

By Hovanes Egiyan , Jefferson Lab

# HPS Slow Controls Plan

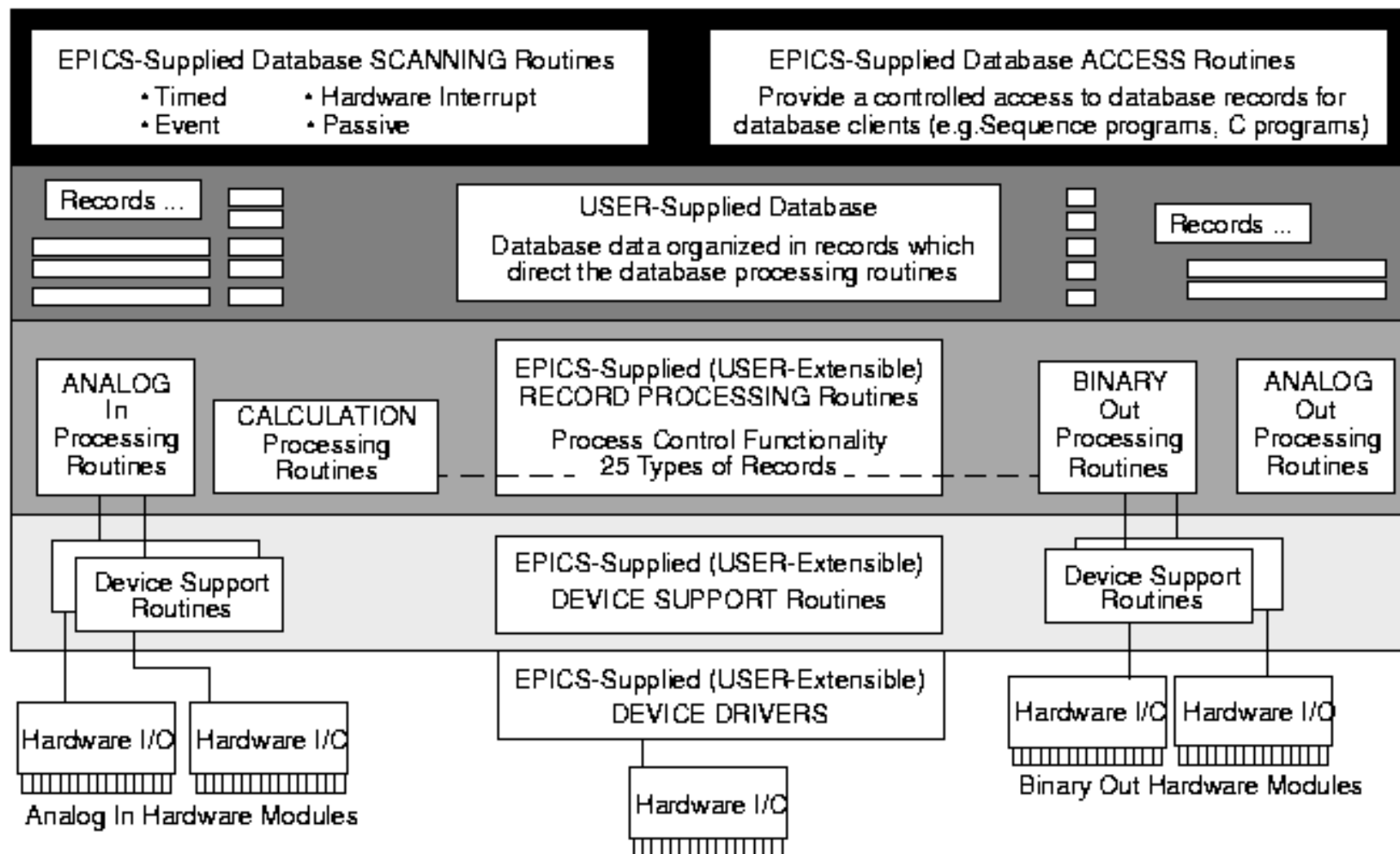
# Adding a Component

- Get a request from detector group
- Study the existing hardware
- Make a basic design the controls system
- Purchase the hardware (I/O modules, CPU, cables, etc)
  - Usually a wide selection pool
- Write software (EPICS)
  - EPICS driver
  - Device support
  - Application
  - GUIs
  - Other

