RICH-II January 2022 Update

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Detector Support Group
January 25, 2022

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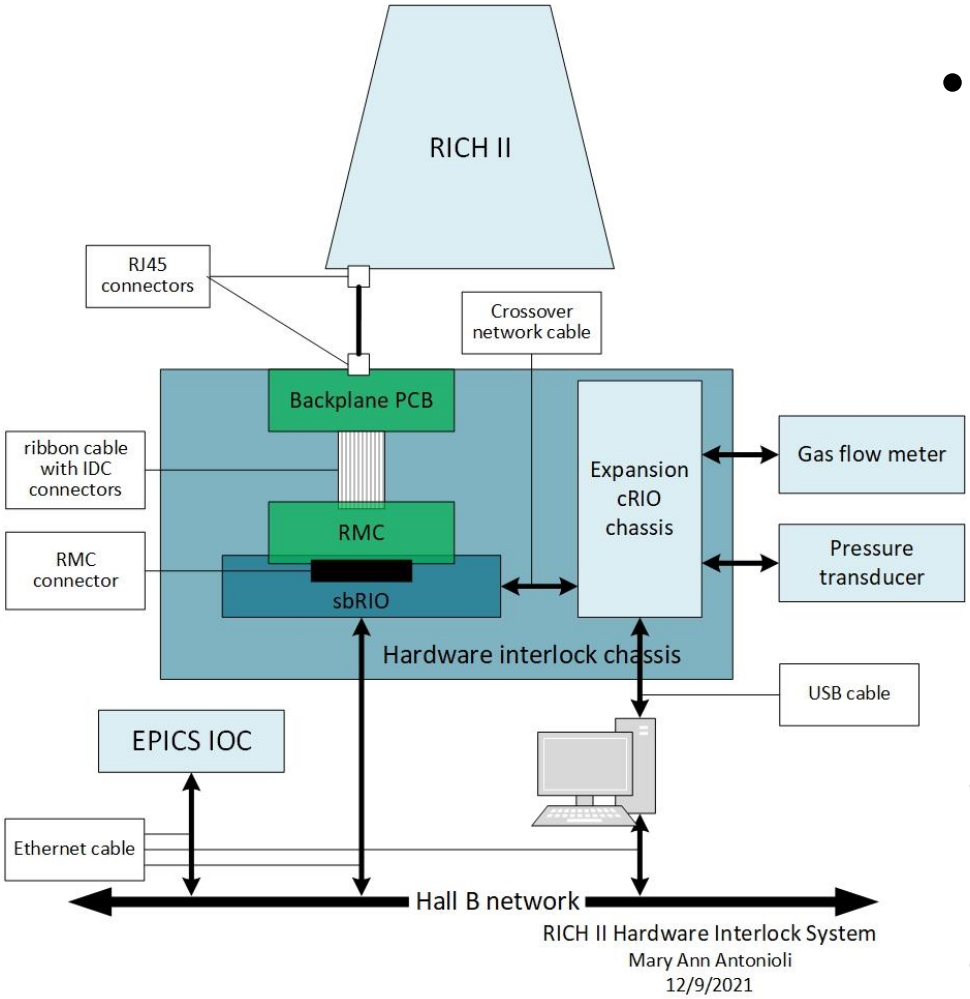
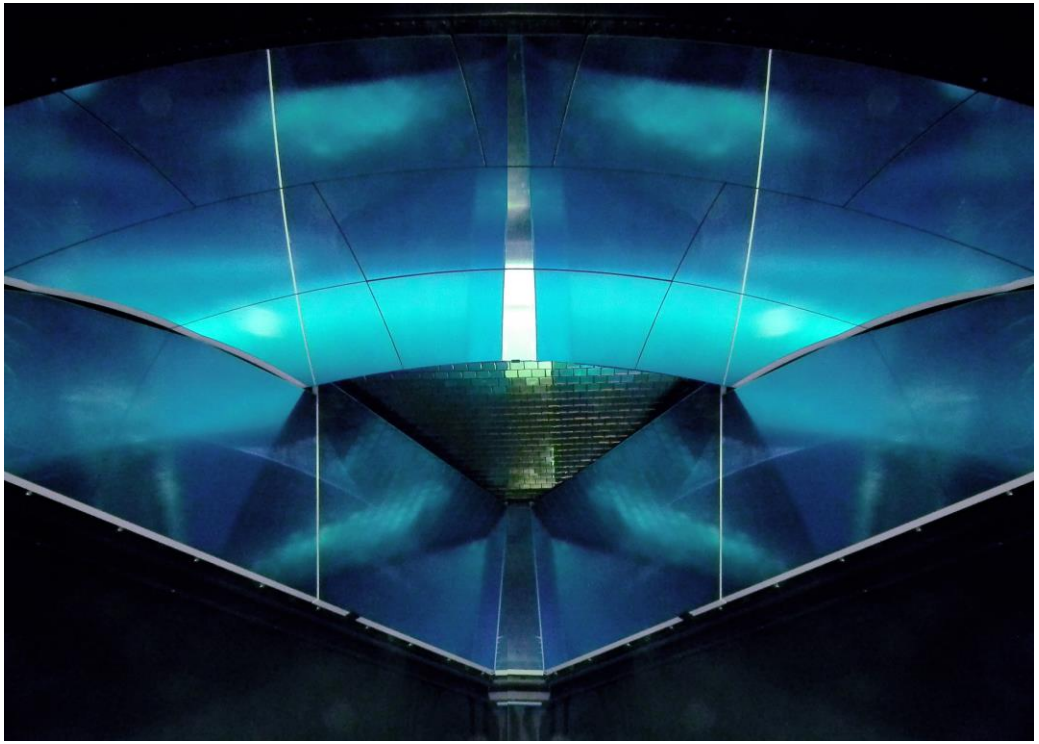


