USER FACILITY STATUS IN 1999

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During 1999, the K1200 cyclotron operated for 6 months (January through June), before it was shut down on July 1, 1999 for 18 months for constructing the Coupled Cyclotron Facility. In the January-June period, the cyclotron delivered beam for research and development for a total of 2636 hrs, distributed as follows: 2350 hrs for 18 PAC-approved experiments, 225 hrs for 9 short test runs and discretionary experiments, and 61 hrs for accelerator and equipment development. Of the 18 PAC-approved experiments, 15 used secondary beams produced by the A1200 fragment separator.

A priority goal for the NSCL experimental program during this operating period was the completion of most, and hopefully all, PAC-approved experiments by the end of June. This goal was largely met. Only one (non-thesis) experiment had to be cancelled because of accelerator problems. Efforts to reschedule this experiment failed because the time slots available were too inconvenient for the experimenters who then decided not to run the experiment.

Approximately 145 scientists took part in these experiments: 42 from within the NSCL and 103 from outside. They came from 41 institutions in 13 countries. The number of foreign visitors was 41. The number of students (mostly graduate students) participating in the experiments was about 28, consisting of 18 from the NSCL and 10 from other institutions.

The operation of the facility was generally smooth. However, as alluded to above, there was an unscheduled downtime of 5 days in early March when, following a 2-week scheduled shutdown, the return path on one of the dee cooling water lines was accidentally left closed. The dee got hot and melted a solder connection, which let water into the cyclotron. An interlock that should have prevented RF operation in the absence of water flow did not work, even though it had been tested and found satisfactory a few days earlier. Subsequent to the accident, all the flow switches on the dee lines were re-checked and re-calibrated. The five-day downtime resulted in the cancellation of one experiment.

As reported in the last Annual Report, a study undertaken in 1998 identified a significant number of projects which would improve the reliability of operation of the (future) coupled cyclotron system. The most important of these were a major upgrade of the helium refrigeration system and improvement of the K1200 deflector system. Good progress was made in 1999 in these two projects as well as in a number of smaller projects.

The used helium plant of 1.75 kW cooling capacity at 4.5K that was obtained in 1998 from the Bureau of Mines operation at Masterson, Texas was refurbished at Jefferson Laboratory in 1999. At the end of 1999, the construction of the new cryobuilding needed to house this plant was 95% complete, with only electrical and water connections remaining to be done. Two cooling towers were installed, plumbed to their pumps and heat exchangers, and tested. Delivery and installation of several large pieces of equipment will start in January 2000. These include: the refurbished 1.75 KW helium refrigerator; the turbine oil skid for the refrigerator; two 1500 HP compressors; the main distribution box, which has been designed and built at Jefferson Laboratory; the main oil coalescer; the purifier oil coalescer; the old NSCL Blue helium refrigerator, which will now serve as a helium purifier; and the old NSCL 2500-liter helium dewar.

The continuing effort to increase the power handling ability of the K1200's electrostatic deflectors led to a satisfactory outcome when a septum design was found that was able to handle up to 1 Kilowatt of beam power. This design used 25-mil thick tungsten, ground down to 10 mils in the vicinity of the median plane, in all three sections of the first electrostatic deflector (E1). Following this result, the deflector development activity changed its focus to increasing the high-voltage-holding ability. The voltage-holding tests used the deflector test stand in the Transfer Hall. Even though access to the Transfer Hall was constrained by the experimental schedule (until the shutdown began in July 1999), some encouraging results were obtained. The high-voltage feedthrough to the vacuum was tested up to 100 kV, which is higher than can be reached in the cyclotron. Following the shutdown, the test stand was relocated in the N1 vault and its diagnostics were improved. Keeping tungsten as the septum material, various materials, geometries, and conditioning techniques were tested for the high-voltage feed-through, anode, and cathode. These studies are continuing.

The second half of 1999 saw the completion of several projects intended to reduce the recovery time following some possible breakdowns of the K500 cyclotron. These included plating of hill extensions, modifications to the water system to make it easier to trouble-shoot and fill the different sections, work on the probes, etc. The old turbo-molecular pumps on the ECR beamline were replaced. Radiation safety enhancement projects like upgrades to various safety switches (wall plug switches, door switches, etc.) were completed or are underway. Upgrade of the cryomonitors used on the beamlines was close to completion at the end of the year. Six units of new electronics for the neutron monitor system, with improved electronics and logging capabilities, were acquired.

