Virtual National Laboratory for Heavy Ion Fusion Sciences

Issue Number 2, 2008

HIFS News

New HIFS-VNL target chamber facility for target experiments with low-range-heavy ions.

The recent addition of a new, state-of-the-art target chamber facility has propelled the Heavy Ion Fusion Science - Virtual National Laboratory into a new era of warm-dense matter target physics experiments using low-range heavy ions. This article briefly describes the features and capabilities of the new target chamber, which can be installed on NDCX-I (300 keV K^+ beam) as well as the future follow-up experiment NDCX-II (3 MeV Li^+ beam).

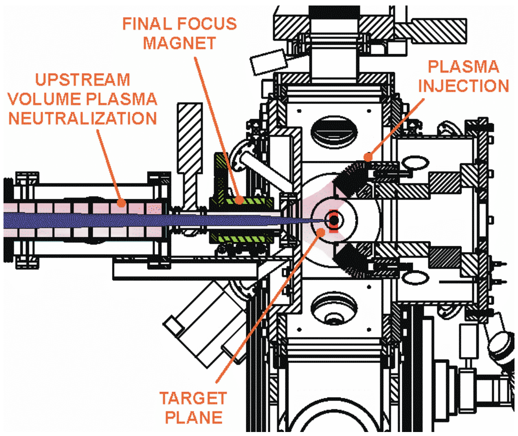
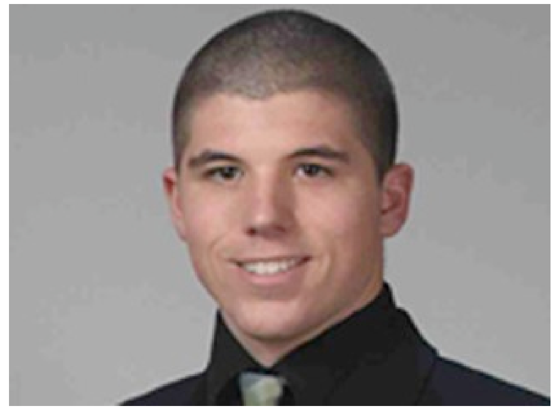


Figure 1: Schematic set-up the NDCX final focus arrangement.

The HIFS-VNL pursues low-range ion heating to isochorically heat targets. The heating uniformity is maximized by reaching the peak ion energy loss (dE/dx) inside a thin target foil. This technique permits the use of smaller accelerators since the Bragg peak for most ions and target materials is in the MeV range. However, this approach has significant and unique consequences for the experimental target and target chamber setup: a) intense (approximately tens of Amperes) ion beam currents must be focused to less than 1 mm diameter on target in order to achieve sufficient heating power for these low kinetic ions. This is only made possible by the neutralized drift compression technique recently developed in the HIFS-VNL; b) because of the low ion range thin (micro-meter) targets or foams have to be used.

To limit hydro-motion of these thin targets the incident ion beam has to be compressed to a short pulse (approximately 1 nano-second). These aspects are reflected in the actual target chamber design, which must provide: a) sufficient dense (10^{12} to 10^{14} cm^{-2}) plasma injection to neutralize the space charge of the incoming ion beam; b) a strong (8 to 15 Tesla) final focus solenoid for radial ion beam compression; c) fast optical target diagnostics with access to the front, side and back of the target foil; d) accurate (micron range) target alignment capabilities, as well as; e) provisions to exchange target foils without venting the accelerator vacuum system.



We are saddened to report the tragic death of UC Berkeley undergraduate senior Christopher Wootton who was fatally stabbed near his fraternity on May 3, 2008. Chris worked in our group with VNL physicist Steve Lund from the summer of 2007 on an analysis of beam centroid steering in solenoidal transport channels for application to NDCX-1. In his limited time with the group, Chris rapidly became a valued and appreciated contributor from both a personal and a professional standpoint. Chris was an unusually driven and efficient worker for an undergraduate student. In addition to being the top undergraduate student in the Nuclear Engineering Department at UC Berkeley he worked with the group about 16 hours a week during the terms and was a productive researcher. His work with the group was instrumental in improving understanding of beam centroid evolution and control in solenoidal transport channels. This research is presently being applied in NDCX-1 and will be submitted for publication. Additional information about Chris and this tragedy can be found on the Nuclear Engineering web site at UC Berkeley http://www.nuc.berkeley.edu/.

A letter written by Steve to Chris's family and friends can be found at: http://www.lbl.gov/today/2008/May/08-Thu/chris.pdf. The Nuclear Engineering Department has established an annual award for the top graduating senior in honor of Chris.

- Steve Lund

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Figure 1 displays schematically the final focus set-up for NDCX. The longitudinally compressing ion beam is transported through an upstream neutralization section to minimize space charge defocusing. It enters the target chamber from the left and is focused to approx. 1 mm diameter by a strong (8 Tesla), pulsed solenoid. Additional neutralizing plasma has to be injected in front of the target in order to maintain the space charge neutralization of the now longitudinally as well as transversely compressed beam bunch. Because of the low energy of the incoming ion beam the focal length of the final focus solenoid is short (~40 cm). This makes the HIFS-VNL target chamber unique since each sub-component has to be tightly packed in space.

