End-of-Sector Boxes & DAQ

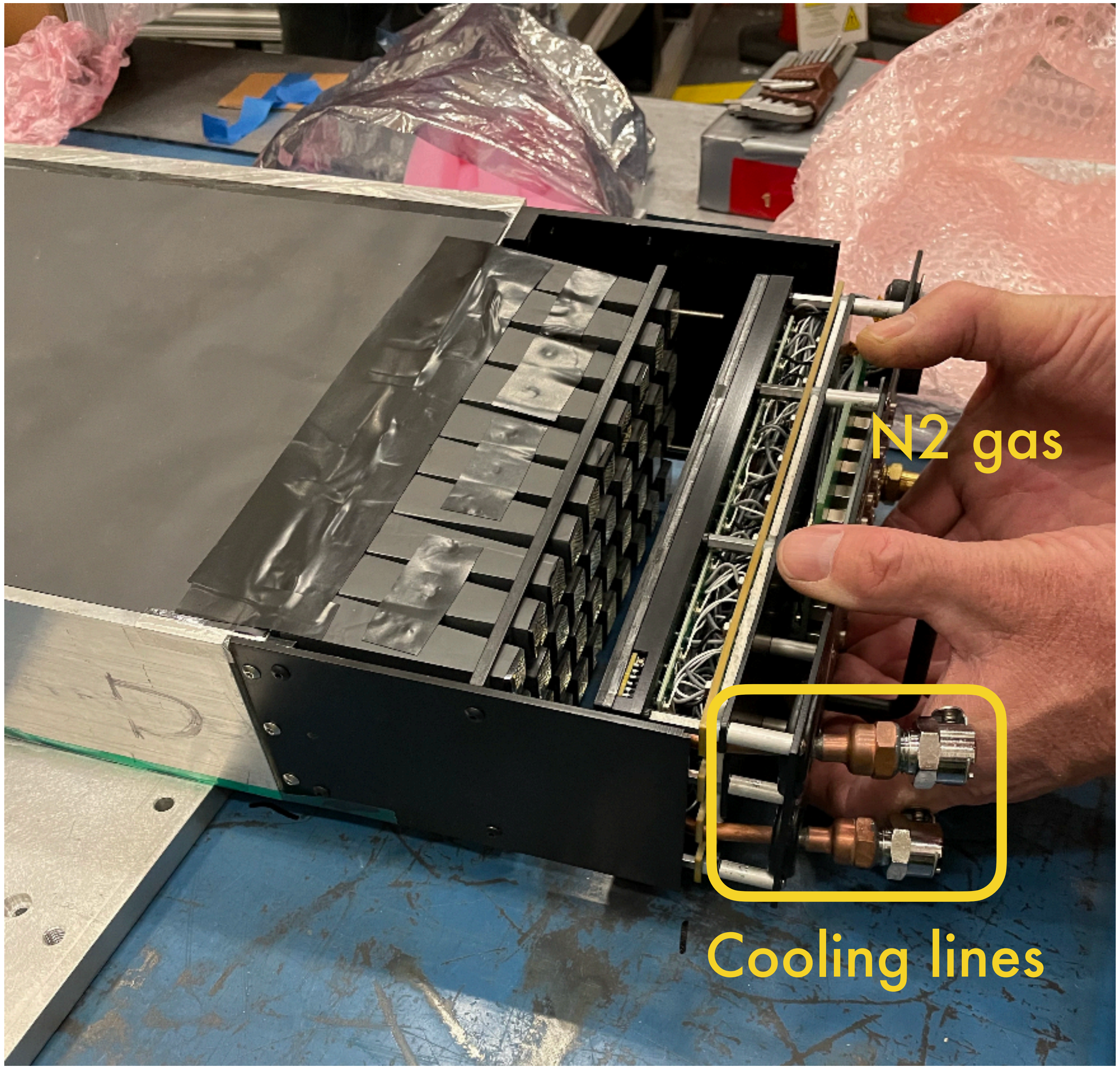
Barrel Imaging Calorimeter

Z. Papandreou

BIC General Meeting Meeting

February 14, 2025

BCAL "Wedges"



- **BCAL:**
  - Integrated box for installation
  - Push/snap along length
  - Discrete electronics: 28 LEMO signals (16 ADCs, 12 TDCs)
  - 40 S12 SiPMs/end
  - air gap; contiguous LGs
- **BIC**:
  - Integrated box for installation
  - Tilt/snap radially
  - CALOROC, streaming
  - 60 S14 SiPMs/end
  - Si cookie, bulk plus SFIL LGs, ETCs

Interface Specifications

3.1 Introduction

The purpose of the ESB is to power, cool, control, and receive signals from the SiPMs and AstroPix sensors. The distance from the end of the Pb/SciFi section to the end of the ESB should be 12 cm or less, including space to slightly move ESBs off the PbSciFi along its length to then remove it radially outwards, for servicing.

The SciFi section of the BIC is readout by 60 light guides which are each instrumented with a single Hamamatsu S14161-3050 SiPM array for a total area of 1.2 cm x 1.2 cm.

The AstroPix staves and trays will terminate near the end of the SciFi section, at which point they connect to the end-of-tray card (ETC). The ETC will control and send power to the AstroPix modules. The digital signals from the AstroPix will enter the ETC and go to the AstroPix FPGA.

3.2 Mechanical Interfaces

This section details the mechanical envelopes within the ESB, allocating space within the ESB for the various subcomponents. The different regions within the ESB are:

- Optical coupling (light guides and optical cookies)
- Readout boards and cooling
- AstroPix end-of-tray cards
- Walls and patch panel
- Empty space for connectors (this is part of our envelope).

The ESB mechanical envelope matches the cross-sectional shape of a BIC sector, and has a total length of 12 cm. Fig. 3.1 shows an engineering drawing of these mechanical envelopes.

The ESB interfaces with the thick aluminum back plate of the calorimeter, and to the bottom of the first AstroPix tray.

Interface Specifications

3.4 Cooling

HGCROC chips dissipate around 2W each, and typically operate around 40°C without cooling.

The SiPMs response is a function of temperature, so the SiPM active areas should be temperature controlled such that the gain is stable over time. Furthermore, the higher the temperature of the SiPM, the higher the noise floor will be. The S14160 series SiPM operating voltage changes by 34 mV/°C. The gain of the S14160 series changes by a factor of 0.93E6/V, and the nominal operating gain is 2.5E6. Therefore, a change of 1 °C will result in a change of gain of around 1%. The S13360 series operating voltage changes by 54 mV/°C, and the gain changes by 0.13E6 per V.

The AstroPix and ETC should be kept below 60°C.

3.5 Light

The ESB should be light tight to prevent erroneous signals in the SiPMs. Additionally, light produced inside the ESB (from e.g. LEDs on PCBs) should be reduced as much as possible and/or shielded from the SiPMs.

