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PROPOSED INTERCEPTING FOIL SEM GRID FOR THE FNAL 400 MEV LINAC

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ABSTRACT

It is proposed to build beam profile monitors for the 400 MeV linac which are intercepting foil secondary emission monitors (SEM's). The SEM design is based on that built for the NuMI beamline, which utilizes 5 μm thick Ti foils. This note summarizes physical specifications of the device.

I. INTRODUCTION

For the NuMI project, we designed and are constructing 10 SEM profile monitors. The main features of these devices, as compared to the standard FNAL multiwires, is that

1. The device must survive ~10^{20} particles/cm^2 per year, whereas it is known from CERN that the signal from W or Au-W will degrade at such beam exposures. Ti foils are demonstrated to suffer negligible signal loss at such an integrated fluence.
2. Beam loss is 5×10^{-6}, a factor 25 lower than the existing multiwires.
3. The aperture must be 4".
4. The device must be removable from the beam without turning off the beam (*ie:* the frame of the devices completely avoids the beam during insertion/removal).
6. Replacement of the device in the beam must be achieved to 50μm positional accuracy.

To achieve these main requirements, we borrowed from a CERN design that utilizes a set of 5μm thick Ti foils. The foils are segmented into strips (see Figures 1 and 2). Two planes of foils thus provide *X* and *Y* profile information. In the case of NuMI, halo foils are also provided (see Figure 2), which may also be of use for the proposed Linac SEM.

For those interested in the choice of Ti SEM material, or in the choice to build a foil detector instead of a wire detector, please see the two internal notes NuMI-B-933 and NuMI-B-926.

The NuMI SEM actuates in and out of the beam linearly (see Figures 2 through 6). The paddle onto which the foils are mounted wraps around the beam, so that when the foils are drawn out of the beam the frame does not pass through the beam (see Figure 1). This has the advantage of not having to interrupt beam in order to insert or remove the device. A ball screw linear motion stage driven by a DC stepper motor provides the linear actuation. The motion is transmitted through a 5" stroke vacuum bellows, so no complicated motion parts are located inside the vacuum chamber.

Like the existing FNAL multiwires, kapton ribbon flex circuits are used to route the signals out of the vacuum chamber from the signal paddle. In our case, the kapton cables flex along side the paddle as it actuates in and out of the beam (see Figure 2). Guides prevent the cables from intercepting the beam.

II. PHYSICAL SPECIFICATIONS OF THE NUMI SEM'S

In this section we note the specifications for the NuMI SEMs, and also note in italics proposed changes for the linac SEM's.

I. Foil Specifications

1) Strip pitch = 1mm, with a total of 44 strips. The observed tolerance on this pitch is <25μm (based on first two SEM's constructed). *For the linac SEM, it is perhaps better to use 2 mm pitch since the beam is wider.*

2) The width of the signal strips intercepting the beam is 0.15mm. This has been measured for the first two SEM's (see Figure 2).

2) Insertion of the foils into the beam is achievable without dropping the beam permit system; *ie:* the frames are always out of the beam, which is achieved by building a paddle that surrounds the beam (see Figure 1).

4) The SEM's provide 4" clear aperture with foils out of the beam. With foils in the beam, any frames are >2.0" radius from the beam axis.

5) For the NuMI SEM's the profile measuring area is 44mm in both *X* and *Y* views. Halo foils fill the remaining aperture. *For the Linac SEM's, if 2mm pitch is adopted, then the measurement area could easily be stretched out to 3" width, and the halo foils omitted.*

6) Bias foils are interleaved with the signal foils. These will be 2.5μm thick Titanium. For NuMI, these were solid foils with a 12mm ∅ beam hole. *For the linac, we would probably make a segmented bias foil of strips to reduce mass in the beam.*

II. Vacuum:

1) The SEM chamber after bakeout should hold constant pressure of 3×10^{-8} Torr isolated on a 30 l/sec ion pump.

2) The chamber should pump down from 1atmosphere dry N_2 to 10^{-6} Torr (turn-on pressure of the ion pump) using 200 l/s turbo within <4hrs.

3) The connection of the SEM to adjacent beamline elements is made via two 4"OD beam port tubes. These tubes are fitted with "Main Injector 4in. diameter Quick Disconnect" flanges (Fermilab dwg # 9512-MB-359521). *For the linac SEM's, alternate flanges could be specified.*

III. Physical Size:

1) The flange-to-flange distance along the beam is 9.25".

