

A Scintillator Based Muon Detector for the Linear Collider



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Division of Particles and Fields
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Outline

Collaboration

Overview

- Physics Goals

- Principle of Operation

- Detector Challenges

- Simulation and Pattern Recognition

Scintillator

- extrusion and coating

Fibers

- clear-WLS splicing

- WLS/scintillator coupling

Photon Detection

- Hamamatsu MAPMT calibration

- Solid State Devices: GPD, SiPMT

Resistive Plate Chambers

Conclusions

Scintillator Based Muon Collaboration

Fermilab: Alan Bross, H. Eugene Fisk (Co-contact Person),
Kurt Krempetz, Caroline Milstene, Adam Para, Oleg Prokofiev, Ray Stefanski

Northern Illinois University: Gerald Blazey, Dhiman Chakraborty,
Alexandre Dychkant, David Hedin, Arthur Maciel

Notre Dame University: Mitchell Wayne

Rice University: P. Padley, M. Matveev, J. Roberts

University of California, Davis: Mani Tripathi, Richard Breedon

University of Texas, Austin: Karol Lang

Wayne State University: Ray Brockhaus, Alfredo Gutierrez,
Paul Karchin (Co-contact Person)

http://www-d0.fnal.gov/~maciel/LCD/awg_lcdmu.html

Physics Goals

- high efficiency for muons over wide momentum range
- large suppression of hadron misidentification
- improvement of calorimeter resolution for hadronic jets ("tail catcher")

Principle of Operation

momentum from central tracking

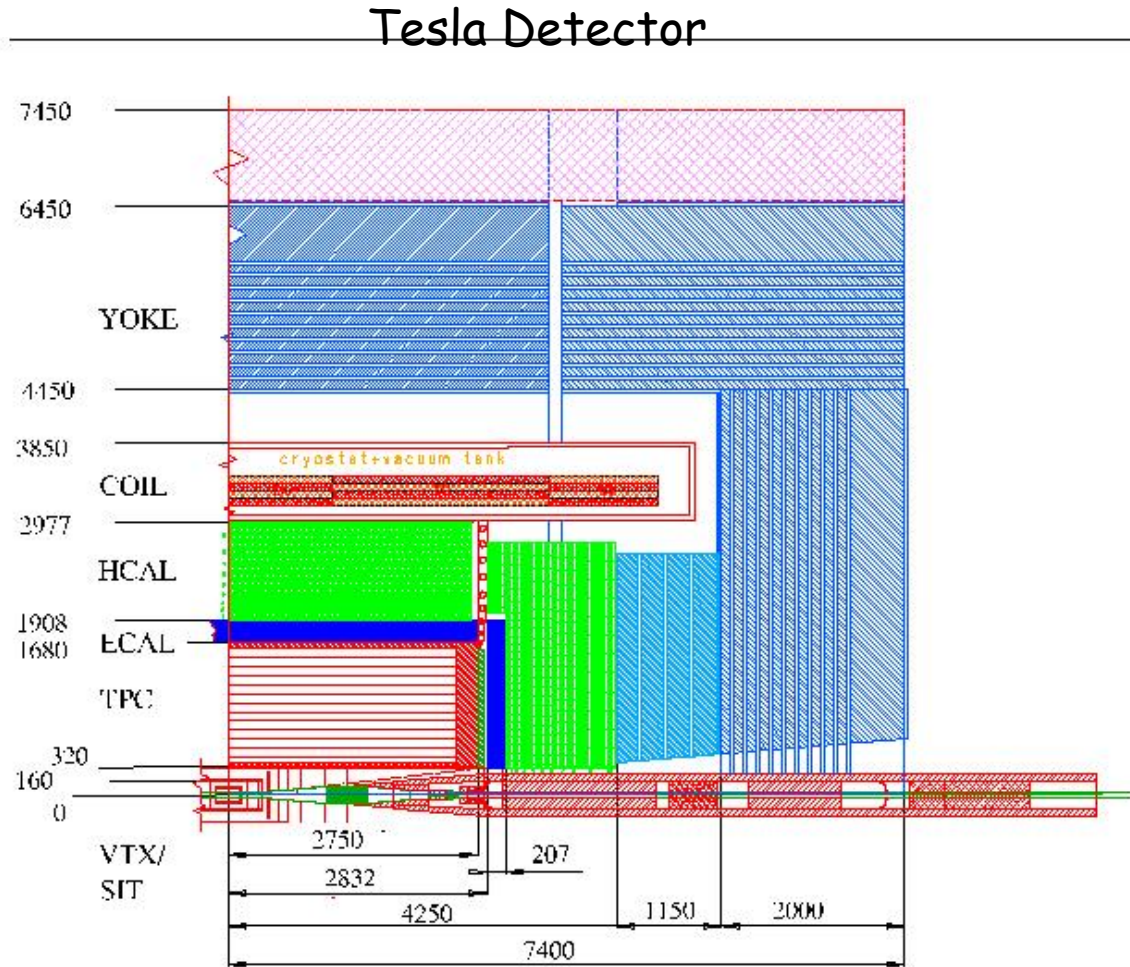
particle ID from:

penetration of Ecal, Hcal, SC Coil, μ Fe

matching μ detector track with central track

Ecal & Hcal energy deposition - min. ion. vs. em or hadronic

hadronic shower tail energy measured by analog μ detector



Detector Challenges

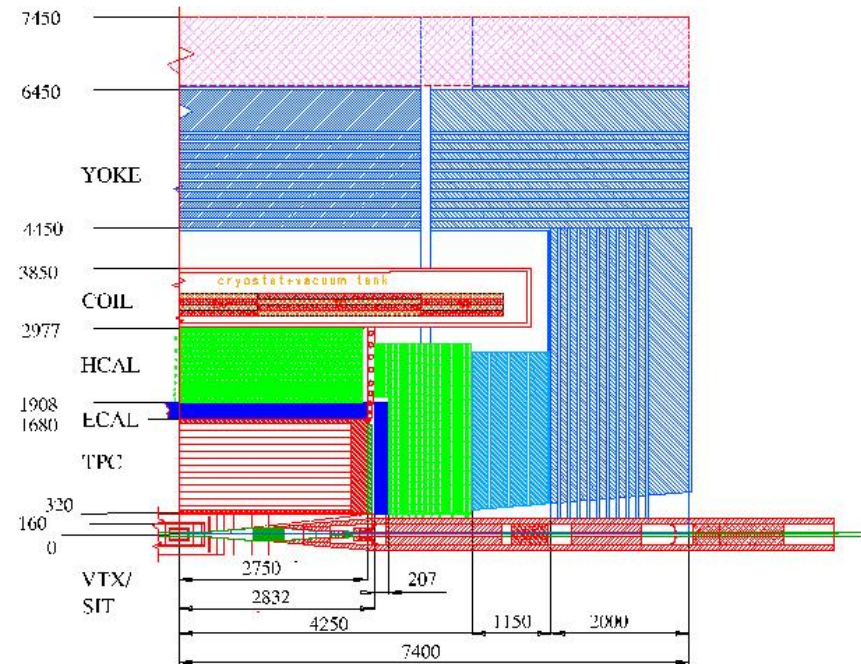
trade-off of detector cost with physics performance
(photon yield, analog vs. digital, timing ...)
integration of large, expensive detector sub-system

long term stable operation of inaccessible detector

WHY IS MUON DETECTOR R&D
NEEDED?

above challenges have more than
one proposed solution

TECHNOLOGY IS CHANGING!



