

## Preliminary results from 3D CMS Pixel Detectors

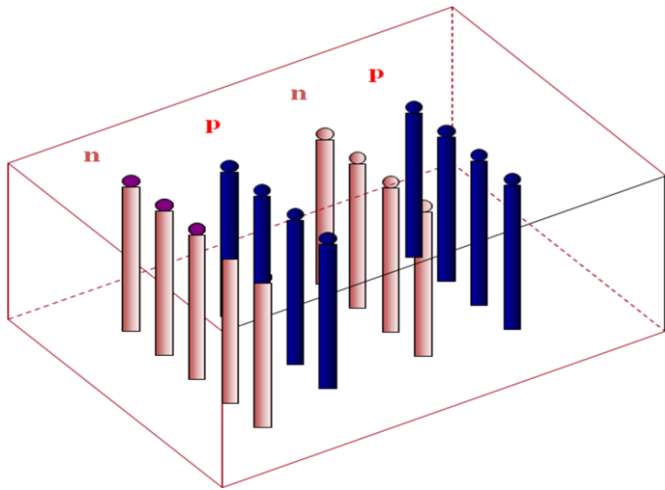
Ozhan Koybasi<sup>1</sup>, E. Alagoz<sup>1</sup>, K. Arndt<sup>1</sup>, D. Bortoletto<sup>1</sup>, I. Shipsey<sup>1</sup>, G. Bolla<sup>1</sup>, T. E. Hansen<sup>2</sup>, A. Kok<sup>2</sup>, T. A. Hansen<sup>2</sup>, N. Lietaer<sup>2</sup>, G. U. Jensen<sup>2</sup>, A. Summanwar<sup>2</sup>, R. Riviera<sup>3</sup>, M. Turqueti<sup>3</sup>, L. Uplegger<sup>3</sup>, and S. W. L. Kwan<sup>3</sup>

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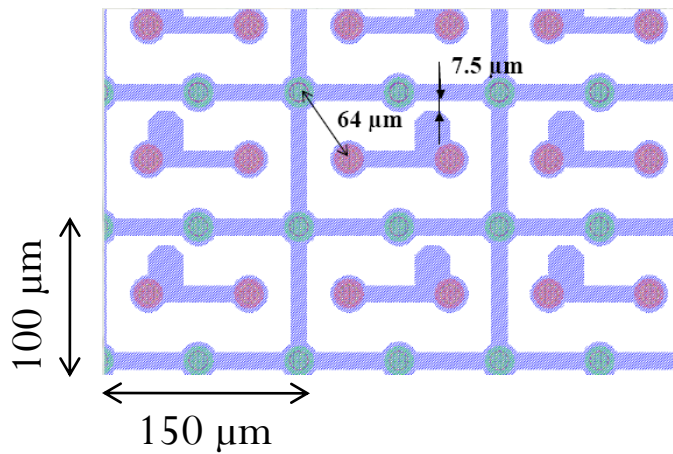
<sup>3</sup>Fermilab, Batavia, IL 60510-5011 USA

16<sup>th</sup> RD50 Workshop ,Barcelona, June 2<sup>nd</sup> , 2010



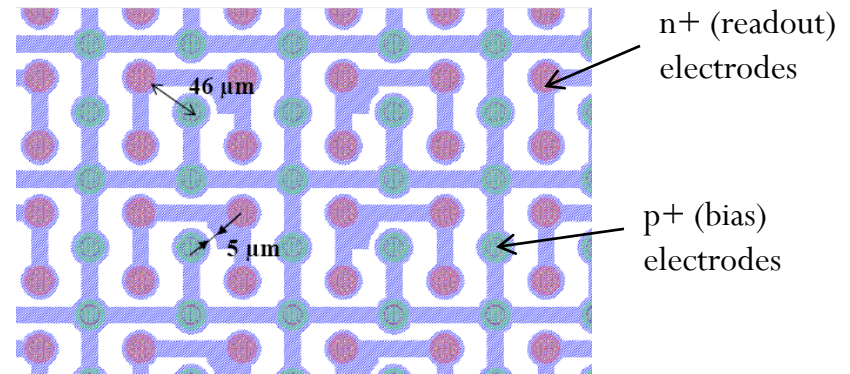
- First fabricated at Stanford Nanofabrication facility in 1997
- As a part of “3D Collaboration” , fabrication transferred to SINTEF for small and medium scale production
- Two different 3D CMS layouts:
  - 4 readout electrodes per pixel (4E)
  - 2 readout electrodes per pixel (2E)

2E Configuration



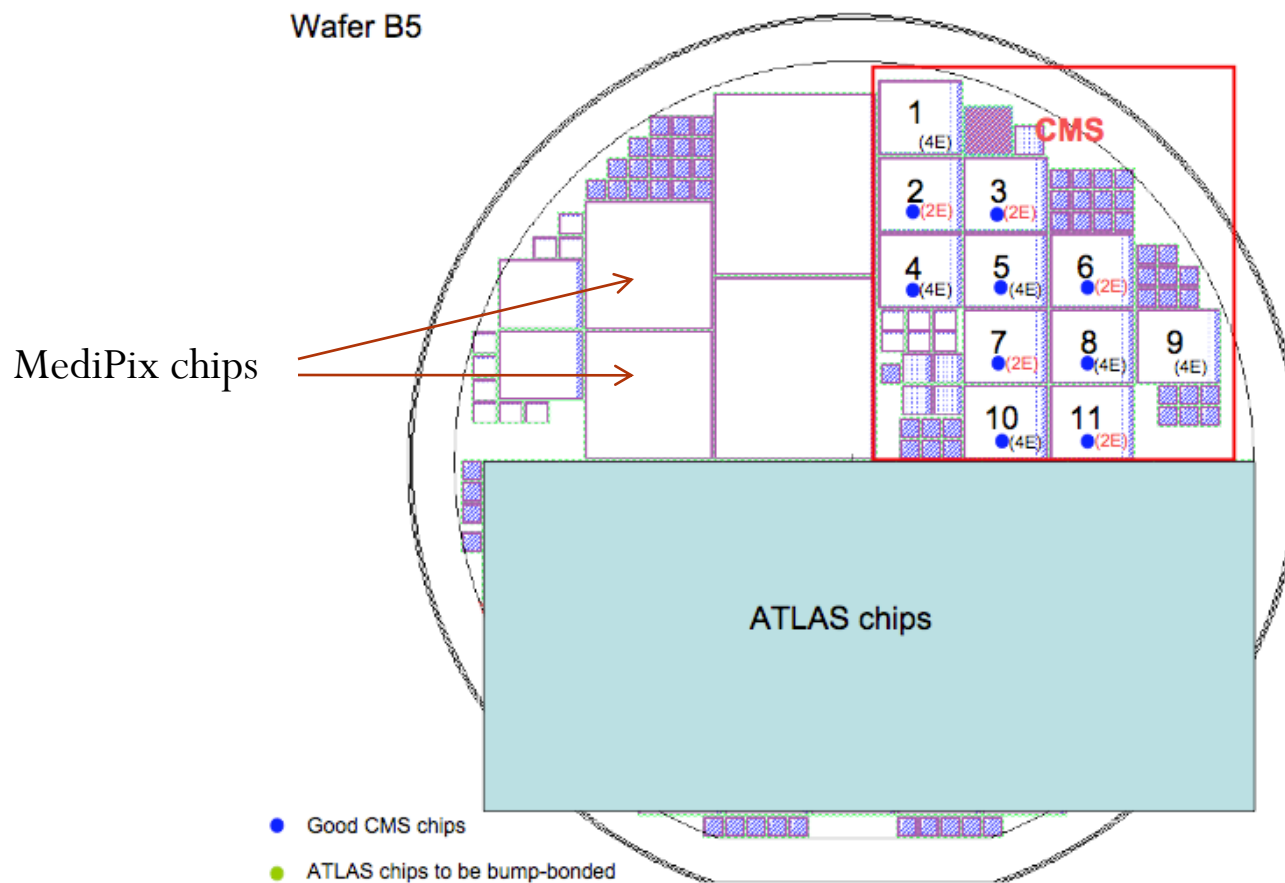
- Lower noise
- Larger active volume

4E Configuration

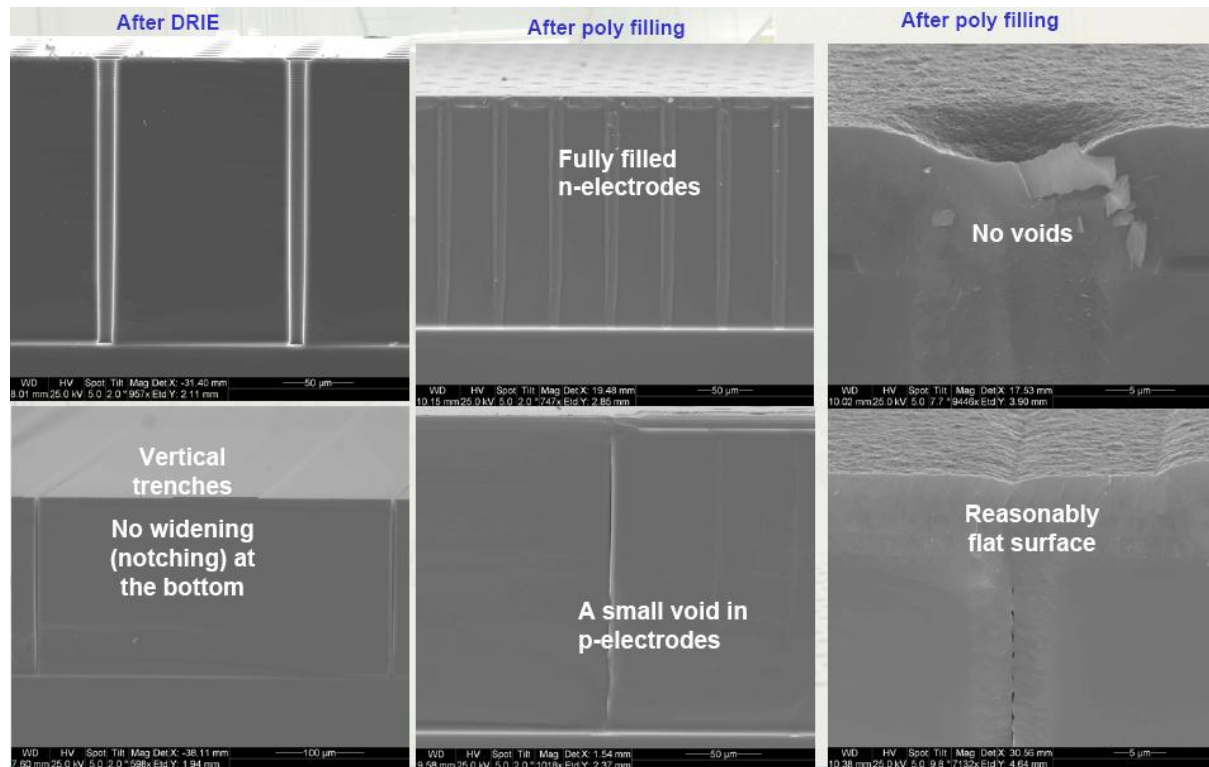


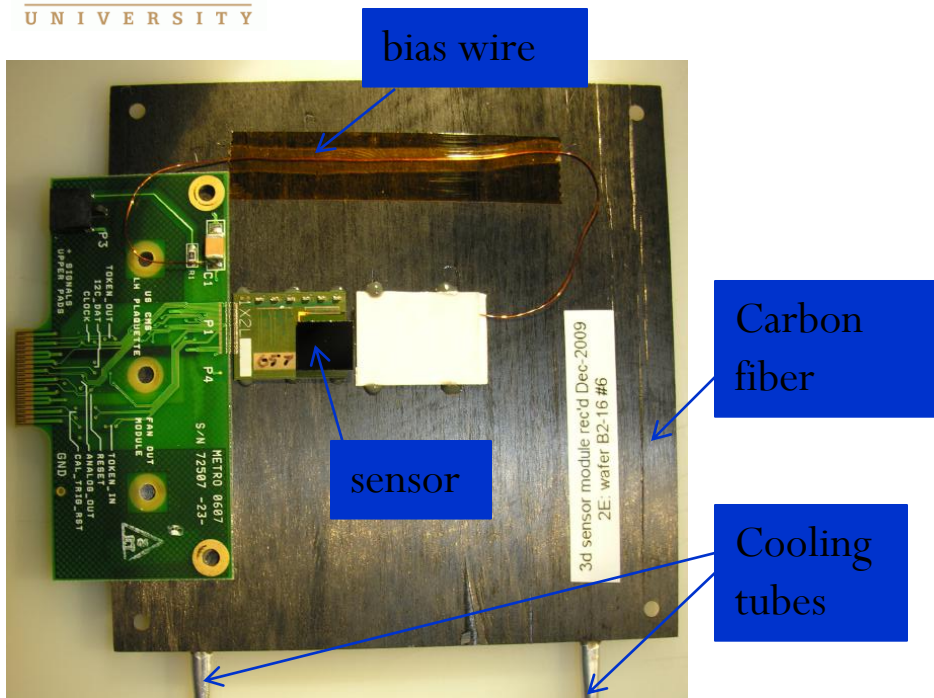
- More radiation hard:
  - Faster response
  - Lower depletion voltage
  - Less trapping

