Beam Instrumentation for the Ultra Low Energy Storage Ring at the Facility for Low Energy Antiproton and Ion Research

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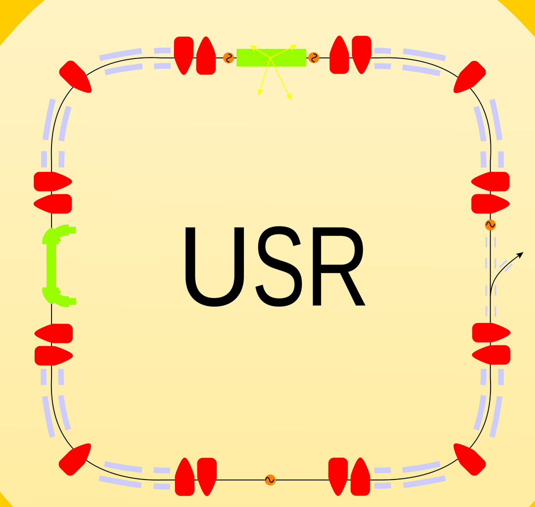
Abstract

The future Facility for Low Energy Antiproton and Ion Research (FLAIR) in Darmstadt, Germany, will supply users with high-luminosity low-energetic beams of antiprotons ①. The antiparticles will be slowed down to 20 keV by the Ultra-low energy Storage Ring (USR) ②. Aiming to offer world-wide unique conditions for both in-ring studies and experiments with extracted slow beams, the USR puts challenging demands on the necessary beam instrumentation ③. The following contribution presents novel diagnostic solutions required for the operation of the USR. This includes reliable methods for the measurement of the beam position, beam profile and beam intensity.

Parameters

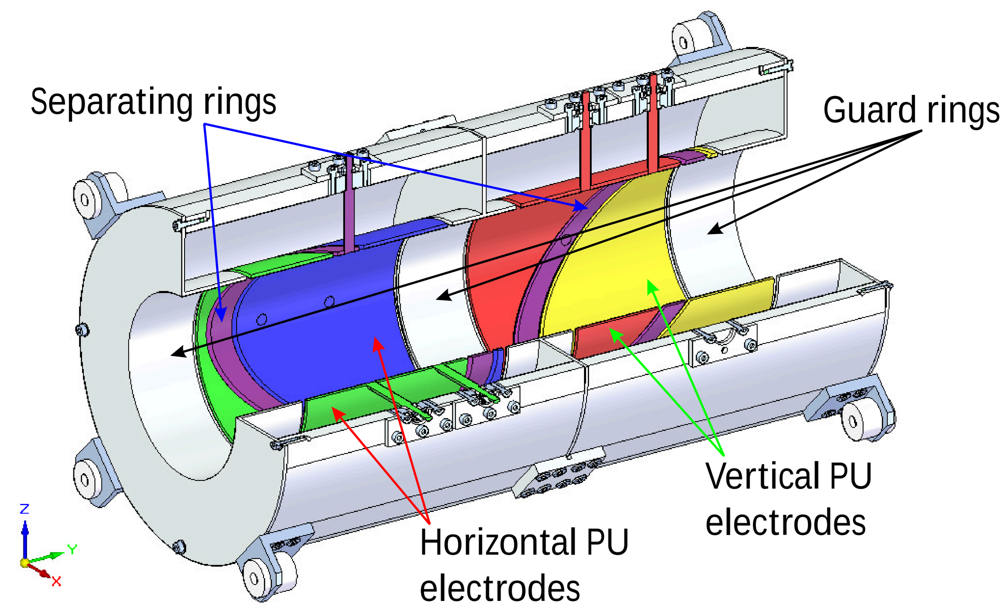
Table presents beam parameters of the Ultra-low energy antiproton Storage Ring.

Beam energy	300 → 20 keV
Velocity (% of speed of light)	2.5% → 0.6%
Number of antiprotons ($\bar{p}$)	$< 2{\cdot}10^7$
Revolution frequency	46 → 177 kHz
Bunch length	1 ns ↔ DC beam
Effective $\bar{p}$ rates for in-ring exp.	$10^{10} – 10^{12}$ pps
Average rates of extracted $\bar{p}$	$5{\cdot}10^5 – 10^6$ pps

