

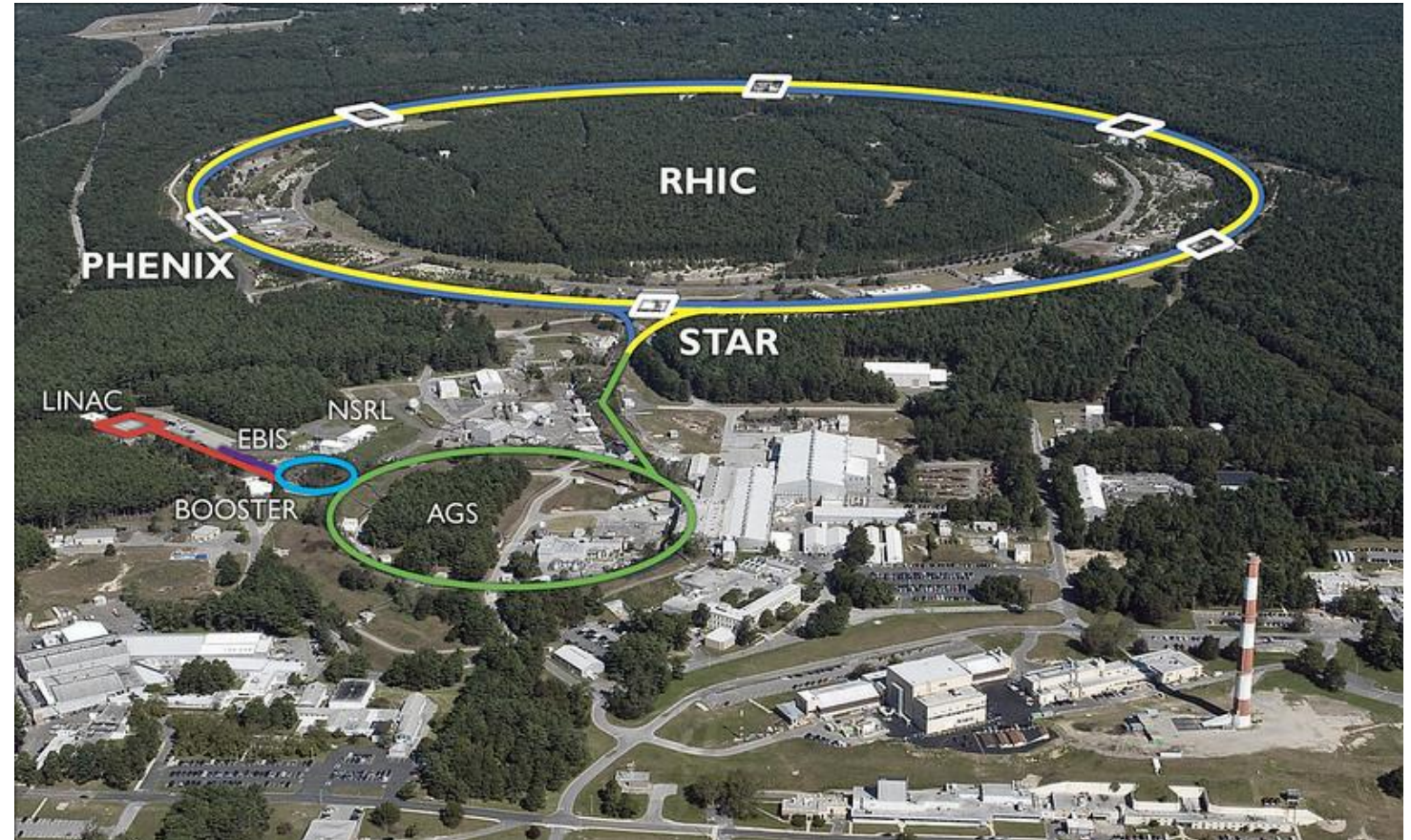
Configuration control

METHODS OF CHECKING AND MAINTAINING
PROPER DEVICE CONFIGURATIONS



BNL's Collider-Accelerator Complex

- ~2 million control points
- “World first” systems alongside elderly ones.
- Multiple concurrent programmes.
- Frequent configuration changes.
- “Open door” policy for accessing controls.



