# FIGURE-8 STORAGE RING – ION BEAM INJECTION INTO A CLOSED, MAGNETIC SYSTEM

H. Niebuhr*, A. Ates, M. Droba, O. Meusel, U. Ratzinger
Institute for Applied Physics, Goethe-University, Frankfurt am Main, Germany

*Abstract*

To store high current low-energetic ion beams of up to 10 A, a superconducting storage ring (F8SR) based on solenoidal and toroidal magnetic guiding fields is investigated at Frankfurt University. Besides simulations, a scaled down experimental setup with normalconducting magnets was built. Investigations of beam injection into closed, magnetic guiding fields are in progress. Therefore, a new kind of injection system consisting of a solenoidal injection coil and a special vacuum vessel was constructed. It is used to inject a hydrogen beam from the side between two toroidal magnets. In parallel operation, a second hydrogen beam is transported through both magnets to represent the circulating beam. The current status of the experimental setup and first experimental results will be shown.

## F8SR – FIGURE-8 STORAGE RING

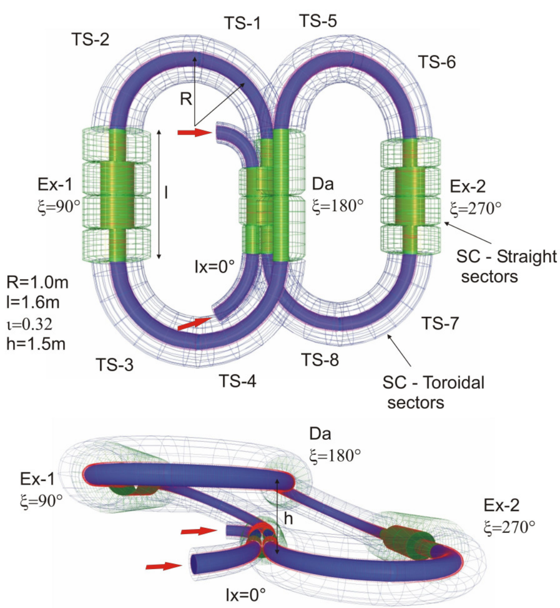


Figure 1: F8SR – Low-Energy Superconducting Magnetostatic Storage Ring.

The F8SR is a low-energy superconducting magnetostatic storage ring for high current beams. For example it is possible to transport two proton beams of up to 10 A with an energy of up to 150 keV, one in each direction. In order to manage the high current beams, toroidal magnets (called toroids) and solenoids are used around the whole ring for continuous beam focusing. The twisted Figure-8 geometry is necessary to compensate the RxB drift which causes an up or down drift of beams transported through toroidal magnetic fields. If two beams are transported independently – one in each direction – interaction experiments can be performed at two areas of the ring where the beams cross naturally. One possible design of the F8SR is shown in Fig. 1.

## THE INJECTION EXPERIMENT

To investigate the beam dynamics of such a storage ring experimentally a scaled down experiment with two 30 degrees toroids with a magnetic field of up to 0.6 T is used. Investigations regarding the beam transport through toroidal magnetic fields were done before [1]. At the moment the experiment is being reconstructed to investigate the beam injection between the two toroids. Therefor an injection system with a new injection coil was designed and manufactured. The final layout of the complete injection experiment is shown in Fig. 2.

Although the injection experiment is still under construction, the biggest and most important part of the experiment – the injection system – is built in and the vacuum tests were successful. The injection system consists of a height-adjustable vacuum tank system and the solenoidal injection magnet. Besides the injection system the two injectors, the two filter channels [2], the two toroids, the end tank and the whole periphery (power supplies, high voltage terminals, etc.) are ready for use. Only the xy-flange is still in production. The xy-flange is used to change the injection position of the injection beam into the solenoidal injection coil. The simulations show that this is necessary [3]. The entire possible offset of the flange is 100 mm in each radial direction.

The assembly of the experiment will be finished in summer 2017. In Fig. 3 a photo of the current status of the experiment is shown.

