

# **A Compilation of Results for Solid State Photo-detectors**

**Jerry Blazey**

**Northern Illinois University**



**NORTHERN ILLINOIS  
UNIVERSITY**

**SLAC-LCWG**

**March 18-22, 2005**



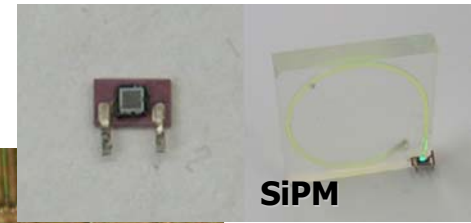
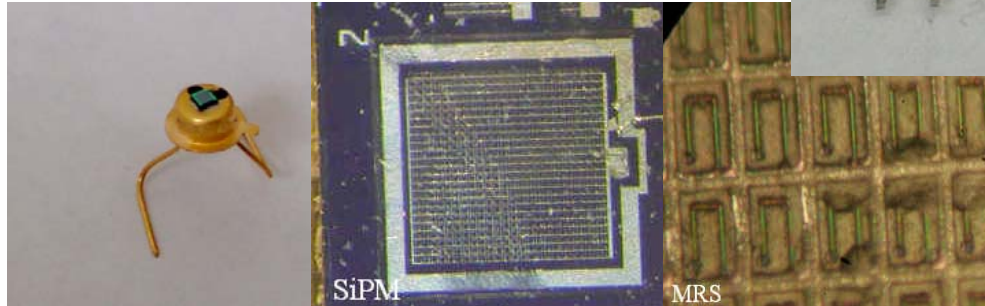
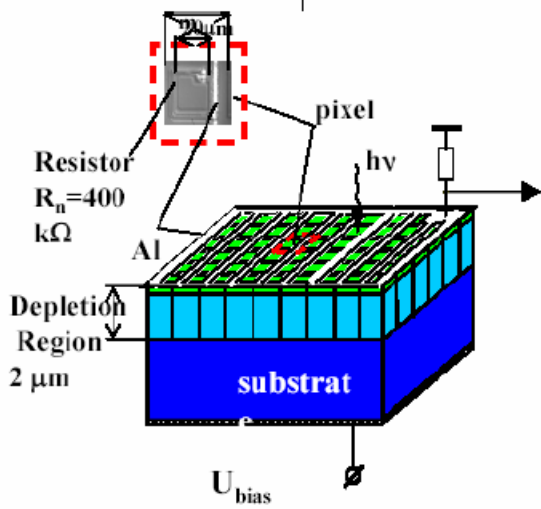
*Jerry Blazey  
March 2005  
LCWG*

# References

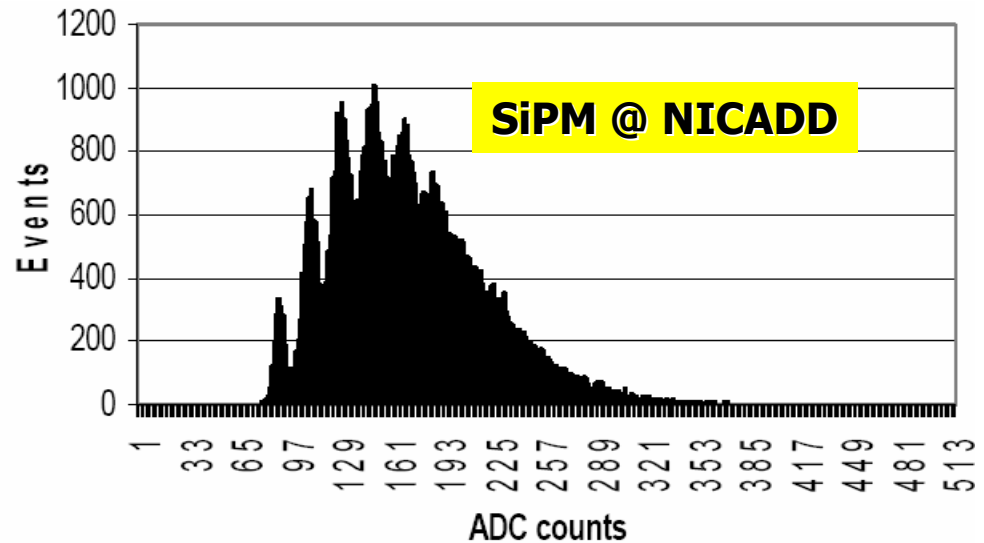
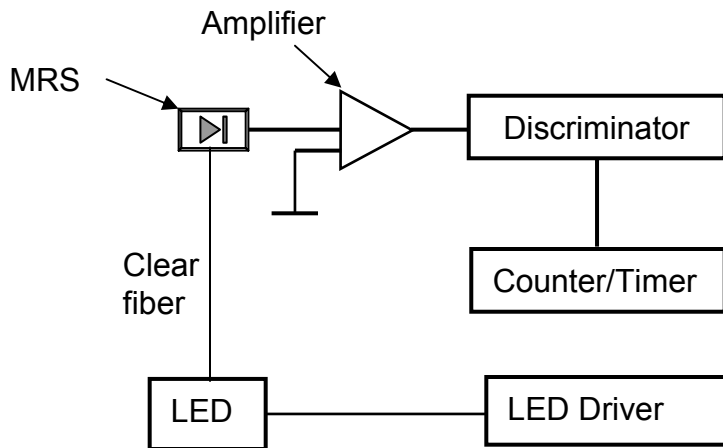
- **Towards a Scintillator-based Digital Hadron Calorimeter for the Linear Collider Detector", A. Dyshkant et al, IEEE TNS vol. 51, N4(2004 ).**
- **"`Small Scintillating Cells as the Active Elements in a Digital Hadron Calorimeter for the  $e^+e^-$  Linear Collider Detector", A. Dyshkant et al, J. Phys. G30:N1 (2004).**
- **"`Investigation of a Solid-State Photodetector", D. Beznosko et al, submitted to NIM A.**
- **"`The MRS Photodiode in a Strong Magnetic Field", D. Beznosko et al, FERMILAB-TM-2284.**



