All-hadronic Z'->$t\bar{t}$ search in CMS, Phase1 Forward Pixel Upgrade and High Granularity Calorimeter

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July 28th, 2017

Career Path

- 2011-2016: Graduate student at State University of New York at Buffalo
  - 2014-2016: LPC resident at Fermilab
    - All-hadronic Z'->$t\bar{t}$ Search
    - Forward pixel detector phase 1 upgrade
      - May2016-January2017: LPC Guest and visitors program
- March 2017-present: Postdoctoral research associate at Fermilab
  - High Granularity Calorimeter
    - Collaborating with LPC residents

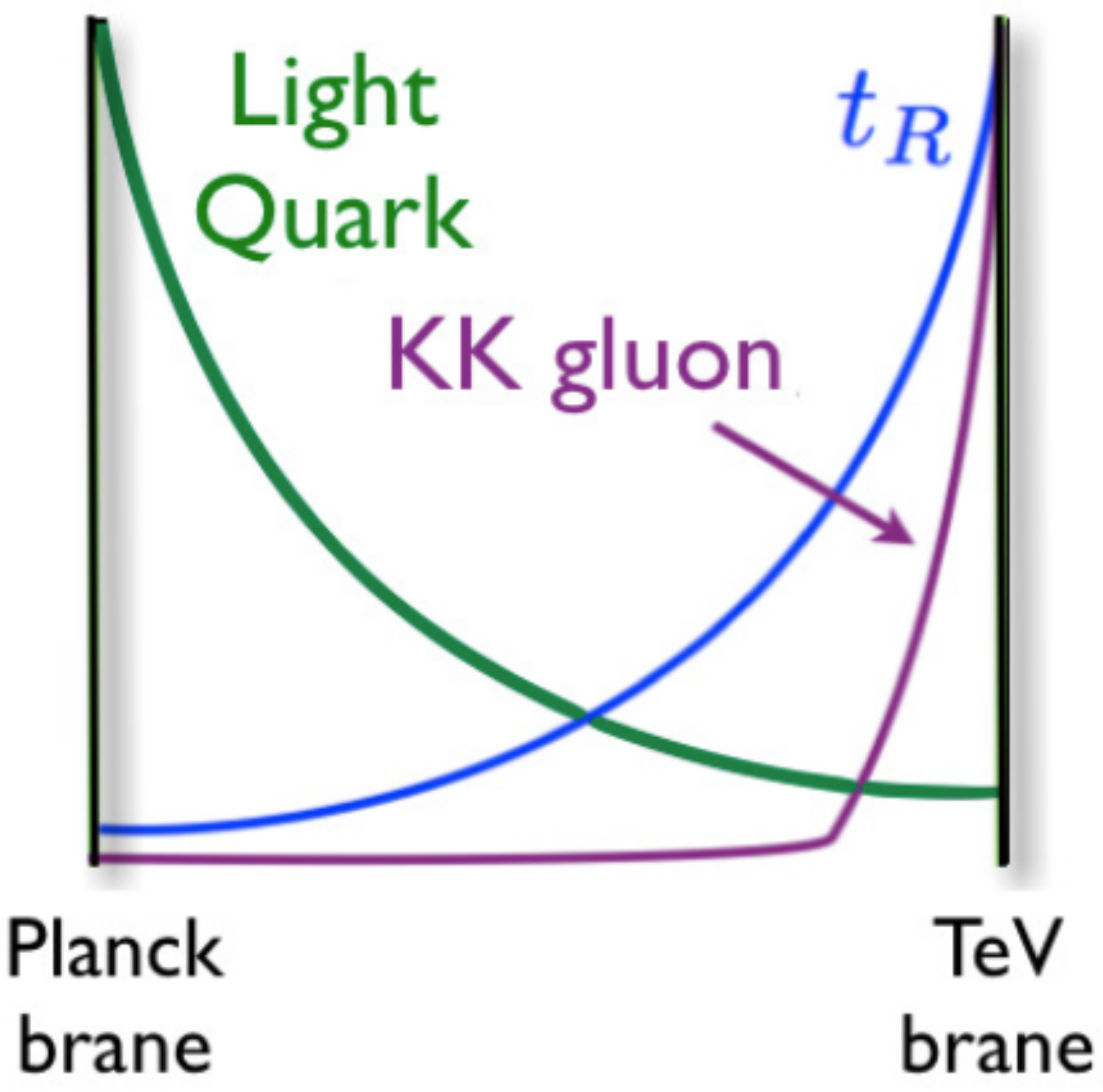
All-hadronic Z’->$t\bar{t}$ Search

All-Hadronic Z'->$t\bar{t}$ Search

- Solving the hierarchy problem
  - Models predict existence of extra dimensions and heavy gluons
  - Many other Beyond Standard Model(BSM) models predict presence of heavy resonances (for example Z') decaying to $t\bar{t}$

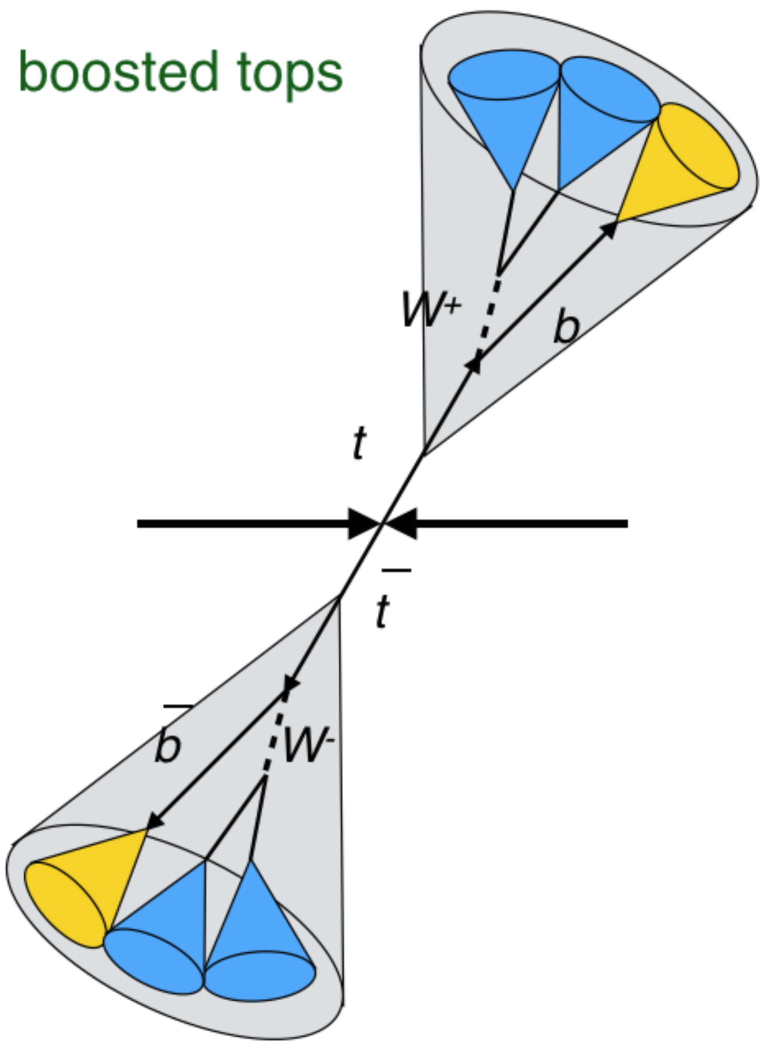
- Goal: Searching for heavy resonances decaying to top quark pairs using the all-hadronic decay mode

