# Scintillator-based Muon System

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# Muon strip-scintillator system.
## Work plan after validation 9/14/2009

Demo proof of principles: SiPMs and FE elect:

- Confirm prelim. finding of ~20 p.e. for 1m strips: two 7.1m long strips w/r.o. 1 or 2 ends.
- Meas. noise & signal attn. vs. length, etc.
- Calib. scheme w/noise pulses: 0, 1, 2 p.e.
- Vendors w/adequate QA and cost.
- FE electronics and electronics chain incl. cables, etc.

# Very preliminary results

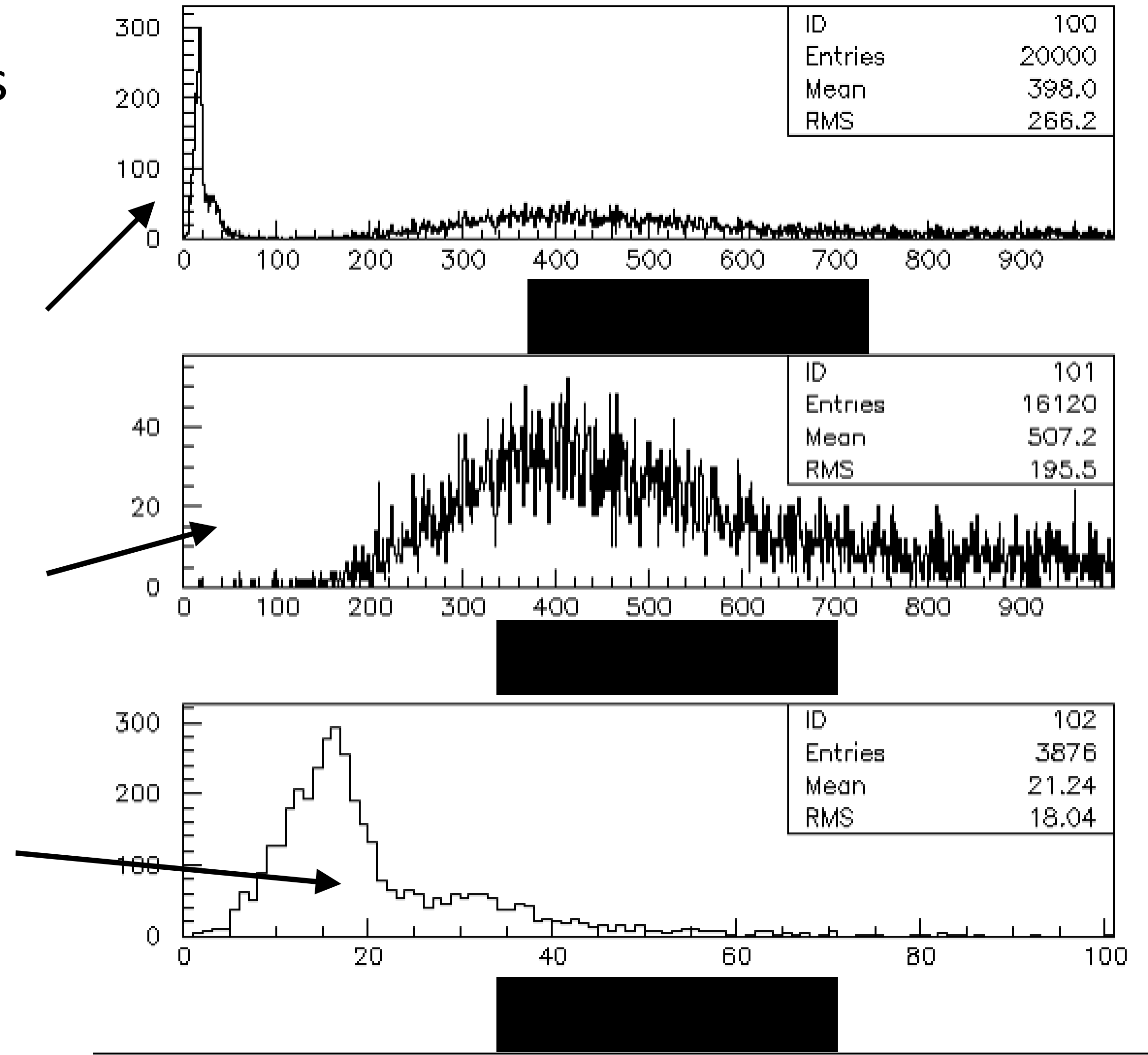
