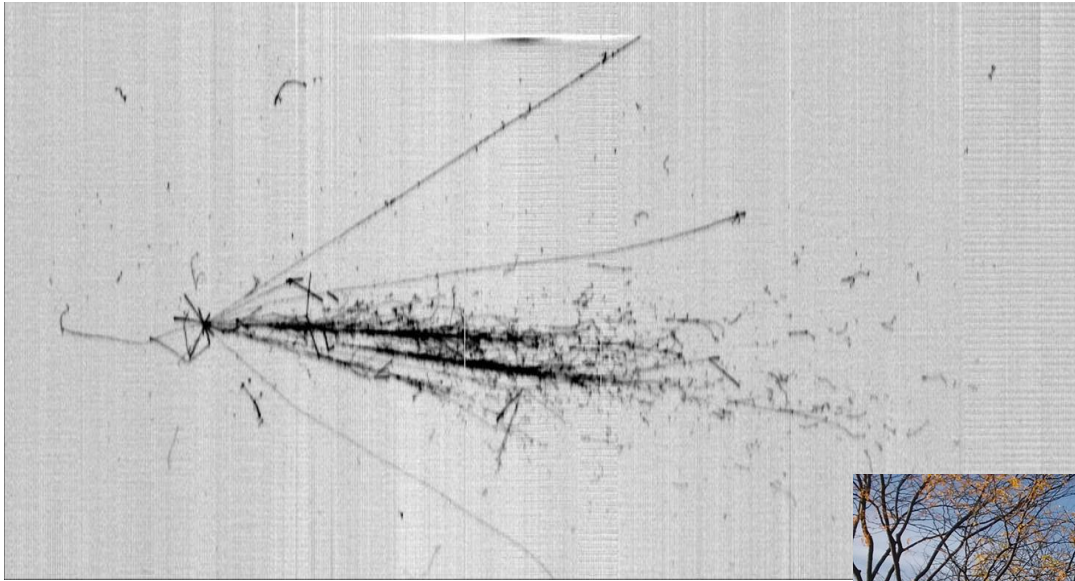
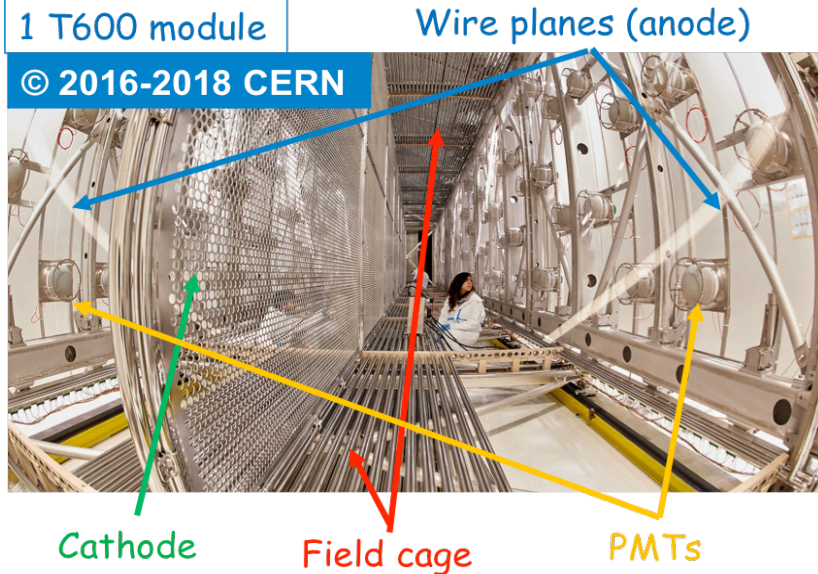


