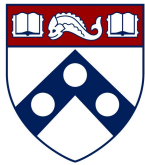


SBND Hardware Trigger System

TAUP, 29th August 2023

Tereza Kroupová
SBND Collaboration

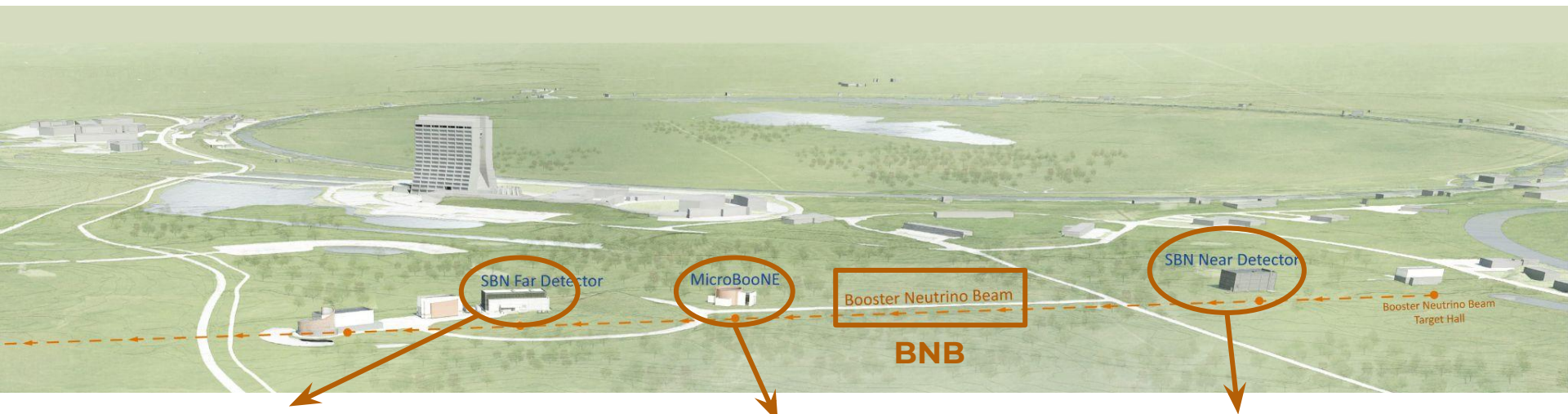


Penn
UNIVERSITY of PENNSYLVANIA



Short-Baseline Neutrino Program at Fermilab

Three detectors of the same technology along the same neutrino beam



ICARUS

476 tons active volume
L = 600 m

“Far detector”

