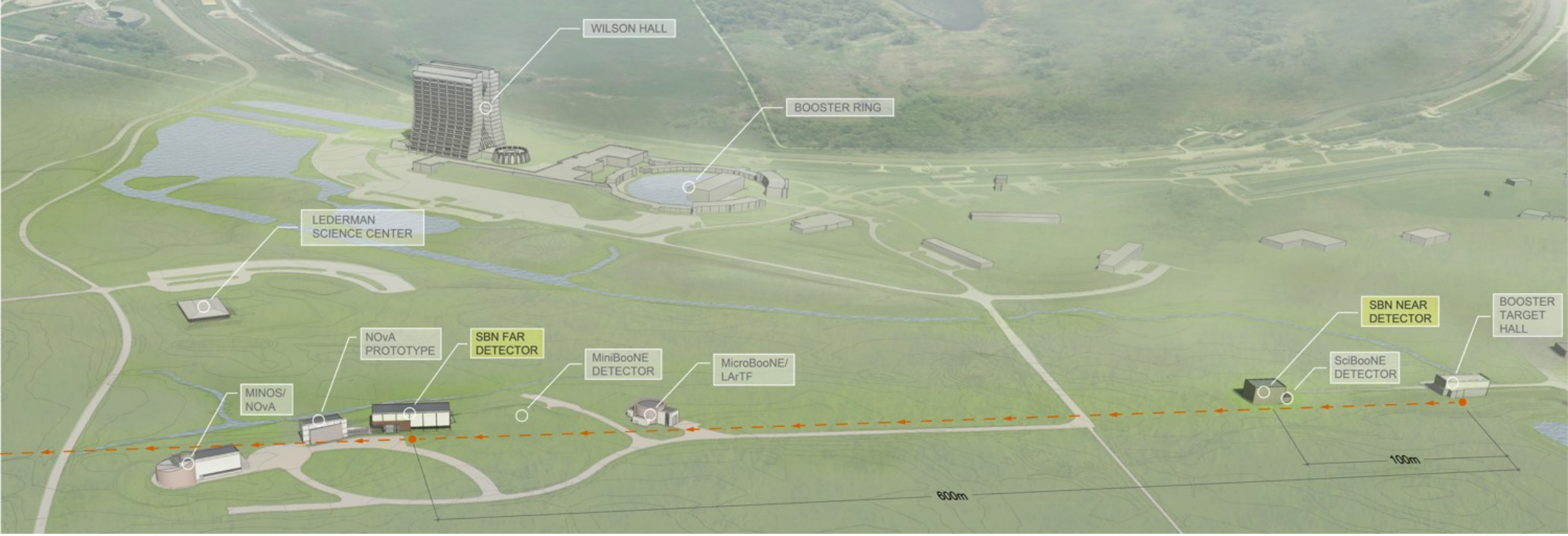
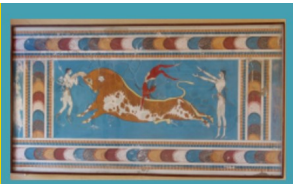


The **S**hort **B**aseline **N**ear **D**etector at Fermilab

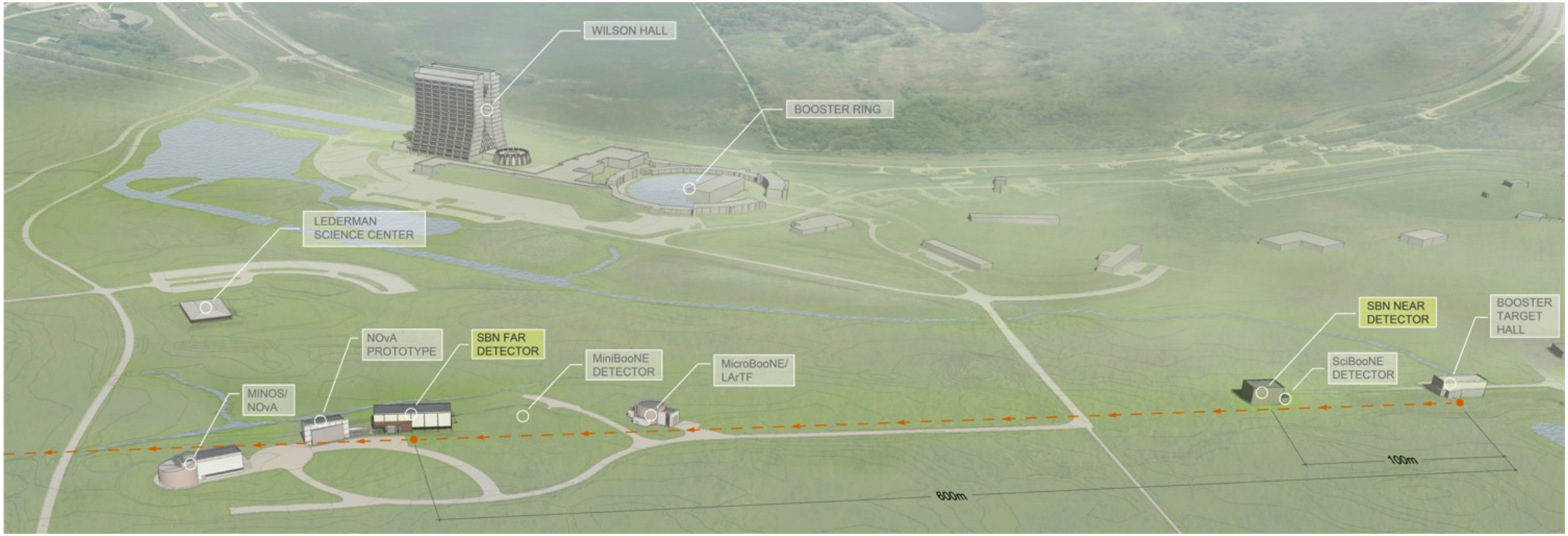
Thomas Mettler for the SBND Collaboration
University of Bern

LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

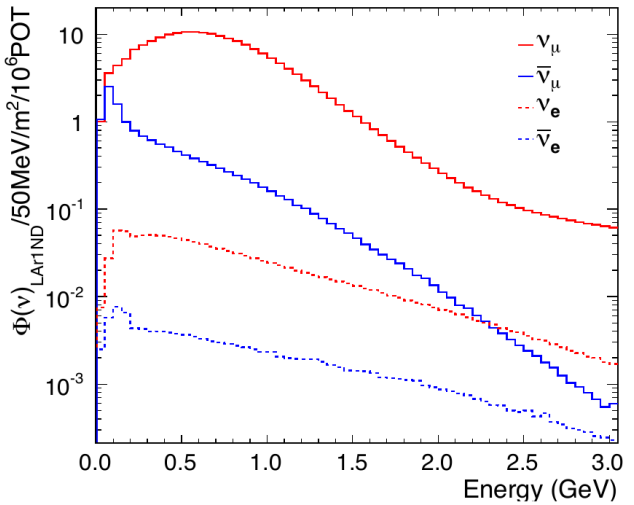


6th International Conference on New Frontiers in Physics (ICNFP2017)
17. - 29 August 2017

