Advanced Research Center for Beam Science
– Particle Beam Science –

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Dr ZIMMERMANN, Frank — CERN, Switzerland, 22 July
Mr HE, Zhengqi — Tsinghua University, China, P.R., 28 October –23 December
Dr JAMESON, Robert A — Goethe University, Germany, 1–30 November

Scope of Research

The Following Subjects are being studied: Beam dynamics related to space charge force in accelerators: Beam handling during the injection and extraction processes of the accelerator ring: Ultra-low Emittance state of a proton beam created by the electron cooling: Laser cooling of Mg^{+} ion beam: Irradiation of short bunch proton beam by electron cooling and phase rotation: Research and development of permanent quadrupole magnets for final focusing of International Linear Collider(ILC): Development of electron-cyclotron resonance(ECR) ion source for small neutron source.

KEYWORDS
Beam Physics
Accelerator Physics
Beam Cooling
Phase Rotation
Neutron Optics

Selected Publications

Noda, A., Ion Beam Cooling at S-LSR Project, *Nucl. Instrum. Meth.*, **A532,** 150-156 (2004).

Shirai, T.; Ikegami, M.; Fujimoto, S.; Souda, H.; Tanabe, M.; Tongu, H.; Noda, A.; Fujimoto, T.; Iwata, S.; Shibuya, S.; Smirnov, A.; Meshkov, I.; Fadil, H.; Grieser, M., One Dimensional Beam Ordering of Protons in a Storage Ring, *Phys. Rev. Lett.*, **98,** [204801-1]-[204801-4] (2007).

Nakamura, S.; Ikegami, M.; Iwashita, Y.; Shirai, T.; Tongu, H.; Souda, H.; Daido, H.; Mori, M.; Kado, M.; Sagisaka, A.; Ogura, K.; Nishiuchi, M.; Orimo, S.; Hayashi, Y.; Yogo, A.; Pirozhkov, A. S.; Buranov, S. V.; Esirkepov, T.; Nagashima, A.; Kimura, T.; Tajima, T.; Takeuchi, T.; Fukumi, A.; Li, Z.; Noda, A., High-Quality Laser-Produced Proton Beam Realized by the Application of a Synchronous RF Electric Field, *Jpn. J. Appl. Phys.*, **46,** L717-L720 (2007).

Wakasugi, M.; Emoto, T.; Furukawa, Y.; Ishii, K.; Ito, S.; Koseki, T.; Kurita, K.; Kuwajima, A.; Masuda, T.; Morikawa, A.; Nakamura, M.; Noda, A.; Ohnishi, T.; Shirai, T.; Suda, T.; Takeda, H.; Tamae, T.; Tongu, H.; Wang, A.; Yano, Y., Novel Internal Target for Electron Scattering Off Unstable Nuclei, *Phys. Rev. Lett.*, **100,** [164801-1]-[164801-4] (2008).

Iwashita, Y.; Tajima, Y.; Hayano, H., Development of High Resolution Camera for Observations of Superconducting Cavities, *Phys. Rev. S.T.-Accel. Beams*, **11,** [093501-1]-[093501-6] (2008).

Approach to High Efficiency Indirect Transverse Laser Cooling

At S-LSR, a laser cooling has been applied to $^{24}Mg^{+}$ ions in order to realize a crystalline beam with the use of a very strong cooling force of laser cooling. Cooling in the longitudinal direction has already been attained for both a coasting beam and a bunched beam. Indirect transverse laser cooling by synchro-betatron coupling [1] has also been demonstrated as shown in Figure 1, the cooling efficiency of which, however, was found to be not so high as enables the crystalline beam getting over the hill of heating force due to Intra-Beam Scattering (IBS) (Figure 2 [2]). For this purpose, it is required to reduce the beam intensity in order to suppress IBS. The reduction of the beam intensity, however, results in a deterioration of signal to noise ratio for measurements of the beam, especially for the optical measurement of spontaneous emission from laser excited Mg ions with the use of a cooled CCD in order to measure the horizontal beam size.

