Overview of the TAMUTRAP facility

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The primary goal of the Texas A&M University Penning trap facility (TAMUTRAP) [1,2] is to search for a possible admixture of a scalar component to the predominantly *V-A* form of weak interaction by measuring the β-ν angular correlation parameter ($a_{\beta\nu}$), for T=2, super-allowed β-delayed proton emitters. The plan is to trap the radioactive ions in a Penning trap and observe the decaying particles. In order to achieve the precision necessary for a standard-model test, we have designed and commissioned a unique closed-endcap cylindrical Penning trap which is the world's largest. The TAMUTRAP facility has been commissioned using off-line ion sources and has demonstrated the ability to perform mass measurements. Fig. 1 shows a detailed overview of the TAMUTRAP beam line.

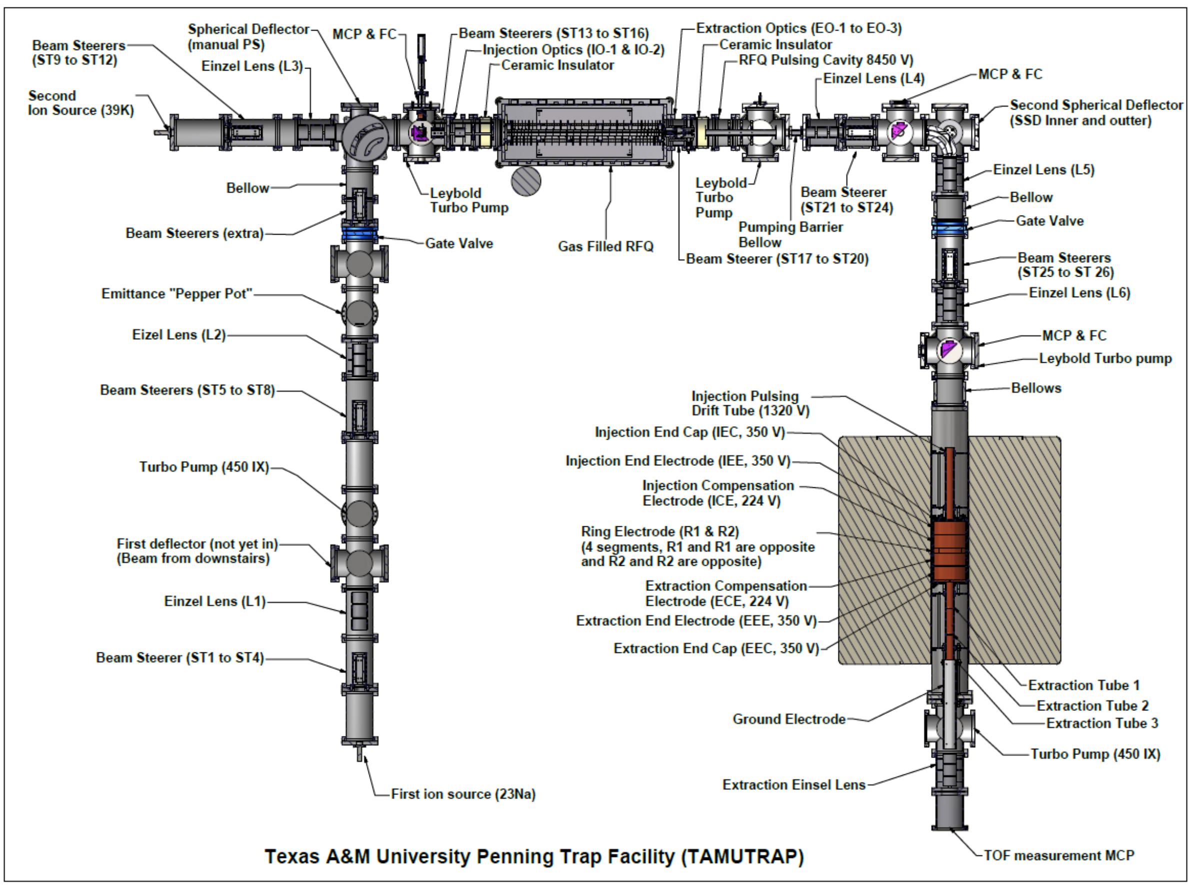

Fig. 1. Overview of the TAMUTRAP beamline.

