Recent Progress in Silicon Modules and Scintillator Calorimetry

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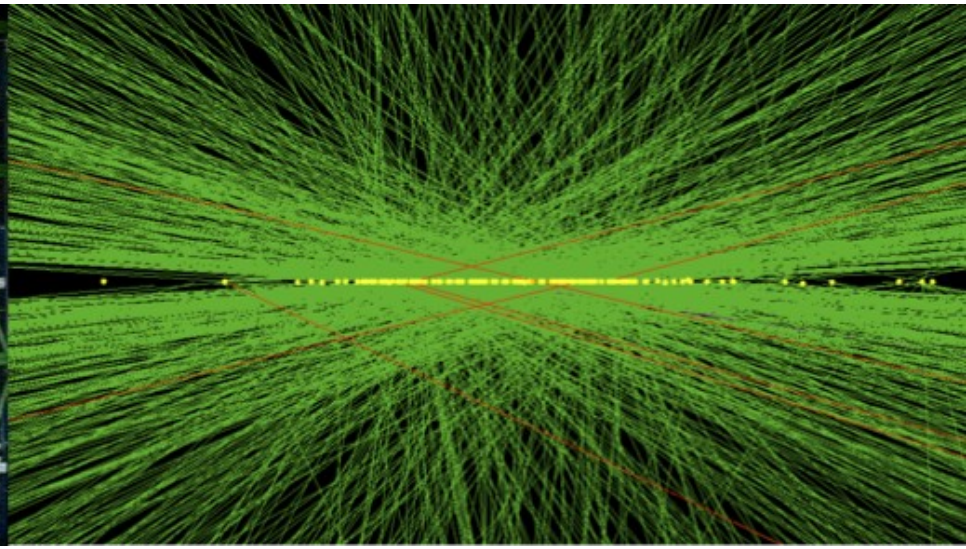
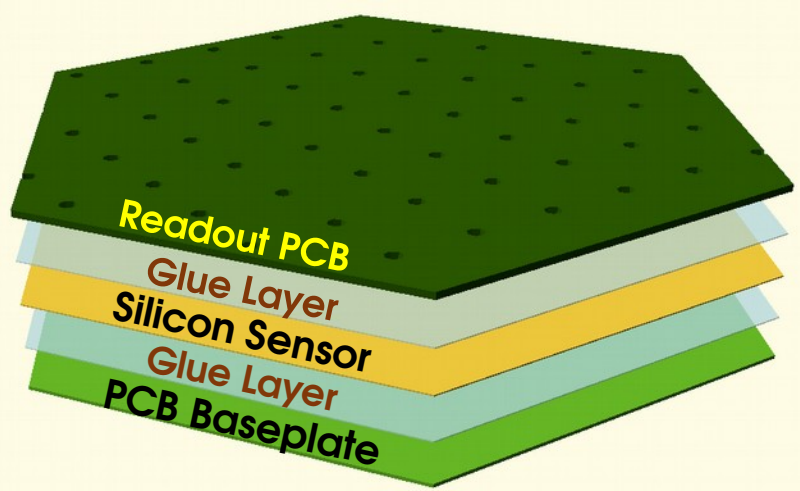
CD1 Director's Review

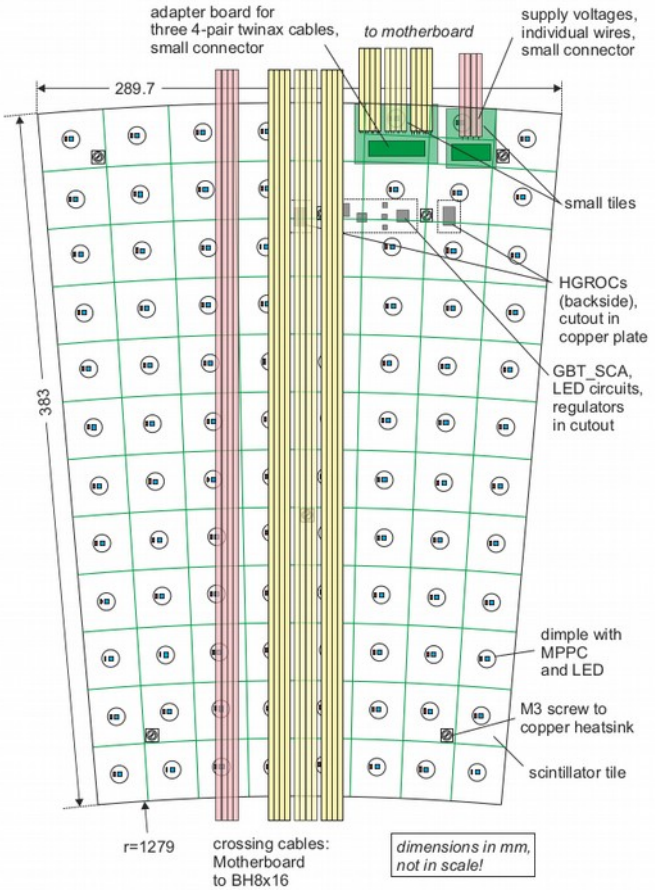
March 19, 2019



Outline

- Recent Updates on Silicon Module Construction
- Recent Updates on Scintillator, SiPMs, and Tile Modules



