ILC

The ILC Global Control System Design

J. Carwardine, *N. Arnold, F. Lenkszus, C. Saunders (Argonne), K. Rehlich, S. Simrock (DESY), B. Banerjee, B. Chase, E. Gottschalk, P. Joireman, P. Kasley, S. Lackey, P. McBride, V. Pavlicek, J. Patrick, M. Votava, S. Wolbers (Fermilab), K. Furukawa, S. Michizono (KEK), R.S. Larsen, R. Downing (SLAC)*

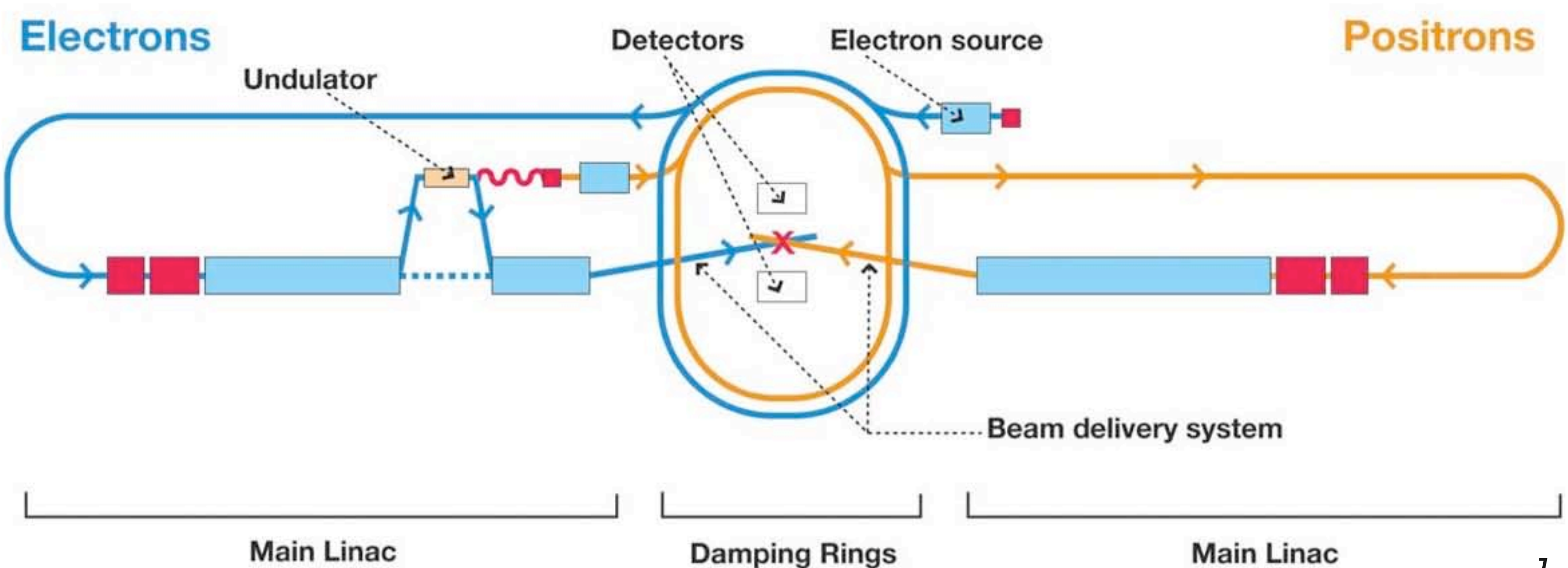
Control System Reference Design

- The Control System Reference Design serves several purposes
  - Establish a functional and physical model for costing purposes
  - Establish a starting point for engineering design and R&D efforts
  - Communicate our vision of the control system

- Some assumptions and limitations
  - Reflects current requirements to the extent they are known
  - Requirements were gathered for all machine areas, but the main focus for the design model was on the linac.
  - The design model is intended to be technology independent.
  - Assumes a high degree of functional and technical standardization
  - Functional and technical requirements will be placed on the technical systems, eg limited options for communication interfaces.

ILC Accelerator overview

- Major accelerator systems
  - Polarized PC gun electron source and undulator-based positron source.
  - 5-GeV electron and positron damping rings, 6.7km circumference.
  - Beam transport from damping rings to bunch compressors.
  - Two 11km long 250-GeV linacs with 15,000+ cavities and ~600 RF units.
  - A 4.5-km beam delivery system with a single interaction point.



J. Bagger

Control System Requirements and Challenges

- General requirements are largely similar to those of any large-scale experimental physic machines …but there are some challenges

- Scalability
  - 100,000 devices, several million control points.
  - Large geographic scale of the ILC accelerator: 31km end to end
  - Multi-region, multi-lab development team.

- Support ILC accelerator availability goals of 85%.
  - Intrinsic Control system availability of 99% *by design.*
    - *Cannot rely on approach of 'fix in place.'*
    - *May require 99.999% (five nines) availability from each crate.*
  - Functionality to help minimize overall accelerator downtime.

Requirements and Challenges …(2)

- Precision timing & synchronization
  - Distribute precision timing and RF phase references to many technical systems throughout the accelerator complex.
  - Requirements consistent with LLRF requirements of 0.1% amplitude and 0.1 degree phase stability.

- Support remote operations / remote access (GAN / GDN)
  - Allow collaborators to participate with machine commissioning, operation, optimization, and troubleshooting.
  - At technical equipment level there is little difference between on-site and off-site access - Control Room is already ‘remote.’
  - There are both technical and sociological challenges.

