ILC Muon Identification RPC and Scintillator Detector Plane Studies

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Collaborators

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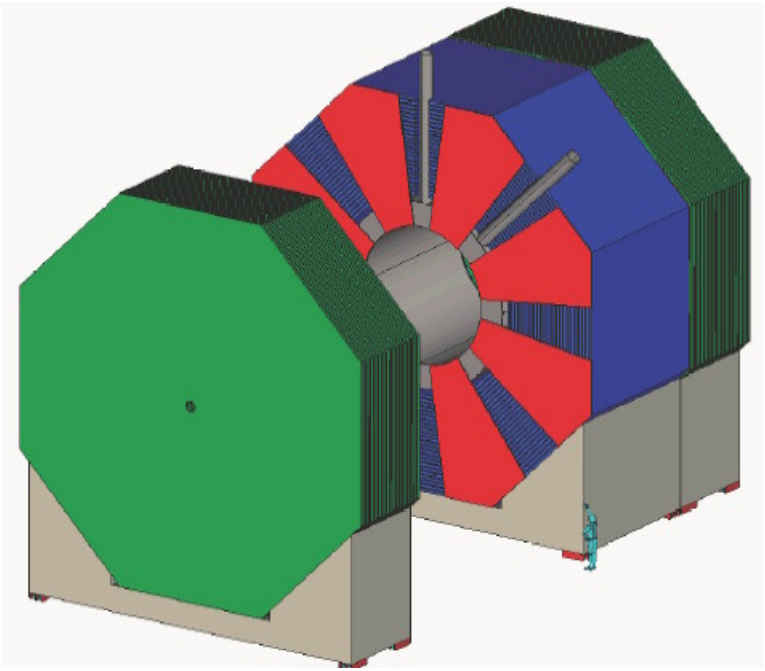
*T956 spokes person.(T956 participants in italics)

Outline

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

Proposed SiD Muon System/ Tail Catcher



•Central Muon System:
After 4.6 nuclear interaction lengths (λ) Of calorimeters and the 5T solenoid coil and cryostat 1.27 λ → ~6 inter. Length.
• Installed in the Iron of the 5Tsolenoid flux return ~ 2.30m of Fe:~18 λ total.
• Central barrel 5.7 m long, R = 3.5 m.

•Barrel and EndCaps Muon System unit: 10 cm thick Fe; 4 cm gaps

•Total detector area ~6000 m^2 for 14 layers.

Candidate detector technologies: RPCs and/or Strip-scintillator

SiD μ Detector Candidate Technologies

- Resistive Plate Chambers with signal pick-up strips.

  Used in several experiments;

  Ease/low cost of manufacturing;

  Dual gap – for high efficiency.

- Scintillator strips, WLS fiber and photon detectors.

  Employed by MINOS and other experiments with MAPMTs.

  New photo-detector technology, multi-pixel Si detectors, may be a cost effective alternative to MAPMTs.

Muon Detector - RPC Studies

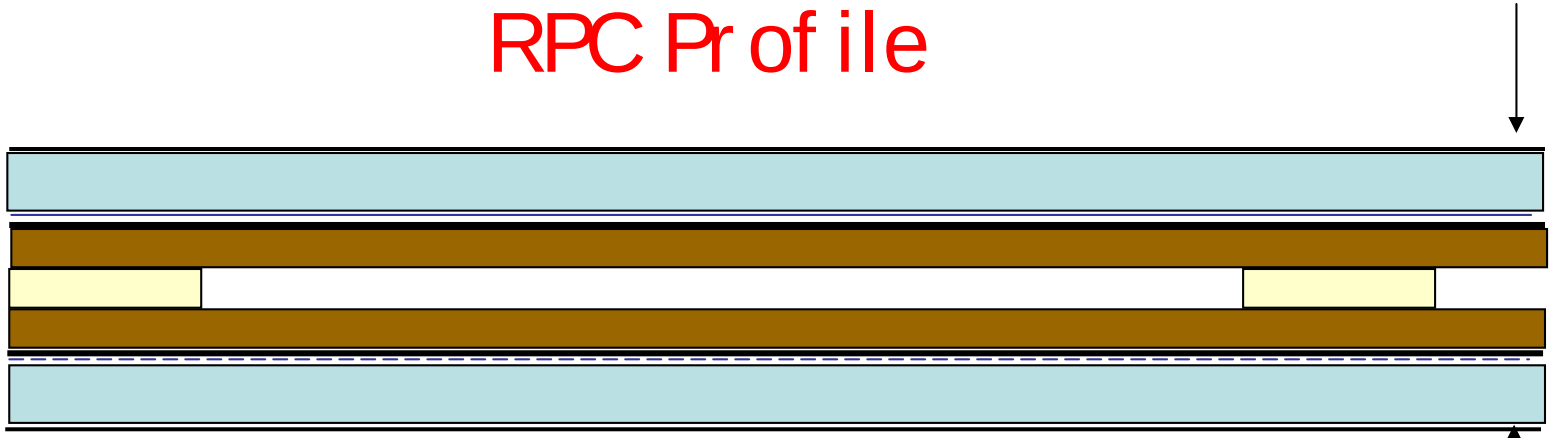
- Survey of RPC detector performance at:
  - BaBar
  - BELLE
  - BES
- Understand problems and successes.

- BES has manufactured ~ 2000 m^2 of Bakelite RPCs.

- Princeton Chan-Guo Lu (ALCPG Workshop, Snowmass, Aug14-17,2005 & Proceedings) and Wisconsin, H. Band are following tests and progress.

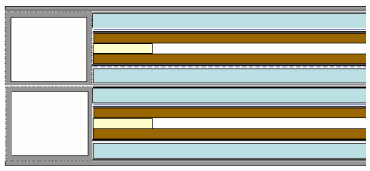
A few transparencies from H. R. Band's presentation at the last SiD meeting in October 2006 follow.

RPC Profile

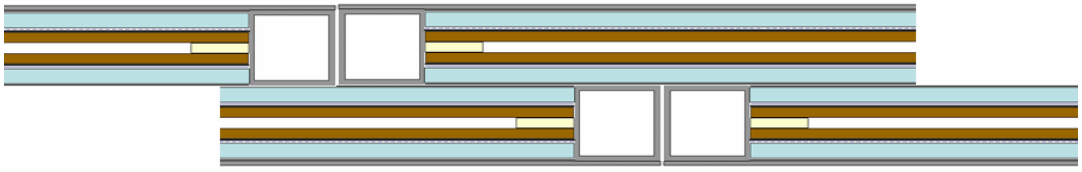


Ground plane	.1 mm
Foam	3 mm
Pickup strips	.1 mm
PET Film	.1 mm
Graphite	.1 mm
Bakelite	2 mm
RPC gas	2mm
	13 mm total

Outside edge

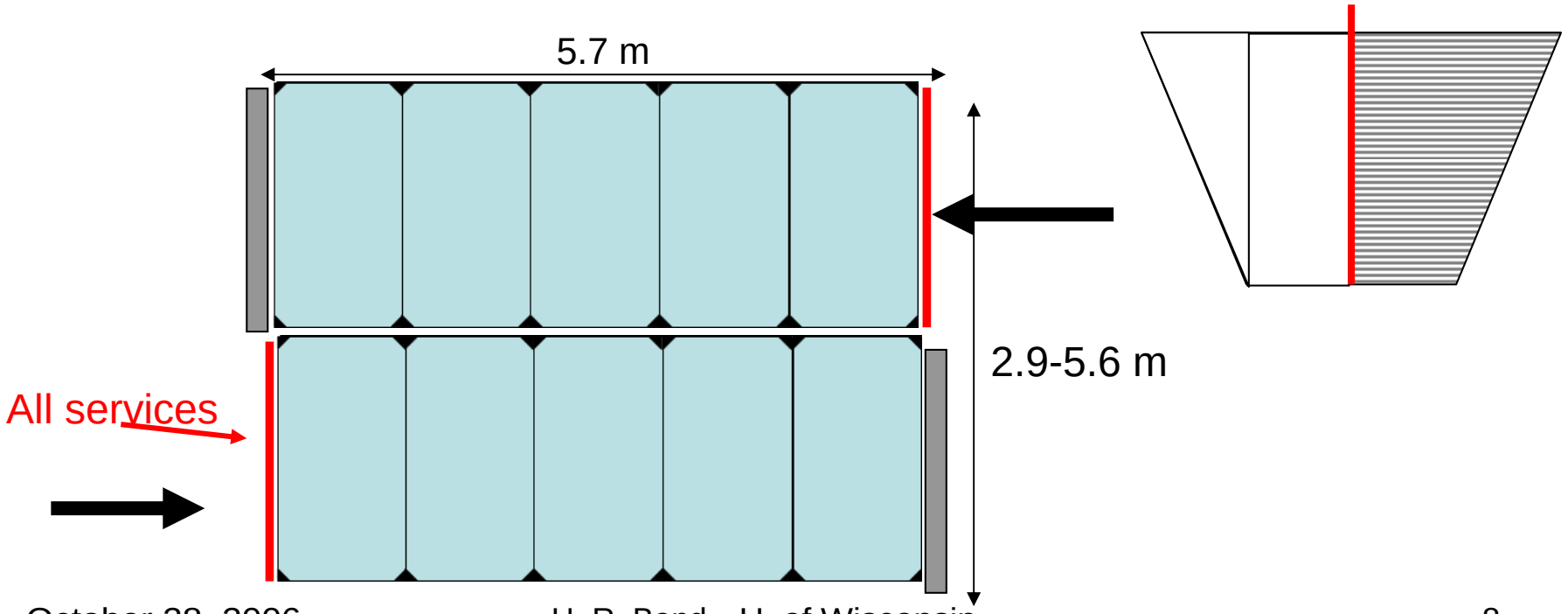


Mid-layer Overlap



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**



RPC R&D Issues

- RPCs have proven to be less robust than initially promised
- Many observed failure modes
  - Improperly cured linseed oil
  - Eroded graphite coatings
  - Too much humidity - BELLE glass RPCs
  - Too little humidity - BaBar bakelite RPCs
- However, extensive R&D has led to a better understanding of aging mechanisms
  - Improved construction techniques
  - Avalanche mode
  - Humidified gas
  - Aging tests to simulate 10 years of LHC operation.
- Will know in several years from the operational experience of CMS, ATLAS, BELLE, BaBar, BESIII if RPCs can be made reliable

