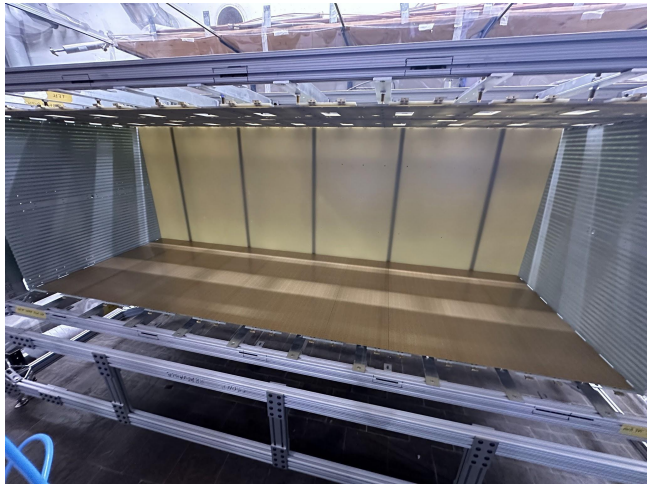
FSD Assembly Update

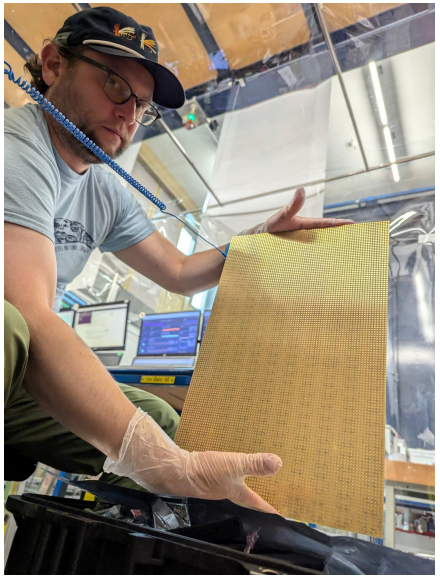
Roberto Acciarri on behalf of FSD Assembly Team

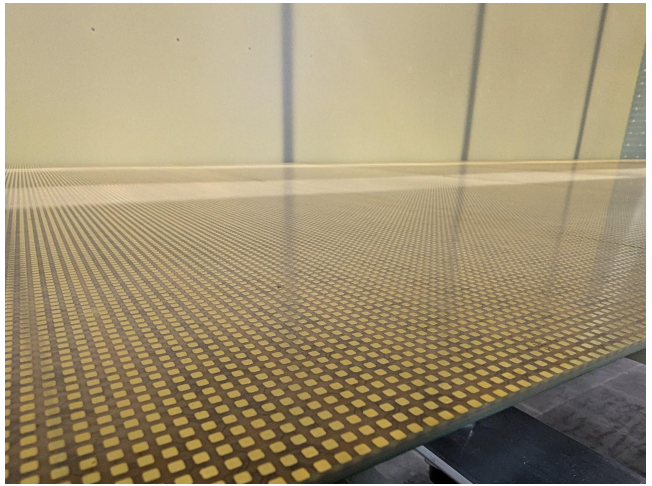
ND-LAr Consortium Bi-Weekly Meeting

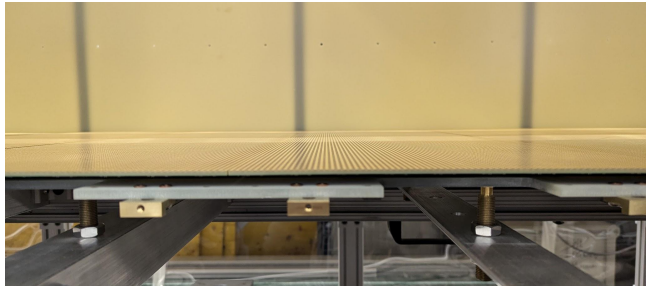
October 10th, 2024

Week September 16th-20th (since last Consortium Meeting)



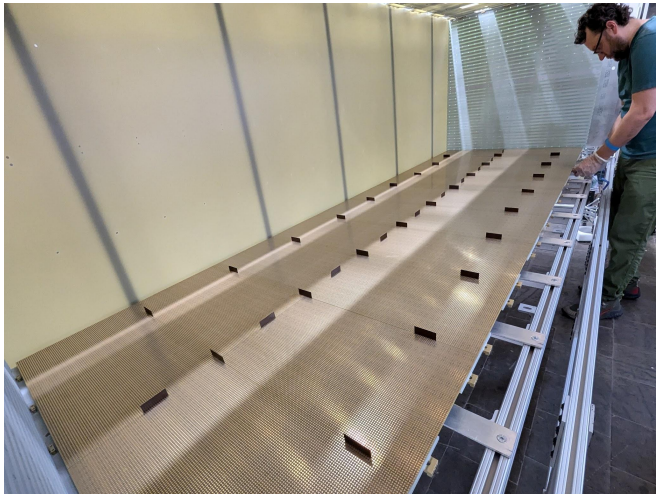


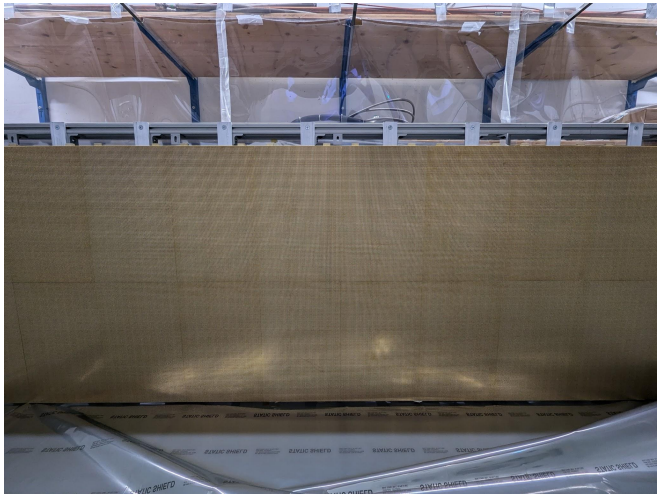


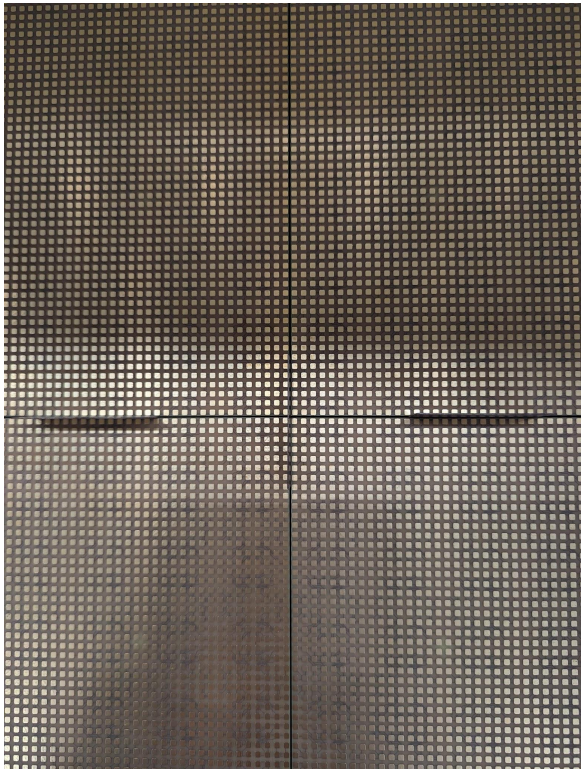


- Completed installation of first anode!
- All tiles visually inspected prior to installation (cold tested at LBNL prior to shipment)
- All bolts torqued to 1.0 N-m
- Expecting a full anode can be installed, aligned and torqued in 1 day

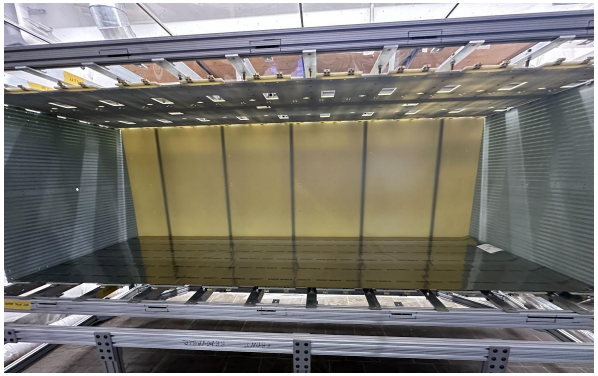
Week September 16th-20th



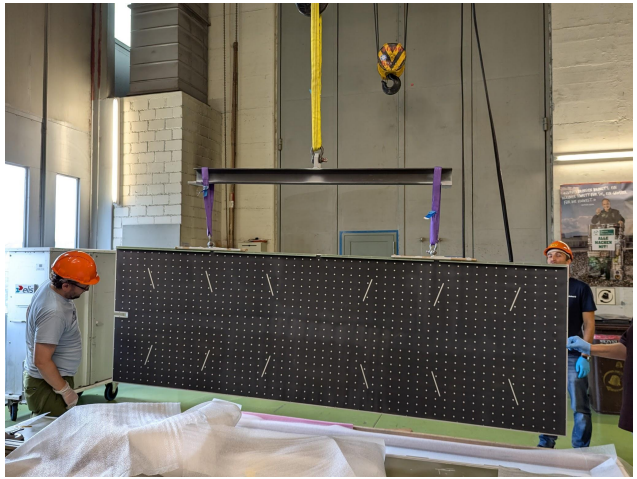




- 0.5 mm thick shims used to control tile spacing and perform alignment
- Anode covered with ESD film for protection (both dust and electrostatic)



