ILC Muon Identification Scintillator Detector Plane Test BeamStudies

Caroline Milstene
Fermilab
In Collaboration with G. Fisk & R. Abrams

Outline

- Muon Detector R&D Objectives
- Scintillator Detectors and Test Beam Setup
- Measurements and Test Results
- Near Term Plans
- Future Plans

Proposed SiD Muon System/Tail Catcher

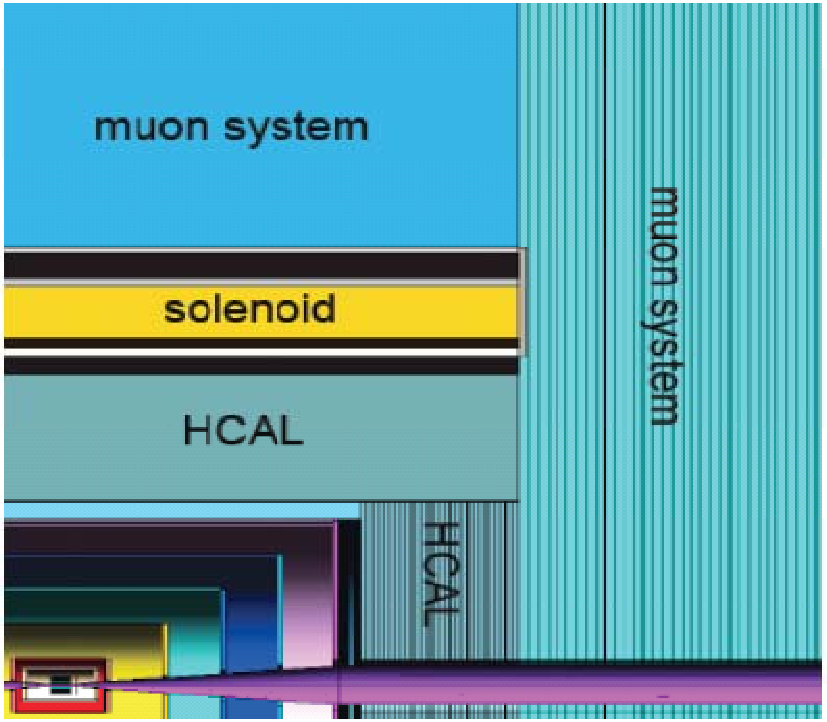


Figure 1 Illustration of a quadrant of SiD.

The Muon Detector follows
- ~6 Interaction lengths (λ) of material
  - 0.8 λ from Ecal
  - >4 λ from Hcal
  - ~1.3 λ from the Coil

Is located in the Iron used for the flux return of the 5 Tesla Magnet –
Total detector area ~6000 m2 for 14 layr

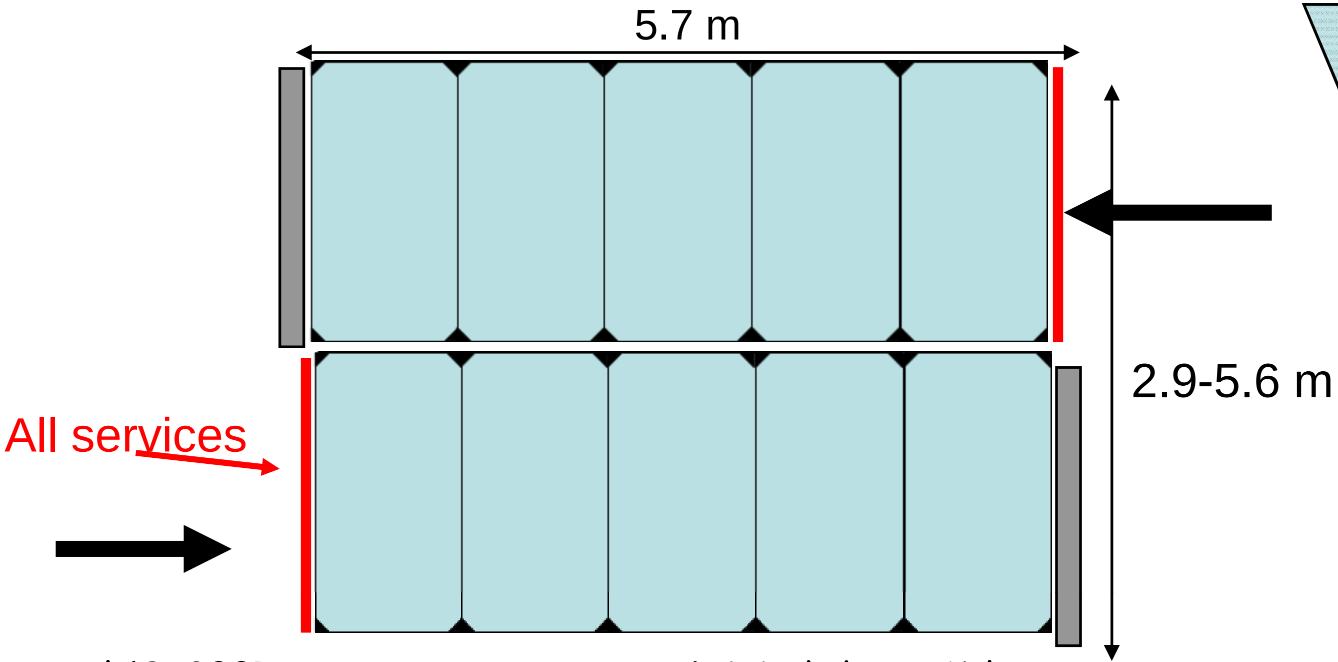
Detail: In both the Barrel and the End-Caps
- 14 layers with 10 cm thick Fe
- 4cm gap Instrumented

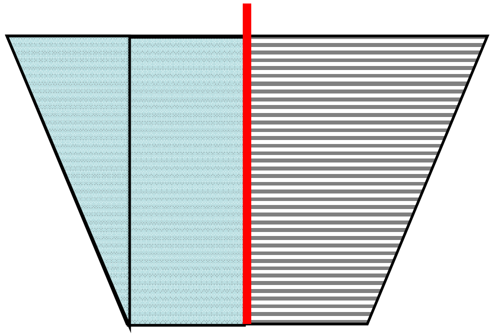
Technologies mostly considered
- RPC /GEM and **Scintillator Strips**
- Scintillator Strips with Wave length shifting fibres spliced to clear fibres and Multi-anode Photomultipliers (MAPMT) Hamamtsu H7546B

Remark: Multi-pixel Si detector may be a cost effective alternative is under study

Barrel Layout

- **Assume Octant geometry**
  - **½ width covered by staggered gusset plates on each end**
  - **2 ½ width chambers inserted from opposite ends**
- **# of layers and gap thickness drive outside radius and amount of steel needed**

