ILC High Availability Electronics & Controls

DOE Program Review

SLAC June 5-6, 2006

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Outline

- I. Why High Availability & Why Now?
- II. HA ILC Power Systems Architectures
  - Modulators, Power Supplies, Kickers
- III. Diagnostics Processor
  - Intelligent platform management for Hardware, Software
- IV. HA ILC Controls, Instrumentation Standards
- V. Summary & Conclusion

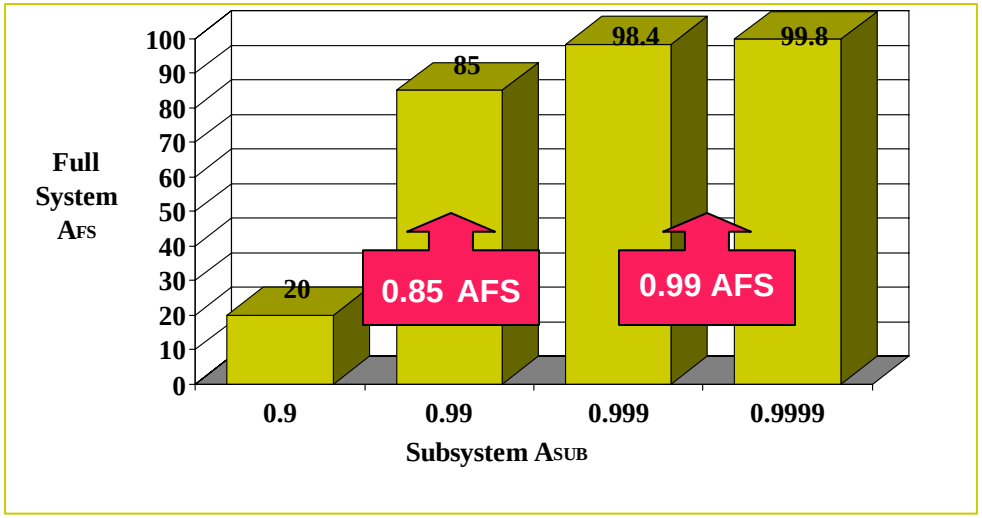
I. Why HA and Why Now?

Why HA?

- Computer Modeling[1] demonstrates that ILC can achieve only ~20% uptime (Availability) with current subsystem architectures, component reliabilities, c.f. 85% or higher goal.
- Reliability = MTBF; Mean time to repair = MTTR
- Availability one component or subsystem, A_1= MTBF/(MTBF-MTTR) $\rightarrow$1 as MTBF $\rightarrow \infty$ or MTTR$\rightarrow$ 0.
- Availability of system of N components or subsystems $A_N = (A_1)^N$
- For 85% Total Machine Availability N major subsystems, A_T=0.85, all subsystems must have average A_N of $(0.85)^{1/N}$
- For 20 major subsystems, required average $[A_N]$=0.992
- Strive for $[A_N] > 0.99$ by HA design:
  - Increase MTBF: Use n/N modular failure-tolerant architectures
  - Reduce MTTR: Hot swap failed n/N modules without interrupting operations
  - Accomplish at minimal incremental capital and operating costs