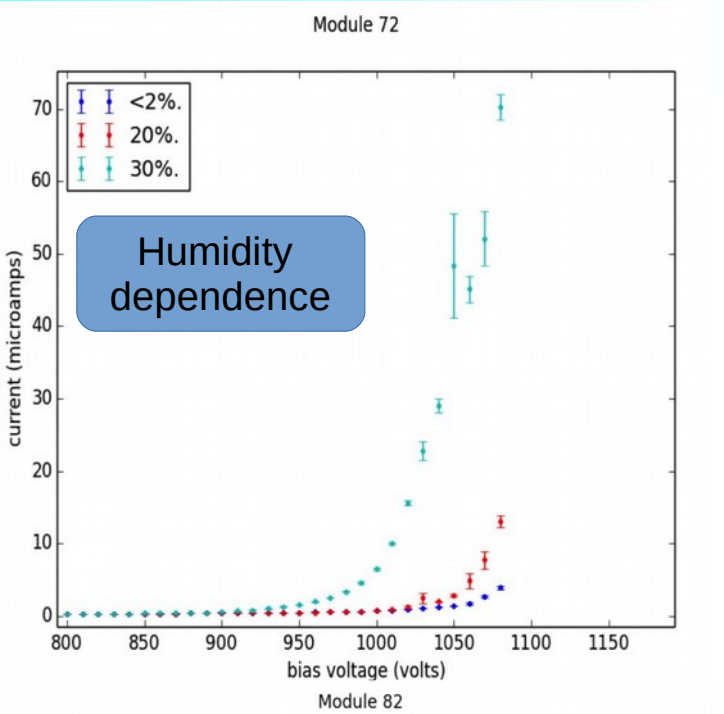


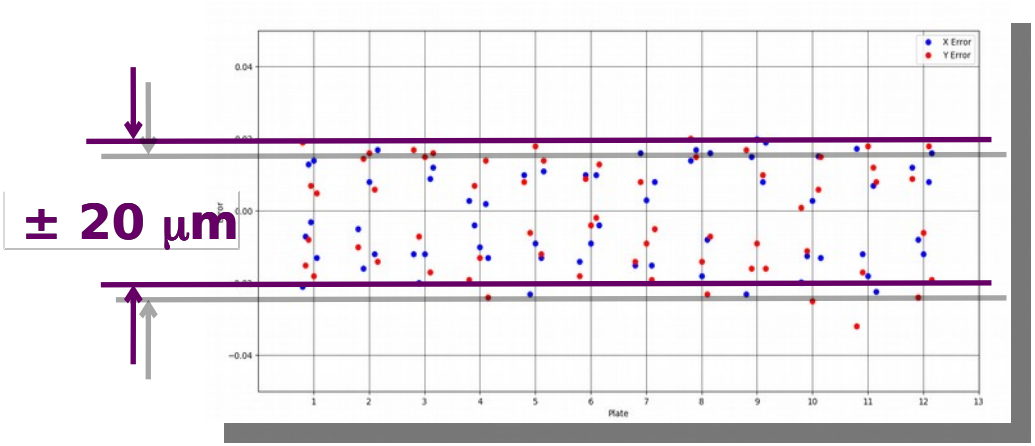
Module Construction Strategy

- UCSB – International Lead Module Assembly Center (MAC)
  - Responsible for developing procedures, baseline software tools, specifying equipment, defining site commissioning protocols
    - For both US and international sites (IHEP-Beijing, Taiwan NTU/NCU, India BARC)
  - Responsible for assembly of limited-run odd-sized modules
- Texas Tech University
  - Standard hadronic modules, high-throughput center
- Carnegie Mellon
  - Standard hadronic modules, high-throughput center
- Multi-site solution provides redundency in case of risk, opportunity for acceleration of production if required

Studies at UCSB

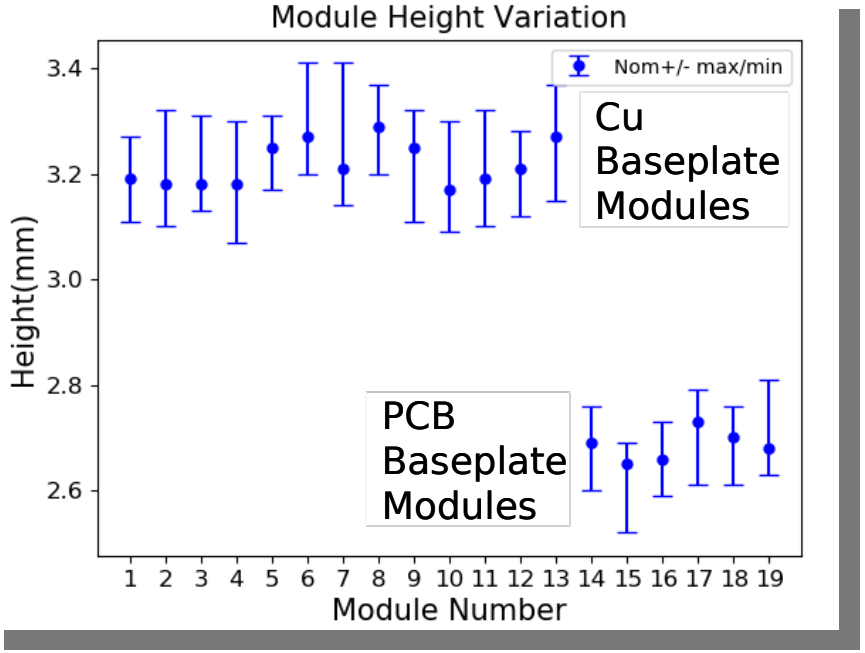
- Some concern with leakage currents in testbeam modules early in 2018
  - Observations have been understood, important implications of humidity and "burn-in" first high-voltage cycle
- Excellent sensor-placement accuracy measured throughout production

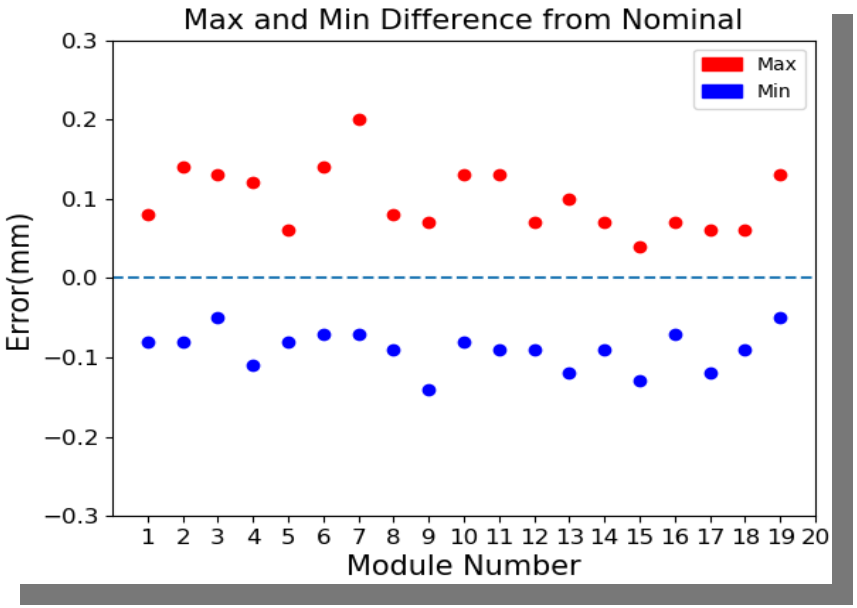




Mechanical Studies

- Module heights measured for 19 of the 6” modules
  - All have 300 mm sensors
  - 13 have 1.20 mm thick Cu baseplates of which 7 had two Au/Kapton layers
  - 6 used 0.90 mm thick PCB baseplates

