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EtherCAT (Beckhoff) for advanced LIGO

January 25, 2011

CDS Meeting, LHO

ISC Implementation

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Why?

- Need to replace VME based EPICS system
- Used in the aLIGO PSL
  - Don’t want to maintain more systems than necessary
  - Used in the squeezer for slow controls
- Good enough
  - 100base Ethernet (no expensive backbone)
  - Low latency: Datagrams processed on the fly
  - Fast: 1-10 ms readout standard; 100us possible
  - Software: Windows based with EPICS interface
  - Modern
- 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

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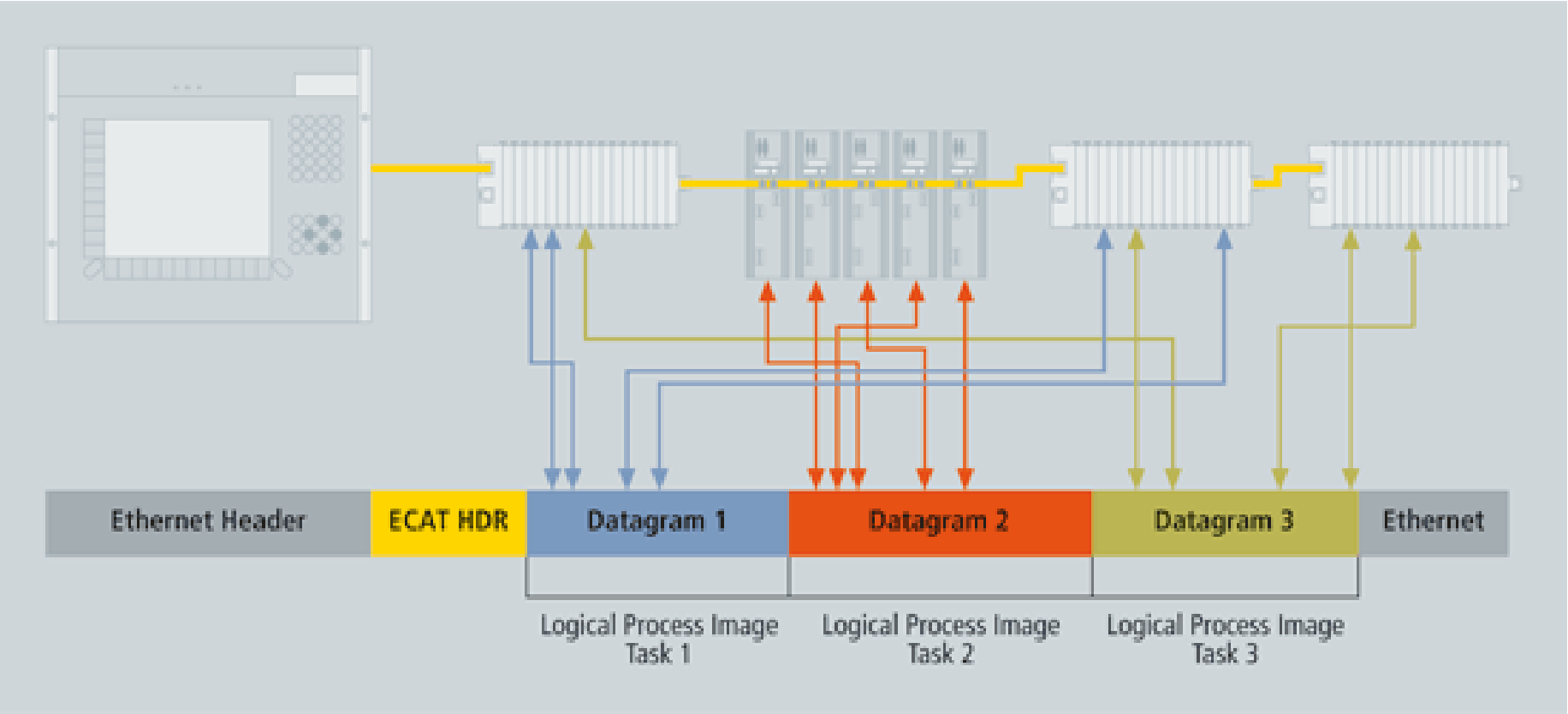
What is EtherCAT?



