Test Beam Studies of Scintillation Strips for Muon Detection

LCWS08

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Introduction

- Continuation of T956 as reported by G Pauletta at LCWS07 and additional progress reported by G Fisk at Boulder

- Test Beam studies of scintillating strips with WLS and SiPM readout*
  - Just getting rolling –first beam Nov 8th
  - Still using CAMAC electronics (long live Disco!)

* the new part

Goals and Motivation

- Project to investigate the application of SiPMs to optical readout of scintillator based muon detectors and calorimeters
- Goal is to co-develop scintillators, SiPMs and electronics to understand the necessary compromises and tradeoffs
- Our approach is to emphasize flexibility and all around utility
  - Not designing for a specific detector

Institutions

I’m sure to miss people if I list names, so..

Fermilab

IRST/INFN-Udine

Indiana Univ.

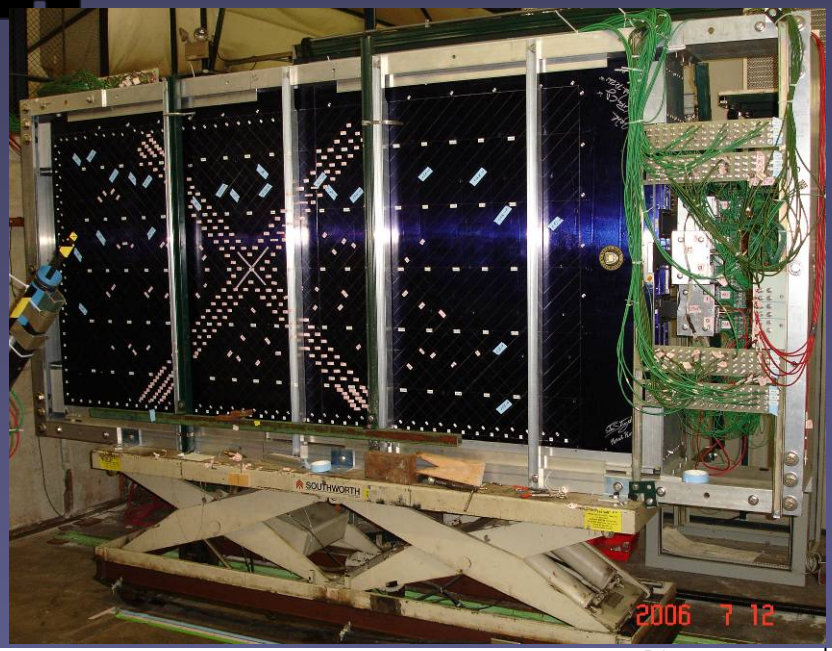
Northern Illinois Univ.

Univ. of Notre Dame

Wayne State Univ.

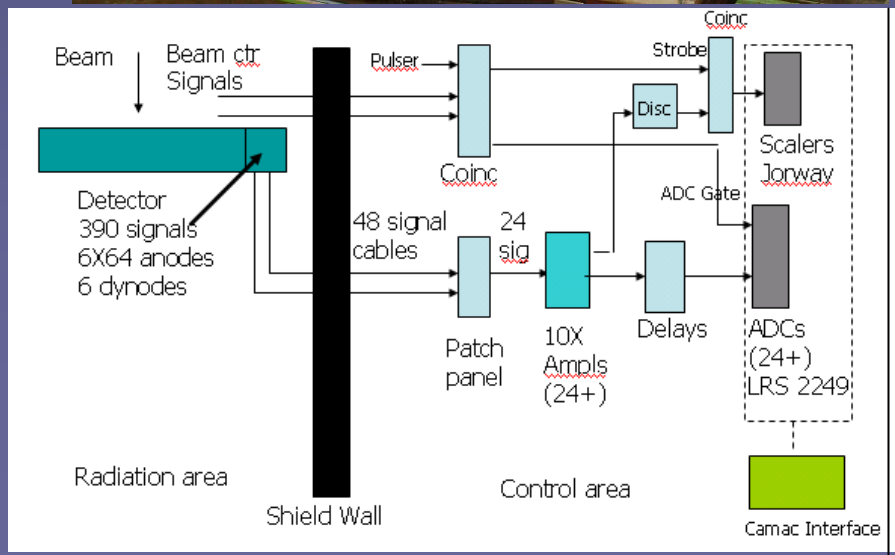
Previous Test beam activity

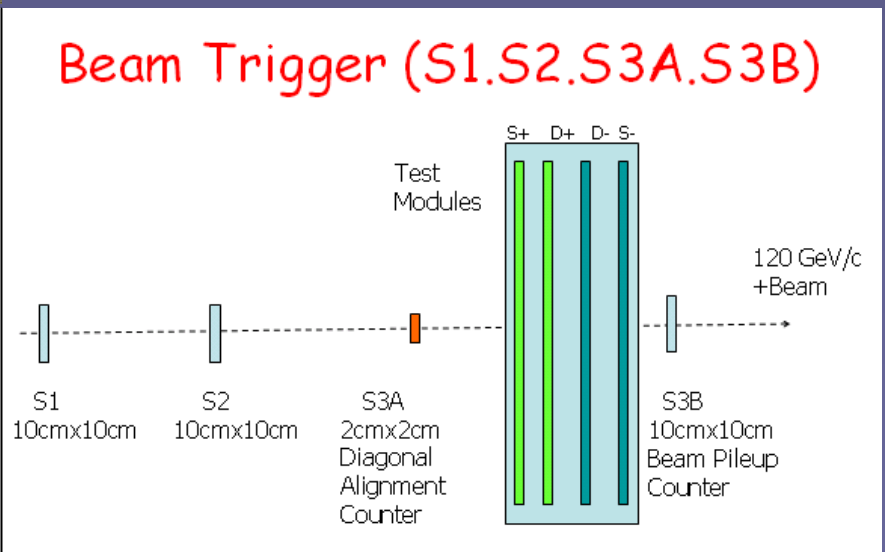
Jul 2006



Scintillator-strip planes installed in Fermilab Beam Test Facility
Planes: 1.25m X 2.5m

256 scintillator strips: 4.1cm (W) X 1cm (T) X 1.8m (L). Two planes have single- ended readout and 2 planes have both ends of strips readout. Read out by 384 PMT channels