- p-type wafers with resistivity  $> 10 \text{ k}\Omega\cdot\text{cm}$
- Two different wafer thicknesses:
  - B5 :  $280\mu\text{m}$  thick
  - B2-16 :  $200\mu\text{m}$  thick
- Include ATLAS, CMS, and MediPix devices

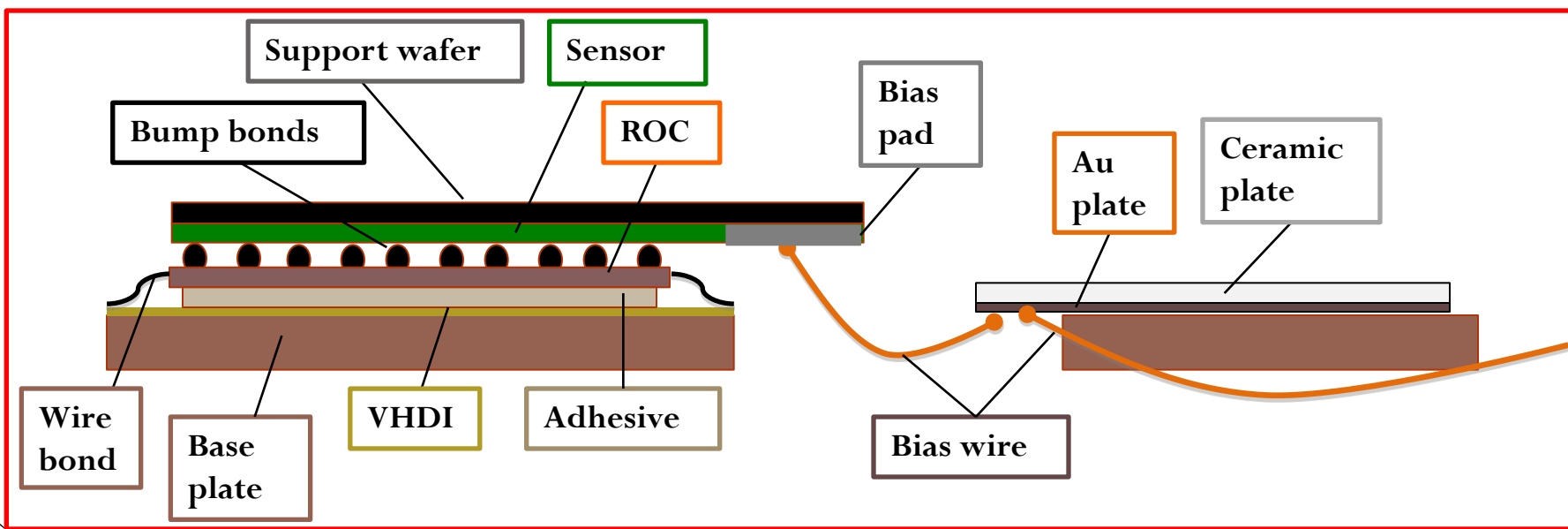


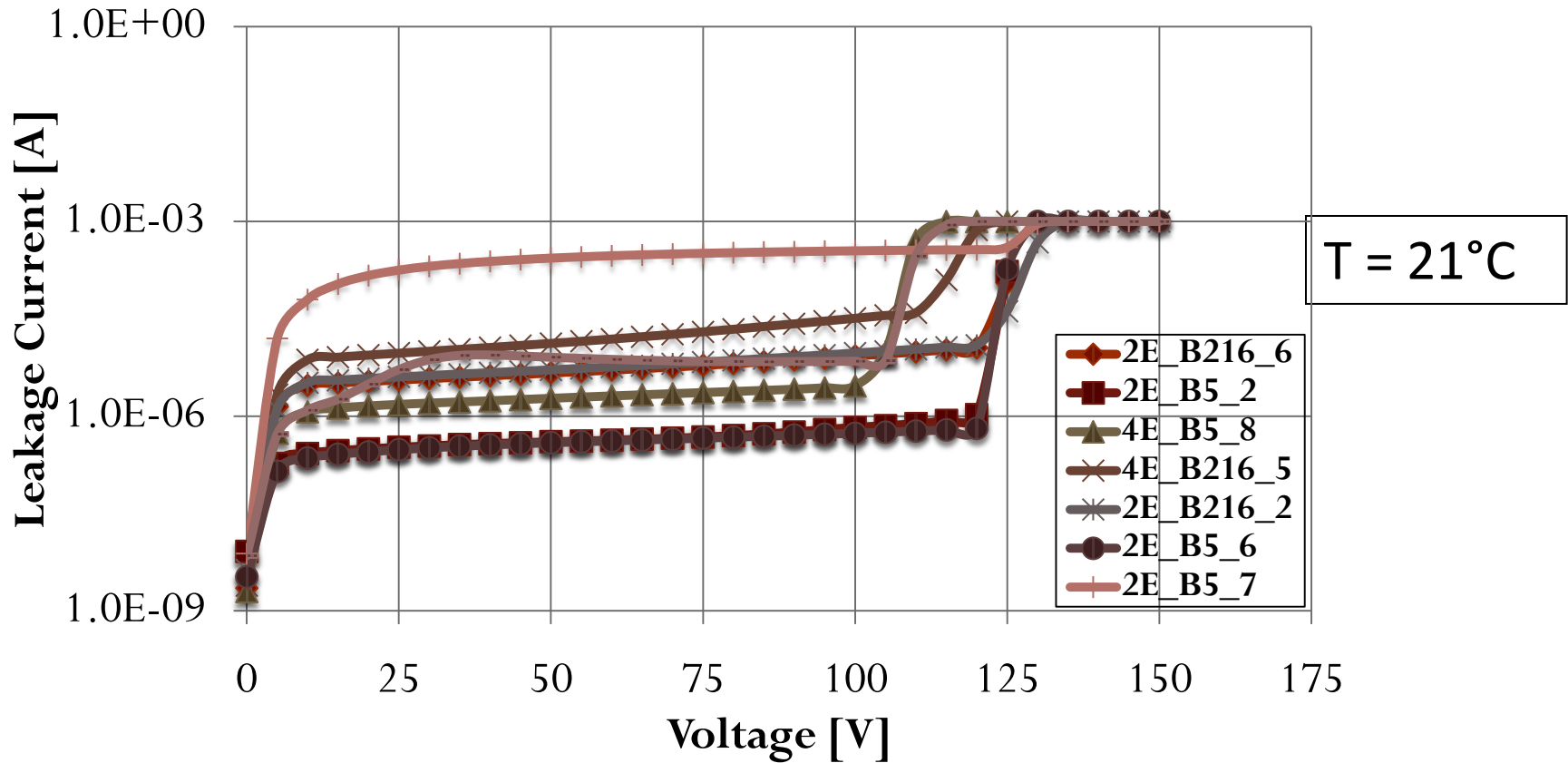
- p-spray isolation :  $6 \times 10^{12} \text{cm}^{-2}$ , 60keV, through a 60nm oxide. Annealed at 900°C for 30 minutes
- Wafer bonding by direct fusion bonding
- Deep Reactive ion etching (DRIE) & polysilicon filling and doping of electrodes
  - n-type electrode etching & filling (diameter of 14  $\mu\text{m}$ )
  - 300nm thermal oxide barrier protection
  - p-type electrode and active edge etching & filling (5  $\mu\text{m}$  active edge)
- Metal layer deposition & patterning
- Passivation layer of 0.5 $\mu\text{m}$  oxide and 0.25 $\mu\text{m}$  nitride deposition by PECVD & patterning



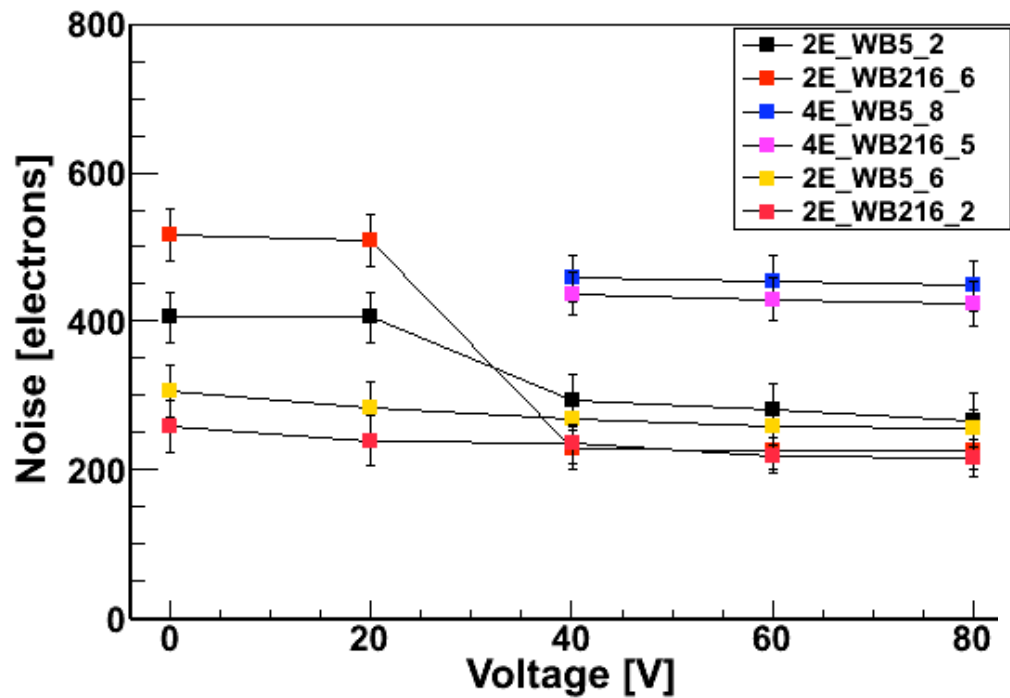


- Support wafer made wire-bonding challenging ( especially high voltage wiring)
- Cooling done by a chiller
- Sensor temperature measurement: an RTD placed on the carbon fiber (cooling tubes side):  $\Delta T = 6 \text{ } ^\circ\text{C}$

