SPEAR 3 Overviews

AC Distribution System - Marjorie Widmeyer

Magnet Power Supplies - Paul Bellomo

August 2003

AC Distribution System

- ***Purpose***
  - ***Provide required power to power supplies and support equipment***
  - ***Allow power supplies to be easily isolated for shutdown and maintenance***
  - ***Separate control and utility supplies***
- ***Scope***
  - ***AC Distribution – one line overview***
  - ***Lock out/Tag out***
  - ***PPS***

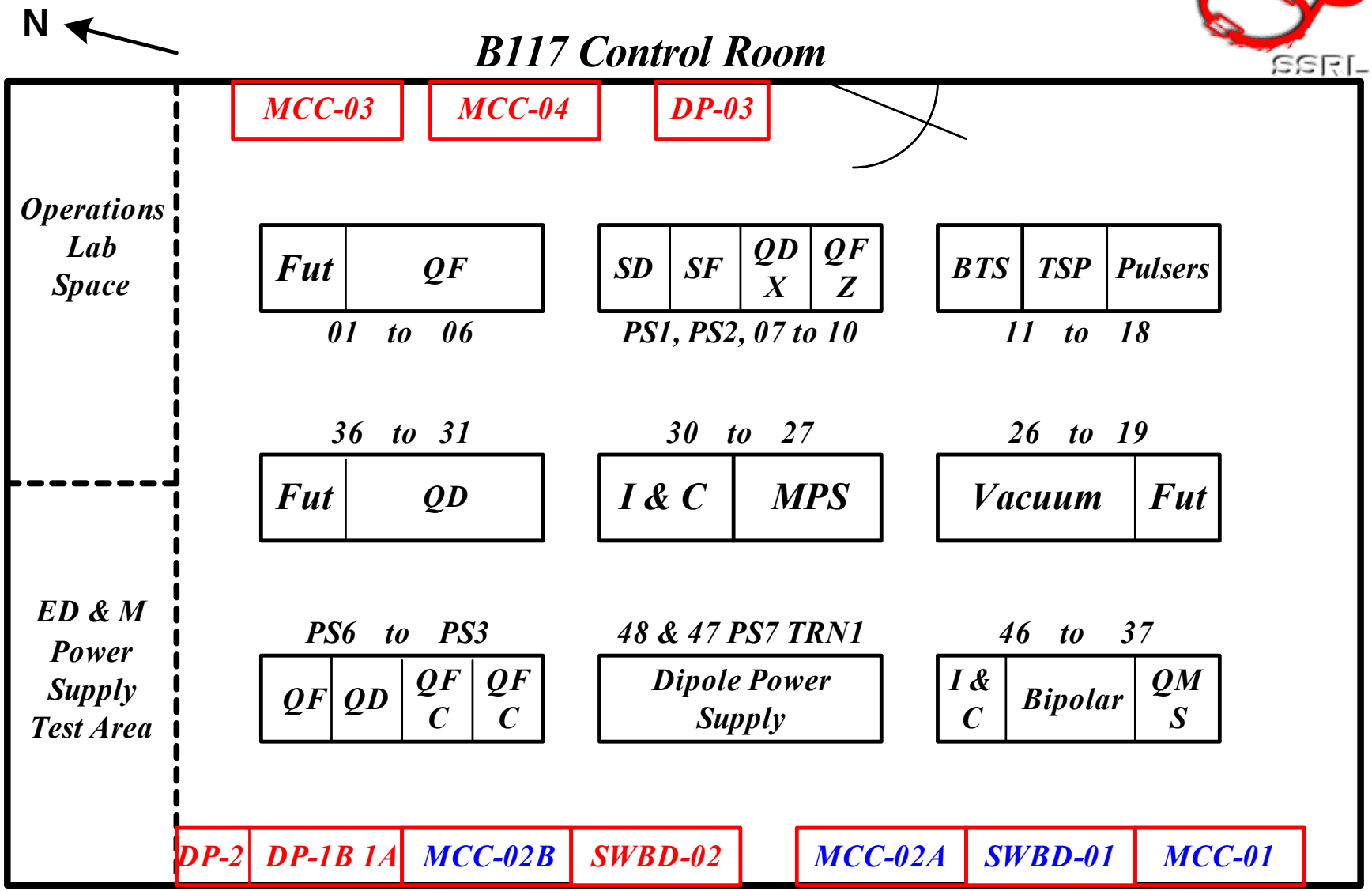
AC Distribution System

SPEAR 3 AC Distribution and layout drawings:
http://www.slac.stanford.edu/grp/md/dcon/draw/draw.html

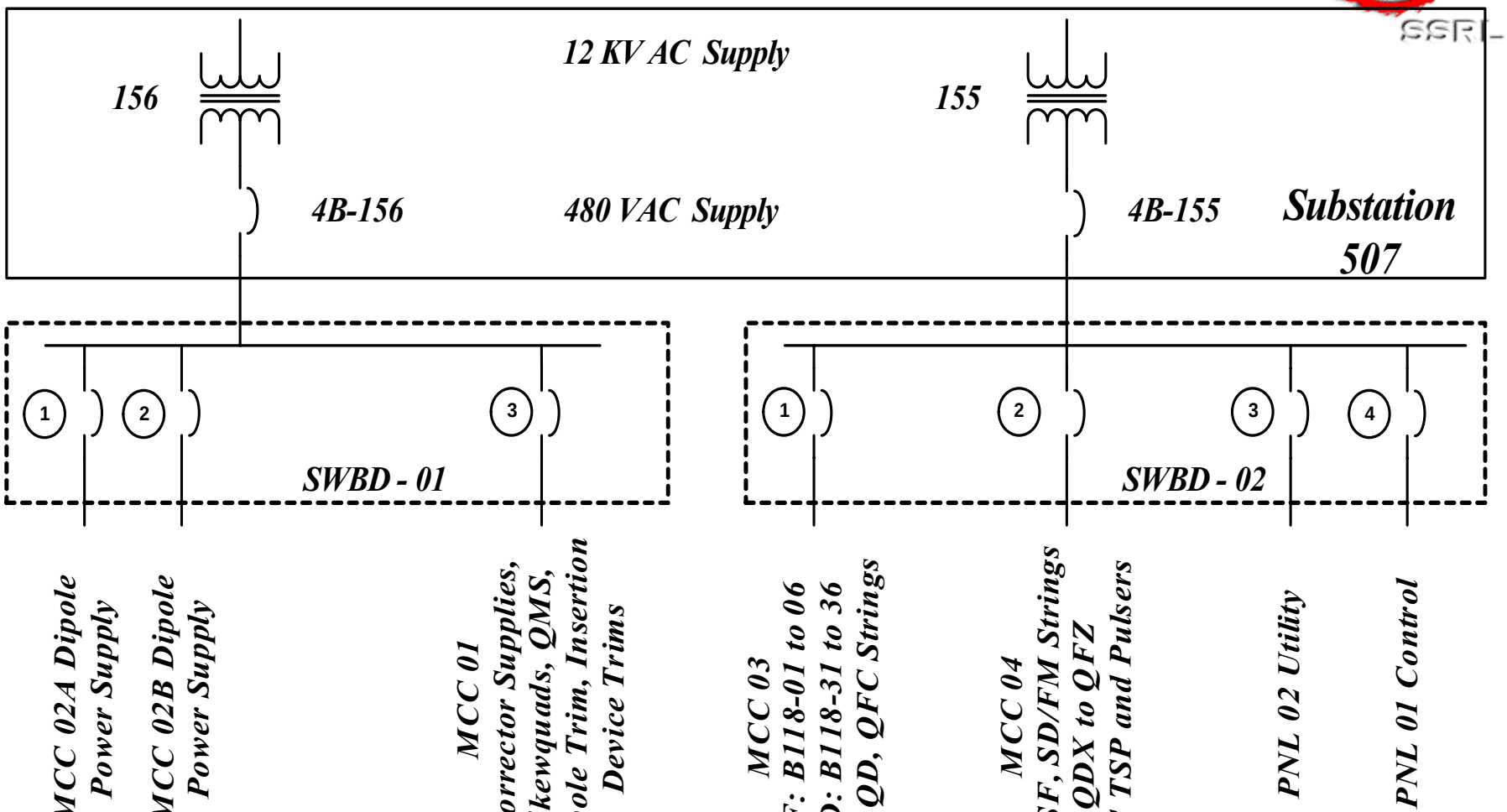
The drawing number blocks are:

- ***ID-439-720-20*** — ***Substation 507 HV Distribution Single Line Diagram***
- ***444-500-00 to 444-500-99*** — ***B118 Layouts***
- ***444-690-00 to 444-690-99*** — ***B118 AC Distribution***

