Fiber Loss Monitor and Carbon IP Scanner

Setup and operational tips

August 15 2008

Fiber loss monitor

- General information.
- Installation
- Calibration & tips on loss location.

IP Carbon wire scanner

- General information.
- Operational Tips.

Fiber General Information

- The fiber is made by the Japanese company Toray. The normal use for this fiber for data transmission applications. It has a 960um core (PMMA), 40um cladding (Fluorinated Polymer) and a black jacket with a 2.2mm OD. It is designed to work with 660nm LED. Attenuation of the fiber used at ATF2 is 0.3dB/meter at 660nm.

More Info.

- This general type of fiber has been used at other labs like DESY and Fermi Lab. Use at SLAC as a loss monitor was begun at NLCTA and has now been installed in various parts of LCLS. The sensitivity of the fiber is better than the ½" gas filled PLIC cables used in other parts of SLAC, and because of its small size the fiber can be placed directly on the beam pipe and inside of magnets. The faster rise and fall times, make resolving discrete losses is easier.
- When purchased in lots 2000ft the cost of the fiber is only 75cents/meter. The cost of the fiber for the ATF2 beam line was only about $75.00.

Radiation damage

- Because the fiber is plastic, radiation damage is an issue. Tests done at SLAC with a cobalt source indicate that the fiber was usable to at least 10000 rads. After 50000 rads the fiber was noticeably darkened and was no longer serviceable.

Beam loss and signal amplitude

- The attenuation of light in the fiber is listed at 0.3db/m at 660nm. Signals produced at the end of the fiber result in lower amplitude PMT pulses.
- The 1st and 2nd fiber lengths are about 43m and 59m respectively. Signals produced near the ends of the fibers will be attenuated by as much as 18db.
- This variation in signal strength along the fiber makes difficult to use the fiber as an absolute loss monitor.

ATF2 installation

The fiber is installed in two sections.

- The 1st piece runs from just down stream of the first extraction kicker and ends a couple meters downstream of QD20x.
- The 2nd starts at about QD16x and runs to the dump.
- Each fiber is coupled to a PMT on the floor and shielded by lead .
- Signals come to the old eel's bedroom on the old septum loss monitor signal cables. Cable 3 for the 1st fiber Cable 5 for the 2nd.
- An web interface was setup to bring the scope picture to the control room.
- Remote control of the scope is desirable

