

Dual Phase Drift Cage Production Status

WA105 Joint TB/SB Meeting
May 3, 2017

Jaehoon Yu for

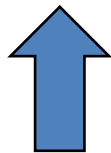
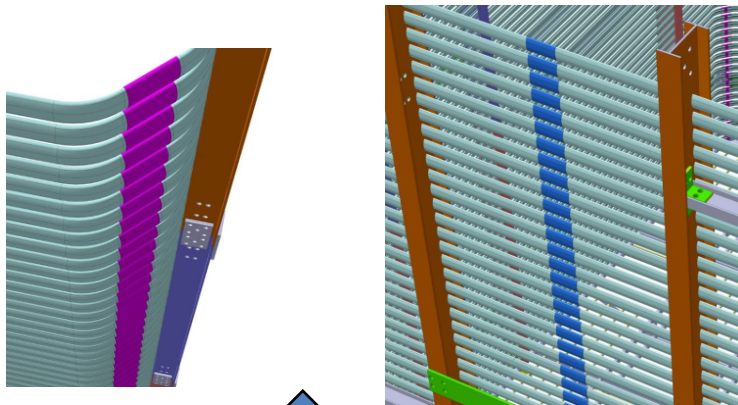
A. Chatterjee, S. Shshsavarani, G. Brown & UTA Team

A. Gendotti, S. Murphy, C. Cantini & ETH Team

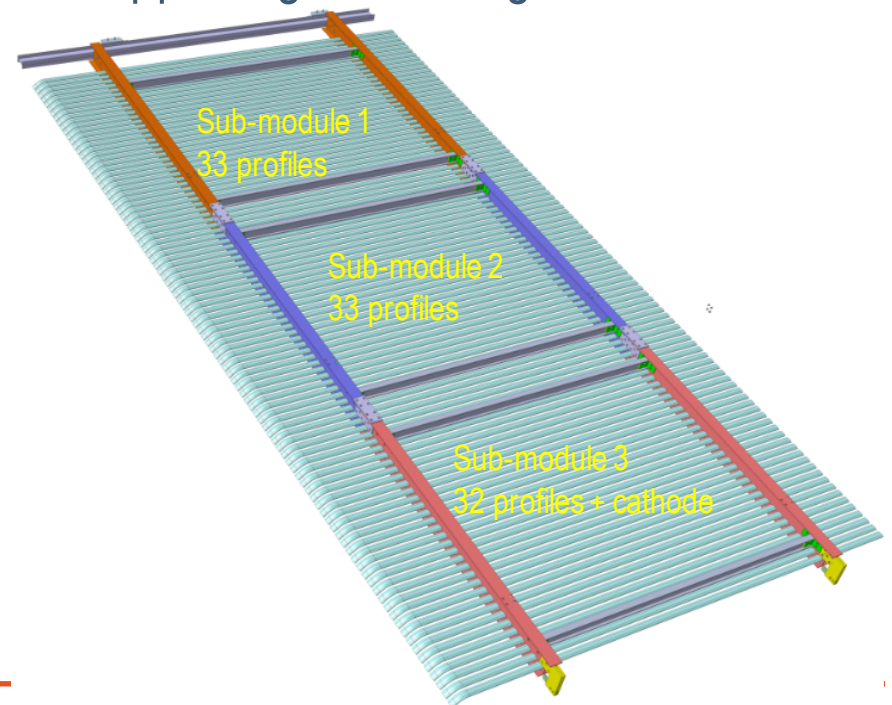
F. Pietropaolo & CERN Team

Drift Cage Design

- Shares common basic structural elements w/ ProtoDUNE-SP
- Consists of 8 vertical modules of 6310 x 3010 mm² (2 modules per detector face)
- Each module is assembled out of 3 distinct sub-modules
- 11 profiles with one end bent at 45 degrees are electrically connected by 1 HV divider board
- 98 electrically continuous rings in 60mm pitch using straight aluminum clips
- Three distinct types of sub-modules with 33, 33, and 32 profiles each held by a frame with two 6" and two 3" horizontal FRP I-beams
- Inter-module connections made with FRP plates connected with FRP threaded rods
- Each profile is made of extruded aluminum with a supporting rib running in the middle



Continuity at center and borders w/ Al clips



The Team

- Postdoc: [A. Chatterjee](#)
- 4 graduate students: [S. Shahsavarani](#), [G. Brown](#), T. Bates, S. Kumbhare
- 8 UG Students: E. Amador, M. Avila, T. Foster, B. Hale, [D. Koss](#), N. Lira, [M. Rapp](#), [D. Zenger](#)
- All students are involved in the cleaning and measurements and are getting well trained for construction. Adapt well to clean room operation.