## THE NEW DETECTORS

For the investigation of the beam dynamics measurements of the positions and the diameters of the two ion beams are necessary. Therefor two new detector systems were developed, built and tested successfully. Detector Number One is a destructive detector which consists of 64 single Faraday cups (FDCs) with secondary electron suppression. Each of the 64 signals are measured independently using a resistor-box and a multichannel voltmeter. The small detector can be positioned at nearly any position inside the vacuum chamber, for example in the blind spot of another detector. A photo of this detector and a measurement example of an ion beam are shown in Fig. 4.

* niebuhr@iap.uni-frankfurt.de

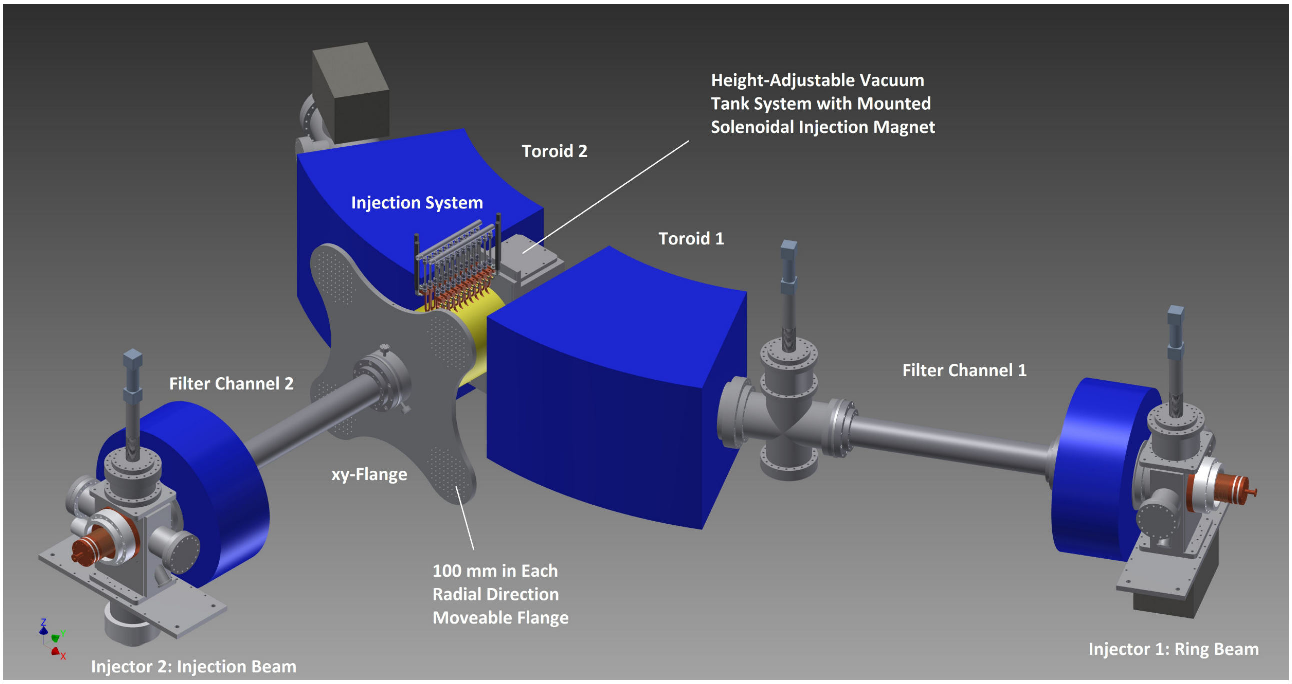


Figure 2: The complete layout of the experiment.

