Status of the Short-Baseline Near Detector

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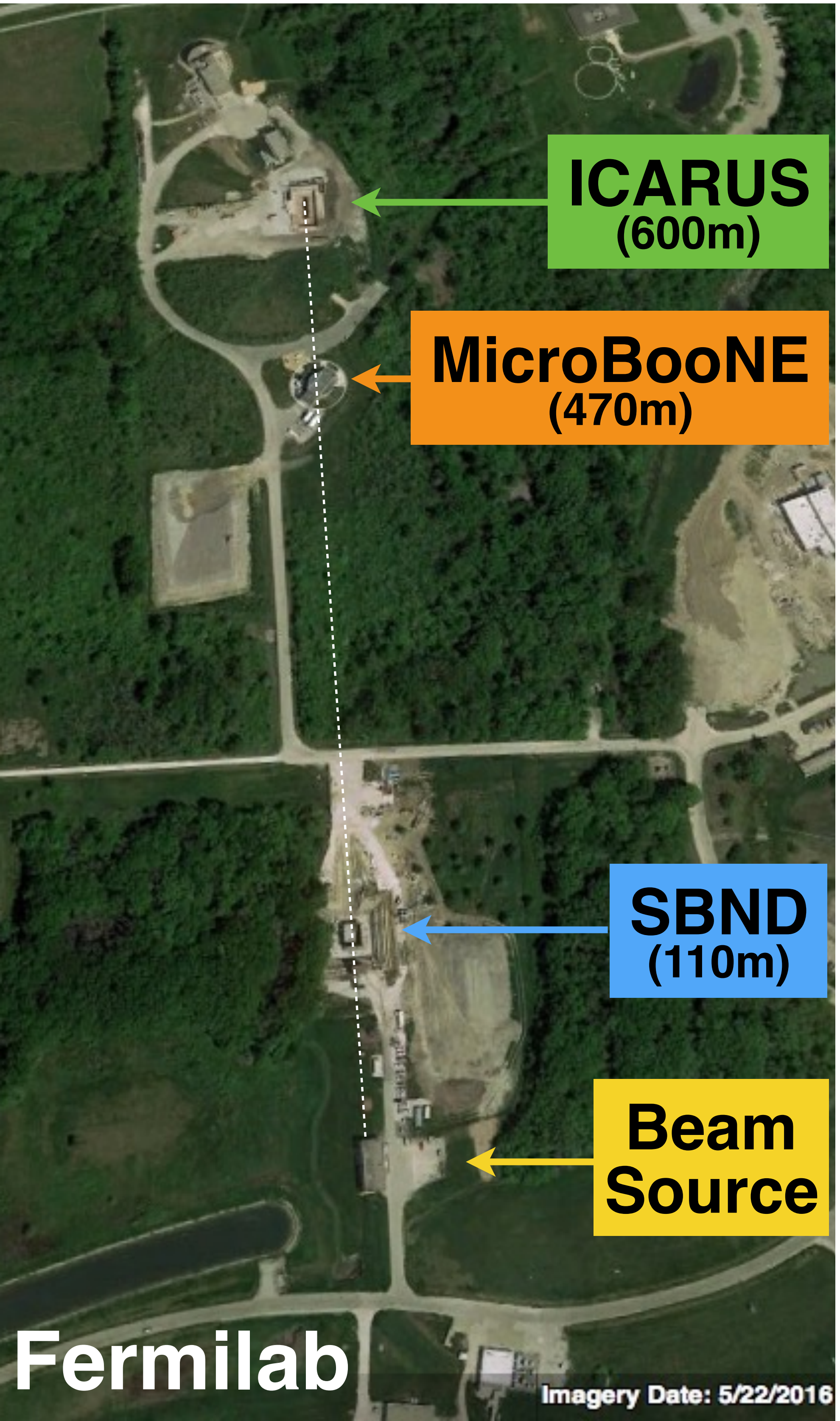
Fermilab
(On behalf of the SBND Collaboration)

NuFact 2018,
Virginia Tech, VA
August 14th, 2018

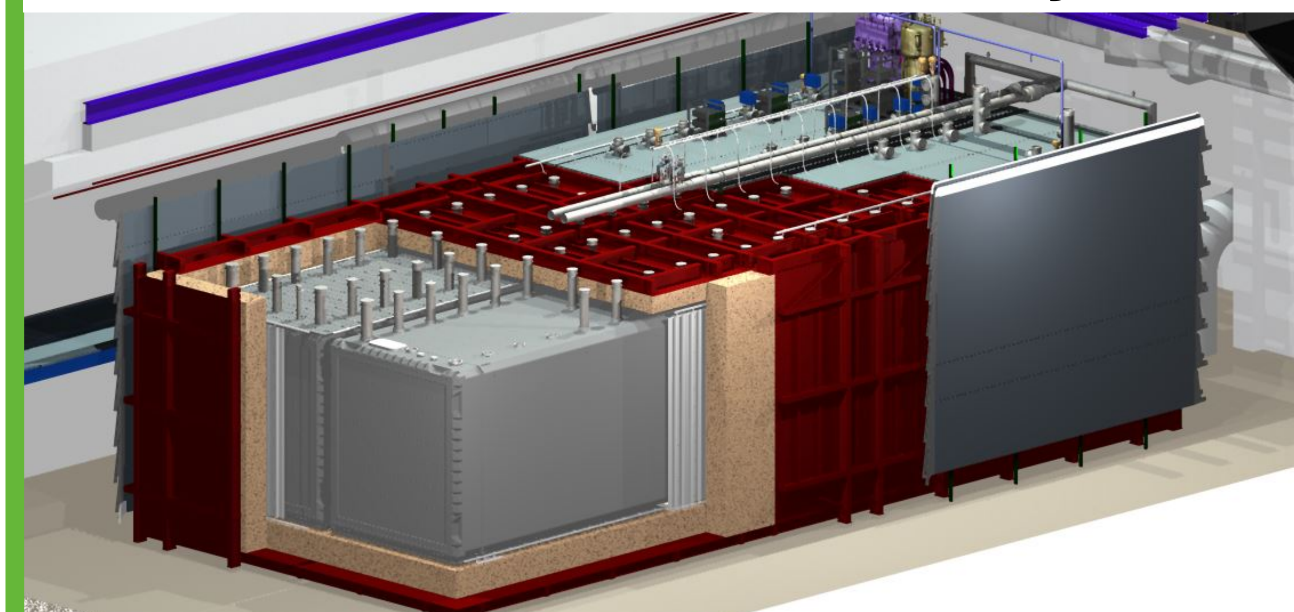
SBN Program

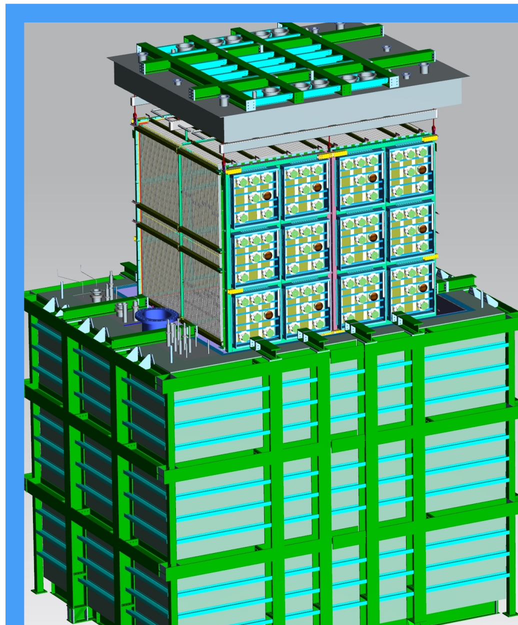
See A. Fava's talk Thursday

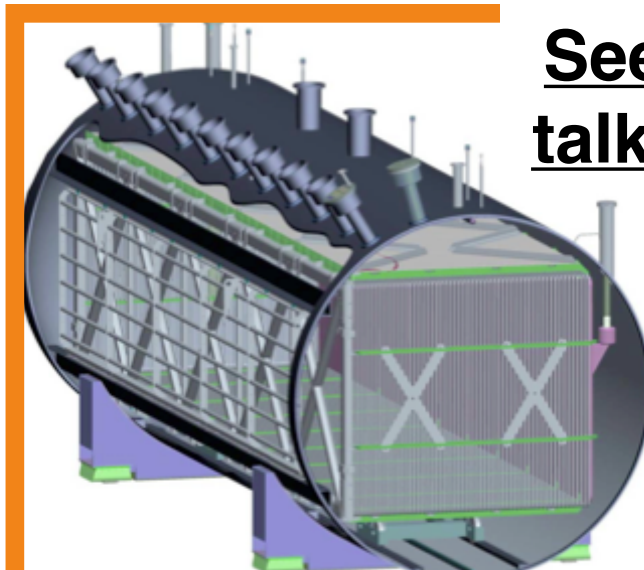


Three detectors at different baselines from the Booster Neutrino Beam searching for sterile neutrino oscillations

