National Electrostatics Corp.
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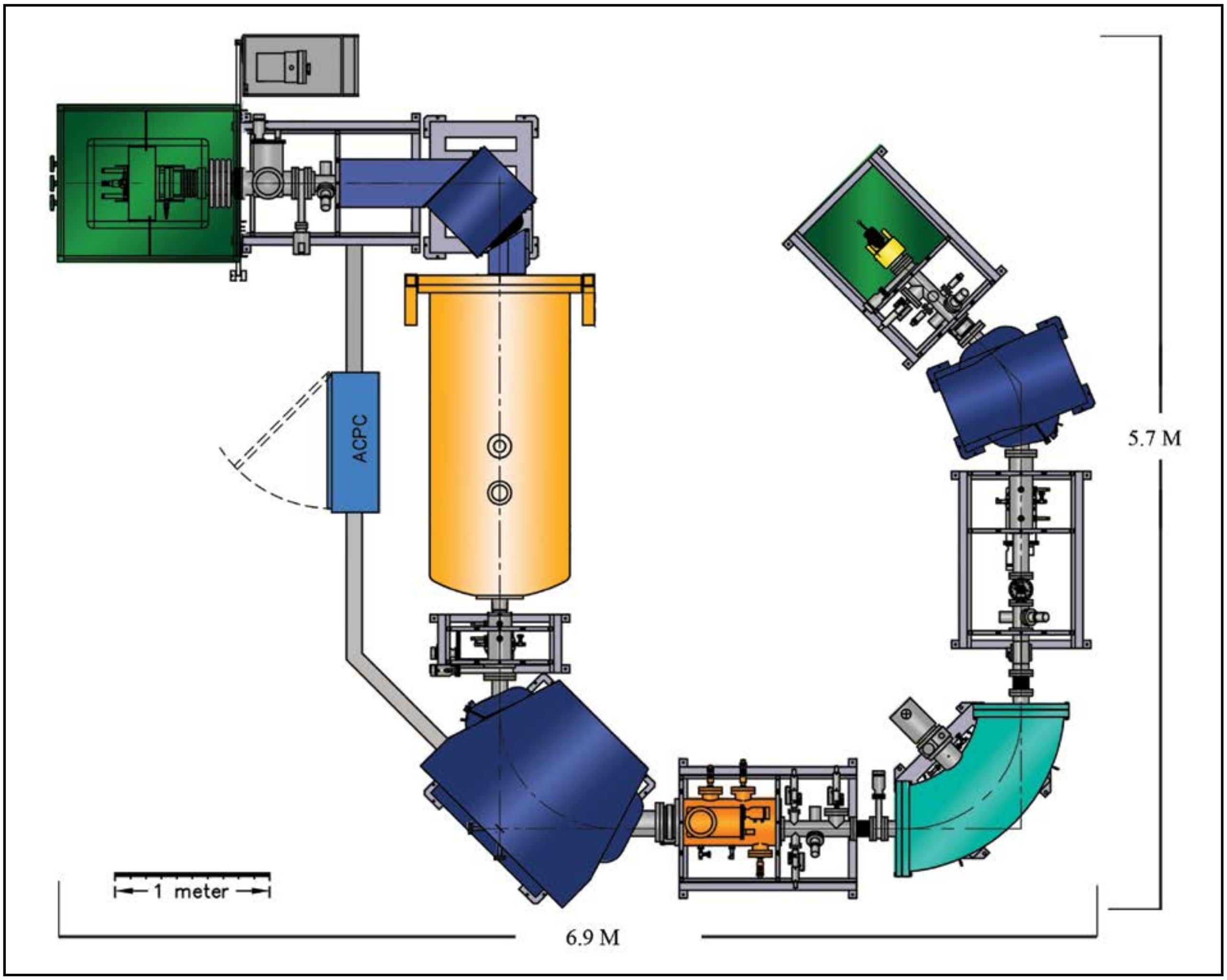
08/14

XCAMS
Compact Accelerator Mass Spectrometry System for Be, C, and Al

DESIGN



The NEC XCAMS is designed for high precision measurement of carbon, berilium, and aluminum radioisotope ratios. This is a complete system with all necessary hardware and software for both on-line and off-line isotope ratio measurements.