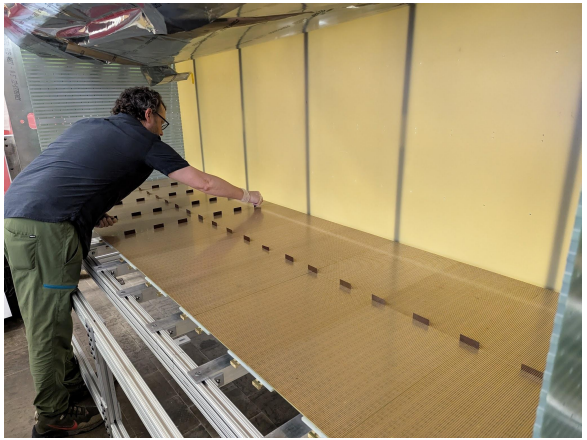
Week September 16th-20th

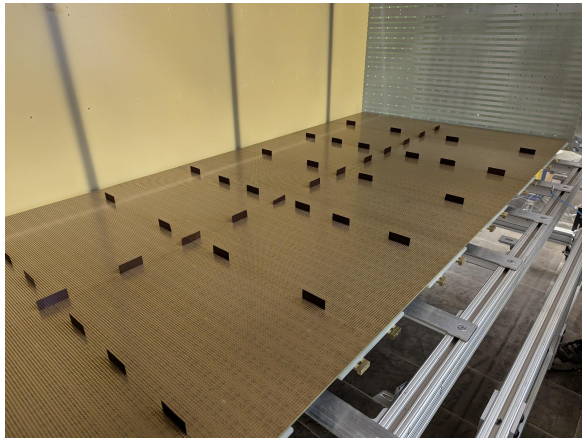


- Cathode unpacked and transferred to foam padded carts in Grosslabor
- Cathode brackets and HV socket installed
- Targets gluing and cathode installation took place the following week

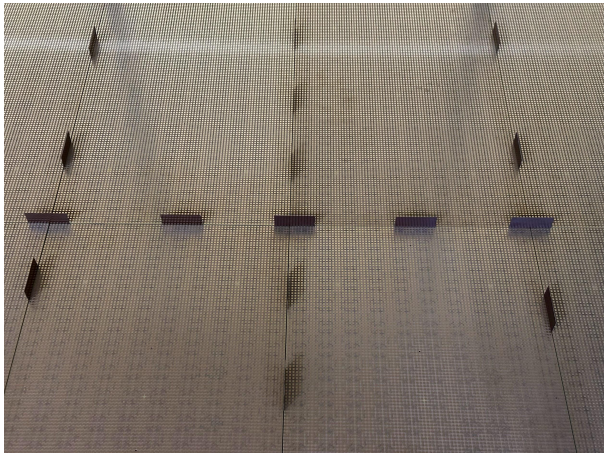
Week September 16th-20th

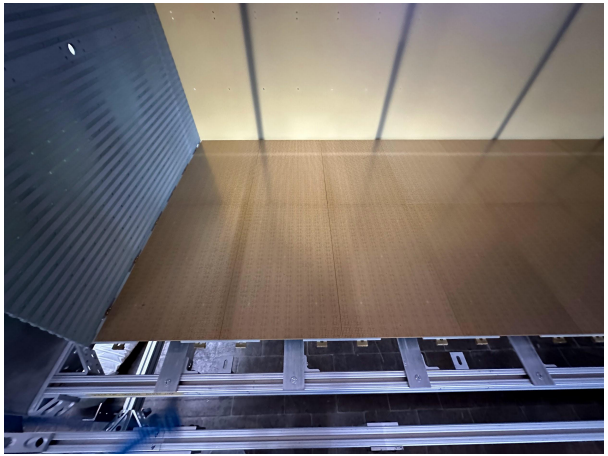
- Frame rotated and 2nd anode plane tiles installed
- ESD shield installed also on the back of anode plane
- Shims between tiles placed in preparation for final alignment and bolt torquing



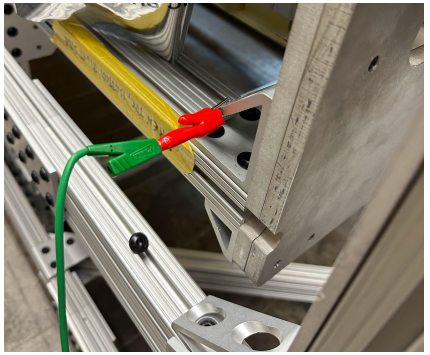


Week September 23rd-27th

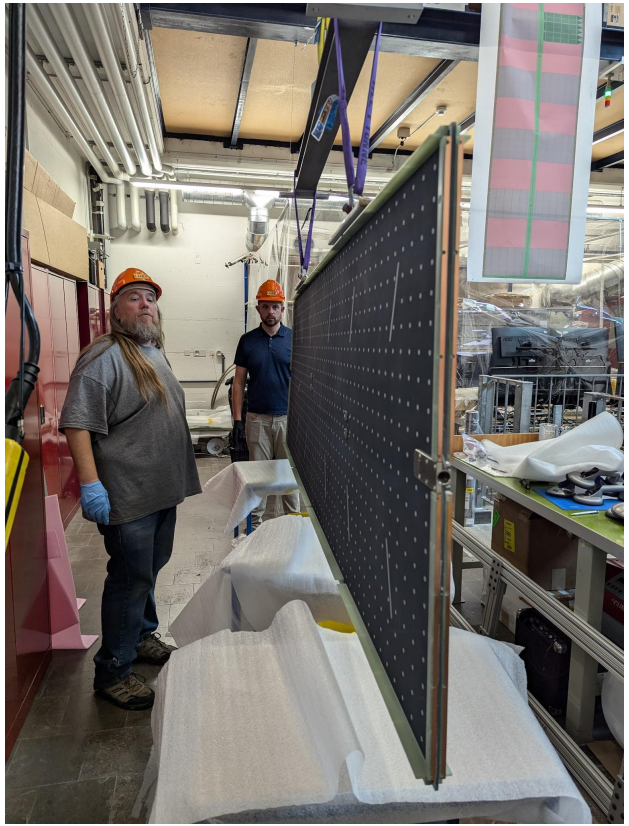




- Completed final alignment of pixel tiles on 2nd anode panel
- Covered completed anode and pixel tile assembly with ESD protective film
  - Both anode assemblies are covered with ESD protective film and the assembly frame is grounded to the building
- Installed 409,600 CRO channels…<u>entire 2x2 has 337,600 CRO channels</u>

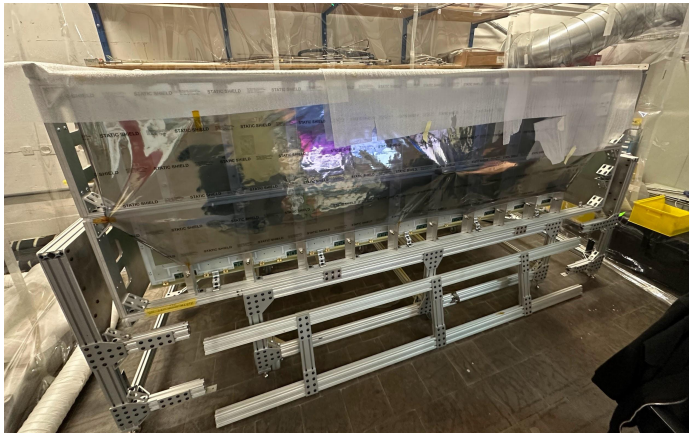


Week September 23rd-27th



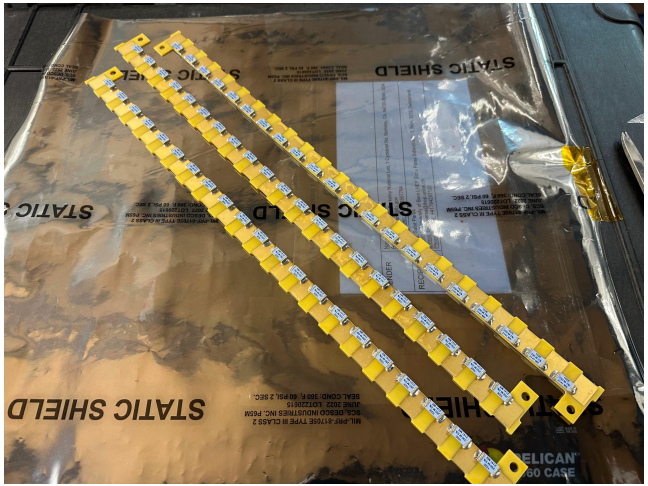
- Applied final torque to PEEK bolts on cathode
- Rigged cathode for insertion to the TPC using spreader bar and slings
  - Slings are kept vertical (0 deg angle) to not impart an lateral loads to cathode
- HV socket is visible at the top of the cathode
- Copper strips on brackets also visible