SBN Program

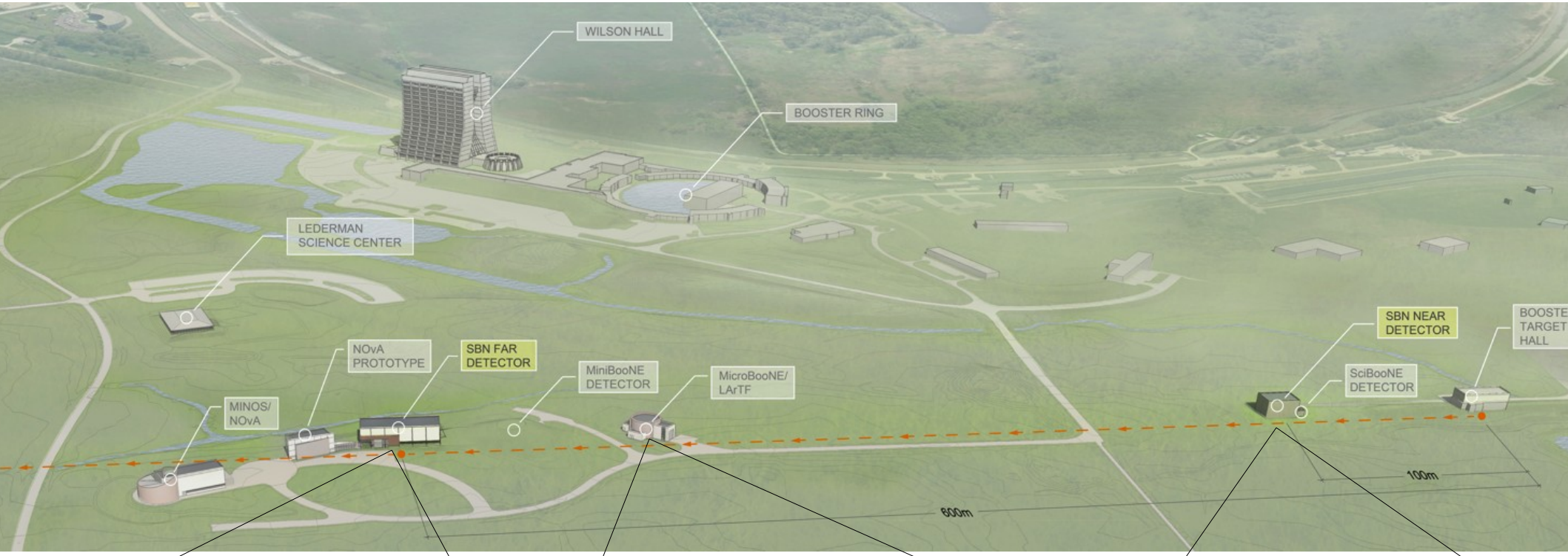


- Short Baseline Neutrino program (SBN)
- 3 liquid Argon Time-Protection Chambers (LArTPCs): SBND, MicroBooNE, ICARUS T-600
- Booster Neutrino Beam (BNB):
  - 8 GeV protons
  - ⟨E_ν⟩ ≈ 700 MeV

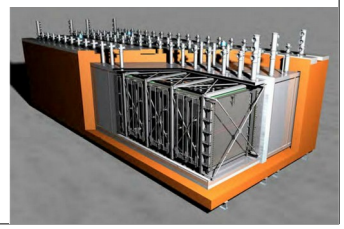


arXiv:1503.01520v1

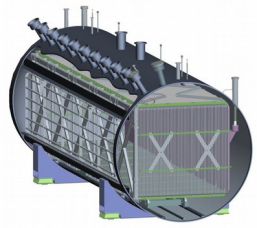
SBN Detectors



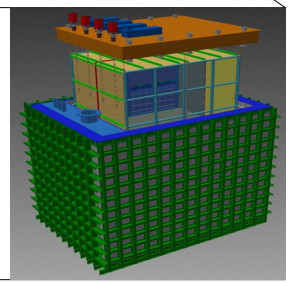
ICARUS-T600:
600 m
470 t



MicroBooNE:
470 m
86 t



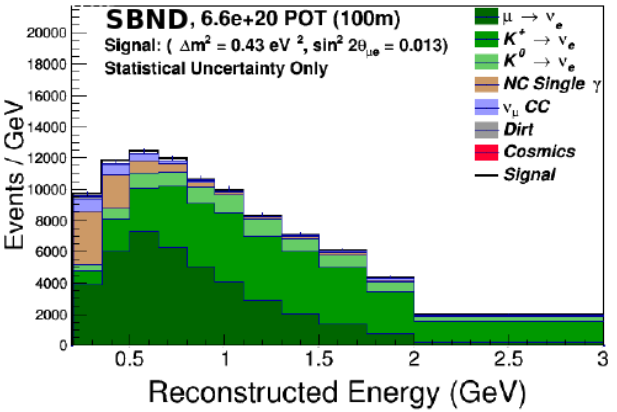
SBND:
110 m
112 t

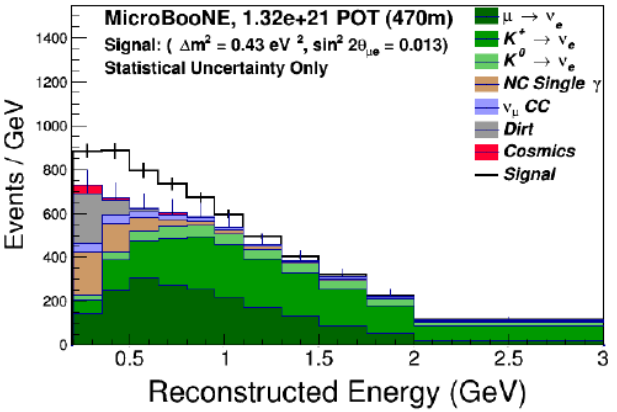


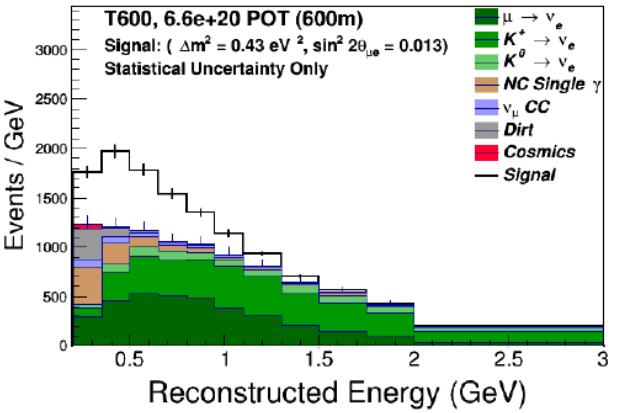
arXiv:1503.01520v1

SBN Physics program

- Sterile Neutrino driven by LSND/MiniBooNE
  - Separation of e/γ
- Neutrino cross section in Argon
- LArTPC R&D







arXiv:1503.01520v1

Physics Goals of SBND

- Measure the unoscillated flux of Neutrinos from BNB:
  - Measuring the interactions of ν_μ-CC, ν_e-CC and NC, characterize the BNB for oscillation searches with MicroBooNE and ICARUS.
- Study neutrino-nucleus interactions in Argon
  - SBND will collect a huge data set, allowing for precise cross section measurement & study of rare interactions.
- Additional searches:
  - supernova neutrinos, dark matter etc...

