JLab Accelerator Controls

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MaRIE discussion
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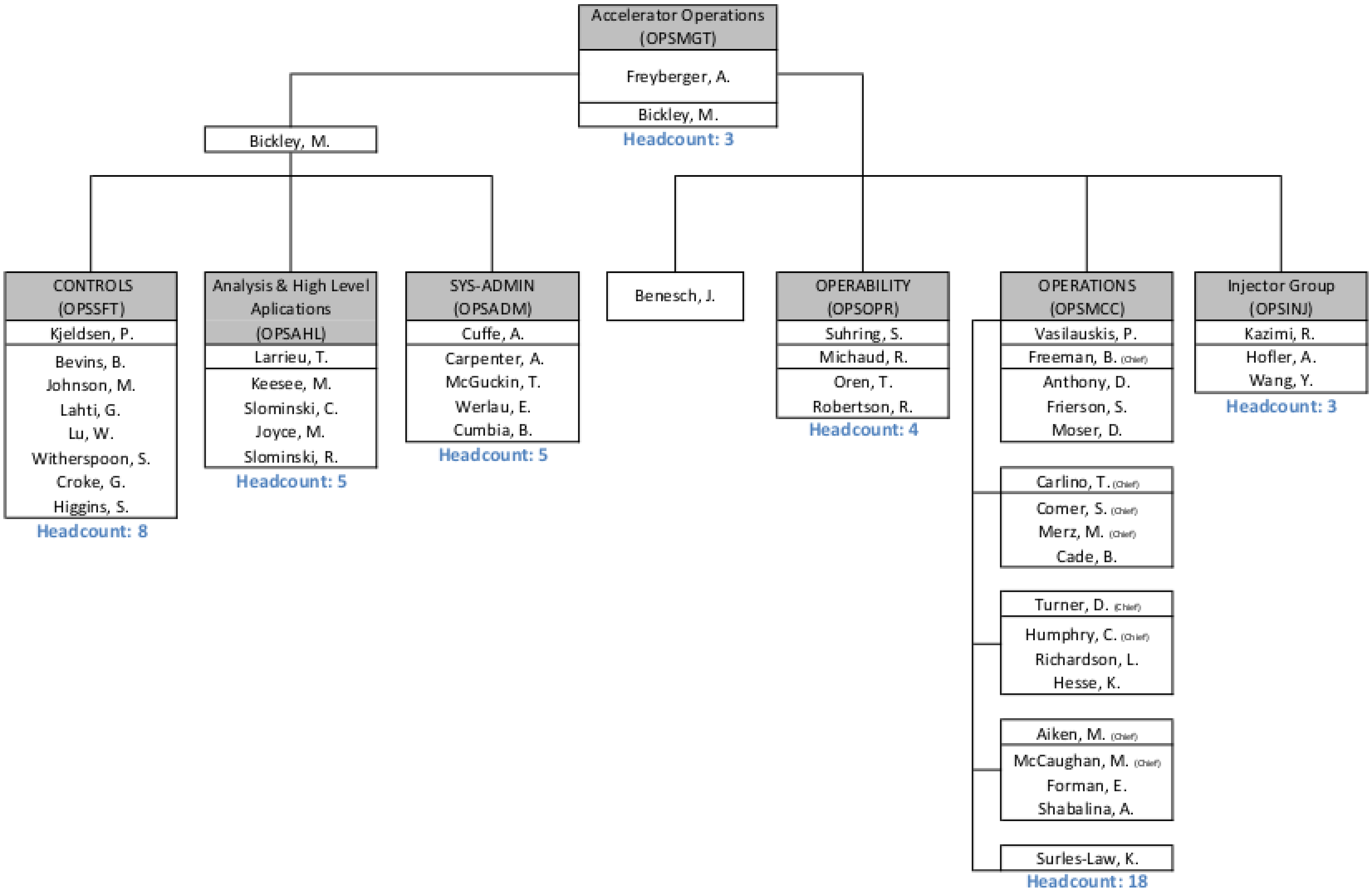
Outline

- Controls scope and architecture
- CEBAF controls; a brief history
- Subsystems

Controls Scope

- Support 24/7 operation
  - Accelerator: from the injector to the beam dumps
  - Central Helium Liquifier (CHL)
  - Low-Energy Recirculator Facility (LERF)
  - Portions of the experimental endstations
  - Unified Injector Test Facility (UITF)
- Develop and maintain device control, high-level software and manage computing environment
  - Dynamic accelerator environment with regular changes to hardware and configuration
- Collaborate with the world-wide controls community

