U1.03.03.04 - SPX Controls

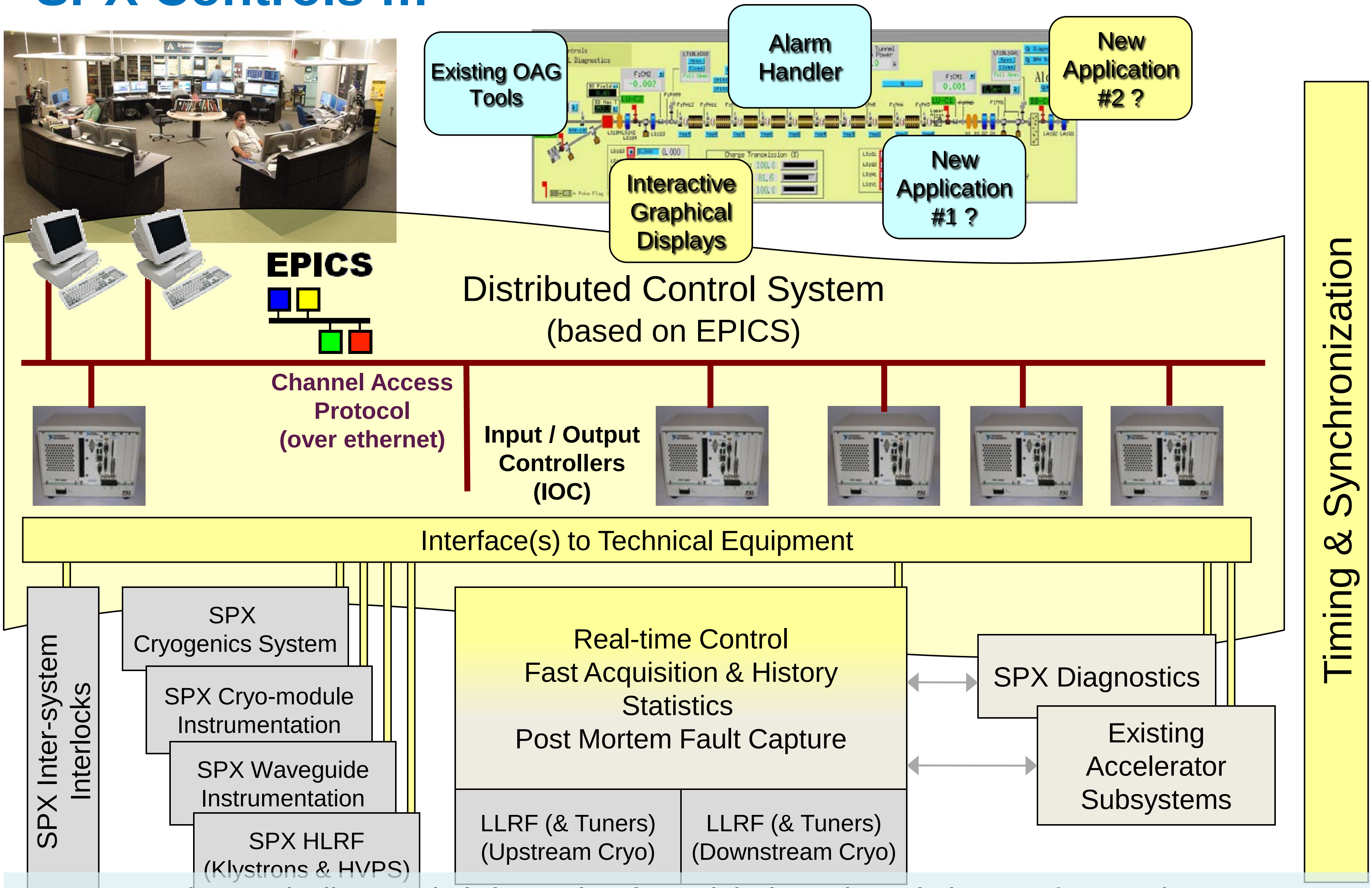
U1.02.01.03.04 - SPX R&D Controls

Ned Arnold

SPX Controls Requirements

- The entire SPX system must be thoroughly integrated with the existing APS storage ring controls, timing, and diagnostics. Since any instability in the operation of the SPX cavities will impact all APS users, thorough instrumentation and diagnostics will be required to detect any operational abnormalities. The primary responsibilities for SPX controls are as follows:
  - Provide remote monitoring and control to all SPX subsystems consistent with APS standards and existing OAG tools
  - Provide the necessary interfaces between the SPX and other APS systems as required by the SPX needs (e.g. RTFB, MPS, Event System, etc.)
  - Provide a real-time data processing environment for the SPX control algorithms to ensure they can be executed at the necessary rate (TBD)
  - Provide thorough diagnostic information and tools to assist in quick determination of SPX performance and post-mortem fault analysis (required for maintaining high availability).

