CREATION, TRACKING, AND REPORTING OF RELIABILITY STATISTICS AT THE APS

RANDY FLOOD
Main Control Room Supervisor

October 2017
Accelerator Reliability Workshop Versailles, France

ABOUT THE APS

The Advanced Photon Source (APS) at the U.S. Department of Energy's Argonne National Laboratory is a third generation light source that provides ultra-bright, high-energy storage ring-generated x-ray beams for research in almost all scientific disciplines.

Argonne NATIONAL LABORATORY

The APS is one of the most technologically complex machines in the world. This premier national research facility provides ultra-bright, high-energy x-ray beams to more than 5,000 (and growing) scientists from across the United States annually. These scientists (we call them "users") come to the APS from universities, industry, medical schools, and other research institutions. Our users bring with them ideas for new discoveries in nearly every scientific discipline, from materials science to biology, chemistry, environmental, geological, and planetary science, and fundamental physics.

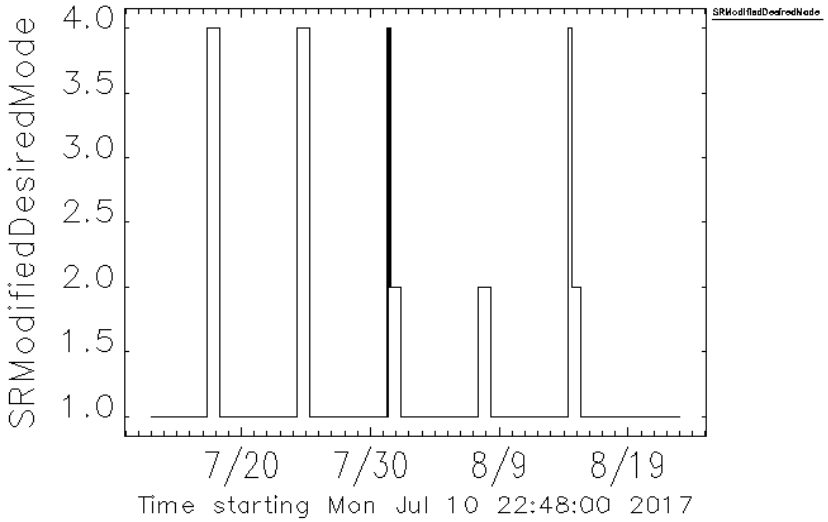
THE APS USES A COMBINATION OF AUTOMATION AND MANUAL WORK TO TRACK AND REPORT OUR RELIABILITY STATISTICS

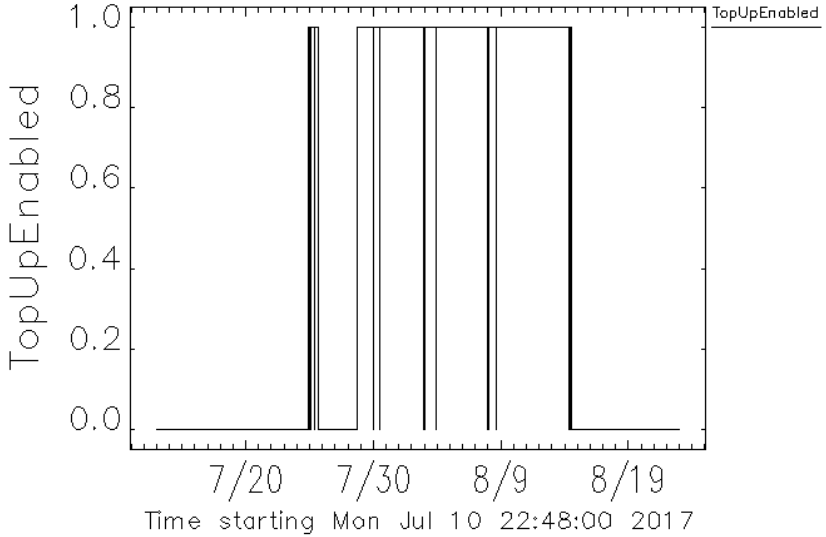
- Data loggers collect information every eight seconds on desired beam characteristics and are extrapolated to provide smooth plotting
- A web page is generated once an hour tracking the data logger information
- Once a week, a spreadsheet is updated to the web to reconcile automatic data with actual times and assignment of downtimes
- At the end of each user run, a series of charts, tables and spreadsheets are generated to compile data for the run, fiscal year and year to date statistics
- Quarterly and annual reports of availability are then generated and submitted to the Department of Energy

