ICARUS CRT system

ICARUS collaboration Meeting

May 14, 2018

Anne Schukraft, Fermilab

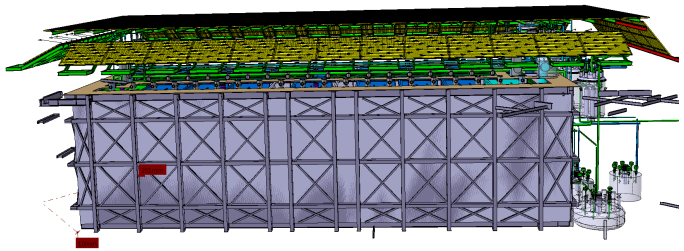
ICARUS CRT sub-systems

- The ICARUS CRT system is broken up into three individual sub-systems with different modules and different readout electronics

Top

(Responsibility: CERN, INFN, European institutions)

- ~400m^2
- New scintillator modules (quantity: 125)
- 8 X and 8 Y strips per module
- Two fibers per scintillator strip
- SiPM-based readout
- "Barn-style" installation
- Top CRT will tag ~80% of cosmic muons entering the TPCs

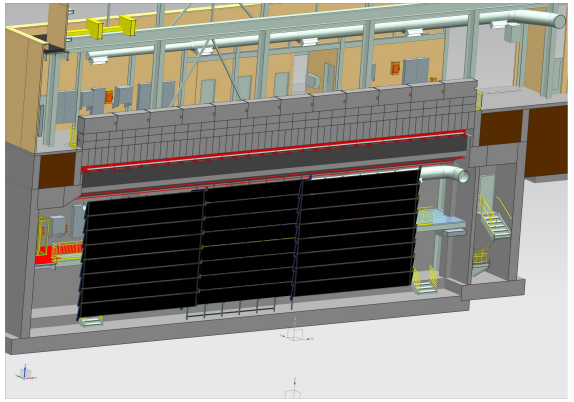


First prototype module assembled at Bologna. Production to follow at Frascati.

Sides

(Responsibility: FNAL, CSU)

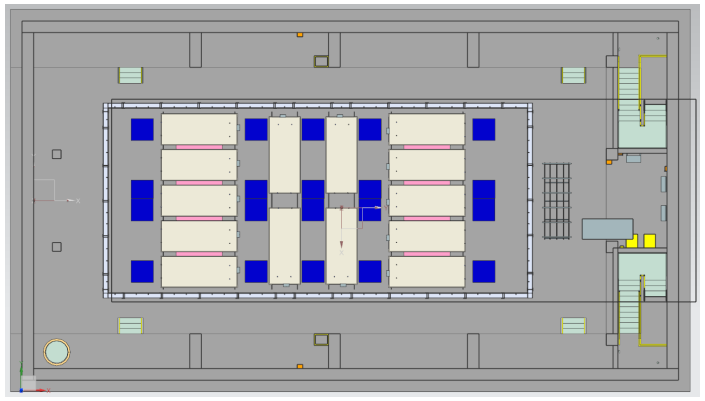
- ~500m^2
- MINOS scintillator veto shield modules (quantity: have 173 = 1100m^2)
- 20 strips per module, all parallel
- Single fiber per scintillator strip
- Designing new SiPM-based readout
- Double layer installation on East, West, North, South sides



Bottom

(Responsibility: FNAL)
(Supported by: UChicago, VT)

- 200m^2
- Double Chooz veto modules
- 32 strips per module: two layers, all parallel
- Single fiber per scintillator strip
- PMT readout
- 14 modules installed (80m^2)



US Involvement

US Collaborators

- Colorado State University
  - Tyler Boone (GS), Chris Hilgenberg (GS), Bob Wilson
  - Bob Adame (M), Jay Jablonski (T), Dave Warner (E)
  - Sarah Earl (UG), Blake Troska (UG)

- Fermilab
  - Simone Marcocci (PD), Anne Schukraft, Cat James
  - Mike Matulik (EE), Justin Tillman (D), John Belle (ME)
  - Joanne Bader, Kevin Bardan (summer interns)

