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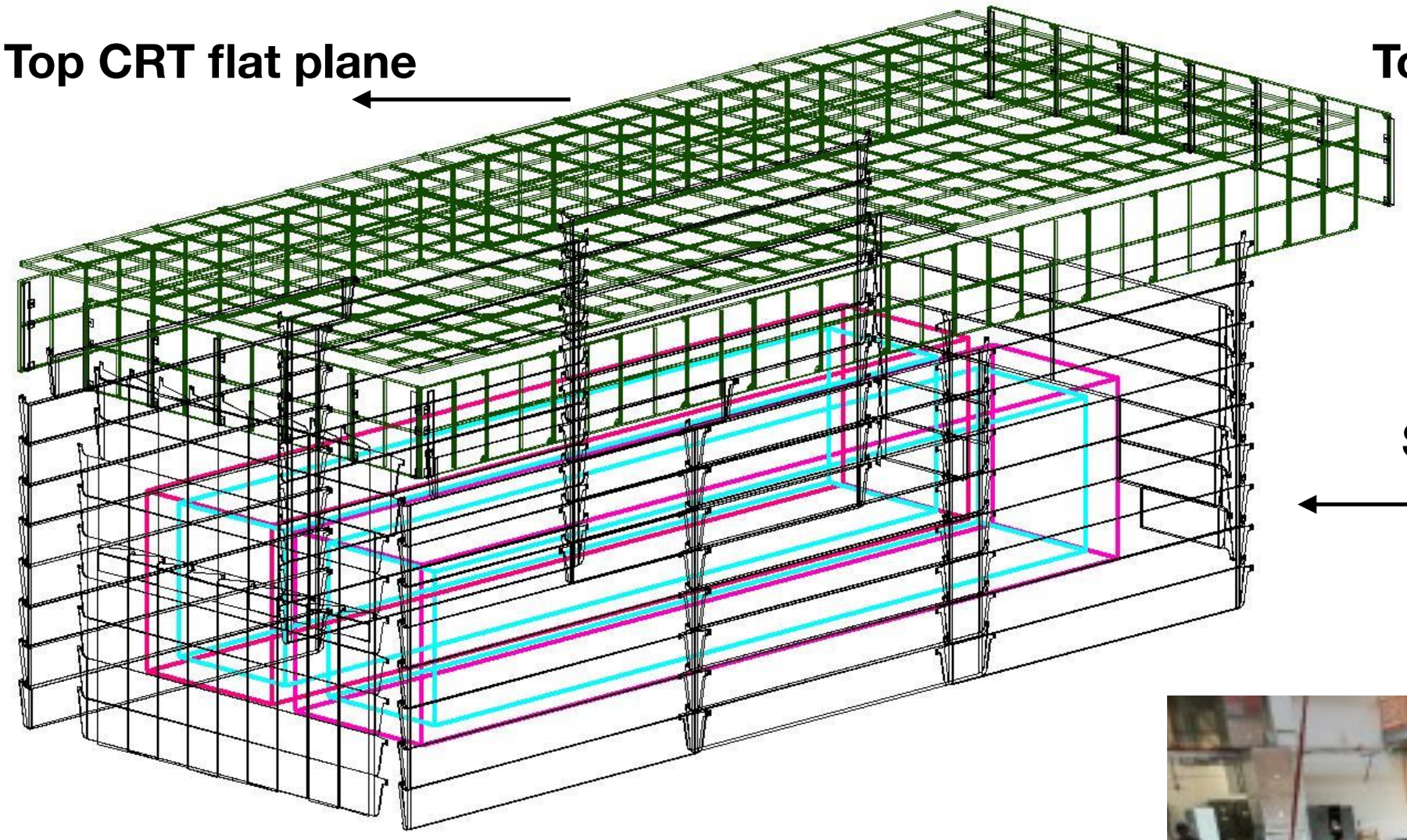
Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

ICARUS CRT

Minerba Betancourt and Umut Kose on behalf of the CRT group

September 12, 2019

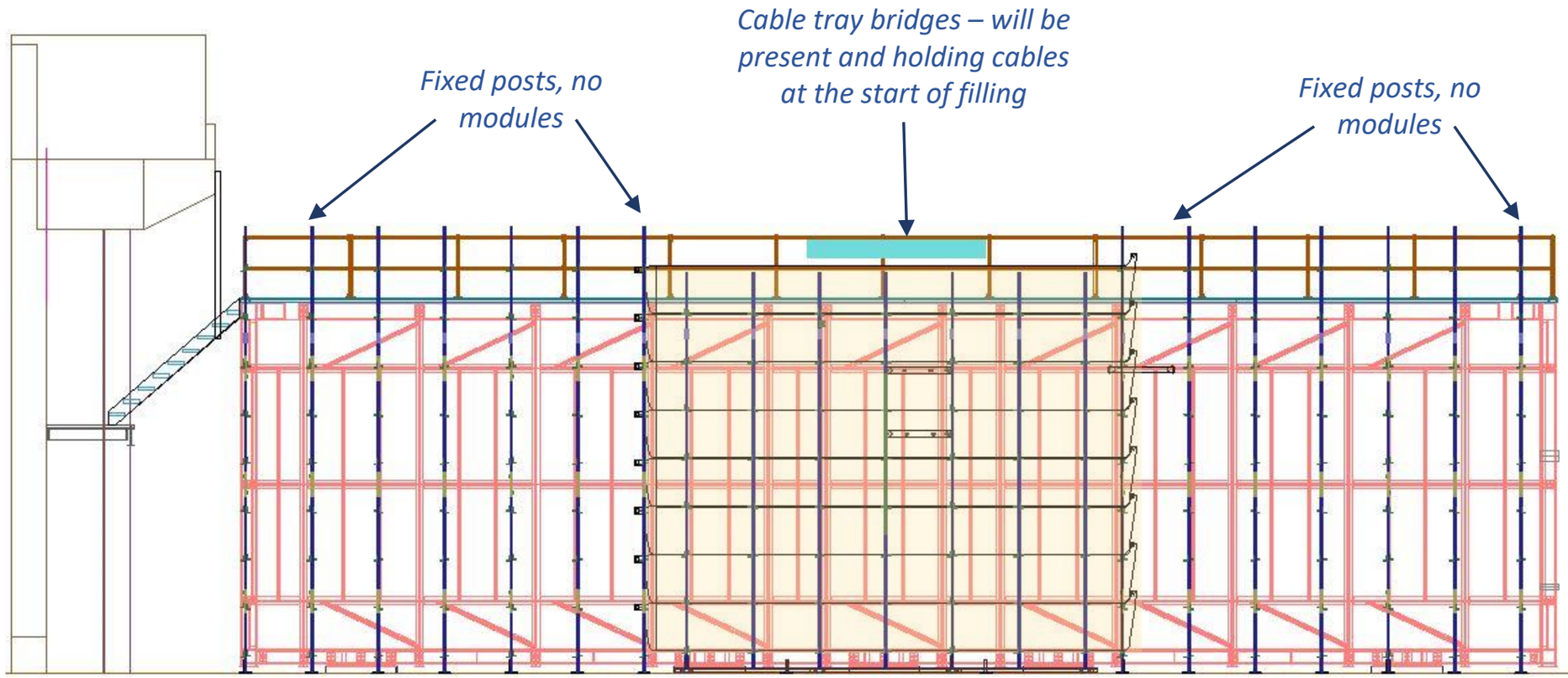
Overview of the ICARUS CRT



Bottom CRT planes: installed and tested
Setting the DAQ interface

Modules at the West and East Sides

- Working on getting support structures installed
- Remaining side CRT is going to be installed after the cold commissioning is completed



