SNS D-plate System
Preliminary Design Review - Introduction

Los Alamos, July 18, 2001

by Michael Plum

Agenda

- Welcome and charge to the committee (Plum) 15 min.
- DTL commissioning overview (Stovall) 30 min.
- Requirements, physics and interfaces (Plum) 30 min.
- Mechanical systems (Ross Meyer) 40 min.
- Beam stop (S. Konecni) 30 min.
- Vacuum and water systems (J. Bernardin) 30 min.
- Lunch (provided for review committee and out of town visitors)
- Committee deliberations
- Committee out brief

- Note: Must terminate video link and adjourn to Roost Conference room at 12:15.

Review Committee

- Bob Webber, FNAL (chairman)
- Mike Borden, LANL
- Sasha Aleksandrov / ORNL
- Tom Powers / JLab
- Frank Bieniosek / LBL

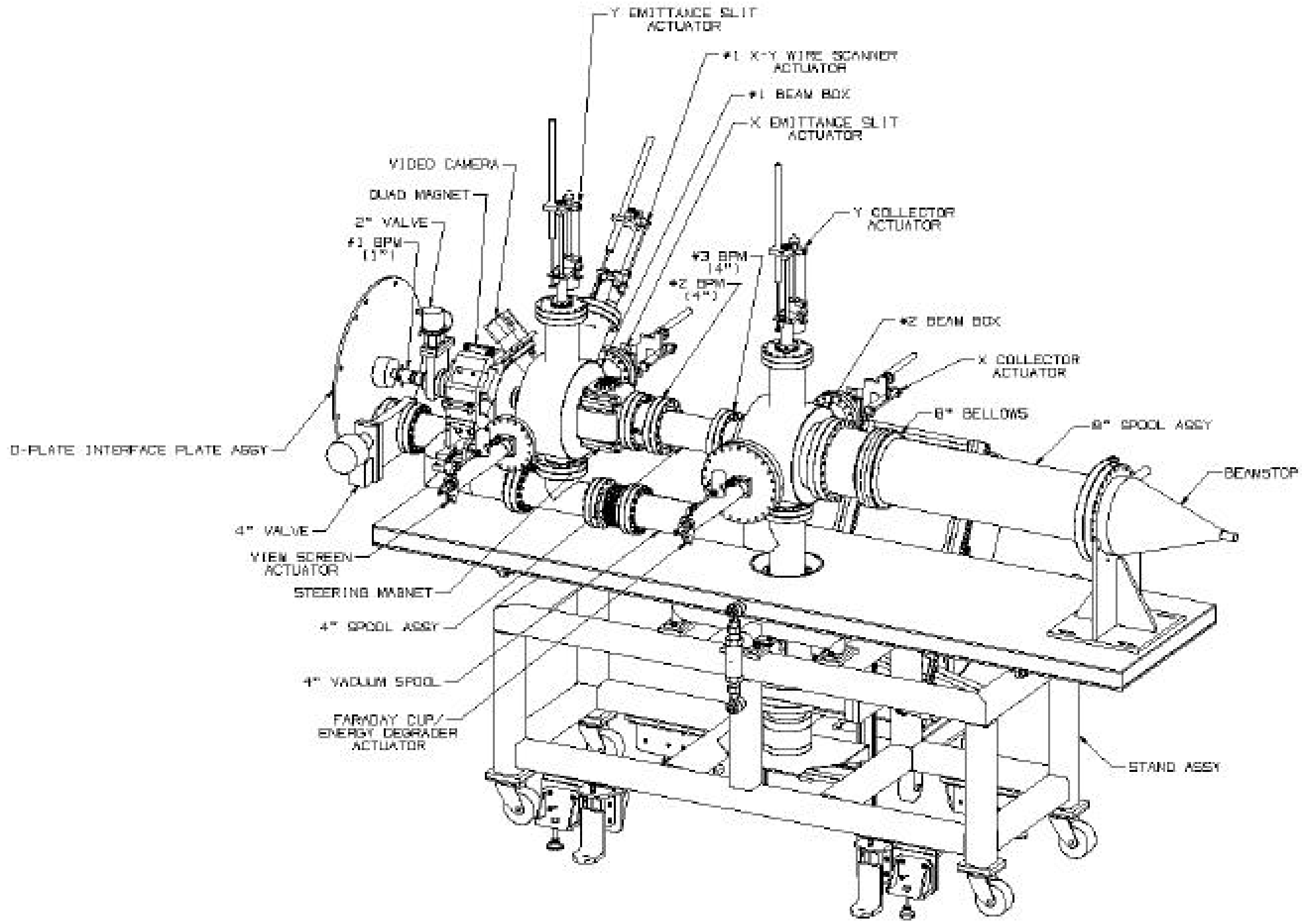
Design Review Process

- **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

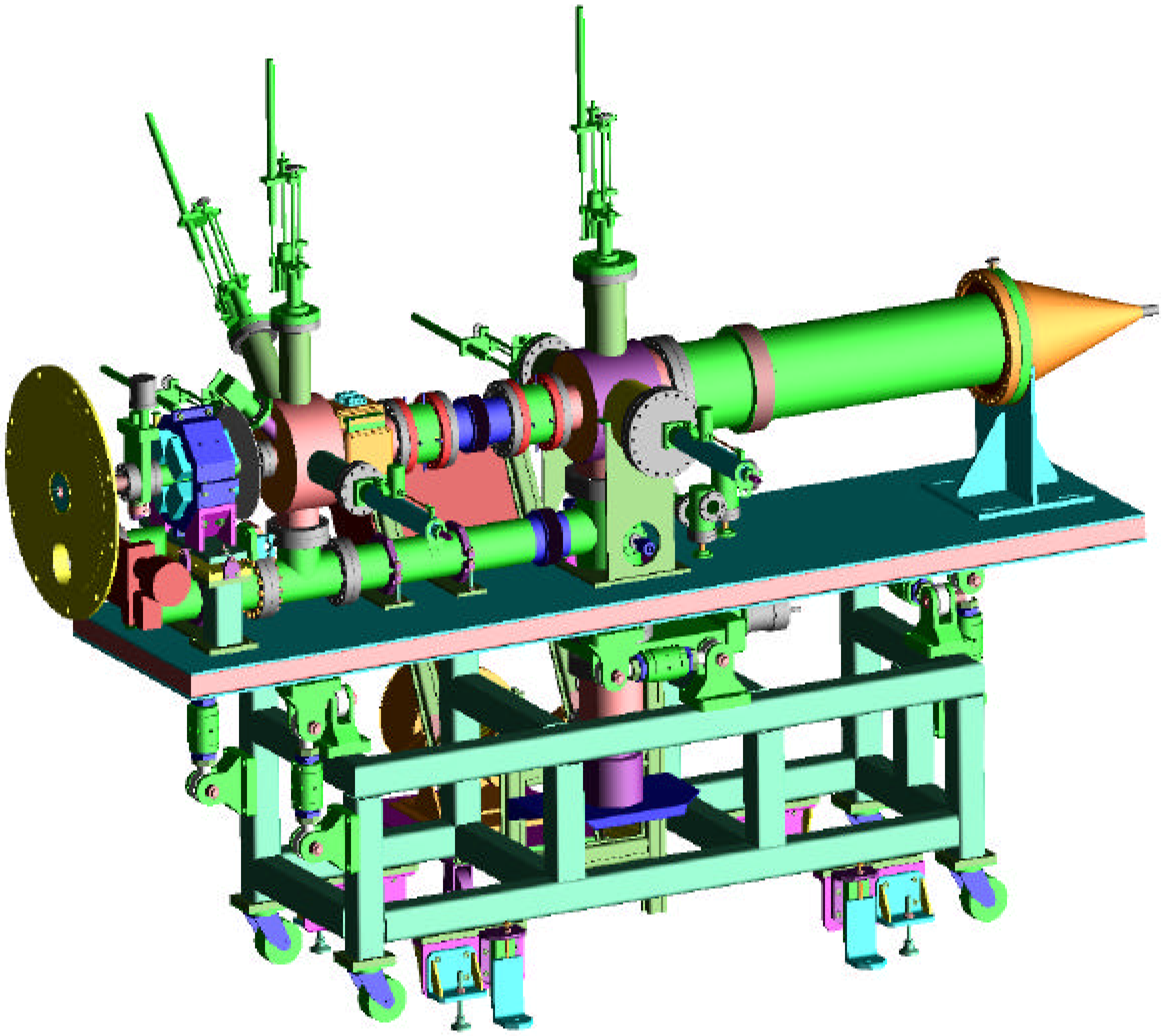
- **Review the design**
  - Are the design requirements adequately defined?
  - Is the D-plate design at PDR status? (I.e., ready to proceed with final detailed design and build prototype units.)
  - Are the right analyses/tests being done/planned?
  - Does the work from PDR to FDR (Winter `01) look 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**
- **Write a report**

D-plate components



D-PLATE ASSEMBLY

D-plate isometric image



D-plate instrumentation

- **Beam current measurement.**
- **Beam position measurement (3 ea.).**
  - Also time of flight energy measurement.
- **Video profile and position.**
- **Wire scanner profile (3 planes).**
- **Slit and collector emittance measurement (2 planes).**
- **Faraday Cup / energy degrader.**
- **Halo scraper.**

Beam Commissioning Using the DTL Tank 1 Diagnostic Beam Line (D-Plate)

J. Stovall

18 July 2001

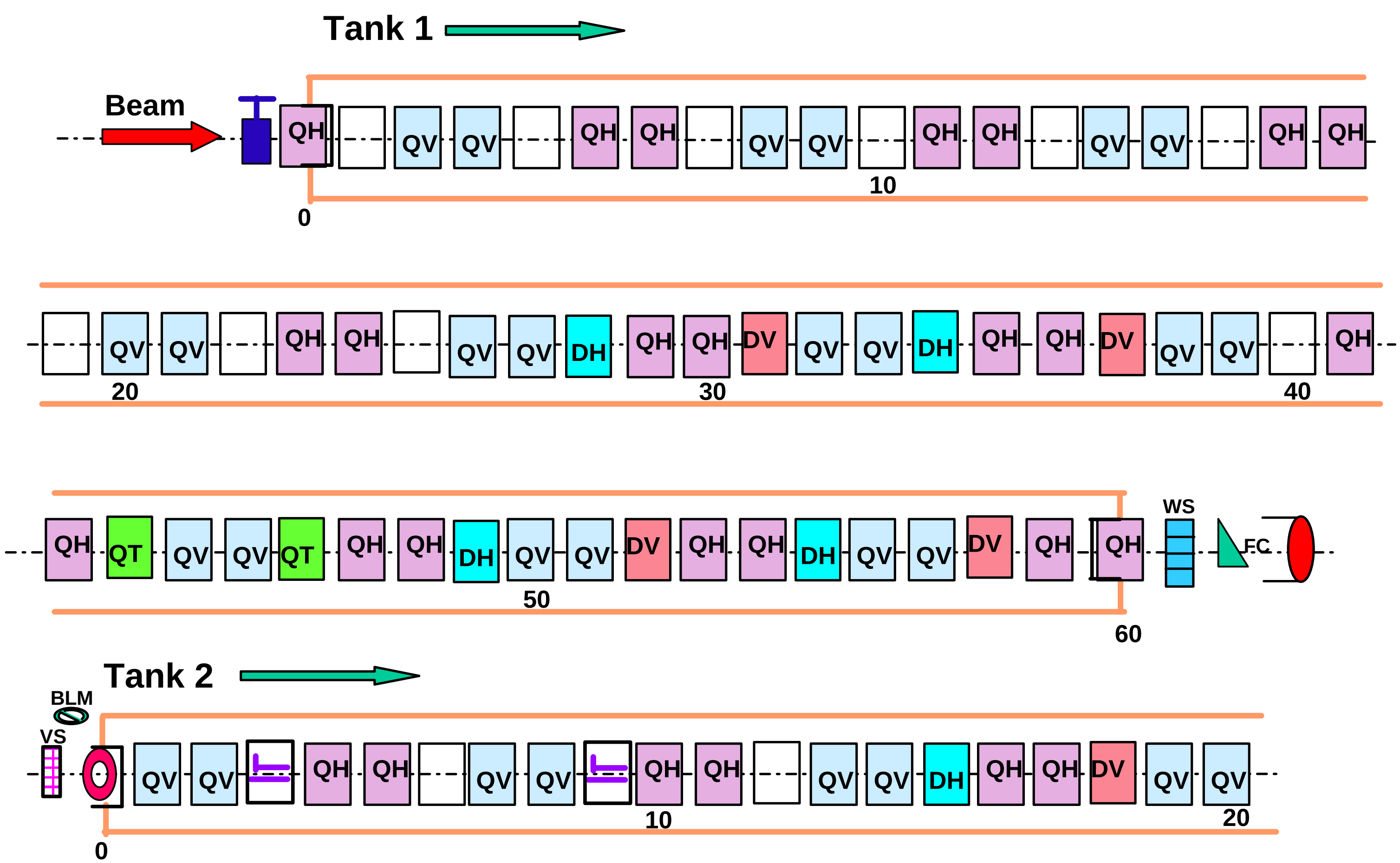
Beam Commissioning: Setting Parameters Based on Beam Measurements

- Steering
  - beam position monitors
- Transverse matching
  - emittance & profile
- RF phase & amplitude
  - beam loading, current, phase & Δ-phase (TOF)
- Longitudinal matching
  - beam current & phase width

Some Diagnostics are Built Into the DTL

- Profile; wire scanner
- Current; beam current transformer & F-cup
- Energy thresh; degrader
- Δ Energy; BPMs
- Position; BPMs
- Phase; BPMs

Tank 1 Diagnostics Ideogram



D-Plate Diagnostic Requirements

- Tank 2 diagnostics
  - BPMs
  - BCM
- Transverse emittance
  - slit & collector
- Production beam dump
  - 7.5 MeV * 2 mA = 15 kW
  - 7.5 MeV * 1.5 mA = 11 kW

D-Plate Offers Our Last Chance for One Critical Measurement

- Emittance is a function of
  - Ion source & FE operation
  - RFQ performance
  - MEBT tuning; 14 quads + 4 cavities
  - DTL-1 phase & amplitude
- Emittance predicts
  - Beam loss throughout the linac
  - Final emittance at ring injection

D-Plate Offers Our Last Chance to Operate Integrated Linac at Production Levels

- Next opportunity occurs when the Hg production target is ready
  - 100 kW in 3 years (CD-4)
  - 1 MW in 5 years (?)
- Integrates:
  - Injector RFQ
  - MEBT DTL (1)
  - Cooling Vacuum
  - Diagnostics Controls
  - 6 RF high- & low-level rf systems
  - Converter/modulator
  - Safety Facility
  - Etc. …

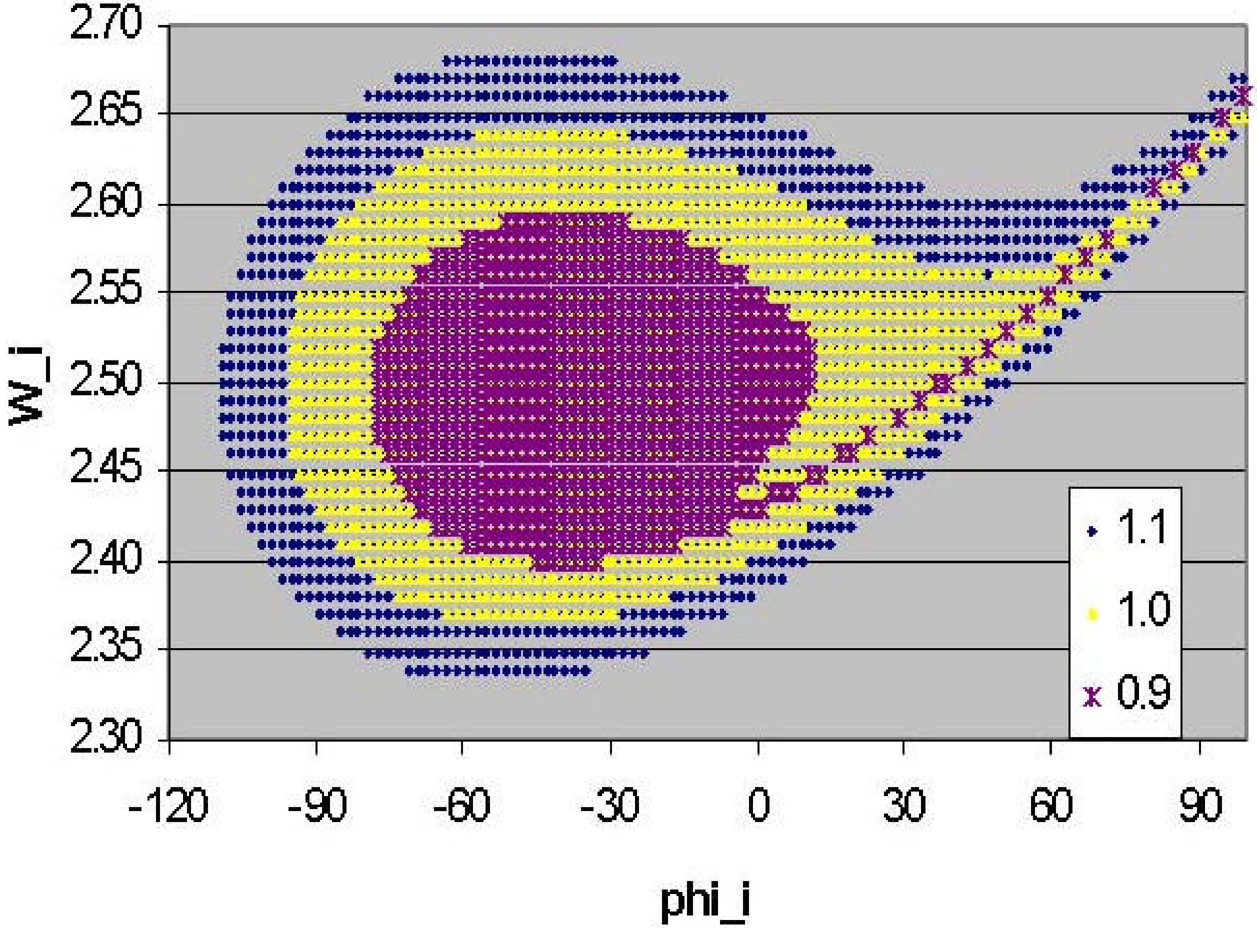
Tank 1 Commissioning Objectives

- Verify construction, tuning, installation & alignment
- Develop/validate beam tuning algorithms
  - MEBT tuning & matching, transverse & longitudinal
  - Steering; MEBT & DTL
  - DTL rf; phase & amplitude
- Characterize 7.5 MeV beam properties as a function of:
  - Source & LEBT parameters
  - RFQ amplitude
  - MEBT tuning/matching
  - DTL tuning
  - Beam current
- Correlate Emittance with profiles
- Demonstrate production level operation

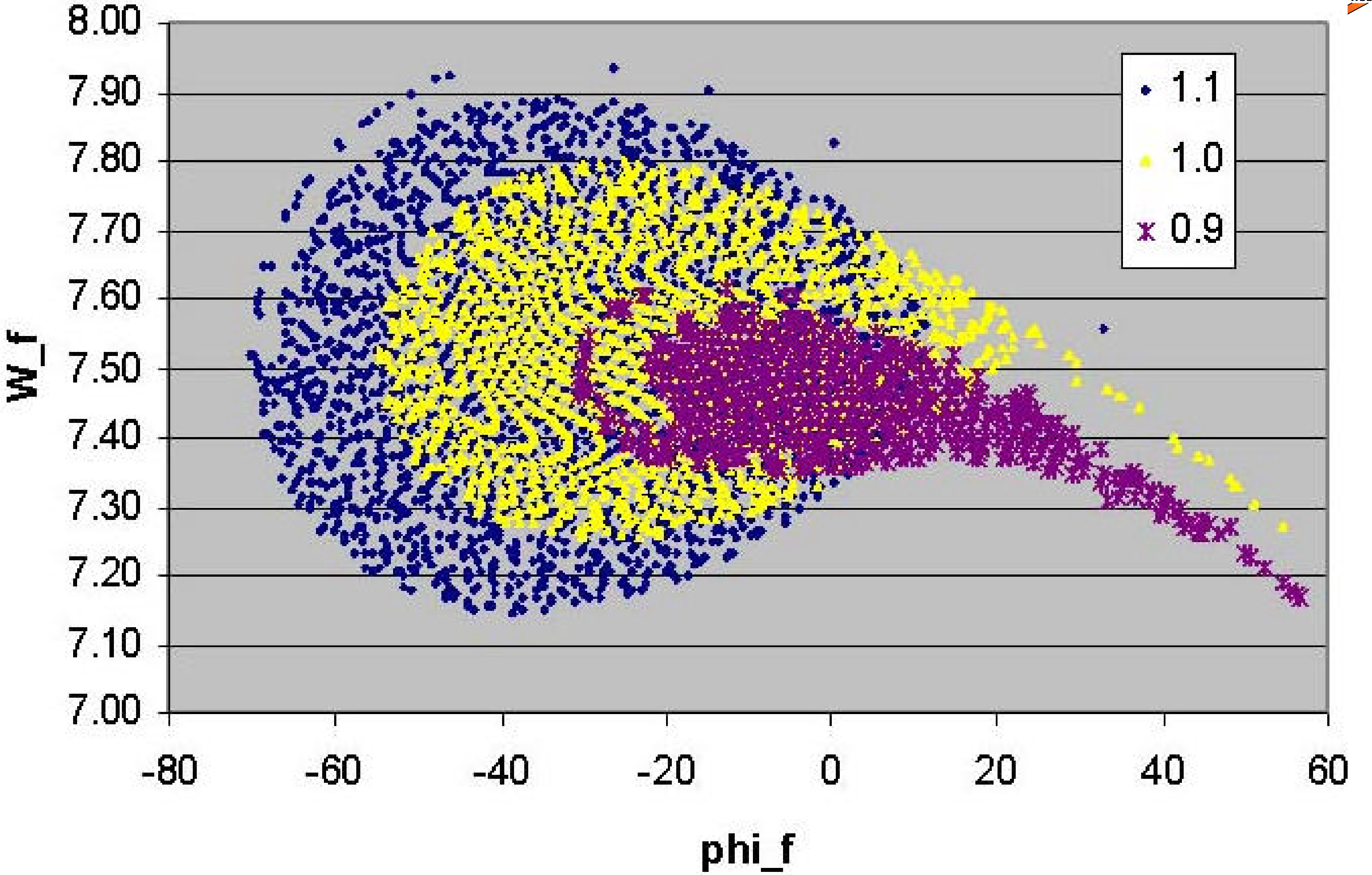
A Tank 1 Commissioning Scenario (1)

- Introduce smallest MEBT aperture
- Measure input beam emittance in the MEBT
- Match reduced-current beam per calculated values
- Set linac in low beam-duty-factor mode
- Measure phase acceptance using beam-loading technique
  - Transmitted beam goes toward D-plate dump
- Set Tank-1 phase & amplitude
  - Unaccelerated beam is not transmitted

