Virtual National Laboratory for Heavy Ion Fusion

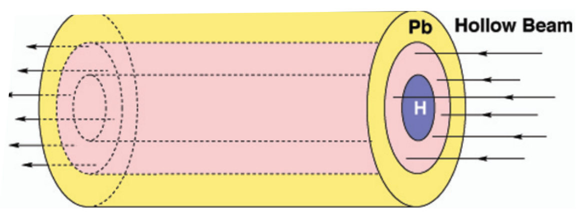
July-August 2003

HIFNews

LBNL-PUB-844-03-08

High Energy Density in Matter at the Future SIS-100 Facility at GSI Darmstadt

Construction of the 100 Tm synchrotron, SIS-100 will significantly increase the accelerator capabilities of the Gesellschaft fuer Schwerionenforschung (GSI) Darmstadt. This facility is designed to generate an intense uranium beam with an intensity of 10^{12} particles, delivered in a single bunch, and a wide range of particle energy (400 MeV/u - 2.7 GeV/u) providing a capability to perform a variety of experiments. The bunch length is expected to be 90 - 20 ns respectively, over the above energy range, while the beam focal spot diameter (full width at half maximum) is expected to be of the order of 1 mm. Numerical simulations show that such a beam will deposit a specific energy of a few hundred kJ/g in solid lead, generating temperatures of the order of 20 eV. Due to the long range of these ions in matter, it will be possible to create large samples (with dimensions of about a cm) of uniformly heated material near solid density. This facility would therefore be a very suitable tool to study high energy density (HED) states in matter. One very interesting experiment will use the SIS-100 beam to achieve a low entropy compression of a multi-layered cylindrical target that contains a sample material like hydrogen.



The beam-target geometry is shown in Figure 1. The right face of the target is irradiated with the beam that has an annular focal spot. The target length is assumed to be much less than the ion range resulting in uniform energy deposition along the particle trajectory. Moreover, the inner radius of the beam focal spot ring is larger than the radius of the hydrogen cylinder so that the hydrogen is not directly heated by the ion beam. The high pressure in the absorption region launches a shock in the hydrogen. This shock reverberates between the target axis and the hydrogen lead boundary leading to a low entropy compression of hydrogen. Simulations have shown that using the SIS-100 beam with an annular focal spot could achieve a density of 1-2 g/cm^3 and a pressure of 5-10 Mbar while the temperature remains low (a few thousand K). This is the region where the hydrogen is expected to metallize. Analytic modeling of this problem has shown that the results are very insensitive to large variations in the beam and target parameters, indicating that the beam-target geometry is very robust as is essential for the success of the experiment. We have calculated that a beam with an annular focal spot can be achieved with an rf-wobbler that will rotate the beam with a very high frequency. In order to achieve a high level of symmetry in the driving pressure (of the order of 1% asymmetry), the beam should perform 10 revolutions. This means a rotation frequency of 0.5 GHz to 0.1 GHz for the pulse duration of 20-100 ns. These results have been published in POP and PRE by Tahir or Piriz et al.

– Naeem A. Tahir

HCX superconducting quadrupole test results.

A collaboration of LBNL, LLNL, MIT Plasma Science and Fusion Center, and Advanced Magnet Lab (AML) is developing superconducting focusing quadrupoles for near-term experiments that could be applicable to future HIF drivers. Optimization of the HCX baseline design by LLNL led to significant improvements. A coil end geometry with tight bends followed by straight segments resulted in better magnetic length and field quality. SSC-inner strand with low copper ratio allowed increasing the gradient. The coil holder material was changed from stainless steel to aluminum to reduce cost.

A prototype cell of the optimized design, fabricated by AML, was recently tested at LBNL. The prototype demonstrated excellent quench performance, achieving a conductor-limited gradient of 132 T/m in only two quenches. No retraining was observed after a thermal cycle, and no significant degradation of the quench current was observed for ramp rates as high as 100 A/s. The results of magnetic measurements show integrated harmonics within a few parts in 10^4, consistent with HCX requirements for a 100-quadrupole transport channel. Correlation of the measured harmonics with as-built dimensions, better control of the fabrication tolerances and correction of the design systematics will result in further improvements in future models.

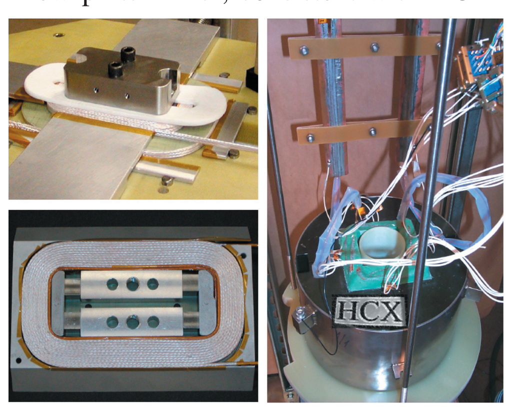


Fig. 1. HCX quadrupole fabrication and test.

– L. Chiesa, A. Lietzke, N. Martovetsky, G. Sabbi, and P. Seidl.

For comments about the content of the HIF News, contact Art Molvik (925)422-9817, or molvik1@llnl.gov.
To get on the mailing list of the HIF News, send a request to WWTabler@lbl.gov
This work was performed under the auspices of the U.S. Department of Energy by the University of California Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48 and by Lawrence Berkeley National Laboratory under contract No. DE-AC03-76SF00098 (LBNL), and by Princeton Plasma Physics Laboratory performed under the auspices of the U.S. Department of Energy under contract No. DE-AC02-76CH-O3073.