SCL Laser Wire Progress Report

Diagnostic Groups: BNL, LANL,LBNL And ORNL

Collaborators: SLAC, FNAL

Presented by Saeed Assadi

September 3, 2002

Multi National-Lab Diagnostic Collaborators

ORNL — Tom Shea, Sasha Aleksandrov, Saeed Assadi, Willem Blokland, Craig Deibele, Warren Grice, Dave Purcell

BNL — Peter Cameron, Roger Connolly, Craig Dawson, Chris Degen, Sheng Peng, Marty Kesselman, Bob Sikora,

LANL — Mike Plum, John Power, Bob Shafer, Jim Stovall

LBL — Larry Doolittle, Darryl Oshatz, Alex Ratti

SLAC — Joe Frisch , Keith Jobe, Marc Ross,Jim Crisp (FNAL), Bob Webber (FNAL)

Outline:

- Design progress report.
- Summary of the collaboration of ORNL and SLAC report.

3) Measurement results from MEBT and BNL 200 MeV line very briefly. Just to show where we are going from here

4) What's Next (Schedule)

Background--Laser Wire Development Collaboration

- Until Fall 2001, All Laser wire development and R&D were conducted at BNL as one of the kind SNS diagnostics. Data from BNL 750 keV line looked promising

- September 2001, LANL, ORNL and SLAC have joined BNL to study the feasibility of using Laser Wires as a potential alternative to carbon wire scanners or to conjugate them.
- May 2002, after successful demonstration of MEBT laser-wire, better data acquisition and analysis, Carbon and Laser-wire data from BNL 200 MeV line, the project approved the Laser-wire in place of carbon wires in the SCL. **** The hard work began ****

Time Table

Apr 02	May 02	June 02	July 02	Aug 02

Studies at LBNL

Studies at BNL

VC meeting with SLAC and FNAL

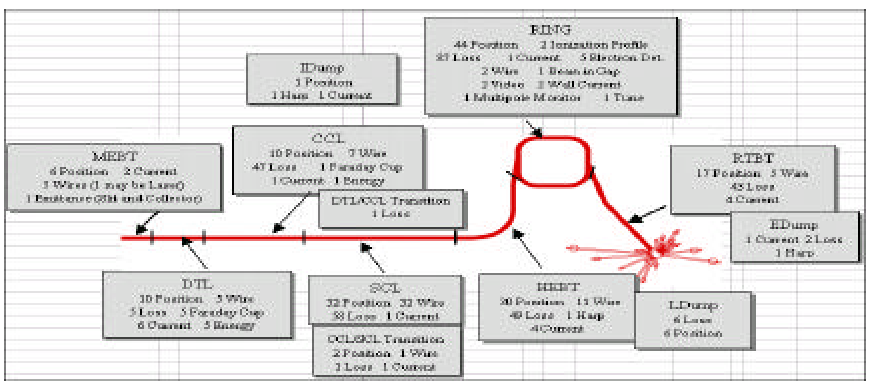
Simulation/Modeling

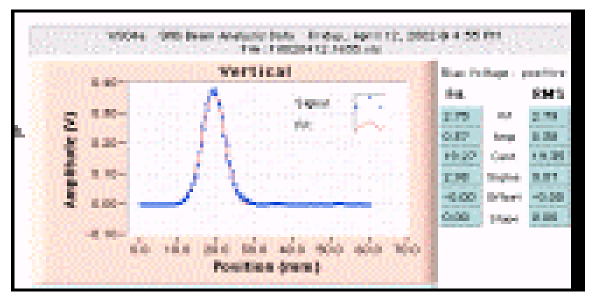
Proposal accepted

Mechanical Design

Procurement

Cont. All





1. Design information:

names, locations, …

Collaboration Highlights:

1) We had a one and half day workshop at SLAC to discuss the Laser wire design, Choices of Lasers, transport line, optics, laser room and safety.

2) We had two video conferences one with FNAL/BNL/SLAC/LANL, one with SLAC. We held a one day meeting with Marc Ross (SLAC) on design issues.

3) We have done an extensive studies of signal to noise ratio, 5 Tech notes are produced that has lead us to concentrate on Q-switch Laser *(We have laser on order)*

4) We have studied the effect of laser beam reflection from the laser beam dump (Ghost effect). *(all concerns are answered)*

5) We are considering a number of detectors including electron detectors.*(design complete)*

6) We have conducted Laser studies on the MEBT and the BNL 200 MeV line.*(results are presented by Roger Connolly at various conferences)*

7) We are at early stages of establishing collaboration with FNAL to test the Laser-wire at 400 MeV LINAC plus test the electron detector (??-2002-03) besides BNL tests.

Methodology:

- Tightly coupled design and implementation philosophy. The physicists, engineers and designers are working with the expert reviewers and alignment group to develop the SNS Laser-wire system.

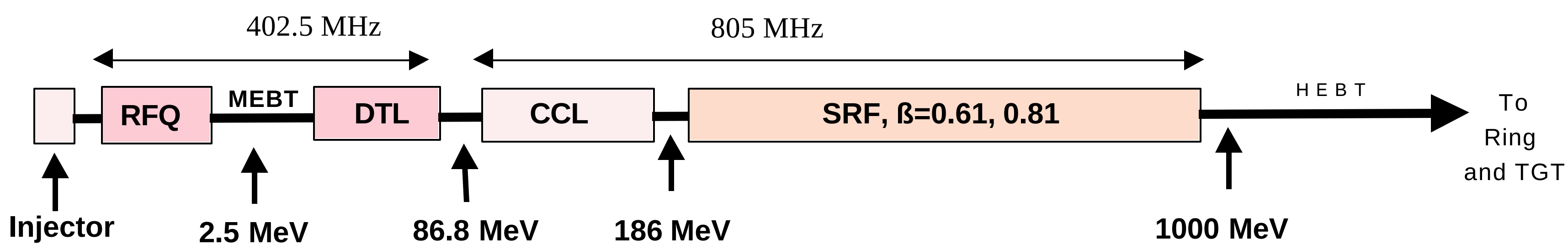
2) We are taking advantage of our collaborators expertise to Compensate for the short development time.

3) We hope to test our detectors on our collaborators' beam-lines. Number one on our list is to fully understand the Electron detector at BNL/FNAL. Compare detectors and test The vacuum windows.

ORNL Laser Wire Design Team

Alignment: Joe Error
Data acquisition and analysis: Wim Blokland
Electron Collector: Craig Deibele
Mechanical Design Team: Graeme Murdoc, Danny Mangra, Dan Stout, Arnold DeCarlo , James Kelly, Kerry Potter
Mechanical Design Advisory Team: Peter Ladd, Mike Hechler, Paul Gibson.
Magnet design: Ted Hunter
Optics: Warren Grice
Physics: Sasha Aleksandrov
Project Lead: Saeed Assadi

SCL Laser Wire Locations



MEBT	DTL	D-plate (7.5 MeV)	CCL	SCL	HEBT	RTBT
5 WS (elec. only)	**5 WS**	**1 WS**	**8 WS**	**32 WS (16 elec.)**	**3 WS (dumps)**	1 Harp
6 BPM (elec. only)	10 BPM	3 BPM	12 BPM	32 BPM	22 BPM (elec. only)	
2 Sl&Col (act. only)	6 CM (p/u only)	1 CM (p/u only)	2 CM (p/u only)			
	5 ED/FC	1 ED/FC	1 ED/FC			
		2 Sl&Coll emit				
		1 Phosphor screen				
		1 8 seg. halo scraper				
		1 Beam stop / F-Cup				

4 LW from 186 MeV,
4 LW from 386 MeV
Laser Wires Locations

Key
WS = wire scanner
BPM = beam position monitor
Sl&Col = slit and collector emittance station
CM = current monitor
ED/FC = energy degrader & Faraday Cup

Design Progress Report Since May-20-2002:

1) Vacuum beam box design for tests at BNL/FNAL is complete. It is being manufactured.

2) Electron collector design is complete. It is sent to be manufactured.

3) Magnet design simulation is complete. Detailing of the magnet design is complete and sent for fabrication.

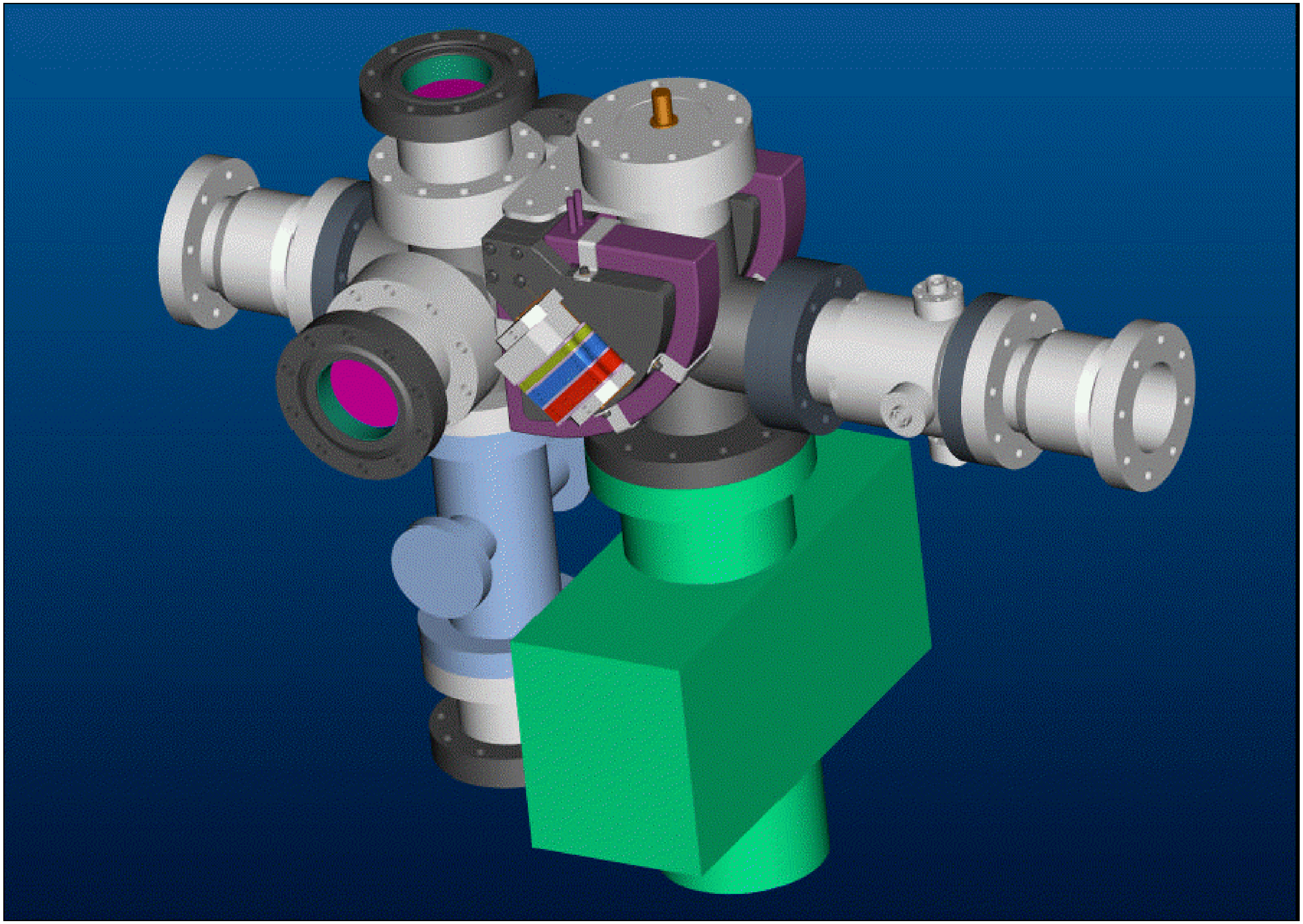
4) Vacuum beam box design is complete. We will send it out for manufacturing this week.

