



DØ Control System Tutorial

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Outline

- Terminology
- Control System Components
- Alarm States
- Process Variable Naming Convention
- Significant Event System
- Detector Configuration Management
- Operator Displays



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Terminology

- **Process Variable (PV)**
 - ◆ **Smallest unit of control data associated with the detector**
 - **status, readback, setpoint, parameter, ...**
 - ◆ **Referenced by name**
 - ◆ **The primary object of the Channel Access Protocol**
- **Record**
 - ◆ **The mechanism by which a Process Variable is defined in an IOC**
 - **Data structure that realizes an instance of a PV**
 - ◆ **Composed of fields with a type (behavior), access rules, and value(s)**
 - **Scan rate, timestamp, value, alarm severity, ...**
- **IOC (Input/Output Controller)**
 - ◆ **A computer running a set of EPICS routines used to define process variables and implement real-time control algorithms**



Terminology

- **Channel Access (CA)**
 - ◆ The communication protocol used by EPICS
- **Channel Access Server**
 - ◆ Software that provides access to a Process Variable using the Channel Access Protocol
 - ◆ Usually, an IOC
- **Channel Access Client**
 - ◆ Software that requests access to a Process Variable using the Channel Access Protocol
 - ◆ Usually, a host-level computer
- **Field bus**
 - ◆ The electrical medium by which a detector element is connected to an IOC



Terminology

- **Device**

- ◆ A component of the detector, often an entire module in a crate, that performs a unified, high-level function
- ◆ Can have 1 to more than 30 associated PV's



Control System Components

- **Process control sub-system**
 - ◆ **EPICS (Experimental Physics and Industrial Control System)**
 - ◆ **Open source**
 - ◆ **Maintained by HEP community**
 - ◆ **Scalable architecture**
 - ◆ **Provides tools and building blocks for constructing a control system**
 - ◆ **Based upon a transport protocol (Channel Access)**
 - ◆ **Extensive collection of host-level support applications**
- **DØ-specific extensions to EPICS**
 - ◆ **New drivers**
 - **MIL/STD1553B field bus**
 - ◆ **New record types**
 - **HV channel state machine**
 - ◆ **New device support**
 - **Rack monitor**
 - **AFE boards**



Control System Components

- **Field buses**
 - ◆ VME
 - ◆ MIL/STD1553B
 - ◆ CANBUS (Run IIB)
- **Application processes**
 - ◆ Channel Access clients
 - ◆ Significant Event System
 - Alarms
 - ◆ Comics
 - Configuration management
 - ◆ Graphical resource displays
 - ◆ Data archivers



Control System Components

- **Size**
 - ◆ ~15 host-level processors
 - ◆ ~150 IOCs (Input/Output Controllers)
 - ◆ ~7000 high-level devices
 - ◆ ~150000 process variables
- ~20 major detector sub-systems
- Host-Level processes written in Python
- Source management - CVS

