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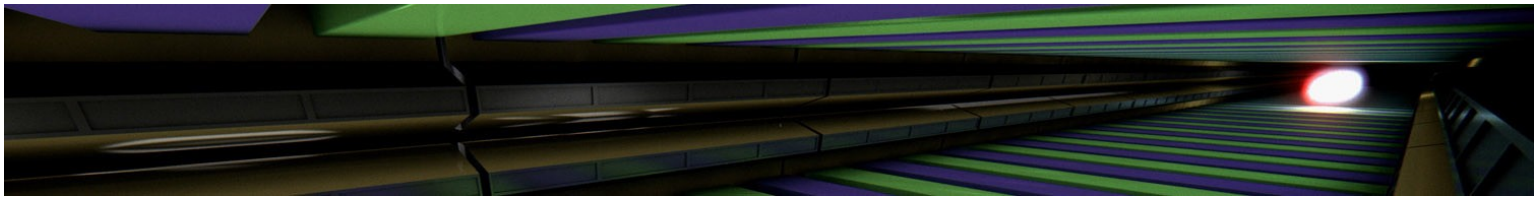


Accelerator DAQ

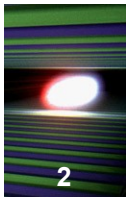
1st Meeting of the European XFEL Accelerator Consortium

Vladimir Rybnikov and Tim Wilksen, DESY
WP 28

DESY

HELMHOLTZ ASSOCIATION

Outline



- **Accelerator DAQ**
  - Motivation
  - Generic Layout
- **DAQ Data**
  - Access Methods
    - → Middle Layer Services
    - → Archiving Services
  - Tools and Applications at FLASH
- **FLASH Example**
  - Implementation
  - Performance
- **Outlook**

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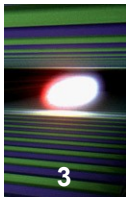
Accelerator DAQ - Motivation



- Help in commissioning, operations, performance analysis, and any kind of R&D work by monitoring and recording data from accelerator and diagnostics experiments.
- Provide a standardized way of accessing synchronized, beam-related data.
- Unique event identification across any data source to correlate machine events and experiment data.
- Central data store for online middle layer services with standardized access methods.
- Archive event-triggered, shot-synchronized data for expert analysis.

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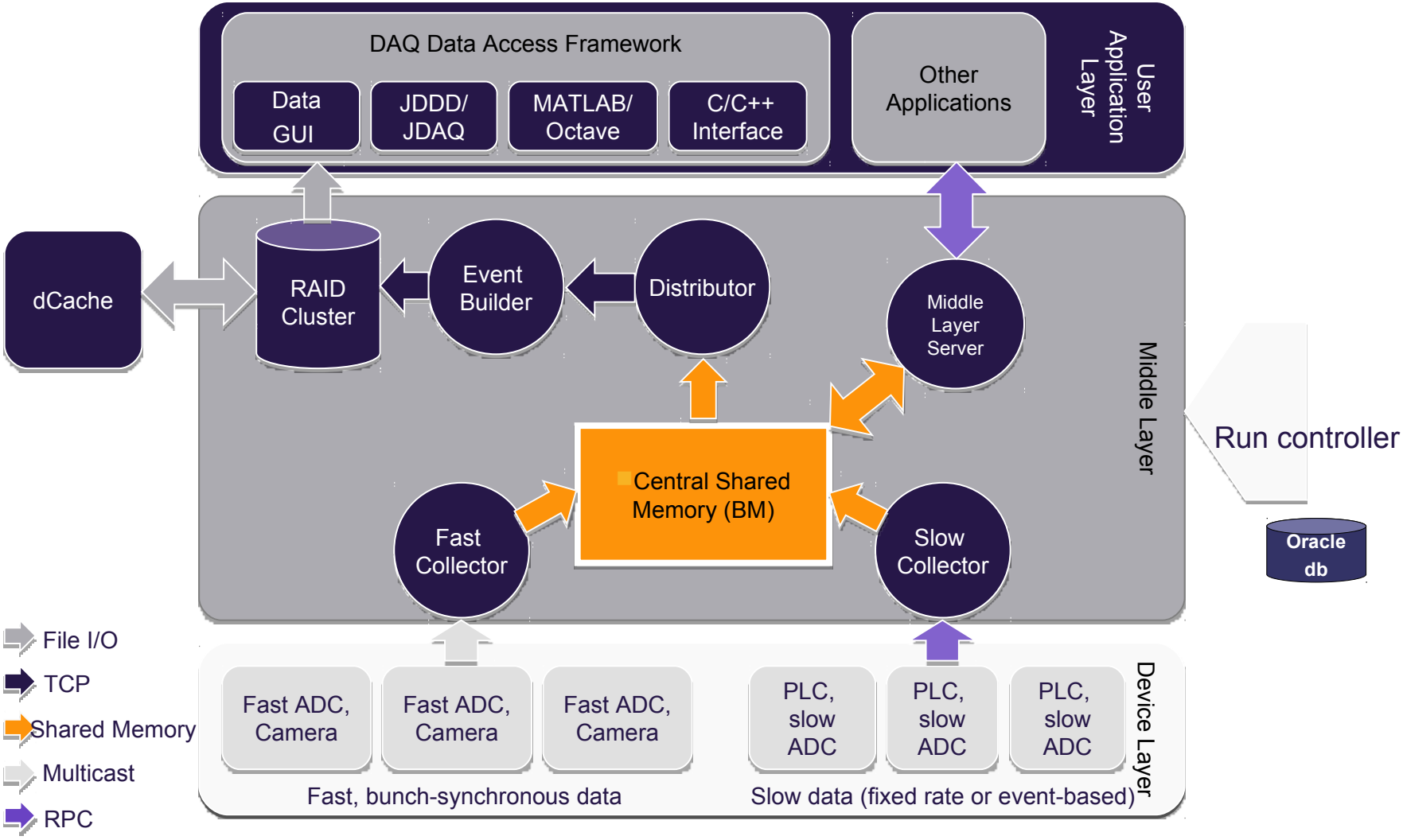
Accelerator DAQ – Generic Layout