5) Data acquisition: EPICS is installed on the oscilloscope, Runtime LabVIEW is running on the scope. Shared memory is running on the scope and serving data.

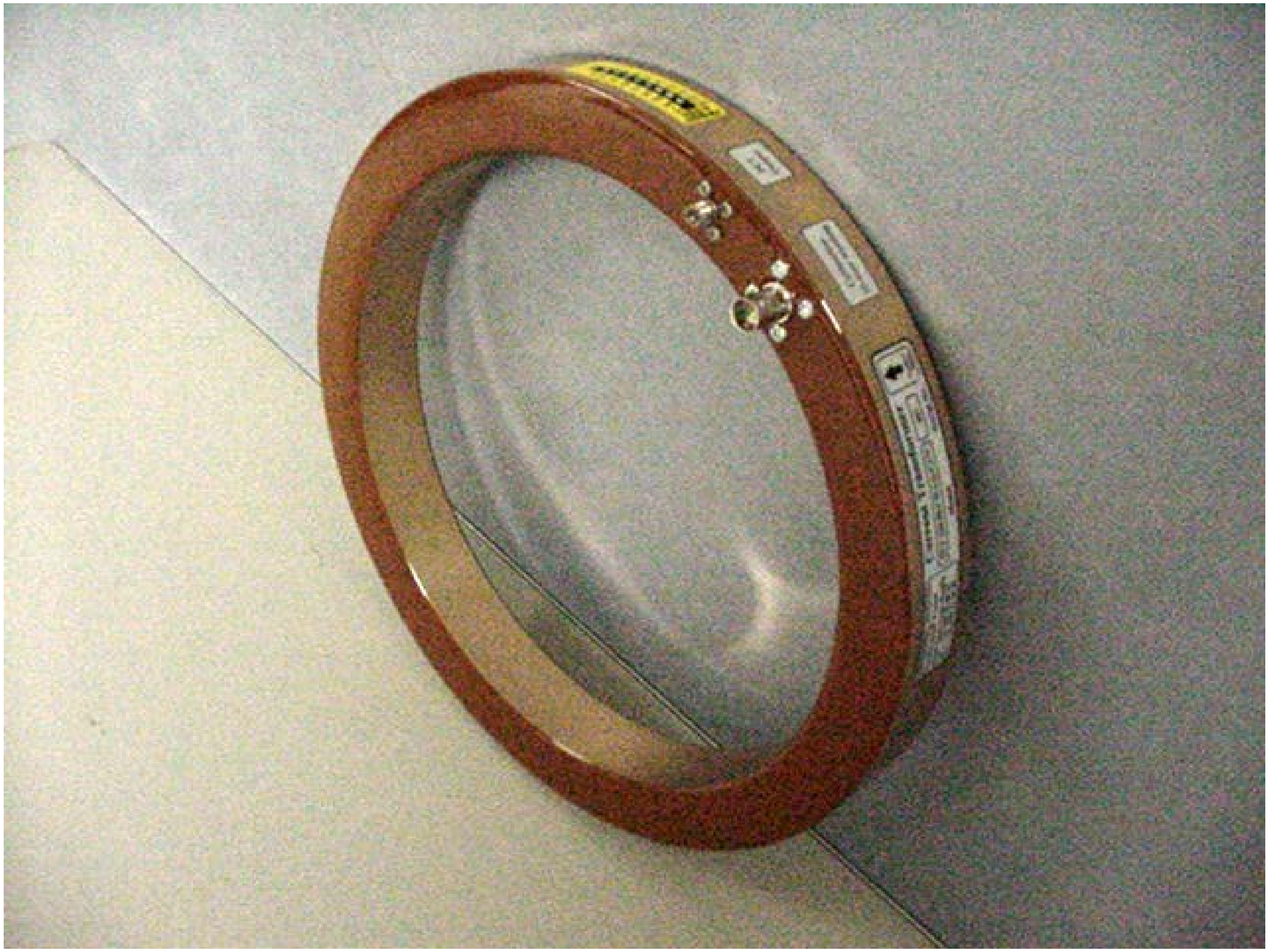
6) Optics design (50%), Transport line (20%), Laser Room at RATS (50%)

7) What is next

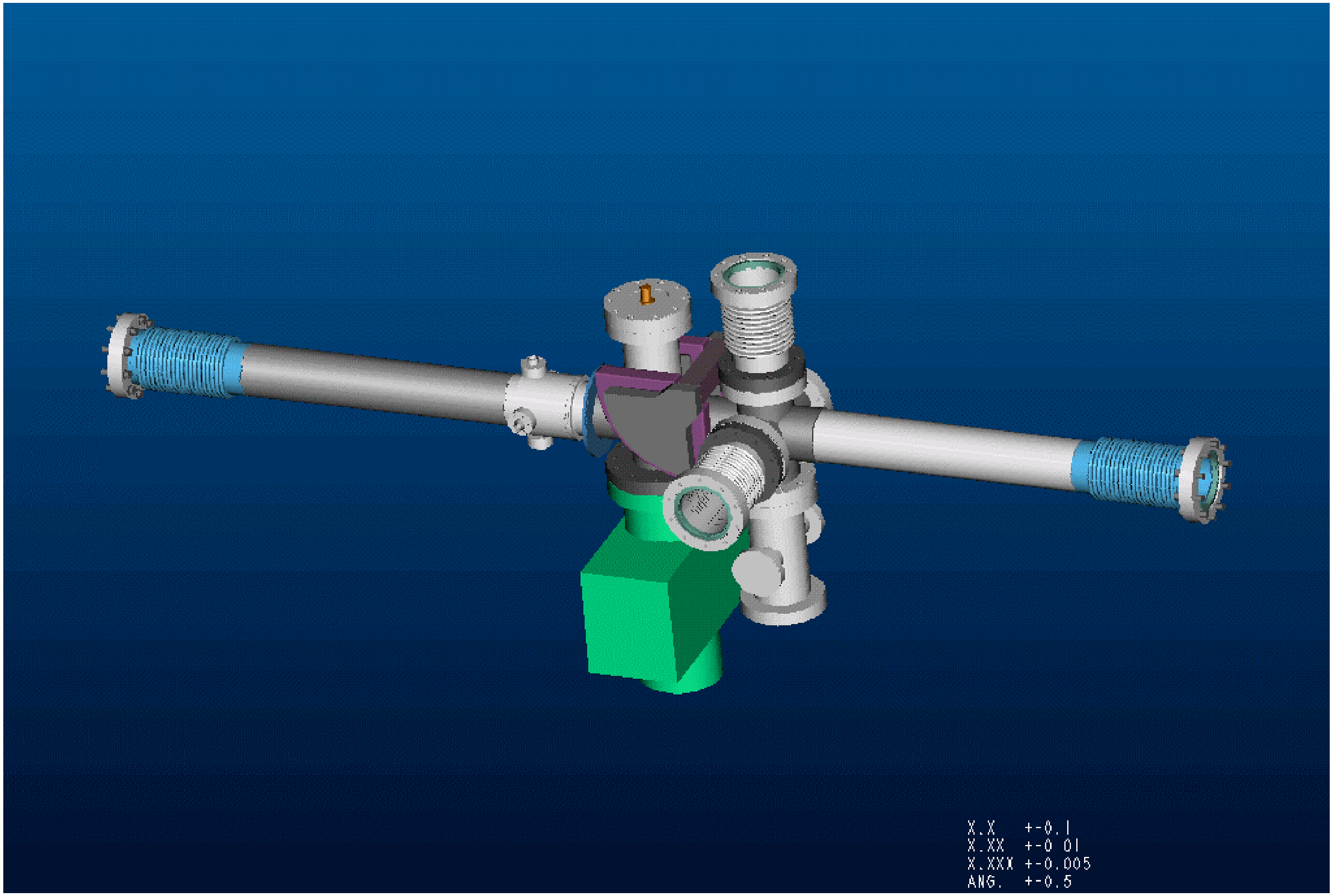
Vacuum Box for tests at BNL and FNAL



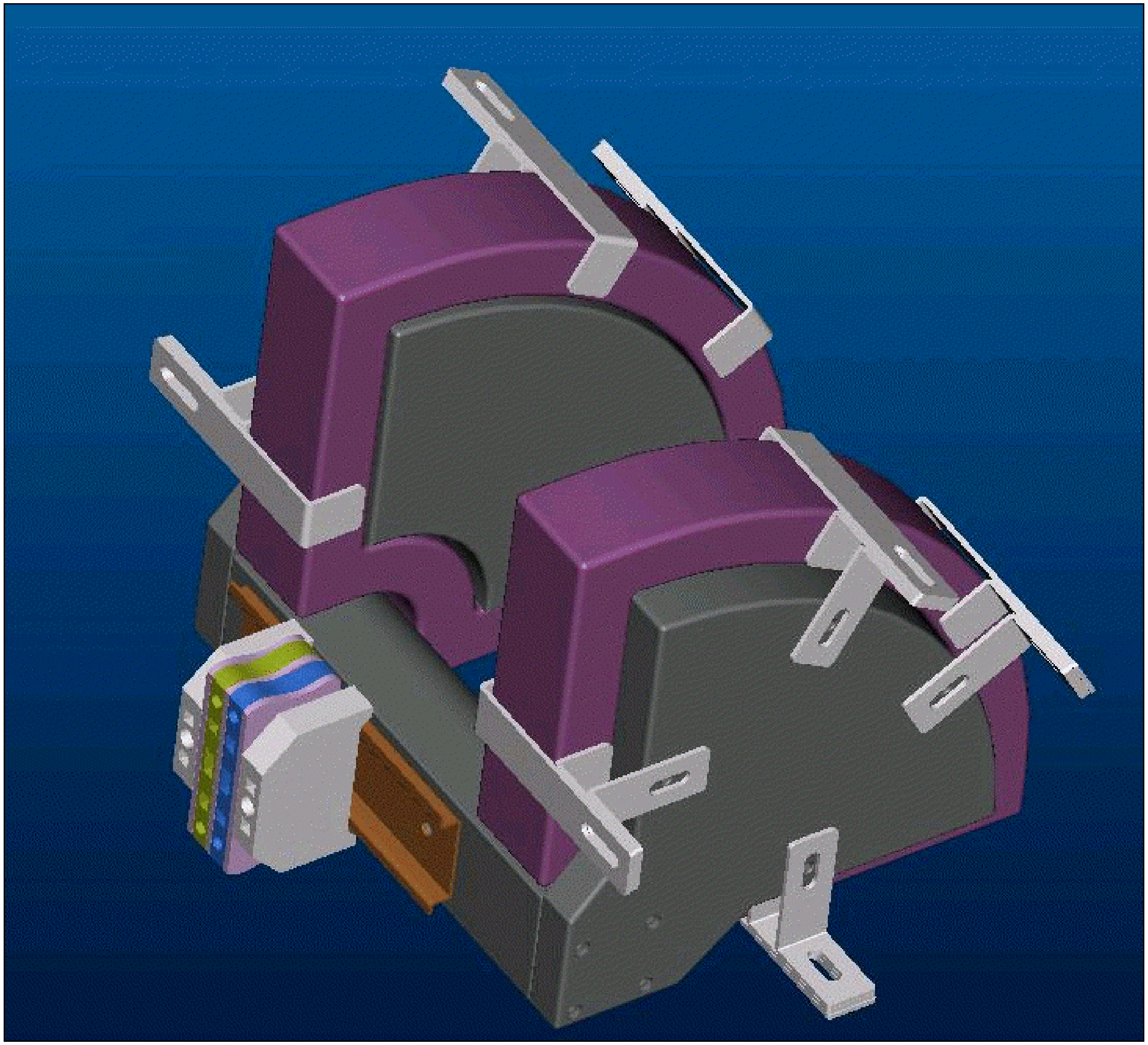
To calibrate and evaluate the electron detector, we will use two BCMs