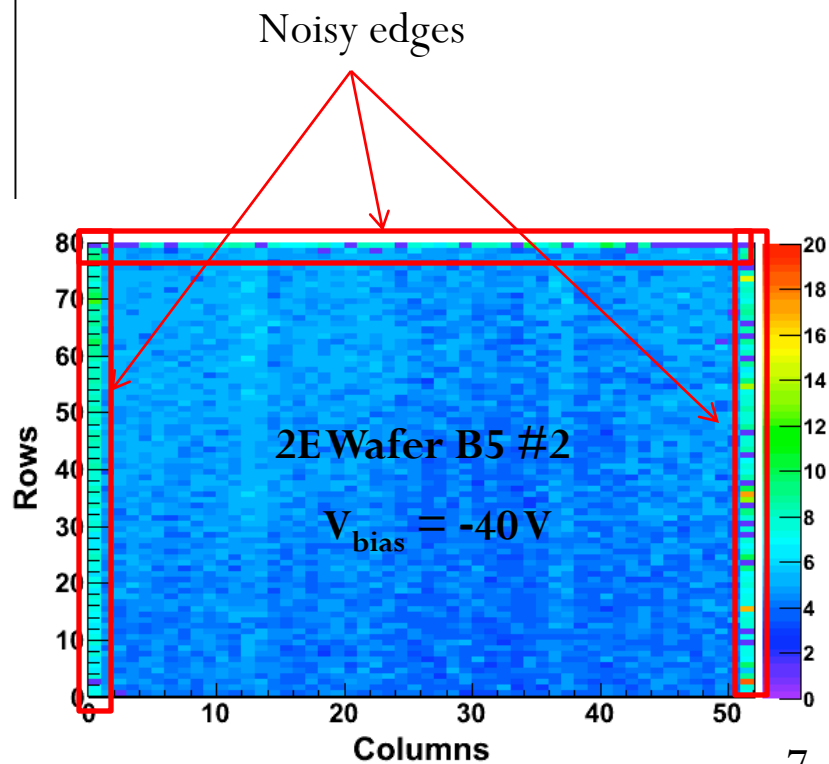


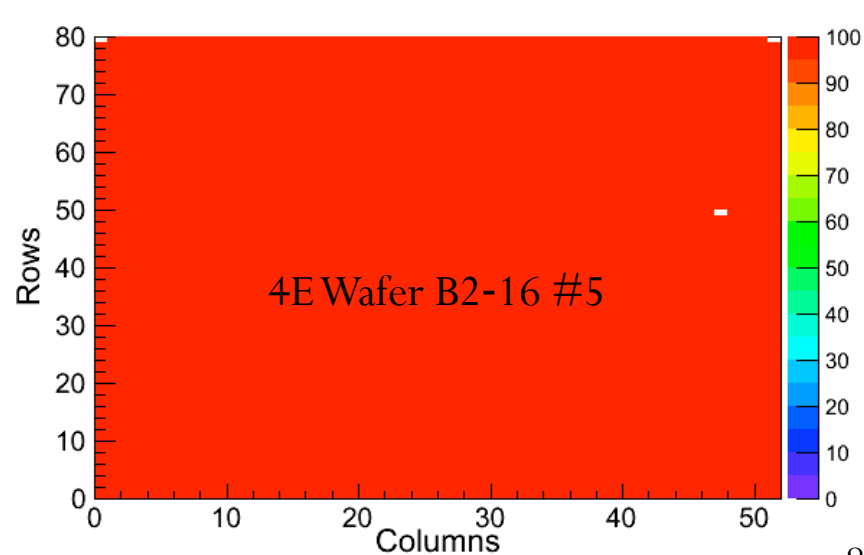
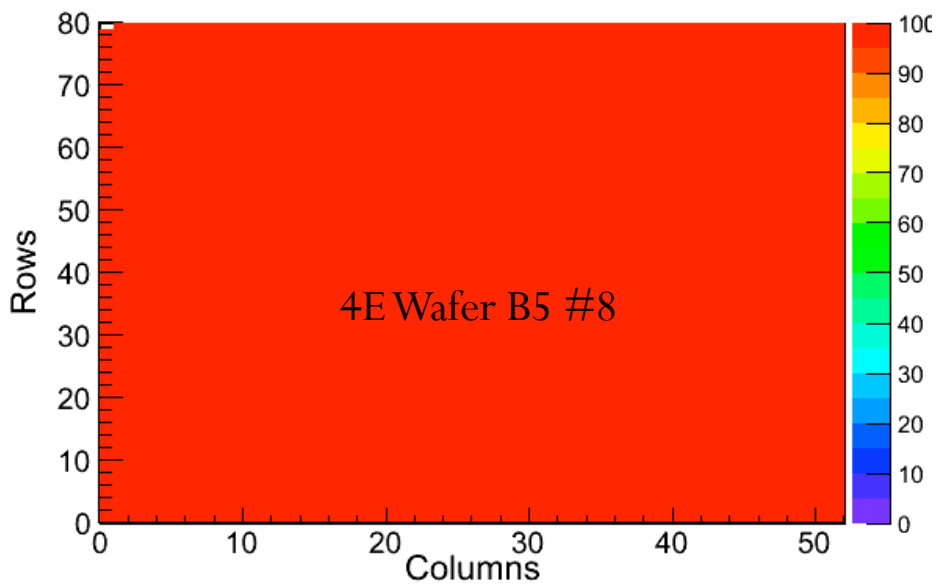
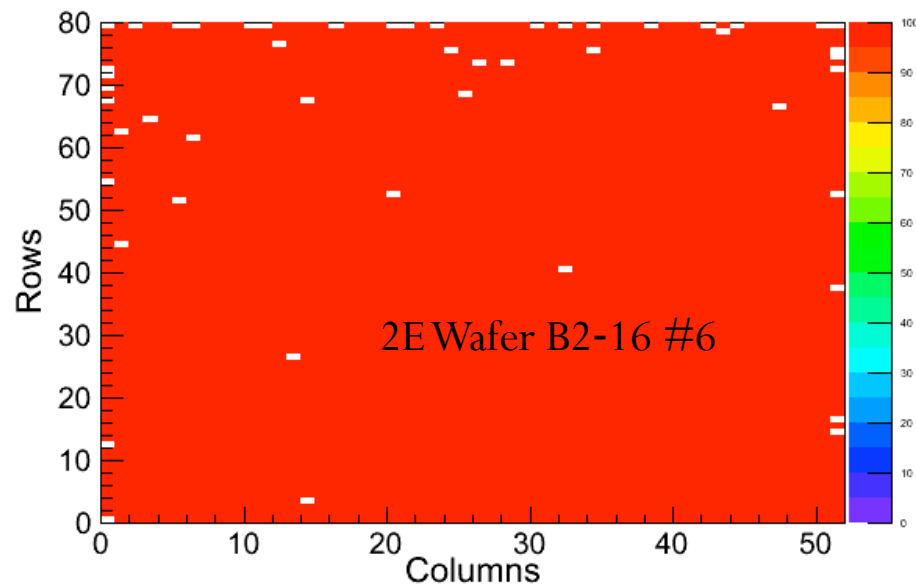
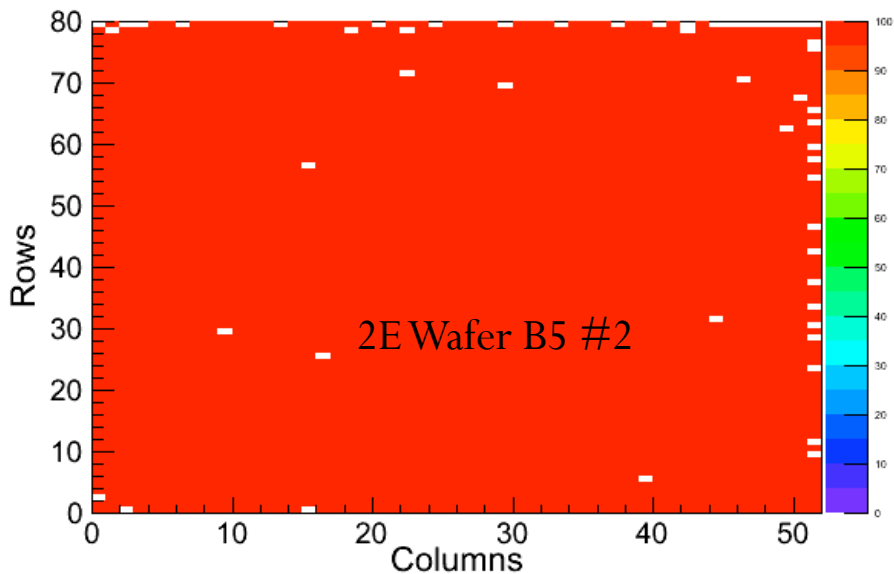


Detector	I (@40V) [ $\mu$ A] / Chip	I(@40V) [nA] / Pixel	Breakdown Voltage [V]
2E-WB5-2	0.7	0.35	120
2E-WB2-16-6	5	2.5	120
4E-WB5-8	2	1	100
4E-WB2-16-5	10	5	100

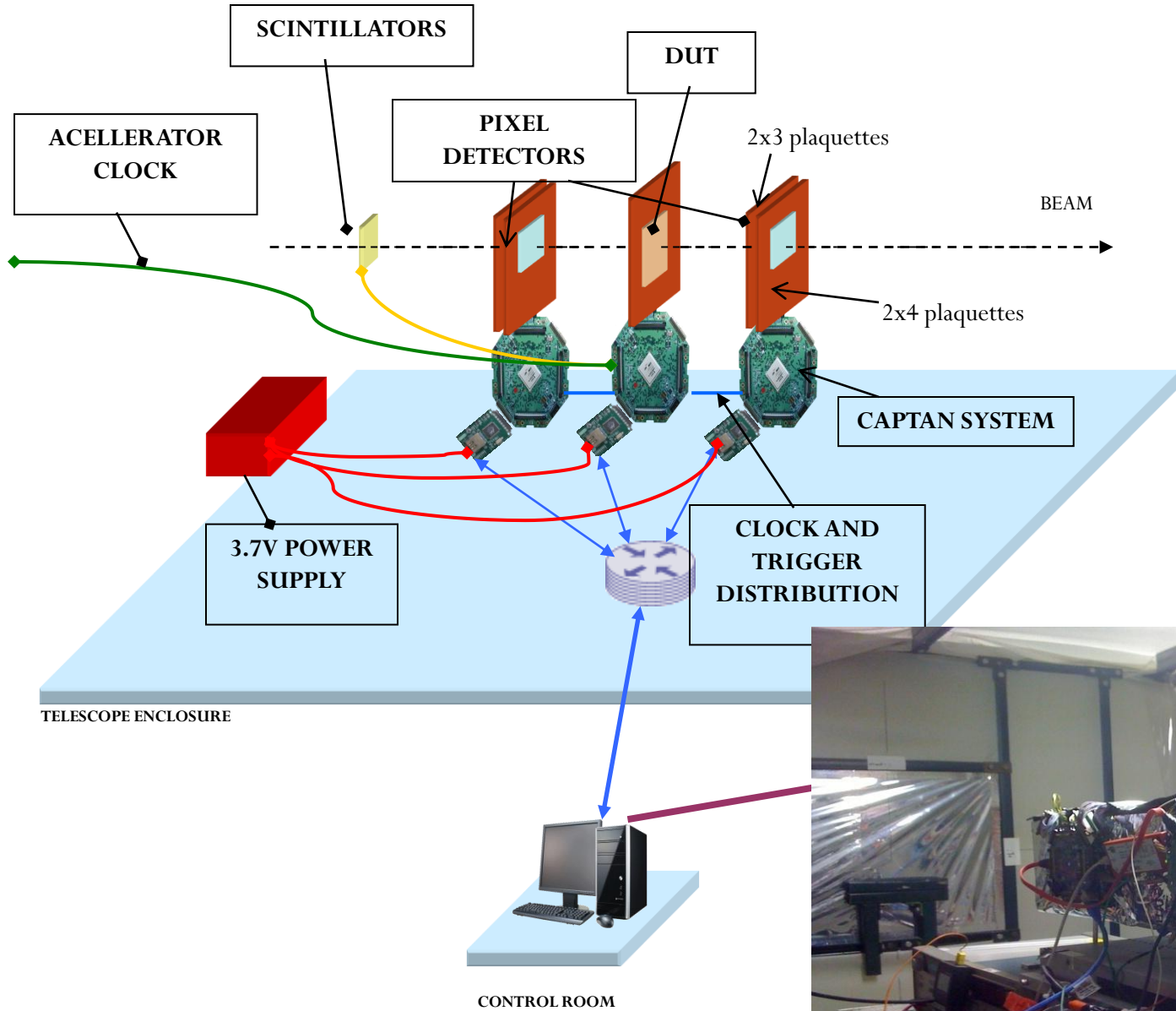


- Measured at room temperature
- Unable to measure noise at  $V_{bias} < 40V$  for 4E sensors

