LAr TPC Wire Experiments

B. Hansen

Short Wire Experiments

1.) Feasibility and Accuracy of Determining Tension Via Frequency.

2.) Tension verses Displacement Experiments.

3.) Liquid Nitrogen Cool Down Experiments.

Motivation

- To begin to understand the mechanical and technical challenges of tensioning and stringing 4 mil wires and their survivability during the cool down phase of the experiment.

1. Feasibility and Accuracy of Determining Tension Via Measuring Frequency.

- From Classical Mechanics:

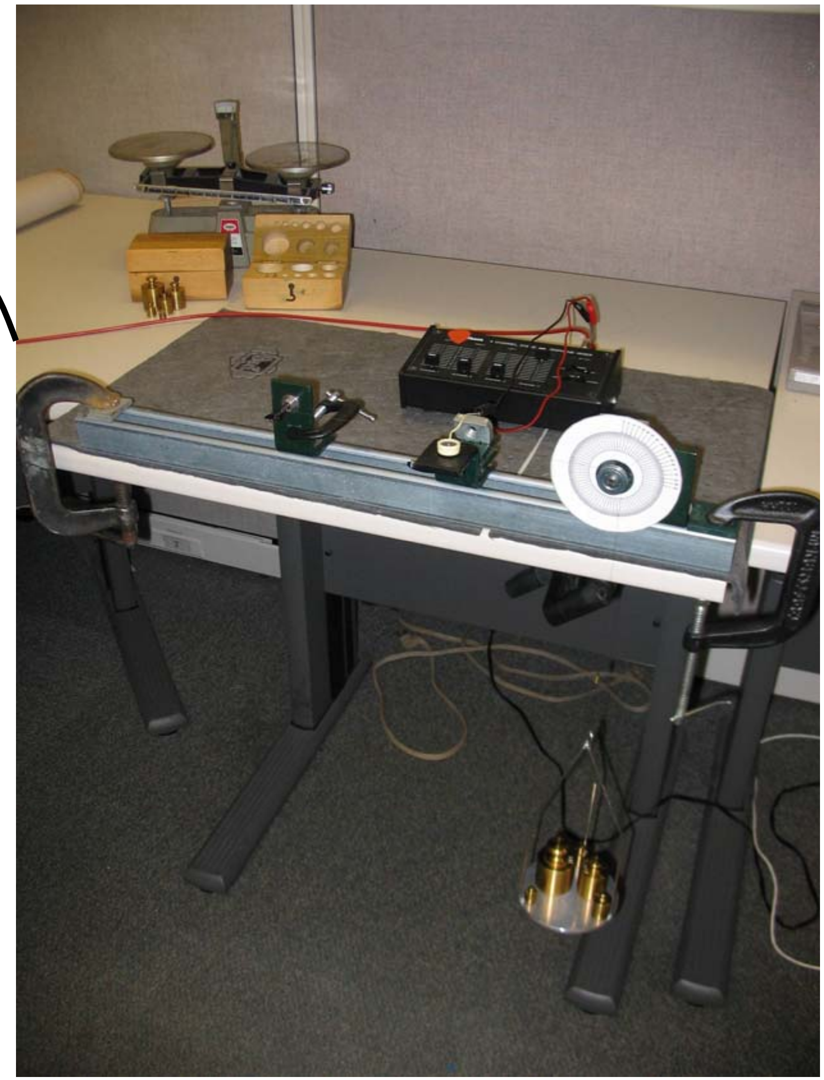
$$f_n = \frac{1}{2 \cdot L}\sqrt{\frac{T}{\mu}} \longrightarrow f_n = \frac{1}{d \cdot L}\sqrt{\frac{T}{\rho \cdot \pi}}$$

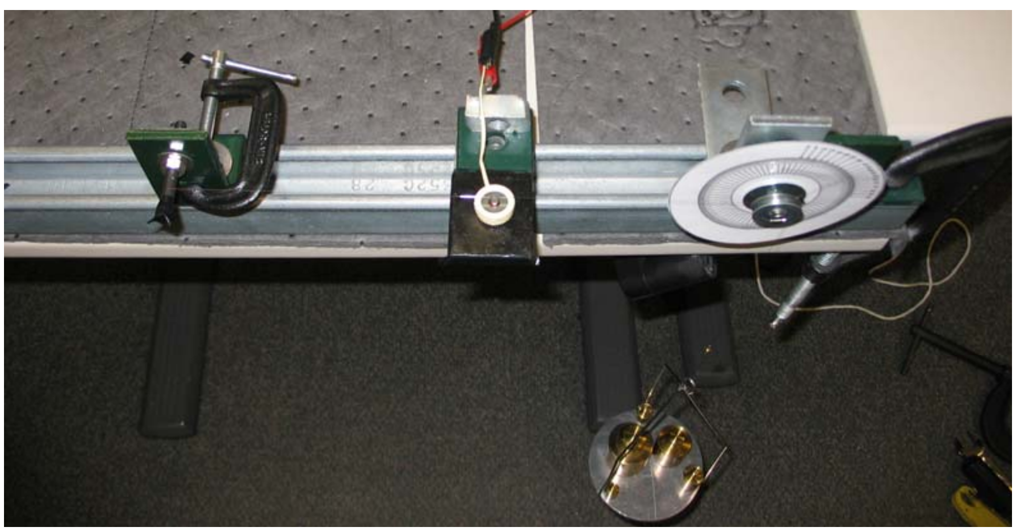
- Where the actual diameter of the wire was measured to be 3.85 mils.
- For increased accuracy Poissons ratio with theoretical displacement in length is used to find deflection in diameter.

