



System Downtime Management at 12 GeV CEBAF

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JLab Accelerator Operability

ARW 2015

Jefferson Lab

CEBAF

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Ames, Iowa
- 2 Argonne National Laboratory
Argonne, Illinois
- 3 Brookhaven National Laboratory
Upton, New York
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- 5 Lawrence Berkeley National Laboratory
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JLAB:

- Experimental, computational, and theoretical nuclear physics
- Continuous Electron Beam Accelerator Facility (CEBAF)
- 12 GeV, 2 superconducting LINACs, 5.5 Passes, 4 Experimental Halls, CW duty factor

Purpose

The purpose of recording system failure events, referred to as 'System Downtime' events, is:

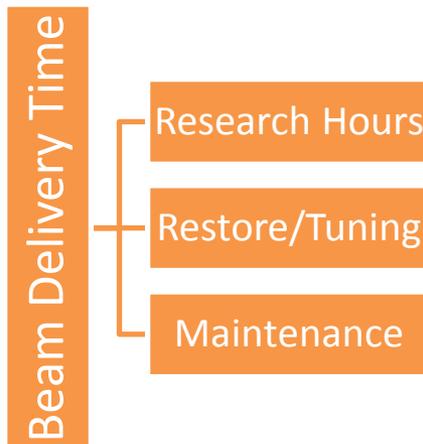
- Gather statistics concerning system and equipment failures that can be analyzed.
- From the analysis, better decisions can be made to allocate resources and investigate changes in equipment maintenance, selection, or design.
- Upgrade components to improve individual systems availability, influencing overall accelerator availability.

Make the machine run better.

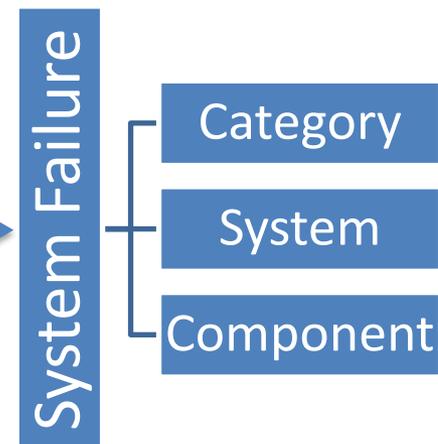
Beam Time and Failure Tracking

- **Beam Time Accounting** is tracked for the accelerator program and delivered beam time; *CEBAF 'Timesheet.'*
- **System Downtime** is tracked for any system failure(s) that impact the scheduled accelerator program. Concurrent failures are tracked simultaneously to monitor individual system health.