# Introduction to EPICS

- Experimental Physics and Industrial Control System
- Free Open Source software based on C with a large user base
  - Main controls framework of CEBAF
- Server/Client model:
  - Input/Output Controller (IOC) serves variables over Ethernet using ChannelAccess protocol.
  - Clients on different hosts communicate with IOC(s) displaying, modifying, archiving values.
- Applications are usually written in form of EPICS record database
  - Each EPICS record type has a variety of fields, like VAL, SCAN, STAT.
  - Each record type has a set of functionalities, hence function block programming
  - Individual EPICS record instances (PVs) can have different processing
    - Periodic, S/W Event, Passive, H/W Interrupt
- EPICS community provides various tools, like display management, alarm handling, archiving of variables.

# EPICS Structure



# Control Screens, Alarms etc

- Hall B has been using **MEDM** EPICS extension for display management
  - Very simple, small capabilities
  - Old package from gos, but we do not have manpower to upgrade to newer framework.
  - HPS can use this
- Hall B has been using the EPICS alarm handler **ALH**
  - Configurable through a text file
  - Old package from gos
  - HPS can use this
- Hall B has been using **StripTool** EPICS extension to display time evolution of PVs
  - Standalone packages, old technology, works well
  - HPS can use this.
- Can use what CLAS12 decides to use for EPICS archiving
  - **MYA** supported by the JLab accelerator division, Hall B is moving towards this choice
  - Hall B may need to procure some hardware for CLAS12

# HPS Slow Controls Applications

- Magnet power supplies and beamline
  - Use existing power supplies and control, almost no changes is expected here.
  - May need some work on GUIs if we use a new display management framework
  - New VxWorks and EPICS versions
- Motion control
  - Harps, SVT scans, target, collimator, beam blocker
  - We need to develop the applications for SVT scans, others are pretty much ready
- High/Low Voltage control
  - Beamline, ECAL, SVT, Muon Detector
  - Need mostly to develop control and alarm screens
  - Interlock SVT power supplies
- Temperature monitoring
  - ECAL and SVT temperature monitoring, chiller for SVT, interlock for SVT
  - Can use a different approach to signal IO like PLC readout
- Monitoring of scalers
  - Main feedback from detector components
  - Need to develop EPICS support for JLab modules

# Magnet Controls

- Our plan is to use existing Hall B magnet power controls.
  - No money allocated for these in the project.
- Control cables have been disconnected, not documented
  - The main dipole (PS magnet) control is simple, serial communications
  - Krister will need to spend some time on restoration of the following:
    - Frascati magnet controls (minitorus power supply)
    - Moeller polarimeter quads
    - Moeller target Helmholtz coil power supply
- Tagger magnet will be handled by the accelerator divisions controls group
- Gaussmeter readout in the Pair Spectrometer and one Frascati magnet will use existing EPICS-based setup.
- No new application development is foreseen.
  - May need small modifications to the GUIs

# Motors

- Beamline Motors
  - 2C21 harp (1 axis)
  - Moller target (1 axis)
  - 2c24 harp (1 axis)
  - Collimator (1-axis)
  - 2Hoo harp (1 axis)
  - HPS target ladder (1 axis)
  - Beam blocker (1 axis)
- SVT motors
  - SVT sensor positioner (2 axes)
  - Need to send a setup to SLAC to test the full system before installtion
- We will use CLAS6 boxes with OMS drivers for motor controls
  - Each box can driver four axis
  - Each driver box needs an OMS VME control board
  - Krister built these boxes, installation of these should not be a problem
- We need one Hall-B motor control box with 4 axes upstream (space-frame), and 2 control boxes with total of 8 axes downstream (pie-tower)
- EPICS support for the basic operations of these motors exists.



# Stepper Motor Control

- The control modules from OMS has EPICS interface.
  - “motor” EPICS record type
- We did not use any of the HPS motorized stages during 2012 test run.
  - Interfacing to EPICS should be pretty straightforward since the hardware was selected Hall B controls framework in mind.
  - For potentiometer readout we need analog input channels.
- An application needs to be written if the motor is expected to do any automated motion
  - Create EPICS database or state code to set the appropriate fields of the motor record at appropriate times.

