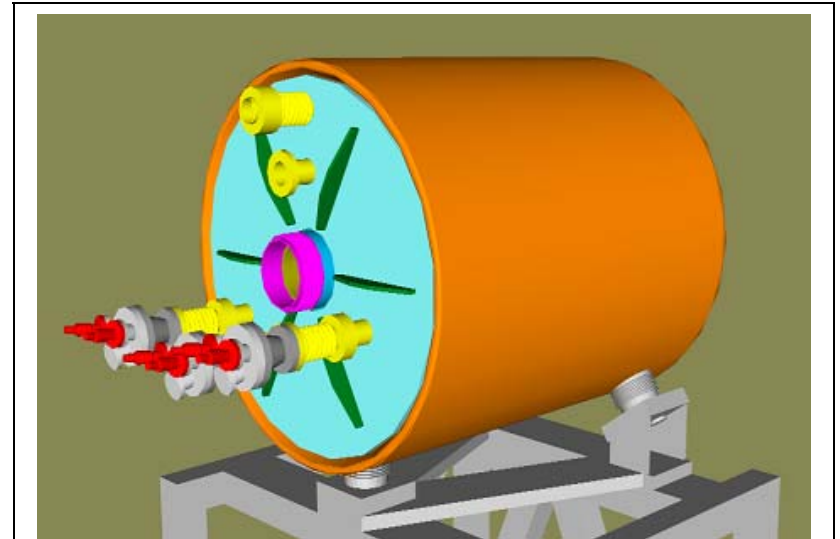




**MERIT**  
**Magnet Status and Testing Plans**

**NuMu Collaboration Friday  
Teleconference: October 28, 2005**



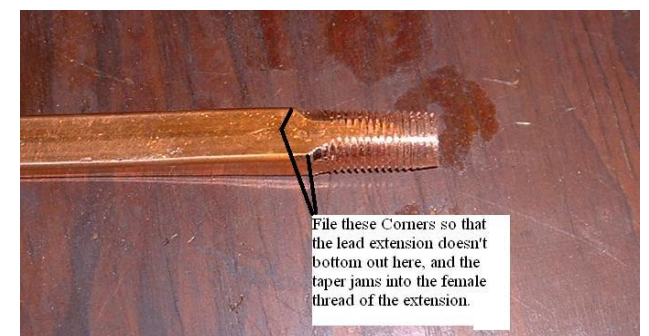
**MERIT Pulsed Magnet –Inertially Cooled , 80K LN2  
Cooled Between Shots**

**Peter H. Titus**  
**MIT Plasma Science and Fusion Center**  
*(617) 253 1344, [titus@psfc.mit.edu](mailto:titus@psfc.mit.edu), <http://www.psfc.mit.edu/people/titus>*

## Nested Coils as They Appeared at Everson Prior to Shipping to CVIP

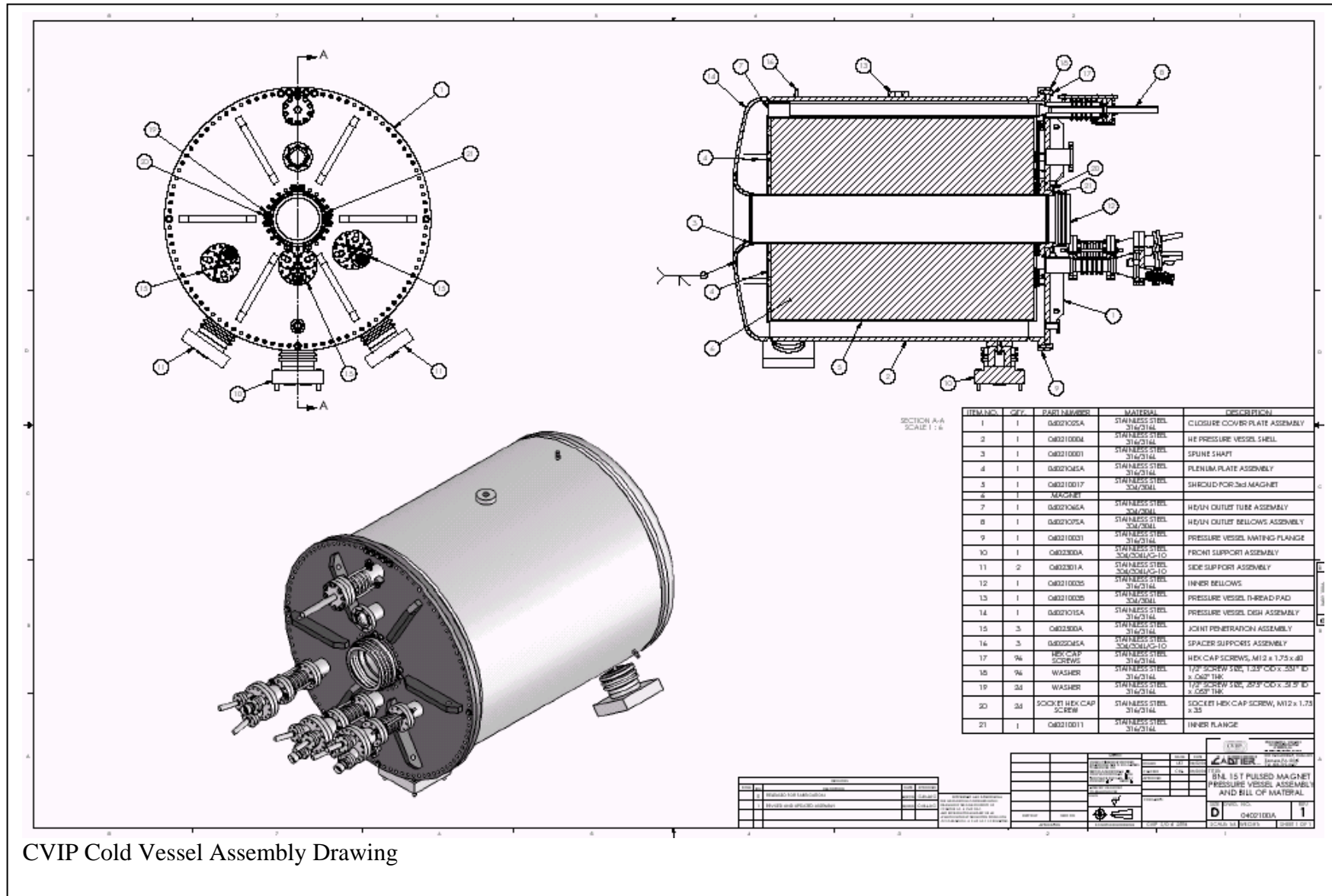


Leads threaded, Coils being prepared for shipping



Lead Pipe Thread

# CVIP Vessel Manufacturing Status



CVIP Cold Vessel Assembly Drawing



Metallic seals for the cover flange



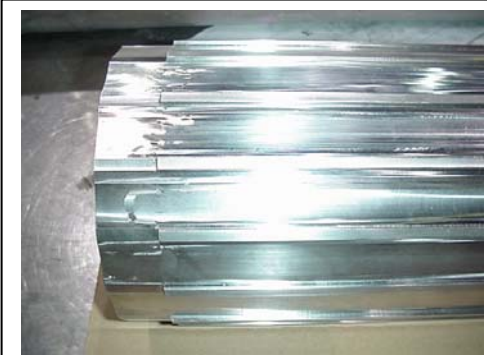
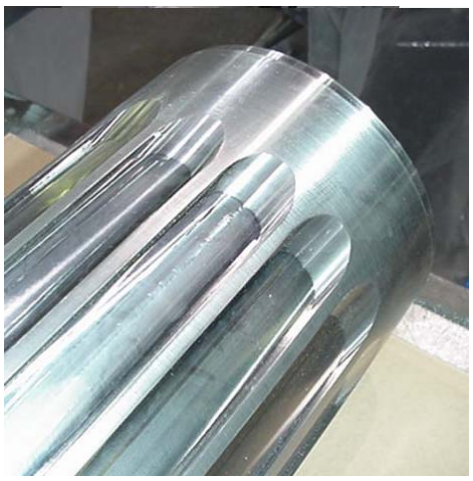
Outer Vacuum Shell at CVIP