- RICH-II Monitoring
  - Electronic Panel monitoring
  - Nitrogen Volume monitoring

    Temperature
    Humidity
    Cooling airflow
    Cooling system air pressure
    Nitrogen flow
- Detector shell assembly
- Estimated Schedule for Installation

Overview

- RICH has two distinct areas that need to be monitored
  - Electronic panel
  - Nitrogen volume
- Main parameters that are monitored:
  - Temperature
  - Humidity
  - Cooling airflow
  - Cooling system air pressure
  - Nitrogen flow
- If any parameter goes out of bounds, interlock system will either trigger an alarm or toggle a relay to disable RICH-II's CAEN power supply

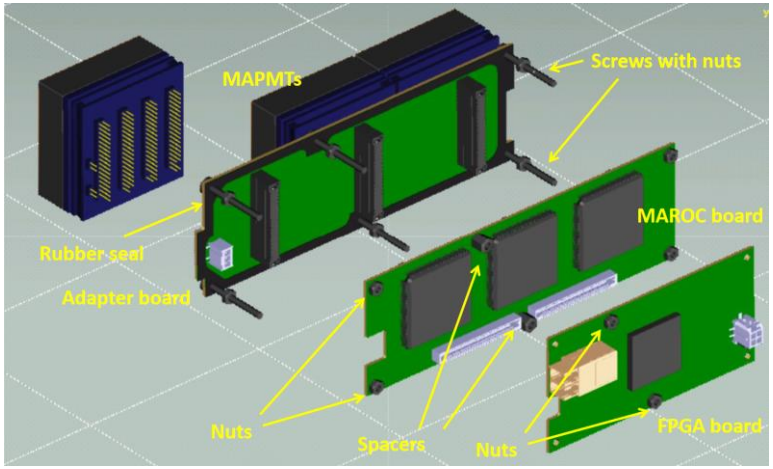


Interior of assembled RICH-1. Photo shows MAPMT array (center), spherical mirror array (top), and planar mirrors (sides).

Electronic Panel Monitoring

- Area that houses all electronic readout boards
  - 391 multi-anode photomultiplier tubes (MAPMTs)
  - 138 MAPMT Readout Chip (MAROC) boards
    - two or three PMTs per adapter board
  - 138 PMT readout boards
  - 138 FPGA boards
- Critical that FGPA temperatures in area stays under 80° C
- Cooled via airflow provided by Atlas Copco compressors

Back of electronic panel with PMT readout boards, FPGAs, and cabling. **When installed in detector, there is a cover over this portion**.

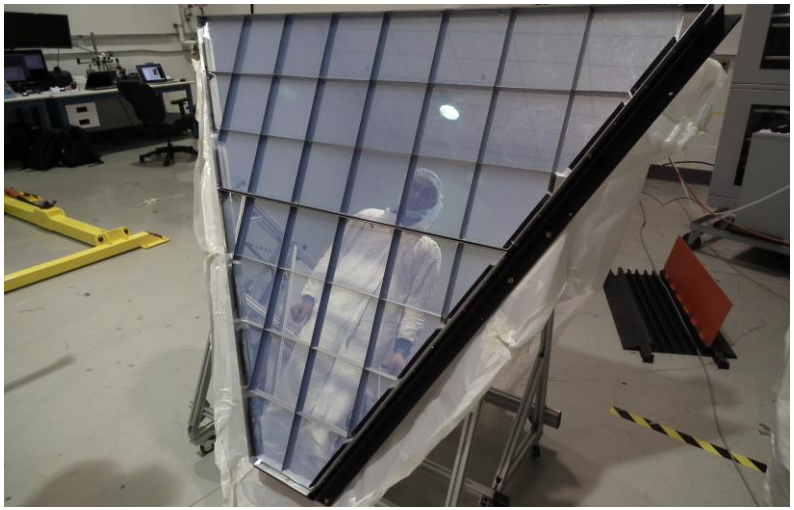


Left: 3D model of electronic boards stack. In stack, electronic panel would go between adapter board and MAROC board.

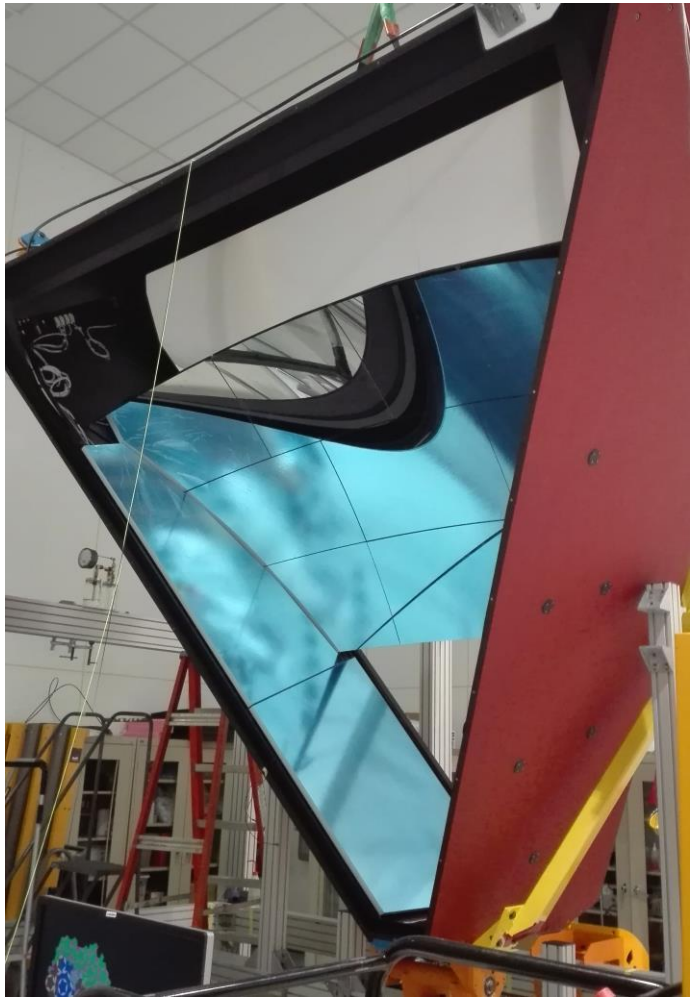
Right: Front of electronic panel showing the 391 MAPMTs.

