國家同步輻射研究中心
National Synchrotron Radiation Research Center

Design Status of the TPS Control System

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Taiwan Photon Source - Major Parameters

Circumference C (m)	518.4
Energy E (GeV)	3.0
Natural emittance ε_{x0} (nm-rad)	1.6
Revolution period (ns)	1729.2
Revolution frequency (kHz)	578.30
Radiofrequency (MHz)	499.654
Harmonic number h	864
SR loss per turn (dipole) (MeV)	0.85269
Betatron tune ν_x/ν_y	26.18 /13.28
Momentum compaction (α_1, α_2)	2.4×10^{-4}, 2.1×10^{-3}
Natural energy spread σ_E	8.86×10^{-4}
Damping partition $J_x/J_y/J_s$	0.9977/1.0/ 2.0023
Damping time $\tau_x/\tau_y/\tau_s$ (ms)	12.20/ 12.17 / 6.08
Natural chromaticity ξ_x/ξ_y	-75 / -26
Dipole bending radius ρ(m)	8.40338

Taiwan Photon Source Site Bird View

Total budget: ~ 200 Million USD

Schedule:

Most probably groundbreaking date: before the end of this year

Commissioning start in late 2013

Technical Selection for the TPS Control System

- Control system framework => EPICS toolkit.

- Budget and support consideration:
  Acquire as many of parts from local vendors as possible
  => Adopt cPCI, μ/aTCA, and other embedded solutions
  for IOC layer.

- Borrow available resources from other labs.

- Adopt updated products which will not phase out soon.

- Limited manpower limit too much development.
  Adopt available resources as possible.
  Only limited development is possible.

TPS Control System Infrastructure

Consoles and Servers

Intranet

Router, Firewall

DB Server, Beam Physics Server, Alarm Server, AP Server, … etc.

Storage Server

Control Network (100 Mbps/1 Gbps/10 Gbps Ethernet)

μ/aTCA IOC | cPCI IOC | cPCI IOC | Soft IOC

IOC (Input Output Controller)

Signal Conditioning

Switches

Soft IOCs

PLC-IOC

Hard IOCs
- cPCI, μ/aTCA IOCs
- Intel CPU/Linux (fully preemptive kernel)
- Hard real-time
- High volume I/O
- High speed serial connection

Network attached EPICS Devices (e.g. PS, EPICS oscilloscope, … etc.)

- Pentium/XScale/ARM/IXP/IOP Linux
- Soft real-time system
- CCD camera server
- PLC (safety type system)
- Bunch-by-bunch feedback system interface
- Special applications

Safety Type System

TPS Control Network Infrastructure

Control Room

Server & Network Room

Control Console | EPICS Control Server | Database Server

Rack | Rack | Rack

Internet

Firewall / NAT

NSRRC Intranet

Remote Multi-Display

Control system lab

Core Switch x 2 Redundancy

12-port Switch

IOC | IOC

Private Network

24-port Switch

PS | PS

Gateway

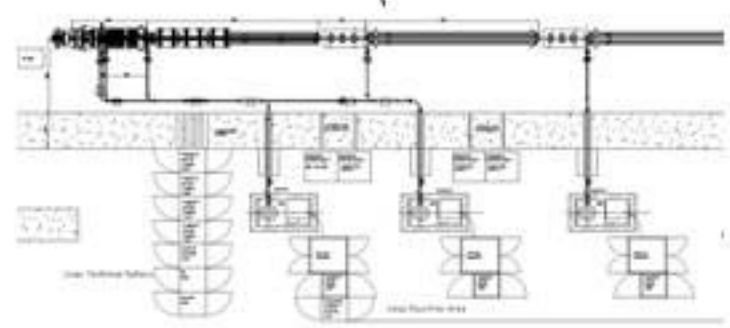
BL Control

Front End | Vacuum ...

