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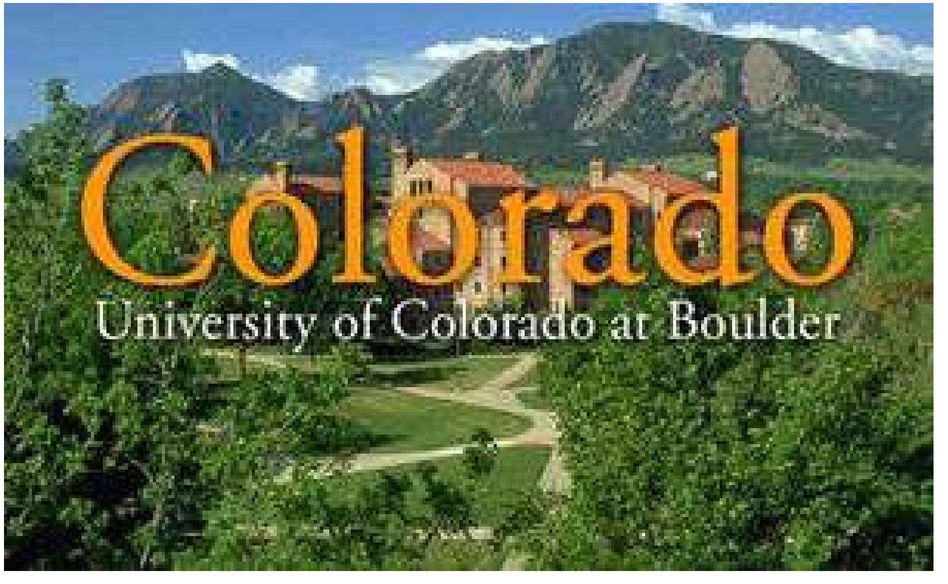
Aspects of a fiber/scintillator-based EM-calorimeter

- Martin Nagel
- Keith Drake



- Joseph Proulx
- Kyle Miller

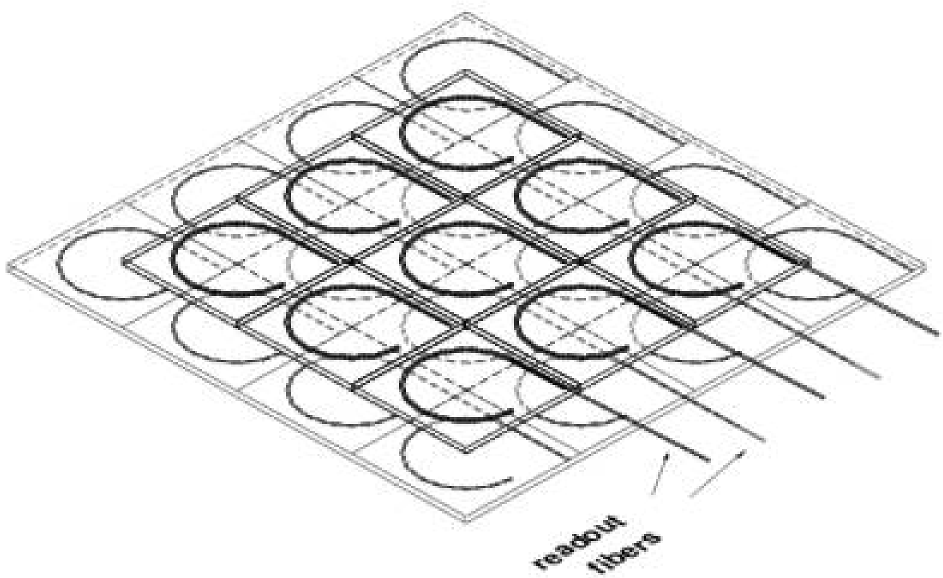
Snowmass 2005

Outline

- Overview of fiber/scintillator-based EM-calorimeter
- Radius of curvature effects?
- Long-term effects of fiber degradation?
- Detector dynamic range studies
- SiPM readout
- Conclusions

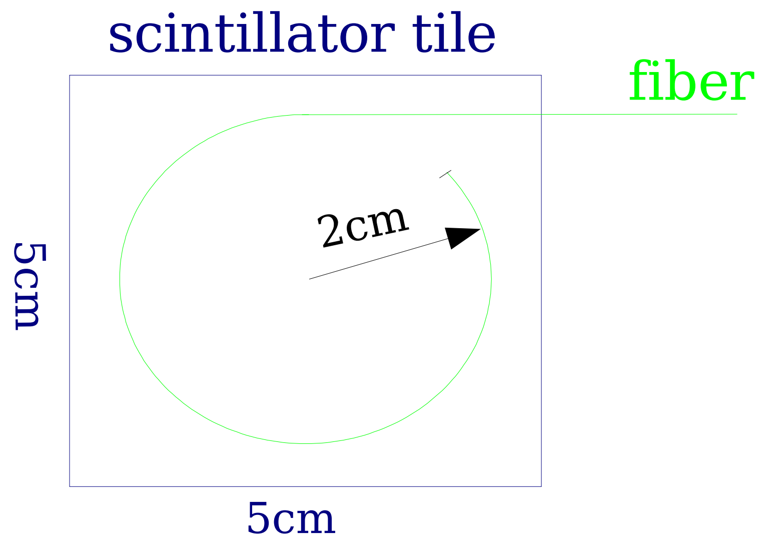
Fiber/scintillator-based ECal

- 40 layers of 3mm scintillator alternating with ½X_0 W
- scintillator layers divided into tiles
- adjacent scintillator layers are offset to get higher effective spatial resolution



