SCL Laser Wire Design and Implementation

Diagnostic Groups: BNL, LANL,LBNL And ORNL

ICFA 2002

Collaborators: SLAC, FNAL

Presented by Saeed Assadi

October 21-23, 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,**
FNAL	**Jim Crisp, Bob Webber**

Outline:

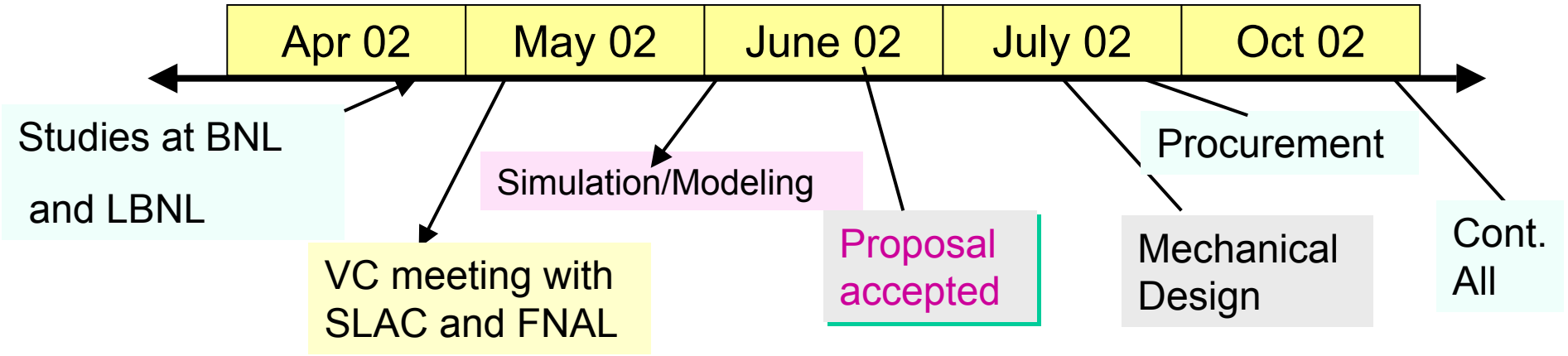
1) Summary report of the collaboration.

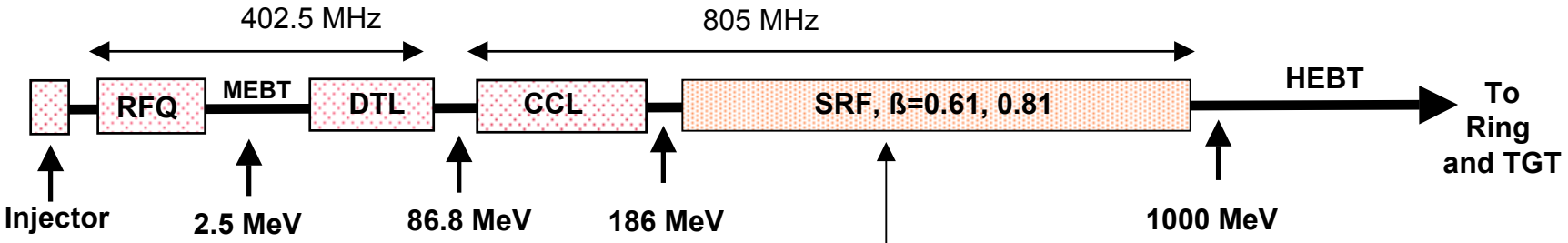
2) Measurement results from MEBT and BNL 200 MeV line very briefly. Just to show where we are going from here

3) Design progress report.

4) What's Next (Schedule)

Time Table and SCL Laser Wire Locations





4 LW from 186 MeV,
4 LW from 386 MeV
Laser Wires 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 ordered the laser)*

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.

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 (90%), Transport line (70%), Laser Room at RATS (90%)

7) What is next

Laser wire Design is based on the Physics requirements

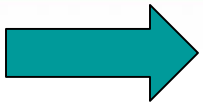
Physics requirement on Carbon/Laser Wire for transverse matching

- Measurement uncertainties in the rms beam size (or its equivalent) should be less than 7% of the rms beam size at 1s of the distribution of measured values for an adequate transverse matching (SNS/ASD-NOTE-AP-0057).

From: Dong-o Jeon

What does the Laser do? Photo-neutralization

H^-

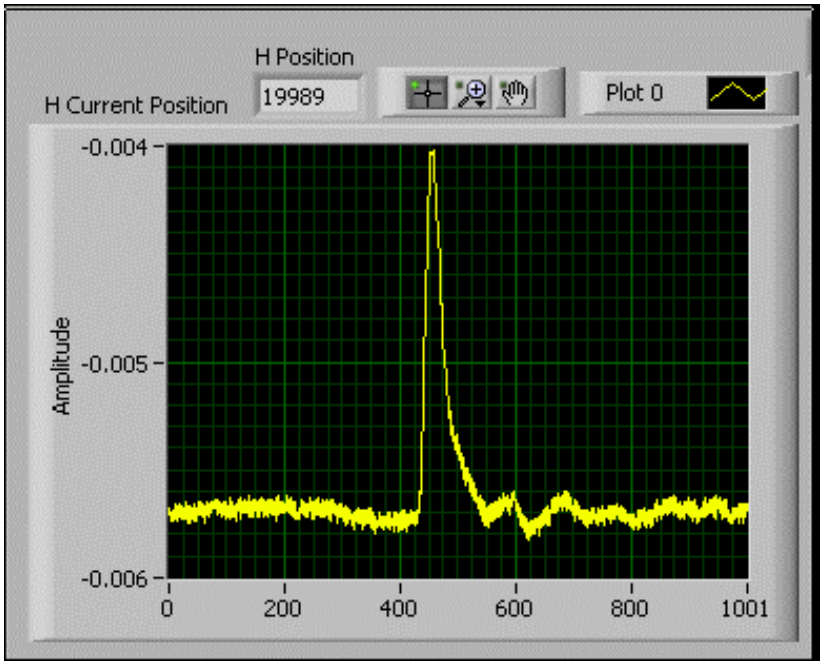


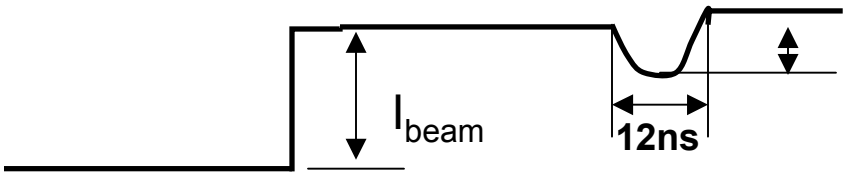
$H^0 + e$

$h\nu$

Requirements

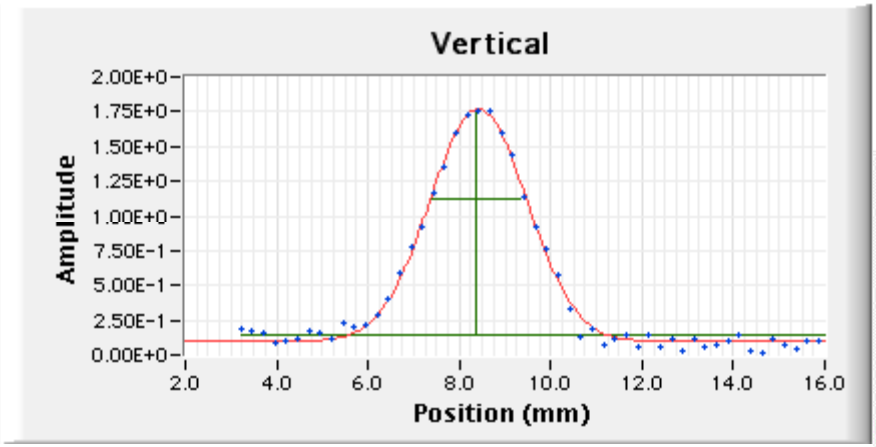
- *High peak power*
- *Small spot size*
- *Transverse scan*
- *Temporal stability*
- *Detection*