Week September 23rd-27th



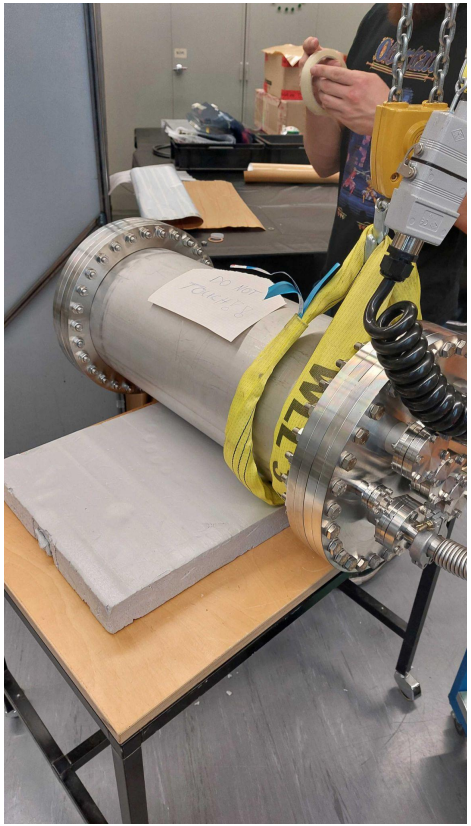
- Cathode is installed to the TPC main body, notice ESD protective film on anodes
- TPC wheeled back into tent and covered with foam wrapping to protect against dust

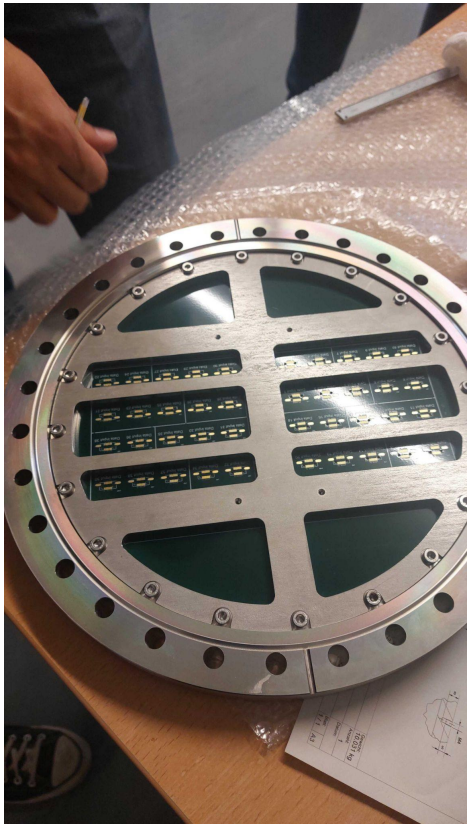
Week September 23rd-27th



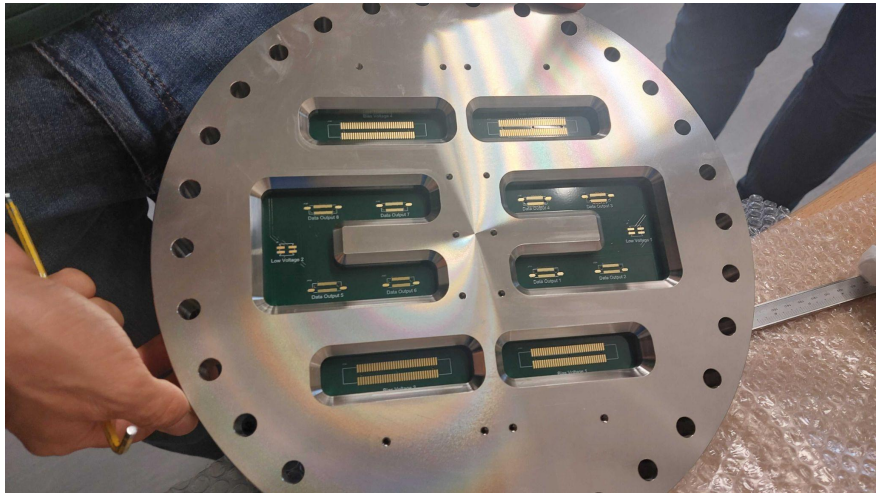
- Visual inspection of resistor boards for Field Shell
  - Also verified functionality
- ADCs and VGAs are in the VME crate
  - VGAs tested and ready
  - ADCs are tested & software upgraded

Week September 23rd-27th



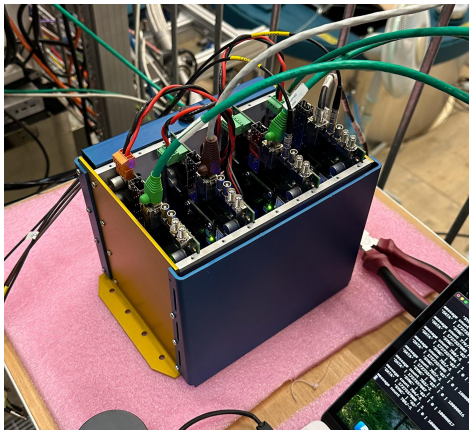


- Light Readout feedthrough both leak and pressure tested
  - Leak tight
  - Pressure tight
- Ready for TPC assembly

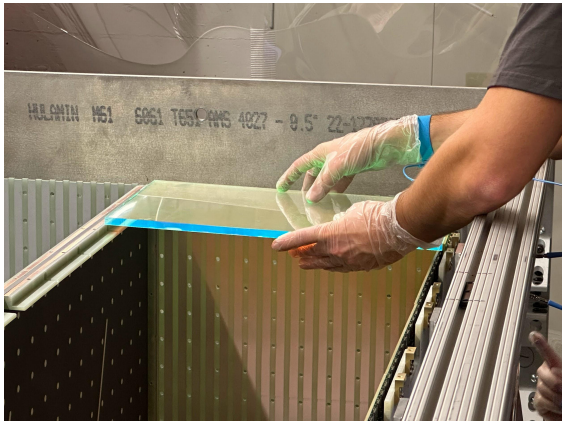
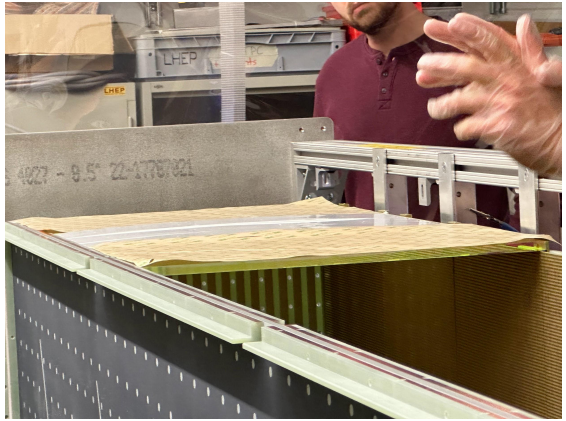


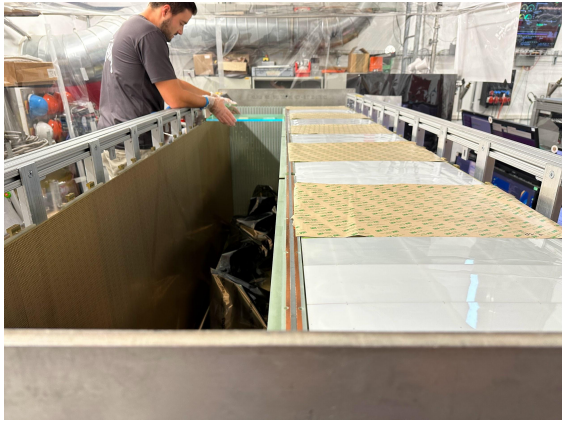
Week September 23rd-27th

- PACMAN electronics enclosure is assembled
  - All 4 PACMAN tested
- All Cold LRO PCBs assembled!