# SiPM/MRS



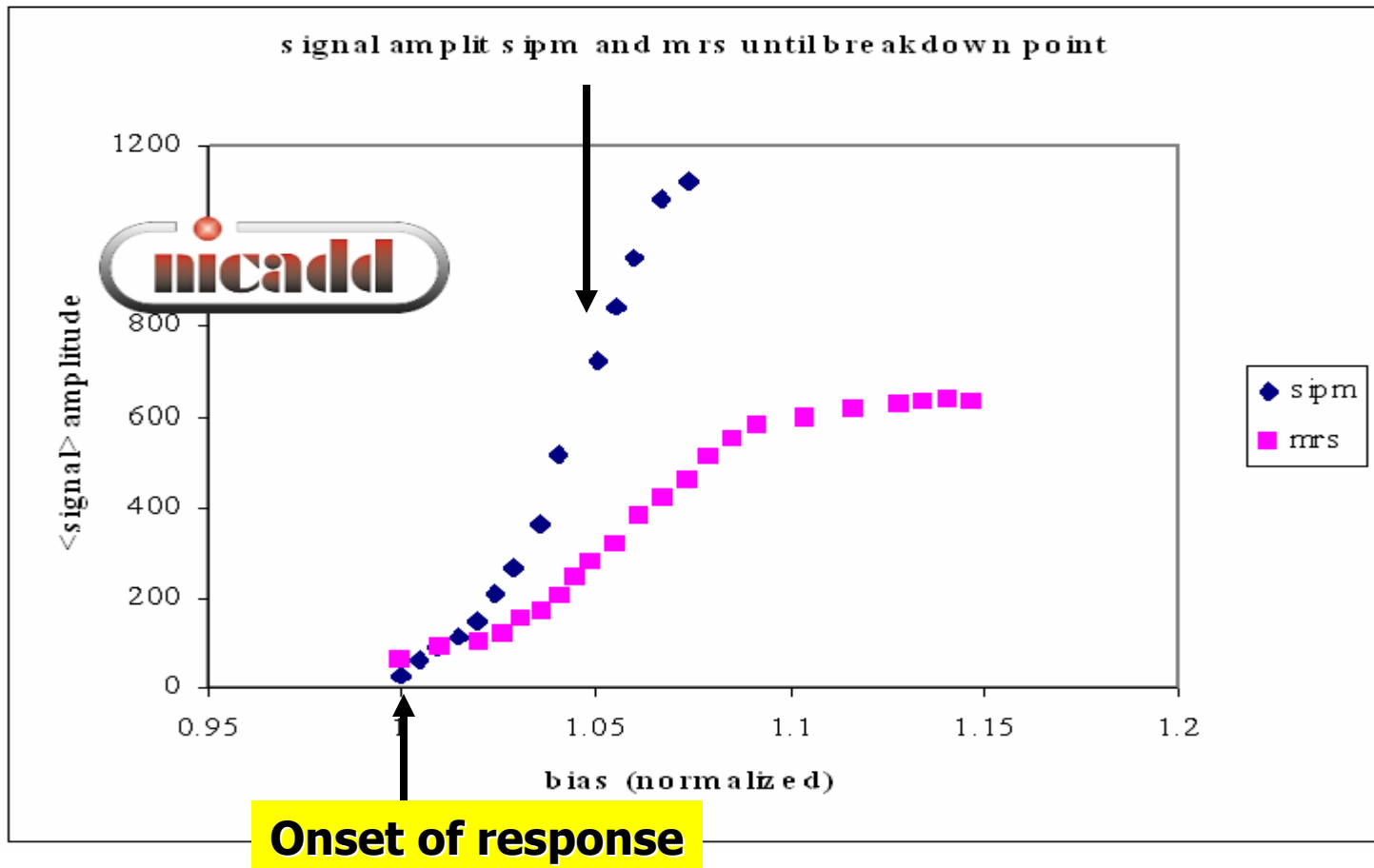
**~1000 pixels on 1mm x 1mm; Limited Geiger multiplication mode; Bias voltage ~ 50-60V; Gain ~  $10^6$ ; Quantum  $\epsilon$  x geom ~ 12-15%**