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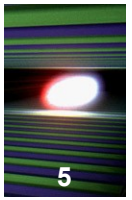
DAQ Data – Access Methods



- Overview of application programming interfaces (API) and tools to access and retrieve data recorded by the DAQ

Interface	Kind	Storage Type	Access Method
Buffer Manager	API	Online	Local Buffer Manager
Middle Layer Services I	API	Online	Local Buffer Manager
Middle Layer Services II	API	Online	Local Buffer Manager
C++	API	Offline	NFS-based and remote file access
Java	API	Offline	NFS-based and remote file access
MATLAB / Octave	Tool	Offline	NFS-based and remote file access
Mathematica	Tool	Offline	Remote file access
DAQ Data GUI	Tool	Offline	NFS-based and remote file access
jDDD	Tool	Offline	Remote file access
DAQ Data Converter	Tool	Offline	Remote file access

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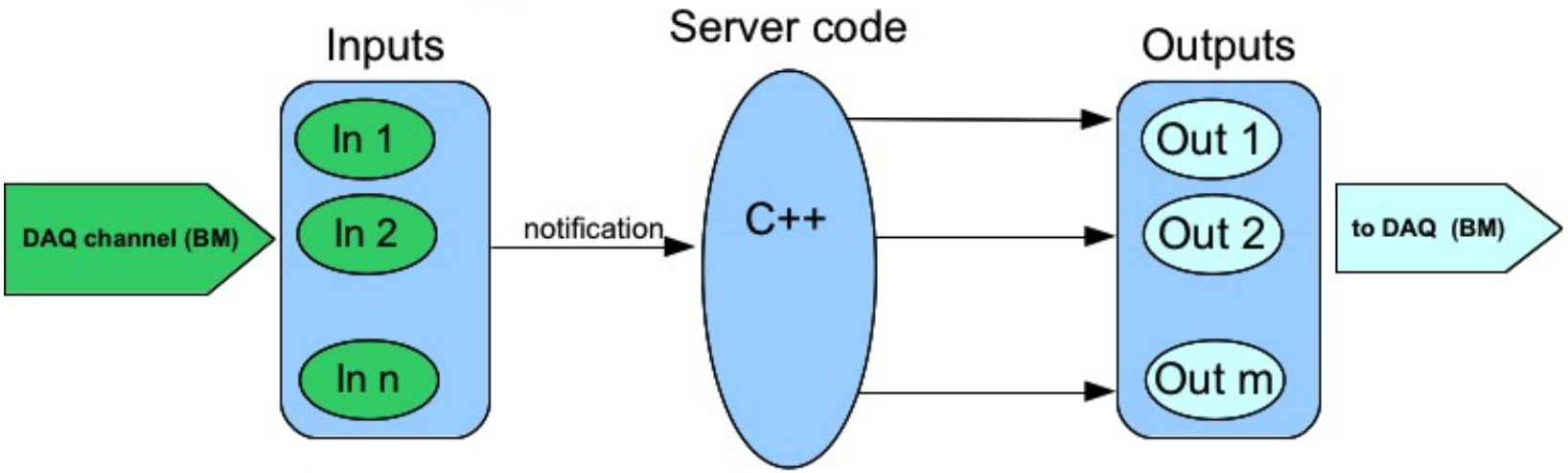
DAQ Data - Middle Layer Services I

