SNS WS System
Preliminary Design Review

Los Alamos, July 17, 2001

by Michael Plum

Agenda

- Welcome and charge to the committee (Plum) 15 min.
- WS requirements, physics and interfaces for linac (Plum) 25 min.
- WS requirements and interfaces for ring, RTBT (Cameron) 15 min.
- Laser wire (Connolly) 30 min.
- Wire heating (CJ Liaw) 15 min.
- HEBT, ring, RTBT actuators (Jim Cullen) 30 min.
- Ring, RTBT electronics (Al DellaPenna) 20 min.
- Linac actuators (Ross Meyer) 40 min.
- MEBT, linac, HEBT electronics (Chris Rose) 30 min.

- Lunch (provided for review committee and outside visitors)

- Committee deliberations
- Committee out brief

- Note: Must terminate video link at 12:15 Los Alamos time.

Review Committee

- **Bob Webber / FNAL (Chair)**
- **Marc Ross / SLAC**
- **Tom Powers / JLab**
- **Joe Preble / JLab**

Design Review Process

- **Evaluate design against design criteria and functional requirements**
- **Items to address**
  - Assumptions
  - Relevant calculations
  - Options considered
  - Interface requirements
  - Manufacturing/procurement plan
- **Consider committee's feedback**
- **Respond in writing to the committee's report**

Charge to committee

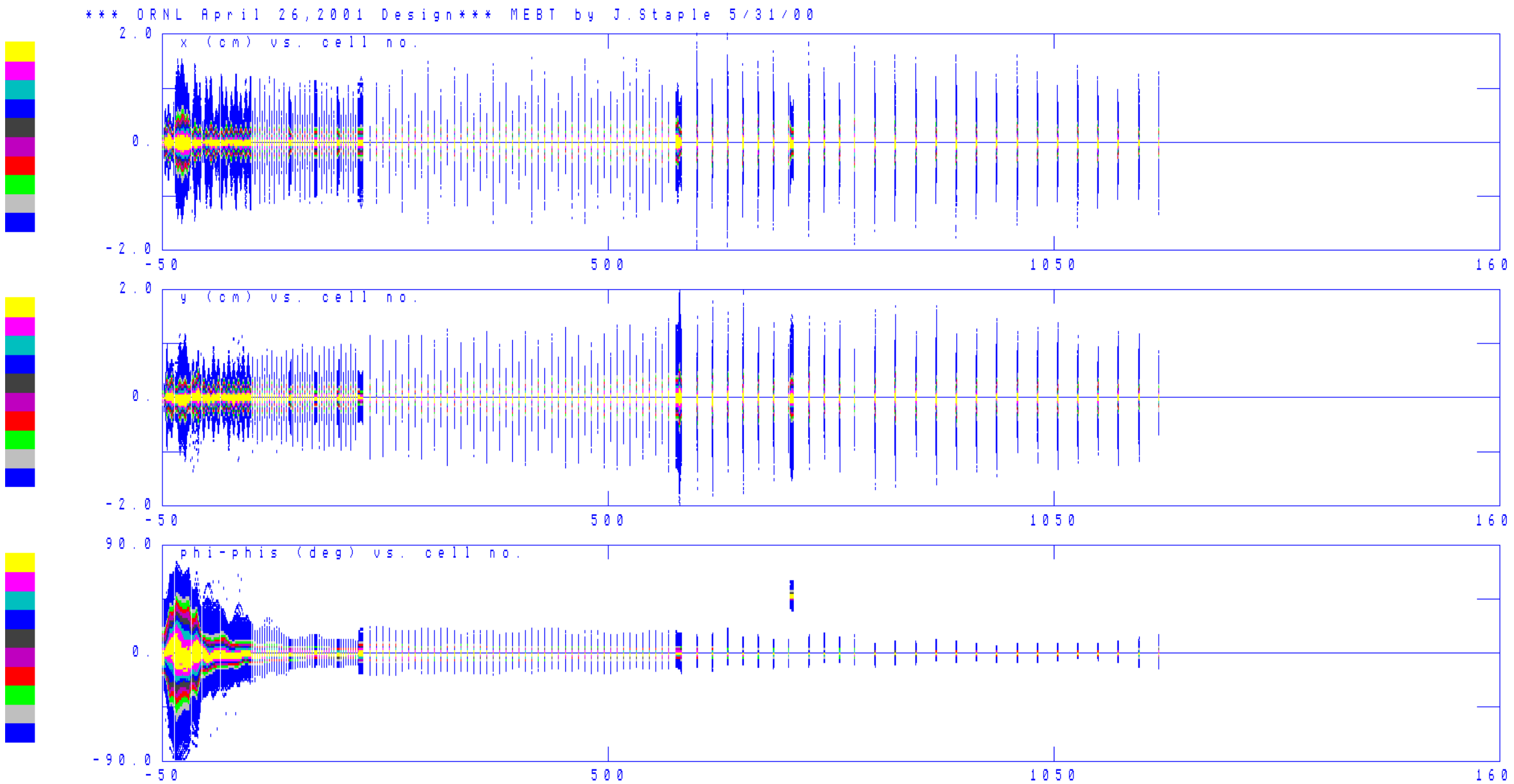
- **Review the design**
  - Are the design requirements adequately defined?
  - Is the WS system design at PDR status? (I.e., ready to build and thoroughly test prototype units.)
  - Are the right analyses/tests being done/planned?
  - Does the work from PDR to FDR (Winter `01) look reasonable?
  - Are there “gaps” in the design?
  - Are the interfaces defined, understood, and addressed?
- **Categorize findings**
  - Critical (potential “show stoppers”)
  - Observations/recommendations
- **Consider key observations from audience participants**
- **Give us an outbrief**
- **Written report**

Linac WS system usage scenarios

- **Commissioning**
  - Measure beam profile and position for reduced duty factor beams (50 to 100 us at 1 Hz). Distinguish between ramp and flat top.
  - Check match of beam between linac sections (MEBT – DTL – CCL – SCL1 – SCL2). Need as many WS's as possible for this measurement.
  - Indirect measure of beam emittance.
- **Normal operations**
  - Profile measurements will not be possible during normal operations. The wire would not survive, and the beam loss would likely be unacceptable.
- **Troubleshooting**
  - Check of beam position and profile.
  - Check matching.
- **Development**
  - Same as commissioning.

Linac WS system usage scenarios (cont.)

- **Example of beam size variations for a mismatched beam.**



Profiles are at quadrupole centers.

From H. Takeda.

Linac wire scanner count

- **DTL – 5 ea.**
- **CCL – 8 ea.**
- **SCL – 32 ea. (May install a few less because of the empty cryomodule locations.)**

Beam parameters for commissioning

MEBT commissioning	1 – 10 Hz; 1 to a few minipulses or 10 – 100 us overall pulse length, 20 – 30 us ramp; 10 to 60 mA peak (as measured during mini pulse); 300 ns to unchopped mini pulses.
DTL commissioning	1 – 10 Hz; 1 to a few minipulses or 50 us overall pulse length; 20 – 30 us ramp, 10 to 60 mA peak (as measured during mini pulse); 300 ns to unchopped mini pulses.
CCL commissioning	1 Hz, 1 to a few minipulses or 50 us overall pulse length, 20 – 30 us ramp; 10 to 60 mA peak (as measured during mini pulse); 300 ns to unchopped mini pulses.
SCL commissioning	1 Hz; 1 to a few minipulses or 100 us overall pulse length, 100 us ramp; 10 to 60 mA peak (as measured during mini pulse; 300 ns to unchopped mini pulses.
Ring commissioning	1 – 10 Hz, 1 mini pulse, 10 to 60 mA peak (as measured during mini pulse), 300 to 700 ns long single mini pulses.

* All beams are H^-

Beam parameters for normal operation

Peak beam current	38 mA averaged over 690 ns mini pulse (26 mA avg.). (Was 52 mA in original design.)
Mini pulse period	~ 950 ns
Mini pulses per pulse	~ 1000
Pulse length	1 ms
Rep rate	60 Hz
Beam sizes	MEBT: x = 1.3 – 3.4 mm, y = 1.0 – 2.8 mm (1 σ) DTL: x = 1.8 – 2.7 mm, y = 1.0 – 2.7 mm (1 σ) CCL: 2.3 to 3.1 mm (1 σ, x and y sizes are same) SCL: 3.1 to 3.6 mm (1 σ, x and y sizes are same) HEBT: x = 0.5 – 2.0 cm, y = 0.5 – 2.0 cm (1 σ) Extreme sizes are about sqrt(5) times larger

Beam diagnostics design requirements

- The beam diagnostics design requirements are divided into three parts: minimum requirements, target requirements, and desired requirements.
  - It is necessary to meet the **minimum requirements** to commission and tune the SNS facility at the most basic level. If the minimum requirements can not be met then fabrication and installation of the system should be reconsidered.
  - It is necessary to meet the **target requirements** for smooth commissioning and operation of the SNS facility and for maintainability of the diagnostics system.
  - The **desired requirements** provide further enhancements of the diagnostics system that would allow improved understanding of the beam dynamics or improved beam or instrument troubleshooting capability. These requirements should be considered only if they do not impact the reliability, cost, or schedule.

Linac WS Design Requirements

Requirements as defined in Design Criteria Document SNS_104050000_DC0001_R00; April 30, 2001.

Requirement	Minimum	Target
Installed units	Partial installation in SCL. 4 units at beginning of low beta region, 4 units at beginning of high beta region.	All stations fully populated except SCL, where half the units will be instrumented.
Scanning modes	Fly mode and step mode. Step mode will average given number of beam pulses per step.	
Peak beam current range	15 to 60 mA.	5 to 60 mA
Beam pulse length	Limited by wire heating. At least 50 us ramped for DTL and CCL units, at least 100 us ramped for SCL units.	
Position accuracy[2]	±2 mm	
Width accuracy[2]	15%	10%
Bandwidth	35 kHz (see note 1 below).	

[1] Need 35 kHz bandwidth to resolve features at the 10 us level, which is required to get the beam profile after the 30 us ramp is completed for DTL and CCL commissioning beam parameters.

[2] When data is fitted with a Gaussian or similar profile function.

Note: SNS parameters list, SNS-100000000-PL0001-R05, May 2001, lowers the peak current to 38 mA, and the average current to 26 mA.

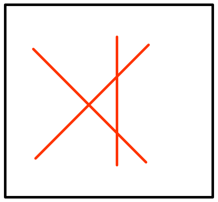
Linac WS Design Requirements (cont.)

Requirements as defined in Design Criteria Document SNS_104050000_DC0001_R00; April 30, 2001 (cont).

Requirement	**Minimum**	**Target**
Positioning accuracy of wire	1 mm.	0.25 mm
Position read back accuracy	1 mm.	0.25 mm
Wire positioning rate	2 Hz in step mode.	5 Hz
Number of signal wires	3 (x, y, and x-y).	
Wire type and diameter	Not specified at this time.	
Signal wire bias	~ 100 V dc, bi-polar.	
Stroke	All wires must scan entire beam pipe aperture. The fork and wire mounting fixtures must never be in the beam pipe aperture. Apertures range from 25 mm in the DTL to 75 mm in the SCL.	

Linac WS system design issues

- **Electronics will be based on a PC platform, similar to platforms used in other diagnostics systems at SNS.**
- **We have chosen to measure the SEM current off the signal wire for the profile measurement (as opposed to measuring beam loss with a downstream loss monitor).**
- **We have chosen 3 signal wires to measure x, y, and the x-y correlation. It is possible to have all 3 wires in the beam at the same time.**



- **Choice of signal wire.**
  - Carbon – good thermal properties, bad oblation properties.
  - SiC wires – good thermal properties, bad conductivity.
  - Tungsten wires – OK thermal properties, bad beam scattering properties.
  - We will likely use carbon wires in DTL. We are still considering our options for the CCL and SCL.
- **Signal wires will burn up if linac duty factor is too high.**
  - Protection via CM measurements at beginning of linac.
  - Protection via MPS that monitors when actuators are off their out limits.

Linac WS system design issues (cont.)

- **Biasing.**
  - We plan to bias the wires negatively to drive off the secondary electrons May need to change polarity for low energy operations, where H^- particle is stopped in wire.
- **Scan time.**
  - Scanners will primarily be used at 1 Hz beam rep rate. For about 30 data points, plus overhead, need about 40 seconds per scan with no averaging. Need a couple minutes with averaging.
- **Halo measurements.**
  - May be possible depending on signal levels, beam energy, background noise, etc.
- **Qualification tests.**
  - Failure of the SCL wire scanner has particularly high consequence. The prototype actuator unit will be carefully tested for particulates, ruggedness, and cycled for about 8,000 times.

Linac WS system design issues (cont.)

- **Self test features.**
  - Circuit to monitor for signal wire conductivity (See Chris Rose' talk).
  - Circuit to inject test signal at electronics front end.
  - Plot motor pulses issued vs. position readback for actuator mechanical test.
- **SCL wire scanner actuator.**
  - Actuator pivots (as opposed to the usual linear translation).
  - This design allows the use of formed bellows, which is required by the proximity to the super conducting cavities.
  - The three signal wires are therefore not always perfectly horizontal, vertical and at 45 deg. They will vary from their ideal orientation by about ±4 deg. over ± half the beam pipe radius.
- **Project Change Request approved June 2001 calls for two signal processors per PC platform to save $$$.**

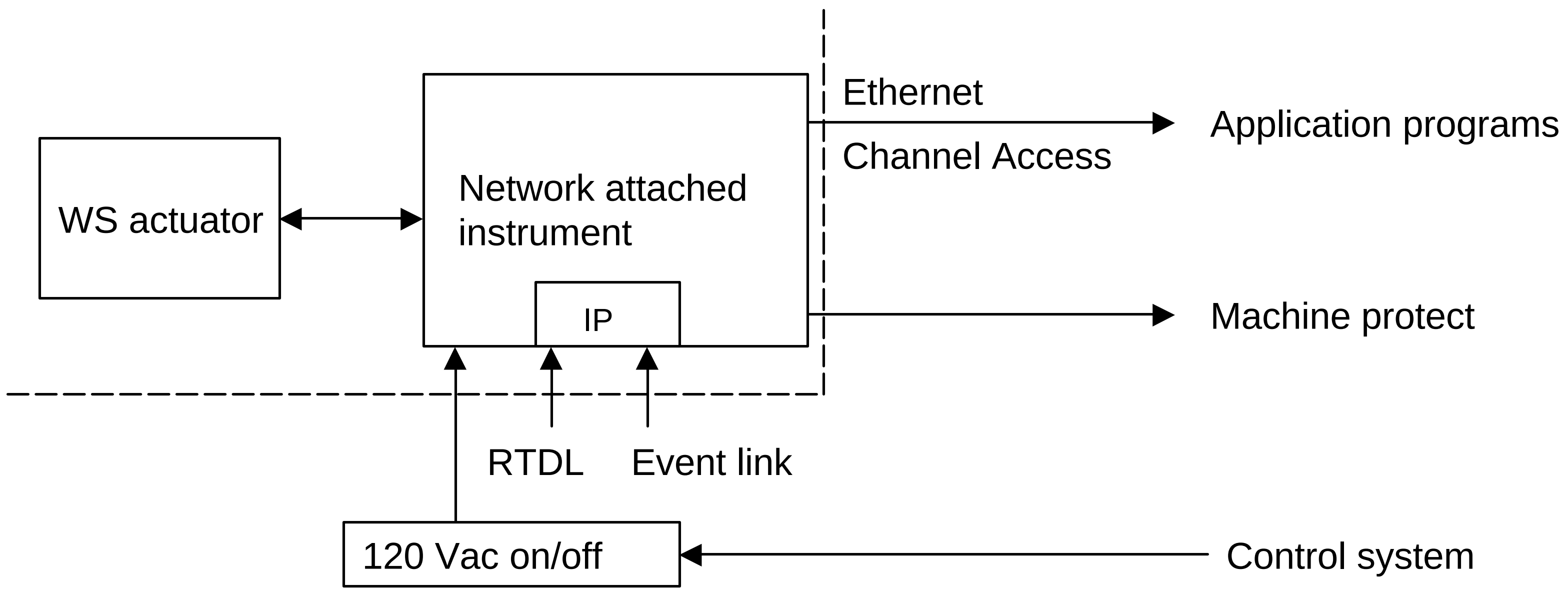
Signal Level Estimate

Signal estimates for 32 micron C wire.

Beam energy (MeV)	Peak beam current (mA)	Beam size (mm, rms)	Wire diameter (mm)	Fraction of beam intercepted	Electron stop signal	Electron SEM signal	Proton stop signal	Proton SEM signal	Total signal per H- particle	Peak WS signal (mA)	Comment
2.5	36	1	0.032	0.01277	-2		1	0.3	-0.7	-0.3217	
2.5	36	3.7	0.032	0.00345	-2		1	0.3	-0.7	-0.0869	
			0.032								
7.5	36	1	0.032	0.01277	-2			0.4	-1.6	-0.7353	
7.5	36	2.7	0.032	0.00473	-2			0.4	-1.6	-0.2723	
			0.032								
1000	36	2.3	0.032	0.00555	-2			0.04	-1.96	-0.3916	Electrons stopped.
1000	36	3.1	0.032	0.00412	-2			0.04	-1.96	-0.2906	
			0.032								
1000	36	2.3	0.032	0.00555		0.06		0.04	0.1	0.0200	Electrons pass thru.
1000	36	3.1	0.032	0.00412		0.06		0.04	0.1	0.0148	

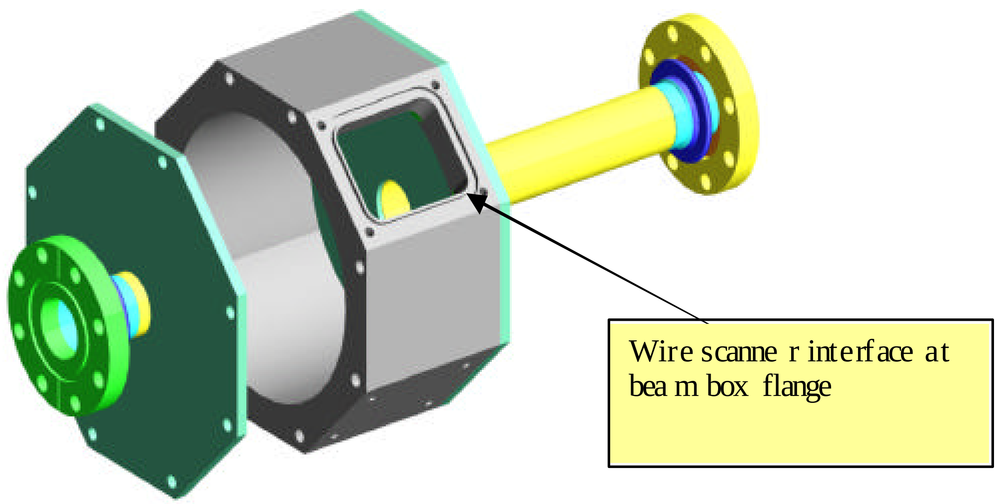
Interfaces

- **The electrical interface occurs at the rack (except for pickup cables) where the electronics are mounted. I/O from the RTDL / event link, Ethernet, MPS, 120 Vac on/off.**



Interfaces (cont.)

- **The mechanical interface occurs at the beam pickup flange or weld joint.**
- **Example of mechanical interface definition for the CCL wire scanners (taken from the DCD).**



System responsibilities

- **Saeed Assadi, responsible for ORNL portion of project.**
  - Acceptance of WS systems and integration into SNS project.
  - Oversight of installation and testing.
- **Mike Plum, responsible for LANL portion of project.**
  - DTL, CCL, SCL actuators.
  - Linac electronics. (Same electronics design will be used for MEBT and HEBT).
  - LANL may become responsible for HEBT, ring, and RTBT actuators.
- **Pete Cameron, responsible for BNL portion of project.**
  - MEBT, HEBT, ring, RTBT actuators.
  - HEBT, ring and RTBT electronics.
- **Larry Dolittle, responsible for LBL portion of project.**
  - MEBT electronics.
- **Responsible parties will work together to develop a handoff strategy and agree on the criteria that define a successful system handoff.**

Schedule

- Plan to have electronics design complete by fall 2001 so it can be used by LBL for MEBT commissioning.
- First deliverable for LANL is DTL tank 1 wire scanner actuator and electronics, and D-plate actuator and electronics, approx. Nov. 2002.
- Last deliverable is the SCL actuators and electronics, now scheduled to be around summer 2004.

Summary

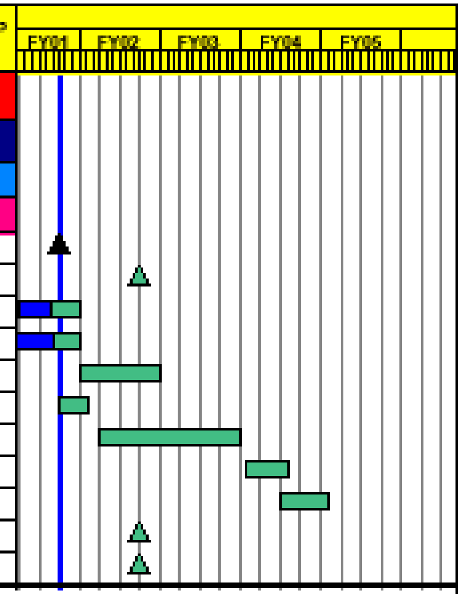
- We are on track to deliver, on schedule, a WS system that meets all target requirements.

Wire Scanners - Peter Cameron

- No MEBT Presentation
- Schedule
- System Specifications
- Level of Design - Laser Wire
  - Roger Connolly
- Level of Design - Carbon Wire
  - CJ Liaw - wire heating
  - Jim Cullen - mechanical design
  - Al DellaPenna - analog front end
- Conclusions

Schedule

Group	Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float	RESP
1.0 Spallation Neutron Source Project							
1.5 Ring and Transport System							
1.5.7 Ring Systems Diagnostics Instrumentation							
1.5.7.6 Wire Scanner							
DI	R805014601	Wire Scanner P D R	0	05JUL01A			PC
DI	R805014602	Wire Scanner F D R	0	01JUL02		26	PC
DI	R805014606	Wire Scanner System Definition (FY01)	207	01JAN01A	28SEP01	212	PC
DI	R805014609	Wire Scanner Design - Summary [FY01]	248*	02OCT00A	28SEP01	0	PC
DI	R805014610	Wire Scanner Detail Design - Summary [FY02]	249*	01OCT01	30SEP02	122	PC
DI	R805014639	Wire Scanner Procure, Fab&Assy-Sum[MEBT] [FY01]	85*	02JUL01	31OCT01	1	PC
DI	R805014640	Wire Scanner Procure, Fab&Assy-Sum [FY02]	438*	31DEC01	30SEP03	122	PC
DI	R805014680	Wire Scanner Installation - Summary	130*	27OCT03	05MAY04	122	PC
DI	R805014690	Wire Scanner Comp. Test @ Site - Summary	153*	25MAR04	29OCT04	122	PC
DI	R805014B19	*Wire Scanner I C D - Final > Controls [LANL]	0		28JUN02	148	PC
DI	R805076019	*RING Wire Scanner I C D - Final>Controls[LANL]	0		28JUN02	26	PC



AP Requirements on SNS Profile Monitors

SNS Profile Monitor AP Requirements 3/21/01

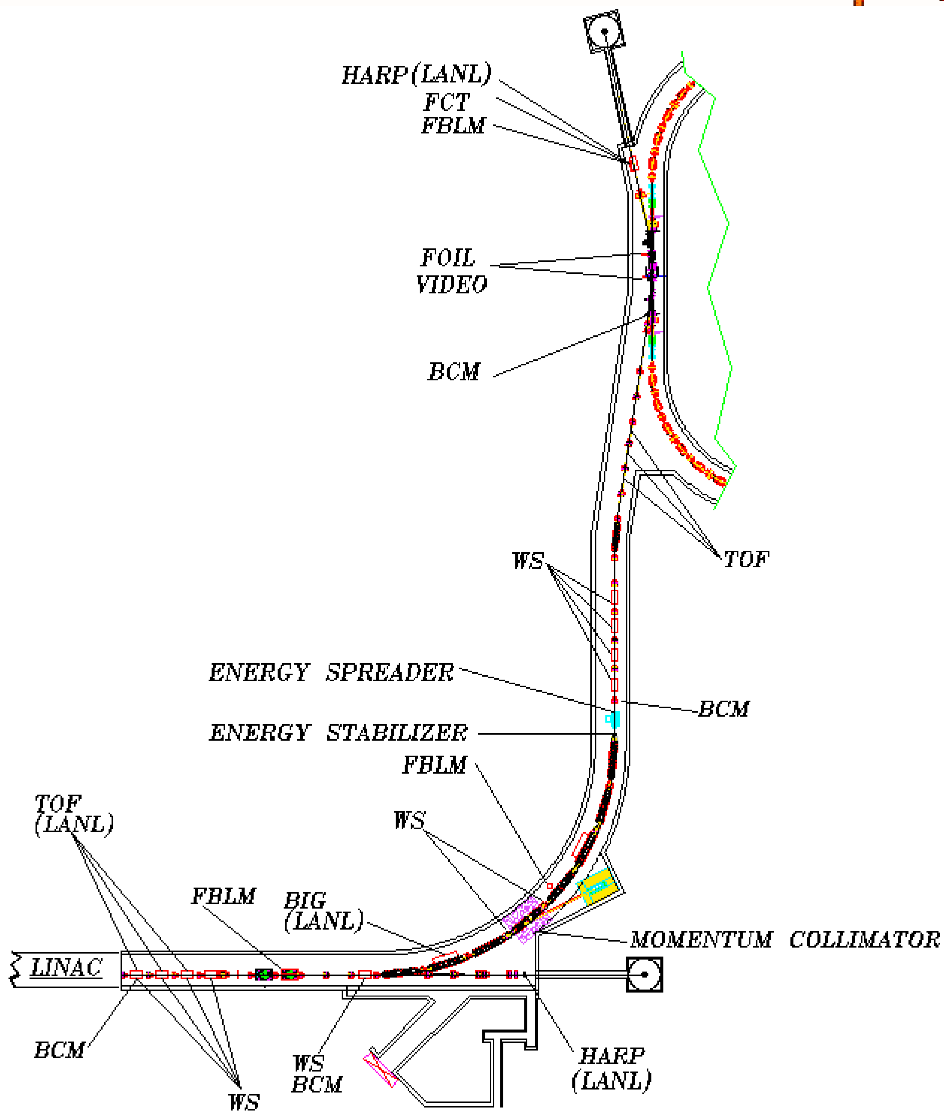
Device	Location	Qty	Intensity [ppp]	Pulse Length [microsec]	Range	Accuracy	Resolution	Data structure	Comments
Wire	MEBT	5		.3-100	+/- 15mm		0.2mm		three planes
	DTL	0							
	CCL	8		.3-100	+/- 15mm		0.2mm		three planes
	SCL	32		.3-100	+/- 15mm		0.2mm		three planes
	HEBT	11		.3-1000	+/- 50mm		0.2mm		three planes
	Ring	2	5e10 - 2e14		+/- 100mm		0.2mm	turn-by-turn	three planes?
	RTBT	5	5e10 - 2e14		+/- 100mm		0.2mm		three planes?
	total	63							
Harp	DTL			.3-50	+/- 10mm		1mm		
	HEBT		3e11 - 2e14		aperture	1mm pitch	.5mm	single shot	
	RTBT		3e11 - 2e14		aperture	1mm pitch	.5mm	single shot	
IPM	Ring	2 (3?)	5e10 - 2e14		+/- 64mm	2mm	2mm	few per turn	three planes (?)
Moment	Ring	1 (2?)						few per turn	quadrupole, octupole,...
Inj Foil Video	Ring	1						fill?	
Ho Foil Video	Inj Dump Line	1						fill?	

