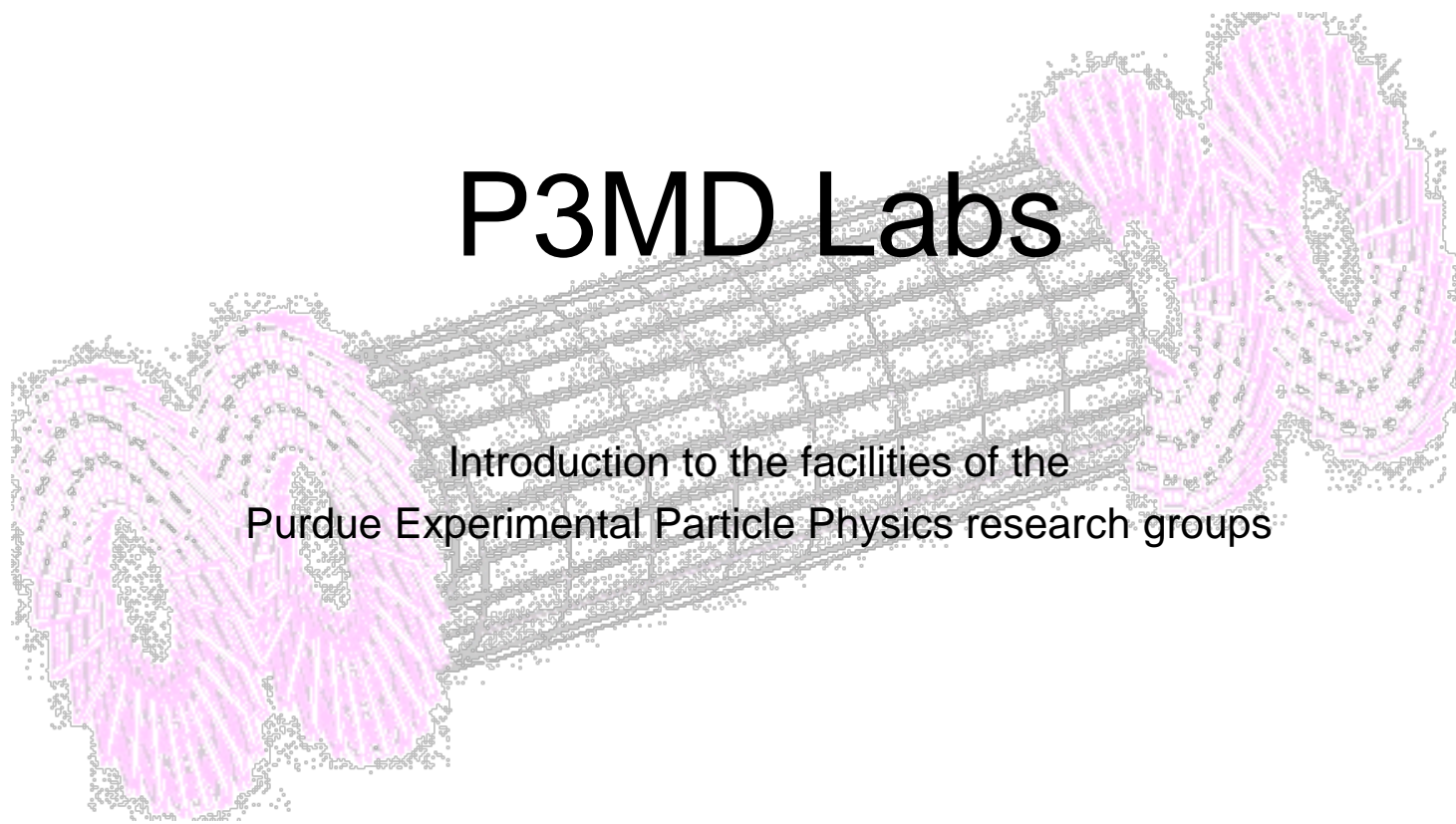


# P3MD Labs

Introduction to the facilities of the  
Purdue Experimental Particle Physics research groups



# Cleanrooms

- 3000 sq. ft. of clean rooms in 3 labs
- Temperature and humidity control
- ESD protection



