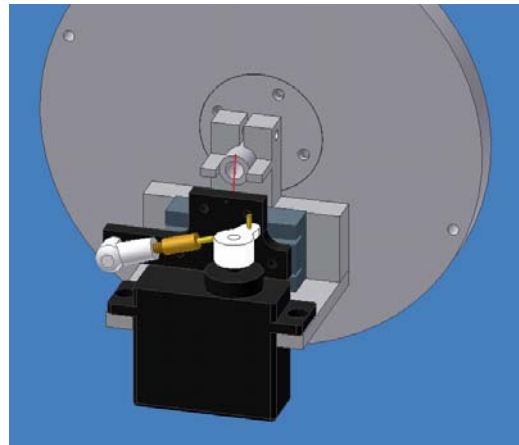


## The Beam Width Probe

The Beam width probe is an optional module that can be added to all versions of the AMS. It is designed to precisely step a wire of a known dimension (typically .3 to .5 mm diameter) across the particle beam path in a controlled fashion inside the vacuum system of the AMS. The resulting attenuation of the particle beam as measured by a decrease in ion intensity for a given mass component yields information on the width of the particle beam. This device has been developed to measure beam widths and to provide a quantitative correction to AMS mass loadings due to less than unit collection efficiency of particles at the detector. In addition, since particle beam widths are related to particle morphology this device will also provide insight to particle shape.

The beam width probe assembly is designed to mount on the 1/4" OD channel aperture located at the end of the TOF chamber (see Figure 1). This design provides an "alignment free" mounting solution as the channel aperture (0.15" ID) defines the beam axis. The beam width probe is fully assembled and adjusted outside of the vacuum system. Installation into the AMS is accomplished by removing one of the 2-3/4 blank flanges at the end of the TOF chamber, sliding the probe assembly onto the channel aperture and tightening the clamping screw. The assembly will operate in any orientation.

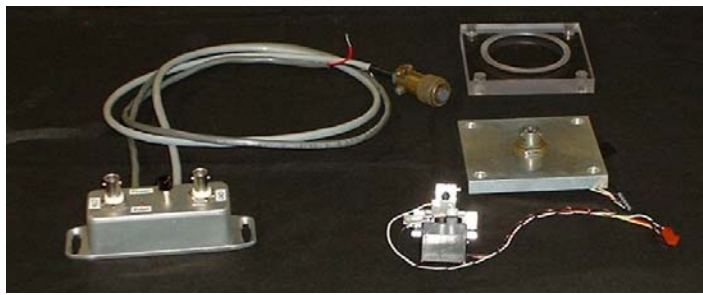


**Figure 1. Beam width probe assembly shows mounting on 1/4"OD channel aperture located on internal flange at end of TOF chamber. Attenuating wire shown in red and torsion springs shown in blue.**

The beam width probe has three components: 1) a power supply/signal junction box, 2) a 2-3/4 (NW63) custom vacuum flange with electrical feedthru, and 3) the probe assembly. The individual components are shown in Figure 2. The probe assembly consists of the attenuating wire that is mounted to a precision linear bearing slide and a stepper motor to position the wire.

### Hardware and Electrical Requirements

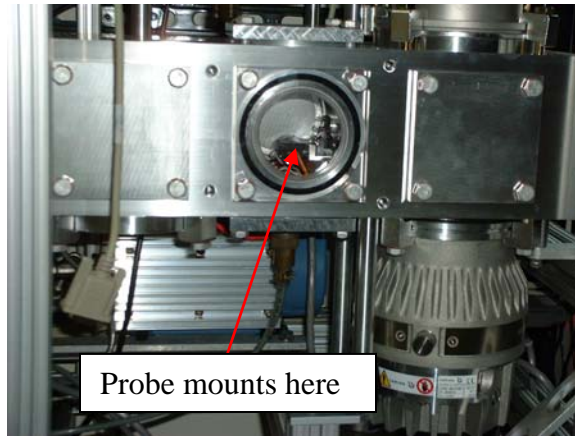
To operate the probe the power supply/signal junction box requires 9-32 DCV input. The two flying leads should be connected to a suitable DC supply in this voltage range. The RED wire is the positive (+) volt lead and the BLACK wire power supply GROUND lead.