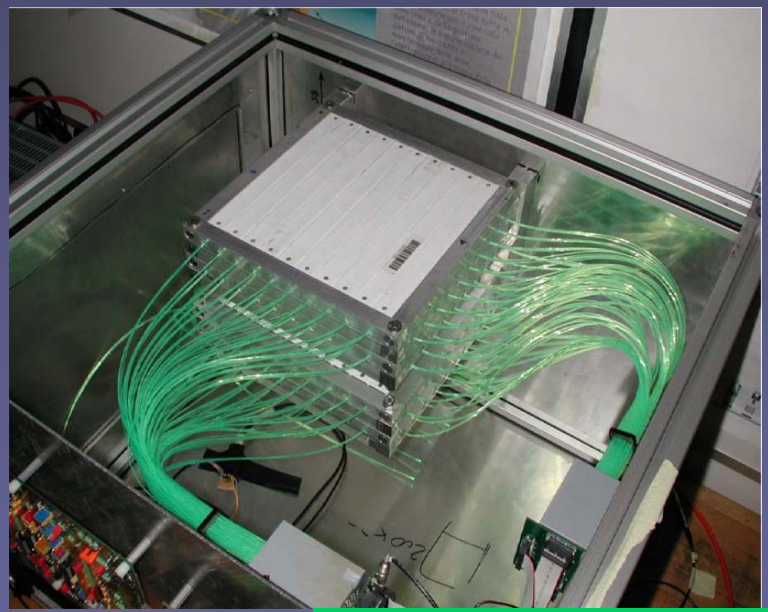




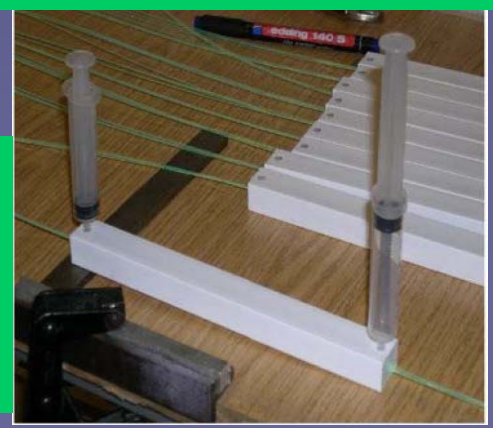
Previous Test beam activity

Test beam at CERN (May/June 2008)

In collaboration with the MICE experiment: 8 extruded scint. bars (1.5x1.9x19 cm3) with wls fibers read out by SiPMs (IRST and Hamamatsu), all other bars of the MICE calorimeter read out by MAPMT. An ad hoc mechanical receptacle was realized to couple and align the fibers with the SiPMs

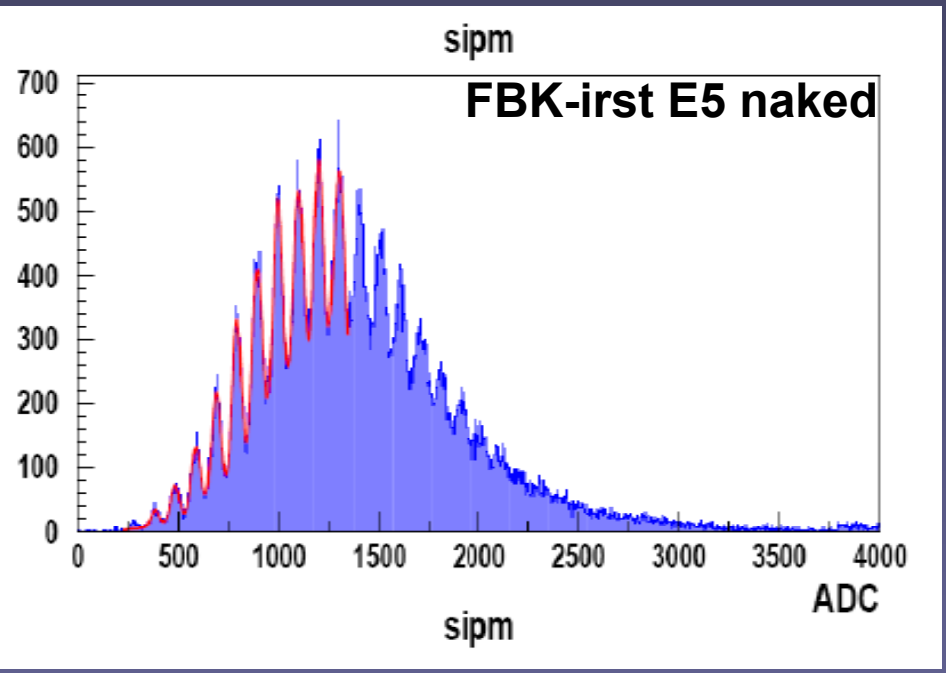


➢Extruded bar scintillators (1.5x1.9x19 cm3)
➢4 WLS fibers of 0.8mm per bar
➢Readout with Hamamatsu 64 multianode PM and tests with a SiPM (on the other side of the fibers)
➢Frontend: VA64TAP3.1 + LS64 by Gamma Medica-IDEAS; trigger signals sampled by an Altera with a 320 MHz clock

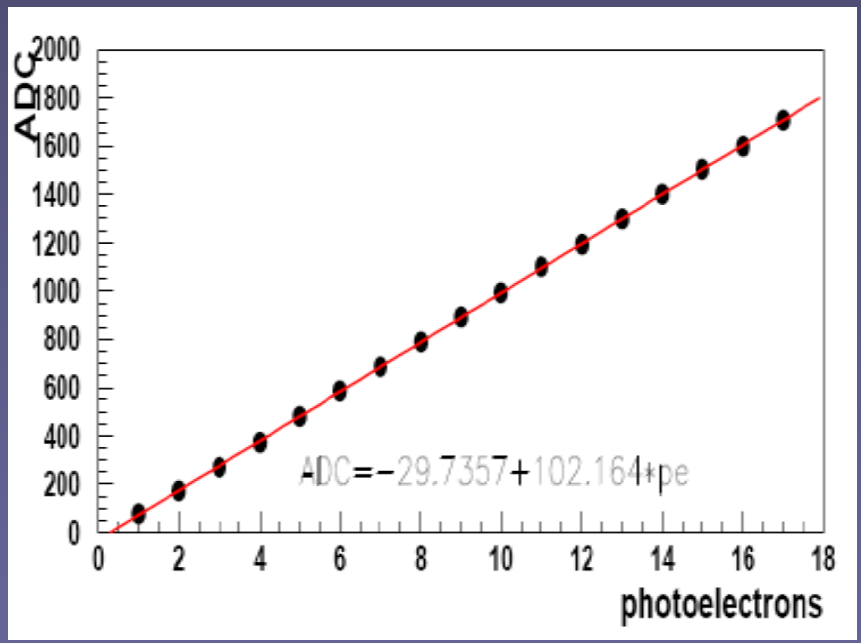


8 channels of the MICE EMR calorimeter prototype (extruded scintillator bars with WLS fibers) were coupled to SiPMs and tested in a 2 GeV positron beam at CERN in May-June 2008.