SCL Warm section: Laser ports, magnet and the electron detector is shown



Magnet assembly



Required Magnetic Field to Collect Electrons in SCL:

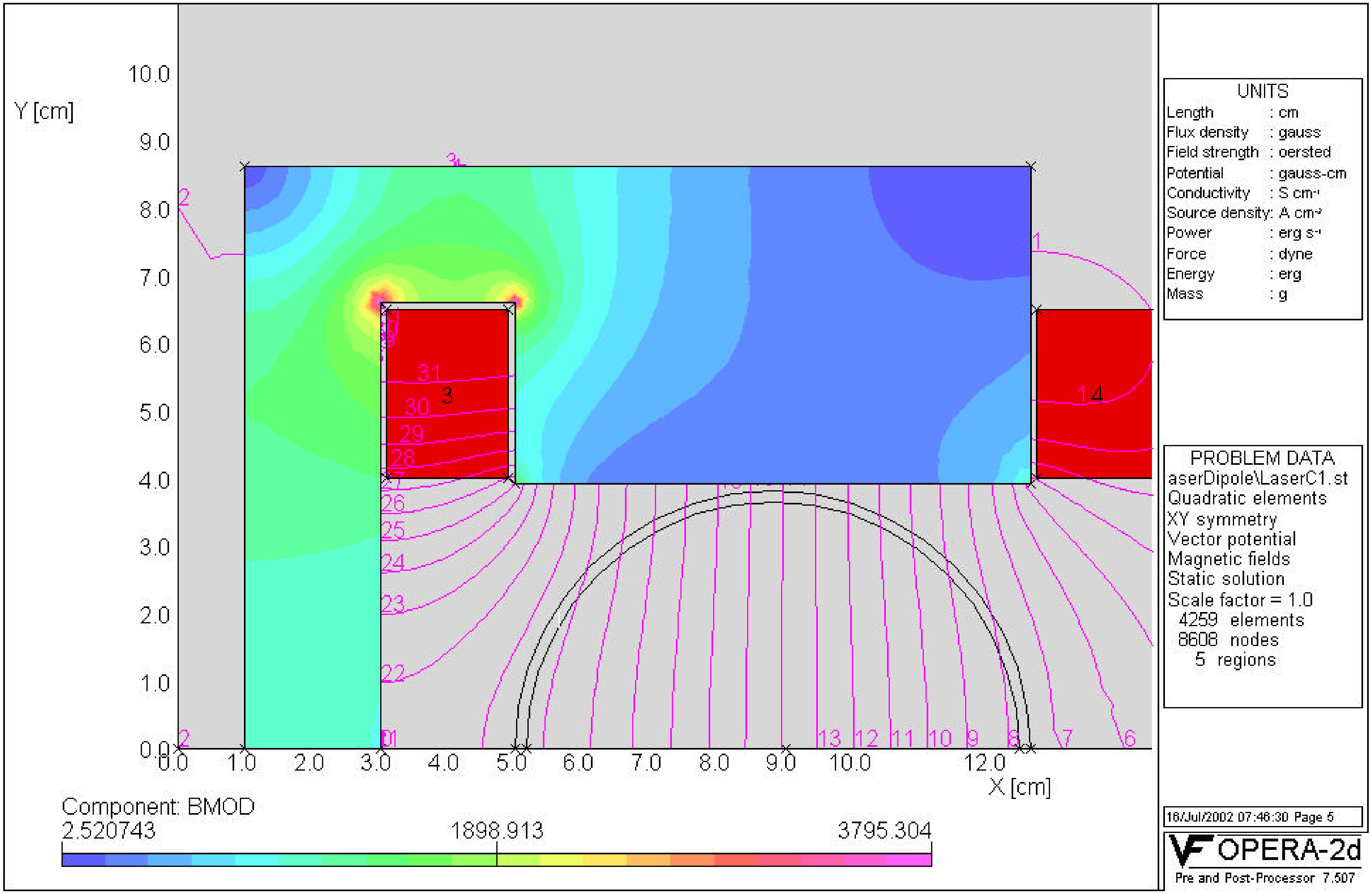
Choosing: $R \cong \frac{L^2}{d}$

$$R[cm] \cong \frac{1700}{B[Gs]} \cdot \beta \cdot \gamma$$

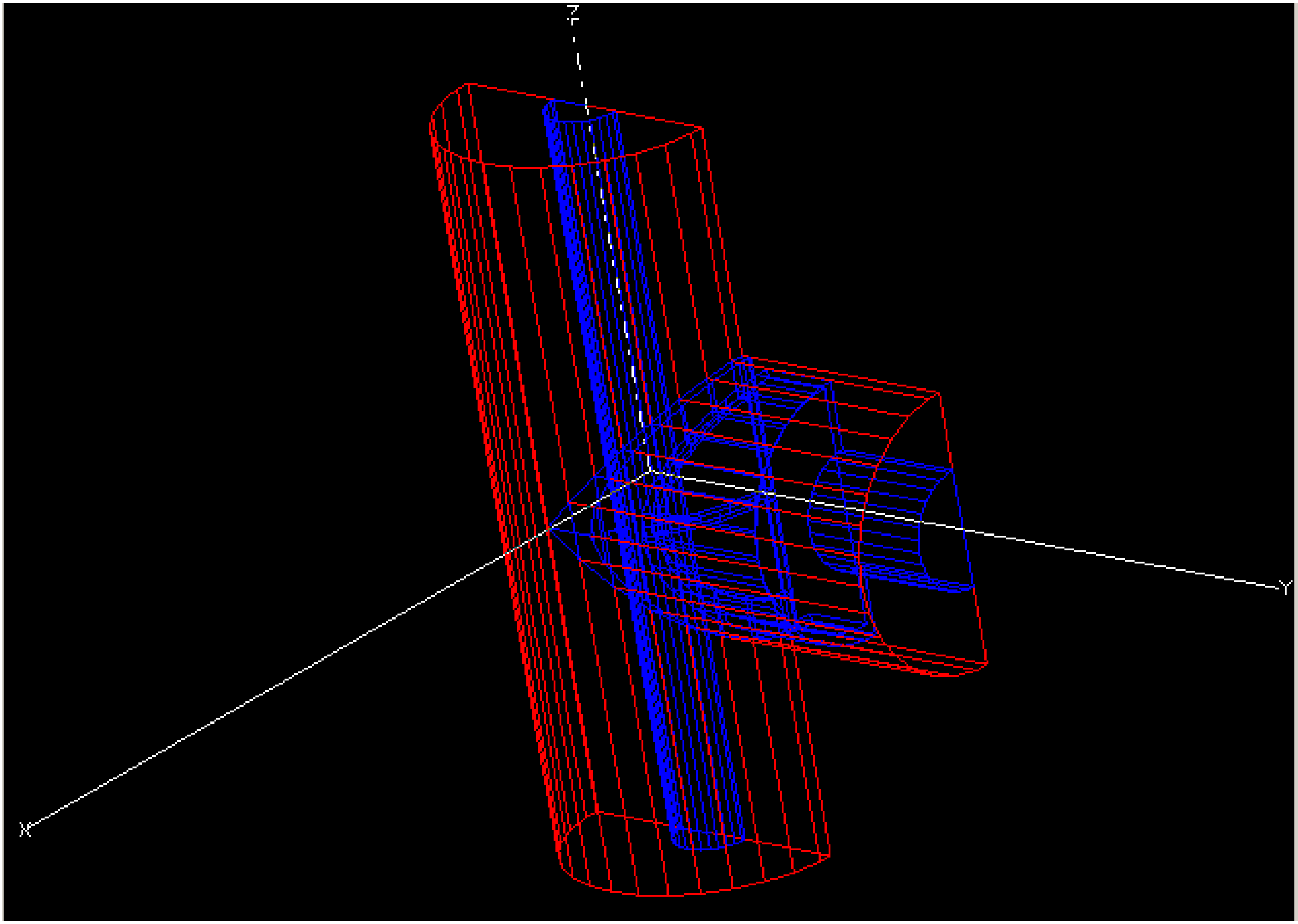
Table1.

E[MeV]	186	204	223	241	259	277	296	314	332	351	369	387
B[Gs]	70	74	77	80	84	87	90	94	97	100	103	105
E[MeV]	438	489	540	591	642	694	745	796	847	898	949	1000
B[Gs]	113	121	128	136	143	150	157	163	170	177	183	190

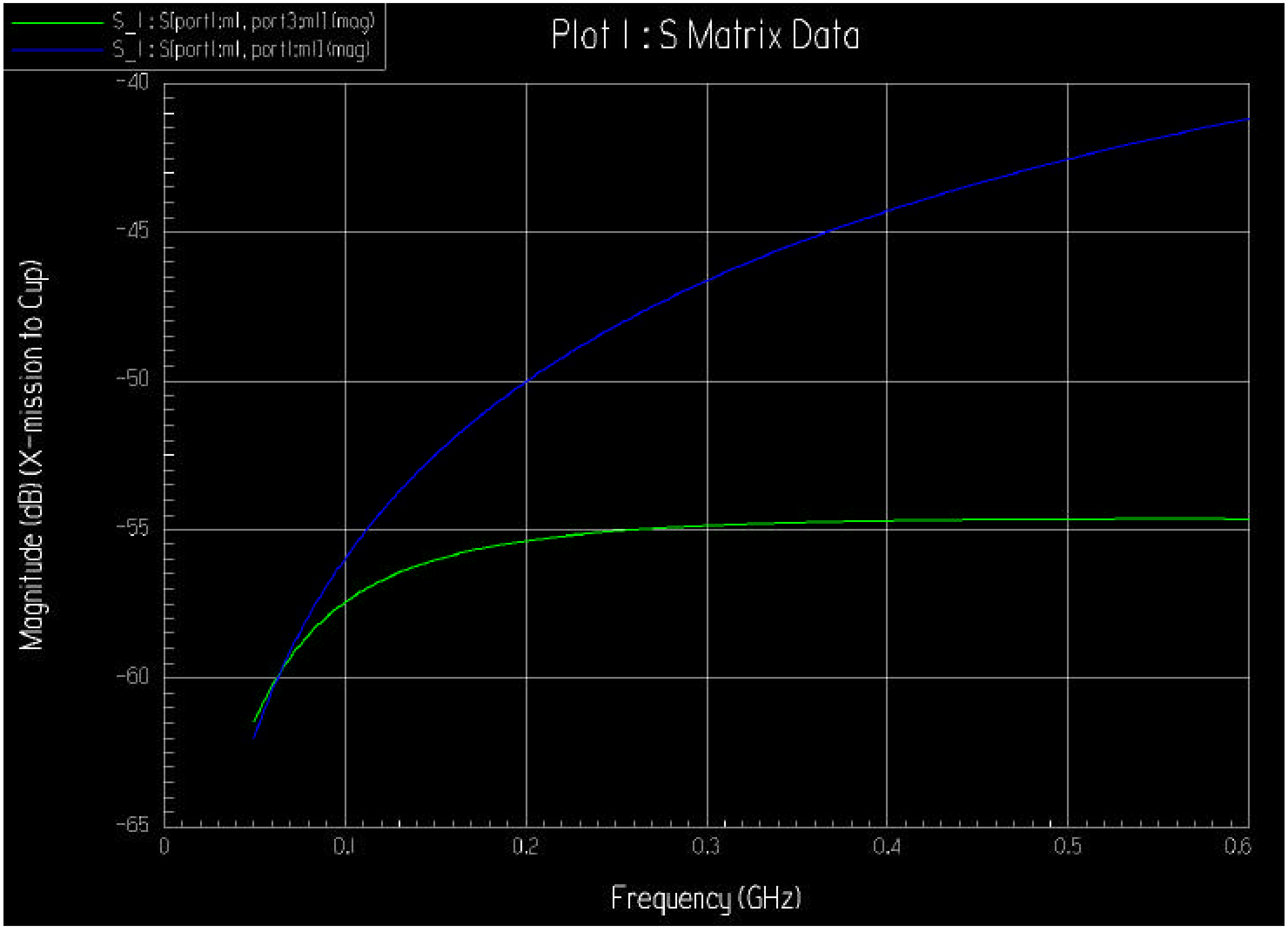
Very Simple air cooled dipole magnet is designed