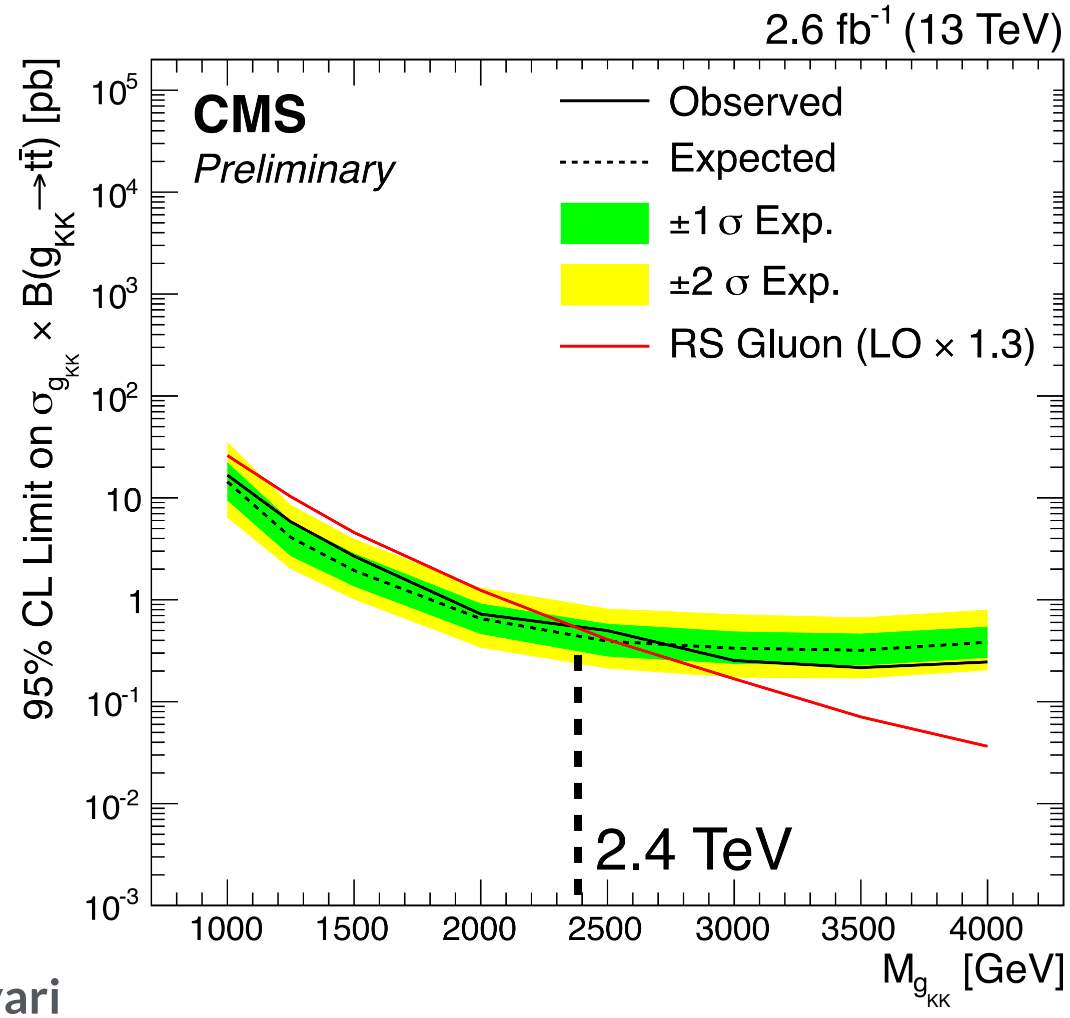
- Generic search that sets explicit limits for Z' and kk gluon masses



All-Hadronic Z'->$t\bar{t}$ Search

- High mass -> boosted top quarks
  - Dijet event topology
  - Top-Tagging algorithms
  - Subjet b-tagging algorithms
- Being located at the LPC made it possible to:
  - Directly collaborate with experts of boosted regime analyses
  - Collaborate with experts in b-tagging/top-tagging



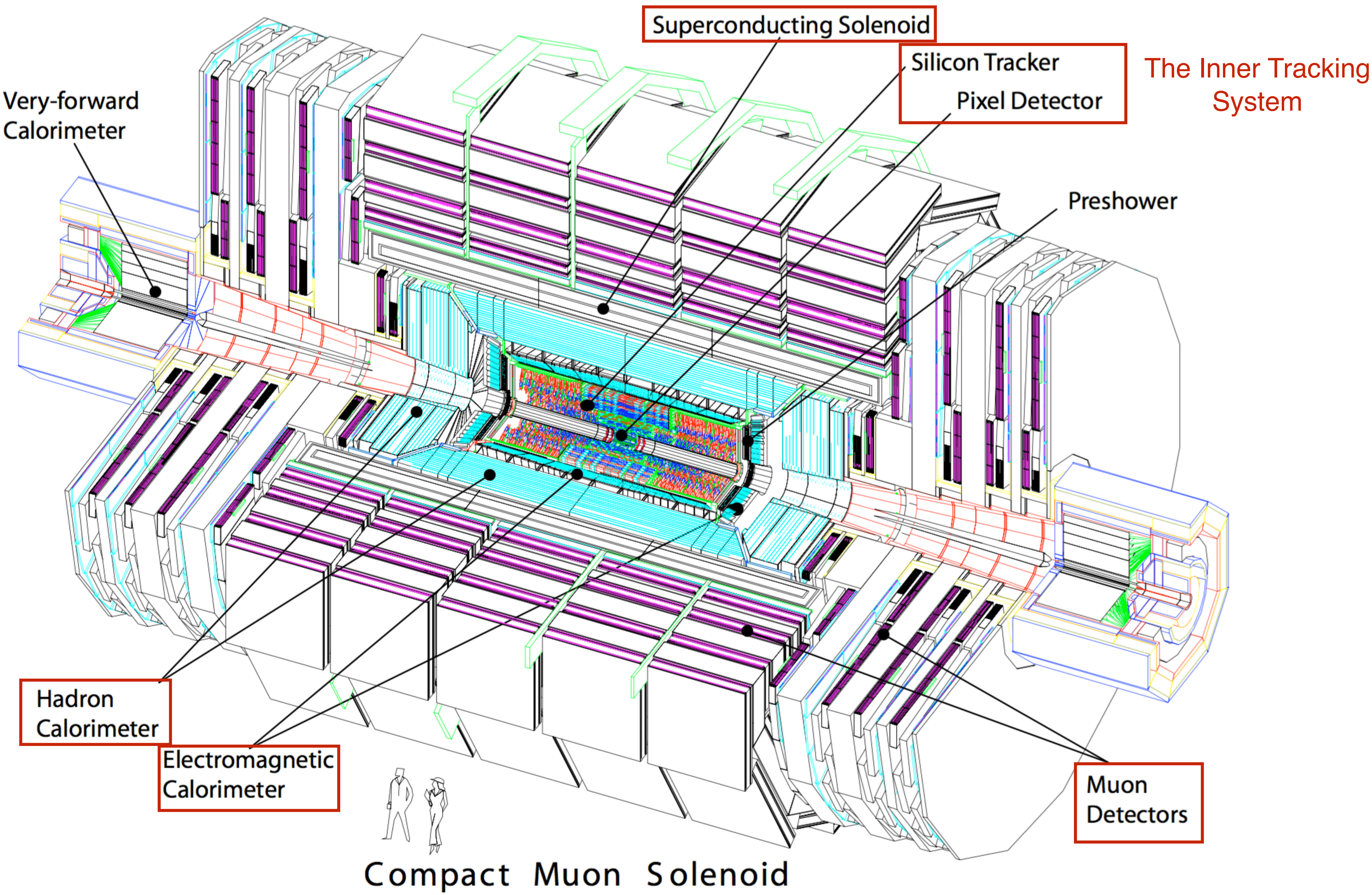


- LPC provided the computing resources essential for running and debugging the analysis
  - LPC Computing Discussion Group

