Vibrating Wire Monitor for Beam Profiling

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Outline

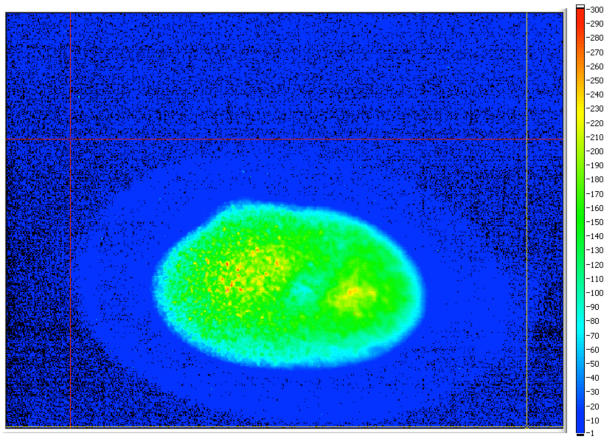
- Introduction
- Beam Halos
- Beam Measurement Devices
- Vibrating Wire Monitor
- Characterization
- Results
- Problems
- Future
- Acknowledgements

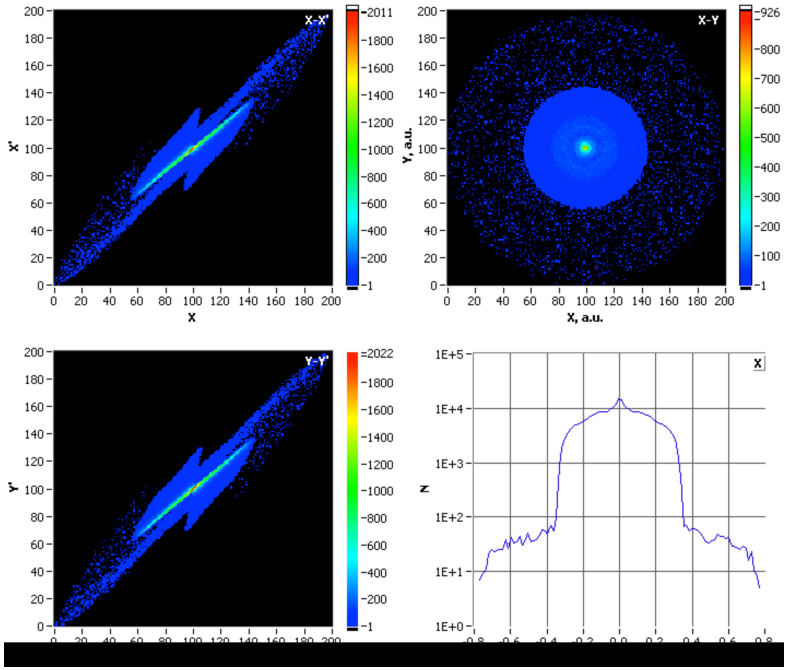
Introduction

- Large Aperture Vibrating Wire Monitor (VWM)
- Bergoz Instruments
- Monitoring of Beam Halos
- PXIE, PIP-II, Main Injector, and other beam lines
- Goals:
  - Documentation
  - Characterization

Beam Halos

- Repulsive space-charge forces
- Beam Loss
- Radioactivity
  - Time and Money
- High-intensity beams
  - More particles = More data

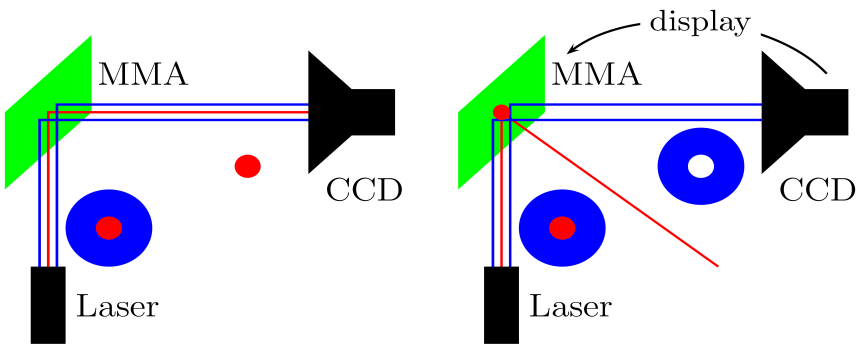




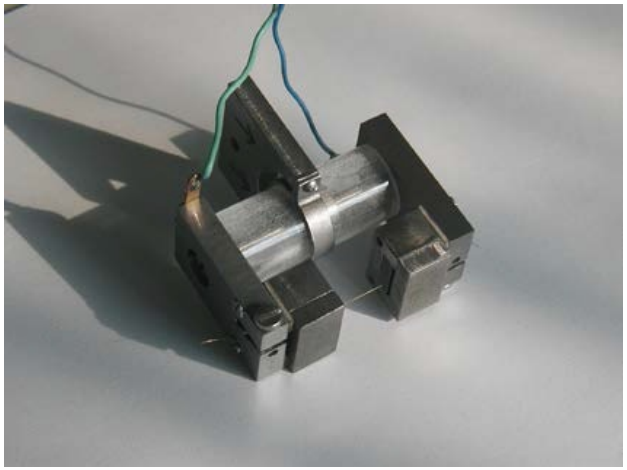
Source: http://newsline.linearcollider.org/