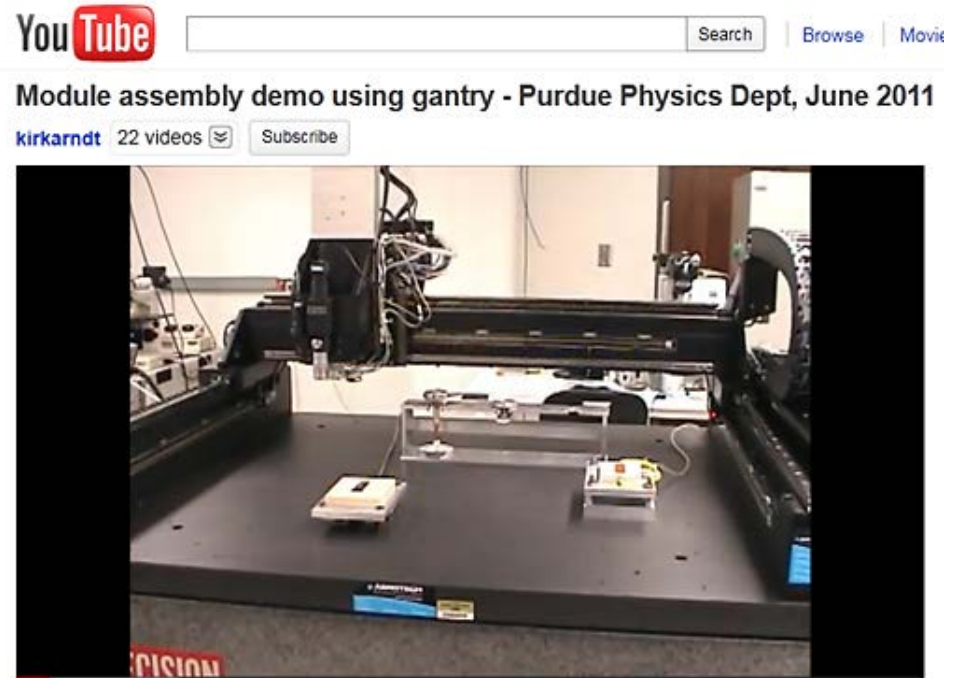
# Coordinate Measuring Machine

- Assembly alignment and surveying are done using an optical probe on our Mitutoyo Coordinate Measuring Machine
- Dimensional inspections of fixtures and detector mechanics are done using a touch probe on the CMM



# Semi-automated module assembly station

- Developing a robotic 'pick-and-place' machine for module assembly
- Gantry positioning system integrated with vision, pattern recognition, vacuum tools, adhesive dispenser, electro-valves and sensors
- Demonstrations of 'pick-and-place' pixel module assembly posted on YouTube



# Wire bonding



- 2 automated ultrasonic wire bonding machines
- Wire bond pull tester for quality control

# Flip Chip Bonding



- High accuracy bonder for aligning, placing and reworking flip chip and ball grid array modules

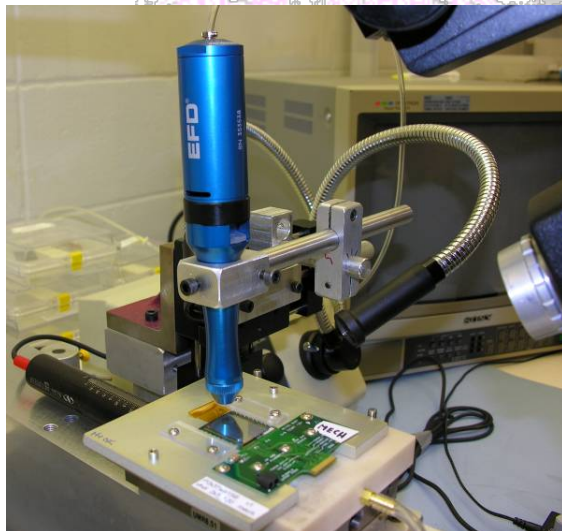


# Processing equipment

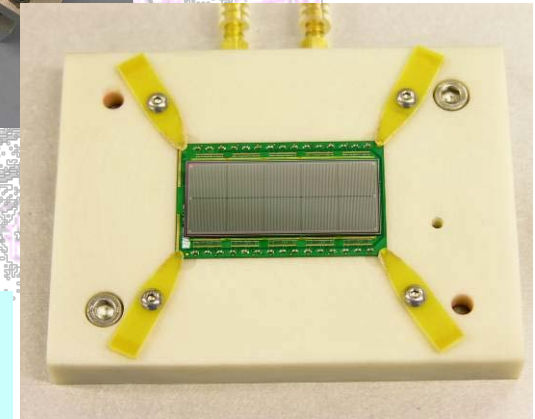
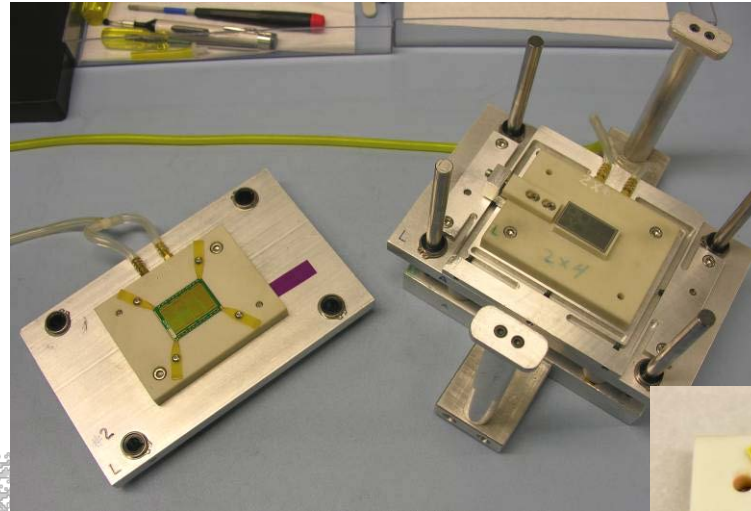
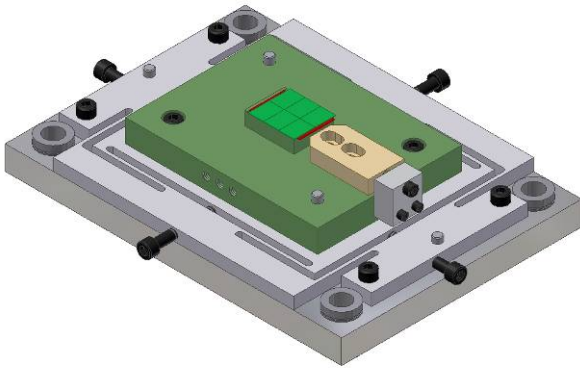
- Optical inspection stations
- Vacuum oven
- Microwave plasma etcher
- Environmental chamber
- Encapsulation station
- Dry cabinet storage