Programmes

- BLIP (Brookhaven Linac Isotope Producer)
 - Continuous high intensity proton beams require precise control to avoid potentially serious radiation incidents.
- NSRL (NASA Space Radiation Laboratory)
 - Slow extracted beam with varied ion species, charge states, and energies.
 - Quick changes, reliability, and repeatability are critical.
- RHIC (Relativistic Heavy Ion Collider)
 - Beam energy scan project requires repeated mode switches for collider and parts of the injector chain. Consistency is critical.

Specific times of vulnerability

- **Collider/Injector mode changes**
 - Changes made to thousands of devices—must be consistent every time.
- **Complex-wide maintenance**
 - Changes to many systems that interact in many different ways.
 - Mistakes made in maintenance activities.
- **Power disruptions**
 - Can cause hundreds of mini-failures, often breaking things in unexpected ways.
- **Spontaneous changes**
 - Old equipment can degrade or change with no warning.
 - New equipment is not always well understood, and can act in unexpected ways.

Configuration Control Tools

REACTIVE

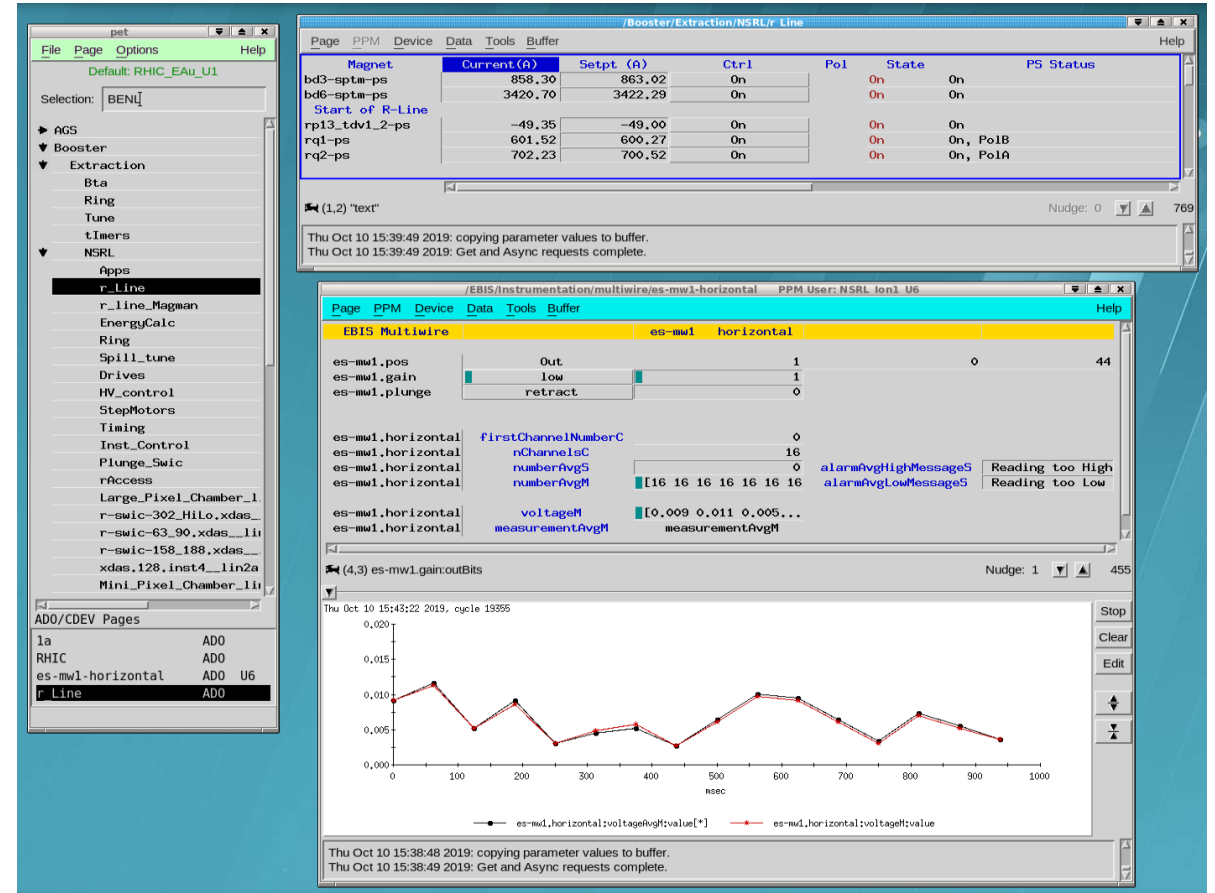
- **Settings archives (through “Pet”)**
 - Device lists with values.
 - Saved on a timer or by users.
- **Set History**
 - All settings saved to database.
- **pscompare**
 - Saved on a timer or by users.
 - Creates a list of greatest to smallest differences among power supplies.