[1]*Availism*, T. Himel

I. Why Now?

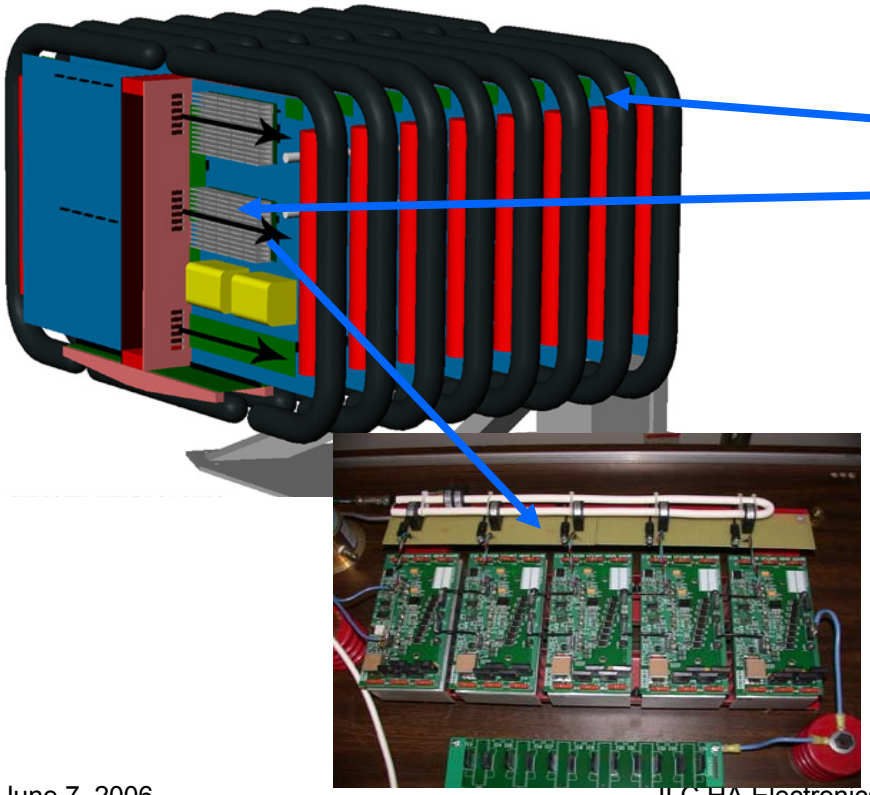


- Limited Window of Opportunity to advance critical HA designs
- Strong investment in hardware and software R&D over 2-3 years needed to learn how to design, implement effective HA at modest cost.
- Program
  - Apply HA principles to Power, Controls and Instrument Systems
  - Investigate multi-level 1/n redundancy, modular design and hot-swap strategies.
  - Down-select architectures by end FY2009.

II. Power Systems - Marx Modulator

- 670 10MW RF Stations ~ 12% TPC
- Modulator Goals: Raise Availability, reduce modulator cost by >50%
- Demonstrate first prototype in lab at full power in FY06