Rolling posts and modules

Supports

Drawing courtesy of Cat

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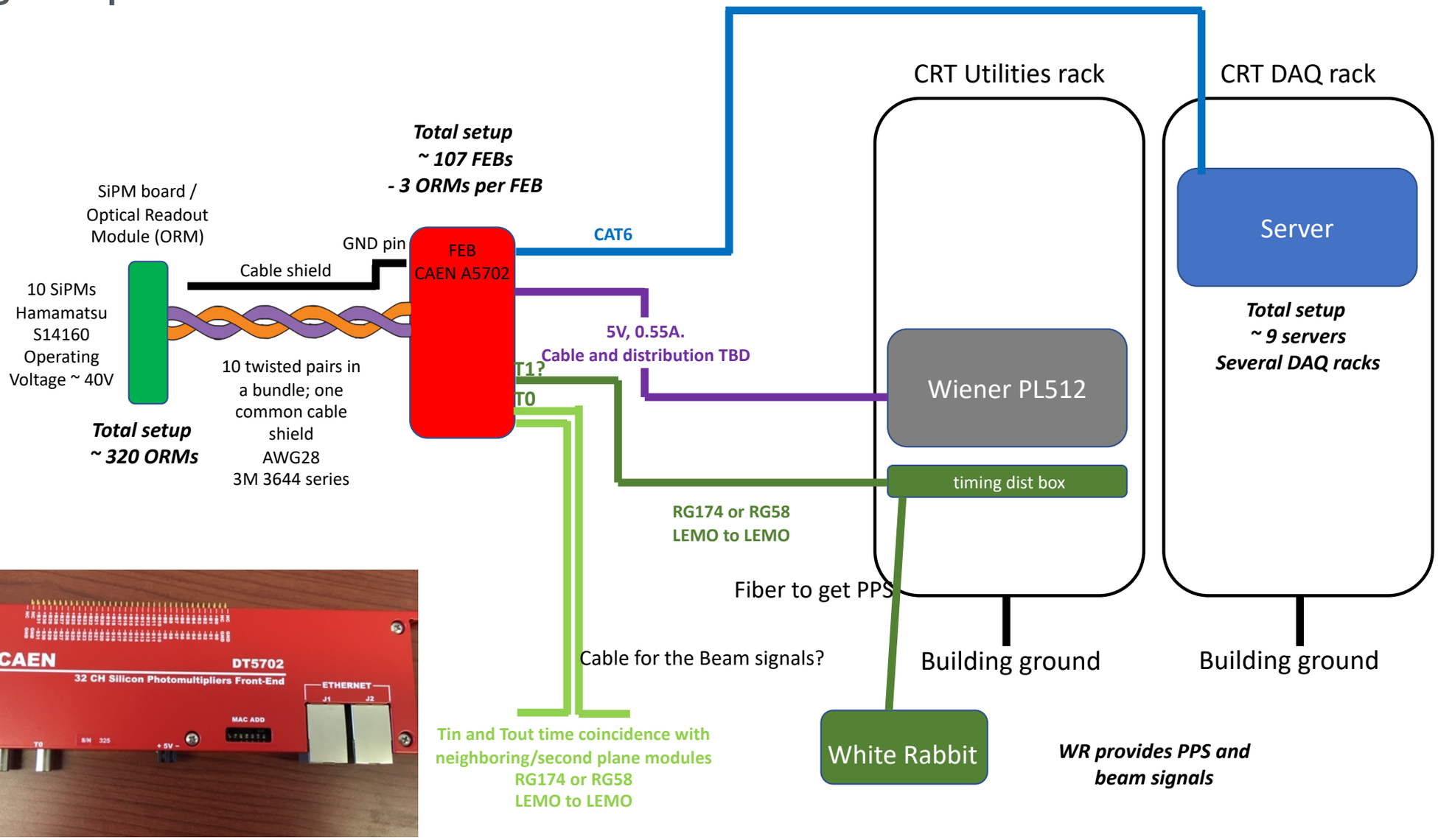
Schematic

- Preparing the utility rack, several components on site Fermilab (FEB, optical readout, timing distribution and servers)
  - Power supplied is scheduled for delivery in a couple of weeks
  - Testing the power distribution



We received 40 FEBs from Marzio for the side CRT

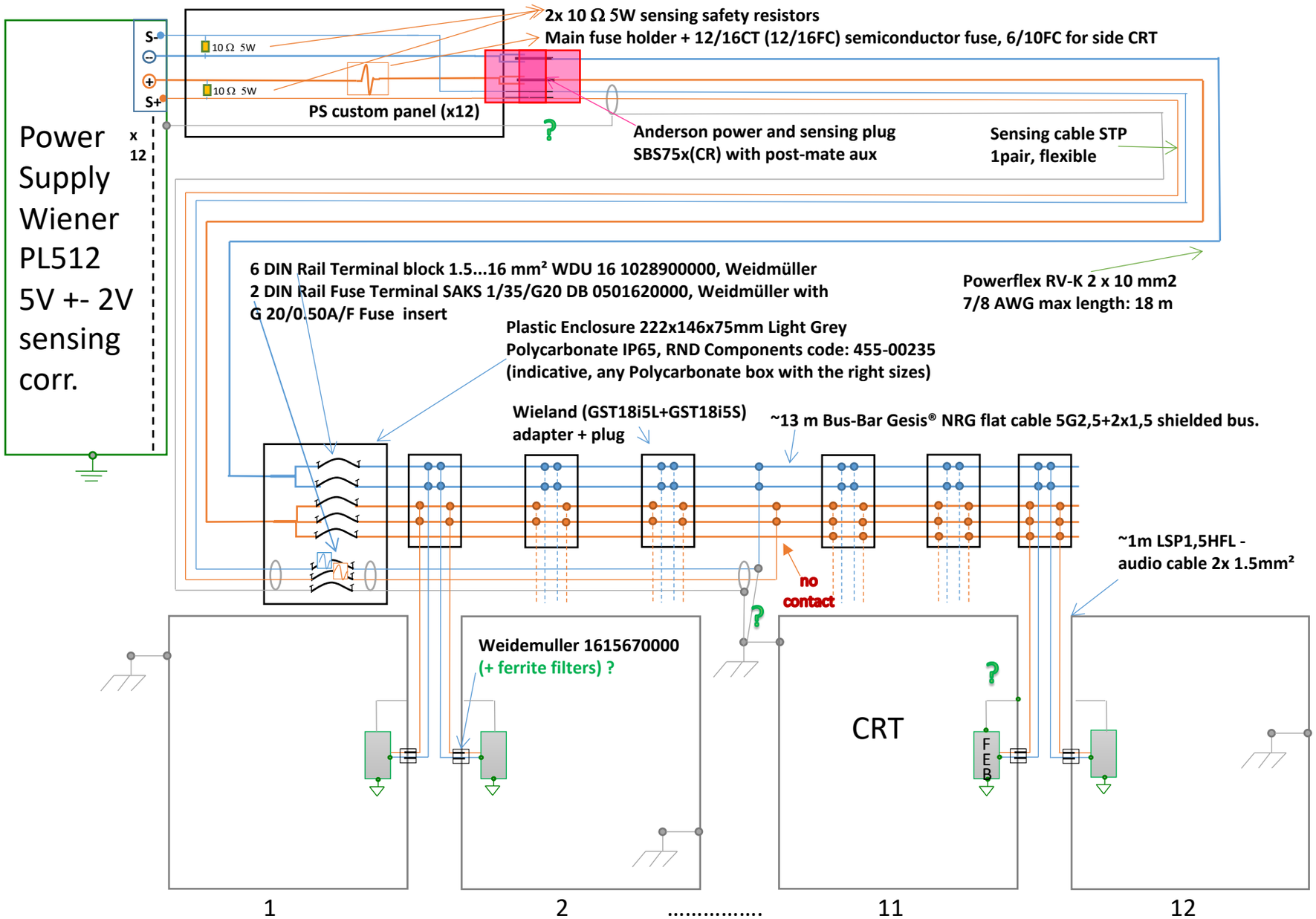
Power Distribution

Umut and Mihai

- Design criteria:
  - Minimal line & circuit power drop
    - Full power supply sensing compensation
    - Ripple/noise reduction
  - Minimal voltage spread
    - To keep all the FEBs within the working voltage (5.1 V)
  - Reliability
    - Long term operation
    - Safety
    - Easy access and troubleshooting
  - Uniform distribution
    - Balanced load
    - Easy replacement
    - Note: since the top CRT will have maximum load (12 FeBs/line, twice the side system) the layout was optimized accordingly. Using the same cabling for the side is straightforward, since derivations are similar for CRT pairs or single

