PIRE Conference

September 17-18, 2009

University of Nebraska - Lincoln

CMS Advanced Silicon Pixel Detector Collaborative

PIRE

Program in Research and Education

Main Goal: Get students to Foreign Country

NSF Grant from Oct 1, 2007 – Sept 30, 2012

University of Kansas
Kansas State University
University of Illinois – Chicago
University of Nebraska – Lincoln
University of Puerto Rico – Mayaguez

With Swiss Institutes: Paul Scherrer Institute and ETH- Zurich

Research: CMS with silicon pixel detectors

Education: Study Abroad for science students
ETH – Zurich exchange program
Undergraduate Research

NSF and PIRE

- 33 PIRE awards total until 2009
  - We are only particle physics one and one of two in Switzerland
- Annual PIRE conference in Washington for PIs
  - How we can be successful at what we are doing
  - Interface with associated NSF program directors
  - Requires a poster from each group
- What I think NSF wants aside from our own success:
  - Recruit a diverse group of US students for program
  - Provide evaluation (We have external evaluation next year)
  - Leverage other resources and disseminate info
  - Figure out how to continue collaboration without OISE funding

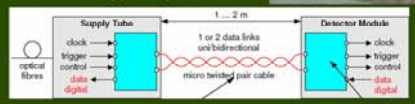
"At a time when scientific and engineering research is becoming increasingly global, this NSF program is designed to enable US scientists and engineers to build strong long-lasting international research collaborations and to develop a new cadre of globally engaged US scientists and engineers."

PIXEL DETECTORS STUDY ABROAD

Collaborative research with the Paul Scherrer Institute and ETH on Advanced Pixel Silicon Detectors for the CMS detector

http://physicsweb.phy.uic.edu/pire/

Above—1/2 of CMS barrel pixel detector
Below — Conceptual design of new readout for upgraded pixel detector



Group at Nuclear plant

Chris and Cody at ETH

Ten students went to Switzerland during 2008

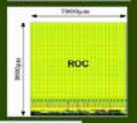
Two undergrads spent semesters studying at ETH Zurich

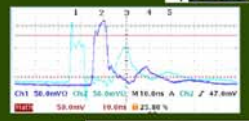
Conference at University of Kansas brought each institutions international studies/study abroad personnel together to discuss how to recruit more science students into study abroad programs

Tours of science facilities and sightseeing in Switzerland

SWITZERLAND

Above—test setup for micro twisted pair wire testing
Right top—test chip
Right middle—picture of current readout chip
Bottom — scope trace to measure impedance and transmission





RESEARCH PROJECTS:

Integration and Commissioning the CMS Pixel Detector

Participants helped to install and test the 66 million channels

Position Resolution with the CMS pixel detector

A Monte Carlo study was made of how the calibration parameters affect the position resolution of tracks

X-ray Calibration on individual pixels

This study compared the amount of electron charge per DAC setting for individual pixels and entire readout chips. The calibration was studied with different energy sources.

Charge Collection Efficiency of Irradiated Sensors

To establish a fluence limit for radiation hardness of the CMS pixel detector and for n-on-n sensors in general, sensors were irradiated with both pions and protons up to 4×10^{15} Neq/cm^2 The response to a Sr-90 source was investigated. Acceptable efficiencies up to 6×10^{14} Neq/cm^2 were found with depletion voltages of around 450V. Studies of samples irradiated to higher fluences are continuing.

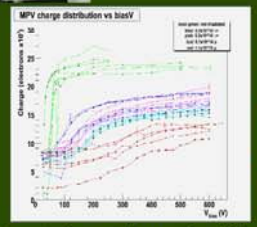
Impedance and Loss of Micro Twisted Pair line

The current barrel pixel detector contains more material than needed at the endflanges and along the support tube. To eliminate three separate kapton cables, transmission along a 2m long twisted pair cable was studied. The impedance and loss were simulated and then measured for the 125µm diameter cable. Initial results are favorable to using these cables.