**Figure 2. Beam width probe component parts.**

Power (24 VDC) is most conveniently obtained from the screw terminal strip on the AMS which is used for the turbo pumps fans. An external power supply could also be used. Computer control of the moveable wire requires use of one General Purpose Counter (GPCTR) and one Digital Input/Output (DIO) line both of which are available from either the 6110E or 6024E National Instrument boards which are part of the AMS data system. GPCTR0 and DIO0 from the 6024E board are chosen as the default in the software. These signals can be tied to the USER BNCs on the BNC 2090 or BNC2110 interface boards. A BNC cable is used to connect to the appropriately labeled BNC connector (CTR and DIO) on the power supply/signal junction box to the NI board.

This version of the probe assembly is designed to be mounted at the end of the TOF chamber. The clear Lexan flange provides a viewing port but is not essential. The recommended mounting location for the electrical feedthru connector flange is on the bottom port. For systems that include the light scattering module this arrangement will be different as the light scattering components consume this section of the chamber. In this case the electrical feedthru flange will be mounted at the next forward port (see drawings in Appendix I). The suggested mounting location of the power supply/signal junction box is on the front end of the AMS 80/20 frame. *When mounting the assembly in the vacuum system, make sure the wire does not touch the channel aperture. Try to provide ~ 2mm of clearance between the wire and the front surface of the channel aperture.*



## Description of Operation

The movement of the wire is controlled in a semi-closed loop mode. At either end of travel the wire will make contact with a wire stop. The known distance between these two stops (0.252", 6.4 mm) determines the range of motion of the wire. The beam attenuating wire is biased at a TTL "high" level and its voltage level is checked at each new position. When the wire makes contact with the wire stop (which is at ground potential) the TTL level drops to low thus indicating the end of travel has been reached. The software senses this then changes the direction of travel if necessary. The total number of positions or steps between the two feedback points can be determined and as the distance between the two points is known, intermediate wire positions can be calculated/predicted. Fine adjustment of the wire position while under vacuum is set via a software controlled calibration sequence. The red LED on the power supply box indicates the TTL signal level status. When lit (the TTL level is low) this LED indicates the wire is at the off axis position, also referred to as the "parked" position.

Wire movement is computer controlled and operates independently from the AMS data acquisition program. The following discussion describes the wire control interface. The program has two modes of operation: Manual control and Automated control. The

manual mode of operation allows the users to choose the wire position. This mode also provides a calibration sequence that defines the range of motion that the wire can travel as described above. The calibration must be run before activating the automated mode.

The automated movement mode is used in sequence with the AMS acquisition program. In this mode the wire position is stepped at defined time intervals which must be set to the "auto data save interval" in the AMS acquisition program. Each data file output from the AMS program then corresponds to a given wire position. Although neither the AMS acquisition program nor the beam width program "know" one another they both monitor the same system clock and can operate in sequence.

When operated in the automatic control mode the beam width program appends data to a file *wire.dat* under C:\AMS\AMSDATA\AMSLogFiles\. The structure of this file is listed below, there are no headers or footers, it is space delimited.

```

19:32:31 245 70.3510E+03 29 -1 1 0 0 0 7 81 -1.20 9.93
19:32:46 245 70.3660E+03 81 -1 1 0 0 0 7 81 3.00 .00
19:33:01 245 70.3810E+03 37 -1 2 0 0 0 7 81 -0.60 15.49
19:33:16 245 70.3960E+03 81 -1 2 0 0 0 7 81 3.00 .00
19:33:31 245 70.4110E+03 44 -1 3 0 0 0 7 81 0.00 16.93
19:33:46 245 70.4260E+03 81 -1 3 0 0 0 7 81 3.00 .00
19:34:01 245 70.4410E+03 51 -1 4 0 0 0 7 81 0.60 15.49
19:34:16 245 70.4560E+03 81 -1 4 0 0 0 7 81 3.00 .00
19:34:31 245 70.4710E+03 59 -1 5 0 0 0 7 81 1.20 9.93
19:34:46 245 70.4860E+03 81 -1 5 0 0 0 7 81 3.00 .00
19:35:01 245 70.5010E+03 29 -1 1 1 0 0 7 81 -1.20 9.93
19:35:16 245 70.5160E+03 81 -1 1 1 0 0 7 81 3.00 .00
19:35:31 245 70.5310E+03 37 -1 2 1 0 0 7 81 -0.60 15.49
19:35:46 245 70.5460E+03 81 -1 2 1 0 0 7 81 3.00 .00
19:36:01 245 70.5610E+03 44 -1 3 1 0 0 7 81 0.00 16.93
19:36:16 245 70.5760E+03 81 -1 3 1 0 0 7 81 3.00 .00
19:36:31 245 70.5910E+03 51 -1 4 1 0 0 7 81 0.60 15.49
19:36:46 245 70.6060E+03 81 -1 4 1 0 0 7 81 3.00 .00
19:37:01 245 70.6210E+03 59 -1 5 1 0 0 7 81 1.20 9.93
19:37:16 245 70.6360E+03 81 -1 5 1 0 0 7 81 3.00 .00
.
.
.
19:37:31 245 70.6510E+03 29 -1 1 2 0 0 7 81 -1.20 9.93