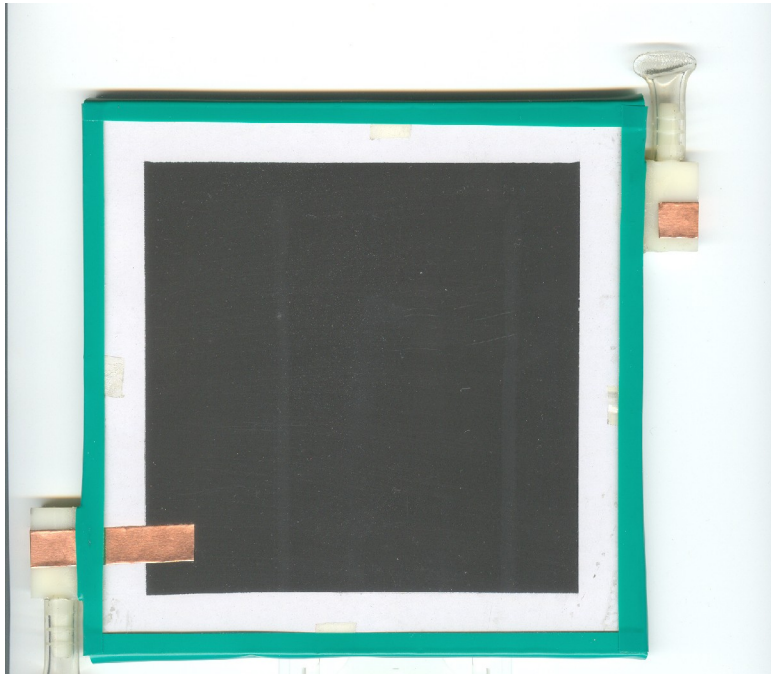
Status of present streamer mode RPCs

- BELLE glass RPCs doing well after changes to gas plumbing
  - No signs of aging when rates are limited (0.2 Hz/cm^2).
  - Outer endcap layers turned off
- 2nd generation BaBar Bakelite RPCs
  - < 2 Hz/cm^2 few problems in 4 years
  - >20 Hz/cm^2 losing efficiency
- BESIII installing ~2000 m^2 of Bakelite RPCs
  - Innovative plastic film surface - no linseed oil
  - Prototypes show stable performance

RPC Aging Studies

- BaBar (Wisconsin&Roma)
  - Avalanche mode
  - Fluorine production (HF) & absorption
  - Humidity
  - High Rate effects
- Princeton
  - Avalanche mode
  - Surface quality studies
  - Gas
  - Fluorine production (HF) & absorption
- Bakelite Experience
  - Need glass RPC tests

- Study BES III RPC response to humidity and HF

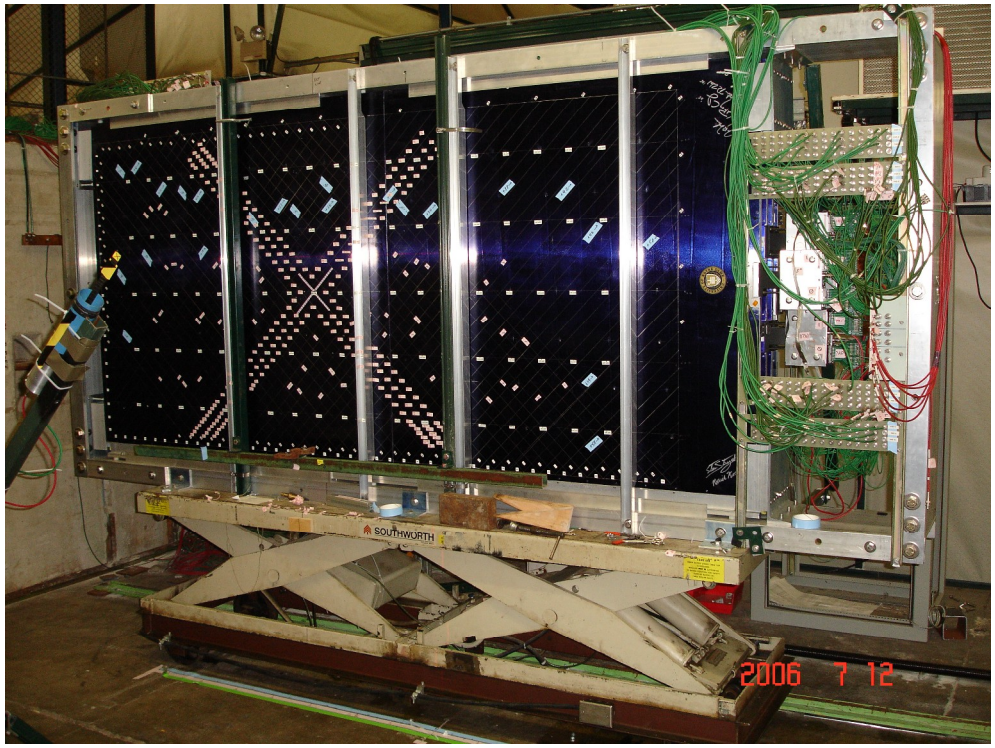


Prototype Scintillator R&D Goals

- **Performance Related**
  - To determine the single muon detection efficiency per layer. Meas. charge => no. of photo-electrons. WLS fiber ϕ?
  - What is the uniformity of the response across the detector?
  - How effective is the detector for use as a tail catcher

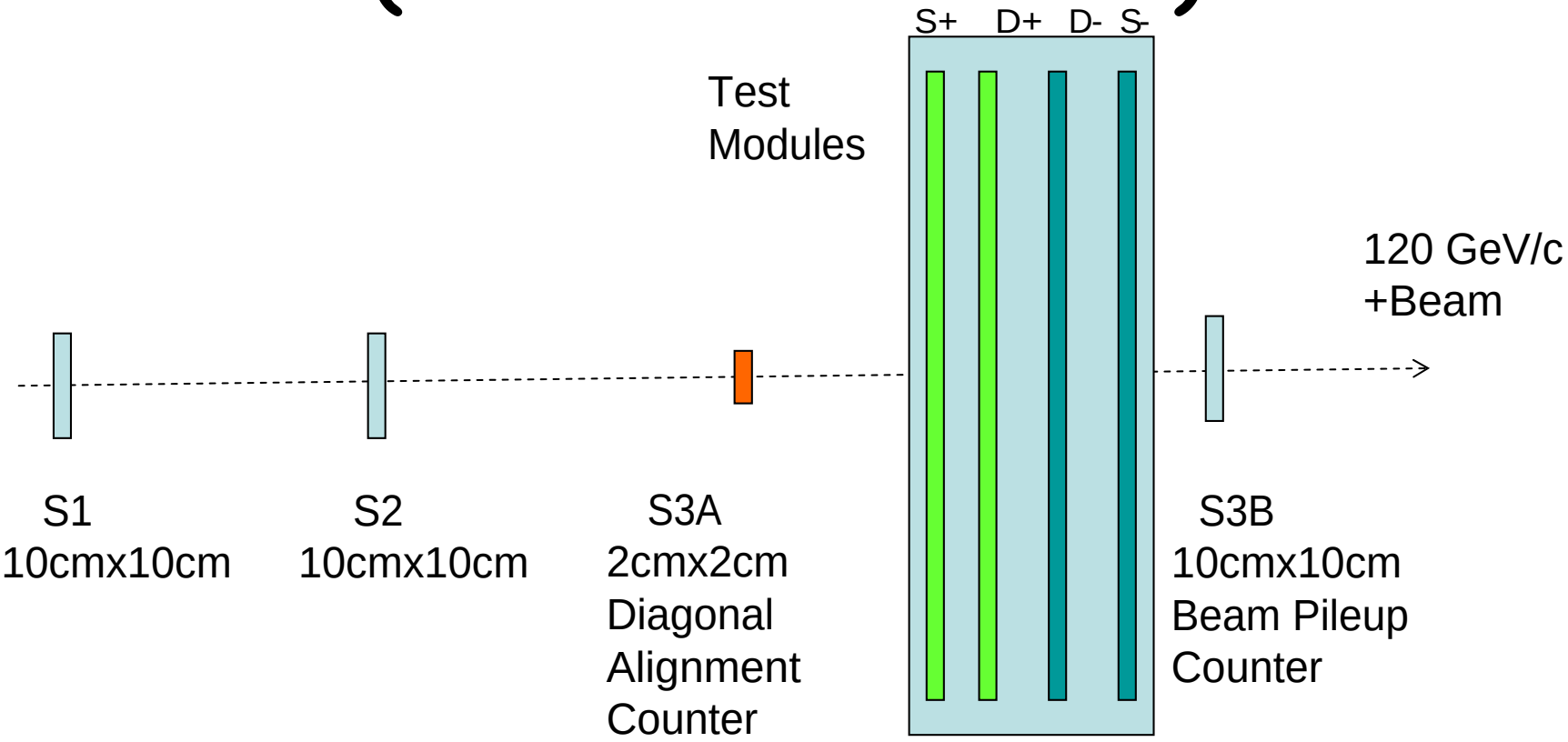
- **Design and Cost Related**
  - Do we need to readout both ends of each strip? (cost effectiveness)
  - Refinements or modifications needed? e.g. "To glue or not to glue WLS fibers?"
  - Obtain cost estimates, possible cost reductions.
  - Provide basis for comparison with other techniques.
  - New photo-detector technology?