Shared equipment on campus including:

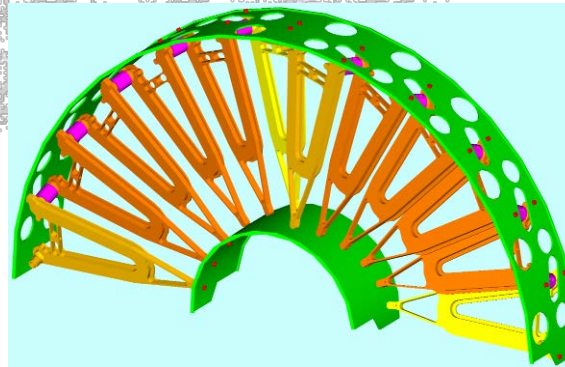
- Mask design, mask & detector fabrication
- SEM, Scanning Auger spectroscopy
- Ion Beam cutting, Reactive Ion Etcher
- Dicing saws
- Ribbon and Ball Wire bonders
- Profilometer, Ellipsometer, Tensile tester



# Custom Design

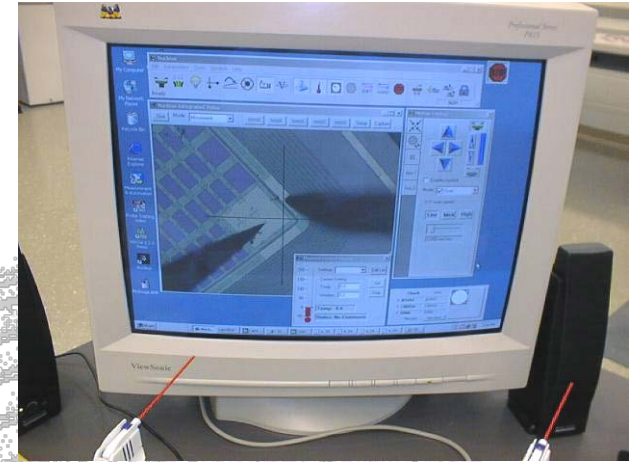


- CAD modeling for assembly and testing fixtures
- Design and engineering of detector mechanics
- Expert Purdue machine shops for fabrication



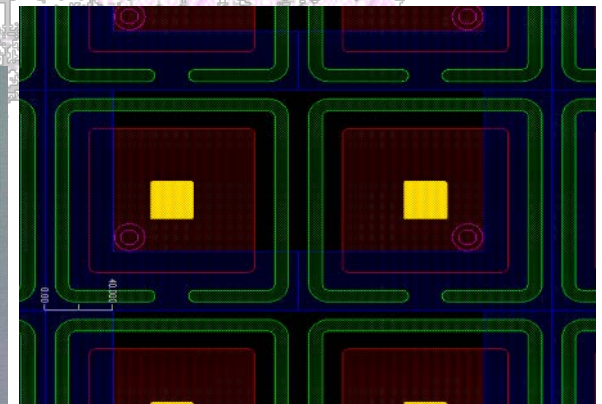
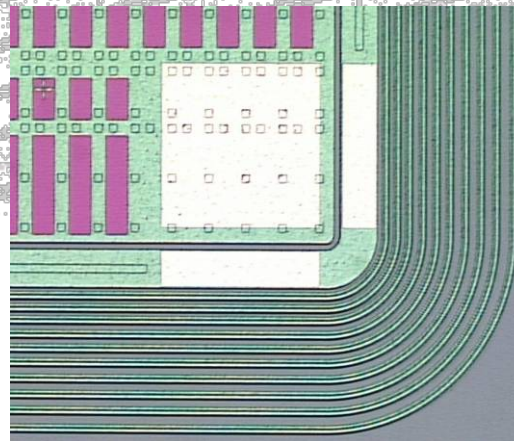
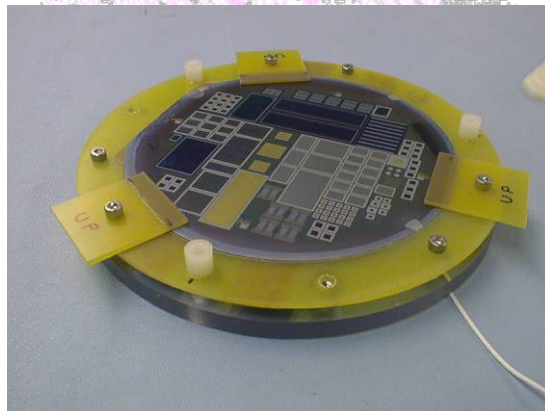
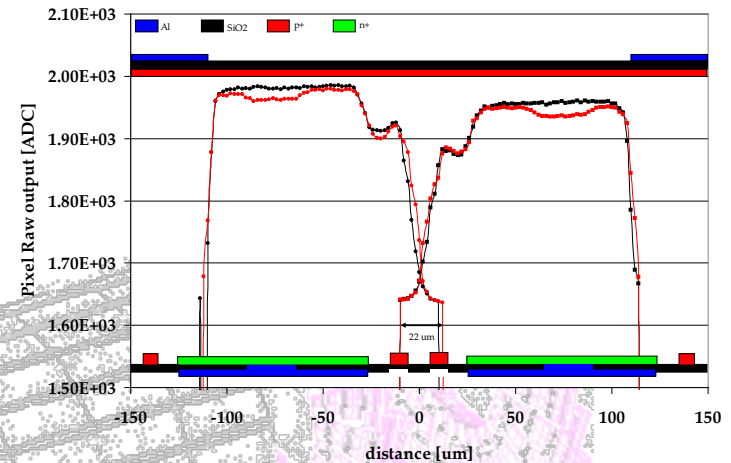
# Probe Stations

