



SoLID Slow Controls

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Summary

- Slow controls for project on this scale is significant
 - Hall B → 2+ FTE (professionals) for ~2 years (6 people made significant contributions)
- 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
 - Everything will be more \$\$\$ and more complicated than you may expect...
- 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
 - Control Systems Studio (CSS) framework is recommended
 - Can be good student projects, but needs sufficient lead time.

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 (\$200k + \$people)
 - pressure systems / code requirements 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 gases too...
 - (Hall B can take advantage of grandfathering, SoLID can't)

**Some development/
discussions begun
2018**

- HV / LV power (previous slide)
- Fast interlocks / shutdowns?
- Gas system
 - 5% SF6 + 95% R134 + 5% Isobutane
 - Initial gas inventory + operating cost: ???
 - Will likely need capture/recirculation system
 - *Almost certainly subject to formal Design Code regulations*
 - Phenix HBD / STAR MRPC gas system suggested as a model (need some/any details)
- NB: \$20k for gas system in updated preCDR seems extremely low
- ALICE MRPC used a water cooling system to avoid heat buildup (gain drifts, etc) in the preamp card region — does that apply here?

Comments / Questions?

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...

Frontend GUIs

- EDM (MEDM) / JTABS

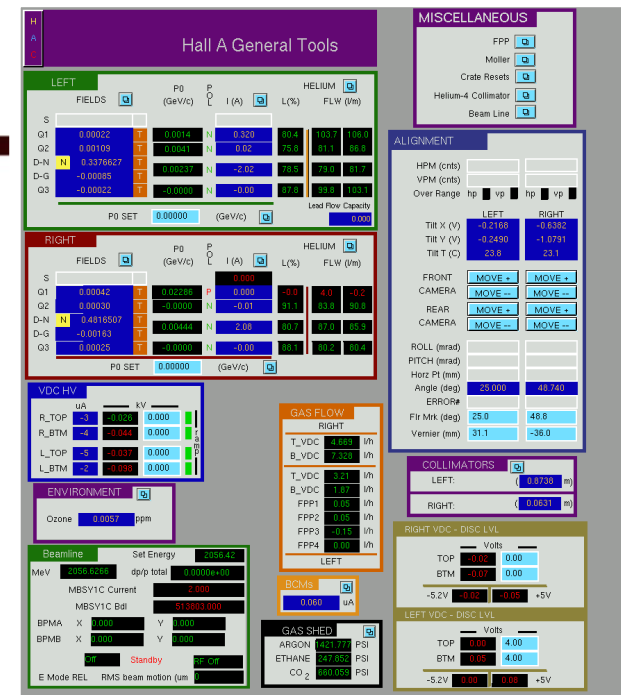
- Forward-port of JLab's 6 GeV EPICS screens
- Still developed, but dated

- **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



CSS launcher scripts

1. clascss , opens CSS with MEDM-style.
2. clascss-alarm, opens CSS in alarm perspective with menu to the left.

Both generate **temporary** Workspaces, provides consistent behavior and user experience.

The screenshot displays the CS-Studio Alarm perspective. The main window is titled 'Alarm Table (HalIB)' and shows a list of 'Current Alarms (7)'. The table columns are: PV, Description, Alarm Time, Current Seve, Current Status, Alarm Severit, Alarm Status, and Alarm Value. The table contains several rows of alarm data, including major alarms for SHLD.T_AVG and CCM.DT_AVG, and minor alarms for SVT N2 Supply Flow.

Below the current alarms, there is a section for 'Acknowledged Alarms (8)'. This section also contains a table with similar columns, listing previously acknowledged alarms such as 'minor-ack'ed alarm: Torus upper vacuum and 'major-ack'ed alarm: Nitrogen.

The interface includes a left sidebar with a 'clas' logo and a 'Detectors' menu listing CTOF, DC, ECAL, FT, FTOF, HTCC, LTCC, RICH, and SVT. Below this is a 'Subsystems' menu listing Asym, Devices, Gas System, HV, IOCs, Moeller, Motors, Scalers, Torus, and Wiener Crates. At the bottom left, there is a 'Tools' menu with 'Strip Charts'.

On the right side, there is a vertical menu with 'Detectors' (CTOF, DC, ECAL, FT, FTOF, HTCC, LTCC, RICH, SVT) and 'Subsystems' (Asym, Devices, Gas System, HV, IOCs, Moeller, Motors, Scalers, Torus, Wiener Crates). At the bottom right, there is a 'Tools' menu with 'Strip Charts'.