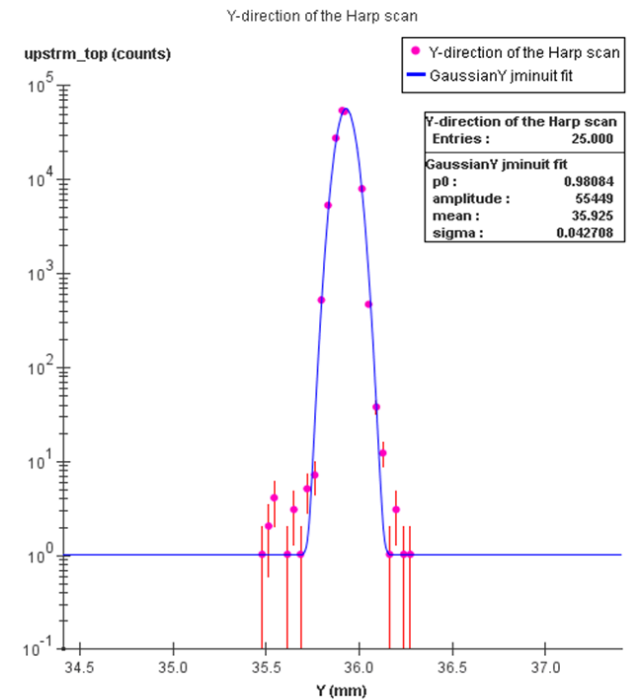
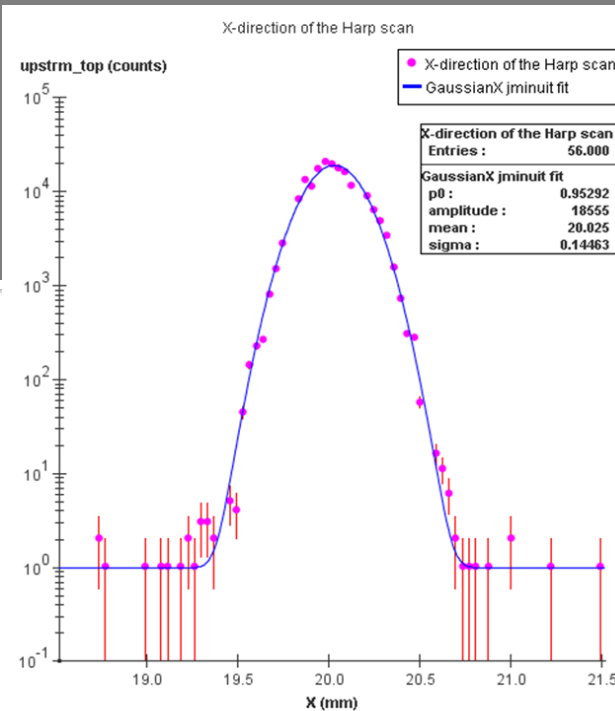
The screenshot displays the EPICS control interface for a stepper motor, titled 'harp\_tagger (epics: harp\_tagger)'. The interface is organized into several sections:

- Drive Section:** Contains fields for 'Hi limit' (150,000), 'Readback' (0,000), 'MoveAbs' (0,000), and 'Lo limit' (-150,000). It also features 'JogR', 'JogF', 'HomR', and 'HomF' buttons. A red 'Stop' button is visible.
- Dynamics Section:** Includes 'Speed' (0,500), 'Base Speed' (0,010), 'Accel.' (0,010), 'Backlash distance' (0,000), and 'Move Fraction' (1,000).
- Calibration Section:** Features 'Cal' (Use/Set), 'Off' (0,000), and 'Dir' (Pos/Neg) controls.
- Setup Section:** Contains 'Motor res.' (0,001), 'Encoder res.' (0,001), 'Readback res.' (0,000), 'Retry deadband' (0,001), and 'Retries' (0).
- Status Section:** Displays 'State 0x' (0x105), 'CurrDir' (1), 'Moving' (0), 'At Home' (0), 'MotorPos' (0), 'Encoder' (0), 'MIP 0x' (0x0), 'Err' (0,000), 'Version' (4,30), 'VME Card#' (0), and 'Precision' (5).