Requirements and Challenges …(3)

- Extensive reliance on machine automation
  - Manage accelerator operations of the many accelerator systems, eg 15,000+ cavities, 600+ RF units.
  - Automate machine startup, cavity conditioning, tuning, etc.

- Extensive reliance on beam-based feedback
  - Multiple beam based feedback loops at 5Hz, eg
    - *Trajectory control, orbit control*
    - *Dispersion measurement & control*
    - *Beam energies*
    - *Emittance correction*

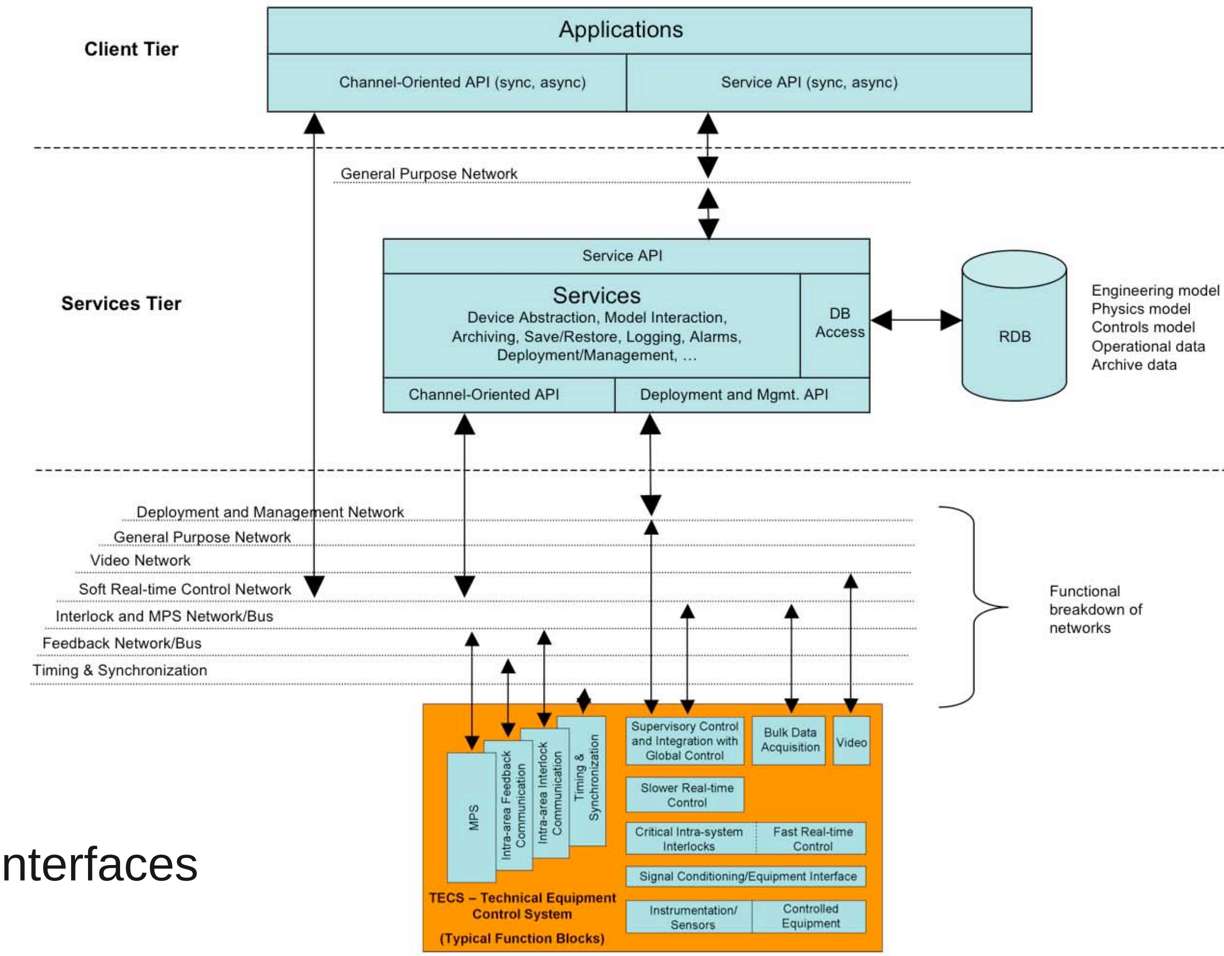
- Control system should provide appropriate infrastructure to support feedback and automation.