See Y.T. Tsai's talk Friday

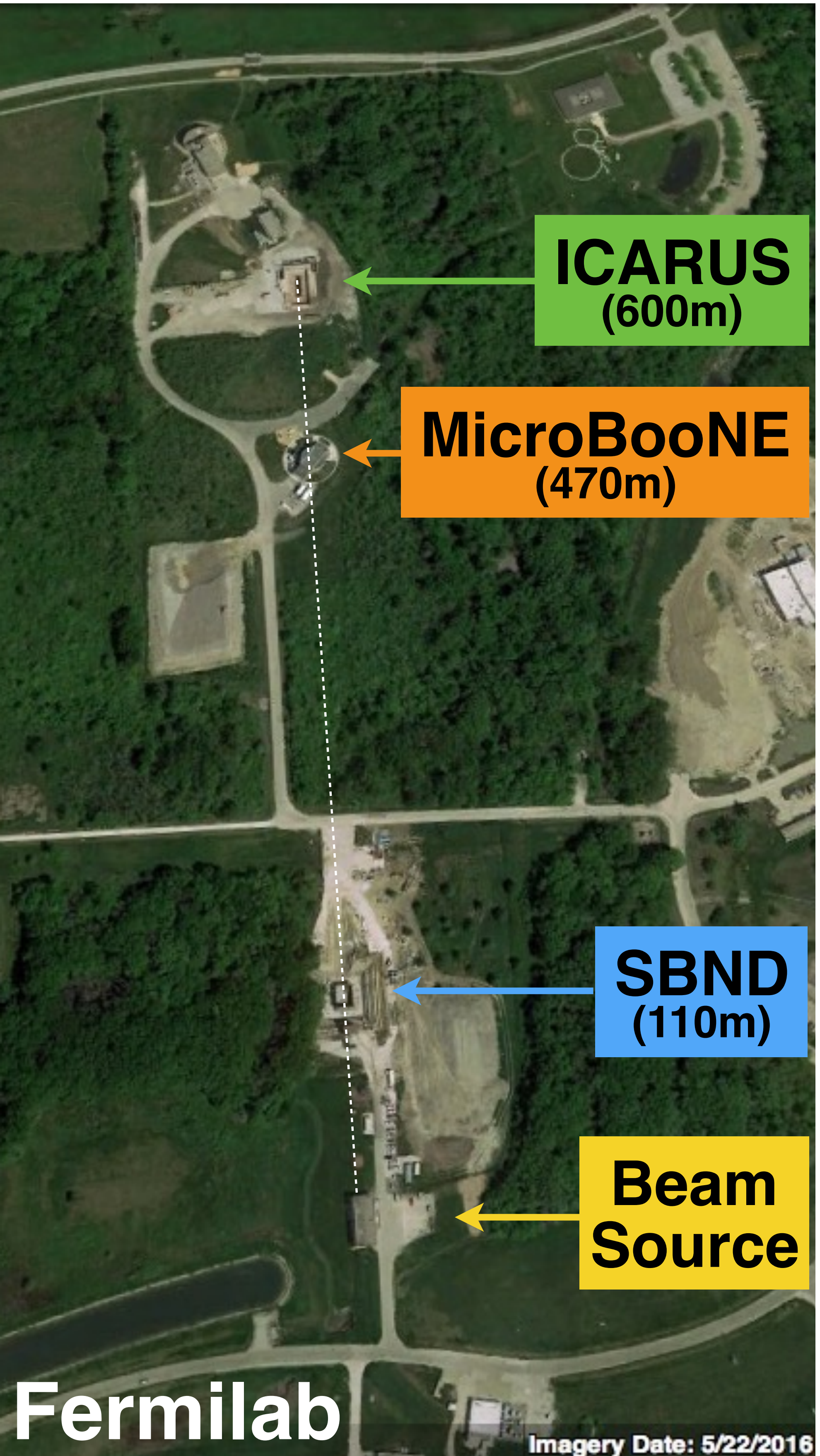






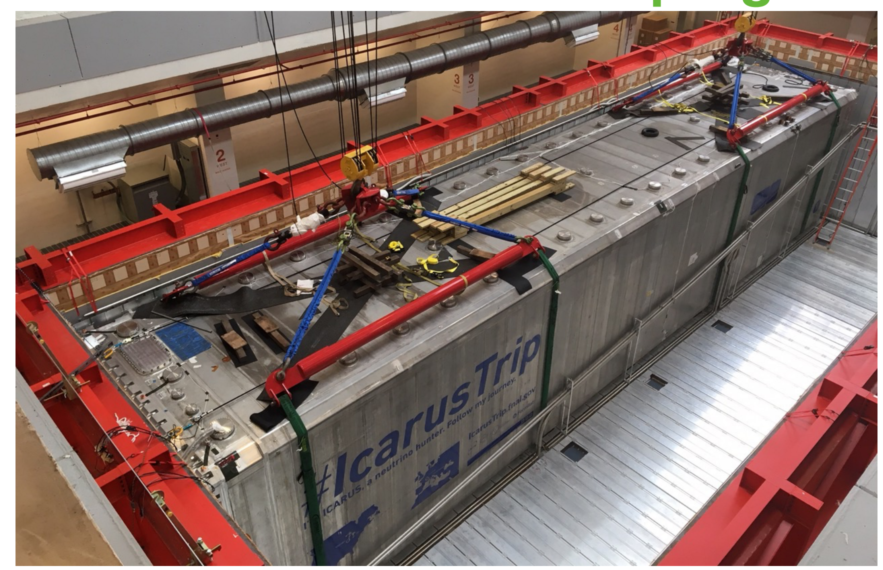
See L. Jiang's talk previously

SBN Program

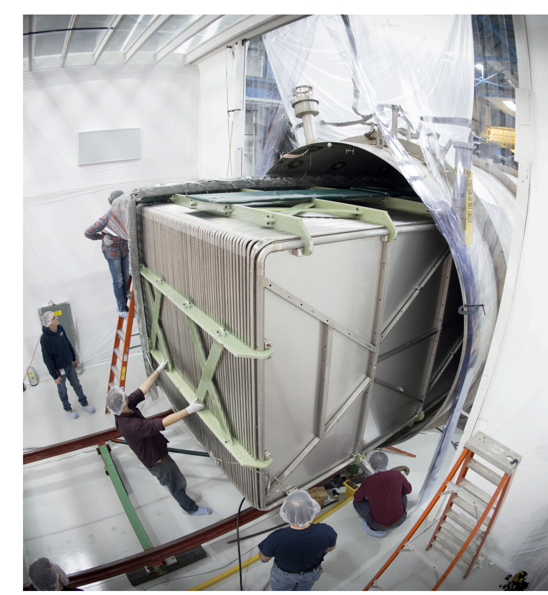


Three detectors at different baselines from the Booster Neutrino Beam searching for sterile neutrino oscillations

Cold vessel installation in progress…

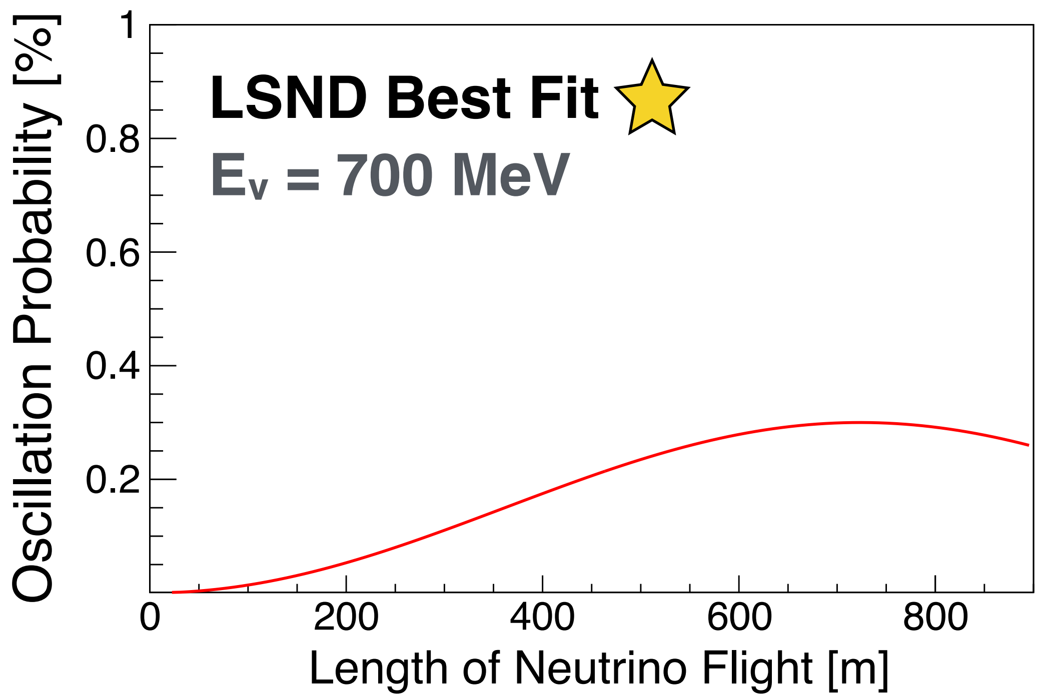


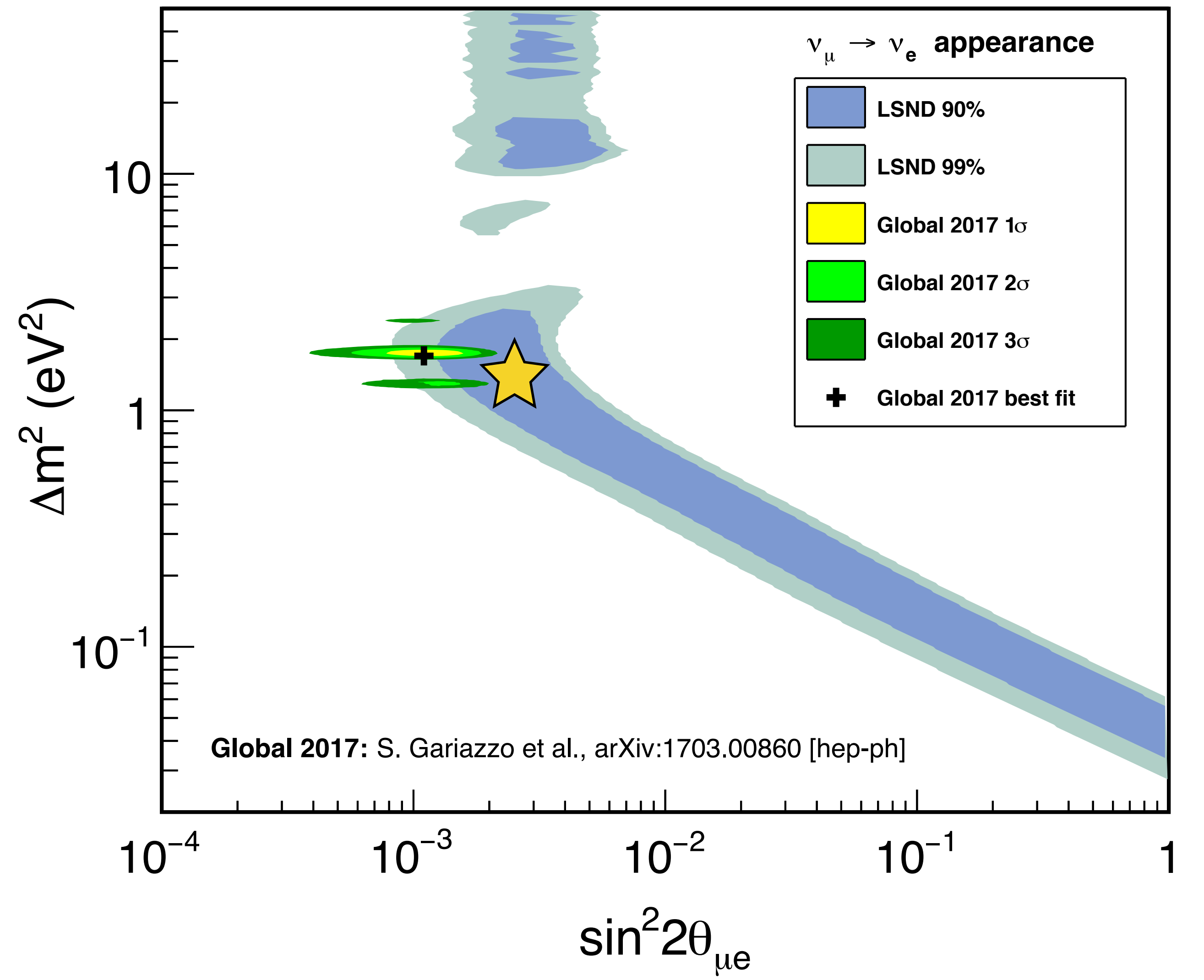
First wire planes completed!



Data taking started in 2015!

