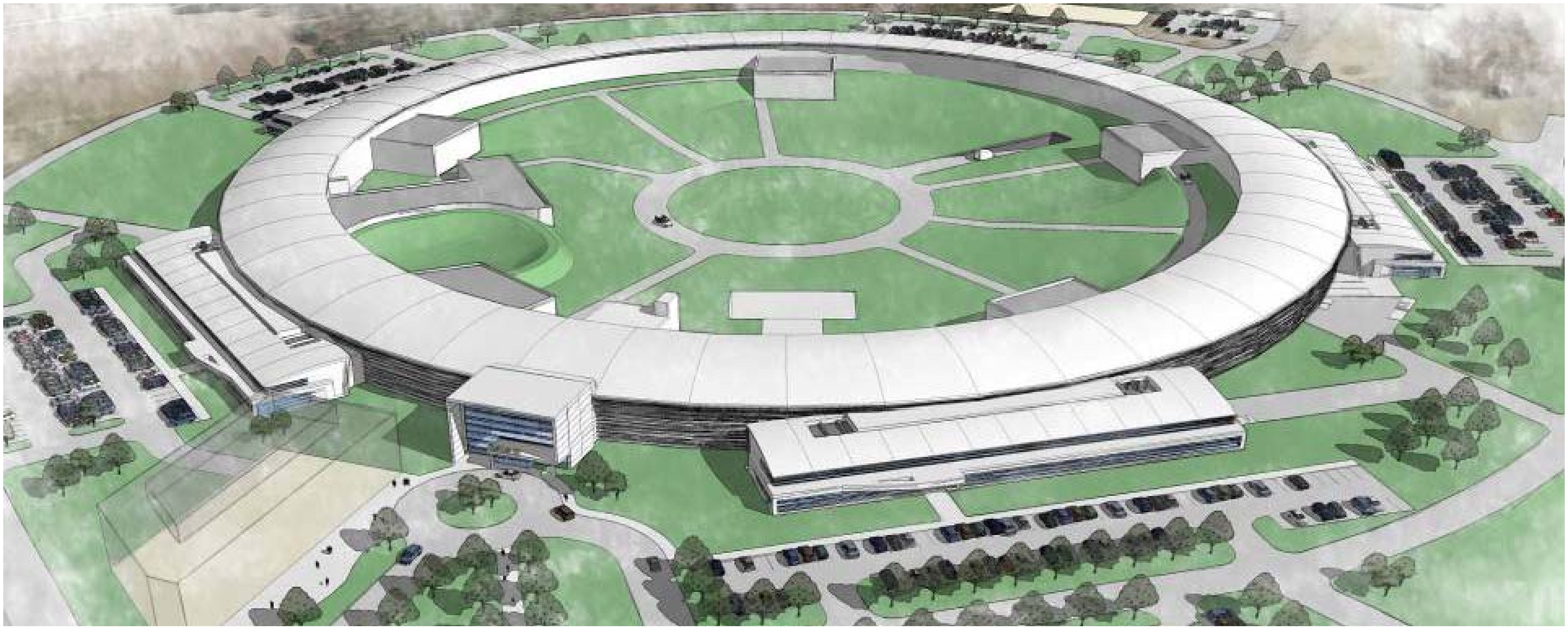
Control System Overview



Bob Dalesio

NSLS-II Control System ASAC Review

October 8, 2007

Office of Science
U.S. DEPARTMENT OF ENERGY

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Outline

- Requirements
- Standard Control System Components
- Development Opportunities
  - Embedded Device Control
  - Client/Server Architecture for High Level Applications
  - Relational Database and tools for all configuration parameters
- Risk Analysis
- Near Term Plans
- Concluding remarks

Control System Requirements – 1 of 2

- Bunch Length 11-15 psecs
- 2.6 usec ring revolution
- Top off bunch train 200 nsec
- Top off every 1 minute
- Top off damping time 10-30 msecs (no extraction)

- Manual control of orbit trims, quadrupoles, sextupoles, and insertion devices are asynchronous
- ~10 Hz write/read is suitable for "turning knobs" for a power supply
- 5 Hz updates to operators of up to 1000 chosen parameters
- Archive up to 6000 parameters at a rate of .5 Hz continually Must scale to support 150,000 physical I/O connections and 400,000 computed variables
- 99.99% availability 24/7

