sPHENIX Director's Review
Calorimeter Front End Electronics

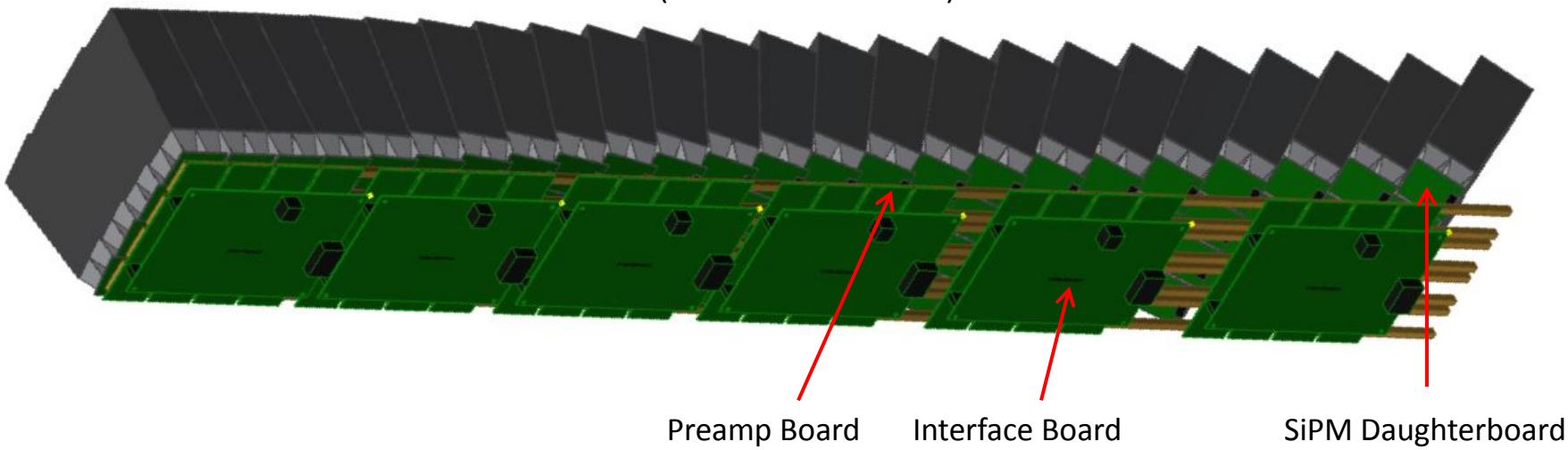
Steve Boose

August 2-4, 2017

BNL

Calorimeter Front End Electronics

(EmCal Sector Shown)



- Physics Dynamic Range 30MeV (MIP) to 40GeV, additional high gain range for calibration.
- Channel gain controls
  - Stabilized against temperature variation.
  - Compensated for radiation effects (increased SiPM current leakage).
  - Adjustable to compensate for sensor variation.
- Charge injection and LED test pulse sources for periodic channel testing.

Calorimeter Electronics Technical Overview

- SiPM parameter control.
  - Gain vs temperature stabilization.
  - Compensation for increased current leakage due to neutron damage.
  - Channel gain trimming.
- Preamplifier
  - Shaping must be compatible with 60MHz ADC sampling and 106nS RHIC cycle time -> 30nS peaking and recovery to baseline within 106nS.
  - High gain channel for resolving single microcell peaks during calibration.
- Discrete COTS circuitry chosen for readout system.
  - Low risk.
  - Reuse of existing PHENIX readout technology.

Scope

EmCal

- 6144 SiPM Daughterboards.
- 1536 Preamp Boards.
- 384 Interface Boards.
- 6144 Internal Signal Cables.

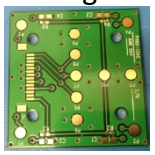
HCal

- 13824 SiPM Boards.
- 3072 Preamp Boards.
- 128 Interface Boards.
- 128 Backplane Boards.
- 128 LED Driver Boards.
- 1536 Internal Signal Cables.

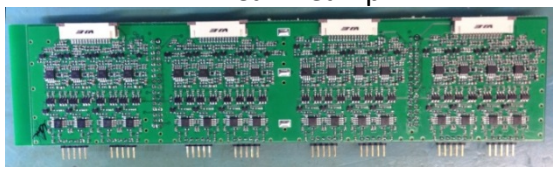
System

- 80 Controller Boards.
- 1792 External Signal Cables.
- 192 LV/Bias Cables.