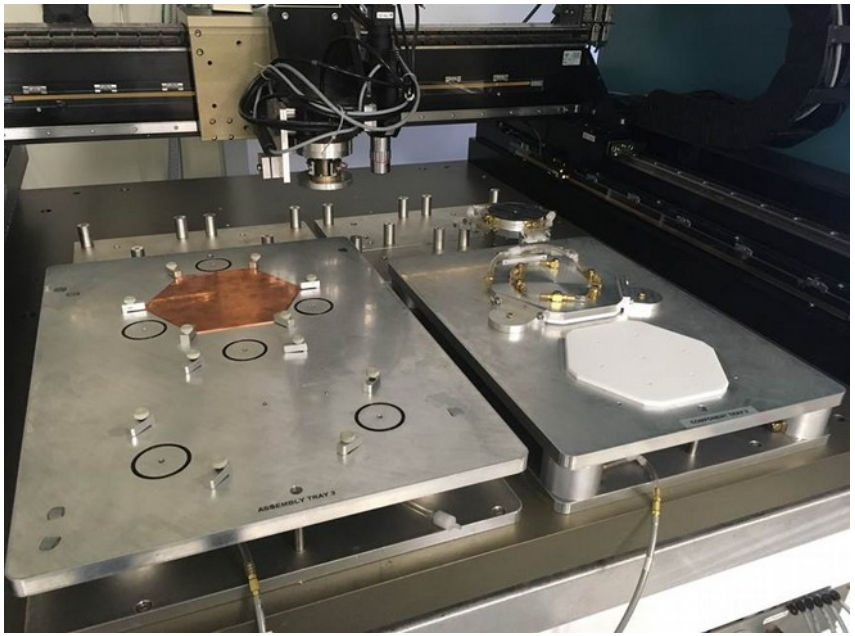


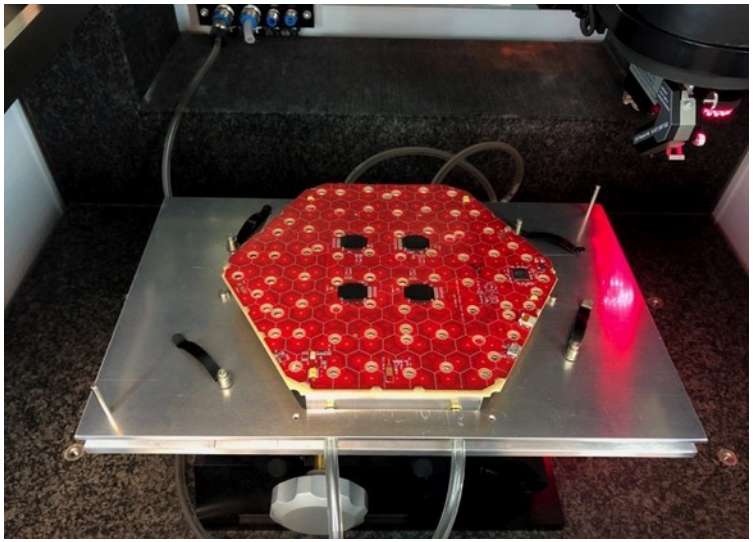


- Results
  - Modules all within -150 µm and +200 µm (σ~100 µm)
  - most in range ±100 µm

8” Module Assembly Status

- New 8’’ fixtures and tooling delivered by shop
  - Wirebonding fixture, Carrier Tray
  - PCB Tray, PCB Pick up tool
- Received PCB Baseplates from FNAL
- Currently practicing building dummy modules with acrylic PCB layers and dummy G-10 baseplates to qualify gluing patterns.
- Next step will be to build with an HPK dummy sensor and a PCB with 2 bad SKIROC chips.
  - Expect to be complete by end of month





MAC Documentation

TWiki > CMS Web > SLHCWikiHome > HGCALWikiHome > HGCALSiliconSensors > HGCALModuleAssemblyCenterSetup (2019-03-06, BrunelConstantineOdegard)

This page contains documentation for the setup of High-Granularity Calorimeter (HGCal) Module Assembly Centers.

If you have questions that aren't covered here, please check the FAQ page. If your question is not answered there, feel free to post it in the Q&A page (if it's not already there.)

Page Contents

Equipment

Back to top

This section contains information about the equipment used by Module Assembly Centers. It will include model numbers, weight and floorspace information, and resources on acquisition and setup of the equipment. For information on using the equipment once it's set up, see the pages on module assembly and module testing.

Gantry

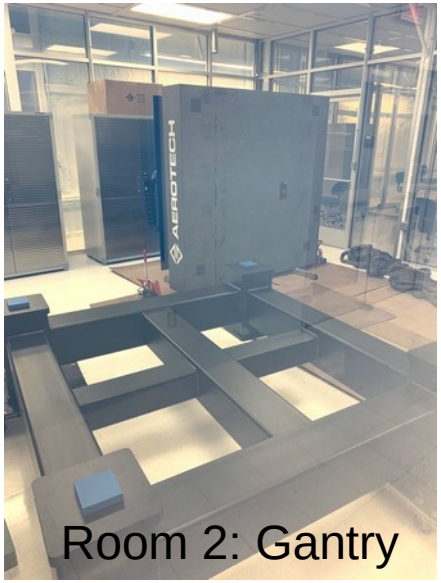
UCSB has an Aerotech AGS10000-750-750 gantry (series 10000, 750mm x 750mm travel area.)

MACs should acquire the AGS15000-1250-1250 (series 15000 gantry with 1250mm x 1250mm travel area to accomodate the production of six 8-inch modules at a time.