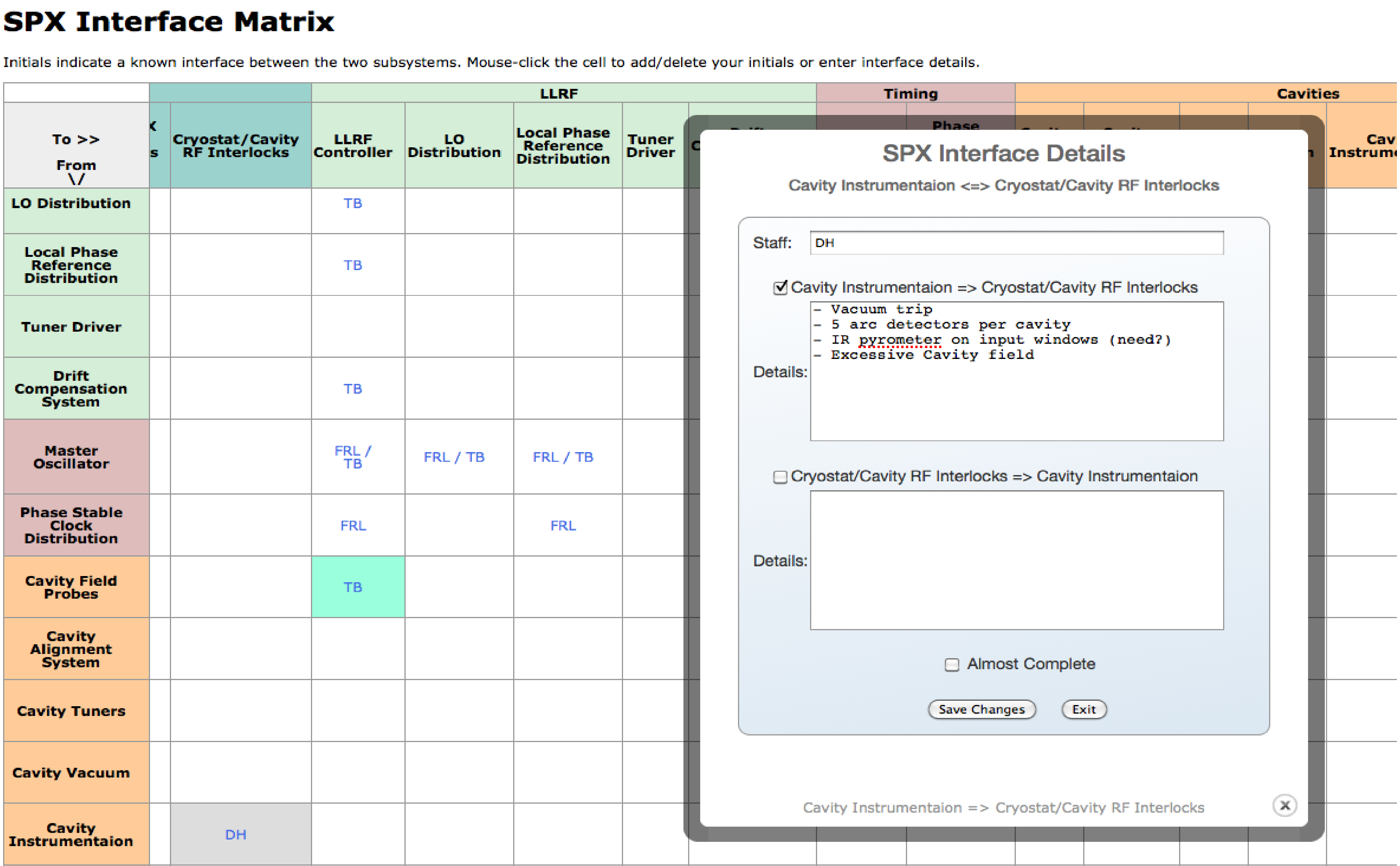
SPX Controls …



… thorough diagnostic information for quick detection of abnormal operation…

Capturing Details of Interfaces Between Subsystems

- Web-based matrix for initial collection (convenient editing and perusing)
- Formal ICDs for final design



SPX Interface Matrix

Initials indicate a known interface between the two subsystems. Mouse-click the cell to add/delete your initials or enter interface details.

