BOTTOM CRP BDE INTERFACE

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for the US CRP/BDE team

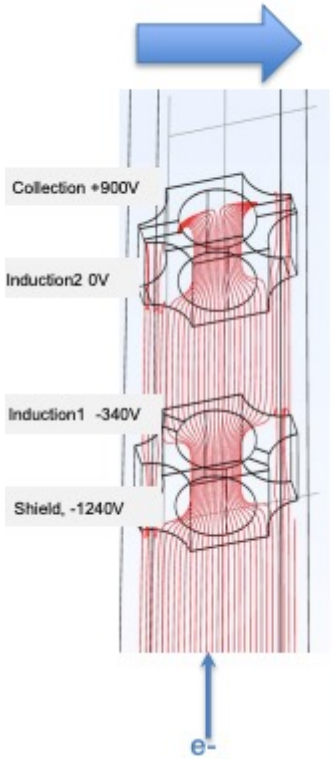
BDE Preliminary Design Review
April 25, 2022

Outline

- Charge Readout Plane (CRP)
- CRP BDE interfaces
- Bottom CRP assembly
- Bottom CRP installation
- Deliverables
- Conclusion

Charge Readout Plane

CRP #1



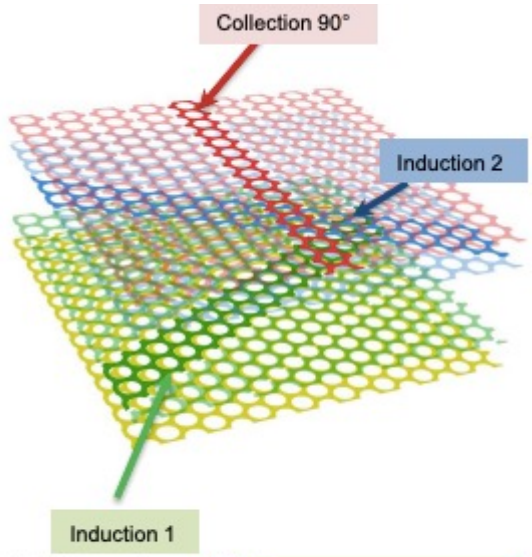
CRP

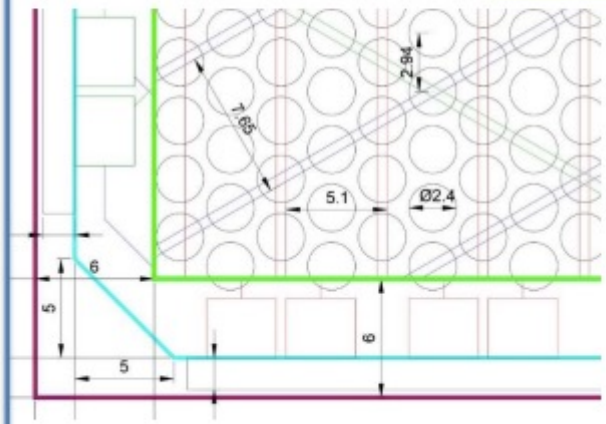
- 2 sheets of *anode PCB*
- *Adapter boards* from PCB to readout electronics (BDE)
- *Composite frame* for stiffening
- Bias *HV filter boards*

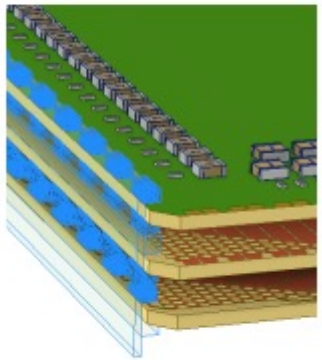
(+30°,-30°,90°)

- ✓ 2.4 mm hole
- ✓ Collection strips in the transverse direction, 5.1mm width
- ✓ Induction2 strips at 30° wrt beam, 7.65mm width
- ✓ Induction1 strips at -30°
- ✓ Induction1 strip pitch: 7.65mm
- ✓ 10 mm PCB spacing
- ✓ Bias: -1500, -500, 0, 1000 V

