Modernizing Accelerator Mass Spectrometery Data Aquisition

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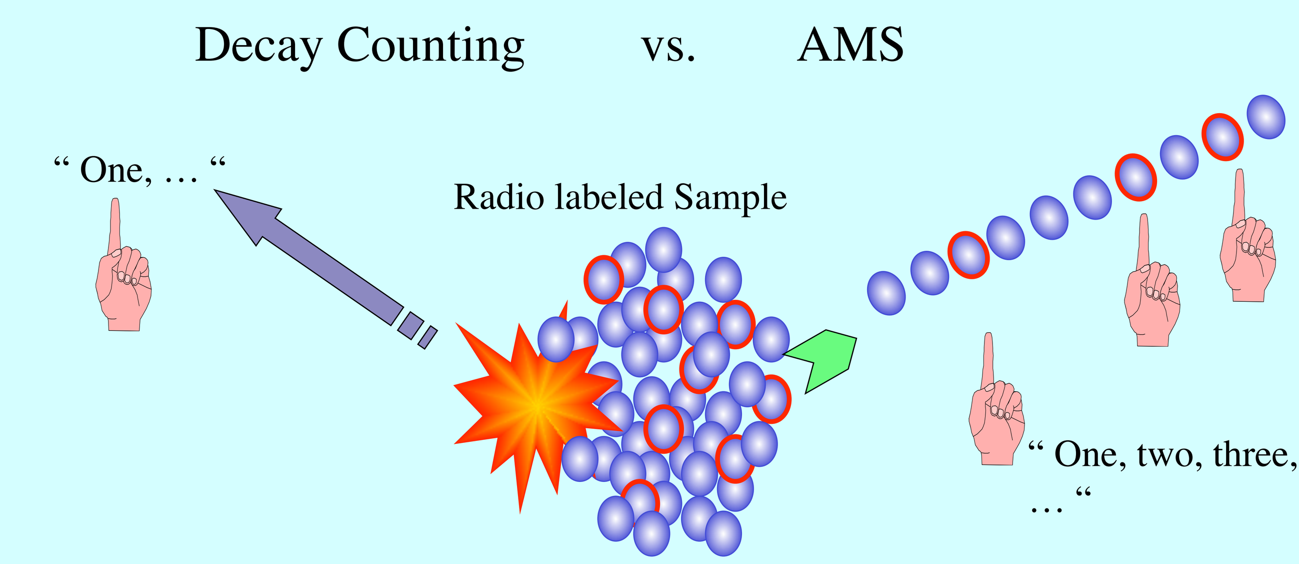
Abstract

In Accelerator Mass Spectrometry [AMS] signal and digital processing instrumentation capture measurements of the ratio of rare isotopes to stable isotopes, such as carbon 14 to carbon 13. The importance of accuracy, speed and maintainability in their data acquisition [DAQ] systems is paramount. The goal of this project was to build a test bed to prototype a new architecture for AMS DAQ. A 90's vintage CAMAC Crate Controller [CCC] was replaced by an Ethernet based controller. This allows replacement of an obsolete unsupported computer and circuit cards with a general-purpose computer with Ethernet communications, i.e., a Mac Mini. A test bed with a NIM crate and a CAMAC crate were assembled. Relevant aspects of the older AMS system were replicated; a pulse generator simulated an ion detector and LabVue simulated the older MAC. Once this test bed was debugged a CAEN CCC replaced the older CCC. New CCC command sequences were debugged using a telnet interface to its ASCII TCP/IP socket port. Then a new program was written for the Mac Mini Studio basic program to send either single crate commands, scripts containing command sequences or LUA programs to the CCC and store the measurement results on the MAC. In this project, a prototype/test bed exploiting newer DAQ technologies was built as a basis for completing a robust DAQ tool and for developing and testing further enhancements.