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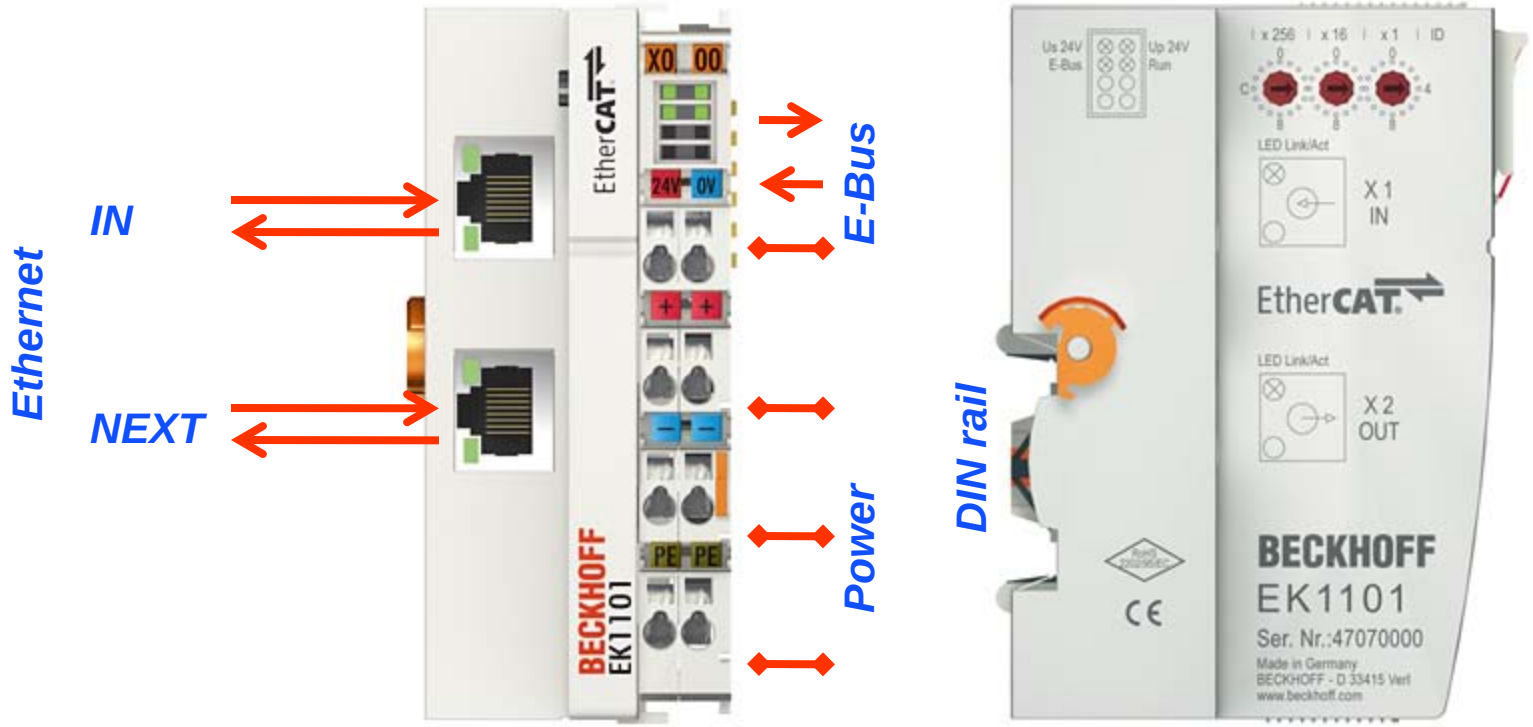
What is EtherCAT?

