

# R&D of Calorimeter using Strip/Block Scintillators with SiPM

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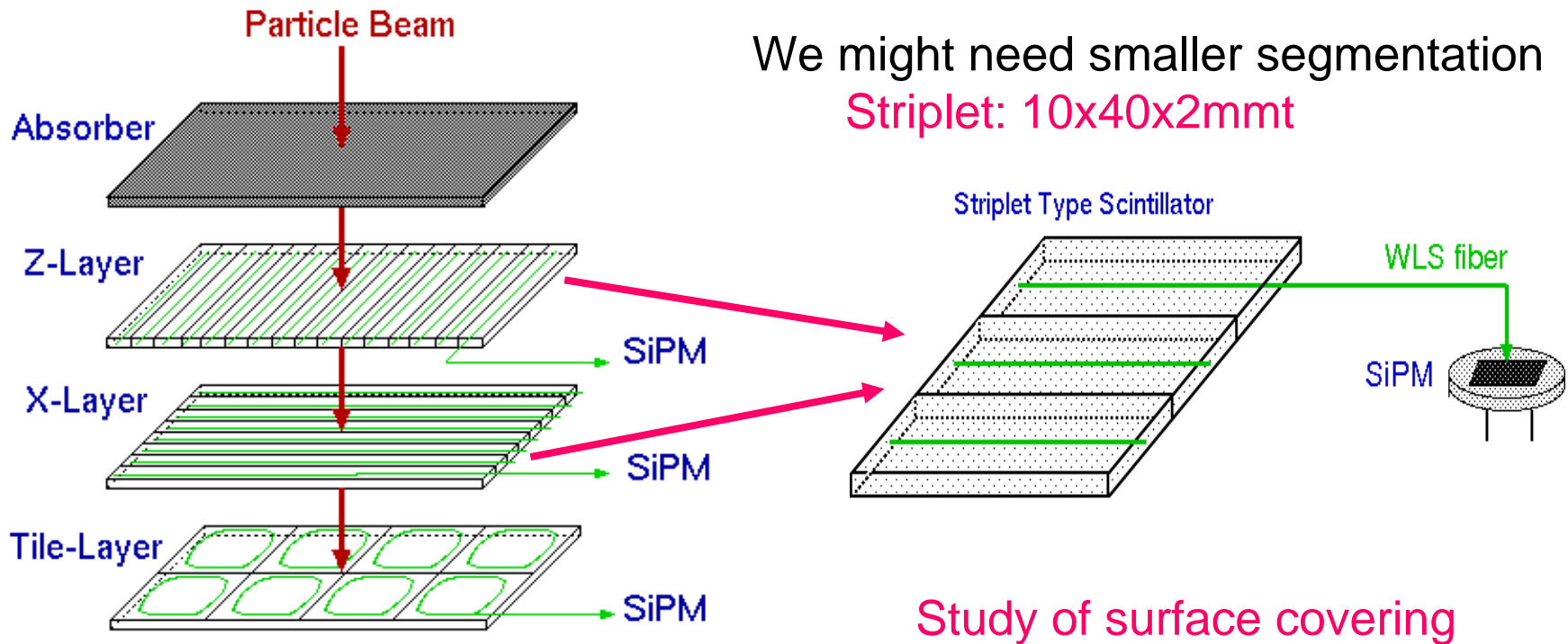
1. Motivation
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Calorimetry and Muons session  
LCWS05 at Stanford  
March 19, 2005

# 1. Motivation

## Present design of GLD Calorimeter

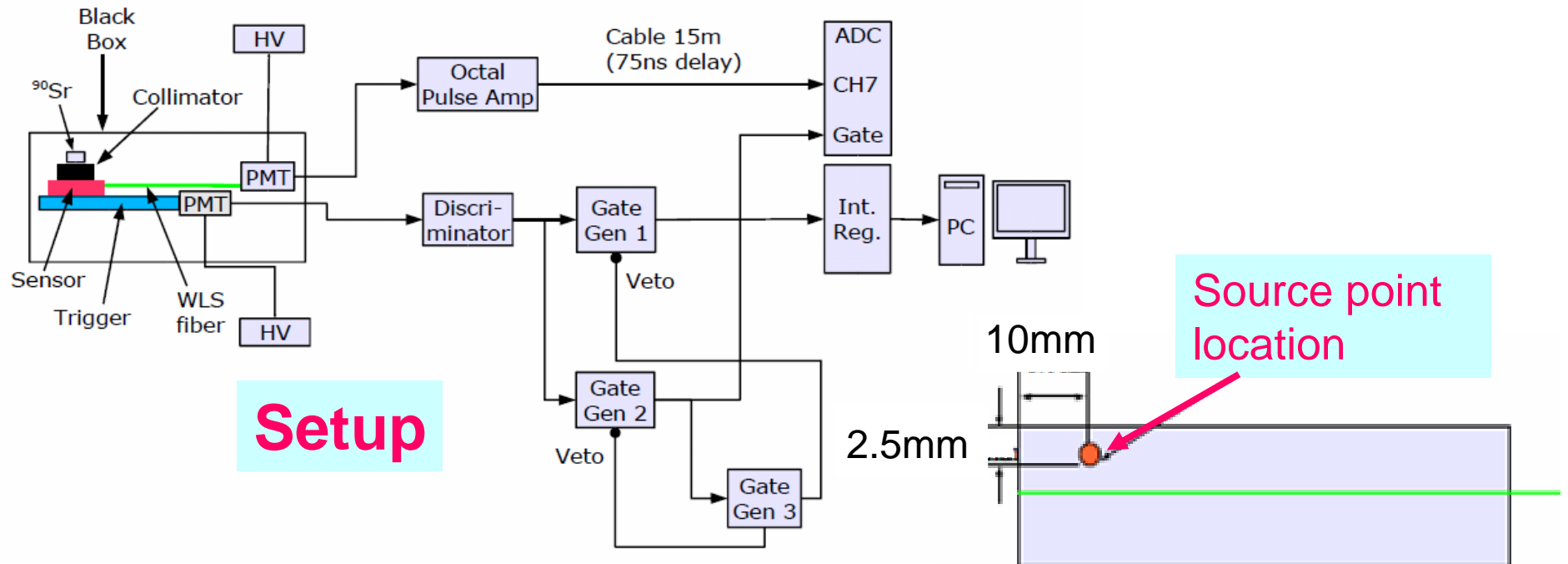
Fine segmentation scintillator  
read out by SiPM