# Scan procedure

- A harp is moving continuously at  $\sim 0.5\text{mm/s}$  speed across the beamline
  - The control modules for the motors are in a VME crate.
- VME scalers attached to the beam halo detectors or other detectors are continuously read out.
  - In Hall B scaler readout happens on VME bus.
- Every few millisecond both motor position and scaler readings are written to the disk.
- The scaler readout and harp motion needs to be synchronized.
  - The level of synchronization depends on the speed of the harp and required precision in the beam position.
  - Having both motors and scalers and motor controller on the same VME bus is sufficient.
  - If these are in different crates communicating over Ethernet:
    - The motor control module needs to send out strobe signals for scaler latching.
    - Scan needs to progress “sufficiently” slow, scans take long time

# Scans



- HPS needs 3 harp scans (3 motors):
  - Standard Hall B 2C21, 2C24, and 2Hoo harps
  - Hardware and software mostly exists
- Scans with SVT wires (2 motors):
  - New scans that will require
    - Detector channel that can be connected to scalers
      - Beam halo counters downstream of SVT
      - ECAL channel connected to a discriminator and scaler, unlikely
    - New analysis software to determine the X- and Y- position of the SVT frame.

# Voltage Controls

- ECAL, beamline (and muon system) HVs will be provided by CAEN modules housed in SY1527 chassis
  - Used this in HPS Test, CLAS6, will be used by CLAS12 and GlueX
  - Need two SY1527 crates for HPS
  - We have experience with CAEN SY1527 EPICS support
- Wiener MPOD-based HV/LV system for SVT biases and LV
  - HPS SVT will use one MPOD crate
  - SNMP-based EPICS interface exists, used by Hall B and Hall D

# CAEN SY1527 and Wiener MPOD

- EPICS support for CAEN
  - From CLAS6 slow controls
  - From Canadian Light Source
    - Hall D will use this one, modified by Nerses
    - Reads the content of each chassis and configures EPICS IOC DB automatically
- EPICS support for MPOD
  - MPOD voltage parameters are obtained using SNMP driver for EPICS
  - Small MPOD specific driver written to autoconfigure the IOC by reading the content of the chassis.
- Both of these pieces of hardware will be used in CLAS12 and GlueX
- The list of channels for SVT biases and LV and ECAL voltage grouping are already available
  - The actual board/channel-to-detector mapping for SVT and ECAL will be determined later when the detector design is complete.
- EPICS IOC will be configured by YerPhi (Nerses)
  - Scheme similar to what used for GlueX
- GUIs for SVT and ECAL will be handled by Glasgow (Bryan)
  - New main GUIs
  - Use the CLAS6 scheme to generate MEDM and alarm GUIs.

# Voltage GUI Prototypes

svtStatusPS.adl

HPS SVT POWER SUPPLIES

WARNING  
TO BE USED BY SVT EXPERTS ONLY !

Bias Voltage Setpoints 0

TOP SVT

	TRIPS	ON/OFF	MEASURED CURRENTS			BIAS VOLTAGE	
			IVDD	AVDD	V125	MEASURED	DEMAND
Hybrid 0	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 1	●	OFF ON	0,000	0,000	1,000	0,000	0,000
Hybrid 2	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 3	●	OFF ON	0,000	0,000	0,000	0,200	0,000
Hybrid 4	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 5	●	OFF ON	0,000	0,000	1,000	0,000	0,000
Hybrid 6	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 7	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 8	●	OFF ON	0,000	0,000	0,000	0,100	0,000
Hybrid 9	●	OFF ON	0,000	0,000	0,000	0,000	0,000