Nitrogen Volume Monitoring

- Large area that houses aerogel, planar mirrors, and spherical mirrors
  - 134 aerogel tiles
  - Ten spherical mirrors
  - Seven planar mirrors
- Critical that humidity in area stays as low as possible to prevent aerogel from absorbing moisture out of the environment



Layer of 2-cm thick aerogel tiles in front of planar mirror on front panel of detector shell during assembly of the first RICH sector.



Spherical mirrors and planar mirrors in nitrogen volume during assembly of first RICH sector.

Sensirion SHT35 Sensor

- New Sensirion SHT35 sensors selected for monitoring temperature & humidity
  - Better temperature and humidity accuracy than previously used sensors

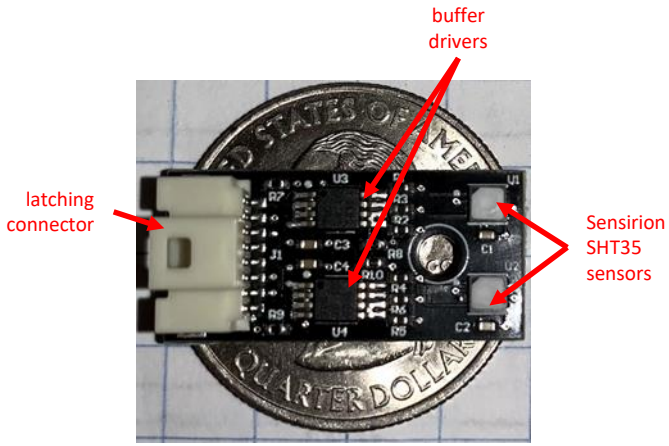
- Custom PCB **designed by DSG** to hold two SHT35 sensors, two buffer drivers, two sets of pull-up resistors, and a latching connector

	Parameter	Specification
Humidity	Accuracy	±1.5% RH
	Long-term drift	<0.25% RH/year
	Operating range	0–100% RH
	Resolution	0.01% RH
	Repeatability	0.08% RH
Temperature	Accuracy	±0.1°C
	Long-term drift	< 0.03 °C/year
	Operating range	–40 to 125 °C[1]
	Resolution	0.01°C
	Repeatability	0.04 °C
Communication interface		I^2C

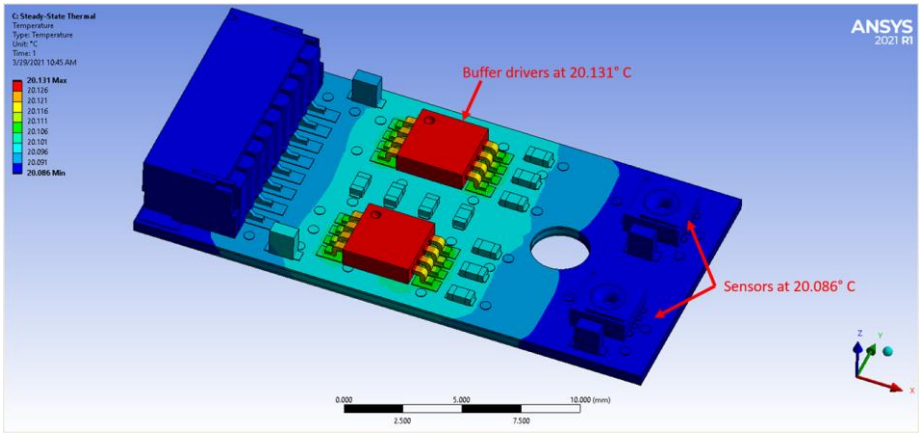
Previously used Honeywell humidity sensors have ±3.5% RH accuracy

Previously used Omega RTDs have ±0.15° C accuracy

SHT35 specifications
DSG Note 2020-28 by Peter Bonneau



SHT35 PCB with US Quarter behind it to emphasize the PCBs small size



PCB modeled in ANSYS to ensure that component power dissipation does not effect SHT35 sensors' temperature readout on PCB

