EPICS7 at APS

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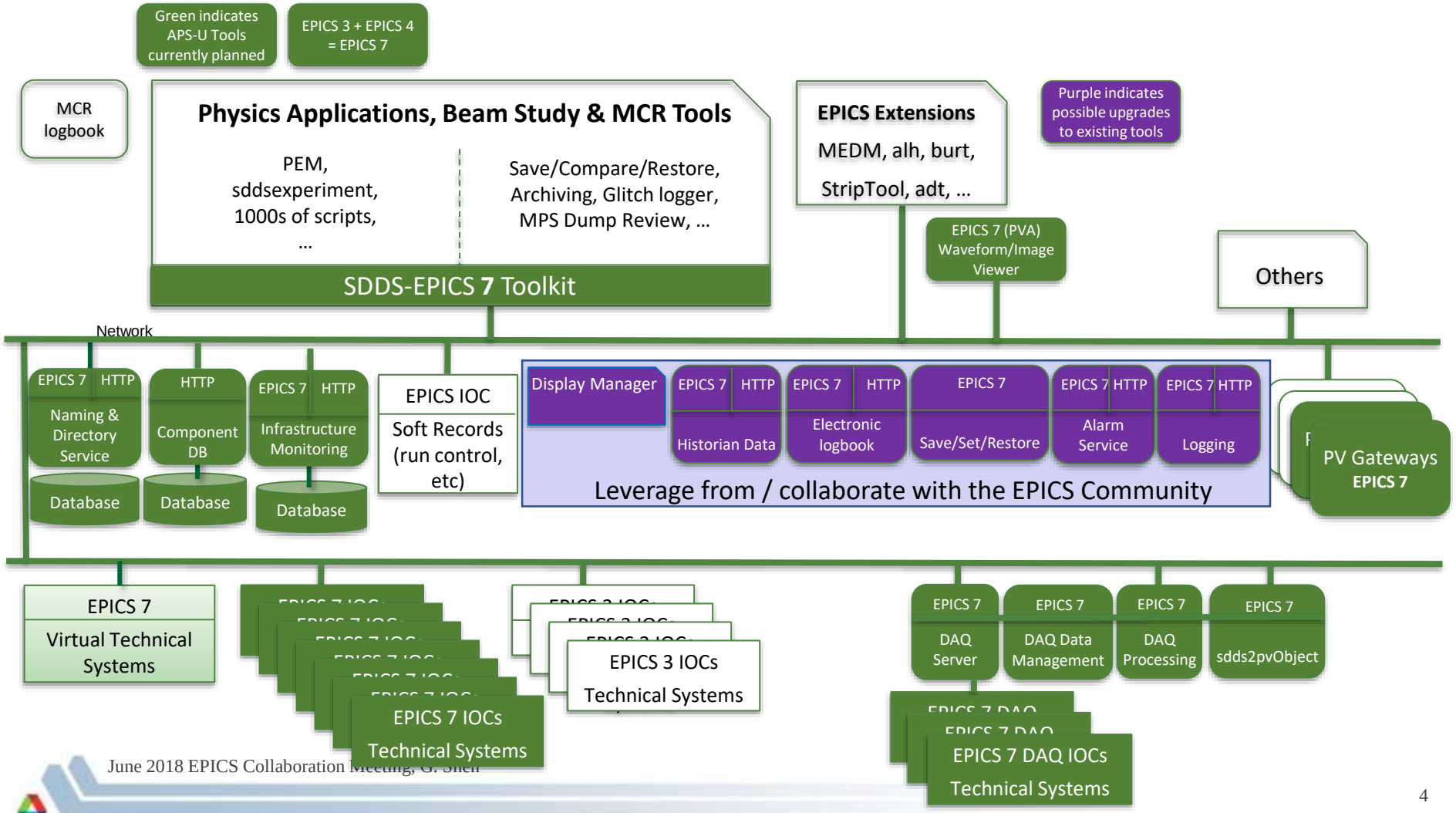
Content

- APS/APSU Controls Software Architecture
- EPICS7 and High Performance DAQ
- EPICS7 and Digital Video System
- PvaPy
- Conclusion

