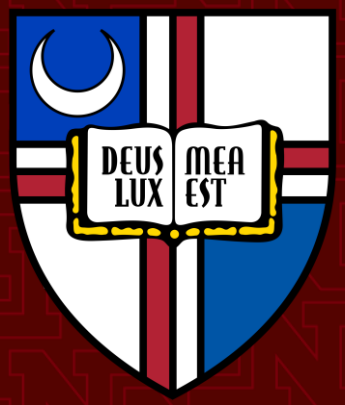


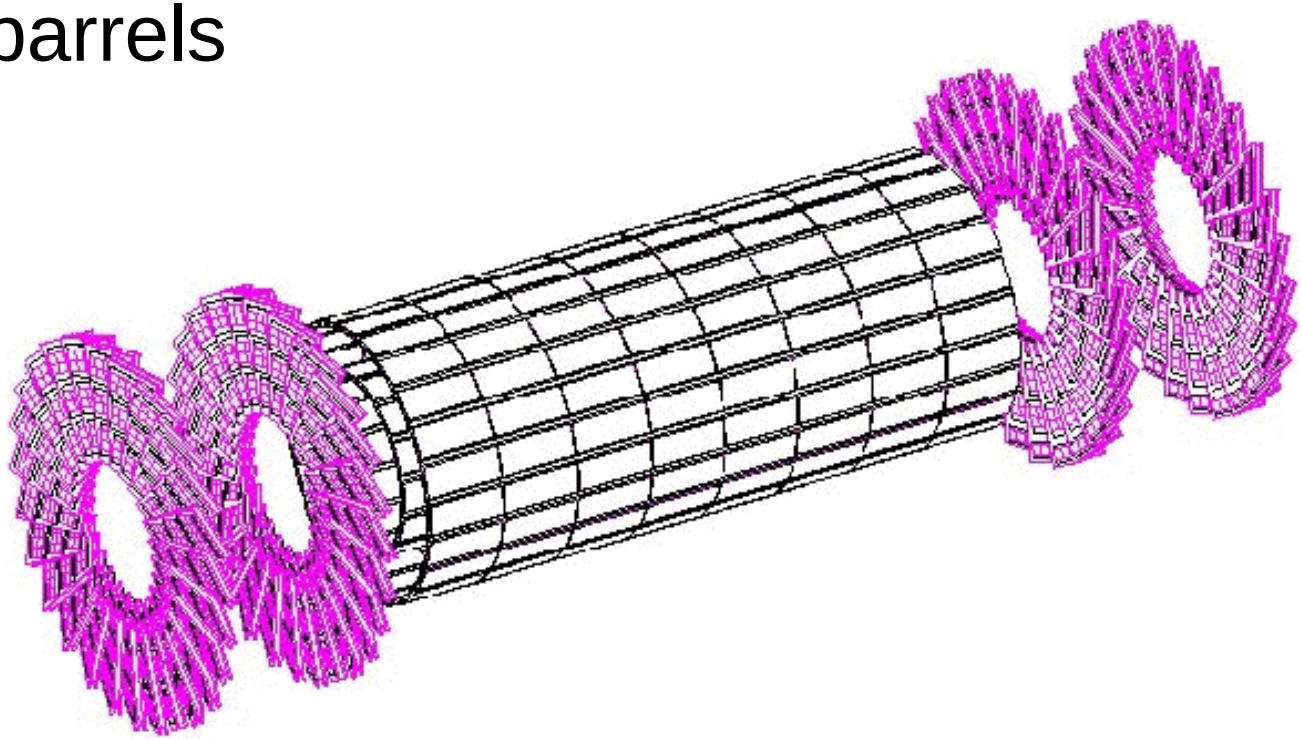
Assembly

Rachel Bartek

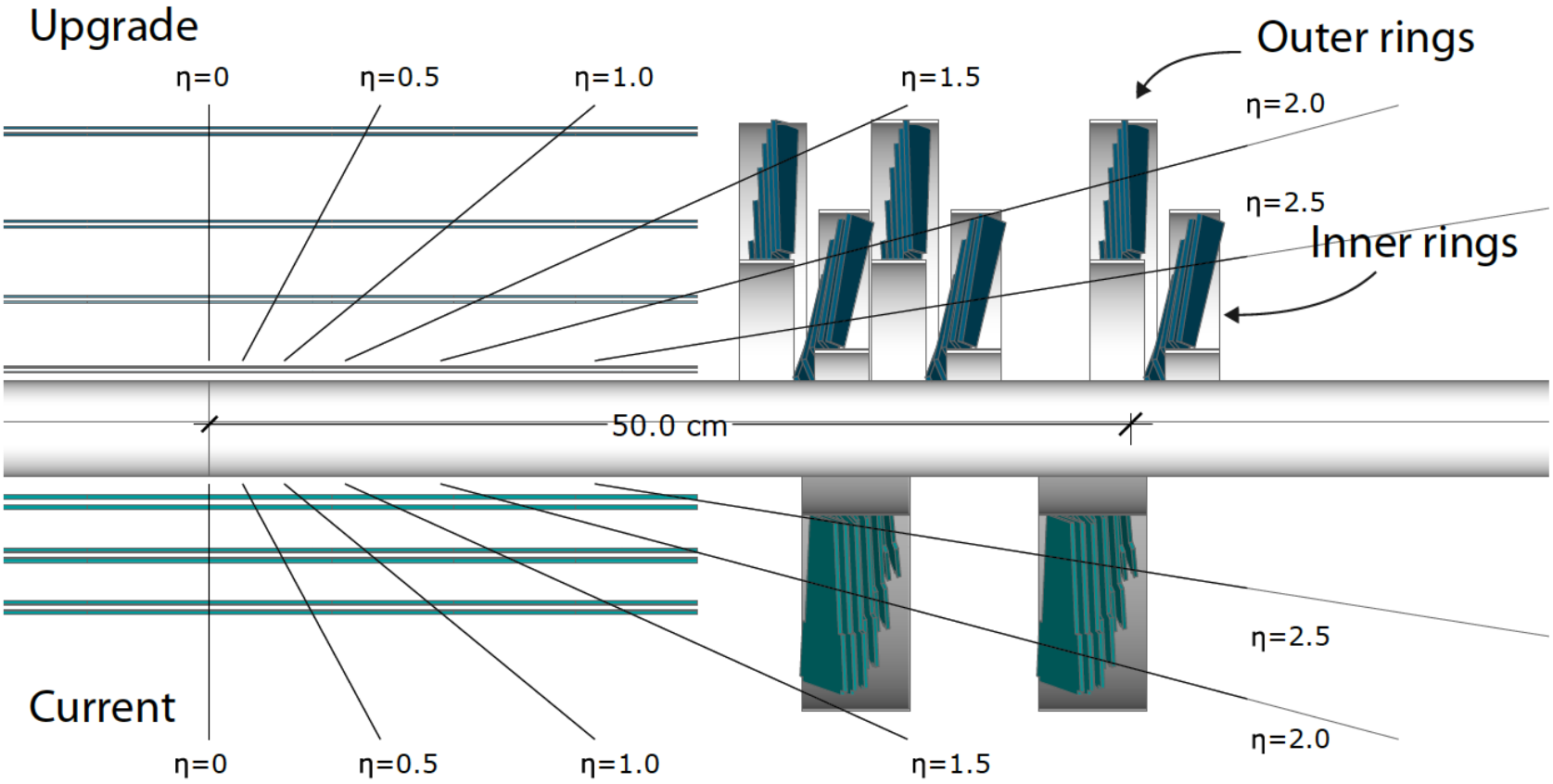
The Catholic University of America

Geometry

- We would like to build a spherical detector but the mechanics are tricky
- Disks become more cost effective than barrels