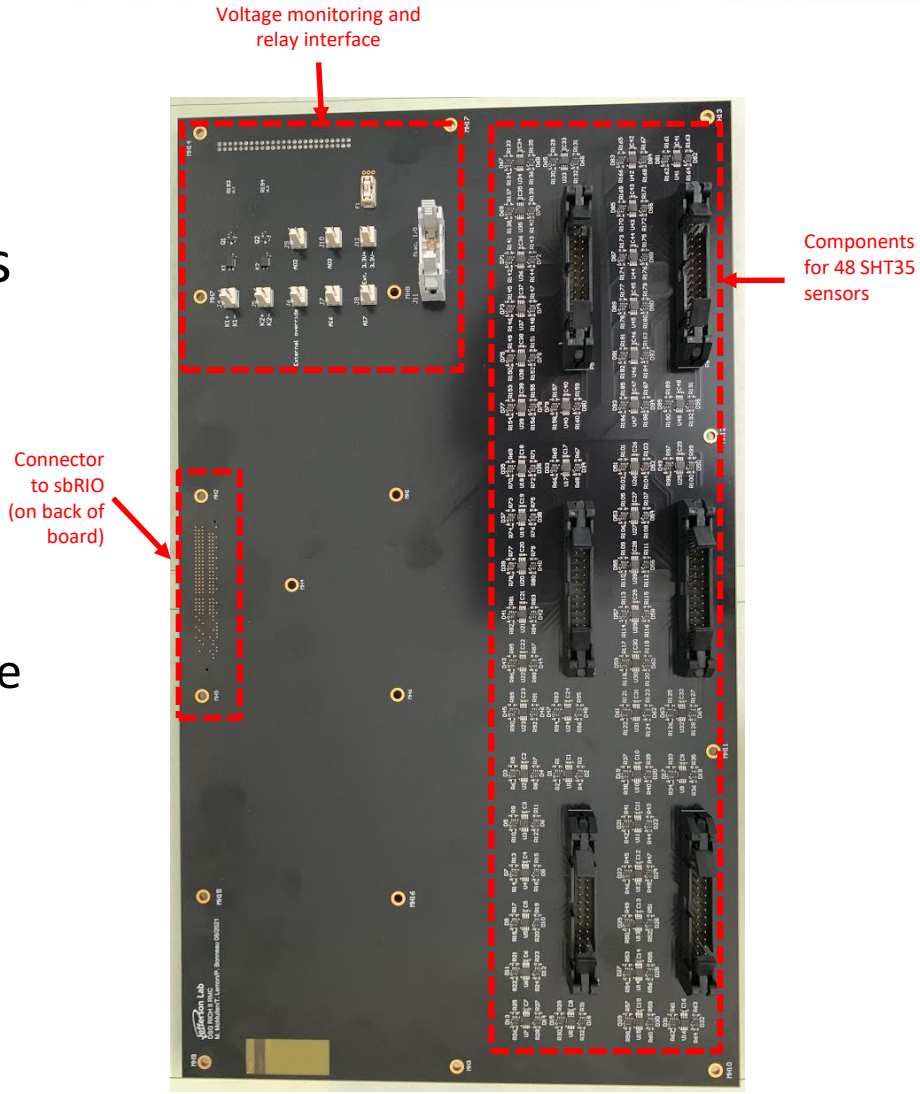
Single-Board RIO (sbRIO) Controller

- National Instruments sbRIO-9629 FPGA and Real-Time controller
  - FPGA portion will be used for I^2C communication to sensors
  - Real-Time portion will be used to process data, evaluate interlocks, and write data to EPICS
- Program for interlock system written in LabVIEW
- sbRIO can communicate to Hall B network over Ethernet
  - Users will be able to monitor system using EPICS screens
  - Experts will be able to monitor system using a LabVIEW remote interface

Photo of sbRIO-9629 from National Instruments

Reconfigurable Input/Output Mezzanine Card (RMC)

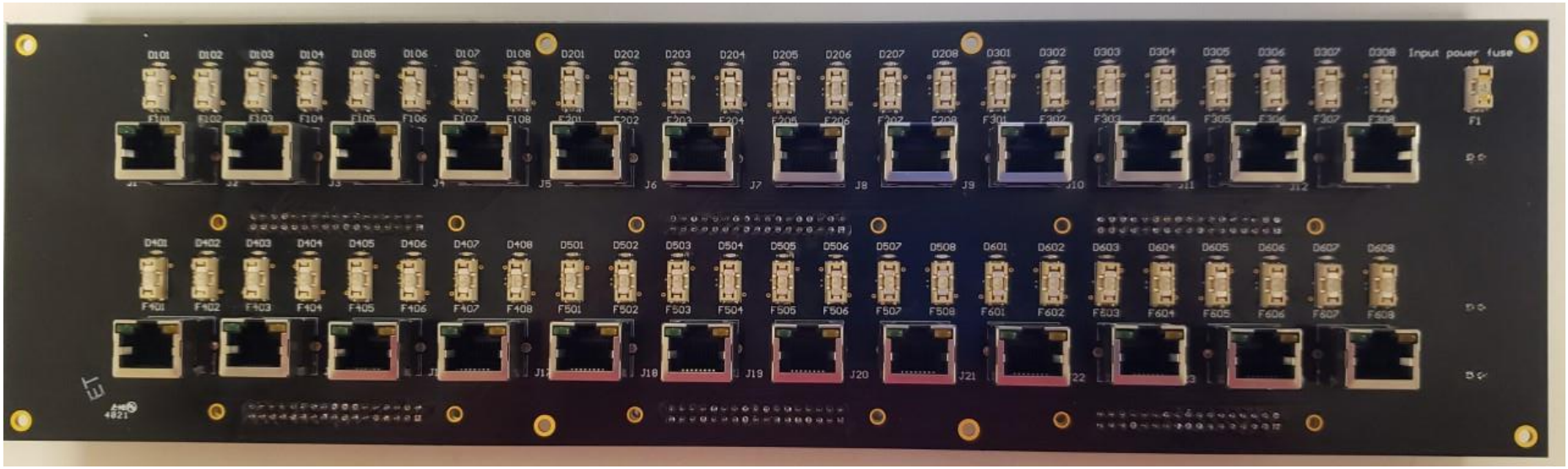
- **DSG-developed and designed**
- RMC's main purpose is to act as a hardware interface for I^2C components and sbRIO-9629
- Secondary functions:
  - Hardware interlock chassis voltage monitoring
    - Monitors external 3.3 V, sbRIO's 3.3 V, and sbRIO's 5 V power
  - Relay interface for interlocking RICH-II's CAEN power supply