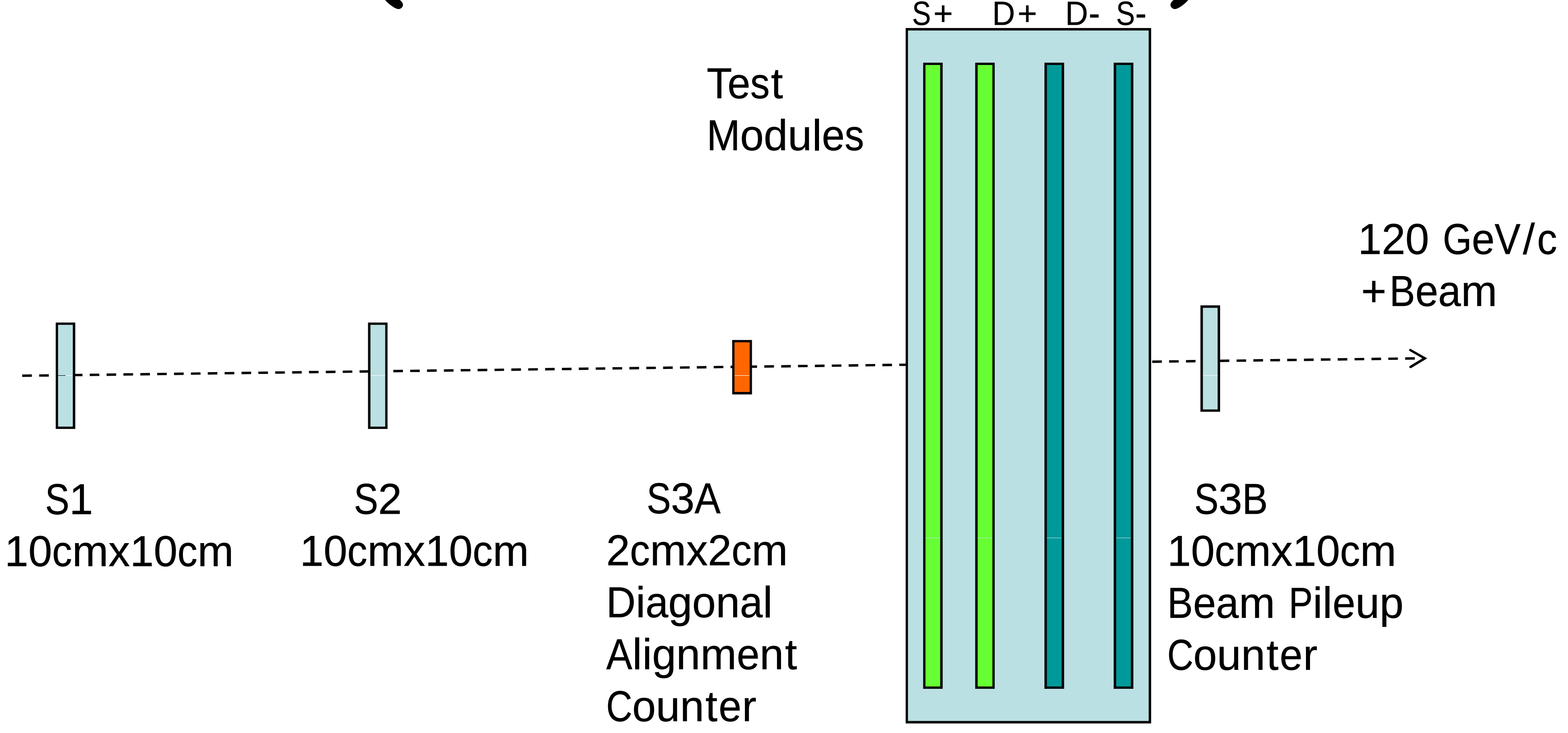




Prototype Scintillator R&D Goals

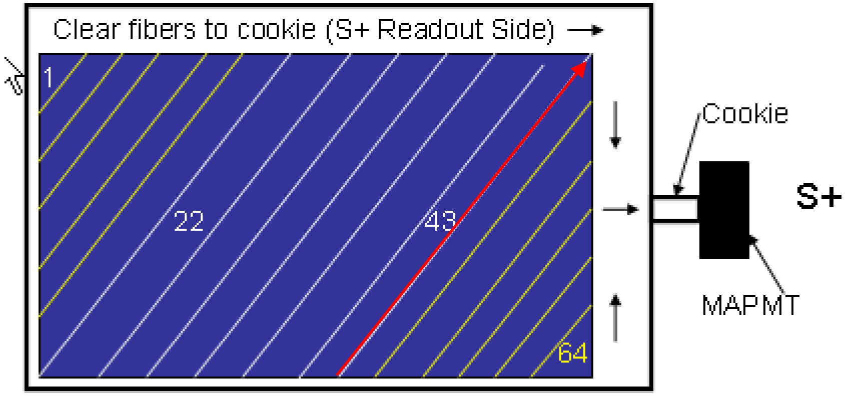
- **Performance Related**
  - -Muon detection efficiency per layer.
    - Meas. charge => no. of photo-electrons.
    - Dependence on WLS fiber.
  - Uniformity of the response across the detector?
  - Utilization as a tail catcher
- **Design and Cost Related**
  - Readout both ends versus one end of each strip? (cost effectiveness)
  - Refinements or modifications needed? .
  - Basis for comparison with other techniques. e.g. RPC's
  - New photo-detector technology? e.g. Si PM

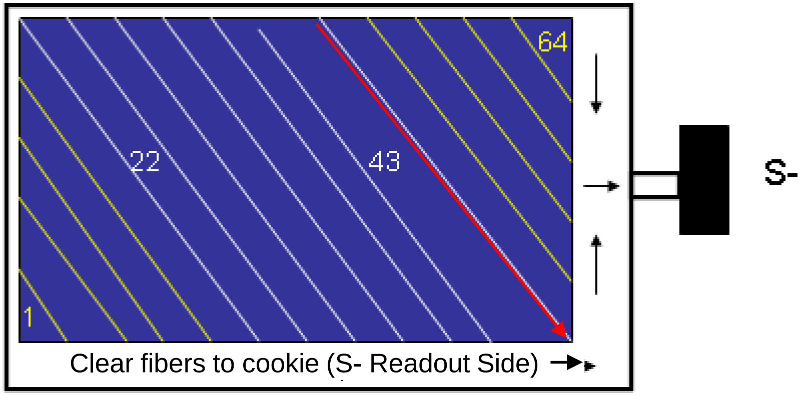
Beam Trigger (S1.S2.S3A.S3B)