SOFTWARE ARCHITECTURE

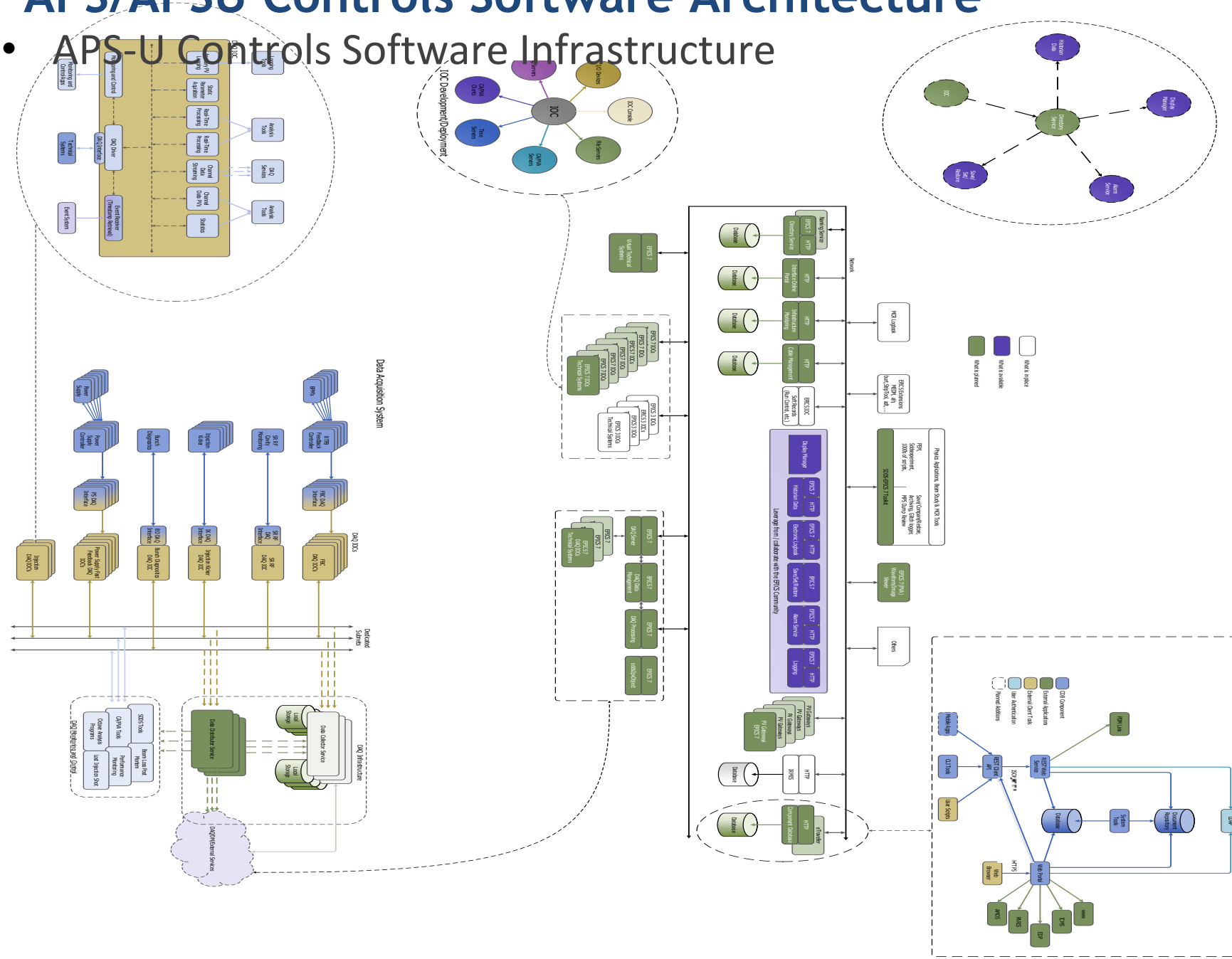
APS/APSU Controls Software Architecture

- Current APS Status and APS-U Proposal



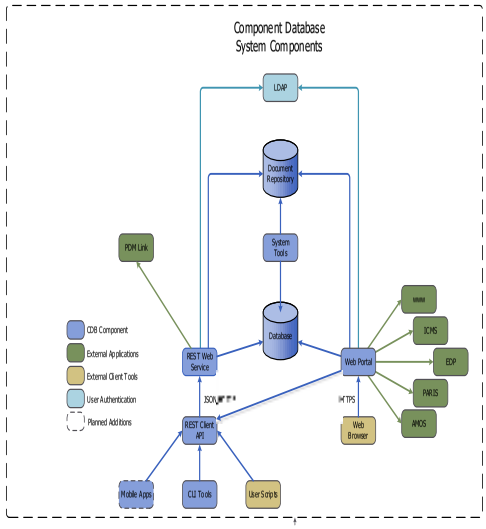
APS/APSU Controls Software Architecture

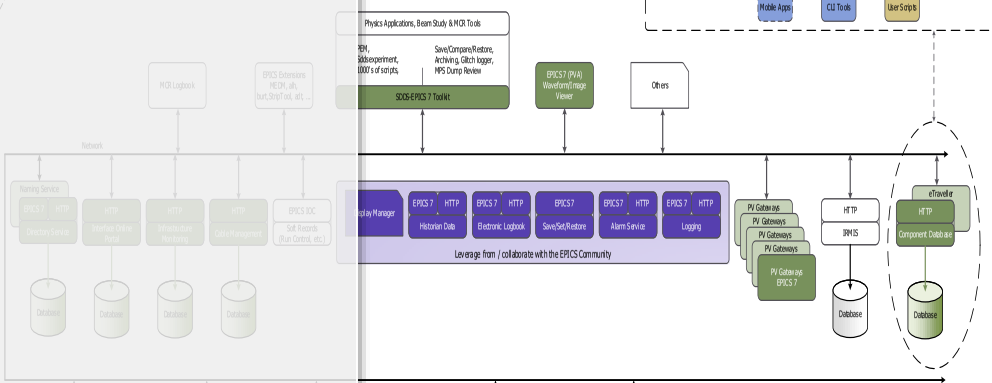
- APS-U Controls Software Infrastructure