Final production RMC

Backplane PCB

- **DSG-developed and designed**
- Purpose is to provide an interface from exterior cabling to RMC
  - IDC connectors for cables to RMC
  - 24 RJ-45 ports for connection to exterior I^2C cabling



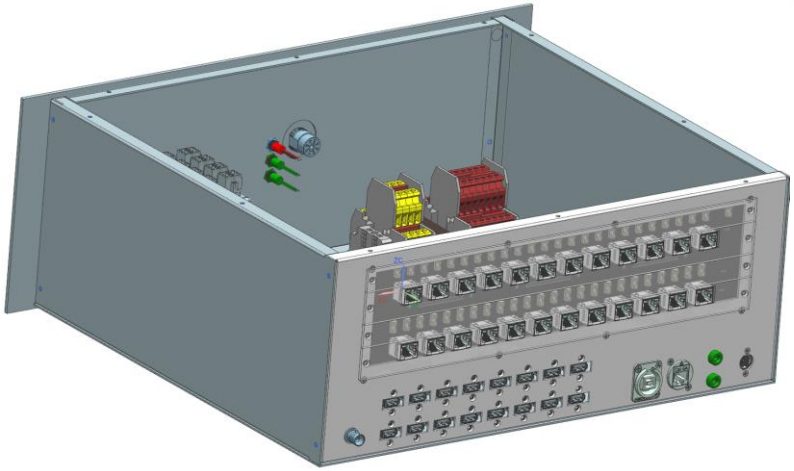
Backplane PCB

Gas System Monitoring with cRIO Expansion Chassis

- Gas system sensors monitored using a cRIO-9147 expansion chassis
- Measures airflow, air pressure, and nitrogen flow using isolated analog voltage and current inputs
- Communicates directly to sbRIO via a direct network connection
  - Does not rely on network connection
  - Only sbRIO can read from expansion cRIO over network
  - Experts can still connect to expansion cRIO with a local USB connection

Chassis Design – NX12 Design

- 4 U (7”) tall x 15” deep x 17” wide, rack mount chassis designed to house all hardware interlock system components
  - sbRIO
  - RMC
  - Backplane PCB
  - Power supply and distribution
  - Gas system sensor feedthroughs
  - Expansion cRIO chassis
- **Chassis fabrication complete**
  - Awaiting delivery of pins for PCB power connectors for chassis assembly



