



XARAPUCA Production Process, QA/QC, Lessons Learned

DUNE FD2 FINAL DESIGN REVIEW, APRIL 2023

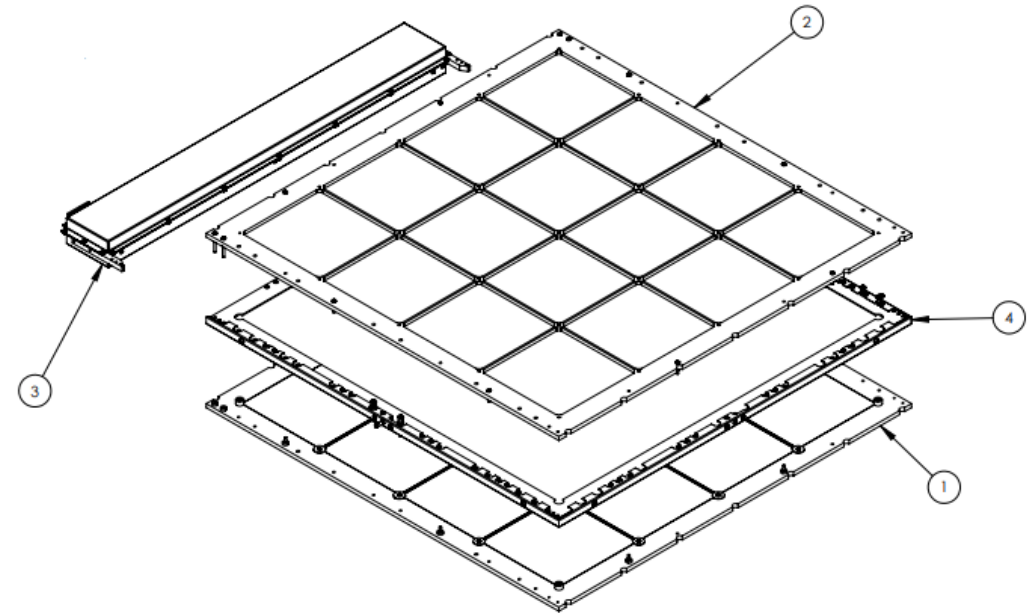
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4/18/2023

Outline

- Overall Design and Assembly Guidelines
- Design of subassemblies and lessons learned
 - Module core
 - Dichroic filter frames
 - Membrane mount backplane
- Fabrication & QC plans for DUNE FD2
- Conclusion