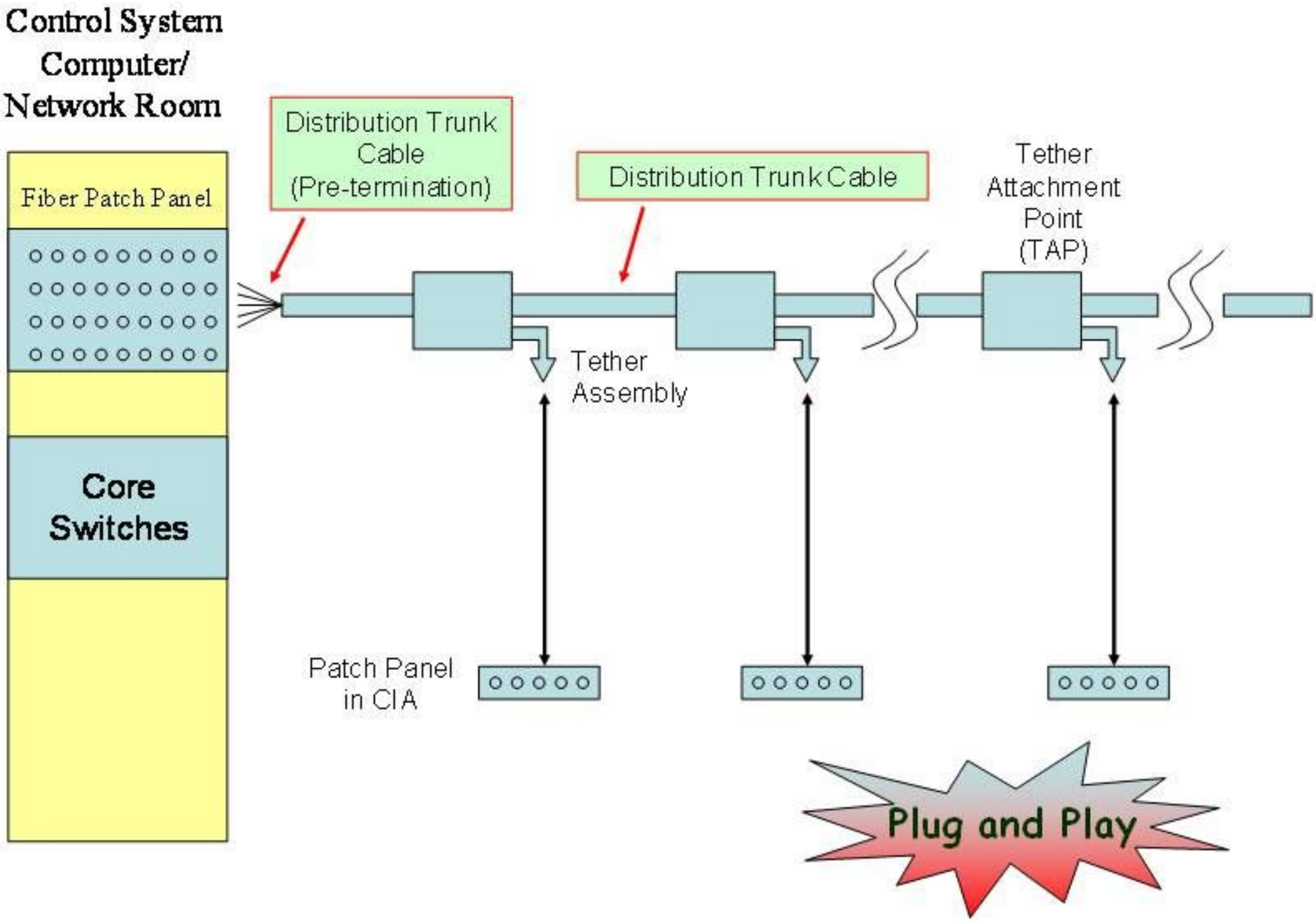
CIA-01 | CIA-02 | CIA-24

Injector

SR Dipole, Booster Dipole & Quadrupole Power Supply Equipments Area



Modular Cabling System



Hardware Building Blocks @ EPICS IOC Level

CompactPCI IOC (Linux)

cPCI CPU board

128 Bits DI/DO

ADC/DAC

EVG, EVR in 6 U cPCI form factor

BI, BO, AI, AO, Timing, Network attached devices

ACQ IOC (Linux)

