

EtherCAT for Advanced LIGO

January 4, 2012

Advanced LIGO

Implementation

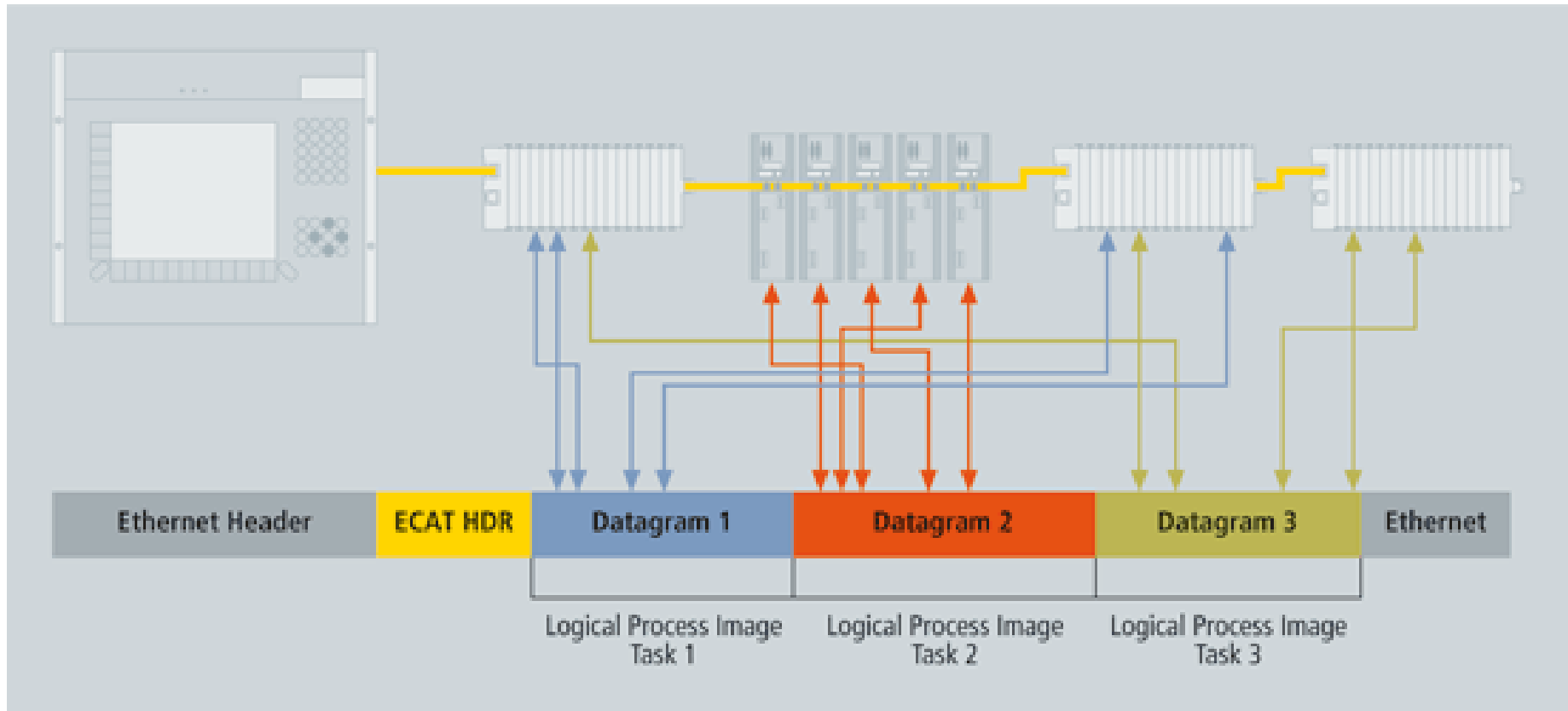
Motivation

- ❑ Need to replace VME based EPICS system
- ❑ 100's of slow controls channels (tags) in ISC alone
- ❑ Vacuum system is still running legacy hardware
- ❑ Preferably a commercial solution
 - High reliability
 - Long term availability
 - Operator friendly (documentation, external support, etc.)
- ❑ Separate the computer from analog
 - Need a field bus, lot to choose from:
Proprietary, Modbus, CANopen, Profibus/ProfiNet, EtherCAT, Sercos III, Ethernet IP, Devicenet, ...