Tank 1 Longitudinal Acceptance For 3 Values of E_0



Exit Coordinates of all Stable Particles in Tank 1



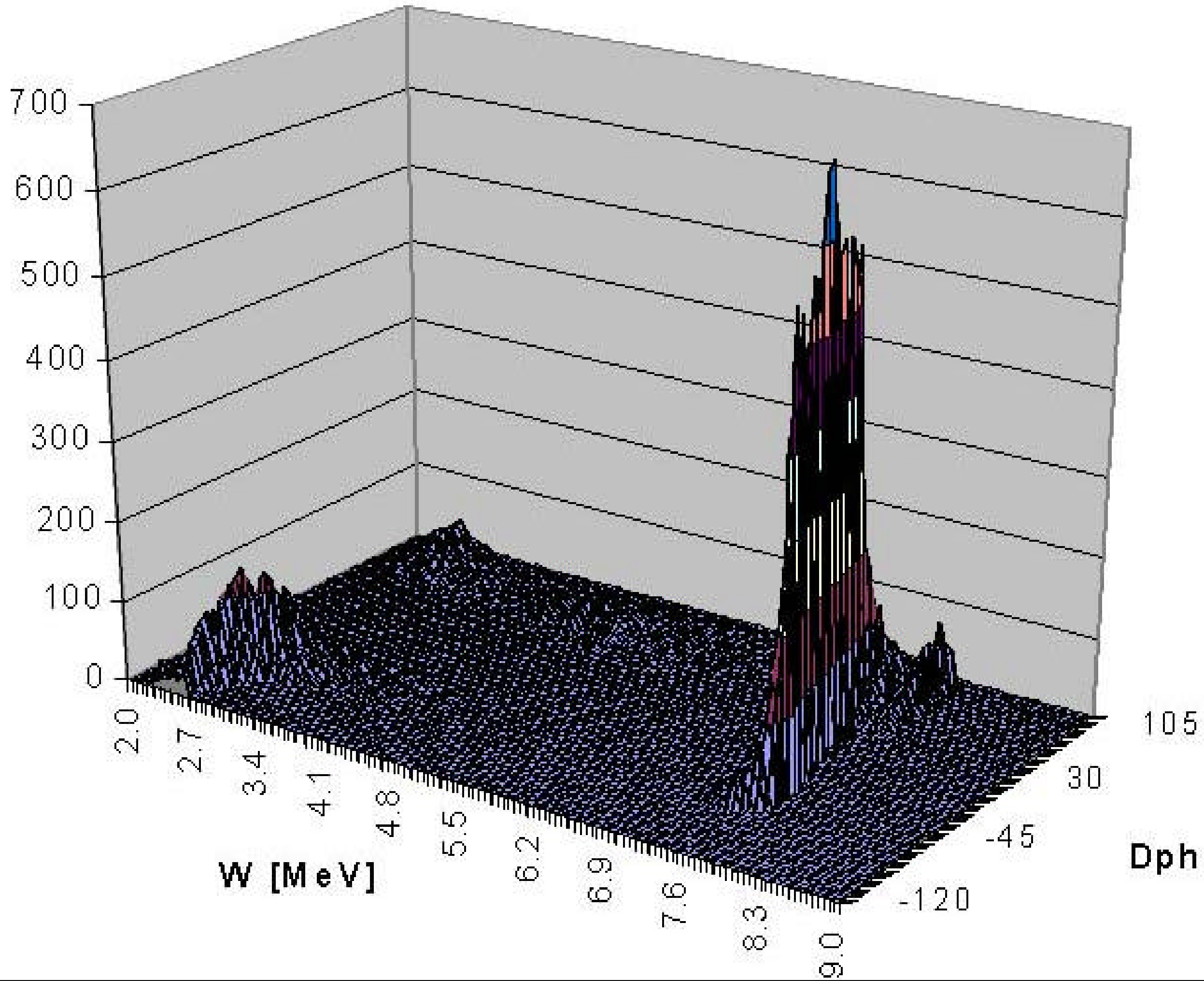
A Tank 1 Commissioning Scenario (2)

- Measure Tank-1 transverse acceptance
  - D-Plate BCM vs. MEBT steering
- Re-steer beam into Tank-1
- Steer 7.5 MeV beam into D-Plate dump
- Measure output emittance
- Rematch input beam to optimize output emittance
- Maximize transmission as a function of buncher tuning
  - using D-plate BCM
- Iterate on above
  - Details of matching are strongly dependent on space-charge effects

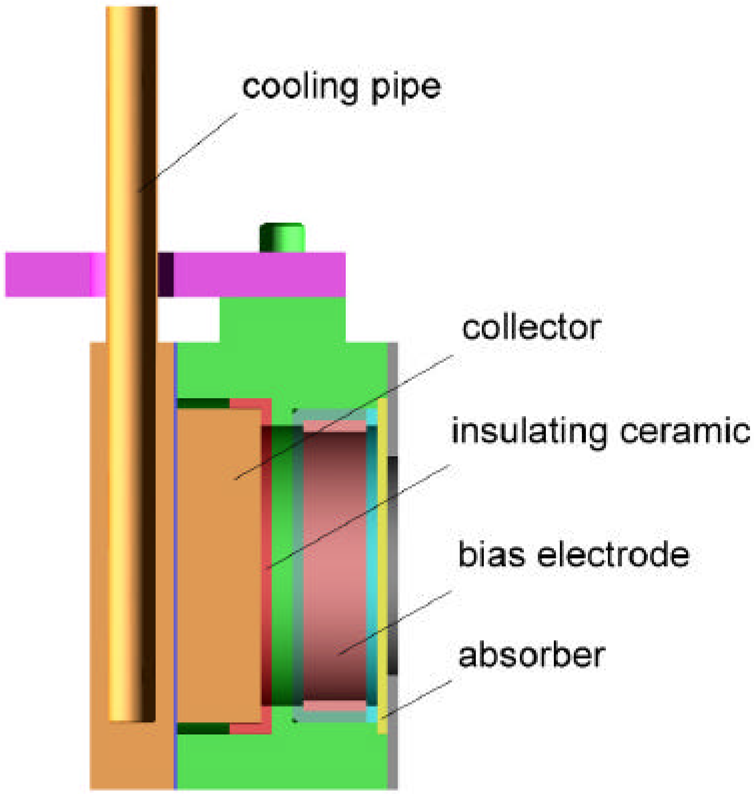
Low Current Beam is Now Nominally Matched & Tuned

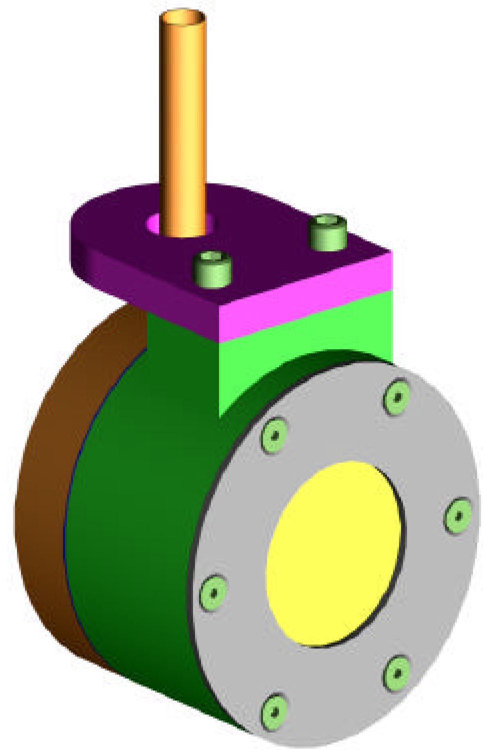
- Carry out phase scans using energy degrader & Faraday cup
  - Re-set phase & amplitude
  - Characterize phase width
- Re-tune bunchers for optimum phase width
- Iterate on above

There Will be no Beam at Intermediate Energies

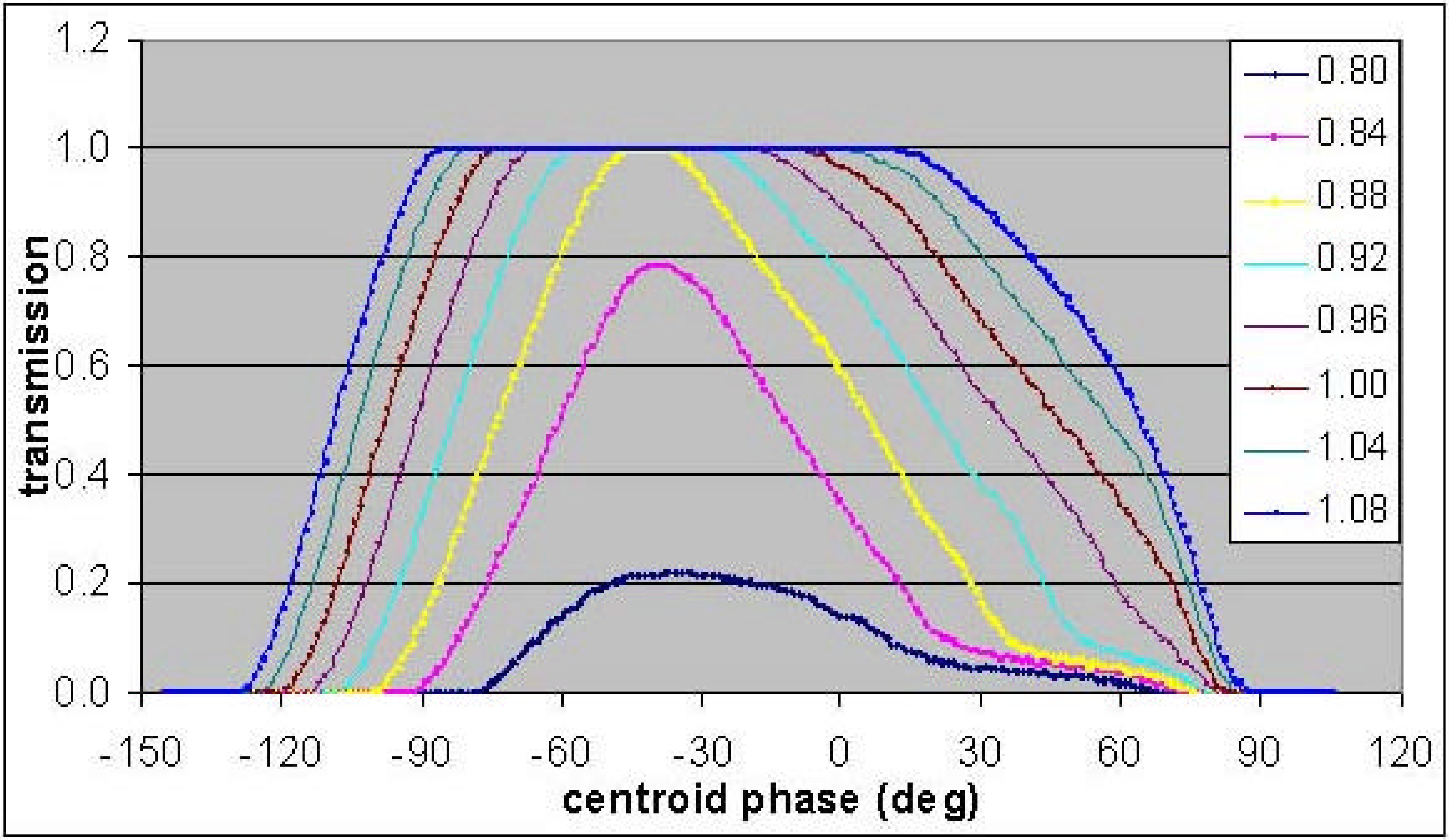


Energy-Degrader/Faraday-Cups Are Located Between Tanks





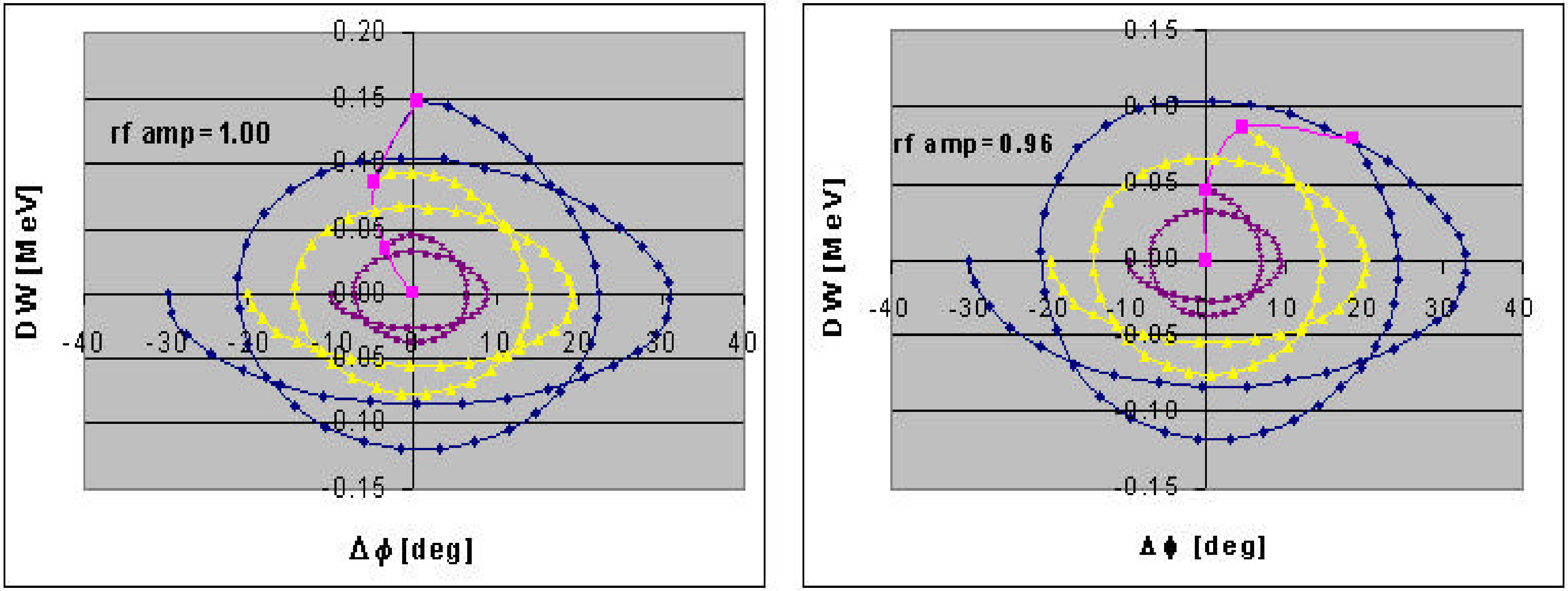
Tank 1 Phase Scan for E_0 = 80-108 % of Design RF Amplitude



A Tank 1 Commissioning Scenario (4)

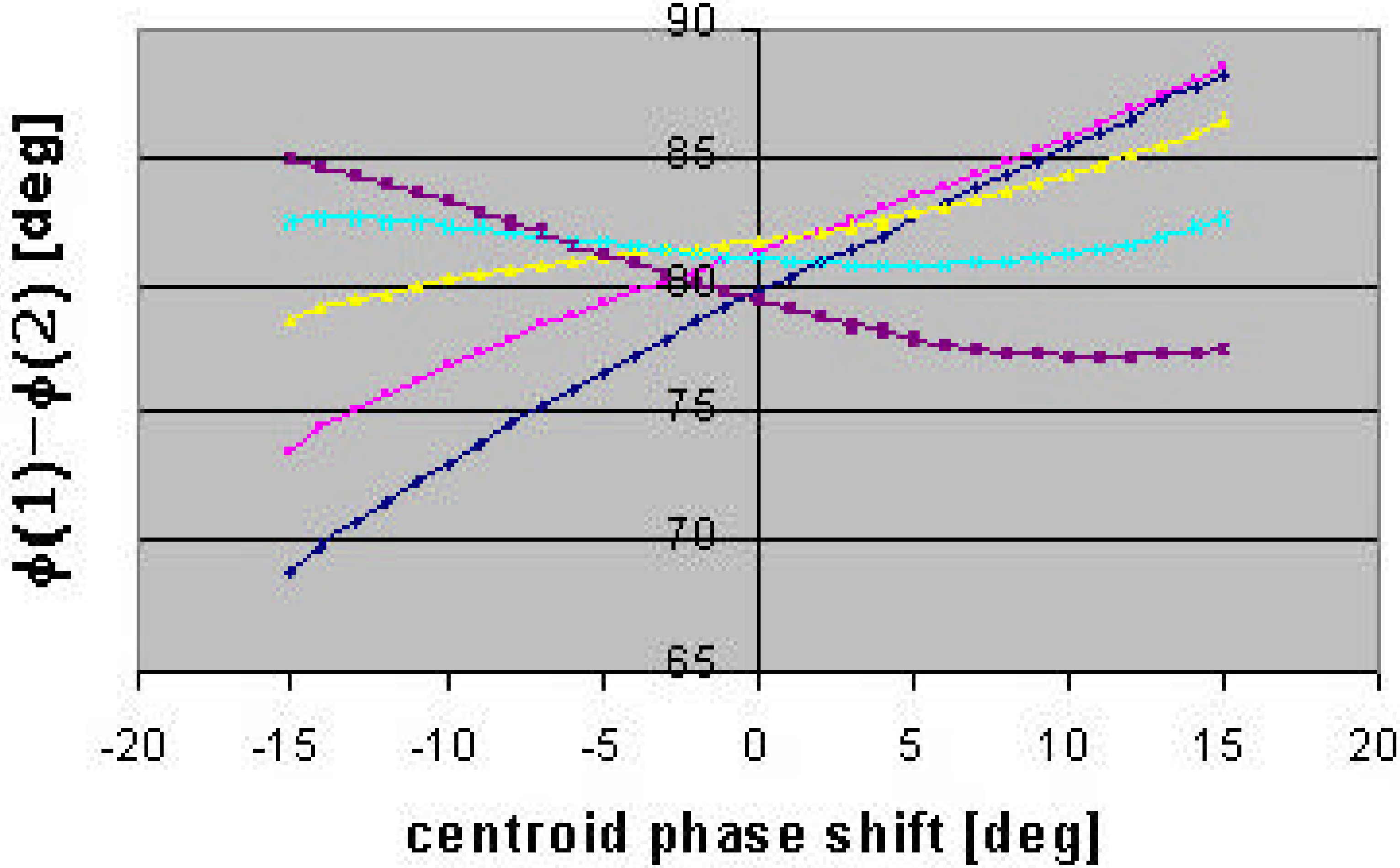
- Develop MEBT tuning & matching algorithms
  - Bunchers
  - Quads
- Develop phase scans using D-plate BPMs

Longitudinal Motion in a DTL Tank



- Phase advance for 100% and 96% of design

TOF Phase Scan of Tank 2



Transverse Emittance Will be Our Most Important Measurement

- Linac was designed assuming a elliptical water-bag distribution
- Initial Front-End emittance measurements show exotic beam distributions
- Properties of the initial distribution are not filtered by the RFQ
- Significant beam loss is expected due to shortcomings of the injected beam
- DTL matching is the most important tuning parameter affecting beam loss and final emittance
- The D-Plate slit & collector is the only diagnostic
  - Except profile

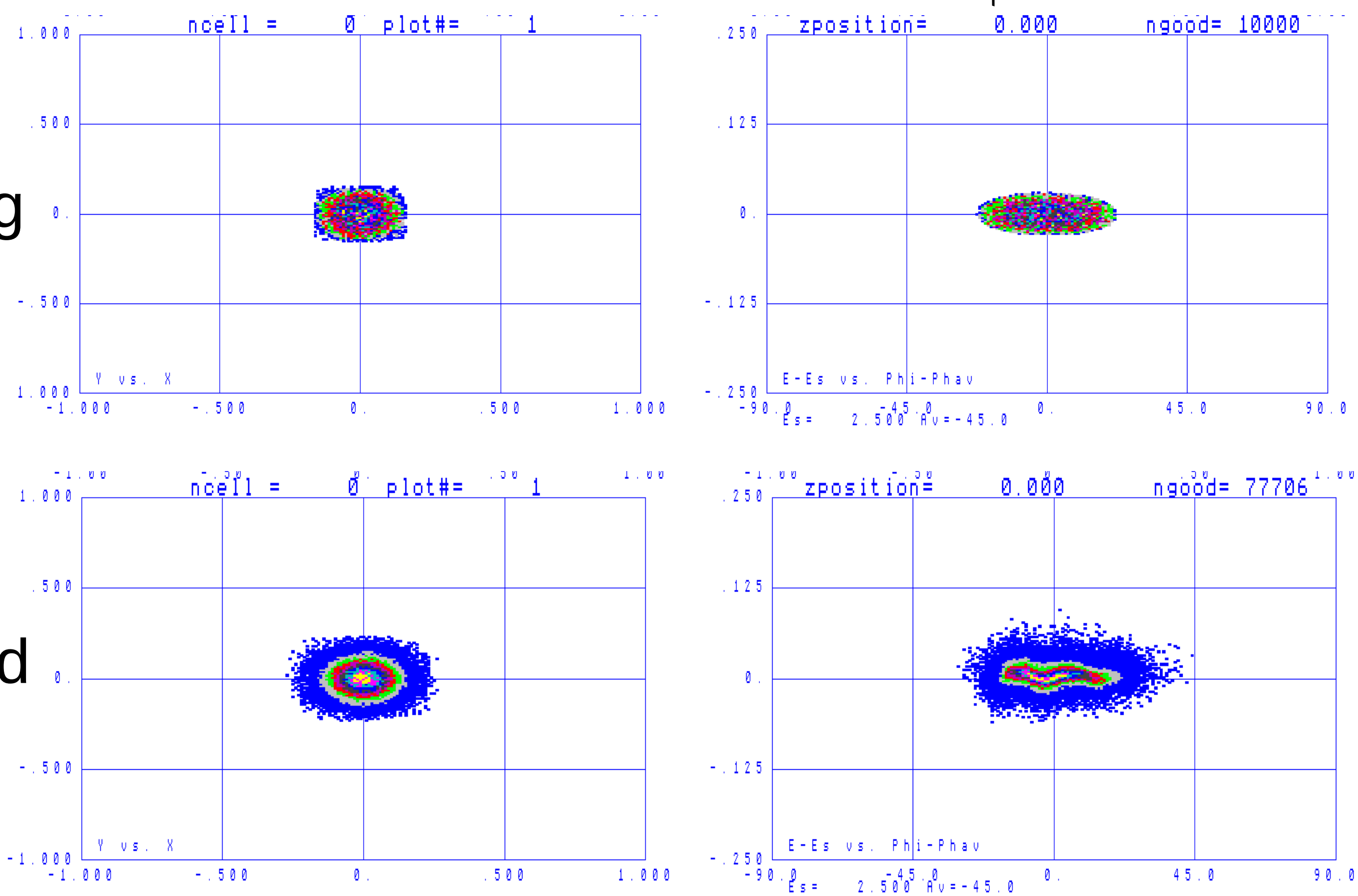
Beam Distributions at the RFQ Exit

X-Y

ϕ-W

Water bag

Measured

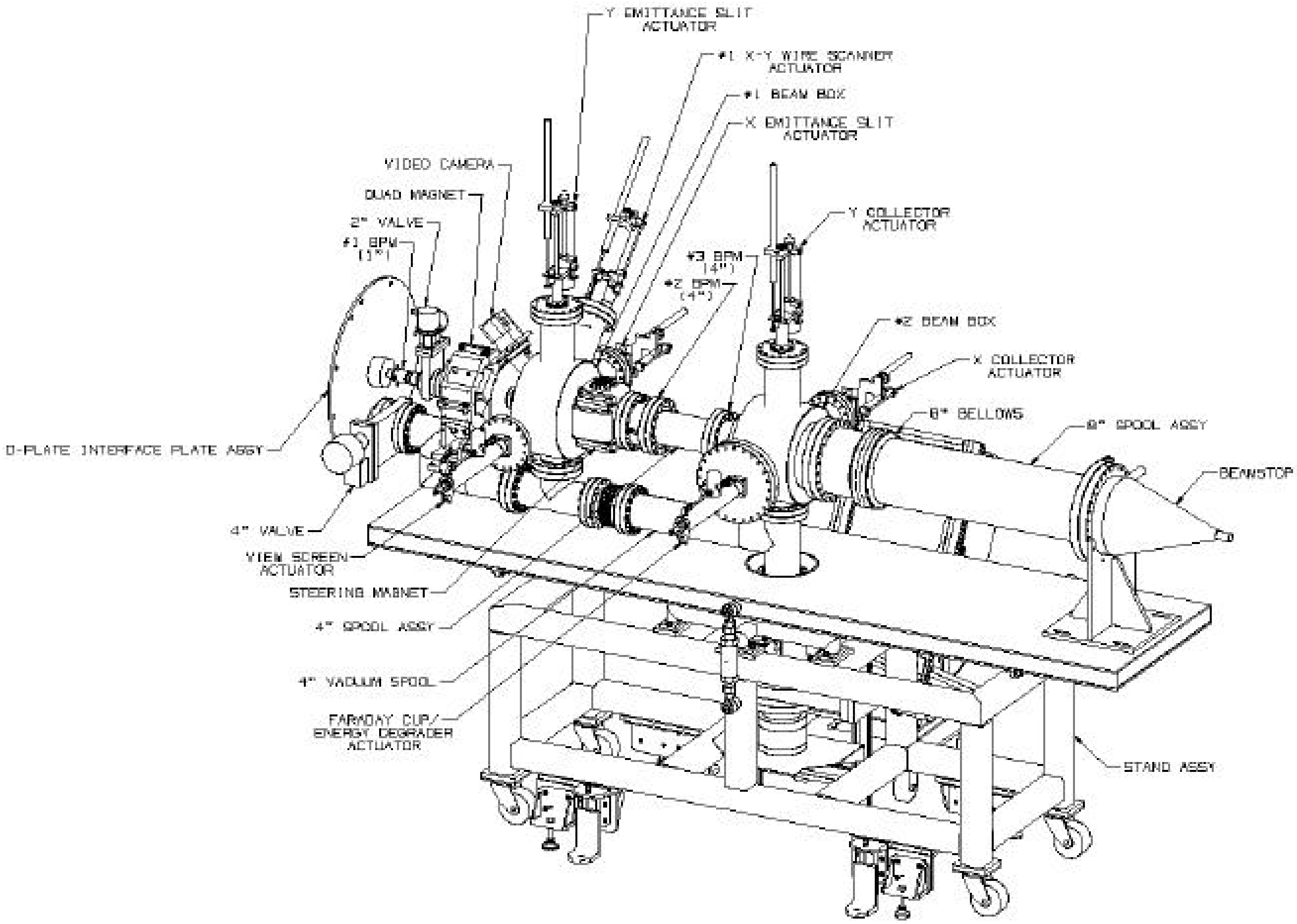


SNS D-plate System
Preliminary Design Review –
Physics, Requirements, and Interfaces