Library based ML server Interface



settings done via configuration file

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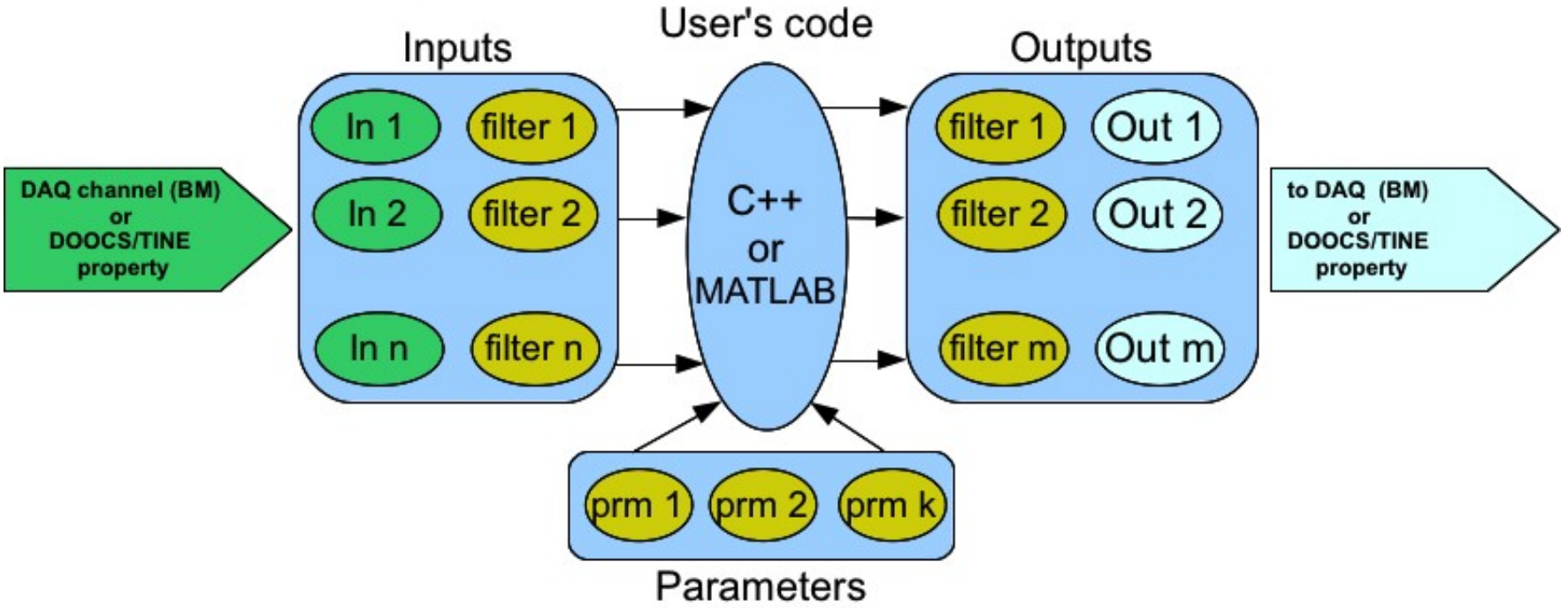
DAQ Data - Middle Layer Services II

Template based ML server interface



settings done via configuration file

changeable on-line

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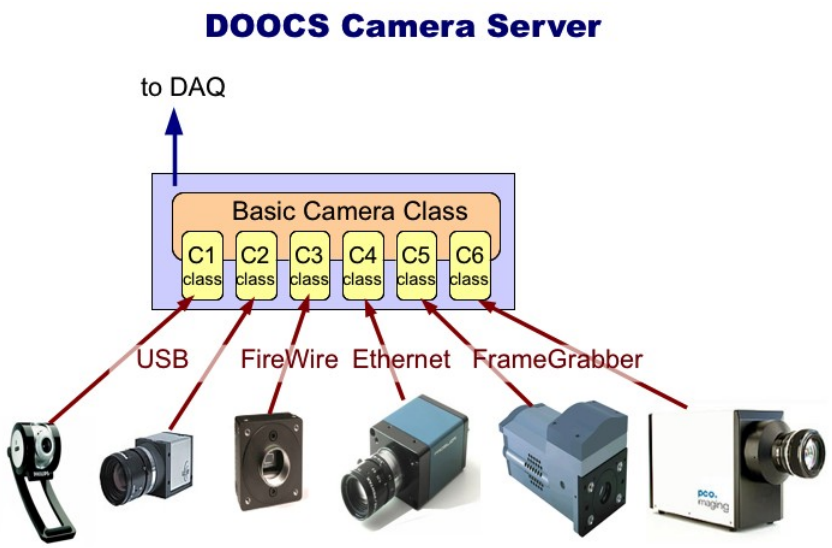
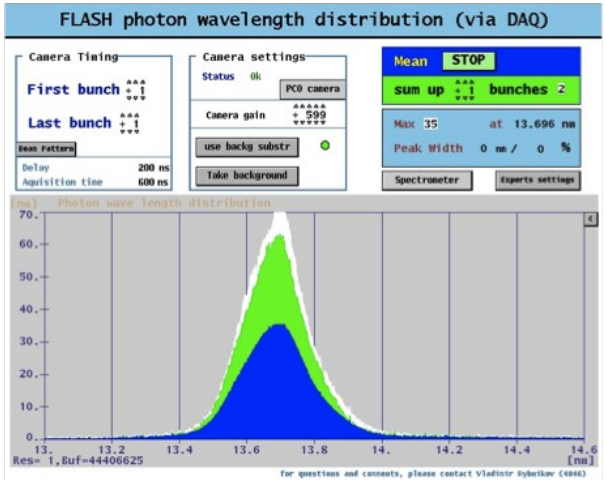
DAQ Data – Middle Layer Services FLASH Example