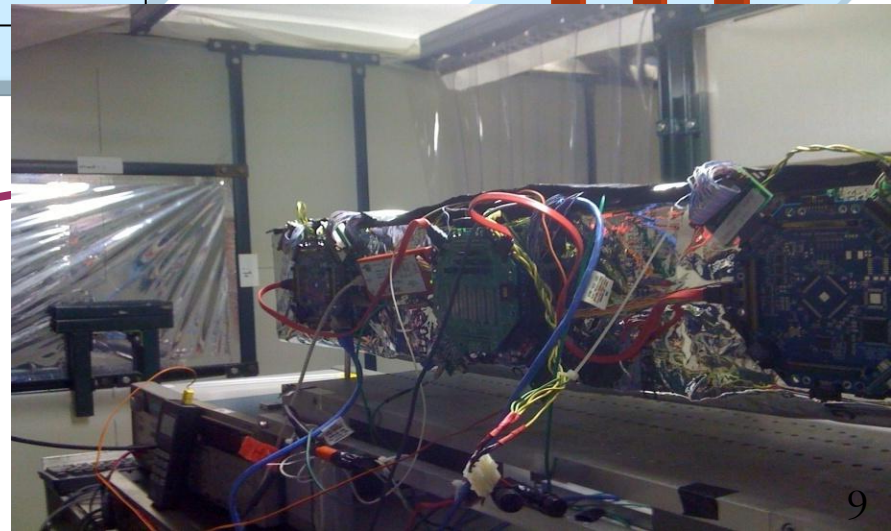




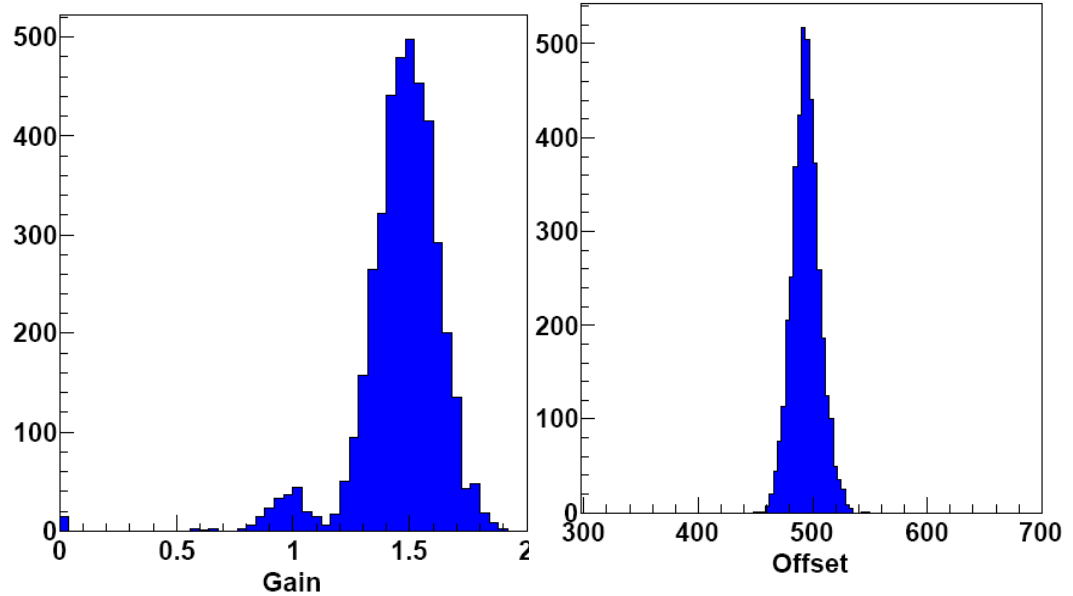
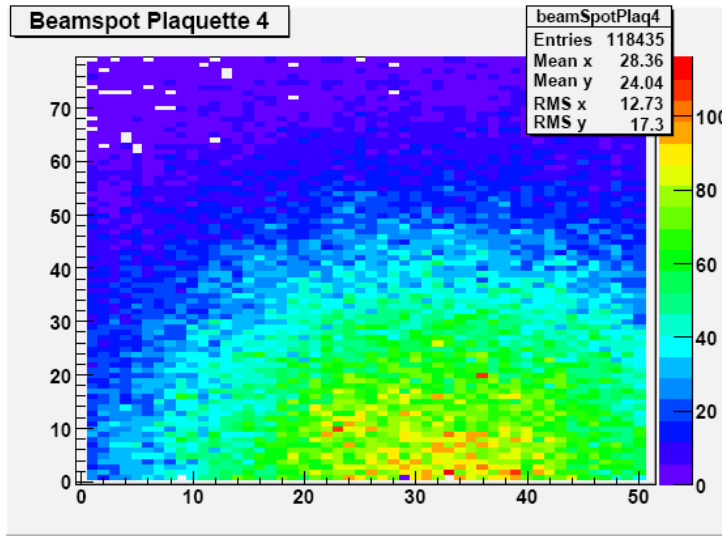




- 120 GeV protons
- No B field



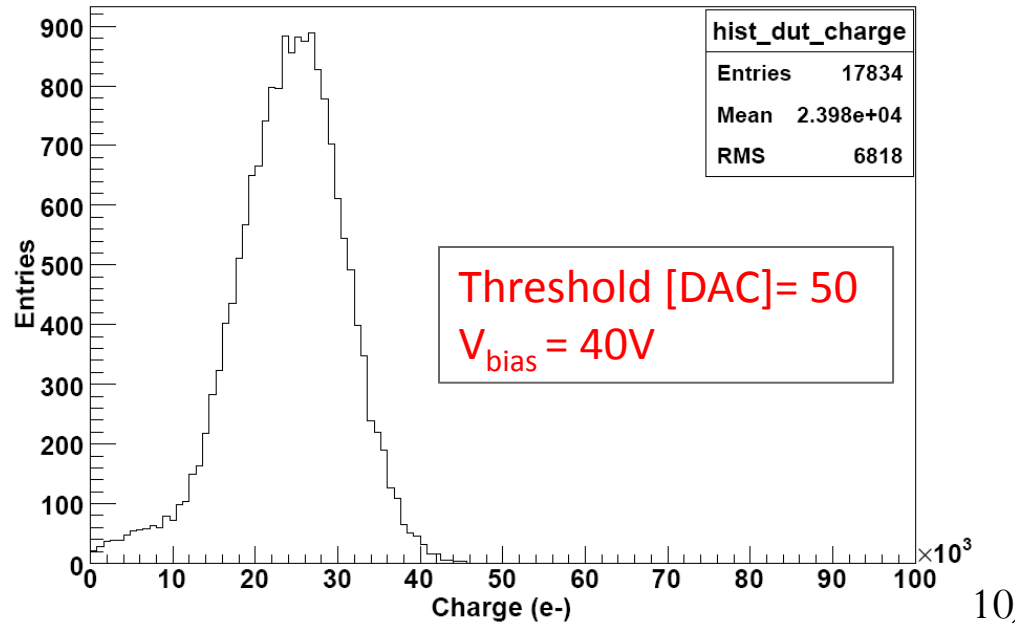
Beam spot on 3D

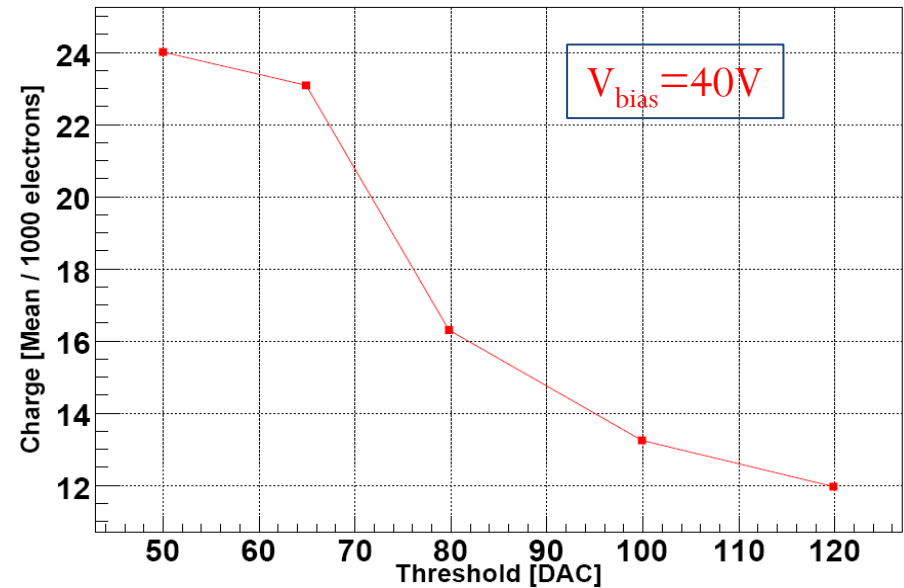
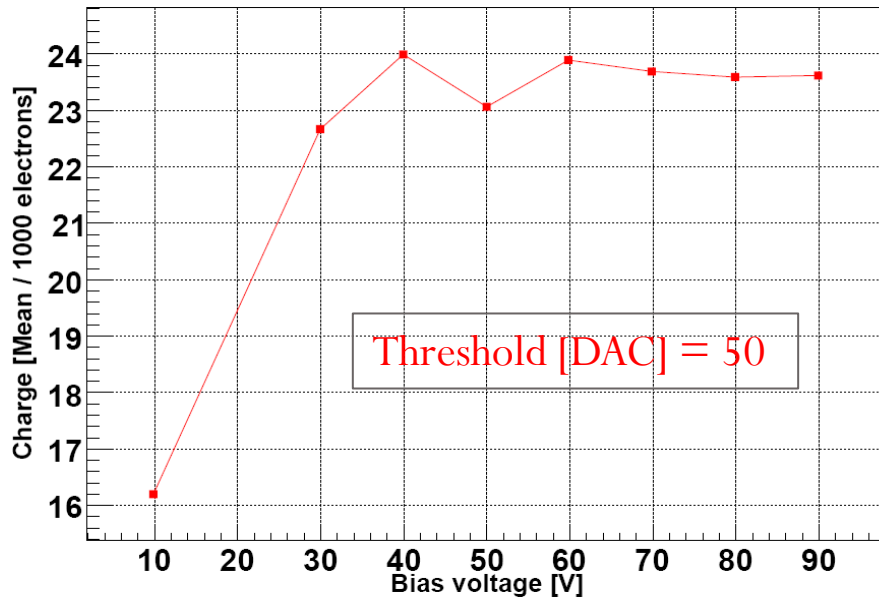


- ADC to electron conversion:  
 $V_{cal}^* [DAC] = ADC \times gain - offset$   
 $Charge (e^-) = V_{cal} \times 65.5 - 410$

\* 1 Vcal [DAC] = 65.5 electrons

- $T \approx 11 \text{ }^\circ\text{C}$  on carbon fiber  
 (estimated to be  $6 \text{ }^\circ\text{C}$  higher  
 on the sensor)

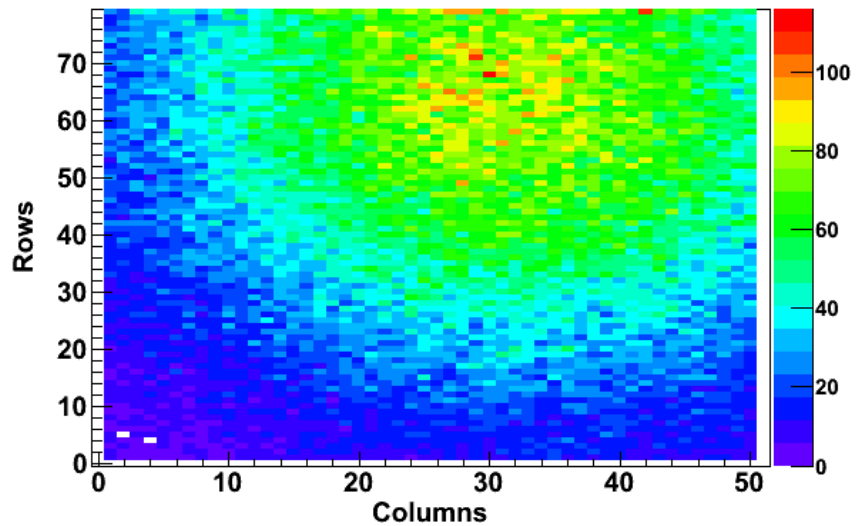




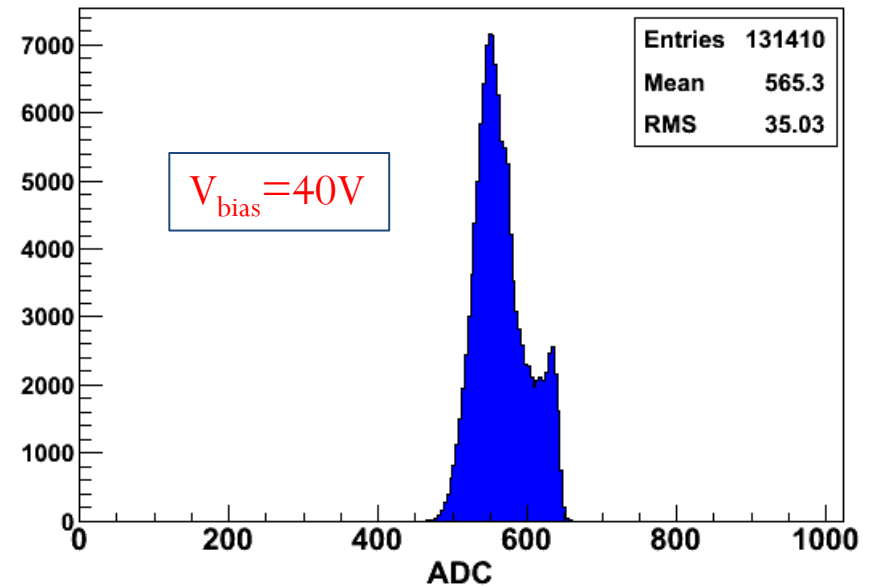
- Each point is charge distribution mean
- Most probable value to be determined after re-doing gain calibration
- Electron equivalence of threshold to be determined with CAPTAN system