PROACTIVE/PREVENTIVE

- **“TAPE” scripting language**
 - Provides consistency in mode switching.
- **watchManager**
 - Separate devices with user set limits.
 - Sends alarms when limits are exceeded.
- **Permit Reference Display**
 - For Machine Protection or Beam Permit systems.
 - Highlights configuration problems.

Pet—Parameter Editing Tool

- Basic interface used to control most devices in the complex.
- Very powerful. Looks like it was made with cardboard, markers, and a glue stick.
- Features like nudge, graph, setting history and archives are a click or two away.
- Hundreds of pages.



Archive Comparisons

- Archives saved periodically and manually as needed.
- Measurement differences show up in blue, setting differences in yellow.

/Booster/Extraction/NSRL/r Line													
Magnet	Current (A)	Setpt (A)	Ctrl	Pol	State	PS Stat	Magnet	Current (A)	Setpt (A)	Ctrl	Pol	State	PS Stat
bd3-sptm-ps	404.49	400.03	0n		On	On	bd3-sptm-ps	404.37	400.03	0n		On	On
bd6-sptm-ps	3302.96	3304.65	0n		On	On	bd6-sptm-ps	2065.86	2066.56	0n		On	On
Start of R-Line							Start of R-Line						
rp13_tdv1_2-ps	-27.19	-27.00	0n		On	On	rp13_tdv1_2-ps	-27.20	-27.00	0n		On	On
rq1-ps	260.02	259.99	0n		On	On, PolB	rq1-ps	260.02	259.99	0n		On	On, PolB
rq2-ps	328.91	327.99	0n		On	On, PolA	rq2-ps	328.88	327.99	0n		On	On, PolA
rd70_tdh3-ps	8.16	8.10	0n	PolB	On	On, PolB	rd70_tdh3-ps	8.17	8.10	0n	PolB	On	On, PolB
rp73_tdv4-ps	0.01	0.00	Stby	PolB	Stby	Standby, PolB	rp73_tdv4-ps	0.00	0.00	Stby	PolB	Stby	Standby, PolB
rarc20-ps	639.86	633.75	0n		On	On, PolA	rarc20-ps	639.96	633.85	0n		On	On, PolA
rq3-ps	399.79	398.99	0n	PolA	On	On, PolA	rq3-ps	399.95	398.99	0n	PolA	On	On, PolA
rq4-ps	401.13	397.99	0n	PolB	On	On, PolB	rq4-ps	401.24	397.99	0n	PolB	On	On, PolB
rd137_tdh5-ps	0.01	0.00	Stby	PolA	Stby	Standby, PolA	rd137_tdh5-ps	-0.03	0.00	Stby	PolA	Stby	Standby, PolA
rp140_tdv6-ps	0.00	0.00	Stby	PolA	Stby	Standby, PolA	rp140_tdv6-ps	0.00	0.00	Stby	PolA	Stby	Standby, PolA
roct1-ps	135.88	135.00	0n	PolB	On	On, PolB	roct1-ps	135.81	135.00	0n	PolB	On	On, PolB
rq5-ps	335.40	334.99	0n	PolA	On	On, PolA	rq5-ps	335.55	334.99	0n	PolA	On	On, PolA
rd178_tdh7-ps	0.04	0.00	Stby	PolB	Error	PolA	rd178_tdh7-ps	0.00	0.00	Stby	PolB	Error	PolA
rp181_tdv8-ps	0.00	0.00	Stby	PolA	Stby	Standby, PolA	rp181_tdv8-ps	0.03	0.00	Stby	PolA	Stby	Standby, PolA
roct2-ps	174.34	174.98	0n		On	On, PolA	roct2-ps	175.56	174.98	0n		On	On, PolA
rq6-ps	245.45	244.98	0n	PolB	On	On, PolB	rq6-ps	245.52	244.98	0n	PolB	On	On, PolB
rq7-ps	264.29	263.98	0n	PolA	On	On, PolA	rq7-ps	263.99	263.98	0n	PolA	On	On, PolA
rq8-ps	167.24	166.00	0n	PolA	On	On, PolA	rq8-ps	167.24	166.00	0n	PolA	On	On, PolA
rd250_tdh9-ps	0.03	0.00	Stby	PolA	Stby	Standby, PolA	rd250_tdh9-ps	0.03	0.00	Stby	PolA	Stby	Standby, PolA
rp253_tdv10-ps	18.50	18.00	0n	PolB	On	On, PolB	rp253_tdv10-ps	18.47	18.00	0n	PolB	On	On, PolB
rq9-ps	744.01	749.99	0n	PolB	On	On, PolB	rq9-ps	744.14	749.99	0n	PolB	On	On, PolB
R Arc20 Feedback							R Arc20 Feedback						
Measured Field	field average	Target field	diff from target			gaussmeter	Measured Field	field average	Target field	diff from target			gaussmeter
	5963.4	5963.4	0.0	Capture		OK		5963.2	5963.4	0.2			OK
Field Control							Field Control						
	command	state	status					command	state	status			
	HoldAtTarget	HoldAtTarget	Holding at Target			rarc20_fdbk c		HoldAtTarget	HoldAtTarget	Holding at Target			rarc20_fdbk c
D6 Feedback							D6 Feedback						
Measured Field	field average	Target field	diff from target			gaussmeter	Measured Field	field average	Target field	diff from target			gaussmeter
	5553.1	3510.9	-2042.2	Capture		OK		3510.9	3510.9	0.0			OK
Field Control							Field Control						
	command	state	status					command	state	status			
	OFF	OFF	OFF			D6_fdbk det		OFF	OFF	OFF			D6_fdbk det
(27,5) blank cell							Nudge: 0						
Wed Oct 9 12:25:42 2019: Loaded buffer from archive.													
Wed Oct 9 12:26:06 2019: Loaded buffer from archive.													