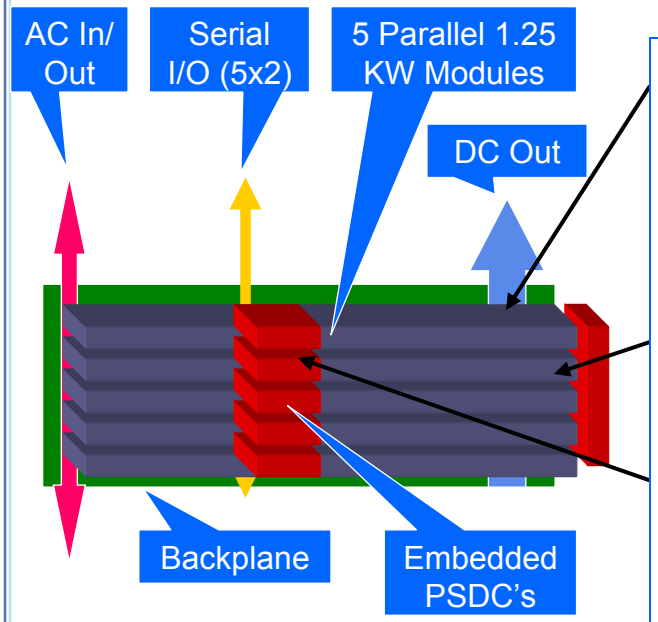
2m x 2m x 2m Enclosure Air Cooled



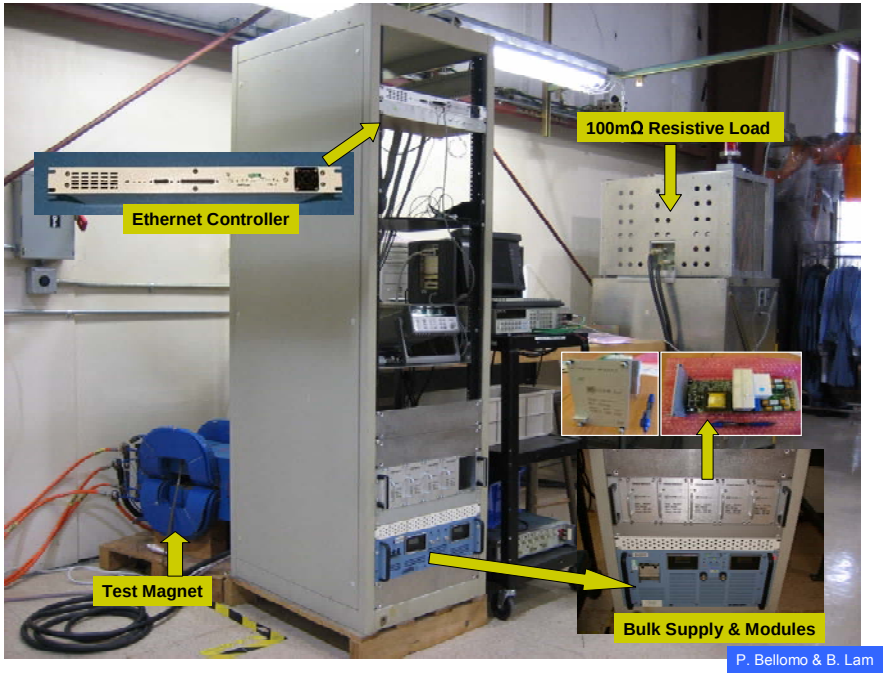
- >MTBF: 3-Level n/N Redundancy
  - +2% RF Stations in overall system
  - 2/14 Mother-boards
  - 1/5 IGBT switch subassemblies
- <MTTR: Quickly replaceable "Cells"
- Intelligent Diagnostics
  - Fault management at Main Control
  - Imbedded diagnostics & control in every MBrd
  - Networked by redundant fiber to Main Control

II. Power Systems: DC Magnets

- Approx. 18,000 magnets & supplies in all systems
- For A~0.99 require modular n/N, Dual Bulk, Dual Controller
- Improved MTBF magnets, water systems, cable connections etc.
- FY06-08 Goals: Demonstrate all HA features on multi-unit test system.

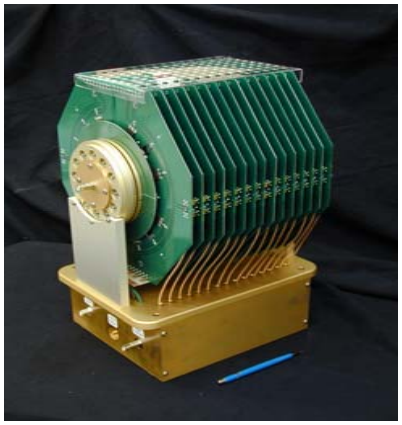


- 1/N parallel modules for DC magnet supply (1/5 shown)
- Independent dual controller
- Diagnostics each module
- Overall load current feedback



Prototype Test n/N Auto-Failover

II. HA Kicker System Goals

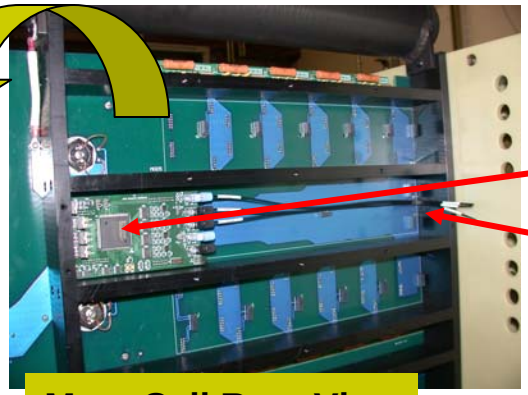


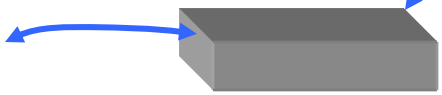
- Critical System to support 6 km rings
- 10-20 Modular Units in HA topology
- n/N redundant at Unit, Board levels
- Intelligent Diagnostics
- Auto-failover for boards
- Access for unit hot-swap (while machine running if possible)