MicroBooNE

85 tons active volume
L = 470 m

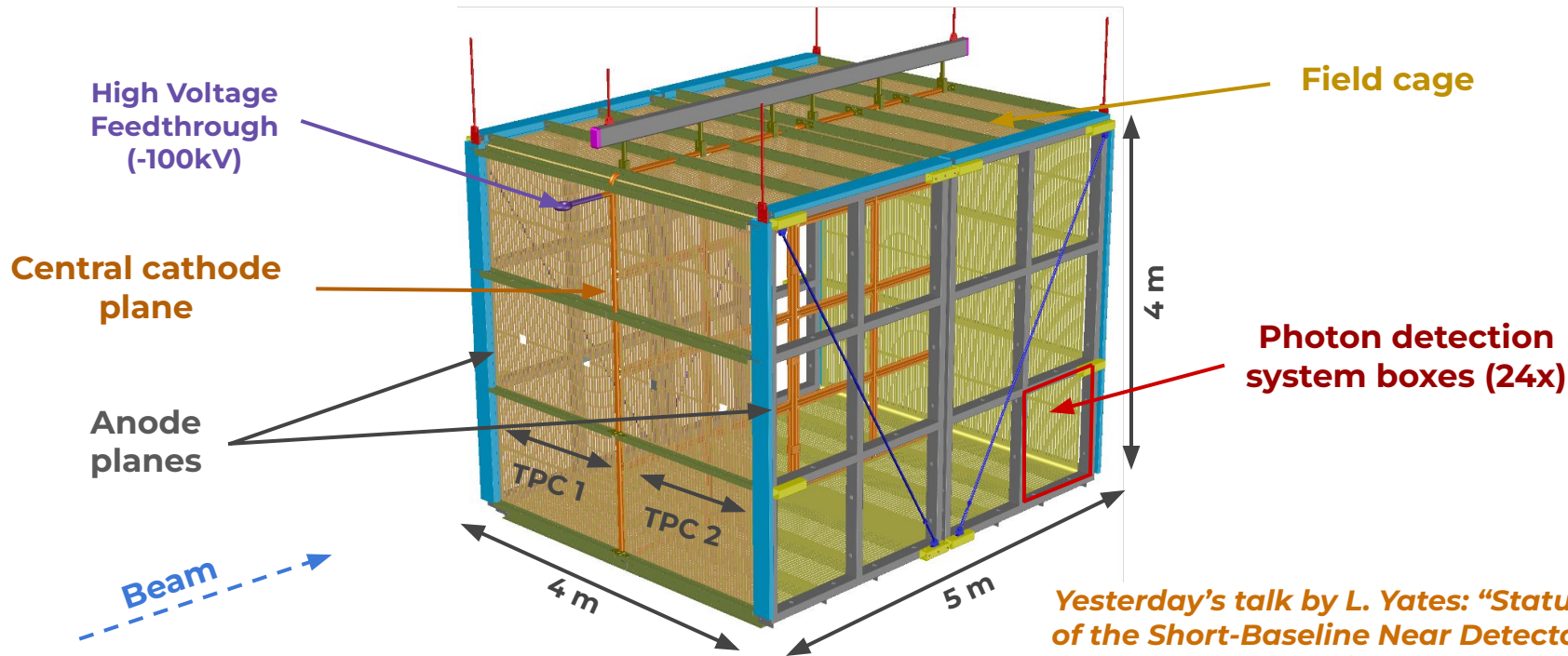
SBND

112 tons active volume
L = 110 m

“Near detector”

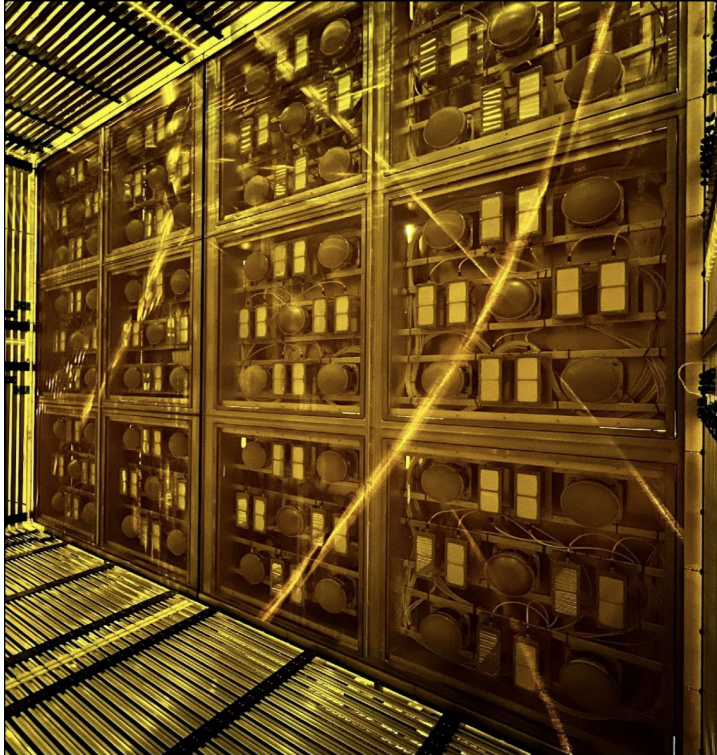
The SBND Experiment

112 tons of LAr between two drift volumes separated by central cathode



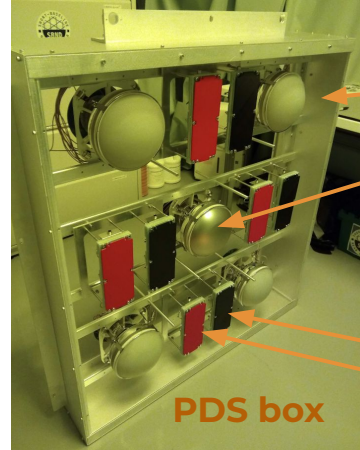
Yesterday's talk by L. Yates: "Status of the Short-Baseline Near Detector at Fermilab"

Photon Detection System (PDS)



PDS system behind each anode plane to detect **fast LAr scintillation light**

- Direct and cathode reflected light
- Uses CAEN digitisers to readout waveforms
- **Nanosecond timing and trigger**



120 PMTs

- 96 TPB coated
- 24 uncoated

192 X-ARAPUCAs

Light guides with dichroic filters and wavelength shifter coupled to SiMPs

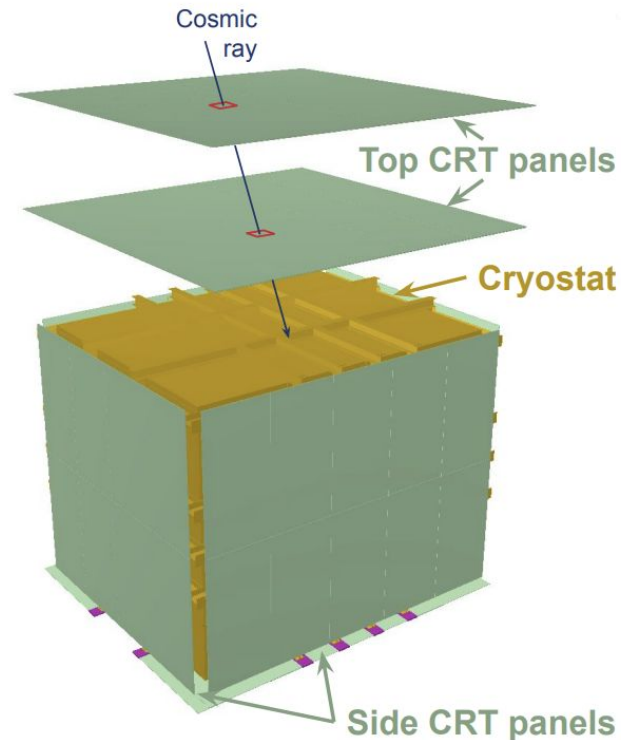
- 50% PTP coated
- 50% uncoated

Cosmic Ray Tagger (CRT)