Why EtherCAT?

- ❑ PSL is using it
- ❑ Experience in H1 squeezing experiment
- ❑ Modern design (Ethernet done right)
 - 100base Ethernet (no expensive backbone)
 - Low latency: Datagrams processed on the fly
 - Fast: 1-10 ms readout standard; 100us possible
 - Software: IEC 61131-3 with EPICS interface
- ❑ Cost effective for large number of slow channels
 - Stackable, DIN-rail mounted units with 1-4 channels typical
 - 16 bit analog channel: ~\$50-\$100
 - Binary channel: ~\$10-\$20

What is EtherCAT?



What is EtherCAT?

- ❑ Protocol: (Raw) Ethernet frames
 - Memory mapped access (4GB)
 - UDP/IP encapsulation possible
- ❑ Performance
 - Real-time kernel on PC
 - 1000 distributed I/Os in only 30 μ s
- ❑ Topology
 - Line, star or tree; hot connect of branches possible
 - up to 65,535 devices
 - E-bus (LVDS) for DIN mounted modules
 - Stand-alone modules (IP67)
- ❑ Distributed Clock
- ❑ Special Safety Terminal
- ❑ Useful [information video](#)

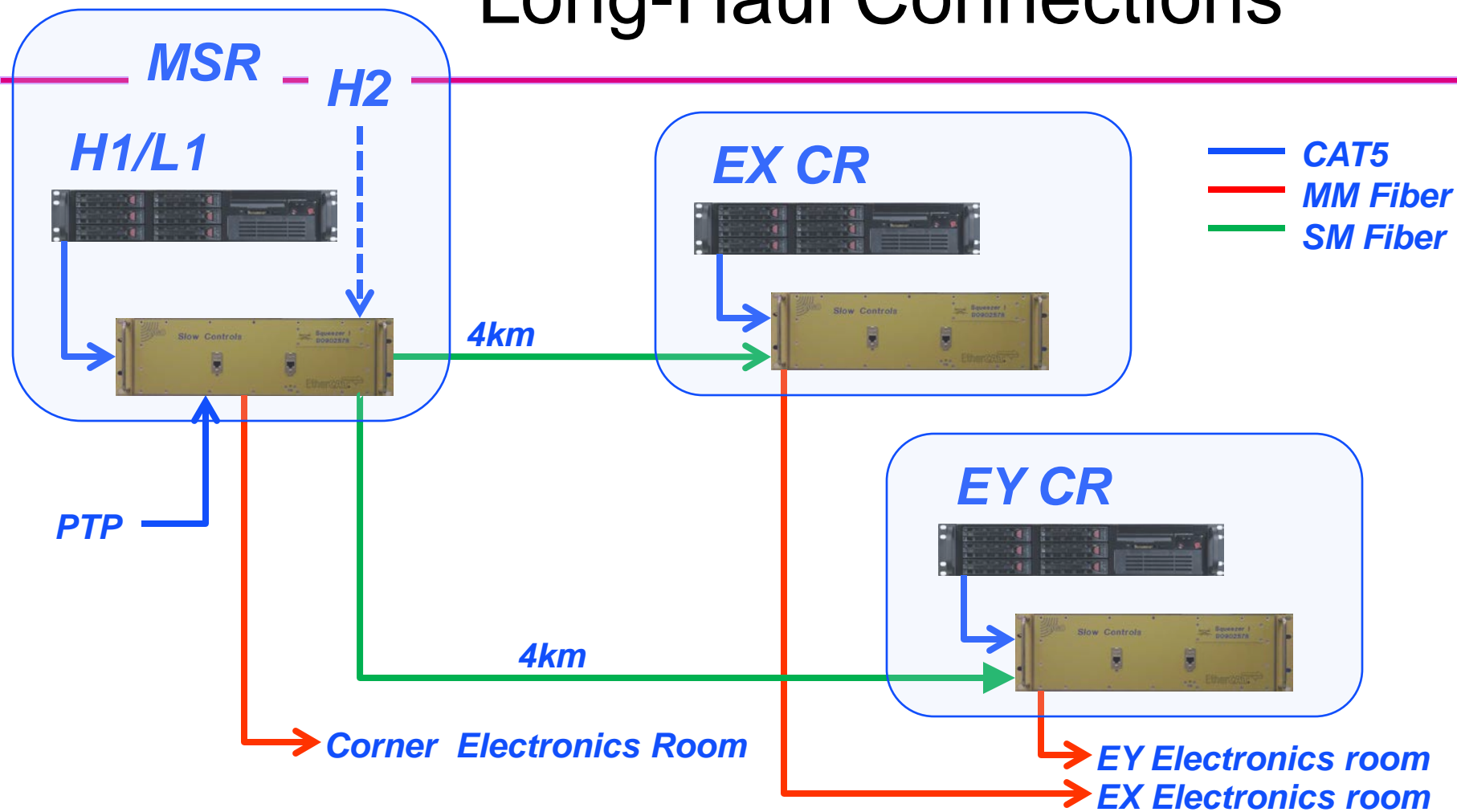
Where does it fit in?