New chip components test

The current drivers and analog to digital converters were tested on the new readout chip prototype

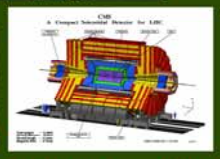
Left — Test box for Irradiated sensor readout
Bottom Left — Charge Collection efficiency measurements for irradiated sensors



CMS detector
Left — muon endcap
Top — central region
Right top— at PSI
Right — Beat & Stephan assemble pixel detector

Presentations at International Conferences and Publications:

1. *Signal height in Silicon Pixel Detectors Irradiated with Pions and Protons*
   7th International Conference on Radiation Effects on Semiconductor Materials Detectors and Devices, Florence, 15-17 October, 2008
   Publication in Nuclear Instruments and Methods A expected soon
2. *Design studies of a low power serial data link for a possible upgrade of the CMS pixel detector*
   TWEPP-08 Topical Workshop on Electronics for Particle Physics, 15-19 September, 2008
3. *CMS pixel detector upgrade*
   Pixel08 International Workshop, 23-26 September, 2008 at Fermi National Accelator Lab
4. *Signal height in irradiated Silicon Pixel Detectors*
   13th RD50 Workshop, 10-12 November, 2008, CERN



CMS COLLABORATION FOR LHC

University of Kansas | Kansas State University | University of Illinois Chicago | University of Nebraska Lincoln | University of Puerto Rico Mayaguez | Paul Scherrer Institut | ETH Zurich

2008

10 Students in Switzerland
- Spring: 3 Grad, 1 UG
- Summer: 6 Grad, 4 UG
- Fall: 2 Grad, 1 UG

1UG/1G in US as well

ETH Study Abroad:
- 1 KSU, 1 KU student through KU exchange
- Set up UIC/ETH exchange

Research:
- 3 Intl. Conference talks with our results
- 1 publication

2009

11 Students in Switzerland

- Spring: 3 Grad, 1 UG
- Summer: 4 Grad, 7 UG
- Fall: 2 Grad

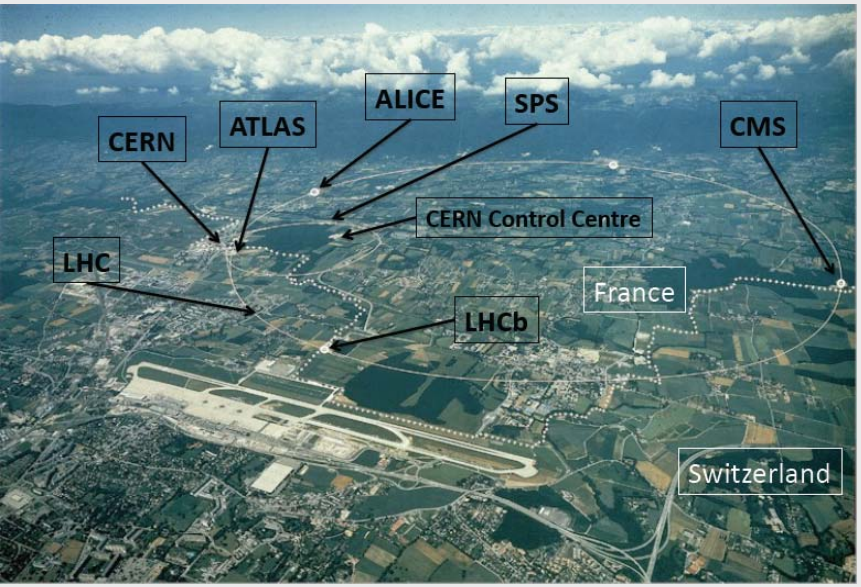
ETH Study Abroad:

- 1 KSU UG student through KU
- 1 UIC Grad through UIC

Research:

- Happening at US home institutes
- 2 Conference talks
- 2 Posters
- 3 refereed publications pending

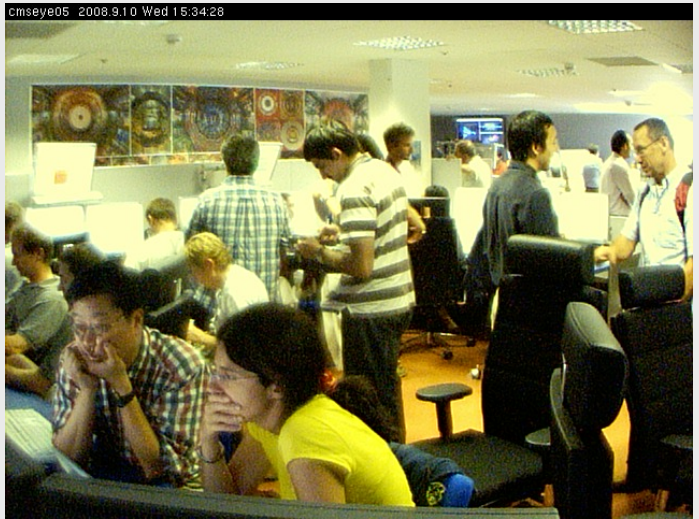
Research:
CMS in the LHC



- The LHC will (eventually) have Proton-Proton collisions at 14 TeV at a luminosity of 10^{34} $cm^{-2}s^{-1}$
- CMS is one of the large all purpose detectors with a collaboration of over 2500 people from at least 35 countries
- The CMS detector was ready for 1st beam Sept 10, 2008. See Valeria on shift