Cryostat surrounded by plastic scintillator panels coupled to SiMPs

- near 4π coverage
- time resolution of a few nanoseconds

Cosmic tagging for background rejection and creating samples useful for commissioning



SBND Trigger

TPC events beautiful but large - event rate for analysis restricted to ~ 1 Hz
SBND will receive 20-30x higher LAr statistics than currently available

SBND data:

BNB rate of 5Hz
Neutrino event every ~ 20 beam spills
Potential beam-related BSM signatures
kHz of cosmics on surface

Trigger on light activity across the detector
(localised or spread out)
paired with programmable logic
(beam coincidence, prescaled spills, CRT triggers, ...)



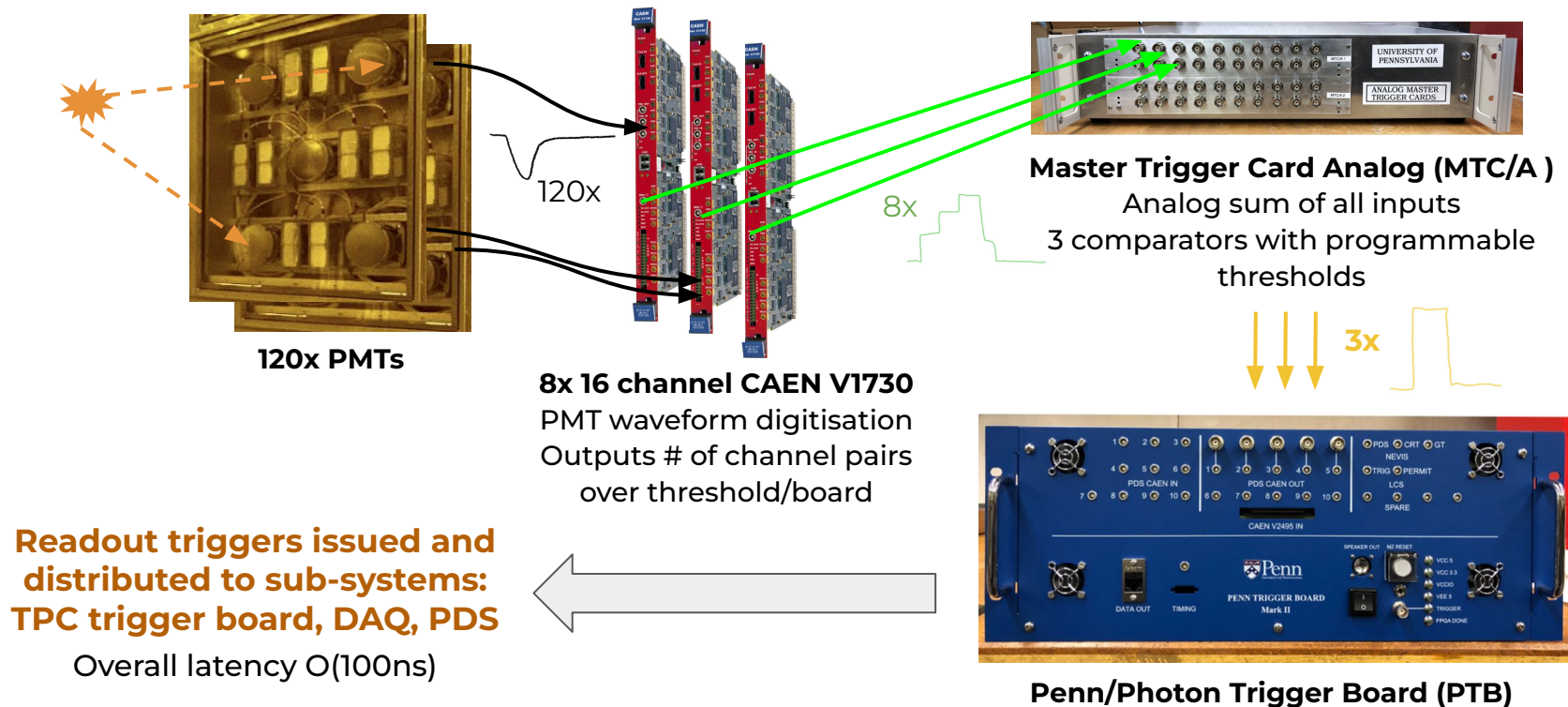
Master Trigger Card Analog (MTC/A)