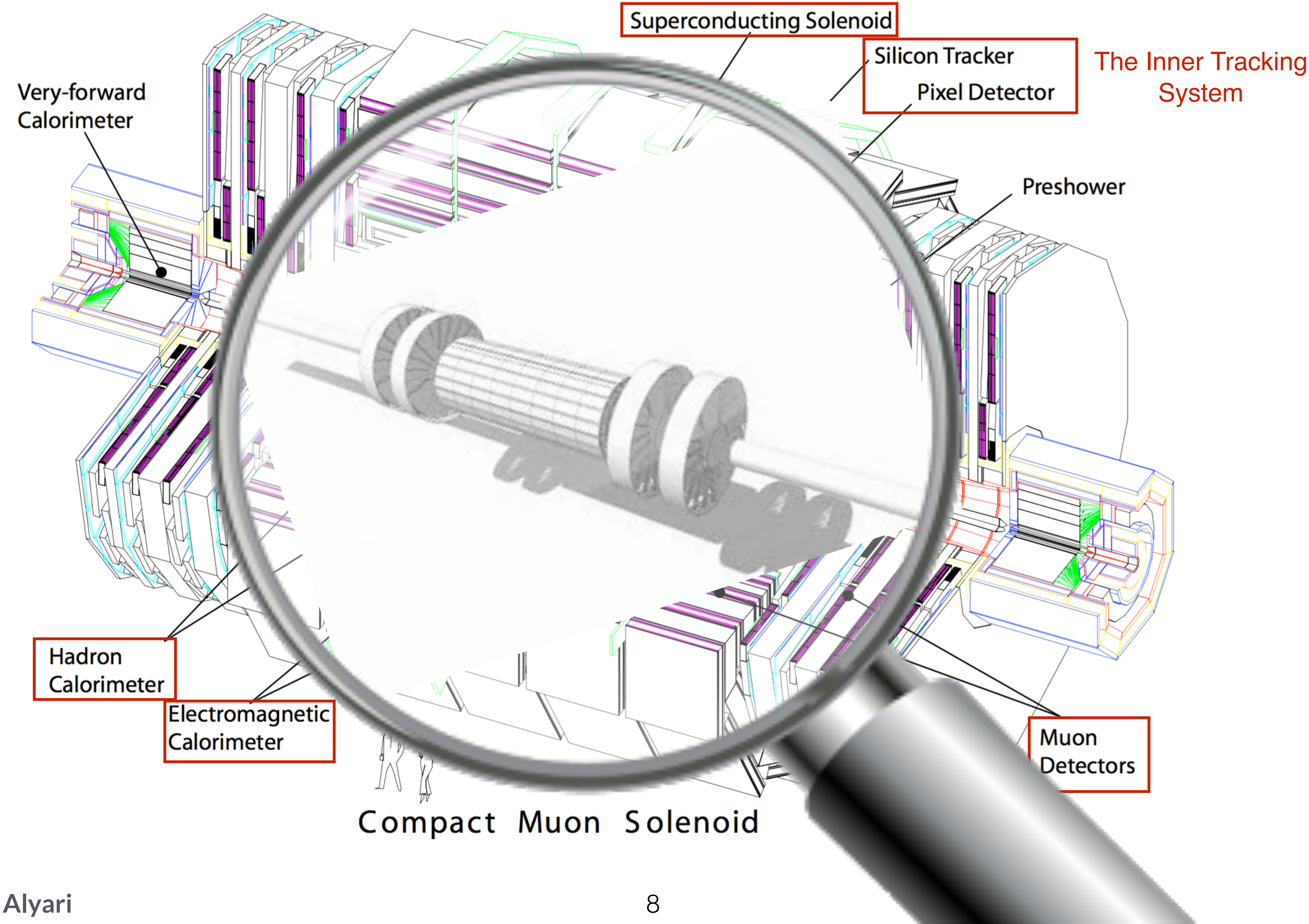
    Every other Friday at 1 pm

Forward Pixel Detector Phase 1 Upgrade

Pixel Tracker within CMS Detector

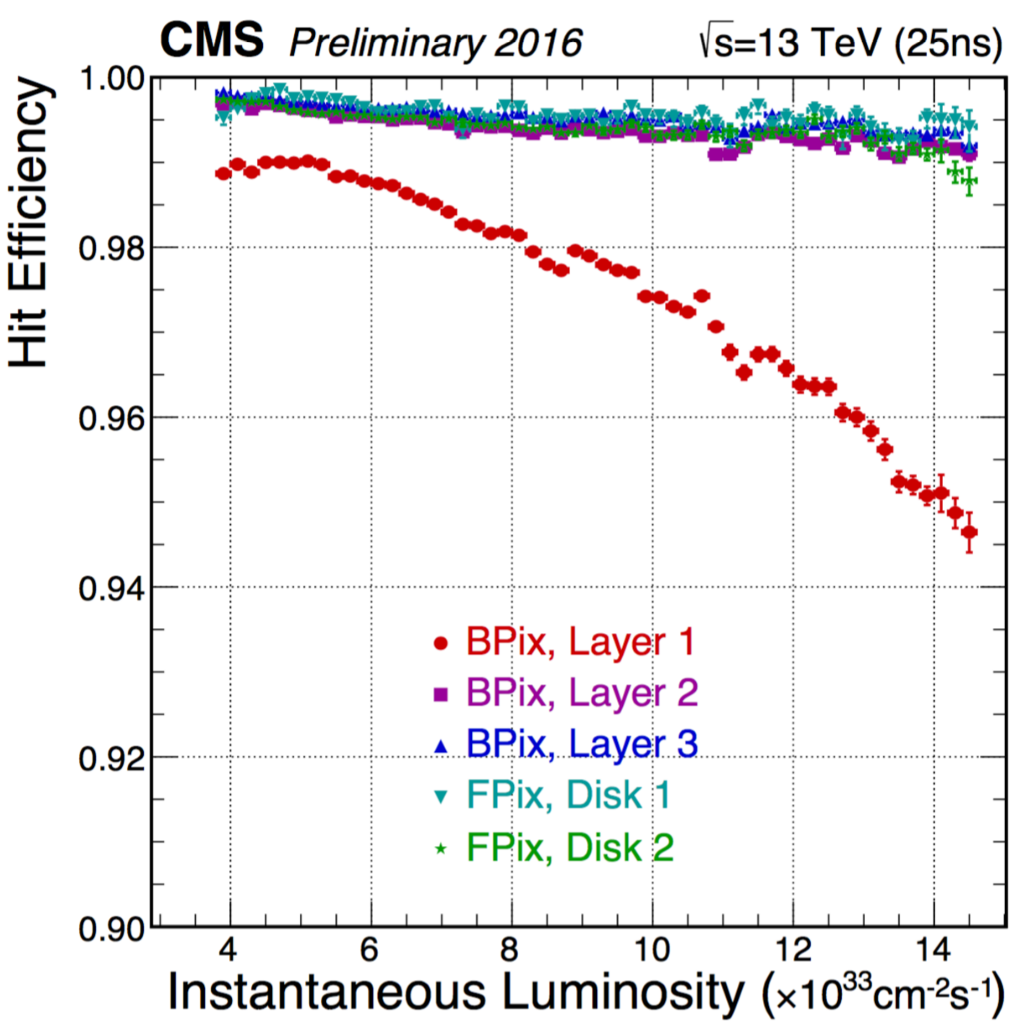


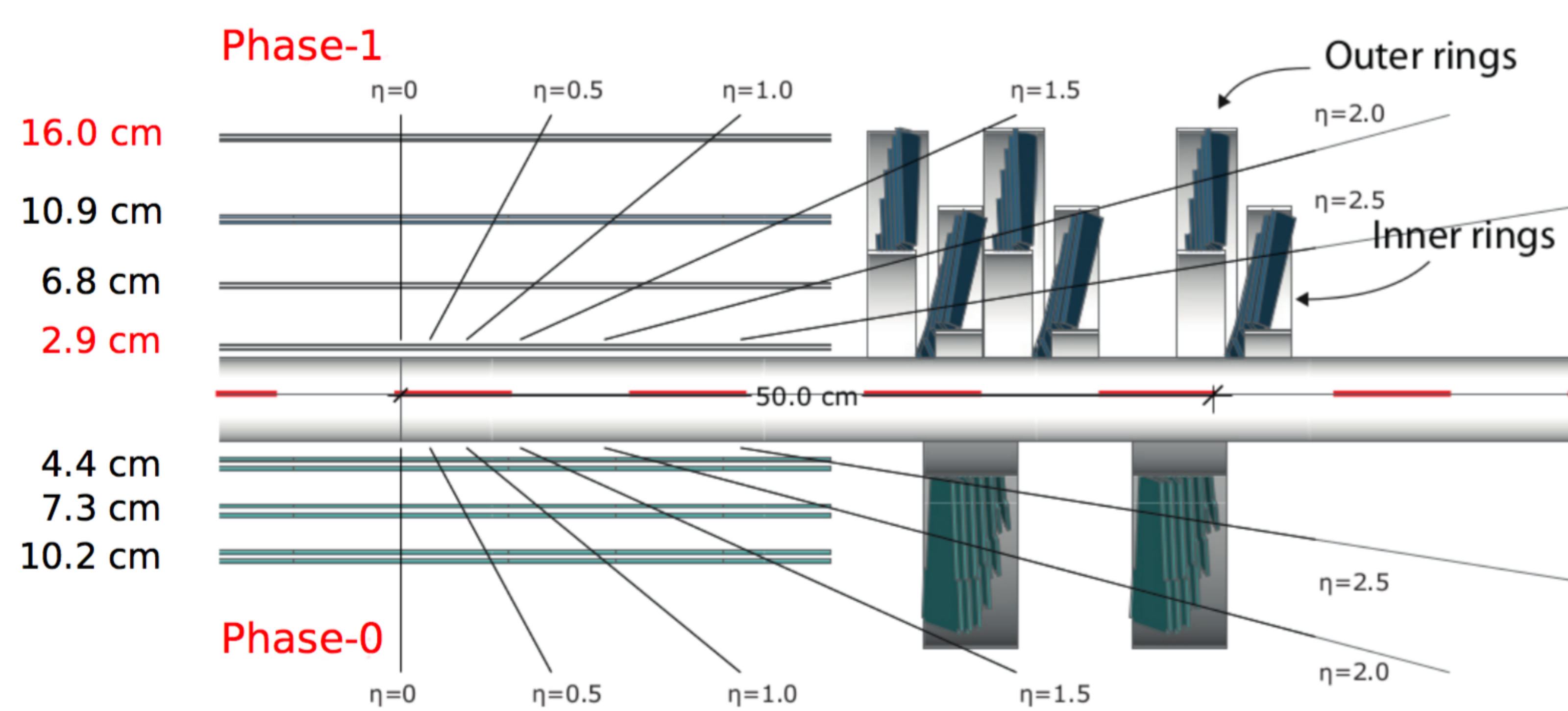
Pixel Tracker within CMS Detector



Upgrade Motivation

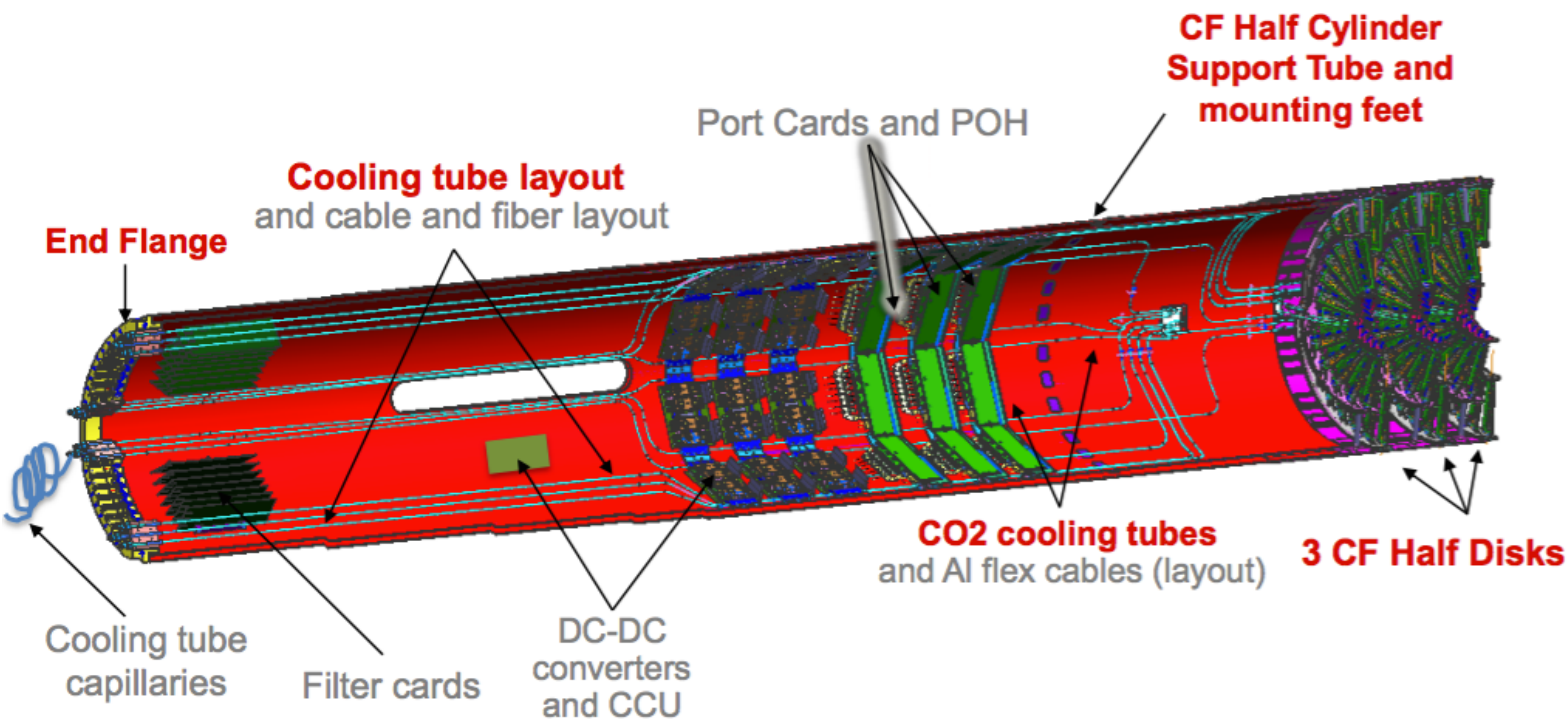
- The LHC has exceeded the designed instantaneous luminosity of $10^{34}\ cm^{-2} s^{-1}$
- Dynamic inefficiencies / dead time caused by limited size of readout bandwidth, affecting detector performance for instantaneous luminosity >1.6 x $10^{34} cm^{2} s^{-1}$