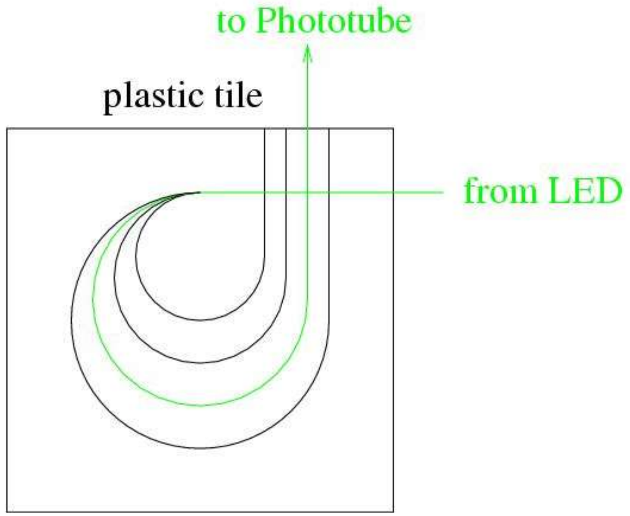
Fiber/scintillator-based ECal (cont.)

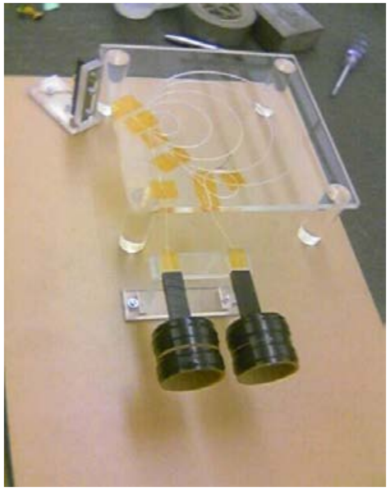
- tiles of area 5x5cm^2 -> ~2.8million tiles
- optical fiber embedded into each tile with radius of curvature of 2.3cm (tile end mirrored)
- each tile wrapped with highly reflective foil
- readout by silicon photomultiplier



Setup for radius measurements

- 4 circular grooves of radii 2, 4, 6, and 8cm in plastic tile
- optical fiber of equal length subsequently placed in various grooves
- light pulses from green LED (pulsed at ~10Hz) coupled into fiber and transmitted light measured by phototube
- pulse is integrated and analyzed





