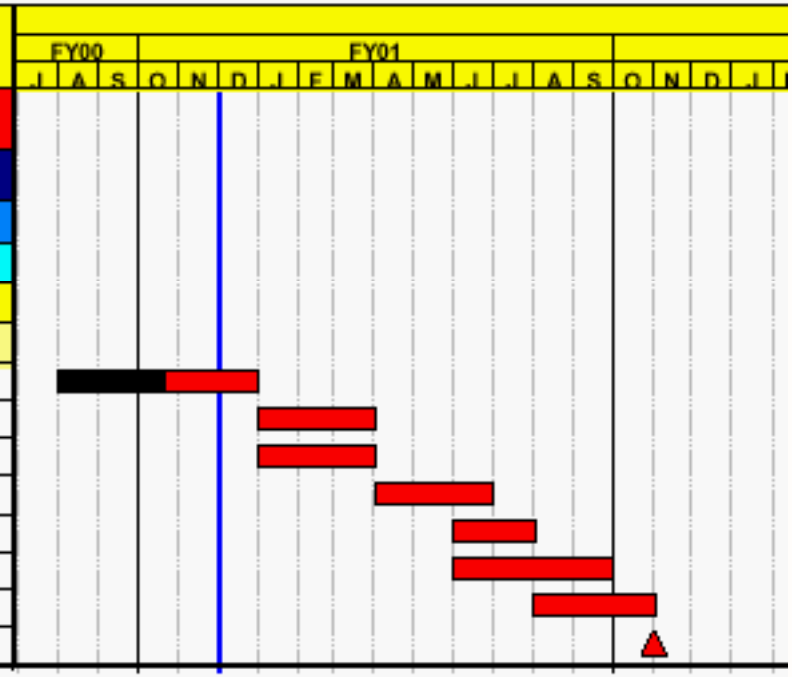
Wire Scanners - Peter Cameron

- Schedule
- System Specifications
- Level of Design
- Design Details
  - Wire Heating
  - Velocity Criteria
  - Actuator
  - Analog Front End and Digitizer
- Conclusions

MEBT Wire Schedule

Activity Description	Early Start	Early Finish
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		
HEBT		
MEBT		
MEBT Wire Scanner Prelim Design	01AUG00A	29DEC00
MEBT Wire Scanner Prototype Test (@ AGS)	02JAN01	30MAR01
MEBT Wire Scanner Detail Design	02JAN01	30MAR01
MEBT Wire Scanner Procure/Fab/Assy	02APR01	29JUN01
MEBT Wire Scanner Test	01JUN01	31JUL01
MEBT Wire Scanner Install	01JUN01	28SEP01
MEBT Wire Scanner Comp. Test @Site	01AUG01	31OCT01
MEBT Wire Scanner - Required by LINAC		01NOV01*



Wire Schedule

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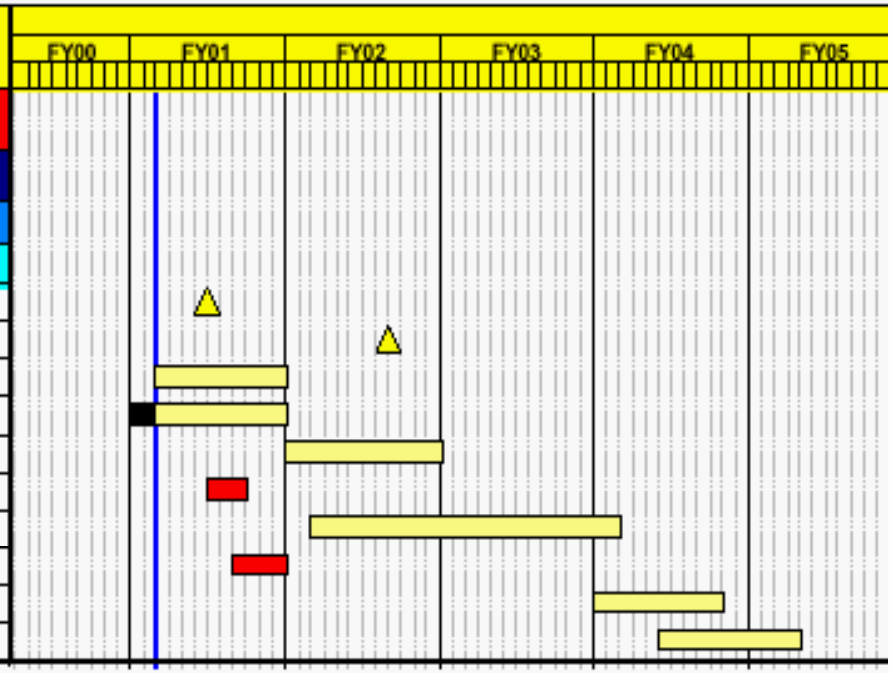
1.5 Ring and Transport System		
1.5.7 Ring Systems Diagnostics Instrumentation		
1.5.7.6 Wire Scanner		
Wire Scanner P D R	02APR01	
Wire Scanner F D R	03JUN02	
Wire Scanner System Definition (FY01)	01DEC00	28SEP01
Wire Scanner Design - Summary [FY01]	02OCT00A	28SEP01
Wire Scanner Detail Design - Summary [FY02]	01OCT01	30SEP02
Wire Scanner Procure, Fab&Assy-Sum[MEBT] [FY01]	02APR01	29JUN01
Wire Scanner Procure, Fab&Assy-Sum [FY02]	03DEC01	26NOV03
Wire Scanner Installation - Sum (MEBT) [FY01]	01JUN01	28SEP01
Wire Scanner Installation - Summary	01OCT03	30JUL04
Wire Scanner Comp. Test @ Site - Summary	01MAR04	31JAN05



System Specifications

- AP Requirements
  - Resolution - 200μ
  - Range
    - MEBT thru SCL +/- 5mm
    - 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

Level of Design

- All Energies - wire heating analysis complete
- MEBT
  - Final Design Review complete
  - Prototype (part of Laser Wire POP)
    - Assembly complete
    - Installation at AGS RFQ in progress
    - NI 7344 motion control
    - LANL LabVIEW software
- HEBT, Ring, RTBT - conceptual design
- ICD - draft in progress, collaboration with LANL

