TAMUTRAP facility status report

R.S. Behling, B. Fenker, M. Mehlman, D. Melconian, and P.D. Shidling

Significant progress has been made toward the completion of the Texas A&M University Penning Trap facility (TAMUTRAP). TAMUTRAP is a new ion trap facility dedicated to the study of fundamental symmetries of the weak interaction and for providing a low-energy radioactive ion beam (RIB) for various other applications. Electrostatic transport elements and a gas-filled radio frequency quadrupole (RFQ) Paul trap are planned to achieve efficient transport and preparation of the beam for the measurement trap. The design requirements of the TAMUTRAP beam line are twofold: first, the beam must be transported efficiently from the distribution point of the heavy-ion guide to the Penning trap system; second, the beam must be prepared in such a way that it can be accepted by the Penning trap, *i.e.* it must be bunched and have a low emittance (narrow energy, angular, time-of-flight and spatial distributions).

Initial simulations were performed with the SIMION ion trajectory simulation software[1]. After this, mechanical designs were detailed using the 3D CAD software Autodesk Inventor as shown in Fig. 1. These models were optimized within the framework of the existing cyclotron facilities to ensure that the final design would be feasible in terms of space constraints and assembly. Following is a brief description of the beamline, highlighting several central components.

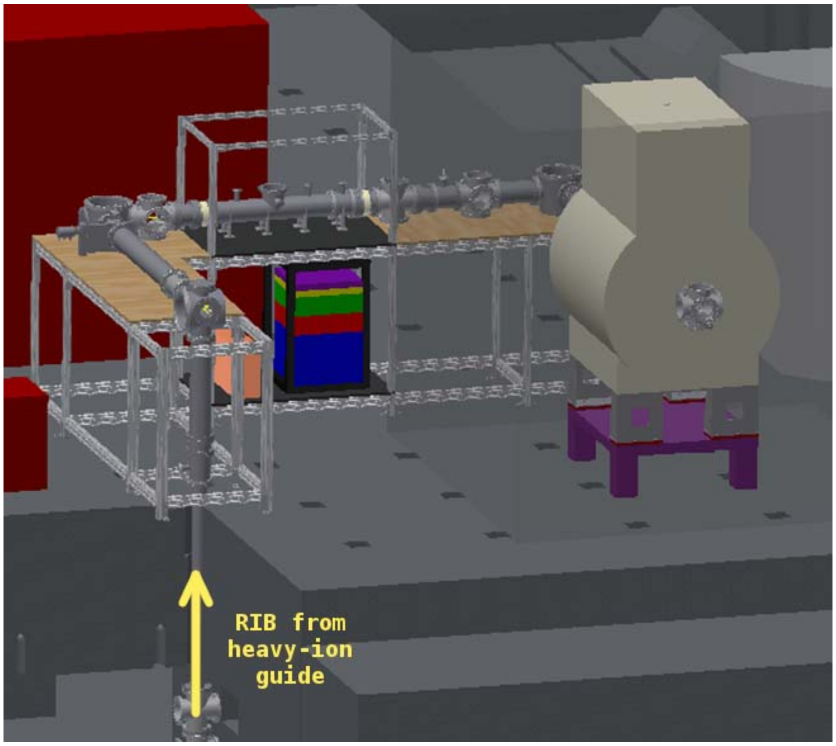

FIG. 1. 3D design of the TAMUTRAP facility.

---

[1] SimION—Industry standard charge particle optics simulation software (http://simion.com).

Upon leaving the high voltage platform of the heavy-ion guide, the radioactive ion beam (RIB) will be accelerated to 10-15 keV for transport up through the TAMUTRAP beamline. The RIB will be guided vertically by an x-y electrostatic steerer and a 3 electrode Einzel lens (a CAD drawing of this component is shown in Fig. 2).

