Workshop on Power Converters for Particle Accelerators

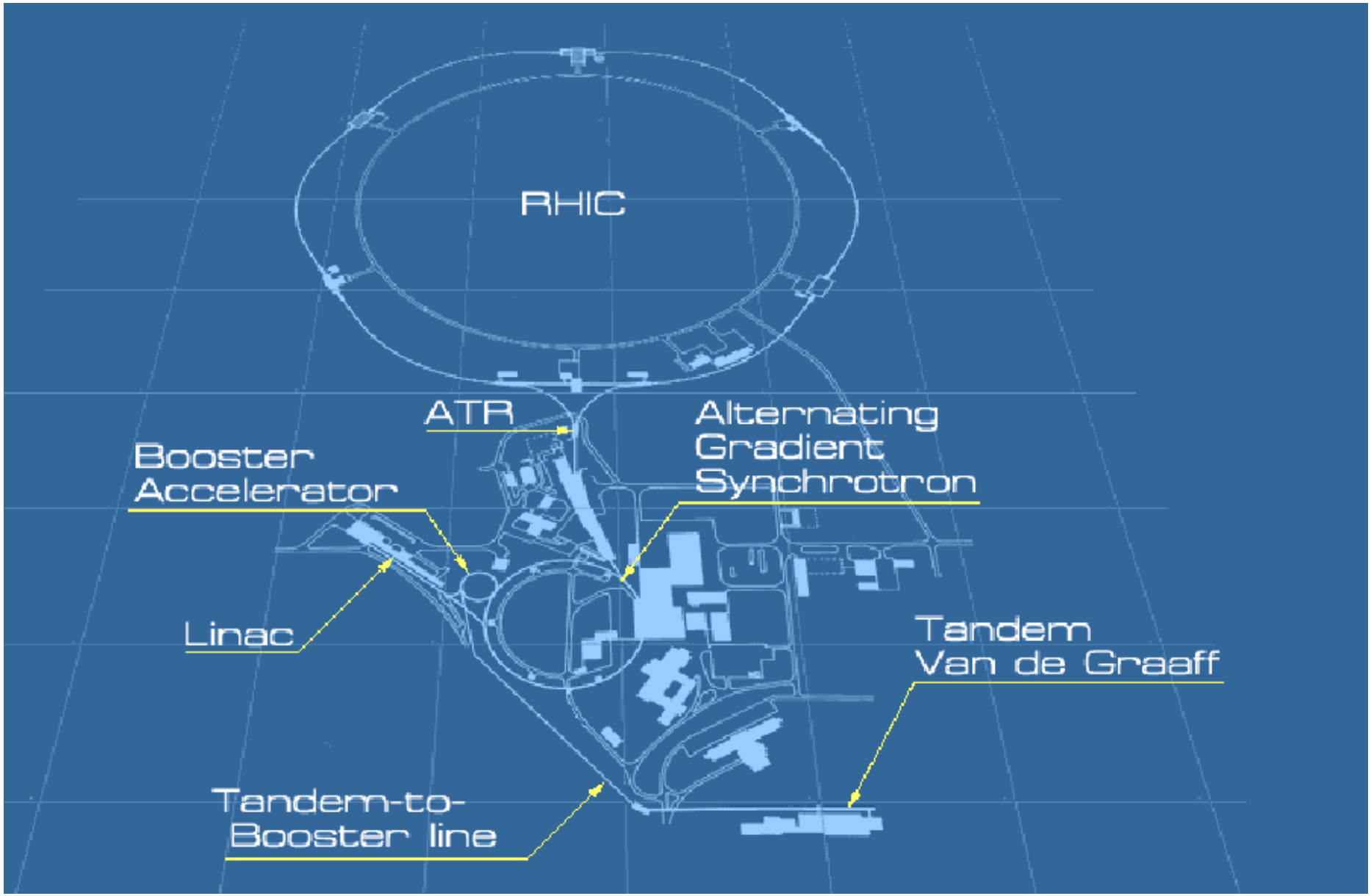
Reliability of the Operational Power Converters at RHIC

5/19/08

Outline

I. Background
II. MTBF, Availability, Average Time of Repair
III. PS Maintenance Organization
IV. Hardware Problems/Improvements
V. Software Improvements
VI. More Reliable Power Converters

Background


RHIC
ATR
Alternating
Gradient
Synchrotron
Booster
Accelerator
Linac
Tandem
Van de Graaff
Tandem-to-
Booster line

Number of RHIC P.S.’s

- 4 main P.S.’s (2 dipole and 2 quad)
- 620 Corrector P.S.’s
- 237 Insertion Region P.S.’s
- 48 sextupole P.S.’s
- 24 Gamma T PS’s
- 8 snake P.S.’s
- 16 spin rotator P.S.’s
- 4 AGS Cold Snake PS’s
- Manufacturers: SCE, Dynapower, Bruker, Inverpower, BNL

Total p.s.’s = 961 (excluding 80 ATR line ps’s)

Power Supply Ratings

Main PS's	**Polarity**	**Voltage (V)**	**Current (A)**	**Power (kW)**	**Quantity (2 rings)**
Dipole Ramp	mono	400	5500 3300Arms	2200 peak 1320	2
Dipole FT	mono	30	5500	165	2
Quad Ramp	mono	90	5500 3300Arms	495 peak 297	2
Quad FT	mono	15	5500	82.5	2

Power Supply Ratings

Insertion Dipoles	Polarity	Voltage (V)	Current (A)	Power (kW)	Quantity (2 rings)
Type A	mono	20	2000	40	14
Type B	mono	20	600	9	7

Insertion Quads	Polarity	Voltage (V)	Current (A)	Power (kW)	Quantity (2 rings)
Type A	bi	15	150	2.25	96
Type B	bi	15	300	4.5	14
Type C	mono	15	200	3	48
Type D	mono	15	300	4.5	24
Type E	mono	15	450	6.75	16
Type F	mono	20	600	12	16
Quad Offset	mono	40	300	12	2

Power Supply Ratings

Correctors	**Polarity**	**Voltage (V)**	**Current (A)**	**Power (kW)**	**Quantity (2 rings)**
Dipoles	bi	20	50	1	468
Skew Quads	bi	20	50	1	48
Octupoles	bi	20	50	1	48
Low Beta	bi	20	50	1	56
Gamma-T's	pulsed	300 peak 20Vrms	40 peak 60Arms	12 peak 1.2	24
Sextupole A	mono	100	100	10	24
Sextupole B	mono	33	33	1.1	24

Power Supply Ratings

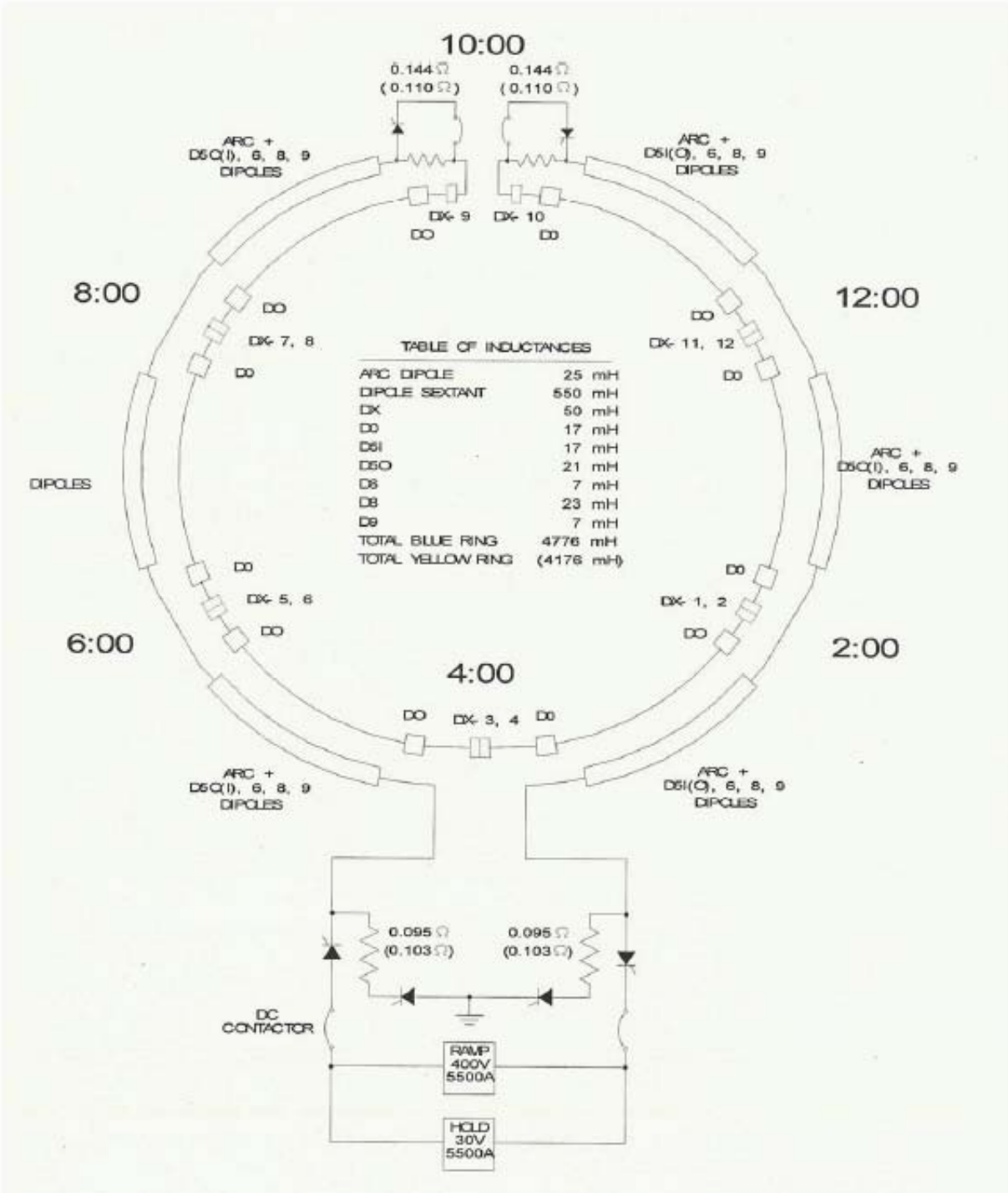
Snake & Rotators	Polarity	Voltage (V)	Current (A)	Power (kW)	Quantity (2 rings)
Snakes	mono	15	440	6.6	8
Rotators	mono	15	440	6.6	16

AGS Cold Snake	Polarity	Voltage (V)	Current (A)	Power (kW)	Quantity
Helical	mono	50	400	20	1
Solenoid	mono	15	440	6.6	1
Correctors	bi	20	50	1	2

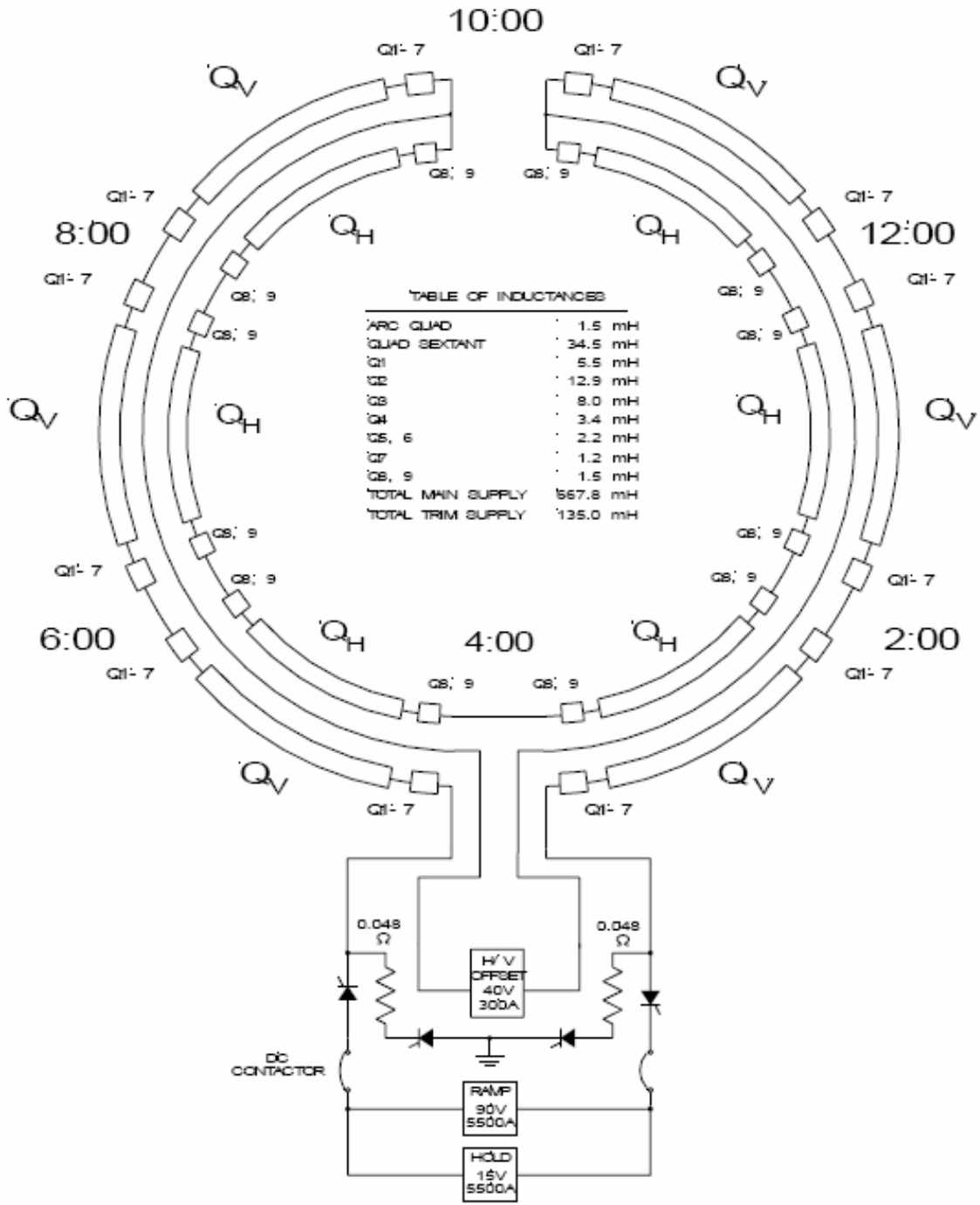
Some Other equipment

- Quench Protection Assemblies
- Quench Detection
- Qpaic’s
- Node cards
- Permit bypass chassis’s
- AC compartments
- 6kA quench switches
- Connectors and Connections
- 3u chassis control cards
- Magnet Division responsible for superconducting magnets
- 80 ATR line ps’s not part of this MTBF
  - 1-1MW ps’s, 3- 450kW, 1- 375kW, 20-25kW, 15-15kW, 30 – 600W trims, 7-16kW, other assorted SCR type ps’s that were upgraded