Beam Halo Instruments

- Charge injection devices (CID)
- Charge coupled devices (CCD)
- Optical transition radiation
- Micro mirror array
- Wire Scanner
- Single Wire VWM



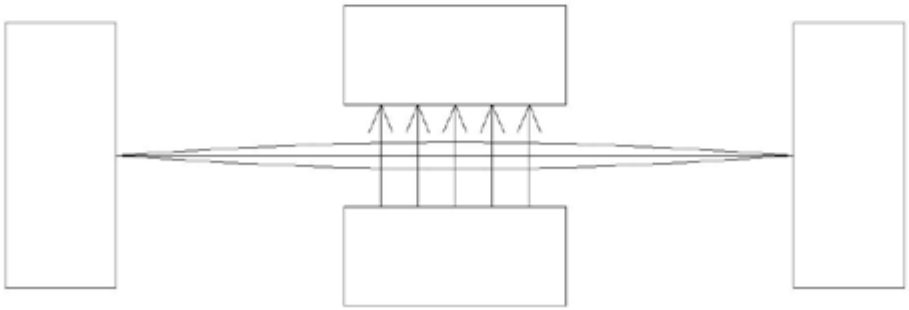
(a) Laser profile measurement (b) display beam core on MMA

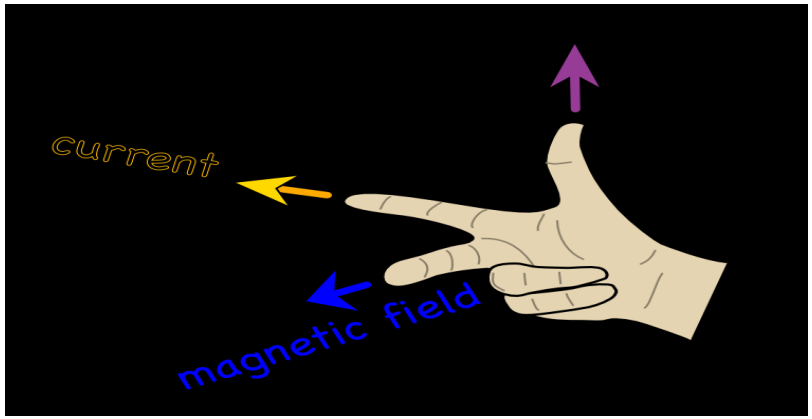


Source: J. Egbertsa and C.P. Welsch, Suren Arutunian, Yerevan Physics Institute, Armenia

Large Aperture VWM

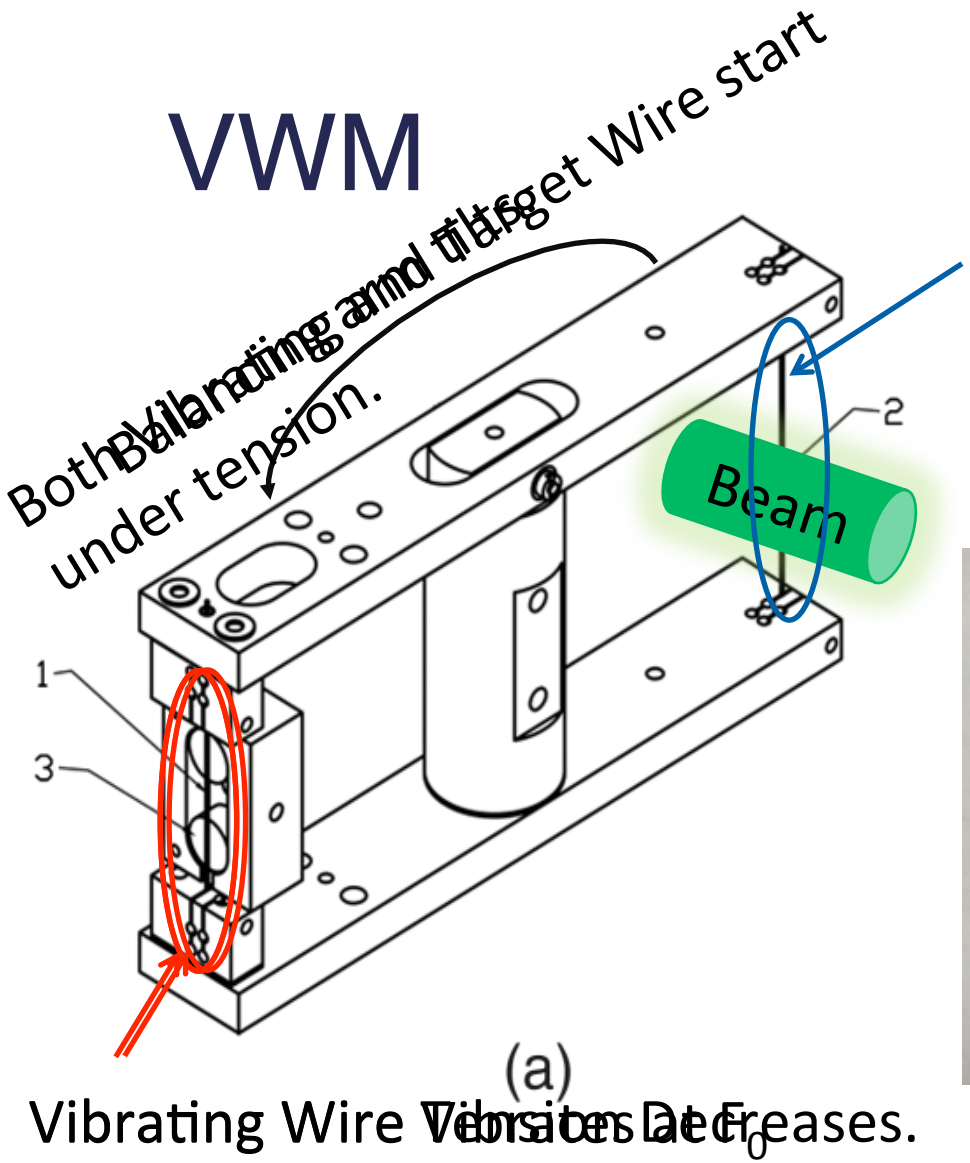
- Two Wires
- Vibrating Wire
  - Magnetic Field
    - Samarium Cobalt
    - 0.5-0.7 T
  - Alternating Current
- Target
  - Response Time
  - Thermal Properties
  - 60mm Aperture
  - Materials
    - .125mm Beryllium Copper
    - .1mm Tungsten
    - .1mm Stainless Steel
- Balancing Arm