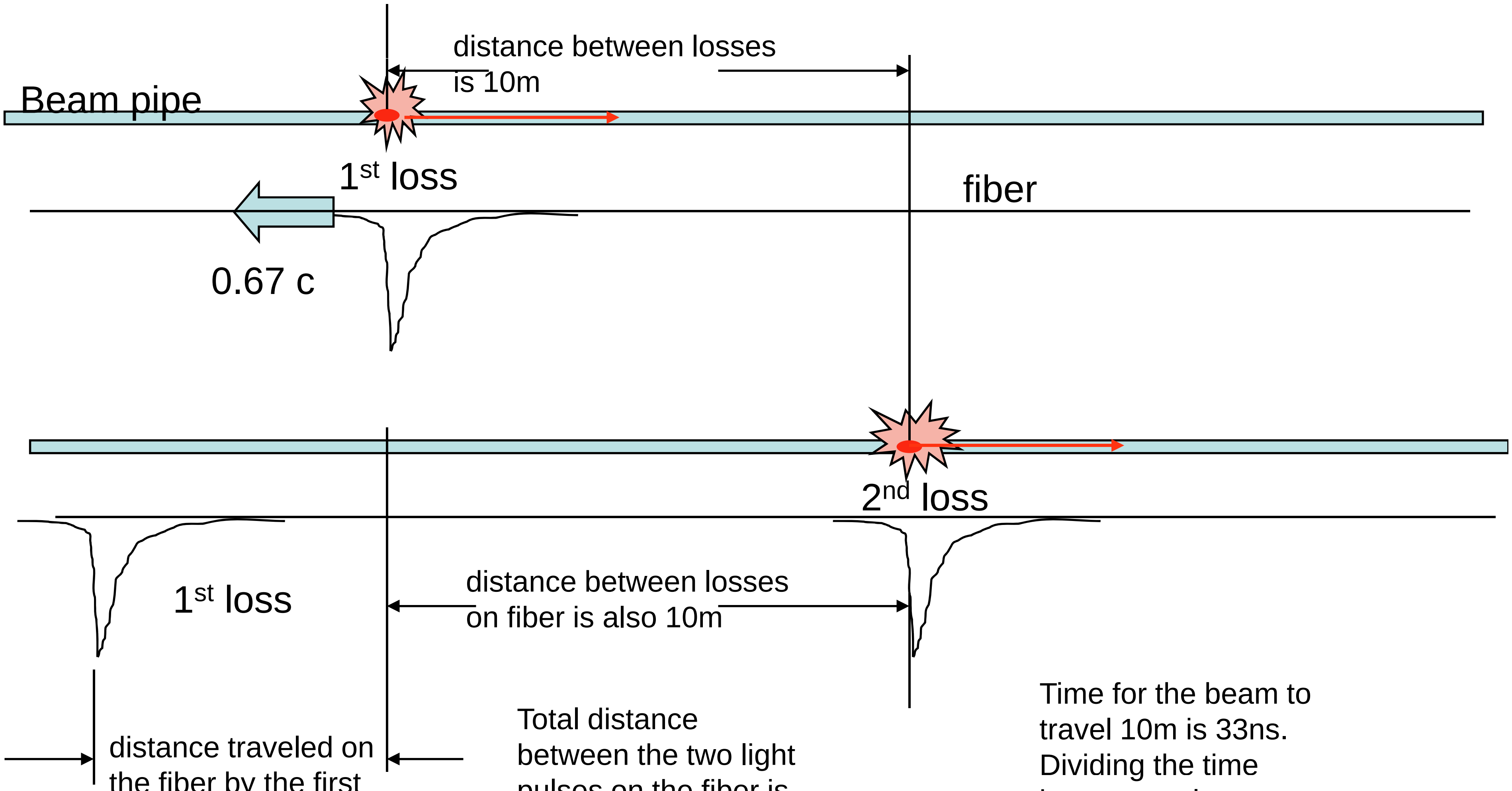
Locating losses

- Calibrating the fiber
  - Tests at NLCTA have indicated that the speed of light in the fiber is about 0.67c.
  - This means that dividing the time between the losses on the scope by 2.49 will give the actual beam travel time between losses. dividing that number by 3.3ns/m will give the number of meters between the losses.
  - Referencing the fiber to locations along the beam line is best accomplished by inserting objects into the beam line. This gives an immediate shower of radiation, and earliest negative edge of this signal from the fiber marks the location of the inserted obstruction. Using this reference, the position of any other loss along the beam line can be calculated.
  - Screen monitors are the typical obstructions used to calibrate the fiber. Vacuum valves also produce excellent calibration signals.

ATF2 Calibration

- The ATF2 has only 2 profile monitors one in each section of fiber. These should be enough to provide adequate references.
- It is important to find the earliest signal from the obstruction.
  - Expanding the vertical range on the scope will show the earliest portion of the signal. Placing a cursor at this location marks the fiber signal. The location of all other losses can be determined by measuring from the first cursor. Losses typically can be pinpointed to under a meter of their actual location.