Sterile Neutrino searches with the ICARUS detector at FNAL

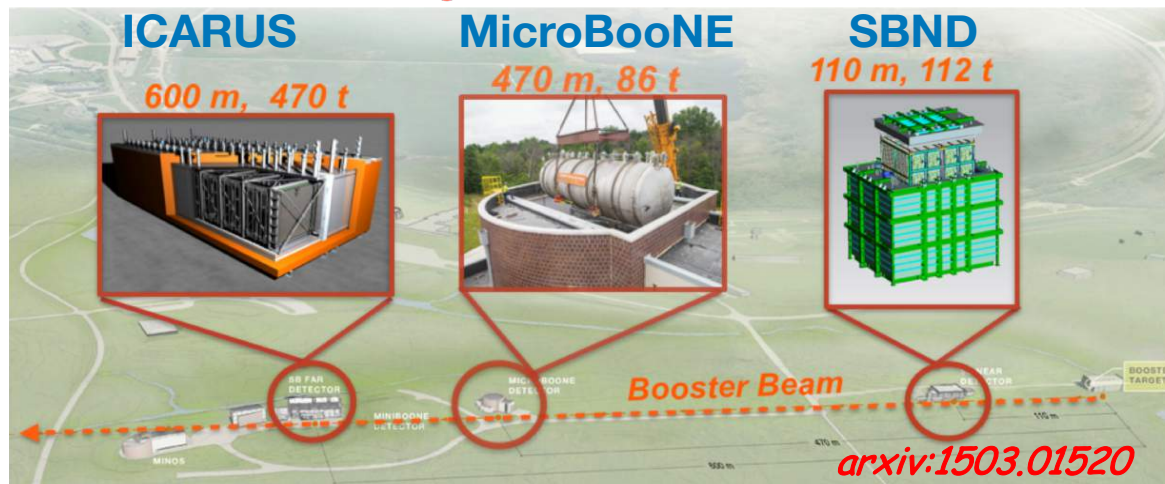


The ICARUS T600 and the SBN project

- ICARUS-T600 LAr TPC is a high granularity uniform self-triggering detector with 3D imaging and calorimetric capabilities, ideal for ν physics. It allows to accurately reconstruct a wide variety of ionizing events with complex topology.

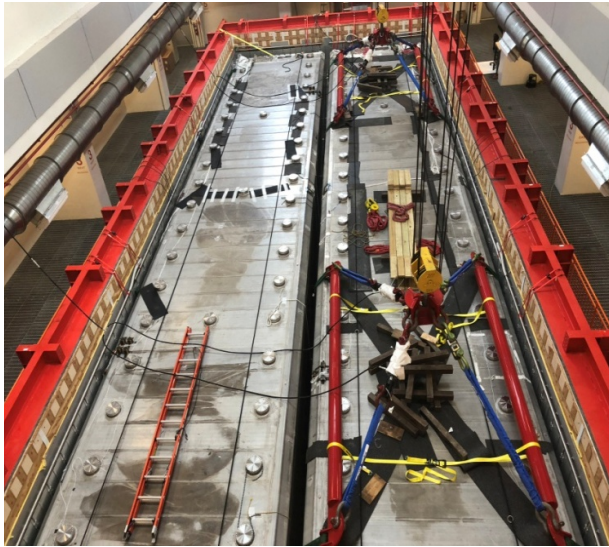


- 2 identical module, 476t total active mass, 2 TPC's per module, with a common central cathode: $E_{\text{Drift}} = 0.5 \text{ kV/cm}$, $v_{\text{Drift}} \sim 1.6 \text{ mm}/\mu\text{s}$, 1.5 m drift length;
- 3 "non-destructive" readout wire planes per TPC, ≈ 54000 wires at $0^\circ, \pm 60^\circ$ w.r.t. horizontal;
- 360 8" PMT's, coated with TPB wls, for t_0 , timing and triggering.

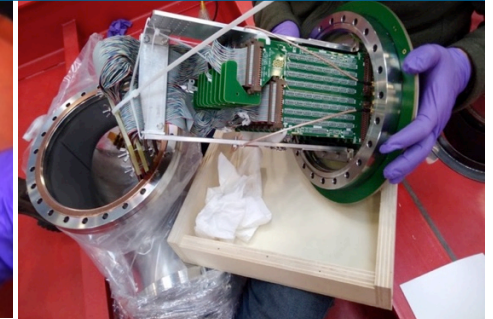
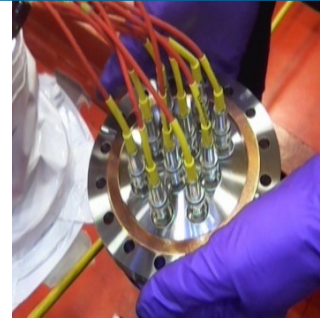