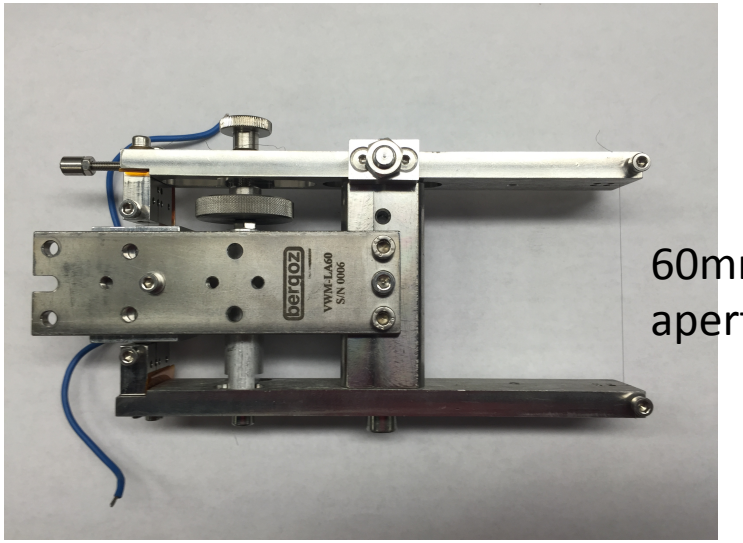


Source: Suren Arutunian, Yerevan Physics Institute, Armenia and http://montessorimuddle.org/

VWM



Target Wire absorbs particles causing it to heat up and expand. Tension decreases.



60mm aperture

Source: Bergoz Instruments

Vibrating Wire Tension Decreases. Causing Frequency to Decrease. $F < F_0$.

VWM

- Change in Temperature of Target Wire
- Change in Frequency of Vibrating Wire
- Readout Circuit
  - “Autogeneration” Circuit
  - Operational Amplifiers
  - Positive Feedback
  - Voltage-Controlled Resistor
  - Digitizer

VWM

- Millihertz Resolution
- Dynamic Range: 2 X 10^5

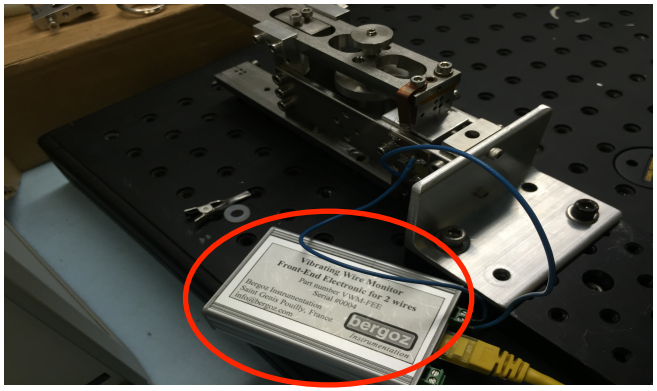
VWM Resolution	$\Delta FMIN = 0.01 Hz$
$F0 > 3000 Hz$	$\Delta FMAX = 2000 Hz$
$F0 < 3000 Hz$	$\Delta FMAX = (F0 - 1000 Hz)$

