Telescope to test CMS Pixel Phase-II Upgrade ROCs and sensors

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The innermost layer of the CMS Detector at the LHC is the Silicon Pixel Tracker. The current version of the detector has performed well and been critical to the physics program of CMS. However, as the LHC produces higher instantaneous lumenosities and higher center-of-mass energies, the detector must be upgraded to accomidate. The Phase-II Upgrade of CMS will replace the entire silicon tracking system. As part of this upgrade, a new section of the pixel tracker will be added in the so-called "Very-Forward" (TODO: η range)region of the detector. This new section of the detector will have different pixel geometries than the current detector, and these new geometries must be comissioned. Therefore, a telescope is being developed for the express purpose of characterizing these sensors so pixel geometry can be optimized before settling on a final design to be placed in CMS. The telescope operates by using eight layers of silicon-strip sensors, with the device-under-test placed with four on each side. A charged-particle beam is directed so it passes through both the strip sensors and the device-under-test. Measurements from the telescope are taken to reconstruct individual particle tracks.

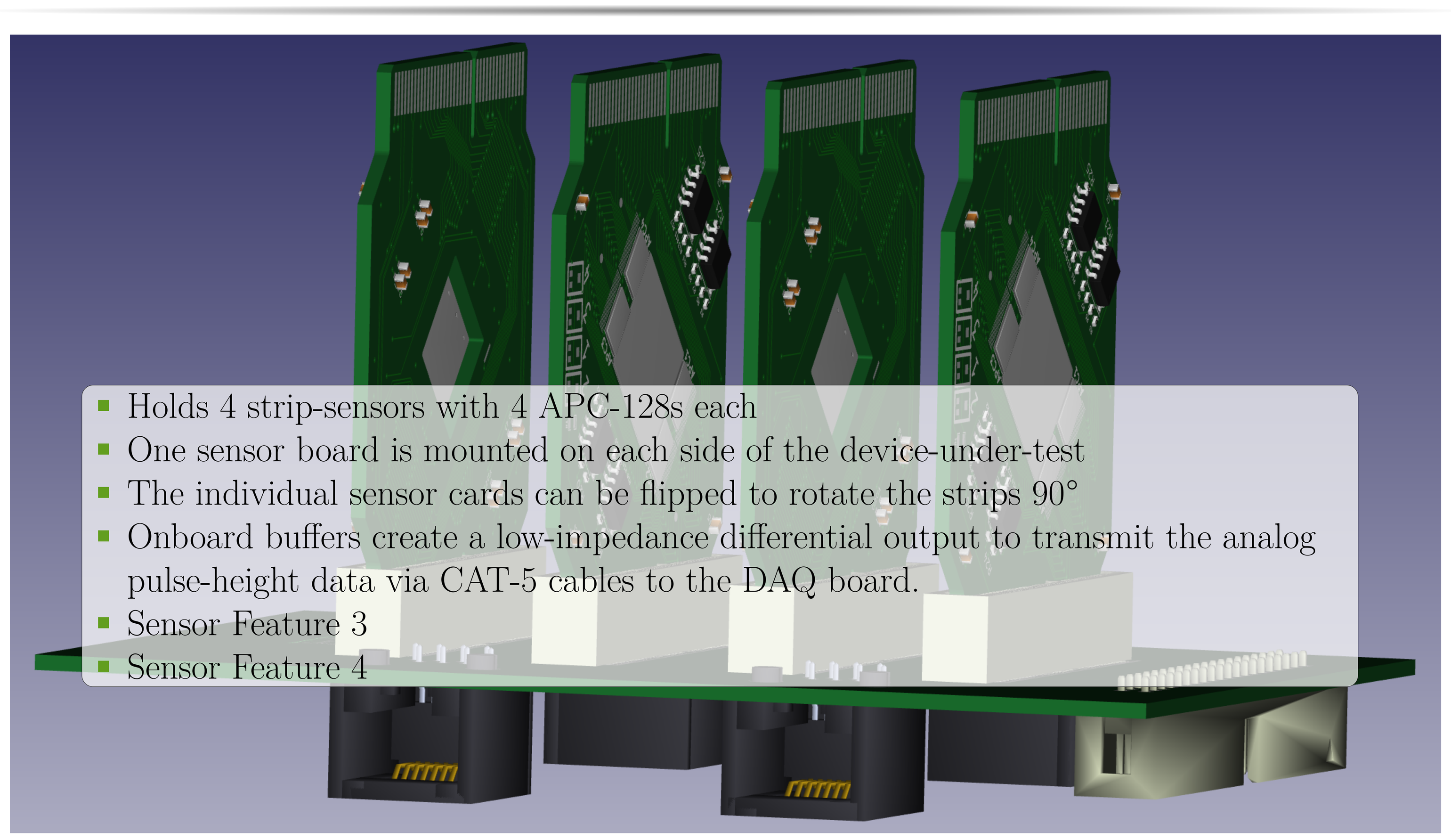
Readout Overview

- The sensor is essentially a silicon NP-Junction operated in "reverse-bias" mode where all free charge carriers are evacuated
- A energetic charged particle passing through the silicon deposites energy to create free electron-hole pairs which are then separated by the electric field produced by the biasing voltage
- The electrons create a current spike that the readout chip, the APC-128, samples and stores
- Upon recieving a trigger, the APC-128 serializes the analog pulse-height sample from each of the 128 channels