- In the SBN experiment the T600, as far detector, will be exposed, to the Booster neutrino beam searching for sterile ν oscillations measuring both appearance and disappearance channels;

1. ICARUS installation @ FNAL (2018-2020)



ICARUS placement *inside the warm vessel after the overhauling at CERN (Aug 2018)*



Installing PMT, TPC signal feed-throughs (Jan 2019)



All cryogenic equipment installed/test ed (May 2019)



Readout electronics

Power supply

CRT side walls installation also progressing

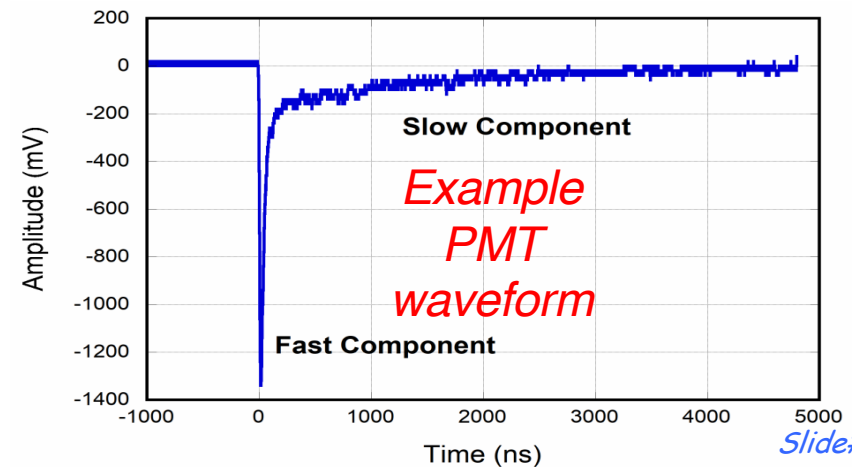
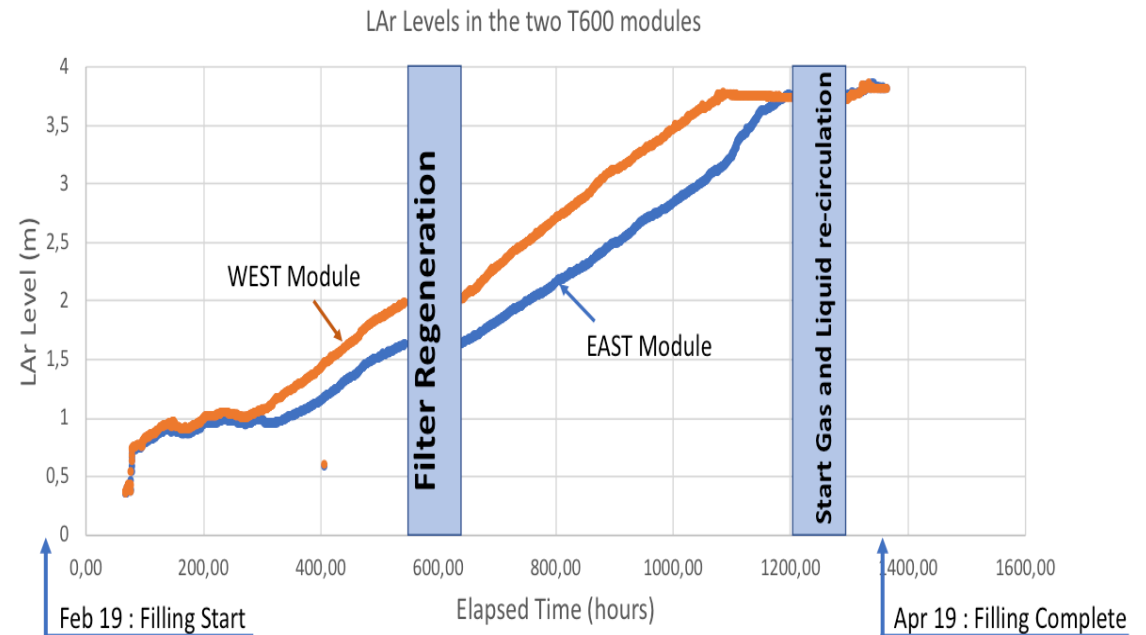


... Installing the readout electronics (Summer 2019)