Operations Department



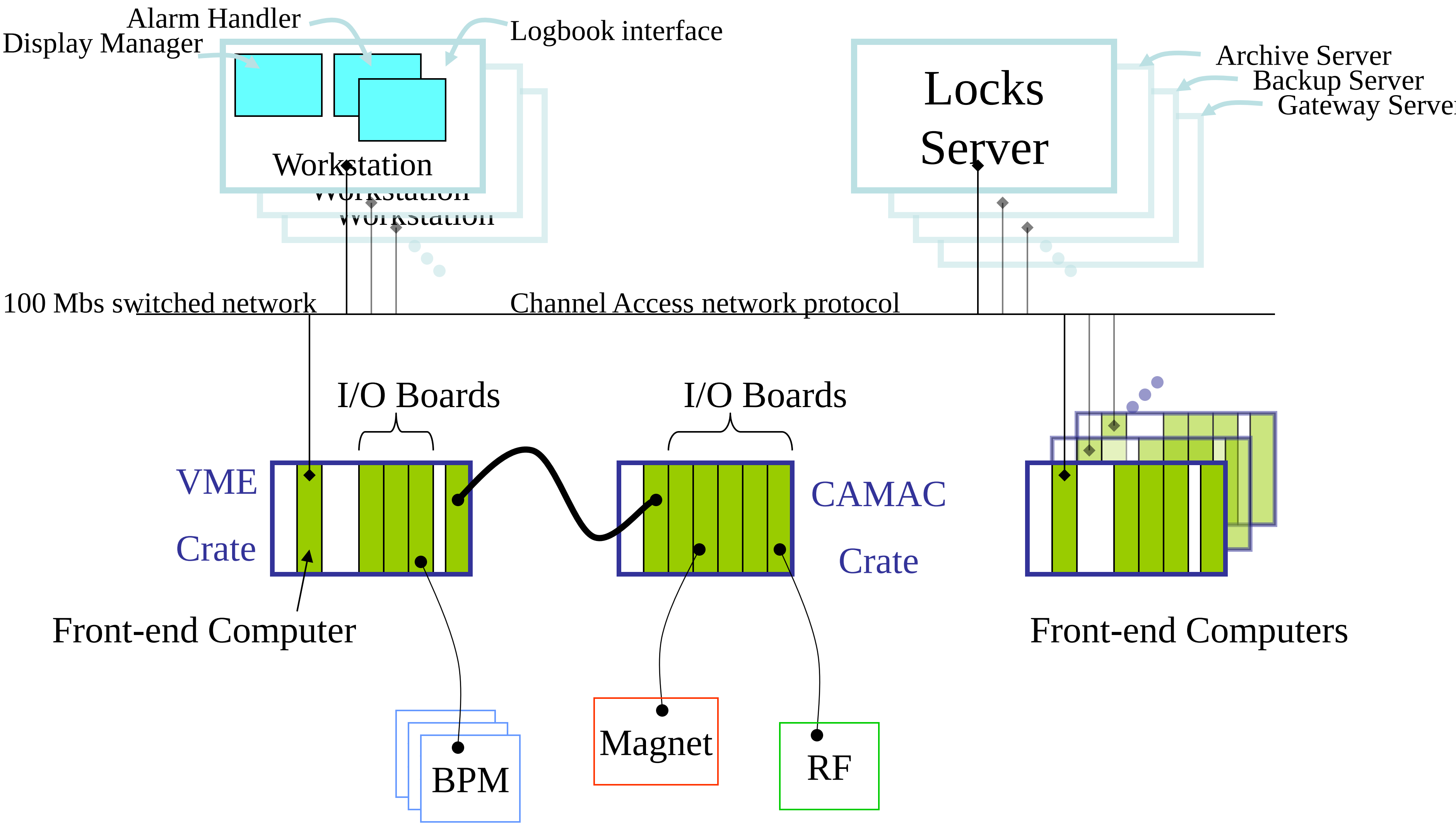
Control System Architecture

- Based on the Experimental Physics and Industrial Control System (EPICS). See http://www.epics.org/
  - Open-source control system toolkit
  - Started at Los Alamos; advanced by Argonne; furthered by JLab starting in 1995
  - More than 100 EPICS collaboration members today
- Scale of CEBAF controls
  - 550 front end computers
  - 50,000 hardware control points
  - 300,000 “soft” control points

Control System Architecture

- Applications
  - Beam diagnostics and controls
  - Synoptic displays, alarm managers, stripchart, archivers
  - Databases, logbooks, planning and coordination tools
  - LINAC energy management, orbit and energy locks, beam optics and steering tools
- Technologies
  - EPICS-based control system
  - VxWorks, RTEMS and soft front ends
  - C, C++, Java and PHP for code development
  - X-windows based user interfaces