Source: Bergoz Instruments

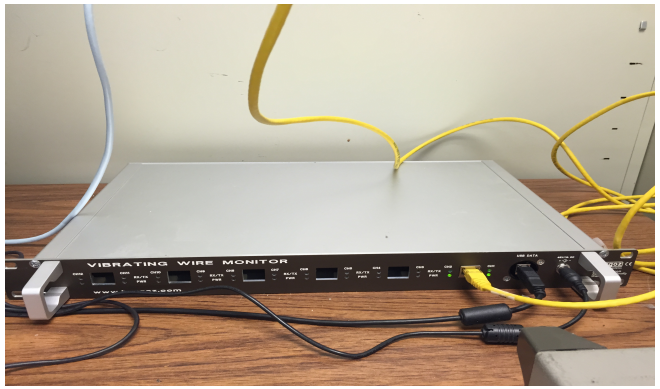
Gate, s	Resolution, mHz
0.1	50
1	5
30	.16

Source: Suren Arutunian, Yerevan Physics Institute, Armenia

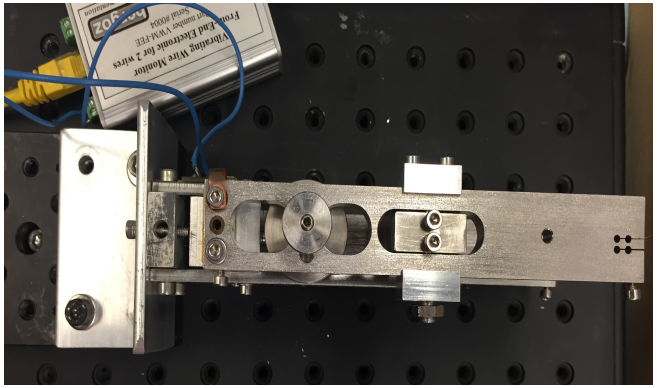
VWM



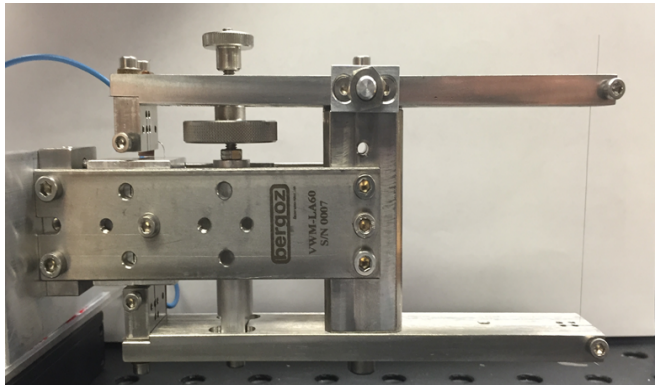
"Autogeneration" Circuit



Multi-wire Read Out



Top View

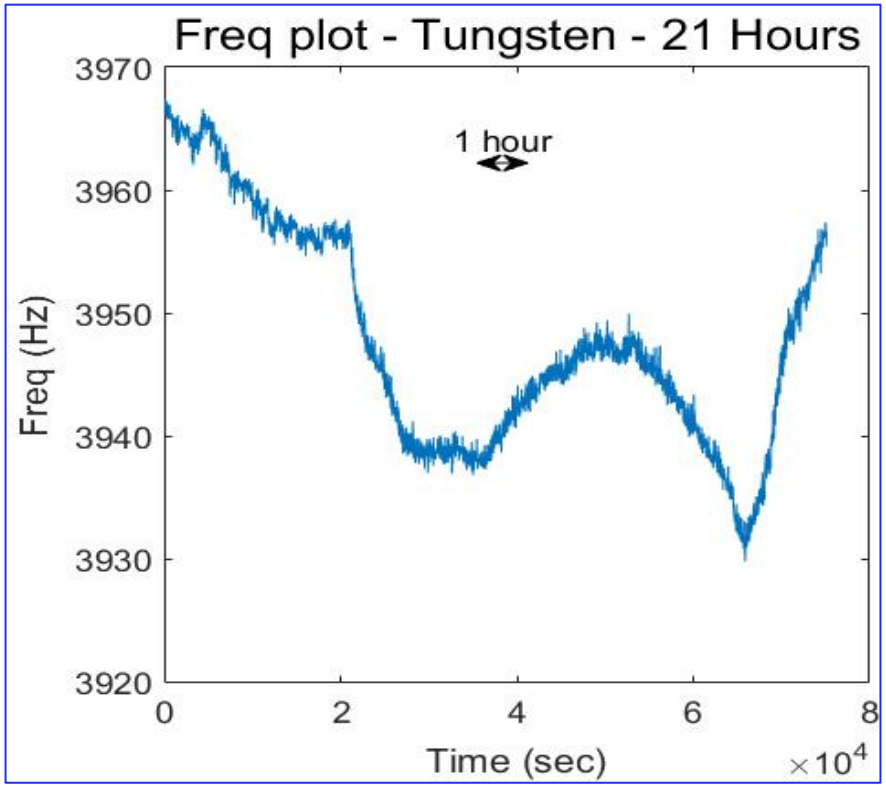


Side View

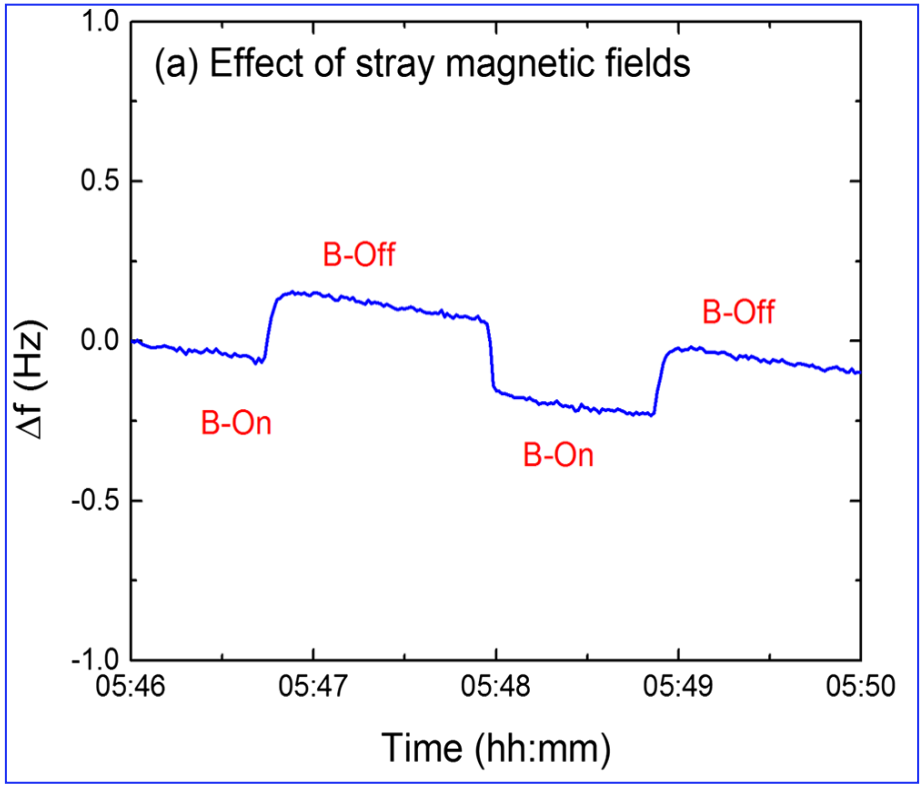
Characterization Studies

- Stabilization