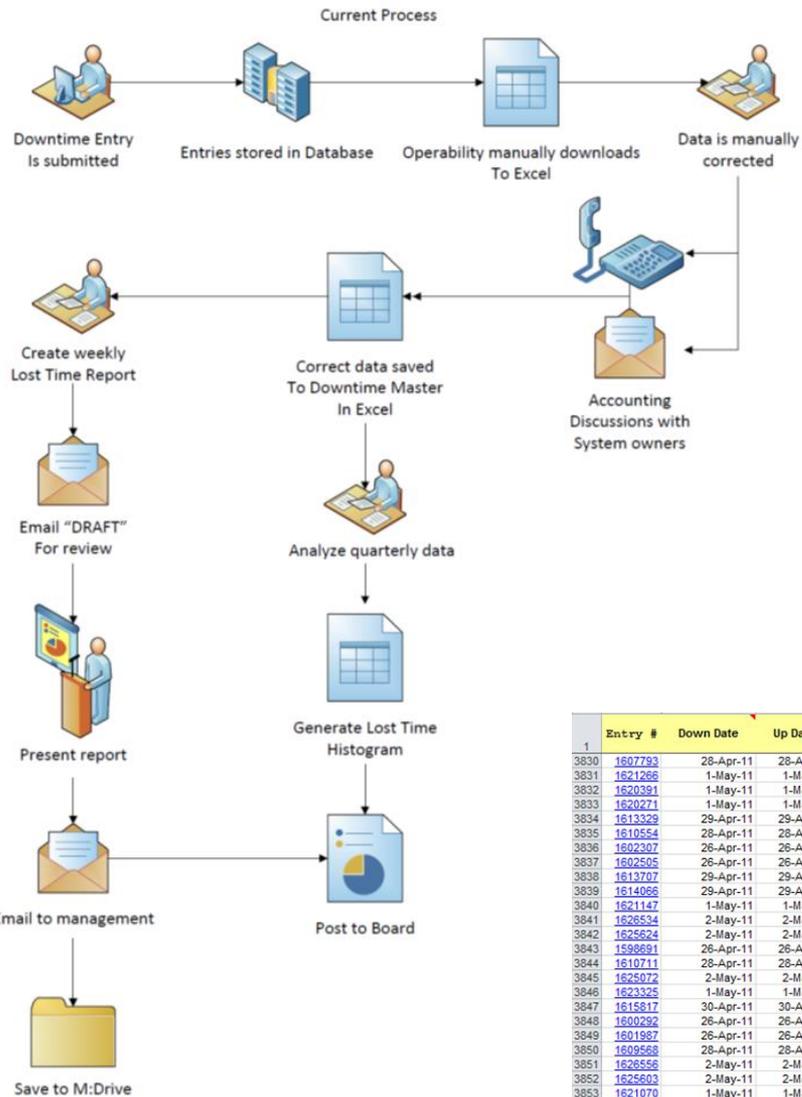
Beam Time Accounting



System Downtime



System Downtime - History



Accelerator Operability: Tracking System Downtime since 1998

- Operator entry form; static menus
- Data stored in an Oracle database
- Weekly, data was downloaded into Excel; Entries reviewed and correctly categorized
- Weekly "Lost Time Report" created and presented at scheduling meeting
- Downtime Master Spreadsheet maintained with corrected downtime data

Downtime Master Spreadsheet

Entry #	Down Date	Up Date	Restore Date	Down	Up	Restore	Sys. Down	Recovery	Total	System	Item	Problem	Description	
3830	1607793	28-Apr-11	28-Apr-11	28-Apr-11	4:15	4:41	4:41	0.43	0	0.43	DC PWR	2A	Mismatch	Arc 2 mismatch; cycled stack and trim
3831	1621266	1-May-11	1-May-11	1-May-11	3:54	8:41	8:41	4.78	0	4.78	DC PWR	5A	DC Overload	Arc 5 Trips for 3rd time on DC overload; EES-DC rep
3832	1620391	1-May-11	1-May-11	1-May-11	3:15	3:47	3:47	0.53	0	0.53	DC PWR	5A	DC Overload	Arc 5 Box Supply tripped on DC overload again; Sec
3833	1620271	1-May-11	1-May-11	1-May-11	2:32	3:03	3:03	0.52	0	0.52	DC PWR	5A	DC Overload	Arc 5 Box Supply trip on DC Overload; Reset trip, atte
3834	1613329	29-Apr-11	29-Apr-11	29-Apr-11	10:56	11:43	11:43	0.78	0	0.78	GUN	Injector	No Problem Found	Spot move;
3835	1610554	28-Apr-11	28-Apr-11	28-Apr-11	18:22	20:12	20:12	1.83	0	1.83	RF	0L03-1	BLM Loss	1C12 BLM trip investigation: 18:58... Steering looks go
3836	1602307	26-Apr-11	26-Apr-11	26-Apr-11	19:46	20:42	20:50	0.93	0.13	1.07	RF	0L03-1	Gradient Loop Error	BCM trips caused by unstable RF cavity: RAT and RF
3837	1602505	26-Apr-11	26-Apr-11	26-Apr-11	22:28	22:49	22:49	0.35	0	0.35	RF	0L03-6	BLM Loss	0R04 BLM trips: Auto-steered, no dice. Took a little bit ba
3838	1613707	29-Apr-11	29-Apr-11	29-Apr-11	13:29	13:47	13:47	0.3	0	0.3	RF	0L03-6	Beam Motion	0R04 BLM Trip Investigation: Around 13:15, we started
3839	1614066	29-Apr-11	29-Apr-11	29-Apr-11	14:47	15:27	15:27	0.67	0	0.67	RF	1L02	No Problem Found	1L02 Out of High Voits: 15:00 Called EES RF for assista
3840	1621147	1-May-11	1-May-11	1-May-11	7:38	8:01	8:01	0.38	0	0.38	RF	1L11	Missing or invalid	1L11 HPA Overload fault: After VBV1L12A was fixed, t