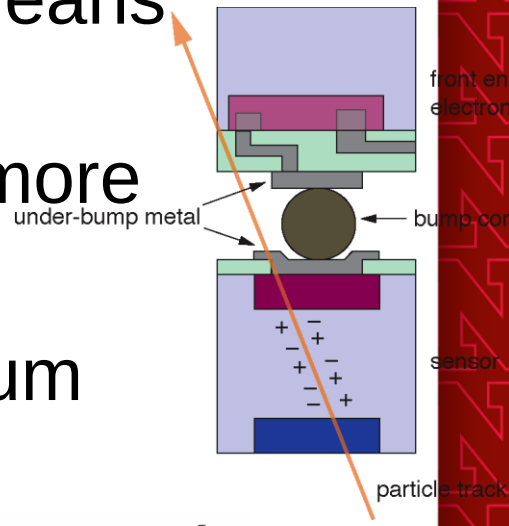


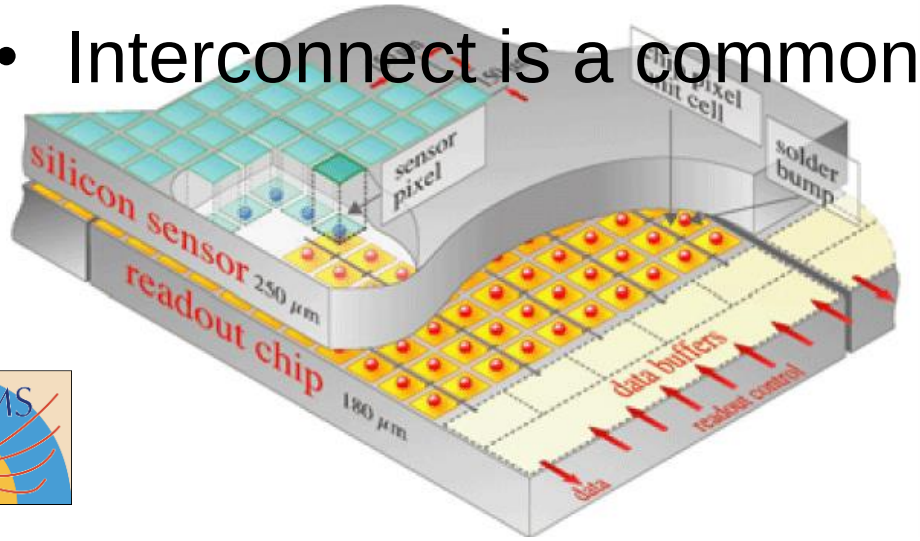
The CMS Phase I Pixel Upgrade

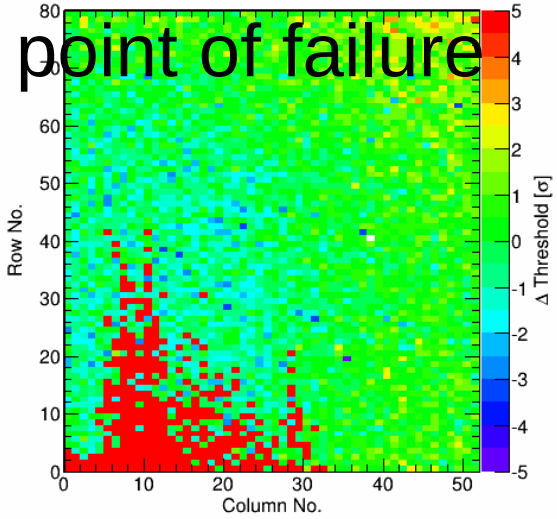


Pixel Unite Cell

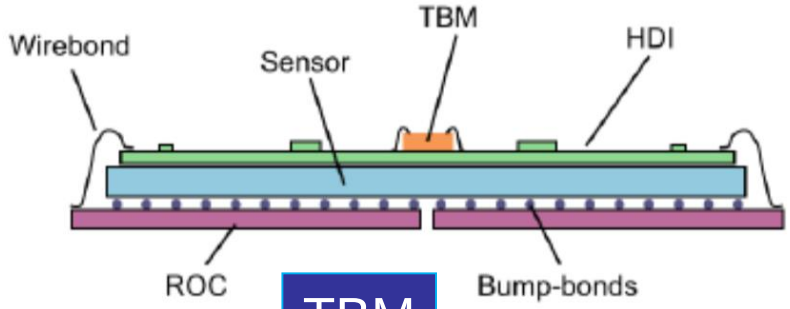
- Another dimension of information means more complex interconnect, more challenging electronics, and many more channels
- Hybrid pixel interconnect using indium bump bonds
- Interconnect is a common point of failure







