



# SoLID Slow Controls Update

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# What are Slow Controls

- “Infrastructure support” systems and logging
  - Status monitoring of power, vacuum, temperatures, etc
    - Includes logging and alarms/notification services
    - Safety interlocks between systems
      - fast valve closure on vacuum problems
      - disable power on temperature/cooling failure, etc.
  - Remote control of motors, pumps, actuators, stepper motors, etc...
  - Typical meas./response time scale on the order of 1 Hz
- Examples include
  - High voltage / Low voltage power controls (R/W)
  - 'Read-only' logging of temperatures, pressures, B-field, flow rates, ...
  - Magnet/Target control systems
    - Complex control process loops: vacuum, temperature, power
  - Gas systems
    - simple “set and forget” open loop STP systems *without* recapture
    - complicated control systems running a distillation/purification system
  - Etc...

# EPICS

- Experimental Physics and Industrial Control System
  - <http://www.aps.anl.gov/epics/>
    - Open source, actively developed, lots of users
    - Based on C; APIs available for Java, Python, LabView, etc...
  - Covers both input/output controllers (IOCs) that do the real work
    - *ie.* poll for and respond to data in real time
    - publish data for other systems to consume
    - IOCs can be single board computers running vxWorks, embedded devices that support the EPICS protocols, or 'softIOCs' which are applications that can run under conventional OSes (linux, etc)
- Main slow controls 'backend' used at JLab
  - A lot of expertise in Accel Div. that we can leverage
    - However, we need to schedule (and budget for) the developer time well in advance!
  - Archiving of slow controls data can be integrated with existing (Accel) MYA Archiver

# Frontend GUIs

- EDM (MEDM) / JTABS

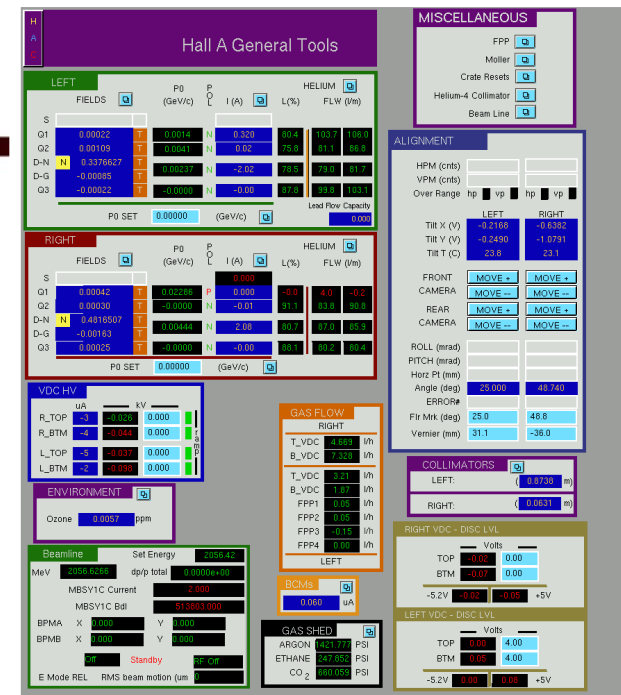
- Forward-port of JLab's 6 GeV EPICS screens
- Still developed, but dated

- Control Systems Studio

- <http://controlsystemstudio.org/>
- Eclipse-based toolkit designed for systems like this
  - SNS, BNL, FRIB, DESY using this system
  - JLab: Hall D (in use), Hall B (evaluating), Hall C (evaluating)

- Let's settle on some standards

- Avoid LabView
- Avoid custom/proprietary code as much as possible
  - if not possible, provide EPICS interface for integration



# Hall D CSS example

The screenshot displays the TAG5C Magnet PS GUI with several key components:

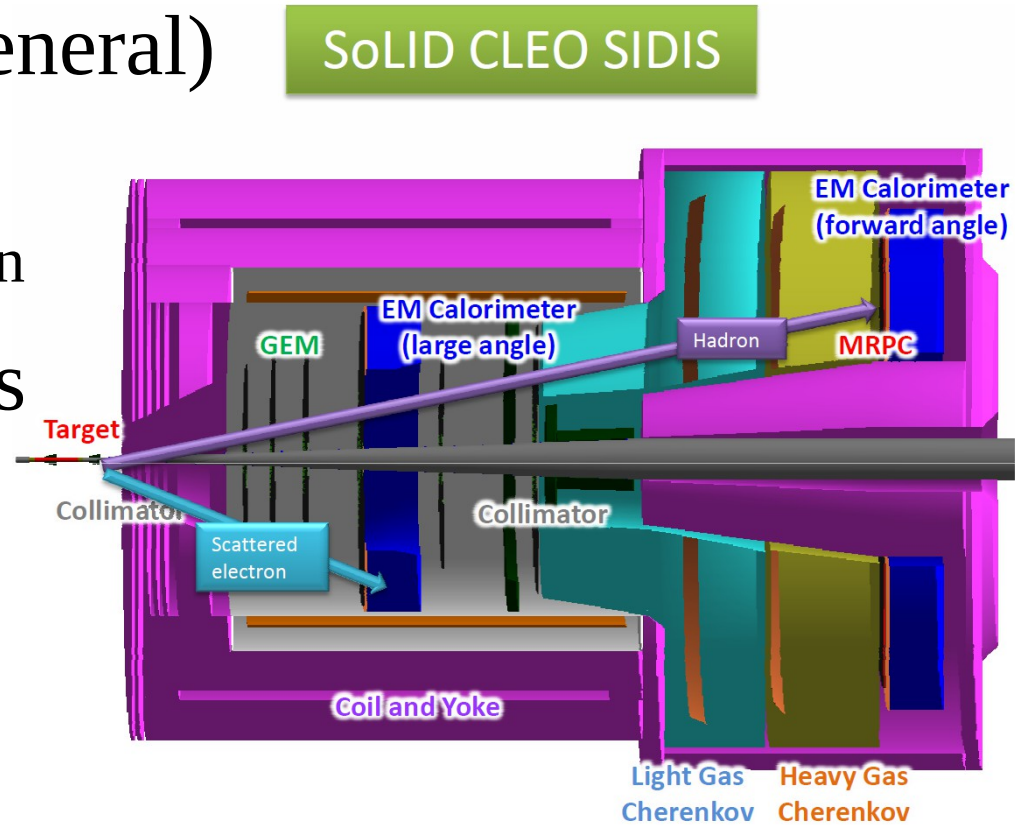
- Top GUI Selector:** A red circle highlights the top-left navigation icons, with an arrow pointing to the text "Top GUI Selector".
- Power Supply Control:** A large green button labeled "TURN POWER ON" is visible.
- Readbacks:** Displays "Main Power ON", "Power Supply Ready", and "Remote Mode".
- Status:** A list of indicators including IOC Heartbeat, Box Heartbeat, STANDBY, NOT READY, LOCAL MODE, Fan fault, NO RESPONSE, Rx data overflow, Unexpected address, Rx data corrupted, Bad rx termination, Tx command error, Setpoint error, Polarity stuck, Polarity change, External interlock, POWER OFF, Sum interlock, DC overcurrent, DC overvoltage, Regulation module, Max current set, Phase / unbalance, Waterflow fail, Earth leakage, Thermal breaker, Overtemperature, and Panic button / doors.
- Current and Power Supply ADC:** Shows "Current Setpoint 0.000 Amps" and "Current Readback 0.000 Amps".
- Input Selection & Detailed Setpoints:** A table with columns for Input Select, Current, BDL, Setpoints, and Nominals. Row 1 shows Current 0.000 amps and BDL 11,200.001 G-cm. Row 2 shows Current -0.000 amps and BDL 11,200.001 G-cm. Row 3 shows Current -0.000 amps and BDL 11,200.001 G-cm.
- Calculated:** Shows "Setpoint Out 0.000 Amps", "Ramp Rate 0.00 A/sec", and "Resistance 0.000 Ohms".
- Hysteresis / Tracking:** Includes "Keep On Loop" with "TURN OFF" and "ABORT" buttons, and parameters like HMAX (275.000), HMIN (4.000), Cycle Time (120.000), Cycle Rate (0.452), Tolerance (0.300), Scan Rate (Passive), and Timeout (0 Hyst Type 1).
- External Primary in:** A list of indicators including PSS Permit, Shunt 1A, Shunt 2A, Shunt 3A, Primary 5, Primary 6, Primary 7, Primary 8, Primary 9, and Primary 10.
- Main Action Bar:** A red arrow points to a yellow banner that says "STANDARDIZING OFF HYSTERESIS".
- Graph:** A plot of Value vs Time (16:17:57.080 to 16:30:00.000) showing a blue line at approximately -0.2.

The screenshot displays the Bias Channels GUI with the following components:

- Turn OFF ALL:** A red button with "Bias" and "LV" sub-buttons.
- START COUNTER CHANNELS:** A large green button.
- SAVE/RESTORE:** A green button.
- ALL LV:** A green button.
- Bias Channels:** A circular selector with 30 numbered slots (1-30) around a central "ALL Bias" button.
- Chassis Channels:** A table with columns for Menu, Voltage (V), and Current (mA). Values: +5V (5.005 V, 0.475 mA), -5V (5.000 V, 0.470 mA).
- Preamplifier Channels:** A table with columns for Menu, Voltage (V), and Current (mA). Values: +3V (5.000 V, 0.568 mA), -3V (5.002 V, 0.572 mA).
- LV Voltages:** A bar chart showing voltage levels for 5 boards.
- LV Currents:** A bar chart showing current levels for 5 boards.
- Bias Channels Voltages:** A bar chart showing voltage levels for 30 boards.
- Bias Channels Currents:** A bar chart showing current levels for 30 boards.
- Bias Channel Module 1:** A detailed view for Module 1 showing "Menu" and "OFF" buttons, "Voltage (V) 76.054", "Current (mA) 0.00073", and "Temperature 25.00 °C".