- 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 µs
- 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

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

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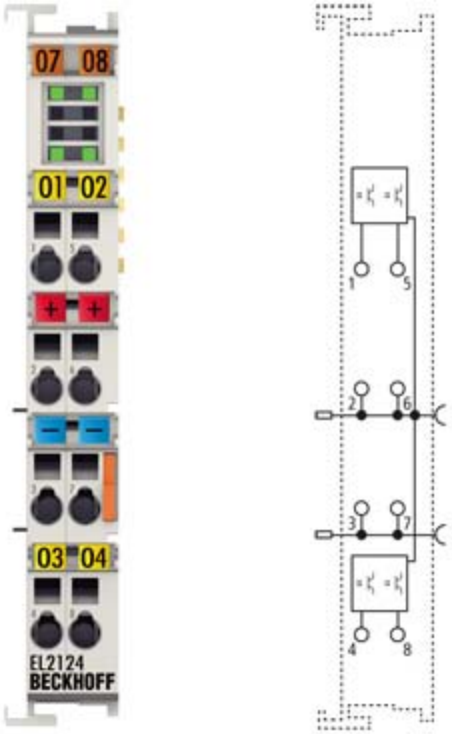
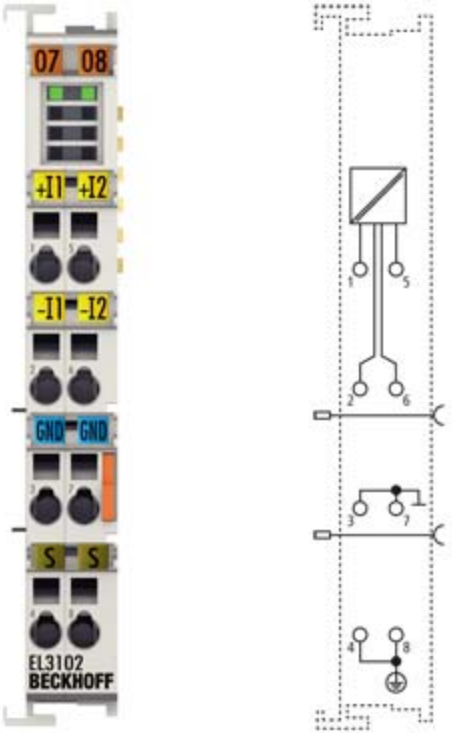
EtherCAT Terminal