Los Alamos, July 18, 2001

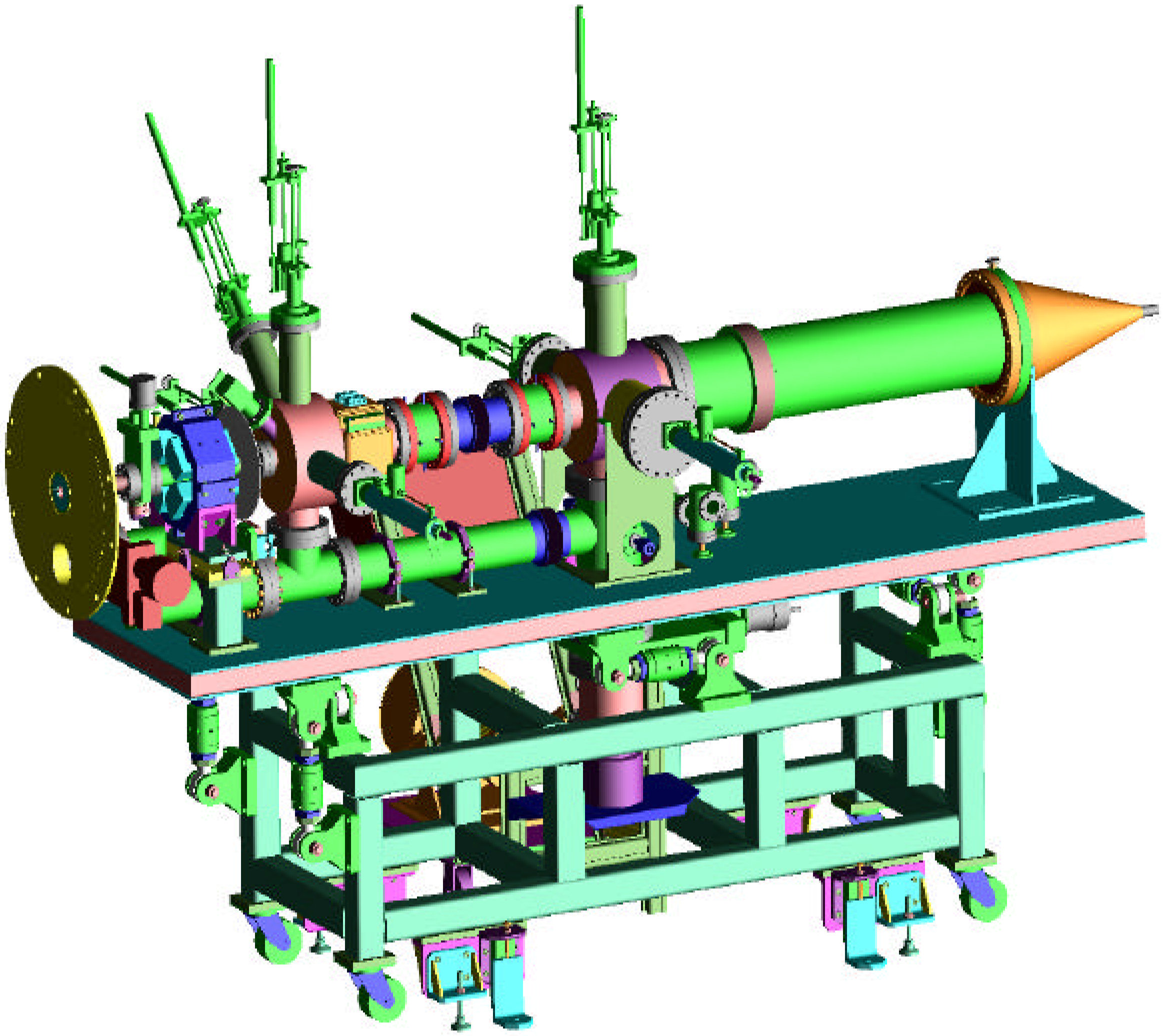
by Michael Plum

D-plate components



D-PLATE ASSEMBLY

D-plate isometric image



D-plate instrumentation

- **Beam current measurement.**
- **Beam position measurement (3 ea.).**
  - Also time of flight energy measurement.
- **Video profile and position.**
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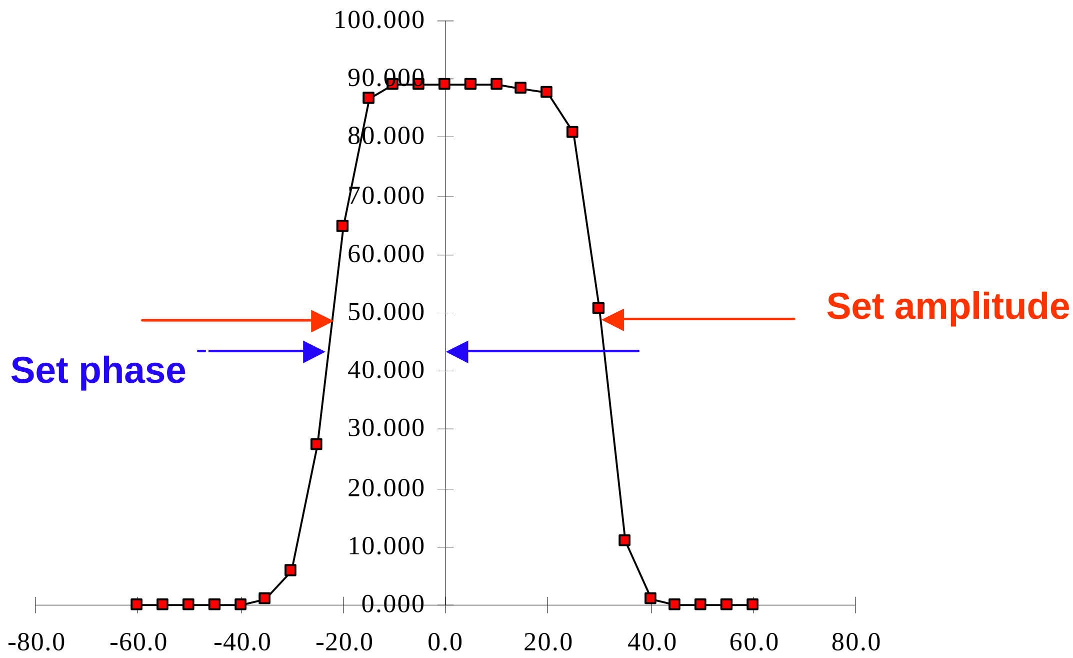
- **Faraday Cup / energy degrader.**
- **Halo scraper.**

D-plate usage scenarios

- **Set DTL tank 1 phase and amplitude.**
- **Measure properties of beam exiting DTL tank 1.**
  - Beam energy by time of flight between two identical BPMs.
    - $\delta E = mc^2 (\beta^*\gamma)^3 (c/L)\, \delta t$ gives 26 keV accuracy, or 0.5% tank 1 energy gain.
  - Beam profile measurements with wire scanner, phosphor screen, and emittance gear.
  - Beam emittance measurement with slit and collector (x and y).
  - Beam current with toroid.
- **Accommodate DTL tank 1 aperture scans.**
- **Test DTL diagnostics (WS, CM, ED/FC) and steering magnets.**
- **Check MEBT to Tank 1 matching.**
- **DTL transmission measurement.**
- **Beam stop for full power tests of front end systems plus DTL tank 1.**
- **Tests of methods to improve MEBT beam quality.**

D-plate usage scenarios (cont.)



Example of PARMILA model of LANSCE DTL tank 2 phase scan.

(From L. Rybarcyk)

Beam modes and parameters

- **The D-plate must function under a variety of beam parameters, depending on the beam mode.**
  - *Commissioning mode beam parameters*
  - *Nominal beam parameters during normal operation*
  - *Troubleshooting beam parameters*
    - Same as commissioning beam parameters.
  - *Beam development beam parameters*
    - Same as commissioning beam parameters.

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) Extreme sizes are about sqrt(5) times larger

D-plate system requirements

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

Table 2-10. Measurements and diagnostics on the D-plate.

Measurement	**Diagnostics used**
Beam profiles	Wire scanners
Beam current	Toroid, Faraday cup, with energy degrader foil
Beam synchronous phase	BPM
Beam energy	BPM time of flight (20 cm flight path)
Emittance	Slits and collectors
Beam image	View screen
Halo	Segmented halo scraper (fixed aperture)
Beam stop	36 mA, 7.5 MeV, 1 ms, 60 Hz (16 kW)

Note: SNS parameters list, SNS-100000000-PL0001-R05, May 2001, lowers the peak current to 38 mA, and the average current to 26 mA. (11.7 kW)

Table 3-9. Commissioning requirements for DTL tank 1.

Aperture scans	Faraday cup with energy degrader
Transmission efficiency	Differential current measurements (toroids) Faraday cup with energy degrader Beam loss measurements (ion chamber)
Beam size (transverse matching)	Wire scanners
Phase, energy and amplitude scans	Beam synchronous phase, Beam energy (time of flight) Delta-E delta-t measurements

D-plate system requirements (cont.)

- **DTL tank 1 phase and amplitude set point requirements are ±0.5° and ±0.5% (WBS 1.4 SRD, WBS 1.4.2 DCD).**
  - Time of flight system accuracy is ±0.5%.

D-plate design issues

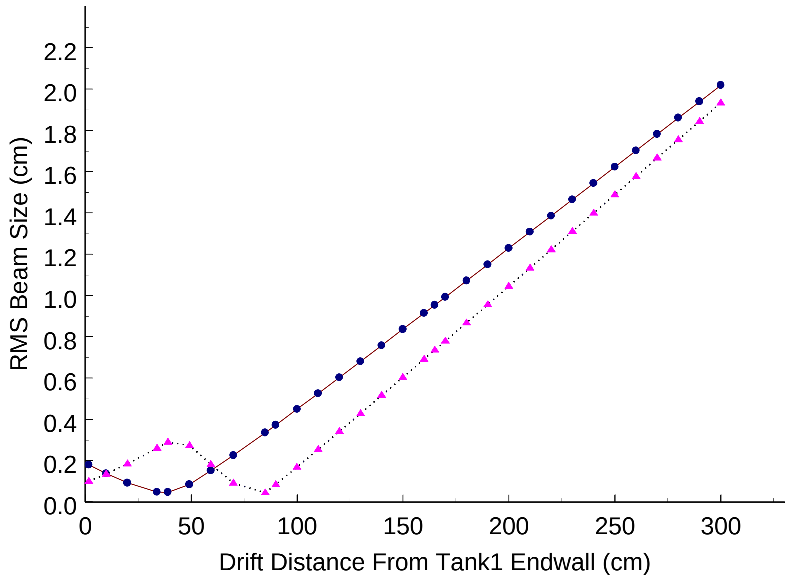
- **The D-plate is the last point in the linac where the machine can be run at full nominal beam current until spallation target is commissioned.**
- **Need a system that will insure average beam current is kept within limits. 60 Hz, 1 ms pulse length, unchopped beam, will exceed the operating envelope.**
  - Plan to use the machine protection system and a the current monitor system to limit beam power.
- **Emittance measurement will use electronics now being developed at LBL.**
- **To reduce costs we are utilizing as much used equipment as possible.**

Other reviews relevant to the D-plate

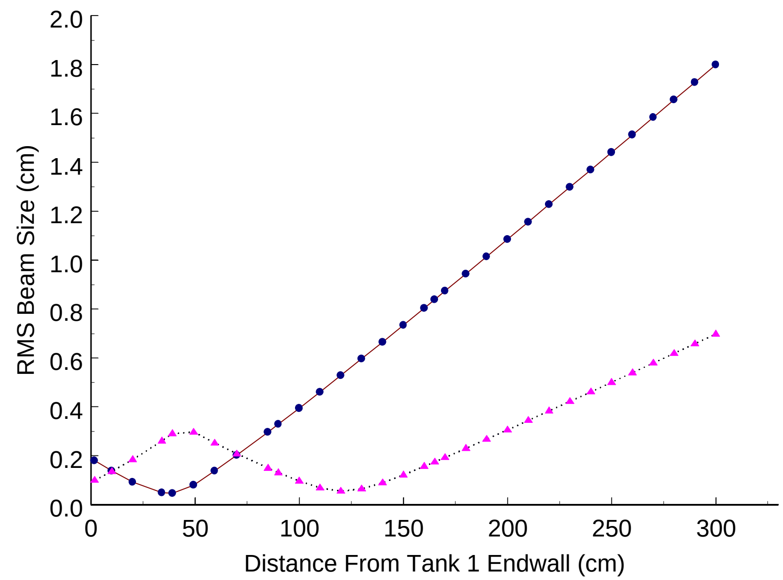
- **BPMs – PDR held Feb. 2001.**
- **WS – PDR held Jul. 2001.**
- **CM – PDR not yet scheduled.**
- **ED/FC – PDR not yet scheduled.**

- **Systems for which we have no plans for a separate PDR:**
  - Phosphor screen profile measurement.
  - Slit and collector emittance measurement (but there may be one for the MEBT emittance measurement).
  - Beam stop (but there will be a safety review).

D-plate optics



Plot of rms beam size vs. distance for the **beam stop tune**. The solid line and circles show the horizontal rms beam size, and the dotted line and triangles show the vertical rms beam size.

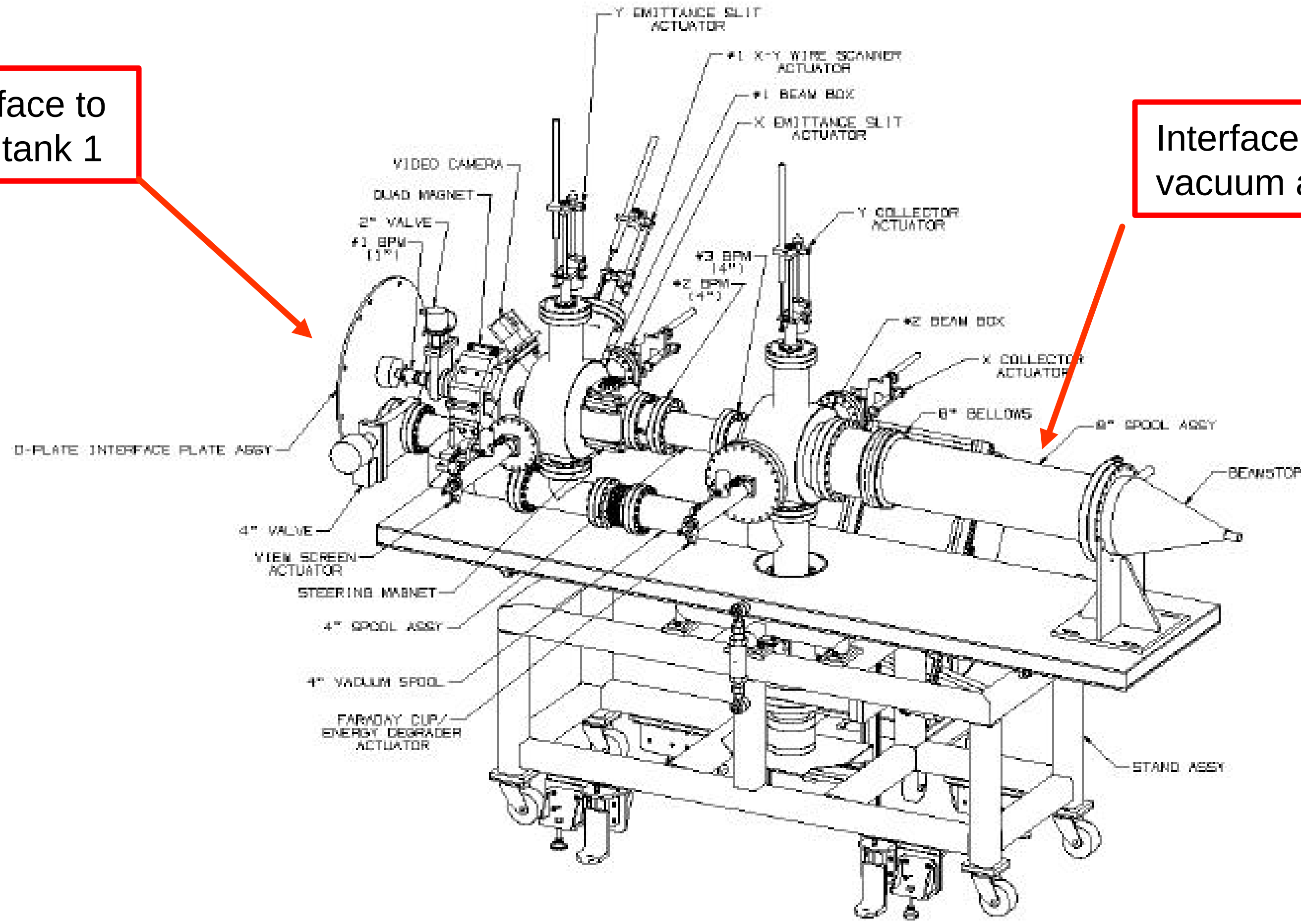


Plot of rms beam size vs. distance for the **emittance tune**. The solid line and circles show the horizontal rms beam size, and the dotted line and triangles show the vertical rms beam size.

Interfaces

Interface to DTL tank 1

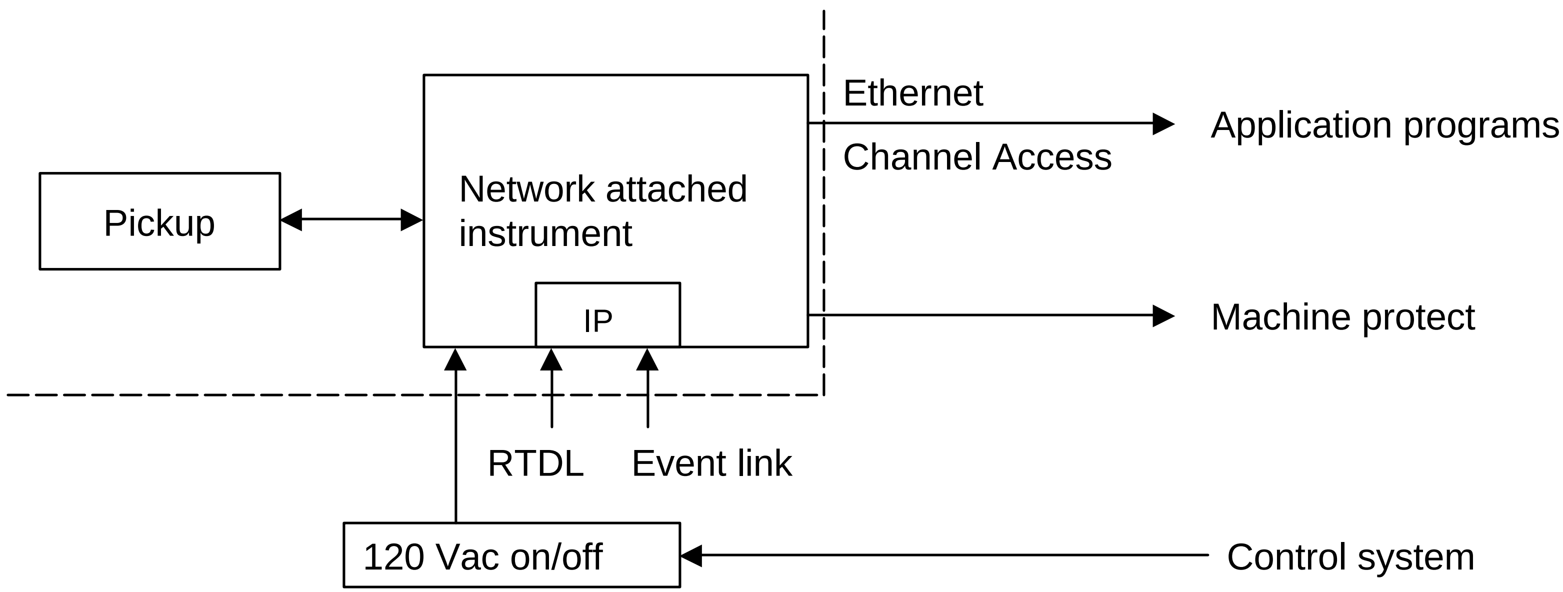
Interface with DTL vacuum and water system



D-PLATE ASSEMBLY

Interfaces (cont.)