The Inner Cold Vessel at CVIP



"Spline Tube – Main Magnet Support



## LN2 Volume Reduction Fillers

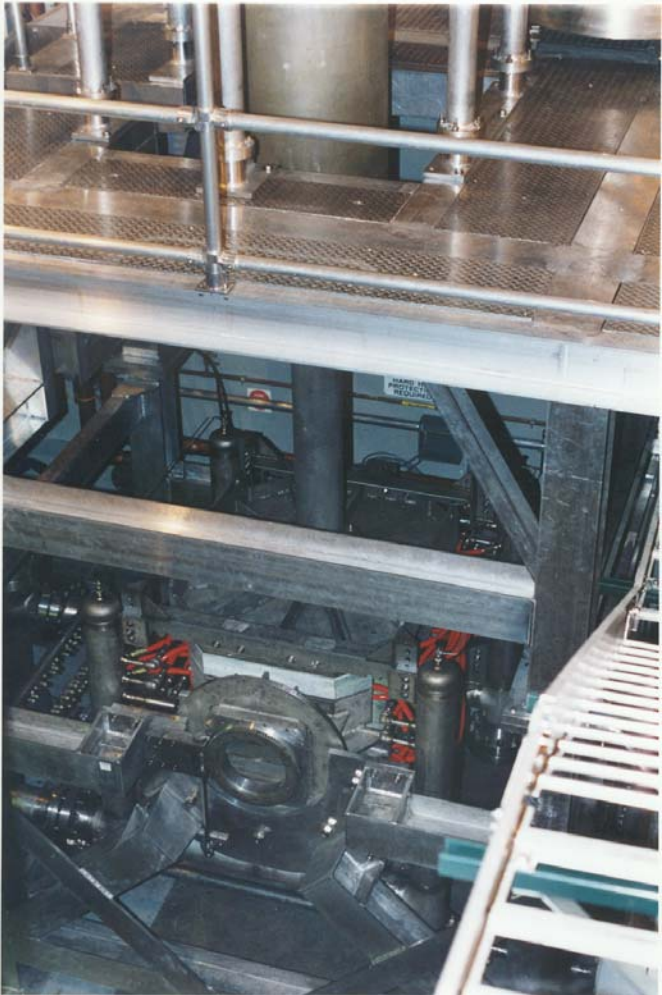


Attached are pictures of Epikure 3140 + Epon 815C epoxy sample. We did not use glass bead as filler because we think it may come loose and damage the valve seat of N2 flow control. It's also not recommended by the manufacturer.

OK- The only problem with deleting the glass bead is that the contraction of the epoxy is about twice that of steel. With the glass bead, the contraction is close to steel. As long as the fillers are not bonded to the steel it will be OK, otherwise we will have some scary noises when we cool down for the first time. In our larger experiment across the street they use quartz sand for filler, and haven't had problems with fouling valves, but they do have screens in the sump. Even pure epoxy has flakes and chips that can clog valves – especially when it cracks on cooldown. I think these should be flushed out during the tests at MIT. Eliminating the glass filler eliminates a concern that I didn't talk to you about: activation of any boron containing glass. So leaving out the filler eliminates one more type of material that might activate. "Epoxy only" filler in the dished head will shrink about 3 mm on the diameter with respect to the steel. You had talked about welding some studs or tabs to the head to hold the epoxy block to the head. The contraction could shear off studs. If they are closer to the ID they would probably just bend.



## Plans for Testing at MIT:



**Lower Water Cooled Split Pair Copper Magnet - The BNL Pulsed Magnet will be in front of this, where the HXC Prototype cryostat is now positioned.**

**The test location is the Pulsed Test Facility (PTF) at MIT-PSFC primarily used for testing of superconducting joints in a transient high field background. The test area will need to be cleared of extraneous equipment. Magnetic materials and tools will be removed.**



**PTF Upper Cryostat**



**View of test area at floor level**



**View of the test area floor. The dewars at left and HCX components at right need to be removed**



## Cryogenic System for the Test

Only atmospheric liquid nitrogen cooling will be employed during pre-operational testing at MIT, although the system is intended to retain the capability to be cooled using gaseous Helium, or sub-cooled LN2.

The requirement to remove the LN2 during the experiments in CERN stems from the radiation environment causing activation of Nitrogen, and the creation of Ozone. Neither of these problems exists during preoperational testing. This would allow a further simplification of the system planned for CERN. However LN2 purge will be simulated at MIT

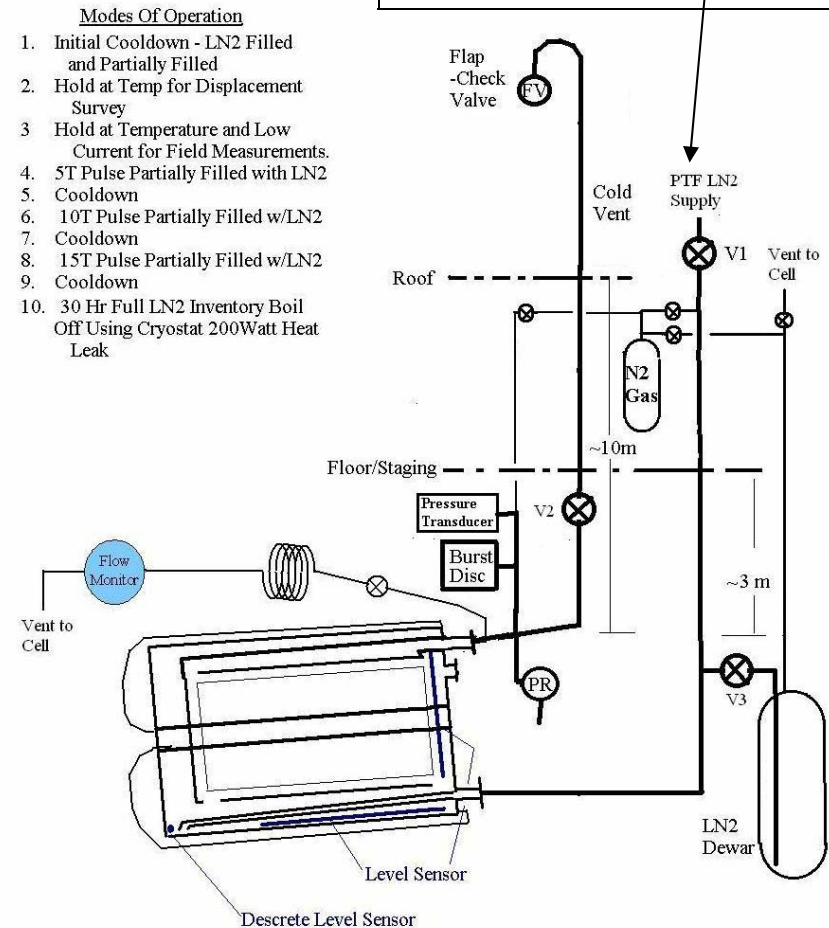
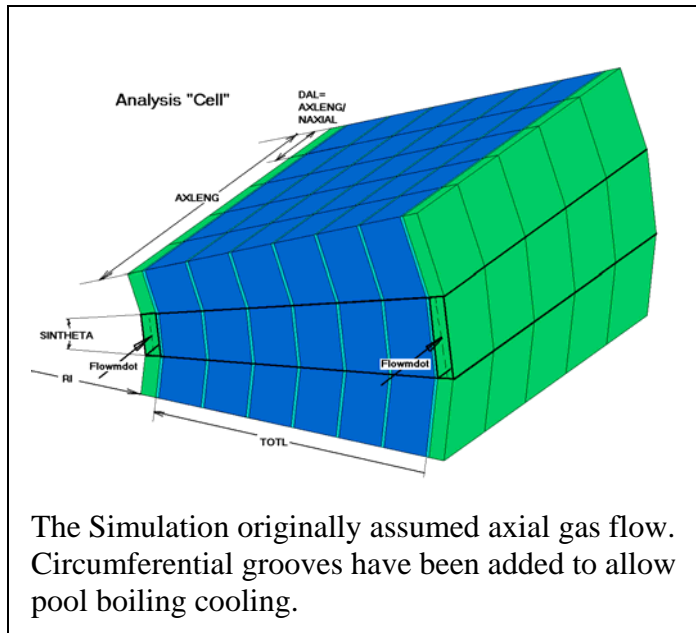
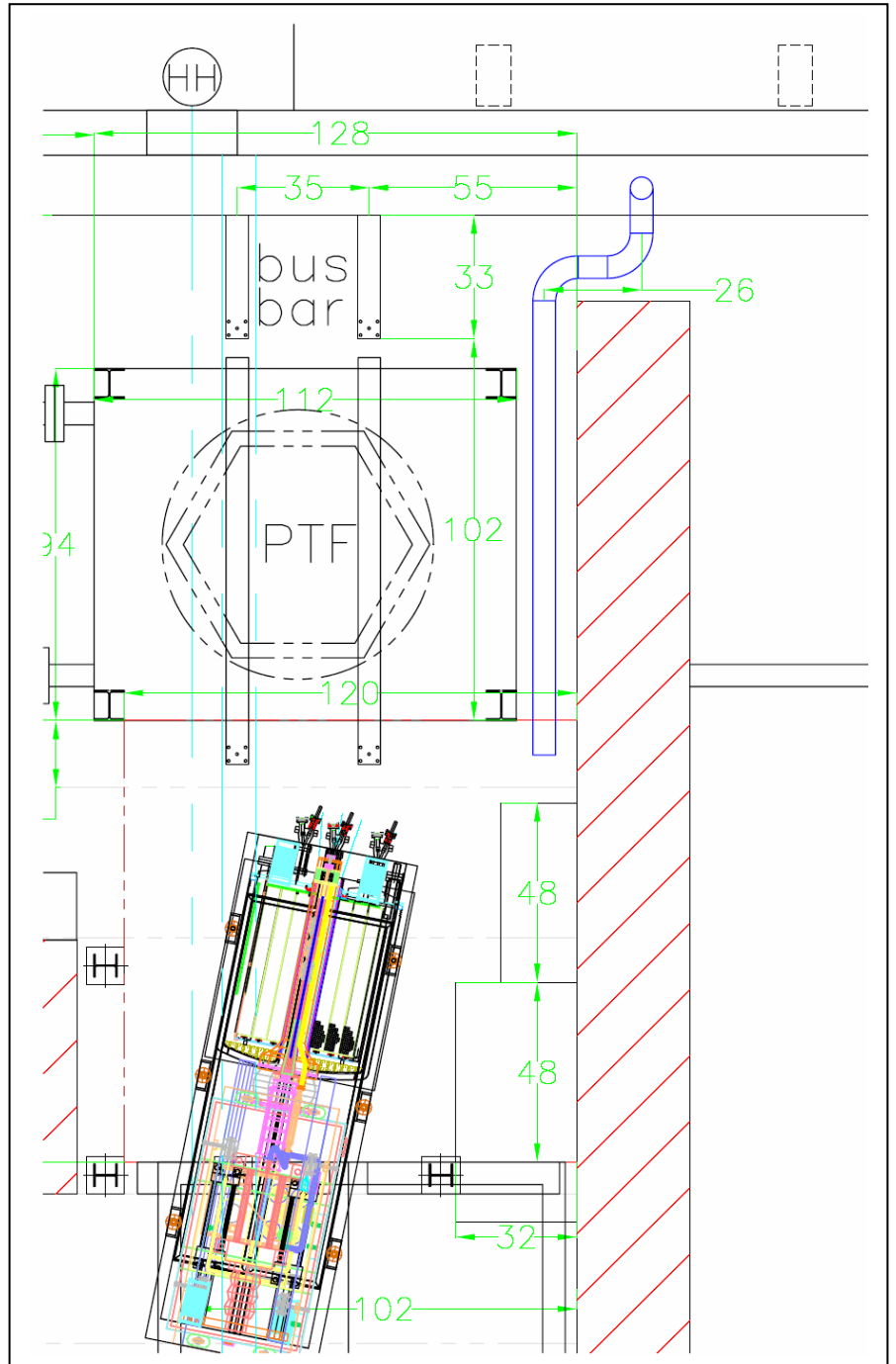
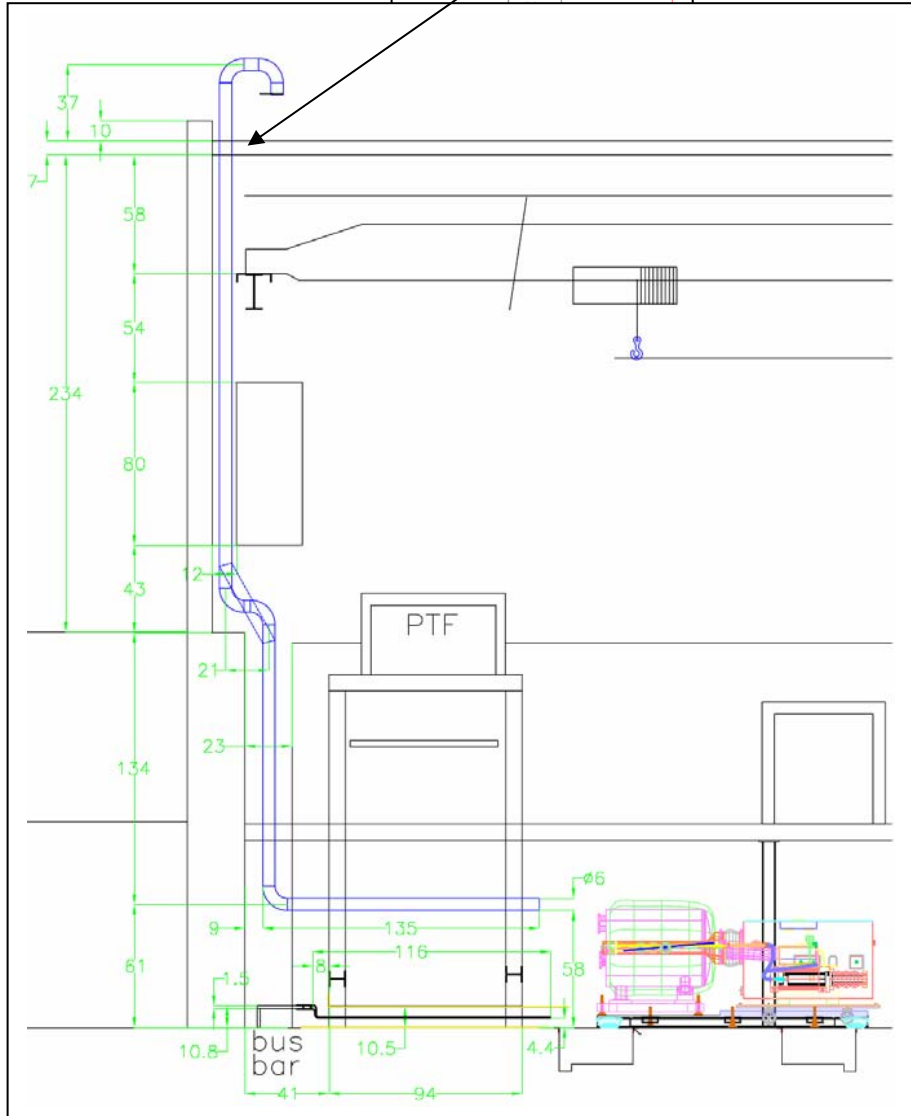
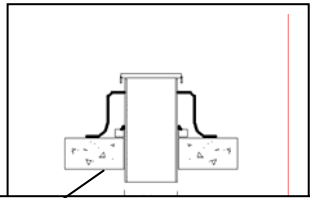


