

## TAMUTRAP facility annual report

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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  $T=2$  superallowed 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 Penning trap system composed of two cylindrical Penning traps. Additional scientific goals for this system are mass measurements, lifetime measurements,  $ft$ -values, and providing a low-energy radioactive ion beam (RIB) for various other applications.

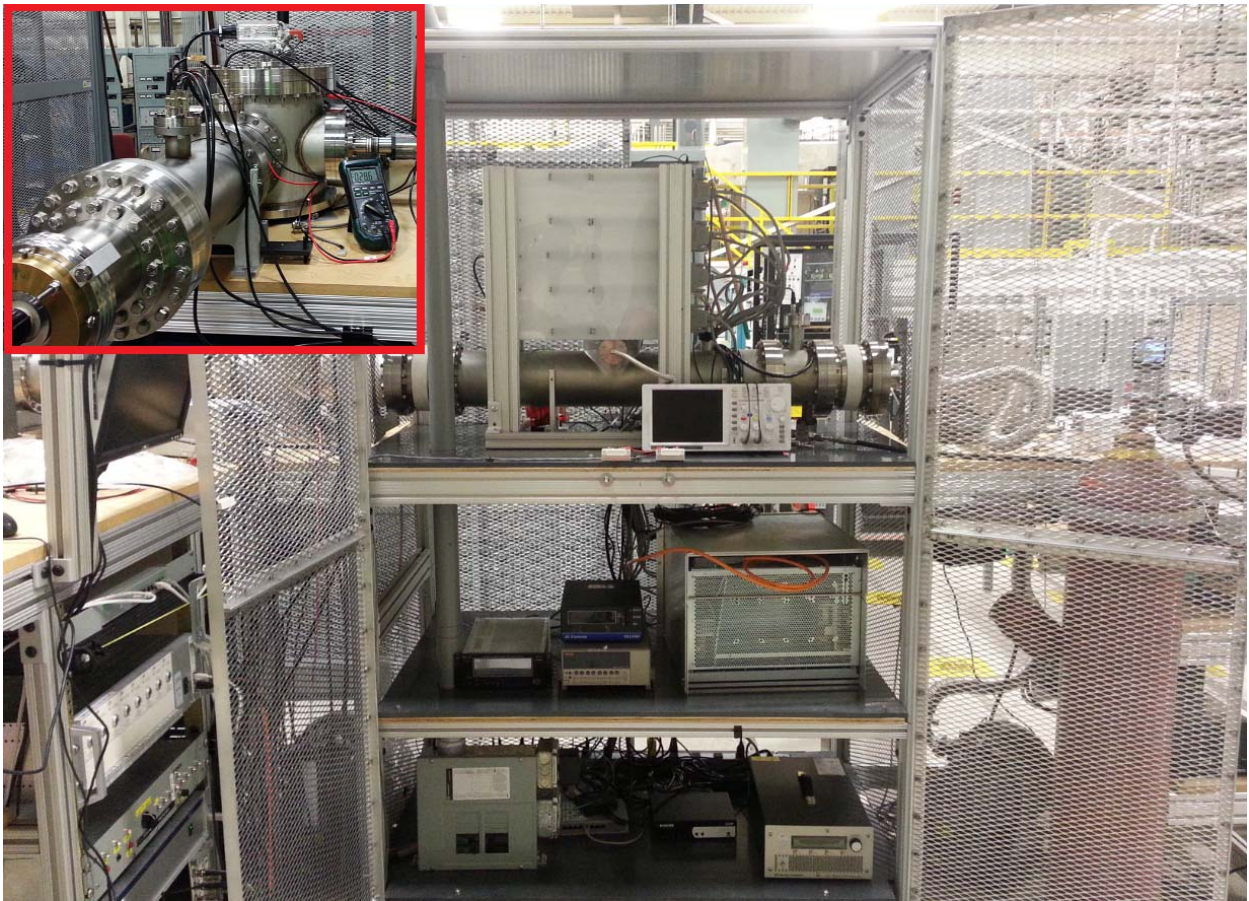
Over the past year, significant progress has been made toward the commissioning TAMUTRAP (Fig. 1). The geometry for the large, open-access Penning trap has been finalized and shown to be theoretically competitive with traps employed in other prominent facilities [1]. Critical systems such as the high voltage platform, power supplies, radio frequency (RF) voltage systems, and gas pressure controls for various beam line elements have been commissioned. Testing of several meters of beamline as well as the RFQ Paul trap used to bunch the incoming beam and lower emittance has begun with an offline ion source, and beam transmission through these elements has been confirmed. Additional beam optics have been fabricated and are currently being tested.