- **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.**



System responsibilities

- **Saeed Assadi, responsible for ORNL portion of project.**
  - Acceptance of D-plate and integration into SNS project.
  - Oversight of installation and testing.
- **Mike Plum, responsible for LANL portion of project.**
  - Delivery of D-plate to ORNL.
- **Responsible parties will work together to develop a handoff strategy and agree on the criteria that define a successful system handoff.**

Schedule

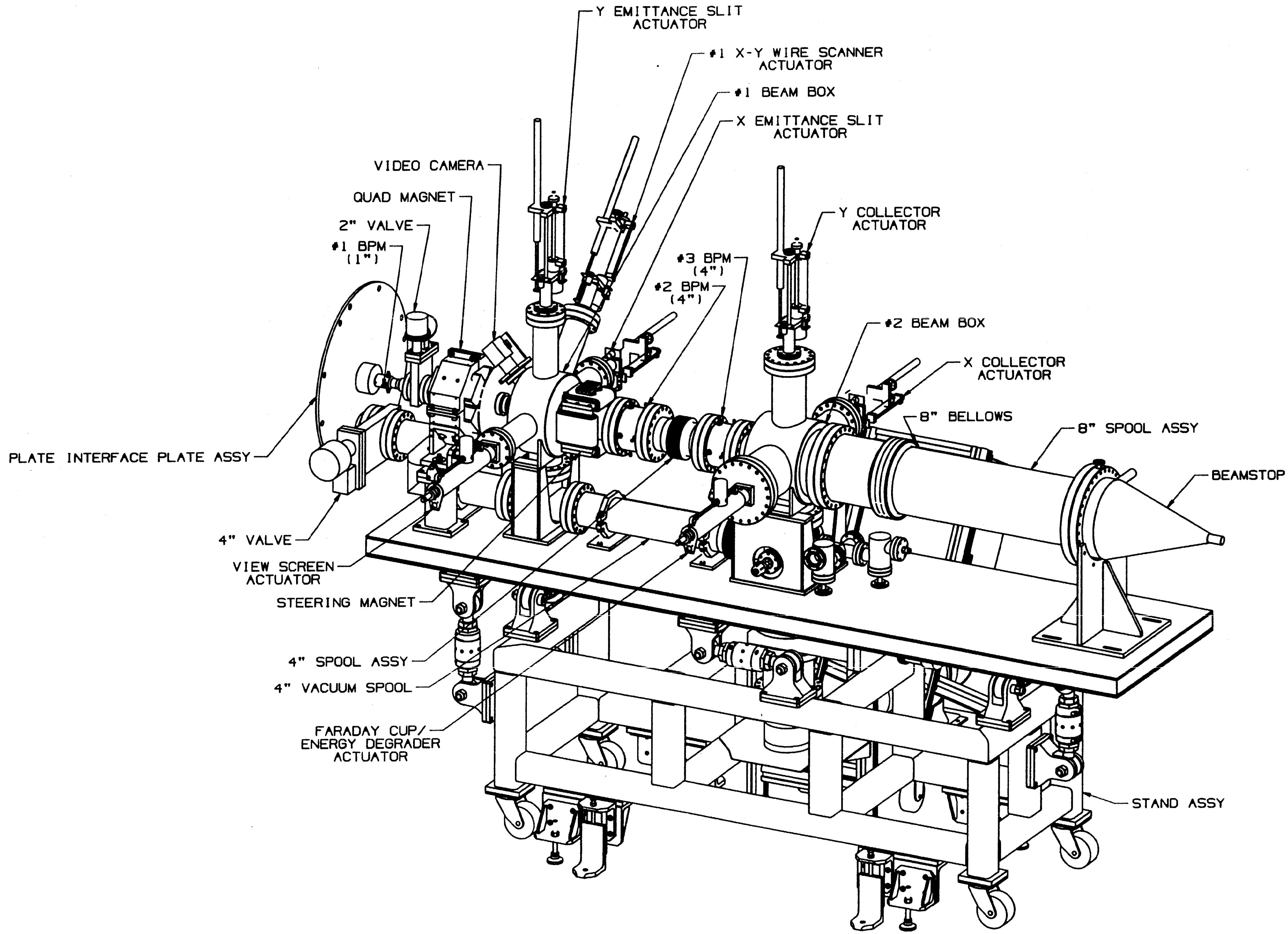
- The MEBT will be delivered to ORNL in the summer of 2002.
- DTL tank 1 installation complete and ready for D-plate installation 26/Nov/01.
- The D-plate will be delivered to ORNL in the fall of 2002.

Summary

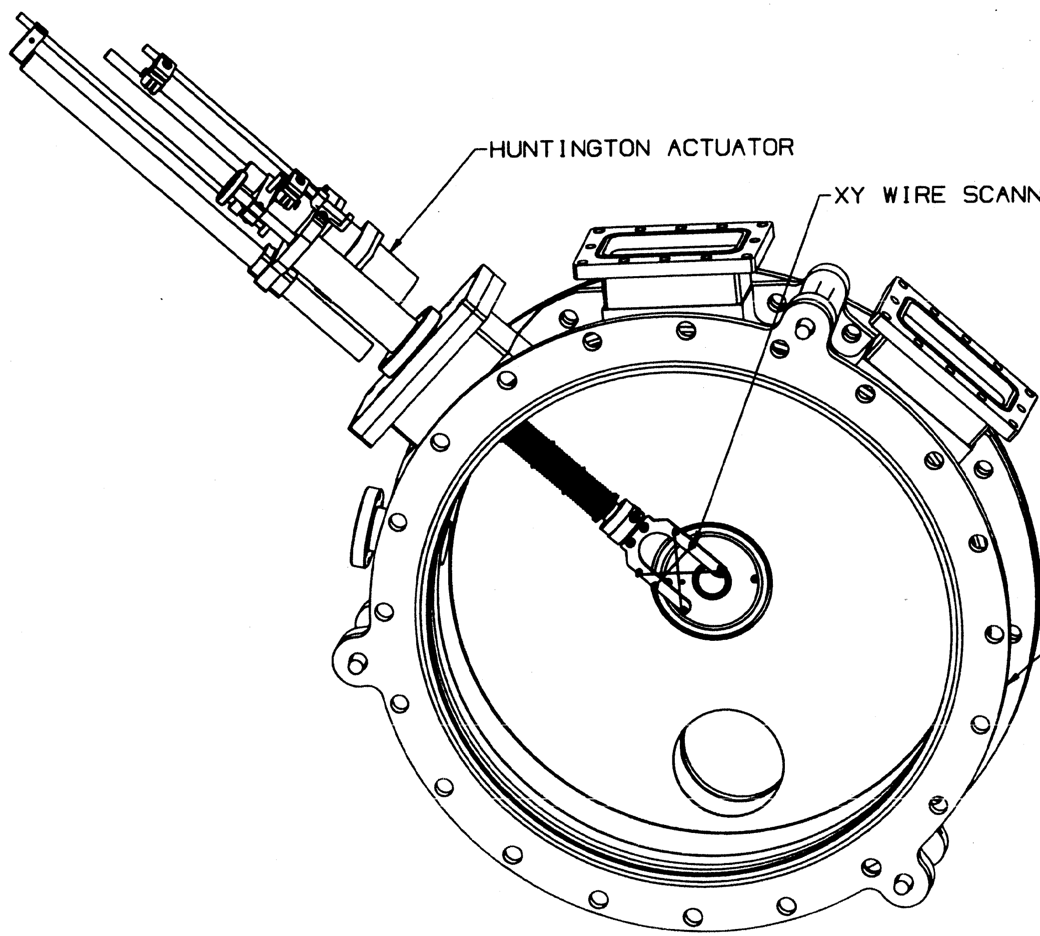
- **We are on track to deliver, on schedule, a D-plate that meets all target requirements.**

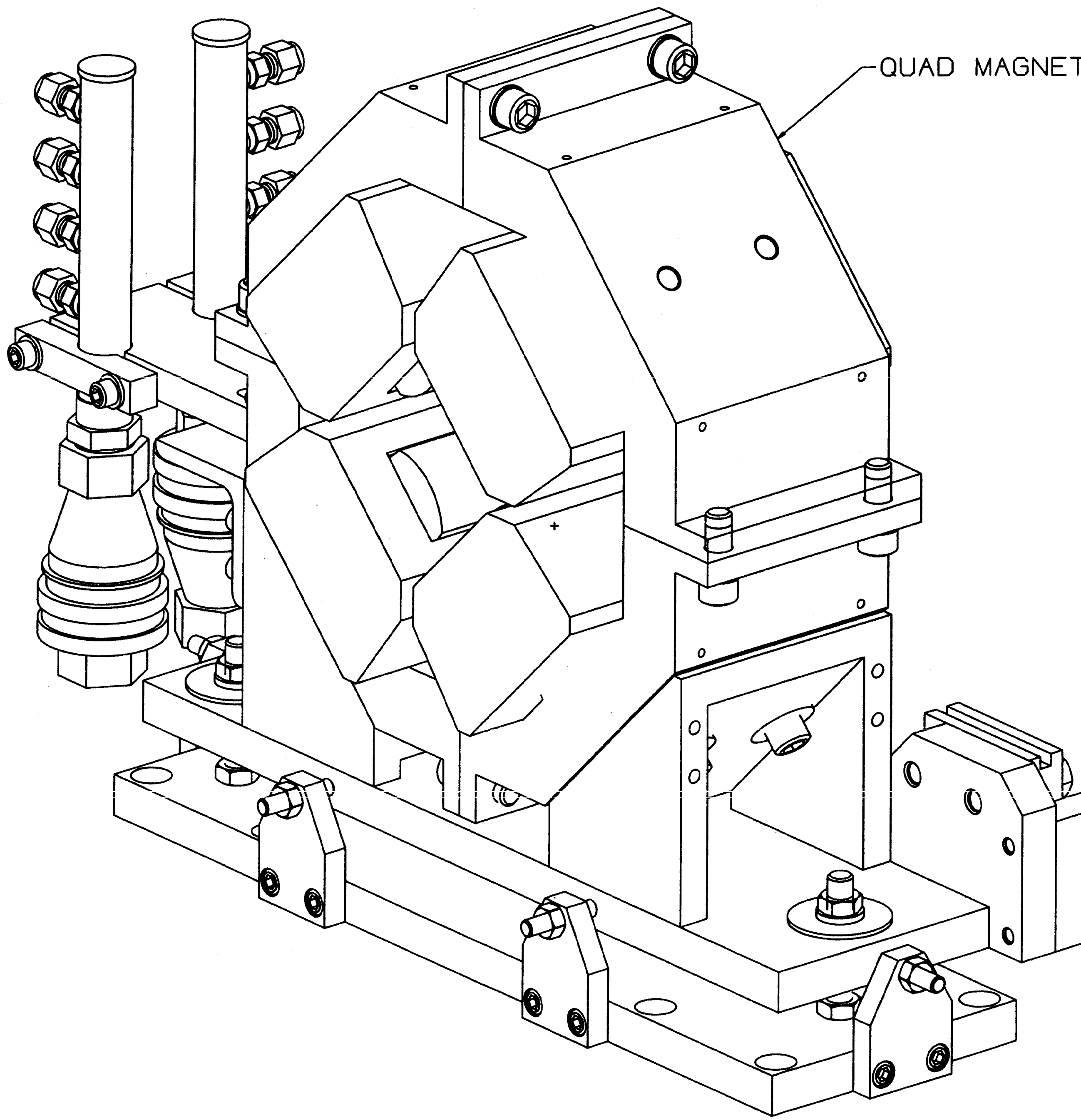
SNS Linac D-plate Design Review
July 18, 2001.
Los Alamos

by Ross Meyer, Sr.



D-PLATE ASSEMBLY


HUNTINGTON ACTUATOR
XY WIRE SCANNER
TANK 1 DOWNSTREAM ENDWALL


QUAD MAGNET

GTA Exp 2D Quad

LANL Drwng No. 112Y-2696777

Magnetic Parameters at 200 A

Gradient:	28 T/m
Gradient Length Product:	3.4 T
Effective Length:	12 cm
N=6 Component:	1.1% at R = 21 mm

Mechanical Parameters

Bore Diameter:	52 mm
Pole Length:	10 cm
Width:	25 cm
Height:	25 cm
Length:	15 cm
Weight:	35 Kg

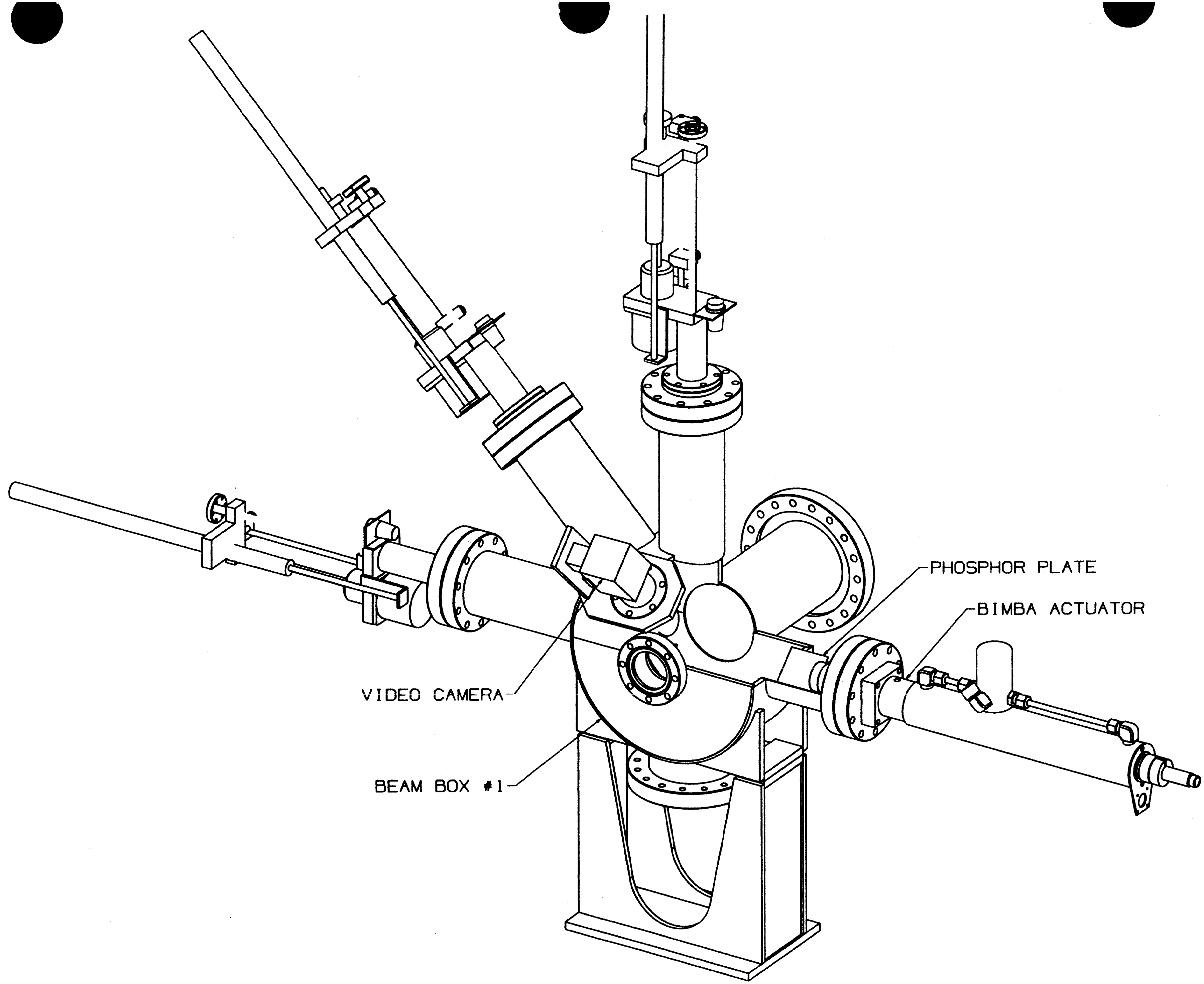
Conductor and Coil Parameters

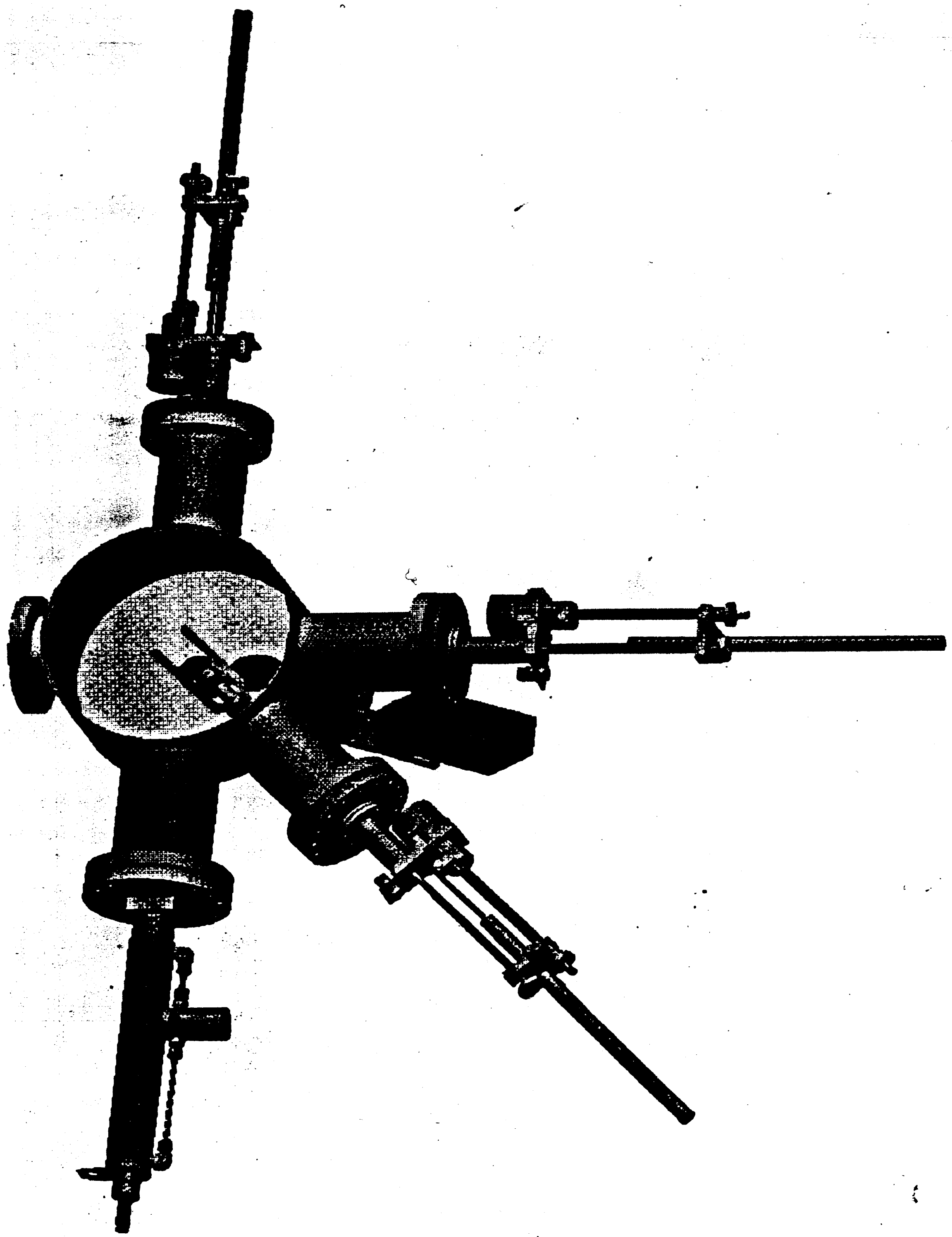
Conductor OD:	0.1875" SQ
Conductor ID:	0.125" RD
Turns per Pole:	40
Water Circuits per Pole:	1
Nominal Current:	200 A
Nominal Voltage Drop:	16 V
Pressure Drop:	90 psi
Coolant Flow:	1.2 gpm