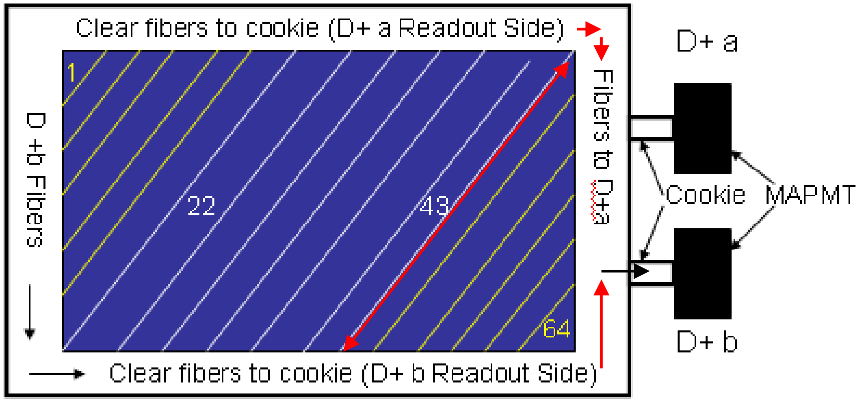
Four Detector planes

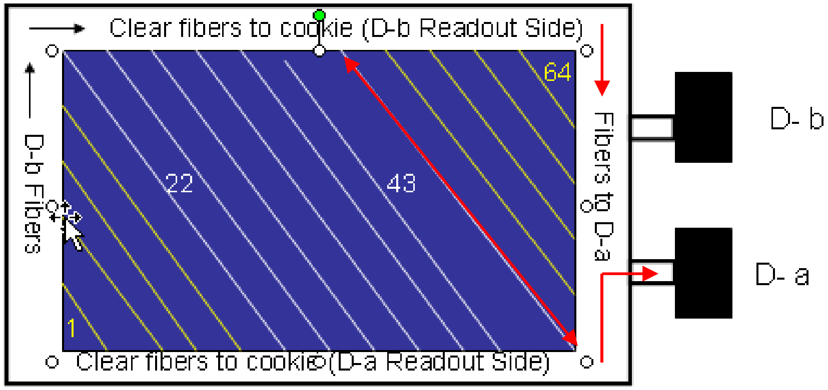
Single ended readout





Dual readout

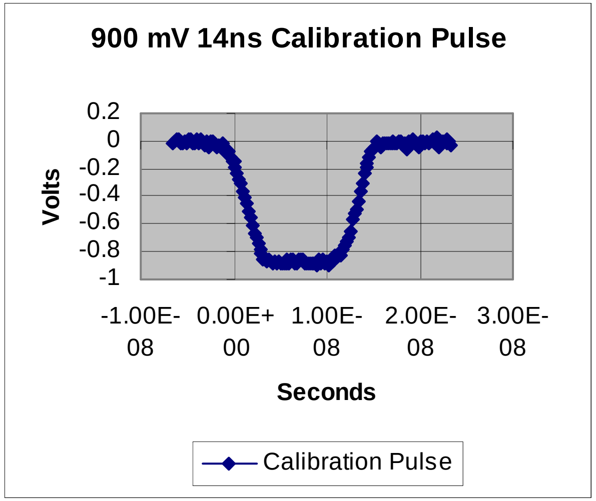


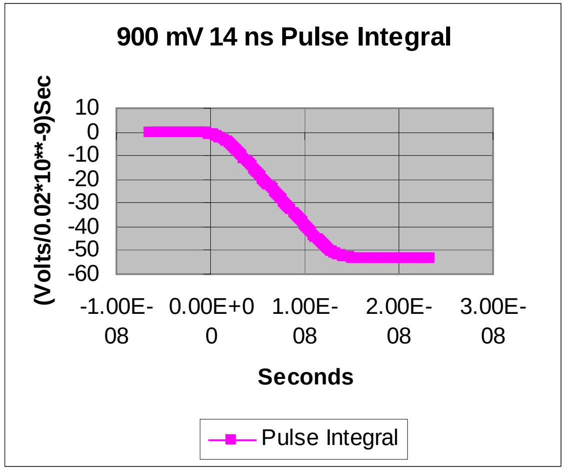


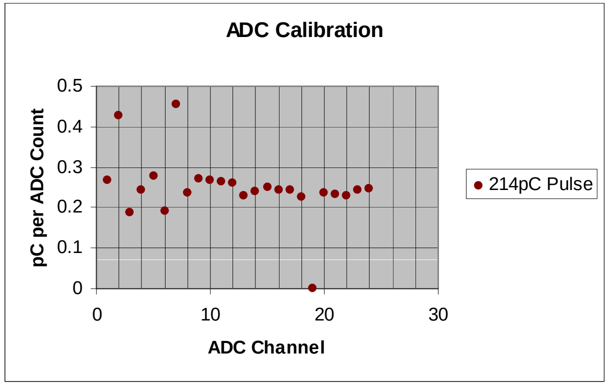
Beam Operating conditions

- DAQ triggered on beam; no strips in the trigger.
- As prime user we had low intensity, ~ 1000p/sec during spill, two 1-sec spills/minute, 12 hours/day.
- As secondary user we operated up to ~20,000p/sec.
- DAQ data rate limited < 50Hz.
- Beam spot at +120 GeV/c ~ 1 cm FWHM
- Additional beam particles within ADC gate (170ns) ~10% of time, even at low rates.

Calibration of ADCs

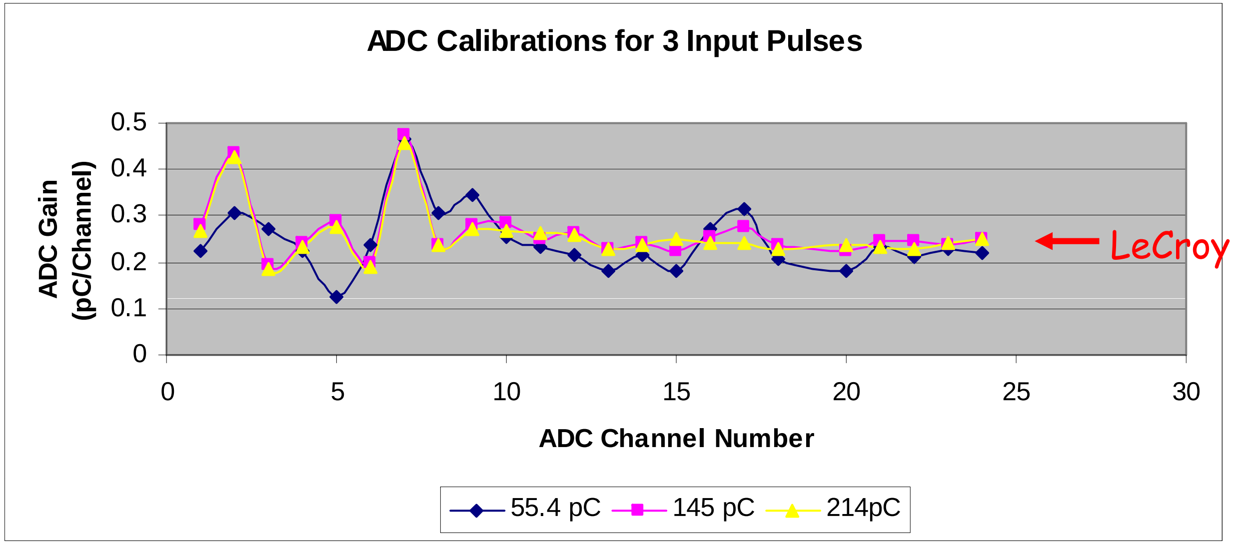






107.2 e-10 V-s
Q=214 pC

Additional Calibrations for 56.4 pC and 146pC



Distributions from Composite Run 6446 at (+38, -38)