Sterile Neutrino Oscillations





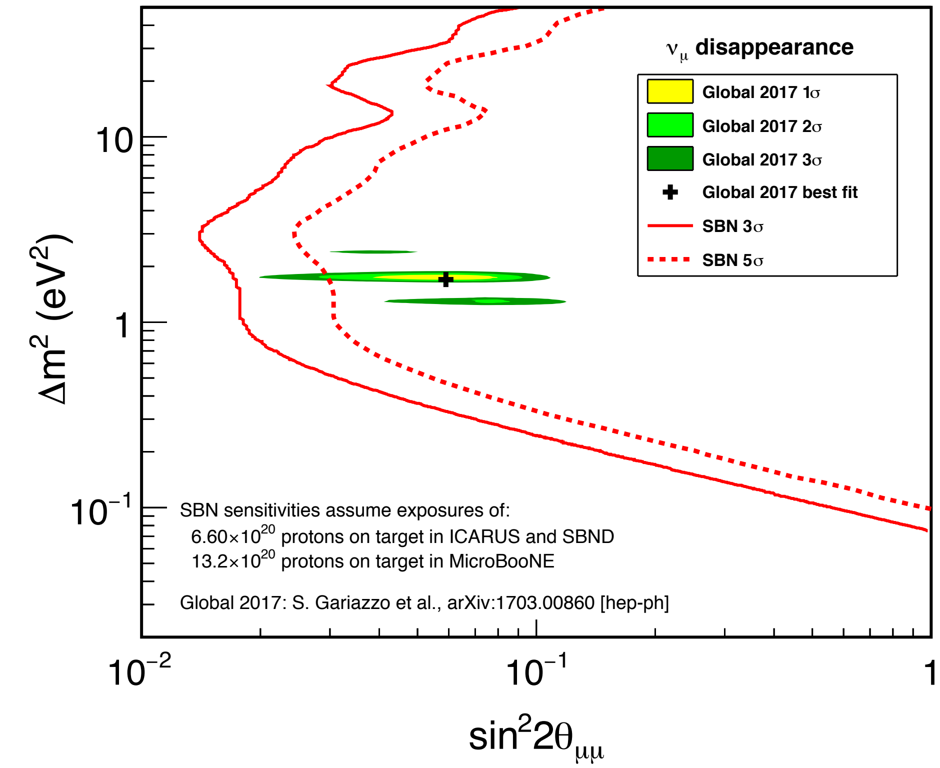
- Fits of world data for sterile neutrino oscillations point to minuscule oscillation probabilities (<1%)
- Resolving such small signals will require careful control of systematic uncertainties

Power of the Multi-Detector Program

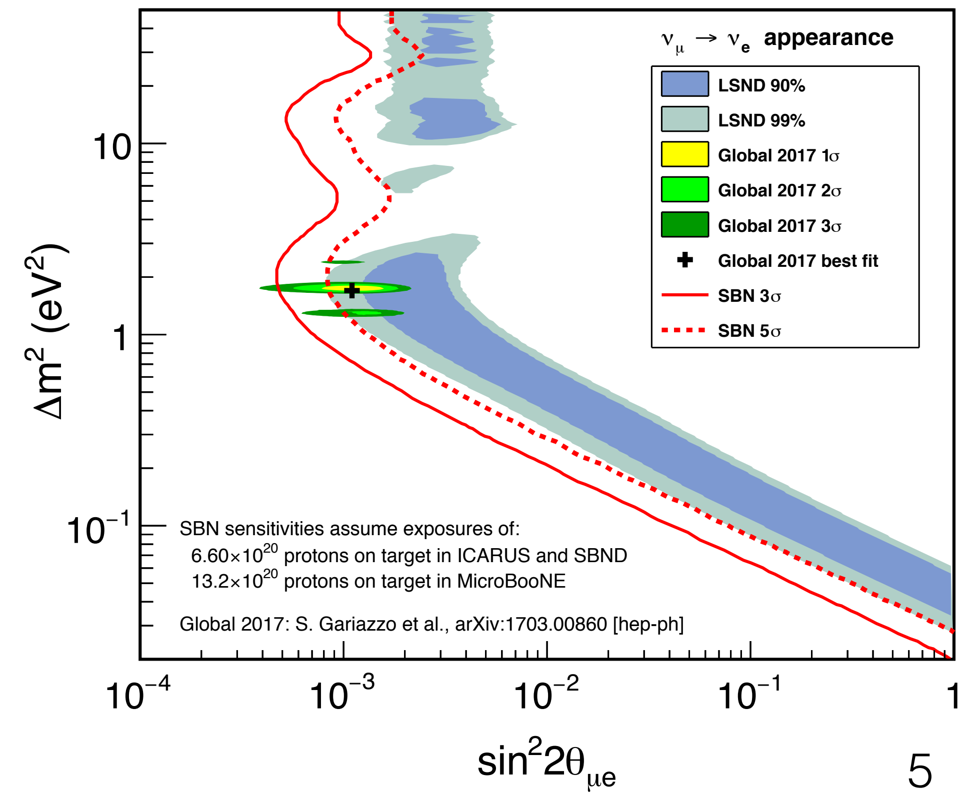
- Bringing together three functionally identical detectors enables us to constrain systematic uncertainties to the percent level

- This enables us to perform searches for both ν_μ disappearance and ν_e appearance in the same experiment
  - Will explore the global best fit points at better than 5σ in both channels

- SBN Program aims to be a definitive experiment in the search for sterile neutrino oscillations



SBN 3σ
SBN 5σ
3 years exposure

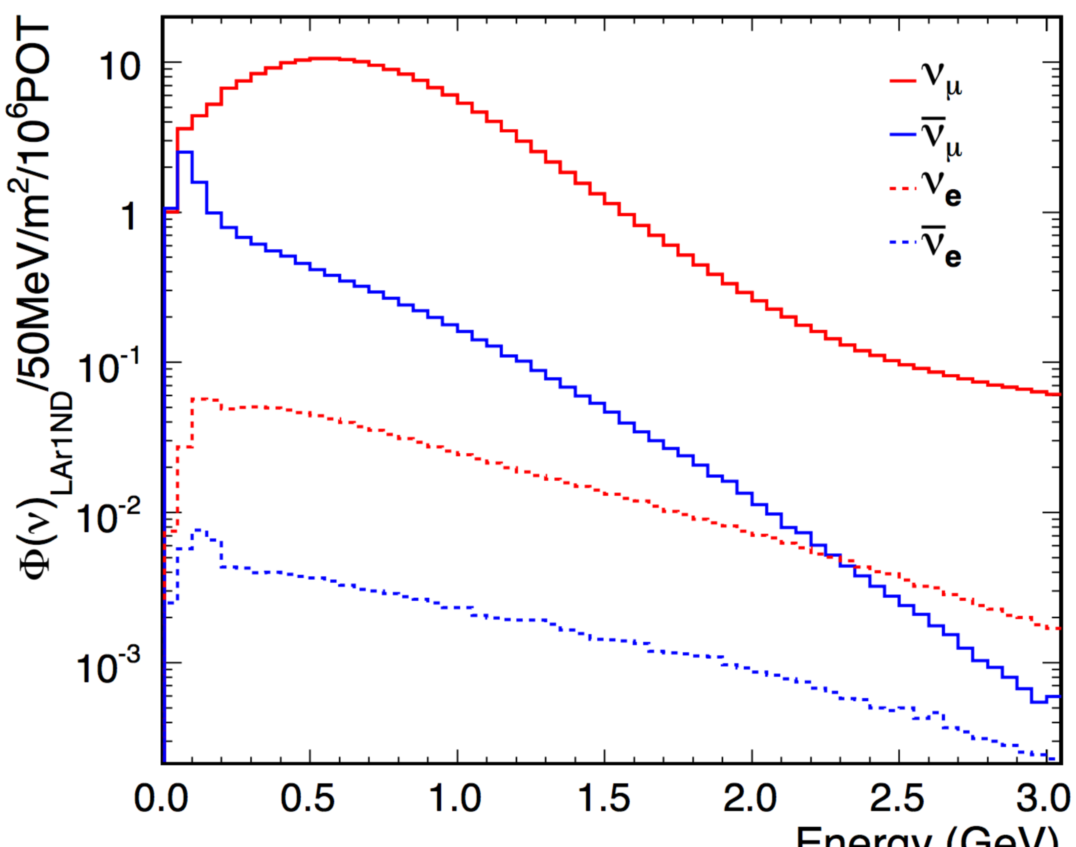


SBND Cross Section Program

- SBND builds upon the cross section program of MicroBooNE
  - Offers significant new paradigm shift in studying neutrino interactions

- **Large mass and near location means SBND will collect more than 5 million ν_μ CC inclusive events in 3 years**
  - Build upon the MicroBooNE program with high statistics differential measurements
  - MicroBooNE expects to see 150,000 ν_μ CC inclusive events in the same beam exposure

- These event rates will allow us to perform stringent tests of our neutrino interaction models



SBND For Rare Cross Sections

- These incredible event rates will enable us to probe rare processes
  - Modern measurements of neutrino production of hyperons, charm-baryons, and other rare processes enabled with 100s of events
- Using >10,000 ν_e CC interactions to directly study low energy ν_e+argon scattering