We are investigating the capability to reduce the beam intensity without deteriorating S/N ratio so much by “Controlled Scraping”, which applies two dimensional laser cooling with the use of resonant coupling together with a time variable scraping as illustrated in Figure 3. The essential feature of this scheme is gradual reduction of beam aperture by a scraper according to the performance of horizontal beam size reduction with an indirect horizontal laser cooling using synchro-betatron resonant coupling. Recent beam experiments showed the elongation of beam life by putting a scraper closer to the beam center after application of two dimensional laser cooling.

[1] H. Okamoto, A.M. Sessler and D. Möhl, Phys. Rev. Lett. **72,** (1994) 3977.
[2] M. Bussmann et al., Presentation at SPARC07.

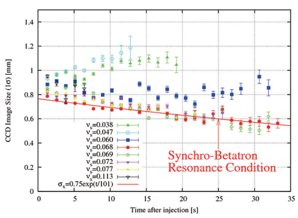

Figure 1.

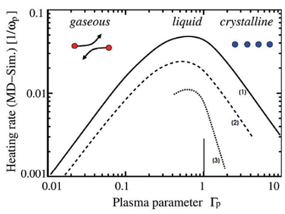

Figure 2.

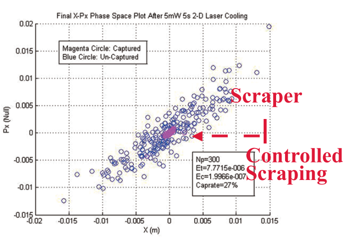

Figure 3.

Permanent Magnet Focusing for Klystrons

Applying permanent magnet technology to beam focusing in klystrons can reduce their power consumption and increase reliability. These features benefit a variety of applications especially for large facilities that use a number of klystrons such as the International Linear Collider (ILC), one of the important future projects of high energy physics. A Japanese group proposes a Distributed RF System (DRFS) to eliminate a complicated RF waveguide system, where about 4000 relatively small modulating anode (MA) klystrons will be used. Because of the large number of units, the failure rate of every component has to be minimized. A low beam voltage owing to the moderate output power and less stress to the RF window should make the lifetime of the klystrons longer. The maintenance problem caused by the large number of electromagnets and power supplies will be relaxed by replacing the electromagnets by permanent magnets, which eliminates 4000 power supplies and cooling systems. Hence the down time of the RF system can be expected to be small. The low magnetic field needed for the purpose allows us to apply inexpensive ferrite magnets instead of magnets using rare earth material. The magnet system is designed by a 3D magnetic field calculation code and fabricated at 1/2 scale. The results will be used to fabricate a full scale model for a real klystron, which will be evaluated by a power test next year.

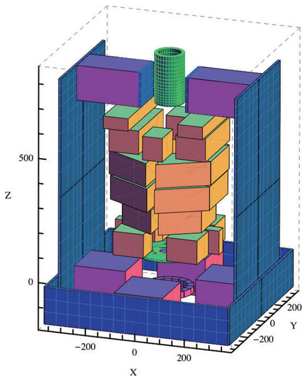

Figure 4. Permanent magnet focusing system designed with RADIA4.29.

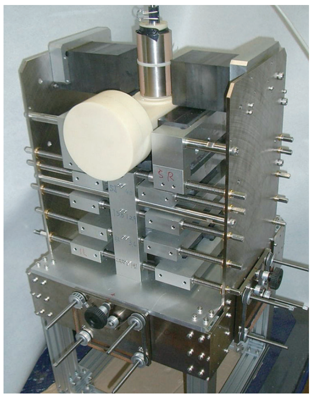

Figure 5. Fabricated half scale model of the permanent magnet focusing system. A 1/2 mockup of the klystron is inserted to check the geometry.