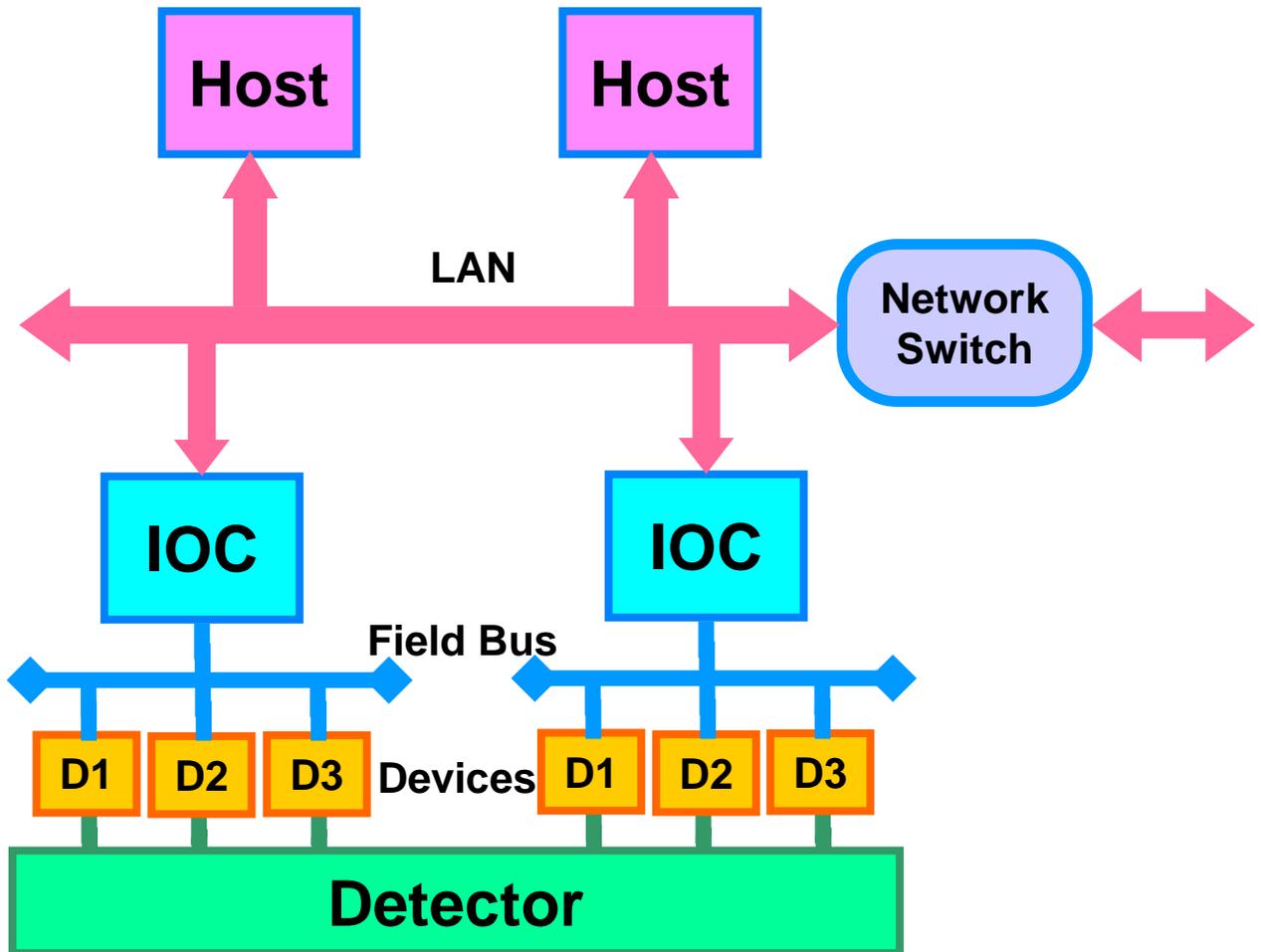


Control System Components

- **Operating systems**
 - ◆ Host processors - Linux
 - ◆ IOC processors - vxWorks
- **Controls staff**
 - ◆ Core system – 2 ½ FTEs (3 people)
 - ◆ Detector-specific components - ~2 FTEs
 - Primarily from other institutions



Control System Components



Host – Linux Servers
IOC – MVME162, MVME23XX, MVME5500
Field Bus – VME, MIL/STD1553B, CanBus



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Control System Components

- **Accelerator System Gateway**
 - ◆ Gateway link to ACNET system
 - ◆ Bidirectional
 - ◆ *Data access only (no control)*
- **Cryogenics and Gas Gateway**
 - ◆ Gateway link to DMACS system
 - ◆ Read-only
 - ◆ *Data access only (no control)*
- Gateways appear as CA servers (IOC's) to EPICS



Alarm States

- Process variables (EPICS records) exist in one of four alarm states
 - ◆ No Alarm [GREEN]
 - Value within normal range
 - ◆ Minor [YELLOW]
 - Value outside of normal range but not data corrupting
 - ◆ Major [RED]
 - Value outside of normal range and potentially data corrupting
 - ◆ Invalid [PURPLE]
 - Value returned by the device is not meaningful
 - Field bus error
 - Network connection lost
- Host-level processes add an additional state
 - ◆ Undefined [GREY]
 - Unable to find (connect to) the process variable
- In GUI display fields the background colors indicate the alarm state



Process Variable Naming Convention

Template

<det>[<sub>]_<dev>_<loc>/<attr>[:<io>] [. <field>]

Name Elements

Element Name	Symbol	Example
Detector	<det>	CAL
Sub-det	<sub>	N
Device Type	<dev>	VBD
Locator	<loc>	01
Attribute	<attr>	STATUS
I/O	<io>	W
Field	<field>	SCAN

