Controls Overview
May 28, 2004

- **Outline**
  - Goals
  - Status update
  - Resources
  - Design Slides for Global Systems
  - Task descriptions
  - Next 12 months
  - Conclusions

- Note: As this is being recorded – please add " it is my impression" and "we expect " wherever appropriate.

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LCLS Control System Goals

- Provide a fully integrated control system to support the construction, test, installation, integration, operation and automation of the LCLS Accelerator
- Standardize on all devices and components across all subsystems.
- Identify all data either by pulse id, beam pulse related time stamp, or 500 msec rough time stamp.
- Full integration with the SLC – timing, use of LCLS data in SLC high level applications, and use of SLC data in LCLS
- Work with ESD to provide an upgrade path for the SLC

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Update: February 2004 – May 2004

- Unify the design efforts across the WBS (made it to the Undulator)
- Global control effort added for support
- Design changed to include SLC-aware IOC
  - Allowed new designs outside of CAMAC
  - Caused extensive re-costing throughout the WBS
- Design discussions started on SLC-aware IOC and timing hardware required
- Contact made with potential personnel
- Prepared for the EIR (External Review that turns on $$)

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Personnel – Resources

	2004	2005	2006	2007	2008	Total
Ctl. Elec. Engineer	2.42	10.37	8.12	6.07	3.26	30.24
Ctl. Sr. Elec. Tech.	.56	3.44	2.66	1.90	.77	9.33
Ctl. Elec Tech.	.07	.60	2.20	4.63	.62	8.12
Pwr. Elec. Engineer	1.94	1.39	.32	.51	.10	4.26
Pwr. Sr. Elec. Tech.	.42	.86	.31	.72	.05	2.37
Control Prog.	.81	10.18	10.29	6.32	6.56	34.17

Ramp up plan: starts now with two on board, two more starting in June and two more in October.

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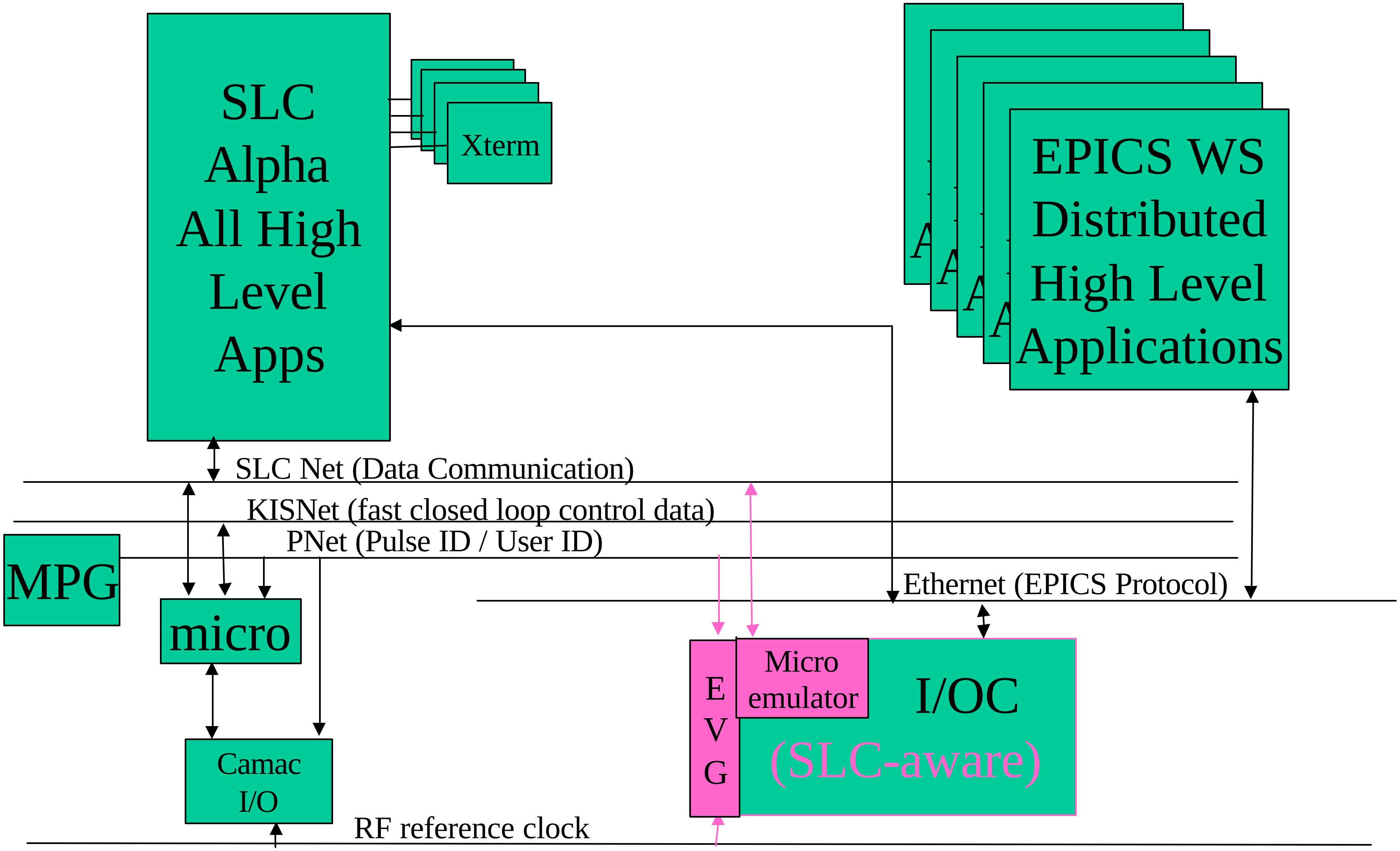
Integration with the SLC Control System



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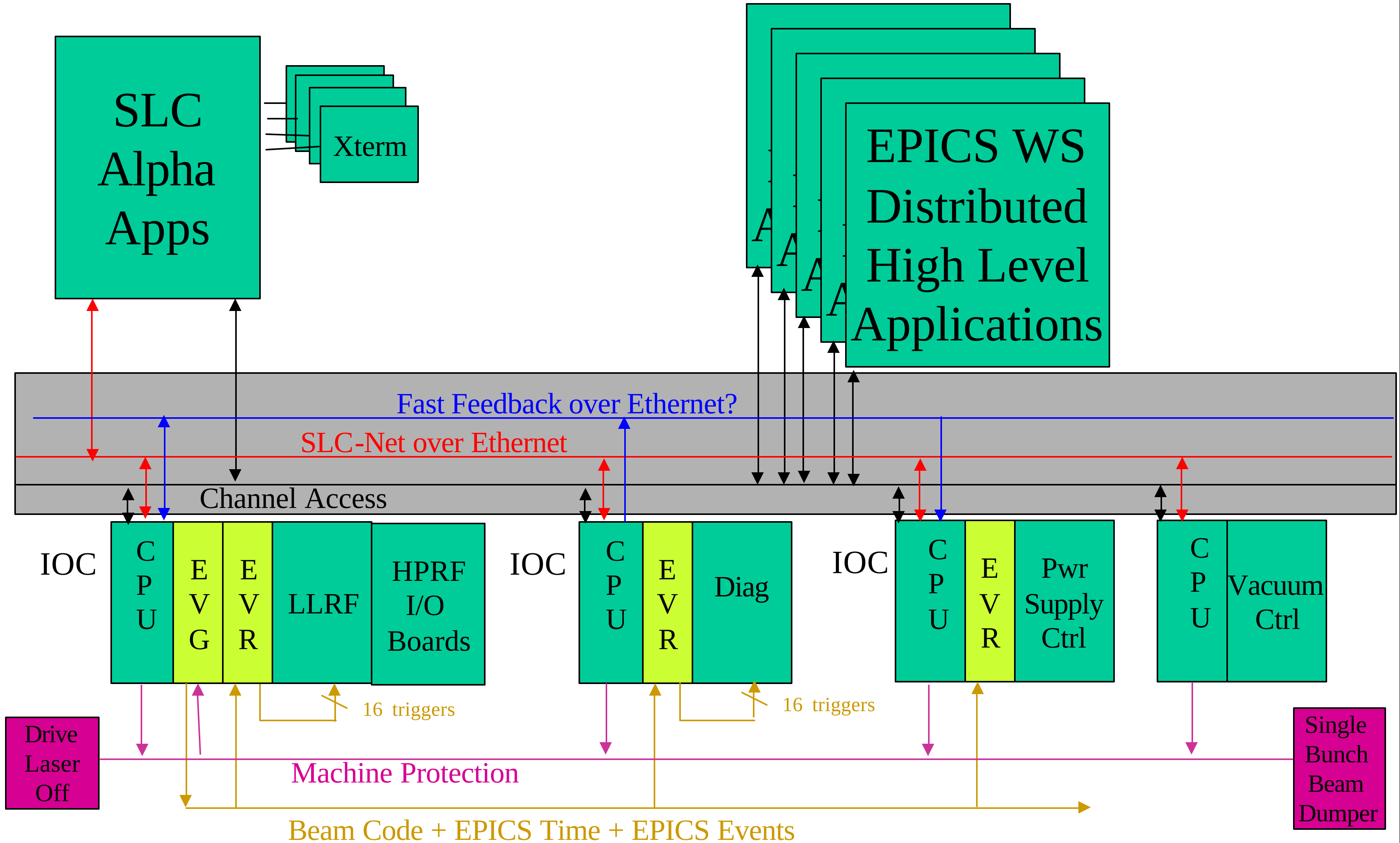
Global Communication Buses