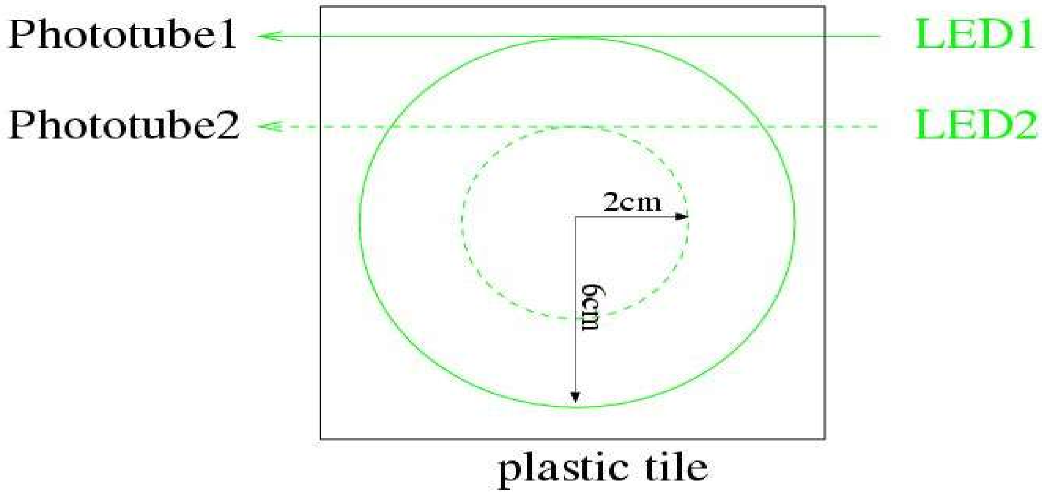
Results of radius measurements

Radius in cm	8	6	4	2
Mean integrated voltage in 10^-8 Vs	1.58	1.55	1.53	1.56

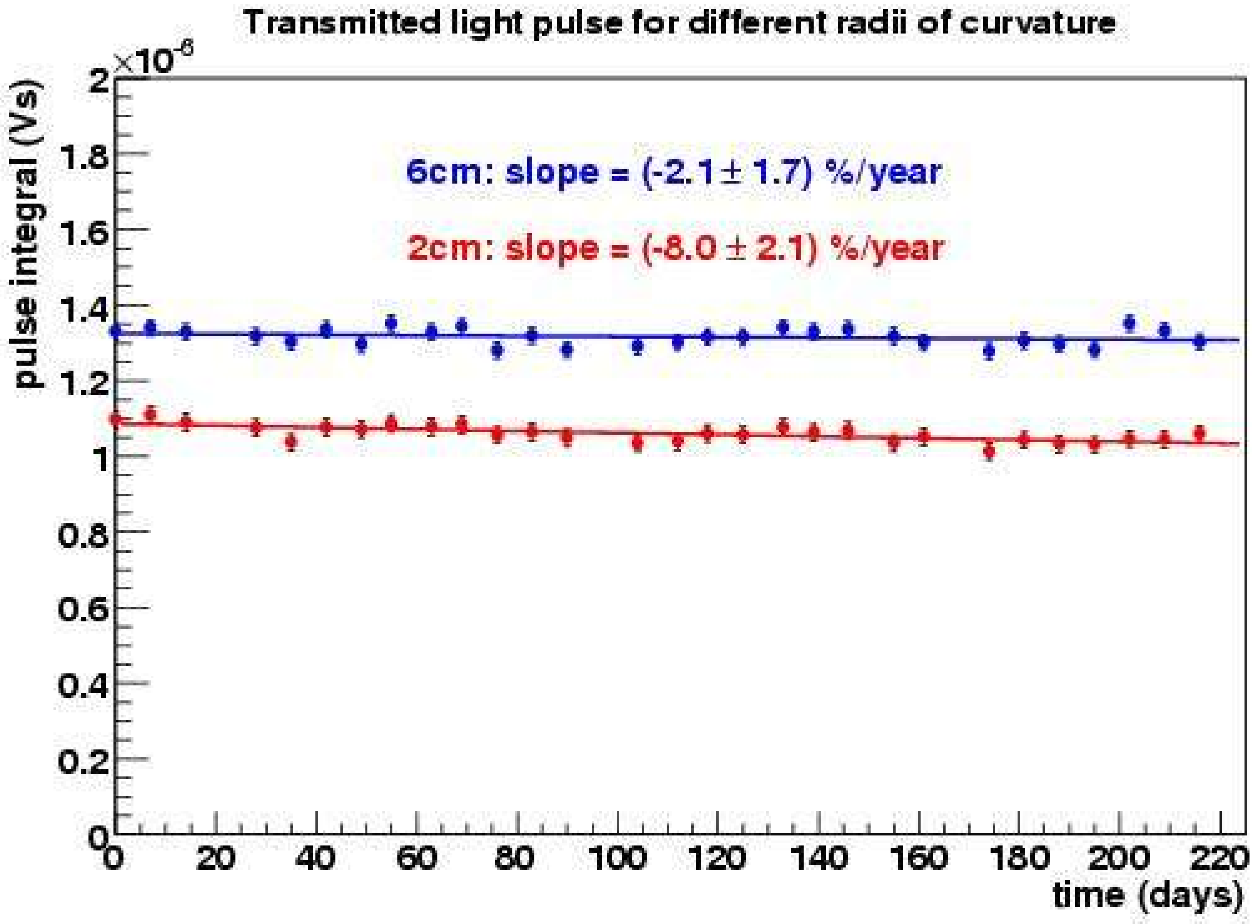
→ no significant light loss because of small radius of curvature of fiber (in the range between 8cm and 2cm)

Long-term effects of fiber bending?

- degradation of light transmission over time?
- dependence on radius of curvature?
- stationary setup in 'black box' with 2 sets of LED/fiber/phototube to avoid manual switching:

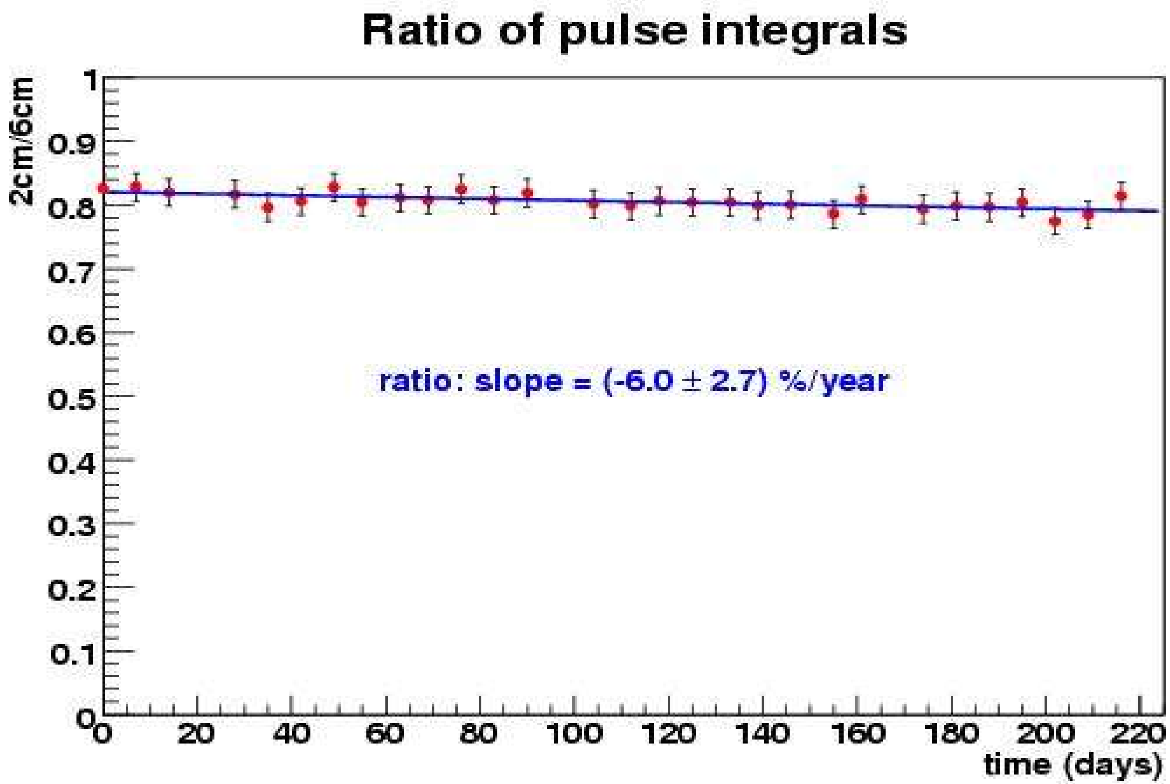


Degradation of optical fiber transmission over time for different radii of curvature



(cont.)

to cancel out common systematical errors, take ratio:

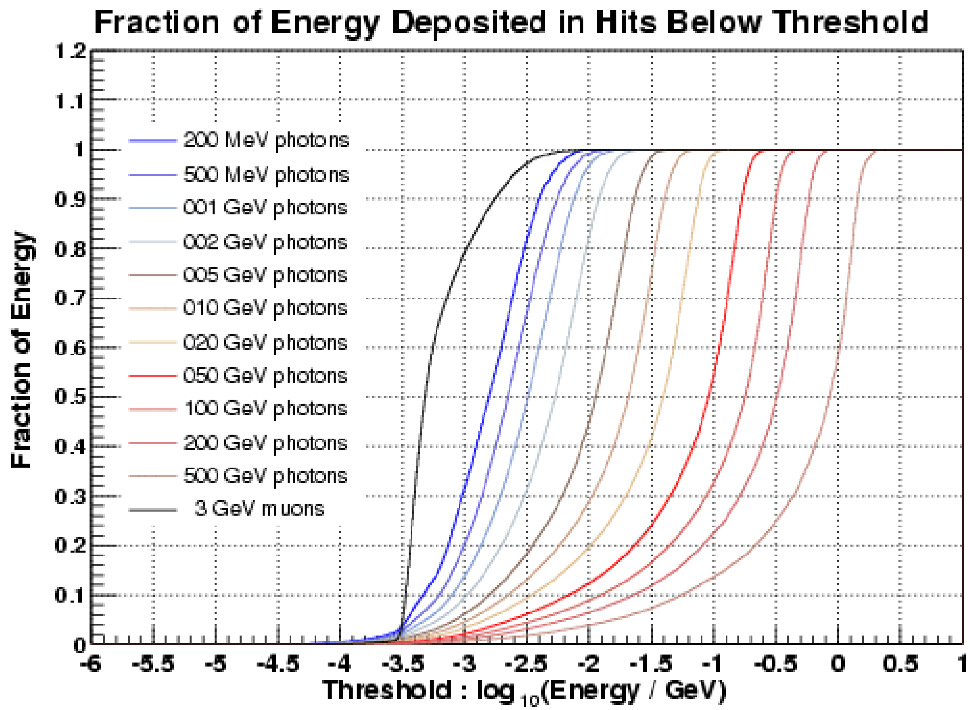


Result: slight decrease in transmittivity over time; effect larger for smaller radius of curvature

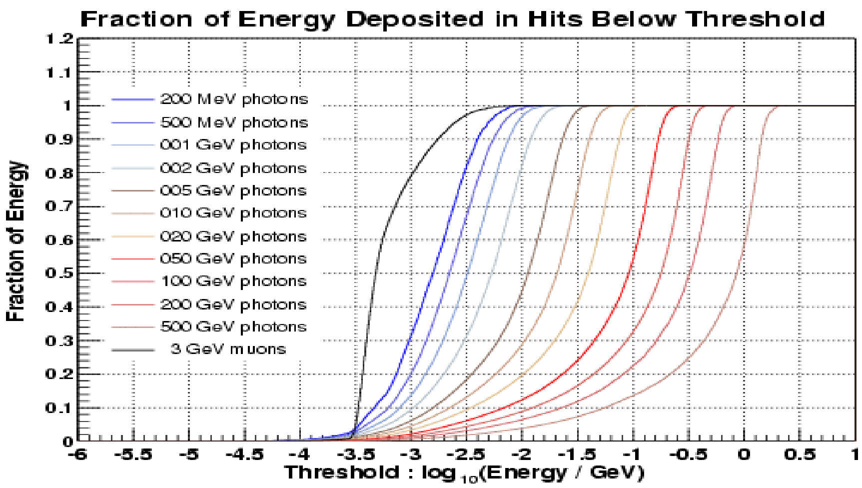
(work in progress)