Week September 23rd-27th

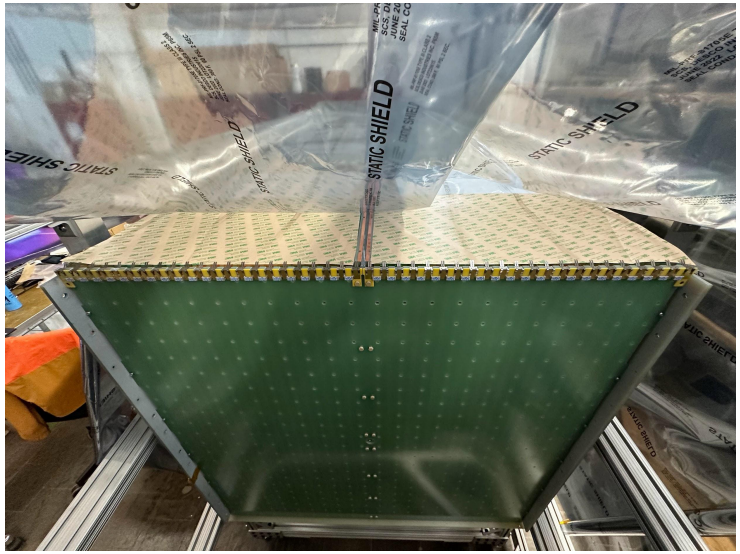




- Installation of 10X ArCLight and 10X LCM completed!
  - Easy installation, all bolts torqued
  - 120 SiPMs installed, next 120 SiPMs installed 10/1
    - 240 total in FSD

Week September 23rd-27th

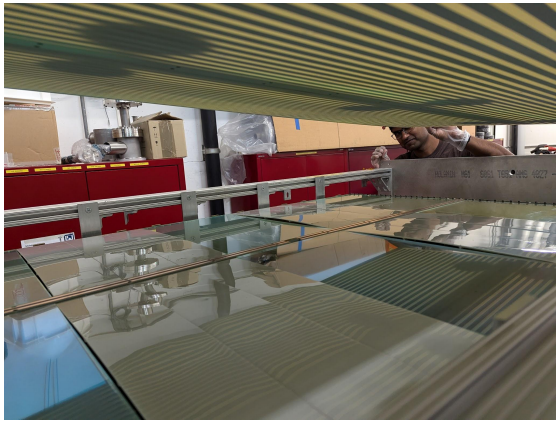
- 4X Resistor PCBs installed to Top/Bottom Field Shell Panels
  - Contact clips installed prior to side panel installation (9/27)

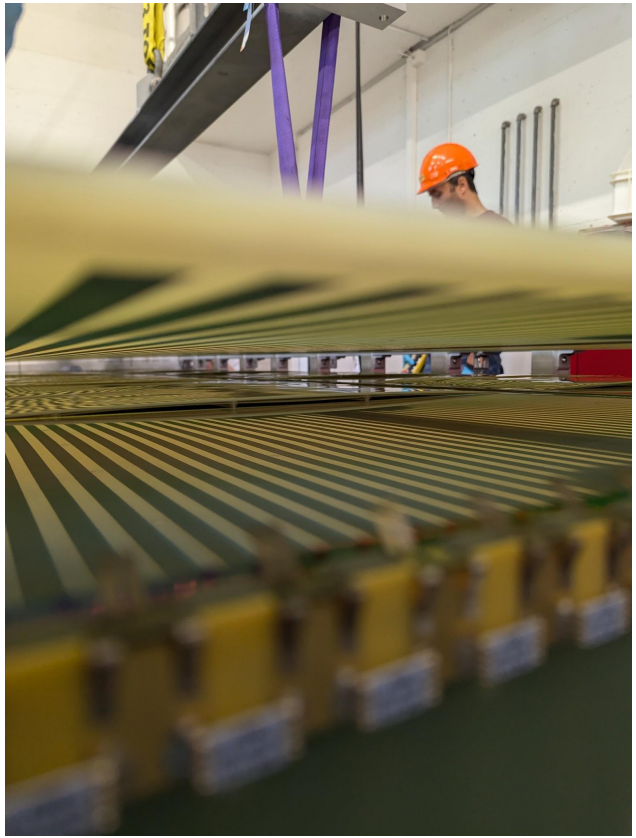
Week September 30th - October 4th

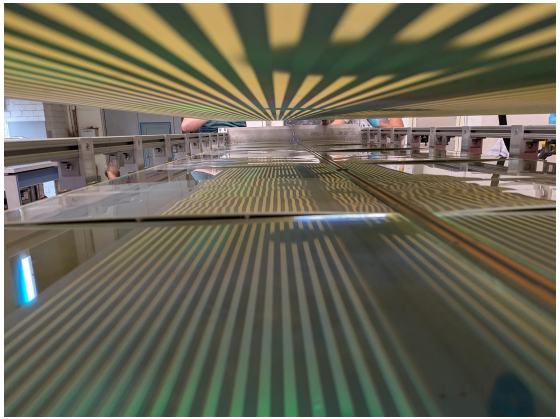


- Installed field shell clips that create electrical contact between resistor boards, top (or bottom) field shell, and side field shell
  - Validated connectivity with multimeter

Week September 30th - October 4th

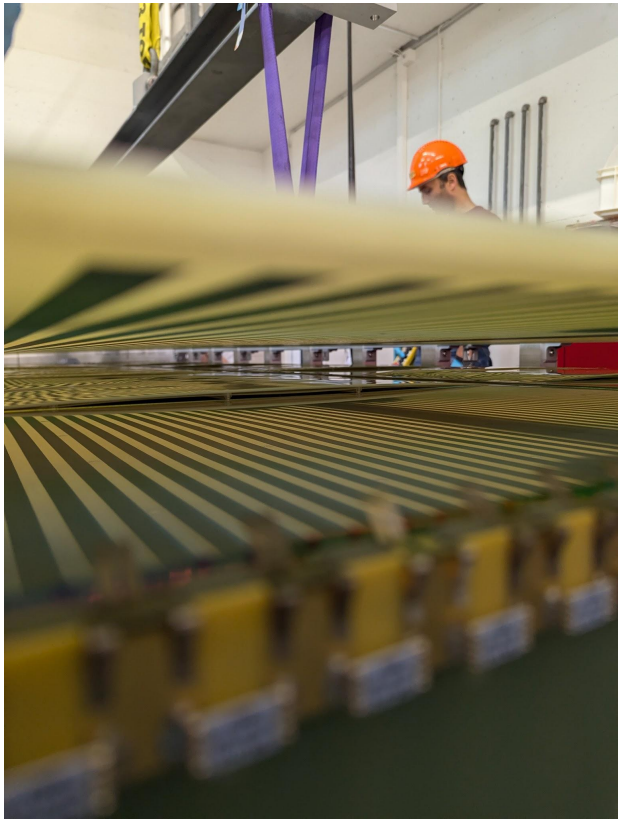






- Installation of first field cage side panel
  - Can see zinc strips and their reflection
  - Use crane to gently lower field shell
  - All fasteners torqued

Week September 30th - October 4th



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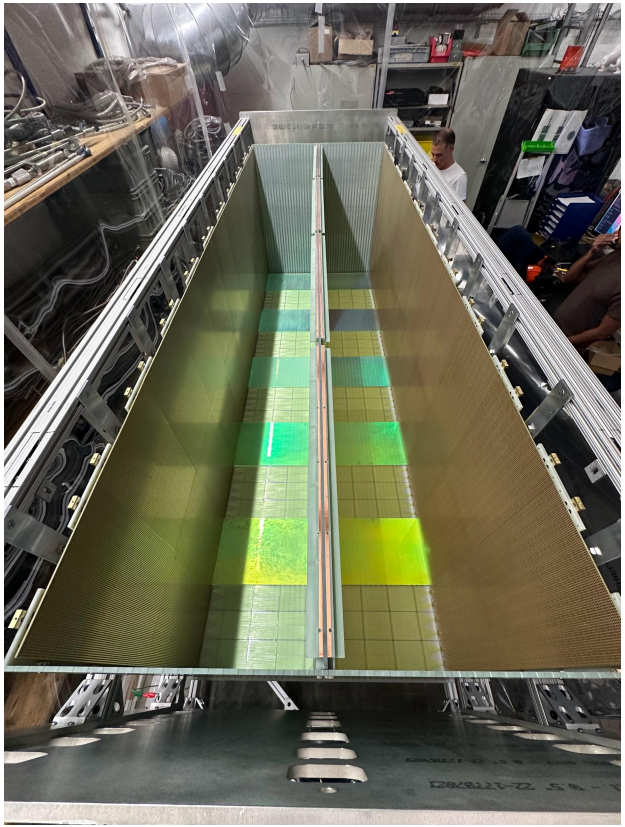
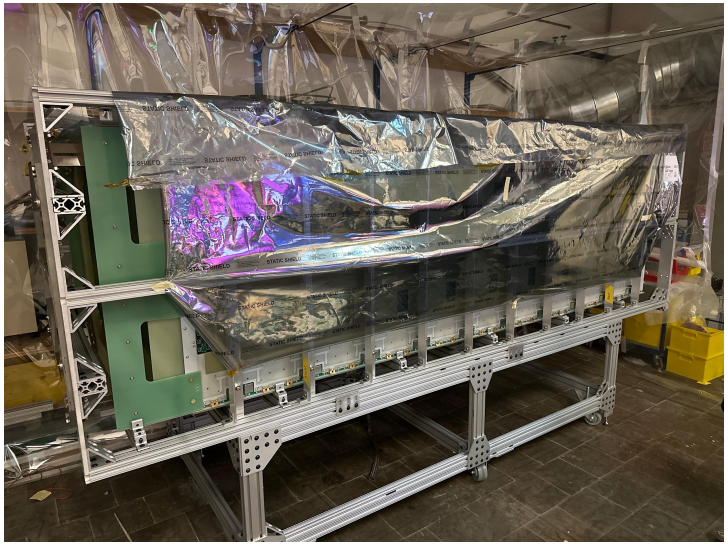
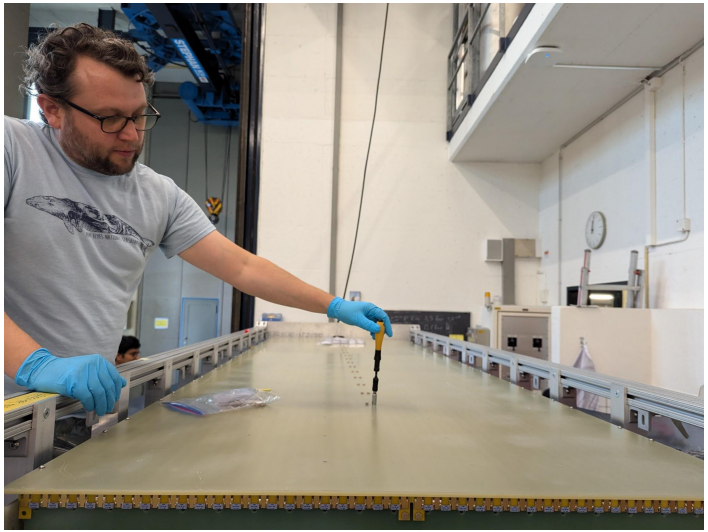