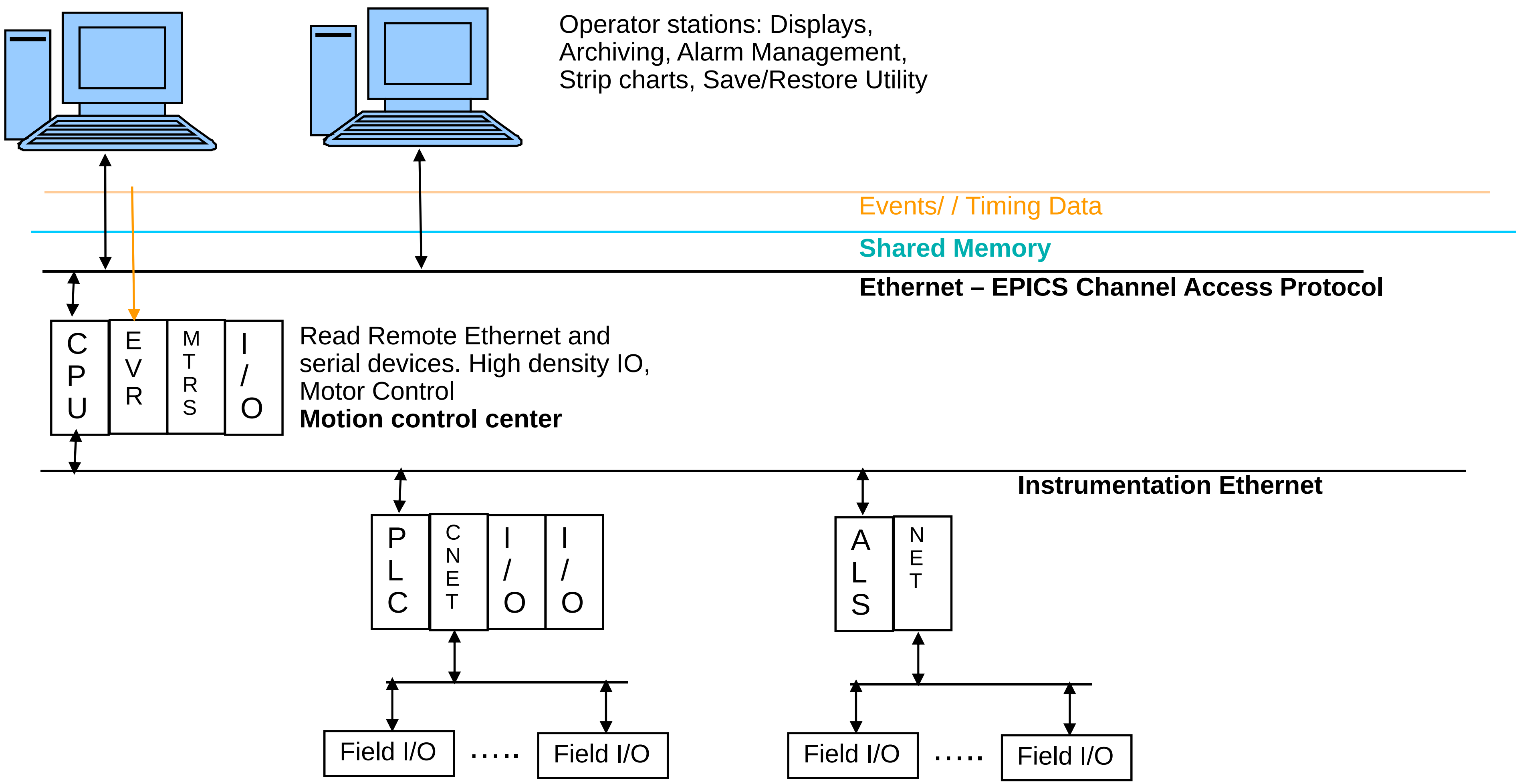
Control System Requirements – 2 of 2

- Provide data for all control aspects
- 1 Hz model based control
- 10 kHz power supply read backs triggered from timing sys
- 10's of Hz Data Collection for RF loop correction at 1 Hz rate
- 5 KHz RF Feedback on beam phase
- 5 kHz orbit feedback, 180 BPMs 120 Corrector PS in 90 I/O Controllers (IOC) (200 usec loop time)
- 80 psecs pulse to pulse timing jitter at a 1 Hz rate
- 20 msec equipment protection mitigation
- Take coherent turn by turn orbit data for up to 800 channels 1024 turns
- Latch the last 10 seconds of data from all parameters in the storage ring

Control System Standards

- EPICS based
- Embedded Real-Time Operating System choices: RTEMS which is in use at LCLS, Spear, and CLS or VxWorks which is in use at APS, SNS, Diamond, and SLS.
- Linux Workstations
- Use of standard EPICS engineering tools: Extensible Display Manager, Channel Archiver, Striptool, Alarm Handler
- Visual Database Configuration Tool w/ Modifications for Table Entry
- Use of physics applications: Matlab Middle Layer Toolkit (MMLT) which is in use at LBL, Spear, Diamond, SLS, CLS, and ASP, and eXtensible Acclerator Language (XAL) which is in use at SNS.