Event Rates

- Interactions for

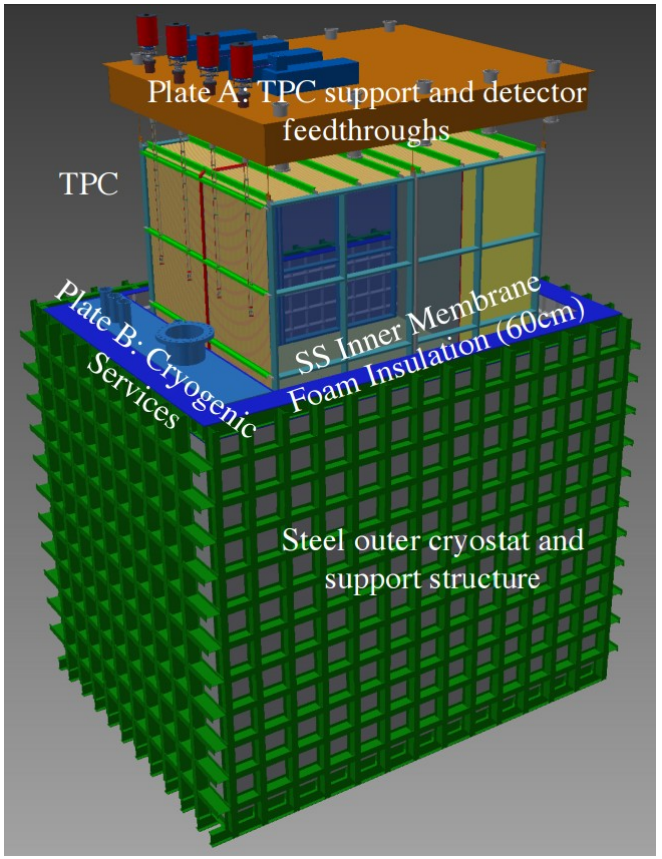
  6.6 * 10^{20} POT
- 3 years of data taking
- ν_μ-Ar interactions: 7*10^6
- ν_e-Ar interactions: 5*10^4

Process		No. Events	Events/ ton	Stat. Uncert.
	ν_μ Events (By Final State Topology)			
CC Inclusive		5,212,690	46,542	0.04%
CC 0 π	$\nu_\mu N \to \mu + Np$	3,551,830	31,713	0.05%
	· $\nu_\mu N \to \mu + 0p$	793,153	7,082	0.11%
	· $\nu_\mu N \to \mu + 1p$	2,027,830	18,106	0.07%
	· $\nu_\mu N \to \mu + 2p$	359,496	3,210	0.17%
	· $\nu_\mu N \to \mu + \geq 3p$	371,347	3,316	0.16%
CC 1 $\pi^\pm$	$\nu_\mu N \to \mu +$ nucleons $+ 1\pi^\pm$	1,161,610	10,372	0.09%
CC $\geq 2\pi^\pm$	$\nu_\mu N \to \mu +$ nucleons $+ \geq 2\pi^\pm$	97,929	874	0.32%
CC $\geq 1\pi^0$	$\nu_\mu N \to \mu +$ nucleons $+ \geq 1\pi^0$	497,963	4,446	0.14%
NC Inclusive		1,988,110	17,751	0.07%
NC 0 π	$\nu_\mu N \to$ nucleons	1,371,070	12,242	0.09%
NC 1 $\pi^\pm$	$\nu_\mu N \to$ nucleons $+ 1\pi^\pm$	260,924	2,330	0.20%
NC $\geq 2\pi^\pm$	$\nu_\mu N \to$ nucleons $+ \geq 2\pi^\pm$	31,940	285	0.56%
NC $\geq 1\pi^0$	$\nu_\mu N \to$ nucleons $+ \geq 1\pi^0$	358,443	3,200	0.17%
	ν_e Events			
CC Inclusive		36798	329	0.52%
NC Inclusive		14351	128	0.83%
Total ν_μ and ν_e Events		7,251,948	64,750	

arXiv:1503.01520v1

SBND Detector

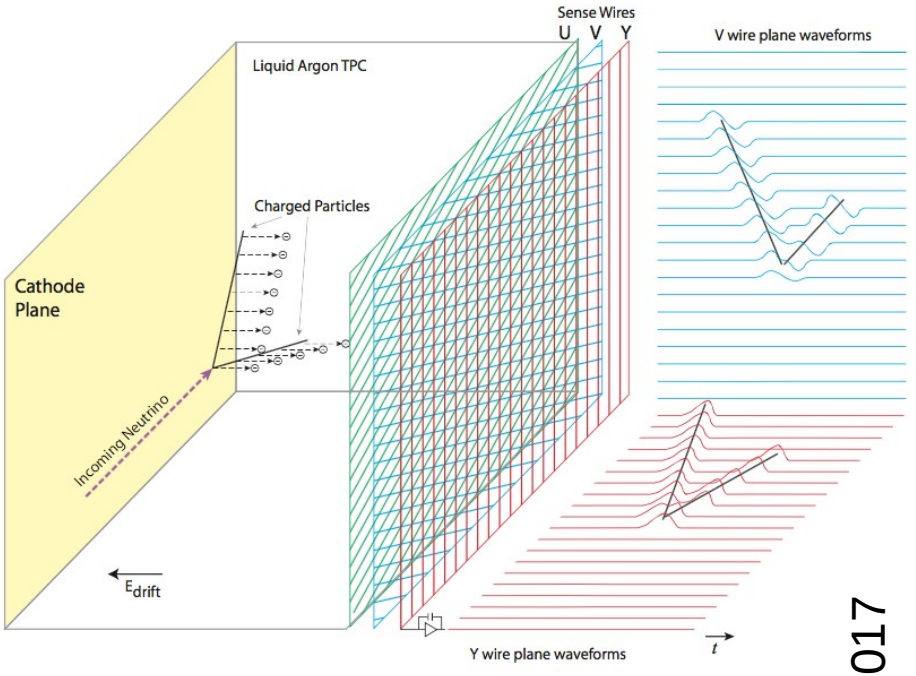
- 110 m from target
- LArTPC with 112 t of LAr
- 4 m * 4 m * 5 m active volume
- 3 wire planes on both sides
- 2 m drift distance
- Cold electronics
  - Preamplification, digitisation
- UV laser-based calibration system
- Cosmic Ray Tagger system

