SiD EMCal Testbeam Prototype

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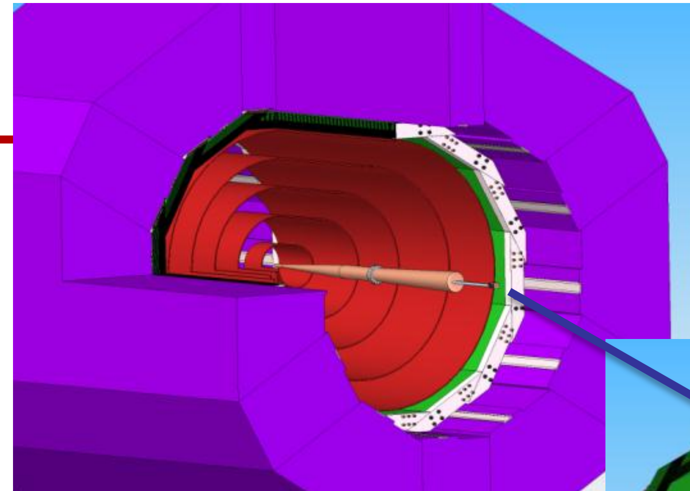
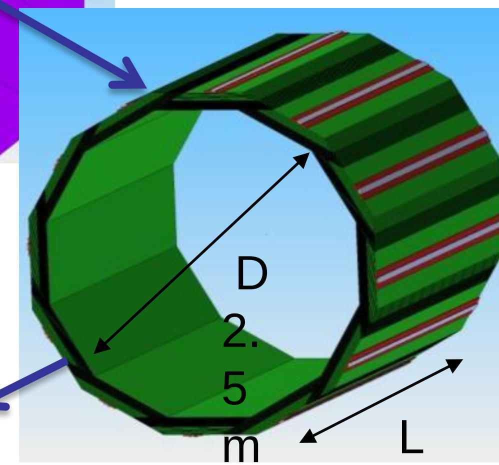
ECAL

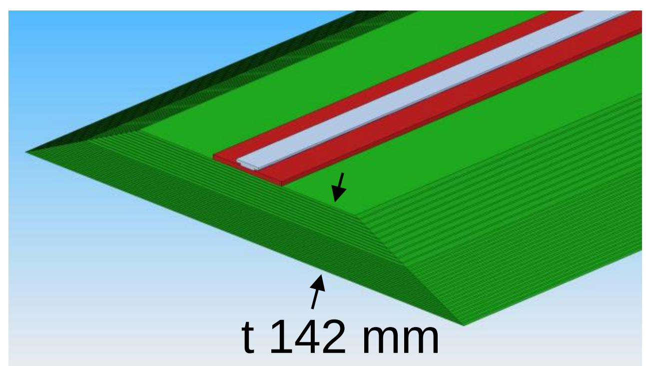
Prototype Goals:
•Replicate full EMCal stack and test – 30 sensors.





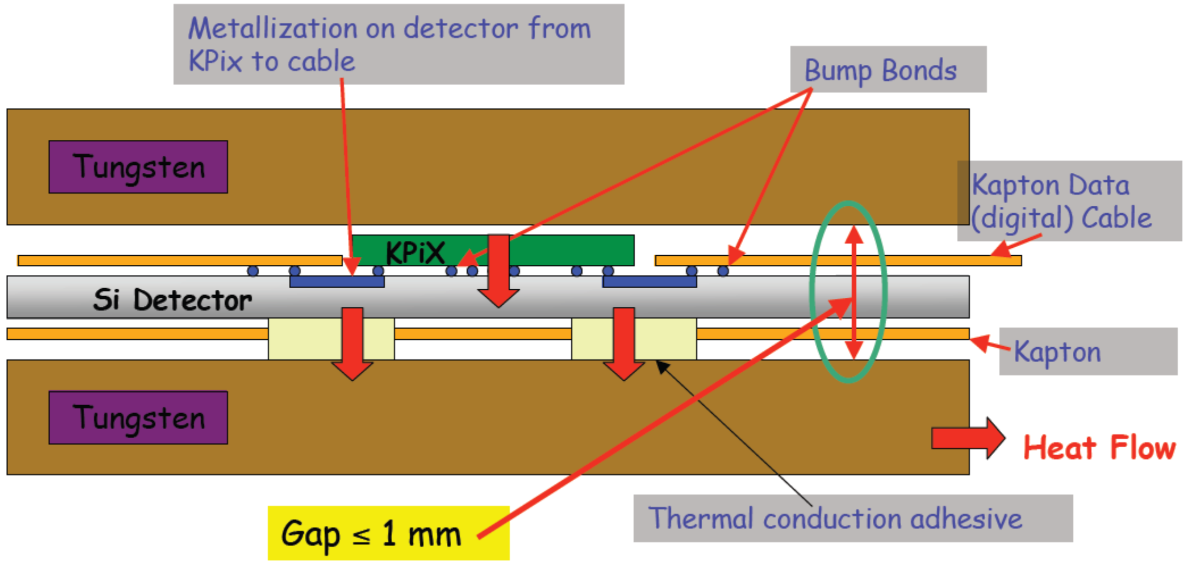
L 4.36 m

20 layers 2.5 mm W (5/7 X0)
10 layers 5 mm W (10/7 X0)
30 gaps 1.25 mm w Si pixels sensors
29 X_0; 1 λ
$\Delta E/E = 17\%/\sqrt{E}$;
Effective Moliere radius = 13 mm



SiD

Detail of Structure.