X,Z-layer strip scinti.: 10x200x2mmt

Tile-layer: 40x40x2mmt

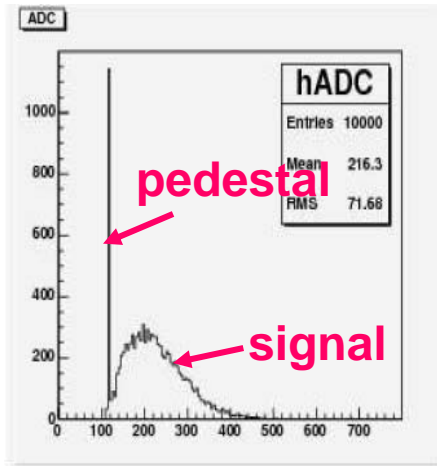
## 2. Scintillator study



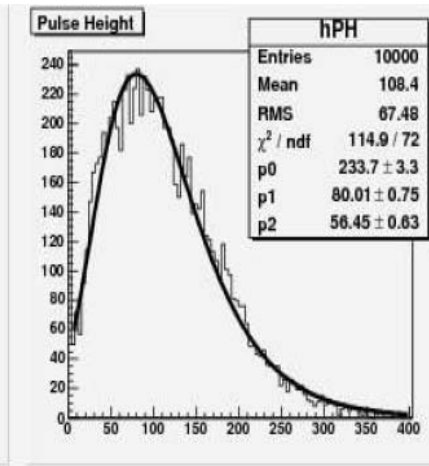
- Sensor : Strip type scintillator (10mmx2mm with length: 4,8,12cm)
- Surface covering: Black tape, White paint, Teflon wrapped, White+Teflon, Al and Gold evaporation
- WLS fiber diameter: 1.0mm (length 13cm, 22cm)
- Source : Sr-90 (beta-ray)
- PMT (sensor) : 16 Ch MAPMT H6568-10, HV : -950V

# PH vs strip length for different WLS fiber length

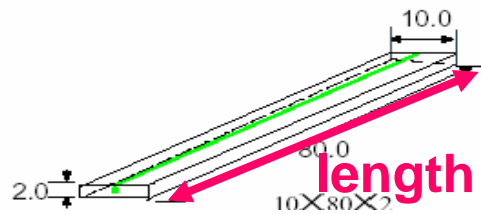
Signal



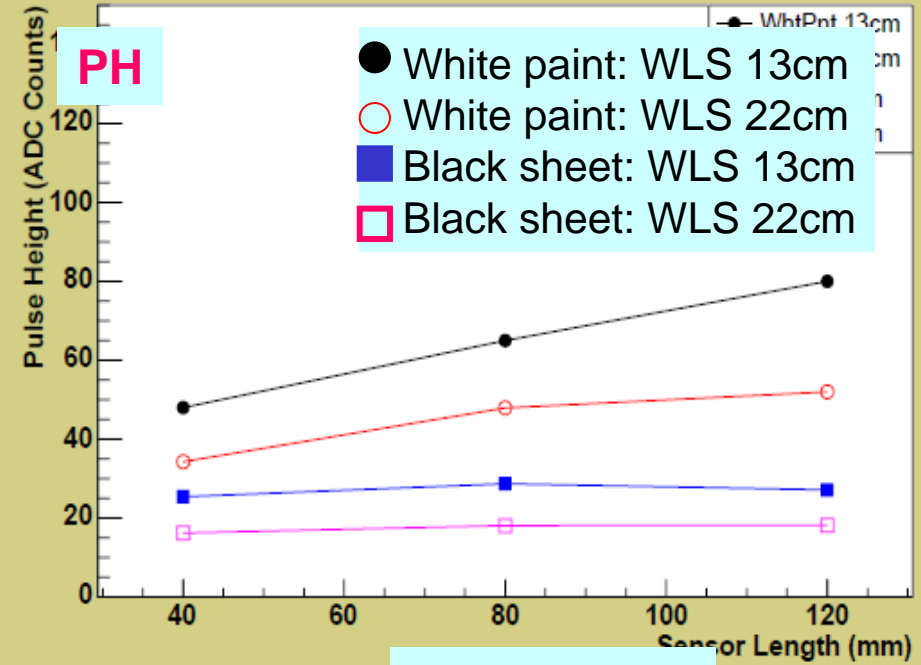
Pulse Height



Sensor Size: 10x120x2mm



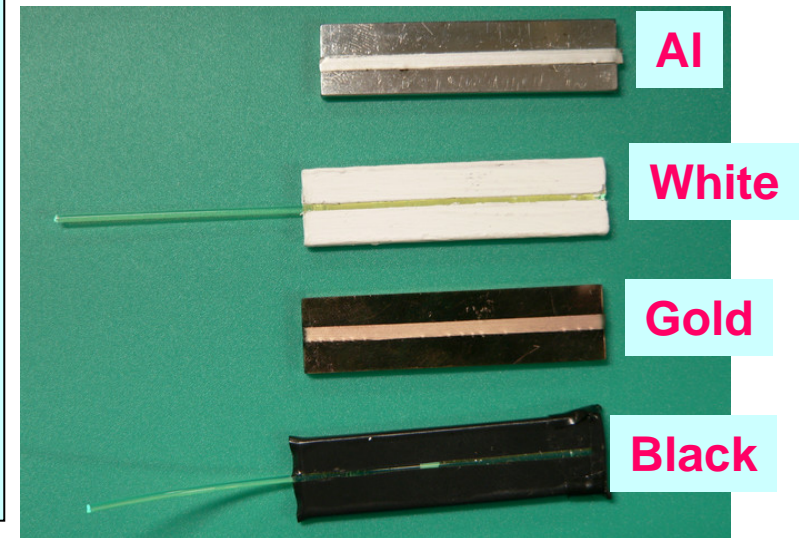
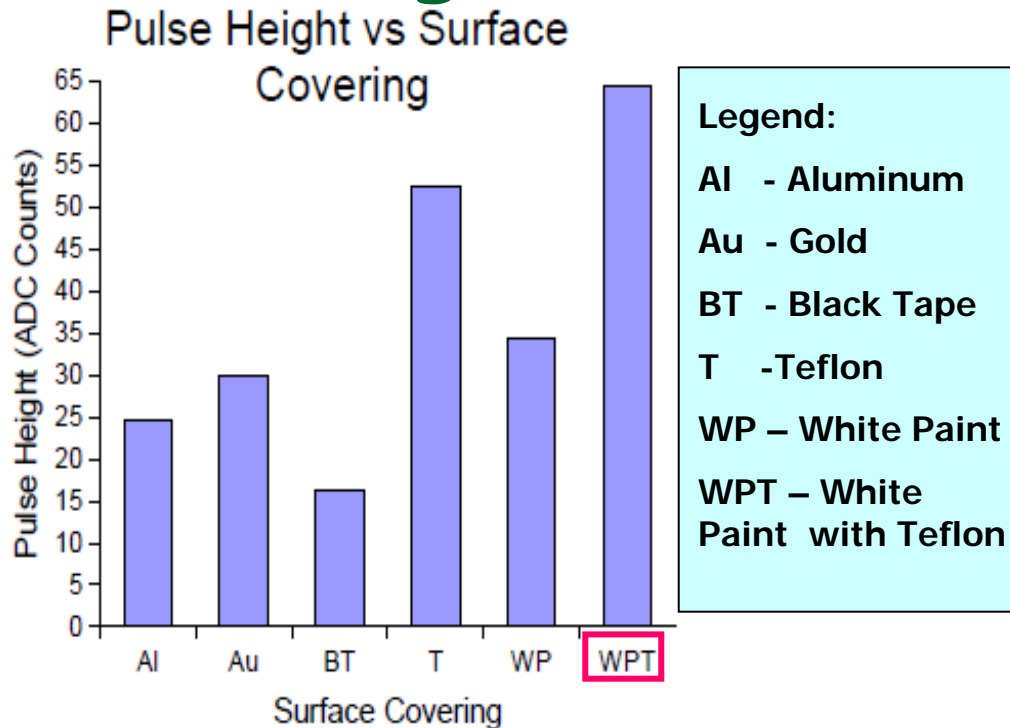
PH vs Strip Sensor Length