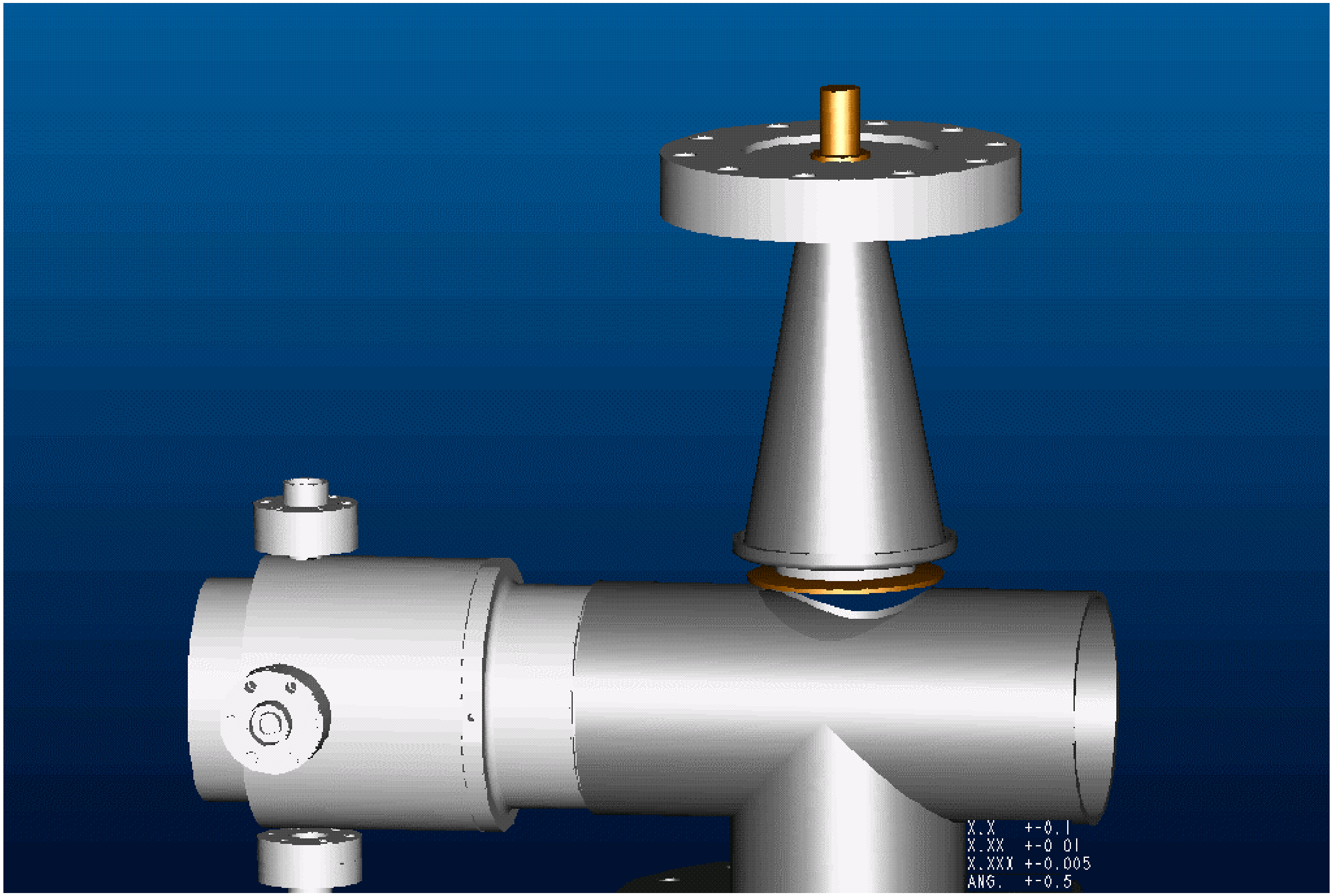
3-D model of the electron detector is complete and 60 dB or noise (rf) rejection is obtained



We expect to measure 120 mV from electron collector at 38 mA, expected noise is about 1 mV (-60dB– Green Curve).

