BROOKHAVEN NATIONAL LABORATORY

Work Permit # DRL-2013-014
Work Order # ___
Job# ___ Activity# ___

See "Instructions for Filling out the Work Permit" contained in the Work Planning and Control for Experiments and Operations Subject Area.

1. Work request WCC fills out this section. ☐ **Standing Work Permit**

Requester: Don Lynch	Date: 10/28/2013	Ext.: 2253	Dept/Div/Group: PO/PHENIX
Other Contact person (if different from requester): Carter Biggs			Ext.: 7515
Work Control Coordinator: Don Lynch		Start Date: 10/28/2013	Est. End Date: 03/31/2014
Brief Description of Work: Mechanical assembly and Installation of Partial MPC-Ex Dtector subsystem			
Building: 1008	Room: IR	Equipment: MPC-Ex (South partial)	Service Provider: PHENIX technicians and sPHENIX experts

2. WCC, Requester/Designee, Service Provider, and ESS&H (as necessary) fill out this section or attach analysis

ESS&H ANALYSIS

Radiation Concerns	☒ None	☐ Activation	☐ Airborne	☐ Contamination	☐ Radiation	☐ NORM	☐ Other
☐ Special nuclear materials involved, notify Isotope Special Materials Group				☐ Fissionable/Radiological materials involved, notify Laboratory Nuclear Safety Officer			
Radiation Generating Devices:	☐ Radiography		☐ Moisture Density Gauges		☐ Soil Density Gauges		☐ X-ray Equipment

Safety and Security Concerns	☐ None	☐ Explosives	☐ Transport of Haz/Rad Material	☐ Pressurized Systems
☐ Adding/Removing Walls or Roofs	☐ Critical Lift	☐ Fumes/Mist/Dust*	☐ Magnetic Fields*	☐ Railroad Work
☐ Asbestos*	☐ Cryogenic	☐ Heat/Cold Stress	☐ Nanomaterials/particles*	☒ Rigging
☐ Beryllium*	☐ Electrical	☐ Hydraulic	☐ Noise*	☐ Silica*
☐ Biohazard*	☒ Elevated Work	☐ Lasers*	☐ Non-ionizing Radiation*	☐ Security Concerns
☐ Chemicals/Corrosives*	☐ Excavation	☐ Lead*	☐ Oxygen Deficiency*	☐ Suspect/Counterfeit Items
☐ Confined Space*	☐ Ergonomics*	☒ Material Handling	☐ Penetrating Fire Walls	☐ Vacuum
* Safety Health Rep. Review Required	☐ Haz, Rad, Bio Material Exceed DOE 151.1-C Levels - Contact OEM			☒ Other: work near beampipe

Environmental Concerns	☒ None	☐ Work impacts Environmental Permit No.	
☐ Atmospheric Discharges (rad/non-rad)	☐ Land Use Institutional Controls	☐ Soil Activation/contamination	☐ Waste-Mixed
☐ Chemical or Rad Material Storage or Use	☐ Liquid Discharges	☐ Waste-Clean	☐ Waste-Radioactive
☐ Cesspools (UIC)	☐ Oil/PCB Management	☐ Waste-Hazardous	☐ Waste-Regulated Medical
☐ High water/power consumption	☐ Spill potential	☐ Waste-Industrial	☐ Underground Duct/Piping
Waste disposition by:			☐ Other
Pollution Prevention (P2)/Waste Minimization Opportunity:	☒ No ☐ Yes		

FACILITY CONCERNS	☒ None	☐ Intermittent Energy Release		
☐ Access/Egress Limitations	☐ Electrical Noise	☐ Potential to Cause a False Alarm		☐ Vibrations
	☐ Impacts Facility Use Agreement		☐ Temperature Change	☐ Other
☐ Configuration Management	☐ Maintenance Work on Ventilation Systems		☐ Utility Interruptions	

WORK CONTROLS

Work Practices

☐ None	☐ Exhaust Ventilation	☒ Lockout/Tagout	☐ Spill Containment	☐ Security (see Instruction Sheet)
☒ Back-up Person/Watch	☐ HP Coverage	☐ Posting/Warning Signs	☐ Time Limitation	☐ Other
☐ Barricades	☐ IH Survey	☒ Scaffolding-requires inspection	☐ Warning Alarm (i.e. "high level")	☐ Electrical Inspection Required

Personal Protective Equipment

☐ None	☐ Ear Plugs	☒ Gloves as appropriate	☐ Lab Coat	☒ Safety Glasses as appropriate
☐ Coveralls	☐ Ear Muffs	☐ Goggles	☐ Respirator*	☐ Safety Harness

☐ Disposable Clothing	☐ Face Shield	☐ Hard Hat	☐ Shoe Covers	☒ Safety Shoes as appropriate	☐ High visibility cloths/vest	☐ Other

Permits Required (Permits must be valid when job is scheduled.)

☒ None	☐ Cutting/Welding	☐ Impair Fire Protection Systems
☐ Concrete/Masonry Penetration	☐ Digging/Core Drilling	☐ Rad Work Permit-RWP No
☐ Confined Space Entry	☐ Electrical Working Hot	☐ Other

Dosimetry/Monitoring

☒ None	☐ Heat Stress Monitor	☐ Real Time Monitor	☐ TLD
☐ Air Effluent	☐ Noise Survey/Dosimeter	☐ Self-reading Pencil Dosimeter	☐ Waste Characterization
☐ Ground Water	☐ O_2/Combustible Gas	☐ Self-reading Digital Dosimeter	☐ Other
☐ Liquid Effluent	☐ Passive Vapor Monitor	☐ Sorbent Tube/Filter Pump	

Training Requirements (List specific training requirements)

PHENIX Awareness, CA Access or Equiv. Scaffold Training,

Based on analysis above, the Review Team determines the risk, complexity, and coordination ratings below:				**If using the permit when all hazard ratings are low, only the following need to sign: (Although allowed, there is no need to use back of form)**	
ESS&H Risk Level:	☒ Low	☐ Moderate	☐ High	WCC:	Date:
Complexity Level:	☐ Low	☒ Moderate	☐ High	Service Provider:	Date:
Work Coordination:	☒ Low	☐ Moderate	☐ High	Authorization to start	Date:
				(Department/Division, or their equivalent, Sup/WCC/Designee)	

3. Both work requester and service provider contribute to work plan (use attachments for detailed plans)

Work Plan (procedures, timing, equipment, scheduling, coordination, notifications, and personnel availability need to be addressed in adequate detail): See attached Procedure.
Special Working Conditions Required (e.g., Industrial Hygiene hold points or other monitoring) None
Notifications to operations and Operational Limits Requirements: None
Post Work Testing, Notification or Documentation Required:

Job Safety Analysis Required: ☐ Yes ☒ No	Review Done: ☒ in series ☐ team

Reviewed by: * Primary Reviewer signature means that the Review Team members were appropriate for the work that was planned, the Team visited the job site, hazards and risks that could impact ESS&H have been considered and controls established according to BNL requirements. In addition, this signature indicates that applicable JRAs, FRAs, as well as other planning documents have been reviewed and training requirements have been identified and recorded on this permit.

Title	Name (print)	Signature	Life #	Date
ES&H Professional				
F&O Facility Project Manager				
Service Provider				
Work Control Coordinator	Don Lynch		20146	
Safety Health Representative				
Research Space Manager				
Other				
Other (PHENIX Escort)				
Required Walkdown Completed				
*Primary Reviewer				

4. Job site personnel (Supervisor and workers) fill out this section.

Note: Signature indicates personnel performing work have read and understand the hazards and permit requirements (including any attachments) and all training required for this permit is current/complete. Job Supervisor/Contractor Supervisor signatures also includes verification that worker training required for this permit is current/complete.

Job Supervisor:		Contractor Supervisor:	
Workers:	Life#:	Workers :	Life#:

Workers are encouraged to provide feedback on ESS&H concerns or on ideas for improved job work flow. Use feedback form or space below.

5. Department/Division, or their equivalent, Line Manager or Designee

Conditions are appropriate to start work: (Permit has been reviewed, work controls are in place and site is ready for job.)

Name:	Signature:	Life#:	Date:

6. Worker provides feedback.

Worker Feedback (use attached sheets as necessary)

a) WCM/WCC: Are there any changes as a result of worker feedback? ☐ Yes ☐ No

Note: See Work Planning and Control for Experiments and Operations Subject Area section 2.6.

7. Post Job Review/Closeout: Work Control Coordinator (authorizing dept.) checks quality of completed permit and ensures the work site is left in an acceptable condition. (WCC can delegate clean up of job site to work supervisor.) The WCC ensures that the change process to update drawings, placards, postings, procedures, etc., is initiated, if necessary.

Name:	Signature:	Life#:	Date:
Comments:			

Attachment to W.P. #DRL-2013-13 September 15, 2013

MPC-Ex

Introduction

The Muon Piston Calorimeter (MPC) Extension, or MPC-EX, is a Si-W preshower detector that will be installed in front of the existing PHENIX MPC's in both the north and the south Muon Magnets. This detector consists of eight layers of Si "minipad" sensors interleaved with tungsten absorber and enables the identification and reconstruction of $\pi 0$ mesons at energies up to ~80 GeV.

The PHENIX Collaboration will install this new detector subsystem prior to run 15, but an engineering run consisting of a partial detector installed in the south Muon Magnet piston hole is planned for run 14. This document describes the work plan to assemble and install this partial detector.

MPC-Ex Design

(Please see the attached Assembly and Installation Plan for illustrations of the following design, assembly and installation descriptions.)

The MPC-Ex design consists of 8 layers (plates) of 2.0 mm thick tungsten spaced 4.5 mm apart. There are upper and lower halves to the MPC-Ex and north and south stations in the north and south Muon Magnets, respectively. On to each tungsten plate a carrier board is adhered. To each carrier board 12 micromodules consisting of a minipad silicon sensor sandwiched and glued between a ceramic base and a Dual SVX-4 Readout Card. The card is then wirebonded to the silicon sensor. On the side farthest from the PHENIX IP, a Delrin plate will be attached provide a light tight closure beyond the last layer of carrier board.

Assembly of the MPC-Ex detectors requires gluing fixtures for the micromodules and for the carrier board/tungsten plate lamination.

The 8 layers are stacked up and spaced using threaded rods and threaded spacers, then the upper and lower ends are capped with support covers. Low voltage distribution boards are mechanically attached to the upper and lower support covers. Each Carrier board has power connections between itself and the LV distribution board and bias voltage connections. The LV distribution boards have power and communication cables to a control racks mounted on the north and south MuTrigger racks.

In addition, each carrier board has 2 ribbon cable pig tails which connect via a 2 meter ribbon cable to a front end module. The front end module in turn connects back to the control rack via flat LVDS cable. Communication from the rack room to the MPC-Ex control racks will be via fiber optic cables.

Cooling for the MPC-Ex will be accomplished using the PHENIX dry air system, which is already providing cooling for the MPC detectors.

In order to accommodate the MPC-Ex, minor modifications to existing equipment is required as follows:

1. The "bellows spreader" which prevents lateral and twisting movement of the bellows in the south Muon Magnet (MMS) (while allowing unimpeded longitudinal movement) will be removed and replaced with a new design which has a smaller radial footprint to allow maximization of detector coverage. This new design is referred to as an "anti-squirm" device to more accurately describe its function. (Note: there is no bellows spreader in the north Muon Magnet [MMN], and as such no anti-squirm device is required i the north magnet.

2. Light collection boxes for the existing MPC's will be moved to the MuID station 1 front end electronics plate (FEE plate) on both north and south detector stations. MuID cables and components on the FEE plate will be relocated / rerouted as necessary to accommodate the light collection boxes.

3. MPC Fiber optic extensions and adapters will be fabricated to allow the light box relocations.

4. Other minor modifications on the side panels of the MMS and MMN to accommodate mounting of MPC-Ex Front End modules will be undertaken as necessary.

Mounting clips are designed to attach to the walls of the MMS and MMN piston cavities to precisely locate the MPC-Ex in the piston holes. Mating mounting tabs are designed for the multiple purposes of aligning and attaching the 2 halves of the detectors to each other around the beam pipe, guiding the insertion of the MPC-Ex detector into the piston holes and precisely positioning the MPC-Ex's in the piston holes.