```

The above data is printed from the following VB code with 5 steps per pass selected.

```

Open "c:\ams\amsdata\amslogfiles\Wire.dat" For Append As #1
Print #1, Format(Now, "hh:mm:ss ");
Print #1, Format(JulianDay(Now), "##### ");
Print #1, Format(SecondsAfterMidnight(Now), "###.###0E+00 ");
Print #1, Format(ServoPos%, "###0 ");
Print #1, Format(ServoDirection%, "##0 ");
Print #1, Format(StepNum%, "##0 ");
Print #1, Format(NumCycle#, "#####0 ");
Print #1, Format(State%, "##0 ");
Print #1, Format(BeenThere%, "##0 ");
Print #1, Format(Val(MinPos.Text), "##0 ");
Print #1, Format(Val(MaxPos.Text), "##0 ");
Print #1, Format(Pos_mm, "##0.#0 ");
Print #1, Format(Atten, "##.#0")
Close #1

```

When the Moveable wire program is operated in the auto control mode the variables *JulianDay* and *SecondsAfterMidNight* should be identical to the corresponding values saved by the AMS program when it is operating in the auto save mode allowing the data

to be temporally aligned. The variable *ServoPos%* is the position of the wire. The maximum range of this number is between 0-100 and is an integer, the actual range is determined by the calibration routine, typically 10-90. The difference between the minimum and maximum values of *ServoPos%* defines the distance traveled in these digital units. The actual linear distance can be computed from the known distance between the wire stops (*distance between the stops (6.40 mm) less one wire diameter*). The variable *ServoDirection%* has the value 1 or -1 and indicates the direction of travel. The variable *NumCycles#* indicates the total number of passes the wire has made across the particle beam. At each new start of the program or activation of the auto control mode "Start Process" button (see below) this variable is reset to zero. The file parameter *Pos\_mm* is the wire position in mm with respect to the chosen center position. *Atten* represents the percent attenuation or wire coverage of the 3 mm diameter projected heater area at the position of the wire. For simplicity, it assumes a uniform and homogeneous particle beam.

Data is written to the file *wire.dat* after the wire is moved. As a result the AMS data file that is saved at the same point in time that the wire is moved corresponds to the wire position saved one step earlier within this file.

### Beam Width Control Program

The software program that controls the movement of the wire is introduced below. There are three views or form sizes that show or hide certain aspects of the control program. The blue button at the top of the Automated Control panel toggles the different views. *Before installing the probe assembly in the vacuum chamber it is recommended to operate the probe "on the bench" to become familiar with how the assembly responds to the various software commands.*

**Figure 3. Full program form view showing Automated Control, Calibration and Manual Control and NI board parameters. Blue button toggles between different form sizes.**

Control of the moveable wire requires use of one General Purpose Counter (GPCTR) and one Digital Input Output (DIO) line both of which are available from either the 6110E or 6024E National Instrument boards which are part of the AMS data system. GPCTR0 and DIO0 from the 6024E board are chosen as the default. These parameters can be changed when the full size form is displayed. These are volatile variables. When the program is restarted values other than the default will need to be re-entered. In a later version of this application (after it matures) these variables may be written to a parameter file so they will be saved/reloaded at each new start.

