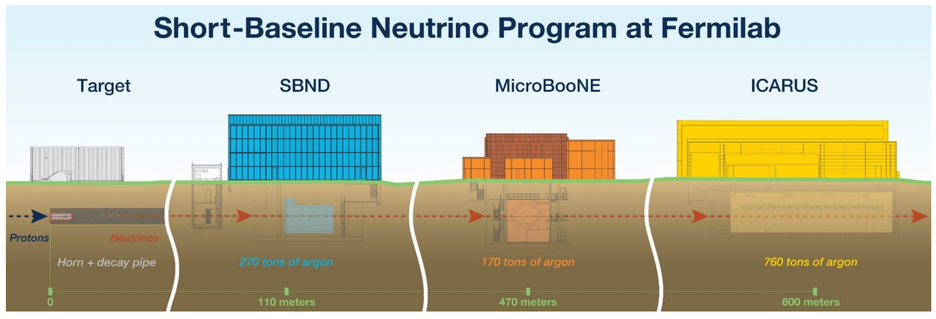
X-ARAPUCA as photon detection system of SBND

Ana Machado for SBND Collaboration



Three LArTPC detector to study short range neutrino oscillation

- **Neutrino-argon interactions** at GeV energy scale.

Millions of ν_μ and thousands of ν_e from two neutrino beams

- **Verify** the "low-energy excess" anomaly

Investigate the excess of ν_e observed by MiniBooNE experiments

- **Search** for sterile neutrino

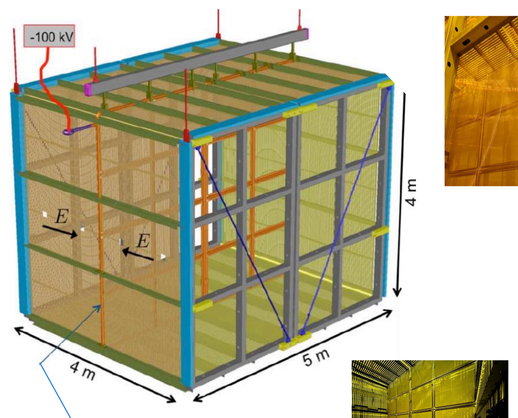
Discover or exclusion of 1 eV-scale sterile neutrino mass region

- **Beyond** Standard Model Physics

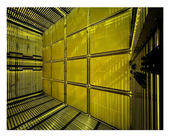
ShortBaseline

ABSTRACT

Short Baseline Near Detector TPC



Cathode Plane at -100 kV divides the detector into 2 drift volumes. Drift distance is 2 m, drift time is 1.28ms



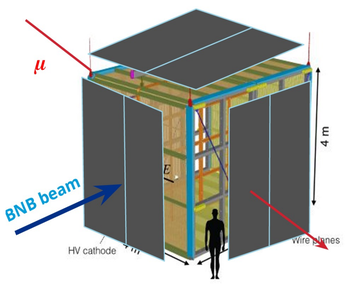
Anode Plane on either side. Each consists of 3 planes of wires with 3 mm spacing and different angle per plane. Total of 11,260 wires

SBND_TPC

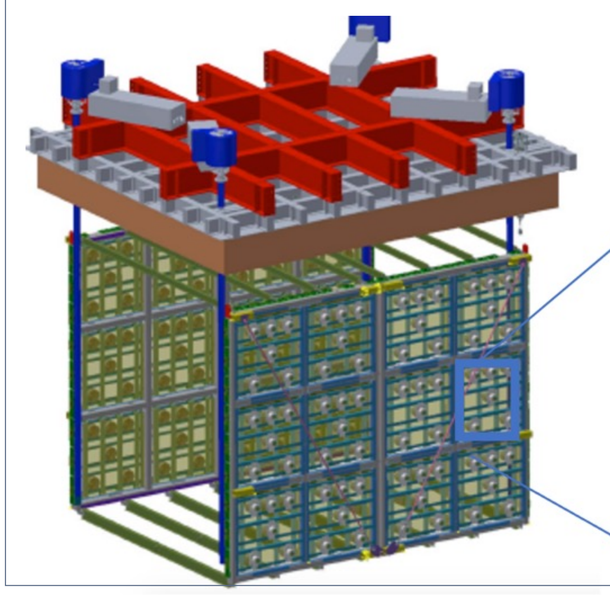
Cold (89K) Electronics to pre-amplify and digitize signals