To >> From \/	Cryostat/Cavity RF Interlocks	LLRF Controller	LO Distribution	Local Phase Reference Distribution	Tuner Driver
LO Distribution		TB			
Local Phase Reference Distribution		TB			
Tuner Driver					
Drift Compensation System		TB			
Master Oscillator		FRL / TB	FRL / TB	FRL / TB	
Phase Stable Clock Distribution		FRL		FRL	
Cavity Field Probes		TB			
Cavity Alignment System					
Cavity Tuners					
Cavity Vacuum					
Cavity Instrumentaion	DH				

LLRF | Timing | Cavities

SPX Interface Details

Cavity Instrumentaion <=> Cryostat/Cavity RF Interlocks

Staff: DH

☑ Cavity Instrumentaion => Cryostat/Cavity RF Interlocks

Details:

```
- Vacuum trip
- 5 arc detectors per cavity
- IR pyrometer on input windows (need?)
- Excessive Cavity field
```

☐ Cryostat/Cavity RF Interlocks => Cavity Instrumentaion

Details:

☐ Almost Complete

Save Changes | Exit

Cavity Instrumentaion => Cryostat/Cavity RF Interlocks

Capturing Real-time Processing Requirements

- Identify end-to-end functions

High Level Tools

Automation (PEM)
Alarm Tools
Save / Compare / Restore
Graphical Displays
SPX Diagnostic Tool
Data Logging (long term)
Fast Automated Sequences
Post Mortem Fault Capture (including History Buffer)
Real-time Signal Correlations (RF Power/Phase, HVPS Voltage, BPMs, temperature)

Real-time Functions

Prudent Operating Constraints (software interlocks)
FFTs/NAFF on RF, BPM, actuator signals
Filtering / Statistics
Fast History Buffer

Deflection Control

Fault / Exception Response
Sector Adjust to Minimize orbit/emittance Disturbance (differential phase)

Sector LLRF Control (N cavities

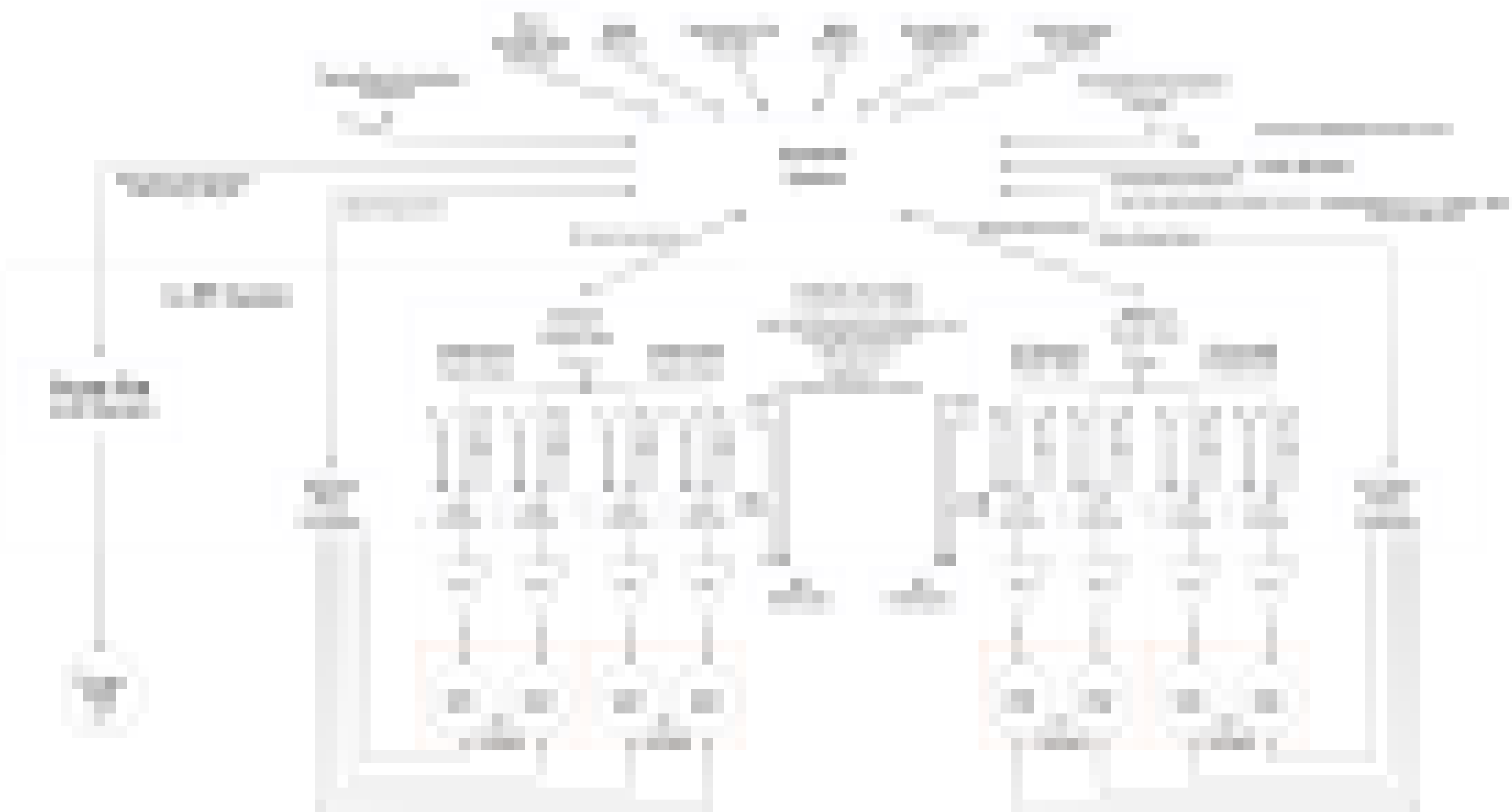
US Sector Adjust to Achieve Desired Tilt (phase/amplitude)
DS Sector Adjust to Minimize Residual Tilt (differential amplitude)
Vector Sum Phase/Amplitude
Intra-sector control (for lattice tuning)

