Cold Electronics Development for SBND and DUNE

Ongoing Collaboration

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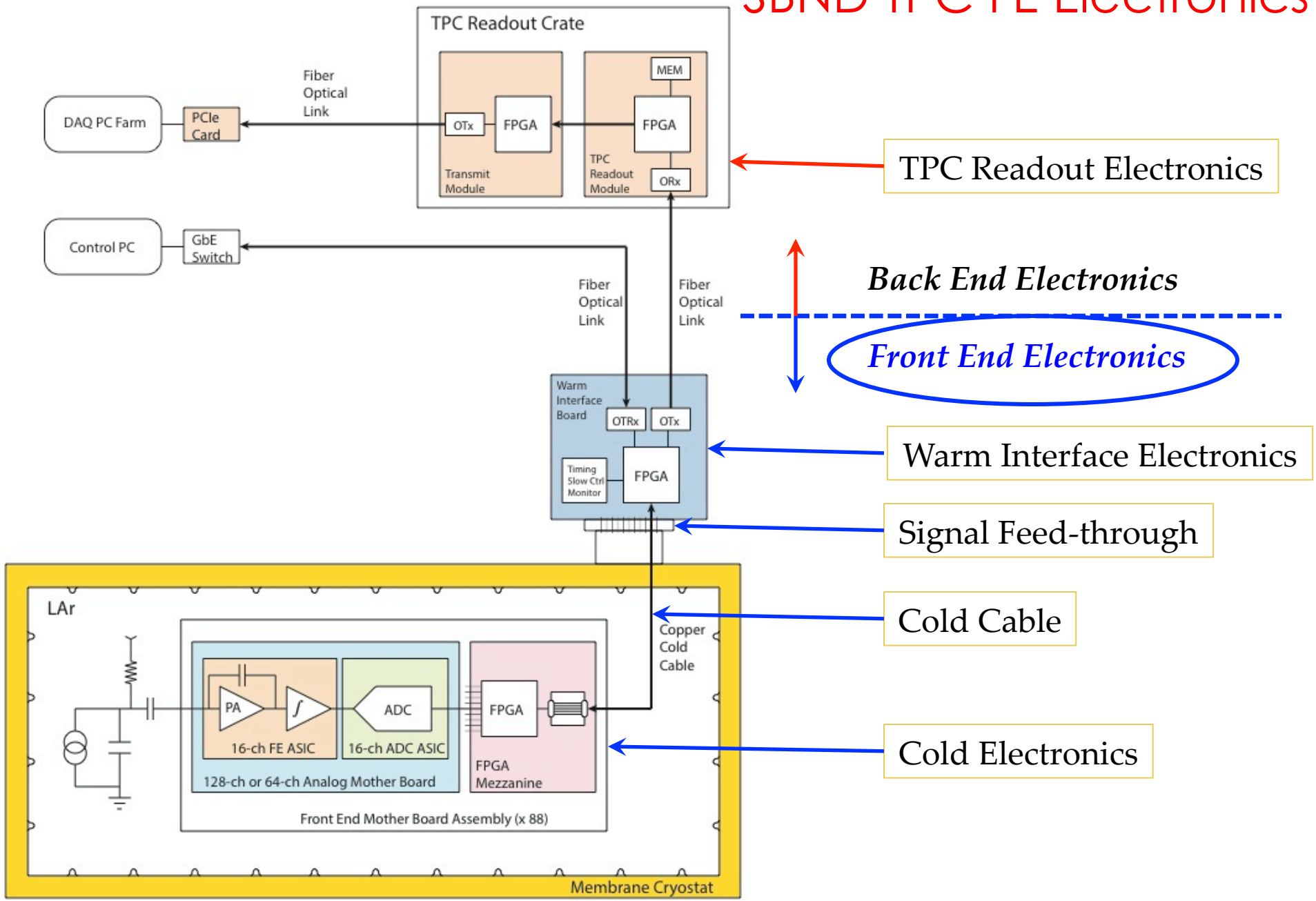
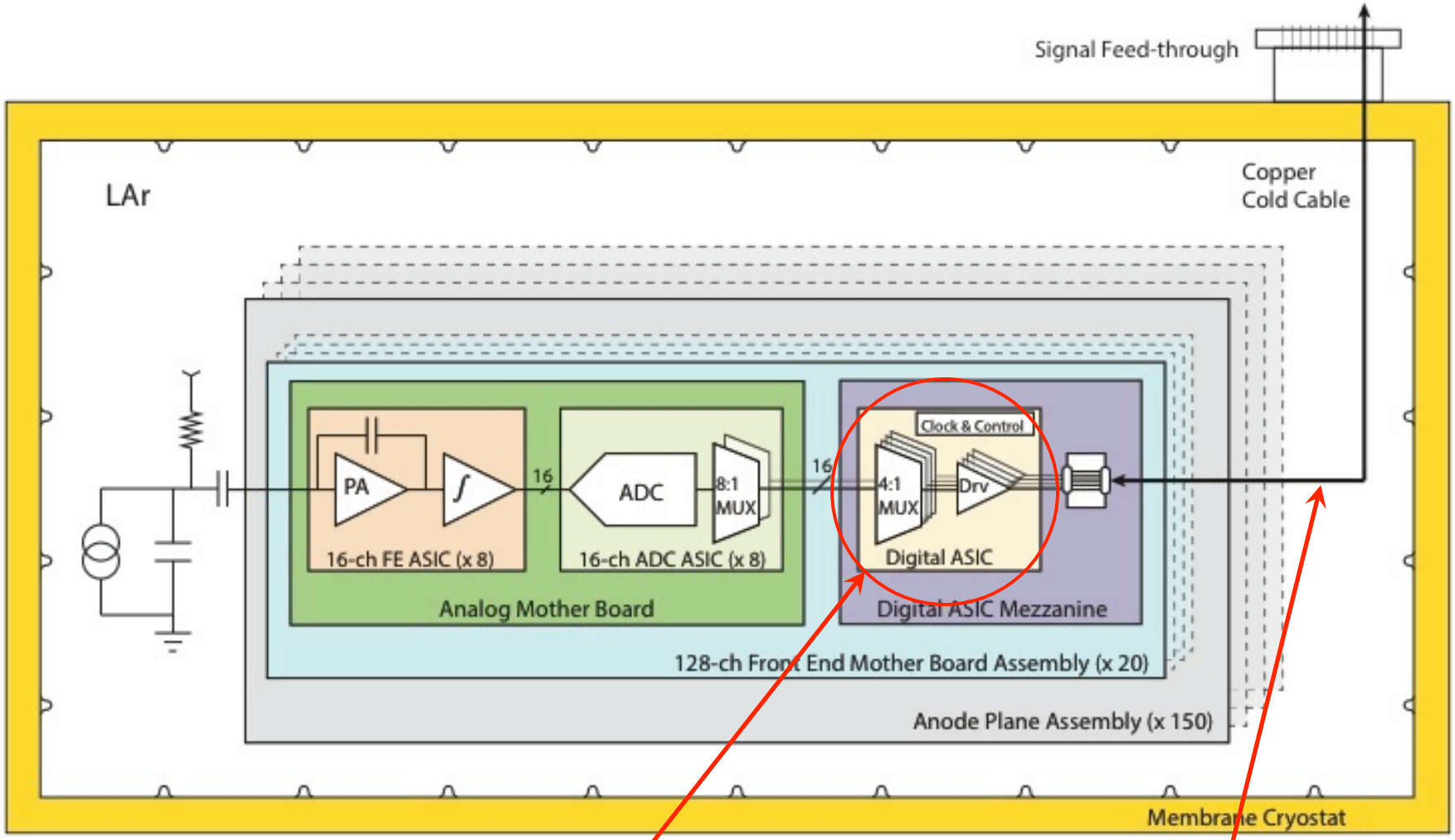
Outline