Set History

- All setting changes (regardless of how they are made) are recorded to a searchable database.
- Very helpful for finding rogue changes—and rogue users.
- Tends to get choked, so careful filtering is required. This slows down investigations a lot.

Device Set History <@cscompile03.pbn.bnl.gov>

Start: Oct 14 2019 14:00:00 Device: rarc20-ps Use Generic Search Advanced Search

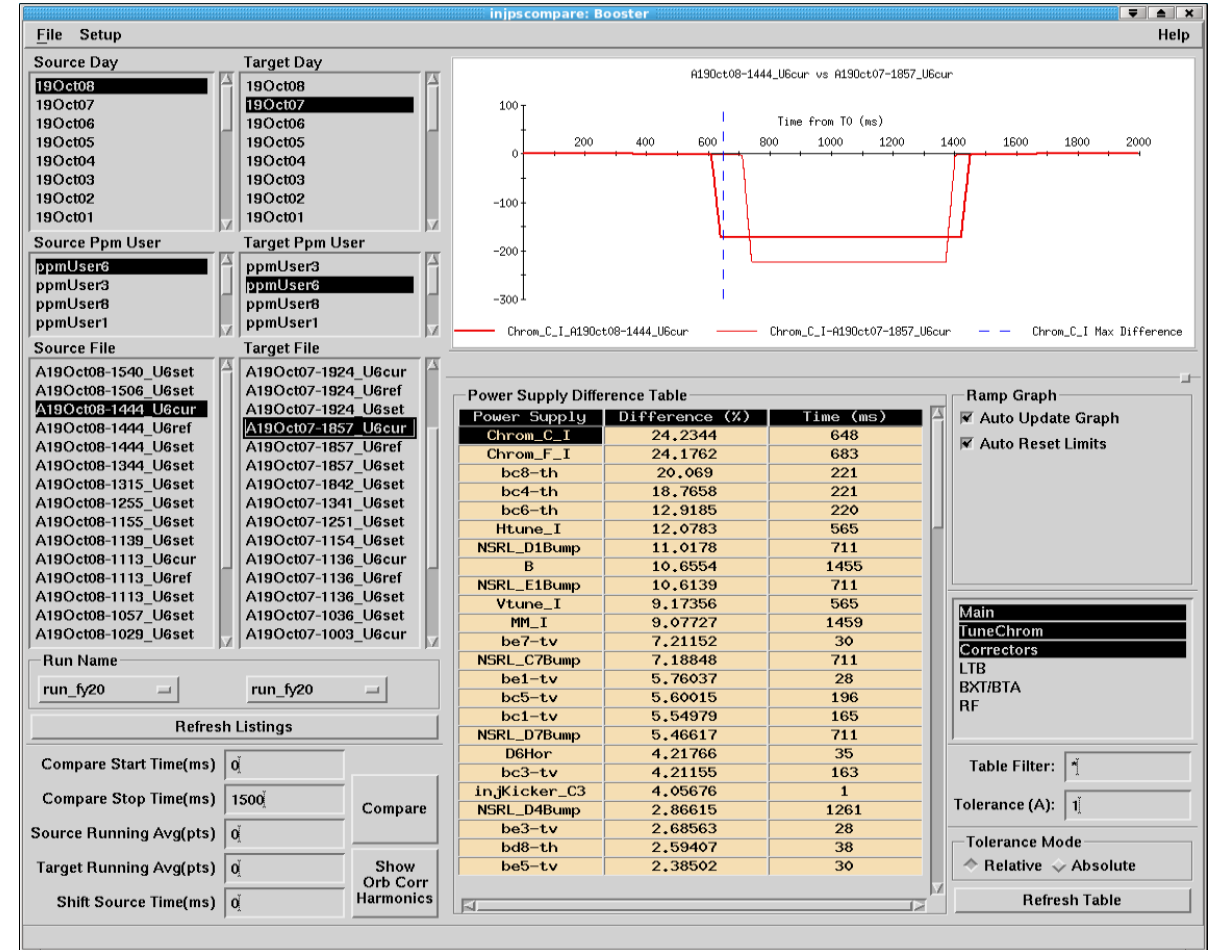
Stop: Oct 15 2019 14:00:00 Property: setpointS