Starting with CRP #2



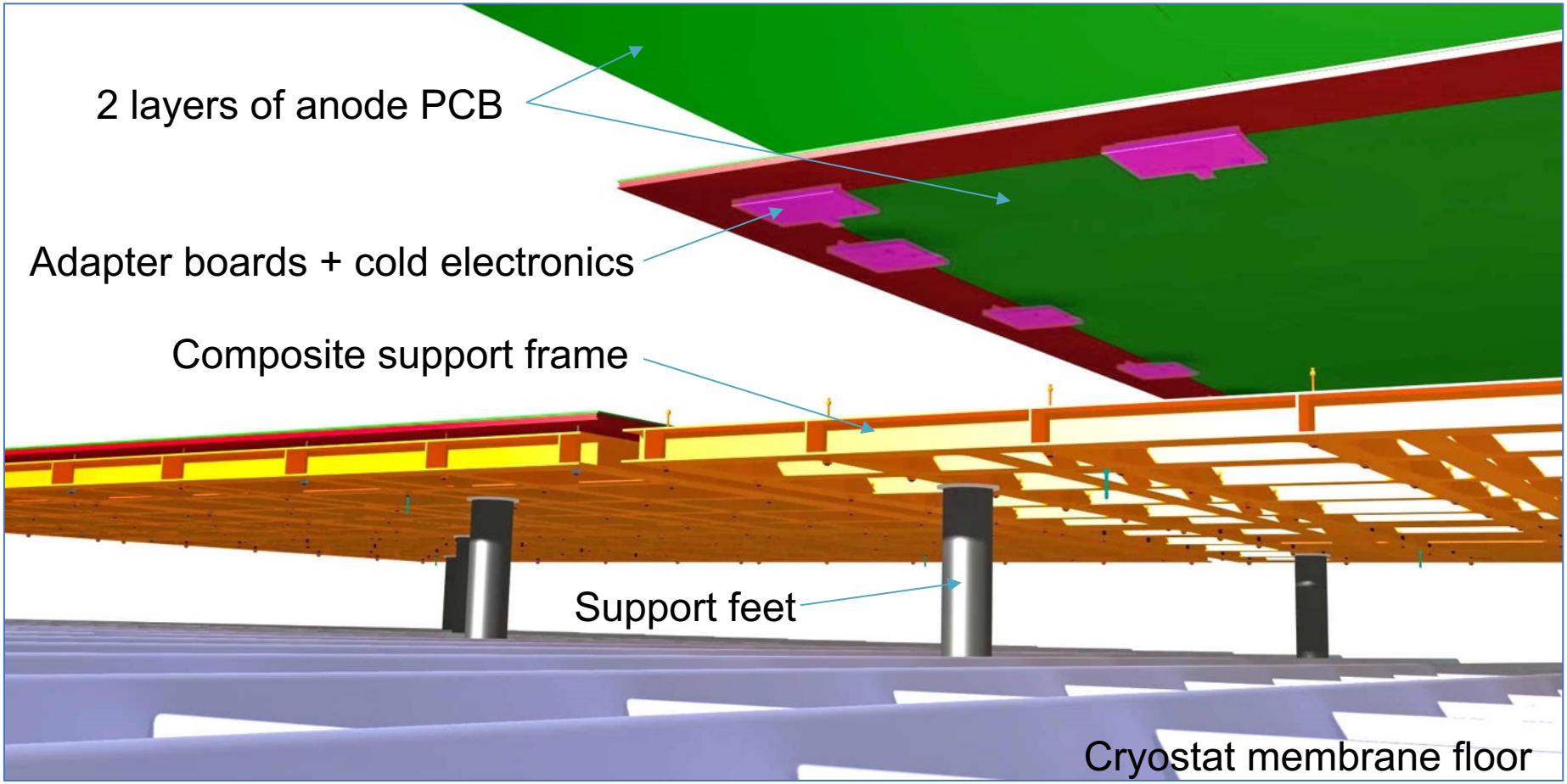




Use of edge connectors for board inter-connection

Bottom CRP

80 3x3m^2 bottom CRP are required for FD-2



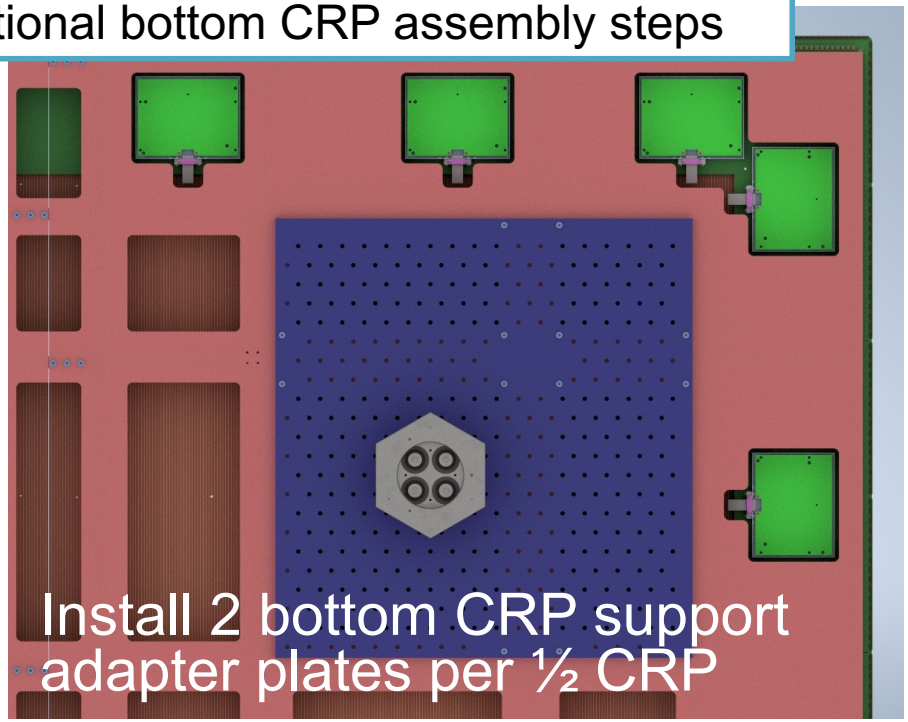
CRP BDE Interfaces

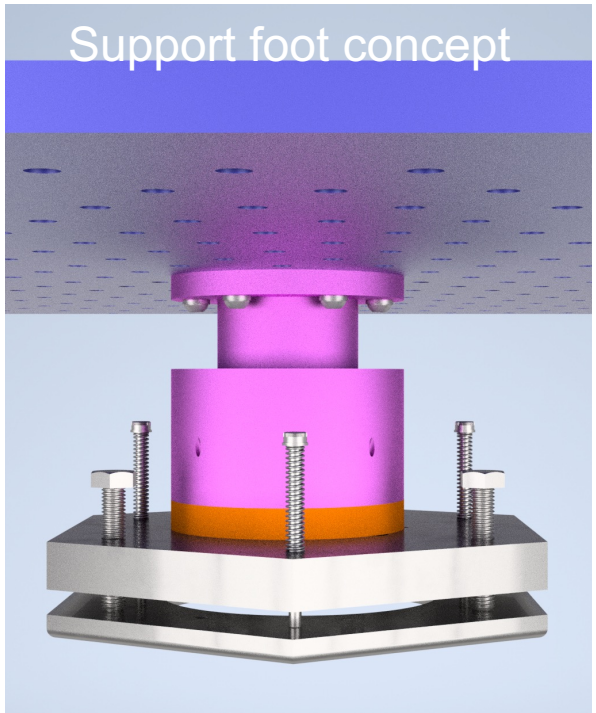
1. FEMB attach to adapter boards via two 96-pin connectors and are enclosed in CE Boxes which attach to adapter boards via screws
2. BDE patch panels attach to composite frames via screws
3. CE Boxes, short CE cables, and patch panels are installed and tested at the CRP factories
4. CRP are attached to the long CE cables in the cryostat at the patch panels and tested warm during far detector installation
5. Bias voltages are brought to the CRP filter board via cables from the CE flange

Bottom CRP Assembly

- Bottom CRP mechanical assembly is identical to top CRP assembly, all work is done in ½ CRP units
  - Anode PCB layers are stacked with spacers and screwed together
  - Edge connectors and adapter boards are inserted
  - Composite frame is placed on top and attached