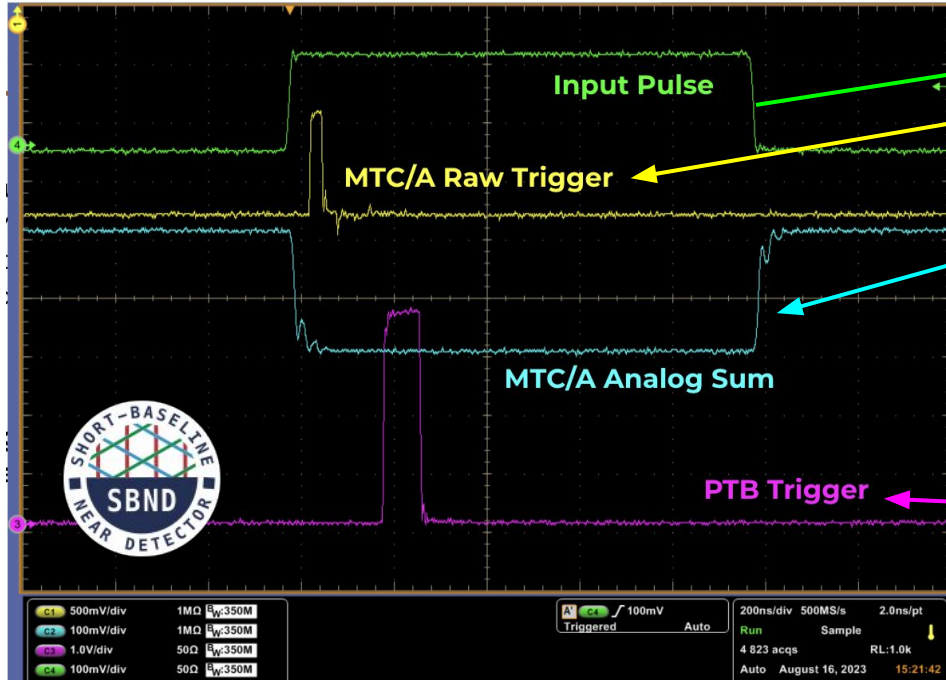
Penn/Photon Trigger Board (PTB)

Efficient trigger allows for **lower energy thresholds** while keeping manageable data rate
Important for low energy cross-section measurements and BSM physics

Main Hardware Trigger Path



Main Hardware Trigger Path



Master Trigger Card Analog (MTC/A)

Analog sum of all inputs

3 comparators with programmable thresholds

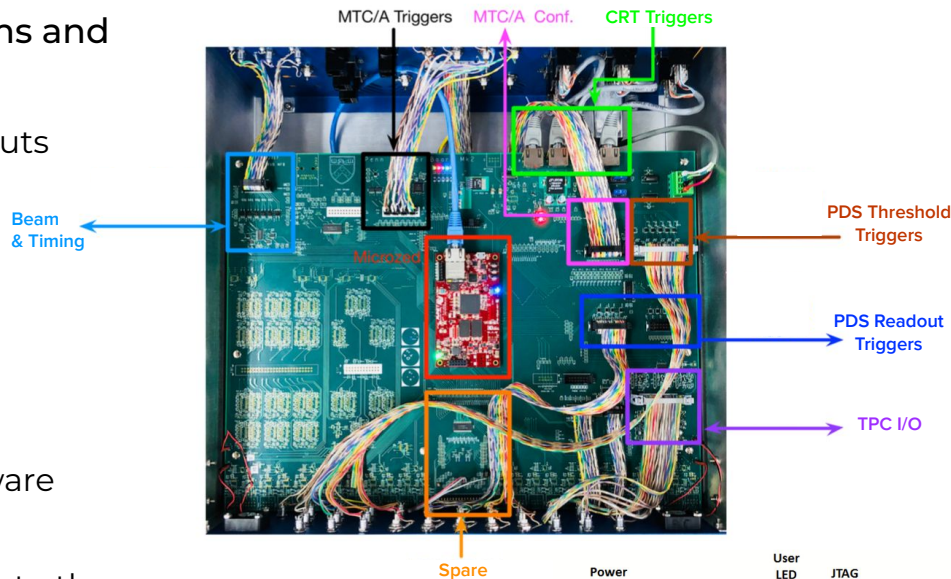


Penn/Photon Trigger Board (PTB)

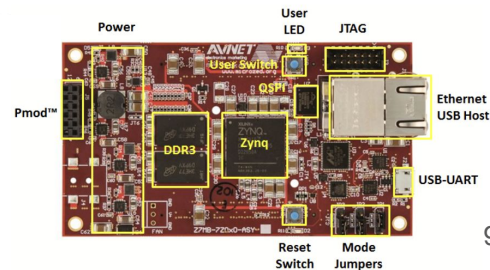
Penn/Photon Trigger Board (PTB)

PTB receives signals from different subsystems and issues readout triggers AND other signals

- Highly **flexible inputs** (ECL/TTL/...) and outputs from various subsystems
- ~100 I/Os total
- Configurable and compact board
- MicroZed with Zynq-7Z020 SoC (System-on-Chip)
- **Programmable logic** - FPGA running firmware containing all HW trigger logic
- Linux **processing system** with direct access to the FPGA