EmCal Daughterboard

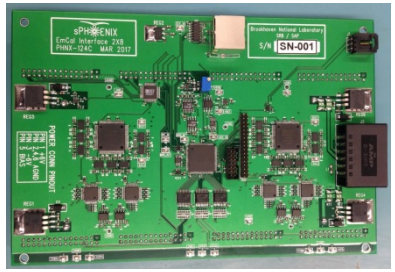


EmCal Preamp

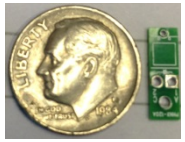


Controllers

EmCal Interface

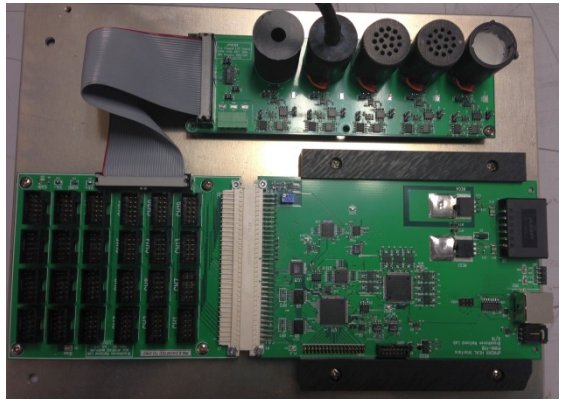


SiPM Board



HCal Preamp

Backplane



LED Driver

HCal Interface

Subsystem Collaborators

Steve Boose - Electronics Engineer

- Electronics and software design.

Robert Pisani – Scientific Associate

- Cooling System design.

Sal Polizzo - Technician

- PC Board layout, prototype assembly and testing.

Martin Purschke – Senior Physicist

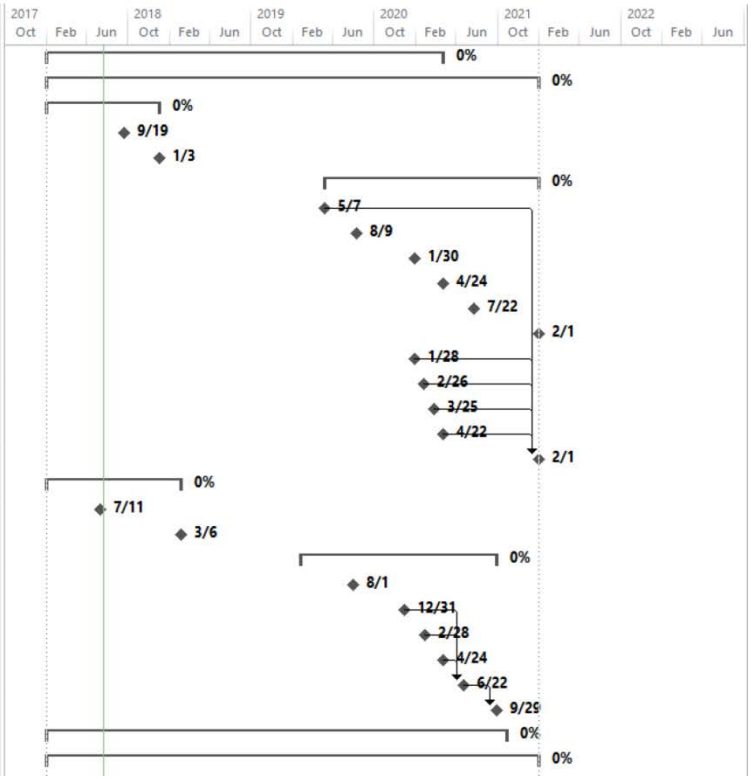
- Test stand programming.

Collaborators are being recruited for much of the production assembly. Potential institutions include University of Michigan, University of Augustana, Debrecen and Georgia State etc.

Schedule Drivers

- EmCal Preamps and Interface boards.
- EmCal internal cables.
- Completion of electronics reviews.
- Float for EmCal Preamp delivery ~6 weeks. 1st delivery 1/30/2020, required for EmCal module assembly 3/10/2020.
- Float for EmCal Interface boards: 1/28/2020, required for EmCal module assembly 3/10/2020.
- Float for cables, ~4 weeks.