System Specifications

- AP Requirements
  - Resolution - 200μ
  - Range
    - MEBT thru SCL +/- 15mm
    - HEBT +/- 50mm, Ring and RTBT +/- 100mm
  - Rate to console - 5 seconds
- Additional Requirements
  - Don't 'melt' the wire!
  - Sensing emission current requires T < 2000K
  - Fit in limited space along beamline
  - Relative profile accuracy - 10% at 1σ? 5% at 2σ?
  - Halo measurement - 5σ?
  - Profiles along the 600ns mini-pulse - BW ~ 5 MHz
  - Gain Switching in Ring and RTBT

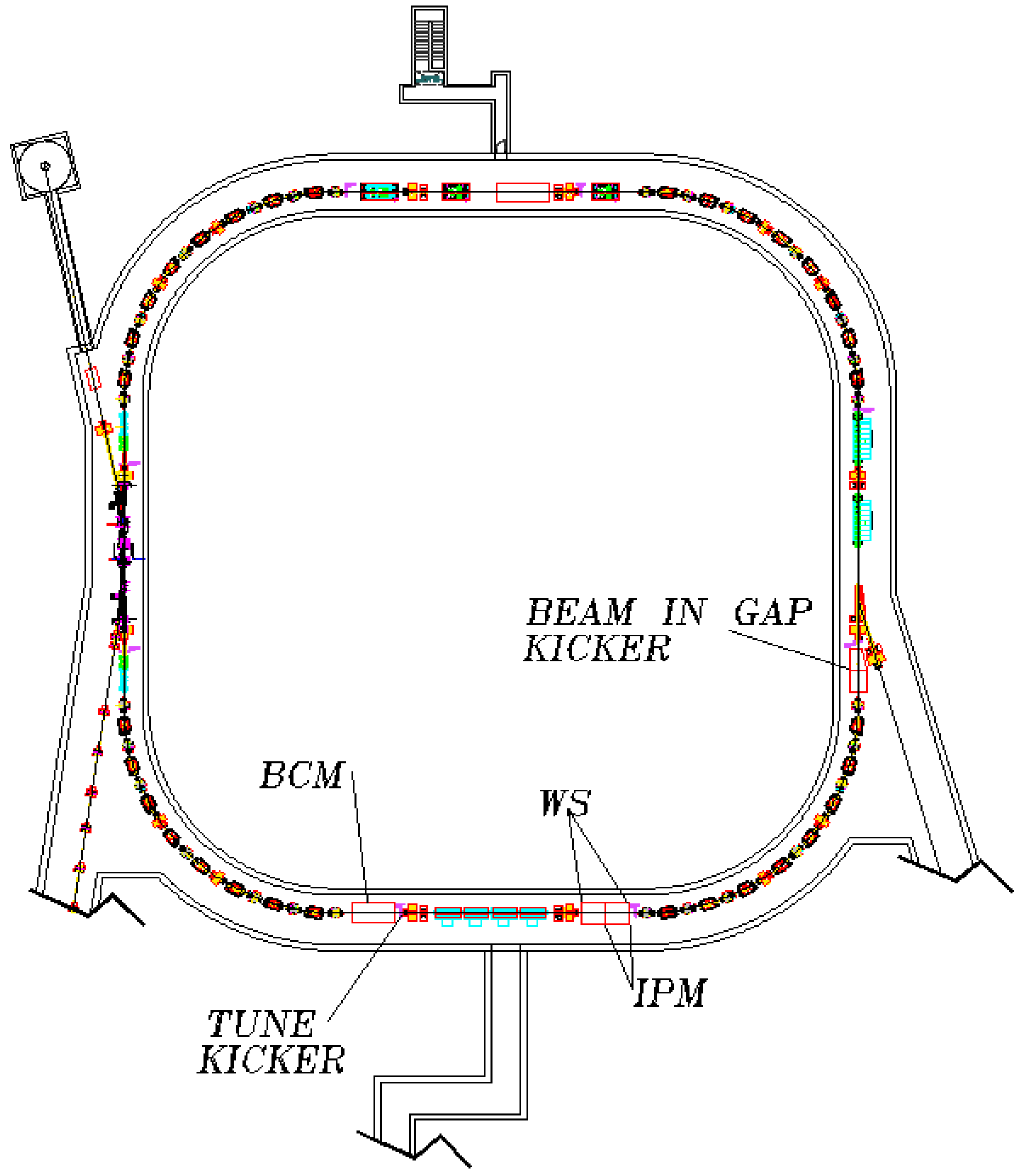
HEBT Beam Instrumentation

Detector	BNL	LANL
BIG	0	1 (0?)
BPM	16	0
TOF	0	2
FBLM	3	0
BLM	52	0
BCM/FCT	5	0
WS	11 (0?)	0 (13?)
FOIL VIDEO	2	0
HARP	0	2 (0?)



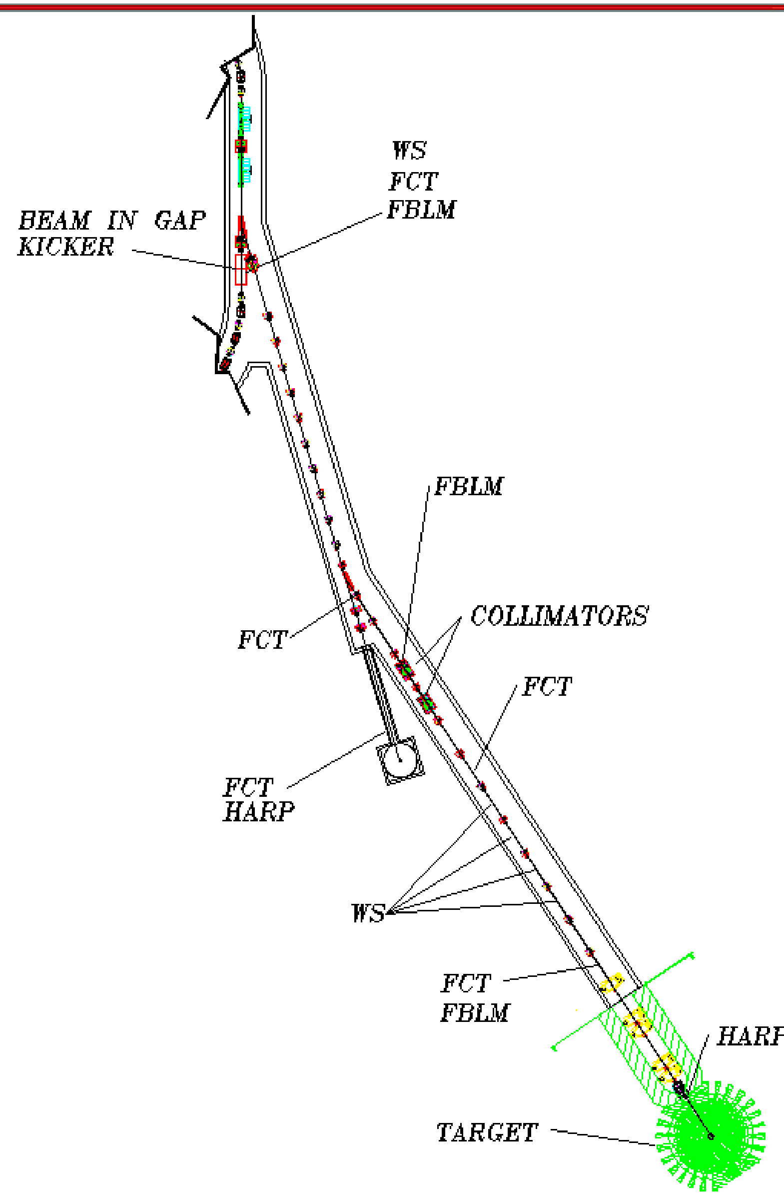
SNS Ring Instrumentation

Detector	Qty	Note
BPM	44	Dual Plane
BPM	2	RF radial loop
BLM	75	Ion Chamber
FBLM	12	Photomultiplier
BIG	1	Kicker+PMT
IPM	2	H + V
WS	2	H + V
Coherent Tune	1	Kicked
Incoherent Tune	2	PLL & QMM
BCM/FCT	1	
WCM	2	Including RF
Electron Detector	5	
Higher Moment	1	



RTBT Beam Instrumentation

Detector	Qty
FBLM	3
BLM	40
BPM	14
DUMP HARP (LANL)	1
FCT	5
WS	5
TARGET HARP (LANL)	1



Wire Scanners - Quantities Summary

• MEBT	5
• DTL	5
• CCL	8
• SCL	32
• HEBT	11
• Ring	1 (2 actuators)
• RTBT	5 (10 actuators)
• TOTAL	62 (68)

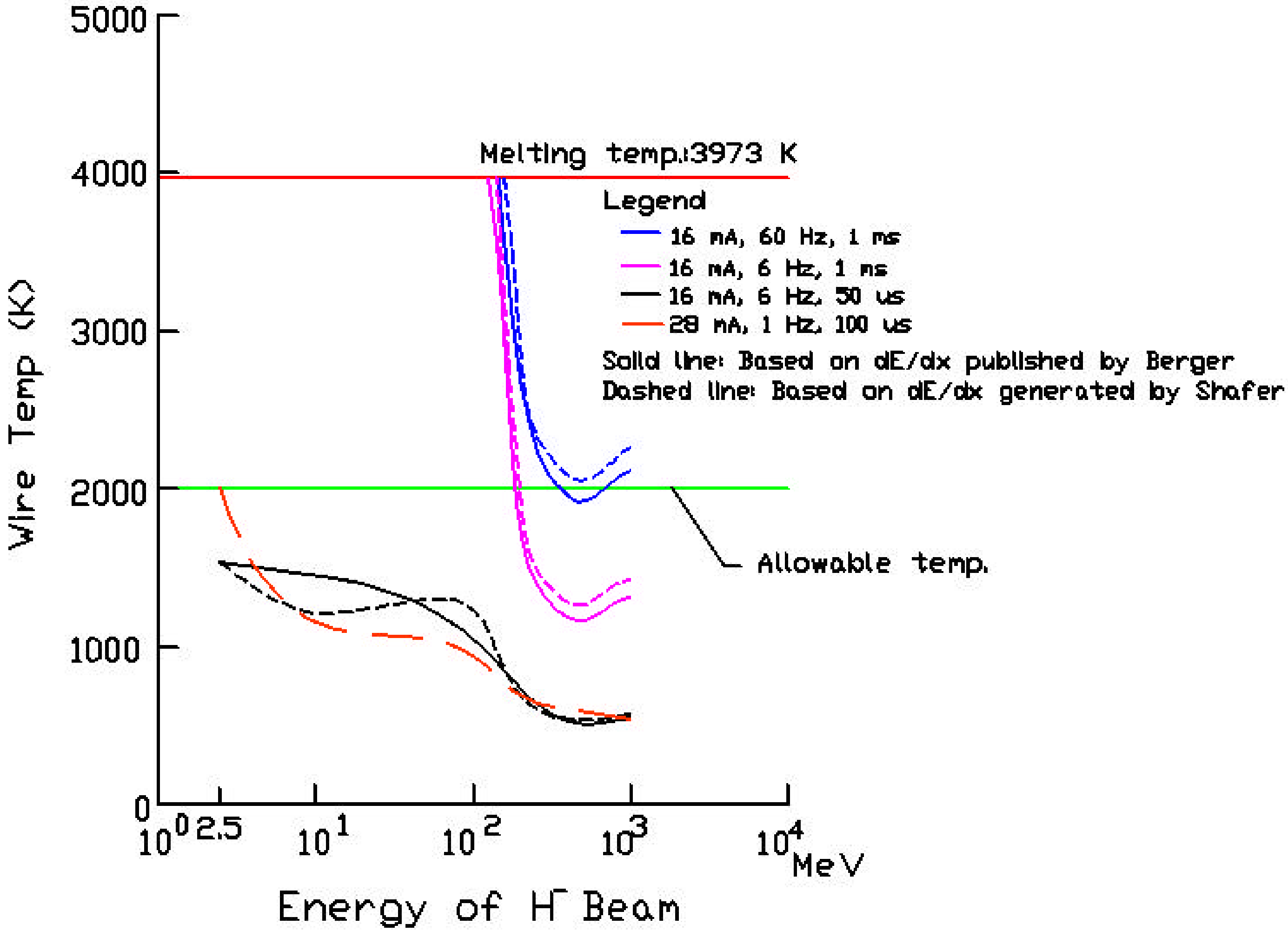
Level of Design - Laser Wire

- POP experiment at 750KeV complete
- POP experiment at 200MeV ready for installation
- MEBT layout complete, detail design in progress, parts ordered, September delivery?
- CCL/SCL ports included in design
- HEBT proposal to make Laser Wire the baseline?
  - Radiation resistance
  - Dollars are OK

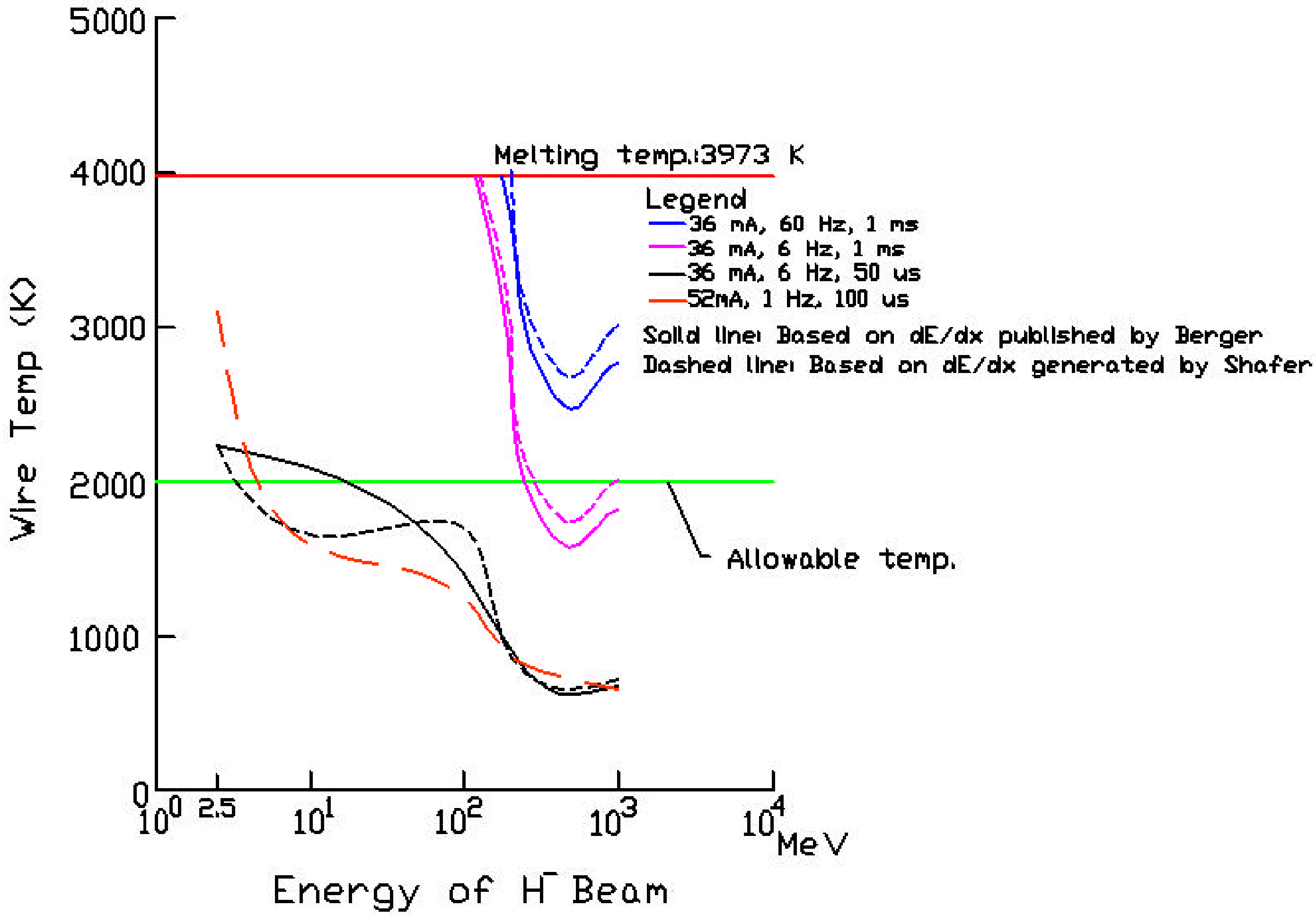
Level of Design - Carbon Wires

- All Energies - wire heating analysis complete
- MEBT Actuator
  - Detail Design Complete
  - First Article Assembly Complete
  - LANL to provide motion control, readout electronics, interface to Controls
- HEBT, Ring, RTBT
  - conceptual design complete
  - LANL to provide motion control, readout electronics, interface to Controls (under negotiation)
  - LANL may provide actuators

Max. Wire Temperature In The Injection Line (1 MW case)



Max. Wire Temperature In The Injection Line (2 MW case)



Wire Scanner Duty Cycle

- Normal machine operations
  52mA beam current during 690ns minipulse
  1000 minipulses/1ms pulse
  60 Hz pulse rate
- Diagnostics and setup machine operations
  52mA beam current during 690ns minipulse
  50-100 minipulses/50-100 μs pulse
  6 Hz pulse rate
  1 Hz pulse rate?

Wire Heating in Ring and RTBT

- Ring - Stationary Wire
  - 1 MW, 64μ wire gives T=2600K
    - 1msec pulse gives T=940K
  - 2 MW, 64μ wire gives T=3300K
    - 1msec pulse gives T=1380K

Conservative design assumptions - linear area growth, no hole in center of distribution

- RTBT - Stationary Wire
  - 1 MW, 75μ wire gives T=460K
  - 2 MW, 75μ wire gives T=530K

S/N Comparison of Laser and Carbon Wires

Take 36 ma beam at 1GeV - for a single 1ms pulse, at the center of the beam we have

- Carbon ~ 55dB S/N
- Laser ~ 55dB S/N

As we move to lower energy the acceptable duty factor of carbon goes down and the electron cross section to the laser goes up, so that the S/N advantage of the laser increases

Other advantages include no vacuum penetration, operation during normal duty cycle.

Conclusions

- HEBT, Ring, and RTBT are all in conceptual design stage
- Conservative, simple actuator approach - design to the stationary wire limit where possible, limit duty cycle
- Laser Wire looks promising - we are considering to propose it as the baseline profile monitor in HEBT.
- Further Detail in AP Requirements would be helpful
  - Error over the profile
  - Relaxation of resolution in Ring and RTBT
  - Two (baseline) vs three planes in Ring and RTBT
- Details between LANL and BNL to be smoothed yet
  - Dump harps/Wire Scanners?
  - Responsibility for Ring and RTBT electronics, controls,...?
  - Responsibility for HEBT(?), Ring, and RTBT actuators?

Laser Profile Measurements of an H^- Beam*

R. Connolly, P. Cameron, J. Cupolo, M. Grau, M. Kesselman,
C-J. Liaw, and R. Sikora
Brookhaven National Lab, Upton, NY, USA

*This work was performed under the auspices
of the United States Department of Energy.

Laser Beam Profile Monitor

First ionization potential for H^- ions is 0.75eV. Photons with λ<1500nm can remove an electron leaving neutral H plus electron.

Nd:YAG laser can be used to select portion of beam and detector is beam current transformer.

This method has been used at Los Alamos for transverse and longitudinal emittance measurements.

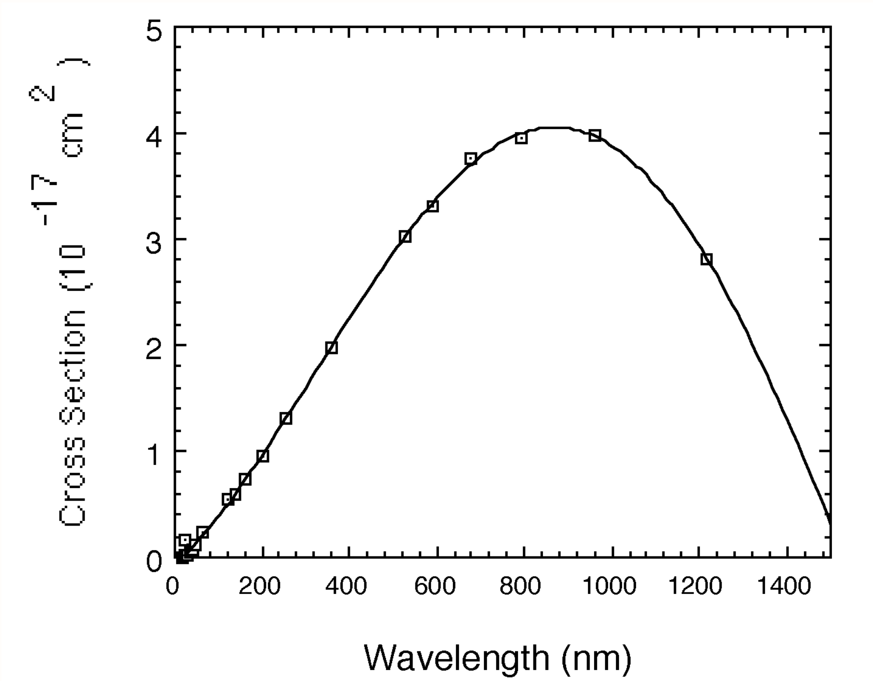
System is completely non-invasive. Beam can be monitored continuously with nothing in the beamline.

Eliminates risk of damage to superconducting cavities.

Proof-of-principle experiment has been done on BNL linac.

MEBT platform is being built.