Example

CALN_VBD_01/STATUS:W.SCAN



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Significant Event System

- The significant event philosophy
 - ◆ Alarms are only a sub-set of the significant events
 - ◆ The control system does not generate all of the significant events
 - ◆ Alarm utilities enhance reliability
 - Detect impending failures and fix them *before* they fail
 - Minimize the time to correct failures
 - ◆ Why look at detailed displays until they have something interesting to show?
 - The alarm display shows which detector elements should be viewed in detail
 - No comfort displays, they only clutter the screen
 - ◆ Archive all event transitions
 - The archive is a history of the state transitions of the experiment
 - Tools provided to search the event archive



Significant Event System

- **A server-based event (alarm) system:**
 - ◆ **IOCs and user processes connect to and send alarm transitions to the server**
 - **Pushed by sources not pulled by the server**
 - ◆ **Server holds the current experiment (alarm) state**
 - ◆ **Server has a filter for each receiving client**
 - **Makes use of name structure**
 - ◆ **Rapid display startup of receiving clients**
 - ◆ **User processes may also declare events via API (C, C++, Python)**
 - ◆ **Written in Python**

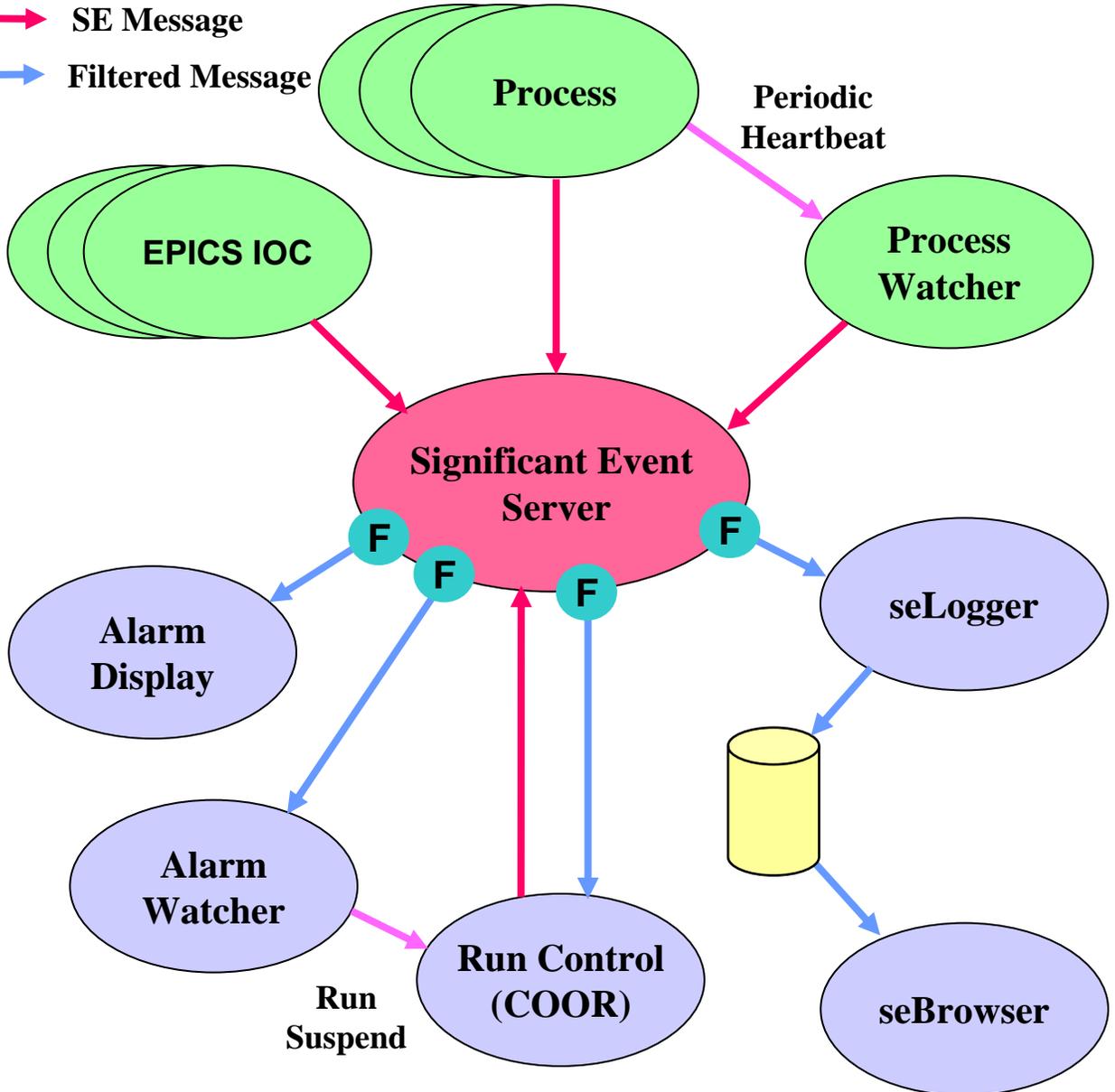


Significant Event System

F Filter

→ SE Message

→ Filtered Message



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Significant Event System

Alarm Table Display

The screenshot displays the 'Alarm Display' software interface. On the left, a sidebar lists various system components: CAL and ICD, CFT, L1CTT, MUO, SMT, LUM, Control, Online, SDAQ, Magnet, Level 3 D, Level 2, Level 1, FPD, Trigger, STT, and Alarm Wa. The main area shows a table with columns for MAJOR and MINOR alarm counts. A pop-up window titled 'STT:Minor Alarms' lists several alarm types, with 'STT_FRC_72/BM1B1E' selected. A third pop-up window provides detailed guidance for this specific alarm, including error type, description, and action steps.

	MAJOR	MINOR	STT:Minor Alarms	OOD
CAL and ICD	0	1	STT_BC_75tfc1/STADER	42