AGS RFQ Laser Wire Proof-of-Principle

Proof-of-Principle at AGS RFQ - 750 KeV

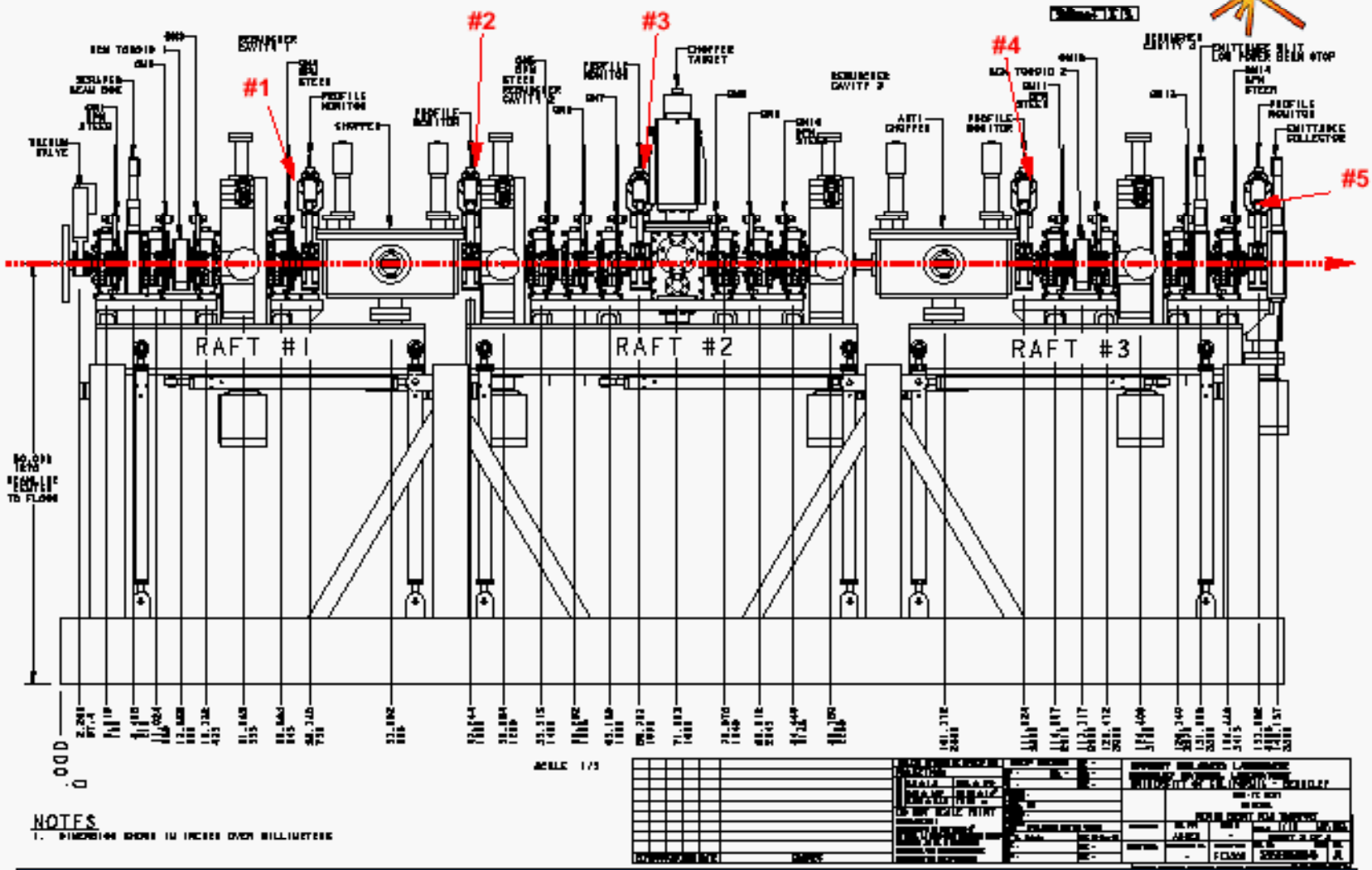
Hardware includes:

- Carbon wire scanner
- Broadband BCM
- Laser
- Two axis optics

AGS RFQ Laser Wire Proof-of-Principle 2

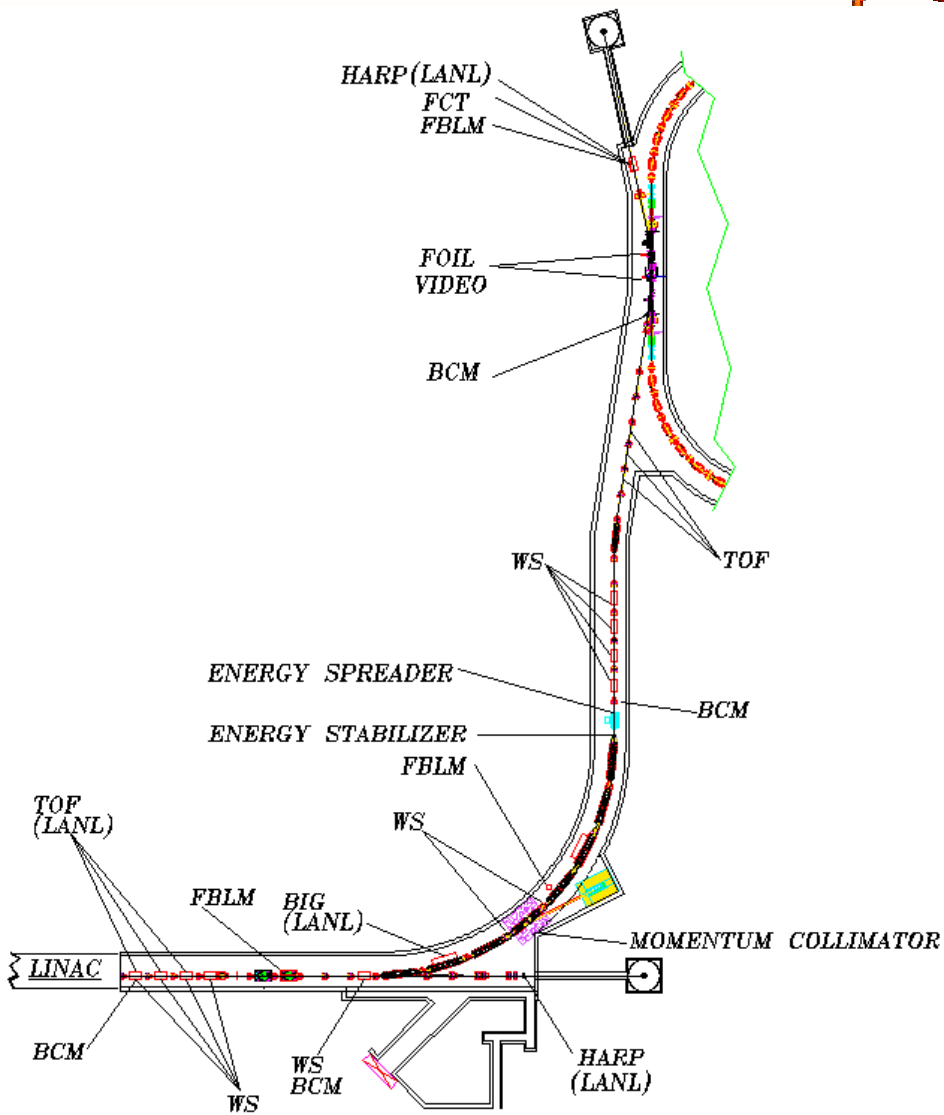
AGS RFQ Laser Wire Proof-of-Principle 3

Profile Monitor Locations



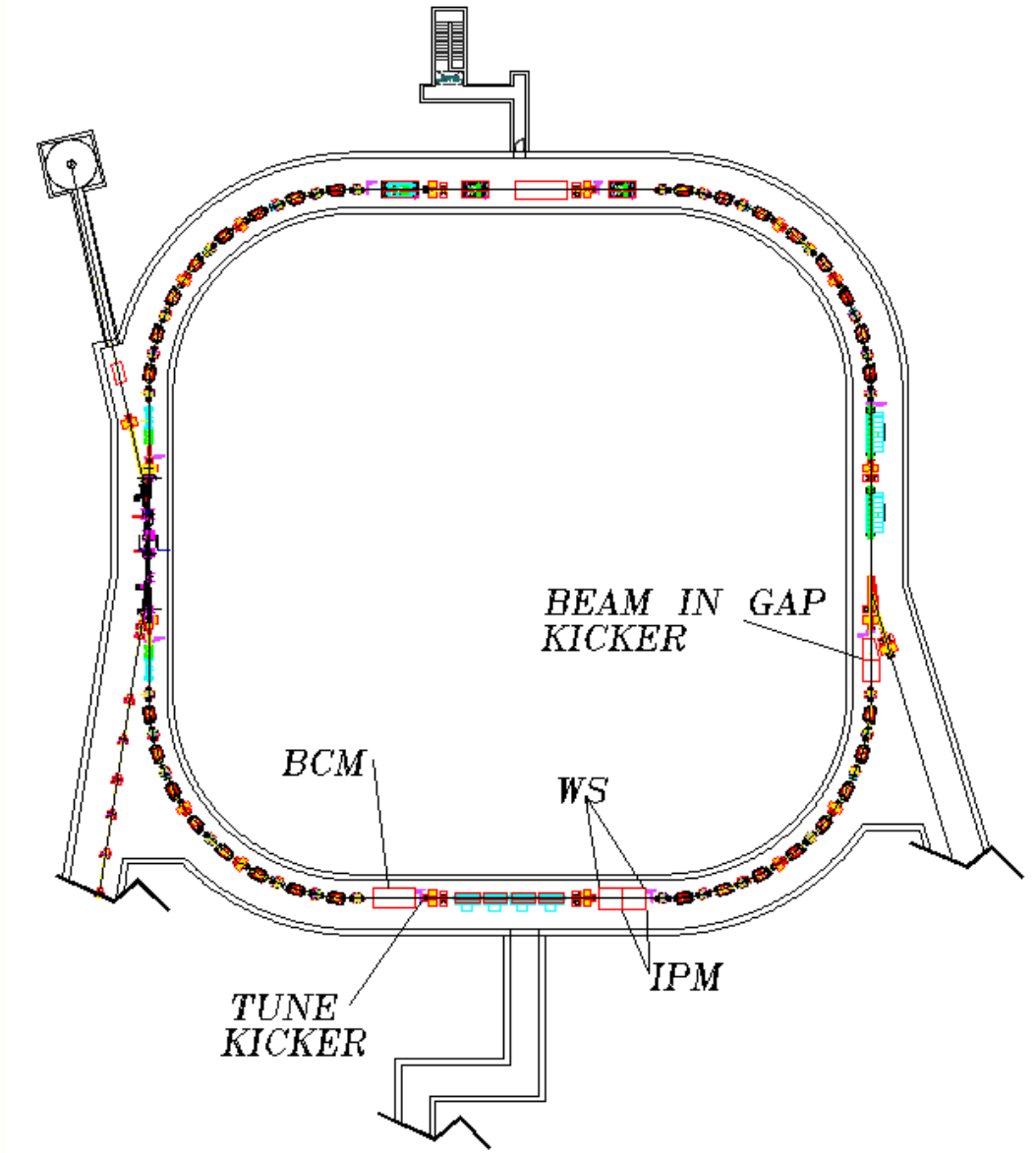
HEBT Beam Instrumentation

Detector	BNL	LANL
BIG	0	1
BPM	16	0
TOF	0	2
FBLM	3	0
BLM	52	0
BCM/FCT	5	0
