Status of ICARUS commissioning

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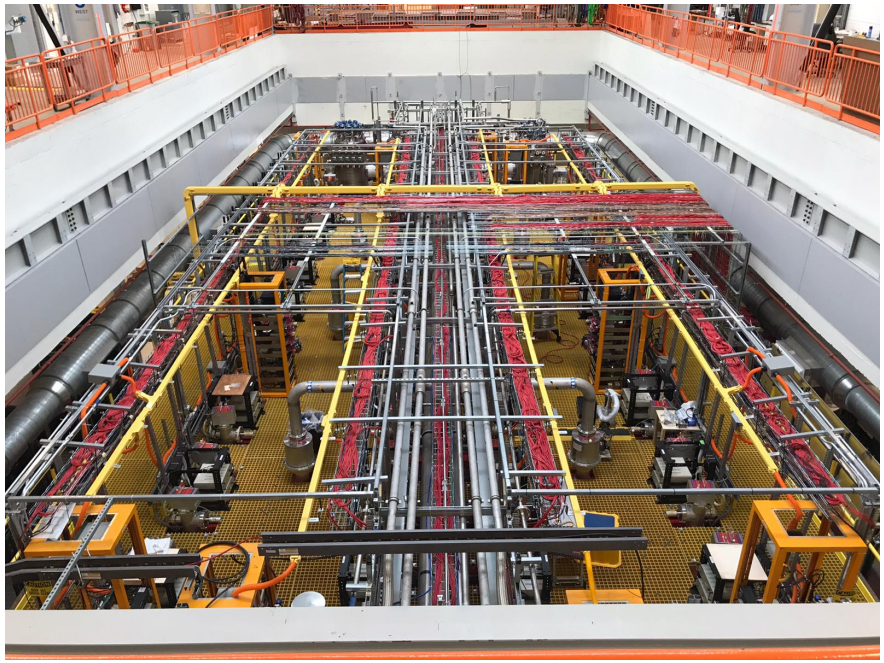
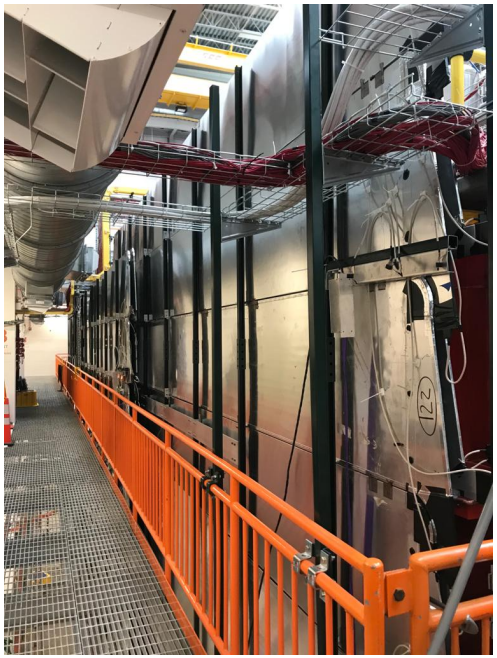
Current status of ICARUS detector

- Icarus cryogenic system operative in stable conditions since the end of May 2020.
- TPC, PMT and DAQ installation activities complete. CRT installation complete for bottom and ¾ sides, remaining South wall and top.
- 24/7 shifts since February 14th. Remote only shifts since March 17th.
- Presently in detector commissioning, with no access onsite (Covid-19) for international collaborators, many of which have historical expertise of the detector.