11450 Total Events

S+ mean 439.2

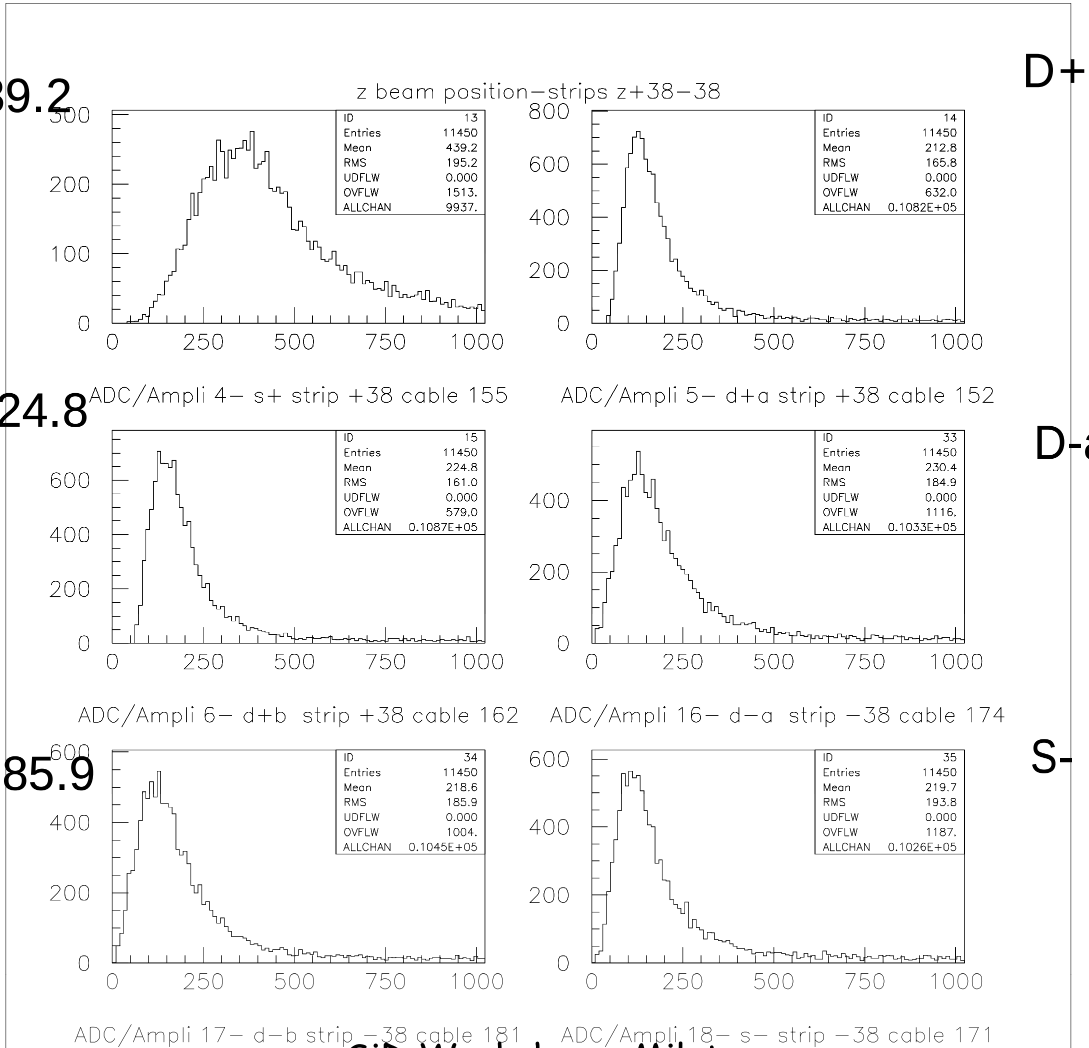
D+a mean 212.8

D+b mean 224.8

D-a mean 230.4

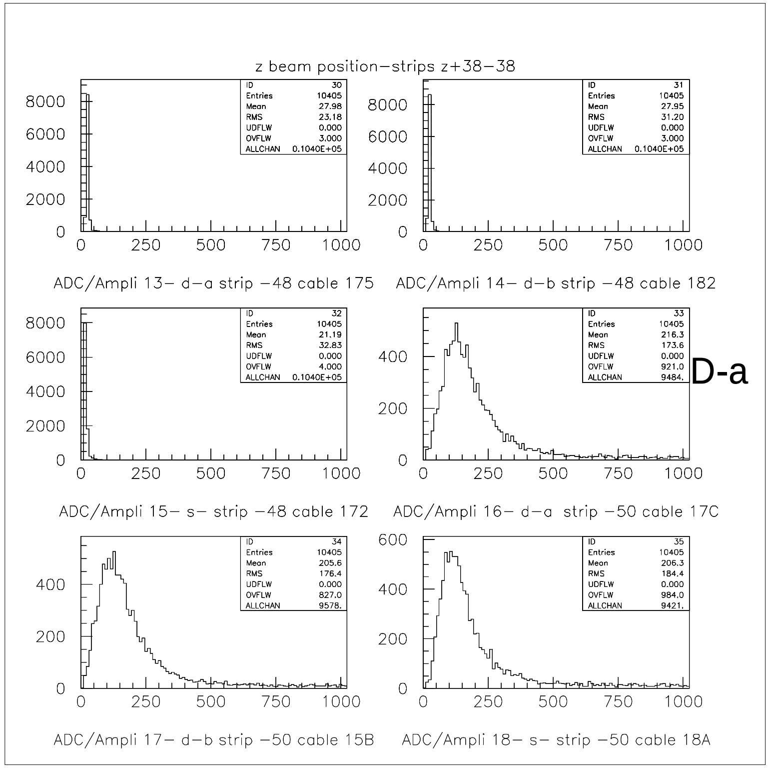
D-b mean 185.9

S- mean 219.7



Single and Double Beam Events from Run 6446

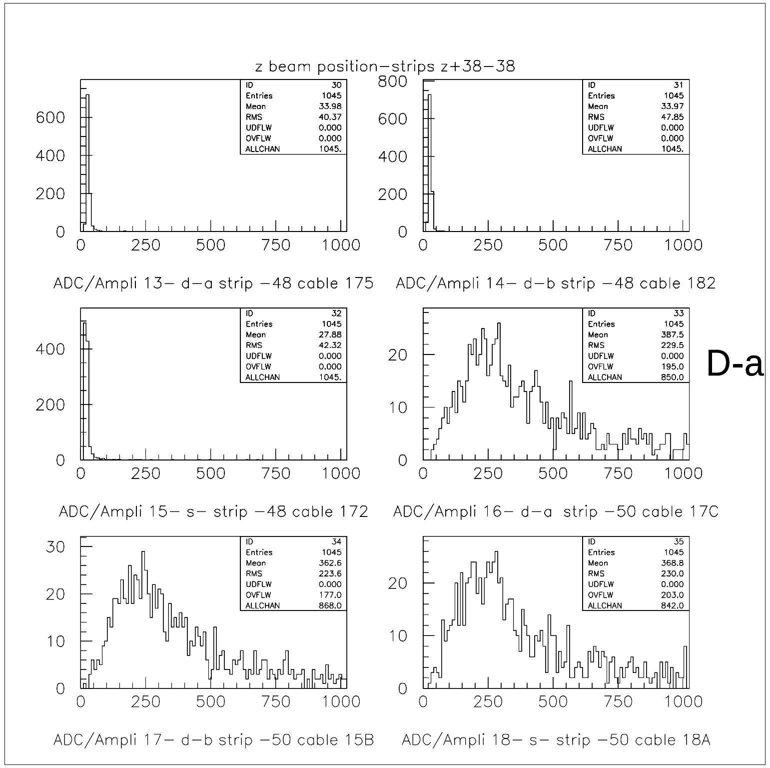
10405 Single Beam Particle Evts



D-a Mean = 216.3

D-a Overflows =921 = 8.8%

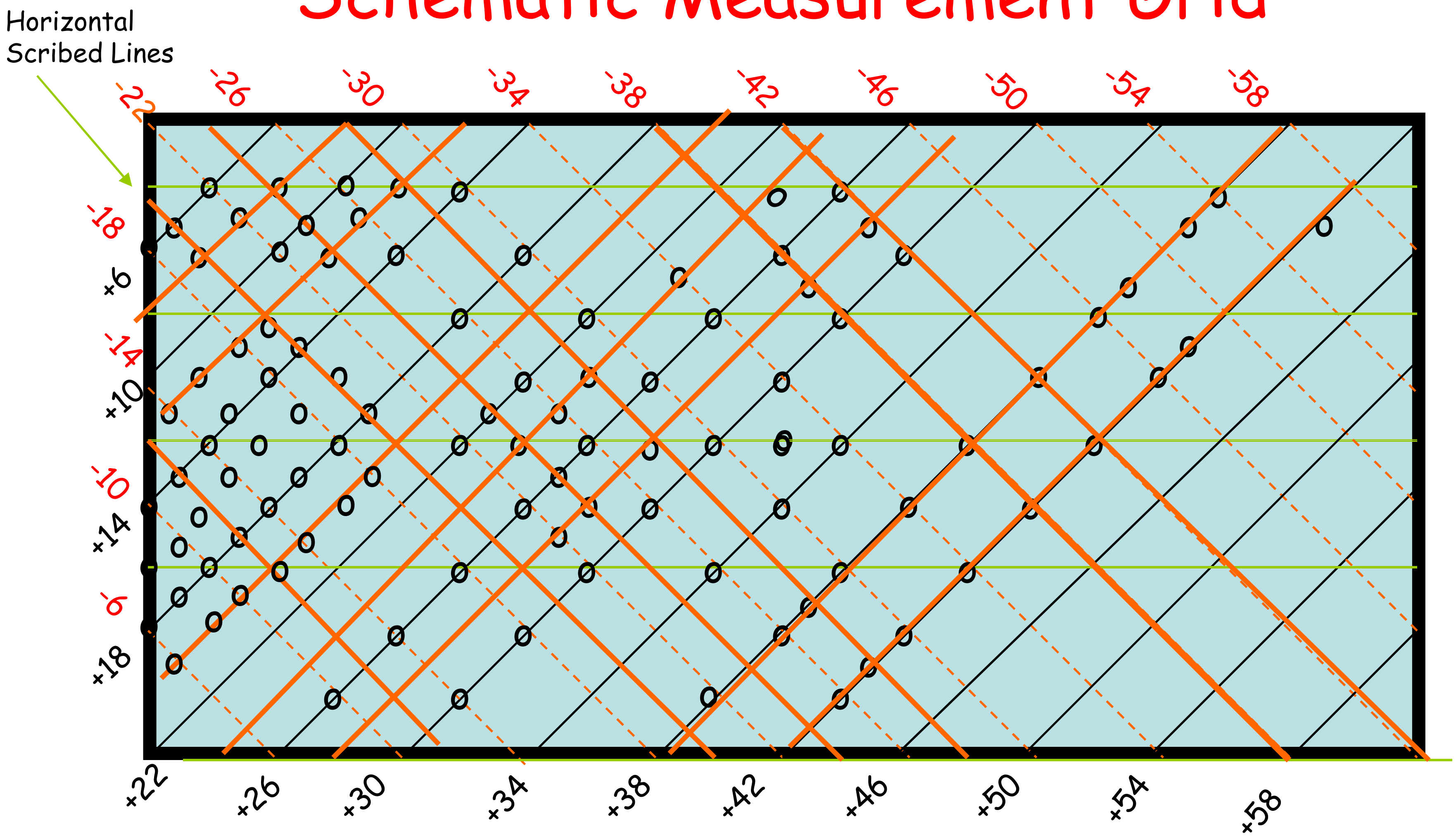
1045 Double Beam Particle Evts



D-a Mean = 387.5

