ePIC SVT DSC – Purdue U plans

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Purdue Tracking Detector Team

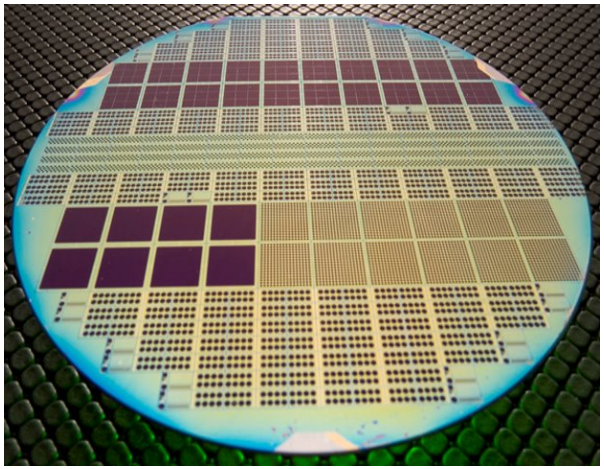
- Matthew Jones (Associate Prof)
  - Successfully lead & completed CMS phase I silicon pixel assembly
    - Purdue achieved a capacity of 6 modules/day
    - Phase I detector fully operational since May 2017
  - Lead institute developing the project for the HL-LHC TFPX silicon module production, Jones is US & iCMS L3 manager for TFPX module

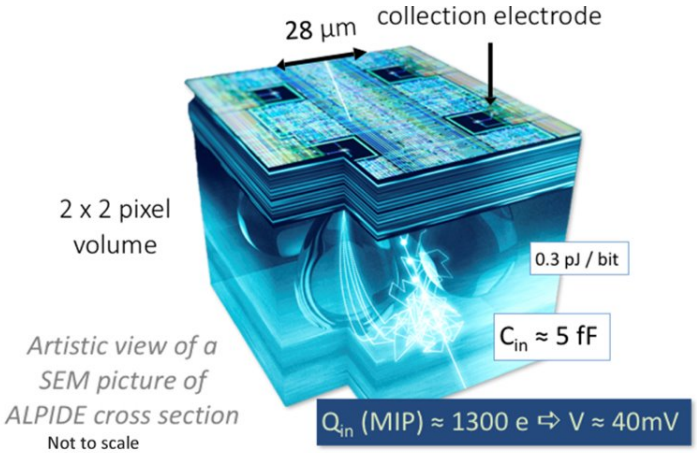
- Mia Liu (Assistant Prof.)
  - Fast ML on GPU/FPGA, trigger-less readout
  - CMS MAPSA testing for HL-LHC

- Andreas Jung (Associate Prof)
  - Experienced in R&D for low mass support structures.
  - Working on the light-weight composite tracker support structures for CMS.
  - Technical lead for all CF-based supports in CMS, includes design, manufacturing and procurement of raw materials

Silicon sensor experience

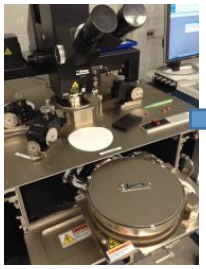
- In-house / commercial parylene coating for spark protection
  - Ref. to come
- TCAD in-house sensor simulations for fast timing signals
  - Ulitima workshop proceedings, 2018
- Skywater intends to build $2B fab at West Lafayette, Purdue
  - Larger effort between Skywater and Fermilab, UIC, Purdue, U Chicago, NU, etc. to co-design & test new sensor designs (LGADs, fast timing, monolithic pixel detectors, etc.)