Hall D CSS example

The screenshot displays the TAG5C Magnet PS GUI with the following sections:

- Power Supply Control:** Includes a "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 lists "Power Supply ADC" readbacks for 8-bit, Output Voltage, and various supply voltages.
- 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.
- Input Selection & Detailed Setpoints:** A table with columns for Input Select, Current, BDL, Setpoints, and Nominals. It shows three input channels with a BDL of 11,200.001 G-cm.
- 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" (TURN OFF, ABORT), 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).
- External Primary Interlocks:** A list of interlocks including PSS Permit, Shunt 1A through 3A, Primary 5 through 9, and Primary 10.
- Graphs:** A "STANDARDIZING OFF HYSTERESIS" graph showing Value vs. Time for MTAG5C and MTAG5CM.

Annotations include a red circle around the "Main GUI Selector" icon in the top toolbar, labeled "Top GUI Selector", and a red arrow pointing to the "Main Action Bar" text near the graph.

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

- Control:** Includes "Turn OFF ALL" (Bias, LV), "START COUNTER CHANNELS", and "SAVE/RESTORE" buttons.
- Bias Channels:** A circular selector with 30 positions (1-30) and an "ALL Bias" button.
- Chassis Channels:** Shows voltage and current for +5V and -5V rails.
- Preamplifier Channels:** Shows voltage and current for +3V and -3V rails.
- LV Voltages and LV Currents:** Bar graphs showing voltage and current for each board.
- Bias Channels Voltages and Bias Channels Currents:** Line graphs showing voltage and current for each board.
- Bias Channel Module 1:** Shows "Menu", "Off", "Temperature" (25.00 °C), "Voltage (V)" (76.054), and "Current (mA)" (0.00073).

Detectors / Crates

- We want remote access to:
 - crate status: temperatures, fans, remote resets
- Standardize on a crate model:
 - among other advantages, allows for consolidation of spares
 - 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

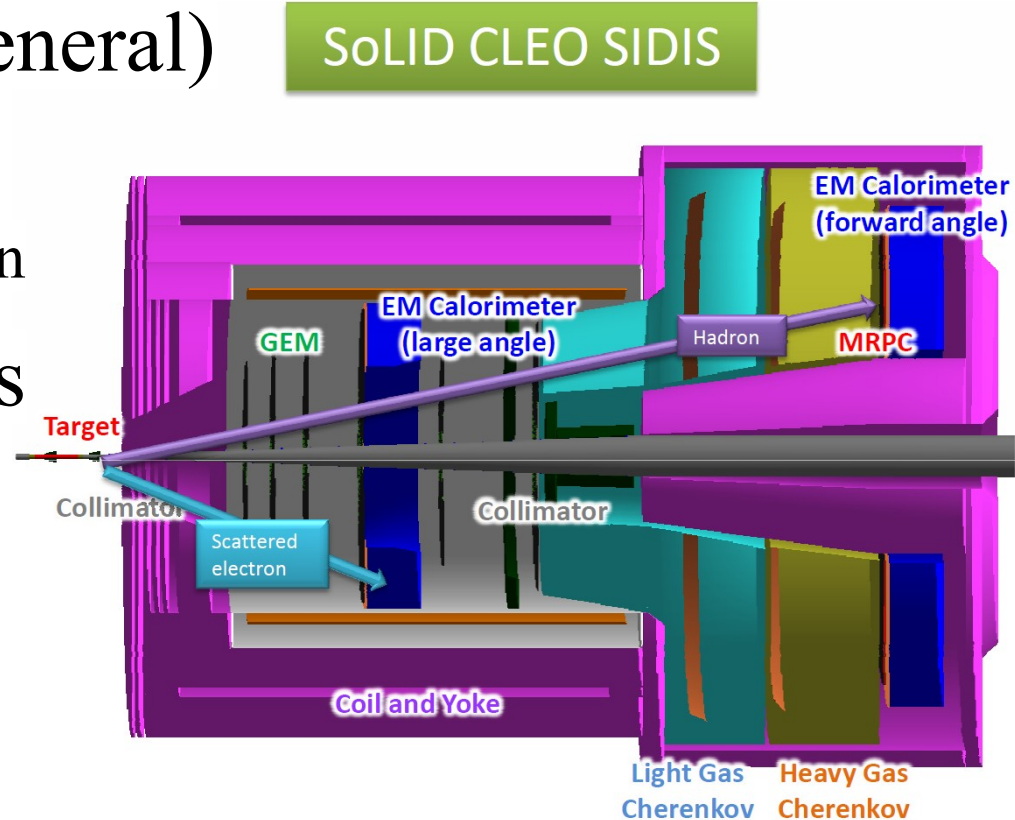
- High Voltage hardware should be standardized
 - CAEN SYx527 system
 - Hall B / Hall D / Hall C
 - Built-in EPICS support, supplied controls GUI (java), other GUIs available on-site (Hall C)
 - A7030 is new high density board (48 ch for significantly lower \$/channel)
 - NOTE: 1 mA max. current/chan – 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
 - ??

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

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