MAXIMISING BEAM AVAILABILITY AT THE AUSTRALIAN SYNCHROTRON

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Abstract

The Australian Synchrotron has been open to users since April 2007. Beam availability is now consistently above 98%, with a Mean Time Between Failures (MTBF) of approximately 50 hours and a Mean Down Time (MDT) of approximately 1 hour. This paper discusses the program of activities that has been undertaken to improve beam availability, and to maximize the MTBF and reduce the MDT.

BACKGROUND

One of the most important Key Performance Indicators (KPI) for the Australian Synchrotron, now into its 4th year of operations, is beam availability greater than 97%. In striving to actively improve performance and reliability in many areas, it was realised that one of the major factors in maximising availability, is implementing preventative measures and recovery procedures after an unscheduled beam loss [2]. By successfully implementing improvements in these areas, we have already managed to achieve availability > 98%, which is above our long term target (see Fig. 1).

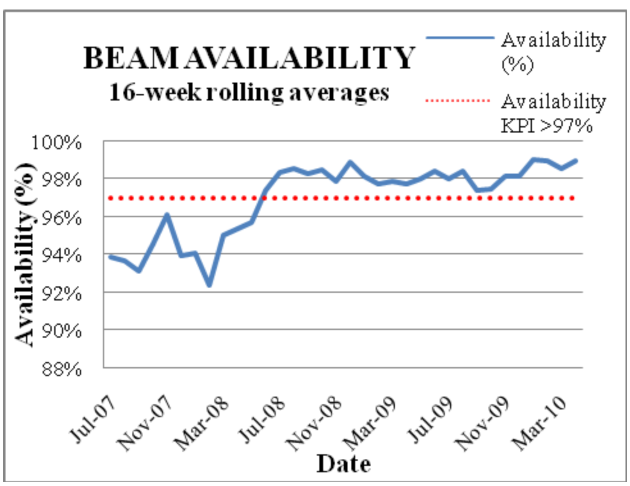

Figure 1: Beam Availability for 16 week rolling averages [1]

This achievement has also directly improved the MTBF and MDT respectively (see Fig. 2). With KPI's of greater than 50hrs for MTBF and less than 1.5hrs for MDT, we are currently meeting these performance goals.

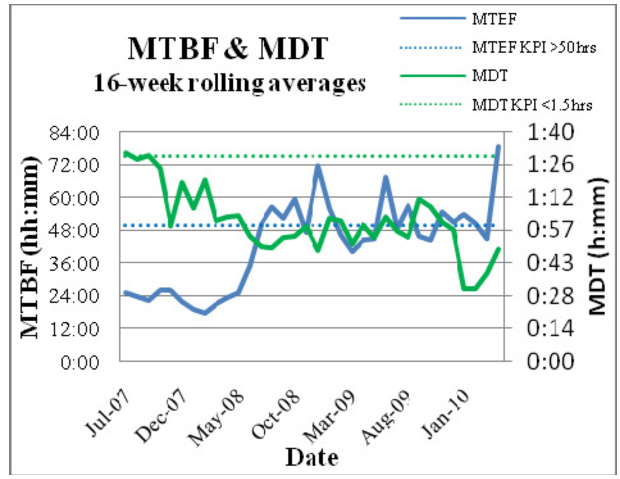

Figure 2: MTBF and MDT for 16 week rolling averages [1]

We categorise our faults into 8 different categories (see Table 1). Beamlines, Controls, Human, Plant, Power (site feed), Power Supplies, RF, and Vacuum.

Table 1: Yearly Operation statistics till 2009 [1].

Cause	Total Number of Faults			MDT (h:mm)			MTBF(h:m)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
BEAMLINE	18	11	16	0:35	0:27	0:19	148:54	429:38	306:07
CONTROLS	17	17	5	0:51	0:54	1:12	157:40	278:00	979:36
HUMAN	17	10	13	1:09	0:31	0:37	157:40	472:36	376:46
PLANT	6	11	9	3:55	1:31	1:08	446:43	429:38	544:13
POWER	7	22	42	3:06	2:04	1:13	382:54	214:49	116:37
POWER SUPPLY	6	15	2	1:15	0:54	0:40	446:43	315:04	2449:00
SR-RF	35	26	13	0:37	0:33	0:25	76:34	181:46	376:46
VAC	12	4	3	2:47	0:34	2:20	223:21	1181:32	1632:40
TOTALS	**118**	**116**	**103**	**1:18**	**1:01**	**0:55**	**22:42**	**40:44**	**47:33**

Significant improvements have been made to increase the reliability in all areas. Reliability Plans were developed with the scope of increasing each fault area's MTBF and reducing MDT. The following broad preventative actions were applied to each area to reduce the fault from occurring again and reducing the MDT:

- Engineer protection: Wherever possible provide a level of protection or confirmation to inhibit the application of unsuitable or undesirable operating conditions. Also engineer in redundancy measures to duplicate critical components of a system with the intention of increasing the reliability.
- Procedural change: Ensure that procedures are current and in place for all common tasks and in particular for processes which have limited engineering protection.
- Staff knowledge and training: Improve the depth and breadth of documentation, training and knowledge to reduce the possibility of errors.
- Preparation for a specific action: Where an uncommon or one off procedure is to be implemented ensure that all possible mitigations have been applied.

EXAMPLE FAULTS AND MITIGATION

Beamline

Fault: EPS vacuum fault mode interaction with storage ring - A vacuum fault (i.e. loss of vacuum) in a beamline should result in the immediate closing of gate valves to protect the ring vacuum. If the photon shutter is open, this could result in the irradiation of the closed gate valve by the photon beam. To prevent this, the RF is immediately tripped. Unnecessary RF trips, however, were caused by beamline vacuum faults when the photon shutter was closed – with no possibility of hitting gate valves with beam.