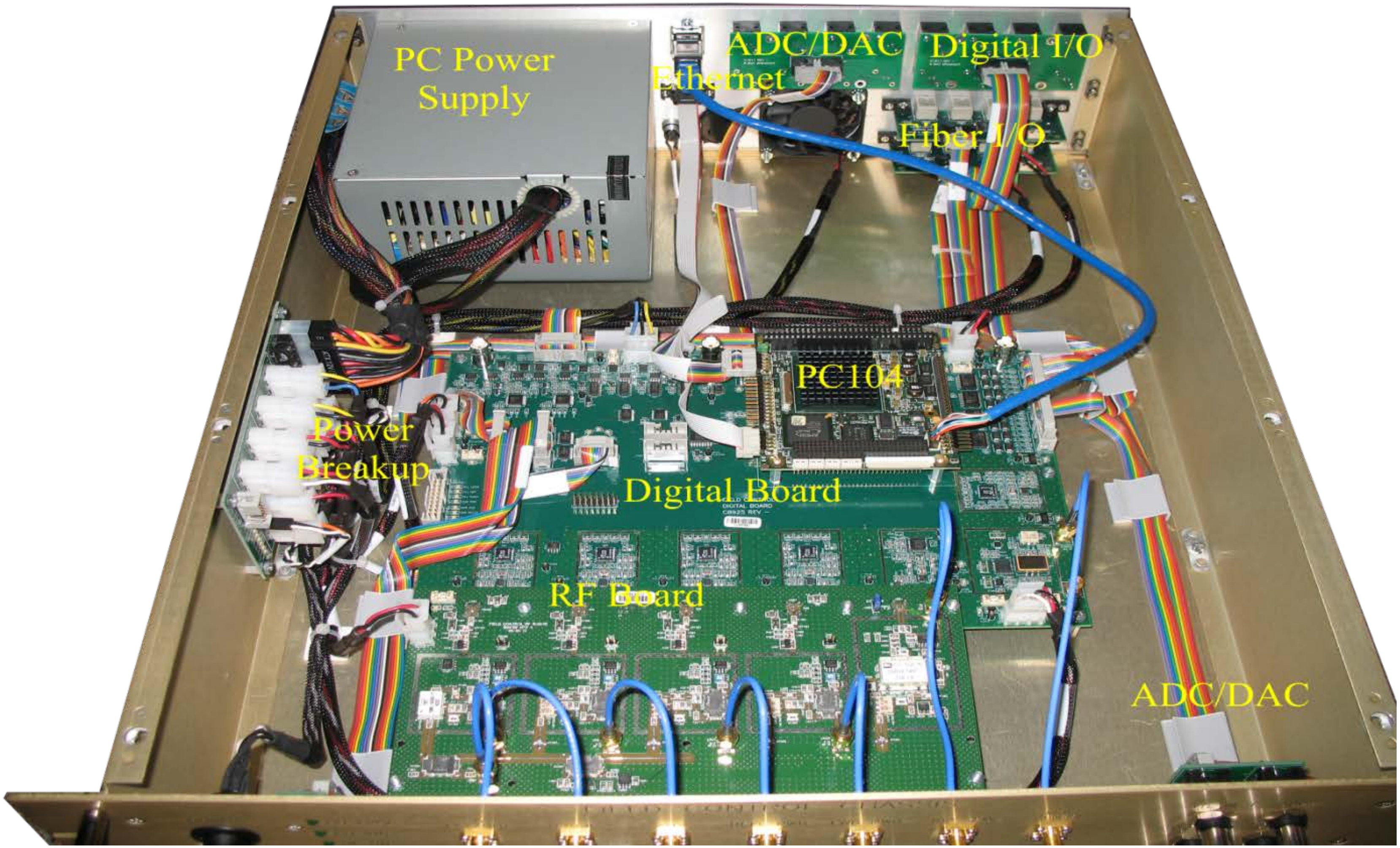
Control System Architecture



PC104 and custom FPGAs

- Front end executes on small form-factor, low-performance PC (PC104)
- Narrow interface from front end PC104 to Field-Programmable Gate Array (FPGA)
  - ISA (16 bits, 8 MHz)
  - PCI (32 bits, 33 or 66 MHz)
- FPGA executes customized high-performance digital signal processing and control algorithms
  - Low-level RF field control
  - Beam Position Monitor signal processing
  - Beam Current Monitor signal integration

Digital Field-Control Chassis



"Soft" Front Ends

- Front end computer with only a network connection
  - Executes on any computer
  - Increasingly used on virtual machines
- Controls development tools and environment are the same as those for hard front ends
- Enables isolation of controls
- Makes network-based adapters very appealing
  e.g. ethernet->GPIB adapters

Controls History

- Started in 1990 with custom HP-based software communicating only with CAMAC crates
- Adopted EPICS in 1994; VME-based SBCs
- Sun servers added in 2001
- Migration to (RedHat) linux on back ends started in 2003
- PC104/custom FPGAs in 2012
- “Soft” front ends in widespread use in 2013