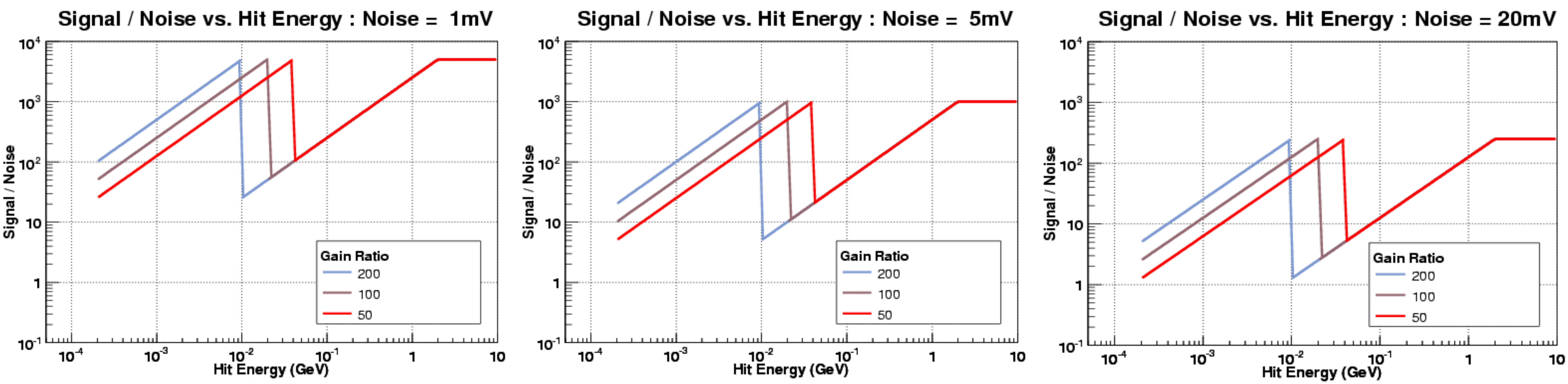
Detector dynamic range

- range of energies to be covered by detector: $\sim 10^4$



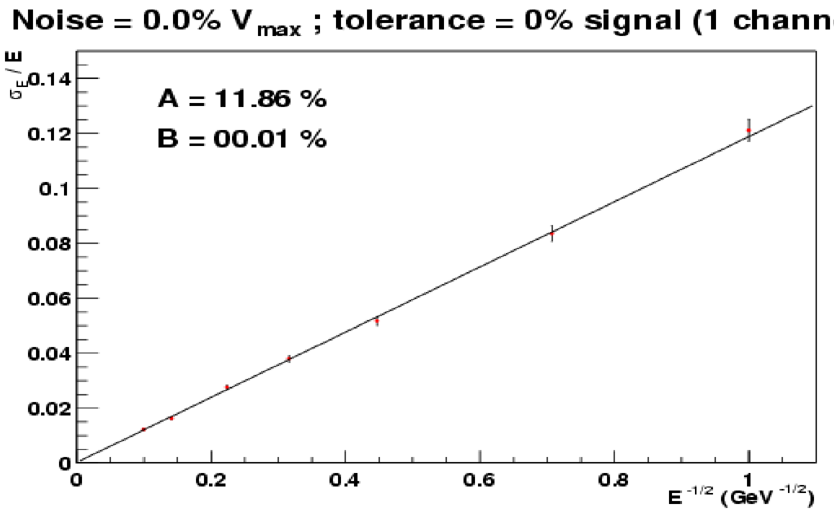
Solution: 2 amplification regimes

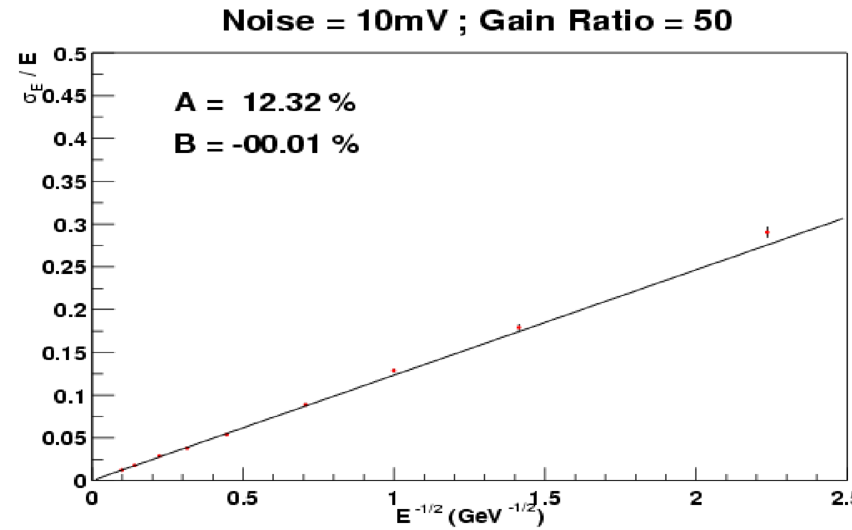