Intel IOP + ADC

16 bits, 96 Channels
24 Bits, 64 Channels

Analog Reading
10 Hz rate and 10 KHz rate

μ/aTCA IOC
and
Feedback Platform
(Linux, Realtime Linux, FPGA)

AMC Module

Carrier Module

Compute Blade

Switch Blade

Carrier Blade

Special Applications

PLC Embedded
EPICS IOC

Libera IOC
(Intel XScale. Linux)

Scope IOC

Network attached devices

Control Console Solution - Remote Multi-display Graphics

Remote multi-display graphics for human being comfortable environments with 24/7/365 :
- Improve control systems maintenance and life cycle support
- Climate and noise control for console consoles
- Better workspace management and ergonomics

Server Room ⇐ ⇒ Control Room

Better Cooling

Noise reduction
Save space
Don't need consider thermal problem
Slightly expensive

Interface Standard

- cPCI crate
  - Low cost, high performance and reliable cPCI system.
  - Redundant and hot swappable crate power supplies.
  - Remote crate management.
- cPCI I/O modules
  - 32/64 channel 24 bits ADC (with transient signal capture capability, D-tACQ)
  - 16/32 channel 18 bits DAC (D-tACQ)
  - 128 bit DI, 128 bit DO (ADlink)
  - Timing solution: EVG, EVR (cPCI & PMC form factor, MRF)
  - In house designed electrical/optical fanout, patch panels
- aTCA crates system
  - Network attached devices
  - Fast feedback
- Fast waveform capture : Scope IOC, LXI oscilloscope
- Camera (diagnostic): GigE Vision

Interface Standard - cont.

- Ethernet and LXI Compliant devices
  - Power supply
  - Diagnostics
  - LXI oscilloscope
  - DMM
  - Temperature monitor
  - … etc.
- Motion control: Ethernet based motion controller
- PLC solution
  - S7/300 PLC testbed: turnkey system from EU (Siemens or VIPA)
  - Yokogawa M3R PLC embedded EPICS IOC
  - Safety PLC (selected by the safety group)
- RS-232C/422/485 devices
  - Ethernet to RS-232/422/482 serial device servers or IOC

Power Supply Control Interface

- Large (Digital regulator)
  - Ethernet interface
  - ENOB > 18 bits
  - Communication protocol is still pending
- Medium power supply
  - Ethernet interface
  - ENOB > 18 bits
  - Communication protocol is still pending
- Booster synchrotron large and medium power supply
  - Ethernet interface with waveform capability
- Small power supply (analogue power supply)
  - Analog interface (18 or 24 bits)
  - cPCI 18 bits DAC

Turnkey System Interface

- Turnkey systems compliant with EPICS based controls.
- Turnkey systems include:
  - Linac (contracted out in December 2008)
  - RF transmitter (contracted out in December 2008)
  - Outsource insertion devices
  - Monochromator and other beamline components
  - … etc.
- Possible turnkey EPICS devices included:
  - BPM electronics, Scope IOC, …
- Minimize workload of integration and maintenance
  - Standard components should be chosen to get consistency of hardware
  - Provide EPICS development environment and documentation
  - Follow TPS PV name convention

Linac System Control Environment

EPICS

TPS Control Environment

TPS Control Network

Timing Network

EPICS OPI

Diagnostic IOCs (Transient Digitizer, GigE Vision Camera,... etc.)

Linac Timing IOC (Linux)

cPCI IOC + Event Receiver + cPCI CPU board + Fine delay + Fanout (Electrical, Optical)

Scope IOCs

ACCEL's EPICS Soft-IOC

Local Control Panel

Linac Control Ethernet Switch

Trigger Signal

Gun grid pulser, Klystron Current/ Voltage, RF, Faraday Cup, Current Transformer, ... etc.

Optical Fiber

Gun Trigger

Local Controller (PLC, ..etc.) — Gun

Local Controller (PLC, ..etc.) — Modulator #1

Local Controller (PLC, ..etc.) — Modulator #2

Local Controller (PLC, ..etc.) — Modulator #3

Local Controller (PLC, ..etc.) — Power Supply

Local Controller (PLC, ..etc.) — Rf

Local Controller (PLC, ..etc.) — Vacuum Interlock,...etc.