Laser neutralization cross section

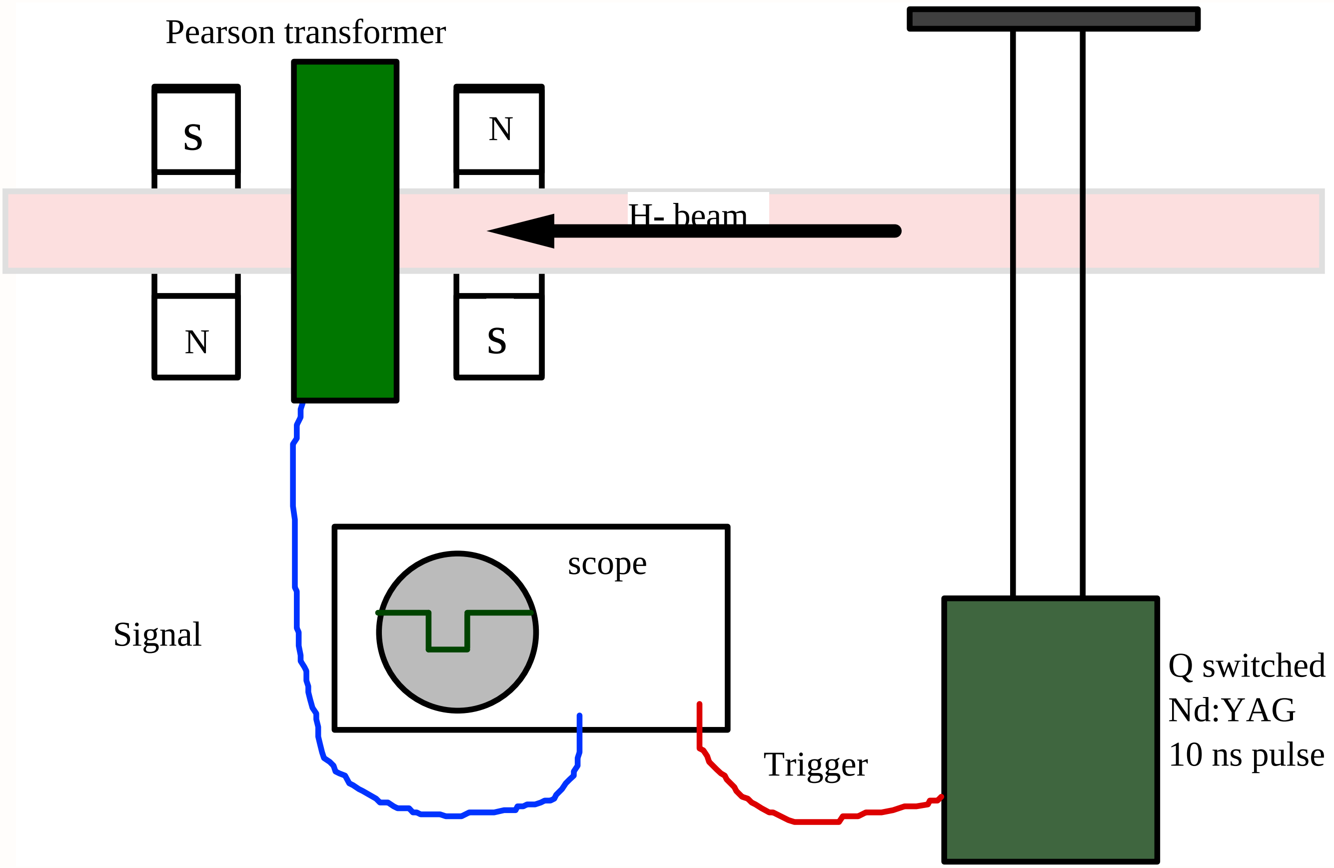


Calculated cross section for H- photoneutralization as a function of photon wavelength.*

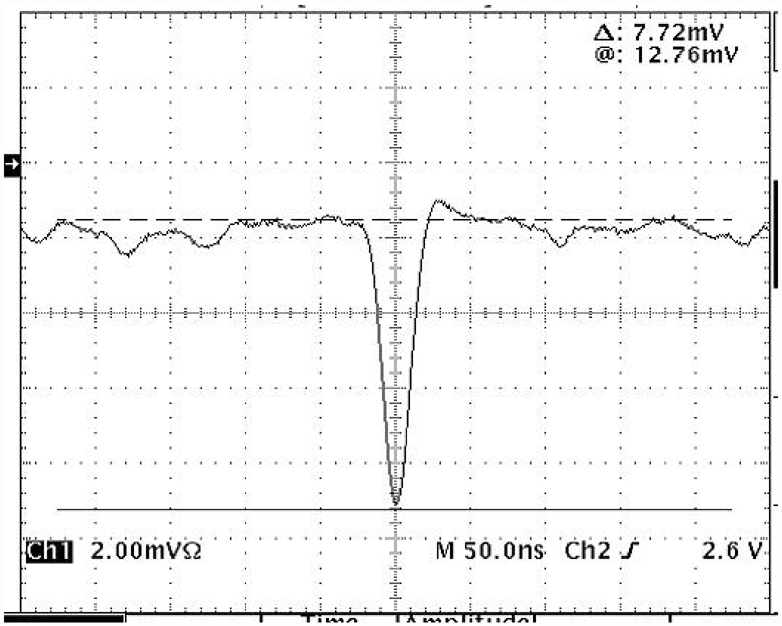
Nd:YAG laser has λ=1064 where the cross section is about 90% of the maximum.

*J.T. Broad and W.P. Reinhardt, Phys. Rev. A14 (6) (1976) 2159.

Laser profile experiment on BNL linac



Scope trace of current notch



Ocilloscope trace of output of current transformer showing current notch created by laser.

The signal is filtered with a 50 MHz low pass filter to remove the linac 200 MHz rf.

Profile measurements were made by measuring the notch depth at each mirror position.

Optical arrangement for experiment

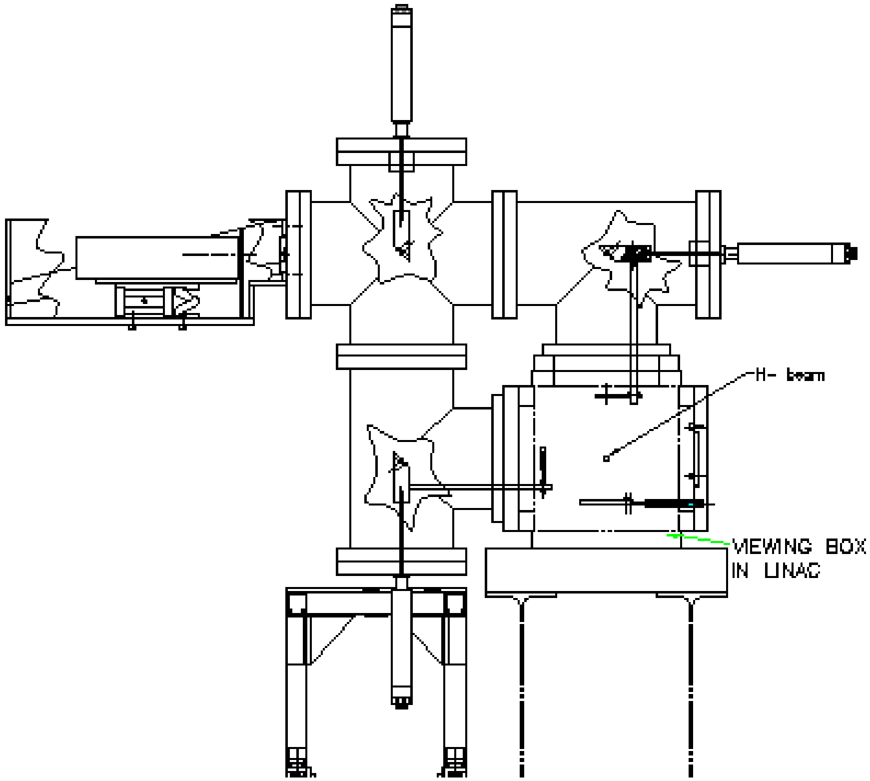
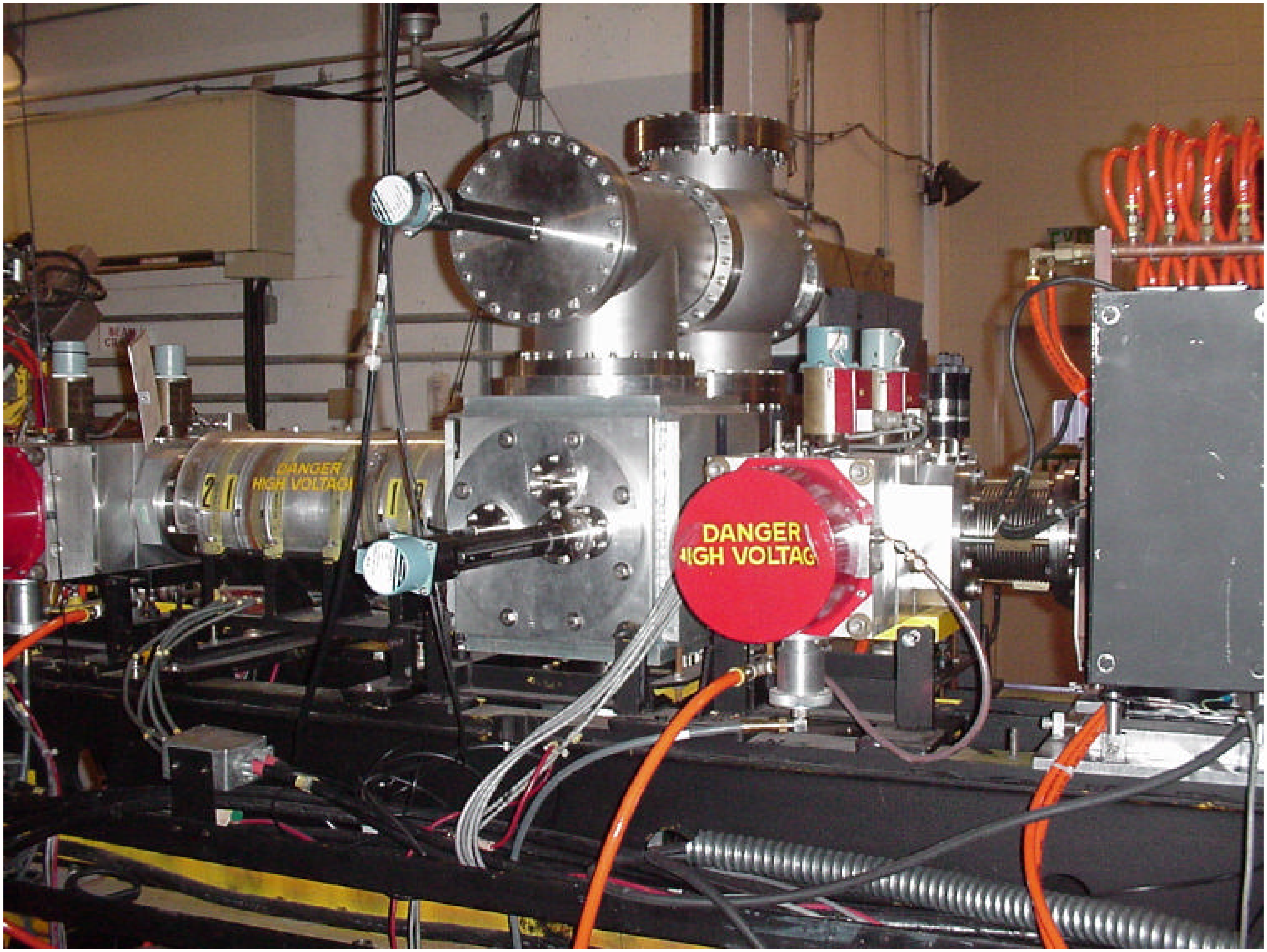
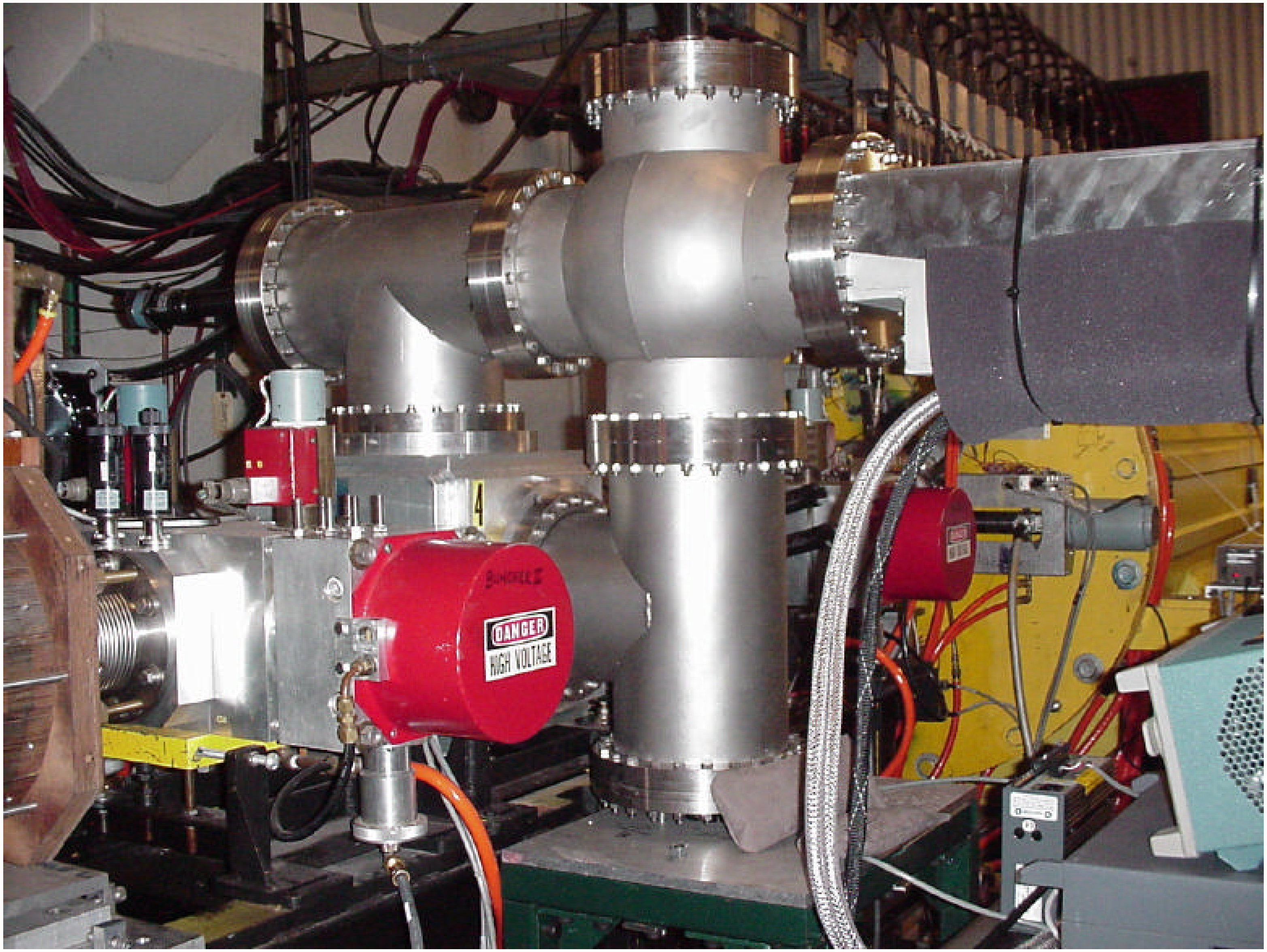


Diagram of experiment installed on BNL linear accelerator. The laser is on the platform at the left. The top-center mirror switches between vertical and horizontal scans. Mirror at top-right scans horizontally and mirror at bottom left scans vertically.

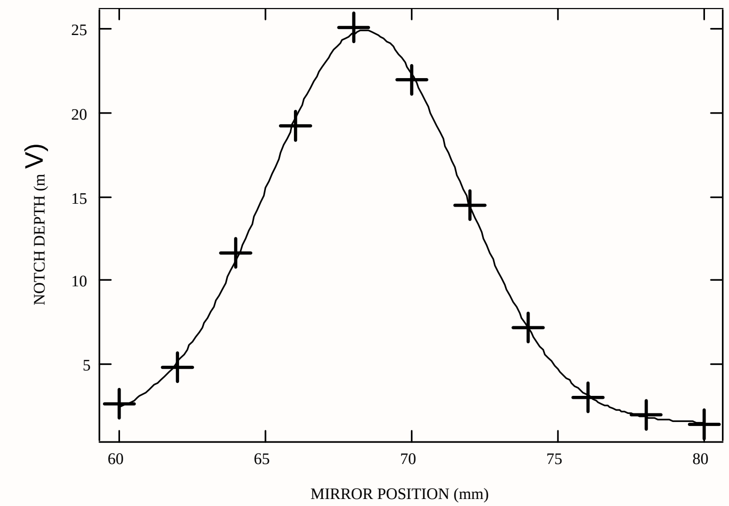
View from side of linac opposite laser platform

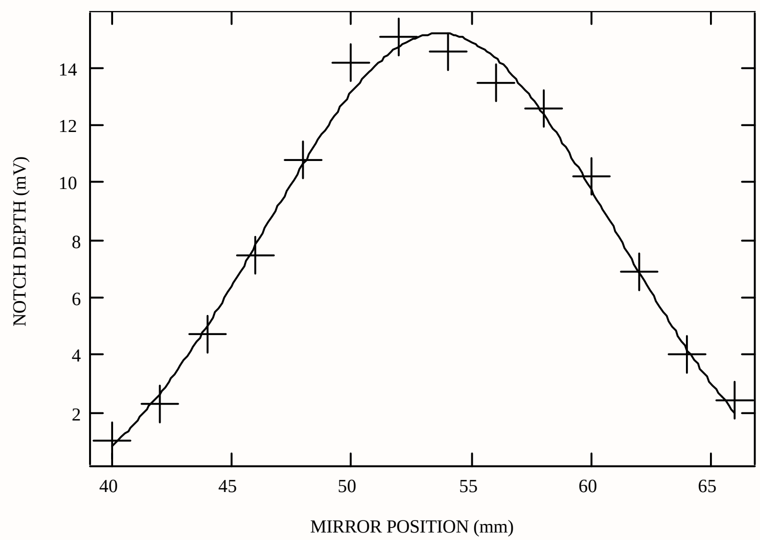


LPM on linac. Laser is upper right



Beam Profiles Measured on BNL linac





Horizontal (top) and vertical profiles of the BNL linac beam. Measurements were made after the rfq with 750 keV beam.

The markers are the data and the lines are gaussian fits.

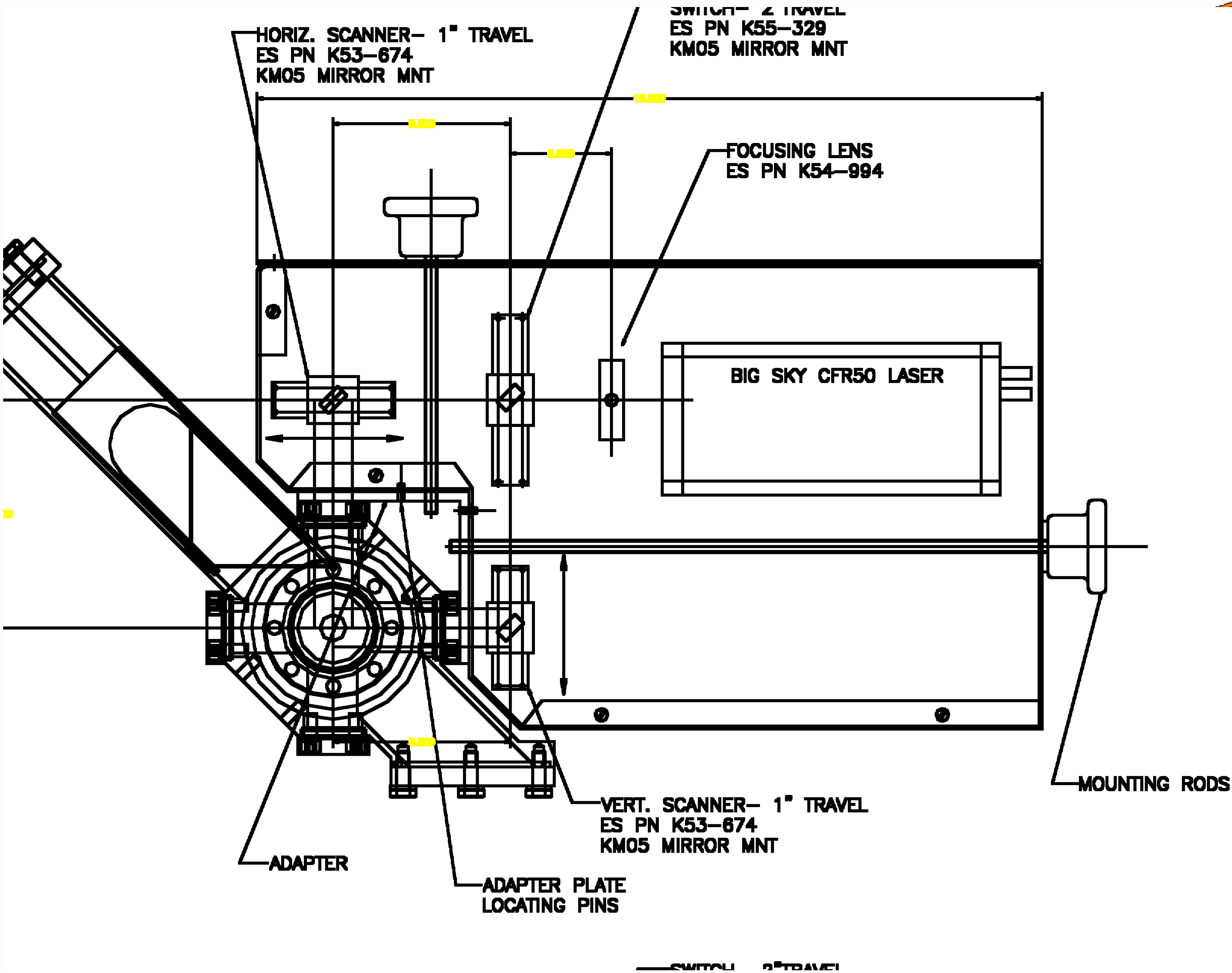
Widths of fits:

$\sigma_x = 3.32 \pm 0.05$ mm

$\sigma_y = 7.3 \pm 0.6$ mm

Each data point is from averaging 15 pulses.

Scanning platform for MEBT



SNS Wire Scanner Preliminary Design Review

Carbon Wire Heating due to Scattering in the SNS

By

C. J. Liaw, BNL

July 17, 2001

Assumptions

- **Beam Energy:**

Injection Line: H^- beam, From 2.5 MeV (MEBT) to 1.0 GeV (HEBT)

Accumulator ring & RTBT: 1.0 GeV Proton beam

- **Beam profile:**

2-D Gaussian distributed in the injection line

Quasi-uniform in the ring & RTBT

Assumptions

Carbon wire

Size

Injection line: 32 μm dia.

Ring & RTBT: 64 ~ 100 μm dia.