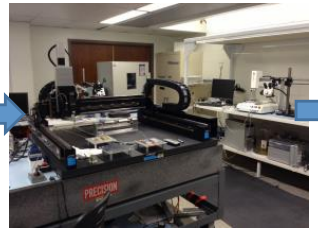


Resources from Purdue: PSDL

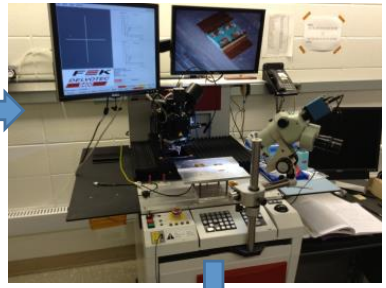
- PSDL is equipped to assemble silicon pixel modules, right.
  - The class 10,000 space has standalone air handling and filtering providing temperature control to ±1ºC and control of relative humidity to ±5%
- Relevant equipment
  - New Hesse wirebonder
  - Cascade Microtech Summit 12K semi-automatic probe station (with thermal chuck, -50C chiller, and probe card holder
  - Alessi semi-automatic probe station
  - Uni-Tek wire bond pull tester
  - Electrical equipment, licences
  - Etc.



Bare sensor and assembled module probing.

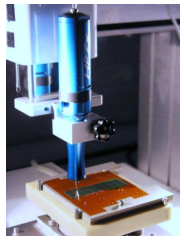


Module assembly on robotic gantry.



Wire bonding readout chips.

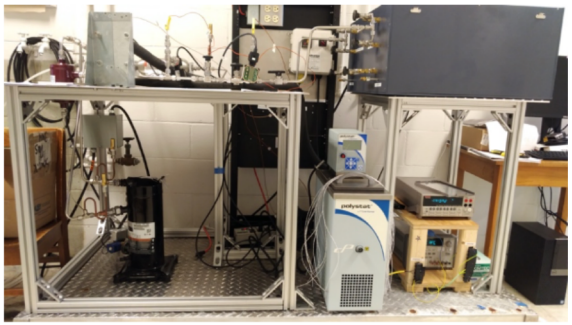
Electrical tests.



Encapsulation.

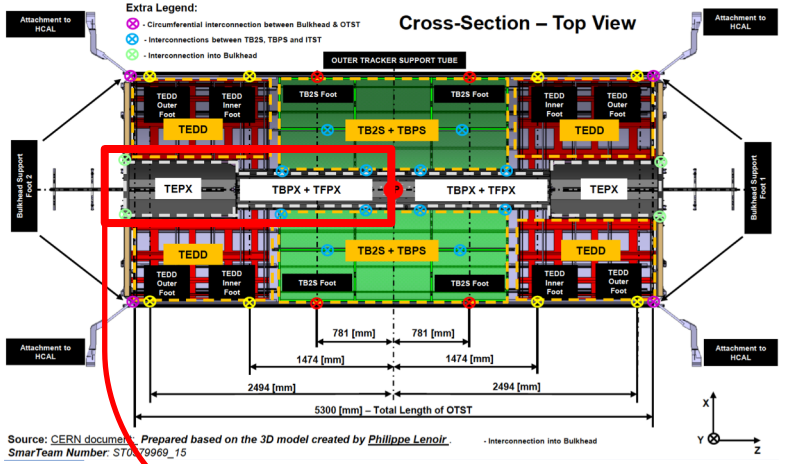
Thermal cycling.

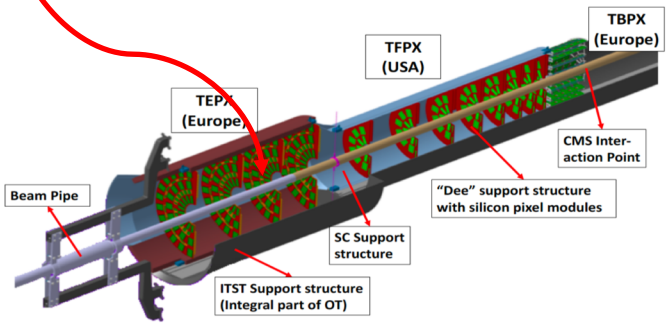
Cold box setup for thermal performance studies of mechanical mock-up modules

