Assembling, Cleaning, and testing of a unique open-ended cylindrical Penning trap

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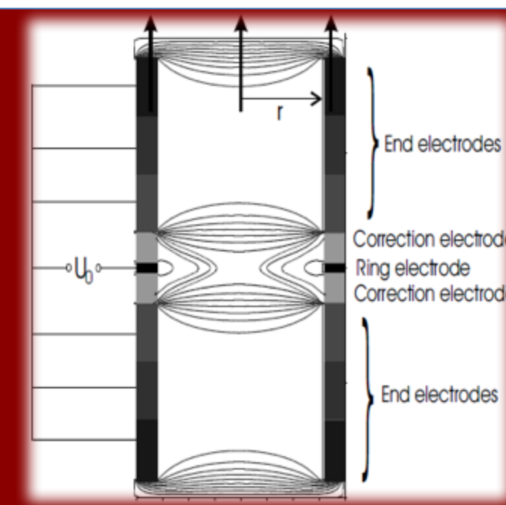
Abstract

A new experimental beamline containing a prototype cylindrical penning trap has recently been constructed at the Cyclotron Institute at Texas A&M University. The new beamline will enable precision experiments that enhance our understanding of the limits on non-SM processes in the weak interaction through the measurement of the $\beta-\nu$ correlation parameter for T = 2, $0^+ \rightarrow 0^+$ supper allowed β-delayed proton emitters. The prototype TAMUTRAP consists of an open-ended cylindrical penning trap of diameter of 90 mm with gold-plated electrodes of oxygen free high conductivity copper to prevent oxidation. The trap's electric quadrupole field is provided by a SHIP TRAPS RF electronic circuit to the four segmented electrodes at the center of the trap while the trap's 7 Tesla magnetic field is provided by an Agilent 210 mm ASR magnet.

Motivation

What is a Penning trap?

- ❑ It is an ion trap which uses:
  1. An electric field for axial confinement.
  2. A magnetic field for radial confinement



M. S. Rahaman, Ph.D. thesis, University of Heidelberg, 2005.

Why use a Penning Trap?

- ❑ Enhance our understanding of the limits on non-SM processes in the weak interaction
  - ❑ By measuring the β-v correlation parameter for T = 2, $0^+ \rightarrow 0^+$ supper allowed β-delayed proton emitters
    - ❑ The parameter is determined by observing the proton energy distribution
- ❑ Capable of performing a wide range of other possible experiments such as mass spectroscopy.

Cleaning and Assembling

This Prototype Penning Trap is a 7 Electrode trap:

- ❑ Two end caps, two end electrodes, two compensation electrodes, and a four-fold segmented ring electrode
- ❑ Fabricated using oxygen-free high conductivity copper
- ❑ Gold-plated to avoid oxidation
- ❑ Segmented using aluminum oxide (Al2O3)
- ❑ With a diameter of 90 mm (currently the largest penning trap)

Constructing and Aligning the Beamline

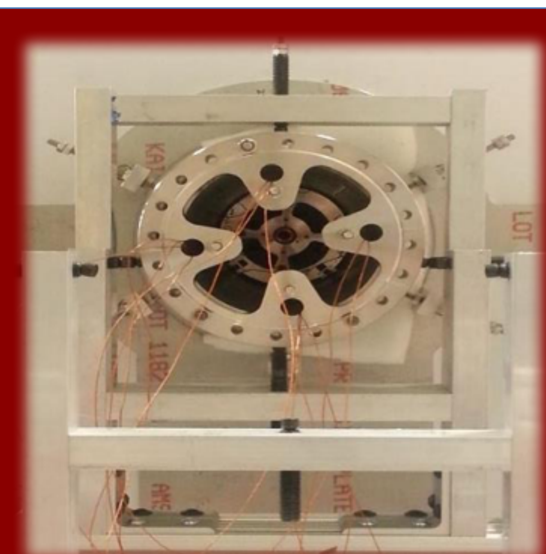
This beamline was constructed with a variety of elements :

- ❑ A surface ion source
- ❑ two Faraday cups (before and after the magnet)
- ❑ Einzel lenses
- ❑ two bellows
- ❑ a deflector
- ❑ two x-y steerers
- ❑ and two MCP detectors (before and after the magnet).

