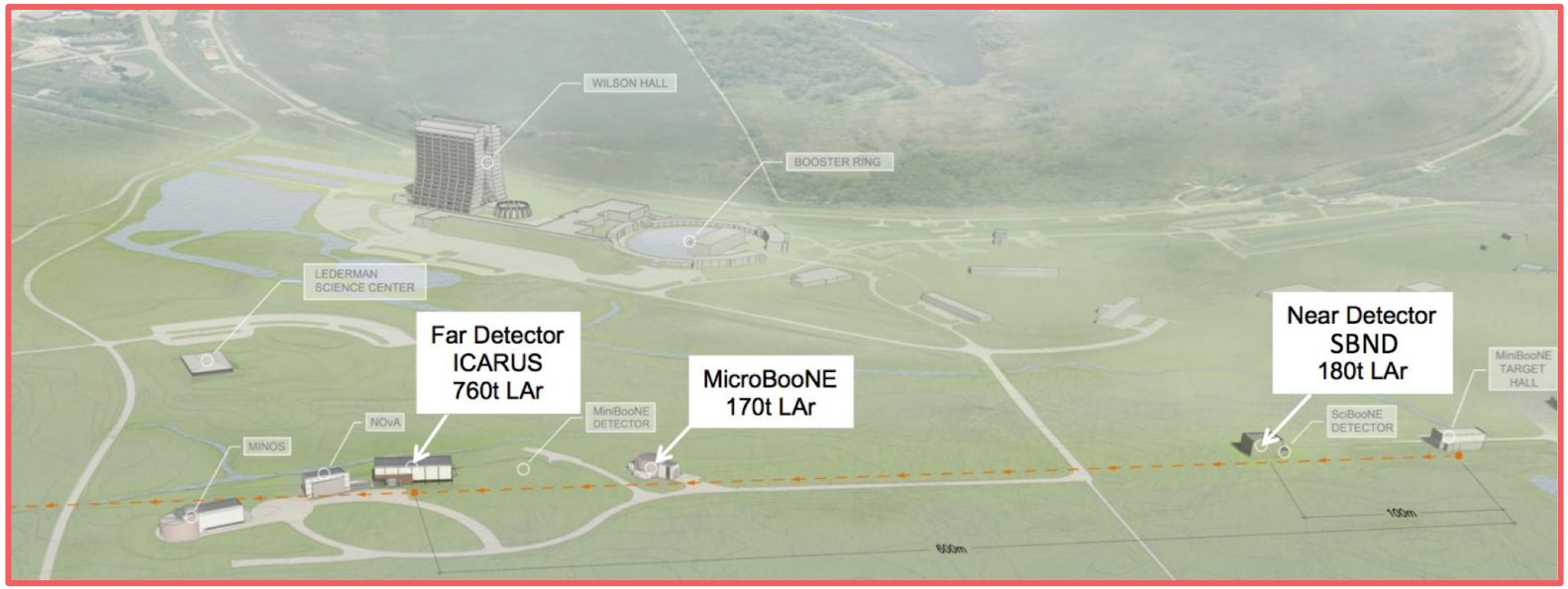
# SBND
# in 10 minutes

Mônica Nunes


# SBND: Short Baseline Near Detector



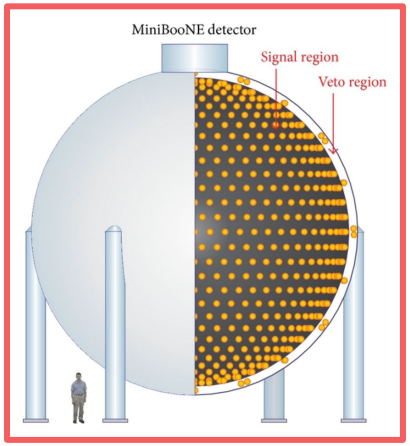

SBND will be the Near Detector for the Short Baseline Program at Fermilab;
Booster Neutrino Beam (BNB);
Three LArTPCs: SBND, MicroBooNE and ICARUS.

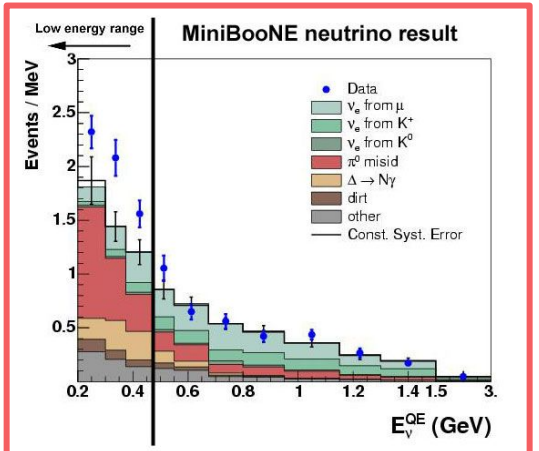
# SBN: Motivation

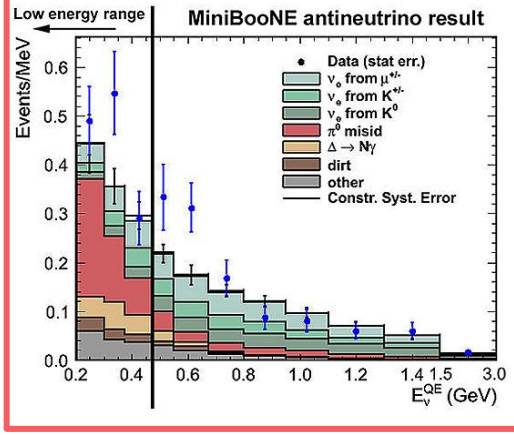
**Evidence** for an electron-like **excess** from neutrinos from particle accelerators (the "LSND and MiniBooNE anomalies").

**Low Energy Excess Problem!**

- Cherenkov detector.
- Booster Neutrino Beam - Fermilab.
- Short Baseline.
- A clear excess in $\overline{\nu}_\mu \rightarrow \overline{\nu}_e$ and $\nu_\mu \rightarrow \nu_e$ appearance is observed in a low energy range.

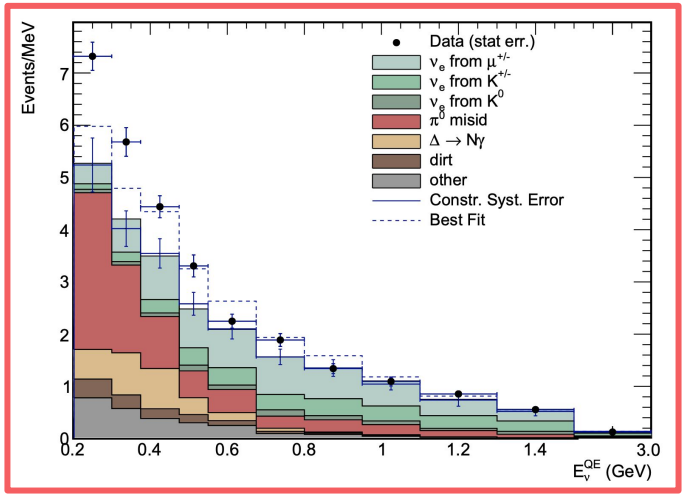


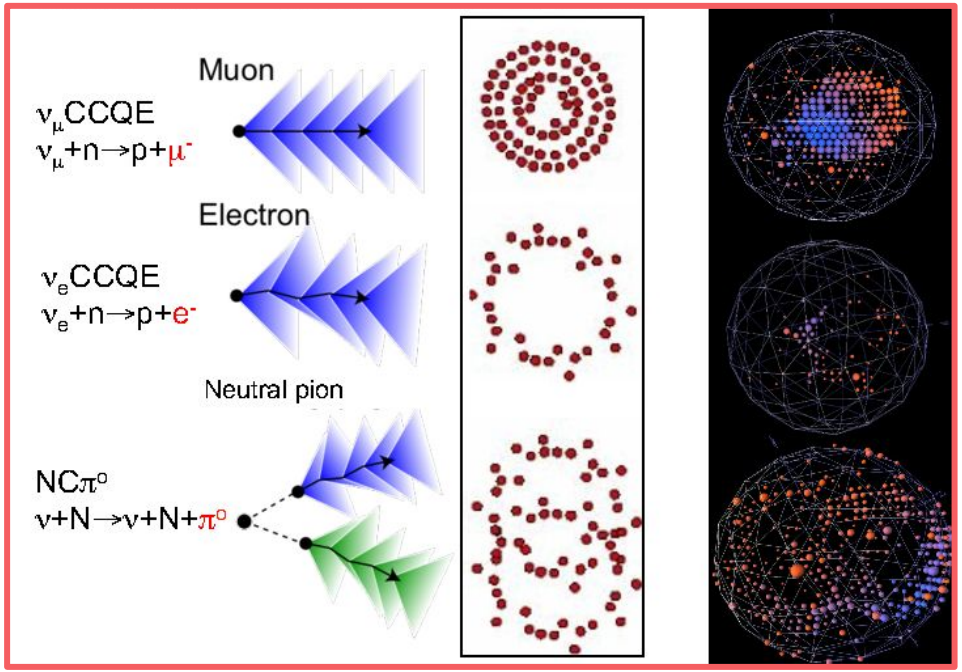



# Low Energy Excess Problem

**Cherenkov** detectors **cannot distinguish** electron from single gamma and cannot determine the composition of the excess.