- Gain calibration needed

Beam spot on 3D



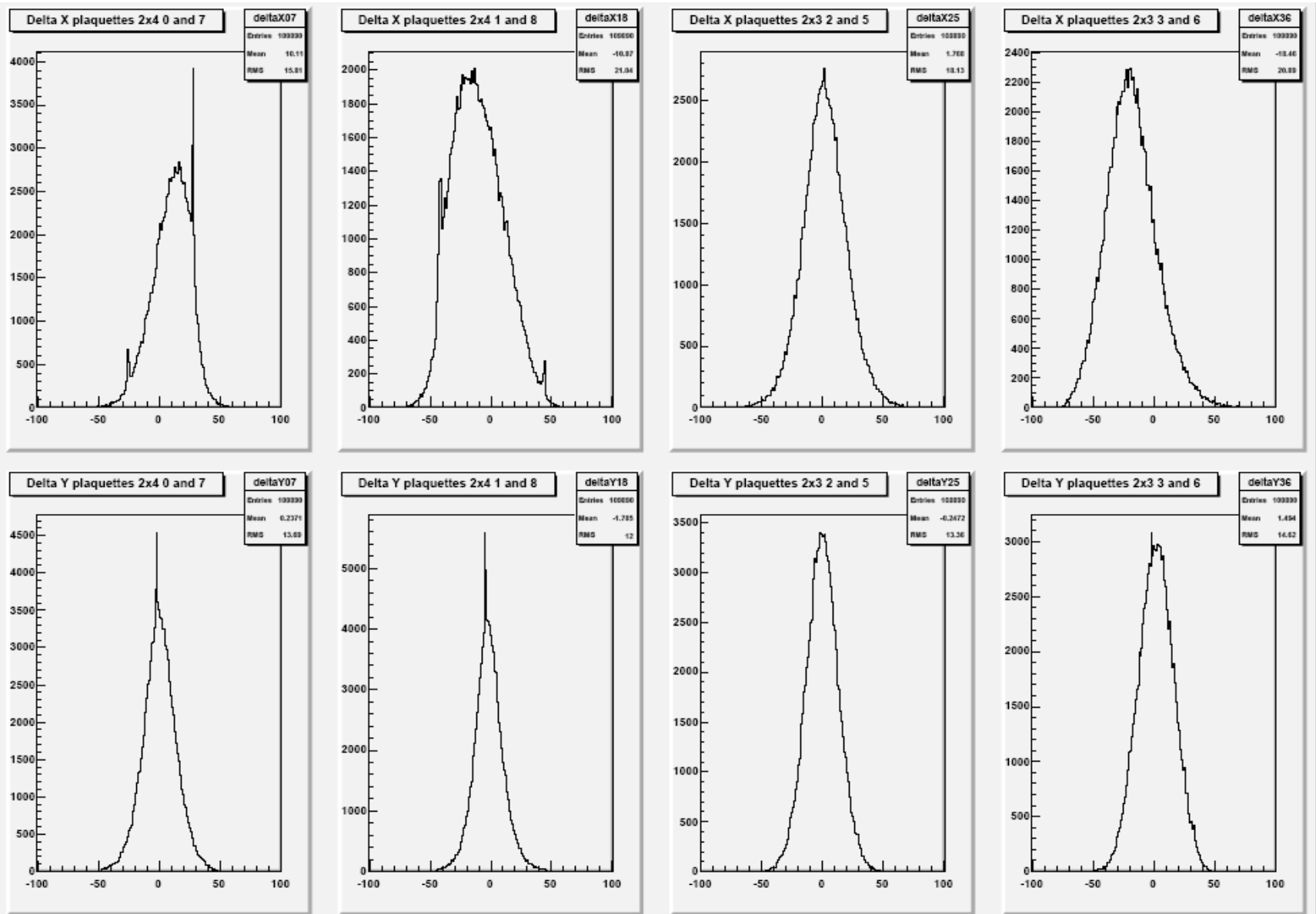
ADC distribution



- Bump-bonded 3D CMS pixel sensors with 2E and 4E configurations assembled into plaquettes and characterized.
  - Good I-V behavior except one 2E sensor
  - High noise :  $\sim 450$  electrons for 4E sensors and 250-300 electrons for 2E sensors
  - Good bump-bond quality
- Some sensors tested at FNAL with 120 GeV protons
  - Bias and threshold scans of charge performed. Gain calibration to be re-done and equivalence of threshold to be determined with CAPTAN system at Purdue
  - Results for 2E sensors are promising while 4E sensors failed.
- More sensors to be studied more thoroughly with test beam at FNAL and radioactive source at Purdue before and after irradiation

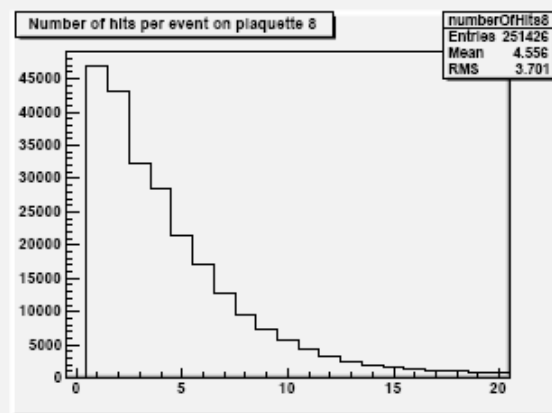
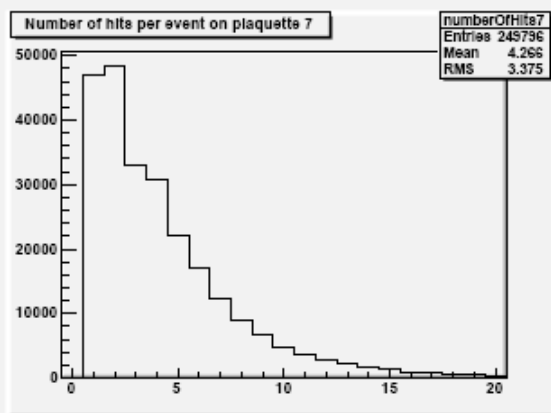
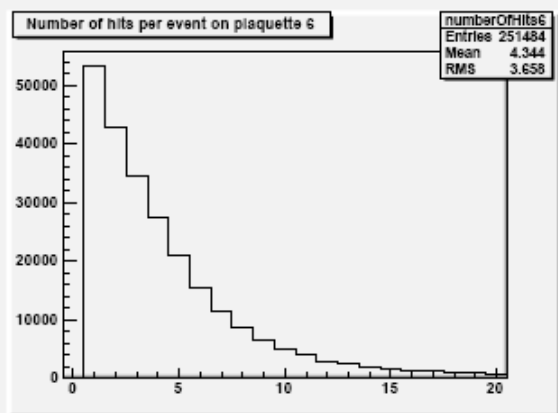
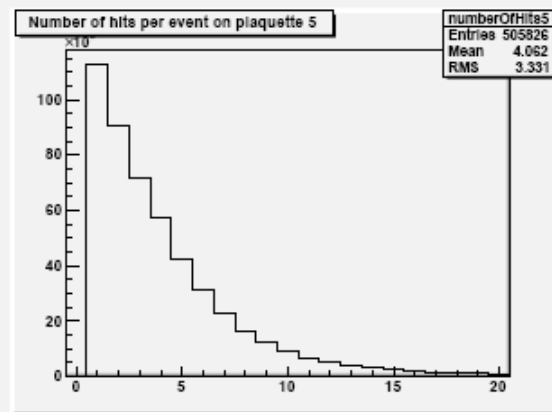
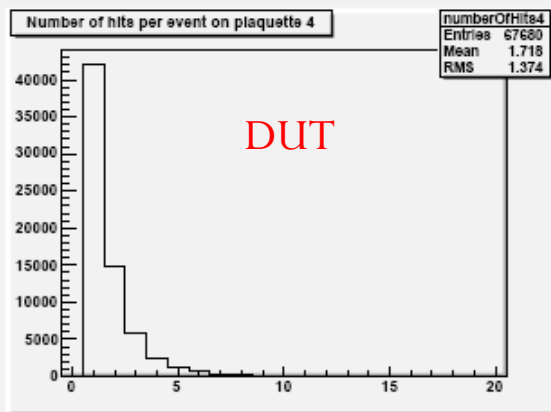
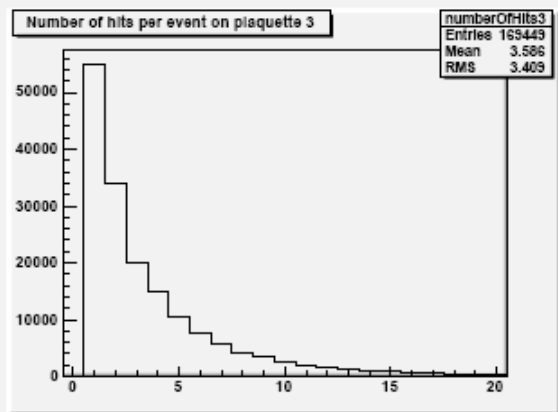
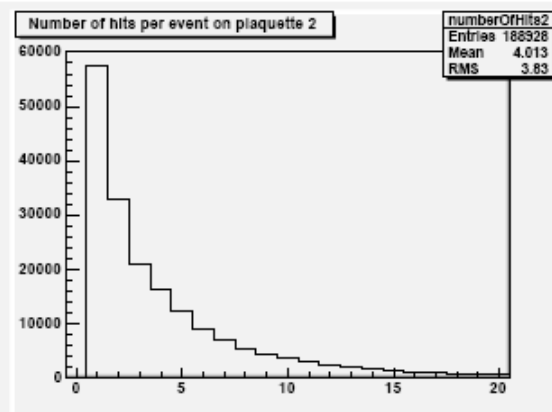
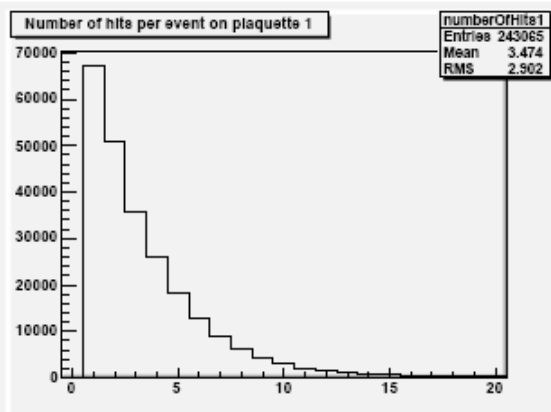
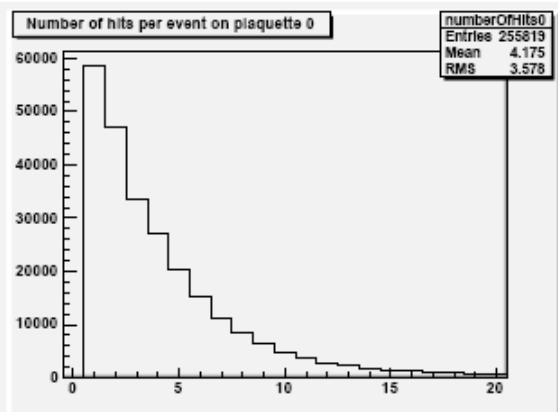
**BACKUP SLIDES**