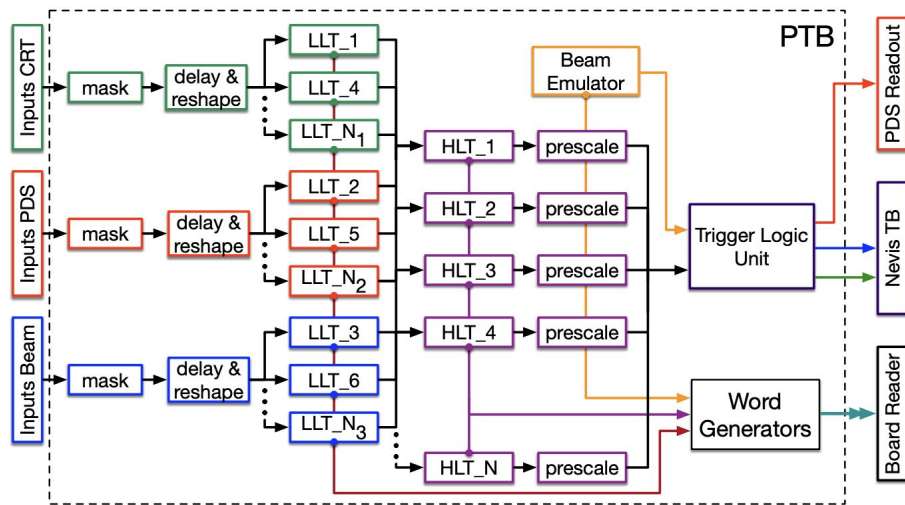


Version of PTB used in DUNE 35t, protoDUNE SBND and EOS experiments



PTB Architecture and Capabilities

Firmware architecture allows high flexibility by employing Low Level Triggers (LLTs) and High Level Triggers (HLT)



All LLTs and HLTs timestamped and recorded

Low level triggers from single subsystem

High level triggers across subsystems

LLTs masked in from a configuration file
Distributed to TPC and PDS for readout

Logic of each trigger configurable at run time

Coincidences and vetos

Counting triggers

Fake beam triggers for cosmics

Also:

Inhibits & resets to avoid subsystem deadtimes

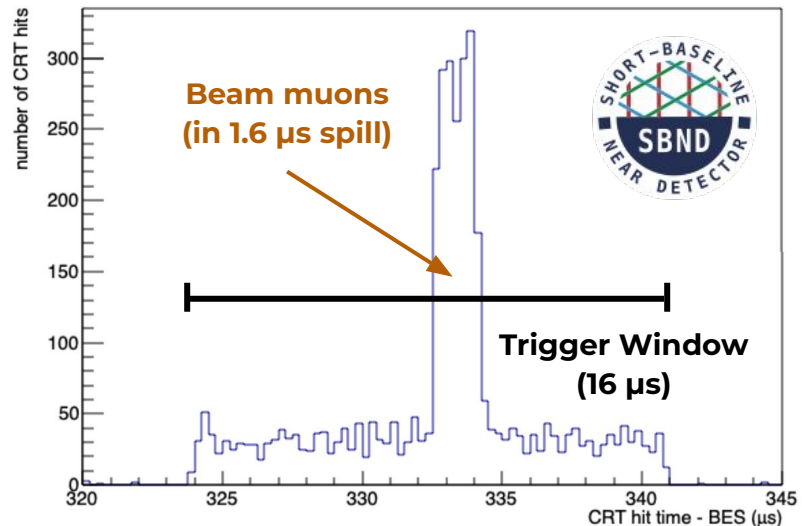
Multiple PDS “flash” triggers/TPC trigger, ...

CRT and Trigger Commissioning

CRT panels temporary installed on the side of the cryostat for early commissioning
Horizontal crossing muon trigger in coincidence with beam demonstrated



Beam



Time between a CRT hit and beam extraction (BES) signal in a triggered event

Conclusions

SBND highest statistics of any neutrino LAr experiment to date will provide opportunity for measuring **neutrino cross-sections** and potential **BSM physics**

Definitive answer on existence of **eV-scale sterile neutrinos** as part of the SBN program

Efficient and configurable hardware trigger to optimise readout for maximal physics sensitivity given data size restrictions

PTB is a flexible and powerful solution for SBND trigger needs

Commissioning work ongoing - stay tuned!