An interconnection between two magnets vaporized last fall and repairs and new diagnostics have been ongoing

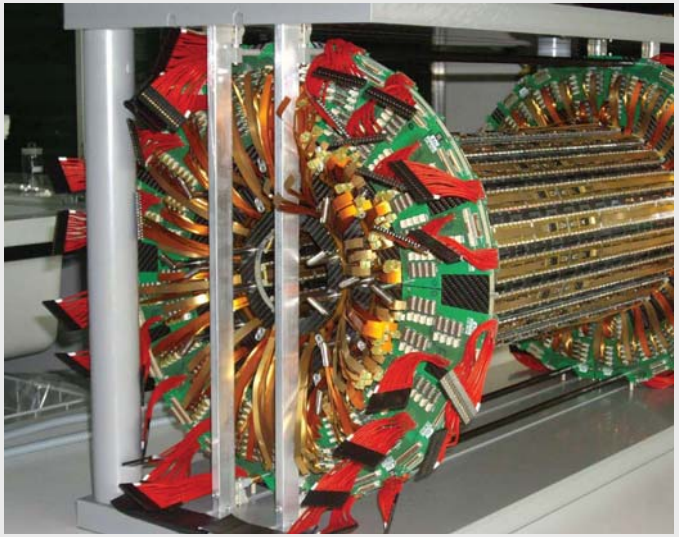
LHC is expected to start providing collisions at 7 TeV in November, 2009

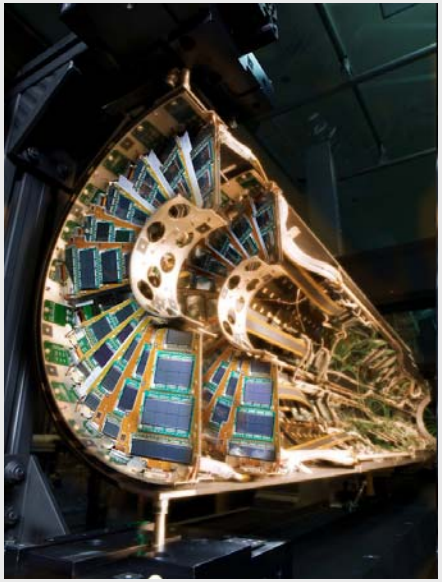


CMS pixel detector

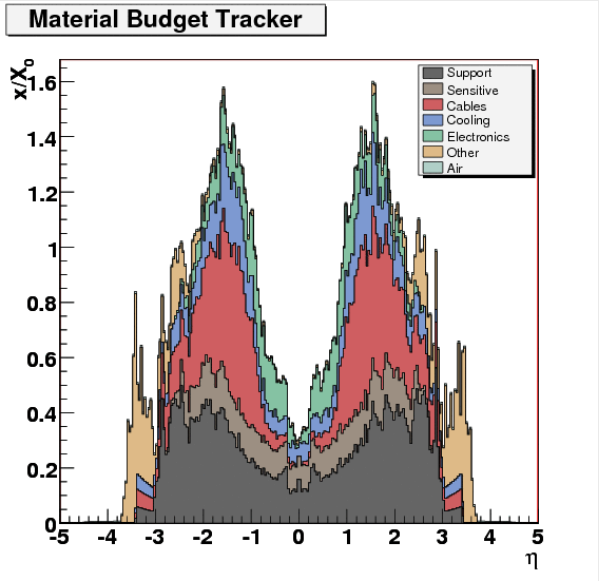
- 66 million pixels
  - 3 layers of barrel
    - Built at PSI
  - 2 Forward disks on each side
    - Built in US
- Innermost silicon detector measures position to about 10μm for tracking
- Installed into CMS
  - July 2008

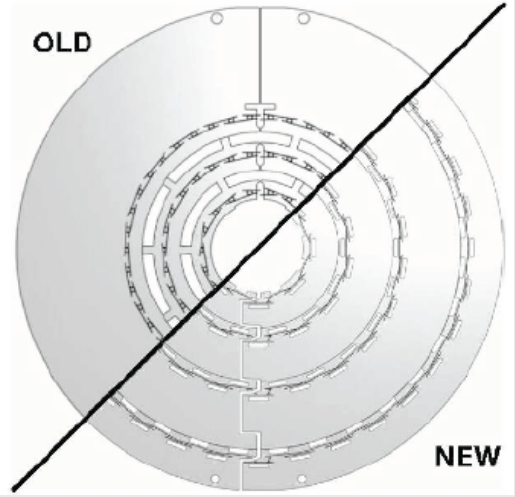
Our work with the PIRE project is to assure that this detector is fully commissioned and runs well