WBS	Task Name	Fixed_Cost_sPHEN
1.5.1	**Optical Sensors**	$1,095,500.00
1.5.2	**Calorimeter Front End Electronics**	$1,684,900.00
1.5.2.1	**EMCal Electronics: Preproduction Prototype**	$24,600.00
1.5.2.1.14	Safety and Design Review Complete: EMCal Preproduction Electronics	$0.00
1.5.2.1.24	EMCal Electronics Review Complete: Preproduction Protoype	$0.00
1.5.2.2	**EMCal Electronics: Production**	$1,042,100.00
1.5.2.2.1	L3 Oversight: EMCal Electronics Production	$0.00
1.5.2.2.14	Production Readiness & Safety Review: EMCal Electronics	$0.00
1.5.2.2.22	25% EMCal SiPM Daughter Boards Delivered: Production	$0.00
1.5.2.2.23	50% EMCal SiPM Daughter Boards Delivered: Production	$0.00
1.5.2.2.24	75% EMCal SiPM Daughter Boards Delivered: Production	$0.00
1.5.2.2.25	100% EMCal SiPM Daughter Boards Delivered: Production	$0.00
1.5.2.2.27	25% EMCal Preamp and Interface Boards Delivered- Oroduction	$0.00
1.5.2.2.28	50% EMCal Preamp and Interface Boards Delivered- Production	$0.00
1.5.2.2.29	75% EMCal Preamp and Interface Boards Delivered- Production	$0.00
1.5.2.2.30	100% EMCal Preamp and Interface Boards Delivered- Pproduction	$0.00
1.5.2.2.32	EMCal Electronics Complete: Production	$0.00
1.5.2.3	**HCal Electronics: Preproduction Prototype**	$15,500.00
1.5.2.3.16	HCal Electronics Safety Review	$0.00
1.5.2.3.28	HCal Preproduction Electronics Complete	$0.00
1.5.2.4	**HCal Electronics: Production**	$602,700.00
1.5.2.4.16	Hcal Frontend Electronics Production Review	$0.00
1.5.2.4.25	25% Hcal SiPM & Preamp Boards complete: Production	$0.00
1.5.2.4.26	50% Hcal SiPM & Preamp Boards complete: Production	$0.00
1.5.2.4.27	75% Hcal SiPM & Preamp Boards complete: Production	$0.00
1.5.2.4.28	Hcal SiPM & Preamp Boards Complete: Production	$0.00
1.5.2.4.32	HCal Electronics Complete: Production	$0.00
1.5.3	**Calorimeter Digitizer System**	$1,700,600.00
1.5.4	**Project Management**	$0.00



Cost Drivers

- EmCal Preamps: $400k
- EmCal/HCal Signal Cables: $500k

Basis of Estimate and Resource-Loaded Schedule

	sPHENIX Detector Relativistic Heavy Ion Collider BASIS of ESTIMATE (BoE)	Date of Est:	3/20/2017
		Prepared By:	E. J. Mannel
		DocNo. (refer Rev.	DocDB-66

Work Package Name:	WBS Number:	Control Account Number
EMCal Electronics: Preproduction Prototype	1.5.2.1	

WBS Dictionary Definition:

The work package covers the design, layout, fabrication and Q/A testing of the EMCal preproduction prototype electroncs. The front end electronics includes the all front end analog circuits, the SiPM components (WBS 1.5.1), the digital control and monitoring electronics, signal and power cables "on detector", and power systems. It will deliver a total of 384 channels of EMCal f electornics for installation on the preproduction EMCal module. Installation and post-installation testing are part of WBS 1.3.

Estimate Type (check all that apply):

	Work Complete
	Existing Purchase Order
X	Catalog Listing or Industrial Construction Database
X	Documented Vendor Quotation based on Drawings/Sketches/Specifications
X	Budgetary Estimate by Vendor/Fabricator based on Sketches, Drawings, or other Written Correspondence
X	Engineering Estimate based on Similar Items or Procedures
X	Engineering Estimate based on Analysis
X	Expert Opinion

Supporting Documents (including but not limited to):

Task Summary
Costing

Guidelines Used in Developing Estimate

The following guideline were used in the cost estimate: 1) For designed boards, the bill of materials was used to look up catalog prices for all components. 2) Printed circuit board and assem were estimated on early R&D production or production of similar design and functionality. 3) Commercial vendors are assumed for all board fabrication and assembly. 4) Costs include a 10% yield.

The following guidelines were used for the time estimates: 1) Component/PCB orders are less then $10K per order, <1 month for PO to be issued. 2) Componets catalog items with short lead month delivery AOR. 3) PCBs are standard type PCBs with not special fabrication requirements and have standard delivery times, 2-3 weeks. 5) Board assembly is done by assembly houses a no non-standard assembly procedures. Post-assembly testing is done "in-house" by BNL/Collaboration engineers, technicians and students.