IV. Controls, Interfaces:

1) The drive mechanism for the SEM paddle is a 6 wire, unipolar motor (to be controlled by the stepper controller system developed by Al Legan in the FNAL Controls Dept.). The motor specs are that it should draw <3A, and be <3mH inductance, <2ohms, and operated at 48V.

2) The motor is halted by two limit switches at the ends of travel. These are ceramic-insulated switches by Honeywell, also used in Tevatron scrapers due to rad hardness.

3) An LVDT (Schaevitz HR050 0.050" range) LVDT is used to measure the final "beam in" position of the paddle. The beam out position is not measured since it is not critical (at the beam out position, a limit switch engages). The LVDT puts out a 10V (maximum) DC signal, which is consistent with the controls system requirements from Al Legan.

4) The SEM requires one bias voltage channel with a voltage <500V. The high voltage connection is via an SHV connector on the SEM.

5) The SEM has two 50-pin D-sub connectors for readout of the signal strips.

V. Foil Positioning:

1) The foils are insertable and retractable from the beam. When reinserted into beam, the foils' position relative to its previous insertion must be known within 50μm accuracy.

2) The exterior of the SEM has reference markers. The foil position inside the vacuum can be referenced with respect to these external survey markers on the device within 0.005".

3) The foils must be inserted in the beam within a time span of <15seconds.

4) The SEM motion drive system is rated to survive 20,000 insertions into the beamline.

VI. Maintenance:

1) Replacement of device is to be performed by swapping of entire vacuum can. Repair of internal foil is to be done in dedicated lab outside the accelerator tunnel.

VII. Environmental:

1) The devices are relatively radiation resistant. Within the vacuum chamber, only ceramics, kapton cable, or Titanium and stainless steel are present. Outside the vacuum chamber, the LVDT is a Schaevitz "mildly radiation resistant" model, the linear motion stages are lubricated with rad-resistant grease, and the limit switches are ceramic insulated. The stepper motor is not rad hard in any way, but is inexpensive to replace.

2) The electrical connections of the SEM are protected against humidity and possible dripping water by placing a plexiglass cover over the brackets supporting the linear motion stage.

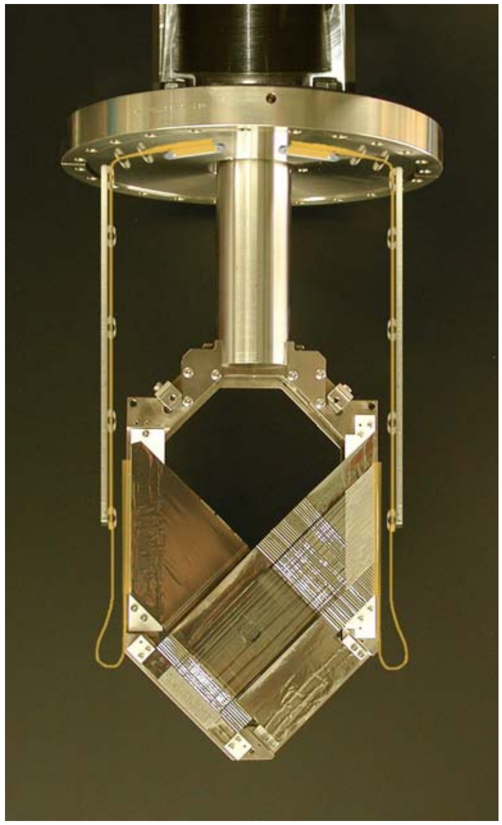

Figure 1: Ti foil SEM paddle built for the NuMI beamline. The 6-sided paddle wraps around the beam and actuates up-down in the above photo. A 4” ∅ beam hole is at the top of the paddle for the “out position (paddle actuated down), and the paddle actuates upward to place the foil SEM grid into the beam.