The first step in data acquisition is determining if we are:

A) In user mode or machine studies mode and

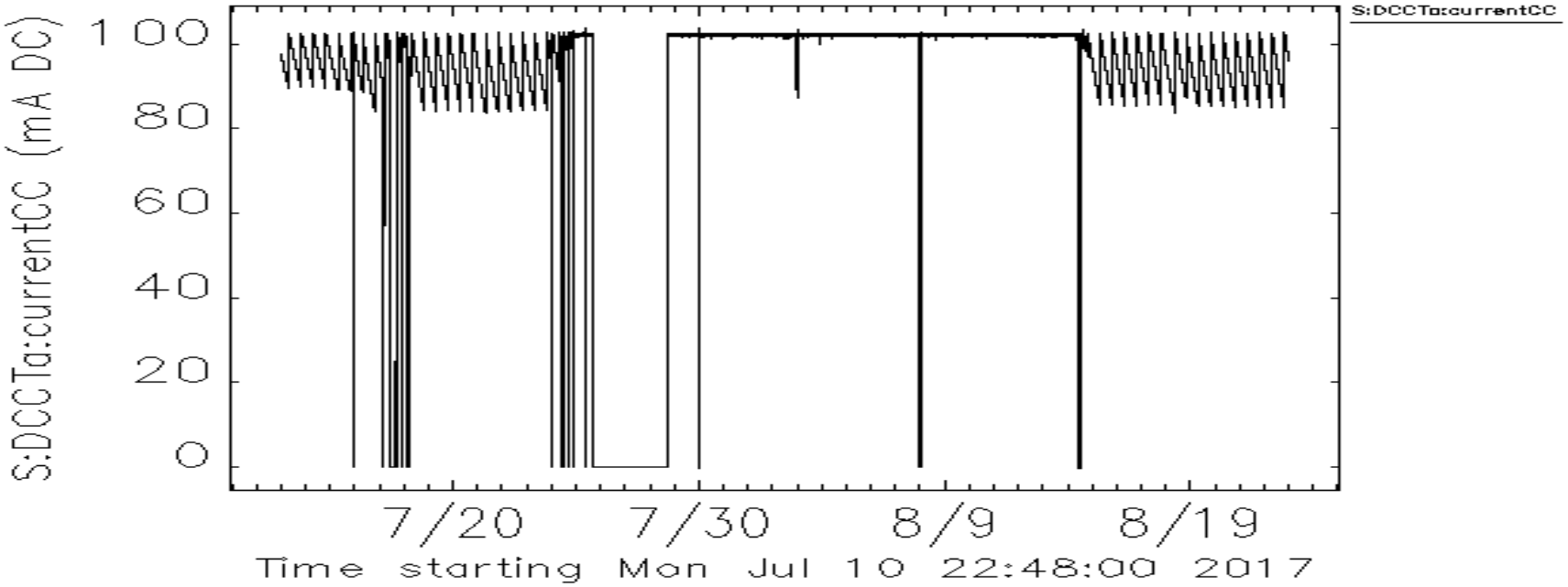
B) If we are in top up mode.





When in Top Up mode, target storage ring current in 102mA. It is considered injector downtime if it falls below 100mA and remains there for >10minutes.

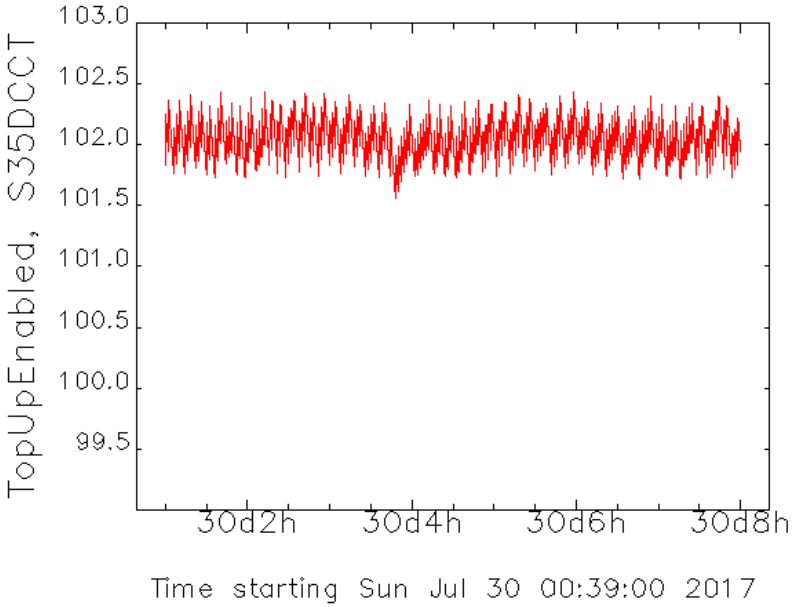
When not in Top Up, refills are performed twice a day at ~85mA.