Installation of the MPC-Ex detectors will require scaffolding, a custom designed insertion/installation tool, and a rigging fixture to lift the upper and lower halves onto the insertion/installation tool. Locating guide

MPC-Ex Partial Assembly for Run 14

The partial detector planned for the MPC-Ex engineering run during Run 14 will be assembled and installed as follows:

- A single station will be installed in the MMS piston hole.
- The partial detector shall be a full mechanical assembly of tungsten plates and spacers and shall have both upper and lower covers.

- 4 of the 8 lower tungsten plates will have carrier boards laminated to them; the other 4 lower tungsten plates will not have carrier boards.
- All 8 upper tungsten plates will be assembled without carrier boards.
- Both the upper and lower sections of the will have their Delrin closure plates installed.
- Approximately 12 micromodules will be installed on the 4 carrier boards. Exact number, location and orientation will be determined by MPC-Ex experts at assembly.
- The edges of the detector will be closed using an opaque material for light tightness, but allowing cooling air to flow through and be exhausted. This will be accomplished using an opaque adhesive tape. Details of this procedure will be worked out y MPC-Ex experts at assembly.
- The anti-squirm will be installed for run 14.
- The insertion/installation tool and lifting tool will be designed and used for installing the partial detector in run 14.
- Cables, fiber optics and cooling supplies will be adequate to support the installed electronics at assembly as determined by MPC-Ex experts. Routing of cables to and from detector, front end modules and control rack will be accomplished as worker planned work by PHENIX technicians and MPC-Ex experts.
- Communication between MPC-Ex control rack and rack room will be accomplished using existing MuTrigger trunk cables.

Assembly Procedures for Run 14

Micromodule Assembly

Using the micromodule gluing fixture:

1. Lay the ceramic sheet on a clean flat granite table
2. apply appropriately sized kapton tape to the table precisely around the edges of the ceramic sheet to define the gluing surface.
3. apply glue to the ceramic sheet and squeegee to achieve precise thickness
4. lay the silicon sensor sheet on the table and similarly mask and apply glue to the sensor, except on the end where the wire bonding pads are, place the tape over the bonding pads to prevent adhesive from sticking to the pads.
5. position the ceramic sheet in the vacuum gluing fixture base then turn on vacuum to hold part in place
6. place the silicon sensor on the glue laden ceramic sheet, leaving the tape on the wire bond pads and carefully positioning the sensor to align precisely with the ceramic.
7. place the SVX-4 readout card on the silicon sheet on the glue carefully positioning the card to align precisely with the sensor and ceramic.

8. position the slotted micromodule glue fixture side lock on the base and slide it to align the SVX-4 board to the ceramic and sensor sheets, then lock it in position with the thumb screws (finger tight only)
9. Place the gluing fixture weight distributor top on the readout card being careful not to shift the stack.
10. Place 2 20-lb bricks on top of weight distributor gluing fixture top cap).
11. Let sit for 30 minutes, then loosen and remove slotted side lock.
12. Carefully peal the kapton tape off the sensor wire bonding pads.
13. Let the weighted assembly sit for at least 8 hours to allow adhesive to completely set.
14. Remove micromodule from gluing fixture.
15. Inspect for imperfections in stack and/or gluing
16. Send micromodule with vacuum base to instrumentation for wirebonding.
17. Acceptance test

Carrier Board/Tungsten Lamination Assembly

1. Place tungsten plate in laminating fixture on flat granite table
2. Apply double-sided thermal conductive adhesive tape to entire upper surface of tungsten plate
3. Peel off double-sided tape backing and make sure adhesive is distributed to all edges
4. Carefully position carrier board on adhesive covered side of tungsten plate
5. Place 1/4 inch (minimum) anti-static foam on top of carrier board, then place a 1 inch thick steel plate at least large enough to cover the entire area of the the carrier board. (~40 lbs weight)
6. Let stand for at least 1 hour for adhesive to set.
7. Inspect for imperfections in lamination
8. Acceptance test

MPC-Ex Partial Detector Assembly

Assemble Upper and Lower halves of MPC-Ex in accordance with MPC-Ex Assembly drawing (preliminary drawing attached). Modify assembly in accordance with partial detector description above. (worker planned work).

MPC-Ex Partial Detector Installation

(Note: Scaffolding for installation of MPC-Ex was designed and installed for Muon Tracker work in previous and current shutdowns. Design and

installation including all appropriate approval paperwork is provided in the current work permit # DRL-2013-08/SS-2013-227 Muon Tracker Station 1 South Maintenance and Repair.)

1. Affix temporary beampipe support to beampipe in station 1
2. Remove existing "bellows spreader"
3. Install new anti-squirm device
4. Remove and relocate MPC light collection boxes
5. Install fiber extensions using fabricated fiber connectors and holders provided
6. Drill and tap mounting holes for MPC-Ex mounting clips
7. Install MPC-Ex insertion/installation tool
8. Install mounting clips
9. Using MPC-Ex lifting fixture, install upper and lower MPC-Ex detector halves on insertion/installation device with mount mounting tabs
10. Install MPC-Ex into piston hole.
11. Install front end module(s) on magnet sides.
12. Route cables, fibers and cooling lines as necessary
13. Test and commission partial new detector
14. Remove station 1 scaffolding
15. restore MMS to run position

Closeout

After installation is complete, document and record any lessons learned in this initial installation. Sign and close out the MPC-Ex work permit and the Muon Tracker Station 1 south work permit (for scaffold use).

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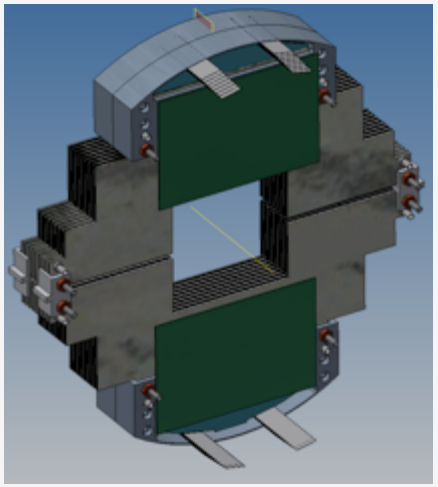
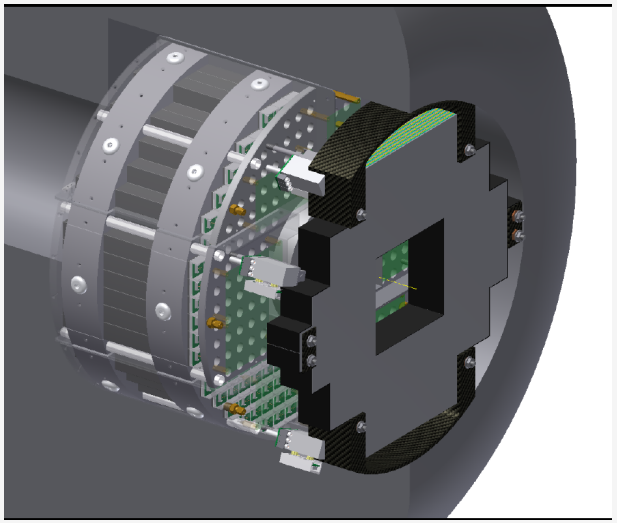
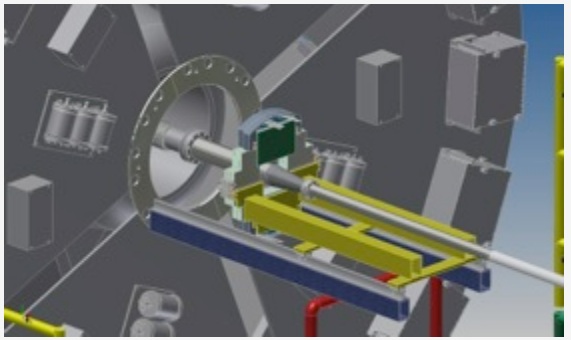
Run 14 MPC-Ex Assembly and Installation Plan







Oct. 31, 2013

Don Lynch

PHENIX

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Current Plan for partial MPC-Ex Installation for Run 14

For Run-14 the goal will be to install four mechanically complete layers of the MPC-EX for the bottom half, the other 4 tungsten only layers on the bottom half and 8 tungsten only layers on the top half (16 tungsten plates) in the south muon magnet piston. Four layers will have carrier boards (bottom $\frac{1}{2}$ only, top $\frac{1}{2}$ will be tungsten plates only), and those carrier boards will be partially populated so that we have partial coverage in azimuth with full coverage in depth.

Having a complete installation in azimuth will make the detector mechanically complete and effectively "close off" the piston hole. This will allow us to test the cooling, as well as see if the trapped neutron flux we see in simulations causes any problems.

The south arm was chosen because the north arm may not move during this shutdown. This will require the redesigned anti-squirm device to be built and installed on the beam pipe. The MPC light boxes will need to be moved for the south.

For cooling we will use the existing dry air system, we will need to determine the manifolds, supply lines and exhaust plan.

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Subassemlies:

ROC Micro-modules: There are normally 12 of these for each half layer, 392 total for both MPC-Ex's. Approximately 12 of these will be included in the Run 14 partial installation. Each ROC micro-module is assembled as a PC board, a silicon sensor module and a ceramic sheet which are all glued together in a gluing fixture. The sensor is then sent to instrumentation to have its sensor leads wire bonded to the electrical distribution pads on the PC board.

Carrier boards: Produced outside.

Tungsten/Carrier board modules: The carrier boards are fastened to 2mm thick tungsten plates at PHYSICS using a positioning fixture and double sided adhesive.

Upper and Lower, North and South Detector segment assemblies are then mechanically assembled. Each is made of 8 T/C modules and a single Delrin cover plate (design identical to tungsten plates). The space between tungsten plates is made uniform by threaded spacers and the entire assembly is held together with threaded rods on which the spacers ride. The top and bottom modules have their upper and lower ends protected by a Delrin "cradle" which provides extra support, protection for the signal cables and support for the power supply/PC interface boards.

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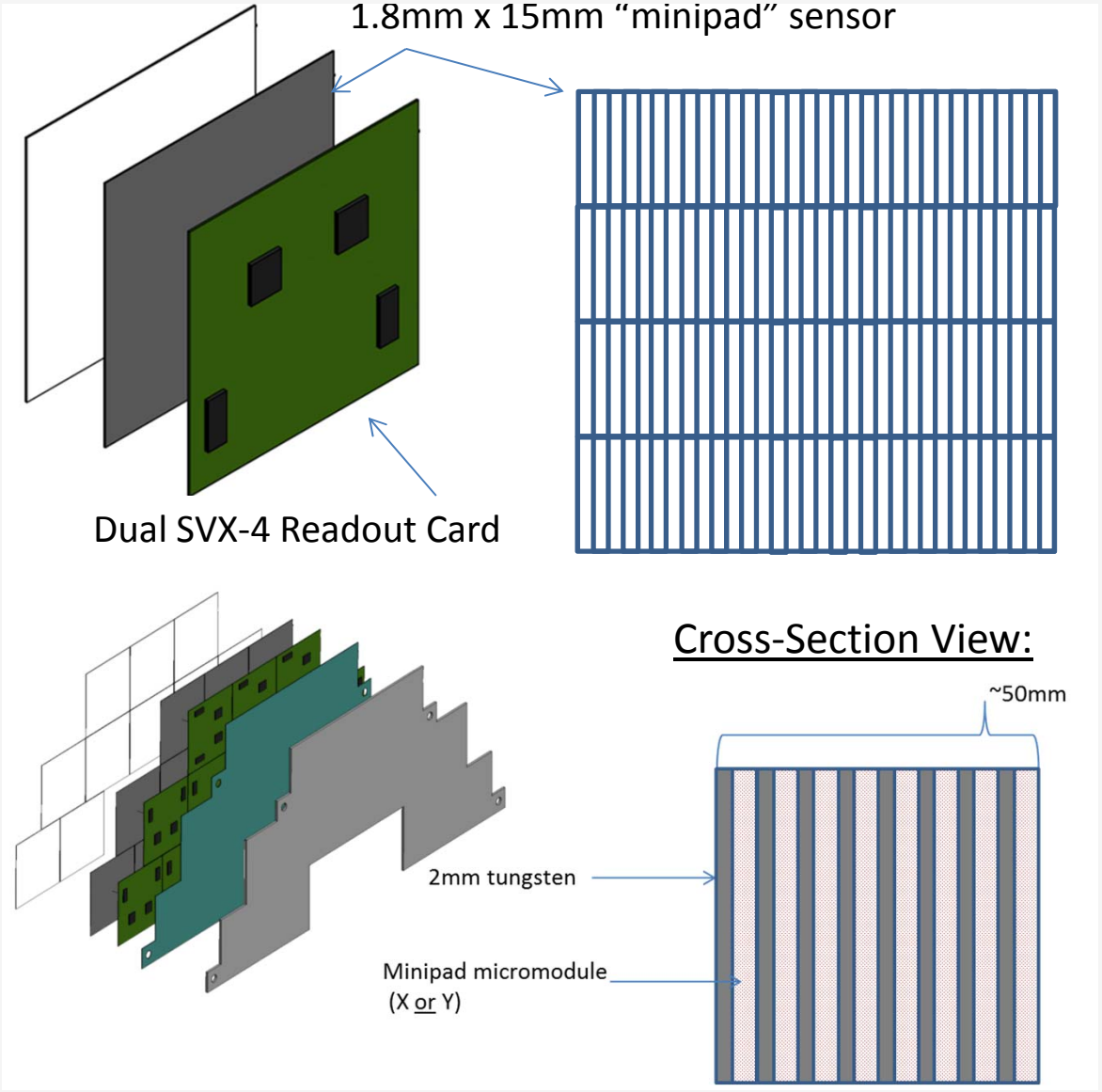