$$\delta_l = \frac{PL}{AE}, \nu = \frac{\varepsilon_d}{\varepsilon_l} = 0.3$$

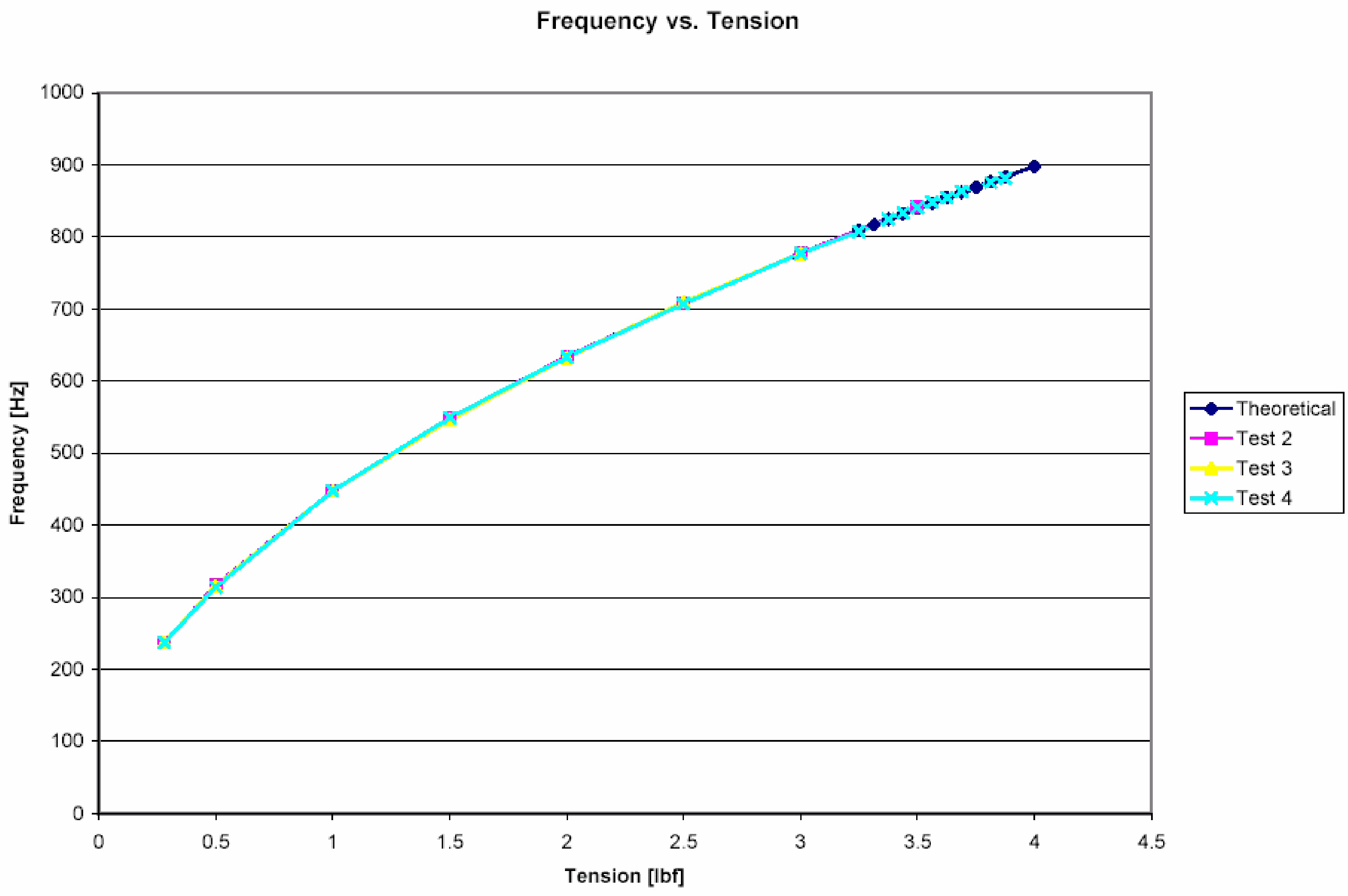
Test Setup

To Computer





Results



Frequency vs. Tension
Frequency [Hz]
1000
900
800
700
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Tension [lbf]
Theoretical
Test 2
Test 3
Test 4