Control System Functional Model

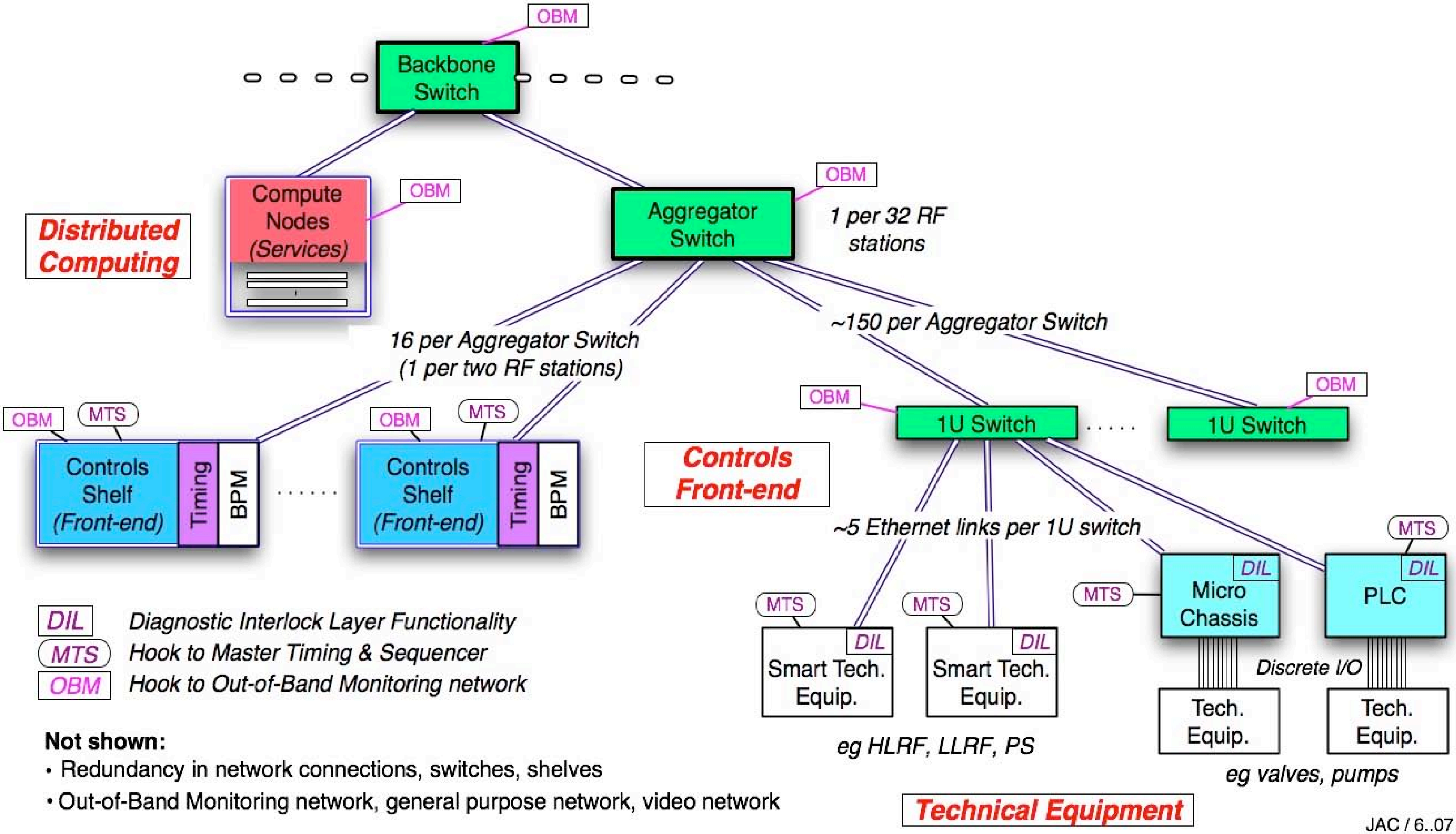
Client Tier
- GUIs
- Scripting

Services Tier
- “Business Logic”
- Device abstraction
- Feedback engine
- State machines
- Online models
- …