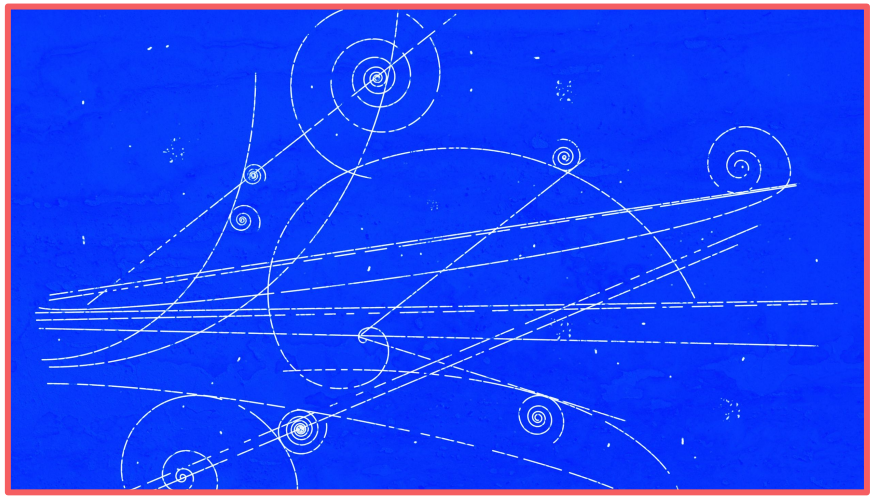

– Electrons or photons?




**LArTPCs can help us with this!**

# What are LArTPCs?

**L**iquid **Ar**gon **T**ime **P**rojection **C**hambers



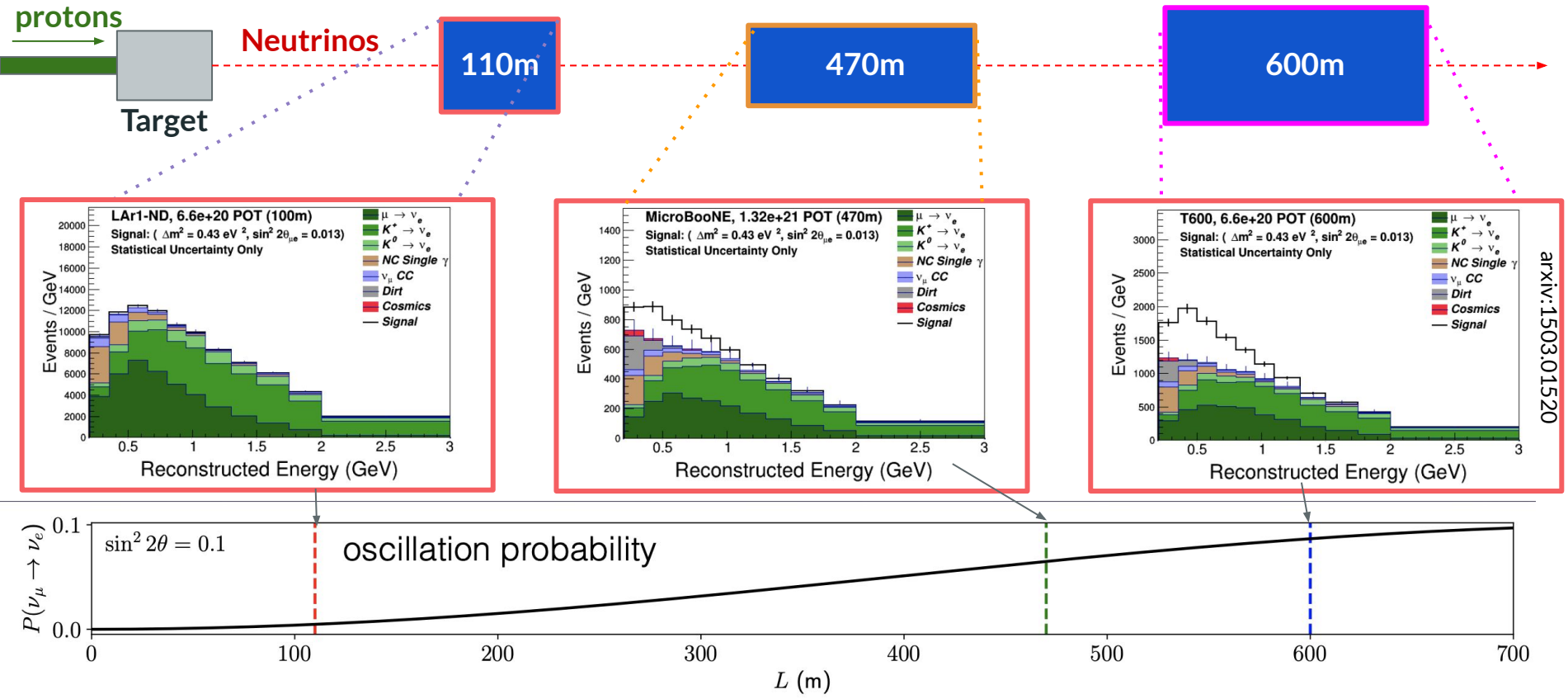
Digitized bubble chamber! -> **Imaging** and **Calorimetry.**

Three-dimensional reconstruction of particles **trajectories** and **interactions.**

**Argon** as the neutrino **target** and as the **detector.**

Scalable to **large volumes**!

# SBN: search for sterile neutrinos



# SBND – Near Detector

## SBND - Short Baseline Near Detector

**112 ton** active volume **LArTPC;**

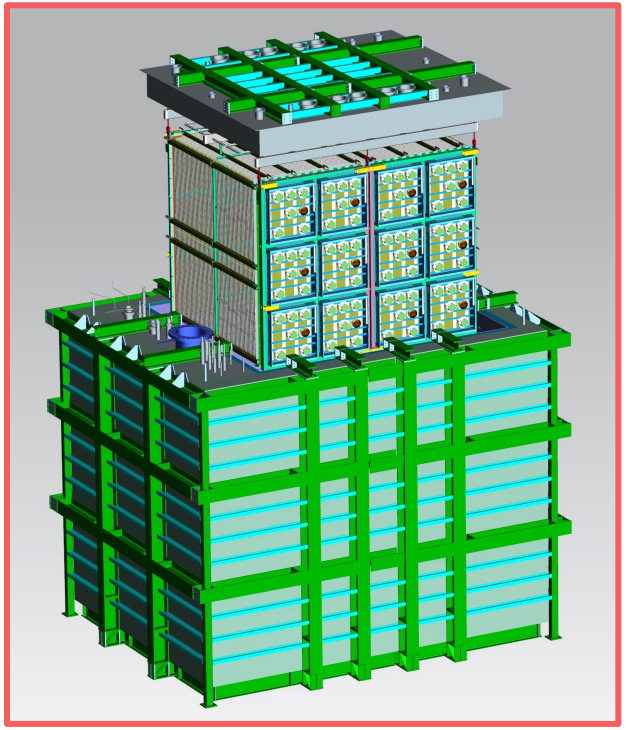
**110 m** from BNB neutrino **source;**

Over a **million** neutrino **interactions per year**!