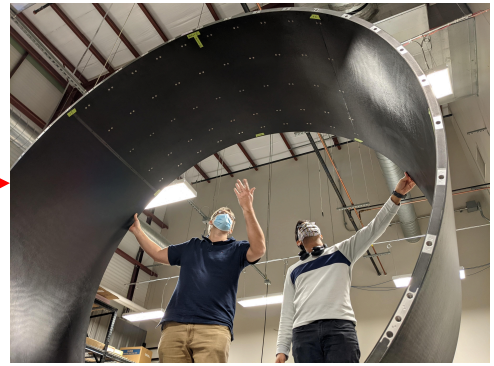


Experience from Purdue

- CMS upgrade relies on Purdue for design & manufacturing of mechanical support structures
  - Service Cylinder housing the Inner Tracker (IT)
    - 4+2 half cylinder structures with a length of 2.9m and transition region between small & large radii
    - Barrel, Forward, and Extended Pixel Detectors
  - Components for Inner Tracker pixel
    - Sandwich structures to mount pixel modules (Dee's) for the forward pixel (US project)
    - CFRP structures for the barrel pixel (European led)
  - Inner Tracker Support Tube (ITST)
    - Supports the 4 IT Service Cylinders, separates Inner Tracker and Outer Tracker volumes
    - Longitudinal stiffness for the entire Outer Tracker
  - Components for Outer Tracker (OT) modules
    - CFRP stiffeners (~3000ft^2) for the OT modules assembly
  - Barrel Timing Layer Tracker Support Tube
    - Supports the entire IT + OT + Timing Layer of CMS

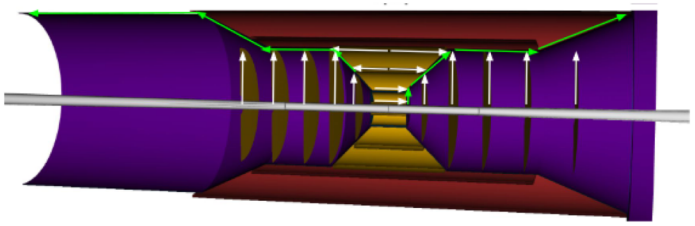






Our interests & where to contribute…

- Based on our experience we'd like to contribute to the **disc/dee layers of the tracking detector in EPIC** (EDx and/or HDx)
  - **Happy to collaborate and join a team engaged in this!**
  - **Lots of experience in collaborative pixel detector design & construction**
- Experience w system engineering (cooling, electrical interfaces, mechanics, power distribution)
  - Electrical & Mechanical mockup module for thermal performance
  - Cold-box setup in case liquid coolant/system is desirable
- Designed and operate the testbeam telescope at Fermilab
  - Written framework and firmware for testbeam campaigns
  - Developed DUT readout firmware for variety of ASICs
  - Happy to join any effort/activities