•5730 year half-life for ^{14}C
•15 fmol gives 1 dpm sample,
•10,000 ^{14}C atoms counted in 7 days

•Highly efficient use of sample
•Half-life irrelevant to measurement
•10,000 ^{14}C can be counted in < 30 sec

AMS counts atoms, not decays

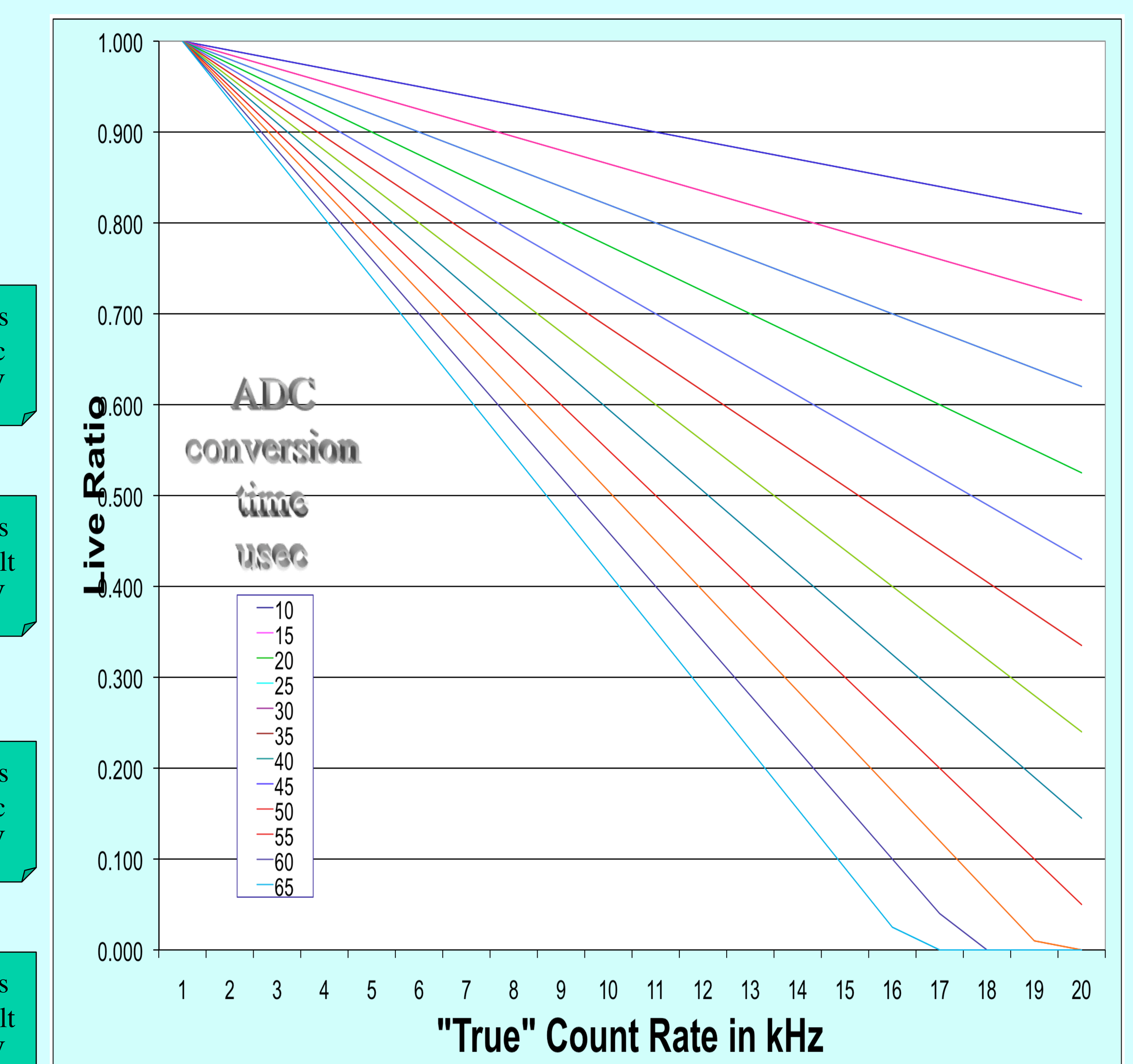
Introduction:

Accelerator Mass Spectrometry (AMS) is a type of isotope ratio mass spectrometry used to quantify radioactive isotopes with half-lives ranging between 10 and 10^7 years with extremely high selectivity and sensitivity. Within a sample, the amount of the radioisotope (i.e., ^{14}C) is measured in an ion detector and compared to the level of the stable isotope (i.e., ^{13}C) which is measured in a Faraday cup. Data collection in AMS relies on instrumentation commonly used for nuclear physics experiments. Detector anodes collect charge resulting from the slowing down and stopping of the highly energetic ions. Signals from the detector are amplified and sent to an ADC for digitization of the peak energy. Hardware gates are established to only select those ions with an acceptable energy range and that deposit energy in multiple anodes within a specified time period. Data is stored in 64K memory modules and sent to a computer through a Dataway interface.