AC Distribution System



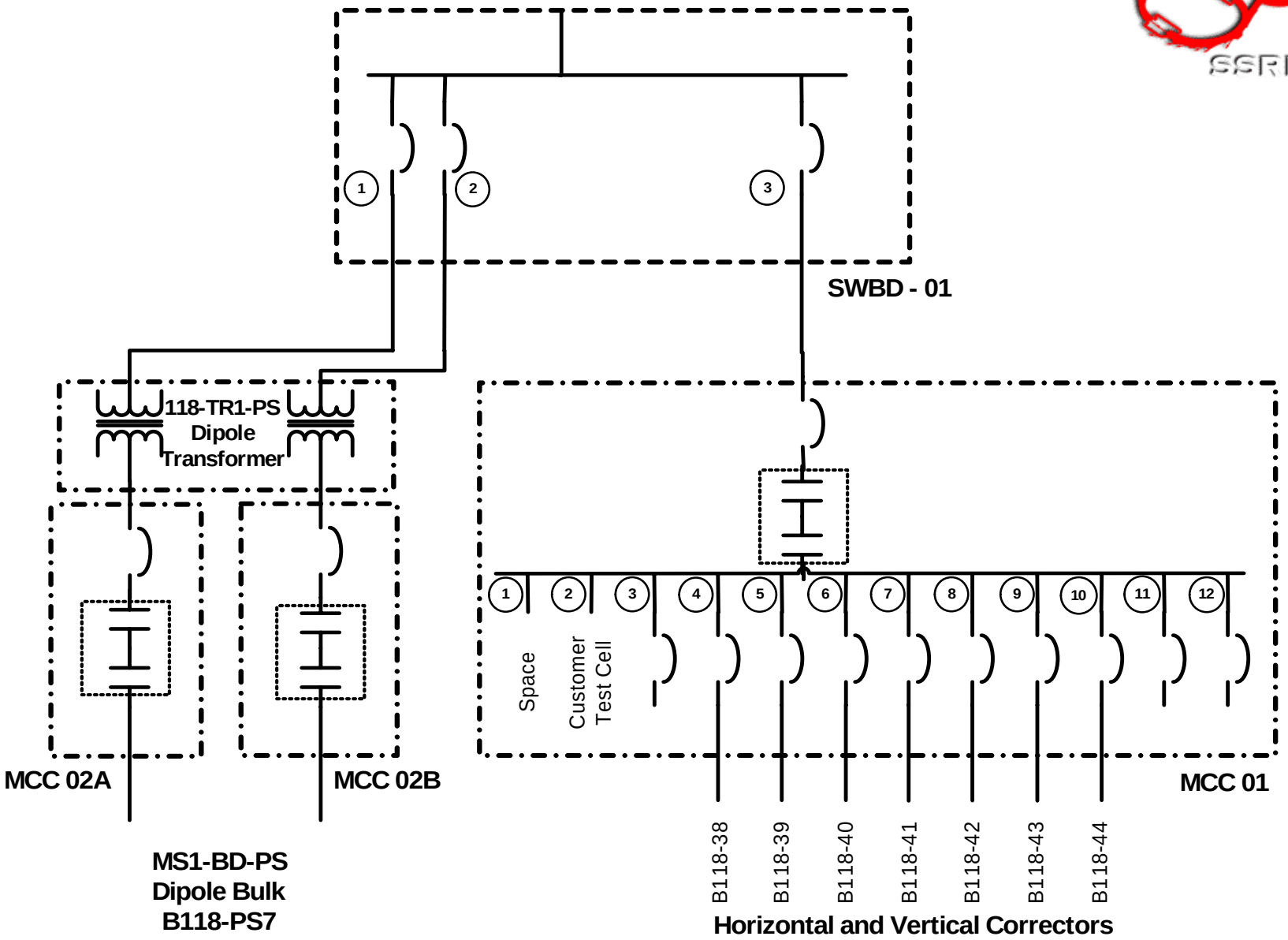
AC Distribution System



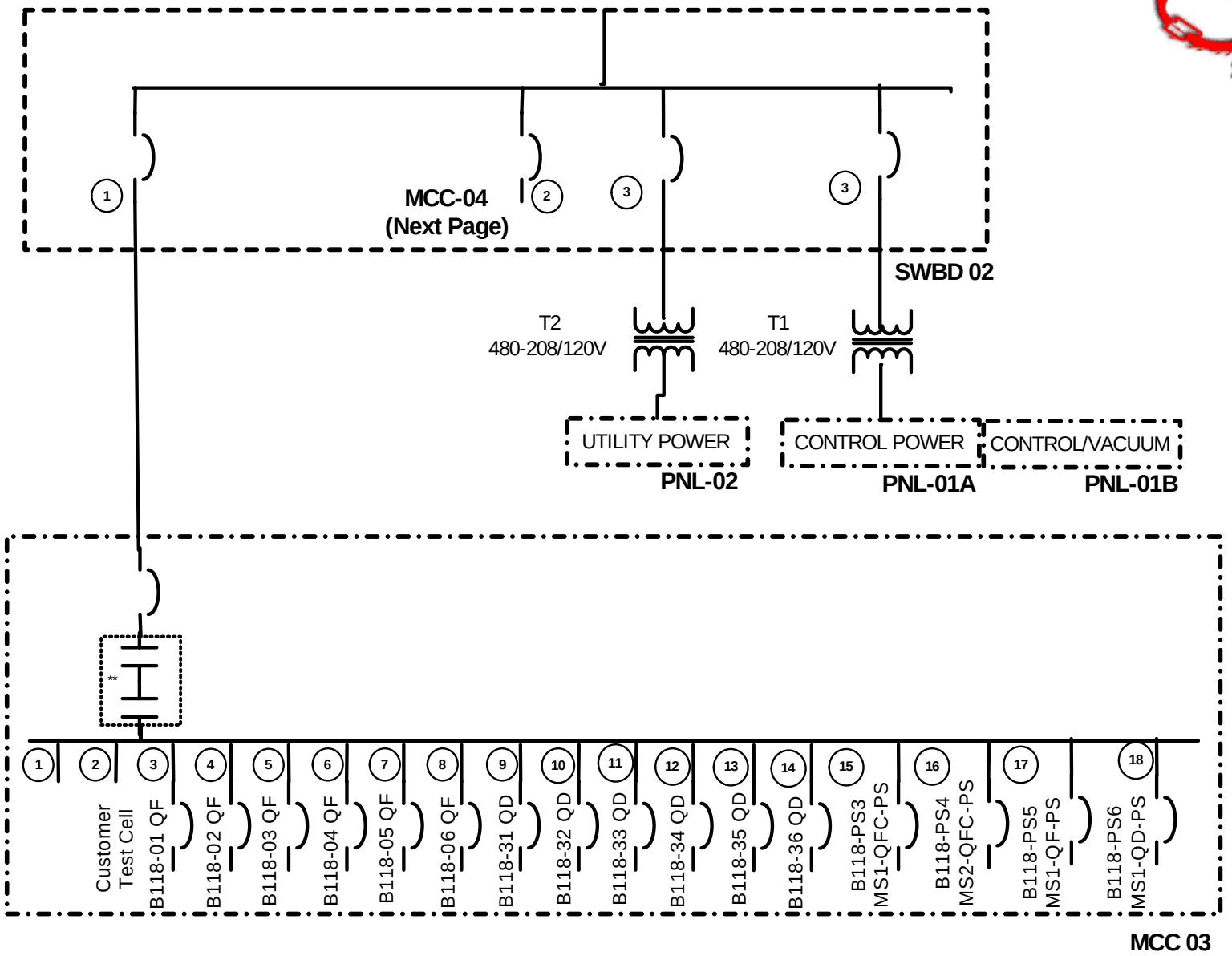
Some Details

- ***The total power draw of all the SPEAR 3 magnet power supplies is about 2,300 kVA. This is about 33% less than SPEAR2.***
  - ***No electromagnetic wigglers***
  - ***Magnets have copper windings instead of aluminum***
  - ***Power supplies are more efficient***
  - ***Dipole power supply at about 1,100kVA takes almost ½ of this power***
- ***The load is roughly balanced on 4B-155 and 4B-156 and on Switchboards 4PB118-SWBD-01 and 4PB118-SWBD-02***

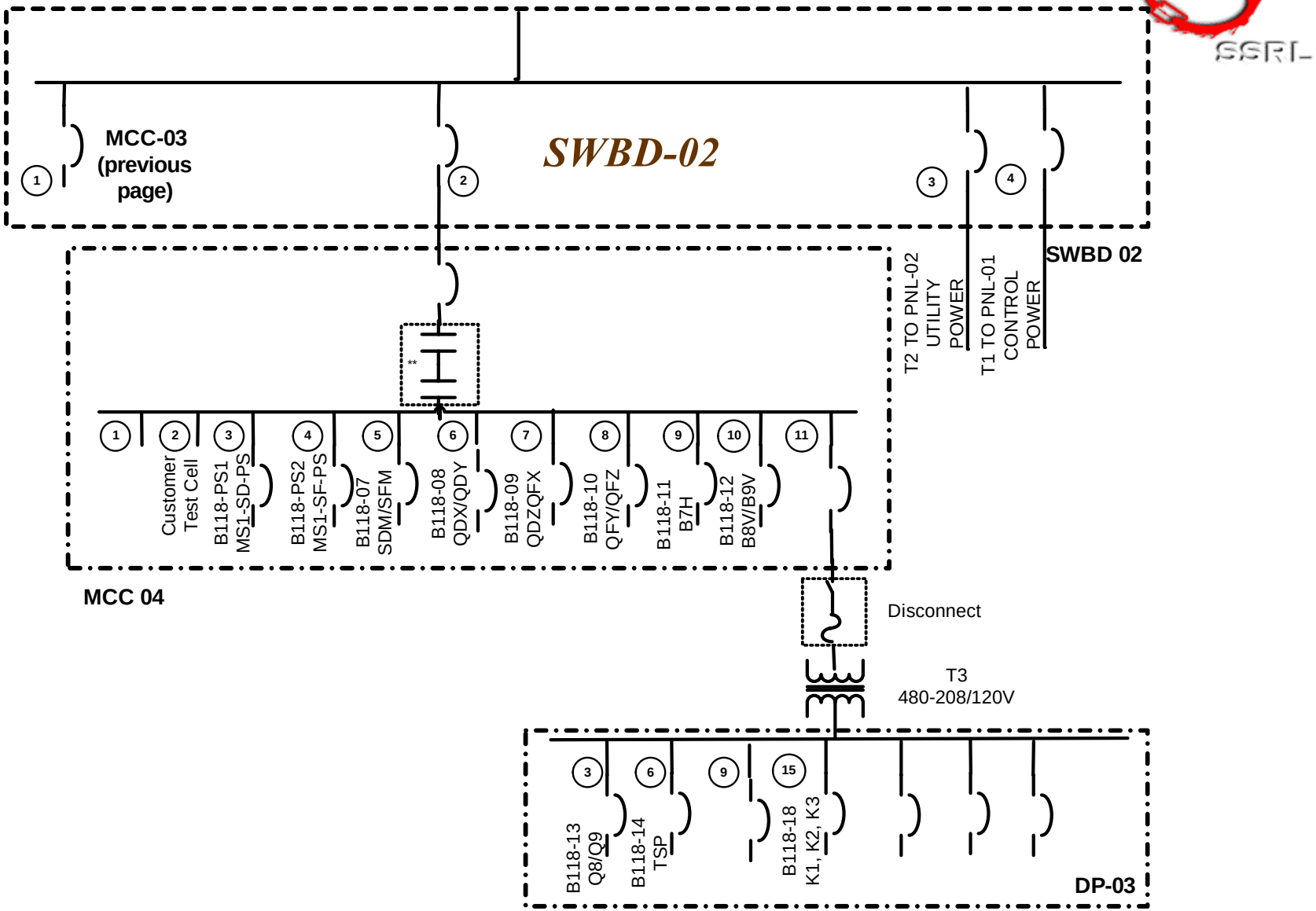
AC Distribution System SWBD-01



AC Distribution System

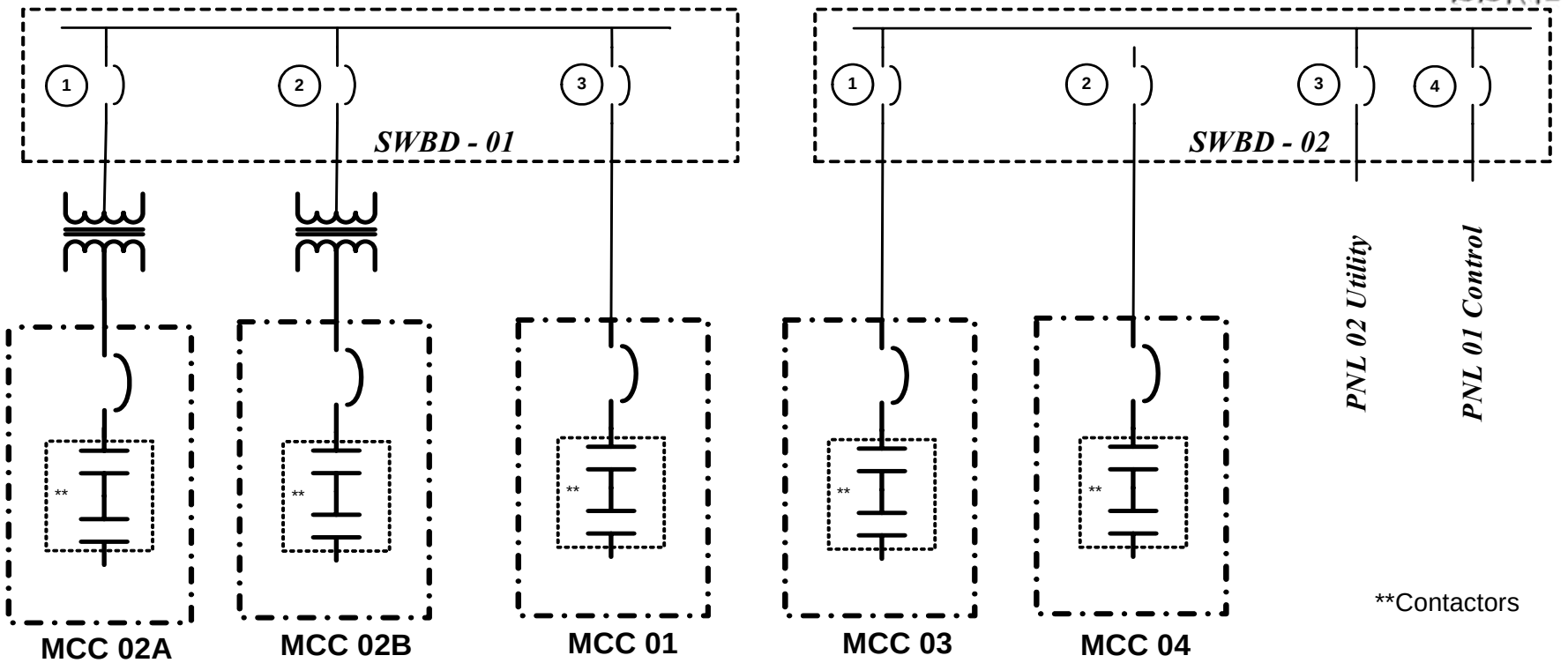


AC Distribution System



AC Distribution System

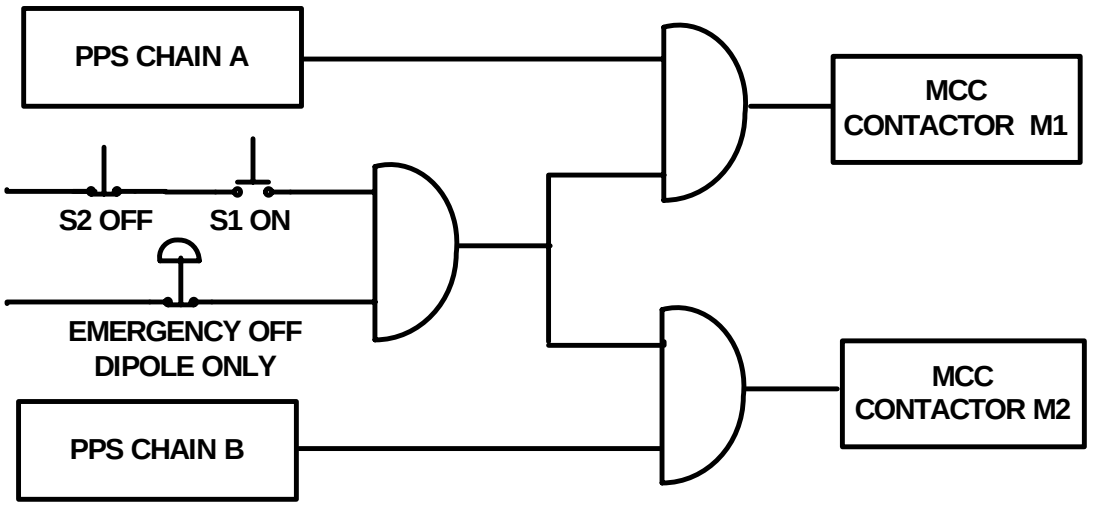
Lock Out/Tag Out

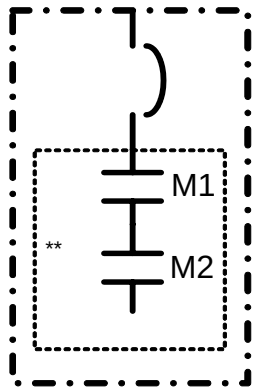


- *Lock off all B118 power supplies via 5 MCC main breakers*
- *Lock off an entire rack of power supplies at the MCCs*
- *Lock off individual power supplies*

AC Distribution System

- *PPS Controls Contactor on each MCC*
- *Contactor Control*
  - *Local on off switch*
  - *PPS Chain A & B*
  - *Emergency Off – Dipole Only*
- *Door covering contactors is mechanically interlocked with the door for the main breaker of the MCC to prevent opening the contactor door when the Main Breaker is closed*





AC Distribution System
MCC – IQ Analyzer

- *IQ Analyzer Displays:*
  - *Current*
  - *Voltage*
  - *Power system and phase (A, B, C), Real Power (Watts), Reactive Power (vars), Apparent Power (VA),*
  - *Power Factor*
  - *Frequency*
  - *% Total Harmonic Distortion*
- *Information available on line in the future*

IQ Analyzer

AC Distribution System

Utility Power

- Beige power strip
  - Supplies power to all fans
- Quad-receptacle in each power supply rack