The old 90-mm-diameter prototype Penning trap was replaced by the full 180-mm-diameter and 334.9-mm-long Penning trap, doubling the size of what was already the world's largest Penning trap. The new beamline and trap was inserted into our Agilent 7T210/ASR superconducting solenoid's bore from the extraction side and connected to the outer shell of the cryostat with adjustable non-magnetic supports that allow radial and axial adjustment of the tube compared to the solenoid. We transported beam from test ion sources in two separate locations by using $^{23}Na^{+}$, $^{39}K^{+}$, $^{85,87}Rb^{+}$, and $^{133}Cs^{+}$ ions and performed several mass measurements. Fig. 2 shows an example of a TOF ion-cyclotron resonance performed on $^{39}K^{+}$ ions with a 200 ms excitation time. We have measured masses of each stable alkali isotope with ΔM/M≤60 part-per-billion precision, all in agreement with the literature values. A more detailed analysis process can be found in M. Nasser's report [3] of the TOF-fitting code which includes damping caused by the residual gas (mostly helium) in the Penning trap. We also improved the vacuum in the Penning trap by a factor of two by replacing the bellow after the RFQ with one having a smaller inner diameter.

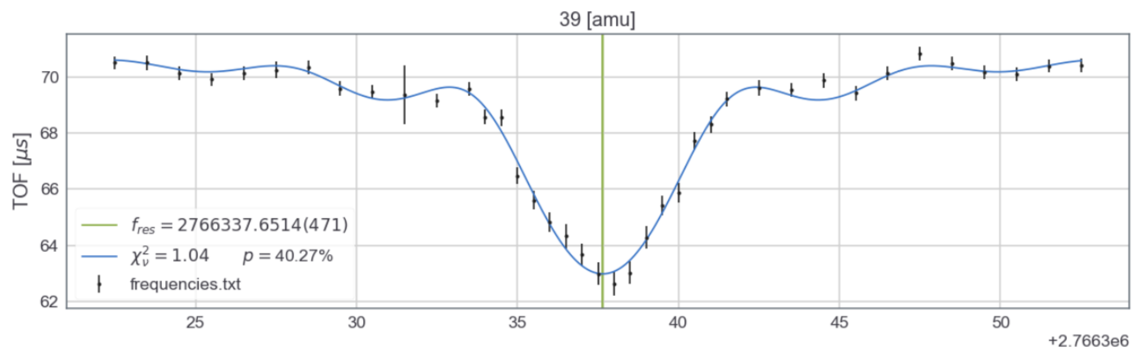

Fig. 2. An example of TOF-ICR frequency scan of 39K+ ions with 200 ms excitation time and fit to a model which includes dampening effects from a finite vacuum.

We have performed isobaric purification and subsequent mass measurements with a single Penning trap. The TOF-ICR resonances of $^{85}Rb^{+}$, and $^{87}Rb^{+}$ ions that were injected simultaneously in the Penning trap are shown in Ref. [4]. We have also implemented and tested a Ramsey-type excitation scheme for the Penning trap; see Ref. [5] which describes the waveform generator setting and timing pattern for the performed test run.

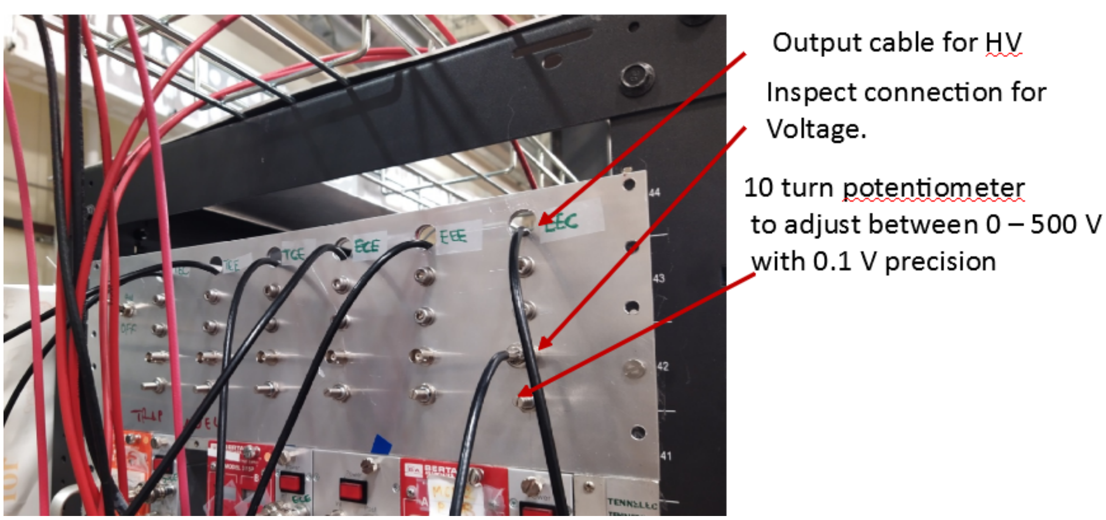

Fig. 3. The control panel for the power supplies used for the Penning trap electrodes.