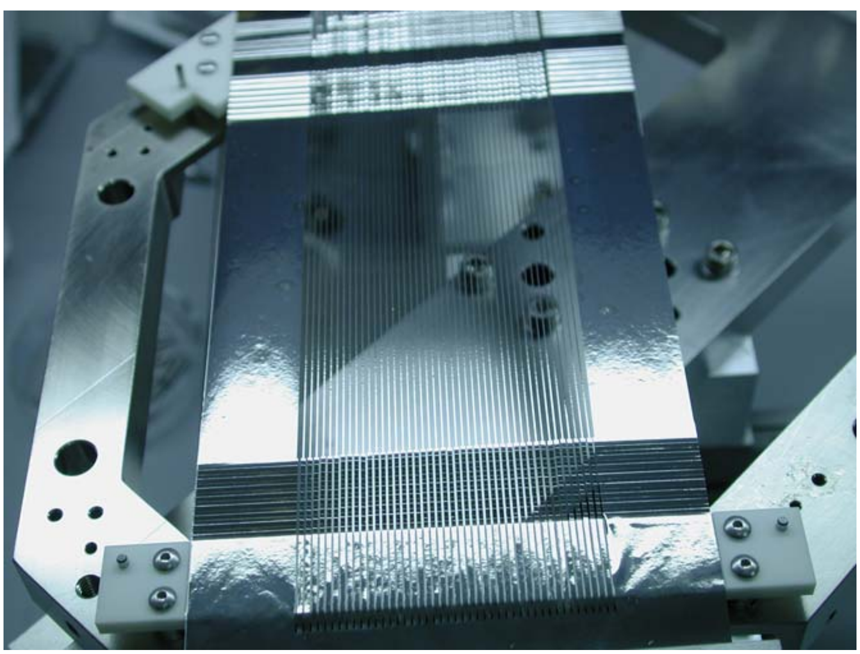

Figure 2: Detail view of the signal foil for the NuMI SEM’s. The Ti foil is mounted on a ceramic “comb”. The strips are at 1mm pitch. Each strip has an accordion spring to absorb beam heating-induced elongation. The 44 strips are 0.15mm wide across the beam aperture. Two halo foils fill out the 3” measurement area.