**\*SiPM --> MPhI/Pulsar  
MRS---> CPTA**

**Jerry Blazey  
March 2005  
LCWG**

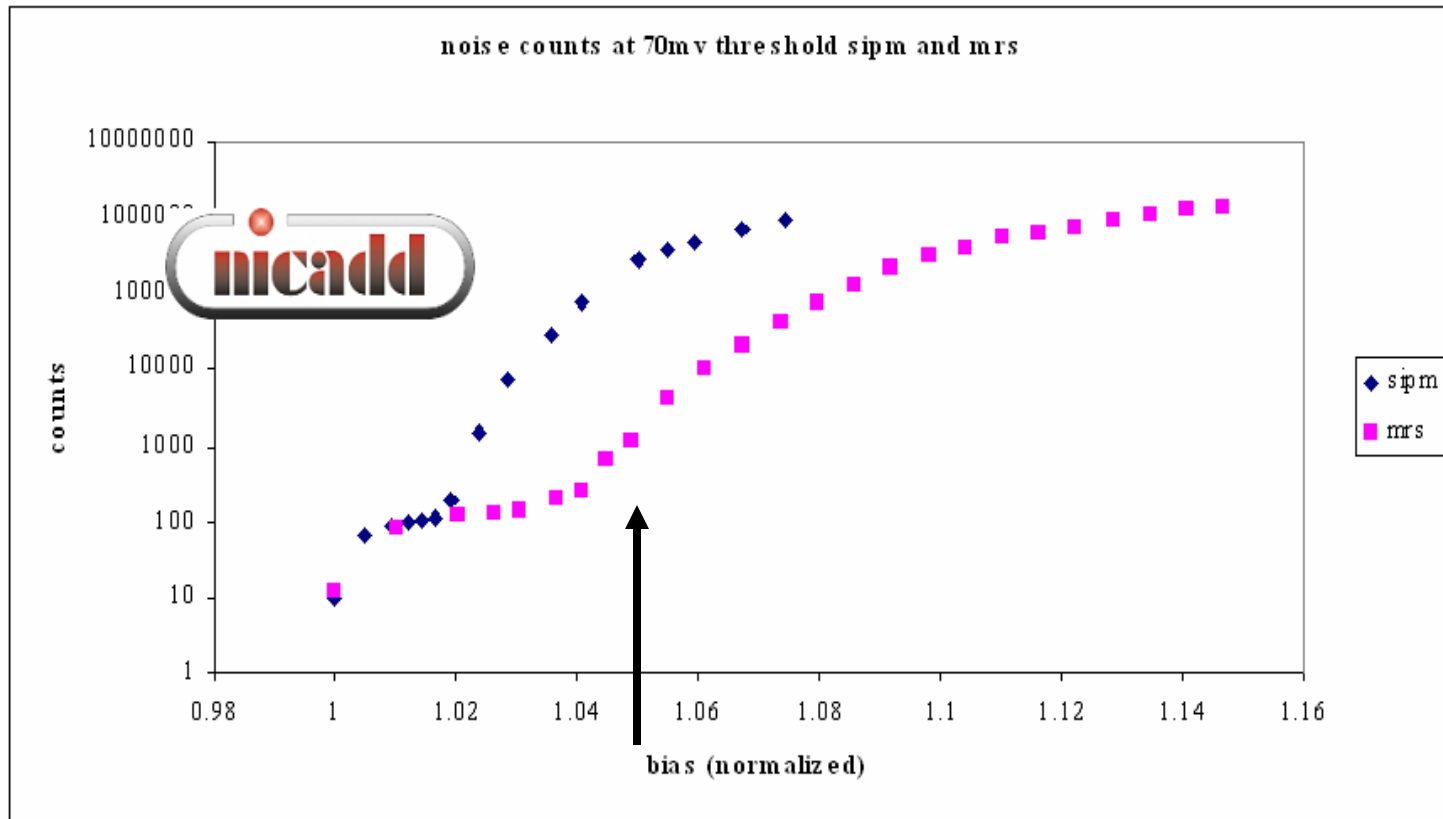
# Signal Amplitude vs. Bias



**Green LED( $\sim 130\text{Hz}$ ) with clear fiber used  
Representative, wafer behavior uniform**

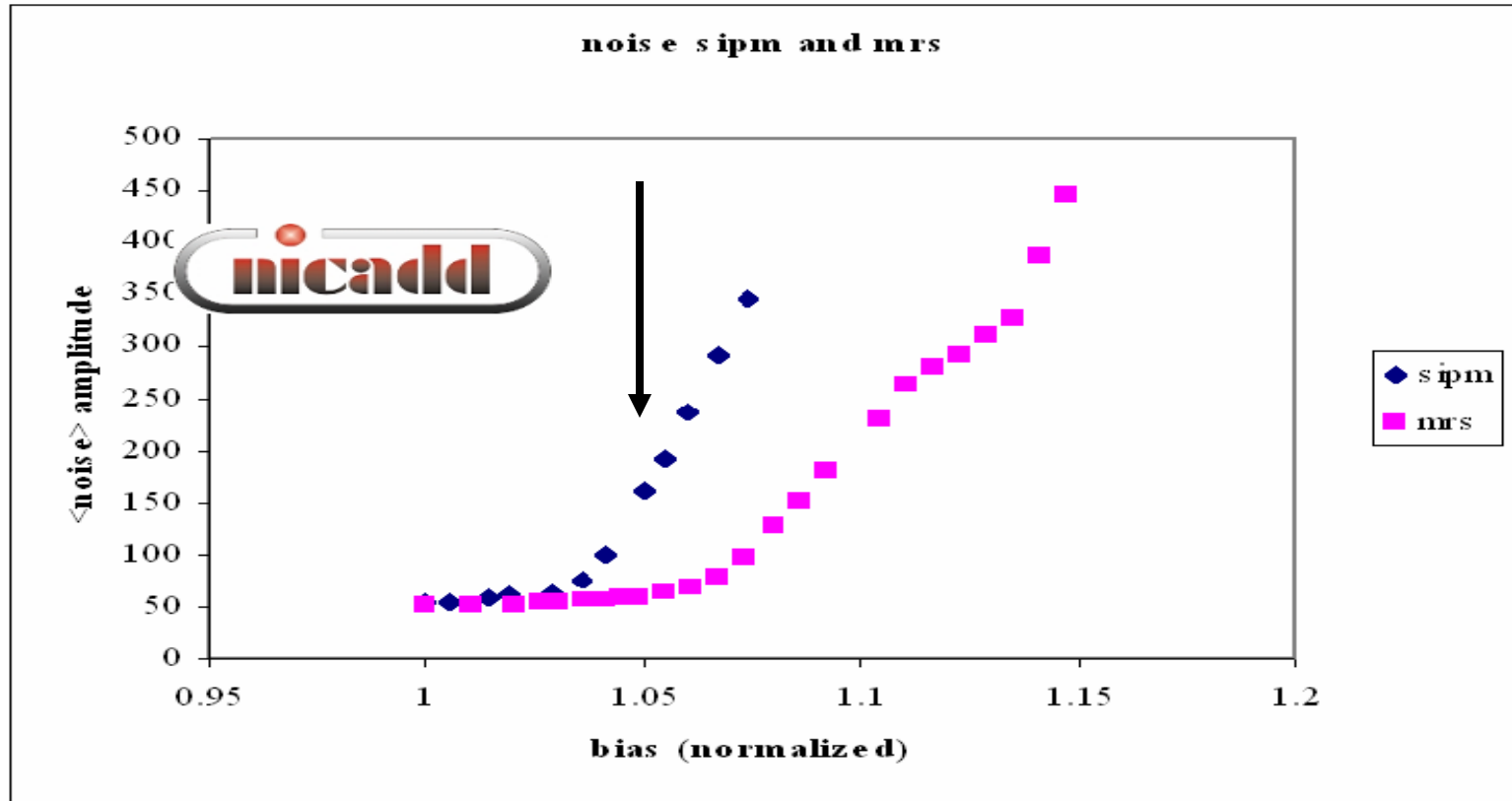
*Jerry Blazey  
March 2005  
LCWG*

# Count Rate vs. Bias



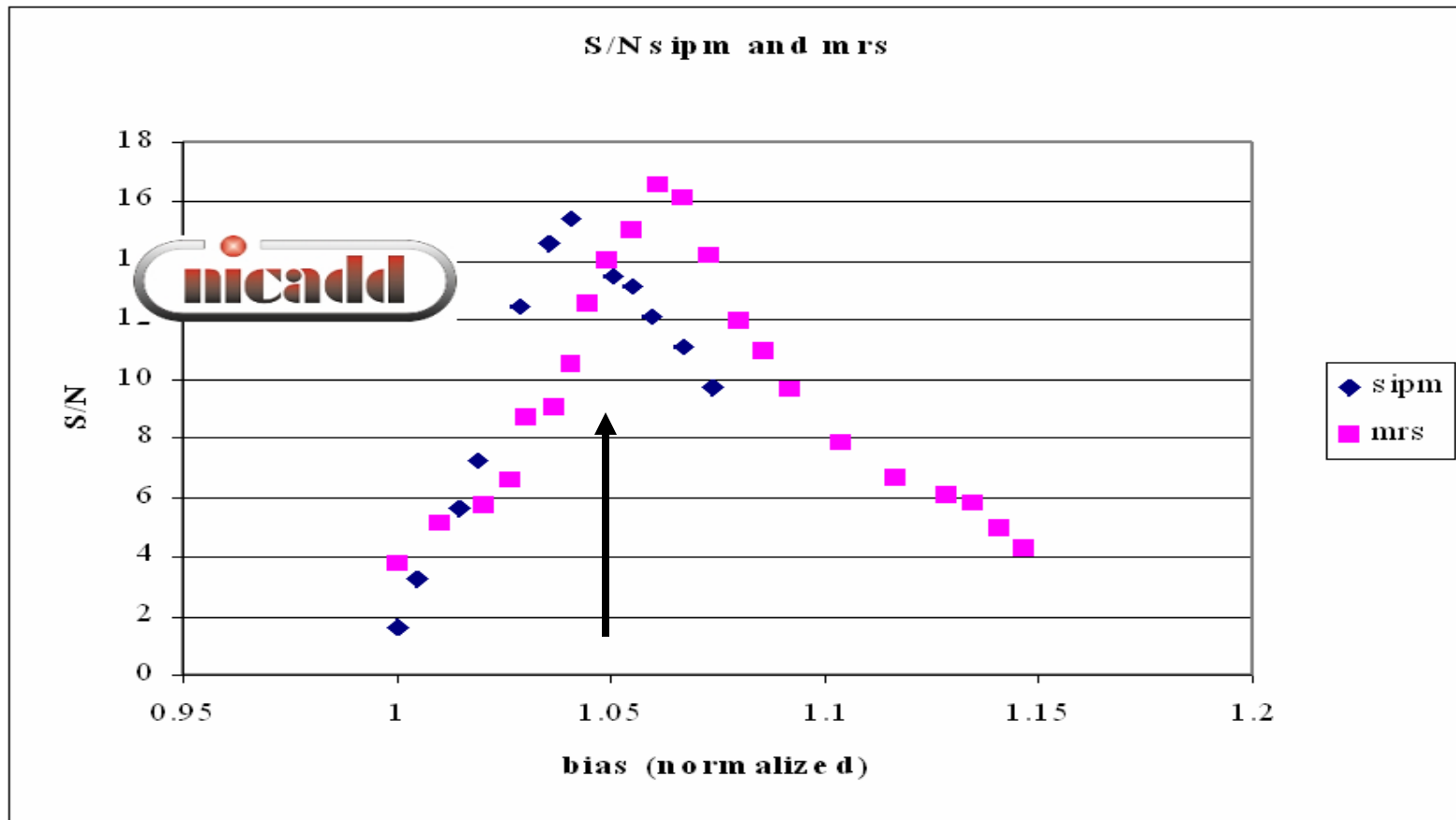
*Jerry Blazey  
March 2005  
LCWG*

# Noise Amplitude(LED off) vs. Bias



# S/N vs. Bias Voltage

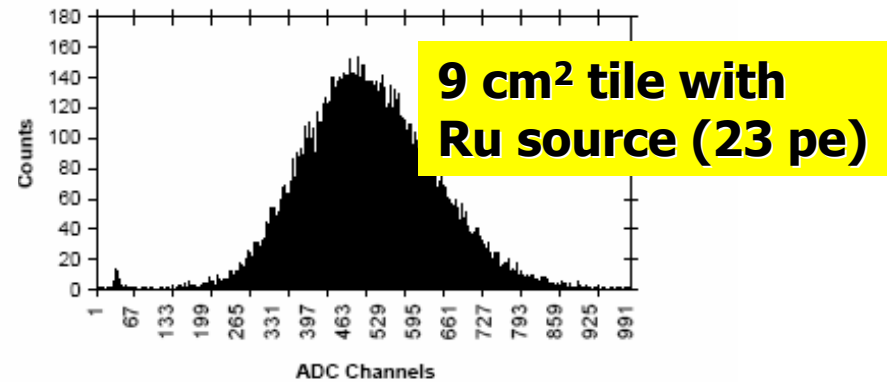
