

T992

SLHC Sensors at MTEST

Simon Kwan
Fermilab

All-Experimenter's Meeting
December 13, 2010

Particle fluence at SLHC

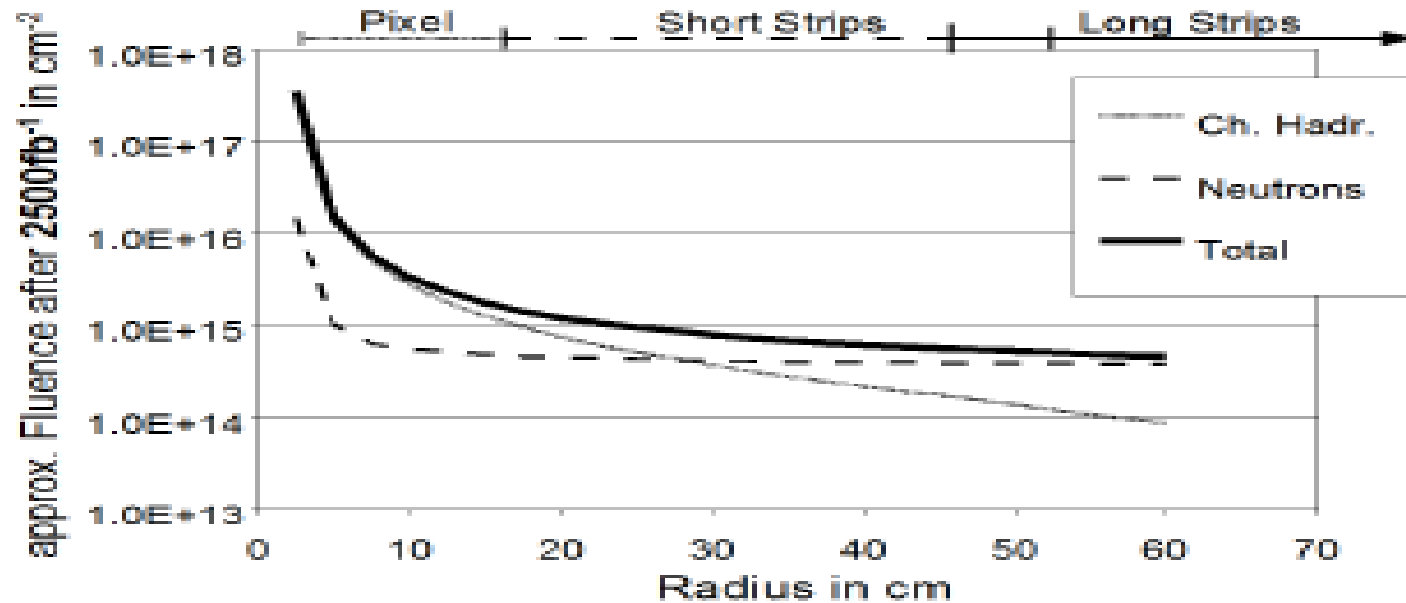
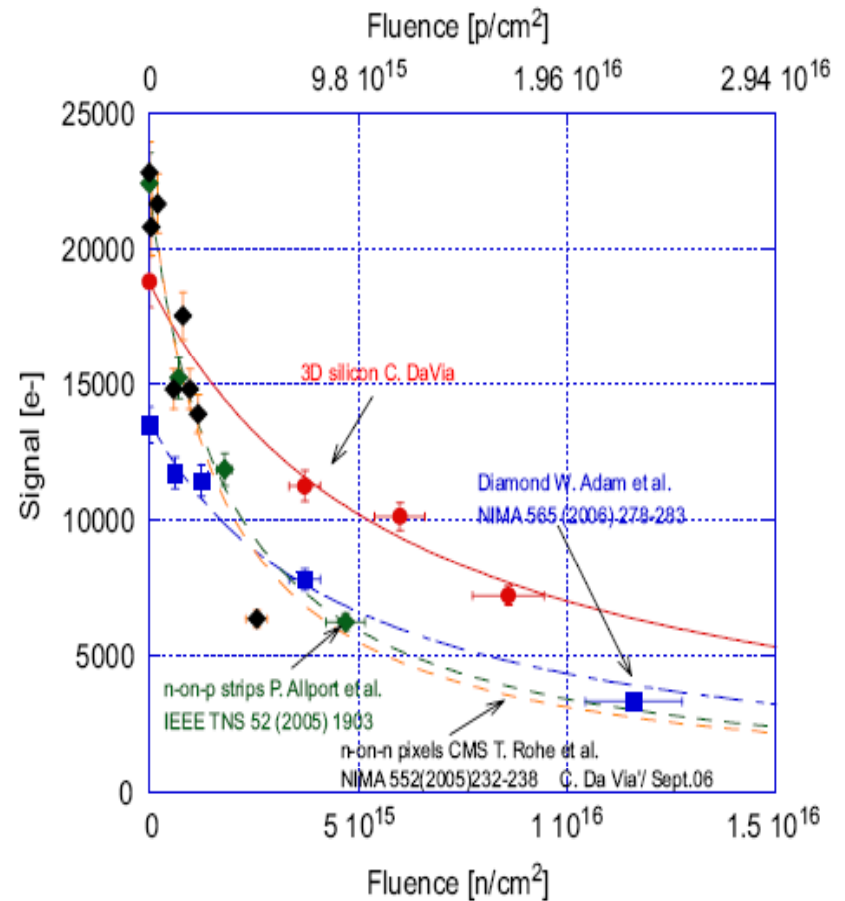
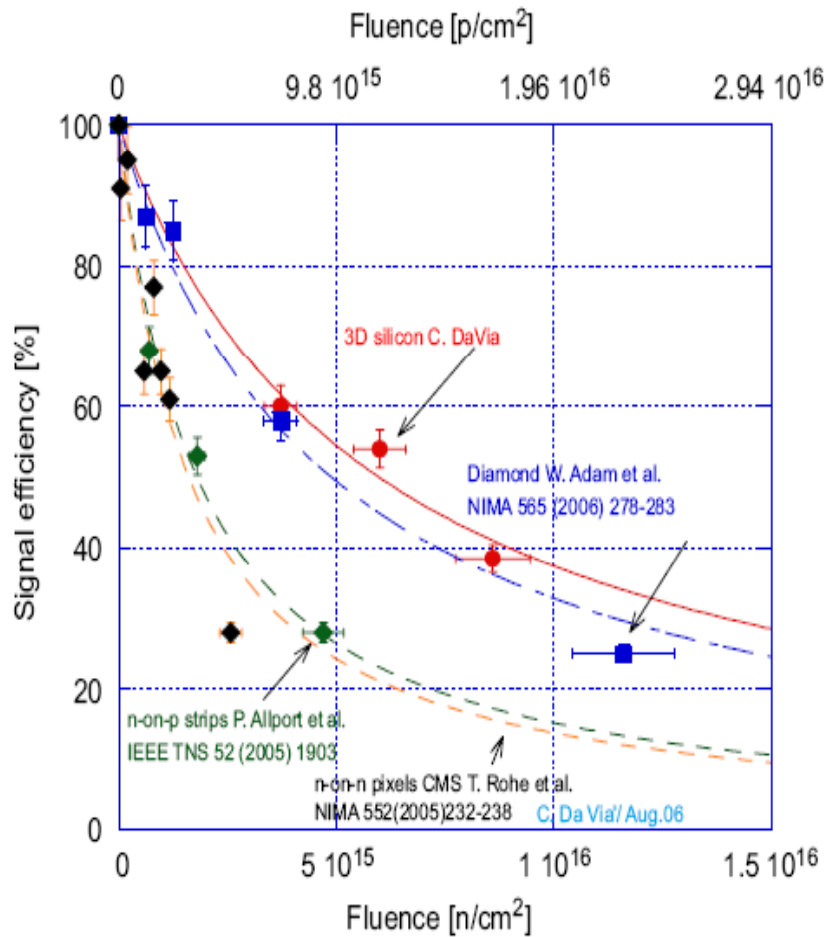