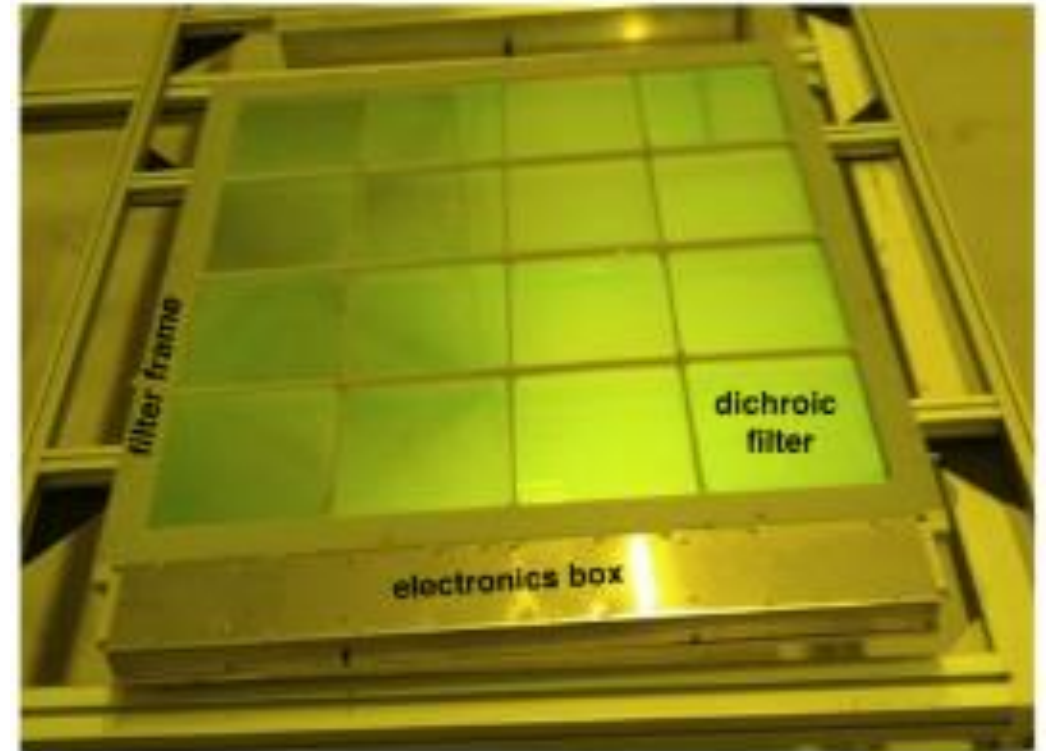
XARAPUCA Design and Assembly

- Design for manufacturability
 - Modular design that allows fabrication and test of subcomponents
 - Minimize time and labor at SURF
- These are the:
 - Module core which houses the WLS plate, photosensors, and electronics