  - Wire Material
  - Sampling Rate (Gate)
  - Magnets
  - Mechanical Vibrations
- Thermal Response
  - Wire Material
  - Heat Gun
  - Heated Wire
  - 2mW HeNe Laser

Results



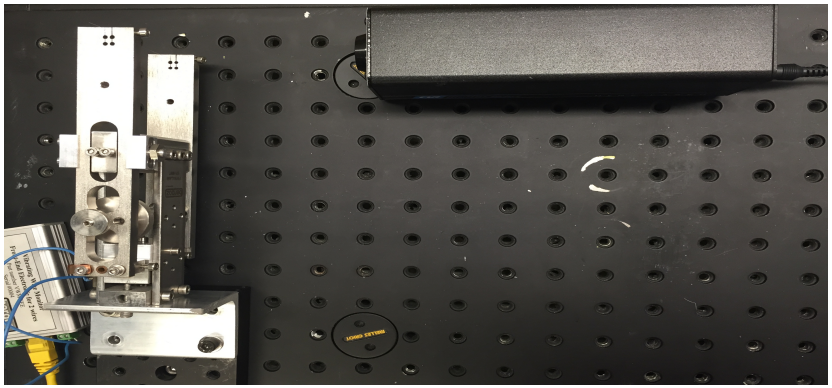
Static stabilization test of VWM. VWM ran for 21 hours only exposed to the surrounding environment.



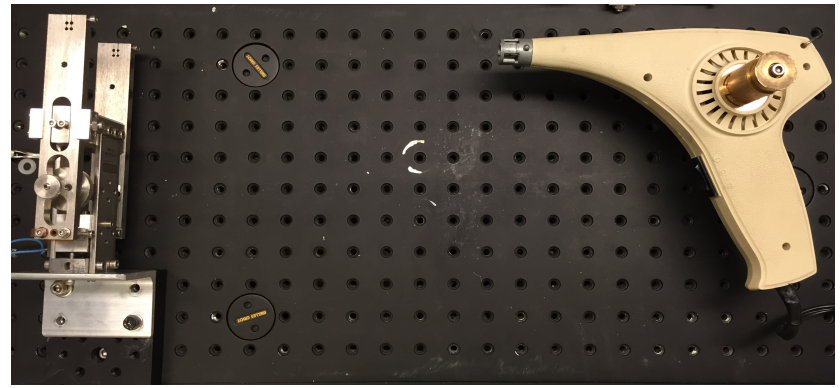
Test done by Dr. Moses Chung. Tests show the effects of magnetic fields in beam line.

