Traditional Control Room

Modern Control Room

EPICS for LIGO-India Control and Data System Prototyping

by

Hitesh Gulati & Arnab Dasgupta

CDS Section, LIGO Division IPR

Bhat Gandhinagar (Gujarat)

Courtesy: LIGO USA, Document Control Center

EPICS for LIGO-India Control and Data System Prototyping

Hitesh Kumar Gulati[1], Arnab Dasgupta[1], Yohan Khrishti[1], R. Sugandhi[1, 2], Amit Kumar Srivastava[1, 2]

Email: hkg@ipr.res.in

[1]Institute for Plasma Research (IPR), Bhat, Gandhinagar, Gujarat – 382428, India
[2] Homi Bhabha National Institute, Anushaktinagar, Mumbai-400094, India

EPICS (Experimental Physics and Industrial Control System) is an open source software platform which is extensively used in various distributed data acquisition and control systems of research and development projects world-wide. However various large projects like ITER, LIGO, SNS and many more have developed software wrappers on top of EPICS backbone depending on their application requirement. The two Laser Interferometer Gravitational Observatories (LIGO) in Hanford & Livingston, USA are being run over EPICS based open source software tool. The upcoming LIGO-India observatory in India will be built and run using similar EPICS based software tools. Presently a lot of LIGO India Control and Data System (CDS) prototyping activities are ongoing in IPR using these tools.

This short talk will give brief overview of these EPICS based software, software architecture, their features and applications areas for LIGO projects.

Keywords: LIGO, LIGO-India, CDS, EPICS

About LIGO-India Project

Construction of an Advanced Interferometric gravitational wave detector in India named as "LIGO-India"