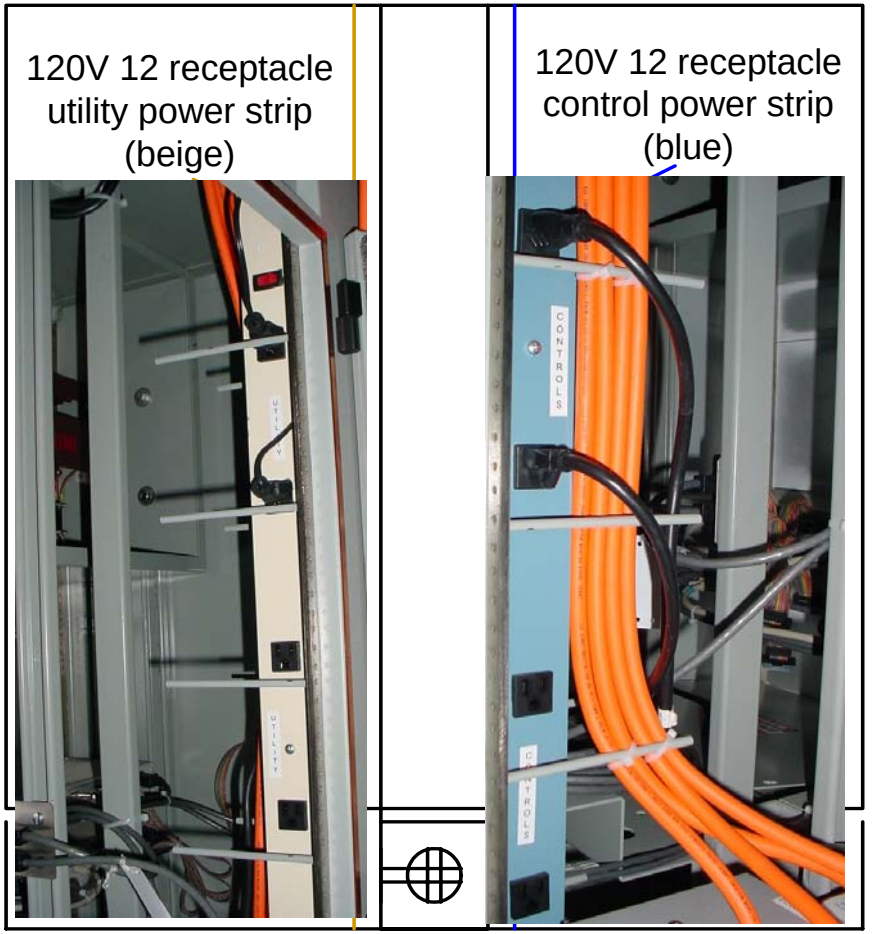
Control Power

- Blue power strip

Lighting

- Power from PPA Circuit 2, 4, 6

Power Supply Double Bay Rack - looking into rear with rear doors open



120V Quad Receptacles - front and rear - powered from utility panelboard

Magnet Power Supply Overview

Topics

1. *Purpose and Scope*
2. *B118 Layout*
3. *Some Generalities*
4. *Electrical Interlocks*
5. *Unipolar Power supplies*
   - *a. Dipole*
   - *b. Large (free-standing)*
   - *c. Intermediate (rack-mounted)*
   - *d. Unipolar Control*
6. *Bipolar Power Supplies*
   - *a. Control for Bipolars*
7. *Pulsed Power Supplies*
   - *a. Control for Pulsed*

1. Purpose and Scope

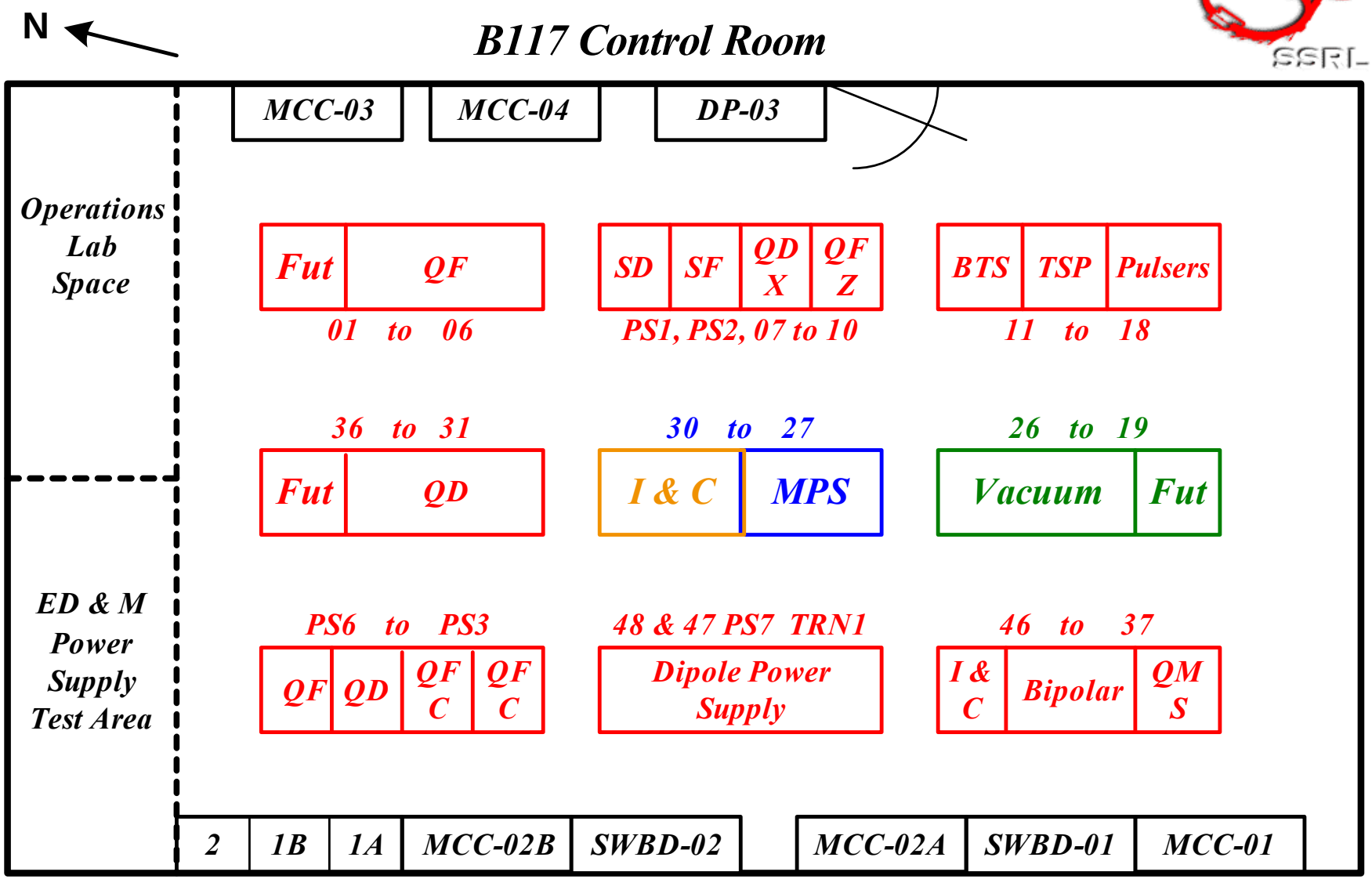
Purpose

Power Supplies convert raw, unregulated AC to precise, controlled and regulated DC for continuous current and pulsed current magnets

Scope

New SPEAR 3 magnet power supplies in B118

2. B118 Layout



Reference Drawings

- SPEAR 3 power supply drawings are available as TIFFs from
  http://www.slac.stanford.edu/grp/md/dcon/draw/draw.html

- The drawing number blocks are:

444-500-00 to 444-500-99	B118 Layouts	S3-0781
444-600-00 to 444-639-99	Unipolar	S3-0781
444-640-00 to 444-654-99	Bipolar	S3-0782
444-655-00 to 444-659-99	Pulsed	S3-0783
444-670-00 to 444-670-99	BitBus Control	S3-0784
444-685-00 to 444-689-00	Racks/Accessories	S3-0785

3. Some Generalities

- ***Little local control. Operation is computer-based***
- ***Air-cooled – Exceptions Dipole Bulk Power Supply, Dipole Chopper Modules, SD, SF with valves / instrumentation above each power supply***
- ***All switchmode (high frequency regulation)***
- ***Output rating ≤ 5kW are 208VAC, > 5kW are 480VAC, no 4160V***
- ***480V/208V and 120V control power sources to each power system***

Control

- *All current sources, except Dipole Bulk, bipolar bulk - these are voltage regulated sources*
- *All unipolar use BitBus - 1 controller per*
- *Bipolars are Ethernet based - 1 controller per 8*
- *Pulsers are GPIB / PLC RS5000 based*

Current Stability

- *Dipole 50ppm (3ppm /°C) diurnal stability*
- *Quadrupoles 100ppm (6ppm / °C) diurnal stability*
- *Sextupoles, Correctors 500ppm (30ppm / °C)*

3. Some Generalities

Local Control	Local Readback
On / off via circuit breaker	Output voltage
Output current limit	Output current
	Power supply faults
Remote Control	**Remote Readback**
On / off	Power supply on / off
Output current	Output voltage
	Output currents 1 & 2
	Power supply fault
	Magnet O/T via MPS fault
	Ground current fault
	Ambient temp

4. Electrical Interlocks

- *PPS turns all off. Interface in AC distribution system, except septum*
- *All are enclosed. Rack doors lockable but not interlocked. Exceptions Dipole Bulk, the Dipole Chopper Module Rack, 6 Large (QD, QF, QFC, QFC, SD and SF) and 3 Kicker Pulsers*
- *MPS (Klixons) - BitBus controllers interface for Unipolars. Fault trips only the affected power supply*
- *MPS (Klixons) - Bulk PS interfaces for Bipolars. Corrector O/T trips off bulk and 8 bipolars*
- *No MPS interface for titanium sublimation pumps (TSPs) or injection kickers*
- *No accessible energy storage – exceptions are Dipole Bulk, Dipole Chopper Module Racks, 6 Large and 3 Kicker Pulsers*

5. Unipolar Power Supplies

5. Unipolar Power Supplies

Dipole Power Supply

- 36 series-connected dipole magnets spaced around the ring
- Δ-Y 1200kVA, 12 pulse to reduce line harmonics
- 4 buck regulators (choppers)
- Three AC power sources

  480V Δ, 480V Y, 120V
- For magnet names and locations ID-444-500-05 / EI-444-610-00

5. Unipolar Power Supplies
Dipole Bulk Power Supply Diagnostics

Vo (Volts) XXXX

Io (Amps) XXX

Ig (mA) XXX

+ to - / + to com / - to com

3-position switch

com / + / -

3-position switch

Output Voltage Adjust

Voltage Monitor Ports

Bridge 1

Unfiltered V | Filtered V

Bridge 2

Unfiltered | Filtered V

Status

- Main AC on (Grn)
- Choppers Ready (Green)
- PS Ready (Grn)
- DC On (Red)

Emergency Off

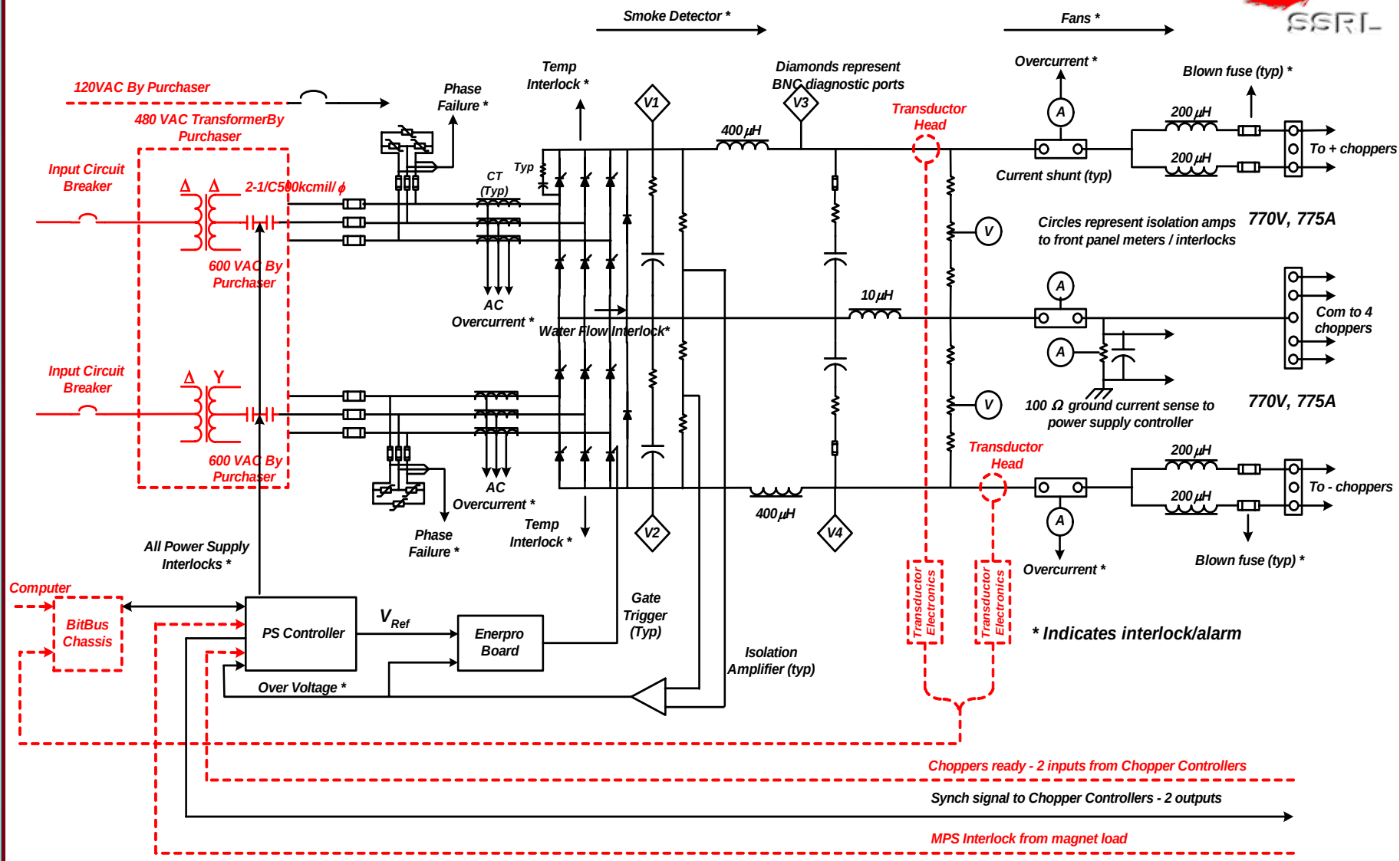
Faults

- AC overcurrent (Red)
- Input ϕ loss (Red)
- Bridge/FW Diode heatsink (Red)
- Water Flow Low (Red)
- Cabinet Temp/Fan failure (Red)
- Door Open (Red)
- Smoke Detector (Red)
- Output fuse blown (Red)
- DC Overcurrent (Red)
- DC Overvoltage (Red)
- Push to Test LEDs
- PS Interlock Reset