Anatomy of a module



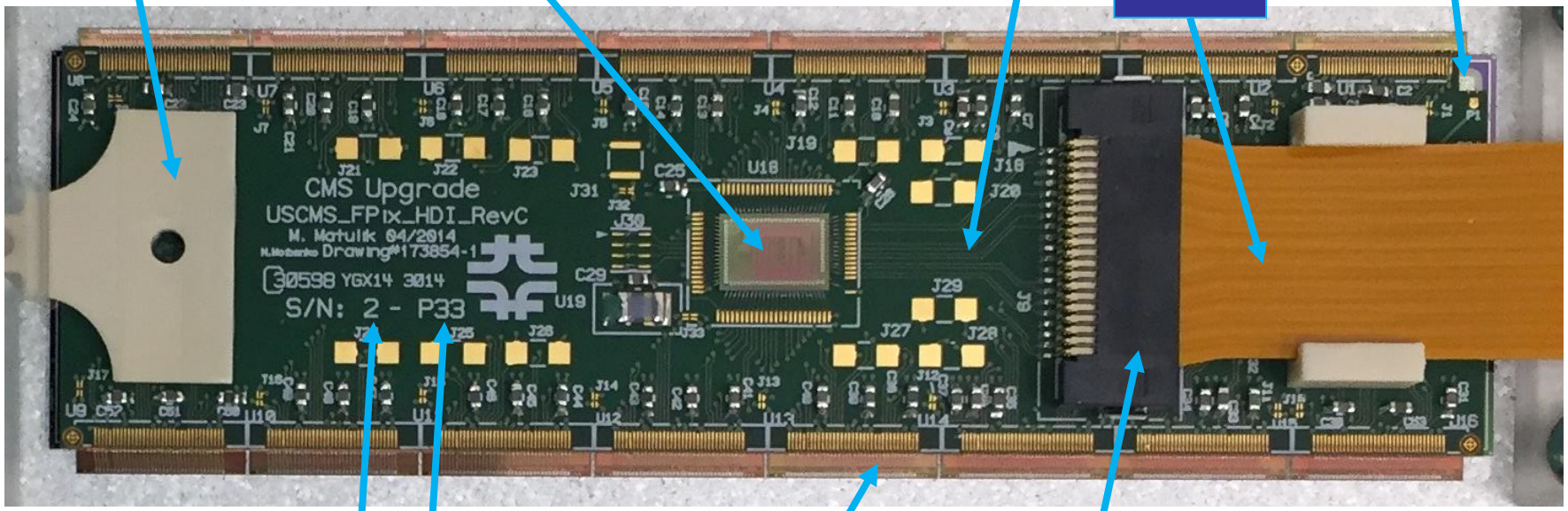
End holder

TBM

HD

Flex cable

HV pad



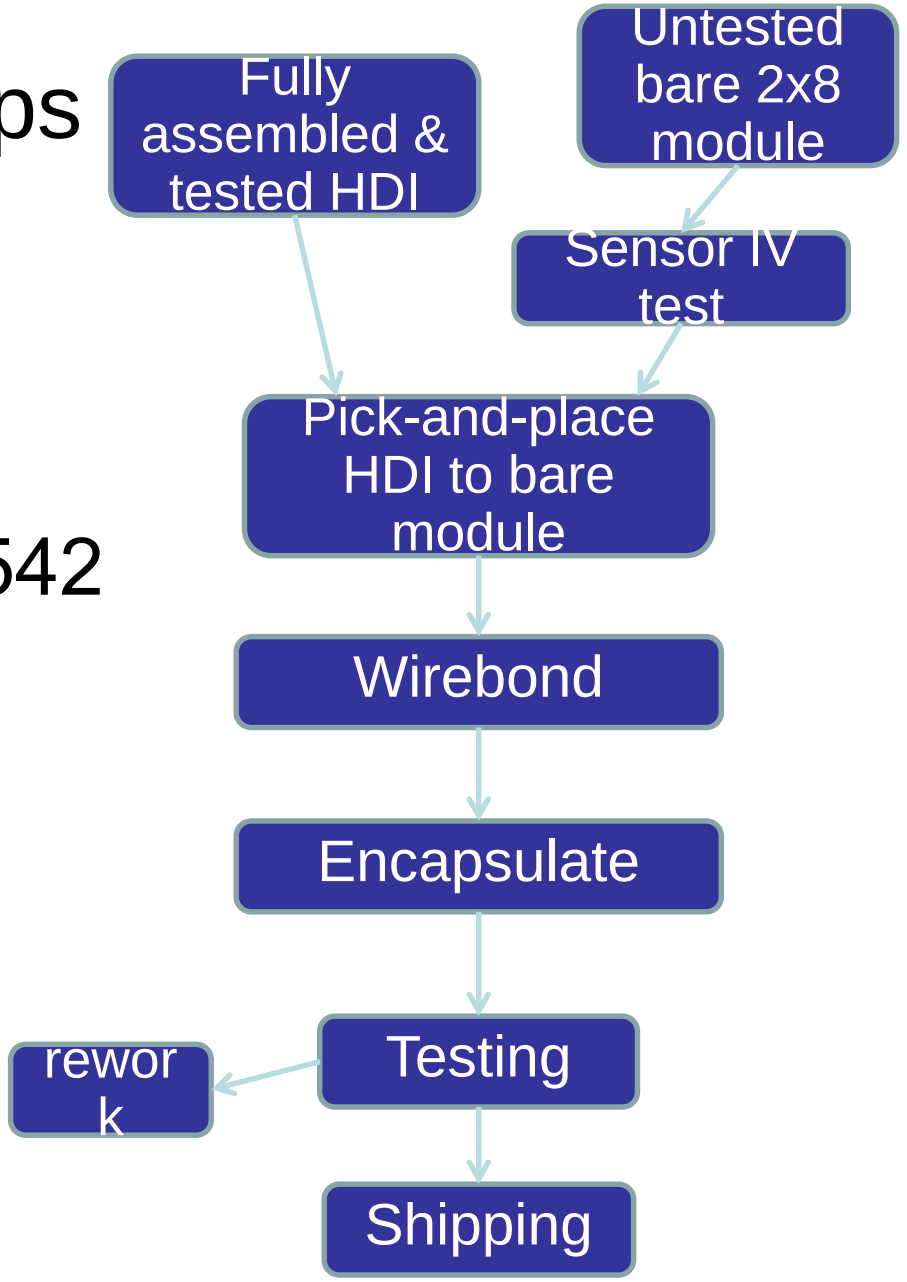
M-?-2-33

2x8 ROC

Connector

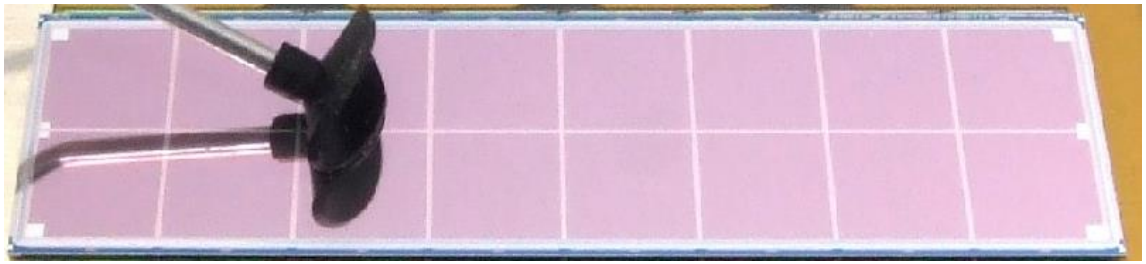
Assembly Steps

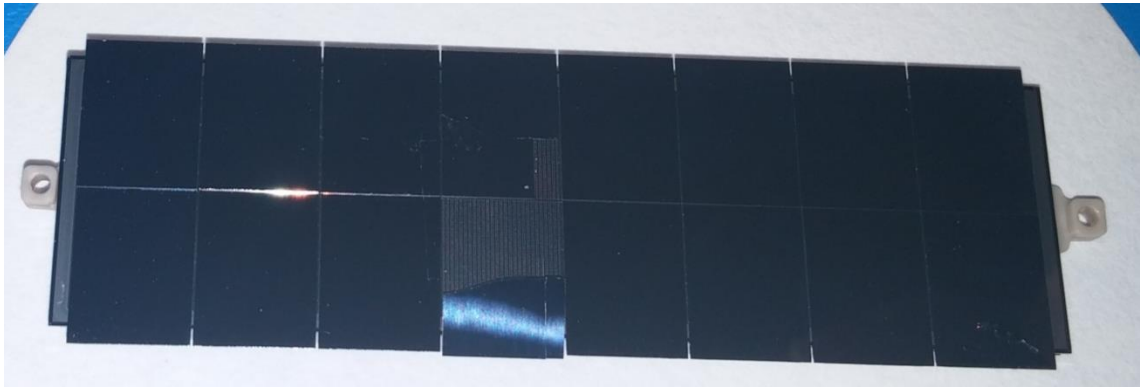
- Tasked with making 500 modules
- We've made 542