Figure 6.0-3 Cryogenic System Planned for Use at MIT

Vent Status:  
Roof Penetration has  
been cut – Vent  
Pipes Arrive Nov 1



## Power Supply Upgrades and Modifications

At the MIT MERIT Collaboration Meeting, Phil Michael of MIT presented plans for Power Supplies and Upgrades. [http://www.hep.princeton.edu/mumu/target/MIT/West\\_Cell\\_Power\\_Convertors.pdf](http://www.hep.princeton.edu/mumu/target/MIT/West_Cell_Power_Convertors.pdf)

### PSFC West Cell Power Convertors

Presented by: Phil Michael  
at the  
Mercury Target Collaboration Meeting  
MIT-PSFC  
17 Oct. 2005

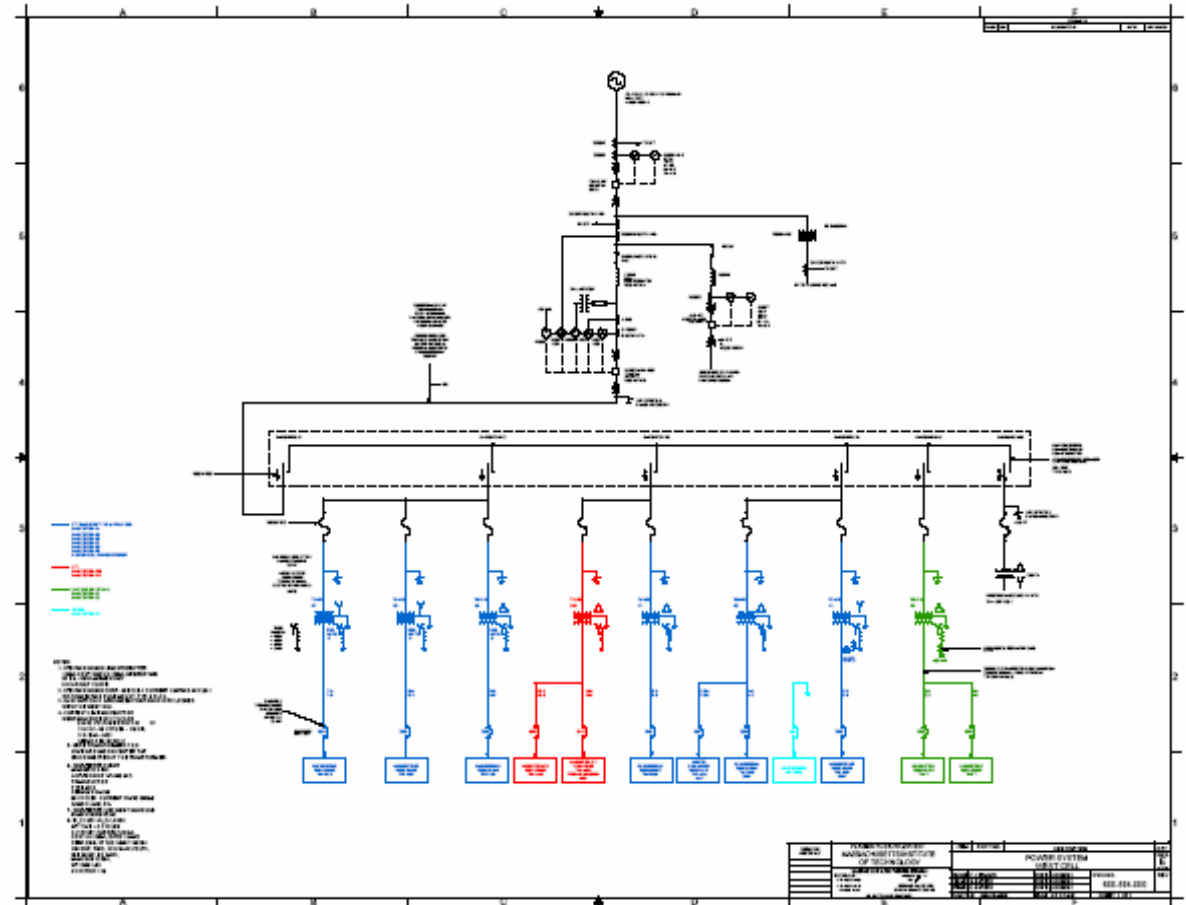
### System overview

- 3-phase 13.8 kV power feed to West Cell penthouse
- Distributed to several pulsed power transformers
- 6-pulse rectification for each convertor
- Six convertors connected via interphase transformer to create 12-pulse supply
- Various transformer tap settings to select maximum dc output voltage