under an **international collaboration** with

Laser Interferometer Gravitational–wave Observatory (LIGO) Laboratory, USA

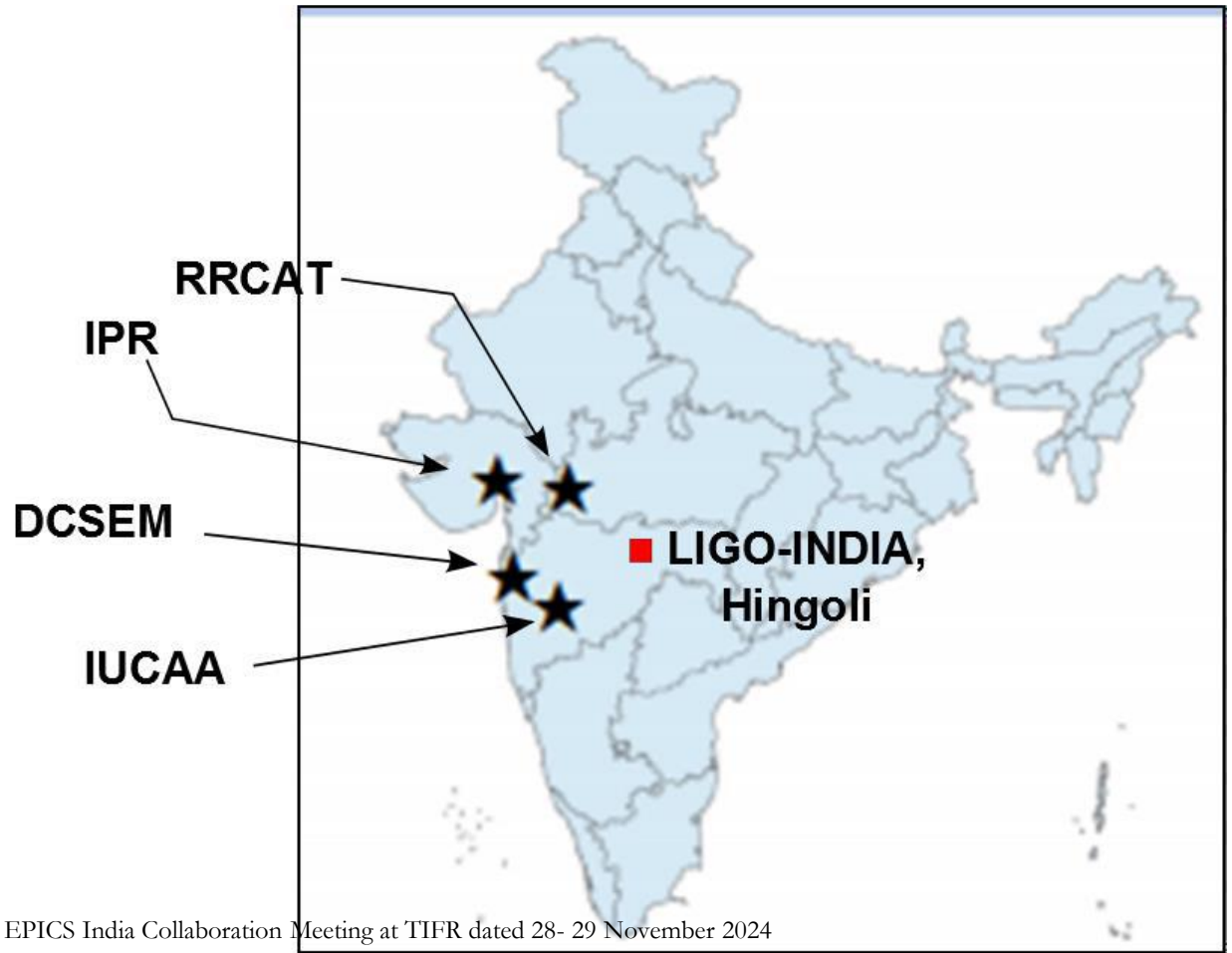
The four Indian lead institutes –

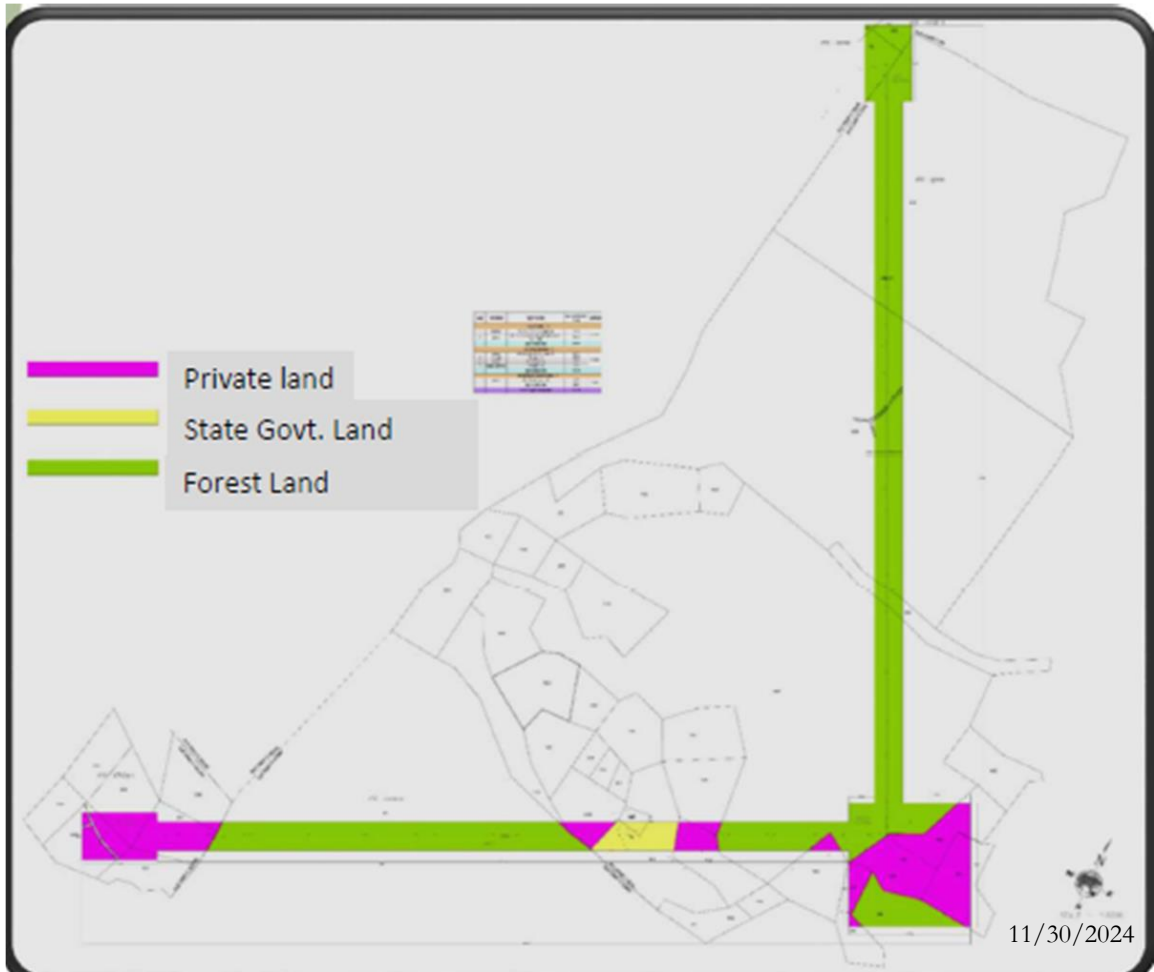
- **IUCAA (UGC), Pune**
- **DCSEM (DAE), Mumbai**
- **IPR (DAE), Gandhinagar Gujarat**
- **RRCAT (DAE), Indore M.P.**