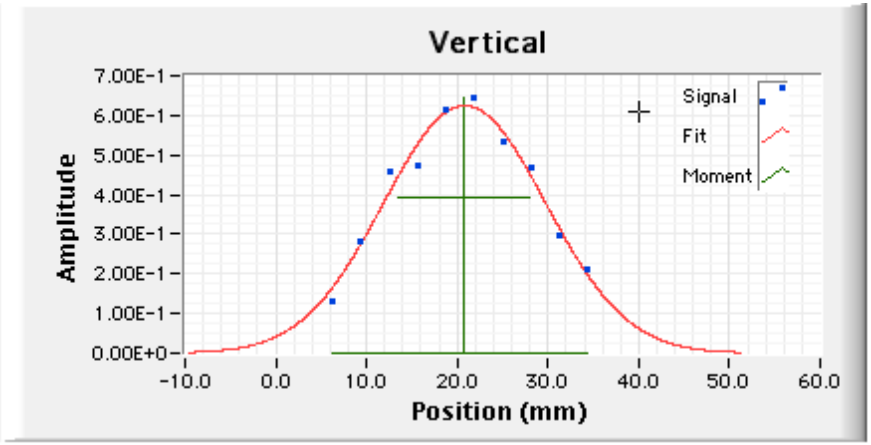


Cross-section is well known therefore stripping efficiency calculation is a matter of algebraic manipulation (tech. notes)

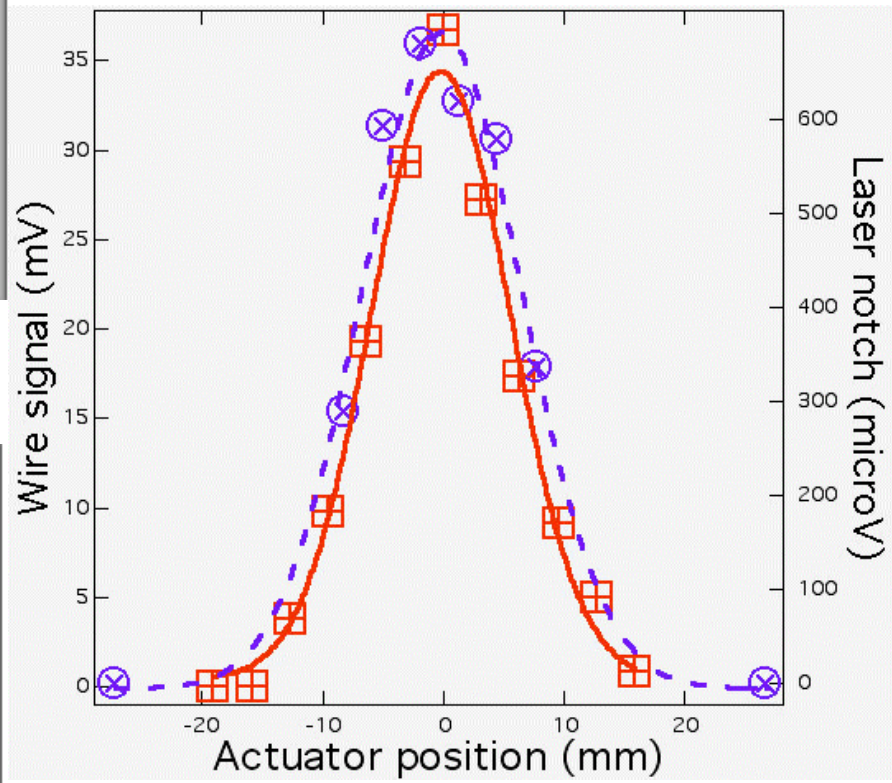
Application of the SNS Laser-wire software on MEBT and BNL Data