Reconstruction Algorithm Development (C. Milstene, H.E. Fisk)

see talk on Victoria Linear Collider Workshop web page

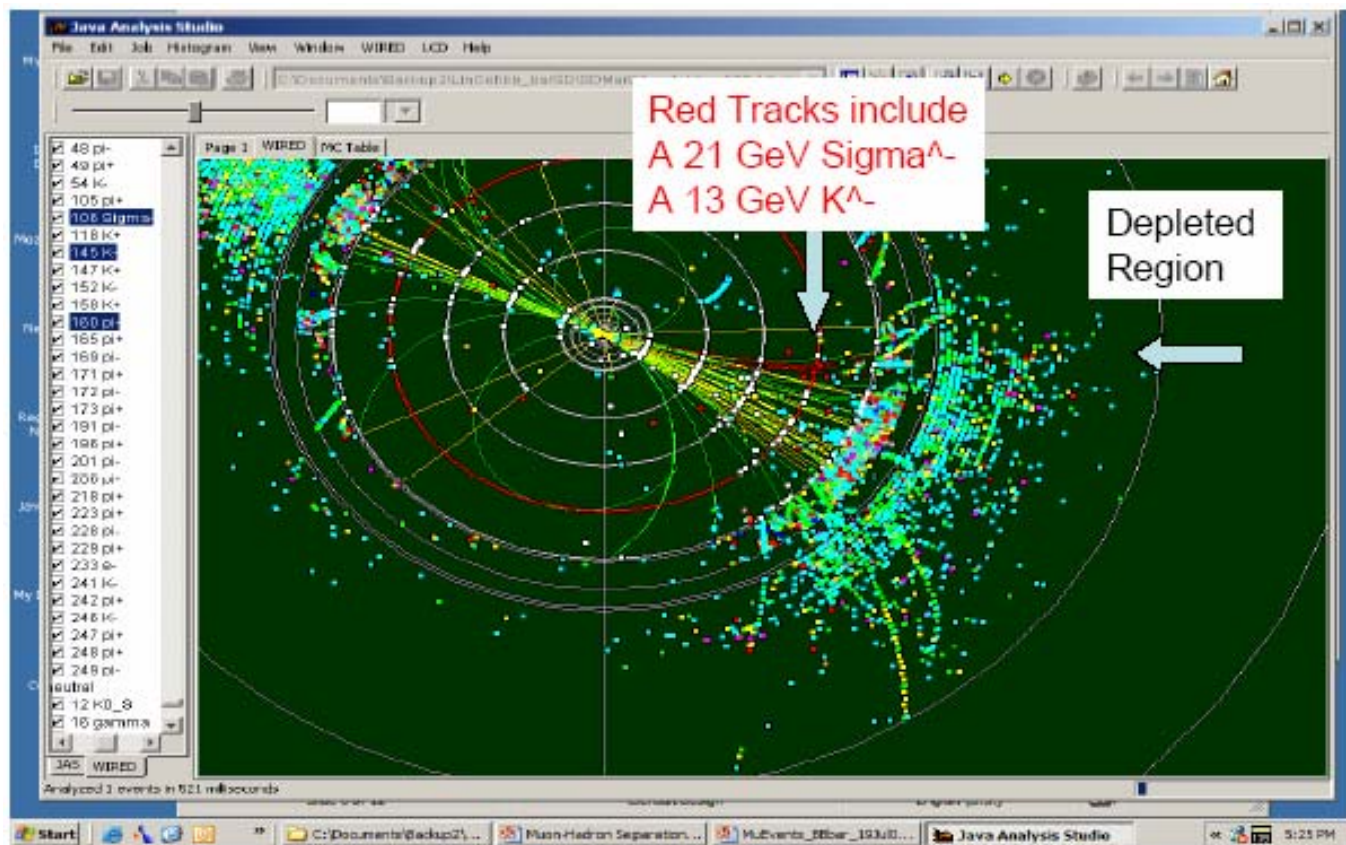
stepper algorithm takes into account effects of dE/dx and B-field

\bar{b} event in
SiD detector

start with tracker

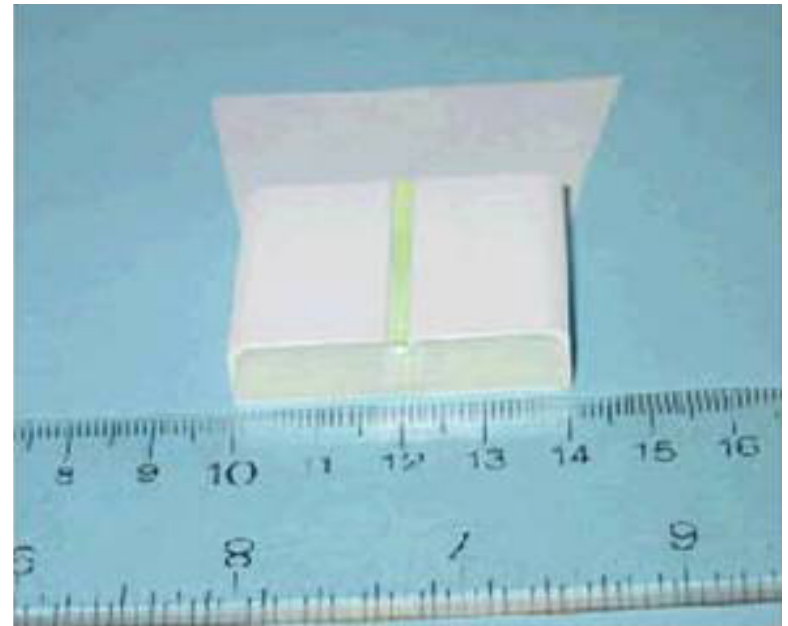
link to muon det.

use HCAL info.