Support from non-collaborators on the bottom CRT

- University of Chicago
  - Ed Blucher

- Virginia Tech
  - Camillo Mariani, Vishvas Pandey (PD)

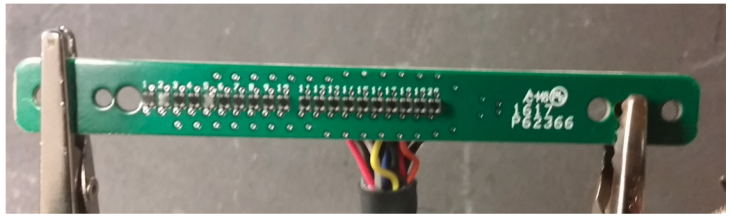
Interest in future CRT activities

- University of Houston
  - Dan Cherdack

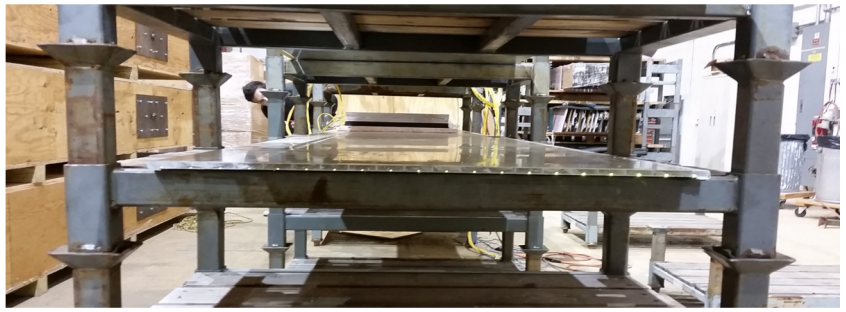
Regular exchange with CERN, Bern, and MicroBooNE

Side CRT system - modules

Side CRT test stand at FNAL (Wideband/PB7 building).



Prototype SiPM boards fabricated at CSU.



Cut MINOS module showing 20 strips with centered fibers.

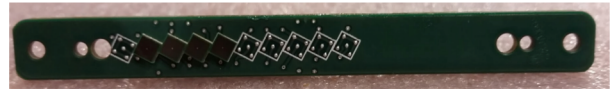
MINOS module snout with 20 fiber ends (same on the other end).

Prototype SiPM board attached to module snout.

- We have 173 modules from the former MINOS far detector cosmic veto shield. *See NIMA 596 (2008) 190–228*
- Modules are 8m long (plus connector), 80.5cm wide, and 1cm thick.
- 20 strips per module (each 4cm wide).
- The strips are glued to and wrapped in a light-tight aluminum skin.
- One fiber per strip, readout on both ends. -> 40 channels per module.
- All modules have been tested during summer 2017 and sufficient number of modules with required quality have been identified. Test results: https://sbn-docdb.fnal.gov/cgi-bin/private/ShowDocument?docid=6212

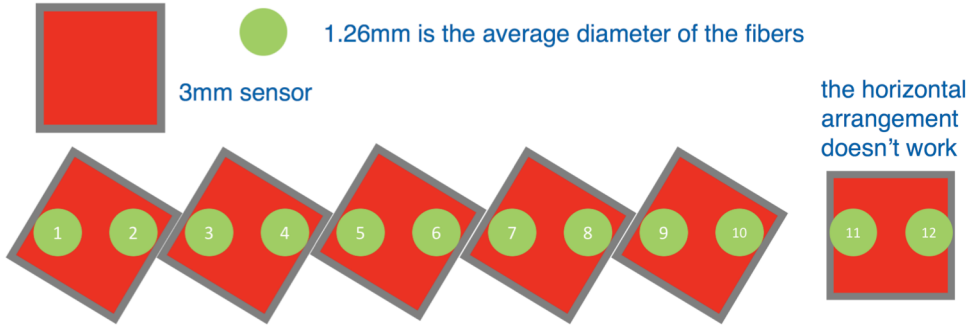
Side CRT system - readout system

Just recently concluded our readout development with a technical review on April 6th, 2018:
https://sbn-docdb.fnal.gov/cgi-bin/private/DisplayMeeting?conferenceid=2612