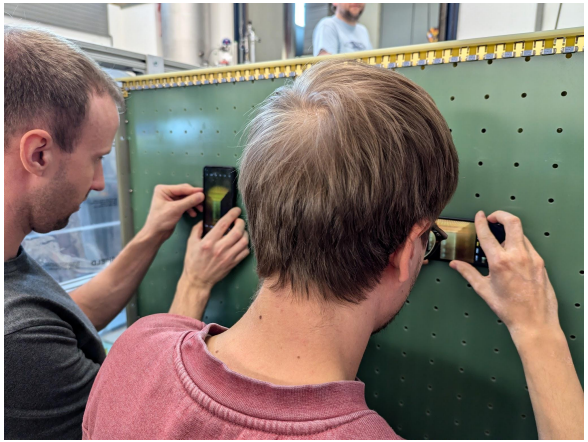
- Began installation of second light readout array
- Can see anodes and first light readout array at far left
- Overall light readout install went very smoothly, about 1 hour to install all light tiles

Week September 30th - October 4th

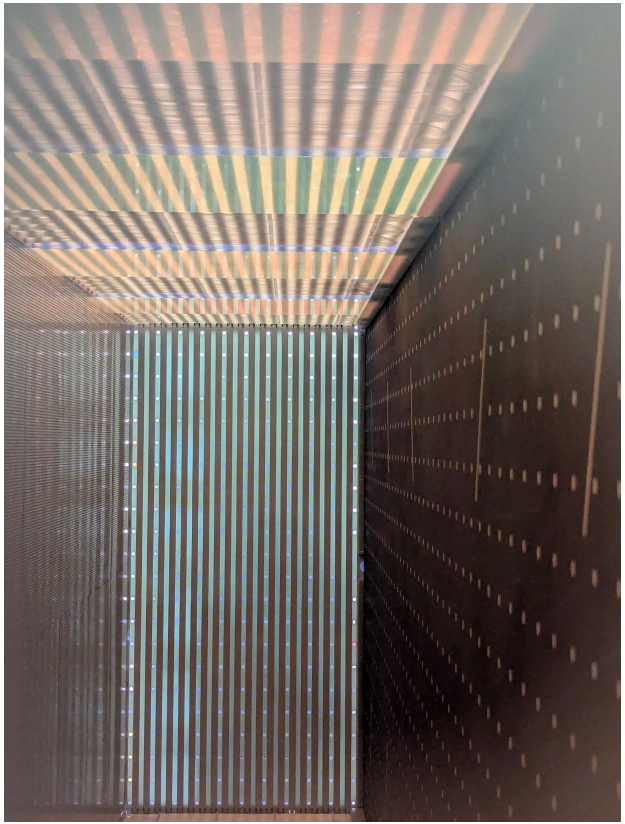


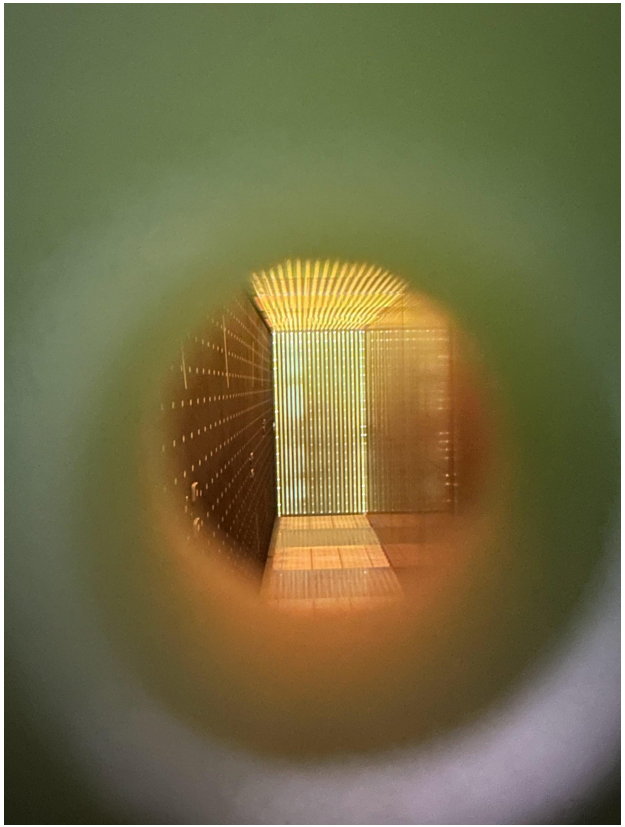
- Installed other set of resistor boards and clips, then ready to install the other field shell side panel
  - Measured conductivity of both field shell side panels
  - Installed and torqued all cathode bolts
  - Second field shell side panel went on very easily -> learned some lessons from installation of the first such as loosening the brass blocks on the anode and aligning with 3 longer screws

Week September 30th - October 4th

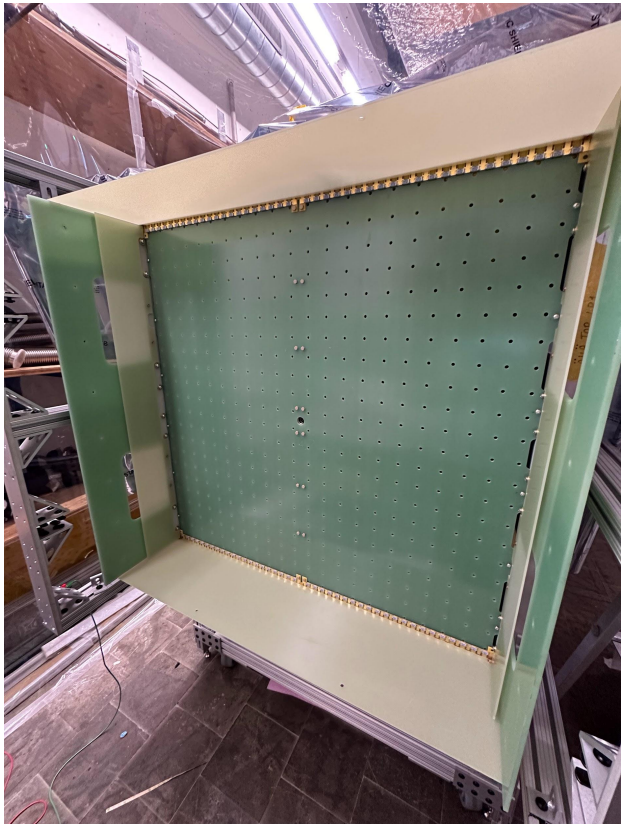


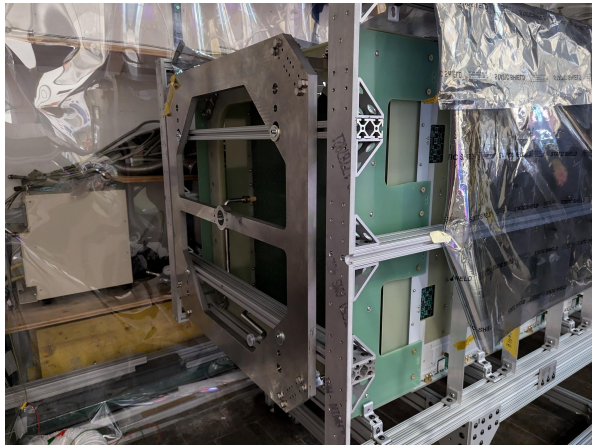
- Picture time!
- Can spy on the inside of the TPC through the holes in the top/bottom field shells
    - Can see charge anode, light tiles, cathode, and field shell