Power distribution box, PDB, will be prepared both for side and top CRT systems

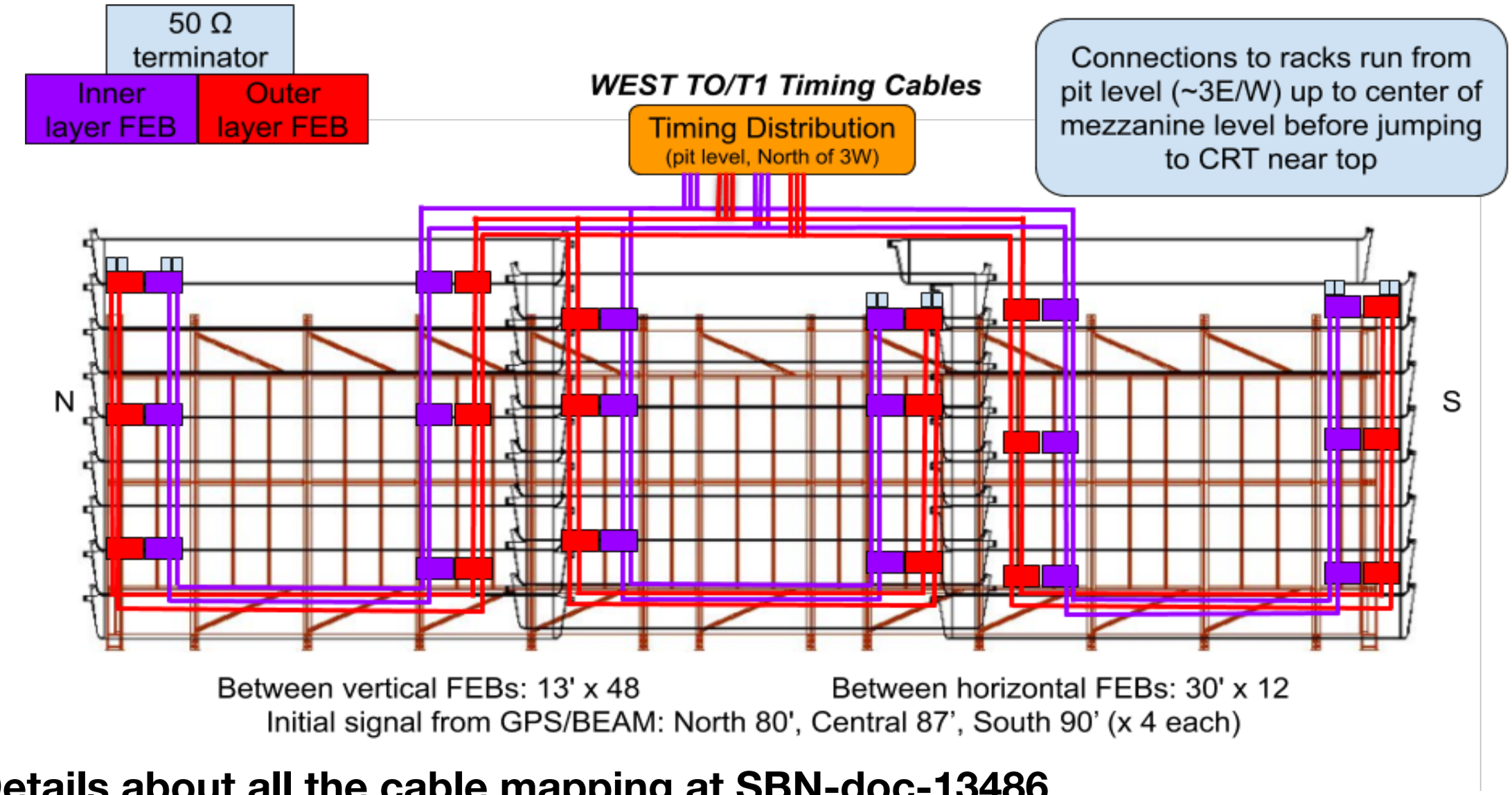
Single power line layout



- **Power distribution line and box are designed and materials identified**
- **A simple simulation with SPICE has been performed.**
- **Voltage drop test has been performed: all the measured voltage drops found to be within estimated range.**
- **Couples of power distribution box in preparation for final test.**

Cable Mapping for the side CRT

- We have all the cable mapping for the side CRT ready for installation
  - Cables for servers, T0 and T1



Details about all the cable mapping at SBN-doc-13486

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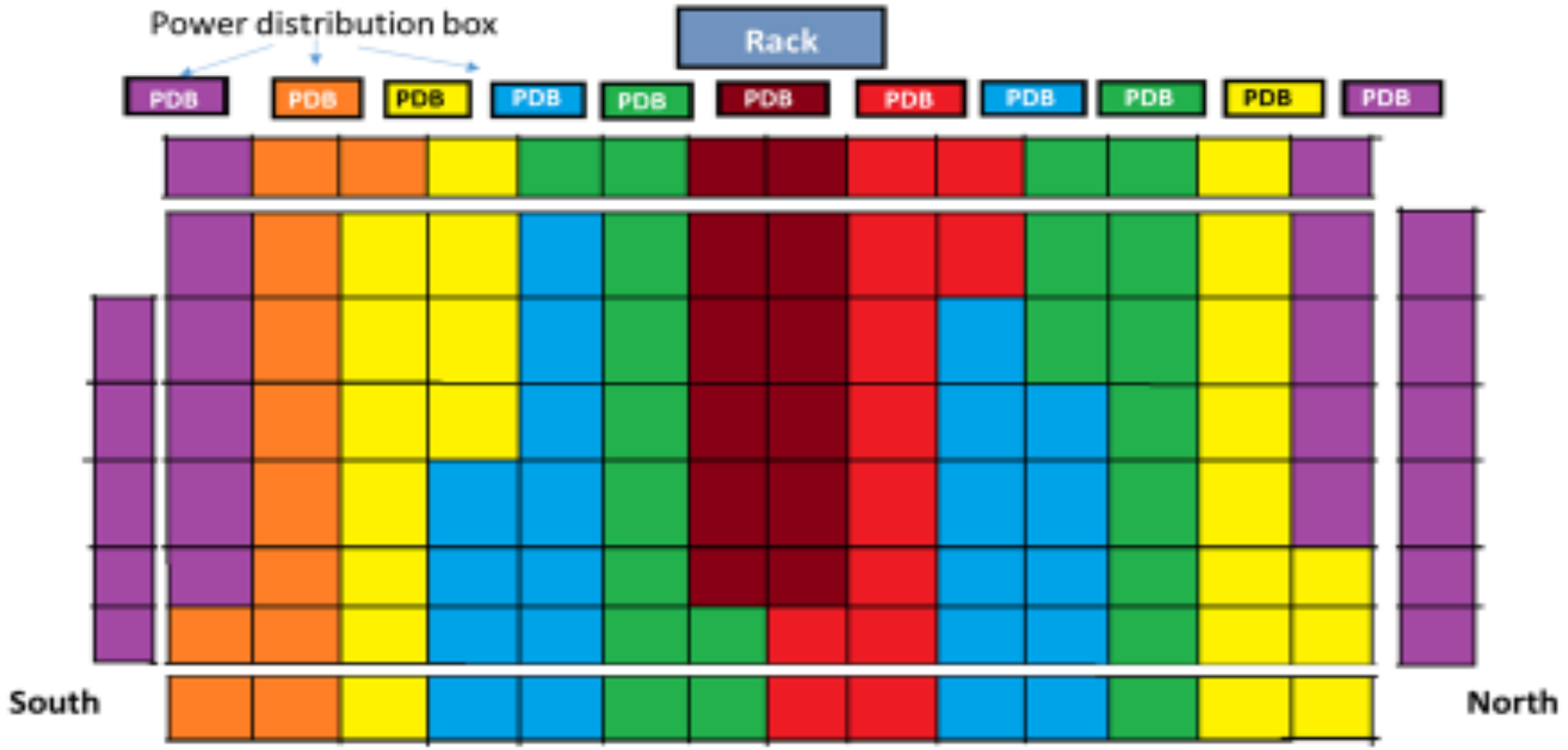
Top CRT grouping

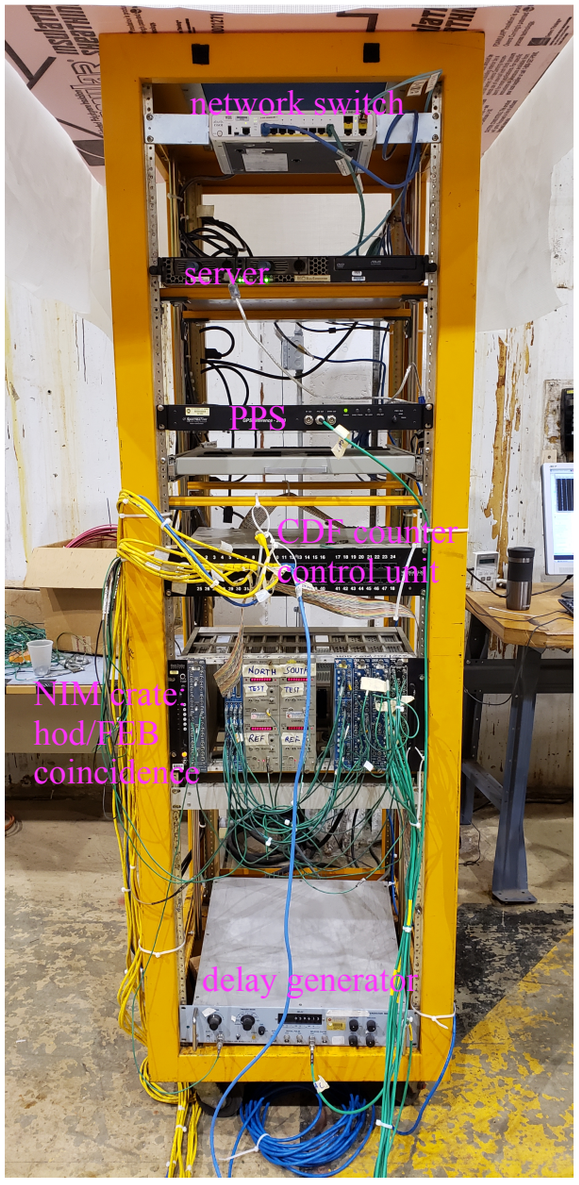


- 11 lines (+ 1 spare)
- max 12 CRT/line
- shortest cables for the chains of 12
- small load spread (9 x 11 + 2 x 12), compensated by the cables
- relatively straight cable paths