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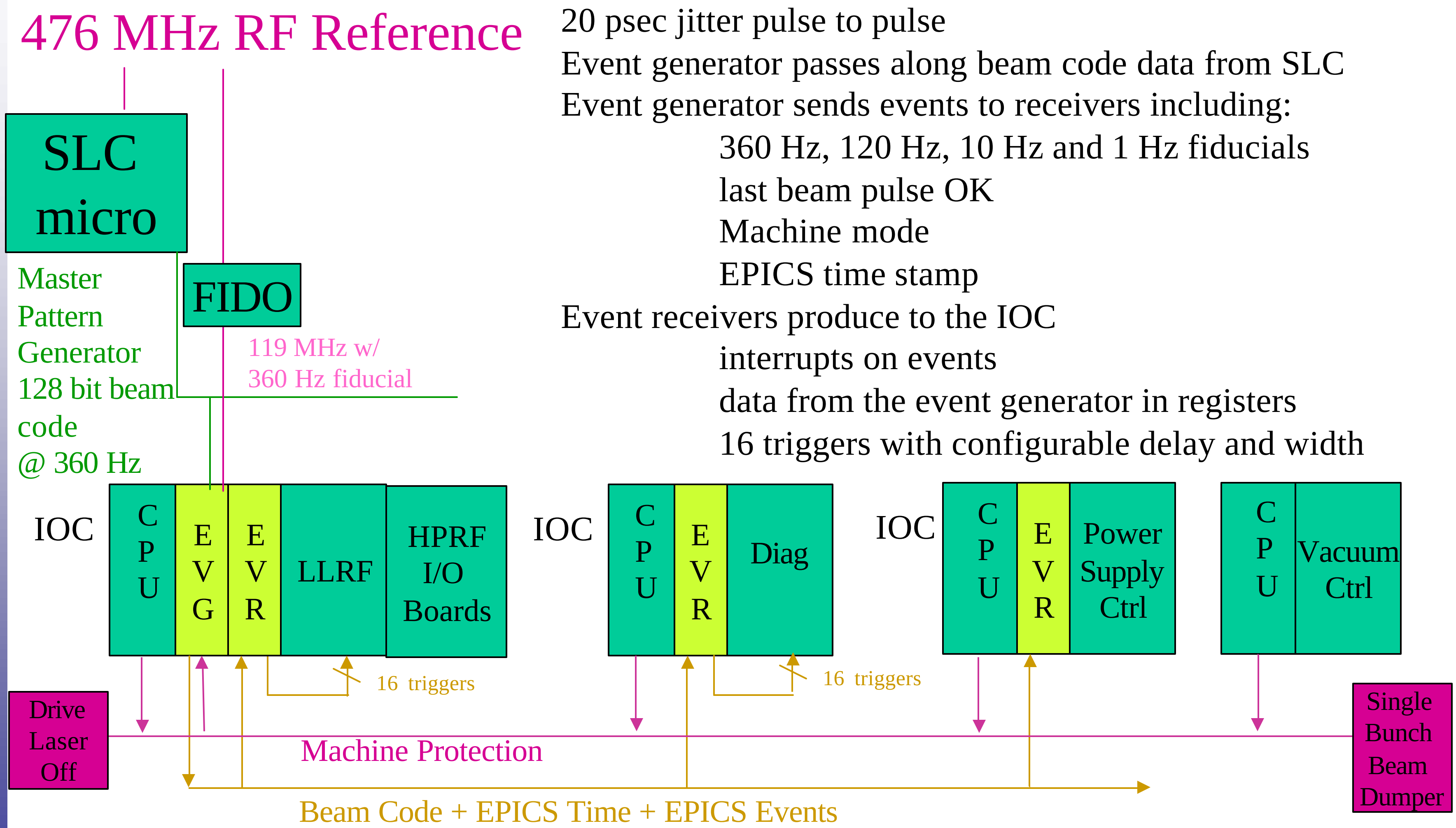
Timing

Nsec resolution on the timing gates produced from the Event Rcvr
20 psec jitter pulse to pulse
Event generator passes along beam code data from SLC
Event generator sends events to receivers including:
- 360 Hz, 120 Hz, 10 Hz and 1 Hz fiducials
- last beam pulse OK
- Machine mode
- EPICS time stamp

Event receivers produce to the IOC
- interrupts on events
- data from the event generator in registers
- 16 triggers with configurable delay and width



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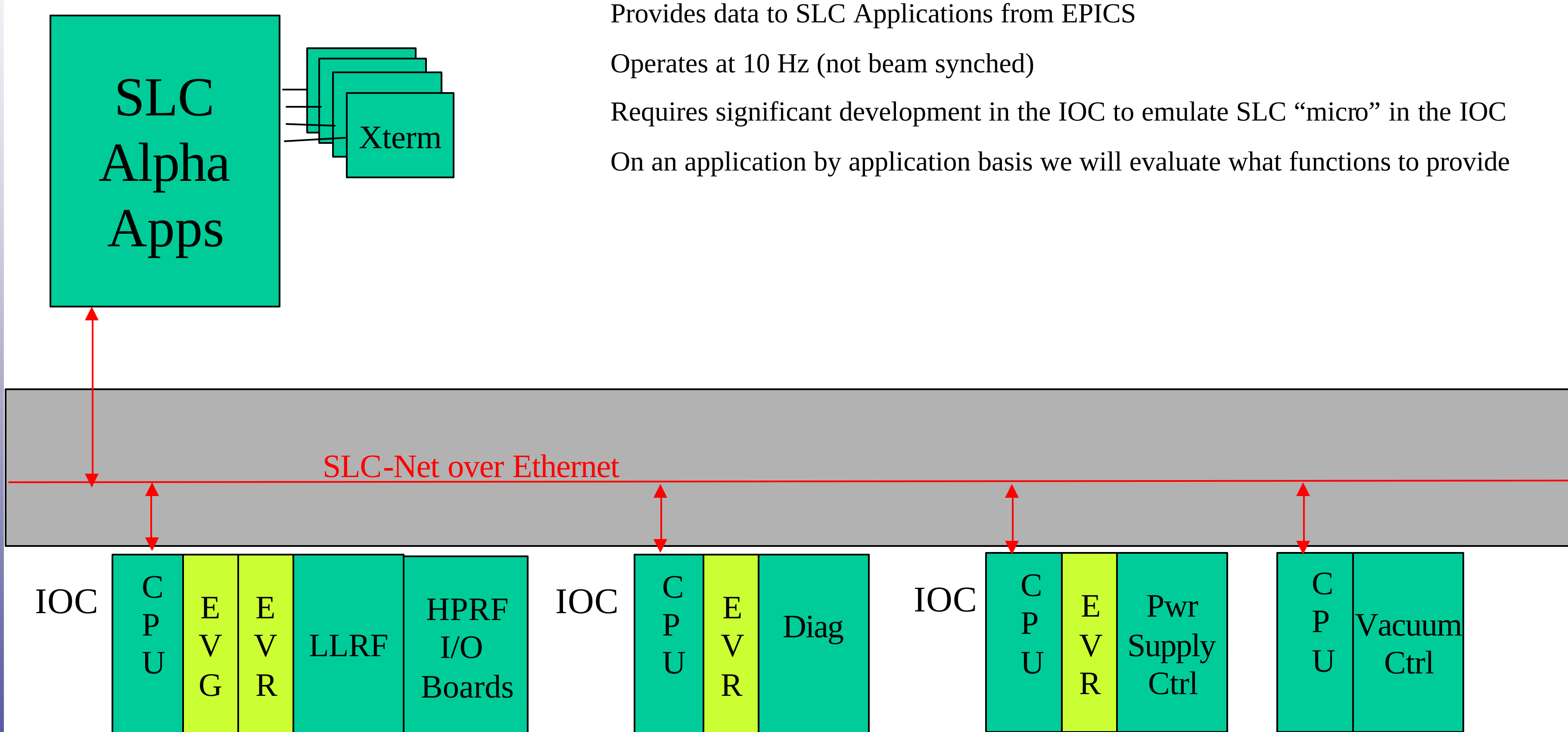
SLC Net "Micro" Communication

Provides data to SLC Applications from EPICS

Operates at 10 Hz (not beam synched)

Requires significant development in the IOC to emulate SLC "micro" in the IOC

On an application by application basis we will evaluate what functions to provide



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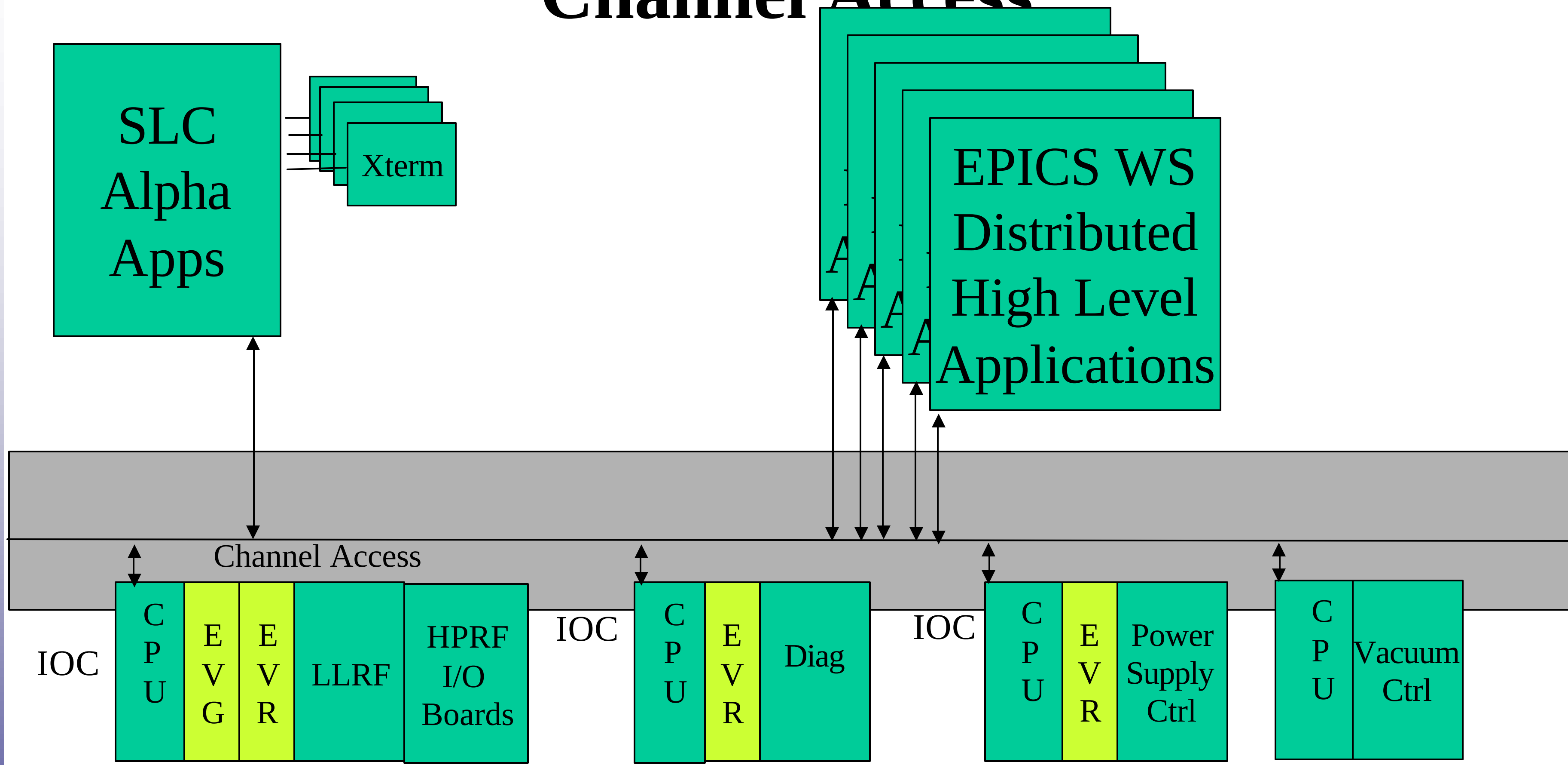
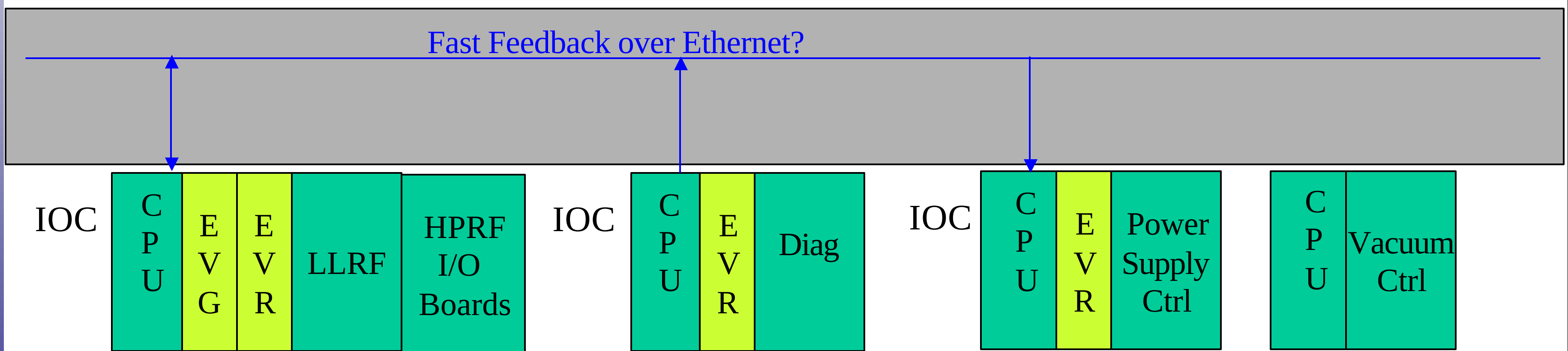
Channel Access