SLHC

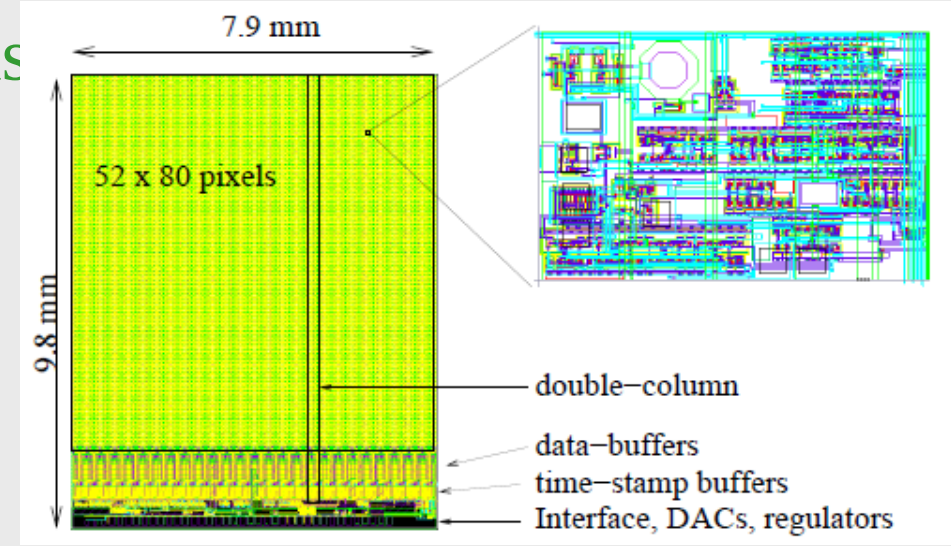


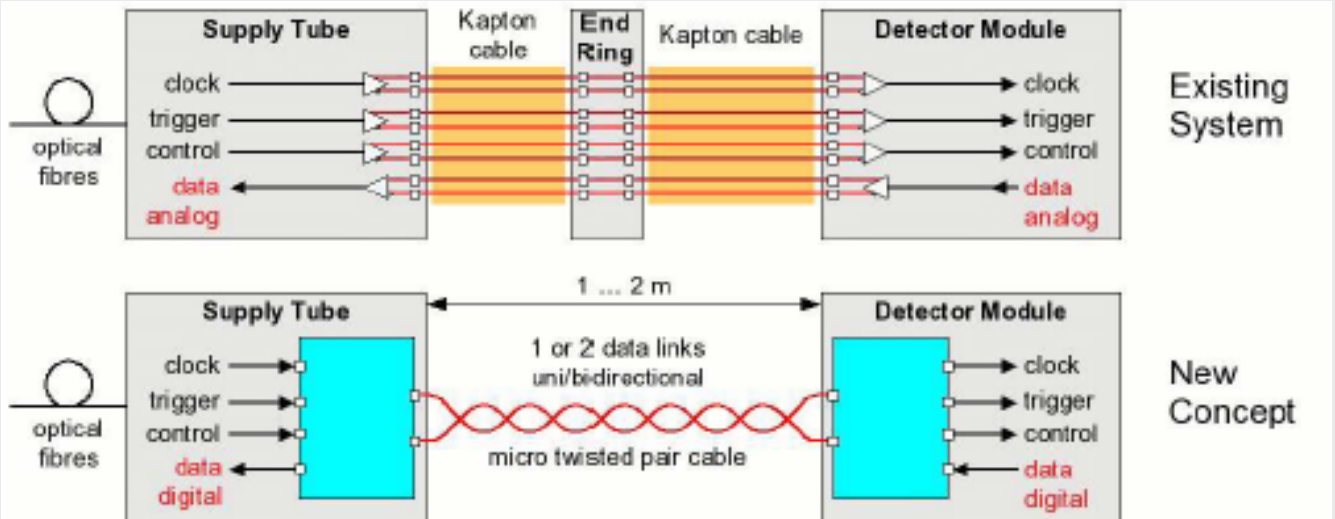


- Super LHC is plan to upgrade the luminosity (rate of data taking) of the LHC starting in 2013-2014 (Phase I)
- Limitations of the current pixel detector:
  - Material can be reduced for better particle detection
  - Radiation damage will degrade resolution
  - Need more data points for pixel stand alone tracking and better track resolution
- New pixel detector is planned as part of Phase I
  - Ultralight mechanics including CO2 cooling
  - Move port card electronics away from ends of detector
  - Build 4 layers
    - Implies a different readout scheme