DC Production Procedure Overview

- This procedure is based on the SP DC End plate group's (LSU group) and is included in the QC Doc
- Production & QC procedure is as follows:
 1. Receipt inspection of the parts for QA
 2. Deburring, defibering, & cleaning of the parts
 3. Pre-assembly of the DP-DC sub-modules
 4. Disassembly
 5. Packaging and Shipping

DC Production – Receipt Inspection/QA

- Inspect profiles, I-beams and other FRP parts for their dimensional and functional qualification
- Visual Inspection for dimensions and structural damages and categorize them by the severity of defects
- Al profiles: deformation or surface damages and bend angle
- FRP I-beams and connecting plates
 - Visual inspection
 - Cracks & Fractures
 - Delamination
 - Dry fiber
 - Burn or thermal decomposition
 - Blisters
 - Dimensional inspection – adherence to the drawing
 - Cross sectional dimensions and lengths
 - straightness, flatness and camber

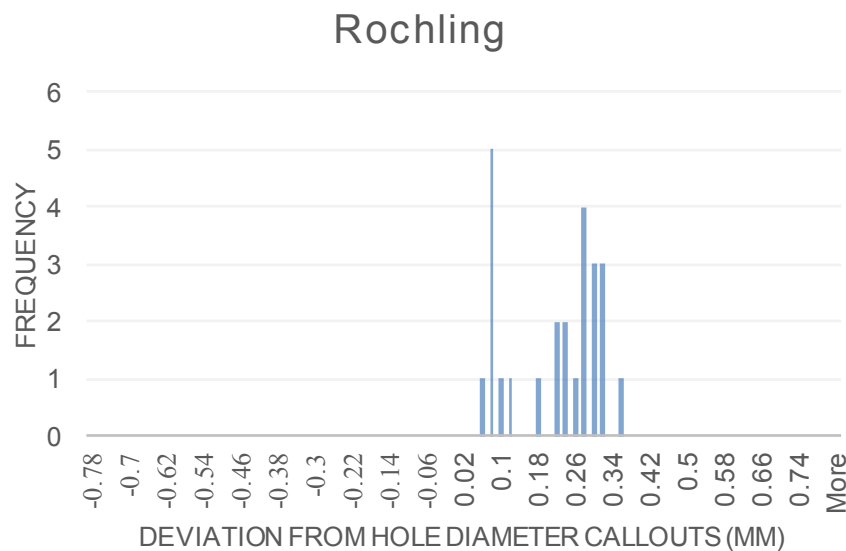
DC Production Status

- We received two sets of I-beams from two vendors – EPI and Rochling
 - Initial inspection show the profile slot alignment quite good based on the laser level measurement
 - Better than 1mm

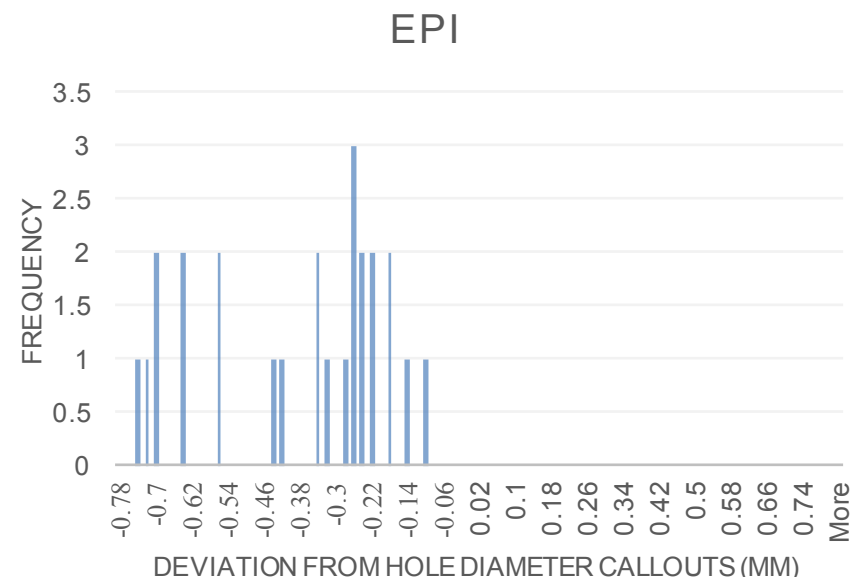


Parts Dimensional Measurements

- Performing measurements of all hole sizes, locations and the flatness of the I-beams
 - Flatness measured wrt a flat surface and a long level → Within the spec of 1mm for 2m length
 - Sizes of the holes and cut outs are within 0.06 – 0.34mm for Rochling and 0.06 to 0.78mm for EPI



