EPICS Meeting:

Experimental Control & DAQ for PAL-XFEL

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PAL-XFEL/Pohang Accelerator Laboratory

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Outline

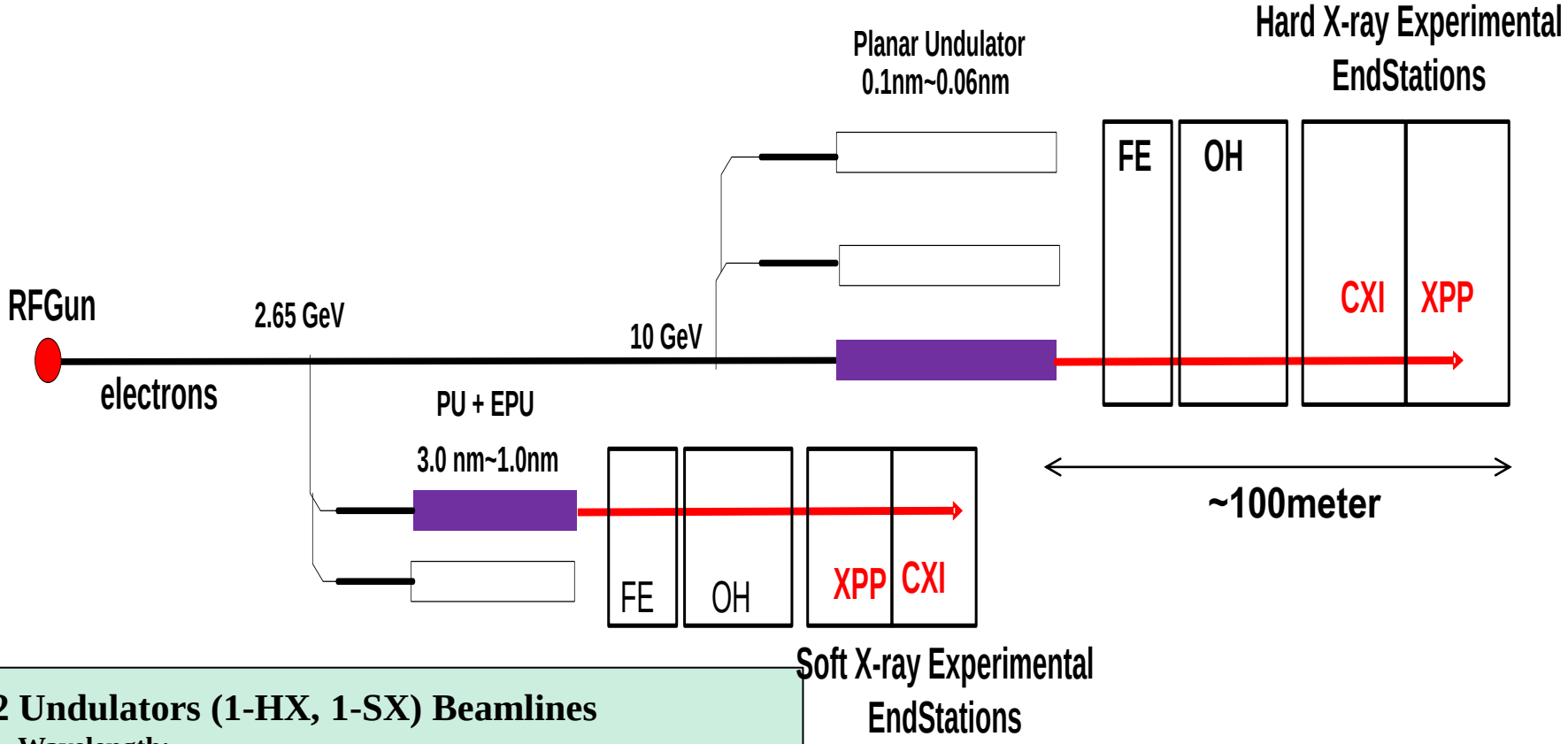
- PAL-XFEL BeamLine
  - Beamline overview
  - Control system layout(Planned)
  - DAQ system layout(Planned)
- Hardware
  - Triggering System for detectors & diagnostic instruments
  - DAQ for 2D Detector
  - xTCA based control system
- Software
  - EPICS Version 4 support for Beam Line Control and DAQ
- Summary & Future Plan

PAL – XFEL site view

Comparison of the XFEL Sources

	LCLS	SACLA	Euro XFEL	PAL XFEL	PSI XFEL
Max. E-beam energy(GeV)	4.5-14.5	6-8	10-17.5	10/3	2.1-5.8
Wave length(nm)	0.15-1.5	0.05	0.05-6	0.06-12	0.1-0.7 0.7-7
Time structure(Hz)	120	60	10	**60**	100
bunches/pulse (Bunch spacing)			2700 Max. (220ns)		2 (50ns)
FEL Duration(fs)	230 FWHM	30 FWHM	100 FWHM	50 RMS	0.3-13 RMS
Band width(%)	0.3	-	0.08-0.65	0.11-0.9	0.03-0.05 0.15-0.25
Commissioning	2009	2011	2015	2014	2015/2018

Beam Line Layout (Phase-I)



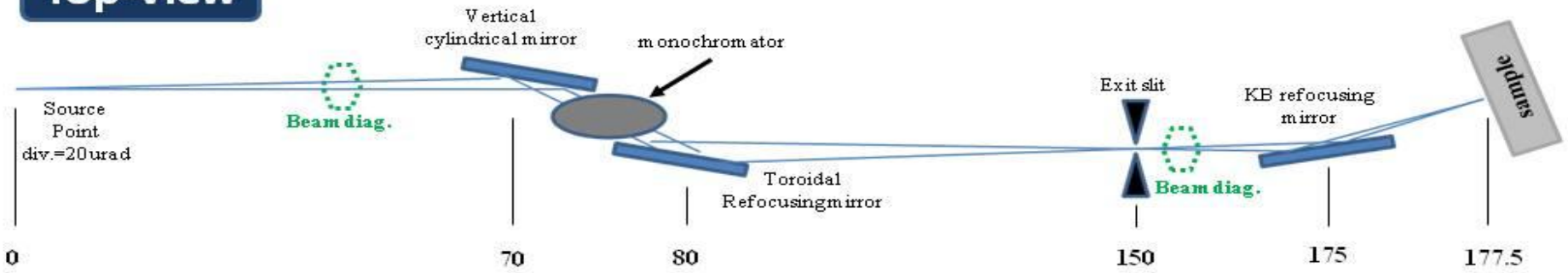
- **2 Undulators (1-HX, 1-SX) Beamlines**
  - **Wavelength:**
    - **Hard X-ray (0.06 nm – 0.7 nm)**
    - **Soft X-ray (1 nm – 10 nm)**
  - **Pulse Width:**
    - **Nominal: 30 – 100 fs @ 200 pC**
    - **Short: < 5 fs @ 20 pC**
    - **Ultra Short: < 0.5 fs (ESASE scheme)**
- **4 Experimental Intrumentations (2-HX, 2-SX)**