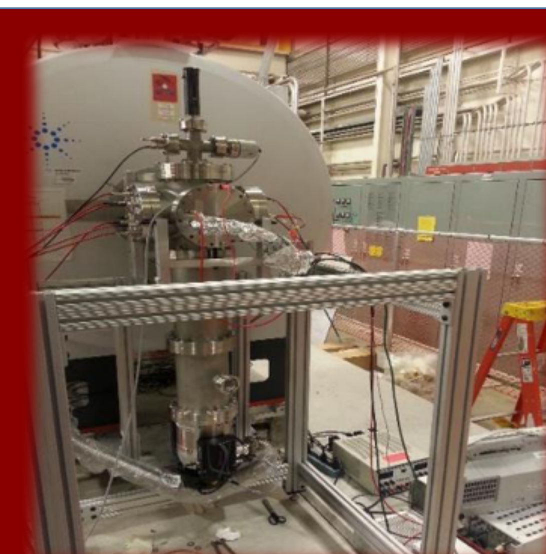
All elements were aligned using an optical transit and two targets located in front of and behind the magnet.

To maintain a high vacuum (10^{-7} mbar to 10^{-9} mbar) copper gaskets were used as well as turbo pumps with backing roughing pumps.

Sliding in and Testing the Trap



The radial magnetic field is applied to the center of the penning trap using an Agilent 7T 210 mm ASR.

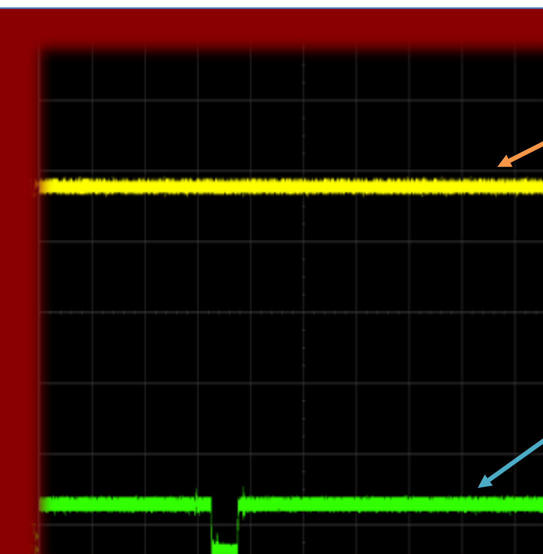


The Microchannel Plate was connected to NIM electronics and the output of the signal was viewed on the Oscilloscope.

Testing the trap:

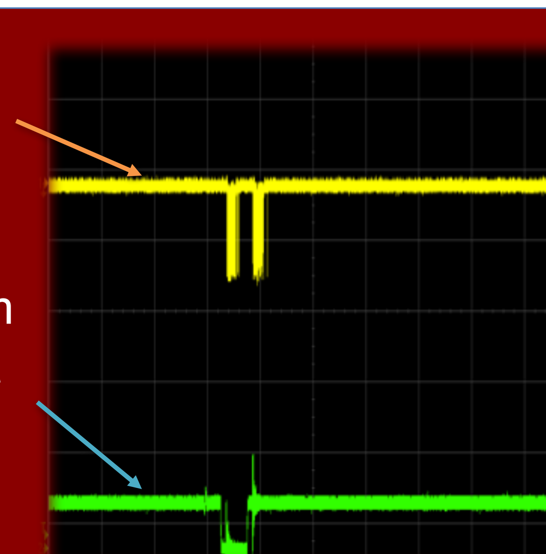
- ❑ A continuous ion beam was provided using a surface ion source
- ❑ Faraday cups were placed before and after the magnet to ensure that the beam passed through the trap
  - ❑ Einzel lenses and x-y steerers were used to align the beam
  - ❑ Once the beam intensity was determined using the Faraday cups a MCP detector (positioned after the magnet) was used to analyze the signal coming from the beam on an oscilloscope.
  - ❑ Each of the Electrodes were grounded except for the trapping drift tube
    - ❑ To bunch the ion beam the trapping drift tube was pulsed using a filter circuit
    - ❑ After bunching the ion source and the ejection end cap was grounded
      - ❑ The bunched signal was then observed using an oscilloscope
      - ❑ The voltages across both of the end caps were adjusted.

Current Status



The output from the MCP.

The output from the pulsing drift tube.



The voltage vs time graph while the ion beam was off and the drift tube was pulsing.

The voltage vs time graph while the ion beam was on and the drift tube was pulsing.

In conclusion:

- ✓ The prototype trap was cleaned and assembled
- ✓ A beamline was constructed and aligned using a optical transit.
- ✓ The intensity of the beam was optimized.
- ✓ The ion beam was successfully bunched using the pulsing drift tube and adjusting the voltage on the ejection end cap.

Future Work

- ❑ Mass Spectroscopy will be used to demonstrate the prototype traps trapping ability.
- ❑ Adjustments to the design of the final penning trap will be made based upon performance testing results.
- ❑ Assembly and testing of the final TAMUTRAP.
- ❑ The Final TAMUTRAP will be connected to the K150 cyclotron.