Strip length

PH increases as scintillator strip becomes long for White paint covering due to the larger acceptance of reflection lights.

# Pulse height vs surface covering

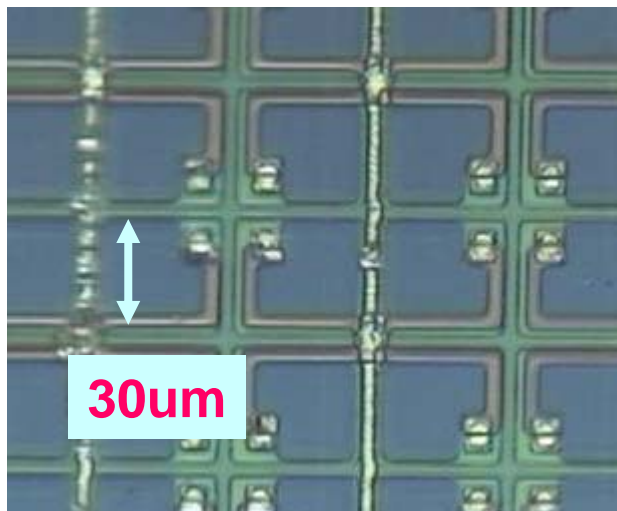
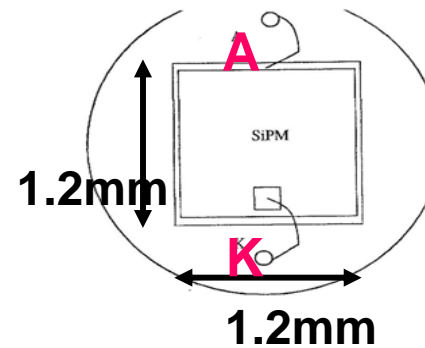
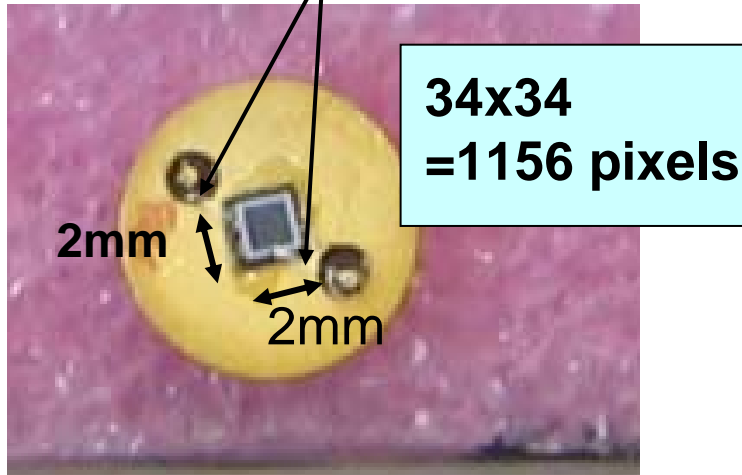


- Used Strip type scintillator: 10x40x2mm, WLS fiber length : 22cm
- Compared surface covering effect on the scintillator  
Black tape, White paint, Teflon wrapped, White+Teflon, Al and Au evaporation