Results

- For Experimental Error;
  Root Mean Squared: RMS = 0.19

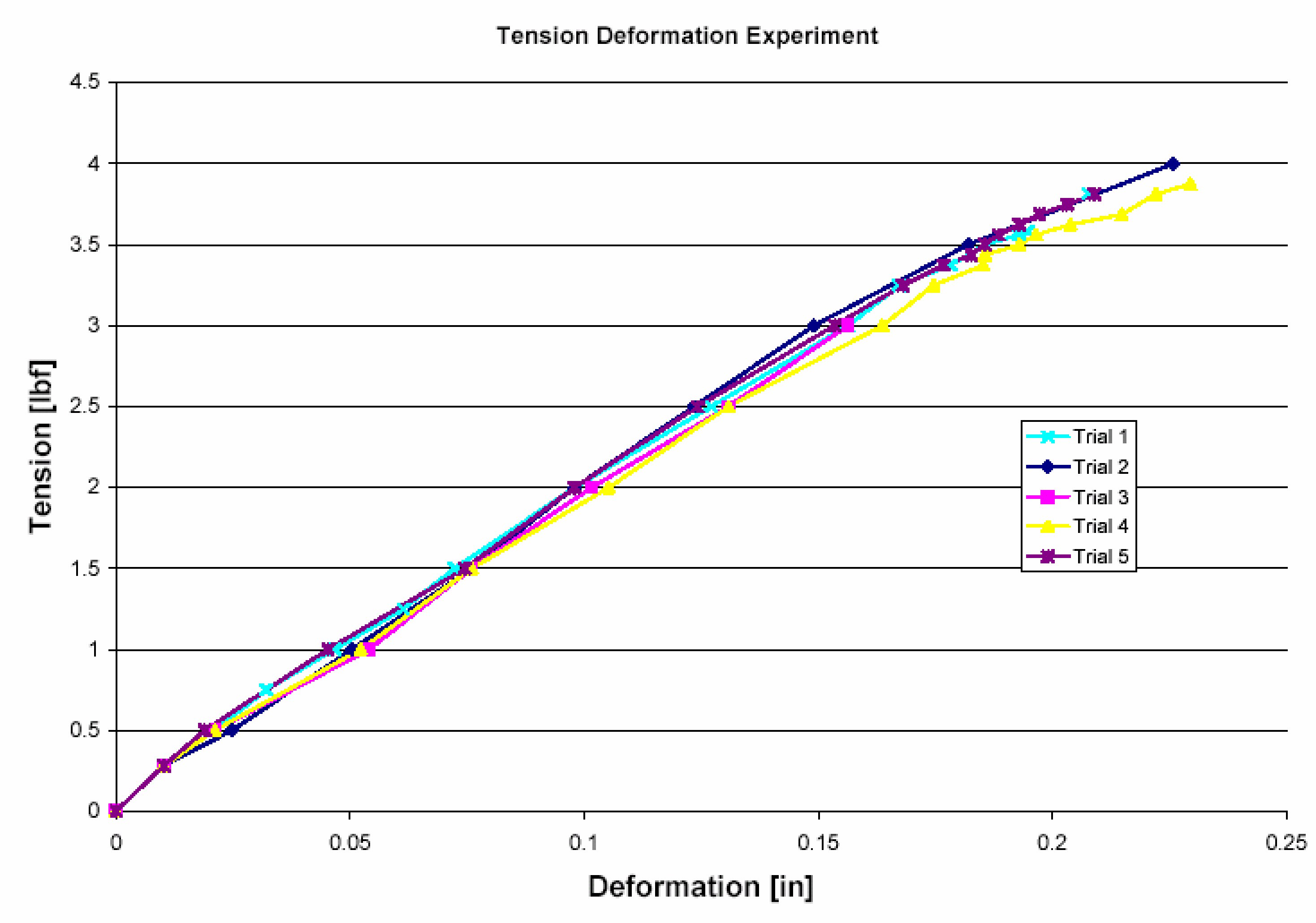
Conclusion

- Tension in a wire can be accurately predicted by measuring the frequency of vibration.
- Predictions in the inelastic region have little effect on accuracy since change in Young's modulus is small.

2. Tension versus Displacement Experiments

- To verify the specified yield point, T = 3.5 lbf.
- By measuring the amount the wheel rotates after each increment of mass.
- Angle of rotation is directly converted to deformation in wire.

Results



*A Small change in Young's Modulus visible at T = 3.5 lbf (yield point).

3. Liquid Nitrogen Cool-Down Experiments.

- The increase of tension in the wires due to thermally contracting faster then the support vessel may cause the wires to yield or break.
- Theoretical increase in tension during cool down: 0.896 lbf.