ESB Interfaces

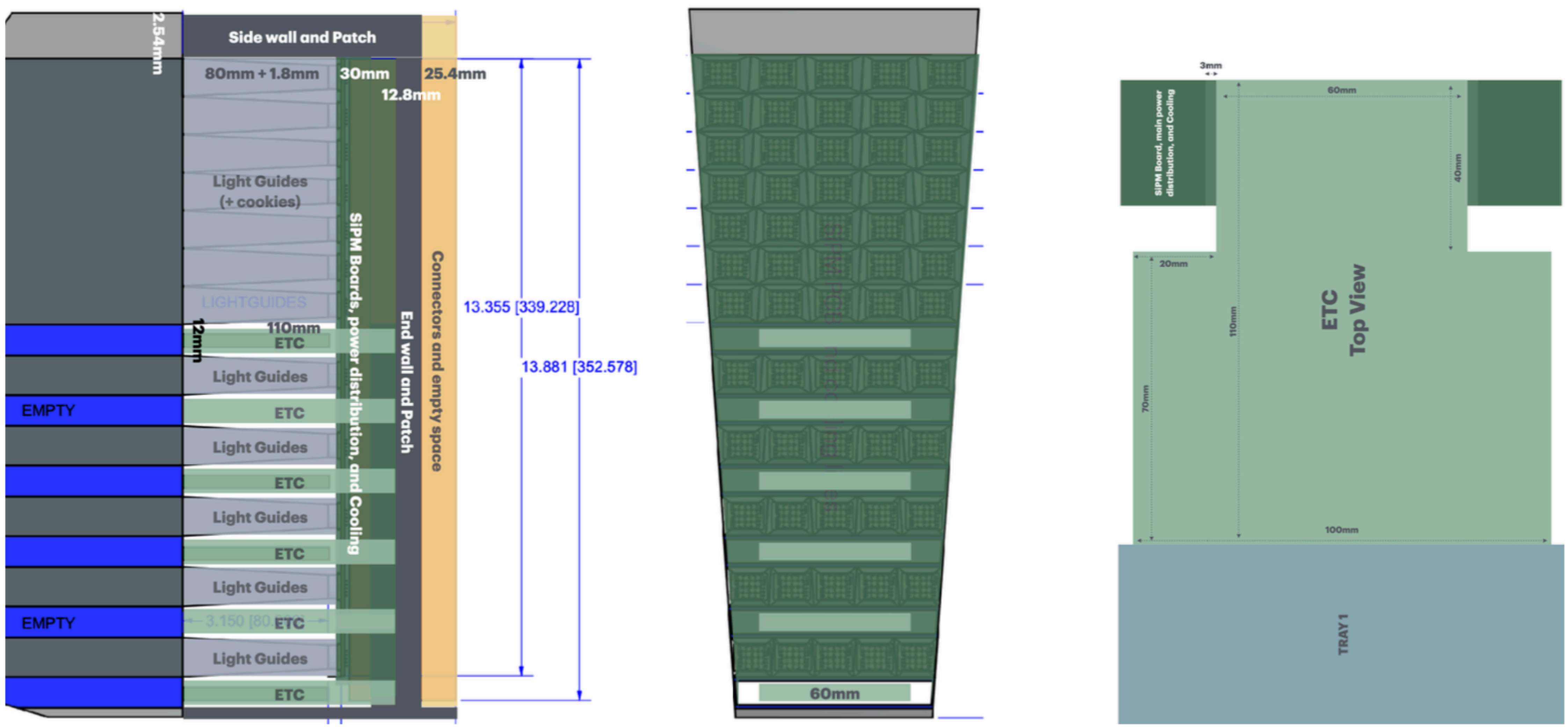


Figure 3.1: Napkin sketch of the mechanical envelopes for the ESB. Left: Side view in the middle of a sector. Center: Rear view cutout at the SiPM PCB Right: Top view of the AstroPix readout FPGA. **TODO: replace with engineering drawings**

Light Guides: Design & Simulations

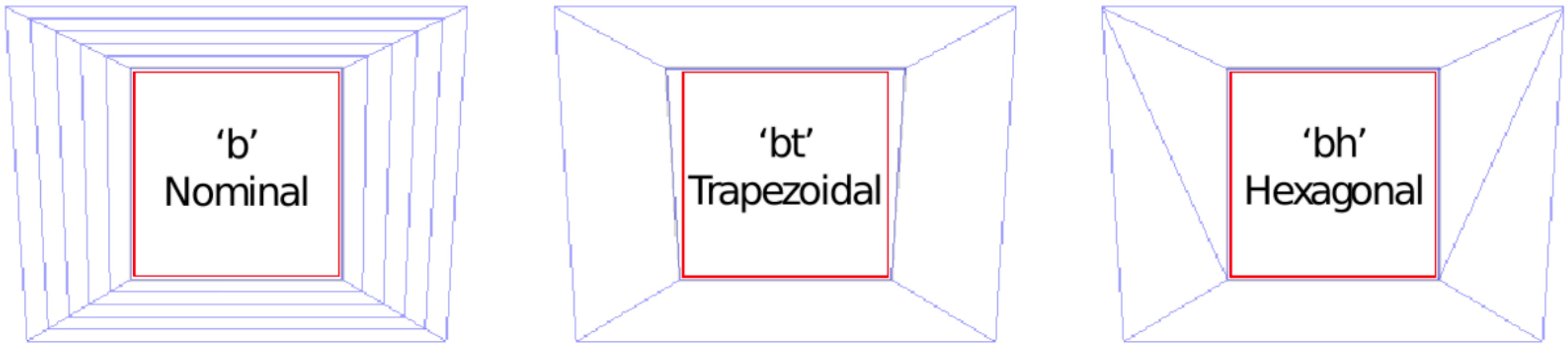
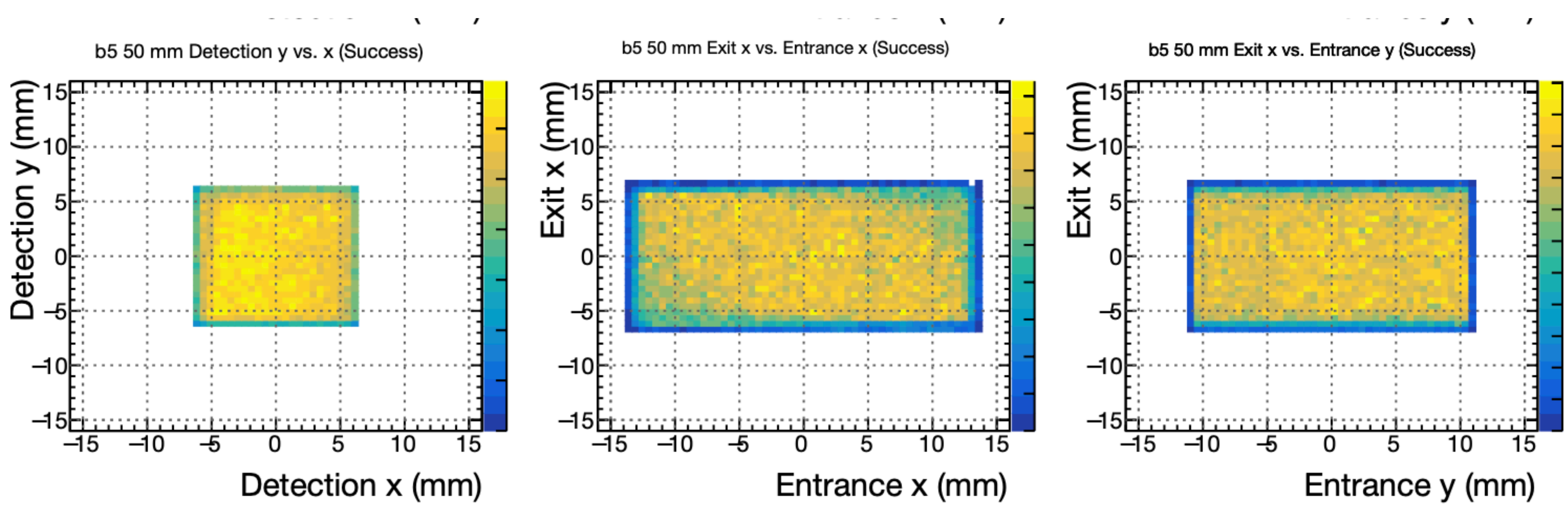
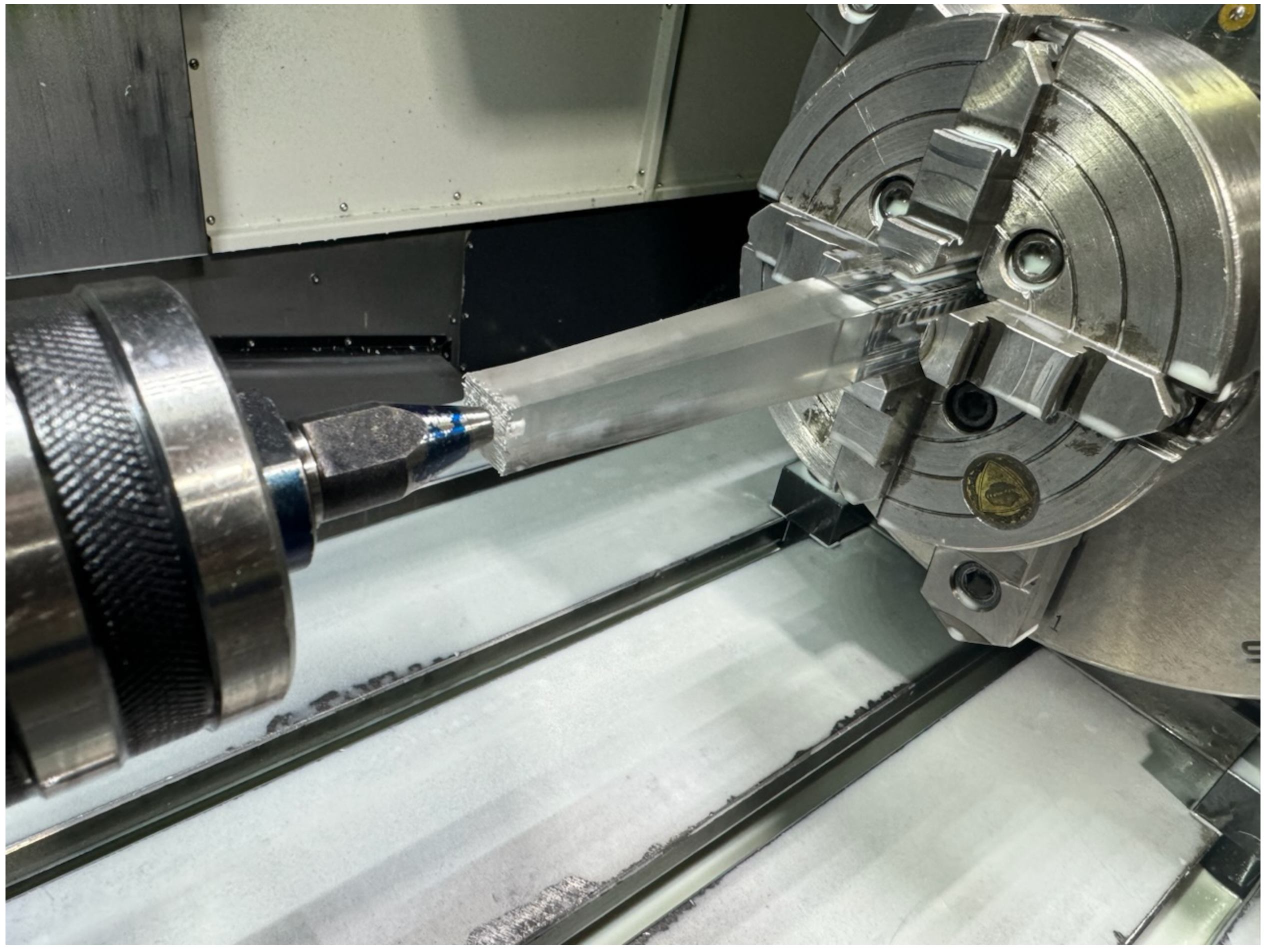