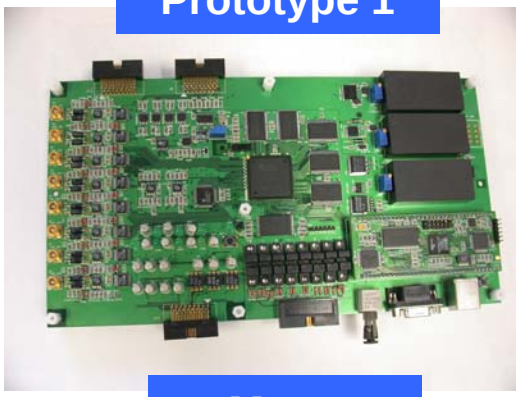
- Prototype tested at KEK
- New MOSFET switch designs in process for shorter pulse
- Goal: Full 3 MHZ unit in FY07

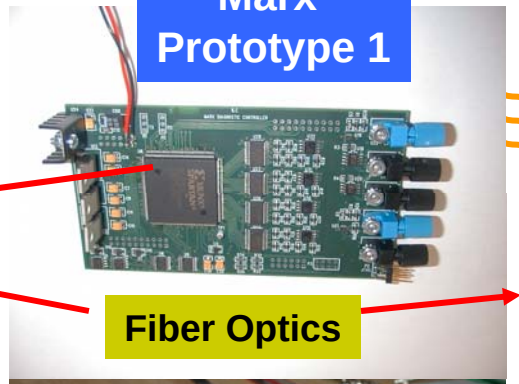
III. Intelligent Diagnostics Fault Management

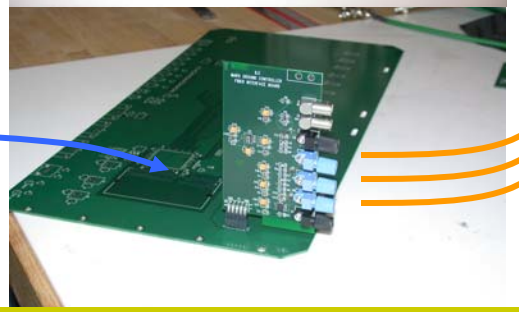
- Apply to all power modular systems
- Board-level controls & monitoring from MCC
- Predict, evade faults to improve Availability
- Report faults to Main Control, Maintenance
- Goal: Test on Marx in FY06, DCPS in FY07-8