Producer	Types	Interfaces
Andor	iStart, iDus, iKon	PCI, USB
Basler	A, ace, scout, aviator	FW, GigE
PCO	dicam pro, sensicam	PCI (optical link)
IDS (uEye)		USB 2.0
Princeton	PIXIS	USB 2.0
ALLIED (Prosilica)	GC, Manta	GigE
V4L API compliant	Philips, Video Grabbers	USB 2.0, PCI
XenICs		USB 2.0
MS Windows based		TCP

- DOOCS front-end server supporting various camera types with built-in image pre-processing.
- Dedicated middle layer server for further processing images using buffer manager API to access images and synchronized machine data:
  - Photon wavelength measurement
  - Photon energy measurement



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DAQ Middle Layer Server – FLASH ML Server

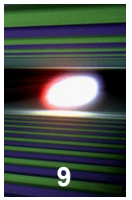

Photo Beam Diagnostics

- GMD Data Provider
- Photon Flux Measurement
- Photon Wavelength Measurement
- Photon Energy Measurement

LLRF

- LLRF Vector Sum Calculation
- Quench Detection
- LLRF Module Diagnostics
- Piezo Detuning

Beam Diagnostics

- Orbit Server
- Charge Calculation (Toroid)
- Energy Measurement
- Beam Power Measurement
- Beam Loss Visualization
- THz Spectrometer (Bunch Length)

Feedback

- Slow RF Feedback

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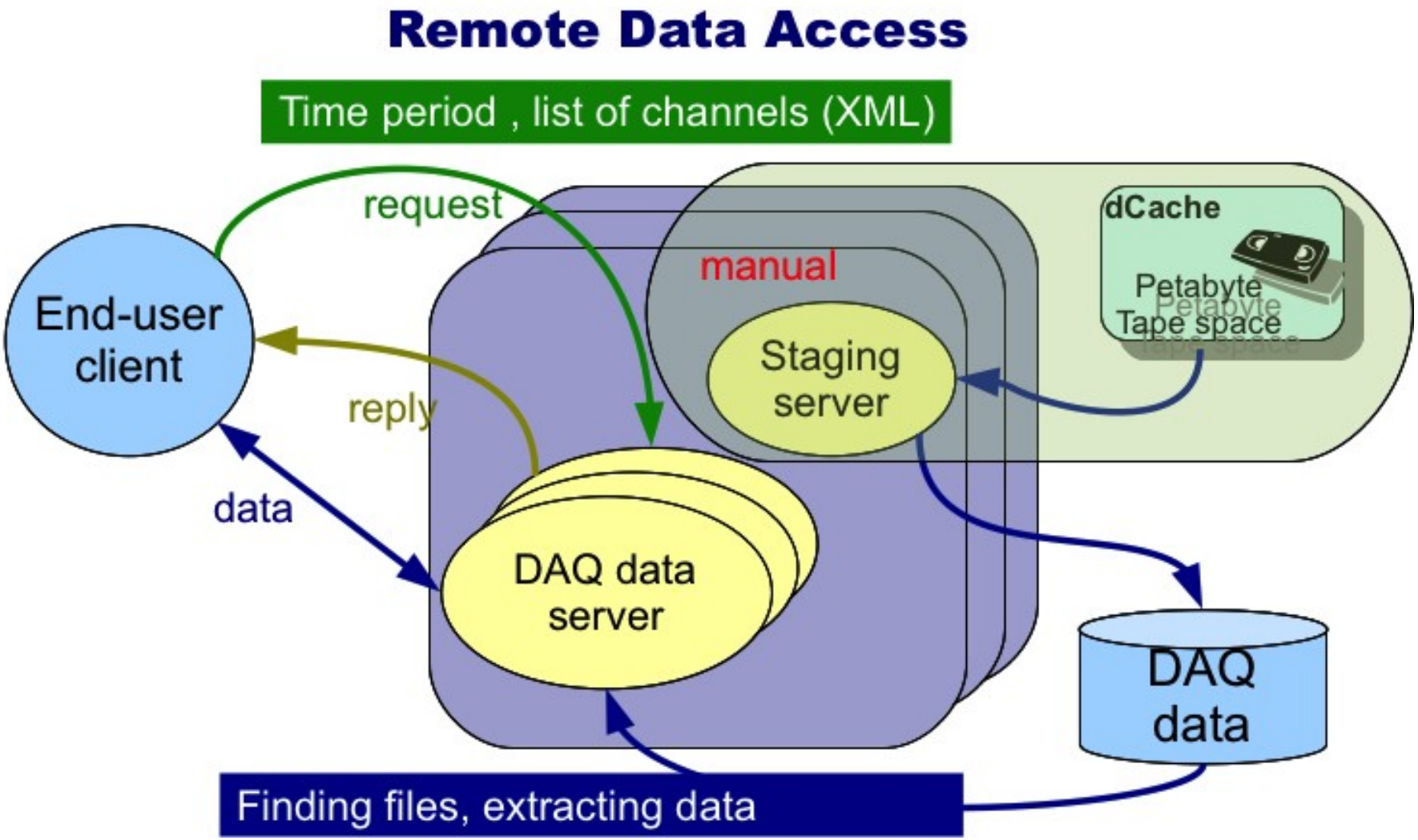
DAQ Data – Archived Data Access