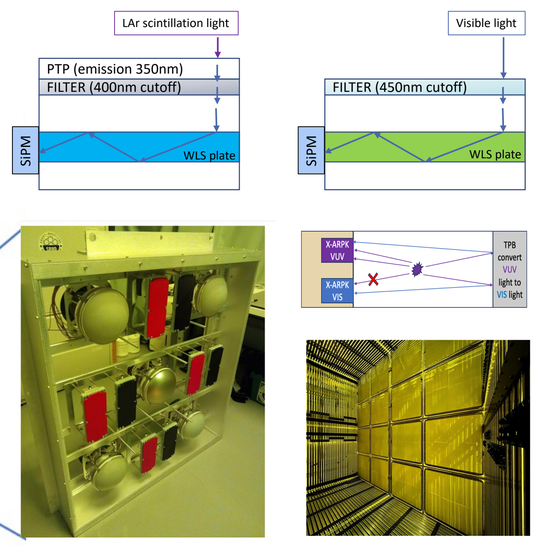
Field Cage that wraps around the 2 LArTPCs to step down the voltage & ensure uniform electric field of 500 V/cm.

Cosmic Ray Tagger (CRT) Scintillator strips with SiPM readout 142x32 channels



Photon Detection System



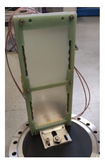


Active elements: on the PD-BOX, behind the anode.

- 120 8" Hamamatsu Cryogenic PMT's (96 TPB coated + 24 uncoated)

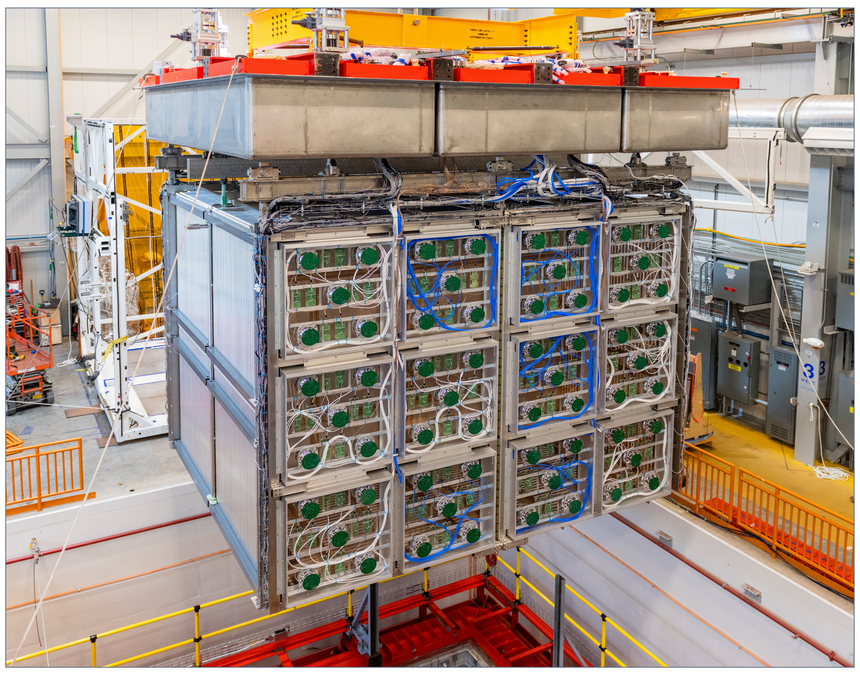
Hamamatsu R5912-mod (cryogenic)

- 192 X-ARAPUCA (96 VIS + 96 VUV)



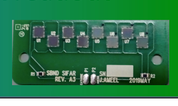
Passive element: at the cathode.

Wavelength-Shifting Reflective plates (TPB coated) 64 double-sided

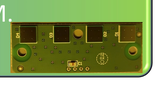


192 X-ARAPUCA

176 ARARA readout
SensL - 3x3m² SiPM. (C-series 30050-A1)



16 APSAIA readout
Hamamatsu - 6x6m² SiPM. (S13360-6050 VE & HS)

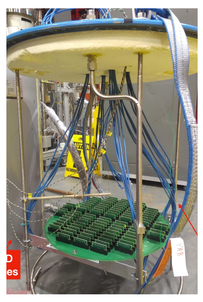


88 VUV	88 Visible	8 VUV	8 Visible
OPTO 400nm	**OPTO** 450nm	**OPTO** 400nm	**OPTO** 450nm
PTP coating		PTP coating	
EJ286	EJ280	Glass to Power	Glass to Power

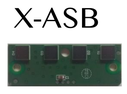
All PCB boards were tested in cryogenic temperature