More SBND at TAUP:

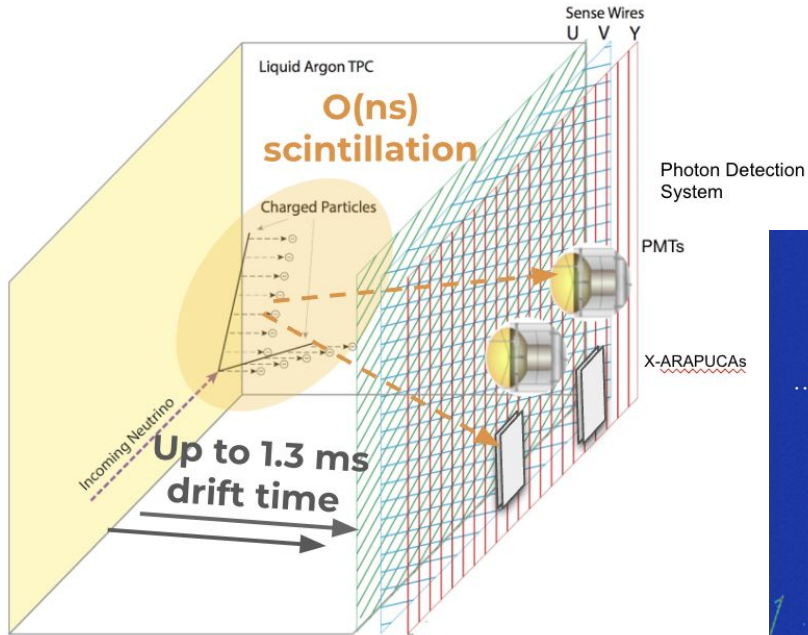
L. Yates: "Status of the Short-Baseline Near Detector at Fermilab" (yesterday)

J. I. Crespo-Anad3n "Searches for Beyond Standard Model Physics in the SBND neutrino experiment" (Thursday)

Thank you for your attention!

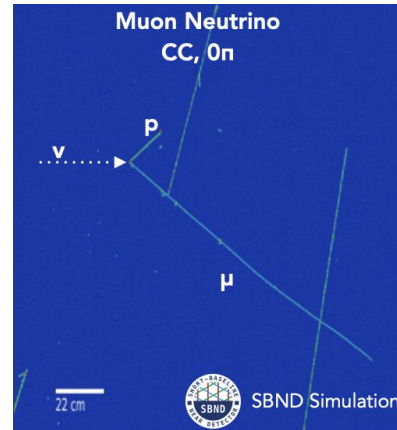


Back up: SBND Events



LAr ionisation from charged particle passage
millisecond drift times to anode

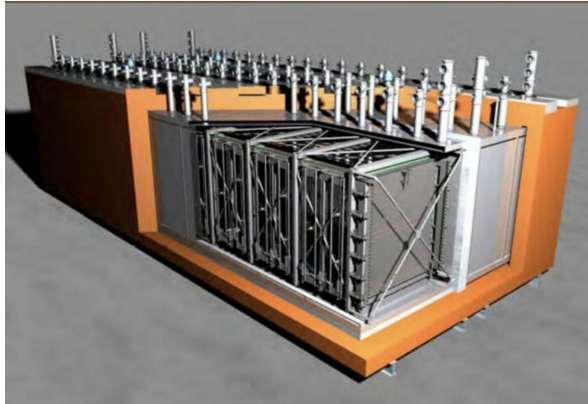
- Multi-dimensional event topology
- Particle Identification via dE/dx



Fast **scintillation light** from LAr detected by photon detection system
→ **Nanosecond timing and trigger**

Back up: SBN Detectors

Three detectors of the same technology along the same neutrino beam

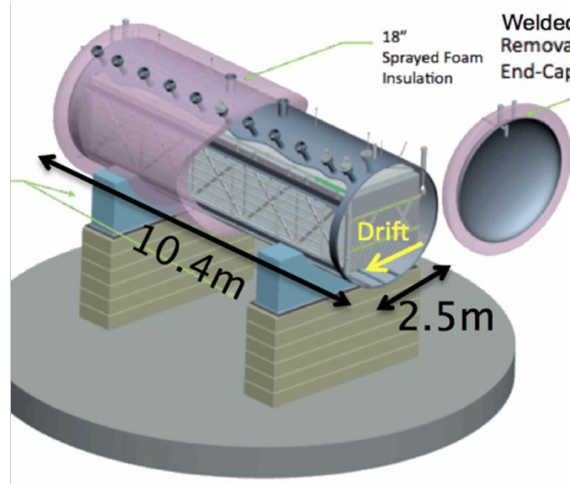


ICARUS

476 tons active volume

$L = 600$ m

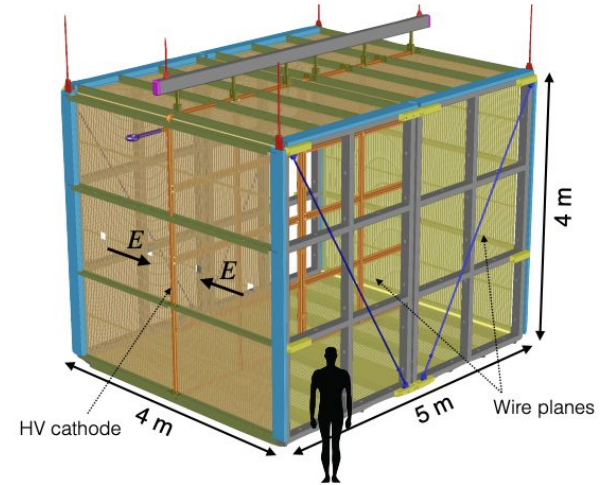
“Far detector”