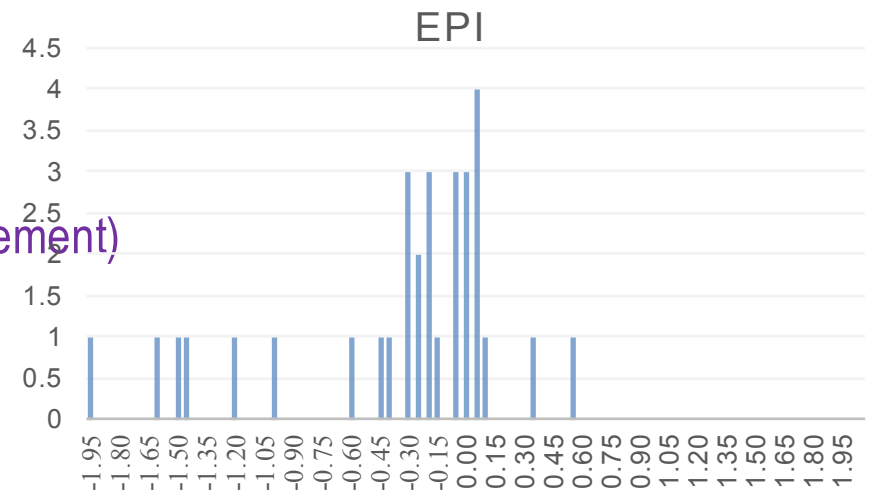
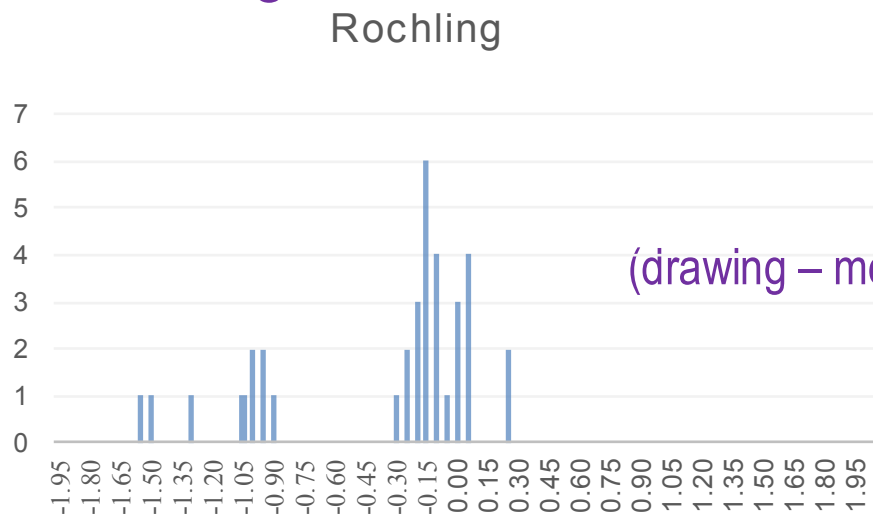
(drawing – measurement)



(drawing – measurement)