**White paint +Teflon is the best surface covering**

# 3. SiPM study

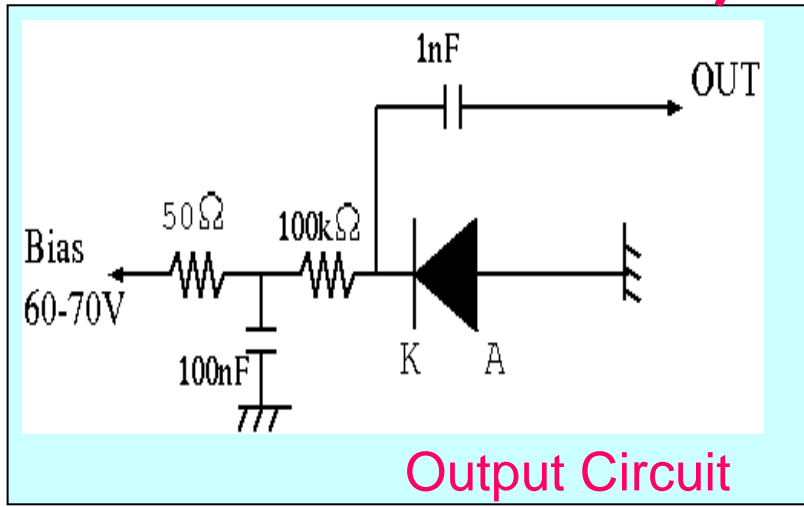
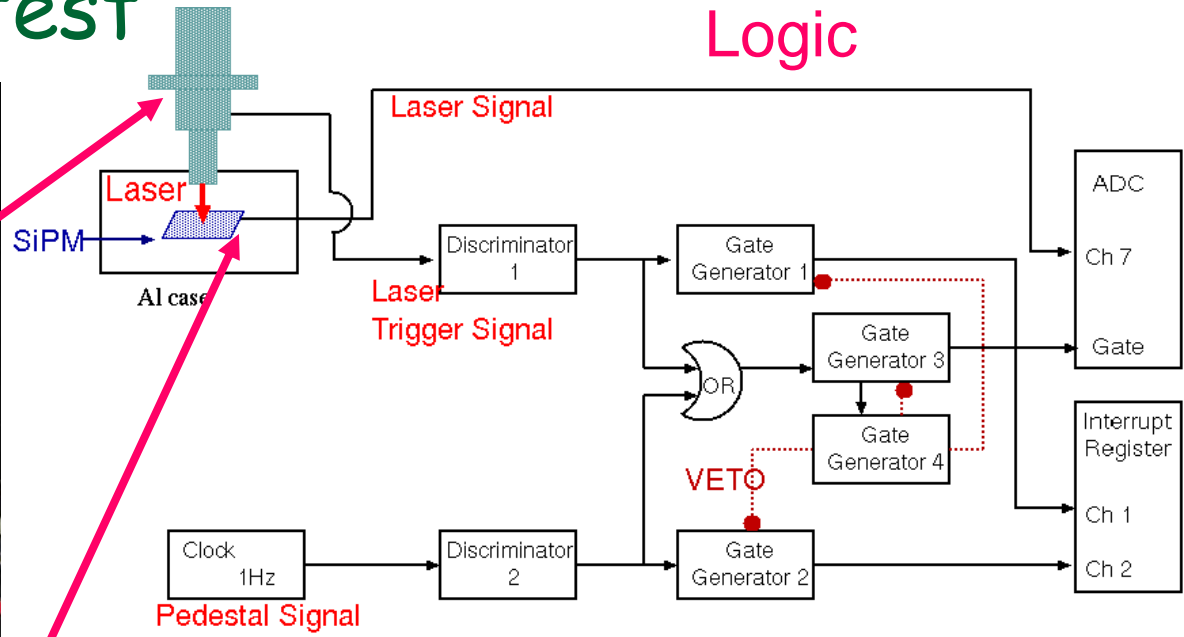
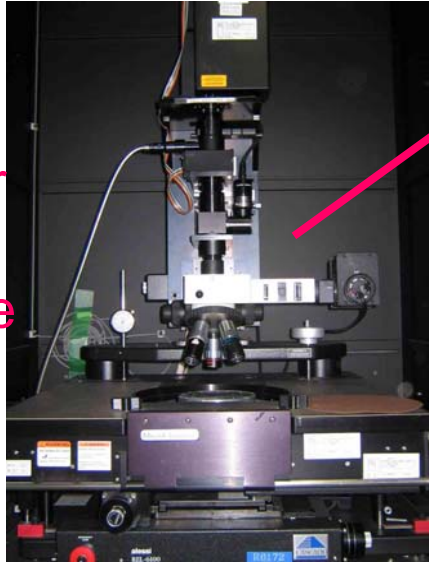
Wire Bonding



- Micro Avalanche Photo Diode (APD) with each pixel in Geiger mode
- 34x34=1156 pixels in small area (1.2x1.2mm)
- Pixel Size : 30x30um
- High Gain :  $\sim 10^6$
- Operational at low voltage (60~70V)

# Setup of laser test

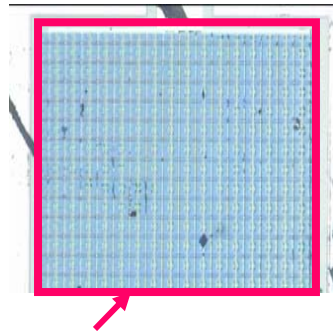
YAG Laser  
&  
Scan Table  
System



## YAG Laser & Scan Table System

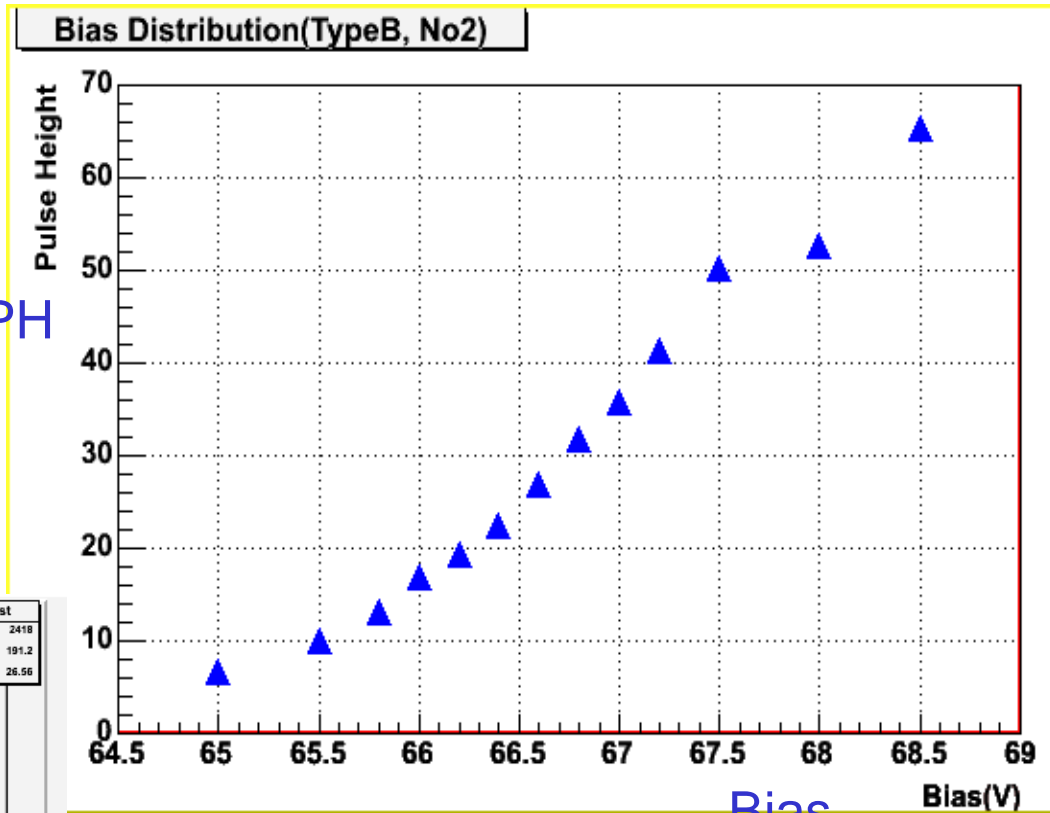
- Wave length & Power:  
532 nm (10mJ), 1064 nm (20mJ)
- Pulse width : < 10nsec
- Filter: down to  $10^{-8}$
- Precision of laser position:  $\pm 2\mu\text{m}$
- Trigger : from laser system