Micromodule layout

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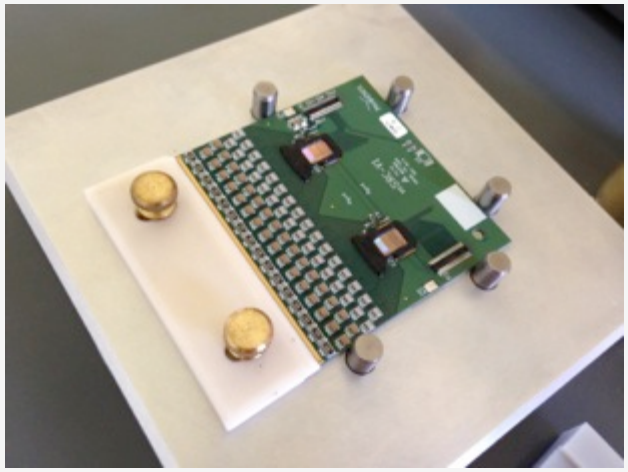

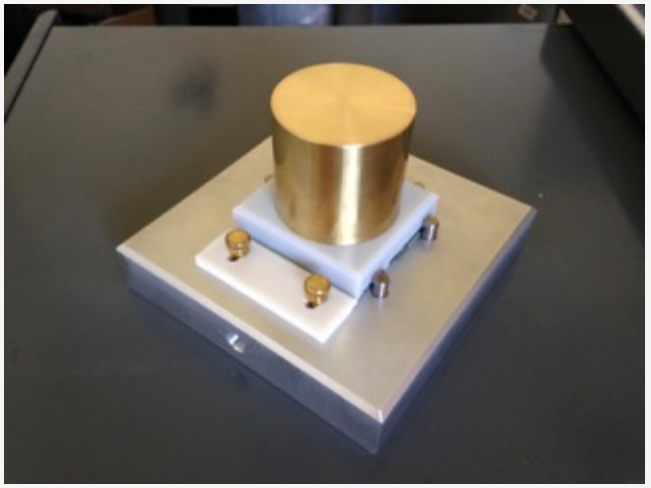

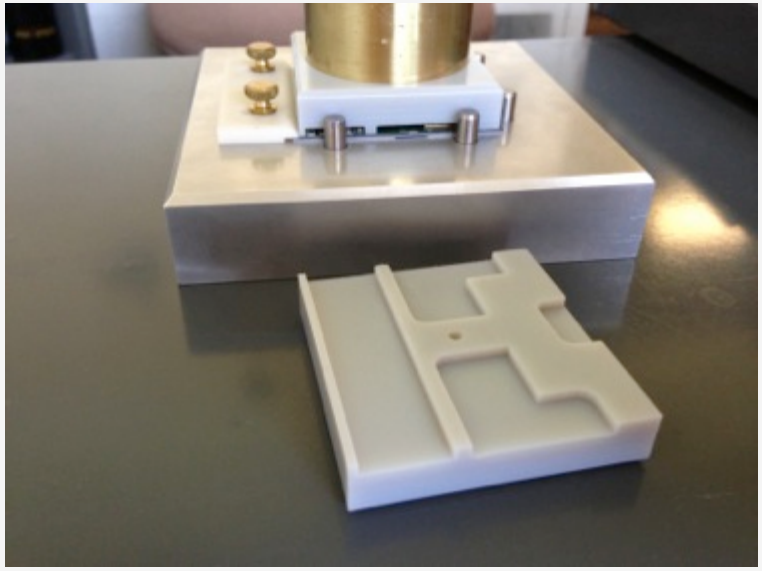

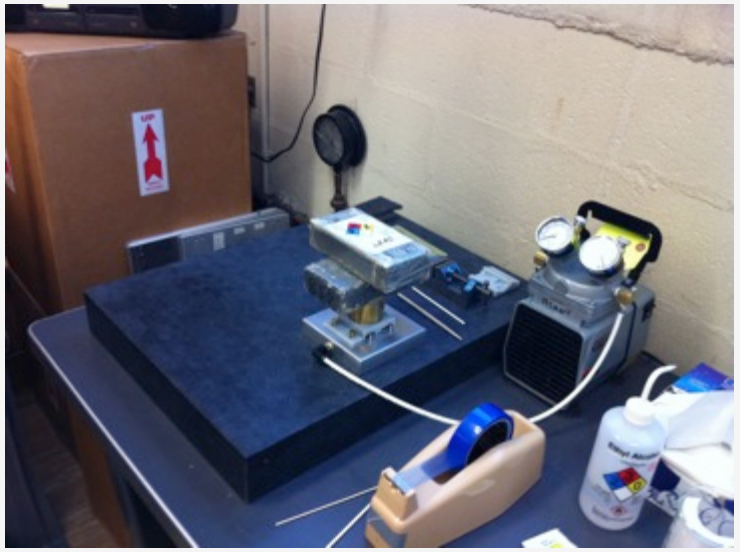

Micromodule Gluing tool micromodule parts and glued assembly currently in production

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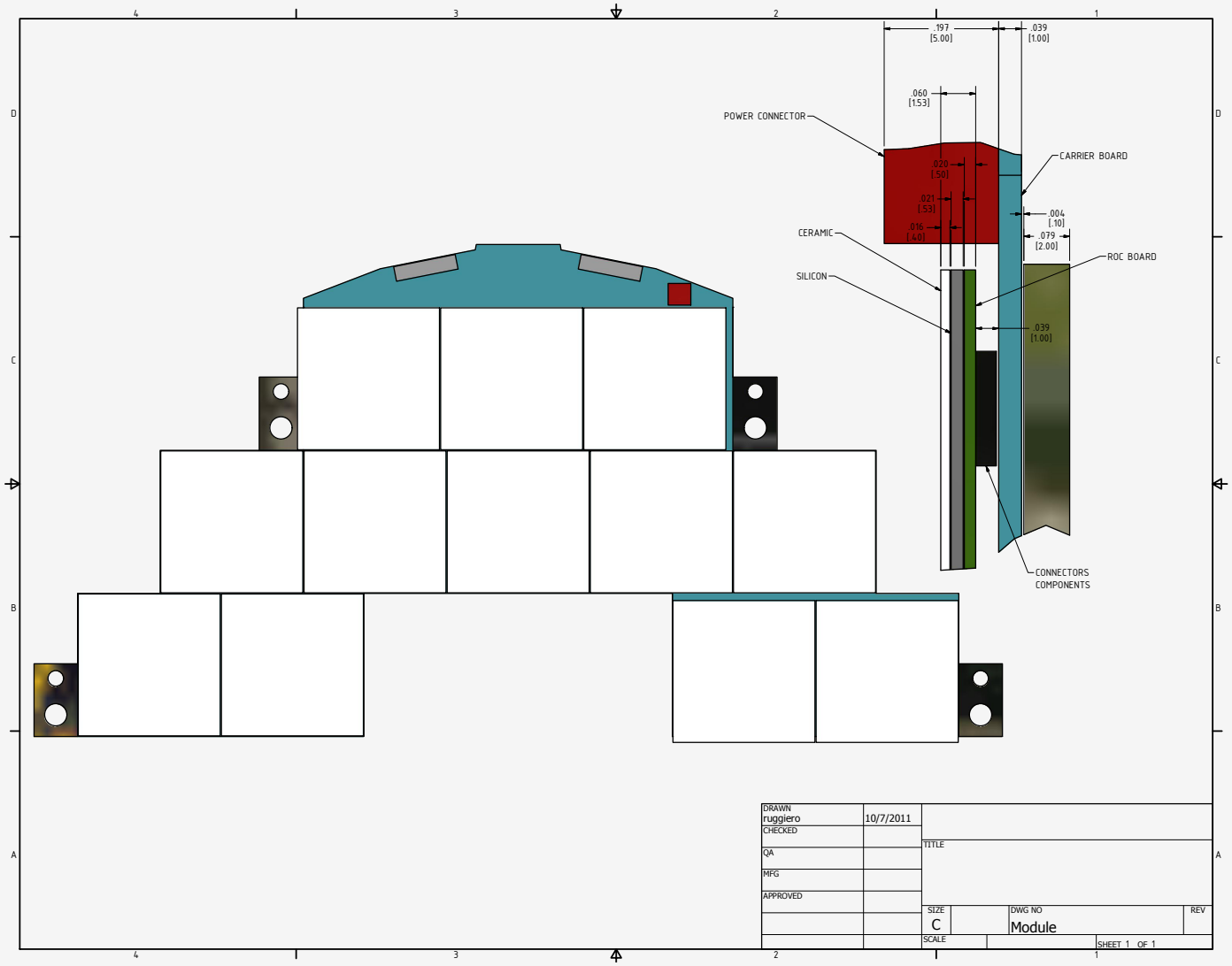
MPC-Ex Design

Single Layer Design



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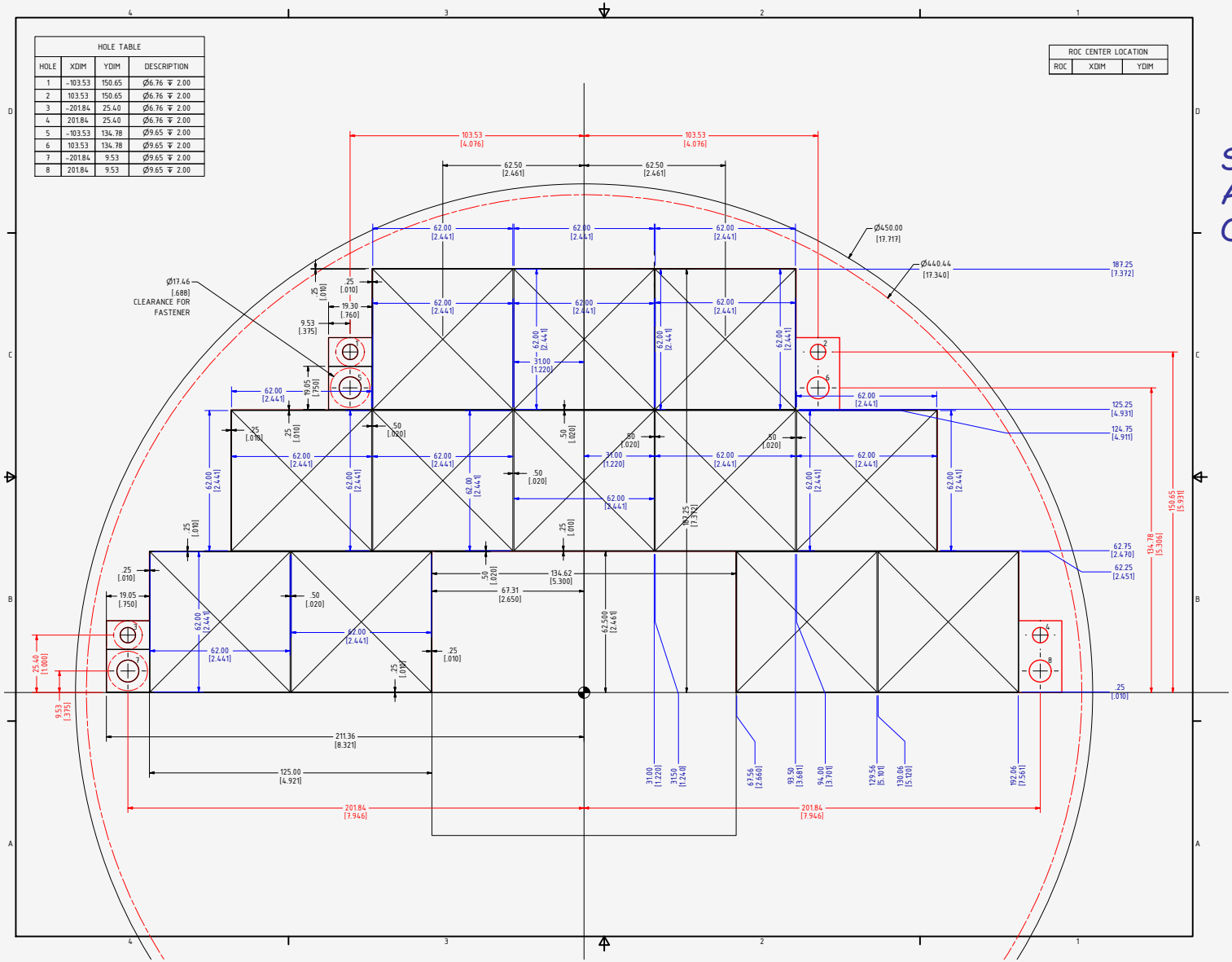