Figure 1: Estimated particle fluence at SLHC extrapolated from simulations for the CMS detector at LHC. [1]

For 2500 fb⁻¹ of data

Radiation Hardness of Sensor



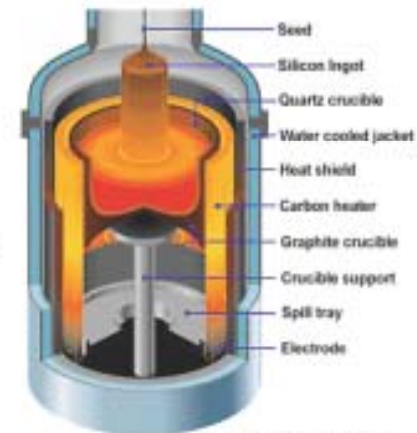
T992 Goals

- Goal is to test new rad-hard sensor candidates for the SLHC vertex detector before and after irradiation:
 - Diamond sensors
 - 3D sensors
 - MCz planar silicon sensors
 - FZ planar silicon, p-type silicon
- Big global effort on Sensor R&D for the SLHC
 - RD42 (diamond)
 - RD50 (rad-hard sensors, mostly on silicon)
 - 3d consortium (3d sensors)
 - ATLAS, CMS, and LHCb effort
- What is unique about our effort is to test all sensor materials using the same readout electronics in the same environment and apparatus -> fair comparison of all candidates
- Open to all, independent of their experimental affiliation or interest in any particular technology

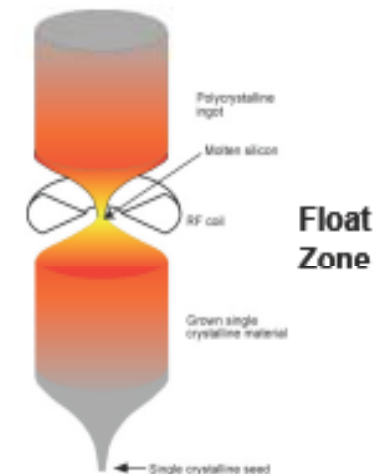


Magnetic Czochralski Process

- Is actually by far the more common process in industry
 - Developed by Jan Czochralski in 1916
- Mono-crystal contained within a quartz crucible
 - Allows larger areas than the float zone (FZ) process
 - But the quartz is a source of contaminants
 - In contrast FZ silicon has a much higher purity
 - Higher resistivity (lower depletion voltages)
- The magnetic process surrounds the crucible with a coil
 - Intended to *limit* the interstitial oxygen concentration
 - (M)Cz 10^{17} - 10^{18} atoms/cm³
 - FZ $<10^{16}$ atoms/cm³
 - (DOFZ $<10^{17}$ atoms/cm³)
 - Also leads to a more homogenous wafer



Cz crystal pulling furnace

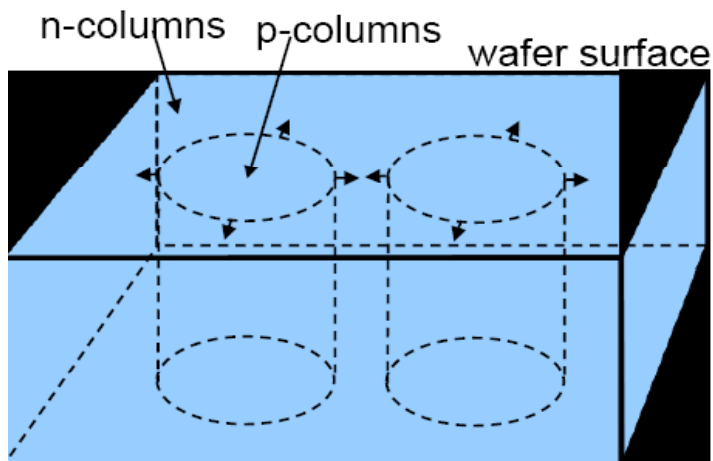
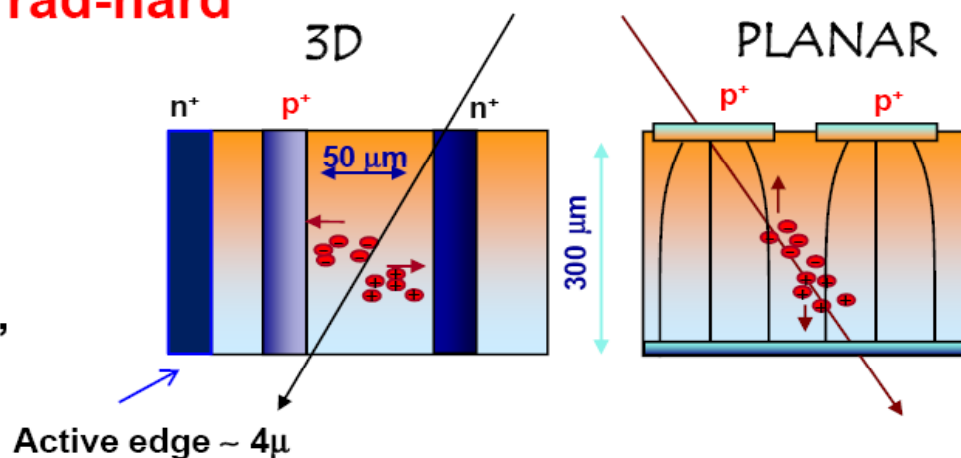


Float Zone

3D Sensors

First proposed by Sherwood Parker in the mid-90s;