Installation on detector and post-installation testing are part of EMCal Preproduction Prototype module assembly, WBS 1.3

Status and Highlights

EmCal:

- Latest preamp revision is ready for Pre-Production Prototype production and assembly phase following system test.
- New prototype 3M signal cabling system design is underway. We need to build a single prototype of this design and test before committing to a Pre-Production run of cables.
- The Interface board design is ready for final system functional testing before Pre-Production Prototype phase.
- An End Cap design concept exists but must be finalized.

HCal:

- Latest revision of preamp board with added channel switching must be system tested prior to Pre-Production order.
- The Interface board design is working well but would benefit from a few minor signal re-routes to make it fully compatible with the same firmware as EmCal.
- New 500uM LED fiber source has been designed and a prototype is being built for testing with tiles.

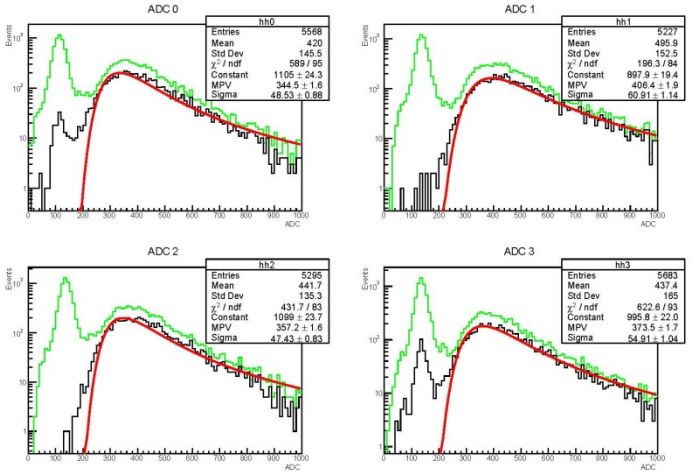
Slow Control:

- New cleaned-up revision of the Controller board is set to go into the layout phase.

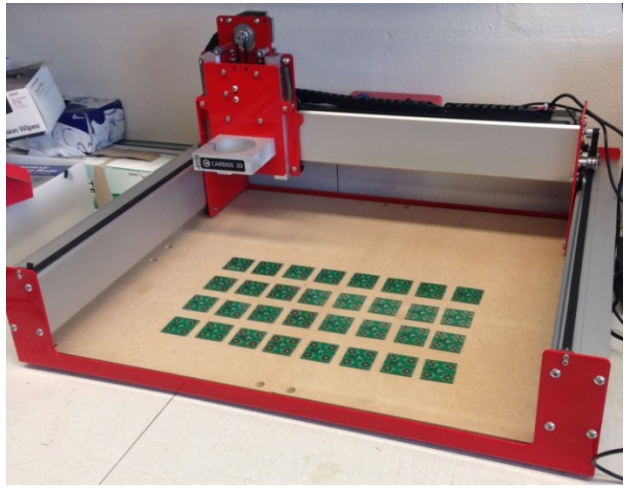
Test Stands

- The Preamp Tester hardware design is near completion. The motherboard must be produced, assembled, programmed and tested.
- The EmCal Daughterboard Tester
  - Will be used for final QA of Daughterboard prior to system assembly.
  - An XYZ table has been acquired and the controller exercised via software.
  - Motherboard concept is in place, design to follow.
- HCal Tile Testers (GSU)
  - For testing tile response using cosmic rays.
  - GSU is making progress on multiple stands for the tile factory and for final test.
  - Based on CAEN 5702 DAQ module.

Response to Cosmics for 4 tiles using CAEN 5702



EmCal Daughterboard Test Table



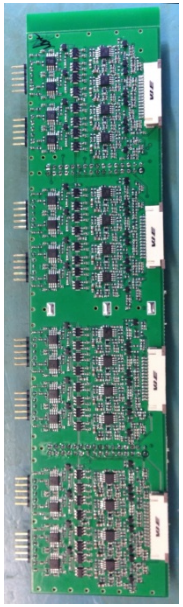
Summary

- Issues and Concerns
  - Space is limited due to cooling and cables. Cooling is still in preliminary design stage. Full scale mockups of both EmCal and HCal are being built to verify form and fit of system components.
- The cost estimate is based on past experience with beam test prototypes.
- There have been 3 successful test beam runs with prototype electronics. Design changes have all been minor, with most of them being to accommodate mechanical design changes in the EmCal and HCal.
- The Pre-Production Prototype electronics package is on schedule for completion by the outlined due dates.