Argonne NATIONAL LABORATORY

A TYPICAL TOP UP SHIFT
INJECTIONS EVERY 2 MINUTES

We are able to maintain continuous Top Up availability at 98-99%



Determining our metrics for success

- Hours Scheduled for User Operation
  - This is the number of hours scheduled for the user beam studies. Any other activities during this time must be parasitic. Scheduled time for shielding verification or accelerator studies is not included. All statistics reported are recorded only during the User Operation. Typically, there are 5000 hours per FY scheduled for user operation.

- SR/X-ray Availability
  - The number of hours that the beam is available to the users divided by the number of hours of scheduled beam delivery prior to the beginning of a run. The specific definition of available beam is that the Main Control Room has granted permission to the users to open their shutters, AND there is more than 50 mA stored beam in the storage ring. The APS considers 97% to be the minimum acceptable level for availability.

Determining our metrics for success (cont.)

- Fault
  - A fault is defined as complete unavailability of beam either via beam loss or removal of shutter permit not related to weather. A fault also occurs when beam has decayed to the point where beam stability and orbit can no longer be considered reliable. At the APS, this threshold is 50mA. If a fault occurs within one hour of delivered beam, the APS does not count this as a new fault, but renders the time before the fault and the fault as part of the previous downtime.

- Mean Time Between Faults (MTBF)
  - A measure of the average time between faults. MTBF is calculated by taking the delivered beam and dividing by the total number of faults. The APS targets, and routinely exceeds, 70 hours MTBF

WEATHER?????

If we have a tornado (for example) it counts as downtime, but not a fault. If we have a lightning strike that damages equipment, it is a fault and downtime. The assumption is that equipment should be able to handle that type of weather, but a tornado becomes a personnel safety issue.

The truth is, our users would stay at their experiment as the building disintegrated around them to collect that last data point. Removing shutter permit forces them to leave the area.

Downtime budgets

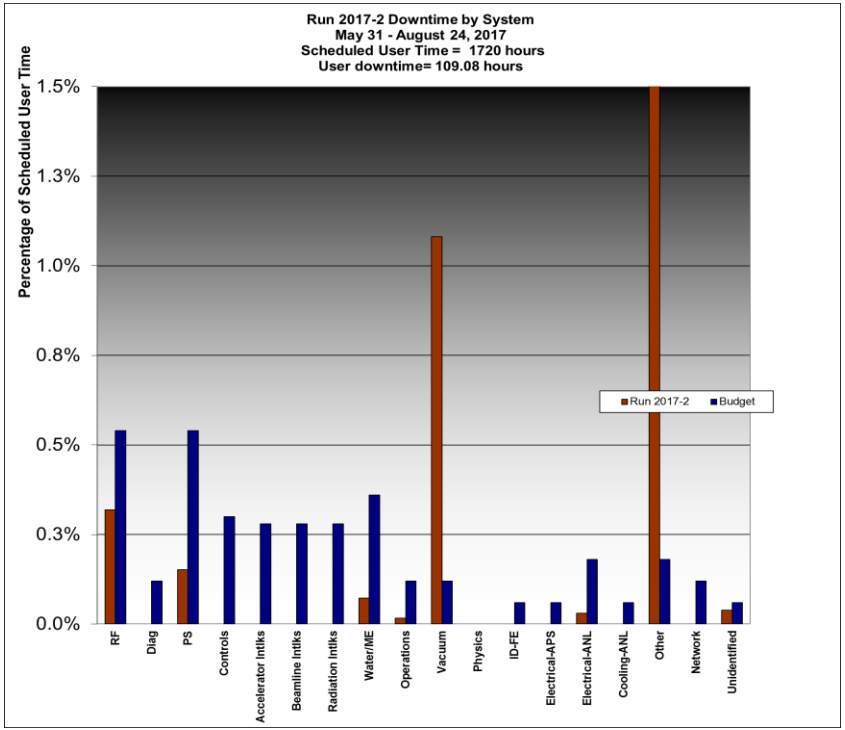
- All downtimes are NOT created equally.
- We started with the assumption that we are allowed no more than 150 hours of downtime per FY (3% of 5000 scheduled user hours)
- Then we factored in historical averages of downtime incidents and modeled the new budget based on the percentage of each group's average made to comply with the 3% goal.
- RF and PS are our biggest downtime creators and account for nearly half of our annual budget
- As RF and PS reliability have improved, our ability to exceed the 97% has increased substantially.