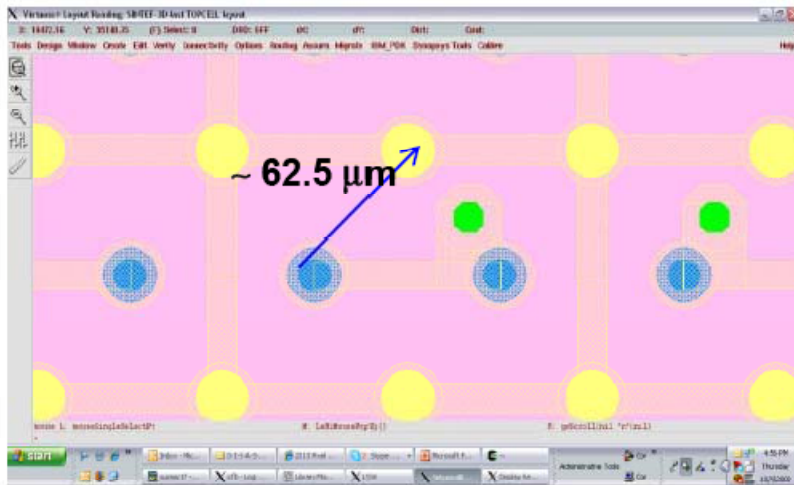
- “3D” electrodes: **narrow columns along detector thickness**,
 - diameter: $10\mu\text{m}$, distance: $50 - 100\mu\text{m}$
- **Lateral depletion: great for rad-hard**
 - Lower depletion voltage
 - Cooling
 - HV power distribution
 - Fast signal
 - Reduced bunch crossing, pileups, rate



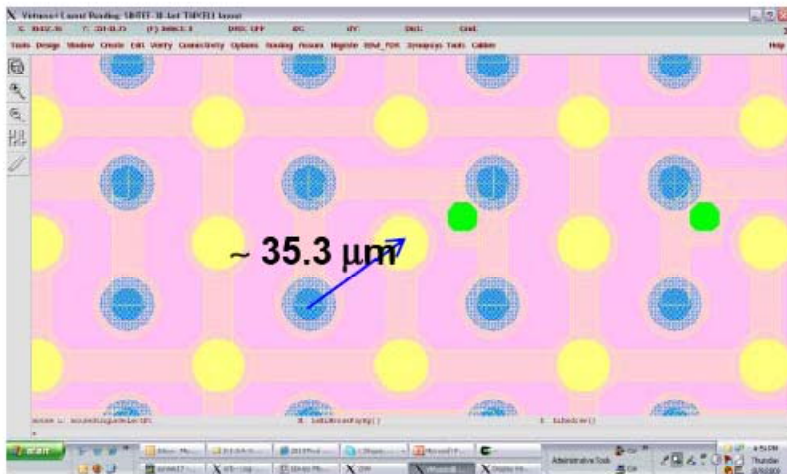
- 3D detectors also allow the implementation of the “Active Edge concept”
- Interest in the Forward physics community
- Active Edge concept can lead to Improving layout geometry which is of general interest

CMS 3D-Pixel Layout

BOLLA, PURDUE

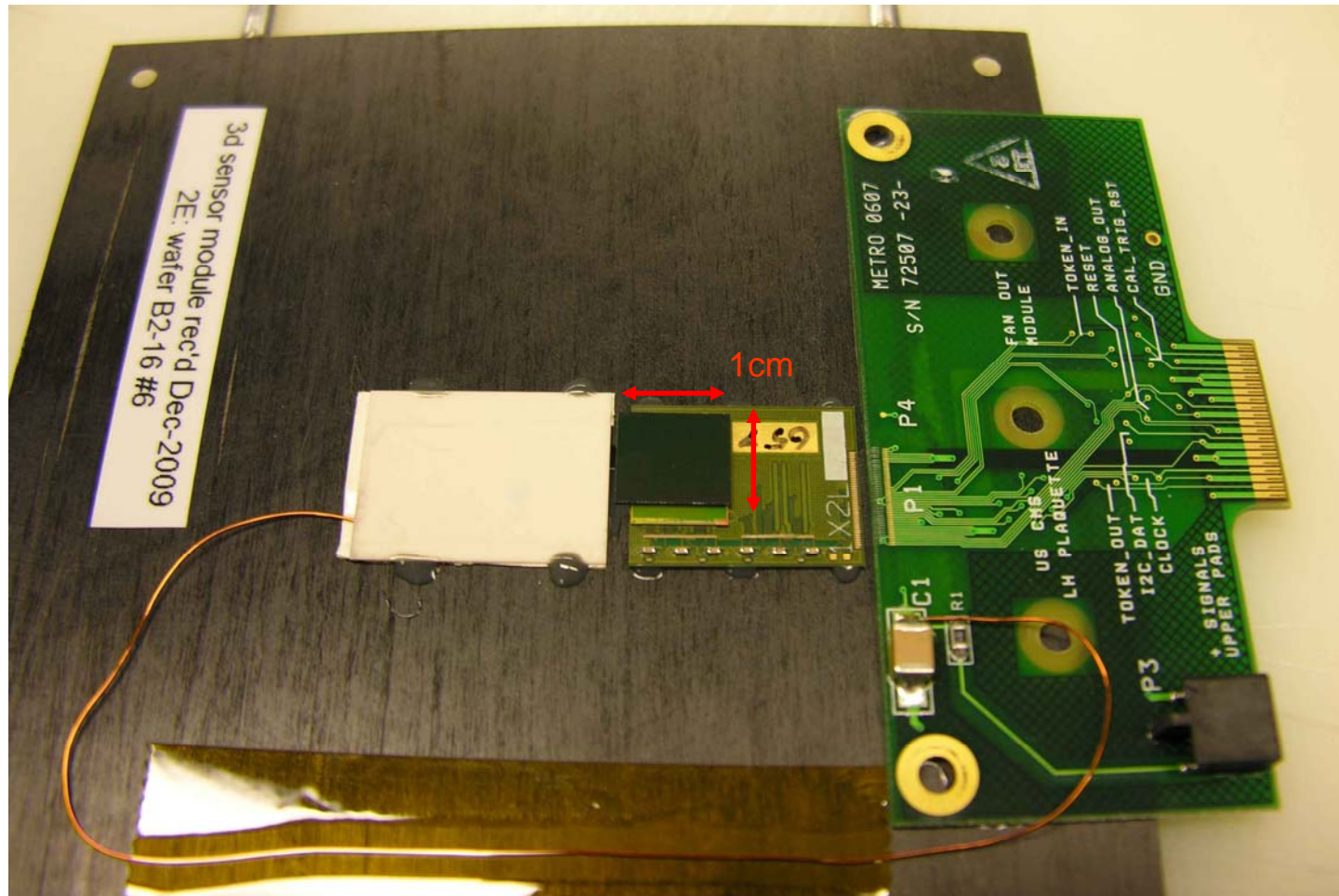


- CMS PSI46 100 μm × 150 μm
- Implemented 2 variations
 - 2 columns pixel
 - 4 columns pixel



