First signals of the X-ARAPUCA in SBND

Pimentel, VL on behalf of X-ARAPUCA PDS working group of the SBND Collaboration

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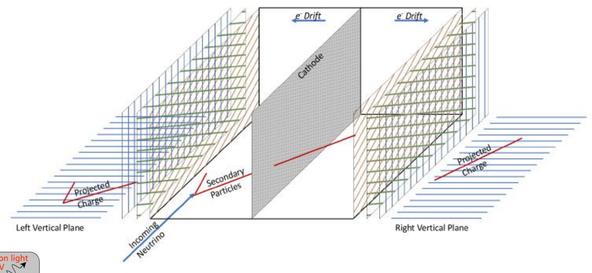
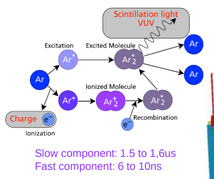
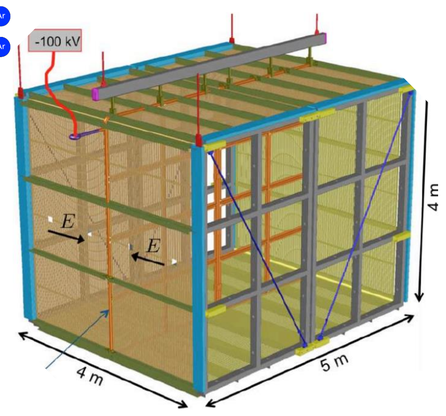
Short Baseline Near Detector LAr-TPC

SBND_TPC

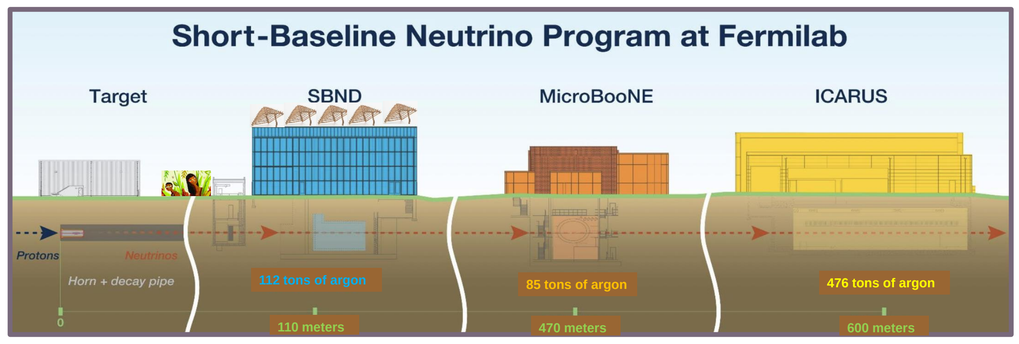




Slow component: 1.5 to 1,6us
Fast component: 6 to 10ns



The SBND LAr Time Projection chamber
The TPC has a volume of 80m^3 with 112 tons of active Liquid Argon



APA - Anodes Planes Assemblies
Two in either side. Each consists of V-U-Y planes of wires with 3 mm spacing and different angle per plane. Total of 11,260 wires

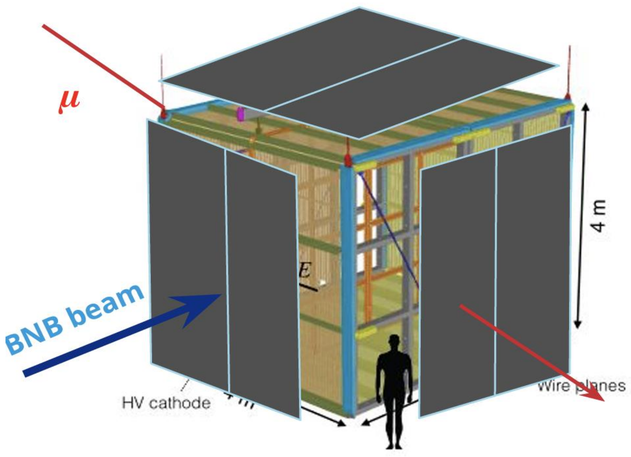
CPA - Cathode Plane Assemblies at 100 KV
Divides the detector into 2 drifts volumes with distance of 2 meters and drift time ~1.28ms

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

Field Cage
That wraps around the 2 LArTPCs uniform electric field of 500 V/cm.