Test beam at CERN PS – results



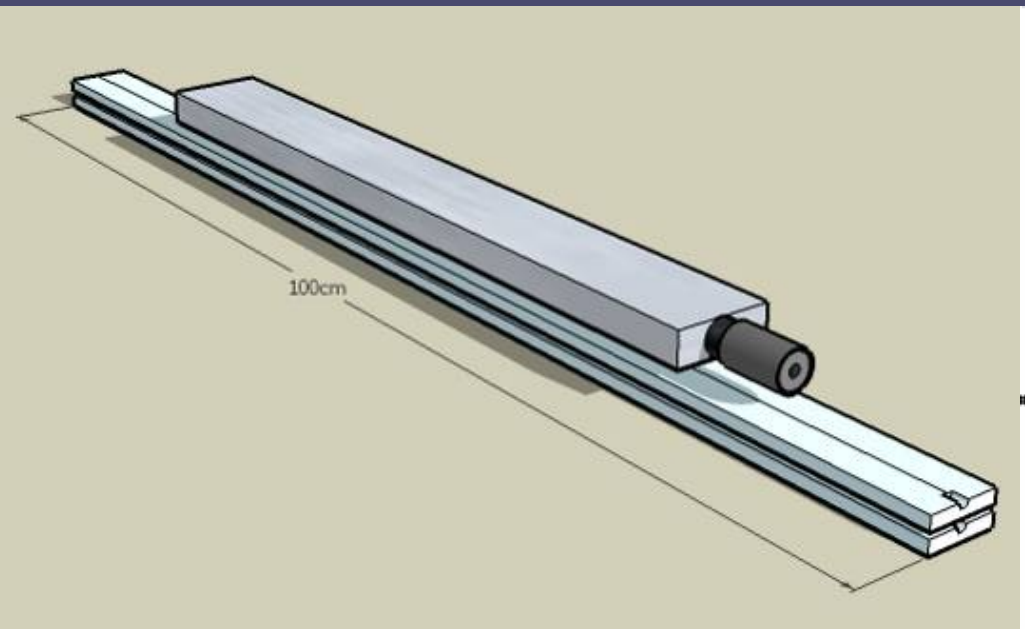
Pulse-height plot of the SiPM obtained selecting good events on the MAPM side

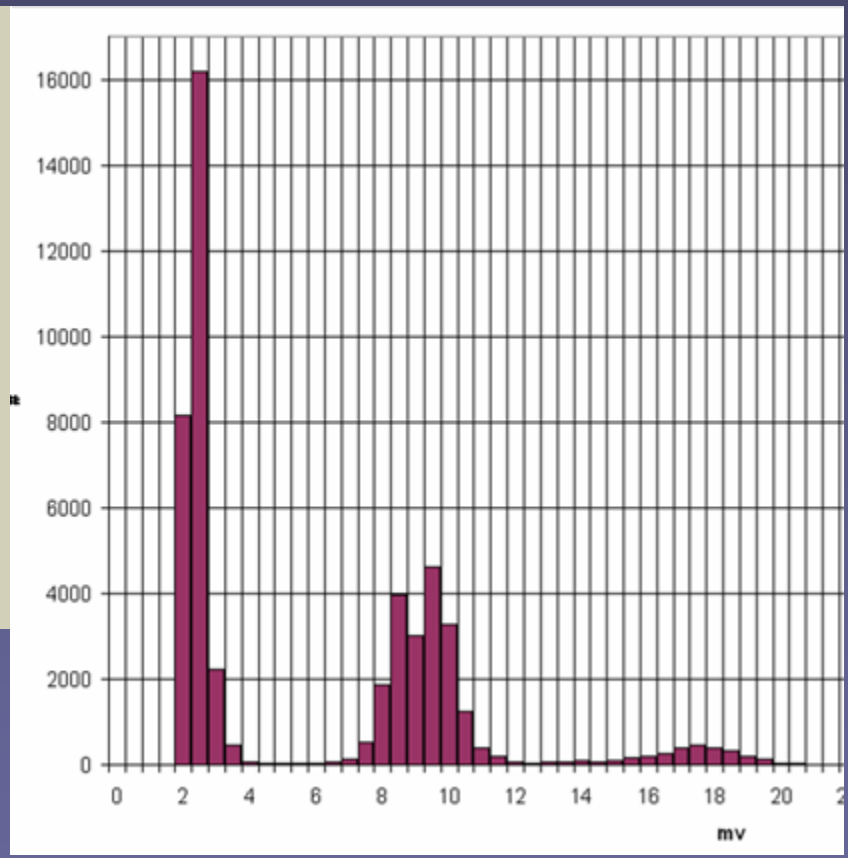


Both plots refer to results obtained with a circular SiPM (Ø 1.2 mm) by FBK-irst operated at ΔV = 2 V.

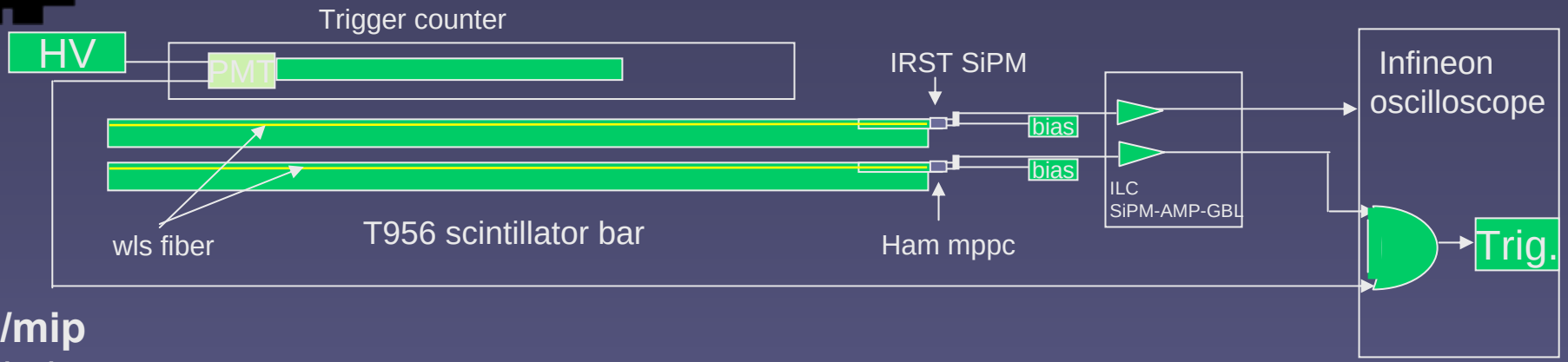
Previous test beam activities

Aug 2008





- Also, we looked at cosmics
  - With Ham MPPC (100pix)
  - And IRST SiPM

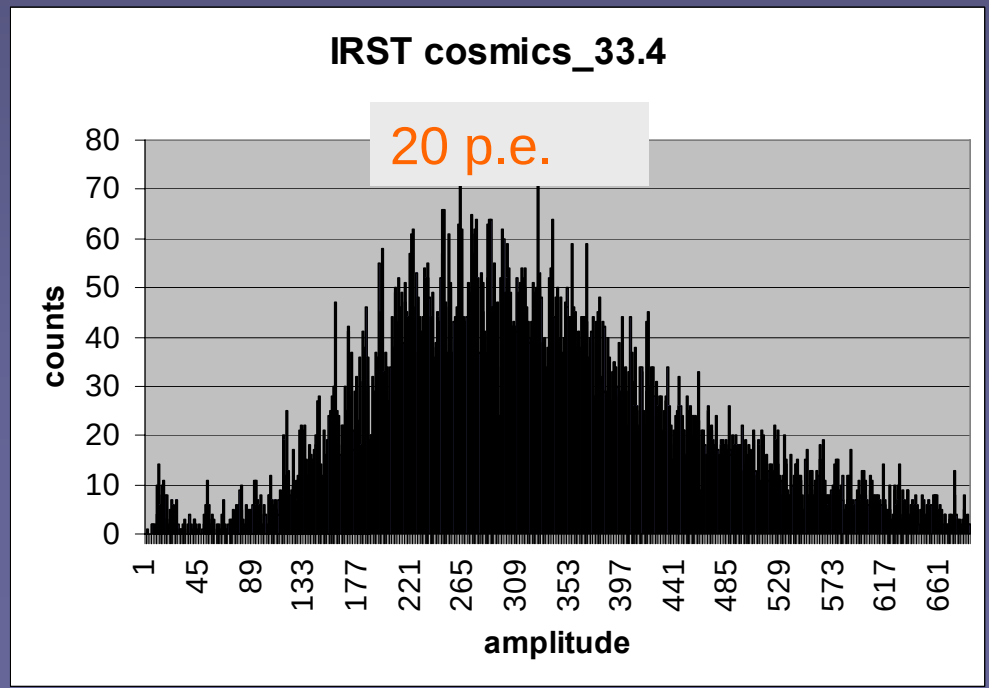


p.e./mip

Preliminary measurement (using cosmics) to determine the number of photoelectrons per mip in T956 scintillator bars.