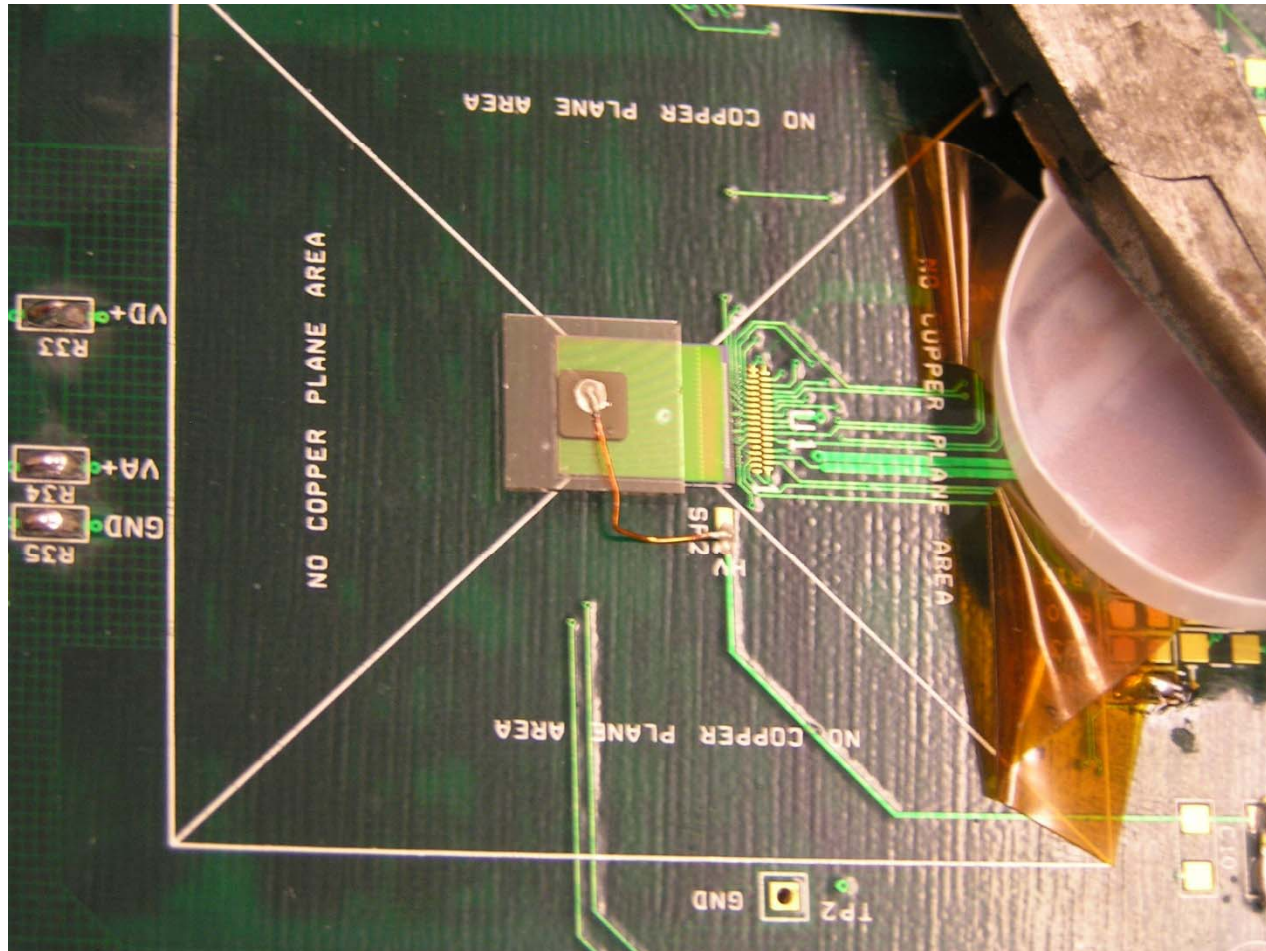
3D Detector

Cooling tubes



- Sensor produced at SINTEF (joint submission ATLAS, CMS, and Medipix). Bump bonded to a CMS pixel readout chip at IZM.

Polycrystalline CVD Diamond



pCVD diamonds from University of Colorado. Expected charge collection distance about 230 microns. Bump-bonded to a CMS pixel readout chip at Princeton University.

Contributors

S. Kwan

A. Prosser

Ryan Rivera

L. Uplegger

P. Tan

F. Yang

I. Osipenkov (TAMU)

Z. Wan (KSU)

A. Kumar (SUNY)

S. Bose (UNL)

A. Zatserklyaniy (UPR)

K. Yi (Iowa)

J. Wang (Syracuse)

E. Alagoz (Purdue)

O. Koybasi (Purdue)

S. Wagner (Colorado)

J. Cumalat (Colorado)

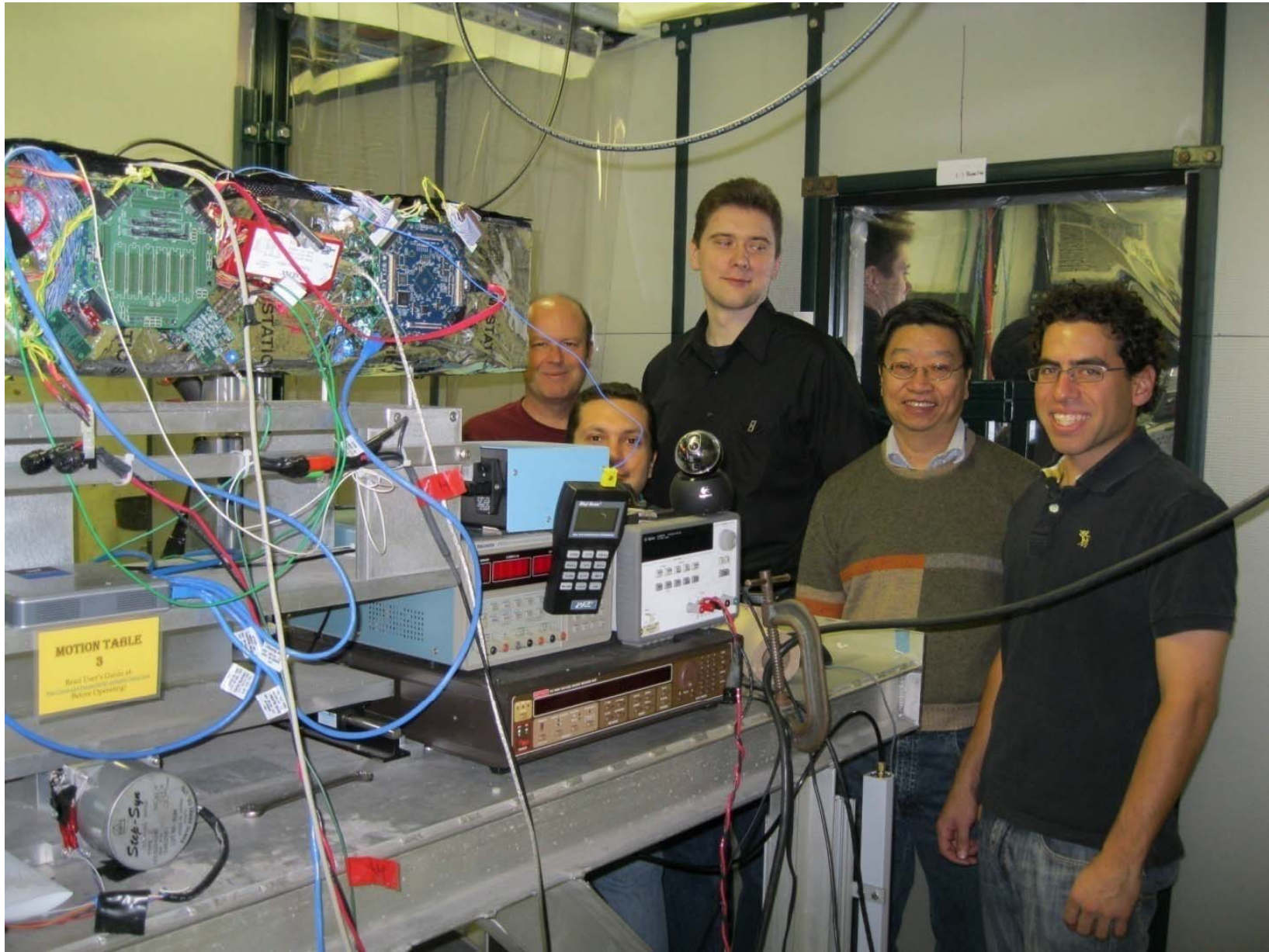
L. Moroni (Milano)