Sensor Layout Alternating X-Y Orientation

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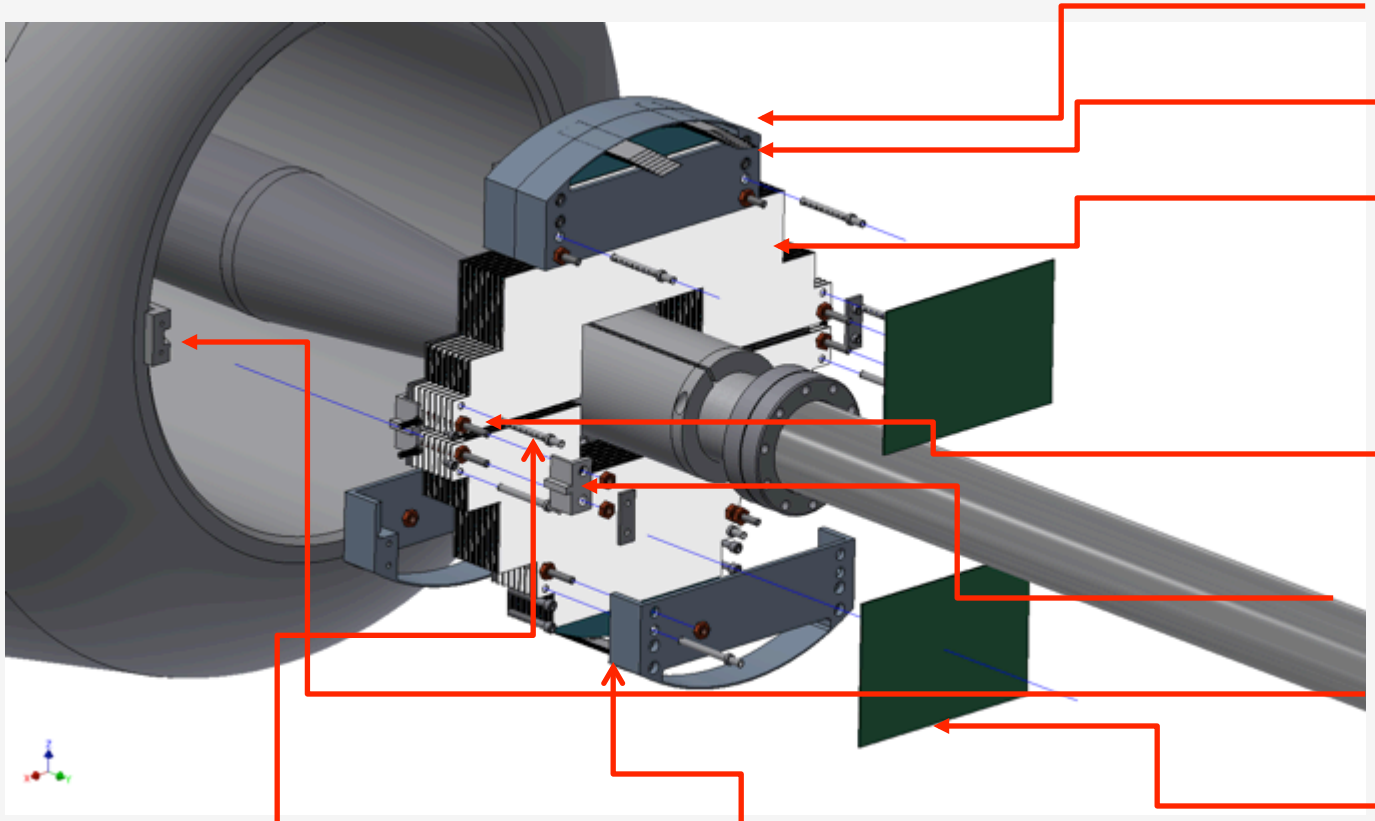
MPC-Ex Exploded view



Upper covers

Signal Cable pigtails

8 layers of tungsten & detector electronics backed by Delrin cover (top and bottom halves)

Threaded rods and spacers

Mounting tabs

Mounting clips

LV distribution boards

Lower covers

Cooling air manifolds

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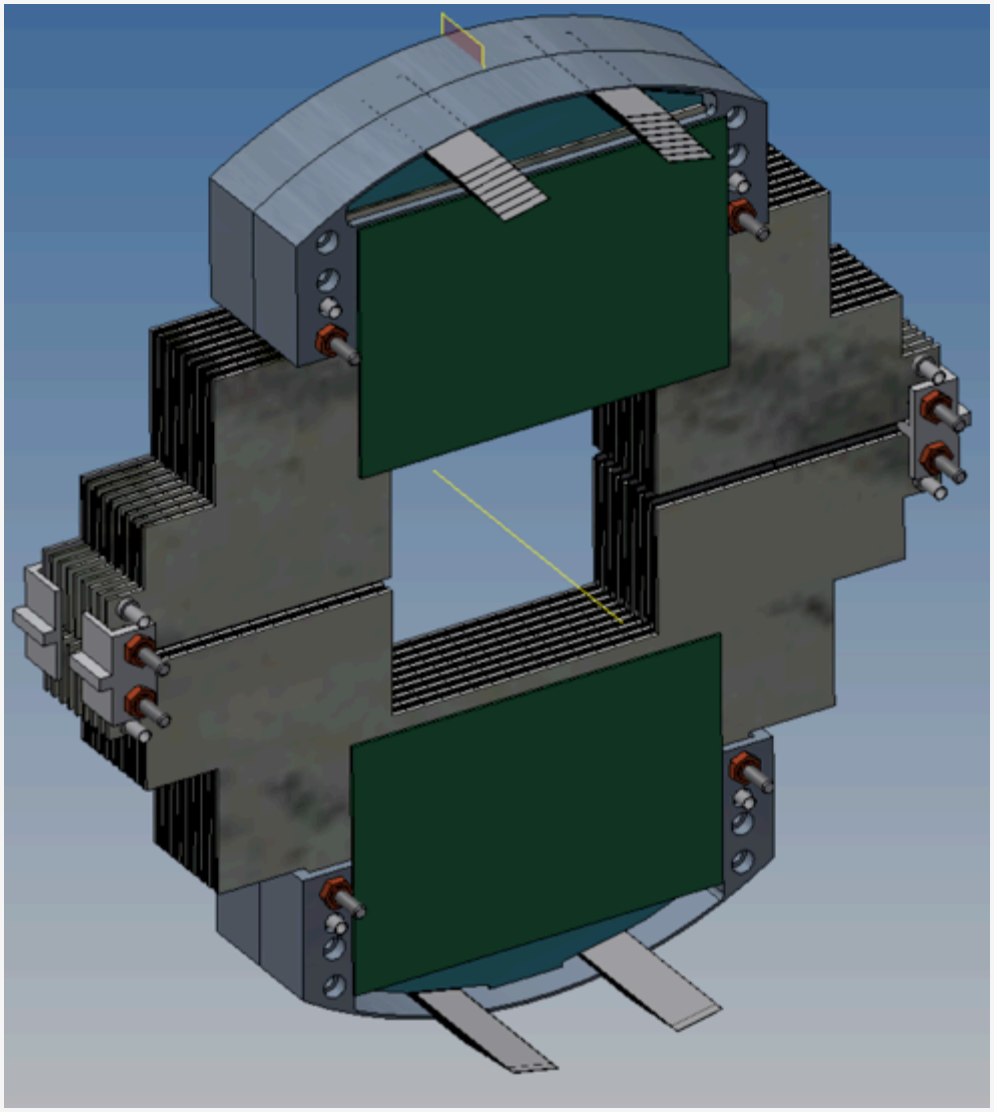

MPC-Ex Full Model

Run 14 Partial installation will include $\frac{1}{4}$ of the electronics and all of the tungsten for the south detector. Edge closures not shown.

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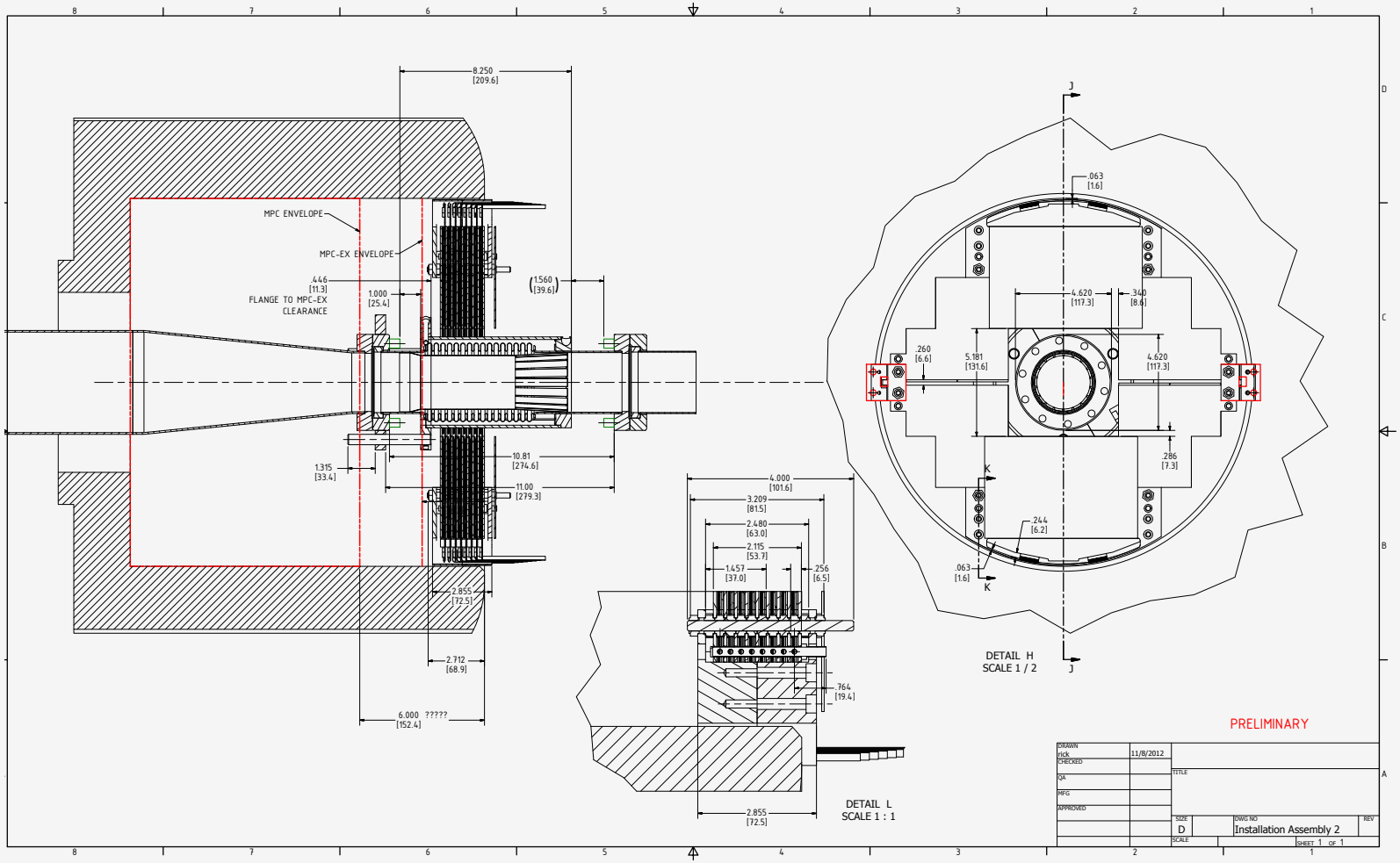