# Bias voltage dependence (532nm)



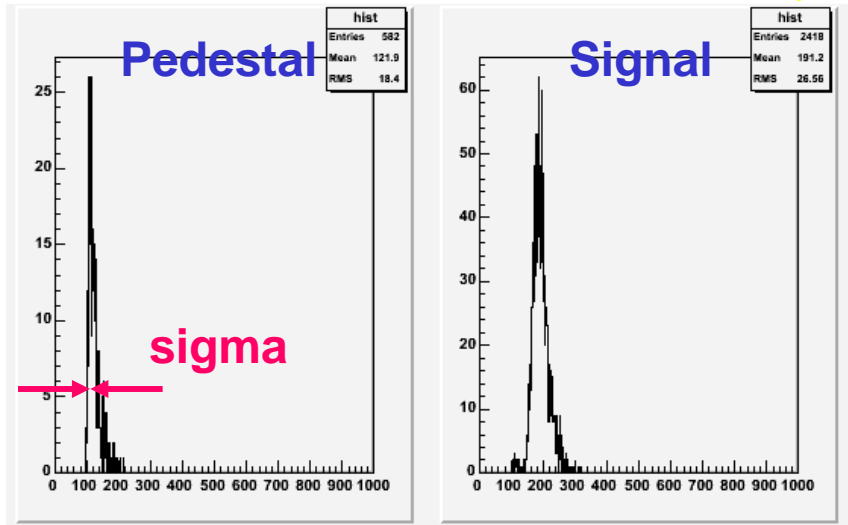
Whole sensitive area is covered by Laser

PH



Bias

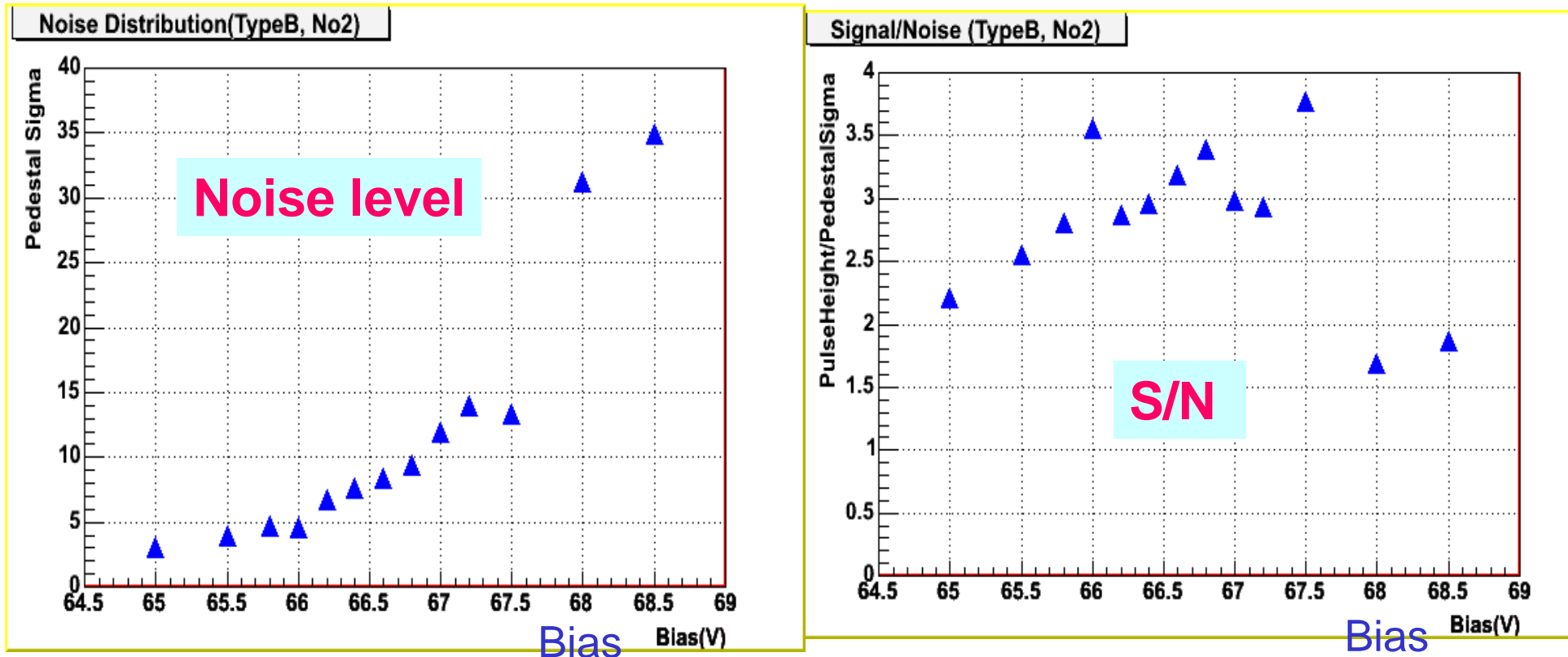
Bias(V)



Very low gain for < 65V  
No saturation up to 68.5V

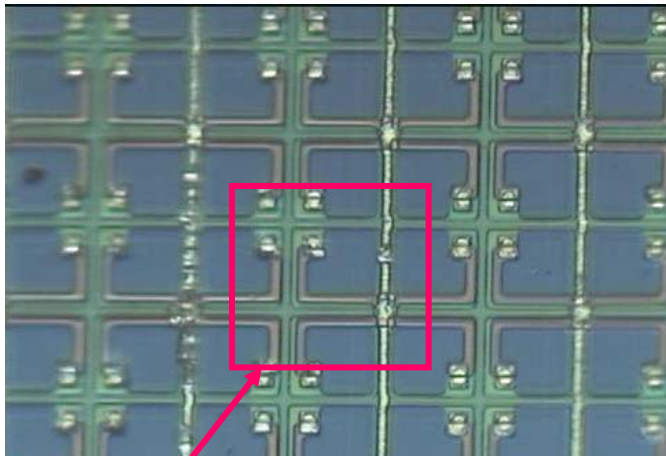
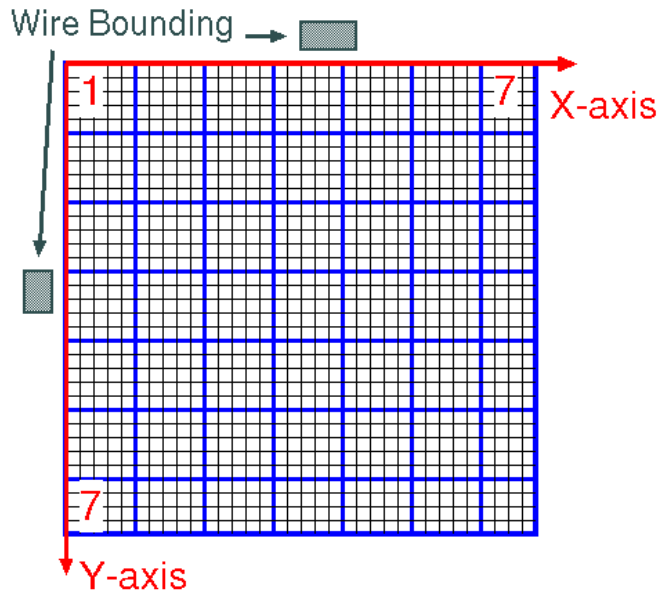