TTU Status

- HESSE Bondjet BJ820 Wire bonder delivered and commissioning is planned for June 2019. Royce 610 pull tester is also delivered
- AEROTECH AGS10,000 (1.25 m x 1.25 m) Gantry is delivered and placed in the cleanroom. Working on commissioning, including the gantry head accessories, this month (March 2019)
- Vacuum and compressed air systems are commissioned
- Filter replacement and cleanroom official certification will follow after all major equipment is moved in. Monitoring systems are in place.
- New personnel joined the technical team full-time (S. Undleeb)


Room 1: Wire bonder



Room 2: Gantry

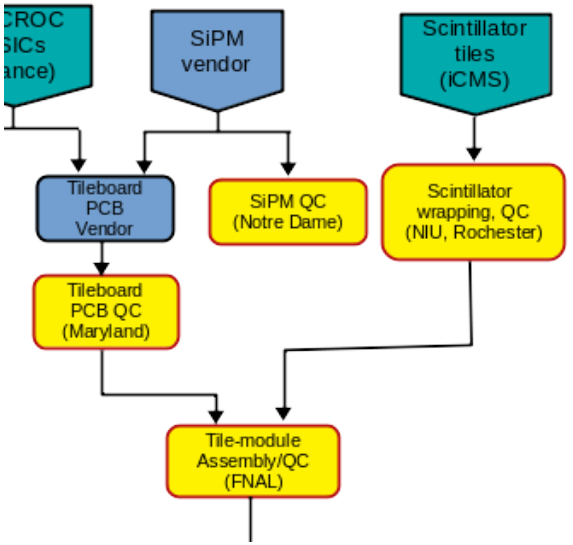
CMU Status

- Expansion of Cleanroom #1 (100 m^2) complete. Sealing and cleaning on-going. Monitoring setup in place: 8 temp/humidity monitors with logging and 2 webcams
- Construction for Cleanroom #2 (60 m^2) to start shortly. Completion expected in April
- HESSE Bondjet BJ820 Wire bonder delivered and placed in cleanroom. 3-day setup and on-site training by HESSE to occur end of March
- Royce 610 pull tester and epoxy dispenser close to be ordered
- AEROTECH AGS10,000 (1.25 m x 1.25 m) Gantry is expected in June 2019
- New electronics engineer hired (start March 15) to join Eric Day (mechanical) in technical team

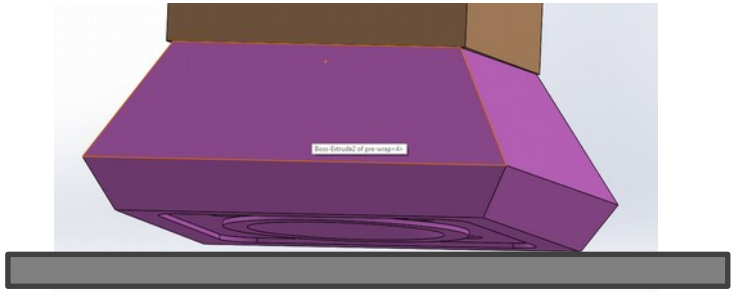
Scintillator Calorimetry

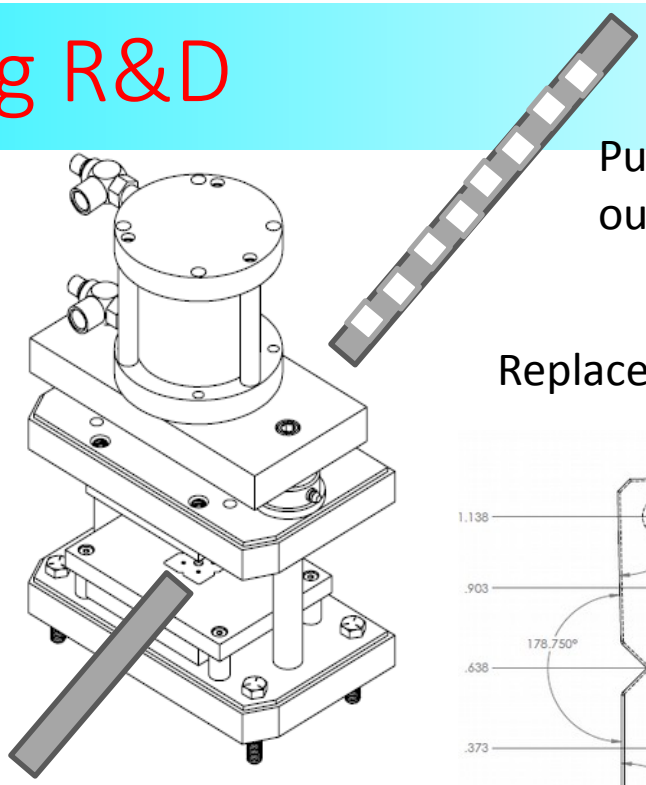
Steps of Contruction

- Tile production : injection-molding (low-dose) and machined cast scintillator (high-dose)
- Tile wrapping with ESR foil
  - Mechanical and light yield QC
- SiPM production
  - Batch QC
- Mounting of components onto the tile PCB
  - QC of assembled tile PCB (inc full SiPM QC)
- Mounting of tiles onto tile PCB to create a tile module
- Integration into a cassette with motherboards and cables