Baseline Scintillator Design

- 1 cm thick scintillator strips in slots between 10 cm thick iron plates
- wavelength shifting (WLS) fiber readout of strip
- clear fiber link between WLS fiber and photodetector
- multi-anode photomultiplier tube opto-electrical conversion



Scintillator Options

commercially extruded scintillator with TiO₂ coating

dedicated HEP extruder (NIU/Fermilab)

tyvek/VM2000 coating



Fiber Splicing R&D

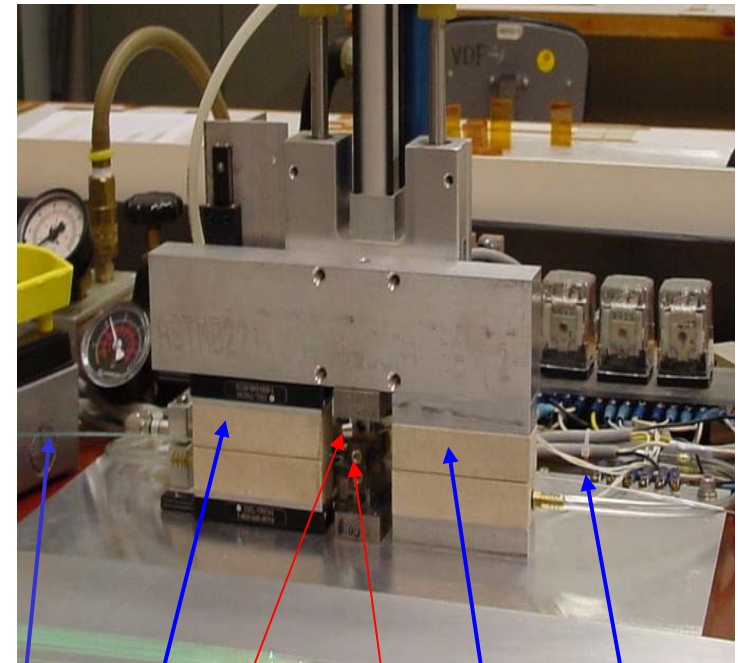
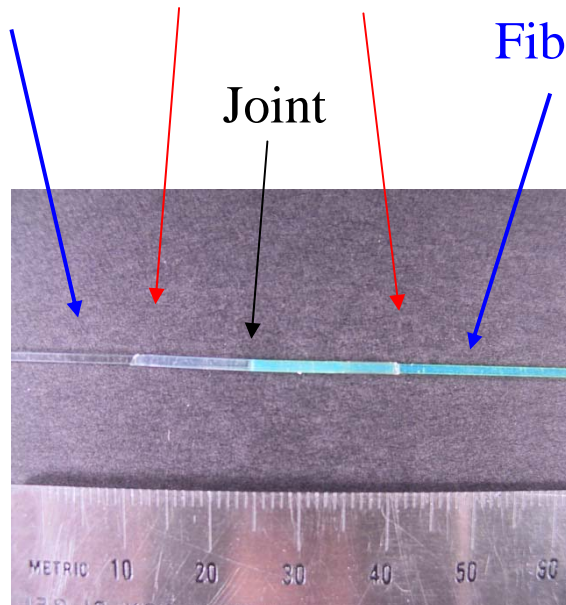
FNAL & Notre Dame