BOTTOM SVT

	TRIPS	ON/OFF	MEASURED CURRENTS			BIAS VOLTAGE	
			IVDD	AVDD	V125	MEASURED	DEMAND
Hybrid 0	●	OFF ON	0,000	0,000	1,000	0,000	0,000
Hybrid 1	●	OFF ON	0,000	0,000	2,000	0,000	0,000
Hybrid 2	●	OFF ON	0,000	0,000	0,000	0,100	0,000
Hybrid 3	●	OFF ON	0,000	0,000	0,000	0,100	0,000
Hybrid 4	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 5	●	OFF ON	0,000	0,000	2,000	0,000	0,000
Hybrid 6	●	OFF ON	0,000	0,000	0,000	0,000	0,000
Hybrid 7	●	OFF ON	0,000	0,000	0,000	0,100	0,000
Hybrid 8	●	OFF ON	0,000	0,000	6,000	0,000	0,000
Hybrid 9	●	OFF ON	0,000	0,000	3,000	0,000	0,000

VOLTAGES

MORE PARAMETERS

Power Supply Interlock ●

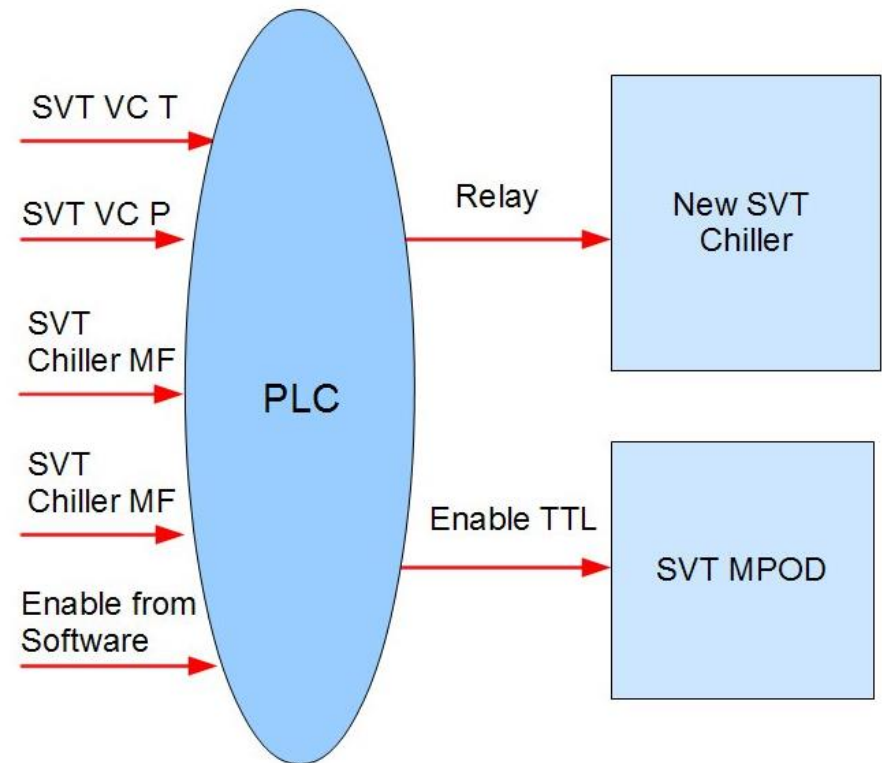
Channel Name	Group#	Measured V	Demand V	Input V	Measured I	Status
R3S1STS1720 (Mf, Slot, Chan):	1 01 06 06	1503,600	1495,000	1495,000	8,040	2771,00

# MPOD Chassis and Boards

- Many labs use MPOD power supplies as standard equipment.
  - Hall D already has experience with using MPOD based chassis
    - Used them during 2012 beam test of GlueX miniBCAL
      - No hardware interlocks are required for GlueX, no in-house experience with this.
      - Interlocks for voltages needs to be designed.
- Interlocks for the MPOD supplies can be either on board level or chassis level
  - Boards can have option for interlock:
    - ISEG EHS HV modules have SL LEMO connector for safety loop (ENABLE) requiring 5mA current to enable channels on the board. Fast shutoff of all channels on the board there is no current.
    - Wiener MPV 8008 modules can have DSUB-37 with ENABLE per group of 4 channels. If TTL level is zero all channels are turned off.
    - Wiener MPV8008 modules have safety loop connectors for DSUB-37 connector for groups of 4 channels. If the loop is open the 4 channels are turned off.
  - HPS chassis will have controller with a DSUB9 connector with ENABLE and SHUT\_OFF
    - All channels on a chassis can be ENABLED by a TTL level (ramp down if zero level)
    - All channels on a chassis can be shut off by a TTL level (delay of 190msec)