Installed Layout

MPC-Ex Site Preparation

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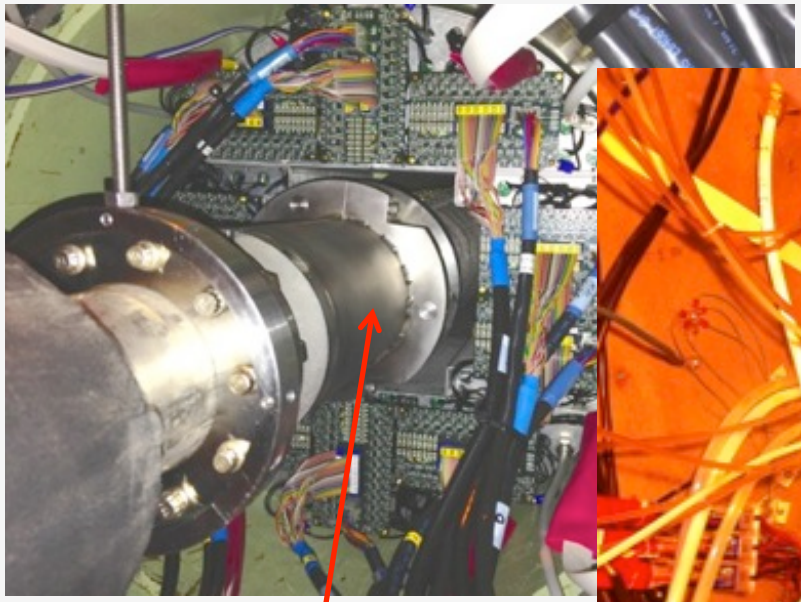
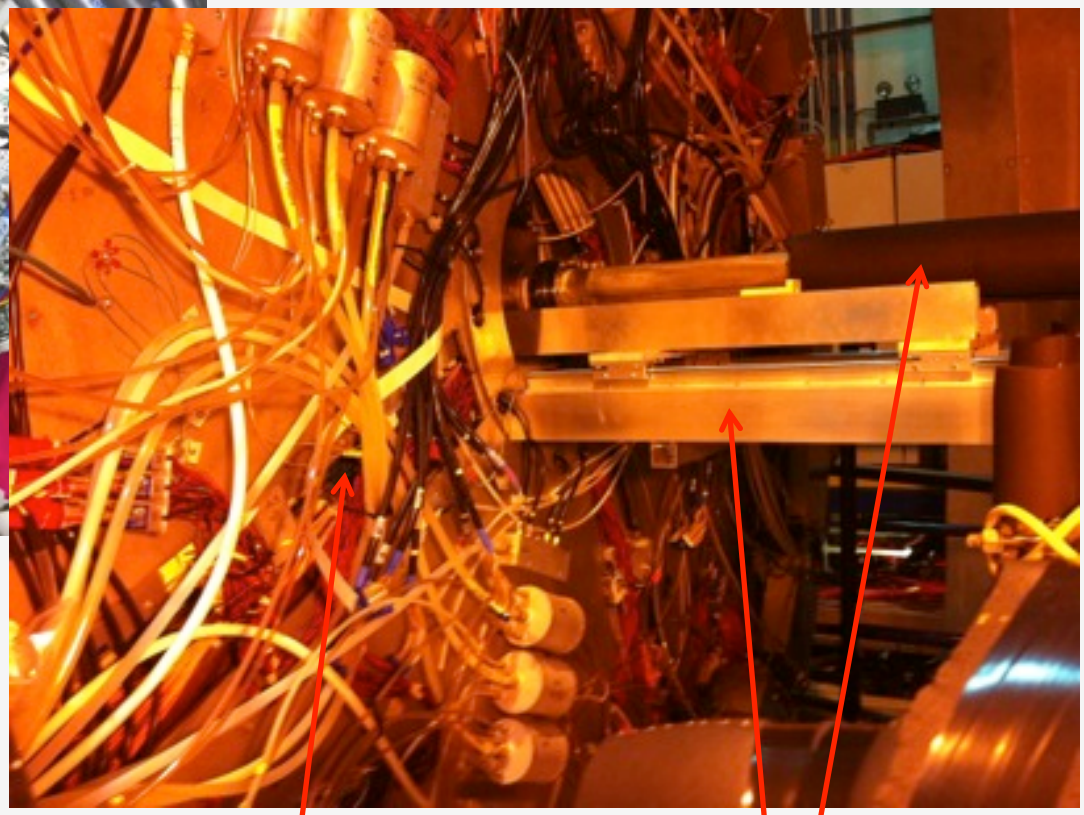


Anti-squirm installed



MPC Light collection relocated to
Mu Tracker station 1 FEE plate

Insertion/installation tool
installed with beampipe
protection

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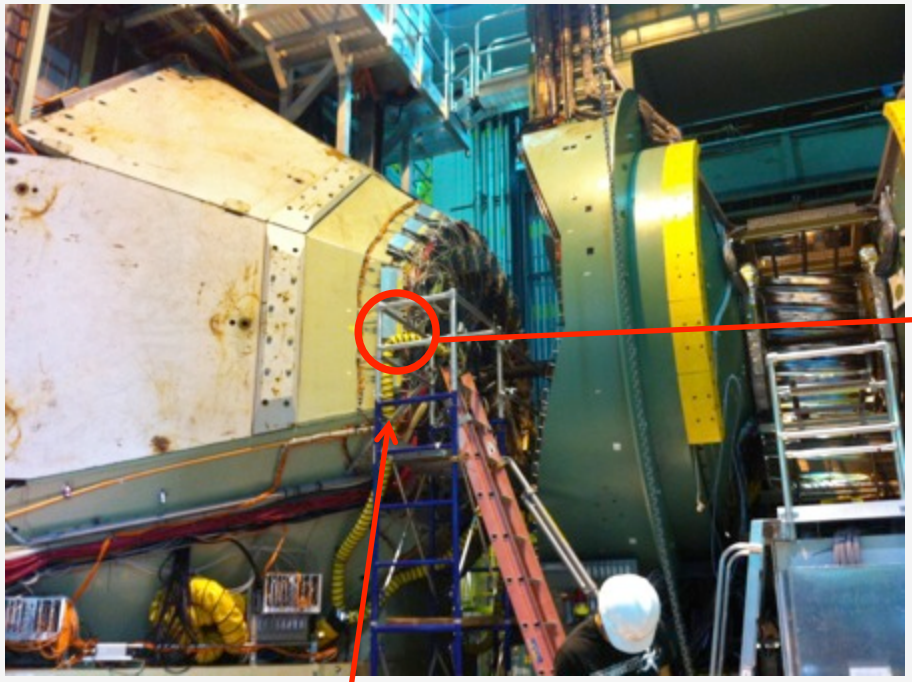

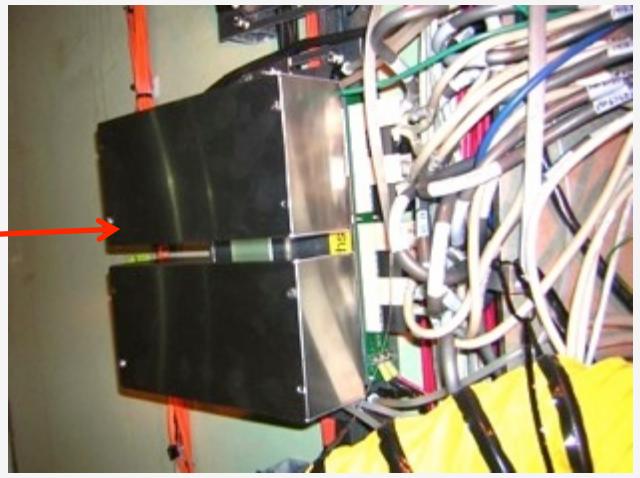

Front end electronics enclosures mounted on existing MuTrigger front end electronics boxes.

Scaffolding in place from MuTr maintenance

MPC Flat cables replaced with round cables (Done last year)

MPC Cables rerouted

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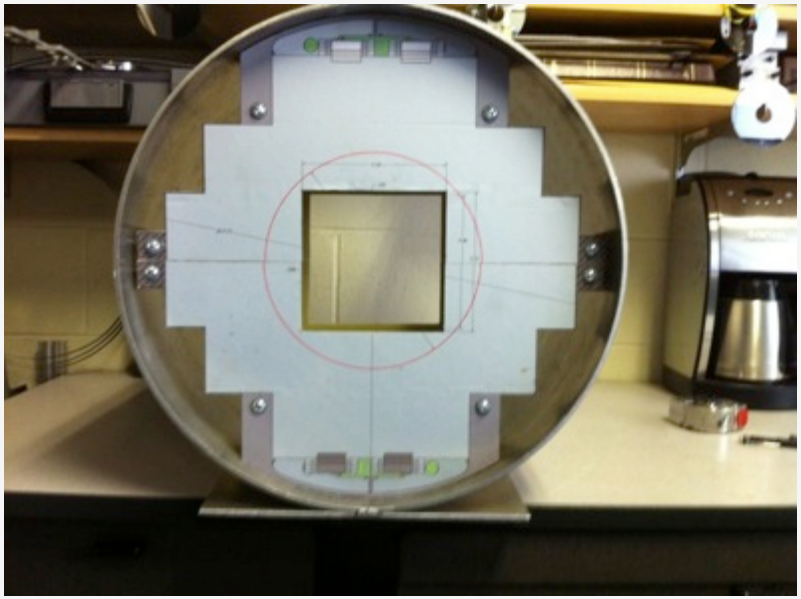
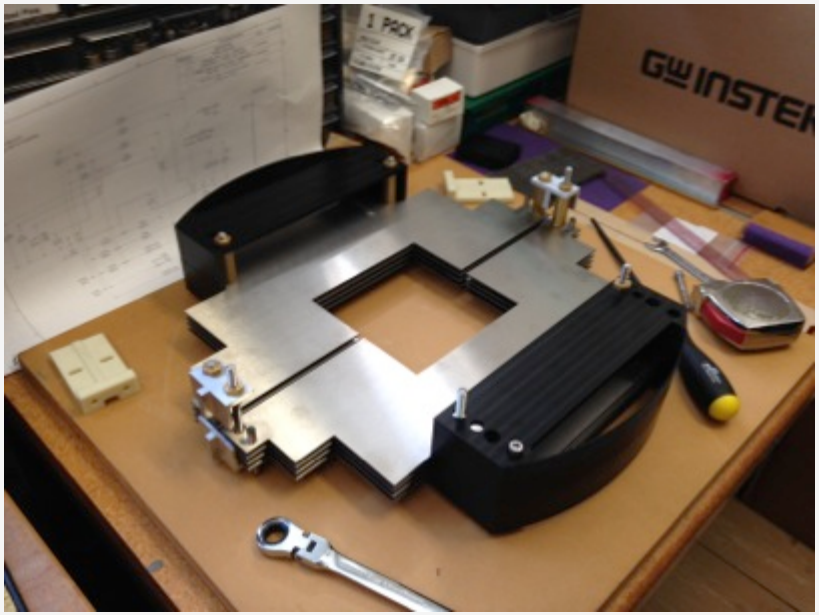