# Noise level & S/N (532nm)

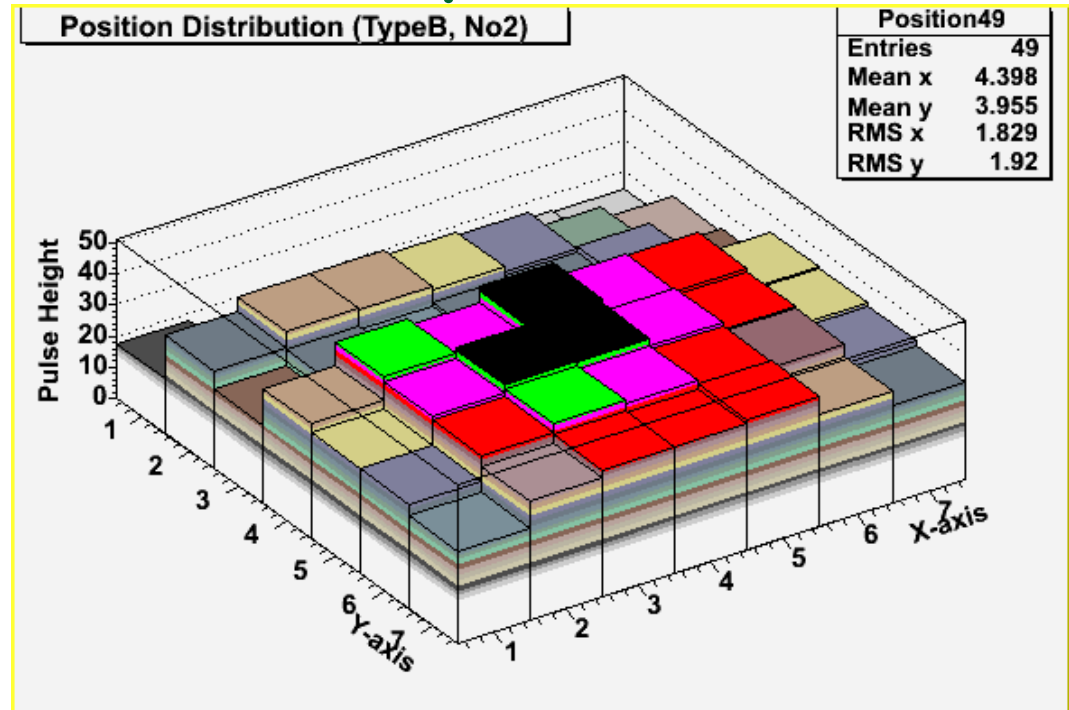


- Noise level (Pedestal sigma) increases for higher voltages
- Best S/N (Pedestal sigma /PH) seems to be achieved around 66.0V ~67.5V

# Position dependence of pixel PH



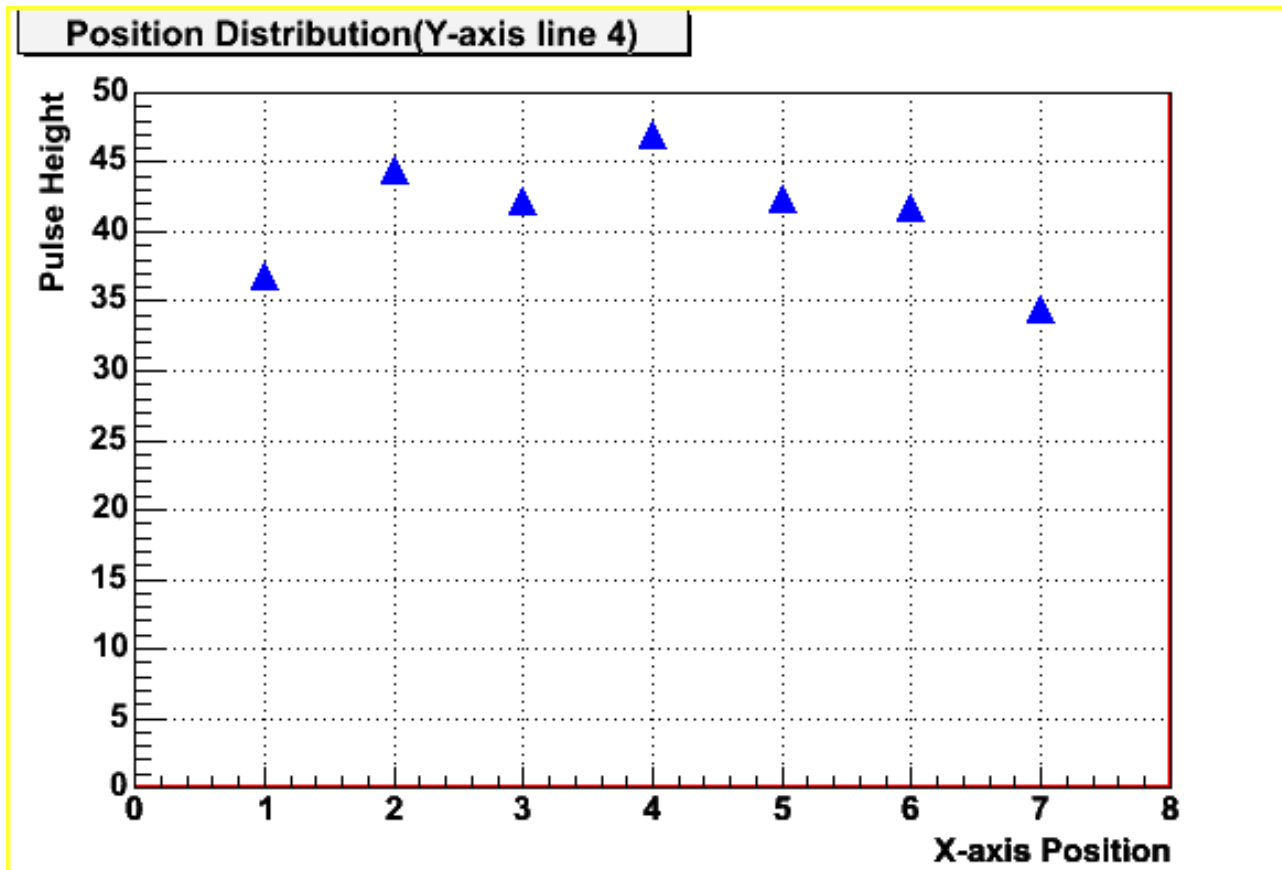
Laser hitting area  
(9 pixels)



- Laser wave length : 1064nm
- Sensor bias : 66.5V
- 49points (7x7points) were measured
- Laser output fluctuation: ~10% or less