CFT	0	3	STT_FRC_71/BM1B1E	3
L1CTT	0		STT_FRC_71/BM1L1E	0
MUO	0		STT_FRC_72/BM1B1E	0
SMT	0		STT_FRC_72/BM1L1E	1
LUM	0		STT_FRC_73/BM1B1E	0
Control	0	3	STT_FRC_73/BM1L1E	14

STT:Minor Alarms

- STT_BC_75tfc1/STADER
- STT_FRC_71/BM1B1E
- STT_FRC_71/BM1L1E
- STT_FRC_72/BM1B1E**
- STT_FRC_72/BM1L1E
- STT_FRC_73/BM1B1E
- STT_FRC_73/BM1L1E

STT_FRC_72/BM1B1E

Guidance from /online/config/ses/guidance/stt/STT_FRC_BM1B1E.txt:

- * BC L1 Error
- * Error type : The BC has raised an L1 Error.
- * Description: The Buffer Controller has declared an error to the framework.
- * Action in case of:
 - * This is probably not a serious problem. Please keep track of how often this error occurs, and email the STT expert (please check the shift schedule to see who the STT expert is this week.)
 - * *However*, if the error has stopped data flow
 - * *ONLY IF THE ERROR HAS STOPPED DATA FLOW* :
- * (1). SCL Init
- * If the problem persists:
 - (2). Check for a PCI hang:
 - Symptoms indicating a PCI Hang:
 - PCI Registers show "0xffffffff" in "Check Status" button in sttResetGui.
- * Warning: Do not click on the "Hard Reset" Button if any of the PCI busses (1,2,3) are hung.



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Significant Event System

Alarm Matrix Display

The screenshot displays the 'Alarm Matrix' application window. The main window contains a table with columns for various system components (CPU, FRC, TFC0, TFC1, STC0, STC1, STC2, STC3, STC4, STC5, STC6, STC7, STC8) and rows for different alarm codes (GS 0x70 to GS 0x75). A status bar at the bottom left indicates 'Connection to server started'. A secondary window titled 'GS 0x73' is overlaid on the main window, showing a detailed view of the alarm event with the following text:

GS 0x73
STT_BC_73tfc0/STADER
STT_TFC_730/EV-TBADF

Below the text are three buttons: SHOW, GUIDANCE, and CLOSE.

	CPU	FRC	TFC0	TFC1	STC0	STC1	STC2	STC3	STC4	STC5	STC6	STC7	STC8
GS 0x70	0	0	1	1	0	0	0	0	0	0	0	0	0
GS 0x71	0	0	1	1	0	0	0	0	0	0	0	0	0
GS 0x72	0	2	1	2	0	0	0	0	0	0	0	1	0
GS 0x73	0	2	2	2	0	0	0	0	0	0	0	0	0
GS 0x74	0	2	2	2	0	0	0	0	0	0	0	0	0
GS 0x75	0	2	2	2	0	0	0	0	0	0	1	0	1