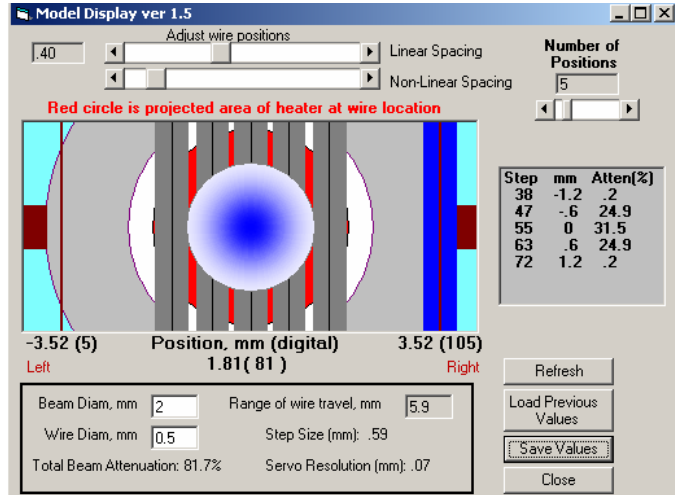
Figure 3 shows the full size form. This view is used to change default values needed to access the National Instrument board and set the movement mode of wire. . Generally, the full size view need not be displayed. The default display is shown in Figure 4.

**Figure 4. Program form view showing Automated Control and Calibration and Manual control features.**

When the program is first started the calibration sequence needs to be initiated by pressing the “Calibrate Travel” button. This routine finds the range of digital steps between the two wire stops and must be run prior to the operating the automated control mode. This routine first puts the wire in the approximate center then takes single steps checking for closure of the digital line after each step. Values for the variables “Left”, “Right”, “Center”, and “Total” are determined as the wire is moved to the left and then to the right. Values for “Left”, “Right” and “Center” can also be input/changed by the user. *If values for "left" or "right" are outside the range of travel (0-100, respectively), the calibration routine will return an error indicating that the assembly will need to be adjusted outside of the vacuum.*

Also within the Calibration and Manual Control window one can move the wire position to “Edge” or “Center” defaults or to a user defined “Goto” position. In addition the wire can be stepped in either direction with a step size between 1 and 20. Note that the "Center" position is the calculated center and not necessarily *exactly* where the particle beam is. Manually stepping the wire while looking at a particle signal (or air beam) may give a different "Center" position. Differences here may indicate that the lens needs slight adjustment of alignment.

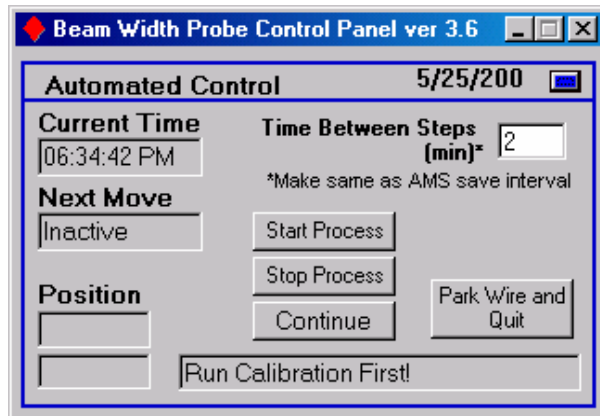
At the end of the calibration procedure the Model Display form is called ("Show Model" button). This display gives a model view looking down the beam axis showing default wire positions, wire thickness, aperture diameter and particle beam diameter. This routine is used to adjust the number of steps and the step size around the center position by clicking on the scroll bar at the top of the display. The red circle is the projected area of the 3.8 mm diameter heater at the location of the wire. As the wire positions are changed they are displayed on the right hand side window. The attenuation values also displayed are with respect to the input beam diameter size, not the effective beam diameter (red circle) as is saved in the data file. Note that as the wire positions are changed the center position is not altered. The center position can be changed by entering a new value in the Calibration and Control input section. The total number of steps is set by the user in this form. Current thinking suggests that the two outer most wire positions should be just within the beam area (red area) as shown in the figure. The dark red squares on the left and right hand side represent the wire stops that are machined into the assembly (6.40 mm between stops). The red vertical lines are the "Right" and "Left" edge wire positions. After selecting the wire positions click the *Save* button. These values are written to the file "c:\ams\amsdata\autosavedata\wire\_positions.dat" and can later be reloaded with the *Load Previous Values* button. *Unreasonable values for selected wire positions will be displayed in the table in red text and are not accepted.*