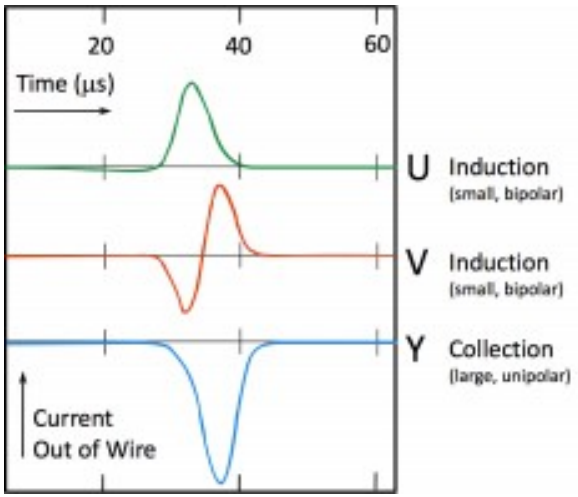


arXiv:1503.01520v1

Working Principle of TPC

- Charged particles ionize the LAr and produce scintillation light
- Photo sensors detect scintillation light and trigger an event
- Electrons drift to anode due to HV
- Read out of the electron charge with 3 wire planes + drift time → 3D image of interaction

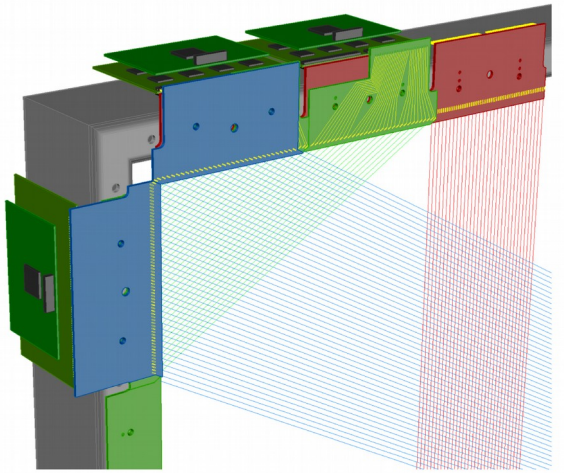


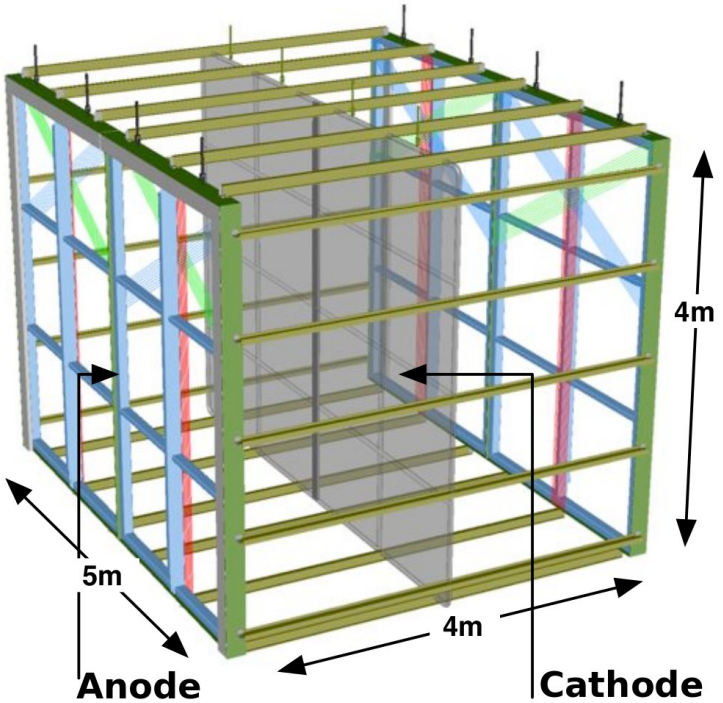


Jinst 12 P02017

Time Projection Chamber

- 3 wire planes with 3 mm pitch
  - Each 5632 channels, 11264 total
- 2 m drift distance
- Voltage: -100 kV → 500 V/cm
- 1.28 ms drift time
- Cold electronics
  - Preamplification
  - Digitisation





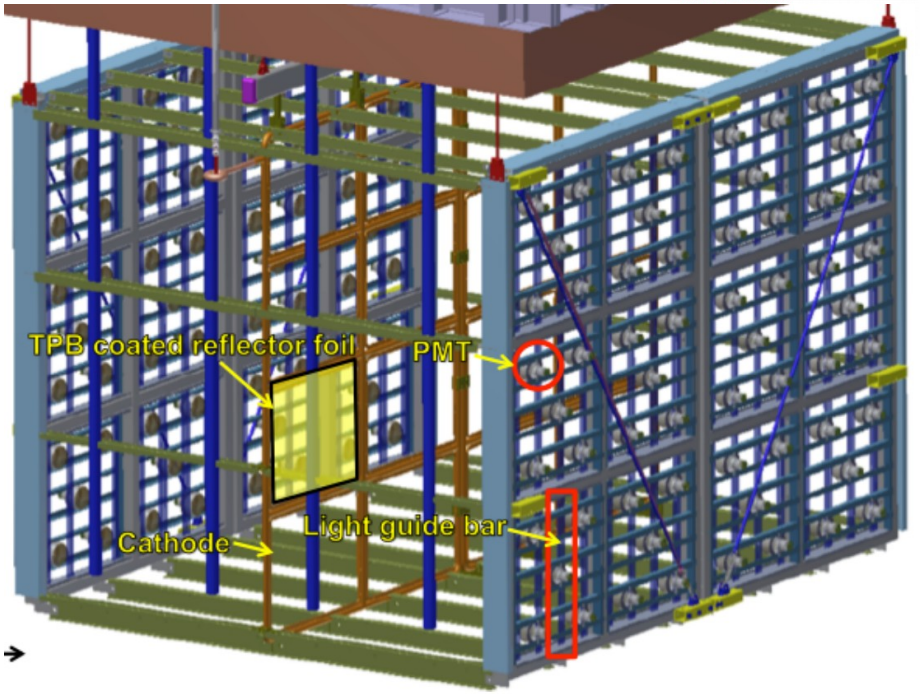
arXiv:1503.01520v1

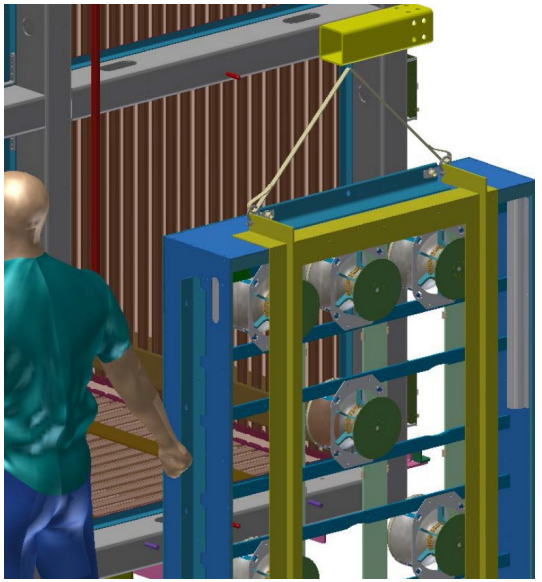
Light Readout

- PMT + Light Guide Bars
- The PMTs are TPB coated
- Providing trigger and time information