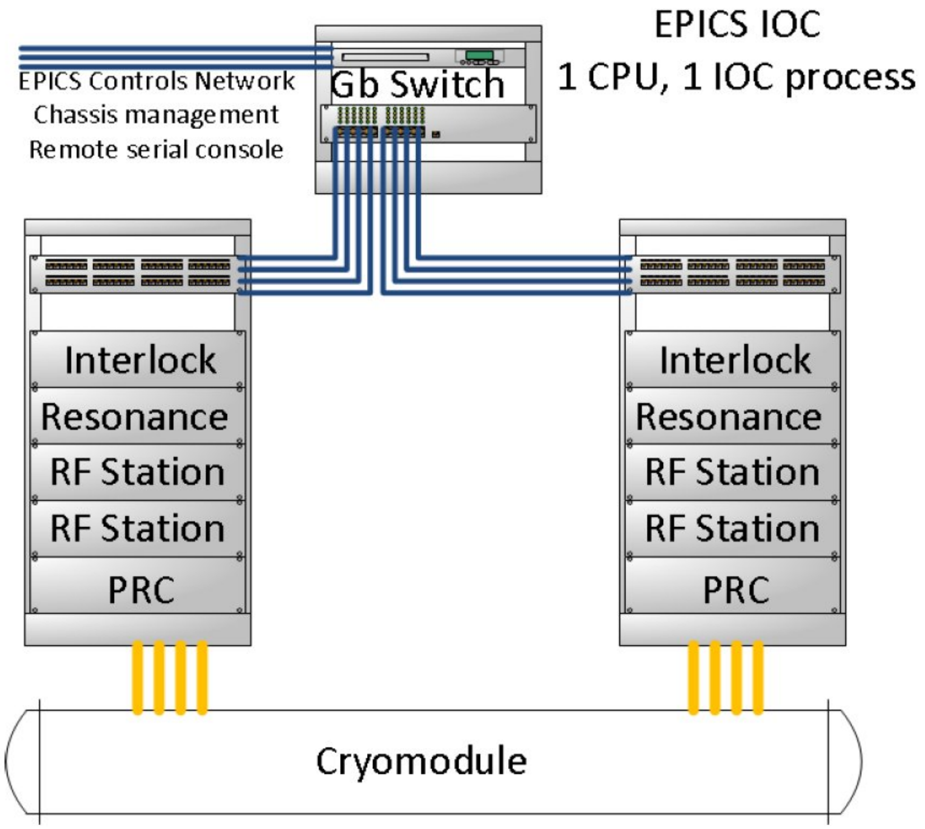
- Overall directions:
  - Away from proprietary hardware and software
  - Increasing flexibility in location of control algorithms (FPGA, hard or soft front ends)

Subsystems: RF

- C20/C50 CAMAC-based analog controls
- C100 PC104-based digital controls
- Future direction: C20 and C50 digital controls
  - PC104 replacement (same fundamental design)
  - LCLS-II design
    - On-site testing starting in summer ‘16
    - Hands-on performance and management experience
  - Next two years will provide a guide

Subsystems: RF (LCLS-II Low-Level RF)

System for One Cryomodule



Subsystems: Safety

- Personnel Safety System
  - Safety PLCs programmed by safety professionals
  - Dedicated, isolated network
  - Read-only monitoring from the control system
- Machine Protection System
  - CAMAC- and VME-based
  - Fast Shut Down
  - Beam Loss Accounting
  - Beam Loss Monitoring
  - Beam Envelope Limit System (beam power)

Subsystems: Cryogenics

- Migrating to PLC-based equipment control
  - CAMAC systems being phased out
  - PLC programming by cryogenics experts
  - Front end->PLC by controls group
- High-level capabilities collaboratively developed
  - Heat management (electric vs. RF heat)
  - Interaction between RF and cryogenic systems

Subsystems: Conventional Facilities

- Maintained by Facilities Management Division
  - Controls interfaces developed as-needed
- Monitoring, archiving and alarming
  - Chillers
  - Low-conductivity water systems
  - Grid power

- Integration outside of system procurement is expensive and time-consuming

CEBAF Element Database (CED)

- Flexible database storing accelerator description
  - Beamline elements (magnets, diagnostics, etc.)
    - Populated from Elegant beamline deck
  - Associated control information
    - Cabling
- Driver for many operational tools
  - Hot checkout
  - Alarm configuration
  - On-the-fly synoptic displays
  - Front-end software configuration

- Development late in CEBAF's life makes this much harder

Controls Plans

- Broaden integration of CED
  - Automated configuration of front-end controls
  - Ties to maintenance database, task management
  - Improve tools to enable data management by system experts (who own the data)
- Replace PC104s in new hardware solutions
  - Increase flexibility and capability
  - Take advantage of new hardware functionality
- Real-time linux on front-end computers
  - Simplify system management
  - Increase flexibility of hardware choices
- Address system administration challenges
  - Many hundreds of front-end computers