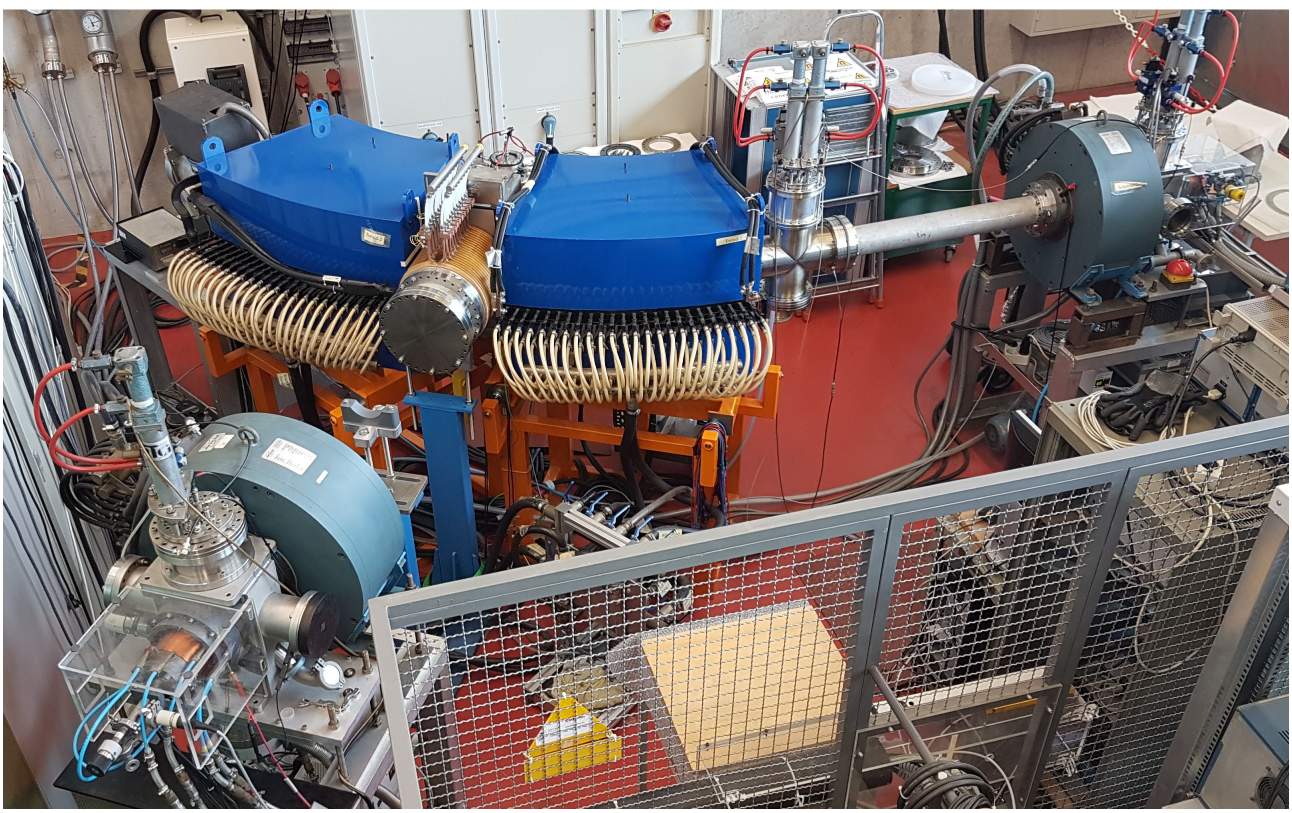

Figure 3: The current status of the experiment (May 2017).

Detector Number Two is a non-destructive detector using two Raspberry Pi cameras as beam induced fluorescence monitors installed directly into the vacuum chamber together with the board computers. The two cameras are positioned orthogonally to each other around the beams at the tube wall. They are controlled per SSH protocol using a network interface and the photos are sent directly to a PC where the beam positions and diameters are calculated. A photo of this detector and a measurement example of an ion beam within the first toroid are shown in Fig. 5.