Large data sample will allow studies of neutrino-argon interactions in the GeV energy range with unprecedented precision

High statistics **measurement** of the **unoscillated** BNB.

critical for neutrino oscillations at the SBN Program



arxiv:1903.04608

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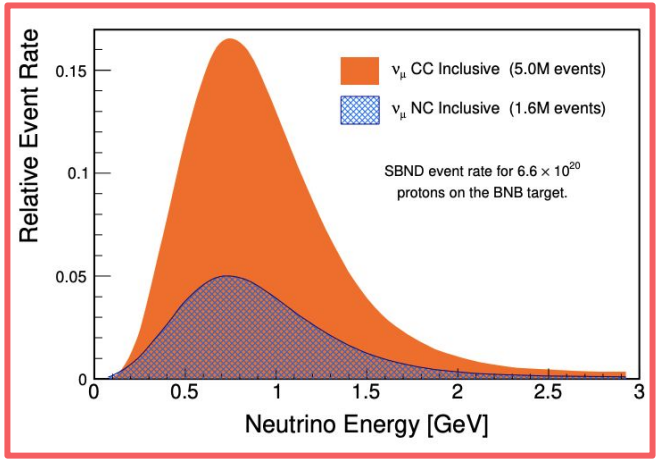


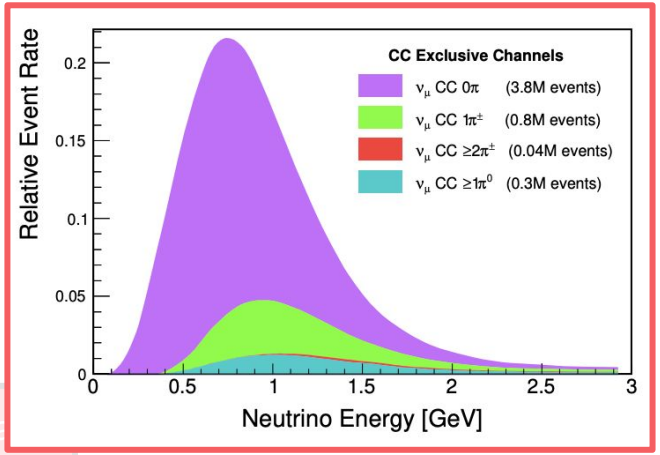


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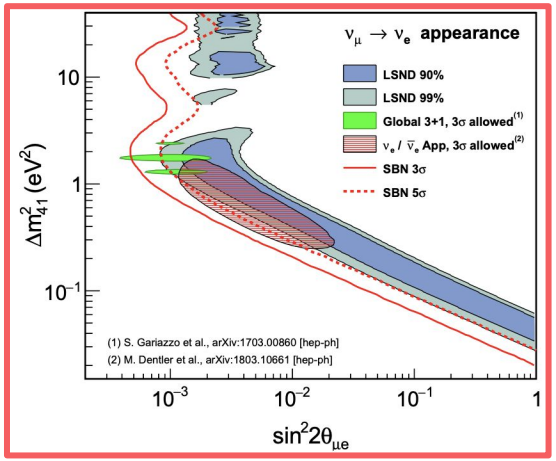


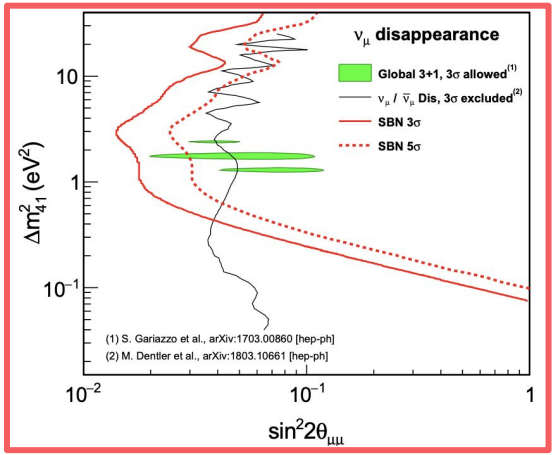


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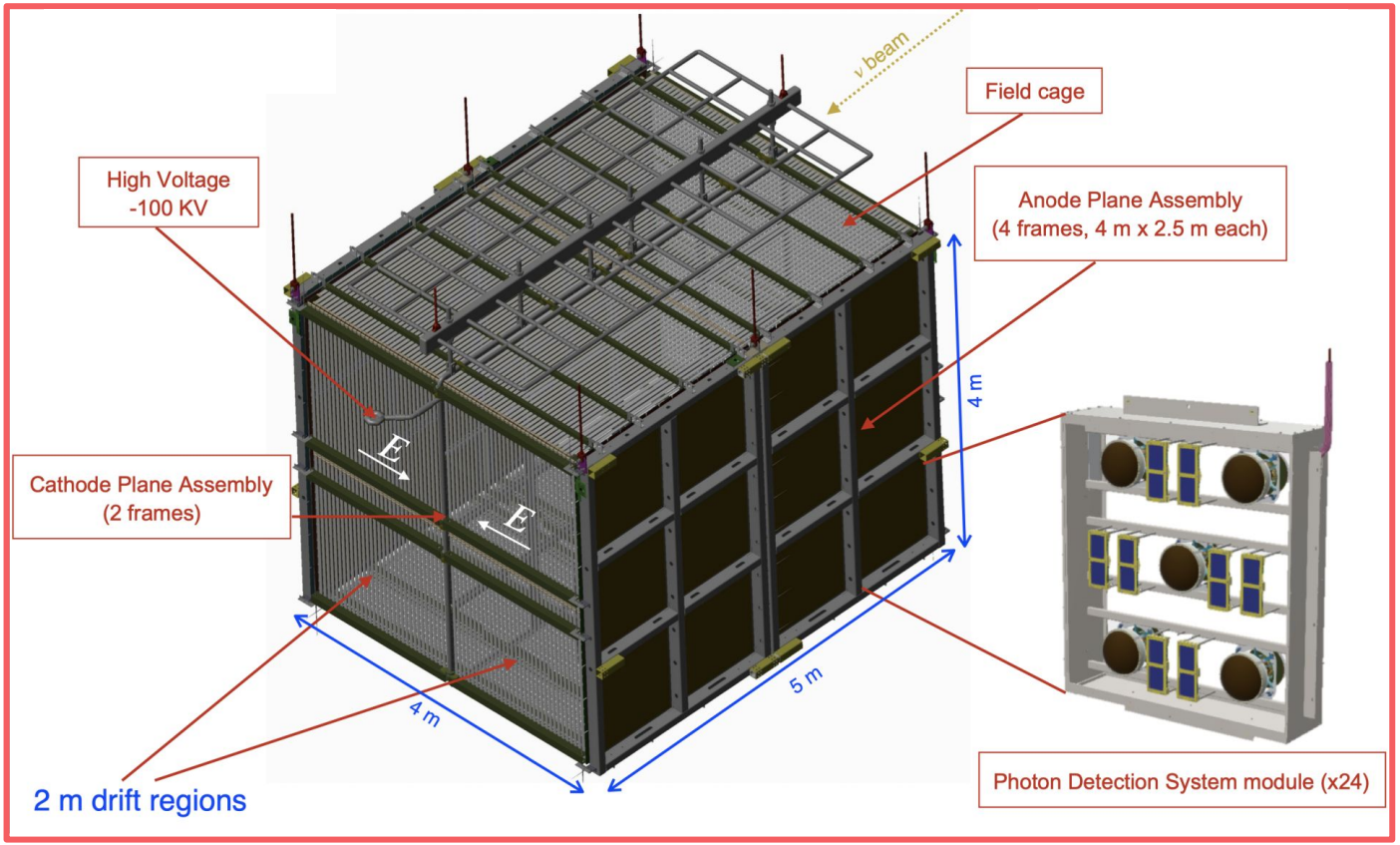
# SBND: a brand-new detector!



# SBND: TPC

**APAs: Anode Planes Assemblies**

-3 wire planes (vertical, +/-60˚);

- wire pitch and plane spacing of 3mm.

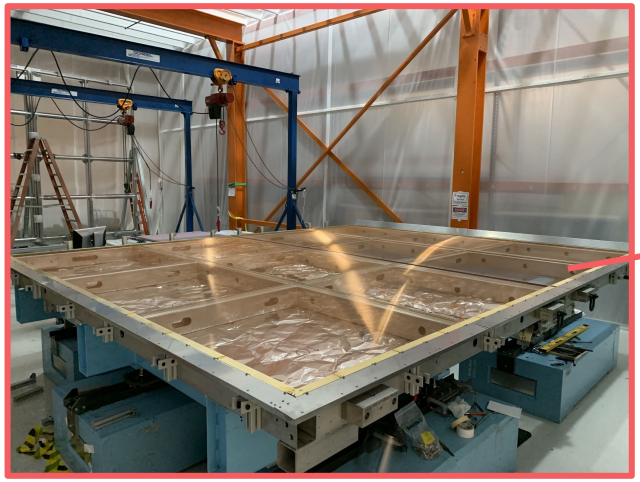
**CPA: Cathode Plane Assembly**

A single central cathode dividing the TPC in two drift regions;

Has reflective foils for the PDS.