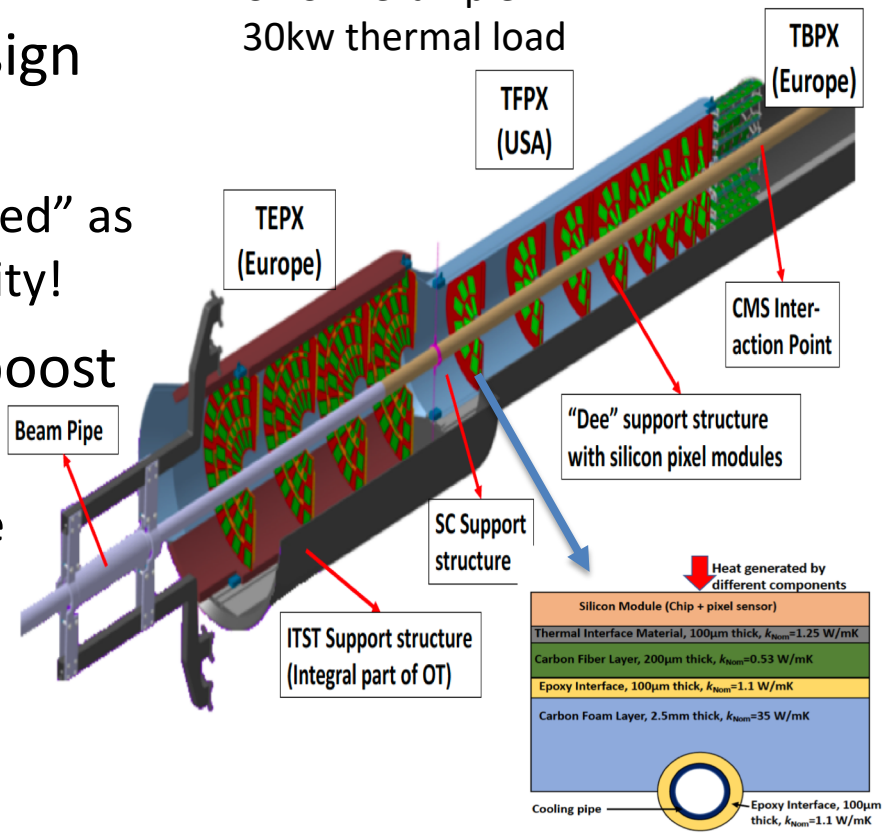


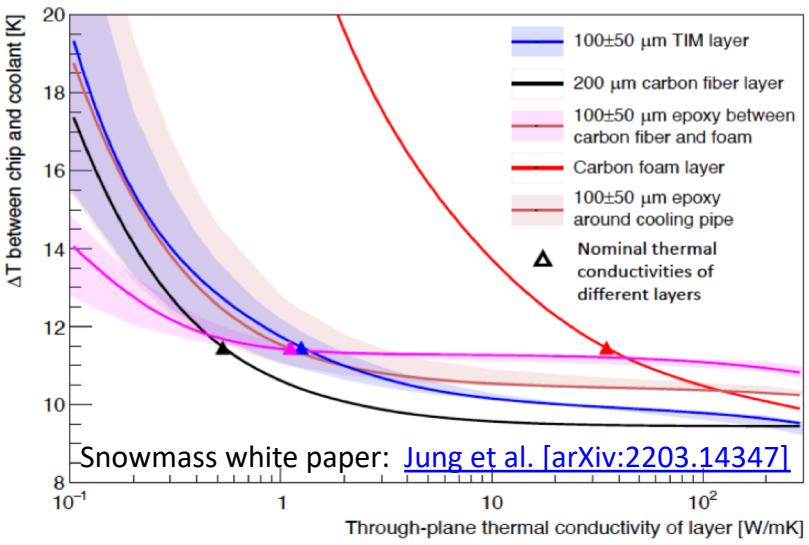
Backups

Mechanical Support Design

- Mechanical support structure design impacts detector performance
  - At times detector mechanics is “solved” as an after-thought – missed opportunity!
- Optimal materials & budget can boost a detectors physics performance
  - Needs timely action, well in advance

CMS IT example:
30kw thermal load





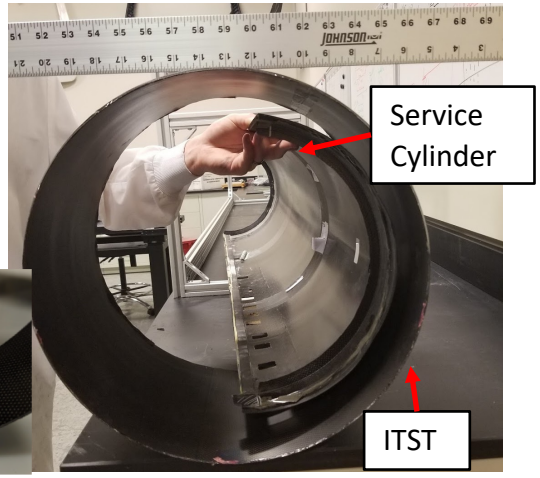
Snowmass white paper: Jung et al. [arXiv:2203.14347]

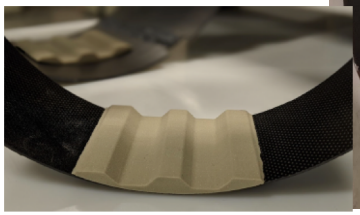
“Sandwich” supports pixel module:

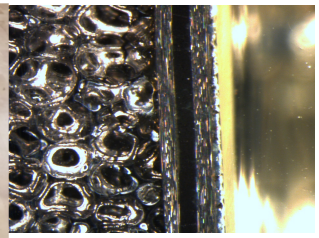
- State-of-the art for multiple systems (inner & outer tracker, timing layers)
- Select materials depending on thermal performance needs
- Applicable to variety of detectors