# System schematic

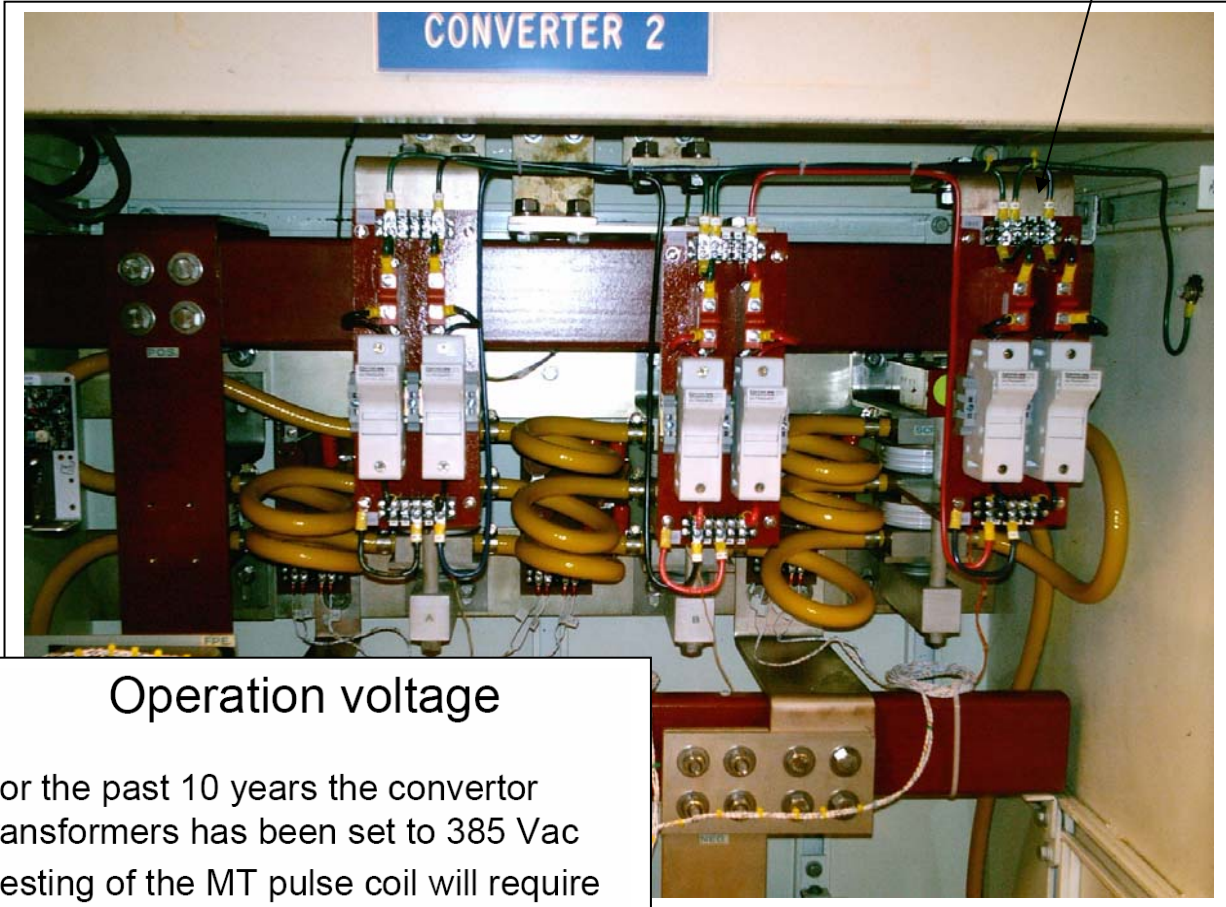
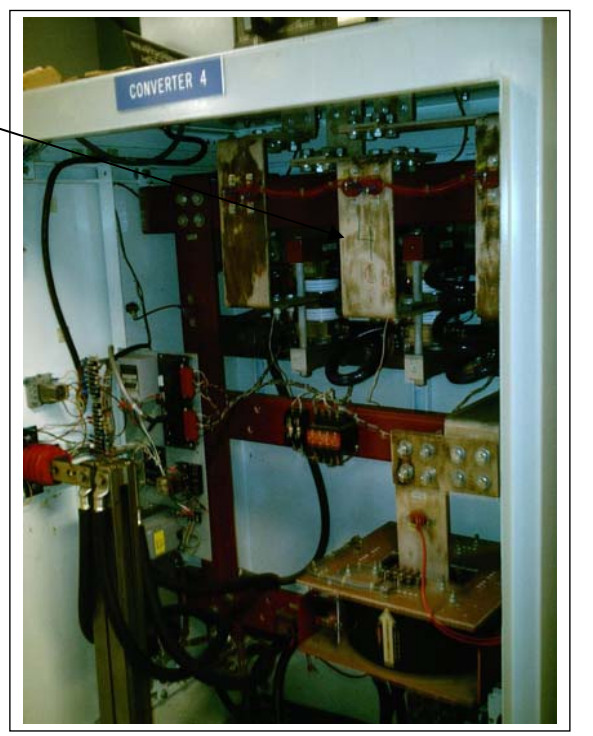