XPP, CXI XPP CXI

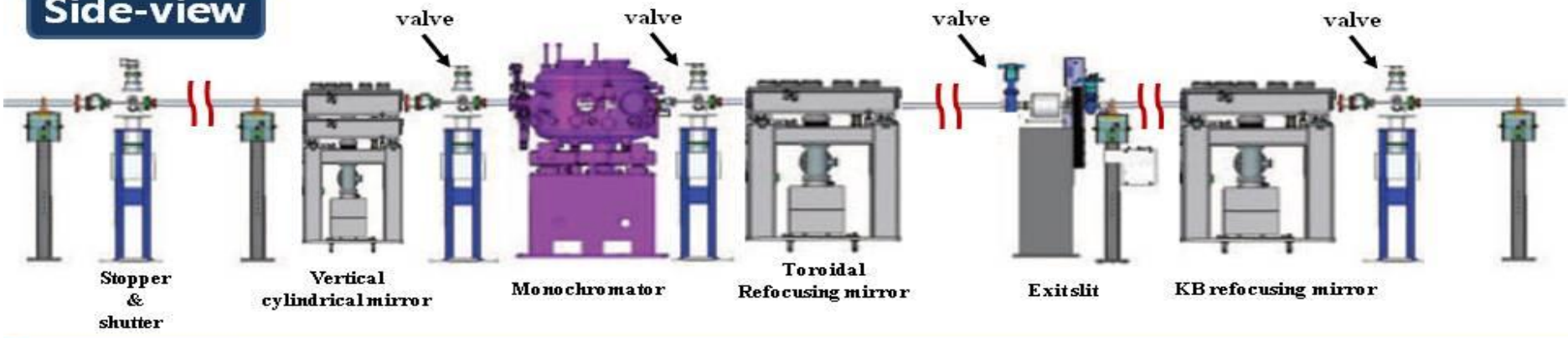
HX: Hard **X**-ray
SX: Soft **X**-ray
FE; Front End
OH: Optical Hutch
CXI: Coherent **X**-ray Imaging
XPP: **X**-ray Pump Probe