Rear, isometric view of chassis in NX12

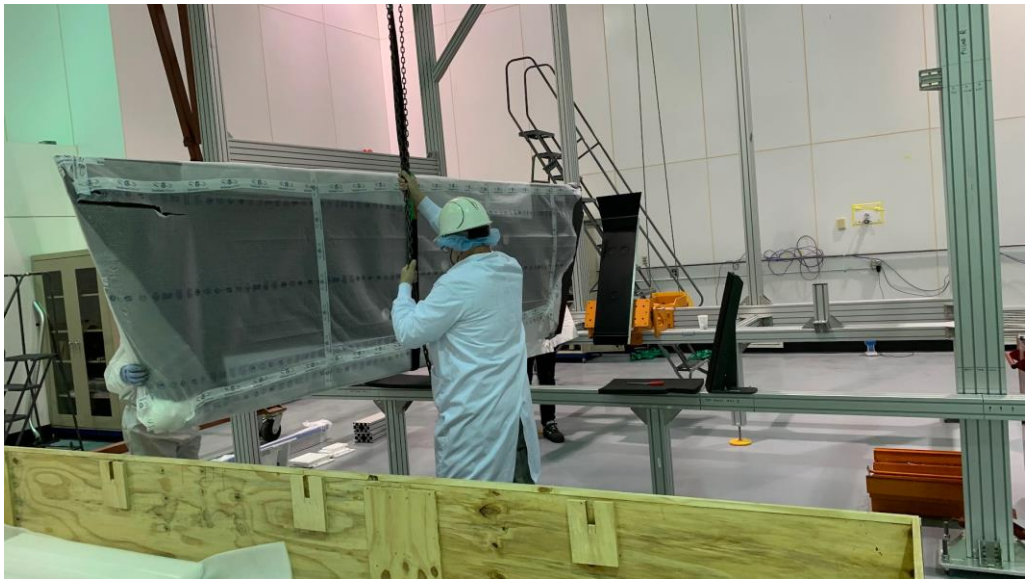
Rear view of empty chassis

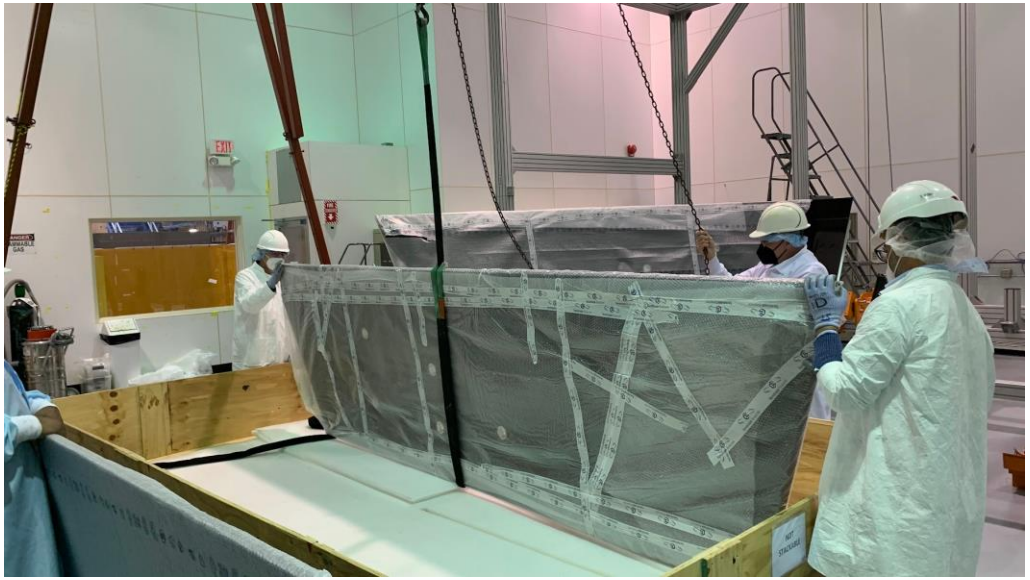
Detector Shell Assembly (as of January 24, 2022)

- January 18, 2022 RICH assembly is started at the EEL clean room
- INFN collaborators on-site
  - Marco Mirazita, Dario Orecchini, and Sandro Tomassini

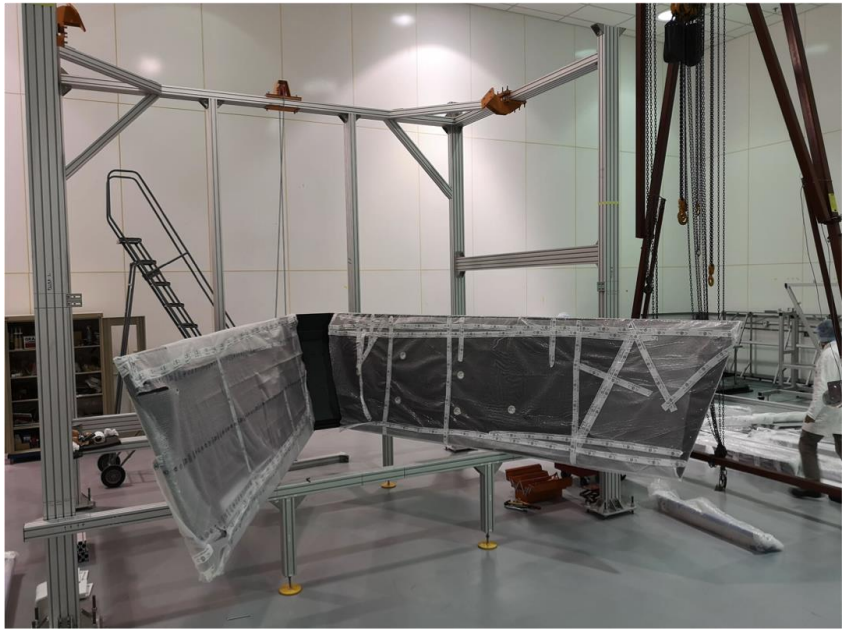
- Crate Unpacking

Using Gantry Crane to Assemble Side Walls

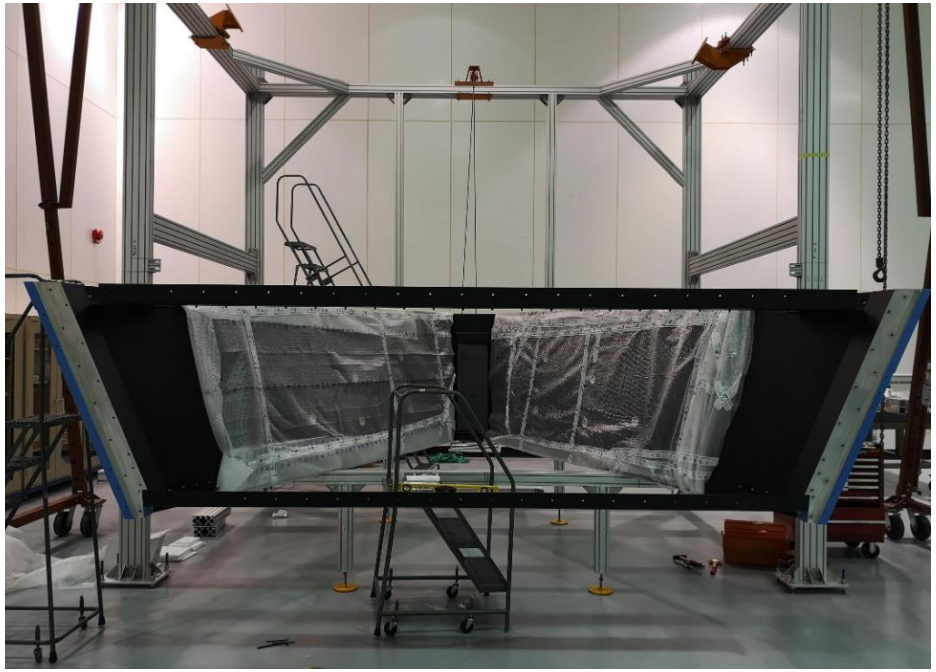




- George Jacobs operating gantry crane with Sandro Tomassini and Dario Orecchini guiding part during assembly of the side walls of detector shell