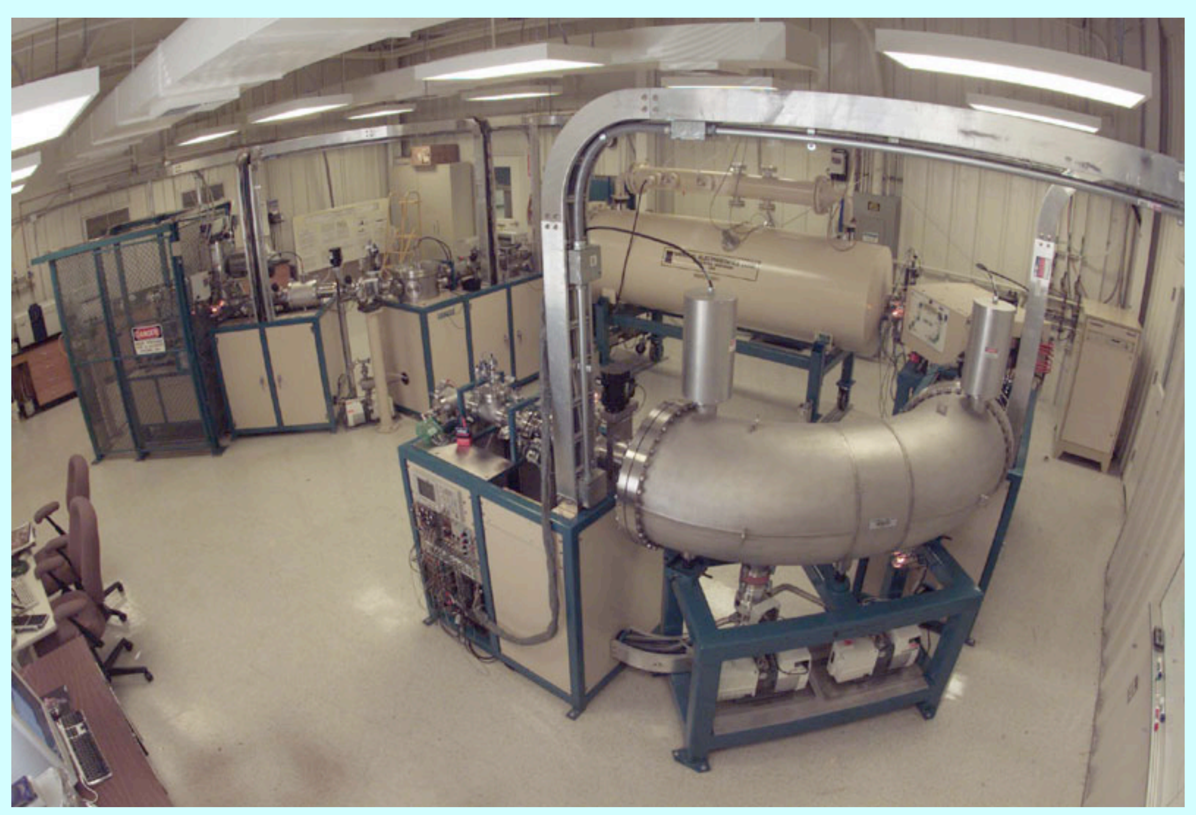
Methods:

•A Test bed using a Pulse Generator to simulate ion detector anode pulses was constructed.
•Mac Mini [MM] Studio Basic TCPIP Socket facilities were used to send crate commands and LUA code to be executed on a new CAMAC Crate Controller [CCC].
•This CCC code controlled and polled CAMAC and NIM instruments. The collected measurement data is then sent to the MM for further processing.