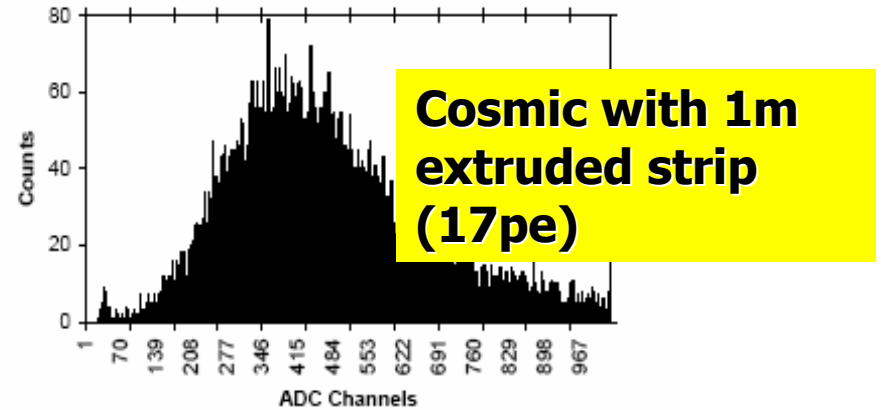
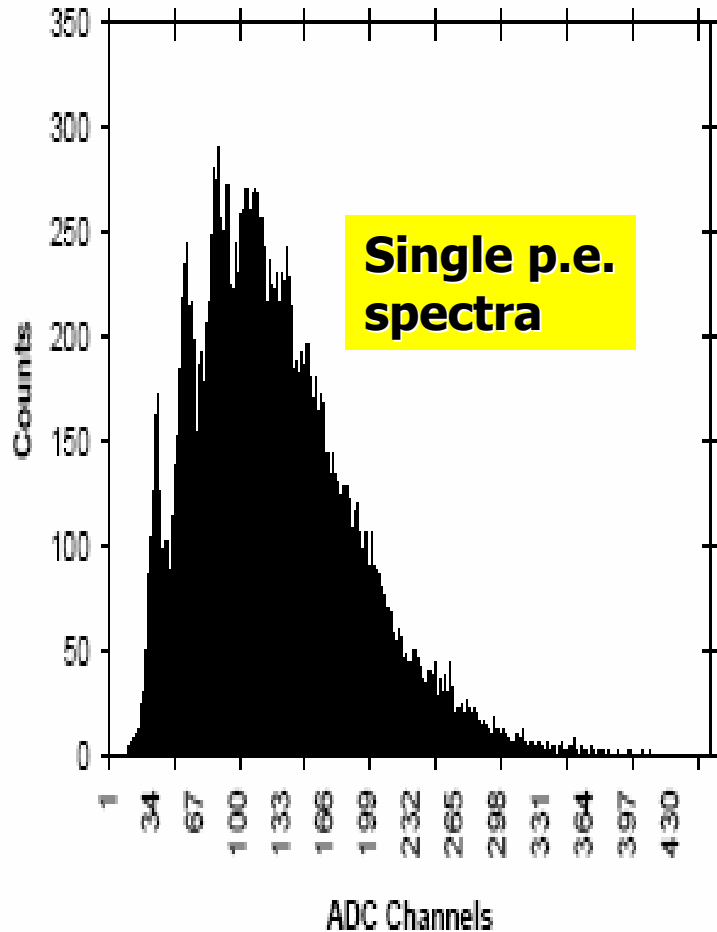
Slide 7 Divided by Slide 5



**Maximum offers operating point with high amplitude and controllable rate, can be adjusted to ensure linearity if needed.**

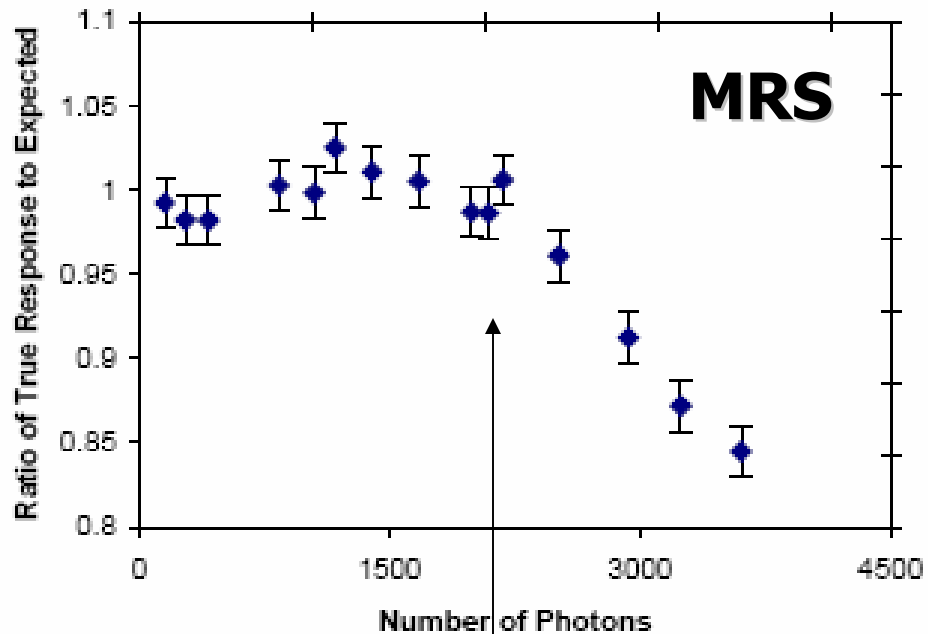
*Jerry Blazey  
March 2005  
LCWG*

# MRS Light Yield





# Linearity



~ 30 MIPS



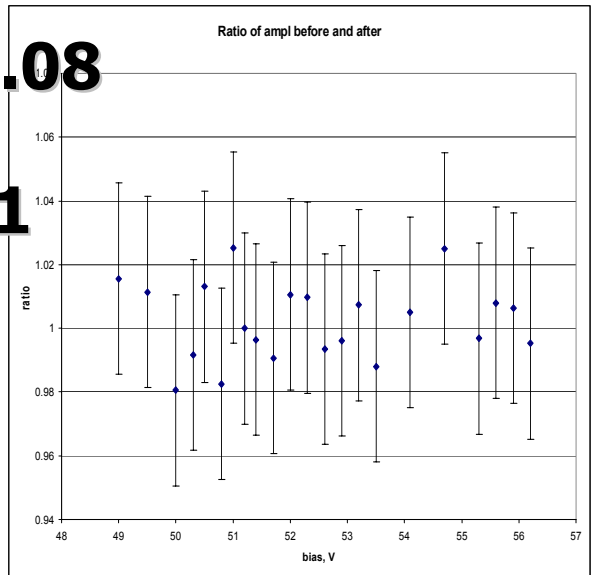
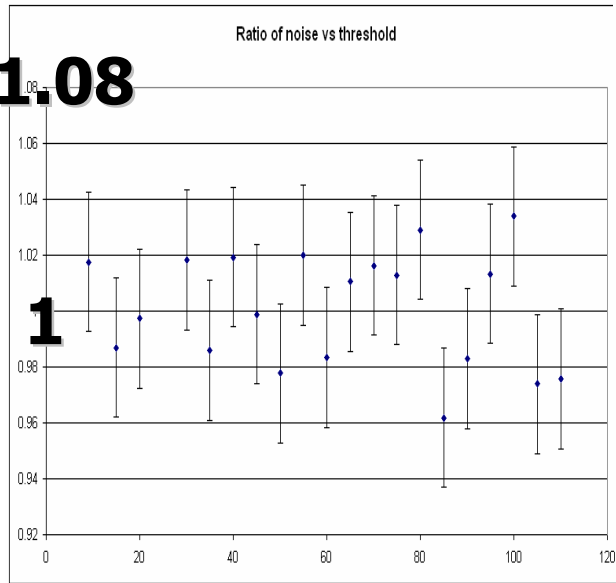
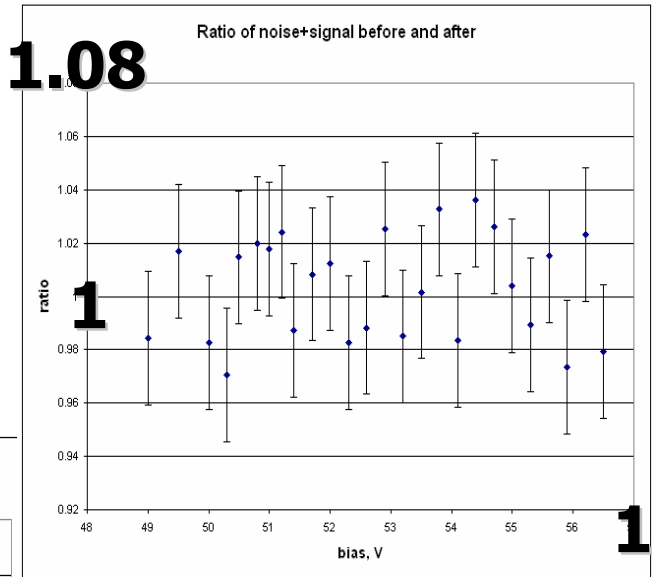
*Jerry Blazey*  
*March 2005*  
*LCWG*