- CMS decided to replace the Pixel detector as part of the phase 1 upgrade
- The upgraded detector has an extra layer of tracking closer to the interaction point





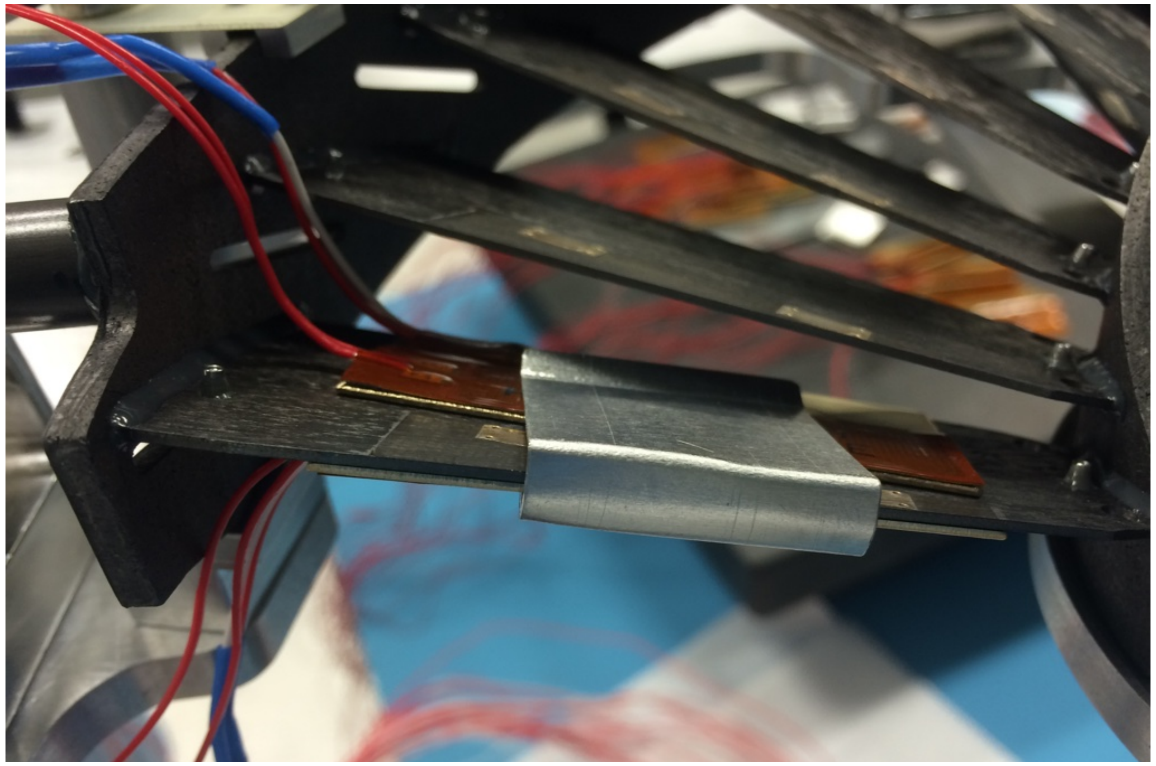
Phase 1 Forward Pixel Detector

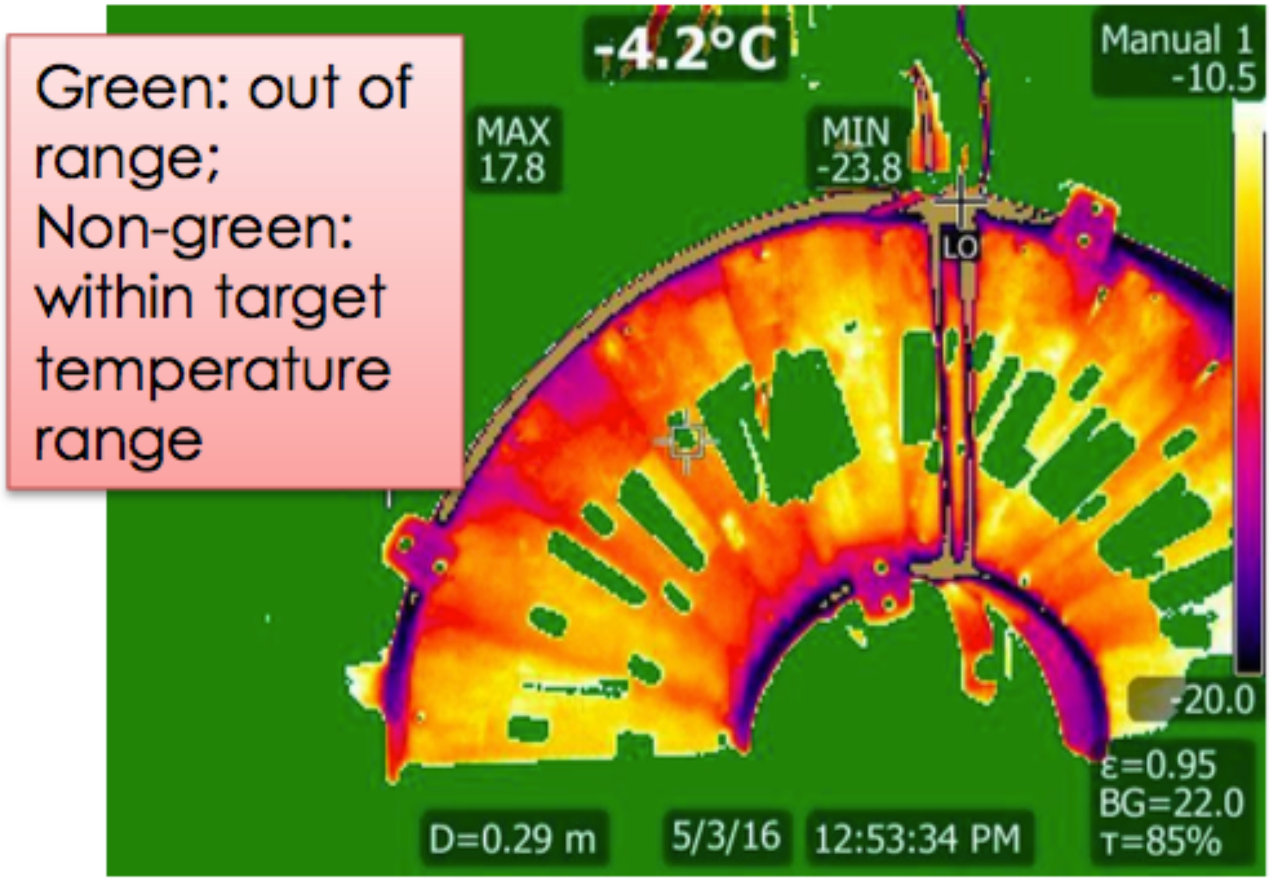
- Phase 1 Forward Pixel Mechanics:
  - 4 Half Cylinders (3 pairs of Carbon Fiber Half Disks in each Half Cylinder)
  - Support structure and cooling for Pixel modules and electronics