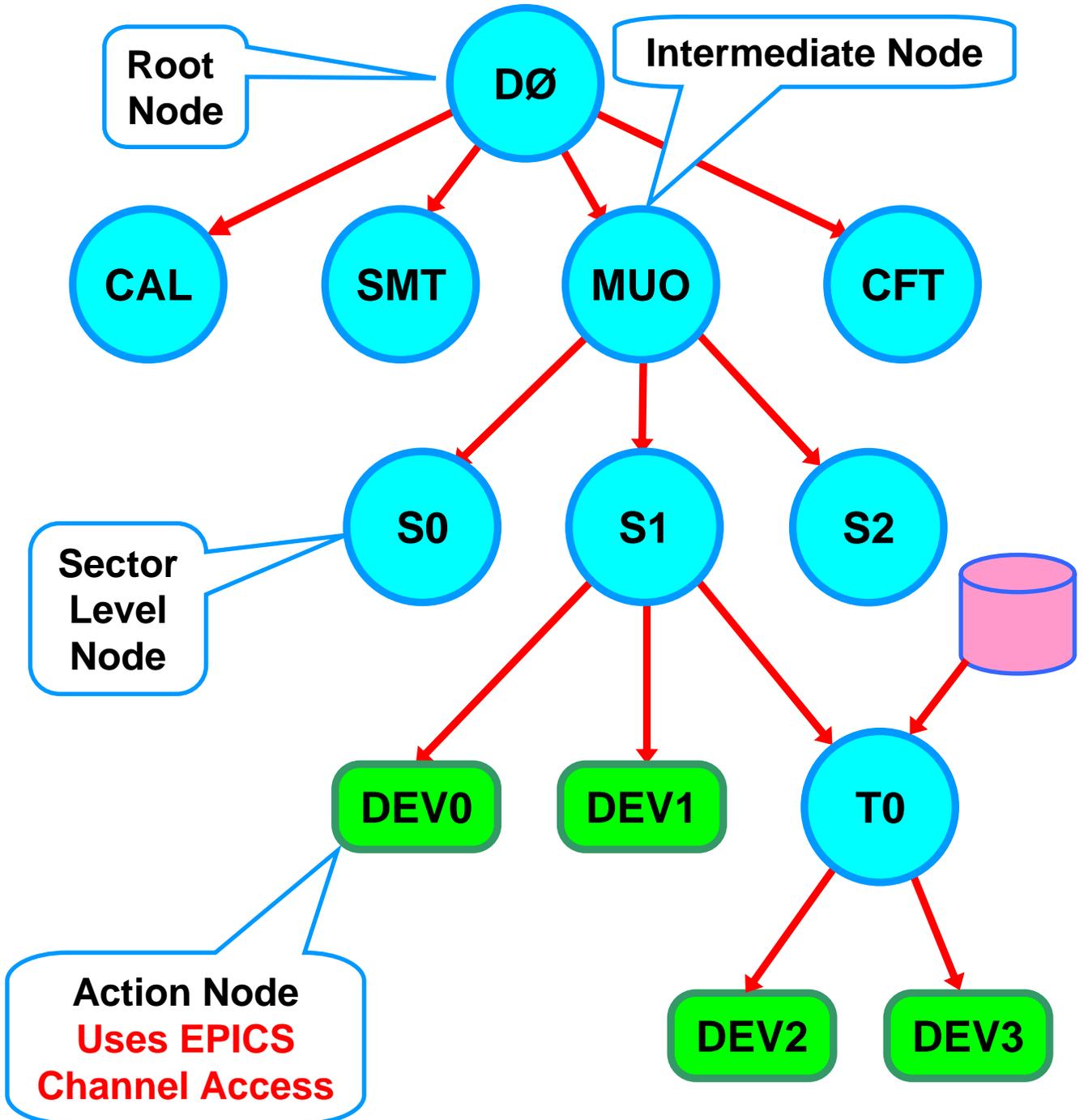
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Detector Configuration Management

- The COMICS system manages the configuration of the detector
- Configuration map is a tree
 - ◆ Directed acyclic graph – no loops
- Tree Nodes
 - ◆ Root Node
 - Origin of the configuration tree
 - ◆ Intermediate node
 - Establishes a layered hierarchy
 - Establishes an execution order
 - ◆ Depth first, left to right
 - ◆ Action node (leaf)
 - Performs all control functions (EPICS)
- Constructed on the server model with multiple clients sending commands