Bare Module

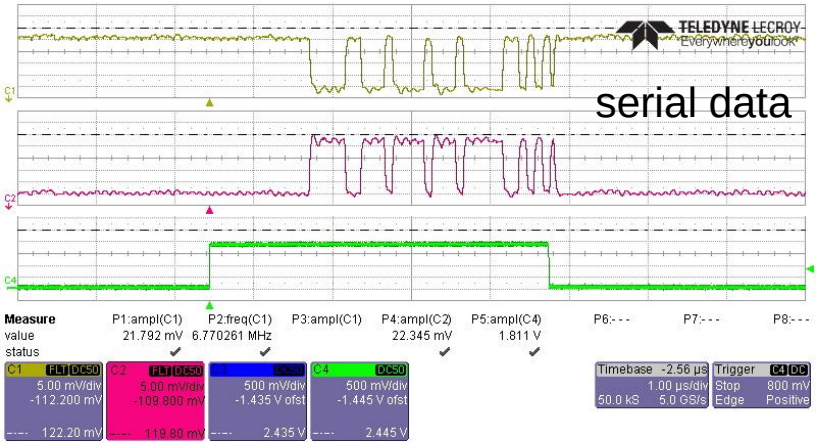
- 16 ROCs bump bonded to one sensor

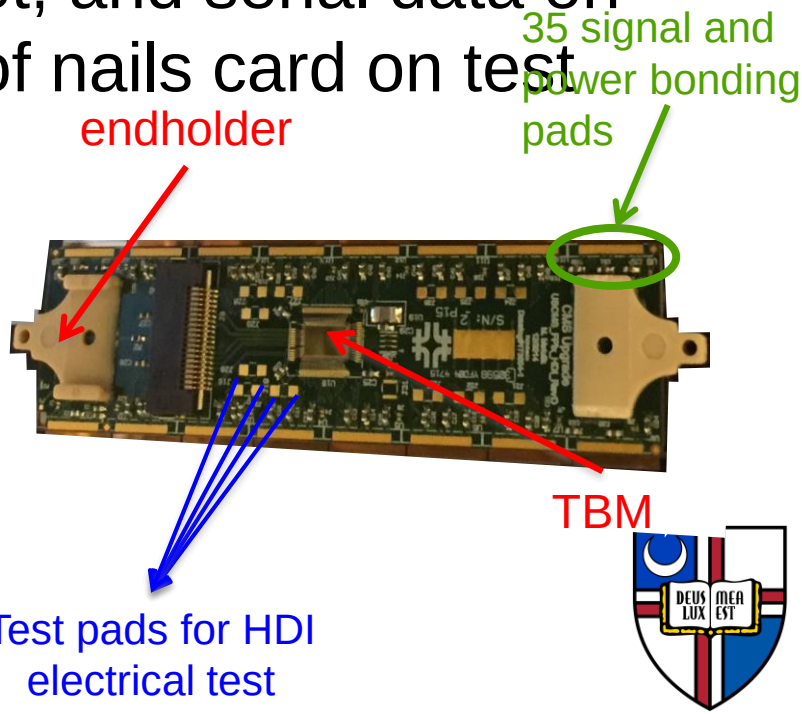




HDI Testing

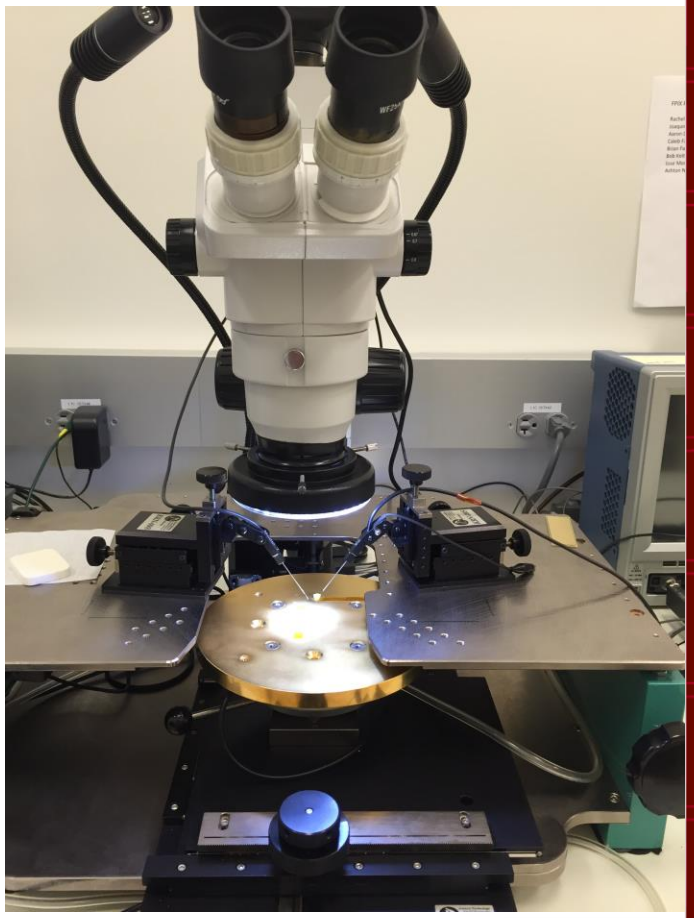
- HDIs tested before shipped to assembly sites
  - Test pads for high voltage, low voltage, clock, calibration, trigger, reset, and serial data on HDI read through bed of nails card on test





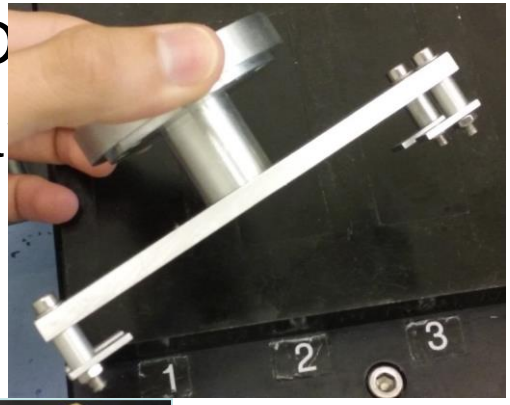
Reception of bare modules

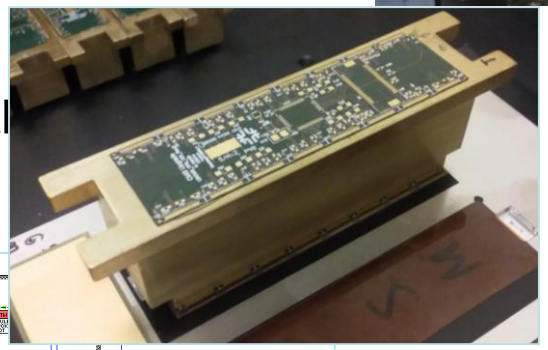
- Remove packaging material unsuitable for cleanroom
- Open ESD safe package in cleanroom
- Perform visual inspection
  - Check for visible defects from shipping on both sides
- Take IV curve
- Place in dry air cabinet in drawer labeled “visually

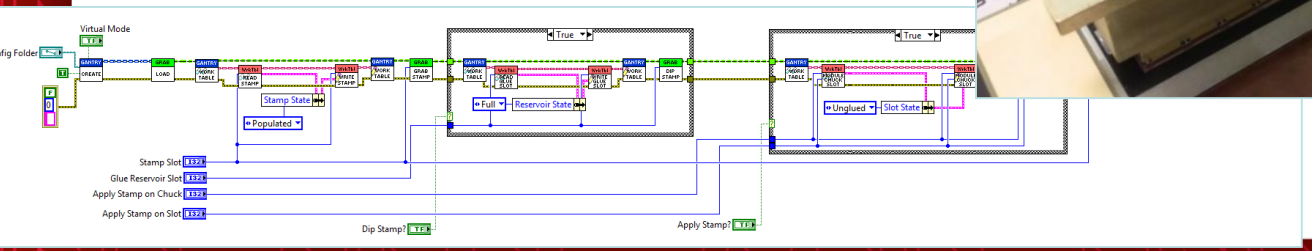


Gluing HDI to bare module

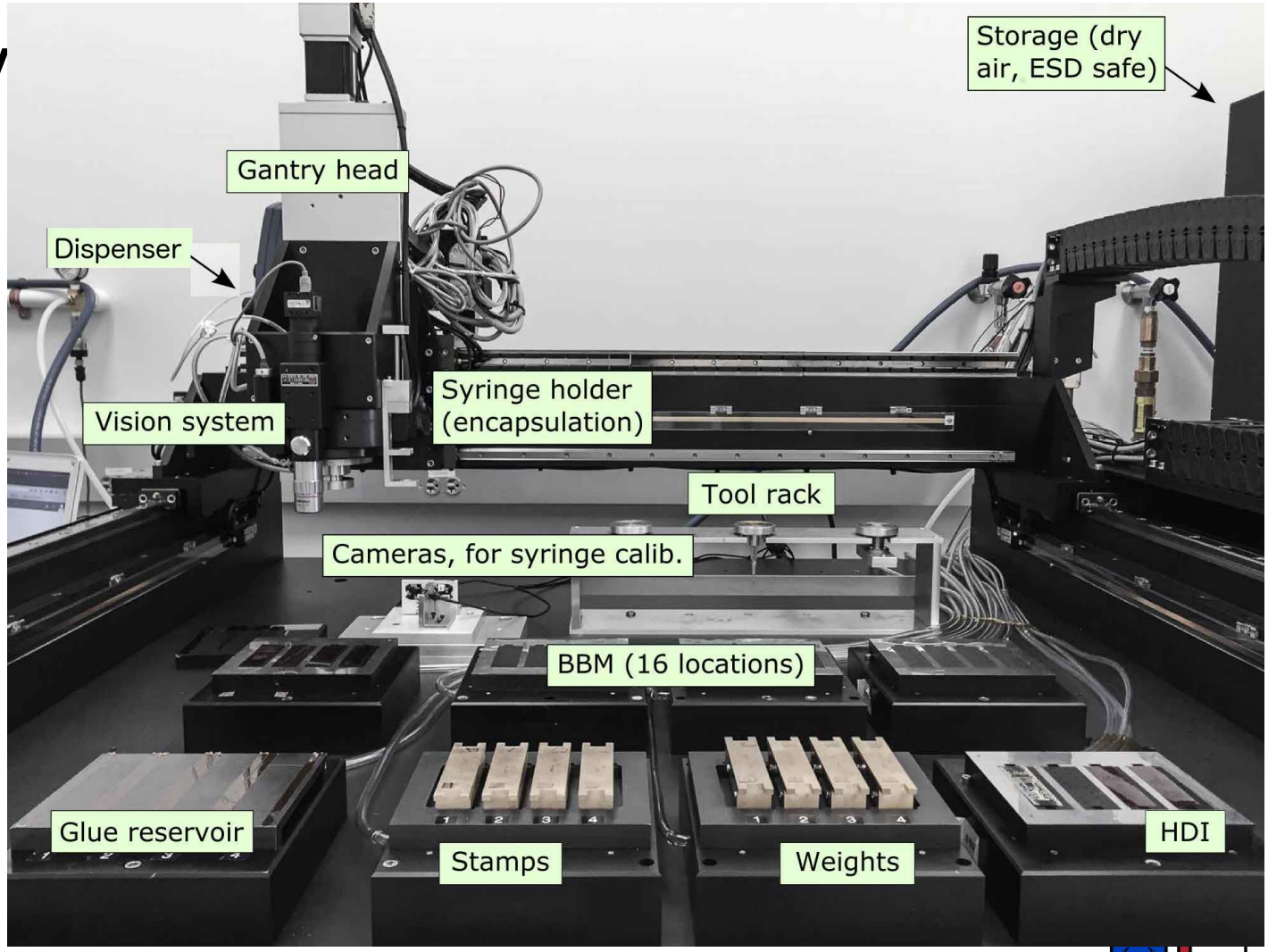
- Robotic gantry using custom tools (next slide)
- LabVIEW program includes the following steps:
  - Get fiducials of bare module and HD
  - Apply glue to bare module using sta
  - Pick and place HDI on bare module
  - Place curing weight on HDI
  - Glue cures for 10h
  - Remove weights by ha