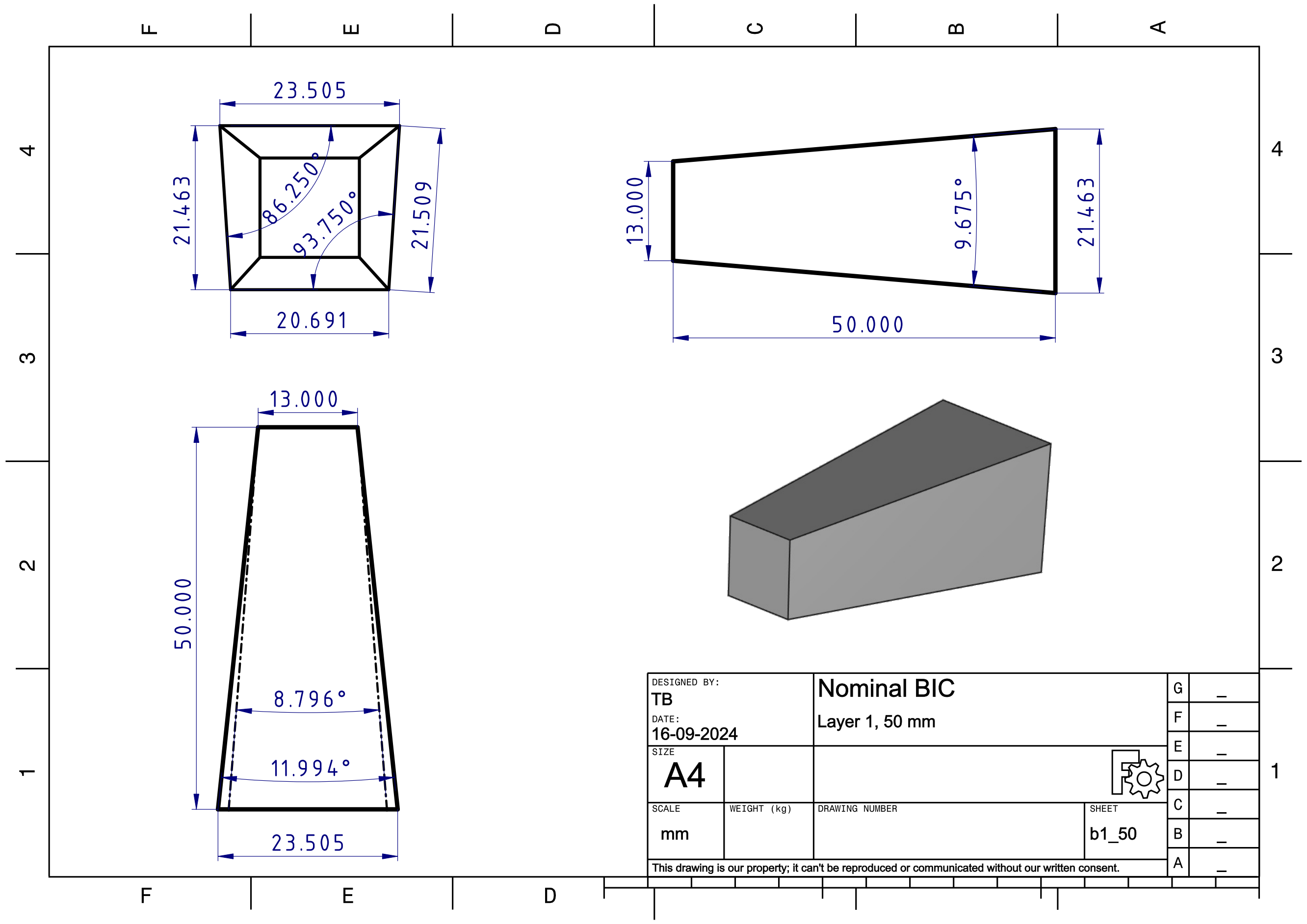
Figure 3: Geant4 renders of the Nominal ('b'), trapezoidal ('bt'), and hexagonal ('bh') BIC light guide shapes. The active SiPM area is shown in red.