WS or PrM	11	0
FOIL VIDEO	2	0
HARP	0	2



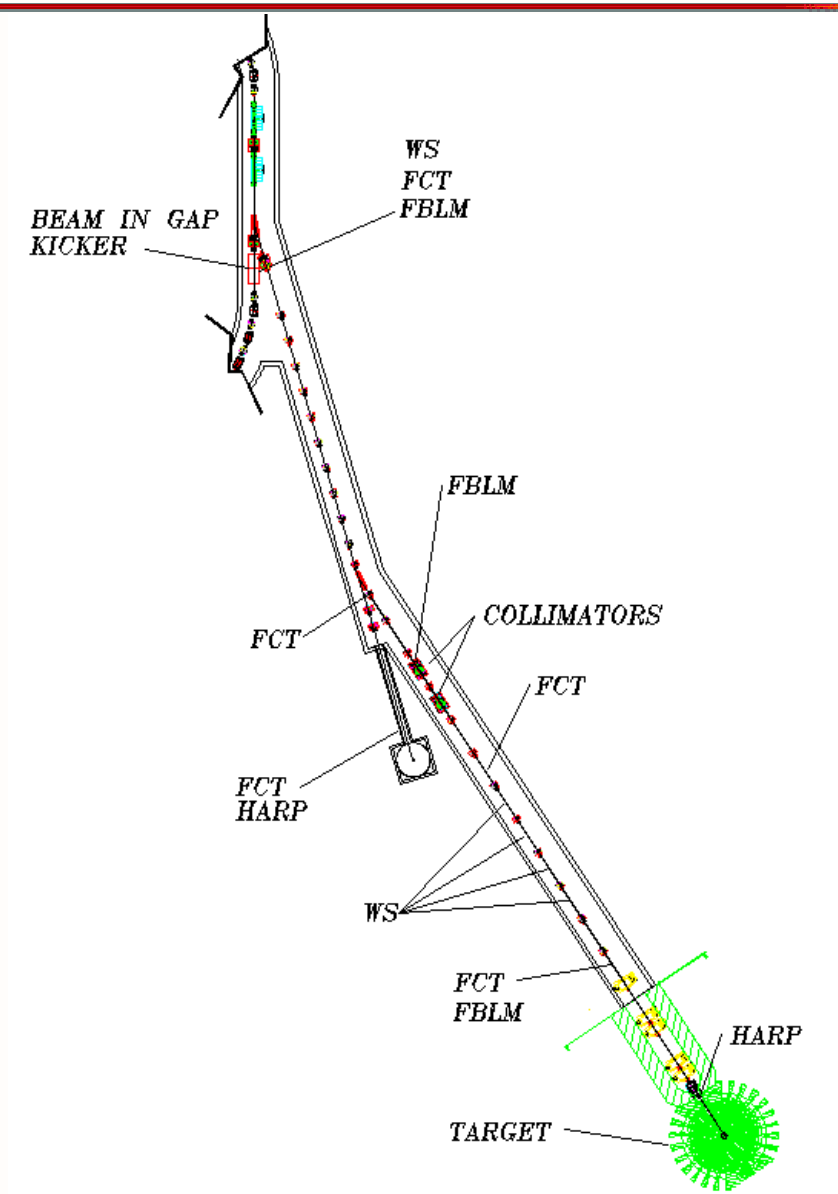
SNS Ring Instrumentation

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

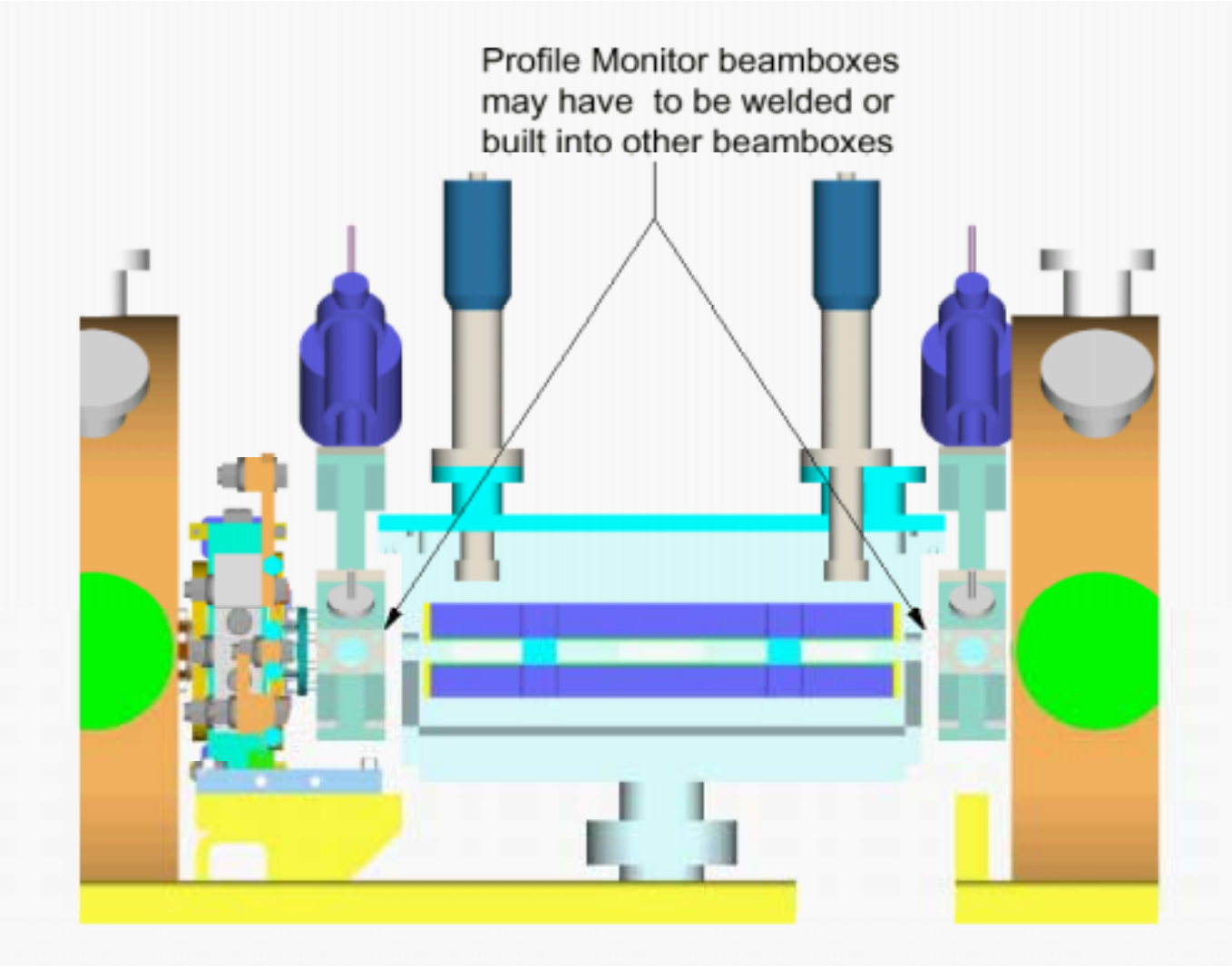


Wire Scanners - Quantities Summary

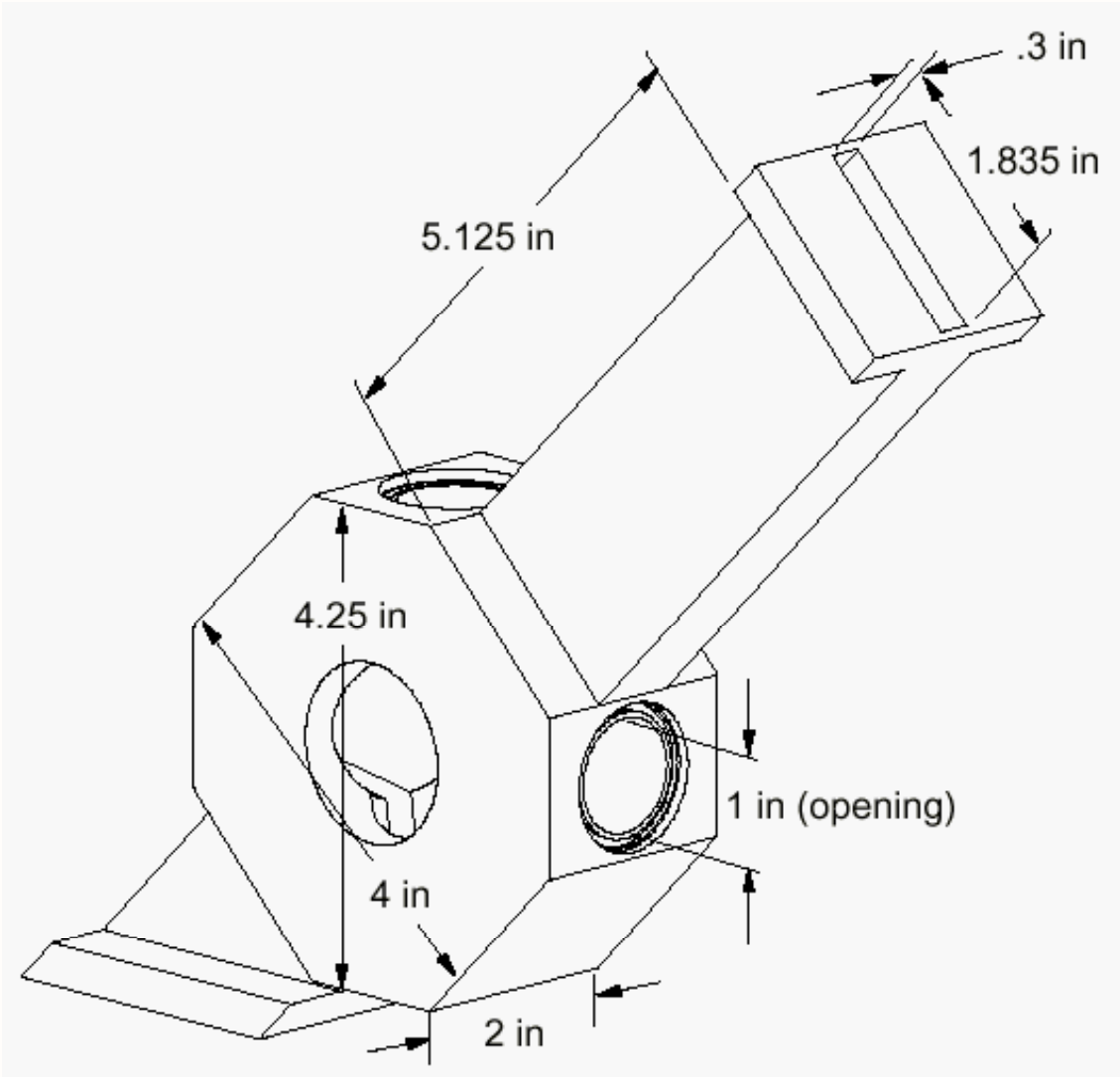
- MEBT 5
- DTL 0
- CCL 8
- SCL 32
- HEBT 11
- Ring 2
- RTBT 5