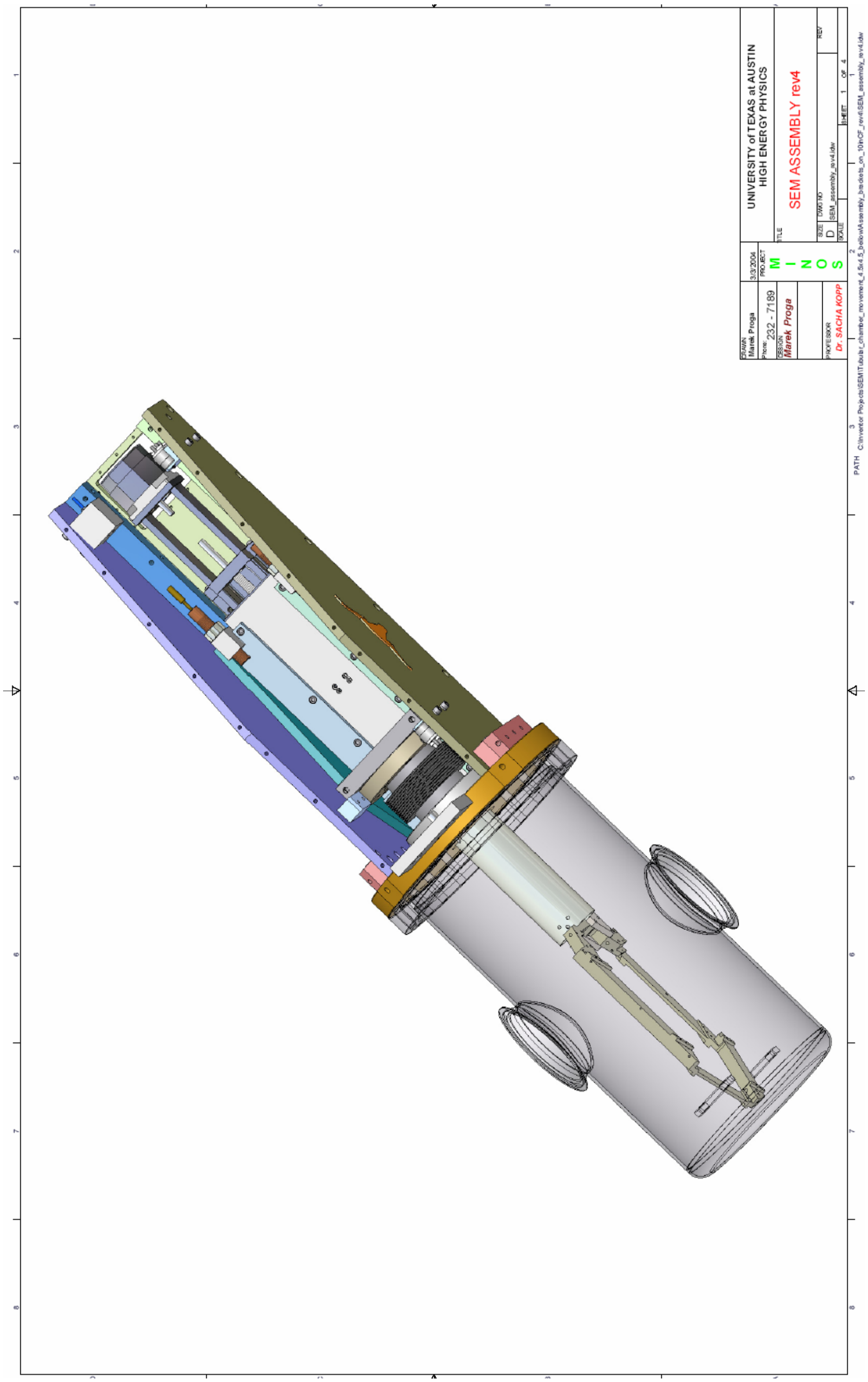

Figure 3: Isometric view of the profile monitor vacuum can, linear motion actuator, and paddle cantilevered at the end of a 2" shaft.