are working together in realizing the LIGO-India of the international gravitational wave detector network in India.

The LIGO INDIA site and current status

- 22 sites were identified and detailed survey conducted
- The site at Aundha, near Hingoli, Maharashtra state is identified as most suitable for LIGO-India and finally acquired the land.
- The tendering process for construction activities is in progress





Wrapper on top of EPICS

…ITER

…**LIGO**

. . . .

. . . .

LIGO Sub-systems

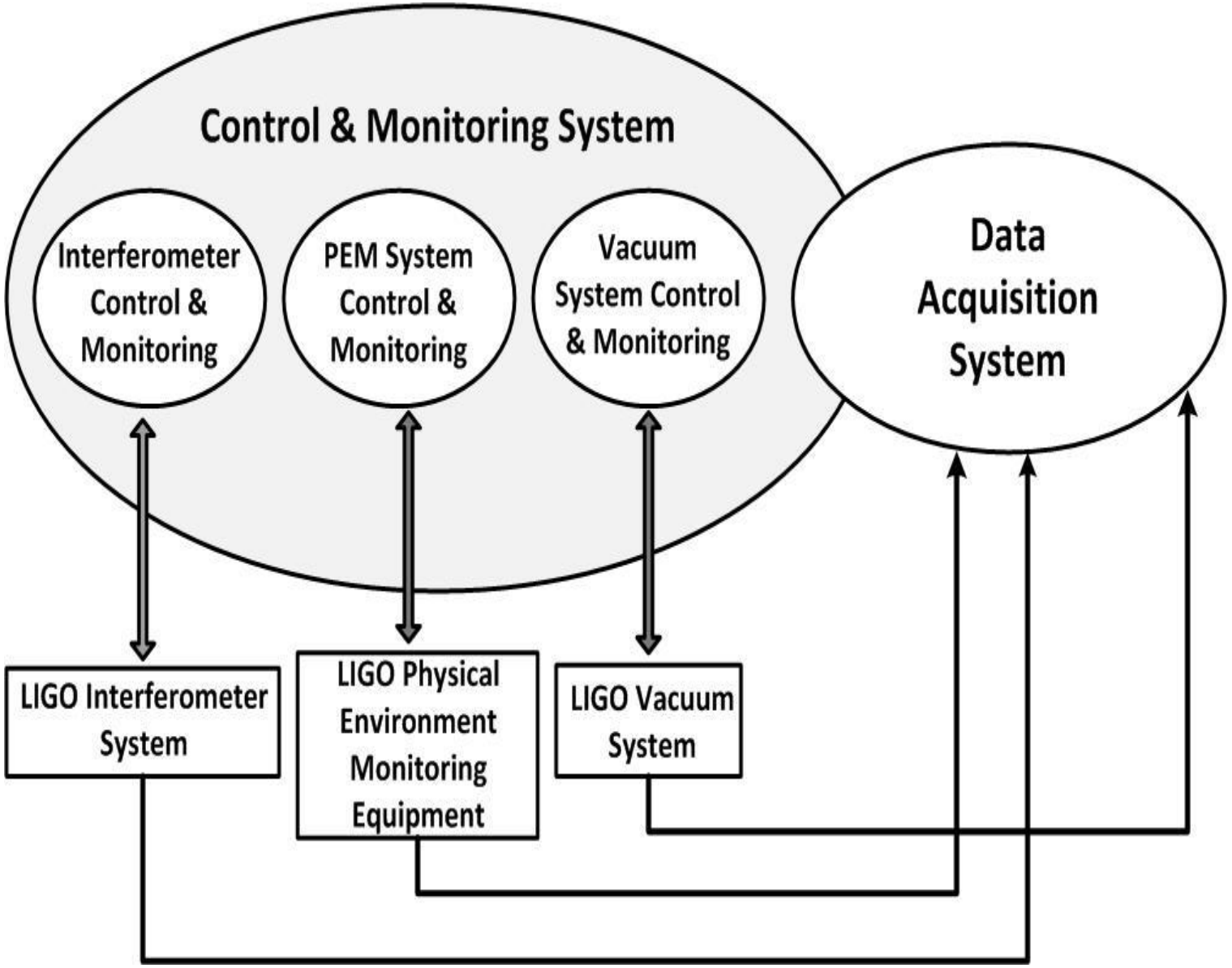
Subsystem	Description
AOS	Auxiliary Optics
DAQ	Data Acquisition
ETR	Electronics Test Rack
FAC	Facilities and Infrastructure
ISC	IFO Sensing and Control
LDR	Laser Diode Room
OAF	Online Adaptive Filtering
PEM	Physical Environment Monitoring
PSL	Pre-stabilized Laser
SEI	Seismic Isolation
SUS	Suspensions
TCS	Thermal Compensation System
VAC	Vacuum
VDC	Voltage - DC