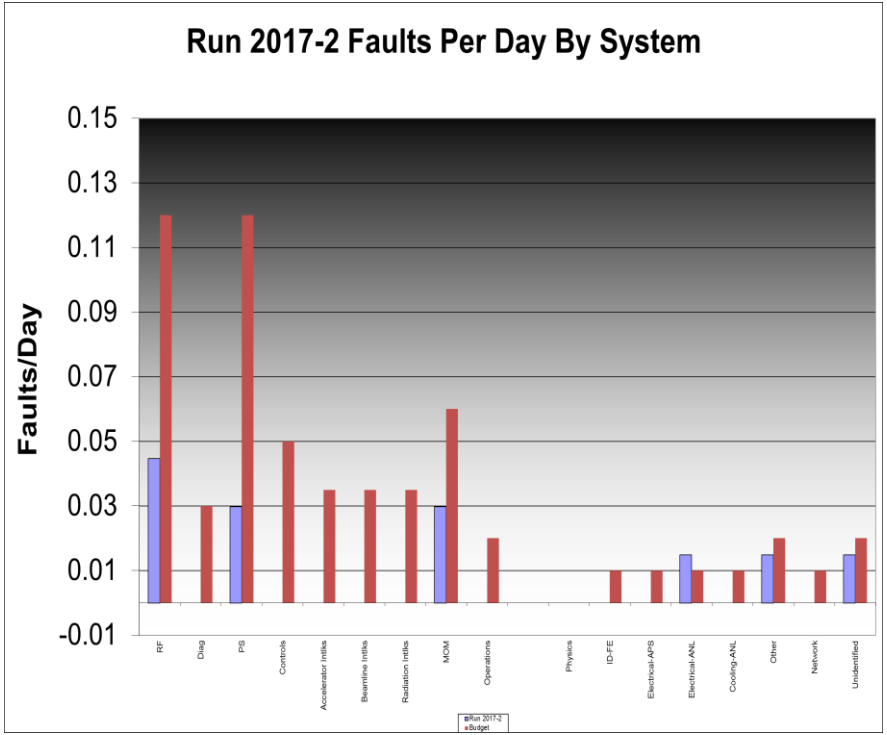
HOW WELL DO WE MEET THE 97% GOAL?

In short, very.

- For the last ten years, we've exceeded our 97% goal in every single run except for FY 08 where we had runs of 96.9% and 96.8% and our last run (which, unfortunately, we will talk about later)
- For a 20 year old facility, our lifetime availability stands at 97.3%
- There have only been two runs in the last ten years where we didn't meet the 70 hour MTBF.