Additional bottom CRP assembly steps

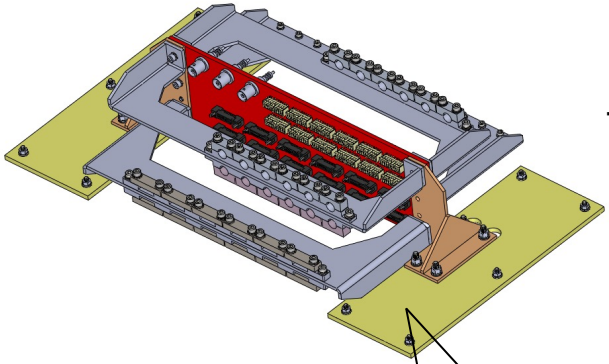




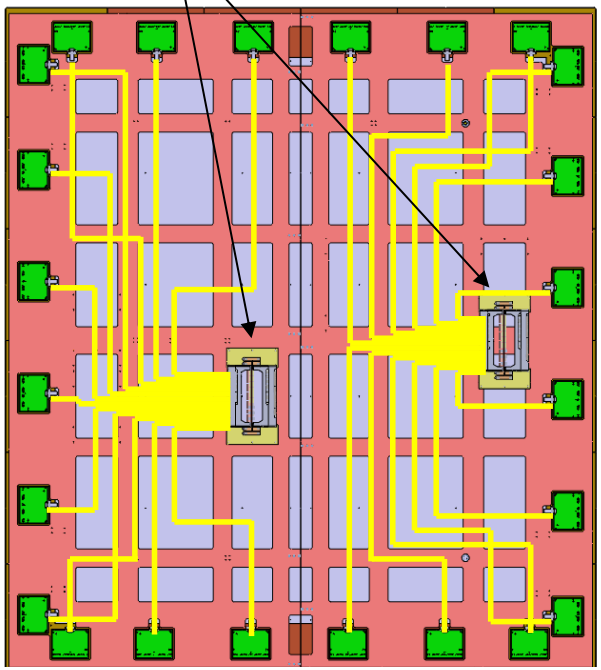
Bottom CRP Assembly

Installation of BDE on ½ CRPs

1. Install BDE patch panels on ½ CRPs with bolts to the composite frame: see M. Zhao slides on FD2 installation details
2. Install 12 Front-End Motherboards (FEMBs) in their CE Boxes per ½ CRP: next slide
3. Route CE cables (data + power) from FEMB to the BDE patch panels



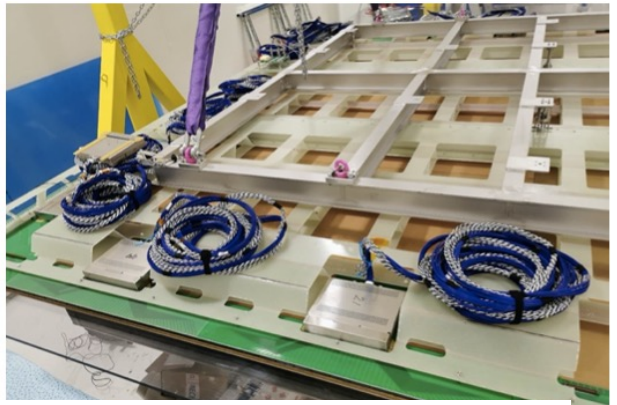
1 patch panel for 12 FEMBs (design A)



Preliminary patch panel + cold cable route concept

FEMB Installation

- 12 FEMB (1,536 channels) are installed one at a time per ½ CRP
  - FEMB connectors are gently attached to the adapter board pins
  - Then the CE Box is attached to the adapter board via screws
  - Finally, the short CE cables are routed to the patch panel
- FEMB can be damaged by discharge during handling: strict ESD safety required during installation and subsequent ½ CRP handling and shipping at US factories
- As each FEMB is installed a warm checkout test (~1 minute) is done, when a full ½ CRP is complete a cold checkout test (1 day cooldown, ~1.5 hrs of testing, 1 day warmup) is done