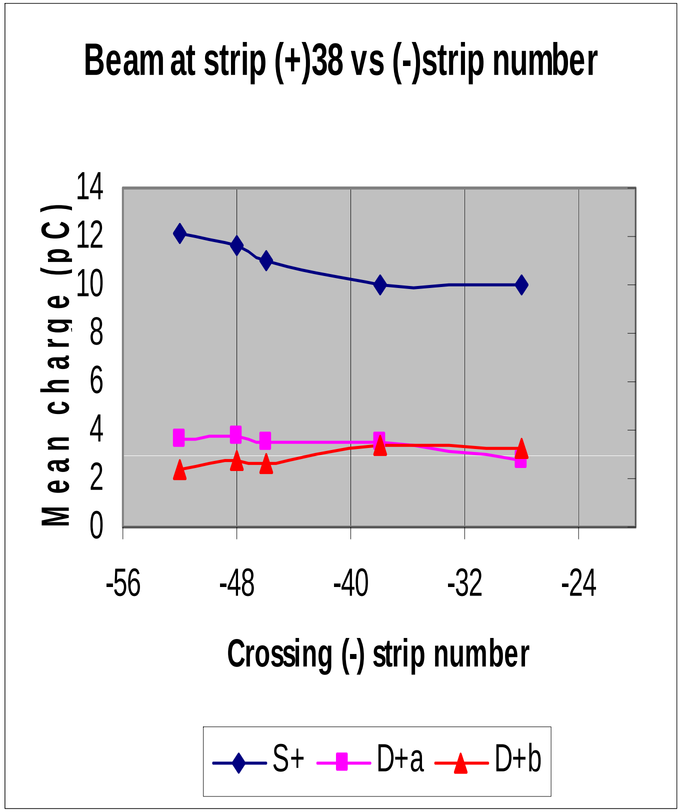
D-a Overflows = 195 = 19%

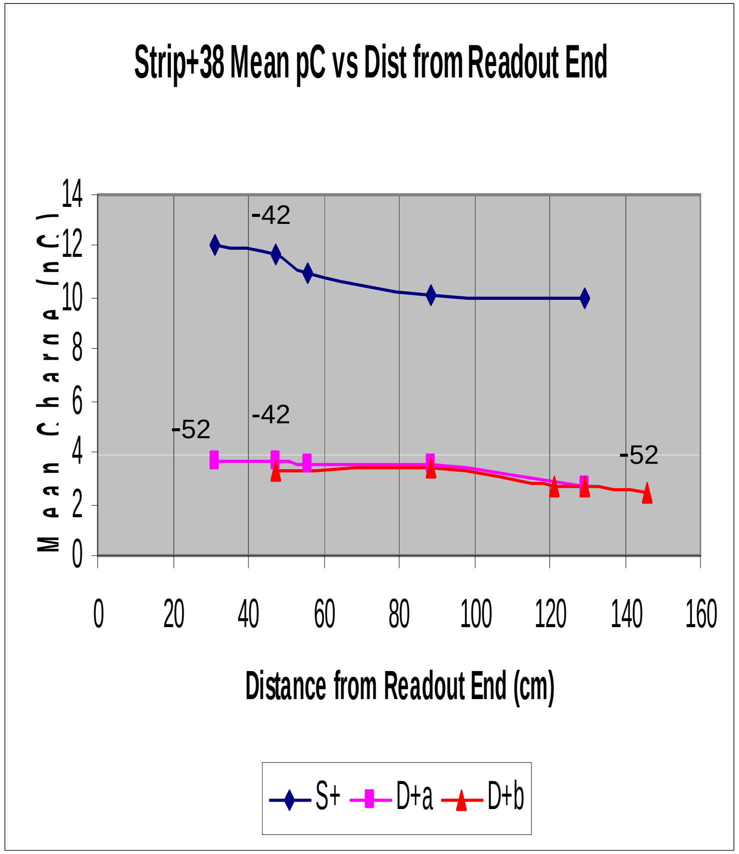
Schematic Measurement Grid



Circles show points that were measured. Numbers indicate strip numbers

Signal along Strips +38



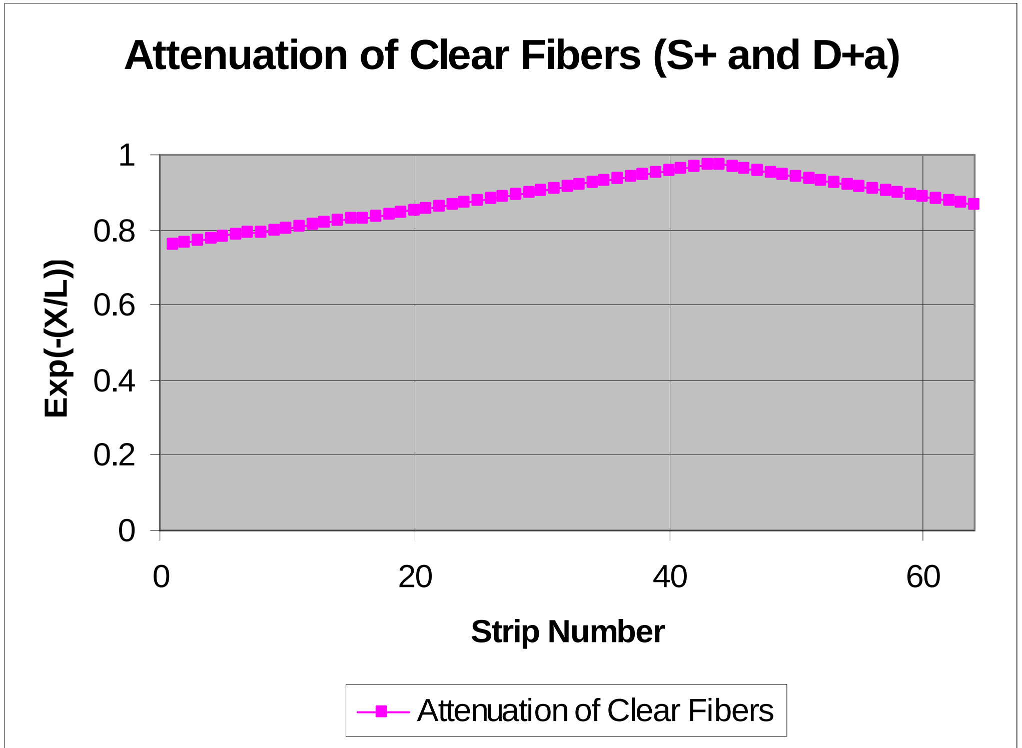


-Blue S+
-Magenta D+a
-Red D+b

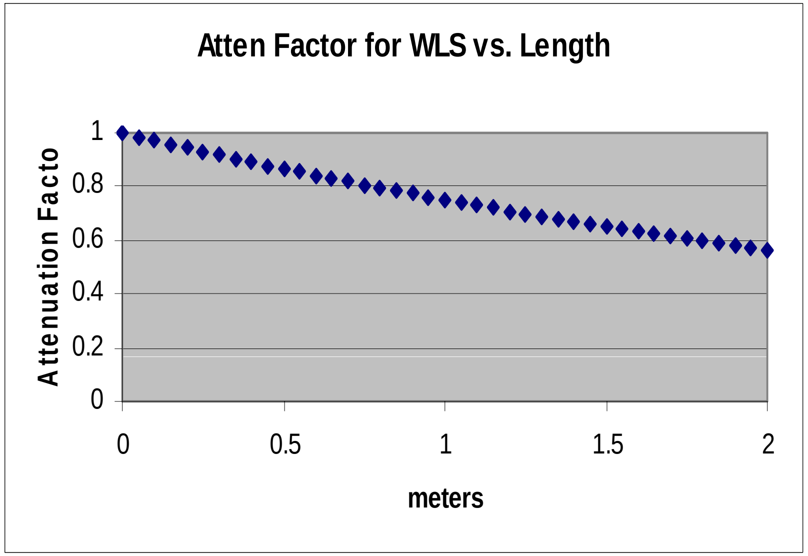
- Pedestal Subtracted and with ADC calibration Included.
- Double beam events removed