- TOTAL 63

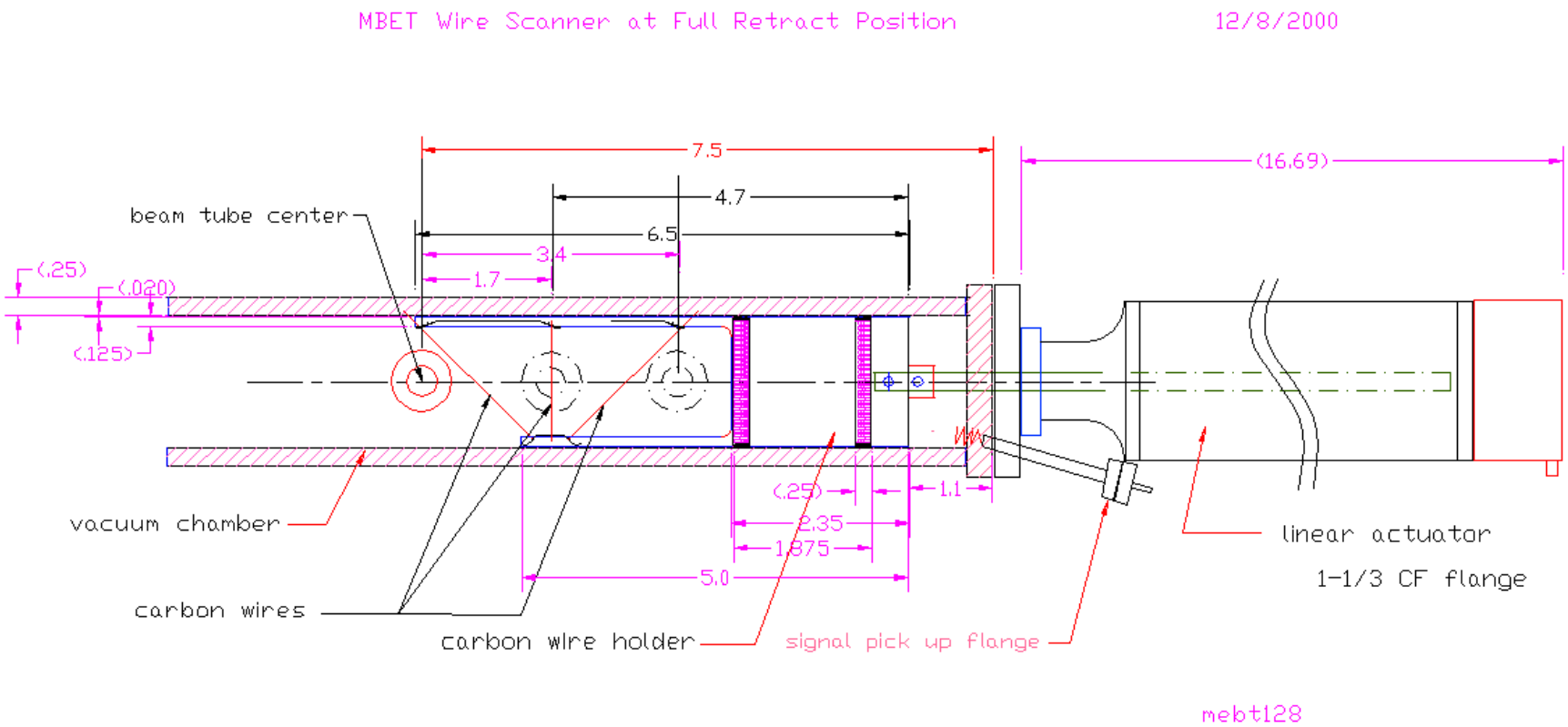
Typical MEBT Scanner Location



MEBT Scanner Vacuum Chamber

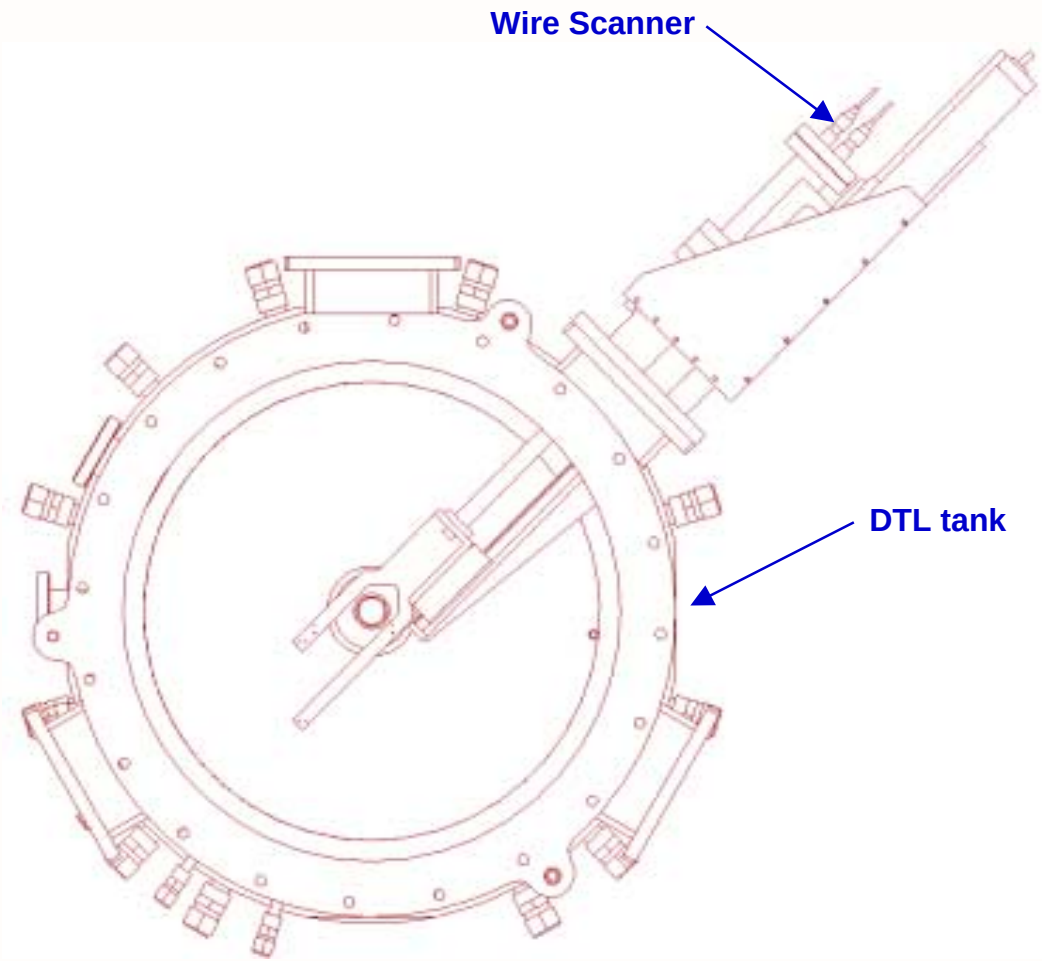


MEBT Wire Scanner



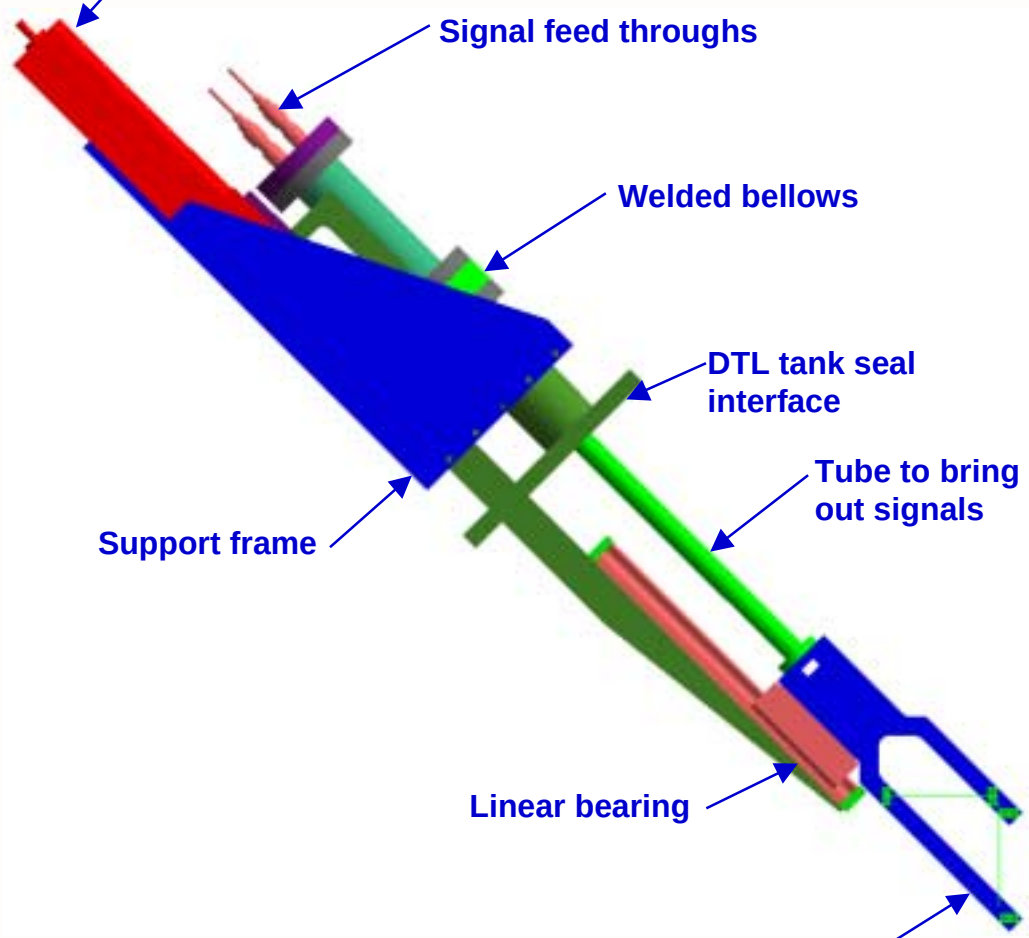
DTL Wire Scanner

- “O” ring seal to DTL spool
- Occupies 1.75” of z length within inter-tank region



DTL/CCL Wire Scanner

- **Designed to fit in space between DTL tanks #1 and #2.**
- **Step motor driven.**
- **Linear travel seal is a welded bellows.**
- **Offset drive, utilizes a commercial slide table.**
- **Guide rails, linear bearings, ball screw, nut, limit switches, encoders come as a package.**