  → measure the drift time

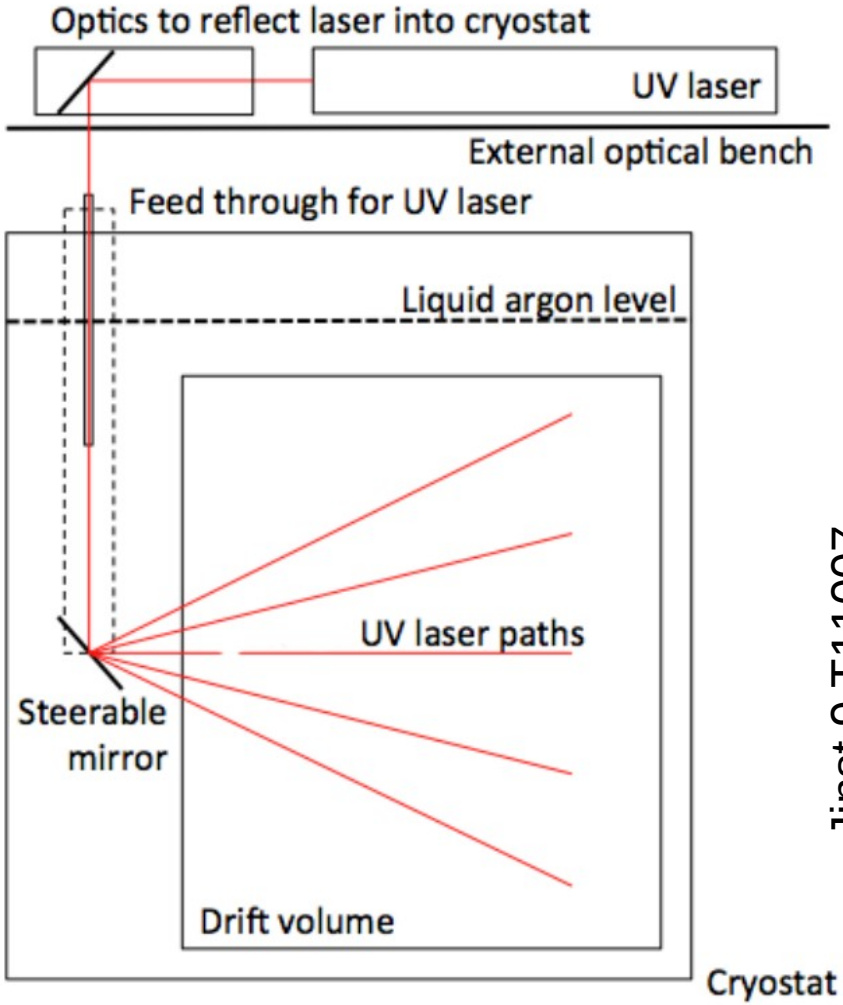
    → position in the third dimension





UV-Laser Calibration System

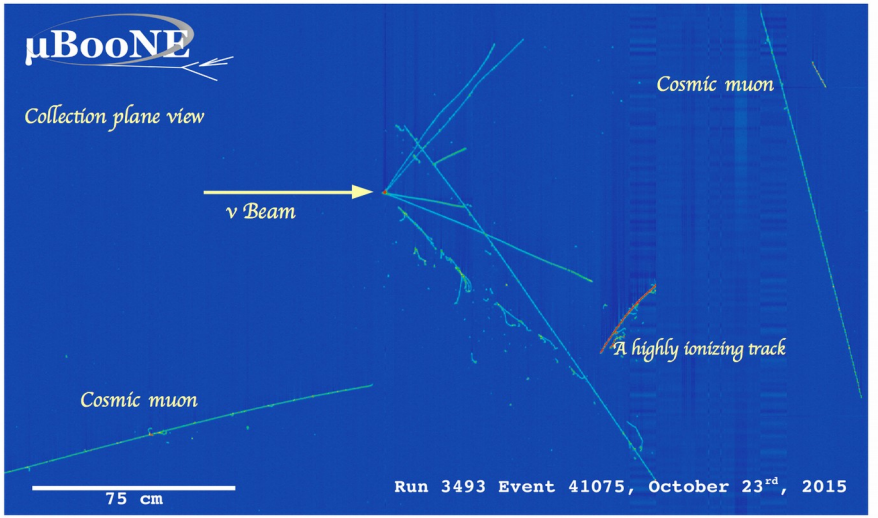
- Positive ions due to ionisation
  - → Distortion of the E-field
- Four steerable UV-laser systems generate straight tracks
- Maps the electric field distorted by the space charge effect
  - Provides frequent calibration of the E-field
- Correct track distortion
- Wavelength: 266 nm
- PPS: 10 Hz

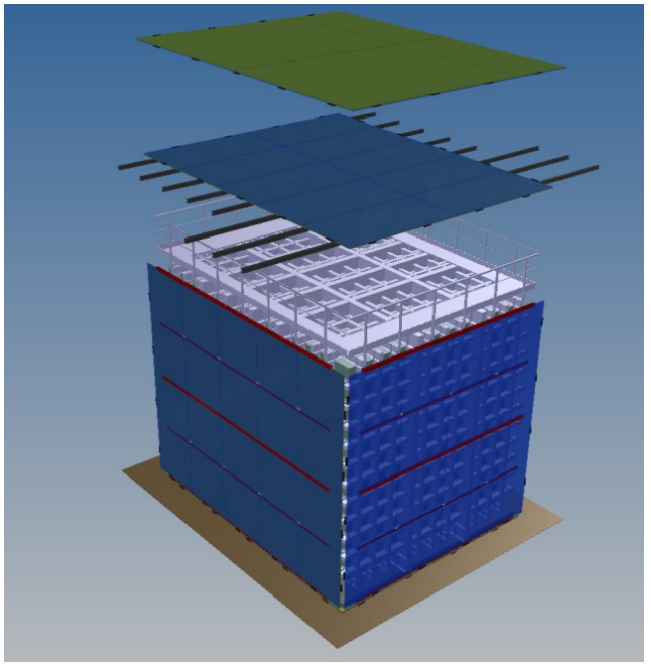


Jinst 9 T11007

Cosmic Ray Tagger

- High rate of cosmic interaction since the detector is on the surface
- Reject cosmic interactions (mainly muons)
- Every neutrino event is surrounded by 3 muon tracks per read out time window on average
- Two top layer telescope with ≈ 8 mrad