Tile Wrapping R&D

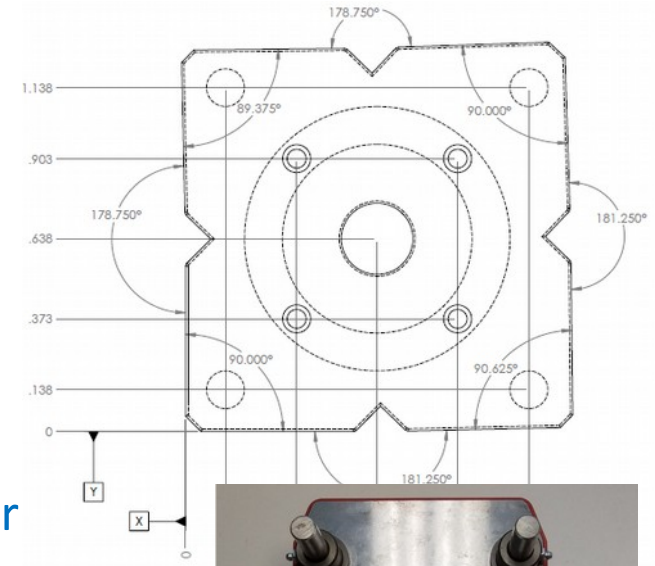




Punched material outlet

ESR in-feed

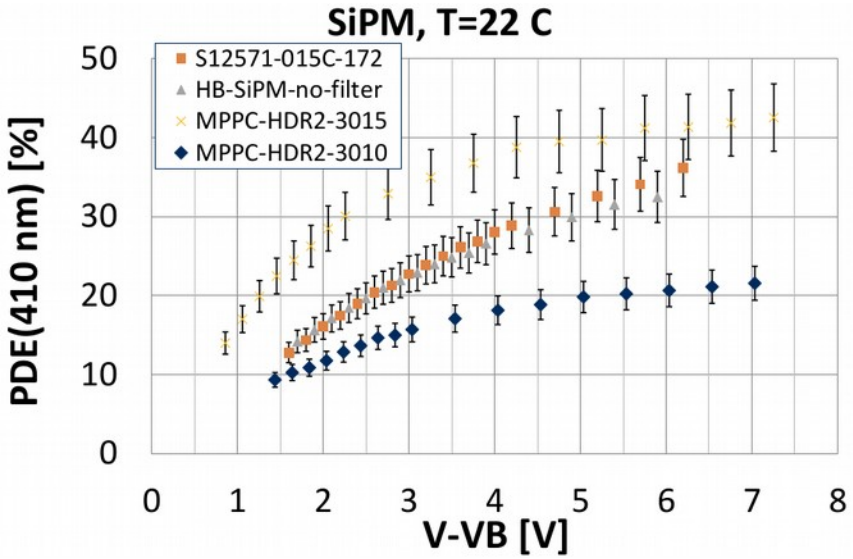
Replaceable die for each size

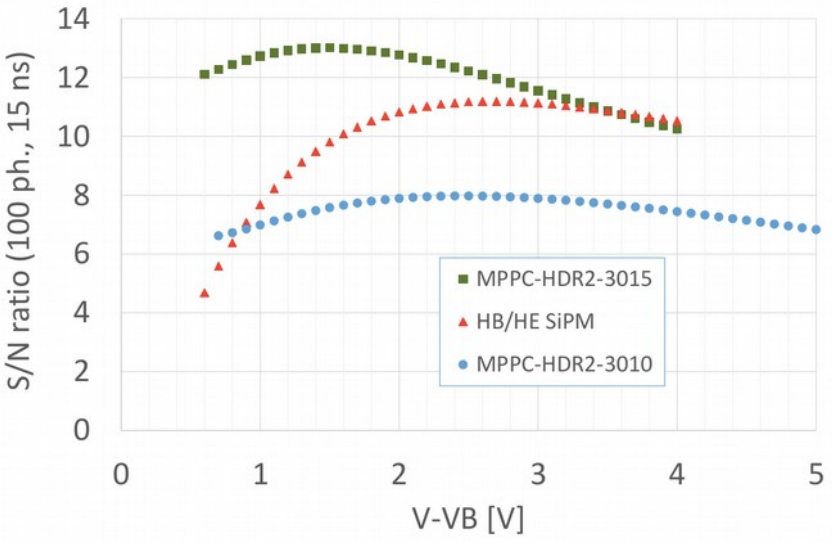


- Studying use of punch/die for ESR cutting
  - High throughput, low dust compared with laser cutting
- Studying use of hydroforming to create pocket for scintillator tiles
  - Forms sharp creases, possibility for higher precision than ‘candy machine’ folding processes

SiPM R&D [Notre Dame]

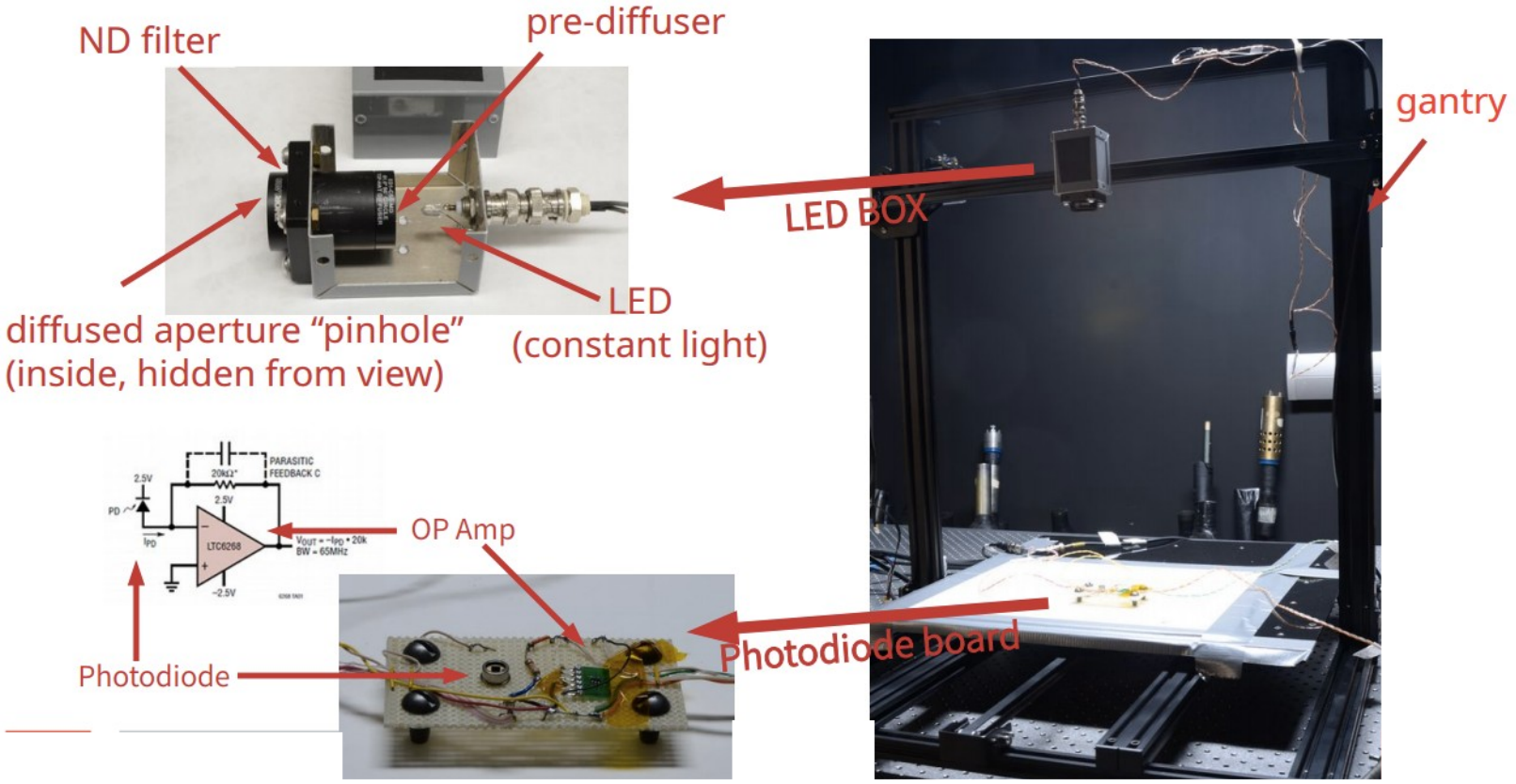
- HE SiPM used as baseline in TDR
- HPK has developed new "HDR2" SiPM with lower cross-talk and better PDE
  - V_{bd} 36V vs 62V
    - Lower power, easier to regulate
  - Temperature coefficient decreases proportionally to V_{bd} (36 mV/K)
  - Radiation-induced V_{bd} shift smaller (0.3V vs 1V)
- Significant work ongoing for packaging of SiPM
  - Standard SMT package has thermal resistance 100 K/W
  - "Through-Silicon-Via" package has <4 K/W, some effects of radiation on glass window