**Model display. Outer gray circular area is channel aperture structure. Inner white area is entrance aperture to detector. Center circle represents particle beam diameter and vertical gray bars show programmed wire positions. Red blocks are wire stops.**

### Automated Control

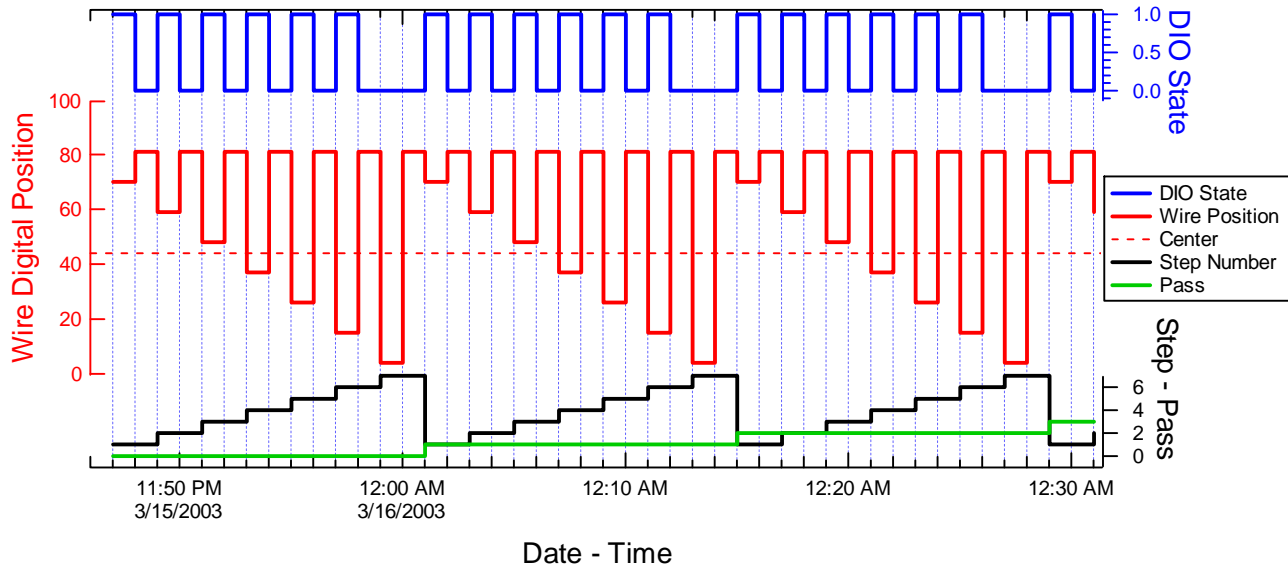
After the wire travel is calibrated and step positions are selected inside the Model Display form the program is ready to be operated in the Automated Control mode. At this point it is assumed that the AMS program is in the AutoSave mode logging data as typically done. The user next needs to set/enter the step interval, or Time Between Steps. This variable must be set to the same



