Update on the TAMUTRAP facility

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The primary goal of the TAMUTRAP facility is to test the Standard Model for a possible admixture of a scalar (S) or tensor (T) type of interaction in T=2 super-allowed beta-delayed proton decays. This information will be inferred from the shape of the proton energy spectrum. The main components of the facility are a Radio Frequency Quadrupole (RFQ) Paul trap used to cool and bunch the ions, and a measurement system based on a large-diameter cylindrical Penning trap. Additional scientific goals for this system are mass measurements, and providing a low-energy radioactive ion beam (RIB) for various other applications.

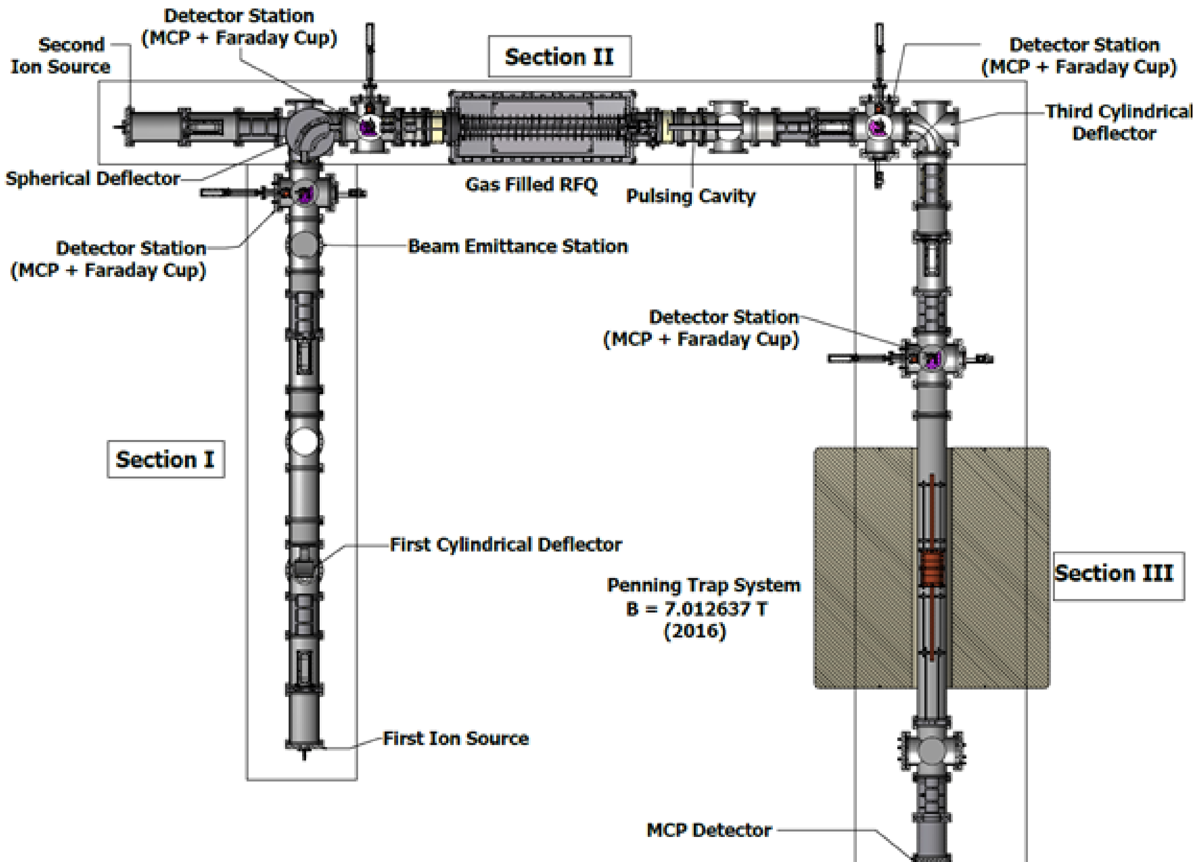

FIG. 1. Texas A&M University Penning Trap Facility (TAMUTRAP).