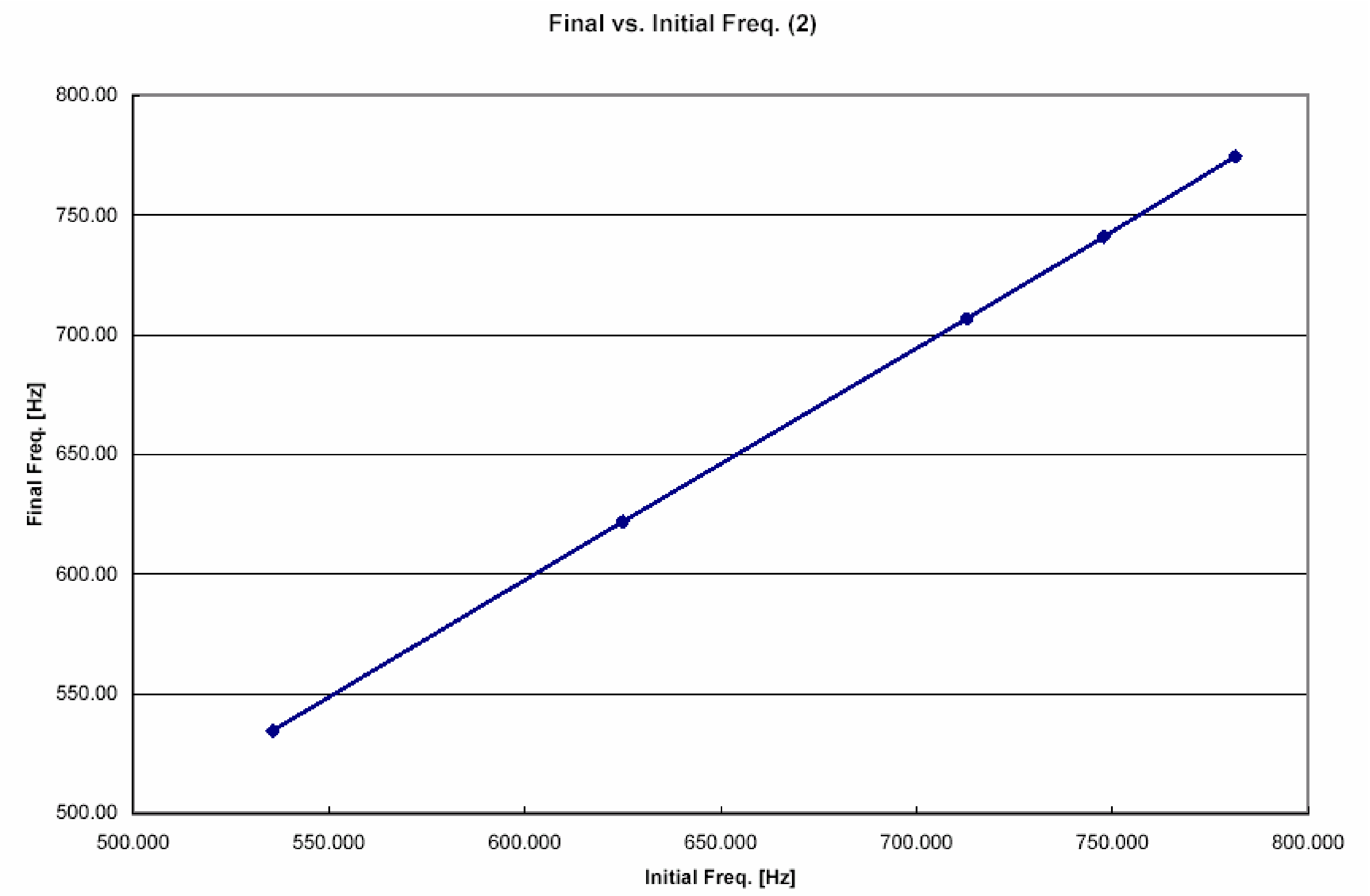
Experimental Setup

- Wire Holder with wire test sample lengths of 11.26”. Wire is fixed at ends by clamping two pieces of metal together.
- Vice Grip to hold Wire Holder vertically upward during tensioning.
- Tapered pin and hole to loop the wire, and hook mass holder to it.
- Mass holder and masses for adding tension.
- Apparatus for measuring frequency.
- Open liquid nitrogen bath.

Experimental Procedure

1. Tension the wire to a desired initial tension, by first clamping one end and then hanging weight from the wire and clamping the other end.
2. Measure the frequency of vibration and calculate the corresponding tension.
3. Dunk the wire into liquid nitrogen for a few seconds, remove and allow apparatus to warm up.
4. Measure the new frequency of vibration and calculate the corresponding tension.
5. Discard tested wire and repeat steps for new wire but at elevated tension.