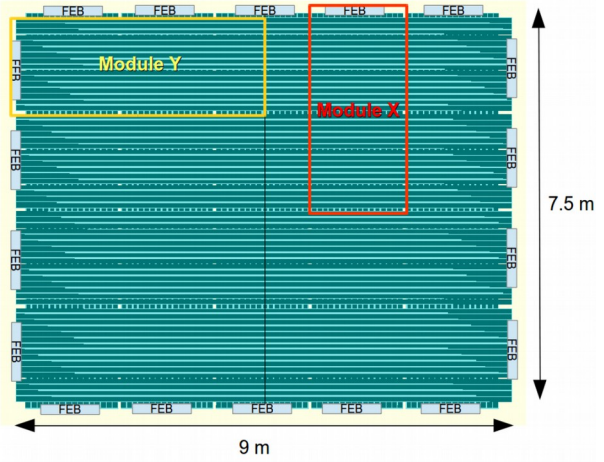


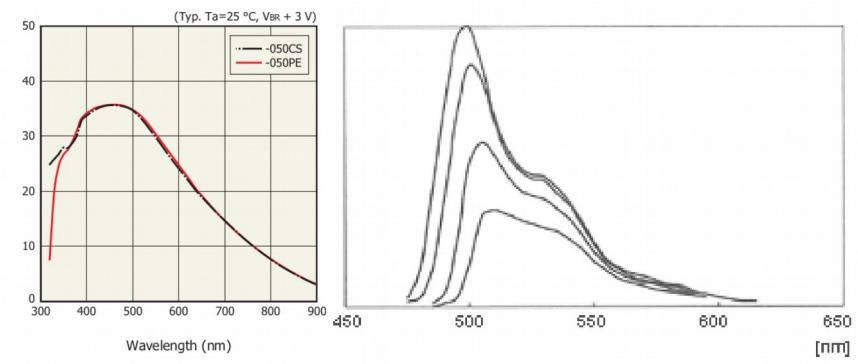


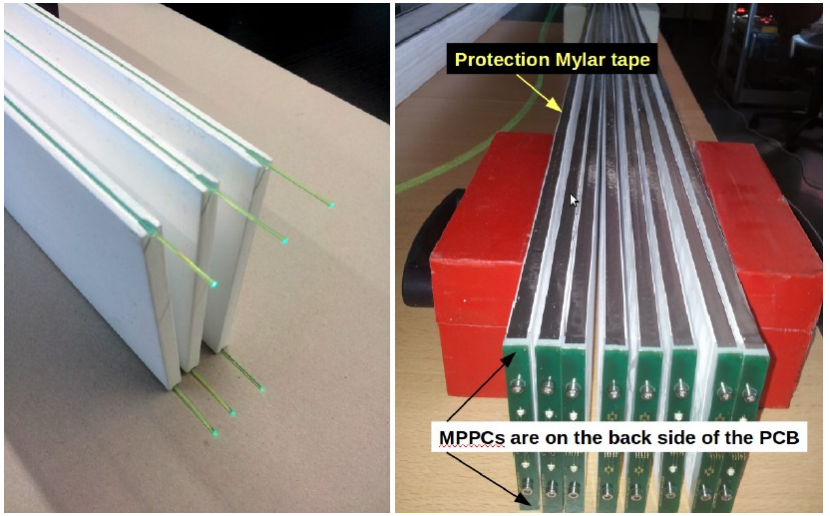
MDPI inst 1010002

Cosmic Ray Tagger

- Planes out of X- and Y-modules
- 16 strips of plastic scintillator in each module
- 2 WLS fibers and 2 SiPM per strip
- 1 Front-End electronic board per module