**Field Cage:**

Maintain 500 V/cm of drift field.



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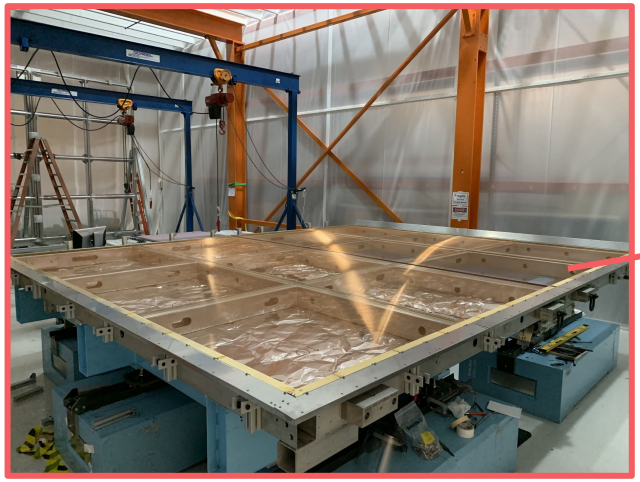

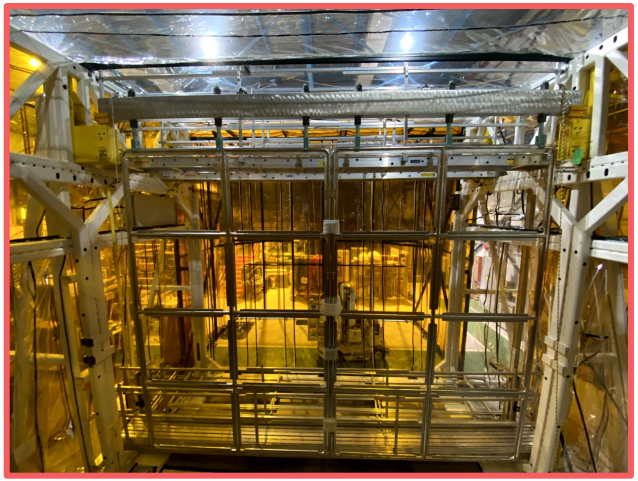

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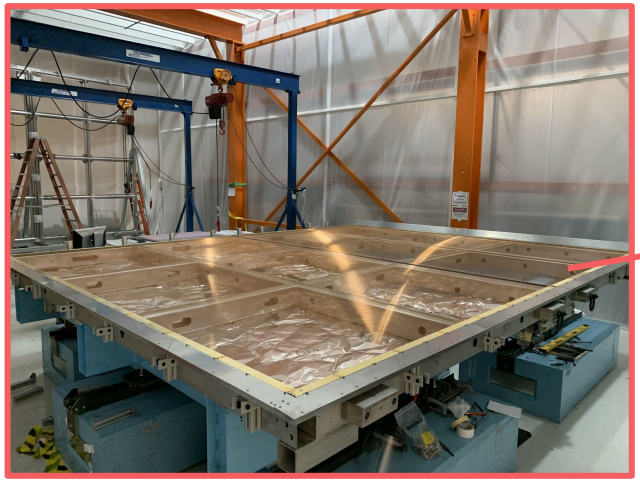
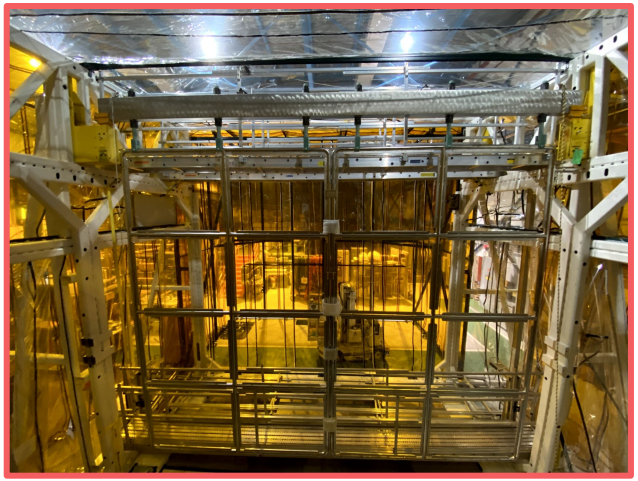
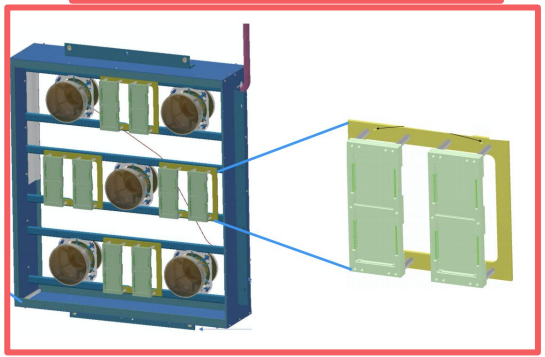


# SBND: PDS and CRT

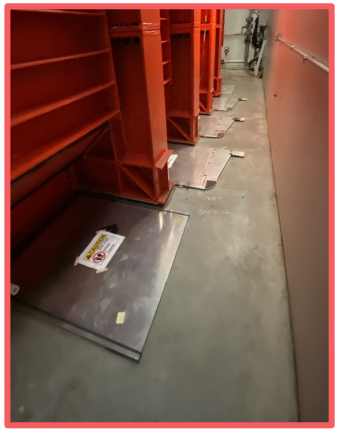


## Photon Detection System:

Modular system behind the APAs: "looking" inside the TPC.
24 PDS modules:

-5 PMTs: Total 120 8” Hamamatsu PMTs

-8 X-ARAPUCAS: Total 192 X-ARAPUCA modules



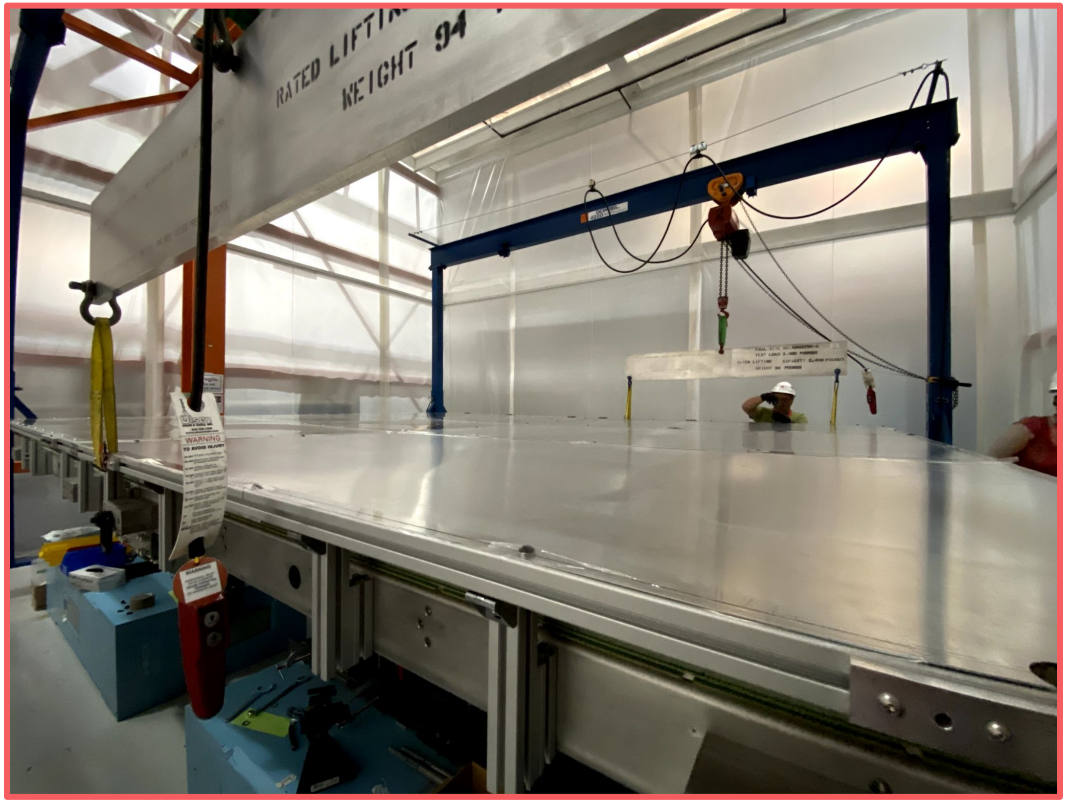
## Cosmic Ray Tagger

Every side of the detector will be covered by planes of extruded scintillator strips