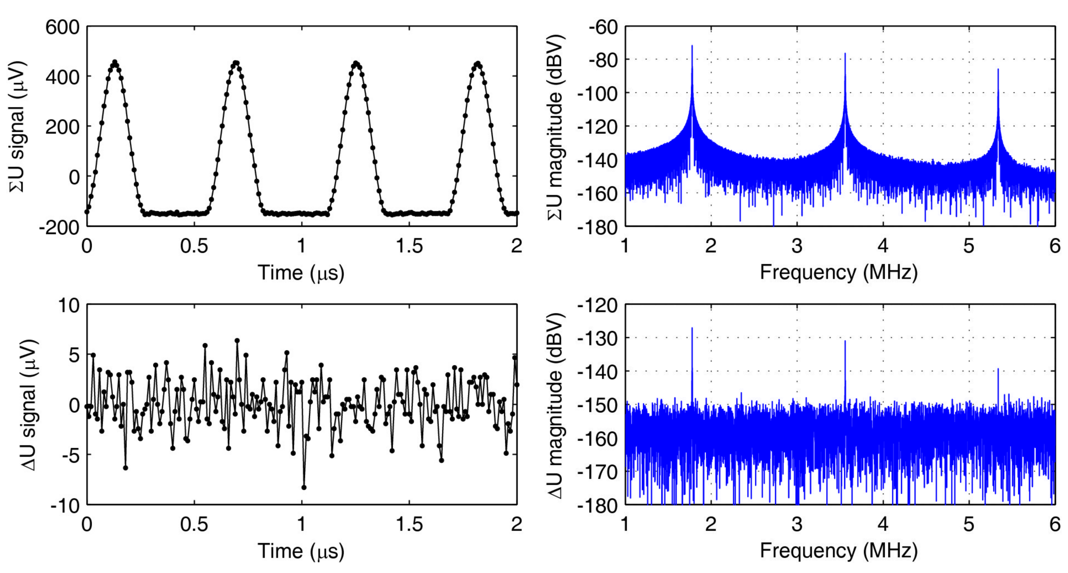


Position

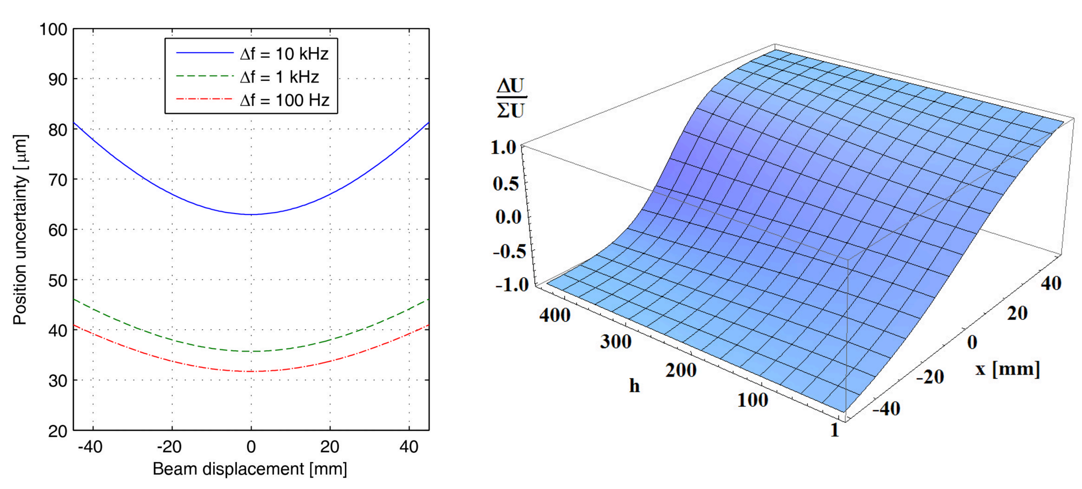
Diagonal-cut capacitive pick-ups (PU) will be used to monitor the position of the bunched beam in a non-destructive manner ④.



The PU mechanical design was optimised in terms of the linearity and coupling. Also ultra-low noise FET pre-amplifiers with a narrowband signal processing system were chosen to improve the signal-to-noise ratio.

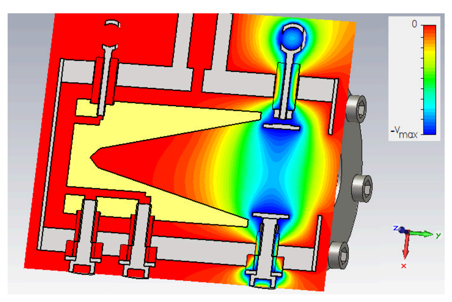


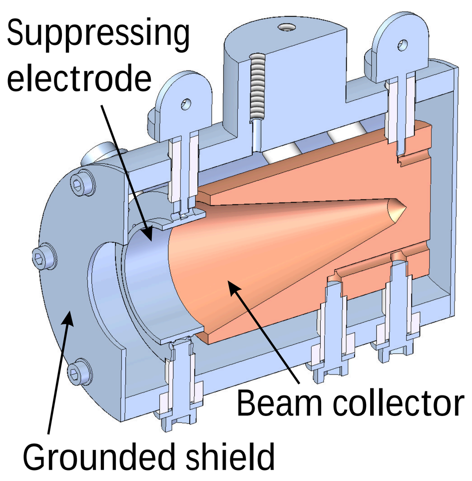
The main challenge for the pick-up system comes from the low number of particles generating very weak signals in the PU plates. In order to detect a beam displacement of 0.1 mm, one needs to be able to measure 300 nV in a noisy environment of beamlines, vacuum pumps and electromagnetic fields.