Soft X-ray beamline layout

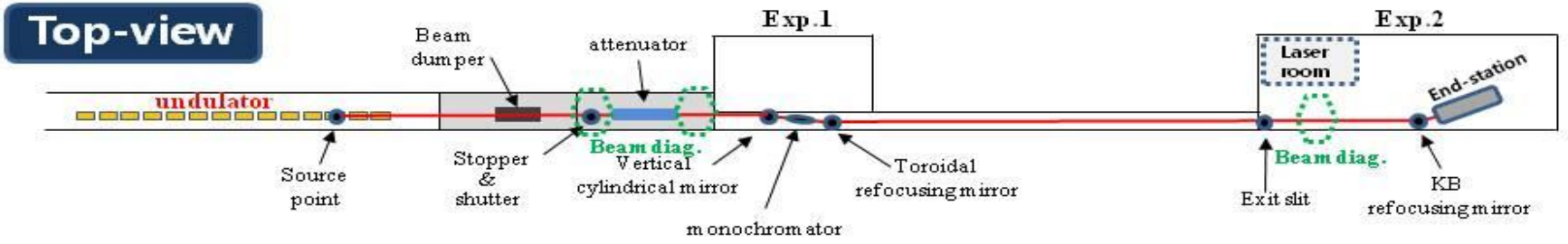
Top-view



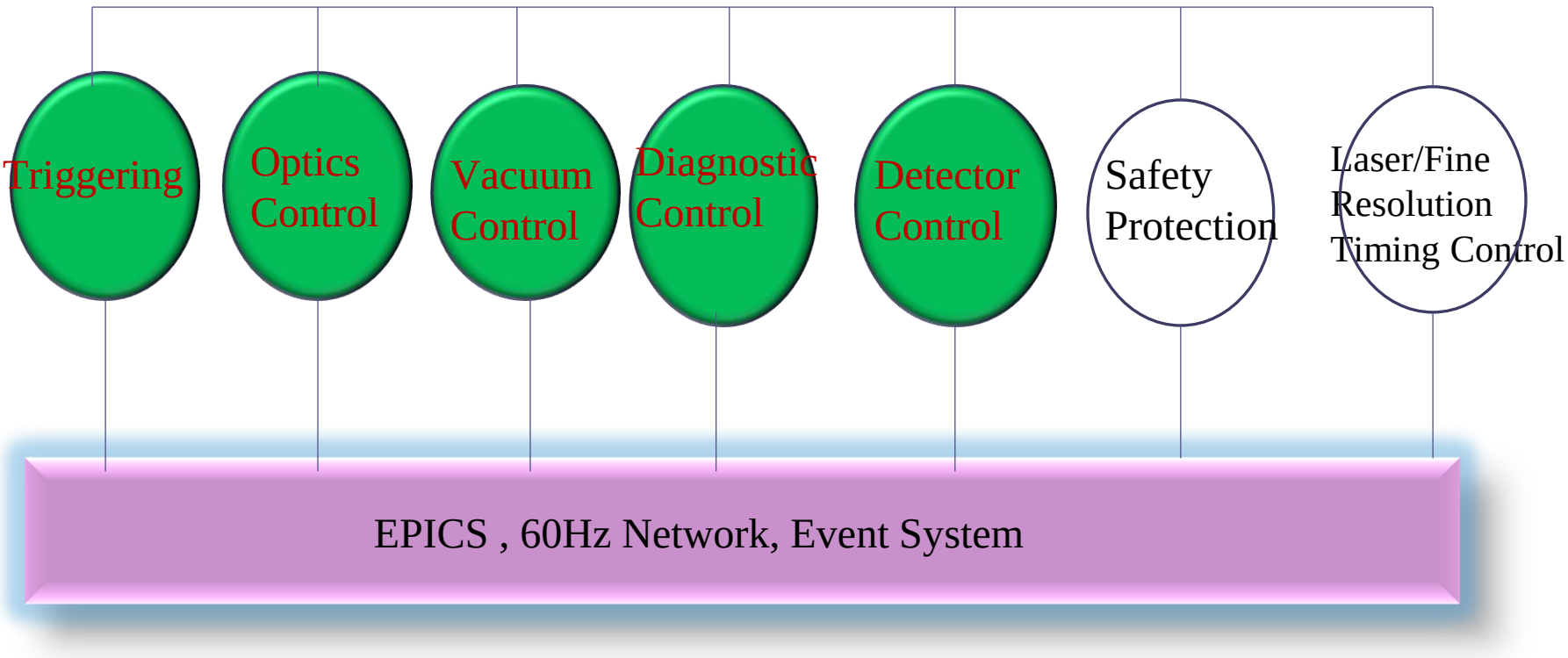
Side-view



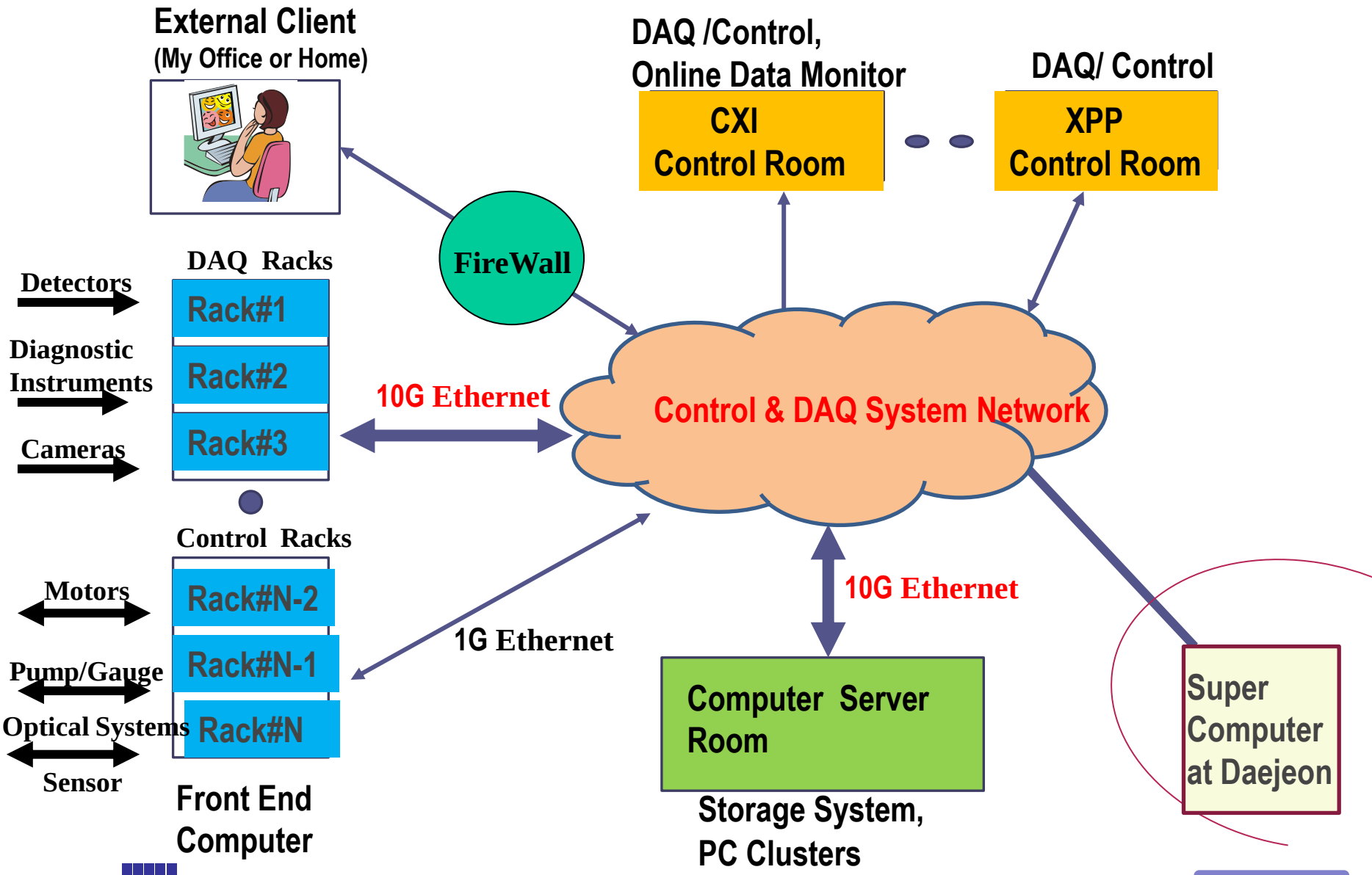
Top-view



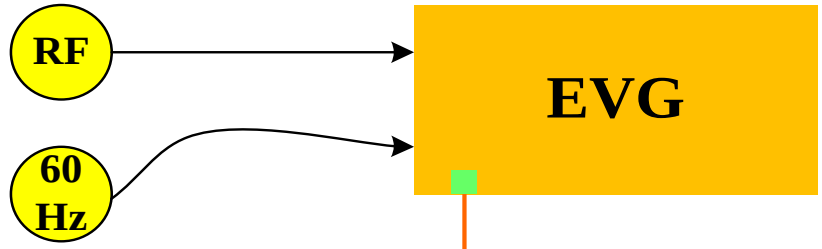
Control & DAQ System Workscope



Geographical Layout for Control/DAQ

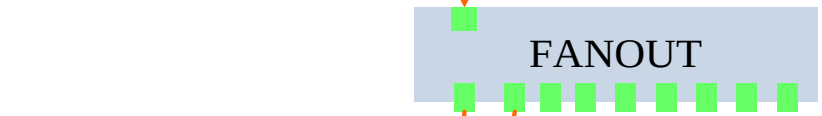


Triggering System



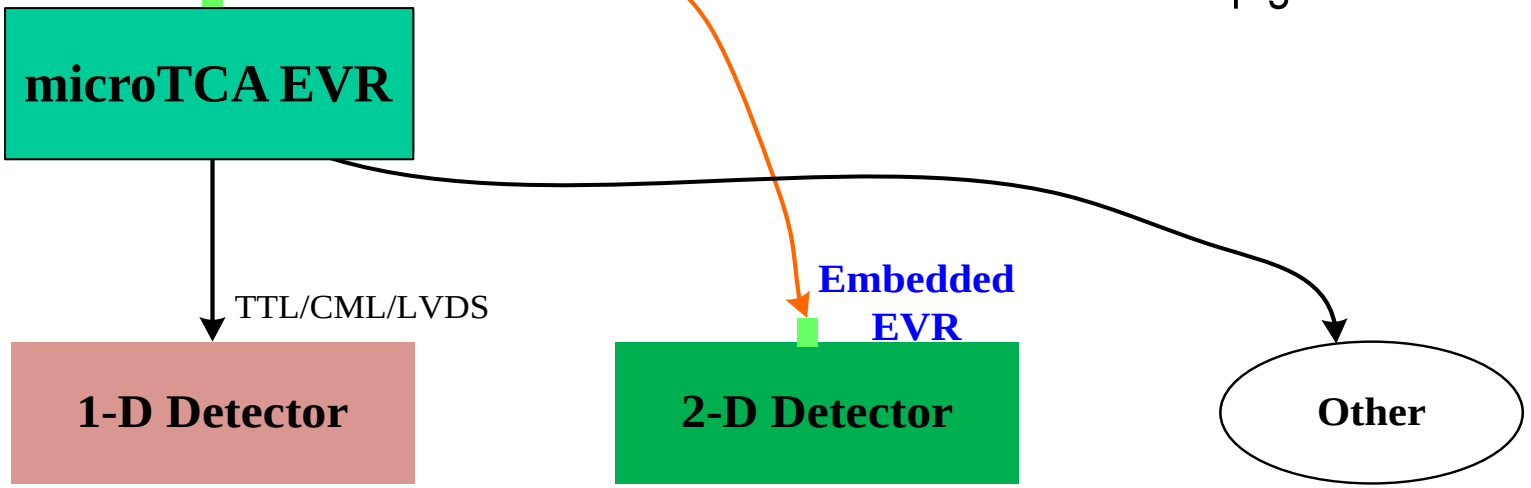
To provide the trigger signal

✓for detector/diagnostic instrument DAQ by Operation mode.