- This is our typical plots

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

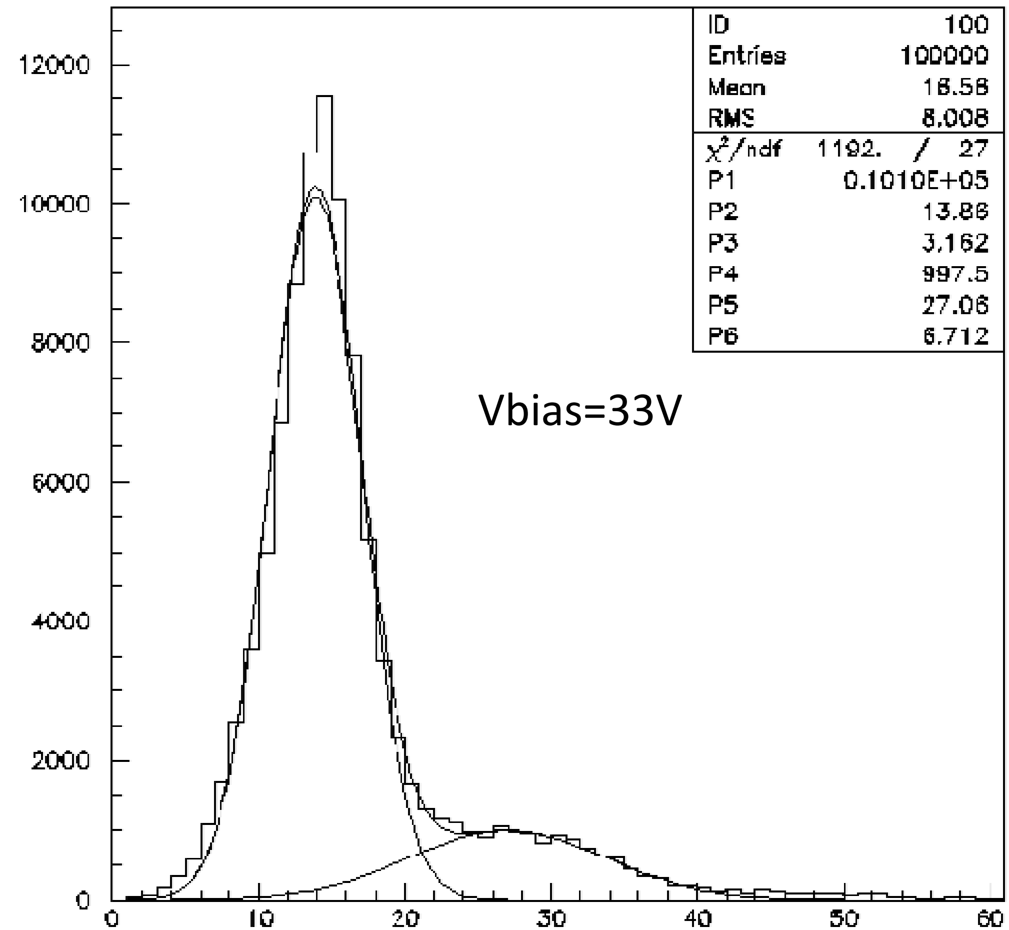


# Very preliminary results

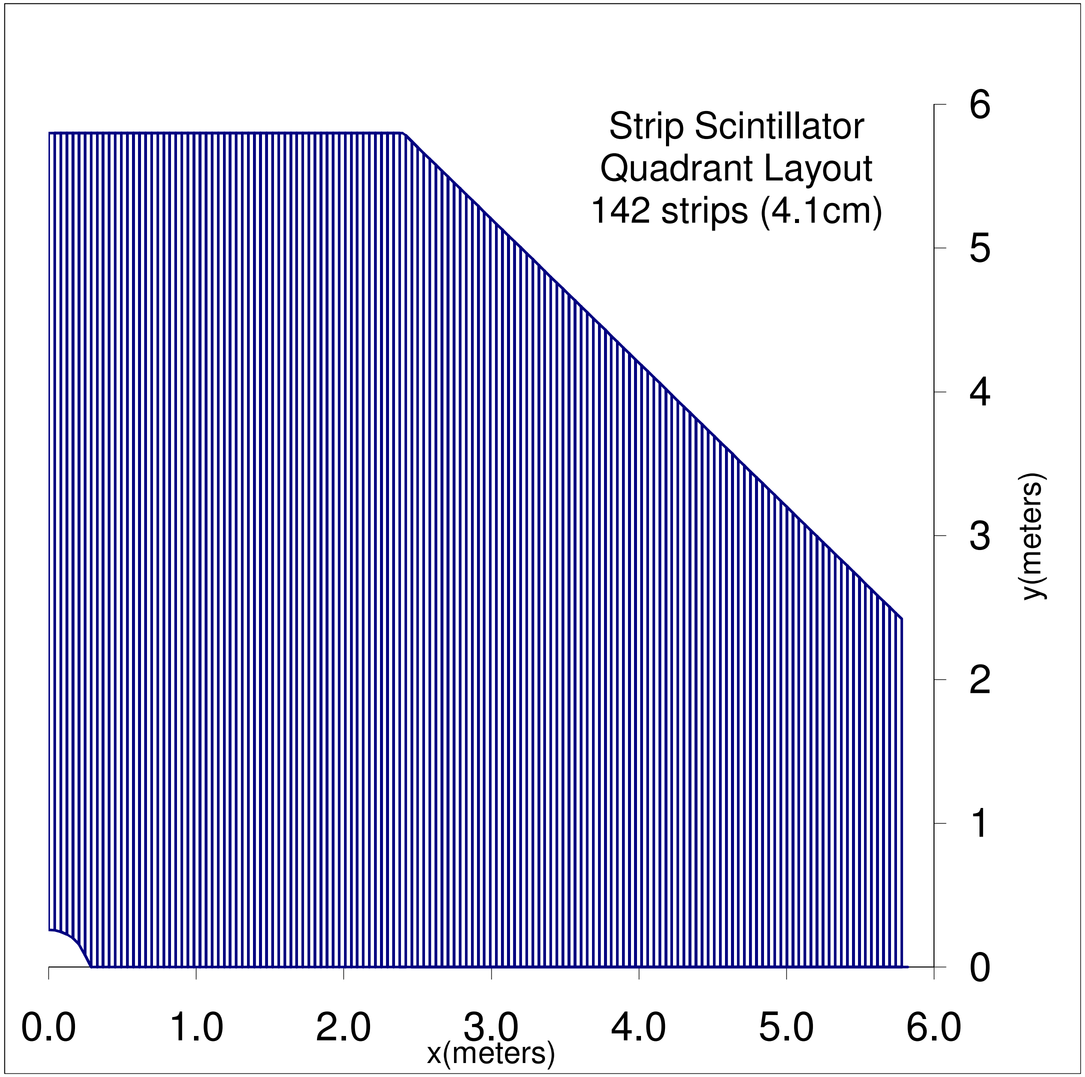
- It seems at least plausible that we can pull out the 1pe peak from the pedestal

(due to dark counts)

- This makes the detector self calibrating



# Forward Muon Strip Layout




The maximum strip length is 6m. From MINOS measurements the attenuation over 6m is ~ 0.3.

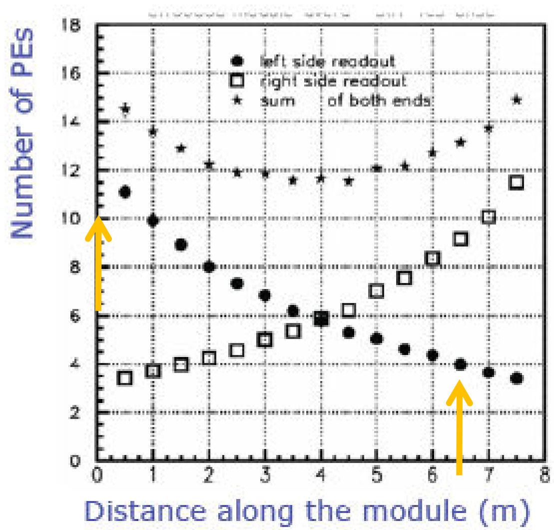
Taking 20 p.e.s as the mean yield for no attenuation, you expect ~ 6 p.e.s from the far end.

With Poisson statistics, the probability of 0 or 1 p.e.s at the far-end is 1.7%

# Mark Thompson – MINOS  July 1995

**Light at PMT depends on:**

- Path-length in strip
- Attenuation in WLS fibre
  - 30 % self-absorbtion of green light  λ ~ 1m
  - Most important component : 70 %  λ ~ 7m
- Attenuation in clear fibres : λ ~ 10m
- Optical connection efficiency
- Typically 8-10 PEs/strip for a normal incidence MIP

