CERN ProtoDUNE Single Phase Cosmic Ray Tagger DAQ

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Outline

- The DUNE experiment
- The ProtoDUNE Single Phase detector
- The ProtoDUNE-SP Cosmic Ray Tagger
- Results
- Conclusion

Deep Underground Neutrino Experiment (DUNE)

- DUNE is a large future long-baseline neutrino experiment
- Designed to observe neutrino oscillation and try to measure CP violation
- Could lead to an understanding of why the universe matter dominated
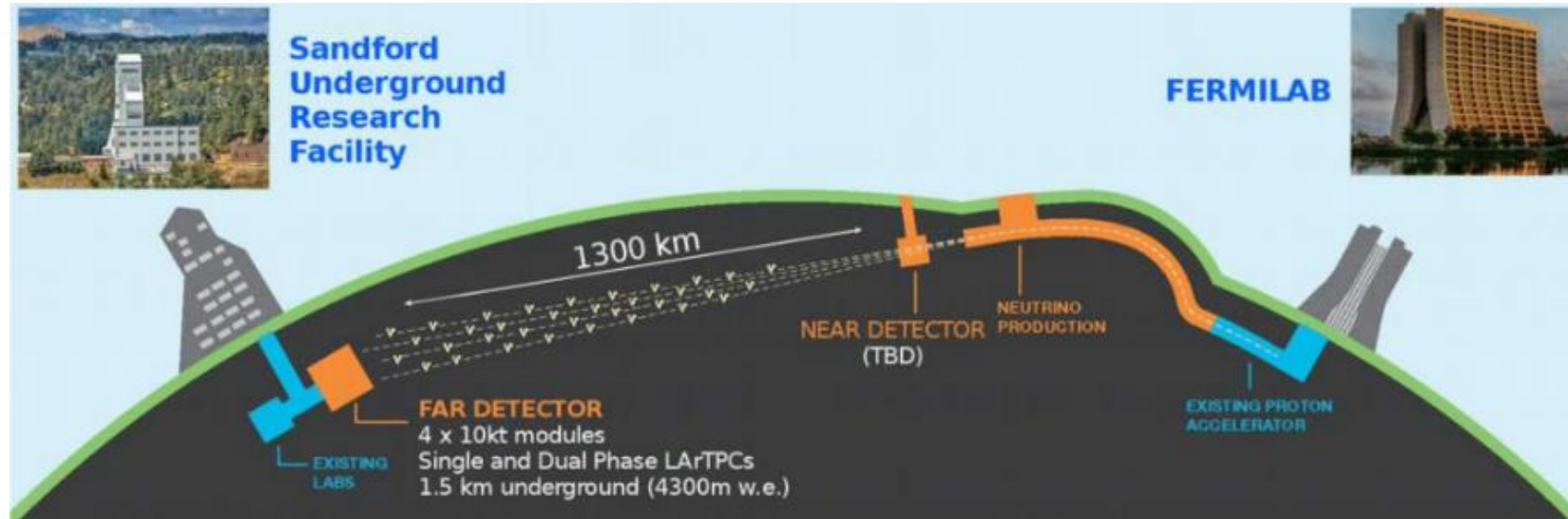
ProtoDUNE Single Phase (SP) Time Projection Chamber (TPC)