Single Cavity LLRF Control

Fault Response
Calibrations
Phase Control
Amplitude Control
Cavity Tuning

Inputs:
- S35 Residual Effects Diagnostics
- Deflected Tilt Monitor
- Residual Tilt Monitor
- Orbit Feedback System
- Beam Arrival Time Monitor

Evolving Concept of Hardware Partitioning …



Overlay Functions with Hardware Partitioning…

Automation (PEM)

Alarm Tools

Graphical Displays

Save / Compare / Restore

SPX Diagnostic Tool

Data Logging (long term)

Fast Automated Sequences

Post Mortem Fault Capture (including History Buffer)

Real-time Signal Correlations (RF Power/Phase, HVPS Voltage, BPMs, temperature)

Prudent Operating Constraints (software interlocks)

FFTs/NAFF on RF, BPM, actuator signals

Filtering / Statistics

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Fault / Exception Response

Sector Adjust to Minimize orbit/emittance Disturbance (differential phase)

US Sector Adjust to Achieve Desired Tilt (phase/amplitude)

DS Sector Adjust to Minimize Residual Tilt (differential amplitude)

Vector Sum Phase/Amplitude

Intra-sector control (for lattice tuning)

Fault Response

Calibrations

Phase Control

Amplitude Control

Cavity Tuning

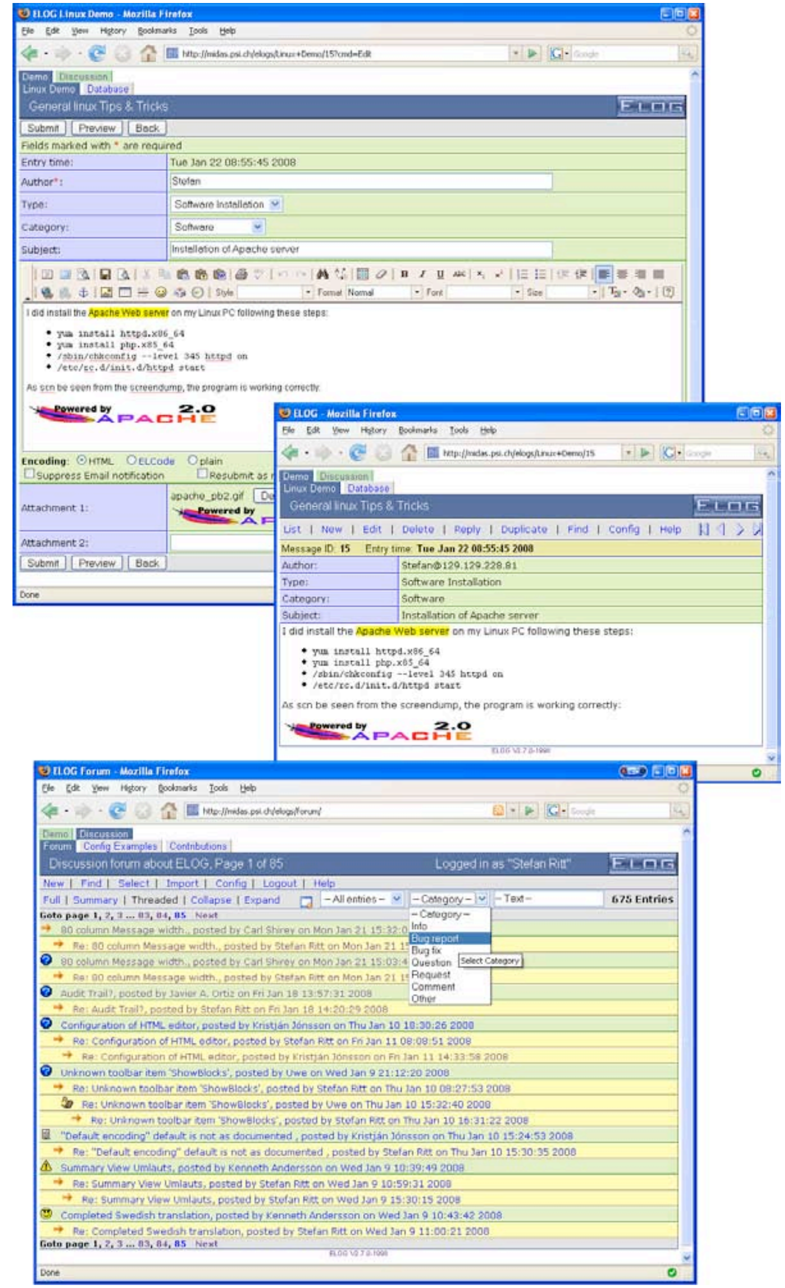
- Map functions to hardware components
- Identify data that must be passed between components
- Result = subsystem requirements + interface requirements