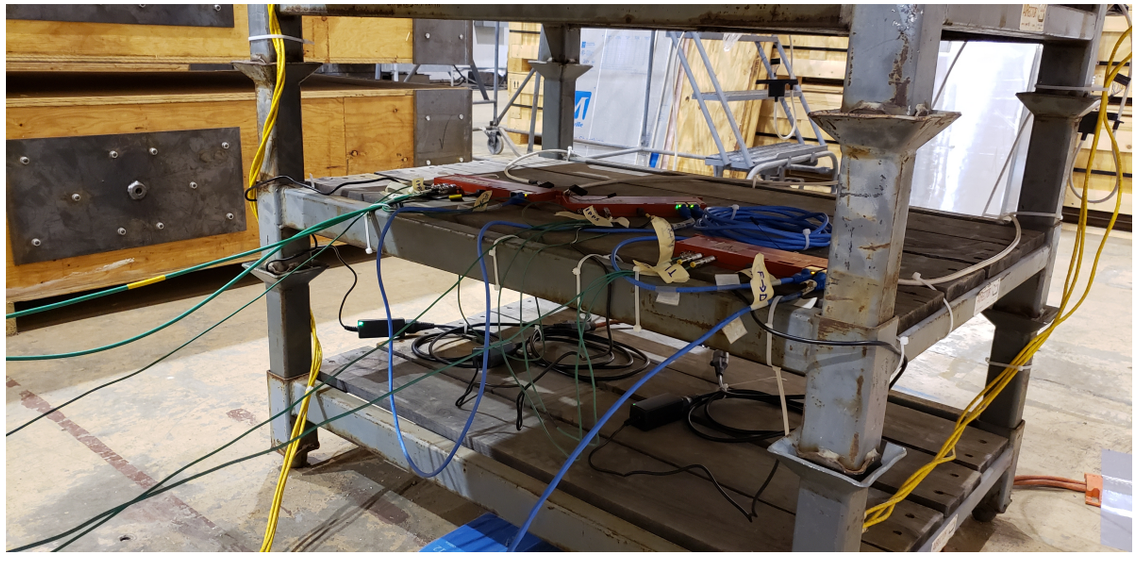
Test Stand at Fermilab

Chris, Tyler, et al.

- Setup a test stand at Fermilab to test the optical readouts and efficiency measurements



- Setup contains six FEBs



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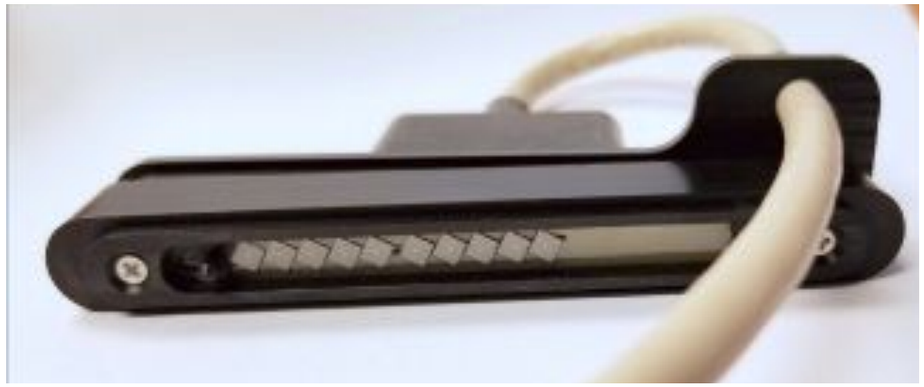
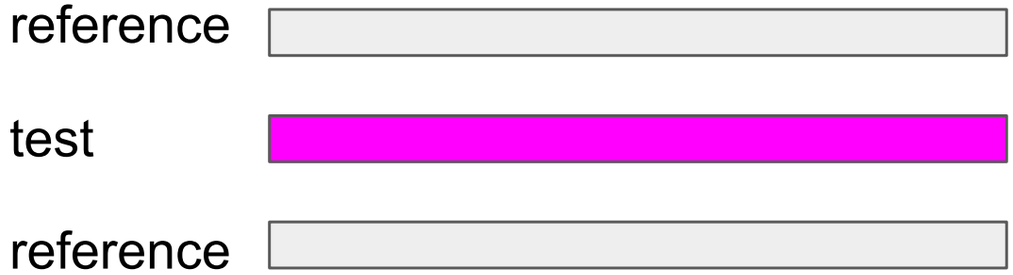
Optical Readout Testing at Fermilab

Chris, Tyler, et al.

- Test stand at Fermilab has three modules in a stack, with one ORM at each end (North/South) connected to its own Front-End Board (FEB)





- Two ORMs are tested at at time on the middle module, top and bottom modules have the same form ORMs on them for all runs
- Two tests are run: one to obtain ADC/PE conversion, as well as check for spurious noise, another to obtain light yield at 4 meter along the module