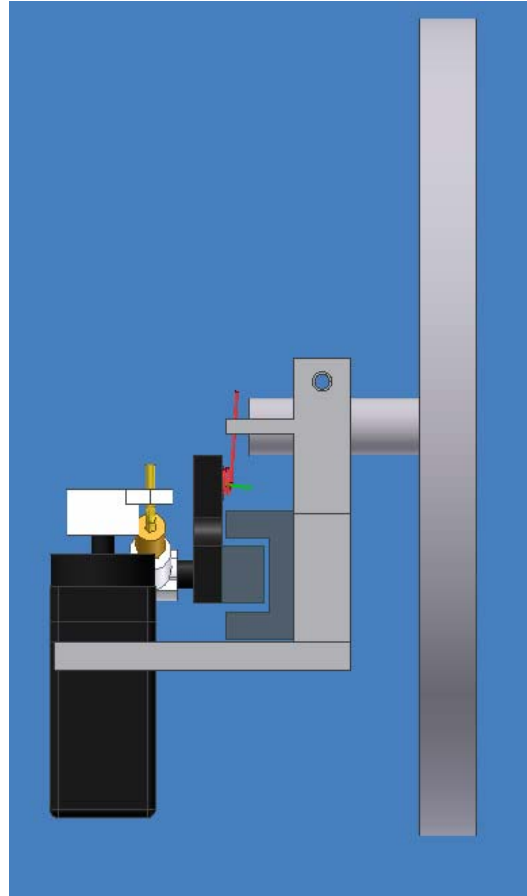
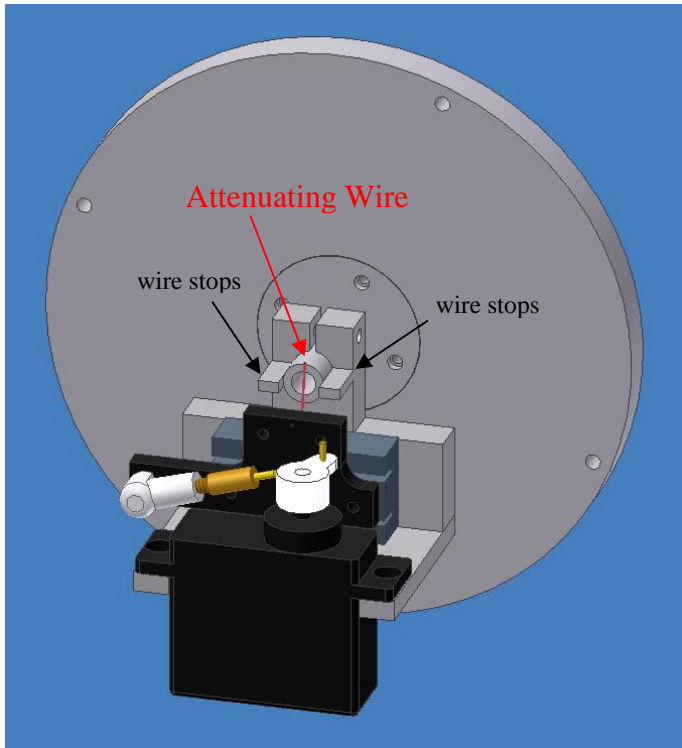
**Figure 5. Program form view showing automated control features.**

value that the AMS program is auto saving data at. At this point the users should press “Start Process” button which moves the wire to the edge and begins the process from the edge position. The wire will now be stepped at each AMS data save and the total number of passes across the beam path will be counted and displayed. The file “Wire.dat” will be created if it does not exist and data will appended to it listing the various parameters described above. If the file already exists, data will continue to be appended so this file will need to be edited or maintained.

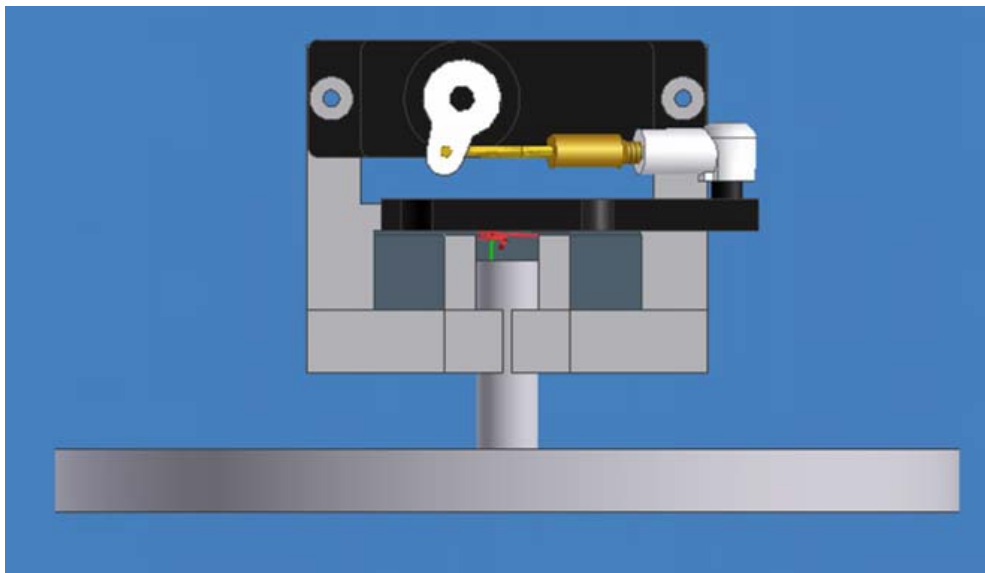
Automated movement in the default "Alternate" wire movement mode (see Figure 3) begins by first moving the wire to the edge until the digital line goes low (0 value). The first step moves the wire towards the center of the beam. The second step moves the wire back to the edge (off axis) and the third movement advances the wire to the second step position (beyond the first step), etc. Information that describes the wire position and movement is recorded in the *wire.dat* output file. A graphical example of how the wire is moved in the Alternate mode is shown in the figure below. In the Alternate movement mode the particle beam is potentially blocked only 50% of the time. One can also chose to operate the automated wire movement control in a continuous mode by selecting "Continuous" in the full form view (see Figure 3). In the Continuous movement mode the preprogrammed wire positions are stepped through without "alternately" returning to an edge position.