Event System

- ✓ Accelerator Standard Timing System
- ✓ Any trigger data format generation
- ✓ Time stamp generation



Comparison of 2D detector for XFEL

	CS-PAD	AGIPD	SOPHIAS	PAL
Pixel size(㎛ x ㎛)	110x110	200x200	30x30	**40x40**
# of pixels/unit	185x194	64x64	891x2157	**512 x 128**
Single photon sensitivity	O	O	O	**O**
Maximum wells size(fF)	565	13,100	450 (3,160 equ.)	**660** **(5,270 equ.)**
Maximum # of photons	2500 @8keV	25,000 @12.4keV	30,000 @6keV ?	**15,000** **@12keV**
Vdd	1.5*	1	2.5	**1.5**
Frame rate(Hz)	120	4.5	60	**60 Hz**
Readout/s	185x194x14x12bit (60M)	64x64x14x 352x10 bit (202M)	891x2157x11x2x60/24 bit (58 M)	**512 x 128 x 14bit x 60Hz= (55 Mbit)**

2-D X-Ray Detector DAQ System

- 3rd generation control system → New part!
- High peak rate & large volume Data generation
- To handle these task , the high processing power is required.
- ATCA(Advanced Telecommunication Computing Architecture) Hardware Platform(including microTCA) is the most promising architecture.
- It is the first commercial open standard designed for high throughput and availability(HA), 99.999%

Front End Computer

- Control Component(Slow &Asynchronous)

  Optical Components -> PLC or uTCA

  Vacuum → PLC or uTCA

  Sensor → PLC

- Data Acquisition(DAQ) H/W Platform

  Diagnostic →uTCA

  Detector → ATCA(2D)/uTCA(1D)

  Camera(Synchroused)

  - Software ->RealTimeOS/EPICS Control

Comparison of hardware platforms

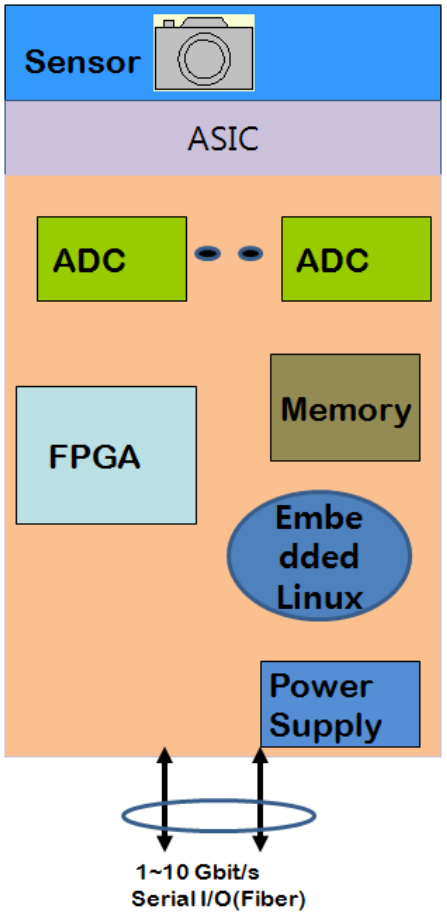
	VME	ATCA	PCI
Vendor Support	**High/Declining**	**Low/Growing**	**Medium/Stable**
Maturity	High	**Medium**	High
Max .transfer rate	VME:40MB/s VME64:80MB/s VME64x:160MB/s VME320:320MB/s	**1Gbps,10Gbps** **(GigabitEtherne)** **250MB/s/lane (PCIe)**	PCI: 133MB/s PCIe:250MB/s/lane (up to 16 lanes)
Topology	Master-slaves	**Star,Dual star,Full mesh**	Master-slaves
High Availability	Medium	**High**	Medium
Form factor	6U(64Bit),3U(32bit)	**12U(ATCA),** **2U(μTCA)**	3U

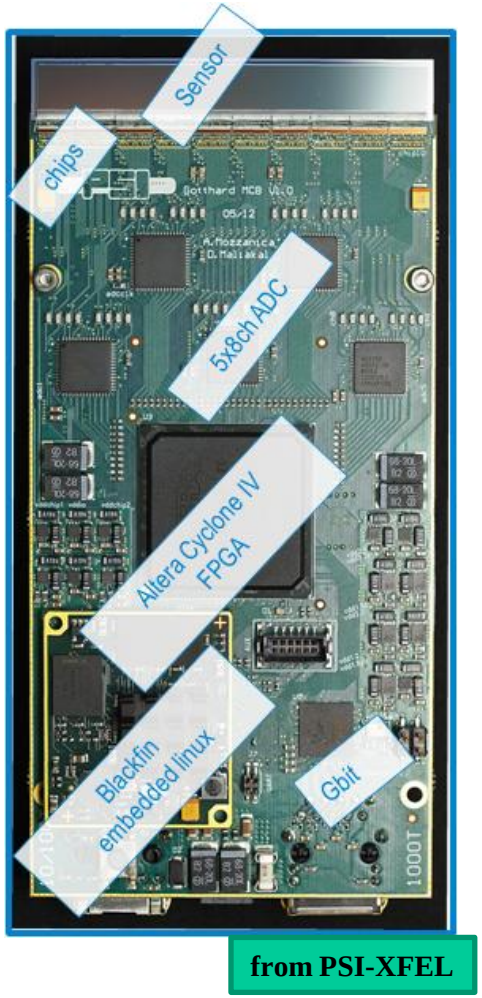
FEM(Front end Electronics Module)

Detector Specific Module.(Non- standard)

Typical Layout (ASIC,FPGA,Embedded S/W,1~10Gbit serial)