Detector Configuration Management



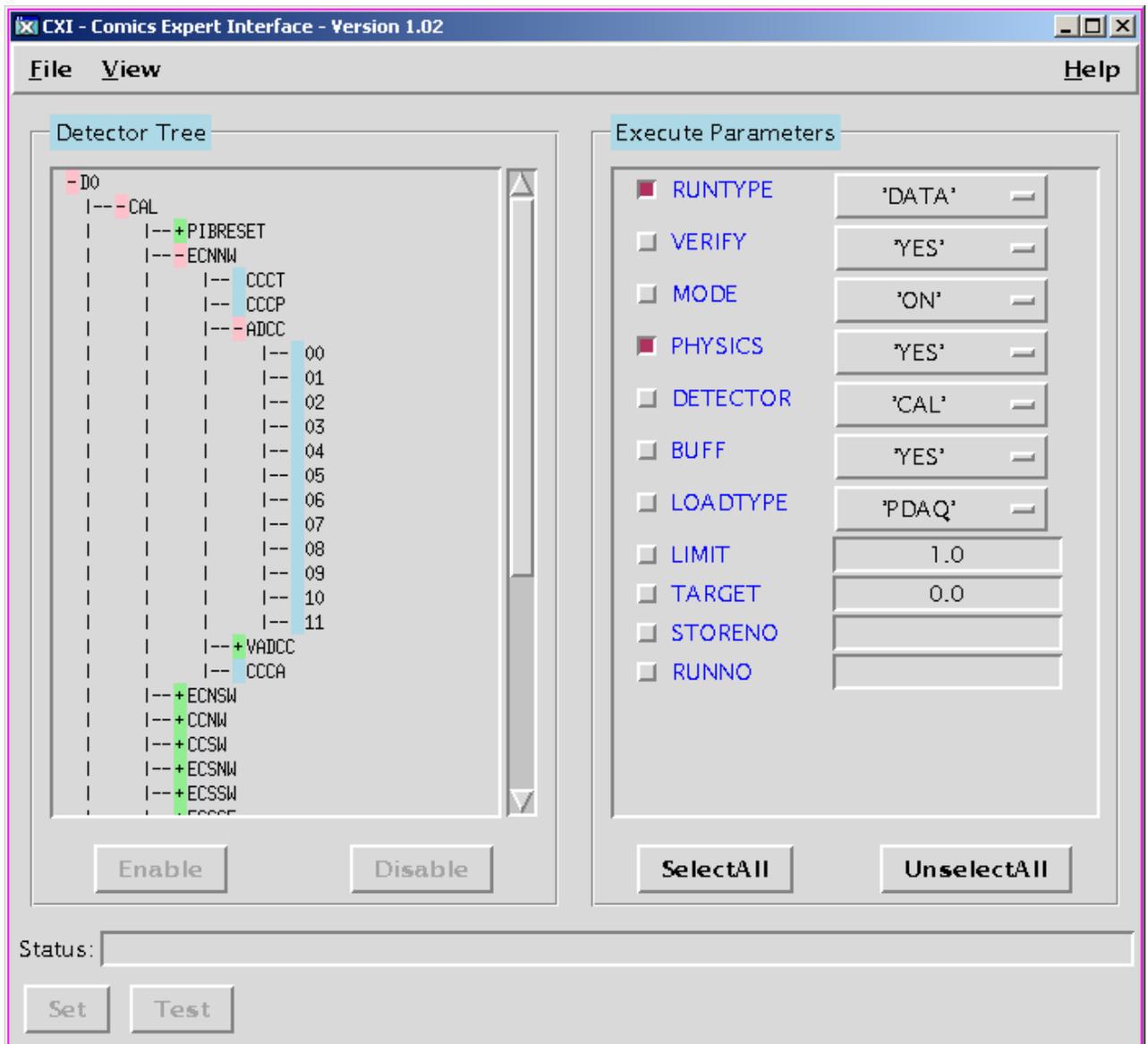
Detector Configuration Management

- **Receives sector execution requests from the Run Control Process (COOR)**
 - ◆ A geographical sector – usually a readout crate -- is the smallest detector component directly managed by COOR
- **Server may be activated independently for configuring detector components**
 - ◆ API (Python only)
 - ◆ Shell script (ComicsTalk)
 - ◆ Expert Interface (ComicsExpertGui)