3841	1626534	2-May-11	2-May-11	2-May-11	14:55	15:08	15:08	0.22	0	0.22	RF	1L12	Missing or invalid	1L12 recovery: 1L12 was recovered.
3842	1625624	2-May-11	2-May-11	2-May-11	8:04	9:12	9:12	1.13	0	1.13	RF	1L12	No Problem Found	1L12 Overload fault: HPA water leak. RF support, repor
3843	1598691	26-Apr-11	26-Apr-11	26-Apr-11	1:19	2:22	2:22	1.05	0	1.05	RF	1L12-2	BLM Fault	adjusting orbit due to 1C12 BLM trips: flattened orbit
3844	1610711	28-Apr-11	28-Apr-11	28-Apr-11	20:54	21:04	21:04	0.17	0	0.17	RF	1L12-4	Beam Instability at SLM	Bypassing 1L12-4: Cavity kept beam loading until SOSING
3845	1625072	2-May-11	2-May-11	2-May-11	5:04	6:22	6:22	1.3	0	1.3	RF	2L06	Missing or invalid	2L06-1 Comm Fault dropped to idle: Watch dog on ca
3846	1623325	1-May-11	1-May-11	1-May-11	19:55	20:24	20:24	0.48	0	0.48	RF	2L06	Readback Incorrect	comm issue (?) on 2L06: entire zone tripped off and
3847	1615817	30-Apr-11	30-Apr-11	30-Apr-11	1:19	1:29	1:29	0.17	0	0.17	RF	2L06	2L06	2L06-7 Stubborn: Started tripping on CWAD faults then
3848	1600292	26-Apr-11	26-Apr-11	26-Apr-11	10:36	11:00	11:00	0.4	0	0.4	RF	2L22	Vacuum Issues	Waveguide Pressure Fault: Inj, NL, SL Dropped to
3849	1601967	26-Apr-11	26-Apr-11	26-Apr-11	20:02	20:03	20:03	0.02	0	0.02	RF	Separator	Insufficient Gradient for	RF separator unstable gradient: Unstable forward
3850	1609258	28-Apr-11	28-Apr-11	28-Apr-11	12:30	14:52	14:52	2.37	0	2.37	SF	2L21	No Problem Found	Access to the SL to make SL21 measurements: As v
3851	1626566	2-May-11	2-May-11	2-May-11	15:50	16:40	16:40	0.83	0	0.83	SW	104	Missing or invalid	CDEV flameserver not working: Additional applicator
3852	1625603	2-May-11	2-May-11	2-May-11	8:45	9:00	9:00	0.25	0	0.25	SW	North Linac	Error Message	LEM Error Message: LEM failed CDEV issue name serv
3853	1621070	1-May-11	1-May-11	1-May-11	4:23	7:38	7:38	3.25	0	3.25	VAC	1L12	Valve Will Not Open	VBV1L12A will not open: Looks like the open limit switc
3854	1619145	30-Apr-11	30-Apr-11	30-Apr-11	20:37	20:39	20:39	0.03	0	0.03	VAC	2L22	vacuum valve:	2L22 vacuum valve:
3855	1611363	29-Apr-11	29-Apr-11	29-Apr-11	0:35	0:38	0:38	0.05	0	0.05	VAC	2L22	Valve Will Not Open	QuickPic - VBV2L22A Fault:
3856	1608471	28-Apr-11	28-Apr-11	28-Apr-11	6:31	6:34	6:34	0.05	0	0.05	VAC	2L22	Beamline Valves - can not	vbv2L22a:

Challenges to Tackle

- Quality of initial data entered by Operators; ~75% of entries required review and correction.
- Operator perception that data was not being used or useful.
- Data correction, report creation, distribution of information a time burden on Accelerator Operability
- Disagreement on how failures were categorized and accounting of repair/recovery durations
- Database data not corrected; feedback mechanism
- Accurate data stored on a single spreadsheet
- System Owners limited access to data

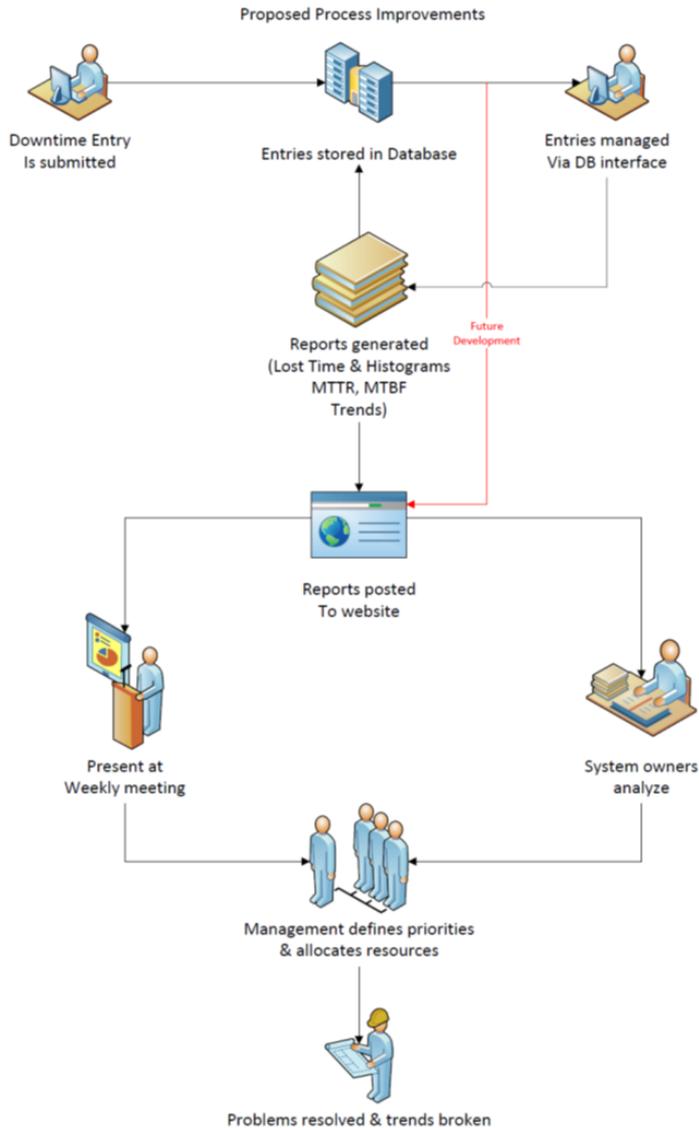


Change

GOAL: Develop a System Downtime Tracking process that addresses the previously stated challenges, empowers all stakeholders, and sets the stage for future development of a reliability focused culture. Provide real-time system performance data available to any JLab user.



System Downtime – Present



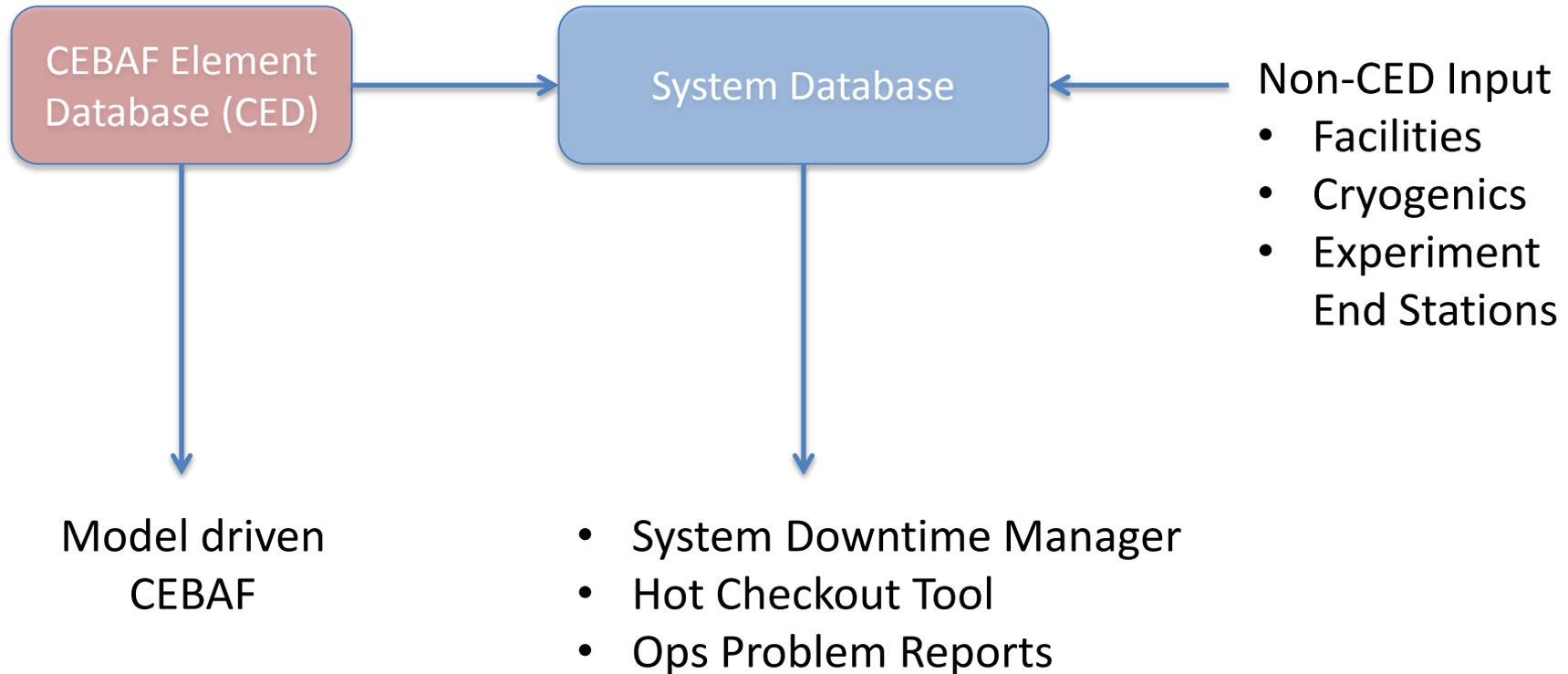
Improved System Downtime Tracking process:

- Align information with model database (CED)
- Develop web database interface (input, management, and reporting)
- Develop System Downtime Guidance document
- Train Accelerator Operators, System Owners, and Managers

The screenshot shows the 'Downtime Manager' web interface. At the top, there are navigation tabs: 'Open Events', 'Events', 'Trips', 'Reports', 'Operability', and 'Help'. A 'Login' link is visible in the top right. Below the tabs, a 'Choose...' dropdown is followed by the heading 'Downtime Events'. The main content area displays a table of events from 09-Mar-2013 00:00 to 16-Mar-2015 00:00, showing 1 to 10 of 786 events. The table has columns for 'Type', 'Title', 'Down', and 'Duration'. One event, 'HLA Spectrometer Arm Adjustment', is highlighted with a yellow border, and another, 'HLA Hall A moller quad work MQO1H02', is highlighted with a red border.