Pixel Readout Electronics

- Readout chip (ROC) needs
  - more buffers
  - 8 bit ADC
  - 160 MHz digital readout
- Serialized binary optical readout at 320 MHz
- Use micro-twisted pair cable to reduce material





PSI Research Projects 2008

-Installation and Commissioning of pixel detector

Tony, Samvel, Codi

- New Readout chip design

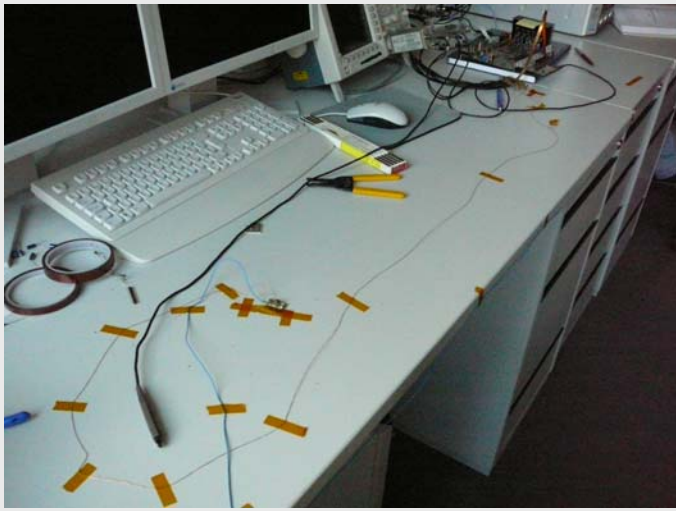
Irakli

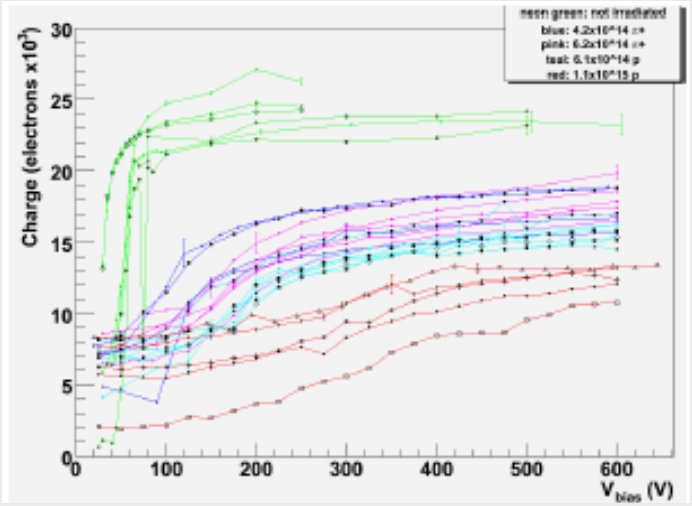
- twisted pair cable characterization

Sandra, David, Nick

-sensor testing after radiation exposure

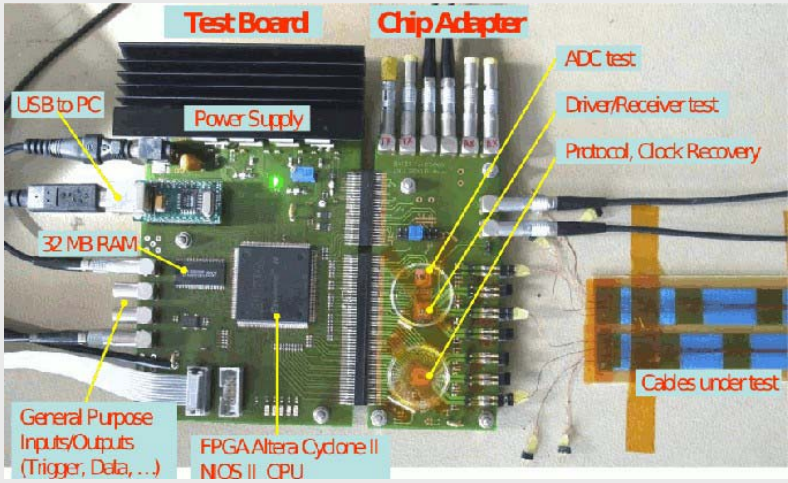
Jennifer, Jhon, Chris



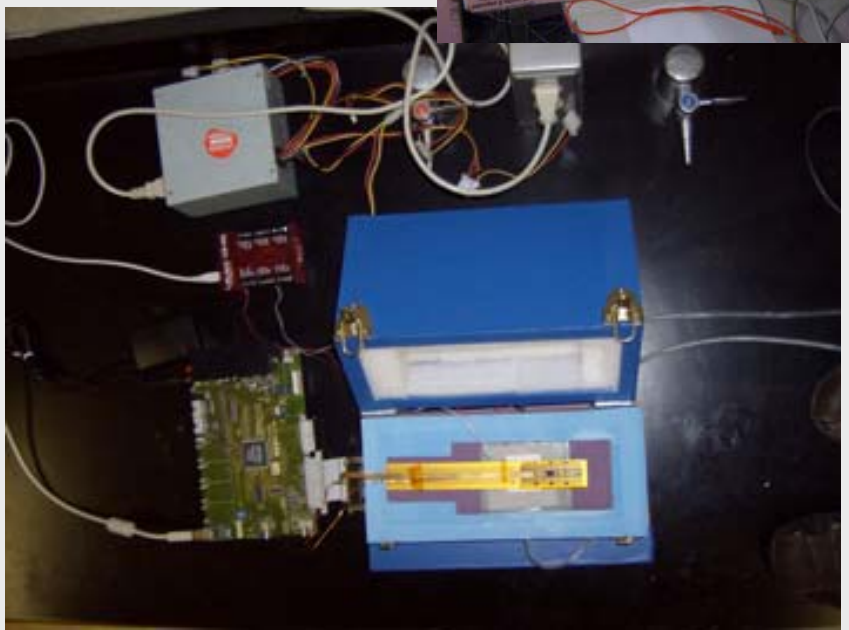


PSI Research Projects 2009

- Current Readout Chip (ROC) calibration
  - Measurement of irradiated ROC
    - Samvel, Eric
  - Trimming at low threshold – Luis
  - Study charge vs temperature and radiation -
    - Tony
- New Readout chip design
  - ADC, PLL – Shruti, Dane
- High rate module testing with X-ray boxes – Ali, Chris
- Pixel sensor design
  - Irradiated sensor efficiency
    - Jennifer, Natalie, Asma
  - Interpixel capacitance and electrical discharge in one-sided detectors - Jennifer



Research in US



- Building pixel teststands