Stationary at the center of the beam

Assumptions

Possible wire heating scenarios in the injection line

Beam currents over a pulse:

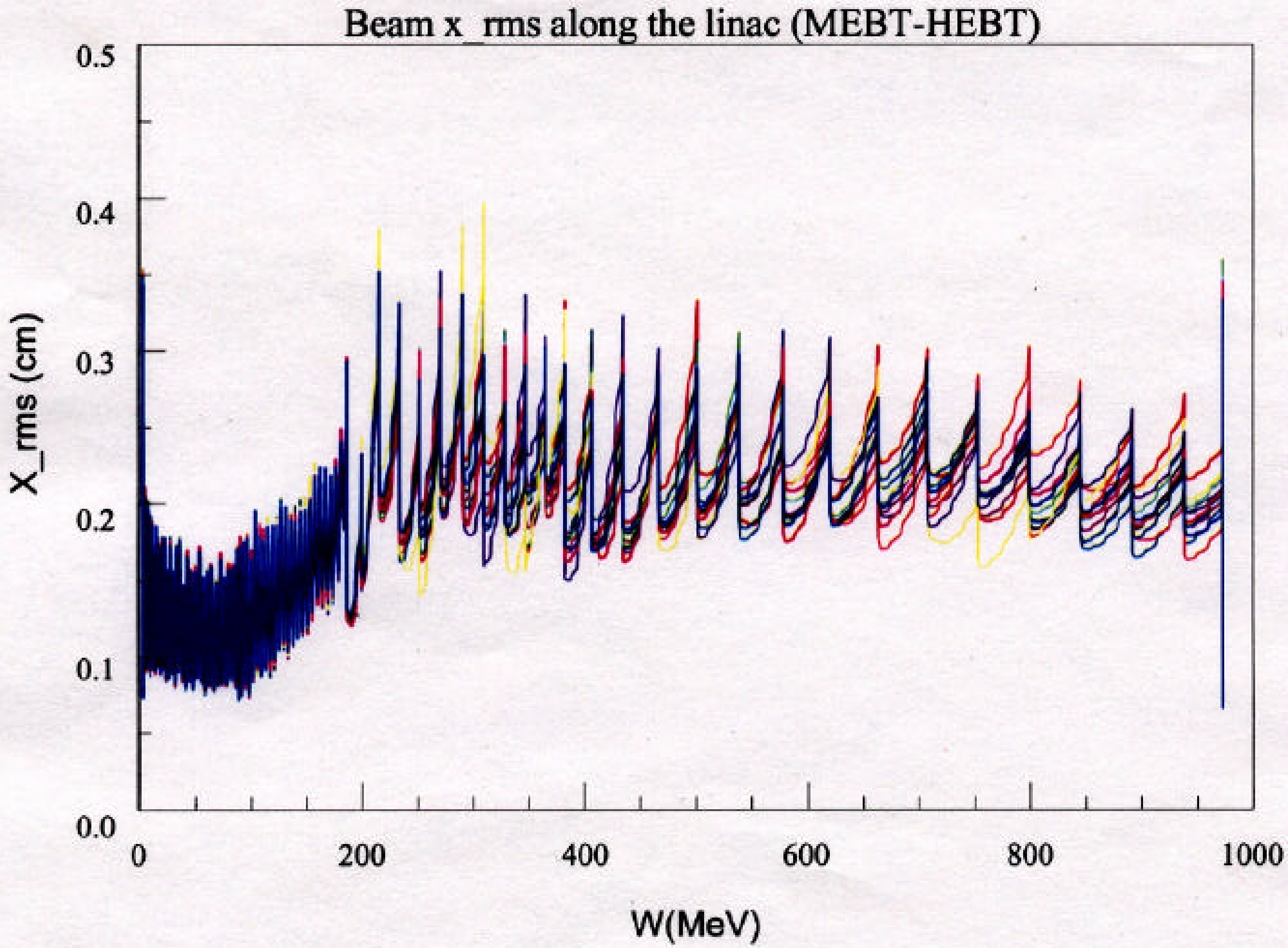
Chopped beam:16 mA and 36 mA (1 & 2 MW case)

Continuous beam: 28 mA & 52 mA (1 & 2MW case)

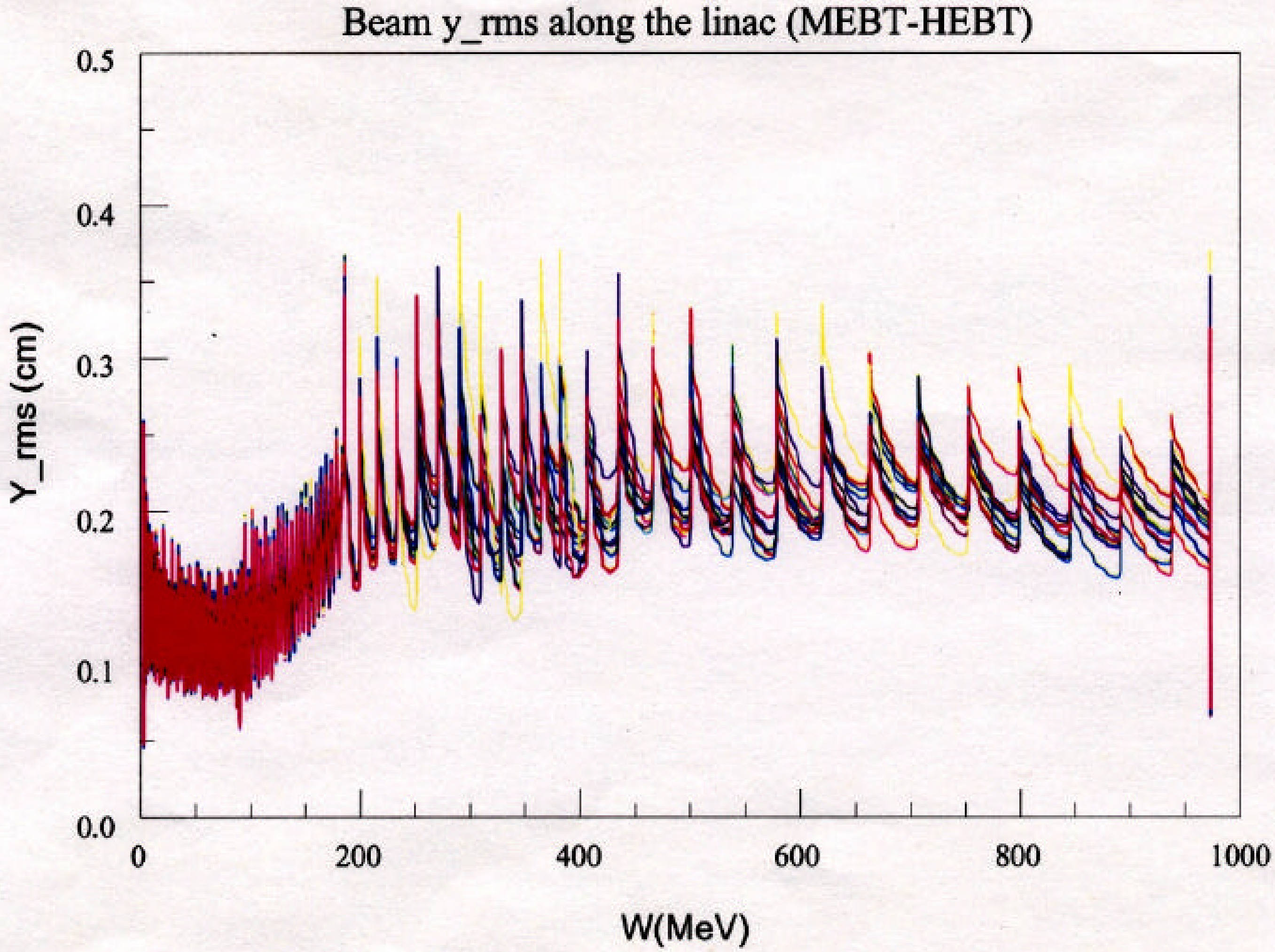
Repetition rate and pulse length:

- 60 Hz,1 ms long
- 6 Hz, 1 ms long
- 6 Hz, 50 μs long
- 1 Hz, 100 μs long

X_{rms} Profiles for 10 runs With Errors



Y_{rms} Profiles for 10 runs With Errors



Assumptions

Wire heating in the ring

• ***Beam current over a pulse:***

1 MW case: 16 mA -> 16 A in 1 ms

2 MW case: 32 mA -> 32 A in 1 ms

• ***Repetition rate and pulse length: 60 Hz and 1ms long***

• ***Beam size (H x V):***

Increase from 3.1 mm x 3.8 mm to 56 mm x 68 mm in 1 ms or

Cross section area A = $6.45 \times 10^{-6} + 3.09 * t$ [m^2], where t = time [sec]

Assumptions

Wire heating in RTBT

• ***Beam current over a pulse:***

16 mA (1 MW case) and 32 mA (2 MW case)

• ***Repetition rate and pulse length: 60 Hz and 695 ns long***

• ***Minimum beam size (H x V): 56 mm x 68 mm***

Assumptions

Radiative cooling is the only cooling mechanism.

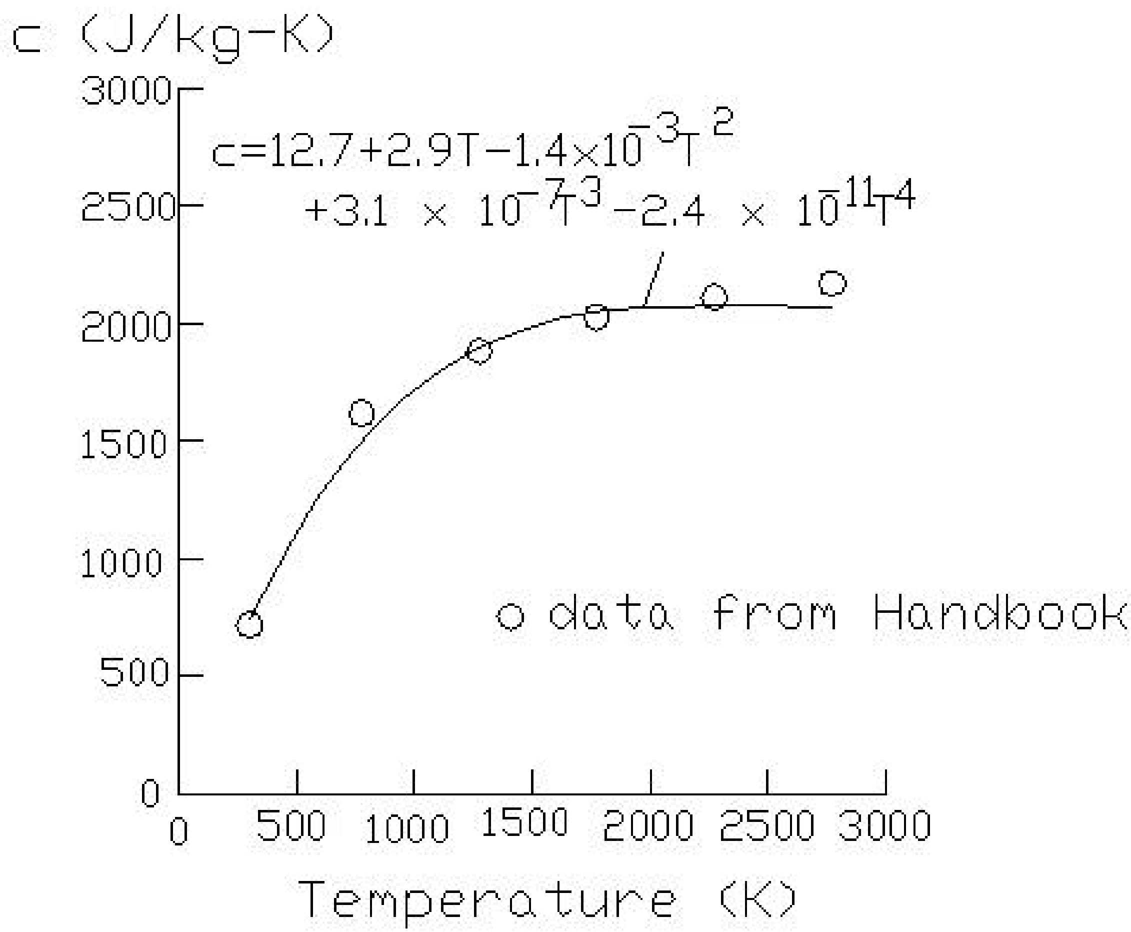
Thermal properties of carbon:

Density = 2000 kg/m^3

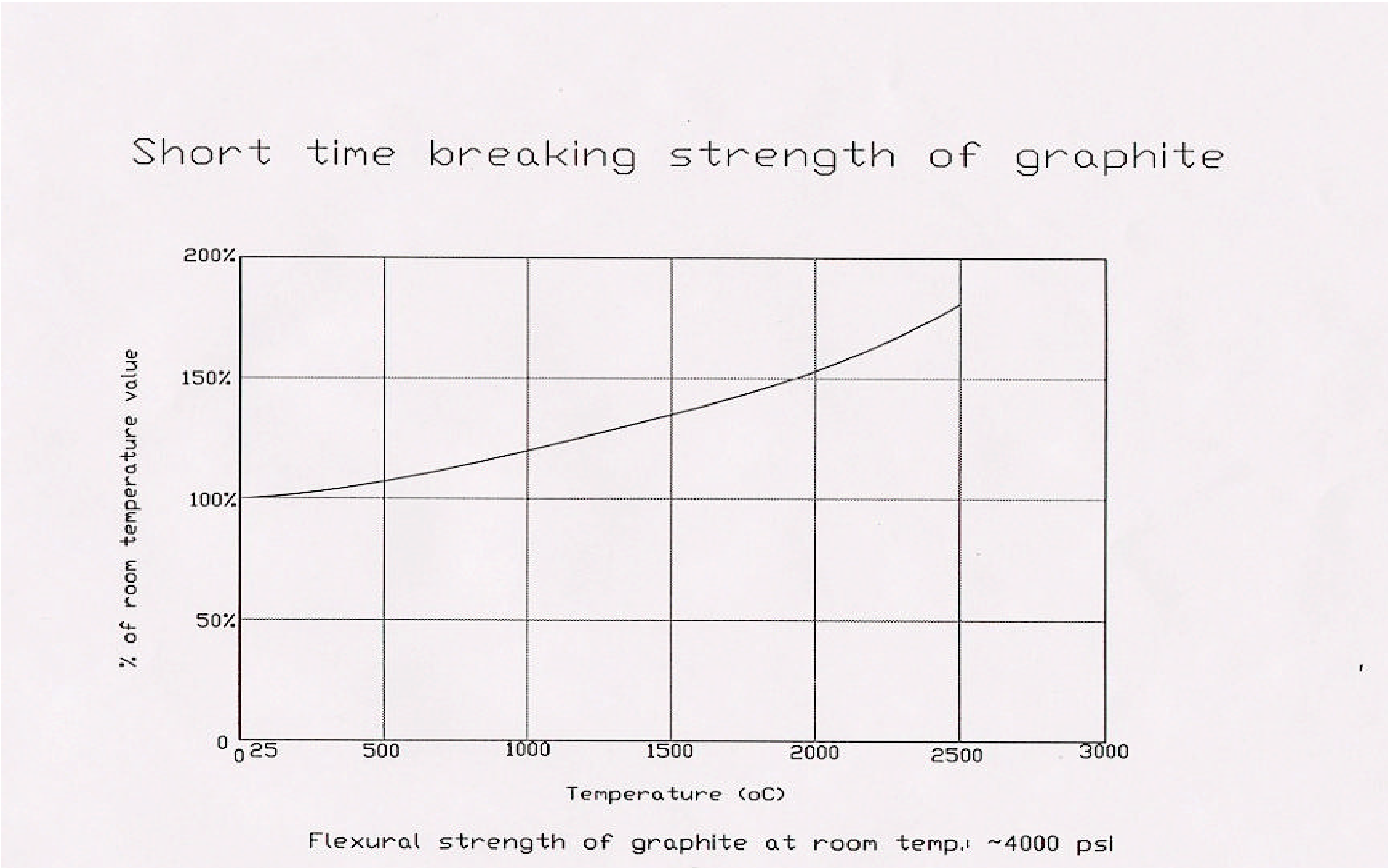
Radiant emissivity = 0.8

Heat capacity (temperature dependent)

Carbon Heat Capacity



Strength of Graphite (from Material Handbook)



Beam Energy Loss Due To Scattering

- ***For 2.5 MeV ~ 1 GeV H^- beam:***

$$P = 1/\rho(dE/dx)_p \, \rho I \, x + 2 P_e \qquad [\text{watts/m}^2]$$

- ***For 1 GeV proton beam:***

$$P = 1/\rho(dE/dx)_p \, \rho I x \qquad [\text{watts/m}^2]$$

where $P_e = 1/\rho(dE/dx)_e \, \rho I x$ $\quad (1/\rho(dE/dx)_e x < P_s)$

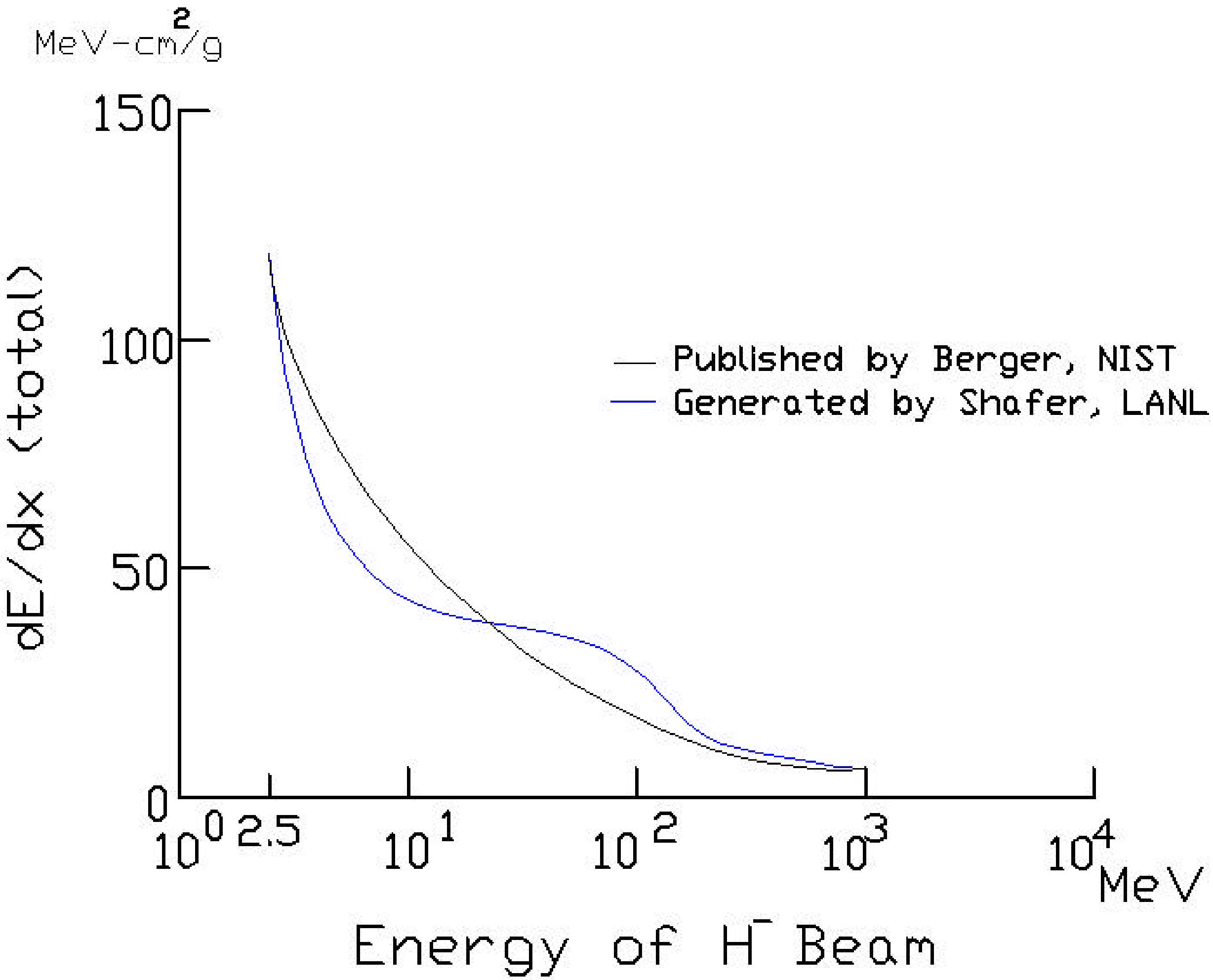
$= P_s$ $\quad (1/\rho(dE/dx)_e x >= P_s)$

P_s = power to stop an electron beam [eV],

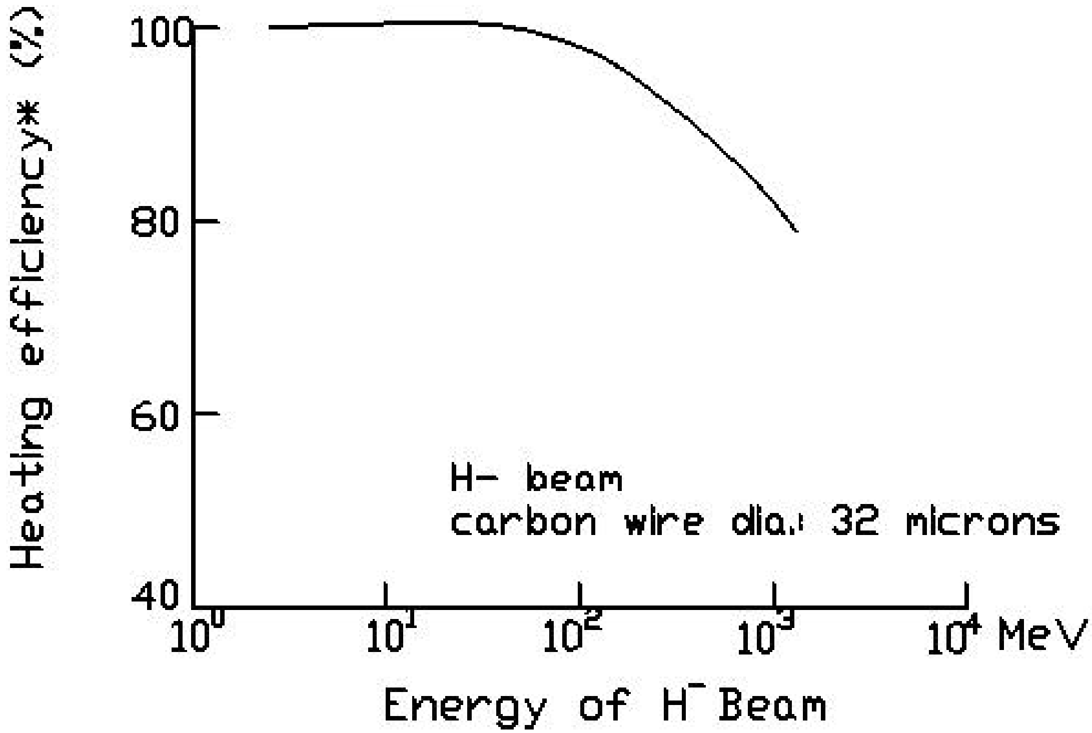
I = beam current density [A/m^2]

$1/\rho(dE/dx)_p$ and $1/\rho(dE/dx)_e$ = Collision energy loss of the proton and the electron beam through the carbon wire [MeV/g/cm^2].

dE/dx of H⁻ beam through carbon wire



Heating Efficiency of Carbon Wire, h



*: Percentage of knock-on electrons which contribute to the wire heating

Power Deposition On The Carbon Wire

$$P_d = P \times \eta$$

Deposition power density	Beam energy loss density	Heating efficiency

Governing Equation

$$dT/dt = 4/(r\,p\,dc)*(P\,h - p\,s\,e(T^4 - T_0^4))$$

where T = wire temperature [K]

T_o = beam pipe temperature = 297 [K]

d = diameter of the wire [m]

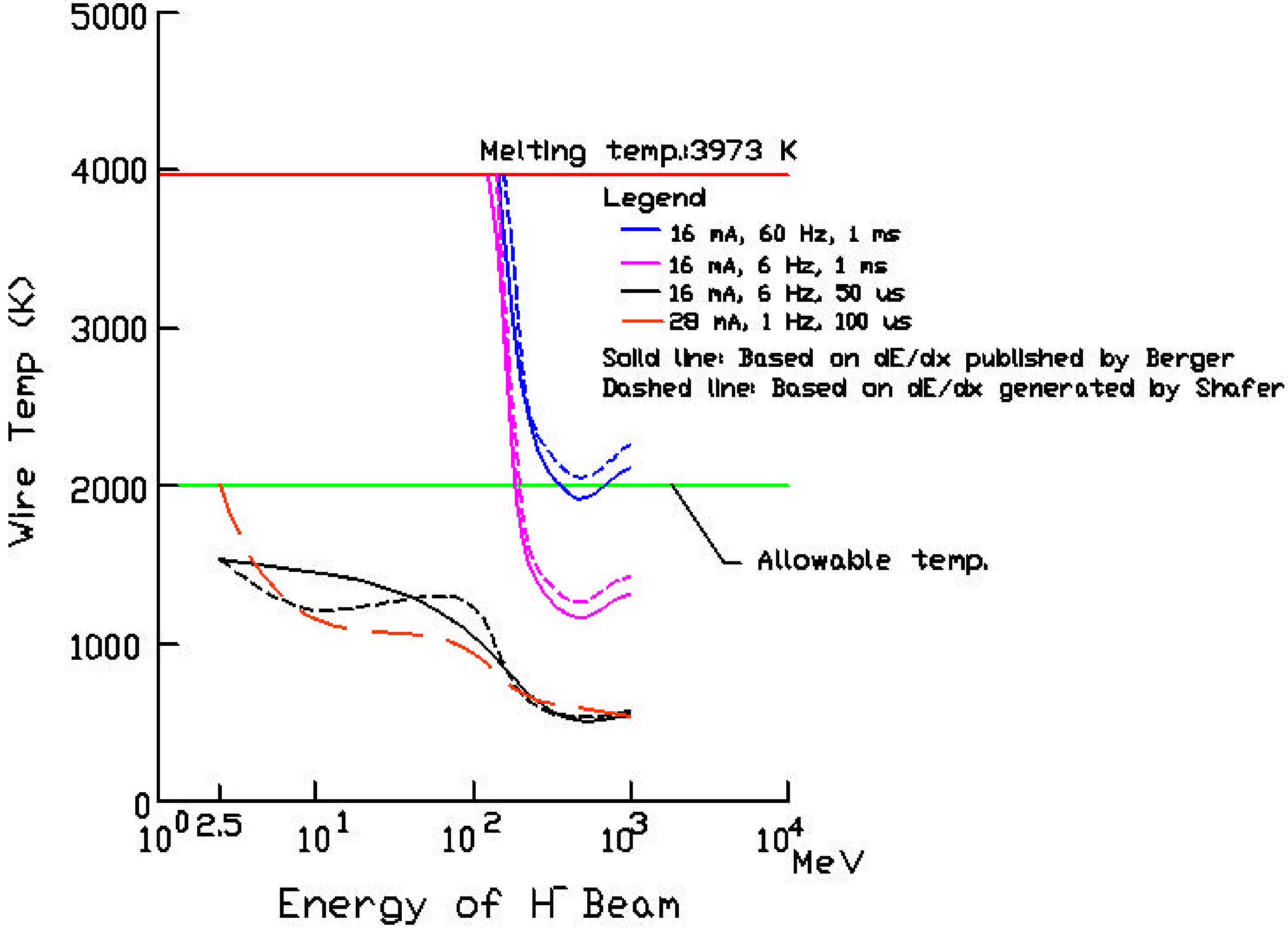
t = time [sec]

η= heating efficiency

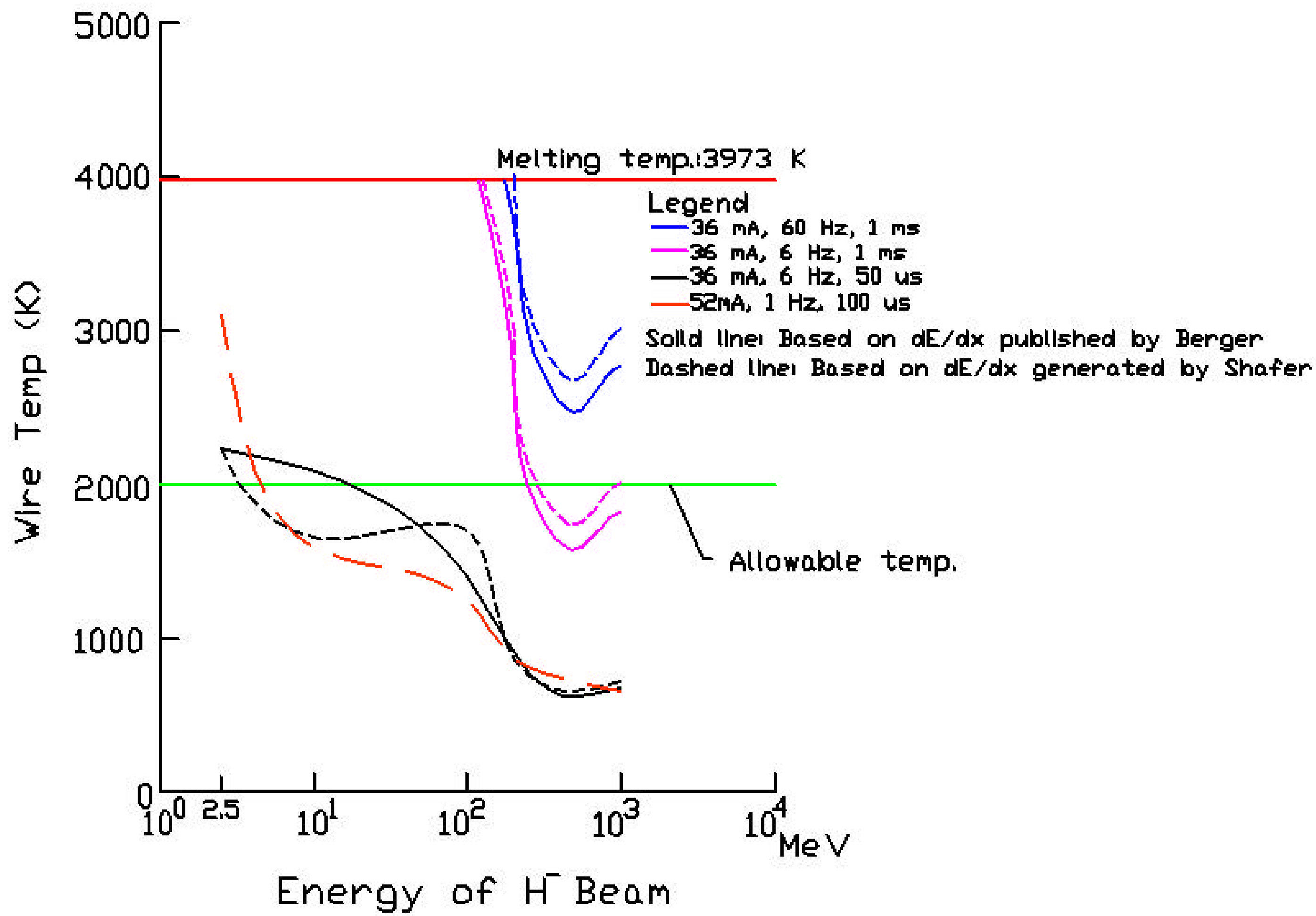
σ = Stefan Boltzmann constant = 5.67×10^{-8} [W/m^2K^4]

ρ, ε, c, and P are defined above.