Type	Title	Down	Duration
HLB	HPS chicane setup	15-Mar-2015 23:29	1 hour 18 minutes
HLA	Hall A target change to home and then carbon hole	15-Mar-2015 13:54	14 minutes
ACC	9S blm trips	15-Mar-2015 11:47	1 hour 36 minutes
HLA	Spectrometer Arm Adjustment	15-Mar-2015 08:09	2 hours 31 minutes
ACC	Injector and BSY dropped to unresolved state	14-Mar-2015 23:54	23 minutes
HLA	Right Spectrometer Arm LCW Leak	14-Mar-2015 16:30	1 hour 30 minutes
ACC	MQO1H03A mismatching after cycling	14-Mar-2015 15:49	1 hour 28 minutes
HLB	Hall B down while working on Hall A optics	14-Mar-2015 11:16	1 hour 52 minutes
HLA	Hall A moller quad work MQO1H02	14-Mar-2015 08:42	4 hours 26 minutes
ACC	2L26-7	14-Mar-2015 07:36	4 minutes

Align Information



Model driven
CEBAF

- System Downtime Manager
- Hot Checkout Tool
- Ops Problem Reports

- Non-CED Input
- Facilities
 - Cryogenics
 - Experiment
End Stations

Operations Data Input

Add Event

Observed | Explained

Event Information

*Title: ARC6 Magnet Power Supply failure

*Type: Accelerator

Time Up: DD-MMM-YYYY hh:mm [Now]

Incident Description

*Title: ARC6 Magnet Power Supply failure Same as Event

*Summary: This power supply has faulted and will not reset. Operator and System Expert troubleshooting.

Incident Period

*Time Down: 10-Apr-2015 09:18 [Now]

Time Up: DD-MMM-YYYY hh:mm [Now]

Incident Cause

Category: [] Filter by Category/System

System: []

*Component: ARC

Create Elog

[Save] [Cancel]

ARC3A
ARC4A
ARC5A
ARC6A

System failures that interrupt the CEBAF program (>5 minutes) are recorded by Accelerator Operators

Operators record the failure in “Observed” form; attempt to identify the specific component. Each component assigned a System and Category in the CED & System database

* Designates a required field. Considerable effort taken to automate data entry. Auto created menus, auto logbook entries, and auto-fill by selection limit time/effort required