PTF Power Supplies



# Power Supply Upgrades and Modifications

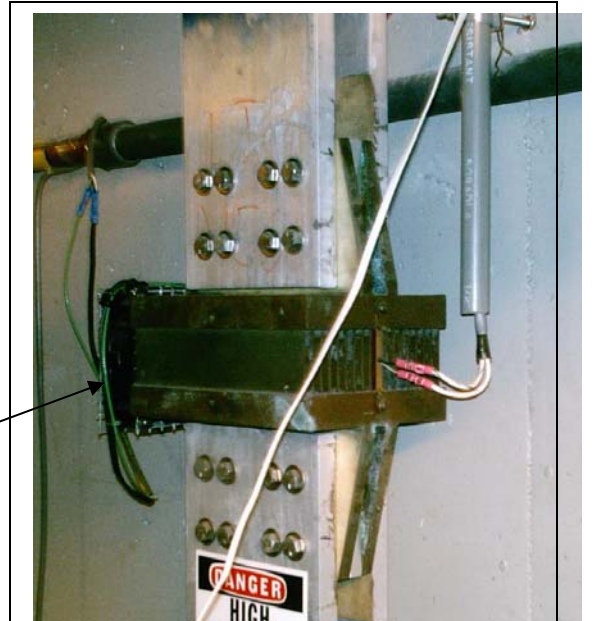
Over Voltage Protection



## Operation voltage

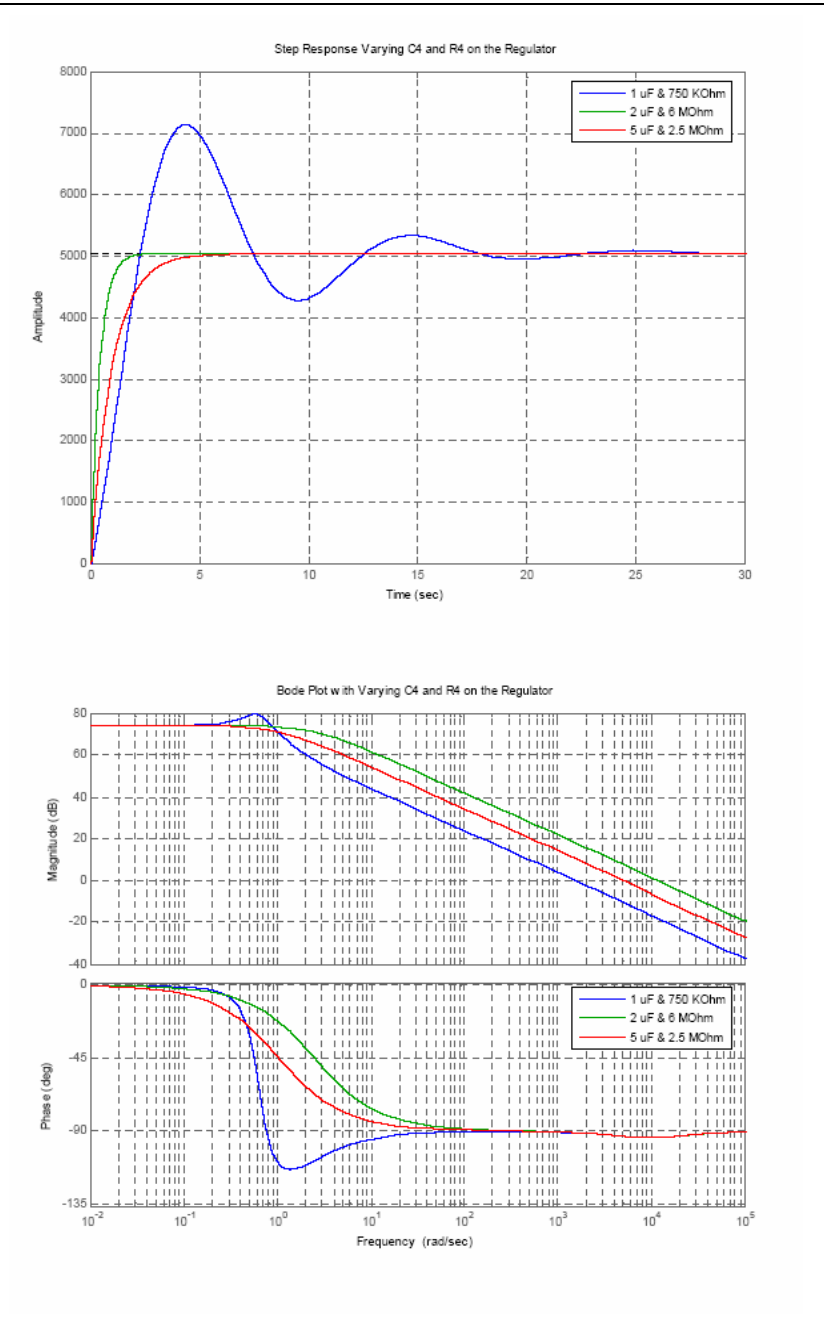
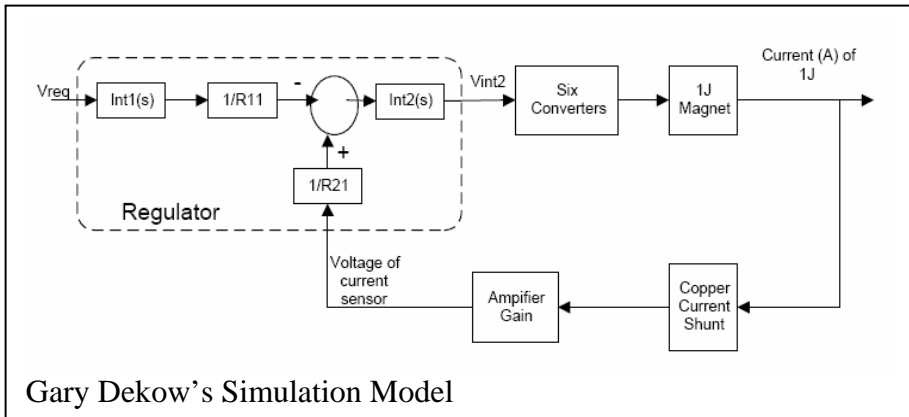
- For the past 10 years the convertor transformers has been set to 385 Vac
- Testing of the MT pulse coil will require resetting the taps to roughly 590 Vac
- The fault protection circuitry in the covertors is ~20 yr old
- Several fault protection components are being upgraded for higher us voltage

Current Shunt

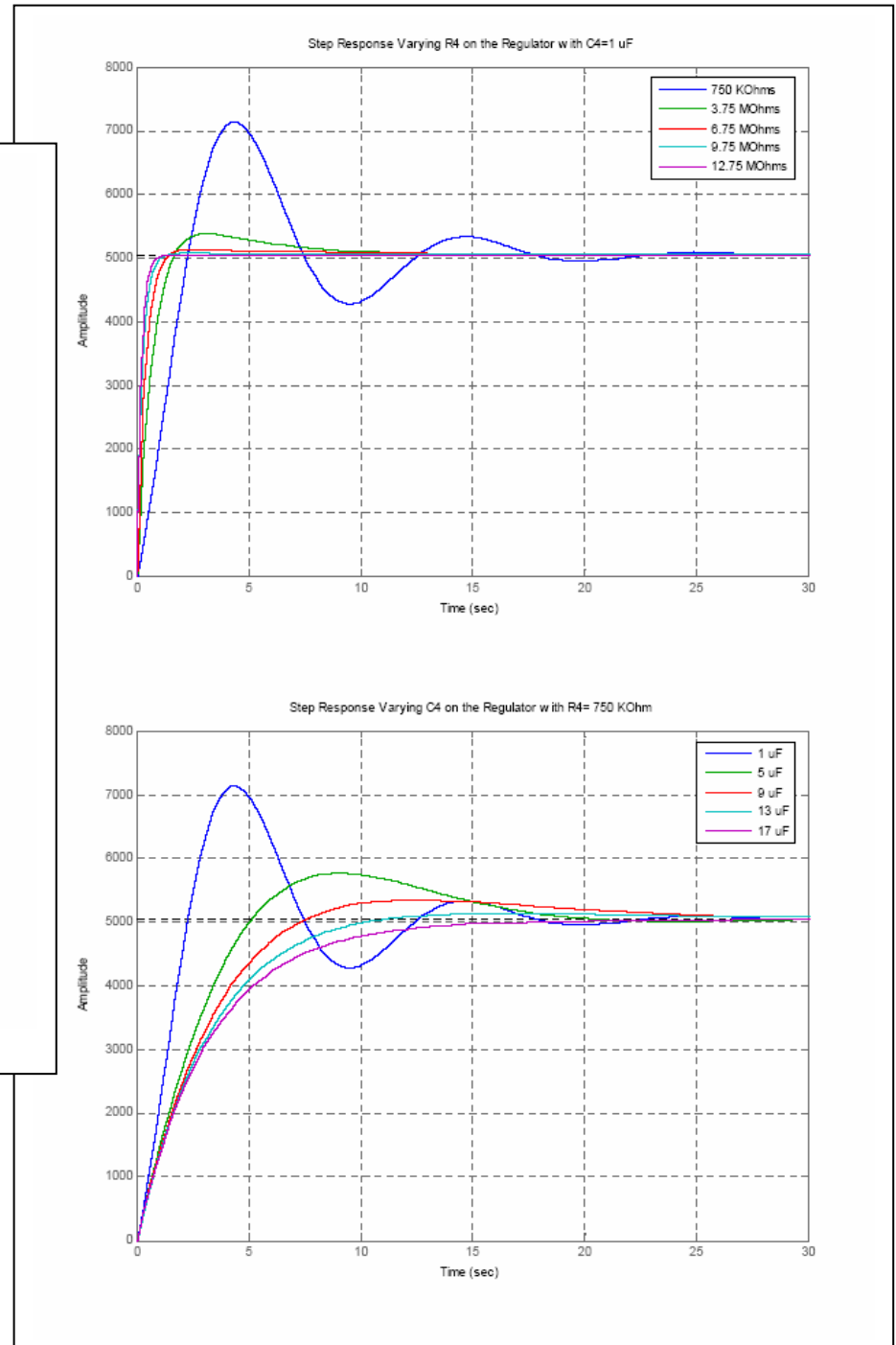
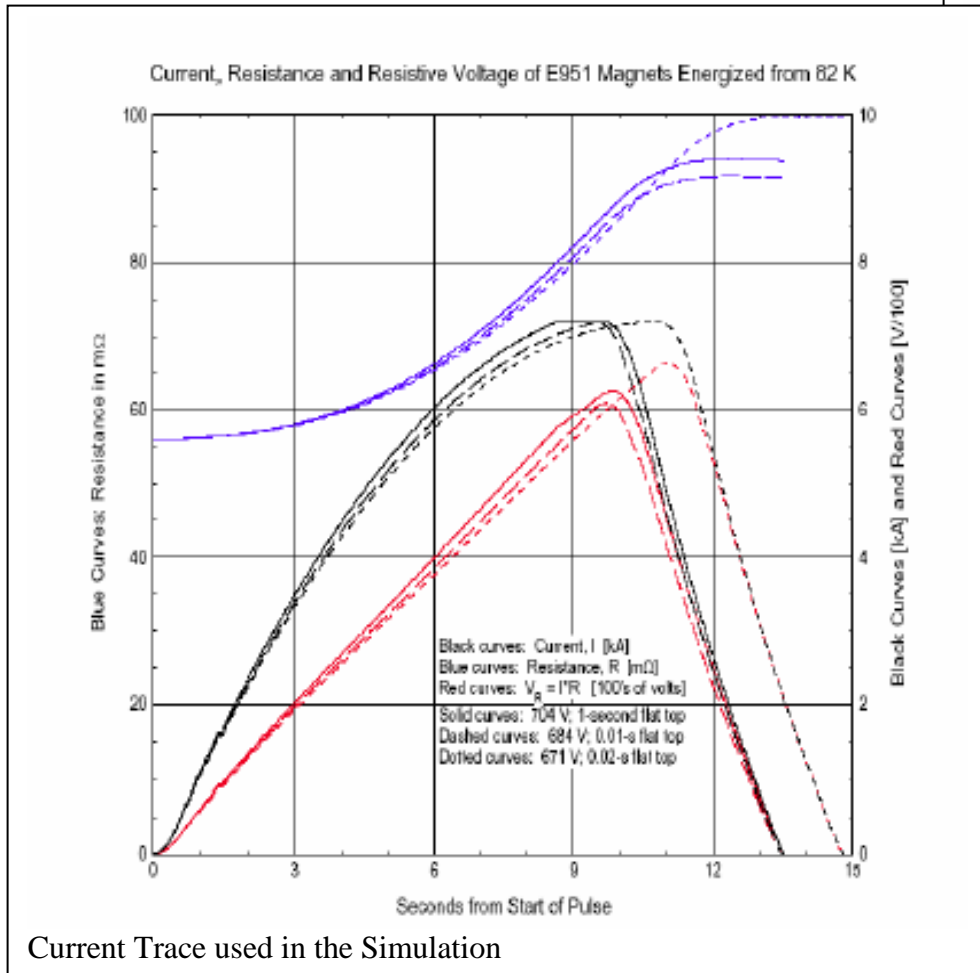


