

Dating The Past: Radiocarbon Dating

Part II

« « « by David N. Cash, PhD

David Cash is a member of the Physical Sciences Department, Mohawk College, Hamilton, Ont., L8N 3T2.

The AMS Method (Radiocarbon Determination by Tandem Ion Accelerator Mass Spectrometry):

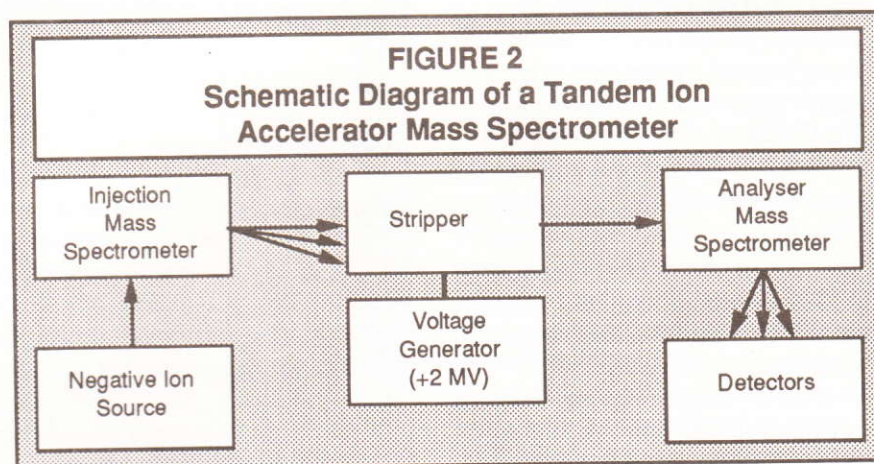
Figure 2 is a schematic diagram of an AMS instrument for radiocarbon dating. The instrument size is usually about 10 m from the injection mass spectrometer system to the analyser mass spectrometer system. A very high vacuum is required, except for the stripper region. All components and data acquisition are under electronic control.

Negative Ion Source:

The sample, typically 1 mg or less of total carbon, is converted to graphite on a metal target. Bombardment in vacuum with sputtered cesium produces C^- ions which are accelerated towards a stripper held at a potential of +2 MV. The use of a negative ion source rather than a positive ion source is essential to eliminate interference by residual ^{14}N , which would otherwise arrive at the same detector as ^{14}C and drown out the signal. Any N^- which forms at the source decays rapidly and does not reach the detectors.

Injection Mass Spectrometer System:

On their way to the stripper, the negative ions pass through an injection system consisting of one or more electrostatic and/or magnetic fields. These fields separate ions of different mass/charge ratios. The control system sets the electric and/or magnetic fields to alternately send pulses of $^{12}C^-$, $^{13}C^-$ and $^{14}C^-$ to the stripper.



Stripper:

The stripper is usually a region containing argon gas. The arriving negative ions collide with argon atoms and lose electrons. At the energy level provided by the +2 MV accelerating potential, substantial amounts of +3 ions are produced. This is important, because all molecular ions of charge +3, such as $[^{12}C(^1H)_2]^{3+}$ and $[^{13}C(^1H)]^{3+}$, which would otherwise arrive at the detector along with $^{14}C^{3+}$ ions, are unstable and break apart. The C^{3+} ions produced are repelled by the +2 MV potential and accelerate away from the stripper.

Analyser Mass Spectrometer System:

The ions pass through an analyser system consisting of one or more electrostatic and/or magnetic fields capable of separating ions of different mass/charge ratios, so that each ion is sent to an appropriate detector.

Detectors:

The $^{12}C^{3+}$ and $^{13}C^{3+}$ ions, being very numerous, are counted at current flow

detectors called Faraday cups. The $^{14}C^{3+}$ ions, being relatively few, are counted individually by a solid state device.

Accuracy:

A factor which limits accuracy is isotopic fractionation at the ion source. Careful comparison of unknowns with known standards prepared and analysed in the same manner usually allows accuracy of better than $\pm 1\%$ to be achieved.

Some Points of Interest in the Application of Radiocarbon Dating:

Isotopic Fractionation:

The process of photosynthesis is not equally efficient for the three carbon isotopes. The uptake of ^{14}C is about 3 to 4% less than that of ^{12}C , varying by plant species. This must be corrected for when calculating the age of a sample.