A new adjustment panel for the Penning trap 1 kV Spellman MPS power supplies have been built. Earlier the voltages were adjusted with coarse internal 1-turn potentiometers that had to be adjusted manually with a screw driver while standing on a ladder. In the present system, a 5 V control voltage has been fed through a Bourns 3590S-2-103L 10-turn, 2 Watt 10-kΩ linear potentiometer which allow adjusting the control input values between 0–5 V. This has been fed into the pin 5s of the 15-pin D-sub connectors of the power supplies allowing the output voltages of the power supplies to be adjusted easily and reproducibly between 0–500 V with a 0.05 V precision. Fig. 3 shows the photograph of the adjustment panel.

The injection electrode of the Penning trap has been modified to be able to pulse it between 0–10 kV instead of the original 0–1.5 kV. This allows us to transport 10 keV ions from the RFQ cooler/buncher to the Penning trap. However, there have been some discharge issues and we are currently working to better improve the shielding. Fig. 4, shows the Inventor illustration of the new design.

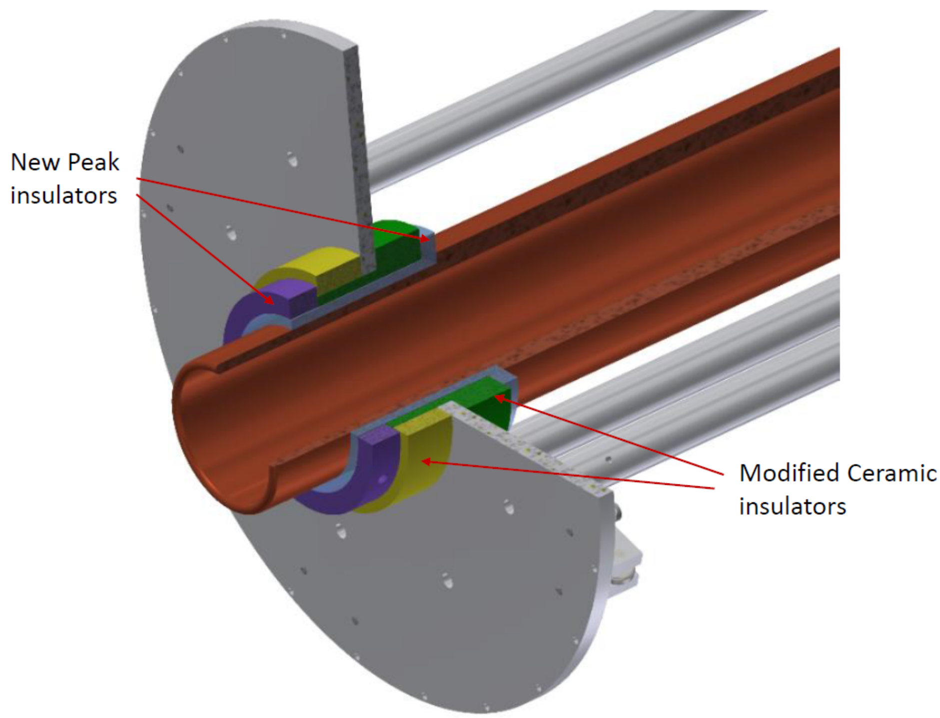

Fig. 4. Modified injection tube of the Penning trap.

We have also carried out test production runs for TAMUTRAP's radioactive ions of interest with a light ion guide technique with and without an RF structure inside the gas cell. Ref. [6] describes the test gas cell and achieved yields of the wanted radioactive ions. In parallel with developing the RIB production, we have started to design "LSTAR," the isobar separator needed to purify the radioactive beam and transport it to TAMUTRAP [7].

A new ion source, an electric discharge ion source is currently being developed to be used inside the light ion guide target chamber. We are also modifying our old surface ion sources used at the testing of the Penning trap. The main modification is the mounting of the source and the focusing lens immediately after the acceleration.

[1] P.D. Shidling *et al.*, Hyper. Interact. **240**, 40 (2019).

[2] M. Mehlman *et al.*, Nucl. Instrum. Methods Phys. Res. **A712**, 11 (2010).

[3] M. Nasser *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2019-2020), p. IV-88.

[4] V.S. Kolhinen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2019-2020), p. IV-98.

[5] V.S. Kolhinen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2019-2020), p. IV-90.

[6] P.D Shidling *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2019-2020), p. IV-95.

[7] G. Chubarian *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2019-2020), p. IV-93.