- **No signal wire service loop required in vacuum.**
- **Linear bearing in vacuum has silicon nitride re-circulating balls, no lubrication required.**
- **Fork is designed to have only one wire in beam at a time. This will be changed.**



Non-Perturbative Profile Monitors

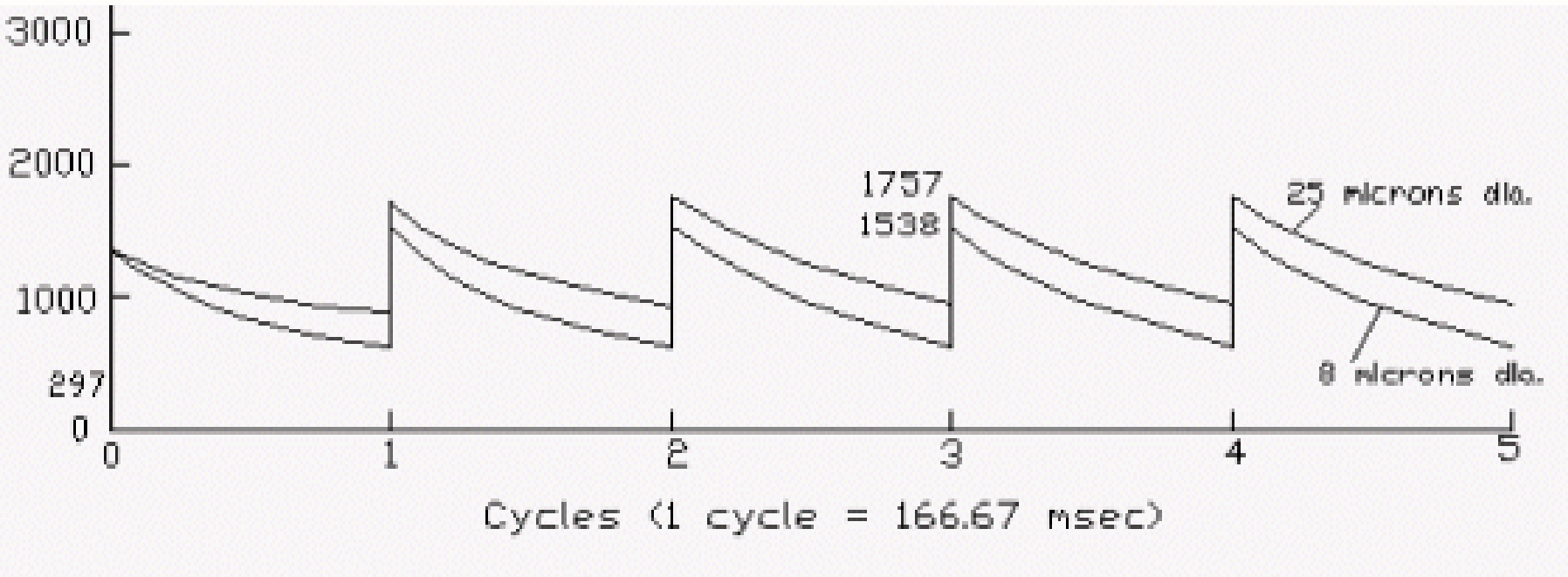
- Easiest - RTBT
  - Low current density, minimal wire heating
  - Large beam, relative profile accuracy easier
- Slightly Harder - Ring
  - Higher current densities
  - Large beam, relative profile accuracy easier
- Hardest - HEBT
  - High current densities
  - Small beam
- Impossible - MEBT
  - Duty cycle