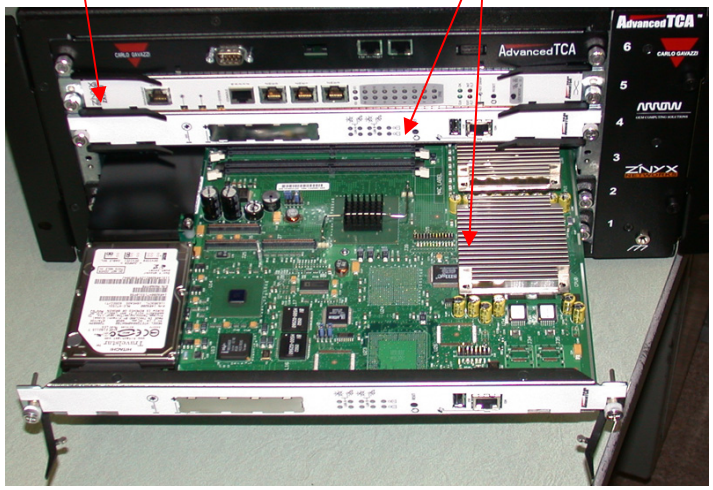


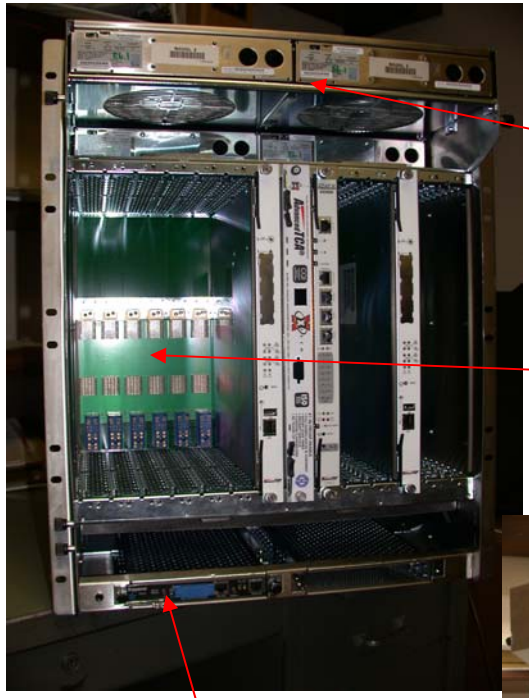
IV. HA Controls & Instrumentation

- Three main goals:
  - High Availability Electronics Systems
  - Modernized platform to support highly integrated instrumentation, processing & communications
  - Standardized approach
- Main Approach: Evaluate Industry Standards
  - Newest HA packaging designs driven by Telecom industry standards consortium
  - Advanced Telecom Computing Architecture (ATCA) designed for crate ("shelf") level availability of "five nines" (0.99999)
  - These are levels needed to achieve ILC Subsystem goals of 0.99 or better
  - Architecture includes intelligent diagnostics for shelf & system management
  - Marketplace very large, multiple vendors, pricing & support favorable
  - Flexible hardware board, daughtercard (mezzanine) options
- Plans: Evaluate industry standards for controls, instrumentation applications
  - Select most optimum approaches for various applications (in crate, standalone etc.)
  - Down-select major approaches for hardware, software by FY09
  - Needs significant investment of resources to succeed
  - Actively supported by ANL (lead), FNAL, SLAC, DESY, KEK, IUIC, others.