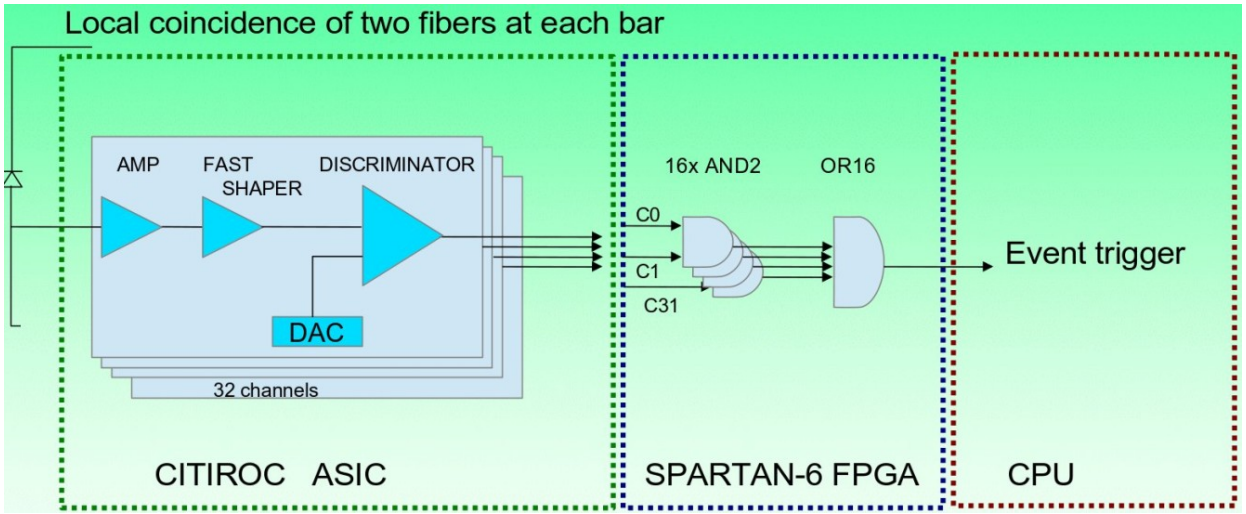


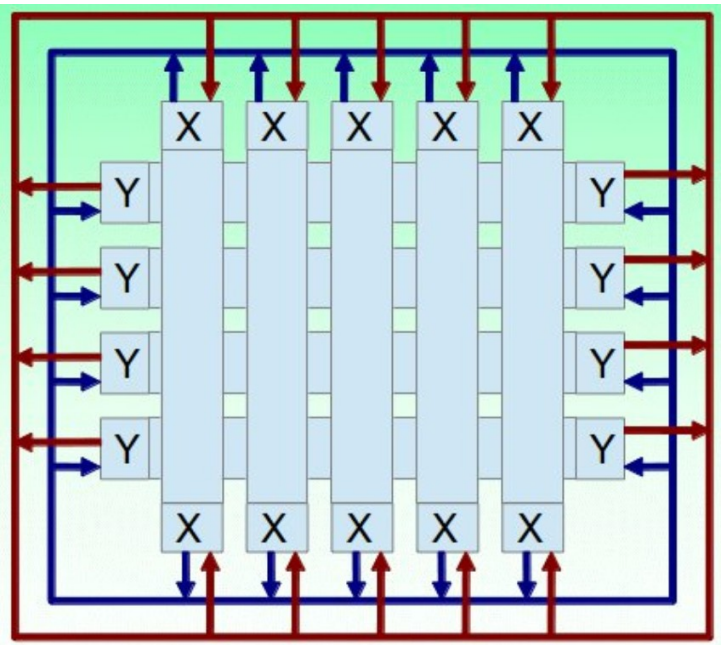
Mdpi inst 1010002

Jinst 11 P10005

Cosmic Ray Tagger

- Both SiPMs have to reach threshold to trigger an event
- X-Y trigger





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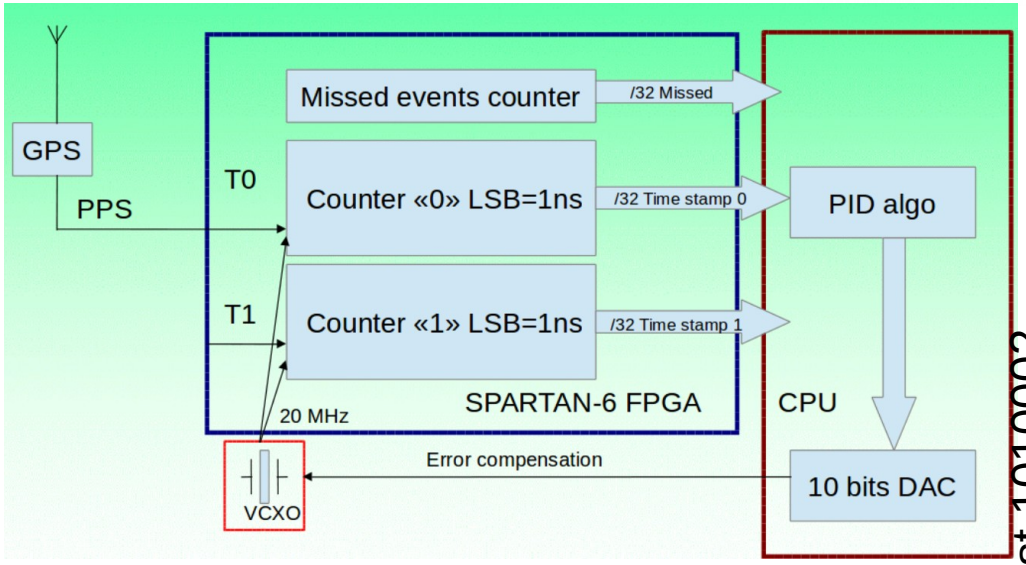
Cosmic Ray Tagger

- Time stamp with global time reference
- Time stamp with beam time reference
- Spatial resolution of 1.8 cm
- Time resolution about 2 ns



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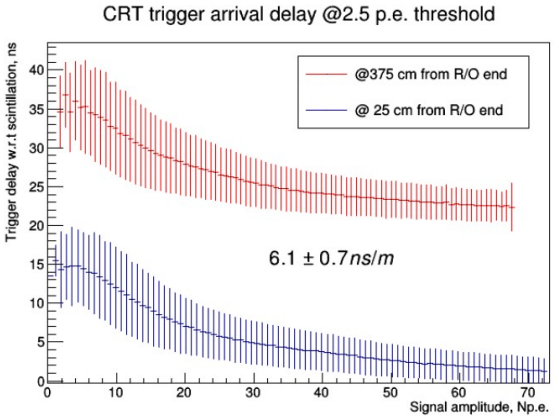
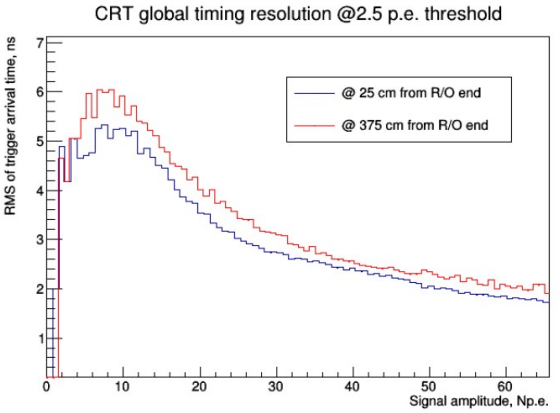




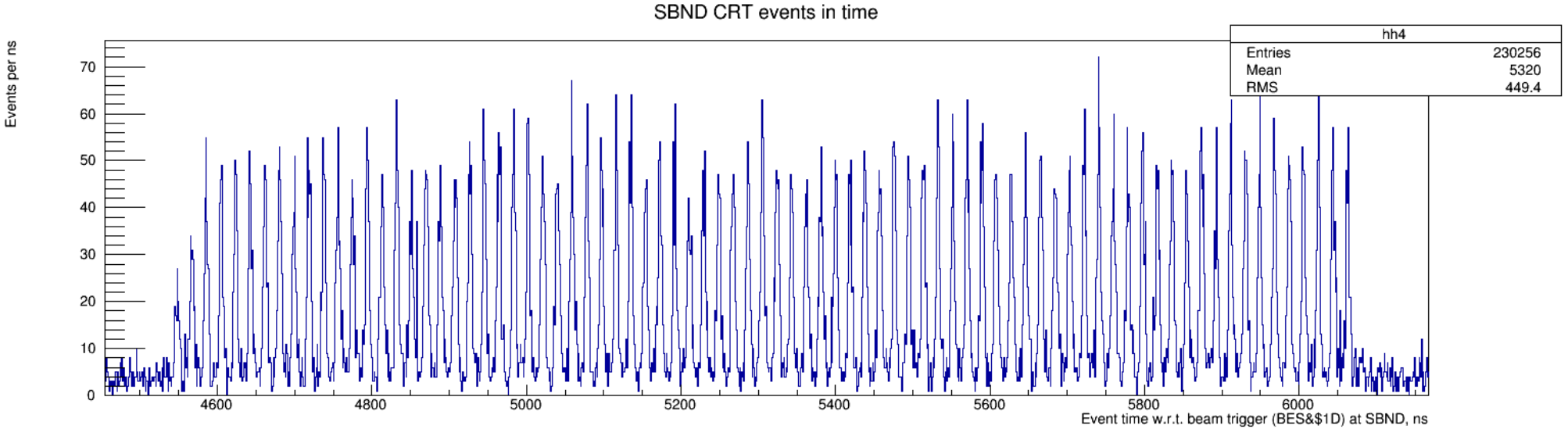
CRT Test Stand

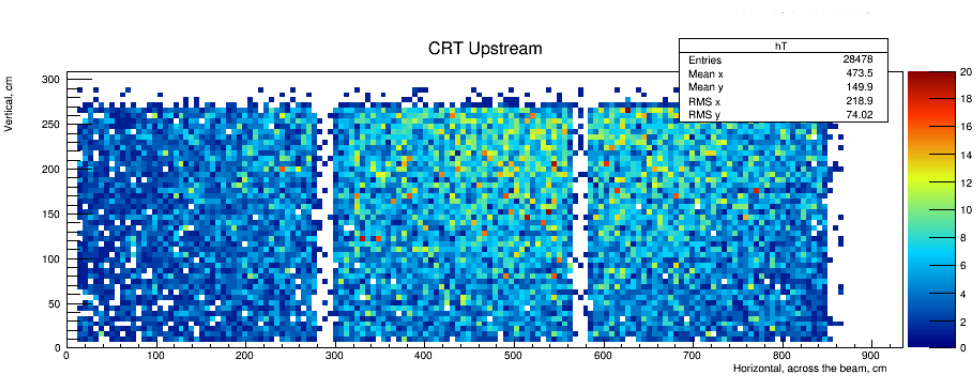
- Installed end of June 2017
- Measuring “dirt” muons of the BNB beam + cosmic rays
- Beam profiling
- Resolving beam structure
- 18 modules up stream
- 6 modules down stream
- 946 cm between up and down stream modules
- Up stream: 2.7 m * 2.7 m * 3

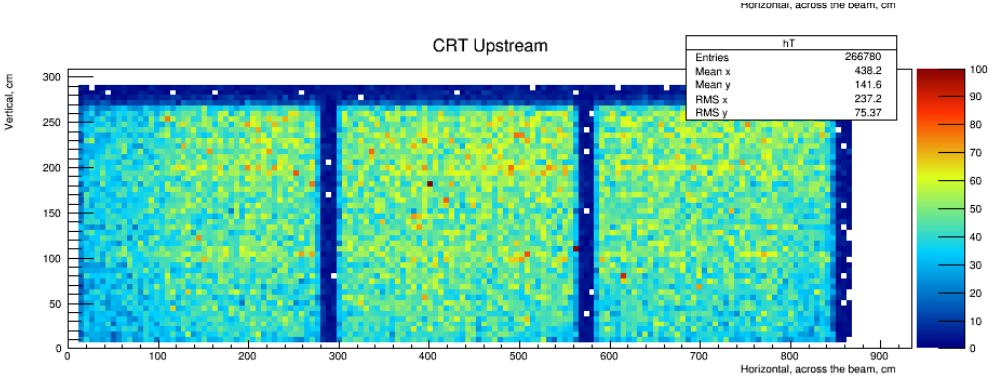
  = 21.9m^2
- Down stream: 2.7 m * 2.7 m * 1

  = 7.3m^2

First CRT Results







BNB events

Cosmic rays

Time Line

- Detector Hall construction : complete
- CRT installation: started June 2017
- Cryostat installation: summer 2018
- TPC production: on going
- Detector commissioning: 2019

Time Line

The detector building of SBND.