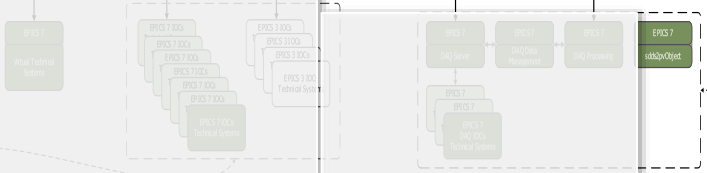


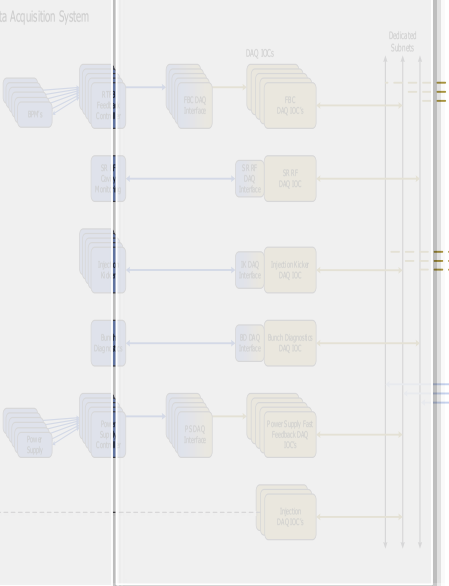
EPICS7 AND HIGH PERFORMANCE DAQ

Controls Software Infrastructure



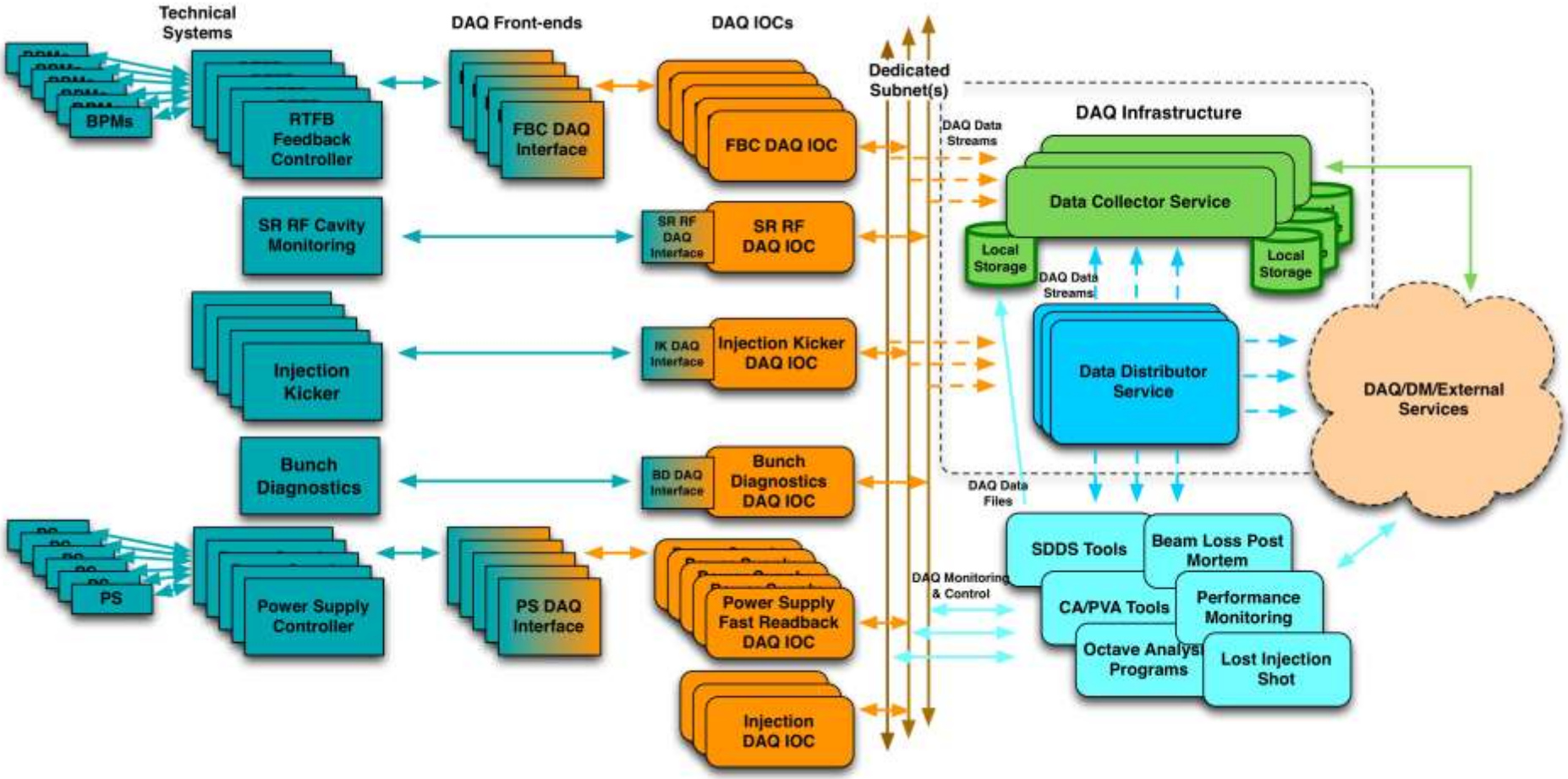






EPICS7 and High Performance DAQ

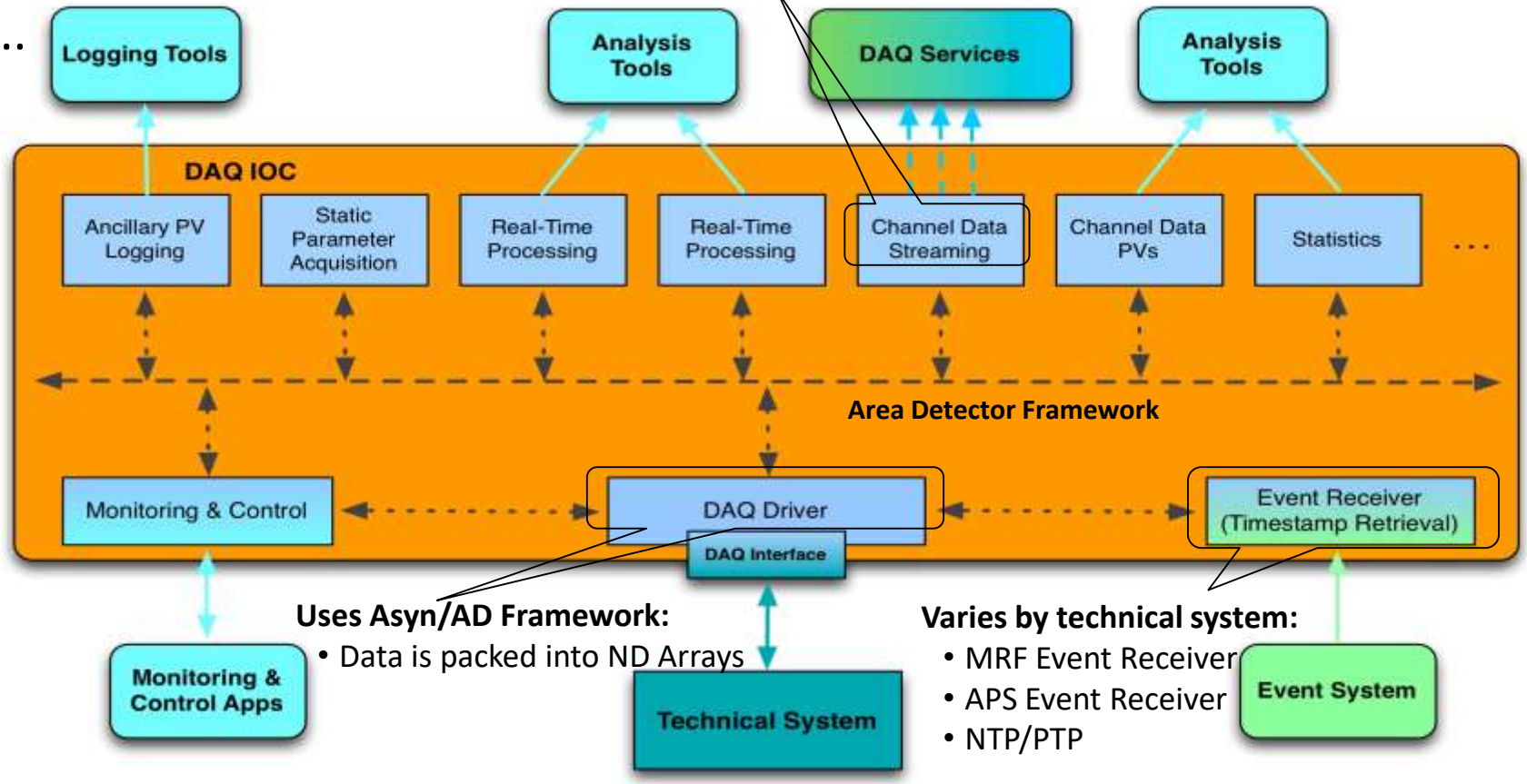
- APSU Data Acquisition System (DAQ)
  - Provides time correlated/synchronously sampled data
  - Can be used for commissioning, troubleshooting, performance monitoring and early fault detection
  - Separated from operational systems to allow troubleshooting during user operations