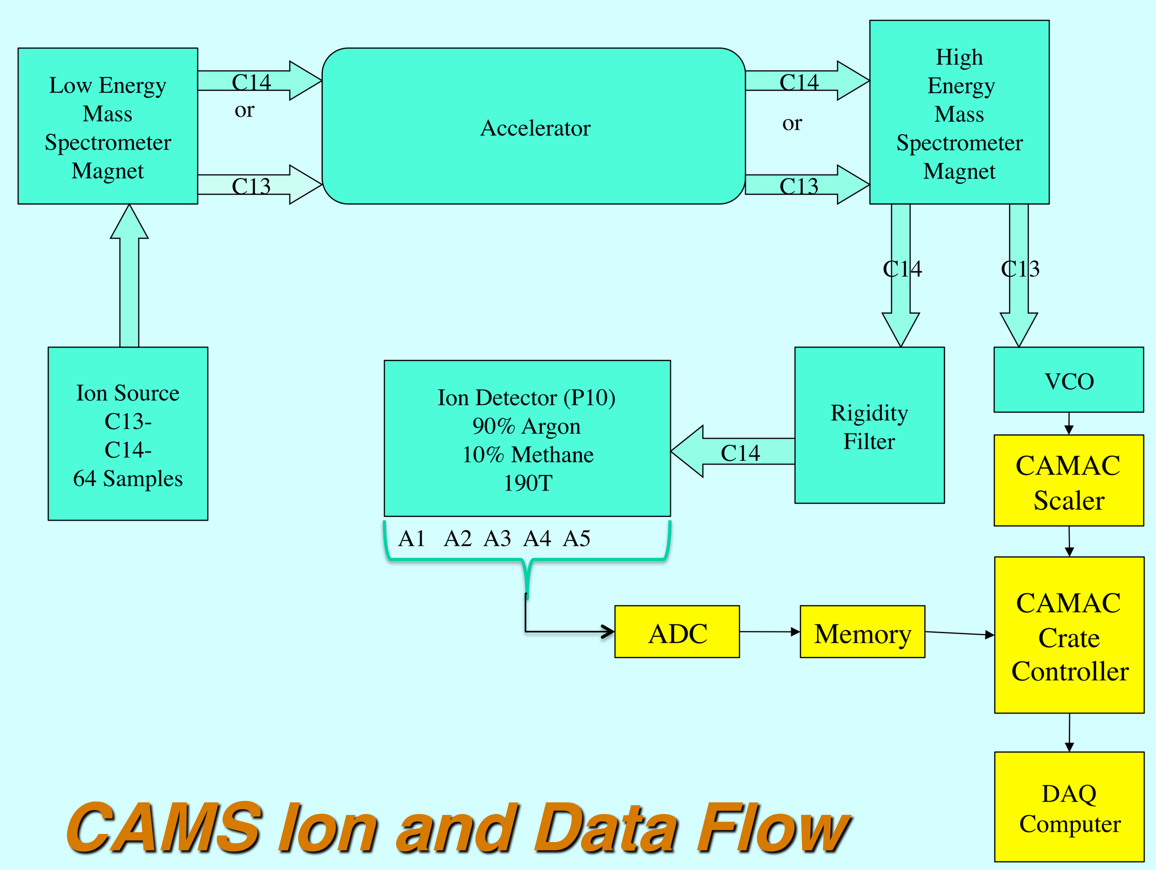
Live Ratio=Live Count/"True" Count
= 1 – Live Count * T ,
where T=ADC busy time/count



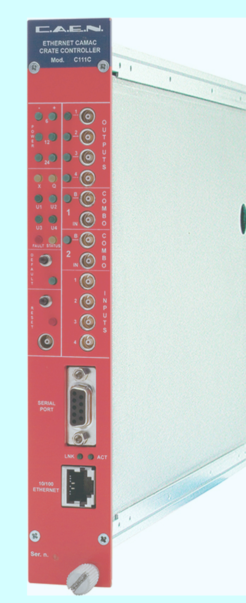
Live Ratio Increases with reduced ADC times