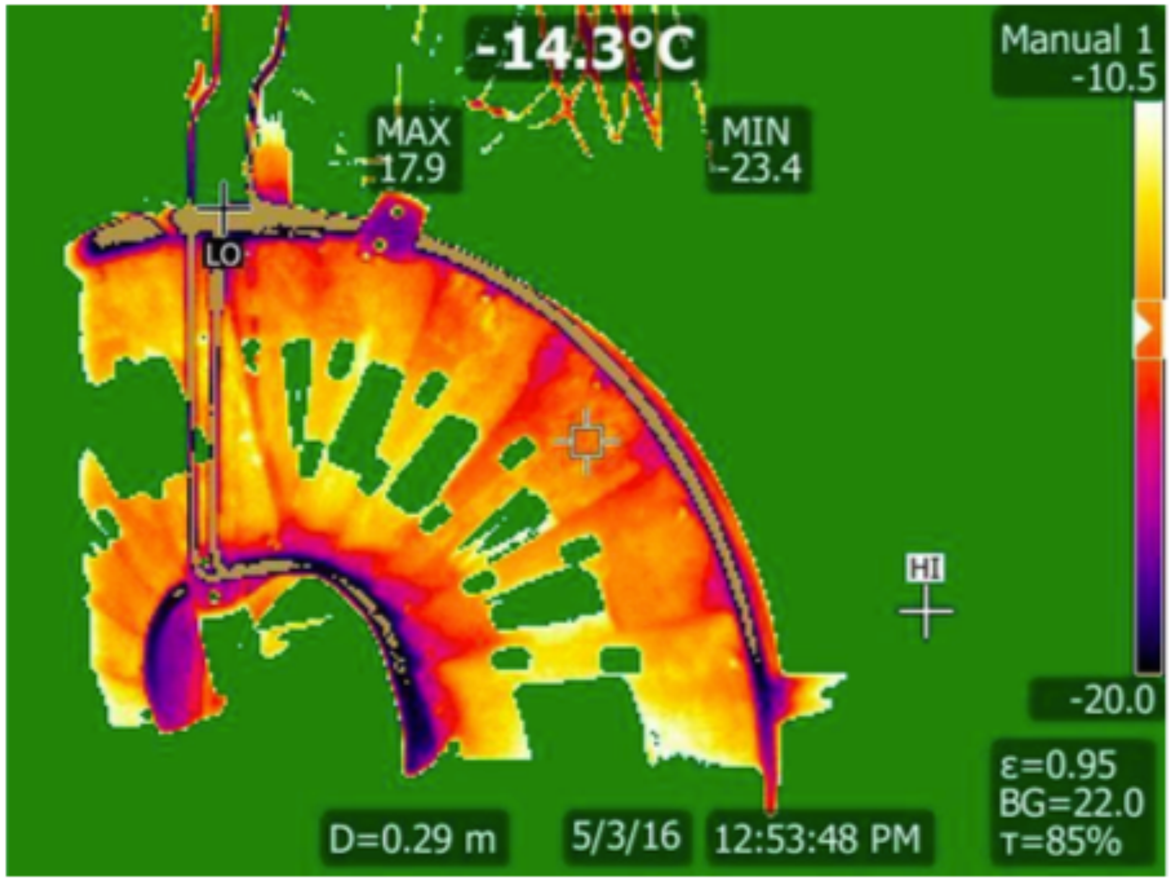


My Contributions to Phase 1 Forward Pixel

- Half disks cooling tests
  - Half disks are thermal cycled after embedding of loops (30 times -40 °C to +40 °C), and then thermally tested at full end-of-life heat load (3W/module).



