Dynamic System Reliability Modeling of SLAC's Radiation Safety Systems

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Introduction

SLAC is a user facility for 3 costly beam programs, and should provide 95% beam availability to end users:

- LCLS: $400M
- LCLS-II: $1B;
- FACET-II: $50M

Radiation Safety Systems (RSS) must be reliable to meet the high availability requirement. In this paper, will examine major components of RSS, and identify the dependency of each beam program to those major pieces of RSS.

Why RSS Availability Matter

RSS Must be reliable:

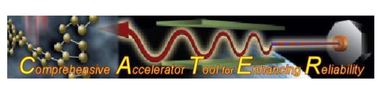
- RSS outputs are permits, enable beam production and transportation
- They are under rigorous configuration control, once faulted, have to be fully repaired before operation
- RSS trips imply there are failures with other protection layer, need more investigation
- Different beam program has overlap in the accelerator tunnel
- RSS are global systems, they cross the beam program boundary.
- For PPS, it is not a single system, but a cluster of small control systems using different technologies

RSS design requires:

- Easy and safe configuration control management
- Quickly isolate and bypass faulted systems not relevant to the safe operation
- Automatic fault bypass under safe conditions
- More diagnostics to shorten MTTR

Reliability methods/data are available for modelling & prediction:

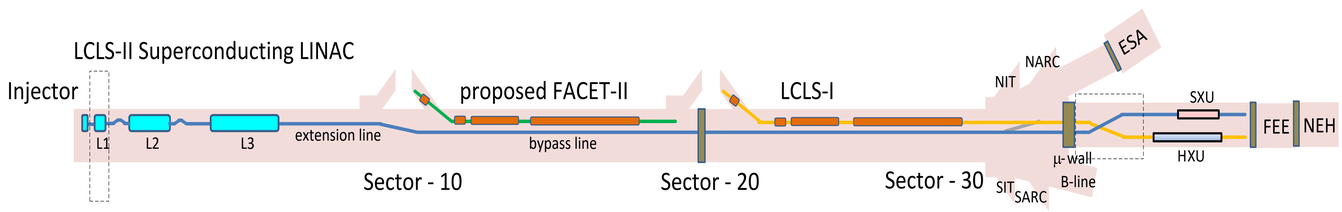
- SLAC's CATER work order database & RSWCF



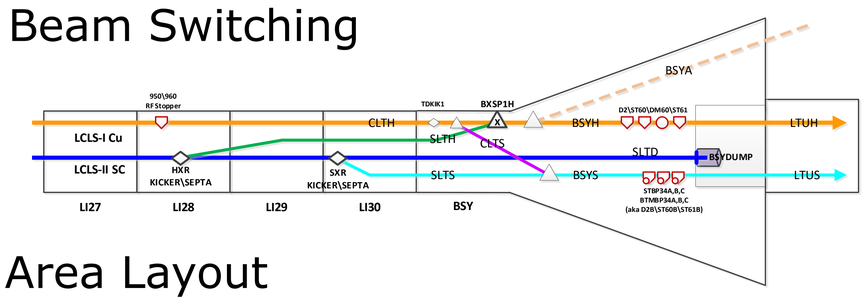
- RIAC EPRD (Electronic Parts Reliability Data) and other data sources
- Use "parts count" method to get a conservative estimation
- PLC vendors' published MTBF data

SLAC's Accelerator Layout & Beam Switching

Total length: ~ 4km

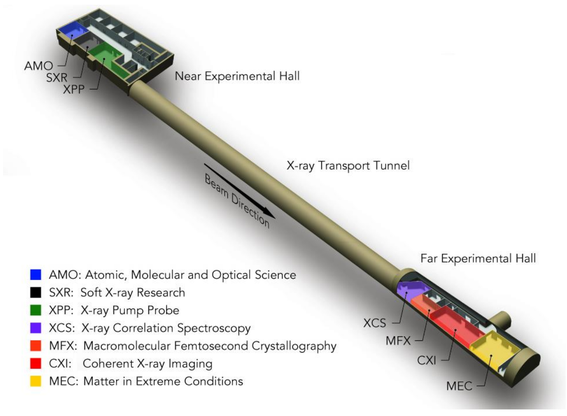


LCLS/LCLS-II Beam Switching



SXR/HXR Exp Area Layout

Now



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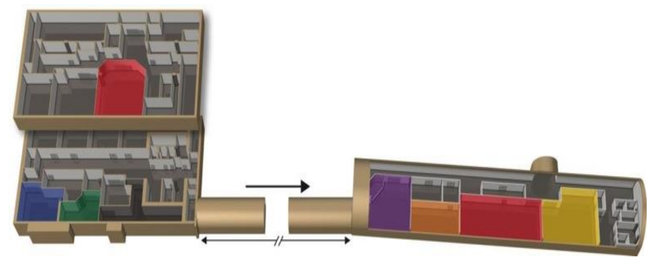
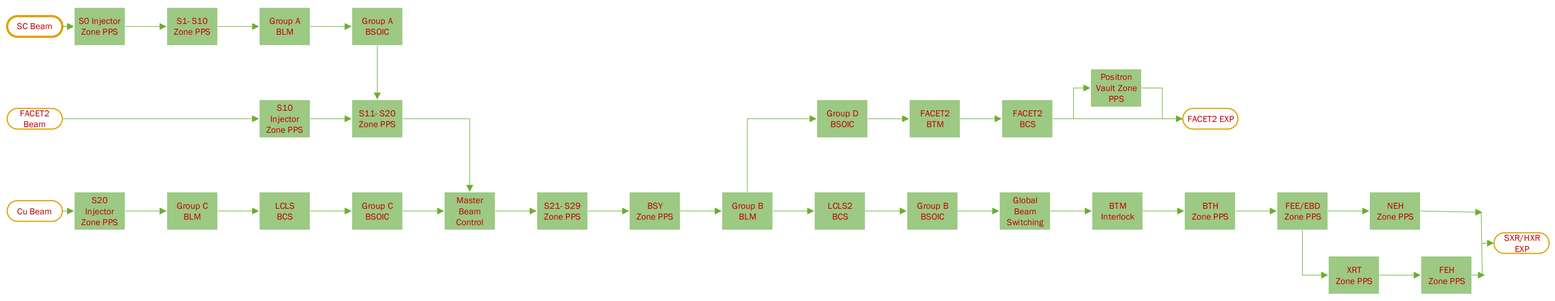


Beam Program's Reliability Block Diagram



Major Components

BSOIC: Beam Shutoff Ion Chamber

BTM: Burn Through Monitor

Master Beam Control: a separate RSS operation interface to complement EPICS

BLM: BCS Beam Loss Monitor, include
Protection Ion Chamber (point)
Diamond (point)
Long Ion Chamber (line)
fiber (line)

Zone PPS: relay based system; or new redundant Pilz safety PLC, and Allen-Bradley/Siemens PLC for access control

BCS: composed of customized electronics; LCLS-II BCS includes a new distributed Siemens safety PLC

Conclusions

- Majority of RSS reliability can be estimated from EPRD, PLC vendors' data, and SLAC's site repair records
- The analysis can go deeper for each experimental hutch
- Transmission of SC beam depends on S11-S20 zone PPS, which is a 50 years old relay based system
- There is coupling between SC and Cu beam, which affects availability
- Safety PLC's fail-safe feature may lower system availability, needs a quick repair/replacement plan
- Preventative maintenance