Linac Timing Box — Linac RF, Diagnostic, ...etc

Booster Synchrotron Control Environment

Control Network

6 cPCI crates for the TPS booster synchrotron,

One cPCI for one period of the booster lattice

Booster Repetition Rate: 3 Hz

EPICS IOC
ADLINK cPCI CPU

ADLINK 128 Bits DI/DO

TEWS
TCP201
IP Carrier

IP ADC

Hytec IP DAC
16 bits, 18 channes

Trigger

register mode
or
waveform mode

Interlock
PLC IOC

Ethernet Switch

Dipole
PS

QM
PS

QF
PS

Q2
PS

Q1
PS

Miscellaneous Control
(Vacuum, ambient parameters, …)

Booster Correctors for one Cell
Power Supply Crate
Hor: 10 sets
Vert: 6 sets
(waveform capability)

Timing Solution

TPS Event System (MRF)

cPCI6U-EVG-300
(in develop)

Fan-Out Concentrator

cPCI-FCT-8

cPCI6U-EVR-300
(in develop)

cPCI6U-EVRTG-300
(=VME EVR230 + GUN-TX
+GUN-RX + 4TIMD)
(in develop)

Hardware will available in late 2010

Prototype system

cPCI-EVG-230

cPCI-EVR-230

Develop EPICS Device and
Driver Supports

Simple Configure Page

Miscellaneous System Interface

- Vacuum system

  BI, BO, AI, AO, serial links, ..etc.

- Diagnostics

  BPM electronics: Ethernet.

  BI, BO, AI, AO, counter

- Machine protection

  Dedicated PLC system with fast link

  Ethernet to control system.

- Personnel protection

  Dedicated PLC system with fast link

  Ethernet to control system.

  .....