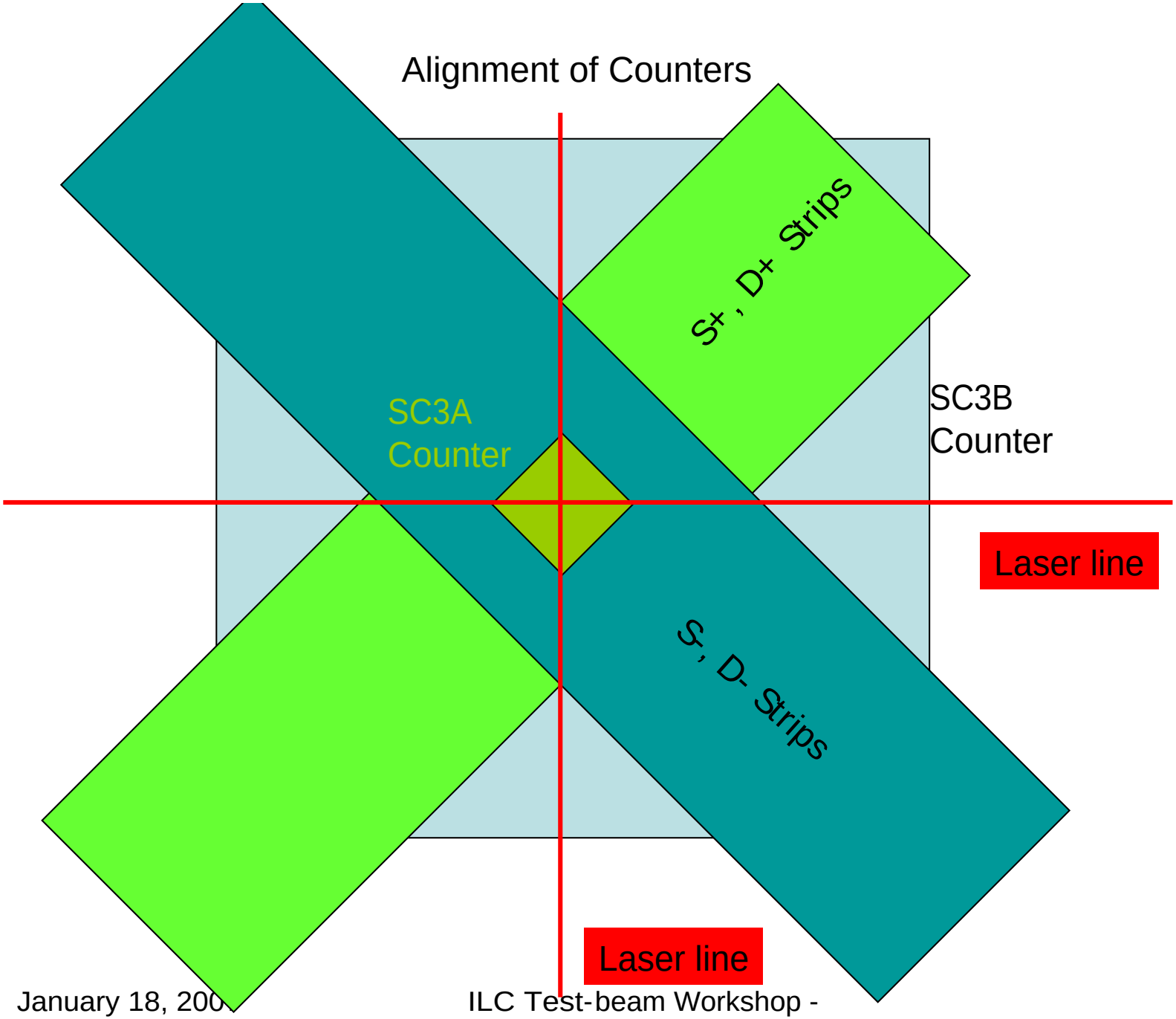
ILC MuonTest Setups



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

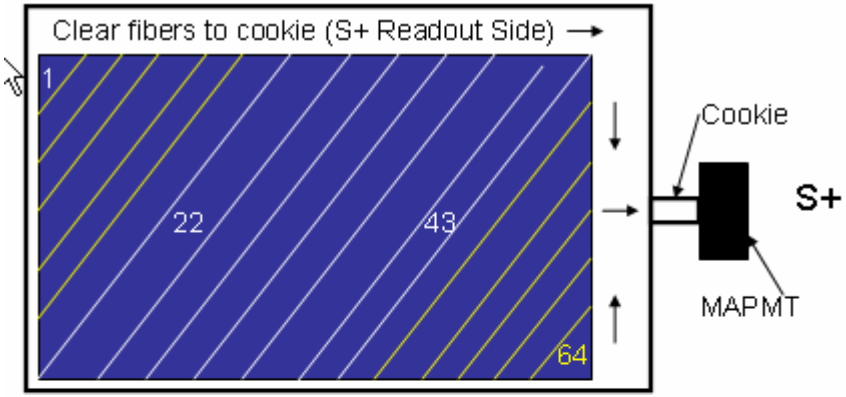
Beam Trigger (S1.S2.S3A.SCB)

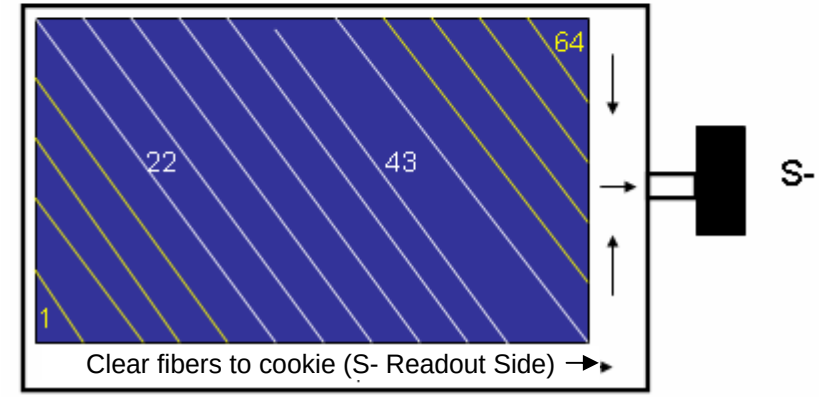



Alignment of Counters
S+ , D+ Strips
SC3A
Counter
SC3B
Counter
Laser line
S- , D- Strips
Laser line