Control Components For Slow Applications



Siemens' PLC
Slow I/O, High Reliability,
Low Accuracy, High Density
Vacuum, PPS, MPS, PS , Cryo

Slow I/O, High Reliability,
Low Accuracy, Low Density
Facility control

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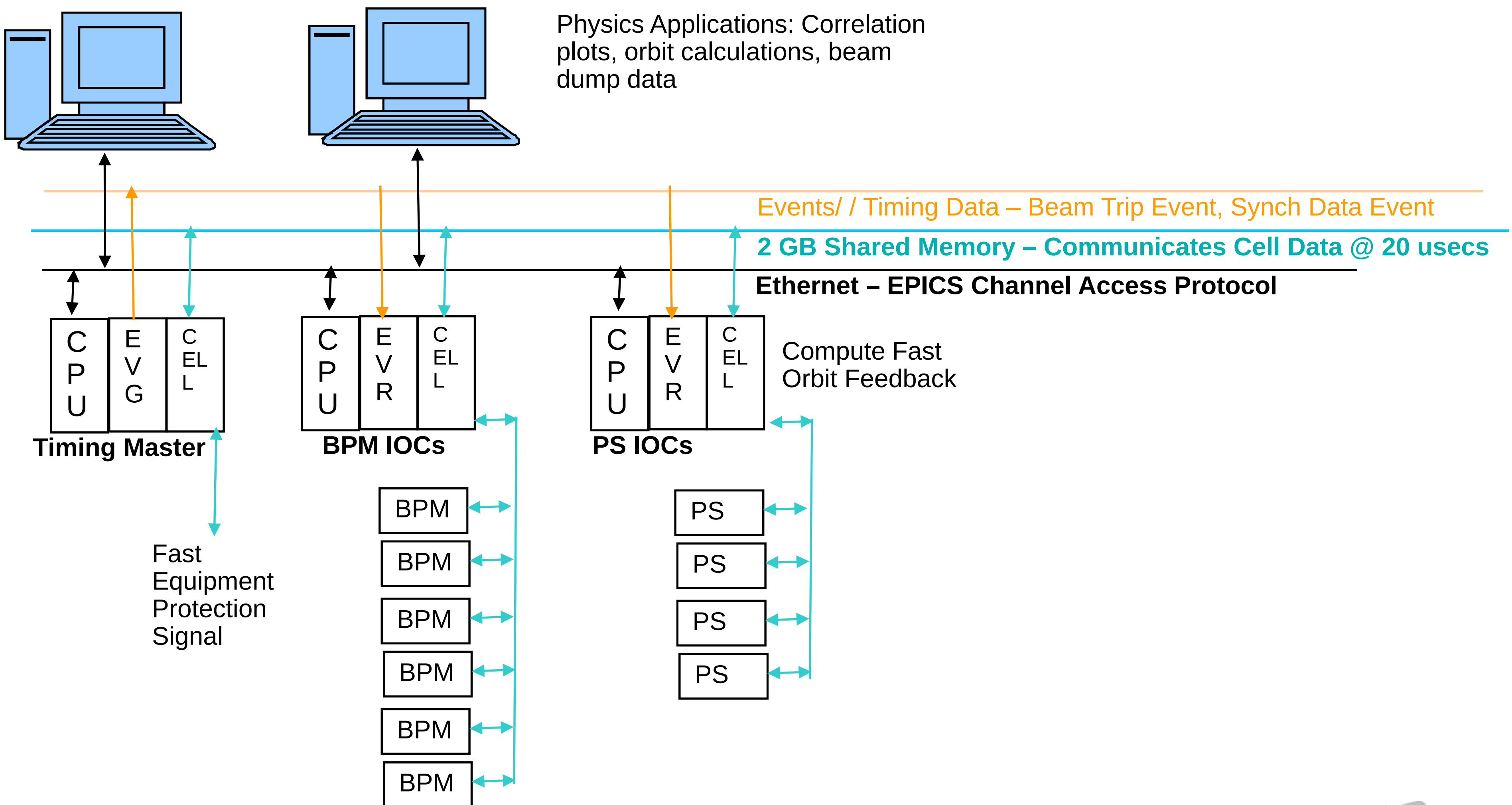
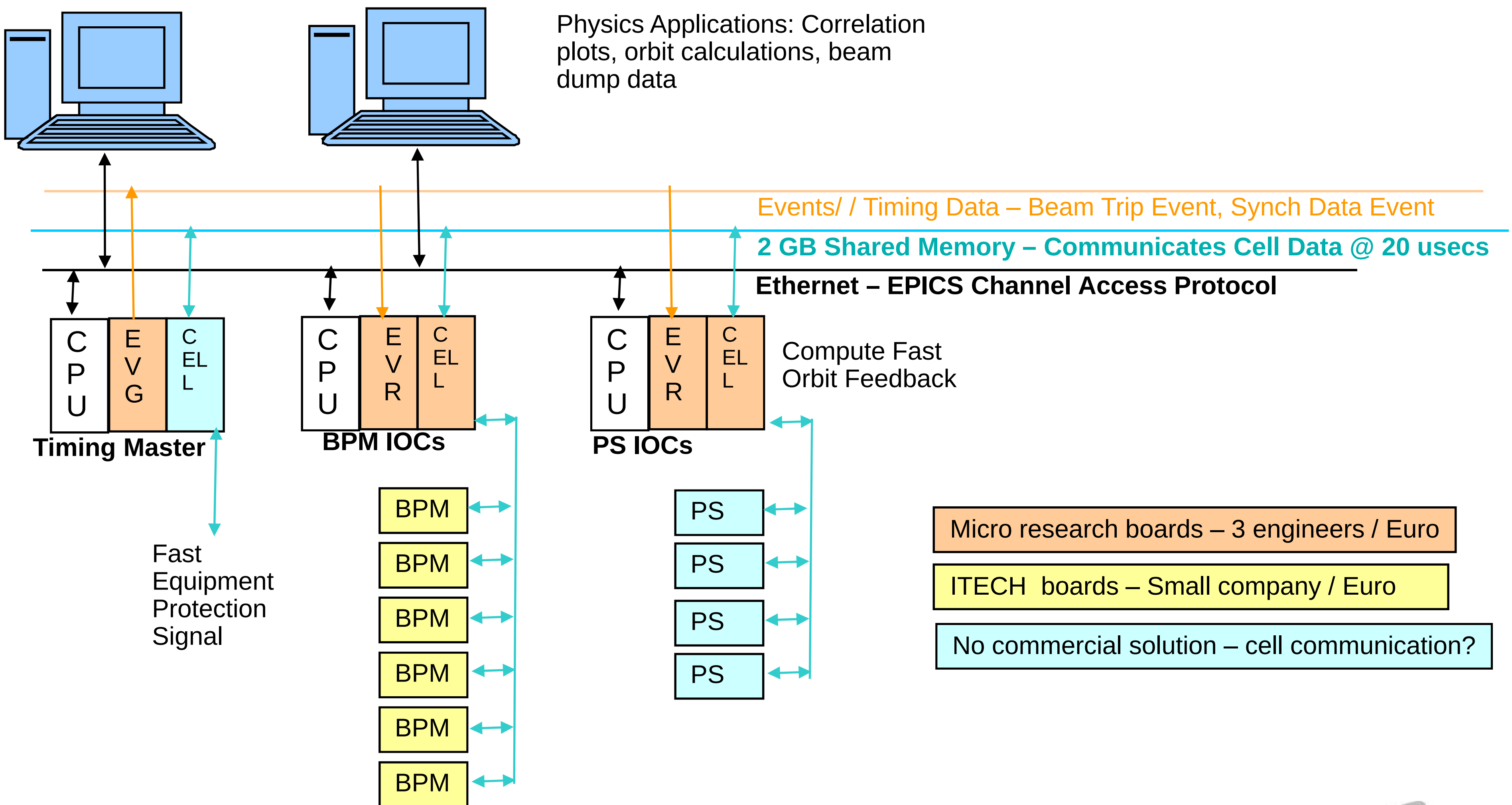
Control Components For Beam Synchronous Applications