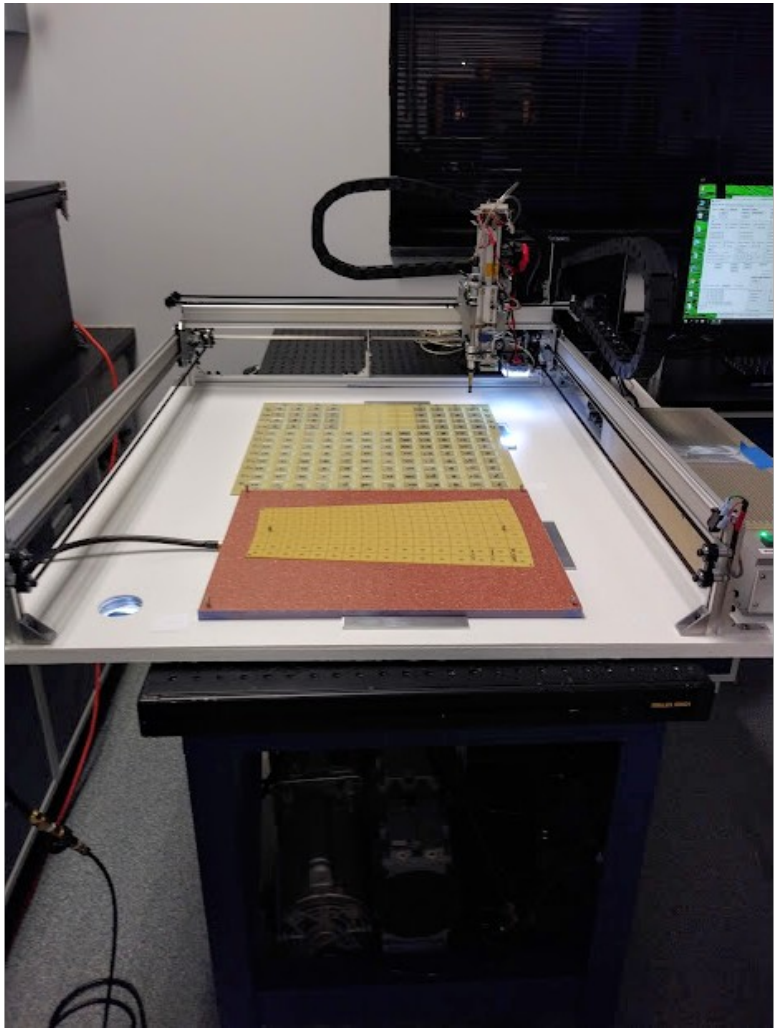
Tileboard QC R&D [Maryland]

- QC of tileboards before mounting scintillator tiles is point where any issues with SiPMs are identified
- Maryland developing a test stand which should be capable of SiPM checkout and also channel calibration over a wide dynamic range using geometry ($1/R^2$)



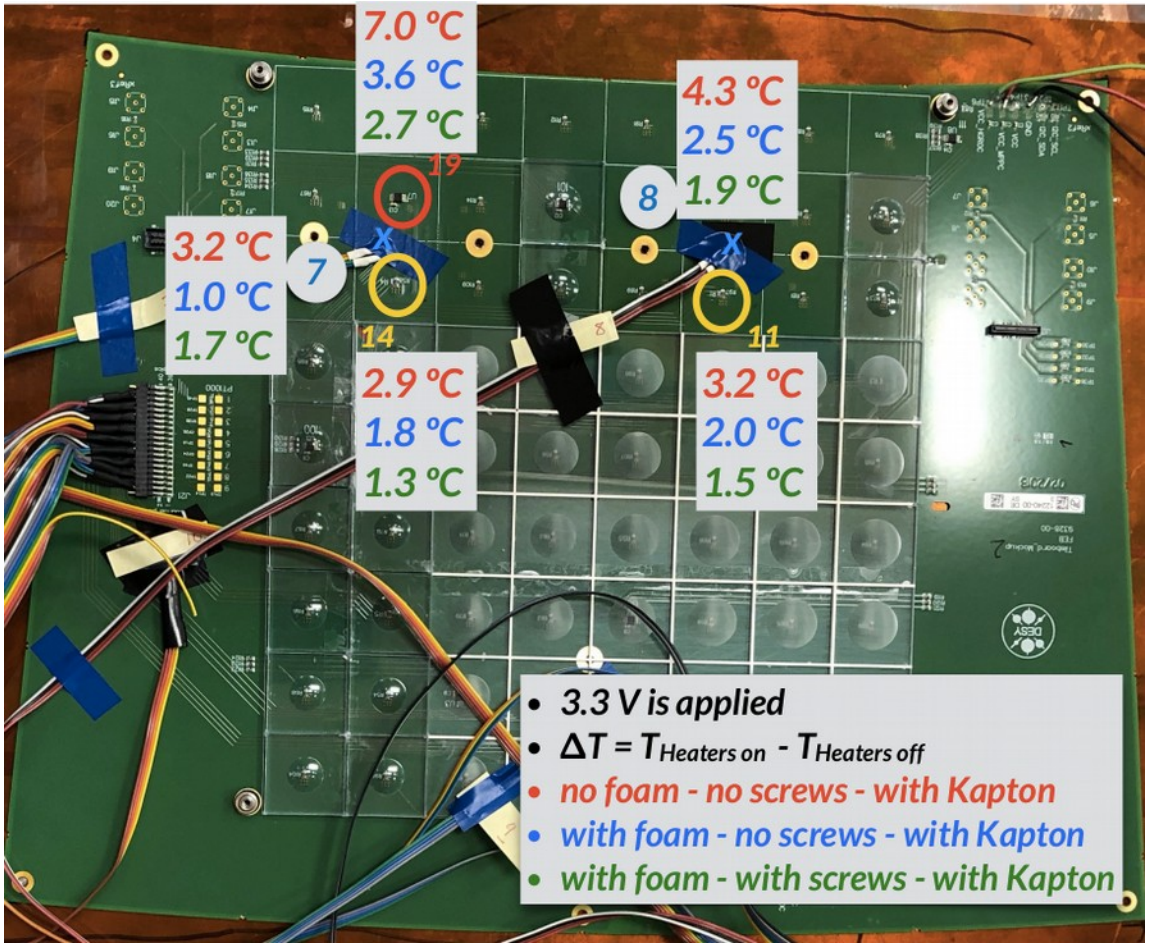
Tile mounting R&D [FNAL]