- **Better than 3 per mil precision**
- **Better than 1 x 10^{-15} background**
- **Graphite samples with option for CO_2 samples**
- **All metal/ceramic acceleration tubes with no organic material in the vacuum volume**
- **Automated data collection and analysis**
- **Fully interlocked system designed for unattended operation**

ACCELERATOR MASS SPECTROMETRY

AMS is a technique for high precision measurement of radioisotope ratios such as $^{14}C/^{12}C$ and $^{14}C/^{13}C$. The AMS spectrometer is actually two mass spectrometers in series separated by a molecular dissociator.

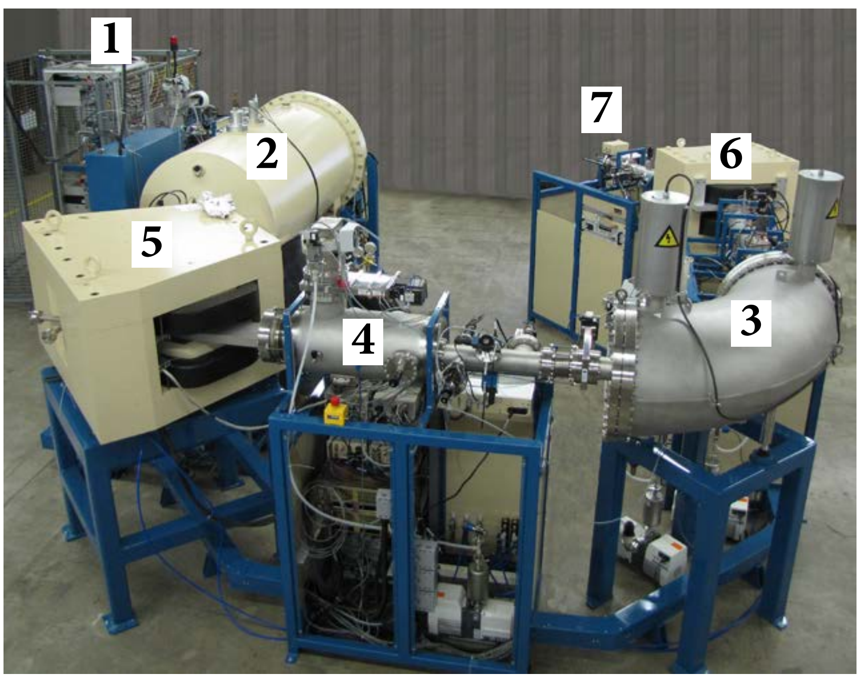
The sample is inserted into the ion source at the entrance to the first spectrometer. The sample is converted to negative ions and is accelerated through the spectrometer for a mass separation of better than 1 out of 200. The 90° bending magnet in this spectrometer has a biased chamber to allow sequential injection of the negative ions of interest.

As the negative ions exit the first mass spectrometer, they are accelerated to high potential into a gas stripper to breakup all negative ion molecules and convert 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 $^{14}C^+$. These positive ions are then accelerated again to ground potential to the entrance of the second mass spectrometer.