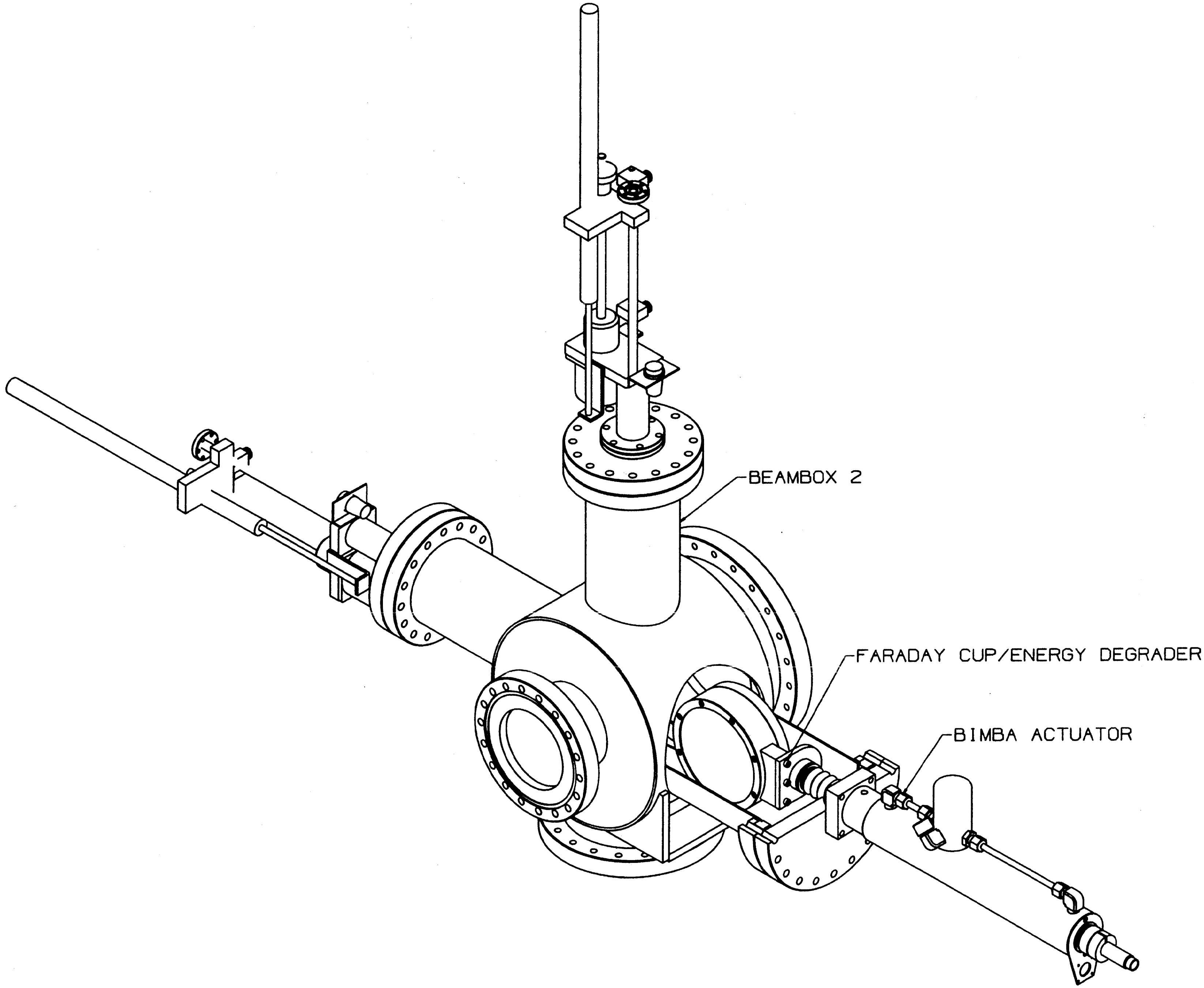
Generic 4" ID Dual Axis Steering Magnet

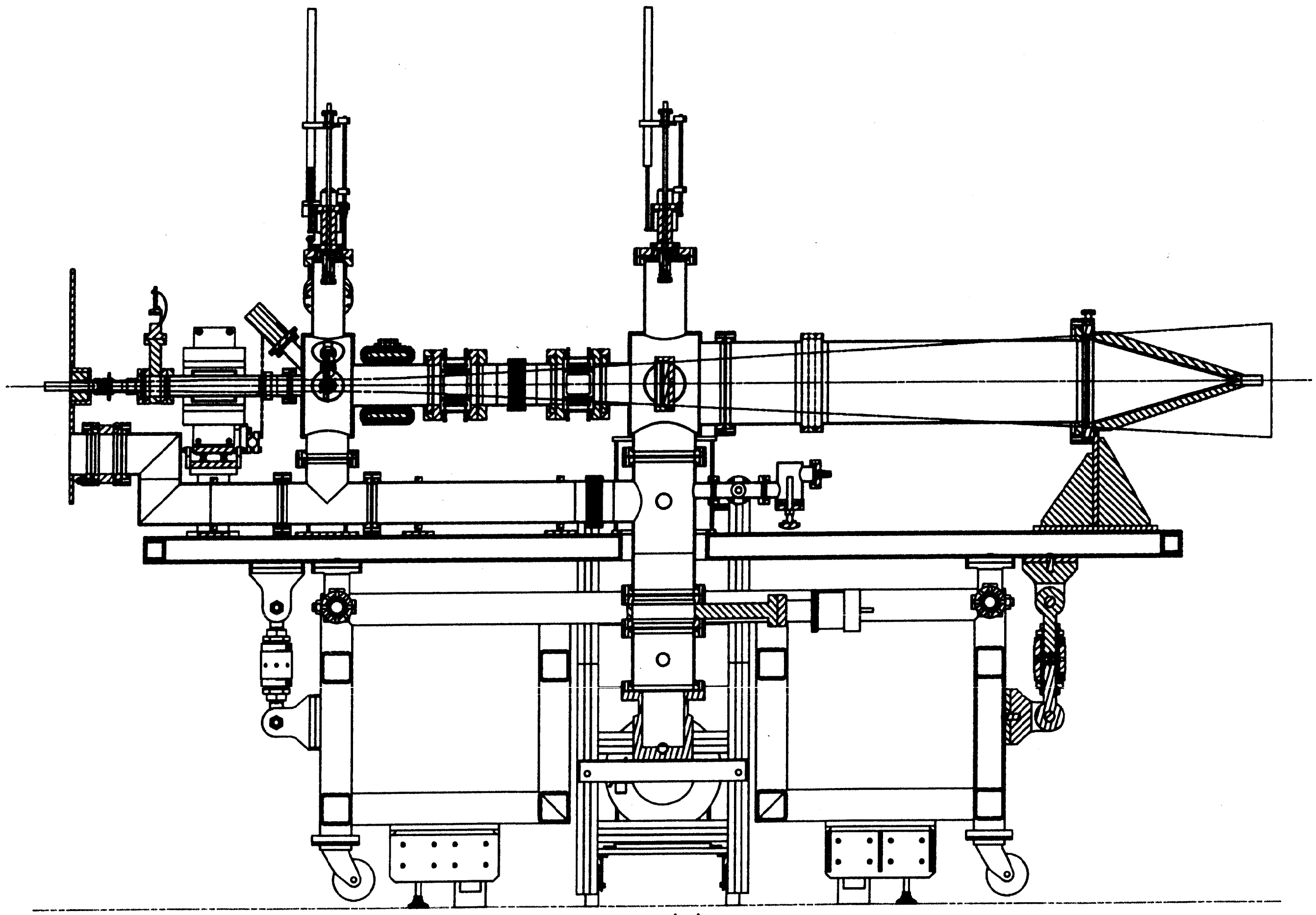
- Each coil consists of 276 turns of #12 AWG copper.
- Yoke is 0.500" thick magnet iron. (e.g. C1006, C1008, or C1010.)
- Maximum current is 6 A.
- For Lpole = 4" and I = 6 A.
  - R coil = 0.85 Ω each axis
  - ΔV = 5.1 V
  - Power = 31 Watts
  - Central field = 148 G
  - B.dl = 3,500 G-cm
  - Steering = 2.2 mr.
  - 2.2% sextupole at R = 4 cm

D. Barlow LANSCE-1 Feb. 8 1999


PHOSPHOR PLATE
BIMBA ACTUATOR
VIDEO CAMERA
BEAM BOX #1




BEAMBOX 2
FARADAY CUP/ENERGY DEGRADER
BIMBA ACTUATOR



SECTION A-A

D-PLATE STRUCTURAL ANALYSIS

- D-Plate structural analysis considered the following components:
  - Anchoring and leveling brackets/hardware at floor
  - Lower frame composed of box section
  - Alignment struts, brackets, and hardware
  - "Table top" platform upon which components are mounted.
  - Stands and hardware mounted to "table top"
- Loads considered included:
  - Gravity
  - Seismic (0.5 g in any lateral direction)
  - Vacuum
- COSMOS (finite element program) and hand calculations were employed.
- Acceptability was based upon acceptable stress levels, as well as acceptable deflections under combined loading.
  - Stresses are maintained below 1/3 of the yield strength for gravity/vacuum loading, and below 1/2 of yield for gravity/vacuum/seismic loading.
  - Deflections are maintained such that they can be compensated for during leveling (deflections due to gravity) or maintained low enough so as not to affect alignment (deflections due to vacuum loads).

COST SAVING MEASURES D-PLATE DESIGN AND FABRICATION

		SAVINGS
1)	Delete the third actuator vacuum box by placing actuators in the second vacuum box.	15 K
2)	Combine the energy degrader and faraday cup into one actuator. (1) D-Plate, (5) DTL, (1) CCL	25 K
3)	Use quad magnet from the GTA Project.	40 K
4)	Use alignment struts from the DTL and CCL stands.	12 K
5)	Use vacuum pump and instrumentation hardware from other parts of the LINAC.	25 K
6)	Use steering magnet drawing package from the IPF project.	9 K
7)	Use BPM drawing package from the IPF project.	9 K
8)	Borrow quad and steering magnet power supplies.	8 K

	TOTAL	143 K

(Design and Fabrication)

Beam Stop: Thermal/Structural Analysis
July 18, 2001

Snezana Konecni, Ph.D.

Spallation Neutron Source Division

Los Alamos National Laboratory

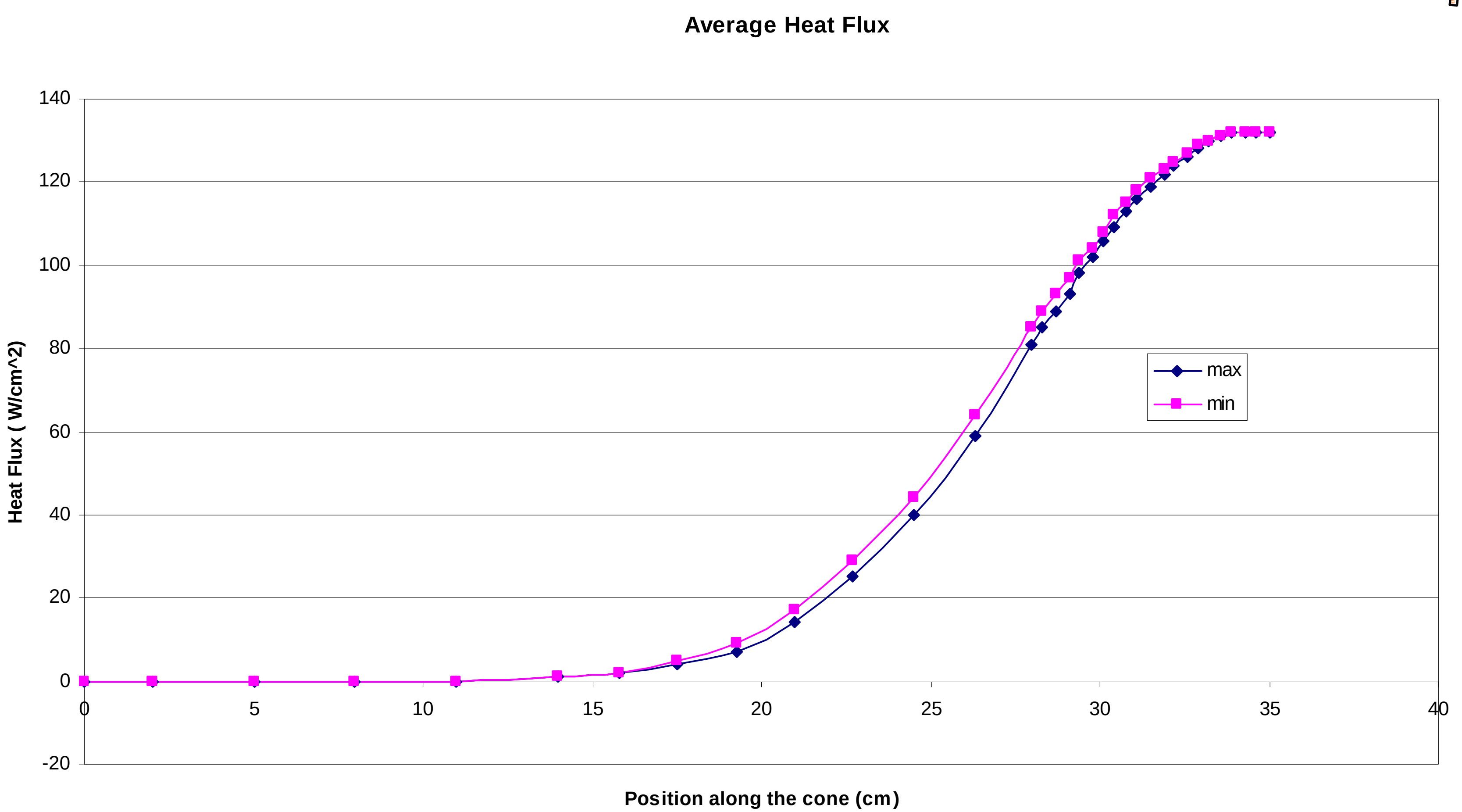
Objectives

- Beam stop is placed between the first and second DTL tank and its use is to stop the beam of protons in order to test the quality of the beam.
- Beam will be under full power and pulsed.
  - **Total power 11.629 kW.**
  - **25 mA, 1ms, 60 Hz.**
  - **Beam shape is elliptical (2.02 by 1.92 cm), there is an azimuthal distribution.**
- Beam stop will be used for a 6 months at full power during commissioning.

Design Criteria

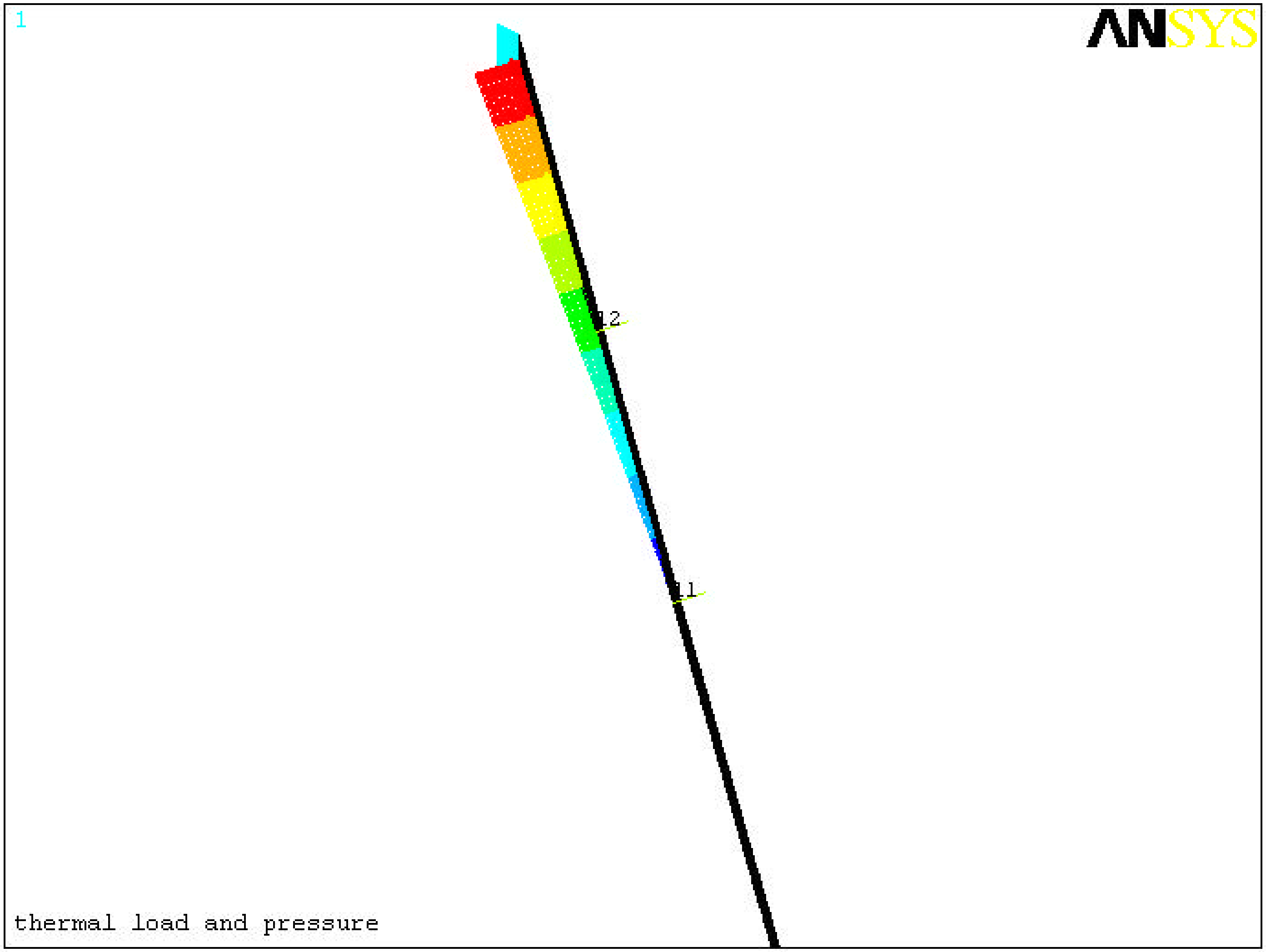
	Weighing factor	Description
Functionality	4	• Effective stopping of the beam • The beam stop hardware must integrate with support structure
Safety	5	Proper control and safety features should be employed to protect personnel and the beam line (equipment and operation)
Procurement, Fabrication and Assembly	2	• Design with standard off-the-shelf parts • Avoid using exotic materials • Assembly and maintenance issues should be incorporated in the design to ensure consistency with other subsystems.
Durability/Reliability	3	A reliable assessment should be performed to ensure the beam stop outperforms other beam system components (minimize down time)
Cost	3	Optimize functionality to minimize procurement, fabrication and assembly cost to fit within the allocated budget.
Maintainability	2	•

Heat Flux Along the Beam Stop Axis



Cone Slope =3.5

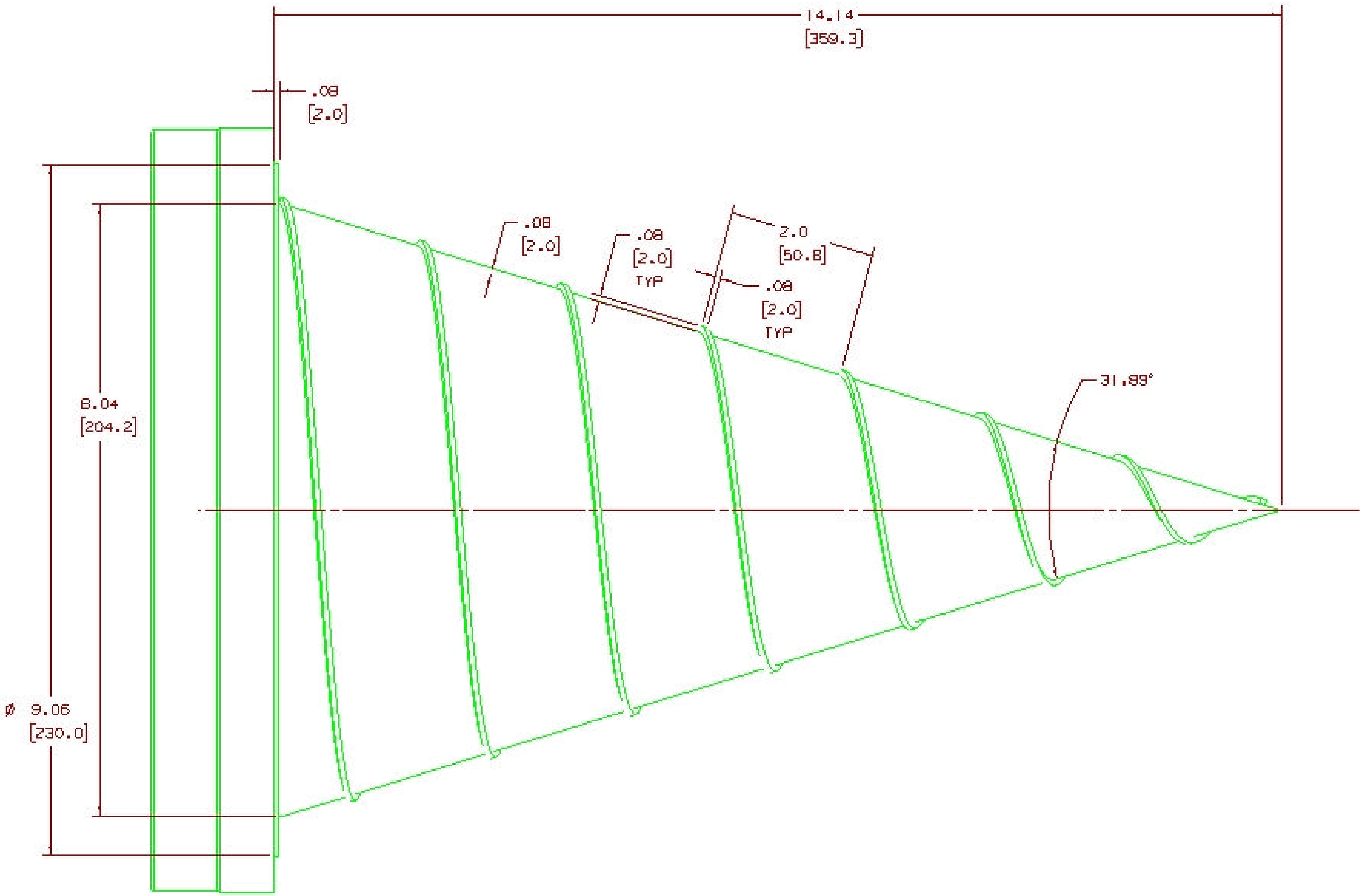
Applied Heat Flux 2-D Model



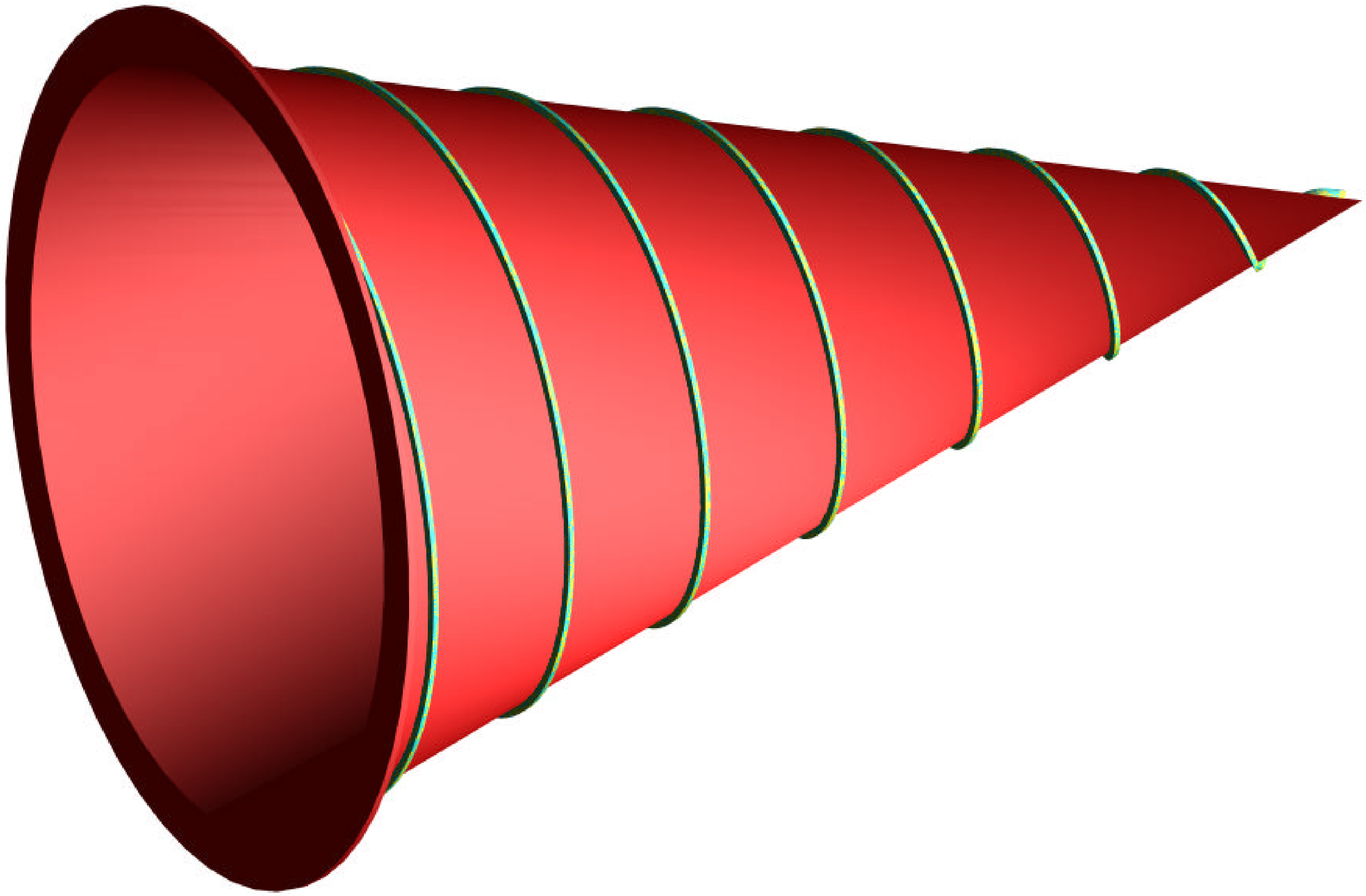
Assumptions

- The beam stop is assumed to be a cone with radius of 10cm base and slope of 3.5 cm/cm (15.95 Degrees) It will be made of Nickel 200, 2 mm thick.
- The cone is cooled with water under pressure to prevent boiling (22 psi This is 50% more than Psat).
- Heat transfer coefficient is based on the velocity of the water in the spiral channel (19623 w/mK).
- Heat flux is symmetrically applied on the inside of the cone in order to do 2-D analysis.
- Total applied power on the inside of the cone is 18.408 kW. (This is 1.58 times more than operational)