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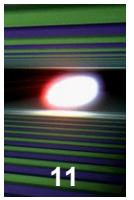
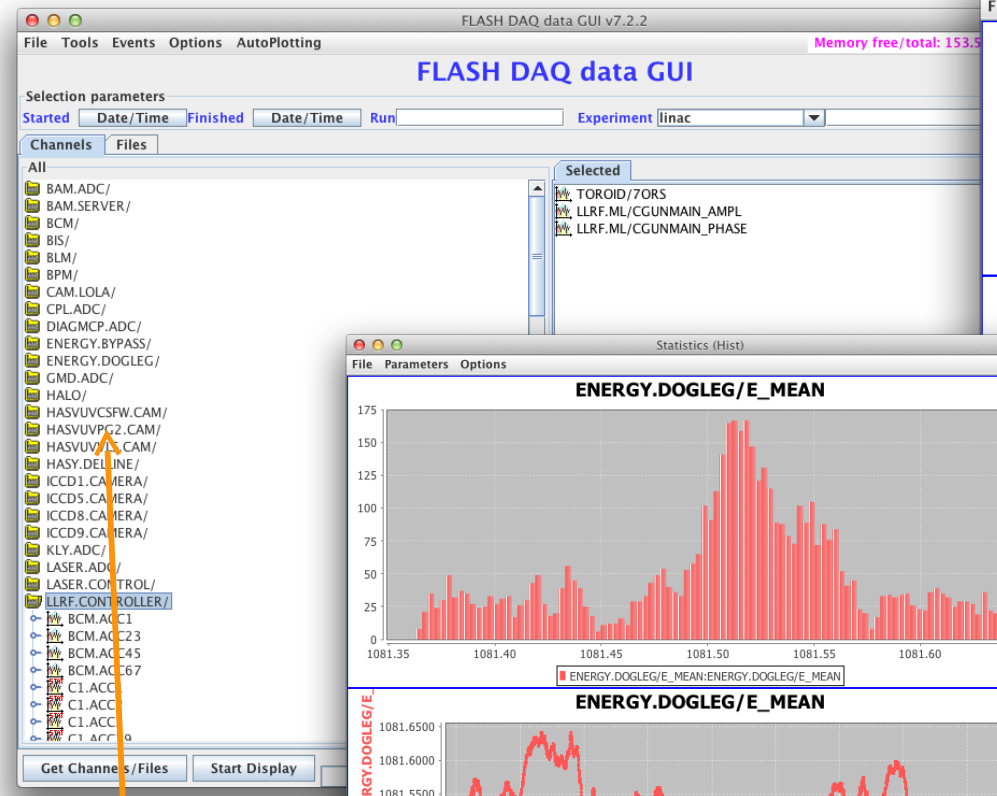
DAQ Data – Tools and Applications FLASH Example