Length:
50 mm:



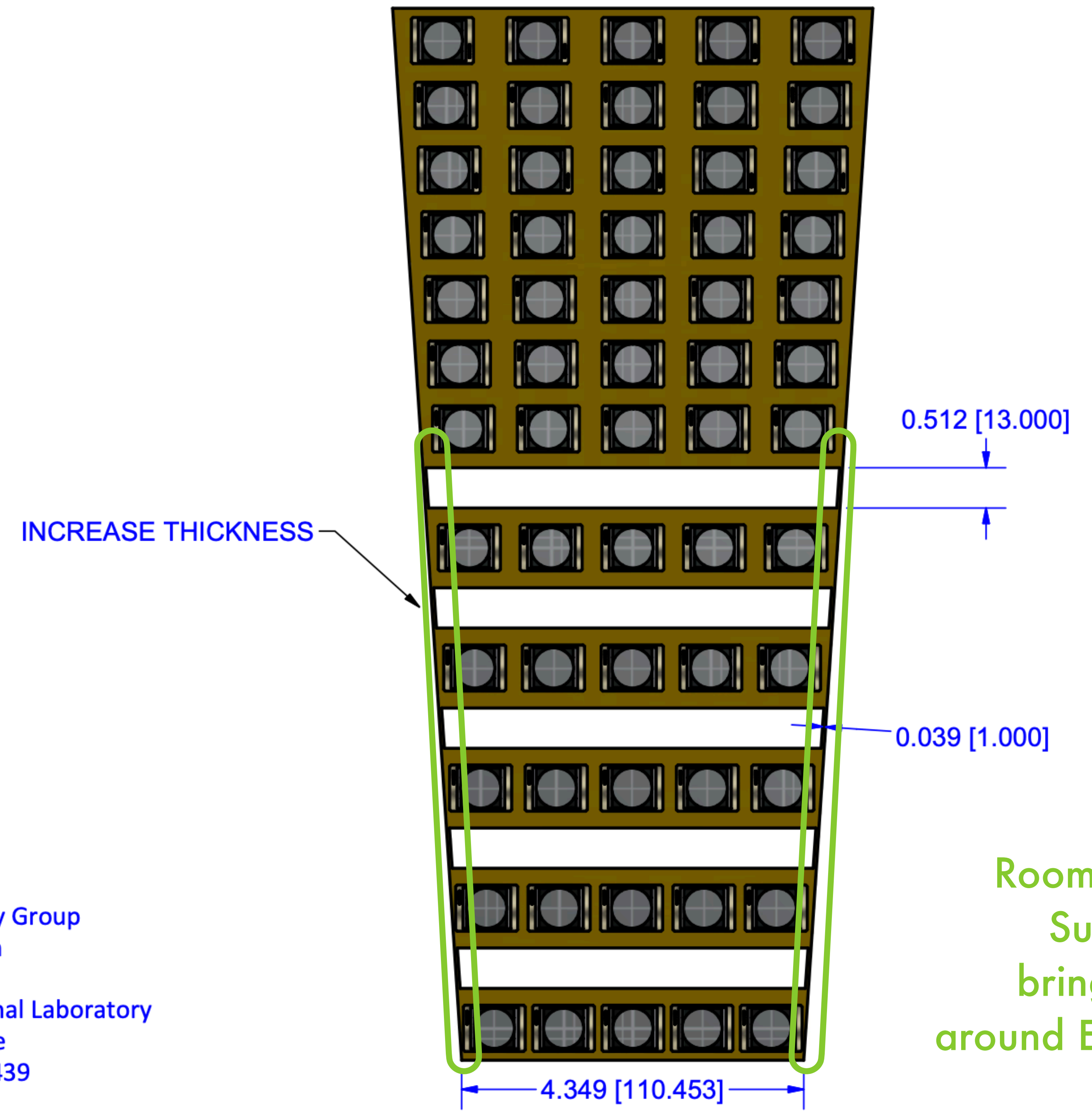
Light Guides: Prototyping





Ross Machine Shop: has machined over 20 LGs; progressively better clarity

Light Guide Layout



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Room for SiPM traces:
Sum each SiPM,
bring summed trace
around ETC and outer SiPMs

Optical Cookies

ELJEN TECHNOLOGY

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sheet procured: 165mm x 265mm x 3mm

SILICONE RUBBER OPTICAL INTERFACE

EJ-560

- Pre-cut, or
- sheets: blade or punch
- Mild deformation
- Sticky; even after cleaning
- Protective film

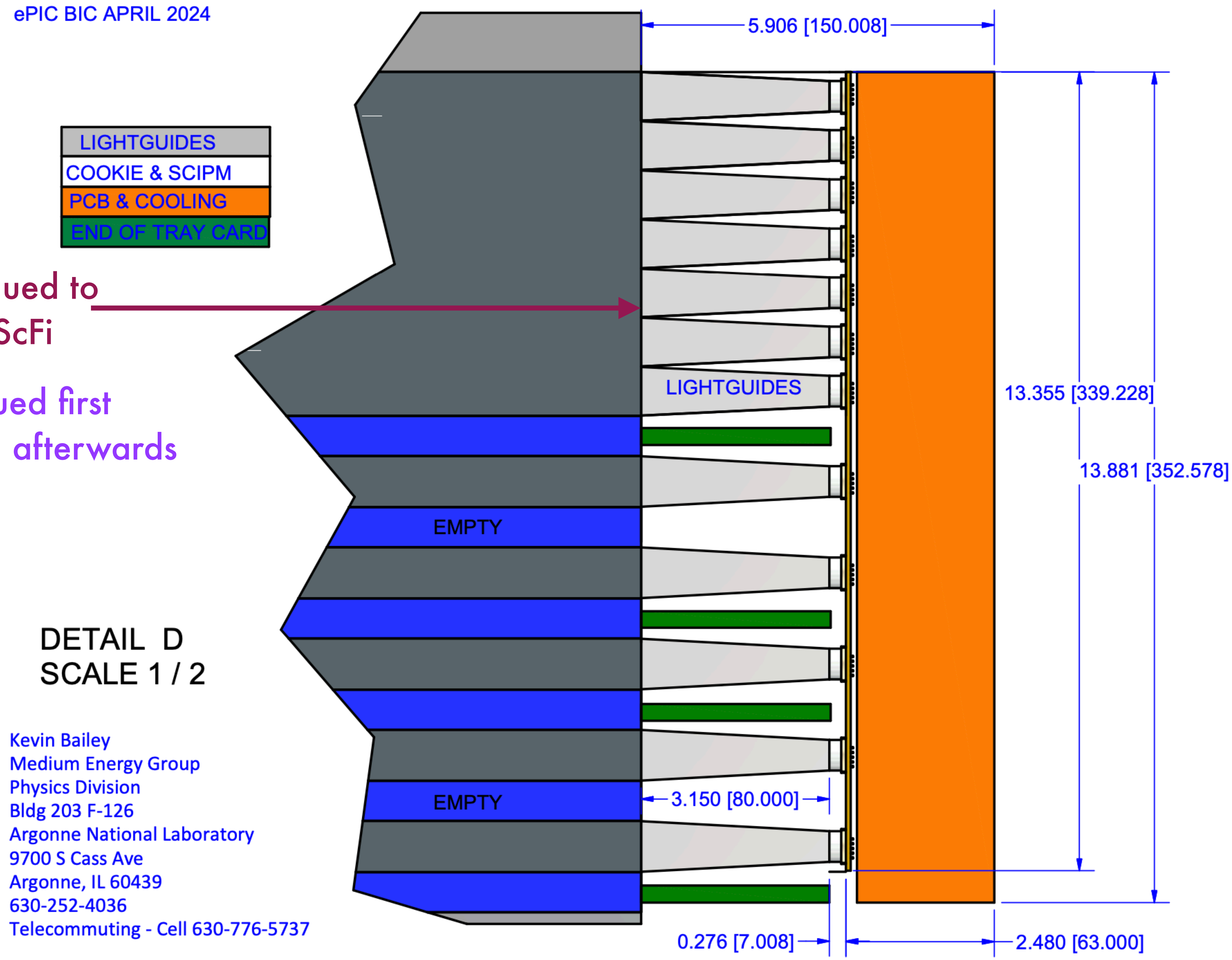
EJ-560 silicone rubber has been developed specifically for making optical joints between photosensors and plastic scintillators. The rubber material is quite soft and flexible and can be made to conform to contoured surfaces. It is a fully-cured polymer designed so its surfaces are slightly sticky to the touch, and it can be deformed under mild pressure. Nevertheless, it does not flow like a grease and will not extrude irreversibly out of its compression region, making it ideal for long-term coupling of photomultiplier tubes to scintillators.

