Developments for the CR stochastic cooling system

C. Dimopoulou[1], D. Barker[1], R. Böhm[1], M. Dolinska[2], R. Hettrich[1], W. Maier[1], F. Nolden[1], C. Peschke[1], P. Petri[1], M. Steck[1], L. Thorndahl[3]

[1]GSI, Darmstadt, Germany; [2]Frankfurt University; [3]CERN, Geneva, Switzerland.

The Collector Ring (CR) serves mainly the fast 3D stochastic cooling (SC) of antiproton and rare isotope beams, which have different requirements. The SC system operates in the frequency bandwidth 1-2 GHz. The main challenges are the antiproton cooling by means of cryogenic movable pick-up electrodes and the fast two-stage cooling (Palmer method, followed by notch filter method) of the hot rare isotopes.

The FAIR Council has allocated this system to GSI as an in kind contribution. A detailed specification document describing the complete system and listing its main components has been prepared. The in-house engineering and design activities on various system components and their integration in the CR building have been intensified.

Electrodes and pick-up tanks

The prototype pick-up tank has been modified in the mechanical workshop in order to accommodate the two novel water-cooled linear motor drive units (Fig. 1) which were designed and manufactured in 2012; their synchronous operation remains to be tested. The cryogenic movable pick-up slotline electrodes were further optimized, the first ceramic electrode plates have been delivered. The pick-up electrodes will be cooled by helium cryoheads to about 20-30 K in order to enhance the signal to noise ratio. The intermediate cryoshield at 80 K inside the pick-up tank has been designed and ordered. It consists of 4 half-shells, each 1 m long and bears holes for the motor drives and openings for assembly purposes, it is made of oxygen-free copper and has to be gilded galvanically so as to reach very low thermal emissivity.

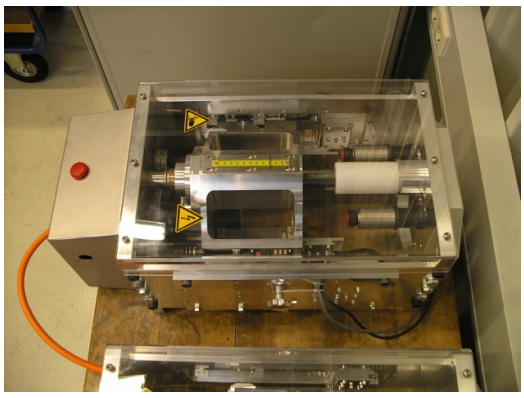

Figure 1: New linear motor drive unit.

Dedicated electromagnetic simulations with the HFSS code have been started in 2012 in order to design the electrodes (of Faltin type) of the Palmer pick-up.

RF signal processing and its components

A flexible RF signal processing scheme (RF block diagram) of the complete SC system has been laid out. It covers the transverse (horizontal, vertical) cooling branches as well as the longitudinal cooling using the notch filter, the time of flight (TOF) or the Palmer method.

The technical specification of the 1-2 GHz power amplifiers has been written, so that the procurement of this critical component can start in 2013. Because of the very demanding antiproton cooling a total cw microwave power of 8 kW is required, in combination with stringent requirements on amplitude flatness and phase linearity. Besides that, the short path between Palmer pick-up and kickers in the CR further restricts the allowed electrical length of the power amplifiers.

The experience gained from the successful tests of the prototype notch filter with beam in the ESR [1] is being used to optimize the set-up in view of the CR. In particular, the 180^0 hybrid which limited the filter performance will be replaced by a 180^0 power splitter.

Simulations of the system performance

The momentum cooling performance in the CR with the notch filter and TOF methods has been investigated theoretically using a Fokker-Planck approach (CERN code). The results confirm the necessity of a high-quality notch filter for efficient cooling; nevertheless, the TOF option is useful for pre-cooling of beam tails or in case of moderate cooling requirements [2].

In parallel, at CERN, a novel approach for simulating the cooling process in the time domain based on an ab initio calculation of the cooling and diffusion coefficients has been developed and applied to the CR case [3].

A numerical algorithm solving the 2D Fokker-Plank equation has been written at GSI [4]. This is a first effort towards a powerful treatment of the Palmer stochastic cooling of ions where, typically, the longitudinal and transverse phase space planes are strongly coupled.

References

[1] F. Nolden et al., ”ESR Operation and Development”, this report.

[2] C. Dimopoulou et al., IPAC’12, New Orleans, USA, May 2012, MOPPD005, http://www.jacow.org.

[3] L. Thorndahl et al., COOL’13, Mürren, Switzerland, http://www.jacow.org (to be published).

[4] M. Dolinska et al., IPAC’13, Shanghai, China, http://www.jacow.org (to be published).