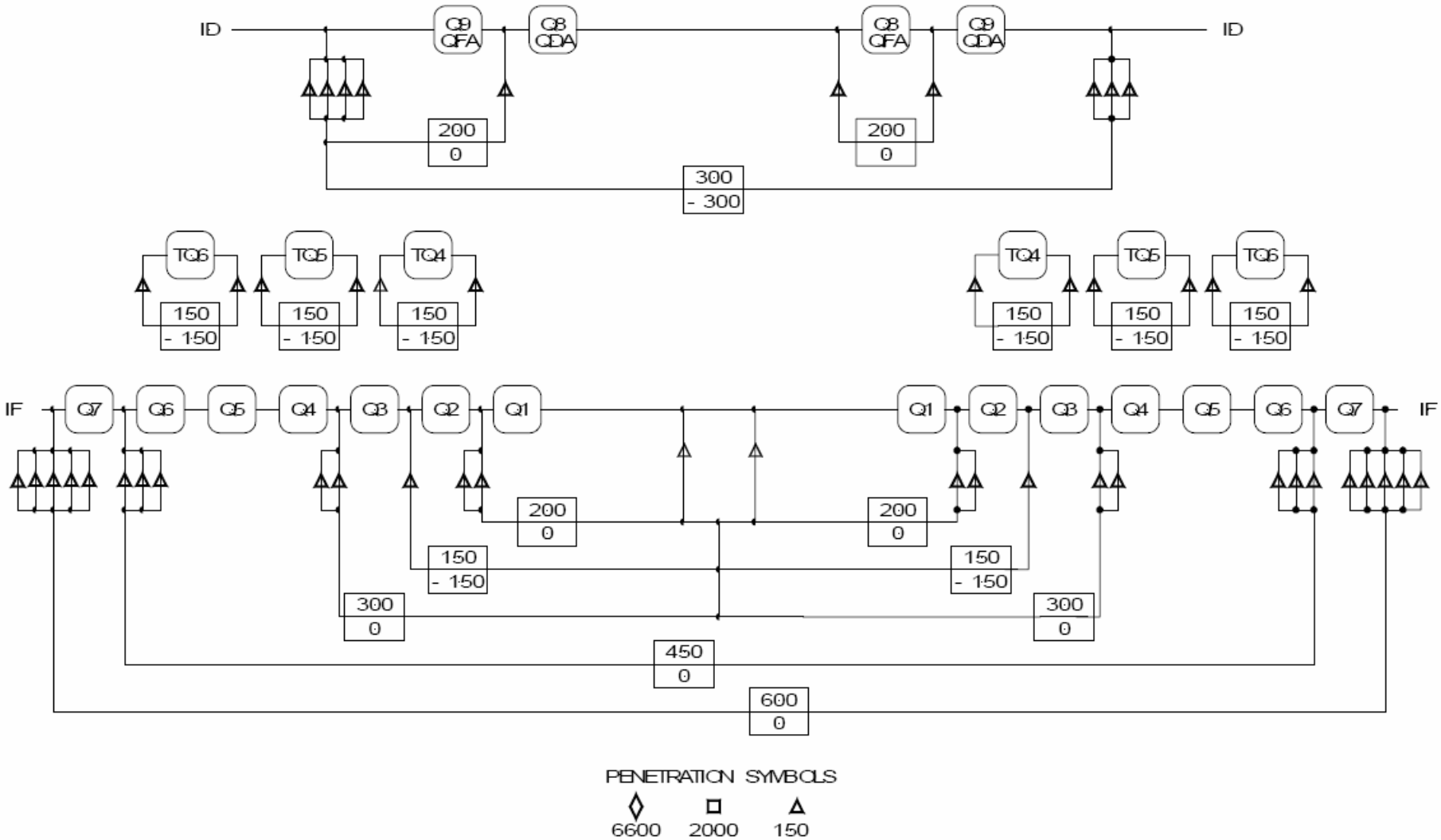
RHIC Main Dipole Bus Layout



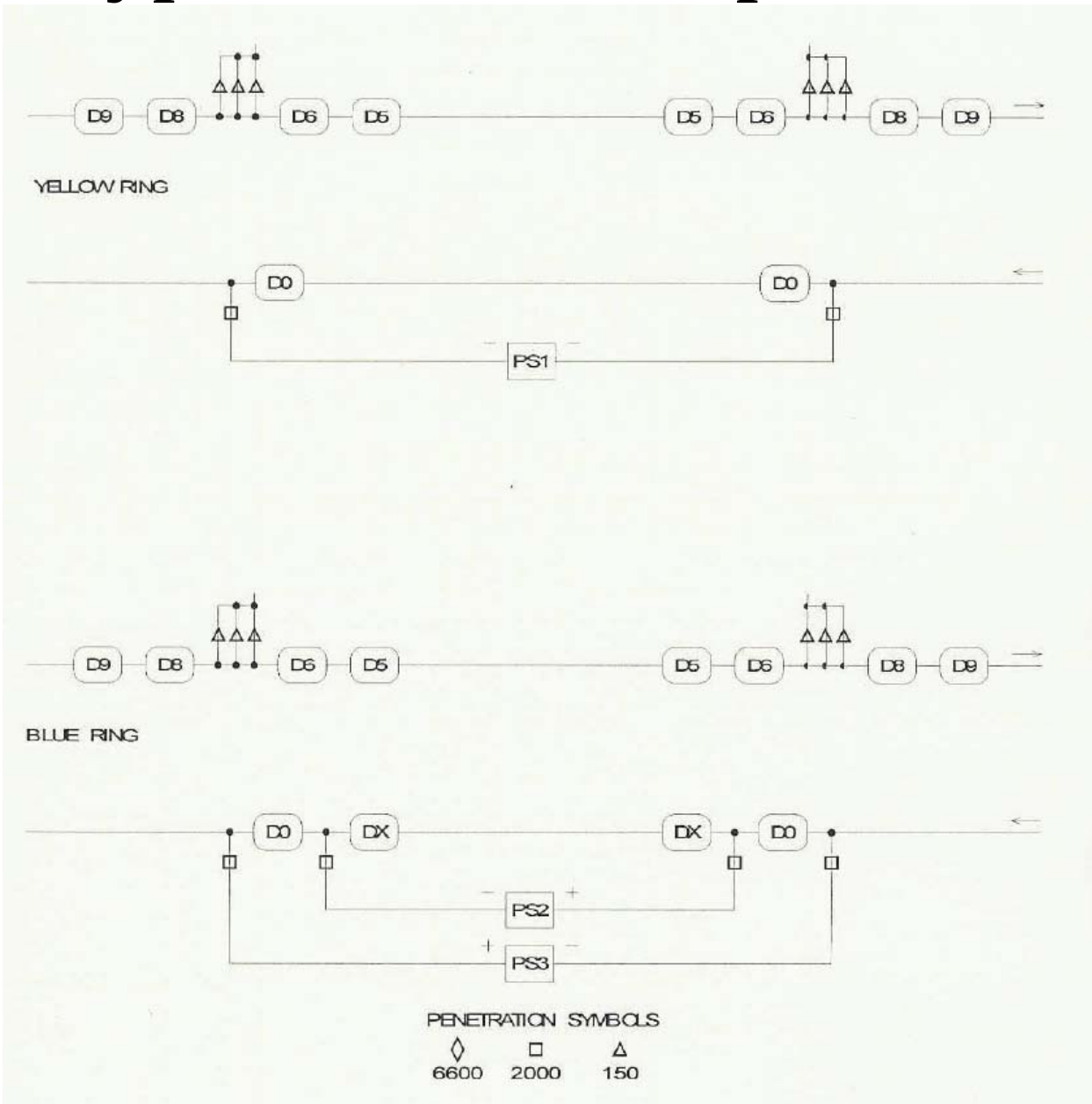
RHIC Main Quad Bus Layout



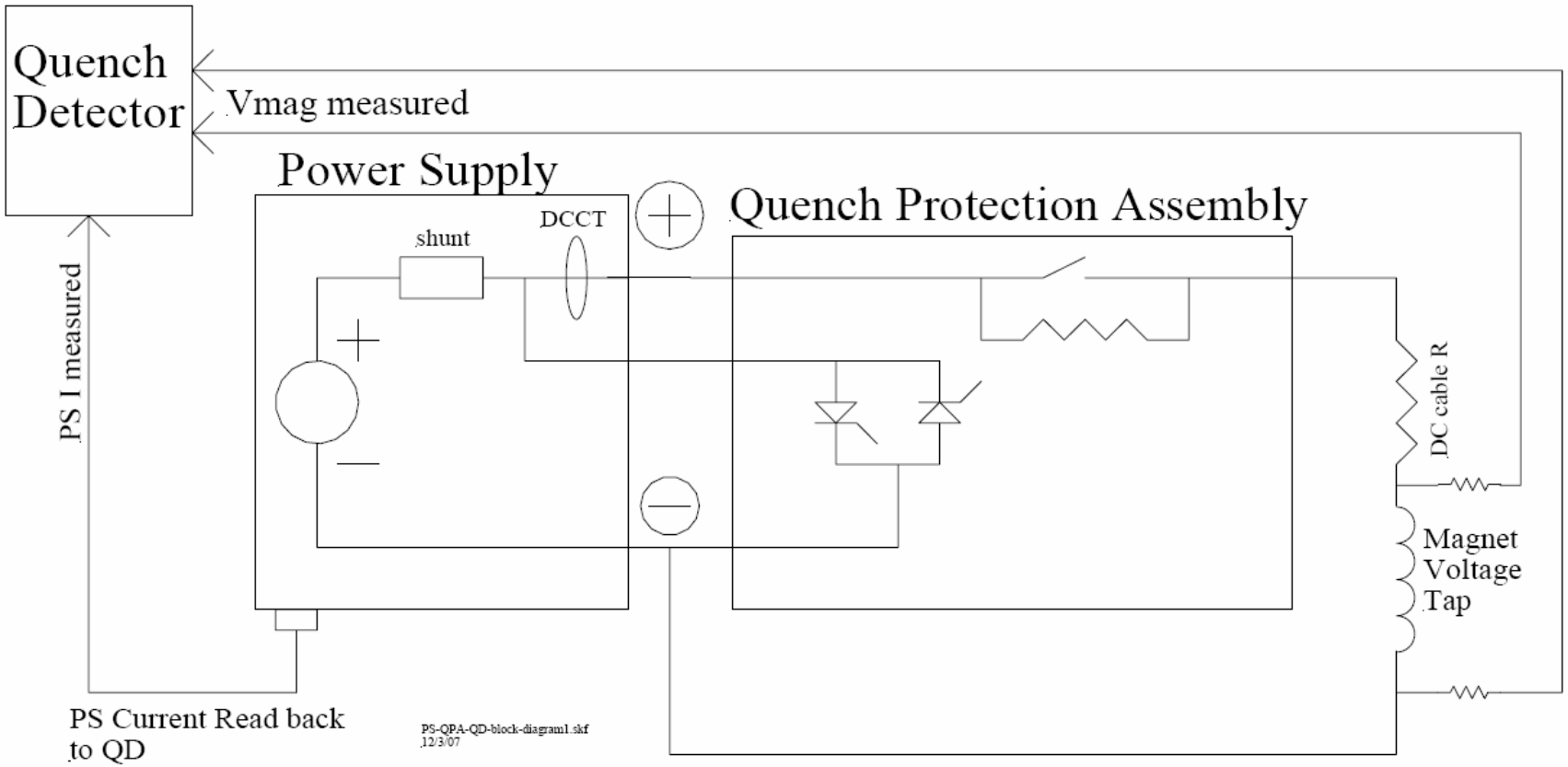
Typical Nested Quad IR



Typical Nested Dipole IR



Block Diagram



Quench Detection/Quench Link

- QD system monitors magnets, shunt buses and gas cooled leads continuously.
- The QD system in RHIC is broken up into 12 subsystems
- Alcoves (6)
  - Arc region dipole and quad magnets
- Service bldgs (6)
  - IR magnets, shunt buses, Gas cooled leads, ps currents
- Service bldgs and alcoves are linked together
- The link must be up before any ps can turn on
- There are ps’s that are not on the Link

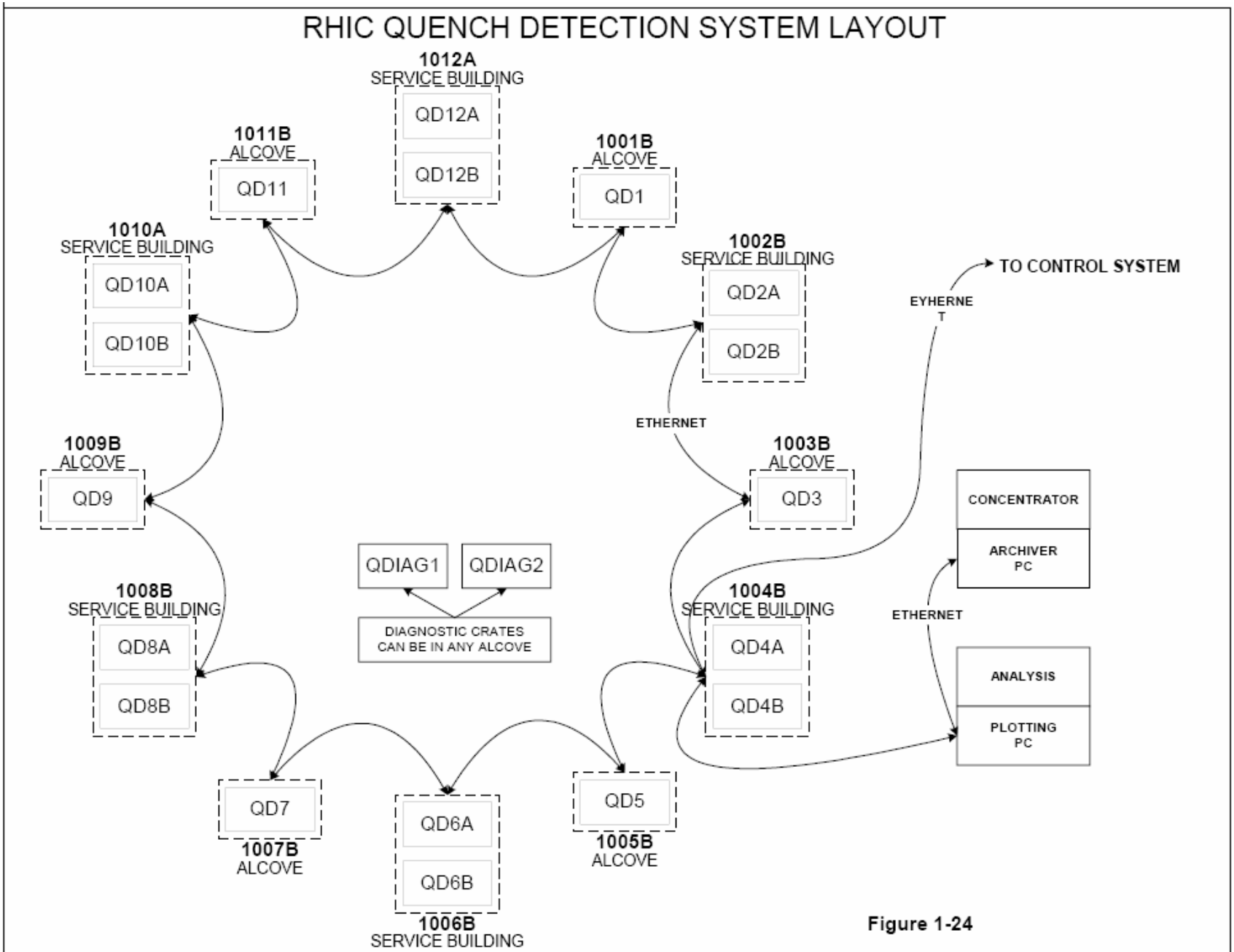
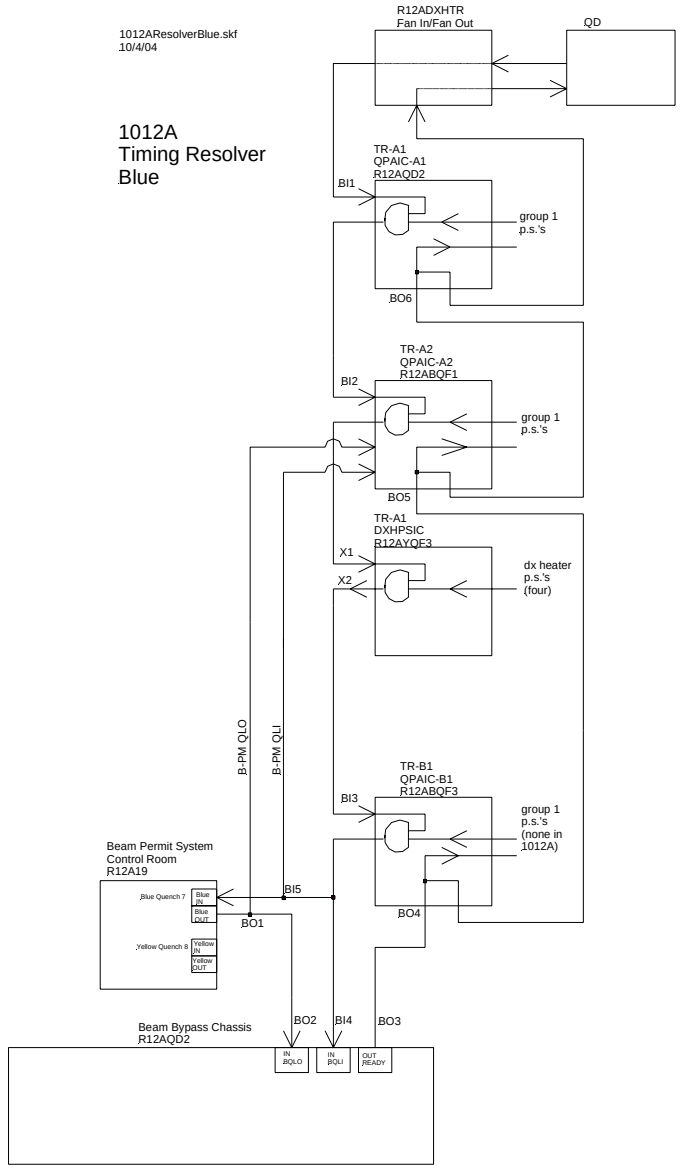