Interferometer Control & Data System

- ~4000 fast & ~150,000 slow channels
- >350 high-performance servo-control loops
- 60 computers,15MB/s data rate
- Physics Environmental Monitor (70 fast & 600 slow channels)

Controllers

LIGO Control and Data Systems (CDS)



Special Requirements for CDS…..

- Round the clock **(24X7X365)** Continuous operation
- Large number of Data acquisition and control channels
- **Distributed supervisory** control
- Networking and Remote access
- System performance and reliability for continuous operation
- Ultra High Vacuum Interface
- **Real-time** application development
- Component testing and **integrated hardware testing**
- Software development and integration
- **Data formatting** and mass storage

Experimental Physics and Industrial Control System

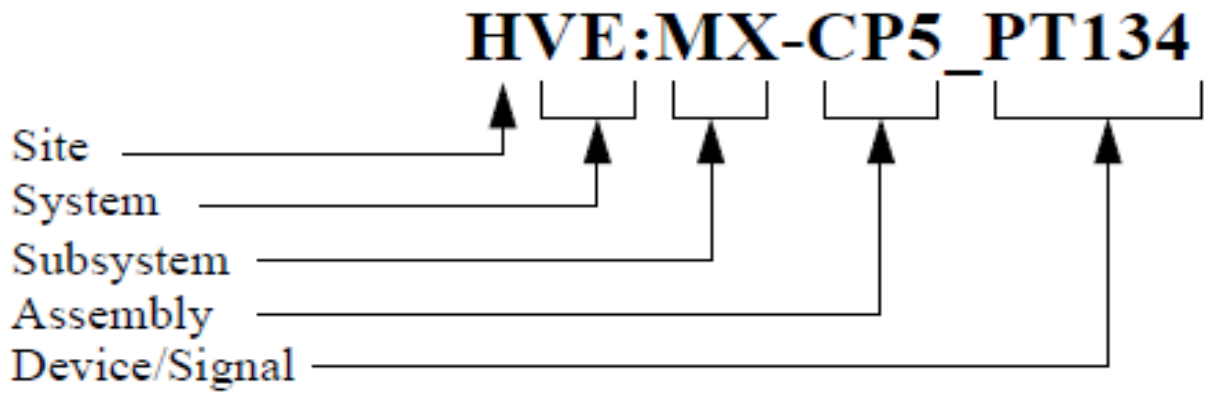
EPICS is the CDS backbone software platform for CDS. It provides:

- Interfaces to instrumentation from data acquisition, **supervisory control**, and steady-state control through a table entry, **distributed database**.
- **Operator interfaces** to all control system parameters through **interactive displays**.
- **Data logging** through a table entry archiving file.
- **Alarm management** through a table entry alarm file.
- Sequential control through a **state definition** language with convenient database interface
- **Channel access routines** for interfacing the control system data to data analysis, **third party software packages**, **adaptive control algorithms** etc.