Areas For Technical Development

- Embedded Controllers for high speed, deterministic functions are not handled by EPICS nor any standard. Determine if we use commercially available boards, or develop an open platform on which commercial boards can be built.
- High Level Applications currently tie together functions through data or file structures. To make the components of High Level Applications modular and distributed, a client/server architecture is needed.
- Relational Databases support data management through the life of a project. Development of adequate tools to enter and report this data is required early.

Embedded Controllers – Commercial Options

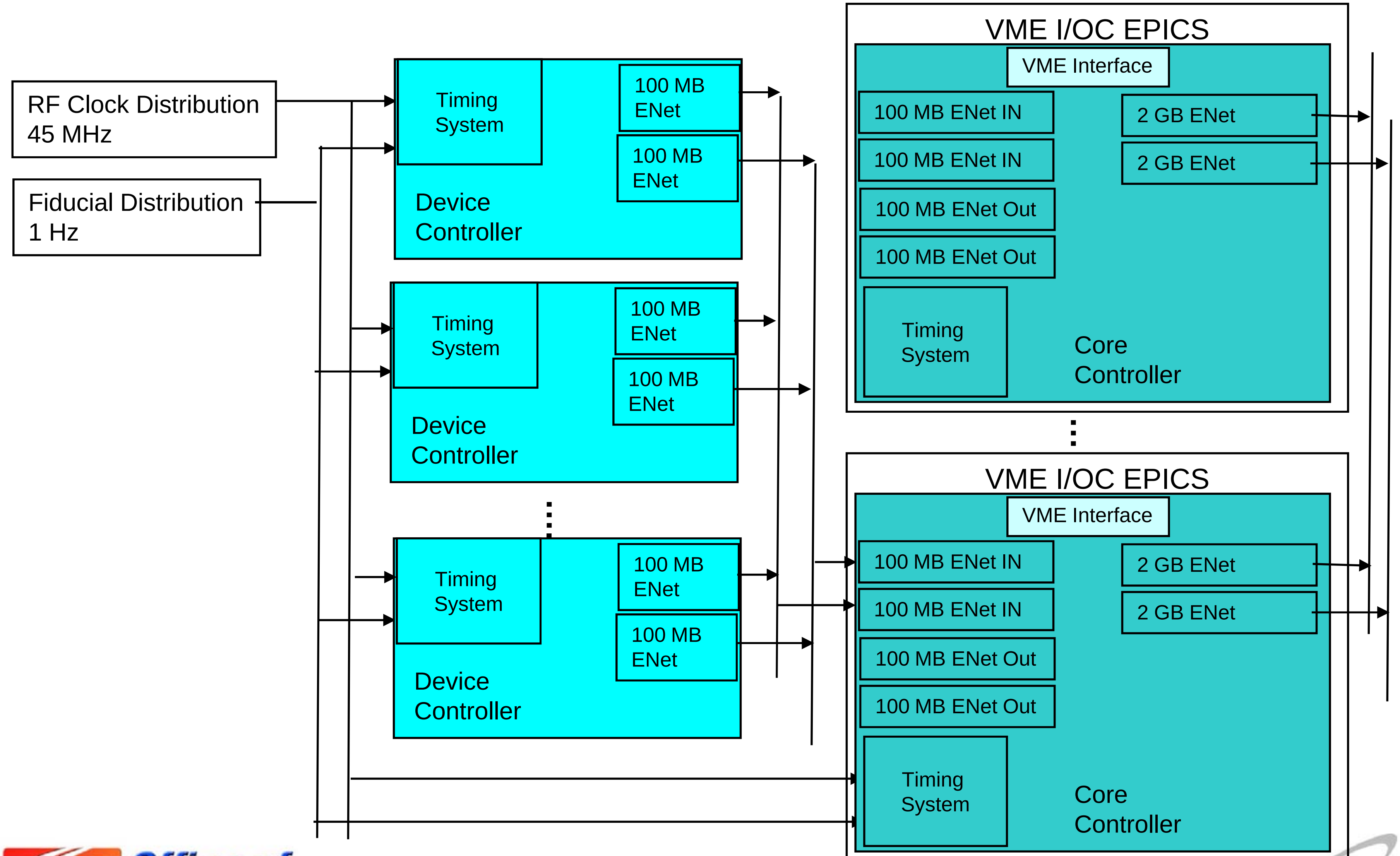


Micro research boards – 3 engineers / Euro

ITECH boards – Small company / Euro

No commercial solution – cell communication?

Embedded Controllers – Two Tier Device Control



Embedded Controllers - Per Cell

+T0

+ - Settling time on BPMs?