Profile from the 2.5 MeV MEBT at Berkeley



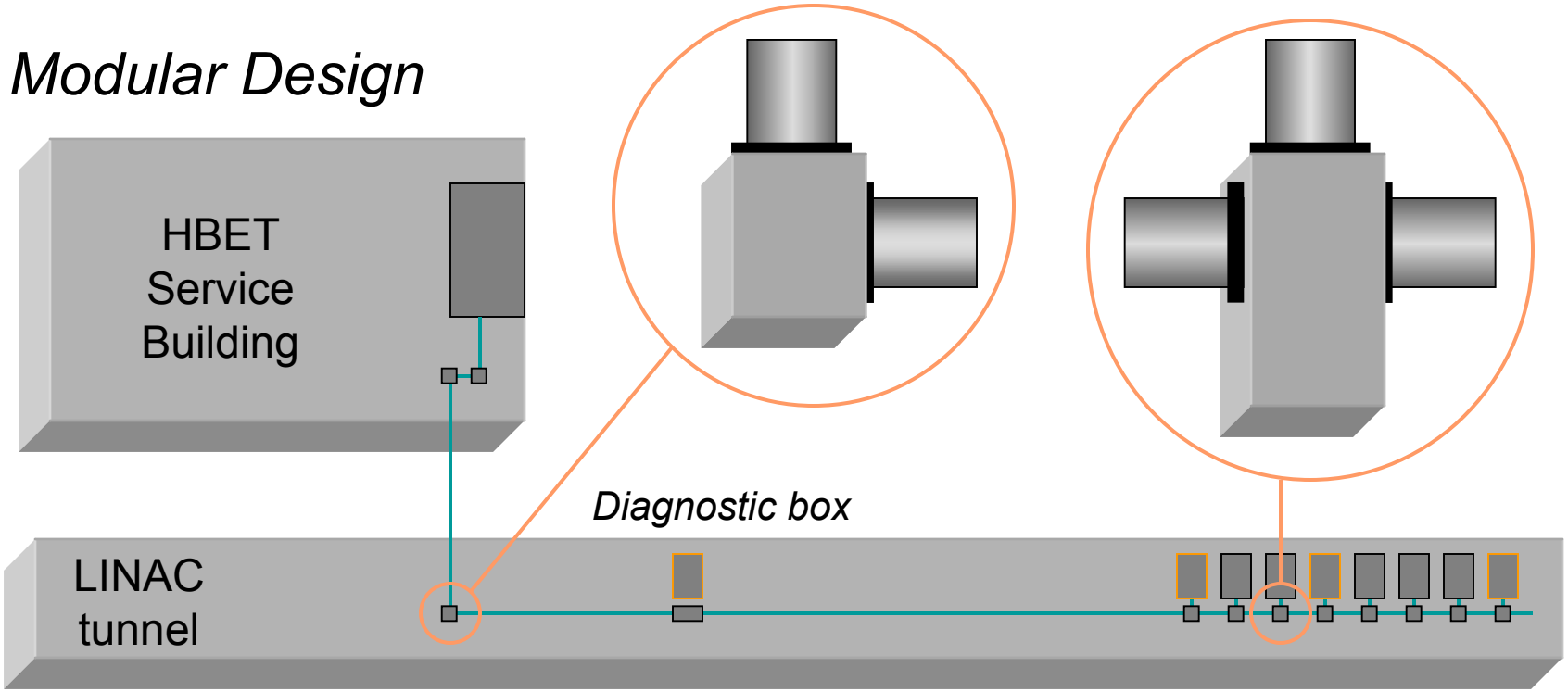
Profile from the BNL 200MeV LINAC



Comparison of Laser-wire and Carbon-wire data at BNL 200 MeV line

SCL Laser-Wire System

Modular Design

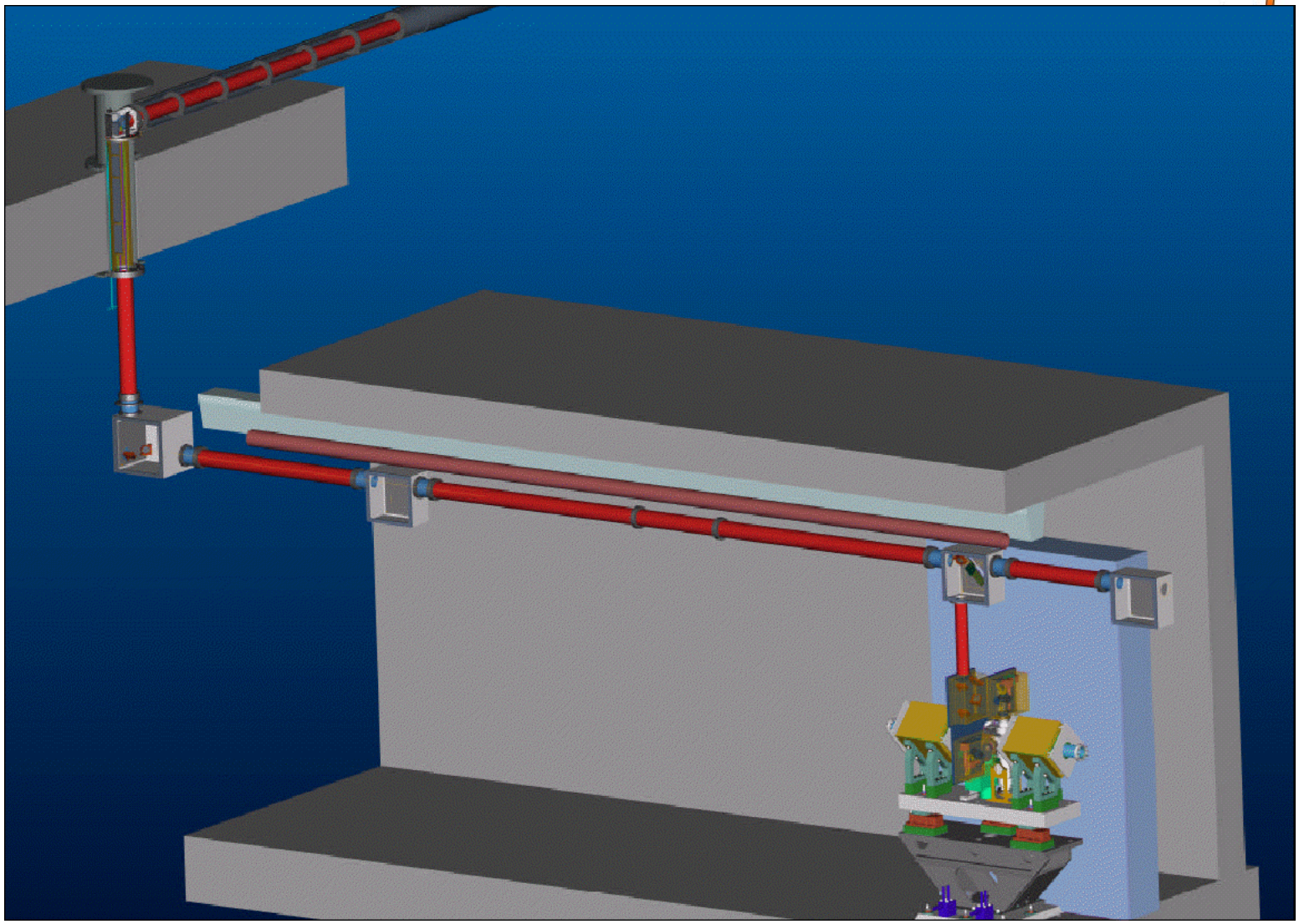


- *Boxes secured to building walls, ceilings, etc.*
- *Designed to accept a variety of optical components*
- *Cable feedthroughs*
- *Pipes mounted between boxes*

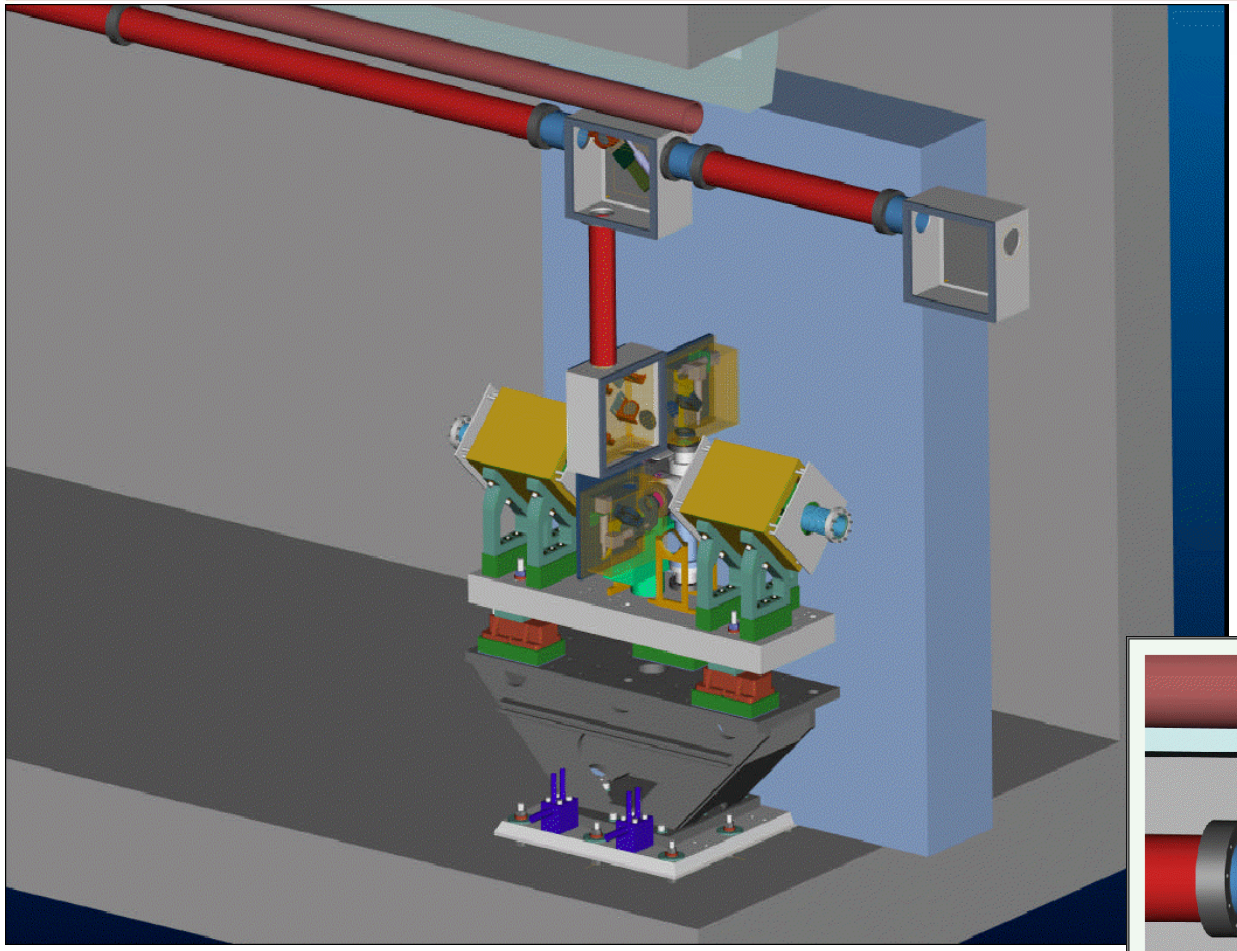
Laser-Wire System

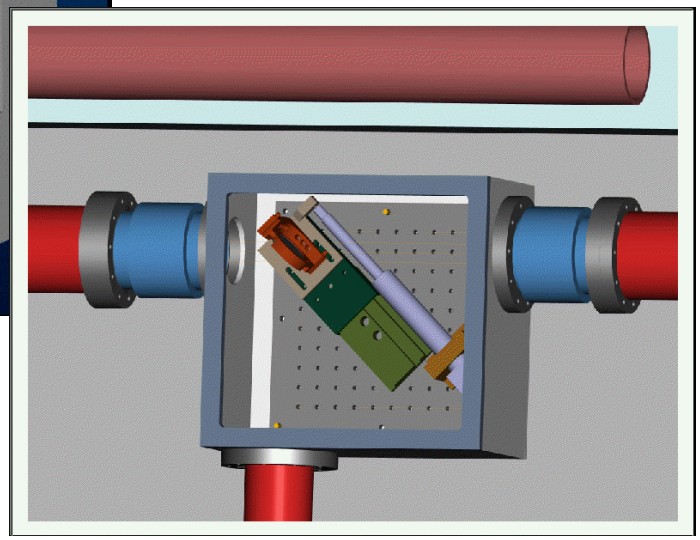
	Mirrors	Diagnostics
Laser Room	2-3	Beam profile Pulse intensity Pulse duration
Transport line	6	Beam size (4) Beam position(4)
Diagnostic	5	Beam size (2) Beam position (2)

Warm Section with the laser wire beam boxes.