Three LArTPC to study short range ν oscillation
- **ν-argon interactions** at GeV energy scale.
- **Verify** the "low-energy excess" anomaly
- **Search** for sterile neutrino
- **Beyond** Standard Model Physics

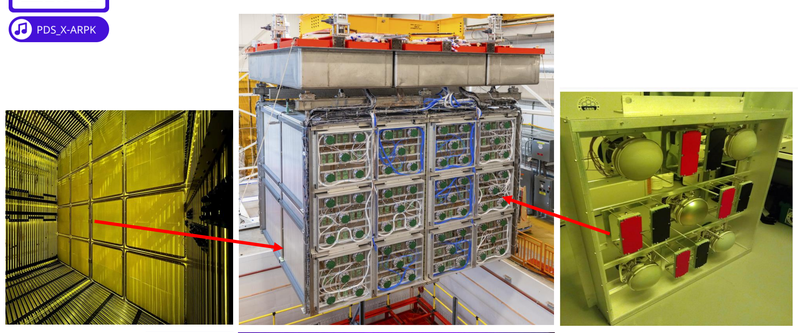
ShortBaseline

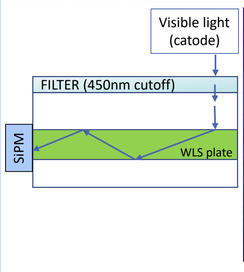


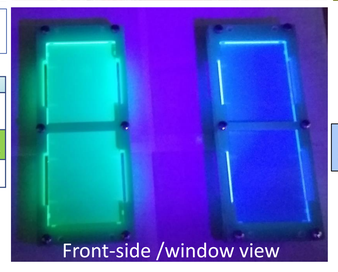
Cosmic Ray Taggers (CRT)
Scintillator strips with SiPM readout 142x32 channels

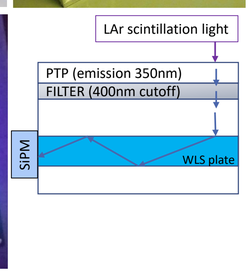
PDS – PHOTON DETECTION SYSTEM

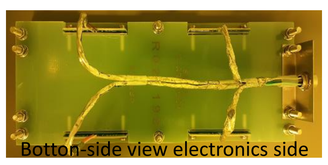
PDS_X-ARPK







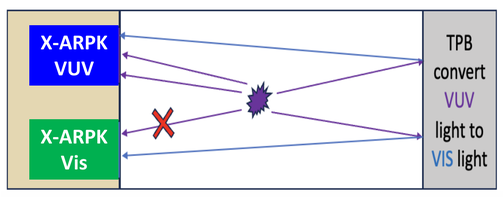




Active elements at APA's:
- LAr-TPC with 2 APAs in each side , WEST and EAST, in a total of 4 APA's
- Each APA with 6 PDBox, behind the anode totaling 24 PDBox
- Each PDBox with 5 PMT's and 8 X-ARAPUCA's
- 120 8" Hamamatsu cryogenic PMT's (96 TPB coated + 24 uncoated)
- 192 X-ARAPUCA (96 VIS + 96 VUV)

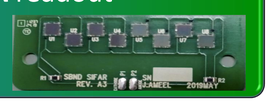
Passive elements at the cathode:

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



192 X-ARAPUCA (with 6 different configurations)

176 ARARA readout
SensL 3x3m^2 SiPM.
(C-series 30050-A1)



16 APSAIA readout
Hamamatsu - 6x6m^2 SiPM.
(S13360-6050 12xVE & 4xHS)

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

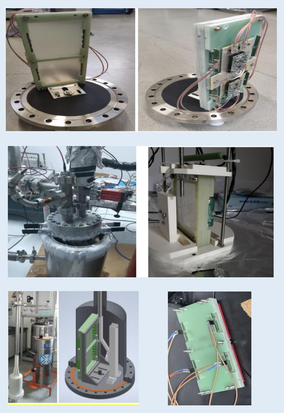
PHOTON DETECTION EFFICIENCY

X-ARAPUCA VUV

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%



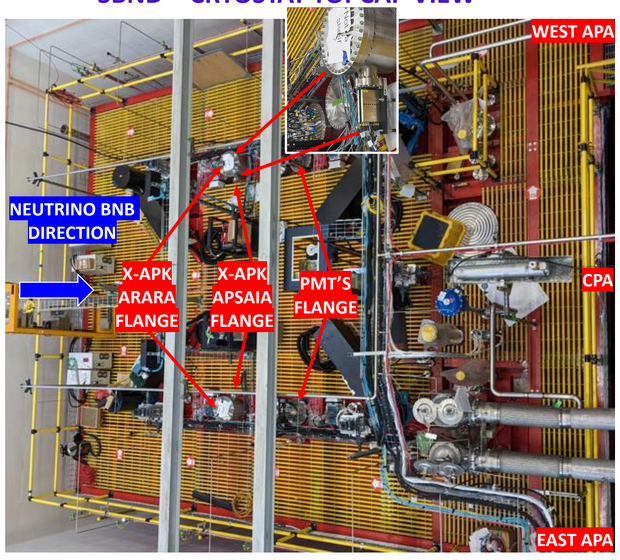
H.V. Souza et al 2021 JINST 16 P11002
C. Brizzolari et al 2021 JINST 16 P09027

X-ARAPUCA VIS

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

PDS – X-ARAPUCAS CRYOSTAT READOUT ELECTRONICS

SBND – CRYOSTAT TOPCAP VIEW

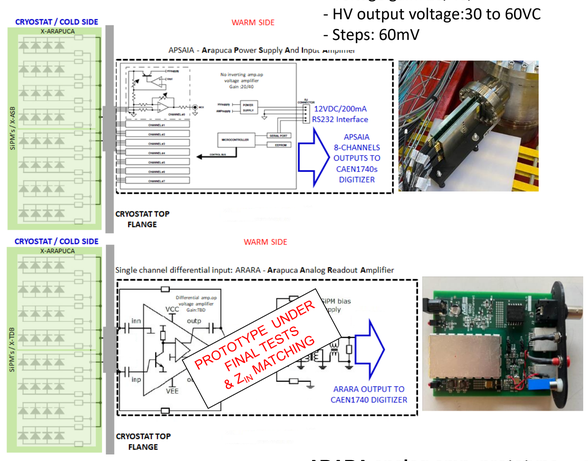


APSAIA – **A**RAPUCA **P**OWER **S**UPPLY **A**ND **I**NPUT **A**MPLIFIER

The 4 APSAIA's power the SiPMs and amplify their 32 output signals. 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. The power supplies and amplifiers are controlled by a microcontroller connected to an RS232C port. The supply voltage for the SiPMs is remotely adjustable up to 60 V with a resolution of less than 100mV

ARARA – **AR**APUCA **A**NALOG **R**EADOUT **A**MPLIFIER

The prototype of 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.