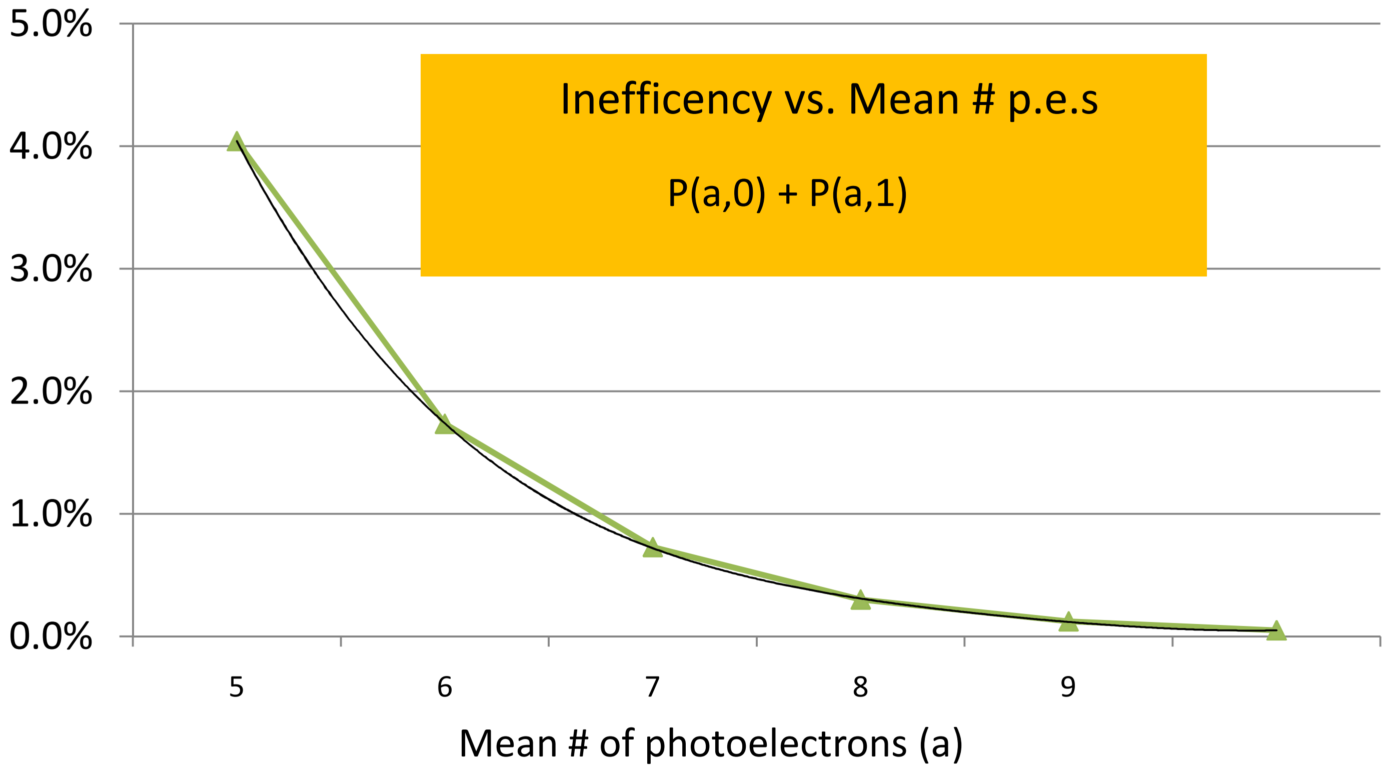



**Note:** in addition to WLS in strip, on average ~0.8m WLS in pigtail and ~3m Clear fibre

Attn(6.5m) = Sig(6.5m)/Sig(0)
= 4/12.5
= 0.32

# Inefficiency (far end) vs. <p.e.s>

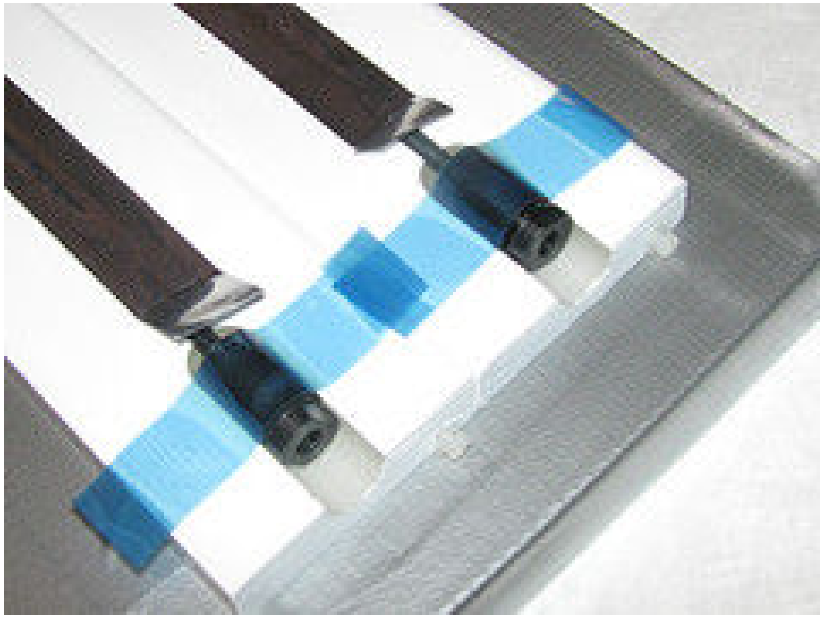
## Poisson statistics only; threshold @ 1.5 p.e.