Fiber Attenuation vs. Lengths

Calculated Attenuations based on the manufacture data
And used in the study

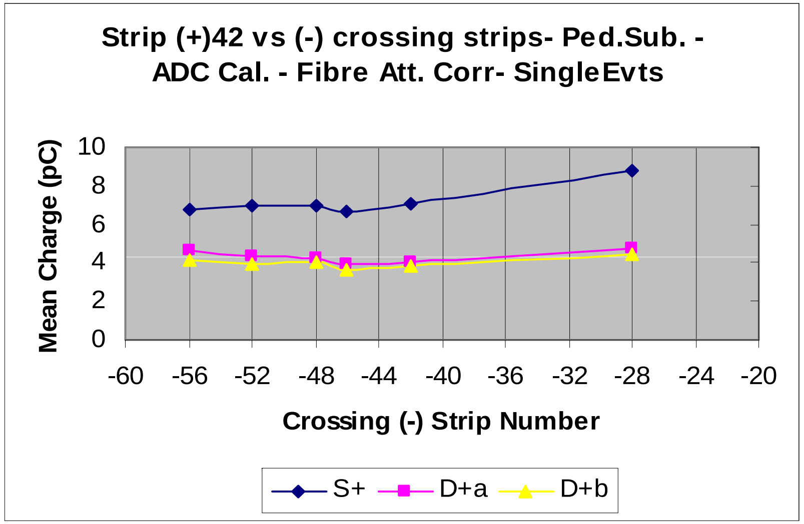


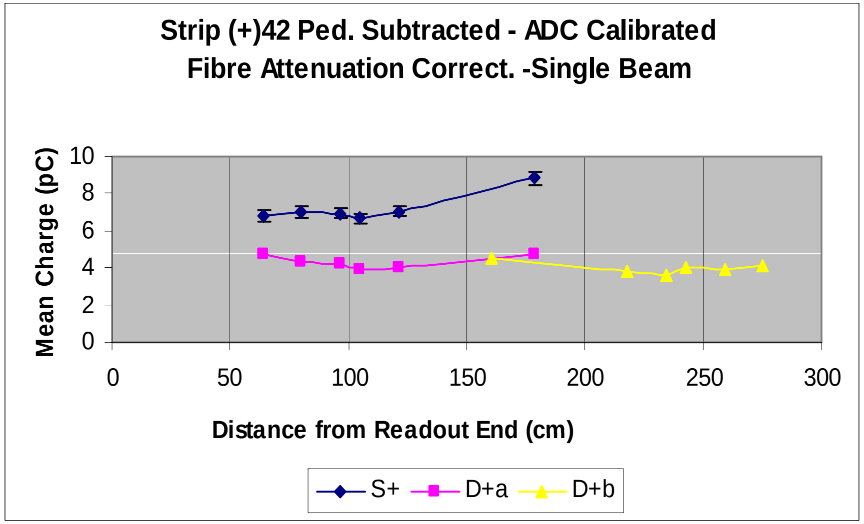
λ = 10 m

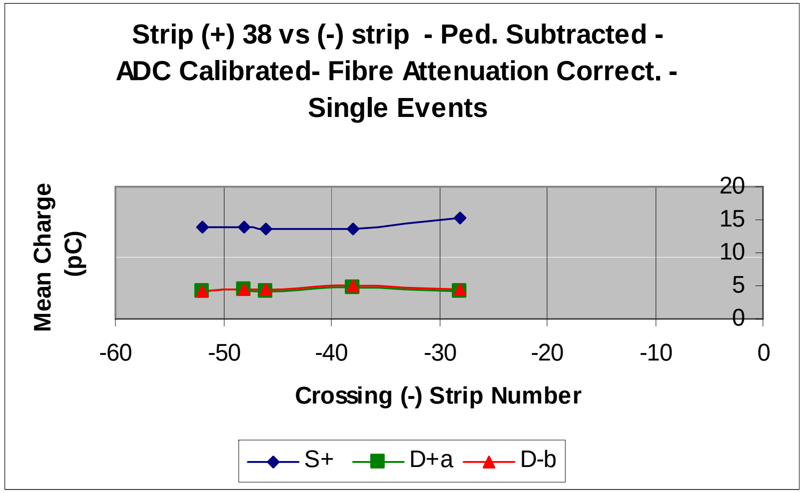


λ = 3.5 m

Signal Along (+42) and (+38) Strips







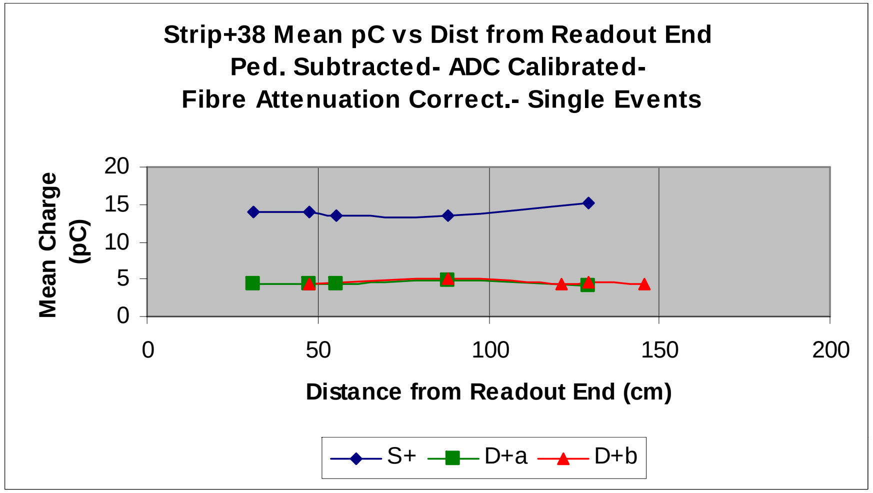
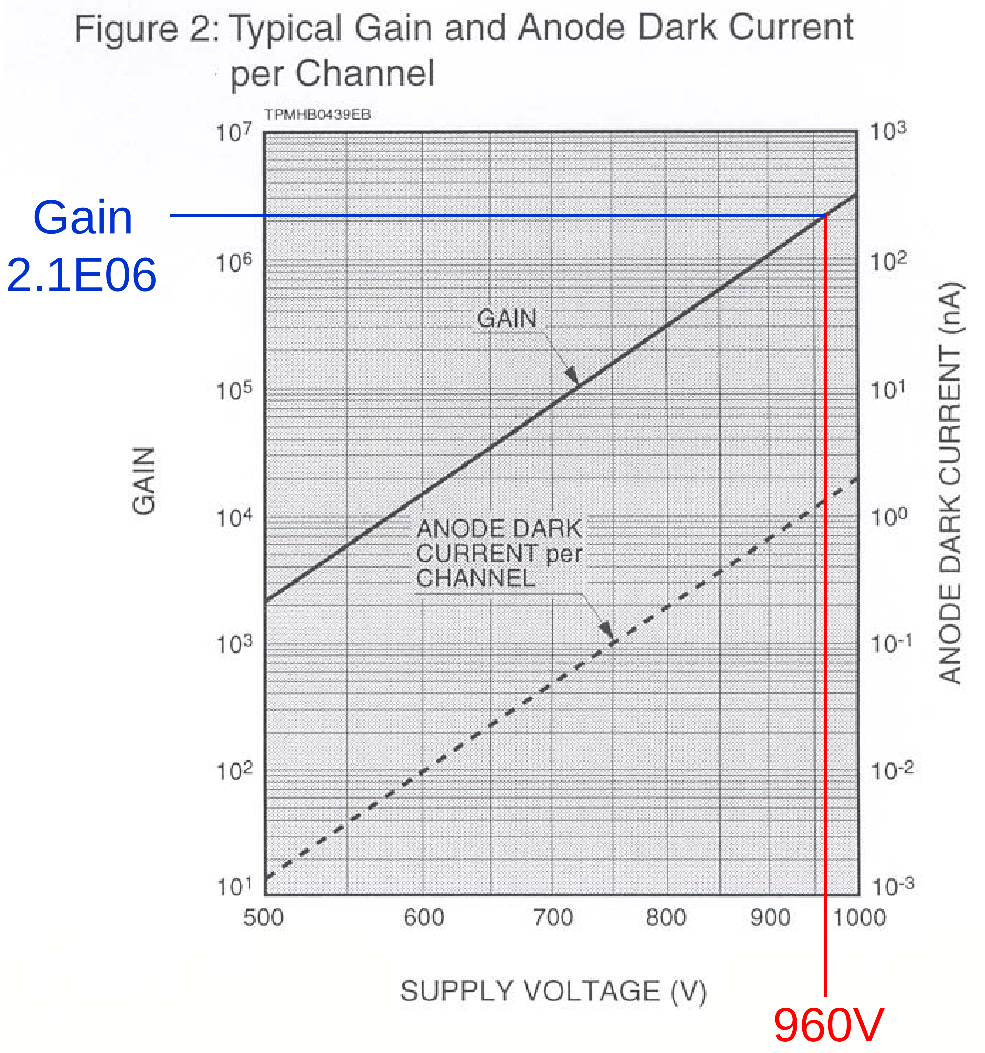