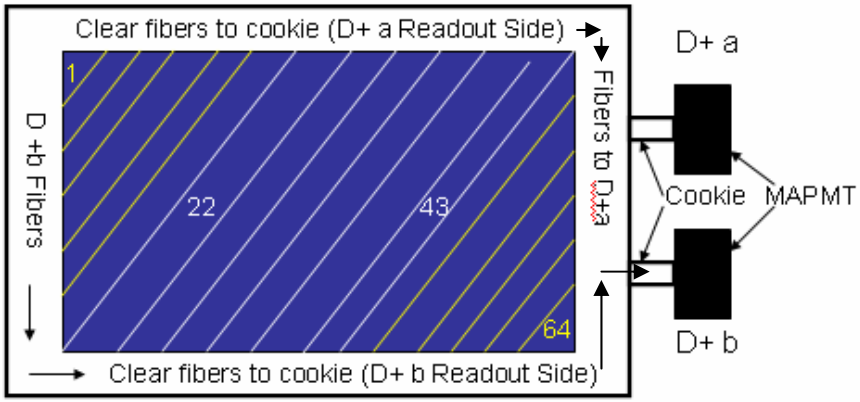
Four Detector planes

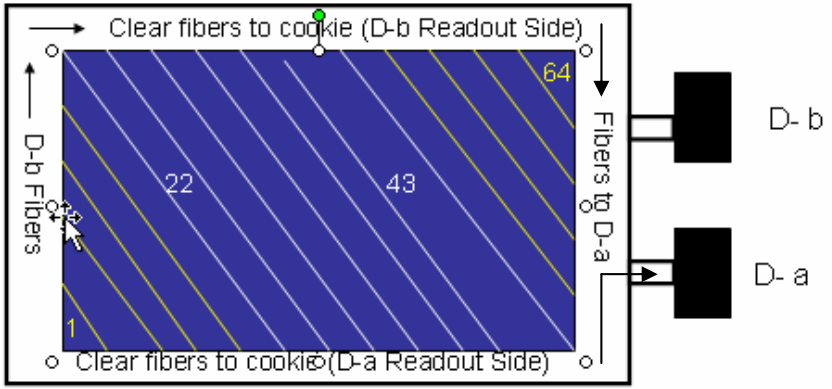
Single ended readout





Dual readout

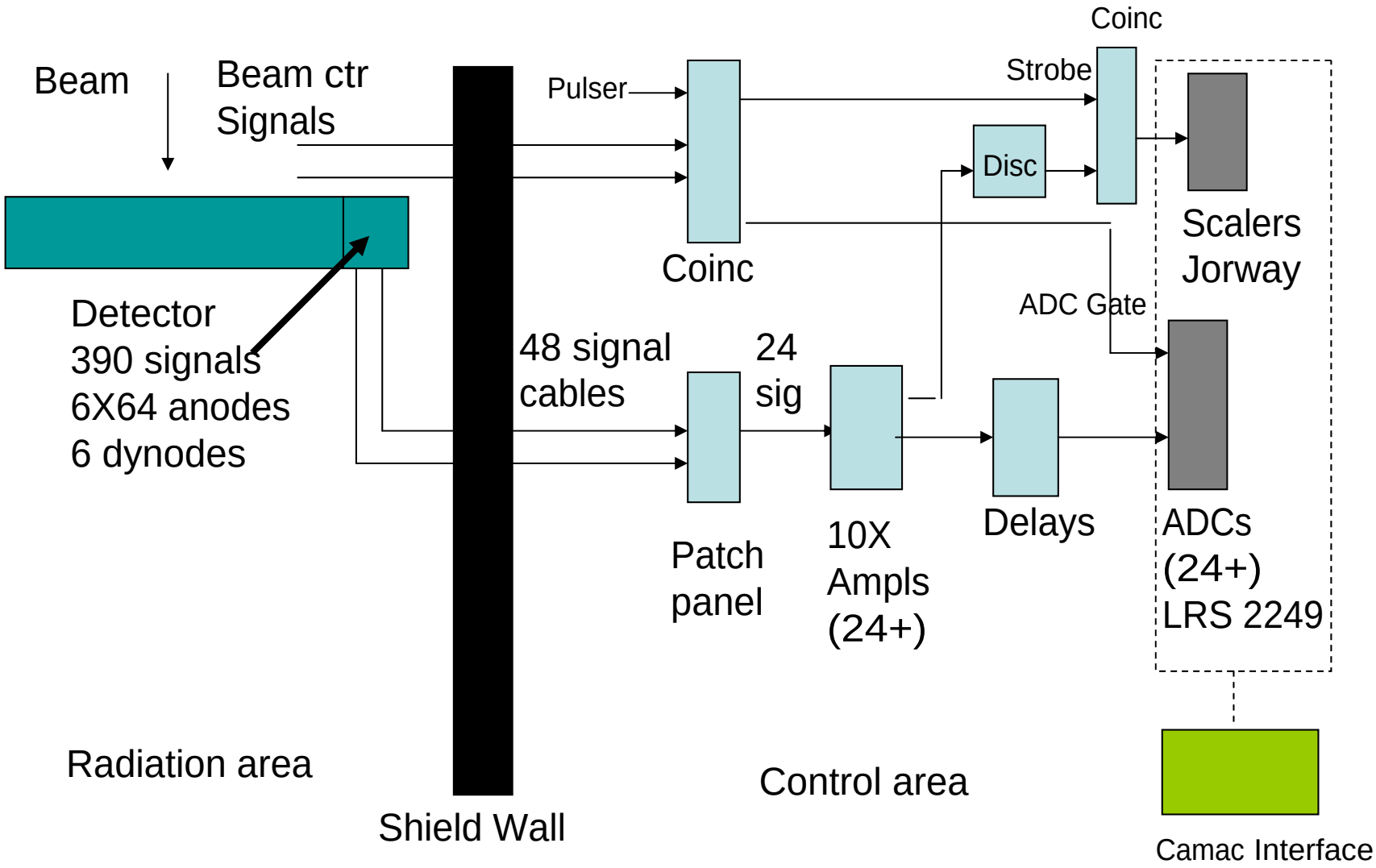




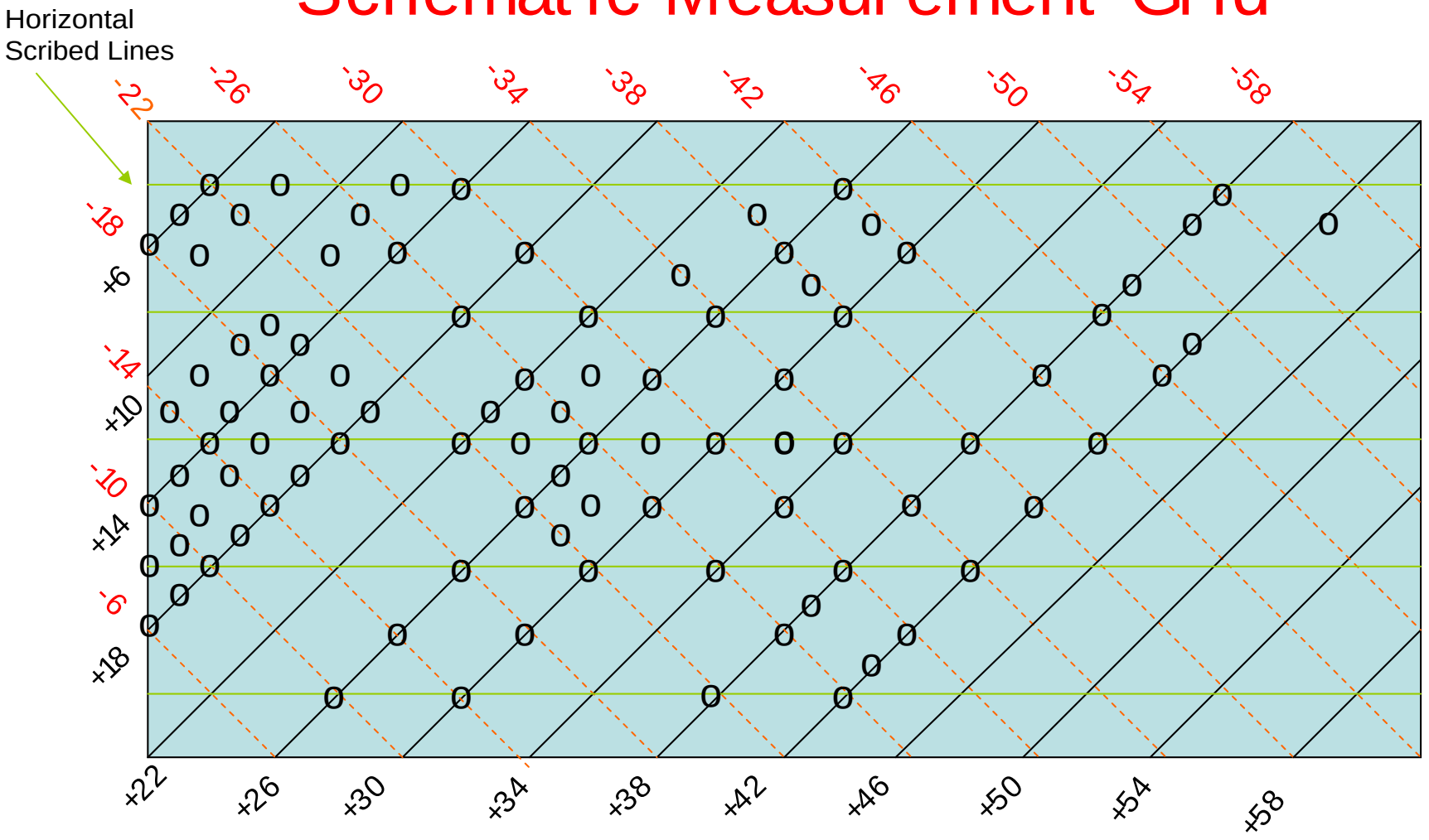
Beam Operating conditions

- 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. (ADC readout time)
- Beam spot at +120 GeV/c ~ 1 cm FWHM
- Additional beam particles within ADC gate (170ns) ~10% of time, even at low rates.