# Other studies.... response of photodetector to irradiation

- **Sent sensors to Michigan  $\gamma$  irradiation facility**
- **Dosage  $\sim$  1MRad**
- **Comparison of noise & signal before & after irradiation**
- **Plan to irradiate with protons**



# MRS Rate, Noise, and Amplitude Before & After

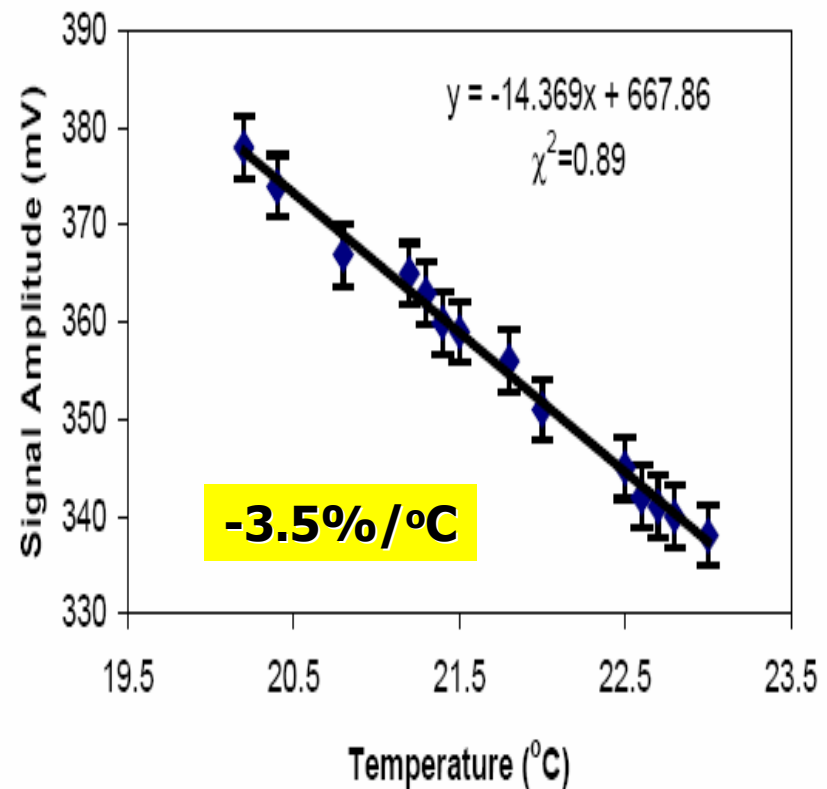
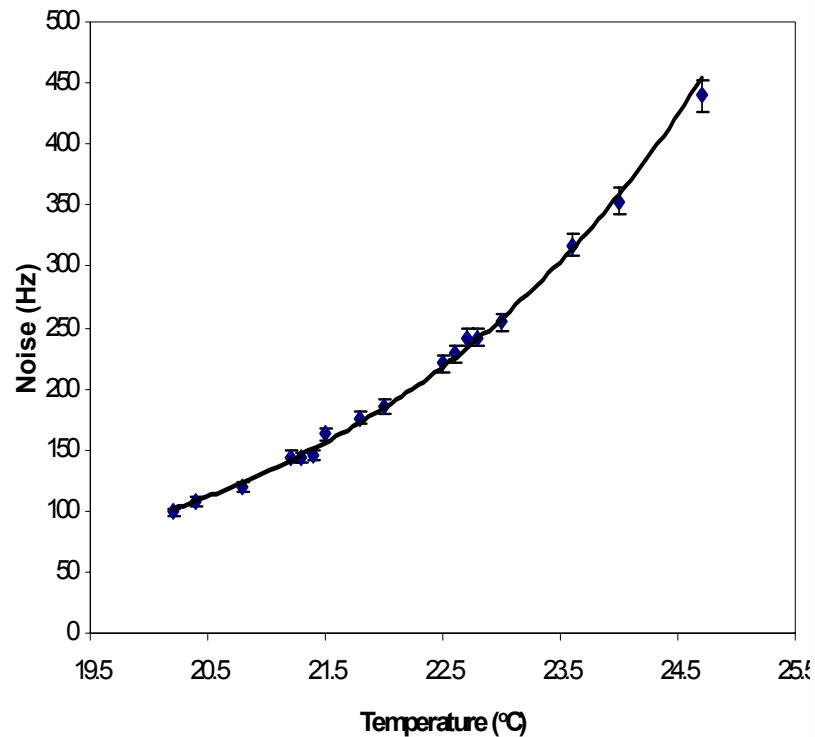


**No measurable change in response**



*Jerry Blazey  
March 2005  
LCWG*

# MRS Temperature dependence of Noise and Amplitude

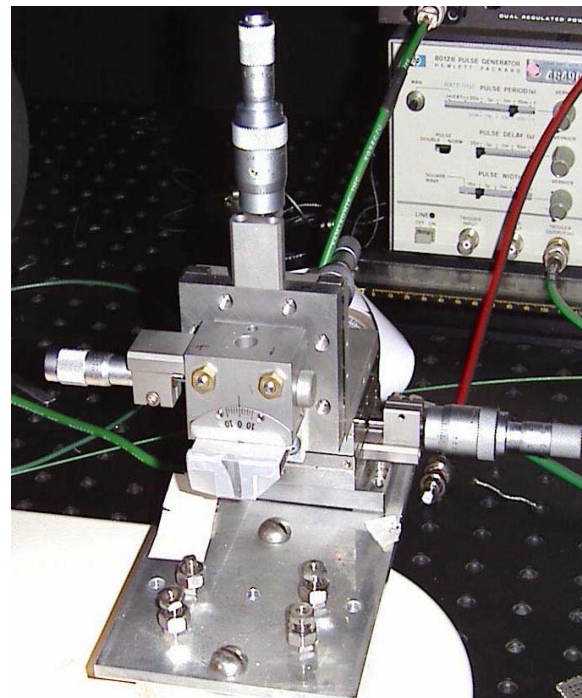
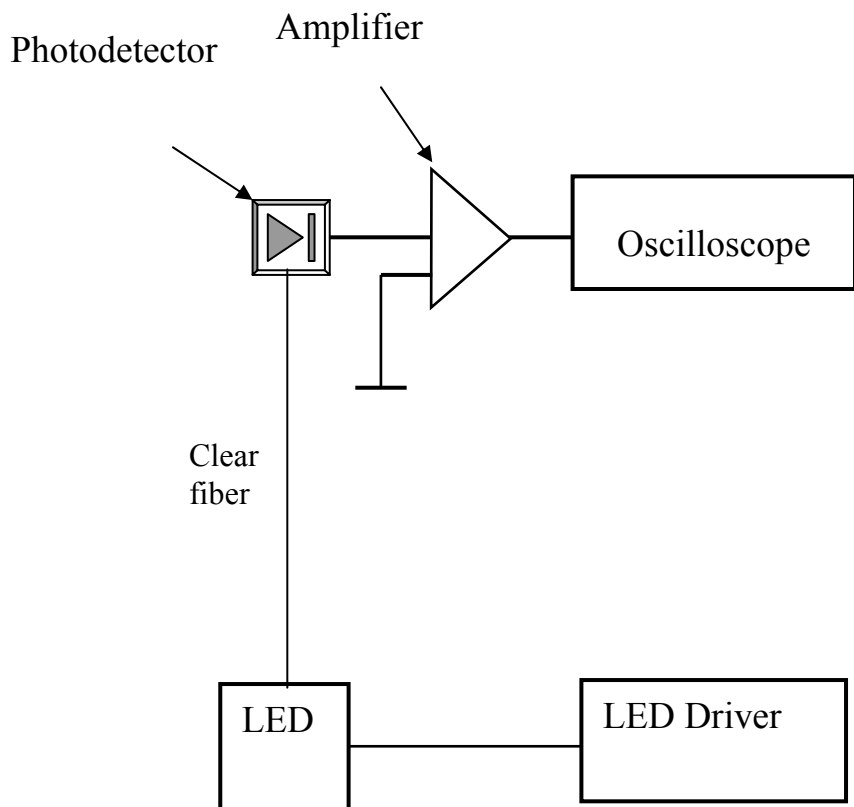