Thermally Fused Fiber Splice

Clear Fiber

1.2 mm Teflon Sleeve WLS

Fiber



WLS Fiber

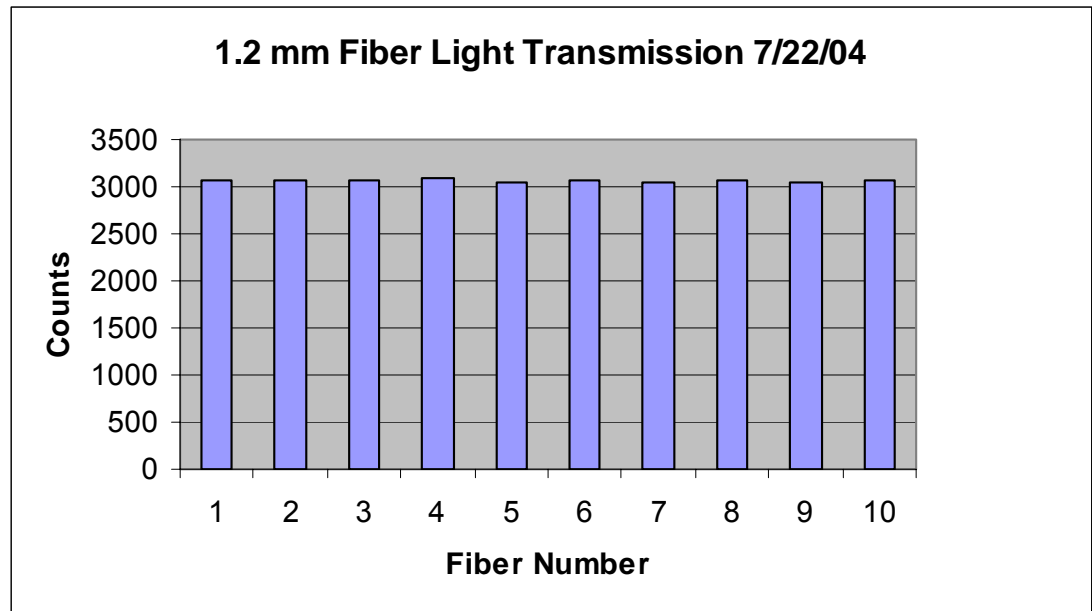
Dual Heating Blocks

Clear Fiber

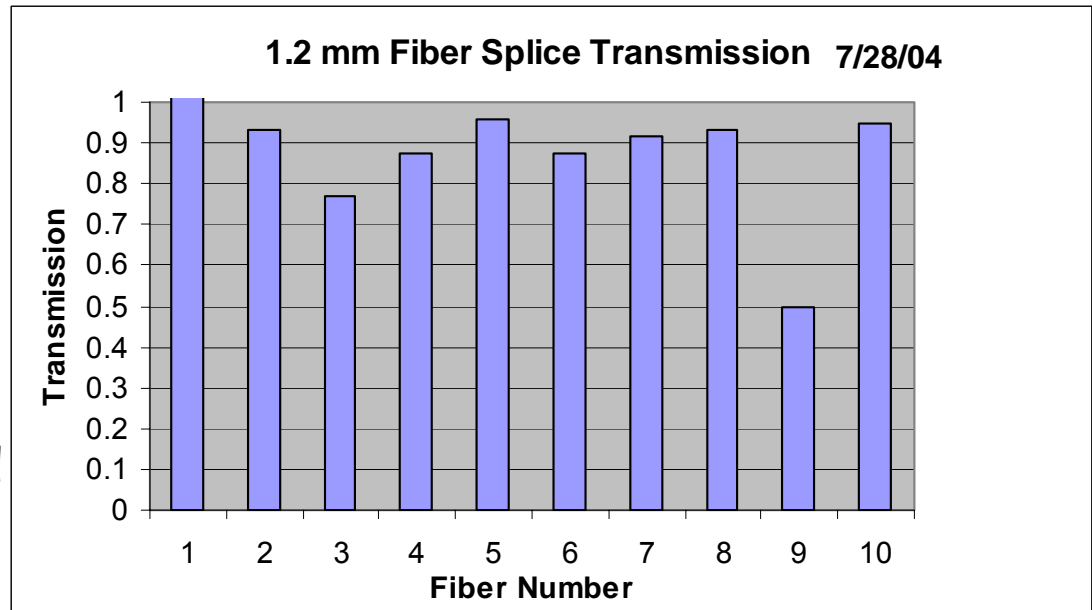
Fiber – Vacuum Clamps

Splicing Test Results

fiber from reel



light transmission of 1 m long,
1.2 mm diameter, clear,
straightened fiber



fiber cut and spliced

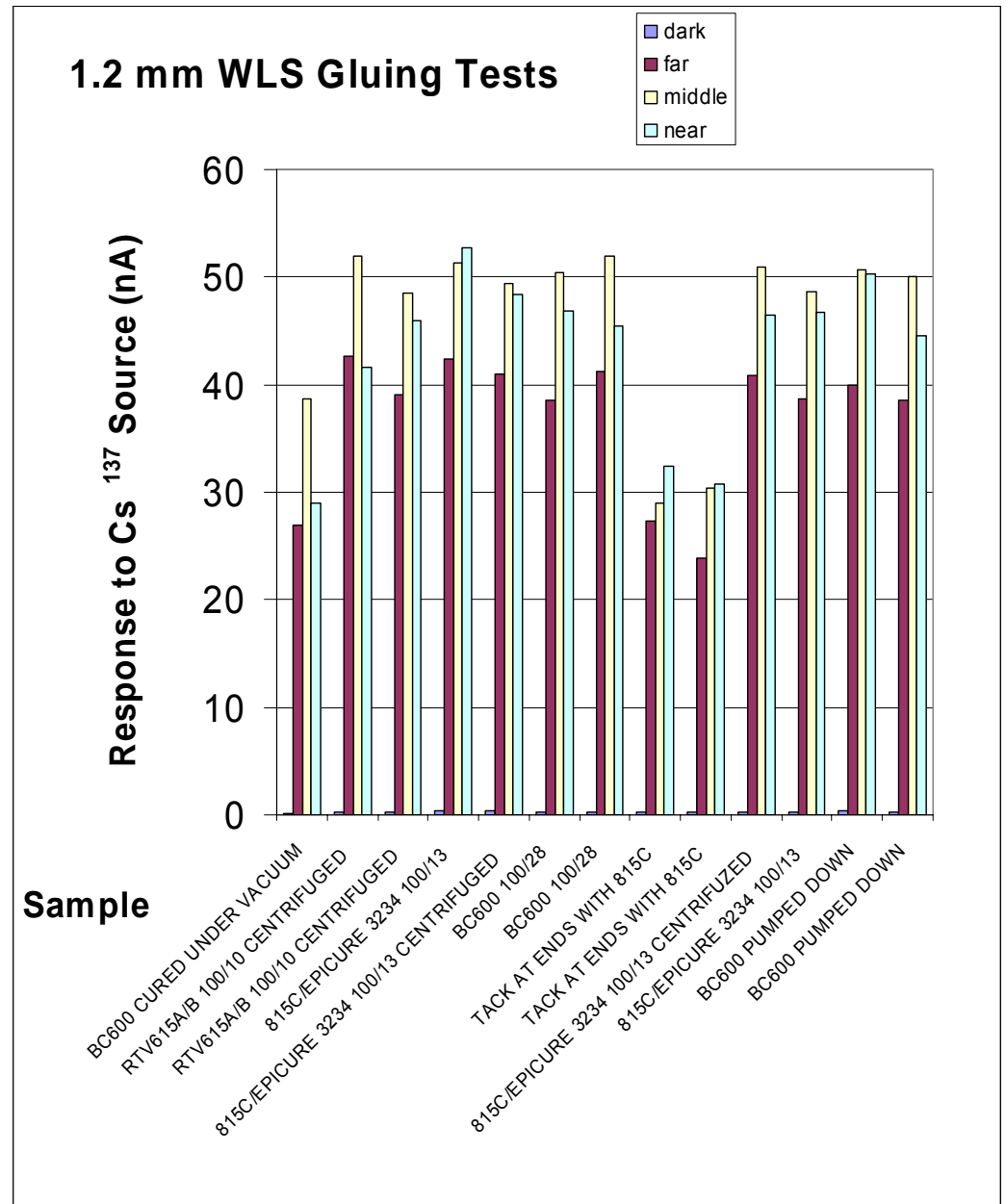
WLS Fiber - Scintillator Coupling Tests

Sasha Dychkant

Measurements of 1 m long strip
response using a Cs^{137} source.