- **Goal: Run slow controls hardware through EtherCAT**
 - Mode cleaner board, common mode board, RF distribution system, HWS, picomotors, shutters, timing system readback, etc.
 - ❖ Slow controls channels are connected to the fast system where it makes sense.
 - No VME based systems in the long run
 - No stand-alone EPICS RS232/Ethernet/Modbus controls computer
 - ❖ Need to port legacy systems: dust monitor, weather station, PC/104(?), etc.
 - ❖ Modbus: Use gateway to EtherCAT, see [wiki](#).
 - Boot into the correct state → no burt restore!
- **EPICS:**
 - Soft IOC and transport layer
 - Screens (medm for now)

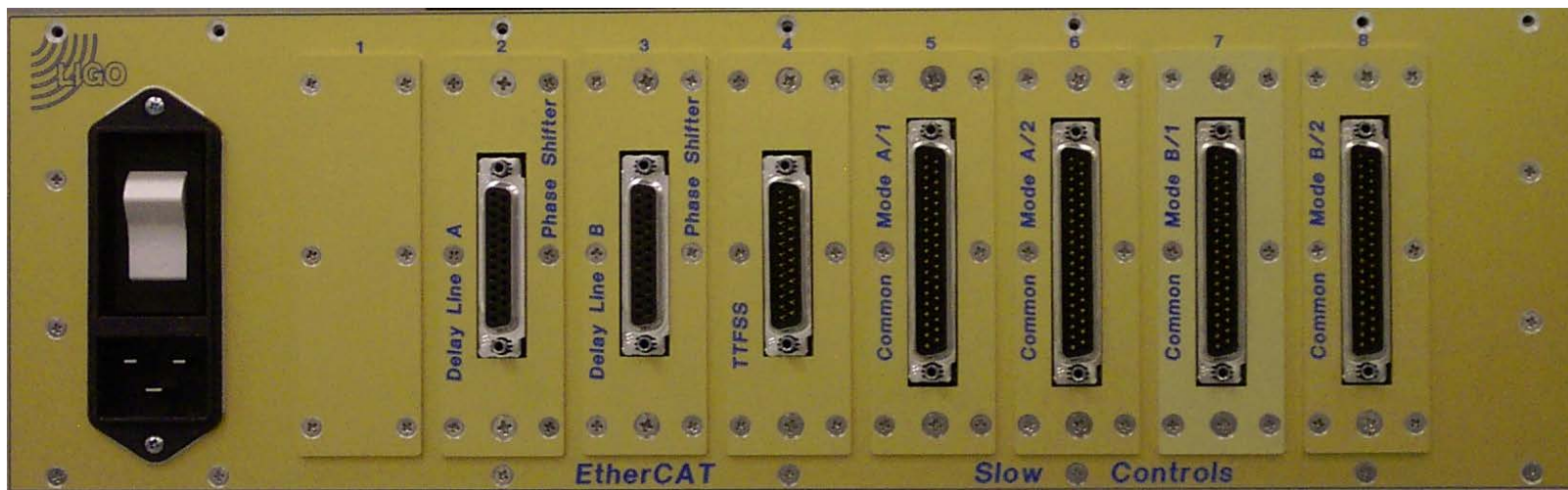