With the improved fill–factor of these SiPMs (44%) we obtain ~20 p.e./mip despite less than optimal SiPM to wls fiber coupling.

Coupling is being optimized



despair.com

Test Beam

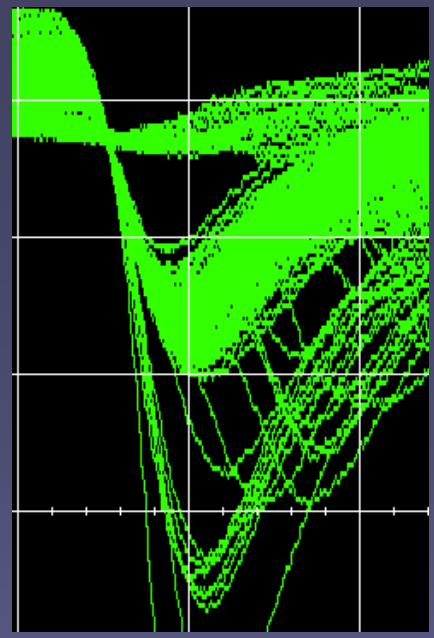
ALL WE ASK IS THAT YOU GIVE US YOUR HEART

MTest 2008

Beam from Nov10 to 16

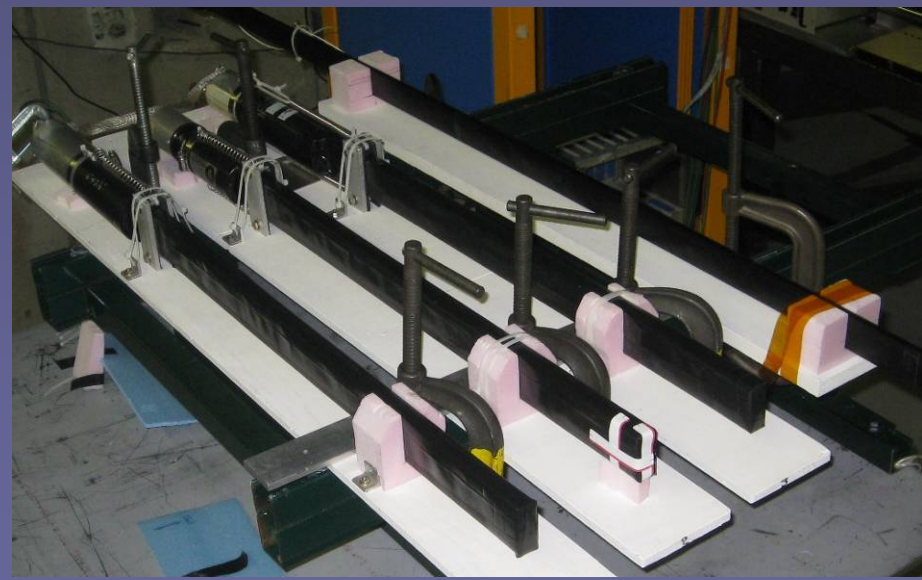
- Minerva test of TOF counters
- Added one bar with SiPM for testing (Ham, IRST)
- Using NIM based 6ch amp built at Fermilab for this work
- Using optical coupling designed at Notre Dame
- Using 120 GeV proton beam (1in x 1in spot)
- Very preliminary results below

MTest 2008



Beam from Nov10 to 16

- Minerva test of TOF counters
- Added one bar with SiPM for testing (Ham, IRST)
- Using MINOS co-extruded bars w WLS fiber glued in groove
- Using NIM based 6ch amp built at Fermilab for this work
- Using optical coupling designed at Notre Dame
- Very preliminary results

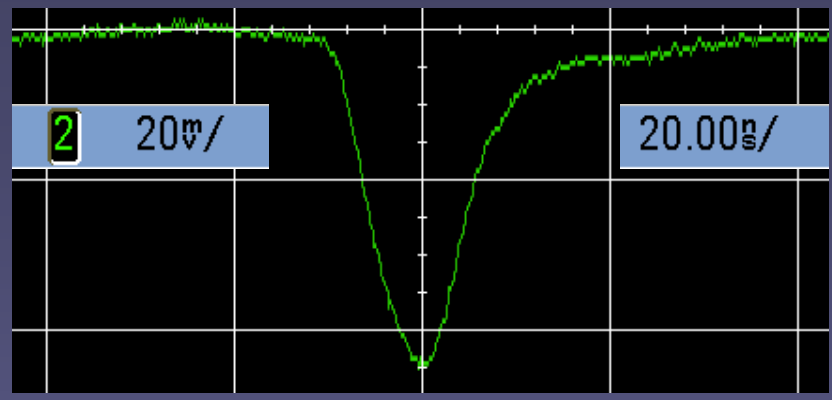


Our setup

Electronics designed for good speed and large gain (AD8351)

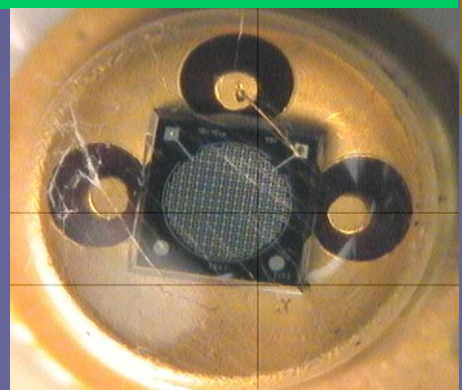
New IRST SiPM with improved fill factor and lower noise

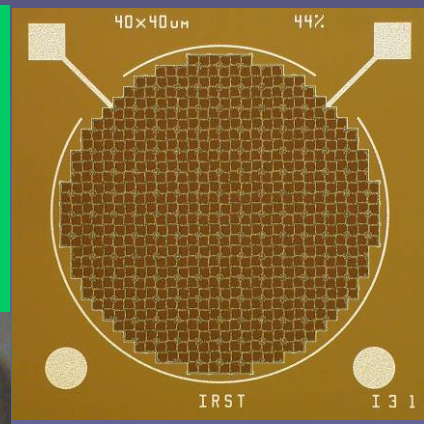
Packaged in trans can with “glob top” epoxy