~ 15 p.e.s

May 19, 2004

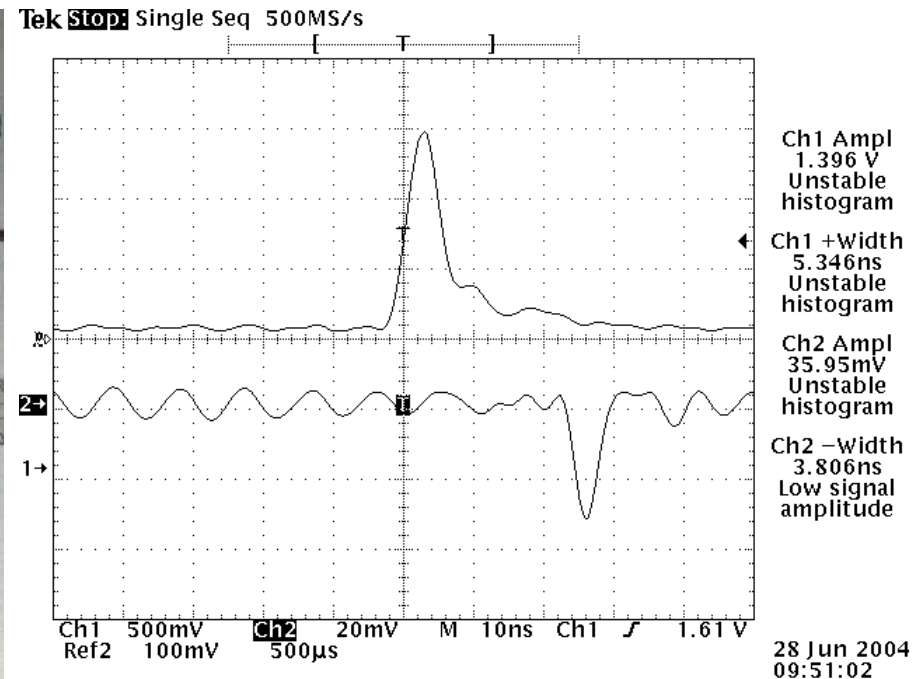
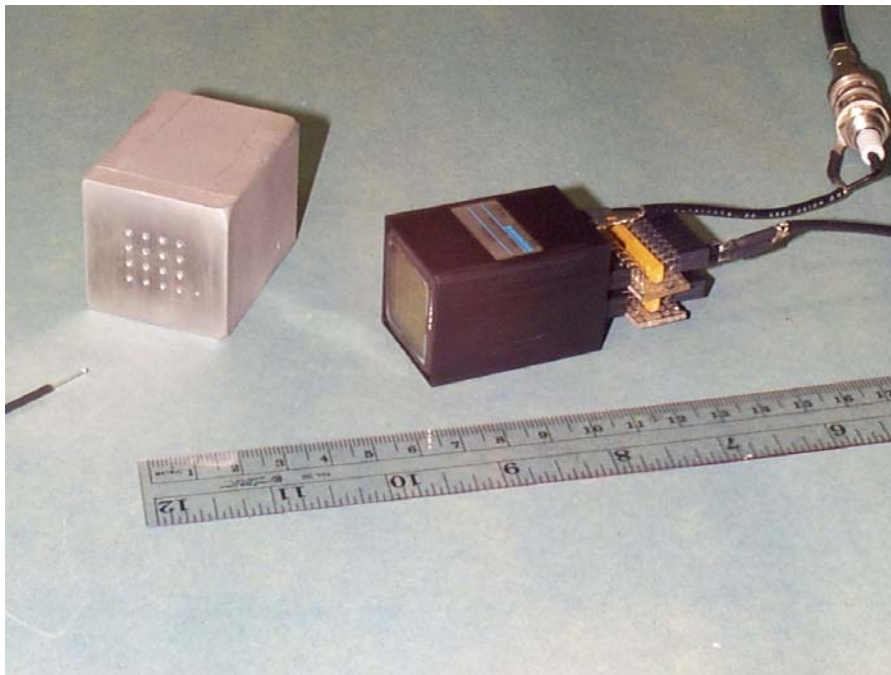


Multi-Anode Photomultiplier Readout

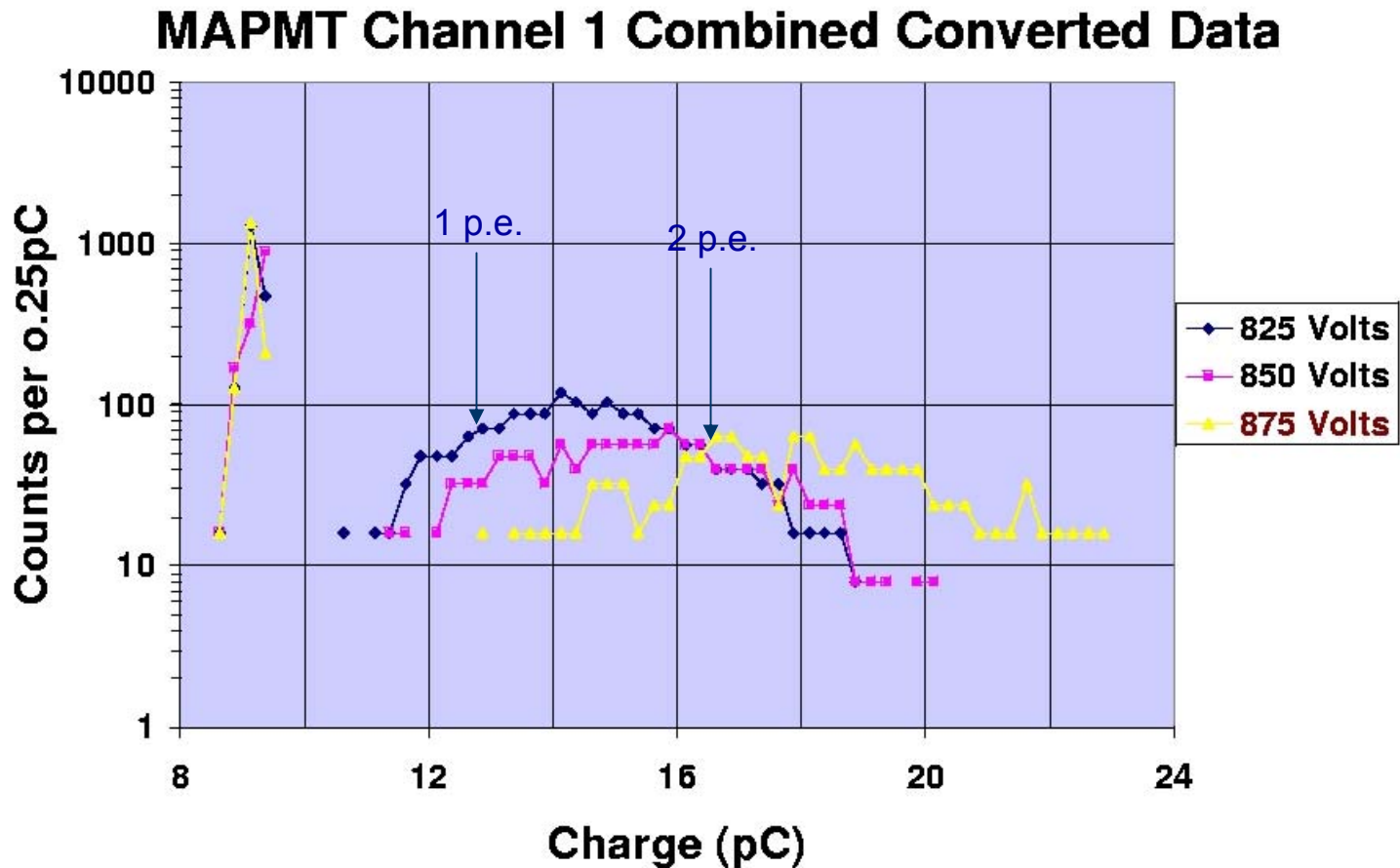
Goals:

develop electro-optical readout for scintillator/fiber prototypes
calibrate single photo-electron response of MAPMT