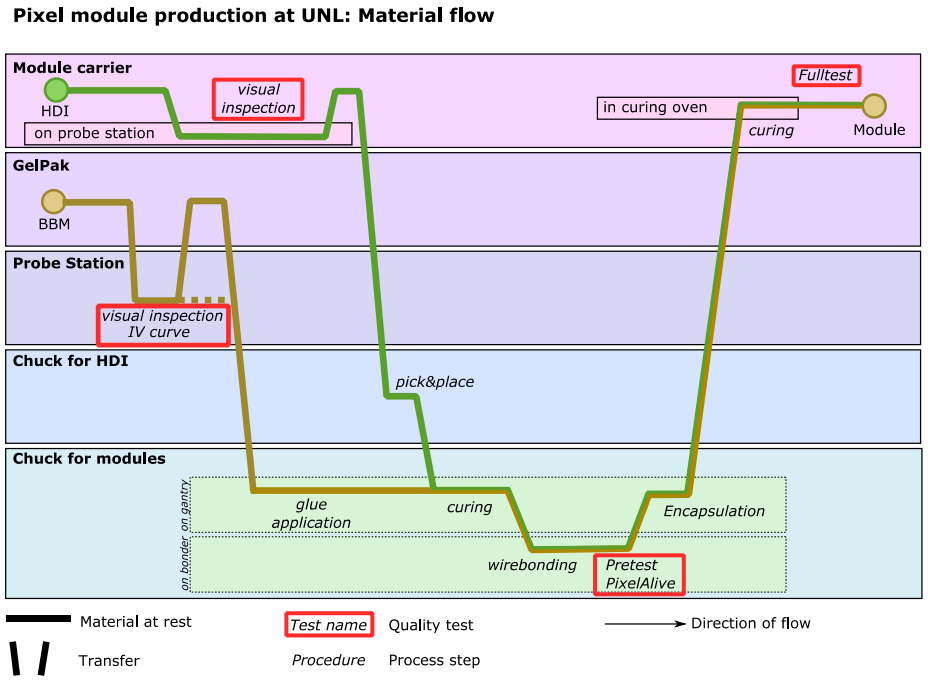


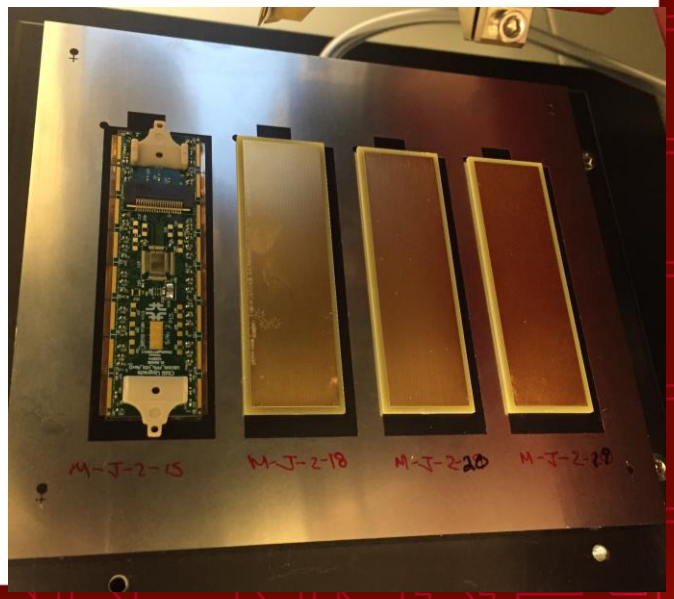
Gantry


Storage (dry air, ESD safe)
Gantry head
Dispenser
Vision system
Syringe holder (encapsulation)
Tool rack
Cameras, for syringe calib.
BBM (16 locations)
Glue reservoir
Stamps
Weights
HDI

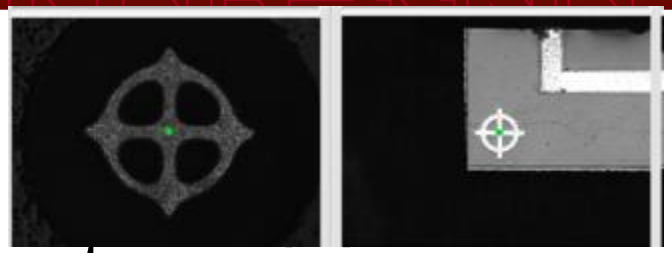
Module Chucks

- Stencils of 100 µm thickness give a good reference position for the bare module
- Work flow designed with chucks in mind

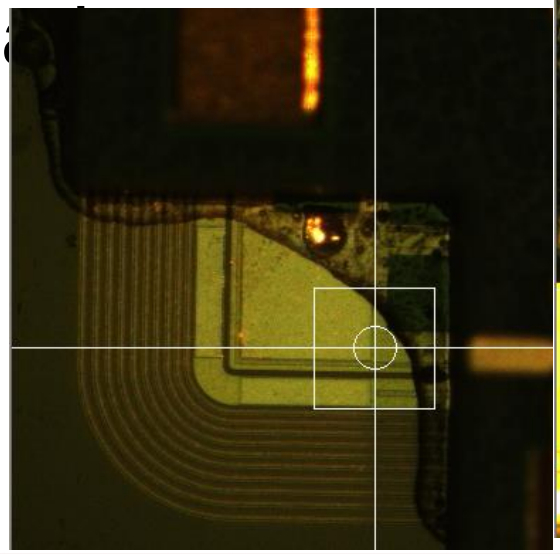


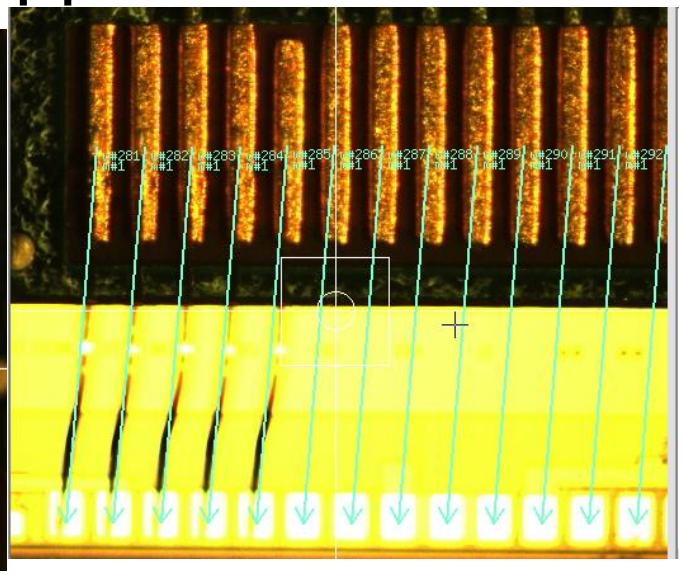


Alignment

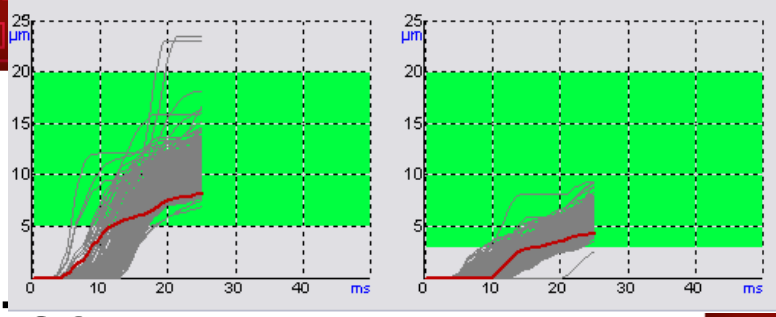


- Use fiducials to get precision measurement of location of parts
- Rotation in wrong direction went unnoticed due to excellent alignment of chucks
- Glue needs to support HDI wire bonding pa