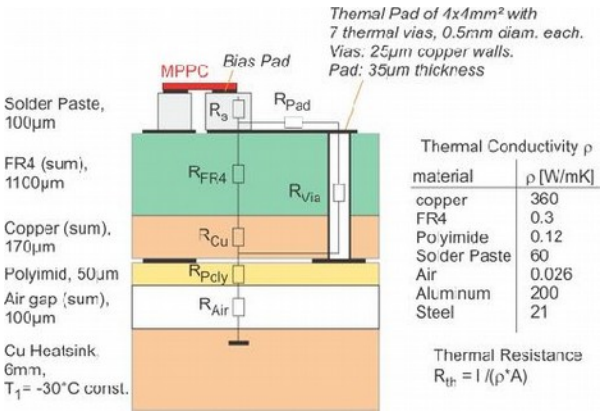
- Pick and place system set up at FNAL to assemble tile modules using dummy tiles, PCBs
- Studying concept of using phase-change film instead of glue



Thermal Tests

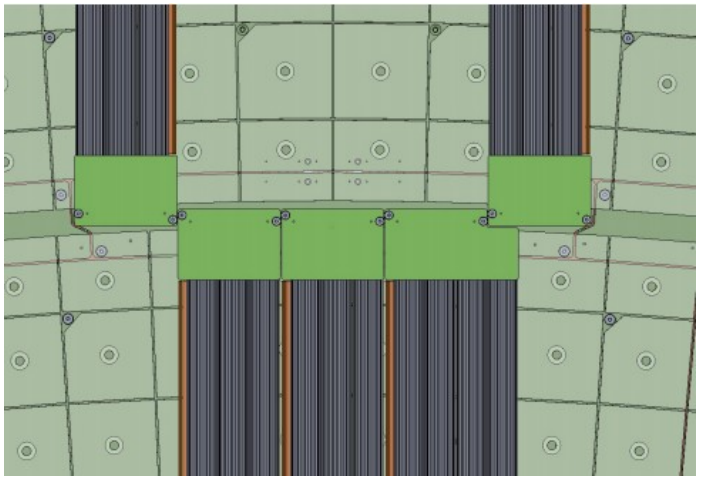
- Thermal teststand at Fermilab
  - Full cycle to -30°C
  - validate SiPM cooling through PCB using thermal vias
  - max increase with load: 2K
  - No strong gradients
  - Study of impact of screws and thermal foams