Method: fast pulse light emitting diode with clear fiber coupling to MAPMT

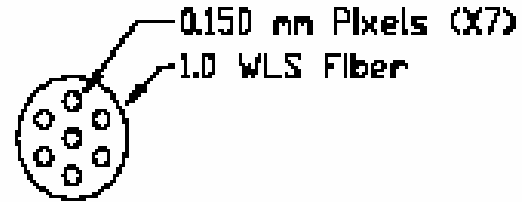


Pulse Charge Distribution



Alternative Photon Detectors - I

Geiger-mode avalanche Photo-Diode arrays (GPD)



Colorado State and aPeak (SBIR)

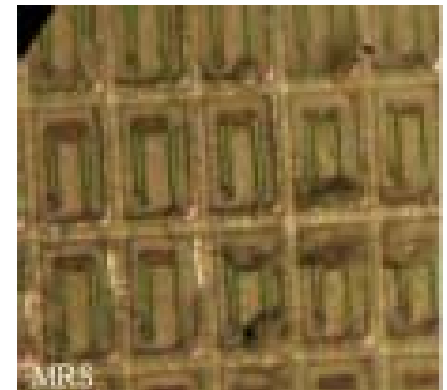
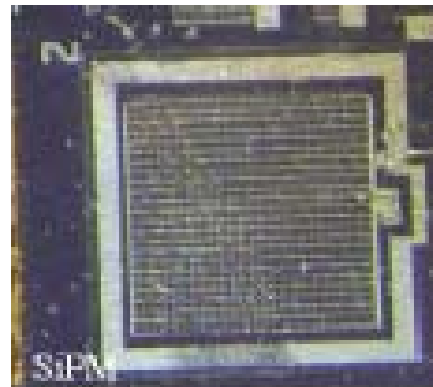
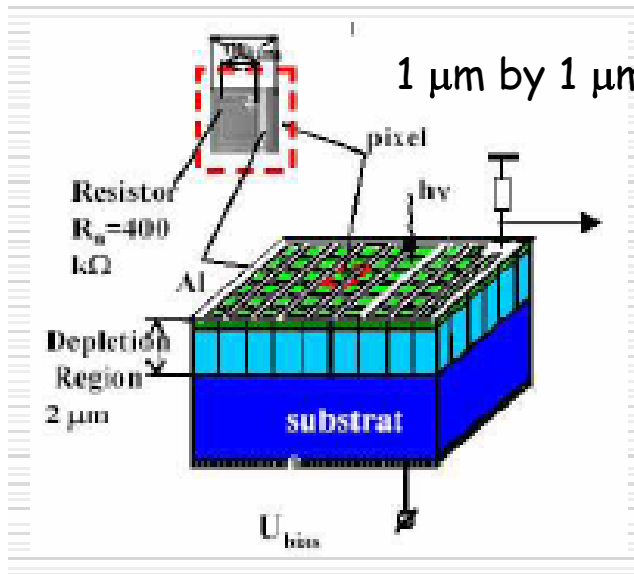
phase II goal: deliver 10 64-channel GPD's with automatic quenching circuits to readout 640 WLS fibers

Single channel solid state photodetectors can be **DIRECTLY CONNECTED** to the WLS fiber thus eliminating the need for clear fibers and routing of clear fiber bundles.

Alternative Photon Detectors - II

Silicon Photomultiplier / Metal-Resistor-Semiconductor micro-cell (SiPM/MRS)

see Golovin and Saveliev, Nucl. Instr. Meth. A 518 (2004) 560.

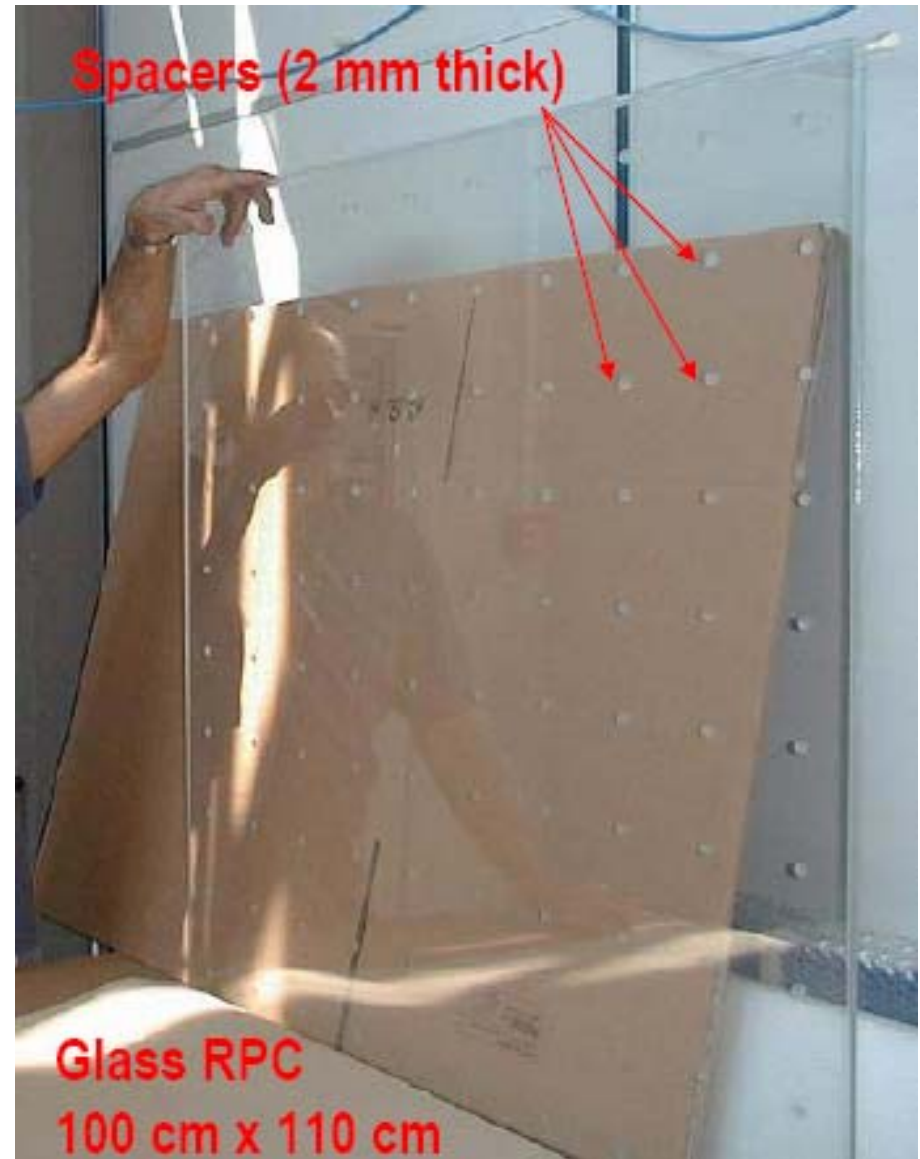


to be used for CALICE tile-cal and NIU Tail Catcher

Resistive Plate Chamber Option

R&D Program in Italy by
CaPiRe Collaboration

RPC μ detector used in BELLE



Conclusions

Optimal design of a scintillator based muon detector requires evaluation of competing hardware technologies for scintillator (extrusion method) and photon detector (MAPMT, GPD, SiPM)