Response to 1.25mV x 10ns pulse

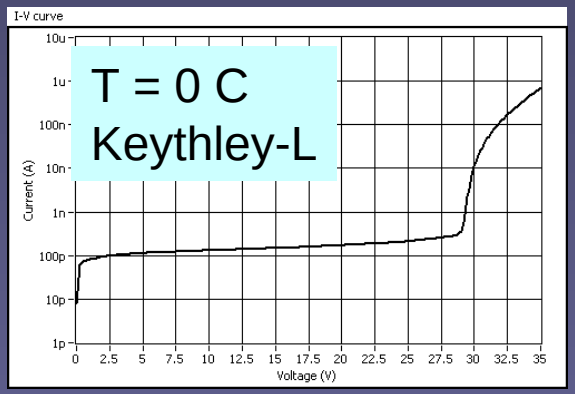
Geometry: circular
diameter: 1.2 mm
Microcell: 40 x 40 μm
Fill-factor: (44%)
Breakdown voltage ~30.5V

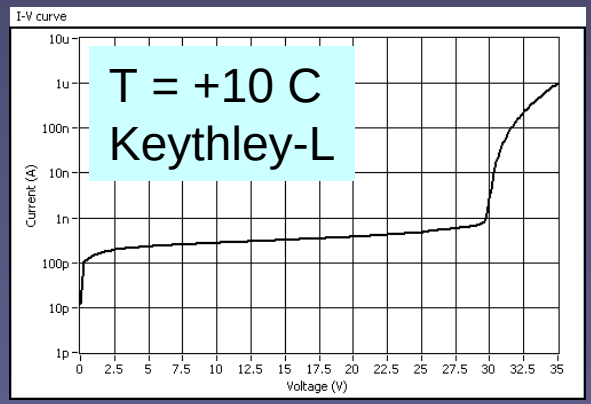


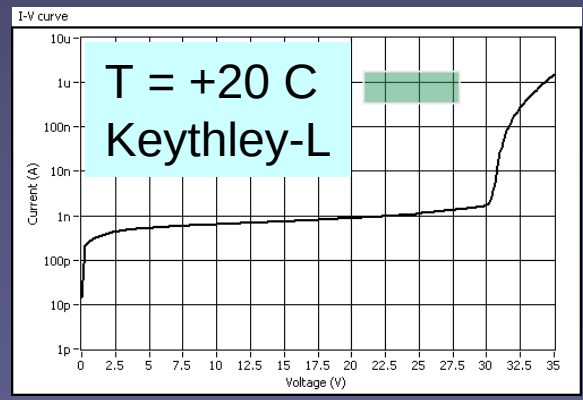


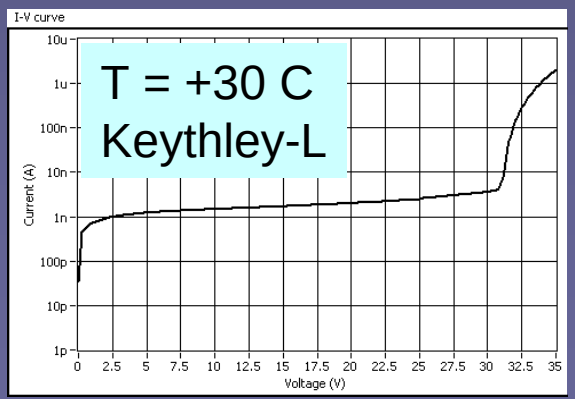
Our setup

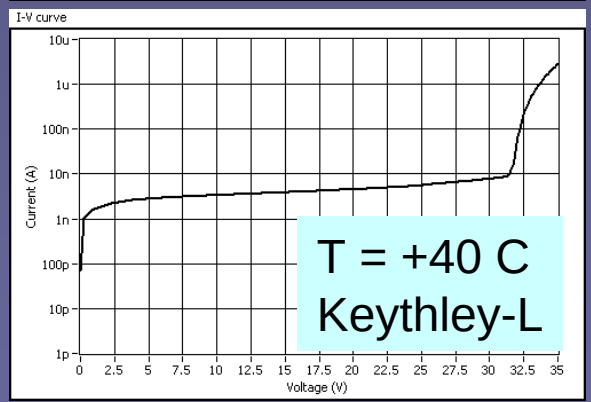
- All our SiPMs have been fully characterized