EJ-560 is available in either pre-cut discs or sheet form. The sheet material can easily be cut to size with razor blades or scissors. All EJ-560 products are shipped with the surfaces masked with an easily removed thin film.

ESB Side View

LGs glued to PbScFi

LGs glued first
ETC plug in afterwards



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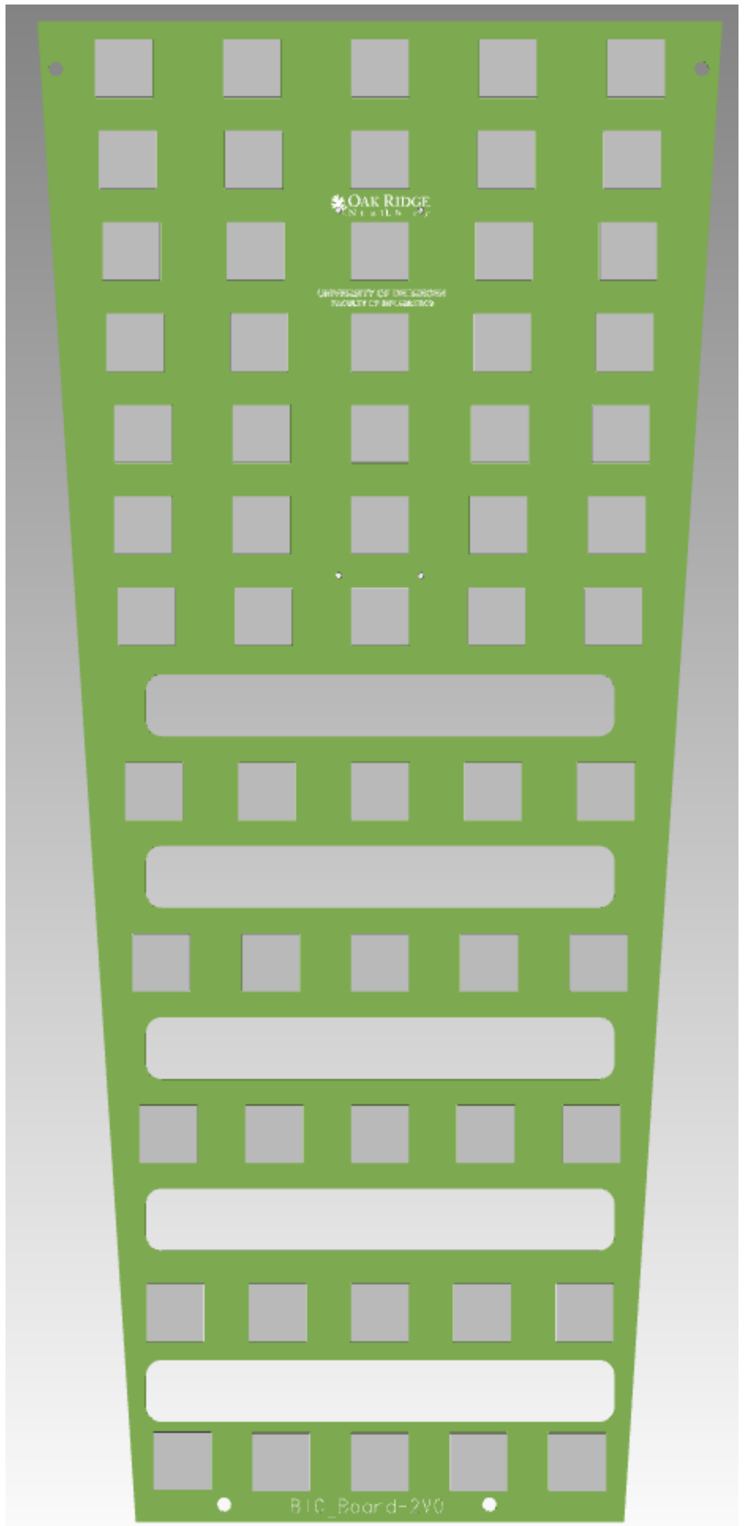
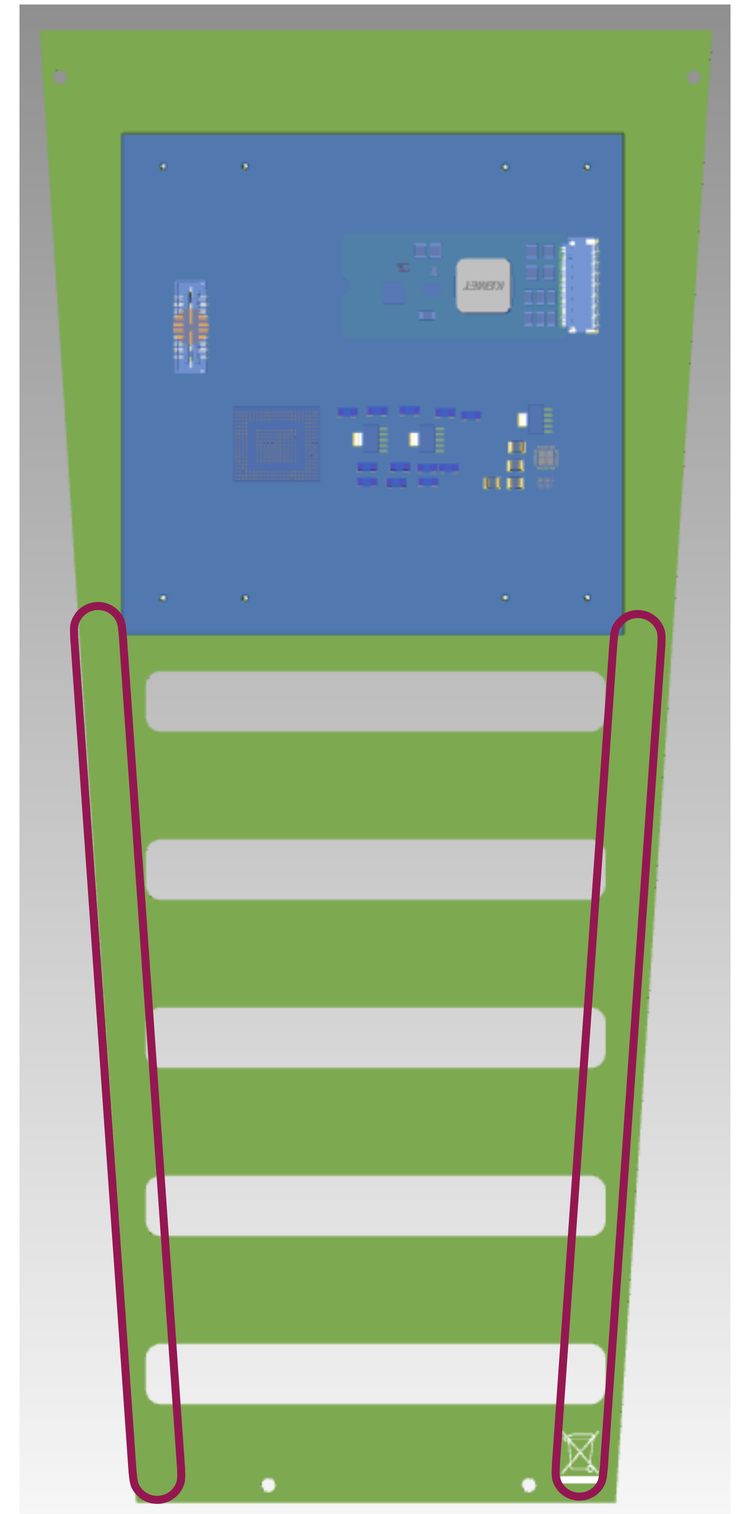
Green and Blue Boards