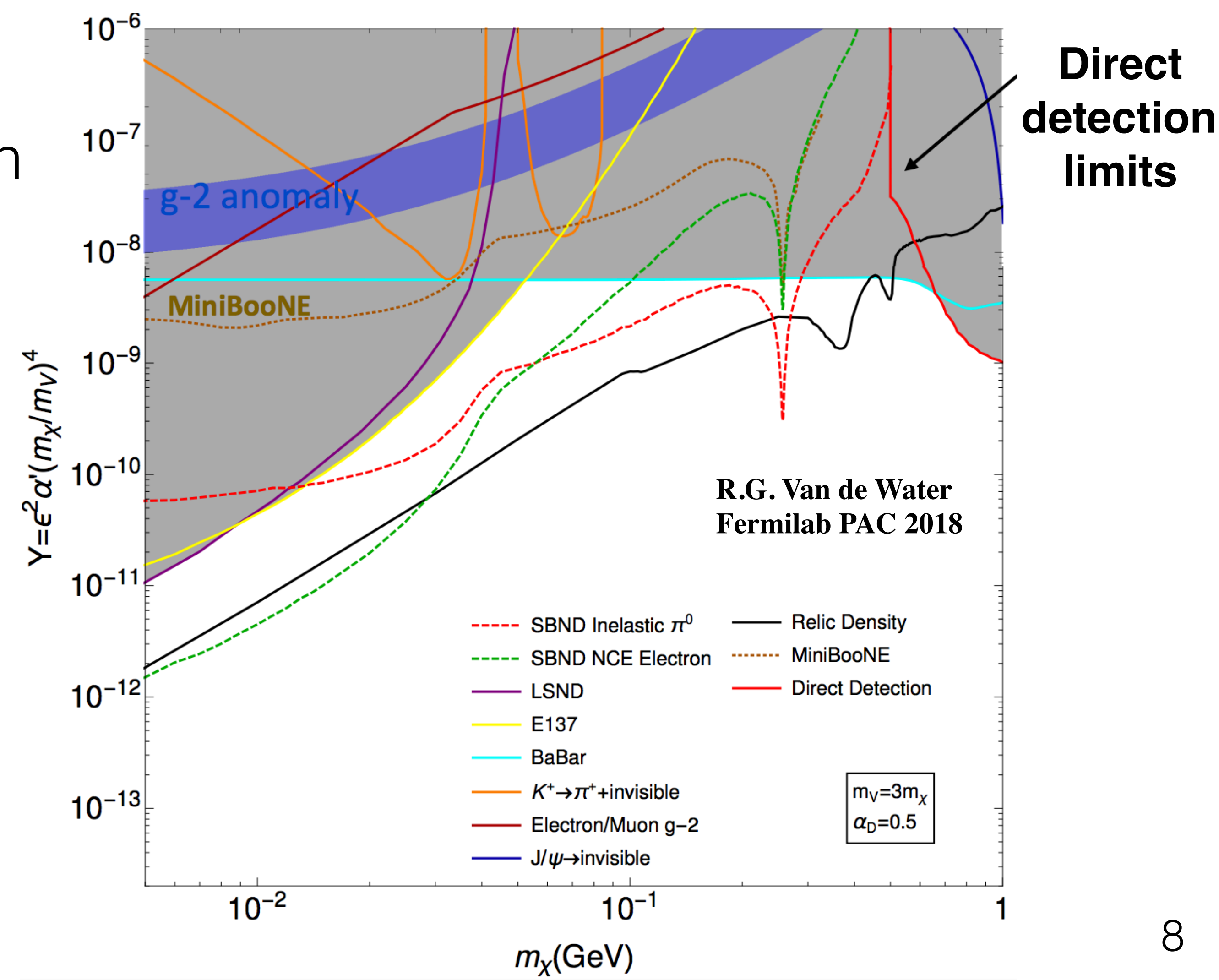
3 year event rates

	Charged Current
ν_μ Inclusive	5,389,168
$\rightarrow 0\pi$	3,814,198
$\longrightarrow 0p$	27,269
$\longrightarrow 1p$	1,261,730
$\longrightarrow 2p$	1,075,803
$\longrightarrow \geq 3p$	1,449,394
$\rightarrow 1\pi^+ + X$	942,555
$\rightarrow 1\pi^- + X$	38,012
$\rightarrow 1\pi^0 + X$	406,555
$\rightarrow 2\pi + X$	145,336
$\rightarrow \geq 3\pi + X$	42,510
$\rightarrow K^+K^- + X$	521
$\rightarrow K^0\bar{K}^0 + X$	582
$\rightarrow \Sigma_c^{++} + X$	294
$\rightarrow \Sigma_c^{+} + X$	98
$\rightarrow \Lambda_c^{+} + X$	672
ν_e Inclusive	**$\approx$ 12,000**

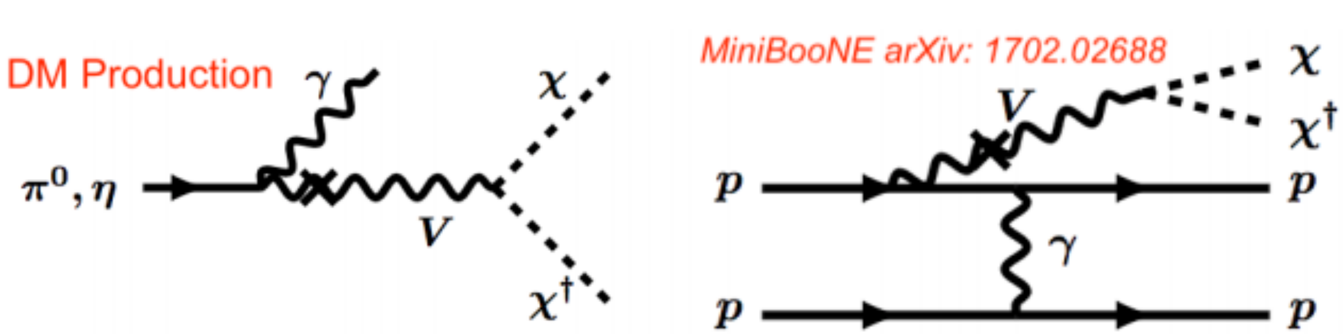
SBND for BSM Physics

- Thanks to its near location and low thresholds SBND can explore new phase-space for direct dark-matter production

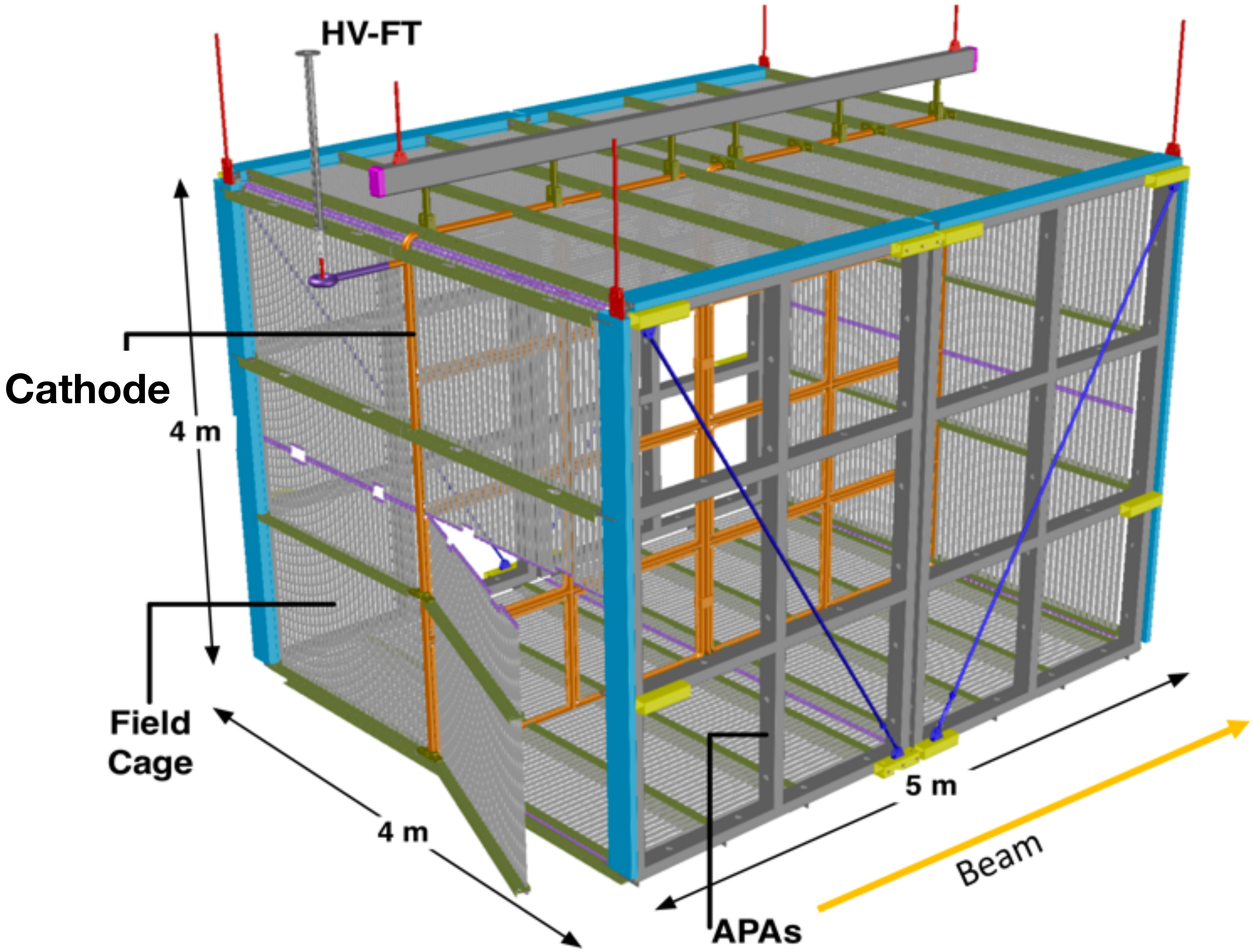
- Many channels offer complementary probes
  - Dark matter scattering off electrons (sensitive for low mass DM) or scattering off nucleus (sensitive for high mass DM)
  - Searches for decays of heavy mediator or heavy sterile neutrino decays through unique topologies



Dark Matter Production



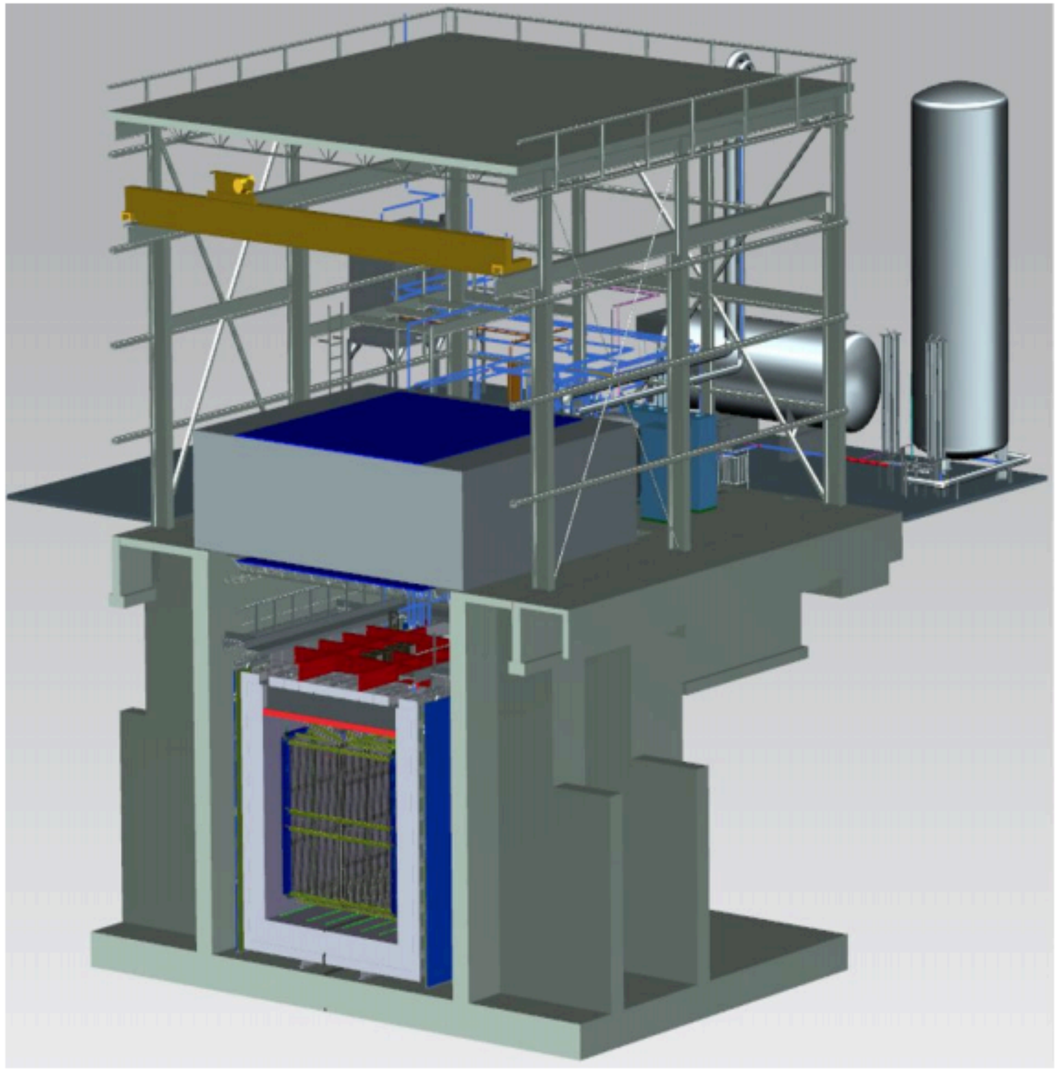
What's in a Near Detector?