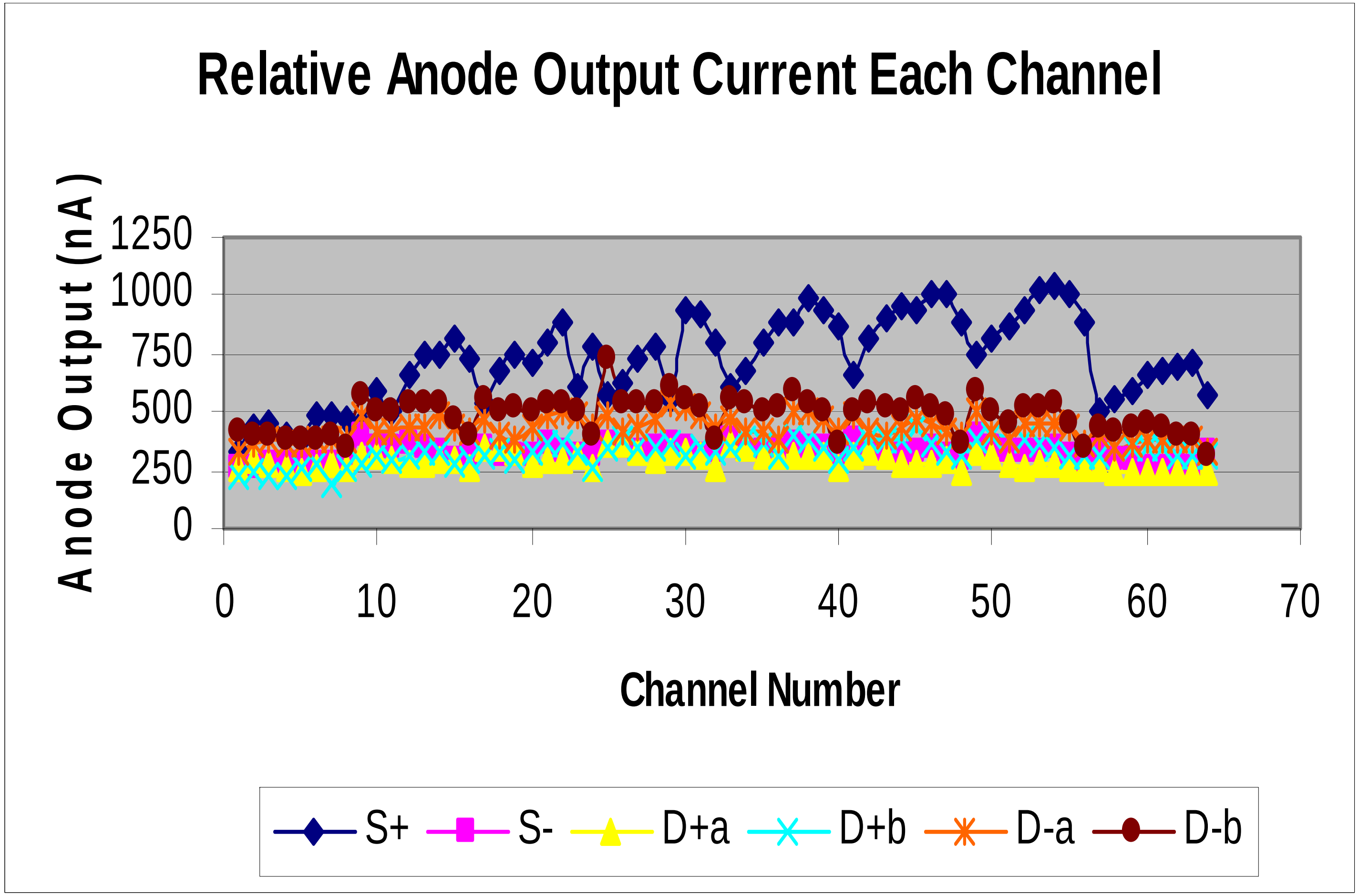
Photo-electron Yield Estimate



2 pC = 12.5 X 10^6 e's

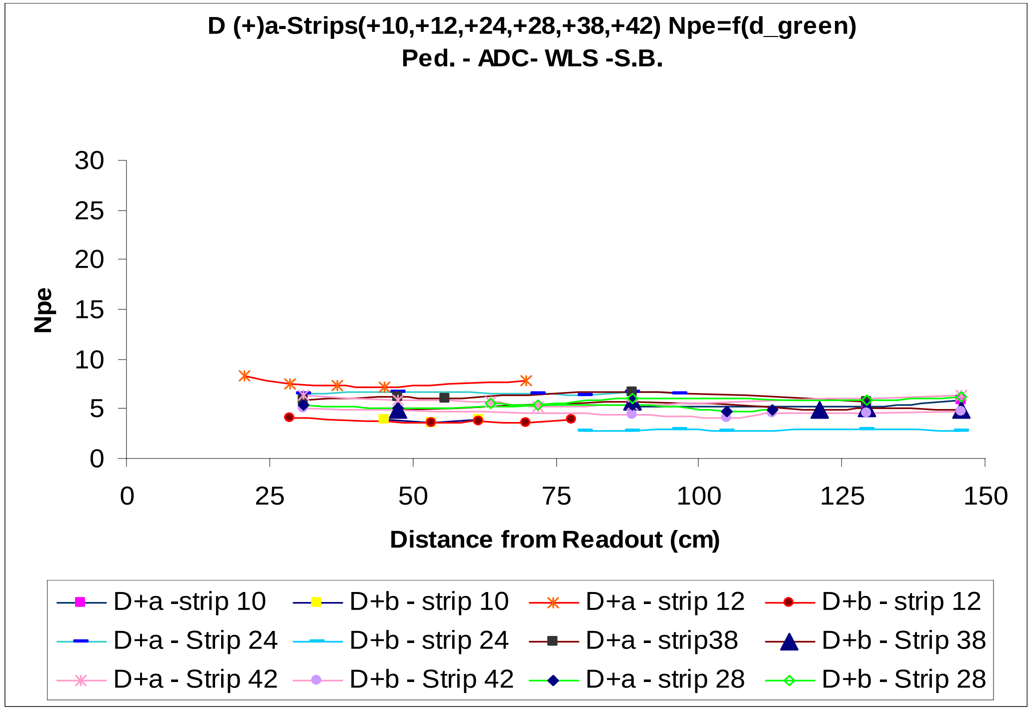
Nom. Gain = 2.1 X 10^6

Hamamatsu H7546B 64 channel MAPMT



Measurement from Sasha Dychkant- (NIU)

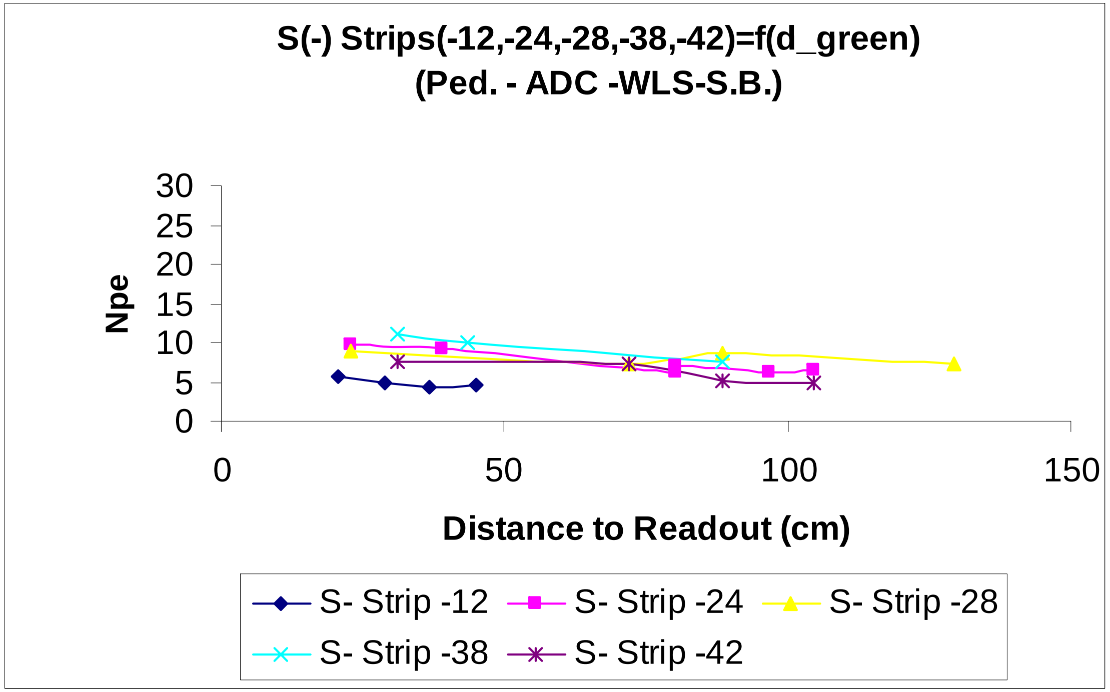
Signal From D+ plane =f (d_green)



d_green is the distance in theWLS fiber.
Within the assumptions below
<Npe>~6

The Signal was taken from both ends of the fibers (dual readout)
Taken after Pedestal Subtraction, ADC calibration and WLS fiber attenuation corrected. The differences MAPMT channels has been accounted for and normalized To the nominal value from the Hamamatsu spec.
One also assume 2pC=12.5 10E06 photo-Electrons from the Hamatsu spec

