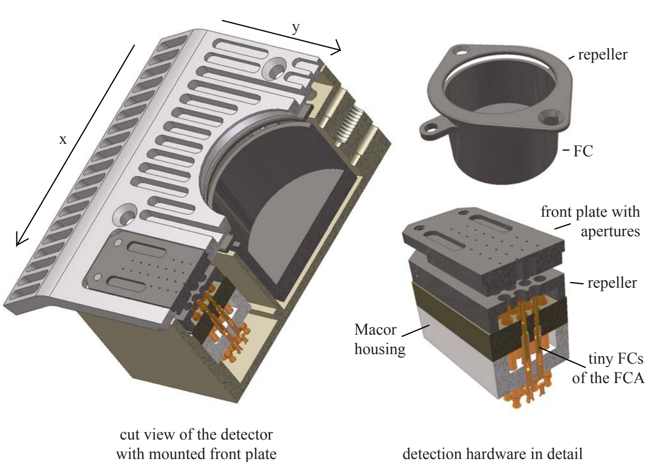

Figure 1: CAD-drawing of the detector.

MECHANICAL DESIGN

Fig. 1 shows a CAD-drawing of the new detector. The Faraday Cup Array (FCA) as the main part of this detector is shown together with a large FC for total current recordings at the right side of that figure. The tiny FCs of the array have an inner diameter of 0.9 mm and are fixed inside an Macor structure. As for the large FC a repeller prevents secondary electron escape. Apertures of only 0.3 mm diameter inside the front-plate reduce the impinging beam diameter to guarantee full absorption of the particles inside the cups in order to inhibit sputtering-induced cross-talk. At the left side of Fig. 1 the complete detector (which is a combination of the FCA and a FC) is shown as it is already in use at our beam line. It is designed to withstand continuous heat loads of about 40 W. As the recording of one profile only takes a few seconds we expect the detector to be usable at distinctly higher beam powers. Fig. 2 shows the assembled detector without front-plate. Next to the large FC the array of micro-FCs covered by the repeller is visible. The higher cup-density in the central region is chosen to increase the spatial resolution in the central part of the beam.

READ-OUT AND SUPPLEMENTAL ELECTRONICS

The supplemental electronics was completely altered compared to the verison described in [1]. Only the main changes will be reported briefly. In the new version each channel (cup) has its own I-U-converter. Every eight channels are multiplexed to a 18bit biploar ADC (400ksps) via

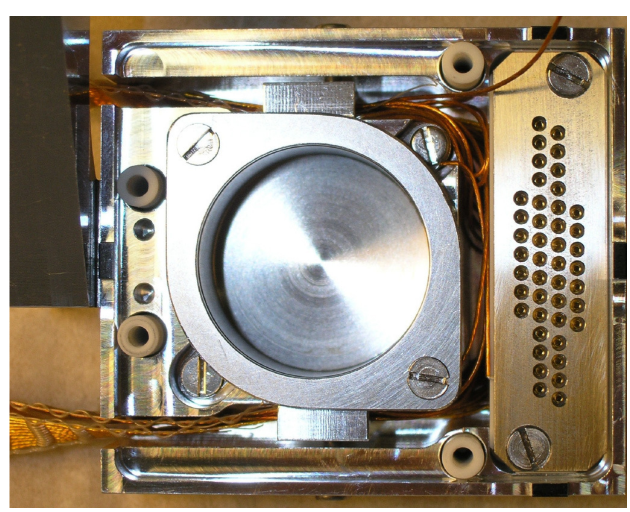

Figure 2: Assembled FCA without front-plate.