 - 1 or 2 filter frames
 - A backplate for the Membrane Mounted XARAPUCAs
- Each can be prepared and assembled and shipped separately for final assembly at SURF



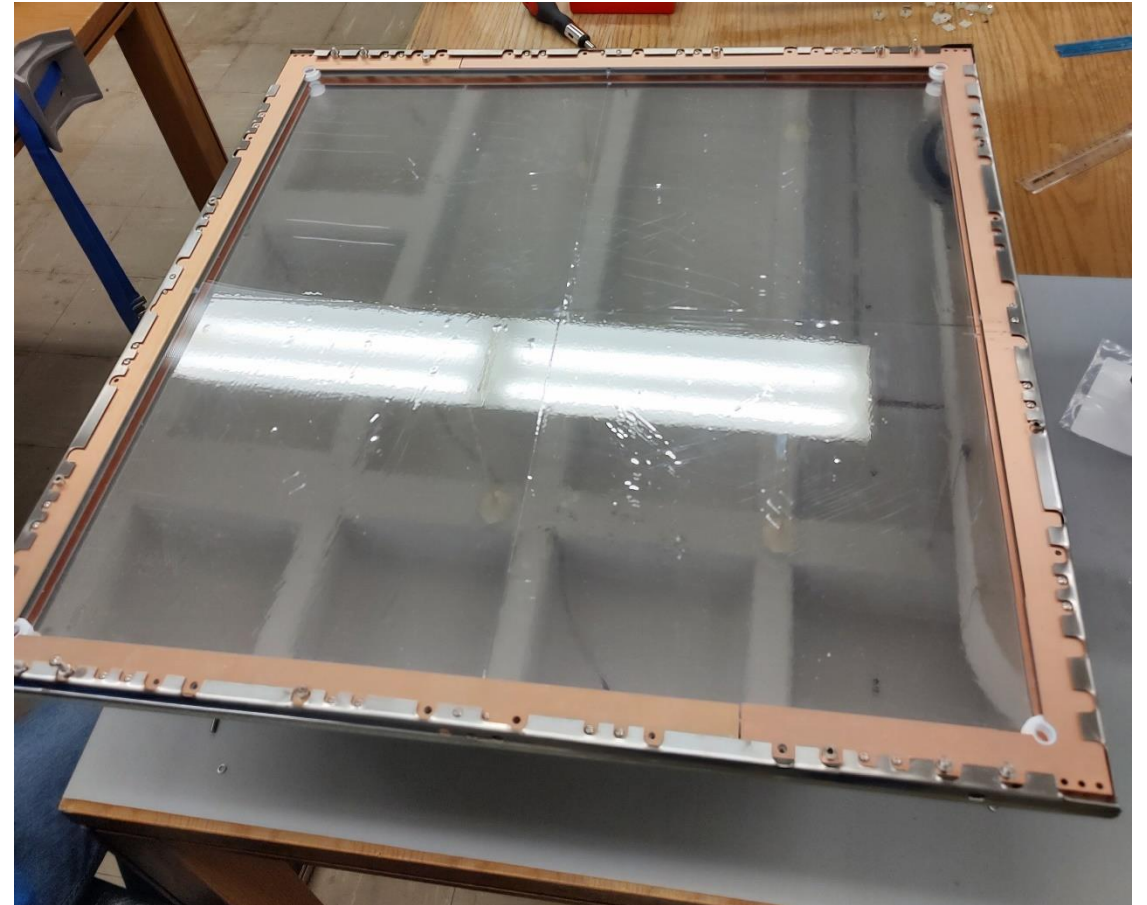
X-ARAPUCA Module 0 Design Lessons Learned