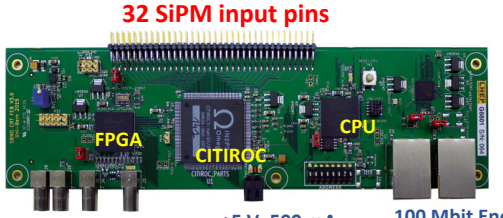
- SiPM sensor will be Hamamatsu S14160-3050HS

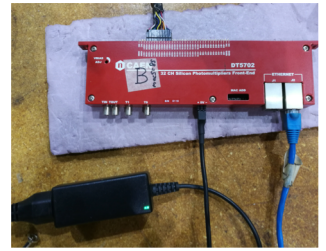
- Sensor arrangement in “diamond style” was tested to collect more light than e.g. 1mm SiPMs with insufficient coverage. Optically combining two fibers reduces our granularity from 4cm to 8cm, but is still sufficient.



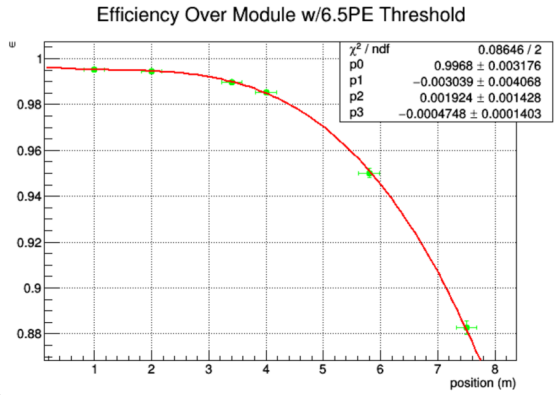
- Front end board electronics will be CAEN A1702 designed by University of Bern and also used in MicroBooNE, SBND, and ICARUS top CRT.

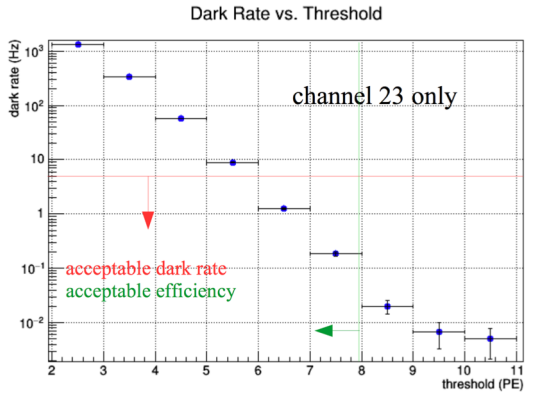
CAEN A1702 (designed by UBern)





- In a performance test with the prototype board we measured an efficiency of 99.3% per module and a dark rate of 1.2Hz per SiPM channel at a potential operating threshold of 6.5 PE.





- Next steps will be to design a production SiPM board and make plans for production and testing.

Synergies with other SBN CRT systems

ICARUS top CRT

- Same FEB
- Synergies in power distribution, integration into experiment timing system & trigger
- Synergies in DAQ software
- Synergies in simulation & reco