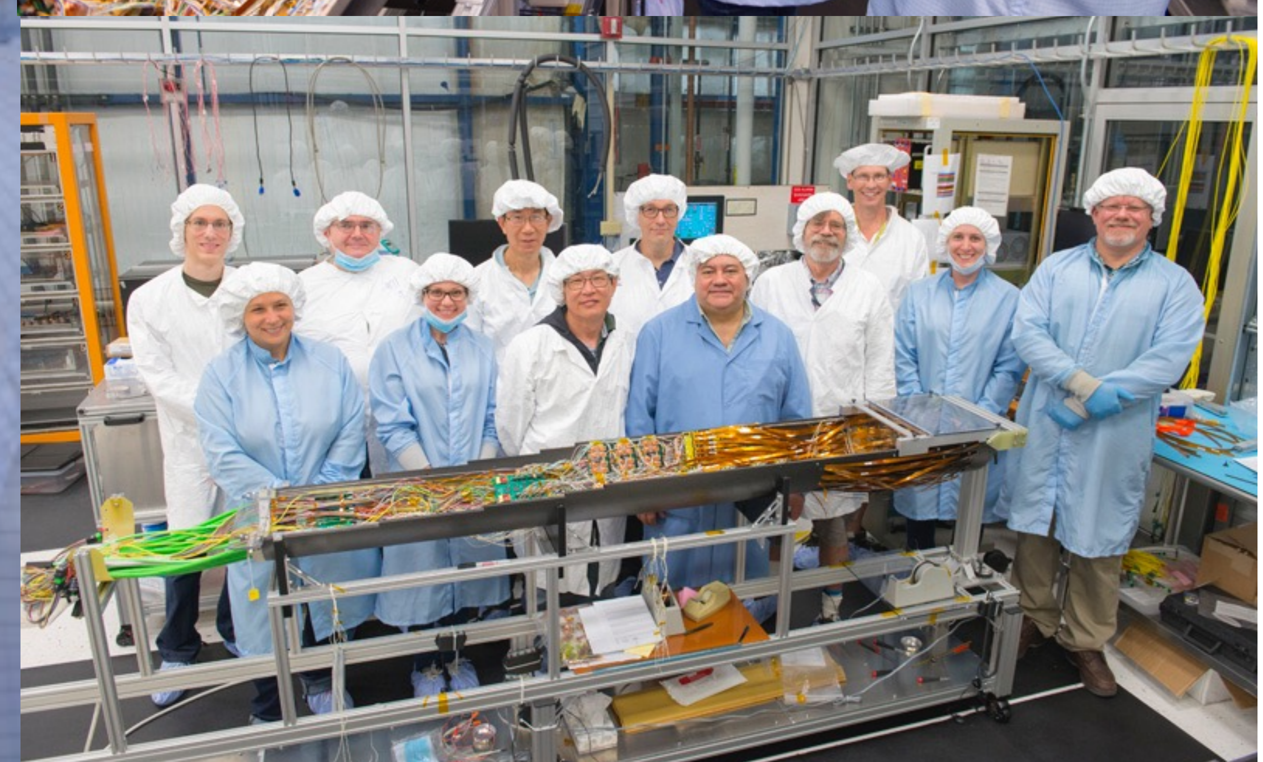




My Contributions to Phase 1 Forward Pixel

- Electronics integration and half disk installation

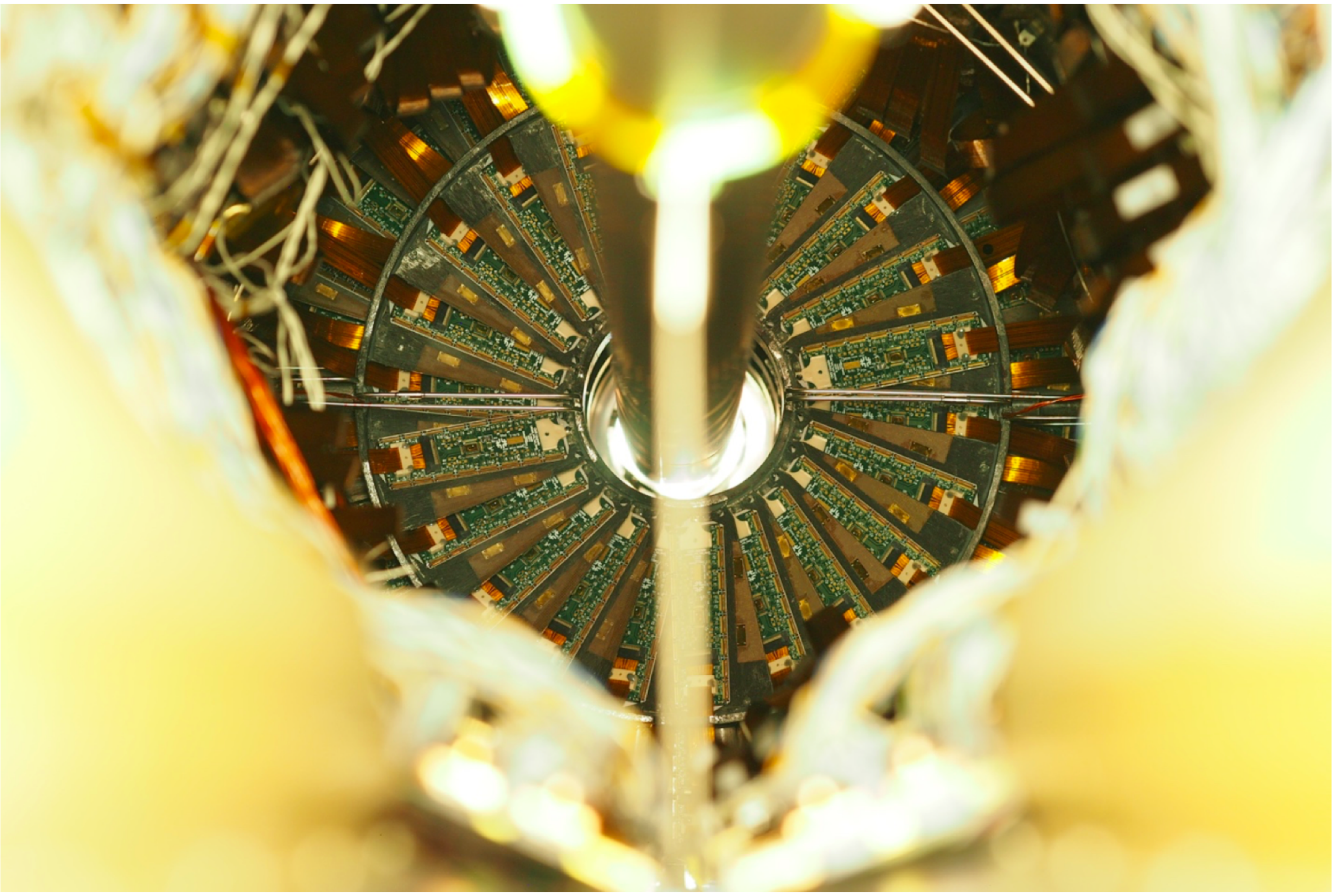




LPC and Phase 1 Forward Pixel Upgrade

- LPC provided me with the opportunity to be part of the phase 1 forward pixel detector efforts through the guest and visitor program (7 months of LPC support)

- Being at LPC made it possible to:
  - Collaborate with scientist, engineers and technicians working on different parts of the upgrade
  - Gain hands-on experience
  - Have access to the Fermilab facilities for performing the QA/QC studies

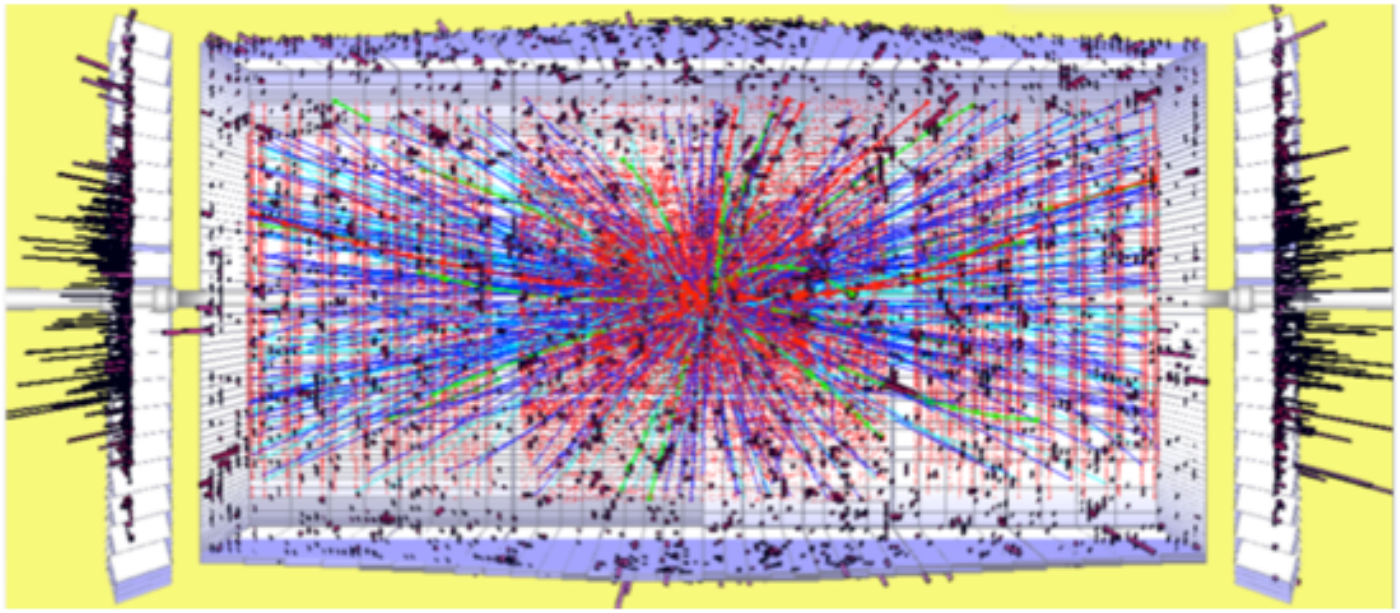


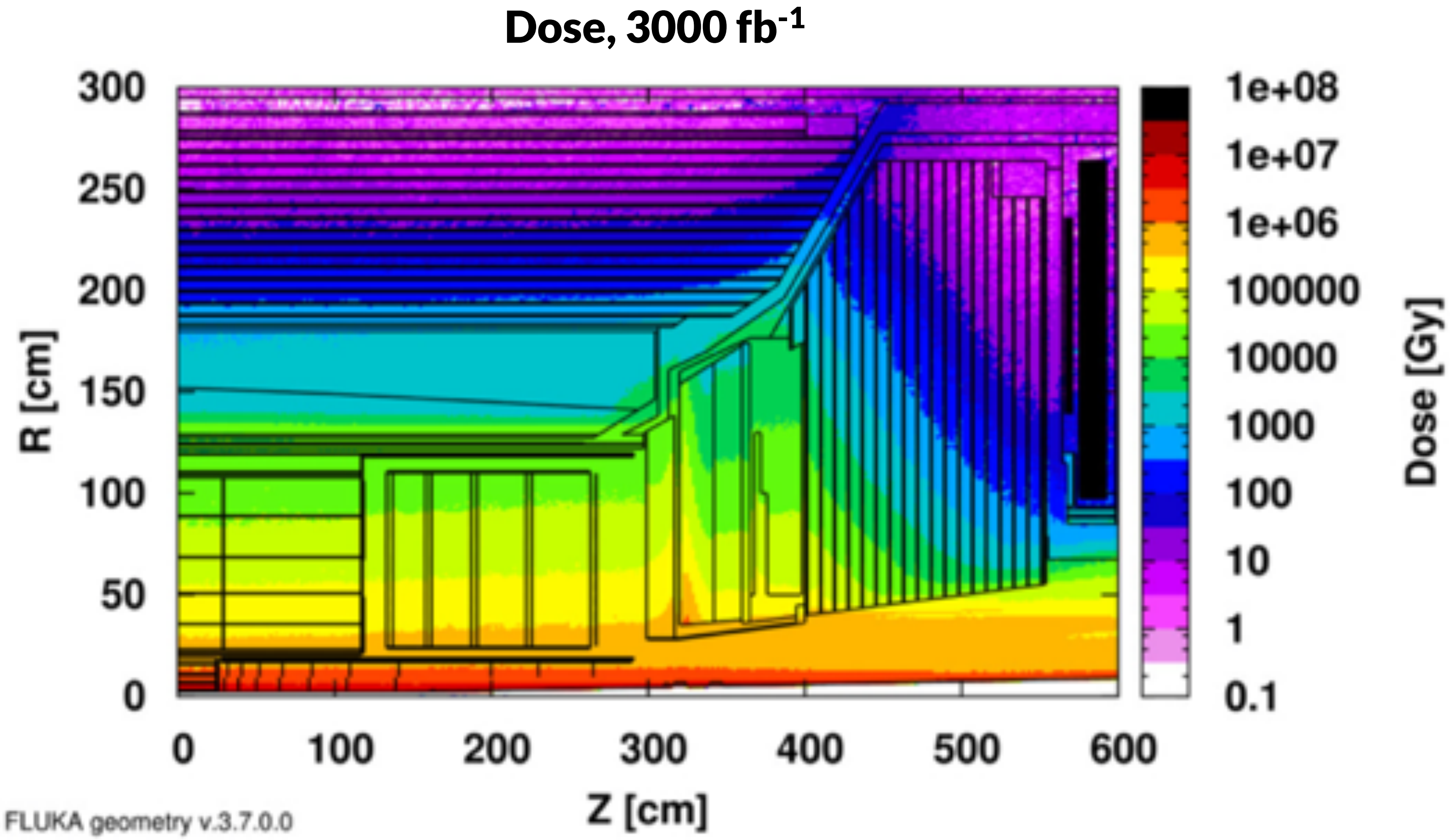
Forwards pixel detector successfully installed inside the CMS