RHIC QUENCH DETECTION SYSTEM LAYOUT
1012A
SERVICE BUILDING
QD12A
QD12B
1011B
ALCOVE
QD11
1001B
ALCOVE
QD1
1010A
SERVICE BUILDING
QD10A
QD10B
1002B
SERVICE BUILDING
QD2A
QD2B
TO CONTROL SYSTEM
EYHERNE
T
ETHERNET
1009B
ALCOVE
QD9
1003B
ALCOVE
QD3
CONCENTRATOR
ARCHIVER
PC
QDIAG1
QDIAG2
DIAGNOSTIC CRATES
CAN BE IN ANY ALCOVE
1008B
SERVICE BUILDING
QD8A
QD8B
1004B
SERVICE BUILDING
QD4A
QD4B
ETHERNET
ANALYSIS
PLOTTING
PC
QD7
1007B
ALCOVE
QD6A
QD6B
1006B
SERVICE BUILDING
QD5
1005B
ALCOVE

Figure 1-24

Bldg Link Example



MTBF

Availability

Average Time of Repair

Definitions

- Refrigerator Time (MCR Machine Time)
  - As soon as the Refrigerator turns on to cool down RHIC to 4.5K
- PS ON time
  - If all the ps's are ON and running or ON and waiting to be used then this adds to the ON time
  - If even one ps (or any one piece of equipment we are responsible for) fails then this subtracts from the ON time
  - If there is a maintenance day and we are working on the supplies then this subtracts form the PS ON time
  - If someone else's equipment fails but all of our ps's are ON and waiting to be used then this adds to the PS ON time
  - While the refrigerator is on and cooling RHIC down the ps's are not available for use because we are testing them so we subtract this time from PS ON time.
- NOF
  - THE NOF increases if any piece of equipment we are responsible for (not only ps's) fails.
  - If a repair is not attempted (or is attempted) and the same piece of equipment fails again then the NOF increases again.

Average Time of Repair and/or Replace (TOR)
Average Downtime (Avg DownTime)

Average Downtime

•The amount of time to repair or replace the ps (TOR) + the time required for MCR to contact a technician or an engineer + any other delays. Also can be know as link down to link up time

•All of the RHIC ps group downtime is added together and divided by the total NOF to calculate the AVG Downtime

TOR

- •Each time a technician goes out for a repair or to replace a p.s. we record how long the repair or replacement took.
- •Each time an engineer gets a call at home we record how long the repair took.
- •All the repair times are added together and divided by the total NOF to calculate an average repair time (TOR).

TOR and Avg Downtime

	TOR	Avg Downtime
Run 4	0.73	1.65
Run 5	0.89	0.92
Run 6	0.833	1.4
Run 7	1.07	1.35
Run 8	0.87	1.19

	MCR Machine Time (Refrigerator time) (Hrs)	PS ON time (calculated by RHIC ps group) (Hrs)	Total PS DownTime (calculated by RHIC ps group) (Hrs)
Run 4	4368	3031.04	244.2
Run 5	5328	4249.02	124.2
Run 6	3576	3077.07	152.6
Run 7	3087	2682.68	244.82
Run 8	3192	2906.88	114.73

MTBF of RHIC ps System due to anything failing in RHIC ps system (everything we are responsible for)

$$\text{MTBF\_all} = \frac{\text{PS ON time}}{\text{NOF}}$$

Subtracts maint days and start up time

	RHIC Run 4	RHIC Run 5	RHIC Run 6	RHIC Run 7	RHIC Run 8
MTBF_all(hours)	20.48	30.79	28.23	14.74	30.28
Number of Failures	148	138	109	182	96

Note: If the same ps fails 3 times that is 3 failures

$$\text{MTBF\_all} = \frac{\text{Refrigerator Time}}{\text{NOF}}$$

	RHIC Run 4	RHIC Run 5	RHIC Run 6	RHIC Run 7	RHIC Run 8
MTBF_all(hours)	29.51	39.00	32.81	16.96	33.25
Number of Failures	148	138	109	182	96

MTBF of RHIC ps System as a function of the number of ps's

$$\text{MTBF\_all} = \frac{\text{PS ON time x NOPS}}{\text{NOF}}$$

Subtracts maint days and start up time

	RHIC Run 4	RHIC Run 5	RHIC Run 6	RHIC Run 7	RHIC Run 8
MTBF_all(hours)	19106	27989	26339	14161	29098
Number of PS's	909	909	933	961	961

$$\text{MTBF\_all} = \frac{\text{Refrigerator Time x NOPS}}{\text{NOF}}$$

	RHIC Run 4	RHIC Run 5	RHIC Run 6	RHIC Run 7	RHIC Run 8
MTBF_all(hours)	26828	35451	30609	16300	31953
Number of Failures	148	138	109	182	96

%Availability of RHIC if we only had RHIC ps system failures

$$\%Av = \frac{[\text{PS ON time} - (\text{NOF} \times \text{Avg Downtime})]}{\text{PS ON Time}}$$

	RHIC Run 4	RHIC Run 5	RHIC Run 6	RHIC Run 7	RHIC Run 8
Av%	91.97	97.09	95.03	90.87	96.07
Number of Failures	148	138	109	182	96

$$\%Av = \frac{[\text{Refrigerator time} - (\text{NOF} \times \text{Avg Downtime})]}{\text{Refrigerator Time}}$$

$$\%Av = \frac{[\text{Refrigerator time} - (\text{Total PS Downtime})]}{\text{Refrigerator time}}$$

	RHIC Run 4	RHIC Run 5	RHIC Run 6	RHIC Run 7	RHIC Run 8
Av%	94.41	97.62	95.73	92.04	96.42
Number of Failures	148	138	109	182	96

RHIC ps Maintenance Organization

What do we do to keep the p.s's running during operation?

Spare Parts and Repairs

- One building dedicated to spare parts & repairs
- We maintain 5% - 25% spares. Would like at least 15% - 20%.
- It is up to the engineer to make sure we have enough spares.
- Still need to make sure we have spares for everything we are responsible for.
- Online Inventory Spreadsheet on our website.
- Try to update our Inventory spreadsheet after each Run.
- Group of 9 technicians in the RHIC ps group responsible for upgrades and repairs.
- In Summer of 2007 (after Run 7) BNL started using an outside company to make modifications to the bipolar 150A and 300A ps's

Some percentages of spares

	In operation	% Spares
bipolar 150	96	15
bipolar 300	14	50
Sextupole 1	24	25
Sextupole 2	24	8
Correctors	620	5
Unipolar's	135	12
Gamma-T's	24	8
Snake/Spin Rotator	24	16
Assorted Chassis's		
Other parts		

How does a failure get repaired?

- Collider Accelerator Support (CAS) should respond first.
- If they cannot fix it MCR calls the engineer. In RHIC the engineer gets called for most of the problems before a repair takes place.
- The engineer attempts to fix the problem with CAS.
- If spares are needed we can find the spares location online and tell CAS where to find the part. (What shelf or cabinet).
- We have procedures online that tells CAS how to make a repair after speaking with the engineer. (LOTO/ What gets disconnected and re-connected, checklist).
- If CAS cannot make the repair, a technician is called in or the engineer will come in.
- If the ps that fails is one ps to one magnet the repair is simpler than if it is a nested ps.
- If the failure is a nested ps then sometimes an analysis must be completed before you an even determine which supply caused the failure. This is because of the quench link.

[1] Feb-09-2008 04:32 Performing analysis for - QDS.1202549340
Sat Feb 9 04:29:00 2008
Blue Quench Link Interlock
First link to drop was the quench link - input permit.12a-ps1.A.
The blue link tripped at Sat Feb 09,2008 04:29:00.436324.
The permit link tripped at Sat Feb 09,2008 04:29:00.436325.
The blue link tripped 0.000001 secs before the permit link.

Analyzing building 12 - due to problem in permit.12a-ps1.A.
Quench detector brought down the link.
Possible problems - Check if
1. A power supply in this building was oscillating
2. beam induced quench. Check qdRealquench pet page, delayed5minutes
please wait 5 minutes for real magnet quenches to be displayed in elog.
3. quench detector problem, such as it being reset
4. Any snake magnets quench before this?
5. Check to see the abort kickers did not pre-fire or mis-fire

If none of these seem to be the cause, consult an expert.

Analyzing qdAlarms page.
qdprocess.12a-qd1 - Blue Quenched [B12QFQ4_6VT Int 1] 02/09/2008 04:29:01 Tq:-24 [rhicMode: AUAU1]

Analyzing service building IR supplies for warning.

Sequencer

[2] Comment Feb-11-2008 11:41 There was no evidence of a Power Supply or QPA Fault. The 12a-qd1-Quench Detector tripped the Blue Link due to a Real Magnet Quench at the b12q4 magnet. Multiple High Losses were recorded throughout the Machine in Sectors 1, 2, 4, 5, 6, 7, 8, 9 (outside of the Abort Station), Sector 11 and in Sector 12 where the only magnet quenched was b12q4. Losses at this magnet b12-lm4 = 43413. From the OC Log, the cause of Beam Loss was due to the blue Polarimeter target frame hit the beam resulting in large beam losses. This is the 23rd Beam Induce Quench for Run 8. Gregg H. [BeamIndQuench]

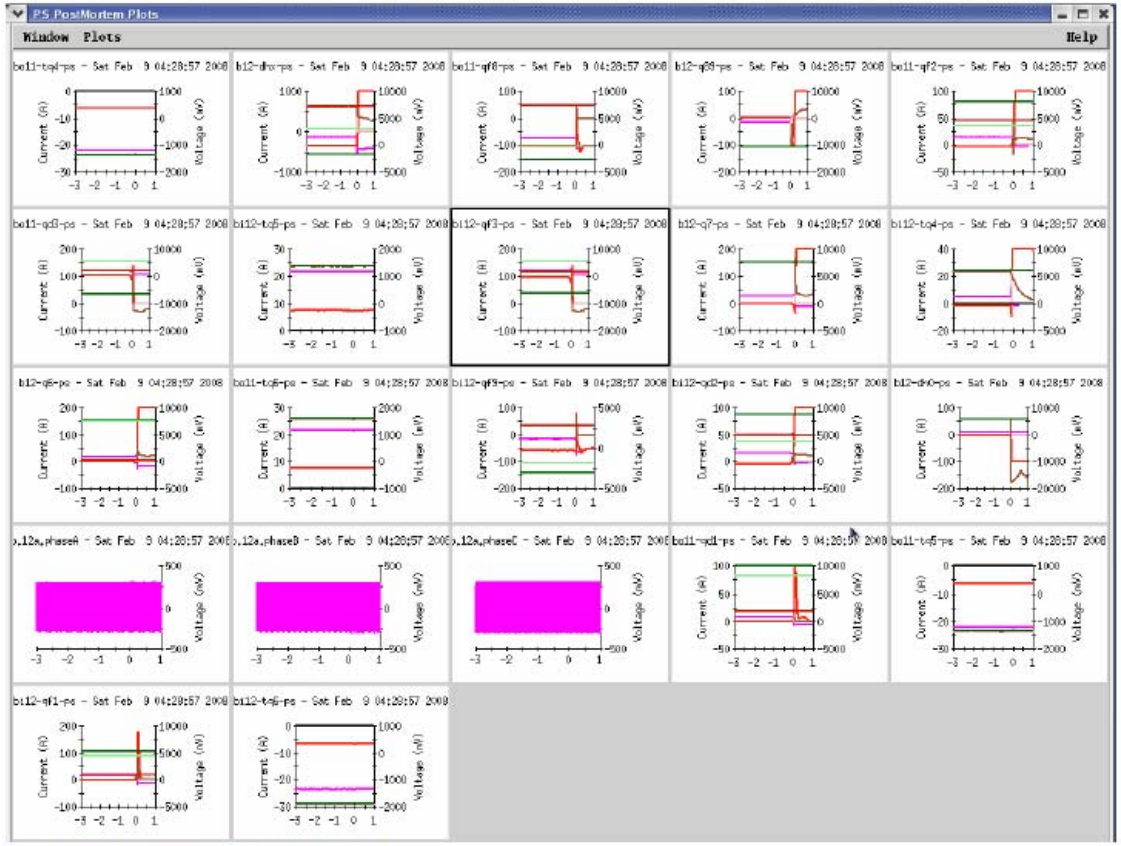
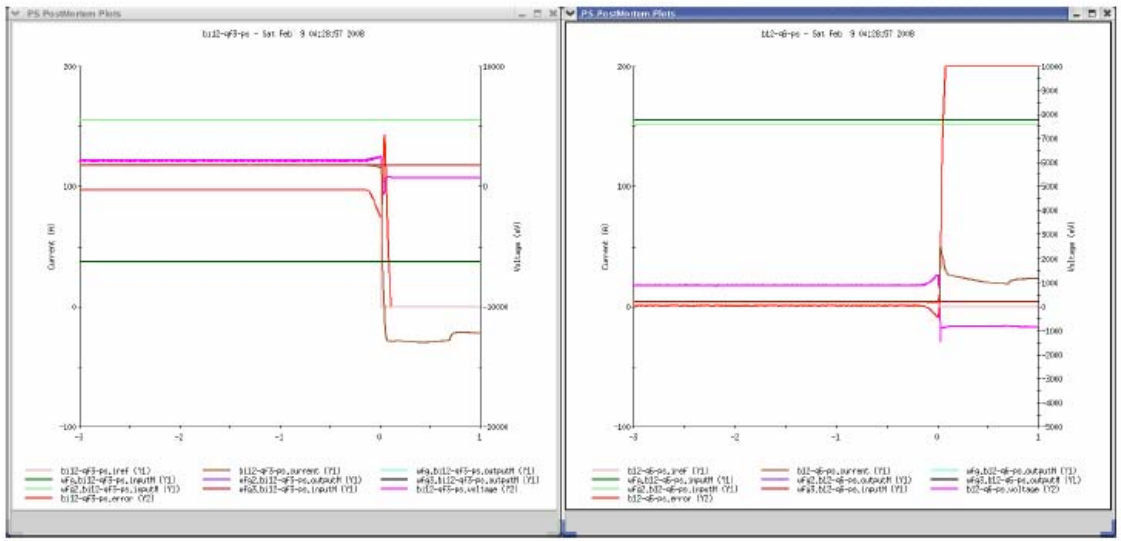
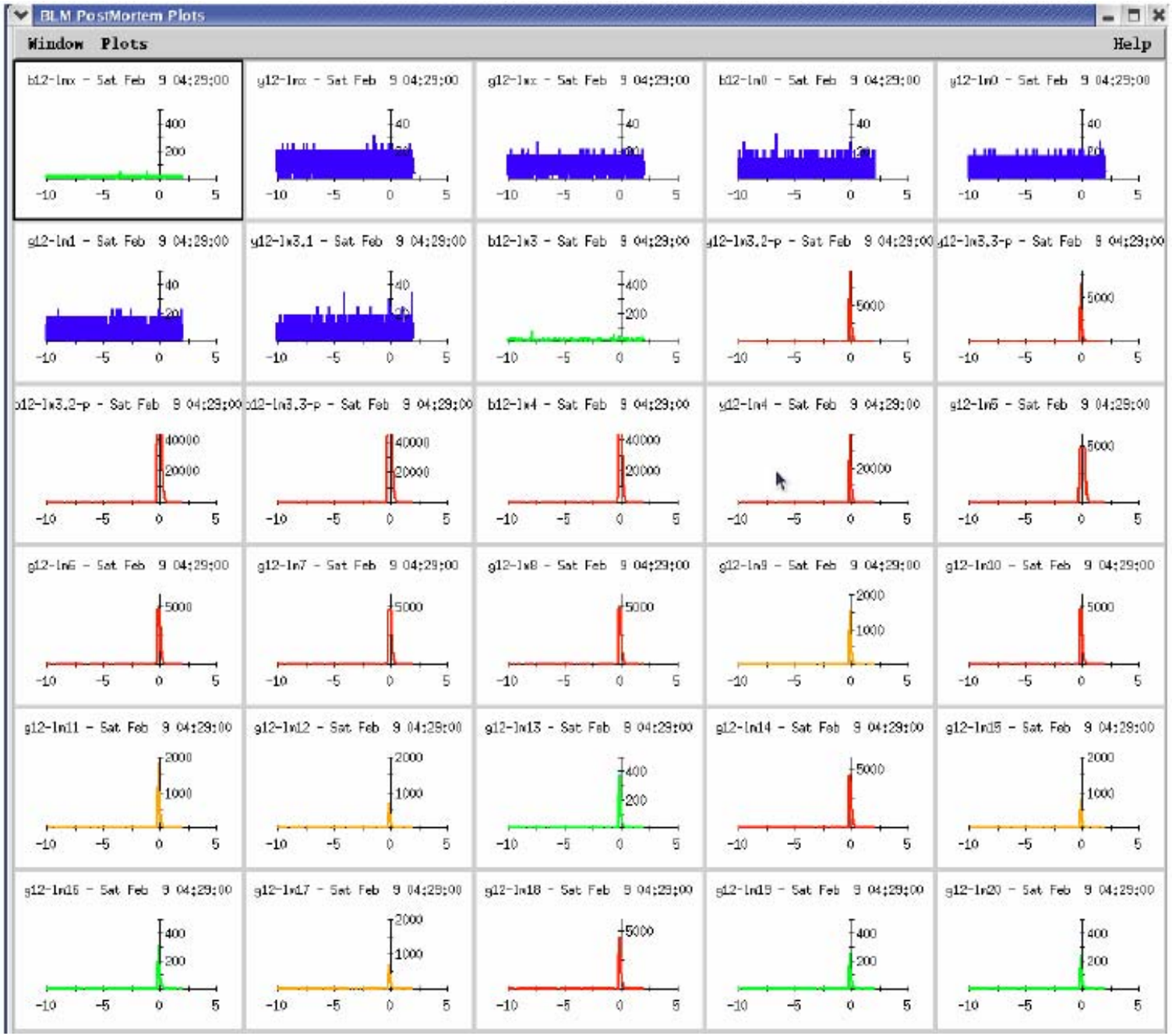
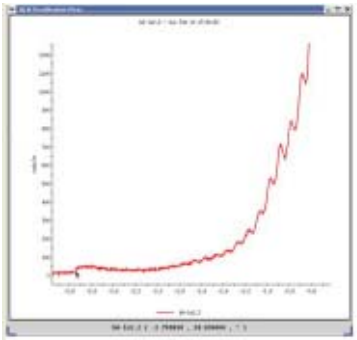


