13 Years of Development – Machine Reliability at the Canadian Light Source

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Accelerator Reliability Workshop

The Canadian Light Source (CLS) had first light in 2004 and has been shining since then. Achieving high operational reliability and availability is done through periodic monitoring of benchmark statistics, and having an organizational structure that can push these statistics in the right direction. Reliability is further enhanced through mitigation of infrastructure failures and priority management. Here we report our historical operation statistics and provide some catastrophic highlights that have motivated risk mitigation.

Our Key Operation Goals

Mean time between trips > 50 hours
Availability > 95%
Delivery > 5000 hours/yr

Continuous but Efficient Communication

- **Daily:** Events from the operation of the accelerator system feeds into an E-log.
- **Weekly:** Events are summarized, discussed, and addressed at an operations meeting and highlighted at a meeting between science and machine divisions.
- **Monthly:** The operation statistics are summarized in a run report.

Run Report
(Statistics Summary)

1-1.5 Months

User Beam Shift ~ 24/7 Event Logging

Wednesday Operations Meeting

1 Day

Thursday Meeting with Science Division

Two weeks

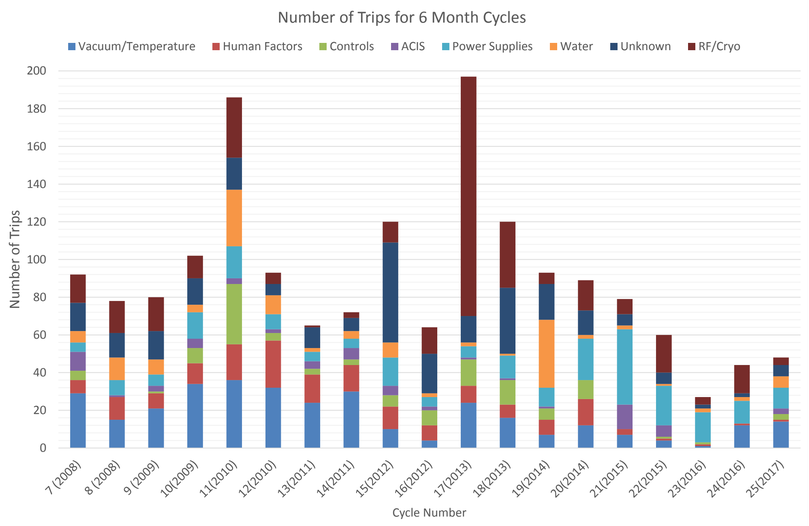
Maintenance /
RF SC Cavity Conditioning Shift

Action

Reliability events occur and must be addressed. The CLS has a granular approach.

- **Minor Issues:** Addressed immediately with machine operation (ex. orbit corrector problem).
- **Small Scale Problems**: Addressed during an 8 hour maintenance shift each 2 weeks. (ex. PLC interlock flaw)
- **Large Scale Challenges:** Diagnosed and remedied during a bi-annual maintenance outage. (ex. Upgrade or replacement of a failing hardware system)

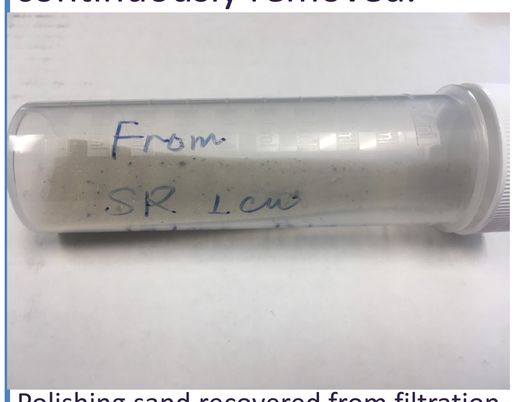
Interesting Trips and Faults



With the exception of some anomalies the number of beam trips has been decreasing.

Human Factors (Oops) Trips: The human side of machine reliability. Over years, each week, we have reduced these occurrences, through systematic training, increasing automation, and improved interlocking.

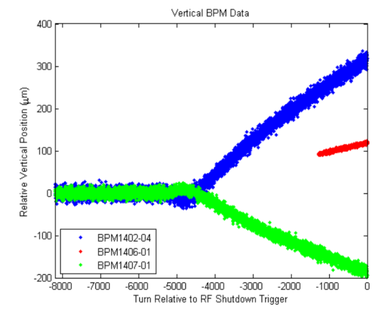
Water Flow Trips[A]: Approaching elimination. In 2012 we added in-line filtration for the LCW water has eliminated clogging of components. Sand polish and metal erosion are continuously removed.



Polishing sand recovered from filtration system.

Filtration System.

Bad Orbits[C]: (2014) They were a real orbit interlock triggered by an embedded firmware bug. *Small changes* in set point resulted in *large changes* in register values during a zero crossing transition. Previously categorized as "unknown" in our trip tracking. Once determined tracked as power supply trips. Now fixed!



DAC Setpoint	Register
2000	00000000000011111010000
-2000	11111111111100000110000
-260144	11111100000011111010000

SC RF Cryo[B]: (2007 & 2008) He transfer line failures due to incorrect bellows ~ 6 weeks downtime.

CESR-B SC RF Cavity.

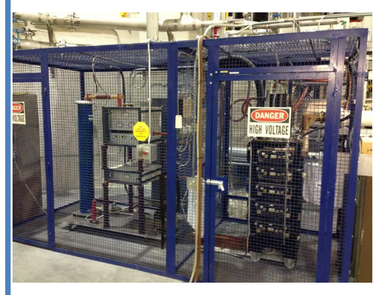
Bellows.

(2012) Air end supply catastrophic failure (160 hours) due to error in compressor manual oil check procedure.

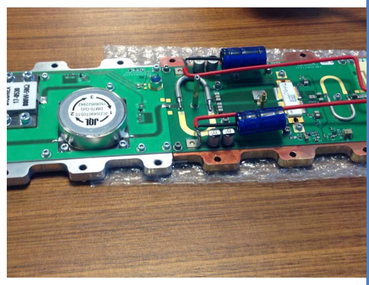
Compressor.

(2013) He leak to cavity vacuum. Small indium seals failed. Downtime ~ 3 weeks. Beam current reduced from 250 to less than 200 mA for ~ 4 months to recondition spare cavity.

Booster RF: (2014) Catastrophic failure of booster RF Klystron tube. Controls flaw allowed it to be turned on at full power. Tube went *kaboom*. One spare ~ obsolete product. Upgrading to Solid State Amplifier in 2018.



Booster Klystron.



Solid State Module (Cryoelectra)

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