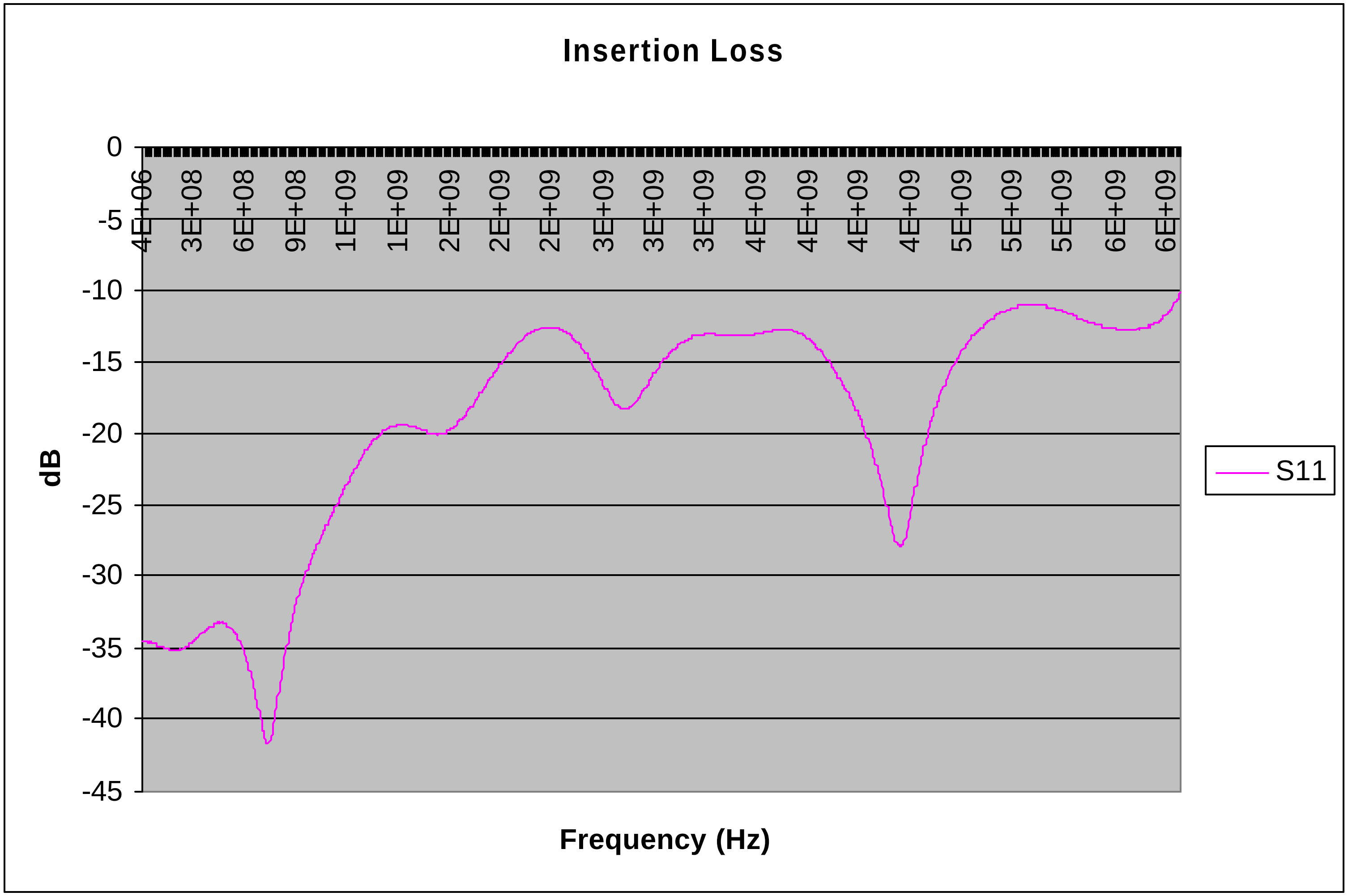


3-D view of the SCL BPM and the electron detector electrode

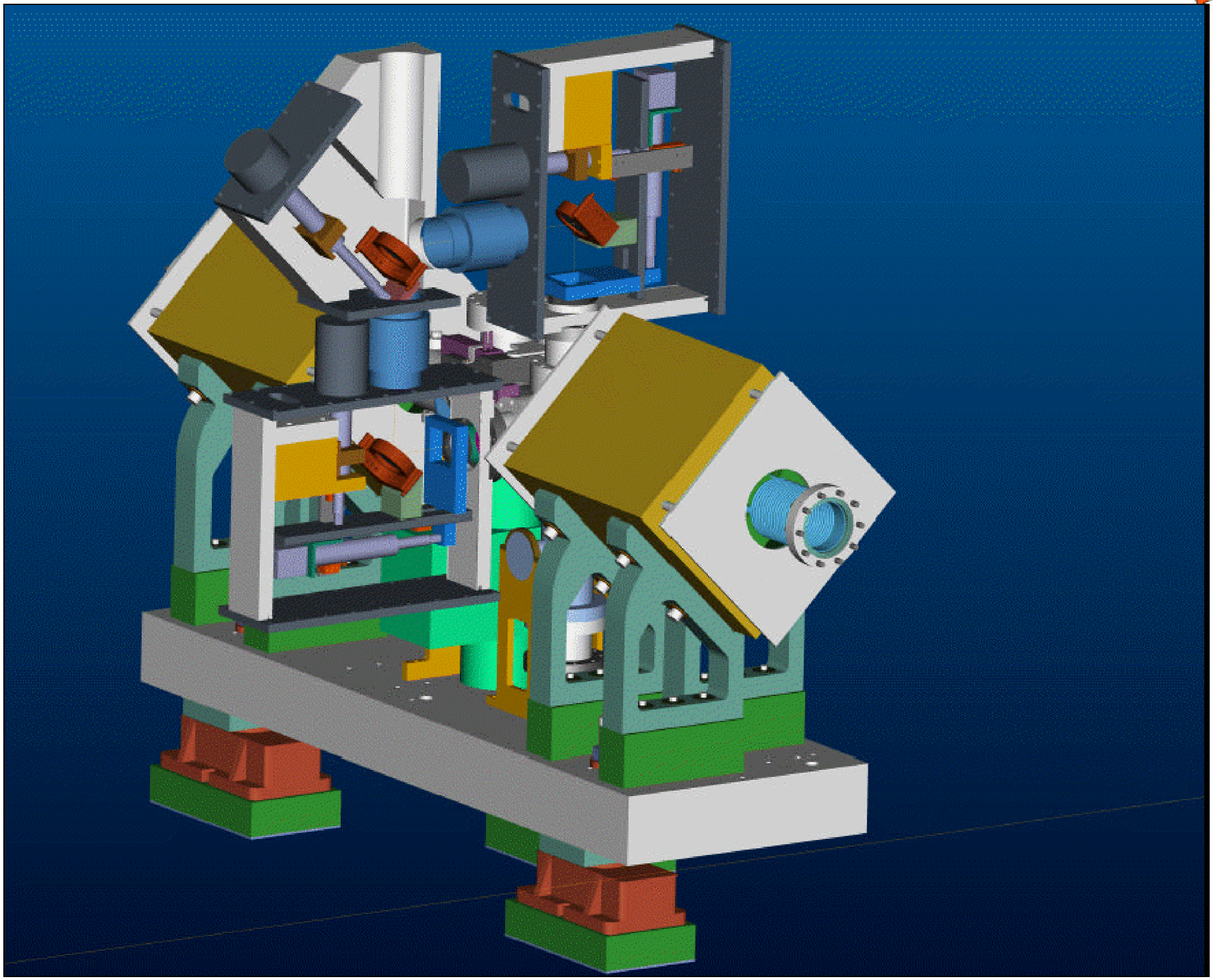


Verification of Connector Weld

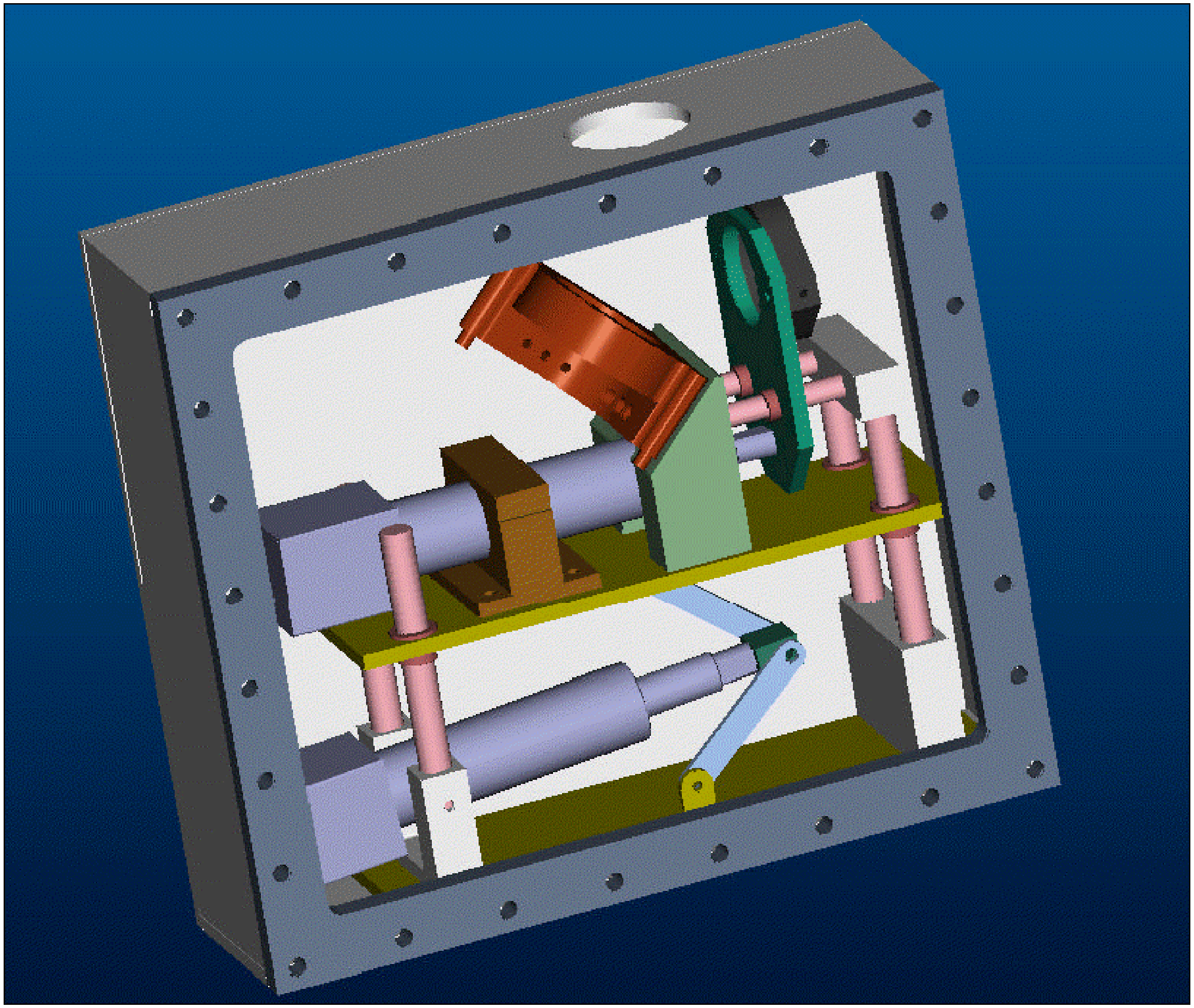
Gated Insertion Loss



Warm Section with the laser wire beam boxes.



Optics Box, Progress Continues

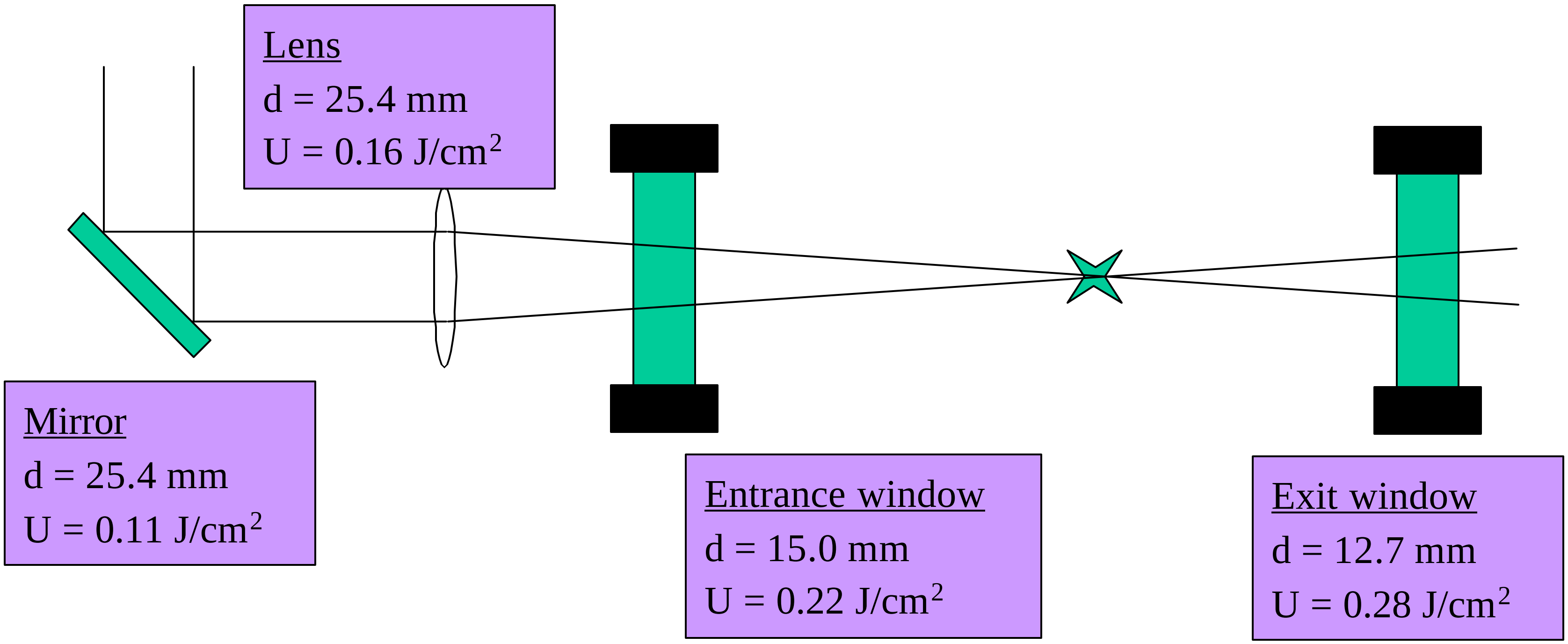


Optics

Optical Requirements

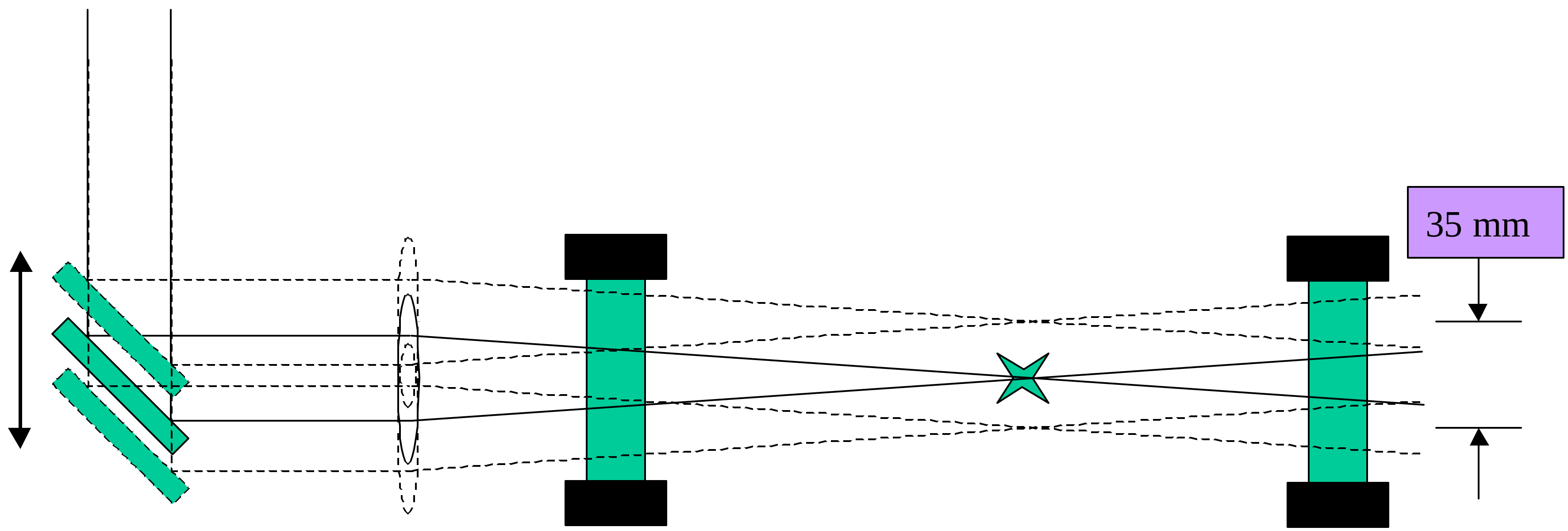
Beam size at target: 100 µm – 2.0 mm
Beam size at windows: > 10 mm
Scan range : 35 mm (limited by window)
Lens travel: 30 mm
Beam stability at target: open question