Figure 9: PMViewer PS PostMortem Plots

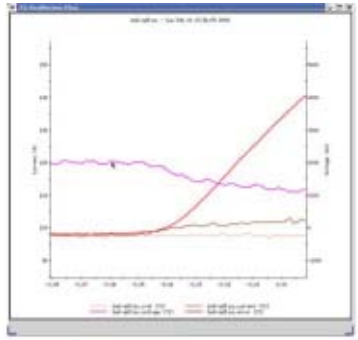



BLM PostMortem Plots
Window Plots
Help
b12-lnx - Sat Feb 9 04:29:00
g12-lnx - Sat Feb 9 04:29:00
g12-lnx - Sat Feb 9 04:29:00
b12-ln0 - Sat Feb 9 04:29:00
g12-ln0 - Sat Feb 9 04:29:00
g12-ln1 - Sat Feb 9 04:29:00
g12-lw3.1 - Sat Feb 9 04:29:00
b12-lw3 - Sat Feb 9 04:29:00
g12-lw3.2-p - Sat Feb 9 04:29:00
g12-lw3.3-p - Sat Feb 9 04:29:00
b12-lw3.2-p - Sat Feb 9 04:29:00
b12-lw3.3-p - Sat Feb 9 04:29:00
b12-lw4 - Sat Feb 9 04:29:00
g12-ln4 - Sat Feb 9 04:29:00
g12-ln5 - Sat Feb 9 04:29:00
g12-ln6 - Sat Feb 9 04:29:00
g12-ln7 - Sat Feb 9 04:29:00
g12-lw8 - Sat Feb 9 04:29:00
g12-ln9 - Sat Feb 9 04:29:00
g12-ln10 - Sat Feb 9 04:29:00
g12-ln11 - Sat Feb 9 04:29:00
g12-lw12 - Sat Feb 9 04:29:00
g12-lw13 - Sat Feb 9 04:29:00
g12-ln14 - Sat Feb 9 04:29:00
g12-ln15 - Sat Feb 9 04:29:00
g12-ln16 - Sat Feb 9 04:29:00
g12-lw17 - Sat Feb 9 04:29:00
g12-lw18 - Sat Feb 9 04:29:00
g12-ln19 - Sat Feb 9 04:29:00
g12-ln20 - Sat Feb 9 04:29:00

QLI Analysis
Quench Link and Permit Link
Timing Illustration



BLM



Power Supply PostMortem

b6-lm2.2, the radiation start rising up 2.734723 sec before the permit link trip

bo6-qd3-ps, the power supply voltage start moving 0.0599722 sec (59.9 ms) before the blue link trip

Time Difference = 2 us

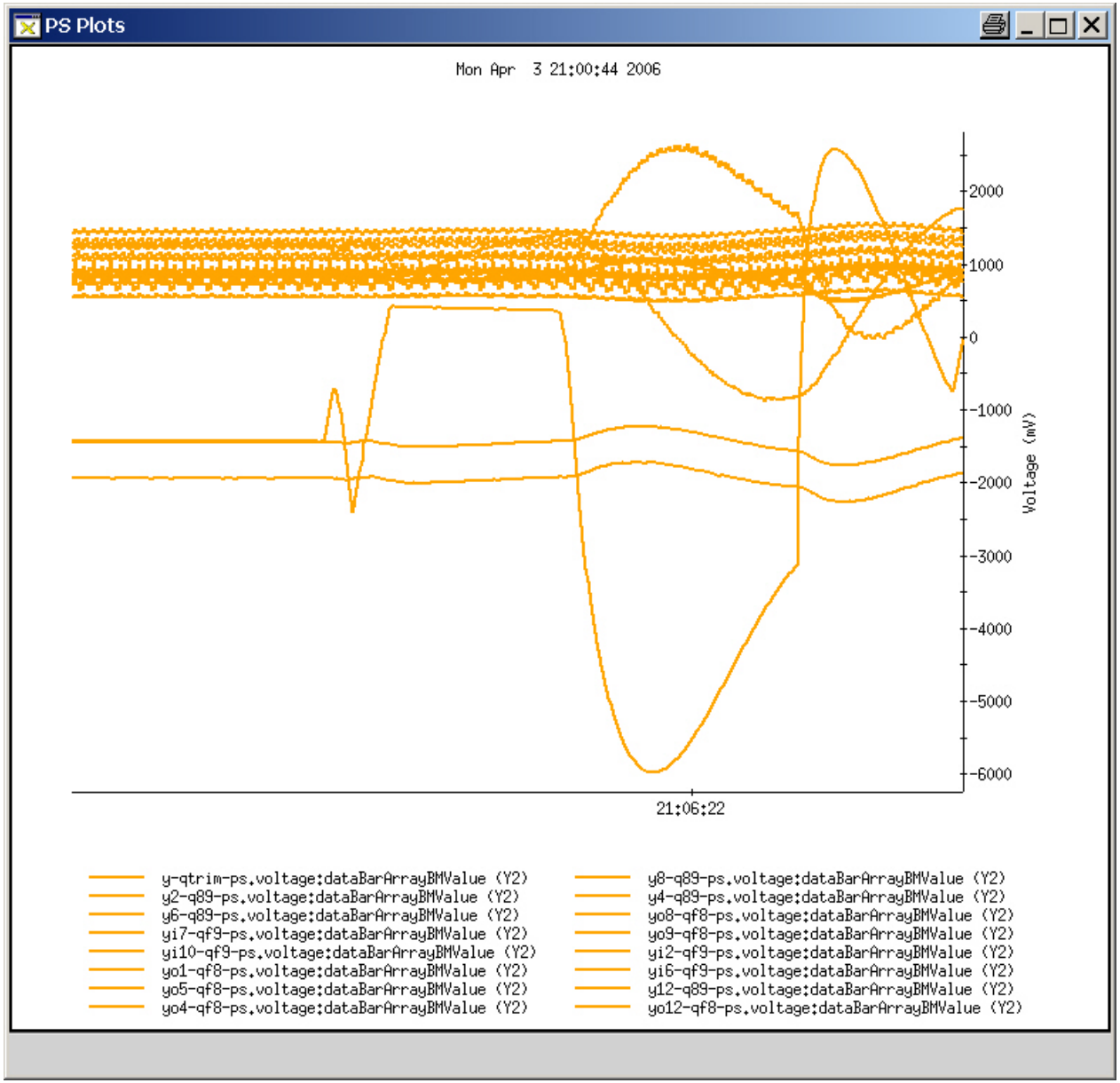
Time Difference = 59.9 ms

Time Difference = 2.734723 s

Time

The Blue link tripped at Sun Feb 10, 2008 17:34:32.008145

The Permit link tripped at Sun Feb 10, 2008 17:34:32.008147


PS Plots
Mon Apr 3 21:00:44 2006
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
Voltage (mV)
21:06:22
y-qtrim-ps.voltage:dataBarArrayBMValue (Y2)
y2-q89-ps.voltage:dataBarArrayBMValue (Y2)
y6-q89-ps.voltage:dataBarArrayBMValue (Y2)
yi7-qf9-ps.voltage:dataBarArrayBMValue (Y2)
yi10-qf9-ps.voltage:dataBarArrayBMValue (Y2)
yo1-qf8-ps.voltage:dataBarArrayBMValue (Y2)
yo5-qf8-ps.voltage:dataBarArrayBMValue (Y2)
yo4-qf8-ps.voltage:dataBarArrayBMValue (Y2)
y8-q89-ps.voltage:dataBarArrayBMValue (Y2)
y4-q89-ps.voltage:dataBarArrayBMValue (Y2)
yo8-qf8-ps.voltage:dataBarArrayBMValue (Y2)
yo9-qf8-ps.voltage:dataBarArrayBMValue (Y2)
yi2-qf9-ps.voltage:dataBarArrayBMValue (Y2)
yi6-qf9-ps.voltage:dataBarArrayBMValue (Y2)
y12-q89-ps.voltage:dataBarArrayBMValue (Y2)
yo12-qf8-ps.voltage:dataBarArrayBMValue (Y2)

Engineers + Technicians

- RHIC PS Group
  - 2 engineers
  - 9 technicians
  - 1 technician supervisor
  - 2 part time engineers
- RHIC Magnet Protection
  - 2 part time engineers
- Booster/AGS Power Supply Group (**341 p.s.'s – breakdown at the end**)
  - 4 engineers
  - 12 technicians (4 are Motor Generator Operators)
  - 1 technician supervisor
- Pulsed Power Group (RHIC + AGS) (~ 50 p.s.'s)
  - 4 engineers
  - 4 technicians
- Collider Accelerator Support (CAS), First Responders
  - 1 technician supervisor
  - 12 technicians (always 2 on site when RHIC is running – shift work)
- Total = 12 engineers, 3 tech supervisors, 25 technicians

How to Speed up Repair/Replace Time

- More training for CAS
- Make it easier to swap out unipolar rack mounted ps's
- Have a spare stand alone ps in each bldg?
- Improve automatic quench Link analysis program
- Building 2 Instrumentation set ups so it won't take a day to connect 4 scopes when we have an intermittent problem.
  - One setup has 100kHz acquisition rate, 16 bit simultaneous sample and hold, 32 channels
  - Another setup uses Analog Devices 5B-01 modules with a National Instrument Data Acquisition box (NI PCI-6254), 10kHz acquisition rate, scanning. Labview, 32 channels
- Fan Trays for quench detectors

Hardware Problems/Improvements

Bipolar 50A

Run	Corrector ps's Replaced
3	60
4	25
5	10
6	6
7	4
8	2

Bipolar 50A ps

- Installed A/C in alcoves
- Tightened AC and DC connections
- Removed 620 correctors 3 separate times for modifications
- Installed parking circuit for current regulator
- 2.5V Ref for OvTmp and quench circuit fixed
- Off trips
  - Replaced micro to ignore OFF pb in remote
- Modified SCR crowbar firing circuit
  - Noise would get in and cause it to fire
- Unexplained Error Trips
  - Problem was dcct card and undervoltage circuit

Unipolar PS Problems

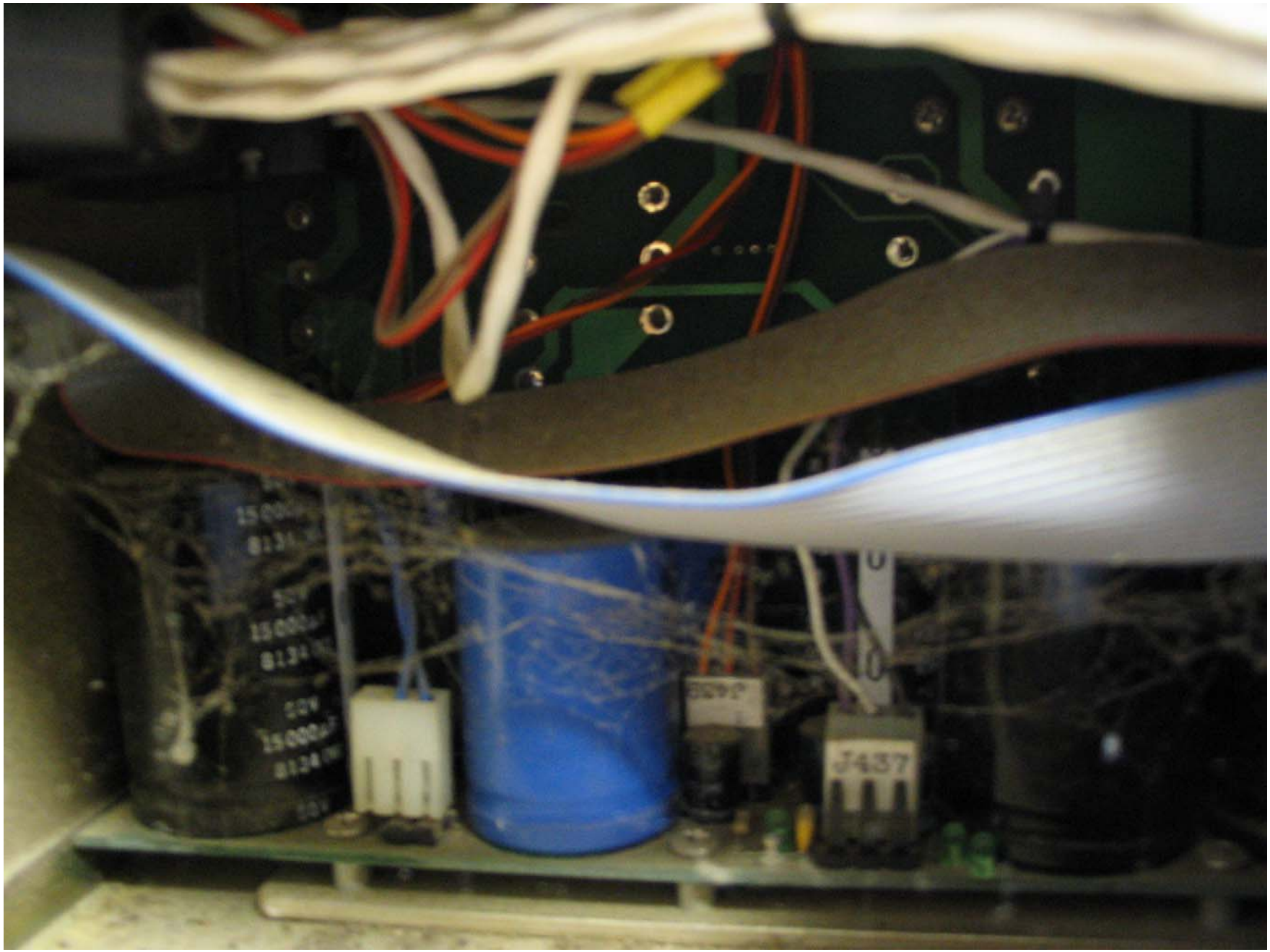
- Voltage Reg card unstable with load, needed to modify board
- Firing card problems, modified board
- ZFCT card output valid signal failed during big temperature swings, Manufacturer recommended a fix.
- 3 channel iso amp board output buffer driver marginally stable. Being replaced this shutdown
- HKPS 208Vac connection problems
- On status relay problems
- Current regulator card relay problems (all RHIC IR ps)
- Added MOV across solid state relay that controlled contactor
- Converted Error and AC phase faults to warnings