- 2 probe stations for device characterization, design and module de-bug, failure analysis
- Thermal chuck ( $-65^{\circ}\text{C}$  to  $200^{\circ}\text{C}$ )

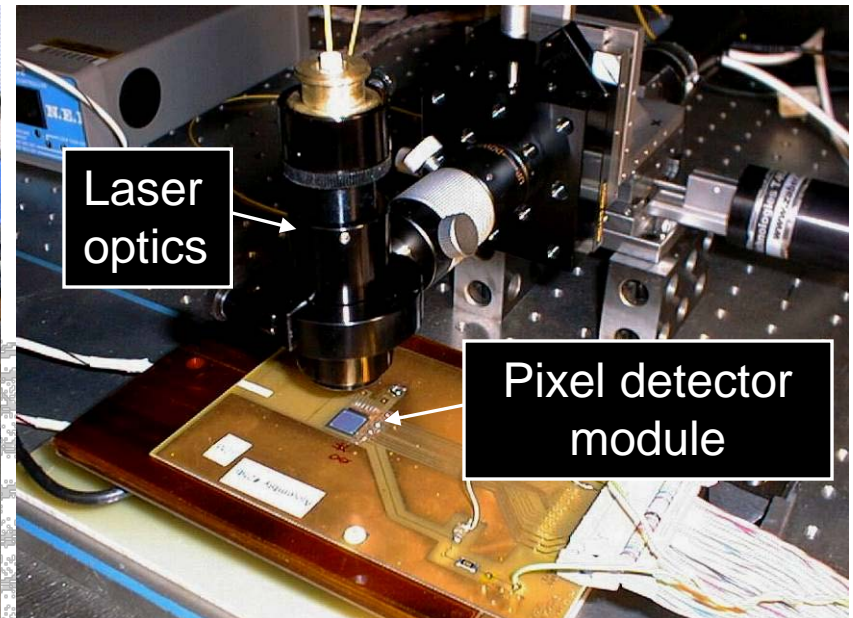
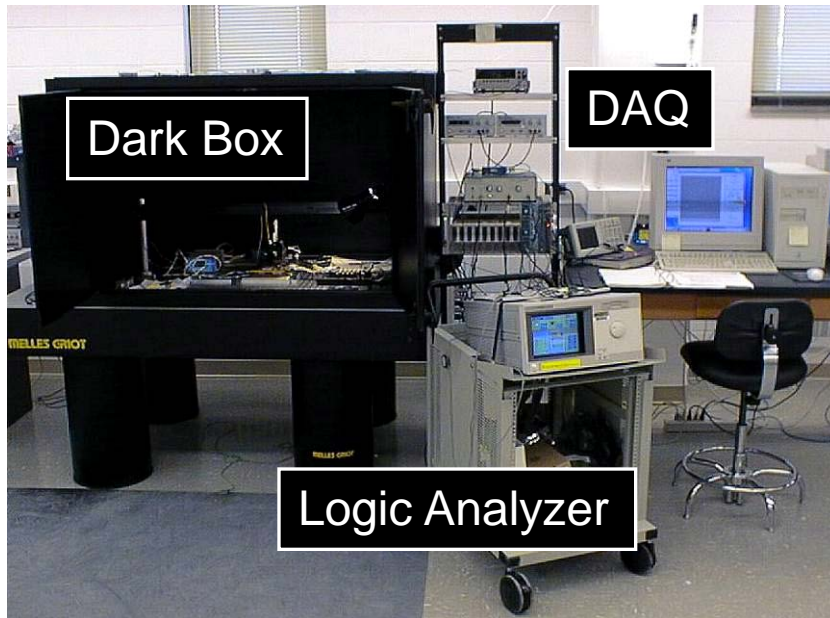


# Sensor Development and Testing

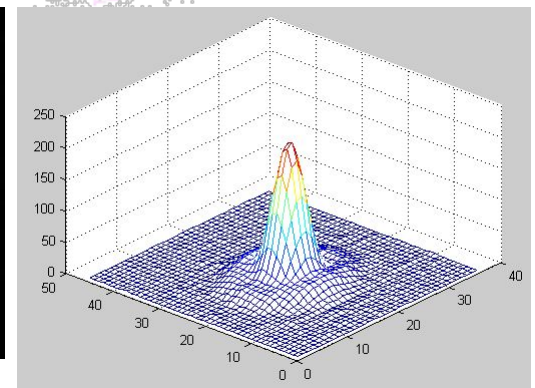
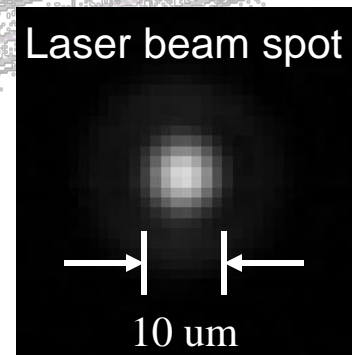
- Computer simulation of sensor performance
- DC characterization
- Charge collection efficiency
- Irradiation and aging studies