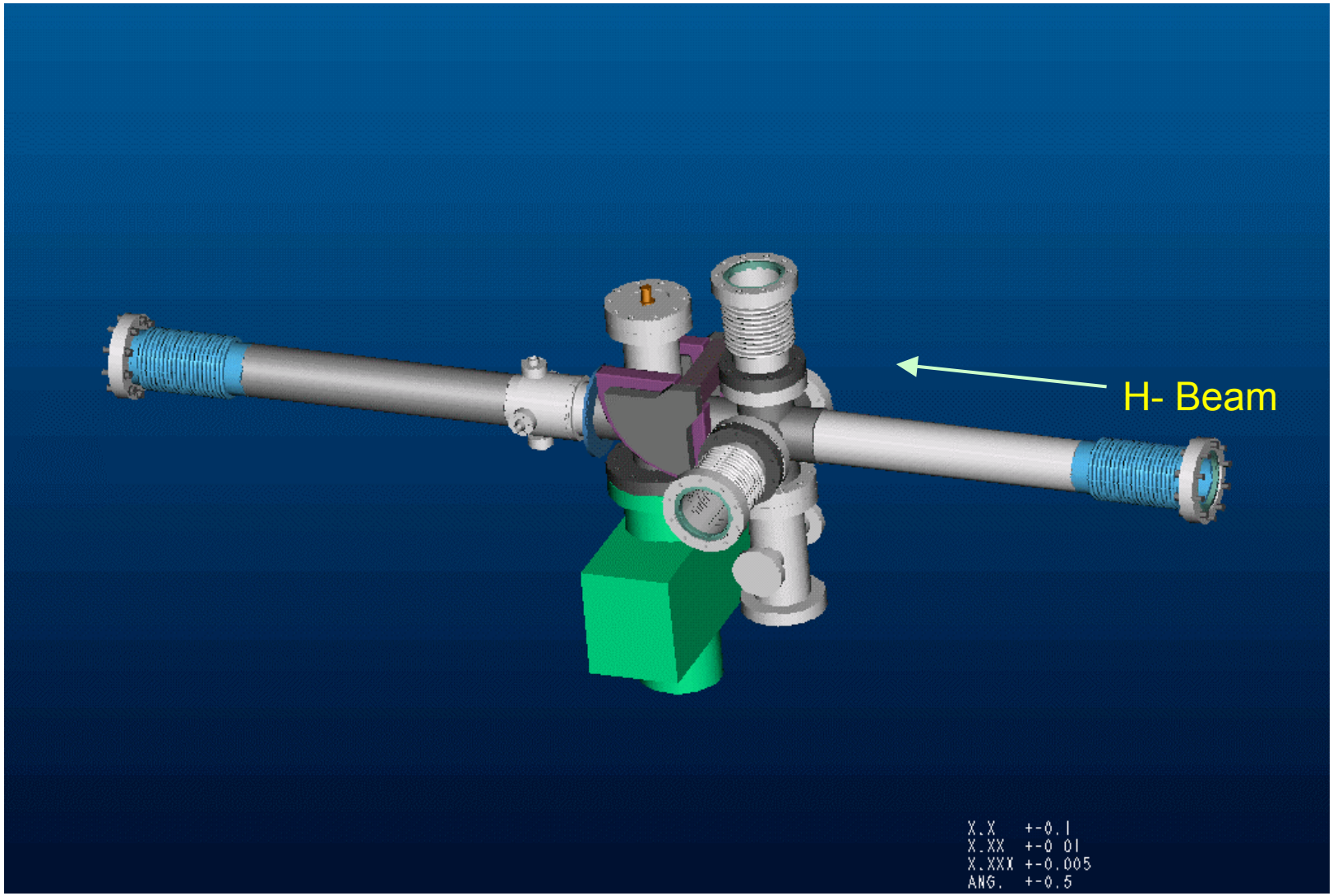
Transport line design is underway





Off the shelf sliders and components are used

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



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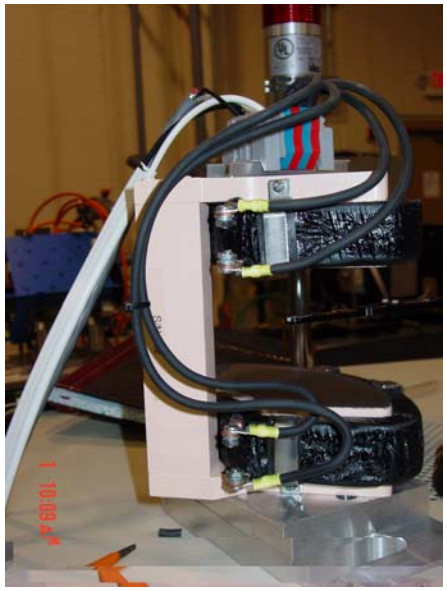
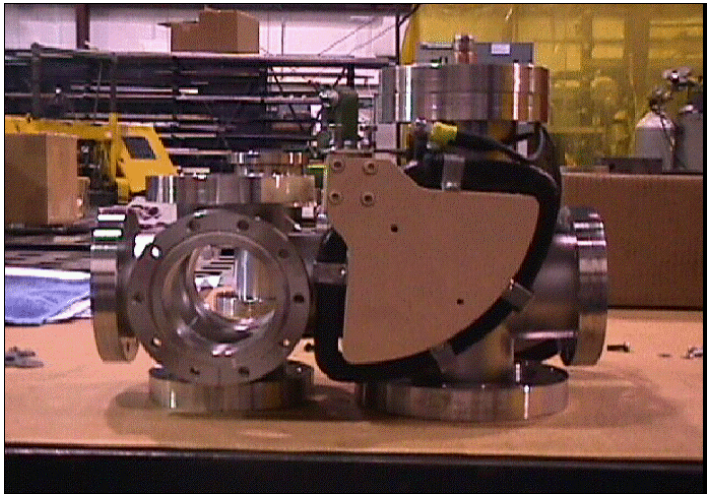
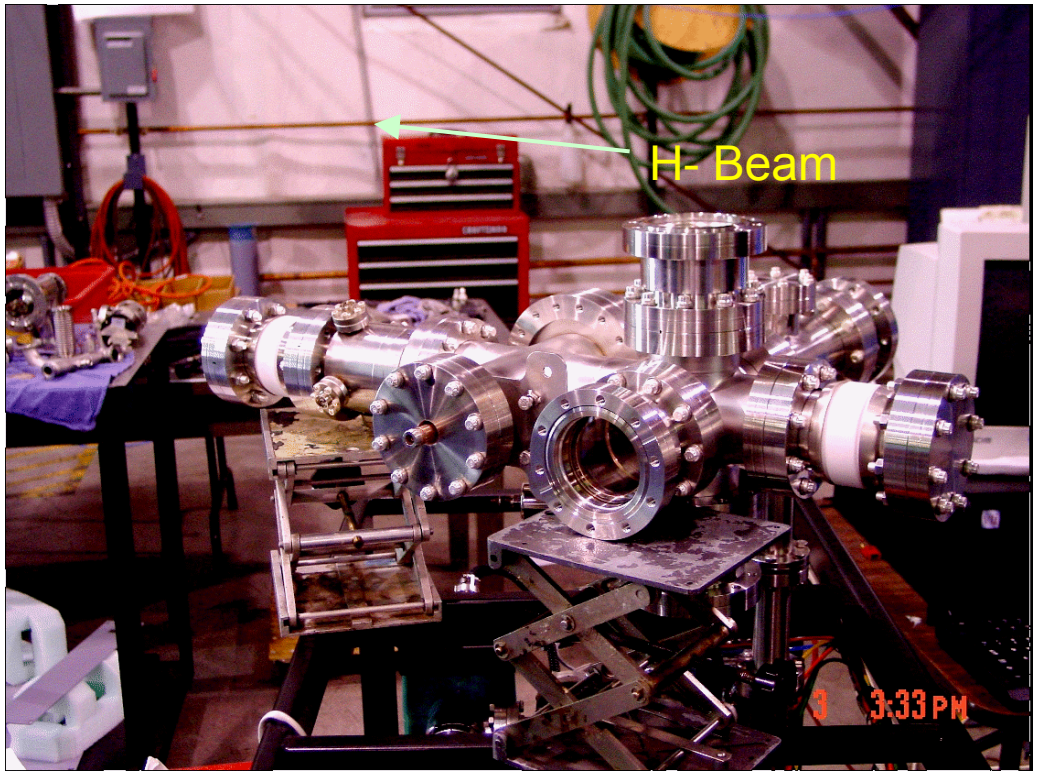
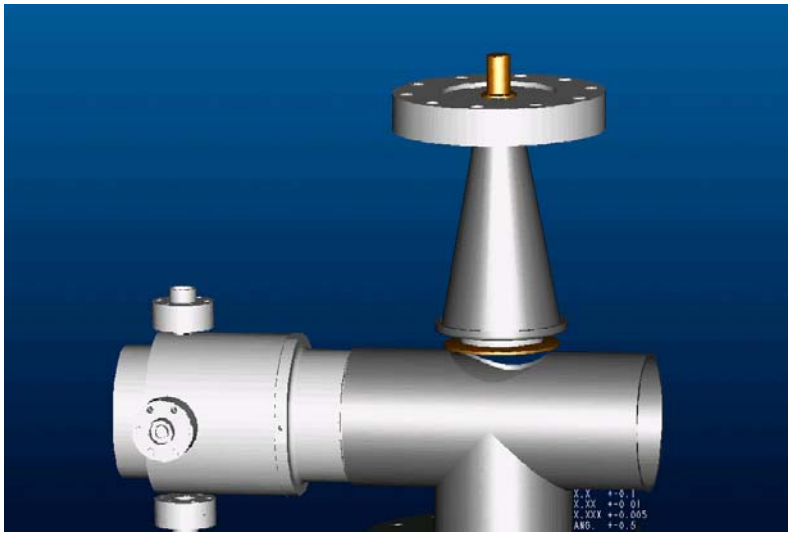