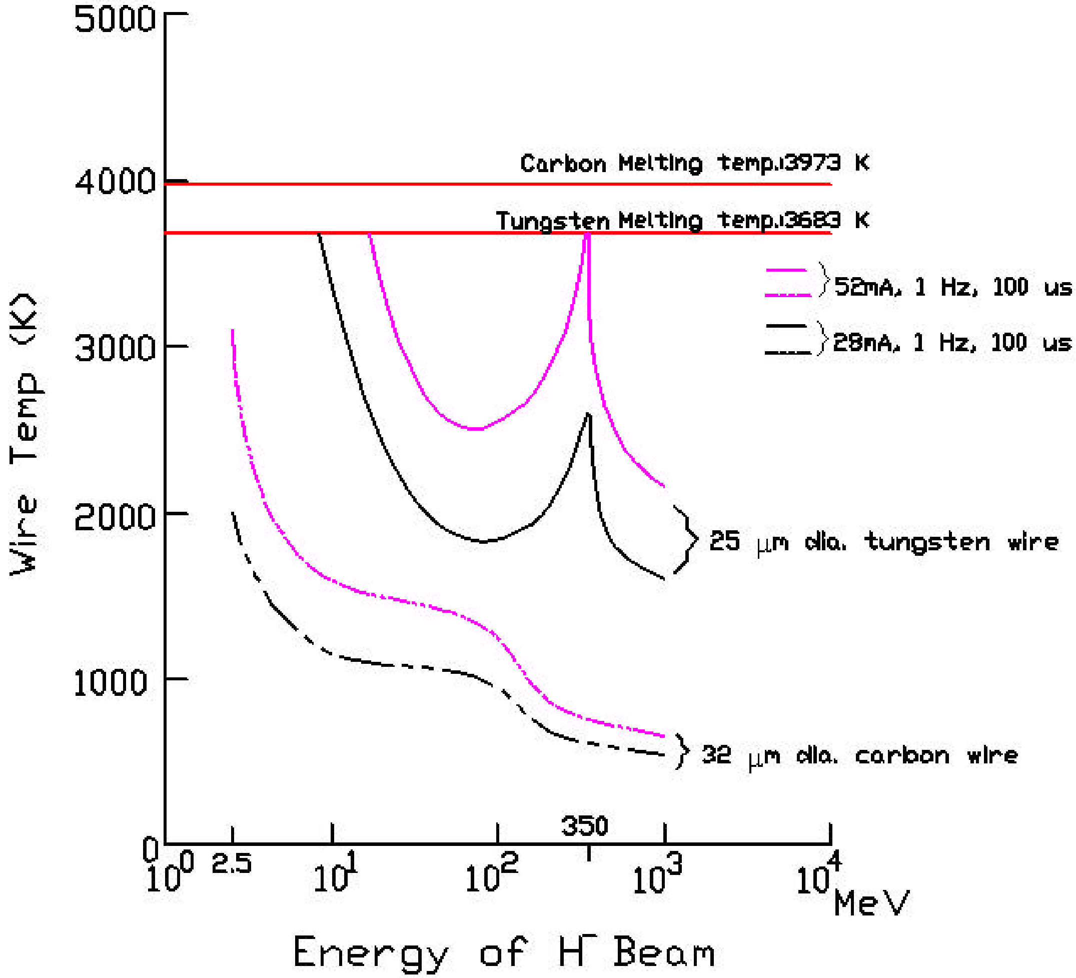
Max. Wire Temperature In The Injection Line (1 MW case)



Max. Wire Temperature In The Injection Line (2 MW case)



Max. Wire Temperature on Carbon and Tungsten Wire



*: Based on dE/dx generated by Shafer in LANL

Maximum Wire Temperature In The Ring

1 MW case: 64 μm carbon wire: 2614 K

100 μm carbon wire: 2901 K

One pass: 936 K for 64 and 100 μm wire

2 MW case: 64 μm carbon wire: 3278 K

100 μm carbon wire: 3610 K

One pass: 1380 K for 64 and 100 μm wire

Maximum Wire Temperature In RTBT

1 MW case: 64 μm carbon wire: 455 K

100 μm carbon wire: 456 K

2 MW case: 64 μm carbon wire: 528 K

100 μm carbon wire: 529 K

CONCLUSIONS

• Carbon wires will survive (i.e.: wire temperature < 2000 K) in the entire injection line with a 6 Hz/50 μs H^- beam and can only be used in the higher energy region with the 6 Hz/ 1 ms and 60 Hz/1 ms H^- beam.

• For the ring, the carbon wire could survive in the 1 ms long H^- beam with a very low repetition rate.

•The wire temperatures in RTBT are low. Lifetime of the carbon wire is not an issue in this region.

SNS Wire Scanner Preliminary Design Review

Wire Scanner Actuators for HEBT, Ring, and RTBT

By

J. Cullen, BNL

July 17, 2001

Physics Requirements

SNS Profile Monitor AP Requirements 3/21/01									
Device	Location	Qty	Intensity [ppp]	Pulse Length [microsec]	Range	Accuracy	Resolution	Data structure	Comments
Wire	MEBT	5		.3-100	+/- 15mm		0.2mm		three planes
	DTL	0							
	CCL	8		.3-100	+/- 15mm		0.2mm		three planes
	SCL	32		.3-100	+/- 15mm		0.2mm		three planes
	HEBT	11		.3-1000	+/- 50mm		0.2mm		three planes
	Ring	2	5e10 - 2e14		+/- 100mm		0.2mm	turn-by-turn	three planes?
	RTBT	5	5e10 - 2e14		+/- 100mm		0.2mm		three planes?
	total	63							
Harp	DTL			.3-50	+/- 10mm		1mm		
	HEBT		3e11 - 2e14		aperture	1mm pitch	.5mm	single shot	
	RTBT		3e11 - 2e14		aperture	1mm pitch	.5mm	single shot	
IPM	Ring	2 (3?)	5e10 - 2e14		+/- 64mm	2mm	2mm	few per turn	three planes (?)
Moment	Ring	1 (2?)						few per turn	quadrupole, octupole,...
Inj Foil Video	Ring	1						fill?	
Ho Foil Video	Inj Dump Line	1						fill?	

Physics Requirements (cont.)

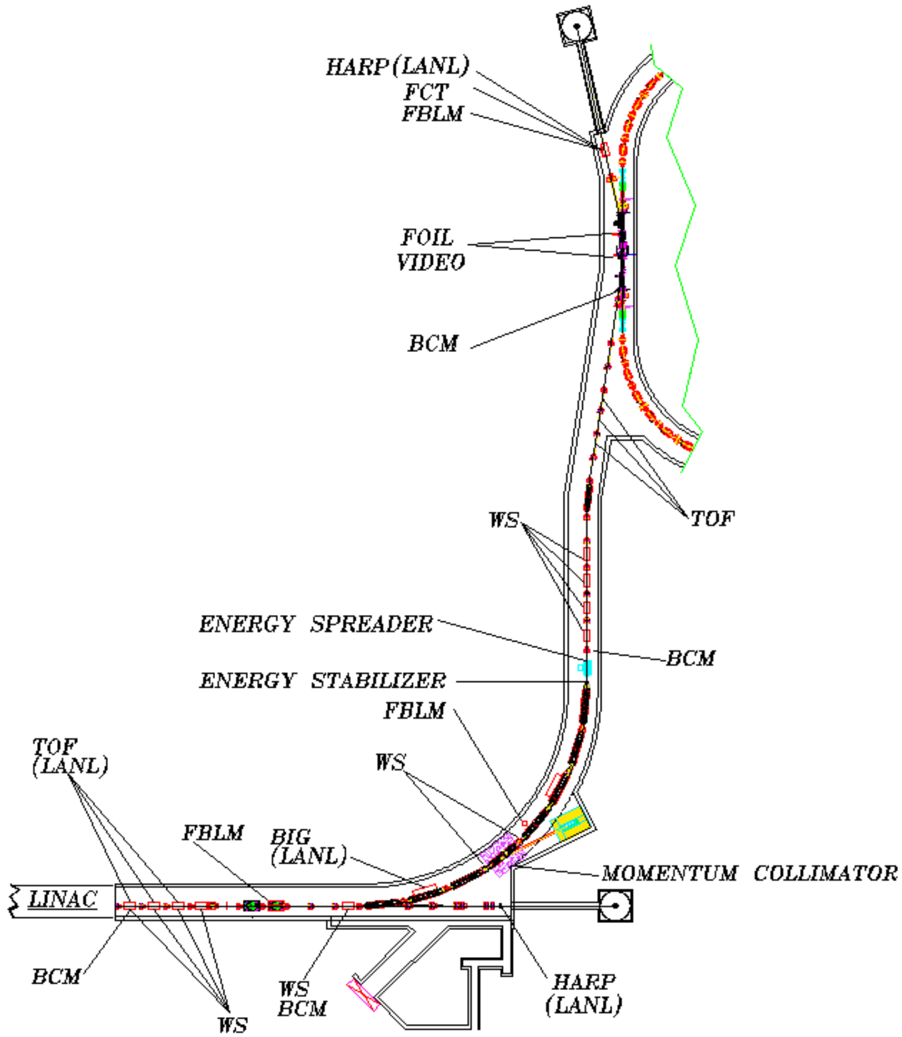
- AP Requirements
  - Resolution - 200μ
  - Range
    - MEBT thru SCL +/- 15mm
    - HEBT +/- 50mm, Ring and RTBT +/- 100mm
- Additional Requirements
  - Don't 'melt' the wire!
  - Sensing emission current requires T < 2000K
  - Fit in limited space along beamline
  - Relative profile accuracy - 10% at 1σ? 5% at 2σ?
  - Halo measurement - 5σ?

Level of Design

- All Energies - wire heating analysis complete
- MEBT Actuator
  - Detail Design Complete
  - First Article Assembly Complete
  - LANL to provide motion control, readout electronics, interface to Controls
- HEBT, Ring, RTBT
  - conceptual design of actuator complete
  - LANL to provide motion control, readout electronics, interface to Controls (in negotiation)
  - LANL may provide actuators

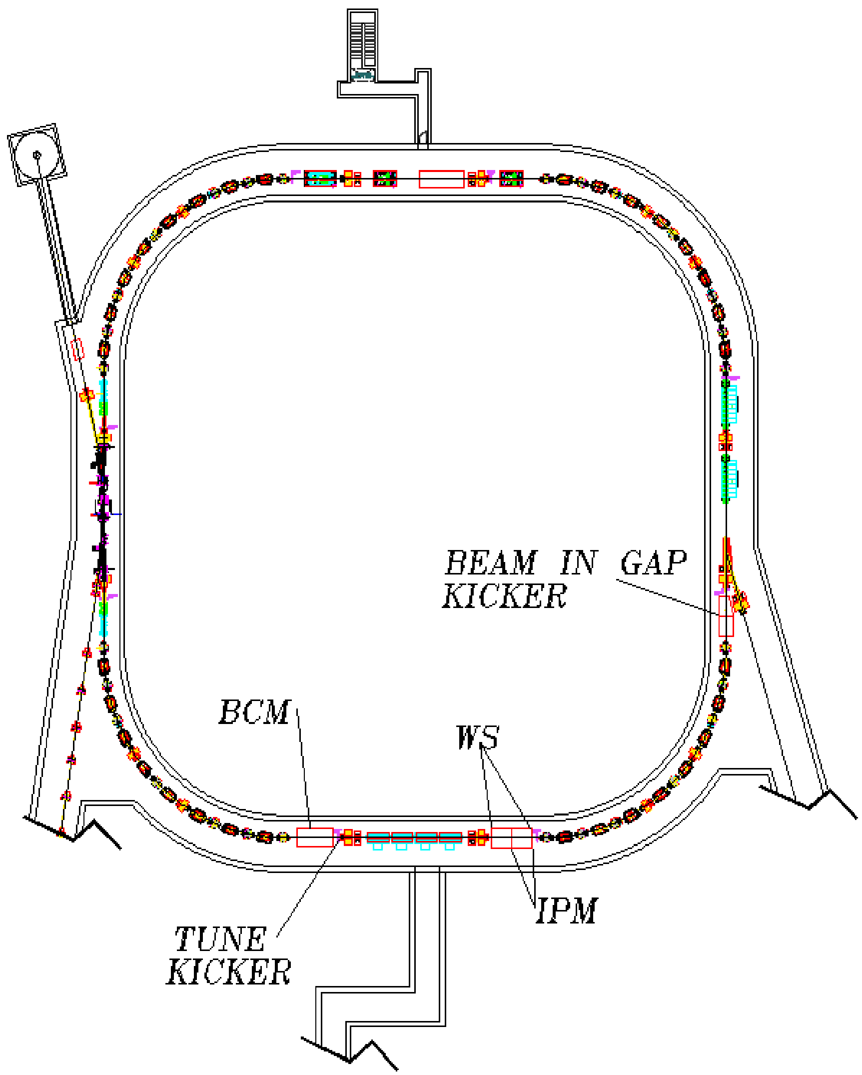
HEBT Beam Instrumentation

Detector	BNL	LANL
BIG	0	1 (0?)
BPM	16	0
TOF	0	2
FBLM	3	0
BLM	52	0
BCM/FCT	5	0
WS	11 (0?)	0 (13?)
FOIL VIDEO	2	0
HARP	0	2 (0?)



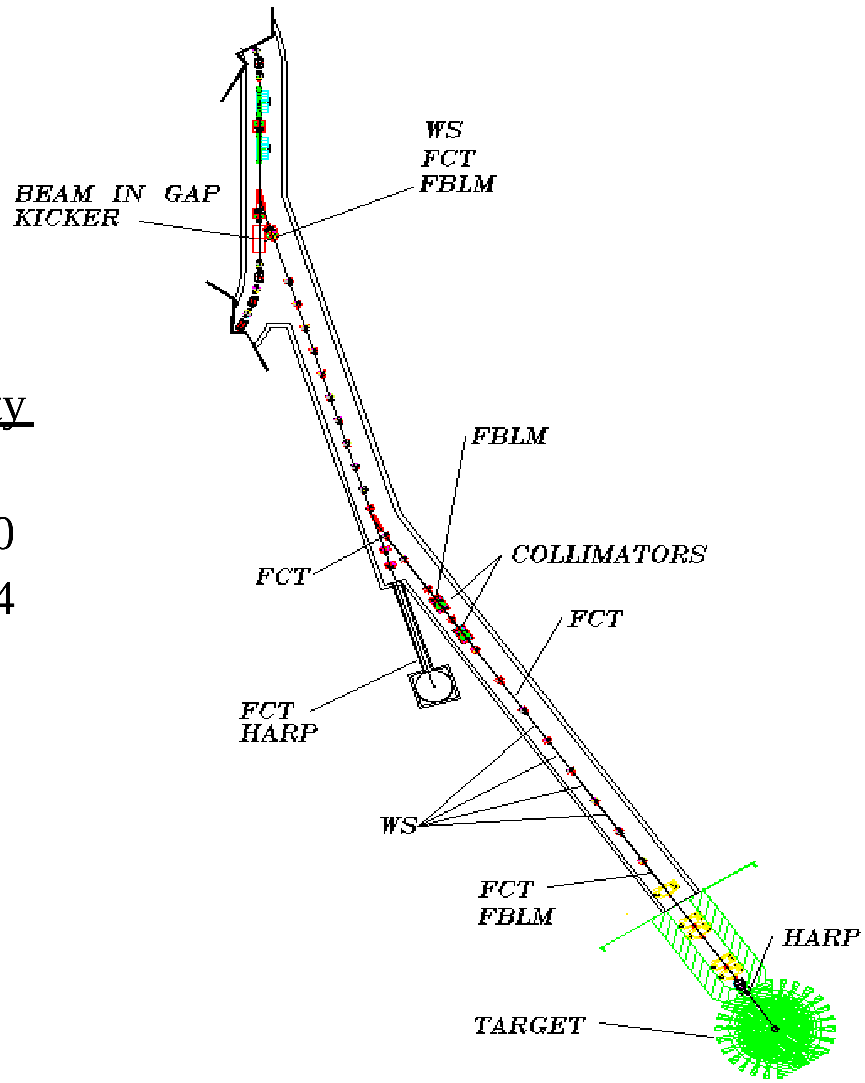
SNS Ring Instrumentation

Detector	Qty	Note
BPM	44	Dual Plane
BPM	2	RF radial loop
BLM	75	Ion Chamber
FBLM	12	Photomultiplier
BIG	1	Kicker+PMT
IPM	2	H + V
WS	2	H + V
Coherent Tune	1	Kicked
Incoherent Tune	2	PLL & QMM
BCM/FCT	1	
WCM	2	Including RF
Electron Detector	5	
Higher Moment	1	



RTBT Beam Instrumentation

Detector	Qty
FBLM	3
BLM	40
BPM	14
DUMP HARP (LANL)	1
FCT	5
WS	5
TARGET HARP (LANL)	1



Wire Scanners - Quantities Summary

• HEBT	11 (3plane)
• Ring	2 (single plane)
• RTBT	10 (single plane)
• Total Actuators	23
• Total measurement locations	17

Linear Motion Feedthroughs

- Linear Motion Feedthru Advantages
  - compact
  - Low cost - $1500 for stock item
  - Available off-the-shelf
- Linear Motion Feedthru Disadvantages
  - Welded bellows
  - Formed bellows available in shorter strokes off-the-shelf, longer strokes custom
- Velocity Limitation
  - Manufacturer says 40 mm/s
  - OK for scanning

Mechanical System Specification

	HEBT	Ring	RTBT
Wire configuration -	3 axis @ 45°	2 axis @ 90°	2 axis @ 90°
Actuator stroke (in.)-	10	8	8
System interface -			
Flange (in.)	6-3/4 CF	10 CF	10 CF
Axial length (in.)	9.86	16	16

Conclusions

- HEBT, Ring, RTBT designs benefit from MEBT
- Conservative, simple actuator approach - stationary wire limit
- 2MW beam problematic in HEBT
- Details between LANL and BNL to be smoothed yet
  - Pending clarification of who does what, we can proceed to more detailed design

Ring and RTBT Wire Scanner Electronics

Al DellaPenna Jr.

Outline

- System Specification
- Signal Size Calculation
- Amplifier Selection
- BW Consideration
- S/N of Measurement System
- Appendix: Comparison of Laser wire and Carbon wire in HEBT

AP Requirements on SNS Profile Monitors

SNS Profile Monitor AP Requirements 3/21/01									
Device	Location	Qty	Intensity [ppp]	Pulse Length [microsec]	Range	Accuracy	Resolution	Data structure	Comments
Wire	MEBT	5		.3-100	+/- 15mm		0.2mm		three planes
	DTL	0							
	CCL	8		.3-100	+/- 15mm		0.2mm		three planes
	SCL	32		.3-100	+/- 15mm		0.2mm		three planes
	HEBT	11		.3-1000	+/- 50mm		0.2mm		three planes
	Ring	2	5e10 - 2e14		+/- 100mm		0.2mm	turn-by-turn	three planes?
	RTBT	5	5e10 - 2e14		+/- 100mm		0.2mm		three planes?
	total	63							
Harp	DTL			.3-50	+/- 10mm		1mm		
	HEBT		3e11 - 2e14		aperture	1mm pitch	.5mm	single shot	
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Moment	Ring	1 (2?)						few per turn	quadrupole, octupole,...
Inj Foil Video	Ring	1						fill?	
Ho Foil Video	Inj Dump Line	1						fill?	

System Specifications

- AP Requirements
  - Resolution - 200m
  - Range
    - MEBT thru SCL +/- 15mm
    - HEBT +/- 50mm, Ring and RTBT +/- 100mm
  - Rate to console - 5 seconds
- Additional Requirements
  - Don’t ‘melt’ the wire!
  - Sensing emission current requires T < 2000K
  - Fit in limited space along beamline
  - Relative profile accuracy - 10% at 1s? 5% at 2s?
  - Halo measurement - 5s?
  - Profiles along the 600ns mini-pulse - BW ~ 5 MHz
  - Gain Switching in Ring and RTBT

Signal size

- $I_{sig} = (I_{beam\ ave}) \times (\text{Ratio}_{wire/beam}) \times (\%\ \text{of beam}) \times (\text{Secondary Emission yield}) \times (N_{turns})$
  - $I_{beam\ ave} = Q / t$;   t = 695ns
    - Q = n x q   ; n = 1.46E11particles , q = 1.6E-19
    - $I_{beam\ ave}$ = 36ma
  - Ratio = Wire size / beam size
    - Wire size = 75µm , beam size = 68000µm
    - Ratio = 1.33E-3
  - % of Beam = .606 @ s = 1
  - N_{turns} = 1000
  - ***Secondary emission*** : Secondary electron yield from a proton striking a metal depends on the proton energy, angle of incidence, and surface conditions[1] .

• I_{sig} = ($I_{beam\ ave}$) x (Ratio $_{wire/beam}$) x (% of beam) x (Secondary Emission yield) x (N_{turns})

SE = secondary emission yield.

SE = .7 x A x E^-0.7

(constant) = 2.52 , E = proton energy(MeV)

SE = .7(2.52)(1000MeV)^-0.7 = 0.02

I_{sig} = (36ma) x (1.33E-3) x (.606) x (.02) x (1000)

= 580µa

Amplifier Selection

- Wide Bandwidth
- Low Noise
- Low distortion
- National Semiconductor CLC400

  BW = 200MHz

  Voltage Noise = 2.4nV / HZ^½

  Distortion = -20dBc @20MHz

Digitizer AD6644 = 65MSPS 14BIT

Bandwidth considerations

- To resolve the details of the minibunch with a period of 695ns we needed a BW of at least 1.5MHz. Taking at least four samples at each minibunch requires bandwidths greater than 6MHz. Our digitizer can sample up to 65MSPS. Having the ability to use this resolution the current design has a BW of 30MHz .

- Taking full advantage of the BW of the digitizer we may be able to use the design for halo measurements down to 3 sigma. For measurements below that threshold it would be more practical to use Loss monitors for detection. Since the loss monitors have better noise immunity.

DC BIASING :

The ability to add a negative DC bias was added to the design to enhance the signal. Some fraction of the very low energy electrons knocked out of the wire may return to the wire due to local electric fields, unless repelled by a small negative bias on the wire[2]. We have chosen a variable supply with a maximum range of –30V.