- ✓ All PMT digitizers, HV electronics and laser system installed and tested;
- ✓ TPC readout electronics (mini-crates, CAEN boards and Power Supplies) installed and verified;

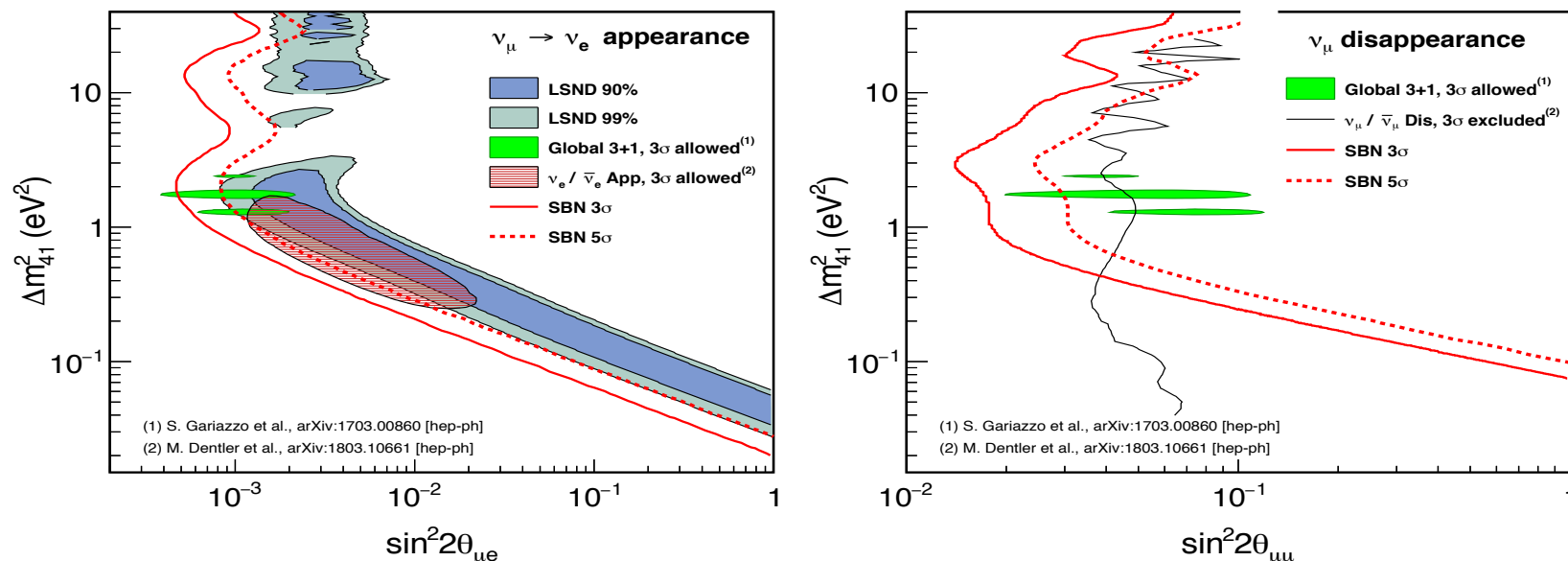
ICARUS filling and cryogenics commissioning

- Filling with Liquid Argon (two months) completed on April 19, 2020
- Increase of TPC wire noise due to capacitive effect agrees with expectations
- Both liquid and gas recirculation are online and in steady state conditions (1.85 m³/hr West, 2.25 m³/hr East)
- Pressure and temperature across both modules are stable
- After filling, commissioning work is going on despite limitations due to Covid19
- HV system brought up to nominal 75 kV voltage: system is stable
- TPC wire bias is under test at nominal values
- All PMTs activated in LAr and PMT calibration with laser is being performed
- Ar³⁹ background was observed



SBN sensitivity

- The comparison between near and far detector will allow to reduce beam and cross-section systematics to few percent
- The LAr-TPC technology will allow efficient ν_e identification and NC background reduction
- Oscillation probability will be negligible at near detector \rightarrow any difference will imply new physics



*Sensitivities from SBN proposal (arXiv:1503.01520)
compared with more recent global fits (arXiv:1903.04068)*

SBN will be able to cover most of the parameter region allowed by past anomalies with 5σ significance in 3 years ($6.6 \cdot 10^{20}$ pot)