PIXEL2012 http://www-conf.kek.jp/pixel2012/

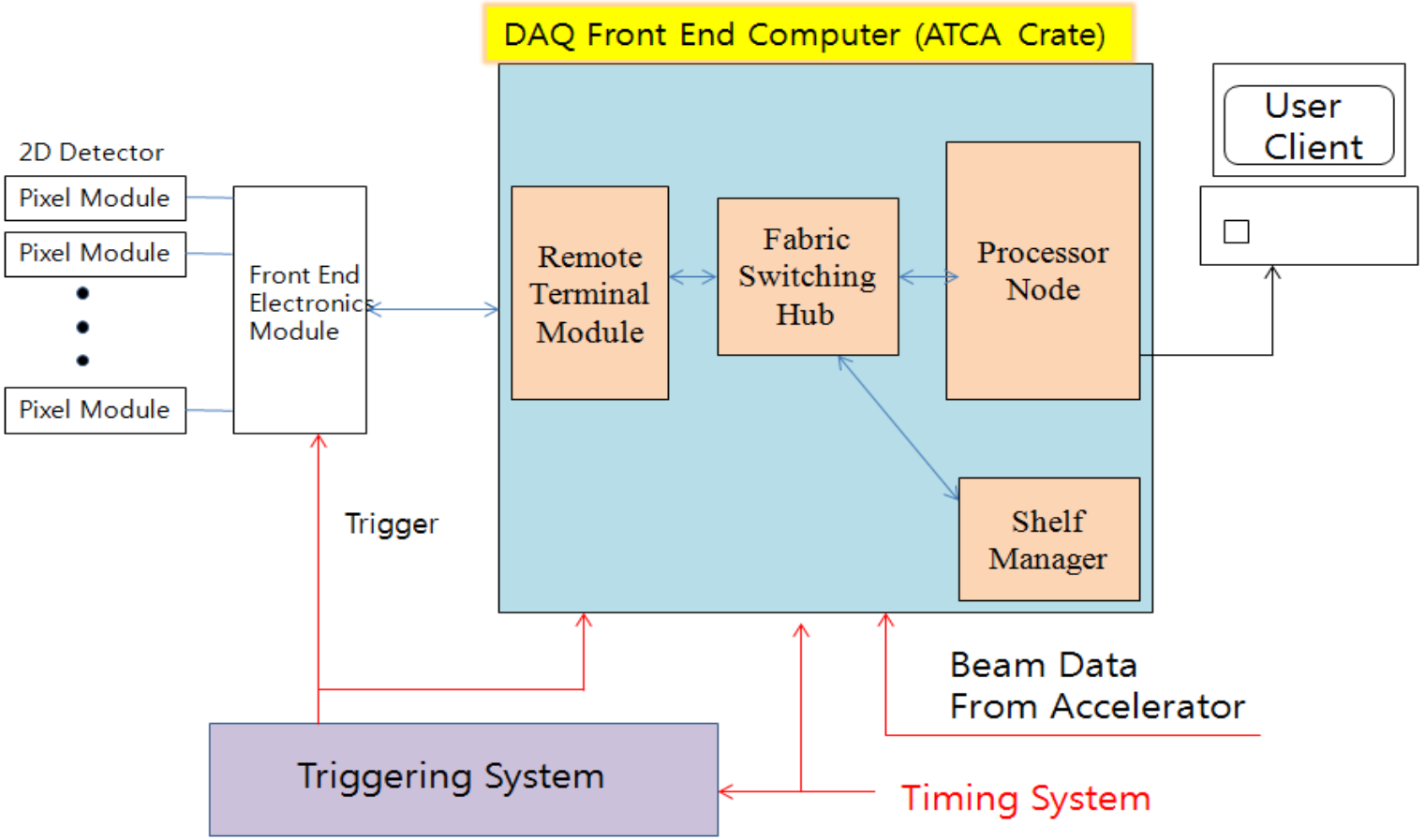




from PSI-XFEL

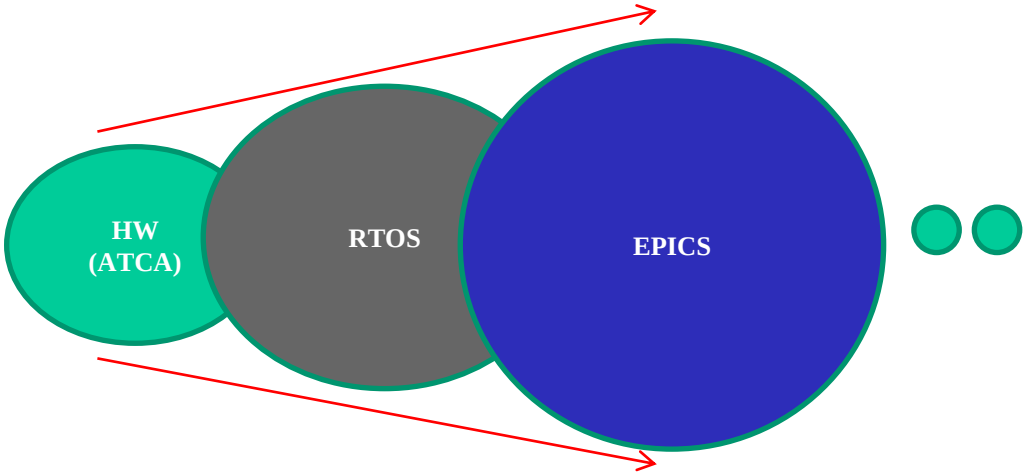
DAQ System Architecture for 2D Detector

Technology Trend,
Standard Hardware platform? ATCA Platform
PIXEL2012 http://www-conf.kek.jp/pixel2012/