# Correlation between planes



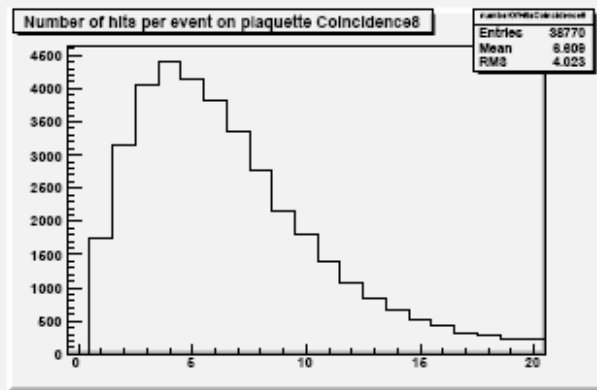
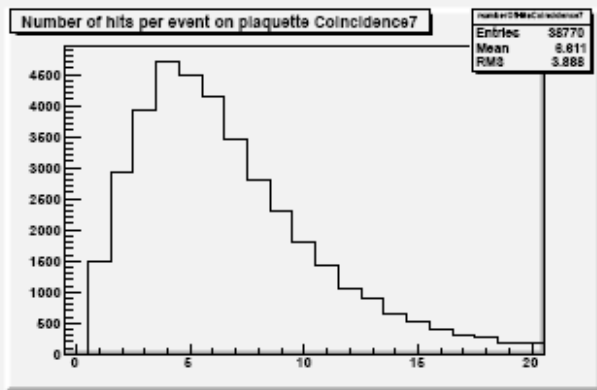
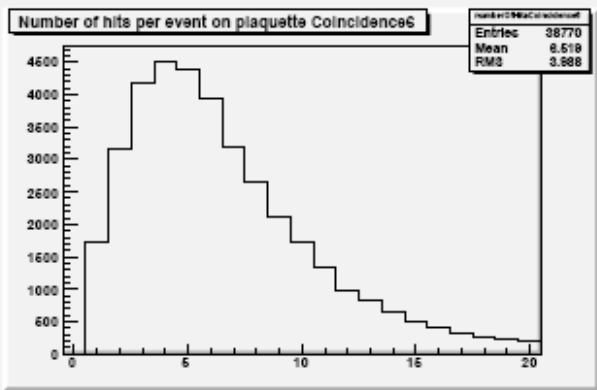
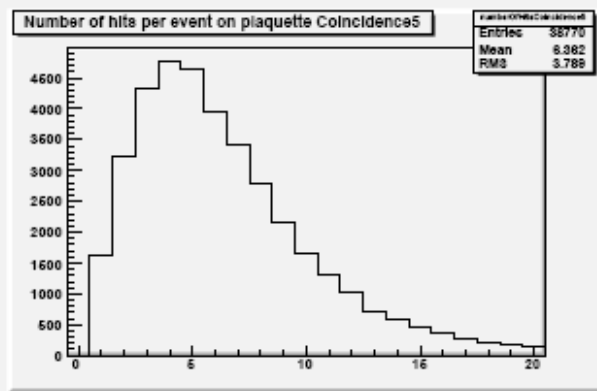
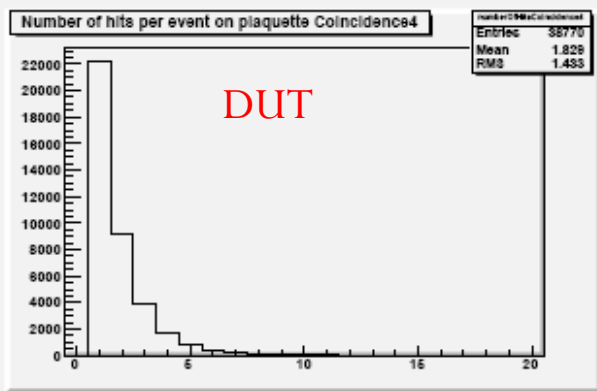
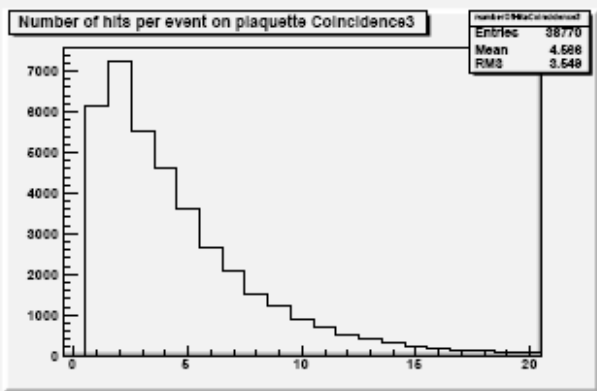
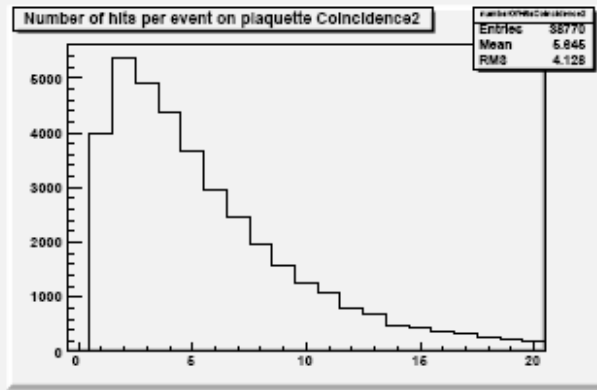
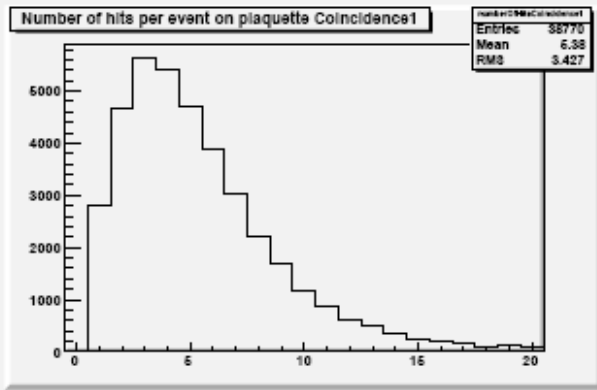
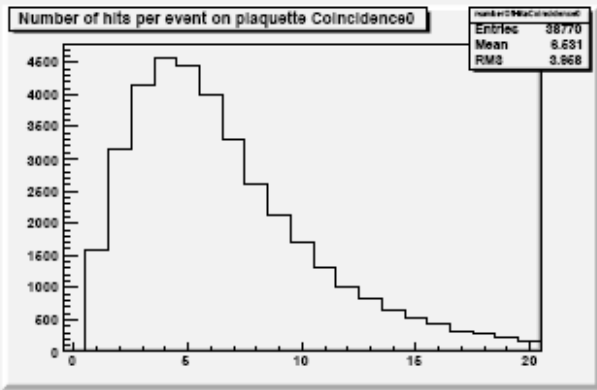
Threshold [DAC] = 50,  $V_{bias} = 60V$

Sensor : 2E\_WB5\_2

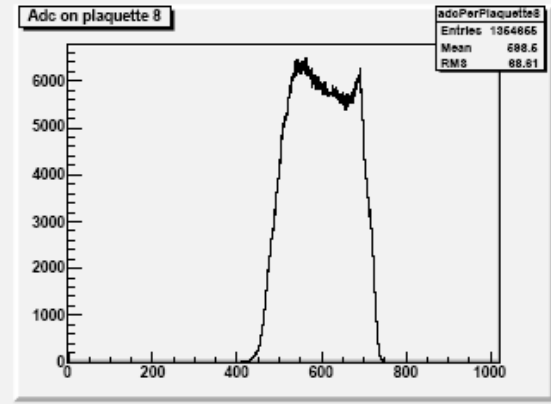
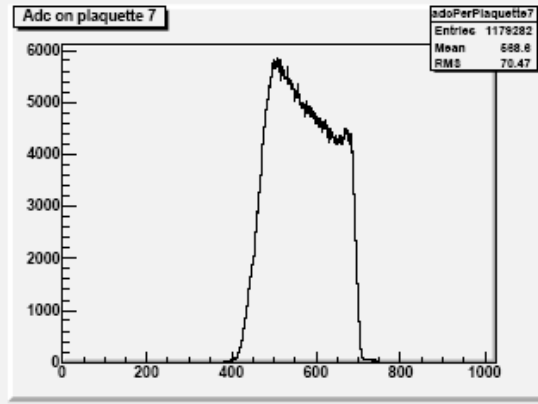
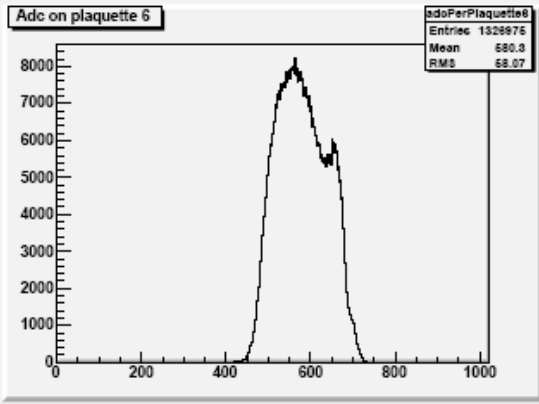
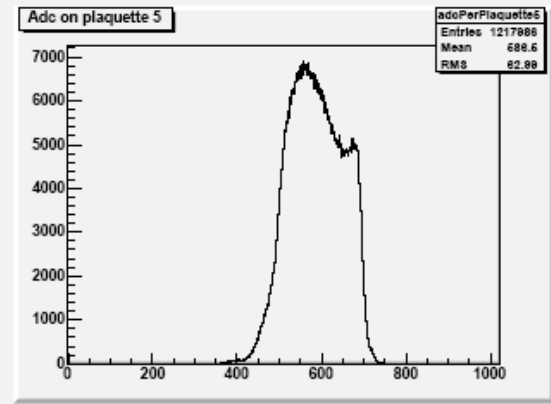
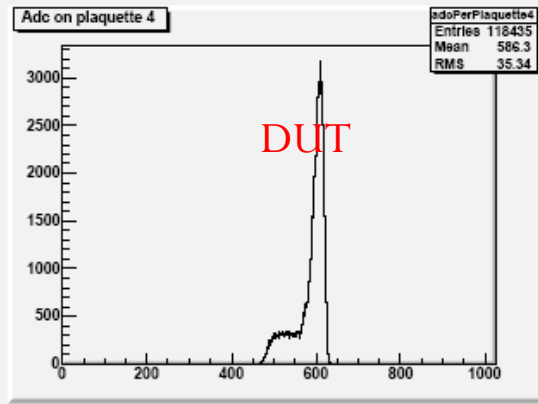
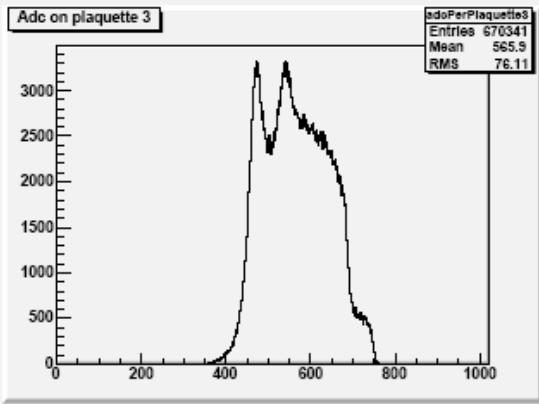
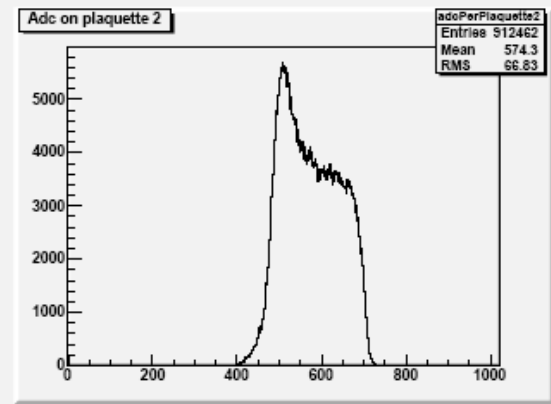
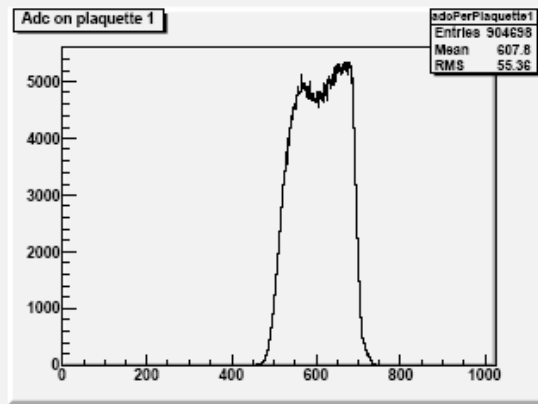
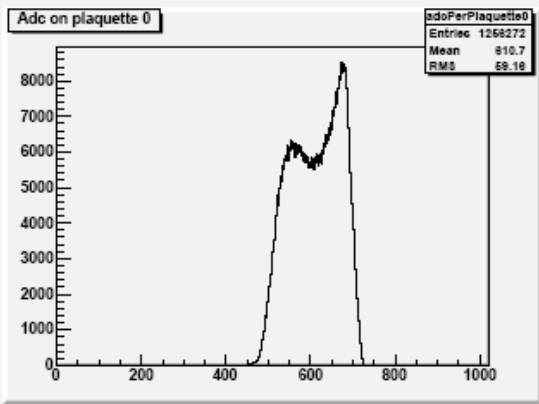