SPX Controls R & D

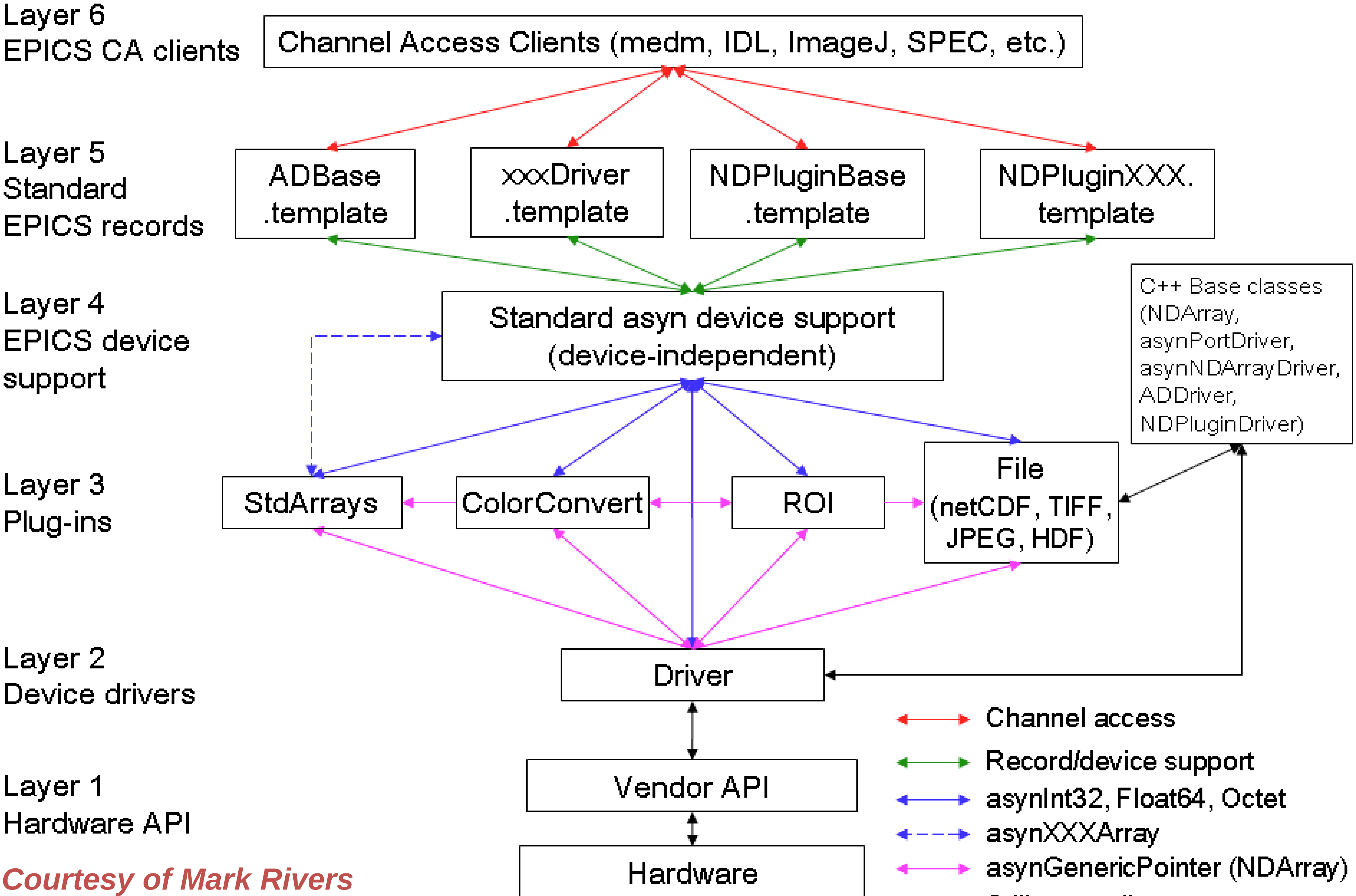
- Support R&D Activities of LLRF, Timing, and Synchronization
  - Lab tests, Test Stands, In-tunnel test
- Support R&D Activities of other Major Subsystems
  - Test Stands, In-tunnel test
- Demonstrate Intersystem Communication Requirements
  - Previous slide illustrated ~12 interfaces to other systems
  - Ensure all are feasible, what is the best architecture?
- Evaluate Platforms & Tools, Identify Necessary Enhancements
  - Research best platform for real-time processing requirements
    - *Cardcage/backplane, etc.*
    - *FPGAs, DSPs, Multiple-cores, a combination, etc.*
  - Assemble details for data-processing, control loops, fast history, statistics, out-of-band detection, …
  - Identify required tools, either existing or new