Bipolar 150A and 300A, before Run 7

- 12V contactor coil problem
- LEM installed incorrectly
- PS ON status relay
- Installed IGBT Soft start delay circuit
- Insulated screws that caused ps to fail hi-pot
- Converter board 208Vac connections
- Install bolt in one bus connection that was stressed during ps cable connections
- Converted Error, AC phase and FET faults to warnings

Bipolar 150A and 300A after Run 7

- Checking all connections
  - Spraying connections with DeOxit
  - Using Torque wrench on bus connections, adding Penetrox
- **Adding fans to improve cooling (90C FET's/chips to 50C with ambient 40C)**
- Adding LEMS on 300's to monitor both converters
- Replacing backplanes on some ps's
- Replacing rusted hardware
- **Cleaning dirt, from inside of supplies**
- Replacing FET drive connector with box style molex connector
- Replacing Converter Board Drive Connectors with box style molex
- Reducing Converter enable signal noise.
- Checking Circuit breaker is correct rating
- **Adding FET monitoring**, Next:
    - FET Warning
    - FET current limiting
    - FET automatic current balancing


J437


35 V
35 V

IR Quench Protection Assemblies

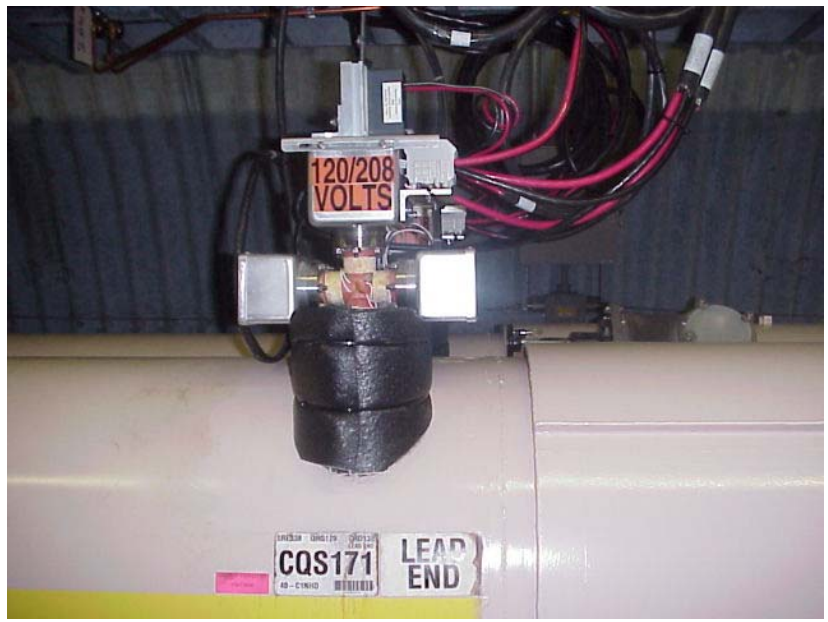
- IGBT driver card power failure problem
- Control card transformer problems
- Smaller energy extraction R for bipoalr 300A qpa's - reduce power dissipation
- False Fan Faults
  - Used ac switch for dc switch application
  - New Fan Switch Circuit with an ac switch
  - Fan warning, instead of Fan Fault

Main Power Supplies

- DCCT programming plug connector problem
- Snubber Capacitor touching ground
- PFN faults due to:
  - poorly crimped wire
  - Relay which failed
  - high humidity and cracked insulation on the PFN HV cable
- Serial link card corrupted setpoints
- Rusted Hardware in OCC
- REG DCCT faults
- Flex I/O module 24V dropout
- DCCT fan failures

Ice Balls

- Heaters would fail and we would not know it until we added temperature sensors.
- Added better insulation, correct klixons, one wire temperature sensors.

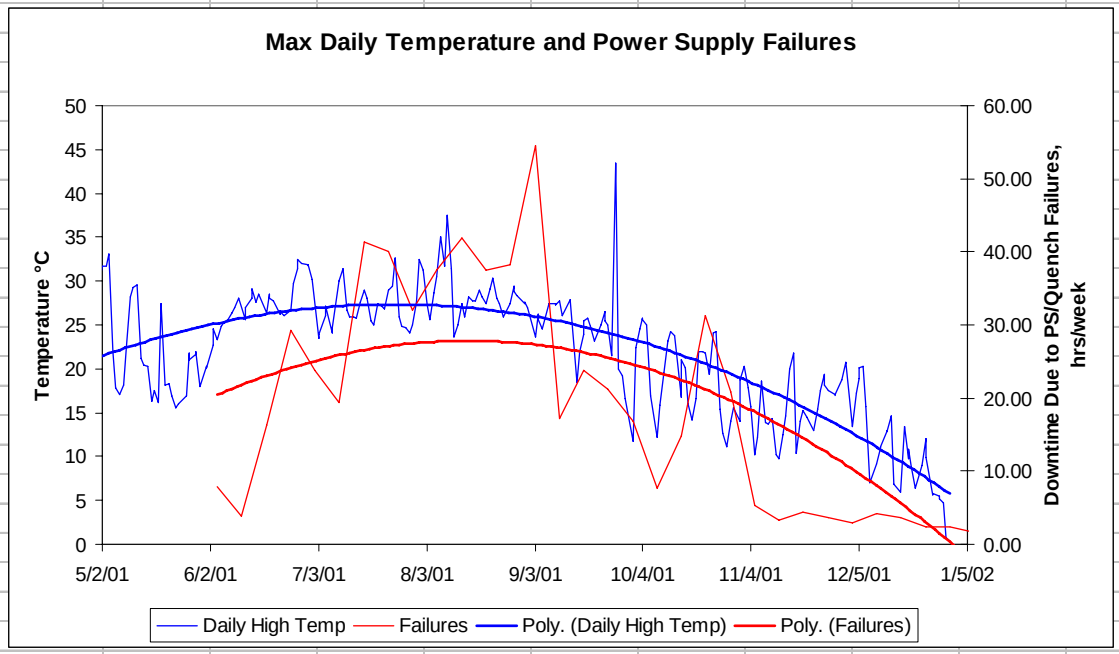


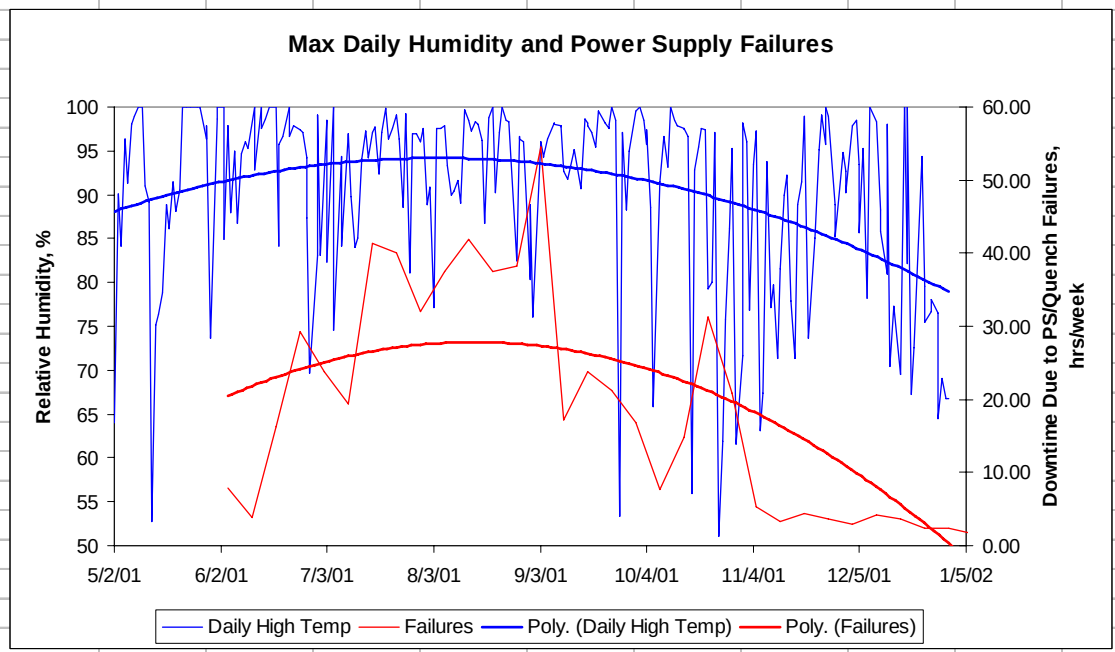
Some PS Diagnostic Software tools

- PSALL
- TAPE (scripts) used for bringing turning on ps's that are part of a link or that are connected to a quench detector
- PostMortem Viewer (PS's on the link)
- Snapshot (PS's on and off the link)
- SnapRamp
- Barshow replaced by psCompare
- Qdplot (pc based)
- Alarm Log
- E-Log Automatic Quench Link Analysis Program (still improving)
- Ramp Designer and psCompare used for Start up.
- Quench Summary page from Day 1
  - Timing Resolver after Run 3

Environmental Problems

- Temperature, Humidity, Dirt
  - Adding Air Conditioning
  - Cleaning ps's (150's and 300's)
  - Cleaning Quench detectors
- Added Transient suppressors to service bldg 208VAC and 480VAC panels


Max Daily Temperature and Power Supply Failures
Temperature °C
Downtime Due to PS/Quench Failures, hrs/week
50
45
40
35
30
25
20
15
10
5
0
60.00
50.00
40.00
30.00
20.00
10.00
0.00
5/2/01
6/2/01
7/3/01
8/3/01
9/3/01
10/4/01
11/4/01
12/5/01
1/5/02
Daily High Temp
Failures
Poly. (Daily High Temp)
Poly. (Failures)


Max Daily Humidity and Power Supply Failures
Relative Humidity, %
Downtime Due to PS/Quench Failures, hrs/week
100
95
90
85
80
75
70
65
60
55
50
60.00
50.00
40.00
30.00
20.00
10.00
0.00
5/2/01
6/2/01
7/3/01
8/3/01
9/3/01
10/4/01
11/4/01
12/5/01
1/5/02
Daily High Temp
Failures
Poly. (Daily High Temp)
Poly. (Failures)

Start Up Software Improvements

- Automatic program to run up correctors
- Automatic program for IR polarity checks
- Automatic program for shutoffs.
- Automatic program to look at ground currents.

More Reliable Power Converters

- Yearly maintenance on all connections (torque wrenches)
- PS Link Boxes
- More space for ps's
  - RHIC stand alone IR ps's installed against one another
  - Bipolar 150A and 300A very tight package, difficult to work on
- Control the environment
  - Air Conditioning or go with water cooling
- If it must be a custom ps choose a manufacturer with a good ps history
- Choose reliable sealed Connectors
  - no spring type such as molex or at least get box style molex
- Commercial ps in voltage mode with our current regulator and Danfysik or Holec DCCT around it.
  - Snake and Rotator ps's
  - Sextupole 2 ps's
  - AGS Cold Snake ps's

Questions

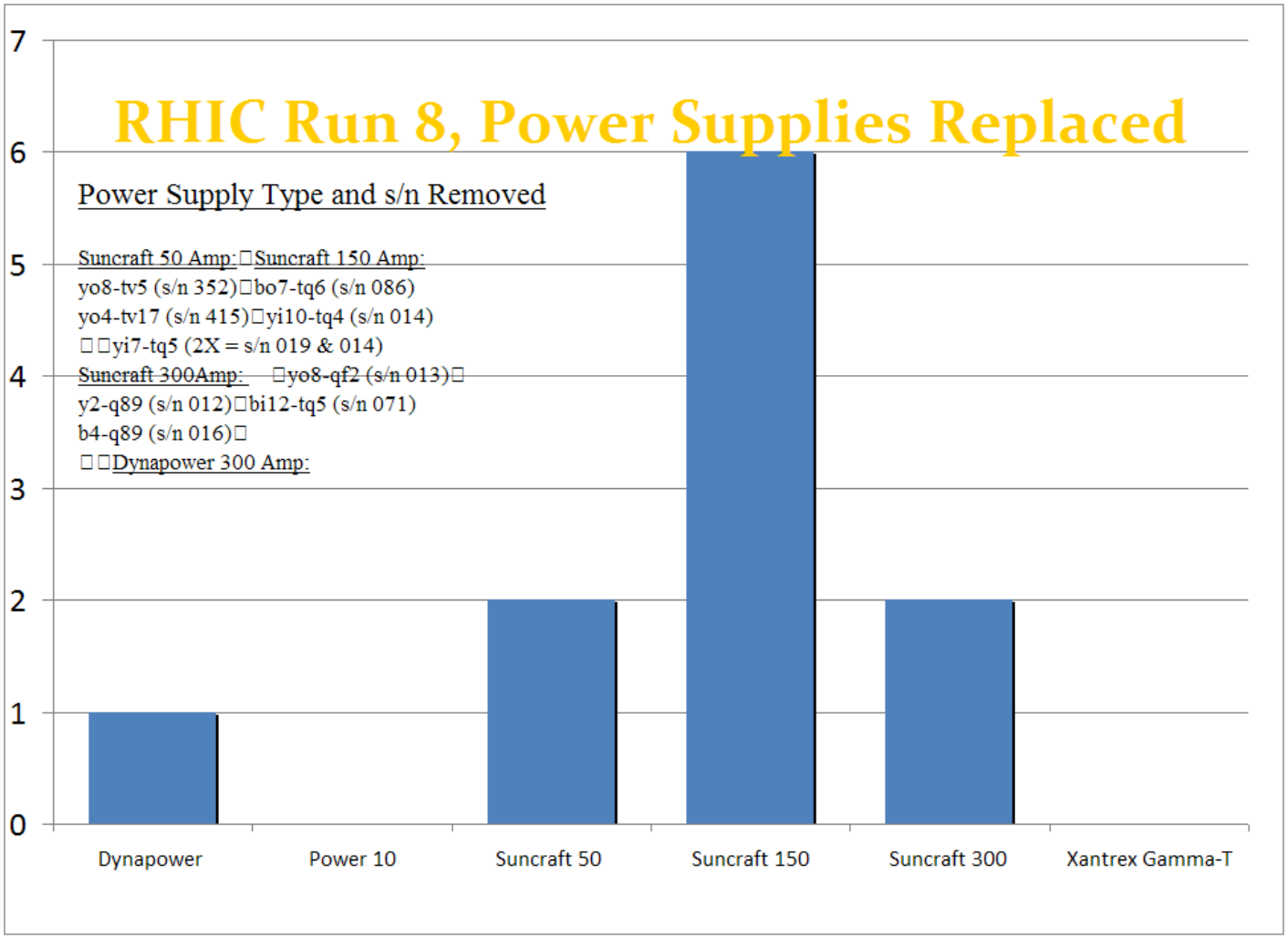
- Can we all use the same method for MTBF?
- What does anyone else do about connection problems, does anyone use a chemical? Does anyone else do yearly maintenance with torque wrenches?
- What does everyone else do about tracking down intermittent problems (instrumentation setups?)