A channel access server in SLC provides data from existing SLC micros to EPICS applications
All IOCs have both a channel access server to allow access and a client to have access
Channel access provides read/write by all clients to all data with a server.
All EPICS high level applications are channel access clients that may or may not have a server.

Global Communication

Fast feedback is required to run at 120 Hz
Values will be transmitted from RF and selected diagnostics to Power Supply and RF IOCs
The communication needs to be reliable, verifiable, and have a well thought out degradation
The entire time budget to read, transmit, commute, control, and settle is 8.3 msec
First estimates are that the control system can use 2 msecs to transmit and receive the data
Can this be done over a common Ethernet with adequate bandwidth – or is a dedicated one needed?



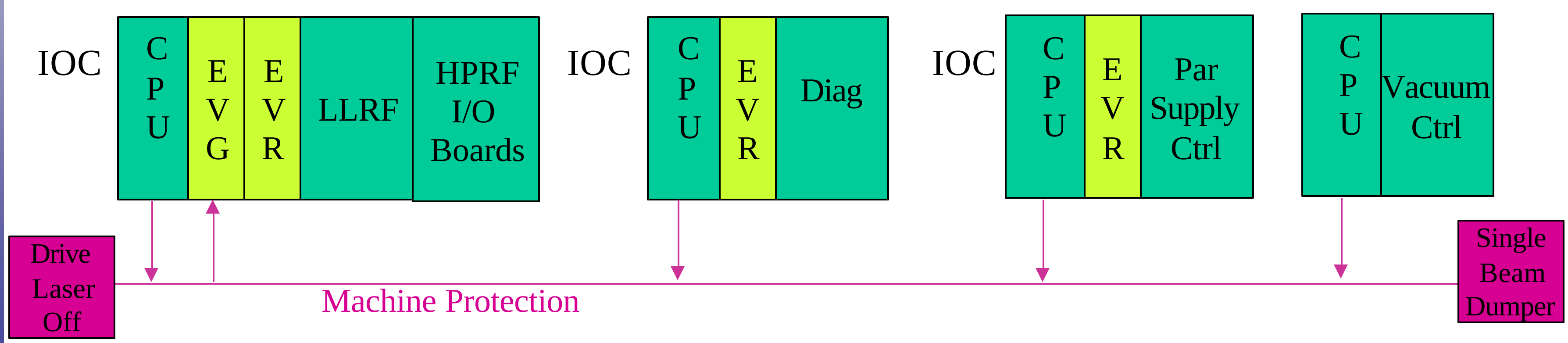
Machine Protection

Machine protection is used here to define faults requiring global mitigation
Response time is under 8 msec
There are two mitigation devices:

- Single Beam Dumper - which prohibits the beam from entering the undulator
- Drive Laser Off – which prohibits beam from entering the cavity

Action must also be taken to reduce the repetition rate of the beam

This new design is required to interrupt the beam before the next beam pulse.



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LCLS Project Engineering Tasks

- 1 RF Control
- 3 Diagnostics

  Toroids & Faraday Cups, Beam Stops, Profile Monitors & Video Devices, Wire, Scanners, Bunch Length Monitors & E/O Diagnostics, Beam Position Monitors, Collimators, All other stops
- Gun Laser and Drive Control
- 1 Vacuum
- 1 Magnet Power Supply Control IOC and software
- 1 Beam Containment / Personnel Protection / Machine Protection
- 1 Low Level Engineer
- 2 High Level Application Engineers
- 1 RDB Manager
- 1 System manager
- 1 Group Leader

LCLS Software Tasks – Purchase/Steal/Develop

- SLC-aware IOC
- Drivers for all new hardware
- Machine Protection / Mitigation (look at SNS)
- Master pattern generator (look at PSI/Diamond)
- Fast Feedback Communication
- High Level Applications (Matlab or XAL)
  - Correlation Plots (look at JLab)
  - Fast Feedback Loops
  - Emittance reconstruction from wire scans and profile monitors
  - Profile monitor image analysis for slice emittance with the transverse cavity
  - Beam Steering and online orbit modeling
  - Beam Steering “scans” to emittance reconstruction from wire scans and profile monitors

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LCLS Software Tasks – Purchase/Steal/Develop

- Data Archiving to support all phases of the project (PEP/SNS)
- Operator Display Tools / Synoptic, Plots, Waveform, Image (EDM, others?)
- Alarm Management (ALH, CMLOG)
- Electronic Log (DESY, JLAB)
- High Level Application Support: Matlab, XAL, Python
- Control System Configuration Tools (VDCT, RDB, EXCEL)
- Relational Database Management in all project aspects (Based on SNS, PEP)
- Naming Standard (PEP)

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LCLS Hardware Tasks – Purchase/Steal/Develop

- Global
  - New timing boards – Master Pattern Generator and Event Receiver Boards (PSI,DIAMOND)
  - Machine Protection System (SNS)
- RF Control – New LLRF Control (SNS, ZTEC)
- Diagnostics
  - Toroids & Faraday Cups
  - Beam Stops
  - Profile Monitors & Video Devices
  - Wire Scanners
  - Bunch Length Monitors & E/O Diagnostics
  - Beam Position Monitors (Integrated Technology)
  - Collimators
  - All other stops
- Gun Laser and Drive Control
- Vacuum Standards
- Magnet Power Supply Controllers (PSI)
- Beam Containment / Personnel Protection

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Next 12 months

- Acquire team: 8 project engineers, 1 low level programmer, and 3 board designers – or contract out or steal designs
- Put together detailed designs per subsystem and have them reviewed – revamp costs.
- Integrate Facility Controls, XRay Transport, Experimental Hall into the control system.
- Prototype/test: PNet, Timing, LLRF, PS, and BPM efforts
- SLC-Aware IOC
- Prototype for 120 Hz Fast Feedback
- Prototype for video diagnostics
- Prototype for position controllers

Conclusions

- The control engineers will be responsible for the system integration of subsystems being developed in a vertical management environment.
- Our key risk is in the design of an SLC-aware IOC and SLC to EPICS timing that will allow us to intermix the SLC and EPICS front-ends. It is also provides a valuable upgrade path for the SLC Linac.
- We need to acquire some key resources to get the critical designs well in hand before they are needed.