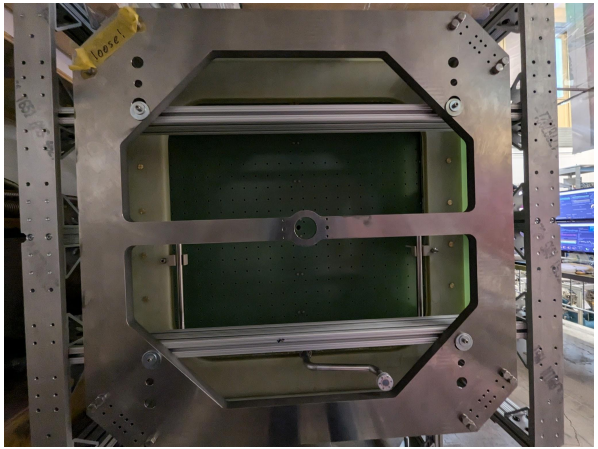




Week September 30th - October 4th

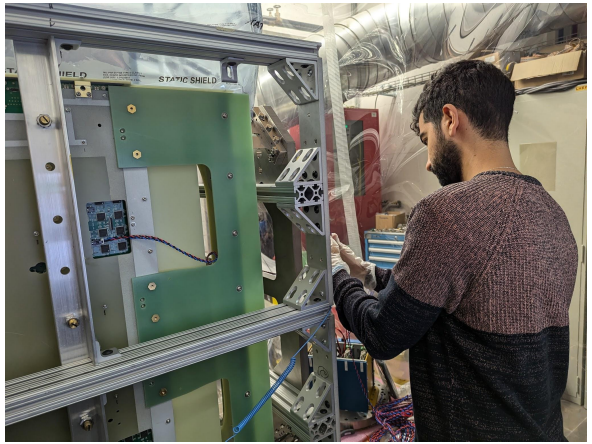


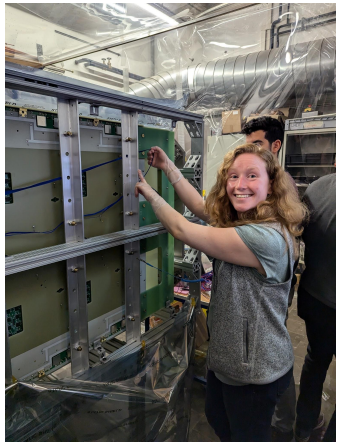


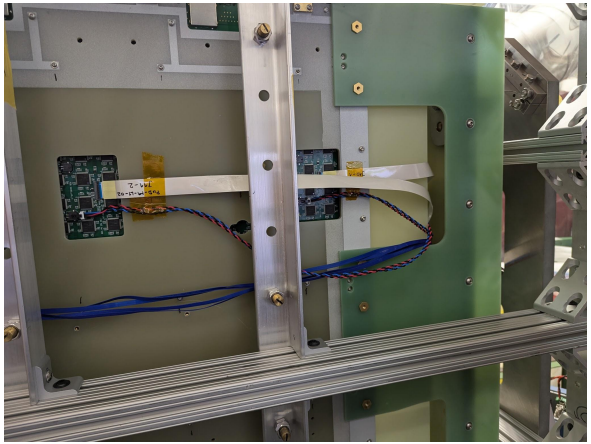


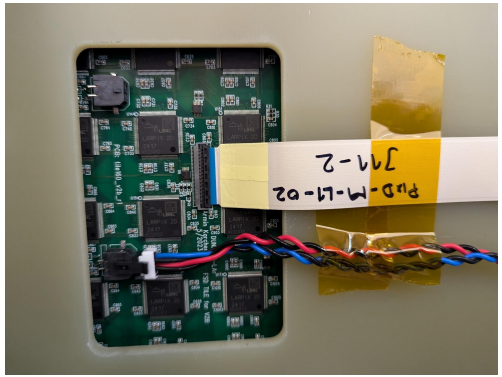
- Once the TPC main body was completed the installation of the upper structures started
  - Installed remaining G-10 components by hand
  - Used crane to install the stainless steel plate
    - This plate interfaces to the support beam that holds a full row of five TPC modules
  - Also installed the liquid distribution lines

Week September 30th - October 4th



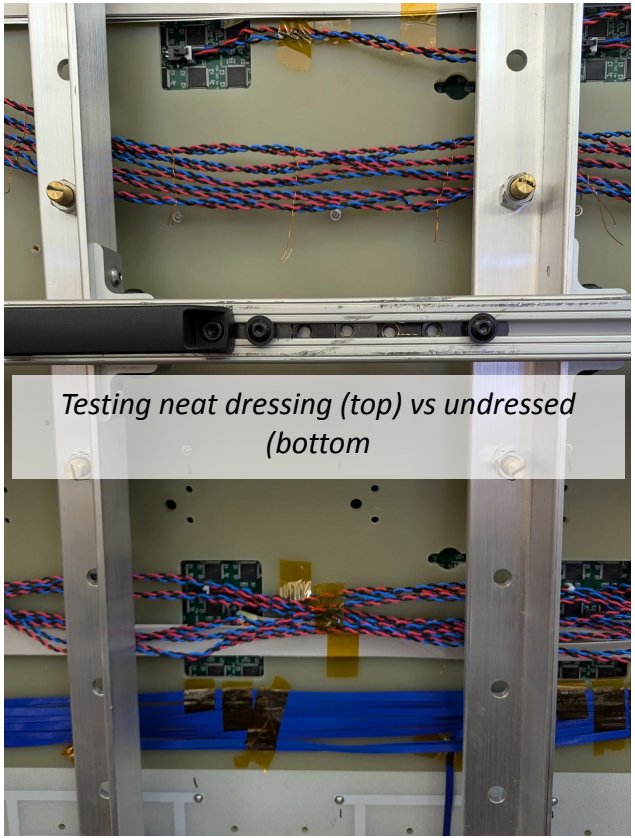




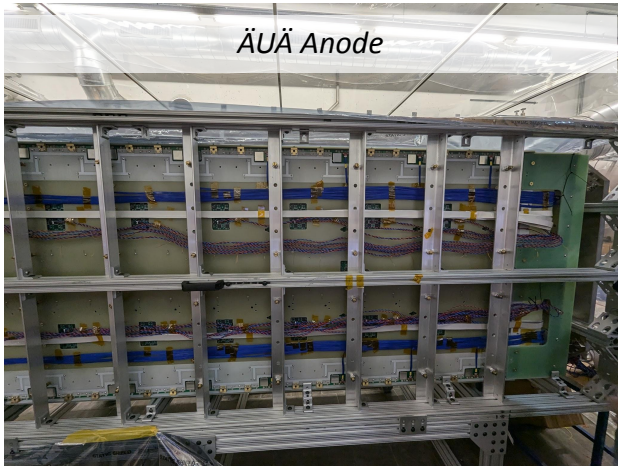


- Started the cabling process on Thursday by testing out cable routing and determining optimal mounting/restraint locations
- Cables held with kapton first, cable restraint system installed after all cables were in place
    - First time using these types of cables on a TPC - all are improved from the versions used in 2x2, but downside is we don't have as much experience routing these specific types

Week September 30th - October 4th



Testing neat dressing (top) vs undressed (bottom

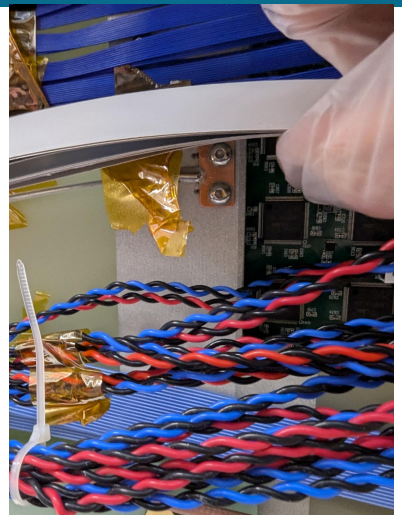


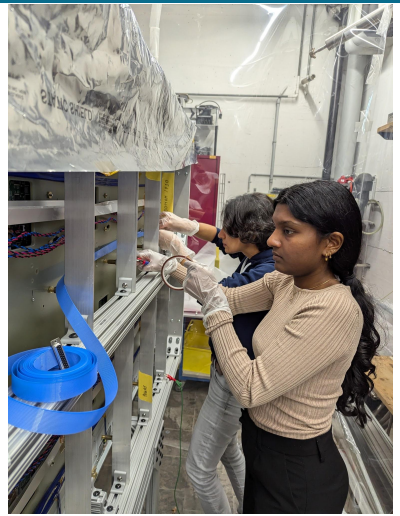
ÄUÄ Anode

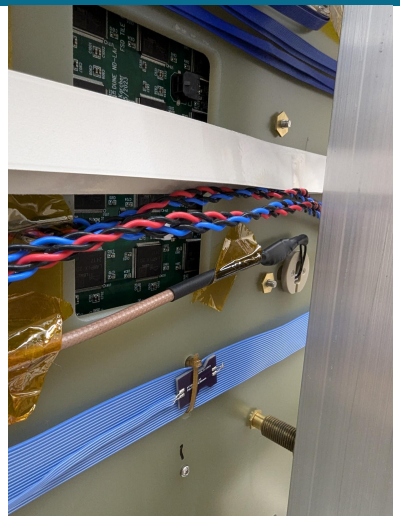
BÄREN Anode

- All light and charge cold cables installed and tested by Friday
- Structure to support module above cryostat assembled

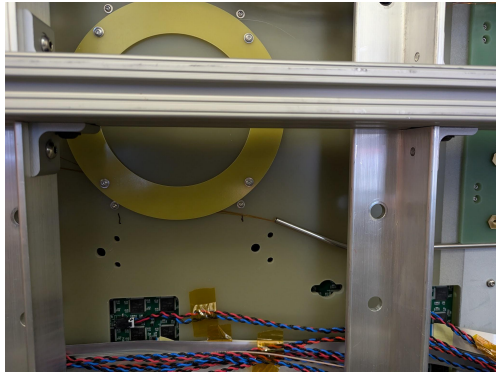
Week October 7th- 11th







- Installed LED pulsers and cables
- Installed HV ground return cables
- Installed calibration fibers
- Installed RTD sensors
- Dressed cables an installed brackets to hold them in place