Implementation in Advanced LIGO

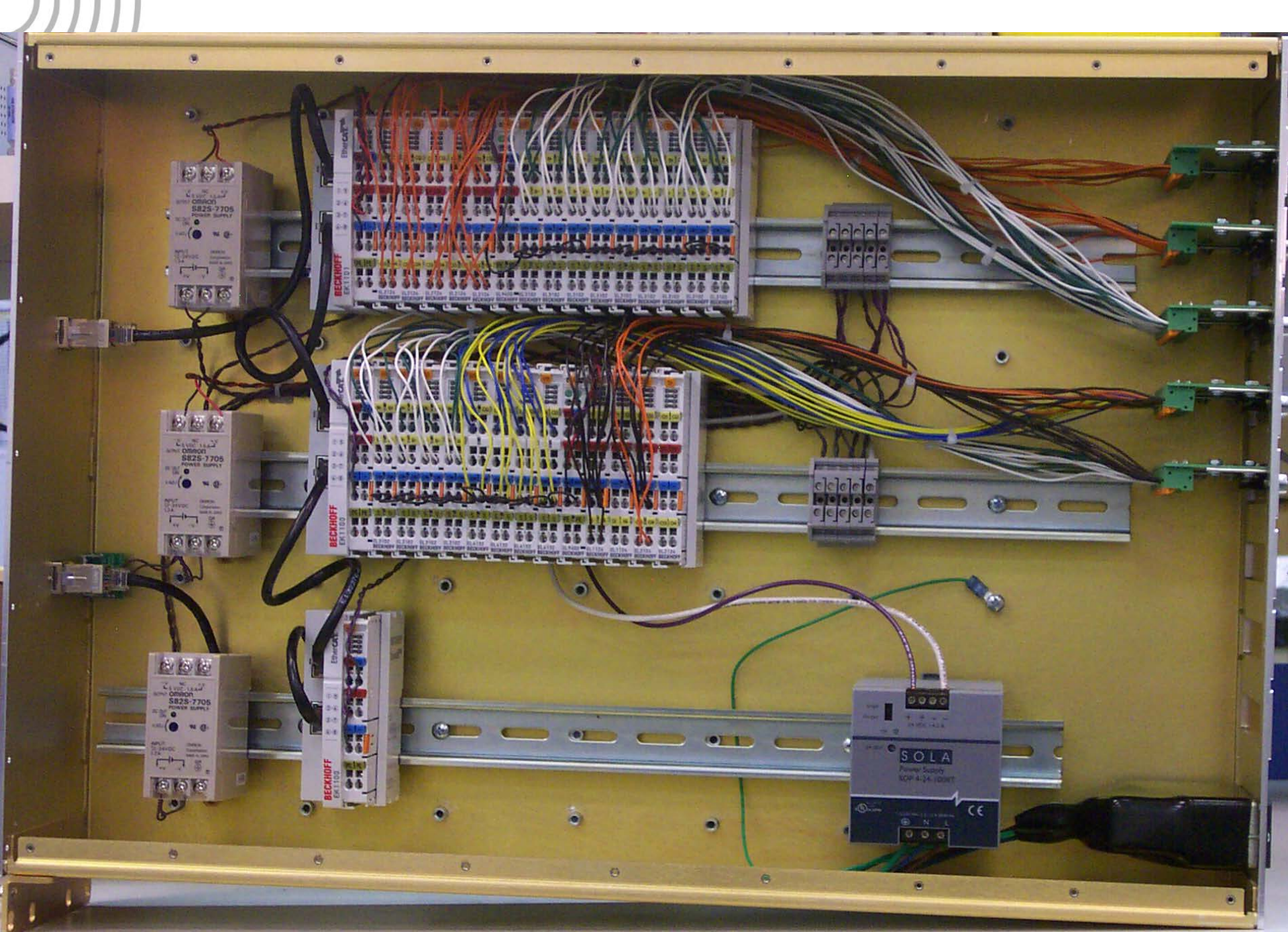
- ❑ **Controller: TwinCAT**
 - Running on rack mounted PCs; 1 controller per building
 - Full featured Programmable Logic Controller (PLC)
 - OPC and EPICS OPC server for controls interface
- ❑ **IO Chassis**
 - 3U, 24" deep; with 3 DIN rails
 - Equipped with EtherCAT Terminals (mostly from Beckhoff)
 - ❖ Stackable DIN mounted modules
 - Field wiring to rear mounted interface connectors
 - ❖ Mostly D-sub, direct, or
 - ❖ DB37 to external signal concentrators
- ❑ **Networking**
 - Fiber between corner and ends (synchronization, data exchange)
 - Separate controls network for vertex and ends, see [D1102294-v1](#).