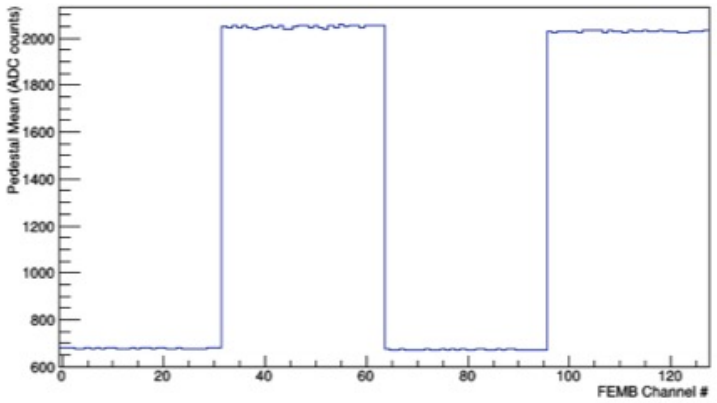


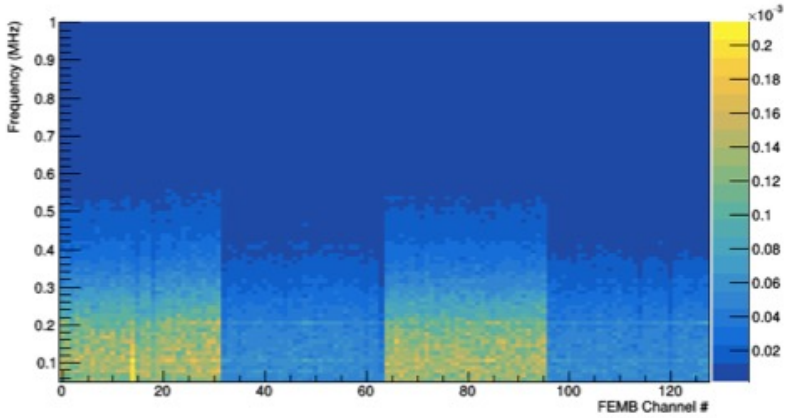
ProtoDUNE-SP FEMB and CE Boxes + cold data and power cables on CRP #1

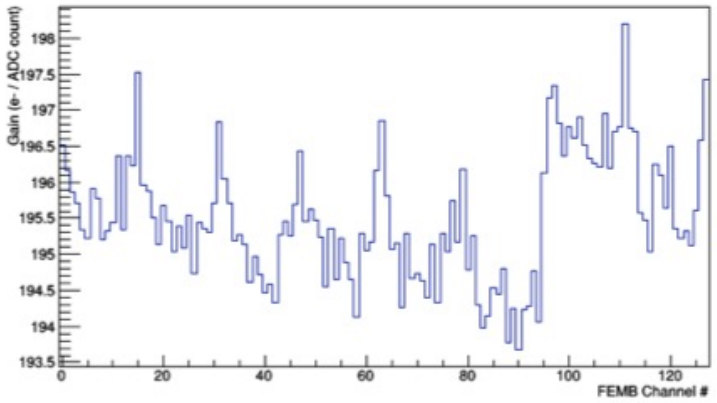
FEMB Testing

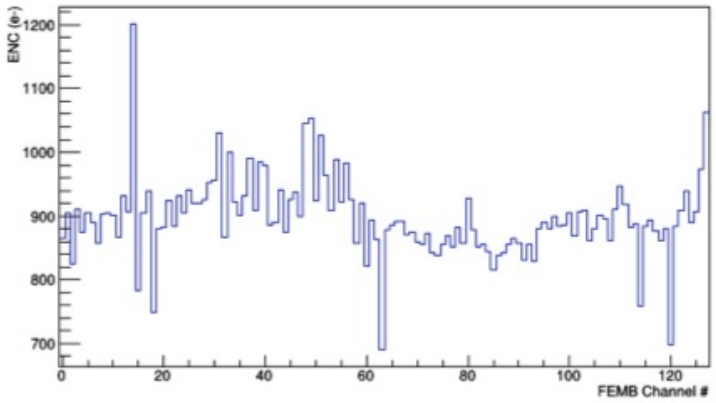
FEMB characterization including full gain calibration using onboard pulser as done for both ProtoDUNE-SP and SBND experiments