# Module electrical test station



- Test setup:
  - IR LED
  - IR Pulsed Laser
  - XYZ-axis motion
  - Thermoelectric cooling





# Experience

- **Design: CDF Run II Sensors, CMS-FPix sensors**
- **Fabrication: CLEO III SVX & CMS-FPix plaquettes**
- **Installation & Commissioning: CLEO III SVX, CDF Run II SVX & L00, CMS FPix**
- **R&D: Si pixel/strip & MPGD for SLHC and ILC**
- **Year-round research experience for undergraduate & graduate student instrumentation PhDs.**

# CMS Forward Pixel Detector

Purdue will assemble and test  
**~1000 Plaquettes**

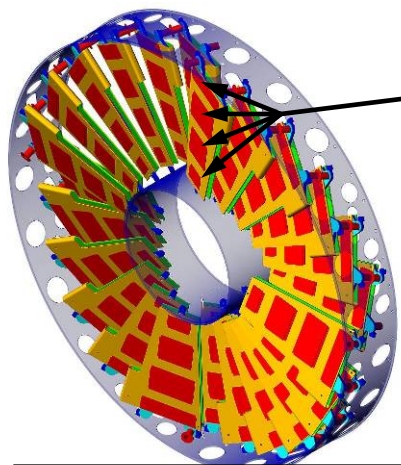
- Pixel Sensors bump bonded to Read Out Chips
- Very High Density Interconnects

Pixel Sensor

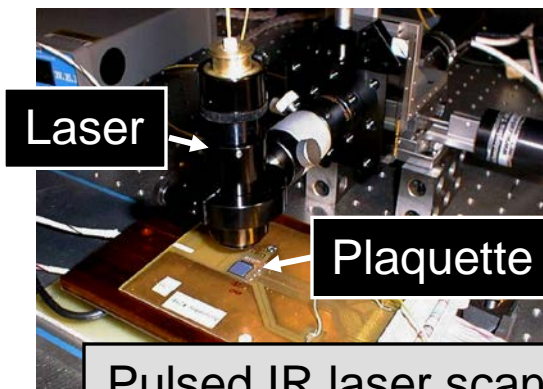
ROCs

VHDI

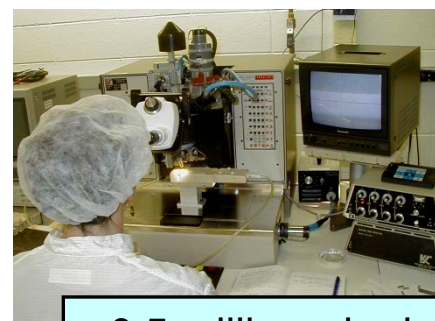
Plaquette



Forward Pixel Disk  
~3 million pixels

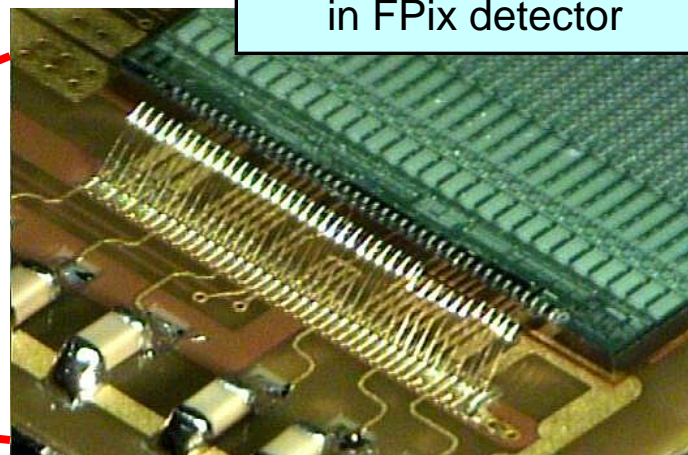
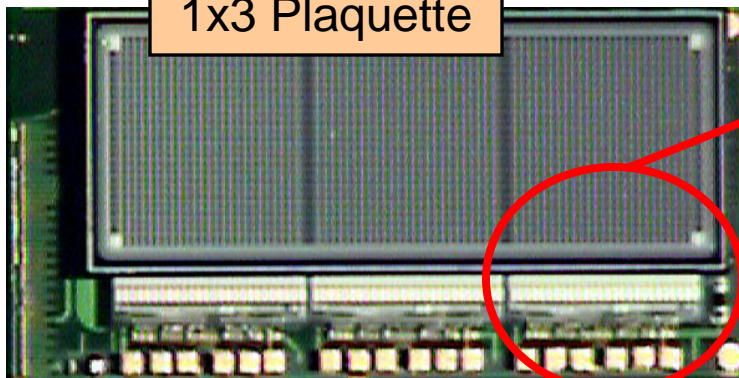