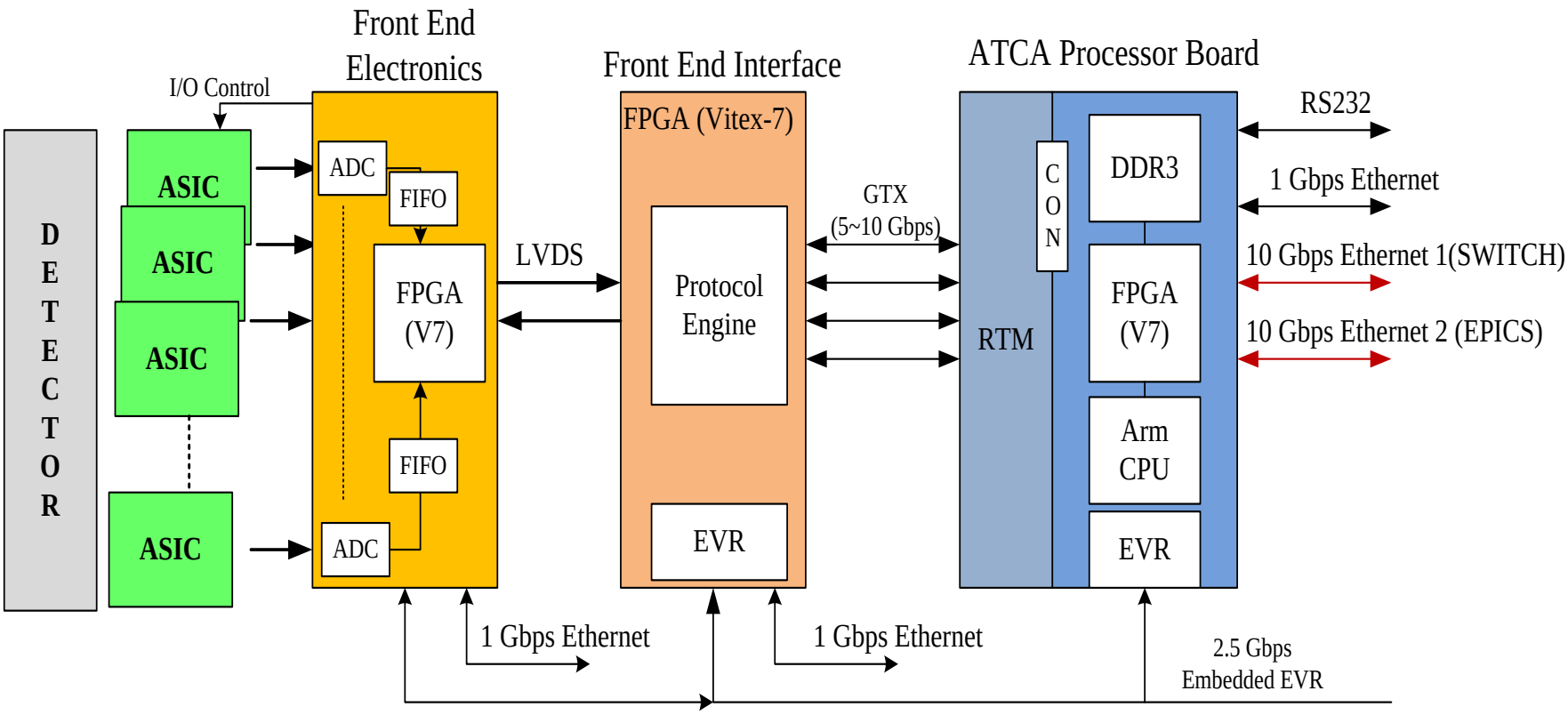
Main Components for 2D detector

→ **Summary (FEM(detetor Specific),ATCA)**



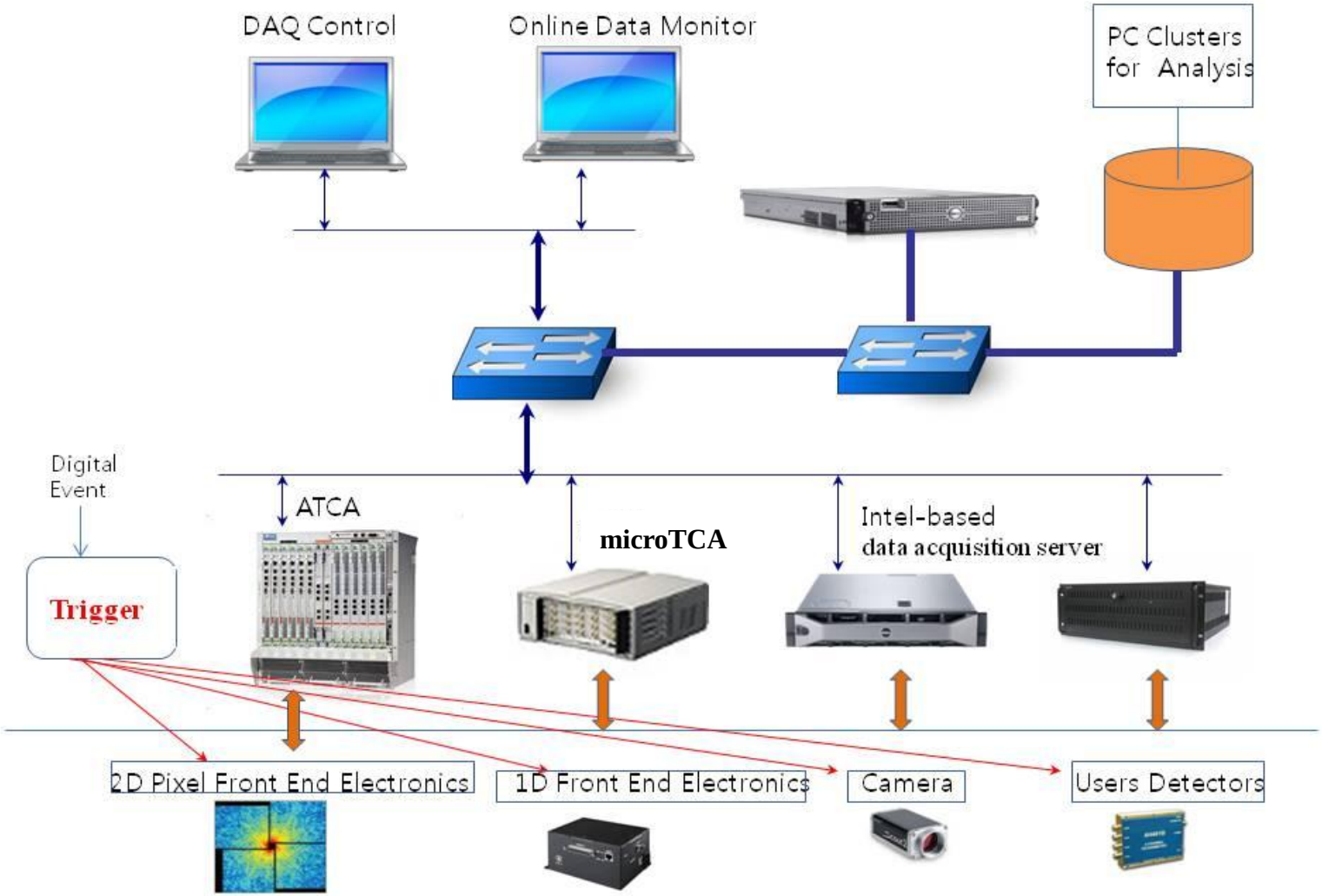
	2D Detector	FrontEnd Computer	Operating System	Software FrameWork
LCLS	csPAD	ATCA	RTEMS	EPICS
SACLA	MPCCD	VME	Linux	MADOCA
Euro-XFEL	AGIPD,LPD,DSS, other	xTCA	RTlinux	Tango

DAQ Front End System Layout for PAL-XFEL



- **Front end Electronics board contains ADC from ASIC(Application Specific Intergration Chip), DAC for calibration,Digital I/O.**
- **Front end Interface board is receiving ADC data from FEE board and transfering to ATCA Board.**
- **ATCA processing board supports the embedded EPICS IOC.**

DAQ Hardware Architecture(Tentative)



ATCA products(Lab, Company) List

platforms	Functions		specifications	Makers	Remarks
ATCA	Processor blade		Dual Sandy/Ivy bridge (16 cores)	Kontron, Emerson, Raidsys AdLink	
	Switch blade		1G/10G/40Gbits	Kontron, Emerson, Raidsys AdLink ,Zynix	
	For ATCA I/Os	Carrier for AMC	4x AMC bays (mid /full size) with 1G/10Gbits Switch	Kontron ,Emerson , Raidsys, Vadatech DESY ,few others	•ATC104 /114(Vadatech) : 7-8 AMC bays with 1Gb ** DESY 3xAMcs with RTM
		Carrier for VMEbus board	Can be configure with VME 64x(2eSST) I/O cards and RTM	VadaTech	ATC106 /ATC116
		Carrie for CompactPCI board	Can be configure with cPCI cards (PICMG2.16) and R TM(3.8)		ATC107
		Carrier board for other form factors	PMC/XMX/PrAMC/PCIe/PC Ix with RTM		ATC103/113/105/115/108 /118/109 etc
		RCE/CI,COB +RTM	Virtex5 FX70 FPGA	SLAC	
	Shelf		2U/5U/13U and others	Schroff, ELMA , COMTEL , Rital etc	Dual Star / full Mesh back plane