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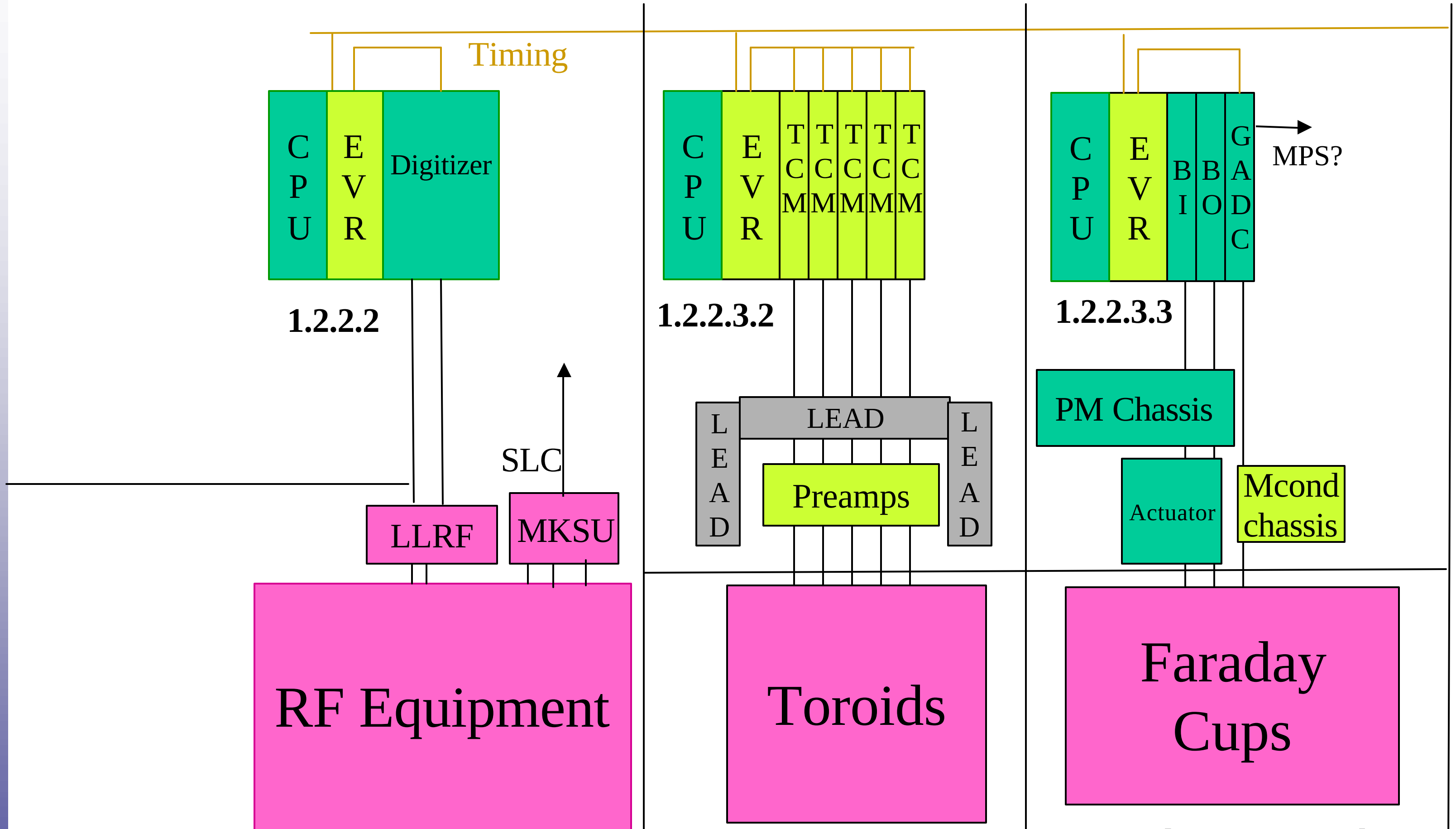
Injector Subsystem Designs



6 instances
(1 for each klystron),
1 IOC in total

5 Toroids
1 IOC

4 Faraday Cups with
YAGs,
share toroid IOC

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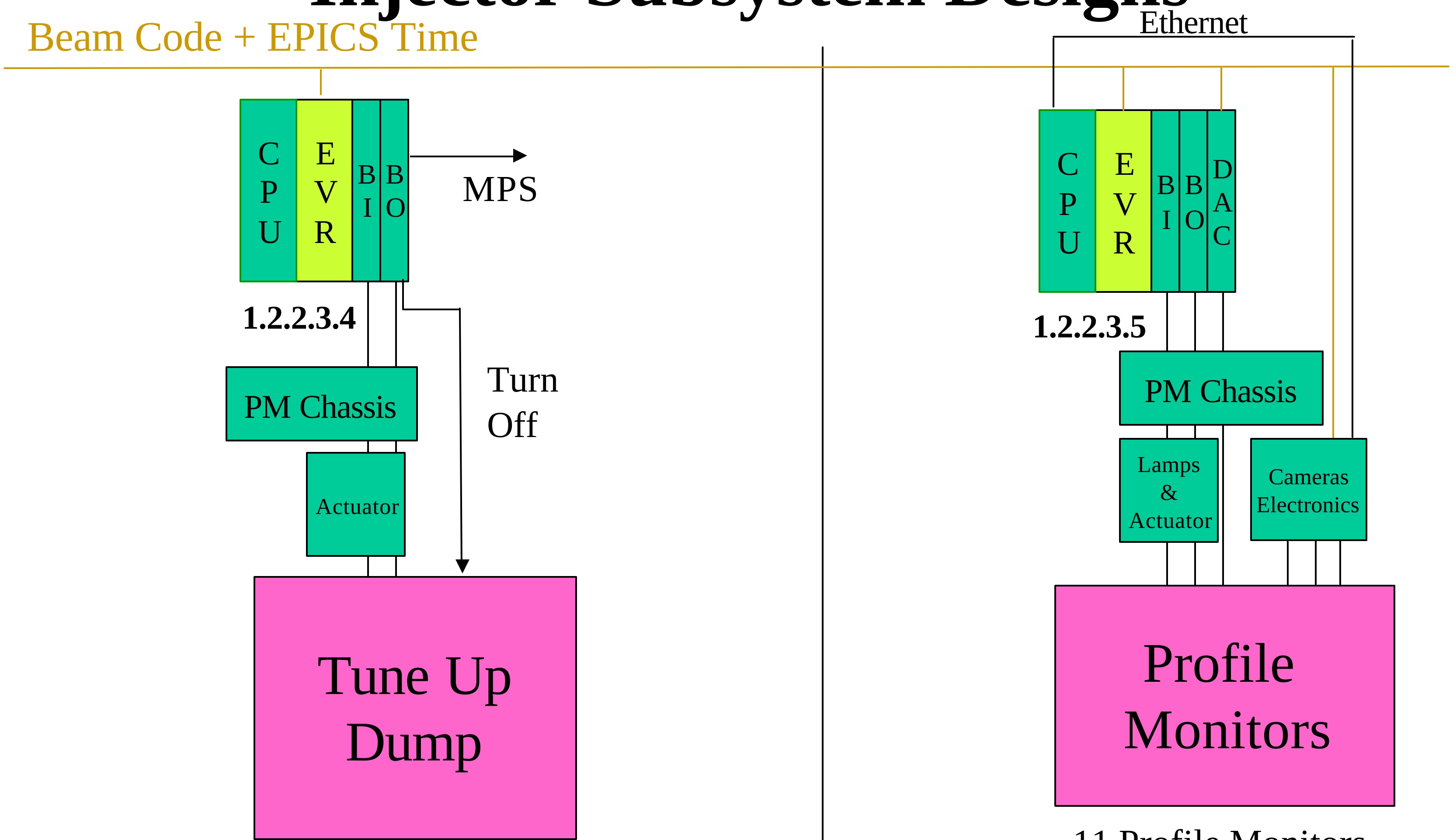
Injector Subsystem Designs



1 Tune Up Dump, shares toroid IOC

11 Profile Monitors (4 YAGs, 7 OTRs), 1 IOC

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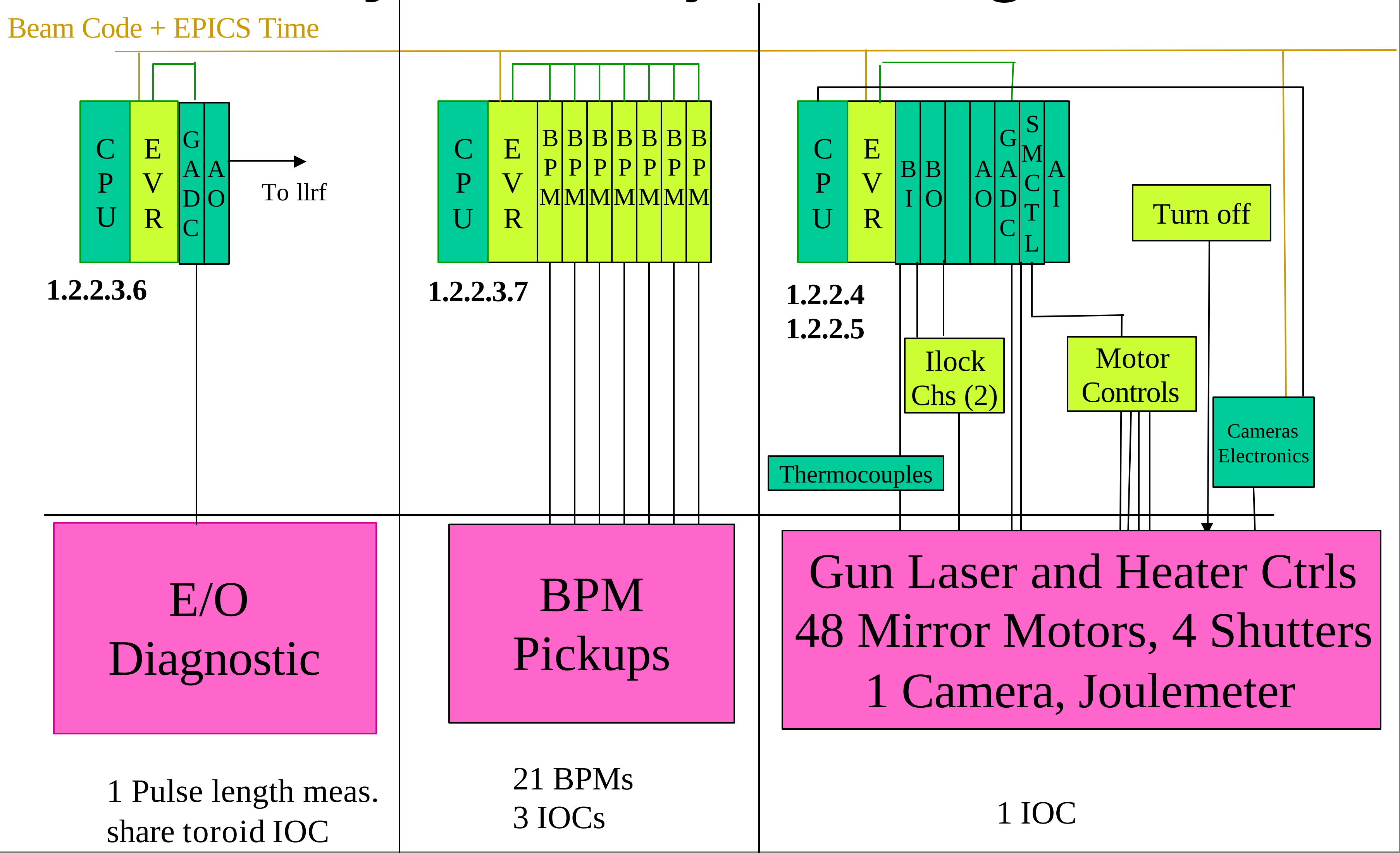