Long-Haul Connections

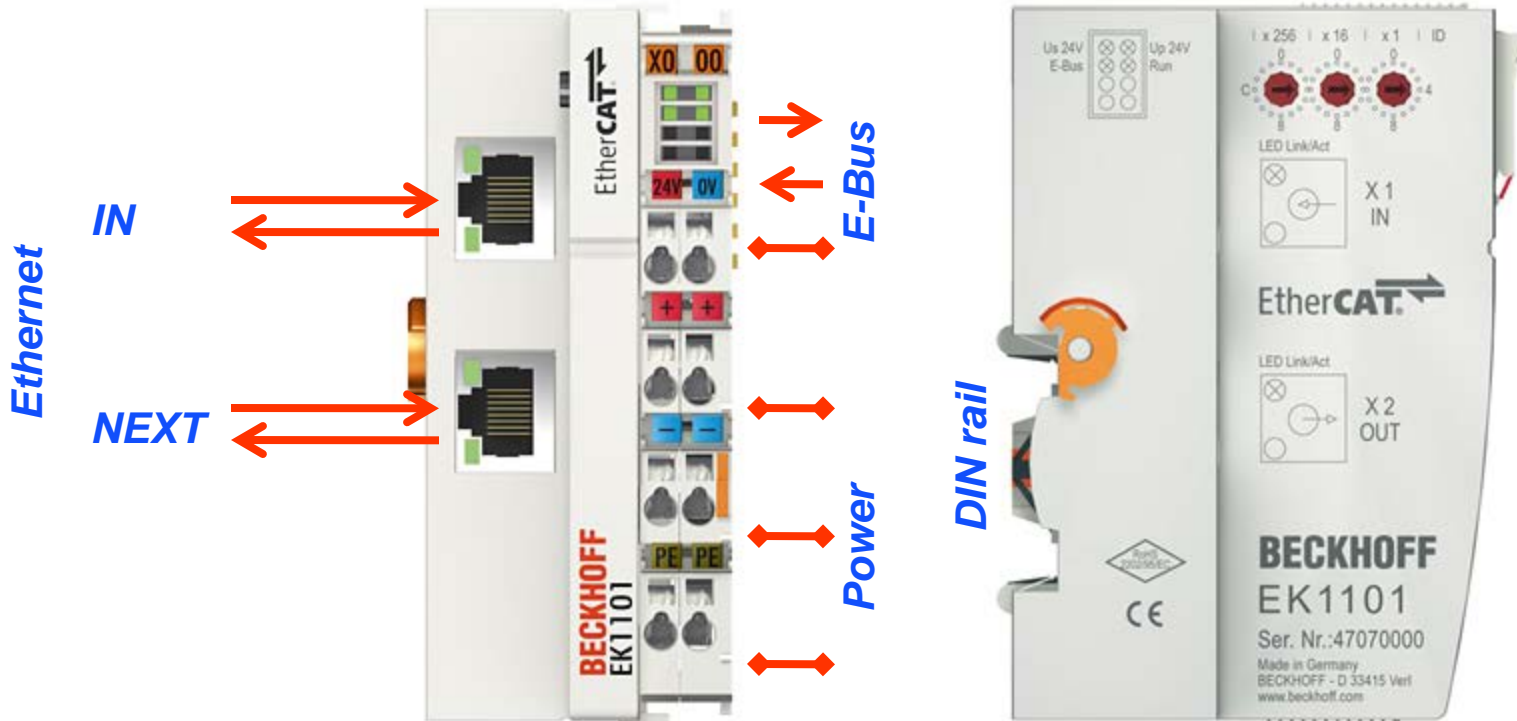


3U Chassis Design





EtherCAT Coupler

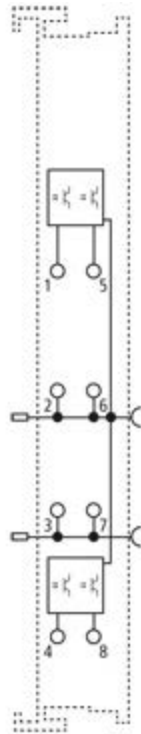


- E-Bus:**
- Ethernet OUT (LVDS)
 - Ethernet IN (LVDS)
 - 5V Power

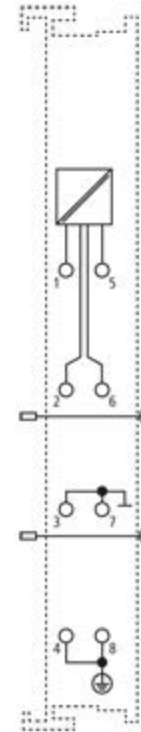
- Power:**
- Positive (24V/5V)
 - Ground
 - Shield