For comments about the content of the HIF News, contact Jean-Luc Vay (Cell 248-961-9115) or JLVay@lbl.gov

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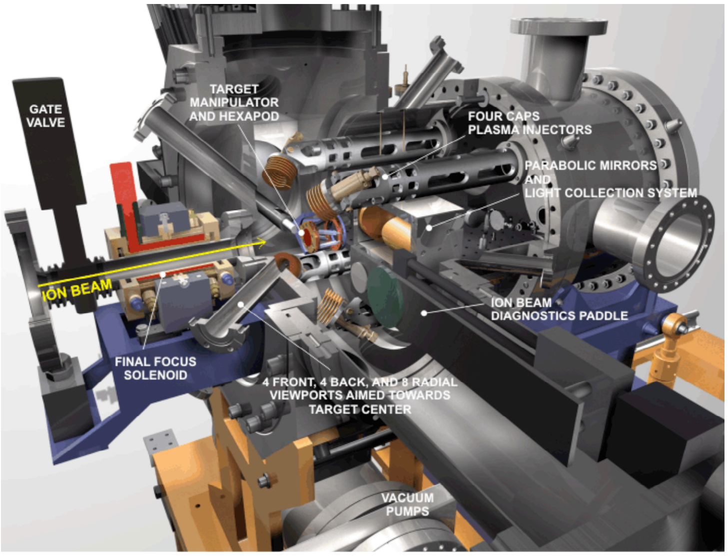

Figure 2: Cut-away view of the target chamber facility with the ion beam entering from the left.

Figure 2 shows a cut-away view of the target chamber facility with the ion beam entering from the left. A gate valve allows to vent the target chamber separately from the NDCX beam transport line in order to allow exchanging targets during NDCX operation. Because of the short focal length, the final focus solenoid is mounted inside a re-entrant front flange. Every available space inside the target chamber is utilized: Four Cathodic Arc Plasma Sources (CAPS) inject plasma into the target region. Two stepper-motor controlled manipulators can insert either ion beam diagnostics (a fast faraday cup or scintillator) or a target holder. The last two of the remaining large access ports are utilized for an external video camera as well as vacuum pumping.

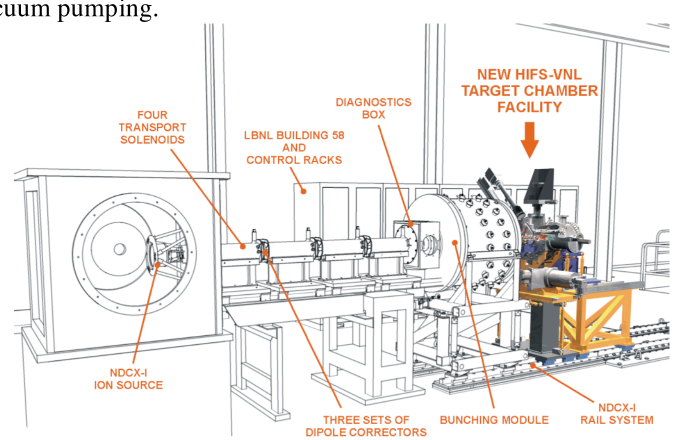

Figure 3: CAD view of the new HIFS-VNL target chamber facility installed on NDCX-I.

The backside of the target chamber houses the light collection system for a fast pyrometer, which is used to measure the target temperature during the nano-second heating pulse. The development of such a fast pyrometer is challenging due to detection of only several hundreds of microwatts of light in visible and near infrared range with sub-picoseconds temporal resolution and tens of nanometers spectral resolution. A precision-aligned collection optic system consisting of two achromatic doublets generates a 1:1 image of the target surface on a fiber bundle (3 fibers), which is connected (through a vacuum feed through) to a pyrometer, streak camera spectrometer and laser Doppler-shift interferometer. Simultaneous imaging of the target's surface is achieved by means of a pellicle beam splitter, which diverts 8% of the collected light to an image guide connected to a CCD camera.

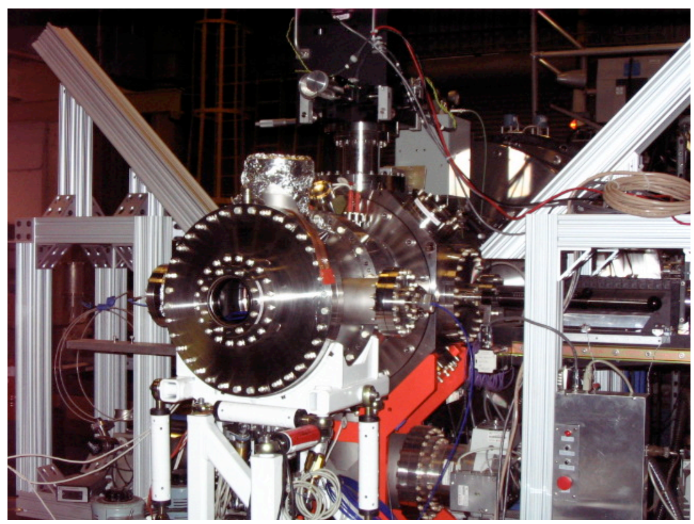

Figure 4: Photograph of the target chamber as installed on NDCX-I.

For alignment purposes both, the target holder as well as the light collection system, sit on a kinematic platform, called a "hexapod". A hexapod can simultaneously align in all six degrees of freedom (x, y, z, roll, pitch, yaw). Although a hexapod structure is not intuitively adjustable and requires a computer program to bring the target or light collection system into alignment, we've opted to develop such miniaturized kinematic platforms for use in a future robotic arm for automated in-vacuum target replacement. Currently the hexapods have to be manually adjusted, but we are in the process of developing computer-controlled versions.

End of May, the target chamber and light collection system have been installed on the NDCX-I beamline as can be seen in figure 3 and figure 4. We are looking forward to a new phase of exciting, actual target physics experiments on a HIFS-VNL accelerator beamline.

- Matthaeus Leitner

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