  - Can acquire data from several subsystems at various sample rates
  - Supports continuous/triggered acquisition
  - Scalability
  - Ability to route data to any number of applications



EPICS7 and High Performance DAQ

- Typical DAQ IOC Structure (Time-correlated DAQ for APS-U)
  - Fast feedback
  - Power Supply fast data in FPGA
  - BPM turn-by-turn data
  - LLRF
  - …

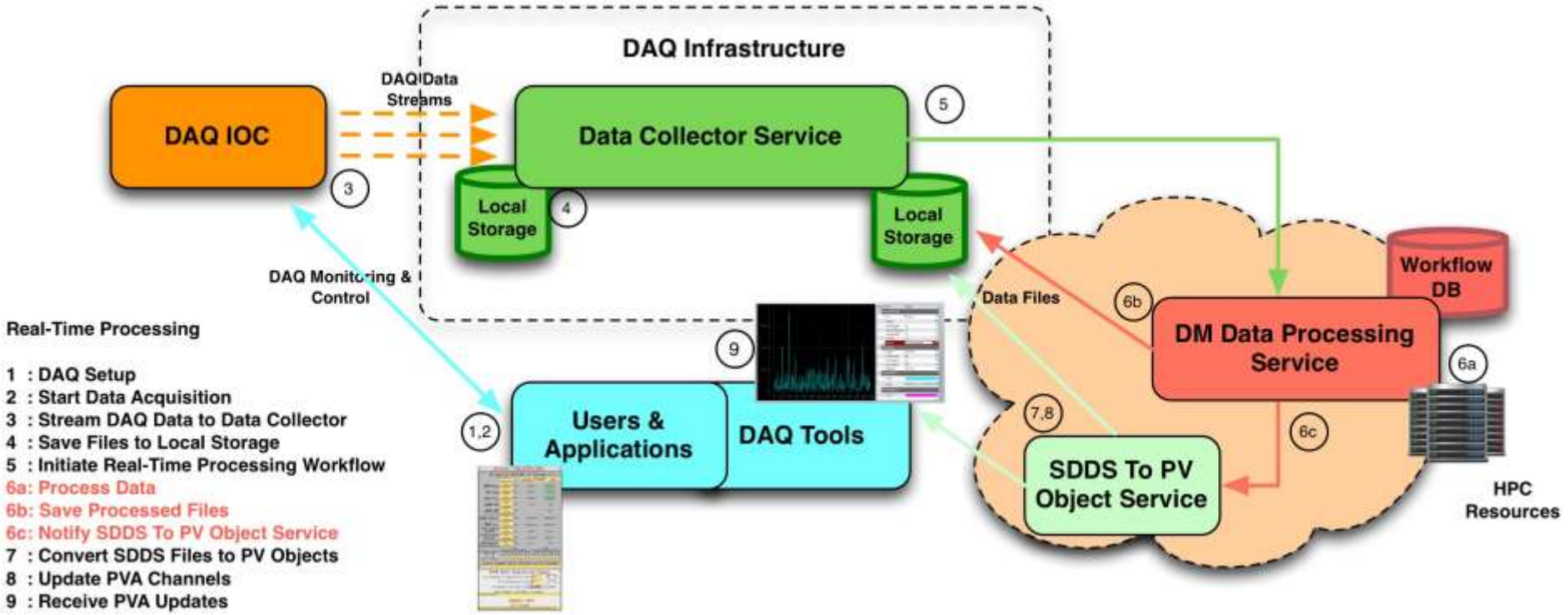
Prototyped several options:
- Custom TCP
- EPICS V4 PVA
- AMQP (QPID)