  - Making PC based testboards
  - X-ray teststand at KU
  - Thermal/Cosmic teststands at UPRM, UNL
- Microtwisted pair readout of modules at UPRM
- CMS commissioning
- NSF MRI R^2 proposal submitted Aug 2009

Talks/Posters

- International conference talks with PIRE results
  - T. Rohe et al., *Signal height in Silicon Pixel Detectors irradiated with Pions and Protons*, RESMDD 08, October 15-17, Florence, Italy.
  - B. Meier, *Design studies of a low power serial data link for a possible upgrade of the CMS pixel detector*, TWEPP 2008, September 15-19, Naxos, Greece.
  - V. Radicci for the CMS Pixel Collaboration, *CMS pixel detector upgrade*, Pixel 08, September 23-26, Fermilab.
  - J. Lazo-Florez, *CMS Pixel Detector for the Super LHC*, CIPANP 2009, May25-31, San Diego, CA.
  - A. Bean for the CMS Collaboration, *The CMS pixel detector and challenges (prospectives) for its upgrade*, SDS2009, June 7-11, Wildbad Kreuth, Germany
  - T. Rohe et al, *Radiation hardness of CMS pixel barrel modules*, SDS2009, June 7-11, Wildbad Kreuth, Germany (Poster)
  - J. Sibille, *Design of CMS Pixels for an LHC Upgrade*, MCPAD Readout electronics workshop, Sept 17-19, 2009, Cracow, Poland (Poster)