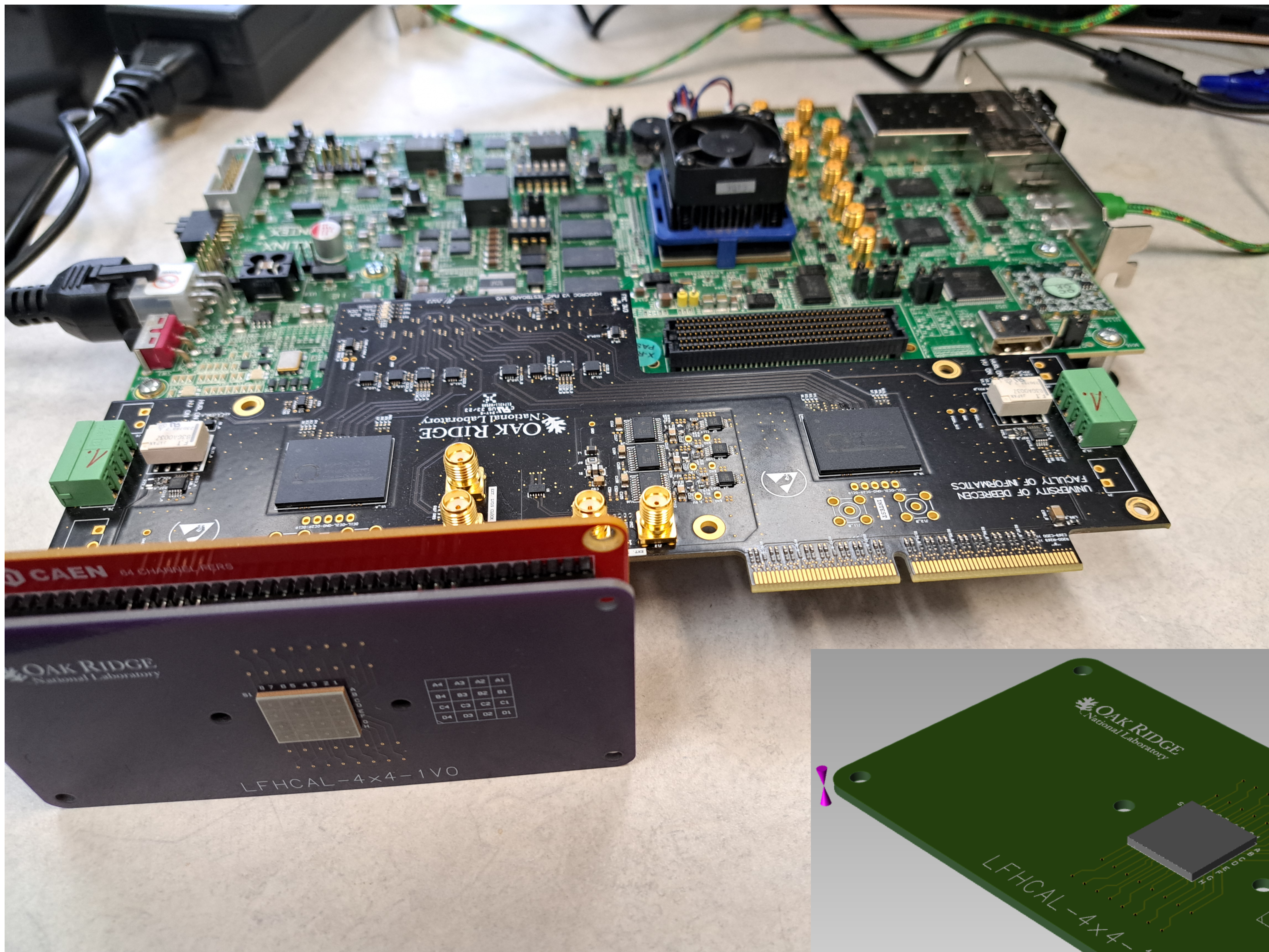
ORNL

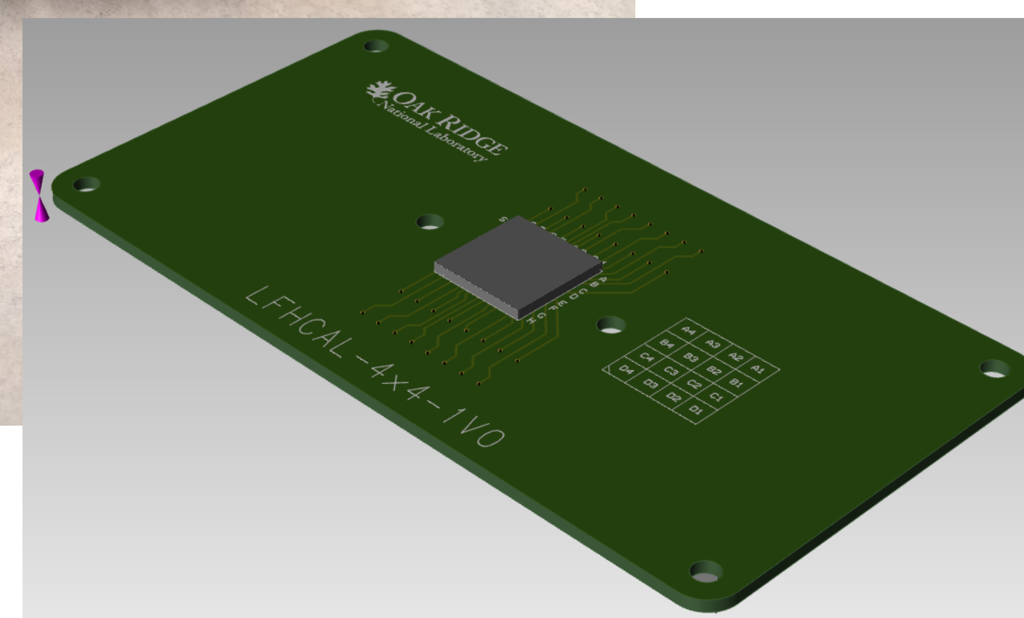
Room for SiPM traces

Cooling?
Liquid or gas?