Uses Asyn/AD Framework:
- Data is packed into ND Arrays

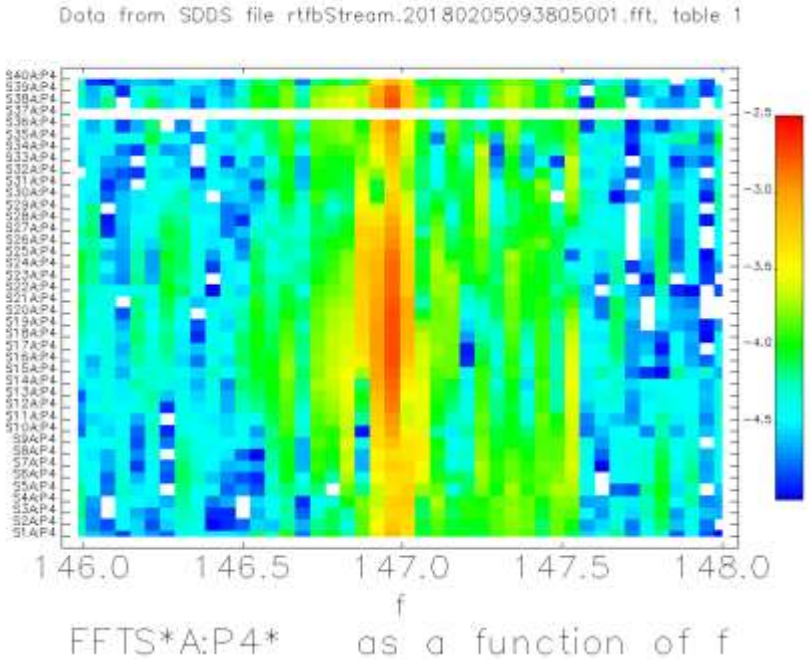
Varies by technical system:
- MRF Event Receiver
- APS Event Receiver
- NTP/PTP

EPICS7 and High Performance DAQ
(Use Case: Automated Real-Time Processing)



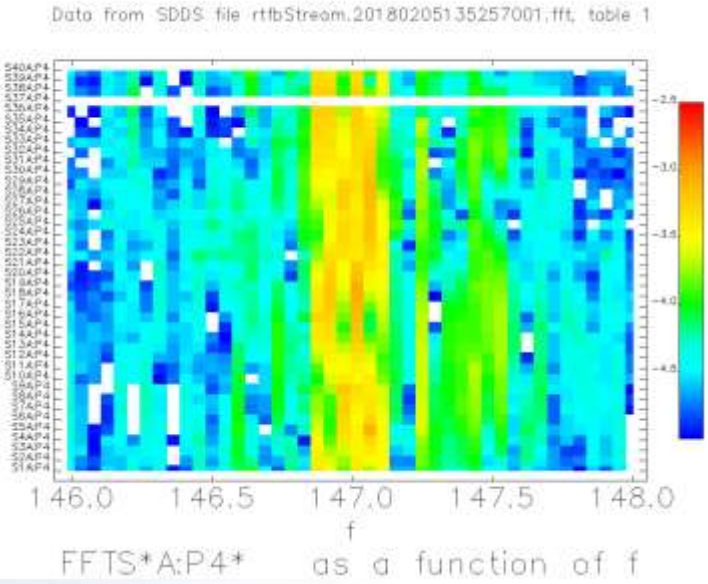
EPICS7 and High Performance DAQ

DAQ Usage Example (L. Emery)