- Liquid Argon detector located at CERN

- Provides prototype for DUNE SP Module

- Began taking data at the end of 2018

- Contains 0.77 kton of LAr

- Active volume of 7.2 m deep, 6 m high and 7 m wide

- External Cosmic Ray Tagger
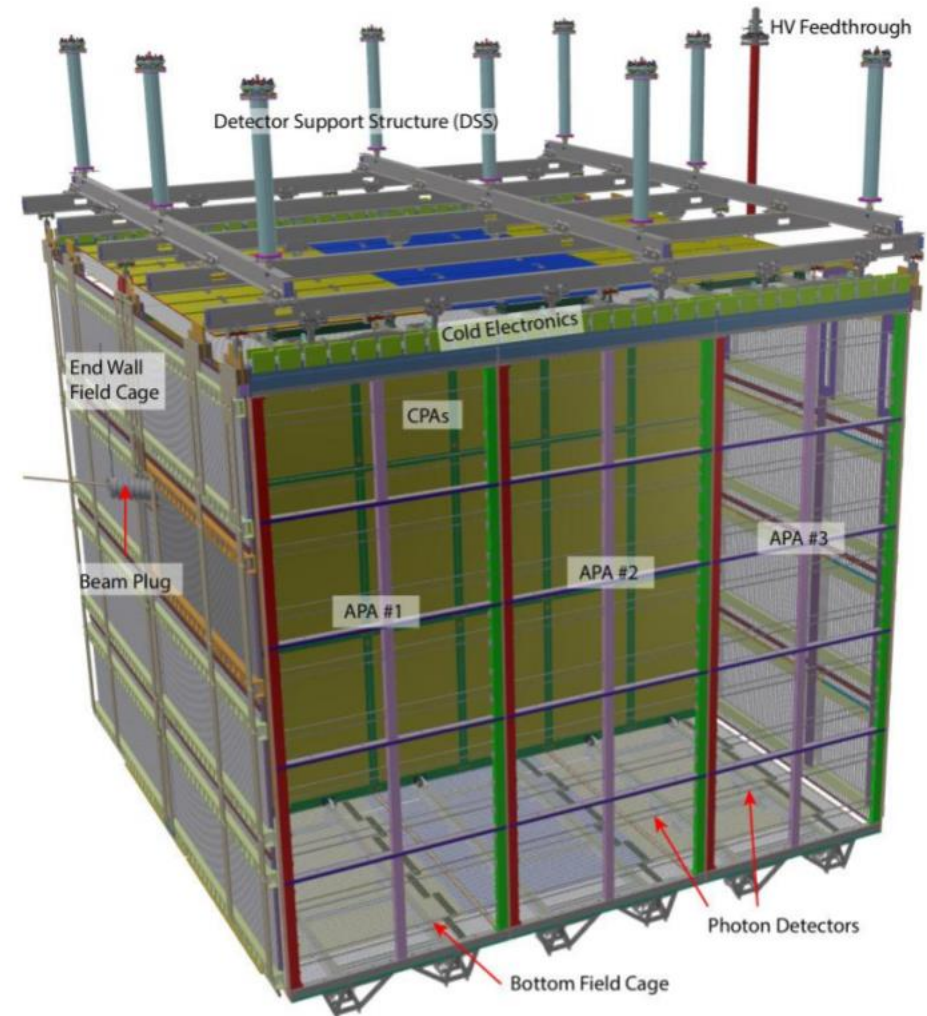
ProtoDUNE-SP Goals

- Develop good procedures for producing and installing the DUNE single-phase far detector

- Use cosmic-ray data to ensure the detector design performs at an adequate level

- Collect large amounts of test-beam data in order to understand and properly calibrate the detectors response to a variety of particles

- Ensure the long-term stability of the detector with the purpose of limiting the risks associated with building the much larger DUNE FD
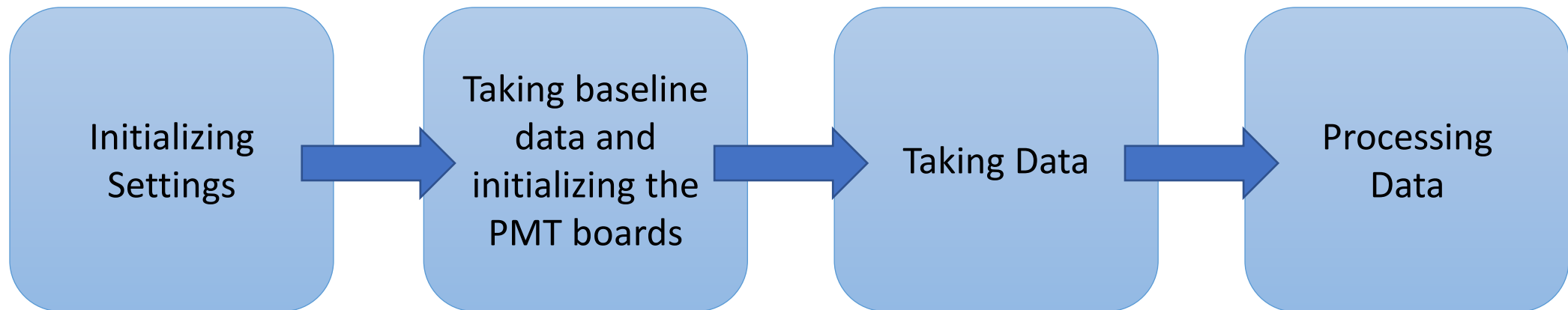
ProtoDUNE-SP Cosmic Ray Tagger (CRT)