- Introduction
  - SBND Front End Electronics
  - DUNE Front End Electronics
  - protoDUNE Front End Electronics
- Key Developments with Commonalities
  - SBND/DUNE Cold Electronics Coordination
- Cold Electronics Development
  - Other Development
- Summary

SBND TPC FE Electronics



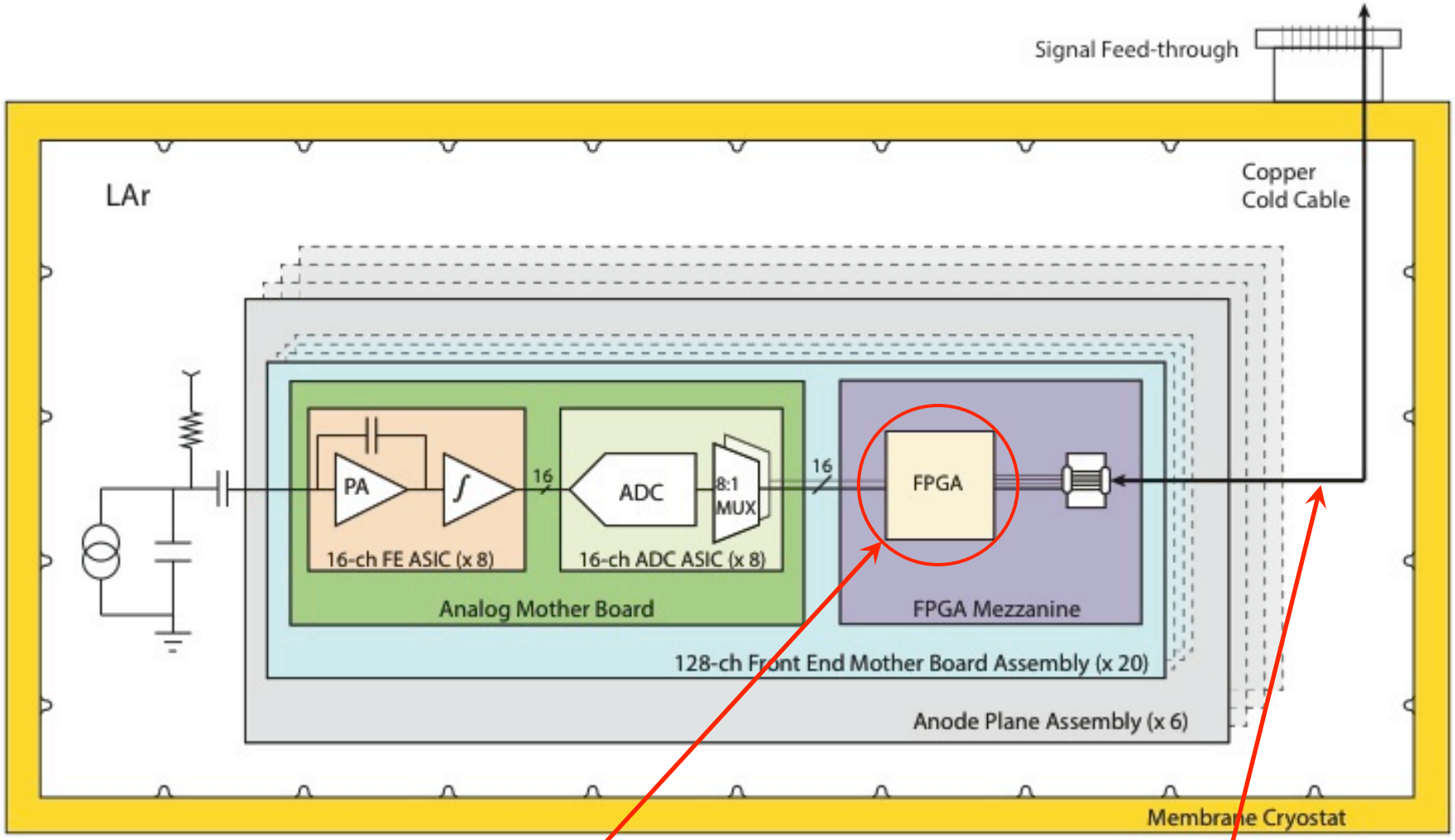
DUNE TPC FE Electronics



Fermilab Development

1 Gb/s data link x 4

protoDUNE TPC FE Electronics



FPGA Mezzanine

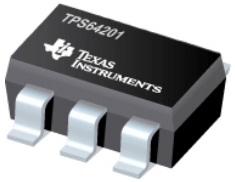
1 Gb/s data link x 4

Key Developments with Commonalities

- Synergy between SBND and protoDUNE
- Cold electronics
  - FE ASIC
  - ADC ASIC
  - Cold FPGA
  - Cold mother board, connections to sense wires
  - Various test stands
- Other development
  - Cold cables
  - Signal feed-through
  - Warm interface electronics

Cold Readout Chain