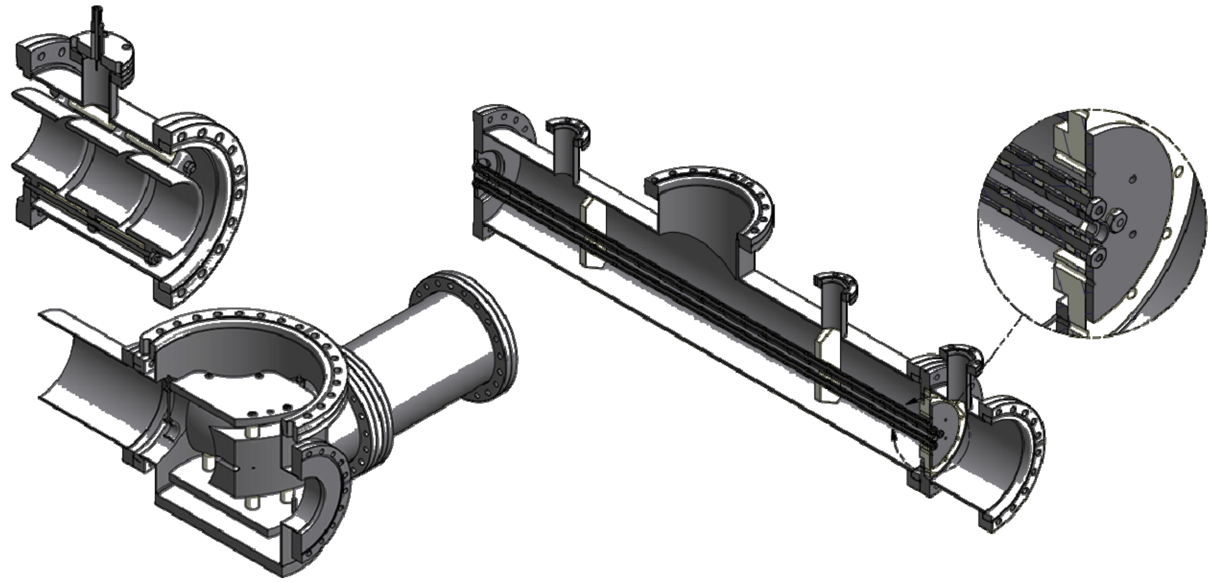

FIG. 2. CAD drawings of some of the beamline components of TAMUTRAP: an Einzel lens in a 3-electrode configuration (top-left); the spherical deflector with through holes in the outer electrode (bottom-left); and the gas-filled RFQ Paul trap used to cool and bunch the radioactive ion beam (right).

Once through the shielding blocks, which separates the heavy-ion guide system from the high bay experimental area, the RIB will undergo a 90° bend achieved by a spherical deflector (also depicted in Fig. 2). The outer electrode of the deflector has been designed with through holes along each beam axis such that it can also be used as a switchyard in the absence of an applied voltage. This feature also provides the ability to inject an offline ion source into the beam line. In addition, the through holes will aid optical alignment of the beam pipe. Following the 90° bend, the RIB will be guided in the horizontal direction using an additional x-y steerer, lens, and diagnostic section, before reaching a second 90° deflector.

After the 2nd deflection, the ion beam will be collinear with the axis of the RFQ cooler/buncher, which is depicted in Fig. 2. The beam will pass through a vacuum station and be reduced to several eV kinetic energy by specifically designed decelerating optics. The last element of these optics is situated on a high-voltage platform, which is held at a potential slightly below the beam energy. The beam will be bunched and cooled in a gas-filled RFQ Paul trap, which will be operated at room temperature with a gas pressure ranging from 10^{-2} to 10^{-4} mbar of ultra-pure helium. Simulations indicate that the bunched beam will have an energy spread of 5-10 eV and a time spread of 1.0-1.5 μs upon exiting the high-voltage platform, and will be further guided by an x-y steerer and Einzel lens. The RIB will then enter the first pulsing cavity which is held at a potential that results in the kinetic energy of the beam being lowered to ≈2.7 keV. While it is within this cavity, the voltage on the electrode will be switched to ground, resulting in a final beam kinetic energy of ≈2.7 keV relative to the beam pipe. The bunched beam will then be deflected by 90° for a final time in order to become collinear with the Penning trap axis. After encountering an additional Einzel lens, x-y steerer, and a diagnostic/pumping station, the beam energy will be lowered to a few tens of eV relative to ground by a second pulsing cavity. As the beam enters the magnet, it will become confined radially due to the ions' Larmor precession within the 7T magnetic field, and will be ready for subsequent loading in the Penning trap.