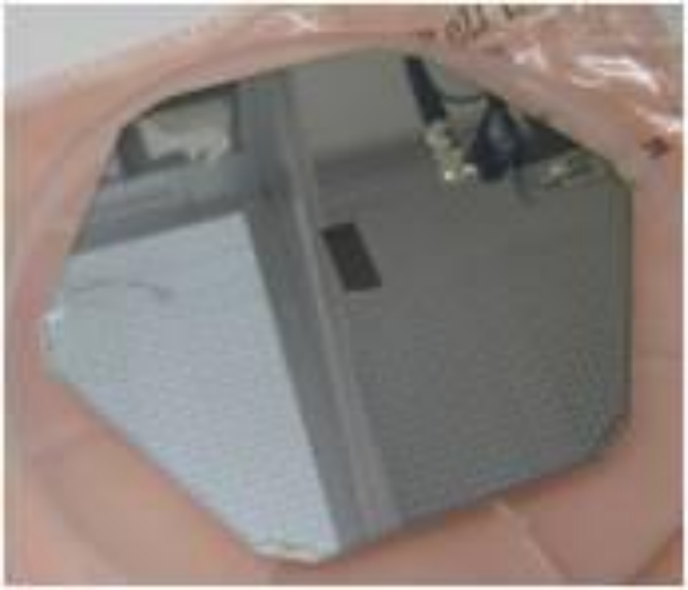
Boundary Conditions

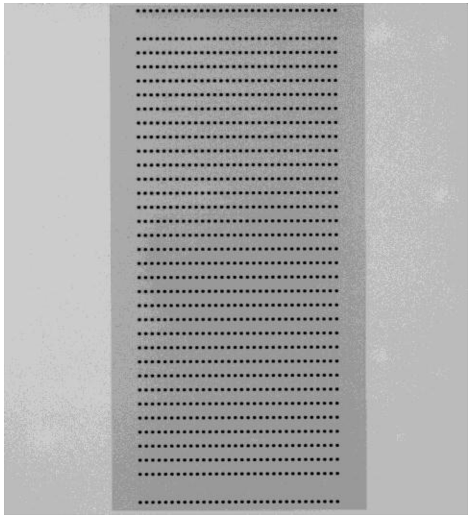
- We have 40 nominally good Hamamatsu sensors.
- We have ~20 nominally bad "mechanical prototype" sensors.
- We have 28 remaining KPiXa (1024 channels).
- The KPiXa's come from TSMC with eutectic Sn-Pb bumps in place in wells on the chip.

- The Hamamatsu sensors (EMCal and Tracker) come with Al pads, so there is a layer of Al_2O_3 which must be removed…

Under Bump Metallization (UBM)

- UCD put a huge effort into UBM:
  - Used the mechanical prototype sensors
  - Zincate – chemistry to remove the Al_2O_3 and plate a stack ending with Au.
  - Sputtering – to directly implant Ti and then a stack ending with Au.
- With miserable results!
  - Possible explanation is that there is something else on the pads, but SEM sees only Al and O.
- We finally went to IZM in Germany who use a sputtering process.
  - They have bonded two KPiXa's to two mechanical prototype sensors.

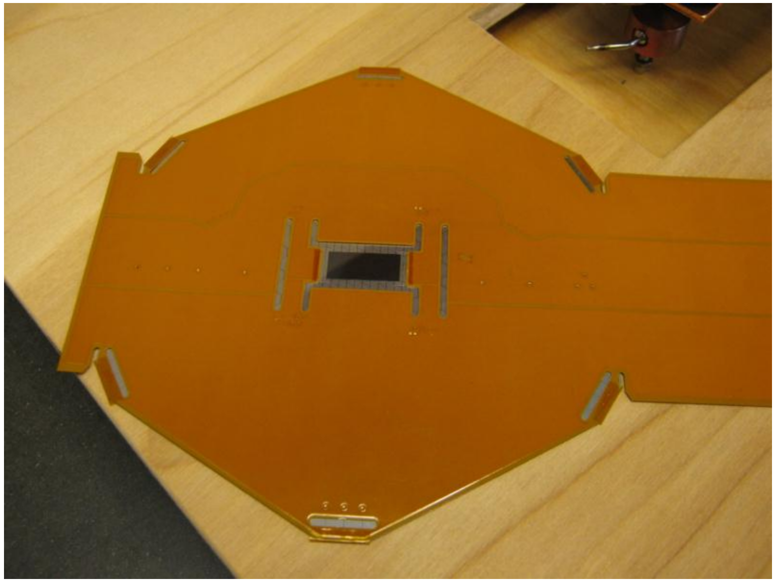


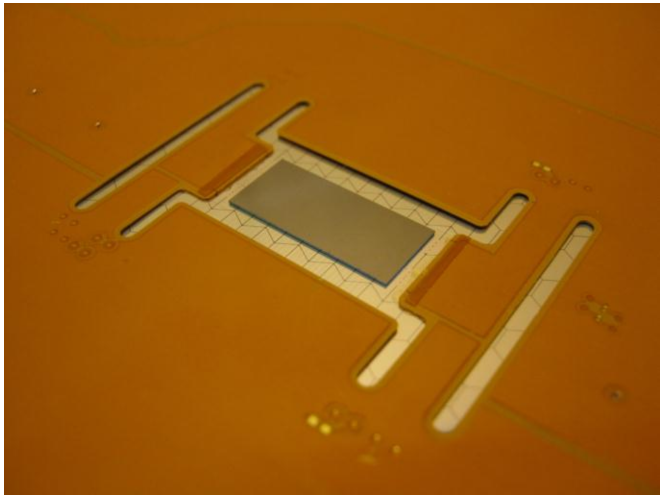


X-ray image of bumps - IZM

Bonded Sensor

- UCD has bonded a cable to one; it is being tested at SLAC.
- UO is probe testing the other. First results ~now.





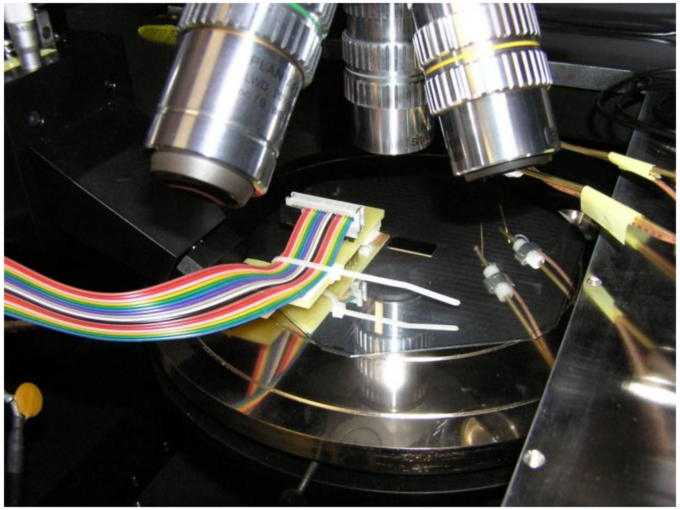
KPiX bump bonded to sensor
Cable bump bonded to sensor
Assembly 1 mm high

Results…

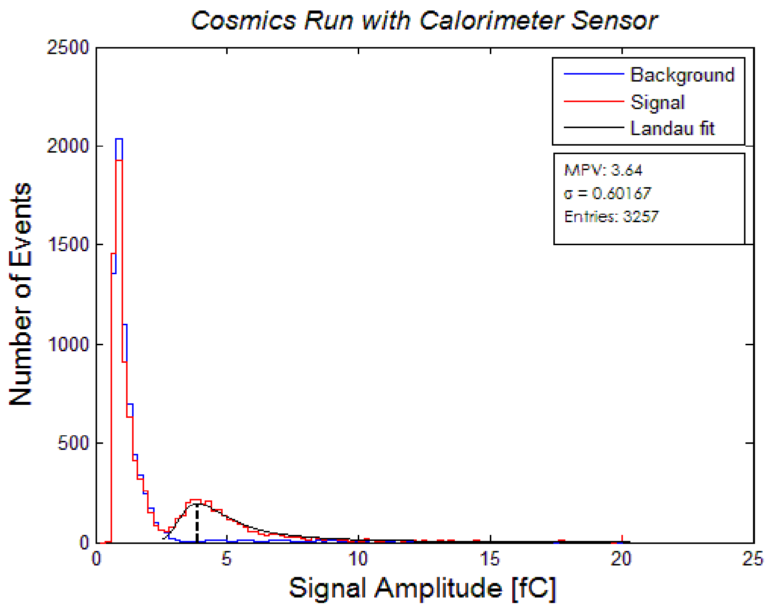
- 752 pixels seem ok.
- 114 pixels appear disconnected – no apparent increase in noise as expected from increased C.
- 158 pixels do not calibrate properly – leakage?