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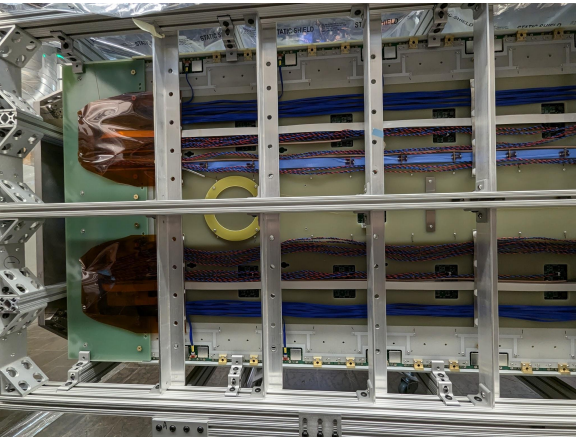
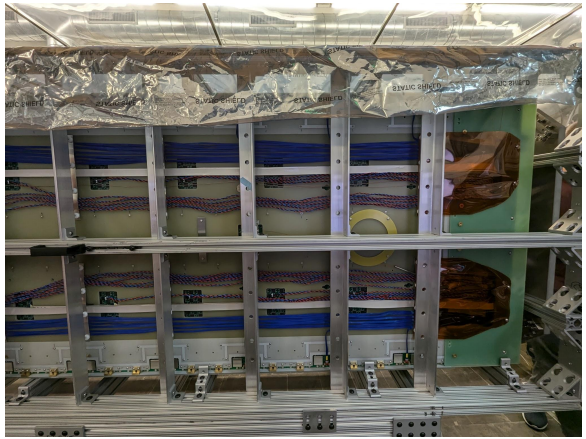
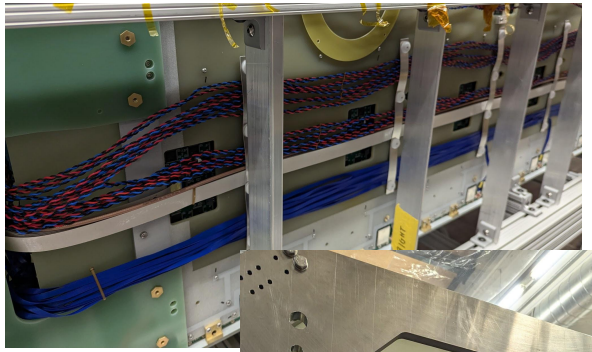
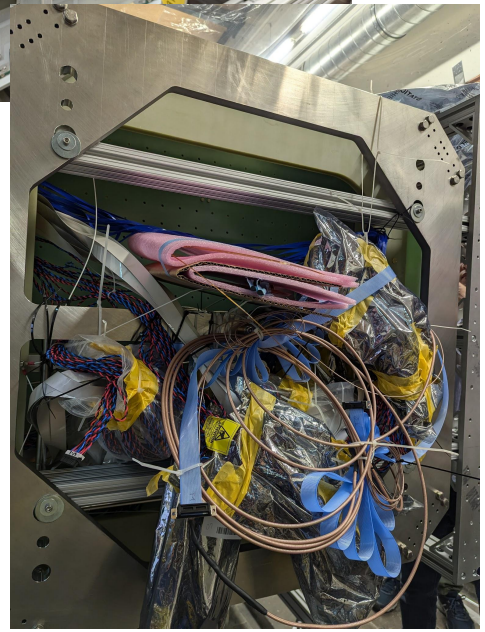


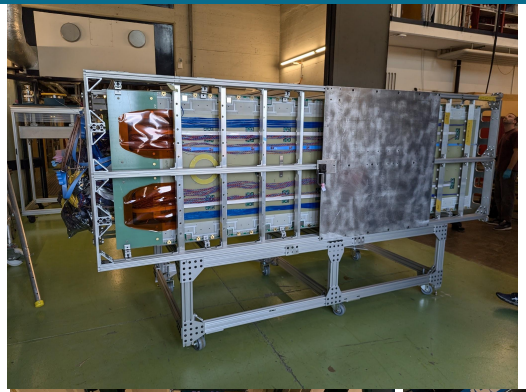


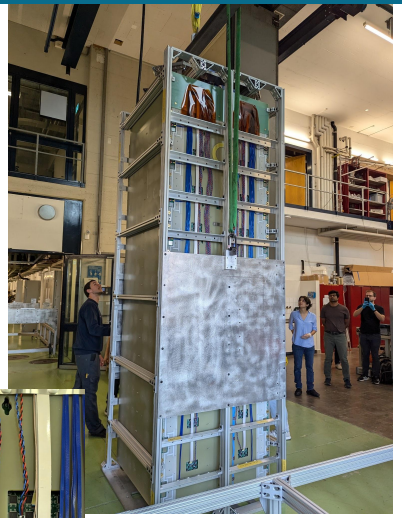


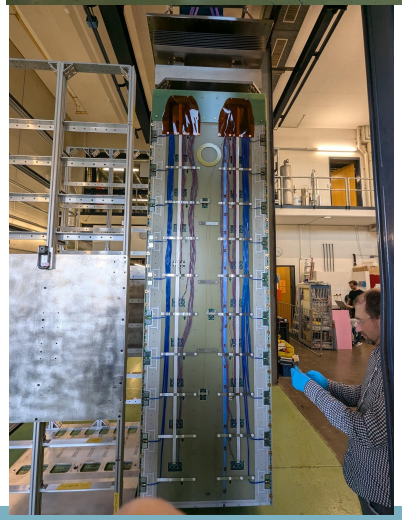
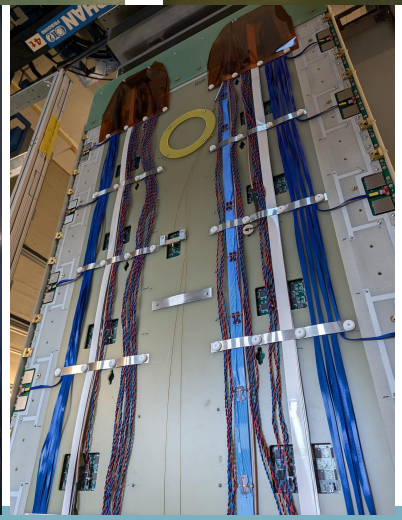
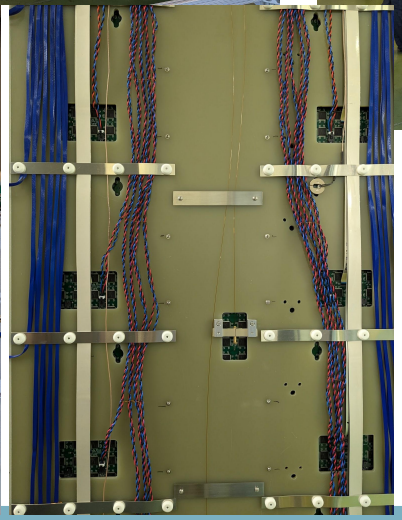


- Dressed cables an installed brackets to hold them in place
  - ~1 full day of work to neatly dress cables along the anodes
  - Added Kapton foils to prevent cables getting caught by the baffles during cryostat insertion
  - “Tidy dressing” on top of the module wasn’t much of an option due to lack of strain relieving points
- Total of 4 days for routing and dressing all cables and fibers

Week October 7th- 11th

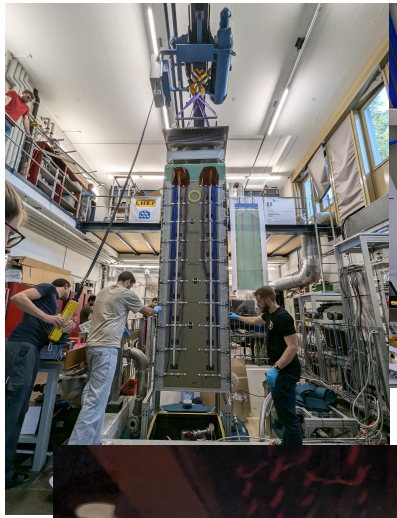


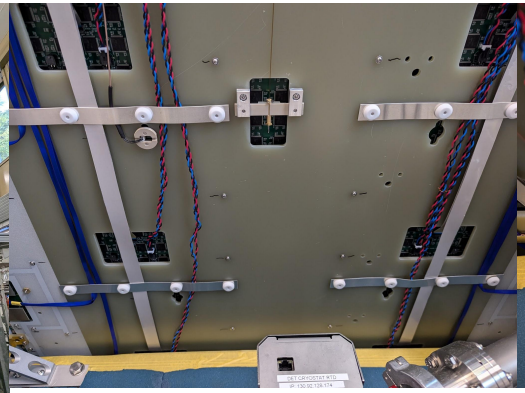


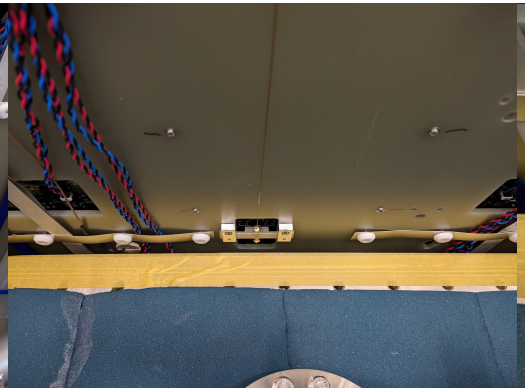




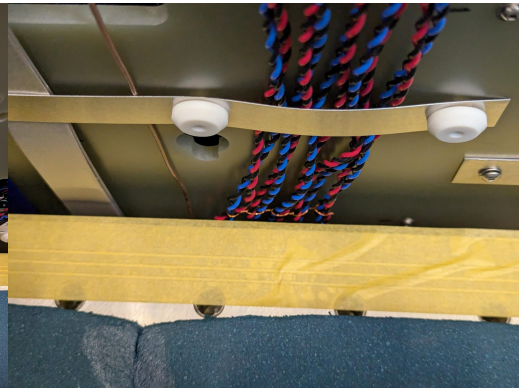
- Wednesday morning: final pre-rotation checks and preparation
- Wednesday afternoon: module rotated and inserted inside the cryostat