IV. C&I – ATCA Evaluation Kits

5-Slot Crate w/ Shelf Manager
Fabric Switch
Dual IOC Processors

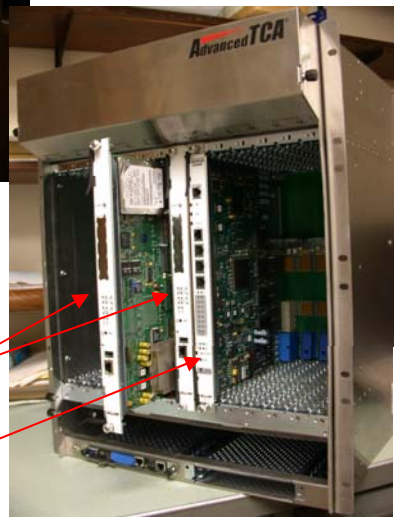




4 Hot-Swappable Fans

16 Slot Dual Star Backplane

Shelf Manager

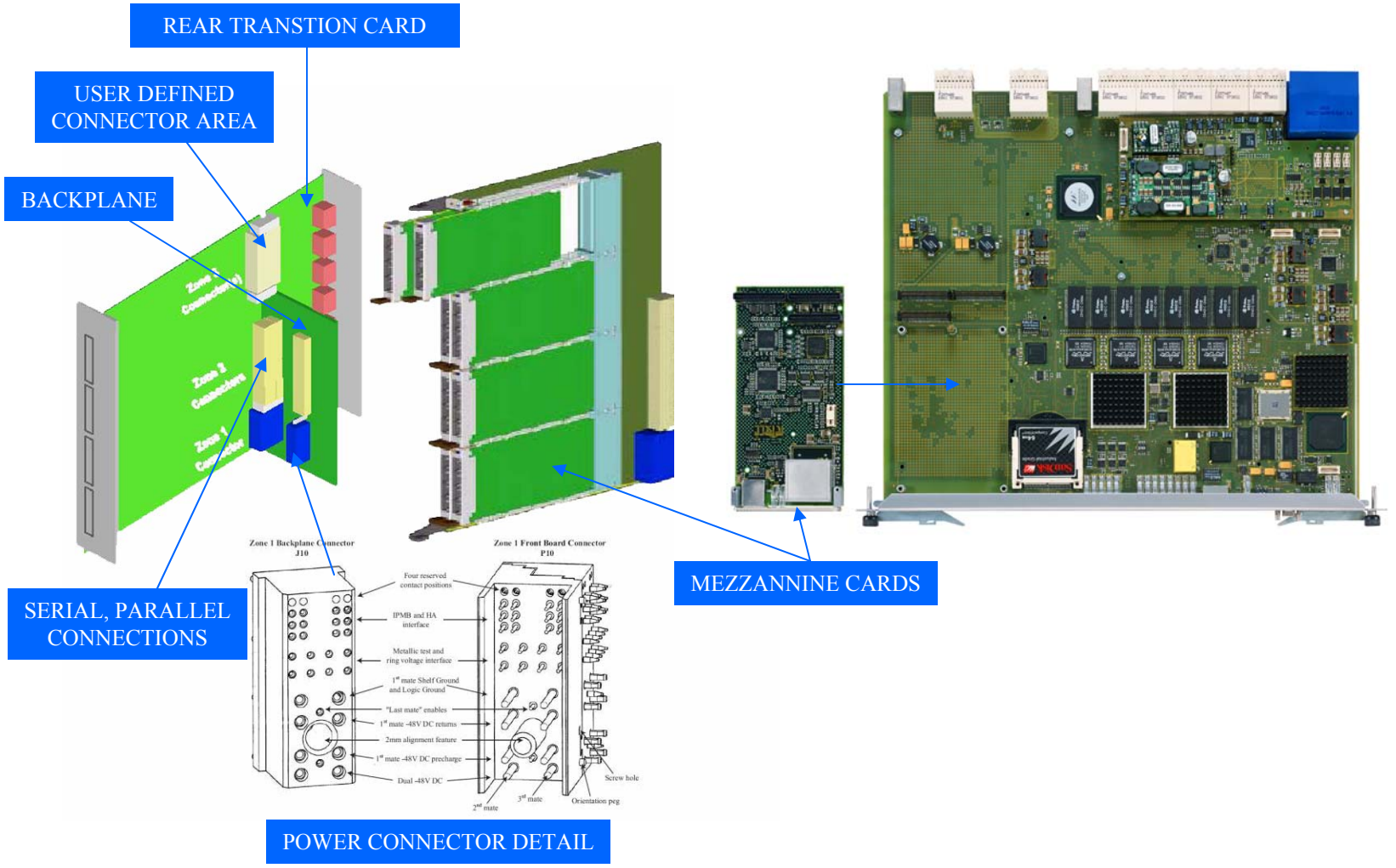


Dual IOC's Fabric Switch

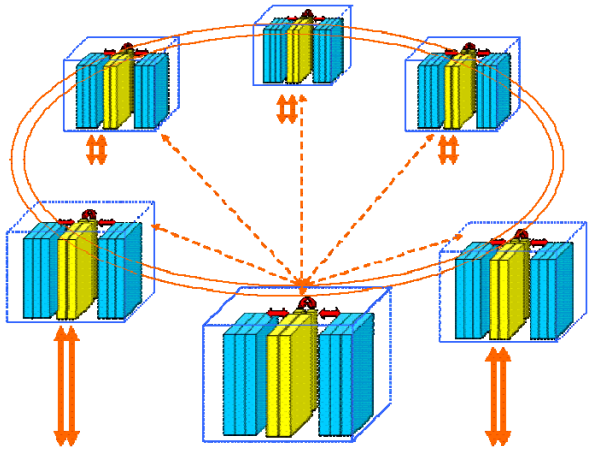
Dual 48VDC Power Interface

Rear View

IV. ATCA Card Options



IV.HA Controls & Instrumentation



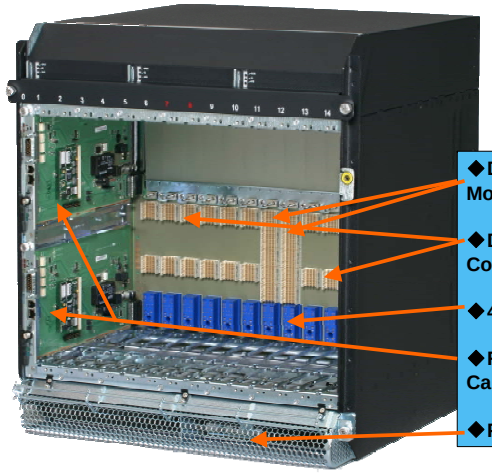
FEATURES

◊ Dual Star 1/N Redundant Backplanes

◊ Redundant Fabric Switches

◊ Dual Star/ Loop/ Mesh Serial Links

◊ Dual Star Serial Links To/From **Level 2** Sector Nodes



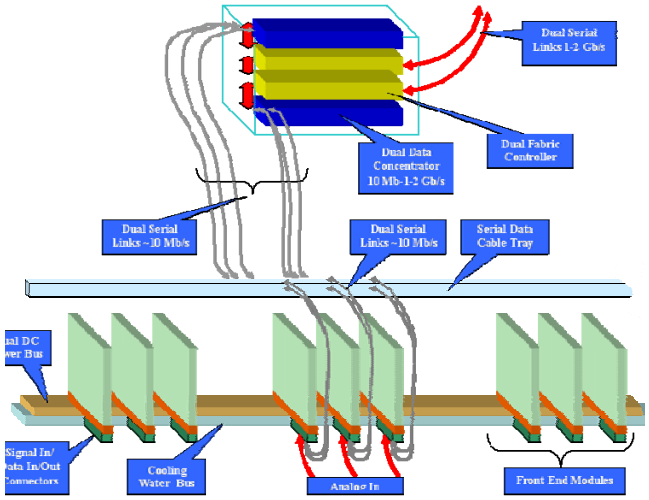
◆Dual Network Switch Module Locations

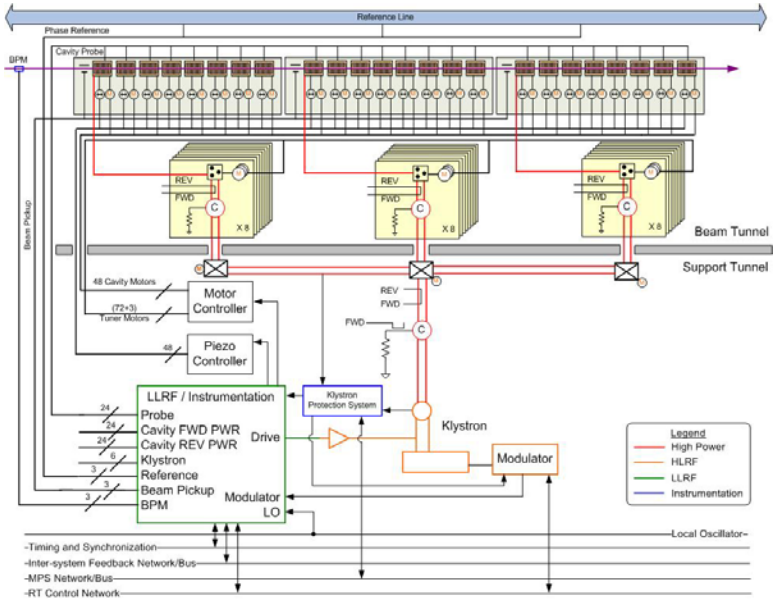
◆Dual Star Fabric Connectors

◆48V DC Power Plugs

◆Redundant Shelf Manager Cards

◆Fan area





V. Summary

- HA Electronics projects vital to success of ILC.
  - Relatively low capital cost, high impact.
- Goal: Select HA architectural features for all critical systems by FY09.
  - Promising progress on HA design of Marx, DC power supplies (base modules available from several vendors), Kickers, Diagnostics controllers.
- Strong interlab collaboration formed for controls and instrument standards. Results also applicable to detectors.
  - More lab effort needed esp. from SLAC in FY07-09
- Strong industry support developing for ATCA, hardware and software. SLAC is associate member of Industry Consortium
- LCFOA vendors expressing interest in providing developmental modular power systems, ATCA controls systems hardware and software.

V. Conclusions

- HA design efforts are well underway in the ILC
  - Cannot meet up-time goals without it.
  - Full machine goal of A>0.85 requires all subsystems to strive for overall average of >0.99
    - *Note: Opportunity Cost of idle ILC ~ 135K$US/hour.*
- New instrument standards based on modern chip technologies needed for next-generation ILC
  - ATCA platform offers ready solution to many controls, instrument applications.
  - Includes intelligent platform management, hot swap that can be leveraged into many other applications for ILC including power systems, utilities etc.
- Increasing levels of C&I support vital to success.