X-TDB

A total of 777 X-TDBs were tested at the LN2 temperatures and able to see light. 704 were required. Only 1 "bad" board was identified



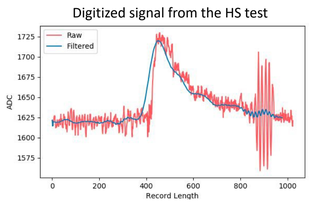
X-ASB



PARAMETERS	VE	HS
Spectral response range (nm)	320 - 900	270 - 900
Peak sensivity wavelength (nm)	450	450
Photo detection effeciency (%)	40	50
Gain (x 10^6)	1.7	2.5

60 SiPMs was teste
- 48 6050-VE (VBr = +53V @RT)
- 12 6050-HS (VBr = +38V @RT)

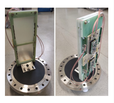
Digitized signal from the HS test



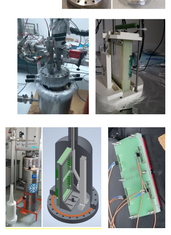
Photon Detection Efficiency

X-ARAPUCA VUV

Different laboratories measured the PDE of the SBND X-ARAPUCA VUV with X-ASB PCB. The results were consistent across all measurements.



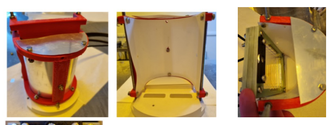
Unicamp
Light guide EJ286 → 2.2 ± 0.5%
MIB
Light guide EJ286 → 1.8 ± 0.1%
Light guide G2P → 2.9 ± 0.1%
U. Naples Federico II
Light guide G2P → 2.7 ± 0.3%



https://arxiv.org/abs/2106.04505
https://arxiv.org/abs/2104.07548

X-ARAPUCA VIS

The measure of a single cell with X-ASB was performed at Unicamp : Light guide EJ286 → 3.20 ± 0.03%



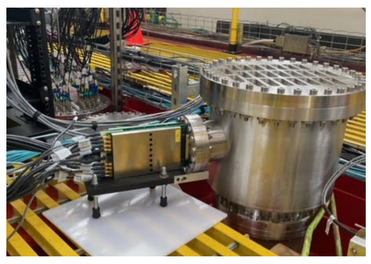
The CIEMAT group is currently conducting measurements of the PDE for all types of X-ARAPUCA with their final configuration.

PDS_X-ARPK

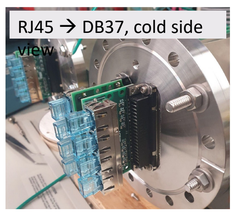
Readout Electronics

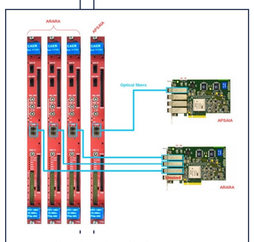
– APSAIA –
ARAPUCA POWER SUPPLY AND INPUT AMPLIFIER

The APSAIA will power the SiPMs and amplify their 32 output signals. It is hosted in the outer flange of SBND. Each board has 8 channels with input connectors. The power supplies are designed to meet the SiPMs' requirements, and the amplifiers process the SiPMs' output signals. Each channel has an MCX output connector. The power supply and serial port connector use a standard DB15 connector. The supply voltage for the SiPMs is remotely adjustable up to 60 V with a resolution of less than 100mV. The power supplies and amplifiers are controlled by a microcontroller connected to an RS232C port.



The amplifier characteristics are as follows:
- Minimum gain of 20, adjustable via microcontroller if other gain values are needed.
- Sufficient bandwidth for processing 30 ns rise-time signals, DC-coupled.
- Output impedance of 50 Ω.





– CAEN V1740 Digitizer –
64-channel, 12-bit 62.5 MS/s Digitizer: 1.5 MS/channel, EP3C16, SE.