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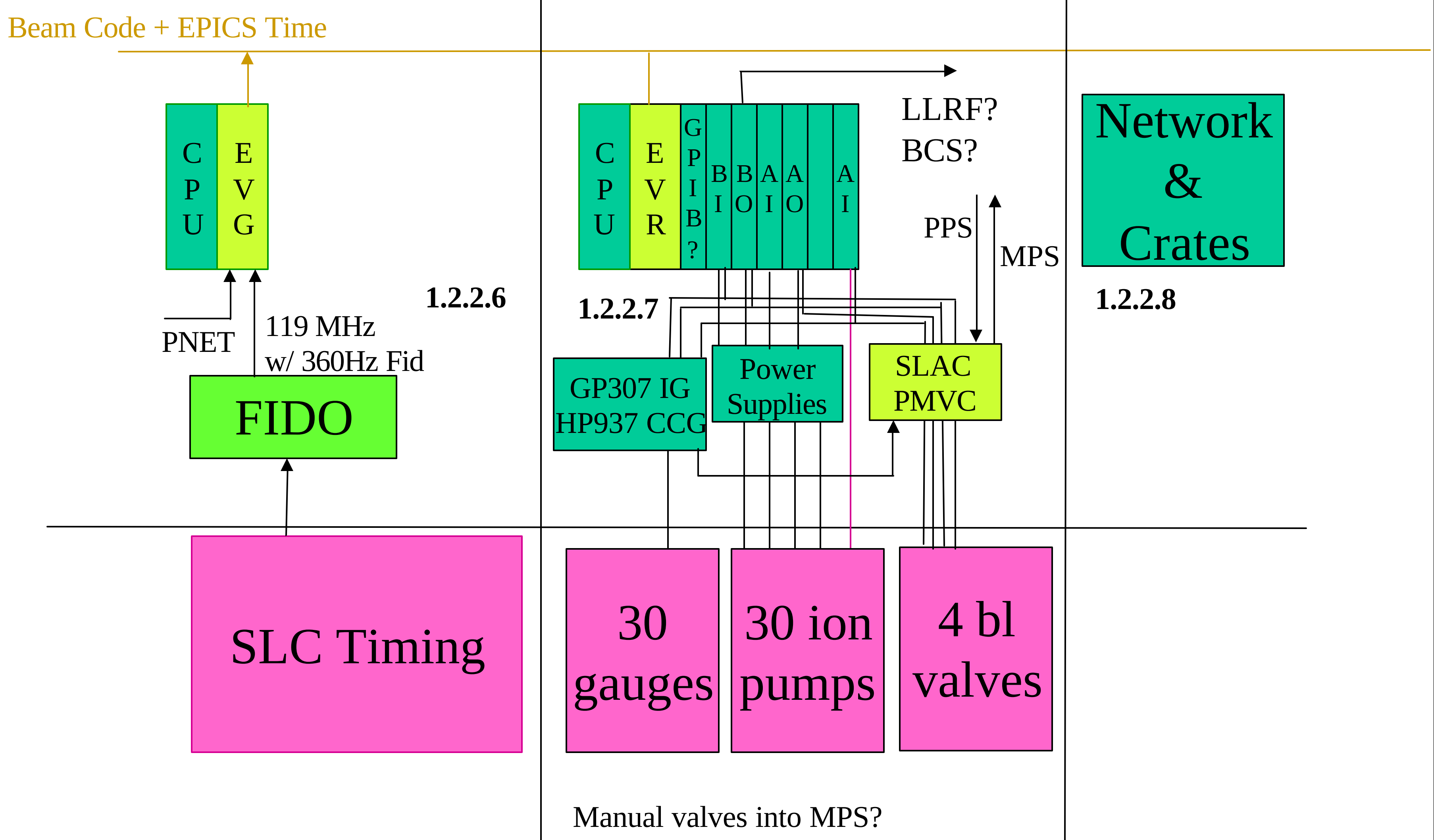

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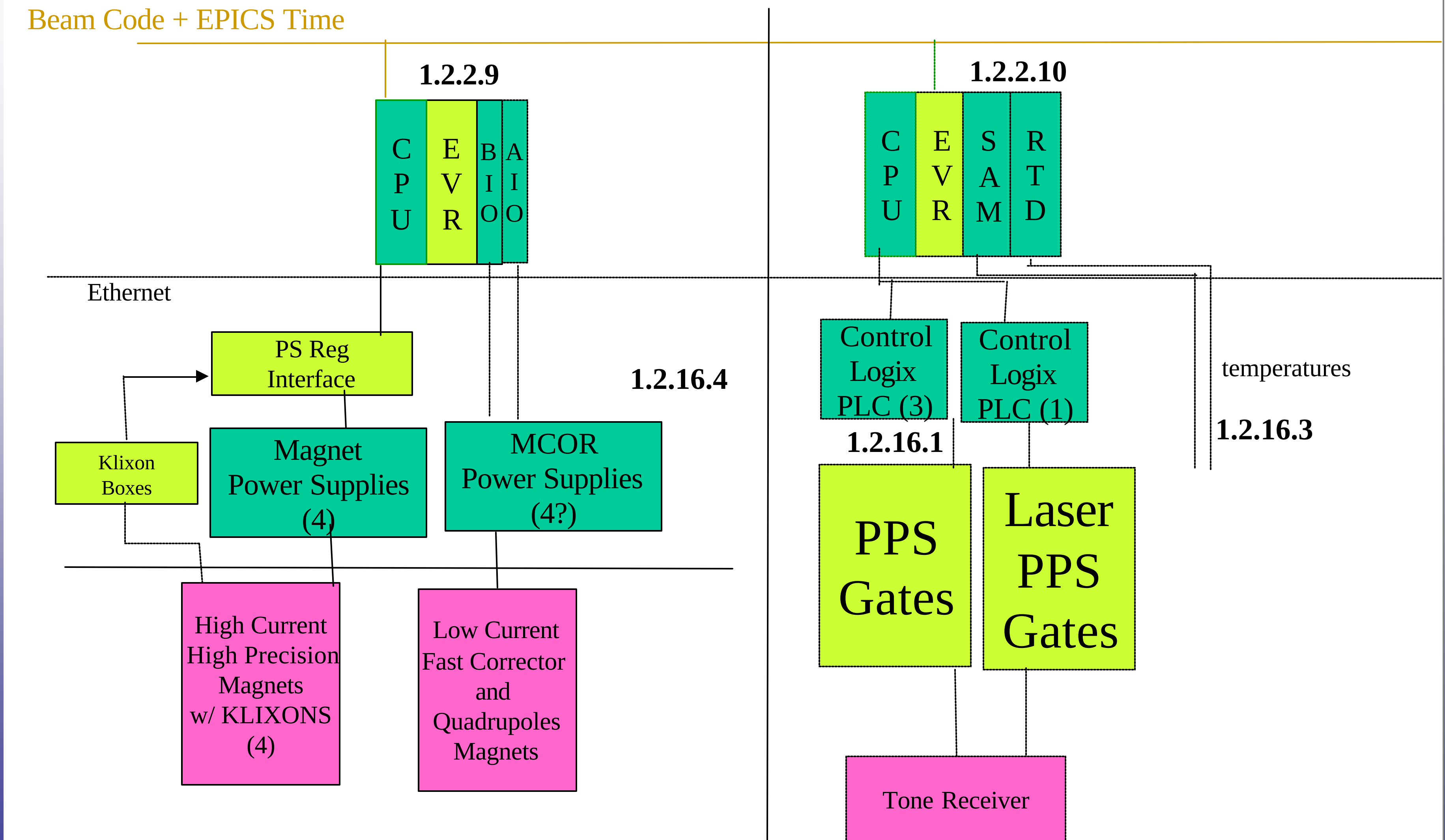

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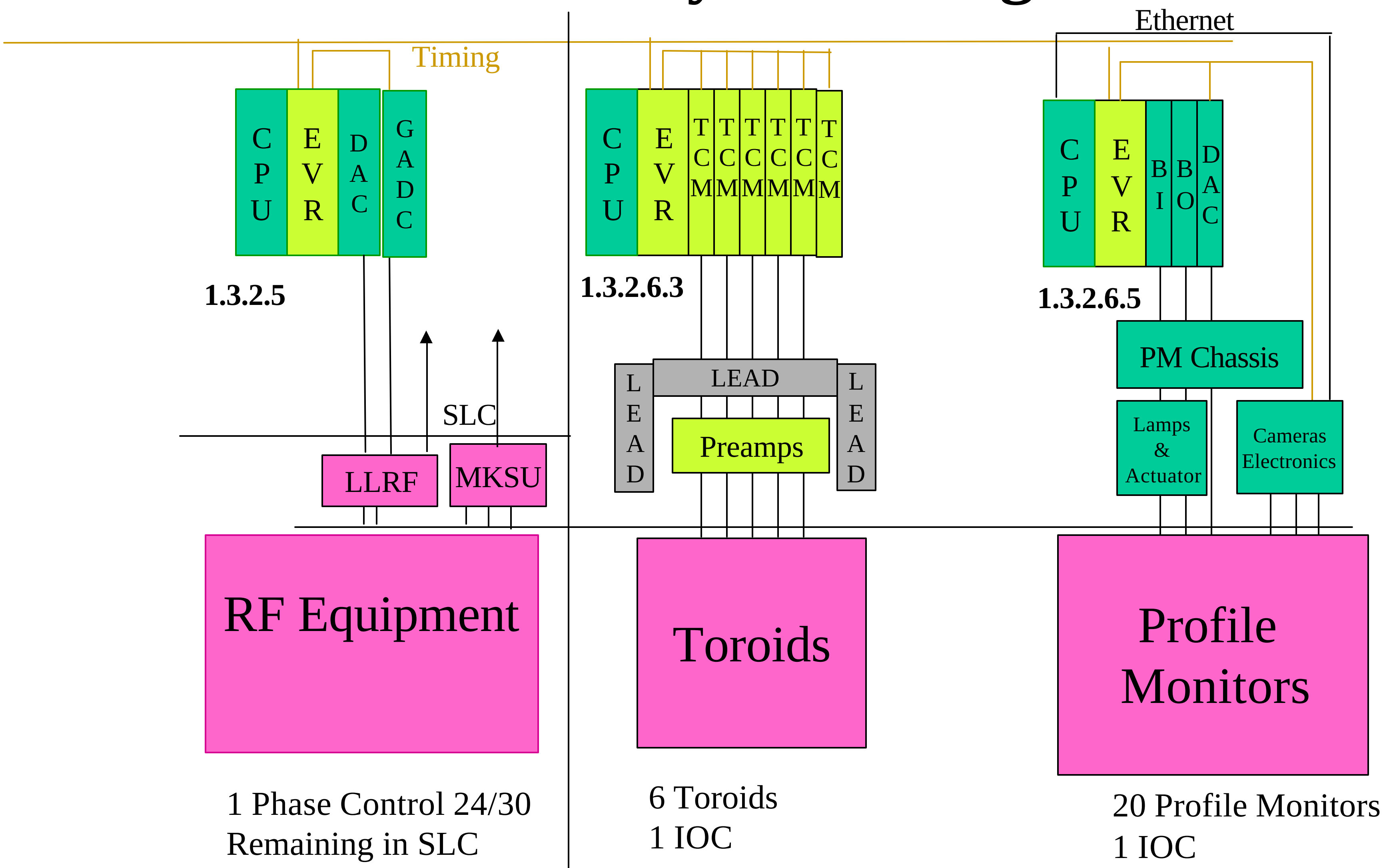
LINAC Subsystem Designs