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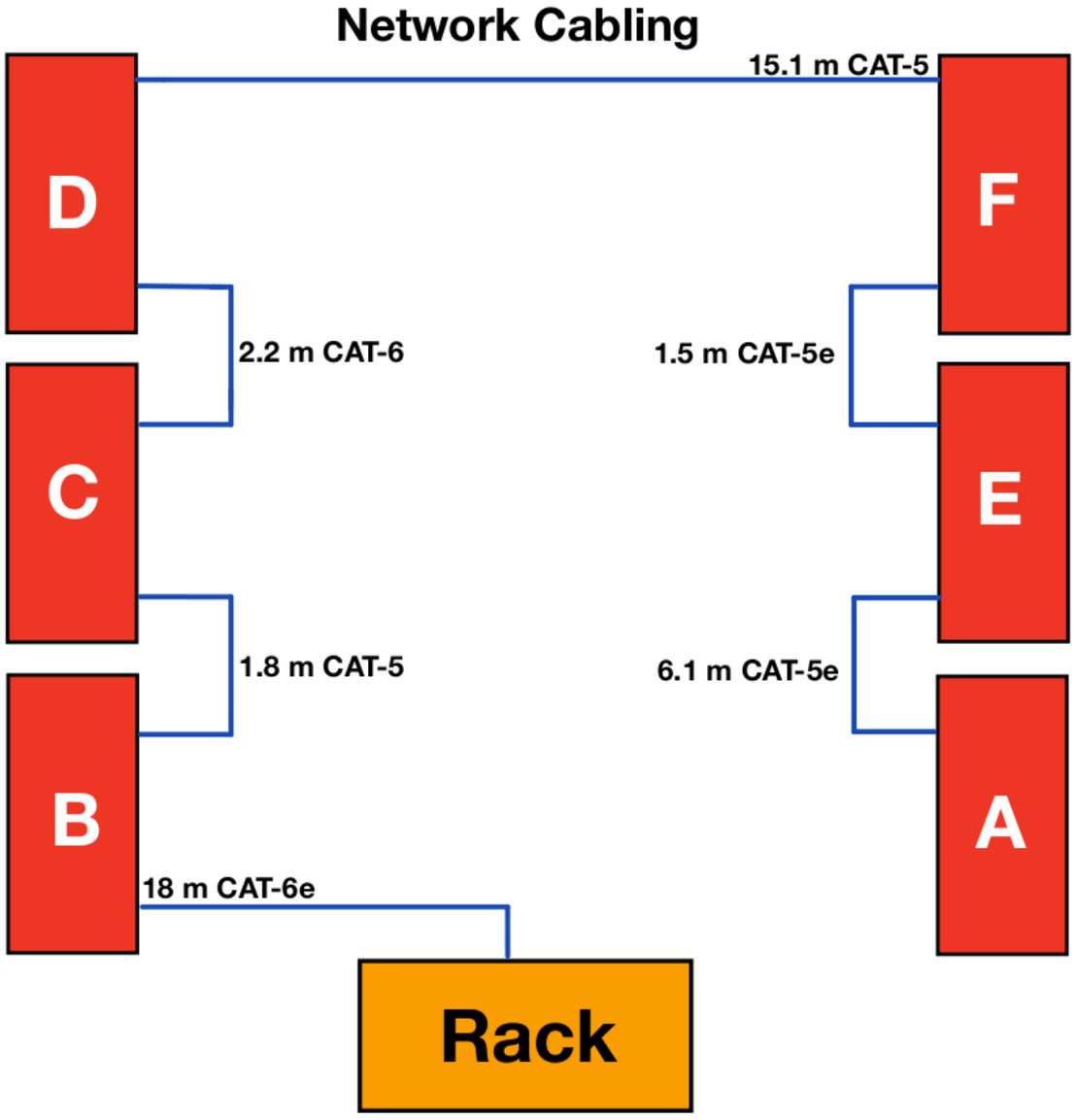
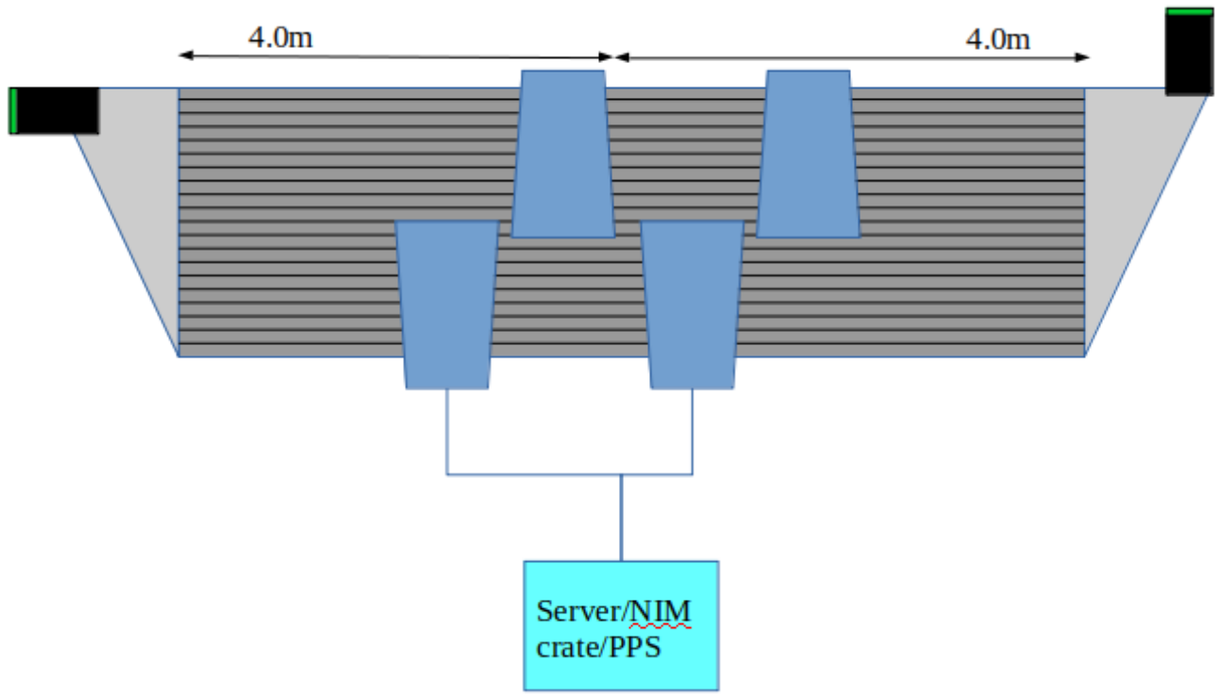
Setup

Chris, Tyler, et al.

- Using daisy chain scheme for distribution of two timing signals: PPS (T0) and hodoscope (T1)
  - Testing the setup we are going to use in the detector