Pulsed IR laser scanning



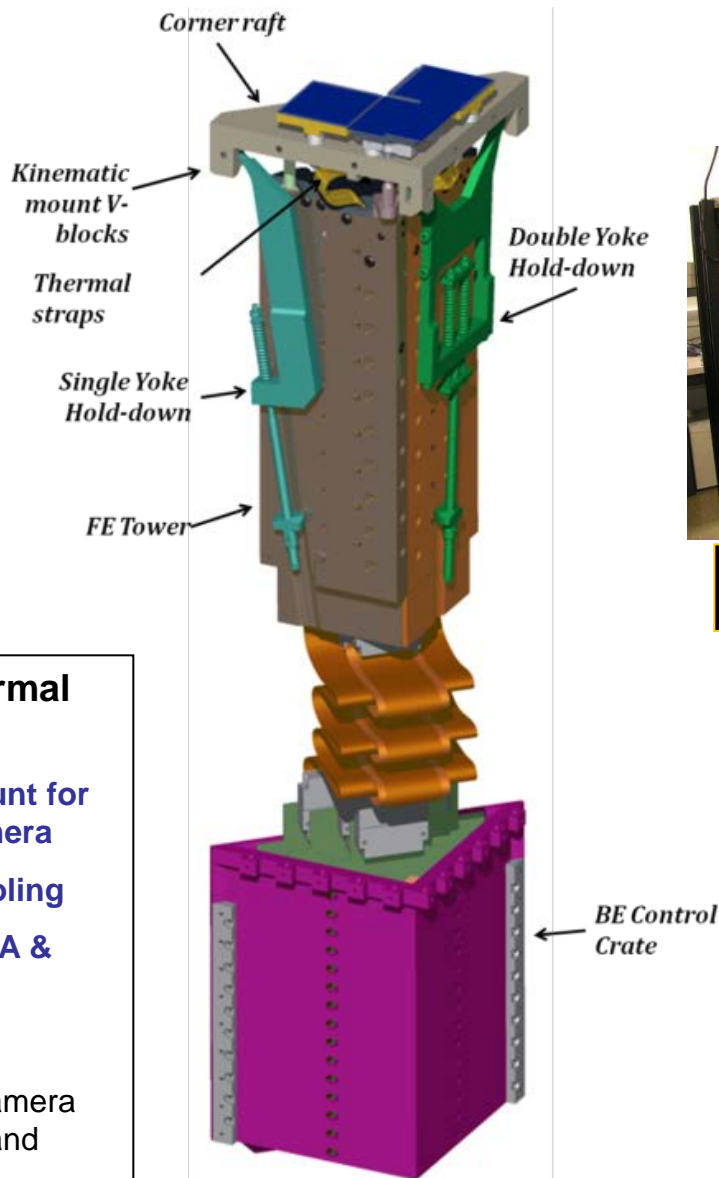
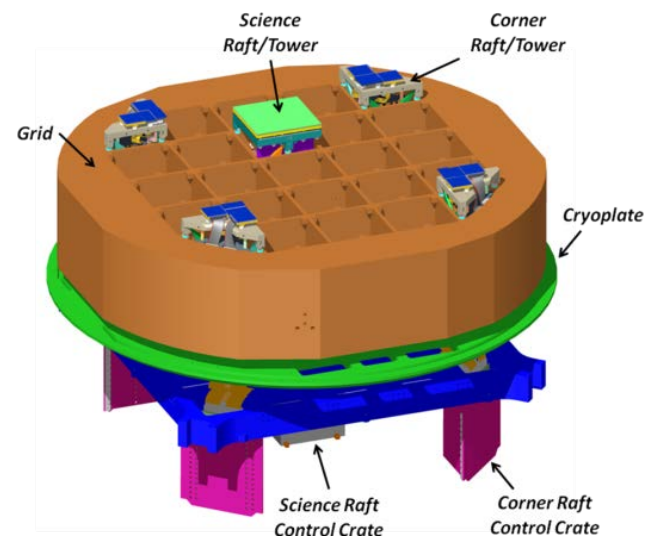
~0.5 million wire bonds  
in FPix detector