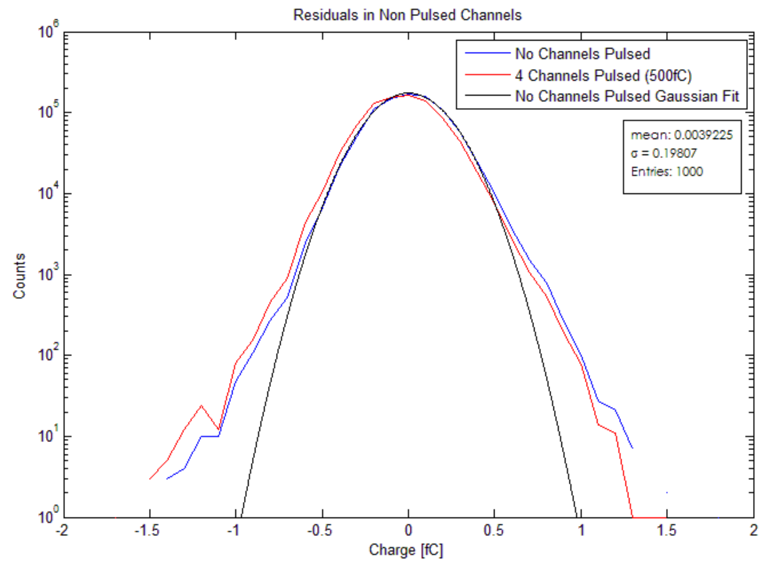
- *But this is a mechanical prototype!!!*

- UO has probed a few other prototype sensors, and sees ~3% opens.
- We do not yet have the corresponding good/open/bad pixel numbers for the UO sensor.



First Performance Studies





Cosmic telescope trigger

Cross talk Study: Red: 4 pixels pulsed at 500 fC,
All other channels shown. Blue: no pixels pulsed.

Performance Comments

- The first version of the electronics reading out KPiX gave excellent “analog” performance – e.g. self triggered multiplicity was ~1, and there were no “everything lights up” events.
- This indicates that KPiX and its sensor, cable, and enclosure environment is satisfactory.
- The new electronics, suitable for 32 KPiX, is not quiet.
- It is probably ok for the testbeam (short window), but the system needs work.

Prototype

Silicon sensors: Meet specs. for SiD Ecal

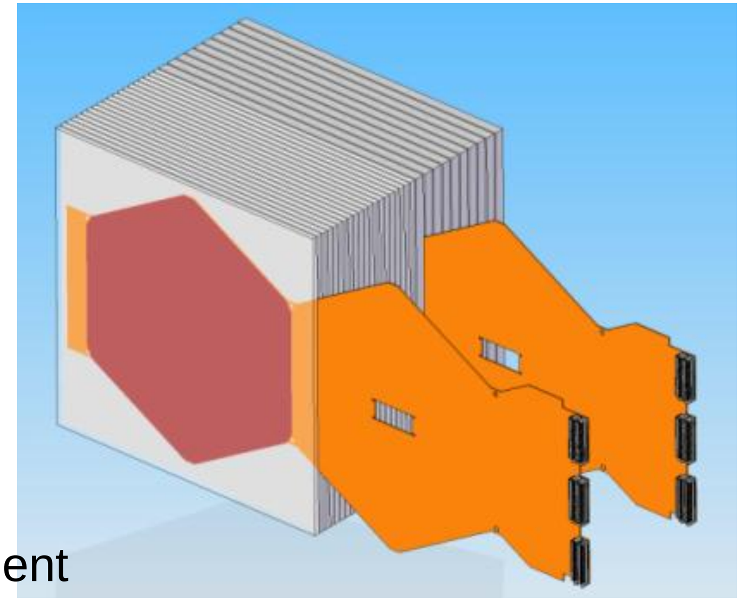
- low leakage current; DC coupled
- sufficient number for prototype (30 layers)

KPiX: prototypes meet SiD specs.:

- low noise (10% of MIP)
- large dynamic range: ~10^4
- full digitization and multiplexed output
- passive cooling (power pulsing)

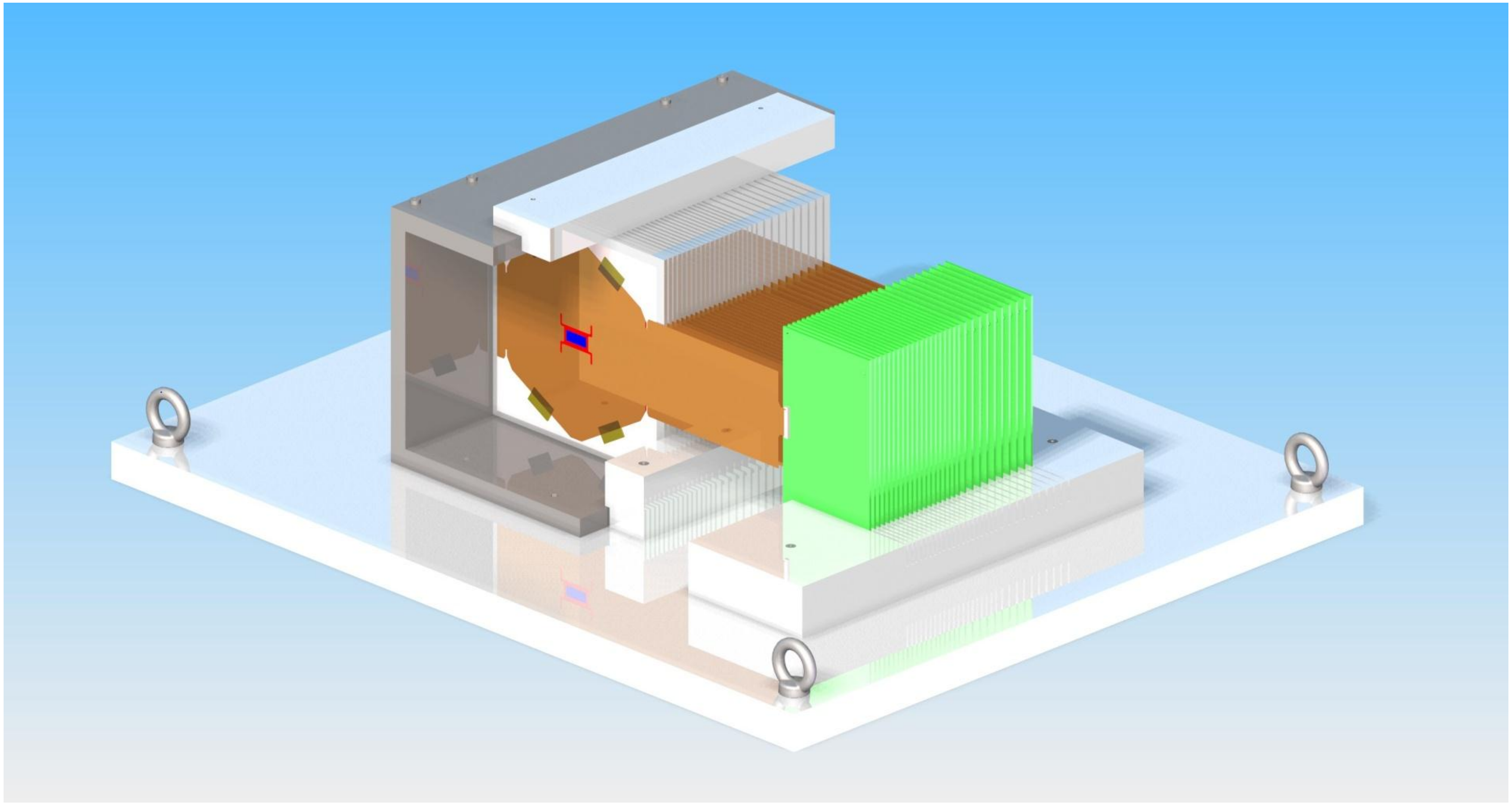
Interconnects:

- Flex cable R&D ok so far – successful attachment to dummy sensors and 1 mechanical prototype.
- Main focus of recent R&D is the KPIX – sensor interconnects … recently successful – we think…

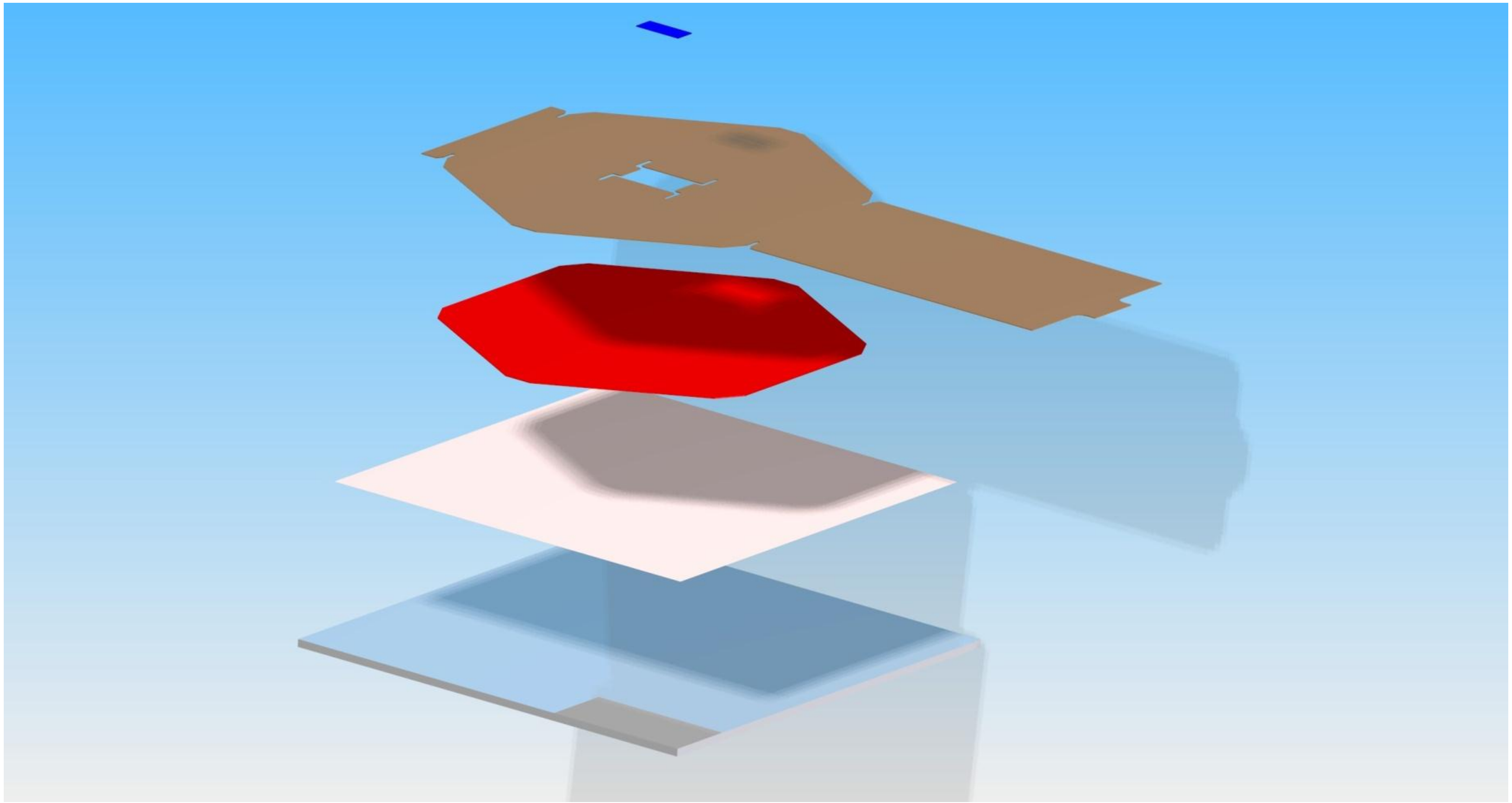


Prototype module – circa LOI

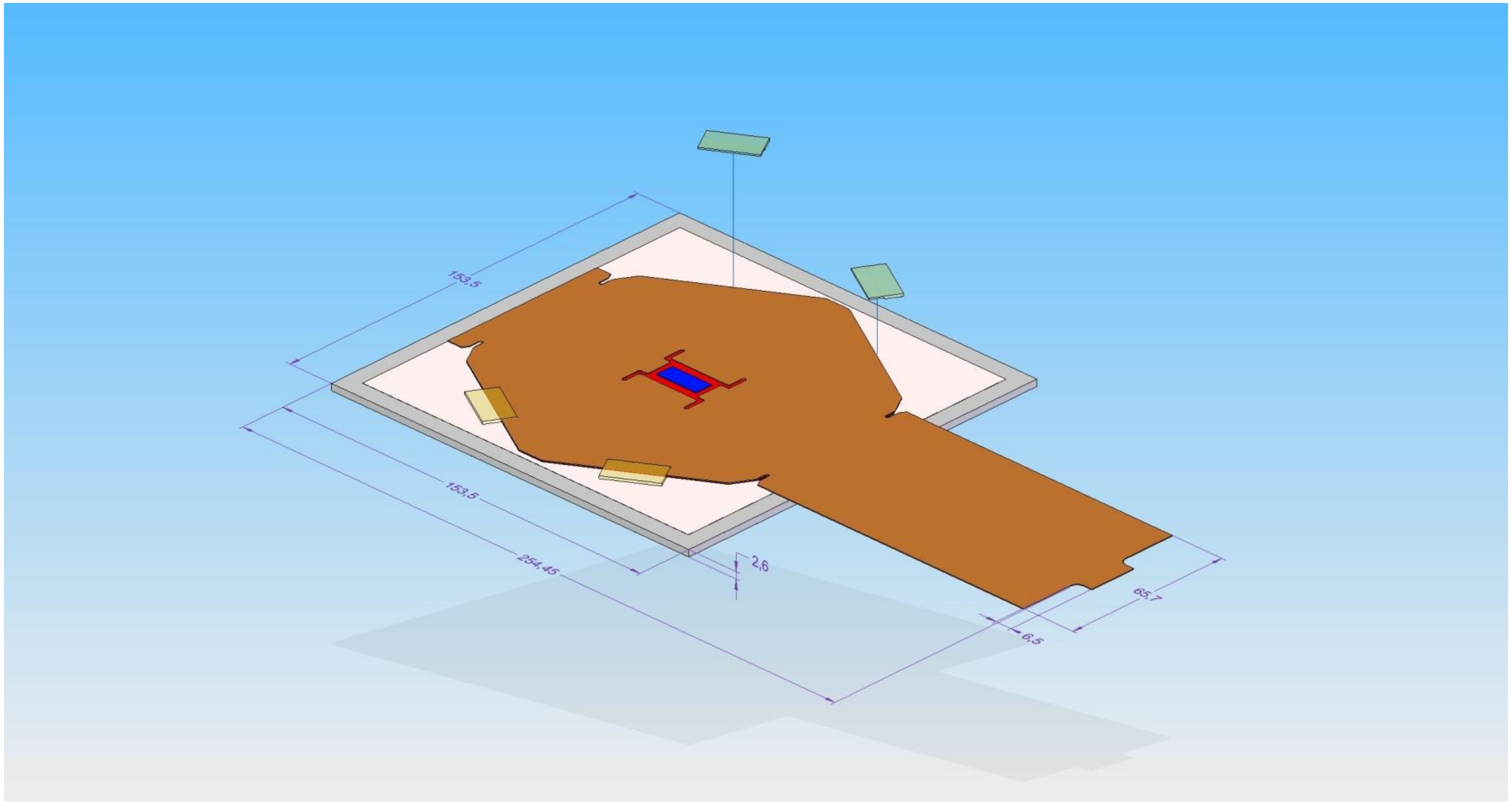
Prototype – Engineering Model



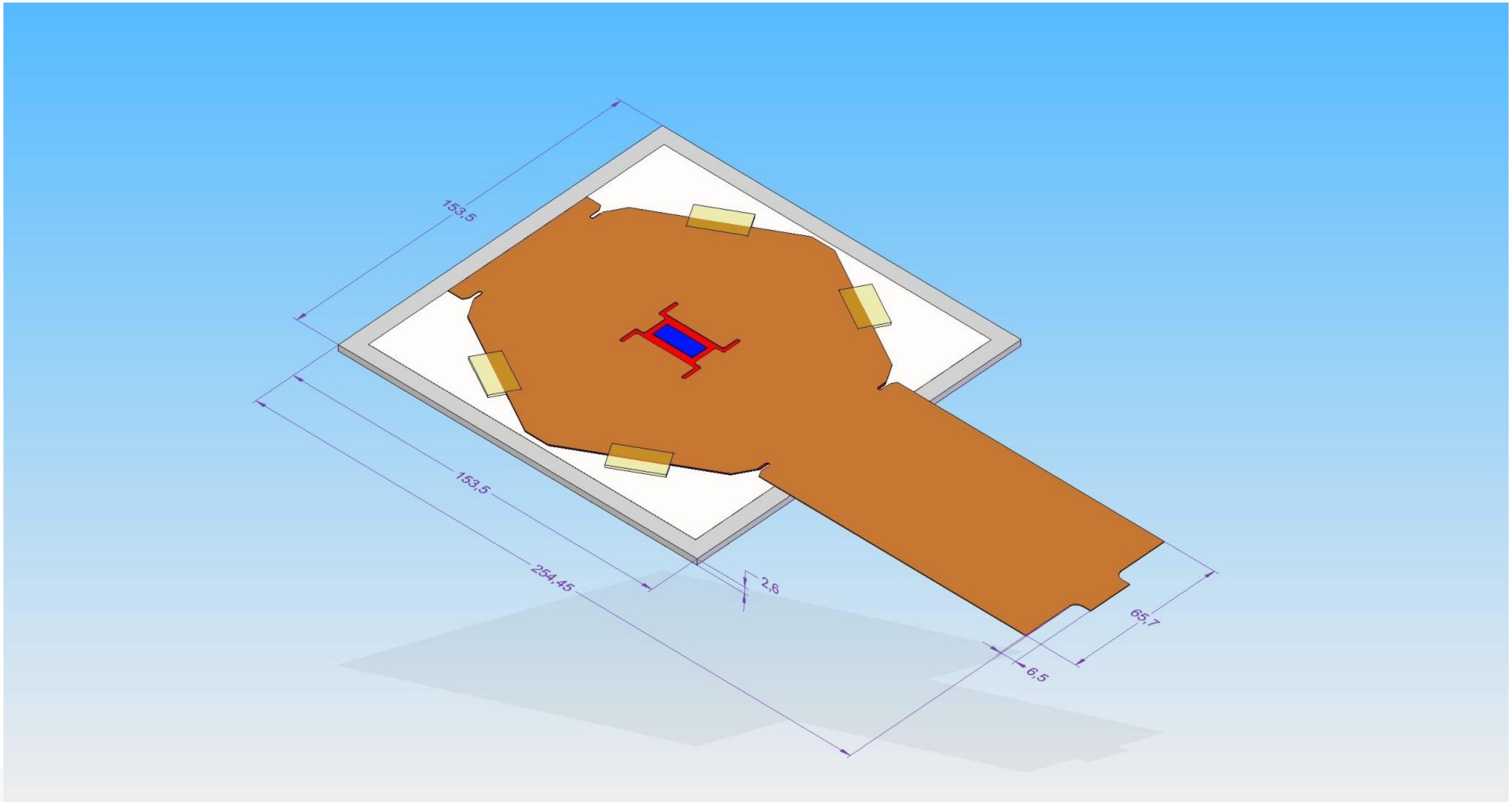
Layer Assembly



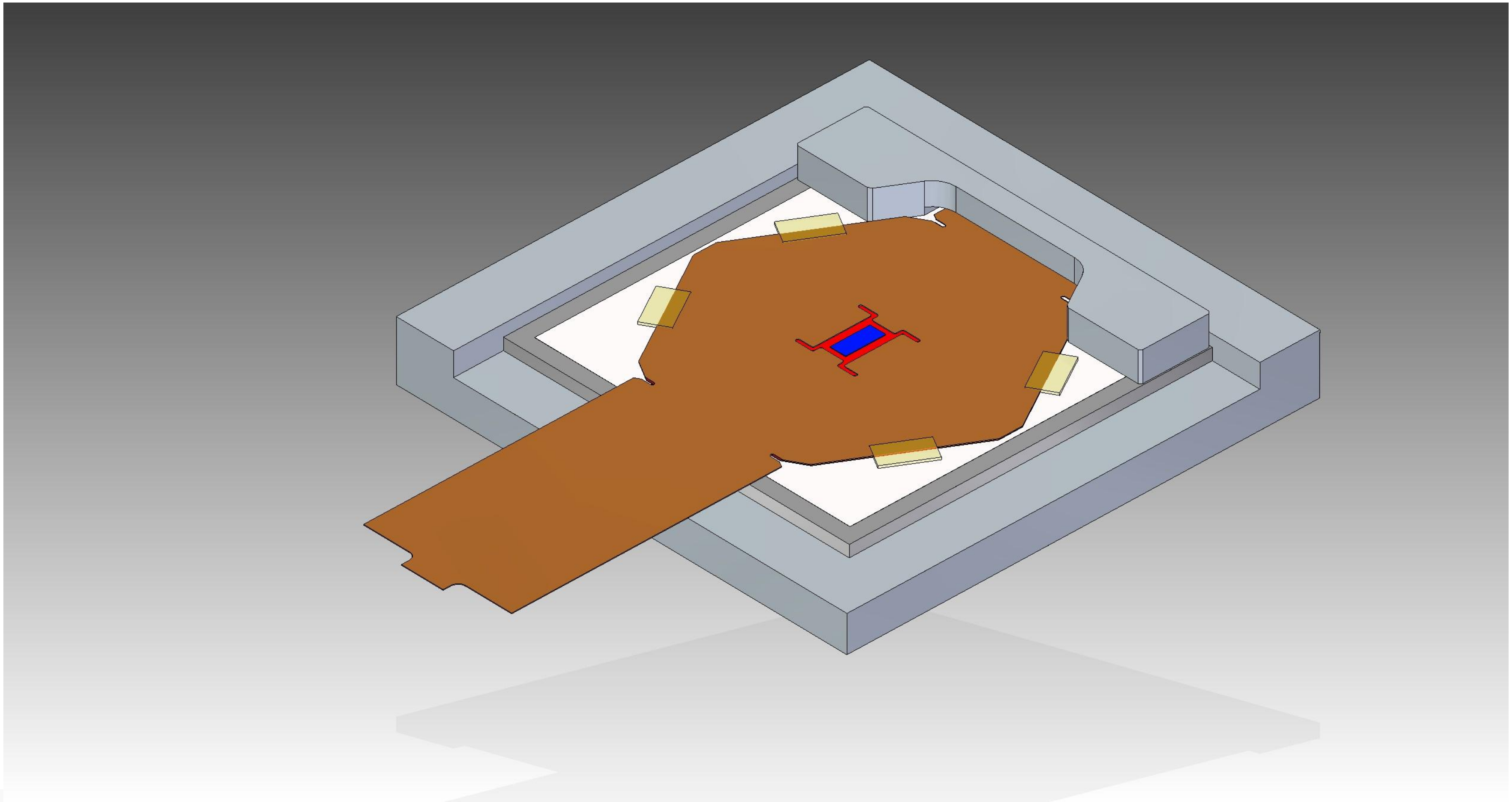
Adding hold-down tabs



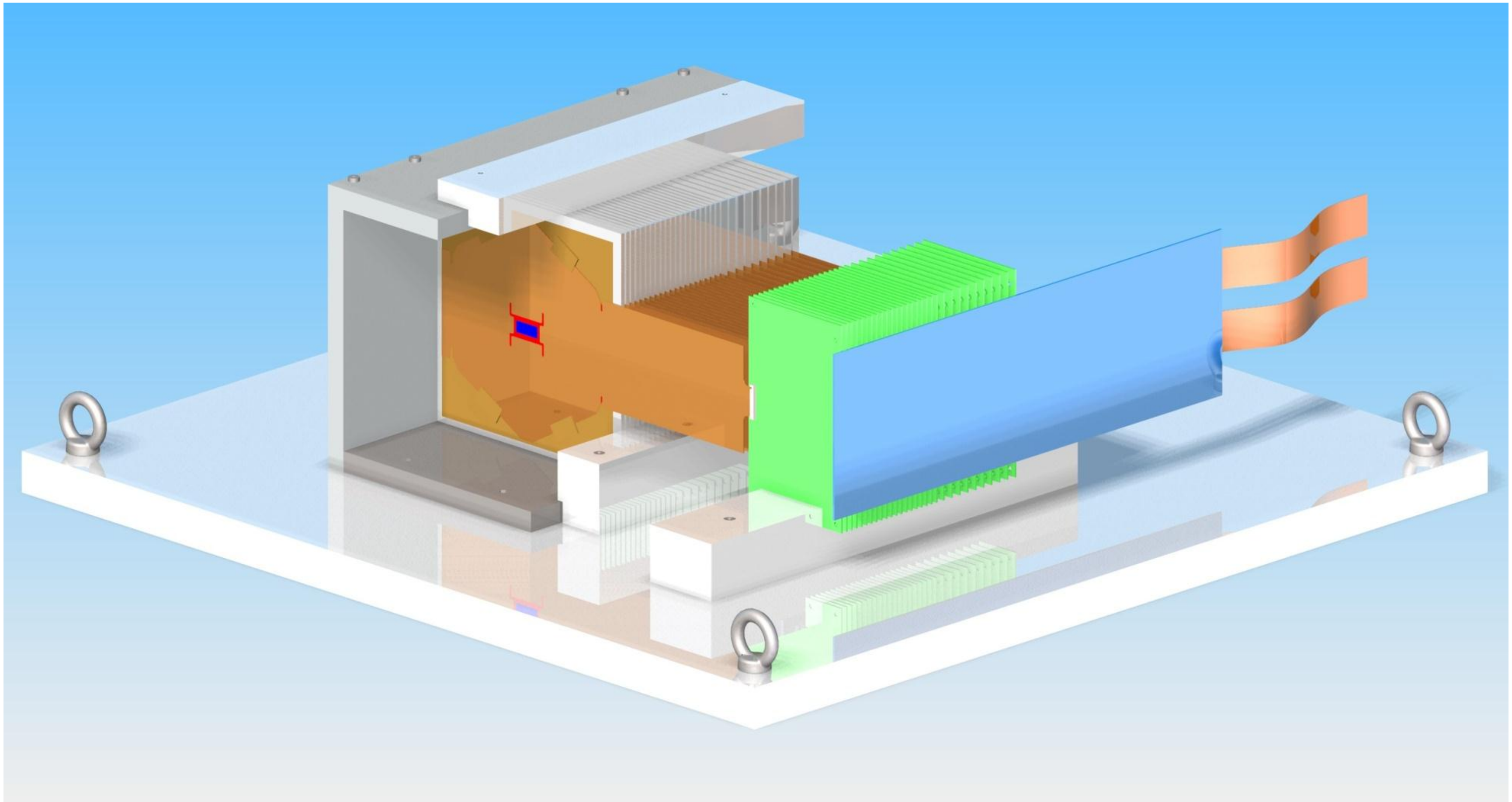
Layer



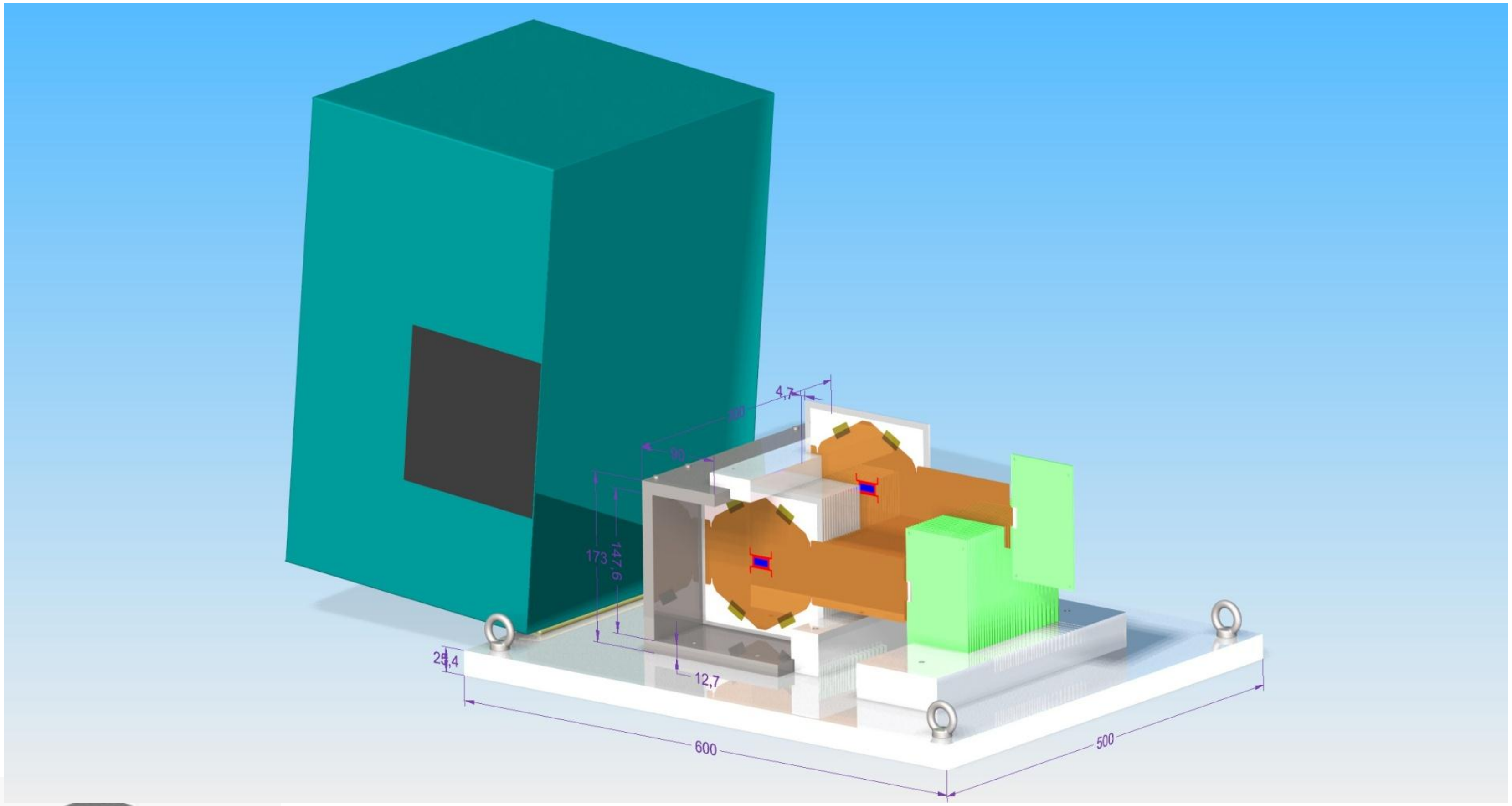
Assembly Tooling



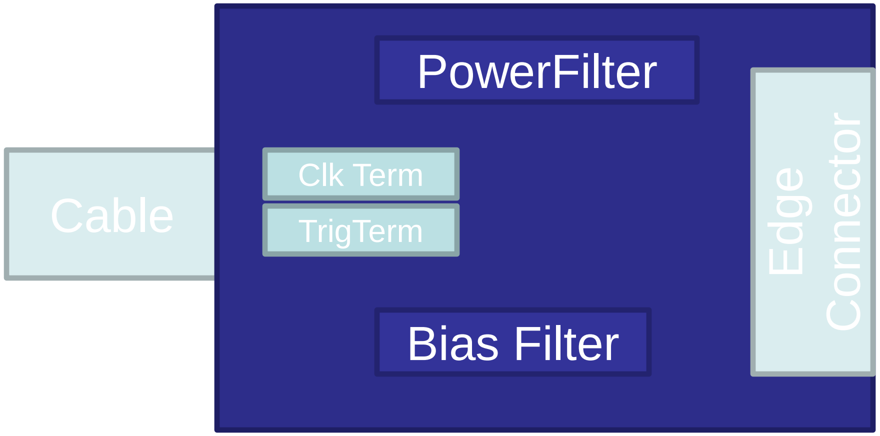