Dipole PS Chopper Module Controller - SLAC

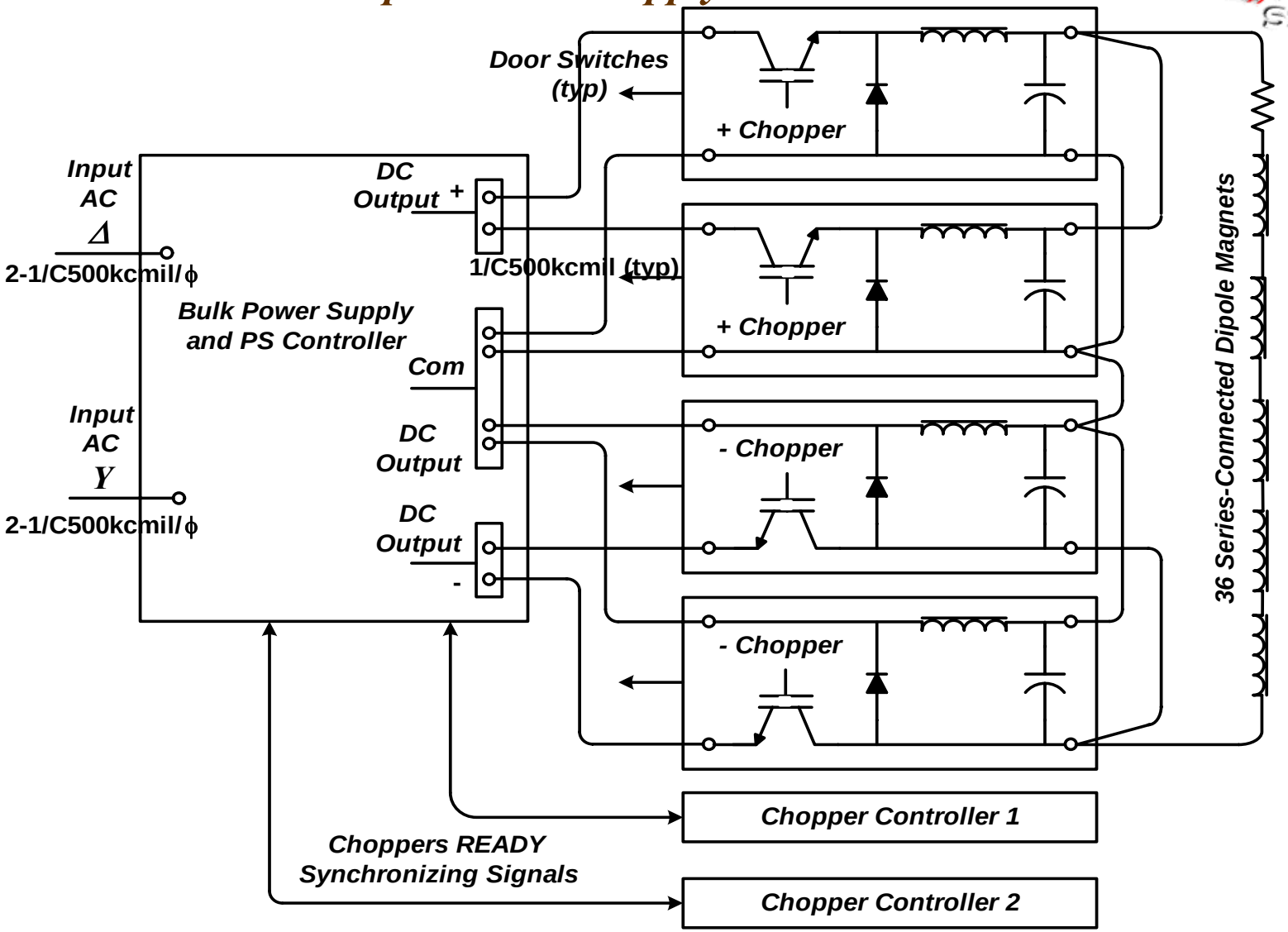
- Controls operation of series and parallel-connected chopper modules
- No front panel controls or adjustments

5. Unipolar Power Supplies
Dipole Power Supply Schematic



5. Unipolar Power Supplies

Dipole Power Supply Schematic



5. Unipolar Power Supplies

B118-PS1 through -PS6

480V / 120V breakers

BitBus controller

Power supply controller

Large Power Supplies – IE Power

- 6 each in a free-standing cabinet
- QD 70 kW for 6 Quadrant 1 magnets
- QF 70 kW for 6 Quadrant 1 magnets
- QFC 70 kW for 7 North Arc magnets
- QFC 70 kW for 7 South Arc magnets
- SD 135 kW for 28 Ring magnets
- SF 135 kW for 28 Ring magnets

5. Unipolar Power Supplies

Large Power Supply Diagnostics

Power Supply Interlocks

- Loss of phase or low AC (Red)
- DC Overcurrent (Red)
- DC Overvoltage (Red)
- Ground Current Limit (Red)
- Air Flow Restricted (Red)
- Cabinet Overtemp (Red)
- Cooling Water Overtemperature (Red)
- Cabinet Door Open (Red)

(Interlock LED's On for Fault)

- Breaker Closed/ Control Power (Grn)
- PS Ready (Grn)
- PS On (Red)
- Current Limit Active (Yel)

PS Interlock Reset

Push to Test LED's

Emergency OFF Switch

Vo (Volts)	Io (Amps)	Ig (mA)
XXX	XXX	XXX

Output Current Limit

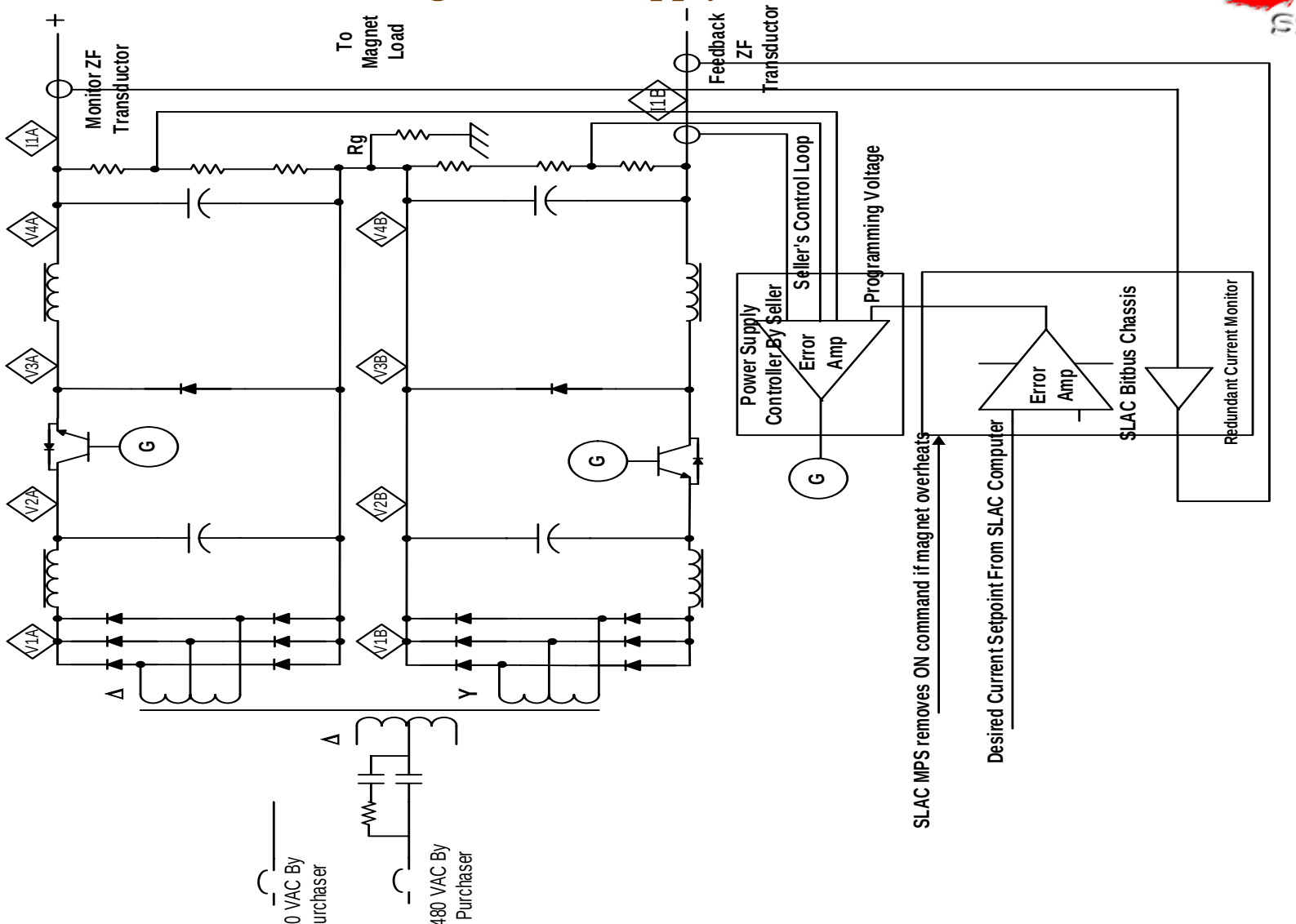
Ground Current Limit

Voltage And Current Monitor Ports

V1A V2A V3A V4A I1A

V1B V2B V3B V4B I1B

5. Unipolar Power Supplies
Large Power Supply Schematic

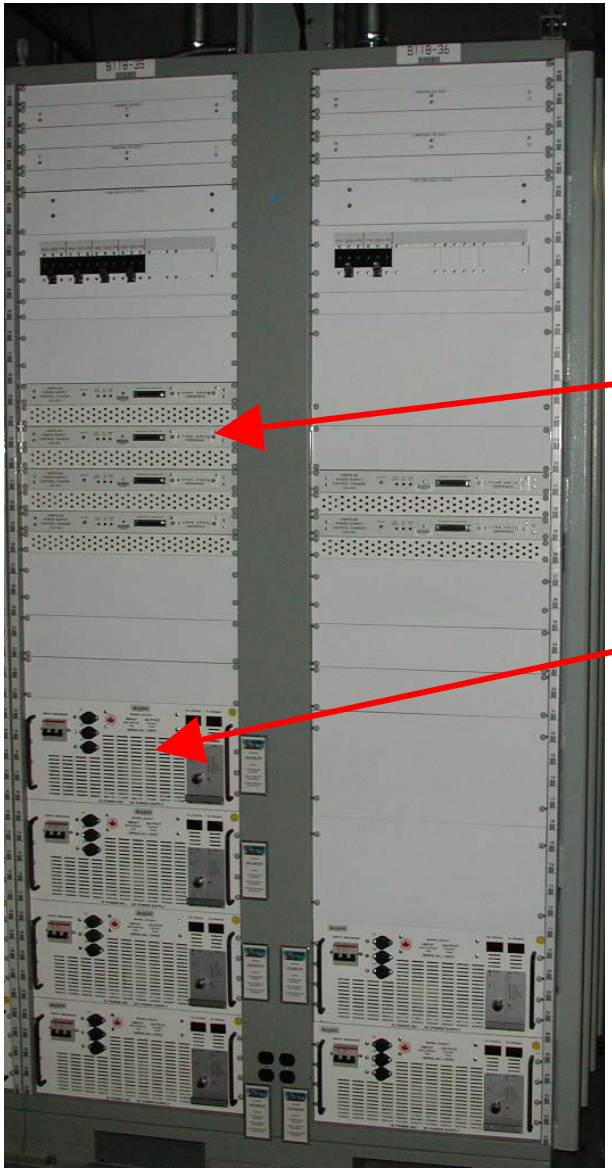


5. Unipolar Power Supplies

Intermediate Power Supplies

Magnet Family	Magnet Quantity	Magnet Location	Power Supply Quantity	Notes
B7H	1	SPEAR side of BTS	2	2 in series
B8V	1	SPEAR side of BTS	2	2 in series
Q8	1	SPEAR side of BTS	1	
Q9	1	SPEAR side of BTS	1	
B9V Septum	1	Ring	1	
QD	20	Ring	20	
QF	20	Ring	20	
TSP	72	66 Ring 6 in SS	4	
QDX	4	Straight	2	2 in series
QDY	4	Straight	2	2 in series
QDZ	4	Straight	2	2 in series
QFX	4	Straight	2	2 in series
QFY	4	Straight	2	2 in series
QFZ	4	Straight	2	2 in series
SDM	8	Straight	1	
SFM	8	Straight	1	
	157		**65**	

