



SoLID Slow Controls

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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

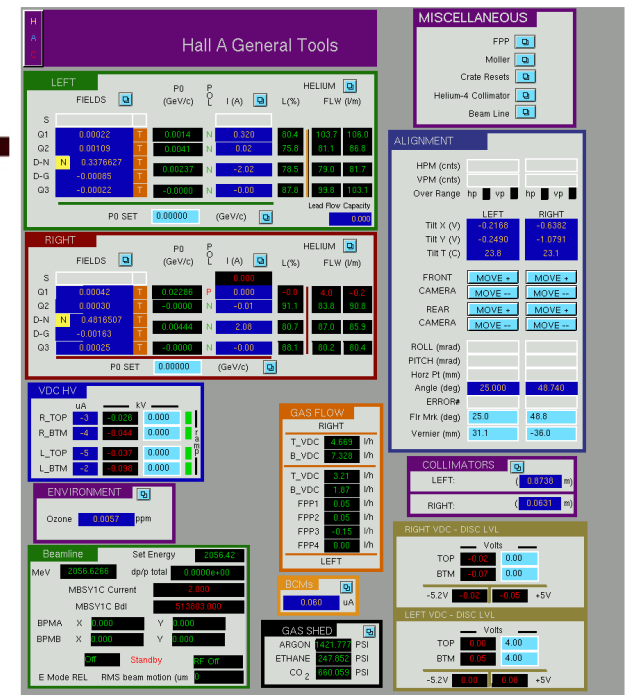
- Forward-port of JLab's 6 GeV EPICS screens
- Still developed, but dated

- **Control Systems Studio**

- <http://controlsystemstudio.org/>
- Eclipse-based toolkit designed for systems like ours
 - 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 toolbar, with an arrow pointing to the text "Top GUI Selector".
- BCAL Panel:** Includes buttons for BCAL Voltages, BCAL Expert Voltages, BCAL LED Pulser, BCAL NIM Pulser, and BCAL Environment.
- CDC / FDC Panel:** Includes buttons for CDC Voltages, CDC Temperatures, FDC Voltages, Main Gas System GUI, CDC Gas System, and FDC Gas System.
- FCAL Panel:** Includes buttons for FCAL Voltages, FCAL Dark Room, and FCAL LED Pulser.
- MAGNETS Panel:** Includes buttons for Solenoid, Tagger, Sweeper, and Pair Spectrometer.
- TAGH / TAGM Panel:** Located at the bottom left of the sidebar.
- Power Supply Control:** Features a large green "TURN POWER ON" button and status indicators: "Main Power ON", "Power Supply Ready", and "Remote Mode".
- Readbacks:** Shows "Current Setpoint" at 0.000 Amps and "Current Readback" at 0.000 Amps. It also displays "Input Selection & Detailed Setpoints" for three channels (1, 2, 3) with values for Current, BDL, and Nominals.
- Status:** A list of indicators with green and red circles, 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.
- Calculated:** Shows "Setpoint Out" at 0.000 Amps, "Ramp Rate" at 0.00 A/sec, and "Resistance" at 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).
- Main Action Bar:** A red arrow points to the text "Main Action Bar" above a graph showing "STANDARDIZING OFF HYSTERESIS". The graph plots Value vs. Time (16:17:57.080 to 16:30:00.000) with a legend for MTAG5C (red) and MTAG5CM (blue).
- External Primary In:** A list of indicators for PSS Permit, Shunt 1A through 3A, Primary 5 through 9, and Primary 10.
- Bottom Right Panel:** Shows "Turn OFF ALL" (Bias, LV), "START COUNTER CHANNELS", "SAVE/RESTORE", "ALL LV", "Chassis Channels", "Preamplifier Channels", "LV Voltages", "LV Currents", "Bias Channels Voltages", "Bias Channels Currents", and "Bias Channel Module 1" with voltage (76.054 V) and current (0.00073 mA) readouts.

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 – General

- HV / LV controls, Temperature, Pressure GUIs with EPICS compatible logging
 - Go with a standard as described and this will be 'easy'. Recommended systems have control, monitoring and alarm loops already implemented, no IOC/PLC development needed.
- “Flow-through” / open-loop gas systems (GEM, LGC)
 - Solved problem with pre-existing GUIs. Go with a standard MFC, etc.
- Recirculating / variable pressure / distillation gas systems will be expensive and will require significant dedicated designer time. (HGC, MRPC)
 - Design must come first, then we can talk about slow controls (but keep the general 'standards' principles in mind!)
- LED Gain monitoring (“on/off”) remote controls are straight forward
- Automated motion / positioning systems are more complicated
 - custom IOC/PLC development, fail-safe design and interlocks, etc.
- Fast interlocks (msec level) that cross system boundaries need to be identified at design stage.