# West End Converters Feedback

Gary Dekow ran his West End Converter Feedback Model with the BNL magnet impedance of 0.484 H and 0.040 Ohm. The results indicate that the regulator will need to be tuned to this load. The current resistance and capacitance on the integrator of the regulator have been set for the 1J load of 0.0106 H and 0.0116 Ohms and their respective values are 750 KOhm and 1 uF. The simulations indicate that these values should be increased and the model suggests values of around 6 MegOhm and 2 uF greatly improve the performance of the system for the BNL magnet. Variable resistor and capacitance devices could be used to tune in the feedback circuit. Attached are figures generated from the simulation results.



Gary Dekow's Simulation Model



## Status of Bus Bars / Leads

The leads are modeled as 1 X 3 inch bar/strap.

### Loads on the Bus Bar Extensions

The total reaction for the 2 pads on the rear lead are:

**FX 113.73N**

**FY 1982N**

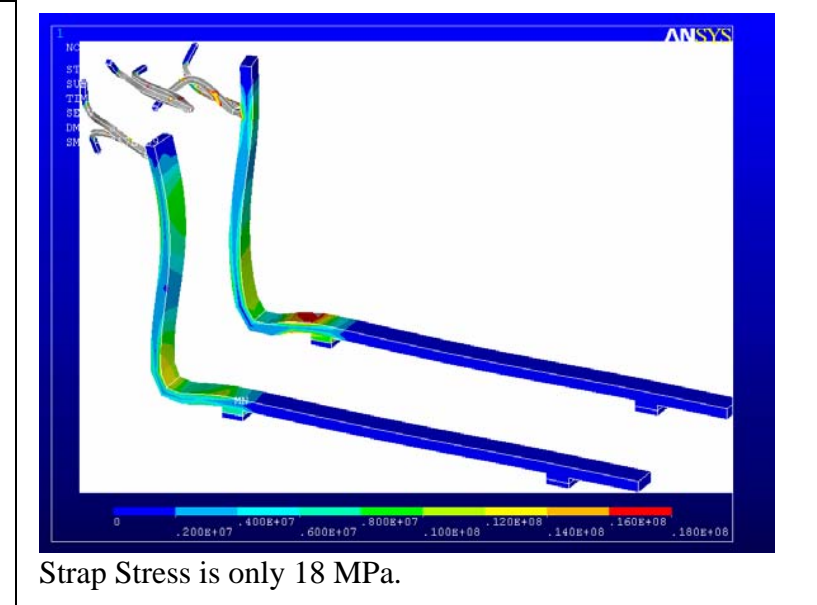
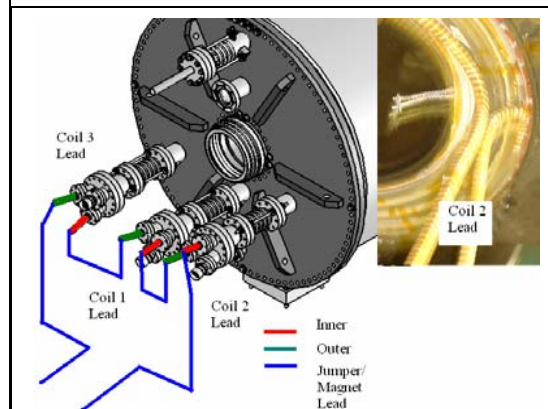
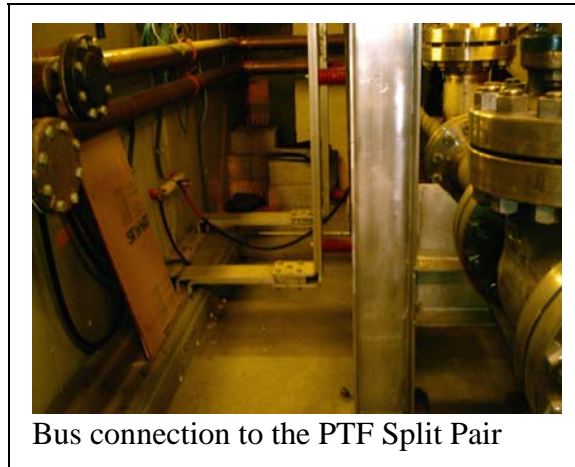
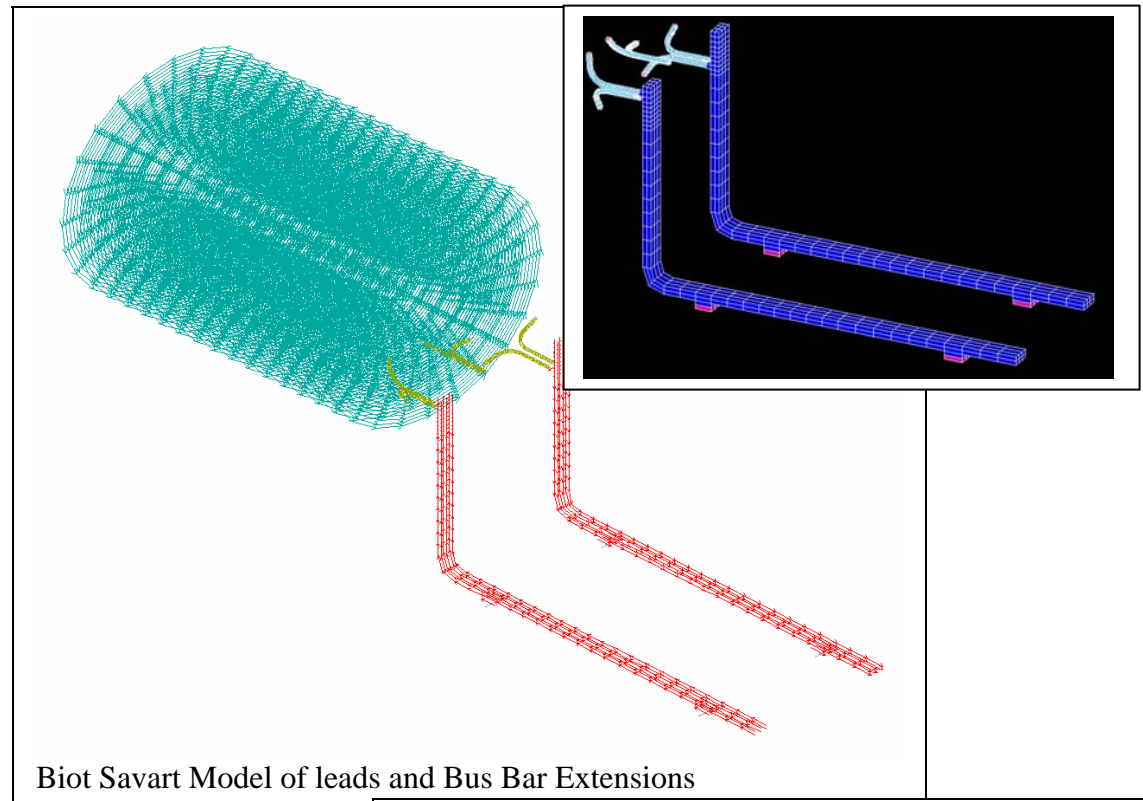
**FZ -24.5N**

The total reaction for the 2 pads on the front lead are:

**FX 627N**

**FY 1714N**

**FZ -17.25N**





# Preparation activities


- Modifications can start during APS fall meeting - Oct. 24~28, 2005
- Installation of over voltage protection components
- Retest of system using PTF coil as reference  
*( We may have to wait until Jan Egedal' VTF Magnetic Reconnection Experiments, and C-Mod's WASP Probe Tests Complete. We are looking into power supplies for low current tests – Inductance, field mapping etc. )*
- Completion of bus work to pulse coil
- Tuning of regulator
- Implementation of test program

## MIT-PSFC Data Acquisition System Plans

At the MIT MERIT Collaboration Meeting Chen-yu Gung of MIT presented plans for data acquisition.