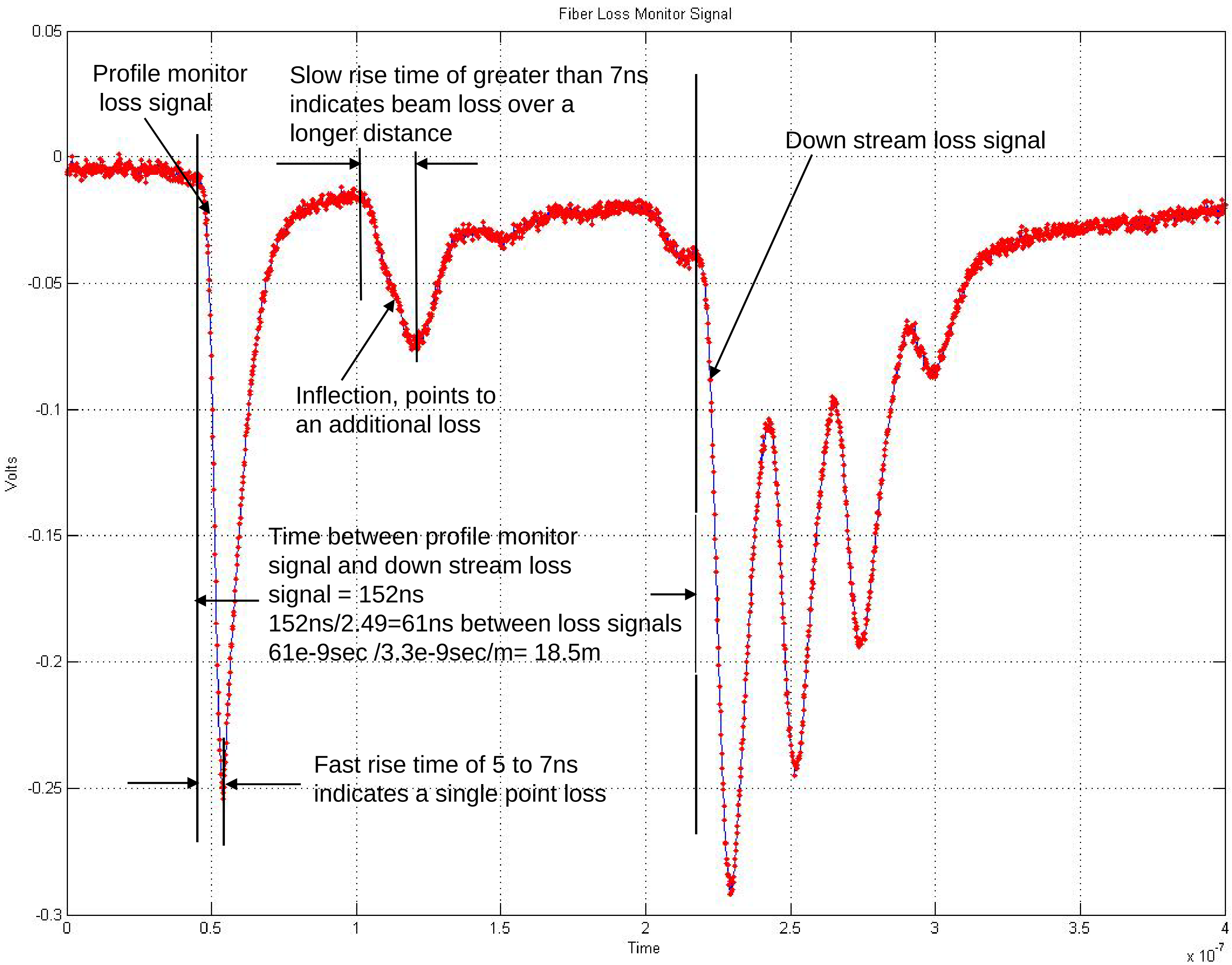
Calculating the distance between beam losses from signals on fiber



distance traveled on the fiber by the first pulse in the time the beam takes to travel 10m is about 33ns x0.67c =6.6m

Total distance between the two light pulses on the fiber is 10m+6.6 m = 16.6m. Total time between the pulses is 16.6m/0.67c=83ns. This is the time on the scope

Time for the beam to travel 10m is 33ns. Dividing the time between pulses on the scope (83ns) by **2.49** yields the correct beam travel time


Fiber Loss Monitor Signal
Profile monitor loss signal
Slow rise time of greater than 7ns indicates beam loss over a longer distance
Down stream loss signal
Inflection, points to an additional loss
Time between profile monitor signal and down stream loss signal = 152ns
152ns/2.49=61ns between loss signals
61e-9sec /3.3e-9sec/m= 18.5m
Fast rise time of 5 to 7ns indicates a single point loss
Volts
Time
x 10-7
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
0
0.5
1
1.5
2
2.5
3
3.5
4