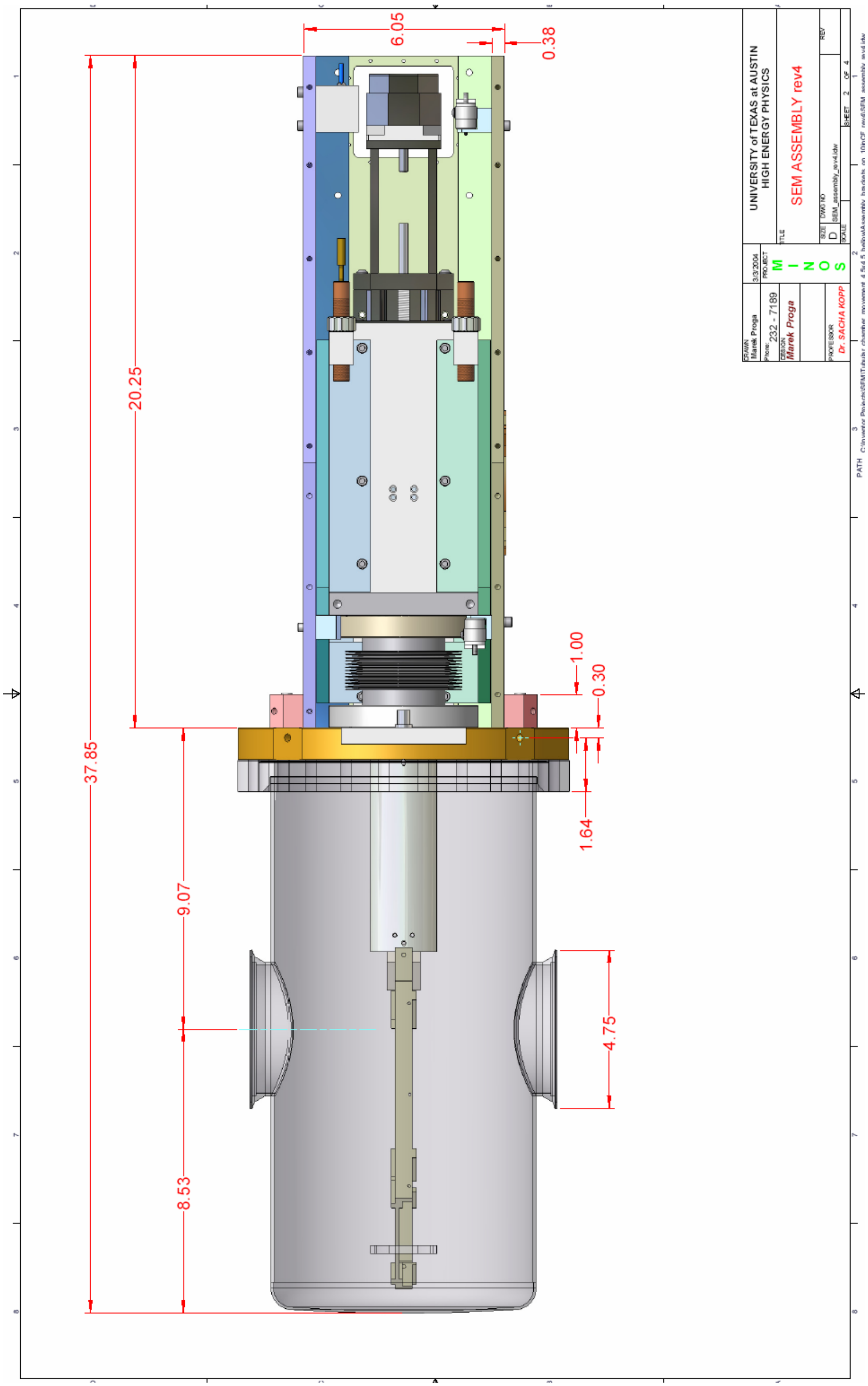

Figure 4: Several dimensions of the UT profile monitor can. In this view the beam traverses left-right, through the two quick-disconnect flanges. The actuator is shown in the fully-down (beam out) position.

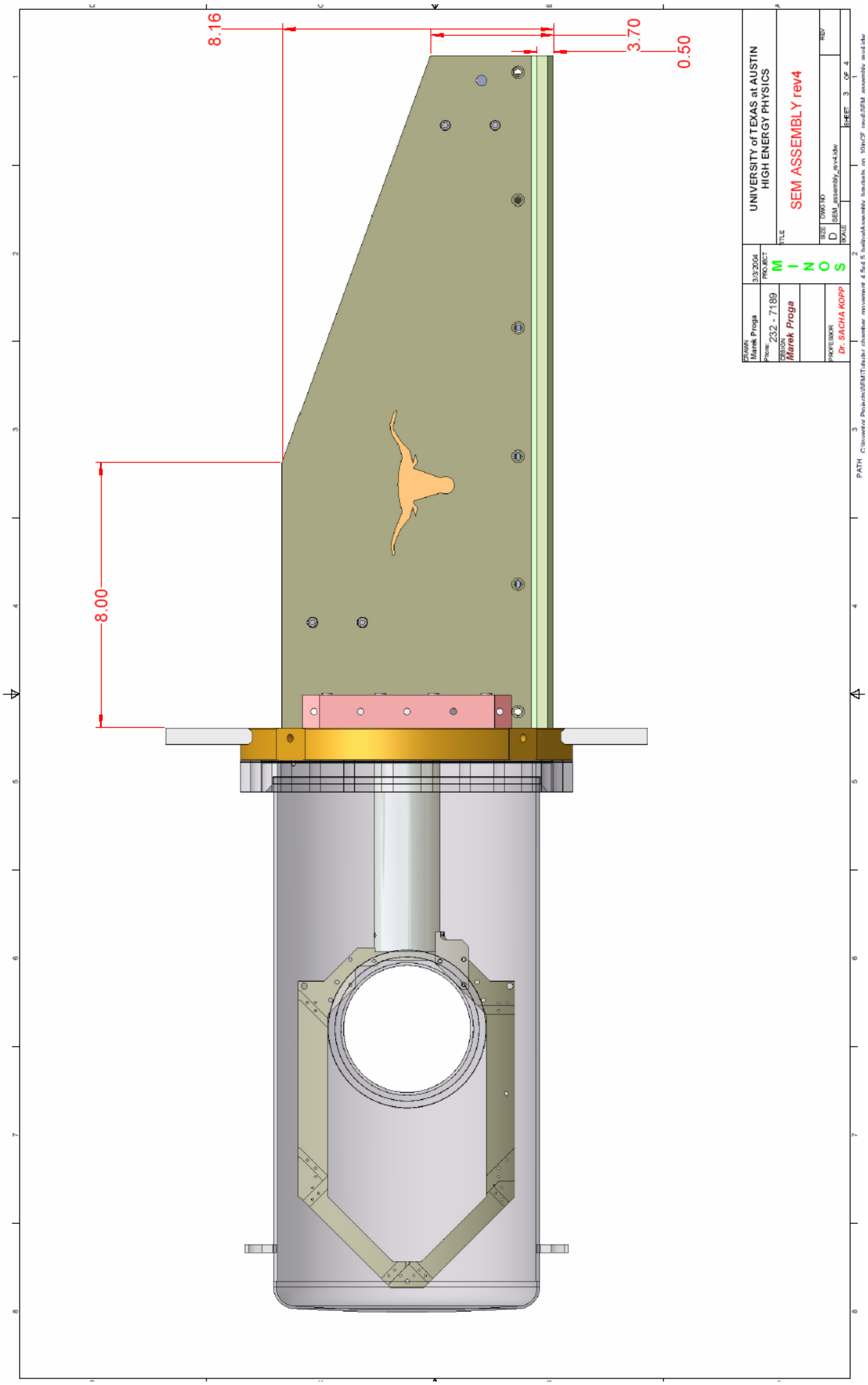

Figure 5: Transverse (beam's eye) view of the UT profile monitor.