This is fun, but very naïve. The noise rate can be as high as 1 MHz/mm$^2$. So we need to understand rates at various thresholds and that will depend on pulse shape, temperature, after pulsing, etc. All of this points to the test beam and the instrumentation that Rubinov and Fitzpatrick have been developing, and the measurements that many of you have been doing. WE NEED YOU!

# Newly assembled strips - McKenna (N.D.) at Fermilab

- Continuous WLS fiber 2 X 142" long.
- Measure charge vs, position.
- WLS U-turn; Measure any reduction in pulse height.
- Measure noise pulses to establish 0, 1, 2 p.e. calibrations.
- Possible optical-coupling modification measurements.



One set of double strips read out at both ends; the other two strips read out at one end (far end of WLS aluminized).
Measure:

- Longitudinal and trasnsverse response
- Inefficiency across inter-strip boundary.
- Edge inefficiency.
- Arrival time of reflected pulse if possible.

# Narrowing the Parameter Space

- How many pixels? 100 to 1000?
- Coupled to area and fill factor. Range?
- Noise? Various vendors – are they all the same?
- After pulsing?
- Temperature compensation? Probably not necessary if stable? $\Delta$T range?
- Amplifier specifications ? Bandwidth, gain, # of bits?
- Cable scheme? Multi-conductor shielded? Readout scheme?

# Scientific and Engineering Goals

NIM paper – an intermediate goal – Not an edict, but food for thought.

- Outline: Name of the paper: Conceptual Design of a Scintillator-based LC Muon/tail catcher system.
- What to include:
- Some MC physics results on which dimensions, no. of planes, etc. depend;
- Basic layout of scintillator;
- Sketches and engineering type drawings of planes and mechanical components.
- Any mechanical test data?
- Specifications of dimensions and mounting schemes.
- Electrical components and motivation for tests and specifications.
- Electronics block diagrams, development and test results from bench tests and comparison with expectations.
- Beam tests and results; comparison with MC or other calculations.
- What about costs? Cost drivers for a muon/tail catcher system?
- Future directions.

# The Immediate Goal: Testbeam

- The Mtest MOU: Giovanni and Gene; a draft exists and it has some feedback from Erik Ramberg.
- A major goal is to use the new Rubinov electronics to make measurements of scintillator pulse charge and determine the number of photo-electrons from minimum ionizing particles. We will want to measure the new strips that Mike McKenna put together two weeks ago, as mentioned earlier.
- We should draw up a list of needs and colleagues who will help address those needs.
- One important need is help with the DAQ and the inclusion of wire chamber information into our system.

# Muon strip-scintillator system.
# Work plan after validation 9/14/2009

Demonstrate mechanical design/cost:

- Engineering design and prototypes – budget & engr/techs estimates;
- Mounting/installation scheme plus impact on Fe flux return design;
- Mech design of cables, collection of signals, digitization specs and costs;
- Detector servicing, fault scenarios, risk analysis.

# Muon strip-scintillator system.
## Work plan after validation 9/14/2009

Push-pull mechanism: muon system mostly contained in the solenoid Fe. Major impact is services and data stream which have to be developed and integrated with the rest of the detector:

- Electrical power and cooling;
- Controls and control data ;
- Data collection;
- Alignment with laser system(?).

# Muon strip-scintillator system.
## Work plan after validation 9/14/2009

Conceptual Integration w/accelerator incl IR design:

- Major issue: muon backgrounds, IR design; costs vs. benefit.
- Upstream toroid designs/calculations;
- Instrumention for measuring muon bckg
- Integration w/machine operations.

# Muon strip-scintillator system.
## Work plan after validation 9/14/2009

Muon system benchmark reactions and backgrounds and 1 TeV:

- HZ production with Z => μ μ
- Inclusive b-pairs for background studies
- 1 TeV: WW and ZZ.

Cost – needs work.