Prototypes components are being manufactured.



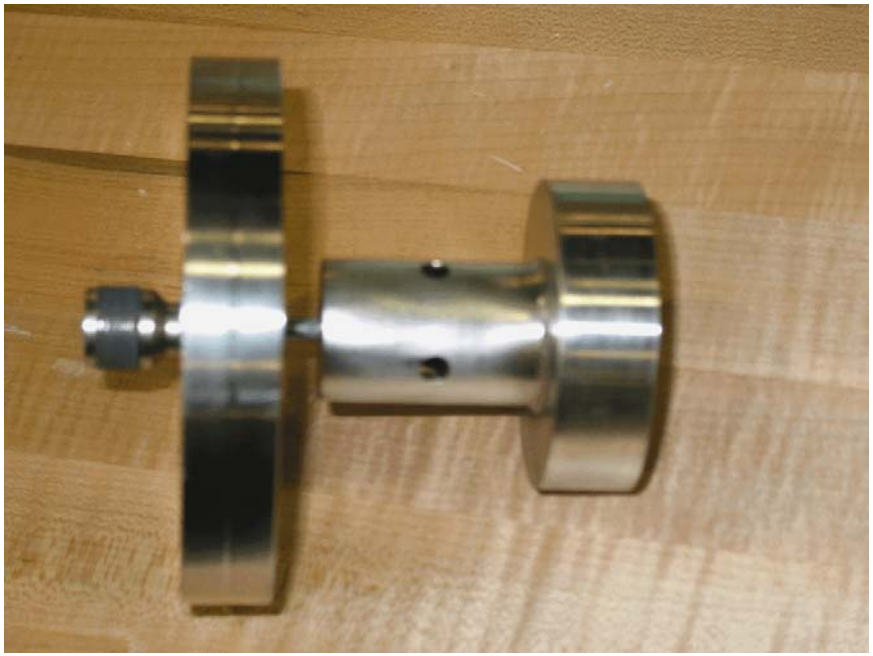


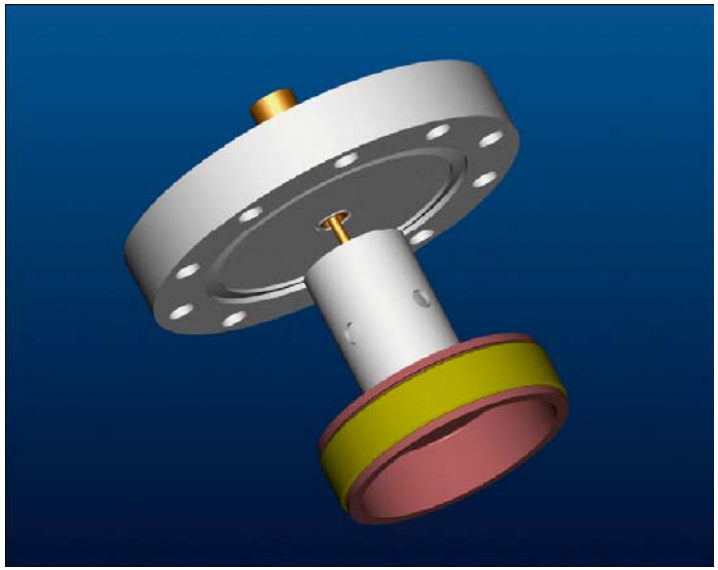
3-D view of the SCL BPM and the electron detector electrode