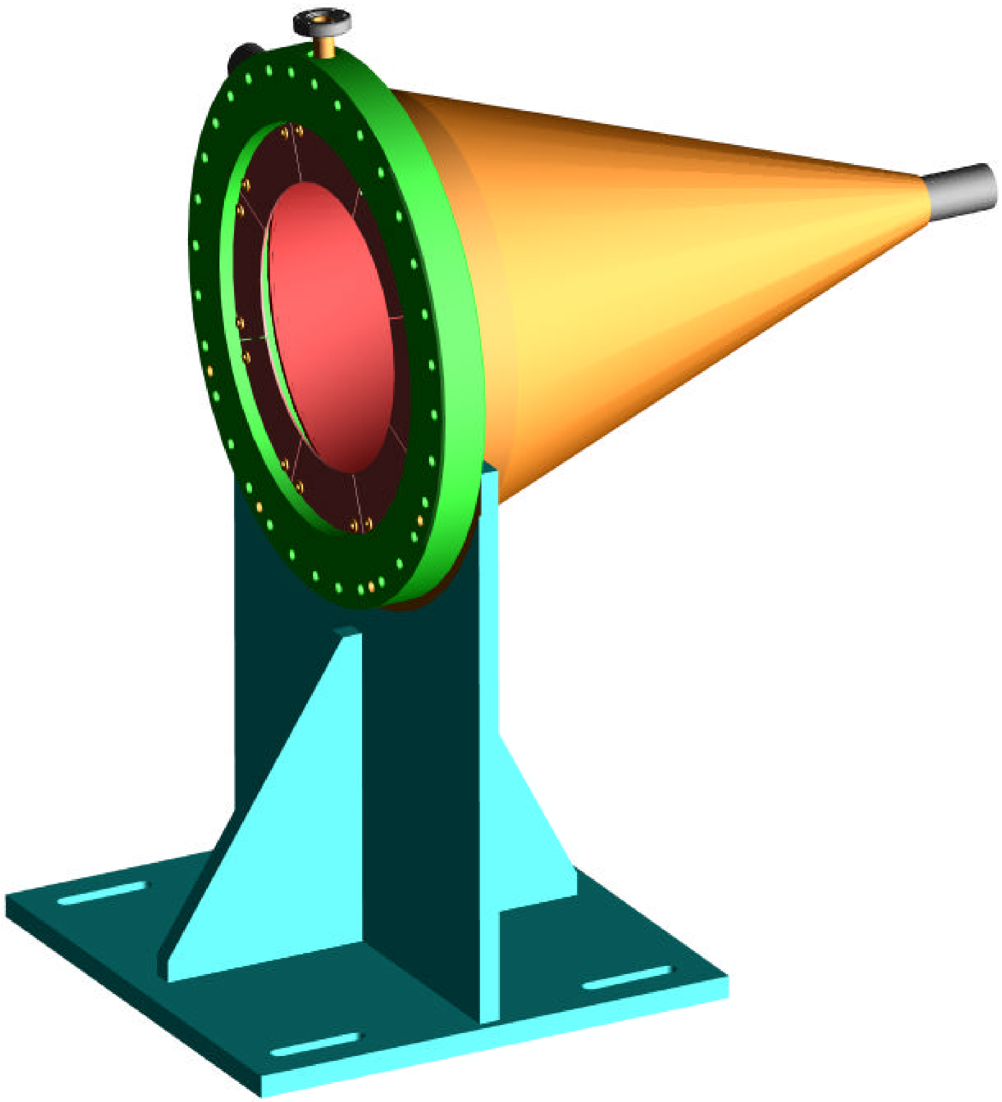
Beam Stop


14.14
[359.3]
.08
[2.0]
.08
[2.0]
.08
[2.0]
TYP
2.0
[50.8]
.08
[2.0]
TYP
31.89°
8.04
[204.2]
Ø 9.06
[230.0]

Beam Stop Cone



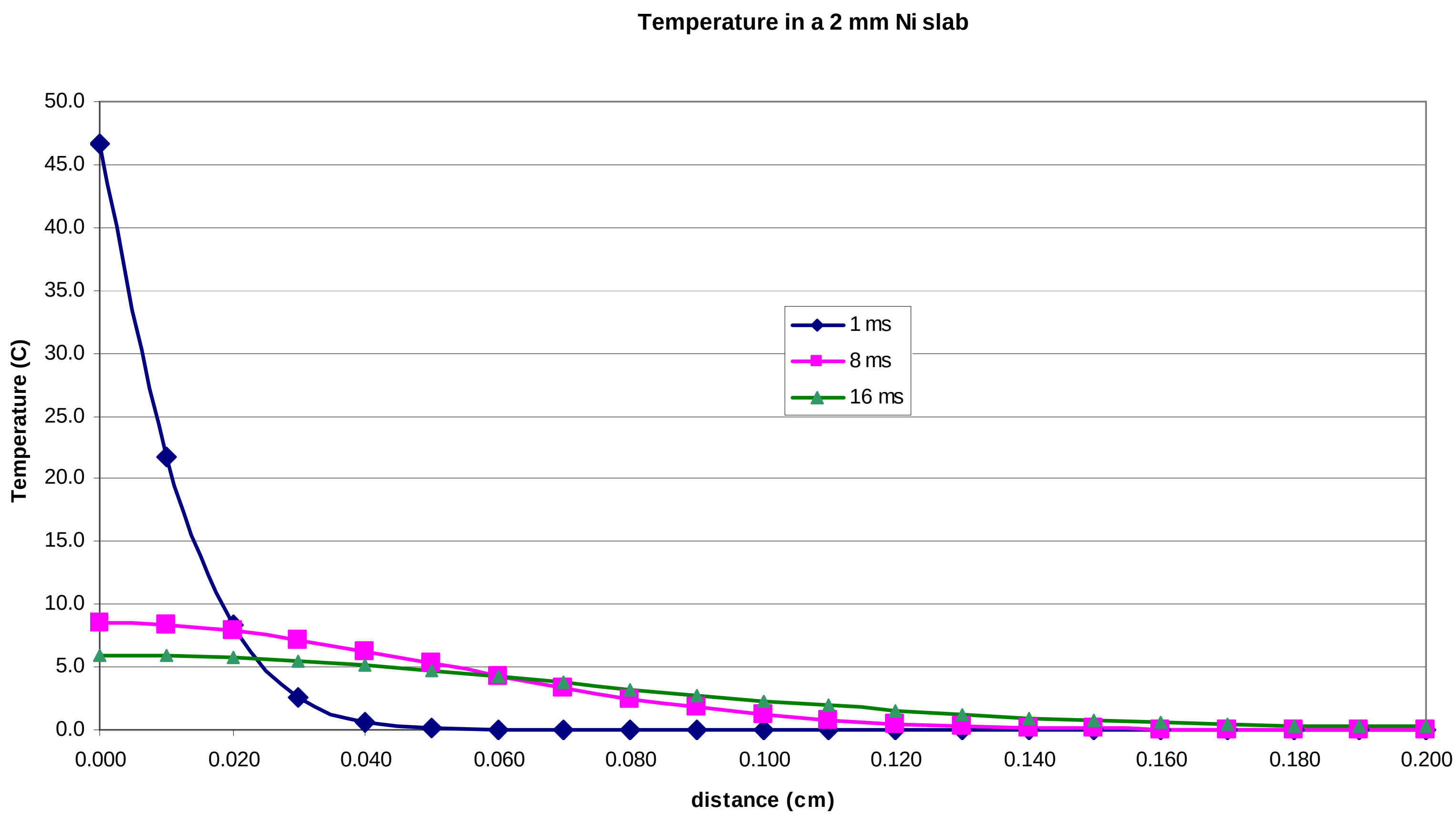
Beam Stop Assembly



Characteristics

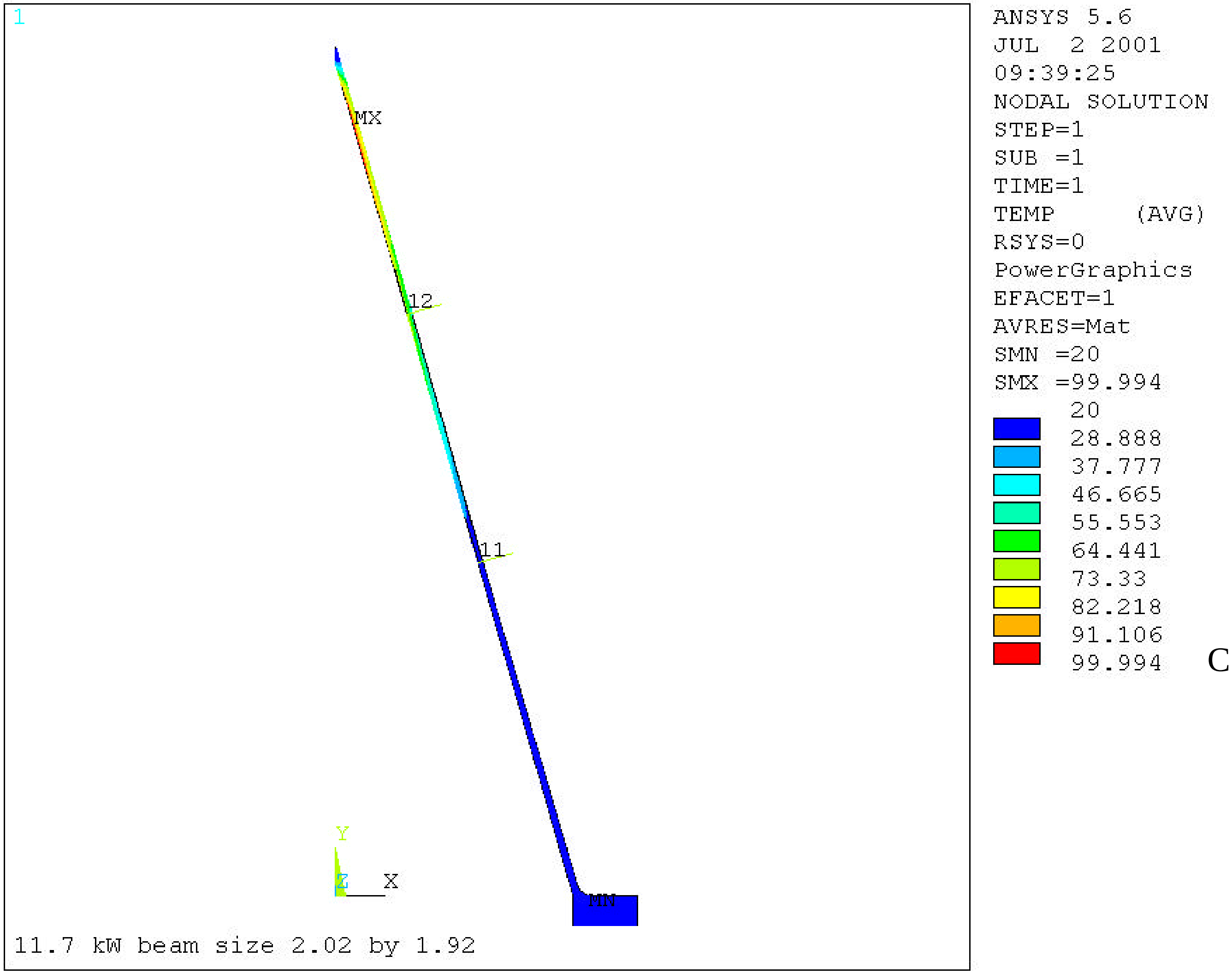
Max. Temperature	(99 °C) 100°C inside the cone (69.93 °C water side)
Operating pressure	1.52 bars (22 Psi) (TO PREVENT BOILING)
Average velocity	6.2 m/s
Flow rate	10 gpm
Inlet water temperature	20° C
Reynolds #	14963
Slot height	2 mm
Spiral width	50 mm
Pressure drop	30 psi
DT	4.42°C

Green's Function Solution

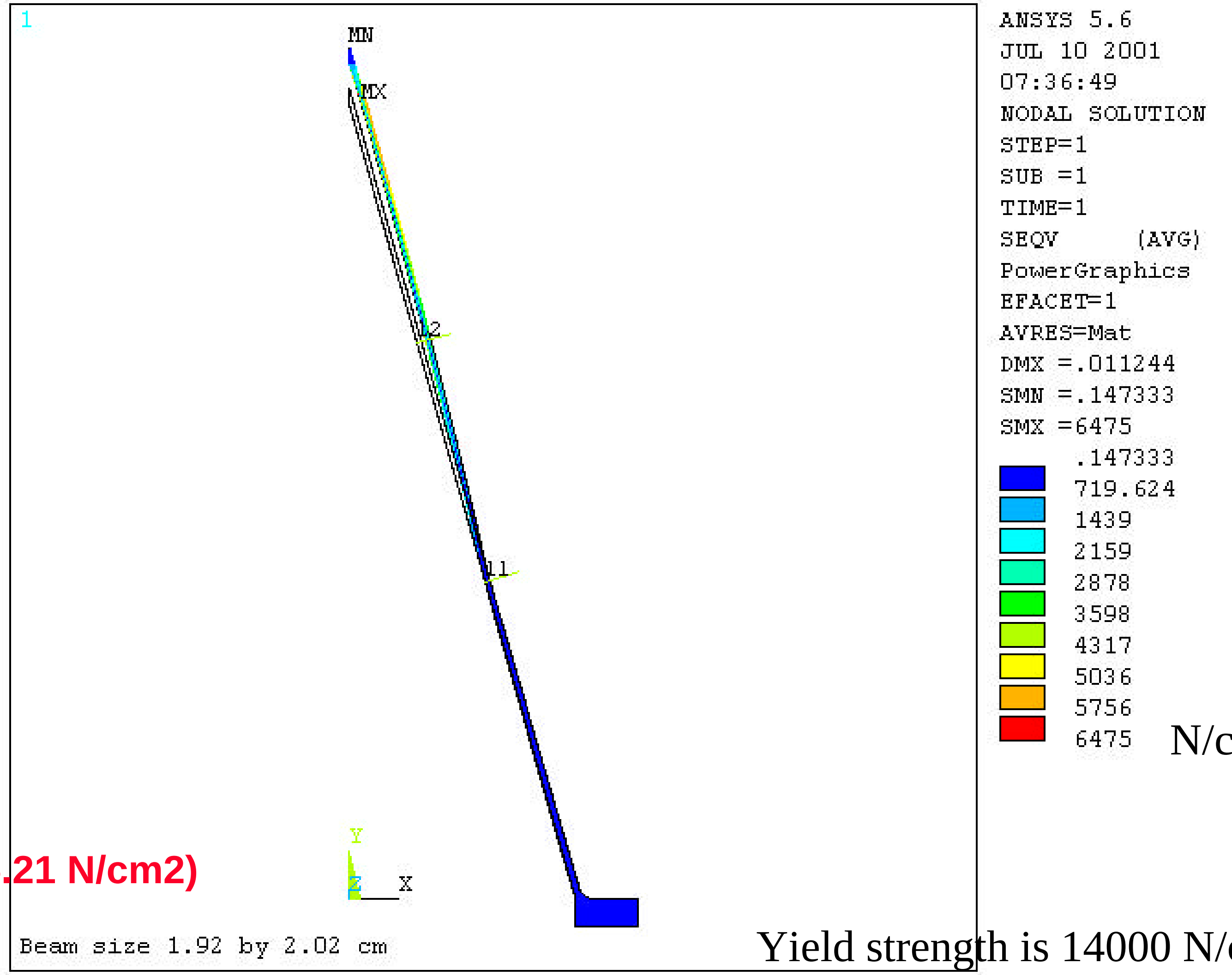


Heat Flux is 2200 W/cm^2, HTC=1.96W/cm^{2}K, 2 mm Nickel slab, duration of pulse 1 ms

Temperature (10 gpm)



Stress for a 2mm Ni200 Temperature and Pressure

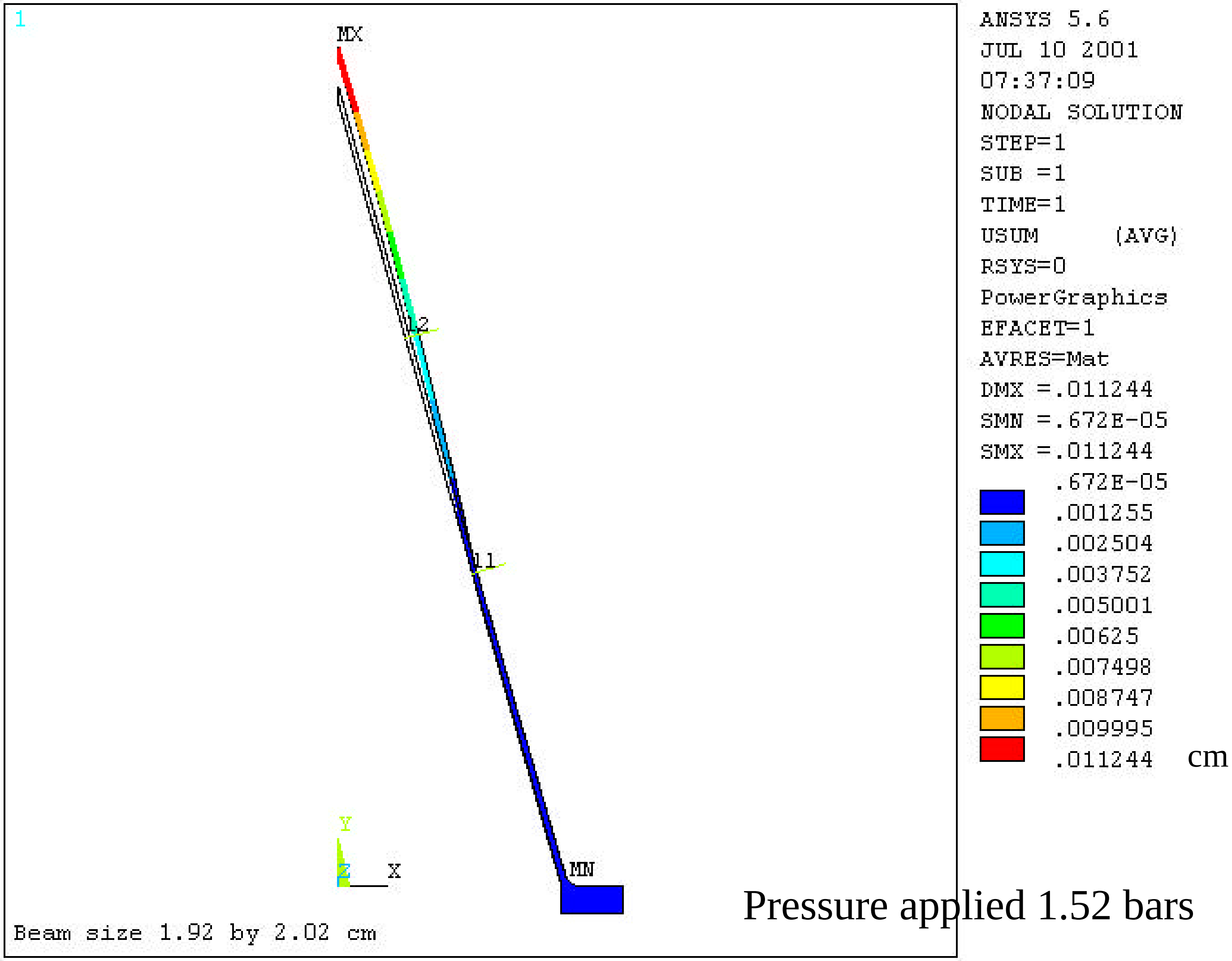


N/cm^2

(load=15.21 N/cm2)

Yield strength is 14000 N/cm^2

Displacement



Pressure applied 1.52 bars

Conclusion

- **Applied total heat in the thermal analysis is 18.41kW which is 1.58 greater than the operational heat load of the beam stop**
- **Water Pressure of 1.58 bars (22psi) is 50% larger than the saturation pressure for temperature of 100 C.**
- **Stresses due to thermal and pressure loads are in the range of the yield strength of Nickel 200 (hot rolled plate yield strength is 140-550 MPa)**