# SoLID Subsystems

- Magnet
- DAQ / Detectors (general)
  - Power (HV, LV)
  - Crate / Chassis selection
- Detector Subsystems
  - Ecal
  - LA/FASPD
  - Cherenkov
  - GEMs
  - MRPC





# Detectors / Crates

- We want remote access to:
  - crate status: temperatures, fans, remote resets
- Standardize on a crate model:
  - all crates should have (at minimum) an ethernet interface on their controller
    - typically have SNMP support, etc, for monitoring/controls
  - select common (high-power spec'd) power supply module
- Wiener 60xx series in common use at JLab (VME/VXS standard)

# Detectors / High Voltage

- High Voltage hardware should be standardized
  - CAEN SYx527 system
    - Hall B / Hall D / Hall C
    - Built-in EPICS support, supplied controls GUI (java), other GUIs available on-site (Hall C)
    - A7030 is new high density board (48 ch for significantly lower \$/channel)
      - NOTE: 1 mA max. current/chan – check your device first!
  - Wiener MPOD system (Option 'B')
    - Hall D, Hall B SVT HV/LV
      - Hall B had some difficulty getting dedicated CAEN boards to work well with SVT (cooling, power, vacuum interlock related challenges)
    - SNMP-based EPICS interface exists
    - *NOTE: Existing/“legacy” Lecroy HV will NOT be used*
- Low Voltage
  - ??



# Detectors – EC (Calorimeter)

- HV / LV power (previous slide)
  - Planning on CAEN SYx527 system
- Fast interlocks / shutdowns
  - HV shutdown on magnet quench (?)
- LED / Gain monitoring?
- Temperatures

# Detectors – GEM

- HV / LV power (previous slide)
  - Wiener-Iseg SHQ 126L (6 kV, 1 mA) used at UVa
    - Has RS232/CAN interface
- Fast interlocks / shutdowns
  - Trip HV if gas flow is interrupted
- Gas system
  - 75% CO<sub>2</sub> / 25% Ar gas mix (simple flow through)
  - Remote monitoring / control required

# Detectors – MRPC

- HV / LV power (previous slide)
- Fast interlocks / shutdowns?
- Gas system
  - 5% SF6 + 95% R134 + 5% Isobutane
  - Will need capture/recirculation system
    - Phenix HBD / STAR MRPC gas system suggested as a model (need some details)  
(ALICE MRPC gas system hw-only: \$250 Euro (2002))

# Detectors – Heavy Gas Cherenkov

- HV / LV power (previous slide)
- LED/Gain monitoring?
- Gas flow/purity monitoring
- Gas Temperature/Pressure regulation
- Gas purification/recirculation (ie. Hall B)
  - $C_4F_8O$  or  $C_4F_{10}$  at 1.5 atm
  - pressure systems / code requirements typically mean professional engineering/designer support is mandatory
    - custom PLC/IOC design needed

# Detectors – Light Gas Cherenkov

- HV / LV power (previous slide)
- LED/Gain monitoring?
- ~~• Special Gas flow/purity monitoring?~~
- ~~• Special Gas Temperature/Pressure regulation?~~
- Gas purification/recirculation system?
  - CO<sub>2</sub> (SIDIS) can just flow (cheap, easy)
  - CO<sub>2</sub> + C<sub>4</sub>F<sub>8</sub>O (PVDIS) mixing + purification system
    - mixing is easy, purification/reuse is complicated...
  - Integration with HGC gas system likely important, but distillation of a CO<sub>2</sub> mix may require significant modifications of a “Hall B” system

Looks like mixed gas will not be needed.

# Detectors – LA/FASPD

- HV / LV power (previous slide)
  - UVa group: assume CAEN(?)
- Fast interlocks / shutdowns?
- Temperatures

# Summary

- Think about and document slow control needs
  - Feed what you need/want to <brads@jlab.org>
  - I'm happy to support research and answer questions!
- Standardize, standardize, standardize
  - Avoid investing time in 'quick' solutions for local implementation. Stick with the standards – steeper learning curve, but it'll save time in the long run (build trained people as well as software).
  - Hacks and workarounds tend to become 'permanent' and unintended dependencies get baked in – good to avoid these.

## Proposed Standards

- EPICS should be our common API/Protocol
- CSS (Control Systems Studio) recommended GUI framework
  - Can be good student projects, but needs sufficient lead time.
- CAEN is recommended HV/LV supplier
  - many channels → more important to go with the standard!
- Weiner 60xx series is recommended VME/VXS crate
  - What are SRS readout crate specs?





# PLCs

- Programmable Logic Controllers
  - integrated hardware + firmware solutions
    - integrated systems often trade higher performance for the flexibility of 'hand-rolled' IOCs
  - modular, off-the-shelf components suitable for many common processes
  - Care needs to be taken to ensure good systems integration with the rest of the world
    - ie. built in EPICS interface very strongly encouraged
  - Allen-Bradley/Rockwell (ControlLogix, CompactLogix) PLCs in common use at JLab
    - will interface well with EPICS
  - Ideally, let's standardize on one vendor/system
- Magnet controls are good use case for PLCs



# Magnet

- Complicated, lots of fast interlocks, high-risk, needs to be expert driven
  - Expert will pick what works best for them, hard to impose outside constraints...
  - One request:
    - Please allow for EPICS interface for easier integration into logging and DAQ systems