Instrumentation

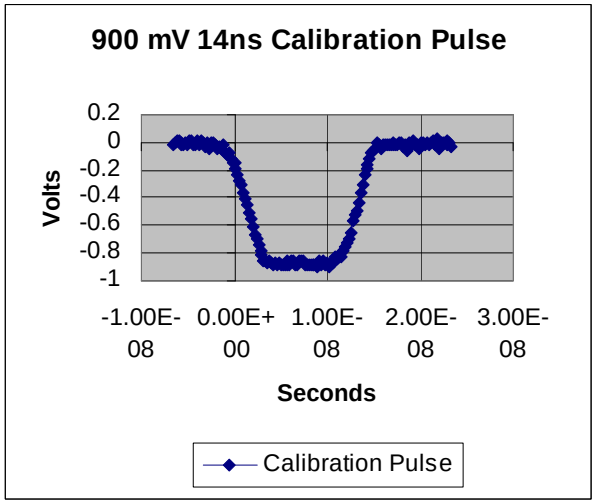


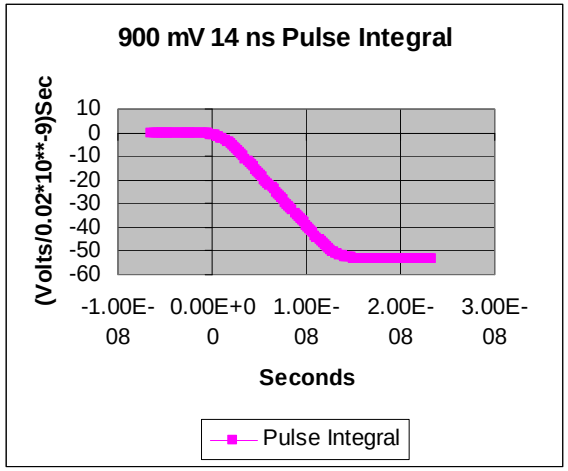
Schematic Measurement Grid

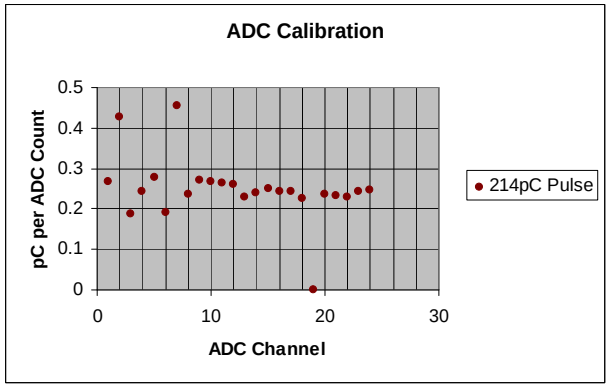


Circles show points that were measured. Numbers indicate strip numbers

Calibration of ADCs

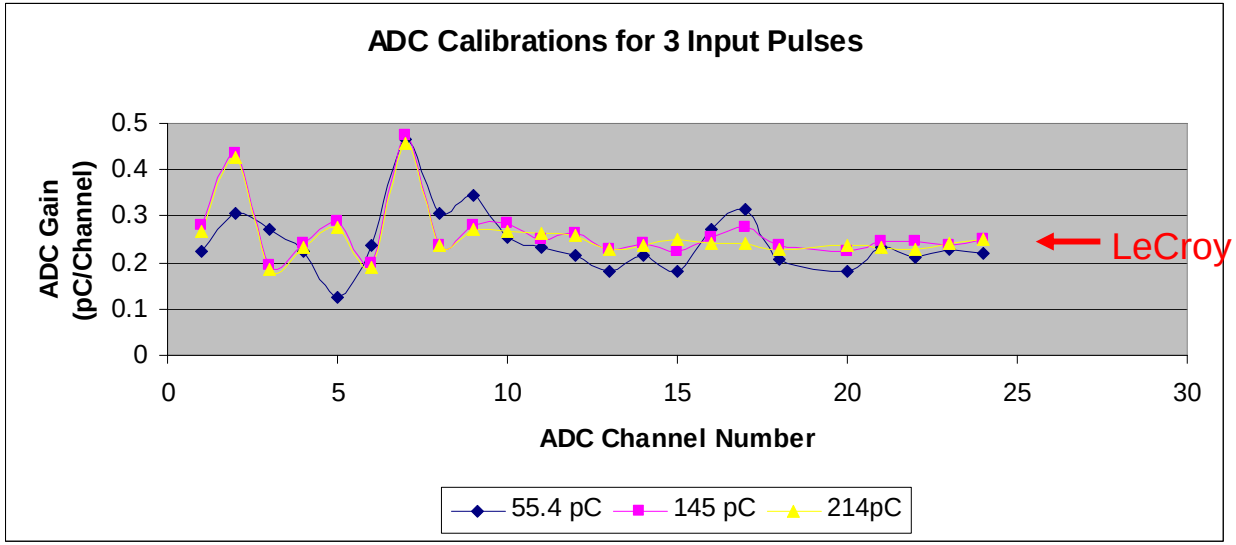






107.2 e-10 V-s
Q=214 pC

Additional Calibrations for 56.4 pC and 146pC

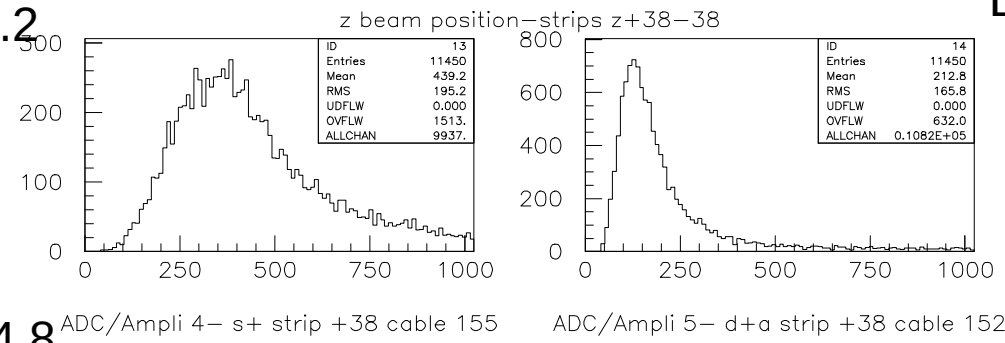


Distributions from Composite Run 6446 at (+38, -38)