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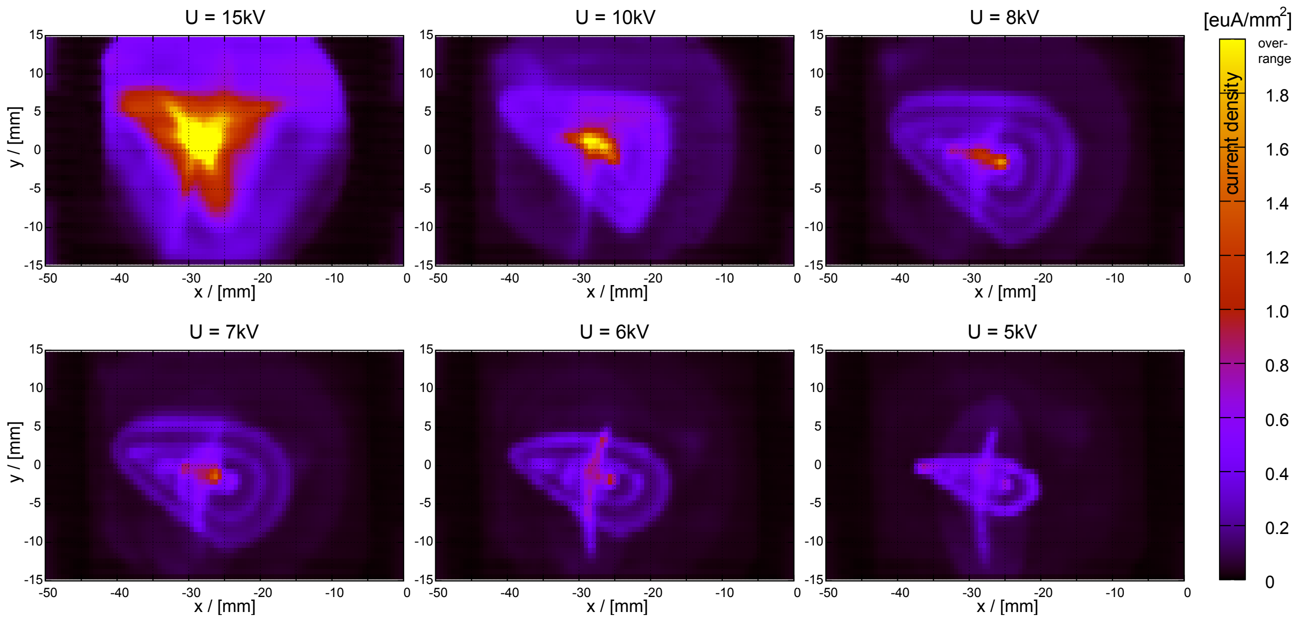

Figure 3: A selection of measured beam profiles at different extraction voltages

a differential amplifier. This arrangement is repeated six times to reach a total of 48 channels that can be digitalized at high speed. The ADCs are read out by a FPGA that can be adressed via a microcontroller from a personal computer. A low-noise power supply and a general purpose stepper driver are also integrated into the new electronics in order to increase its versatility. The single printed-circuit boards (analog, digital, supply, and stepper) are mounted inside a housing that provides very good electromagnetic shielding even among the different boards themselves. The new electronic has increased the systems reliability and speed by far. The data aquisition for a complete profile scan (approx. 4000 readings in our settings) would need less than one second. Due to the low torque of the stepping motor at high stepping frequencies we have to adapt the speed of the electronics to the maximum working speed of the stepping motor that makes the bottleneck in the new setup. Therefore one scan takes five seconds at the moment.

PEFORMANCE AND SUMMARY

The performance of this device can be demonstrated best by analyzing beam profiles that have been recorded using this detector. A selection of these profiles is summarized in Fig. 3. It shows a series of transverse profiles recorded at different extraction voltages. These profiles were recorded amongst others in the context of investigating the focussing and extraction properties of our electron cyclotron resonance ion source as reported more in detail in [2]. One can see beam profiles with a sufficiently high spatial and electrical resolution. These profiles allow the detection of structures on mm-scale. The dynamic range suffices to clearly resolve even lighter structures next to the dominant ones. In conclusion, our micro-Faraday-Cup Array allows fast and flexible beam diagnostics. The beam profile can be acquired within seconds at high spatial and/or temporal resolution. Because it consists of Faraday Cups the array does not saturate and has a linear response across a very wide range of currents and for all practical purposes can be considered linear. In the field of LEBT it is very durable and can withstand typical beam currents for prolonged periods of time.

REFERENCES

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