[http://www.hep.princeton.edu/mumu/target/MIT/DAQ\\_for\\_BNL\\_pulsed\\_magnet-1.pdf](http://www.hep.princeton.edu/mumu/target/MIT/DAQ_for_BNL_pulsed_magnet-1.pdf)

*Technology & Engineering Division*



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# DATA ACQUISITION FOR PRE-OPERATIONAL TESTING OF BNL-E951 15T PUSLED MAGNET

Chen-yu Gung

Mercury Target Collaboration Meeting  
MIT Plasma Science and Fusion Center  
October 17 – 19, 2005

DAQ for BNL 15 T Pulsed Magnet

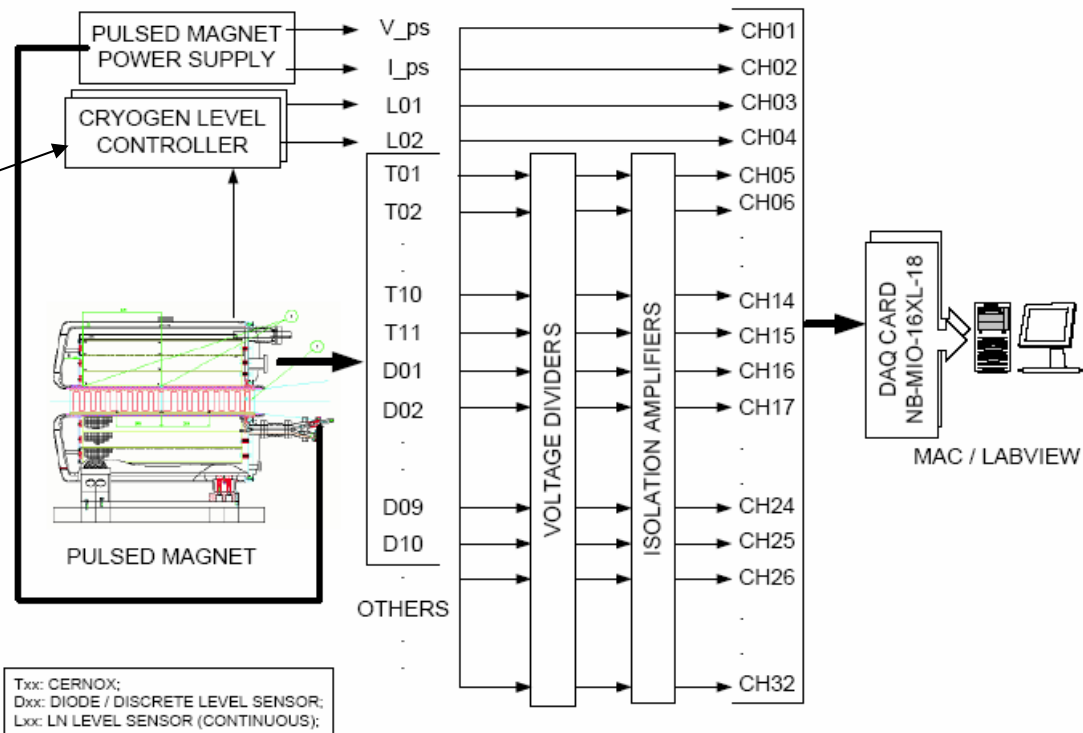
1

## Instrumentation and Signal Level

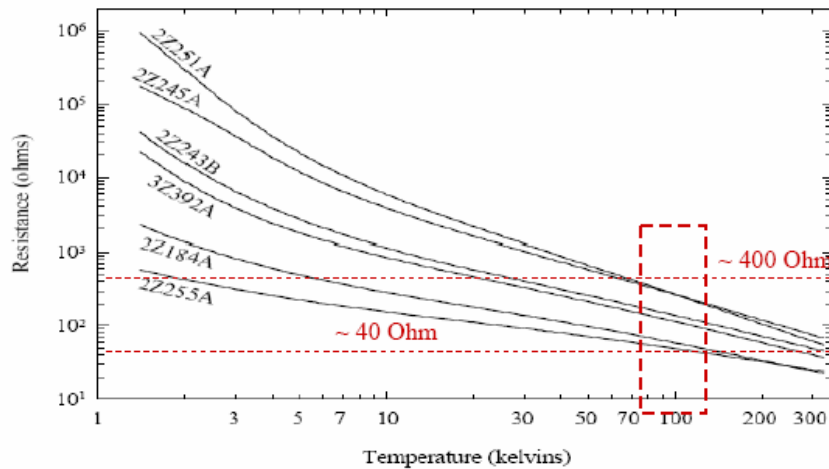
Instrumentation Name	Number of Signals	Signal Level
Power Supply	2 ( $V_{\text{magnet}}$ & $V_{\text{shunt}}$ resistor)	0 – 10 V
AMI LN level sensor	2	0 – 10 V
CERNOX	11	Varies with temperature
Discrete level sensor diode	10	Unknown
Others, such as TC's, Hall probe, etc.	TBD	TBD

- Use 2 National Instrument NB-MIO-16XL-18 in one Macintosh computer.
- DA is programmed in Labview.
  - Thing to do – modify existing program.
- Precision at 16 bit for bipolar DA between  $\pm 10$  V:  $\sim 0.3$  mV.
- Maximum (damaging) input voltage:  $\pm 35$  V.
- Max. sampling rate for single channel DA: 55 Ksamples/sec.
- Max. sampling rate for multi-channel DA: 20 Ksamples/sec.

### SIGNALS AND DATA ACQUISITION FOR PULSED MAGNET TEST

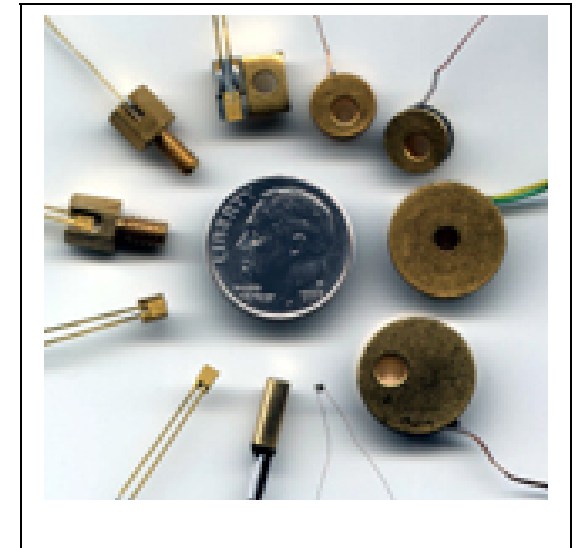


## CERNOX Temperature Sensor



. Typical resistance versus temperature characteristic for each wafer tested for stability.  
 Ref: Courts, S.S and Swinohart, P.R., 'Stability of Cernox Resistance Temperature Sensors', Adv. in Cryogenic Eng., Vol. 45, 2000.

Typical resistances of CERNOX are between 40 Ohm and 400 Ohm at respective temperatures of 120 K and 80K. The sensor voltage signals are between 0.4 V and 4 V if an excitation of 10 mA is used.



***We are investigating using voltage taps at the terminals to check resistance of the three coil segments, and thus their temperature. CERNOX sensors are intended as a diagnostic at MIT and may not be needed at CERN***