MPC-Ex mockup to be used for cable and utilities routing plans



Tungsten plate test fitup

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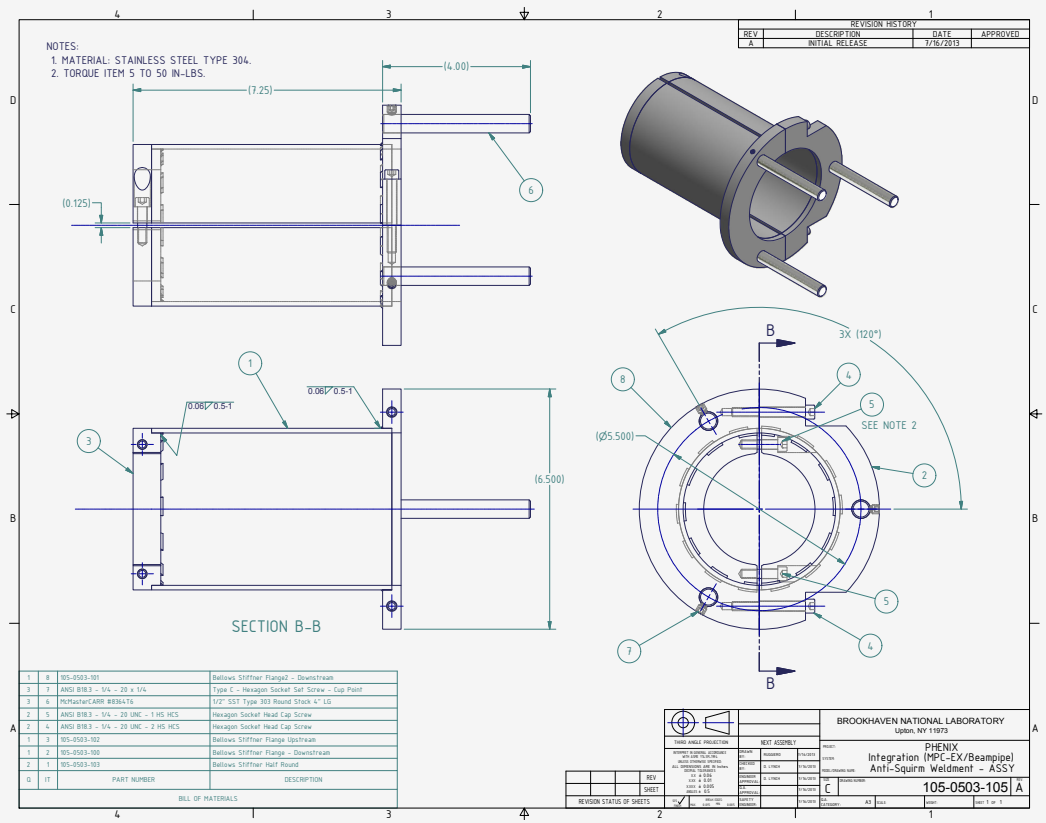
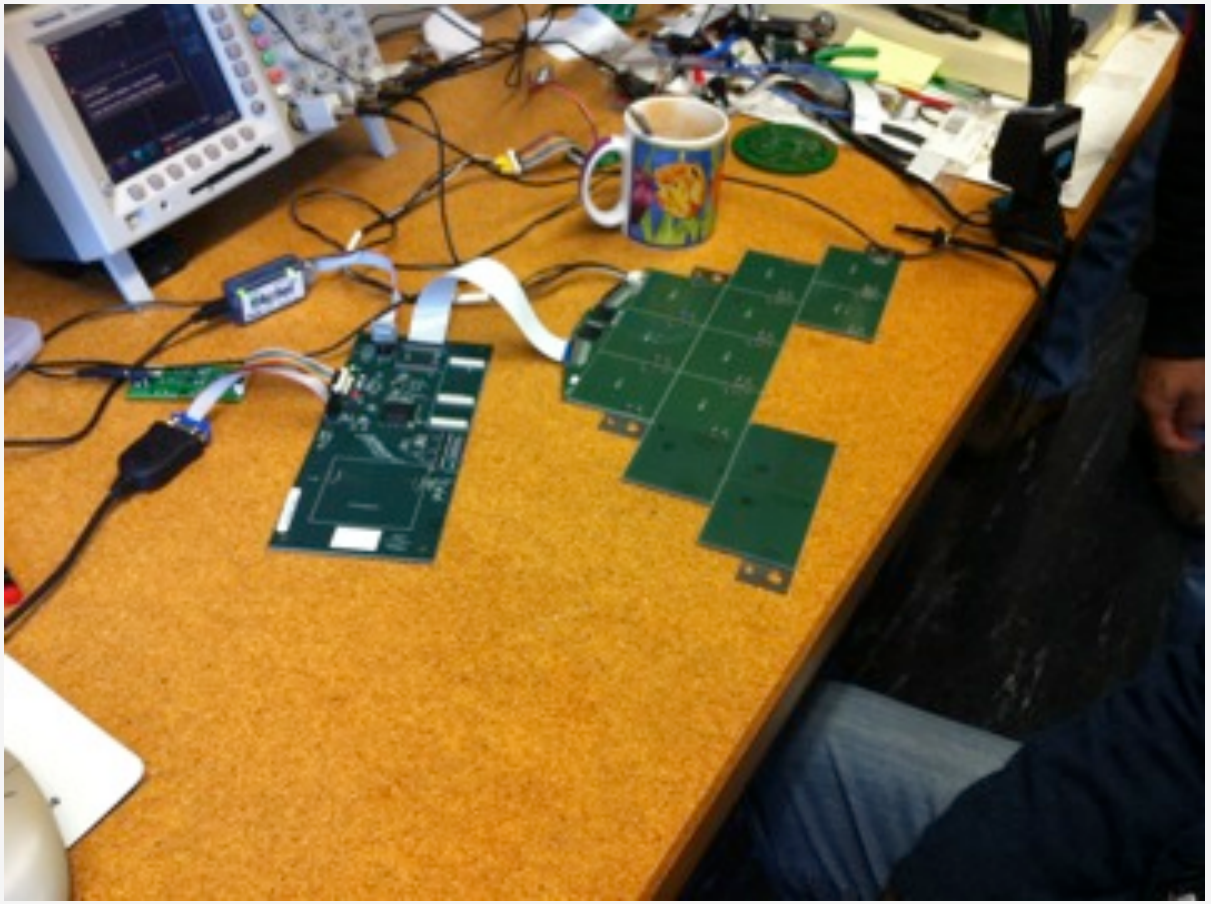


Anti-squirm replaces existing "bellows spreader"

TECHNICAL SUPPORT 2013



1st test of front end module board with laminated tungsten/carrier board & partial micromodules

PHENIX

TECHNICAL SUPPORT 2013

INSTALLATION

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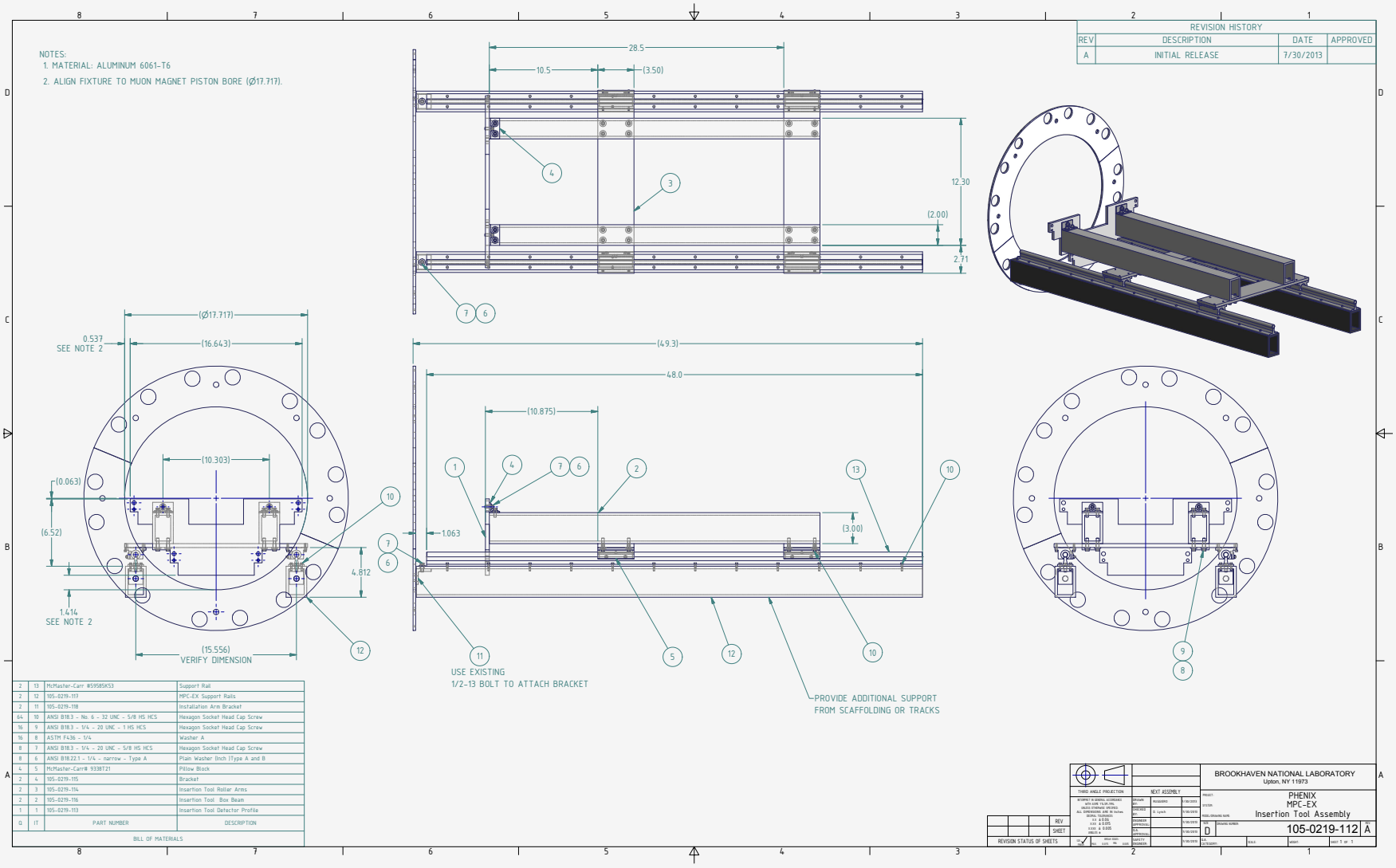
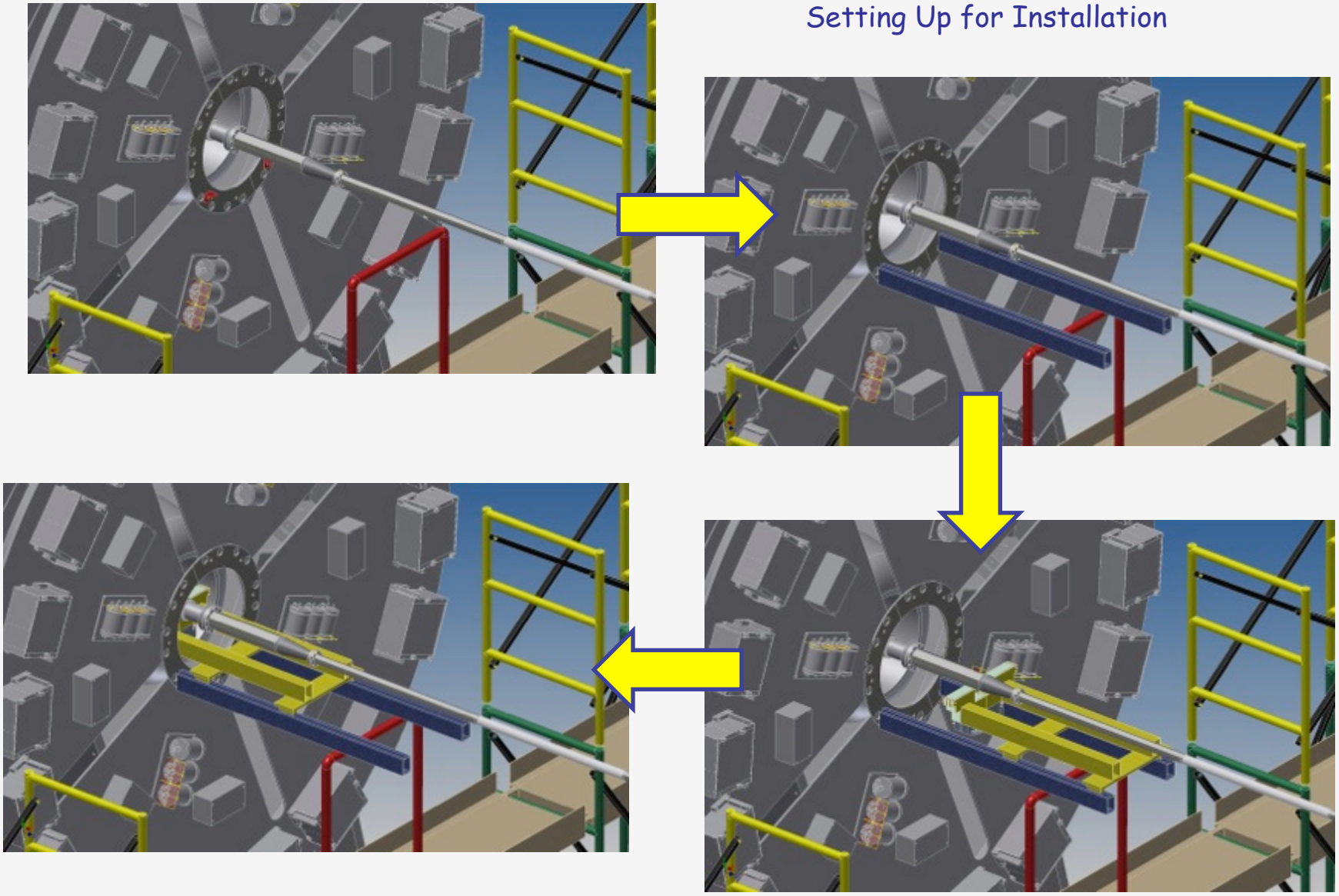
TECHNICAL SUPPORT 2013