High Granularity Calorimeter

Challenges at HL-LHC

- High Luminosity-LHC plans 5e34 $cm^{-2}s^{-1}$ instantaneous luminosity and 3000 fb^{-1} integrated luminosity
  - High pile-up conditions (200 PU)
  - High radiation dose (150 Mrad, 10^{16} n/cm^2)
- Endcap Calorimeter needs replacement





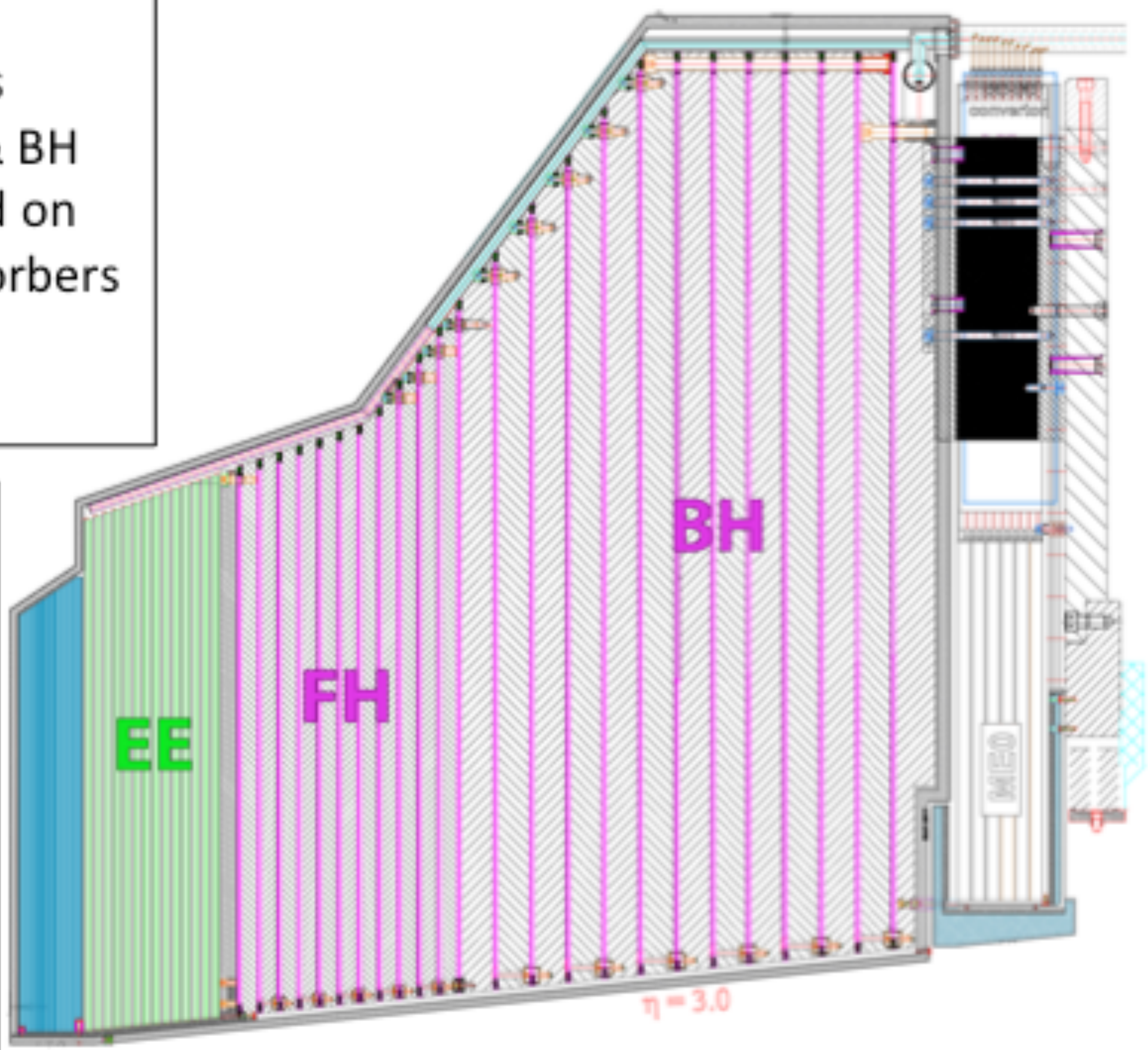
High Granularity Calorimeter

Active Elements:

- Hexagonal modules based on Si sensors in EE and high-radiation regions of FH & BH
- "Cassettes": multiple modules mounted on cooling plates with electronics and absorbers
- Scintillating tiles with SiPM readout in low-radiation regions of FH & BH

Key Parameters:

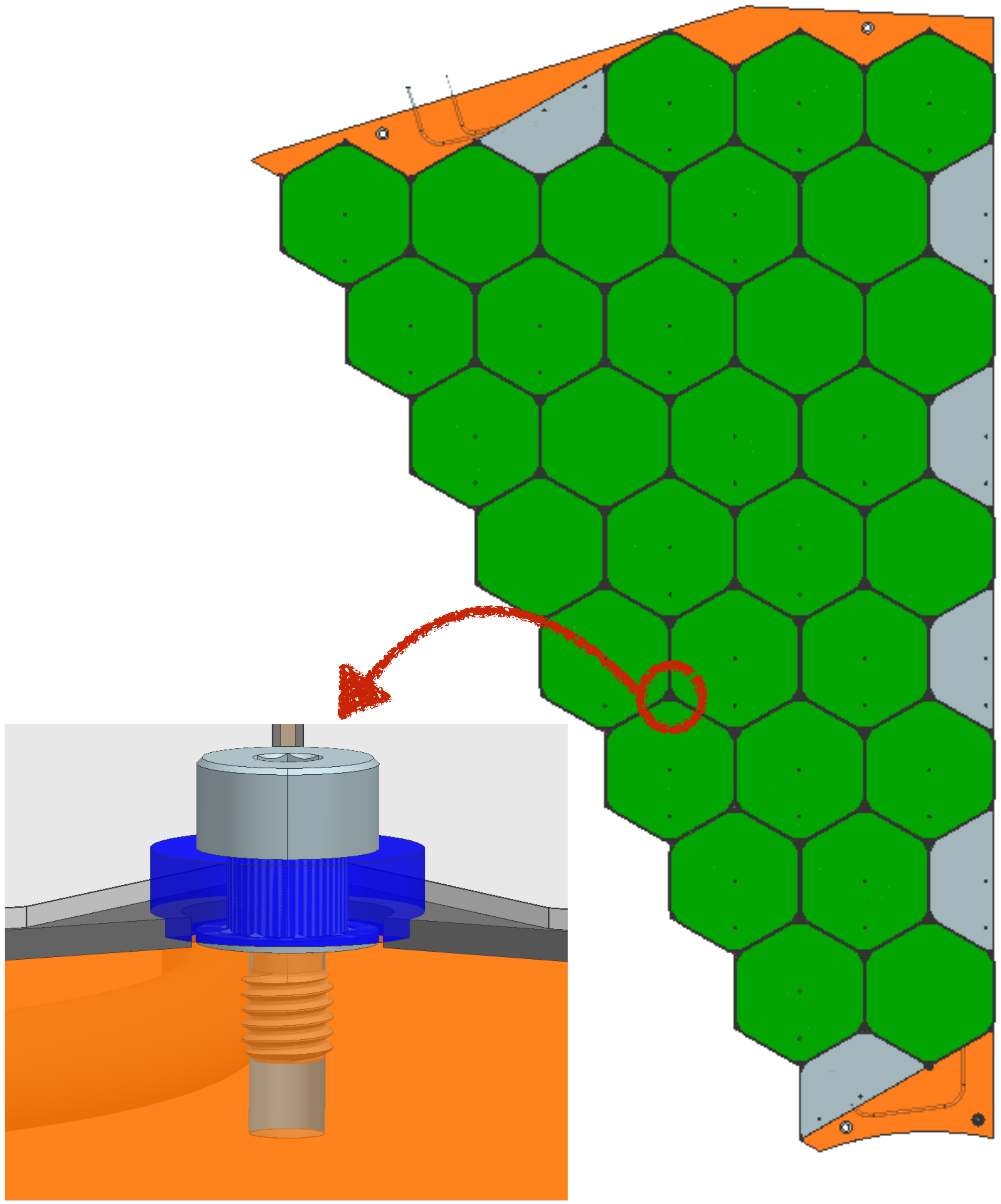
- HGCAL covers $1.5 < \eta < 3.0$
- Full system maintained at -30°C
- ~600m^2 of silicon sensors
- ~500m^2 of scintillators
- 6M si channels, 0.5 or 1 cm^2 cell size
- ~22000 si modules
- Power at end of HL-LHC: ~60 kW per endcap