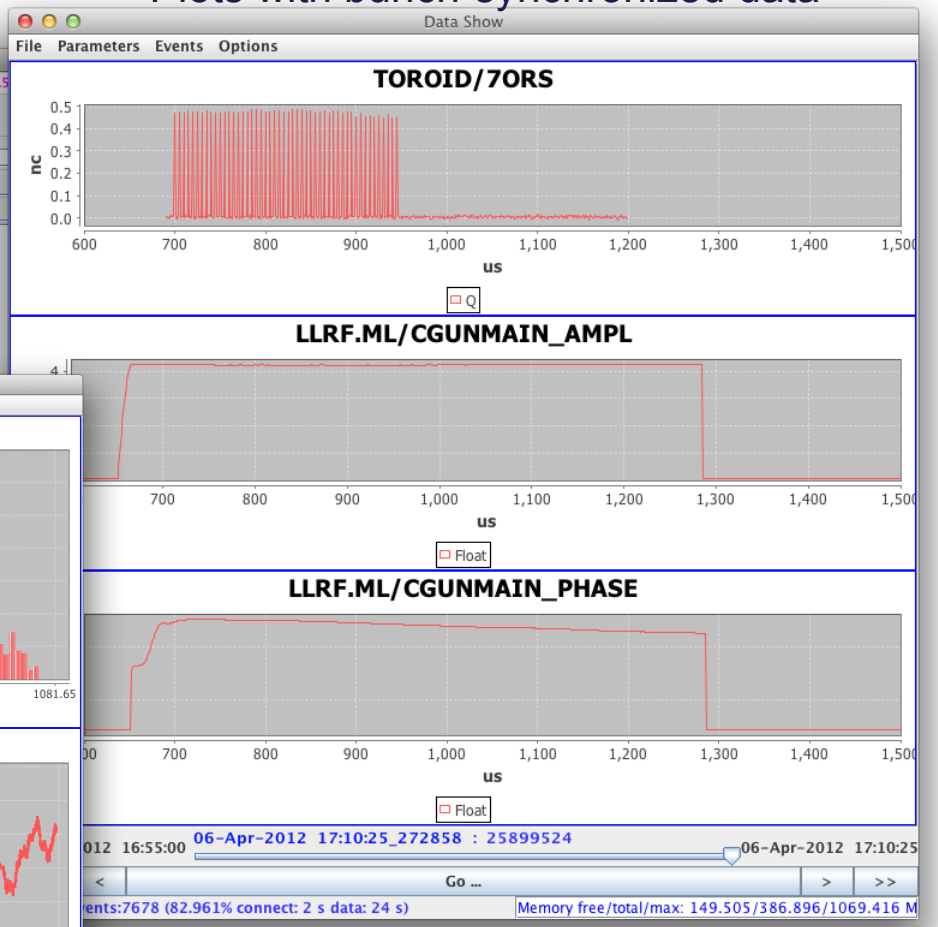


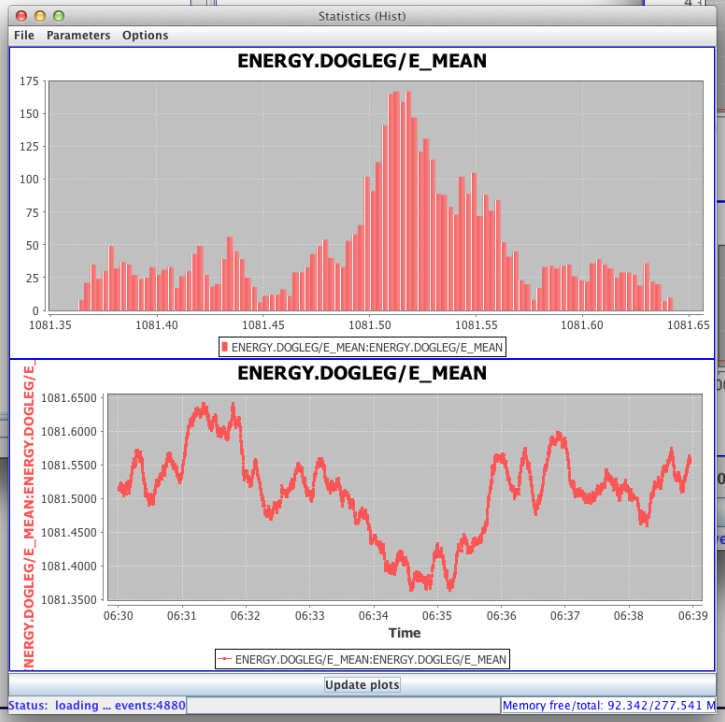
FLASH DAQ Data GUI



Channel list of all recorded channels

Plots with bunch-synchronized data





Histograms and time domain plots

Correlation Plots

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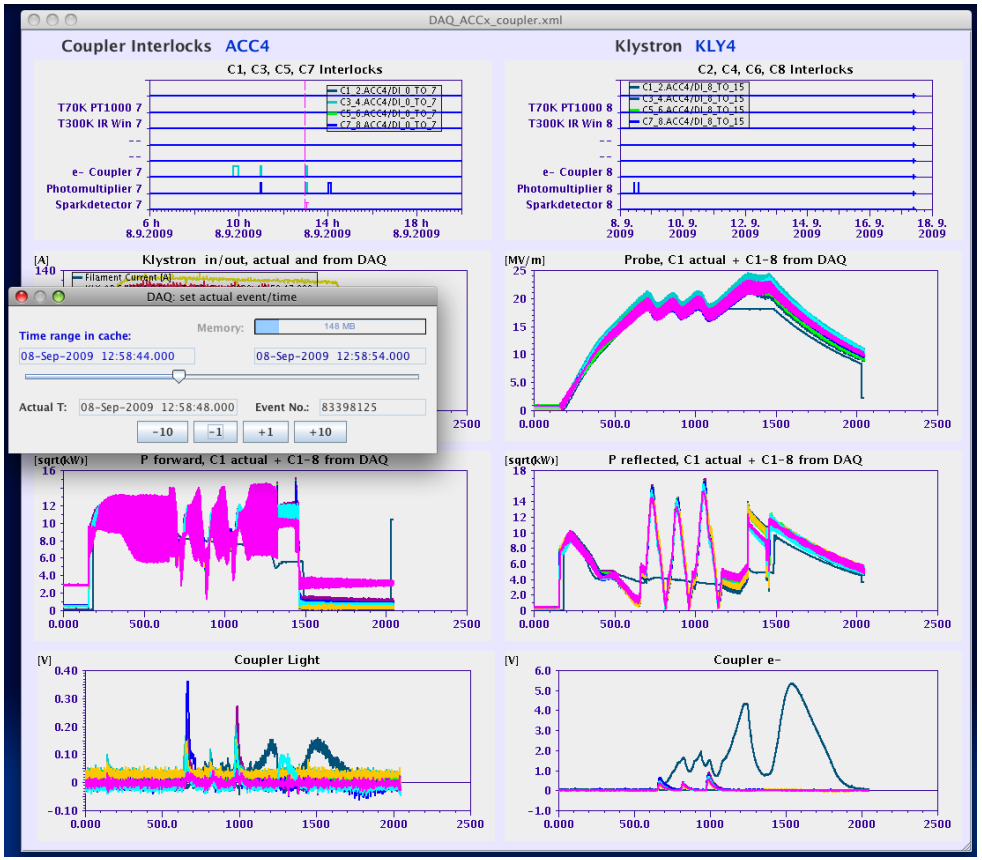
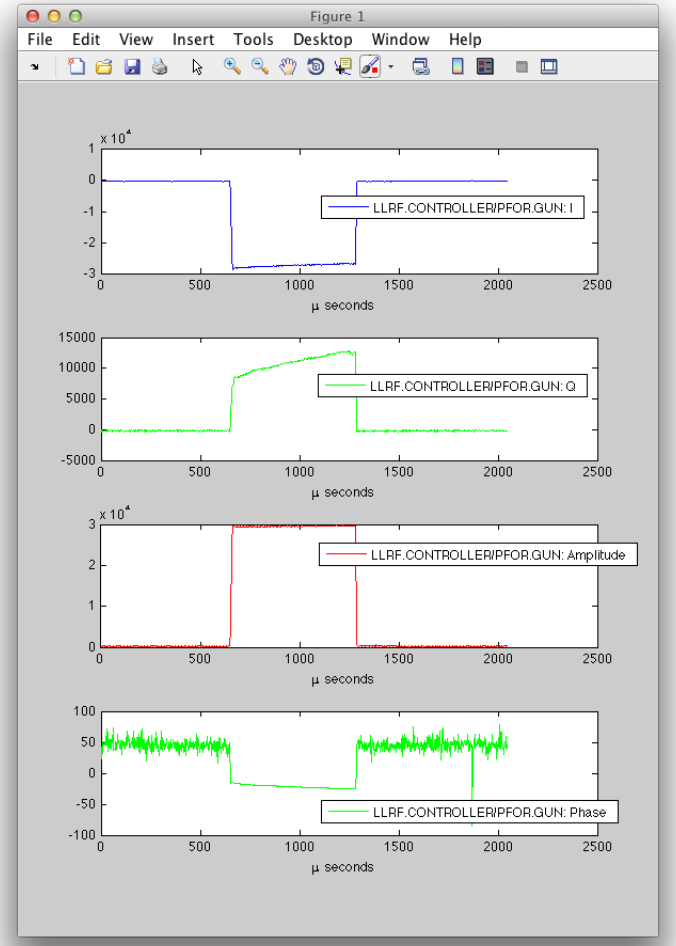
DAQ Data – Tool and Applications FLASH Example