CALIBRATION :

We have the ability to calibrate by inducing a signal through the wire because we bring out both ends of the wire. This freedom also allows for wire continuity tests.

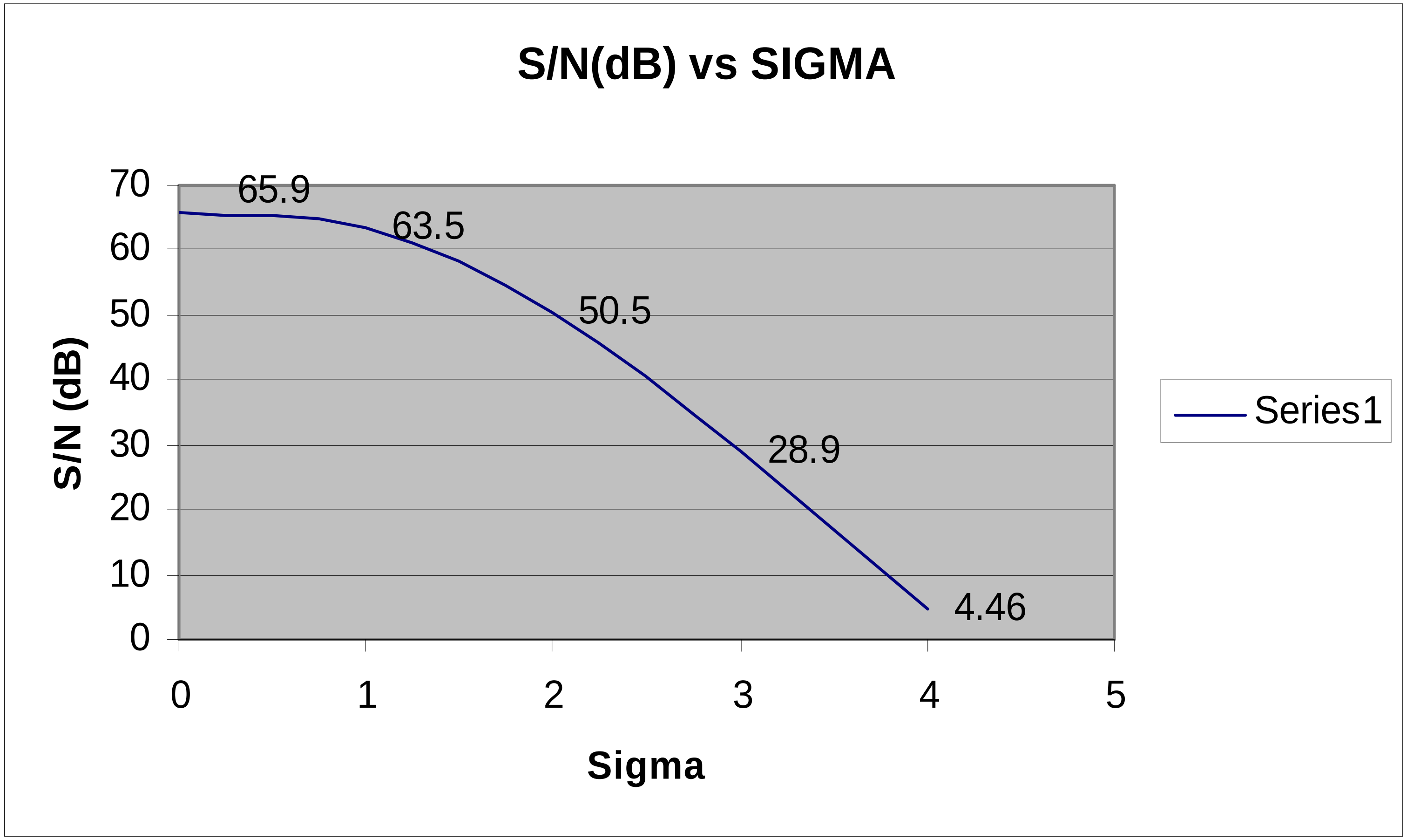
Cable selection

Using 1/4 inch Heliax (50 Ohm, Foam Dielectric)FSJ1-50A; @ 30MHz losses are 5.9dB per 100 meters (300ft). Therefore, for a worse case approximation assume cable losses of 6dB in 300ft of cable[3].

SIGNAL TO NOISE

The Amplifier chosen (CLC400) has a S/N of 2.6nV/ Hz^1/2. With a gain of 27 we have 914µV of noise out of the 3rd stage. Giving us a S/N of approximately 3.85E3 or 71.9dB.

Sigma	S/N	S/N dB 20log(S/N)	S/N-6dB Cable losses
0	3.85E3	71.9	65.9
1	3.0E3	69.5	63.5
2	6.61E2	56.5	50.5
3	56.1	34.9	28.9
4	3.46	10.46	4.46


S/N(dB) vs SIGMA
70
60
50
40
30
20
10
0
S/N (dB)
65.9
63.5
50.5
28.9
4.46
0
1
2
3
4
5
Sigma
Series1

Appendix

HEBT assumptions:

Beam size ~ 2mm

Wire size = 35um

Ratio = .0175

Beam current ~ 36ma

Beam Energy = 1GeV

Signal current = 36ma (.2)(.0175)(.606)

Signal current = 76.3ua (with a 50 Ohm resistor,
A ~ 27 ; 152mV

S/N assuming N= 914uV ; ~ 44.4dB

Laser vs. Wire

Best case of S/N for the Wire scanner is 44.4dB , using the estimates for the Laser scanner we have a S/N of almost 8.5dB better(53dB). The actual measurements at the BNL Linac showed profiles down to 2.5sigma and S/N before filtering of 25dB. The laser is also much more versatile can also be used in beams where wires cannot. i.e.: wire breakage due to heating with intensities greater than 2 x 10^13 protons[4].

Testing

Although a circuit board has not been fabricated, simulations and breadboards confirm theoretical data. The digitizer portion of the design is currently being used in the BCM electronics.

Conclusion

To conclude we have shown that with the preliminary design we should be able to resolve down to 3 sigma. Wire scanners have proven to give consistent profiles of the beam however, laser wire profiles have been taken and the laser is a non-intrusive way of monitoring beam profiles.

References:

1:Roger Connolly , AT-3 Technical Note 88-26 ; Direct Sensing of 1-10MeV H° and H^- beams. Dec. 1988 pg. 2.

2:SLAC-PUB-4605,LBL-25136,UM-HE-88-10; A high resolution wire scanner for micron-size profile measurements at the SLC. April 1988 pg. 7.

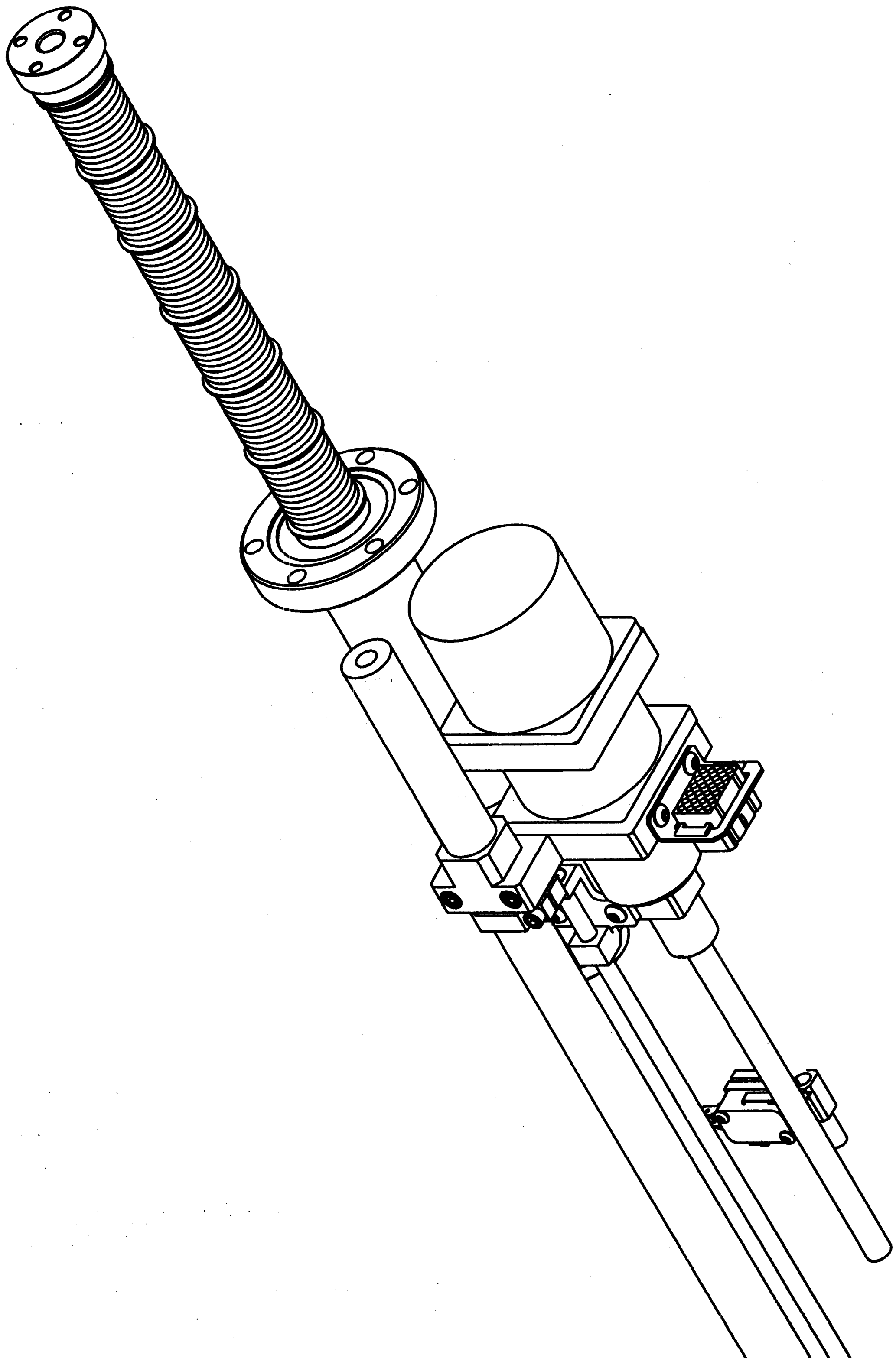
3:Marty Kesselman , Laser wire Estimates ; 2001.

4:H.Huang,W.Buxton,G.Mahler,A.Marusic,T.Roser,G.Smith,

M.Syphers,N.Williams,R.Witkover. PAC1999 ; A flying wire system in the AGS. Pg. 2128.

SNS Linac Wire Scanner Preliminary Design Review
July 17, 2001.
Los Alamos

by Ross Meyer, Sr.



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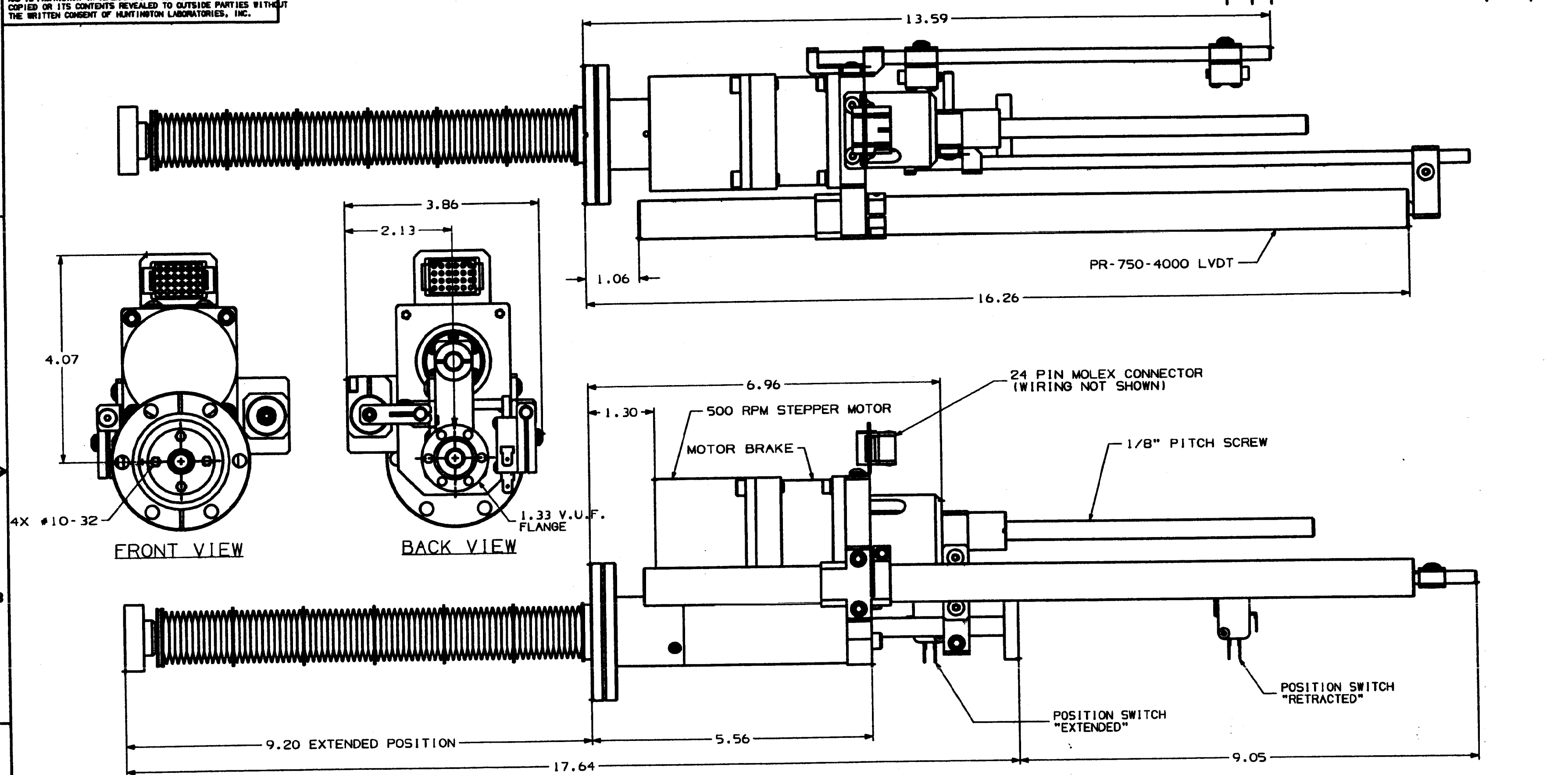


PART LIST

Huntington® Laboratories, Inc.

CAD FILE NAME: 21-11259-01.DWG

DRAWN: KEN C. DATE: 7-1-91

FINAL

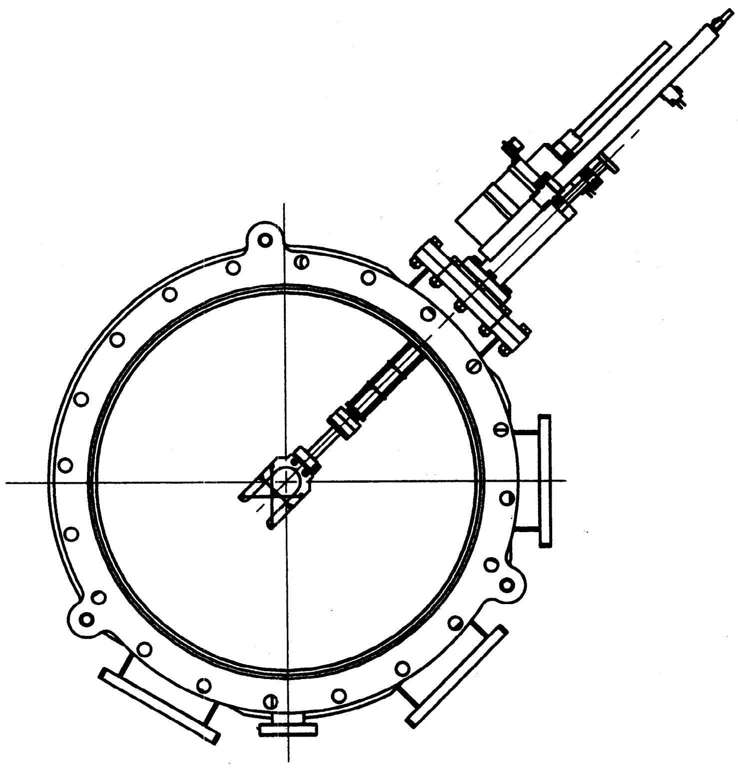
APPLICATION

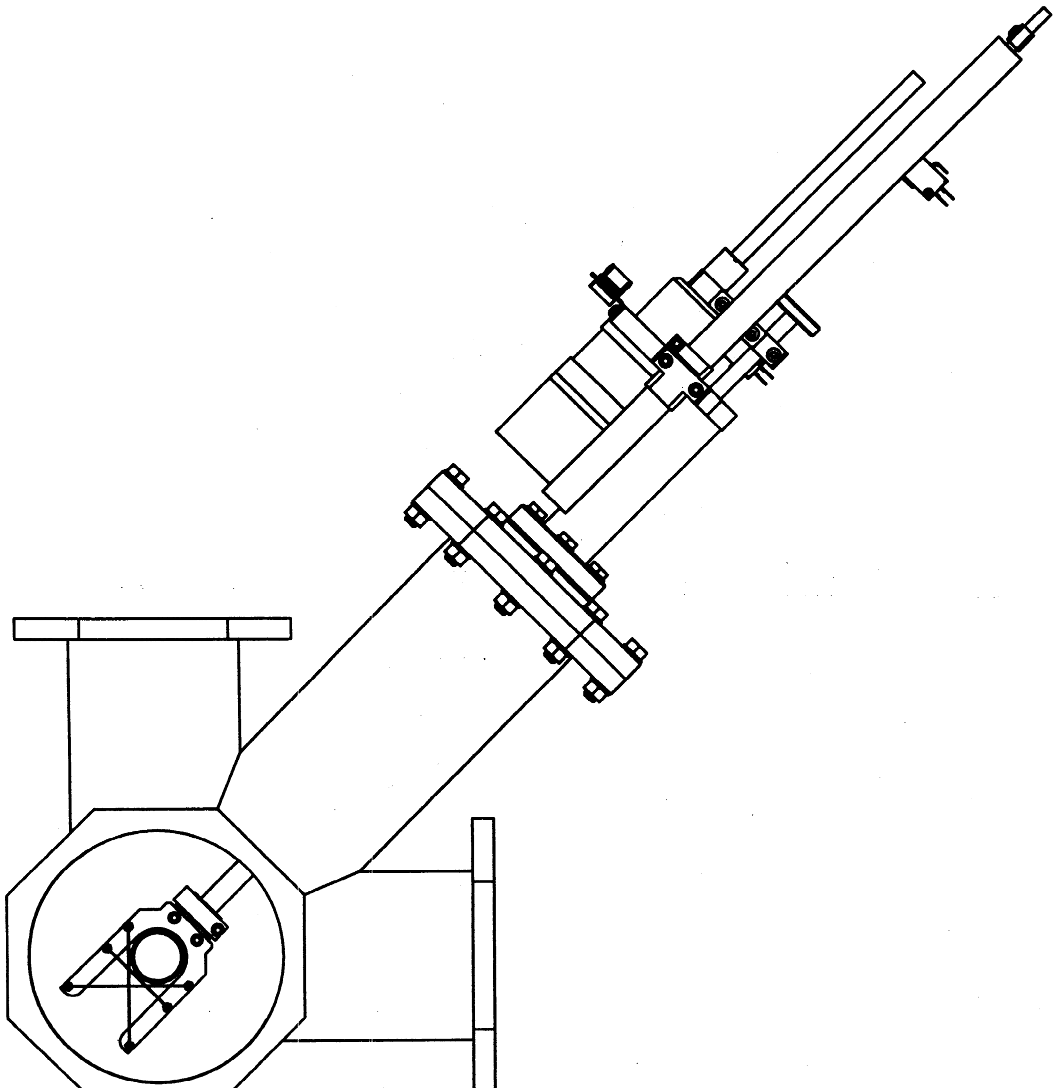
DO NOT SCALE DRAWING

ASSEMBLY, HOLLOW TUBE FEEDTHRU LVDT, SWITCHES, AND BRAKE

D 21-11250-01

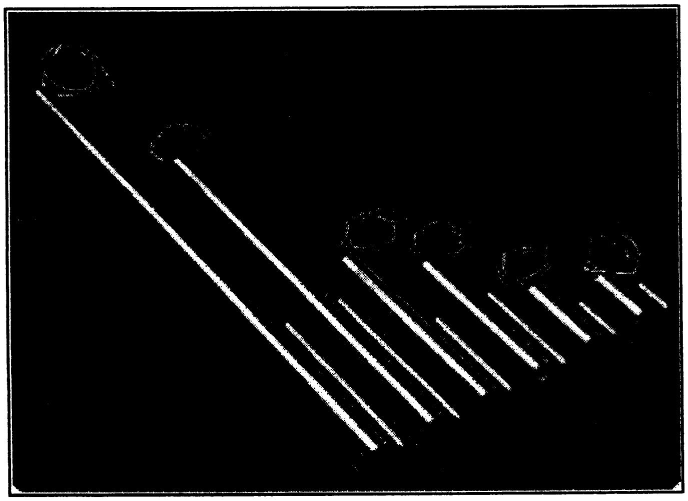
SCALE: 1:1 SHEET 2 OF 2





Macro Sensors
Howard A. Schaevitz Technologies, Inc.

Linear and Rotary Position Sensors



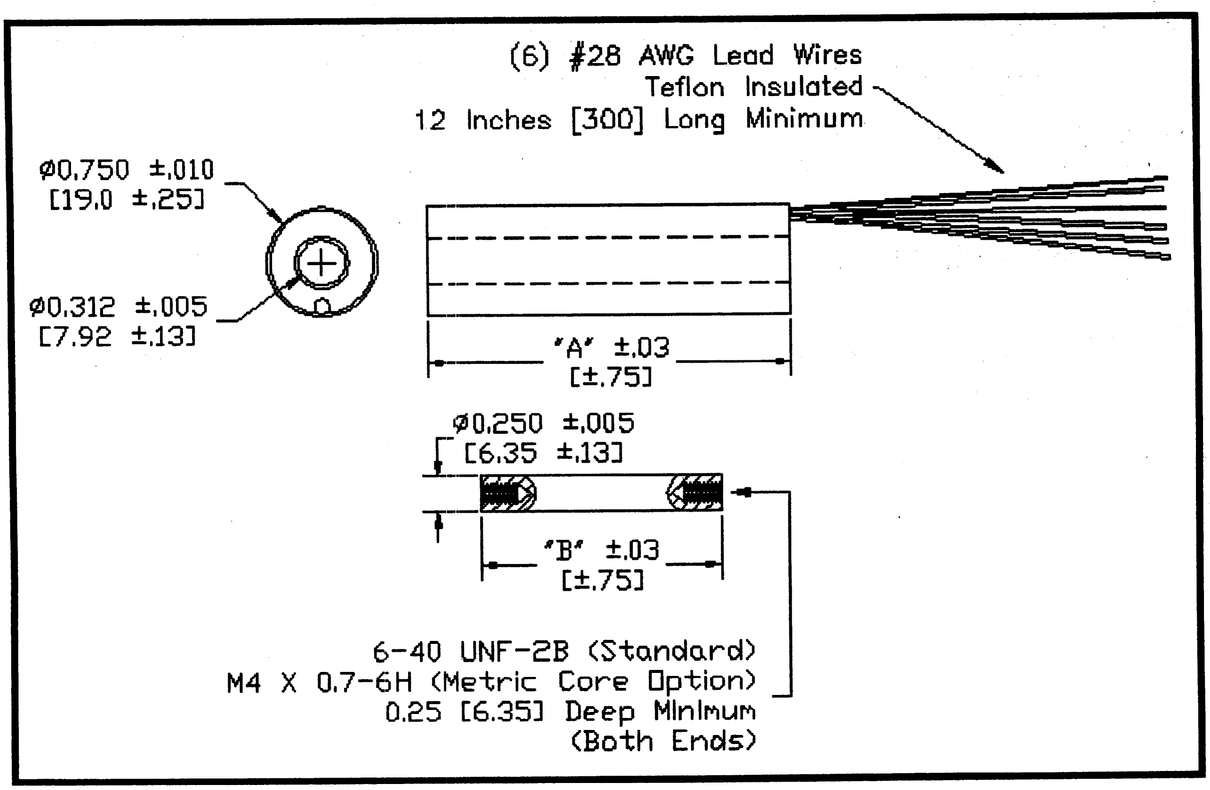
PR 750 Series LVDTs

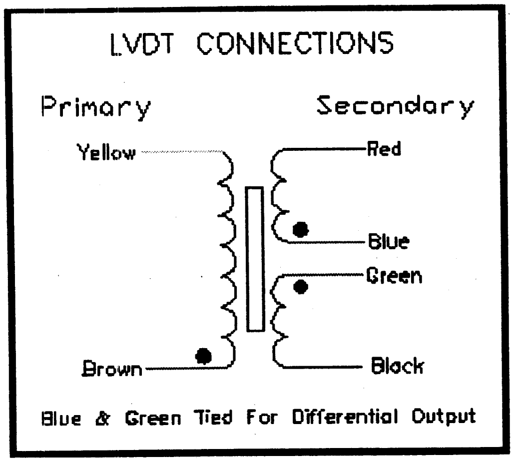
- Proven Reliability
- Superior Linearity
- Interchangeable With Many Manufacturers' Units
- Off-The-Shelf Delivery

The PR750 Series LVDTs are general purpose AC-operated units, featuring superior operating specifications. PR 750s are double shielded, making then ideal for use in electrically noisy environments. These units are designed to be physically and electrically interchangeable with other makers' units. Using proven materials and construction, the PR 750 is a cost effective solution to many measurement problems.