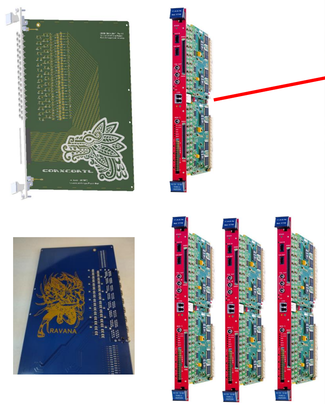


APSAIA parameters:
- 50Ω in/out coaxial amp.op;
- BW: 33.33MHz/30ns;
- Voltage programable RS232;
- Voltage gain: 20/40;
- HV output voltage:30 to 60VC
- Steps: 60mV

ARARA analog amp. prototype:
- Dif. Input TIA amp.op;
- BW: 33.33MHz/30ns;
- Programable RS232;
- Voltage gain: TBD;
- Steps: 60mV

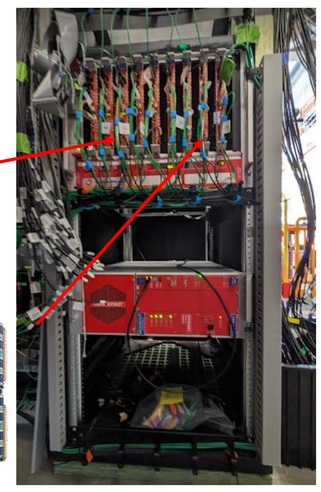
PDS – CABLING CONVERTER FOR CAEN DIGITIZER AT VME CREATE

COAXCOATL:
32-cable passive interface to MCX-LEMO analog signals from 4 APSAIA's to CAEN1740s Ribbon input port



RAVANA:
64 channels passive interface that converts 64 CAT6 cables with RJ45 termination to dual 32 channel ribbon of the CAEN V1740 Digitizer.

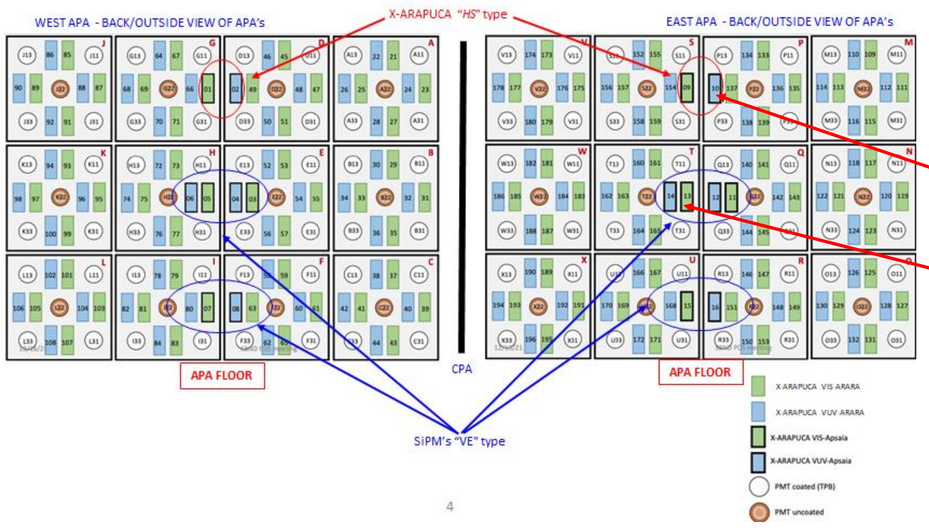
PDS VME CREATE

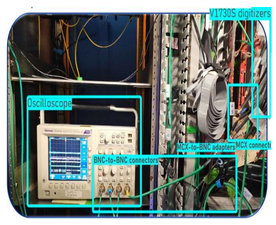


CAEN 1740 DIGITIZERS:
- 3 digitizer, 1 per x-ARAPUCA, total 176 channels
- 64 input channels Dual row ERNI SMC
- 50Ω 2Vpp
- BW: 30MHz
-12Bit & 62.5MS/s