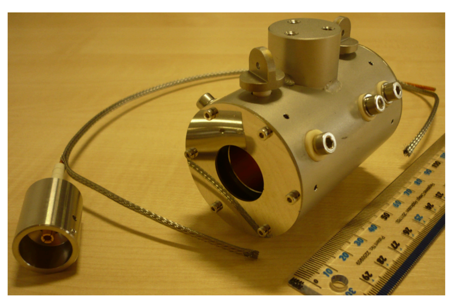


Intensity

Faraday cups will be used to monitor the intensity of the injected and the extracted beams during the commissioning stage with protons or H^- ions ⑤. These destructive detectors were optimised for the absolute, ultra-low current measurements under ultra-high vacuum (10^{-11} mbar) conditions with a flexibility required by the different extraction schemes. Variable gain pre-amplifiers will make it possible to monitor μs bunches with peak currents of about a μA as well as quasi-DC beams with currents as low as 100 fA (approximately 10^6 particles per second).

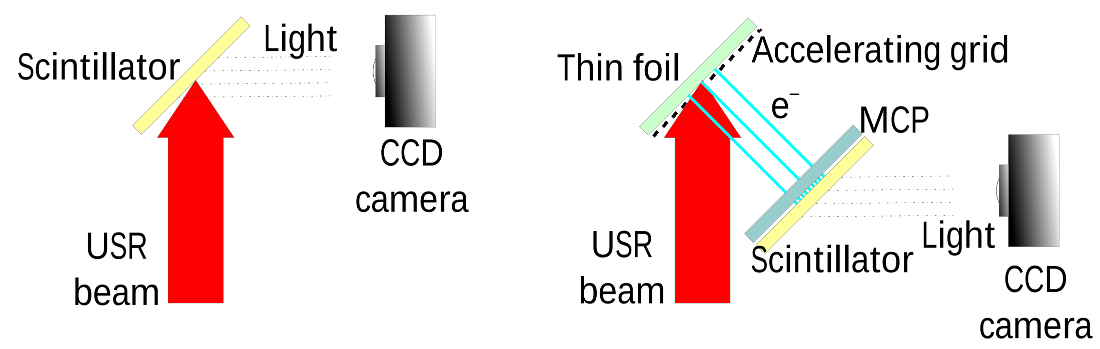




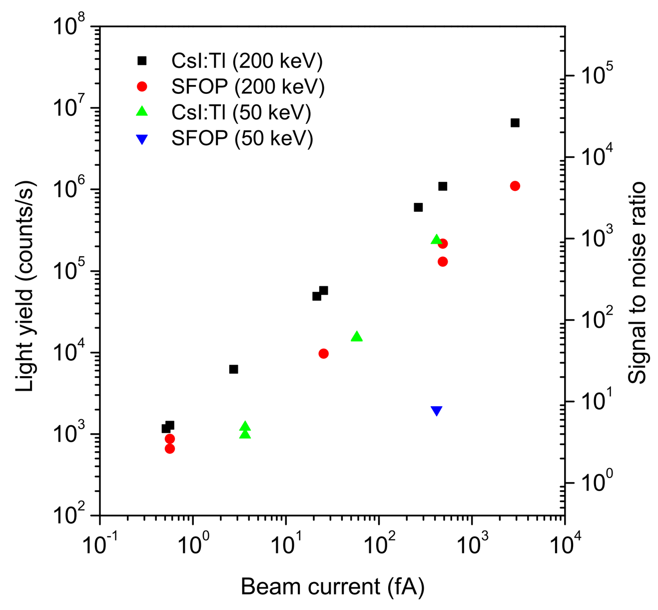


Profile

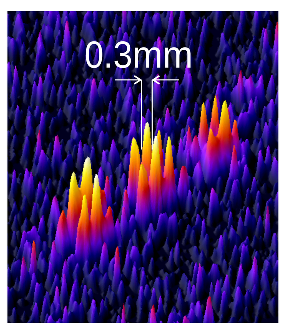
Two types of detection systems have been tested for profile monitoring (shown in the figure below): different scintillating screens (left) and a secondary emission monitor (right).

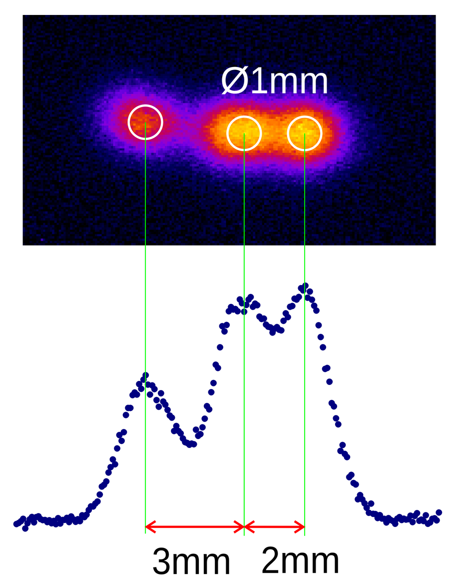


The sensitivity limits of CsI:Tl, YAG:Ce and a Terbium-doped glass Scintillating Fibre Optic Plate were investigated with keV protons in collaboration with INFN-LNS.



The resolution of 0.3 mm was achieved and it was shown that beams with intensities as low as $5{\cdot}10^3$ pps can be monitored ⑥.





A secondary electron emission monitor was tested in collaboration with MSL in Stockholm. A collimator with 1 mm holes spaced 2 mm apart was used to test the resolution ⑦.

References

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