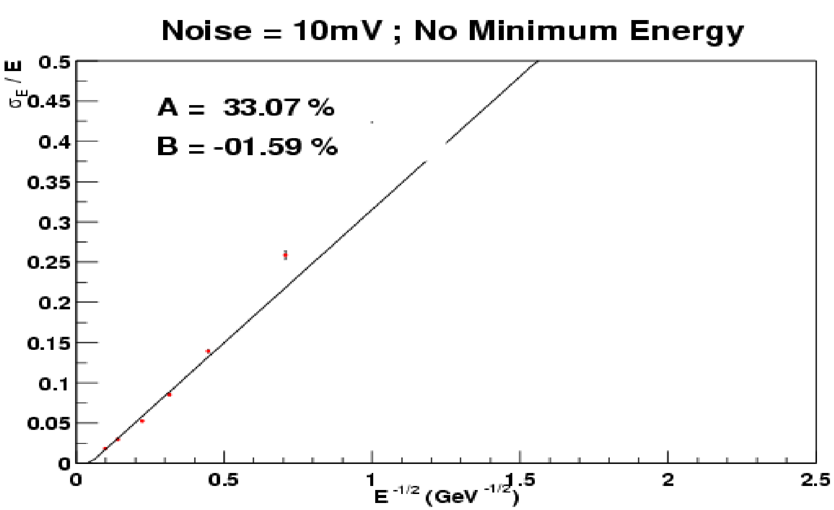


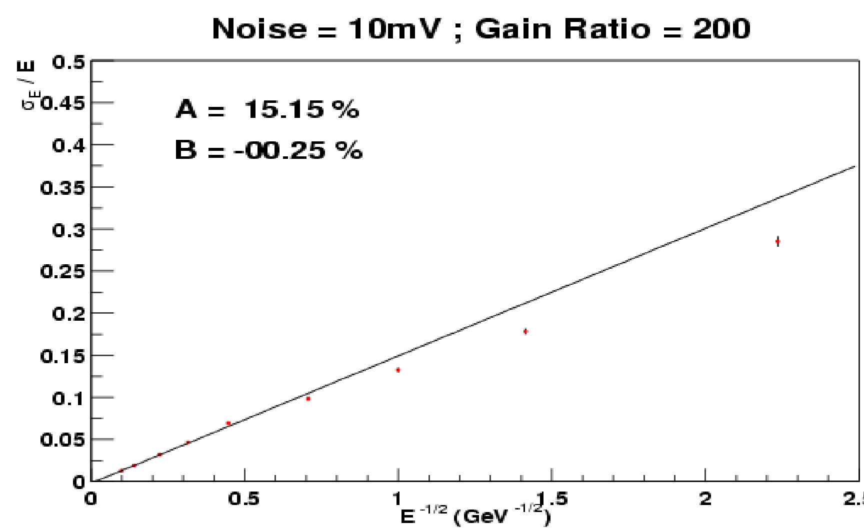
(E_{max}=2GeV corresponds to 5V signal)

Effects on resolution

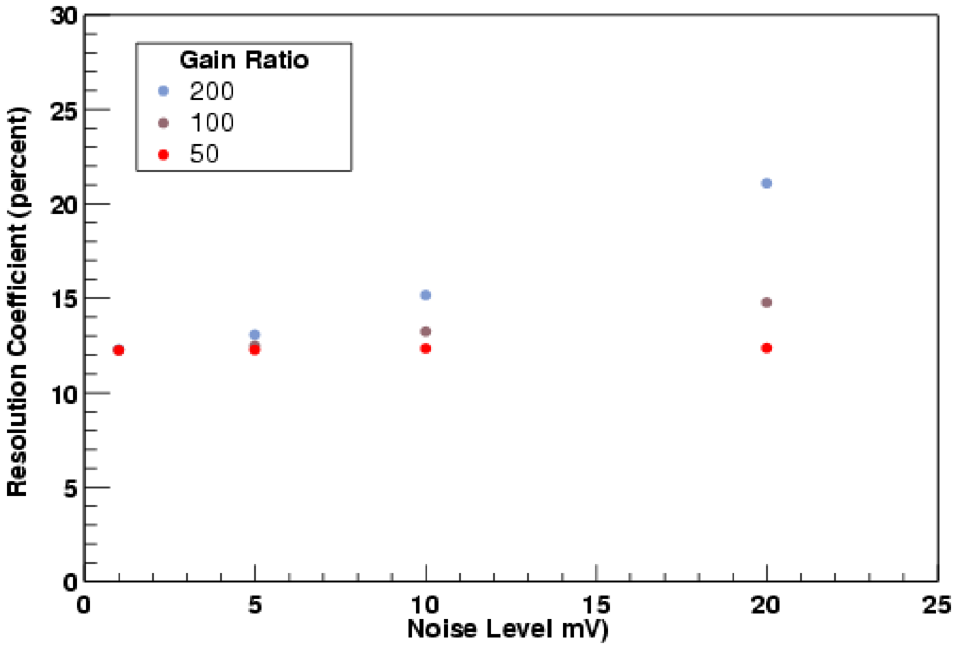








Effects on resolution (summary)