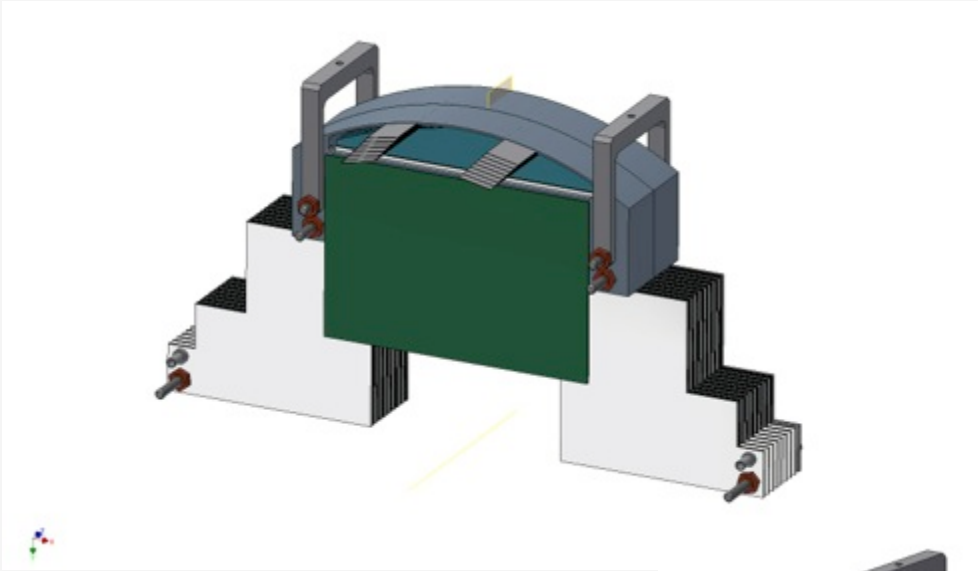
MPC-Ex Insertion/Installation Tool

TECHNICAL SUPPORT 2013

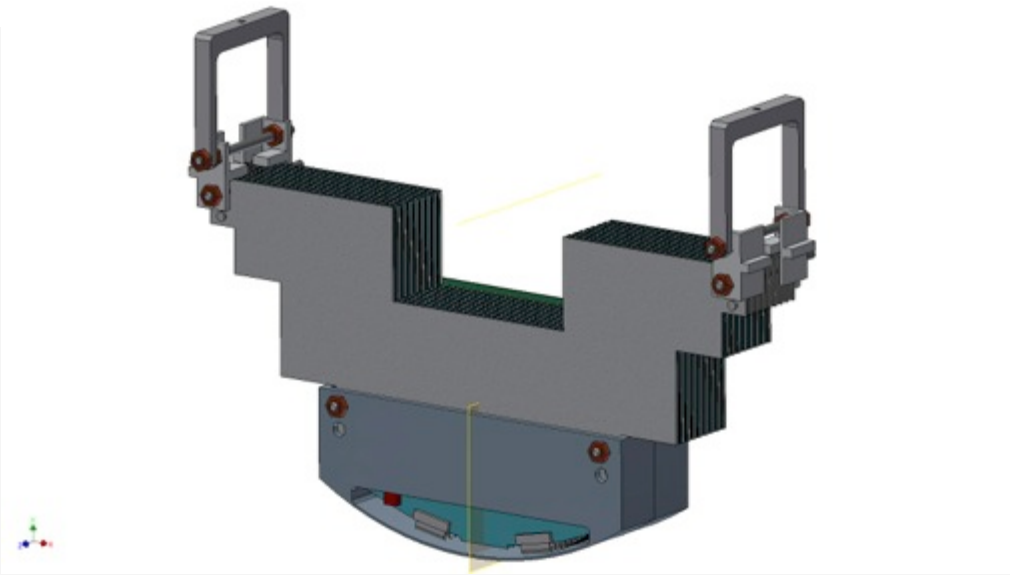
Setting Up for Installation



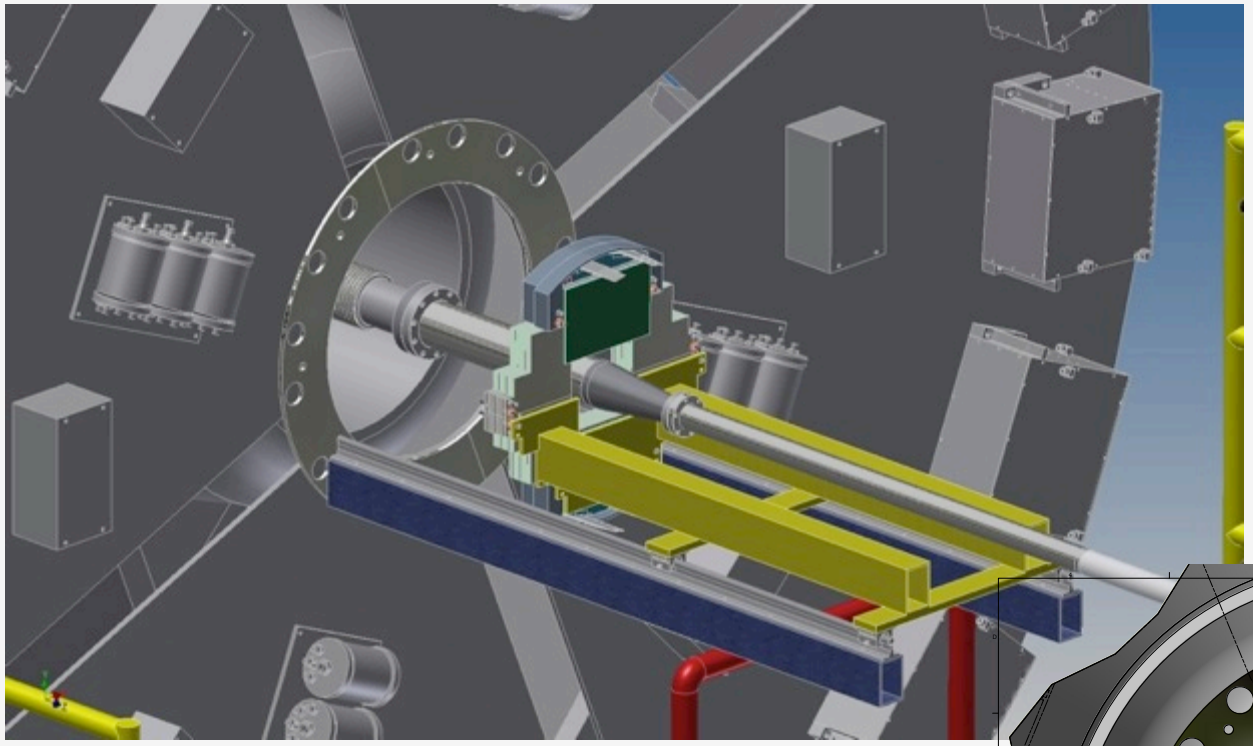
TECHNICAL SUPPORT 2013

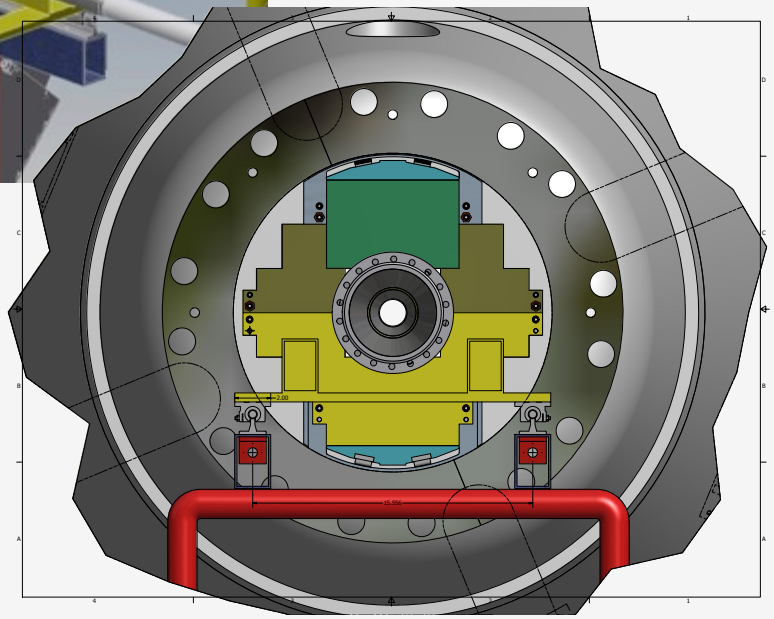


Upper and lower MPC-Ex halves with lifting tools for positioniong halves around beampipe on insertion/lifting tool



TECHNICAL SUPPORT 2013





MPC-Ex installed on insertion/ installation tool ready for insertion/installation

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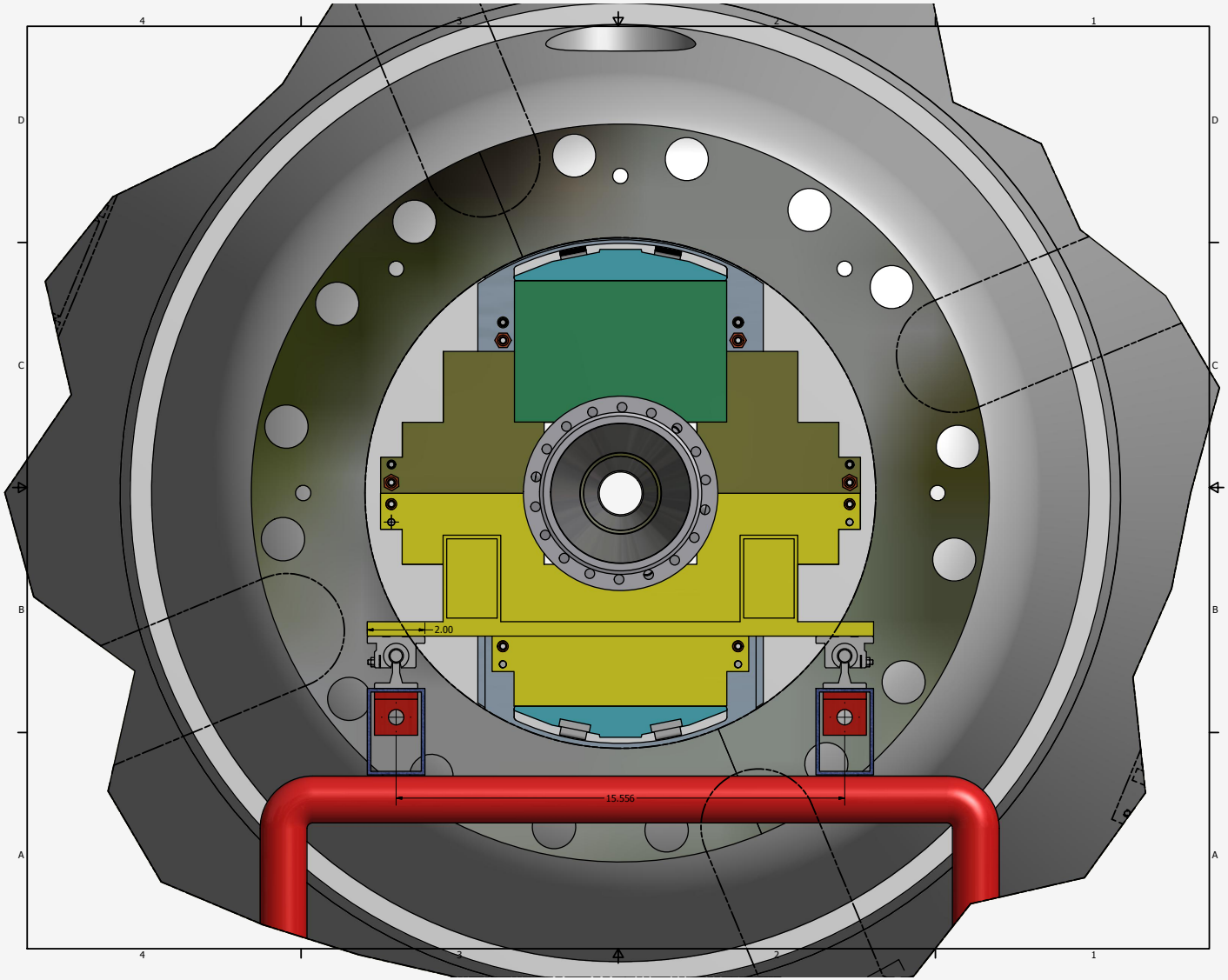
TECHNICAL SUPPORT 2013