(before COLDATA becomes available)

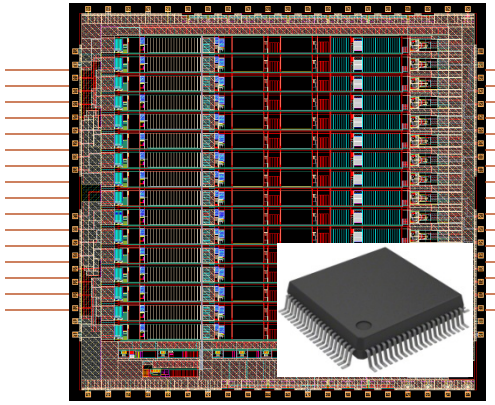


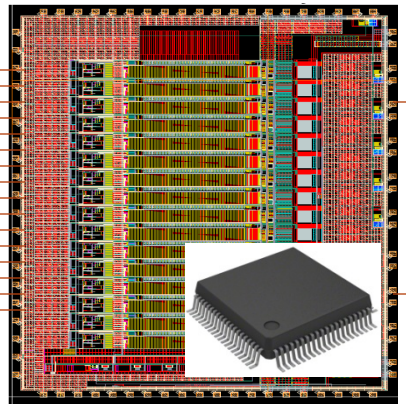
voltage regulation (COTS) (< 100mV dropout)

front-end ASIC ~ 5mW/ch.

ADC ASIC ~ 5mW/ch.

FPGA (COTS) ~ 8mW/ch.



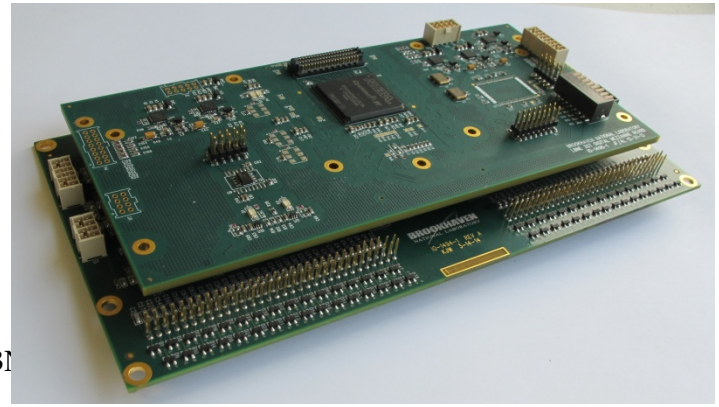


overall 128:4 multiplexing

8 x

1 x

A Full Front End Readout Chain



front-end mother board (FEMB) serving 128 wires ~ 2.4 W

SBND and protoDUNE

- SBND
  - ***11,264 channels (sense wires)***
  - 704 FE ASICs
  - 704 ADC ASICs
  - 88 cold FPGAs
  - 88 cold mother boards
  - 4 sets of cold cable
  - 4 sets of signal feed-through
  - 32 warm interface boards
- protoDUNE@CERN
  - ***15,360 channels***
  - 960 FE ASICs
  - 960 ADC ASICs
  - 120 cold FPGAs
  - 120 cold mother boards
  - 3 sets of cold cable
  - 3 sets of signal feed-through