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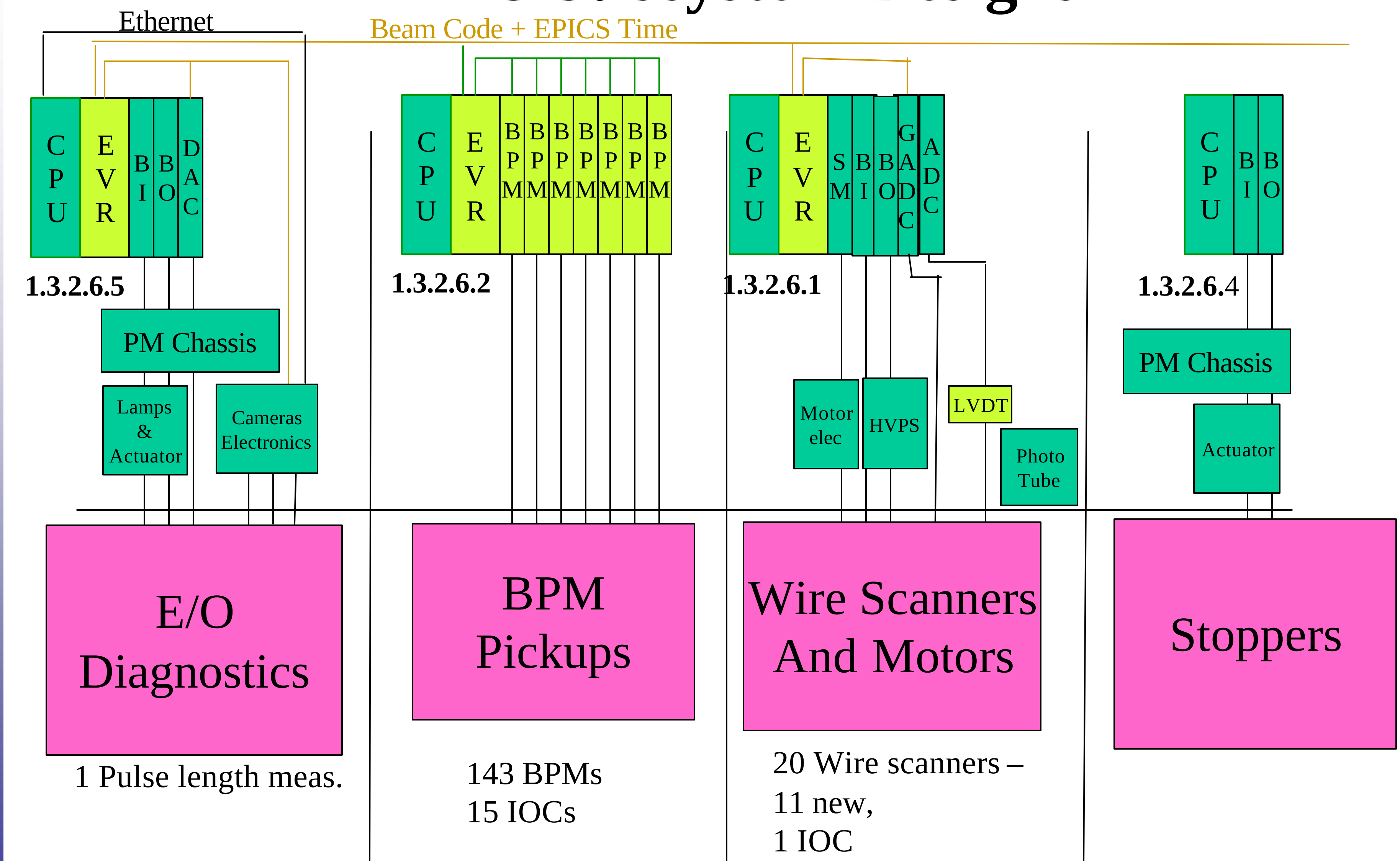

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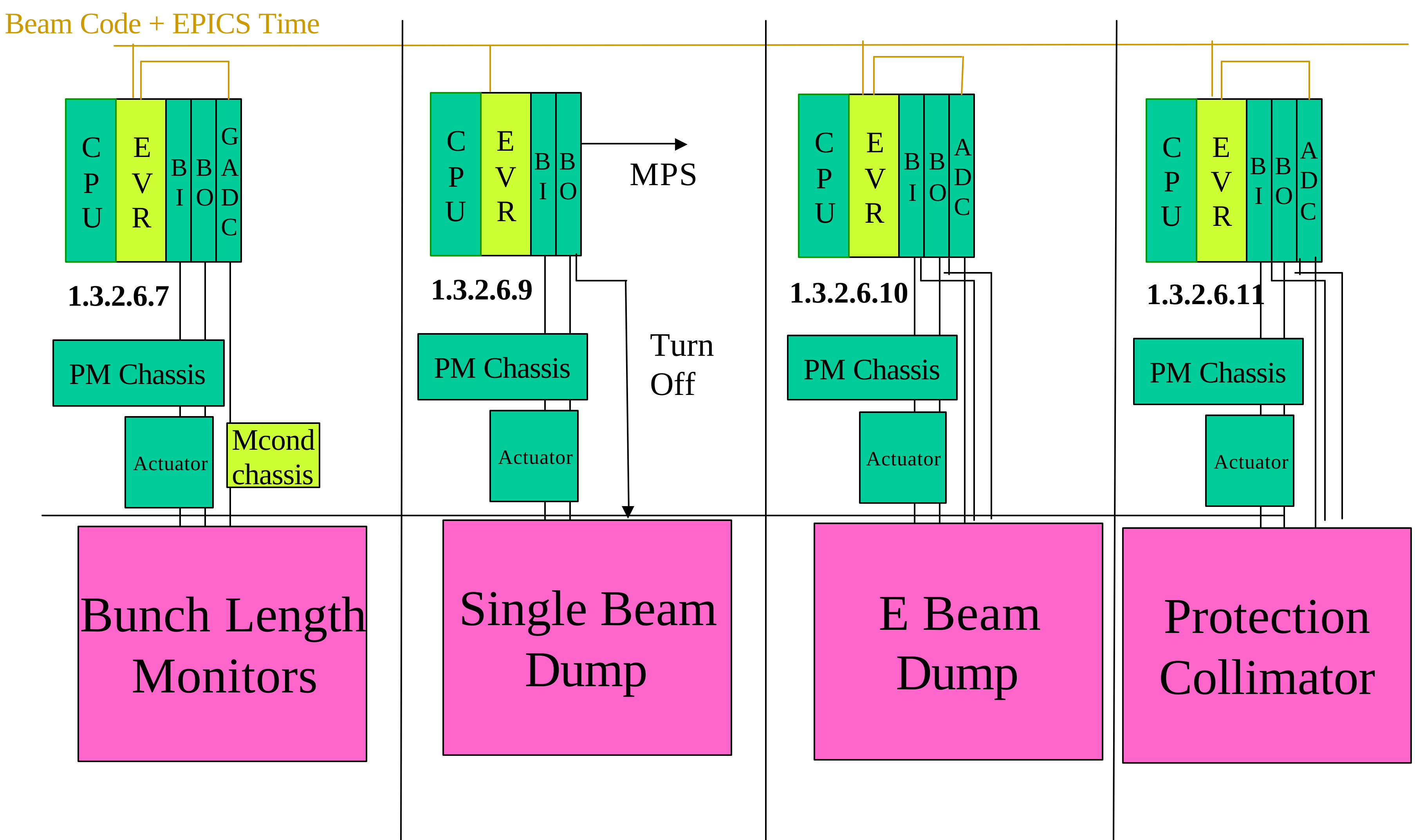

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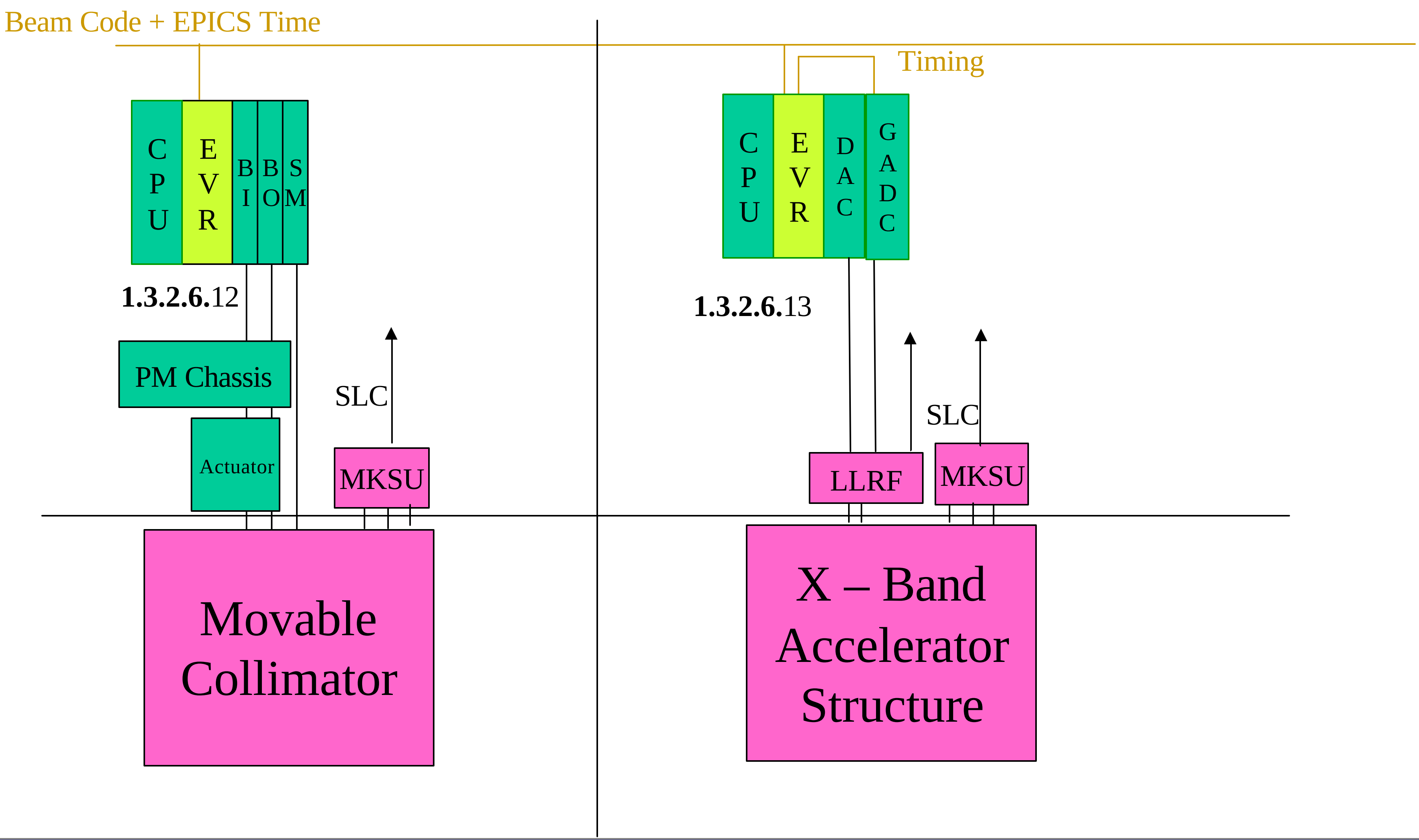