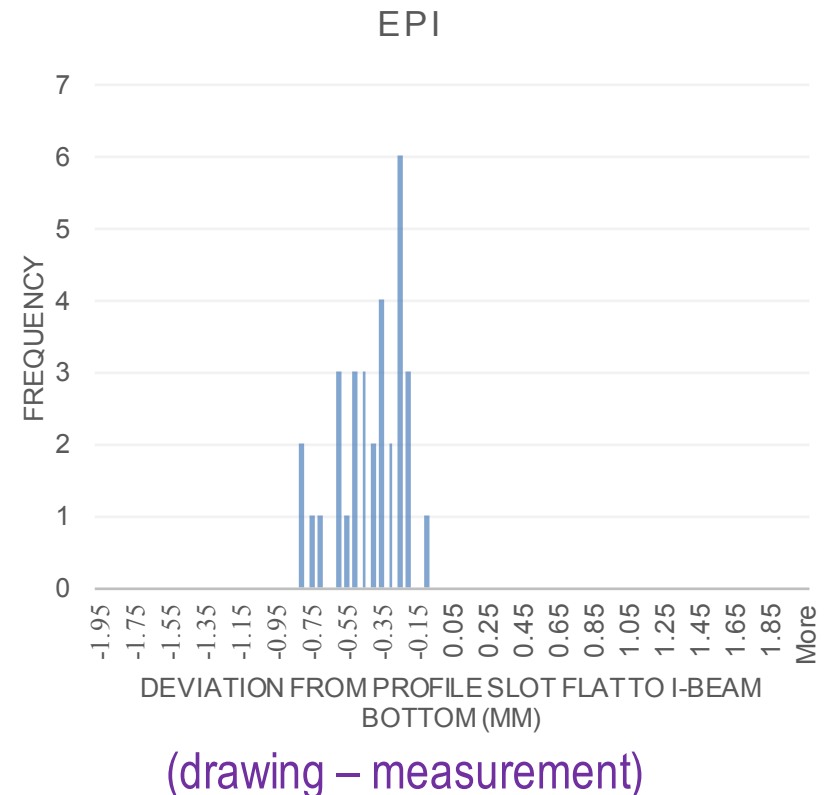
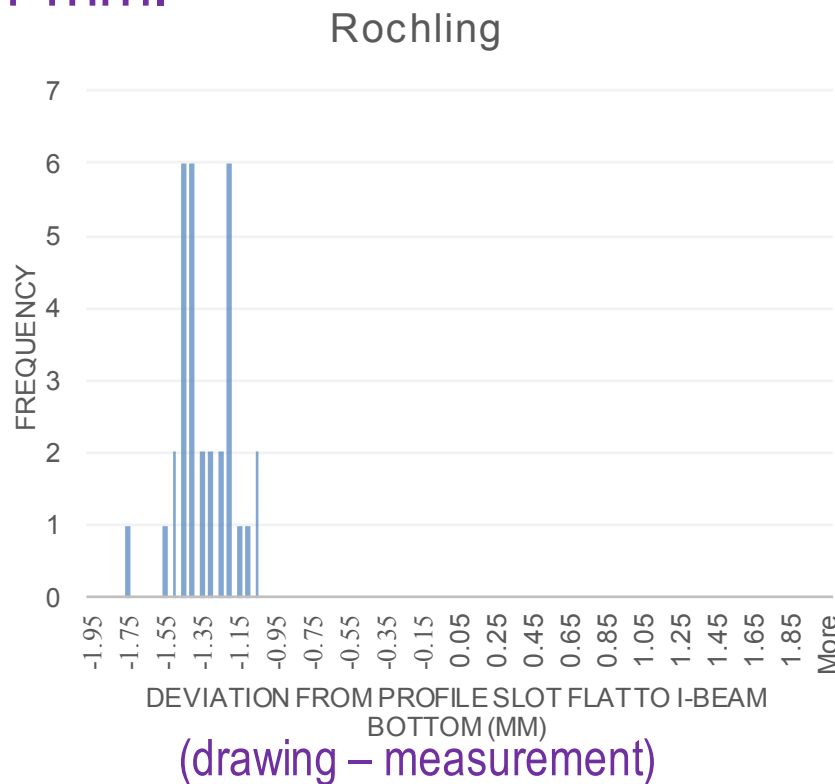
Parts Dimensional Measurements

- Placement of the holes are within 0.23 – 0.55mm & 0.95 – 1.55mm for Rochling and 0.6 to 1.95mm for EPI
- Rochling seems to have a narrower distributions