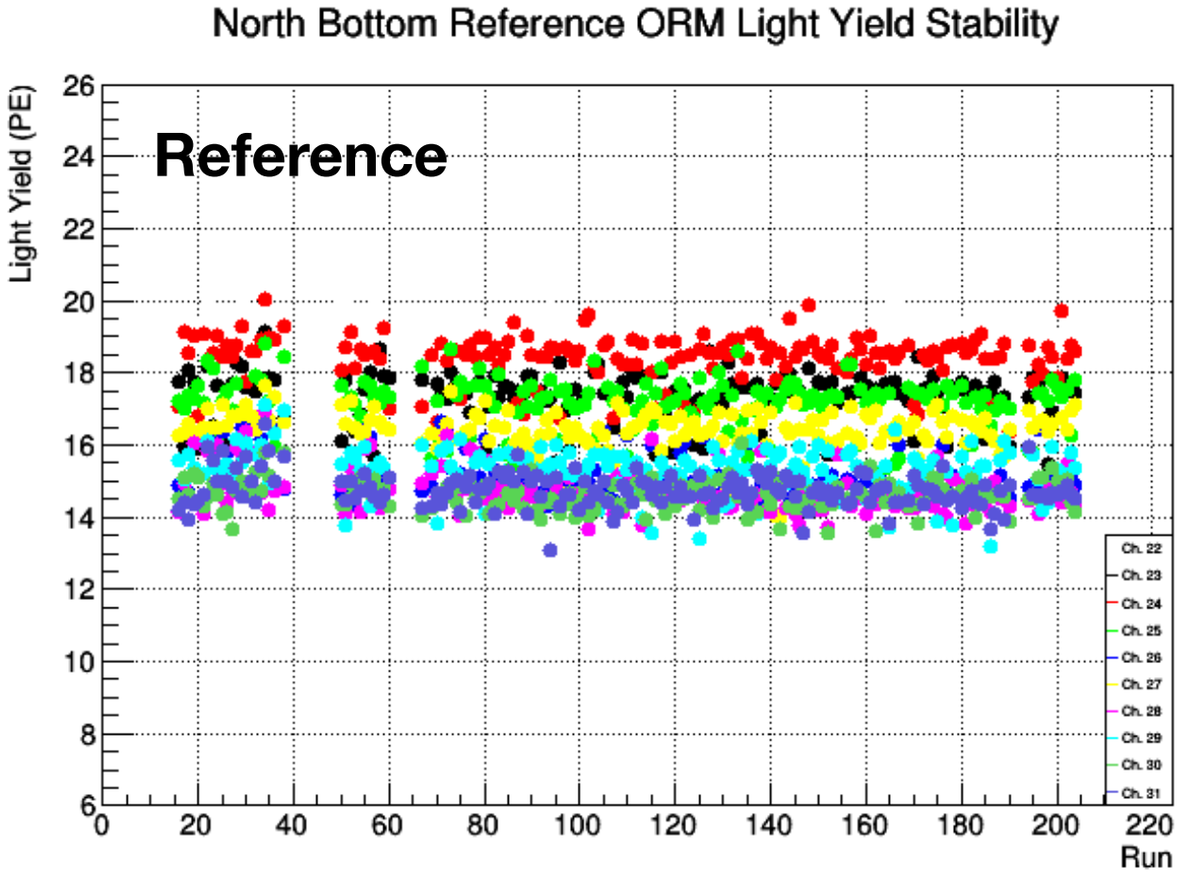


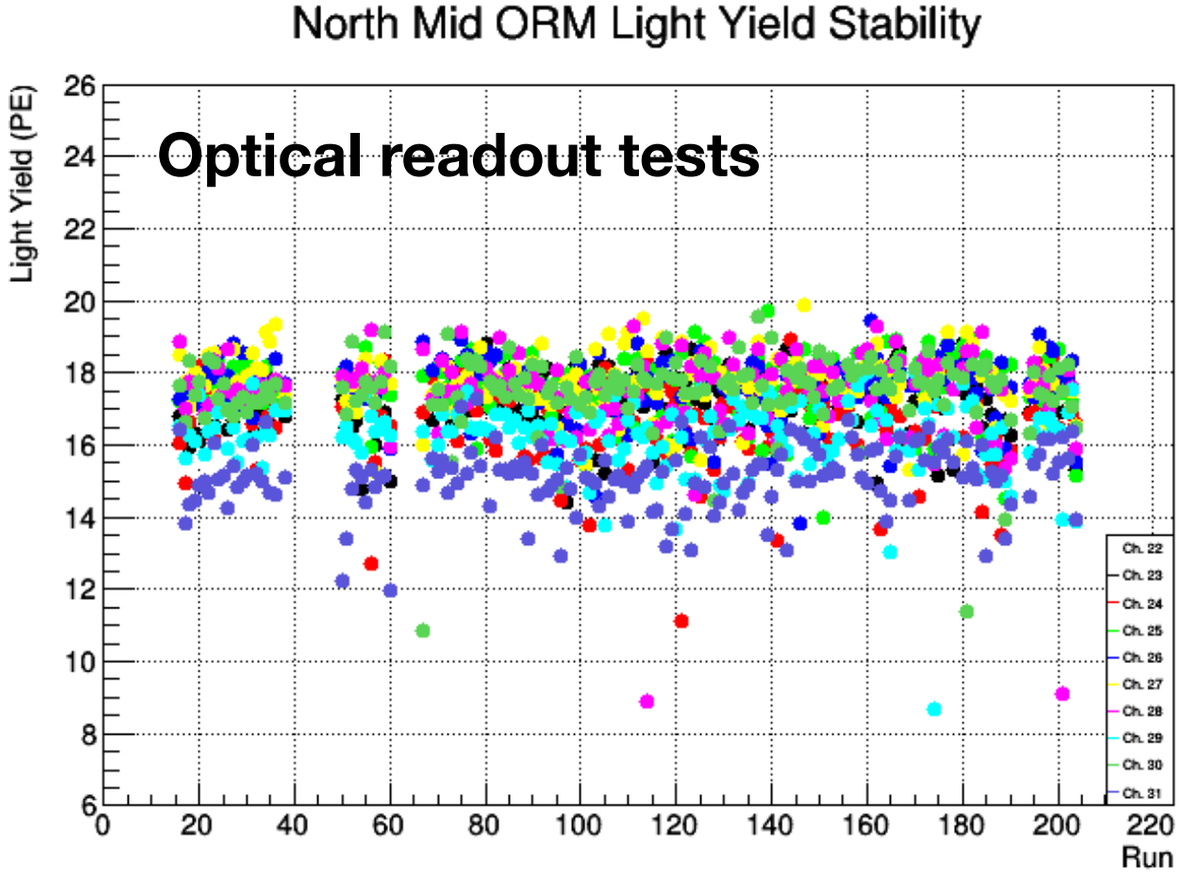


Production Numbers

Chris, Tyler, et al.

- Produced a total of 361 ORMs at CSU
- After QC checks done on site at CSU, 344 were identified as shippable and 340 were sent to Fermilab
- Testing at Fermilab identified a further 13 ORMs as unviable, leaving a total of 327 viable ORMs for use in the detector
- Need a total of 268 for full coverage of side CRT modules, (22% spares for installation)

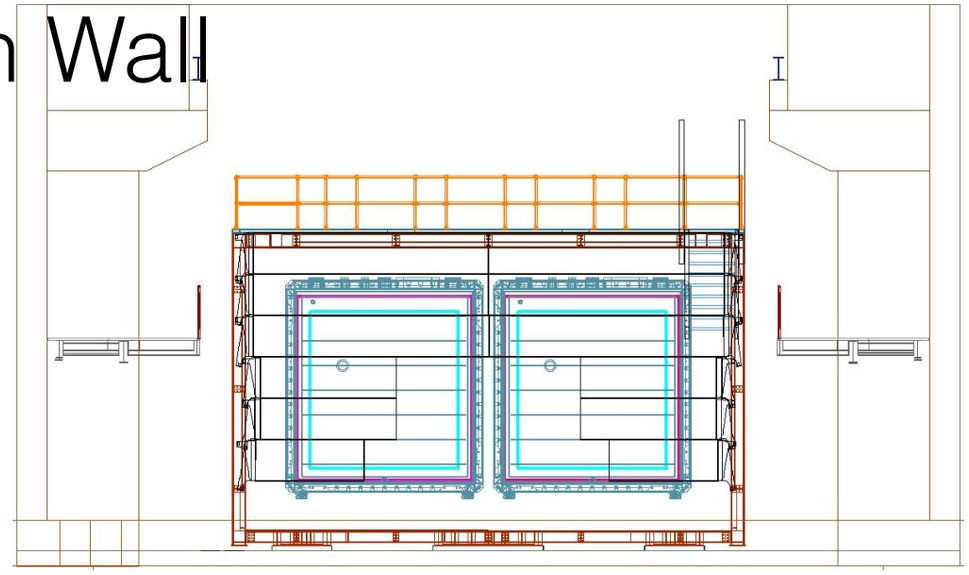




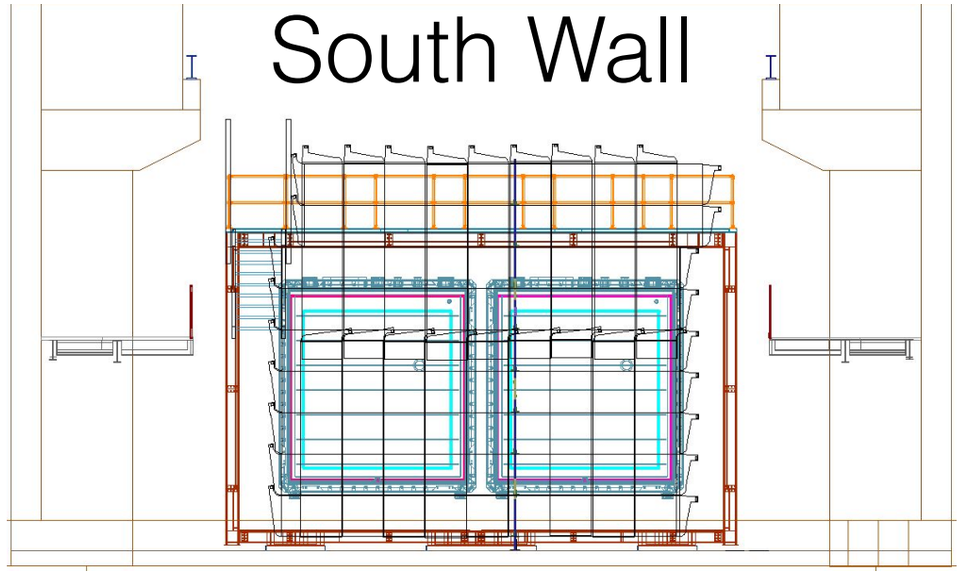
Cutting the modules

- Modules for the south wall have been cut at Wideband
  - We have a few modules that needed to be sealed and tested
- The last layers of the modules for the north wall needed to be cut to avoid interference with the cryo piping
  - Modules have been cut at ICARUS building. We will need to seal and test them

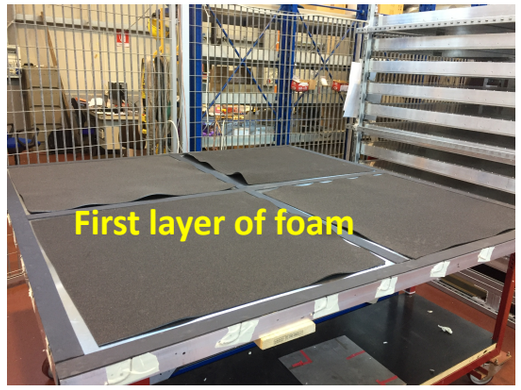
North Wall

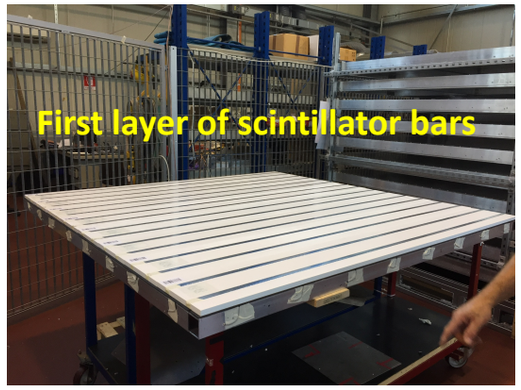


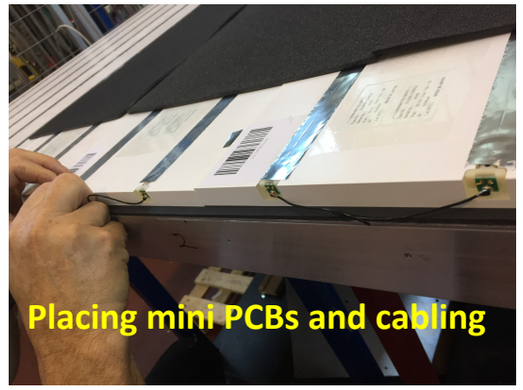
South Wall

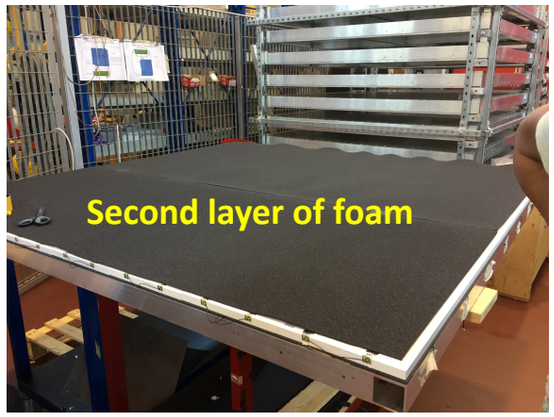


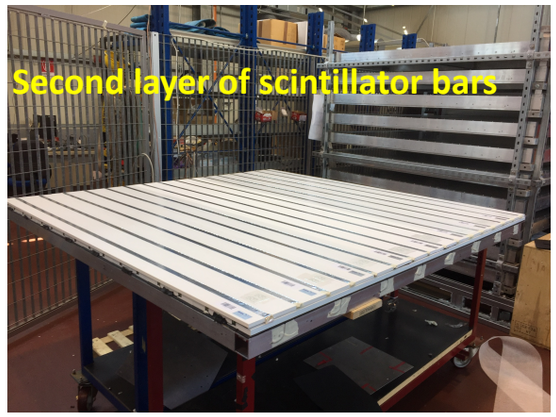
Top CRT assembly steps: (Frascati, Italy)