HGCROC/CALOROC





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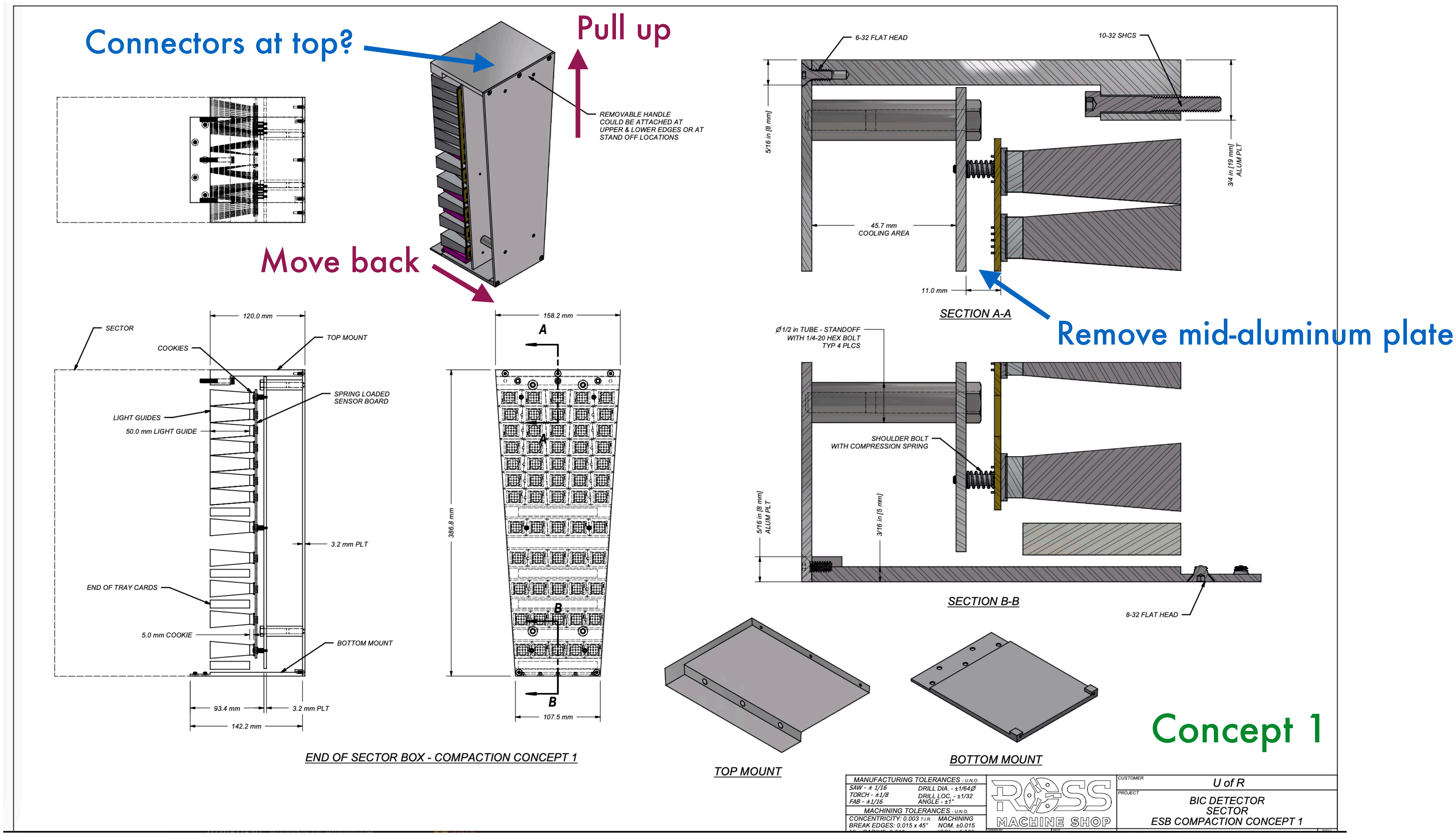
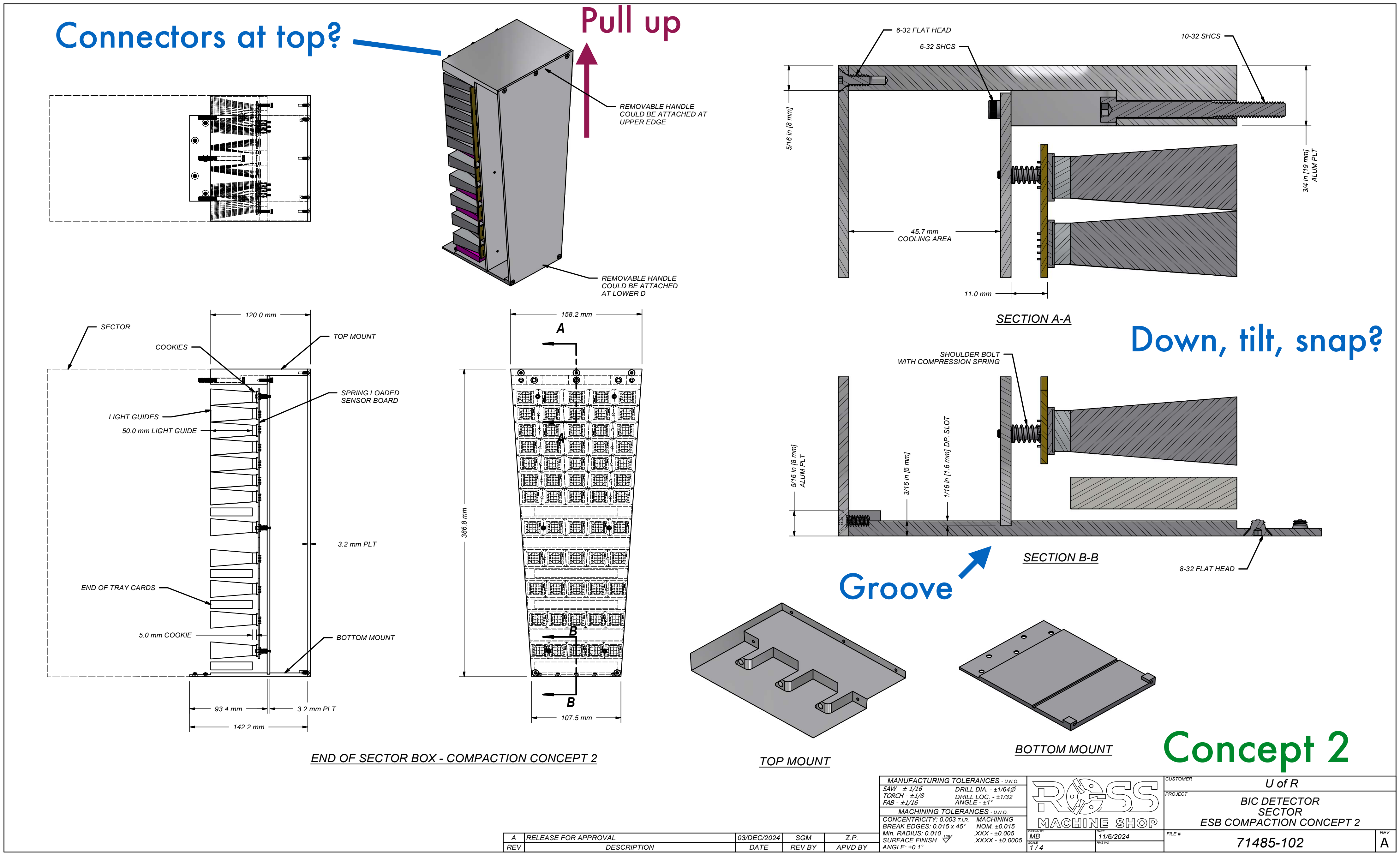
ESB Design & Service



ESB Design Considerations

- Dimensions and rigidity of PC board.
- Eliminate middle aluminum plate.
- Determine ESB side wall thickness.
- See if each ESB is individual, so 46 ESBs per side, or maybe each ESB contains 2 or 3 sectors, so 24 or 16 ESBs per side. These might be harder to remove but might give us more space to work with between sectors.
- Number of connectors and type per ESB. Aram and Oak Ridge collaborator will hammer this out.
- Use non magnetic material (eg stainless 303).