Mitigation: Failure mode of ring EPS has been modified so that RF is not tripped as a result of a beamline vacuum failure when the photon shutter is closed. [3]

Controls

Fault: Input/Output Controller (IOC) hardware failures - The IOC hardware is aging, and the older components are due for replacement. The earlier IOC's are now starting to exhibit end of life failures. Typically, but not always, this is exhibited by failures to their power supplies. Standard computing components were used for the designs – these have a lifetime 3-5 years. One IOC has failed completely, as well as several Micro IOC's. Fortunately, due to good planning and engineering none of these failures impacted uptime.

Mitigation: All IOCS be replaced on a five year cycle. IOC's at four years should be replaced in a criticality order determined by failure severity. [4]

Human

Fault: The longest human error down time was ~9hrs. A Low Conductivity Water (LCW) hose blew off after it was incorrectly fitted to a power supply - This resulted in water being sprayed throughout the rack and adjoining areas. The mop up operation took 9 hours. Procedural changes have been implemented to reduce the chance of this reoccurring. It should be noted that this occurred following a major event which saw 23 power supplies being replaced. It is likely that staff involved in the replacement were tired which may have contributed to the failure.

Mitigation: We replaced all the old hose fittings with quick disconnects, simplifying the changeover of supplies and reducing the risk of the hose connections coming loose. [5]

Plant

Fault: Storage Ring Radio Frequency (SRRF) system LCW temperature oscillations - Oscillations in the SRRF LCW temperature have caused several beam dumps in the past. These oscillations can be caused by:

- A sudden change in load, such as when the beam is lost for another reason. The oscillations will then continue until injection occurs, before the SRRF trips and the beam is lost again.
- A chilled water pump starting. As the chilled water pump starts before the associated chiller a slug of warm water is introduced into the primary chilled water circuit. This then causes a sudden change in the secondary chilled water temperature and the LCW temperature. The sudden change can set the SRRF LCW temperature oscillating and eventually trip the beam.

Mitigation: This problem has now been addressed by altering the Programmable Logic Controller (PLC) control logic that drives the flow control valves to increase the response time of the system. This solution is being monitored and further adjustments may be made to the control parameters in the future. [6]

Power (site feed)

Fault: Brown outs - In the 2009 calendar year, brown outs caused 42 of a total of 103 beam losses events. This contributed to 55% of the total downtime, with a MTBF of 117hrs (Table 1). There are certain issues with the quality of incoming mains power from the substation, but we discovered that certain systems were even susceptible to a dip in mains of just ~5%.

Mitigation: Installation plans are being done to install 3 415V three phase, neutral and earth 50Hz UPS systems to critical systems of the storage ring (eg. SRRF, Storage Ring power supplies, and LCW). This implementation should drastically improve the sites susceptibility to the numerous brown out events. [7]

Power Supplies

Fault: Constant faults due to cycling the multipole magnet power supplies - To counteract the effects of hysteresis in the magnets, the magnet power supplies need to be constantly cycled from 0A to a specific maximum current. This cycling procedure should be well within the operating capabilities of the power supplies, but we are experiencing numerous faults during this process that are significantly impacting further downtimes.

Mitigation: Current investigations into possible power supply upgrades are occurring. Collaborations with other facilities are being conducted to research technical improvements and possible future directions. [8]

RF

Fault: Constant false Arc detector faults - There have been several trips due to Arc detectors, in either the Circulator, Klystron or Coupler. While they may be real arcs, the other associated faults do not really show the characteristics that should be present in the event of a serious arc. Either there are small arcs happening and the sensors are too sensitive, or they are triggering on noise (We know from commissioning experience that the arc detectors can be triggered by radiation). The incidence of these trips seemed to increase over time which led us to investigate the problem.

Mitigation: We investigated the waveguides to determine if arcing was occurring and this didn't reveal any issues. The characteristics of the faults were deemed to not be an event of serious arcing, thus, it was decided to possibly reduce the sensitivity of the arc detectors. A test was done where by the detectors were disconnected and it was noticed that they were still tripping. We concluded that they were being affected by possible electrical disturbances or earthing issues. We are currently investigating and resolving facility earthing issues, which has the possibility of improving the arc detectors. If there are no improvements then further investigation will be required. [9]

Vacuum

Fault: Photon scattering into vacuum gauges during photon shutter transition - During a transition (opening or closing) the edge of the shutter blade passes through the beam. The scatter from this had a direct line of sight to the cold cathode vacuum gauge potentially creating a false reading of pressure. When the white beam shutters are open, this would trip the SRRF.

Mitigation: Additional vacuum tube components (elbows etc) have been installed to ensure that photons scattered from the shutter have no direct line of sight to the gauge heads. [10]

FUTURE DEVELOPMENTS

Resulting from the successful implementation of processes and improvements made to machine availability, we are now investigating implementing this to Beamline availability. As the machine becomes more and more reliable, we need to look into the availability of each Beamline. This will help us deduce fault or issue areas in individual Beamlines which prevent and reduce the users valuable beam time. Implementing an availability matrix for Beamlines might prove difficult, as each Beamline might need a specific individual matrix.

CONCLUSIONS

- By successfully improving and implementing preventative measures and recovery procedures after an unscheduled beam loss, the Australian Synchrotron has improved in reliability
- Only in our 4th year of operations, it can be seen from our increase in beam availability to >97%, that we have become a strong reliable facility.
- As we grow into the future, hopefully the processes we have developed to resolving faults will help us maintain this successfully high availability.

REFERENCES

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