- Consists of modules made up of 64 scintillator strips
- Each module has two layers of 32 strips, each containing a wavelength-shifting fiber
- The fibers are connected to a multi-anode photomultiplier tube (PMT) at one end
- 4 modules combine to form 3.2 m by 3.2 m units, 8 of which are used at ProtoDUNE-SP
- Located in front and back of ProtoDUNE-SP TPC
- Tags muons travelling through the TPC to analyze the beam halo and for calibration
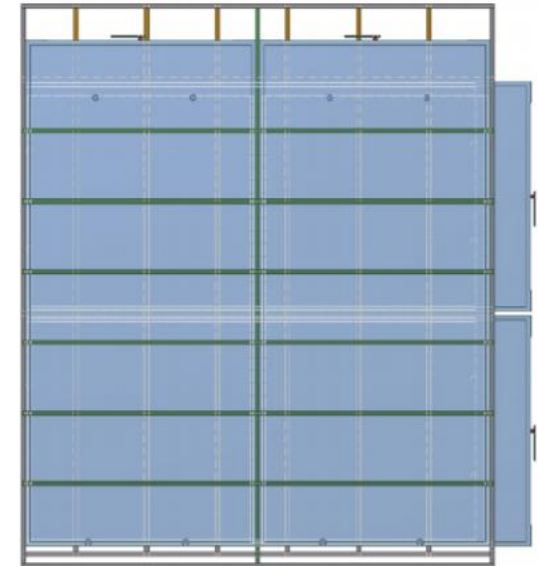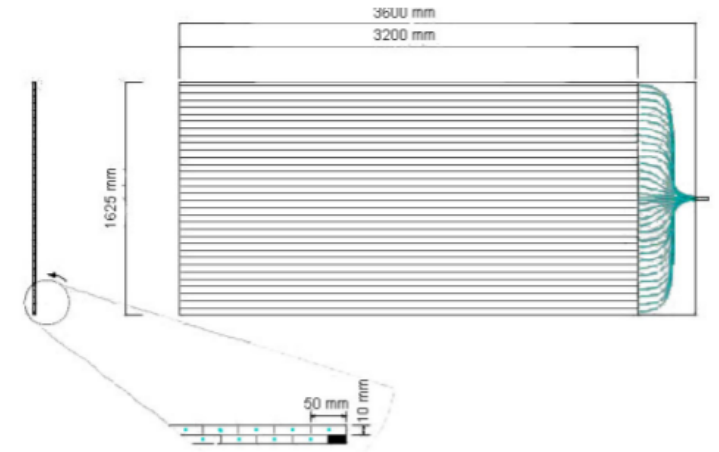
CRT DAQ

- Software framework is based in C++ and contains several files
- The program used to collect data is called oneboard which uses functions contained in other files
- The oneboard basic program structure is outlined below

Initializing Settings → Taking baseline data and initializing the PMT boards → Taking Data → Processing Data

Results

- I tested the code using a setup with 2 USB streams and a Linux Computer
- One USB had one PMT board connected and the other had 7 PMT boards connected
- I ran the code by remotely connecting to the computer
- First, I tested the program with a single USB and PMT board
- After ensuring that it was working, I ran the program with both USB streams and all 8 PMT boards
- I identified a problem with the data for PMT 0 but resolved it by finding a mistake in the code

USB number	PMT number	Hits Per Channel Before	Average Pulse Height Before	Hits Per Channel After	Average Pulse Height After
33	3	691	977.22	694	971.92
17	0	5054	473.24	717	860.67
17	1	722	928.66	717	920.60
17	2	722	983.72	717	983.54
17	3	722	861.31	717	879.43
17	4	722	958.33	717	931.04
17	5	722	854.79	717	833.02
17	6	722	955.74	717	940.49

Results

- After verifying that everything worked well, I stress tested the code by running it with different trigger rates

- Everything performed as expected for this test as shown on the table

Force Readout	Msec	33-3 Hits	17-0 Hits	17-1 Hits	17-2 Hits	17-3 Hits	17-4 Hits	17-5 Hits	17-6 Hits
0b01	1	11040	11457	11457	11457	11457	11457	11457	11457
0b10	16	694	717	717	717	717	717	717	717
0b11	256	43	45	45	45	45	45	45	45

- The results were positive with program running smoothly at various configurations with 2 USB streams and 8 PMT boards

Conclusion

- The new C++ CRT DAQ for ProtoDUNE-SP was tested with various configurations and commissioned
- The data for each run was thoroughly analyzed to ensure the code was working as intended
- The new DAQ code will be imported in the ProtoDUNE DAQ framework
- It will then be tested with the 4 USB streams and 32 PMTs used in the ProtoDUNE-SP CRT
- This success will go toward improving ProtoDUNE-SP and DUNE pushing us closer to important scientific breakthroughs

Acknowledgments

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Thank You