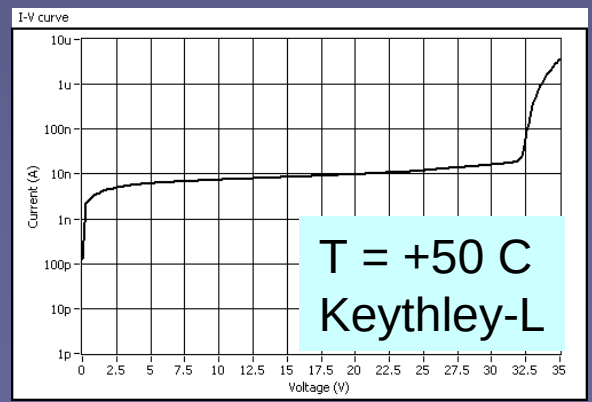








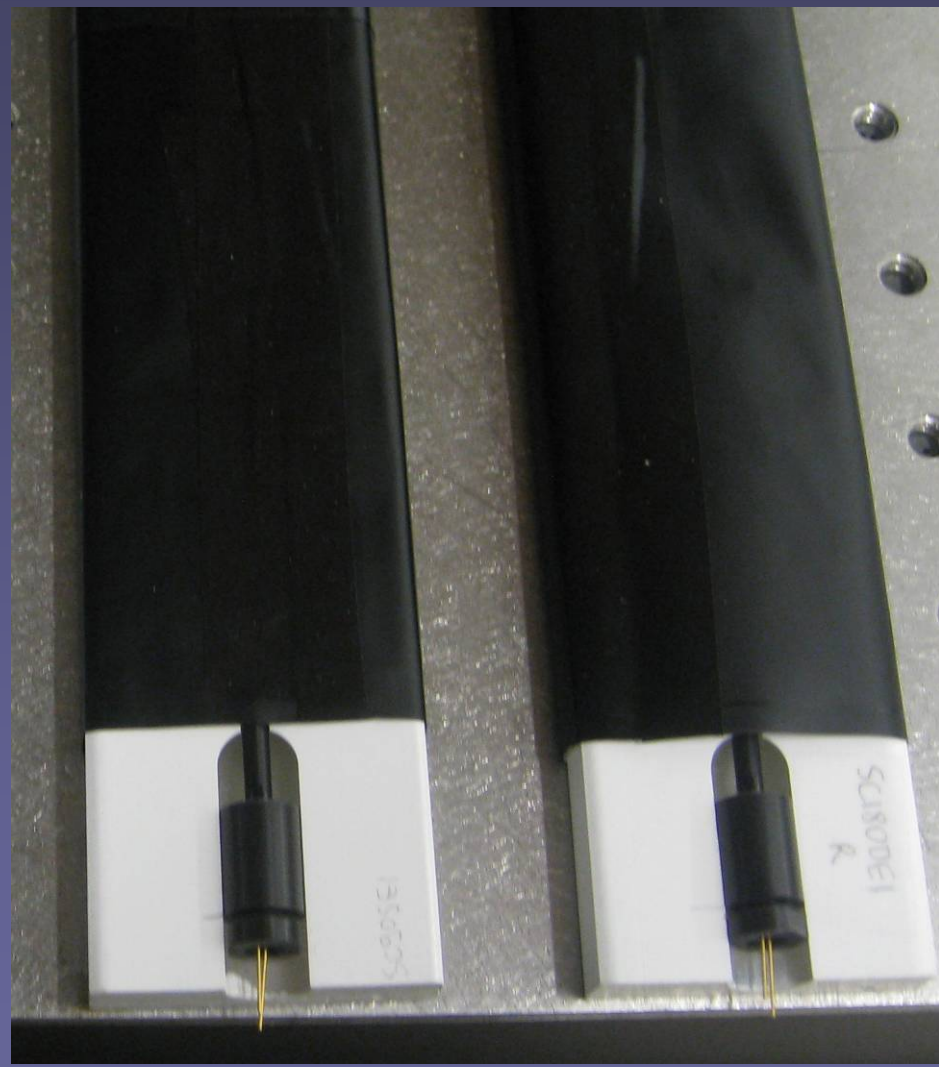




Our setup

Detail of optical coupling and adopter board

using Keithley 2400 for bias (not shown)



Very preliminary results

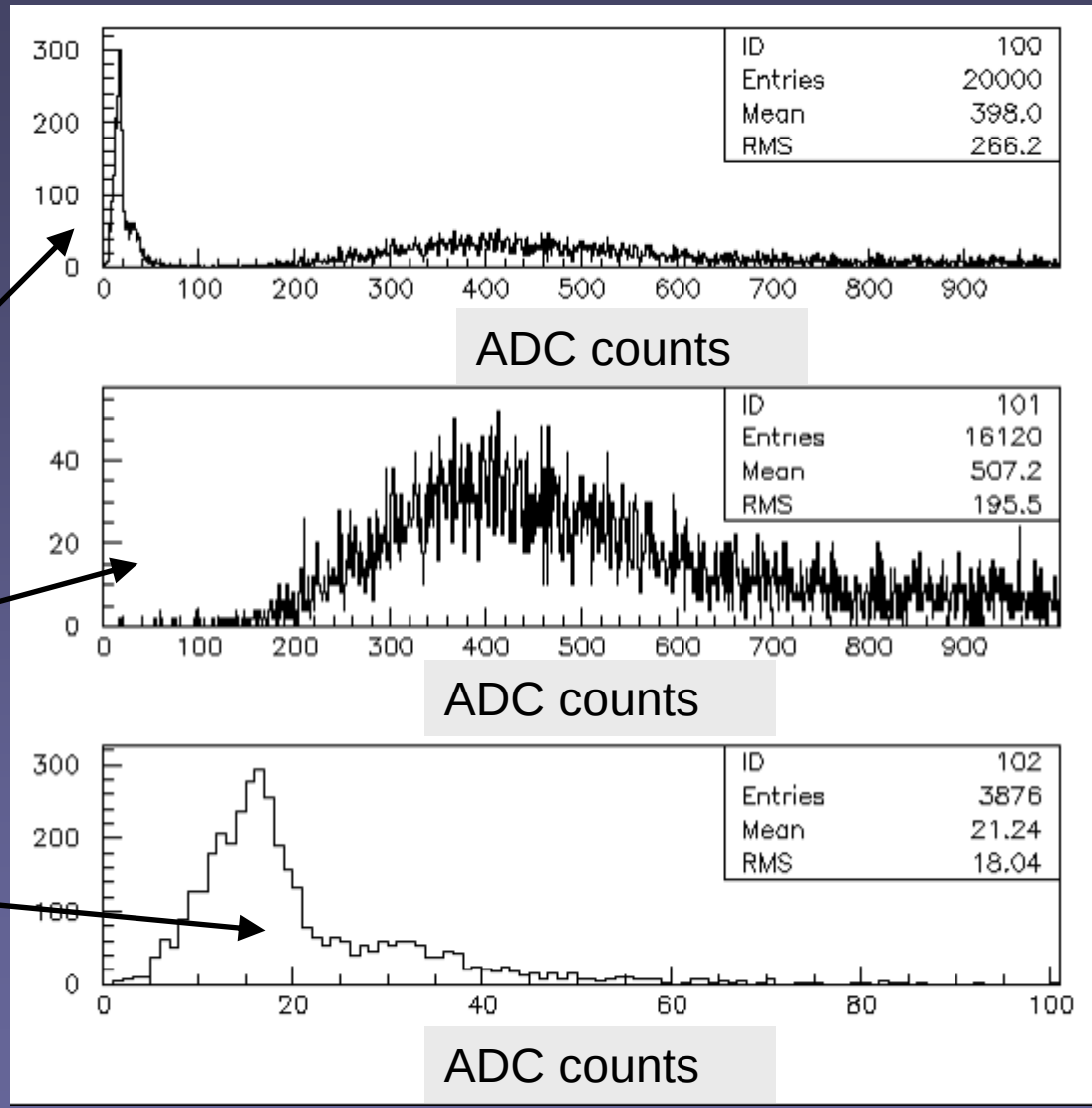
- This is our typical plots

Our strategy is:

Take data with loose trigger to enable us to see pedestal

Use other counters to select MIPs

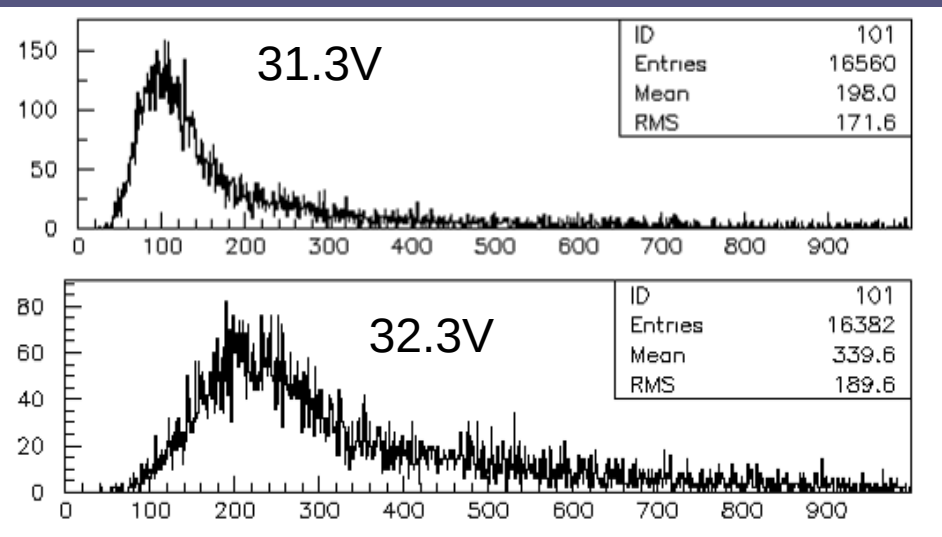
Extract 1pe peak from pedestal

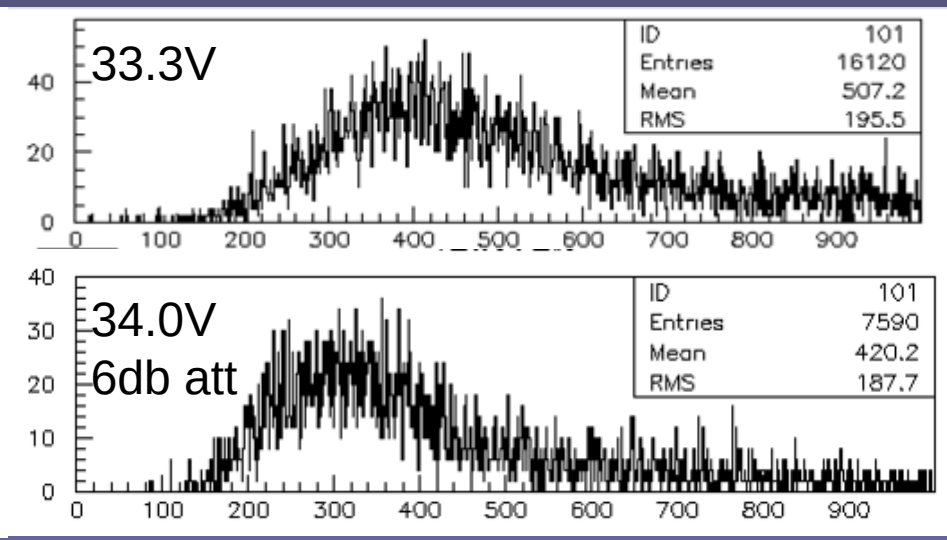


Very preliminary results

- We have taken data at different bias settings, different gate widths, different spots on scintillator
- One sentence summary:

  We have tons of signal. (at least 20pe)



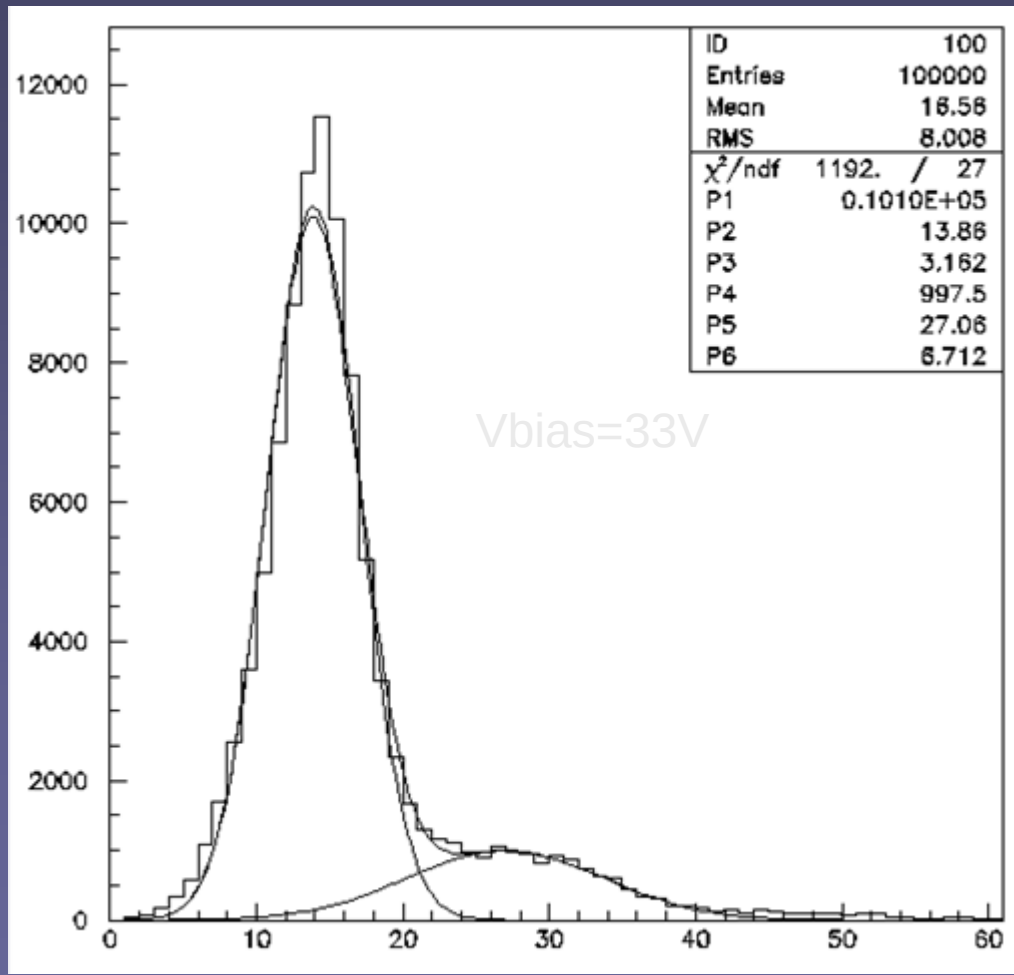


Very preliminary results

- It seems at least plausible that we can pull out the 1pe peak from the pedestal

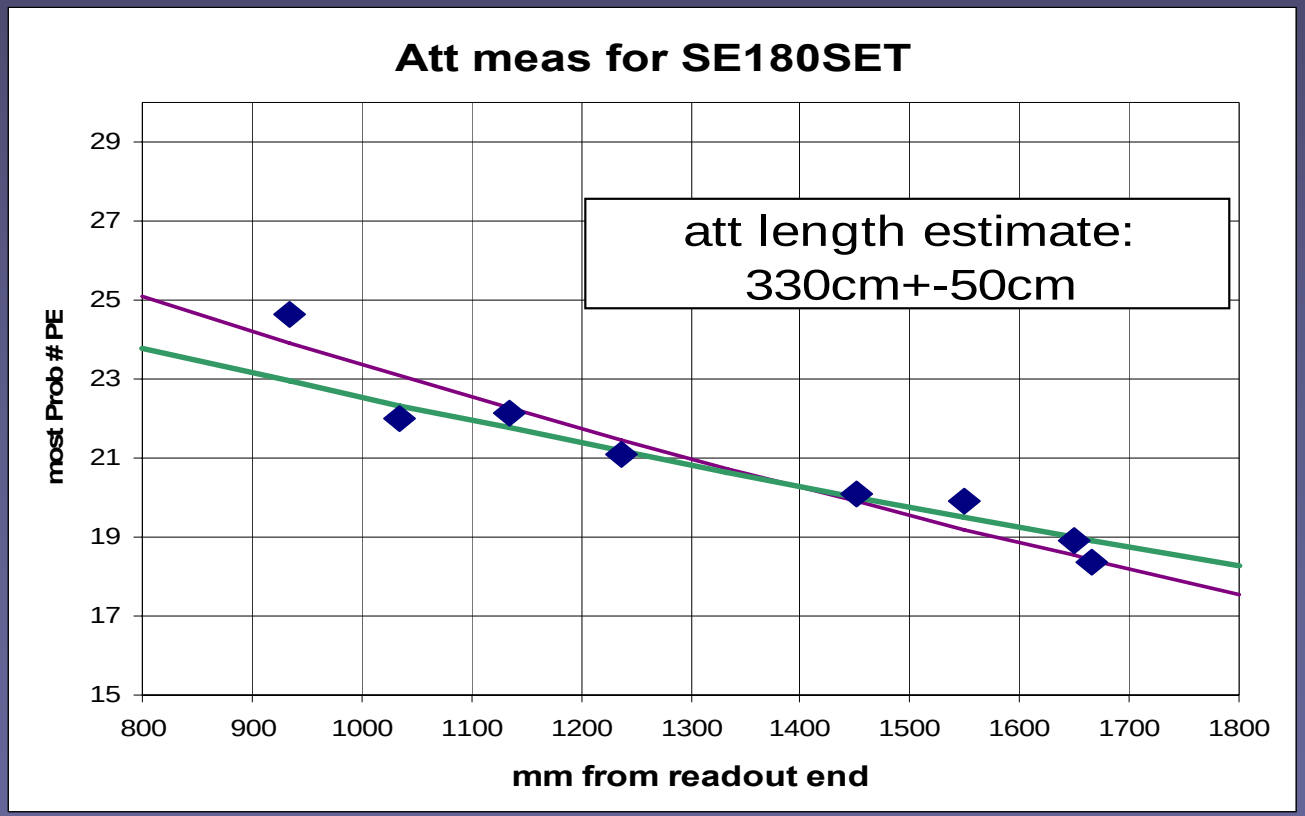
(due to dark counts)