5. Unipolar Power Supplies



Intermediate Power Supplies

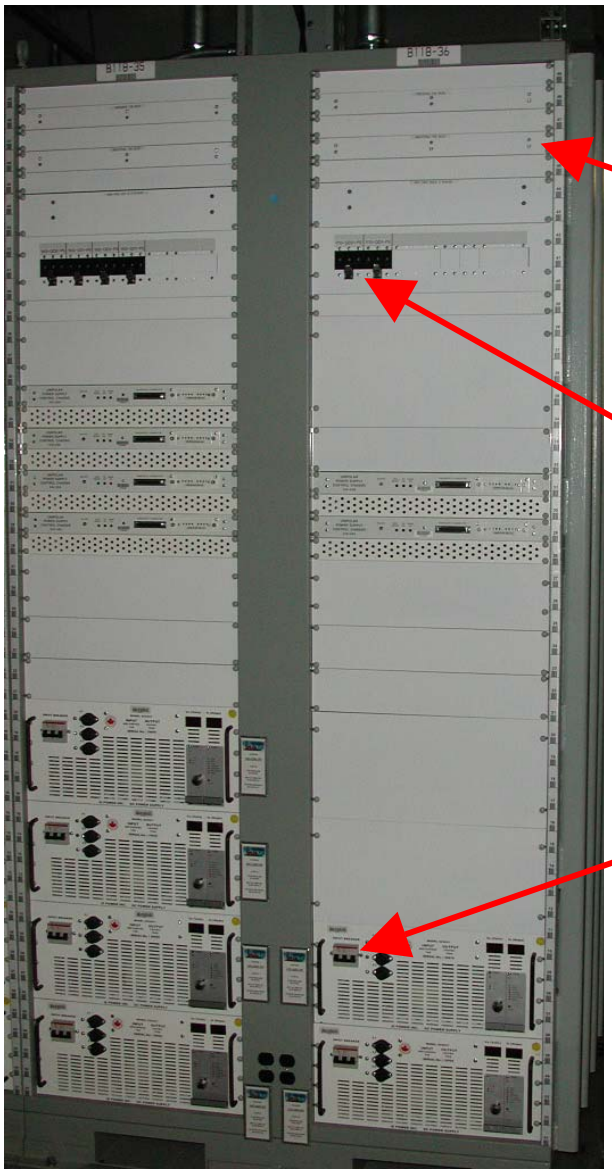
- 2.5 kW, 5.0kW, 10kW, 15kW, 22.5 kW
- IE Power

Typical BitBus Controller

Typical power supply quantity in rack

- 6 - 2.5kW, 5kW
- 4 - 10kW, 15kW
- 2 – 22.5kW

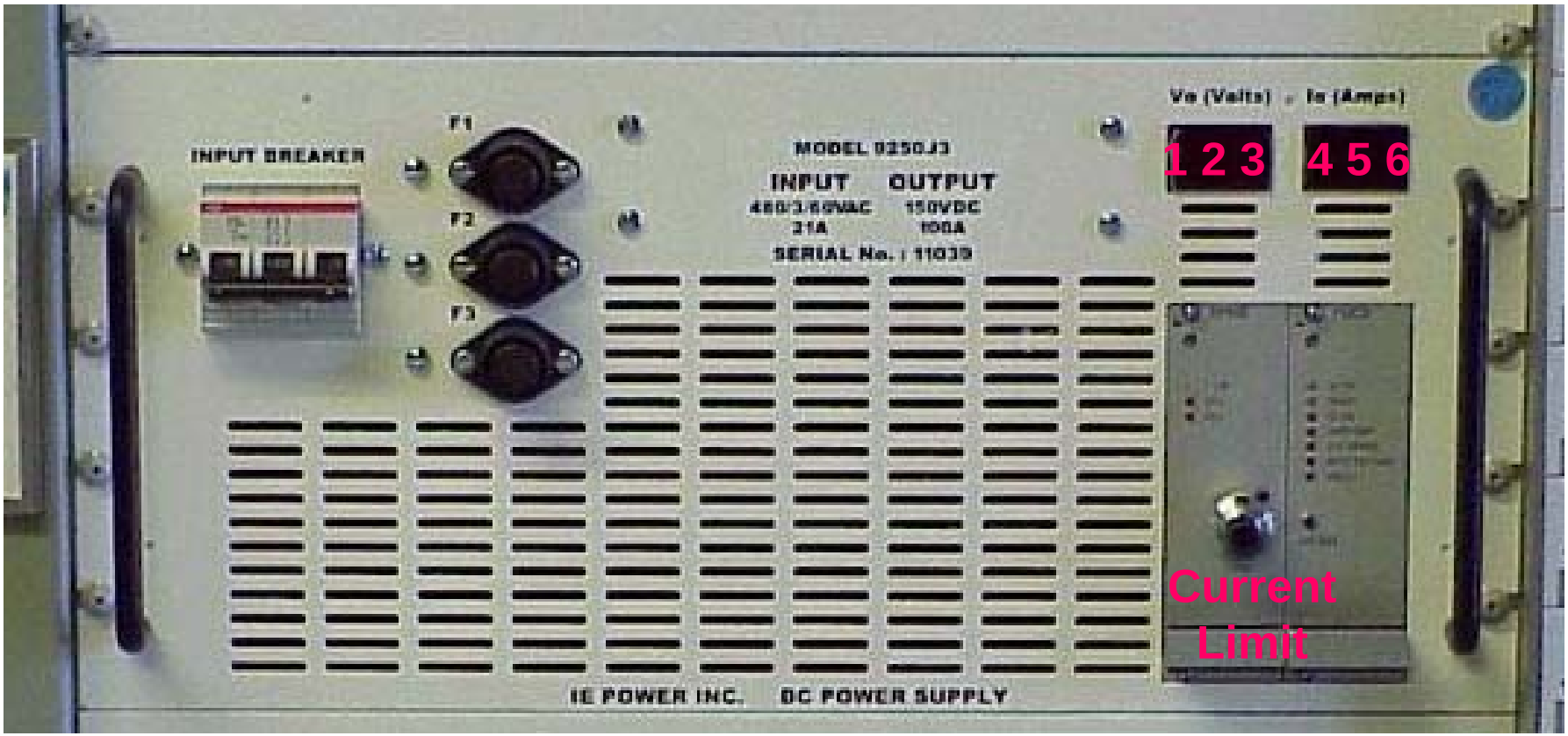
5. Unipolar Power Supplies



Intermediate Power Supplies

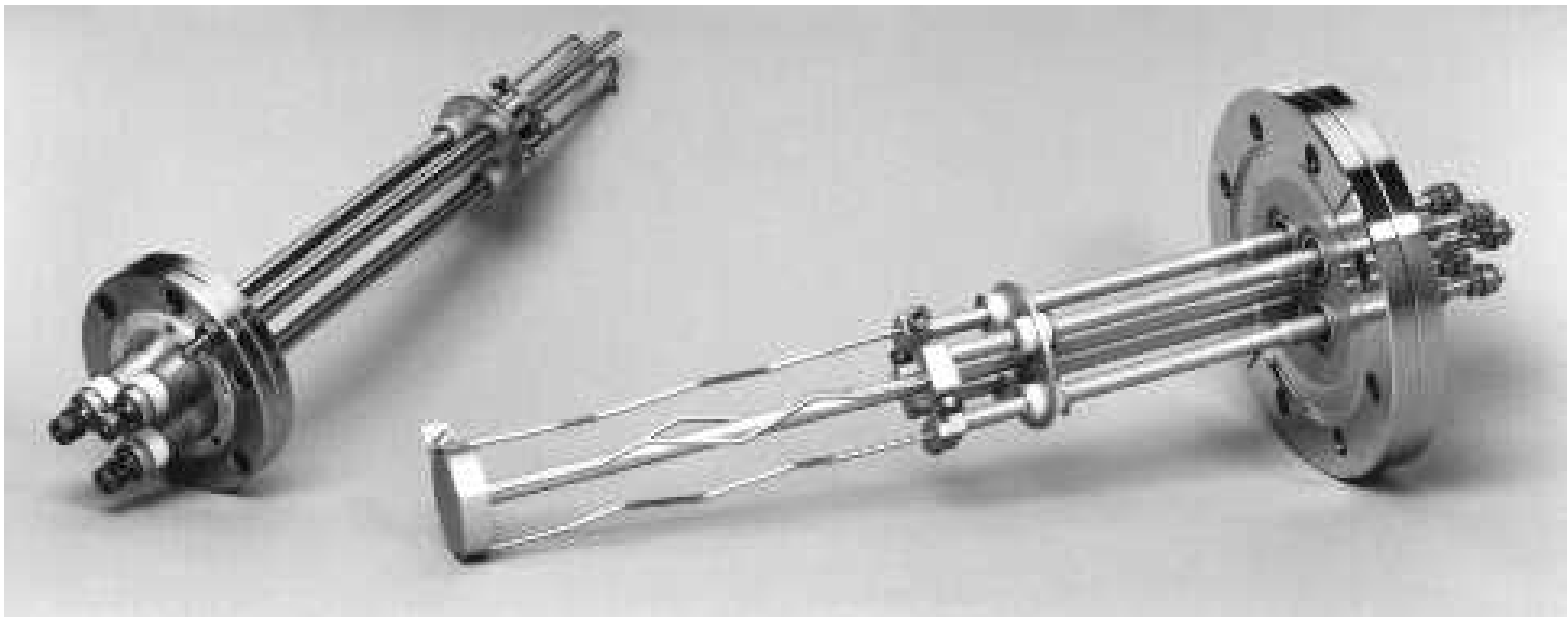
- *Standard 3 Φ 480V or 208V, 150A feed to every power supply rack*
- *Individual rack and PS circuit breakers are 30A*
- *Rack breakers are pad-lockable and fault-current rated*
- *Power supply breakers are on/off only and do not have trip elements*

Intermediate Power Supplies - minimal front panel control



Intermediate PS - Titanium Sublimation Pumps (TSPs)

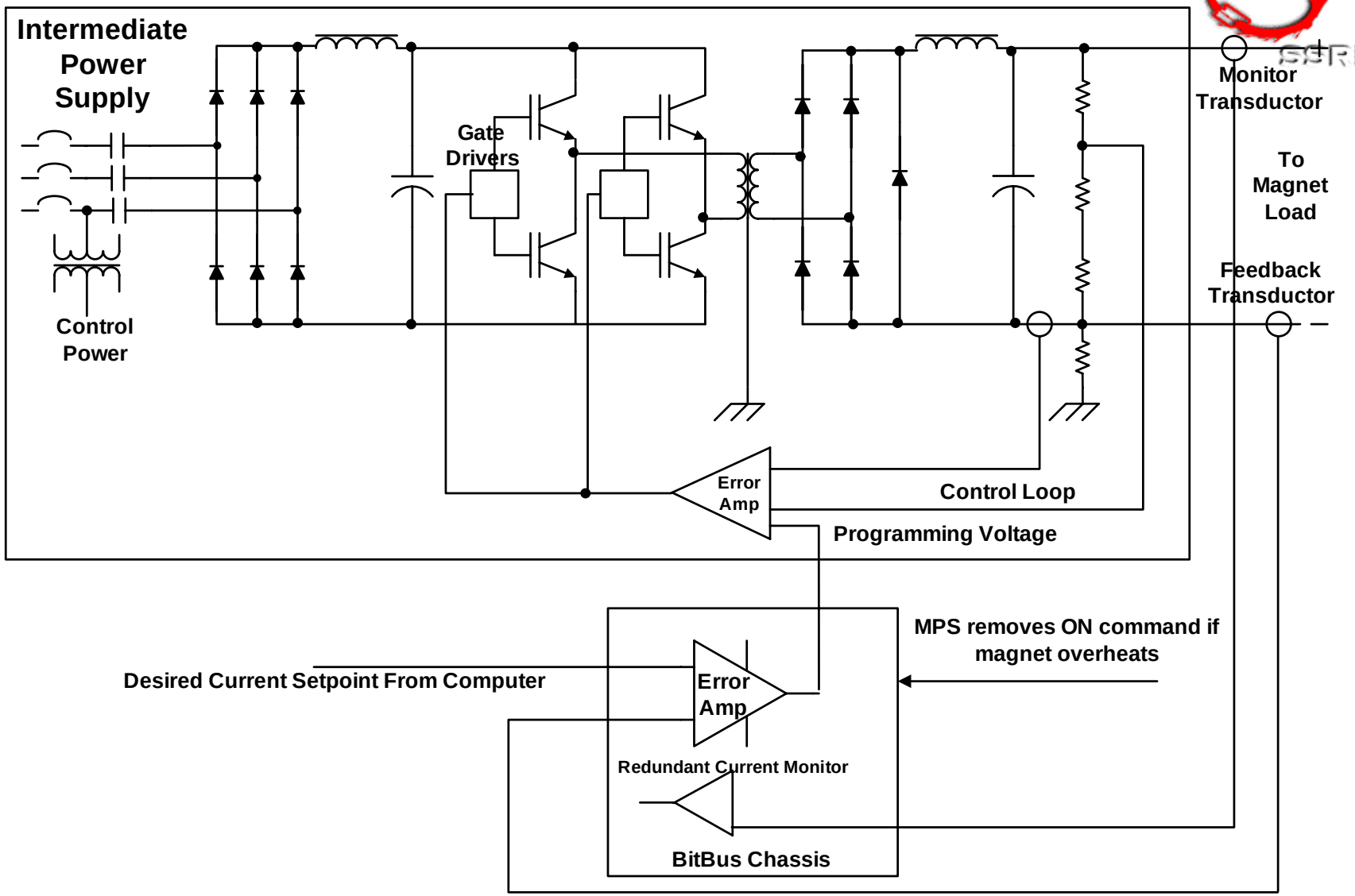
- Used to pump chemically reactive, getterable gases, such as H_2, H_2O, CO, N_2, O_2, CO_2.. Titanium is effective, easily sublimed, and inexpensive.
- Have high pumping speeds, typically 10 l / sec / cm^2.
- Long-life filaments are 85% titanium and 15% molybdenum