1x3 Plaquette

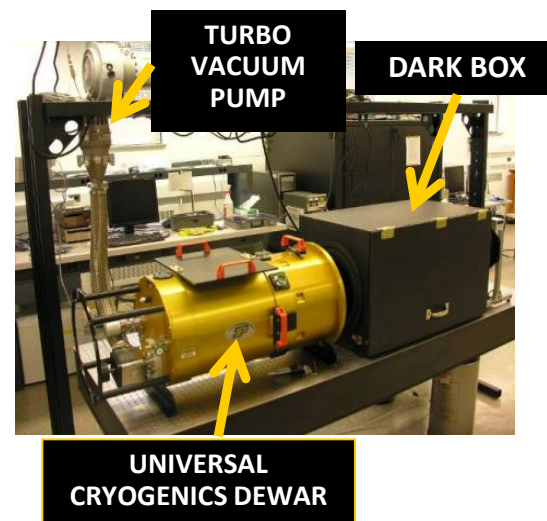


# LSST Instrumentation: Purdue is design & fabrication site for the Corner Rafts of LSST Camera

A challenging project  
146 million pixels/corner



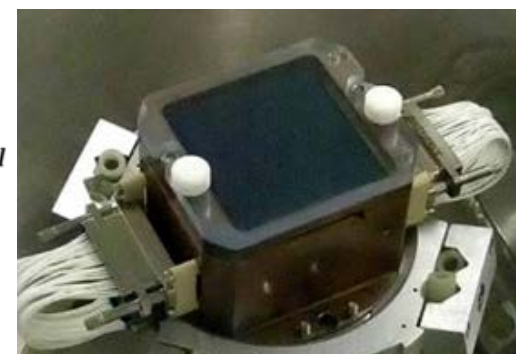
## CCD test station



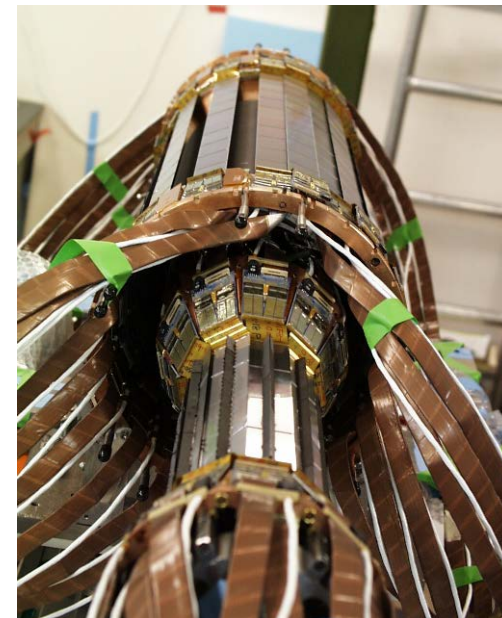
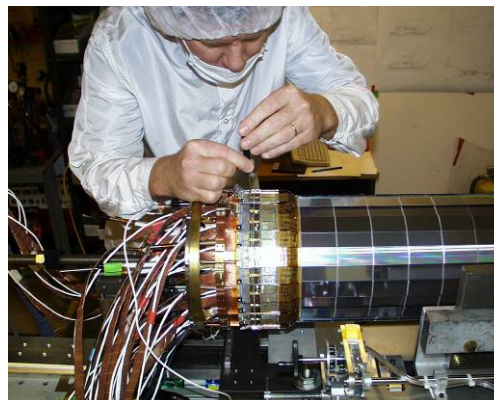
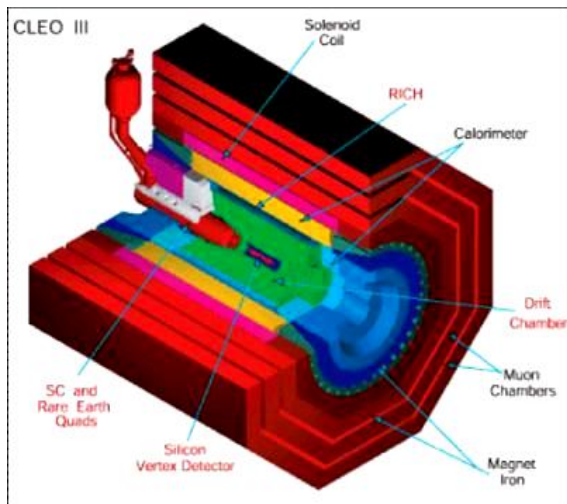
## Purdue leads mechanical & thermal design work

- Design for accurate and stable mount for sensors and electronics in the Camera
- Assembly sequence & insertion tooling
- Mechanical & Thermal analysis (FEA & prototype tests)
- risk & cost analysis
- Also contribute to design of overall Camera (Harvard, LLNL, BNL, Penn, Purdue and SLAC)

## CCD Guide Sensor

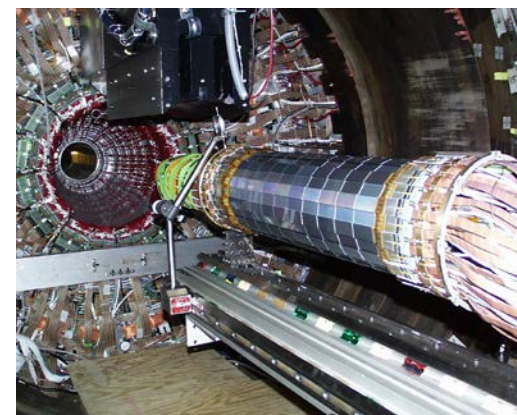


# CLEO III Silicon Vertex Detector

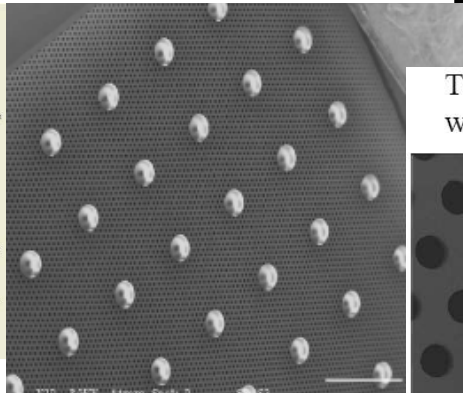
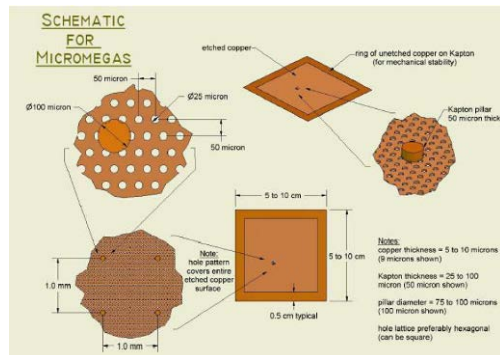