Detector Configuration Management

Comics Expert GUI



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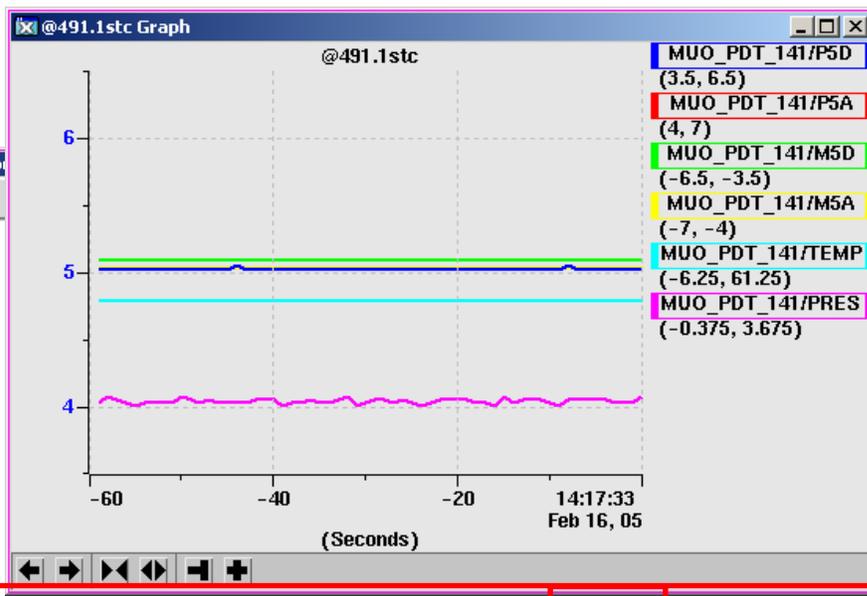
Operator Displays

- **Standard, process flow (synoptic) displays do not adapt well to the monitoring most of the of the detector components**
 - ◆ **Not related in a serial or sequential fashion like, for instance, a cryogenic plant**
- **Tabular (spread-sheet designs) are more natural**
 - ◆ **Similar properties for different devices are easily compared**
 - ◆ **Deviations are apparent**
- **DØ has developed a graphics support library consisting of a series of Python display classes for building tabular displays that collect and display information from EPICS process variables**



Operator Displays

Resource Display



Status:

Reconnect

Clear

Reset



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Operator Displays

HV Channel Display

The screenshot shows the HV Channel Monitor Display software interface. The main window displays a table of HV channels with columns for V_Max, V_Set, V_Read, I_Read, and State. The channels are listed from 00N to 46N. The interface includes a menu bar (File, View, Set, Plot, Start, Help) and a status bar at the bottom with buttons for Reconnect, Offline, Online, Off, On, Ramp, Pause, Resume, Lock, Unlock, and Reset. A callout box labeled 'Limits' shows the following values:

Limits	
HIHI	-1161.0
HIGH	-1670.0
LOW	-1690.0
LOLO	-1695.0

Callouts in the image highlight specific features:

- Paging Tabs**: Points to the tabs for CAL North, CAL South, and CAL Argon Mon.
- Standby Entry**: Points to the 'Standby' option in the 'Set' menu.
- Right-Click For Limits**: Points to the 'Limits' callout box.
- State Change Buttons**: Points to the 'Lock', 'Unlock', 'Pause', and 'Resume' buttons at the bottom.



Operator Displays

Global HV Display

The screenshot shows the 'HV Global Monitor Display - V2.2' window. It features a menu bar with 'File', 'View', 'Start', and 'Help'. The main area is titled 'HV Utility Display' and is divided into two columns: 'M16' and 'Rack - M118'. Each column contains five rows of data, labeled B, C, D, and E. Each row has a header and a grid of 6 columns (0-5). The data is color-coded: red for 'Channel Alarm', green for 'Channel State', and blue for 'State Change Buttons'. A 'Status:' field is located at the bottom left, and a row of control buttons (Reconnect, On, Full, Lock, Unlock, Standby, Off, Reset) is at the bottom right.

Module

Crate

Channel Alarm

Channel State

Left-Click for HV Channel Display

State Change Buttons

Module	Crate	Channel Alarm	Channel State	State Change Buttons
B	ICD North-East	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
C	ICD South-East	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
D	ICD South-West	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
E	Unassigned	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
B	CAL North	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
C	CAL South	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
D	CAL Central	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
E	CAL Argon Mon	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5

Status: _____

Reconnect On Full Lock Unlock Standby Off Reset