[illegible]	
Input:	3.0 V, 2.5k Hz
Operating Temperature Range:	-65° to +221° F
[illegible]	[illegible]
Core-To-Bore Clearance:	0.031 Inch (Radial)
[illegible]	[illegible]
Housing Material:	400 Series Stainless Steel
Environmental Seal:	Epoxy Encapsulation

PARAMETER	UNIT OF MEASURE	PR 750-050	PR 750-100	PR 750-200	PR 750-500	PR 750-1000	PR 750-2000	PR 750-3000	PR 750-4000	PR 750-5000	PR 750-10000
Stroke	Inches	±0.050	±0.100	±0.200	±0.500	±1.000	±2.000	±3.000	±4.000	±5.000	±10.000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Non-Linearity	Plus/Minus %	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%
Sensitivity	mV/V/.001 Inch	6.5	4.0	2.4	0.65	0.65	0.39	0.26	0.18	0.13	0.08
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Phase Shift	Degrees	1.1	-1.5	-5.0	1.0	1.0	2.0	1.0	-2.0	2.0	0.0
Primary Impedence	Ohms	400	990	1890	1400	1655	1875	3300	430	1050	1050
Secondary Impedence	Ohms	2500	3600	4330	750	1660	2000	2700	470	780	1000
Body Length ("A")	Inches	1.13	1.75	2.50	5.02	6.51	10.02	12.75	15.20	17.75	30.64
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Core Length ("B")	Inches	0.8	1.25	1.65	3.45	3.45	5.30	6.20	6.20	6.20	9.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Weight, Body	Ounces	0.9	1.4	1.7	2.8	3.85	5.0	10.0	10.6	11.7	20.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Weight, Core	Ounces	0.14	0.22	0.30	0.72	0.72	1.2	1.3	1.3	1.3	2.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



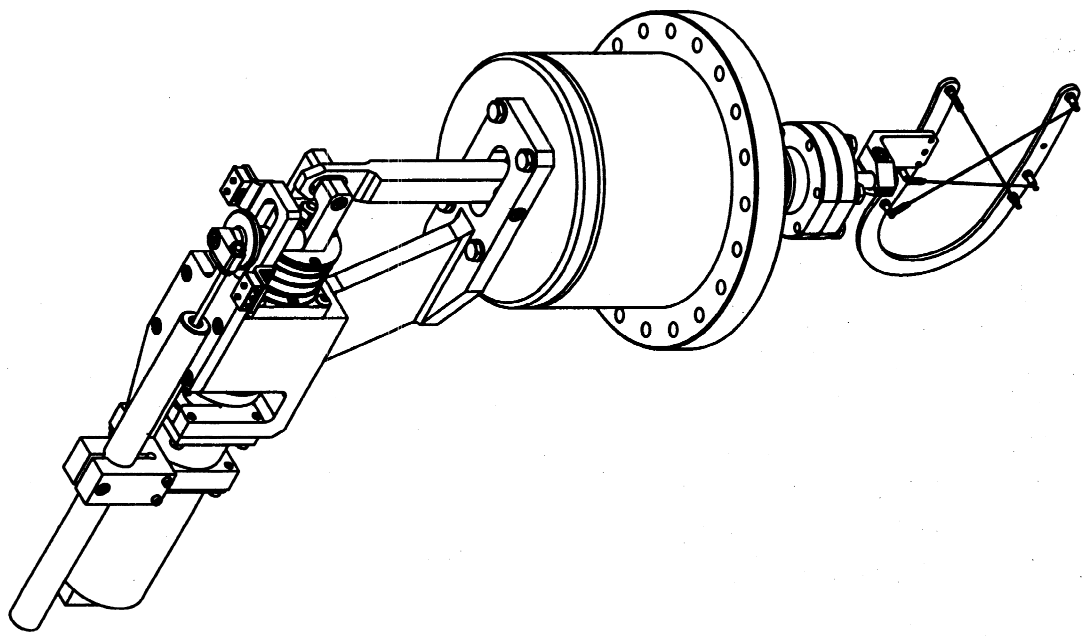
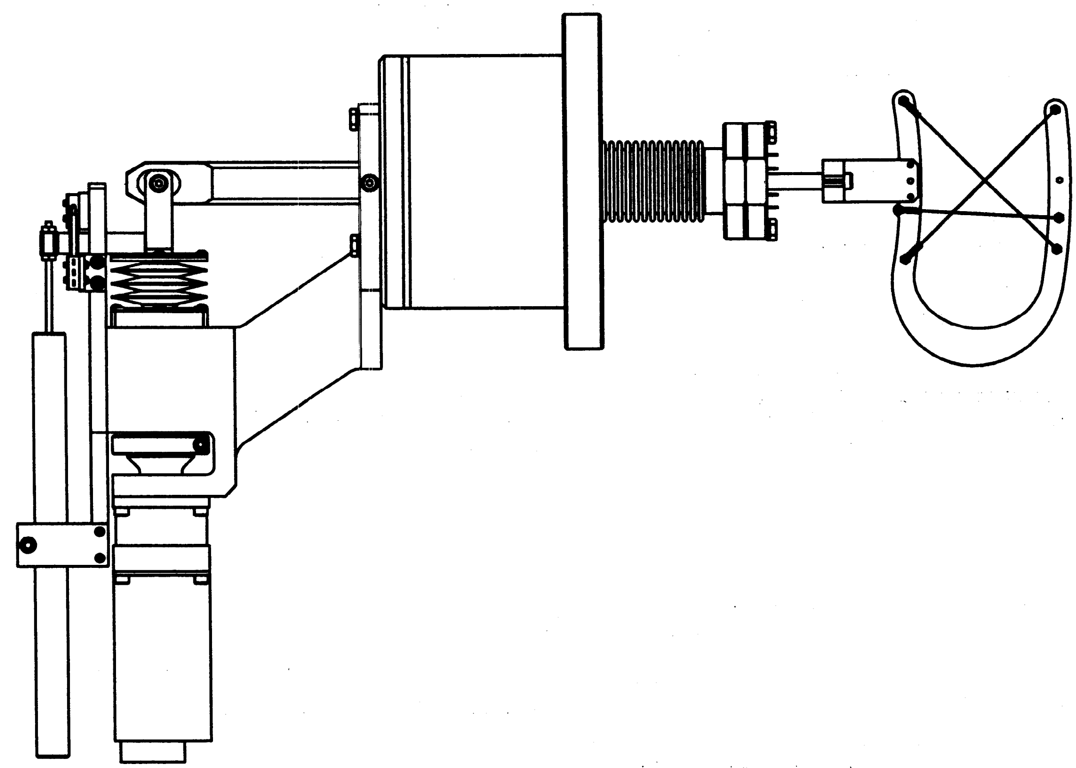


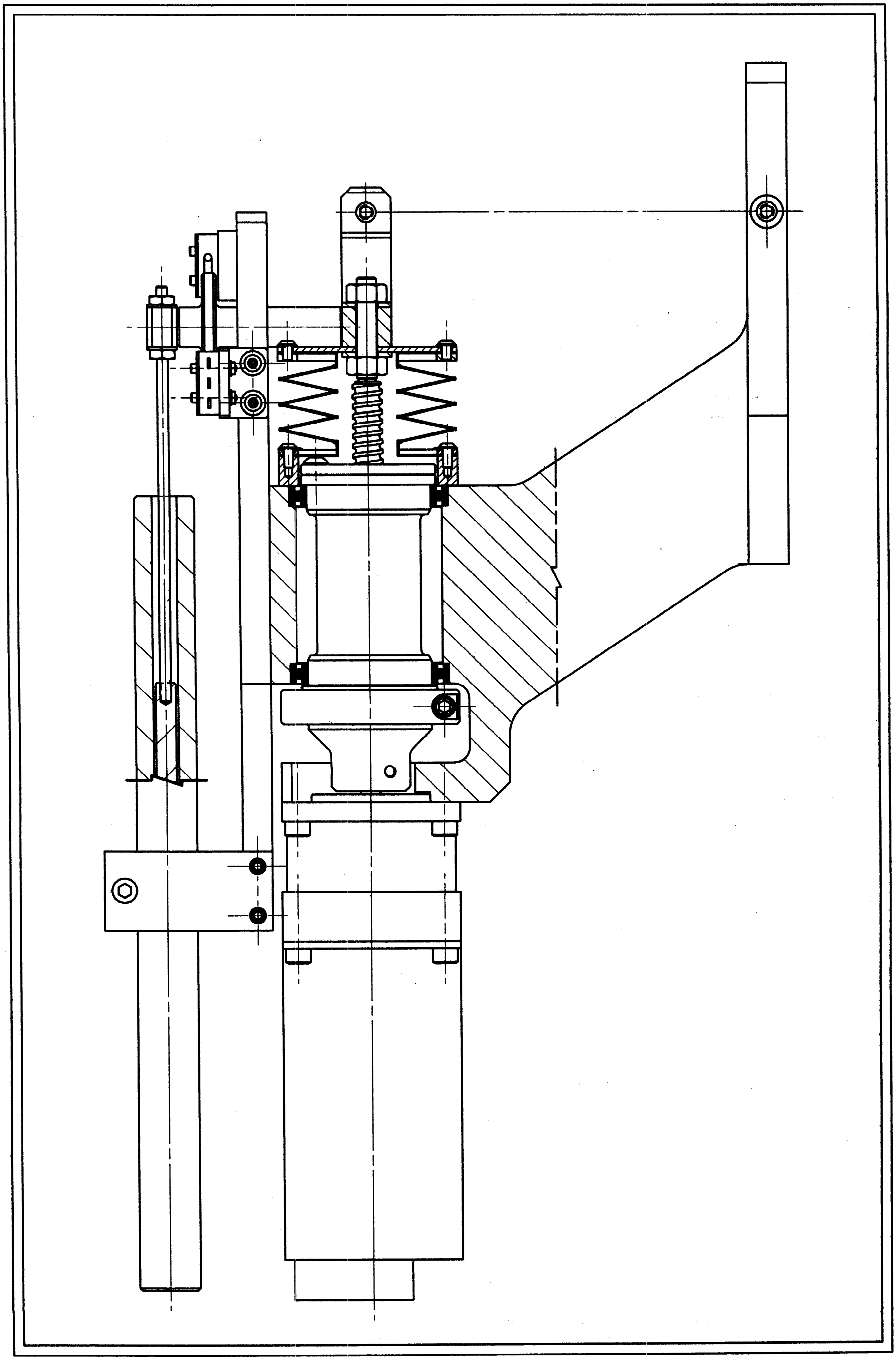
[illegible]		
MODEL	**POWER INPUT**	**OUTPUT**
DCM-1000	±15V DC	±10V DC or 0-10V DC
LVC-2400	24-30V DC	±7.5V DC or 0-7.5V DC or 4-20ma
LPC-2000	110V AC or 220V AC	±10V DC or 0-10V DC or 4-20ma
TIC-9000	110V AC or 220V AC	LED Readout, ±5V DC, Optional RS-232

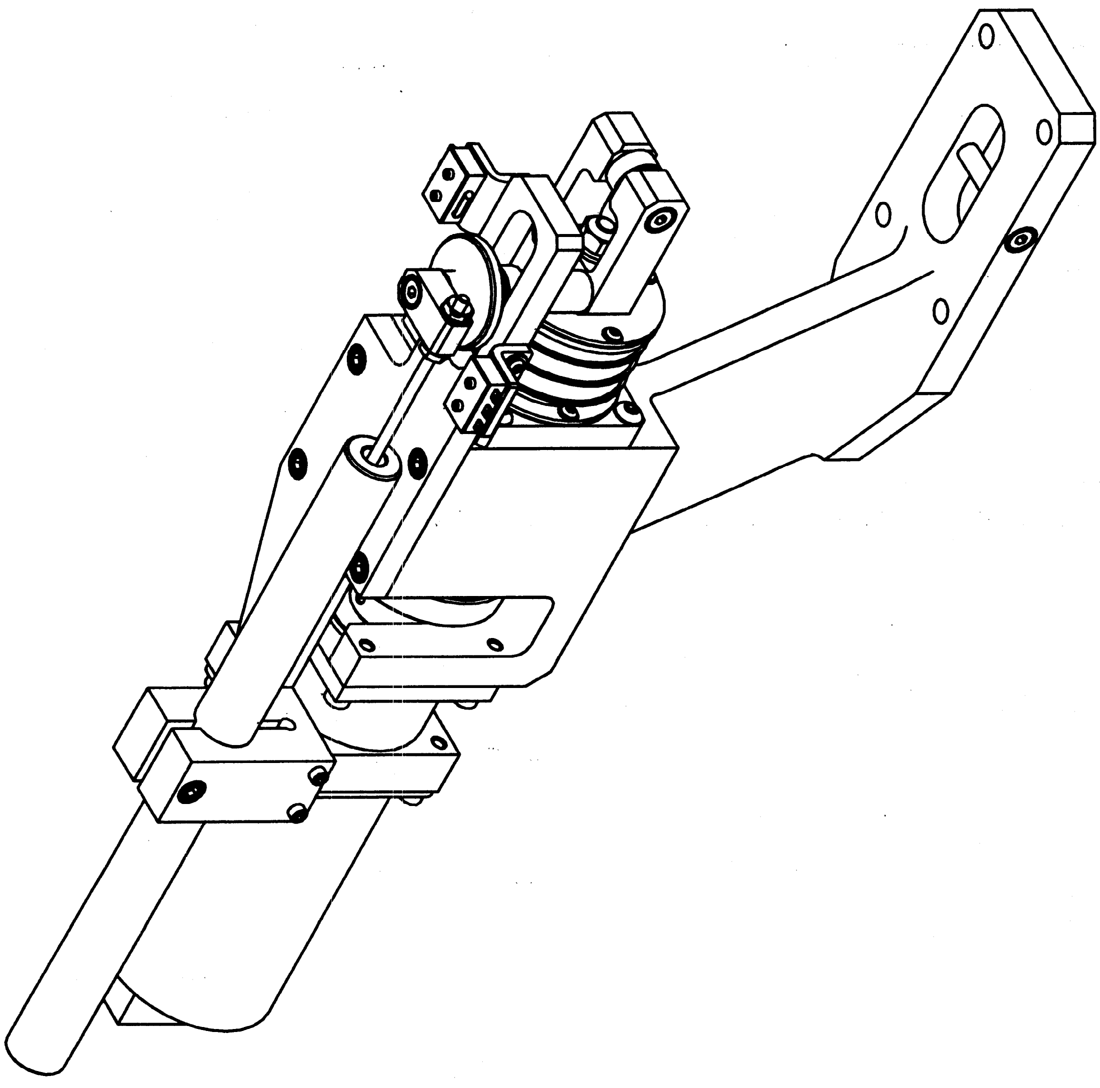
[illegible]
Teflon Bore Liner
Reduced Diameter Core
5k Hz Operation
10k Hz Operation
Core Connecting Rods
Mounting Blocks
Metric Threaded Core
Radiation Resistant Construction
Vented Case (for high pressure applications)
[illegible]

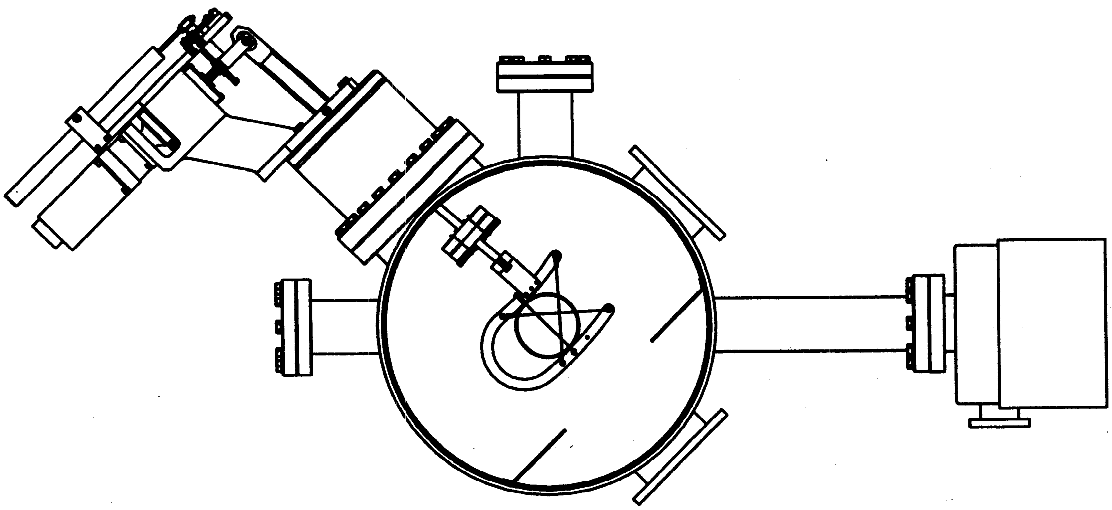
Macro Sensors
Howard A. Schaevitz Technologies, Inc.

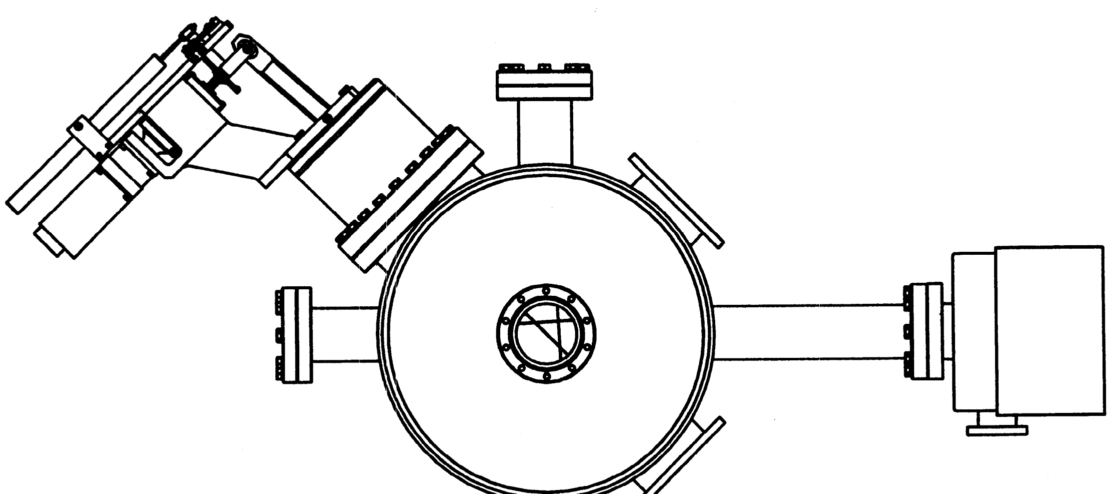
7300 Industrial Center Bldg. 22
U.S. Route 130 North
Pennsauken, NJ 08110-1541 U.S.A.
Phone: (856) 662-8000
Fax: (856) 317-1005

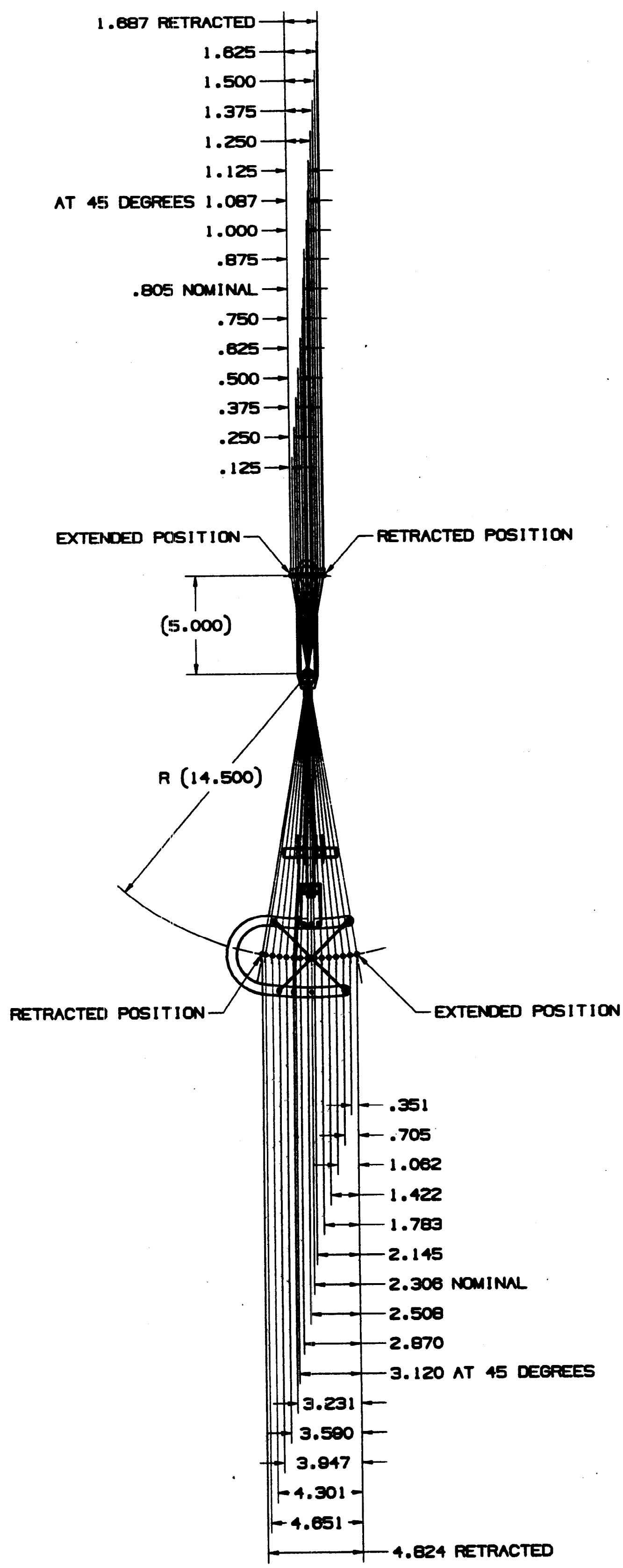



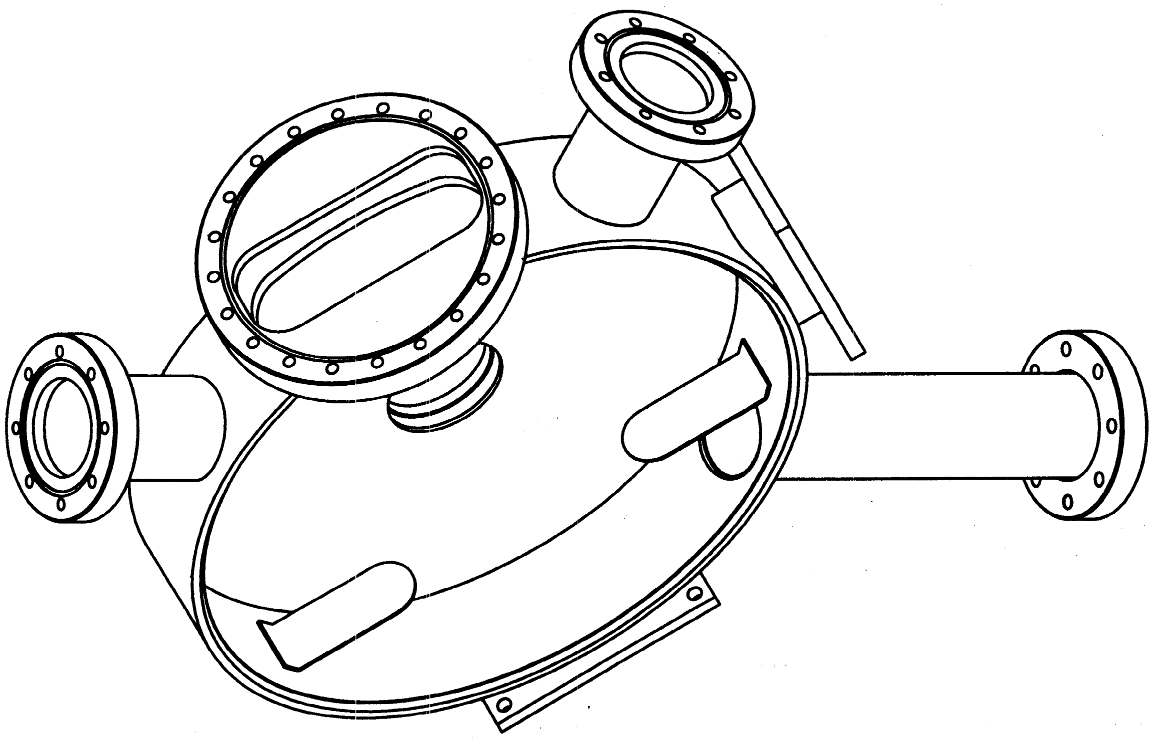


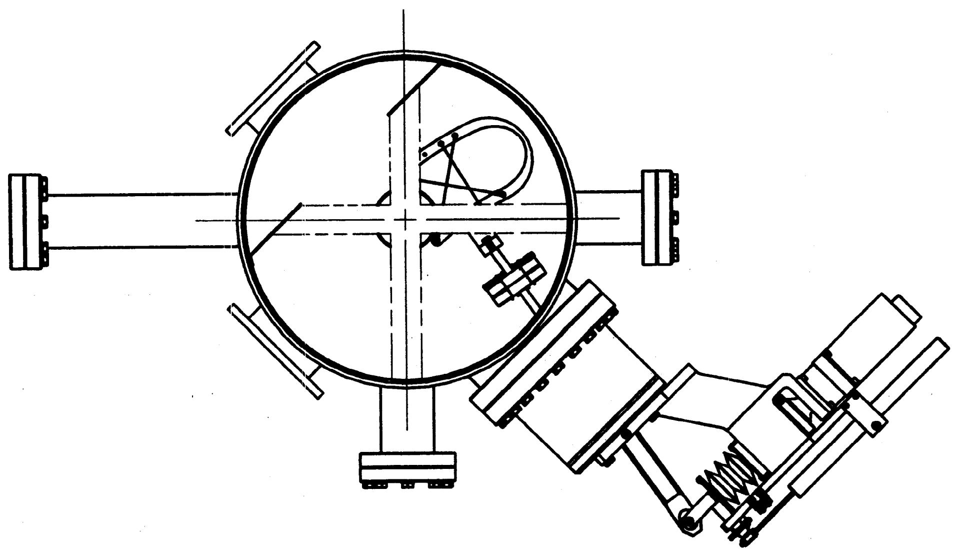


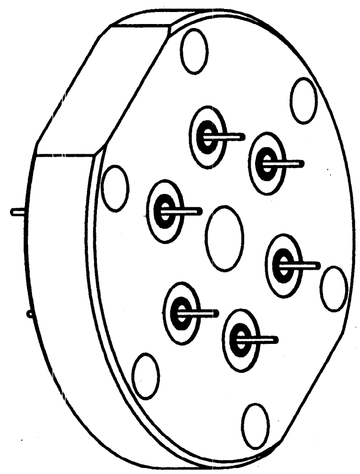





1.687 RETRACTED
1.625
1.500
1.375
1.250
1.125
AT 45 DEGREES 1.087
1.000
.875
.805 NOMINAL
.750
.625
.500
.375
.250
.125
EXTENDED POSITION
RETRACTED POSITION
(5.000)
R (14.500)
RETRACTED POSITION
EXTENDED POSITION
.351
.705
1.062
1.422
1.783
2.145
2.306 NOMINAL
2.508
2.870
3.120 AT 45 DEGREES
3.231
3.580
3.947
4.301
4.651
4.824 RETRACTED