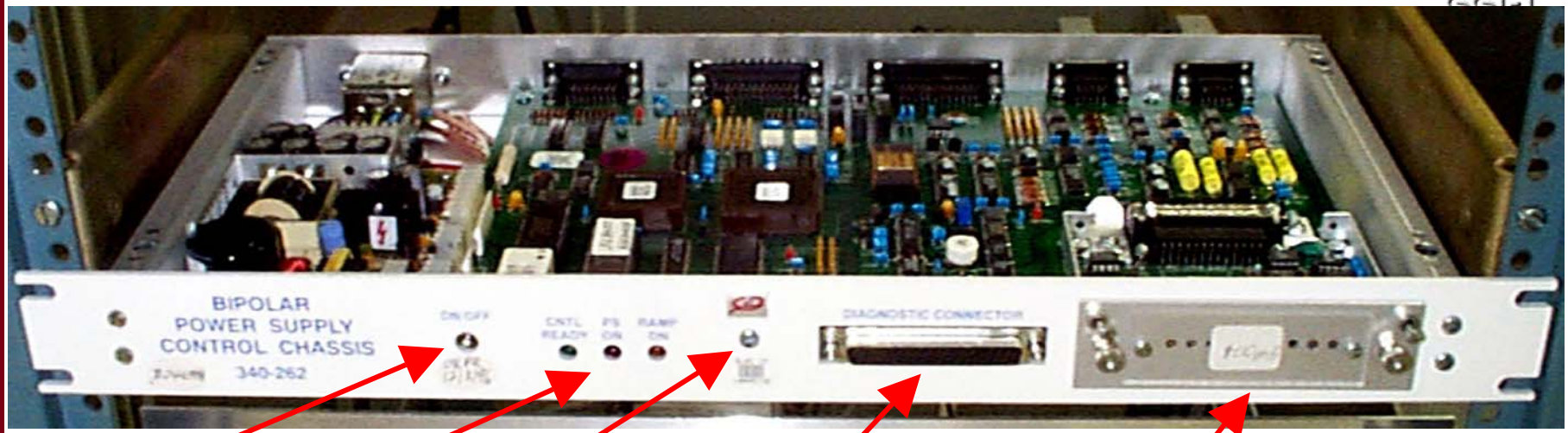
5. Unipolar Power Supplies

- 72 TSPs, 66 in ring, 6 in SS
- 4 operating power supplies – 5th spare
- 5 switching chassis, 16 channels each
- PS control / read-back is BitBus
- Switching chassis control / readback VME (B118-29)
- Operate 1 TSP per PS (quadrant)
- Automatic remote sequential switching with manual possibility
- No ground fault detection / protection
- Possible software PS inhibit if vacuum corrupted

5. Unipolar Power Supplies



5. Unipolar Power Supplies



On / Off

Status

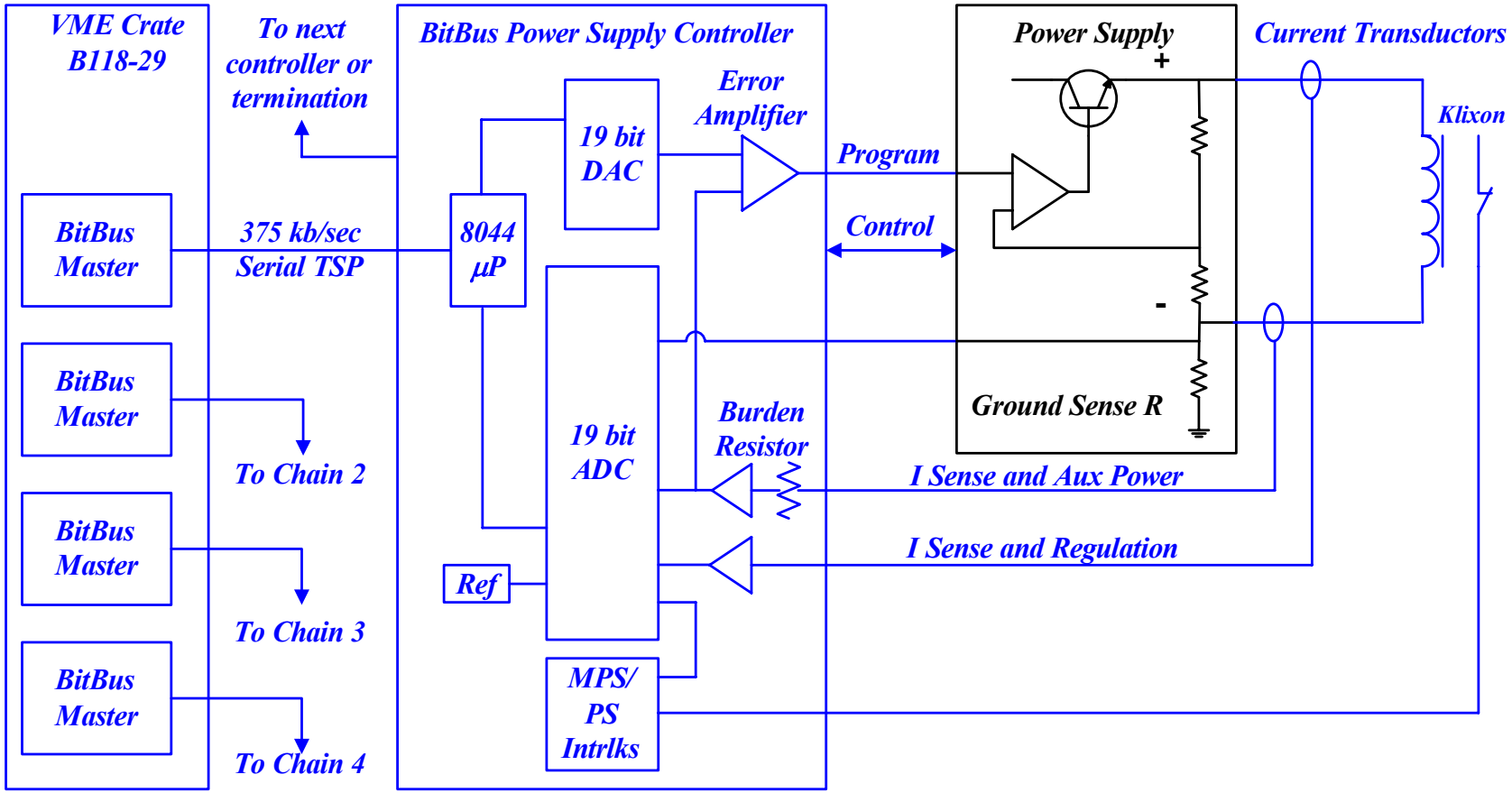
Local / Remote

RS232 Diagnostic Connector

Daughter Board
RC tuning network
Error amplifier
BitBus address
Scaling factors

- *Precision, ultra-stable BitBus Controller*
- *Designed by Dave MacNair*
- *Computer - PS and PS - computer communicator*
- *Feedback loop*
- *MPS interface connector on rear panel*

5. Unipolar Power Supplies



- *Power supplies are voltage regulated*
- *SLAC/SSRL adds external current regulation*

5. Unipolar Power Supplies

Danfysik Current Transductors

Dipole power supply 1000A transductors

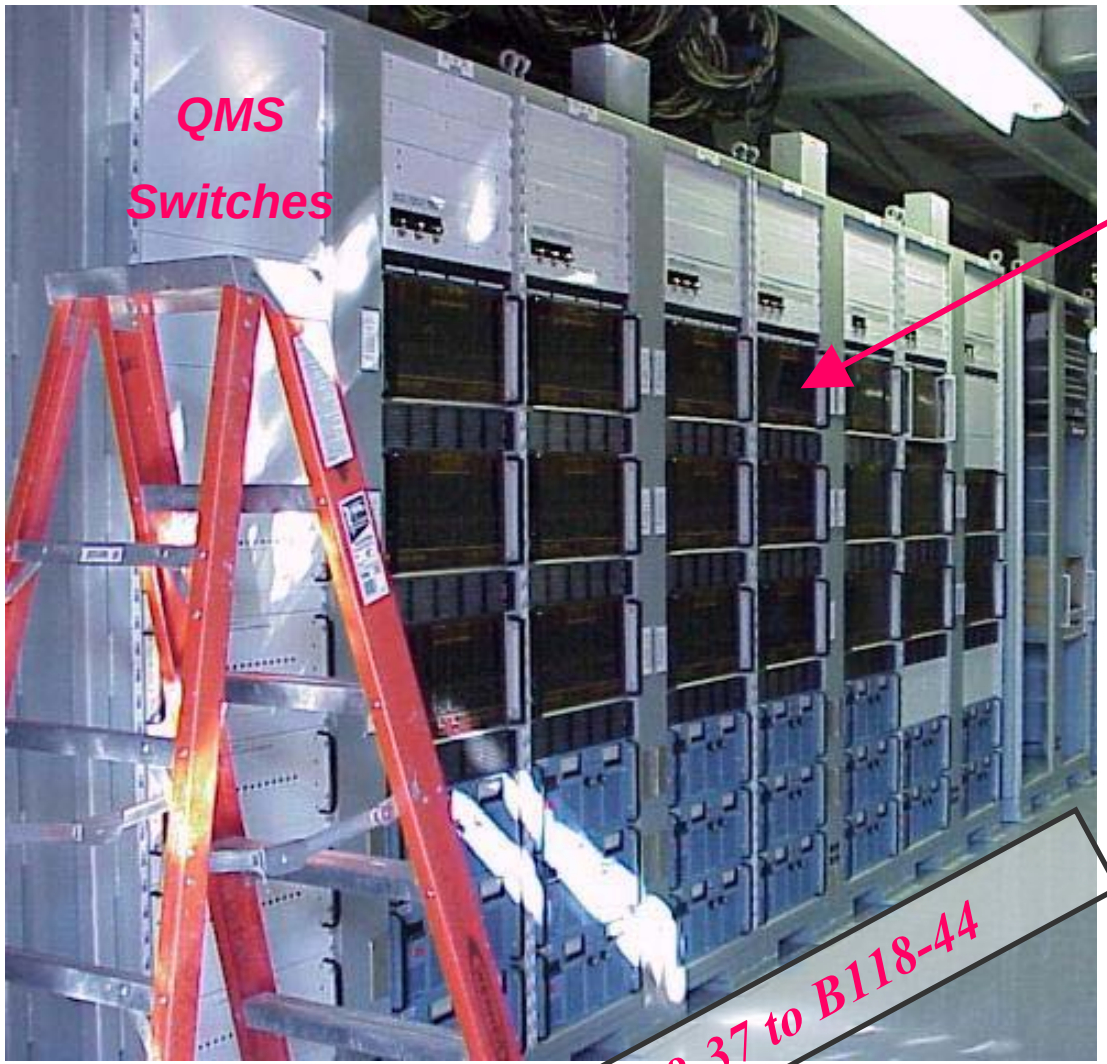
- *Bulk Power Supply*
- *Chopper Module Rack*