SPX Controls R & D

- Support R&D Activities of LLRF, Timing, and Synchronization (Arnold)
  - Includes lab tests, Test Stands, SPX-0
    - *Ongoing gathering of requirements for SPX-0 and final system*
    - *Matlab / Octave libraries to read data files*
    - *Manage electronic logbook for SPX LLRF / Timing / Controls*
    - *LLRF4 support*
      - Get LBL software tools running here
      - Extend EPICS support for the LLRF4 Controller

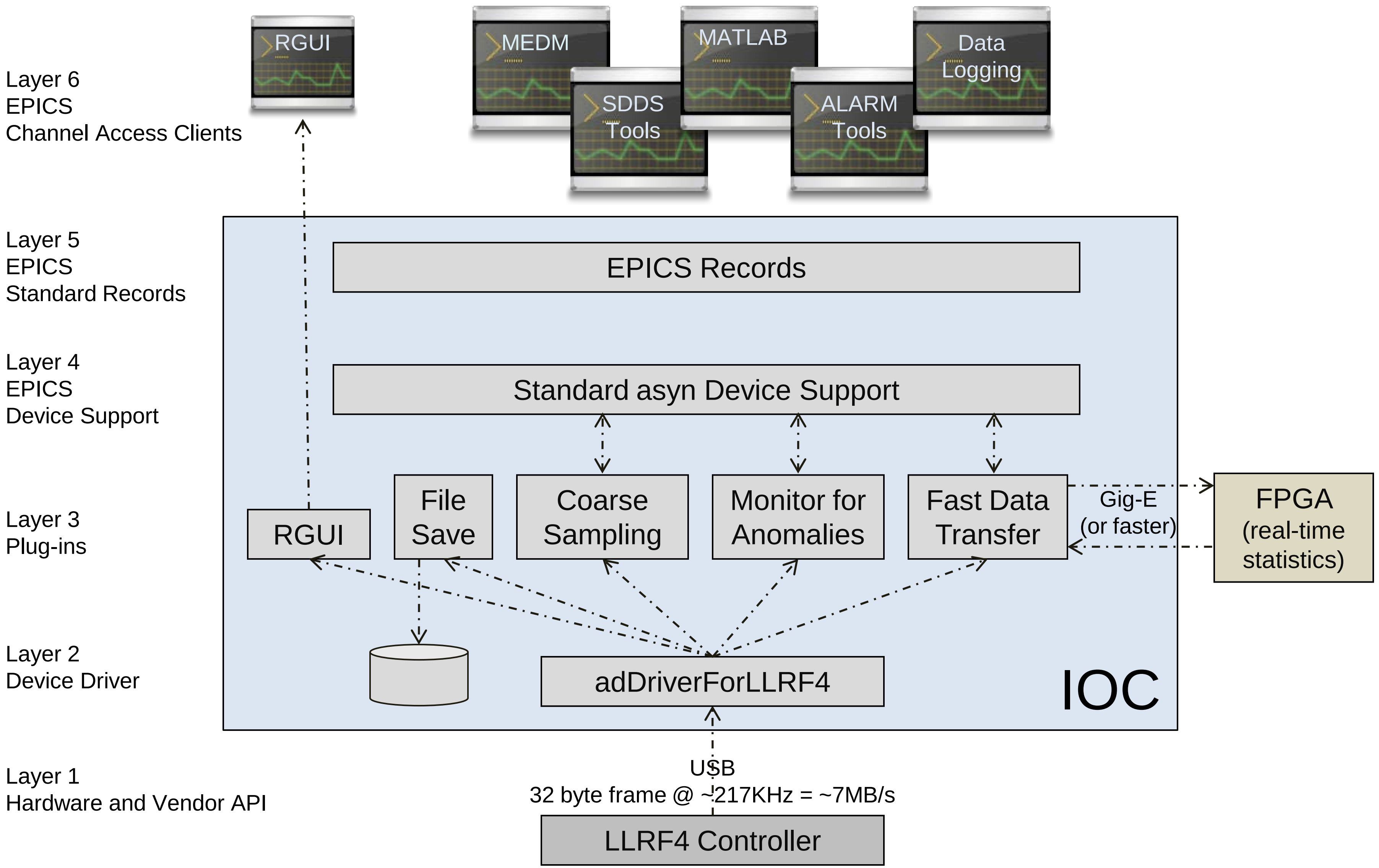


EPICS areaDetector Architecture



Courtesy of Mark Rivers
University of Chicago
http://cars9.uchicago.edu/software/epics/areaDetector.html