Proposed Infrastructure for the TPS Orbit Feedback

- Global orbit feedback loop combined with slow and fast corrector

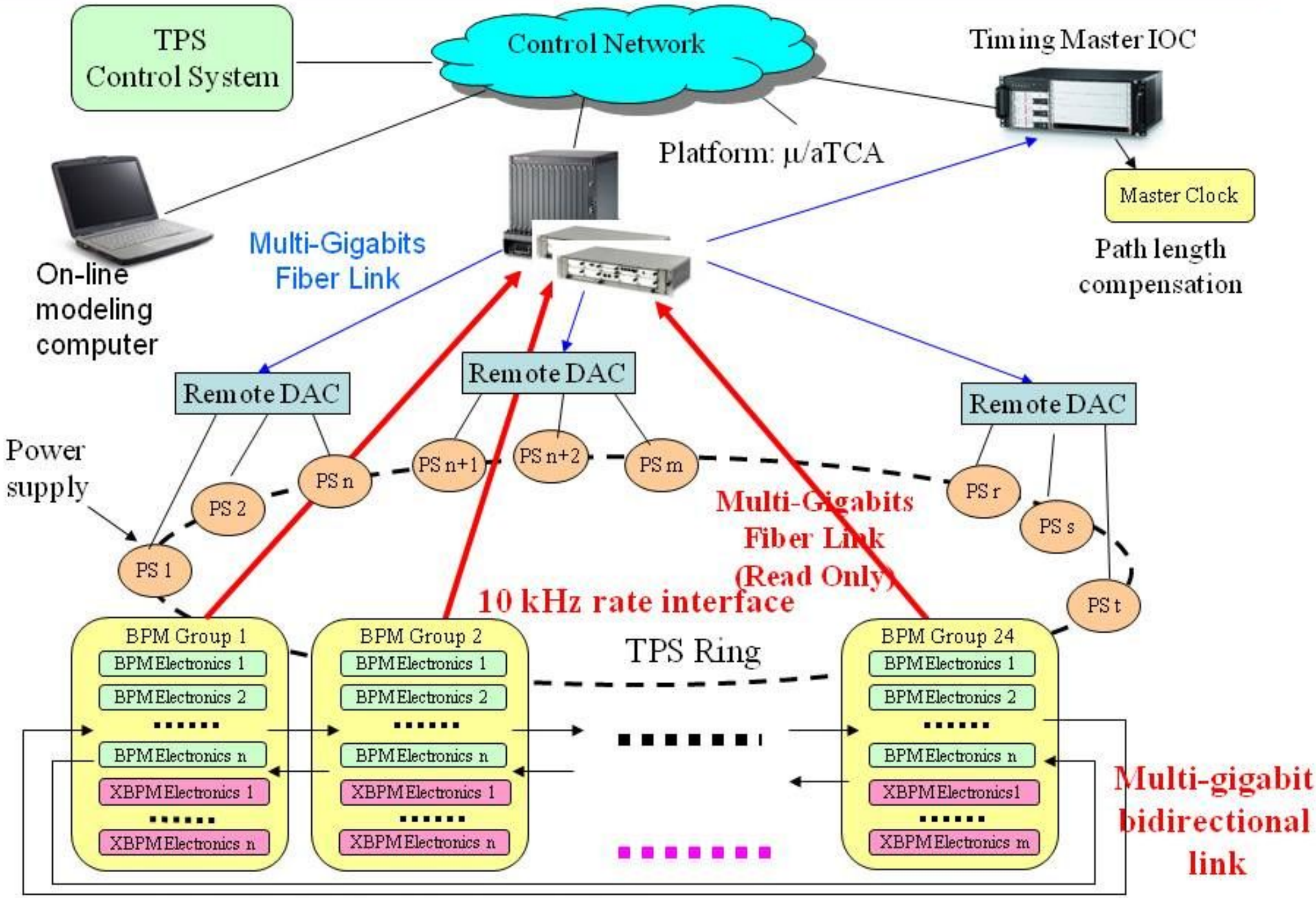
- xTCA platform

- Prefer to FPGA based system

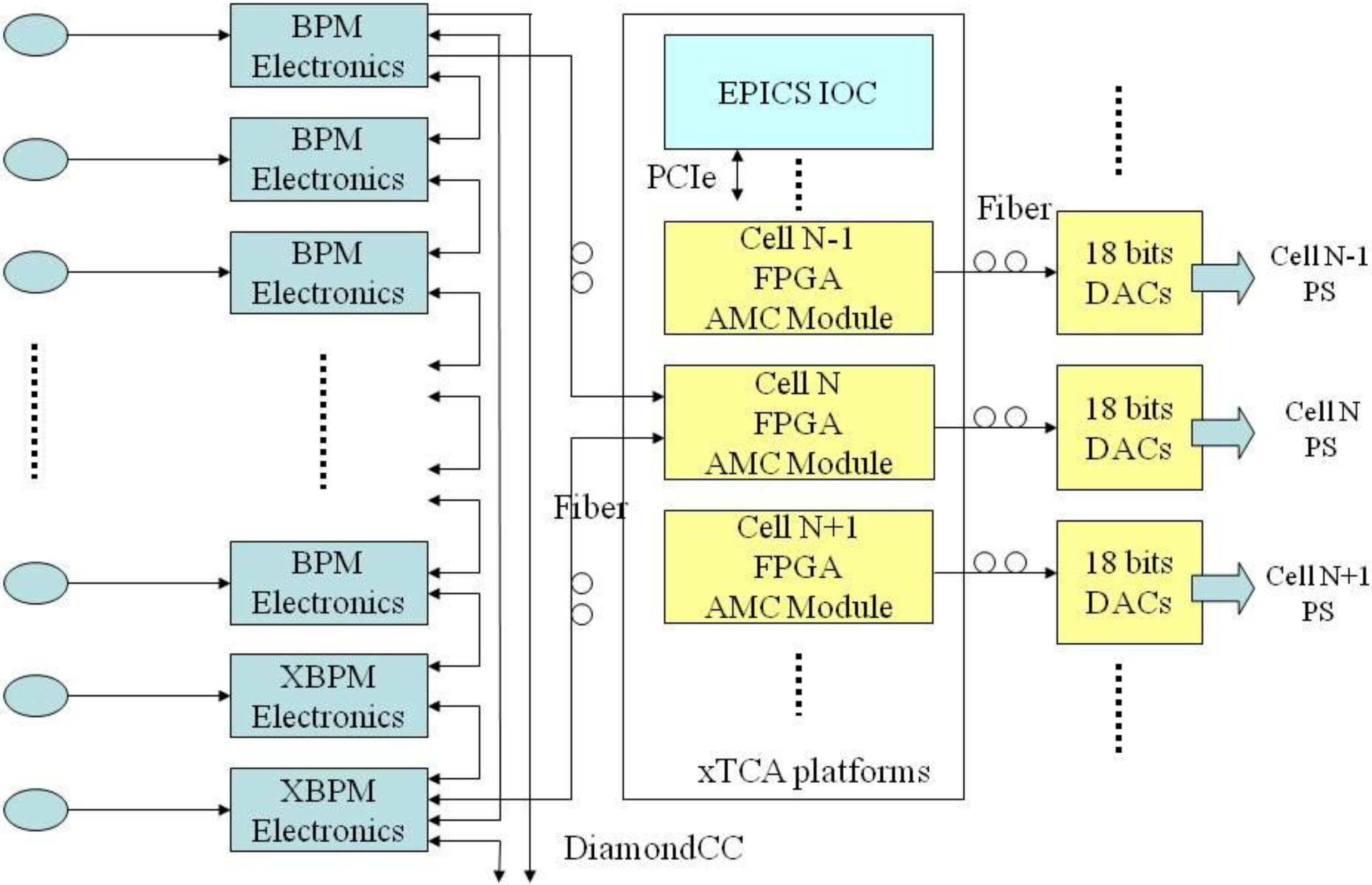
- Fast BPM data transportation
  Gigabit ethernet Libera Grouping or DiamondCC or another scheme