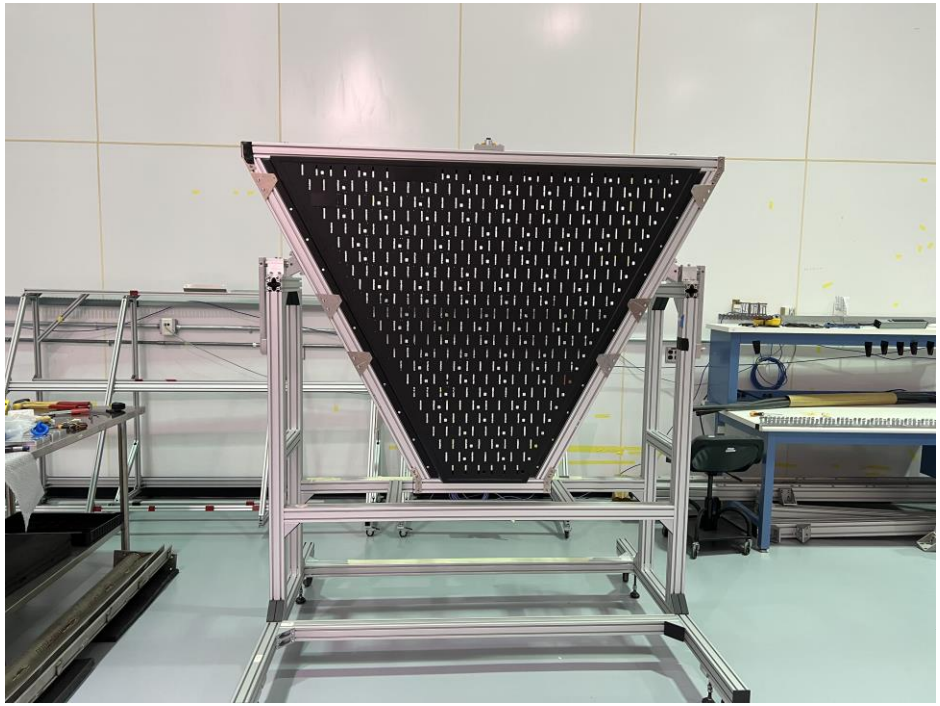


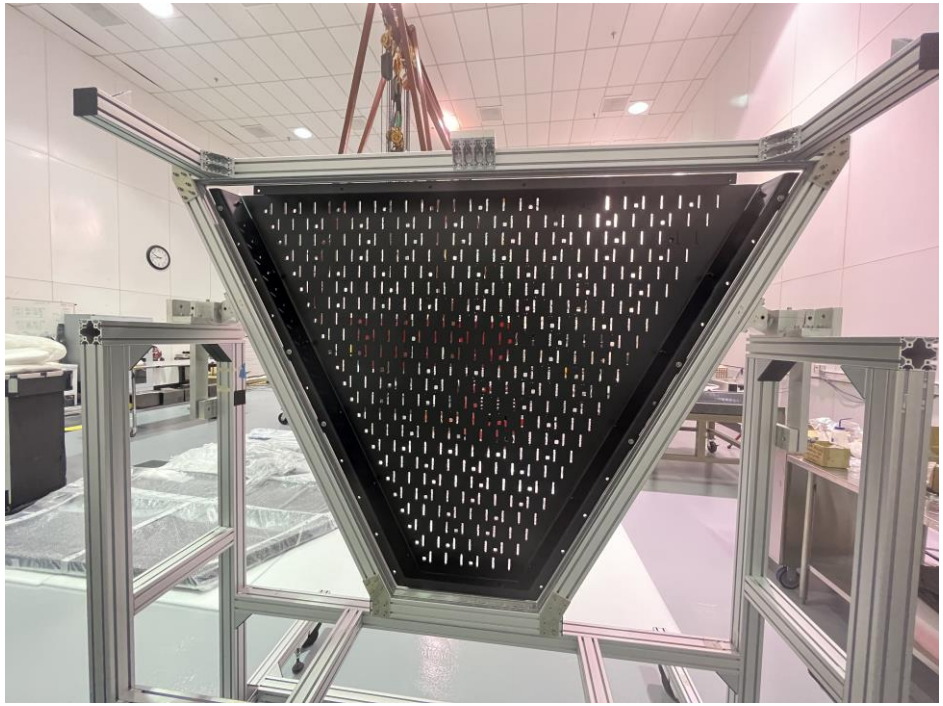
More on shell assembly



- Detector shell after cross-bar supports have been installed at rear of detector
- Rear panel installed onto detector shell