- JDDD Display with DAQ Data Access





- MATLAB with DAQ Data Access

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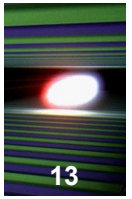
FLASH DAQ Implementation



- Implementations
  - Five DAQ Instances
    - Accelerator DAQ
    - Photon Beam Diagnostics DAQ
    - Photon Beam User Experiment DAQ
    - Test DAQ (FLASH and XFEL)
    - CMTB DAQ
- Accelerator DAQ
  - Basic DAQ implementation has been present and running since 2005.
  - Configured with 6 continuous + 1 event-triggered stream. Non-accelerator streams for machine experiments and special diagnostics. Preserved on disk and in archive.
  - Used since 2009 for ILC R&D (9 mA study group).
  - Integral component of FLASH operation for middle layer services.
  - Used as complementary archive in operations when standard non-bunch resolved channel histories are not sufficient.

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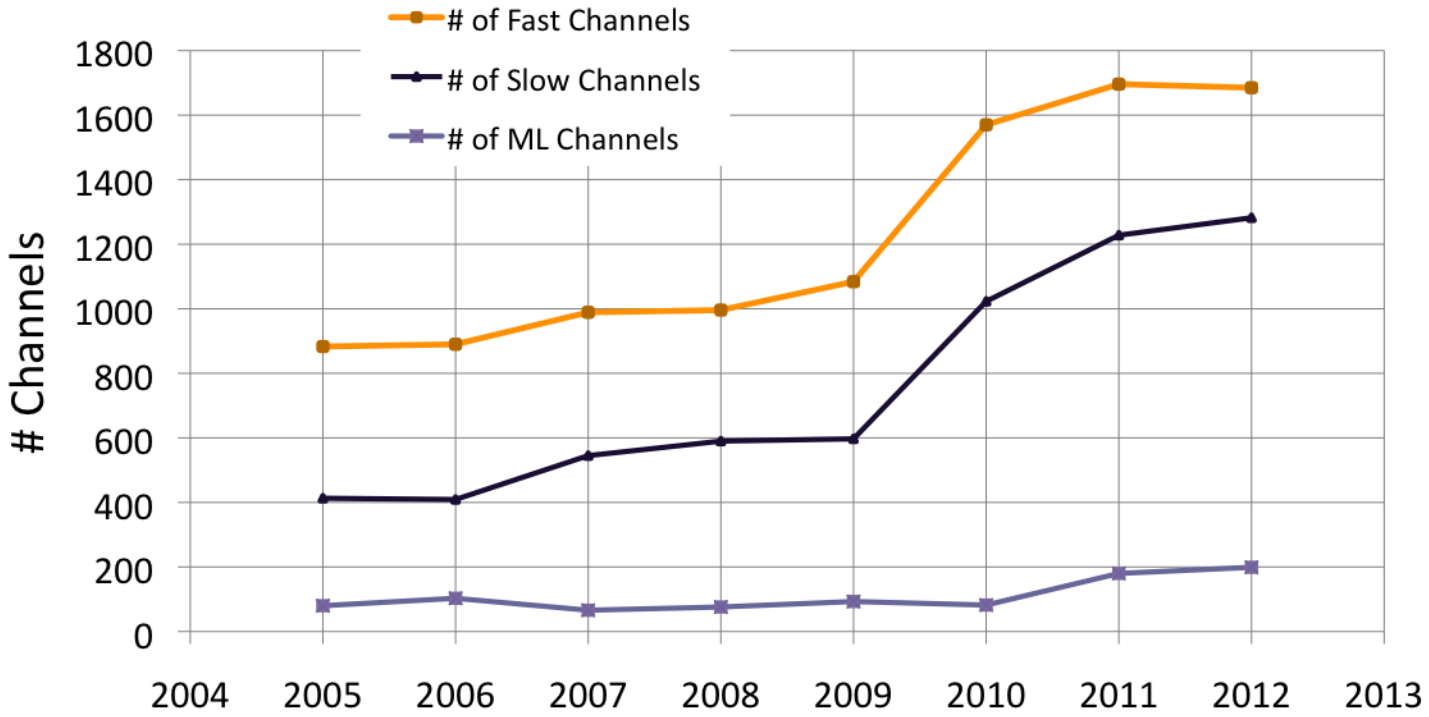
FLASH DAQ – Data Volume