Spot sizes and peak energy densities for 200 mJ pulse



Damage threshold ~ 5 J/cm^2

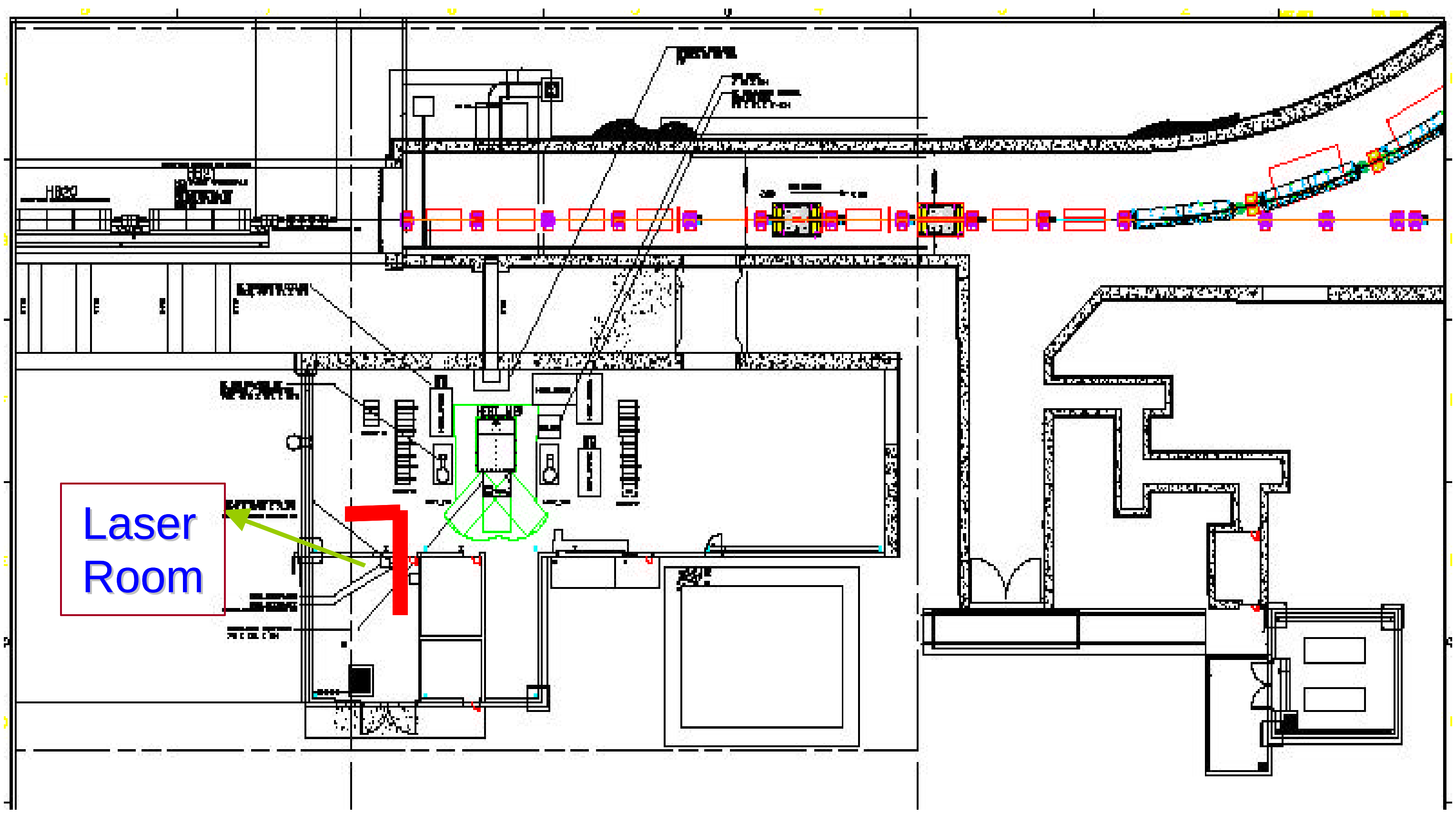
Maximizing the scanning range



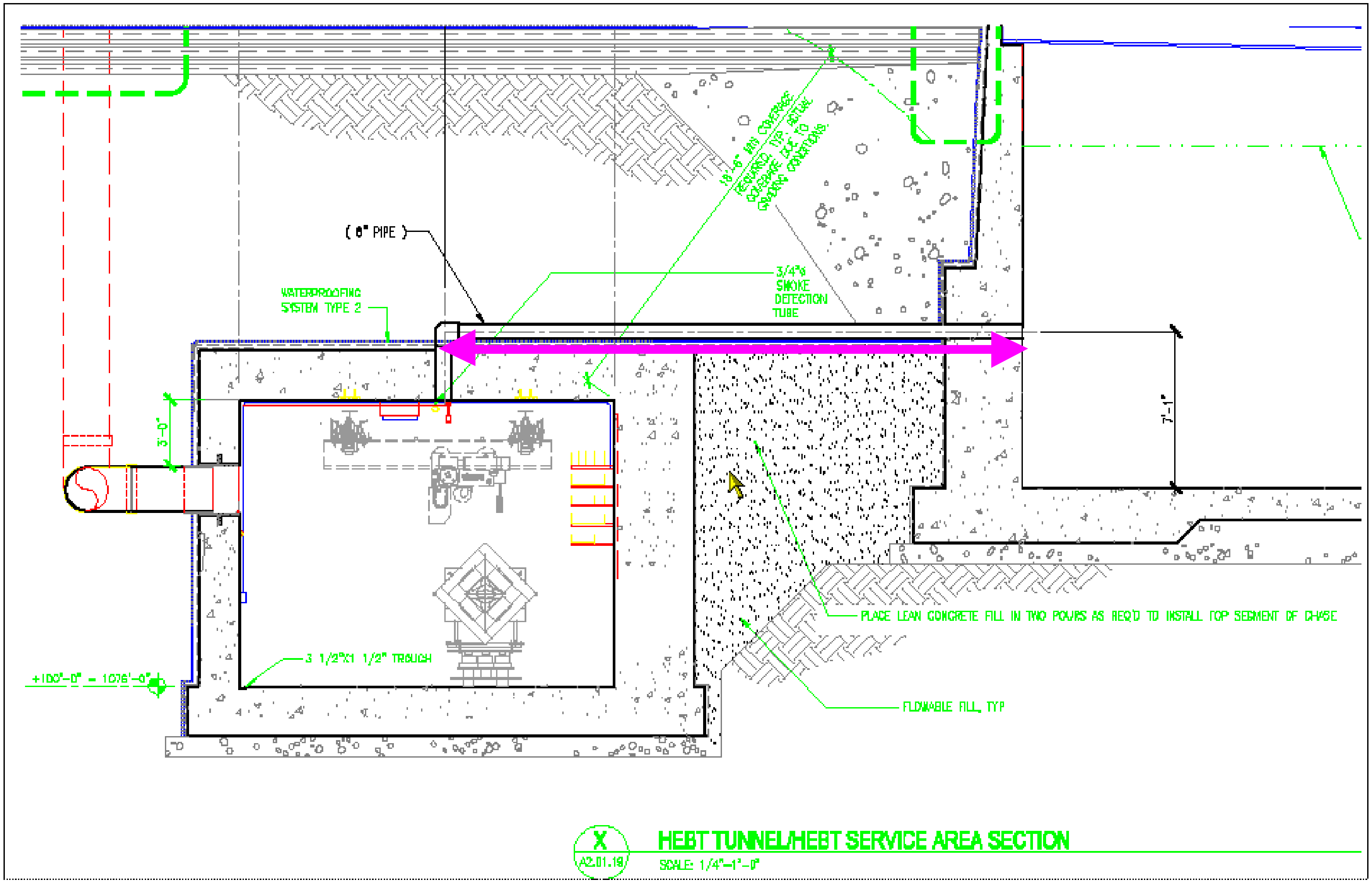
Location of the Laser Room in the HEBT Area