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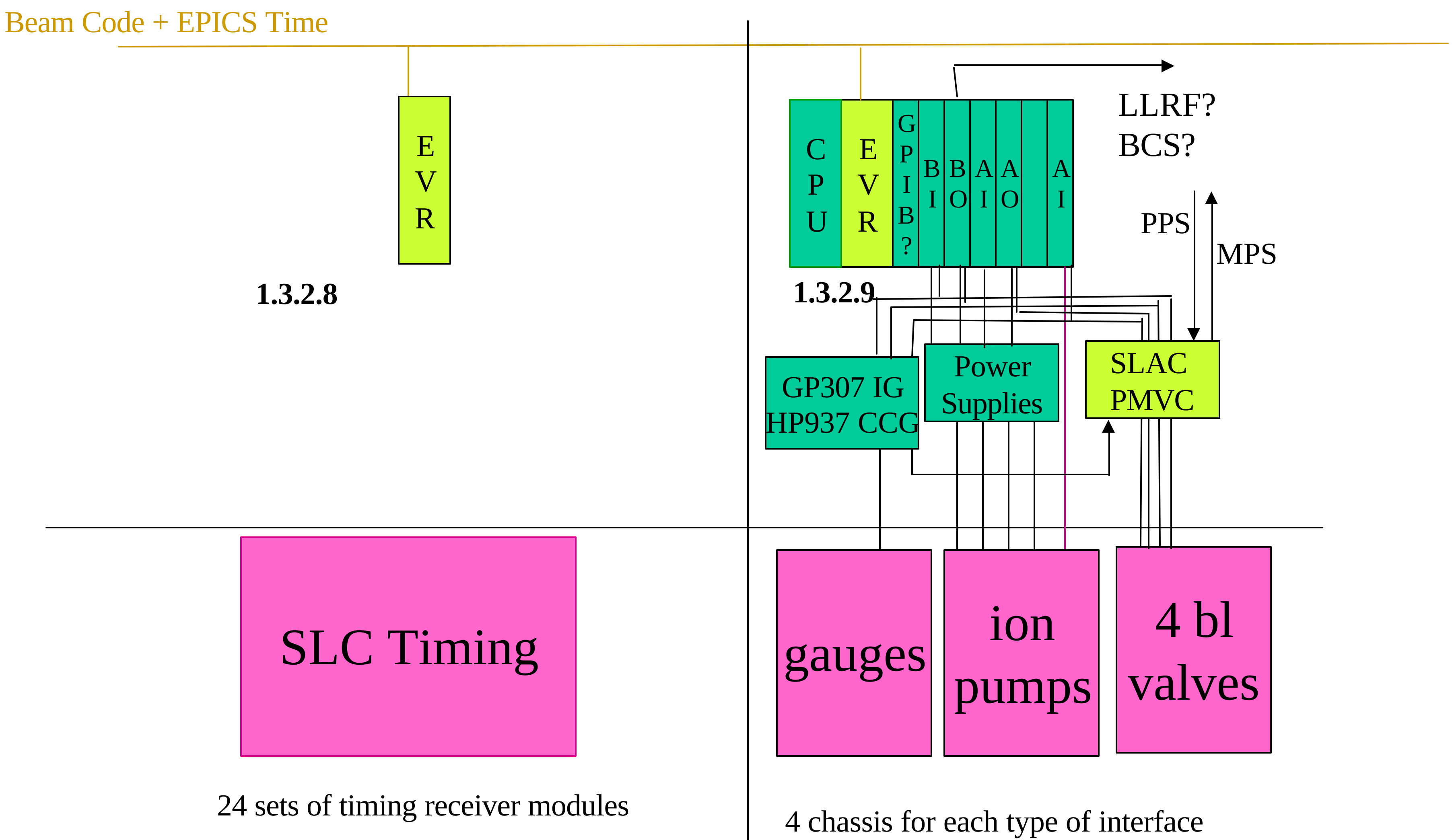

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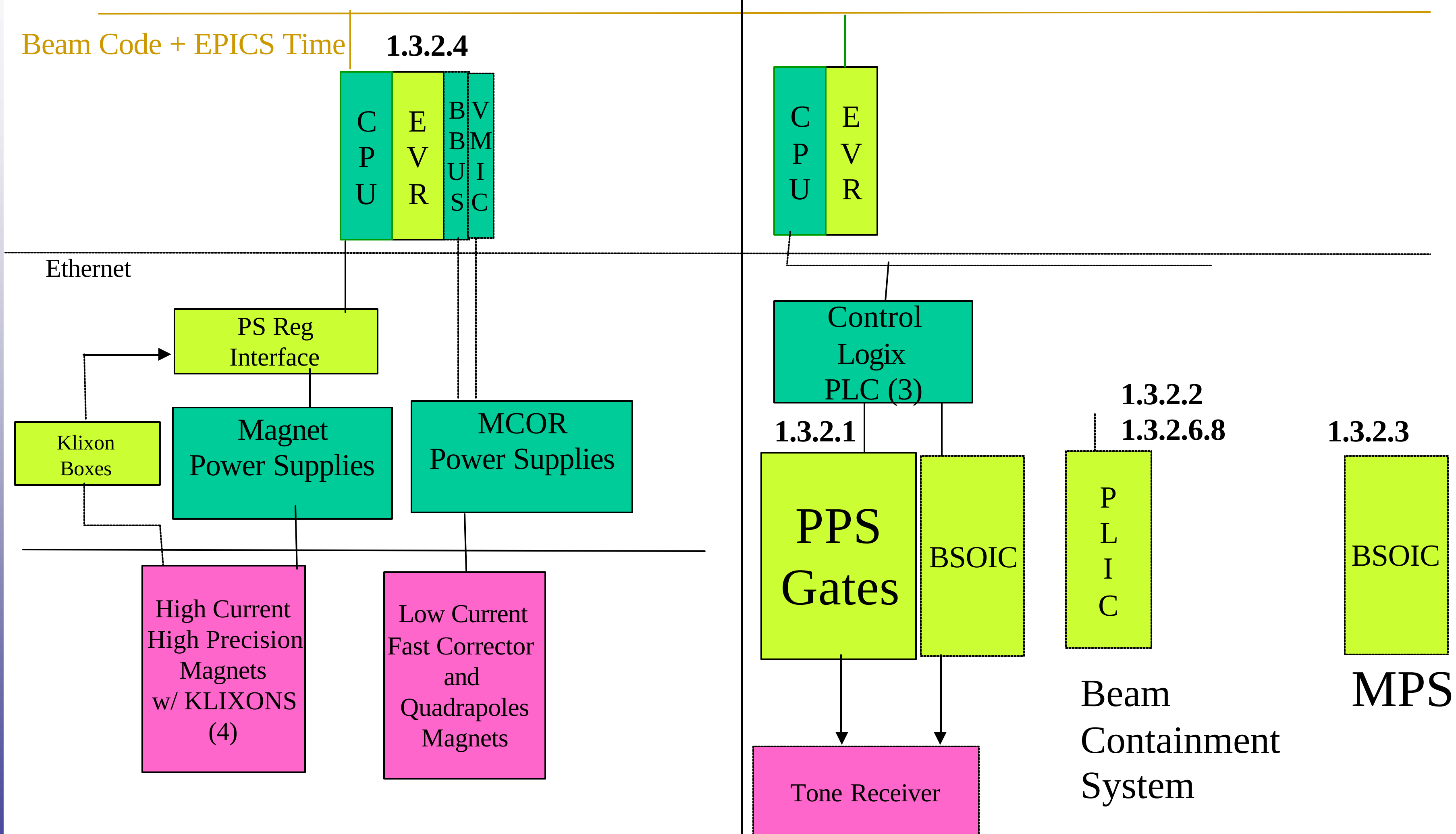