- In 2012 about 1700 fast channels and 1300 slow channels were configured for the LINAC stream (machine parameters). This has to be compared to *O(100k)* control system parameters in total for FLASH.
- Data rate is about 2 TB/day as of 2012 without photon beam user experiments.
- Accelerator data is not preserved, but kept for 10 – 30 days on disk, taped on request.



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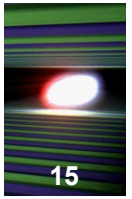
Expected DAQ Data Rates



	FLASH					XFEL				
System	**Channels**	**Sample Size**	**Data Rate [MB/Shot]**	**Measured Size [MB]**	**Data Rate [MB/s] @ 10 Hz**	**Channels**	**Sample Size**	**Data Rate [MB/Shot]**	**Data Rate [MB/s] @ 10 Hz**	**Data Rate [MB/s] @ 25 Hz**
Diagnostics										
Bunch Arrival Time Monitor	56	800	0.17	0.19	1.71					
Bunch Current Monitor	10	510	0.02	0.02	0.19					
Beam Loss Monitor	87	1600	0.53	0.57	5.31	250	2700	2.57	25.75	64.37
Beam Position Monitor	274	510	0.53	0.33	5.33	463	2700	4.77	47.69	119.22
Toroid	12	510	0.02	0.03	0.23	40	2700	0.41	4.12	10.30
	439		**1.28**	**1.13**	**12.78**	**753**		**7.76**	**77.56**	**193.89**
RF/LLRF										
Coupler	244	2048	1.91	1.91	19.06	3264	2700	33.62	336.18	840.45
Klystron	80	2048	0.63	0.64	6.25	224	2700	2.31	23.07	57.68
LLRF Monitoring (Probe, Prefl, Pforw)	215	1024	0.84	1.09	8.40	1632	2700	16.81	168.09	420.23
LLRF Controller (Probe and VS)	398	1024	1.55	1.67	15.55	3264	2700	33.62	336.18	840.45
LLRF Piezo	40	2048	0.31	0.02	3.13	816	2700	8.40	84.05	210.11
LLRF Vector Sum						3264	2700	33.62	336.18	840.45
RF Powermeter	20	2048	0.16	0.17	1.56					
	997		**5.39**	**5.51**	**53.95**	**12464**		**128.38**	**1283.75**	**3209.38**
Photon Beam Diagnostics										
GMD	24	1600	0.15	0.16	1.46					
MCP	8	2048	0.06	0.06	0.63					
Wavelength Measurement (Camera)	1		0.66	0.66	6.60					
	33		**0.87**	**0.88**	**8.69**					
Other										
Laser, special diagnostics, utilities	**300**		**1.23**	**1.23**	**12.30**					
Total	**1769**		**8.77**	**16.27**	**87.71**	**13217**		**136.13**	**1361.31**	**3403.27**

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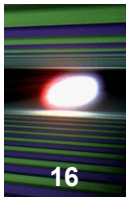
Outlook



- FLASH implementation shows a working accelerator DAQ solution.
- DAQ offers advanced middle layer services with access to shot-synchronized data.
- DAQ archive is complementary to standard archiving and useful for dedicated experiments or studies.

To do

- Test integration of new µTCA platform.
- Test further segmentation of DAQ instances.
- Dynamic configuration of data sources and streams.
- Improve tools and its access to data for operational tasks.
- Web-based access to data statistics (runs, files, channels, …)