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)
 - gets complicated/expensive quickly
 - pressure systems / code requirements typically mean professional engineering/designer support is mandatory
 - custom PLC/IOC design needed
 - C_4F_{10} seems viable for now (single supplier only?), long term options unclear...
 - Gas expensive enough to need purification/distillation system on this scale
 - Need to watch environmental regulations for these gasses too...
 - (Hall B can take advantage of grandfathering, SoLID can't)

Detectors – MRPC

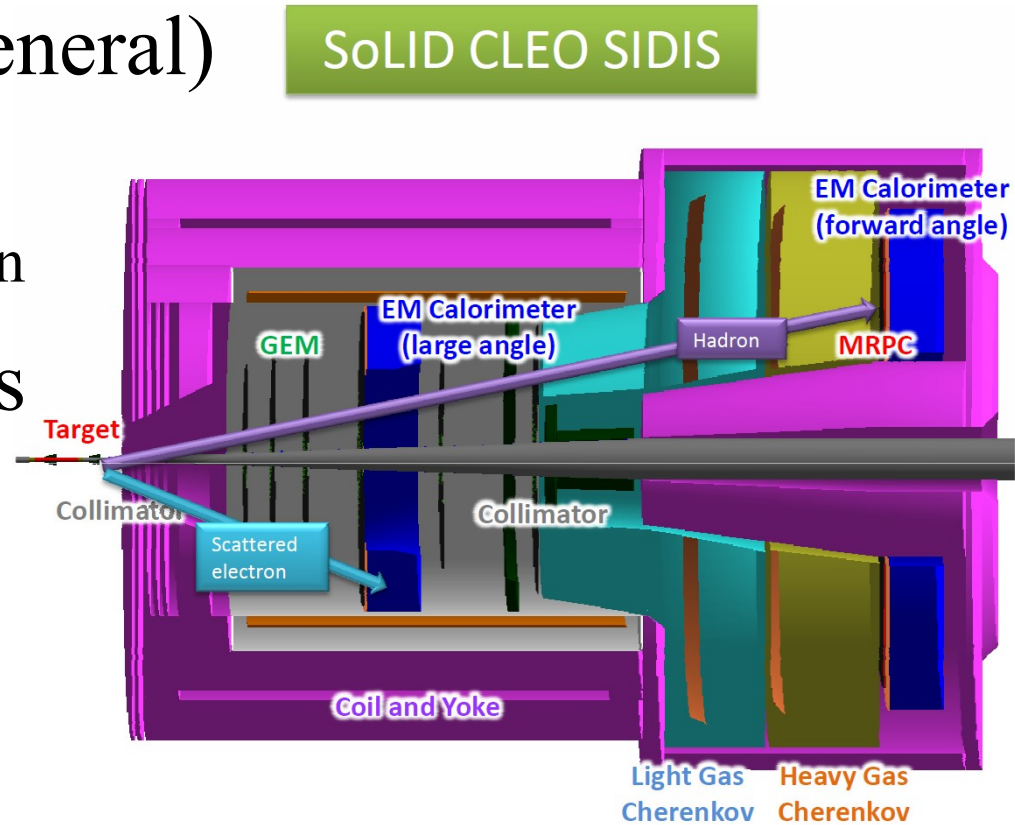
- HV / LV power (previous slide)
- Fast interlocks / shutdowns?
- Gas system
 - 5% SF₆ + 95% R134 + 5% Isobutane
 - Will likely need capture/recirculation system
 - Phenix HBD / STAR MRPC gas system suggested as a model (need some details)

Summary

- Think about and document slow control needs
 - Feed your requirements/design specs to <brads@jlab.org>
 - I'm happy to support research and answer questions
 - Design deadlines (end of 2016?) will arrive quickly. The devil is in the details.
- 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.
 - Proper hardware selection will minimize custom IOC/PLC development.
- EPICS should be our common API/Protocol
- Frontend GUIs/software take time to develop
 - Can be good student projects, but needs sufficient lead time.

SoLID Subsystems

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



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% CO₂ / 25% Ar gas mix (simple flow through)
 - Remote monitoring / control required

Detectors – Light Gas Cherenkov

- HV / LV power (previous slide)
- LED/Gain monitoring
- Gas system:
 - CO₂ (SIDIS) can just flow (cheap, easy)

- Gas flow/purity monitoring?
- Gas purification/recirculation system?
 - CO₂ (SIDIS) can just flow (cheap, easy)
 - CO₂ + C₄F₈O (PVDIS) mixing + purification system
 - mixing is easy, purification/reuse is complicated...
 - Integration with HGC gas system likely important, but distillation of a CO₂ mix may require significant modifications of a “Hall B” system

Not Needed

Detectors – LA/FASPD

- HV / LV power (previous slide)
- Fast interlocks / shutdowns?
- LED / Gain monitoring?
- Temperatures?

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