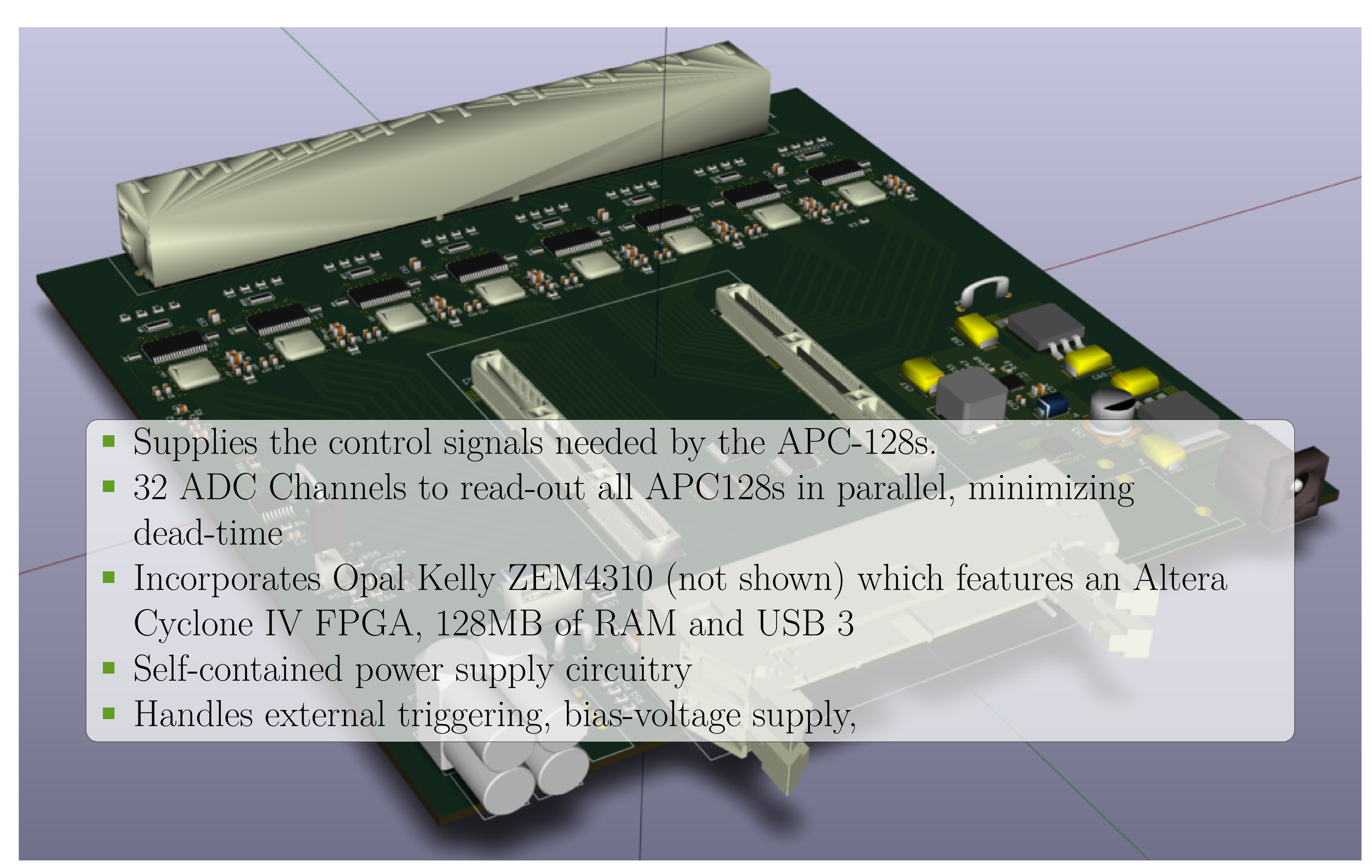
- The analog pulse-heights from the 32 APC-128 in the telescope are digitized by 8 high-speed 4-channel ADCs located on the DAQ Board.
- The digitized values passed to an FPGA board where they are processed into individual sensor hits.
- The sensor hit data is passed across a USB-3 connection to a PC where online software organizes the hits into events and stores them to disk.

- After the event data is stored to disk, it is ready for offline analysis
- Since the detector layers can shift in space significantly, alignment must first be done to accurately measure the geometry of the detector.
- After alignment, the various layer hits can be used to construct tracks.
- The tracks can then be compared for consistency with the data collected in parallel from the device-under-test.

Half-Telescope Sensor Board



DAQ Board



Progress

- ☑System design and parts selection
- ☑Circuit design and PCB Layout
- ☐Assembly and offline testing (in progress)
- ☐FPGA Firmware development and testing
- ☐Online/Offline software development
- ☐Commissioning runs with UNL Diocles electron beam

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References

- **PCB Design Files** https://github.com/cfangmeier/VFPIX-telescope-PCB
- **CMS Phase-II Upgrade**
- reference 3
- reference 4

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