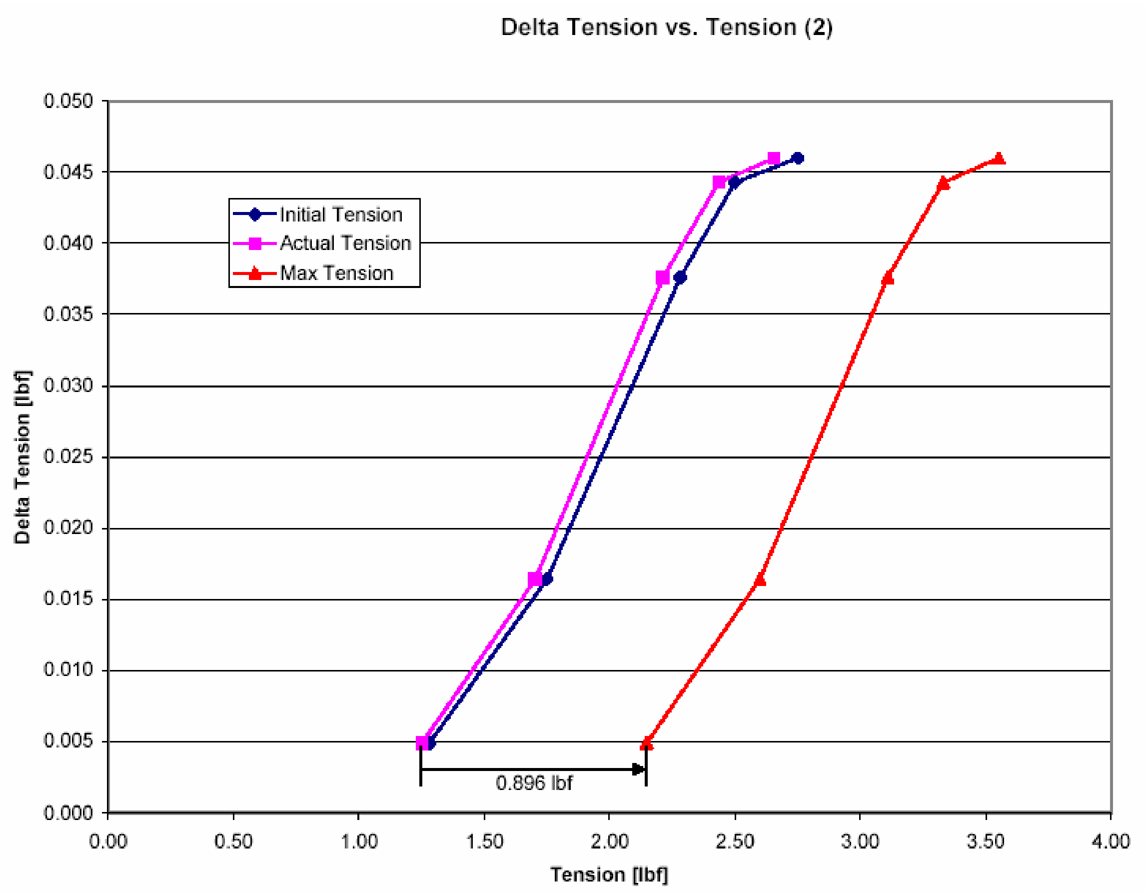
Results



Final vs. Initial Freq. (2)
800.00
750.00
700.00
650.00
600.00
550.00
500.00
Final Freq. [Hz]
500.000
550.000
600.000
650.000
700.000
750.000
800.000
Initial Freq. [Hz]

Results Cont.

- Initial Tension, is the tension created by the mass holder before clamping the wire into place.
- Actual Tension, is the tension measured after clamping.
- Max Tension, is the theoretical maximum tension the wire experienced during cool down.



Max Tension = Actual Tension + 0.896 lbf

Results cont.

- Wire snapped during cool down when at an initial actual tension of 2.86 lbf and a corresponding maximum tension of 3.756 lbf.

- Tension loss from fixing the ends, (6 – 20 Hz) or (0.03 – 0.14 lbf).

- Tension loss from cool down, (1 – 7 Hz) or (0.005 – 0.05 lbf).

Conclusion

- The change in slope may be due to going beyond the yield point - more data in this region should be taken.
- It is believed that the stress concentrations and/or slipping at the ends, is the main cause for the tension drop during cool down.
- A larger tension drop occurred from fixing the ends then from cool down
- The same experiment should be conducted with other methods of fixing the wires.