Front-End Tier
- Technical Systems Interfaces
- Control-point level

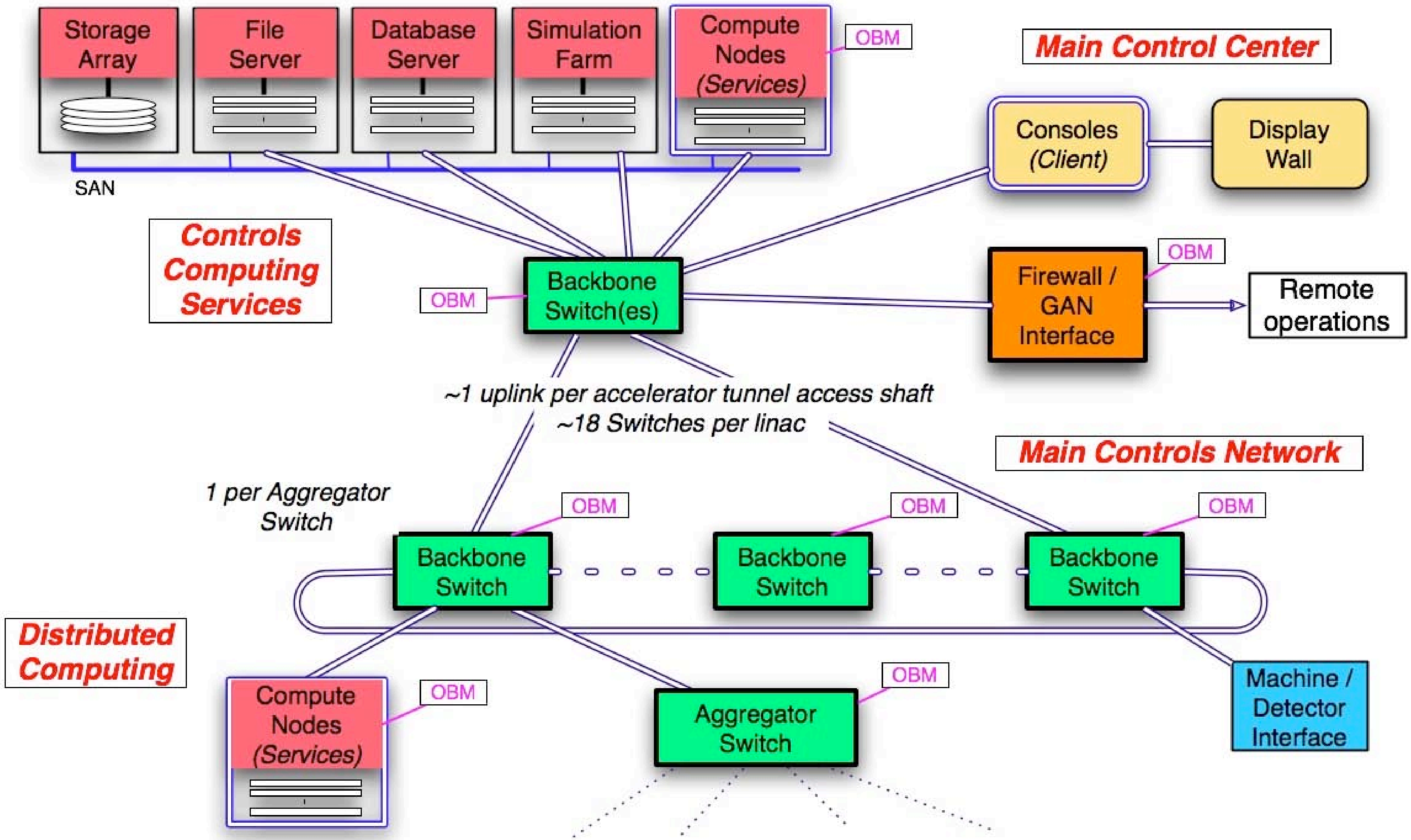


Physical Model as applied to main linac (Front-end)



Not shown:
- Redundancy in network connections, switches, shelves
- Out-of-Band Monitoring network, general purpose network, video network

Physical Model (Global layer)



Some representative component counts

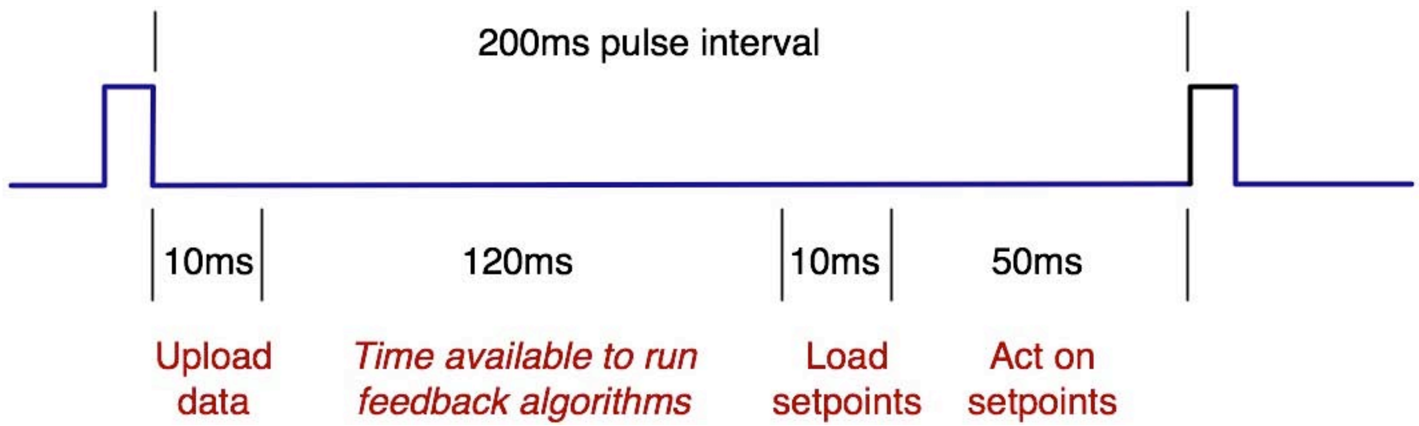
Component	Description	Quantity
1U Switch	Initial aggregator of network connections from technical systems	8356
Controls Shelf	Standard chassis for front-end processing and instrumentation cards	1195
Aggregator Switch	High-density connection aggregator for 2 sectors of equipment	71
Controls Backbone Switch	Backbone networking switch for controls network	126
Phase Ref. Link	Redundant fiber transmission of 1.3-GHz phase reference	68
Controls Rack	Standard rack populated with one to three controls shelves	753
LLRF Controls Station	Two racks per station for signal processing and motor/piezo drives	668