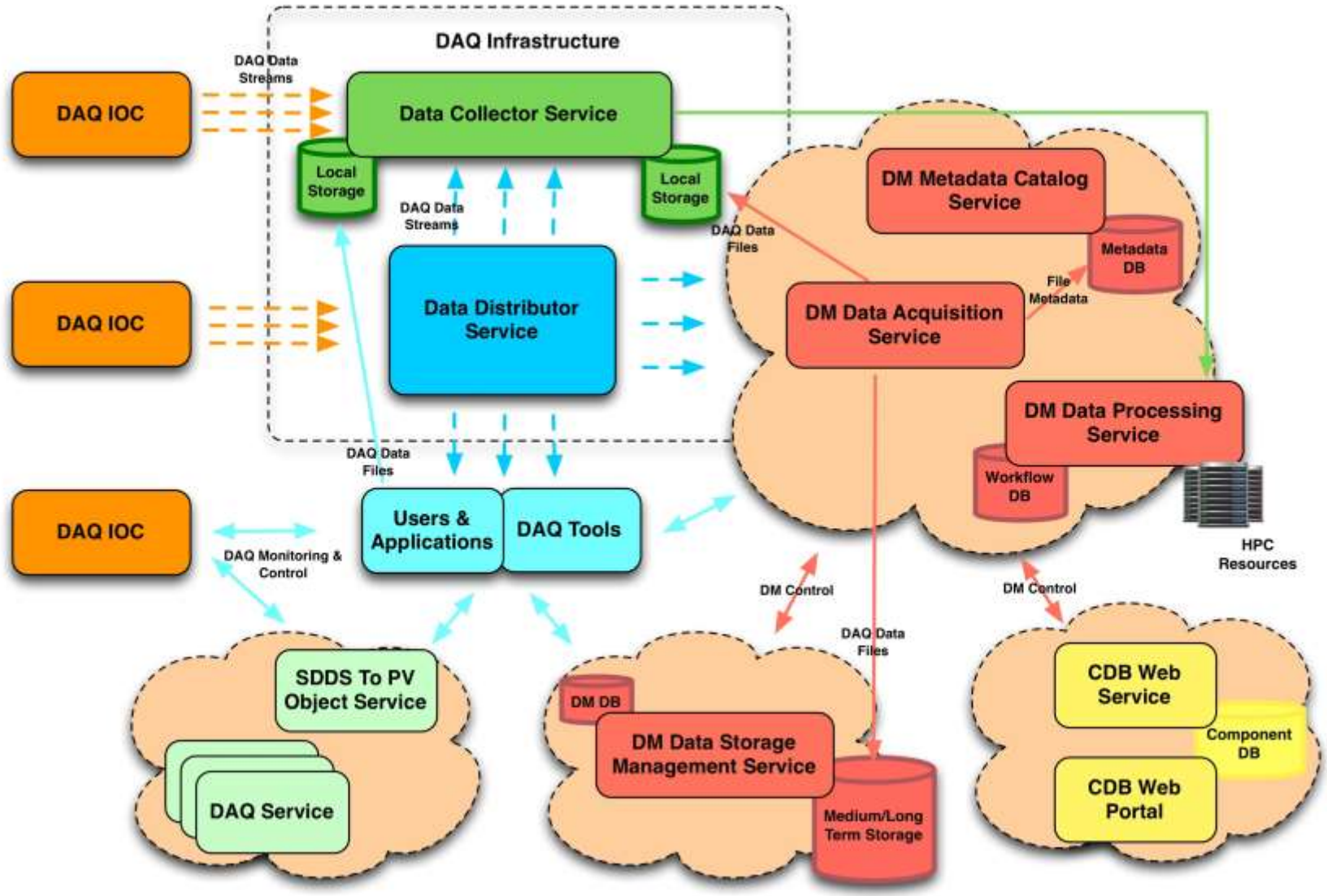
- Suppression of 147Hz vibration source in the ring using the DAQ system + post-processing with FFT
- Vacuum chamber was vibrating and introduced a Bx field; shims were inserted between poles and vacuum chamber (S37AQ3, S37AQ2)

- Identification of the nearest quadrupoles required 400 channels, 20 seconds of continuous DAQ data to get 0.5Hz precision
- This allowed separating line frequencies of 20 pumps
- Figure on the top is showing data before shimming, while the one on the right is showing results after shimming