Loss Locating Tips

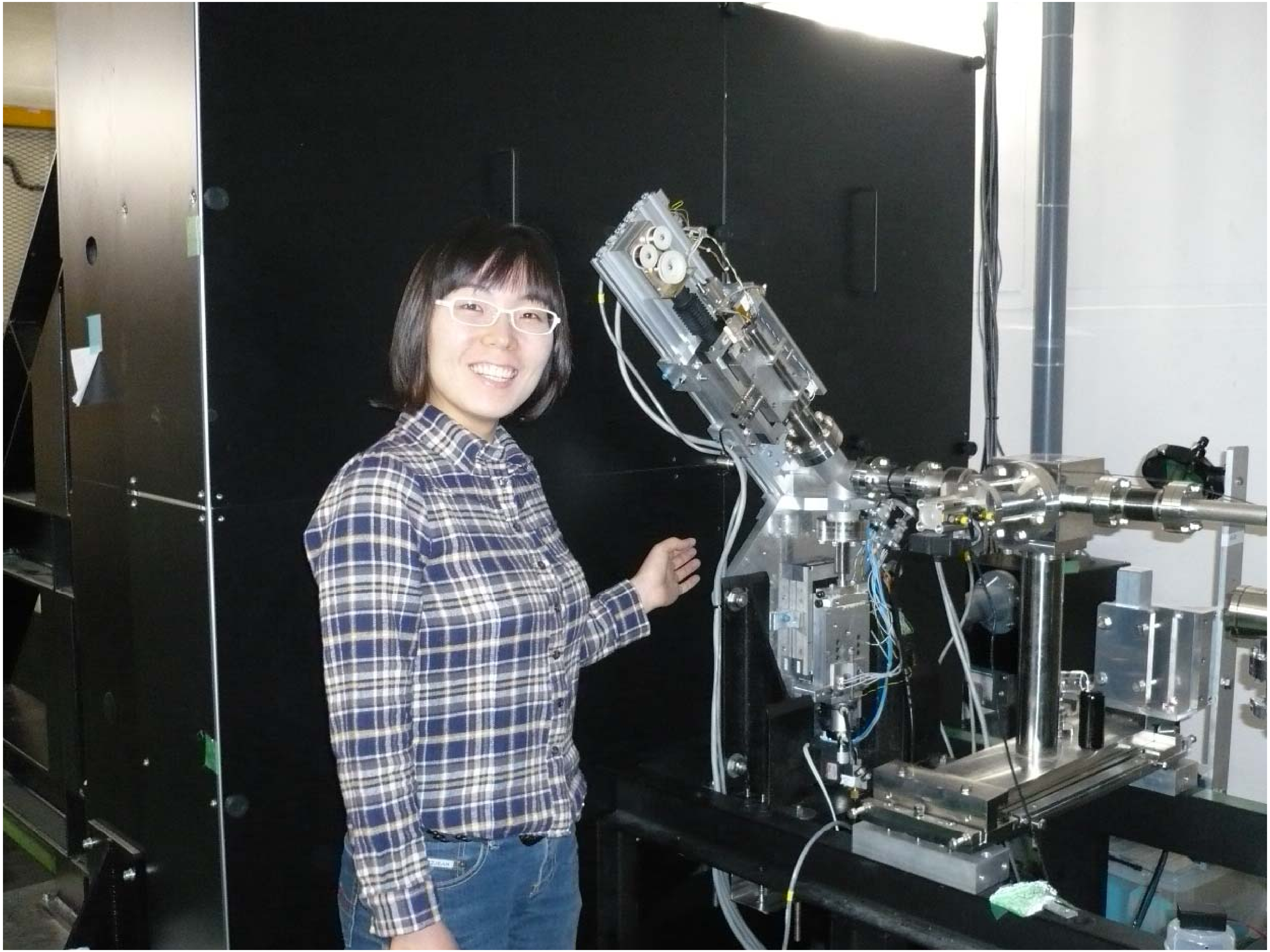
- Find a reference point.
  - Insert a device into the beam
  - Expand the horizontal and vertical scope scale to locate to locate the very start of the loss.
  - Place a scope cursor there to mark the location. Then remove the device.
- Measure the time to other losses
  - Use the other cursor to find the time to the other losses.
  - Calculate the distance from the device that was inserted into the beam line the other losses.
- Only negative slopes are losses.
  - Look for small losses in the positive slope portion of the waveform
- Observe the fall times.
  - Single point losses have a fall time of about 7ns. Fall times greater than that are from consecutive losses.
  - Look for slope inflections in the fall times from consecutive losses.