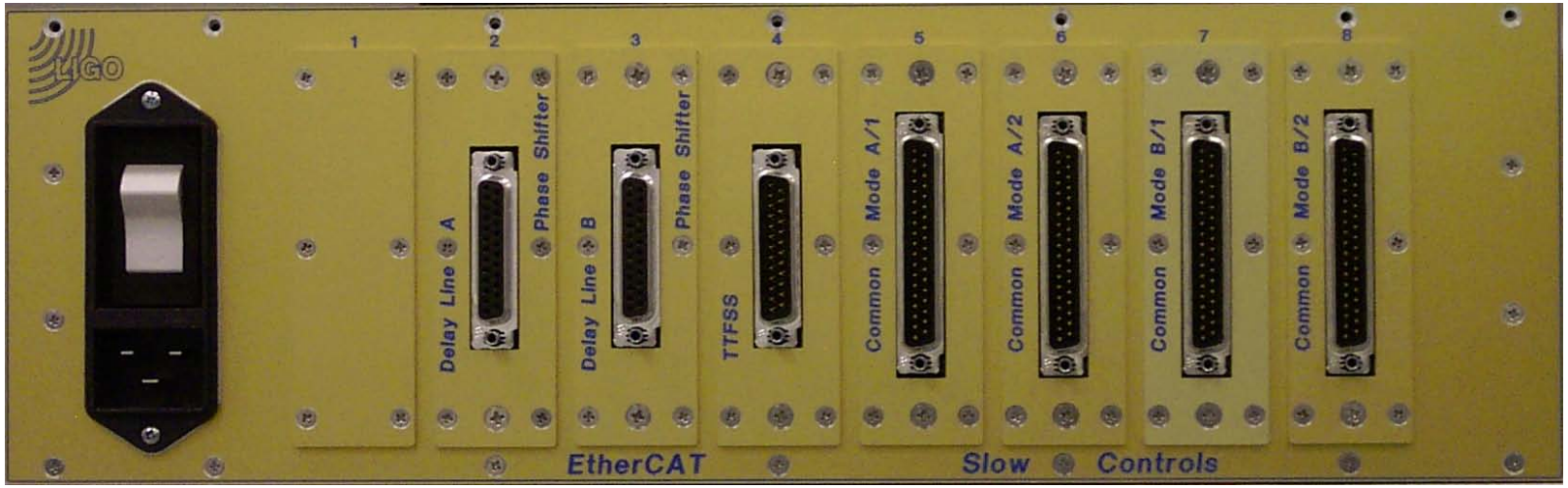


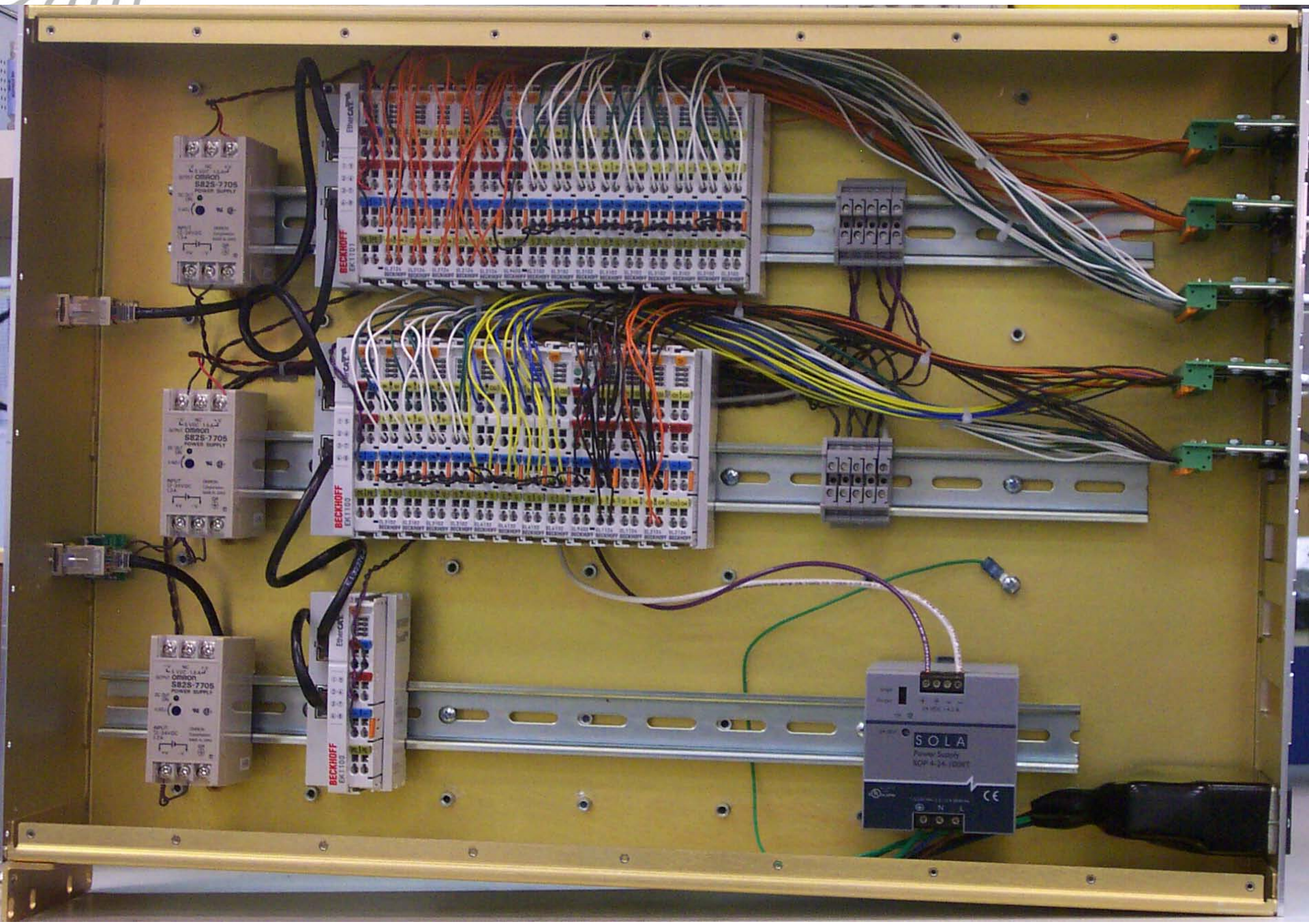
4-channel binary TTL output



2-channel 16-bit analog input

3U Chassis Design




OMRON