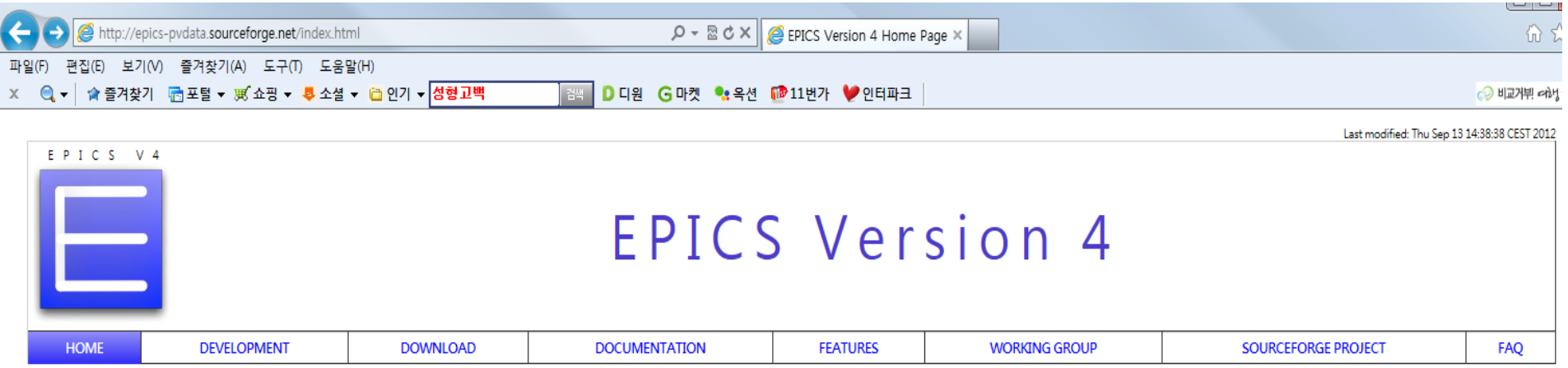
microTCA products List

MicroTCA	**Processor AMC**		i7/Quad (x86) & Feescale	Kontron Emerson Raid sys AdLink Vadatech Concurrents PT GE	
	MCH		MixroTCA.4	Kontron, NAT, Va datech, SAMWAY P T	
	AMC I/O MTCA.4	Digitizer	125MSPS 16bit 10ch	Struck	SIS8300 with RTM
			125MSPS 16bit 10ch and 2ch 16bit DAC	VadaTech	AMC520 with RTM
		IP Adaptor	3 IP pack w RTM	TEWS	TAMC220
		FPGA Adaptor	1 FMC VIRTEX /ALTERA	Vadatech , TEWS	FMC51x /Vadatech TAMC6 51 /TEWS
		PMC/XMC adaptor		Vadatech	AMC100/101
	AMC RTM for MTCA.4	LLRF	Passive DC Downconvert or 1.3-3.9Ghz	SLAC, DESY	with SIS8300
		Interlock	Fast/Slow 12bit ADCs	SLAC	with TEWS651
		BPM	Filter, Calibration IF Lo w chargew button/stripline	SLAC, DESY	with SIS8300
		Sensors Interface	Avalanche photo Diode pulse Stretcher	DESY	with SIS8300
		ADC/DAC	8ch 16bit ADC / 8ch 16bit DAC Coupler interlock	DESY	with DAMC2
		Digital I/O	Machine protection system	DESY, Vadatech	DAMC2 AMC09x (no RTM)
		ADC	Beam Loss Monitors Tor oid Protection / readout	DESY	DAMC2
			Clock & trigger control for exp	UCL	DAMC2
			Wire Scanner	DESY	DAMC2
	Shelf		6/7 and 12 slots	Schroff , ELMA, Vadatech , PT, power bridge	non & redundant confi.with PU and CU

Mezzanine Module into Carrier Board

platforms	Functions	specifications	Makers	Remarks
General AMCs	I/O AMCs	DIOADC/DAC/SIO/FMC	Vadatech, TEWS	with ATCA RTM but no MTCA.4 RTM
General IP pack	I/Os IP modules	moter control /ADC/DAC/SIO/ Fram gr aber and many others	Acrmag, TEWS, HYTEK, Alphi, GE, Dyneng, others	

EPICS V4 Support for Beamline Control & DAQ



"EPICS V4 Expands Support to Physics Application, Data Acquisition, and Data Analysis"

Presented from L. Dalesio(Former LCLS Cotrol Group Leader, Current NSLS_II Control Gr. Leader) at ICALEPCS October 14,2011

Present Deployments

EPICS V4 is also being used now developing beamline image data acquisition and storage, using the facilities of pvData for structured data. Contact James Roland at DIAMOND. It will shortly also be deployed at PSI for back end SQL database access.