+0.0 usecs - BPM to Compute Controller

384 bits = 64 bits * 6 BPMs

4.9 usecs = 384 bits over 100 MBit enet

+4.9 usecs - Compute Controllers to each other

10,290 bits = 30 nodes * 384 bits

10.5 usecs = 10,290 bits over 2 GB enet

+15.4 usecs – Compute local matrix

0 usecs

+ 15.4 usecs - Communicate t Power Supply Controllers

24 = 4 PS * 4 bytes each

3.5 usecs

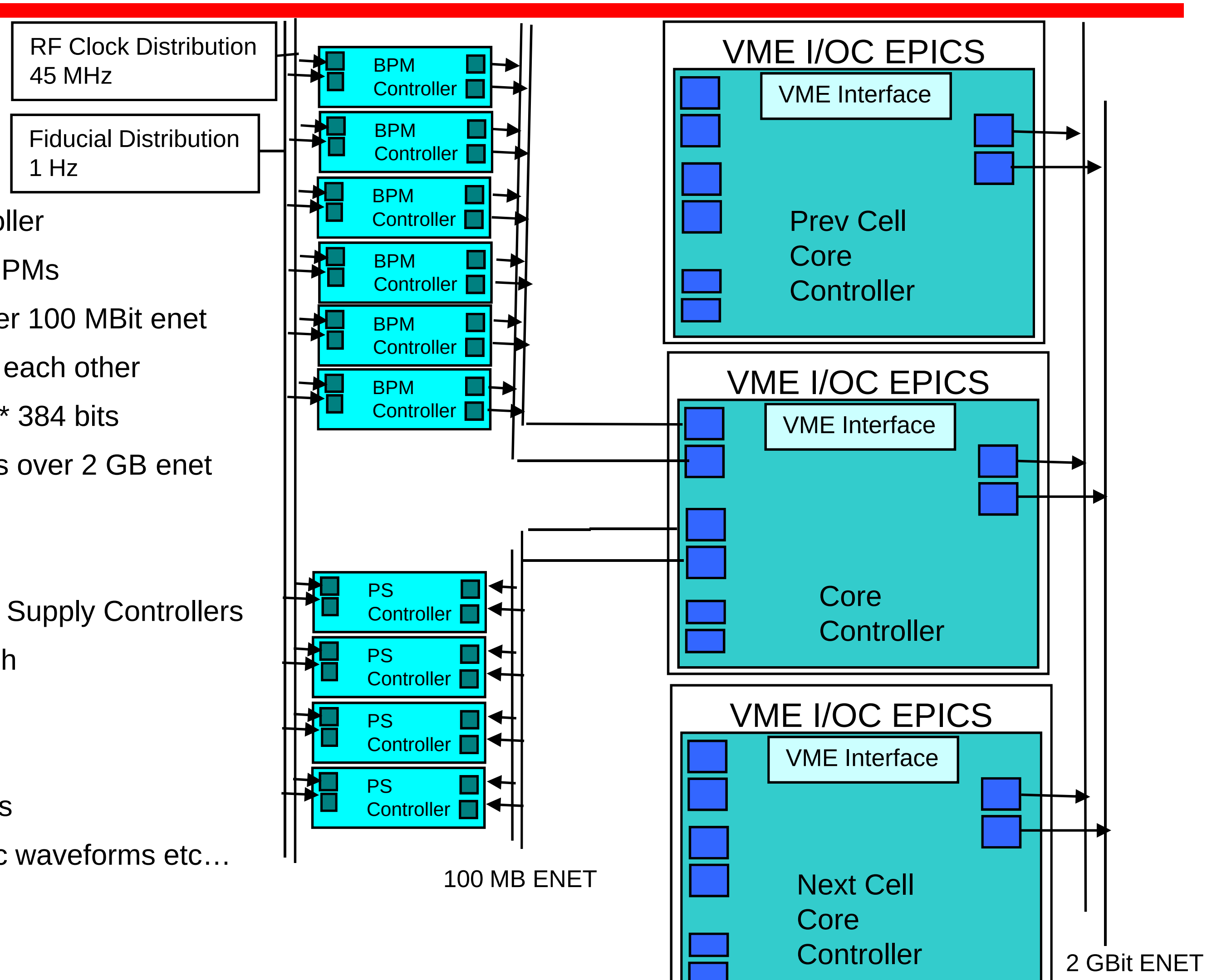
+18.9 usecs – loop complete

settling time for magnets

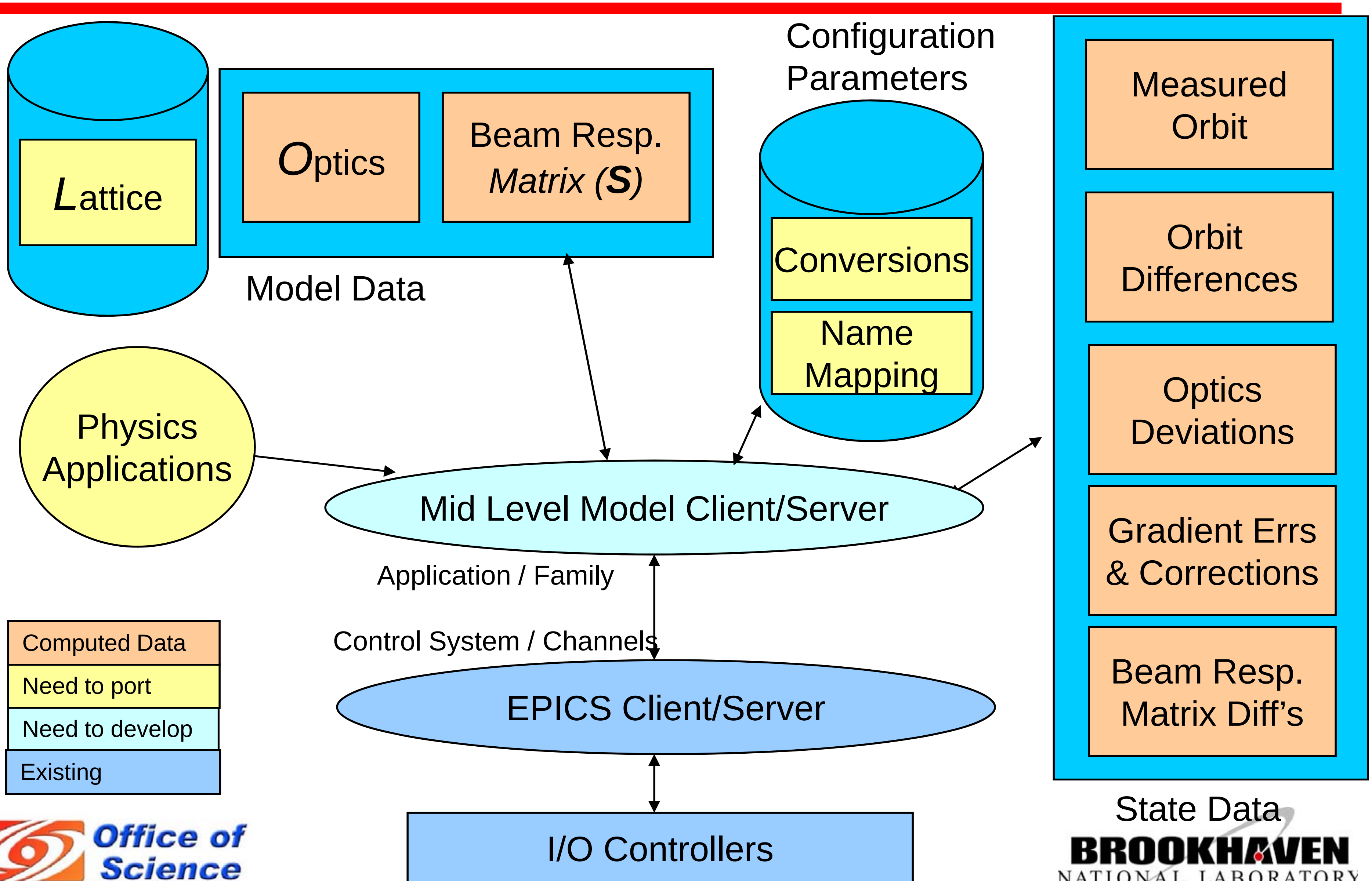
communicate diagnostic waveforms etc…

181.1 usecs headroom

+200 usecs – start again



High Level Applications – Client/Sever



High Level Applications - Approach

- Install an operational NSLS II simulation using Matlab Middle Layer Toolkit
- Define an interface library for physics applications to communicate to the configuration parameters, calibrations, model data, and measured data.
- Port the Matlab Middle Layer Toolkit onto the interface library one application at a time.
- Develop a client/server implementation of the interface library.
- Use an RDB to store configuration parameters and calibrations.

Relational Database

- Support all configuration data
- Provide tools as they are needed throughout the project.
- Make the RDB the source of all configuration data and derive it from there for all uses.

Relational Database - Approach

- Use the IRMIS database as the basis for our component and wiring database which is currently in use at APS, SNS, CLS, Diamond, and SLS.
- Hired, Don Dohan, author of IRMIS, to direct our database efforts.
- Extend the database to support Optics early.
- Develop tools through contracts, collaboration, and the hire of a second RDB expert.
- Schedule the time and put in the project rigor to use the RDB and tools as new portions of the project are needed.

Risk Assessment – 1 of 3

- **Description:**

  As intelligent controllers become prevalent, a standard for integrating them for fast, low latency global functions is needed. These intelligent controllers allow more functionality to be put close to the device and allow the use of a standard Ethernet protocol to be used to integrate it. How this protocol is used needs to be determined.

- **Technical Risk:**

  All current solutions are proprietary, available from small companies, and do not cover all functions.

Schedule Risk:

None

- **Cost Risk:**

  None.

- **Mitigation:**

  Work with experienced board designers to develop an open-source platform for device control early. In parallel, attempt to license the technology from commercial companies. The fallback is to use the higher density I/O controllers in VME and existing proprietary commercial equipment. Require the drawings and source code be put into escrow in case of failure of a small company.