Processing Data from the LLRF4 Controller



SPX Controls R & D

- Support R&D Activities of other Major Subsystems (DiMonte, Stevens, Shoaf)
  - Test Stands, In-tunnel test (SPX-0)
    - *Build portable control system for Test Stands*
    - *Write EPICS device support for numerous instruments to be used*
      - Agilent 52330A, frequency counter with 6GHz input option
      - Rohde & Schwarz SMA100A, signal generator, 6GHz
      - CP&I model VZS/C-6963J2, 300W Traveling Wave Tube (TWT) amplifier
      - Agilent N1914A, Power Meter
      - Boonton 4500A, Peak Power Meter Analyzer
      - Stanford Research Systems SR850, Lock-In Amplifier
      - Agilent 8665B, Signal generator.
    - *Provide interface to subsystems for SPX-0*
      - Includes some PLC work

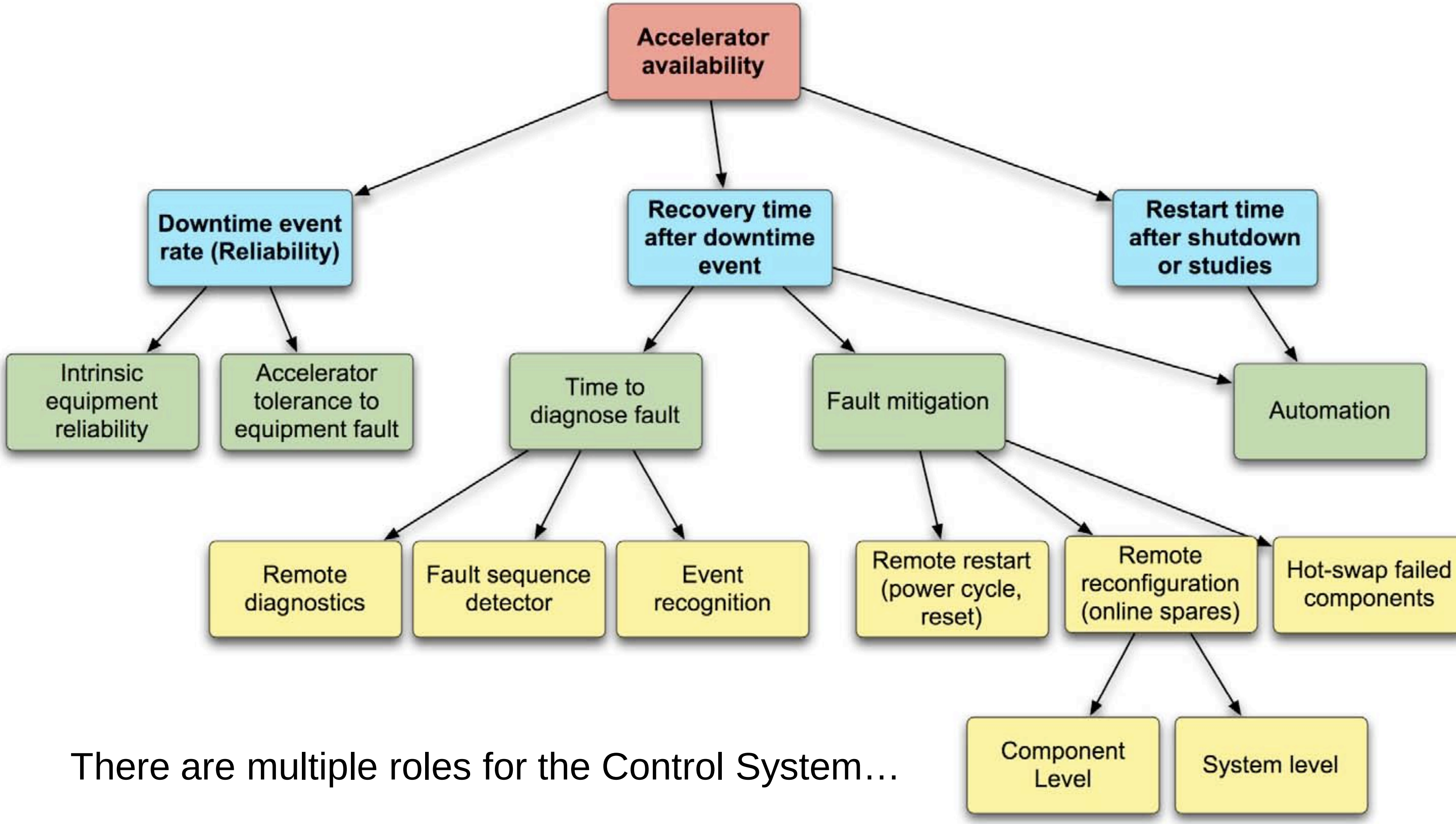
Availability

- Just "How" does one design in "high availability"?