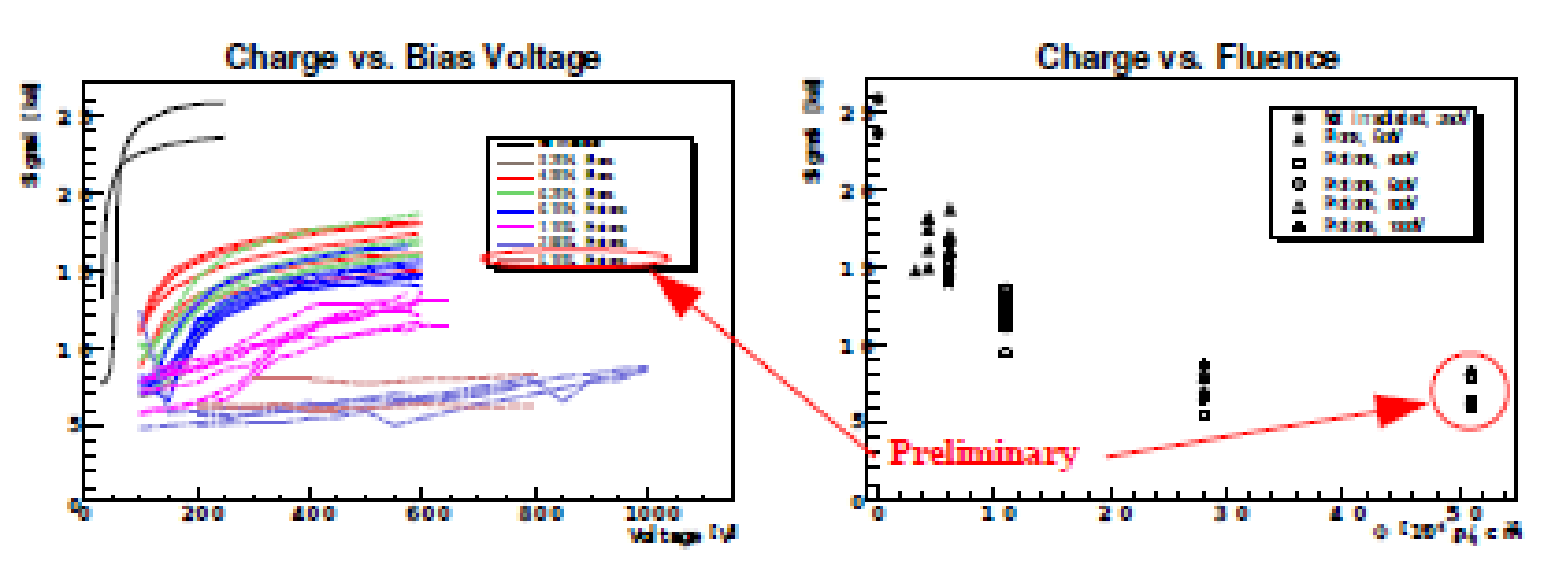
Refereed Publications

Valeria Radicci for the CMS Collaboration ,*CMS pixel detector upgrade*, JINST 4:P03022 (2009).

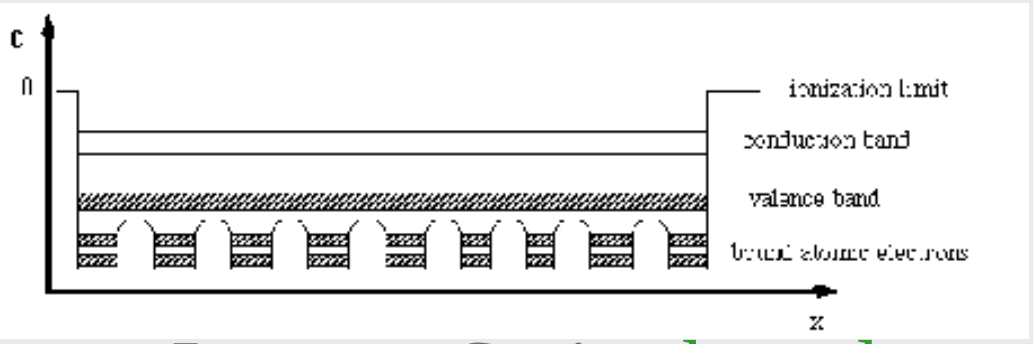
T. Rohe et al., *Signal height in Silicon Pixel Detectors irradiated with Pions and Protons*, Nucl. Instr. And Meth. A doi:10.1016/j.nima.2009.08.012 (2009).

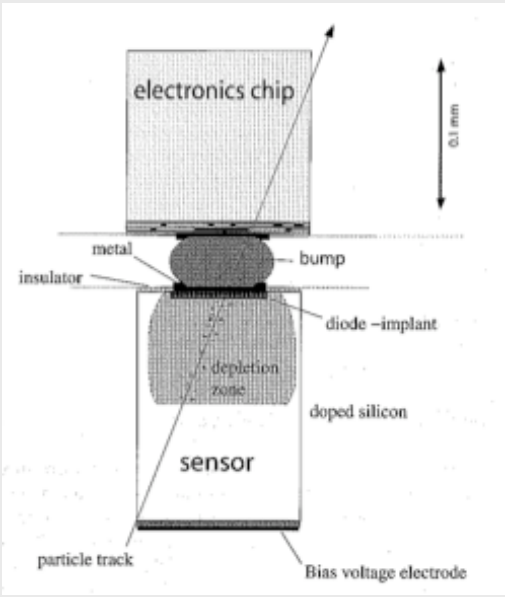
A. Bean for the CMS Collaboration, *The CMS pixel detector and challenges (prospectives) for its upgrade*, submitted to Nucl. Inst. And Meth A (2009)