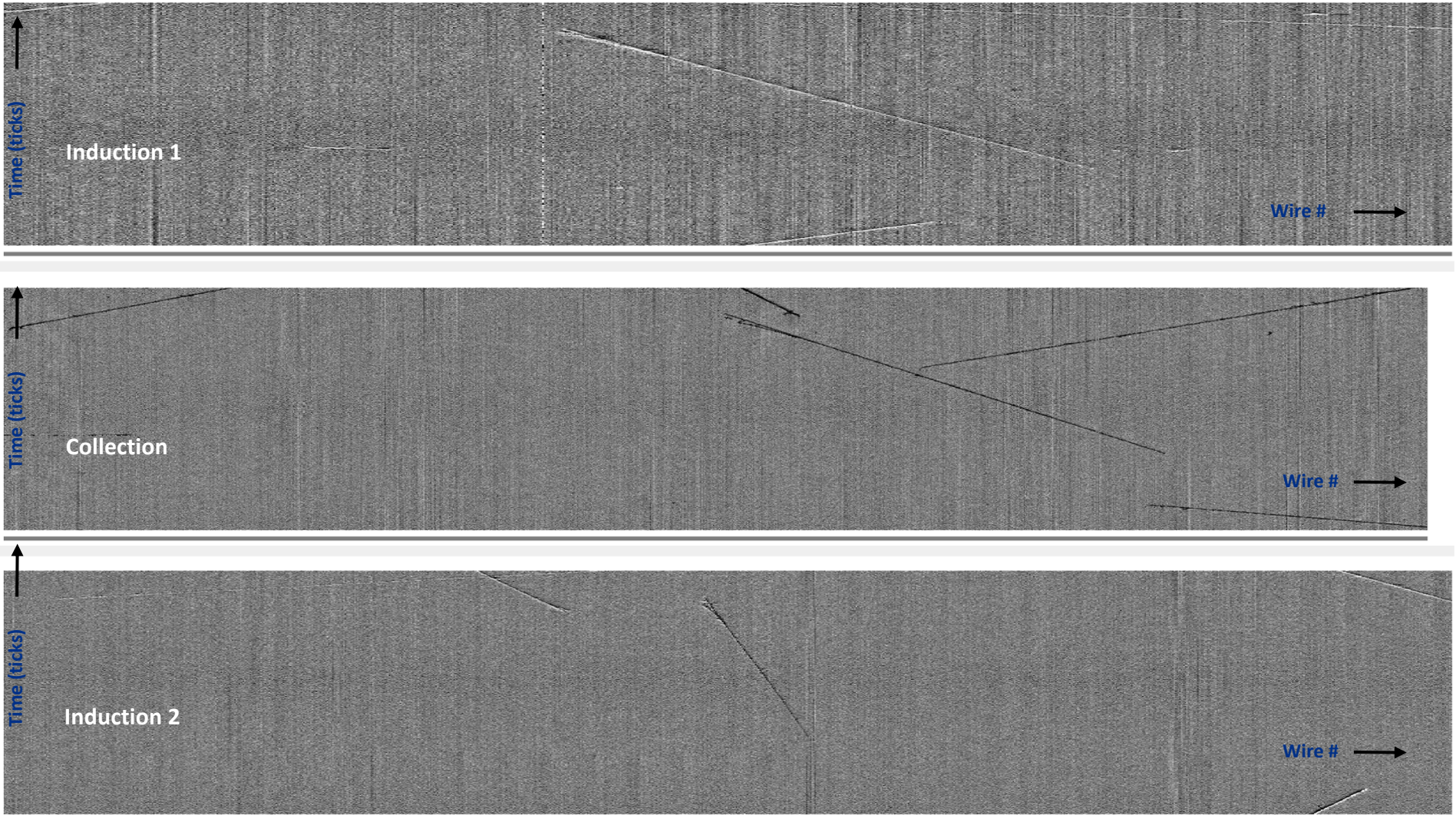
Cryogenic commissioning

- Started on Feb 13th, 2020 by breaking the vacuum in the two main cold vessels.
- Cooldown started on Feb 14th by injecting liquid nitrogen in the cold shields.
  4 days duration, maximum temperature gradient on the TPC chambers 35 K.
- Gas recirculation units activated on Feb 18th for purification of Ar gas before filling.
- Filling started on Feb 24th, interrupted at around 50% to regenerate the filters, and stopped again when the liquid reached 6 cm below the nominal level to perform the final pressure test of the two cold vessels.
- Filling completed on April 19th.
- Liquid recirculation started on April 21st, at 1.85 m^3/hr in the West cryostat and 2.25 m^3/hr in the East.
- Cryogenic stabilization completed around end of May. Steady performance since then, apart from one of the gas recirculation unit not working continuously; no cold spots observed in the external surface of the warm vessel.
- Common effort of CERN/Fermilab teams.

Status of detector commissioning

- Procedure for detector activation started on July 30th with the commissioning of the HV system for the TPC cathode.
- Detector in nominal operating conditions (drift field 500 V/cm, polarization of TPC wire planes appropriate for non-destructive signal readout, PMTs for scintillation light recording at nominal voltages) since August 28th. Overall excellent stability.
- Recording of cosmic ray tracks with random 5 Hz trigger (to emulate maximum data throughput with the Booster Neutrino Beam).
  Used to measure the concentration of impurities in liquid argon, develop the DAQ and monitor the noise conditions in the TPC.
- Equalization of the gain of the PMTs ongoing with laser calibration source.
- Measurement of the LAr purity, based on the charge attenuation along cosmic muon tracks crossing the TPC's, indicate an electron lifetime O(1 ms) with a degradation trend. Investigation of possible causes and consequent mitigations ongoing.
- Preparing for Operational Readiness Review (ORR) Dec 9-11.

- Sample event WW TPC: Run 2269 Event 10 (Monday, Sept 7th).
- Time window is 1.6 ms. Each box represents a zoomed-in display: Ind1 is 2.7 m, Coll 3.6 m and Ind2 2.9 m.



Plan of future activities

- Activities to be ready for data taking/commissioning with BNB in November:
  - improvement of LAr purity conditions;
  - finalization of PMT calibration;
  - optimization and calibration of TPC wire signals;
  - deployment and tuning of the trigger system;
  - final development, testing and integration of data acquisition;
  - testing and finalization of calibration procedures;
  - commissioning of slow controls for components still missing.
- Additional activities remaining to be ready for physics:
  - installation and commissioning of the remaining parts of the side CRT;
  - installation and commissioning of services on top of the detector (ventilation, fire protection system, ODH sensors);
  - delivery onsite, installation and commissioning of the top CRT;
  - installation of the overburden.

High-level commissioning timeline