End

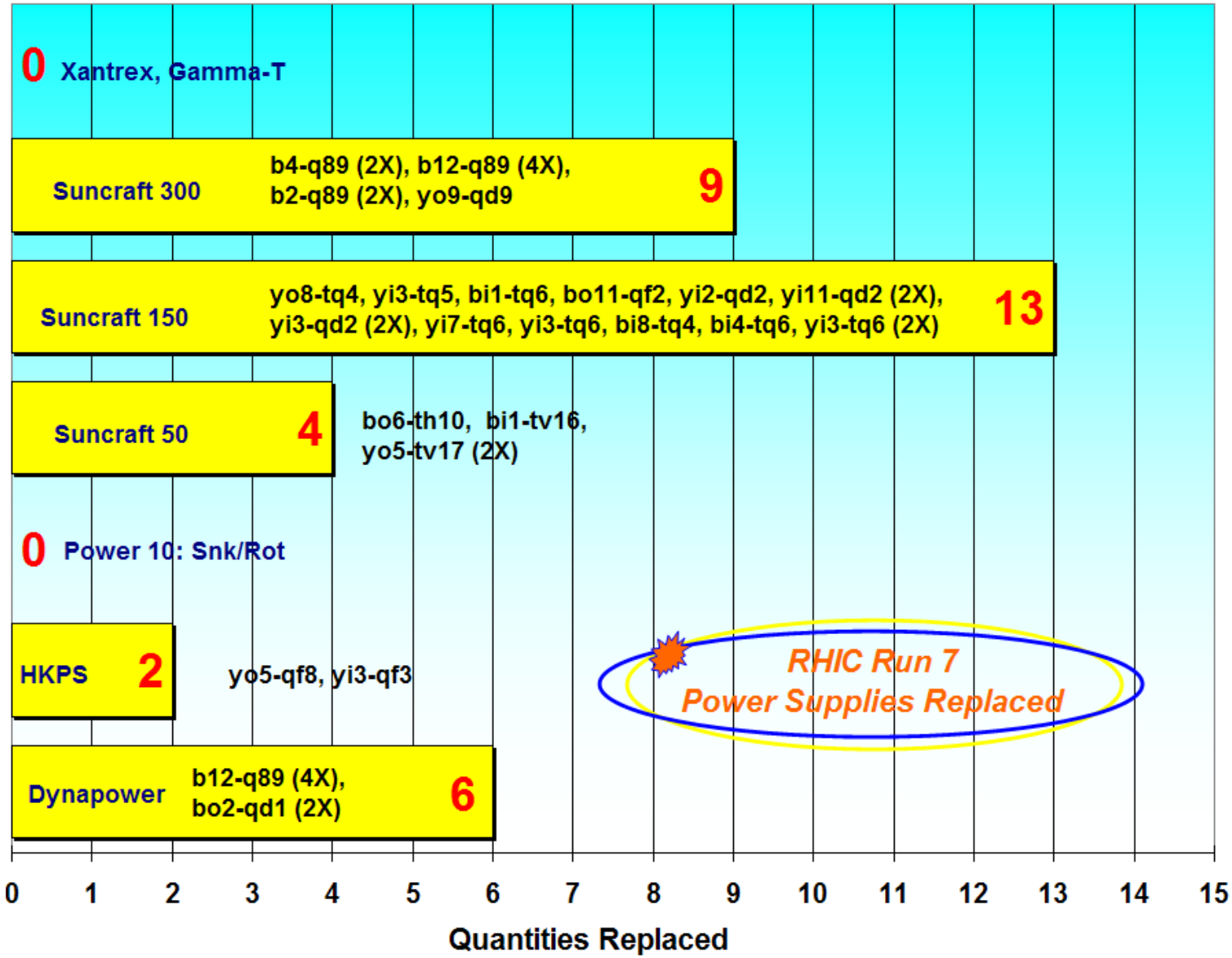
There are extra slides if needed

Extra Slides if Needed

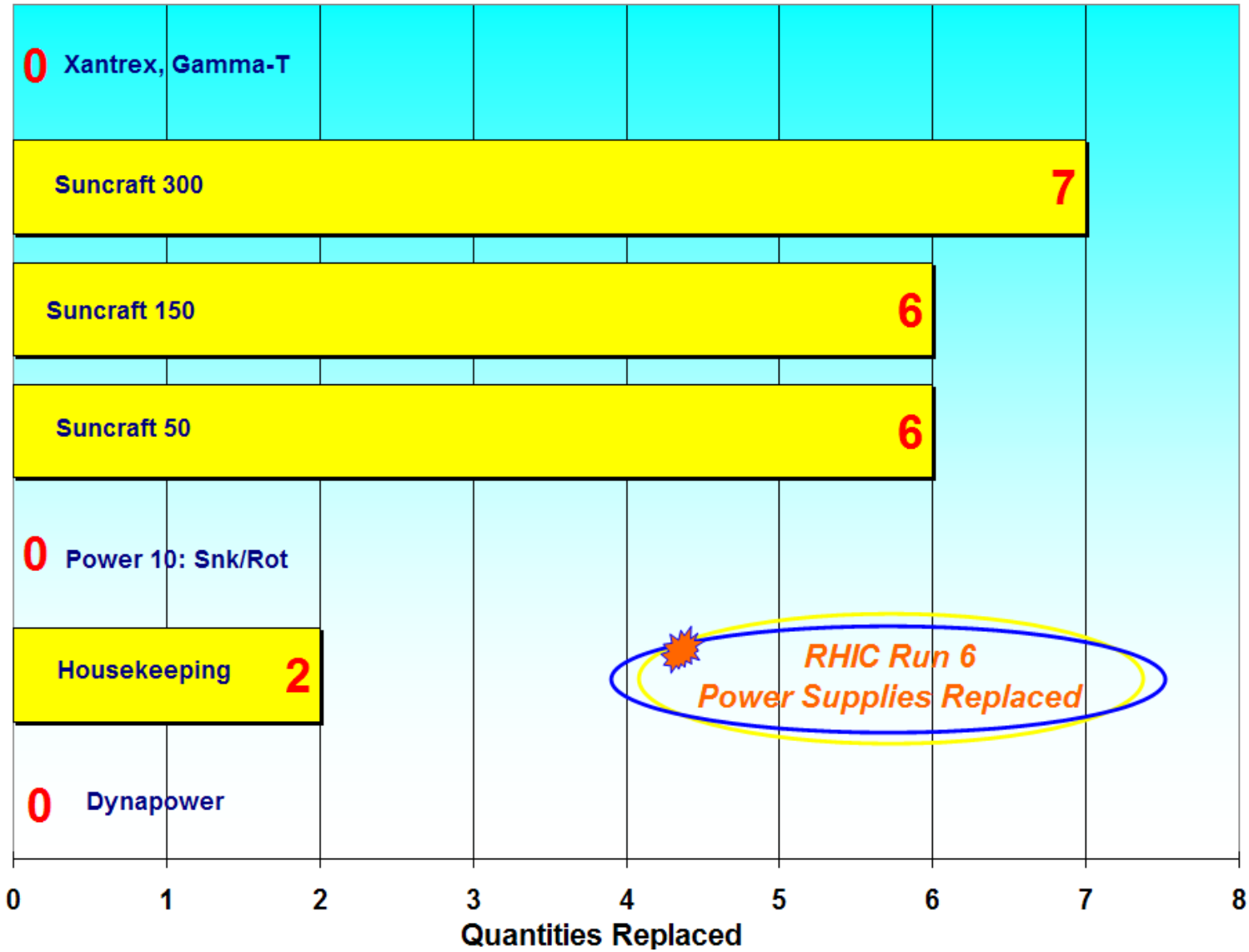
Charts and QLI examples



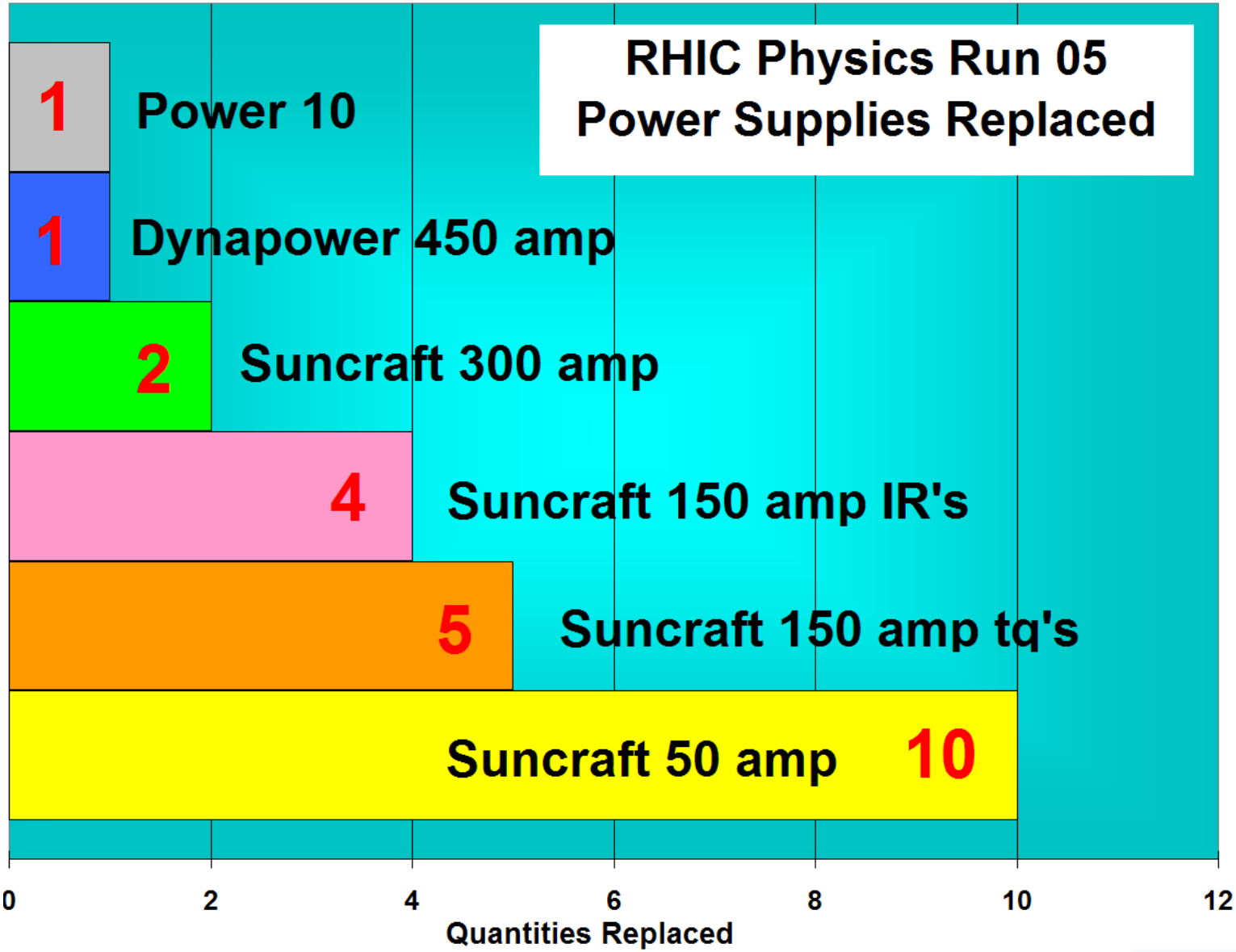
11 power supplies replaced



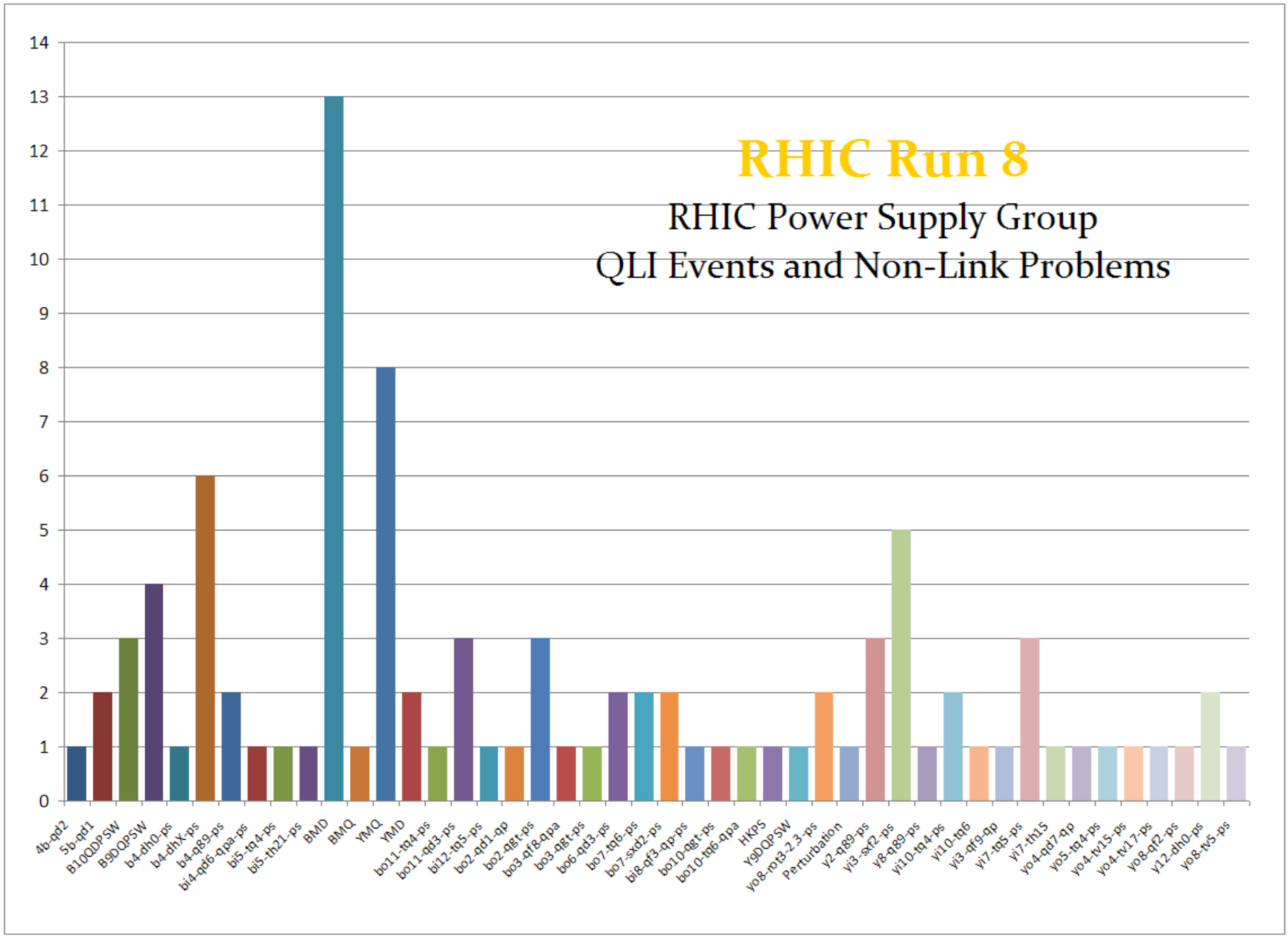
34 power supplies replaced

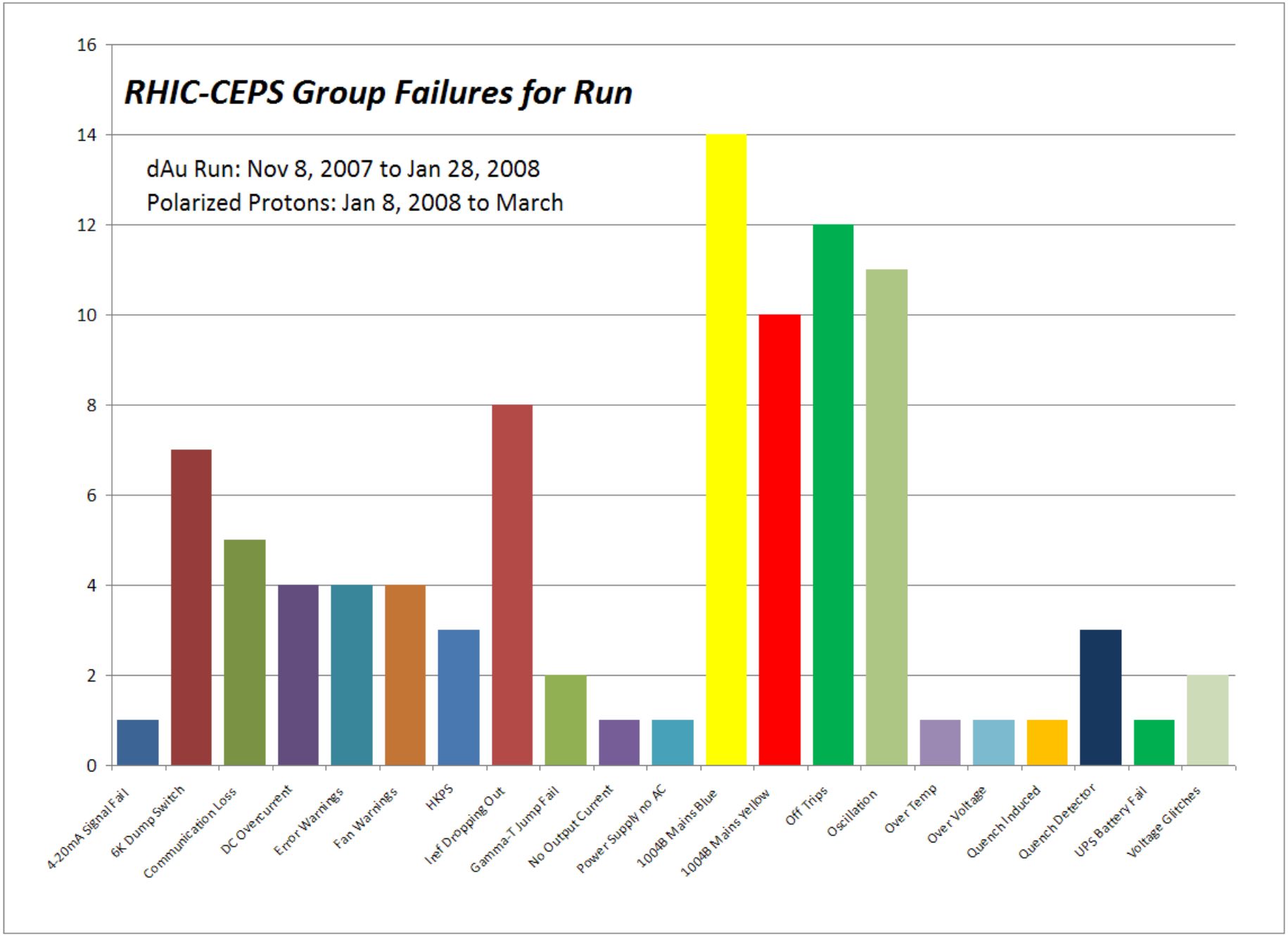


21 power supplies replaced



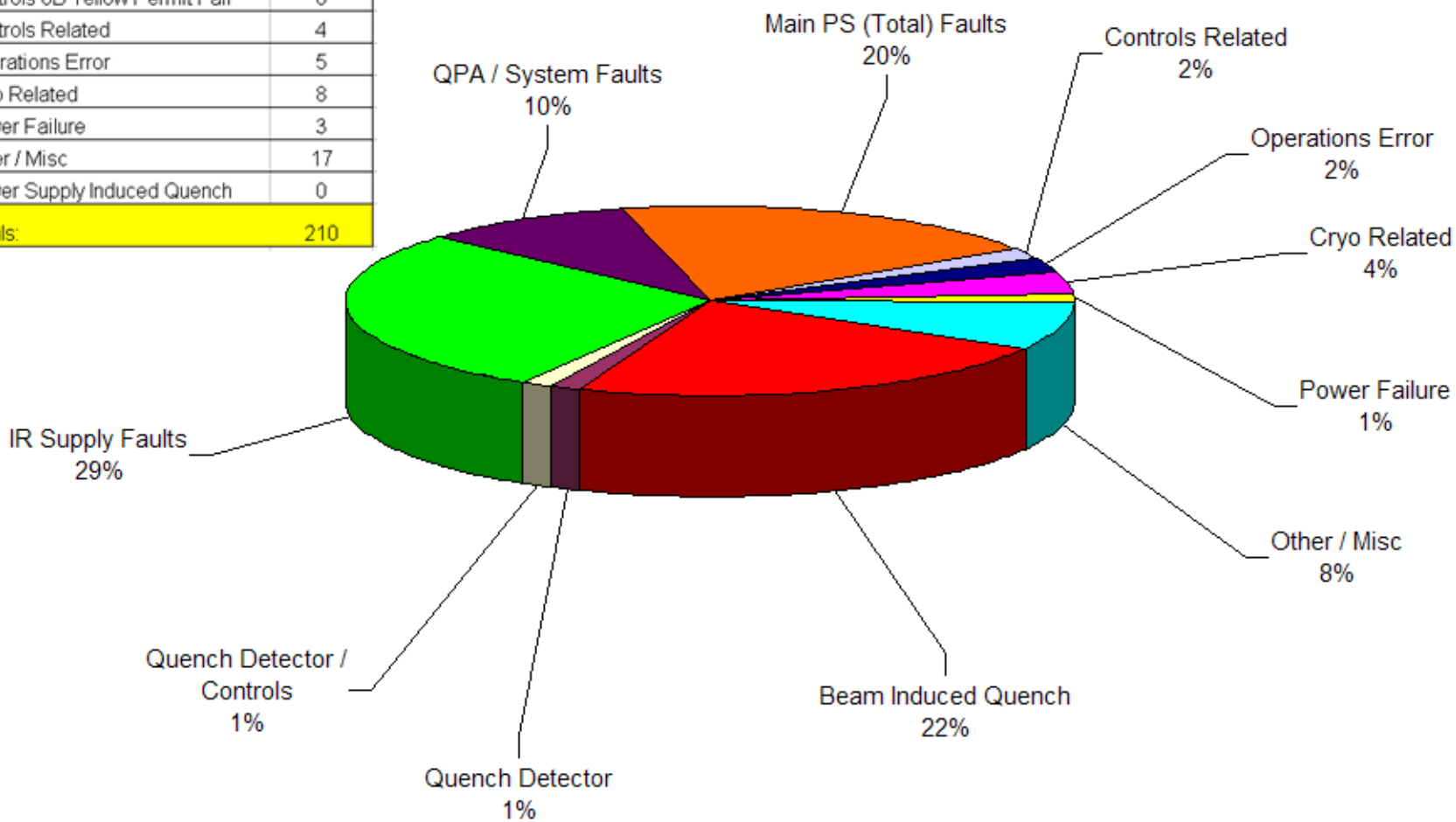
23 power supplies replaced

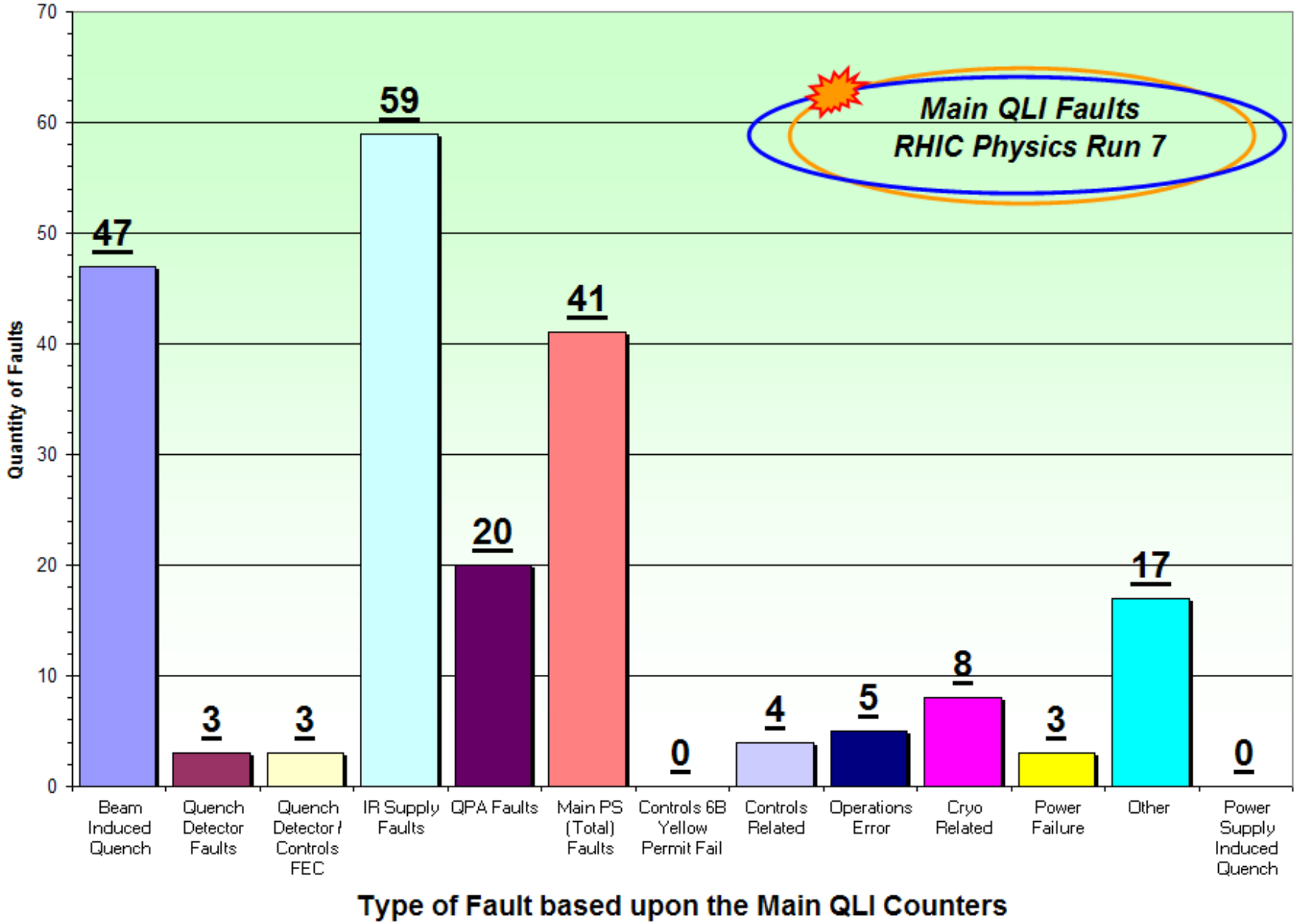

RHIC Run 8
RHIC Power Supply Group
QLI Events and Non-Link Problems
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
4b-qd2
5b-qd1
B10QDPSW
B9DQPSW
b4-dh0-ps
b4-dhX-ps
b4-qd89-ps
bi4-qd6-qpa-ps
bi5-tq4-ps
bi5-th21-ps
BMD
BMQ
YMQ
YMD
bo11-tq4-ps
bo11-qd3-ps
bi12-tq5-ps
bo2-qd1-qp
bo2-qgt-ps
bo3-qf8-qpa
bo3-qgt-ps
bo6-qd3-ps
bo7-tq6-ps
bo7-sxd2-ps
bi8-qf3-qp-ps
bo10-qgt-ps
bo10-tq6-qpa
HKPS
YgDQPSW
yo8-no13-2_3-ps
Perturbation
y2-q89-ps