MicroBooNE

85 tons active volume

$L = 470$ m



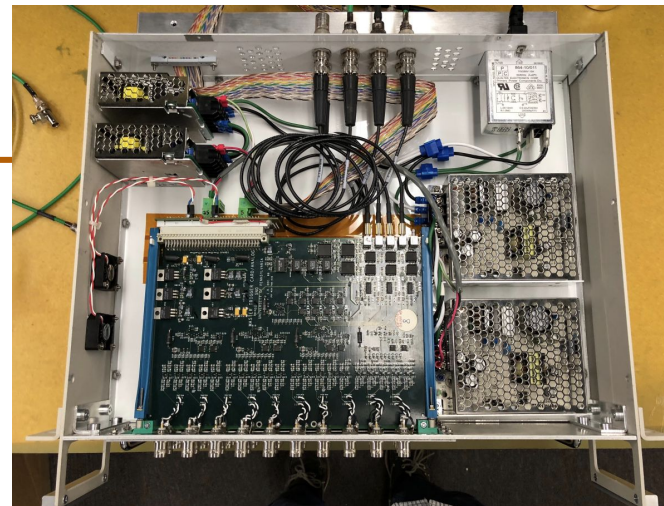
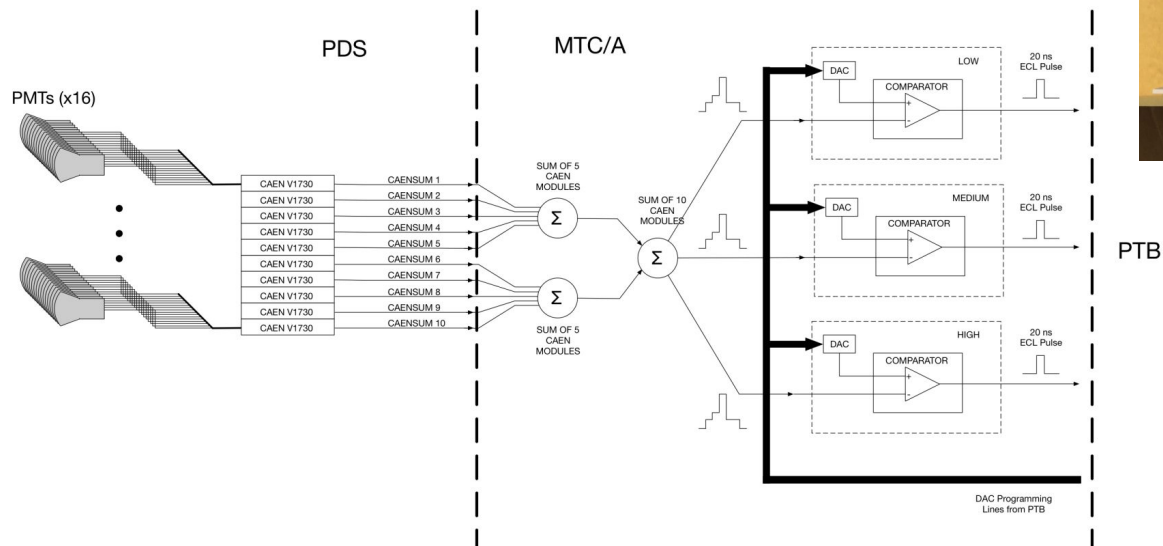
SBND

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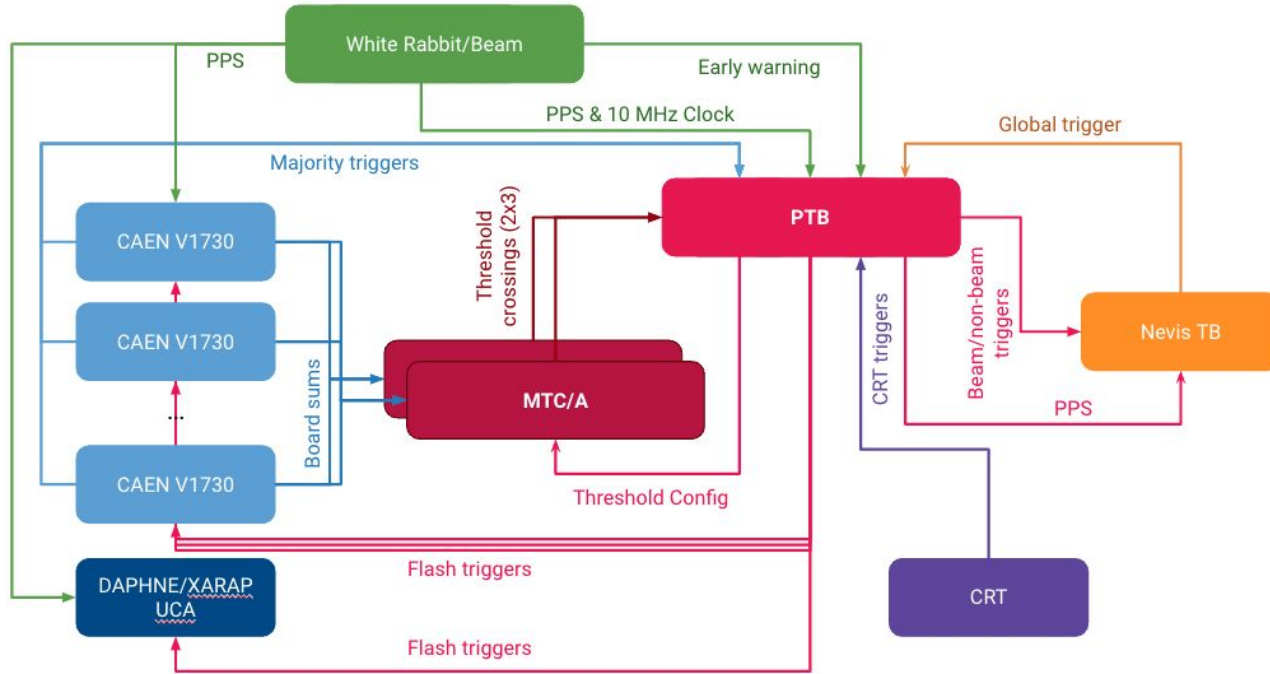
Back up: MTC/A Detail