Study showing concentrator board



With Cover



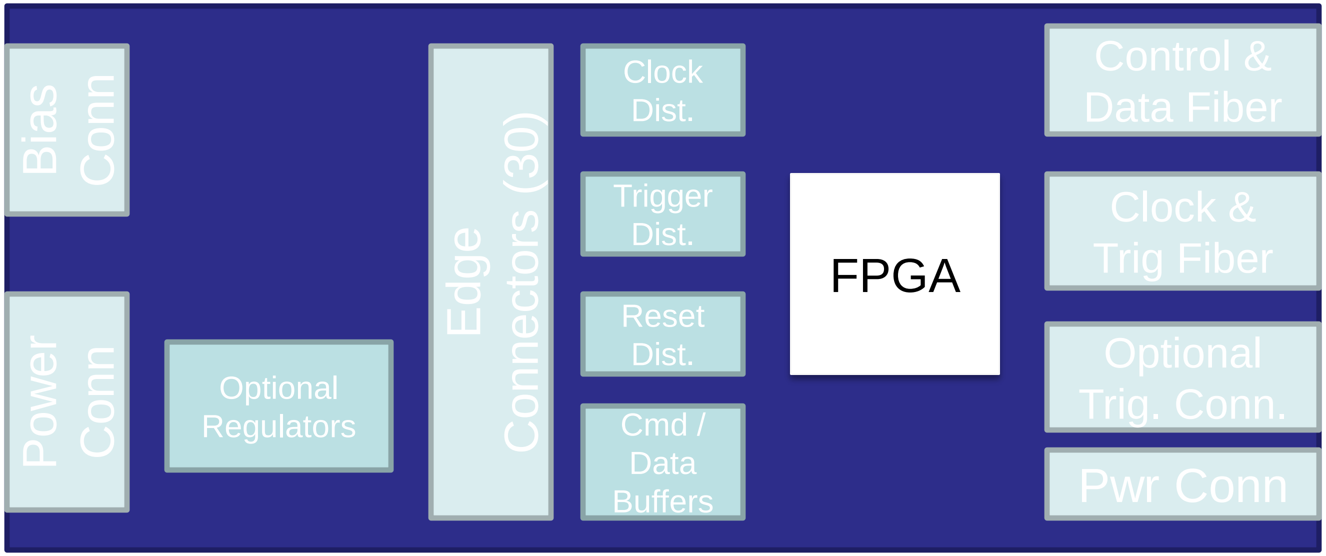
Cable Transition Board



- Signals
  - Power
    - AVVD (2 pins)
    - AGND (2 pins)
    - DVDD (2 pins
    - DGND (2 pins)
  - Bias
    - Bias Pos (1 pins)
    - Bias Neg (1 pins)
  - Signal
    - Clock (2 pins)
    - Trigger (2 pins)
    - Reset (1 pin)
    - Command (1 pin)
    - Data (1 pin)
    - Return (1 pin)

- » Clock & trigger LVDS termination
- » Power supply filtering
- » Bias filtering
- » Edge connector
  - Right angle 0.1” pins
  - 18 pins

Cable Concentrator Board



- Bias input and distribution
- KPIX power input and distribution