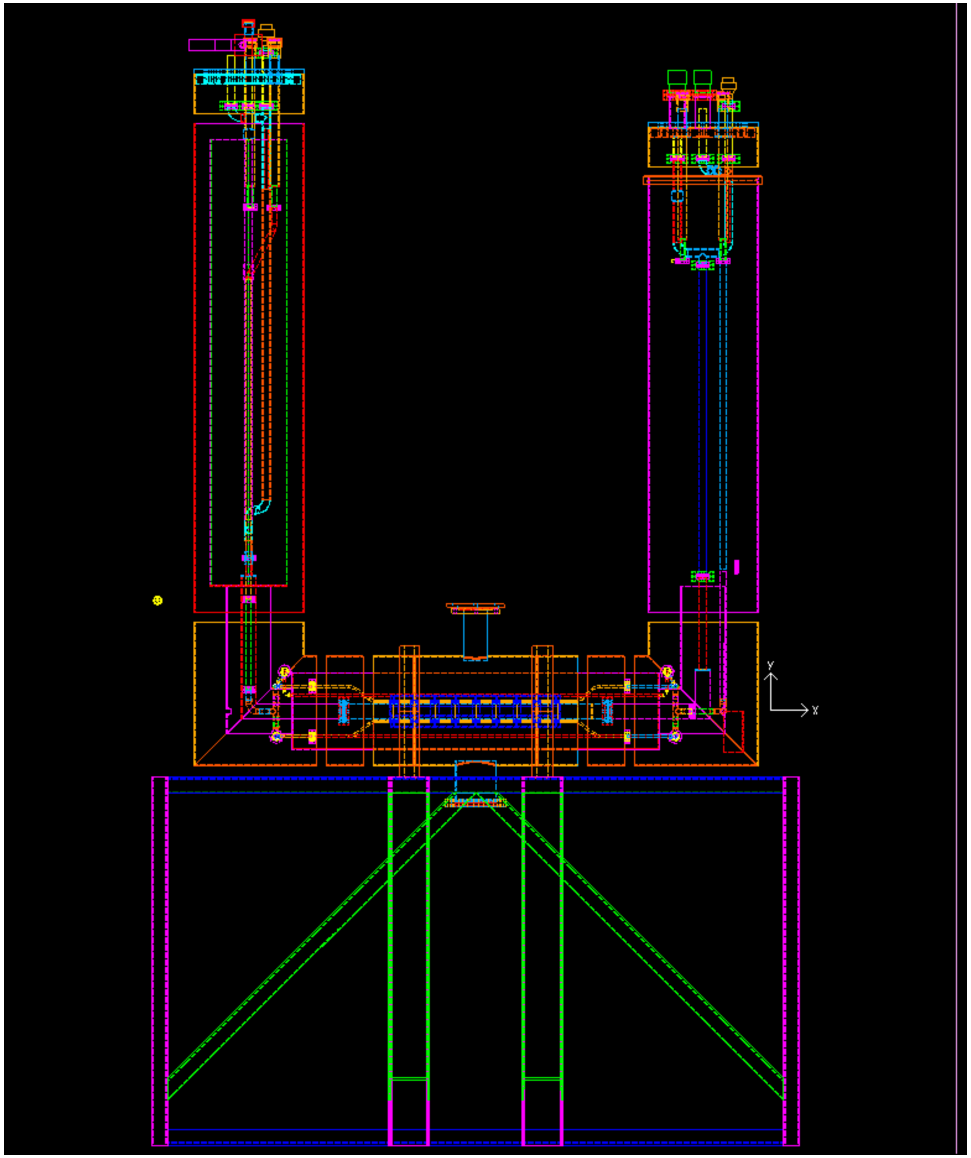
Cryostat for Long Wire Tests

- Requirements
- Conceptual Design
- Future Work

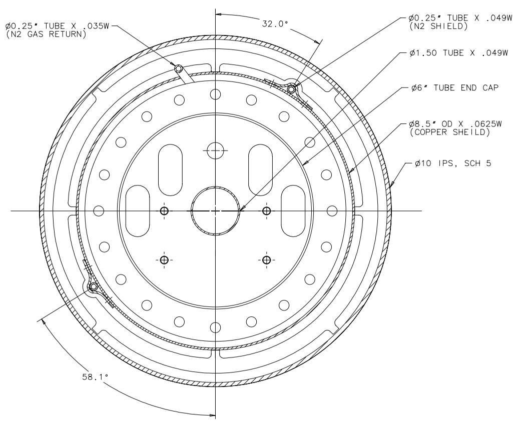
Requirements Goals

- Provide a near perfect liquid cryogenic environment for a matrix of 50 wires starting at 10 ft in length.
- Modifiable to accommodate wire lengths approaching 100 ft.
- Wire chamber easily accessible for repairs and adjustments.
- The option to create a less stable cryogenic environment.
- Use existing material and parts wherever possible.