MEBT Wire Scanner Duty Cycle

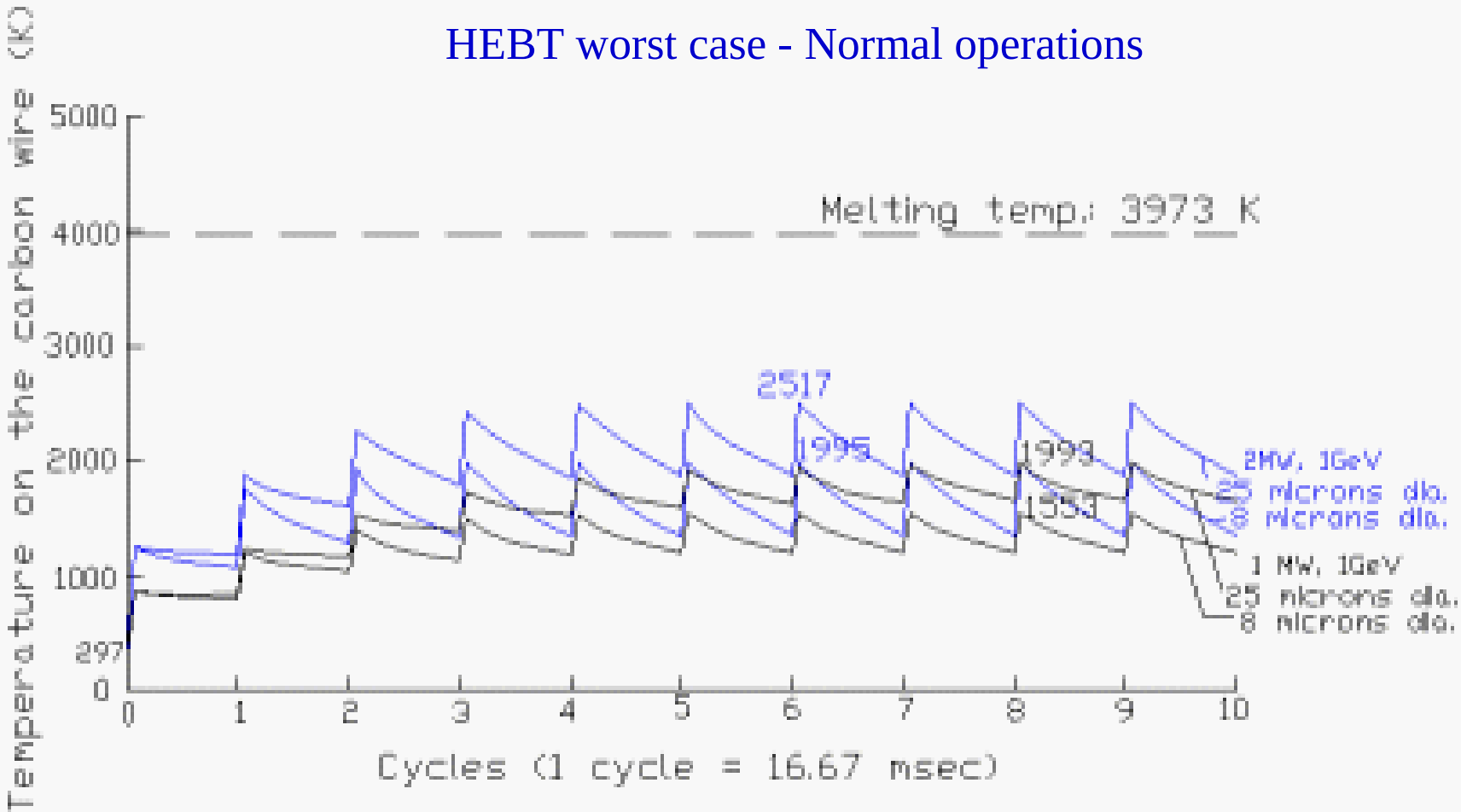
- Normal machine operations
  - 52mA beam current during 690ns minipulse
  - 1000 minipulses/1ms pulse
  - 60 Hz pulse rate
- Diagnostics and setup machine operations
  - 52mA beam current during 690ns minipulse
  - 50-100 minipulses/50-100 μs pulse
  - 6 Hz pulse rate

Wire Heating at 2.5 MeV

Wire Heating - 52mA 50µs 6Hz



Wire Heating at 1 GeV



Wire Heating in Ring and RTBT

- Ring - Stationary Wire
  - 1 MW, 50μ wire gives T=1950K
  - 2 MW, 25μ wire gives T=1950K

- RTBT - Stationary Wire
  - 1 MW, 50μ wire gives T=440K
  - 2 MW, 50μ wire gives T=510K

Velocity Criteria for Scanning and Flying Wires

- Scanning - Sufficient number of Points for a good profile

  v < 4 sigma / N x period < ~ 1mm/s

  sigma ~ 1mm

  N ~ 25

  period ~ 167ms (6Hz)

- Flying slow - heating suggests to clear the beam between pulses

  v > 4 sigma / period > 25 mm/s

  sigma ~ 1mm

  period ~ 167ms (6Hz)