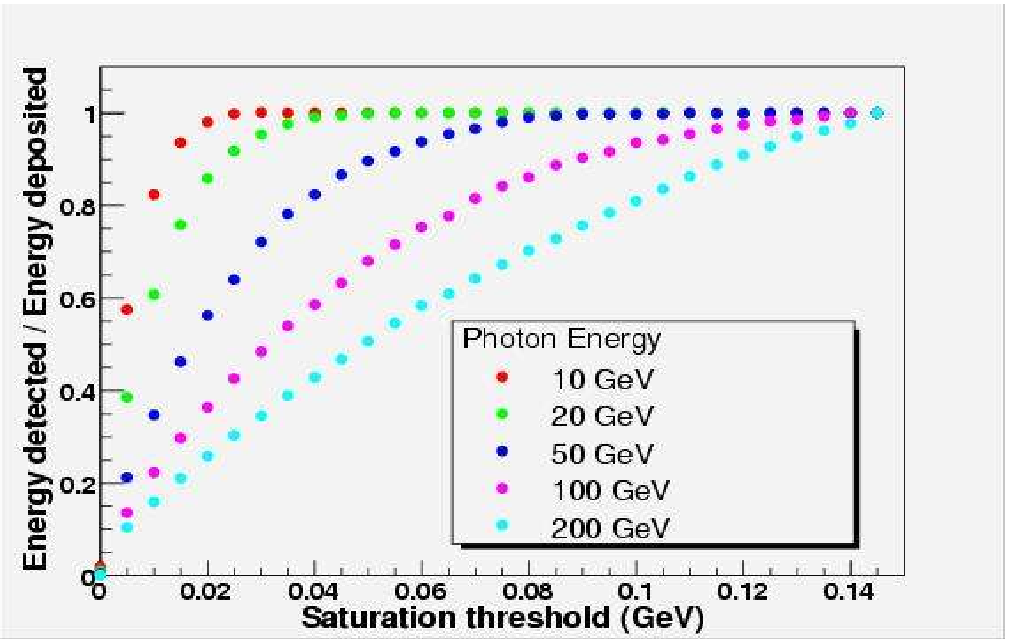


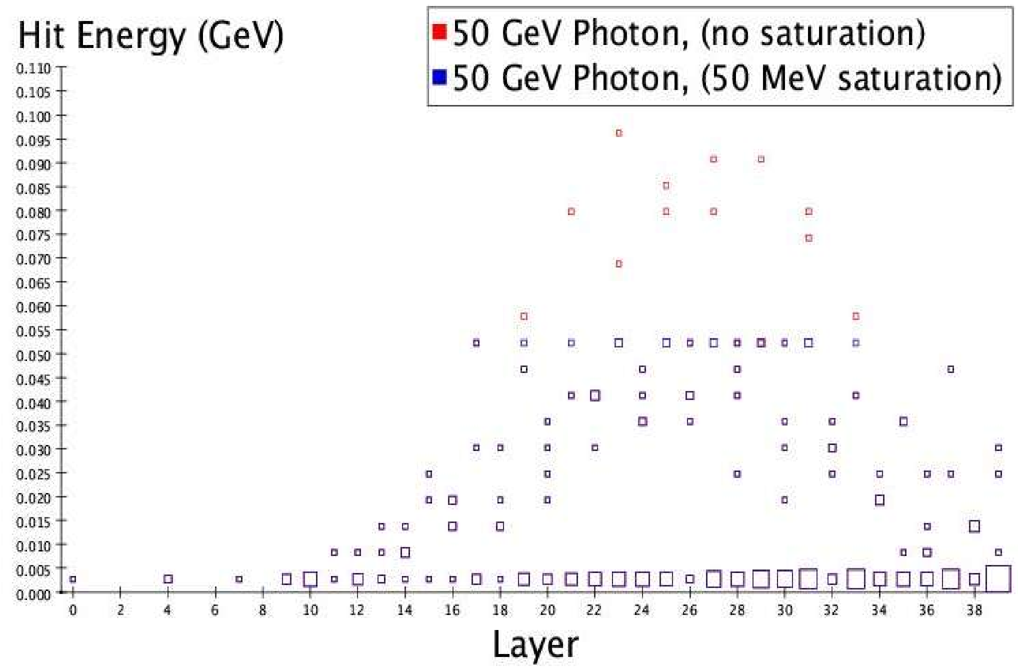
Gain Ratio	Noise 0	1mV	5mV	10mV	20mV
None	12.10	12.43	19.82	33.07	59.37
200		12.27	13.05	15.15	21.07
100		12.25	12.47	13.22	14.76
50		12.22	12.25	12.32	12.36

Trade-off: small gain ratio + high noise level
−> large # of false hits (or loss of low energy hits)

Alternative: tile saturation

- Idea: allow high energy photons to saturate tiles -> no need for 2 amplification regimes; resulting energy cut may be dealt with by fitting