ESB Design & Service

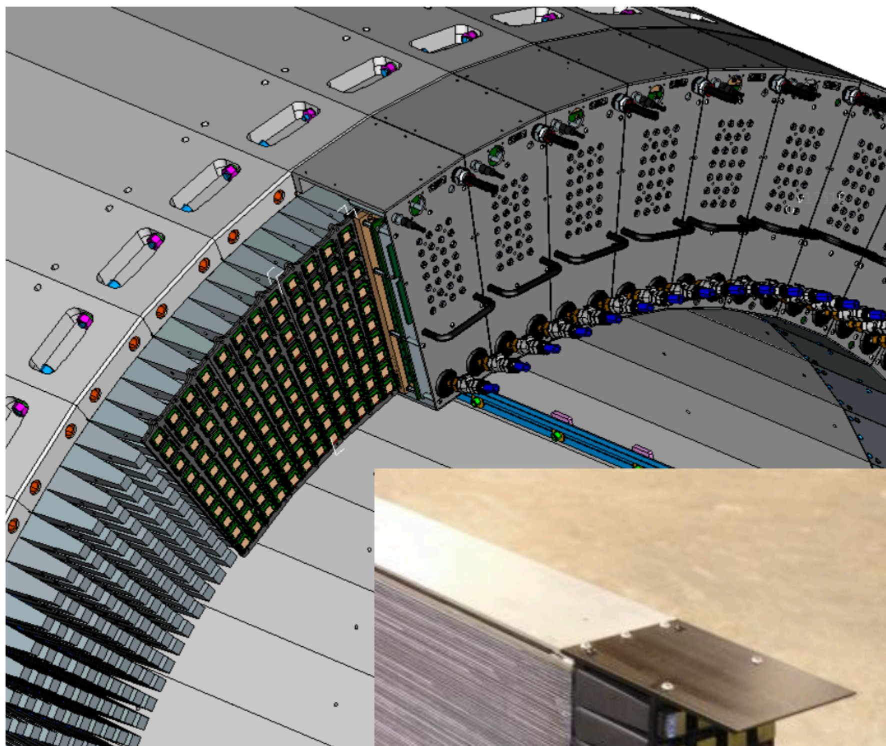


Lots of work ahead

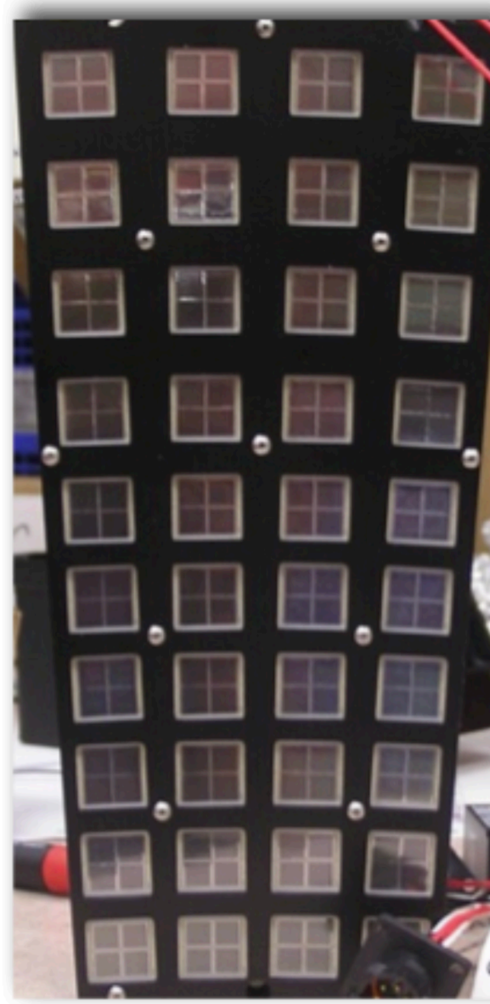
- **ePIC/BIC baseline comparison is to GlueX/BCAL**
- **Biweekly meetings: Next on February 18 (We need frequent and timely communication!)**
- ePIC/BIC
  - **End-of-Sector Boxes @ Regina**
    - PED Funds: Mech Eng/Elec Eng, Postdoc, M&S
    - Timeline: see Maria's Update from EIC slides
    - Canada Foundation for Innovation Grant
    - Korean efforts

Backup Slides

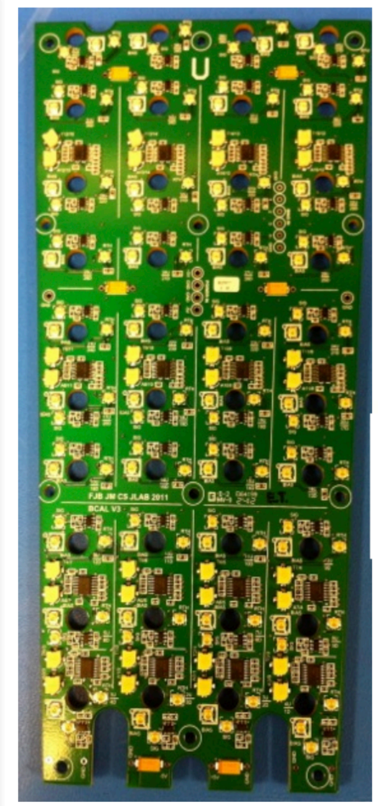
GlueX-BCAL Photosensors



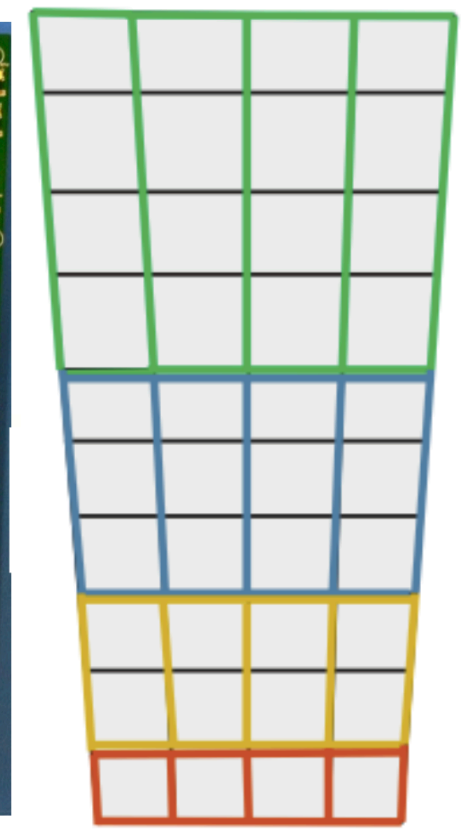
Light guides



Assembly



Electronics



Summing Scheme

GlueX: single bulk, no interruptions; BIC: AstroPix