– ARARA –
ARAPUCA ANALOG READOUT AMPLIFIER

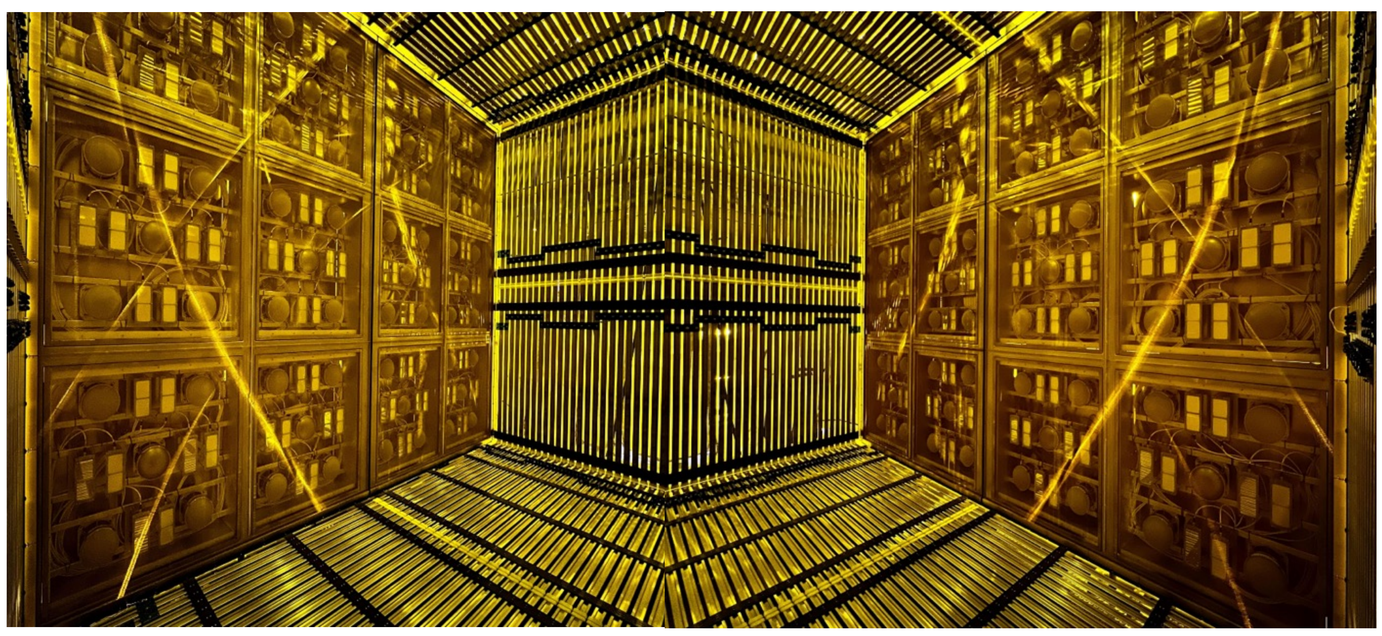
The preamplifier board conditions and biases the signal between the X-ARAPUCA light collection hardware and the signal capture hardware
The bias voltage must be programmed remotely using an RS232c. The power supply is available via a cable with a DSUB9 connector.
The 352 signals for flange are inputs for ARARA board. Into the ARARA board the signals are ganged by 4.

These preamp modules are:
- Double width 6U VME cards in custom crate.
- Powered by externally provided 8V DC
- 64 input channels for 16 output channels
- Compliant with FNAL Electrical Design Standards for Electronics

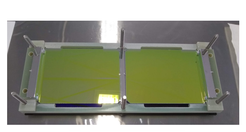
RAVANA board convert signals from the ARARA to the CAEN 1740 digitizers

Single-channel prototype of the pre-amplifier by AGE scientific

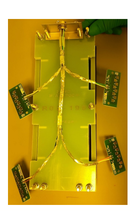
The Scintillation Light in SBND work is now available in → https://arxiv.org/abs/2406.07514

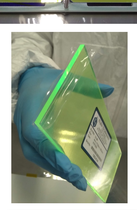


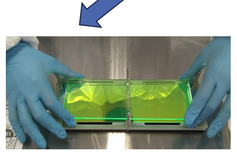
ASSEMBLY & INSTALLATION



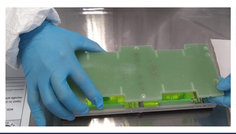
1º step: The assembly of the mechanical and optical parts (dichroic filters and light guide) was done at Unicamp

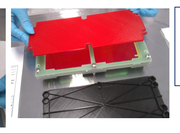




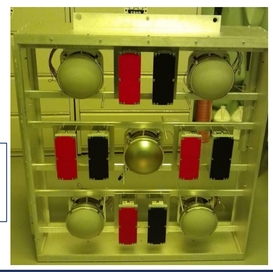


2 º step : The PCB board installation in each X-ARAPUCA was carried out at Fermilab.





Finally, 4 VUV X-ARAPUCAs and 4 VIS X-ARAPUCAs were installed in each PD BOX.



THANKS TO : FAPESP Fermilab UNICAMP Centro de Tecnologia da Informação Renato Archer UNIVERSITY OF MICHIGAN Tufts UNIVERSITY Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

NEUTRINO 2024
June 16-22, 2024 – Milan, Italy