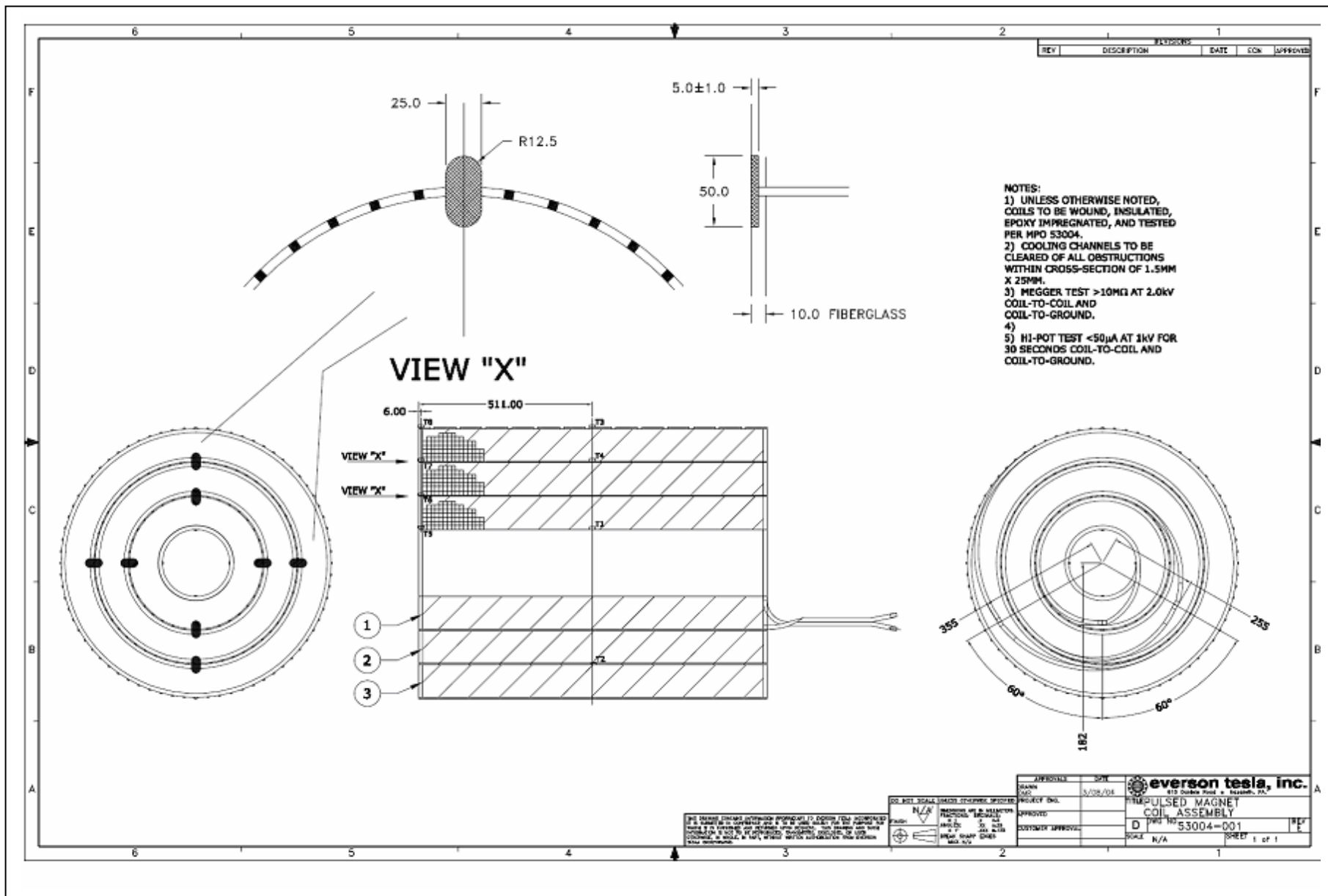
## Excitation Source for CERNOX

Lake Shore Model 120CS Current Source

Output Current	1 $\mu$ A to 100 mA
Accuracy	0.1% on fixed ranges
Stability	Better than $\pm 0.01\%$
Compliance Voltage	11 Volts up to 50 mA

- Each current source will be used to drive 4-5 CERNOX's connected in series with an excitation current set at 10 mA. Connections of the current leads will be made outside the magnet vessel.
- Four lead measurement will be used. The voltage leads will be tapped to the current leads outside the magnet vessel.
- The voltage drop along the lead wires needs be corrected.
- The same type of current source will be used to drive the discrete LN level sensor diodes. Connection: TBD.

# CERNOX Sensor Locations



## Safety, Operational Controls

There are other experiments in the vicinity of the PTF area that may be affected by stray fields. LDX, VTF, particularly its control equipment, and Rick Tempkin's accelerator will either need to be shown insensitive to the field produced by the magnet, or there will be operational controls on the BNL tests to preclude concurrent operation of the BNL magnet and the other experiments.

Magnetic materials will have to be kept clear of the magnet. We should probably consider limited access to the ground floor area near the magnet because of the electrical, cryogenic and magnetic hazards.

### Oxygen Depletion Sensors

A vent line exhausting to the roof is being built. This should eliminate normal venting of N<sub>2</sub> gas. Catherine Fiore indicated that C-Mod has a number of portable sensors that are used during C-Mod operation. They will be beginning operation in Feb 2005 and these will not be available to us. I need to check with LDX to see if they have fixed monitors in the cell, but two portables in the PTF "pit" are needed. These cost around \$600 apiece. Maybe we can borrow them from Brookhaven, Rutherford or CERN. Catherine will accept this kind of equipment from a collaborating lab.

### Magnetic Field Hazard

The 15 Tesla Pulsed magnet will have a significant stray field. Field maps of the cell will be generated and notices will be posted in accordance with MIT standards.

Magnetic fields have set off fire alarms. When the magnet is first energized, the fire marshal will be in attendance to shut off fire alarms as needed.

### Over-Pressure Protection

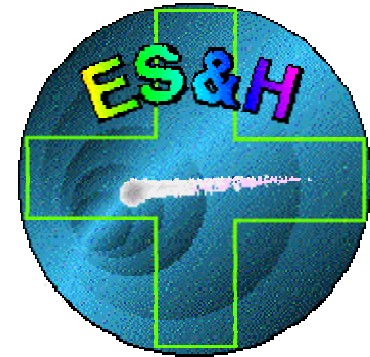
The Gaseous N<sub>2</sub> vent line will be provided with a pressure relief valve, and a burst disk. These will vent into the cell.

### Cryogenic Hazards

The lead end especially will be subject to cryogenic temperatures. with attendant frostbite/ burn hazards.

### Electrical Hazards:

MIT-PSFC Lock-out procedures will be followed: <http://psfcwww2.psf.mit.edu/esh/locktag.html>



## Plasma Science and Fusion Center

**Office of Environment, Safety, and Health**  
**190 Albany Street, NW21**  
**2nd floor**

---

617-253-8440 (Catherine Fiore,  
head) 617-253-8917 (Matt Fulton,  
Facilities Manager)  
617-258-5473 (Nancy Masley,  
administrator) 617-253-5982 (Bill Byford,  
assistant safety officer)

Fax 617-252-  
1808

# Main Elements of the Planned Test Procedure (Needs Revision to Reflect LN2 Purge)

## Initial Set-Up

### Baseline data for CERNOX sensors at RT

First Room Temperature Electrical Tests

Hipot the coils.

### Initial Cooldown, Dimensional Characterization

Stabilize at 80 to 77K. Check instrumentation, Baseline data for CERNOX sensors at LN2 temperature. Check Level sensors. Compare Capacitive and discrete sensors.

### Boil-Off – Heat Leak Test

At ½ fill height, measure level change with respect to time, Calculate heat leak

### Record Cold Dimensional Changes

Map bore dimensional changes due to cooldown.

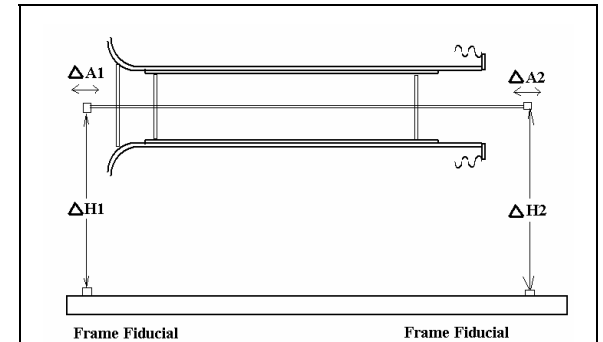
### Inductance Measurement

Measure 3 coil low current static resistance. Measure constant-Low Voltage current ramp

### 5T Test

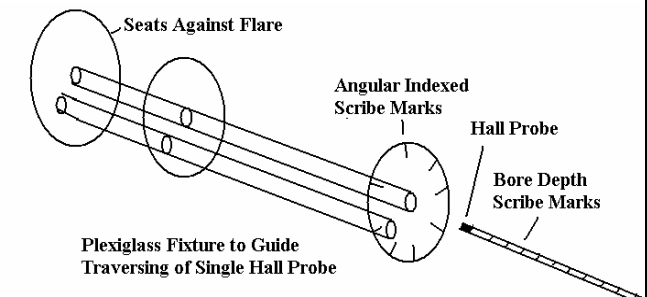
Demonstrate temperature uniformity in the three coil segments. Check target current time traces. Obtain final temperatures for the three coil segments. Check against predictions.

### 10T Test (First)



### Cooldown Displacement Measurements

The fixture is a rod or tube with circular disks that fit against the bore and one disk at the end that rests against the flare in the vacuum jacket. The flare is the entry point for the mercury jet cassette



Field Mapping is planned with one Hall Probe at Low Current. Field will scale with current. There are no non-linearities. A Shunt resistor will be used to calibrate CERN power supplies to MIT's

Demonstrate temperature uniformity in the three coil segments. Check target current time traces. Obtain final temperatures for the three coil segments. Check against predictions.  
Time to cool with primarily gaseous cooling (1/3 fill height of LN2)

### **10T Test (Second)**

Demonstrate temperature uniformity in the three coil segments  
Time to cool with primarily pool boiling cooling (2/3 fill height of LN2)

Second Room Temperature Electrical Tests  
Warm to RT. Conduct Electrical tests

### **10T Test (Third)**

Slow cool to 80K, Run 10T test. Check target current time traces. Obtain final temperatures for the three coil segments. Check against predictions.  
Cool with LN2 1/3 fill height to 80 K. Stabilize temperatures in 3 coils.

### **15T Test (First)**

Demonstrate 15T operational capability. Check target current time traces. Obtain final temperatures for the three coil segments. Check against predictions.

### **15T Test (Second)**

Demonstrate 15T operational capability. Check target current time traces. Obtain final temperatures for the three coil segments. Check against predictions.  
Cooling Behavior 2/3 immersed, Obtain Time temperature plot for cooldown

### **Third, Room Temperature Electrical Tests**

### **Report Test Results**