  Distance = 25mm/s x 1ms = 25μ

- Flying fast - complete profile in single scan

  v > 4 sigma/period > 8 m/s

  sigma ~ 2 mm

  period ~ 1ms

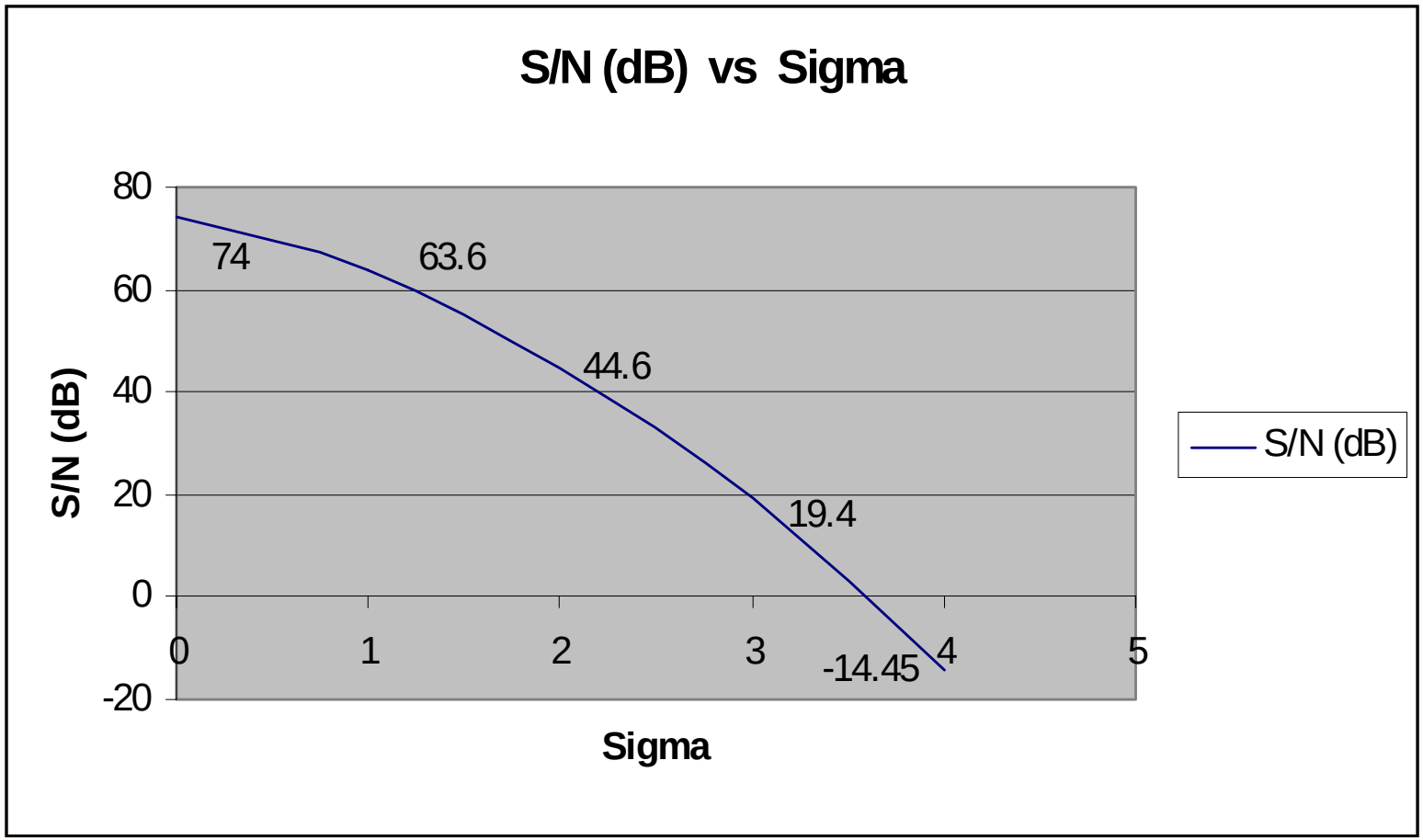
Linear Motion Feedthru

- Linear Motion Feedthru Advantages
  - compact
  - Cheap- $1500
  - Available off-the-shelf
- Linear Motion Feedthru Disadvantages
  - Welded bellows - especially in SRF
  - Formed bellows available in shorter strokes off-the-shelf, longer strokes custom
- Velocity Limitation
  - Manufacturer says 40 mm/s
  - OK for slow flying

Sources of Error

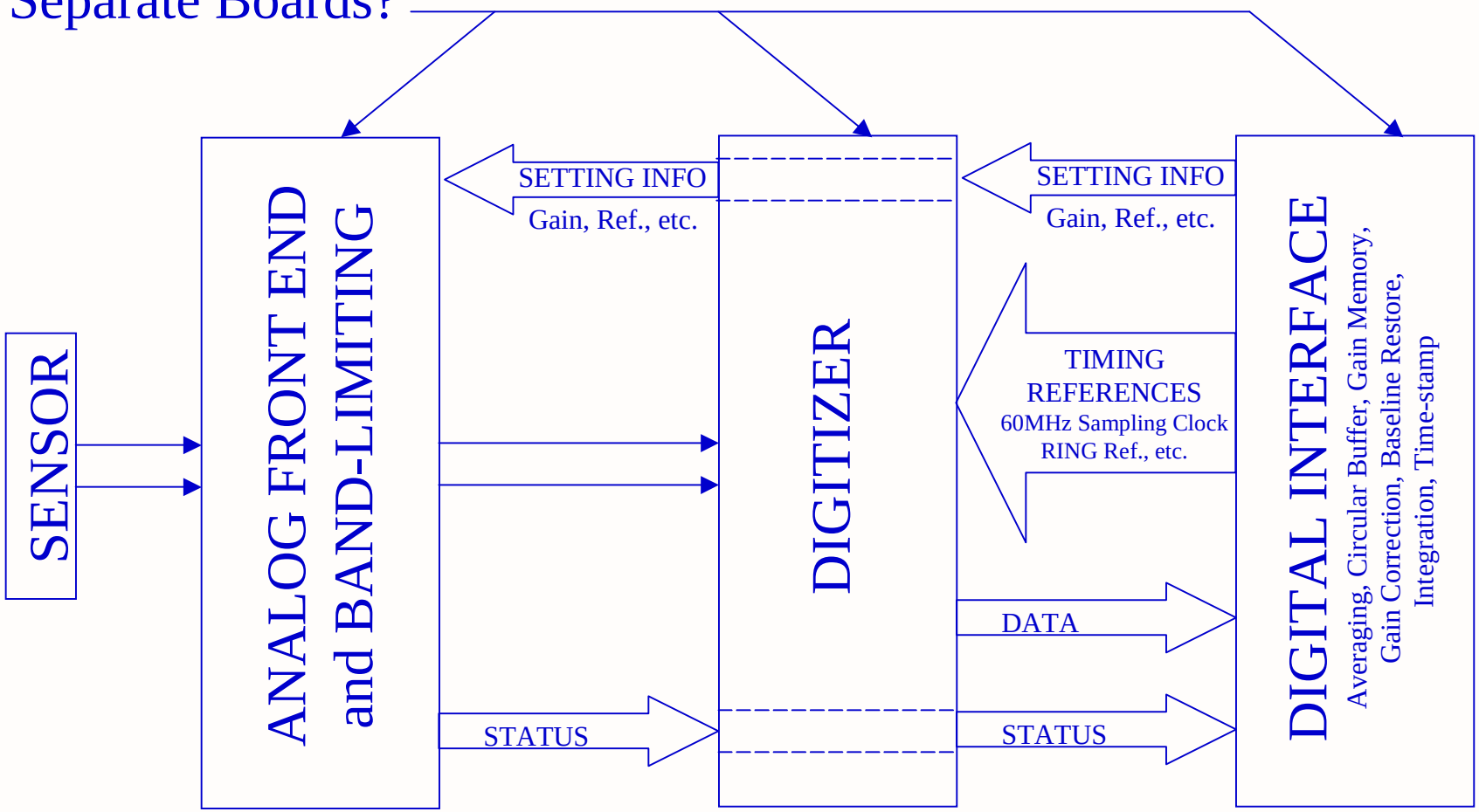
- Crawling wire
  - Thermionic emission
  - Drive Linearity
  - Unwanted mechanical flexibility
  - Beam Position jitter - correlate with BPM?
  - Beam Current jitter - correlate with BCM?
  - Errors in emission current measurement
- Flying wire (slow)
  - All of the above
  - Timing jitter
  - Acceleration and Velocity jitter

S/N of Emission Current Measurement



Ring and RTBT WS Signal Flow

Separate Boards?



Conclusions

- MEBT schedule looks OK - LW POP will give confidence
- HEBT, Ring, RTBT schedules benefit from MEBT driver
- Details between LANL and BNL to be smoothed yet
- Conservative, simple actuator approach - stationary wire limit
- 2MW beam problematic in HEBT - philosophy change later?
- Action Items
  - Actuator cycle test
  - Error budget (mechanical flexibility?)
  - AFE/Digitizer
  - Vacuum Interface
  - Controls Interface