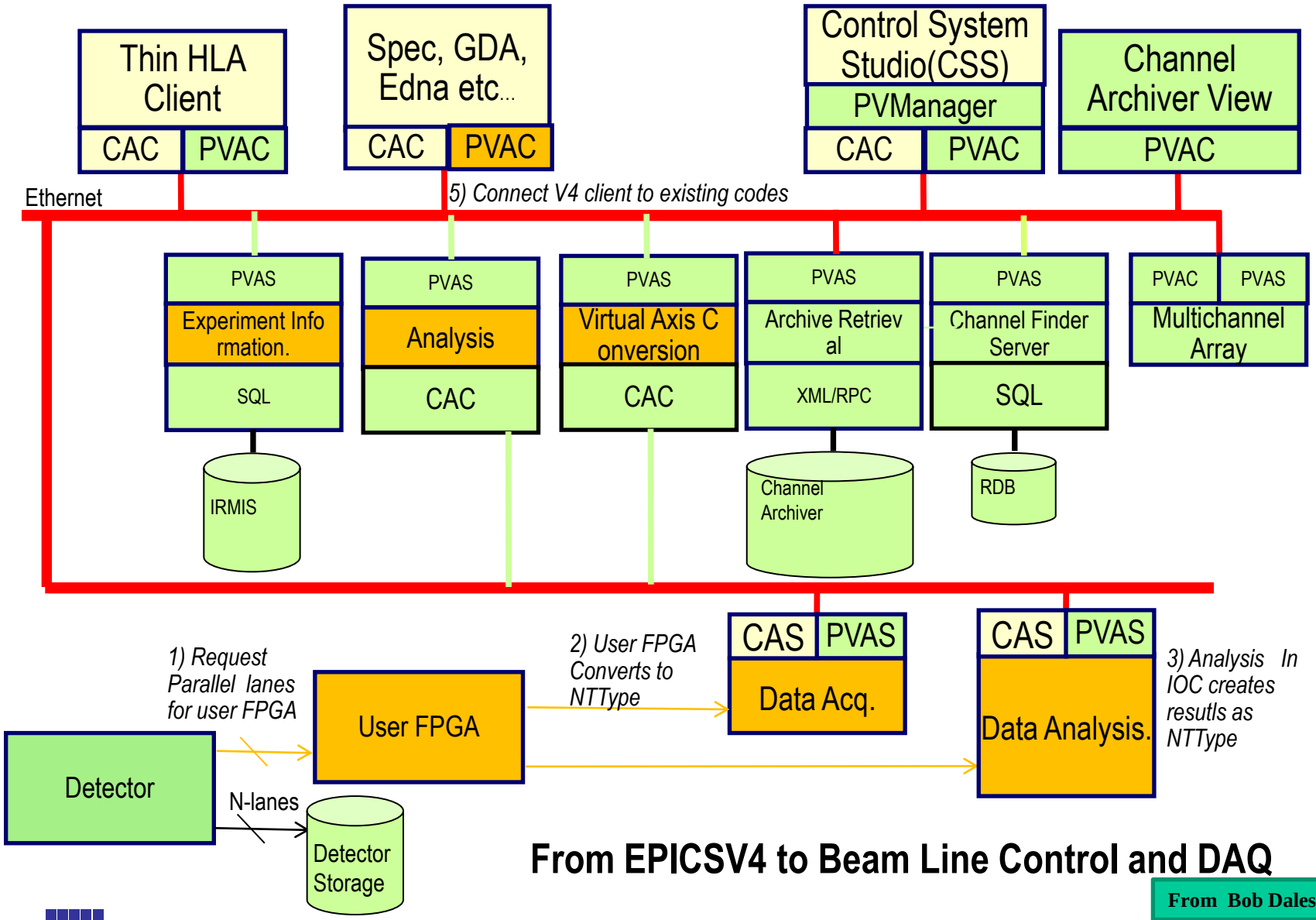
From EPICS Version 4, Homepage

Version 4 Supports Complex Data Structures

- Java IOC can represent devices
  - We will likely not implement devices, as it is still difficult to agree on what these are
  - We will use V3 records at NSLS II.
- PVData (PVs) are available across the network
  - Functions on PVs are: get, put, monitor, put/process/get (command/response)
  - It is also hard to create object models on more complex devices such as a telescope or an accelerator.
- Normative types are defined to provide metadata for more complex constructs: multi-channel array, table, N dimensional Array, Image.
  - PVData always has a time stamp, alarm severity, and alarm status
  - Vectors have useful metadata and distinctions: time domain vector, frequency domain vector, histogram
  - Operations can be performed on two PVs with the same normative types.
  - We have NOT
- PVService supports creating middle layers services
- MANY servers are being developed on this interface to implement middle layer through a collaboration for physics applications. **A second collaboration is being established for beam line control, data acquisition, and data analysis.**

From Bob Dalesio

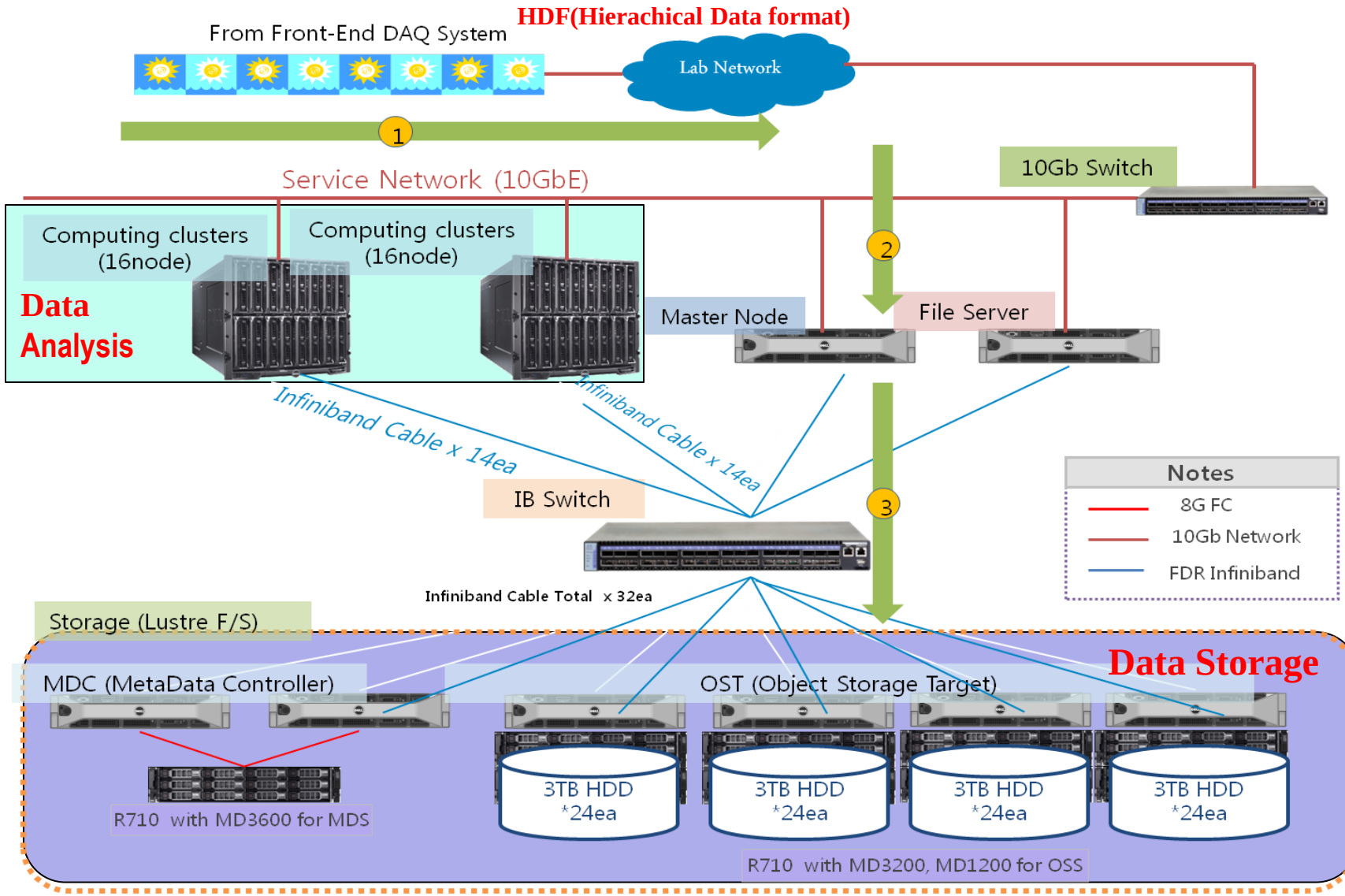
Software Architecture(Control & DAQ)



From EPICSV4 to Beam Line Control and DAQ

From Bob Dalesio

Data Storage & Analysis System



Summary & Future Plan

- Presented Based on the recent Technical Design Report (not published)
- Mainly explained our strategy, planned design to develop DAQ & Control system.
- Proposed drawing, schematic Diagram has not been determined.
- EPICS Version4 directions started to support Beamline Control & DAQ Development.

- Technical review for DAQ System will be before the end of the year
- After TDR, ATCA/MicroTCA -based prototype control system will be configured to evaluate our requirements soon.
- Will consider ways to operate the EPICS V4 Development Team.
- Any suggestions, comments are welcome!

Thank You for Attention!

감사합니다.