4.4.3. Naming Conventions

4.4.3.1 EPICS Records

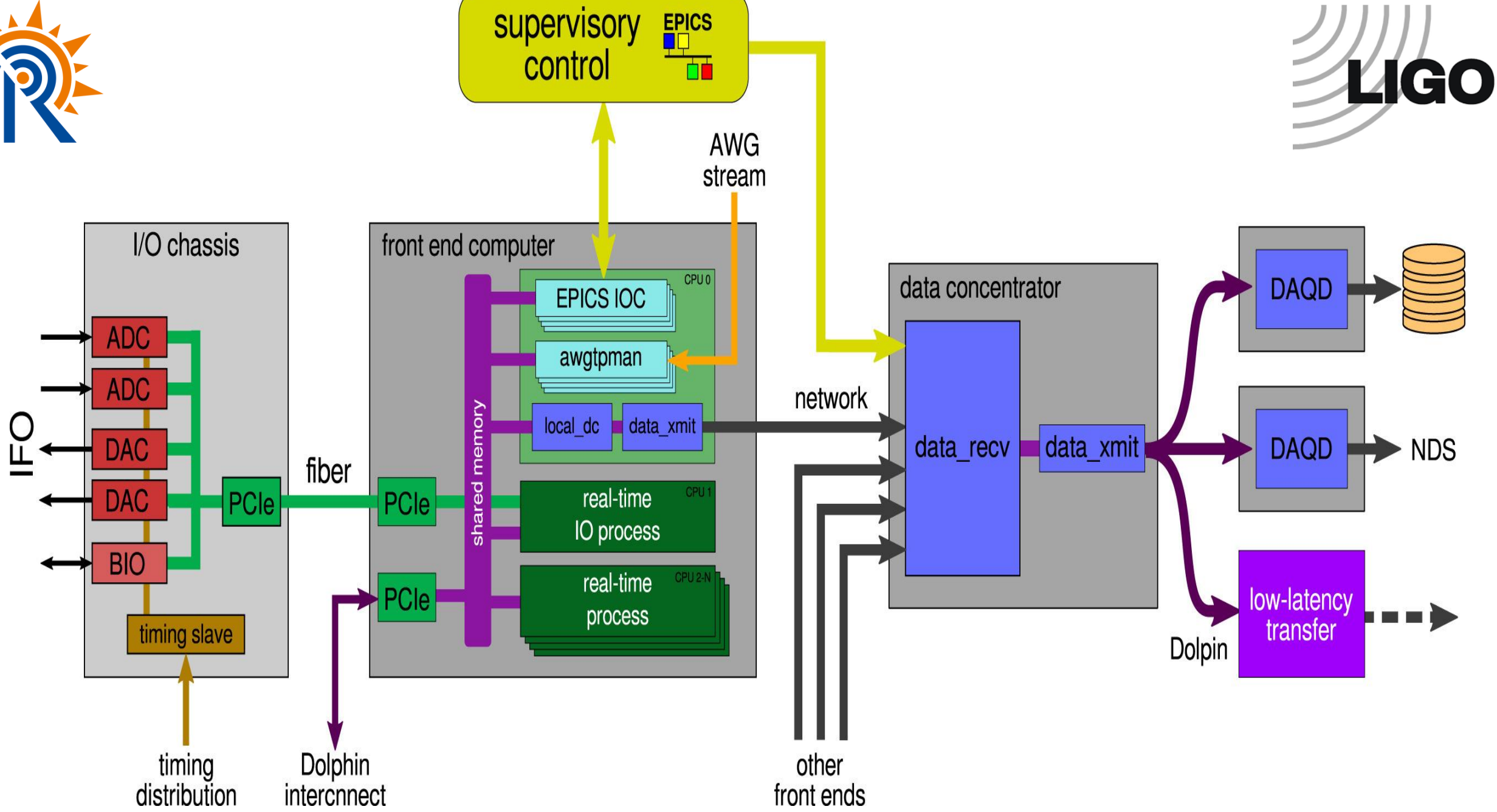
All EPICS database records used within LIGO systems are to have a unique name based on the following standard guidelines.