## Purdue responsibilities:

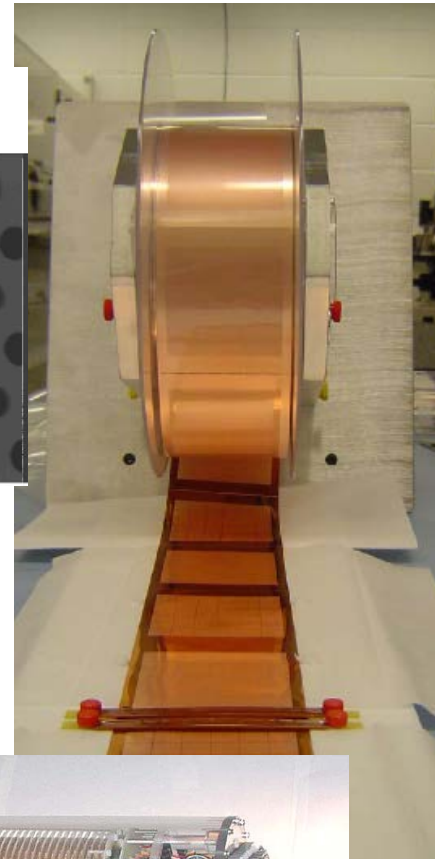
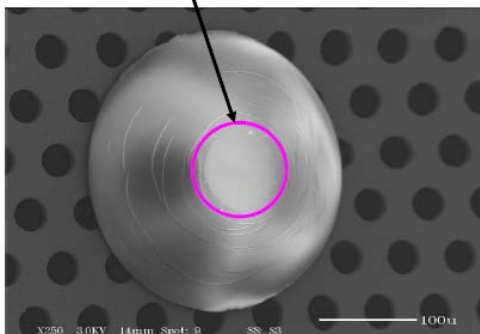
- Mechanical design and engineering
- Assembly of silicon strip ladders using CVD diamond for support, wire bonding, module testing
- Kinematic mounting of ladders on end cones
- Cooling system
- Transportation to Cornell, SVX installation into CLEO



# Micro Patterned Gas Detector Development



The flat area that has a contact with the anode board

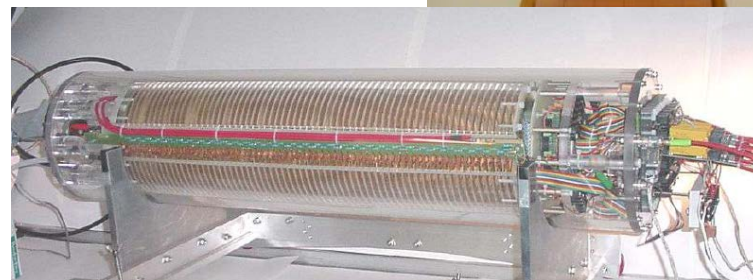


## Purdue Achievements

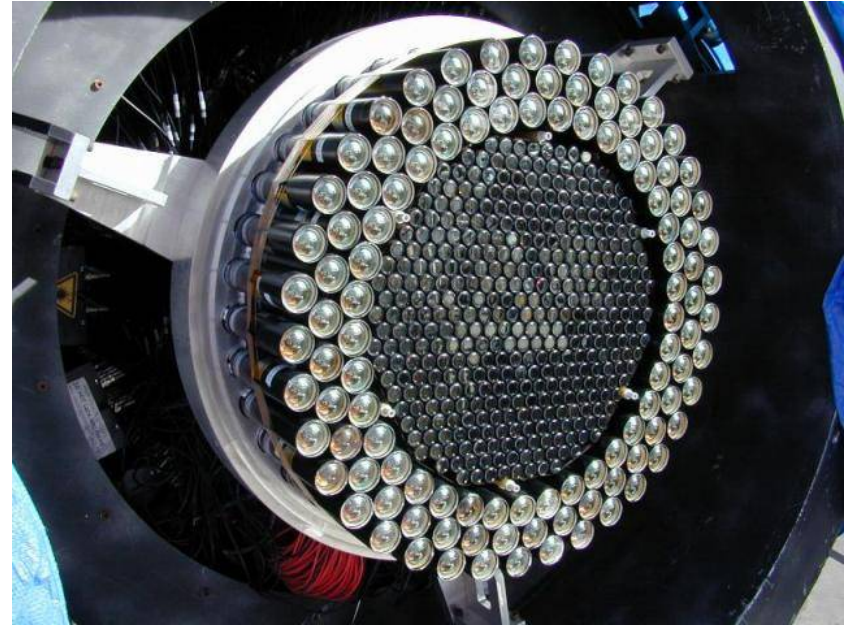
- 1<sup>st</sup> in US to fabricate a MPGD in-house
- 1<sup>st</sup> triple Gas Electron Multiplier
- Most rad hard MPGD
- 1<sup>st</sup> mass production of GEMs and Micromesh for MicroMegas detector
- Cornell TPC equipped with Purdue-3M MicroMegas as charge amplification device

## Facilities:

- X-ray generator for radiation hardness studies
- ultra clean custom stainless steel monitored gas system
- inspection scopes, digital and analog oscilloscopes
- multiple CAMAC/GPIB DAQ systems
- variety of commercial and custom electronics and diagnostics equipment



# Camera for Whipple Observatory



- Designed and managed the fabrication and assembly of an upgrade camera for the Whipple Observatory 10M Telescope.
- The camera was upgraded from the previous 331 pixel camera to a finer resolution 490 pixel camera comprising 379 half-inch and 111 one-inch Photo Multiplier Tubes.
- Each PMT mounted in a spring-loaded,  $\frac{1}{4}$ -turn fitting allowing in-situ replacement of individual PMT's in the camera
- Focal plane (front face of PMT's) flat to 50 microns