Time Line

- Detector Hall construction : complete
- CRT installation: started June 2017
- Cryostat installation: summer 2018
- TPC production: on going
- Detector commissioning: 2019

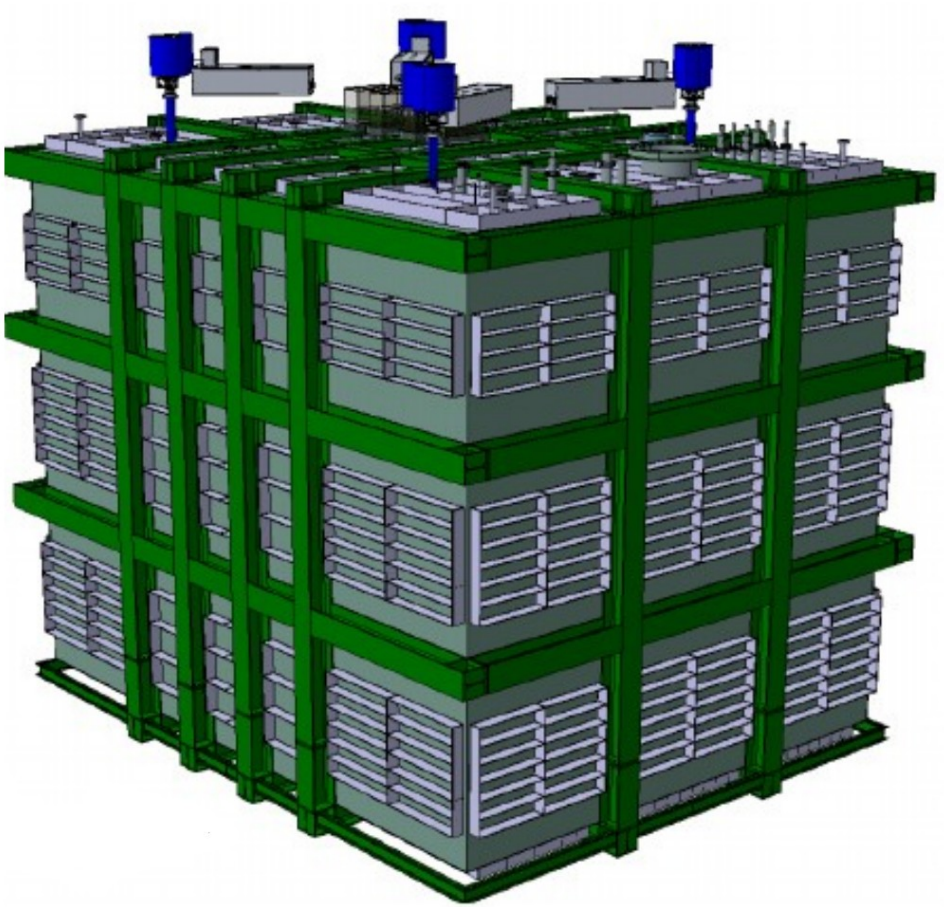
Time Line

View in the pit for the SBND detector. The installed CRT modules downstream are visible.

Time Line

- Detector Hall construction : complete
- CRT installation: started June 2017
- Cryostat installation: summer 2018
- TPC production: on going
- Detector commissioning: 2019

Time Line

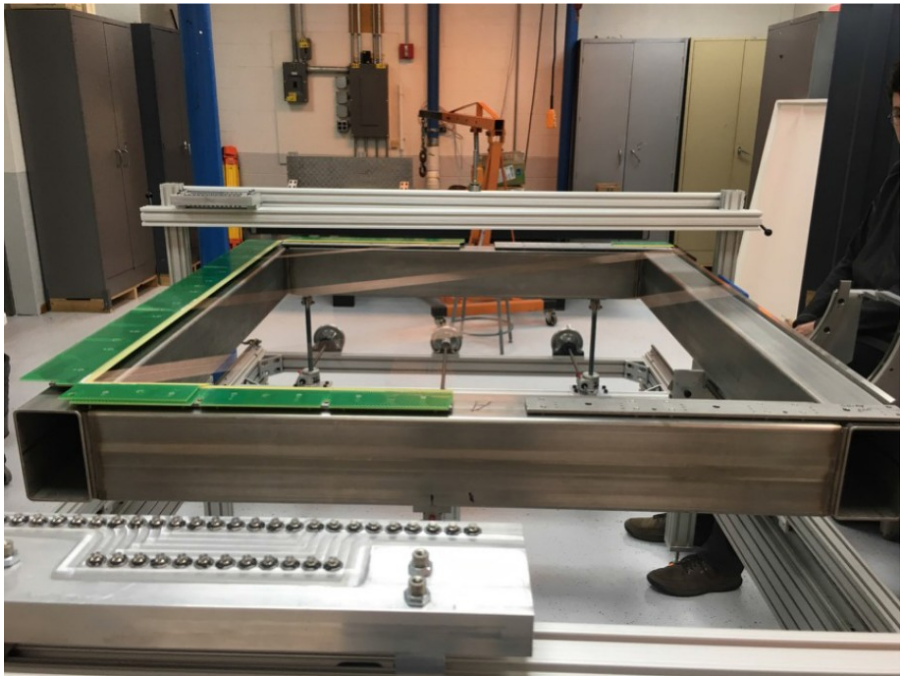


The cryostat is designed by CERN. The experience from currently running prototypes is taken into account.

Time Line

- Detector Hall construction : complete
- CRT installation: started June 2017
- Cryostat installation: summer 2018
- TPC production: on going
- Detector commissioning: 2019

Time Line



The APA frame with first wires.

APA frame being surveyed

Time Line

- Detector Hall construction : complete
- CRT installation: started June 2017
- Cryostat installation: summer 2018
- TPC production: on going
- Detector commissioning: 2019

Summary

- SBND will characterize the BNB flux for the neutrino oscillation studies of MicroBooNE and ICARUS
- SBND will provide a huge data set of neutrino-Ar interactions, constraining cross section uncertainties
- Development of the LArTPC technology for future neutrino experiments
- The detector is being constructed
- CRT test stand already installed and running