ILC

Feedback Infrastructure model

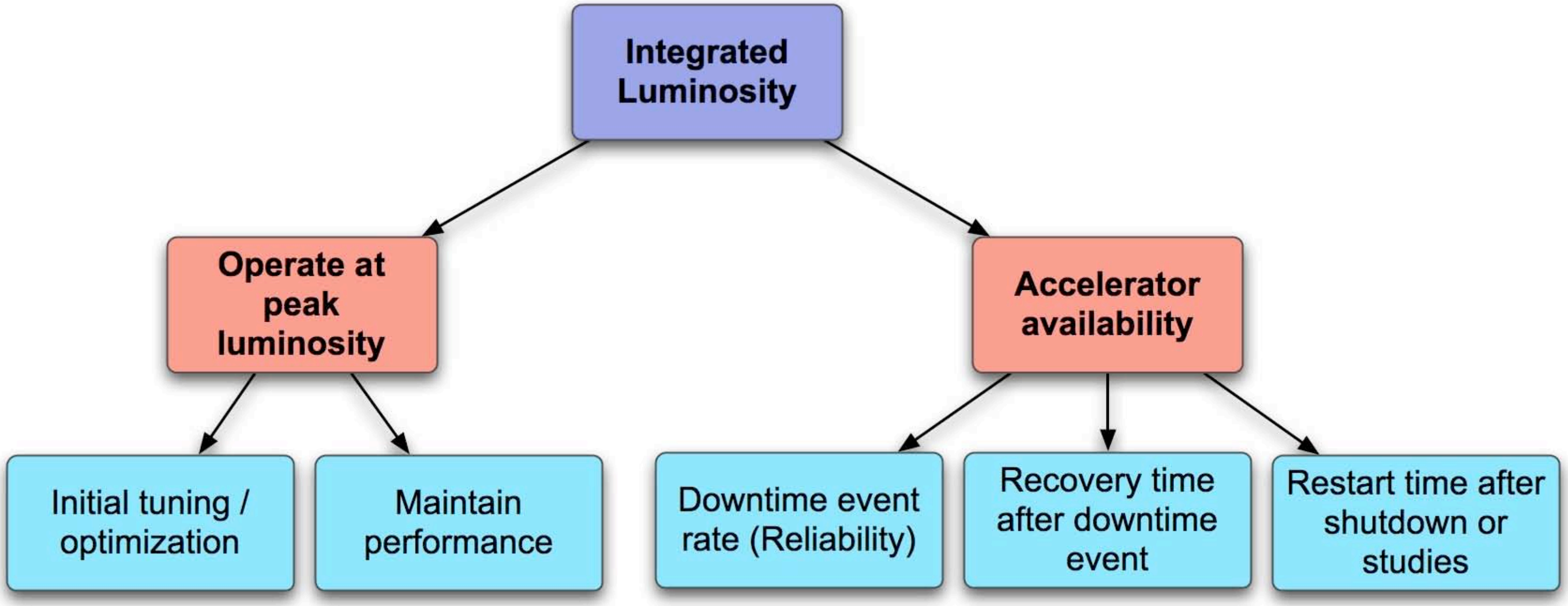
- Physical model assumes that all control and monitoring points are available for use in a 5Hz synchronous feedback loop
  - Allows ad-hoc feedback loops to be create using high level applications without prior assignment of sensors or actuators.
- Feedback algorithms are implemented in Controls Services Tier.

- Requires synchronous operation of technical systems and of the controls network.