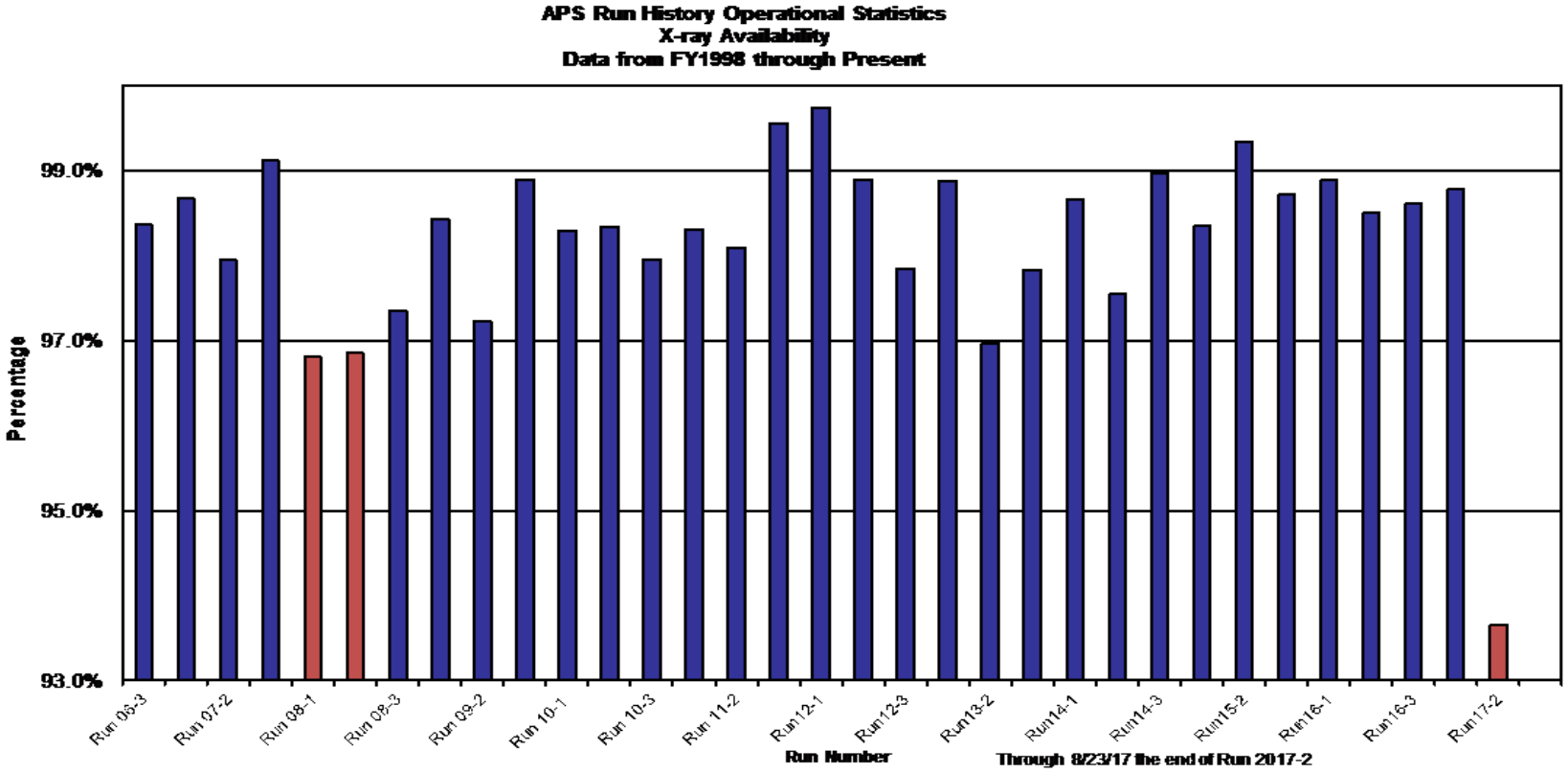
AVAILABILITY AND FAULTS PER DAY BY GROUP



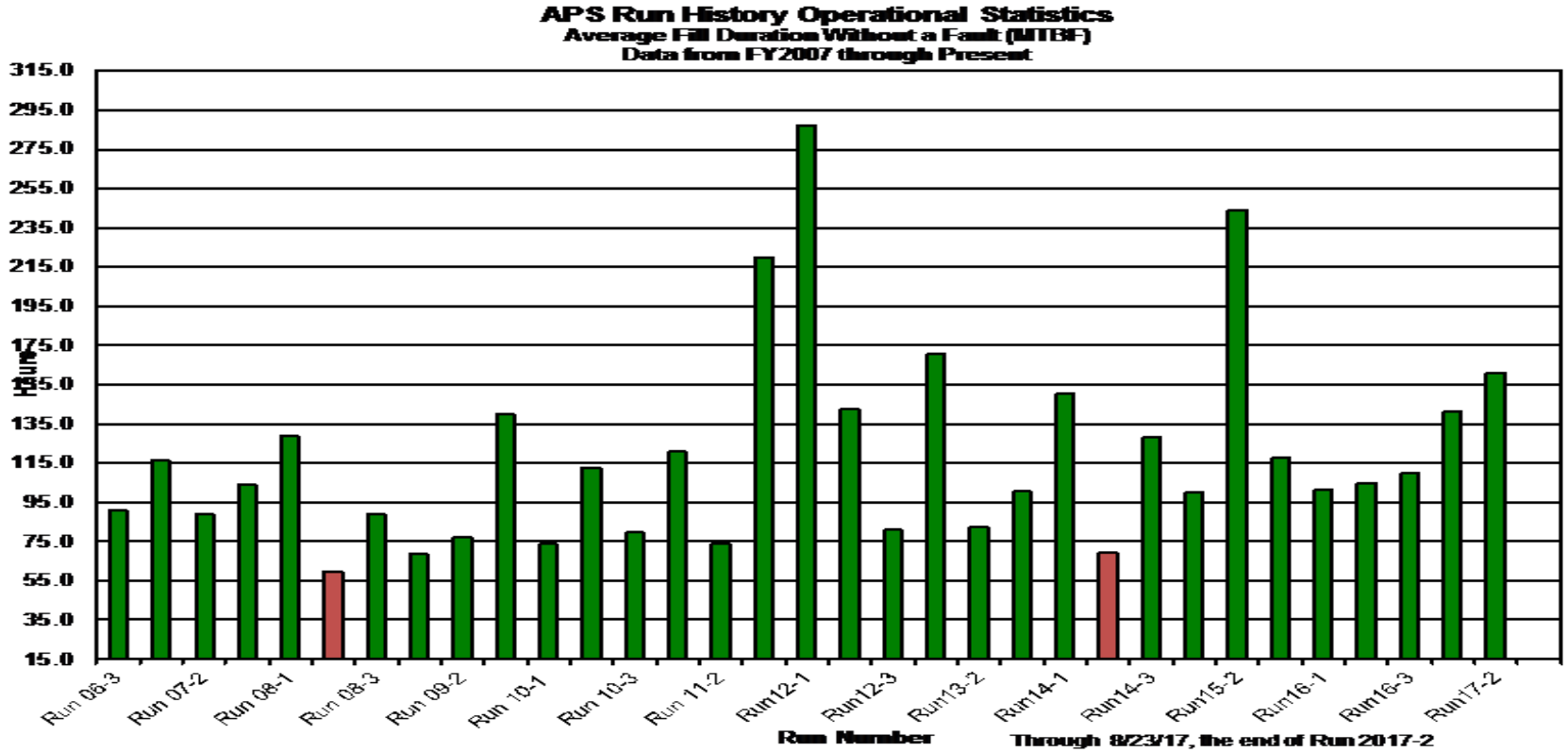


Argonne NATIONAL LABORATORY

AVAILABILITY

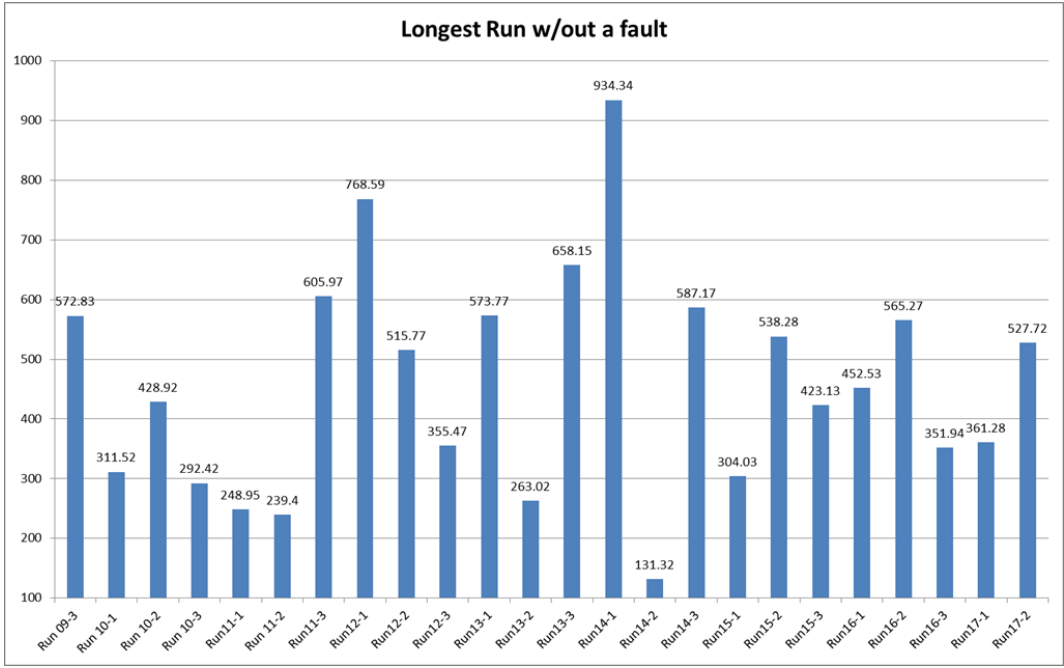


MTBF


APS Run History Operational Statistics
Average Fill Duration Without a Fault (MTBF)
Data from FY2007 through Present
Hours
315.0
295.0
275.0
255.0
235.0
215.0
195.0
175.0
155.0
135.0
115.0
95.0
75.0
55.0
35.0
15.0
Run 06-3
Run 07-2
Run 08-1
Run 08-3
Run 09-2
Run 10-1
Run 10-3
Run 11-2
Run12-1
Run12-3
Run13-2
Run14-1
Run14-3
Run15-2
Run16-1
Run16-3
Run17-2
Run Number
Through 8/23/17, the end of Run 2017-2

LONGEST RUNS WITHOUT A FAULT

Since we started tracking this, we consistently have runs in excess of 200 hours between faults and frequently exceed 400 or 500 hours.
This provides even more peace of mind for users knowing faults are few and far between



RUN 2017-2

- Our most recent run started out with bad luck.