Row	Device:Property	PPM	Time	Value	Login	Machine
1	rarc20-ps:setpointS	1	Oct 15 13:22:16	206.8157	mcr(kling)	acnmcrac5 /
2	rarc20-ps:setpointS	1	Oct 15 13:22:11	209.7923	mcr(kling)	acnmcrac5 /
3	rarc20-ps:setpointS	1	Oct 15 13:22:10	208.8157	mcr(kling)	acnmcrac5 /
4	rarc20-ps:setpointS	1	Oct 15 13:10:40	272.2209	mcr(kling)	acnmcrac5 /
5	rarc20-ps:setpointS	1	Oct 15 13:08:28	207.3274	mcr(kling)	acnmcrac5 /
6	rarc20-ps:setpointS	3	Oct 15 13:08:26	207.3274	mcr(kling)	acnmcrac5 /
7	rarc20-ps:setpointS	3	Oct 15 13:07:36	0	mcr(kling)	acnmcrac5 /
8	rarc20-ps:setpointS	1	Oct 15 13:03:30	272.1721	nsr1	acnlinf5 /
9	rarc20-ps:setpointS	3	Oct 15 13:03:27	272.1721	nsr1	acnlinf5 /
10	rarc20-ps:setpointS	3	Oct 15 13:03:06	0	nsr1	acnlinf5 /
11	rarc20-ps:setpointS	1	Oct 15 13:00:00	547.6646	nsr1	acnlinf5 /
12	rarc20-ps:setpointS	6	Oct 15 12:59:57	547.6646	nsr1	acnlinf5 /
13	rarc20-ps:setpointS	6	Oct 15 12:59:28	0	nsr1	acnlinf5 /
14	rarc20-ps:setpointS	1	Oct 15 12:55:55	1019.01	nsr1	acnlinf5 /
15	rarc20-ps:setpointS	8	Oct 15 12:55:52	1019.01	nsr1	acnlinf5 /
16	rarc20-ps:setpointS	8	Oct 15 12:55:31	0	nsr1	acnlinf5 /
17	rarc20-ps:setpointS	1	Oct 15 12:53:21	418.4146	nsr1	acnlinf5 /
18	rarc20-ps:setpointS	6	Oct 15 12:53:18	418.4146	nsr1	acnlinf5 /
19	rarc20-ps:setpointS	6	Oct 15 12:52:57	0	nsr1	acnlinf5 /
20	rarc20-ps:setpointS	1	Oct 15 12:50:55	207.3274	nsr1	acnlinf5 /
21	rarc20-ps:setpointS	3	Oct 15 12:50:53	207.3274	nsr1	acnlinf5 /
22	rarc20-ps:setpointS	3	Oct 15 12:50:03	0	nsr1	acnlinf5 /
23	rarc20-ps:setpointS	1	Oct 15 12:48:02	169.2409	nsr1	acnlinf5 /
24	rarc20-ps:setpointS	3	Oct 15 12:47:59	169.2409	nsr1	acnlinf5 /
25	rarc20-ps:setpointS	3	Oct 15 12:47:38	0	nsr1	acnlinf5 /