**Example of plotted program output illustrating movement of beam width probe in Automated Alternate movement mode. Three passes are show with seven steps per pass and one minute between steps selected.**

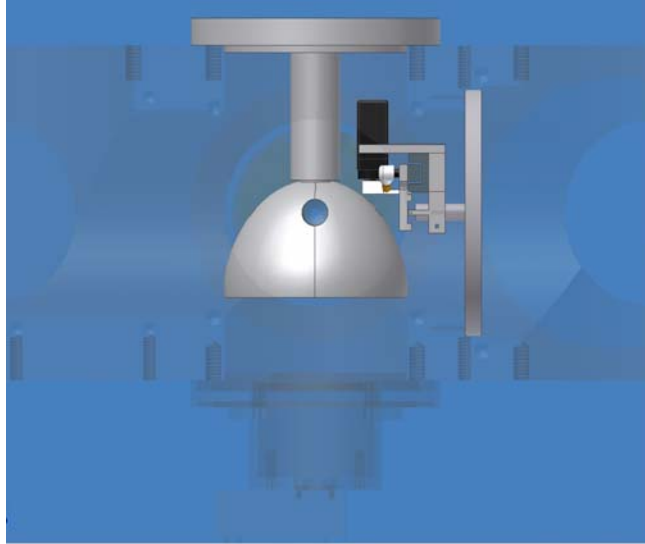


**Additional views of Beam Width Probe assembly mounted to channel aperture. The attenuating wire is spring loaded to prevent deformation from possible servo override.**

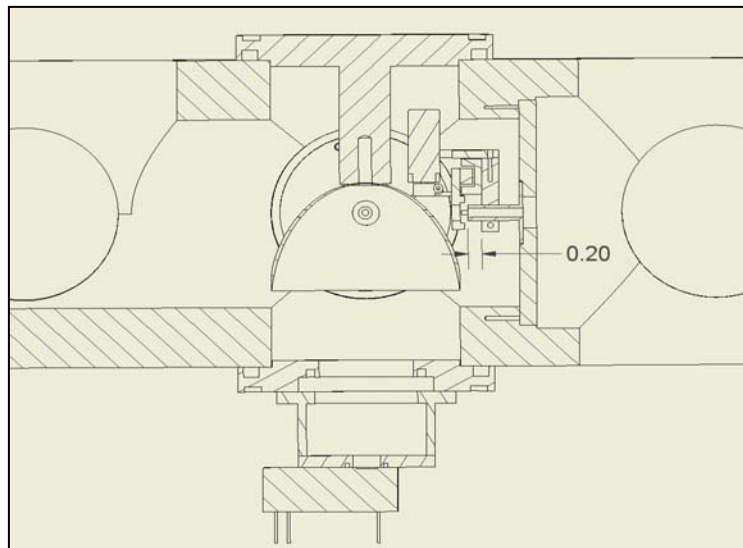




**Appendix I.** Incorporation of beam width probe with light scattering module.



**Figure 5.** View showing the moveable wire assembly mounted with the light scattering module.



**Figure 1.** Cross-sectional view showing moveable wire assembly installed with light scattering module. Beam probe assembly must be  $>0.20''$  down from channel aperture face. The procedure for this installation requires that the beam width probe be installed first (before light scattering parts). The elipsoid and its mounting flange are next installed in separate pieces.