11450 Total Events

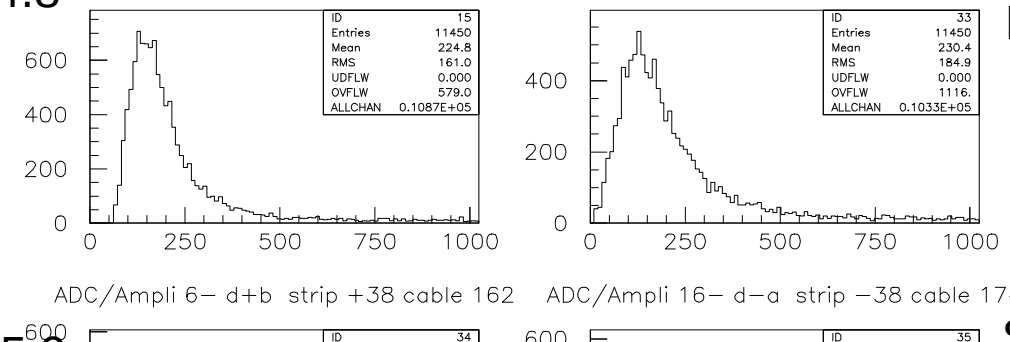
S+ mean 439.2

D+a mean 212.8



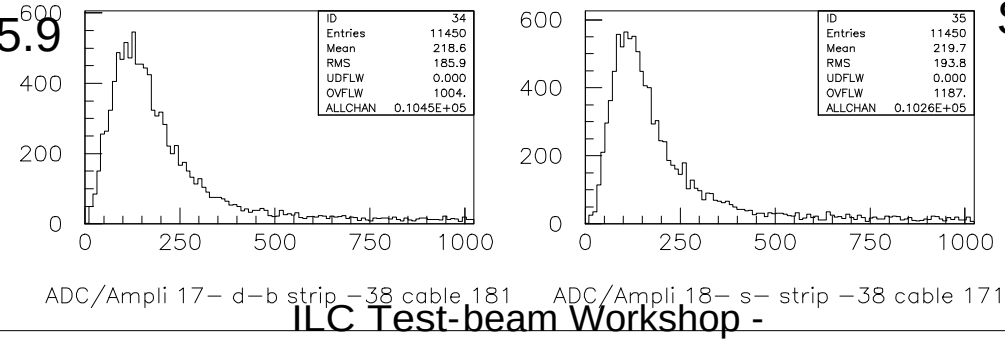
D+b mean 224.8

D-a mean 230.4



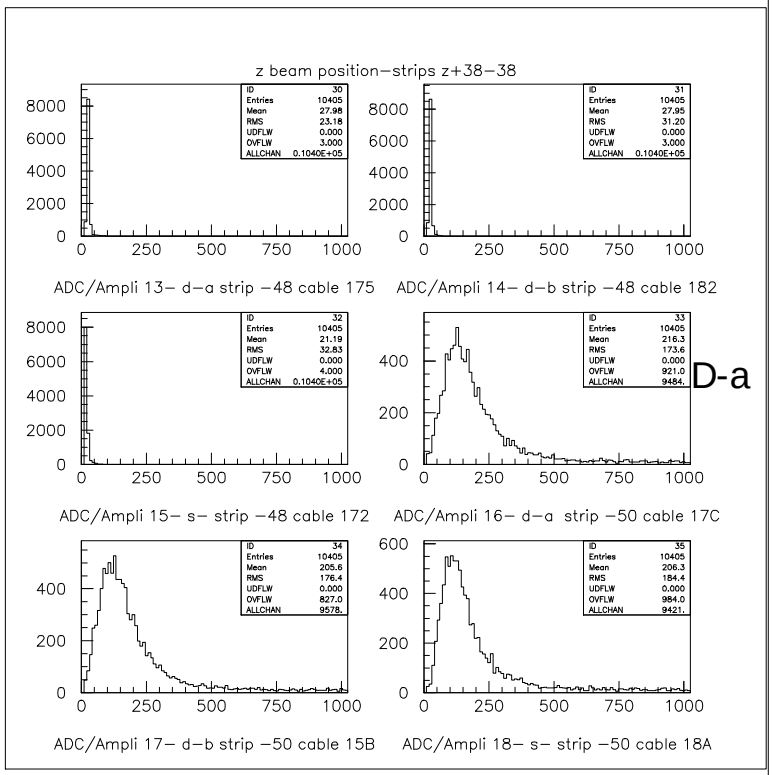
D-b mean 185.9

S- mean 219.7



Single and Double Beam Events from Run 6446

10405 Single Beam Particle Evts

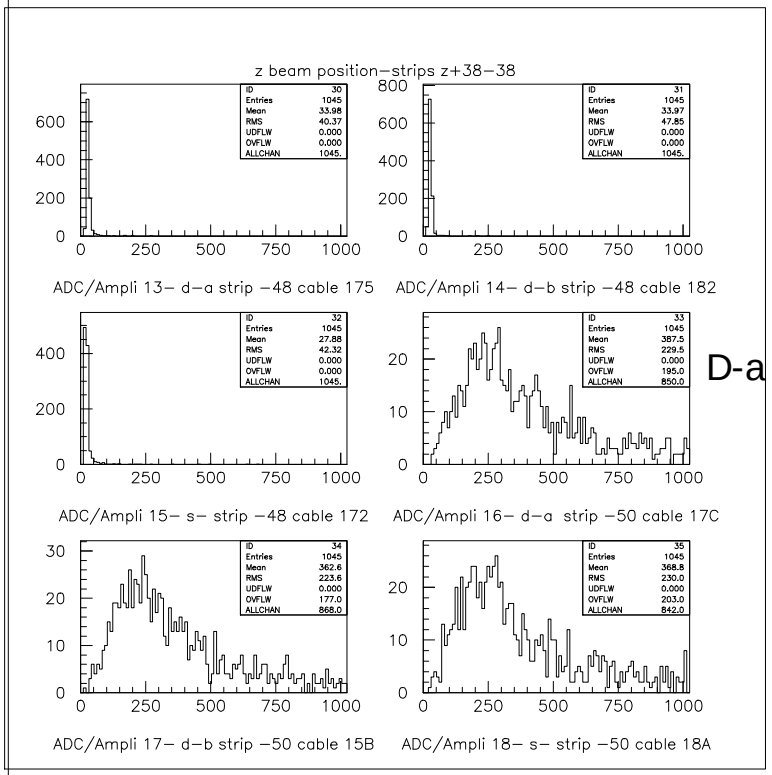


D-a

D-a Mean = 216.3

D-a Overflows =921 = 8.8%

1045 Double Beam Particle Evts

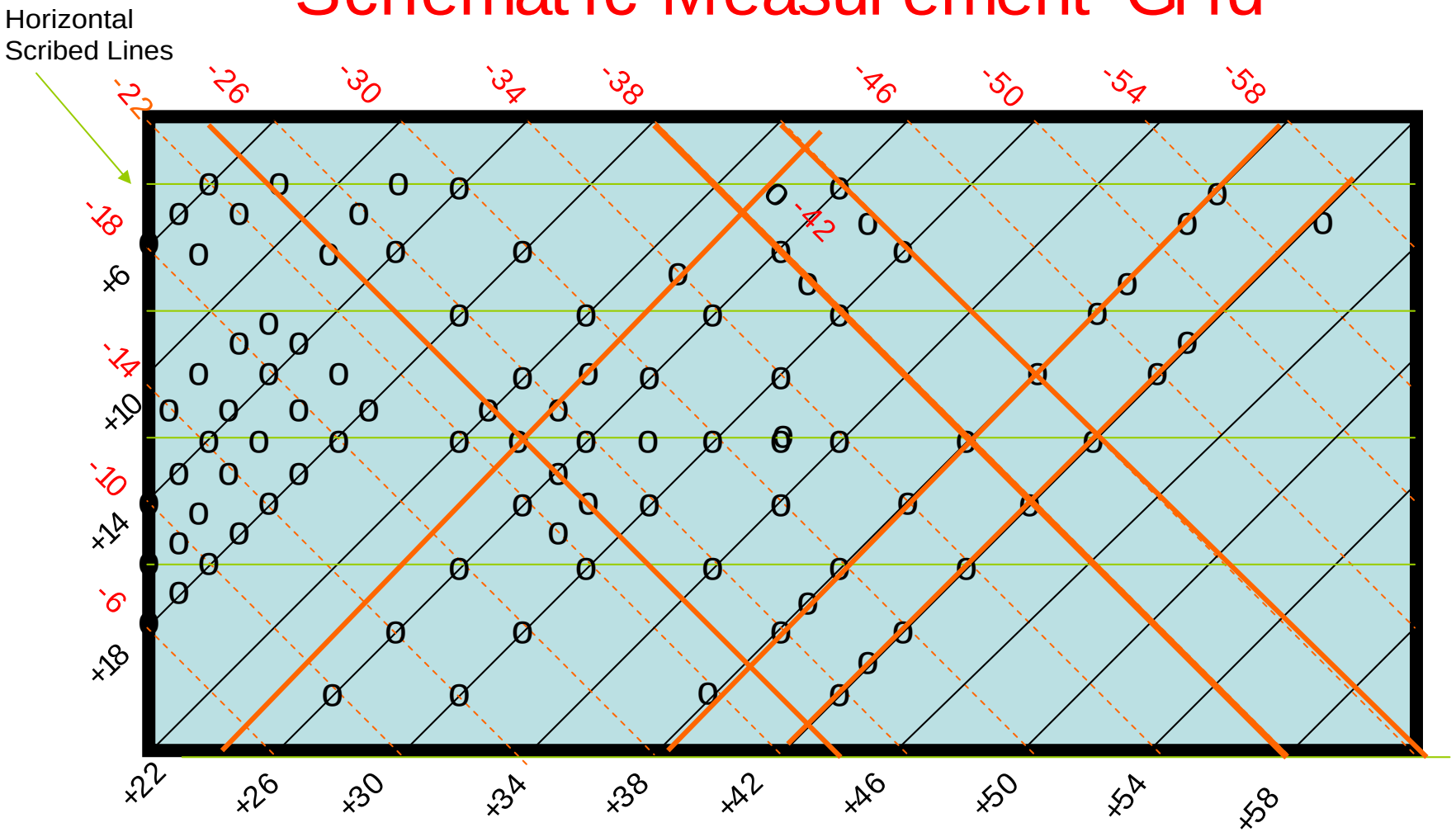


D-a

D-a Mean = 387.5

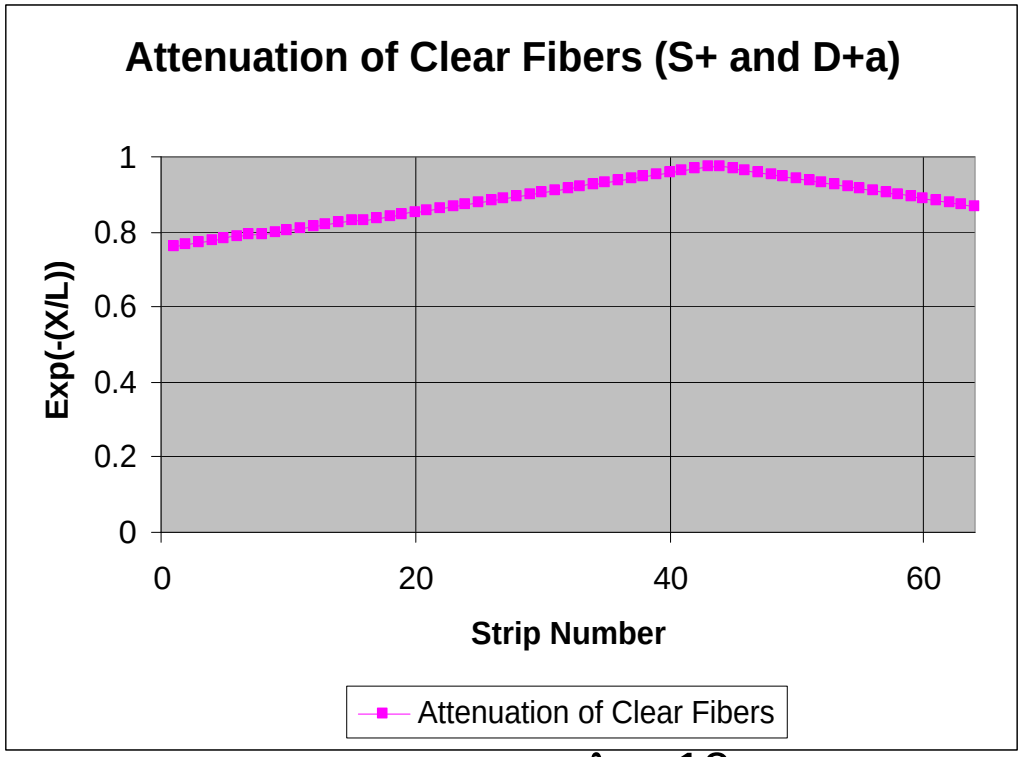