Gain/ENC Measurement: Gain = 14 mV/fC, Shaping Time = 2 us, Internal FPGA Pulser



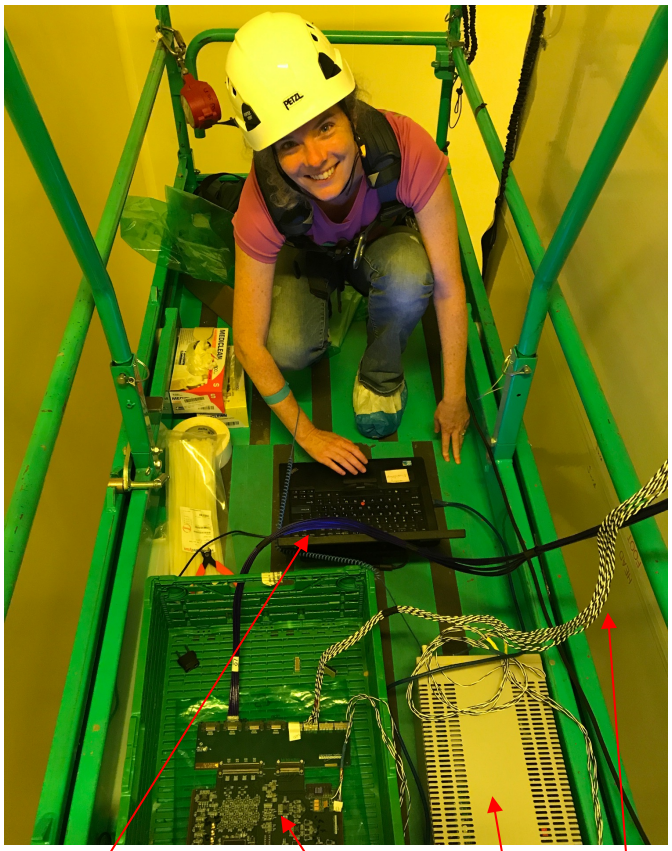




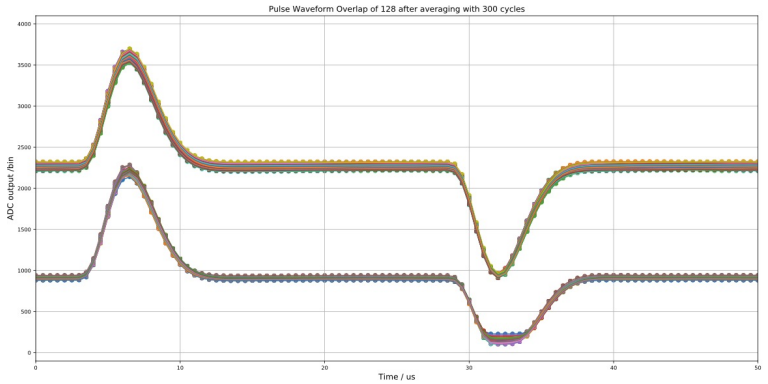


QA/QC

Mobile CE test setup for ProtoDUNE-SP



- Bottom CRP factories can adopt the CE consortium electronics BDE QA/QC plan
- For ProtoDUNE-SP:
  - Tracked all elements at the single channel performance level from ASIC -> FEMB validation -> FEMB installed on APA tests
  - Saved all results in QC database at BNL
- CRP factories will record FEMB location and results from warm and cold FEMB tests at factories
  - ASIC and FEMB validation tests will be provided by CE consortium: see S. Gao's QA/QC slides
- Additionally, the bias HV will be tested



Bottom CRP Assembly

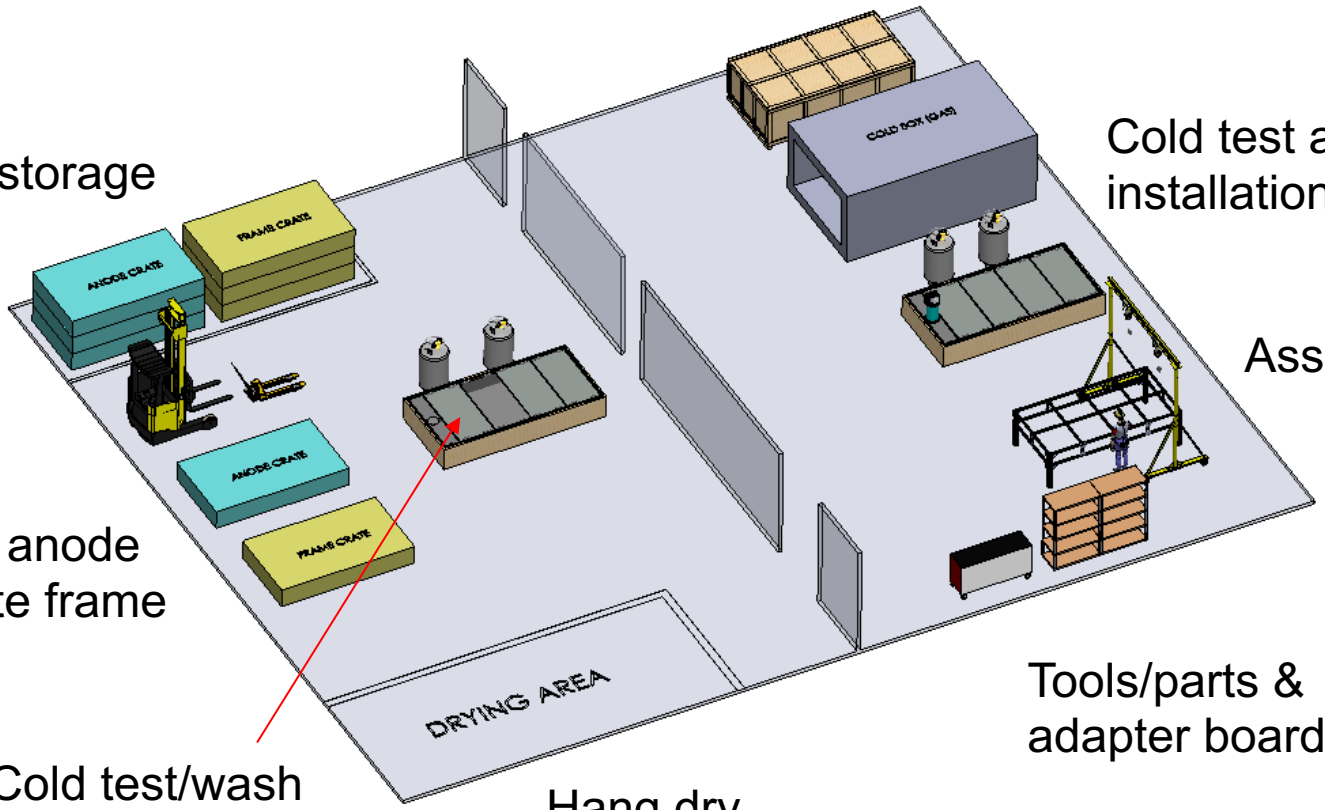
- Labor estimate: 6.5 FTE
  - 1 engineer (management and oversight of factory)
  - 4 students (assembly and testing)
  - 1.5 physicist (testing)
- Bottom CRP labor estimate accommodates FEMB installation and testing while keeping same schedule as top CRP factory