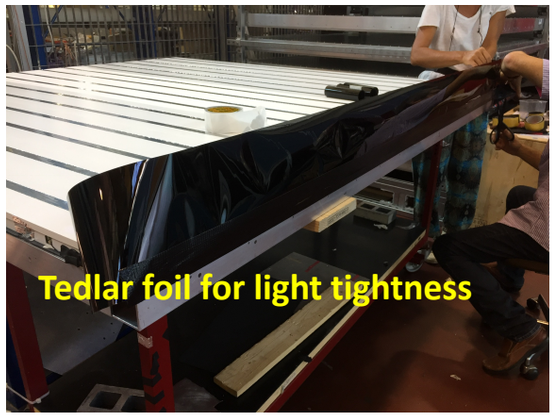


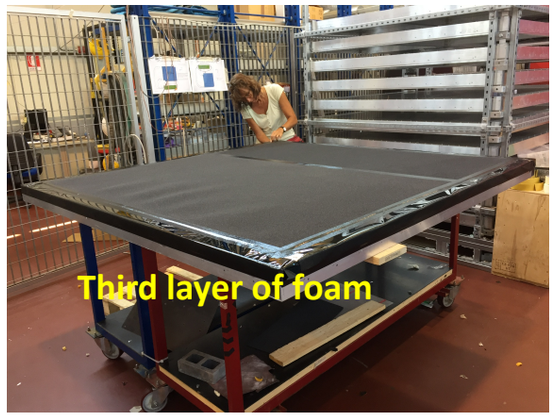


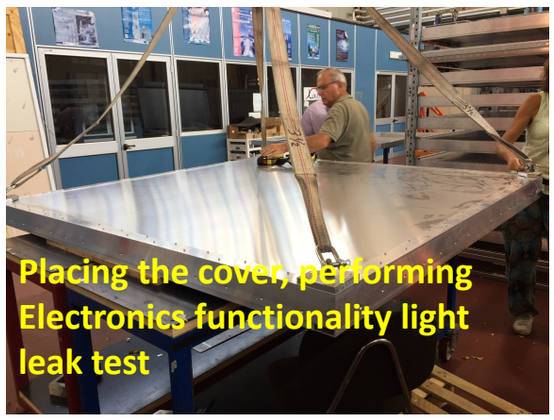


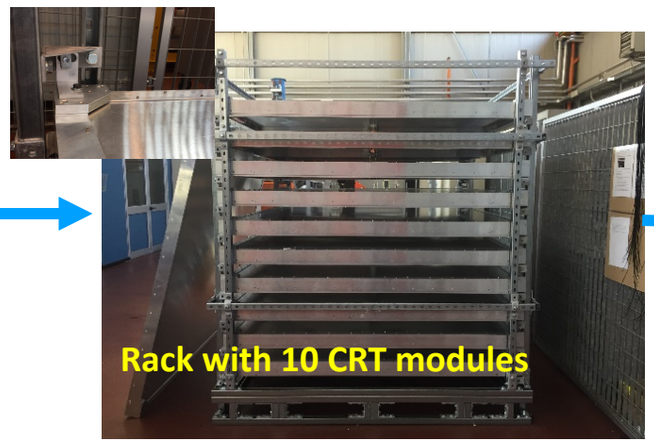












Transporting to CERN then Fermilab with 40inch container

Status

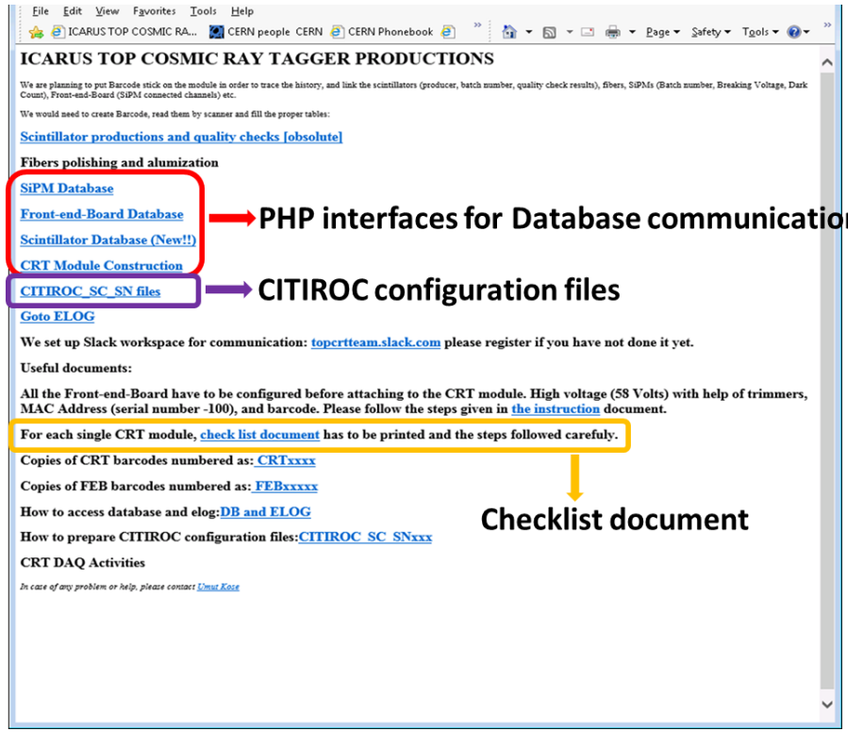
- Top CRT module assembly is on going
- Assembled modules tested for light tightness and efficiency
  - Efficiency found >=94%
- Approved modules stored on the rack
- First container is ready to be transported to CERN
  - Due to custom's clearance complexity (from Italy to Switzerland) shipping being delayed!
- Once custom problem resolved, couple of CRT module will be transported to Fermilab
- The rest of modules to be shipped to Fermilab on February 2020

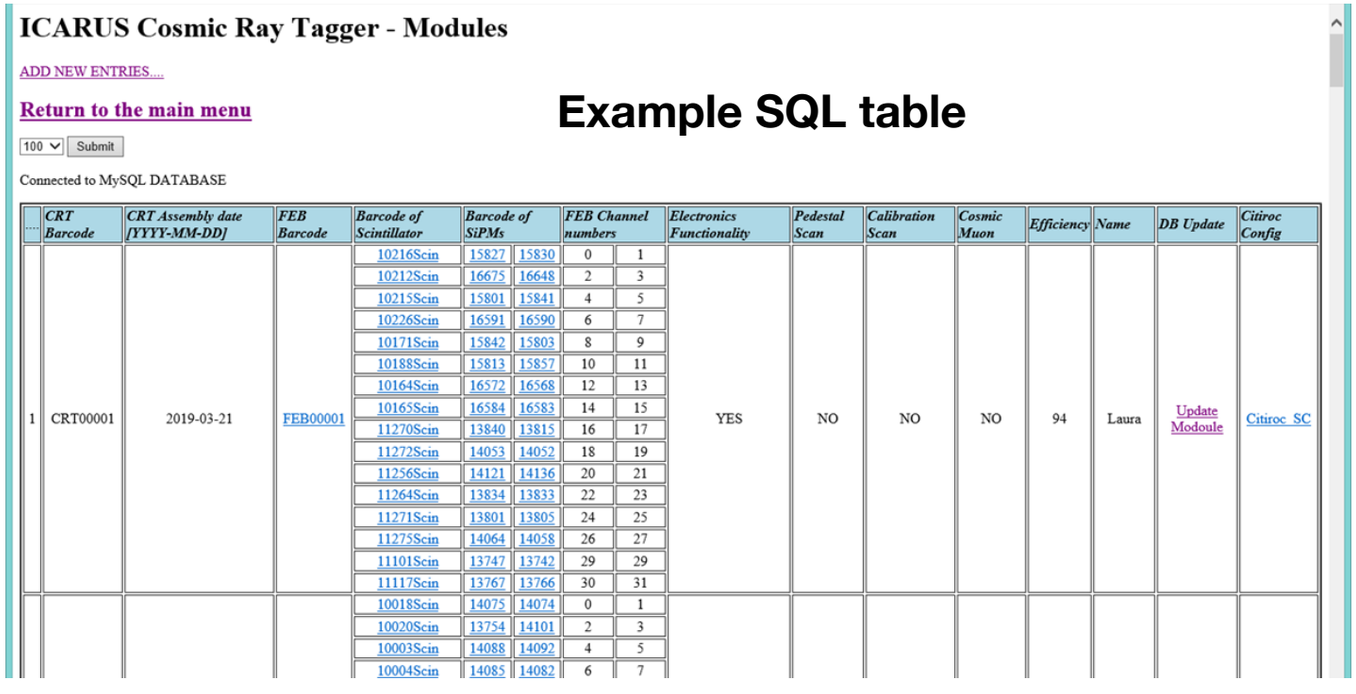
- All modules will be tested again at Fermilab before installation. Space will be needed in the ICARUS hall, preferable a closest area to the truck door

CRT Database at CERN

- We set up a database (MySQL) at CERN to store the history and information of CRT modules.
- Barcode system used for FEBs, Scintillators and CRT modules, Id numbers for SiPMs.