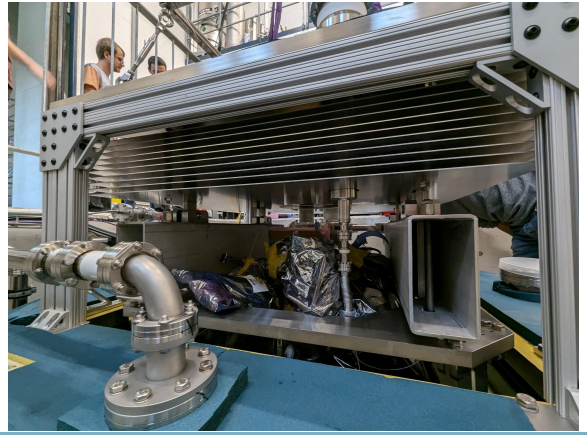
Week October 7th- 11th











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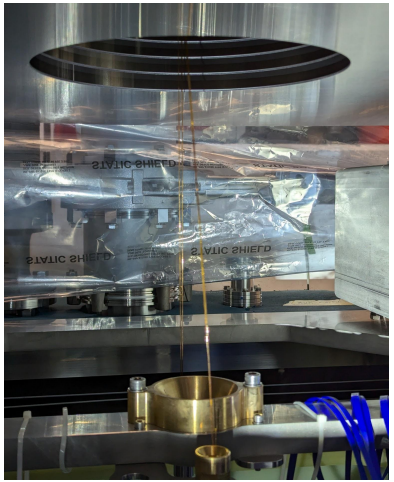
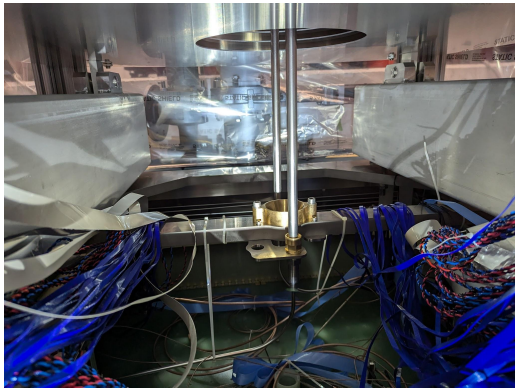
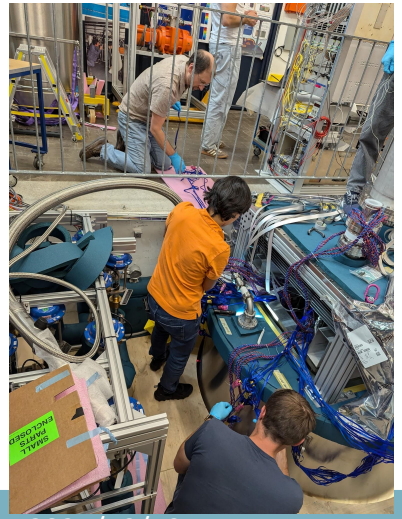
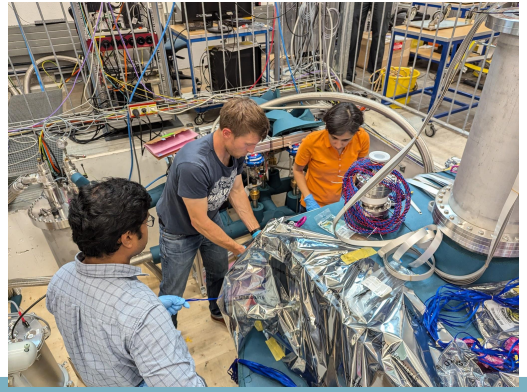
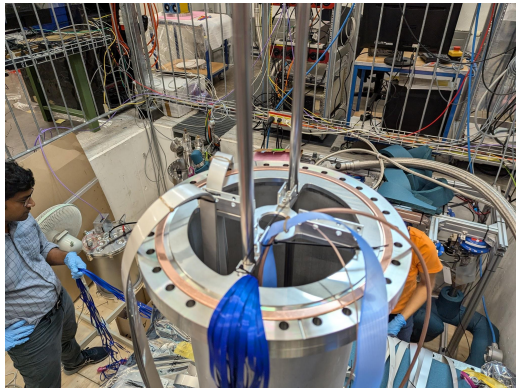
Week October 7th- 11th





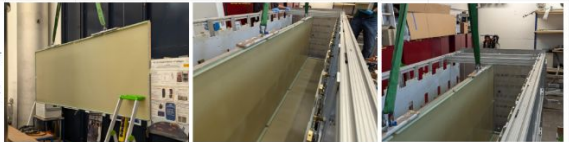






Today and tomorrow: cabling, cabling, cabling!

FSD Lessons Learned

Index	Event Type (Positive or Negative)	Description of the Event	Effects of the Event	Installation Phase	Solution	Photos
1	Positive	Correct order to put together the module assembly frame	Following the right order makes the frame assembly much easier	Preparations of frames for module assembly	1) Assemble lateral walls 2) Set the front side vertical (can align it vertical) and tie to something so that it stays vertical 3)Attach each lateral side, using cribbing to keep them at the right height 4) Bring back side in place and attach to sides	
2	Positive	Use 8020 bars wrapped in plastic or covered with foam or a low-friction plastic (like Teflon) when inserting anode planes in the assembly frame	Makes anode plane insertion easier and safer for the plane itself, minimizing the chances of plane excessive bending	Module assembly	Install 8020 bars with the long edge vertical and covered in foam, or a low-friction plastic. Bars have to stick out from the frame at least0.5 or 1 meter. Brass standoffs have to be lowered so that the 8020 bars are higher than them. Anyway the final standoff height has to be higher than the 8020 one, to allow transfer of the plane from bars to standoffs. Anode plane will first be sit on top of the bars outside of the frame, than slide along the bars into the frame	
3	Positive	Installing brass blocks on anode plane with screw not fully tightened	Makes installation of side, top and bottom field cages much easier	Module assembly	When installing brass blocks on the anode planes, do not tighten the screws completely. Leaving them a bit wiggly will make field cage installation easier. Tighten them after corresponding field cage is in place	
4	Positive	Cathode, top and bottom field cages installation outside of the assembly frame to allow for cathode installation with the crane	Easier, and safer installation of the cathode, minimizing chances of cathode excessive bending	Module assembly	After the first side field cage panel is installed, take frame out of the assembly cradle and back on the handling frame to allow installation of the cathode with the crane from the top. This avoids the need for installing the cathode horizontally, which makes it more challenging not bending it during the installation process	

- Cataloging all Lessons Learned from FSD preparation, assembly, and installation processes, capturing positive, neutral, and negative issues/event and proposing solutions/mitigations
  - To be presented and discussed post FSD, likely in an engineering meeting
  - 40+ entries so far, likely more to come

What's next

- Once cold cabling is concluded:
  - Connectivity test (tomorrow afternoon or next week)
  - Leak test if all checks are ok
  - Cryostat pressurized with Ar Gas and start of warm tests
  - Cooling and filling!

- May still change the order in case of issues found or to optimize days and personnel availability

Summary

- FSD Assembly is at its very end! Many thanks to UniBe LHEP team for preparing the FSD Facility and hosting visitors!
  - Gratitude to all the folks that have traveled here to assist with assembly
  - Thanks as well to those assisting from remote locations by answer questions and shipping spare hardware
  - It has been a huge help to have these contributions!!!
- Collecting Lessons Learned to be incorporated into ND module production
  - Spreadsheet is organized and owned by Roberto Acciarri
- Daily toolbox meeting to plan each day's activities - chaired by Serhan Tufanli, 9AM Bern Time
  - Keep track of who is doing what and where -> personnel and detector safety
- Subscribe to the #fsd-operations Slack channel to follow daily progress:
  - https://dunescience.slack.com/archives/C07FRD20B4K
- Overall the progress is holding to schedule and barring future issues we expect to run the FSD this month

Greetings from Bern!!