- SBND is made of two TPCs with two wire-planes making up each read-out
- A cathode placed in the center of the detector allows for more stable HV operation
  - 2 meter long drift distance

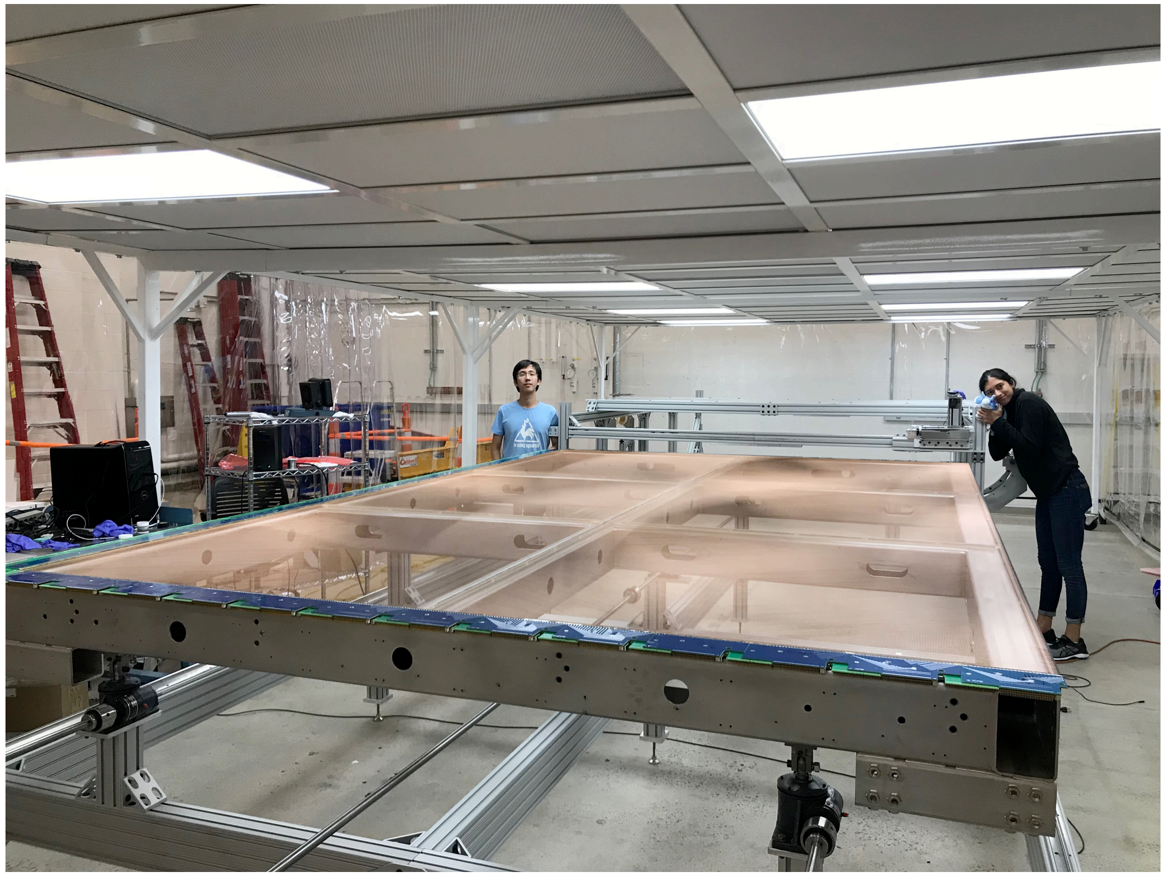
Detector components are built globally by large international collaboration and assembled at Fermilab

Status on SBND Construction

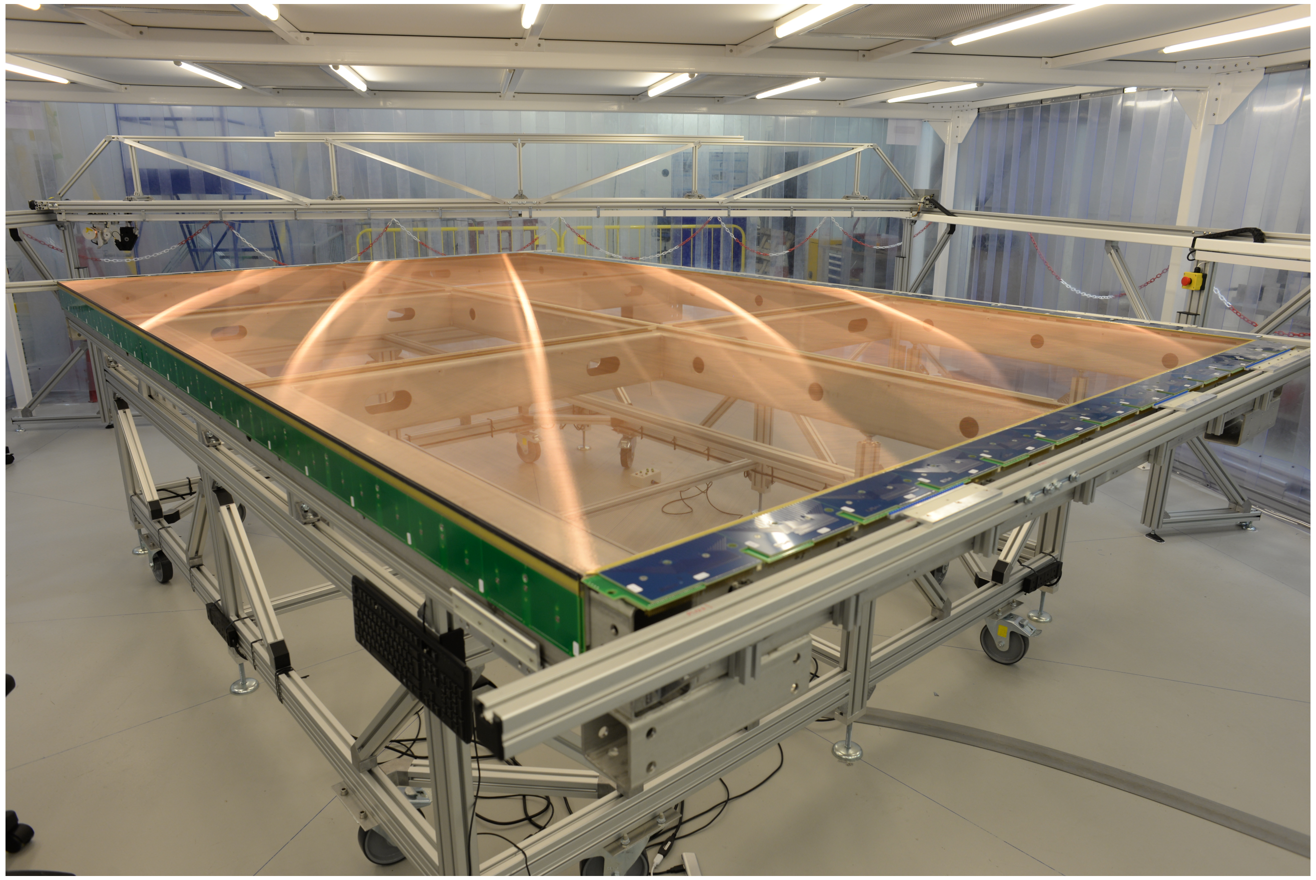


Wire Planes

US Facility

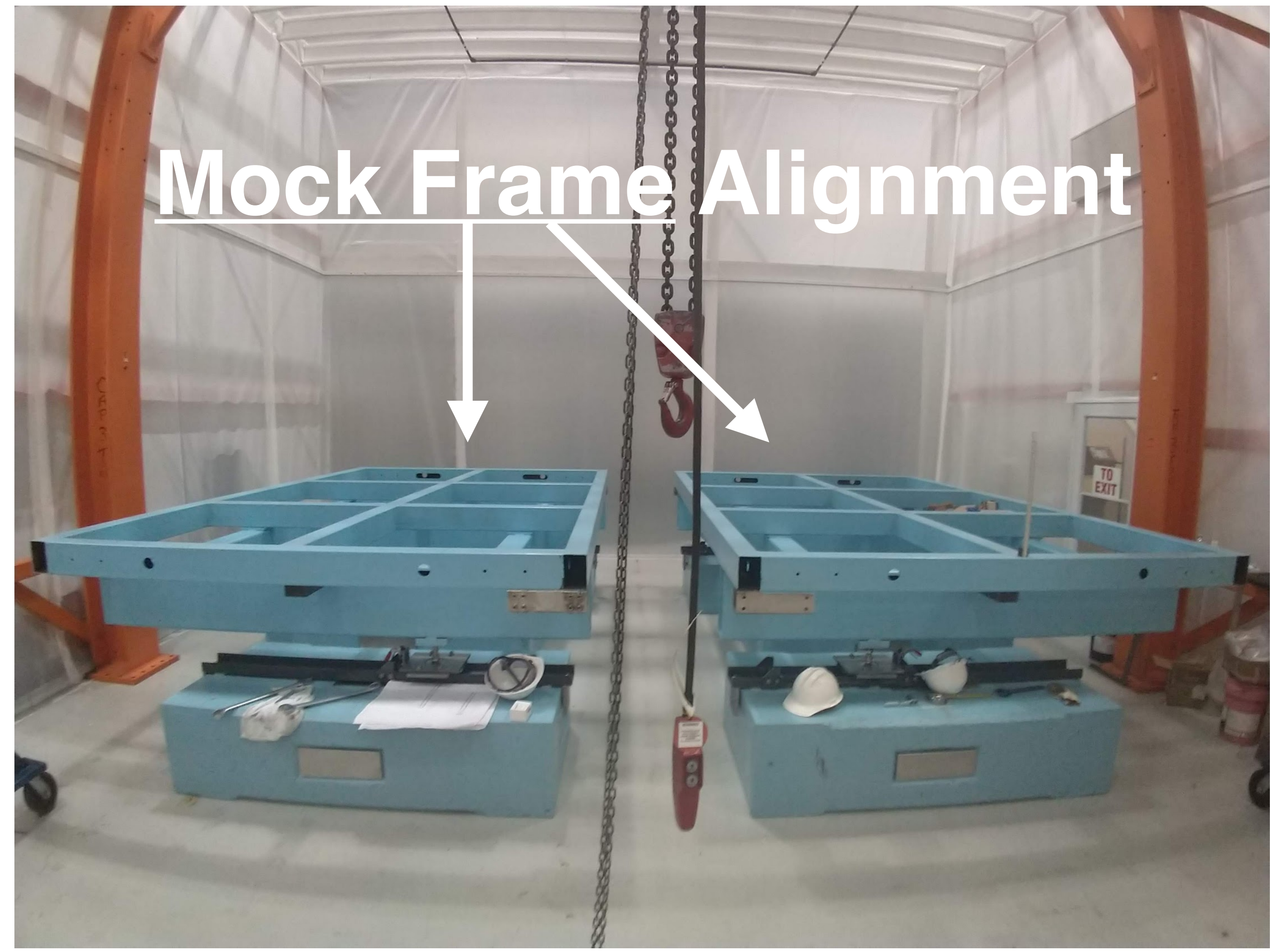


UK Facility



- We have two wire plane fabrication facilities working on making one half our readout planes each
  - **Both halves of the first plane completed wiring!**
  - Awaiting quality testing before being shipped to Fermilab