Plot Close

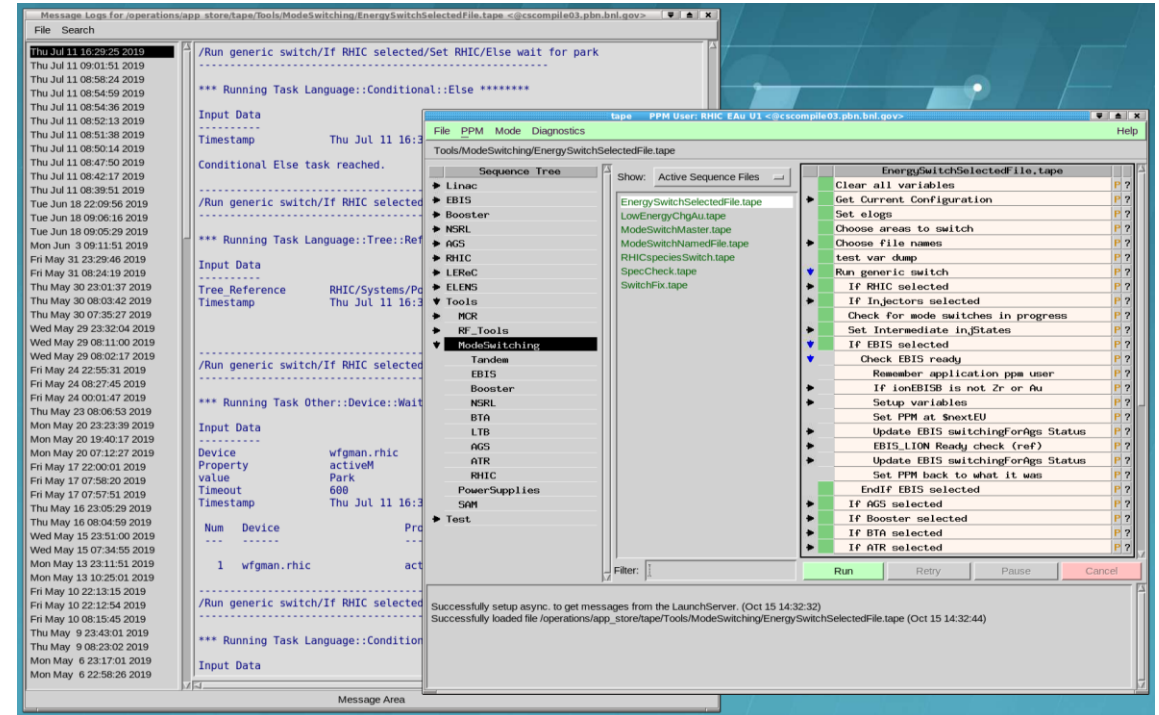
pscompare

- Available for EBIS, Booster, AGS, and RHIC.
- Captures functions and readbacks for comparison.
- Highly configurable and filterable.
- Cumbersome. Gives no sense of the relative importance of different deviations.



TAPE—Tool for Automated Process Execution

- Highly configurable scripting system.
- Allows for hundreds of settings in seconds.
- Every step is visible as it executes. Every step is logged.
- Critical to rapid mode switching.
- Used to restore to known good configurations.



watchManager

- Instances can be created for any steady-state supply.
- Highly configurable, with offsets, scaling ratios, etc.
- Can be tweaked individually by Operators or Specialists.
- Generates alarms for Operator response.
- Static supplies only.