Central part showed higher PH

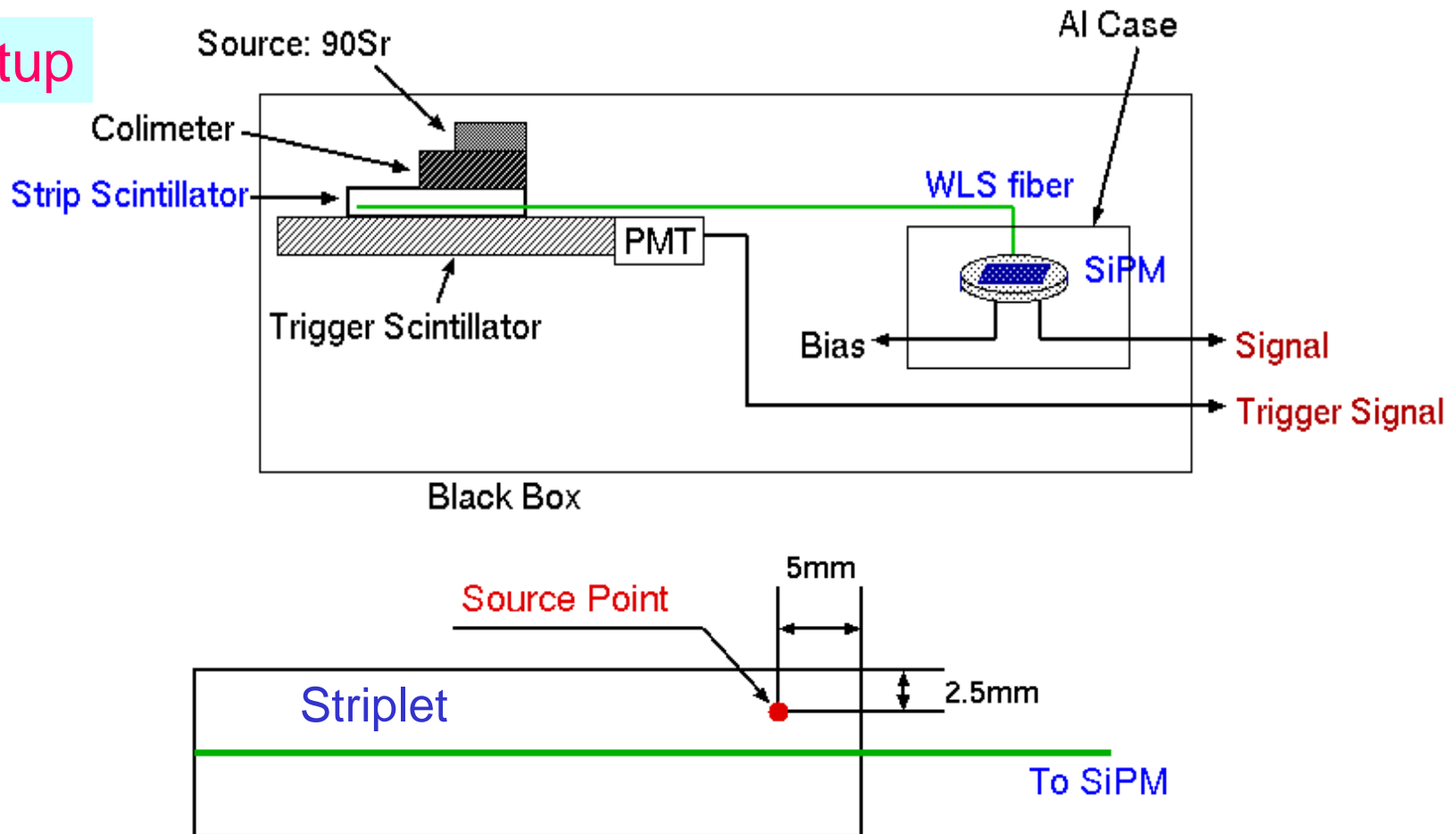
## Cross sectional view



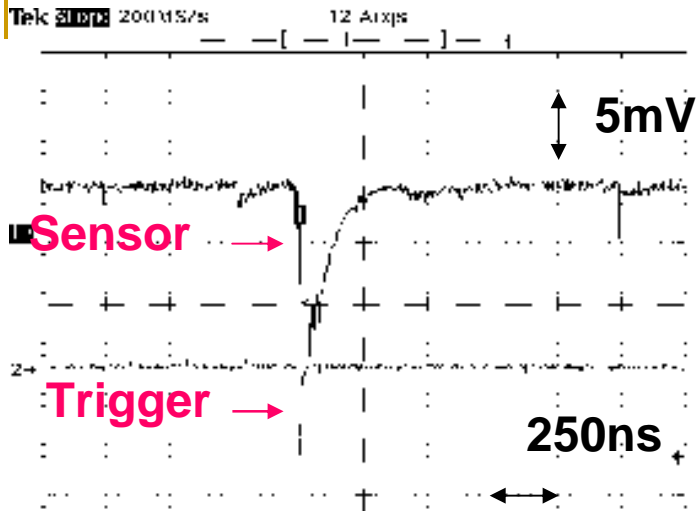
1 pixel = 5 ADC counts

## 4. Source test of scinti. strip with SiPM

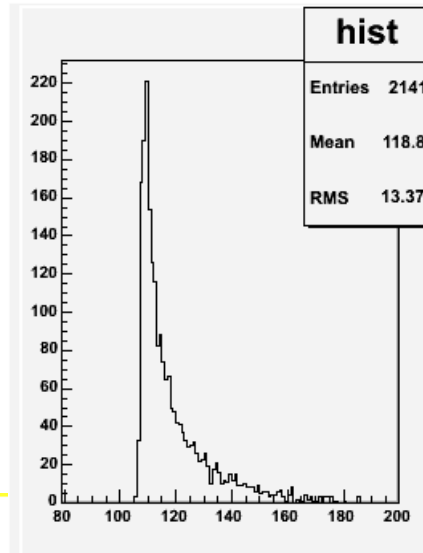
### Setup



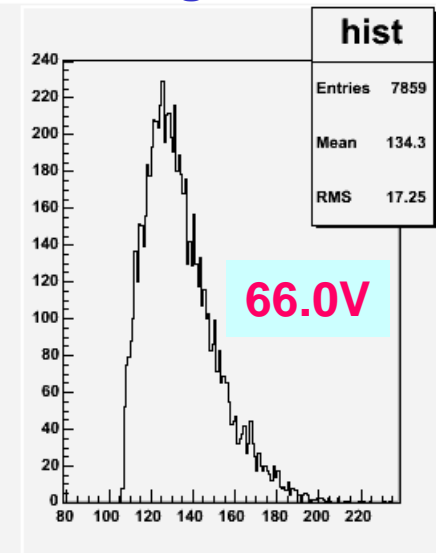
- Sensor scinti. type: 10x40x2mm triplet
- Surface covering: White paint & Teflon wrapped