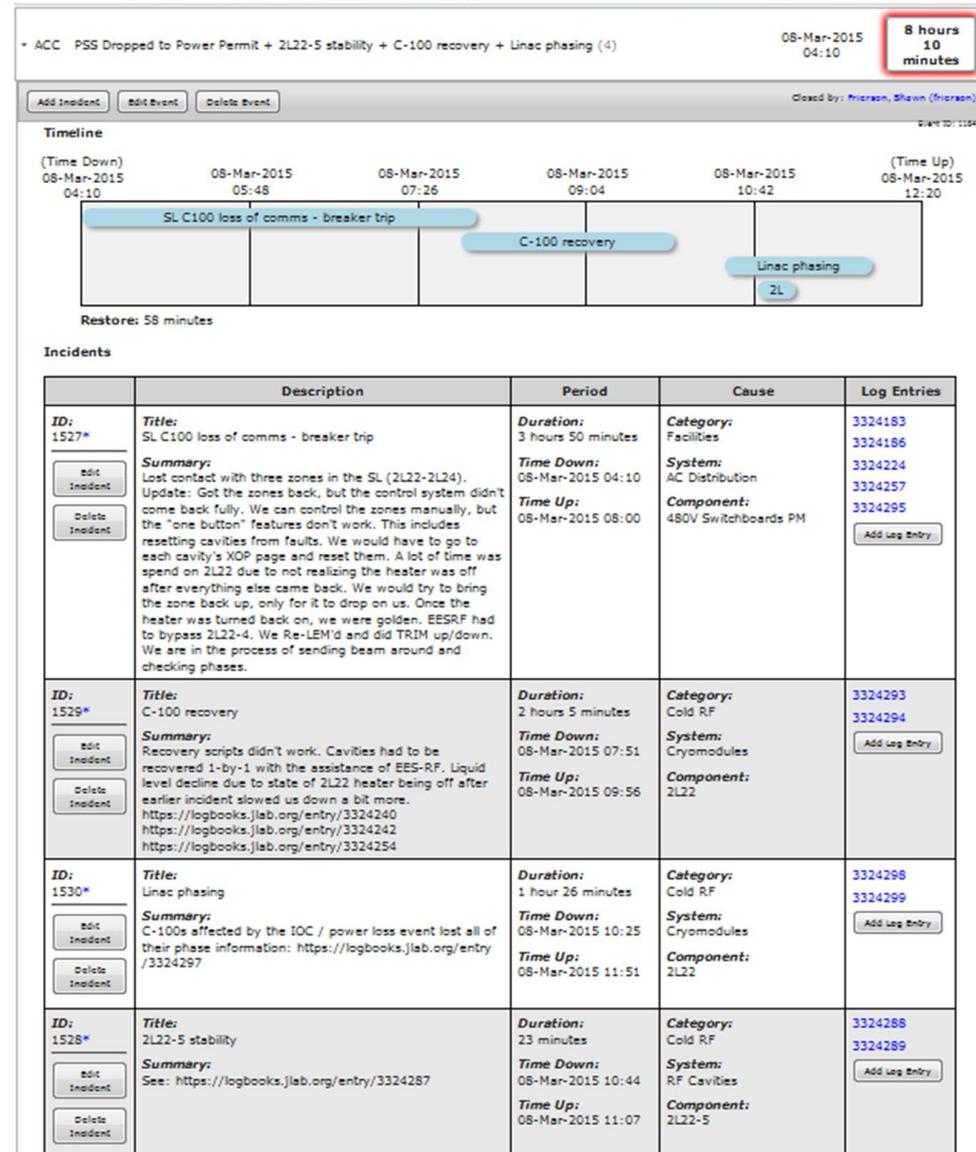
Data Management

Event: Failure resulting in disruption to the scheduled program. “Events” are overarching as Accelerator, Hall A, B, C, or D events.

Incident(s): Capture of a system or component failure. “Incidents” reside within “Events” and occur independent of each other. Multiple system failures are recorded in parallel.

Incident Closed: System owners have repaired hardware and turned system over to Accelerator Operators.

Event Closed: Accelerator Operators have restored the accelerator to the scheduled program.



Data Management

The screenshot shows the 'Downtime Manager' interface. At the top, there are navigation tabs: 'Open Events', 'Events', 'Trips', 'Reports', 'Operability', and 'Help'. Below these is a 'Choose...' dropdown and 'Downtime Events' section. A list of events is displayed with columns for Type, Title, Down, and Duration. One event, 'HLA Spectrometer Arm Adjustment', is highlighted with a yellow box. Below the list is a 'Timeline' section showing a bar chart of downtime periods. At the bottom, an 'Incidents' table lists details for incident ID 1576, including title, description, period, cause, and log entries. A red circle highlights the 'Edit Incident' button in the incident table. A red arrow points from this button to the 'Edit Incident' window on the right.

Type	Title	Down	Duration
HLB	HPS chicane setup	15-Mar-2015 23:29	1 hour 18 minutes
HLA	Hall A target change to home and then carbon hole	15-Mar-2015 13:54	14 minutes
ACC	9S blm trips	15-Mar-2015 11:47	1 hour 36 minutes
HLA	Spectrometer Arm Adjustment	15-Mar-2015 08:09	2 hours 31 minutes
ACC	Injector and BSY dropped to unresolved state	14-Mar-2015 23:54	23 minutes

ID:	Title:	Period	Cause	Log Entries
1576*	Injector and BSY dropped to unresolved state	Duration: 23 minutes Time Down: 14-Mar-2015 23:54 Time Up: 15-Mar-2015 00:17	Category: PSS System: PSS BCMS Component: SBC2C04	3326475 3326485 Add Log Entry

The 'Edit Incident' window shows two tabs: 'Observed' and 'Explained'. The 'Explained' tab is active, showing a 'Resolution' field with the text: 'BCM fault due to IOC issue resulted in PSS A Chain trip. IOC reboot, fault cleared.' Below this is a 'Repaired By:' field with two dropdown menus: 'Ops' and 'SSG'.