- Module 0 Design guided by feedback from coldbox
- Iterative improvements based on feedback from coldbox runs
- For ProtoDUNE II FD2 partial assembly was done at NIU
- Final assembly, testing and installation done at CERN (including WLS, cables, flex circuits and dichroic filters)



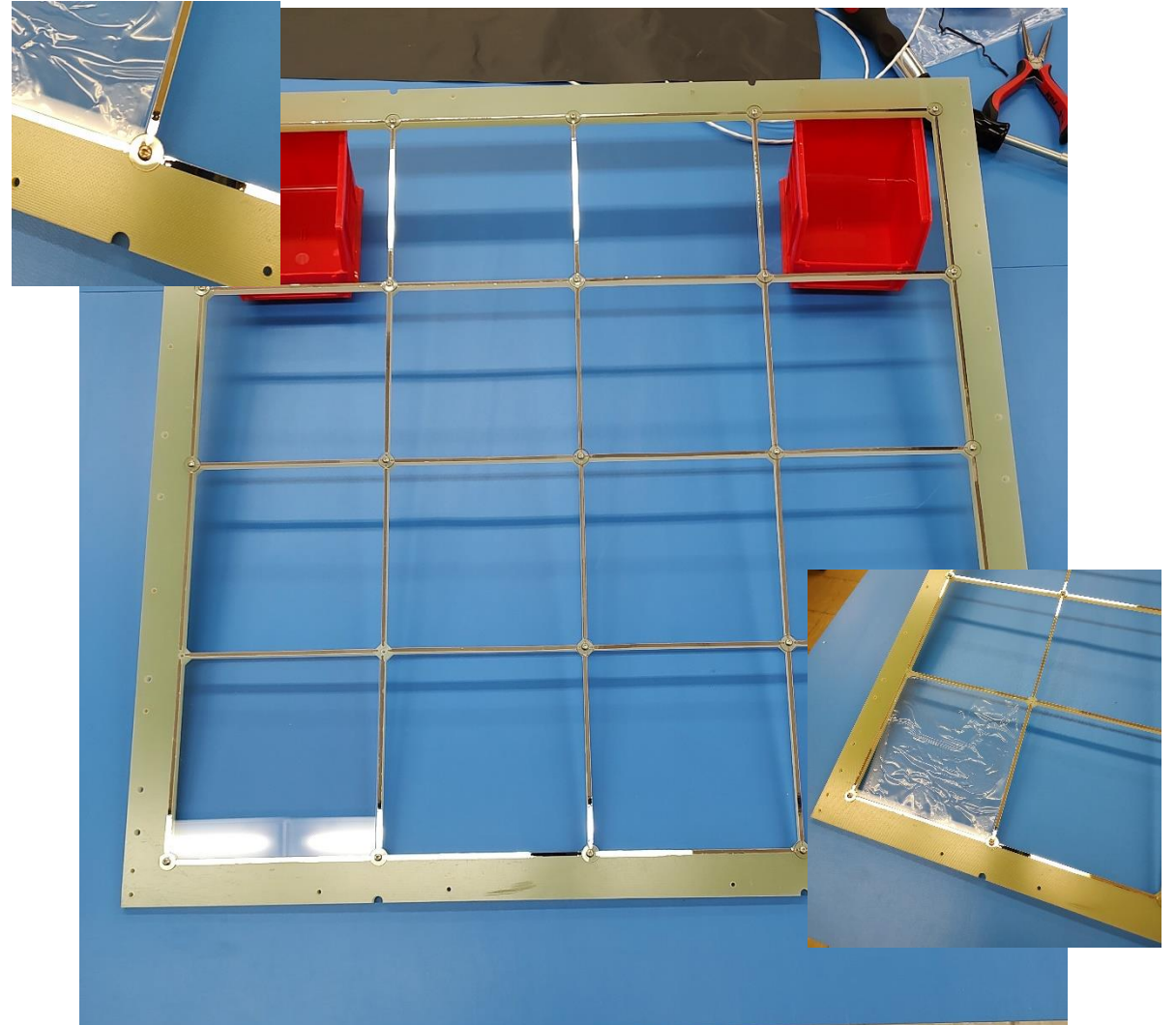
Module Core Subassembly

- The module core is built around WLS plate,
 - with copper clad G10 pieces for electrical shielding and stability
 - spring loaded SiPM backbone, perimeter board, pocket strips and SiPM flex circuits
 - Stainless steel C-channels and electronics box to hold cables and cold electronics
- Lessons learned:
 - Original design had the springs on standoffs that were screwed into the backbone with lockwashers - switched to using loctite to fix the standoffs in place (AA326 + SF7649 recommended by FD1 experience)
 - We Needed to add Vikuiti on the Flex Circuits between the SIPMs
 - Pocket strip with slot for resistors and capacitors on back of flex circuit needs to be modified for slightly different FBK flex
 - One instance the pins holding the WLS plate were bent during shipping: solution is to increase diameter of pins and improve packing by add foam edge protectors
- It is efficient to assemble two or more XARAPUCA at a time