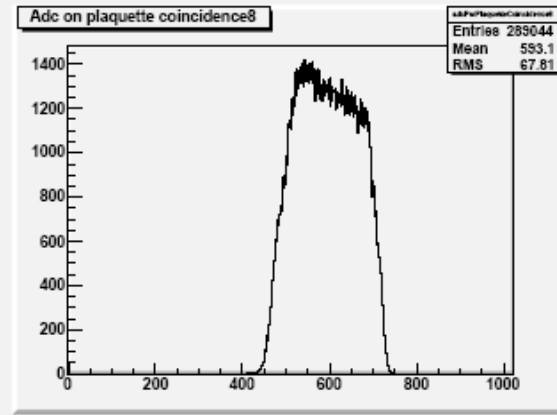
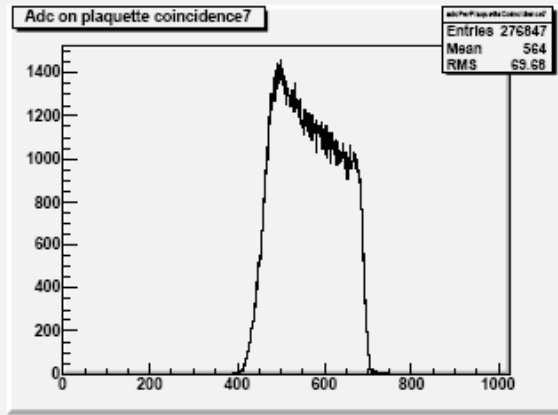
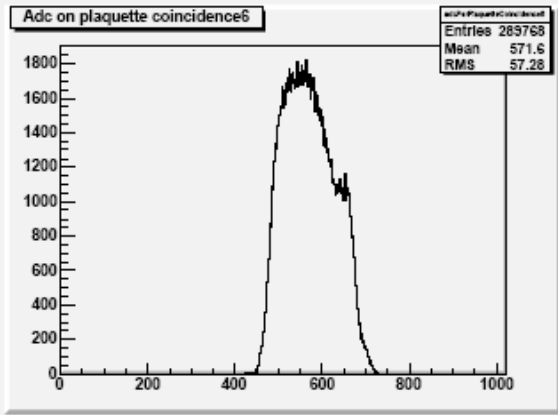
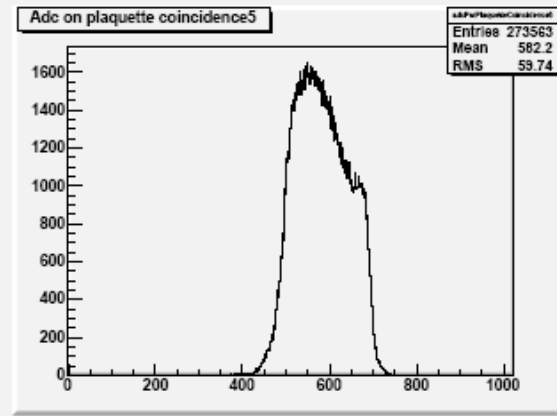
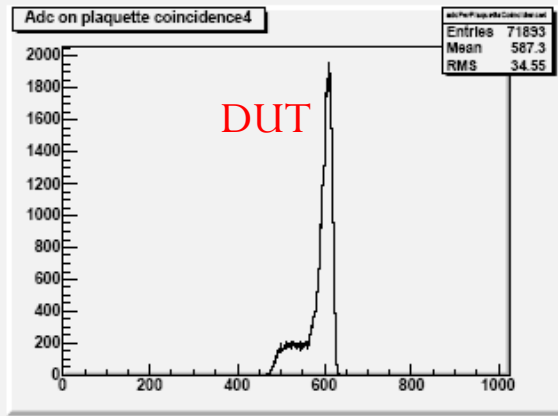
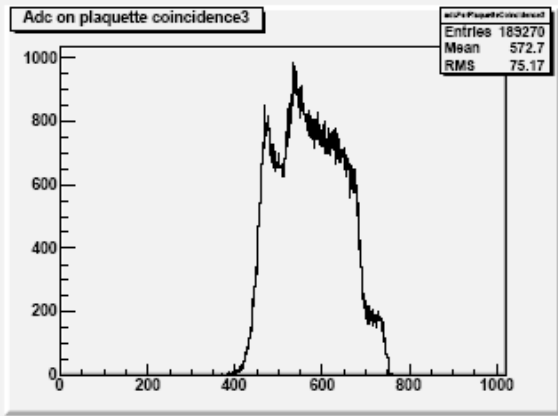
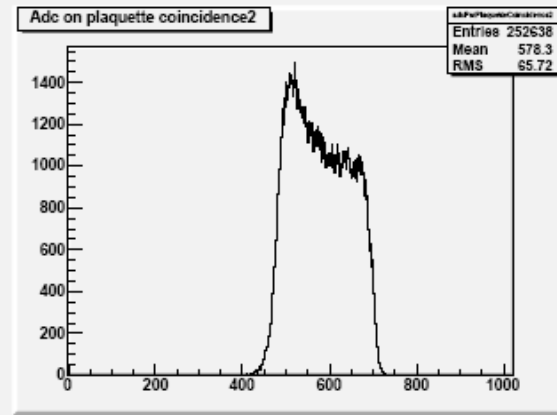
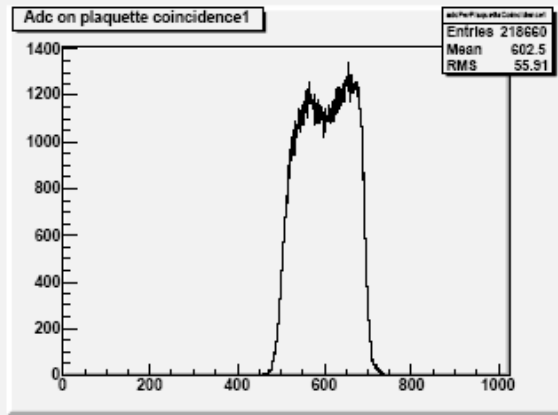
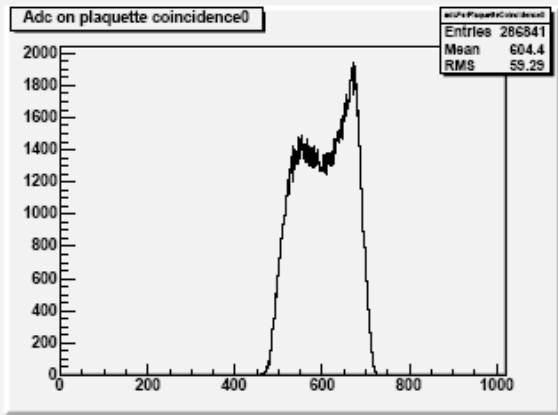
Threshold [DAC]= 50,  $V_{bias} = 60V$



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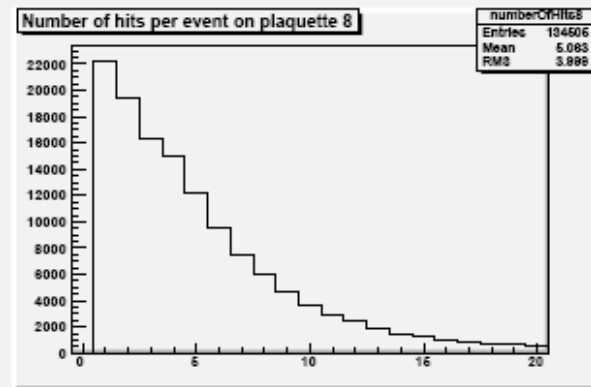
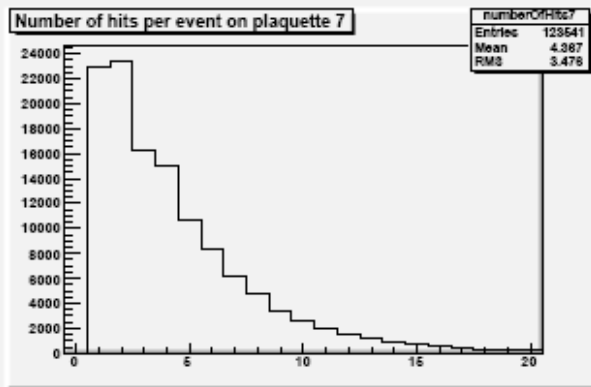
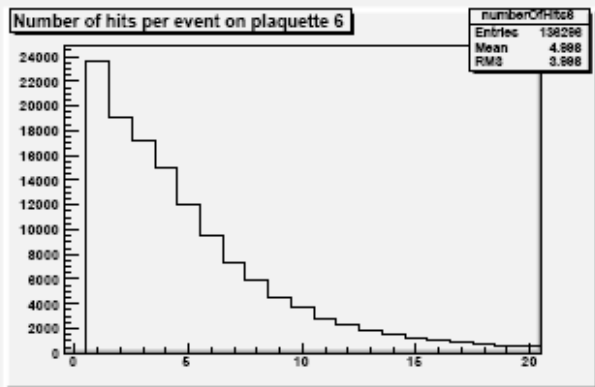
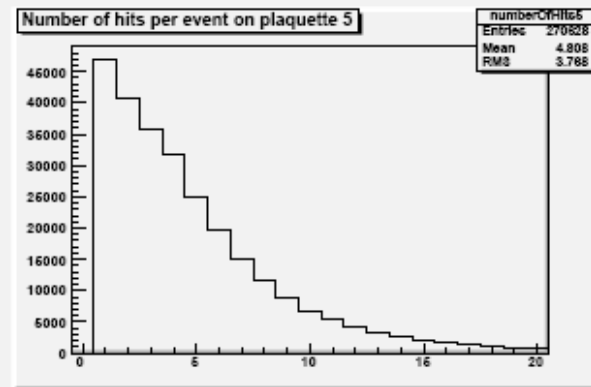
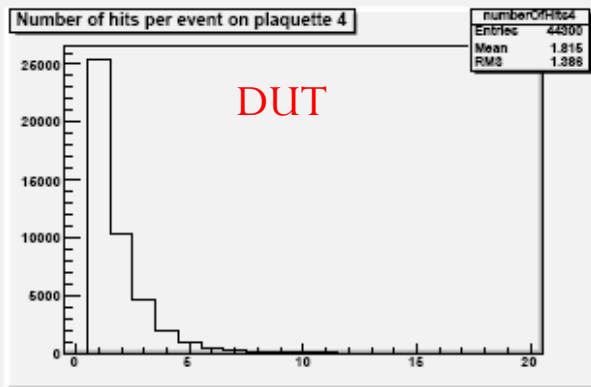
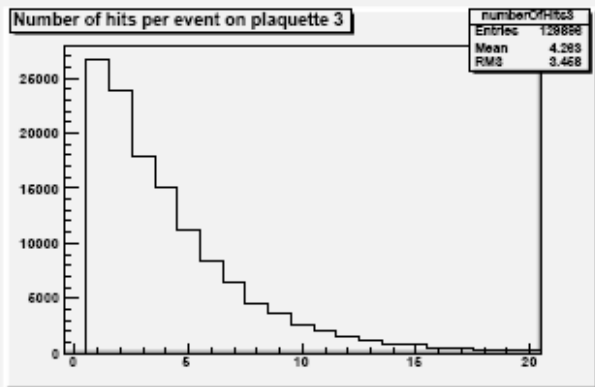
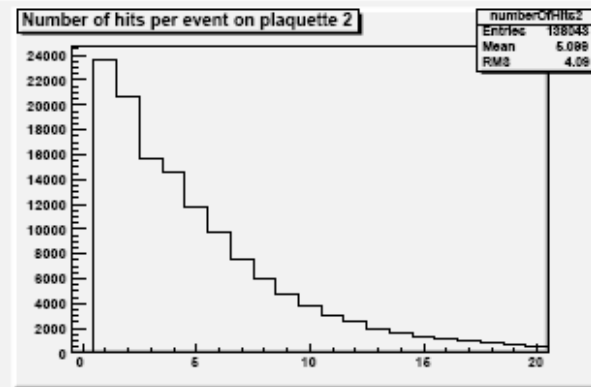
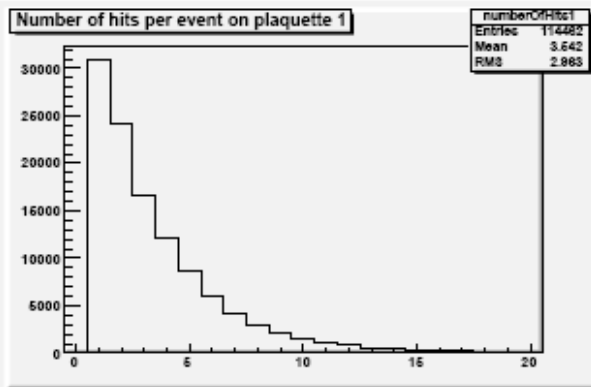
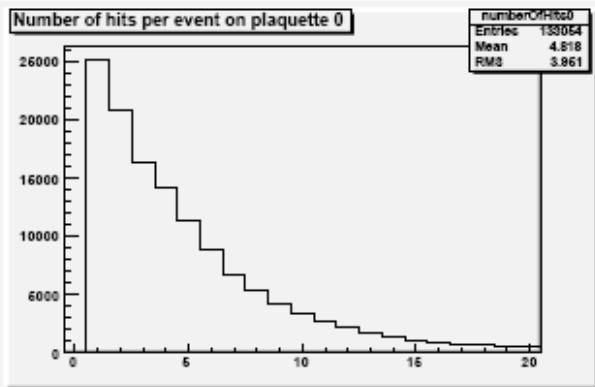