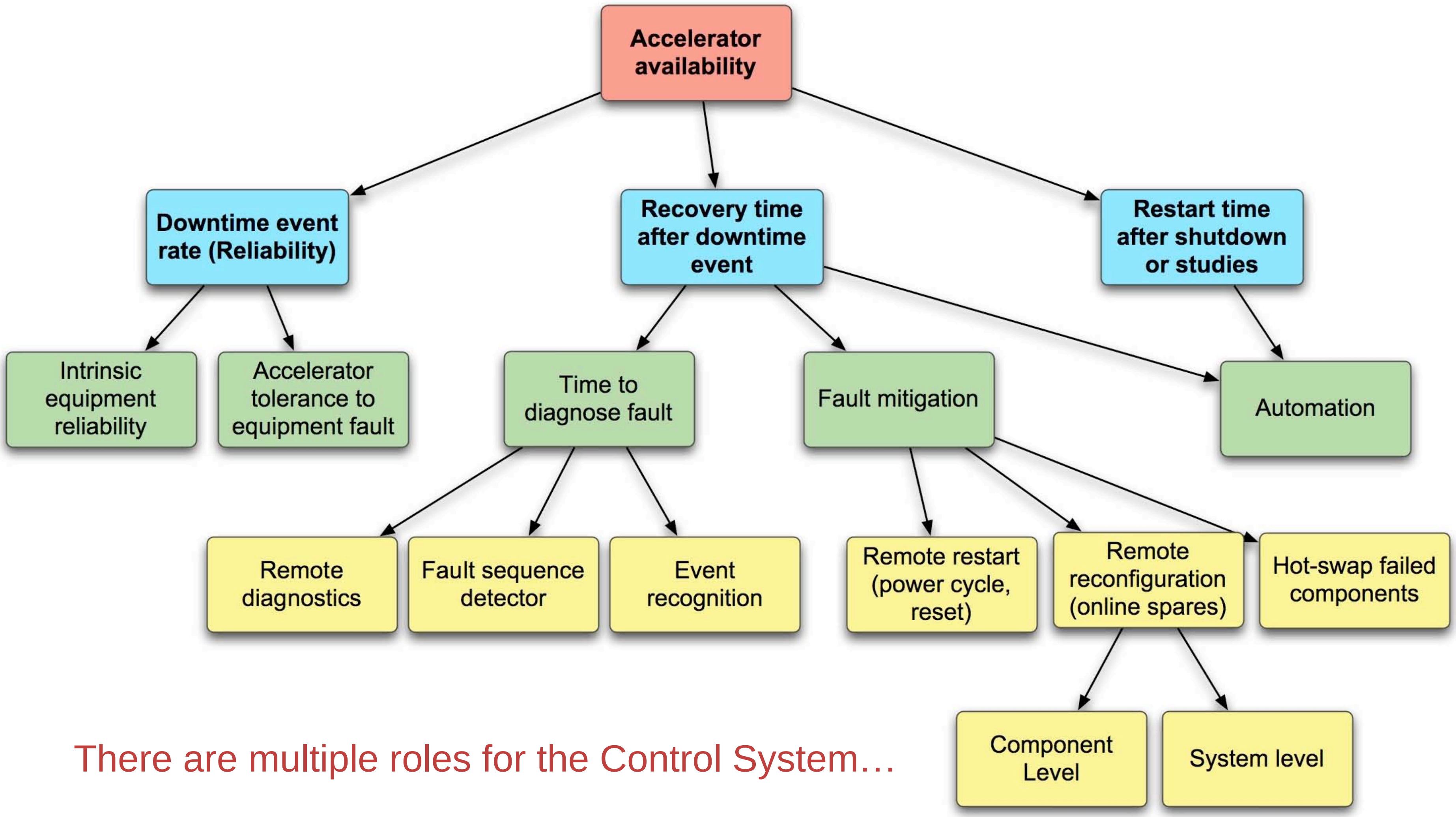


Accelerator Availability

- Availability goals come from the overall integrated luminosity goals
- ILC availability goal is 85% for a 5000 hr/yr operating schedule.
- Availability is about intrinsic reliability and about ability to recover quickly.



Accelerator Availability considerations



There are multiple roles for the Control System…

Reference platform for Front-end electronics

- ATCA has been used as a reference platform for front-end electronics
- Representative of the breadth of high-availability functions needed
  - Hot-swappable components: circuit boards, fans, power supplies, …
  - Remote power management: power on/off each circuit board
  - Supports redundancy: processors, comms links, power supplies,…
  - Remote resource management through Shelf Manager

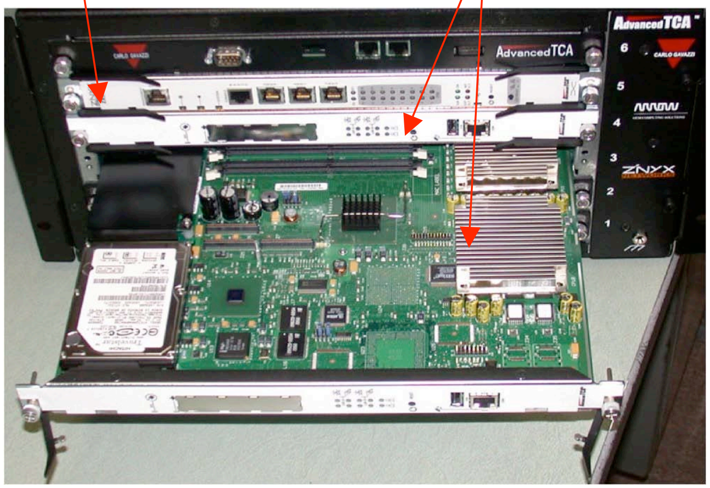
- μTCA offers lower cost but with reduced feature set.

- There is growing interest in the physics community in exploring ATCA for instrumentation and DAQ applications.

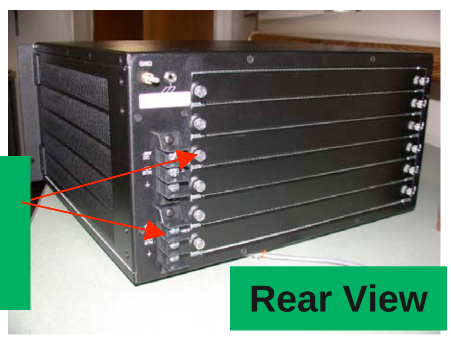
- As candidate technology for the ILC, ATCA/μTCA have strong potential …currently is it an emerging standard.