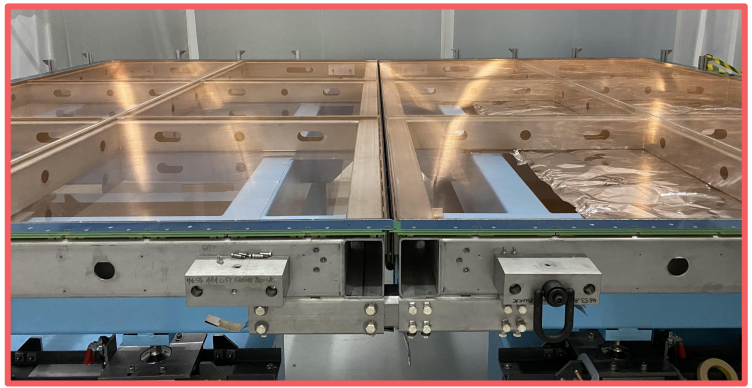
# SBND status:

-**Clean tent:** inner and outer tents to keep a clean environment for TPC assembly and for PDS protection (UV and blue filters).

# SBND status



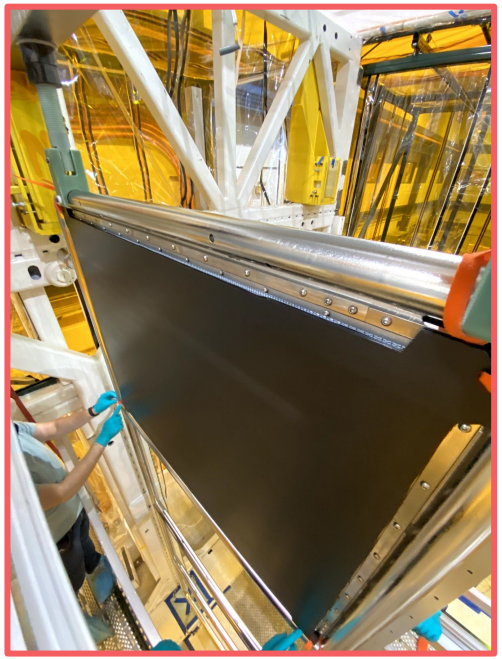

-2 first **APAs** coupled, aligned and covered: ready for installation (waiting for hanger pieces).



# SBND status

-**CPA installed!**

-Mesh panels 12/16 installed!



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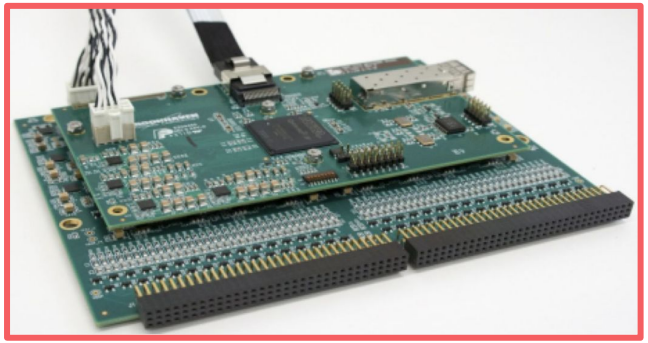
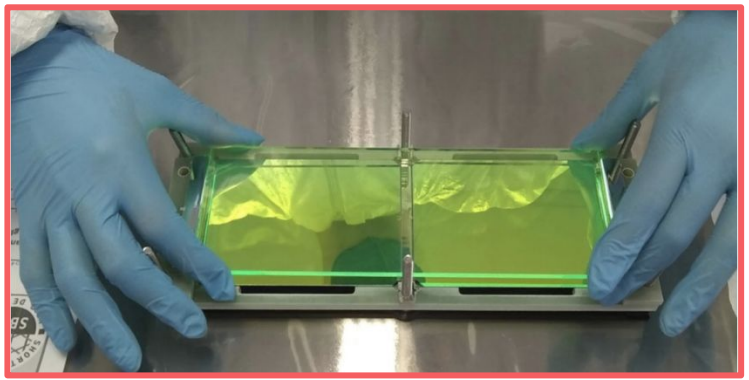
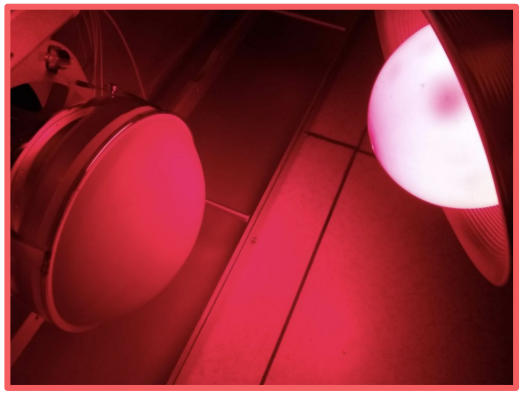


-Cold Electronics are on-site, tested and ready for installation;

-Cable trays are being assembled;

-Field Cage pieces are on-site and installation will start next week;





-X-ARAPUCAs production ongoing at UNICAMP;

-PMTs passed reception test at Fermilab.

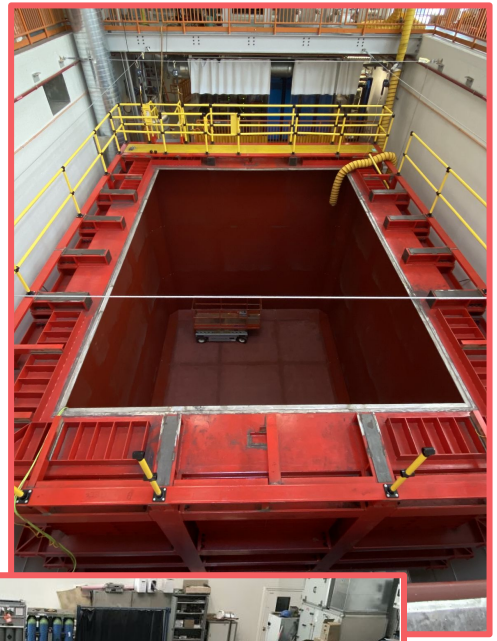
# SBN ND Building

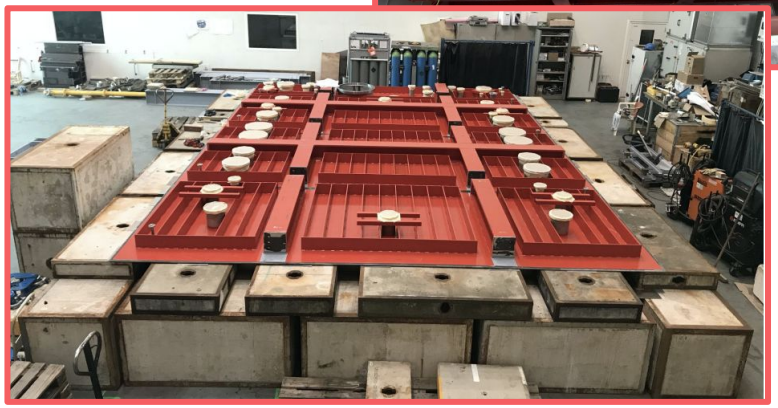
-Warm outer vessel already installed in the SBN-ND building;

-Cryogenics installation ongoing;

-Installation of cryostat membrane starting this August, all the materials on-site;

-Fabrication of cryostat top at CERN completed. It'll be shipped to Fermilab by the end of summer.





# Summary

The SBN program at Fermilab has **sterile neutrino oscillations**, **new physics** searches and **technology development** as main goals.