D-a Overflows = 195 = 19%

Schematic Measurement Grid

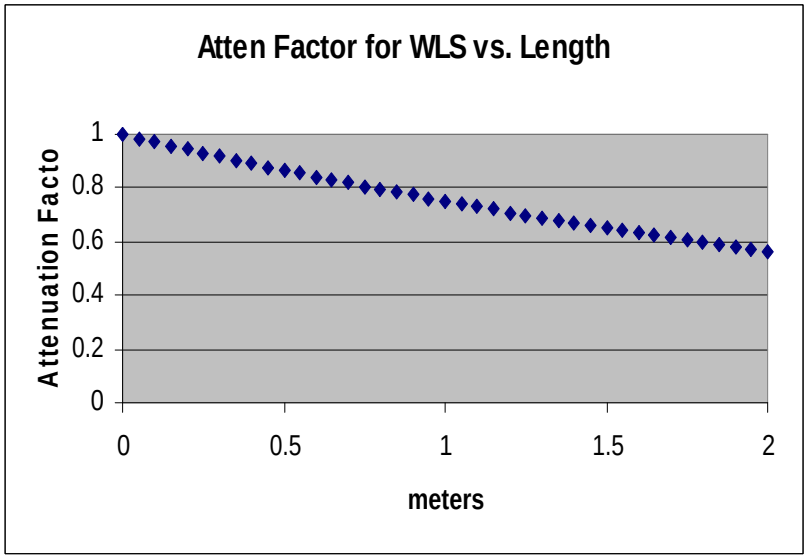


Circles show points that were measured. Numbers indicate strip numbers

Fiber Attenuation vs. Lengths

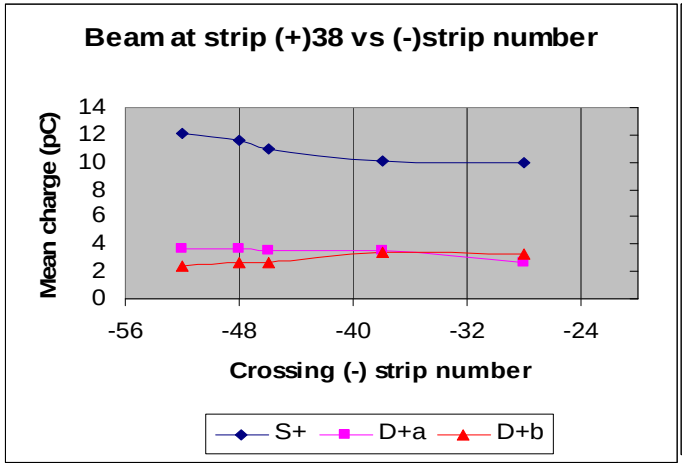


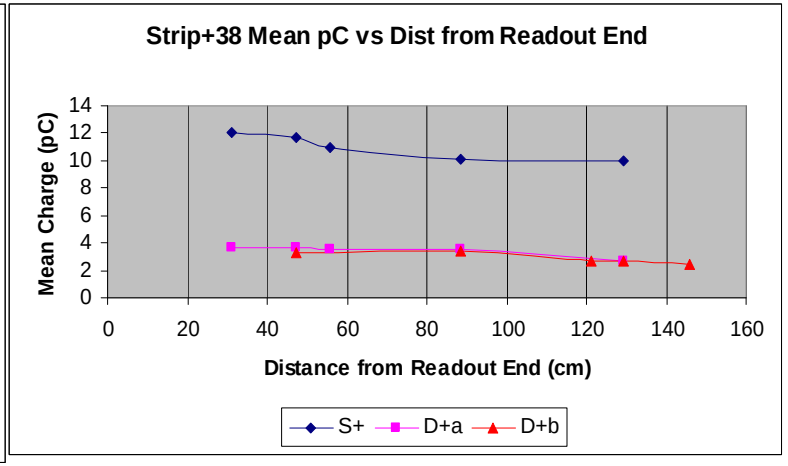
λ = 10 m



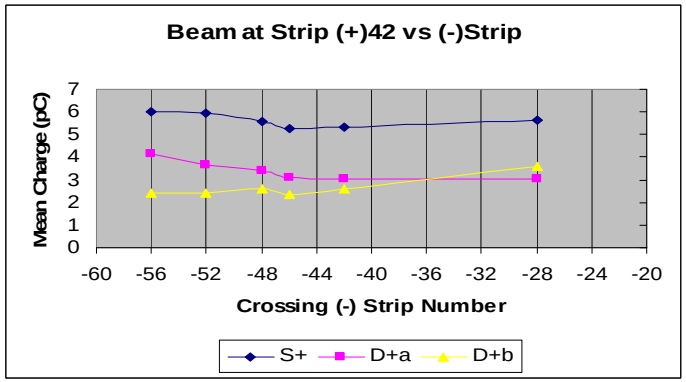
λ = 3.5 m

Signal along Strips +38,+42





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



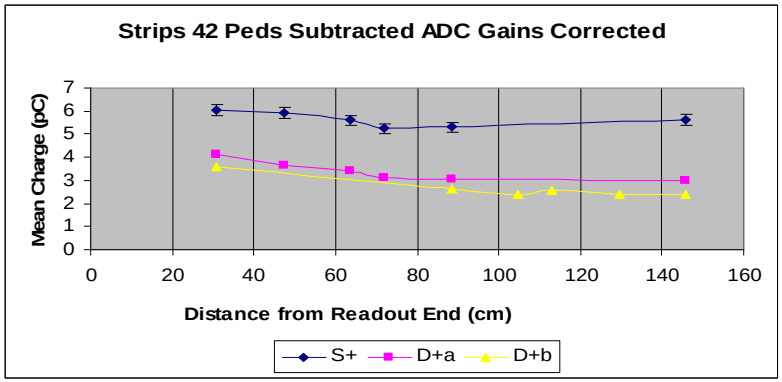
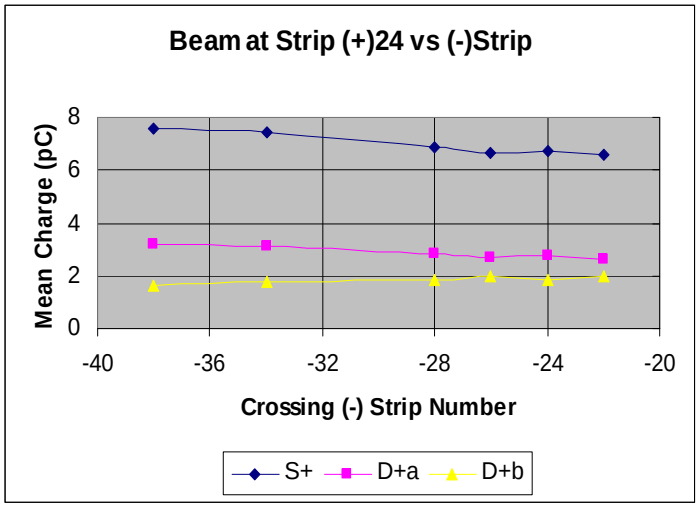
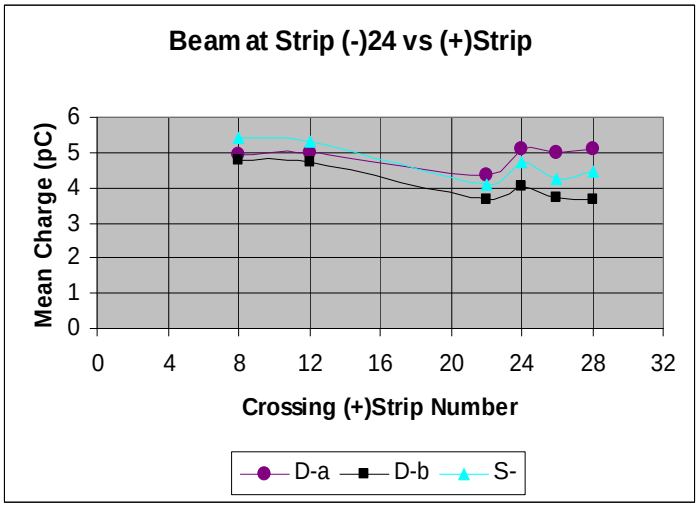