Original Concept

First Prototype

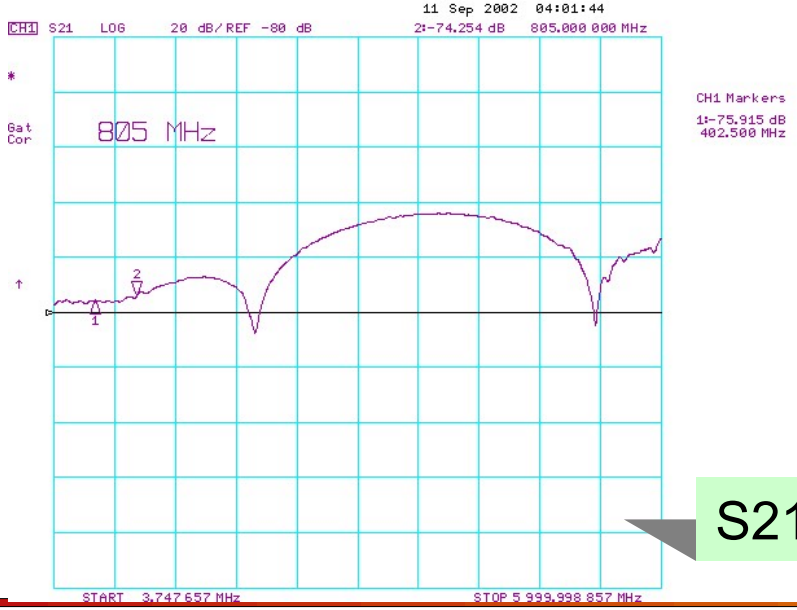




Final design

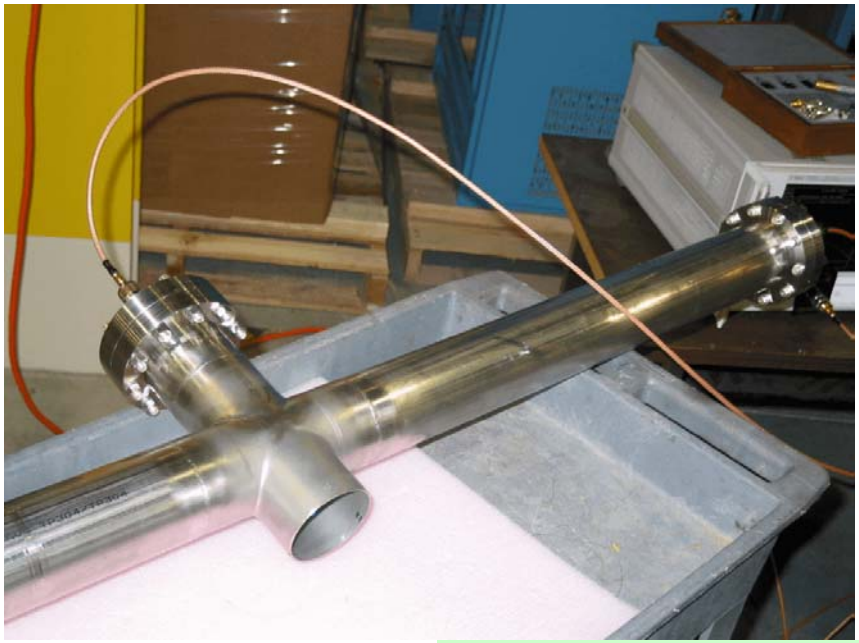
Verification of Connector Weld

Feed-through test



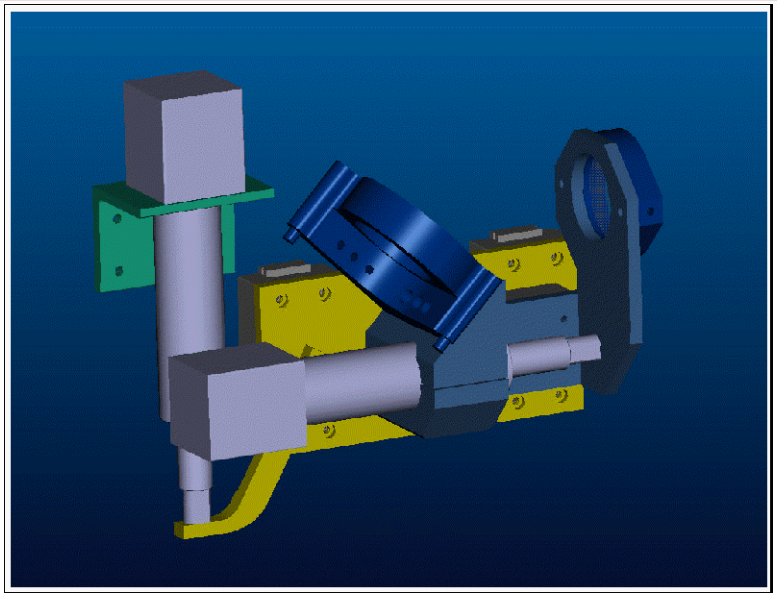
S21 Measurement

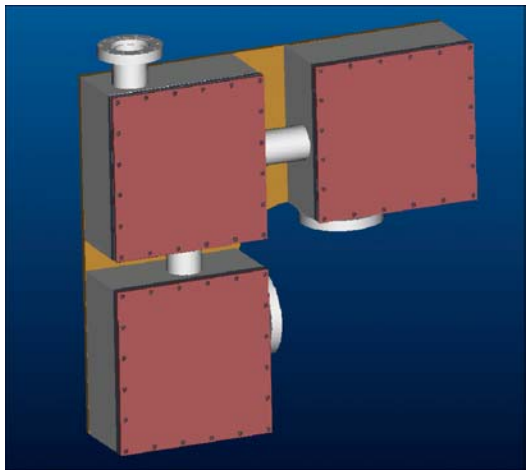
The design of the electron detector is complete and 75 dB of noise (rf) rejection is obtained below 1 GHz. Expected signal Of 100 mV in 50 Ohm and 0.2 mV of RF noise.



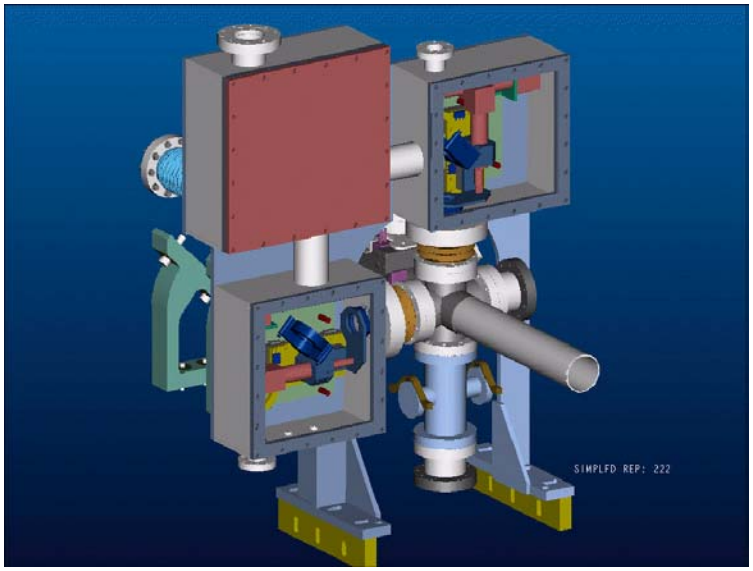
RF testing station

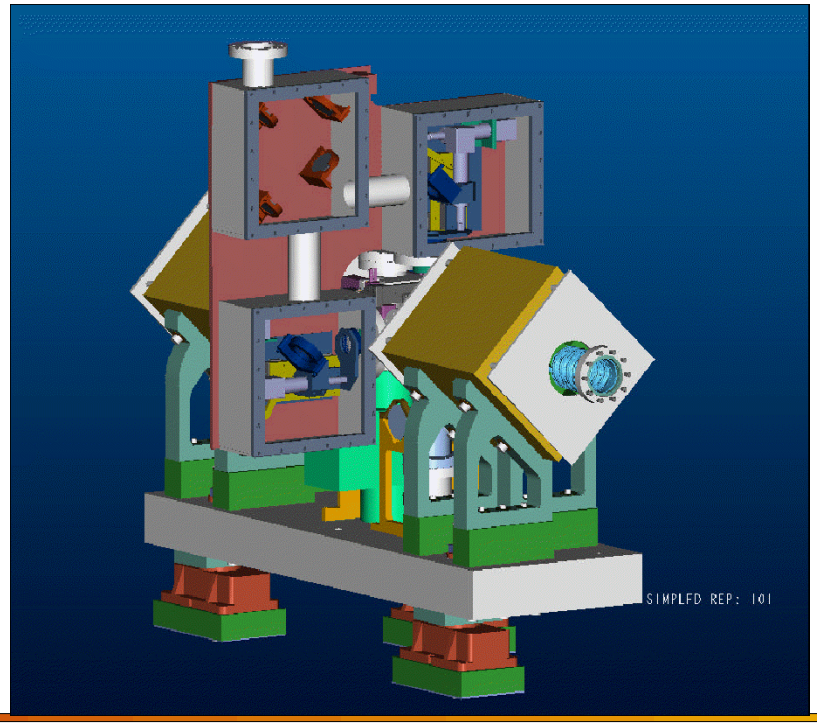
Warm Section with the NEW laser wire beam boxes.





Off the shelf components are used in the new design





Alignment Procedure

Pre-installation

•Scanning optics will be aligned on a bench.

•Position of aligned beam will be pinholed for installation.

Tunnel alignment

•Beam will be aligned incrementally.

•Transport line will be accessible at various locations.

Installation

•Steering mirrors will be used to divert the beam through the alignment pinholes. Some tweaking will be required.

Day-to-day operation

•Alignment will be monitored during normal operation.