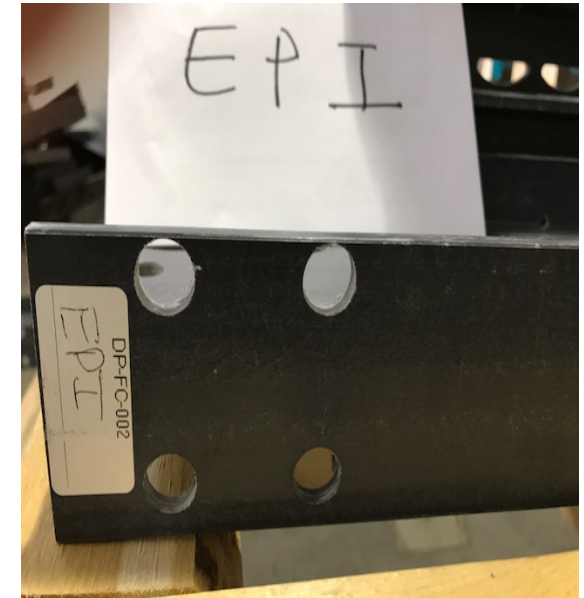
Parts Dimensional Measurements

- Placement of the profile cut outs are within 1 – 1.75mm for Rochling and 0.15 to 0.75mm for EPI
 - All slots are with 0.75mm for Rochling and 0.6mm for EPI
- Rochling seems to have a narrower distributions but away over 1 mm.



DC Production – Parts Cleaning

- This step will be done in a clean and lockable secure area
- All members will wear disposable lab coats, masks, hairnets and non-latex nitrile gloves
- Deburr and defiber the machined holes of the FRP parts with fine sandpaper, vacuuming the fiber as sanding
- Profile slot holes for EPI I-beams have delaminated edges due to the machining procedure.
- Deburring and defibering process takes the longest time in the procedure.



DC Production – Parts Cleaning

- Sand the deburred holes and slots to remove as much fiber as possible
 - Use a deburring tool to speed up large size burs at the edge of the holes and slots
 - Use 600 grit sand paper to take out large remaining fibers
 - Use wet 1500 grit sandpaper to smooth out the small remaining fibers
- Clean FRP I-beams and connecting plates with simple green without color and de-ionized water, using Kimwipes
- Dry and remove moisture from I-beams w/ hot air heat gun
- Clean small parts – threaded rods, nuts, screws, slip-nuts and inserts –in an ultrasonic cleaner w/ ethanol
- Inspect cleanliness of each part after the above processes
- Store cleaned parts on the shelf in the cleanroom

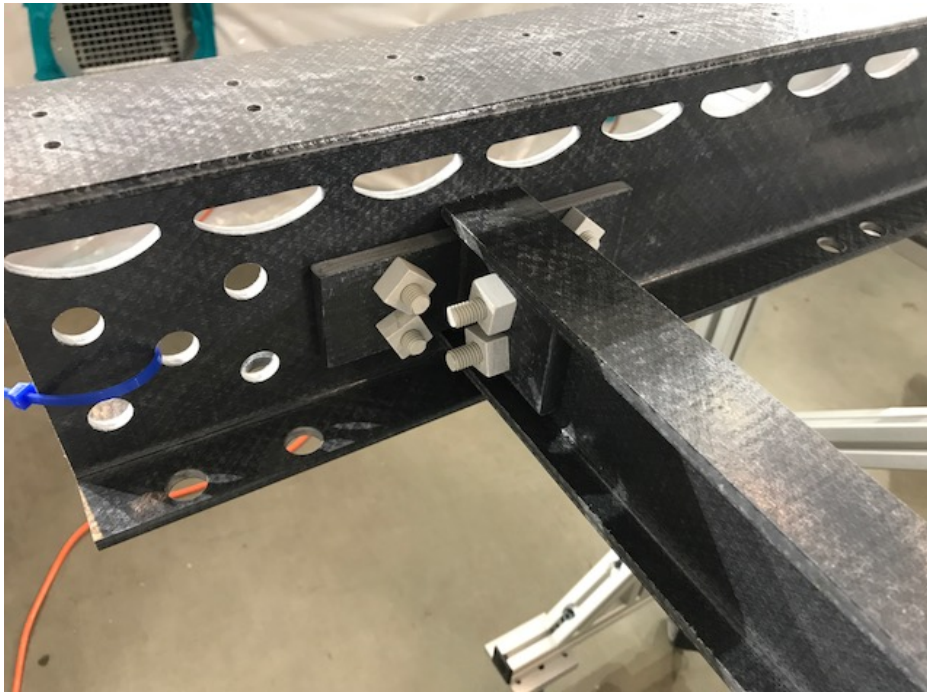


Time Needed for Parts Cleaning

- Based on our experience with four 6" I-beams, four 3" I-beams, 32 L-brackets, threaded rods, FRP nuts, etc, we estimate the following amount of time necessary for complete cleaning process
- 6" I-beams: 2 hours for two people → Total of 8 Man-Hours (Mh) for 2 I-beams per submodule
- 3" I-beams: 30min for two people → Total of 1 Mh/submodule
- L-brackets: 30min for 8 brackets for two people → 1 Mh/submodule
- Total time for cleaning parts for each submodule: 12 Mh w/ 20% contingency
- Can speed up using the deburring tool
- If we have to use resin to further suppress small fiber, curing time needs to be added