- We have machine studies for a week prior to a user run to set up the machine, test upgrades made during the shutdown, etc.
- On one of the last days of studies, a significant vacuum leak was detected
- By the time bake outs and beam conditioning were complete, we started with 24 hours of downtime before opening shutters for the first time.
- To put that in perspective, we had 15 complete runs since 2009 that had 30 hours or less downtime for the whole run

RUN 2017-2 (CONT.)

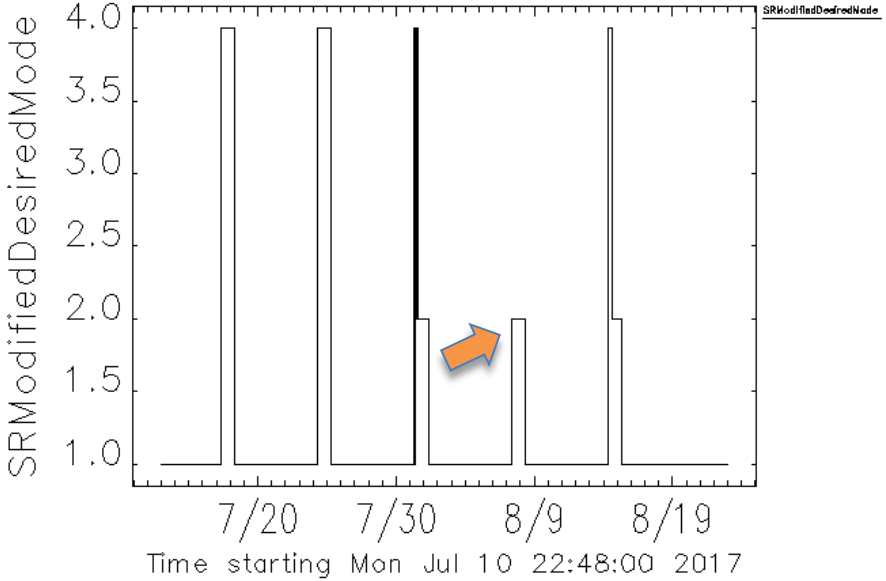
Electrical safety

- In July, we had two electrical safety incidents within a two week period. Our management and DOE agreed that a pause in operations was needed to ensure proper electrical safety practices were being followed at the APS and the user community.
- The administrative stand-down and subsequent recovery was 74 hours prior giving beam back to the users.
- Our availability was the poorest we'd seen in a long time, but it was actually a good run. Even with the vacuum leak, if the admin shutdown hadn't occurred, we would have reached 98.2% availability with 9 faults.

SUPPLEMENTAL TIME

Time given to the users that doesn't improve our stats

- To compensate the users for time lost during the administrative shutdown, we cancelled a significant number of machine studies days and pushed back the start of our extended end of summer shutdown.
- The users recovered 88 hours of the 98 lost due to the vacuum leak and the administrative shutdown.



SUMMARY

- The APS uses a combination of automation and manual entry to create and track our beam availability.
- 2017 was an aberration in reliability and it is entirely attributable to two incidents.
- We are a very reliable facility. This FY ended a string of 15 consecutive years providing over 97% beam availability (96.96% this year) and we've been above 70 hours MTBF since 2004 and are consistently closer to 100 hours than 70.

THANK YOU FOR YOUR TIME