EPICS7 and High Performance DAQ

- DAQ and Data Management Integration



EPICS7 and High Performance DAQ

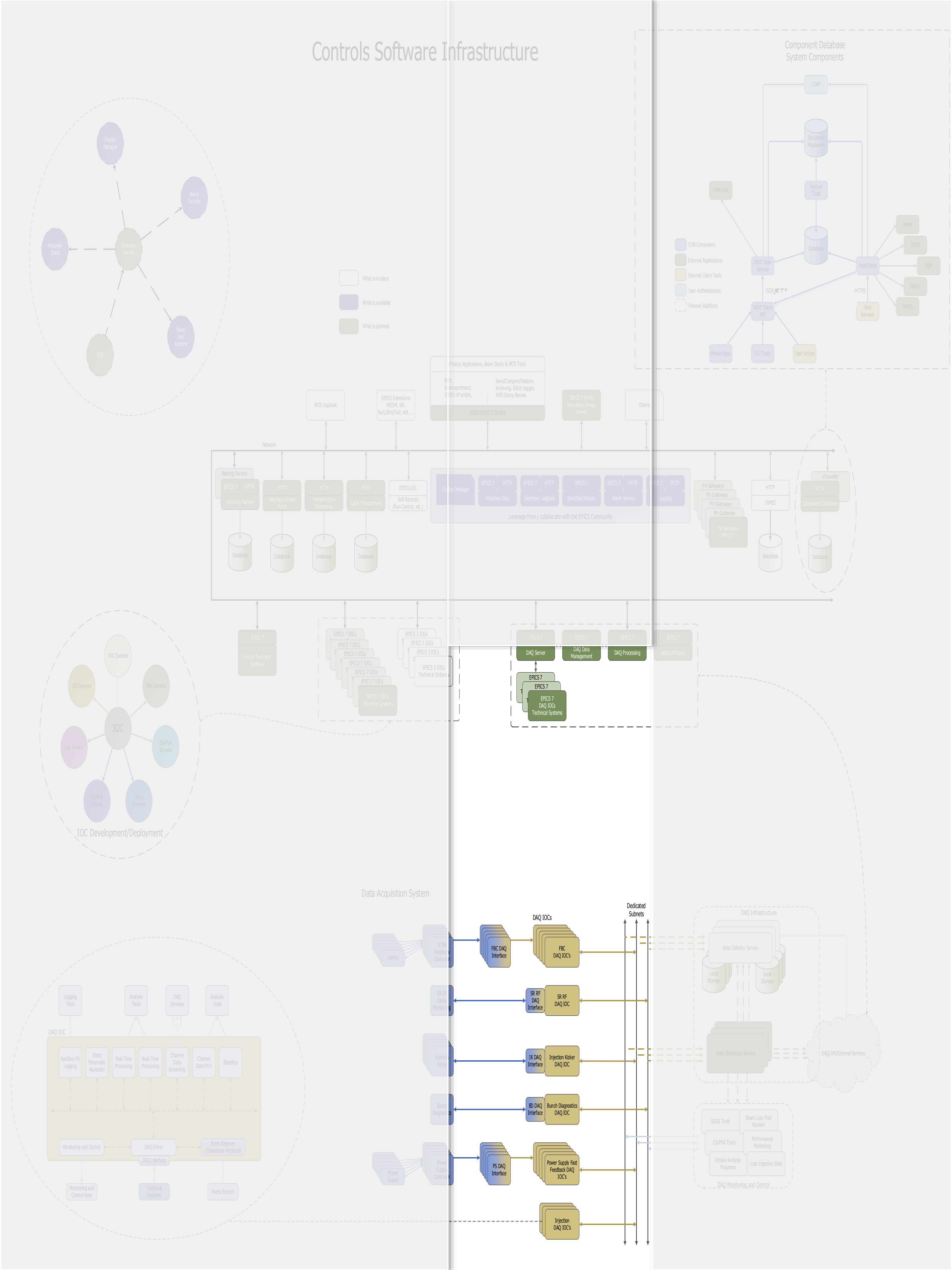
- Estimated Data Rates

Technical System	# of Nodes	Signals per Node	Sample Rate	Data Rate per Node
RF BPMs (Turn-by-turn)	20	30 BPMs x 2 planes	271KHz	65MB/s
X-Ray BPMs	20	5 BPMs x 2 planes	10KHz	0.4MB/s
Fast Orbit Feedback	20	100 signals	22.6KHz	9MB/s
Power Supplies (all types)	20	140 supplies x 3 values	22.6KHz	38MB/s
Injection/Extraction Systems	1	8 waveforms	4GHz	3.2KB/s
SR/Booster RF	3	12 cavities x 3 values	271KHz	39MB/s
Bunch Lengthening System	1	5 values	271KHz	5.4MB/s

- Current Status & Near Term Plan
  - Production deployment for over year
  - Software upgrade all in place, tested, ready for production deployment

		Production	Near Term Upgrade
EPICS7	Base	3.15.4	7.0.1.1
	V4	4.6.0	
pvaPy		0.9	1.1.x
Area Detector		2.5	3.2
Asyn		4-29	4-33