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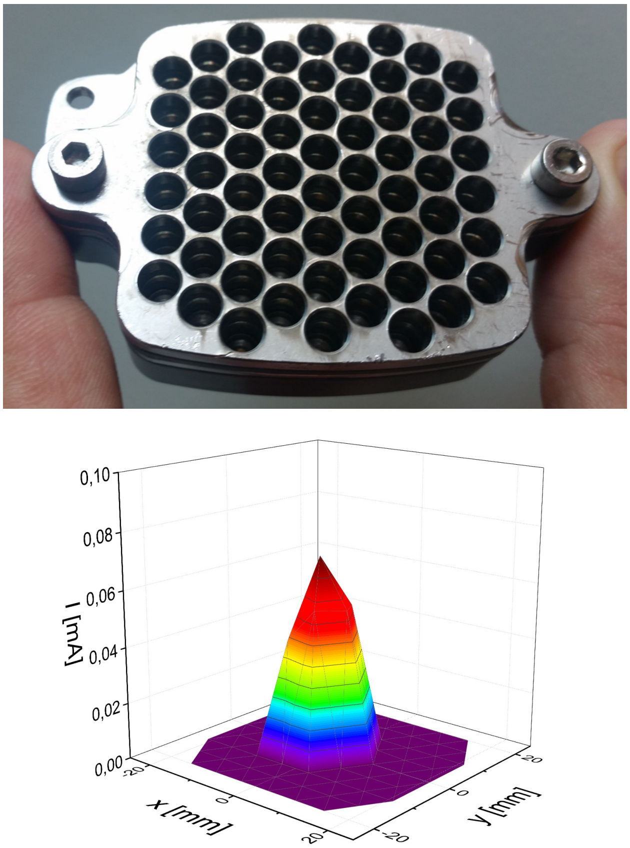


Figure 4: The upper picture shows a photo of the FDC detector and the lower one a measurement of a focused He+ ion beam using the detector.

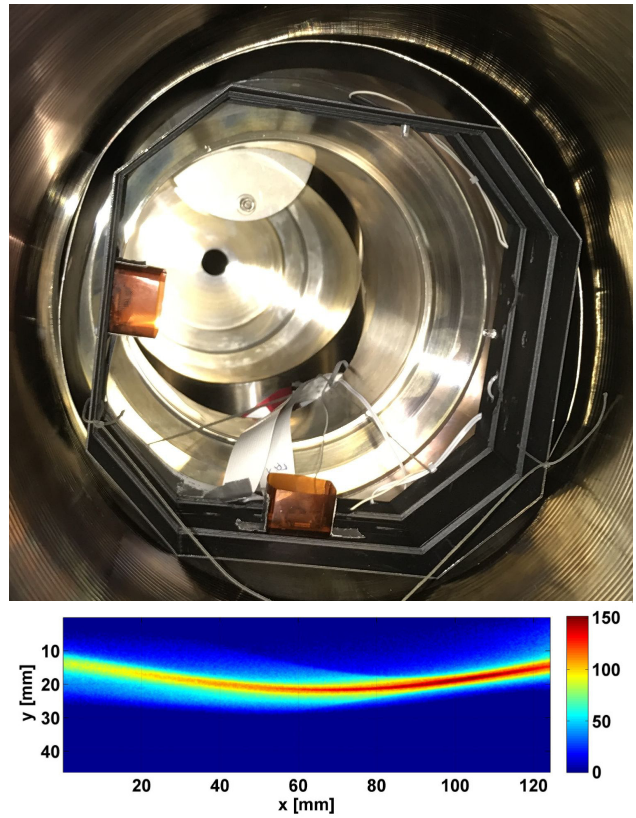


Figure 5: The upper picture shows a photo of the Raspberry Pi fluorescence detector and the lower one a measurement of an H+ ion beam inside the first toroid using one camera of the detector.

Two fluorescence detectors will be used to investigate the beam injection at the injection experiments. One will be positioned at the entrance of the second toroid, the other one inside the injection channel in the middle of the injection coil. Additionally the FDC detector will be positioned directly near the wall in front of the fluorescence detector at the entrance of the second toroid. That is necessary because the injected beam will be transported nearby the wall of the second toroid where the blind spot of the fluorescence detector is around. In a further step it is planned to build a system to move the two detectors positioned at the entrance of the second toroid along the magnet to investigate the transport of the two beams in detail.

## CONCLUSION AND OUTLOOK

The scaled down injection experiment of the F8SR project is still under construction and will be finished soon. The most important part – the injection system – was installed successfully. The whole experiment will be ready in summer 2017. After that, the first experiments will take place by using the two successfully commissioned detector systems. The transverse injection position into the injection channel using the xy-flange, the magnetic field strengths of the three magnets and the height of the injection channel in comparison to the transport channel are the main parameters which will be varied during the experiments. A comparison of the experimental results with the simulations [3] will be done afterwards.

## REFERENCES

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