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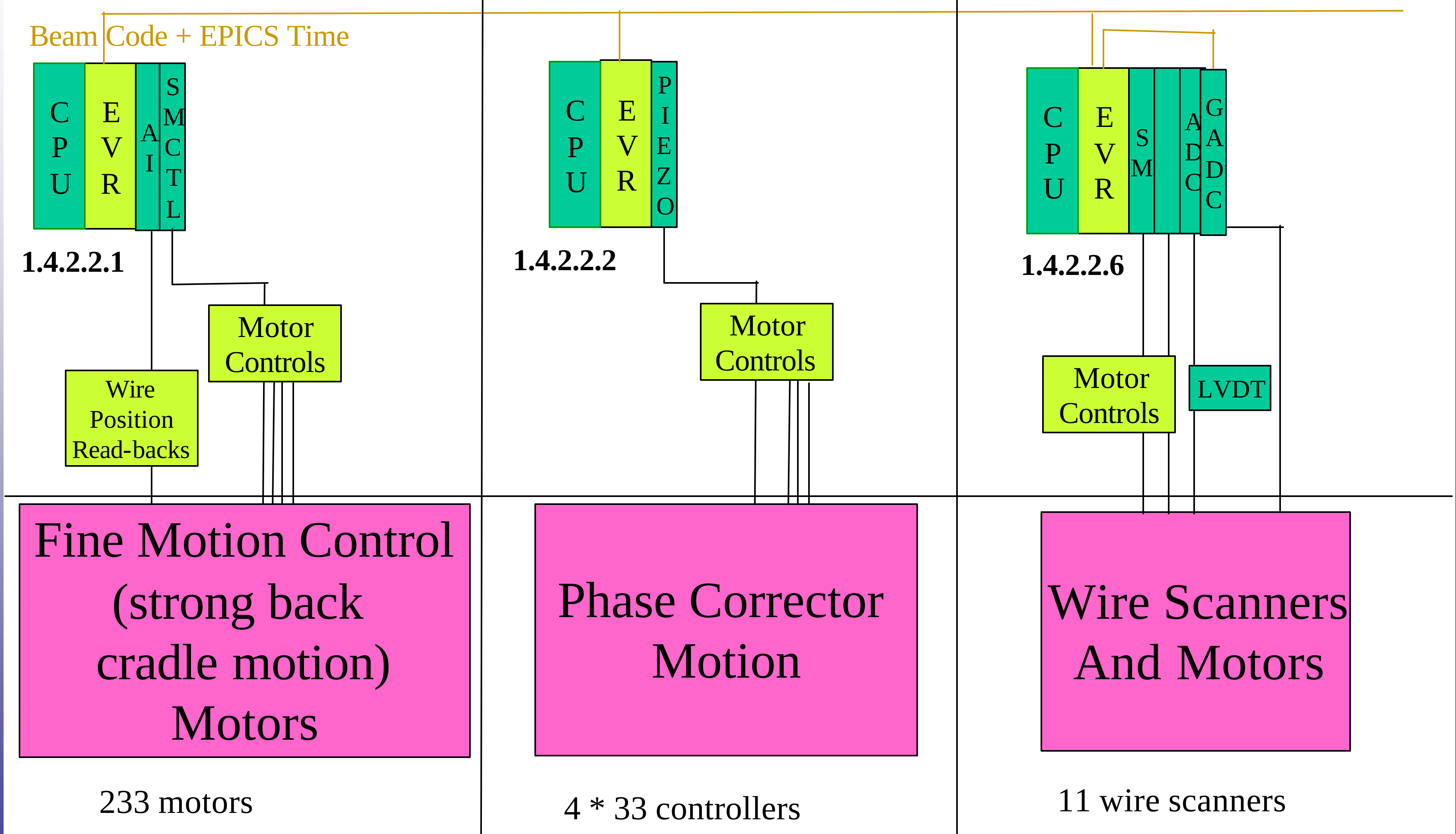
Undulator Subsystem Designs



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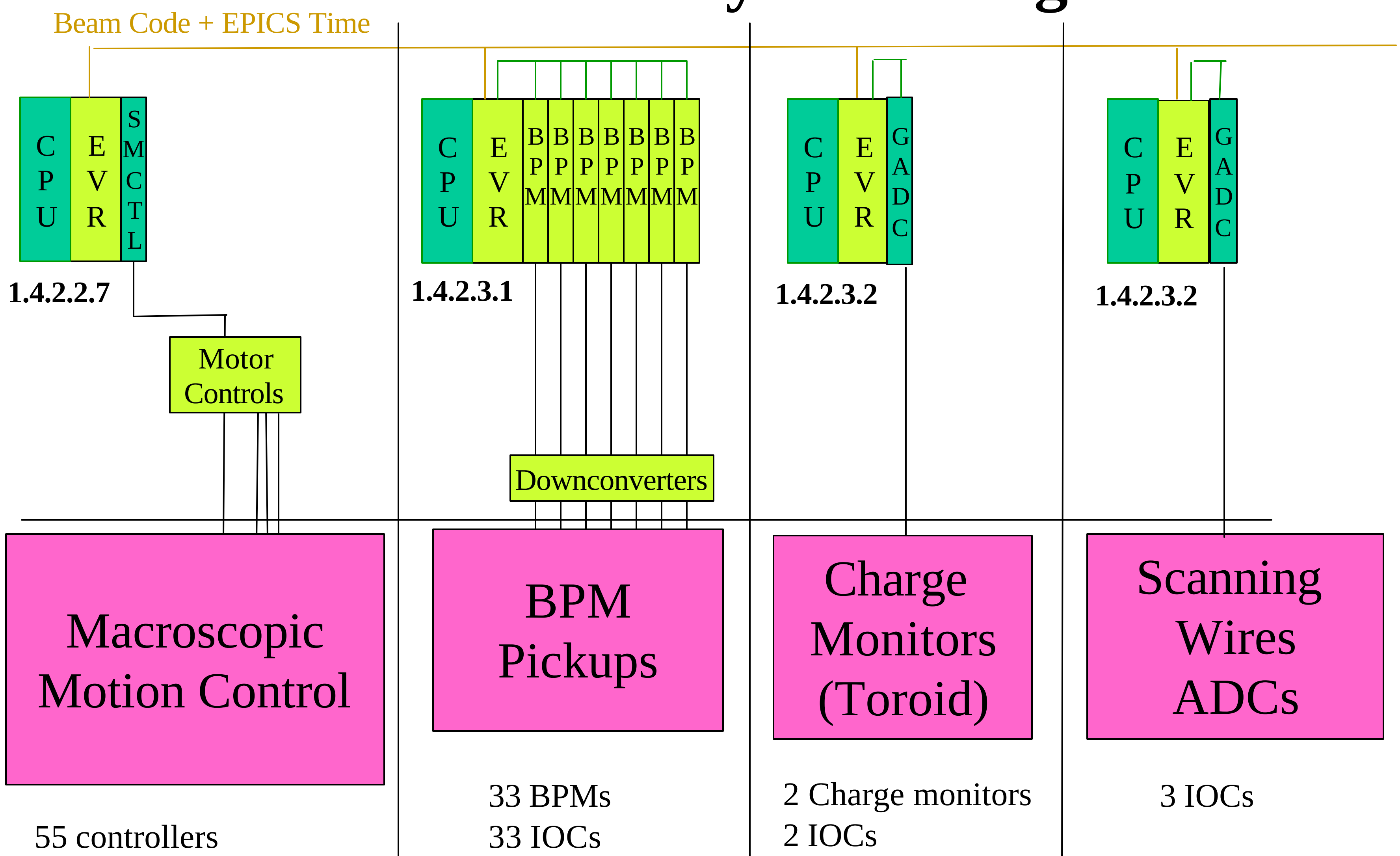

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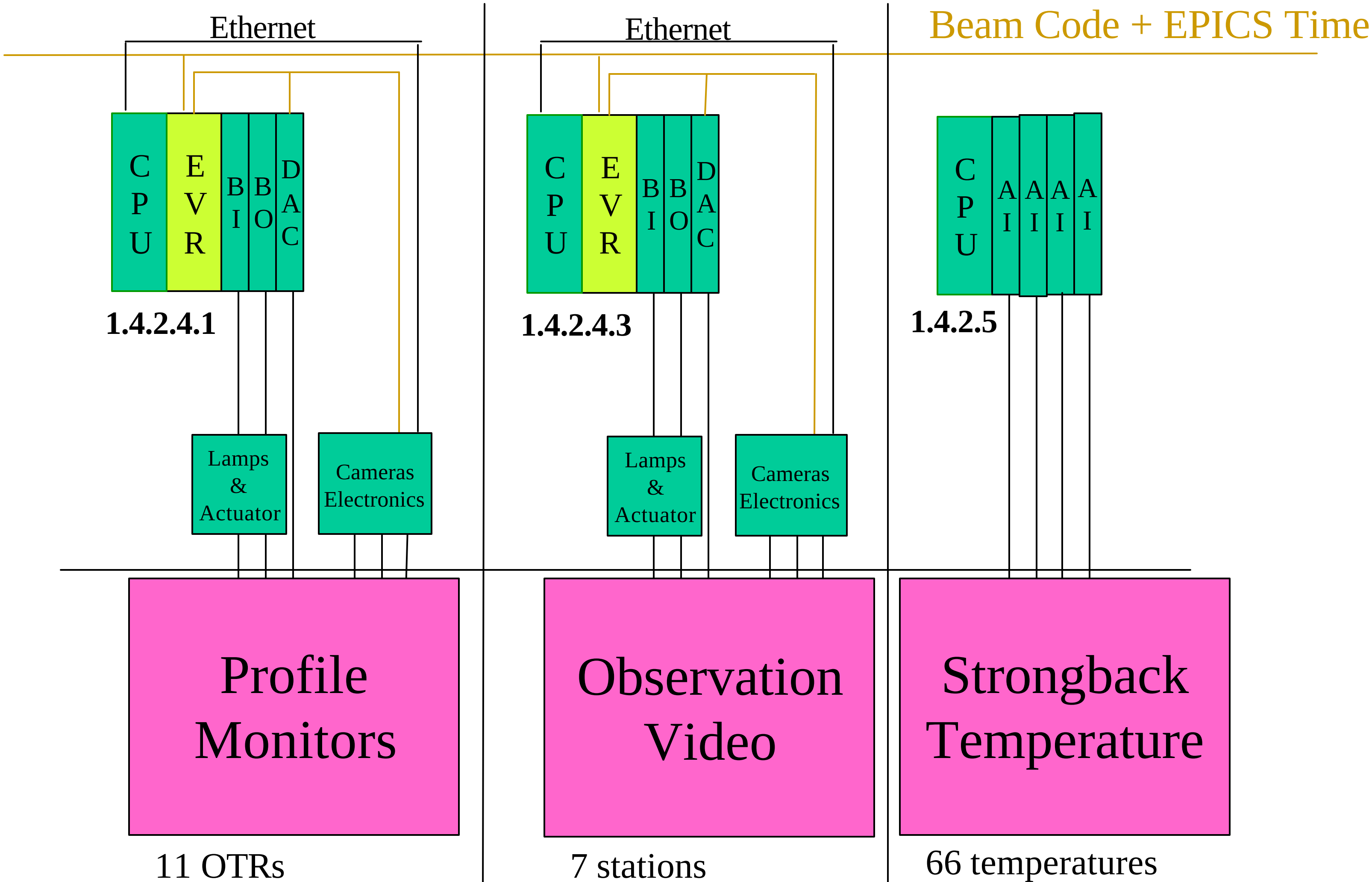

Undulator Subsystem Designs