# SVT Interlocks

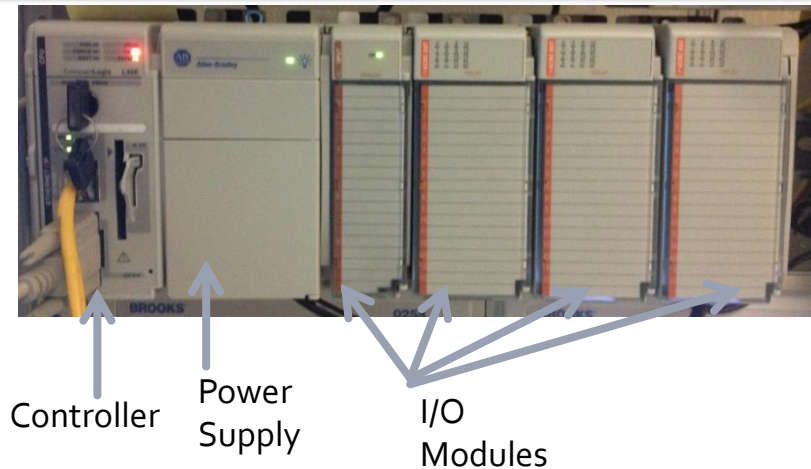
- SVT cooling and need to be interlocked to avoid damaging SVT equipment. Power and coolant flow needs to be shut off when there is a problem with:
  - SVT temperature
  - Pressure in the vacuum chamber
  - Flow in the cooling line
  - Fast-Shut-Down (FSD) from accelerator
  - Software input
- The timing requirements from the SVT group are not very strict, on the order of 200ms.
- Preliminary design based on Allen-Bradley PLC chassis





# A-B CompactLogix 1769 PLC

- Need to have at least three analog inputs.
- At least one digital (TTL) input.
- Fast shutdown signal generation (~200ms).
- 5V digital output for SVT power supplies
- Relay for the chiller shutdown



- Allen-Bradley Programmable Logic Controller (PLC)
  - Modular system, can easily add more I/O modules.
  - Relatively inexpensive hardware (<\$10K for interlocks only).
  - Can program any logic at any time if we have a software license.
  - Easily inefaceable with EPICS to see the statuses and values of the inputs.
  - Hall D developed an interlock system based on A-B CompactLogix.
  - Decisions can be taken and output can be produced on ~50ms time-scale.
  - Used in Hall D, some local expertise and development platforms are available.