~ 4000 channels

SBND CRT

- Same FEB
- Synergies in DAQ software
- Synergies in simulation & reco

~ 4000 channels

MicroBooNE CRT

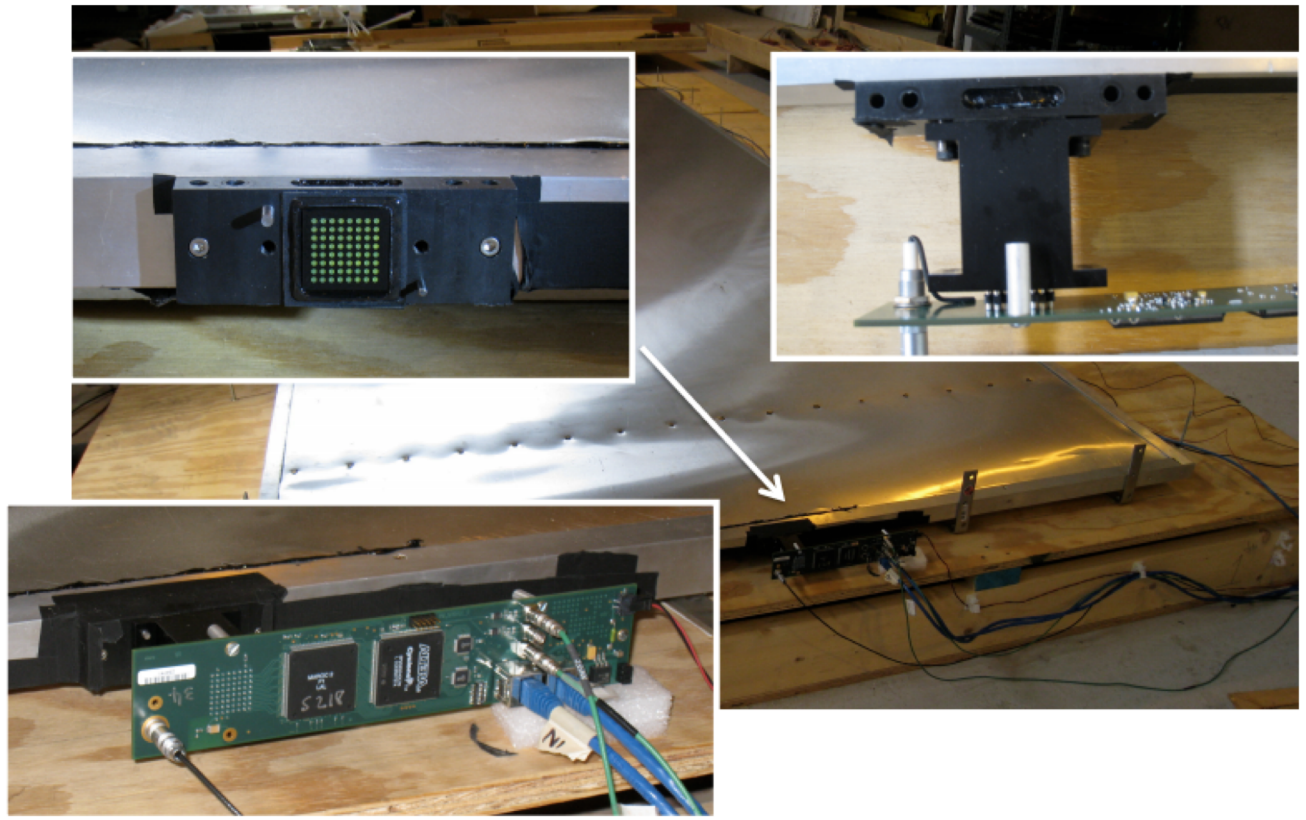
- Same FEB
- Synergies in simulation & reco

~ 2500 channels

Biggest difference: all other systems use new modules with two fibers per strip and can require a coincidence between the two SiPMs. The MINOS modules are the only single-fiber modules with readout on both ends.

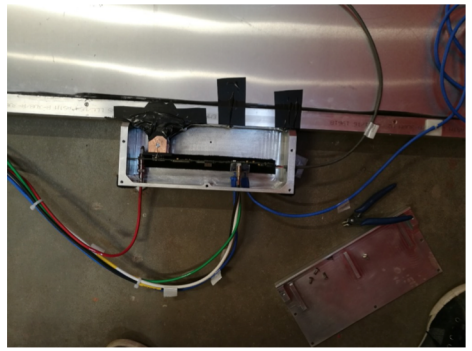
Bottom CRT system

- For time and cost reasons, we are re-using Double Chooz veto modules for the bottom CRT.
- One module consists of two layers of parallel strips.
  Strip width 5cm.
  32 Strips per module. Read out by a 64-pixel multi-anode PMT. Total module dimensions: 4m x 1.6m x 3.2cm.
- Modules were shipped from France to FNAL in spring 2017, and installed in summer 2017.
- We were supported by Ed Blucher (UChicago) on the mechanical side, and Camillo Mariani and Vishvas Pandey (VT) on the electronics and readout testing.
- Same modules being used by ProtoDUNE.