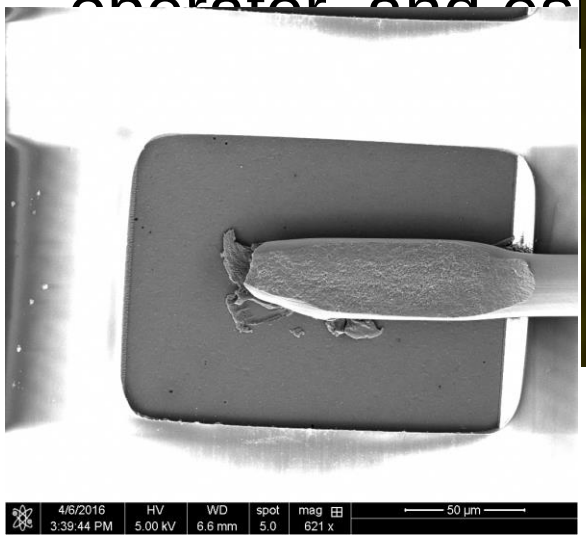


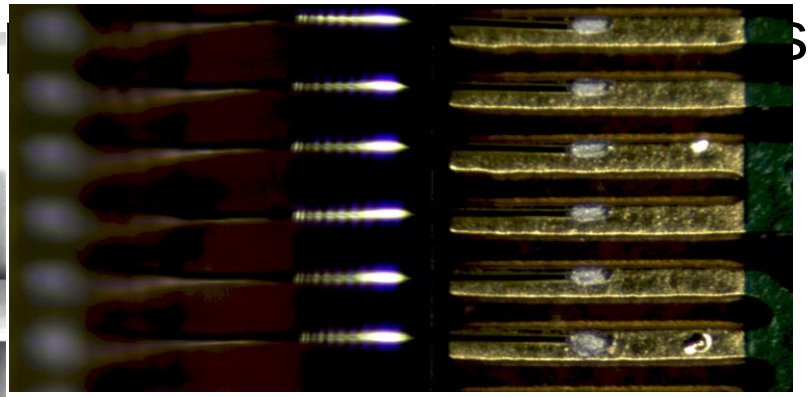


Wirebonding



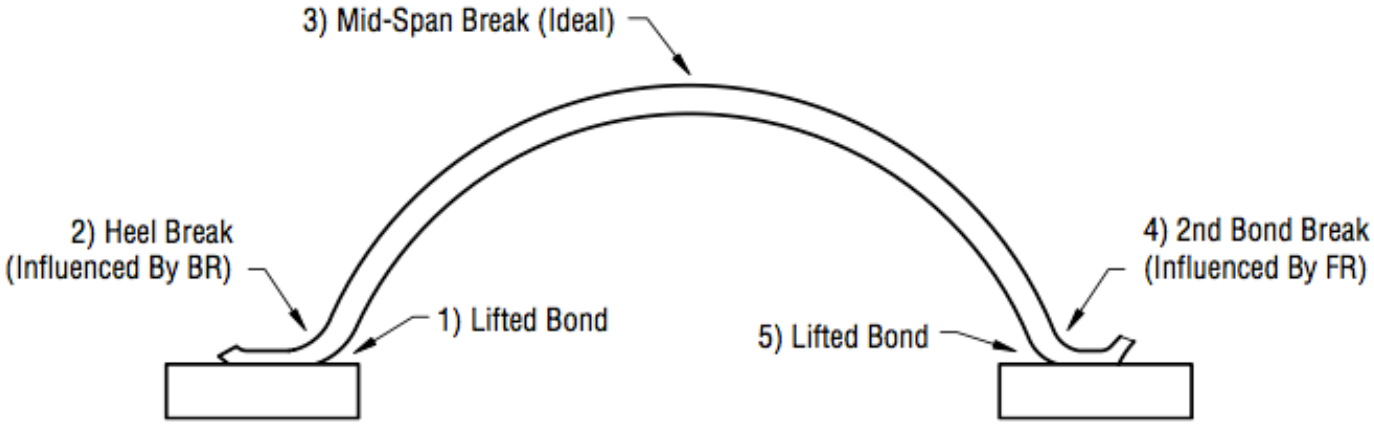
- Aluminum ultrasonic welding
  - Aluminum 45º wedge bonding achieves finest pitch
- This is a bit of an art
  - Getting good bonds depends on machine, operator, and ca[illegible]s





Pull tester

- Pull tester head part of wire bonder
  - Take about a minute to change from bonder to pull tester
- Perform acceptance test for every batch of HDI
- Hook measures force where bond breaks



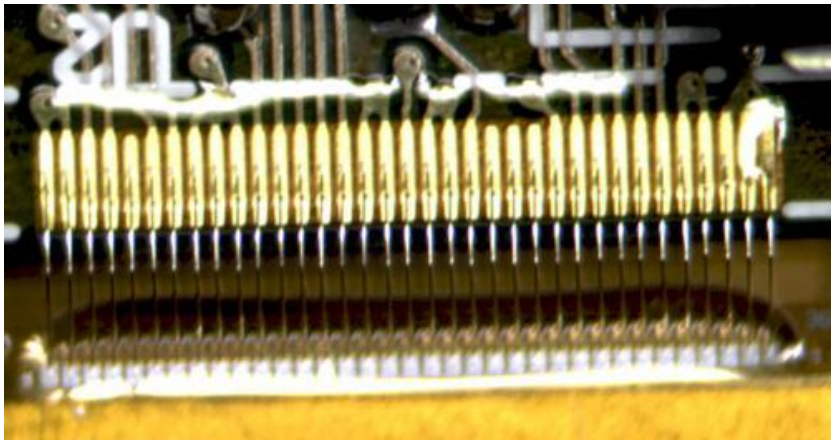
Preferred Failure Modes

- Mid-Span Break (Bond Strength exceeds Wire Tensile Strength)
- 2nd Bond Break
- Heel Break