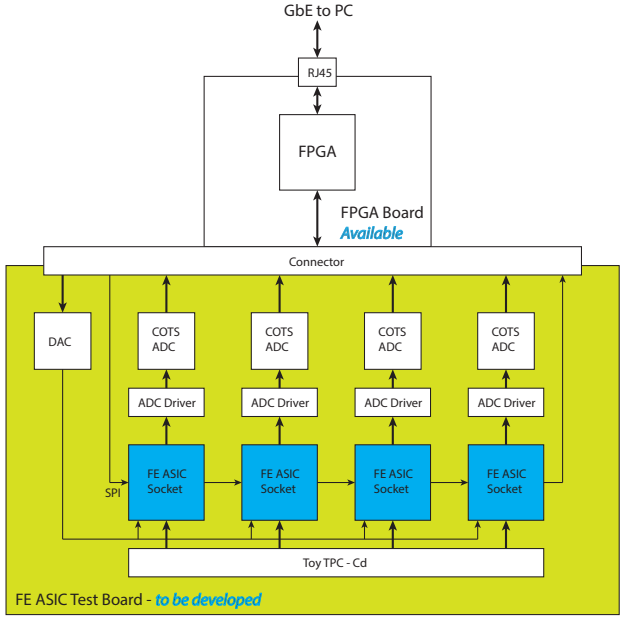
SBND/DUNE Cold Electronics Coordination

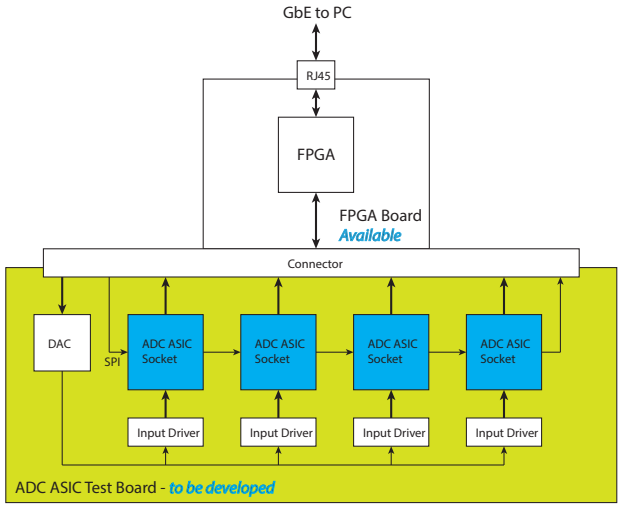
- SBND/DUNE cold electronics coordination meeting was held at BNL on August 20th
  - SBND: T. Miao, G. Rameika (remote), P. Wilson
  - DUNE: B. Hackenburg, E. James, S. Kettell, T. Shaw, J. Stewart
- Extensive discussion of development of cold electronics, production and QA plan
  - Synergy between SBND and protoDUNE
  - Joint support by both projects

Cold Electronics Development

- Cold ASICs Development
  - It has been agreed upon recently to accelerate the cold ASICs development, to meet the requirements of both SBND and protoDUNE at CERN
  - Plan to submit the first prototype of FE and ADC ASICs in January 2016
  - Second submission is planned in July/August 2016 after the full evaluation of the first submission
  - Prototype ASICs will be compatible with both FPGA and COLDATA, based on the interface defined in July
- *FE ASIC and ADC ASIC are common for SBND and protoDUNE*

Cold Electronics Development





- ASIC Test Stand Development
  - Individual test stand for each ASIC
    - All ASICs should be screening tested individually at RT
  - ASIC cold test board to verify the yield of ASIC operating in cold
    - This will help determine if all ASICs need to go through the cold test
    - MicroBooNE tested 201 FE ASICs in the cold, and decided to skip further cold test based on the test results
- *FE ASIC and ADC ASIC test stands are common for SBND and protoDUNE*