Linac/Test_Mod_5/watch PPM User: User5_MSR_Lion

Page	PPM	Device	Data	Tools	Buffer	Help		
setpoint	to watch	alarm low	measure	alarm high	watch on?	alarm?	tolerance (fraction)	ps st (if av
lt5-q3-ps.watch	157.57	132.57	0.00	182.57	Off	0	0.1	
lt5-q5-ps.watch	164.16	139.16	-0.00	189.16	Off	0	0.1	
lt5-q7-ps.watch	150.00	125.00	-0.00	175.00	Off	0	0.1	
lt5-q9-ps.watch	148.90	123.90	-0.00	173.90	Off	0	0.1	
lt5-q11-ps.watch	148.90	123.90	-0.00	173.90	Off	0	0.1	
lt5-q13-ps.watch	148.90	123.90	0.00	173.90	Off	0	0.1	
lt5-q15-ps.watch	147.07	122.07	-0.00	173.90	Off	0	0.1	
lt5-q17-ps.watch	150.00	125.00	-0.00	173.90	Off	0	0.1	
lt5-q19-ps.watch	149.02	124.02	-0.00	174.02	Off	0	0.1	
lt5-q21-ps.watch	147.92	122.92	-0.00	172.92	Off	0	0.1	
lt5-q23-ps.watch	141.94	116.94	0.00	166.94	Off	0	0.1	
lt5-q24-ps.watch	176.07	151.07	0.00	201.07	Off	0	0.1	
lt5-q25-ps.watch	156.65	131.65	-0.00	181.65	Off	0	0.1	
watch.mod5-ps1.A13	0.00	-2.00	1.81	2.00	Off	0	0.1	
watch.mod5-ps1.A14	0.00	-2.00	-6.04	2.00	Off	0	0.1	
lt5-cava-rfamp.watch	3.90	-1.00	-0.46	1.00	Off	0	0.1	
lt5-cava-rfphase.watch	311.70							

4 Critical Alarms

Setup Filter Mask Logs Transfer Diagnostics

ster Tandem EBIS Class: gndFaultCh gndFaultMasterADO omegaCn32Ps omegaDp10000psiCtrl w1HCH w1TCH Include: temperature.* 9*

Filtered View

Last Received @ Wed Oct 9 09:25:38 2015

Count	Name	Description	ppm	State	Time
4	pr5-919-2-913-L-J-18.House:dicomH	Water System Low Flow	seen	Oct 08 14:28	
4	pr5-918-2-913-K-1-18.House:dicomH	Water System Low Flow	seen	Oct 08 14:31	
4	pr5-986-F-912-911-T-E.Bldg:dicomH	Cooler System Common Alarm	seen	Oct 09 09:25	
5	pr5-986-F-912-911-T-E.Bldg:dicomH	Fast Pulsed Quad Cooling System	seen	Oct 09 09:25	

131 Standard Alarms

Filtered View

Last Received @ Wed Oct 9 15:55:03 2015

1	2	Booster variAnp1an hvM	?	assigned	Aug 29 09:31
1	1	b6f-b1w-ps:statem	Sbhy	assigned	Sep 11 16:11
1	12	Booster qp301qch1an gpAvPressureH	range error	assigned	Sep 12 16:48
1	3	Booster qp301qch1an gpAvPressureH	range error	assigned	Sep 12 16:48
1	1	HB-cfe-930sbis-bunc1	No Heartbeat	assigned	Sep 13 16:17
1	4	Tandem qp301qch1an gpAvPressureH	range error	assigned	Sep 18 09:41
1	3	Booster variAnp1an voltagH	range error	assigned	Sep 20 11:38
1	1	b6tr-1p-b6b-hvM	Off	assigned	Sep 24 00:53
1	1	Tandem qp301qch1an gpAvPressureH	range error	seen	Sep 24 00:53
1	4	Tandem qp301qch1an gpAvPressureH	range error	seen	Sep 24 00:53
1	1	Y-8B_H.H:humidifyH	SrvldnAn: Humidity out of ran	seen	Sep 26 08:01
1	70	RHC w1TCH qp1FreshDataM	SrvldnAn: No LabView Data	seen	Sep 26 08:08
1	1	Y-8B_H.H:qp1FreshDataM	SrvldnAn: No LabView Data	seen	Sep 26 08:41
1	1	mx1-1p-205-pel3pand01:tagH	range error	new	Oct 02 22:03
1	1	t11-17-1bdi1:statem0rM	Range Interlock, Transistor fa	new	Oct 04 09:38
1	1	util_914-muxbpm:statemH	Board Init Error	new	Oct 05 00:47
1	1	b6tr-1p-f3h-voltagH	range error	new	Oct 08 15:39
1	1	b6tr-1p-f3h-hvM	Off	new	Oct 08 15:39
1	2	AGS netcom2 up5netAnsweringM	NOT ANSWERING	new	Oct 09 09:06
1	2	EBIS qf9:statemH	Fault	new	Oct 09 14:14
1	1	shs-mux:col-ps:1oErORM	Power supply link down,Missing	new	Oct 09 14:14
1	2	EBIS dac6psOLinac wndCapstatemH	FAULT	new	Oct 09 15:43
1	1	912_UPS:upsInputVoltage1H	range error	new	Oct 09 15:49
1	1	912_UPS:upsInputFrequency1H	range error	new	Oct 09 15:49
1	1	912_UPS:upsAlarmsPresentH	ALARM	new	Oct 09 15:49
1	7	EBIS vacPiezoMan pieValvac0Feedback	Vacuum Valve Closed	new	Oct 09 15:54
1	1	shs-anode_gun-ps:1oErORM	CIC error,Missing feedback	new	Oct 09 15:55