- This makes the detector self calibrating



Very preliminary results

- A scan of the 1.8m bar across the beam gives an estimate of the attenuation length



More?

- I have to stop someplace… but you don't!
- Next steps:
  - Beam is gone for now. Next up is LED studies.
  - larger bars (3.5m) and double ended readout
  - New version of electronics/SiPMs
- Critical to have more resources for this very promising technology

Conclusion and Thanks

- Its kind of neat to have something this simple robust and (apparently) fool proof

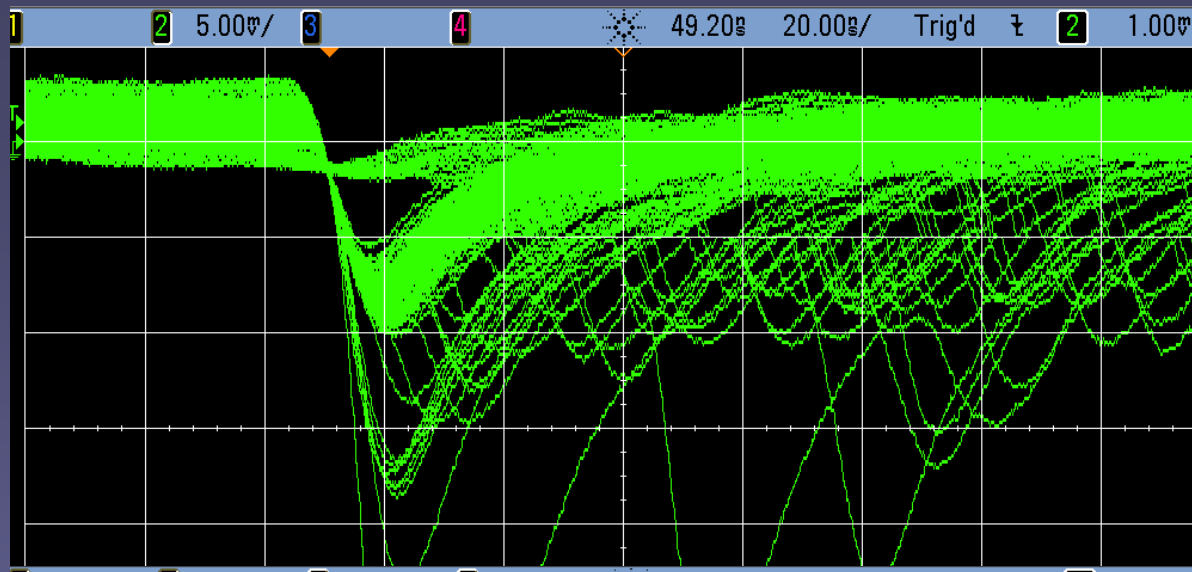
Special Thanks to:

G Paulleta and G Fisk for working like dogs so I did not have to.

And to baby Yoda for helping keep things in prospective.

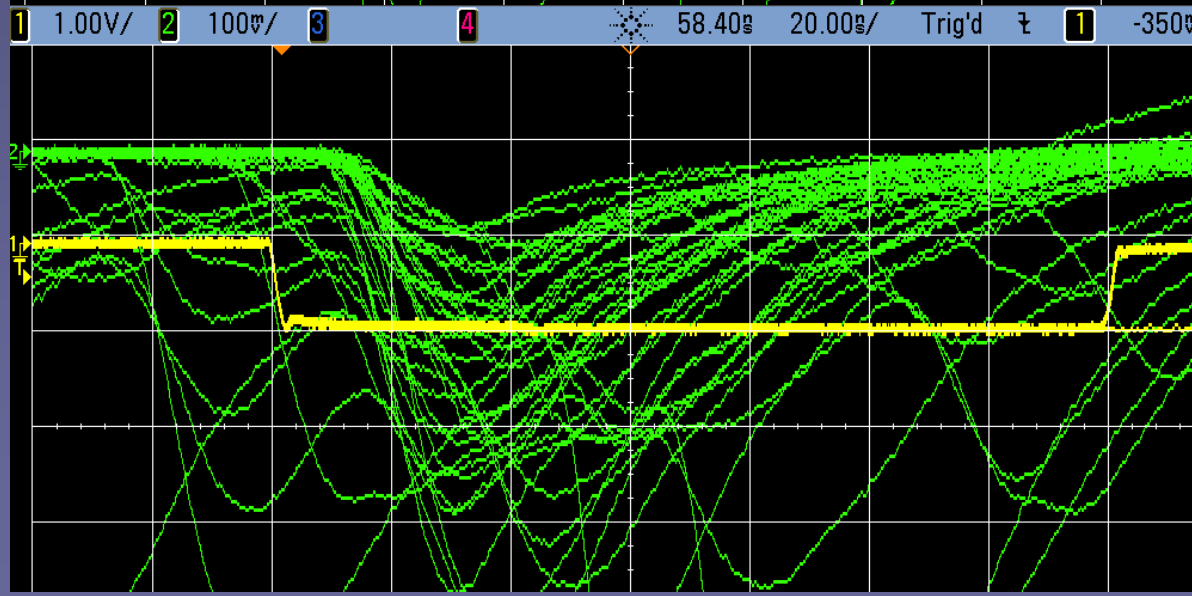
Even more

- Scope traces
  - Dark pulses



Beam signal

Notice factor of
10 scale change!



Beam has evidence of
RF (53Mhz) structure
Too much intensity!

More scope pics

- 4 random scope traces at very high Vbias = 34V, I=1.2uA
- After pulses are very clear