- Schedule estimate
  - Assembly 1.5 days
    - Including bottom CRP support adapter plate, BDE patch panel, and FEMB installation
  - Testing 2 days
    - Includes full test of all FEMB at cryogenic temperatures
  - Assembly and testing are staggered by ½ CRP
- 2 x ½ CRP weekly
- 80 x ½ CRP per year at each factory

Bottom CRP assembly plan under development to finalize schedule and labor

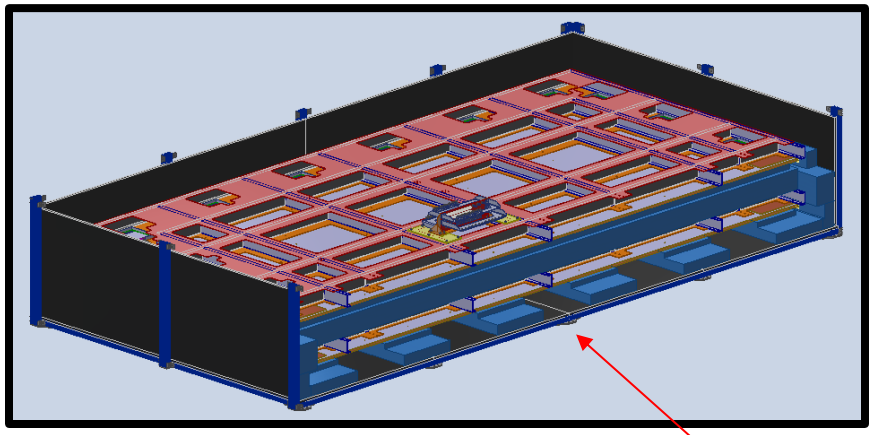
Bottom CRP Factory

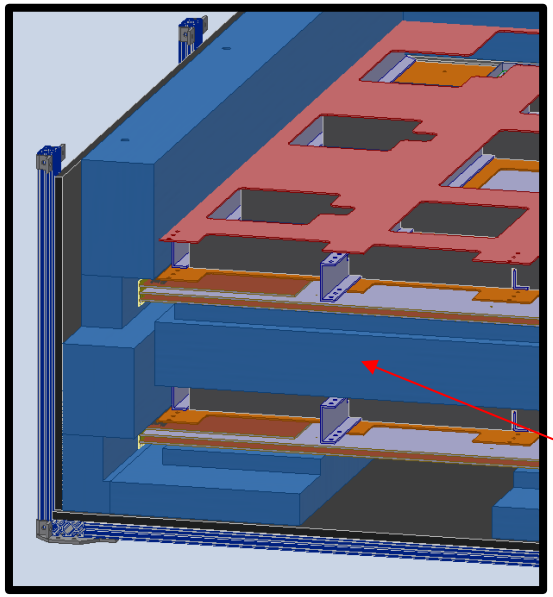
Concept of bottom CRP factory site



CRP Shipping

- CRP provides the bottom CRP shipping crates
- Preliminary design
  - Two ½ CRP stacked in inner shipping box
  - CRP blocked in with ESD foam that has cutouts for edge connectors and patch panels
  - Each CRP will be sealed in ESD bag (not shown)
  - Outer shipping box will enclose the inner box