# PLC for Analog and Digital I/O

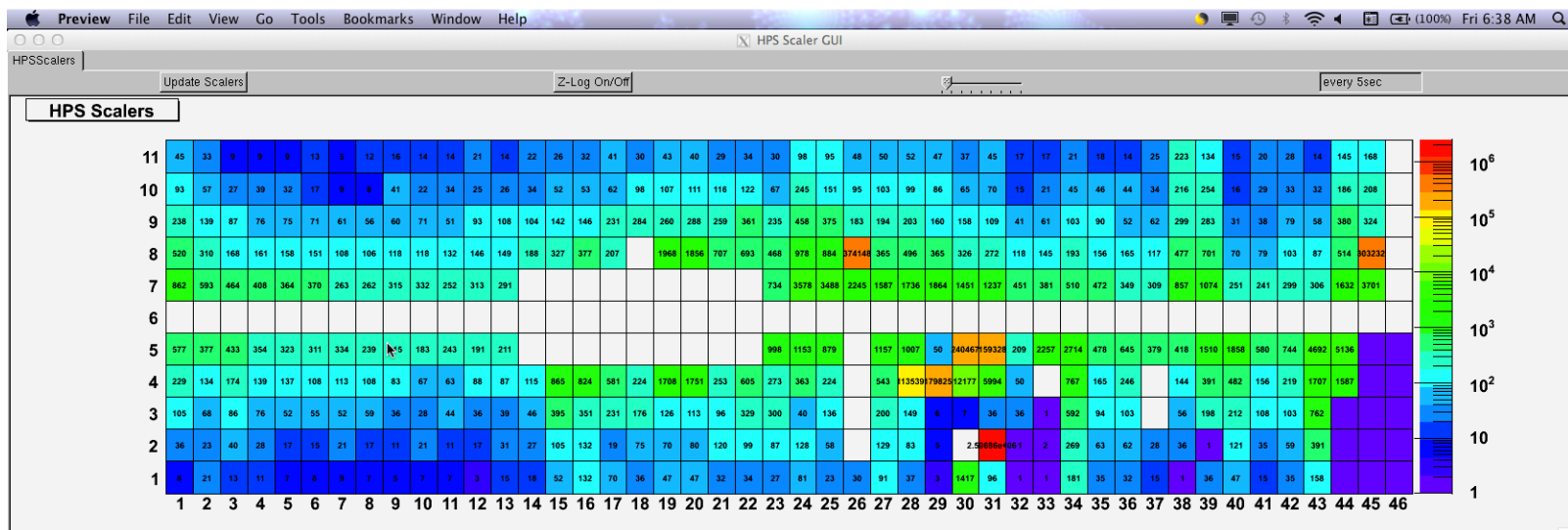
- We can use PLC chassis for the SVT interlocks for Analog and Digital IO
  - Thermocouple inputs
  - Mass flow meter, vacuum chamber pressure readback
  - Potentiometer from motorized stages
  - Any other last minute requests will be simple enough to implement
- Allen-Bradley ControlLogix and CompactLogix PLC are easily interfaced with EPICS through Ethernet (EthernetIP protocol).
  - Extensively used in Hall D for the lowest layer of the control system
  - Developed a set of Python scripts to generate EPICS record database from the RSLogix5000 project file (PLC program).
- Programming PLC requires expertise
  - If only used to obtain the reading for EPICS then not much PLC programming will be required.
  - HPS probably can borrow Rockwell software licenses from Hall D for short amounts of time.

# Temperature Monitoring

- ECAL electronics needs to be thermally stabilized, temperatures need to be monitored.
  - In 2012 the monitoring was done using Omega thermocouples and RS-485 readout modules.
  - If new thermocouples are installed can use PLC readout modules, otherwise use the existing system.
- SVT board temperature is monitored using temperature sensors readout by SVT DAQ when DAQ is running
  - Interfaced with EPICS, but not reliable to be used in interlocks or alarms.
  - We also used thermocouples on the SVT vacuum chamber to monitor temperature.
- SVT cooling requires a chiller that needs to be operated remotely
  - Primex chiller did not match well the SVT needs, caused some confusion
  - HPS will procure a dedicated chiller with remote control that can be interfaced with EPICS, for instance through RS-232.
- Extra temperature sensors not yet implemented can be read out using PLC
  - Hall D uses A-B CompactLogix for a large number of temperature measurements.

# Scaler Monitoring

- It is very important to have as much scaler information displayed online as possible, waiting for offline analysis may lead to time waste.
- During spring run we had scaler values for ECAL in ROOT
  - Sergey wrote the software to read the scalers from the discriminators and plot them.
- It is desirable to have scalers from JLab discriminators and FADC in EPICS
  - Can be view from many locations
  - Can be archived



# ECAL Light Monitoring



- ECAL will have a light monitoring system with two custom-made controllers.
  - The same type as for CLAS12 Forward Tagger
- Glasgow group is developing EPICS support for the CLAS12 Forward Tagger controller and the monitoring procedure which we can use for HPS.
  - Accelerated schedule for Glasgow.

# Summary

- Upgrades in some areas, introduce new features
  - SVT power, interlocks
  - Signal I/O with PLC
  - Motors for SVT and for target
  - New chiller
  - Use CSS for display management and alarms.
- Activities will start this summer
  - Will start bi-weekly meetings this month.
  - Should have a good description of work and a plan by fall
  - Will identify collaborators volunteering to work on controls.
  - Should have a review sometime this fall
- Need input from detector components, can be presented at the meetings
  - Description of the hardware and its functionality
  - Parameters to monitor and control, and how
  - Existing software/firmware description
  - Parameters that need archiving
  - Alarm conditions
  - Software interlocks
  - Backup/restore requirements

# End

- Thank You !