yi3-sxf2-ps
y8-q89-ps
yi10-tq4-ps
yi10-tq6
yi3-qf9-qp
yi7-tq5-ps
yi7-th15
yo4-qd7-qp
yo5-tq4-ps
yo4-tv15-ps
yo4-tv17-ps
yo8-qf2-ps
y12-dh0-ps
yo8-tv5-ps


RHIC-CEPS Group Failures for Run
dAu Run: Nov 8, 2007 to Jan 28, 2008
Polarized Protons: Jan 8, 2008 to March
16
14
12
10
8
6
4
2
0
4-20mA Signal Fail
6K Dump Switch
Communication Loss
DC Overcurrent
Error Warnings
Fan Warnings
HKPS
Ref Dropping Out
Gamma-T Jump Fail
No Output Current
Power Supply no AC
1004B Mains Blue
1004B Mains Yellow
Off Trips
Oscillation
Over Temp
Over Voltage
Quench Induced
Quench Detector
UPS Battery Fail
Voltage Glitches

Main QLI Fault Counters	Qty
Beam Induced Quench	47
Quench Detector	3
Quench Detector / Controls	3
IR Supply Faults	59
QPA / System Faults	20
Main PS (Total) Faults	41
Controls 6B Yellow Permit Fail	0
Controls Related	4
Operations Error	5
Cryo Related	8
Power Failure	3
Other / Misc	17
Power Supply Induced Quench	0
Totals:	210