ATCA as a reference platform…

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



Dual 48VDC Power Interface



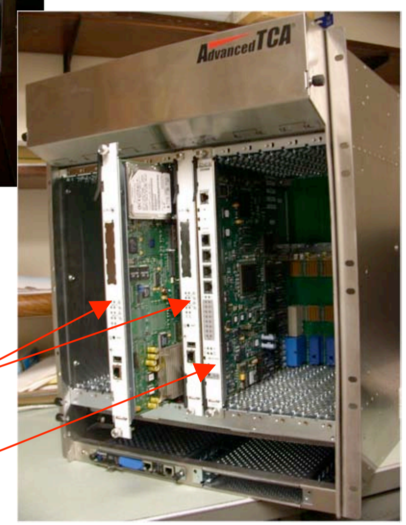
Rear View

4 Hot-Swappable Fans

16 Slot Dual Star Backplane

Shelf Manager

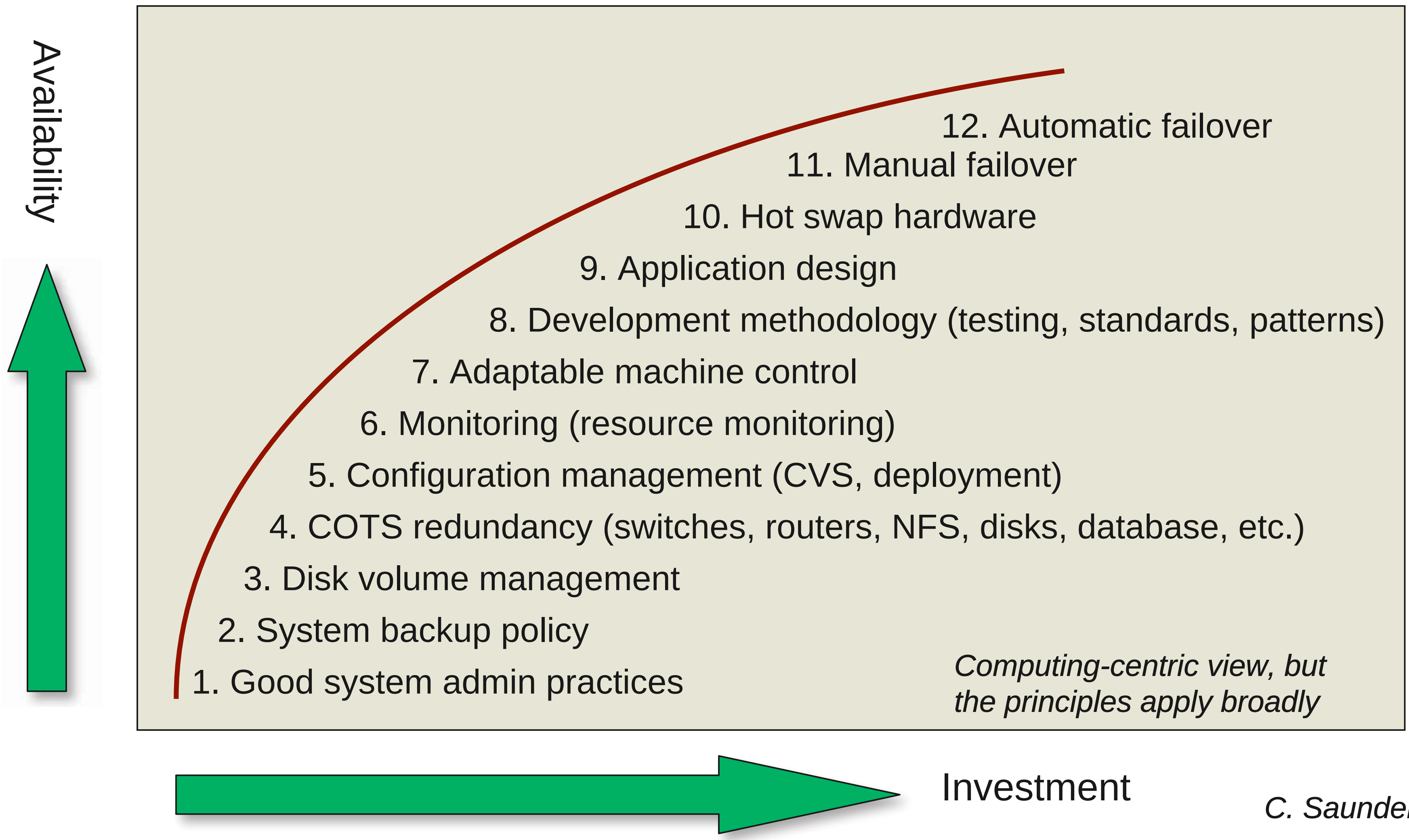
Dual IOC's Fabric Switch



R. Larsen

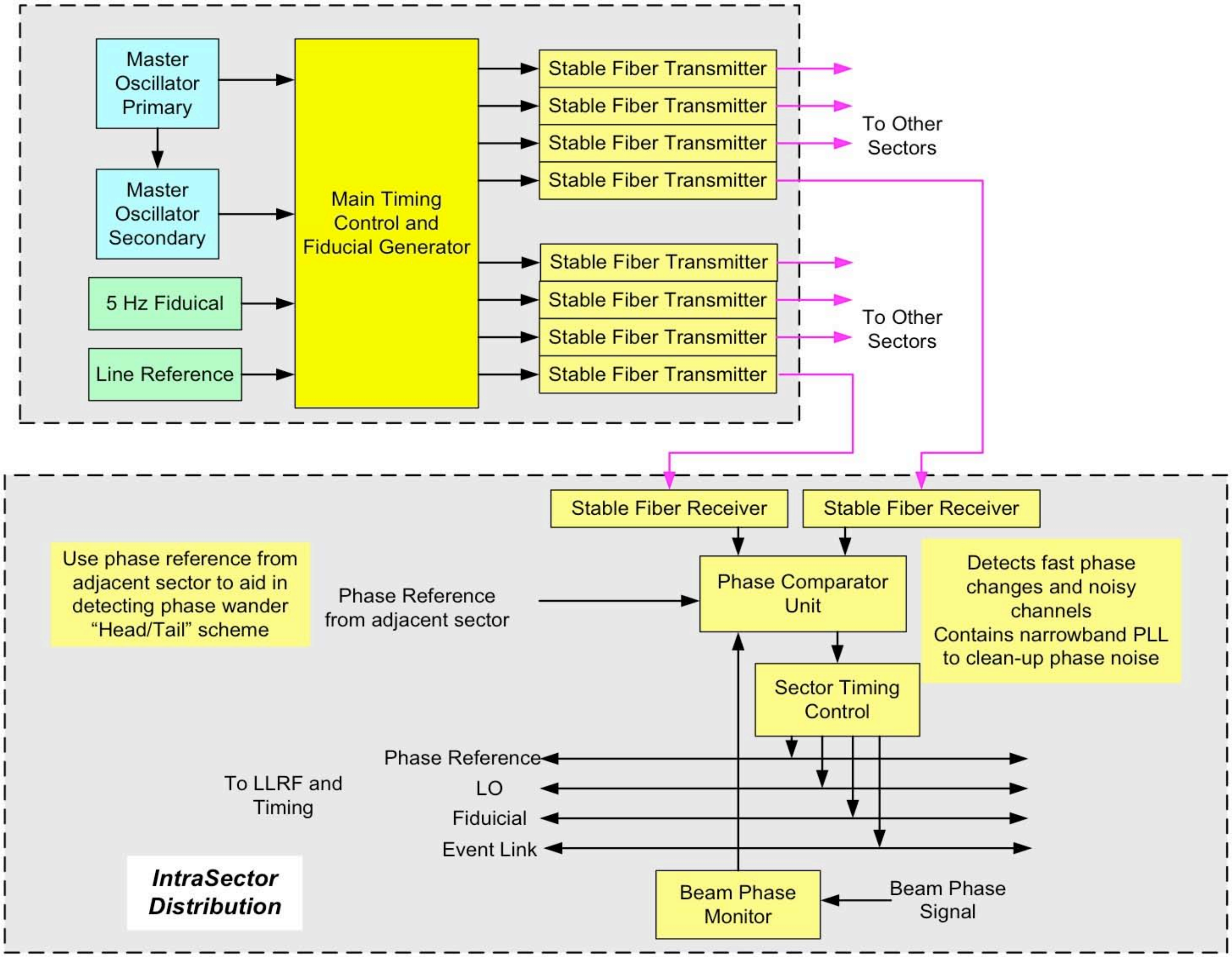
Not just redundancy…

…but also sound design principles, methodology, QA



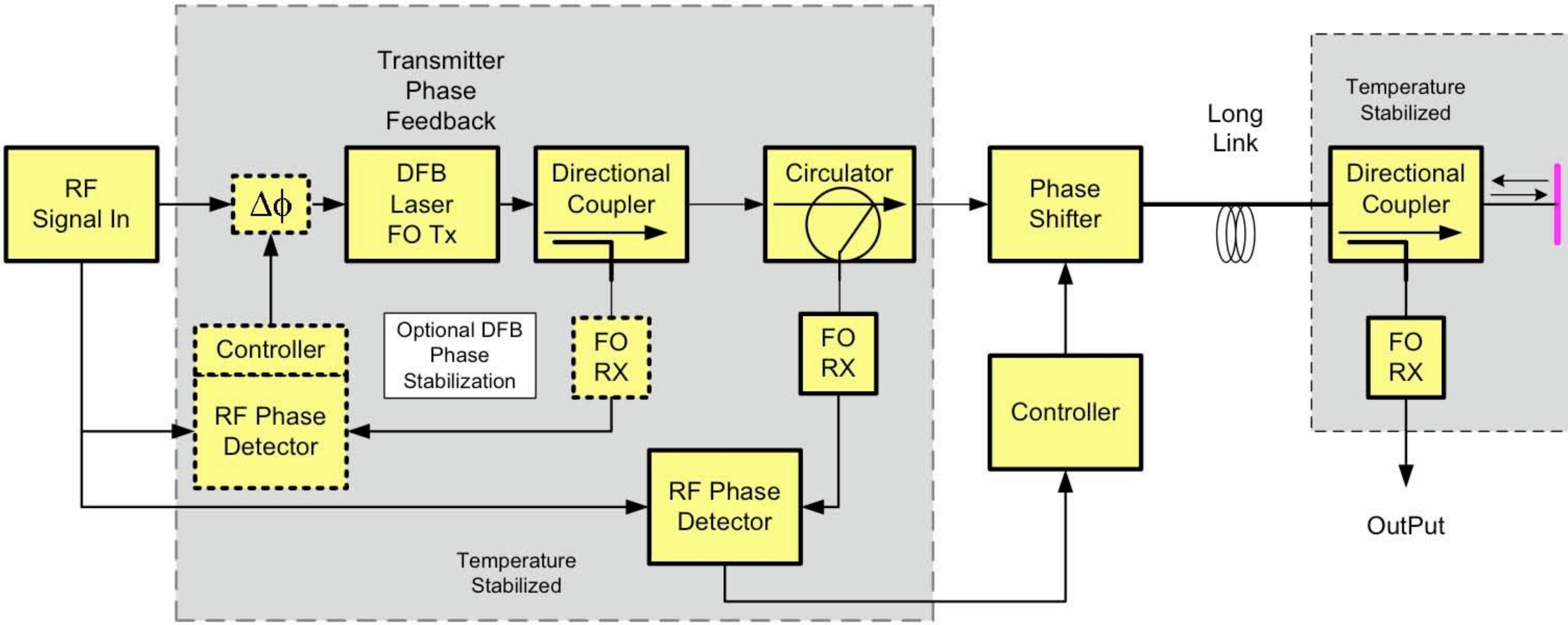
C. Saunders

Phase & timing distribution



F. Lenkszus

Phase stabilized link



F. Lenkszus

ILC R&D Engineering Design (EDR) Phase

- Main focus of R&D efforts are on high availability
  - Gain experience with high availability tools & techniques to be able to make value-based judgments of cost versus benefit.

- Four broad categories
  - Control system failure mode analysis
  - High-availability electronics platforms (ATCA)
  - High-availability integrated control systems
    - *Conflict avoidance & failover, model-based resource monitoring.*
  - Control System as a tool for implementing system-level HA
    - *Fault detection methods, failure modes & effects*

- Aim to leverage activities at beam facilities worldwide to focus activities on specific requirements and to gain field experience.

Summary

- While many of the requirements for the ILC control system are 'conventional,' there are some important challenges that must be met.

- Much of the focus over the next three years will be on beam facilities.
- Controls R&D efforts will focus on answering important questions
  - Precision timing & synchronization (one aspect of LLRF R&D)
  - Techniques & cost-benefit of implementing high availability.

- The control system reference design gives an excellent foundation for moving into the Engineering Design (EDR) phase.