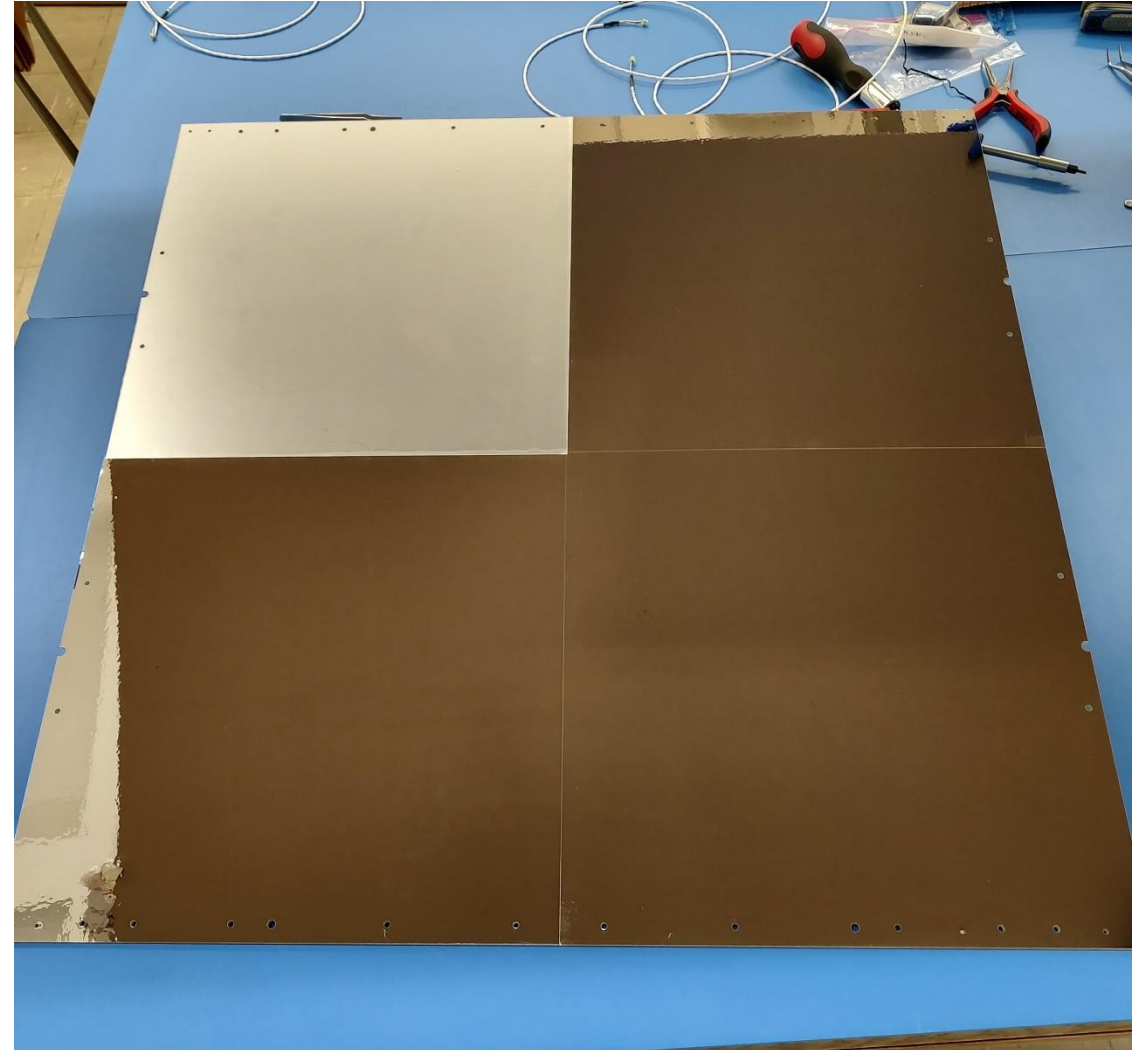
Dichroic Filter Frame

- For Module 0 XARAPUCAs Vikuiti strips were applied to the ribs of the filter frames
- Since Dichroic filters were not available we installed glass blanks in some of the XA to familiarize ourselves with filter installation and to test shipping.
- Most of the XA had screws and washers installed at the corners of the windows to make sure all the holes were threaded correctly
- Lessons Learned:
 - The Dichroic are very fragile it is best to install as late in the assembly process and after testing other components



Membrane Mount XA Backplane

- For Membrane mounted XARAPUCAS there is a solid backplane on one side instead of filter frame
- This needs to be covered by Vikuiti to increase reflectivity and PDE
- This is currently made out of four separate Vikuiti pieces
- Lessons learned:
 - We had some problems with the Vikuiti delaminating after emersion in liquid Argon
 - Possibly causes are:
 - Large pieces in which on part cools and contracts before the rest
 - Slight overlap between the four pieces
 - Presence of air bubbles
 - Possible procedural issues:
 - frost forming when extracting the module due to inadequate warm-up
 - Too fast cooling down
 - We have a number of ideas for long term solutions:
 - vacuum laminating
 - Reducing the overlap between the pieces