**Will require control, monitoring...**



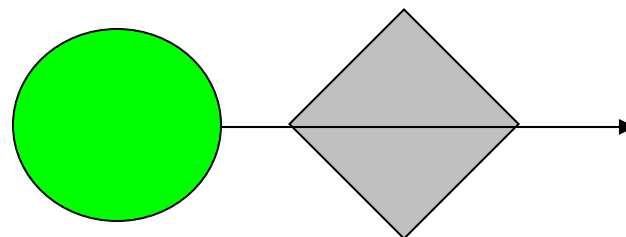
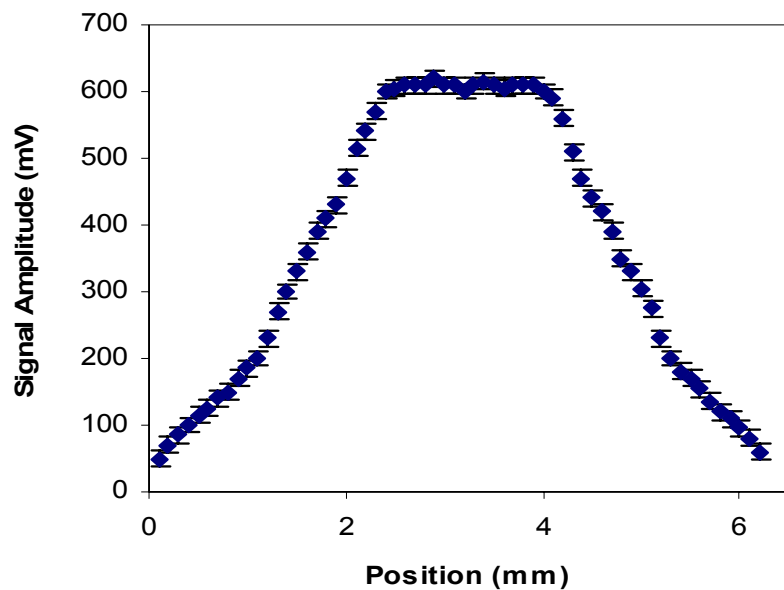
*Jerry Blazey  
March 2005  
LCWG*

# Studies of fiber position and response...



**In collaboration with  
P. Polozov(Itep) &  
G. Sellberg(Fermilab)**

# Uniformity across MRS Photodetector

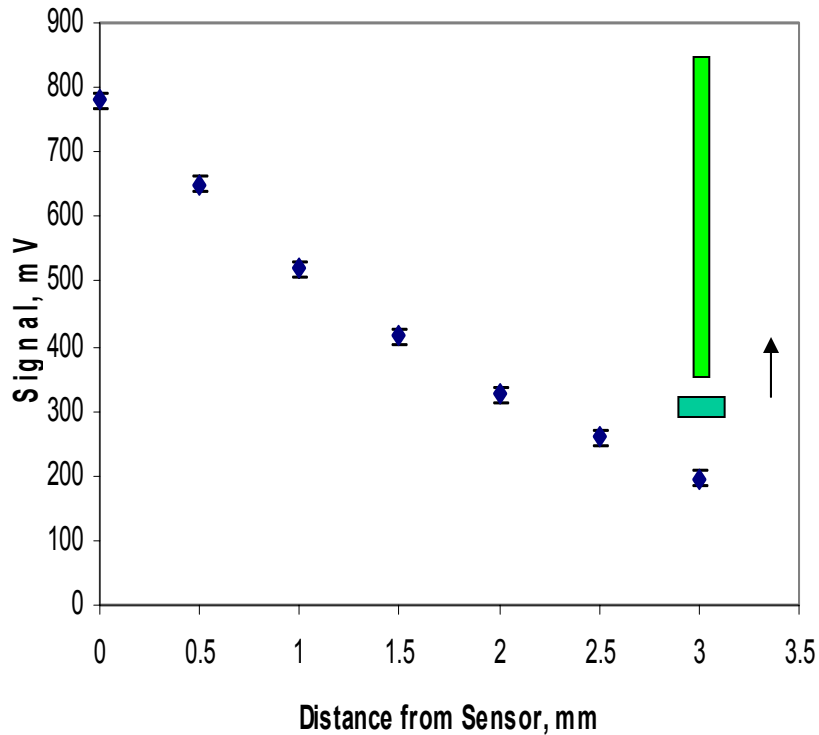


Some leeway in positioning...

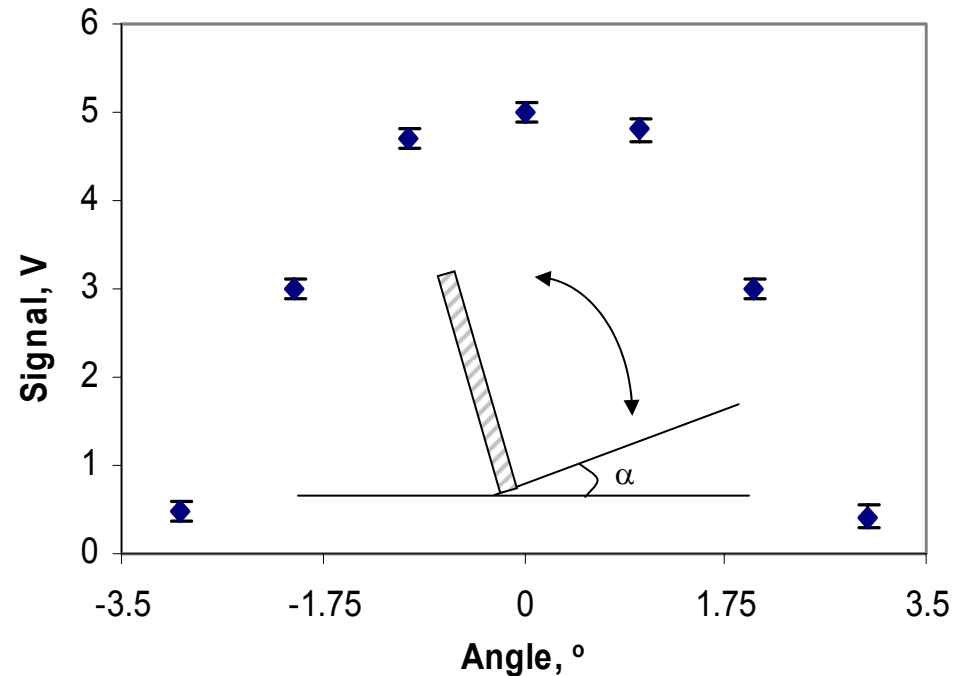


*Jerry Blazey  
March 2005  
LCWG*

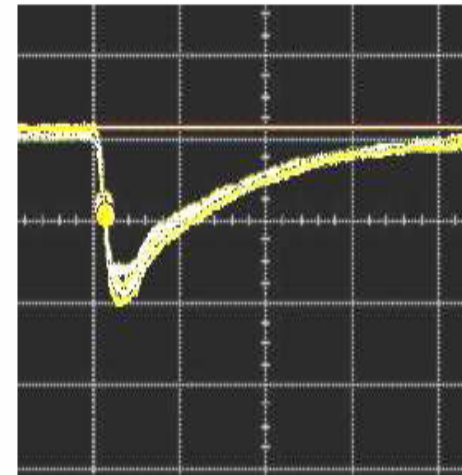
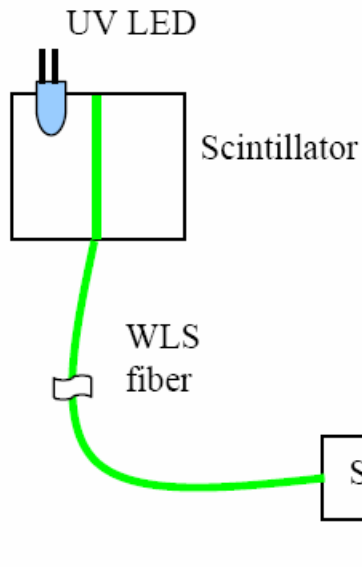
# SiPM Response & Fiber Position/Angle