D. Menasce (Milano)

A. Solano (Torino)

M. Obertino (Torino)

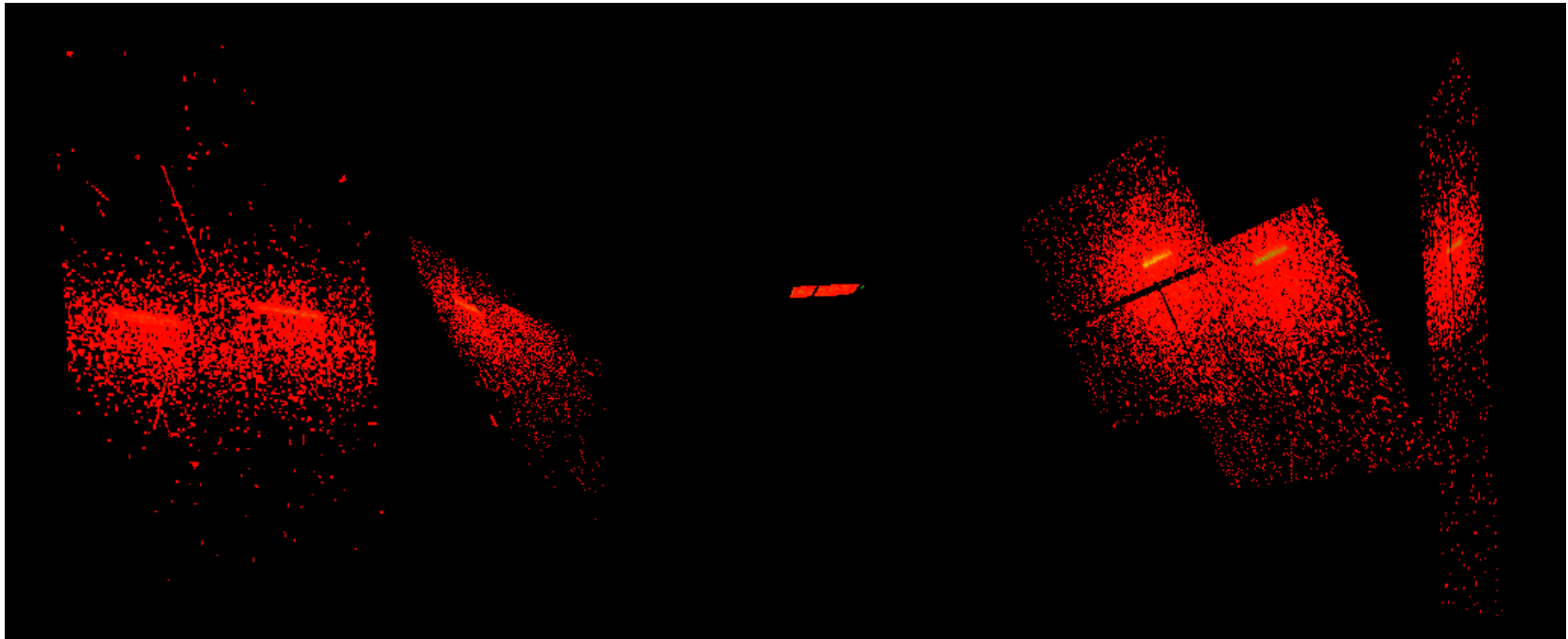
J.M. Brom (Strasbourg)



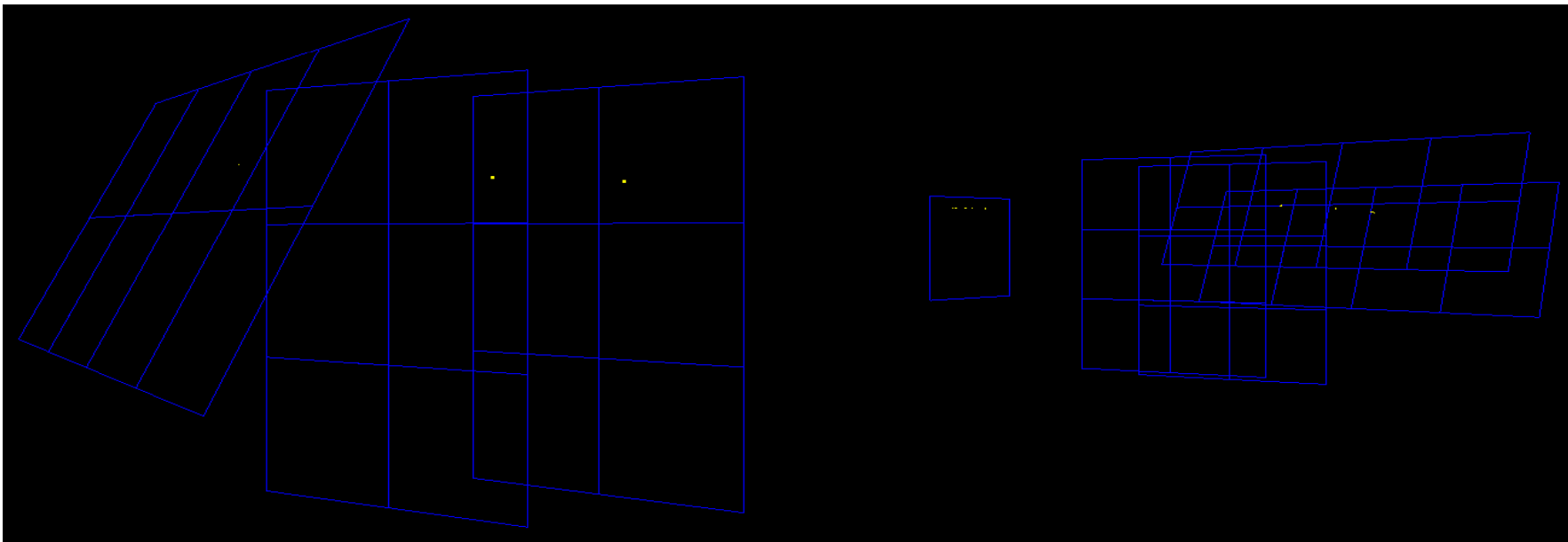
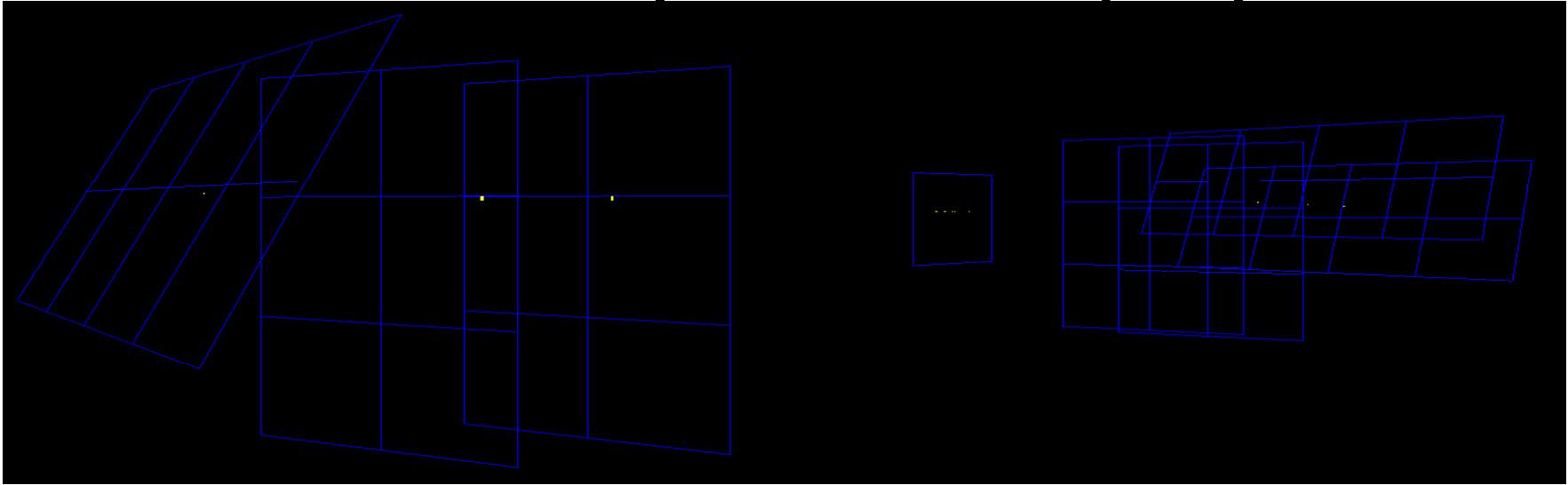
Synopsis of the Recent runs