  - Direct AVDD/DVDD feed or local linear regulator
- Clock, trigger & reset distribution
- Per sensor command & data connection
- Concentrator FPGA
- Optical control and data interface
  - 3.125gbps PGP
- Optical timing / trigger interface
  - Embedded EVR firmware
  - Optional TTL trigger input
- Separate FPGA power connector

Production

- All W plates are in hand.
- Conceptual design drawings for mechanics complete; final drawings shortly.
- 40 good sensors have been sent to IZM.
- 28 KPiXa's (all we have) are on their way to IZM.
- IZM will produce 1 batch of 15 for evaluation.
- We hope to do a production run on more KPiX 1024 channel chips.
- Probe testing available at UO.
- UCD will manufacture and attach cables.
- Testing of cabled sensors at SLAC.
- Assembly and testing of system (pre-testbeam) at SLAC.

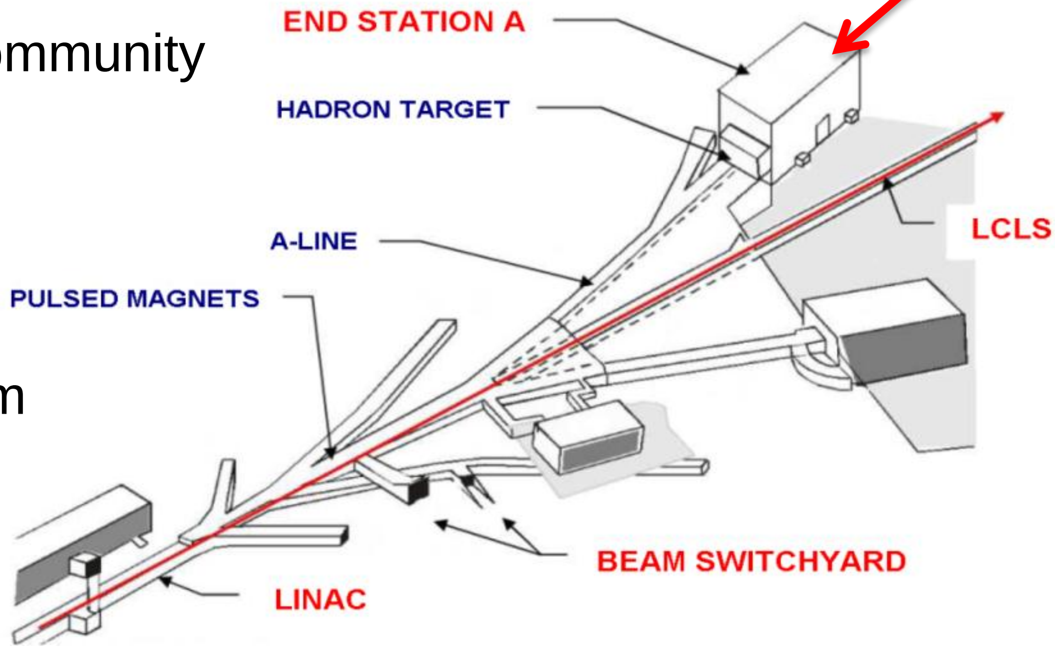
Software

- A new back end system that will handle 32 KPiX is being built, and data and calibration formats have been set.
- Data will be accessible with JAS3, and single KPiX testing is underway.
- UO has built a single event display.

ESTB Mission and Layout

- ESTB will be a unique HEP resource
  - » World's only high-energy primary electron beam for large scale Linear Collider MDI and beam instrumentation studies
  - » Exceptionally clean and well-defined primary and secondary electron beams for detector development
  - » Will serve a broad User community

Test EMCal



Pulsed magnets in beam switch yard to send LCLS beam to ESA

Test Expectations

- Expect to take data with a precisely synchronous bunch – what KPiX was designed for.
- Expect to take data at a range of energies and with mean e^+ multiplicity ~1.
- Measure energy and spatial resolution.
- Characterize KPiX in “synchronous” mode: noise, cross talk, channel uniformity, etc.

- Most important – look for problems with the basic approach.