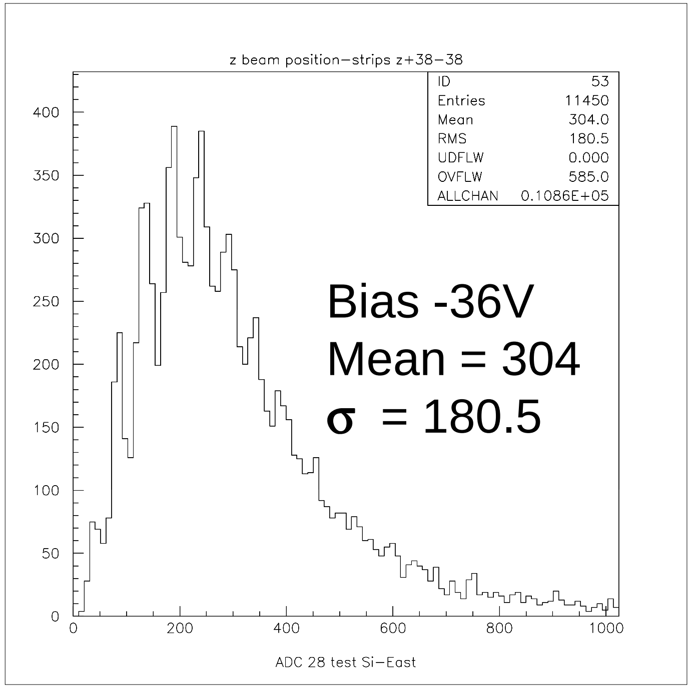
Signal from Single readout=f(d_green)

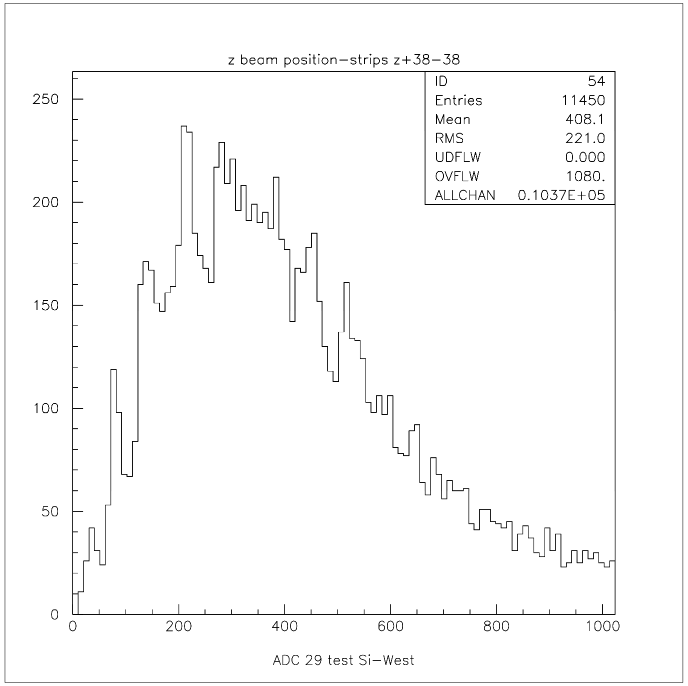


Within the assumptions
Below
< Npe>~6

The Signal was taken from one end of the fibers, the other end has a mirror
Taken after Pedestal Subtraction, ADC calibration and WLS fiber attenuation corrected. The differences MAPMT channels has been accounted for and normalized to the nominal value from the Hamamatsu spec as before.

Italian SiPM Beam Test



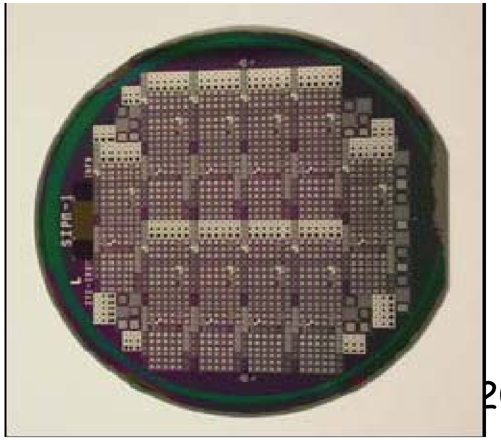


A. Driutti and G. Pauletta – INFN Trieste/Udine

INFN/Udine test of ITC-Irst SiPM's at SiDet using prototype LC muon scintillator plus WLS fiber**.** MTest data Sept 2006.

25 x 25 pixels with each pixel 40µ X 40µ

Gain = 1.6 x 10^7; Noise ~ 0.7 MHz; http://sipm.itc.it



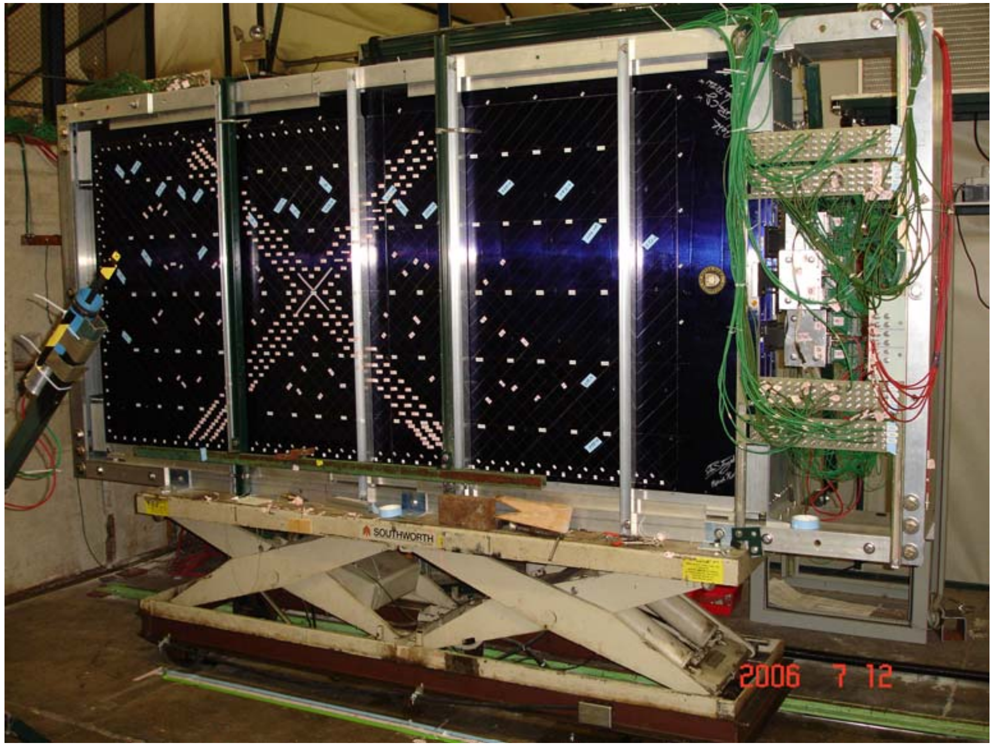
Near Term Objectives

- MAPMT Absolute gain a channel/MAPMT by Wayne State University, work in Progress presented here.
- Replace LeCroy ADCs with 64 channel version of Minerva front-end digitizers and test at MTBF. (IU, FNAL, UCD)

Future Plans

- Procure SiPMs/Multi-Channel Photon Counters;
- Bench Test at SiDet. Continue collaboration with IRST Trento (C. Piemonte) and INFN – Udine (G. Pauletta).
- R&D and beam tests of ILC muon scintillation counters with Si PMs at MTest
  - A supplementary LCRD proposal (IU, WSU, UND, UCD and NIU) has been submitted for this work.
- Test of Geiger-mode Avalanche Photo-diodes developed by A-Peak and Colorado State Univ (SBIR) with scintillator strips at MTest in a few months. (D. Warner - CSU)
- Because SiPM/MPPCs look very promising we expect to build additional prototypes with NIU style scintillator and SiPM readout. Will be tested at MTest.

ILC MuonTest Setups



Prototypes installed in Fermilab Beam Test Facility
256 scintillator strips
384 PMT channels

Instrumentation