T. Rohe et al, *Radiation hardness of CMS pixel barrel modules*, submitted to Nucl. Inst. And Meth. A (2009).



2009 Summer Education Program – Lecture Series

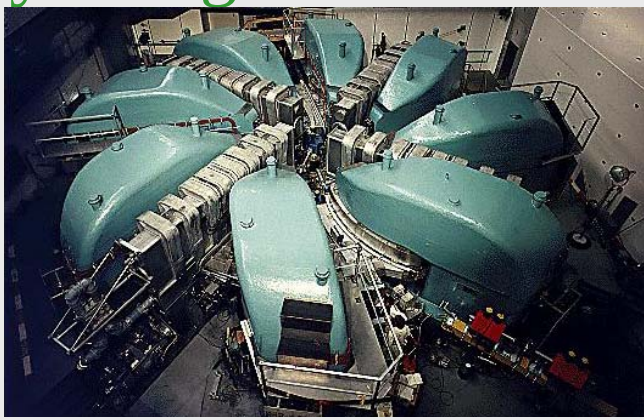




- Lecture Series broadcast over video slides available for future use at:

http://indico.cern.ch/category/Display.py?categId=1830

  - PIRE faculty/grads all gave talks
    - Particle Physics
    - Detectors
    - Software and Tools (ROOT)
  - Also Accelerator Physics talks by R. Horisberger



2009 Summer Education Program (2)

- Facility Tours
  - CMS/CERN
  - PSI
  - Leibstadt Nuclear Power plant

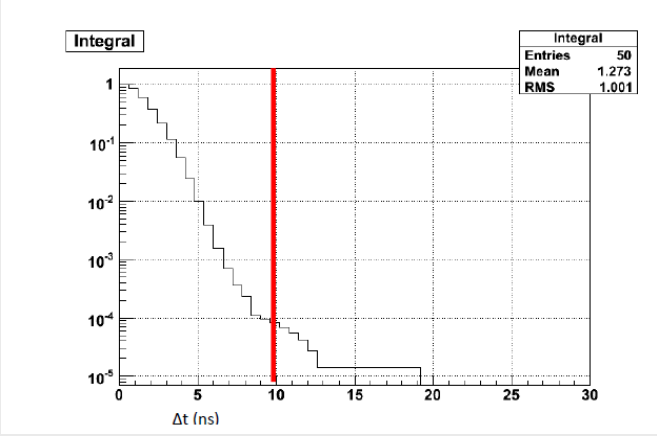
2009 Summer Education Program (3)

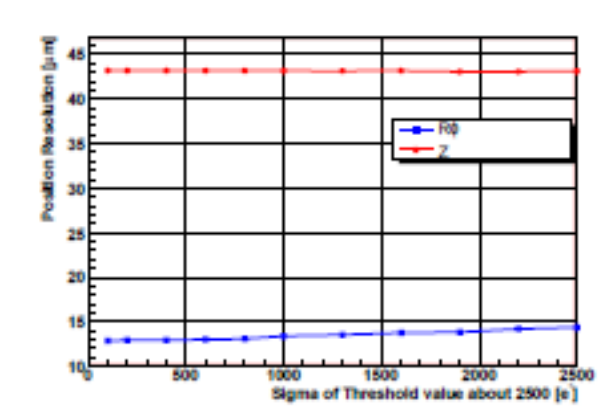
- Cultural
  - City Tours

    Zurich, Geneva, Basel
  - Van Gogh exhibition
  - Hikes (thanks Frank)
  - Meals
    - Fondue with Frank
    - BBQ
    - Waldshut

Academic/Study Abroad

- 2 Students nominated for Goldwater award
  - Dave, Chris (receives honorable mention)
- Jennifer Sibille receives MCPAD fellowship for 3 years of graduate studies
- ETH past students (3 UG, 1G)
  - All four students take home top grades in courses
  - Samvel takes graduate class and research project
  - Asma takes intensive 2 week research class at PSI
  - Chris/Codi do Semester Arbeit projects
  - Chris takes Roland's class in German
  - All take intensive German language training
- ETH Spring 2010
  - Eric from UIC (UG), 1 UG from KSU
  - Jennifer from KU (G)





Summary

- Our group has been very productive with research and undergraduates are heavily involved
- Students are successful at ETH and in their careers
- We have a great program ahead and expect data from LHC collisions shortly