Carbon/ Tungsten IP scanner Overview

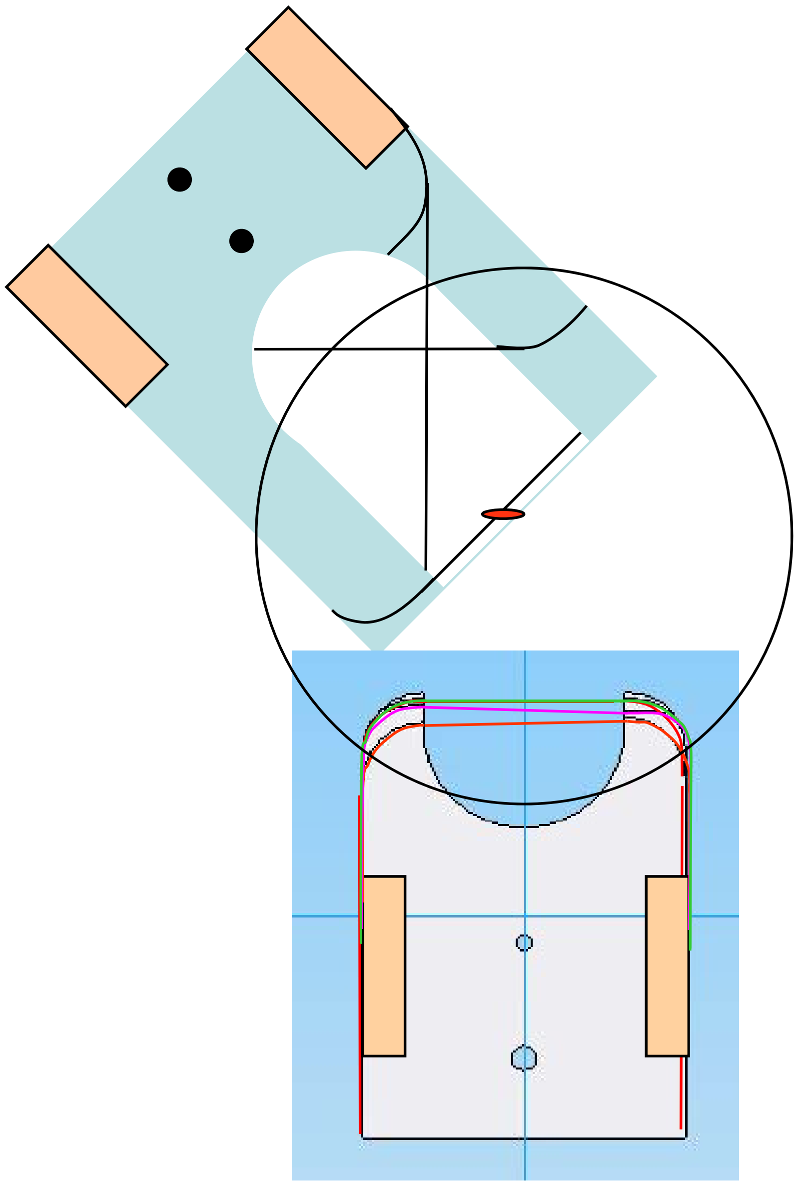
- The IP scanner was assembled from two different wire scanners used in the SLAC FFTB.
  - The 45 degree scanner's slide moves 1um /step. This translates into a wire motion of .707um/step. The vertical slide and wire moves 100nm/step.
  - Additionally the vertical scanner has a pneumatic actuator that moves the fork quickly to the in position where the wire scan is started.
- The 45 degree scanner's three 5um carbon wires were replaced with three10um tungsten wires. It was felt that the 10 um wires would provide a better signal for large initial beam sizes. These wires measure X, Y, sizes and coupling.
- The vertical scanner has three 5um carbon wires. One wire is horizontal while the other two are at +- 1.3 deg to the horizontal wire.

Overview cont.