**The SBND will:**

- Constrain the unoscillated flux for sterile neutrino searches
- Largest sample of neutrino-Argon interactions than any past or present experiment.
- Provide precise cross-section measurements and inform MC generators.
- SBND will be ready for cold commissioning by the end of 2022

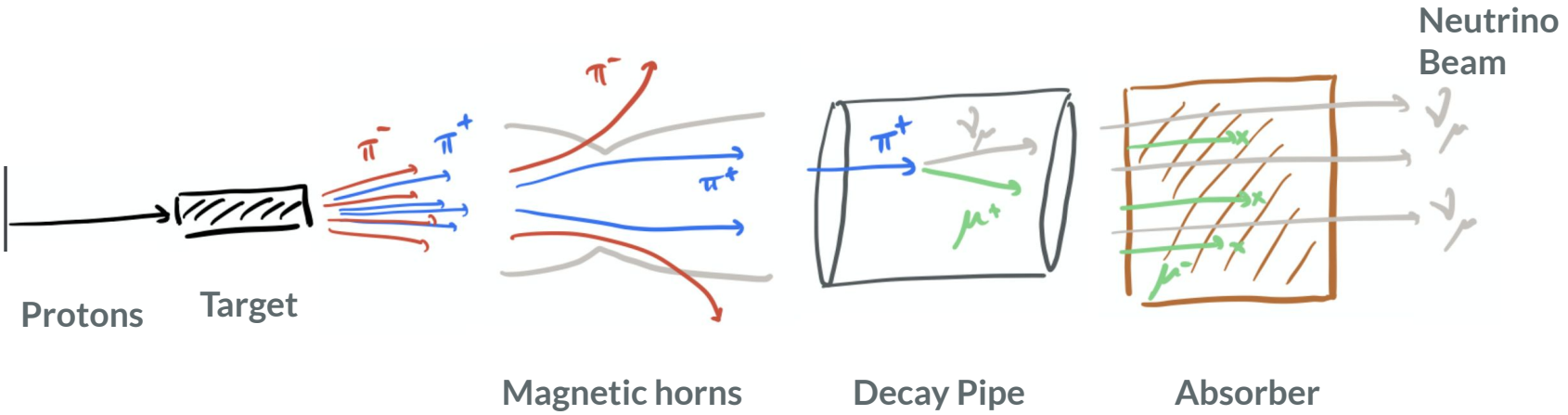
**Exciting  times are ahead!!**

# Obrigada!

**(Thanks!)**

# Backup

# How do we PRODUCE a beam of neutrinos?



# Why LAr?

**For neutrinos experiments, we need:**

- **big detectors!** -> Ar is "cheap"! 1% of the atmosphere.
- **dense detectors!** -> Ar is 40% more dense than water (when liquid!).
- detectors that **respond easily** -> Ionization: 55000 e/cm.
- **light!** -> Produces lots of scintillation light and it's transparent to it ( ~*O* 40000γ/MeV deposited)


| | He | Ne | Ar | Kr | Xe | Water |
|---|---|---|---|---|---|---|
| Boiling Point [K] @ 1atm | 4.2 | 27.1 | 87.3 | 120 | 165 | 373 |
| Density [g/cm³] | 0.125 | 1.2 | 1.4 | 2.4 | 3 | 1 |
| Radiation Length [cm] | 755.2 | 24 | 14 | 4.9 | 2.8 | 36.1 |
| dE/dx [MeV/cm] | 0.24 | 1.4 | 2.1 | 3 | 3.8 | 1.9 |
| Scintillation [γ/MeV] | 19,000 | 30,000 | 40,000 | 25,000 | 42,000 | |
| Scintillation λ [nm] | 80 | 78 | 128 | 150 | 175 | |

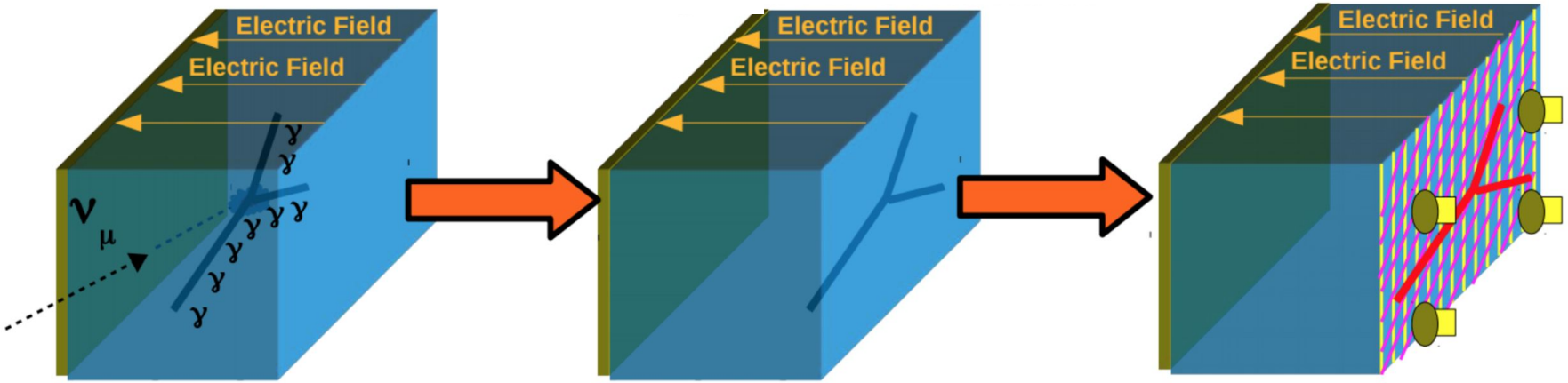
# TPC – Time Projection Chamber

**Neutrino interaction** produces **charged and neutral particles**.

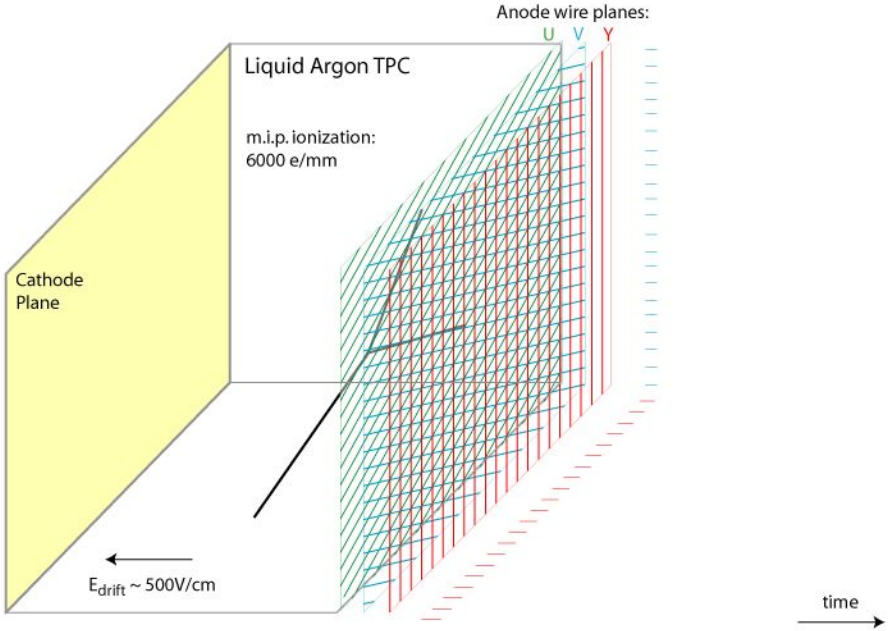
Charged particles **ionize** and **excite LAr** (electrons and 128nm photons will be created).