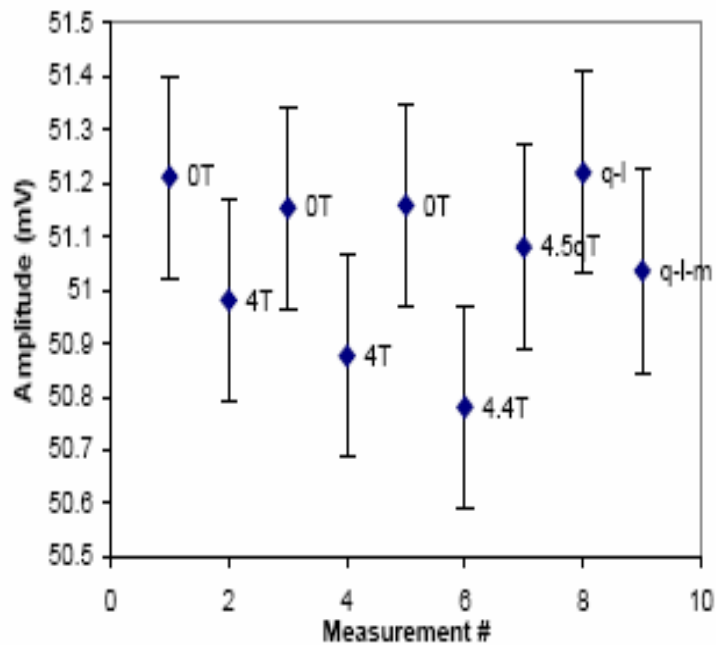
**Response very sensitive to proximity & mildly to normality, need to be minimized.**



# B-field Sensitivity



**Signal shapes at 0, 4, 4.4  
& after quench at 4.5T**



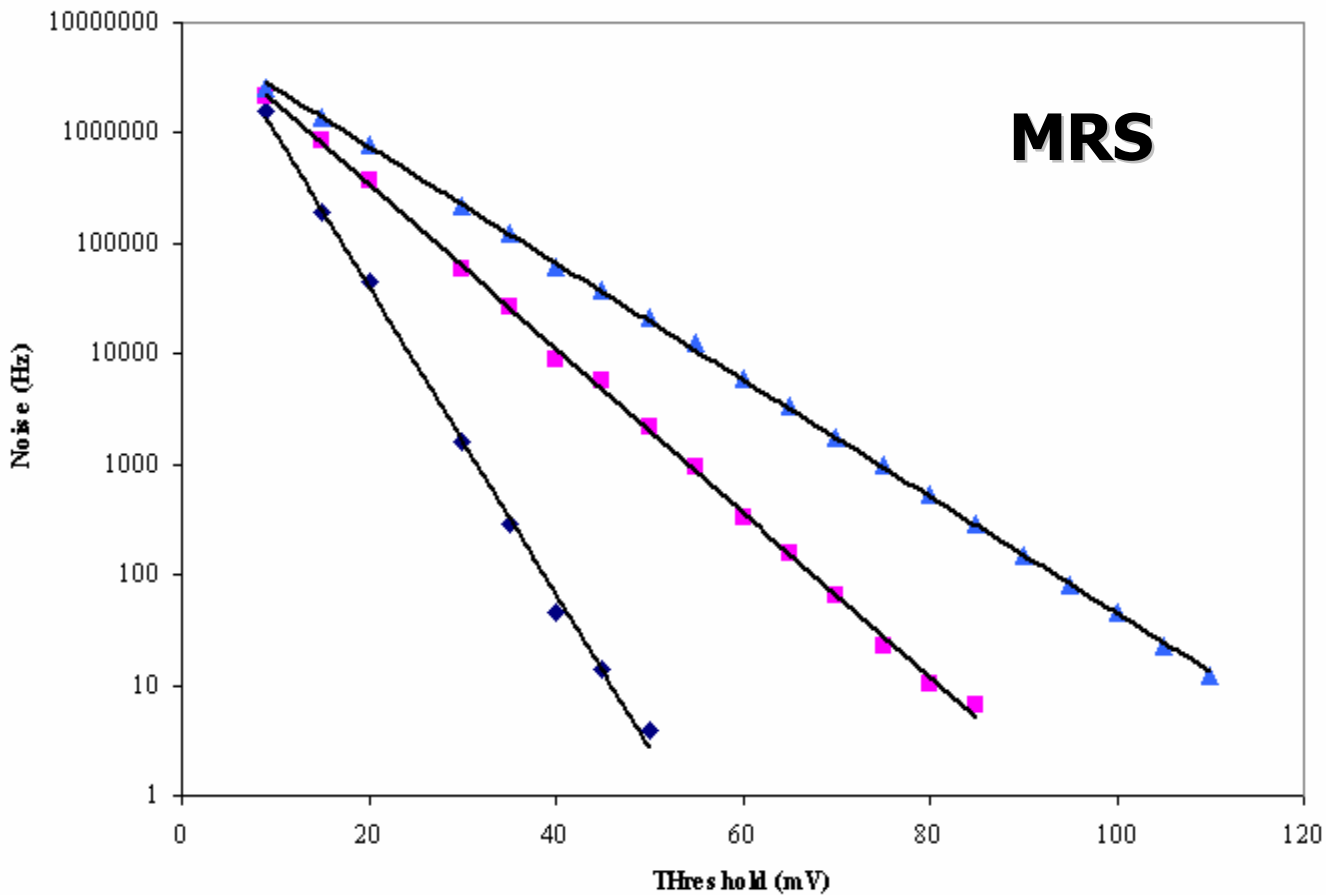


# Conclusions/Closing Comments

- **MRS/SiPM excellent photodetector candidates.**
- **Ample MIP signal & linear**
- **Operating point easily selected for reasonable noise rates and amplitude**
- **Fiber positioning tolerance can be controlled**
- **Robust to irradiation**
- **Impervious to magnetic field**
- **See related talks**
  - **Today 2PM, CALICE TCMT, D. Chakraborty**
  - **Sunday 3:15PM, Studies of NICADD Extruded Scintillator Strips, S.Dychkant**