Accelerator Operability reviews entries daily (~ 15 minutes per day)

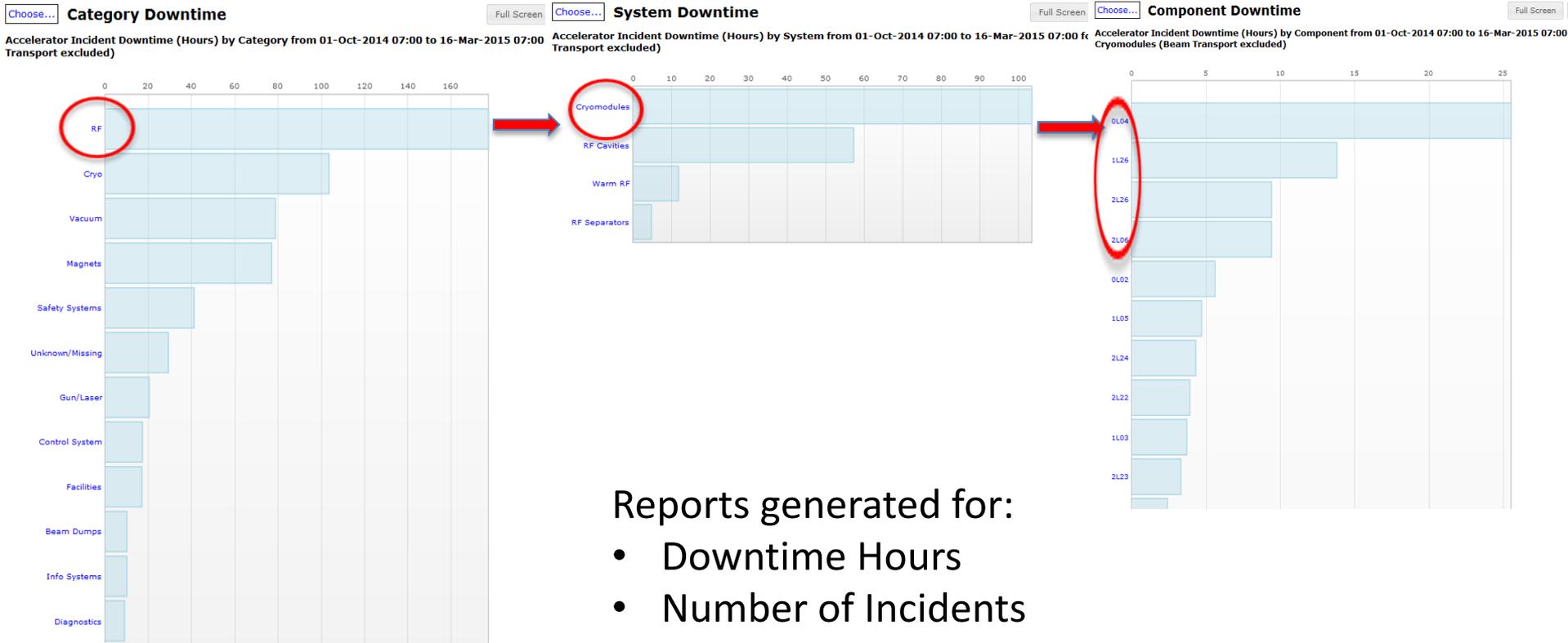
Benefits:

- Reduction of ~ 8 hours per week in data management time
- Database data is reviewed and correct
- ~ 20% of entries require editing (down from 75% and improving!)
- Data is on the web in real time – transparency of information

Accelerator Crew Chiefs review entries created on their shift for accuracy (~ 5 minutes per shift)

Reporting & Monitoring

The 'Reports' section allows users to produce quick, custom histograms for any range of dates and times. This method allows easy application of the Pareto Principle; about 80% of the effects (system downtime) come from about 20% of potential causes (system components). Assists in Root Cause Analysis assignments.



Reports generated for:

- Downtime Hours
- Number of Incidents
- Mean Time to Repair

Reporting & Monitoring

Weekly presented Accelerator Repair Report. Management level summary of the week's activities. Daily data monitoring allows this report to be automated.