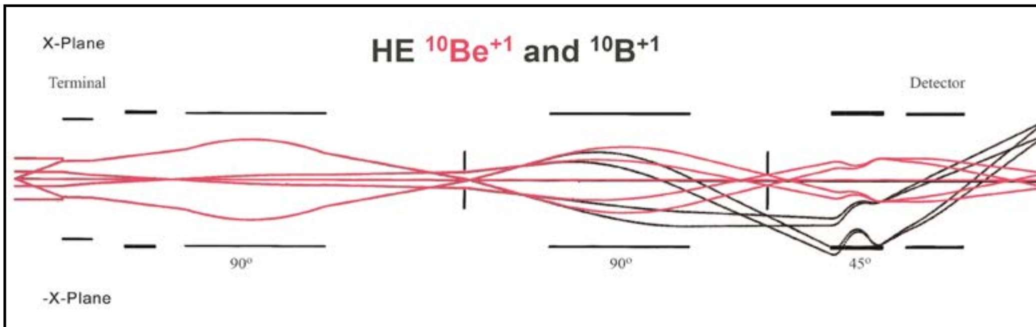
The high energy mass spectrometer is equipped with a 90° dipole bending magnet with a wide exit pole. The abundant isotopes exit this magnet into offset Faraday cups with high precision current integrators. The rare isotope continues on through a 90° electrostatic spherical deflector which removes the ions with incorrect energy. The final element in the spectrometer is a compact gas detector.

The entire system is computer controlled for true unattended operation. Once samples are loaded in the ion source, 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.

The XCAMS system is based on the 500kV tandem Pelletron accelerator.

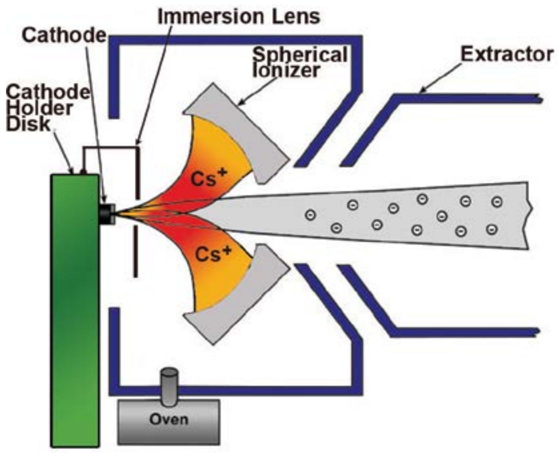


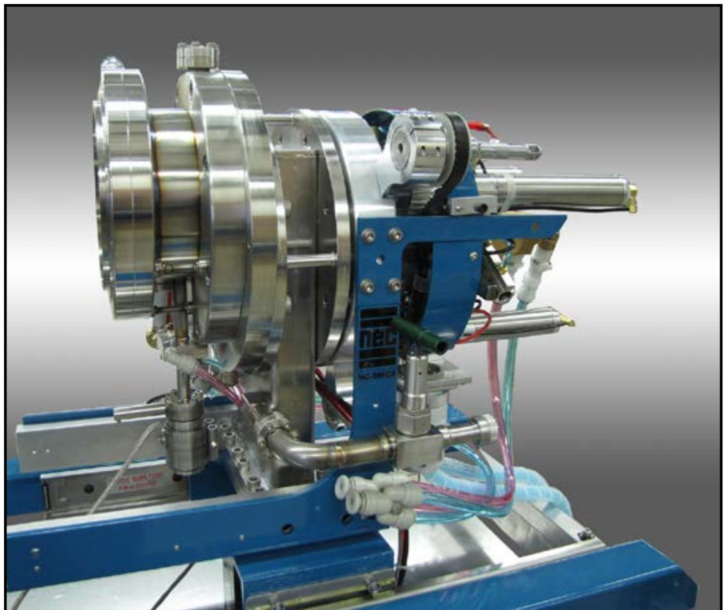
The sample is inserted into the ion source (1). The negative ions are accelerated through the first mass spectrometer (out of view) in to the tandem Pelletron accelerator (2). This accelerator provides the necessary molecular dissociation while increasing the beam energy to about 1MeV for the necessary energy dispersion through the second mass spectrometer (3). The abundant isotopes are stopped in the offset multi-Faraday cup chamber (4) immediately following the 90^o magnet (5). The multi Faraday cup chamber is equipped with high precision current integrators. A 45^O double focusing magnet is needed to precisely measure $^{10}Be/^9Be$ ratios (6). The rare isotope ion beam exits the mass spectrometer into a compact gas detector (7). The entire system is designed with ultra-high vacuum practices in mind.