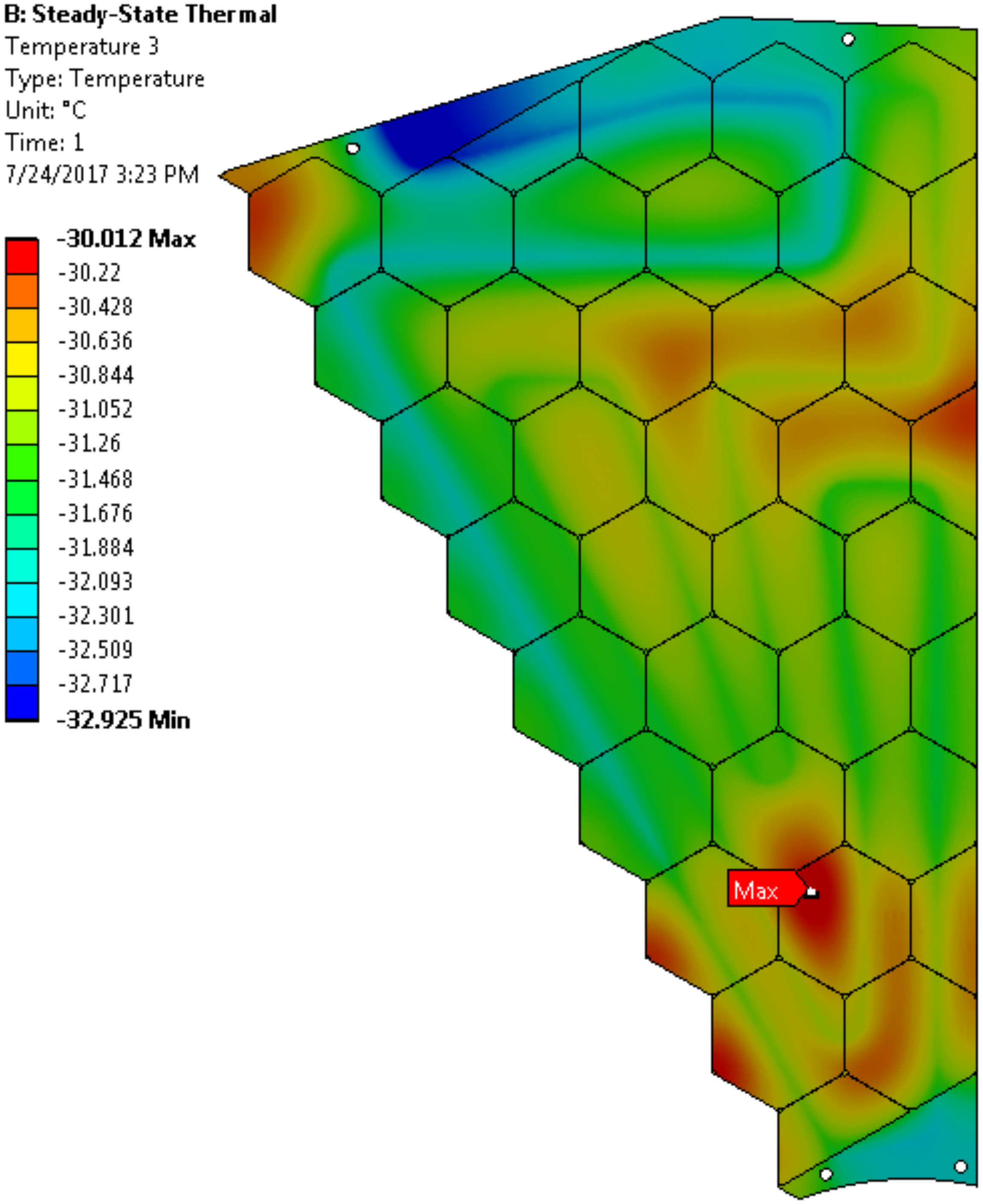
Endcap Electromagnetic calorimeter (**EE**): Si, Cu & CuW & Pb absorbers, 28 layers, 25 X_0 & ~1.3λ
Front Hadronic calorimeter (FH): Si & scintillator, steel absorbers, 12 layers, ~3.5λ
Backing Hadronic calorimeter (BH): Si & scintillator, steel absorbers, 12 layers, ~5λ

High Granularity Calorimeter Efforts

- Cassette R&D
  - Designing dynamic module mounting schemes



- Thermal mock-up
  - Studying thermal and mechanical performance



LPC and High Granularity Calorimeter

- LPC HATS

HCAL HATS@LPC

22 May 2017, 10:00 → 23 May 2017, 13:00 America/Chicago

Sunrise (WH11NE) (FNAL)

13:15 → 15:15 **Hands-On Activity - Session 1** 2h

Activity 3: Characterization of the HGCal Silicon Sensor – Marc Weinberg
https://twiki.cern.ch/twiki/bin/view/CMS/HGCALHATSatLPC2017SensorTesting
The goal of this exercise is to characterize the prototype sensors of the High Granularity Calorimeter planned for the Phase 2 Upgrade of CMS. The hexagonal-shape sensors are made of 6” silicon wafers and contain 135 channels of 1cm2 in area. Participants will measure and visualize the leakage current and capacitance of each channel as a function of bias voltage and will determine the breakdown voltage and depletion depth of the sensor. The setup utilizes a high-voltage power supply, switching frame, digital multimeter and LCR.

Activity 4: Studies of the HGCal Sensor Signal – Maral Alyari
https://twiki.cern.ch/twiki/bin/view/CMS/HGCALHATSatLPC2017SignalStudies
In this exercise we inject charge into the HGCal sensor with a picosecond infrared laser and study the shape and timing characteristic of the response. Due to capacitive coupling (crosstalk), channels adjacent to the the excited one show a non-zero response as well, the amount of which can be measured. The setup is based on the DRS4 evaluation board, a fast USB oscilloscope with 5Gsps.

- Workshops at LPC

USCMS Workshop on Endcap Calorimeter Cassettes

20-21 March 2017
Fermilab - Wilson Hall 11E
America/Chicago timezone

Search...

- Overview
- Timetable
- Contribution List
- My Conference
  - My Contributions
- Registration
- Participant List
- Videoconference Rooms

As the HL-LHC calorimeter endcap upgrade planning and R&D is proceeding, we are holding a series of workshops to review the US plans for involvement, recent results from US groups, and to plan for upcoming efforts. This is the second workshop of the series.

In this workshop we will focus on the R&D and construction of cassettes in the US, with the objective of developing a near-term plan for a cassette mockup/prototyping program focused on achieving the milestone of the thermal and mechanical mockup due 15 Sep 2017. This near-term plan needs also to lay the groundwork for the next major cassette milestone 15 months later for the construction of several fully functional prototype cassettes. The agenda will also include updates on the status of module and scintillator R&D.

Starts 20 Mar 2017 08:30
Ends 21 Mar 2017 17:00
America/Chicago

Fermilab - Wilson Hall 11E
Sunrise Room

Fermilab
Batavia, IL, 60510
USA

Harry Cheung
Jeremy Mans
Jim Strait
Zoltan Gecse

Collaborators

All-hadronic $Z' \to t\bar{t}$ Search

University of California Davis · UB · Universität Hamburg (Der Forschung | Der Lehre | Der Bildung) · Johns Hopkins University

Forward pixel detector phase 1 upgrade

Universidad de Puerto Rico · Purdue University · UB · The University of Iowa · UIC · Kansas State University · The Ohio State University · University of California Davis · UC Riverside · Fermilab · Rice · Rutgers University · The University of Kansas · Wayne State · University of Colorado Boulder · University of Nebraska Lincoln · Purdue University Calumet

High Granularity Calorimeter

University of California Santa Barbara · Minnesota · Fermilab · Texas Tech · Carnegie Mellon University

Conclusion

- LPC brings the experts of all areas together
  - LPC environment makes physics analysis efforts more efficient

- LPC provides support for younger members of the community
  - Provides opportunities for getting involved in physics analysis
  - Provides excellent opportunities for involvement in hardware projects

- LPC environment had a crucial impact on my career path

- As a Fermilab Postdoc I am committed to contributing to the LPC activities