Advantages of a single laser

- *Laser expense shared between stations*
- *Laser not exposed to radiation*

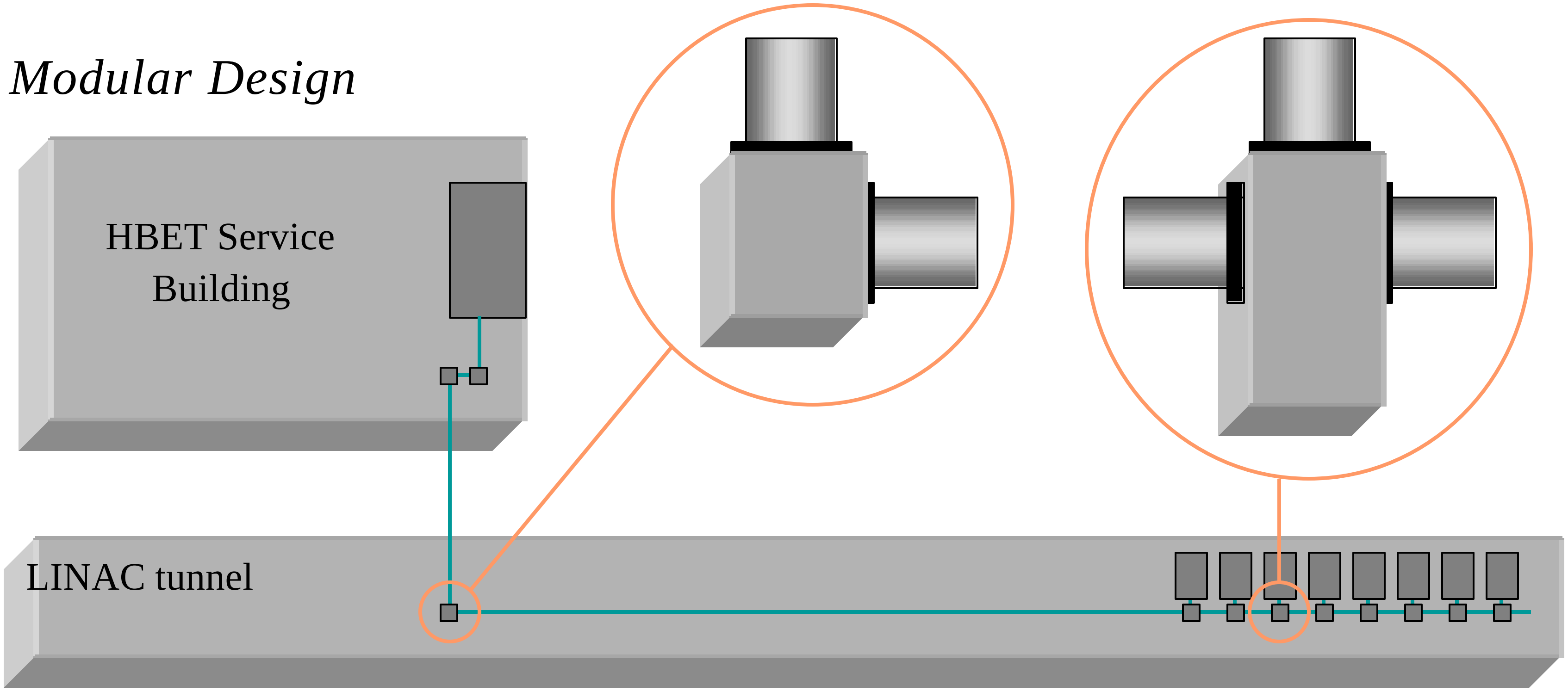


Laser Transport from HEBT Service Area to the Tunnel



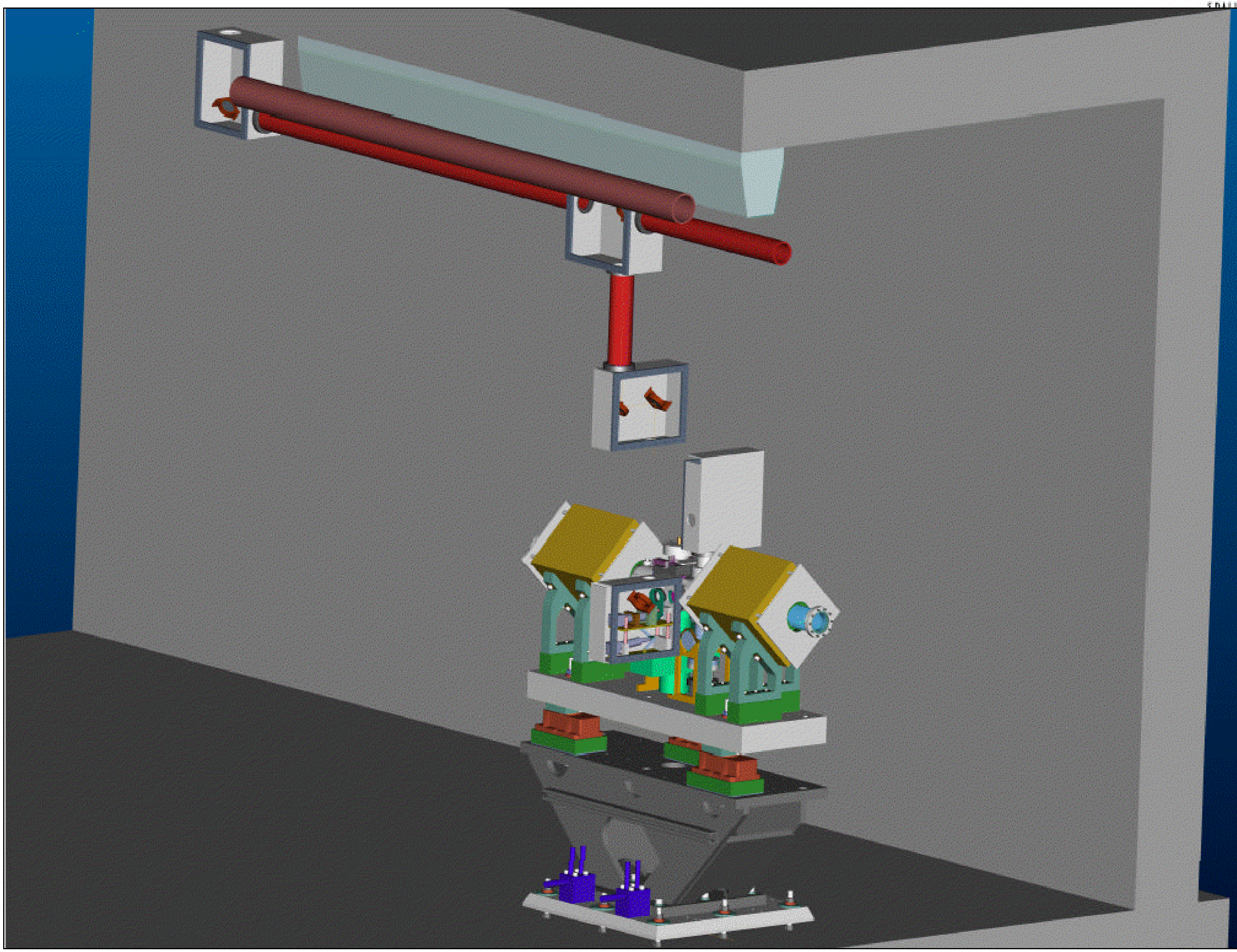
Transport Line

Modular Design

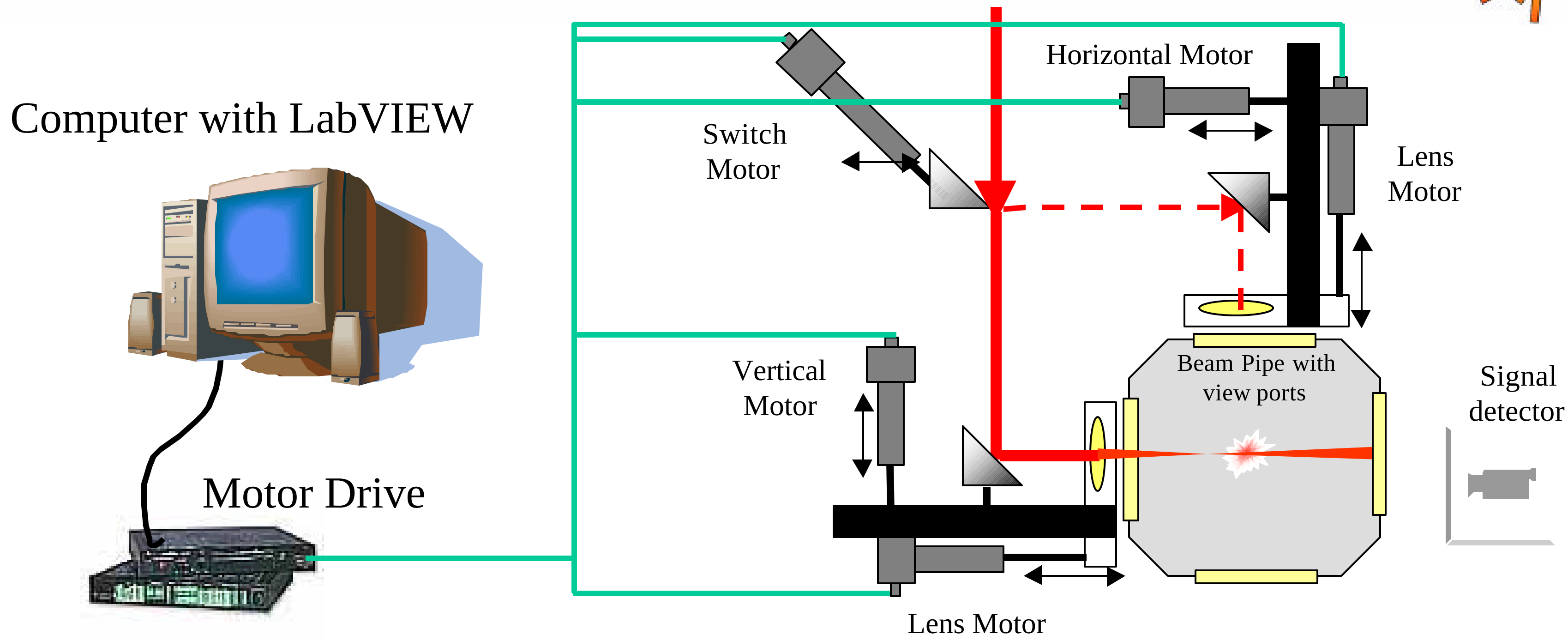


- *Boxes secured to building walls, ceilings, etc.*
- *Designed to accept a variety of optical components*
- *Cable feedthroughs*
- *Pipes mounted between boxes*

Tunnel Layout Concept



Laser-wire Actuator System

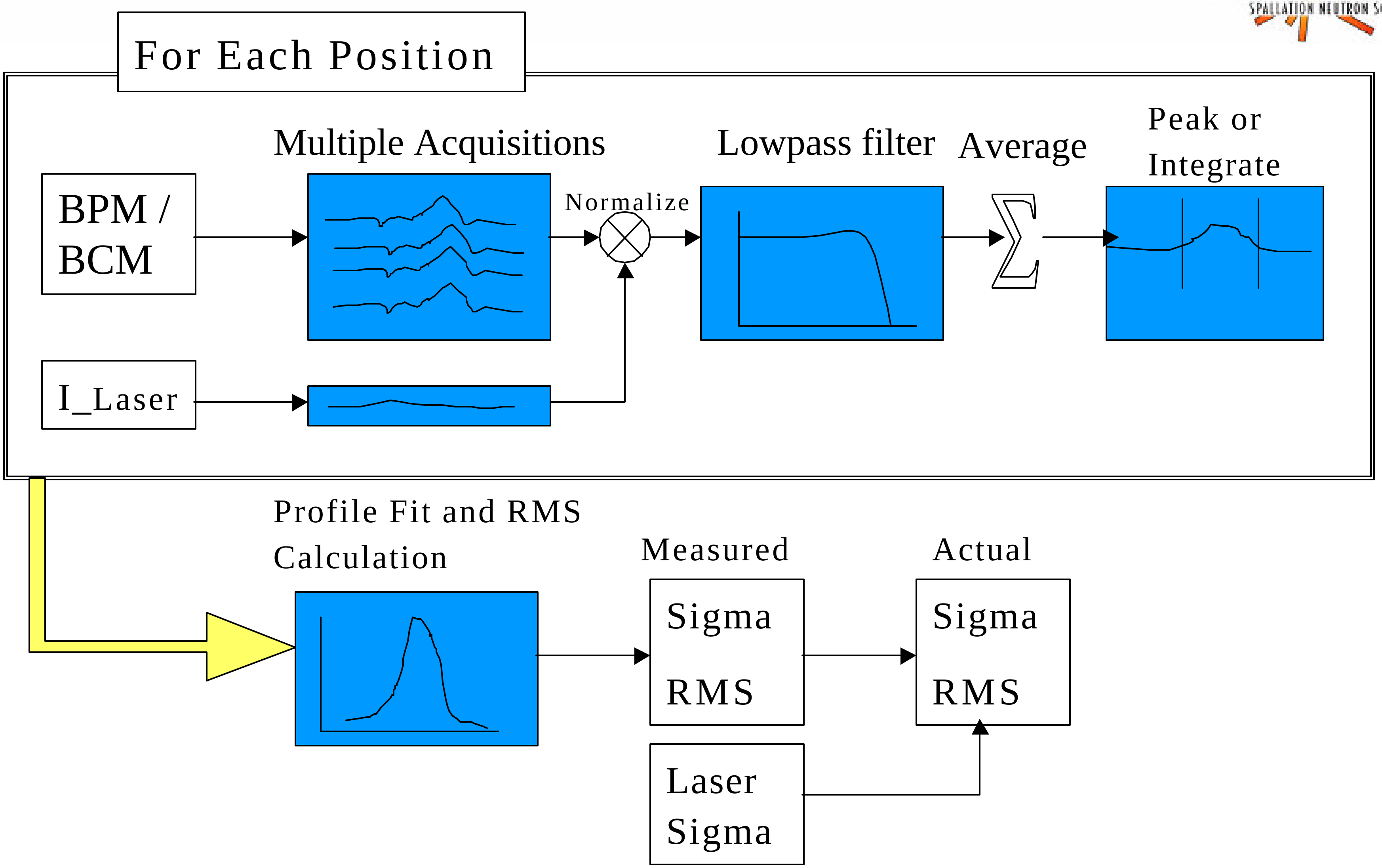


- A rack mounted 2U high PC (Desktop for test)
- NI PCI-7334 motion controller (inside PC) (x2 depending on switch mirror)
- PCI digitizer card (inside PC) (TDS 7404 for test)
- PCI Timing card (inside PC)
- NI MID-7604 4 axis stepper motor driver (1U drive) (x2)
- 4 Ultramotion HT17-075 radiation hard actuators with built-in potentiometer

Laser-wire Data-Acquisition and Analysis

- Data-Acquisition
  - Acquire BCM, BPM, Electrode data at high speeds (possibly lower later) many times during one position (TDS 7404).
  - Acquire Laser Intensity and possibly spot size
- Analysis
  - Correct for Ion and Laser beam intensities
  - Fit and RMS calculation to profile
  - Calculate Laser spot size at Ion beam for correction
  - Possibly correct for position variation

Laser-wire Analysis



Assuming that the position of the Ion beam and Laser-beam are not varying during the acquisitions

Laser-wire Analysis

1) BPM and BCM: Lowpass filter at about 100MHz to filter out the RF and noise.