After demonstrating the ability of trapping and manipulate the ion motions, we began the year by demonstrating the ability to perform high precision mass measurement. The relevant observable in mass measurements using a Penning trap is the ratio of the cyclotron frequencies of the ion of interest and ion used as a mass reference. High precision requires that the two frequencies are measured after one another in the shortest possible time. An in-house-designed ion gun employing a stable sodium (^{23}Na) ion source

("First Ion Source" in Fig.1) was installed at the location of first cylindrical deflector. At TAMUTRAP facility, we measured the cyclotron frequency by the time-of-flight ion cyclotron resonance method (TOF-ICR). The frequency of the minimum TOF would correspond to the mass of the trapped ions. In our case, we used ^{39}K as our reference mass and performed mass measurement of ^{23}Na. At first we used a simplfied excitation scheme, where the quadrupole excitation was applied to four-fold segmented ring electrode for 20 ms to couple two eigen motions. The frequency scan was performed for ^{39}K and the TOF was recorded for 30 different frequencies in steps of 10 Hz close to the expected resonance value. The procedure was repeated by changing the source to ^{23}Na. Both these measurements were carried out on the same day. The reduction in TOF at resonance was around 20%. Normally, the reduction in TOF at resonance is considerable, typically 30%. In order to increase the TOF depth, the beam line at the exit of the magnet (Section III in Fig. 1) was extended by close to 2 feet and einzel lens was installed before the MCP detector. The extended beamline and positive voltage on the extraction drift tube helped us in observing close to 30% reduction in TOF at resonance for excitation time ranging from 20-100 ms. More details on the mass measurement will be discussed in our other report[2].

Apart from mass measurements, the settings of different electrostatic components were optimized to improve the transport efficiency of TAMUTRAP beamline. In particularly, we made close to two order of magnitude improvement in the transport efficiency of section 1 (see Fig.1). There was signifcant loss in bending the beam by 90° using spherical deflector and it was due to the fringe field effects. The huge improvement in the efficiency was possible by adding ground cylinders at the entrance and exit of the spherical deflector with certain aperture which helped to reduce the fringe field effects. In addition to this, we have built a third spherical deflector which will replace the third cylindrical deflector (see Fig. 1) and this replacement will certainly bend the bunched beam by 90° with better efficiency.

The performance of RFQ in bunched mode was improved by rewiring the RFQ electronics and changing the resistors value of last segment which is used to bunch the beam. The change in resistor value of the last segment improved the switching of the last segment during ejection and gave a satisfactory results.

The current prototype Penning trap has an inner diameter of 90 mm and is presently the world's largest Penning trap. However, in order to perform the planned measurement the diameter of the Penning trap needs to be twice the dimension of prototype Penning trap. The mechanical design of the TAMU-Penning trap (180 mm diameter) has been completed. The drawings of the entire TAMU-Penning trap system have been finalized and submitted to different sources for fabrication, including our in-house machine shop. More details of the 180 mm diameter Penning trap has been described in our other report [3]. Geant4 Monte Carlo simulations for the TAMUTRAP Penning trap setup has been initiated and more detail can be found in our other report [4]. We also made significant progress in automating the frequency scan for performing mass measurements and details on this automation has been described in our other report [5].

The immediate outlook for the TAMUTRAP facility involves beam alignment of section 1 (see Figure 1) of the TAMUTRAP facility collinear to Heavy Ion Guide and install gate valves at three different places along the TAMUTRAP beam line. After that, the third cylindrical deflector will be replaced by spherical deflector. We expect all the parts of TAMU-Penning trap system to be ready by mid of June, 2018. We will start assembling the TAMU-Penning trap system and install it in the beamline by mid of July 2018. We will also test the frequency automated scan program sometime in May 2018. We expect to complete the simulation and finalize the dimensions of the detectors by fall 2018.

[1] E. Bennett *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2015- 2016) p. I-62.

[2] V.S. Kolhinen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017- 2018) p. IV-39.

[3] V.S. Kolhinen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018) p. IV-42.

[4] V.S. Kolhinen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018) p. IV-44.

[5] R. Burch *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018) p. IV-46.