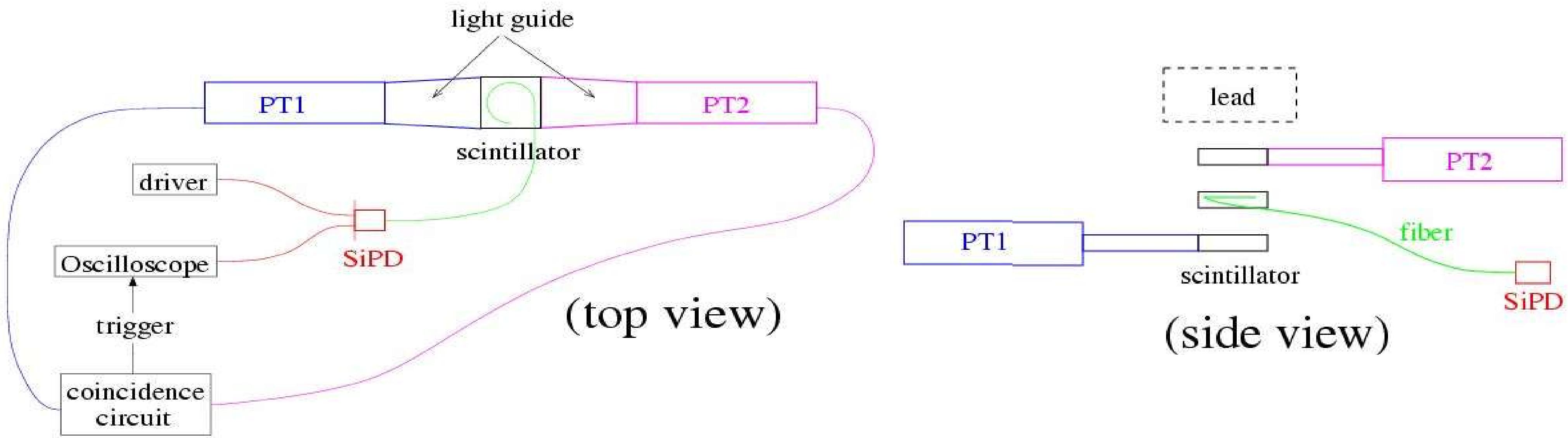


Silicon Photomultiplier

- solid state photomultiplier
- single photon sensitivity (@ 470nm)
- $1mm^2$ active area
- small dimensions:

  4.25mm diameter, 2.6mm height

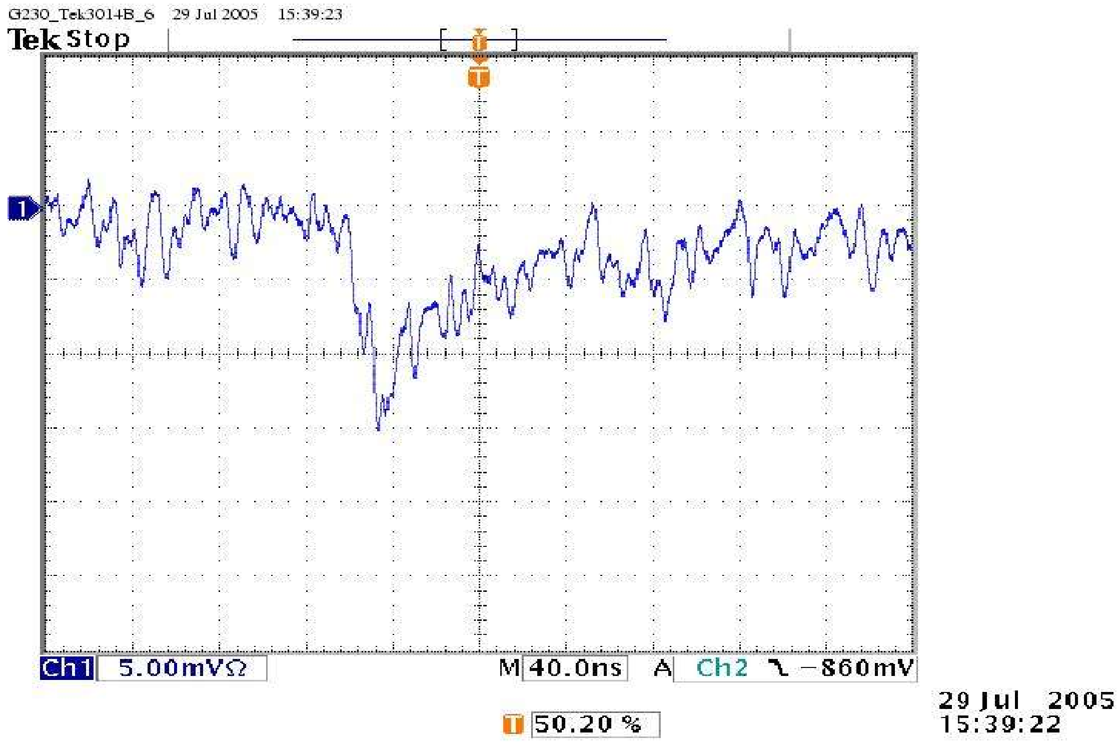
Setup for Silicon PM testing



- 3 scintillator tiles vertically aligned
- SiPM readout triggered by coincidence of both phototubes
- lead placed on top to induce showers/filter out muons

Preliminary results

- typical cosmic ray pulse:



- still ahead: verify single photon sensitivity / determine energy resolution; reduce noise

Conclusions

- tight radius of curvature of fiber ok
- however: decrease in light transmittivity over time is being observed and is under investigation
- 2 amplification regimes necessary for Silicon photomultiplier (alternative: tile saturation)
- investigate performance characteristics of Silicon photomultiplier further