- Each scanner has a LVDT that is used to position the wires for the start of a scan. The resolution of the LVDTs is not great enough to be used during a scan. Step counts are used to provide the wire position during a scan.
- At this time, the motion of the scanners is provided by Joerger camac modules. The maximum speed of the motors must be set with the F17 command to 6009 (hex)



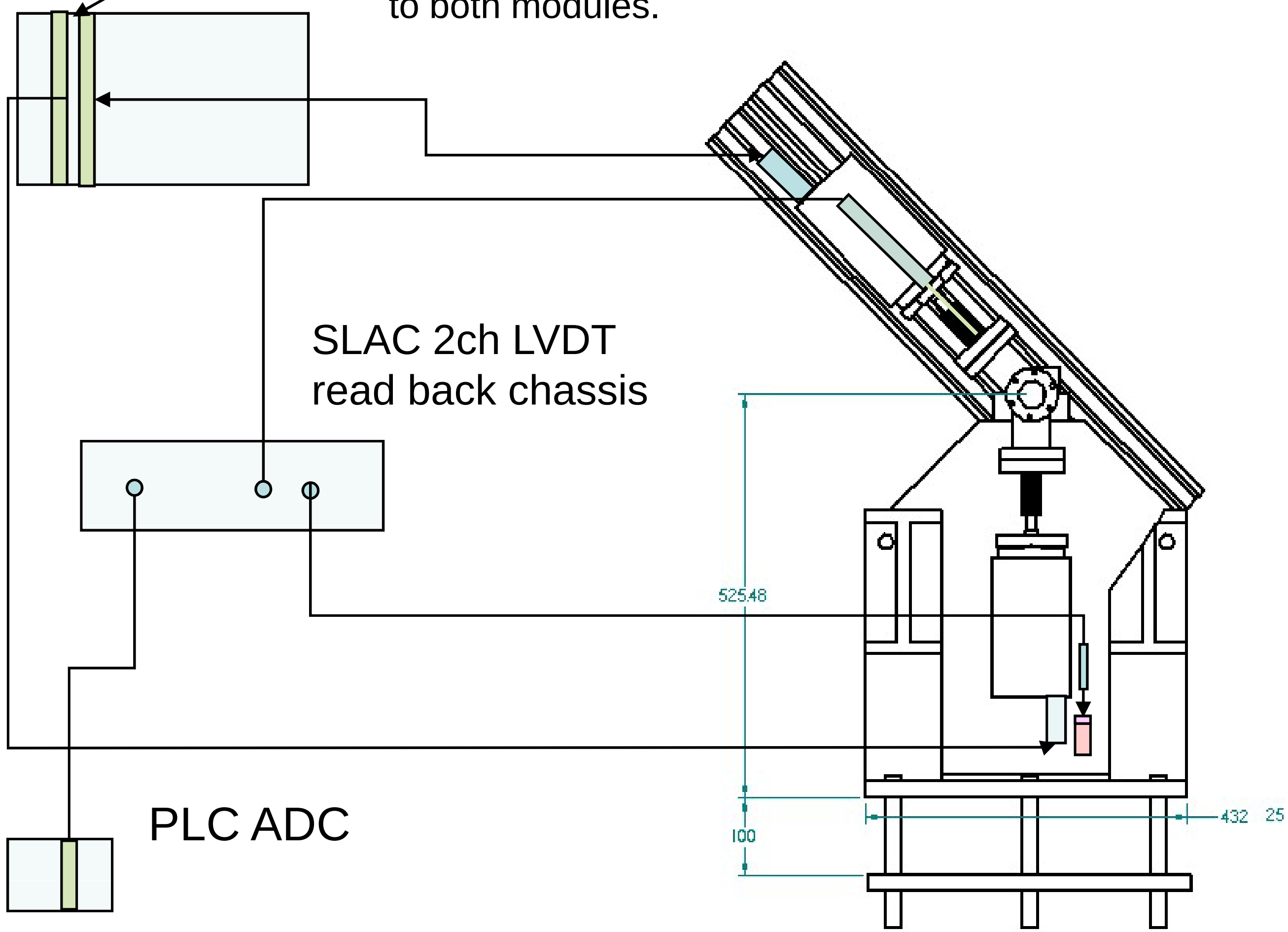
Vertical and Horizontal scanner fork relative positions