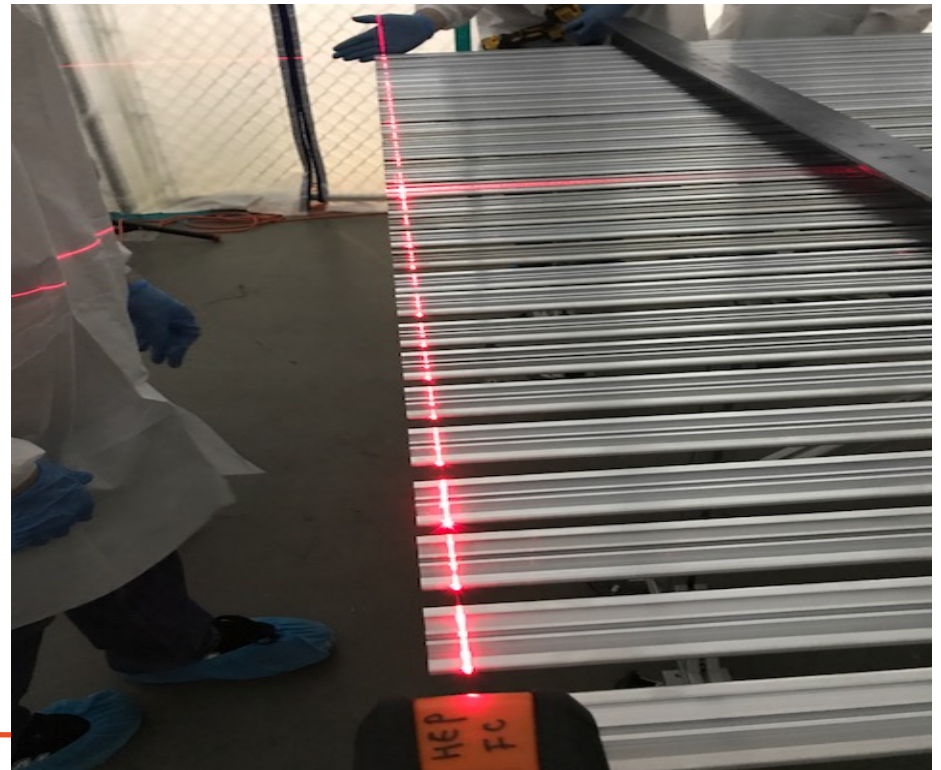
DC Production – Assembly

- This process will be done in a class 100,000 clean room. All members of the assembly team will wear disposable lab coat, mask, hairnet and power-free gloves
- Connect two 6” primary I-beams w/ two 3” horizontal ones using the L-brackets and FRP threaded rods and nuts on the A-frame based assembly stand
 - Put the L-brackets for connecting the 3” I-beams on the 6” I-beams first
 - Insert the 3” I-beams into the slots in between the L-brackets mounted on the 6” I-beam
 - Tighten the FRP nuts with the sockets to ensure the solid connection of the frame



