# SNEAP 2004 Laboratory Report: KCCAMS Facility, UC Irvine

**Guaciara M. Santos and John R. Southon**
Keck Carbon Cycle AM Facility
Earth System Science Department, B321 Croul Hall
University of California, Irvine, CA 92697-3100

The Keck Carbon Cycle AMS Facility was established in 2001-2002 with funding from the W.M.Keck Foundation and University of California, Irvine, to advance understanding of the carbon cycle and its linkages with climate. The facility consists of a National Electrostatics 0.5 MV 1.5SDH-1 AMS system with 40-sample MC-SNICS ion source; a new AMS sample preparation laboratory; and a Finnigan MAT Delta Plus isotope ratio mass spectrometer. The accelerator is the third NEC production model in a new generation of compact AMS systems, and has several improvements over earlier versions installed at Athens (Georgia) and Poznan. These include use of large cryopumps (Cryotorr 8's) to improve vacuum, and provision of extra beam diagnostics (beam profile monitors and adjustable slits) and additional steerers.

The laboratory operated for a year in a temporary location in the UCI Physics/Chemistry Building. In June/July 2003 the system was torn down and reinstalled in the newly completed Earth System Science Building. It took four people just four days to dismantle the AMS system. Nine days were required to move the parts to the new location, re-align and re-cable the system, re-establish vacuum, and bring it back into operation. Three students put the AMS prep lab back together in three days and tested the vacuum lines, while the AMS system was being rebuilt. We certainly do not advocate moving an AMS system every year, but this schedule does illustrate one of the advantages of these small machines.

Overall we are very pleased with the performance of the system. Sample throughput has ramped up to 500 unknowns measured per month, of which about 2/3 come from our own AMS prep lab. Best blanks are 56,000 $^{14}C$ years on graphitized coal and 58,000 years on calcite, and measurement precisions of 2-3 per mil are achieved fairly routinely. Occasional runs show scatter of 4-5 per mil, possibly because the emittances of intense beams from the source are approaching the acceptance limit of the accelerator. The system runs unattended overnight, and the inevitable hardware problems that do occur typically result in little downtime.

**AMS system problems and upgrades**:
**2002**
The spectrometer was delivered in June 2002 but acceptance tests were not performed until October. Delays included a 6 week period of gross ion source instability that we traced to an electrical short between the Cs line heater and a heat-shield, plus 3 weeks of down time when a fault in a circuit board of the Danfysik MPS858 injector magnet power supply coincided with vacation time in Denmark. A substantial amount of time was also spent modifying the ion source for increased output, improved reliability and ease of maintenance (details will be presented elsewhere at this meeting).

Accelerator sparks damaged two tank cooling fans that had to be replaced. Extra shielding around the AC power inputs solved the problem.

Dissatisfaction with the standard NEC data offline analysis software led us to contract a colleague to modify the LLNL AMS software to accept output from NEC's data acquisition code. This removed a significant data analysis bottleneck. We still use NEC's analysis code to scan the cycle by cycle data records to investigate anomalies. This feature alerted us to two problems which were affecting the $^{13}C/^{12}C$ ratios: data overwriting due to an incorrectly set jumper in a CAMAC memory module, and synchronization errors due to a wrongly selected polarity on a current integrator timing output.

**2003**
Dissatisfaction with the NEC sample holders led us to design an alternative sample wheel. Sample holders are now loaded with graphite from the front and are large enough to be labeled, and the loading process has been speeded up. The stainless and copper design is less prone to sparking than NEC's Al wheels, which

require very careful cleaning to remove oxide/hydroxide coatings.

Problems included a vacuum leak in the accelerator terminal (a split blankoff flange on a turbo pump) and two turbo pump bearing failures (Leybold TMP151). During the repairs, we noticed that beam burn marks on flanges near the accelerator tube entrance were not circular, but had an aspect ratio of a least 2:1. This suggested that the geometry of the injection magnet poles was faulty. New magnet poles were manufactured and installed. This cured the problem, but we saw relatively little effect on running room at the stripper.

After several months of testing, we realized that much of the excess count rate from blank samples came from nitrogen generated by beam interactions with residual gas or adsorbed molecules on surfaces near the entrance of the accelerator. We were able to suppress most of this background by biasing internal electrodes (the AMS bouncer) slightly positive to trap low energy negative ions. Best blanks are 56,000 and 58,000 $^{14}C$ years for graphitized coal and calcite, respectively. We added a turbo pump just upstream of the injection magnet to improve vacuum in this region, but saw little additional reduction in backgrounds.

In December we installed a new ion source body incorporating improved cooling and a vacuum-insulated Cs delivery system of our own design. This had a major impact on the stability of the source and on sample throughput and has also reduced maintenance time. Today the typical turn-on time after a sample wheel change is under an hour, and a complete source maintenance and bakeout takes about 6 h. $C^-$ outputs are 100-150 microamps and measurement of a wheel of 40 samples to 2-3 per mil precision takes ~ 20 h.

**2004**

The MC-SNICS sample changer has been outstandingly reliable, but problems with pressure operated microswitches in the controller box twice caused the changer to begin slowing down and timing out. Lubricating the plastic actuators cured the problem temporarily until the switches could be replaced.

A recurring problem of unstable charging currents coupled with erosion of the Pelletron drive pulley and occasional dust problems in the tank was finally traced to a defective suppressor cable. The cable connector at the tank flange had pulled back and lost contact because the flexible shielding conduit for the cable was too long, and subsequent arcing had reduced the banana plug to a crystalline mass of copper salts.

Other problems included a dead computer hard drive (which ultimately led to almost a week of downtime due to a really bad decision to upgrade Linux and NEC's AccelNet software packages), failure of a GVM bearing, a bad chip in a Kinetic Systems KSC 3471 in the CAMAC ion source control system, and a problem with the auxiliary power supply board in the Danfysik MPS858 injector magnet supply. A catastrophic failure of the main analyzing magnet supply was narrowly avoided when the combination of a sudden spike in summer humidity and low cooling water temperatures in the new building left the main transistor banks covered with condensation.

Recent tests using geological graphite and small (0.05 carat) diamonds as cathodes have shown that the inherent AMS system background is far lower than the sample preparation limit. This background is probably due to re-deposition of sputtered material in the ion source and is equivalent to at least 75,000 $^{14}C$ years. First tests on diamond produced almost twice the usual beam currents, and isotope ratios equivalent to 80,000 years, but we anticipate that there will be a few minor difficulties with sample preparation…

We have rebuilt the ion source extractor assembly for improved reliability, ease of cleaning (all stainless steel construction), and improved source pumping. Tests showed that the pumping speed between the source and the downstream cryopump had doubled. We anticipate further improvements in the near future when we replace the present 4" ID preacceleration tube with a new gap lens assembly based on a large Ceramaseal insulator with 5" ID internal shield.

We have modified the detector beamline to place the detector closer to the final waist than in NEC's original design. This allows us to use 10 x 10 mm photodiodes (Hamamatsu S3590-02, $150) in place of larger Si particle detectors, and the smaller beam size will also facilitate the planned installation of a gas detector.