35 Deferred/Orphaned Alarms (5 Critical)

Filtered View

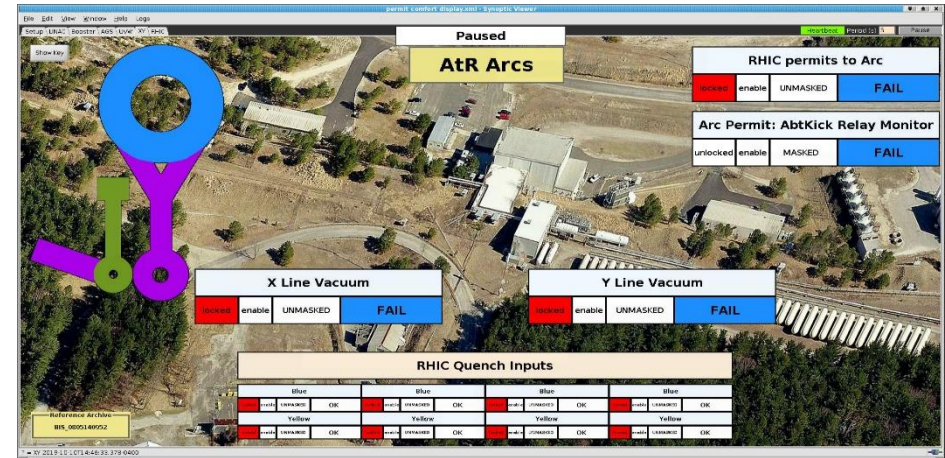
Last Received @ Wed Oct 9 12:28:33 2015

4	1	pr5-933-2-1000P_1005E_1007H:dicomH	ATR MAGNET COMMON ALARM	deferred	Oct 07 09:06
1	1	b6f-gt4m-ps:statemH	Not in Standby	deferred	Oct 09 12:28
1	1	b1f3-ke-ps:statemH	Not Off	deferred	Oct 09 12:28

A filter has not been created (CPU: 0.35, RAM: 400)

Permit Reference Display

- Built using custom manager software and FermiLab/BNL's "Syndi" application.
- Standard permit configurations are saved by users. Each subsystem has a reference configuration loaded.
- Inconsistencies show up in red.
- Failed permits show up in blue.



Future Plans/Upgrades

- A version of watchManager to look at array values (pulsed power equipment, etc) should be available soon.
- Permit Reference Display upgrade to include additional Machine Protection Systems.
- Bug fixes and shading subtleties in Pet archive comparisons will be implemented.
- Resurrect “spy” page to show who is making changes in real time.

Conclusions

- Proper configuration control can prevent hours of downtime or days of degraded performance.
- It can also help prevent catastrophic failure.
- It's a very low-cost/high-impact principle.
- It's not very exciting.
- When it's working properly, no-one notices.

Examples (1)

- Power dips take out kickers. They do not come back the same. Timing can be scrambled. Pulse shapes or heights can change.
- Random lurches of power supply outputs. Often all we see is a loss of efficiency in an accelerator or transfer line. Then we find ourselves scrambling to find the culprit.
- Physicist taking measurements from his office without requesting permission. Naughty!
- “Activate” sent from a stale application left an idle machine in the wrong state. Why is “start pulsing” also “send this function?”

Examples (2)

- Return from machine studies. Configurations can be wildly different and documentation of changes can be poor!
- FEC self-reset with a bad cache. Some values reverted to defaults with no indications! Expert intervention was required.
- A vacuum valve permit was disabled to allow vacuum and kicker work simultaneously. Then it was forgotten about.
- A specialist modified MPS settings without a proper understanding of the effect and consequences.
- Incorrect power supply settings used in initial setup. Experimenters' cross-check used the wrong analysis file.