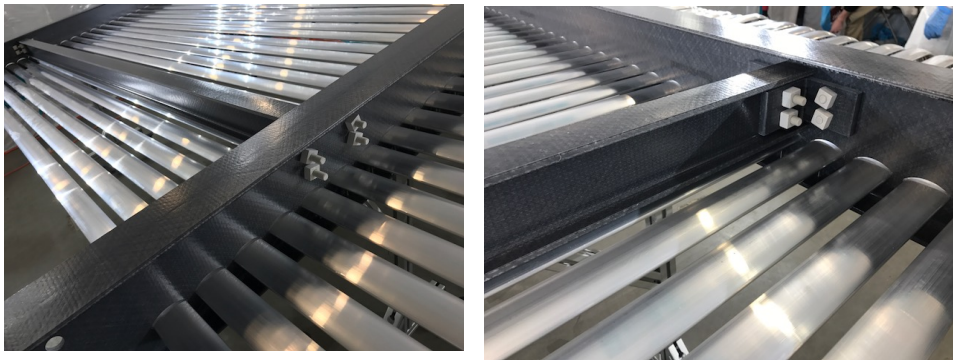
DC Production – Assembly

- Insert a slip nut into the center rib slot from the straight section of the profile and move it to the bent end by lifting up the straight end slightly
- Insert all the aluminum field shaping profiles through the corresponding cutouts and align them all to the correct position
- Secure the profile to the slip-nut to one side of the frame near the bent part
- Check the alignment, straightness and part fitness of the submodule



DC Module Zero!!

- The time it took for us to put together module zero was about 1 hour with four people → We think this can be done in 1 hour for two people
- We will develop a procedure for two people assembly for CERN



Production – Disassembly

- This process will be done in a class 100,000 clean room. All members of the assembly team will wear disposable lab coat, mask, hairnet and powerless gloves
- For shipping, we will disassemble the DC in the following order:
 - Unscrew the profiles one at a time, collecting all screws and slip nuts in a bag, and store the removed profiles on the shelf
 - Unscrew FRP nuts from the threaded rods to disassemble the horizontal I-beams from the primary ones, collecting all threaded rods and nut in a bag
 - Clean all small parts in ethanol in an ultrasonic cleaner to ensure cleanliness and dry off the ethanol and put them in ziplock bags
 - Inspect the I-beams for cleanliness and any damages

Production – Packaging & Shipping

- This process will be done in a class 100,000 clean room. All members of the assembly team will wear disposable lab coat, mask, hairnet and powerless gloves
- Packaging process will be done as follows:
 - Collect zip-lock bags for screws and slip-nuts for profile mounting
 - Collect zip-lock bags for FRP threaded rods and nuts
 - 10% spare parts will be included in the package to ensure the assembly of the sub-module in case they are lost
 - Stack 6” I-beams and 3” I-beams as small a packing factor as possible and mount zip-lock bags for small parts and shrink wrapped multiple layers to ensure isolation from moisture during storage → as small as 165mmx160mmx2000mm
- Each package will contain the list of included parts and be clearly tagged w/ the type of the sub-module (top, middle and bottom) and to ensure proper identification of the locations of the specific sub-module
- The package is then moved into a separate semi-clean room with a lock for storage until shipping

Sub-module Construction Sequence

- In order to prepare strategically for installation into the cryostat, we will build the three sub-modules for one module at a time
- Each sub-module package in shrink wrap will be stored in a clean and secured area
- Ship out to CERN four module worth of sub-modules – 12 sub-modules - at a time, ideally one in early September and in mid to late October 2017
 - The actual shipping dates could be adjusted based on the situation at CERN but the shipping must complete prior to the Thanksgiving to avoid holiday rush and to ensure the safe arrival at CERN prior to the holiday shutdown

DP DC Production Status

- Production readiness documents in review
 - QC Procedure
 - QC Checklist
 - Hazard analysis
 - Vendor documents
- Production readiness review scheduled on May 15 but requested an earlier visit to begin production of I-beams earlier to avoid delays of production I-beams delivery
- Assembly facility preparation complete
- All parts for module-zero delivered
 - Two I-beam vendors identified
- 40 Aluminum profiles with 45 degree bend at hand
- All members of production team in place
- Module-zero in production in progress with initial QC measurements
 - Initial flatness inspection looks good, and the hole dimensional measurements are within the 1mm tolerance
 - All I-beams cleaned but requires a deburring and defibering process
 - Profiles are being cleaned
 - Four profiles put into the slots and screwed in for a trial fit

Conclusions

- The protoDUNE DP DC uses the same modular concept using the same extruded aluminum profiles
- Production/QC/QA facility at UTA is in operation
- Production readiness review documents ready
 - Visit scheduled on May 24
- Cleaning procedure developed and being refined
- Rochling seems to be more careful and precise
 - Need to communicate with the vendors what we've discovered and see if they can adjust their machining process to help us reducing the time for preparing the parts
- Module-zero production complete
- A sample from Rochling has been delivered to CERN and to UTA for further testing → mechanical strength warm/cold, LAr contamination..
- Once we receive a green light, we will place an order for I-beams