Positive Ion Mass Spectrometry (PIMS)

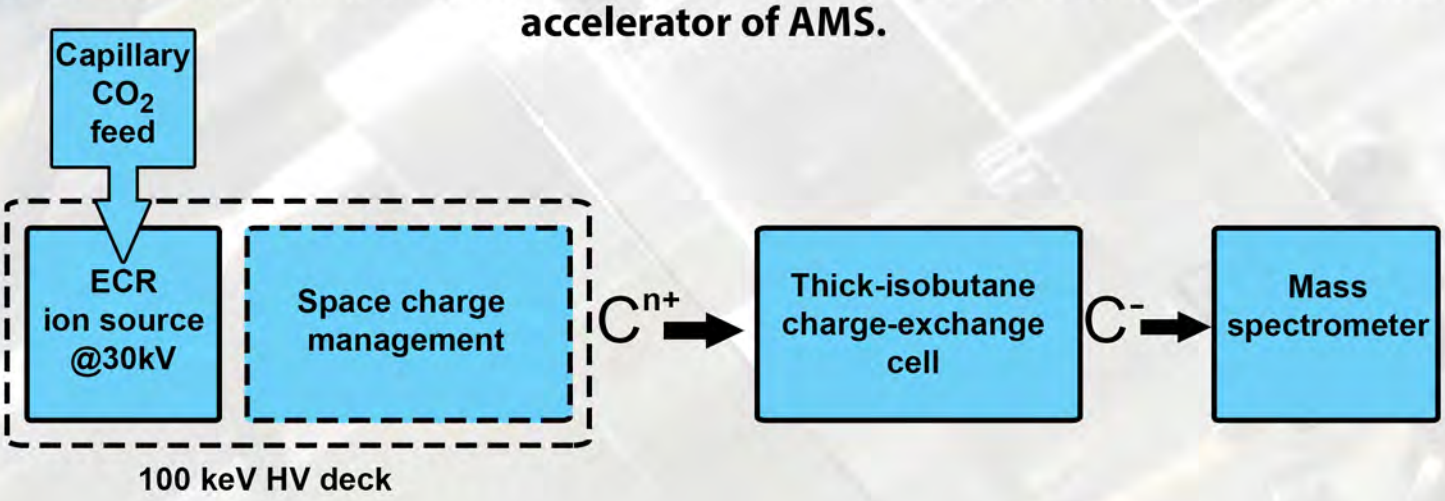
Radiocarbon Measurement Made Easy

PIMS - The AMS Alternative

Different from any other radiocarbon mass spectrometer currently on the market, NEC's PIMS systems are capable of graphite-like perfomance using CO_2 gas.

How does it work?

A PIMS system utilizes a plasma source of positive ions that is capable of very large ion beam production. PIMS combines the anion formation and molecule destruction in a thick-isobutane open-ended gas cell that replaces the particle accelerator of AMS.



Key Features:

- Comparable (or better) performance to graphite AMS instruments
- Low background without memory
- Easy source operation
- Integrated workflow
- Small footprint

Advantages:

- No Accelerator
- No Graphitization
- No Waiting
- No Mess
- No Cathodes

Joint project with Scottish Universities Environmental Research Centre (SUERC) and Pantechnik

National Electrostatics Corp.

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THE PIMS CONCEPT

The concept behind PIMS is a revolutionary idea for radiocarbon data analysis.

In a traditional radiocarbon system, the processed carbon (graphite) is extracted from the source as a negative ion beam. The beam is accelerated and stripped of electrons, yielding a positive ion beam. While this works very well to measure solid samples, the graphitization process is time consuming and labor intensive.

However, when CO_2 is injected into a gas ready ion sputter source in an attempt to remove the graphitization process, the extracted beam currents are approximately 10% of graphitized solid samples. This causes longer measurement times and worse precision than traditional graphite measurements.

Goal:

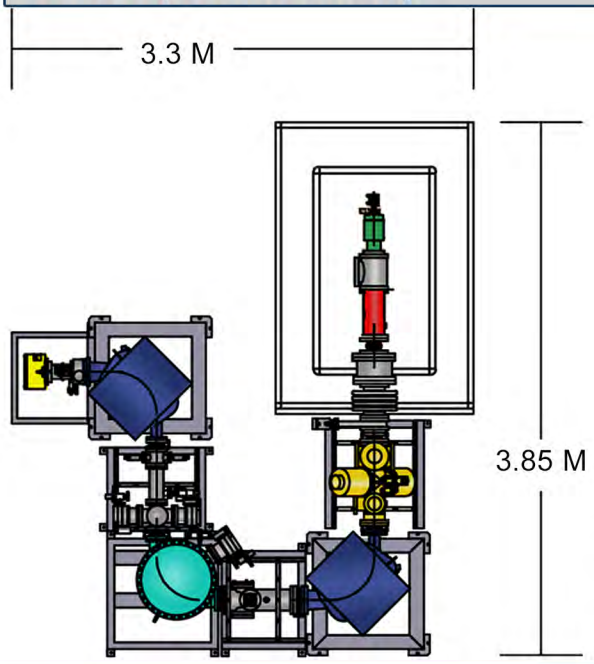
To create a simple gas-only system that will meet or exceed traditional graphite AMS results without the need to make solid samples

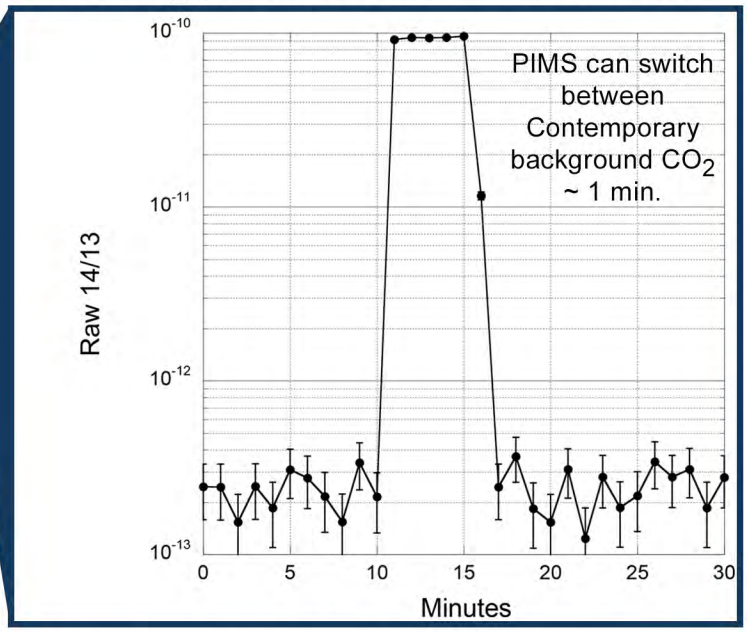
How? - Positive Ion Mass Spectrometry

Instead of using processed graphite samples or gas ready negative ion sputter sources, the NEC Positive Ion Mass Spectrometry (PIMS) system uses only CO_2 gas and creates a positive ion beam using an ECR source.

Advantages of an ECR source:

- No memory effects
- No graphitization
- No cesium
- No cathodes
- No need to clean
- No complicated startup





Layout

The prototype starts with an ECR (Electron Cyclotron Resonance) ion source biased at 100 keV. The next major components are the charge exchange cell (changing the positive ion beam into a negative ion beam), two bending magnets, and one ESA (Electrostatic Spherical Analyzer). These components remove the unwanted interference isobars, allowing background measurements that are comparable with traditional graphite AMS systems. Figure 1 shows measurements for background CO_2 gas for charge states +1 and +2.

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PIMS PERFORMANCE

Dynamic Range

The majority of AMS labs only run samples between background and 1 times modern. NEC has successfully tested discrete samples ranging from background CO_2 to 100 times modern and achieved appropriate results. The discrete samples were injected using a ten-sample NEC CO_2 interface. The samples measured on the prototype PIMS system match nominal radiocarbon values very closely, as shown in Figure 2.

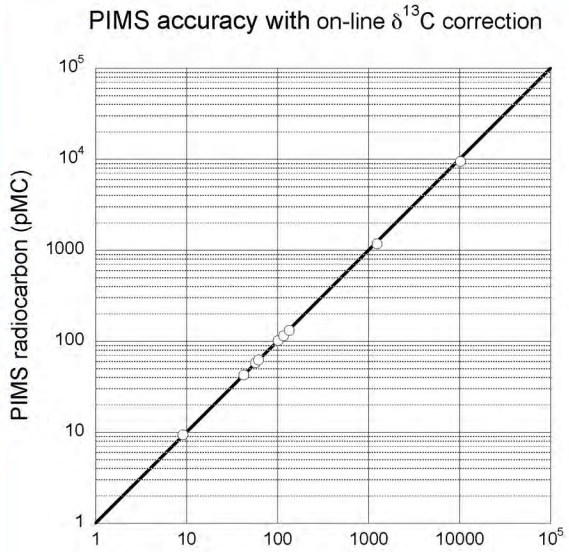

Figure 2

Reproducibility

As Figure 3 shows, stability of the PIMS system was 0.12%. Many customers measuring samples related to earth science expect precision of 0.3% or lower, while customers in the pharmaceutical industry expect values to be within 10%.