Forks are displaced in Z by about 1.5 cm

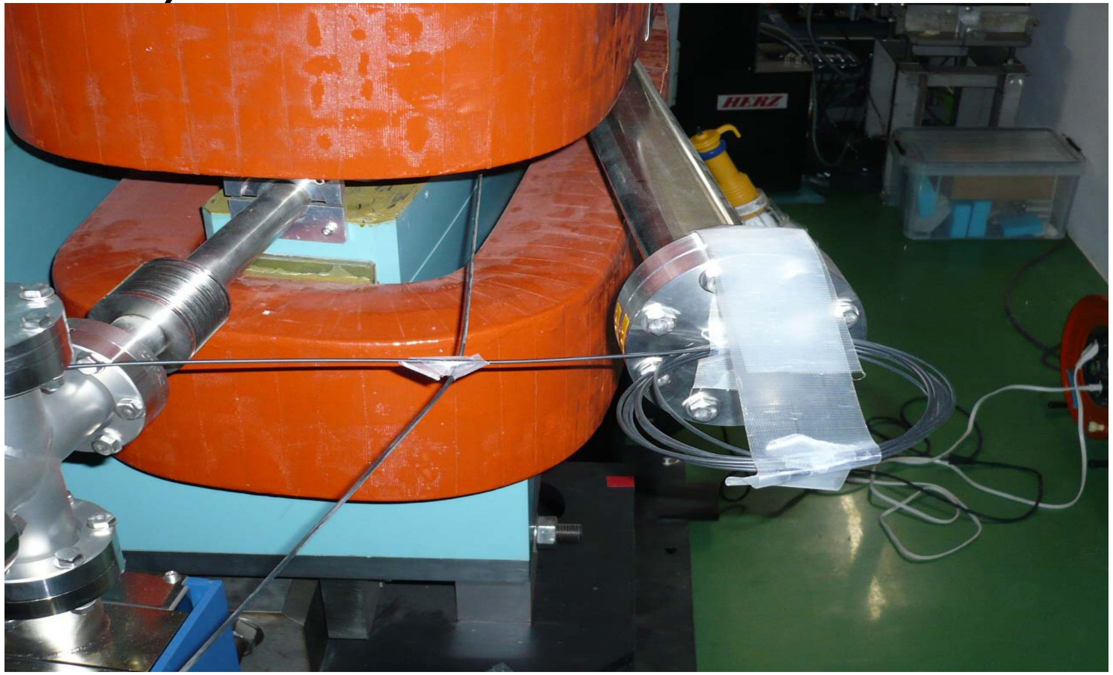
Electronics for Control of IP scanner

Camac Joerger stepper motor modules. Control software by ATF personnel
Wire scanner speeds must be reinitialized after
crate power is cycled.
The f17 =6009 a=0 command is sent
to both modules.



Detectors

- The main detector for the Carbon scanner is the Shintake monitor detector. Other options for detectors are:
  - Old Laser Wire detector.
  - The fiber loss monitor. (signal needs to placed into a gated ADC)



Initial setup and Operation

- Once a stable orbit is obtained through the IP, the position of the wires with respect to the beam can be determined.
- 45 degree scanner
  - Has an range of motion of about 24mm from the out to the in limit switch.
  - Wire is moved into the beam. Max linear speed is about 200um /sec.
  - First wire in is the diagonal wire. When detector signal is observed LVDT readout in mm is recorded.
  - The process is repeated for the vertical and horizontal wires.
- Vertical scanner
  - The air cylinder is activated and the fork is moved into the beam .
  - This scanner only has a range of motion of about +-3.0 mm and a maximum speed of 20um/sec.
  - Depending on the location of the beam, the vertical slide will have to be moved in or out to find the position of the beam.
  - If no beam signal is found with in the range of the +-3.0 mm, an access can be made to adjust the range of the pneumatic actuator.
  - Alternatively the beam can be moved to find the wires. This will indicate which direction the pneumatic actuator will have to be adjusted.

Summary

- Fiber loss monitor
  - Fibers installed and producing signals.
  - Determining the actual location of a loss requires careful observation and measurements of the signals
- Carbon IP scanners
  - Are mechanically ready but need operational detectors.
  - Need to find the position of the wires with respect to the beam.