150A / 600A transductors all other unipolar power supplies

Two transductors per power supply

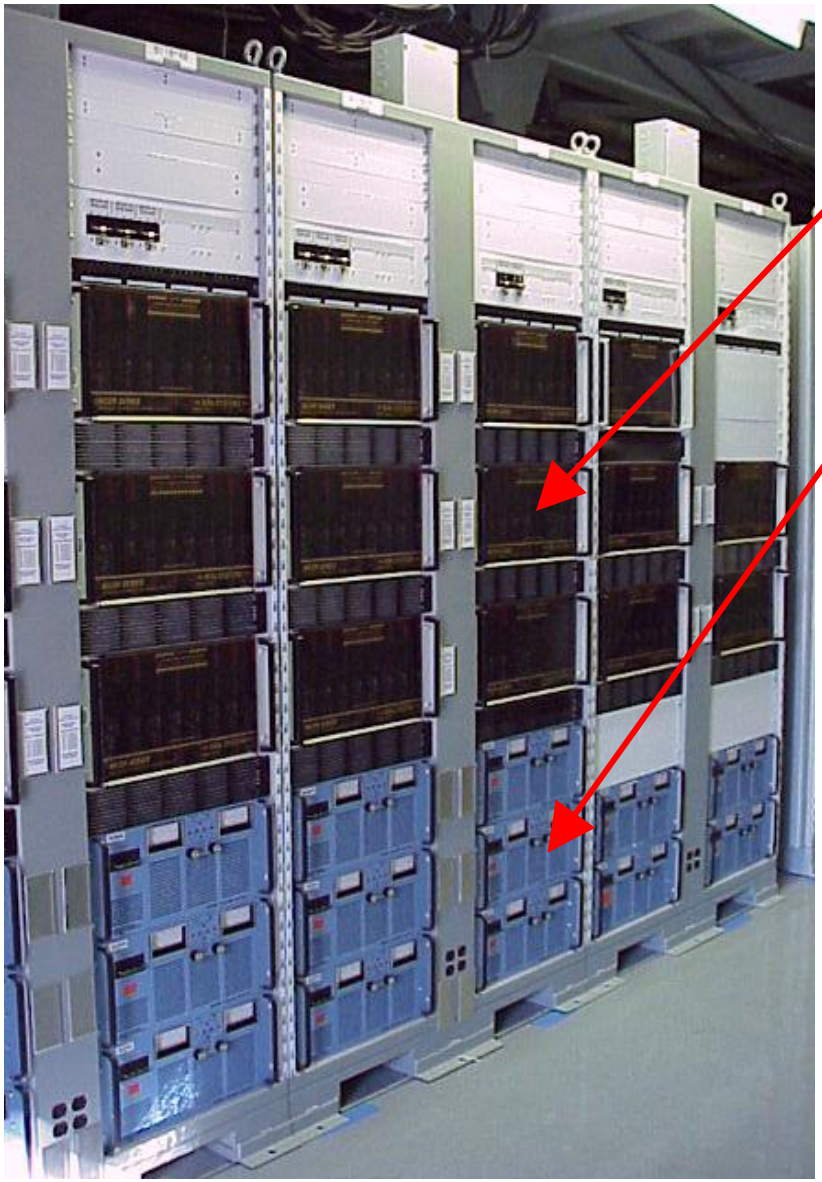
- *Current feedback loop*
- *Verification*

6. Bipolar Power Supplies



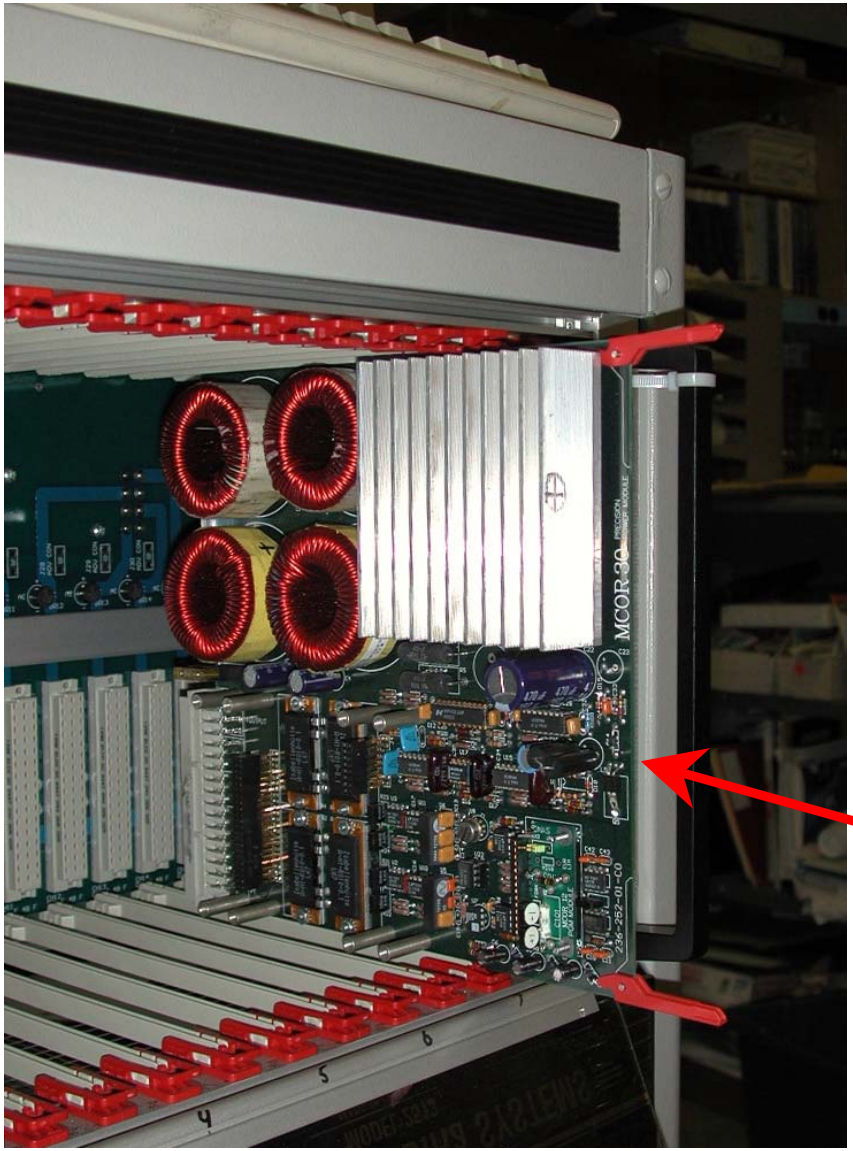
- 30A, 50V "MCOR30"
- Designed by Greg Leyh of PCD
- 108 H & V correctors
- 14 Skewquads
- 15 Insertion Device Trims
- 1 switched Quadrupole Modulation System (QMS)
- 1 Dipole Trim
- 138 total power supplies
- 168 accommodation

6. Bipolar Power Supplies



- *3 crates in a rack*
- *1 bulk power supply per crate*
- *Bulk is a voltage source. Set voltage manually*
- *Bulk local V and I analog meters*
- *No bulk remote control or read-backs*
- *Bulk is MPS interface*

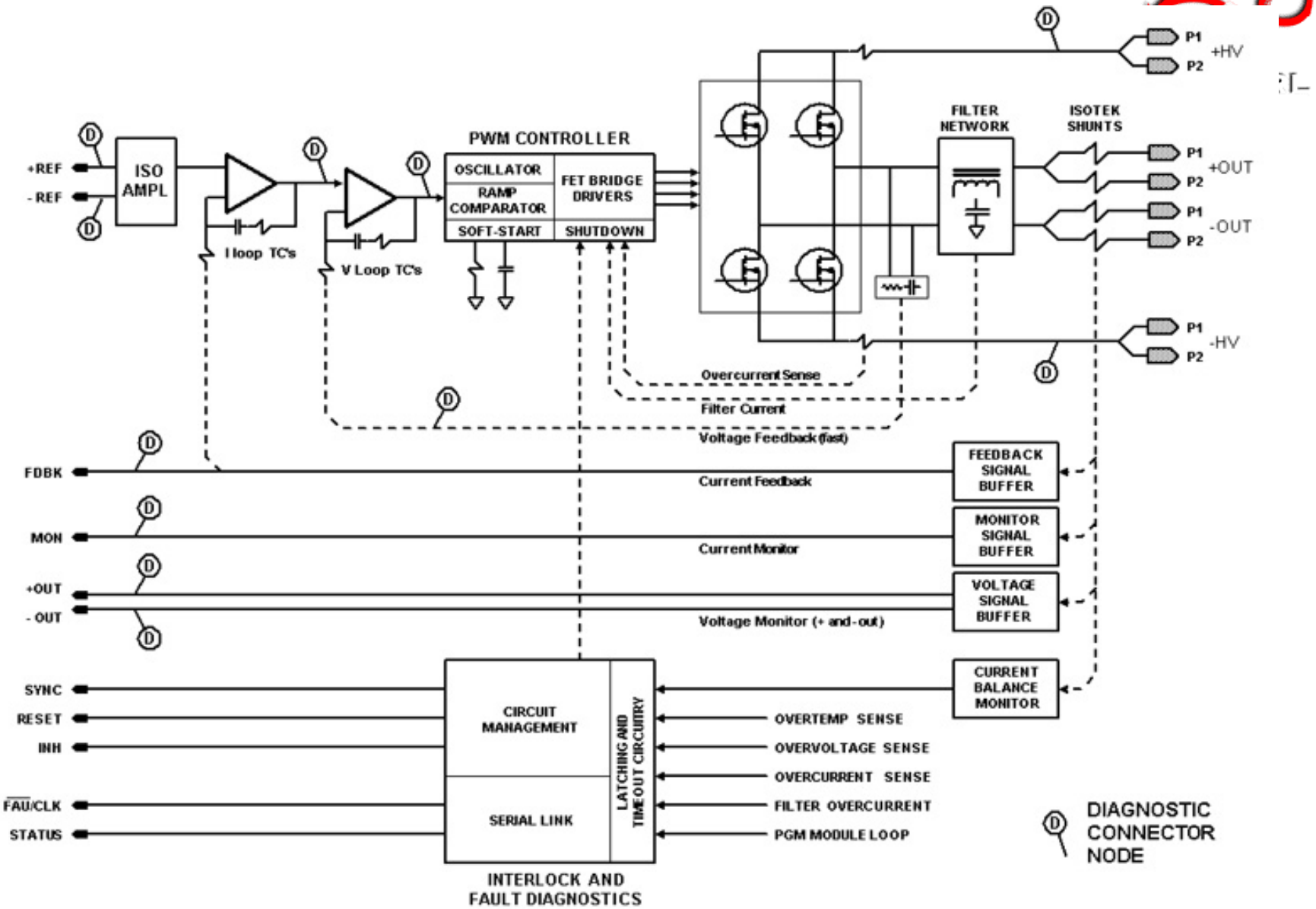
6. Bipolar Power Supplies



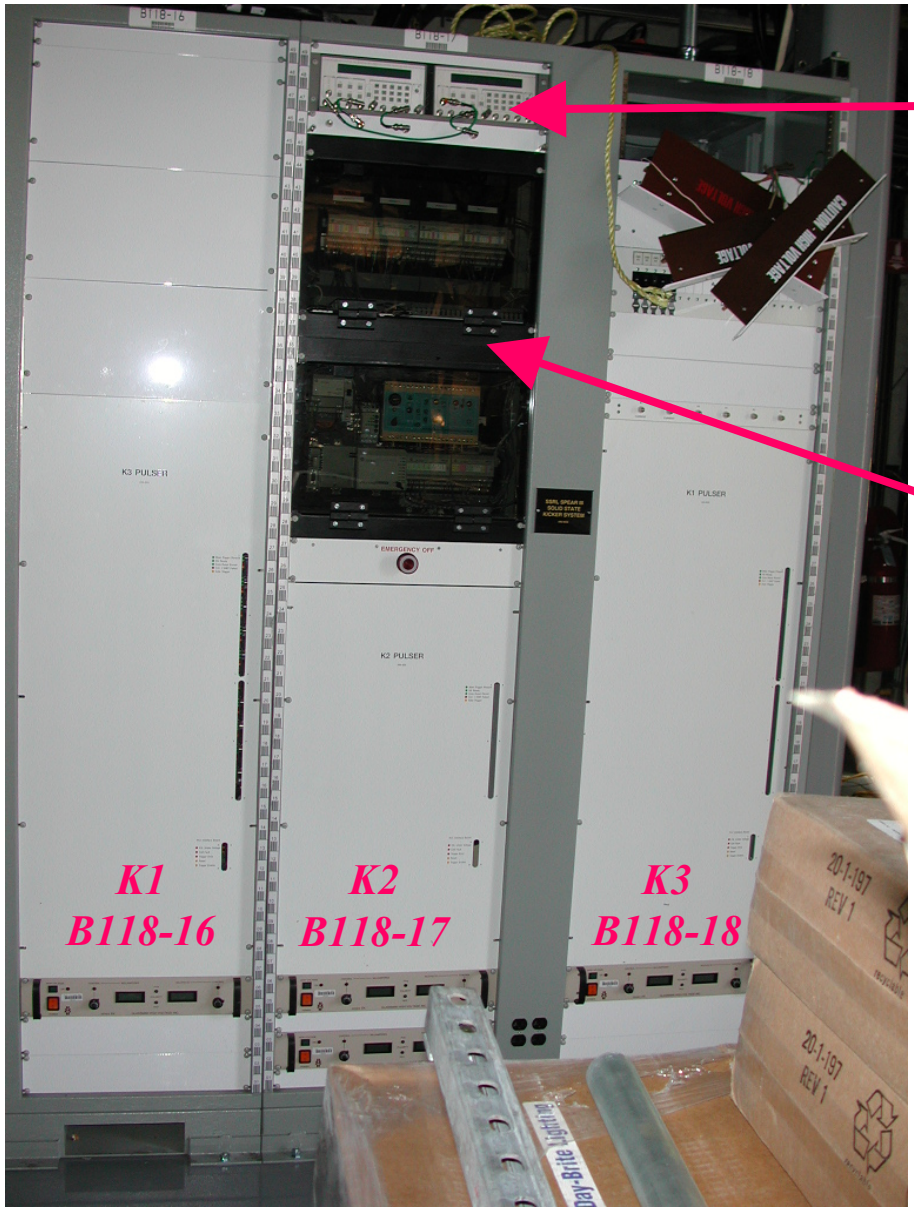
- *50V, 30A rating*
- *Up to 8 in a crate*
- *L to R: Slots 00, 0, 1, 2, 3, 4, 5, 6, 7*
- *Left most slot (00) is a new 8-channel Ethernet-based 100Mbps controller for remote control*