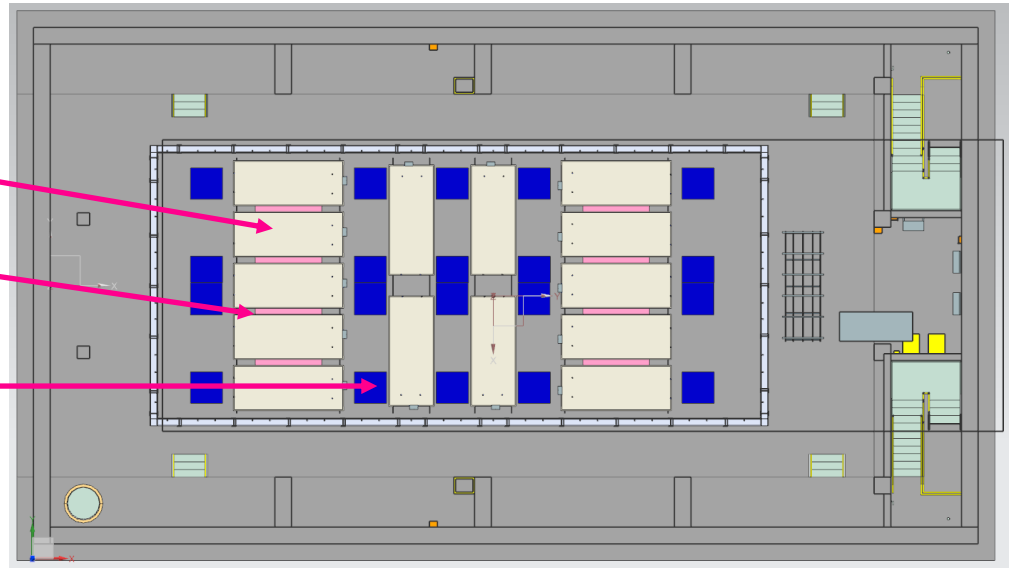





Bottom CRT system - status

- 14 modules were installed in summer 2017 underneath the warm vessel.
- We have a movable test rack which we used to test the module performance before and after installation using a standalone DAQ system running on a laptop.
- Production cables and readout boards are installed. Test rack remains to be upgraded to a final operations rack.
- Bottom CRT remains to be integrated into common experiment DAQ and monitoring.

Bottom CRT layout



Side & bottom CRT – upcoming tasks

Develop a production SiPM board design, board fabrication and testing

Side CRT

- Currently lead by FNAL and CSU
- Following review technical recommendations concluding the R&D phase
- Time scale: start board production in fall
- Major procurements related to this task are purchases of Hamamatsu SiPMs, CAEN front-end boards, and additional electronics

Installation of CRT modules and electronics at the FD building

Side CRT

- Currently lead by FNAL and CSU
- Two-step process: mechanical support structure and module installation lead by FNAL to come this summer. Installation of readout electronics and racks to follow in spring 2019.
- Help is welcome in planning and procurements, as well as hands-on work during actual installation

Integration of the CRT into common experiment DAQ and monitoring

Side CRT, bottom CRT, top CRT

- Synergies with SBND for the side and top CRT
- Synergies with ProtoDUNE for the bottom CRT
- Lots of room for contributions.

Integration of the CRT into simulation, reconstruction and analysis

Side CRT, bottom CRT, top CRT

- Initial effort has been started in the joint SBN analysis group trying to work in parallel for SBND and ICARUS
- Can learn from MicroBooNE, however the MicroBooNE way of merging CRT data with TPC and PMT information is different
- Longer term effort with a lot of room for contributions.

Contributions from current and new collaborators are welcome at all stages.