2) Electrode: Average over trace

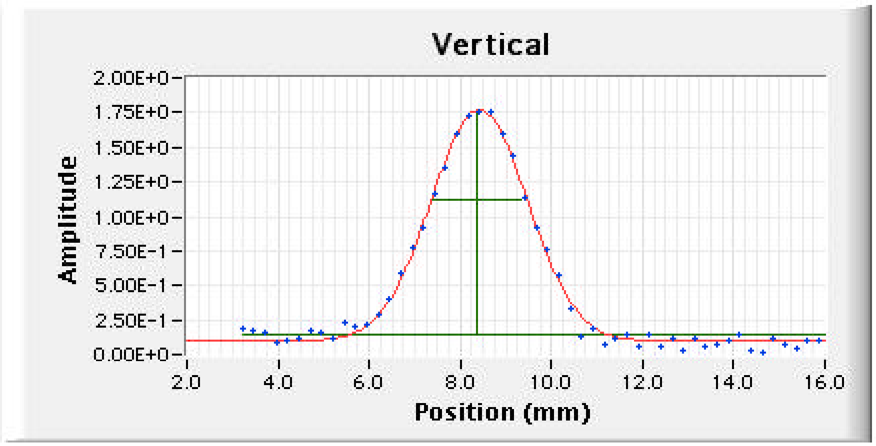
3) All: Averaging over multiple acquisitions at the same position to reduce noise with the possibility of correcting for pulse-to-pulse variations of the beam intensity and laser intensity. Note, if we find that the position of the H^- beam varies significantly from pulse to pulse, the data cannot be directly averaged. The traces will then be stored according to position as measured by the BPM. We will then either average the traces that have positions near the peak of the distribution or allow for more points in the profile and effectively perform the averaging during the fitting or RMS calculations.

4) BPM and BCM: If there is significant background noise or RF in the signal, the notch background is determined by averaging N (about 10) samples right before the notch and right after the notch. The average of this is used as the offset of the notch. This reduces the noise due to frequencies close to the notch frequency. To take the average of the signal before the notch (up to about 400 samples) results in a noisier profile.

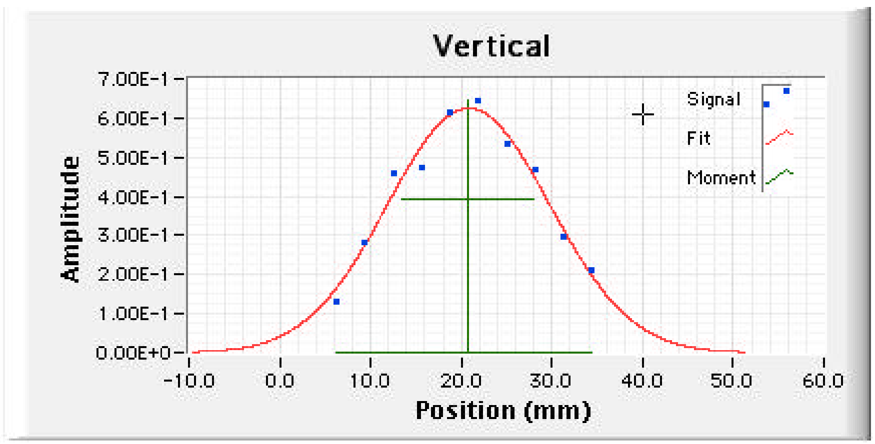
5) BPM and BCM: The value of the notch is determined by the peak value or by integrating over the length of the notch. Both methods give about equal results with the peak method showing less noise in the tails of the profile.

6) All: The resulting profile is analyzed by a moment calculation and a non-linear Levenberg-Marquardt fit to a gaussian function: c0*exp(-0.5*((x-c1)/c2)^2) + c3. In general, the fit performs better as it can better average the data and assumes a Gaussian shape. Also note that the background could vary which affects the moments calculation. The background for the moments calculation can be set to zero or be an average of the first few samples of the profile.

7) All: The results will be corrected by the calculated width of the laser beam at the interaction point. The width of the laser beam depends on the position of the focusing lens and the position of the H^- beam.



Profile from the 2.5 MeV MEBT at Berkeley



Profile from the BNL 200MeV Lineac.

Schedule and Goals

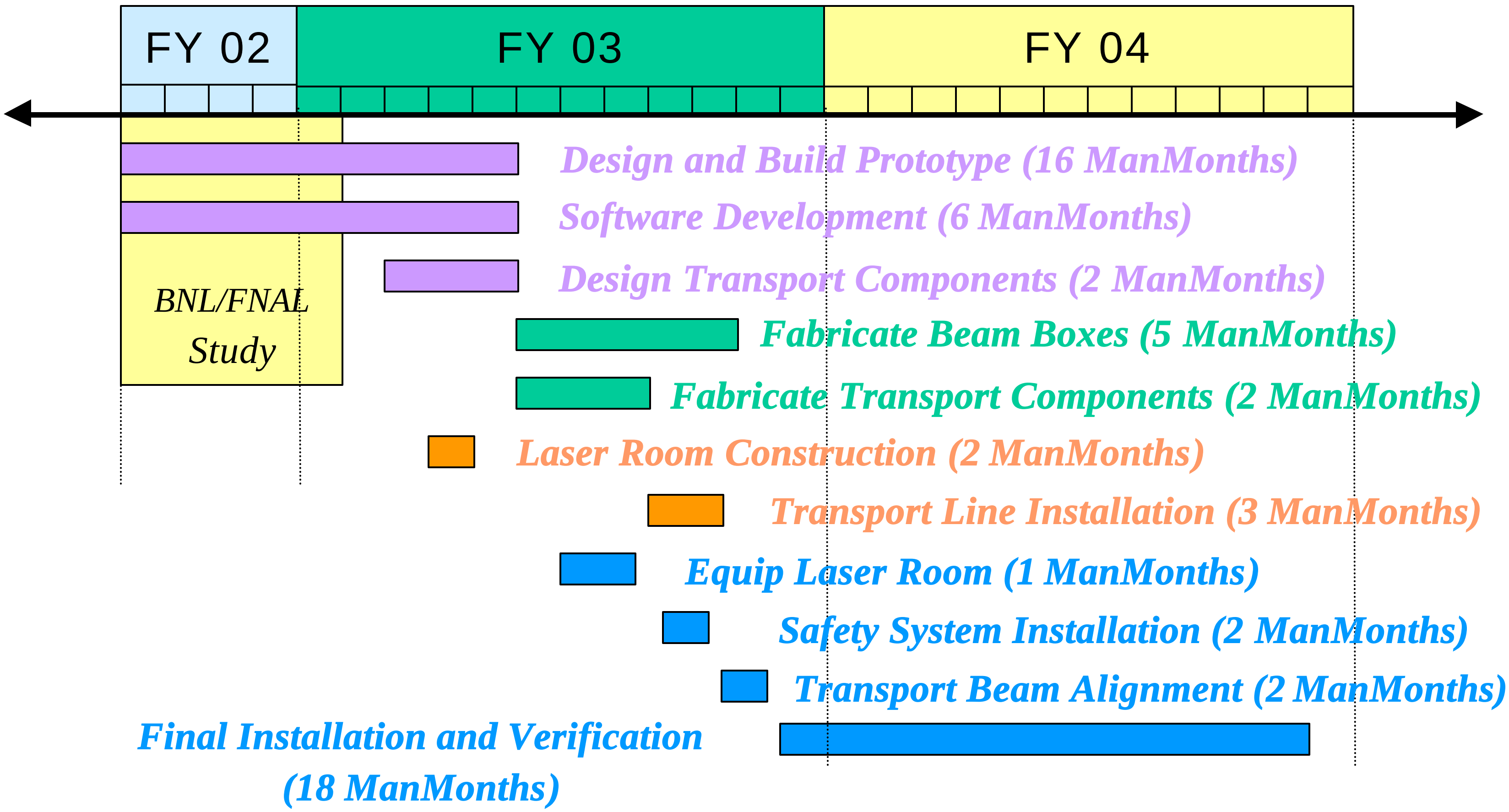
- Magnet design will be completed by July-22-2002, request for cost estimate will go out by the end of July.done

- Complete the electron detector drawing and sent to the shop (July-30-2002).done
- Complete the beam box by July-19-2002. Send for prototype on July-30-2002.vacuum=done, optics box=not yet

- Refine the data acquisition and analysis programs (Aug-30-2002). on target
- Verification of the new laser beam detection at BNL's 200 MeV line (October-2002).on target

6) Collaborative effort on testing laser wire at FNAL (October-2002).??

Schedule



Total Effort: 4.9 ManYears

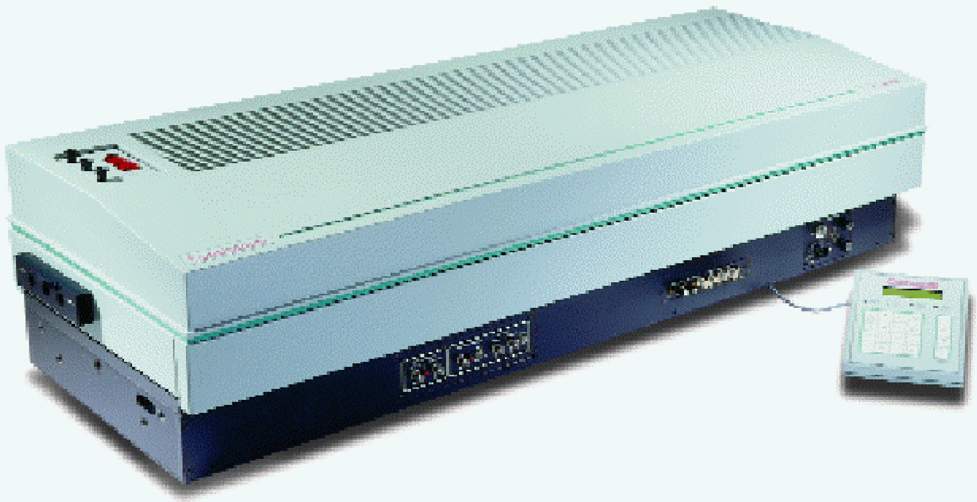
Backup Materials are posted on the web

http://www.sns.gov/diagnostics/documents/Lasermain.htm

Proposed Laser

Continuum

Powerlite Precision II 8000



PRECISION II FEATURES & BENEFITS

<5 Minutes to reach full energy at all wavelengths

<30 Minutes to reach <30 μRadians beam pointing stability

Can be injection seeded for narrow bandwidth allowing pumping of a narrow band OPO, mixing with a dye laser or for high resolution experiments

Laser head can readily be removed for lamp changes and replaced without realignment.

Incorporates Gaussian optics pioneered by Continuum to provide high spatial uniformity in the beam

Laser package physically bolts to tunable laser product such as Panther OPO, Sunlite EX or ND6000 for enhanced stability and ease of use

RLITE SPECIFICATIONS

DESCRIPTION	8000	8010	8020	8030	8050
Repetition Rate (Hz)	10	10	20	30	50
Energy (mJ)					
1064 nm	1200	1650	1200	650	550
532 nm	600	800	550	300	210
355 nm	310	450	300	150	95
266 nm	120	150	80	50	30
Pulsewidth[1] (nsec)					
1064 nm	6-8	6-8	6-8	7-9	7-9
532 nm	5-7	5-7	5-7	6-8	6-8
355 nm	5-7	5-7	5-7	6-8	6-8