- Good topic for Working Group discussions

Accelerator Availability Considerations

The ILC Control System
Particle Accelerator Conference, Albuquerque, 2007
J. Carwardine et. al.



There are multiple roles for the Control System…

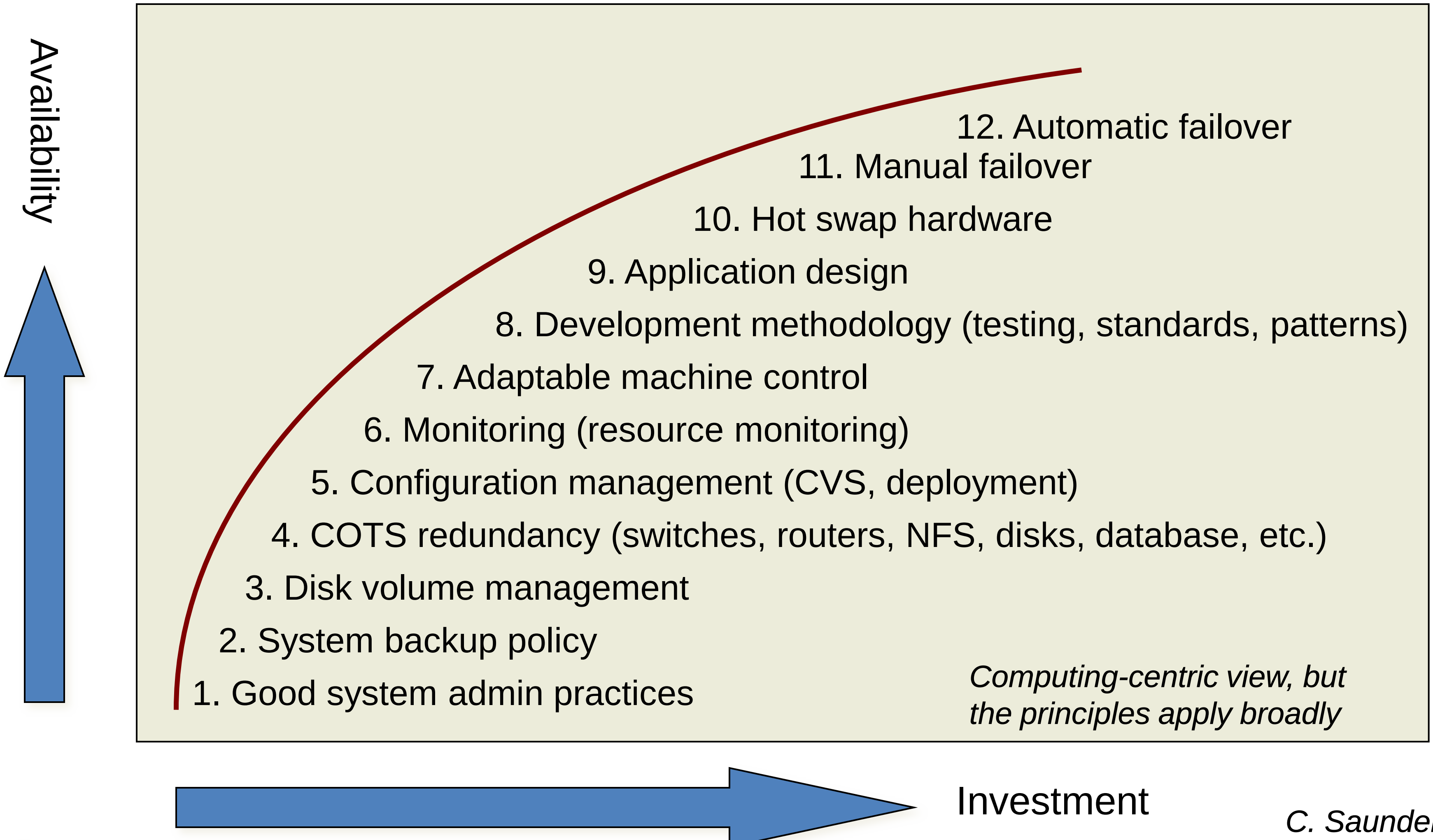
Not just redundancy…

The ILC Control System

Particle Accelerator Conference, Albuquerque, 2007

J. Carwardine et. al.

…but also sound design principles, methodology, QA



C. Saunders