Examples are:

H1:PSL-FSS_PC112 (Hanford IFO 1 : PSL subsystem - Freq. Stab. Servo _ Signal Name

HVE:MX-CP5_PT134 (Hanford Vacuum Equip. : X arm mid station subsystem - Cryopump 5 _ pressure transducer 134



LIGO Control and Data Systems (CDS) Architecture

LIGO Real-time Code Generator (RCG)

Automated tool the LIGO CDS group uses **to develop real-time controls application software**:

How it works: The RCG uses **MATLAB Simulink** as a graphical data entry tool to define the desired control algorithms. Users can develop applications by:

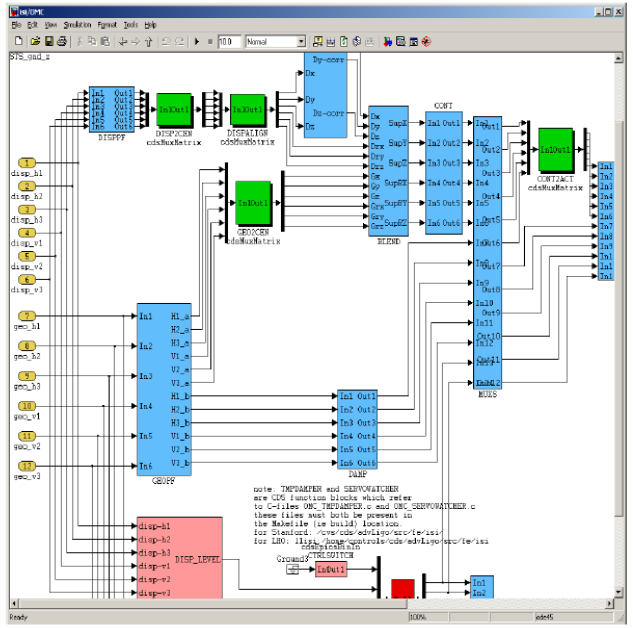
- Graphically placing and connecting blocks in the **MATLAB Simulink editor**
- Saving the user application to the user **.mdl file** in a predefined CDS software directory

Where to find the RCG Users Guide: The RCG Users Guide V4 is available at LIGO DCC.

RCG is Part of three primary components of the advligorts software

- Standard Linux kernel,
- Real-time code generator (RCG),
- Data acquisition daemons (DAQD)

- Subsystem Lead for each major controls subsystem
  - » Controls model and custom C code review
  - » Offline testing and acceptance
- Similar process for other control room applications
  - » At least interface definitions and test suites, as necessary to perform integrated testing with other controls applications



CDS software packages includes

1) **Real-time Code Generator (RCG): This is the standard package used by LIGO subsystem application developers to produce standard CDS real-time control and data acquisition software for use in LIGO.**
2) **Diagnostic Test Tools (DTT):** LIGO standard diagnostic tools designed to aid in system diagnosis and commission activities.
3) **Foton**: Tool for defining control system IIR filter coefficients for use in LIGO control loops.
4) **Dataviewer**: Control room tool used for retrieving and viewing time series data from the LIGO DAQ system.
5) **DAQD**: The "data concentrator" collects data from the distributed front end computers and passes the concatenated data to a DAQD process that writes it to disk,
6) **Network Data Server (NDS):** used to access all data acquired by the system in real-time, or to access archival data that has been stored to disk.

How RCG works

Code Development: done by graphically placing and connecting blocks in the MATLAB Simulink editor supported by the RCG are included in the **CDS_PARTS.mdl** file

Code Generator:

CDS Perl script (feCodeGen.pl) parses the user.mdl file and creates:

1) **Real-time C source code**, in the sequence specified by the links between parts.
2) **Makefile** to compile the real-time C code.
3) A text file for use by a **second Perl script to generate the EPICS code**.
4) An EPICS code Makefile, A header file, common to both the rt code and EPICS interface code, for the communication of data between the two during run-time.
5) Reads/appends IPC signals to an interferometer common text file.

Perl script (fmseq.pl) is invoked, which:

1) **Produces an EPICS DB file, EPICS(SNL) code** module provides communication between CDS workstations on CDS Ethernet and the real-time FE code.