- We took data in September and again in November of this year
- For the September test, we had quite a few problems and got only good data from 1 3d detector and one MCz silicon module. The pCVD diamond and most of the 3d detectors tested didn't work.
- Much better success in November. We took good data for one mCz Silicon module, seven 3d detectors, 2 pCVD diamond.
- Data were taken:
 - MCz: bias scan, angle scan, timing scan
 - 3d: scan of bias, angle, threshold, timing and at two different temperatures
 - Diamond: scan of bias, angle, threshold, timing

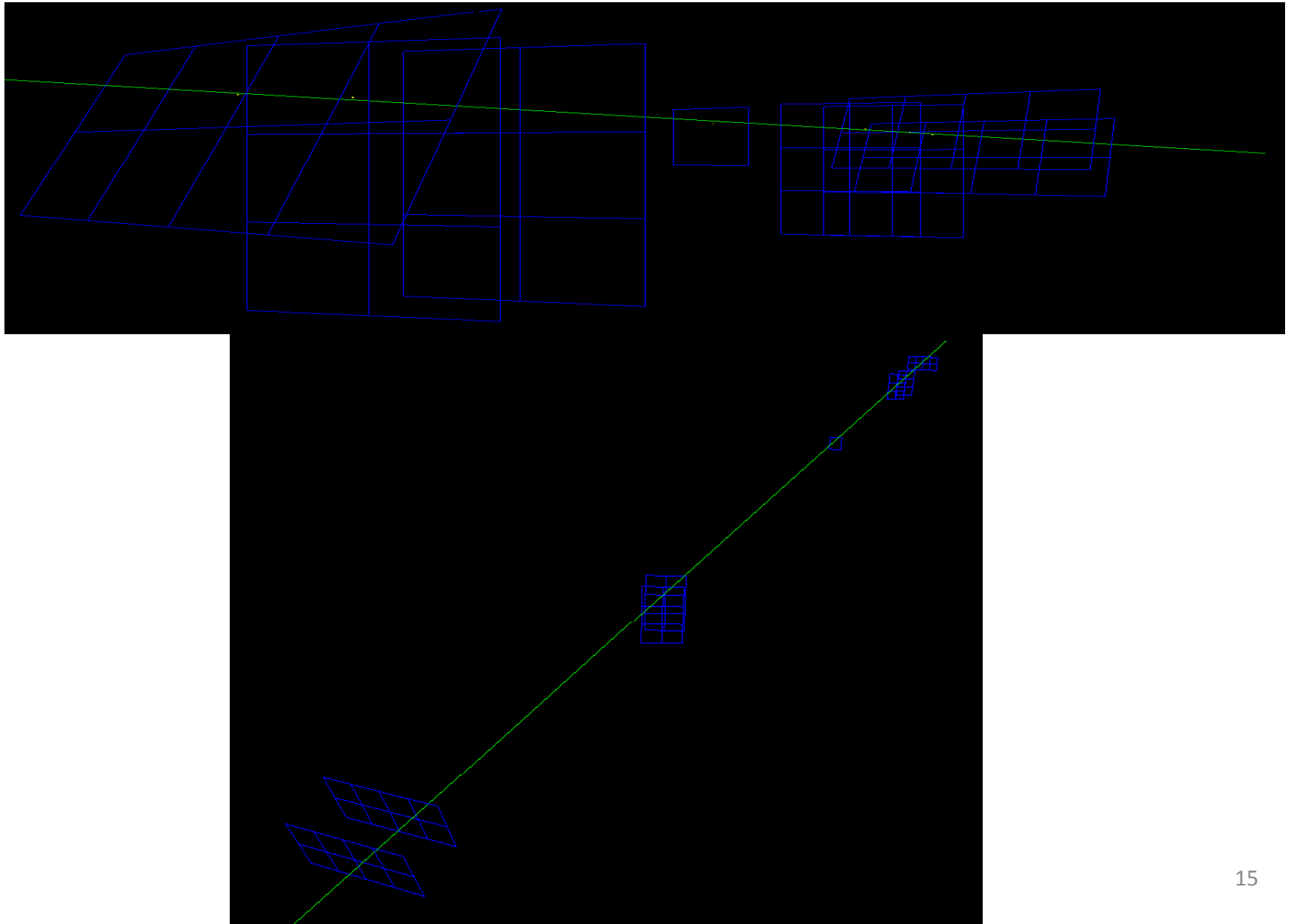
Online quick check



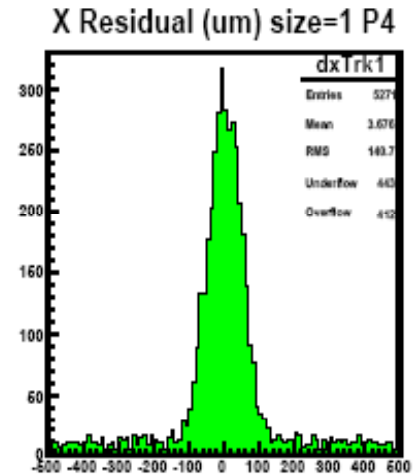
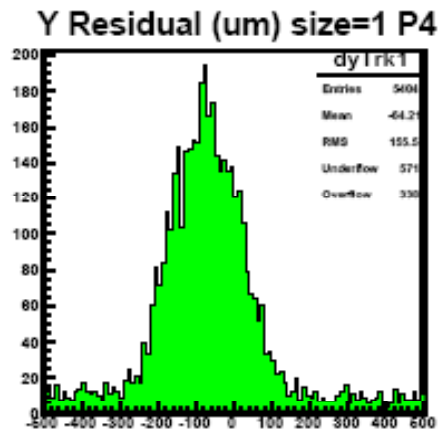
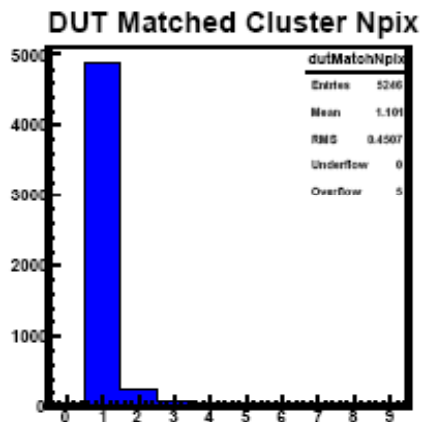
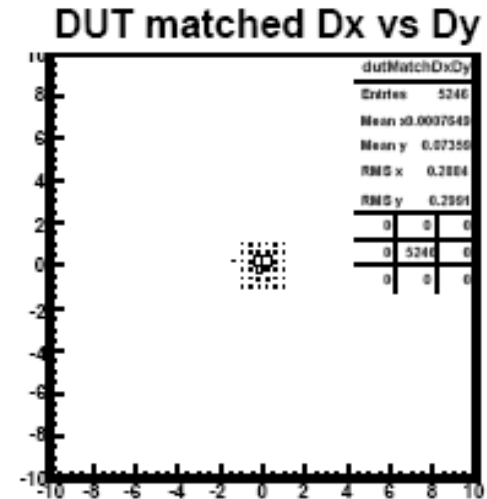
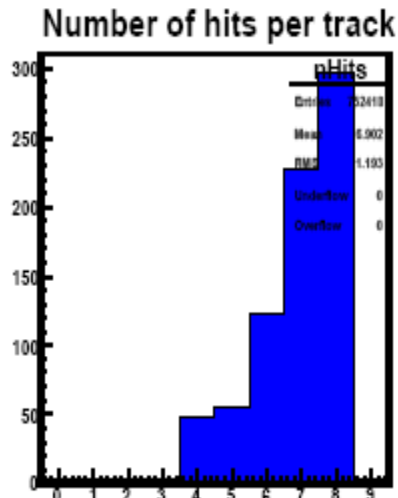
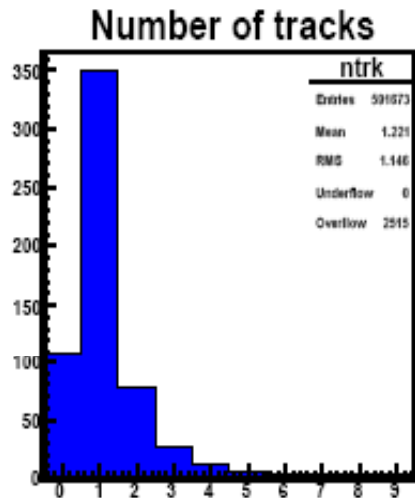
Event by event display



Event display with Tracking

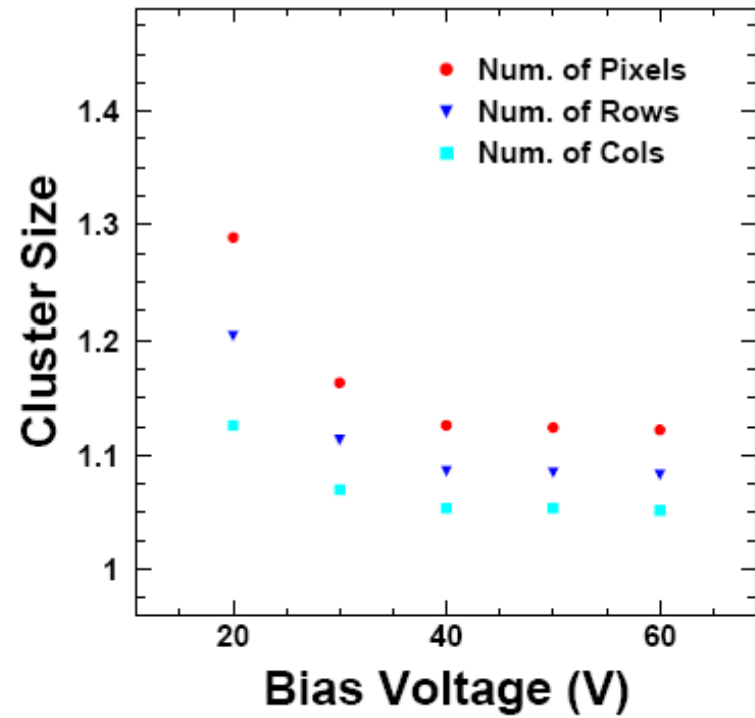
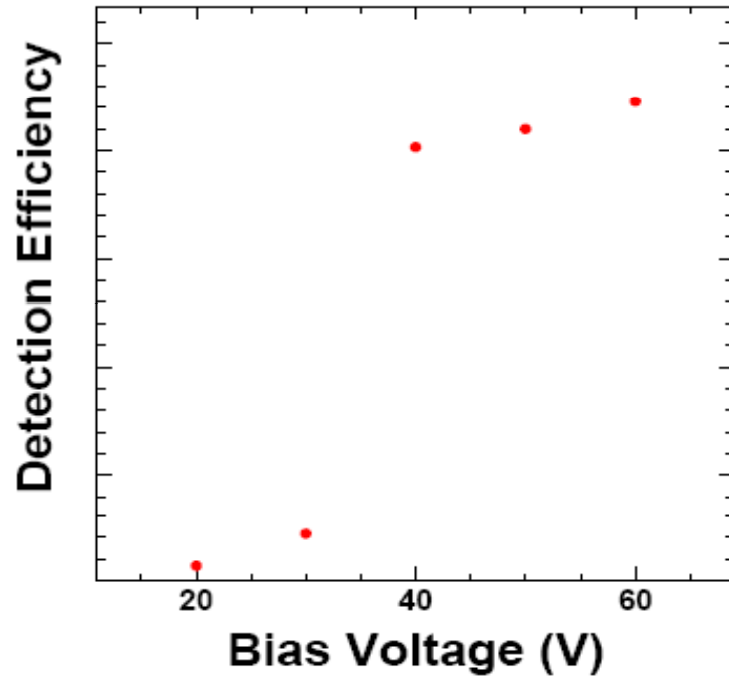