SNS Diagnostics Plate Water Cooling and Vacuum Systems

Preliminary Design Review Presentation

John D. Bernardin

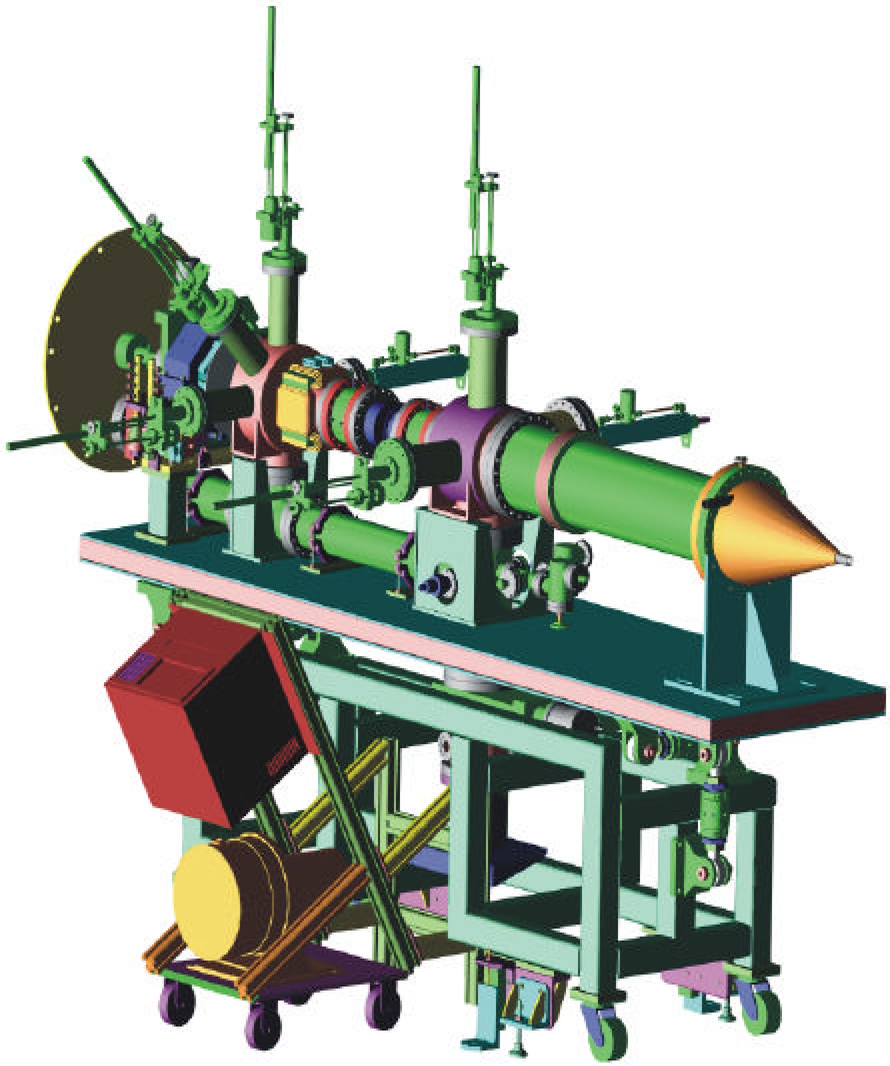
July 18, 2001

Mechanical Engineering Group

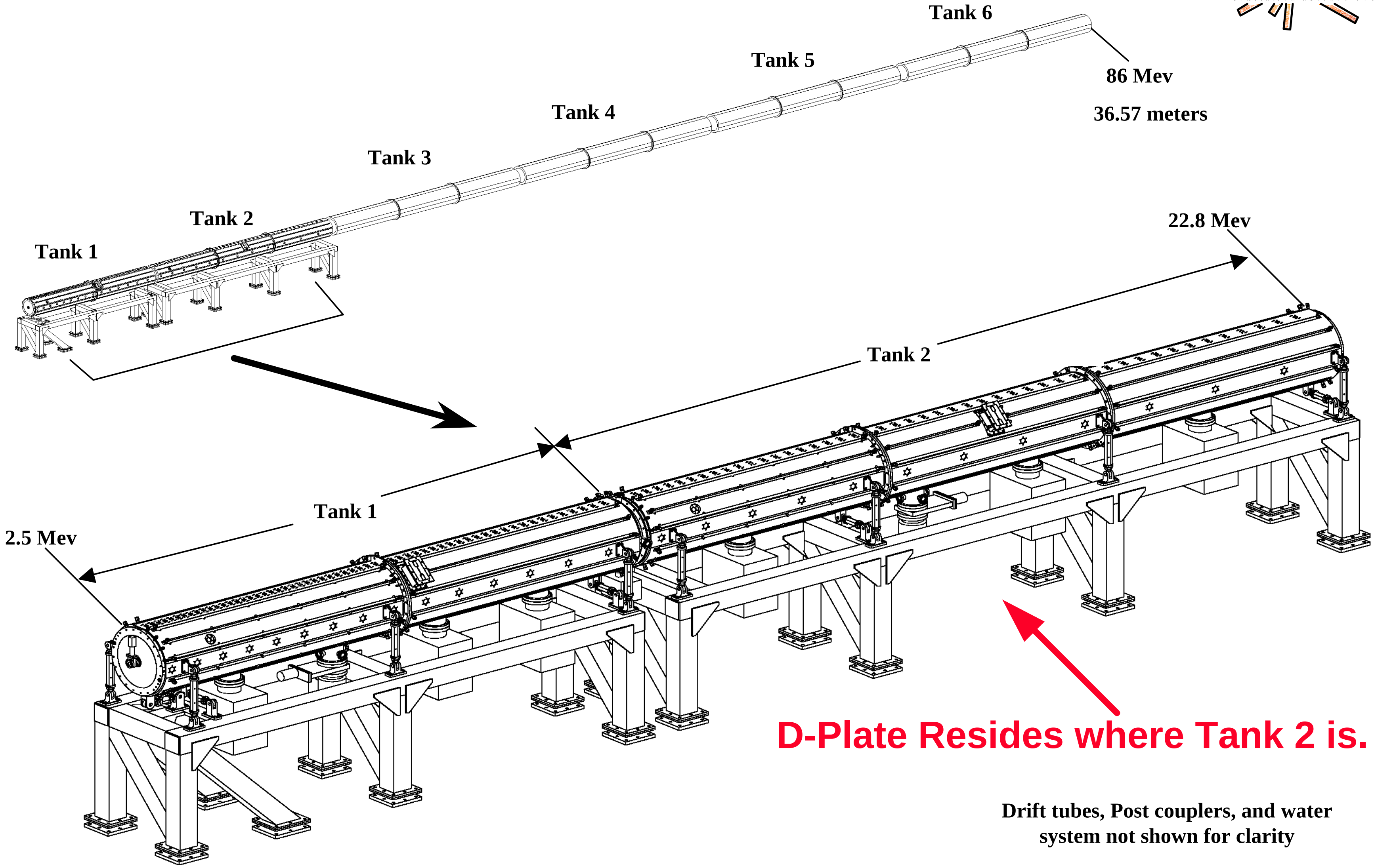
Spallation Neutron Source Division

Los Alamos National Laboratory

D-Plate Assembly



DTL Tanks

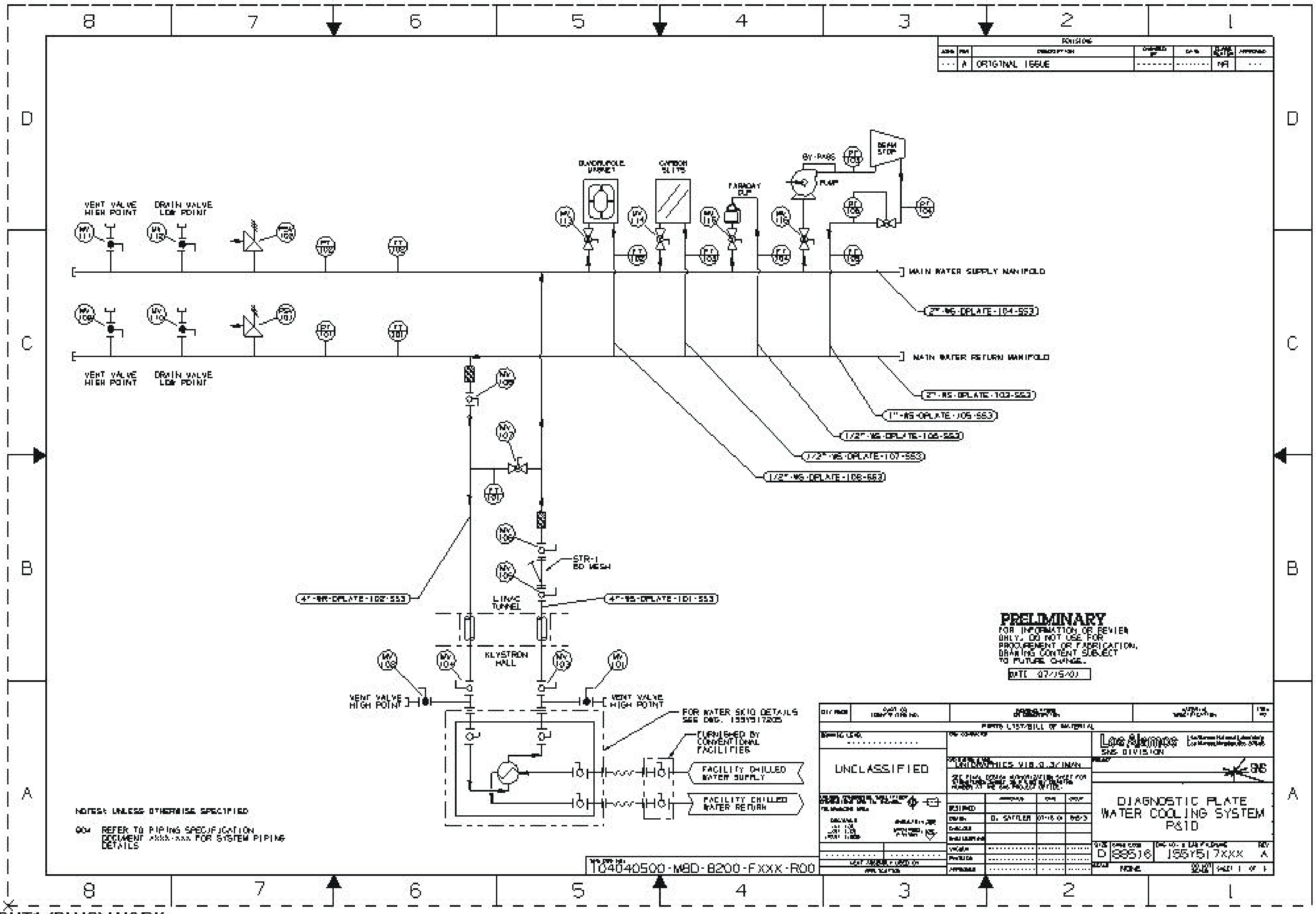


D-Plate Resides where Tank 2 is.

Drift tubes, Post couplers, and water system not shown for clarity

D-Plate Water Cooling System

D-Plate Water Cooling System P&ID



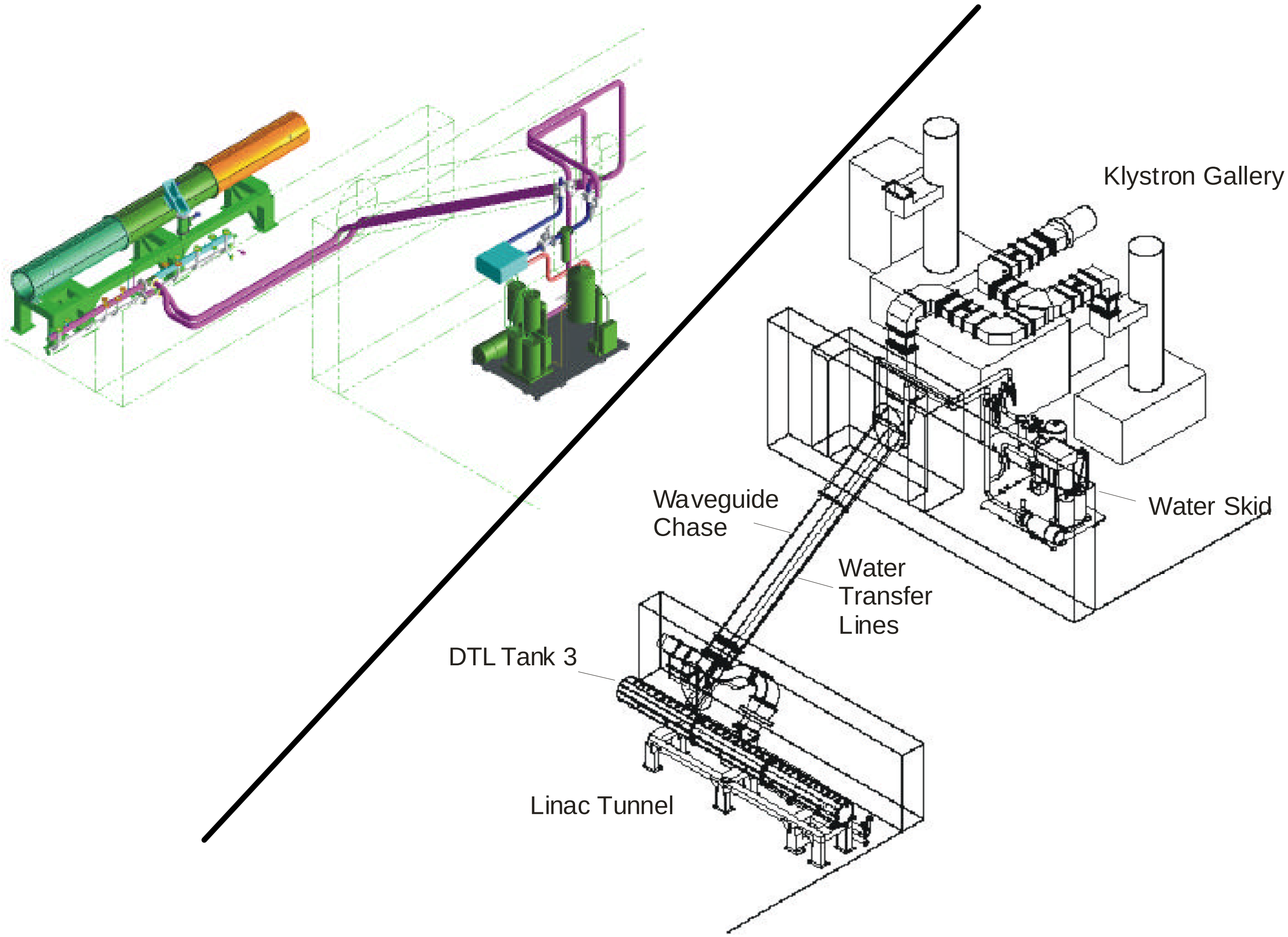
SHT1 (DWG) WORK

DTL Water Cooling System

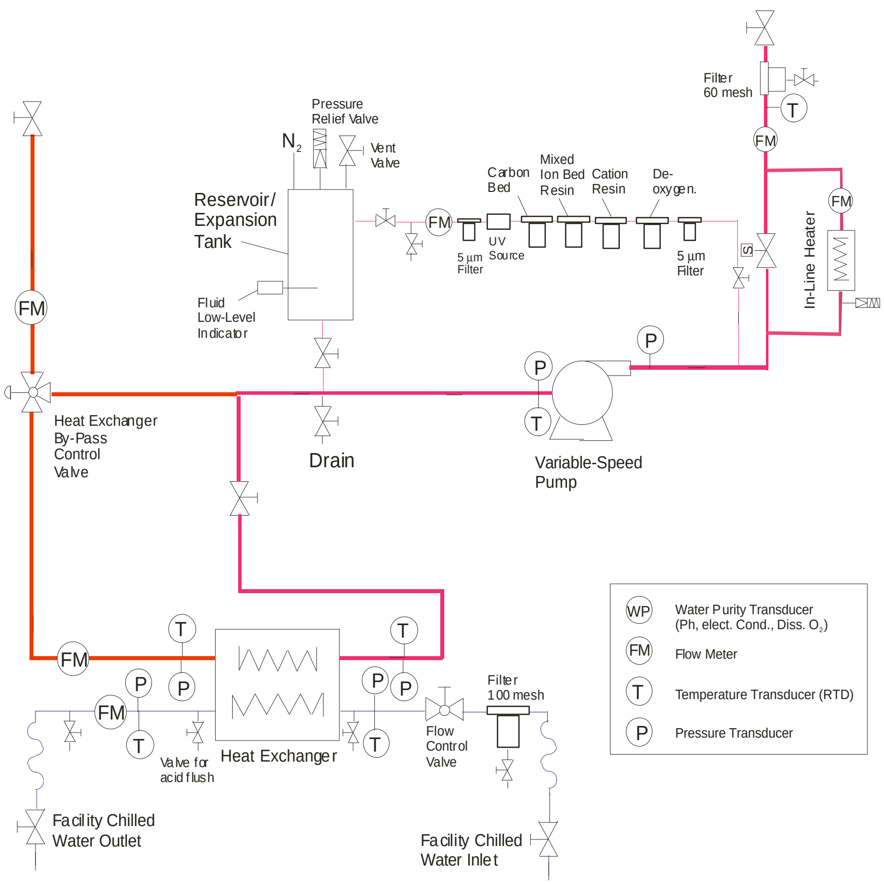
- One closed-loop, modular water cooling and resonance control system per DTL tank
- Closed loop = water skid + transfer lines + manifolds/jumper lines
- Loops remove waste heat from RF structures and transfer it to facility chilled water via a liquid/liquid heat exchanger
- Water skid #2 and its control system will be used to cool D-plate

Component	Heat Load (kW)	Water Flow (gpm)	Pressure Drop (psi)
Beam Stop	11.7	10	30
Quad. Magnet		1.2	
Carbon Slits	0.13	1.0	TBD
Faraday Cup	0.1	1.0	TBD

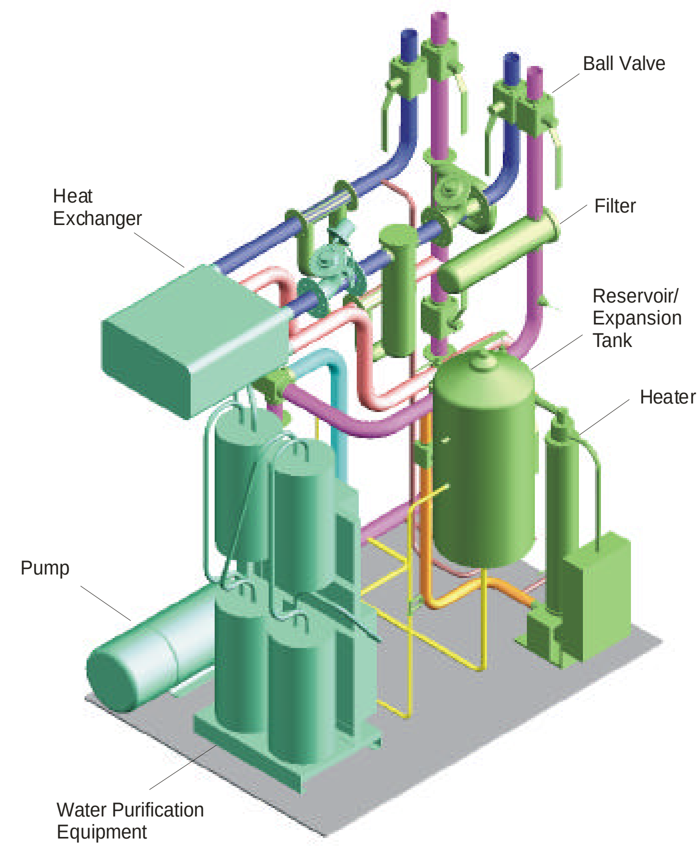
Linac Water Cooling System - continued



Water Skid

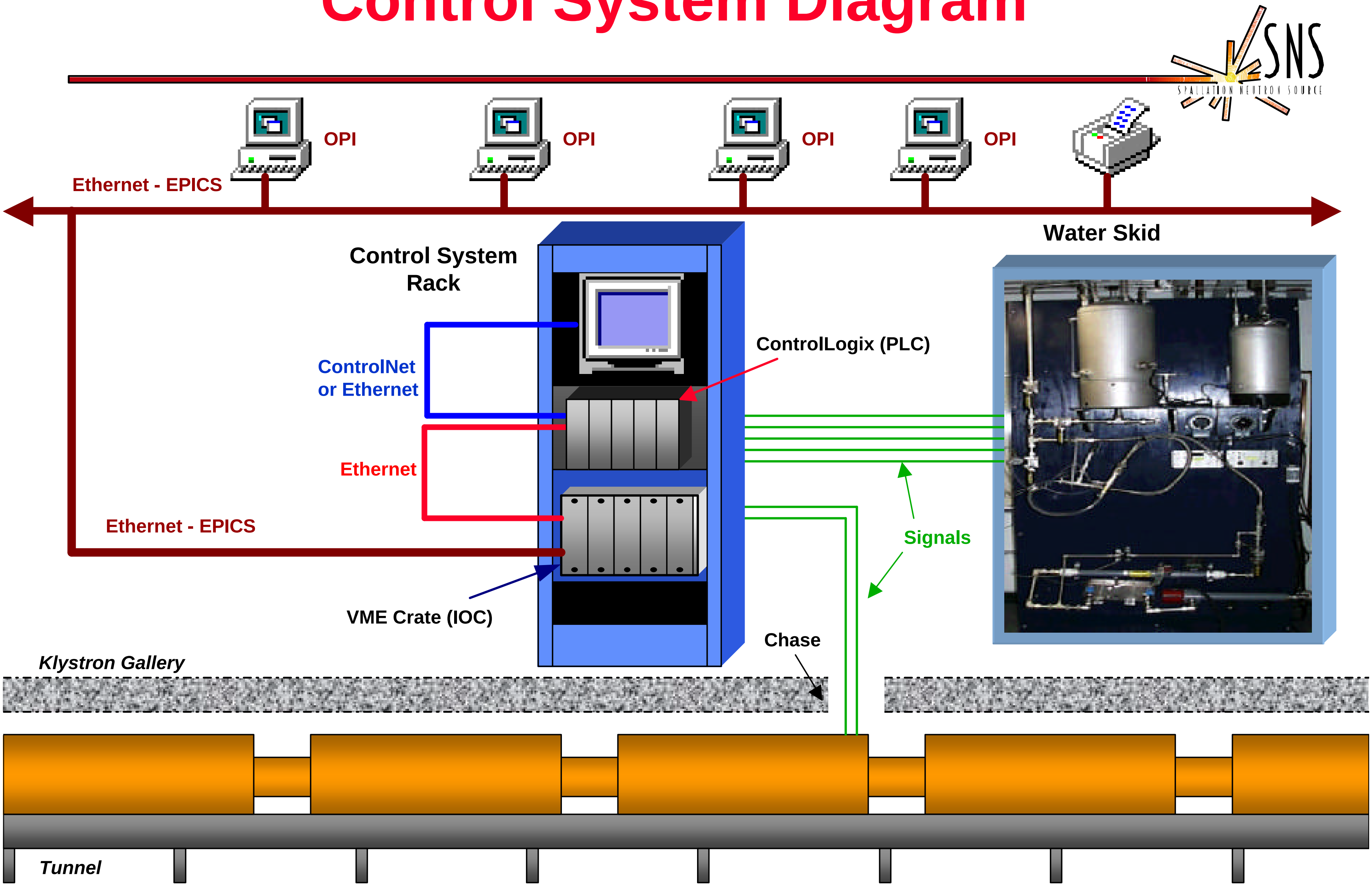


Filter
60 mesh
T
FM
Pressure
Relief Valve
N_2
Vent
Valve
Mixed
Ion Bed
Resin
Carbon
Bed
Cation
Resin
De-
oxygen.
Reservoir/
Expansion
Tank
FM
UV
Source
5 µm
Filter
5 µm
Filter
In-Line Heater
Fluid
Low-Level
Indicator
P
P
T
Heat Exchanger
By-Pass
Control
Valve
Drain
Variable-Speed
Pump
WP Water Purity Transducer
(Ph, elect. Cond., Diss. O_2)
FM Flow Meter
T Temperature Transducer (RTD)
P Pressure Transducer
Filter
100 mesh
Flow
Control
Valve
Valve for
acid flush
Heat Exchanger
Facility Chilled
Water Outlet
Facility Chilled
Water Inlet

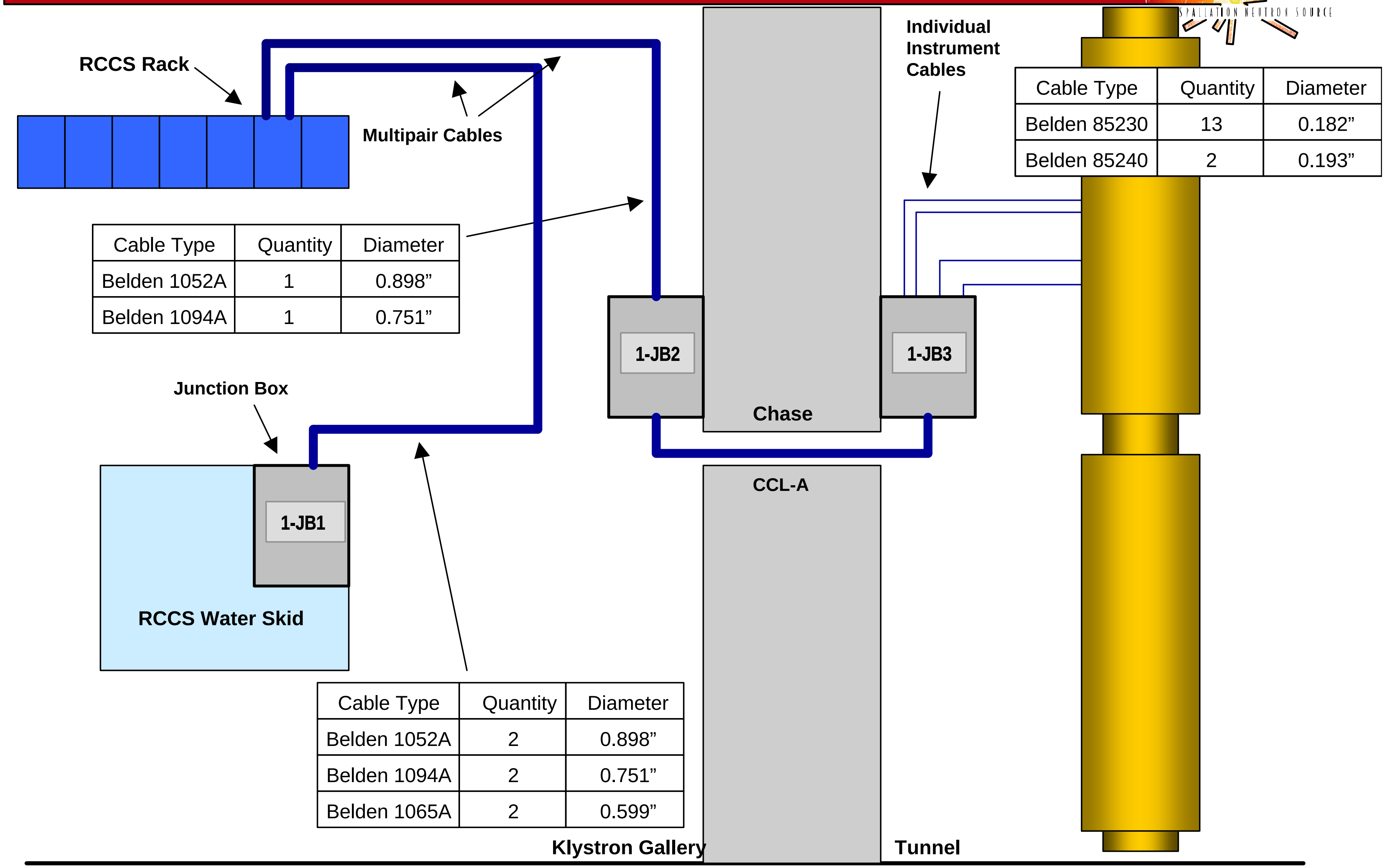


Ball Valve
Heat
Exchanger
Filter
Reservoir/
Expansion
Tank
Heater
Pump
Water Purification
Equipment

Control System Diagram



Cabling Design (DTL #1)



Cable Type	Quantity	Diameter
Belden 85230	13	0.182"
Belden 85240	2	0.193"

Cable Type	Quantity	Diameter
Belden 1052A	1	0.898"
Belden 1094A	1	0.751"

Cable Type	Quantity	Diameter
Belden 1052A	2	0.898"
Belden 1094A	2	0.751"
Belden 1065A	2	0.599"

D-Plate Vacuum System

D-Plate Vacuum System
Scope & Design Requirements

Scope

Design a vacuum system for the D-plate, utilizing vacuum hardware from the DTL vacuum system. Vacuum system must provide a sufficient vacuum for the RF environment and minimizes beam stripping and associated activation.