Combining Wire Planes

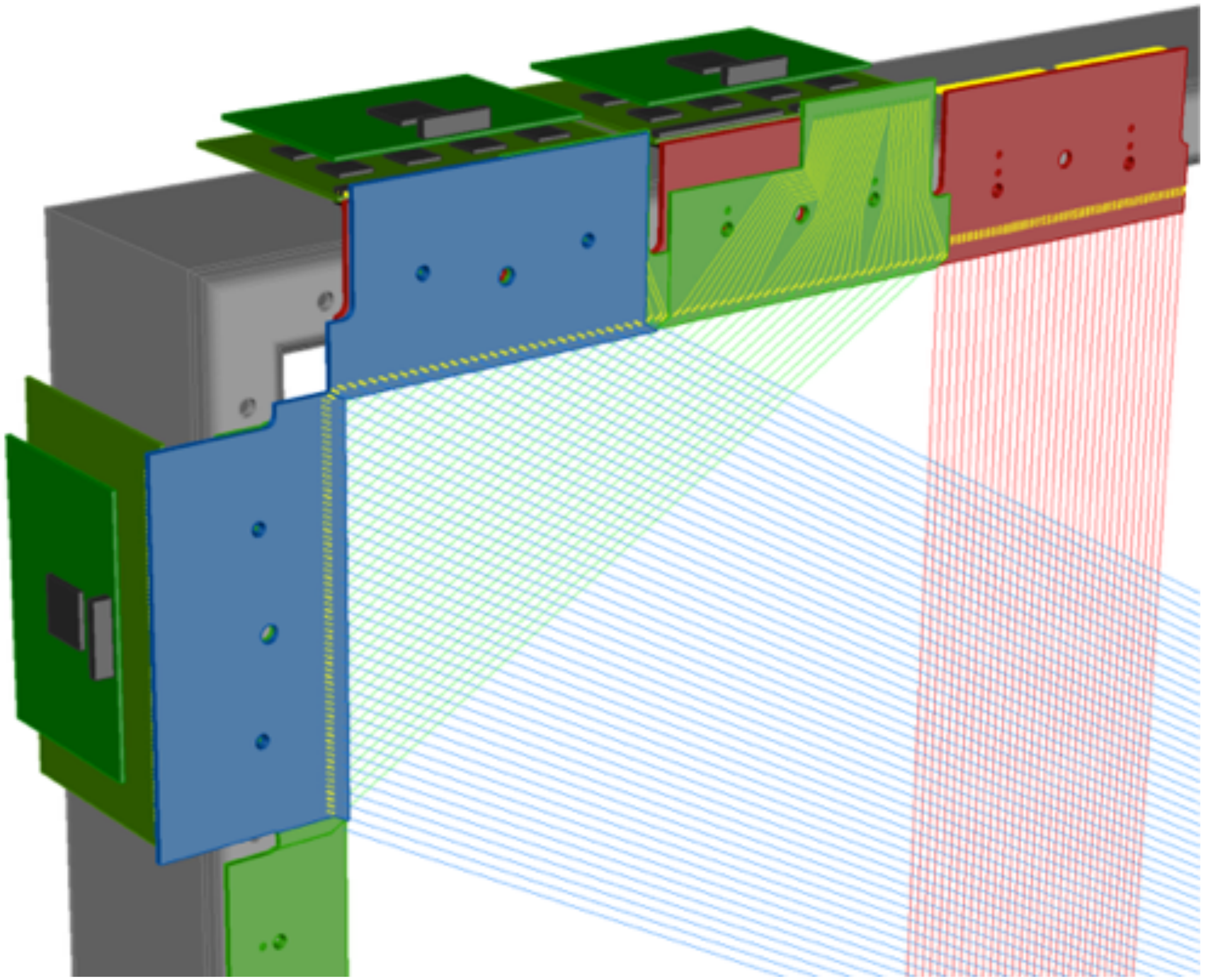


- Once they arrive at Fermilab they will be leveled and then mechanically and electrically coupled

- Full assembly facility currently performing a dry run with a set of mock frames

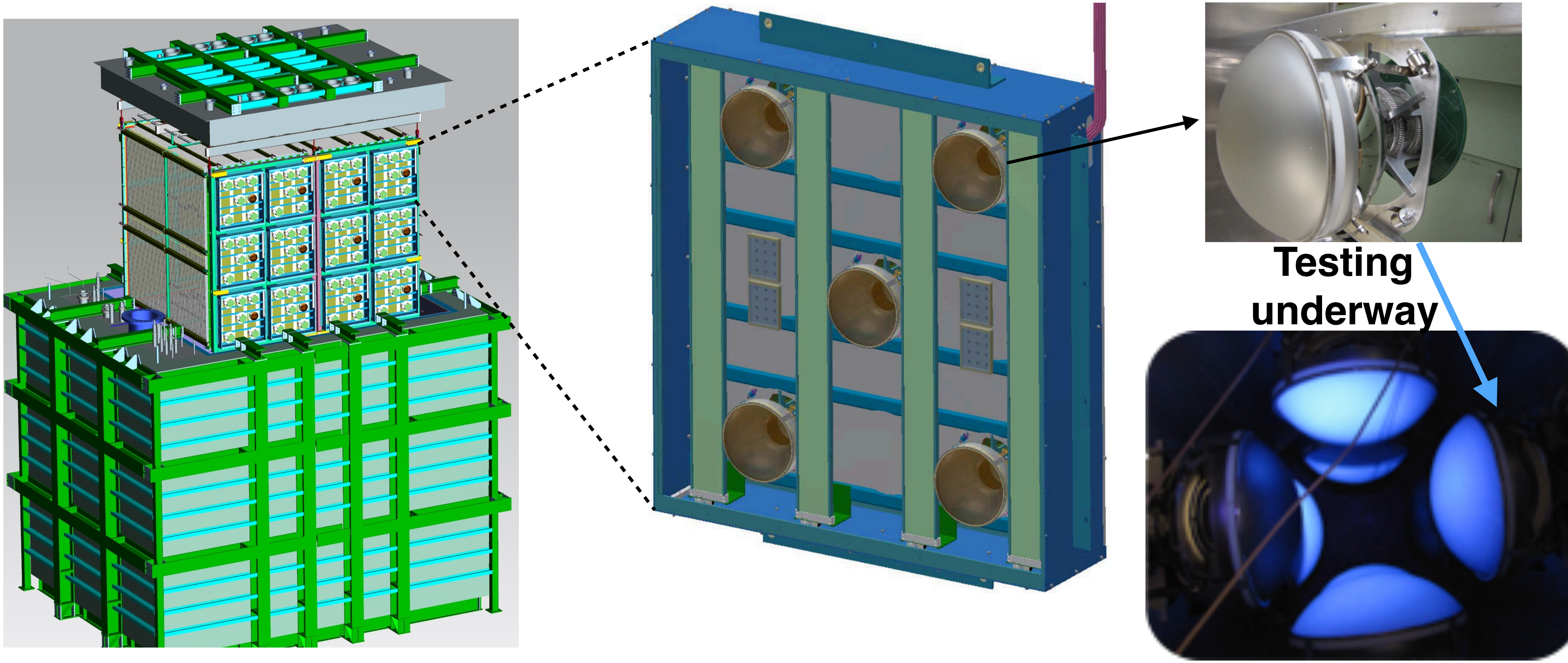
Electronics Readout

Wire planes will be read-out in the cold to minimize electronics noise, commercial ADCs are being tested



SBND electronics tests occurring in LArIAT at Fermilab

Light Readout

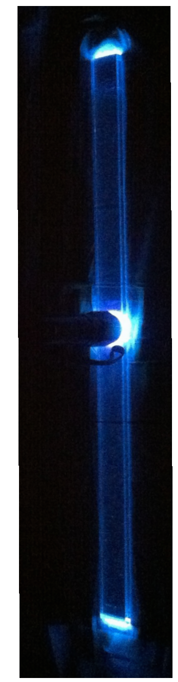


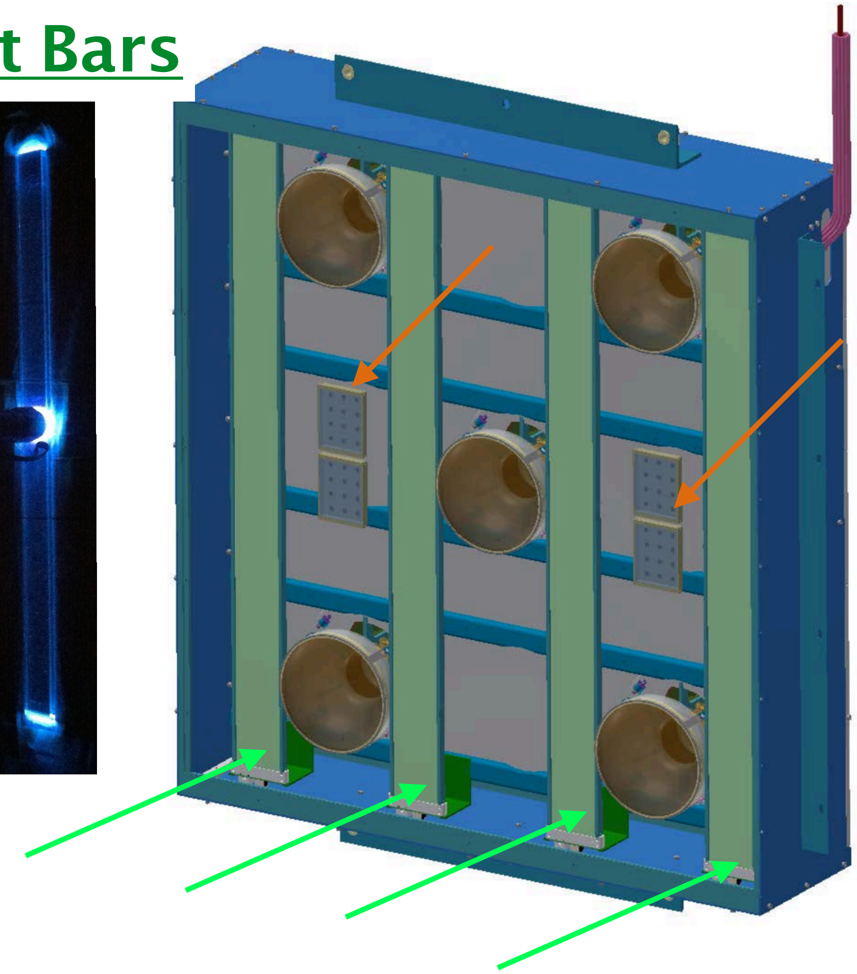
- Array of PMTs will sit behind the wire-planes
- Large number of PMTs enables us to collect an order of magnitude more light than past LArTPCs (~15 PE/MeV at cathode)
  - **Can use light for calorimetry as well as timing in the interaction**