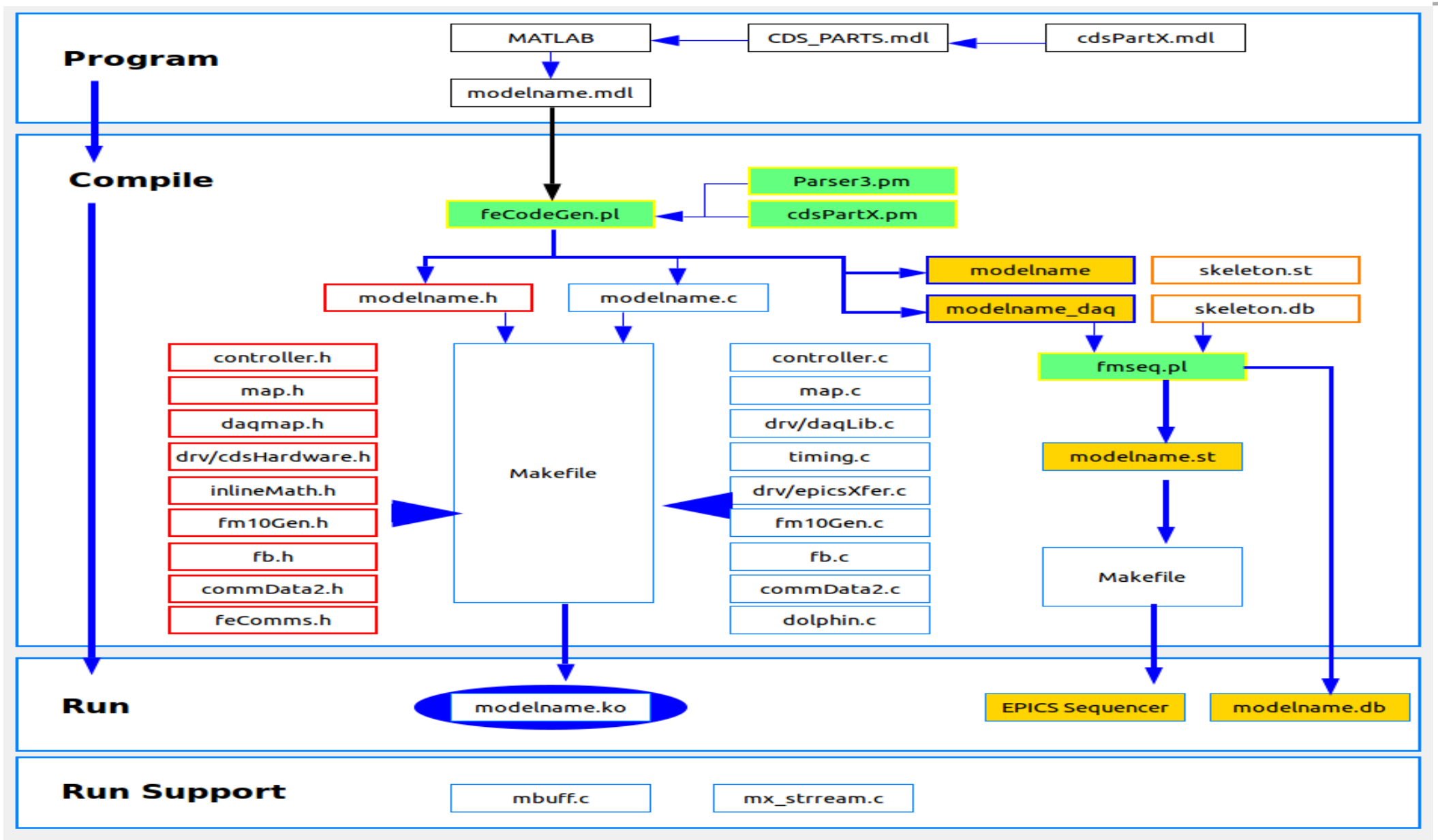
3) **Produces MEDM screens, BURT back-up** file for use in saving EPICS settings, header for the CDS standard filter module coefficient file, list of all test points use by the GDS tools.

7) **A basic DAQ (Data Acquisition) file, list of all EPICS channels** for use by the EDCU (EPICS Data Collection Unit).

Running the RCG Application (Automatic Scripts)

During the make install process, scripts are generated in the */opt/rtcds/<site>/<ifo>/scripts* area for conveniently starting and stopping the user application.

RCG Software Overview



Thanks