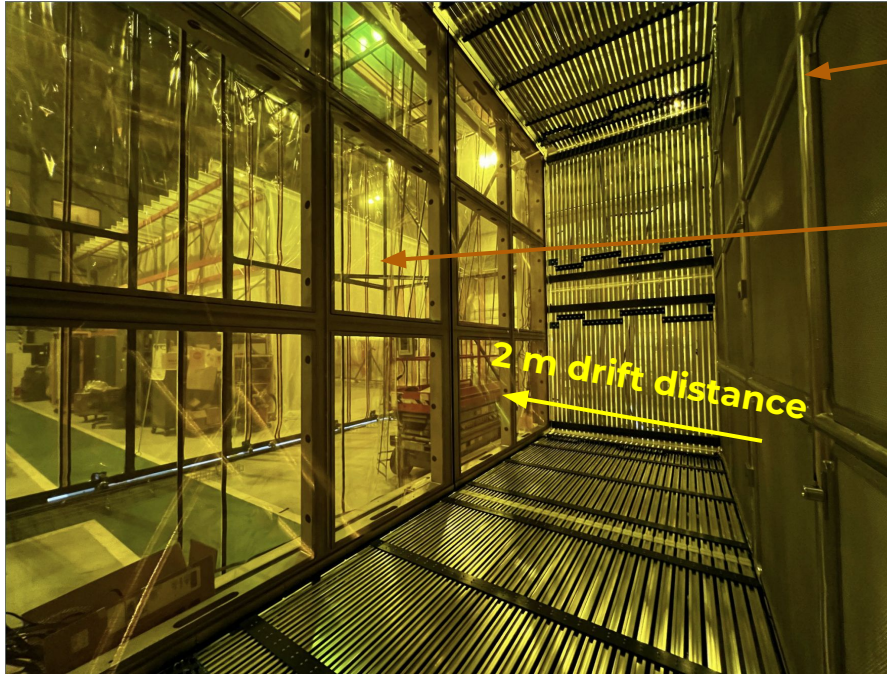
PTB

MTC/As used in the SNO experiment

Back up: SBND PTB connections



Back up: SBND TPC

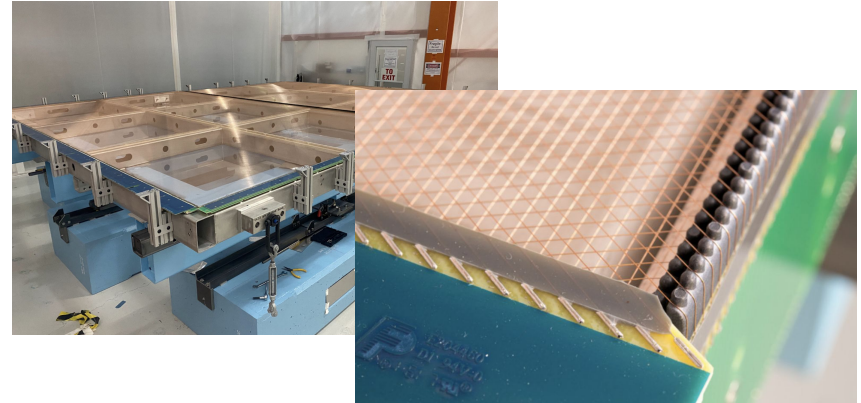


Cathode covered in a wavelength shifting (TPB) reflectors

- Two TPCs optically isolated

2 Anode Plane Assemblies per wall

- 3 wire crossing planes each
- 3 mm wire & plane pitch



Back up: SBND Cryostat

Stainless steel membrane cryostat to allow for LAr operation

