Universal Accelerator Mass Spectrometry System (UAMS) for Actinides

Experience

NEC began building AMS systems over 30 years ago and is one of the premier manufacturers of AMS systems in the world. Of the more than 55 AMS systems provided to customers, the majority are studying carbon, beryllium, and aluminum in the fields of Archaeology, Geology, Groundwater analysis, Metabolite profiling, Microdosing, Atmospheric sciences, Oceanography, Nuclear waste management, Toxicology, Cosmogenic study, Astrophysics, Pharmacokinetics, and many more.

The NEC Universal Accelerator Mass Spectrometer (UAMS) is based around a 1 MV tandem Pelletron for beam energies around 2 MeV. The system is optimized for world-class precision, superb throughput, and low background of common AMS samples. The NEC UAMS is a complete system with all necessary hardware and software for both on-line and off-line isotope measurements.

Design

Once a sample has been appropriately processed and inserted into the ion source (either as graphite or CO_2), the sample is converted to negative ions and is accelerated through the first bending magnet. This first mass spectrometer has a biased chamber to allow sequential injection of the negative ions of interest, allowing low energy ^{12}C- and ^{13}C- to be measured in offset Faraday cups. As the negative ions exit the magnet, they accelerate to higher potential energy (around 1 MV) into a gas stripper that breaks up negative molecules and converts the resulting single nuclei ions to positive ions. In this way, such ions as ^{12}CH-, $^{12}CH_2$-, ^{13}CH-, and others are converted to single nuclei ions, $^{12}C+$, $^{13}C+$, and $^{14}C+$. This eliminates interferences that might be caused by molecular ions when counting $^{14}C+$ ions later in the system. These positive ions are then accelerated again to ground potential to the entrance of the second mass spectrometer, resulting in an improved mass separation, allowing the abundant isotopes $^{12}C+$ and $^{13}C+$ to be measured with high precision current integrators. . The rare isotope $^{14}C+$ continues through a 90° electrostatic spherical analyzer (ESA) which removes any outstanding interferences and the beam is measured in a compact gas particle detector. 10Be AMS has a half-life of 1.4 million years, while 14C AMS can measure samples as old as 50 to 60 thousand years old. NEC AMS systems include full computer control with AMS analysis software to provide chronological ages, carbon content in dpm/gm, or pMC (percent modern carbon) values.

For improved backgrounds of beryllium and aluminum, the NEC UAMS includes an energy depletion foil to remove boron, and an additional 45° magnet following the high energy ESA. NEC's control system involves a save and restore feature to make switching between elements easy.

NEC AMS systems can support several configurations from a single, 40 sample source, to dual 134 sample sources for a maximum throughput of 2,000 samples to 2% precision per week. Sample wheel loading takes less than 30 minutes with full 40 sample wheels typically measured to precision within about 24 hours. NEC ion sources have no noticeable memory effects and are extremely reliable. NEC has provided more than 125 MC-SNICS sources around the world.

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The system proceeds automatically to switch from sample to sample as the required precisions, time constraints, or other criteria are met. The system can be monitored remotely and is fully interlocked in case of power, water or air failure to protect personnel and precious samples.

Specifications

HV Deck

Voltage Range:	Model 3SDH-1: to 1.0 MV
Single Charged Energy Range:	Model 3SDH-1: to 2.0 MeV
Voltage Stability:	Better than 1 kV
Voltage Ripple:	Better than 200 Vrms

Primary Components

Beamline Height:	1.5 m
Pumps:	Turbo molecular pumps, with oil free backing pumps
Vacuum System Base:	$5e^{-7}$ Torr, or better (without beam)
Ion Source(s)/Injector:	Injection voltage, ~50 keV MC-SNICS 40 or 134 source

Acceptance Test Values

Carbon, Terminal Potential:	0.5 MV
^{12}C- (Pulsed Beam):	Current > 40 µA
Beam Transmission:	> 40%

AMS Ratios

^{14}C/^{12}C (abundant)	Precision < 0.2%
^{13}C/^{12}C (abundant)	Precision < 0.2%
^{14}C/^{12}C (background)	Ratio < $7e^{-16}$
^{14}C/^{12}C (CO_2 abundant)	Precision < 0.8%
^{14}C/^{12}C (CO_2 background)	Ratio < $8e^{-15}$
^{10}Be/^{9}Be (abundant)	Precision < 1.0%
^{10}Be/^{9}Be (background)	Ratio < $3e^{-15}$
^{26}Al/^{27}Al (abundant)	Precision < 1.0%
^{26}Al/^{27}Al (background)	Ratio < $5e^{-15}$
^{129}I/^{127}I (abundant)	Precision < 2.0%
^{129}I/^{127}I (background)	Ratio < $1e^{-12}$

Actinides

^{236}U/^{238}U (abundant)	Precision < 2.0%
^{236}U/^{238}U (background)	Ratio < $1e^{-13}$
^{239}Pu (background)	2.0 fg/mg iron
^{240}Pu (background)	0.5 fg/mg iron

NEC will provide Alfa Aesar unprocessed graphite for carbon machine background tests. All acceptance tests are verified using a minimum of three samples.

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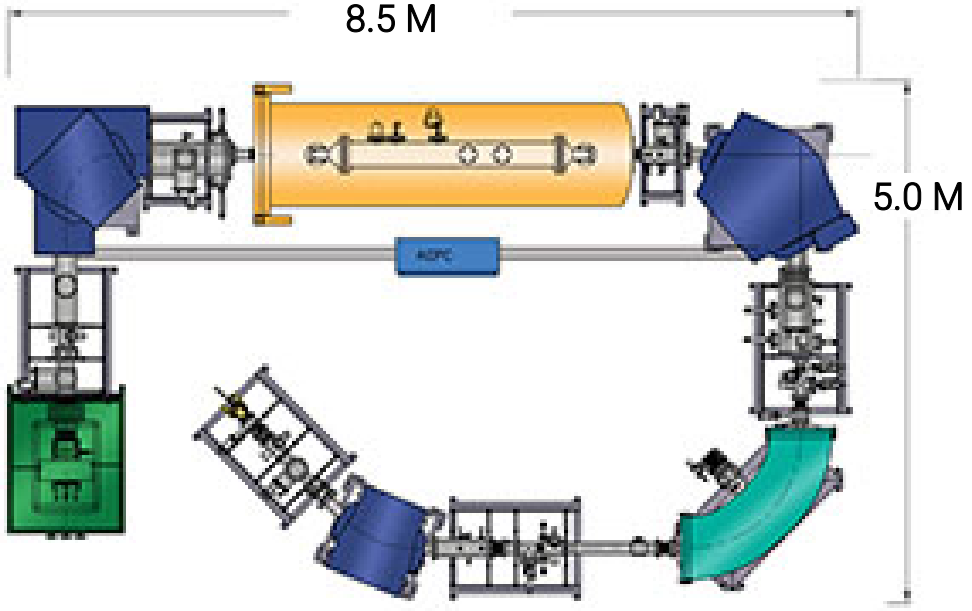
Facility Requirements:
Compressed air: 80 psig
Electrical Power: 43 kVA
Cooling water: 11 gpm (41 l/min)
(Approximate values based on a single source configuration)



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