QLI Events - RHIC Run 7

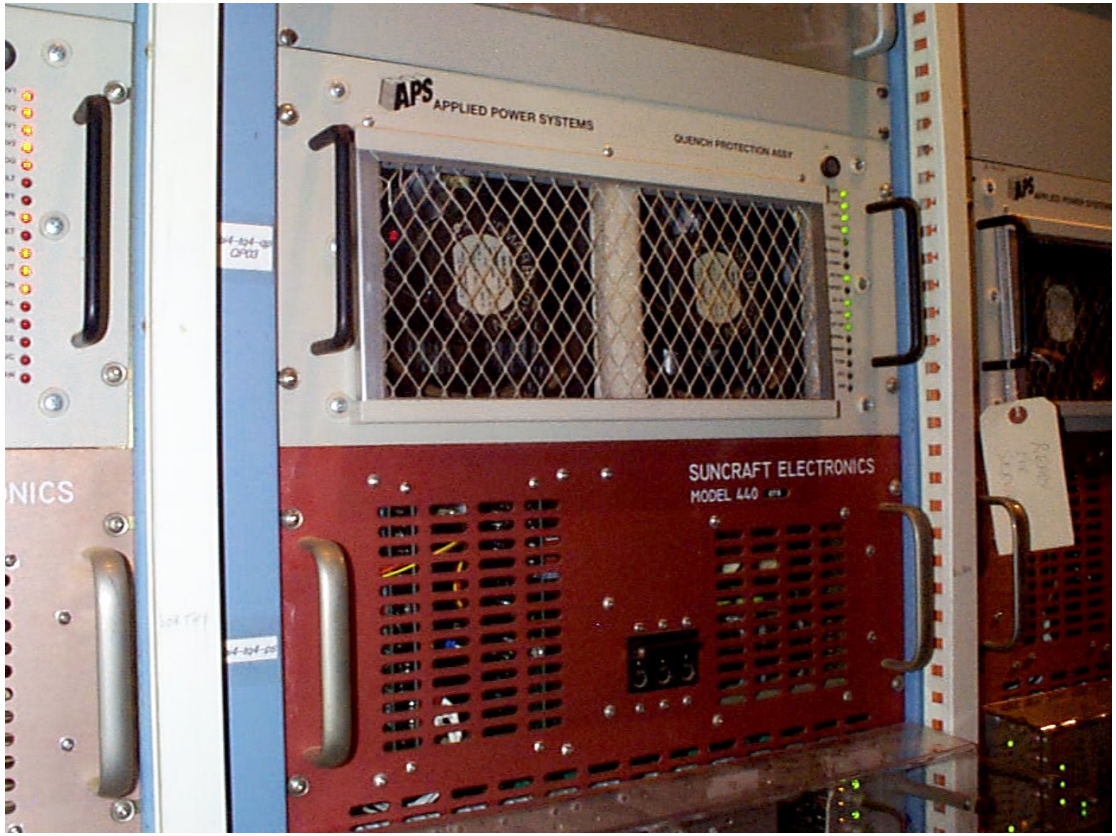


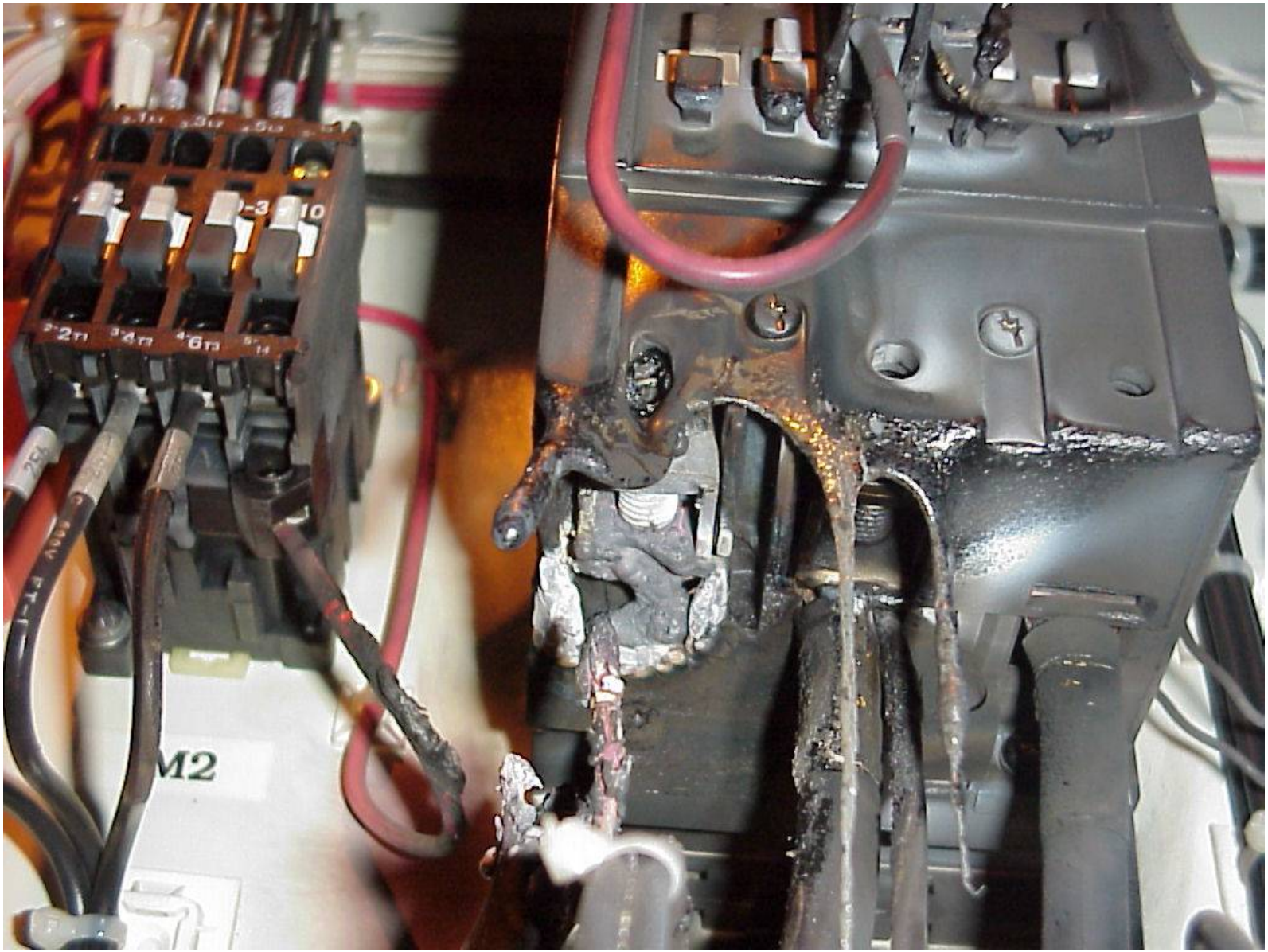

Main QLI Faults
RHIC Physics Run 7
Quantity of Faults
70
60
50
40
30
20
10
0
47
3
3
59
20
41
0
4
5
8
3
17
0
Beam Induced Quench
Quench Detector Faults
Quench Detector / Controls FEC
IR Supply Faults
QPA Faults
Main PS (Total) Faults
Controls 6B Yellow Permit Fail
Controls Related
Operations Error
Cryo Related
Power Failure
Other
Power Supply Induced Quench
Type of Fault based upon the Main QLI Counters

Web Pages

- Collider Electrical PS Group Website
  - http://www.c-ad.bnl.gov/ceps/
- RHIC Configuration Manual
  - http://www.c-ad.bnl.gov/Accel/RCM_TOC.htm


TRONICS
TRONICS
OK TO USE


APS
APPLIED POWER SYSTEMS
QUENCH PROTECTION ASSY
SUNCRAFT ELECTRONICS
MODEL 440



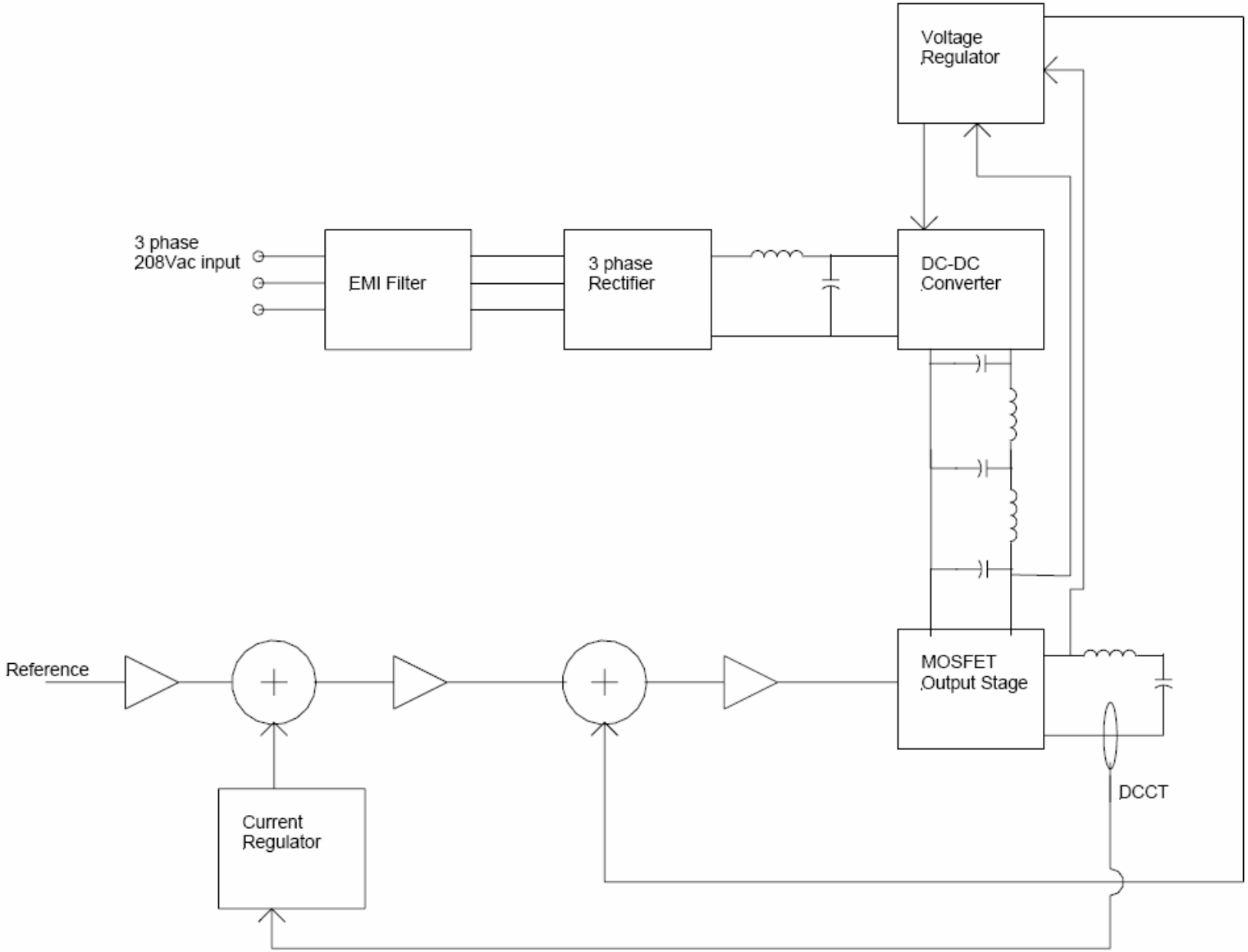


Fig. 2-20 RHIC Bipolar Power Supply Simplified Block Diagram

Species in RHIC

- Run 8 d-Au
- Run 7 Au-Au
- Run 6 p-p, last 3 weeks high current pp
- Run 5 Cu-Au
- Run 4 Au-Au

AGS/Booster/Experimental Power Supplies

Total 341

Ioannis Marneris
Brookhaven Labs

Date: May 10th 2008

SIEMENS MG SET

Westinghouse MG Set

Booster Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
BOOSTER CORRECTORS	930A	+/-25V@+/-25A	28	BNL
BOOSTER CORRECTORS	930A	+/-25V@+/-50A	8	BNL
BOOSTER CORRECTORS	930A	+/-50V@+/-50A	4	BNL
BOOSTER CORRECTORS	930A	+/-10V@ +/-20A	8	INVERPOWER
BMMPS	930A	5000A,@+/-2000V	1	MACRO-AMP
		OR 3000A@+/-6000V		
H-SEXT. V-SEXT (MAIN)	930A	150V@350A	2	DYNAPOWER
ACTIVE FILTER	930A	+/-125V@+/-700A	1	INVERPOWER
D3 SEPTUM	930A	13V @ 2000A	1	ALPHA
D6 SEPTUM	930A	36V @ 5500A	1	ALPHA
D6 CORRECTOR	930A	10V, 100A	1	LAMBDA EMI

Booster Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
LTB STEERES(CORRECTOS)	930UEB	+/-25V@+/-25A	7	BNL
SPARE CORRECTOR IN RK 4607	930UEB	+/-25V@+/-25A	1	BNL
LTB STEERES(CORRECTOS)	930UEB	+/-15V@+/-50A	3	BNL
SPARE CORRECTOR	930UEB	+/-15V@+/-50A	1	BNL
LTB DIPOLE DH1	930UEB	75V @ 1000A	1	BNL/PPA
LTB DIPOLE DH2-5	930UEB	75V @ 1500A	1	BNL/PPA
LTB QUADS	930UEB	15V @ 300A	14	EMI
F8,B4, & C8,E4 SEXTUPLES	930UEB	+/- 40V@+/-600A	2	INVERPOWER
H&V-QUADS	930UEB	600V @ 250A	2	INVERPOWER
DUMP BUMP,BLW'S	930UEB	+/- 40V@+/-600A	6	DANFYSIK
DUMP BUMP,BLW'S	930UEB	+/- 40V@+/-600A	1	DANFYSIK

Booster Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
BOOSTER CORRECTORS	914	+/-40V @ +/-25A	24	BNL
BOOSTER CORRECTORS	914	+/-40V @ +/-15A	6	BNL
SPARE CORRECTOR	914	+/-40V @ +/-15A	1	BNL
SPARE CORRECTOR	914	+/-40V @ +/-15A	1	BNL
BOOSTER CORRECTORS	914	+/- 10V @ +/- 20A	3	INVERPOWER
CORRECTOR SPARE	914	+/- 10V @ +/- 20A	1	INVERPOWER
DH1	914	35V@700A	1	INVERPOWER
DH2&3	914	20V@5000A	1	MEEKER
QV5,QH6,QV7	914	75V @ 1500A	3	BNL/PPA
QH2A&2B,QV1,QV2,QH4	914	75V @ 1000A	4	BNL/PPA

Booster Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
QH8,QV15	L18A	30V@500A	2	INVERPOWER
QV9,QH10,QH12	L18A	35V@700A	3	INVERPOWER
SPARE POWER SUPPLY	918 WH	35V@700A	1	INVERPOWER
QV11,DH4	L18A	40V@300A	2	INVERPOWER
QV13,QH14	L18A	75V@1000A	2	BNL/PPA
DH5	L18A	75V@1000A	1	BNL/PPA
TOTAL BOOSTER POWER SUPPLIES			**150**	

AGS Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
AGS CORRECTORS	E10HOUSE	+/-40V @ +/-25 A	32	ITECO
AGS CORRECTORS	E10HOUSE	+/-50V @ +/-25 A	5	ITECO
E20 WARM SNAKE	E10HOUSE	+/-300V @ 3000 A	1	ACME
AGS CORRECTORS	A10HOUSE	+/-40V @ +/-25 A	32	ITECO
AGS CORRECTORS	A10HOUSE	+/-50V @ +/-25 A	4	ITECO
A20 BLW	A10HOUSE	+/-50V @ +/-90 A	1	ITECO
B2,B4,B5,5 BLW	A10HOUSE	+/-75V @ +/-40 A	1	DANFYSIK
A16,A17,A18,A19 BLW	A10HOUSE	+/-75V @ +/-60 A	1	DANFYSIK
SPARE DANFYSIK CORRECTORS		+/-35V@+/-20A	2	DANFYSIK
AGS CORRECTORS	H10HOUSE	+/-40V @ +/-25 A	32	ITECO
AGS CORRECTORS	H10HOUSE	+/-50V @ +/-25 A	5	ITECO
SPARE AGS CORRECTORS		+/-50V @ +/-25 A	10	ITECO

AGS Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
AGS MMPS RECTIFIERS	928	+/-9500V @ 5500 A	1	SIEMENS
SIEMENS CYCLOCONVERTER	928	+/-270V@+/-1600A	1	SIEMENS
SIEMENS EXCITER	928	+/-300V@+/-1400A	1	SIEMENS
SIEMENS BRAKE PS	928	75V @ 300 A	1	SIEMENS
AGS MMPS MOTOR/GENERATOR	928	MOT. 9MW, GEN.50MVA	1	SIEMENS
AGS ACTIVE FILTER	928	+/-170V@+/-700A	1	INVERPOWER
A17 TUNE QUAD	B18	+/-40V @ 600 A	1	DANFYSIK
B3 PP QUAD	B18	+/-20V @ 2000 A	1	DYNAPOWER
B13 SEXTUPLE	B18		1	BNL
A19 NEW QUAD	C18	+/-80V @ 500 A	1	PEI
B1 NEW QUAD	C18	+/-125V@+/-700A	1	INVERPOWER

AGS Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
J10 DUMP	J18	+/-200V @ 1000 A	1	BNL
DYNAMIC SEXTUPLE PS	F10	+/-80V @ 500 A	1	PEI
E17 TUNE QUAD PS	F10	+/-80V @ 500 A	1	PEI
F20PBLW PS	F10	+/-80V @ 500 A	1	PEI
F1 & E19 NEW QUADS	F10	+/-300V @ 500 A	1	ACME
F3 PP-TUNE QUAD PS	F10	+/-300V @ 500 A	1	ACME
F13 SEXTUPLE	F10	25V @ 100 A	1	BNL
F10 SEPTUM PS	F10	35V @ 5000 A	1	MEEKER
F5 SEPTUM PS	F10	+/-18V @ 2500 A	1	DYNAPOWER

AGS Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
WEST. MOTOR-GENERATOR	911W	MOT. 4MW, GEN.35MVA	1	WESTINGHOUSE
WESTINGHOUSE BRAKE PS	911W	65V @ 300 A	1	DANFYSIK
WESTINGHOUSE EXCITER PS	911W	+/-200V @ 1000 A	1	BNL
WEST. LIQUID RHEOSTAT	911W		1	BNL
V&H- TUNE QUAD PS'S	911MULT.RM	+/-170V@+/-700A	2	INVERPOWER
SKEW QUAD PS	911MULT.RM	+/-80V @ 500 A	1	PEI
V-SEXTUPLE PS	911MULT.RM	+/-170V@+/-700A	1	INVERPOWER
F20 BUMP	911MULT.RM	+/-300V @ 500 A	1	ACME
G20 BUMP	911MULT.RM	+/-300V @ 500 A	1	ACME
H-SEXTUPLE PS	911MULT.RM	+/-300V@+/-600A	1	I E POWER

TOTAL AGS POWER SUPPLIES **157**

NSRL Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
RQ1,2,3,4,5	957	40V @ 1250A	5	DANFYSIK
RD1,2	957	220V @ 3200A	1	DANFYSIK
RQ6,7,8, OCT1, OCT2	957	70V @ 2500A	5	DANFYSIK
DIPOLE TRIM SUPPLIES	957	20V @ 460A	8	DANFYSIK
RP11.RD13	957	+/-35V@+/-60A	2	DANFYSIK
SPARE DANFYSIK CORRECTORS		+/-35V@+/-20A	2	DANFYSIK

TOTAL NSRL POWER SUPPLIES **23**

Experimental Power Supplies

PS CATEGORY	BLDG	PS RATING	QUANTITY	MANUFACTURER
STAR MAIN	1006C	990V @ 5000A	1	MACROAMP
SPACE TRIM EAST,WEST	1006C	50V @ 600A	2	INVERPOWER
POLE TIP EAST, WEST	1006C	140V @ 2000A	2	MACROAMP
PHOENIX MUON NORTH	1008B	120V @ 3800A	2	INVERPOWER
PHOENIX MUON SOUTH	1008B	200V @ 3000A	2	INVERPOWER
PHOENIX CENTRAL INNER	1008B	400V @ 2000A	1	INVERPOWER
PHOENIX CENTRAL OUTER	1008B	200V @ 3000A	1	INVERPOWER

TOTAL EXPERIMENTAL POWER SUPPLIES