MCOR30 in crate

6. Bipolar Power Supplies



7. Pulsed Power Supplies

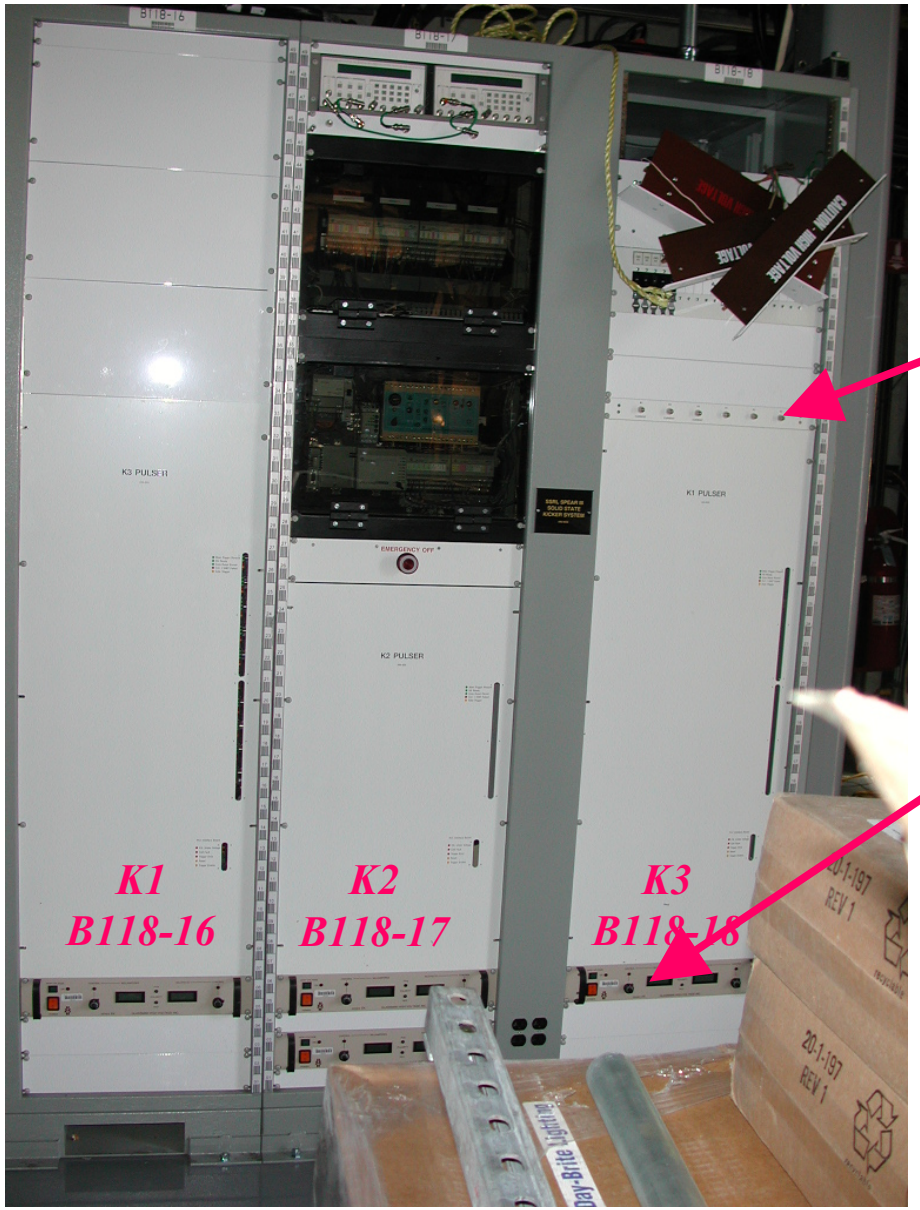


2 SRS Trigger generators – input from timing system and GPIB interface for trigger delay and pulse width adjustments

PLC RS5000 interface-turn on/off, interlock information, set Vo

- *3 injection kicker pulsers*
- *3 magnets Quad 1, Sectors 3 and 4*
- *K1, K3 1.2m 13kV, 2400A*
- *K2 0.6m 7kV, 2600A*
- *Pulse < 780nS. 10 Hz*

7. Pulsed Power Supplies

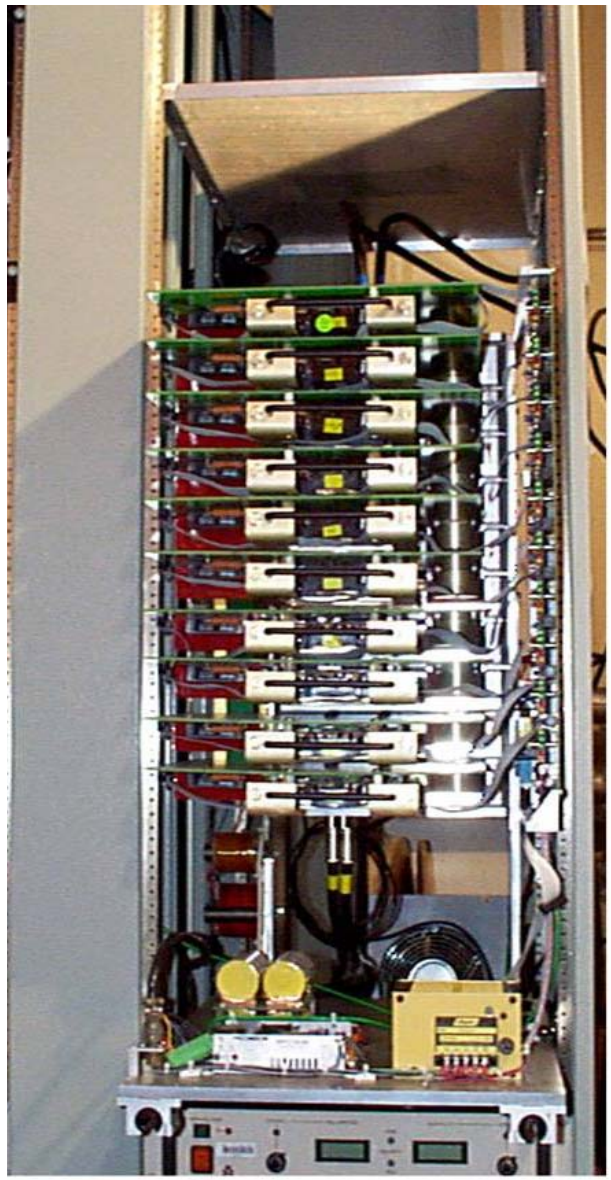


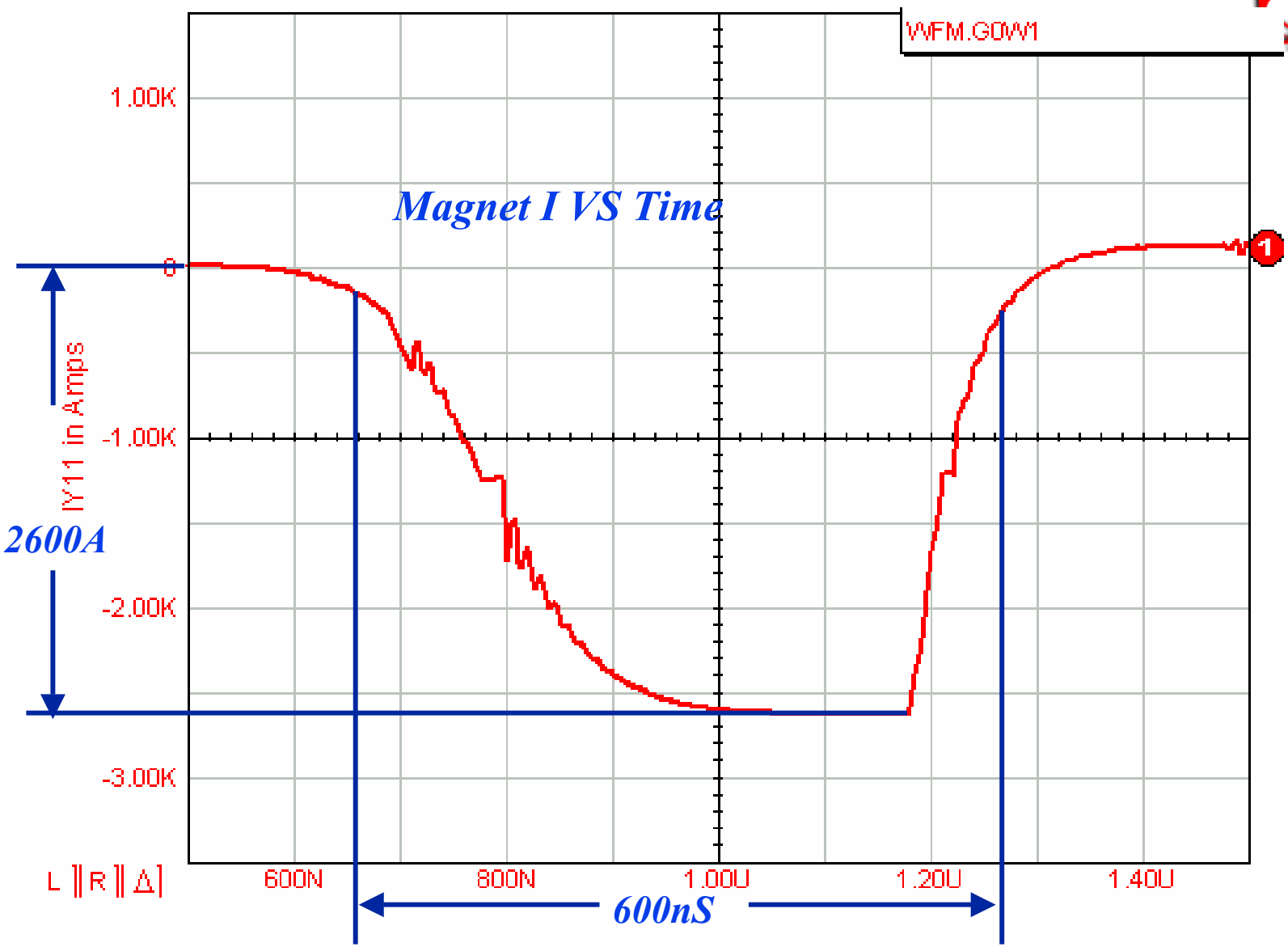
Panel for local magnet current read-backs via CT and tie to Jorgensen digitizers.

Pulse capacitor charger power supplies

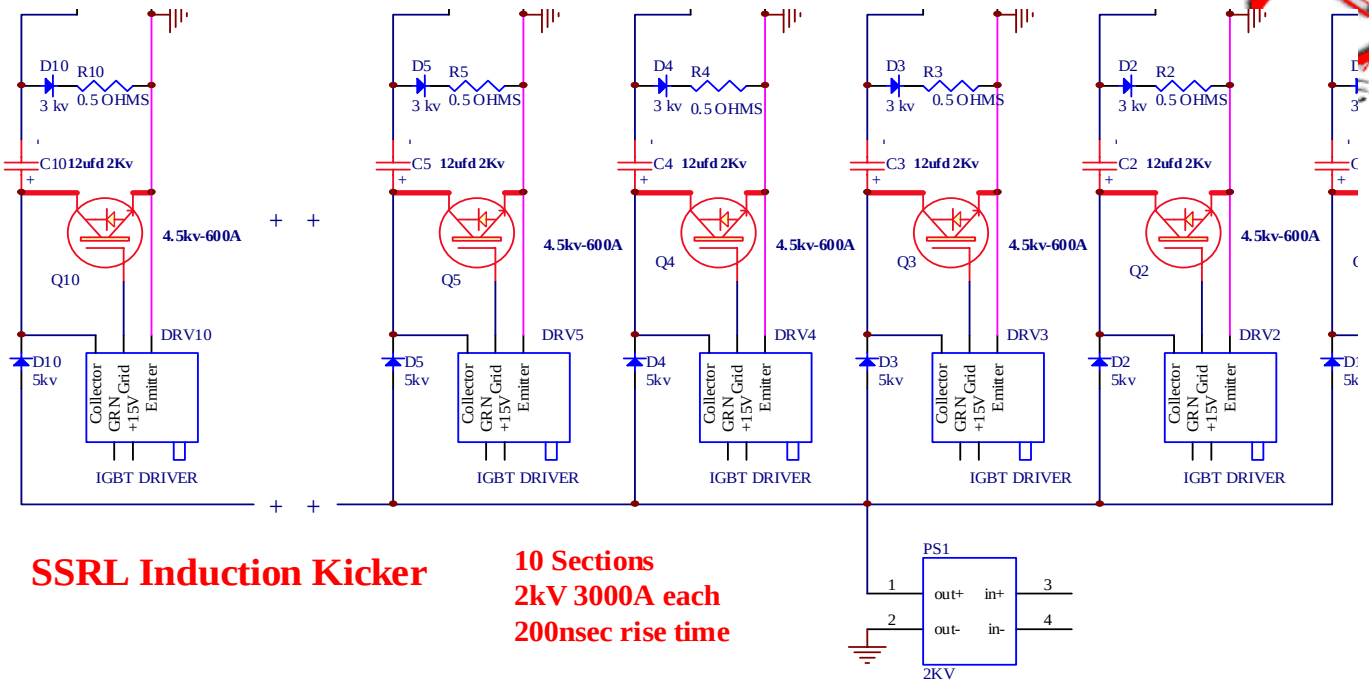
7. Pulsed Power Supplies

- *New solid-state, no PFN or thyratron*
- *Low maintenance, low jitter, high reliability*




WFM.G0W1
1.00K
0
-1.00K
-2.00K
-3.00K
IY11 in Amps
2600A
Magnet I VS Time
L ‖ R ‖ Δ]
600N
800N
1.00U
1.20U
1.40U
600nS

7. Pulsed Power Supplies



SSRL Induction Kicker

10 Sections
2kV 3000A each
200nsec rise time

Happy Operations!