Selected preliminary results for 3d

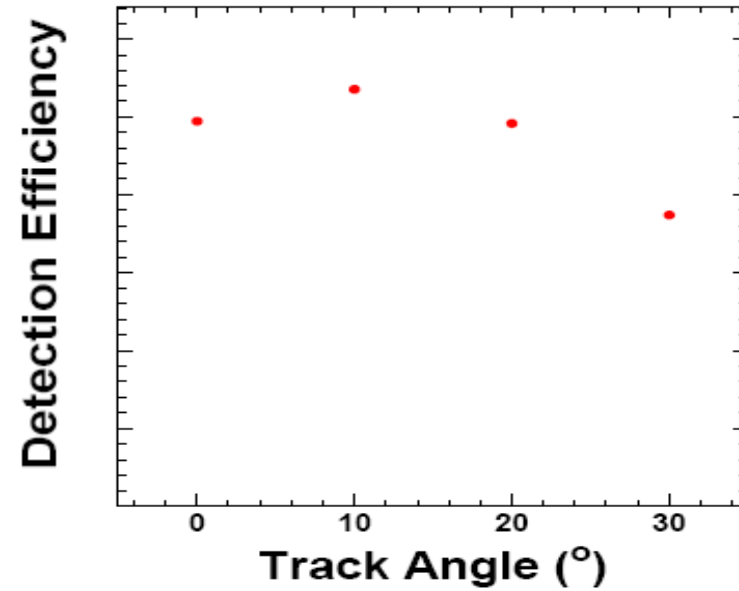
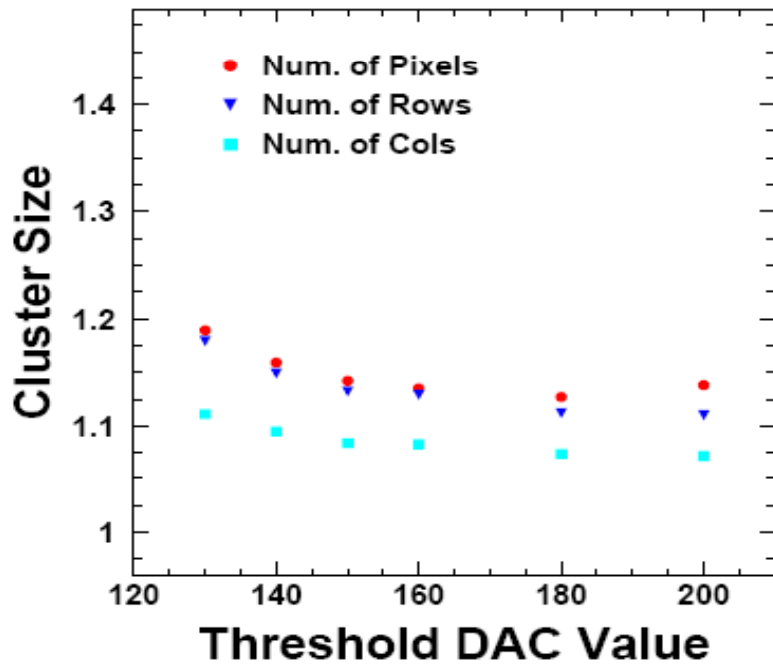
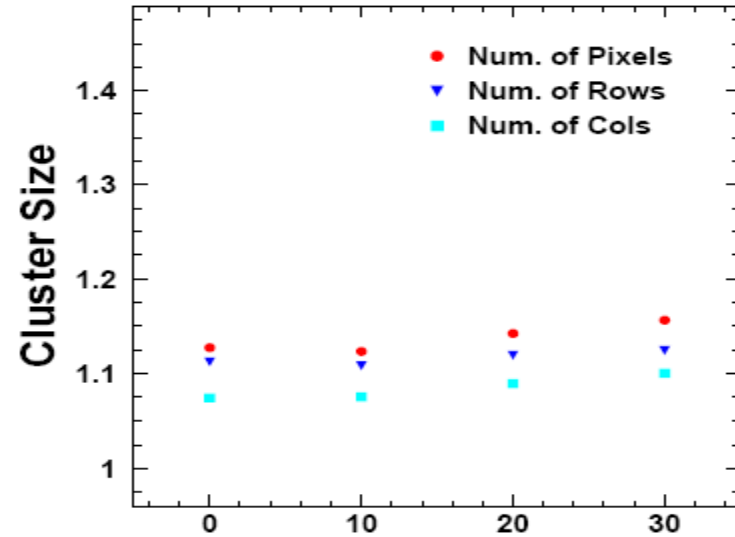
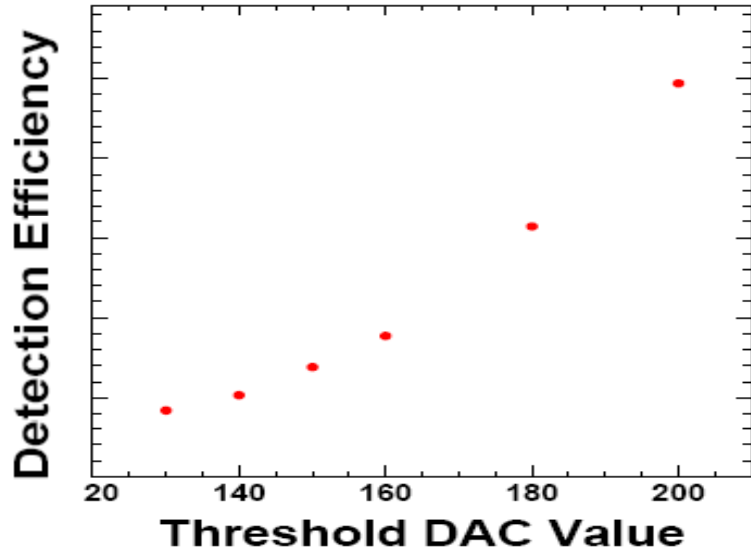


Analysis done by J.C. Wang (Syracuse)

Prelim Results on 3d (2E)



Prelim Results on pCVD



Future Plan

- After the beam test, 6 3d detectors (three pairs of 2E and 4E), 2 MCZ and 2 FZ planar Silicon were sent to LANL for irradiation (800 MeV proton)
- Irradiation were completed on Dec 6
- Nominal fluence received were: 1.2×10^{14} , 2×10^{15} , and 4.7×10^{15}
- We expect to receive the irradiated detectors after the holidays
- Thorough bench test and calibration
- Next test beam slot: March 16-27, 2011
- Test of irradiated detectors
- In the meantime, continue with data analysis