Scintillating Fiber Detectors

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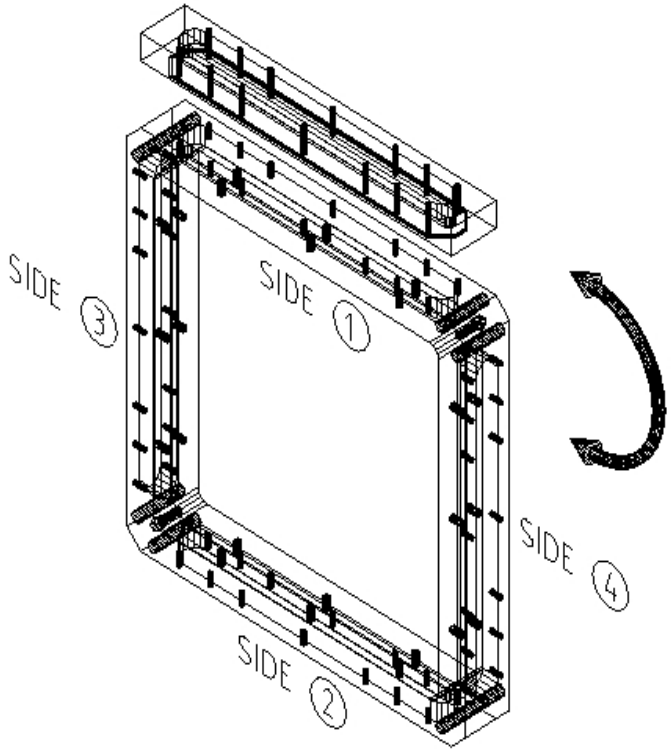
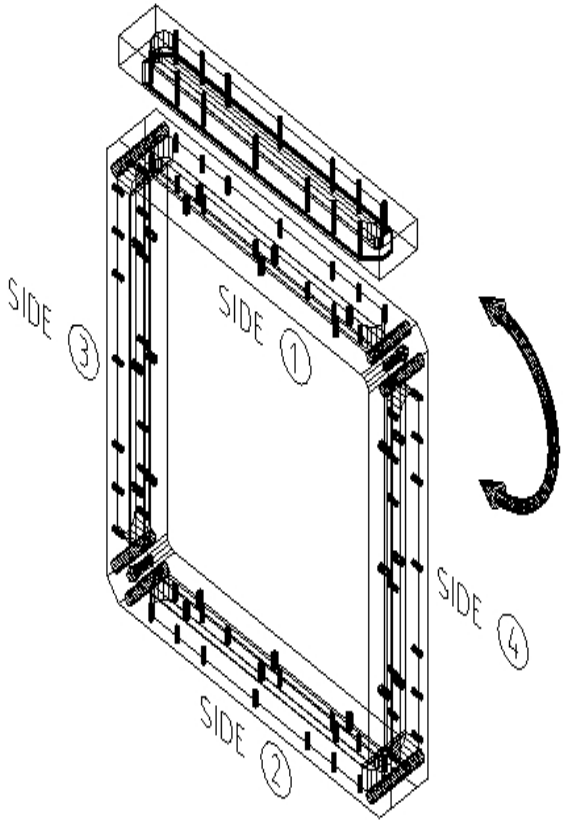


Advantages of SciFi

- Detectors are mostly Hydrogen and Carbon − low radiation length
- Clear fiber is efficient at transporting light − Photo−detectors and electronics can be far from the beamline
- Light yield per unit mass is high − detectors can be very thin
- Detector is very cheap − disposable