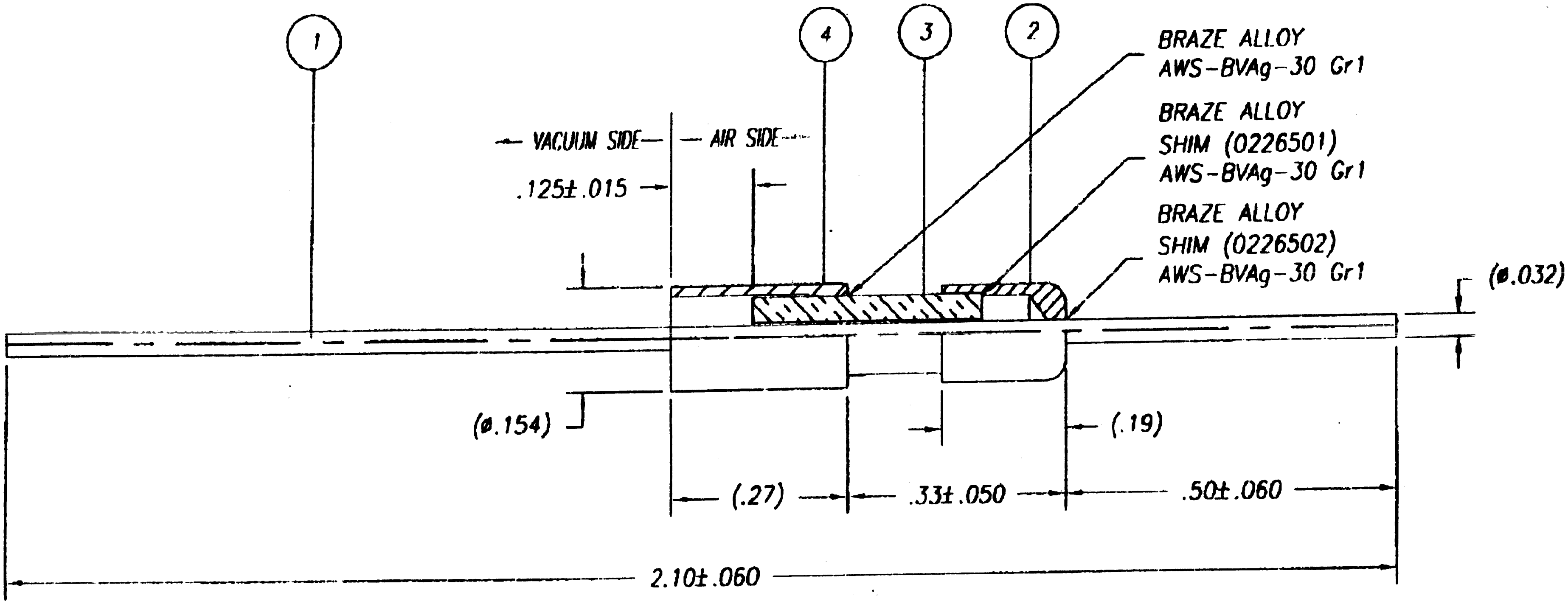






REV	DATE		DESCRIPTION
J	4-27-98		FORMAT UPDATED. DRAWING UNTABULATED.
K	6-24-98	4041	REVISED ITEM#4 DWG. (1) PC. WAS (2) PC.

Cat. No. 9411002 | **No. 0026101** | 6-24-98 | K



UNCONTROLLED COPY

NOTES:

1. LEAK TEST @ 2.0×10^{-10} STD AT. cc/sec HELIUM.
2. RATING: 2 AMPS

ITEM	NAME	DESCRIPTION	QTY.	DRAWING No.
1	CONDUCTOR	NICKEL-200	1	0016040
2	CAP	KOVAR	1	0026201
3	CERAMIC	94% ALUMINA	1	0160201
4	ADAPTER	NICKEL-200	1	0026401

DRAWN	SCALE	DATE	CHECKED	FINISH	PLATING
RTAYLOR	0.25	03-01-78-AD	98-30-06-RT	SUITABLE FOR UHV	

.XX TOL.	.XXX TOL.	ANGLES	SPECIFICATIONS
±.030	±.015	±2°	

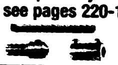
INSULATOR SEAL INC.

DIMENSIONS ARE IN INCHES. DO NOT SCALE PRINT. BLOCK TOLERANCES APPLY UNLESS OTHERWISE SPECIFIED.

TITLE: 500 VOLT POWER FEEDTHRU

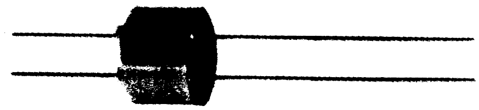
No. 0026101 | REVISION 6-24-98 K

Order connectors separately - see pages 220-1



Conductor Material
Moly, Copper, Nickel Stainless Steel

9411018



9411007

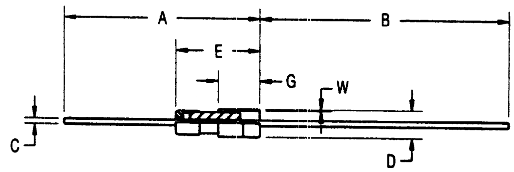


Figure 1

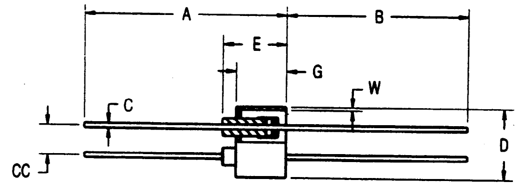


Figure 2

500 Volts / up to 10 Amps / 1 to 8 Pins

Weldable

NO PINS	AMPS	CONDUCTOR MATERIAL	FIGURE	A	B	C	D	E	G	W	CC	DRAWING REFERENCE	PART NUMBER	PRICE $
1	10	MOLY	1	1.10	1.00	.032	.154	.60	.27	.015	-	026104	9411000	25
1	3	COPPER	1	1.10	1.00	.032	.154	.60	.27	.015	-	026103	9411001	25
1	2	NICKEL	1	1.10	1.00	.032	.154	.60	.27	.015	-	026101	9411002	25
1	**	STN STL	1	1.10	1.00	.032	.154	.60	.27	.015	-	026102	9411003	25
1	3	COPPER	1	1.10	1.00	.032	.154	.60	.27	.015	-	211302	9411004	25
1	2	CONSTANTAN	1	1.10	1.00	.032	.154	.60	.27	.015	-	211301	9411005	25
1	**	STN STL	1	1.10	1.00	.032	.154	.60	.27	.015	-	211303	9411006	25
2	10	MOLY	2	.93	1.57	.032	.497	.53	.43	.020	.21	014004	9411007	60
2	3	COPPER	2	.93	1.57	.032	.497	.53	.43	.020	.21	014003	9411008	60
2	2	NICKEL	2	.93	1.57	.032	.497	.53	.43	.020	.21	014001	9411009	60
2	**	STN STL	2	.93	1.57	.032	.497	.53	.43	.020	.21	014002	9411010	60
4	10	MOLY	2	.93	1.57	.032	.497	.53	.43	.020	.25	028204	9411011	70
4	3	COPPER	2	.93	1.57	.032	.497	.53	.43	.020	.25	028203	9411012	70
4	2	NICKEL	2	.93	1.57	.032	.497	.53	.43	.020	.25	028201	9411013	70
4	**	STN STL	2	.93	1.57	.032	.497	.53	.43	.020	.25	028202	9411014	70
8	10	MOLY	2	1.03	1.47	.032	.747	.63	.53	.030	.43	014104	9411015	100
8	2	NICKEL	2	1.03	1.47	.032	.747	.63	.53	.030	.43	014101	9411016	100
8	**	STN STL	2	1.03	1.47	.032	.747	.63	.53	.030	.43	014102	9411017	100

** Instrumentation current only

1000 Volts / up to 15 Amps / 1 to 8 Pins

Weldable

NO PINS	AMPS	CONDUCTOR MATERIAL	FIGURE	A	B	C	D	E	G	W	CC	DRAWING REFERENCE	PART NUMBER	PRICE $
1	15	COPPER	1	1.75	2.25	.050	.247	.75	.37	.015	-	020103	9411018	20
1	5	NICKEL	1	1.75	2.25	.050	.247	.75	.37	.015	-	020102	9411019	20
1	1	STN STL	1	1.75	2.25	.050	.247	.75	.37	.015	-	020101	9411020	20
2	15	COPPER	2	2.13	1.87	.050	.747	.67	.53	.030	.31	020203	9411021	50
2	5	NICKEL	2	2.13	1.87	.050	.747	.67	.53	.030	.31	020202	9411022	50
2	1	STN STL	2	2.13	1.87	.050	.747	.67	.53	.030	.31	020201	9411023	50
4	15	COPPER	2	2.13	1.87	.050	.747	.67	.53	.030	.38	020003	9411024	80
4	5	NICKEL	2	2.13	1.87	.050	.747	.67	.53	.030	.38	020002	9411025	80
4	1	STN STL	2	2.13	1.87	.050	.747	.67	.53	.030	.38	020001	9411026	80
8	7	KOVAR	2	1.25	4.00	.050	.747	.75	.75	.030	.43	187302	9411027	120
8	**	Ni TUBE	2	1.25	4.00	.050	.747	.75	.75	.030	.43	187301	9411028	120
8	**	STN STL TUBE	2	1.25	4.00	.050	.747	.75	.75	.030	.43	187303	9411029	120

** Instrumentation current only

Cyan-blue **Part Numbers** indicate products suitable for -200°C cryogenic applications.

SNS SCRF WIRESCANNER BELLOWS

- Formed 321 stainless steel bellows will be used. (Welded bellows is too difficult to clean).

- Formed bellows is stiffer than a welded bellows. The following were incorporated to maximize flexibility and minimize stress:

  - Minimize the diameter

  - Maximize the overall bellows length

  - Minimize wall thickness

- Vacuum is maintained outside of bellows with atmospheric pressure on the inside (15 psi differential across bellows).

- Bellows is subject to a lateral offset of 1.43 inches corresponding to the 10 degree angular motion of the wirescanner pendulum.

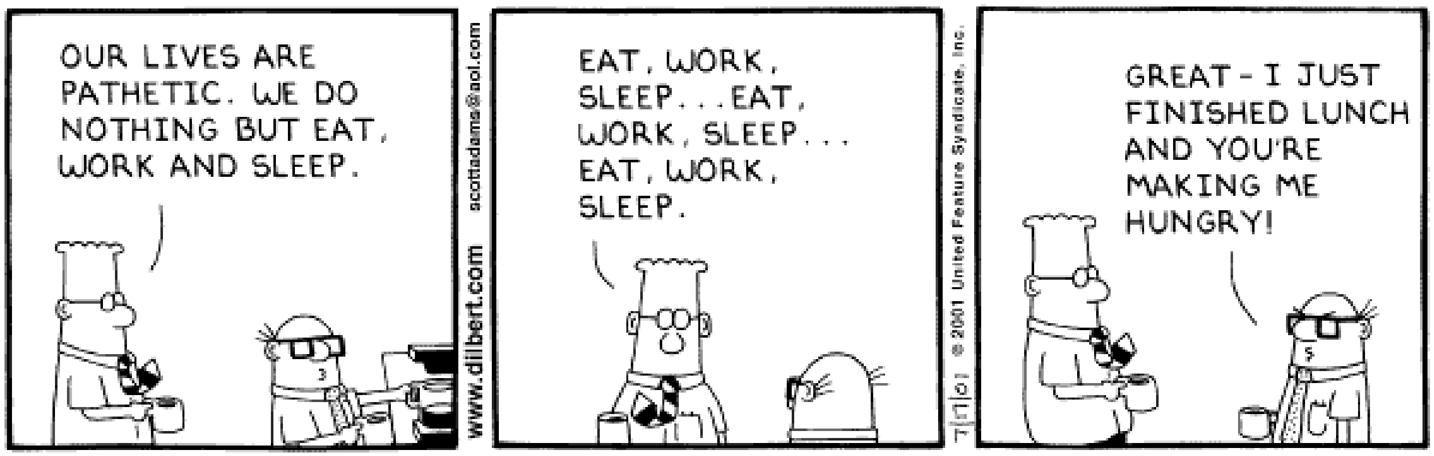
- The maximum stress occurs at the top of the bellows, where it is welded to the flange.

- COSMOS stress analysis was performed at LANL. Maximum Von Mises stress is 65,000 psi. Cold worked 321 stainless steel yield strength is 50,000 to 125,000 psi, while the ultimate strength is 100,000 psi to 150,000 psi. Number of cycles is 8000.

- Stress analysis was performed independently by David Palmer at Bellows Systems (bellows supplier). Stress results showed good agreement with LANL results. Calculated life for bellows is 133,000 cycles (factor of safety on no. cycles is 133,000/8,000 or 16.6 .

Wire Scanner

R. Hardekopf, R. Meyer Sr., C. Rose, M. Plum, J. Power,
R. Shafer, M. Stettler



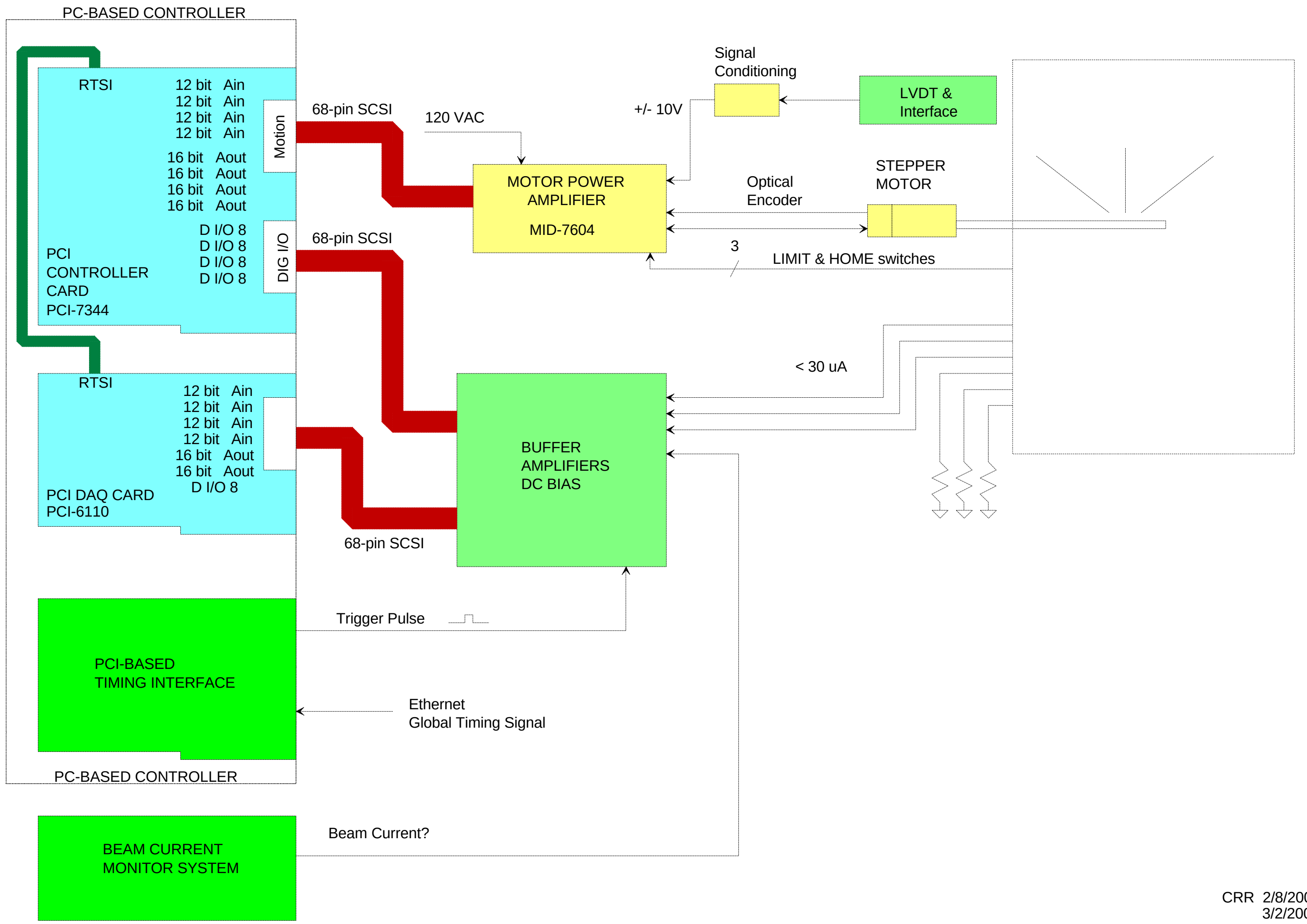
July 17, 2001

Requirements

- 30 uA to 3.5 mA current range.
- up to -100 VDC bias on wire
- <= 100 us pulse width, 10 Hz rep. Rate.
- Detect wire loss
- three channels plus beam current signal
- low-pass filter signals, amplify, ~40 kHz BW
- Interface with NI DAQ card, motion control card,
- Stepper-motor drive, LVDT absolute feedback.
- Uncomplicate cabling
- Incorporate B.I.T. features

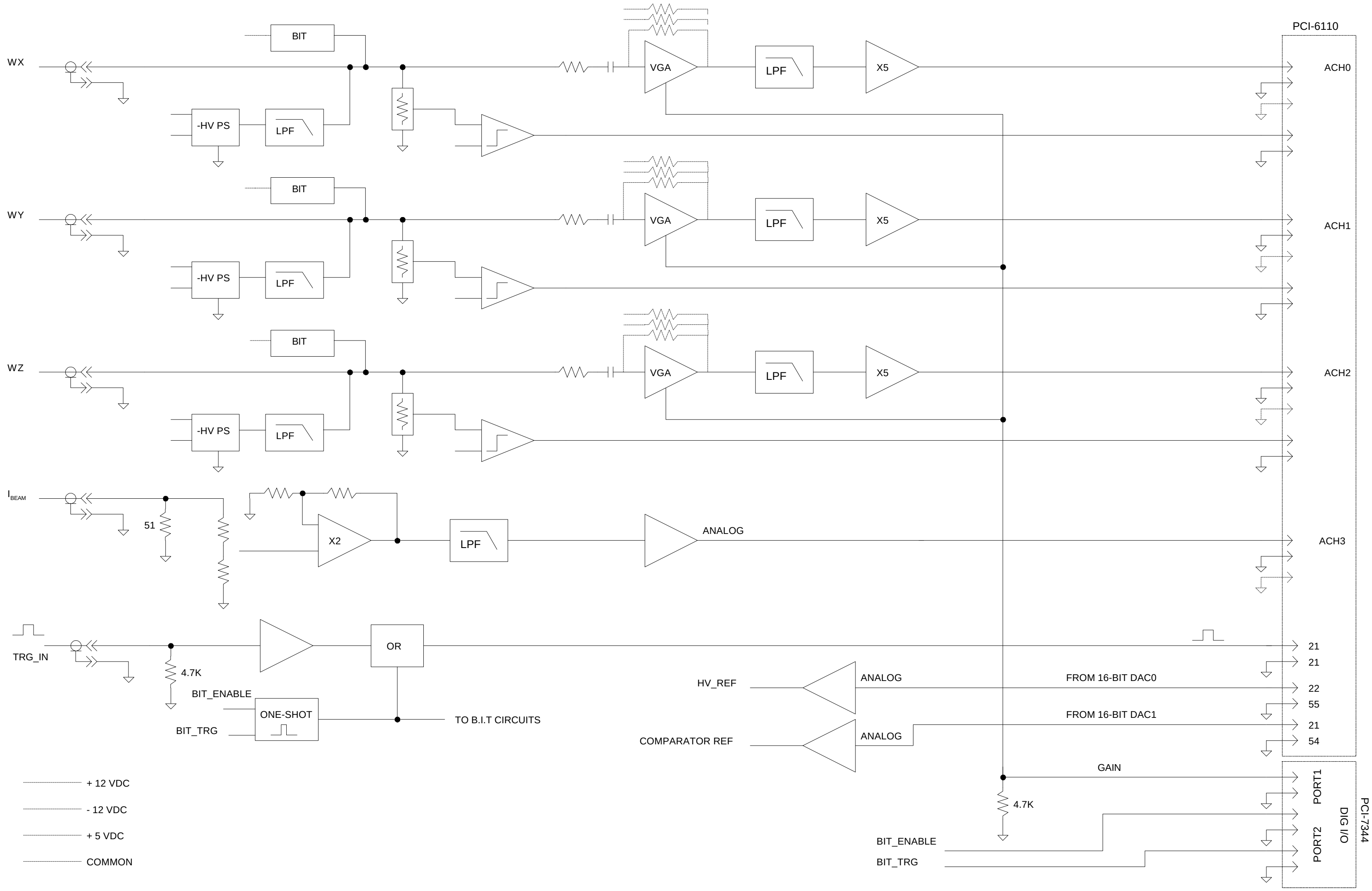
Block Diagram

WIRE-SCANNER BLOCK DIAGRAM



CRR 2/8/2001
3/2/2001

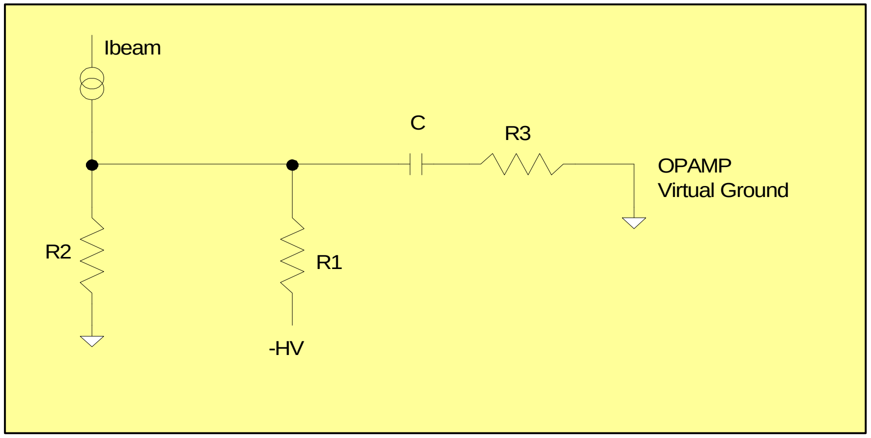
Circuit Block



Constraints

Solver model, linear programming model

R_1pR_2	197577		
R_3_C	0.001	FALSE	
dis_tc	0.015817	4	
		TRUE	
R_3	1200	TRUE	0.0010
C	8.33E-07	TRUE	
R1	19757.7	TRUE	
R2	177819.3	TRUE	
		TRUE	
R_P	17781.93	TRUE	
		TRUE	
		100	



Status

- Prototype circuit board made
- Assembled (one channel)
- Needs to be tested
- schedule