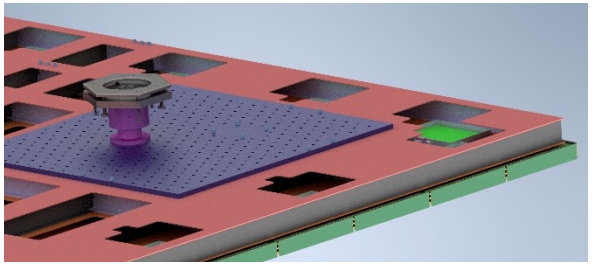


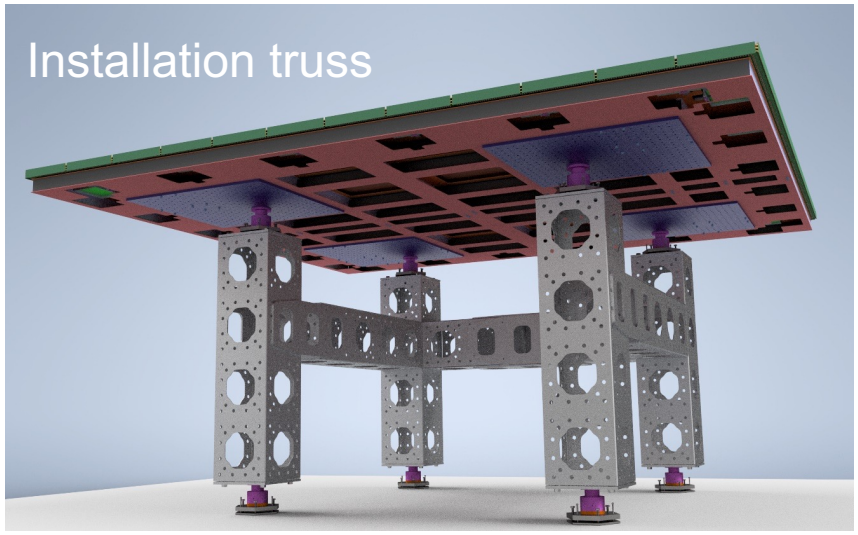
80/20 frame with acetal resin panels

ESD foam

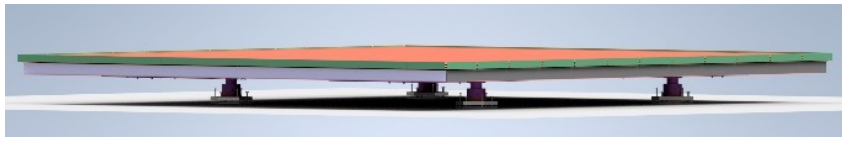
CRP Installation

- Outside of cryostat
  - ½ CRP are unboxed and 2 support feet attached
  - CRP reception test
    - Connect CRP to building ground in clean area
    - Warm test each FEMB with mobile test setup
- Inside cryostat
  - Place two ½ CRP onto installation truss and rivet together
    - Truss is pre-positioned at CRP location on floor
  - Attach long cold cables to patch panel and bias cables to HV filter board
    - CRP now on detector ground via cable return lines to CE flanges
  - BDE team performs warm test via CE flange
  - Survey and level CRP
  - Remove truss and lower CRP onto membrane floor
  - BDE team performs final warm test





Coordination between CRP and BDE teams



Deliverables

CRP provides	BDE provides
Adapter boards with pins and holes to attach CE Boxes	Cold tested FEMBs inside CE Boxes
Composite frame with holes to attach BDE patch panel	BDE patch panels and short cold cables
CE Box installation and warm testing	CE testing hardware (mobile test setup) and training at factories
Cold test of ½ CRPs at factories	CE flange (including PTC/WIBs) and long cold cables at factories
CRP warm reception test at SURF	CE testing hardware (mobile test setup) at SURF
CRP installation in cryostat and attaching long cold cables	Long cold cables from the CE flanges pre-installed in cryostat
Bias HV filter board and attaching bias cables during CRP installation	Bias HV cables from the CE flanges pre-installed in cryostat

Conclusion

- Composite frame and patch panel design: active collaboration between US and French engineering teams ongoing
- CRP assembly at US factory sites includes CE Box, short cold cable, and patch panel installation
  - BDE provides electronics testing hardware and training to CRP assembly factories
  - All CRP will be cold tested after CE installation at US factories
- CRP installation in the cryostat will be done by CRP installation team
  - BDE team will perform warm test during and after CRP installation