Tolerances

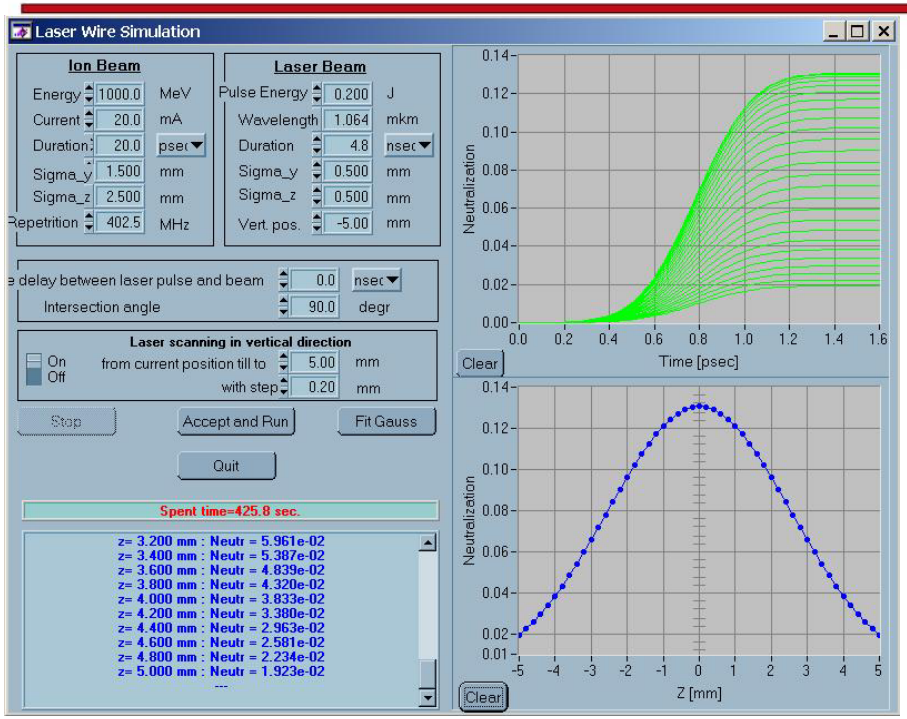
	Δx (μm)	Δy (μm)	Δz (μm)	$\Delta\phi_{yz}$ (mrad)	$\Delta\phi_{xz}$ (mrad)	$\Delta\phi_{xy}$ (mrad)
Focal point	1500	100	2000			
Scan assembly	375	25	100	10	1.3	.067
Focusing lens	375	25	100	Negligible effect	Negligible effect	Negligible effect

Steering mirrors	$\Delta\phi = 60$ μrad

Laser-wire Data-Acquisition and Analysis

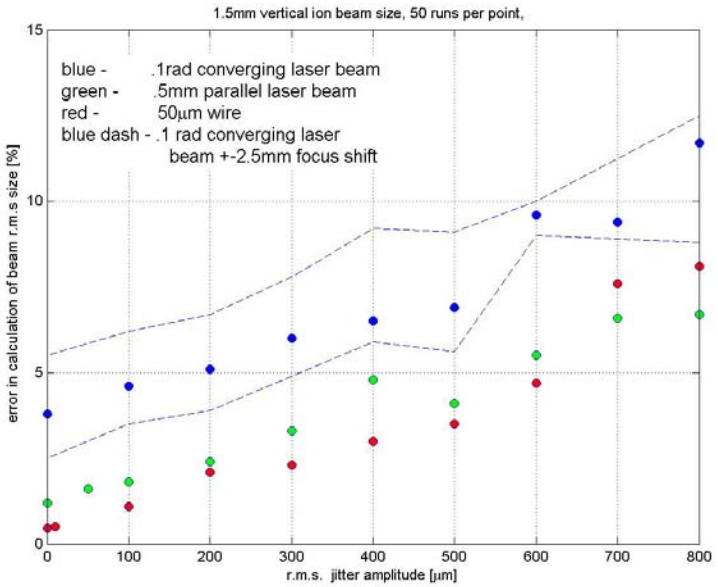
- Data-Acquisition
  - Acquire BCM, BPM, Electrode data at high speeds (possibly lower later) many times during one position (TDS 7404).
  - Acquire Laser Intensity and possibly spot size
- Analysis
  - Correct for Ion and Laser beam intensities
  - Fit and RMS calculation to profile
  - Calculate Laser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

Modeling and jitter analysis guides our design



Models being developed by Sasha Aleksandrov and Victor Alexandrov from BINP

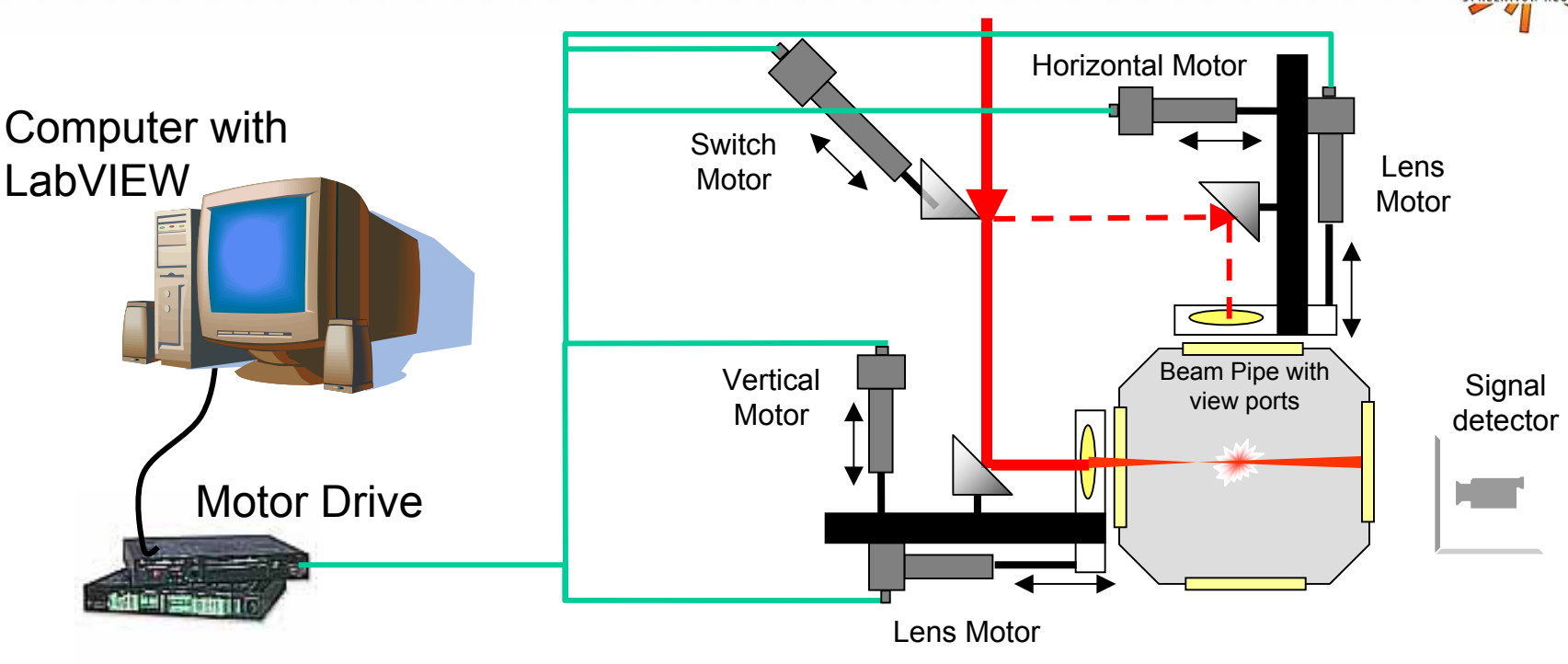
branch at Protvino



Dependence of error upon jitter amplitude for:

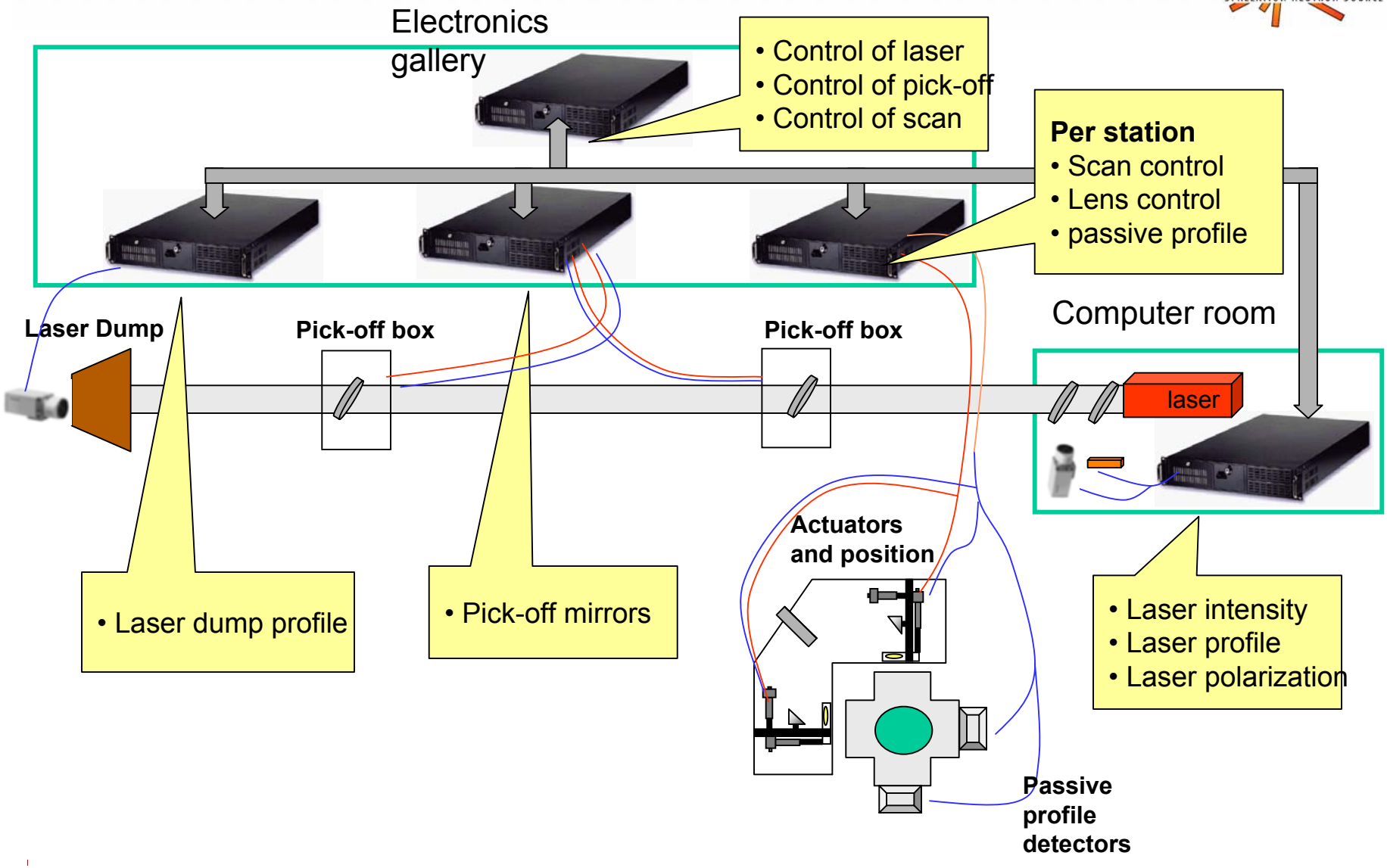
1. Converging laser beam
2. Parallel laser beam
3. Thin wire

Laser-wire Actuator System

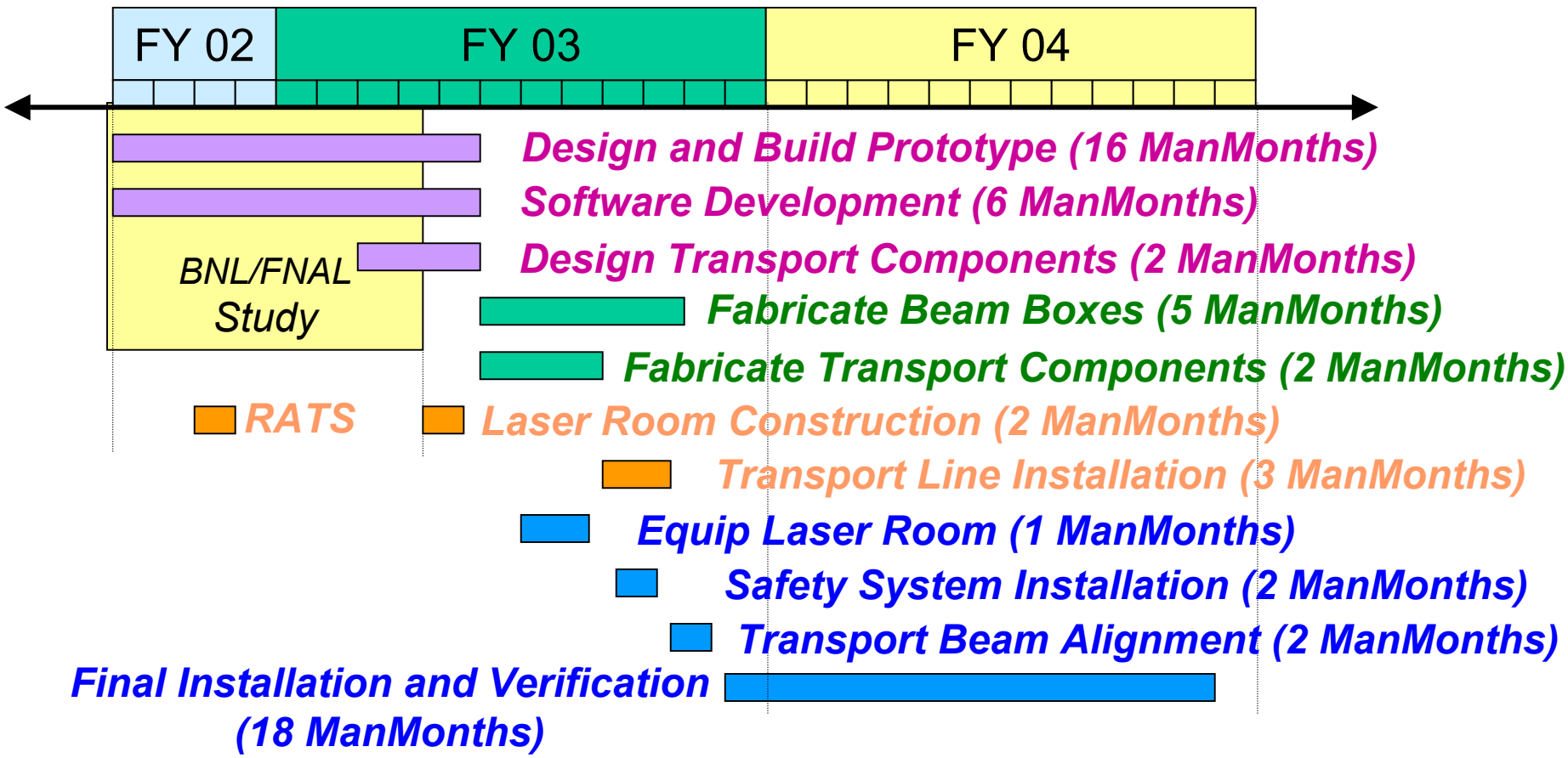


- A rack mounted 2U high PC (Desktop for test)
- NI PCI-7334 motion controller (inside PC) (x2 depending on switch mirror)
- PCI digitizer card (inside PC) (TDS 7404 for test)
- PCI Timing card (inside PC)
- NI MID-7604 4 axis stepper motor driver (1U drive) (x2)
- 4 Ultramotion HT17-075 radiation hard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

Control Overview



Schedule



Total Effort: 4.9 ManYears

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

Our Thanks to Norbert Holtkamp, David Olsen, Marion White, LBNL and the BNL Team

End of Presentation

Backup Materials are posted on the web

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