Technical Specifications

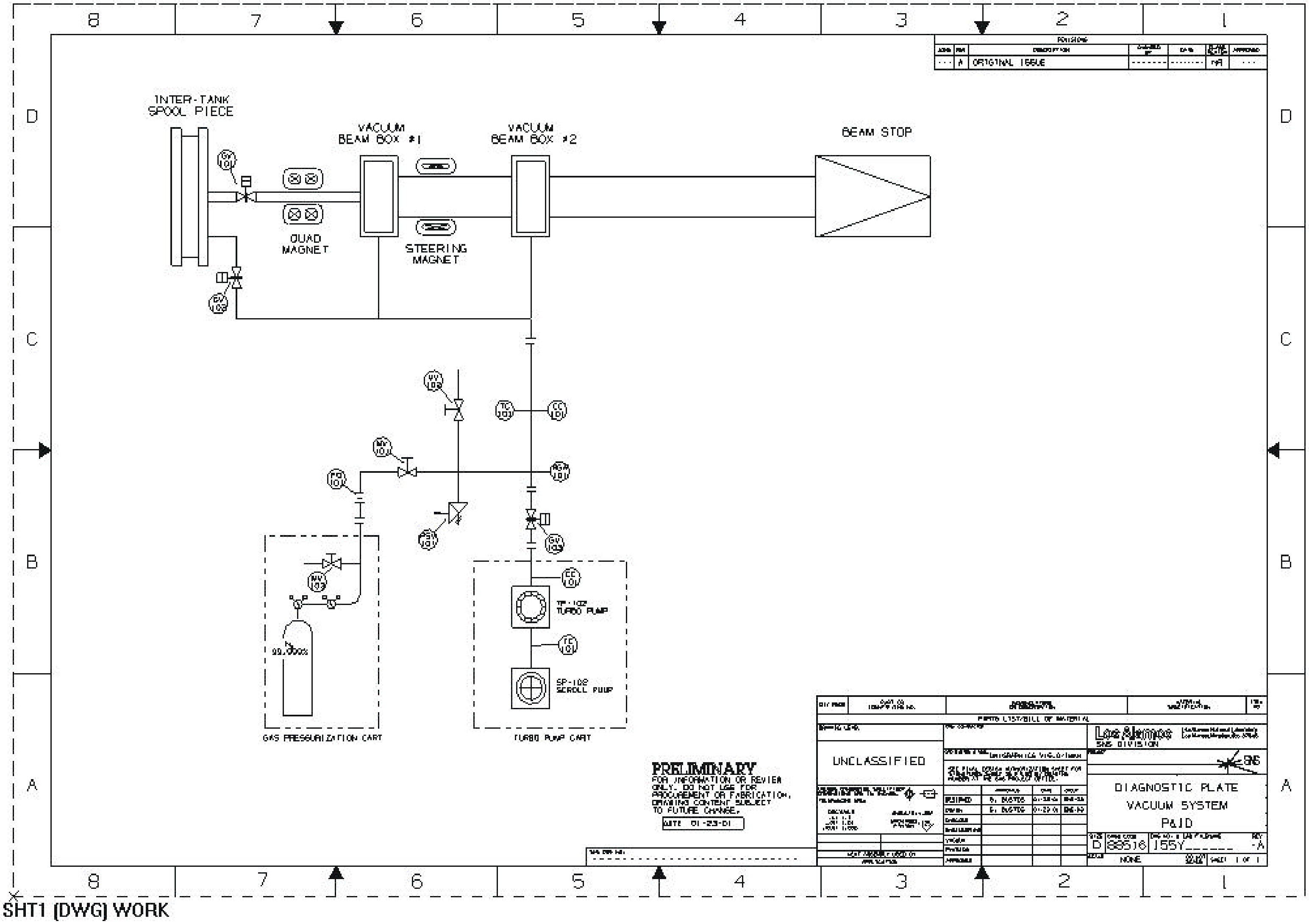
$$P_{allowable} = W_{He} P_{He} + W_{H2} P_{H2} + W_{H2O} P_{H2O} + W_{N2} P_{N2} + W_{CO} P_{CO} + W_{O2} P_{O2} + W_{CO2} P_{CO2}$$

– where the weighting factors for the primary gas constituents of interest are as follows:

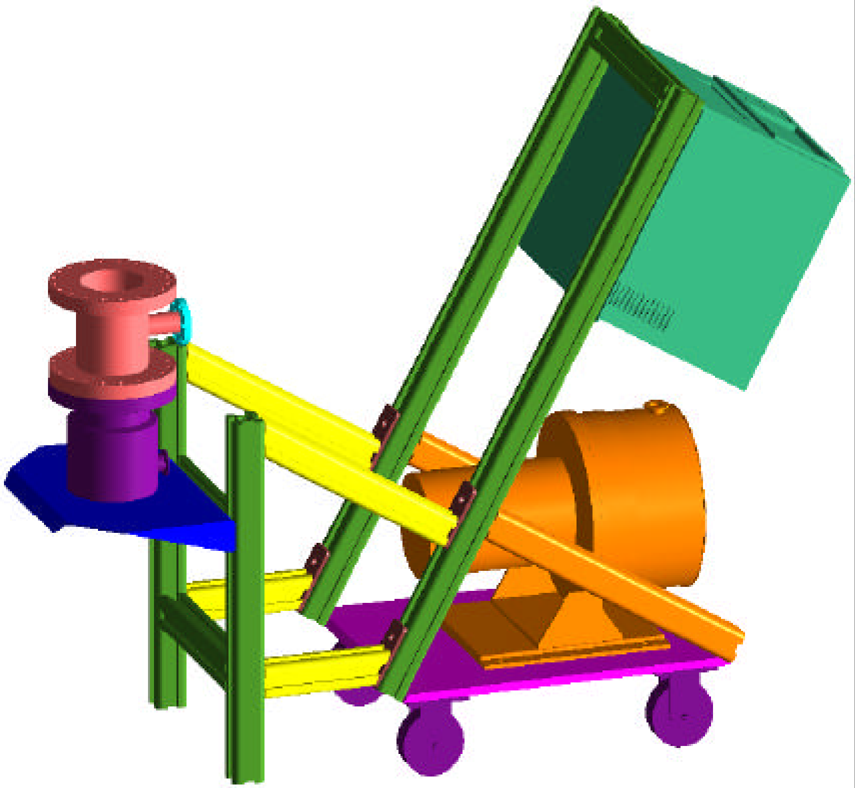
$W_{He} = 0.125$, $W_{H2} = 0.15$, $W_{H2O} = 0.66$, $W_{N2} = 1.0$, $W_{CO} = 1.0$, $W_{O2} = 1.0$, $W_{CO2} = 1.5$

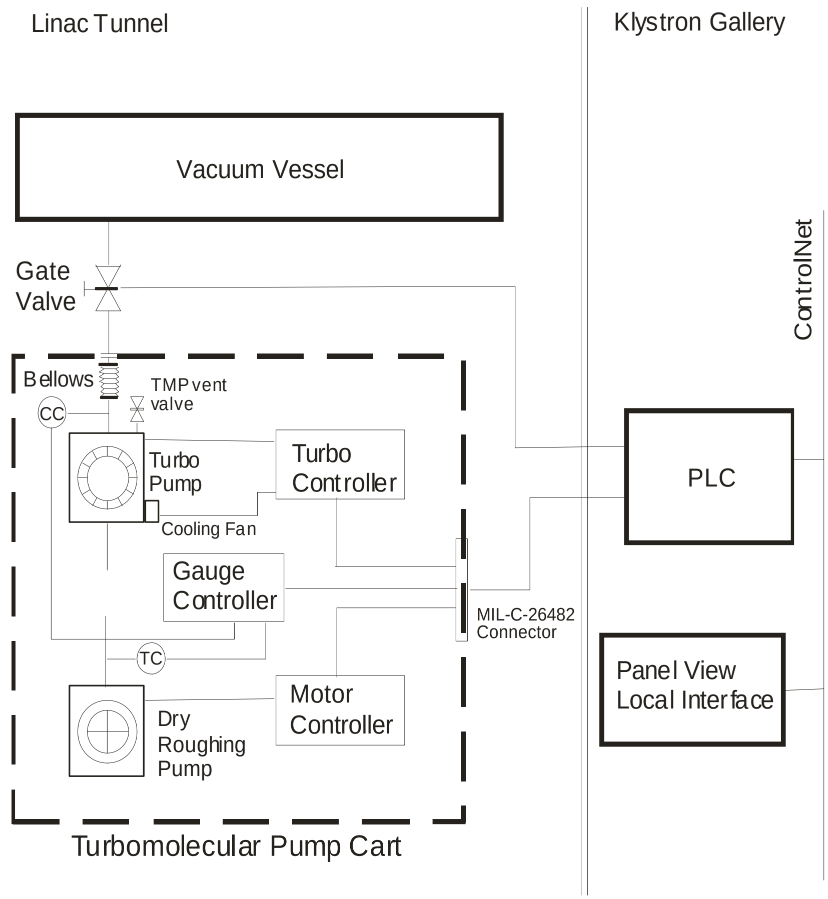
Linac Section	DTL Tank or CCL Module	Exit Beam Energy	Max Allowable Pressure
	No.	MeV	Torr
DTL	1-6	2.5 to 86.8	1.84×10^{-7}
CCL	1	107.2	1.84×10^{-7}
CCL	2	131.1	1.53×10^{-7}
CCL	3	157.2	1.21×10^{-7}
CCL	4	185.6	0.89×10^{-7}

D-Plate Vacuum System P&ID



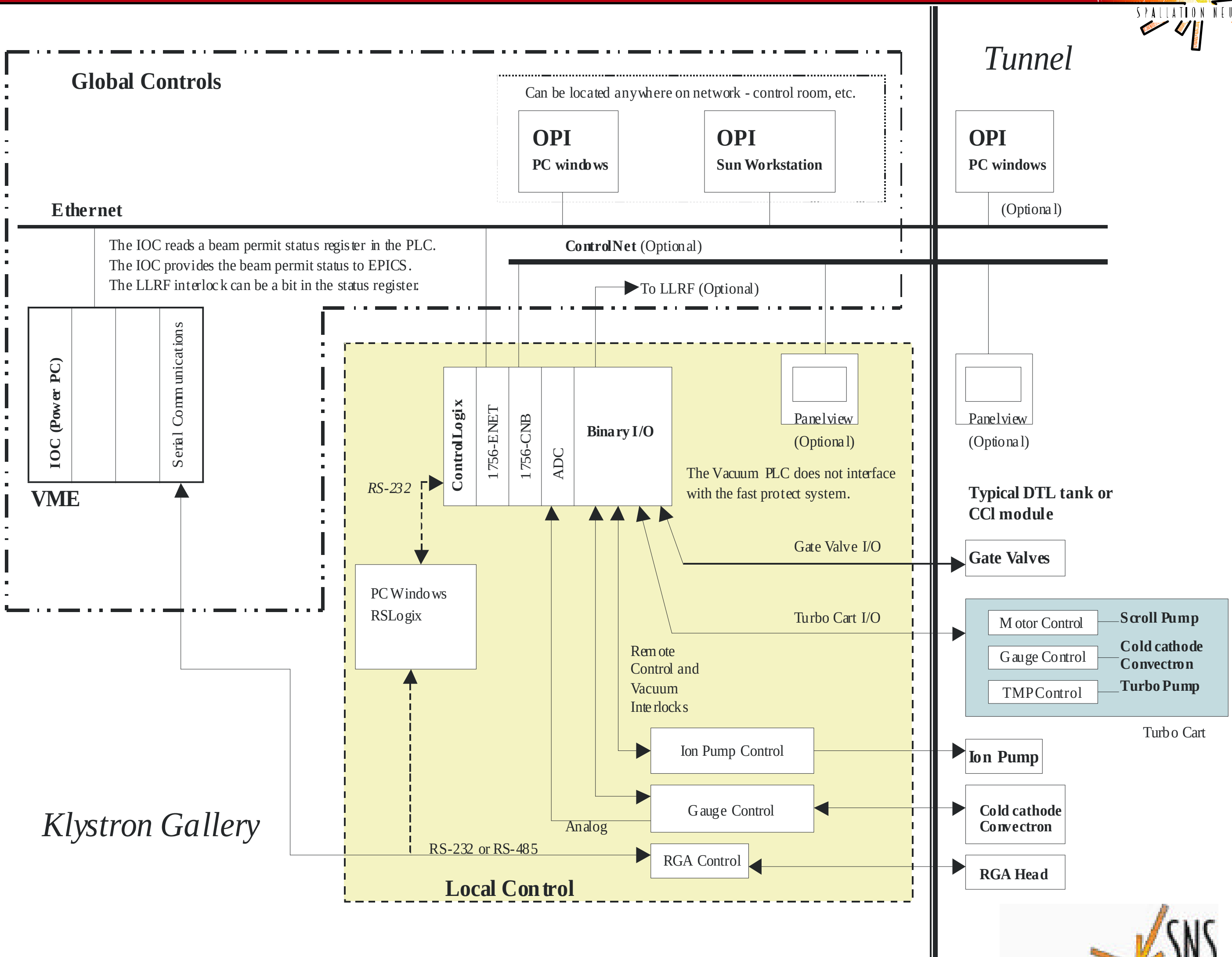
Vacuum Pumps - Turbo Cart from DTL/CCL





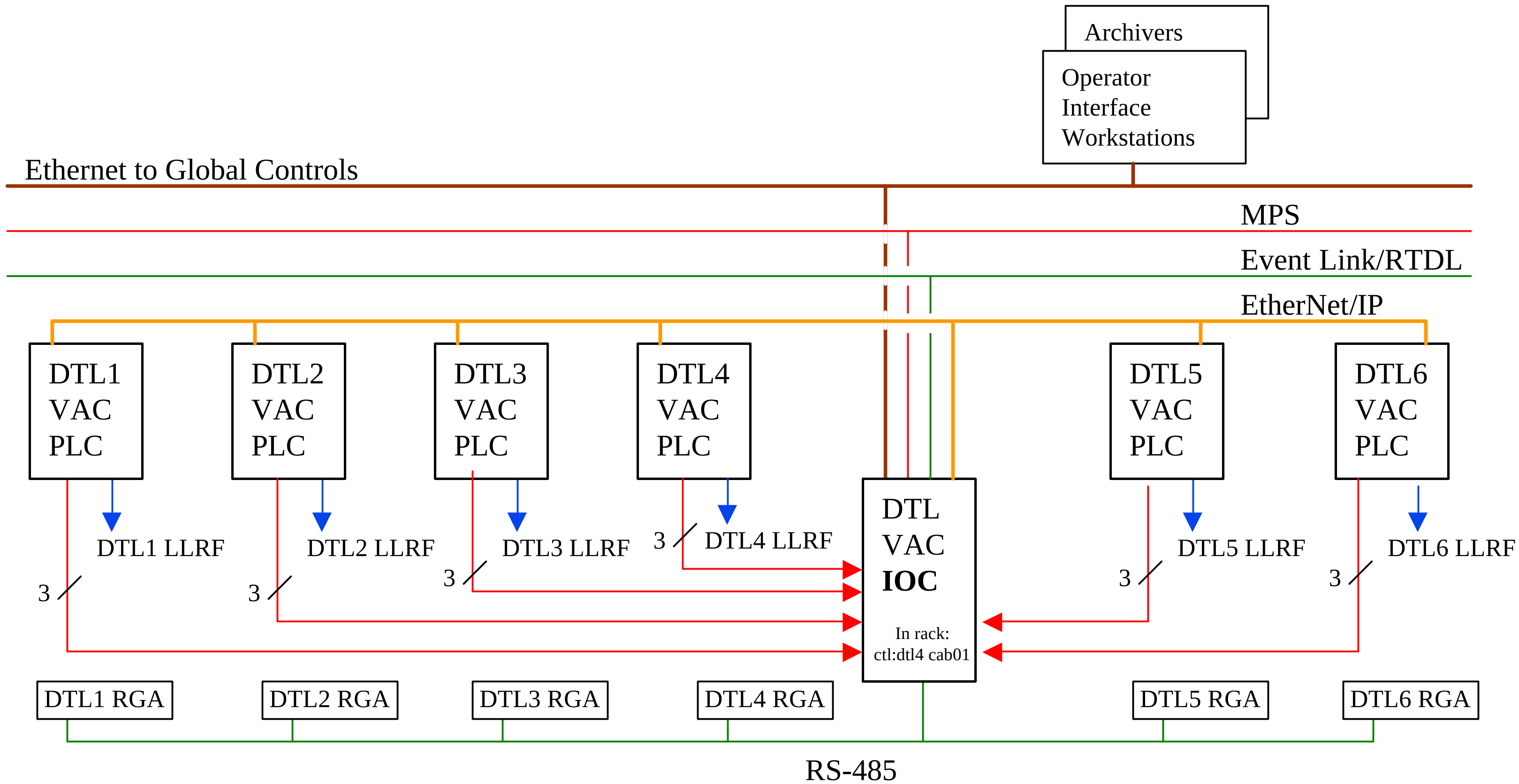
DTL Tank #2 Vacuum Control System

Must modify DTL vacuum control system to adapt to D-Plate vacuum system



Global Control System

IOCs, PLCs, Connections Block Diagram (cont.)



MPS Beam Permit : 3 signals from each DTL
(Cavity vacuum, Window vacuum, Beamline valve)

RF Permit : 1 signal from each DTL to LLRF
(Window vacuum)

Remaining Water & Vacuum System Design Work

Water Cooling System

- Determine beam-stop pressurization scheme
- Optimize line sizes and pressure drop
- Develop signal list
- Integrate with the DTL tank 2 water & global control systems
- Finalize P&ID
- Detail water manifolds and lines

Vacuum System

- Finalize vacuum calculations and required pumping speed
- Finalize plumbing & instrumentation layout
- Develop signal list
- Integrate with the DTL tank 2 vacuum and global control systems
- Finalize P&ID
- Detail vacuum manifolds

DTL Integrated Project Schedule

DTL Vacuum System

Activity	Early Start Date	Early Finish Date
Control System Programming	7-6-01	9-28-01
Purchase Request to Purchase Order	7-10-01	9-18-01
Tank 3 Vacuum Fab & Ship	11-2-01	12-6-01
Tank 1 Vacuum Fab & Ship	1-16-02	2-15-02
Tank 2 Vacuum Fab & Ship	12-7-01	4-12-02
Tank 3 Controls/Racks Fab/Ship	1-23-02	2-20-02
Tank 1 Controls/Racks Fab/Ship	2-21-02	3-20-02
Tank 2 Controls/Racks Fab/Ship	3-21-02	4-17-02
Tank 3 Vacuum Assembly	4-9-02	5-6-02
Tank 1 Vacuum Assembly	9-16-02	11-11-02
Tank 2 Vacuum Assembly	1-3-03	2-27-03
Tank 3 Vacuum Installation	5-7-02	7-2-02
Tank 1 Vacuum Installation	10-15-02	11-26-02
Tank 2 Vacuum Installation	3-20-03	4-30-03

DTL Water Cooling System

Activity	Early Start Date	Early Finish Date
Control System Programming	7-6-01	9-28-01
Water Skid Purchase Request to PO	7-16-01	9-24-01
Water Line Purchase Request to PO	9-5-01	11-7-01
Rack Purchase Request to PO	12-3-01	1-7-02
Controls Purchase Request to PO	12-3-01	1-7-02
Tank 3 Water Skid Fab & Ship	10-10-01	3-13-02
Tank 1 Water Skid Fab & Ship	3-14-02	5-8-02
Tank 2 Water Skid Fab & Ship	5-9-02	7-5-02
Tank 3 Water Line Fab & Ship	1-3-02	3-1-02
Tank 1 Water Line Fab & Ship	3-4-02	4-12-02
Tank 2 Water Line Fab & Ship	4-15-02	5-24-02
Tank 3 Controls/Racks Fab/Ship	1-23-02	2-20-02
Tank 1 Controls/Racks Fab/Ship	2-21-02	3-20-02
Tank 2 Controls/Racks Fab/Ship	3-21-02	4-17-02
Tank 3 Water Line Assembly	4-9-02	5-6-02
Tank 1 Water Line Assembly	9-16-02	10-11-02
Tank 2 Water Line Assembly	1-30-03	2-27-03
Tank 3 Water System Installation	5-7-02	7-2-02
Tank 1 Water System Installation	10-15-02	11-26-02
Tank 2 Water System Installation	3-20-03	4-30-03