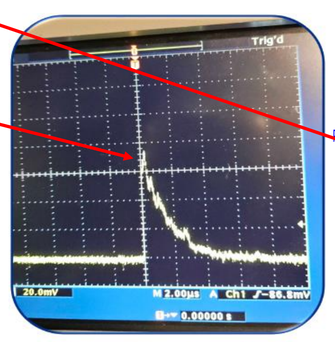
PDS – X-ARAPUCAS READOUT ELECTRONICS

Mapping (under revision) with the position number ID of the PDS at APA's:
- 120 PMTs (96 PTB coated + 24 uncoated);
- 192 X-ARAPUCAs: 96VUV+96Vis... (176-ARARA-OnSemi SiPM's &16 APSAIAs(Hamamatsu SiPMs VE+HS) readouts.

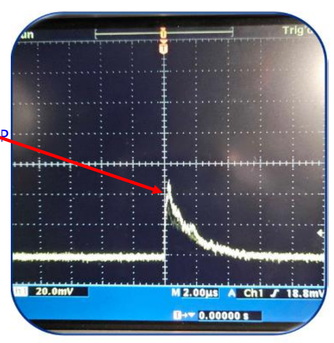




X- ARAPUCAS & APSAIA test setup:
- 4 channel digital oscilloscope (BNC inputs);
- MCX to BNC adapters APSAIAs scope;
- Desktop communication RS232;
- Signals recorded with scope auto-trigger.



APSAIA 1 waveforms at 43 V for CH 0 (X-ARAPUCA 013)



APSAIA 1 waveforms at 32 V for CH 6 (X-ARAPUCA 010)

The first X-ARAPUCA signals recorded under liquid argon at SBND:
- Signals were acquired with an oscilloscope auto-trigger with pulses of the order of ~4us.
- Amplitudes found between 50mV and 80mV$_{peak}$ are compatible with CAEN digitizers Vin=2.0V$_{pp}$.
- The measurements were taken at low gain (20X) at APSAIAs, there is room for increasing the dynamic range.

CONCLUSIONS AND NEXT STEPS:

By the waveforms captured by X-ARAPUCAS VUV and Vis and their position in the APA's, we believe that they originate from LAr and CPA... which demonstrates that both X-ARAPUCA concepts works!!

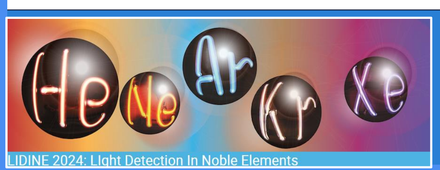
We demonstrate that the X-ARAPUCAs with APSAIA's are operating with a good amplitude enough to be collected by the digitizers, although some noise is being eliminated and several elements of the SBND PDS system are being put into operation.

The CAEN1730 digitizers installed in the PDS VME create will be replaced by new CAEN1740's and have not yet been installed because the COAXCOATL interface is being manufactured. The digitizers are being tested, equalized and calibrated for connection to APSAIAs soon.

CIEMAT groups are carrying out experiments to measure photoefficiency in LAr with the final configurations and components used in the SBND experiment.

The ARARA's X-ARAPUCA's (with ONSemi SiPM's) should only be tested when this readout is ready.

Acknowledgements : FAPESP, Fermilab, UNICAMP, Centro de Tecnologia da Informação Renato Archer, University of Michigan, Tufts University, Ciemat, Istituto Nazionale di Fisica Nucleare



LIDINE 2024

Light Detection in Noble Elements

26th to 28th August - Princípia Institute of Theoretical Physics - São Paulo - Brazil

References:
- **Liquid argon characterization of the X-ARAPUCA with alpha particles, gamma rays and cosmic muons**. SOUZA, H.V. et al.
- **Cosmic Ray Background Removal With Deep Neural Networks in SBND**. ACCIARRI, et al.
- **Construction of precision wire readout planes for the Short-Baseline Near Detector(SBND)**. ACCIARRI, et al.
- **The Liquid--- Argon Time Projection Chamber: A new concept for neutrino detectors**. C.Rubbia. CERN.16May1977.