Role of Unipd within the SBN

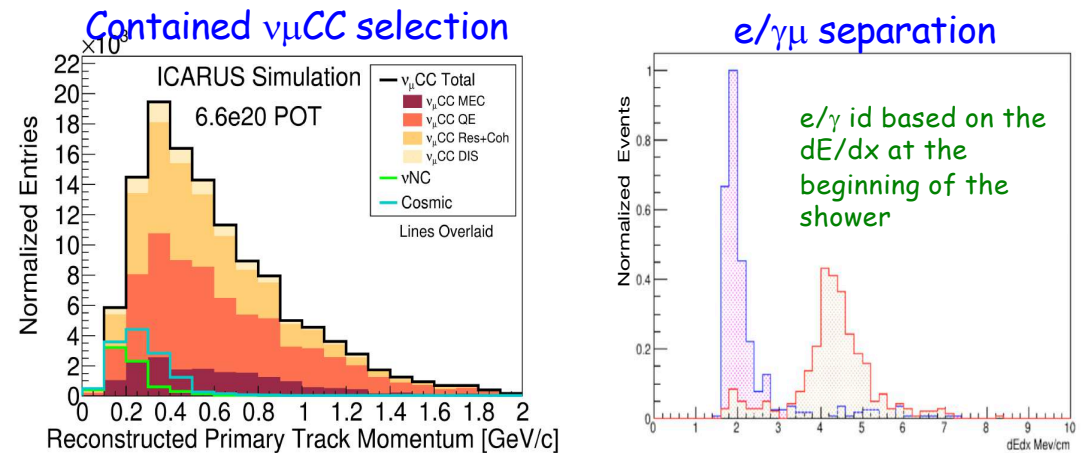
- Unipd is contributing to coordinate together with Fermilab the common activities of the SBN Analysis group in preparation of the oscillation analysis of the SBN project
- This activity is intended to realize simulation and analysis software common to the near and far detectors and to assess residual systematic uncertainties
- A first application of the full analysis chain was performed at the end of 2019 to select $\nu_{\mu}CC$ in both SBND and ICARUS with full simulations of BNB ν events AND overlapping out of time cosmic rays
- The results from this exercise, together with the status of the SBN Analysis activities was presented to the PAC committee of the Fermilab in January by D. Gibin
- Unipd is also coordinating in collaboration with SLAC the preparation of the reconstruction and simulation software specific to ICARUS
- Within the ICARUS trigger group it is also involved in the simulation and reconstruction of the PMT signals and is contributing to the definition and optimization of the trigger

Coordination of a common SBN Analysis

- The first exercise performed in 2019 to select $\nu_{\mu}CC$ in both SBND and ICARUS with full simulations of BNB ν events AND overlapping out of time cosmic rays allowed to identify the reconstruction areas needing upgrades
- The different subgroups started to address these issues and are obtaining significant improvements in the reconstruction tools.
- A special effort was devoted to improve the simulation, addressing possible sources of systematical differences between SBND and ICARUS
- The updated reconstruction tools will then be applied to efficiently recognize the ν interaction and to reject the backgrounds exploiting all the available signals:
 - improved pattern recognition tools will provide the identification of the ν candidates in the TPCs for ν_{μ} and ν_e (vertex id + track/shower id + PID)
 - The matching of the charge and the PMT signals will allow to identify the particles generating the trigger
 - the CRT signals will allow to reject the incoming cosmic particles. The combination of the CRT with the light will mitigate possible autoveto by ν ;
 - a dedicated effort to maximize the CRT usage in order to reduce the dataflow for the reconstruction/analysis is also ongoing

Neutrino selection and background rejection in SBN - next steps

- Promising results were obtained with the 2019 full MC production in the first full analysis loop



- Launching a new massive MC production of BNB ν interactions + overlapping off-time cosmics, including the several improvements of the last months.
- Quantify in the near term how the improvements and the tuning of the reconstruction impact on the selection and reconstruction efficiency of BNB ν interactions and on the mitigation of the overlapping off-time cosmics
- Compute the sensitivity contours including also flux and interaction systematics together with a first detector response error model
- Planning to investigate a different approach to the event selection, making more effective usage of the CRT and inner light information from the very beginning as tools to decimate the background events and reduce computing and storage resources.