Light Collection Test-bed

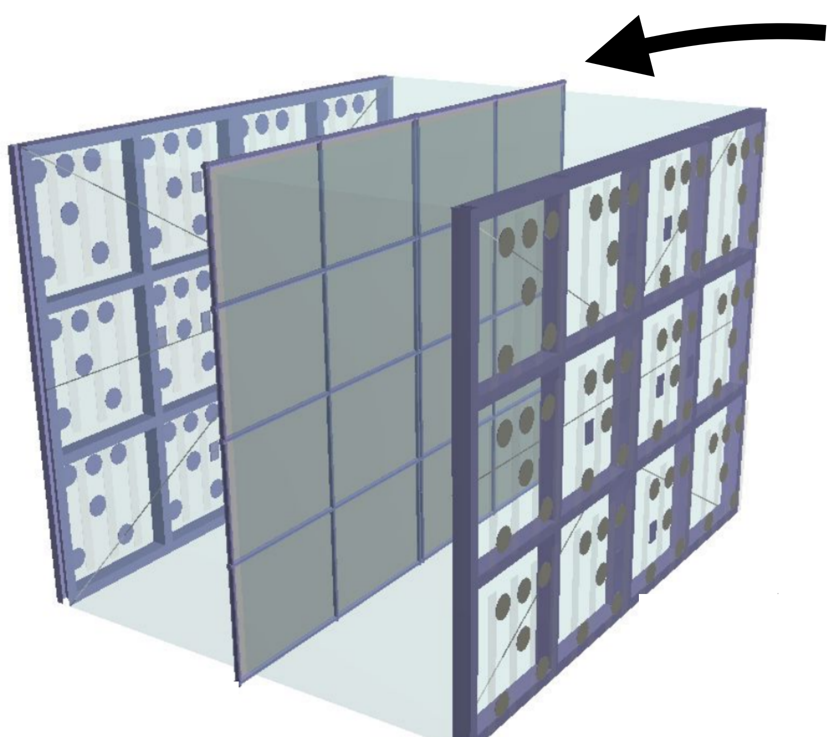
- Implemented new ideas for light detection to complement the PMTs
- Enables side-by-side comparison of new technologies for next generation detectors