Source: Dr. Moses Chung

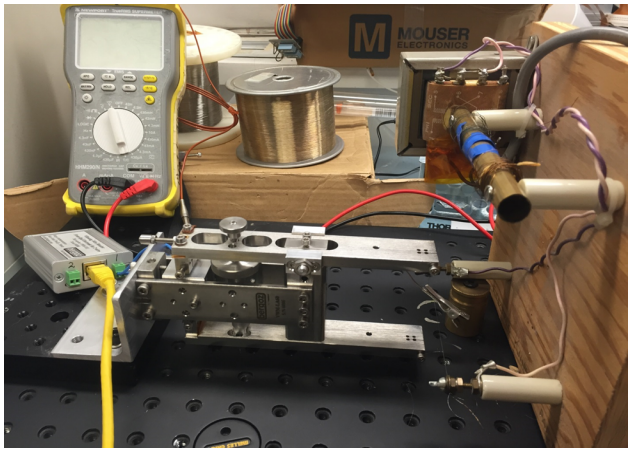
Experimental Setups



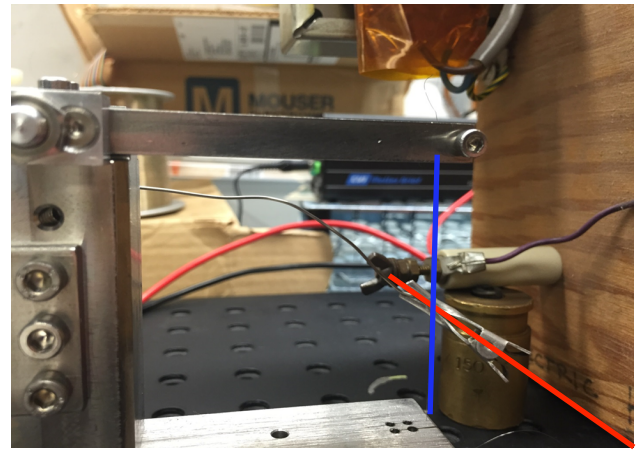
Laser Test



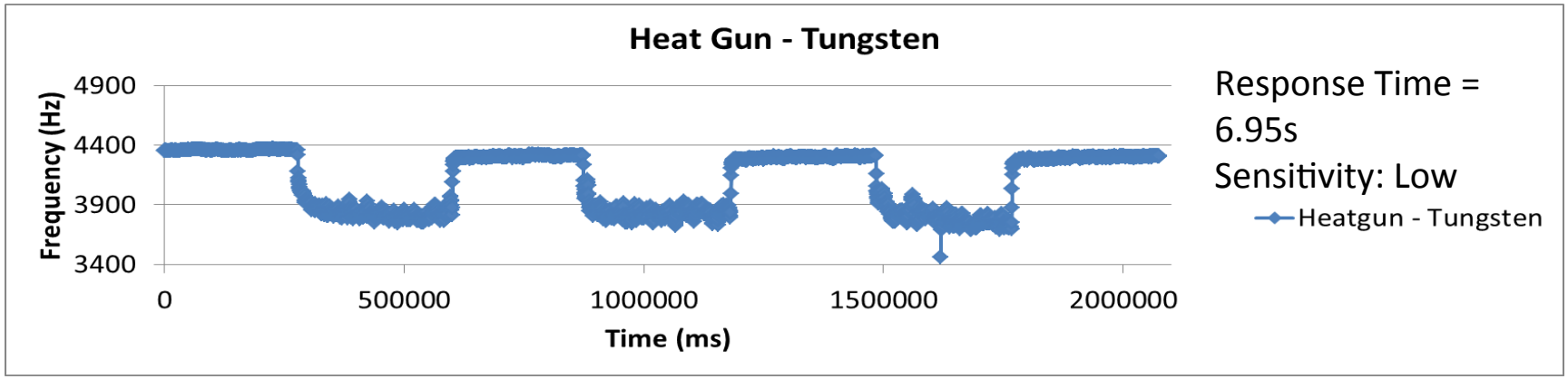