S82S-7705
POWER SUPPLY
BECKHOFF
EK1100
SOLA
Power Supply

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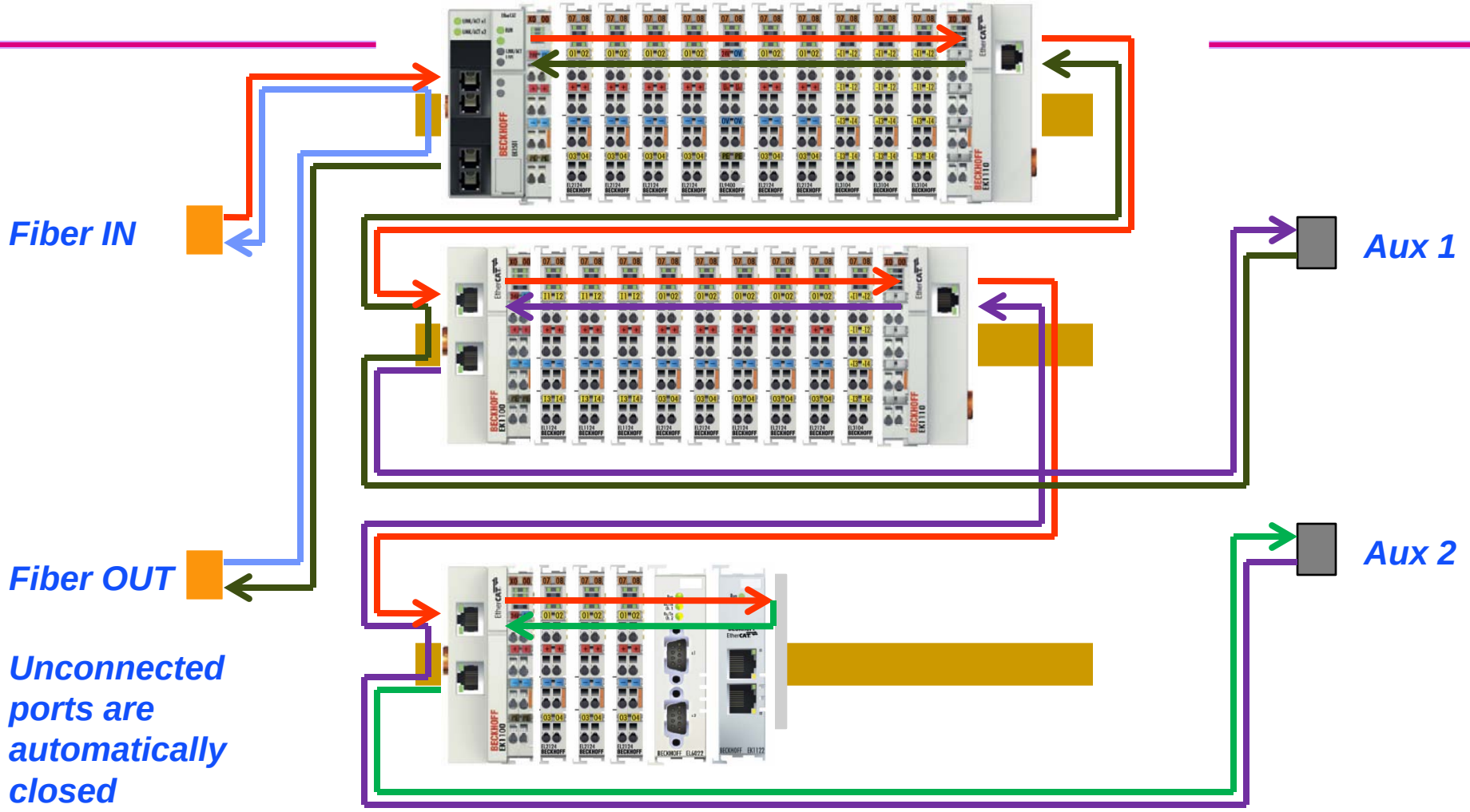
3U Chassis Features