1 MV Accelerator Mass Spectrometer

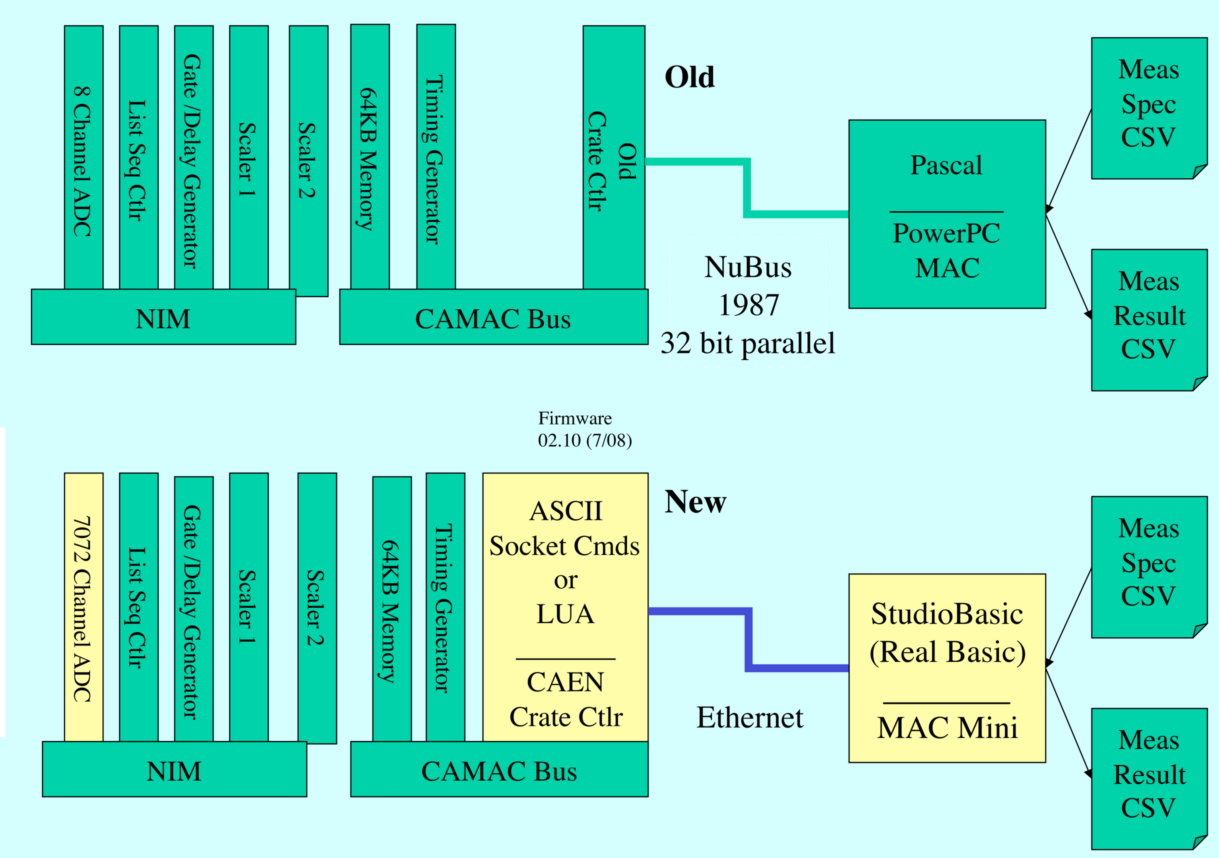


CAMS Ion and Data Flow



CAEN C111C Crate Controller

Mac Mini



AMS Crate Hardware Design

Goals:

The data acquisition system used at the Center for Accelerator Mass Spectrometry at LLNL relies on a NuBus card in a PowerPC Macintosh computer to interface to the crate contollers. These cards, along with the NuBus to CCC are no longer supported. A card fail could disable AMS operations. In addition, the software program relies on computer architecture that is no longer supported (i.e., PowerPC running Mac OS 8.6 or earlier). ADCs supported by the current data acquisition system typically require 10s of microseconds to convert the analog pulse to a digital signal. For high detector count rates, this can lead to unacceptable electronic deadtimes where the data acquisition system is blind to incoming events. Numerous methods are available to accommodate or correct for high detector count rates. However, such corrections can decrease confidence in AMS measurements. We seek to replace our existing ADCs with ones that are able to process signals on the order of 100s of microseconds, reducing data acquisition deadtimes.

The goal of this project is to build a test platform to evaluate a CCC using a TCP/IP socket protocol to communicate to an Apple computer with an Intel processor running a GUI-based data acquisition program. This test platform will be used to evaluate our new ADCs by comparing measured live fractions with input pulse frequencies.

Results:

• TCP/IP socket response time between the Mac and the CCC was approximately 80 microseconds. The hardware throughput reached 180,000 counts/sec.
• It was found that the LUA programming interface to the CAEN CCC made problem diagnosis difficult; only the simplest of LUA programs could be reliably used.
• In this project, a prototype/test bed that exploited newer DAQ technologies was built. This can provide a basis and an architecture for completing a robust DAQ tool and for developing and testing further enhancements.

Acknowledgements:

CAMS
CalPoly CESaME
Prepared by LLNL under Contract DE-AC52-07NA27344.

LLNL-POST-446711

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