Heat Gun Test



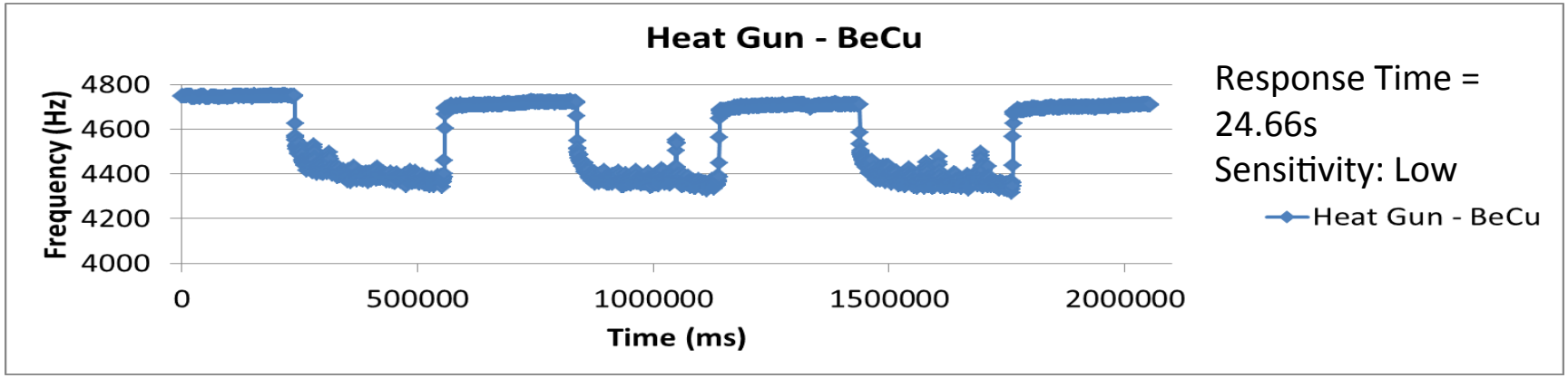
Heated Wire Test



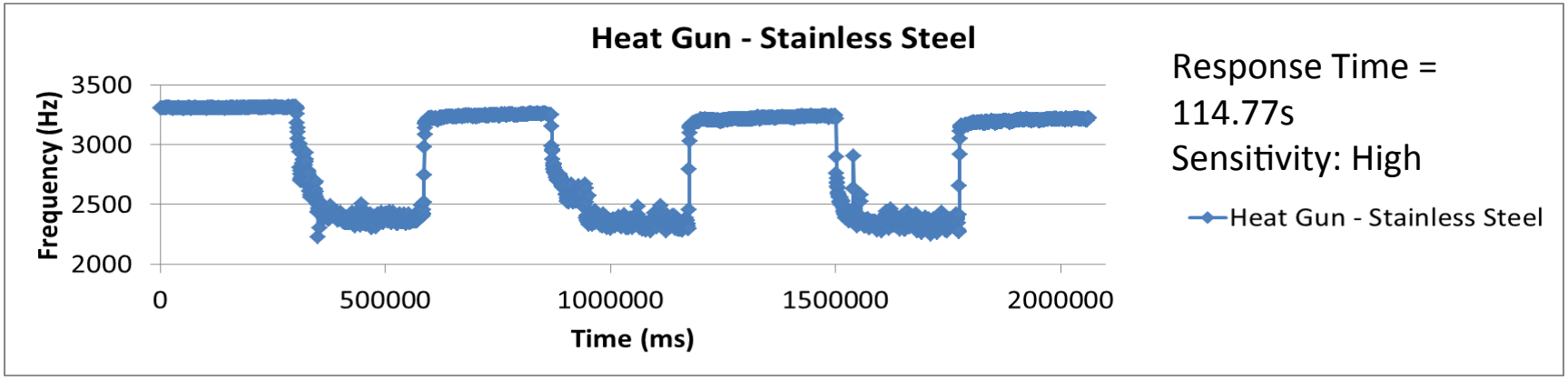
Heated Wire Test
Heated Wire
Target Wire