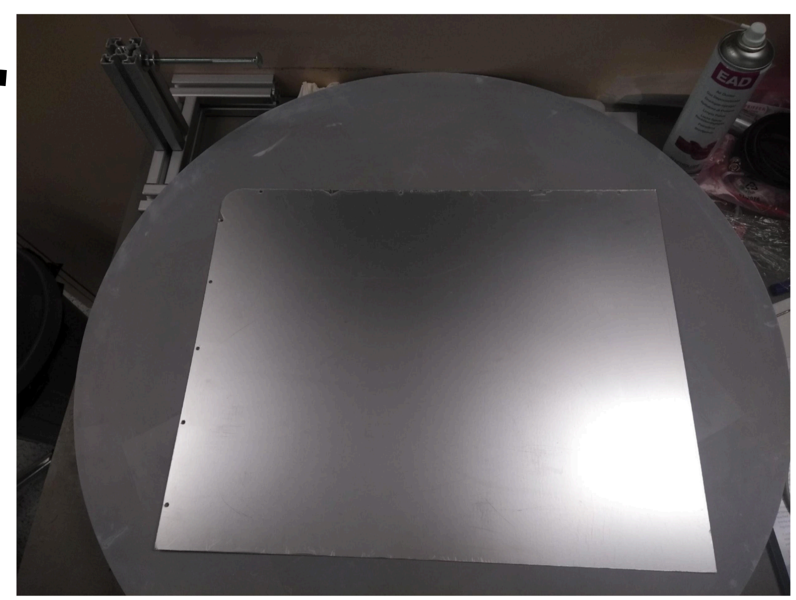
Light Bars



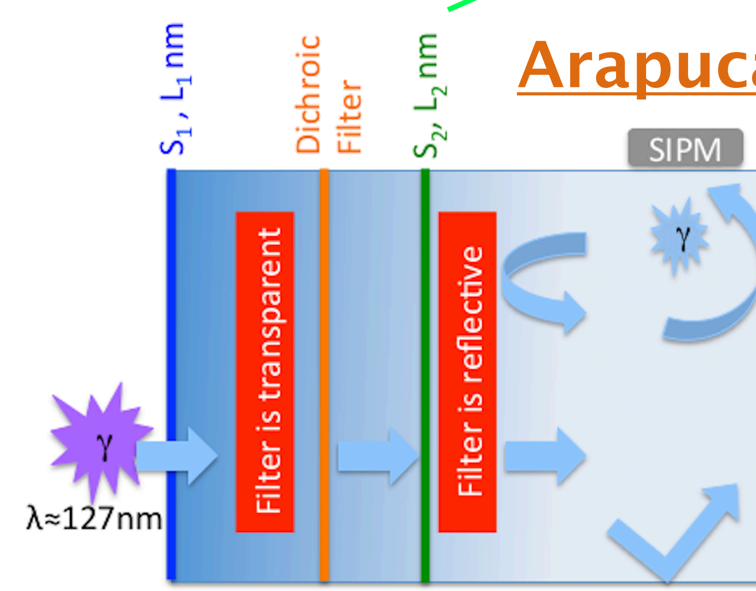


TPB Coated Reflector foils



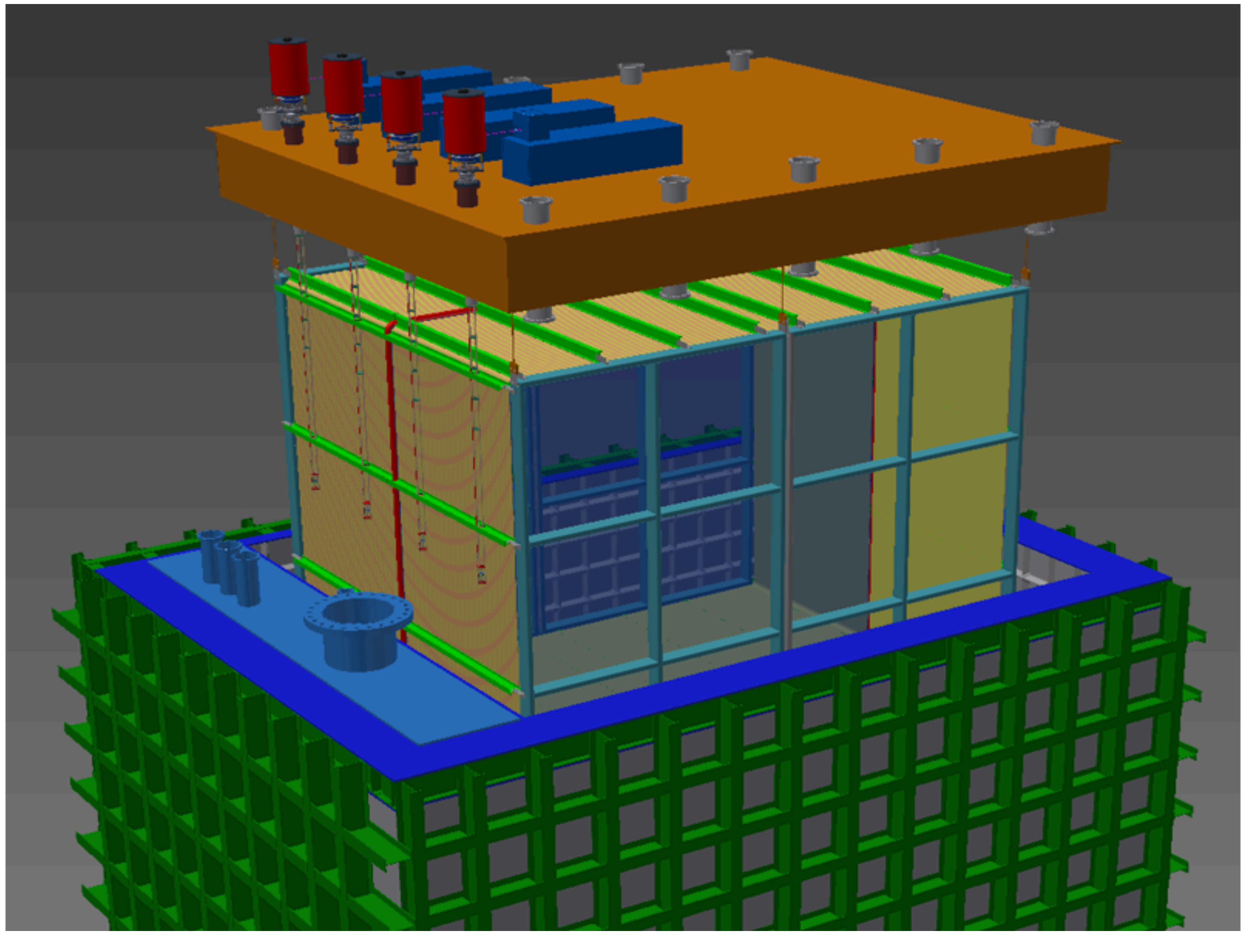


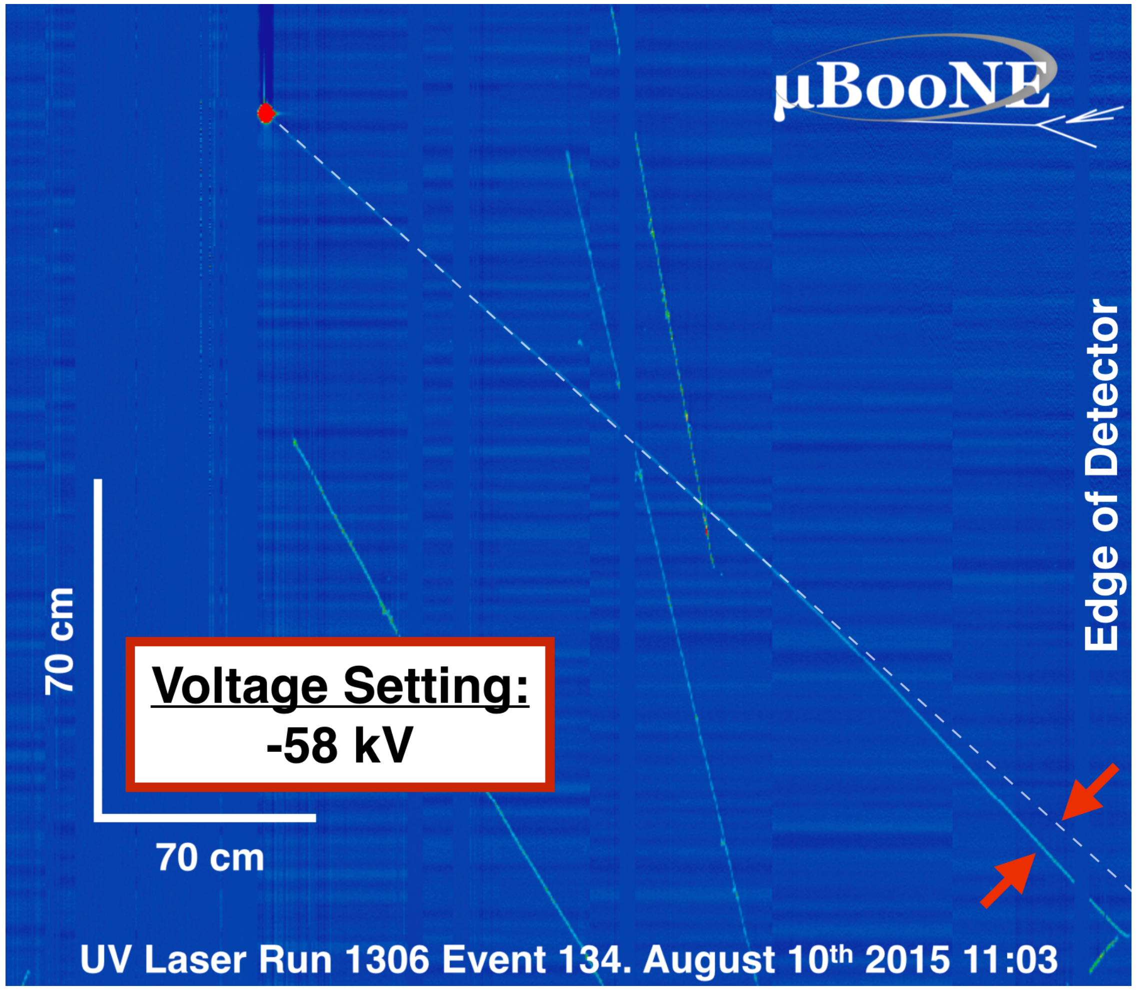
Arapucas



A. A Machado and E. Segreto, JINST 11 2016

UV Calibration Lasers

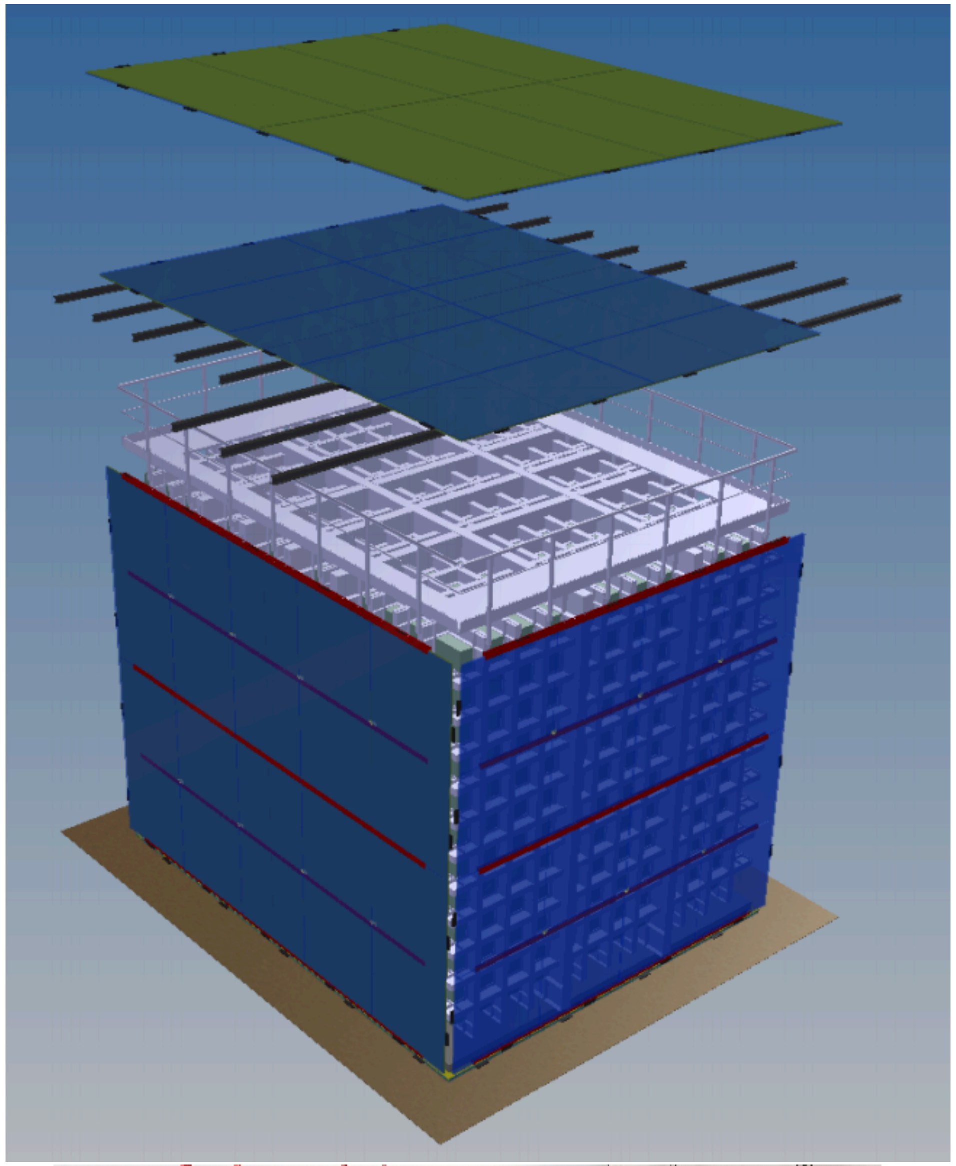




- A major source of systematic uncertainty within SBN will be those associated with detector calibrations
- SBND deploys four calibration laser to create known straight tracks for measuring deformations in the localized electric field
    - This cannot happen coincident with nominal data-taken

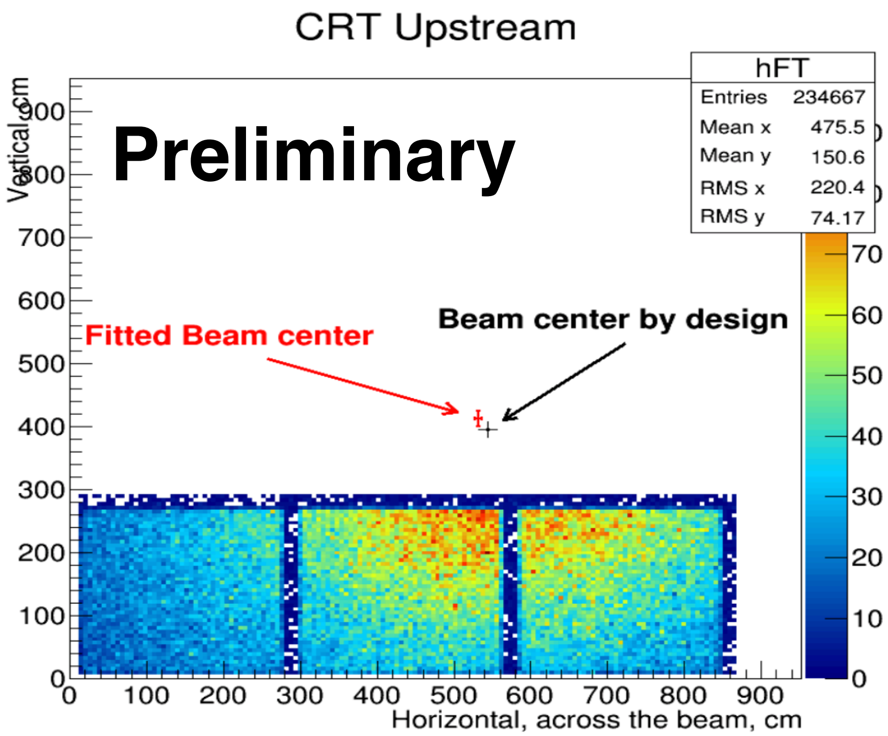
Cosmic Tagging

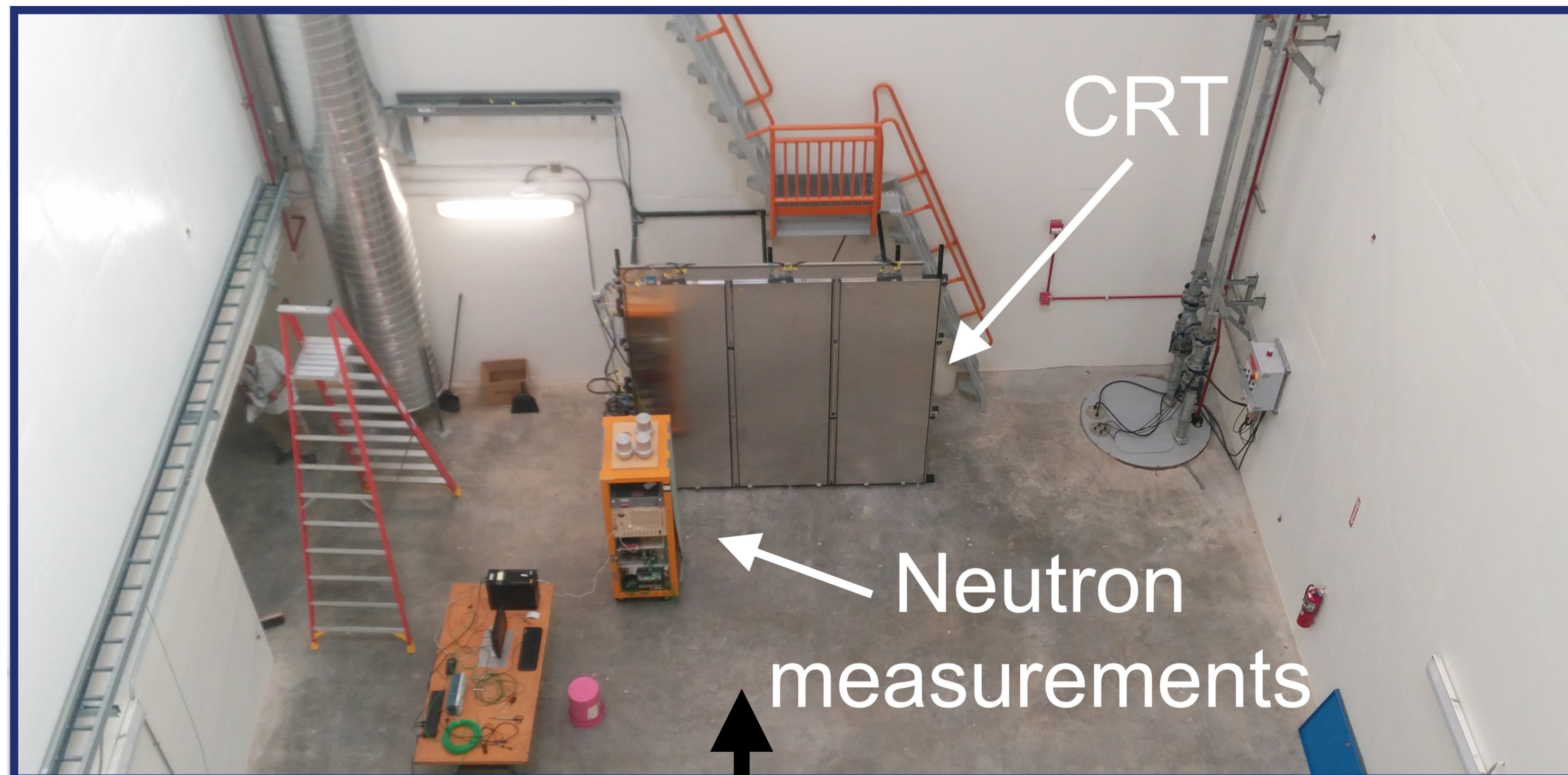
- Being a surface LArTPC O(10) of cosmic rays will cross detector each read-out
- 4π cosmic tagger will surround the detector and enable precise timing and position information of muons
- Tagging muons enables real-time calibration during nominal running
  - This can complement the laser calibration by enabling E-field calibration near edges of the TPC and checking stability during nominal running



CRT panels in SBND Building

Characterizing Beam





Neutrino Beam

- **Installed CRT panels and neutron detectors in hall to begin work to characterize external backgrounds**
    - Muons signals coincident with the beam shows that we will be able to resolve the shape of the beam in SBND

Conclusions

Thanks from SBND!

- SBND provide direct data-driven constraint for sterile neutrino oscillations search
- Near location will enable SBND to be a game-changing experiment for studying neutrino-argon interactions
- Test-bed for LArTPC technologies
- Detector fabrication is fast underway!
    - Data taking is scheduled to begin 2020