Workshop on Machine Protection, focusing on Linear Accelerator complexes

Summary of Fifth Session – Operational Aspects

1) RF Breakdown recovery
2) CLIC (LC) intensity ramping
3) AvailSim
4) BIS Reliability
5) Linac-4 Risk Assessment
6) Systems Engineering Approach

Marc Ross, SLAC

Machine Protection in Linacs

- **High Power linacs are planned or under construction**
- **Many – but not all – of the LHC MPS lessons can be directly applied**
  - (All LHC experience is interesting and useful)
- **Achievable performance will depend on implementation strategy and details**
  1. RF Breakdown 'kicks' → Basic physical effect
  2. Thermal stabilization → Technical systems effect
  3. System modeling → Machine design
  4. BIS reliability → real-life experience
  5. Risk tabulation and evaluation →Criteria (specification) development
  6. Systems Approach → Quality Assurance

Machine Protection in Linacs (2)

- **What should be the performance goal?**
  - (Different issues than with LHC)
- **What are the key questions?**
  - Safety Culture
  - Sub-system boundaries
  - Understanding particular failures and rates and comparing to models → 'benchmarking'
  - Remaining risks
- **Example: 'Accelerator Driven Systems' (ADS) →**

Linac Operation (ADS):

- "I was the chairman of the committee that recommended to the DOE that the Accelerator Driven Systems (ADS) approach to dealing with the long-lived component of spent nuclear fuel be terminated. It was, indeed, an accelerator issue but not the one implied in your article ("Taking the Heat out of Nuclear Waste," February 2012). Superconducting systems were already in use and everyone believed that they could be scaled up to the many-megawatt beam level required for ADS to work. At Los Alamos, the most difficult part, the low-energy front end, had been built and tested. The issue was reliability." ---

Linac Operation (ADS 2)

- **“There are still important safety issues. One of them is related to the frequency of accelerator trips. Frequent starting and stopping of a reactor, even a subcritical facility driven by an accelerator, stress the reactor. The standard fission reactors we use today trip very infrequently and each is investigated to find out why before permission to restart is given. I know of no analysis of allowable trip frequency versus down time that would be acceptable. There are a few early versions, but none has been through the kind of hardnosed peer review that our regulators would require. Clearly an outage of one second does not change temperature much and would not be a problem. Outages of minutes would begin to be.”**
- *Burton Richter, former SLAC Director, in letter to ‘Symmetry’, March 2012*
- **(coloring mine)**

"Complex systems"

- **What is a complex system?**
- **is Linear Collider MPS complex?**
  – (probably yes)
- **If yes, can it be made simpler?**

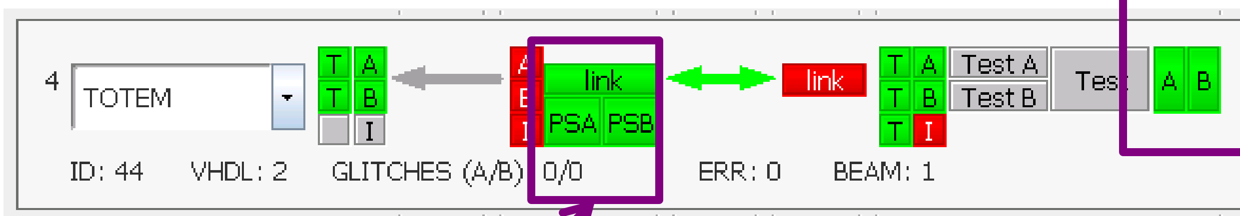
- **See references on reliability performance of complex systems:**
  – e.g. "Normal Accidents: Living with high risk technology", Charles Perrow, 1984

Relevant?

- *Normal Accidents* analyzes the social side of technological risk. Charles Perrow argues that the conventional engineering approach to ensuring safety--building in more warnings and safeguards--fails because systems complexity makes failures inevitable. He asserts that typical precautions, by adding to complexity, may help create new categories of accidents. (At Chernobyl, tests of a new safety system helped produce the meltdown and subsequent fire.) By recognizing two dimensions of risk--complex versus linear interactions, and tight versus loose coupling--this book provides a powerful framework for analyzing risks and the organizations that insist we run them.

Lose availability with multiple failures (Murphy's Law)

1. Software configured to read these power supplies



2. But the failure related to these power supplies

3. which were connected to the same 220V reglette!

4. Loss of availability…

e.g. installation incorrect AND
Software not correctly configured AND
Something trivial failed =
Hours to understand trivial event…

Difficult to diagnose but Easy to fix