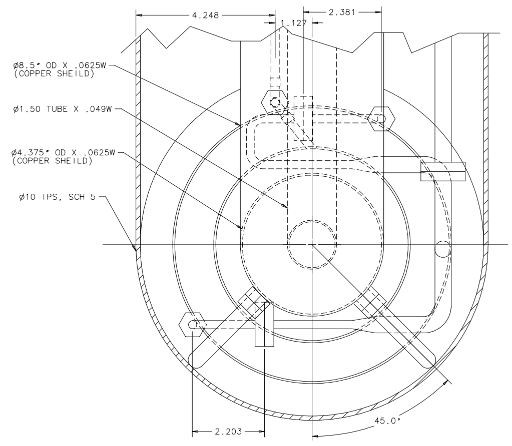
Original Assembly



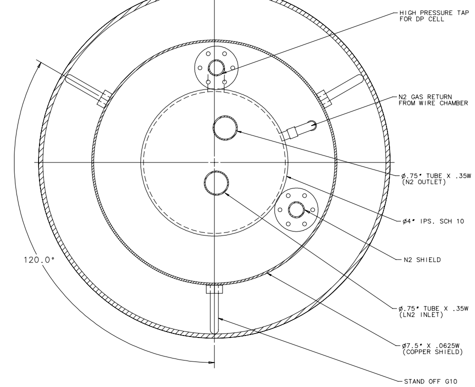
REV	DESCRIPTION	DRAWN / DATE APPROVED / DATE



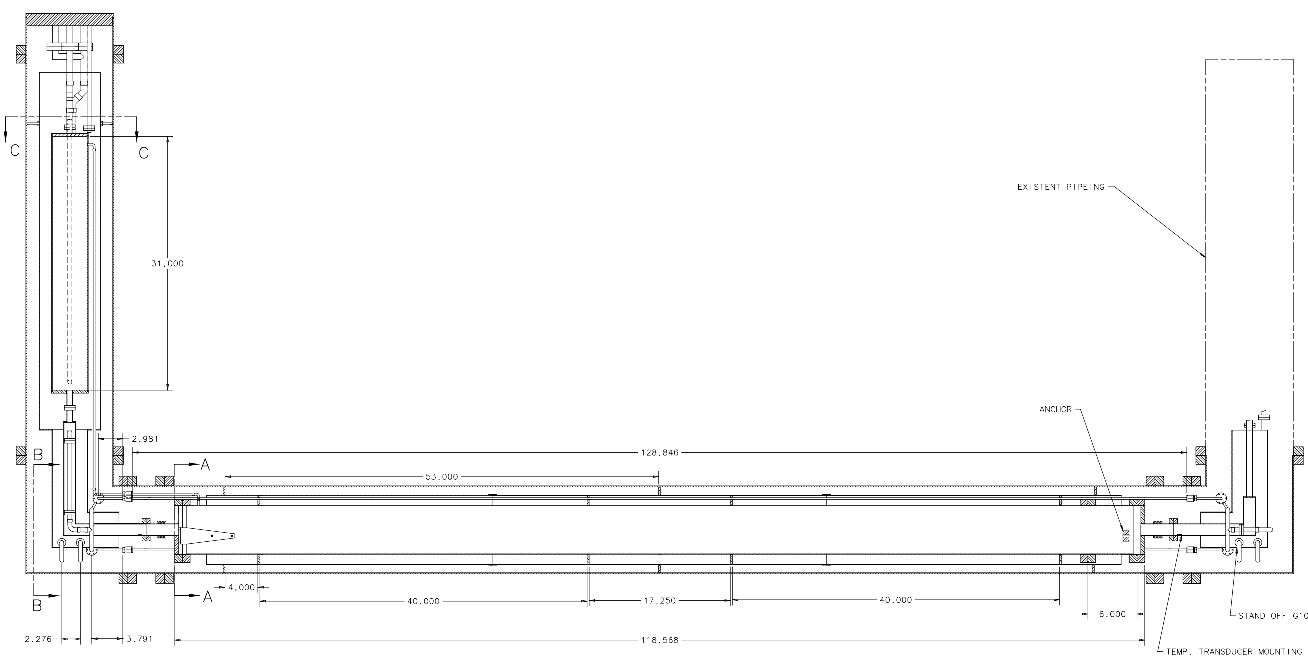
SECTION A-A



SECTION B-B



SECTION C-C



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY
BILL OF MATERIAL			

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	?	00/00/01
.XX	.XXX	ANGLES	DRAWN	?	00/00/01
± .02	±.005	± .5°	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON Asme Y14.5M-1994 4. MAX ALL MACH SURFACES 125			APPROVED		
			USED ON 1650-M- ITEM		
			MATERIAL SEE BILL OF MATERIAL		

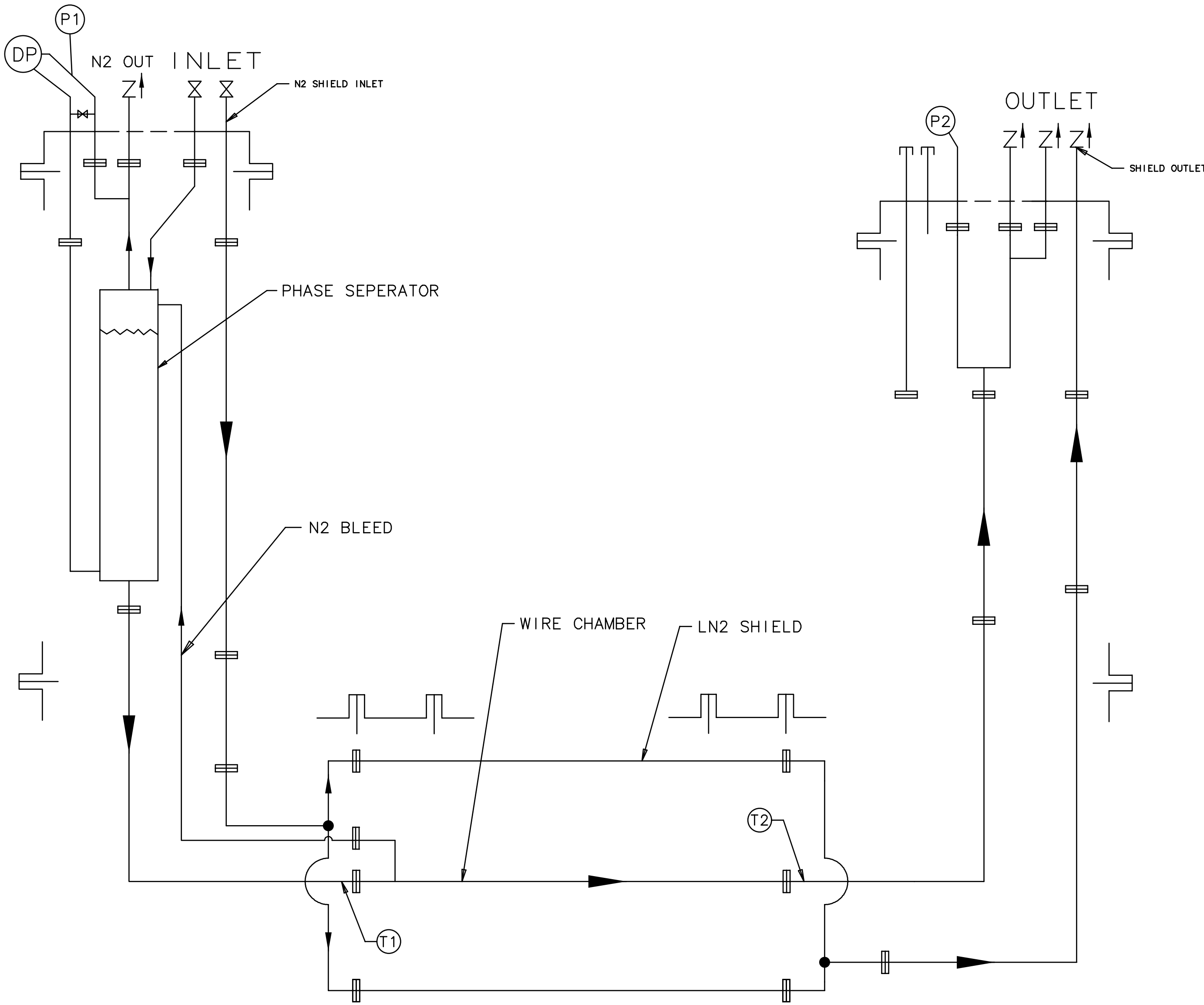
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