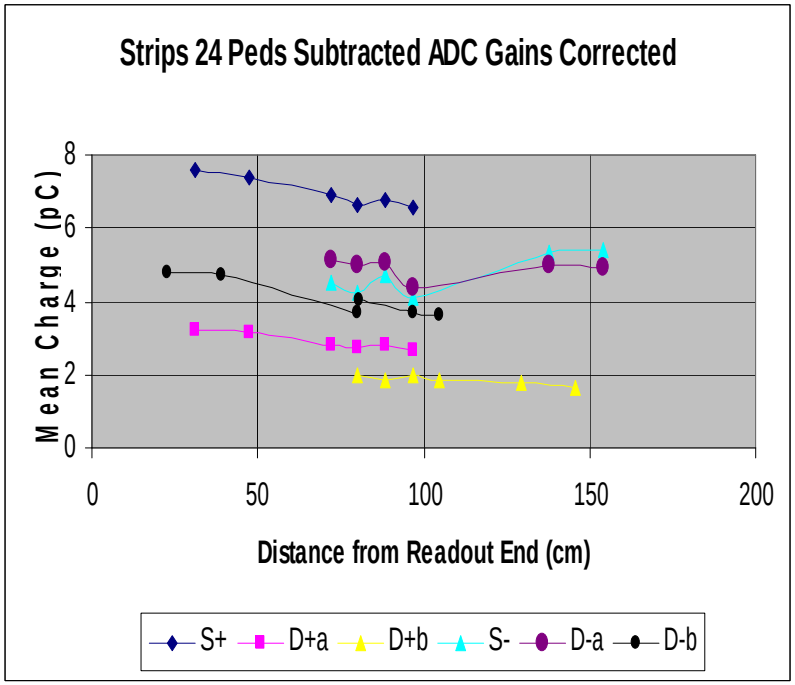
Photo-Electron Yield
~6 p e D+
~12pe S+

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

Signal Along the Strips +24,-24

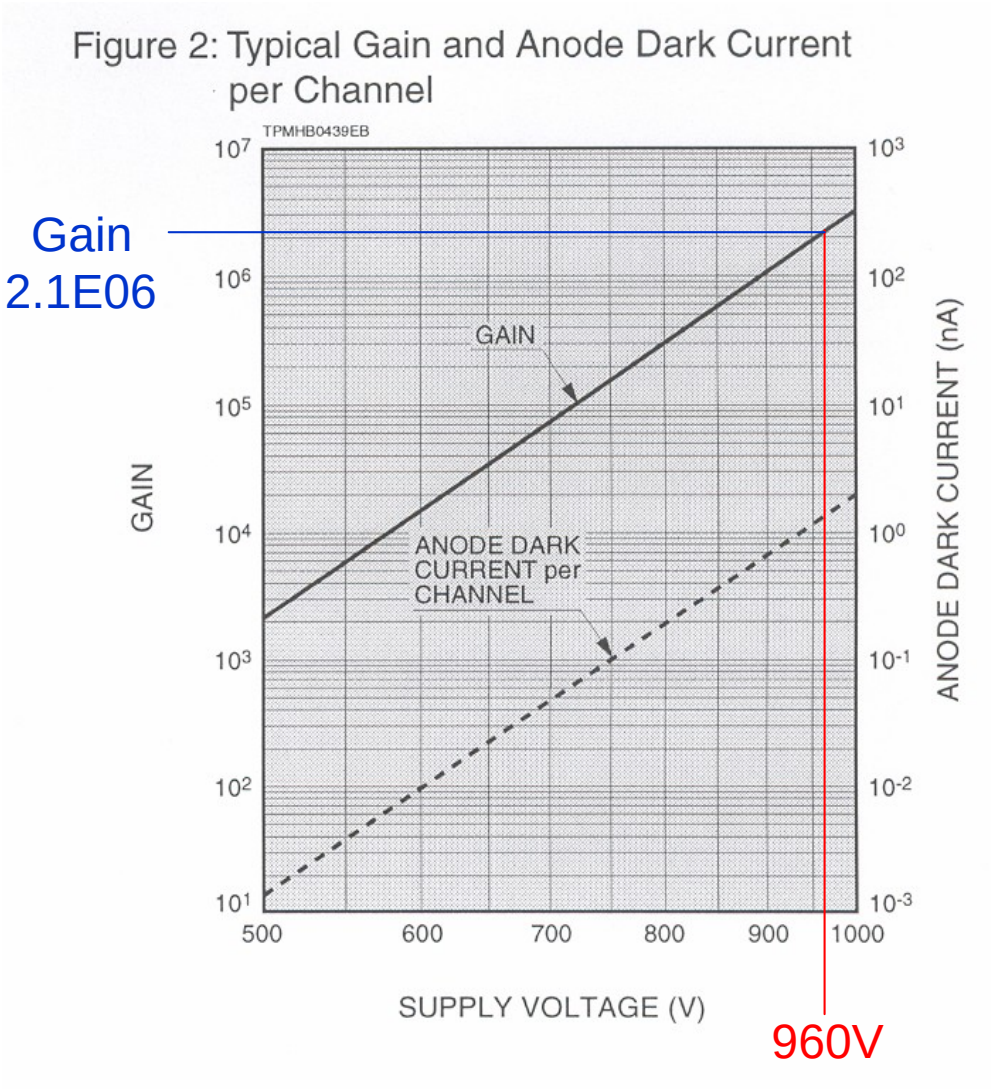






- Pedestal Subtracted and with ADC calibration Included.
- Double beam events removed

Photo-electron Yield Estimate



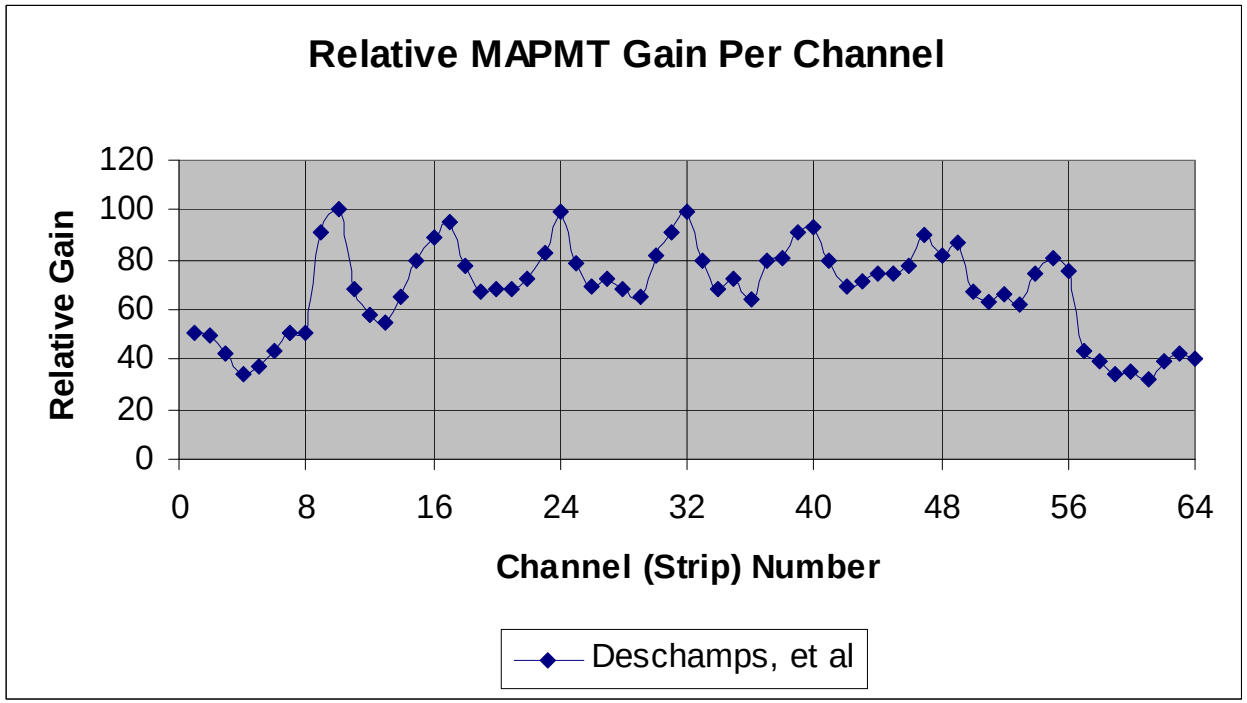
2 pC = 12.5 X 10^6 e's

Nom. Gain = 2.1 X 10^6

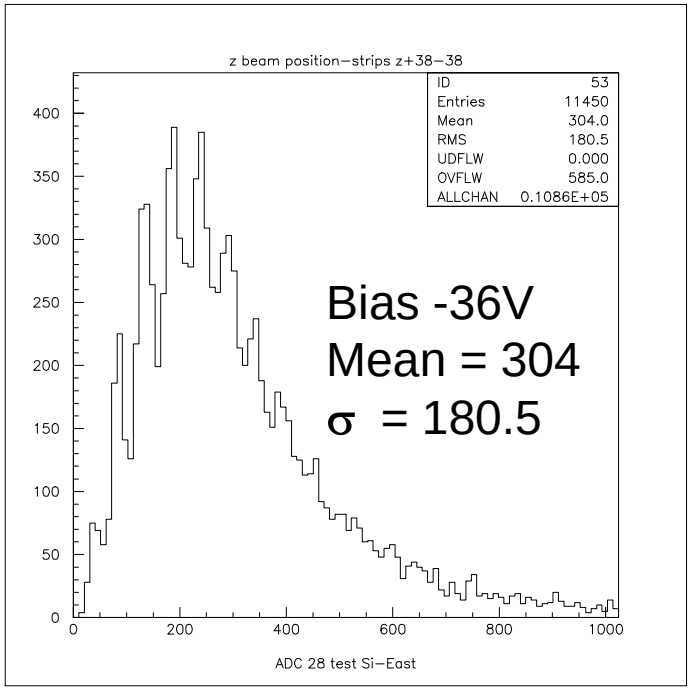
⇒**~6 p.e.'s**

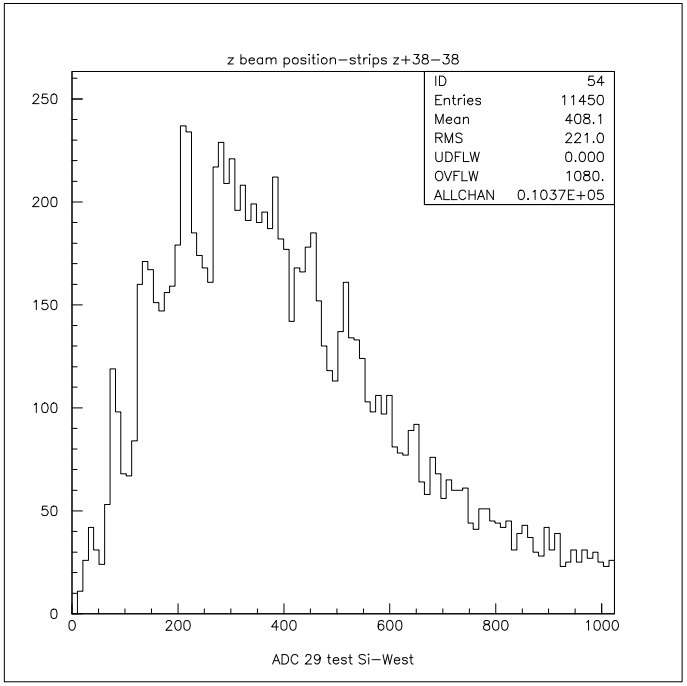
Hamamatsu H7546B
64 channel MAPMT

Effects of Variations of MAPMT Gain per Channel



Italian SiPM Beam Test



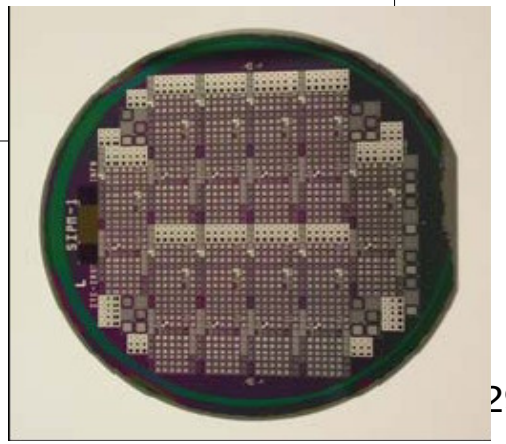


A. Driutti and G. Pauletta – INFN Trieste/Udine

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

- Continue to analyze present data (universities and FNAL; funding problem)
- Calibrate MAPMTs: use measured MAPMT gain (WSU)
- 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 SiPMs 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.