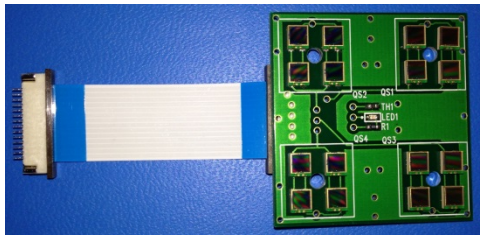
Back Up

EmCal System Boards

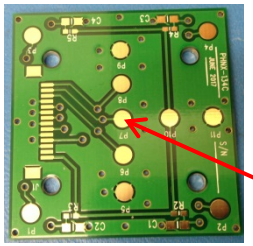
Preamp
(2X8) Channel



Daughterboard

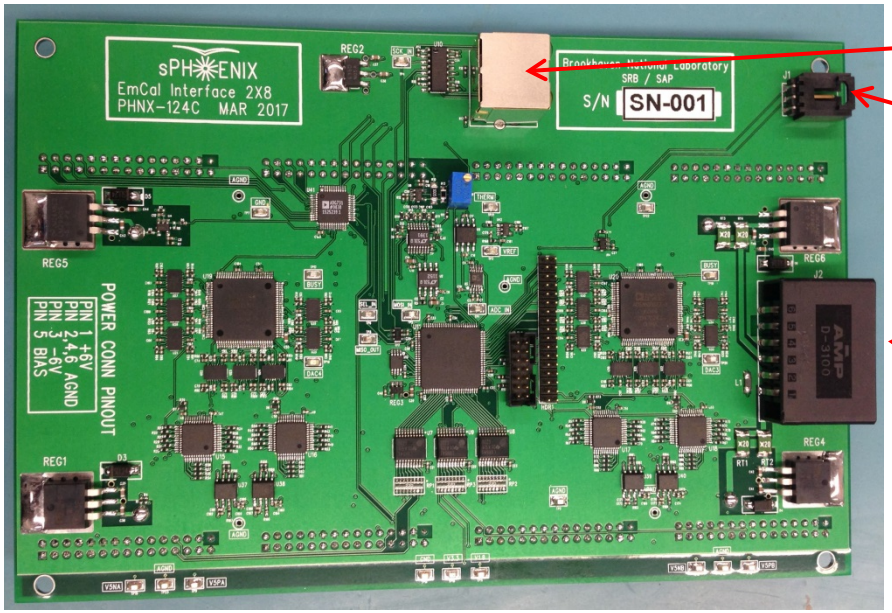


Daughterboard (bottom)