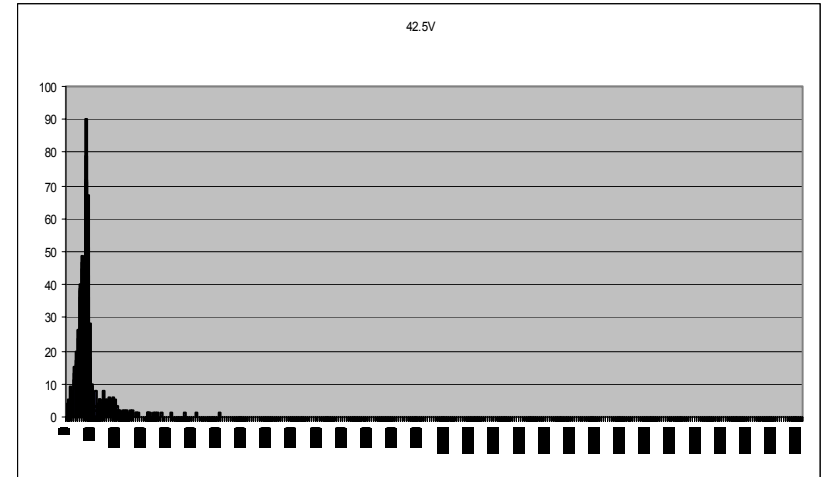
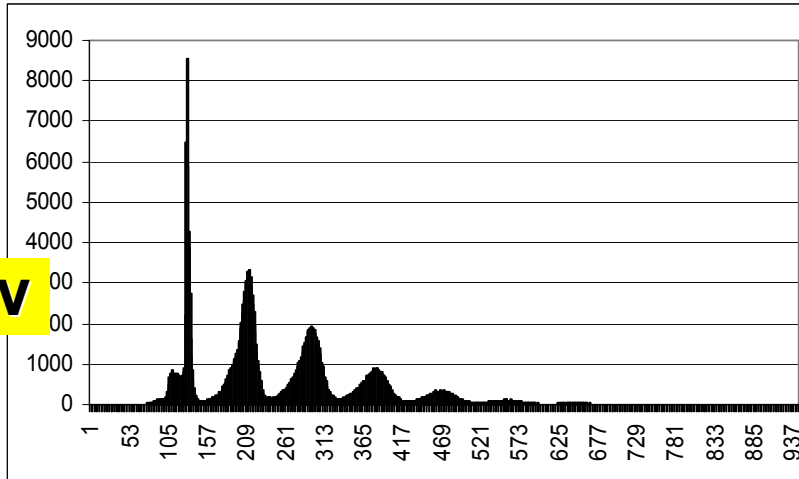


# Dark Rate (LED off)

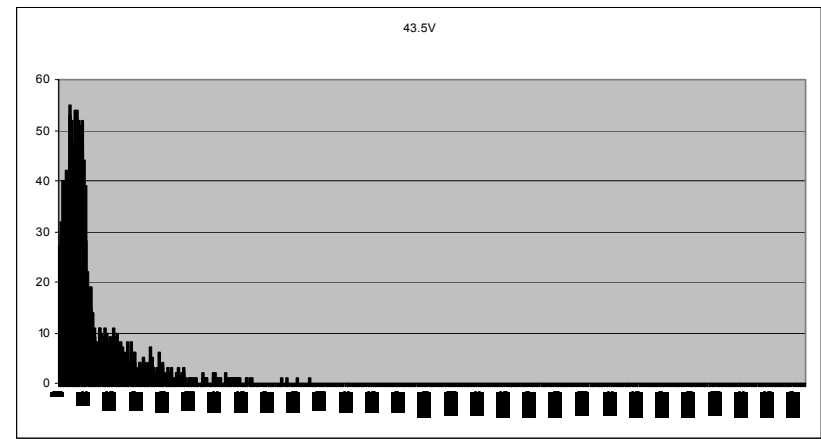
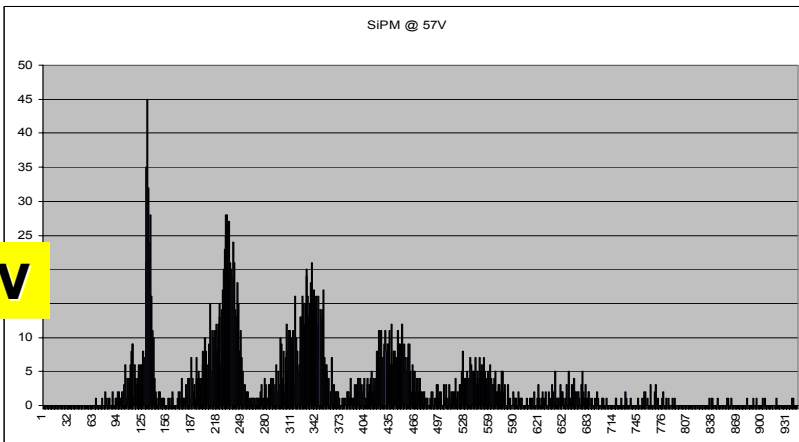


# SiPM Signal & Pedestal examples

42.5V



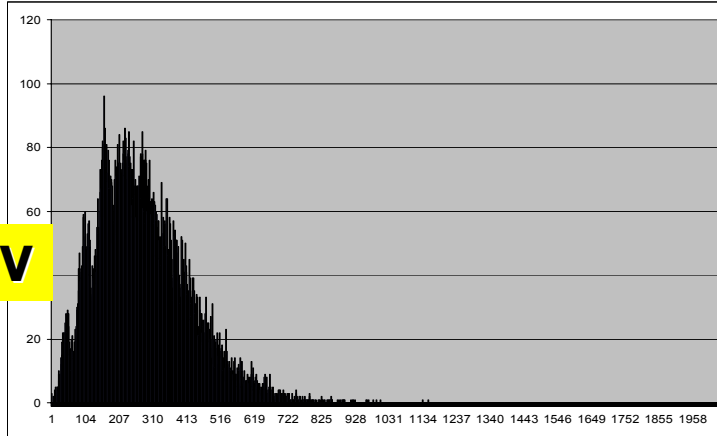
43.5V



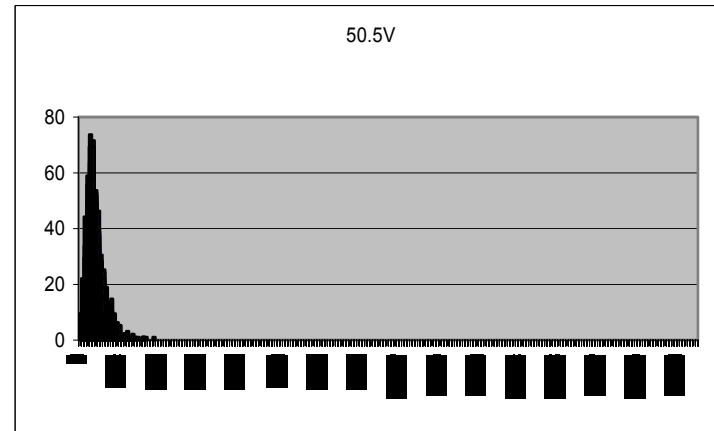
*Jerry Blazey  
March 2005  
LCWG*

# MRS Signal & Pedestal examples

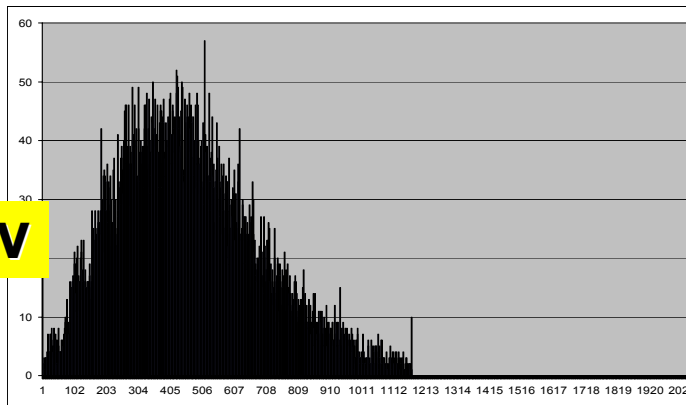
**50.5V**



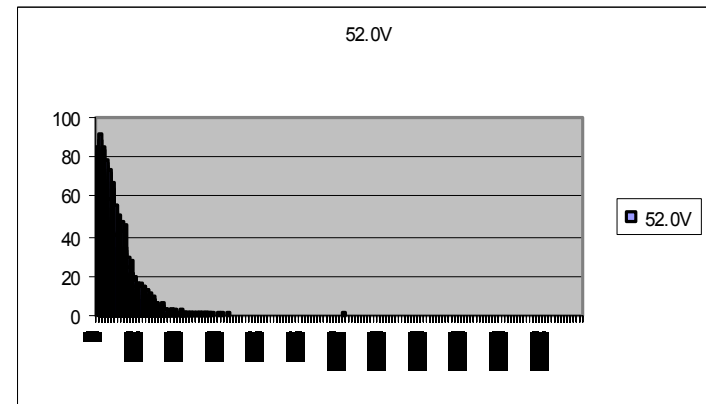
50.5V



**52.0V**



52.0V



*Jerry Blazey  
March 2005  
LCWG*