Risk Assessment – 2 of 3

- **Description:**

  The plan for configuration control and data management is to use a relational database. The RDB would keep all of the accelerator parameters, device list, signal list, wire lists, and run-time database configuration parameters. It is used for model codes to acquire name space and optics information. It is used by the equipment interface to get all configuration data. It is used by other tools to acquire parameter name space to be used for configuring data archiving and viewing.
- **Technical Risk:**

  None
- **Schedule Risk:**

  The infrastructure for these things needs to be in place very early. It would be useful to have these started early to provide useful tools in a timely fashion. Work in both areas could benefit the physics design in the very early stages as well. If the tools are not in place, this data will end up in all sorts of files that require some data management:
- **Cost Risk:**

  None
- **Mitigation:**

  Start early, hire early, leverage off of the work at APS and SNS, and contract to those with proven track records in this area. The fallback is to use flat files where we do not get this in place.

High Level Applications - Risk Analysis

- A version of the high level application programs exists, however, definition of the interface library is a difficult task.
- If the Interface library is not successful there is a working version of the high level applications.
- Development is being made in coordination with high level application experts at LBL, SNS, and Diamond.
- Outside vendors are being used to get a quick start on the project.
- There is **no risk to track** – but an opportunity to make a significant improvement in the development high level applications can be achieved.

Risk Assessment – 3 of 3

- **Description:**

  As NSLS and RHIC remain operational during the NSLS II project, finding control staff may be challenging. ..

- **Technical Risk:**

  Under-qualified staff can miss some of the tougher problems in accelerator control and provide solutions that do not meet all of the system requirements

- **Schedule Risk:**

  Staff that is not familiar with the problem area can easily overrun budgets by not completing the work in a timely fashion

- **Cost Risk:**

  The lack of qualified control personnel in key position jeopardizes the ability to execute the project efficiently

- **Mitigation:**

  Recruit key personnel from the community that are familiar with the tools that we are using. Perform reviews from outside experts familiar with the tools. Augment staff with experienced contractors from the community. Use standards from other projects.