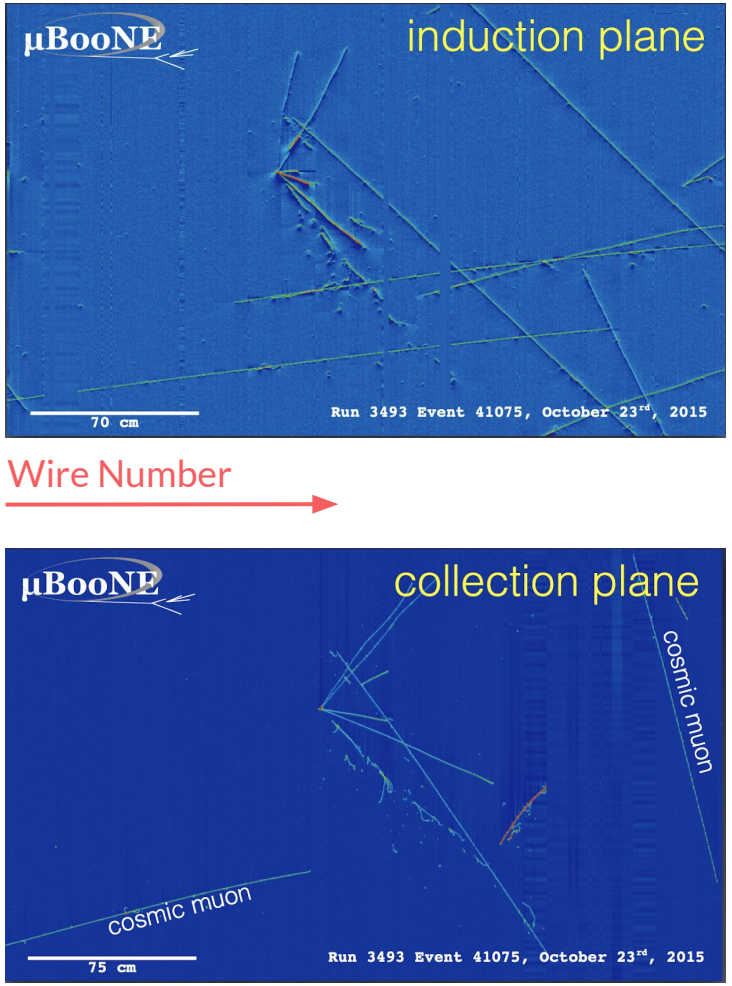
**Photons** are fast and can give us the $t_0$ **of the event**. **Electrons** are drifted by the electric field **towards the wire** planes.

**Read out system** for electrons and light records **precise info** about the interaction.



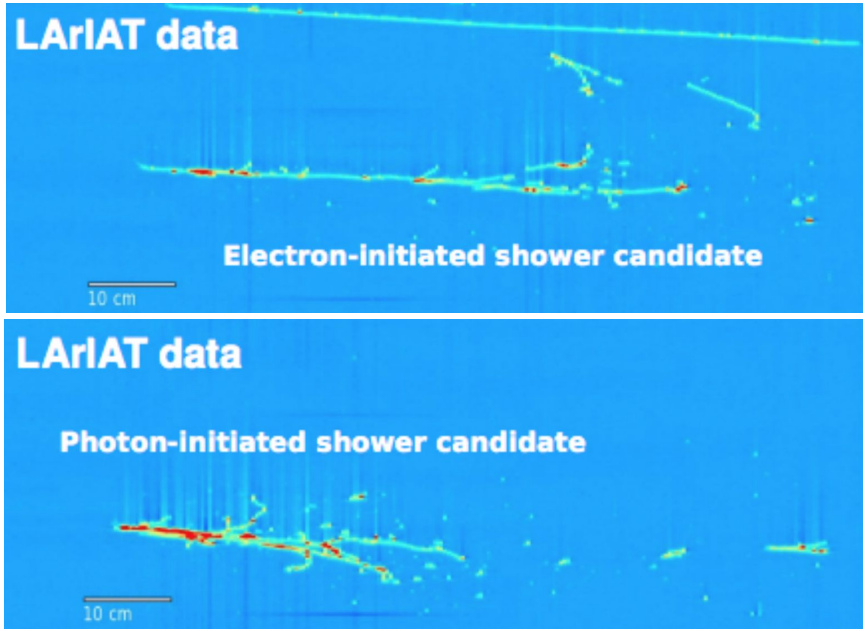
# LArTPC:

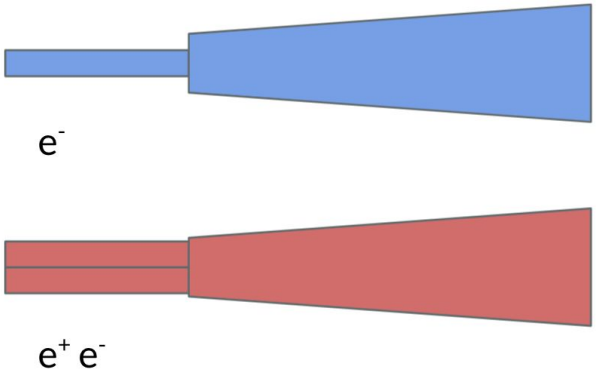

Anode wire planes:
U
V
Y
Liquid Argon TPC
m.i.p. ionization:
6000 e/mm
Cathode
Plane
$E_{drift}$ ~ 500V/cm
time


μBooNE
induction plane
Time
70 cm
Run 3493 Event 41075, October 23rd, 2015
Wire Number
μBooNE
collection plane
cosmic muon
cosmic muon
75 cm
Run 3493 Event 41075, October 23rd, 2015

# Electron – Photon shower separation

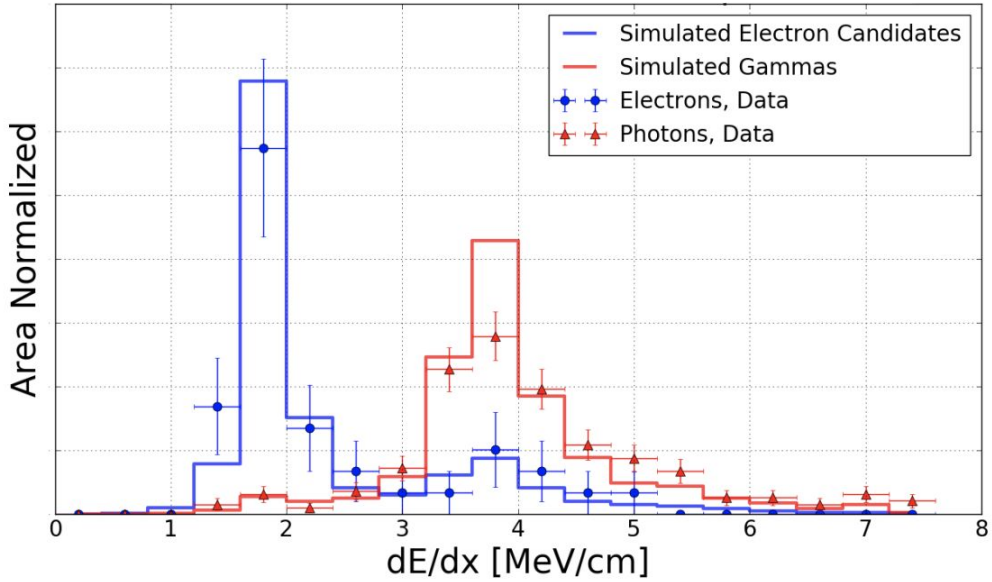
Analysing the dQ/dx of the beginning of the shower is possible to separate electron initiated showers from photon initiated showers.



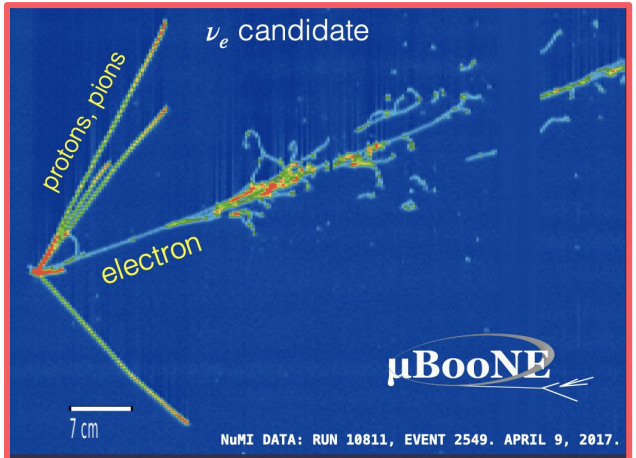



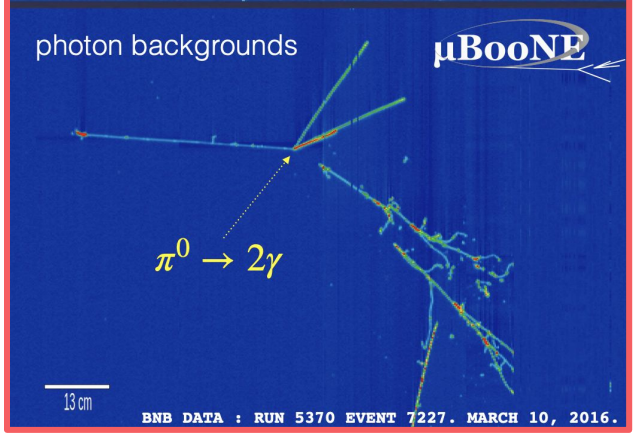
# LArTPCs for e/γ separation

LArTPCs are capable of distinguishing electrons and single photons!