Coupler requires +24V to power E-Bus
Separate power for terminals

EtherCAT Terminal

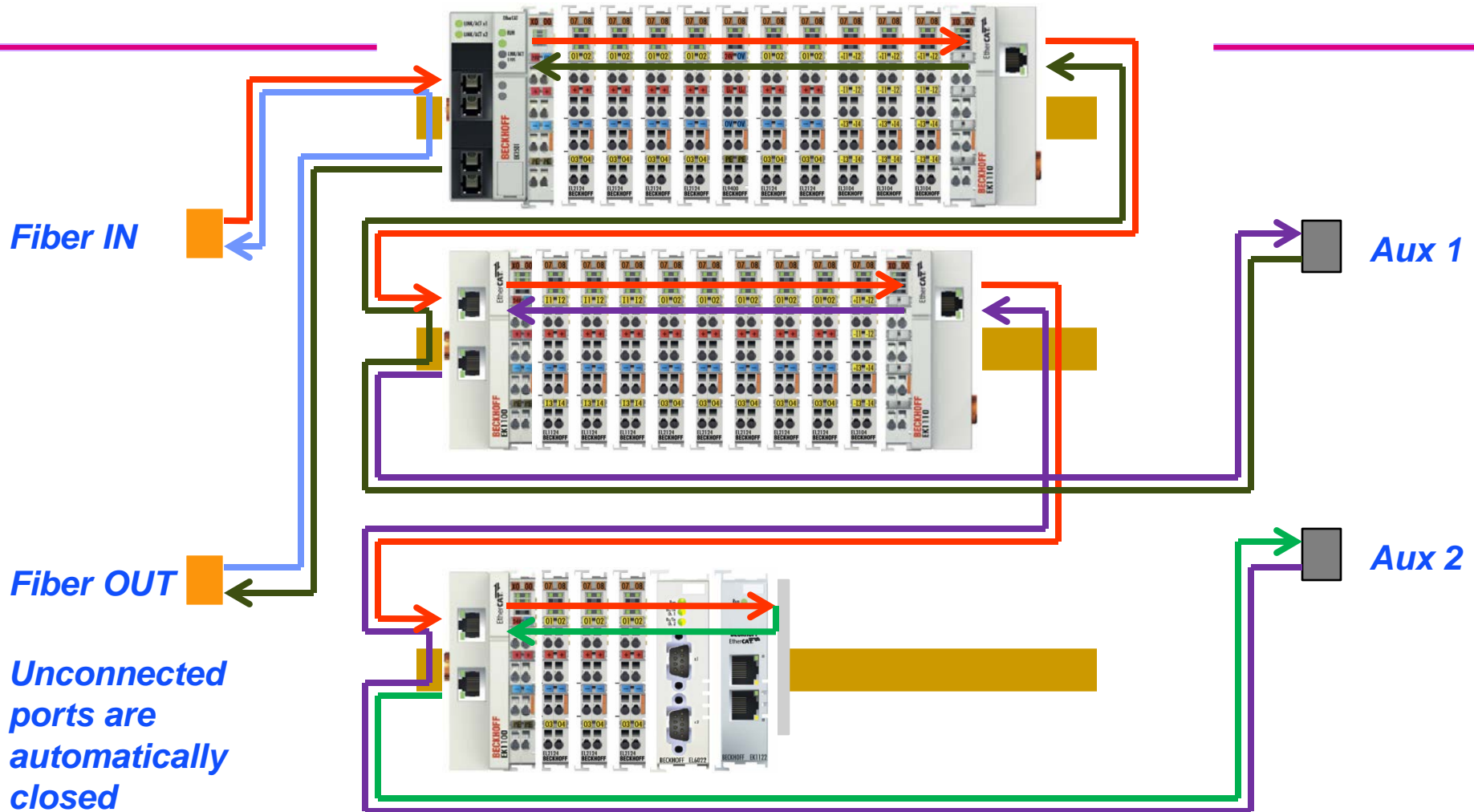


4-channel binary TTL output

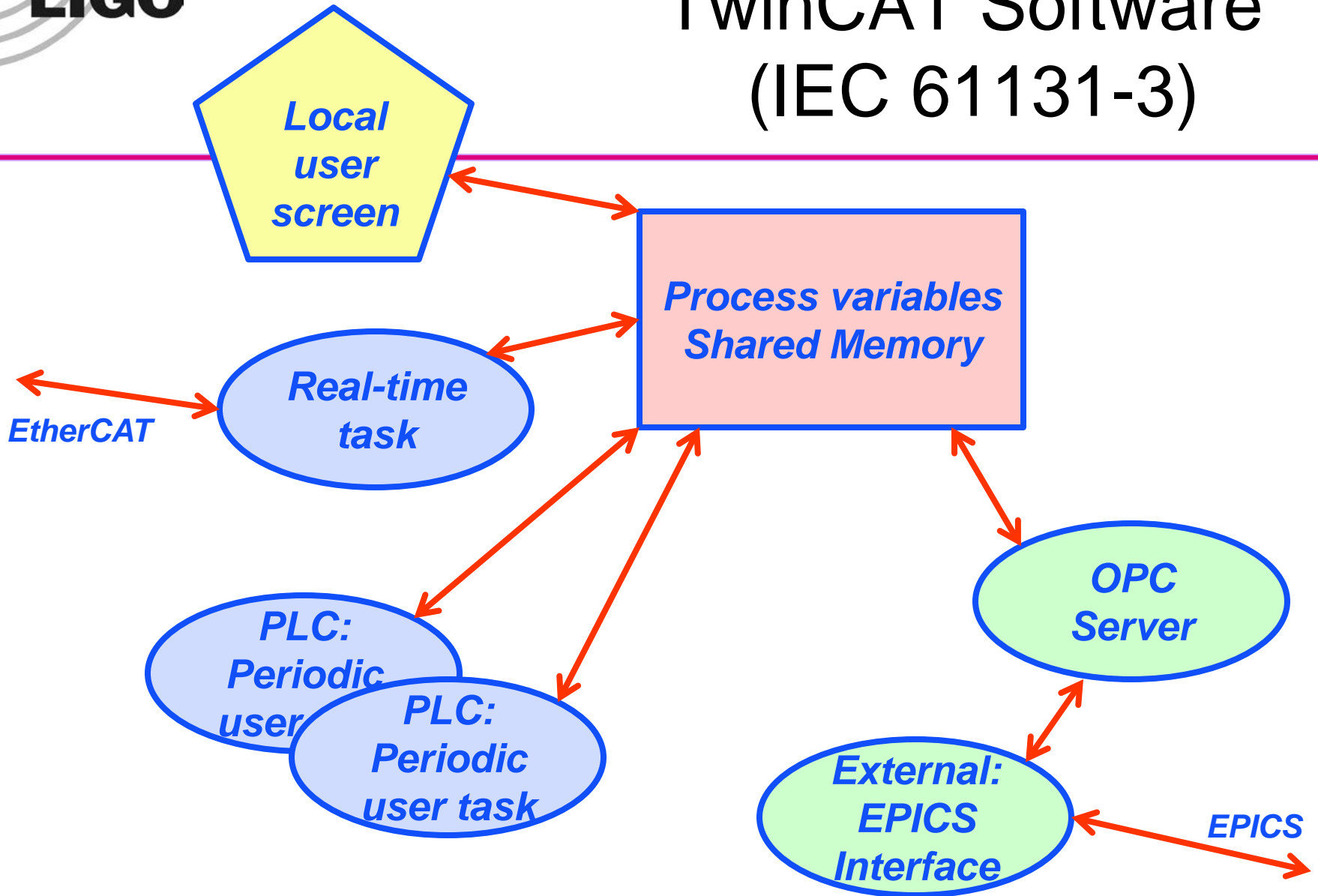


2-channel 16-bit analog input

Ethernet Configuration



TwinCAT Software (IEC 61131-3)



OPC and the EPICS OPC Server

- ❑ OPC: Industrial standard for exchanging controls data and events as well as their history
 - OPC classic: efficient transport requires Windows DCOM
 - OPC UA: modern, platform independent, strong security, information models (i.e., types and hierarchical organization)
 - Has been widely adapted by the automation industry
 - A wide selection of software and hardware solutions are available that are supporting it
- ❑ EPICS OPC Server
 - OPC device support maintained at Bessy

Can we run OPC and EPICS in parallel to leverage existing software and also profit from commercial packages?

Outlook

- ❑ Deploy the first system in January/February 2012
- ❑ Easy to expand; easy to add a few more channels
- ❑ Logic controllers and slow servos can be directly implemented in the TwinCAT PLC
- ❑ The next TwinCAT will support 64bit OS, multi-core and C++/Matlab
- ❑ Opens a way forward to adopt commercial solutions

Further Information

□ EtherCAT

- [EtherCAT Technology Group](#)
- [Wikipedia](#)

□ Hardware and Software

- [Beckhoff website](#)

□ IEC 61131-3:

- [R.W. Lewis, “Programming Industrial Control Systems Using IEC 1131-3”](#)

□ OPC

- [OPC Foundation](#)
- [EPICS OPC Server](#)