A Fermilab based collaboration is developing a prototype with

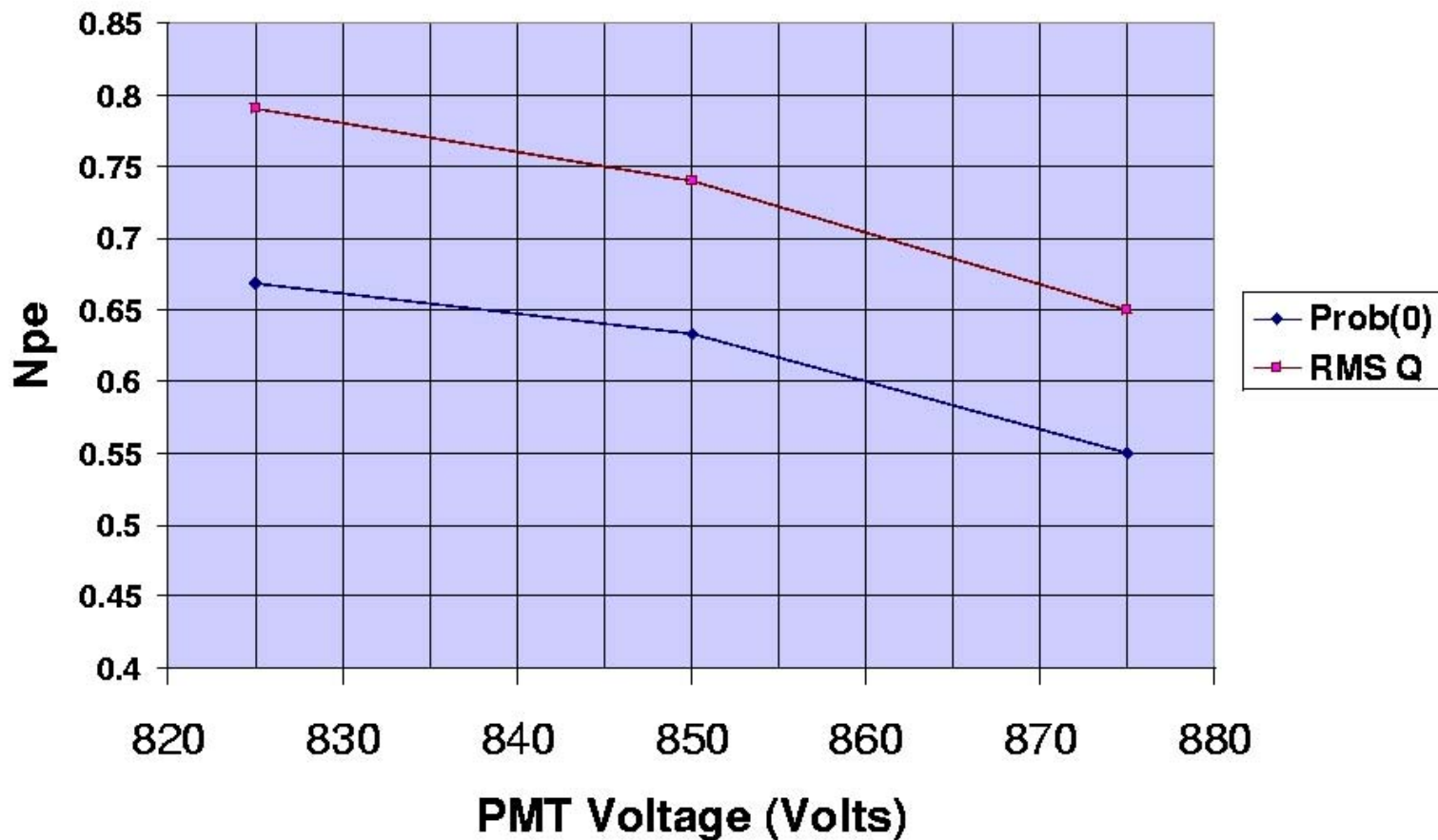
- TiO₂ coated, extruded plastic scintillator
- WLS fiber spliced to clear fiber
- Hamamatsu MAPMT readout

Only US groups are working on a scintillator based muon detector, but this work currently lacks the funding needed to make a useful comparison with an RPC based detector being developed in Europe.