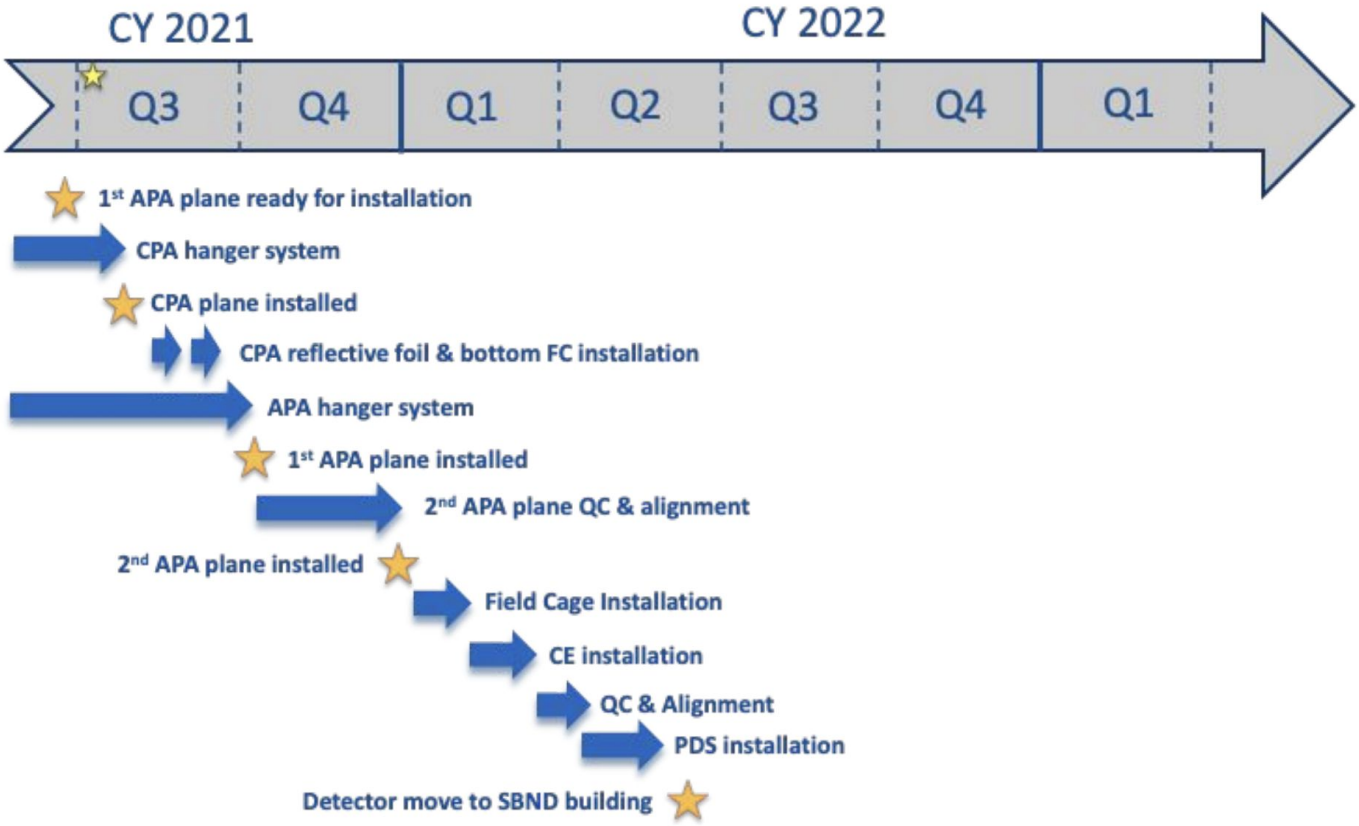



ArgoNeuT Data

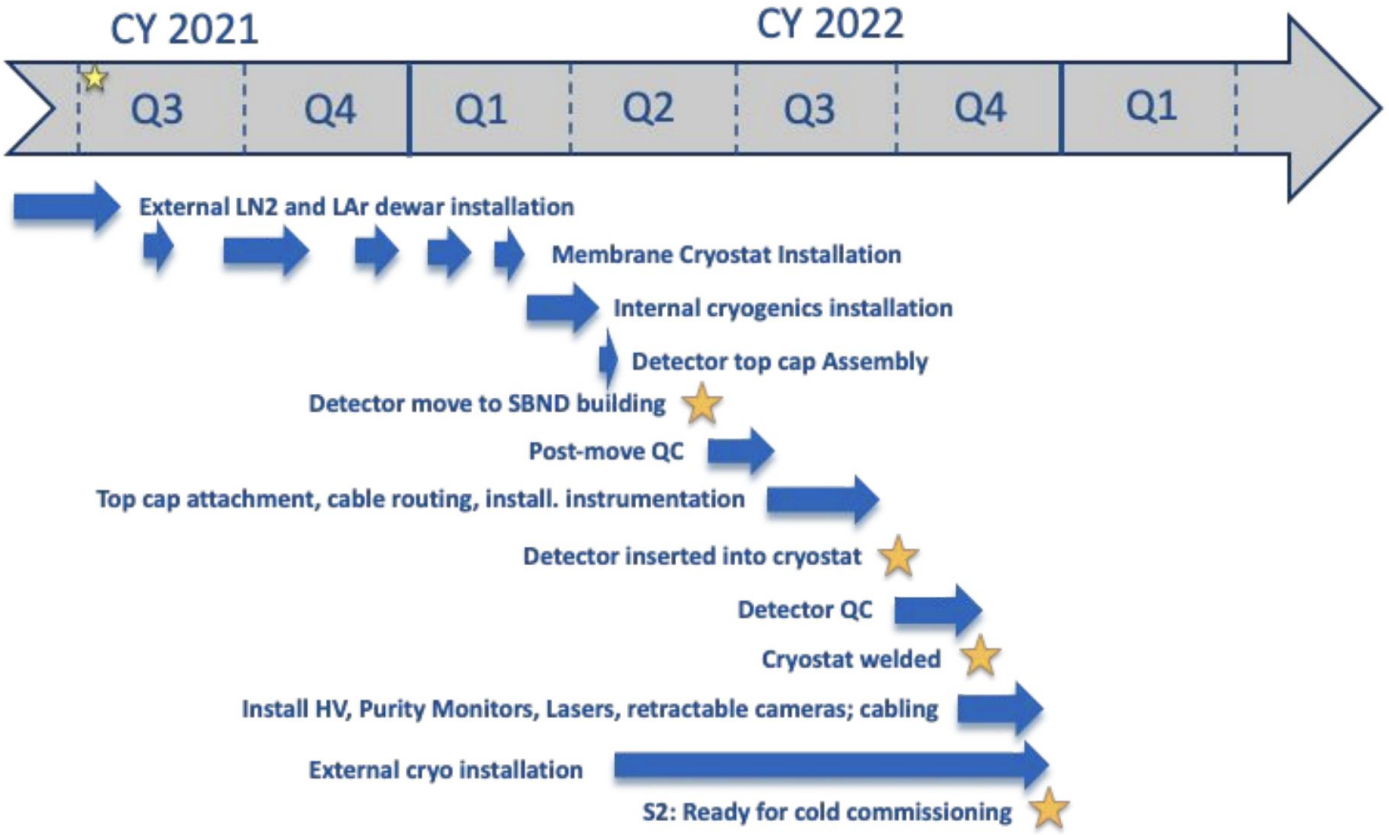


# Timeline


CY 2021
CY 2022
Q3
Q4
Q1
Q2
Q3
Q4
Q1
1st APA plane ready for installation
CPA hanger system
CPA plane installed
CPA reflective foil & bottom FC installation
APA hanger system
1st APA plane installed
2nd APA plane QC & alignment
2nd APA plane installed
Field Cage Installation
CE installation
QC & Alignment
PDS installation
Detector move to SBND building

# Timeline


CY 2021
CY 2022
Q3
Q4
Q1
Q2
Q3
Q4
Q1
External LN2 and LAr dewar installation
Membrane Cryostat Installation
Internal cryogenics installation
Detector top cap Assembly
Detector move to SBND building
Post-move QC
Top cap attachment, cable routing, install. instrumentation
Detector inserted into cryostat
Detector QC
Cryostat welded
Install HV, Purity Monitors, Lasers, retractable cameras; cabling
External cryo installation
S2: Ready for cold commissioning