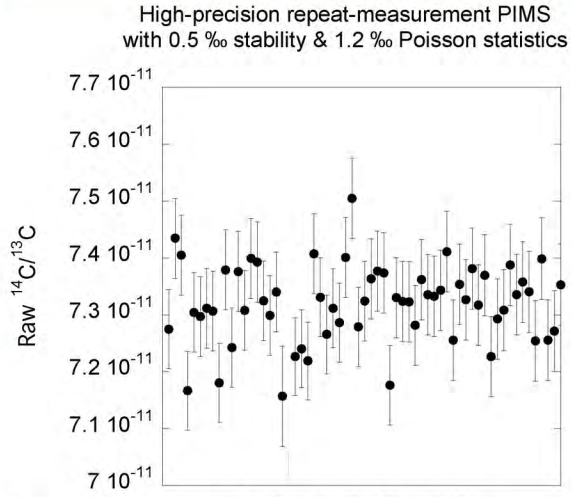

Figure 3

Background Values and Full Data Sets

Figure 4 is actual raw $^{14}C/^{13}C$ data from a single run. It shows PIMS performance over five orders of magnitude of sample radiocarbon content above the >50 kyrs BP background. Gas samples were repeatedly measured and the reference 100 pMC CO_2 was analyzed in triplicate confirming analysis stability.

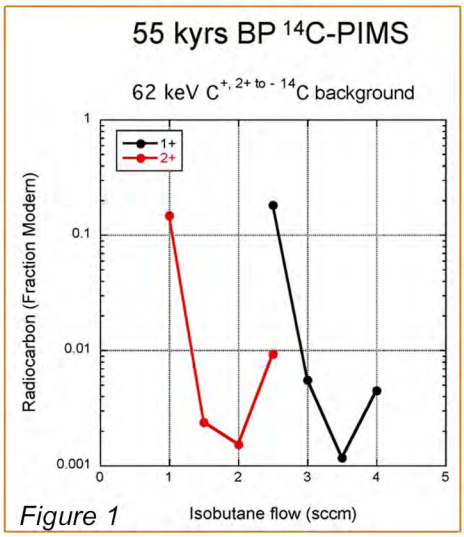

Figure 1

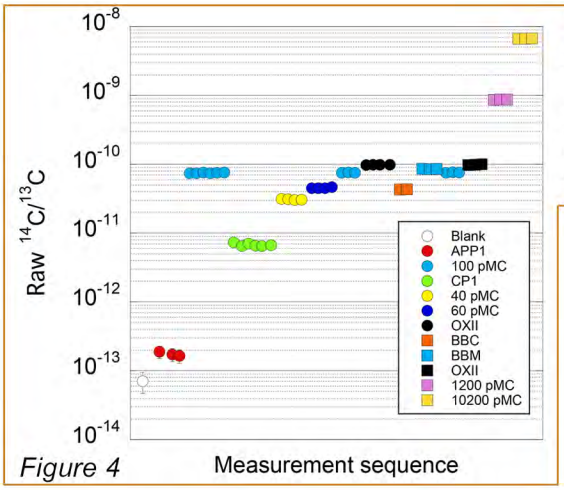

Figure 4

Repeated 14C-PIMS of samples ranging over five orders of magnitude radiocarbon specific activity

PIMS
Positive Ion Source
Powerful Pumping
Small Footprint

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THE FUTURE OF PIMS

The PIMS prototype was first assembled and tested at the NEC facility (shown below). It has now been moved to SUERC (Scotland) for further testing. A new ion source, the Microgan from Pantechnik, will replace the existing Nanogan source. The Microgan is a newly designed source which, in recent tests, has produced $^{12}C^{+}$ beams of over two times that of the Nanogan for injection into the charge exchange cell. This projected increase in beam currents will allow for 0.3% precision to be reached in only a few minutes for most samples.

In order to simplify the complete measurement process further, NEC is developing gas interfaces to Elemental Analyzers, autosamplers, and other standard analysis equipment.

NEC is committed to continual researching and developing methods to reach fast, accurate, and consistent results with ease, all while reducing the equipment footprint. The PIMS system was designed with those goals in mind and is well on its way to reaching them.

Contact NEC for further information regarding availability of a PIMS system.