BEAMS CRYOGENIC SYSTEMS
FLARE WIRE CHAMBER
ASSEMBLY

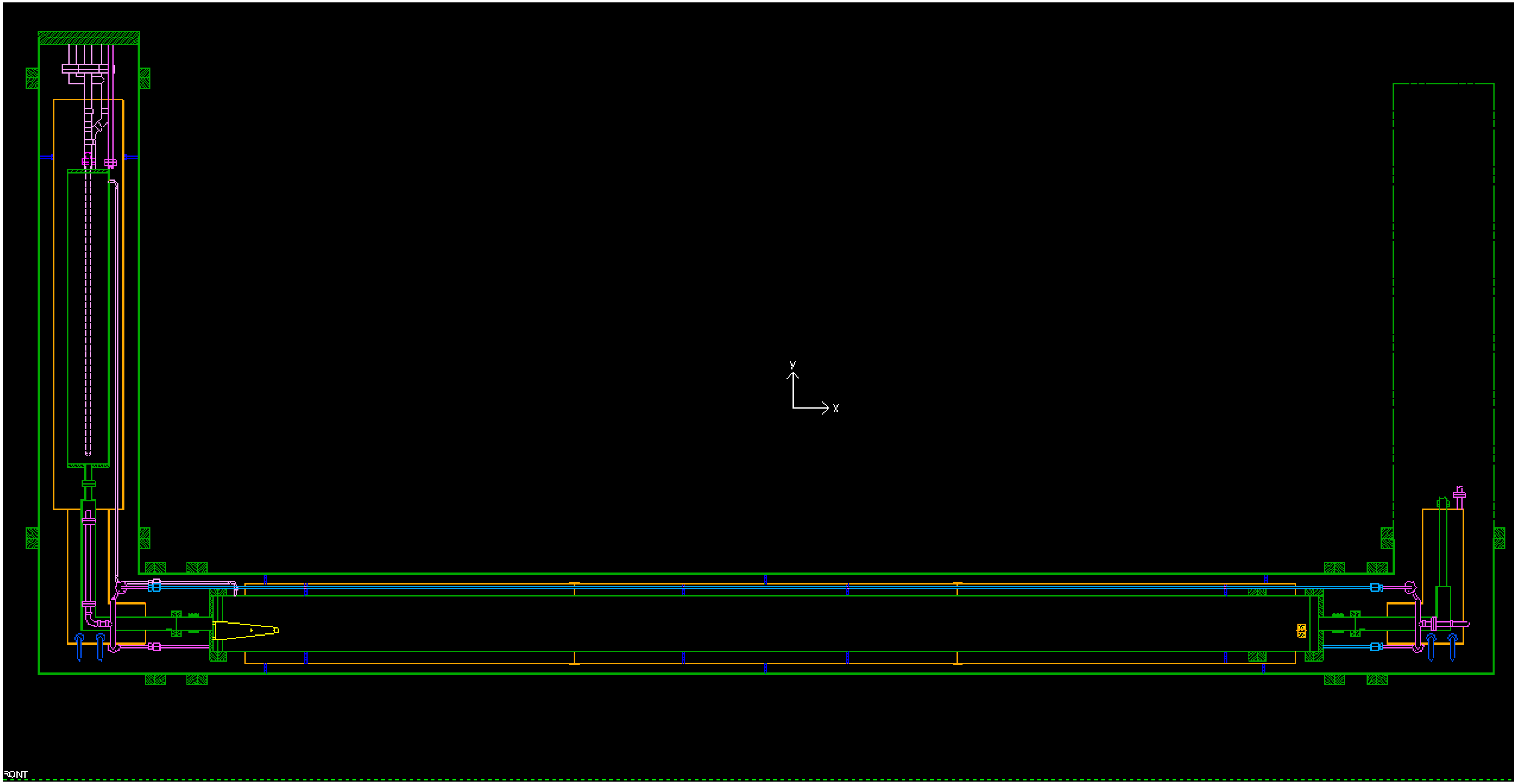
SCALE	FILMED	DRAWING NUMBER	REV
FULL		1650-ME-XXXXXX	

CREATED WITH I-DEAS 8m2

Flow Schematic



Cryostat Assembly



Cryostat Characteristics

- Utilizes a phase separator and nitrogen shielding to insure that the wires are always fully emerged in a stable cryogenic environment.
- The nitrogen shield can be turned off to test the effect of a noisier cryogenic environment.
- Rotatable Flanges allow to test various wire orientations.
- Flange positions allow for easy access to wire chamber.
- Modifiable to accommodate longer wire lengths.
- All piping diameters are less then or equal to 6".
- Made mostly of existing parts and available materials thereby minimizing cost.

Future Work

- Heat Leak and Relief Calculations
- Parts List and Detailed Drawings
- Data Acquisition, Transducers and Electrical Setup
- Fabrication

Thank You