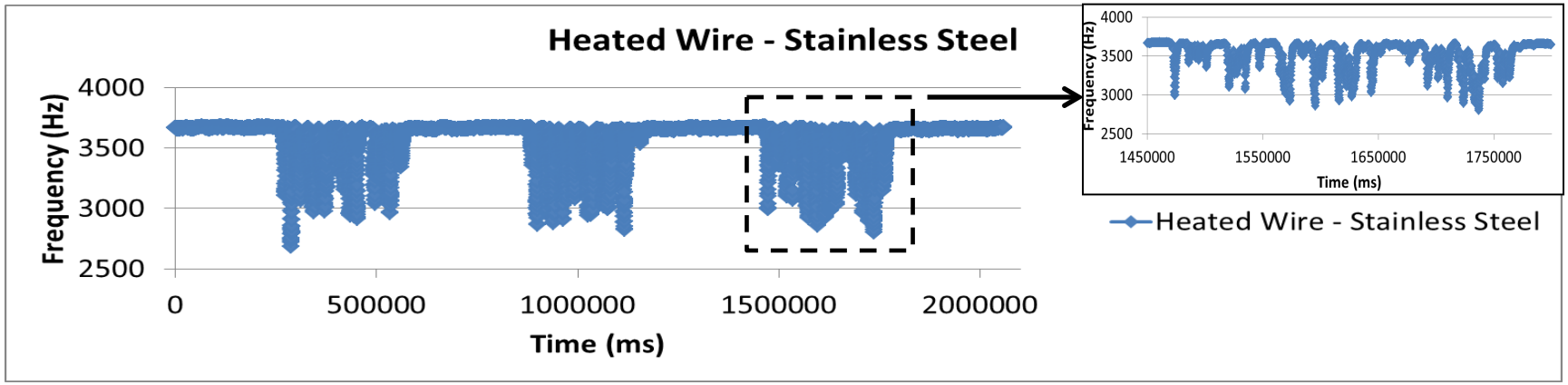
Response Time = 6.95s
Sensitivity: Low

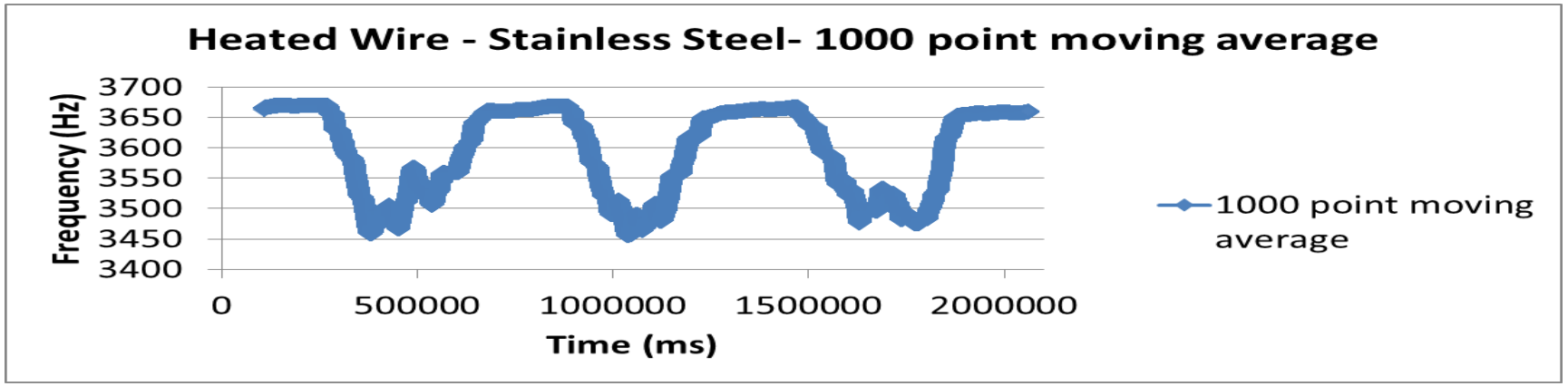


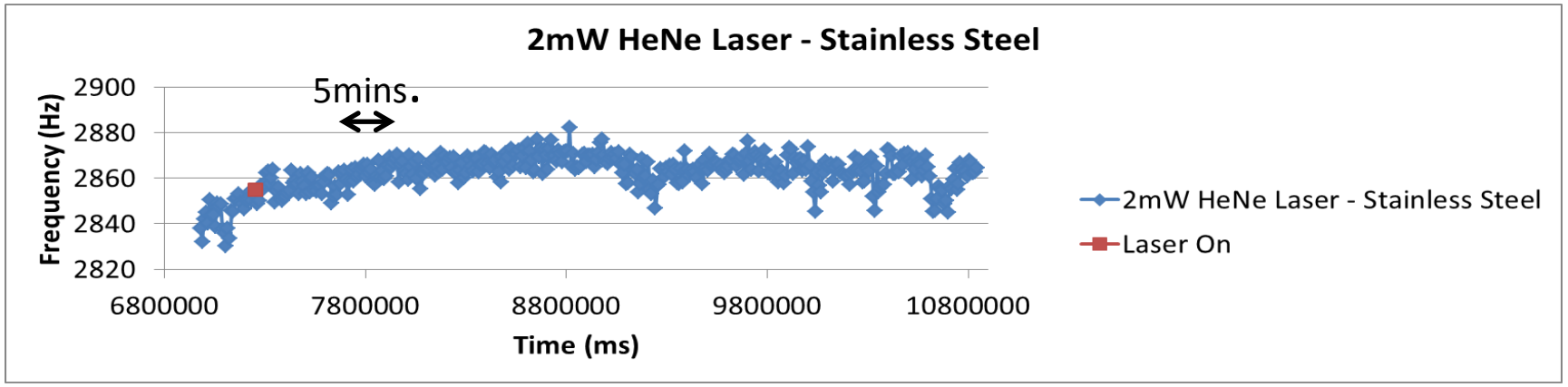
Response Time = 24.66s
Sensitivity: Low



Response Time = 114.77s
Sensitivity: High


Heated Wire - Stainless Steel
Frequency (Hz)
4000
3500
3000
2500
0
500000
1000000
1500000
2000000
Time (ms)
Frequency (Hz)
4000
3500
3000
2500
1450000
1550000
1650000
1750000
Time (ms)
Heated Wire - Stainless Steel


Heated Wire - Stainless Steel- 1000 point moving average
Frequency (Hz)
3700
3650
3600
3550
3500
3450
3400
0
500000
1000000
1500000
2000000
Time (ms)
1000 point moving average


2mW HeNe Laser - Stainless Steel
5mins.
Frequency (Hz)
2900
2880
2860
2840
2820
6800000
7800000
8800000
9800000
10800000
Time (ms)
2mW HeNe Laser - Stainless Steel
Laser On

Problems

- Noise
  - Ambient Temperatures
  - Wind Currents
  - Mechanical Vibrations
  - Magnets
- Resolution
- Wire/E&M Coupling
- Wire Breakage
- VWM Malfunction
- Installation of Wires
- Software

Future

- Calibration Methods
- Laser Power
- Tests in Vacuum
- Dielectric Material
- More Studies of Systematics

Acknowledgements

- Supervisor: Victor Scarpine
- Brian Fellenz – AD/Instrumentation
- Mentor: David Peterson
- SIST Committee
- Co-Workers and Interns
- Thank you!

Questions?