To give the system the capability to precisely measure $^{10}Be/^9Be$ ratios, a 45^o double focusing magnet with a mean radius of 610mm and a pole gap of 50mm is provided to remove lower mass energy particles that have scattered through the ESA from the rare isotope beam.

MULTI-SAMPLE NEGATIVE ION SOURCE





The 40 sample MC-SNICS has proven to be a highly reliable source with rapid cathode change in more than 40 laboratories throughout the world. The simple and reliable pneumatically actuated cathode indexer allows sample change in less than three seconds.

For carbon AMS the sample is either graphite or carbon dioxide. In both cases, the sample is contained in a cathode holder. In the case of carbon dioxide, the gas flows through this cathode holder. Cesium vapor is in the area of the cathode holder which coats the cooled cathode with a thin layer of cesium while cesium is also ionized forming a cesium beam which strikes the AMS sample material. The sputtered particles are converted to negative ions by passing through the cesium layer. The resultant negative ion beam is extracted for acceleration through the mass spectrometer.

The cathode holders are mounted on a removable cathode disk. There is a valve assembly which allows the removal of the cathode disk without disturbing the cesiated volume.

AMS CONTROL SYSTEM

The NEC AMS control system monitors and controls all AMS parameters. The vacuum system is fully interlocked and hardwired to be independent of the computer control system. However, the control system does monitor all vacuum parameters.

The control system hardware is based on CAMAC protocols. The control system software is based on Scientific Linux with X Windows and the NEC AccelNET system. The overall control system is designed for fully automated sample running by events, precision, or time. All parameters can be saved and restored for easy start up. The system is designed for true remote operation via web interface which allows direct diagnostics from the NEC factory for rapid customer support.

System start up and ion beam tuning is made easy by assignable knobs and analog meters. The software is equipped with flat topping routines, energy and mass determination through the bending magnets, software strip chart recorders, and storage of all AMS parameters for every event.

PERFORMANCE SPECIFICATIONS FOR THE NEC XCAMS SYSTEM

PELLETRON SPECIFICATIONS

Insulating Column Voltage Rating	0.6 Megavolts
Voltage Stability	Better than 1 kV
Voltage Ripple	<=500 V FWHM as measured by CPO at 0.5 MV Terminal Voltage
Singly Charged Ion Energy Range	to 1.0 MeV
Charging Current Rating	100 microamps (60 Hz Power) 83 microamps (50 Hz Power)
Acceptance Test Values	
$^{13}C^{+}$	0.3 microamps peak pulsed current at 0.5 MV terminal voltage
^{9}Be+ from BeO	0.2 microamps peak pulsed current at 0.525 MV terminal voltage
$^{27}AL^{+}$ from Al_2O_3	0.1 microamps peak pulsed current at 0.525 MV terminal voltage

AMS MEASUREMENTS

Ratio of $^{14}C/^{13}C$ from measurements of three (3) "modern" graphite carbon samples with a precision of 0.3% or better, using known solid samples of unlimited size provided by the buyer.

Ratio of $^{13}C/^{12}C$ from three (3) solid graphite samples of unlimited size 0.3% or better.

Ratio of $^{14}C/^{12}C$ from three (3) dead graphite samples of unlimited size $2x10^{-15}$ or lower using Alfa Aesar graphite supplied by NEC.

Ratio of $^{10}Be/^{9}Be$ from three (3) BeO^{-} samples with a known ratio of about $2x10^{-12}$ with a precision of 3% using samples of unlimited size provided by the buyer.

Ratio of $^{10}Be/^{9}Be$ from three (3) dead BeO samples of unlimted size $5x10^{-15}$ or lower using dead BeO provided by the buyer.

Ratio of $^{26}Al/^{27}Al$ from three (3) Al_2O_2 samples with a known ration of about $5x10^{-11}$ with a precision of 3% using samples of unlimited size provided by the buyer.

Ratio of $^{26}Al/^{27}Al$ from three (3) dead Al_2O_3 samples of unlimited size $2x10^{-14}$ or lower using dead $A_{l2}O_3$ provided by the buyer.

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