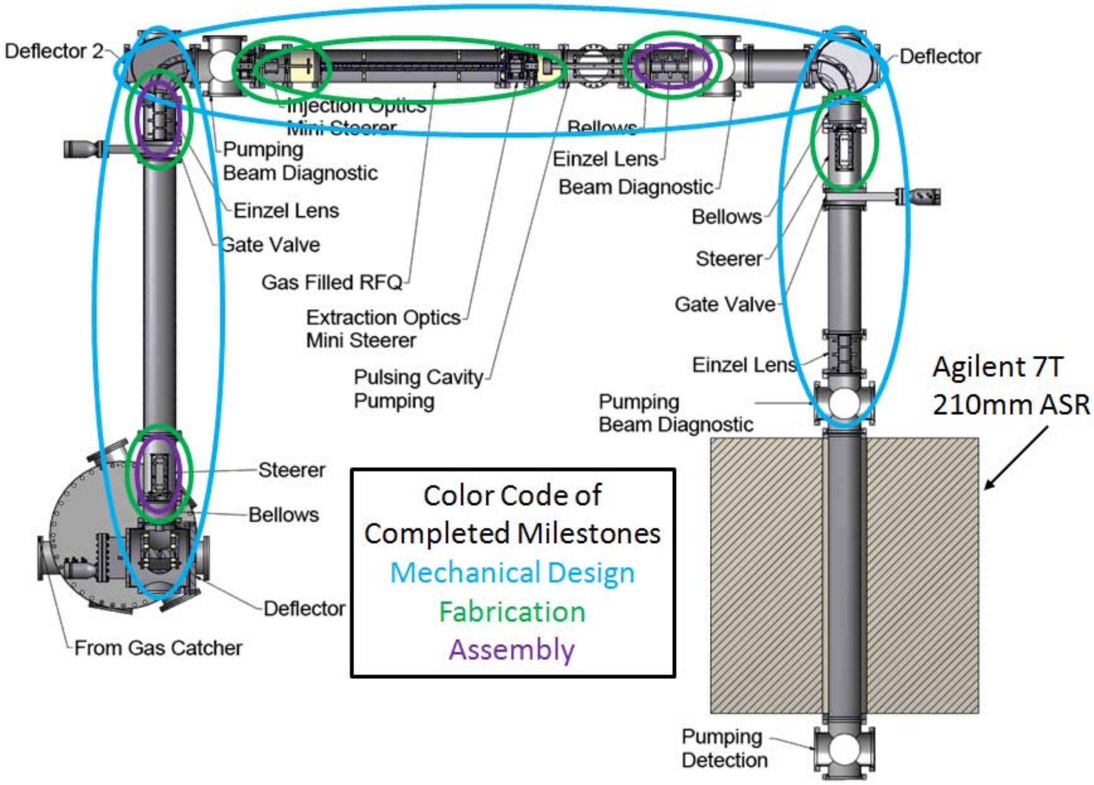

FIG. 3. Current progress towards completion of the TAMUTRAP beamline.

Fig. 3 highlights the current progress of the TAMUTRAP beam line that has been described. Geometrical optimization in SIMION and mechanical designs using Autodesk Inventor has been completed for the entire beam line up to the entrance of the Penning traps. Mechanical drawings have been finalized and submitted to different sources for fabrication, including our in-house machine shop. Fabrication has been completed on several Einzel lenses, beam steerers, and all elements composing the RFQ. Additionally, many standard vacuum components such as crosses, bellows, and beam pipe have been purchased and are ready for installation. A custom beam support and mounting table has been designed and installed using extruded aluminum profiles. Photos of several assembled components can be seen in Fig. 4.

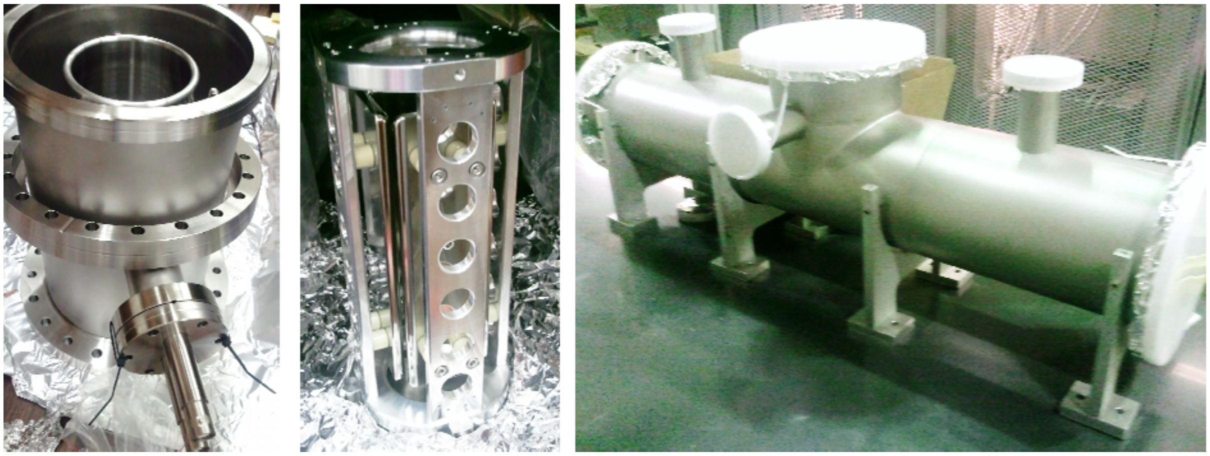

FIG. 4. Pictures of some completed beamline components: an Einzel lens (left), the x-y steerer (middle) and the chamber for the RFQ (right).

In addition to beam line hardware, progress has been made on several critical systems. A pressure maintenance controller for the gas-filled RFQ has been characterized, and many of the high-voltage electronics have been specified and tested. Electronics for the RFQ have been developed and tested. The power supplies necessary for the beam elements are in place. The immediate outlook for the TAMUTRAP facility involves continued assembly of the beam line and its constituent elements. Initial placement and alignment of components at their final locations will begin within this year.