- Corrector control
  Remote high resolution DAC

Proposed Infrastructure for the TPS Orbit Feedback



One of an Implementation Option
μTCA/aTCA/AMC + FPGA + DiamondCC + Remote DAC



Post-mortem Diagnostic Supports

- BPM electronics:

  Post-mortem buffer (turn-by-turn)

  Dedicated fast data capture nodes to capture for more than 5 seconds at 10 kHz rate.

- cPCI ADC module with post-mortem buffer:

  Up to 10 msec time resolution for more than 5 seconds.

- Transient and waveform diagnostic:

  High timing resolution (~ nsec) with segmented sweep multiple-trigger capability

- Beam trip trigger is planned to distribute via event system.

Software Environment

- Control system framework:
  - EPICS toolkits

- High level physics applications:
  - Matlab/Accelerator Toolkit/Matlab Middle Layer
  - Setup virtual accelerator to support high level application development is underway

- Many items are still in study
  - Relation database
  - Technical system interface
  - Documentation, E-log
  - Machine status broadcasting: web, IPTV
  - …etc.

High Level Applications Interface

EPICS Clients

High Level Matlab Applications (scripts and functions)

Matlab Middle Layer

Matlab to EPICS (LabCA)

Accelerator Toolbox (AT) (Model)

Channel Access to Accelerator Hardware

EPICS Process Database

Dipole

Quad

Sext.

Corr.

BPM

RF

Thanks help form G. Rhem and J. Roland (DLS), G. Portmann (ALS)

VA EPICS IOC

EPICS Process Database

Dipol

Quad

Sext.

Corr.

BPM

RF

MML switch2hw switch2physics

Lattice File

AT

Virtual TPS Storage Ring IOC

To enable early testing of applications through the control system, a virtual accelerator has been implemented to give simulation of the accelerators though the intended EPICS PV interface. Current version is AT/MML version.

Works in Proceed

- Cultivate EPICS peoples.
- Define standard hardware, work out on EPICS Device/driver supports.
- Family of various clients and server tools of EPICS.
- Planning for various issues (name convention, networking, …).
- Setup testbed in 2010 ~ 2011:
  - Training system
  - Various IOCs prototype
  - Various EPICS clients applications
  - RDBMS
  - OPI
- Work out a solid plans for the TPS control system:
  - Procurement, development, priority schedule, implementation, installation, commissioning, …

Summary

- Standardization of hardware and software are in proceed.
- Work out EPICS device/driver support to various selection hardware is under way.
- Setup test-beds and dummy IOCs for evaluation and applications development is a short term goal.
- Economic and high performance design and implementation.

Thank You for Your Attention!