MPC-EX

Power Distribution

Power Requirements (One Side)

- Detector split into upper and lower portions with 8 SVX boards each.
- Each portion monitored and controlled by one 8 channel MPC-EX LV Distribution Controller.
- Each channel (SVX board) requires:

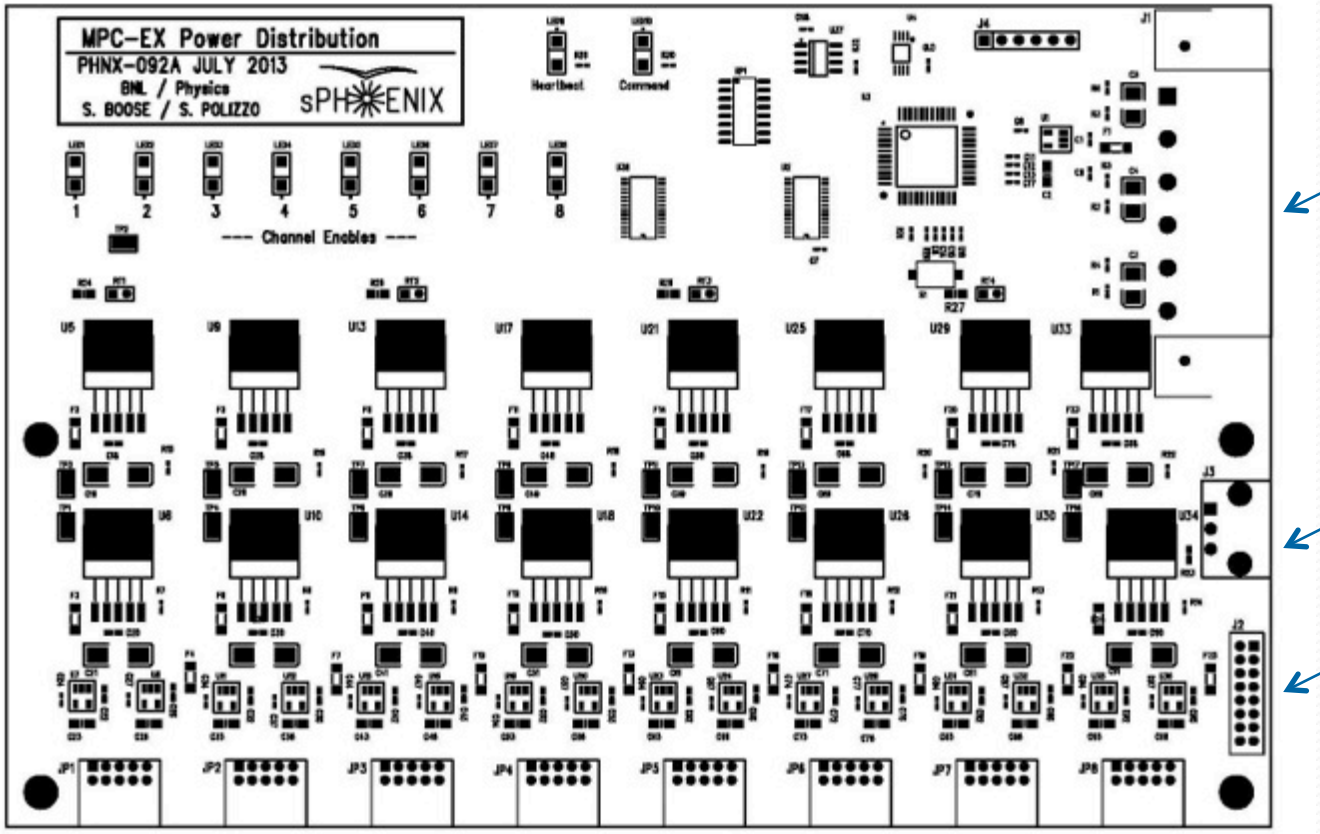
1. 2.5V @ 2A Analog
2. 2.5V @ 1A Digital
3. 1.5V @ 0.2A Digital
4. 3.3V @ 0.2A Config

MPC-EX LV Distribution Board

- Fed by LV and bias from rack mounted power supplies.
- All channels fused by polyswitches.
- 8 channels of bias passively routed to SVX boards.
- Computer controlled via RS485 link from PC:

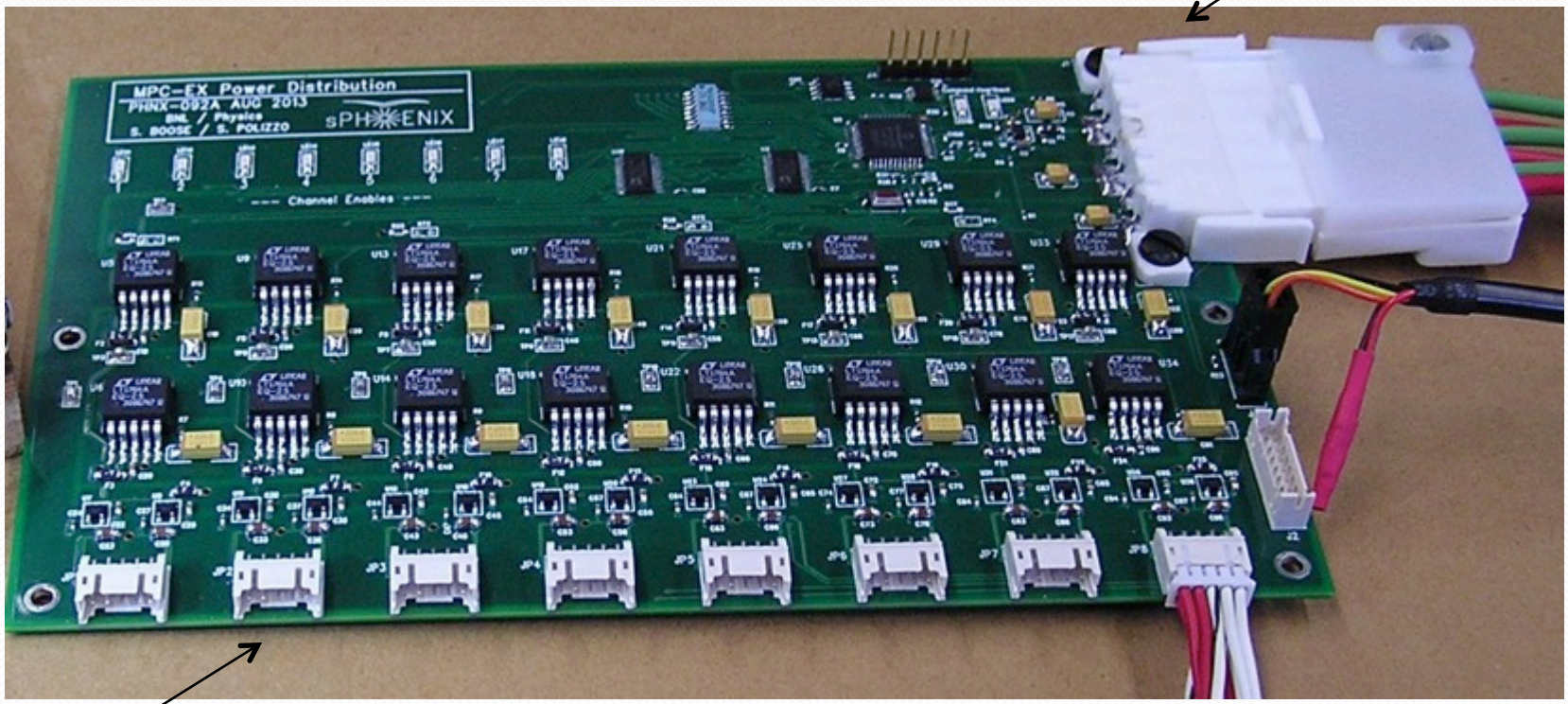
1. Individual channel LV enables.
2. Temperature monitoring of LV Dist and SVX boards.
3. Voltage monitoring of higher current outputs.

MPC-EX LV Distribution Board



MPC-EX LV Distribution Board

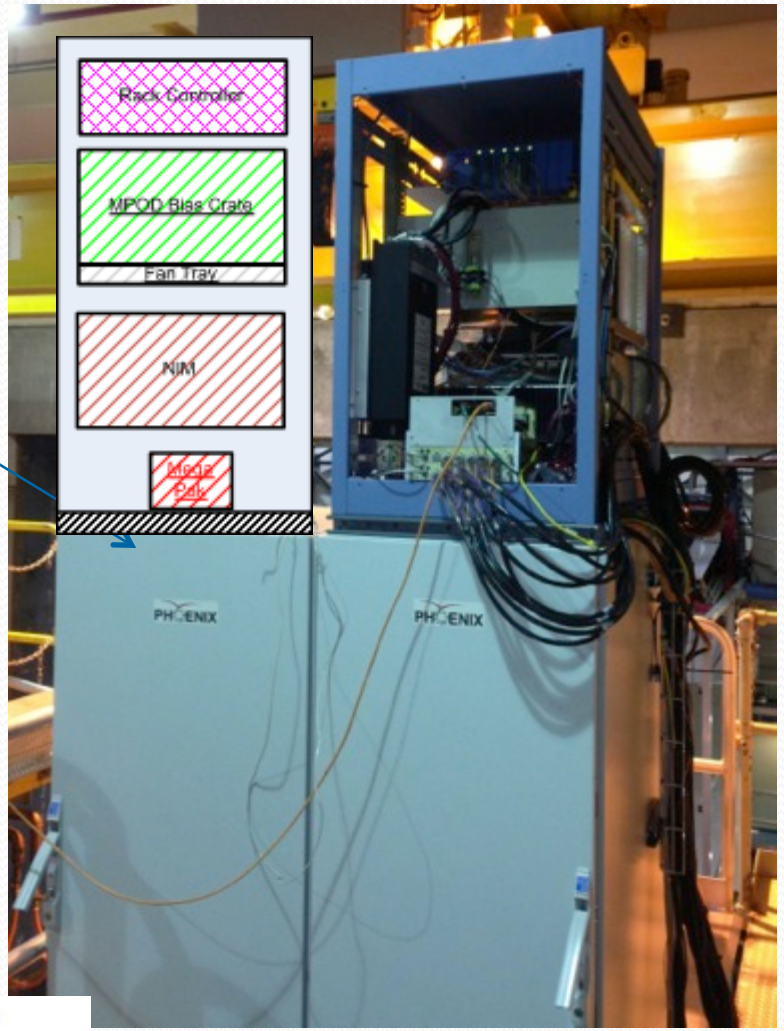
TE Mate-N-Lok



JST PHD Connector

MPC-EX Racks

- Same 1m x 1m type as MPC with 31" of vertical rack space.
- Mounted on top of SMT5 and NMT5 racks.
- Contain low voltage, NIM crate and bias.



Cables, Connectors and Fuses

- Low voltage:
  - Alpha 65205 AWG #12 fused at the source for 15A.
  - TE 640583-3 Mate-N-Lok LV Distribution Board input connector.
  - JST PHD connector, 250V rated, UL94V-0 output channel connector, polyfused for 4A or less.
- Bias voltage:
  - AWG #26 300V rated instrumentation cable.
  - JST PHD connector, 250V rated, UL94V-0.

TECHNICAL SUPPORT 2013

Installation

November 1-15 2013

All components to be installed, all tools for installation, all electronics, cables etc. must be ready for installation by 11/1/2013. Cable and cooling routing will be field fit by PHENIX technicians. Station 1 scaffolding to be removed ~ 11/15/2013. Ladder access as necessary until 11/27/2013. After that EC is rolled in and MMS is moved to run position.