Electronic Panel

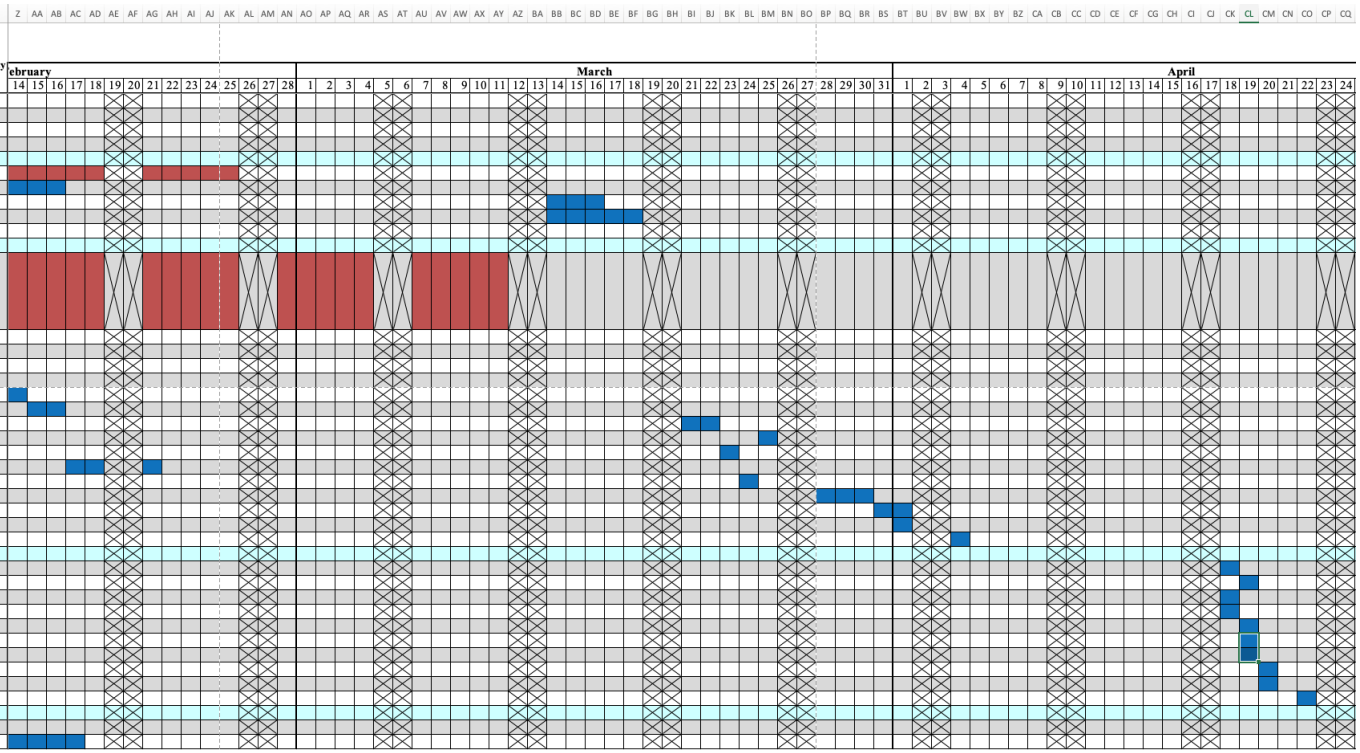




- Electronic panel is ready for the front-end readout boards installation

Task List with Estimated Duration

#	Task	Group	Estimated Duration (no time contingency added)
.3	Fabricate interior LV cables	Fast Electronics	5 days
.4	Fabricate interior HV cables	Fast Electronics	5 days
.5	Fabricate interior signal cables	Fast Electronics	5 days
.6	Fabricate gas system cabling	DSG	5 days
	Testing		
.1	Front end electronics characterization	Fast Electronics	25 days
.2	D0 measurements of spherical mirrors - pre-reflective coating	DSG	3 days
.3	D0 measurements of spherical mirrors - post-reflective coating	DSG	3 days
.4	Reflectivity testing of spherical mirrors	DSG	5 days
.5	Acceptance tests and verification of SHT35 sensor PCBs	DSG	5 days
	Detector Assembly		
.1	Assemble electronic panel	DSG	20 days
.1.1	├---- MAPMT adapter board installation		
.1.2	├---- MAPMT installation		
.1.3	├---- MAROC board installation		
.1.4	├---- FPGA installation		
.1.5	└---- EP cabling		
.2	Install hardware interlock sensors and cabling	DSG	1 day
.3	Set up nitrogen system in EEL	Hall B	1 day
.4	Set up air-cooling compressor in EEL	Hall B	1 day
.5	Install nitrogen supply lines	DSG	1 day
.6	Install cooling supply lines	DSG	1 day
.7	Install planar mirrors	DSG	2 days
.8	Install spherical mirrors	DSG	2 days
.9	Install electronic panel	DSG	1 day
.10	Align mirrors	DSG	1 day
.11	Assemble exit window	DSG	3 days
.12	Install exit window	DSG	1 day
.13	Install aerogel	DSG	3 days
.14	Leak check entire detector	DSG	2 days
.15	Gas seal entire detector	DSG	1 day
.16	Survey before installation	Survey Group	1 day
	Installation in Hall		
.1	Move detector to hall	Hall B	1 day
.2	Install detector on forward carriage	Hall B	1 day
.3	Move of air-cooling system to hall	Hall B	1 day
.4	Connection of detector to nitrogen supply	Hall B	1 day
.5	Install interlock chassis in rack	DSG	1 day
.6	Install DAQ crate in rack	Fast Electronics	1 day
.7	Install CAEN power suppy in racks	Fast Electronics	1 day
.8	Run cables from interlock chassis to detector	DSG	1 day
.9	Run cables from interlock chassis to gas system	DSG	1 day
.10	Survey after installation	Survey Group	1 day
	Documentation		
.1	Create wiring diagrams for interlock chassis	DSG	5 days
.2	Create sensor mapping diagram for interlock system	DSG	5 days



- In red items that we do not have very well defined time estimates
- As a short summary: it looks like without any time contingencies, we would be able to finish everything around the start of May 2022.
- Disclaimer: the spherical mirrors are a critical point in the schedule. We made the assumption that we'll be able to test all of the mirrors before they get their reflective coating in mid-February 2022 and then receive the final, coated mirrors in mid-March 2022. The schedule for when we receive the final mirrors has the largest potential to delay completion of detector assembly.

Conclusion

- DSG is developing and designing a hardware interlock system for monitoring RICH-II parameters
  - SHT35 sensors read by an sbRIO for humidity and temperature in electronic panel and nitrogen volume
    - Custom sensor PCB, RMC, and backplane PCB designed by DSG to read sensors
  - A cRIO expansion chassis monitors gas system cooling airflow, cooling system air pressure, and nitrogen flow
- All components will be housed in a custom chassis
- Detector assembly underway with INFN collaborators