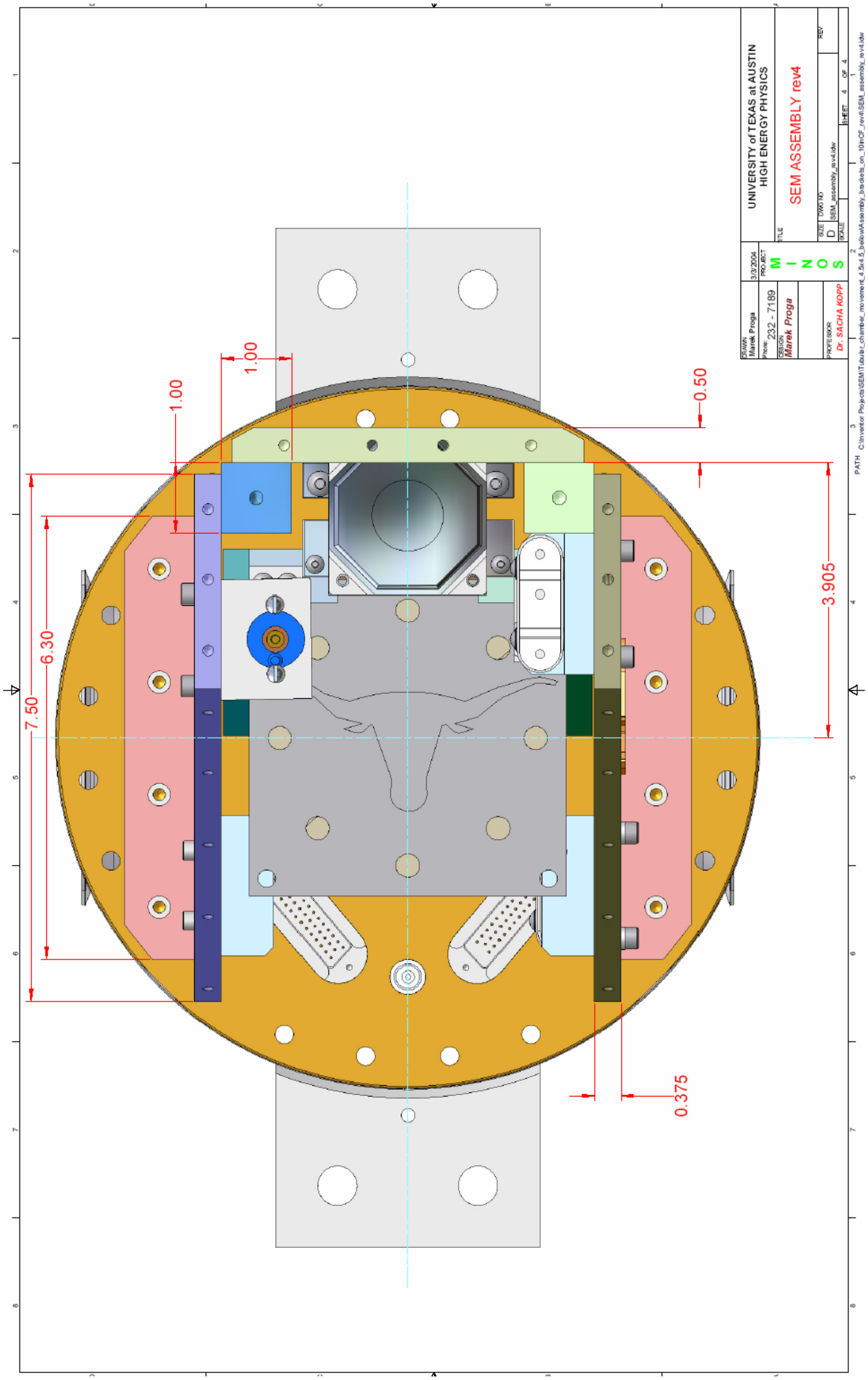

Figure 6: Top view of the profile monitor 10" CF lid. At the top of this view is visible the stepper motor. The longhorn-inscribed plate is the top of the actuator which raises and lowers as the monitor is inserted in the beam. Contacting this plate at the top are a limit switch at its upper-right, and an LVDT at its upper left. Signal feedthrough connectors (50-pin) are mounted in the 10" CF flange.