Accelerator System Repair Report

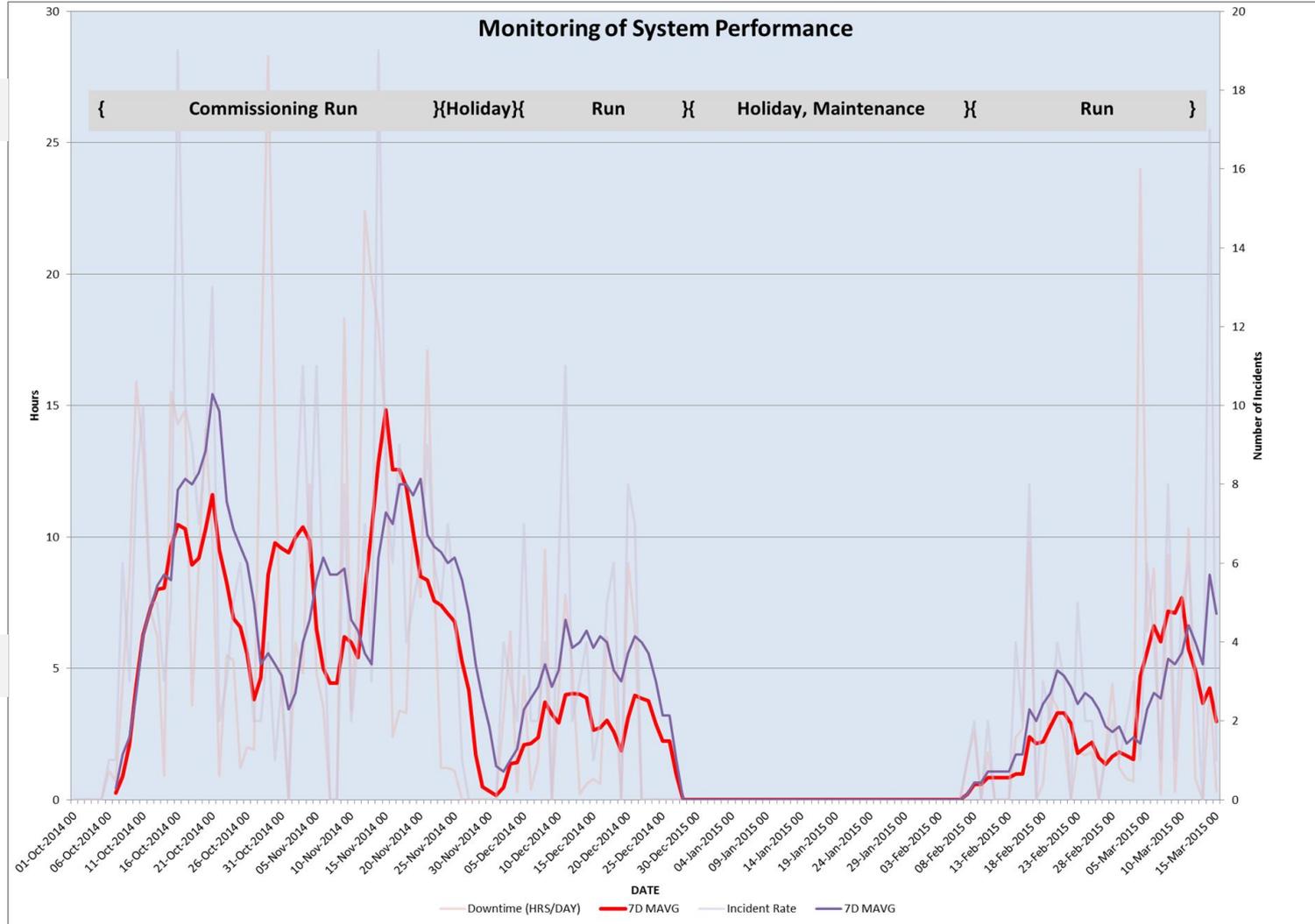
February 17 - 24, 2015

Duration (Hours)	Problem	Solution	System and Component	Incidents Last 4 Weeks	Repaired By
3.9	Chopper 1X	Amplifier failure; replaced.	Warm RF; Chopper1	1	RF
2.4	Gun HV PS trip - FSD fault w/PSS drop	Keithly meter for the Gun High Voltage supply was not communicating with the softIOC.	IOCs; iocin3	1	Low Level Apps; Gun
1.5	1L22-2 Waveguide Vacuum	Cavity bypassed to resume ORFP.	Waveguide SRF; 1L22-2-WG	1	Ops
0.8	iocse14 preventing FOPT use	iocse14 for FFB was rebooted to allow for FOPT.	IOCs; iocse14	1	Ops
0.7	PSS tripped off - INJ/NL	Cause not determined. Additional data being gathered; ongoing investigation.	Access Controls; North Linac Access Controls	4	Ops
3.1	12 Other Incidents				
12.4	Total System Repair Time		0.7 MTTR		

Reporting & Monitoring

Schedule

7 Day



Overall Accelerator Monitoring: Downtime and Incident 7 day moving averages

Continuous Development

- Improve electronic log (ELOG) linking capability to the specific Downtime entry – assist in quick root cause analysis and post mortem investigations.
- Improve database granularity of some system components to expand tracking.
- Redesign Beam Time Accounting and Scheduling methods that would interface with the System Downtime Manager software; allow for real time tracking and automation of Mean Time Between Failure metrics.
- Use data for more in-depth analysis; Reliability Modeling, Risk Analysis, and Spare's Inventory.
- Continue to improve our culture and focus on System Reliability and System Performance Monitoring.

If interested, JLab Software Group may release a version of the System Downtime Manager web interface code for use by others.

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Close

Special thanks to the following:

Ryan Slominski – Lead Software Developer

Accelerator Operators

System Owners

CED Development Group

ARW 2015 Participants

Thank You!

Backup Slides

Backup Slide - Software

- Written in Java
- Hosted in a VMWare environment
- Data is stored in an Oracle database
- Data is published to other applications (logbook) via REST web service