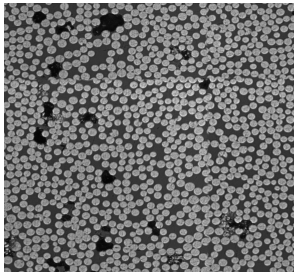
Experience from Purdue

- Prototyping & Manufacturing related to ITST, SC, Dee's
  - Prototypes confronted with FEA predictions, multiple iterations
  - Prototyping and Development of additional structures for IT pixel
    - Cartridges, Portcard holders, all extensively studied for high thermal performance
    - Accompanied by irradiation campaigns: sample prep, characterization, etc.
    - Dedicated measurement of thermal conductivities
    - High thermally conductive materials for 3D printed parts

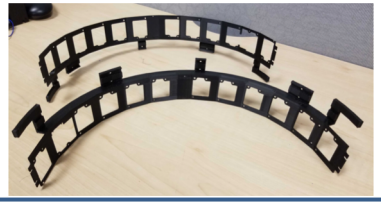


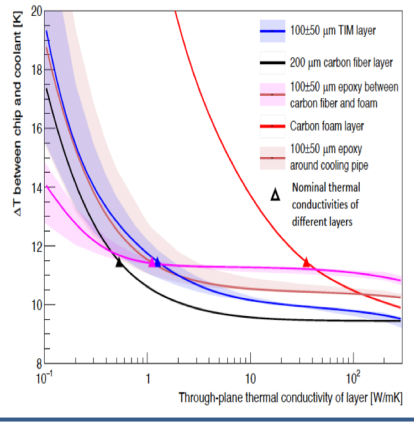


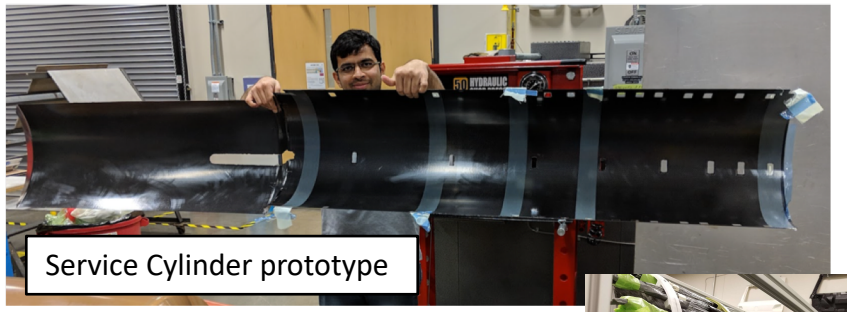


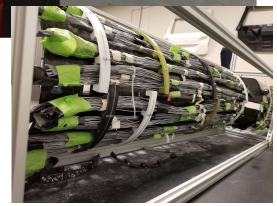


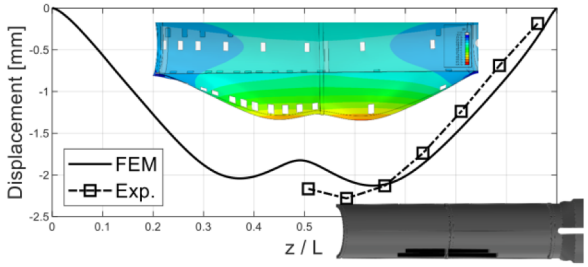
- Forward pixel dee prototype
- Co-cured samples
- Microscopies
- 3D printed mechanical supports
- Critical interfaces via FEA











Resources from Purdue

- Composite Manufacturing & Simulation Center (CMSC) at Purdue, completed in summer 2016
  - Purdue Center of Excellence across disciplines: Aeronautics, Chemical Eng, Materials Eng, Aviation Tech, Computer graphics, **and Physics**
  - A. Jung – Associated member of CMSC
- Professional composite experience:
  - Seven full-time technical staff, five post-doctoral researchers, twenty grad's
  - 35,000 sq. ft. of office and laboratory space
    - 2 large pressurized ovens, 1 larger oven with vacuum hook-ups
    - Larger ovens accessible with industry partners