Forward Proton Detector
Detector Construction

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Detector Needs

- Position resolution of 100µm
  - Beam dispersion and uncertainty in beam position make better resolution unnecessary
- Efficiency close to 100%
- Modest Radiation Hardness
  - Operates at 8σ from beam axis, 0.03 MRad yearly dose expected
- High Rate capability
  - Active at every beam crossing
- Low background rate
  - Insensitive to particles showering along beam pipe
- Small dead area close to the beam
  - Protons are scattered at very low angles, acceptance is very dependent on position relative to beam

- Scintillating Fiber detector meets these needs
Detector Setup

Six planes (u,u',x,x',v,v') of 800 µm scintillating fibers (') planes offset by 2/3 fiber

20 channels/ plane(U,V)(')
16 channels/plane(X,X')
112 channels/detector
18 detectors
2016 total channels
4 fibers/channel
8064 fibers
1 250 µm LMB fiber/channel
8 LMB fibers / bundle
252 LMB bundles
80 µm theoretical resolution
4 fiber bundle fits well the pixel size of H6568 16 Ch.
MAPMT

7 PMT's/detector
16 250 µm fibers each PMT

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Detector Fibers

- Scintillating fiber is spliced to clear fiber
  - Increased halo background with scintillating only
  - Light output improved due to longer attenuation length of clear fiber
  - Cross talk is reduced

- Mirrored side

- Fibers produced by Bicron
  - 0.80 mm square multiclad fiber emitting in blue $\lambda$

- Square fiber can only be polished using ice polishing method at FermiLab Lab 7

- After polishing fibers are inspected for deformity and cladding damage and repolished if needed
Detector Frames

• Cast at FermiLab Lab 5 plastics shop

• Original aluminum machined piece is molded and production pieces are cast in polyurethane
Splicing

• Splicing being completed at UTA
• Fibers spliced using a version of the MSU splicing machine modified for square fibers

• With proper setup, light transmission through splice point of over 90% possible
• Afterwards, splice point is sensitive to bending stresses so care must be taken
  - Shrink tubing cannot be used to strengthen splice due to space constraints
Frame Assembly

• Being completed at UTA
• Detector active area (17.42 mm from bottom) is marked on frame
• Four fibers have splice point aligned
• Splice point is aligned with mark in frame

• Bicron optical epoxy is used to secure the fibers into the frame once completely assembled. The glue cures overnight.
• With x’ frame an additional step is needed because of trigger scintillator
  - Trigger scintillator is cut and glued to wave guide at FermiLab Lab 6
  + Scintillator is coated with Aluminum at FermiLab Lab 7
Cookie Assembly

- After both sides of frame are completed the fibers can be glued into the cookies.

- Detector is clamped to a vertical wooden backboard and proper distances are measured.

- Fibers are secured with Bicron optical epoxy.
Phototube Testing

- At D0 DAB3, phototubes are tested using an LMB with a modified cookie.

- The LMB pulses all 16 channels of the MAPMT simultaneously and ADC information is recorded for each channel.

- The average ADC count of the 16 channels is used to bin the tubes in groups of 7 with spares and these bins are assigned to locations in the tunnel.

- The LMB also strobes the L0 tubes and they are binned in groups of 4 with spares.
Full Detector Assembly

- After arrival at FNAL, the inside edge of the U/V frames are cut and diamond polished at Lab 6 then aluminized at Lab 7

- The detector frames are assembled with care taken in alignment of U/V with the X into a block and secured with screws

- The bottom is cut and diamond polished then aluminized
Mapping

- The aluminized detector is disassembled and mapped using a 2 micron optical scanner
  - The aluminization helps light reflection to measure the edges of three overlapping fibers in each frame

- Each frame is measured in its "native" coordinates. The locations where 3 fibers overlap are used to define an active channel

- Data is collected for alignment of frames with respect to each other and with respect to a common reference point in the pot

- This allows us to have a real pixel map for each detector
Cartridge Assembly

- The cartridge houses the detector and phototubes in the roman pot in the tunnel.

- The cartridge bottom is installed in the tunnel and the detector is pushed to the bottom of the pot.

- The Cartridge top fits over the bottom and is secured down causing good contact between the tubes and cookies.
Detector Installation

- The cartridge bottom is installed in the tunnel and the detector is pushed to the bottom of the pot.

- The Cartridge top fits over the bottom and is secured down causing good contact between the tubes and cookies.

- The HV is tested to ensure that the splitter is working properly.

- Signals are measured from the tubes using dark current to verify bad channels.

- LMB signals are amplified and measured at the SCR using the DAQ.
8 detectors are installed in the tunnel

4 additional detectors are being finished at UTA and assembled for insertion in tunnel. Tubes are available for 10 detectors and installed

8 additional detectors will be constructed for insertion into tunnel next Summer for Phase II

New subcomponent of FPD project is the Veto Counter located on the inside edge of Low Beta Quads at the beam pipe for more effective veto