Fabrication and QC Plans for FD2

- For Cathode Mounted modules:
 - All parts converge at assembly facility (NIU):
 - This includes: frames and other G10 parts, WLS plates, Flex circuits, cables, electronics boxes, cold electronics boards
 - Module Core with electronics box will be assembled and tested warm:
 - At NIU we are building a testing stand that will:
 - use a combination of warm and cold electronics already available (DCEM)
 - Will initialize use off the shelf digitizing electronics like oscilloscopes
 - May eventually use DAPHNE V3
 - This validates the SiPMs, Flex Circuits, and cables
 - After warm testing the cold electronics board will be installed in the electronics box and cold tested in cryogenic conditions
 - Tests performed with
 - Cold electronics will be tested before installation in electronics box
 - – this validates the SiPMs, WLS and cabling
 - Frames are prepared with Vikuiti and shipped separately



Fabrication and QC Plans for FD2 (cont.)

- For the Membrane Mount XARAPUCA modules:
 - They will be assembled, warm and cold tested at CIEMAT
 - An additional assembly site may be set up in Italy
 - The backplane would be covered with Vikuiti and can be shipped with the Module core (or separately)
- Final assembly of frames with dichroic filters to be done inside a clean room at SURF just before installation

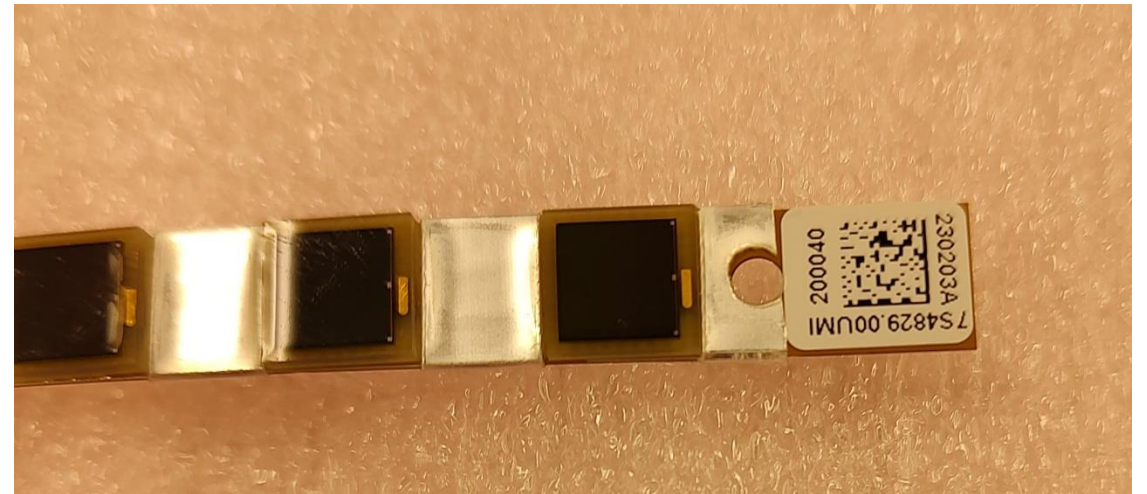
Conclusions

- Coldbox runs gave invaluable feedback for design iteration
- ProtoDune 2 Module 0 gave invaluable experience with assembling many XArapucas with real installation issues
- Plans for DUNE:
 - Module Core with cold electronics will be fully assembled and warm tested and cold tested before shipping to SURF
 - Membrane Mount Back Panels and Frames without Dichroic Filters will be prepared with Vikuiti before shipping to SURF
 - Final assembly with Dichroic filters will be completed at SURF

Backup Slides...

Flex circuits

- Flex circuits
- add vikuiti with laser cut sticker to wrap around flex circuit
- slightly different size of FBK SIPMS required a different sticker
- may need to make a new pocket strip to FBK flexi's because R and C do not align



WLS Retaining Pins

- WLS has slots in the center of each side this is held in place by 2mm pins
- during shipping one of the XARAPUCA (M6) experienced an impact in the that caused the fake WLS to shift enough to cause the pins to bend
- going forward we will add foam edge protectors when packing and
- switch to larger diameter pins