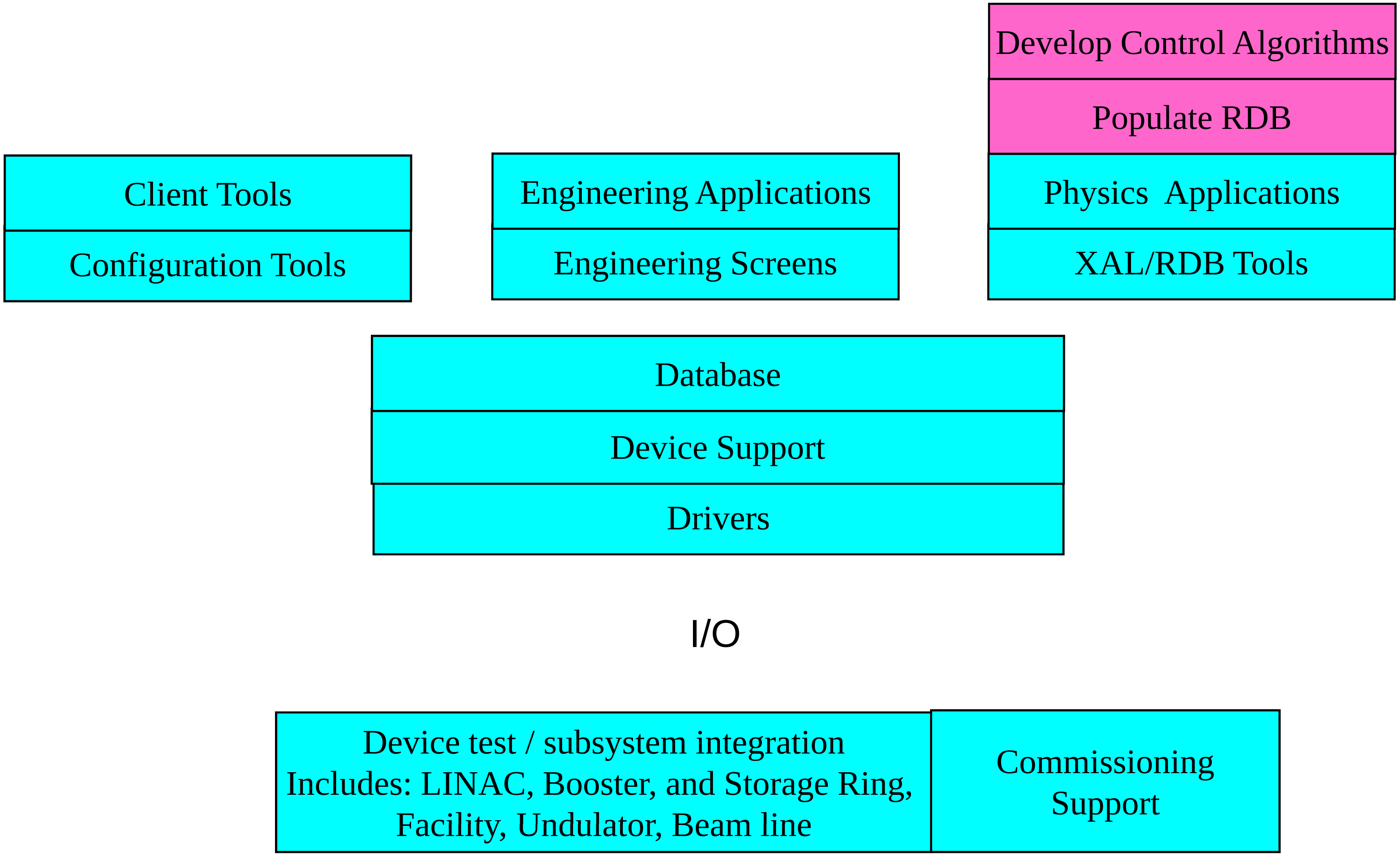
Near Term Plan

- Start R&D
  - Start development of open-source embedded device controllers with LBL team (Larry Doolittle and Alex Ratti)
  - Install IRMIS and extend it to support Optics
  - Develop RDB tools for entry and reports
  - Start High Level Application Environment
- Make Preliminary Hires
  - Control leader – Bob Dalesio signed.
  - RDB engineer(s) – Don Dohan started Oct. 1. Some work being contracted out
  - Key EE/IT – job ads being prepared for High Level Applications work
- Start Preliminary Design

Concluding Remarks

- Global requirements are complete
- Equipment control S/W and H/W infra-structure is selected.
- A collaboration of LBL and SLS EEs along with NSLS II team are prepared to begin the open-source, embedded device controller development
- RDB tables and tools have begun with a key hire and an approach that builds on the success of IRMIS.
- High Level Application environment is selected. The Diamond simulation running under EPICS is to be installed along with the Matlab Middle Layer Toolkit as a starting point.
- The API for High Level Applications is being developed in conjunction with MMLT and XAL authors.

Control System Scope



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WBS 1.03.05 Global Controls System

WBS Dictionary: Hardware and software for the global controls of the linac, booster ring, transport lines, storage ring, network, relational database, data archiving, timing, fast feedback, and physics application support.

WBS Description	Direct $		
	FTEs/yr		Material
1.03.05/01 – 1.03.05.09 Apps: Diagnostics, RF, Power Supply, Vacuum Subsystem Integration of: Insertion Devices, Beam lines, Safety Systems, Facility	7	5.3 M	1.9 M
1.03.05.12 Timing	1.5	1.2 M	0.4 M
1.03.05.11 & 1.03.05.13 High Level Applications	6	4.8 M	0
1.03.05.10 Accelerator Control Room		75K	0.2 M
1.03.05.11 Network	.5	0.3 M	1.3 M

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~ 10% of Accelerator

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