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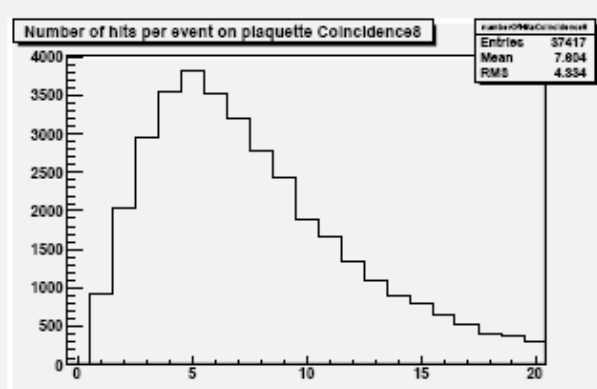
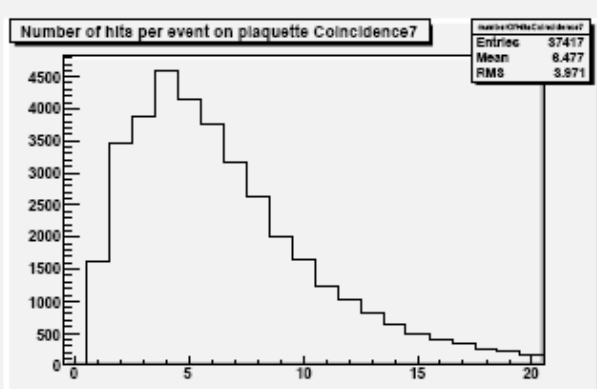
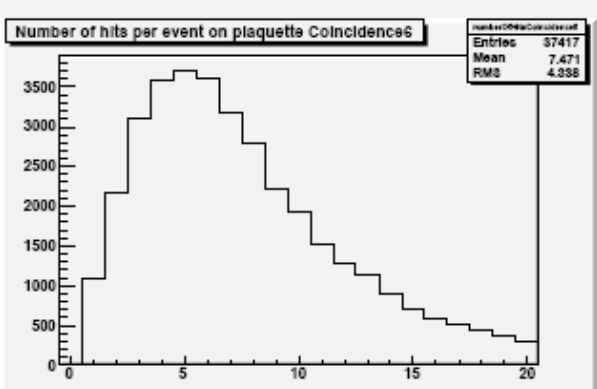
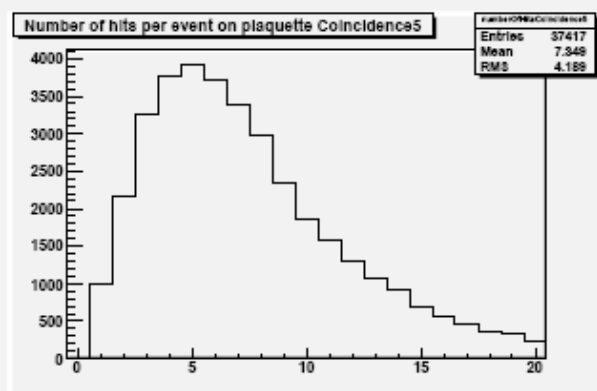
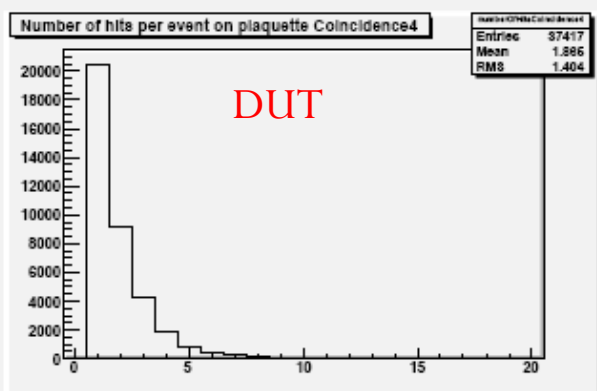
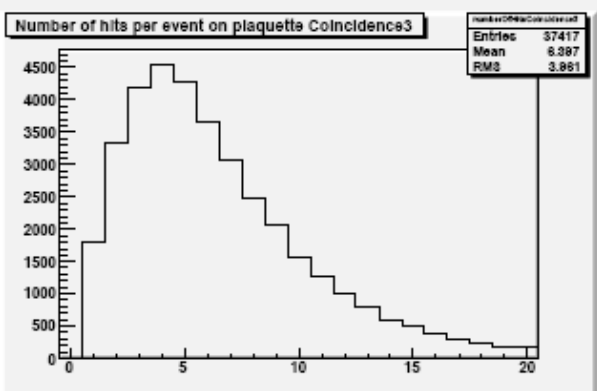
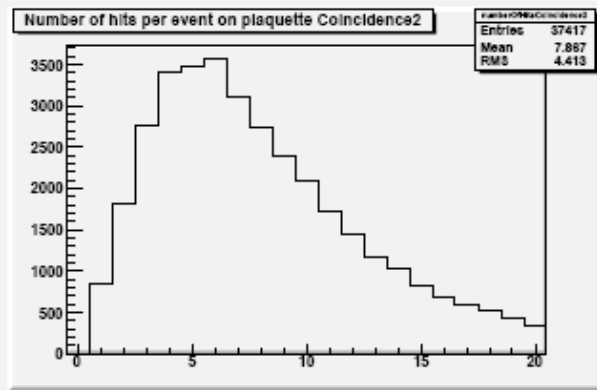
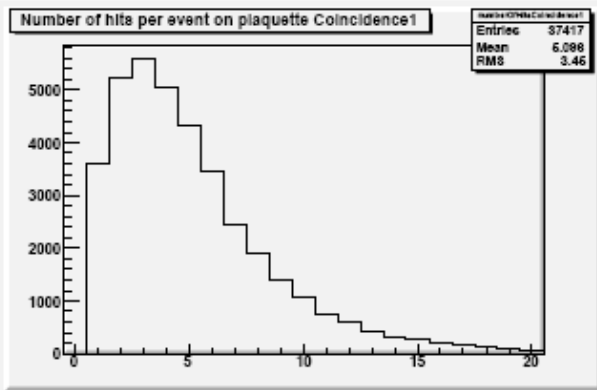
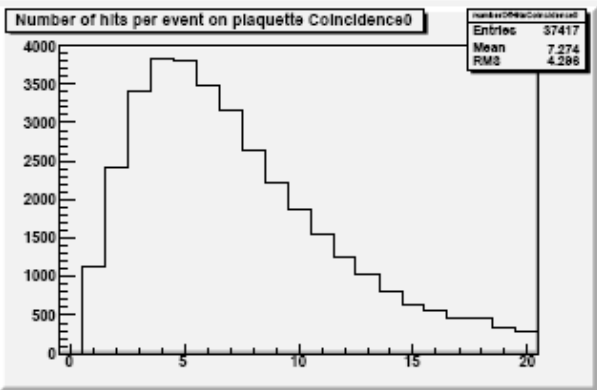


Threshold [DAC]= 50,  $V_{bias} = 60V$

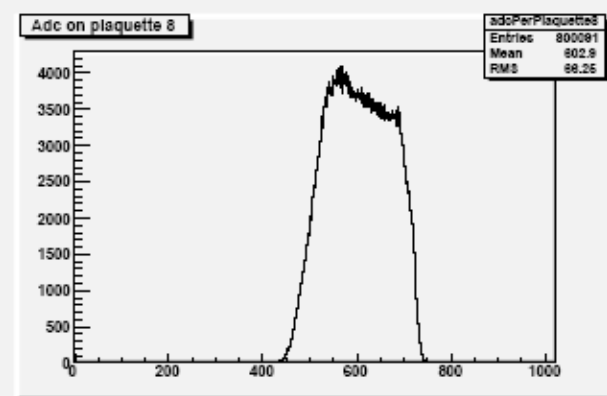
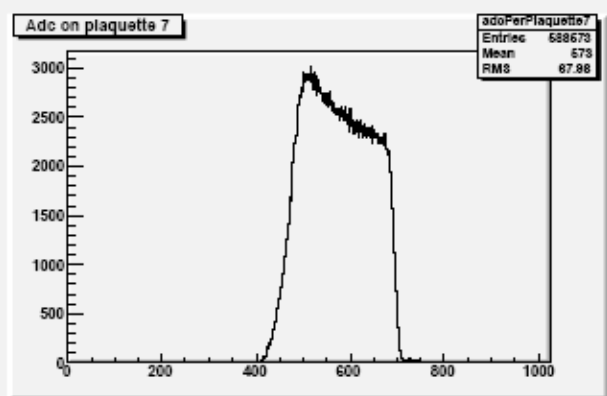
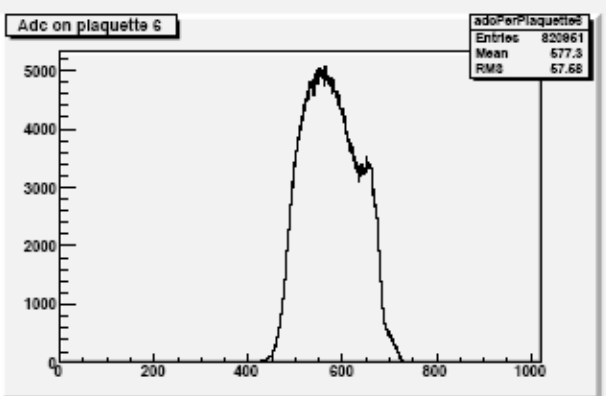
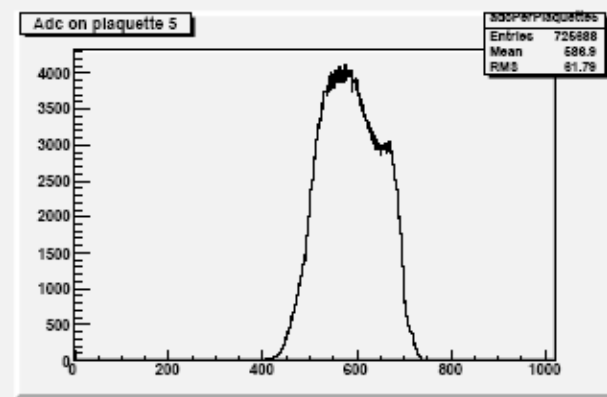
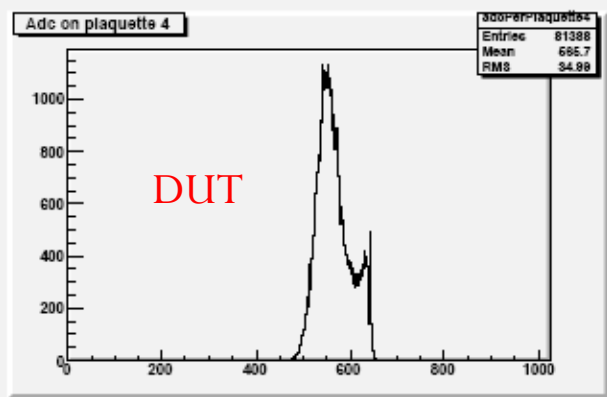
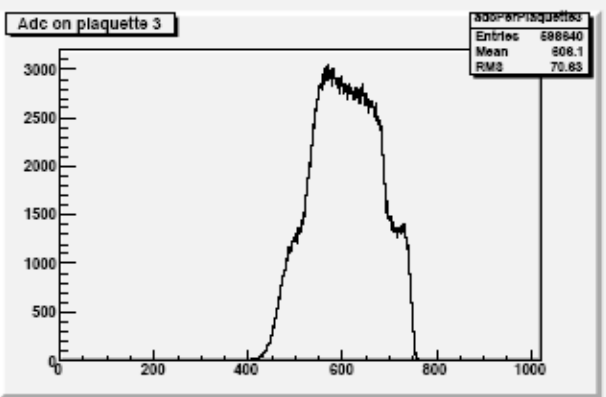
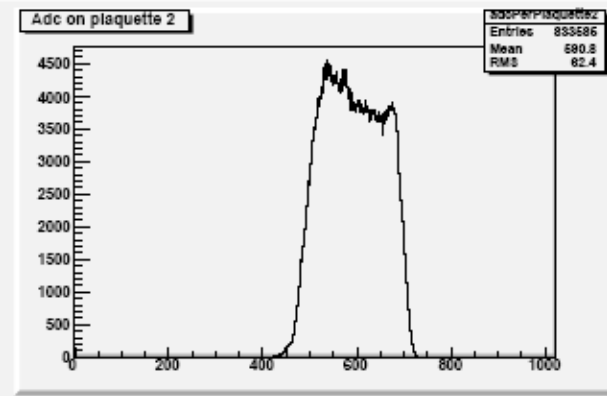
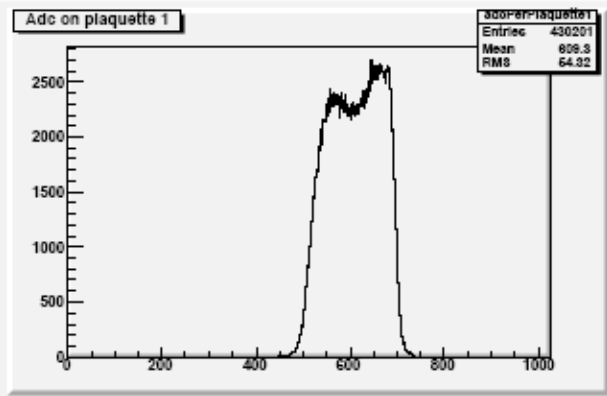
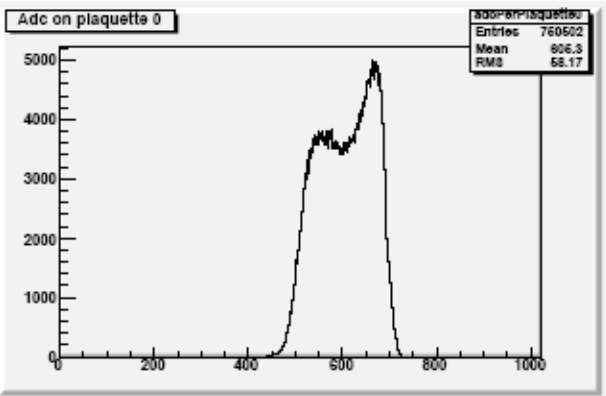
Sensor : 2E\_WB2-16\_6



Threshold [DAC]= 50,  $V_{bias} = 60V$



Threshold [DAC]= 50,  $V_{bias} = 60V$



Threshold [DAC]= 50,  $V_{bias} = 60V$