Cold Electronics Development

- FEMB (Front End Mother Board) Assembly Development
  - Analog Mother Board
    - Same granularity – 128 channels to be handled by 8 FE & 8 ADC ASICs
    - Different mechanical dimension – different wire pitch between SBND (3mm) and protoDUNE (~5mm)
    - Different mating connector to FPGA mezzanine
  - FPGA Mezzanine
    - Same granularity – 128 channels to be handled by 1 cold FPGA
    - Different mechanical dimension
    - Different mating connector to analog mother board
    - Different mating connector to cold cable – different length and termination
- *FEMBs share many common features, but have different designs for SBND and protoDUNE*

Cold Electronics Development

- FEMB Test Stand Development
  - Focus on board level evaluation test
  - Simple readout and DAQ system for easy debug test – possible common design
  - Will be re-purposed to the dedicated debug test station once the system integration test stand becomes available
- *FEMB test stand can share the same development of simple readout and DAQ system for board level evaluation test*
  - *Though would be important to have separate test stands for SBND and protoDUNE*

Cold Electronics Development

- System Integration Test Stand Development
  - SBND
    - Test stand at BNL will focus on the FE evaluation test
    - Test stand at Nevis will focus on the BE evaluation test
    - Test stand at FNAL will focus on the DAQ development and detector integration
  - protoDUNE
    - Test stand at BNL will focus on the FE evaluation test
    - Test stand at FNAL/CERN will focus on the BE evaluation test, DAQ development and detector integration
- Integration test stands for SBND and protoDUNE are ***different***
  - Cold electronics boards, cold cable, signal feed-through, warm interface electronics, DAQ hardware are different for SBND and protoDUNE
  - Development of integration test stands can share the experience and expertise of developers
  - Separate test stands for SBND and protoDUNE should be built and maintained
- *System integration test stand are different, will have different development path for SBND and protoDUNE*

Other Developments

- Cold Cable Development
  - SBND
    - A potential solution has been identified – 3M mini-SAS cable
    - Short cable (6m) and light gauge (30AWG)
    - Custom order from 3M directly
  - protoDUNE
    - A candidate cable has been identified – Gore twinax cable
    - Long cable (25m) and heavy gauge (24AWG)
    - Termination to be developed, custom design with involvement of multiple manufactures

Other Developments

- Feed-through Development
  - Both SBND and protoDUNE consider ATLAS pin carrier as baseline design, while exploring the low cost solution based on PCB
  - SBND
    - PCB based feed-through
    - Double flanges: both cold and warm
    - Low density (2,816 channels) in 14” CF flange
  - protoDUNE
    - PCB based feed-through
    - Single warm flange
    - High density (5,120 channels) in 14” (or 16.5”) CF flange

Other Developments

- Warm interface electronics
  - SBND has warm interface electronics
    - Flexible to interface to DAQ hardware platform
    - Isolate the protocol between cold electronics and DAQ hardware
  - protoDUNE has not decided how the warm interface electronics will be implemented
    - This will be related to both cold electronics and DAQ system design
    - Feed-through design will evolve based on the warm interface electronics design
- *Cold cable, signal feed-through and warm interface electronics development are different, will have different development path for SBND and protoDUNE*

Summary

- Synergy between SBND and protoDUNE has been explored
  - A productive SBND/DUNE cold electronics coordination meeting has taken place at BNL on August 20th
- Front end electronics development has many commonalities, as well as differences, between SBND and protoDUNE
  - Common cold ASICs, ASIC test stand, and FEMB test stand development to be jointly developed by SBND and DUNE
  - FEMB development and integration test stand will have different development path for SBND and DUNE
  - Development of cold cables, signal feed-through and warm interface electronics are different, will have different development plan for SBND and protoDUNE
- Cold ASICs development jointly supported by SBND and DUNE has started