- **Will be merged to the database at Fermilab**





....	CRT Barcode	CRT Assembly date [YYYY-MM-DD]	FEB Barcode	Barcode of Scintillator	Barcode of SiPMs		FEB Channel numbers		Electronics Functionality	Pedestal Scan	Calibration Scan	Cosmic Muon	Efficiency	Name	DB Update	Citiroc Config
1	CRT00001	2019-03-21	FEB00001	10216Scin	15827	15830	0	1	YES	NO	NO	NO	94	Laura	Update Modoule	Citiroc_SC
				10212Scin	16675	16648	2	3								
				10215Scin	15801	15841	4	5								
				10226Scin	16591	16590	6	7								
				10171Scin	15842	15803	8	9								
				10188Scin	15813	15857	10	11								
				10164Scin	16572	16568	12	13								
				10165Scin	16584	16583	14	15								
				11270Scin	13840	13815	16	17								
				11272Scin	14053	14052	18	19								
				11256Scin	14121	14136	20	21								
				11264Scin	13834	13833	22	23								
				11271Scin	13801	13805	24	25								
				11275Scin	14064	14058	26	27								
				11101Scin	13747	13742	29	29								
				11117Scin	13767	13766	30	31								
				10018Scin	14075	14074	0	1								
				10020Scin	13754	14101	2	3								
				10003Scin	14088	14092	4	5								
				10004Scin	14085	14082	6	7								

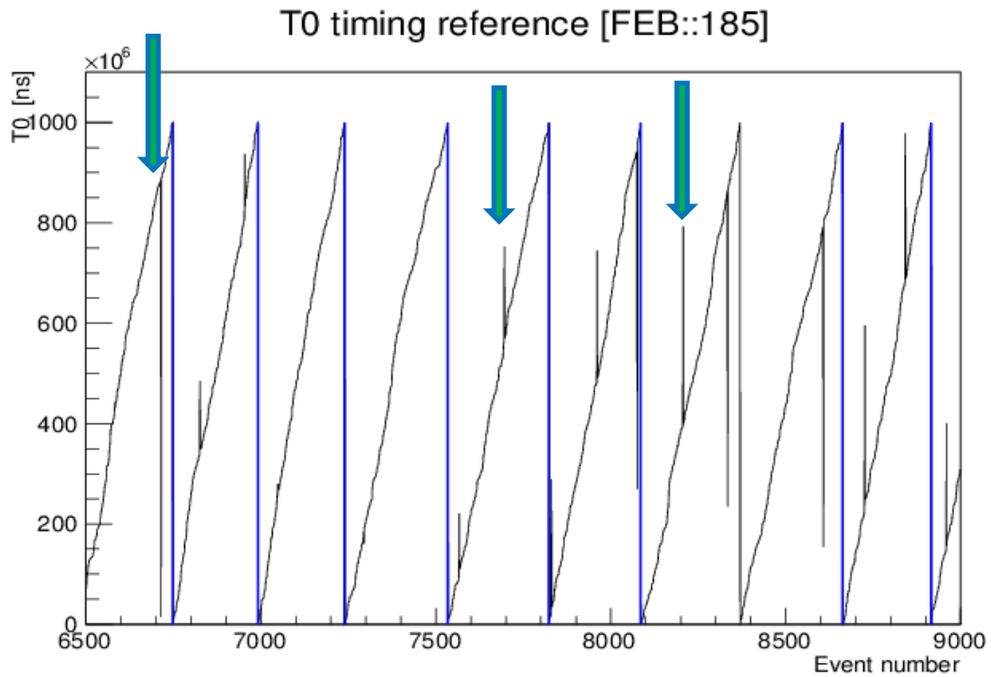
Next Steps

- Reseal and test the modules for the north and south wall
- Install the FEB support
- Install the support for the rolling side CRT
- Install the modules at the rolling side CRT
- Test the power distribution at the Fermilab and Frascati test stand
- Test the DAQ at Fermilab and Frascati test stand
- Finalize the utility and server racks for both systems
- Install the electronics
- Commissioning of the bottom, side CRT and two modules from the top CRT

Back Slides

Front-end-boards

- **All FEBs received from CAEN.**
- **Firmware upgraded with new functionalities.**
- **We have found a bug “stuck event/spikes” on T0 timing reference. Fixing the bug and testing in progress.**

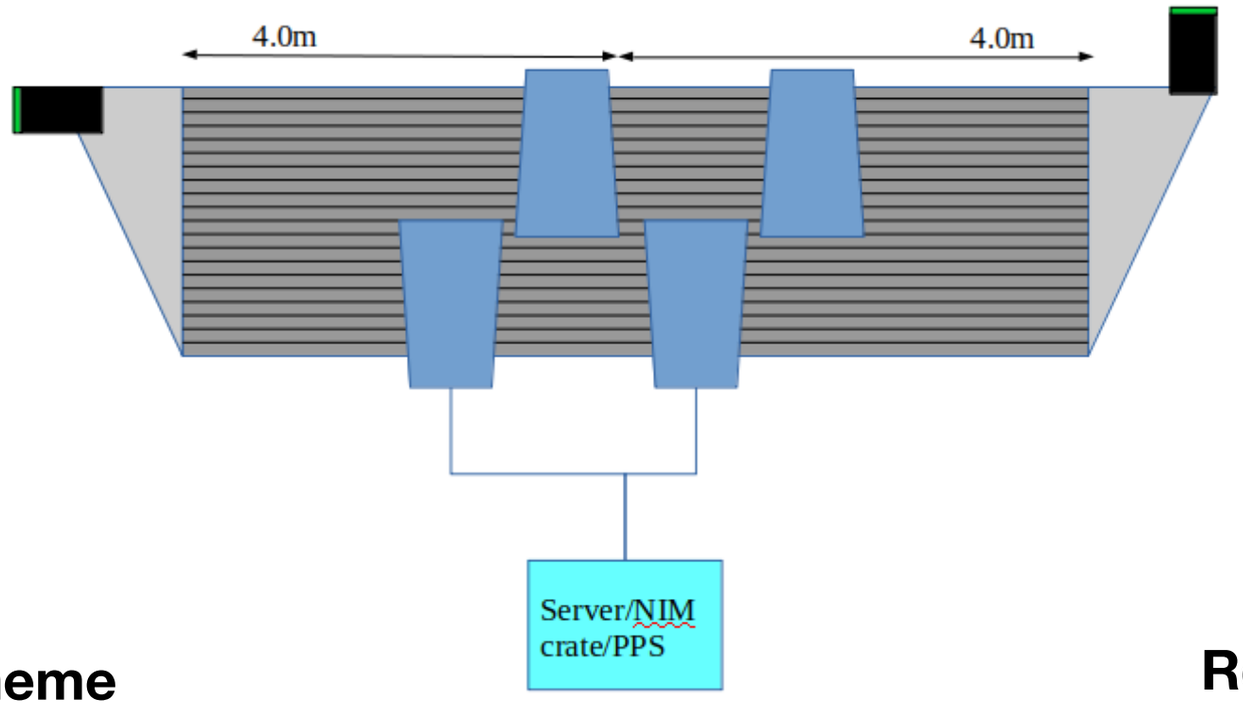


- **After bug fix, timing resolution measurements will be performed once more again.**

Bottom CRT

- Double Chooz veto modules installed, including the PMT readout
- Readout has been tested
- Ongoing work: setting the artDAQ interface

Setup



Using daisychain scheme for distribution of 2 timing signals: PPS (T0) and hodoscope (T1)

Route TOUT signal from each FEB to coincidence unit at the rack