**FIG. 1.** The TAMUTRAP facility as of 4/16/13

One of the challenges in the design of the RFQ is efficiently matching the emittance of the incoming beam to the acceptance of the RFQ due to the need to decelerate it from 10-15 keV to a few tens of electron volts energy. This procedure is achieved by the injection optics, which consist of a ground tube and two cylindrical electrodes. The RFQ cooler and buncher must be floated to a potential slightly less than the beam energy in order to allow the rest of the beam line to remain at ground. In preparation for this, a high voltage platform capable of satisfying the voltage requirements has been built, and an

optical system for transmitting data to and from devices on the platform has been installed. The platform and communication system was tested and safety checked, and works as expected. Relying exclusively on electrostatic beam optics, there are many elements in the TAMUTRAP beam line that require the application of a precise voltage. Power supplies for these optics have been commissioned and tested, including multiple low and high voltage modules. In addition, the RFQ utilizes a high voltage RF signal to manipulate the incoming ion beam. An RF amplifier has been integrated into the RFQ electronics in such a manner that the RF signal will not damage any other power supplies or equipment. This entire circuit has been shown to provide the necessary voltage for proper functioning of the RFQ. Finally, cooling is achieved in the RFQ via interaction with a low pressure buffer gas, in this case ultra pure helium. To meet this requirement a PID system was installed in the beam line and tested for functionality. The vacuum outside the RFQ was designed to be maintained by differential pumping, the functioning of which was confirmed. The RFQ systems are shown in Fig. 2.



**FIG. 2.** The RFQ cooler and buncher and associated support systems with offline ion source (inset).

An in-house-designed ion gun employing a potassium ion source was developed for offline tests. After demonstrating beam properties useful for simulating the output of the heavy ion guide (HIG), including a low emittance when compared to commercially available ion gun designs and up to  $1 \mu\text{A}$  maximum beam current, this ion gun was coupled to the assembled beam line. Subsequent testing has confirmed the function of various lenses, steerers, and injection electrodes by measuring beam current at periodically located Faraday cups connected to precision Keithley picoammeters. Such a method should

ultimately allow for an efficiency determination of the system. At this time, beam transport has been confirmed over several feet of beam line, and a relative efficiency of about 80% for the injection optics has been demonstrated for certain beam energies, though optimization of the injection optics is still ongoing.

Testing on the RFQ itself, coupled to the initial beam line and injection optics, has recently begun. After confirming the functionality of the necessary electronics and support systems (RF, drag potential, gas pressure, etc.), beam was injected into the RFQ and current was measured near the exit of the structure using a Faraday cup. The device has shown transmission of a low energy beam (from 40-120eV), with and without the presence of the Helium buffer gas. Further tests are currently being performed to determine the most favorable operating parameters for the device in order to maximize transport efficiency.

Concurrent with the testing of the beam line and RFQ, additional beam optics and equipment to be needed later in the assembly of the facility were being fabricated and assembled. The beam optics on this list include the spherical deflector needed to bend the beam ninety degrees, a prototype cylindrical deflector (Fig. 3) that could be used for the same purpose (upcoming testing will indicate if its performance is satisfactory), and a pulsing cavity used to lower the beam energy for loading into the measurement trap. The cylindrical deflector is the first of these elements to be completed, and is currently awaiting testing.



**FIG. 3.** The cylindrical ninety degree deflector currently awaiting testing.

In addition to this hardware, TAMUTRAP will also ultimately require precision timed voltage switching for certain beam elements. For this application, a National Instruments FPGA and Behlke high voltage, ultrafast switches have been purchased. Control systems for these devices are now in the works.

The immediate outlook for the TAMUTRAP facility involves initially completing the efficiency tests on the RFQ and injection optics. After that, additional sections of the beam line will be installed and tested, including the fast switching elements mentioned above. Once the efficiency of these sections has been determined, an emittance test utilizing position sensitive multi-channel plate (MCP) detectors will be performed, indicating what quality beam can be expected for feeding the measurement trap. It is expected that significant progress toward these milestones will be made in the upcoming year.

[1] R.S. Behling *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2012-2013), p. I-22.