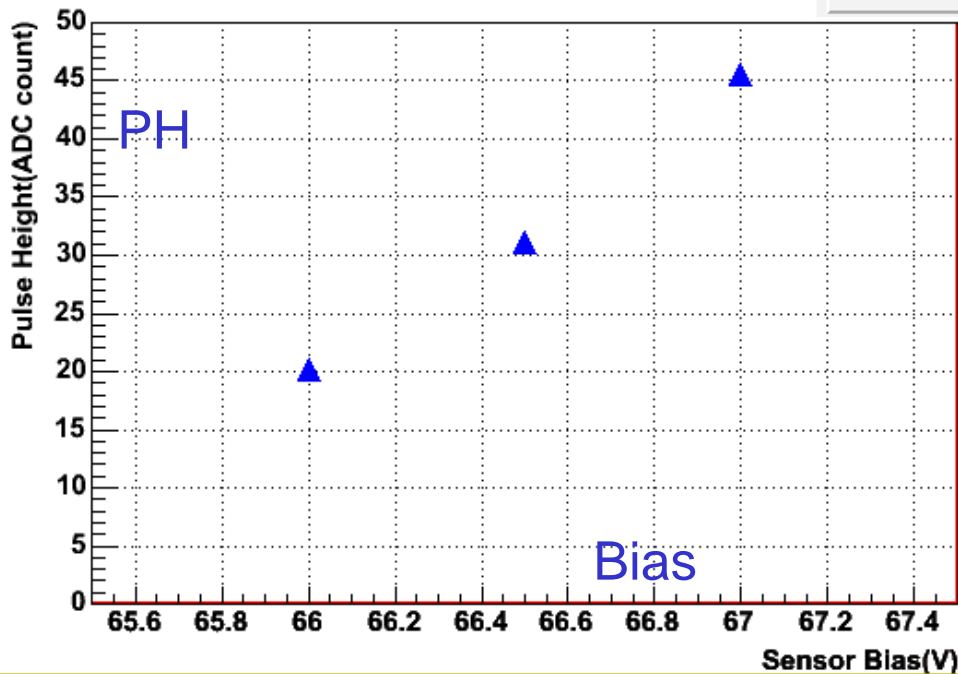
Pedestal



Signal



Bias Distribution(scinti:20x40x2mm)



Comparing ADC counts of laser injection and beta ray signals at same bias voltage (66.5V), the number of photons we observed for beta ray is ~5.

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## 5. Summary

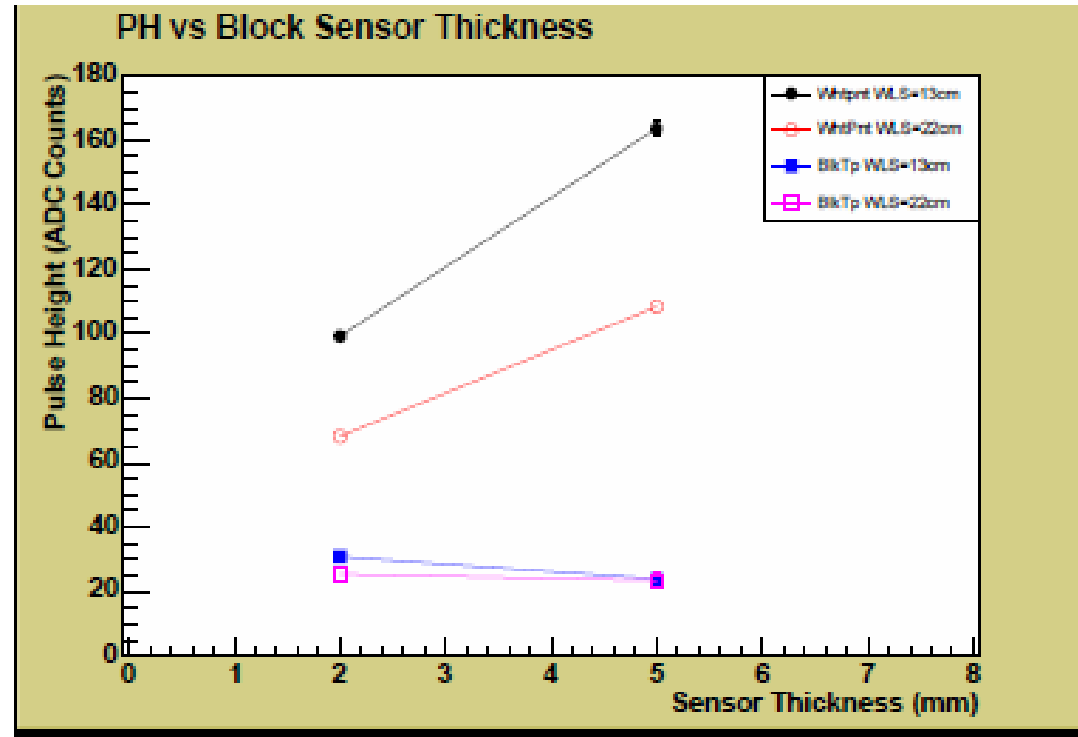
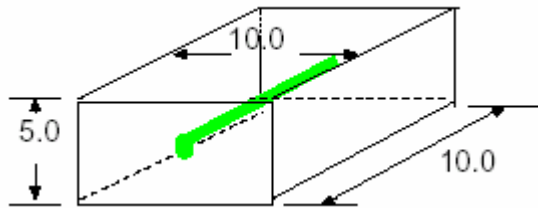
- **Scintillator study**
    - White Paint +Teflon is the best surface covering
    - Longer strip-type with shorter WLS fiber has largest PH
  - **SiPM study**
    - Bias voltage dependence of PH, Noise, S/N were measured. For whole area exposure of 1000 pixels SiPM with 532nm laser light, good operation voltage span was ~1.5V.
    - Central region of SiPM showed higher PH. Need to check more SiPMs.
  - **Beta ray signal from scintillator strip with SiPM**
    - Signal was observed for 10x40x2mmt striplet
    - Number of photons: ~5
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# PH vs Block Type Scintillator Thickness



- Compare the PH vs thickness
- 5mm thick scintillator had greater PH



# Photon number of scintillator and SiPM measurements

- Position distribution(1064nm)
  - Laser insert into 9 pixels
  - Saturation occurred -> 9 photons yielded
  - 66.5V : PH=47 (ADC count)
    - **5.2 (ADC count) / 1 photon**
- Connection scintillator and SiPM
  - 66.5V : PH=31 (ADC count)
    - **~6 photon yielded**