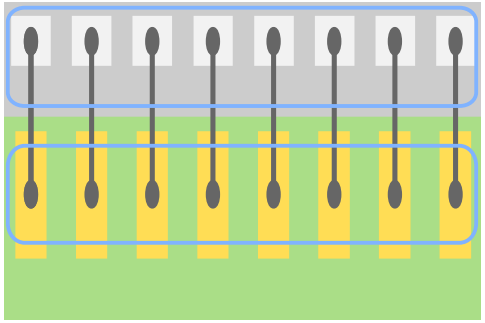
Undesirable Failure Modes

- Low-Strength Heel Breaks
- Lifted Bond

Encapsulation



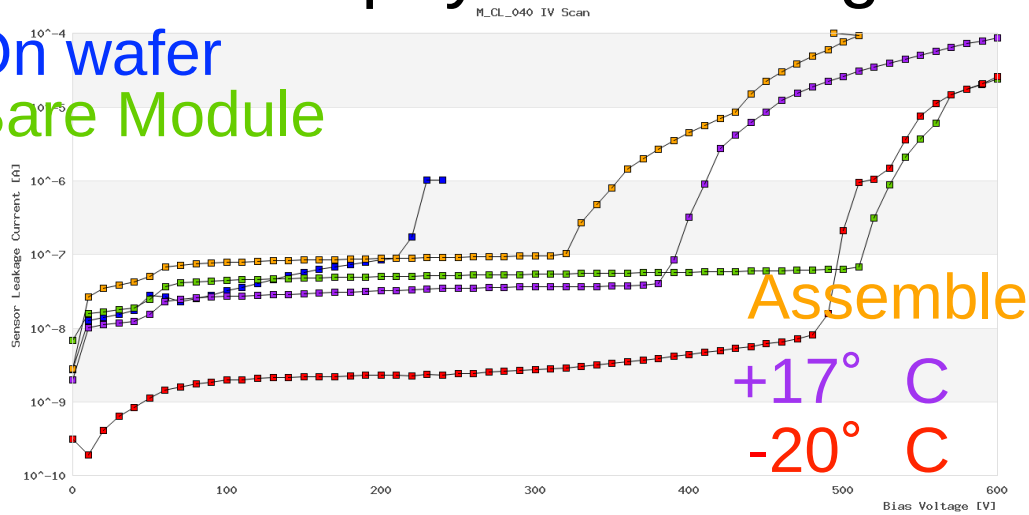
- Why encapsulate?
  - CDF wirebond resonance
  - Humidity control (Dendrites)
- Centrifuge used to remove air bubbles after mixing
- Labview program includes the following steps:
  - Get fiducials of bare module and HDI
  - Calibrate needle
  - Start the flow of Sylgard to needle tip
  - Deposit Sylgard on all bond feet
    - Speed of gantry slows as time from mixing increases



- Module transferred to carrier and placed in curing oven
  - One hour at 50° C

V_{bias} vs I curves

- A high quality detector will have a low leakage current
  - Strongly temperature dependent
  - Require breakdown to be > 150V
- Current can be affected by surface defects, impurities and physical damage