- EtherCAT connections
  - 2 front panel 100baseFX (fiber) input/output connections
  - 2 auxiliary rear panel 100baseT connections (optional)
- Power
  - 24 VDC/5 A max (digital); 3-pin power D-sub
  - On-Off Switch/thermal breaker
  - Internal DC-DC converters for 5 VDC
- 9 rear adapter slots
  - 1x 37pin/25pin D-sub
  - 2x 15pin/9pin D-sub
  - Others…
- 3 internal DIN rails (20”)

Ethernet Configuration



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Power and Grounding (1)

- Analog terminals 1
  - Differential 16 bit analog inputs: EL3101 (1 chn), EL3102 (2 chn)
  - Differential 16 bit analog outputs: EL4132 (2 chn)
  - No connection to power bus
  - Common needs to be connected to
    - Signal ground of controlled chassis (preferred), or
    - Local power ground
- Analog terminals 2
  - 4 channel terminals: EL3104 and EL4134
  - Common connected to power bus ground
  - Connect power bus ground to signal or local power ground
  - May require feed terminal EL9190 to break power bus

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Power and Grounding (2)

- Binary terminals
  - TTL input : EL1124 (4 chn)
  - TTL output: EL2124 (4 chn)
  - TTL ground connected to power bus ground
    - Connect power bus ground to digital ground of controlled chassis
  - Powered from power bus: 5 VDC
    - Requires isolated DC-DC converter 24V in/5V out
  - Typically requires feed terminal EL9190 to break power bus and supply 5 VDC
- Other terminals
  - EL9400: Power supply for E-Bus
  - EK1110/EL9011: Extension end terminal/End cap
  - EL6002/EL6022: Dual RS232/RS422 interface

Programmable Logic Controller (PLC)

Computer room:

Supermicro 2U(?)

FC9022 (dual chn NIC)

Software:
TwinCAT PLC
Controller Toolbox
Serial Communications
OPC Server
EPICS Interface

Fiber to
Electronics room

EtherCAT chassis (optional)
– Fiber converter
– Weather stations, etc.
– Time Synchronization