Pogo pads for testing

Interface Board



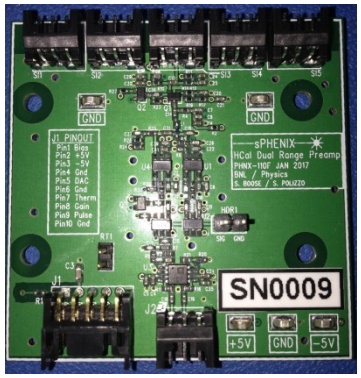
Comm Connector

Test Pulse Connector

Power Connector

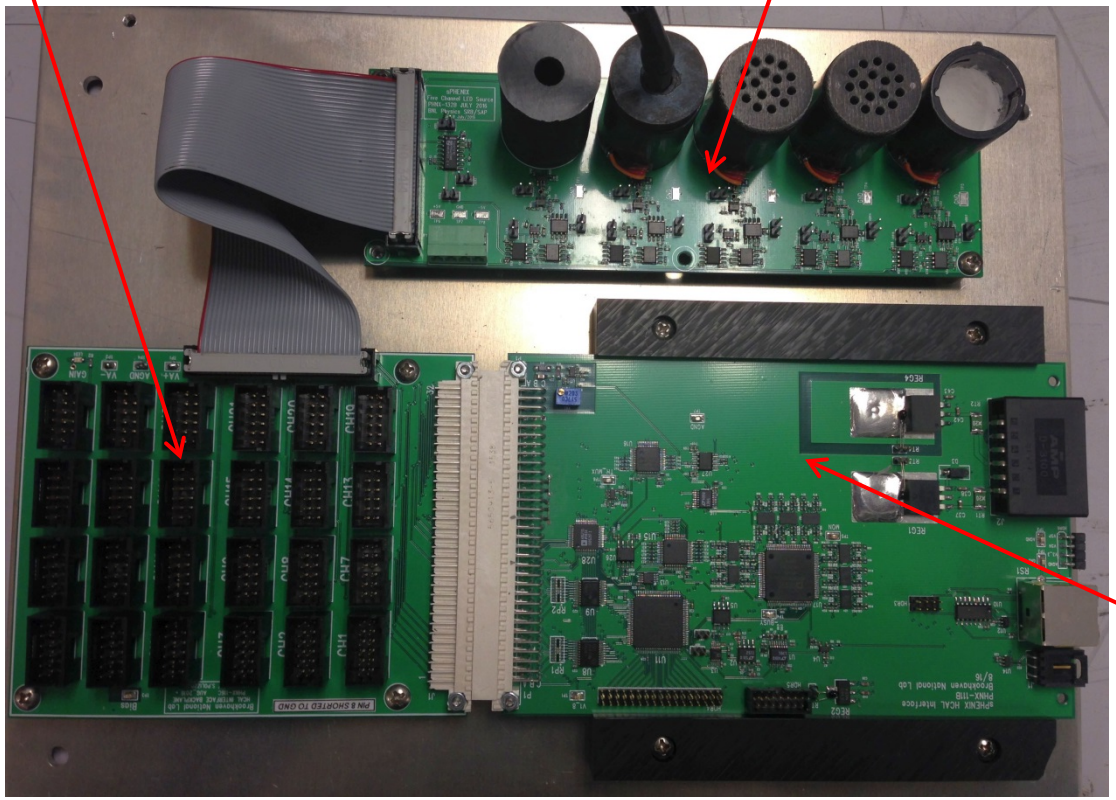
HCal System Components

Dual Gain Preamp



LED Driver Board

Backplane Board



24 Fiber Light Source Plug

Interface Board

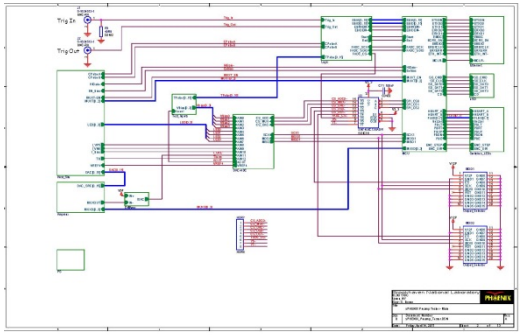
Slow Controls Boards

sPHENIX Calorimeter Controller

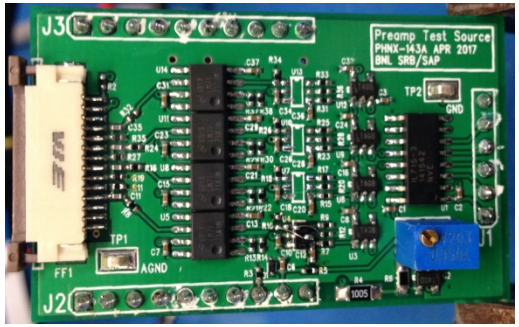
Test Pulse Fanout Module

Preamp Tester

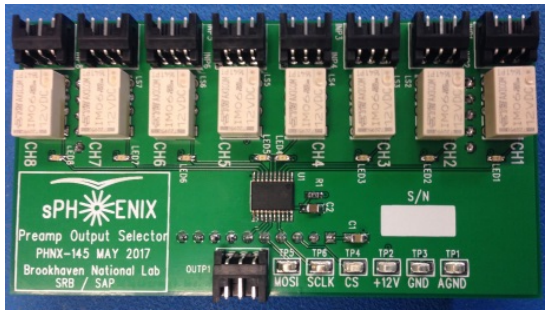
- Will consist of a main board with three plug-in modules, Test Source, Output Selector and ADC module. Main board layout will commence once plug-ins have been successfully prototyped.
- Test Source and Output Selector modules have been built but not yet tested.
- An ADC Module is in process of being assembled.
- Sal and Bill are working on an adapter for HCal preamps.



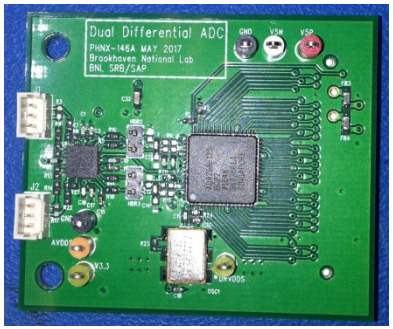
Test Source



Output Selector



ADC



System Layout and Interconnect