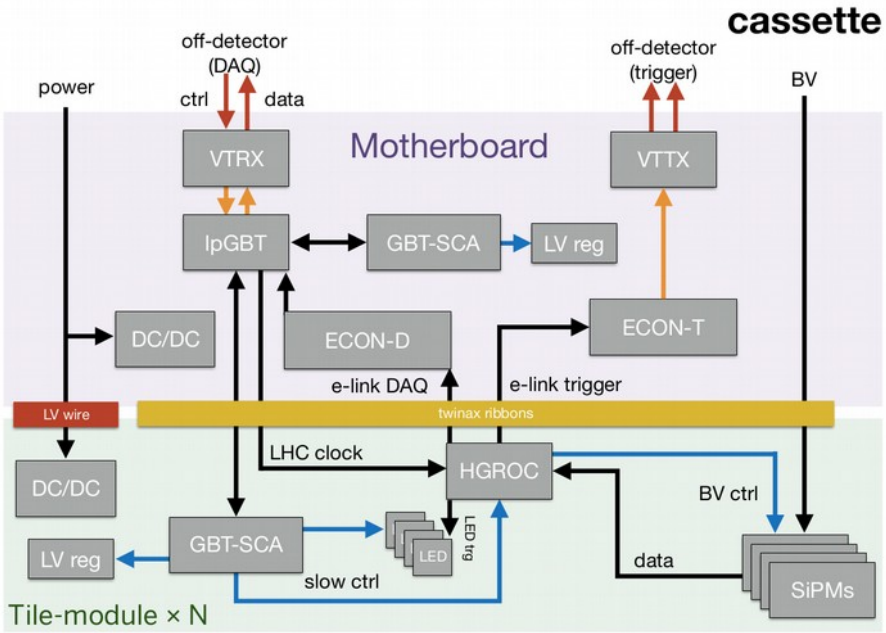


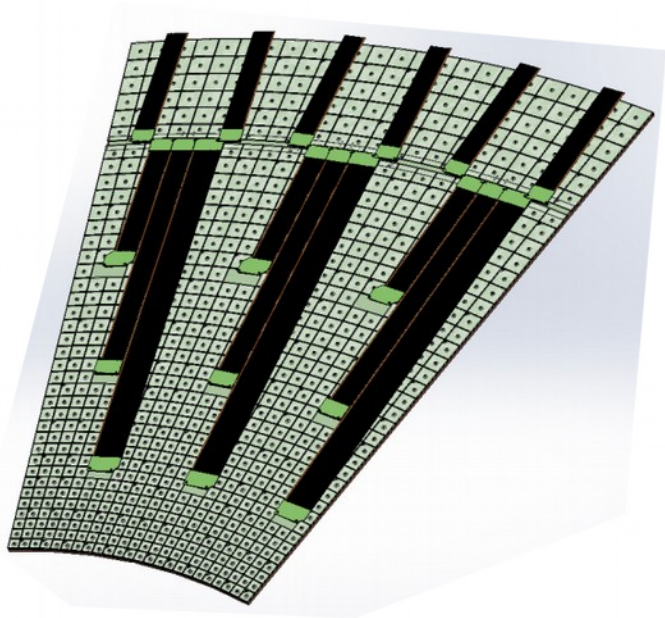


Cassette Integration

- Tileboards must connect to motherboards via cable structures
- US (FSU, Minnesota) working on detailed mechanical design, to be implemented in mockup, prototype 1

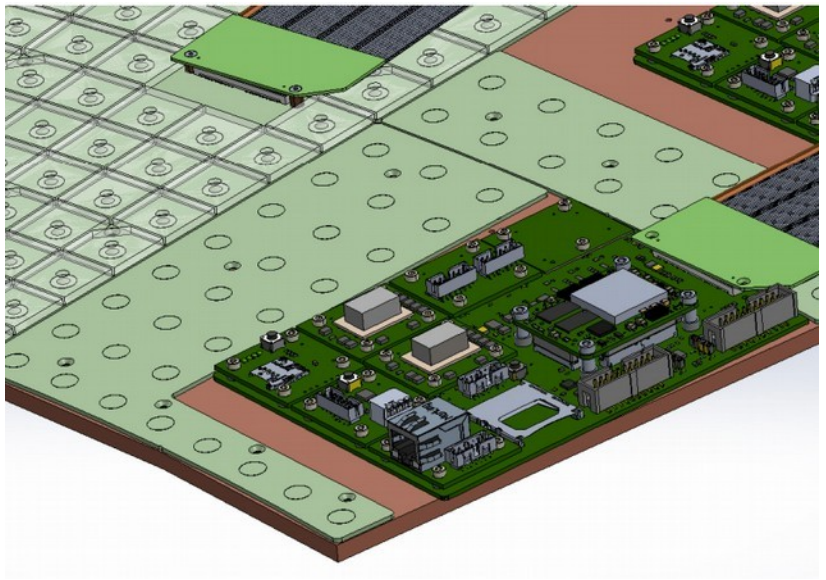


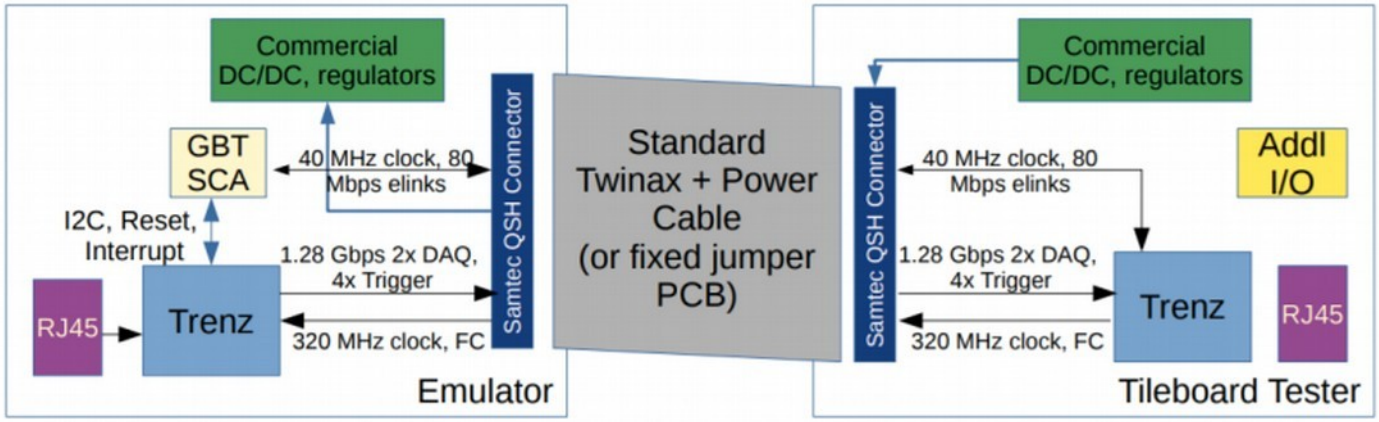


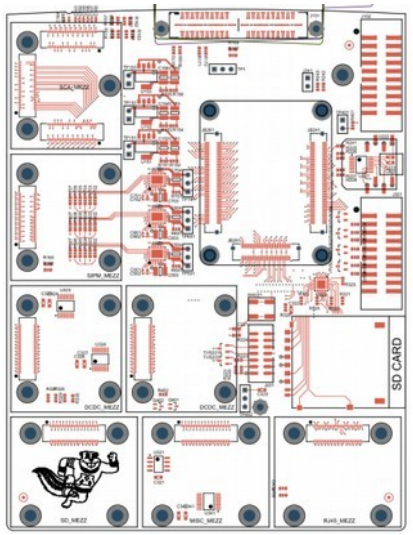


System Integration and Emulation

- US (KSU, Baylor, Minnesota, FNAL) leading the development of emulators and testers which reproduce the expected behavior of HGCROCV2 and the concentrators
- Allows system tests, development of necessary control software and firmware, further study of system issues







Conclusion

- Significant progress made on module construction since June 2018
  - Large scale production of 6” modules
  - Development of 8” module tooling
  - Procurement of major equipment for CMU and TTU module assembly facilities
- Scintillator effort making progress on all fronts
  - Tile-wrapping and QC
  - Tile-board QC
  - Tile mounting to create tile-modules
  - Tile-module thermal performance
  - Cassette integration → mockup
- Effort is very well on-track for CD-2 review next year