Work was completed on the design and construction of a new room temperature ECR source (RTECR2), with a magnetic field configuration similar to that of the Advanced ECR source at the Lawrence Berkeley National Laboratory. The first plasma from this source was struck on August 13, 1999. Subsequent to that, efforts began to optimize the source performance, with encouraging results. The best values obtained by the end of 1999 for the intensities of low- and high-charge-state oxygen ions are: 600 eμA for 3^+, 1000 eμA for 6^+, and 300 eμA for 7^+. The superior performance of the new source is attributed to its higher magnetic field (1.7 Tesla) and the use of aluminum instead of copper for the plasma chamber. In other developments with the new source, an emittance-measuring system based on a pepper-pot screen and a rotating wire scanner, was developed and used to measure the emittance characteristics of a beam of $^{16}O^{3+}$ ions. Initial results from this ongoing study indicate that the voltage on the bias disc inside the plasma chamber has a strong influence on the emittance.

Significant progress was made during the year to advance the experimental equipment capability of the laboratory.

(a) In September 1999, the first prototype detector of the segmented Germanium detector array was received from the vendor (Eurisys Mésures of France) and tested. Except for a few deficiencies which have since been corrected, the detector performed to specifications. The vendor has started serial production and promised an accelerated delivery schedule (from one detector every 6 weeks to one detector every four weeks) starting in October 1999. This will allow completion of the project before the end of the NSCL shutdown. The test-stand, readout electronics, annealing stations, and liquid nitrogen filling system have been completed, and an alignment scheme has been devised and tested.

b) The design of the 4-Tesla superconducting sweeper magnet, a joint project between the National High Magnetic Field Laboratory (NHMFL) at Florida State University and the NSCL, was completed. Construction of the magnet was started at NHMFL and work on the associated superconducting triplet was begun at the NSCL. The purpose of this device is to allow the measurements of the structure of very neutron- and proton-rich nuclei. It will operate at a peak field of 4 T in a 140 mm gap. The main design features were presented at the 1999 Cryogenic Engineering and International Cryogenic Materials Conference in Montreal. The 3D electromagnetic design calculations of the field resulted in a substantial reduction of the tail size compared to the initial geometry. Subsequently, stress calculations were performed. The cryogenics design was changed to a continuous flow mode made possible by the upgraded NSCL-MSU cryogenic system. A first design review took place in September 1999. The magnet will be installed at the NSCL by the middle of 2001.

c) Another Major Research Initiative (MRI) proposal, for a high resolution Silicon strip detector array, by a collaboration of scientists from Michigan State University, Indiana University, and Washington University, was funded in 1999 by the NSF with matching contribution from the participating universities. This device will consist of 24 Silicon-Silicon-CsI(Tl) telescopes, each composed of a 100 μm thick silicon strip detector (ΔE1), a 1.5 mm thick silicon strip detector (ΔE2), and a 4 cm thick CsI(Tl) scintillator read out by a PIN diode (E). While the array allows flexible geometrical configurations, its standard configuration is designed to cover 80% of the laboratory solid angle between $5° \leq \theta \leq 28°$ with a 0.25° angular resolution and with sufficient granularity to allow the coincident detection of charged particles with small relative momenta. The detector will provide excellent energy and isotope resolution over a broad range of energies and particle types. It will be an instrument of choice for direct-reaction nuclear-structure investigations in inverse kinematics (e.g., via inelastic scattering, pick-up, stripping, and knock-out reactions on hydrogen targets) as well as for studies of the N/Z-dependence of the equation of state and the liquid-gas phase transition of nuclear matter. Much of the detector technology is based on a recent prototype array built and successfully used for experiments in 1998-1999 by this collaboration. The scale of the proposed array requires the development of a more cost-effective electronics read-out technology than used for the prototype array. The current plans require adapting the high-density strip detector readout electronics developed for RHIC, CERN and space science experiments. This generation of low-cost, high-density electronics uses specialty ASIC's which couple to multiplexed high-speed flash ADC's. The MRI funds cover the implementation of a high-gain readout suitable for direct-reaction nuclear-structure investigations in inverse kinematics. Development of a lower gain extension of this readout scheme, needed for intensity interferometry, decay spectroscopy, and astrophysically important Coulomb breakup experiments, is proceeding in parallel with the design and construction of this array; its incorporation in the array is envisioned as a later development.

d) A high-rate multi-wire drift detector with a large active area (10 x 10 cm^2), to be used as a tracking detector for secondary beams, was developed, tested, and successfully used in several experiments. This style of detector can achieve counting rates approaching 10^6/s and a position resolution of 200 μm, and is useful in cases where wires in the focal plane are not a problem. Several units of the detector were used in the experiments. They operated at rates of 300 k/s, a factor of 30 higher than what was possible before, and are designed for rates up to 500 k/s.