On wafer

Bare Module

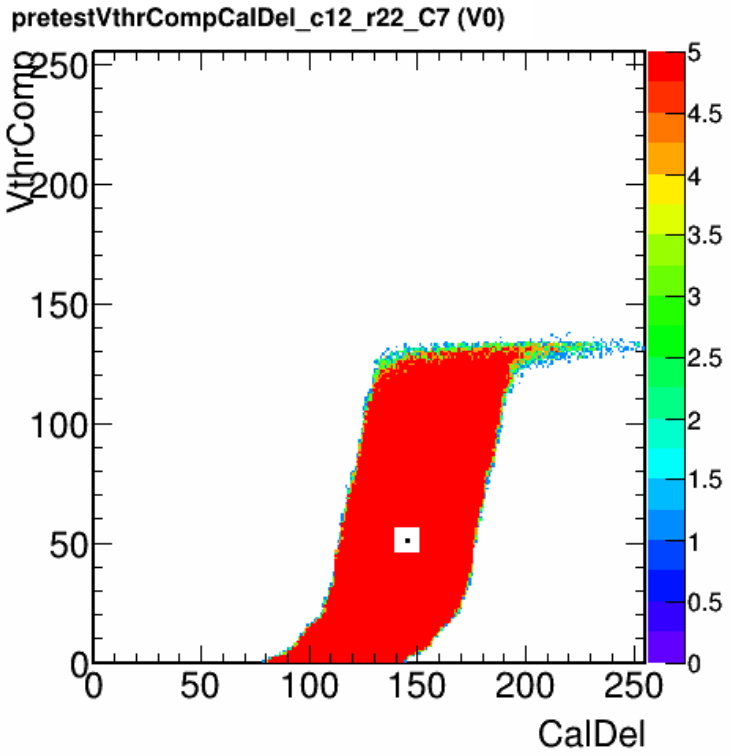
Assembled Module

+17° C

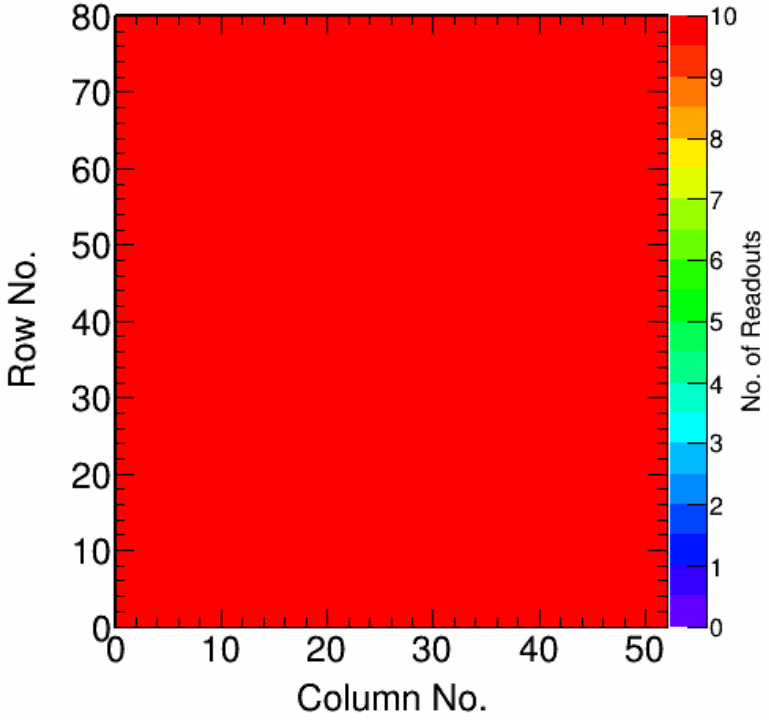
-20° C

Basic functionality tested

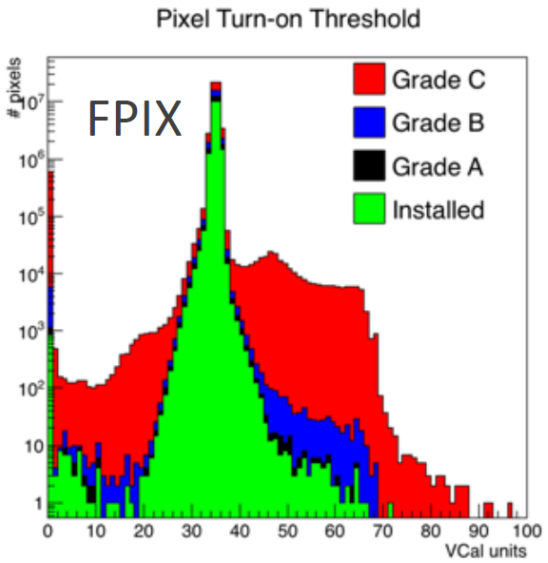
Optimal working

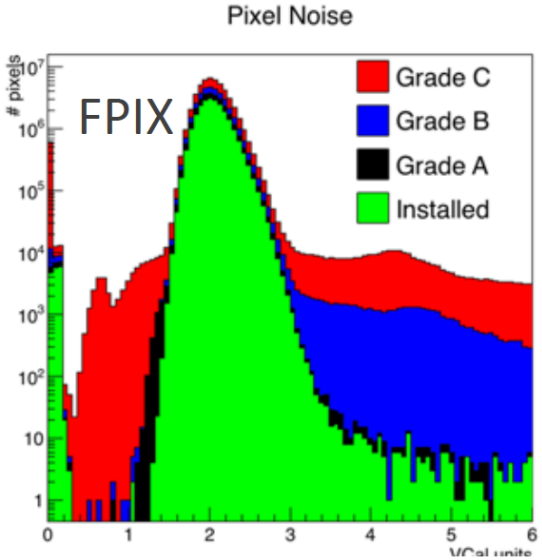


Pixel Alive

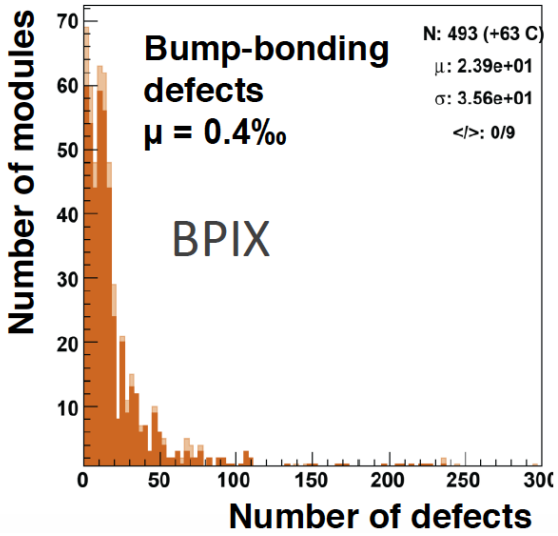


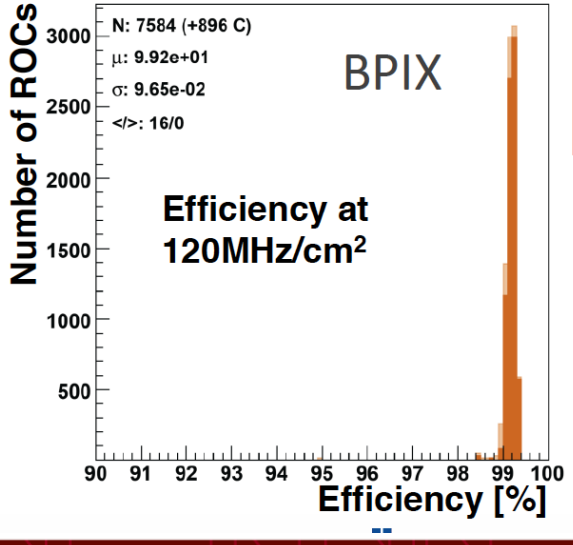
Full Electronic Qualification





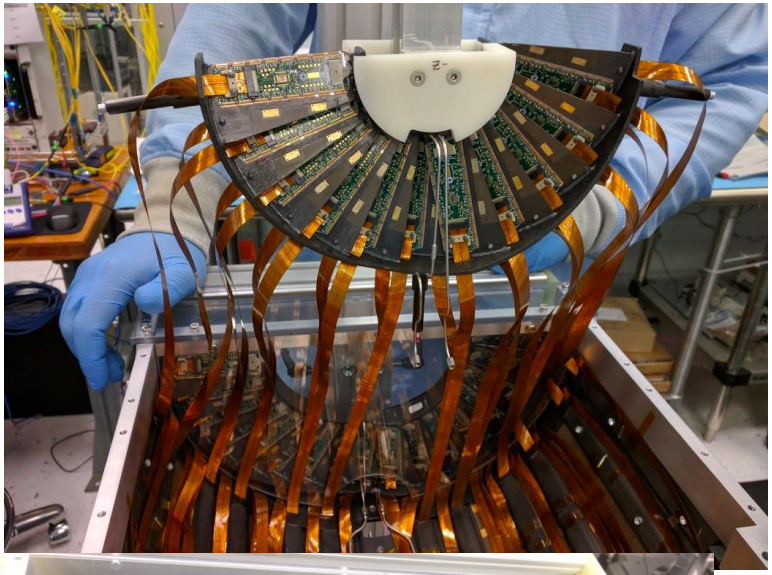
Preliminary

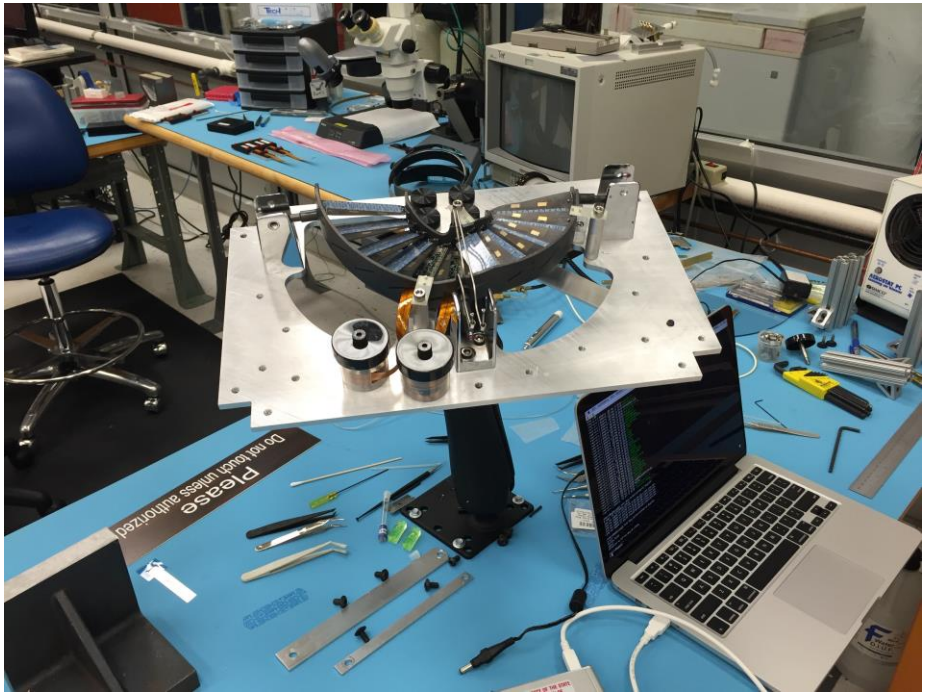




Mounting on disks

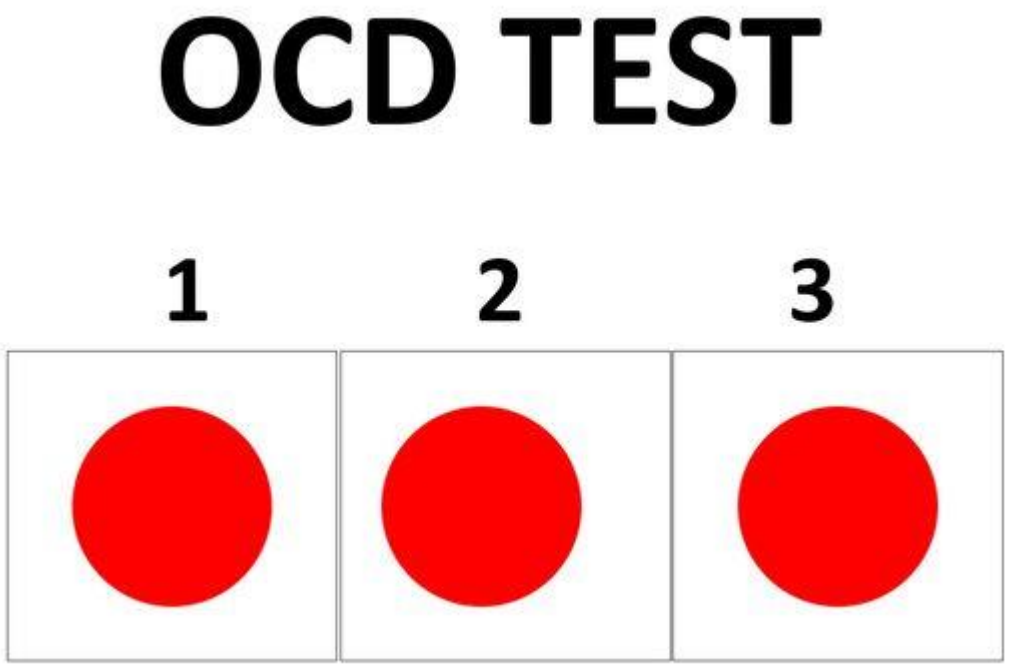
- At FNAL





How to silicon

If you don’t know what is wrong with this picture, please keep your hands in your pockets at ALL times while in the lab



Summary

- Silicon is not for the faint at heart
- Silicon enabled us to do physics at higher luminosities
- CMS Phase I Upgrade of the pixel detector is on target for installation during EYETS