Spare

1 Computer per station and interferometer

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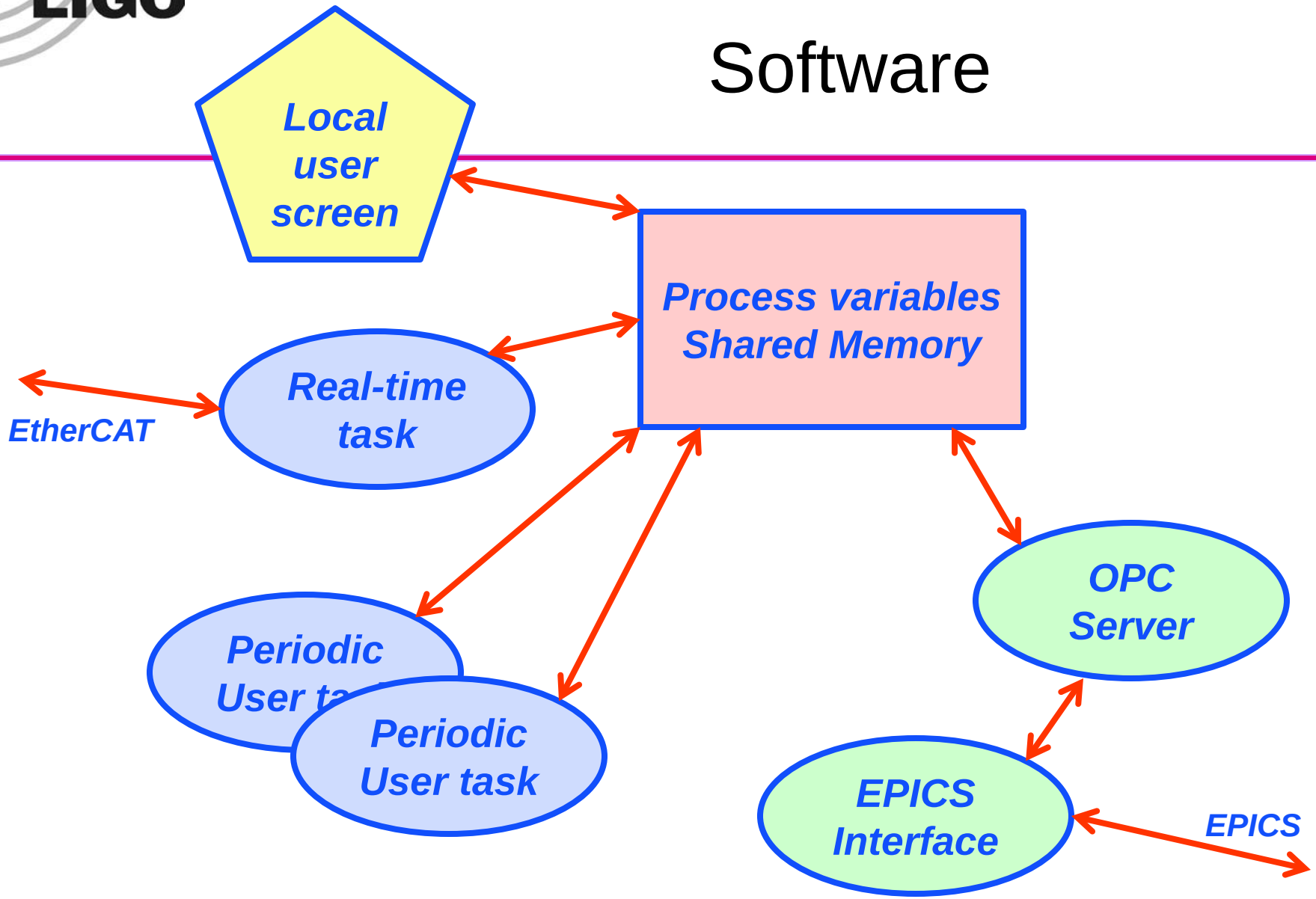
Software



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Outlook

- Easy to expand; easy to add a few more channels
- Simple logic controllers and slow servos can be directly implemented in the Beckhoff PLC
- TwinCAT 3 will support 64bit OS and C++/Matlab
- We can support RS232/RS422/RS485 devices
- Infrastructure to support legacy and “odd-ball” devices (picomotors, dust monitors, rotating waveplates, weather stations, etc.)
- Future of the vacuum controls?