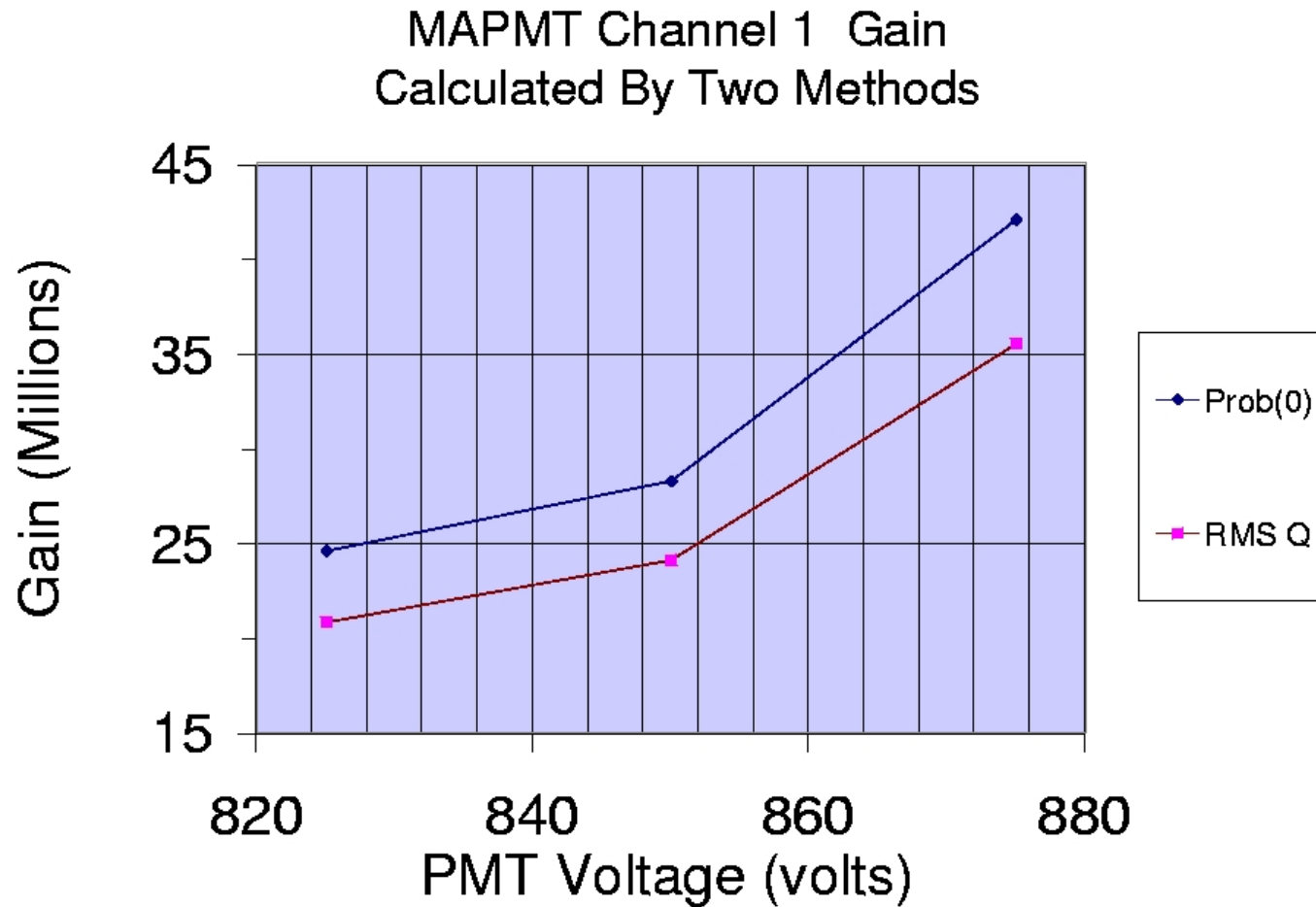
Supplementary Slides

Average Photo-electron yield with LED Source

Npe for MAPMT Channel 1



Gain Measurement with LED Source

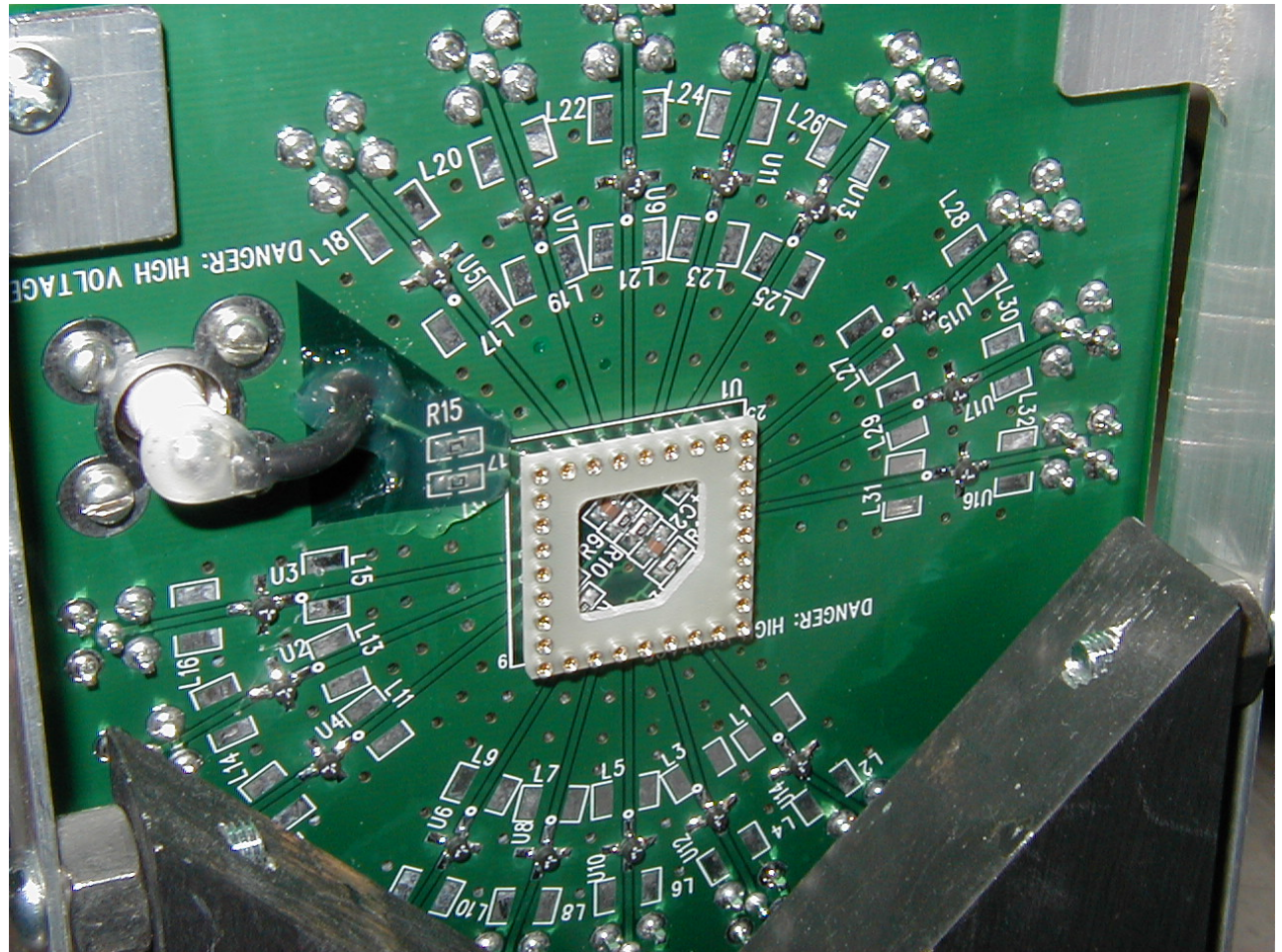


PMT Base and FE Electronics (M. Tripathi)

for 16-channel
Hamamatsu MAPMT

HV bias network

High speed pre-amps



TDC Readout Interface (M. Tripathi)

high speed readout of LeCroy FERA TDC system

FPGA interface to PC parallel port