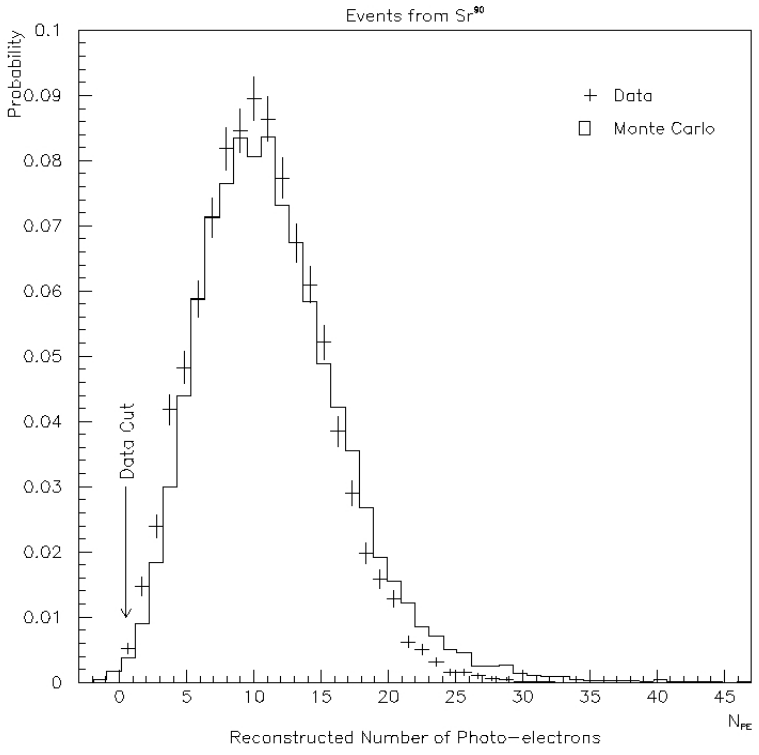
Scintillating Fiber Tracking System



- Composite detector made of Scintillating fiber imbedded in epoxy
- Position resolution of approx. 200 μm
- Time resolution of approx. 500 ps
- Efficiency of > 99% and uniform across the entire active area (30 cm by 30 cm)
- Angular resolution will be 0.2 mrad
- Operates in vacuum vessel

Number of P.E. From Prototype

- A prototype SciFi detector has been built and studied using a Sr90 source
- The overall number of P.E. Expected for a 180 MeV muon is about 18



Construction of a detector

- Two planes of square fibers are used, giving profiles in orthogonal directions
- Fiber planes are vacuum impregnated in epoxy for structural support
- A ’picture frame’ is used for mounting the detector and light guides

Readout Strategy

- Clear Fiber light guides take light away from beam line
- Light is converted to an electrical signal using either multi−anode PMTs or HPDs
- A sample and hold circuit is used for each channel to acquire the analog signal
- Some type of multiplexed ADC is used, due to the large number of channels

Number of Photo−Electrons using 0.25 mm fibers

- 0.055 MeV deposited per muon
- Photon yield is about 8000/MeV dep −> 440 photons
- Capture efficiency is 7.3% −> 32 photons
- Maximum attenuation in fiber is ~27% −> 23 photons
- Transmission to clear fiber is ~80% −> 18 photons
- Quantum Efficiency of a PMT is ~20% −> 3 photo−electrons
- Thickness of detector is 0.12% of a radiation length
- Expect about $5x10^{10}$ P.E./bunch in a central readout channel, so we could make the detector thinner, reduce the scintillator doping concentration or not need much amplification
- We could start building one tommorow

Possible Configuration – 60 cm by 60 cm

- Readout in 1mm strips would yield 1200 channels per detector
- Requires 2.9 km of Scintillating Fiber − approx. 4000 GBP
- Requires 6−12 km of Clear Fiber − approx. 6k−12k GBP
- Requires 1−2 HPD or 19 64−Anode MAPMT − approx. 40k GBP (MAPMT option)
- Front−end electronics and ADCs − ????

A Pixel SciFi Detector?

- Squares of scintillator or of scintillating fiber composite readout with wavelength shifter and clear fiber
- Bring the clear fiber out of the the plane so that all pixels can be the same size
- Geometry is somewhat complicated, is it practical to build such a device?
- Light yield should be similar to the SciFi profile detector, so not a problem
- Likely to be about 0.2%−0.3% of X_0

Questions

- How sensitive are these detectors to radiation from RF cavities?
- What is the likely radiation dose in the cooling channel?
- Are pixels needed?
- How are the detectors to be used? Permanently fixed or retractable?
- What position and time resolution are needed?

Conclusions

- Scintillating fiber devices provide a simple way of measuring the muon beam profiles within the cooling channel
- The detectors present very little material to the beam and require only a small amount of space, including space for signal extraction
- The technology exists now, but needs to proven in the cooling channel environment
- Readout electronics will have to be developed to deal with the large number of channels cheaply