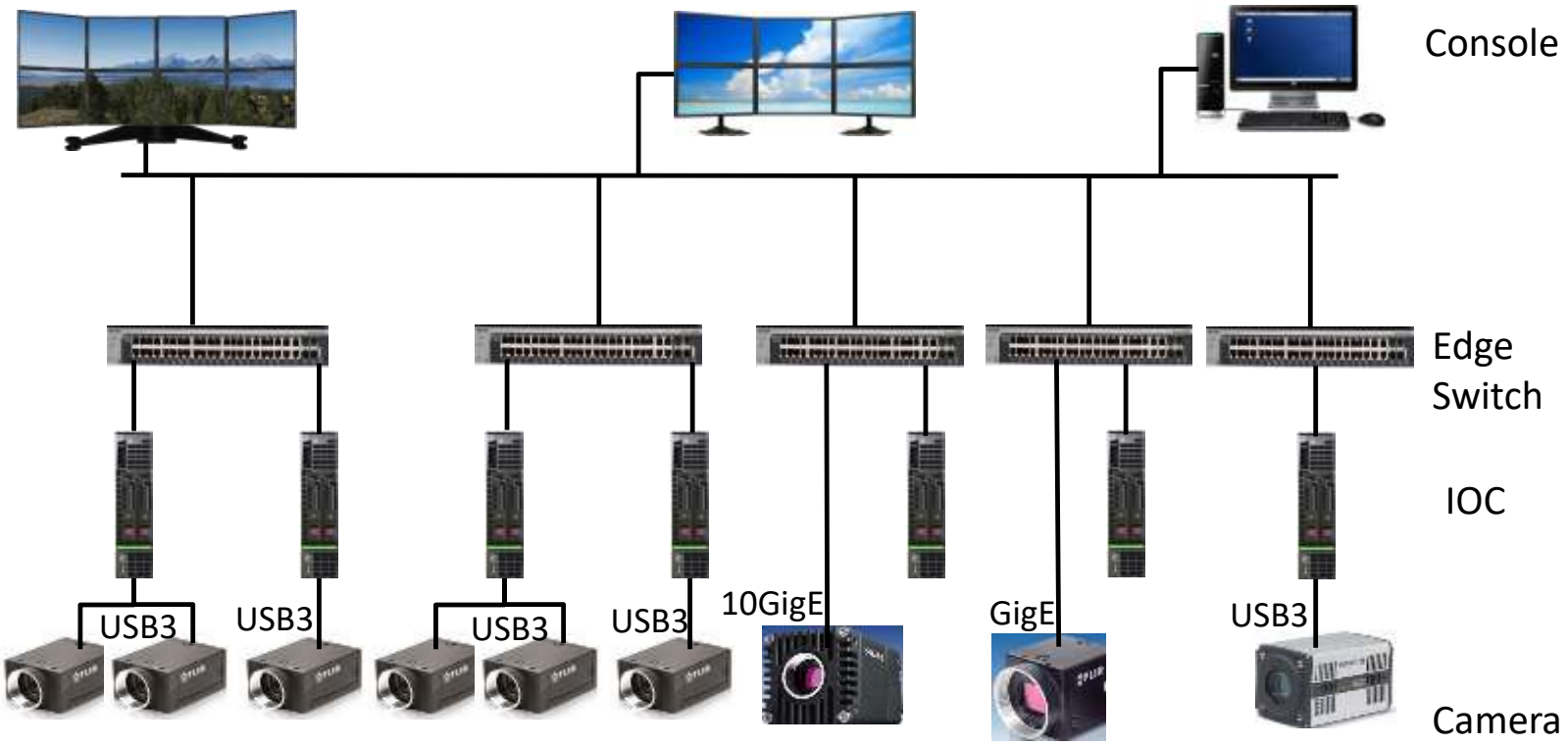
EPICS7 AND DIGITAL VIDEO SYSTEM



Controls Software Infrastructure
Component Database
System Components
What is in place
What is available
What is planned
Physics Applications, Beam Study & MCR Tools
SDDS EPICS 7 Tools
MCR Logbook
EPICS Extensions
Others
Network
Leverage from / collaborate with the EPICS Community
IOC Development/Deployment
IOC
Data Acquisition System
DAQ IOCs
Dedicated
Subnets
DAQ Server
DAQ Data
Management
DAQ Processing
EPICS 7
EPICS 7
DAQ IOCs
Technical Systems
FBC DAQ
Interface
FBC
DAQ IOC's
SR RF
DAQ
Interface
SR RF
DAQ IOC
IK DAQ
Interface
Injection Kicker
DAQ IOC
BD DAQ
Interface
Bunch Diagnostics
DAQ IOC
PS DAQ
Interface
Power Supply Fast
Feedback DAQ
IOC's
Injection
DAQ IOC's
DAQ Infrastructure
Data Collector Service
Data Distributor Service
DAQ Monitoring and Control
DAQ IOC

EPICS7 and Digital Video System

- APS diagnostics digital camera system requirements
  - Canonical needs like most diagnostic camera instruments
  - Or high frame rate to observe beam damping time
  - Or extreme low e^- read noise
- System architecture



EPICS7 and Digital Video System

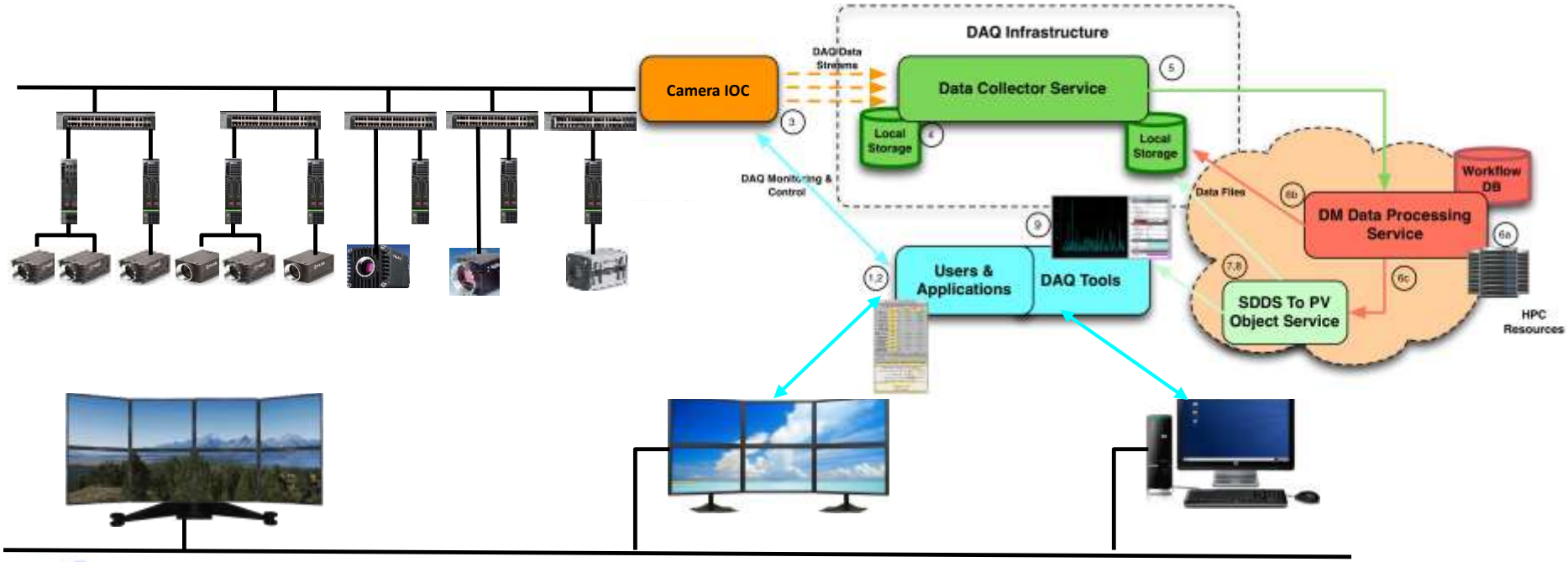
- Hardware choices
  - FLIR (Point Grey) GigE camera for canonical use case
  - FLIR USB3 for high frame rate use case
  - sCMOS camera for low e^- read noise
- Software

	Deployment
EPICS7	7.0.1.1
pvaPy	1.1.x
Area Detector	3.2
Asyn	4-33

- Beam damping observation
  - Deployed for APS PAR
  - 500~600 fps
  - AD PVA plugin (NtNDArray)

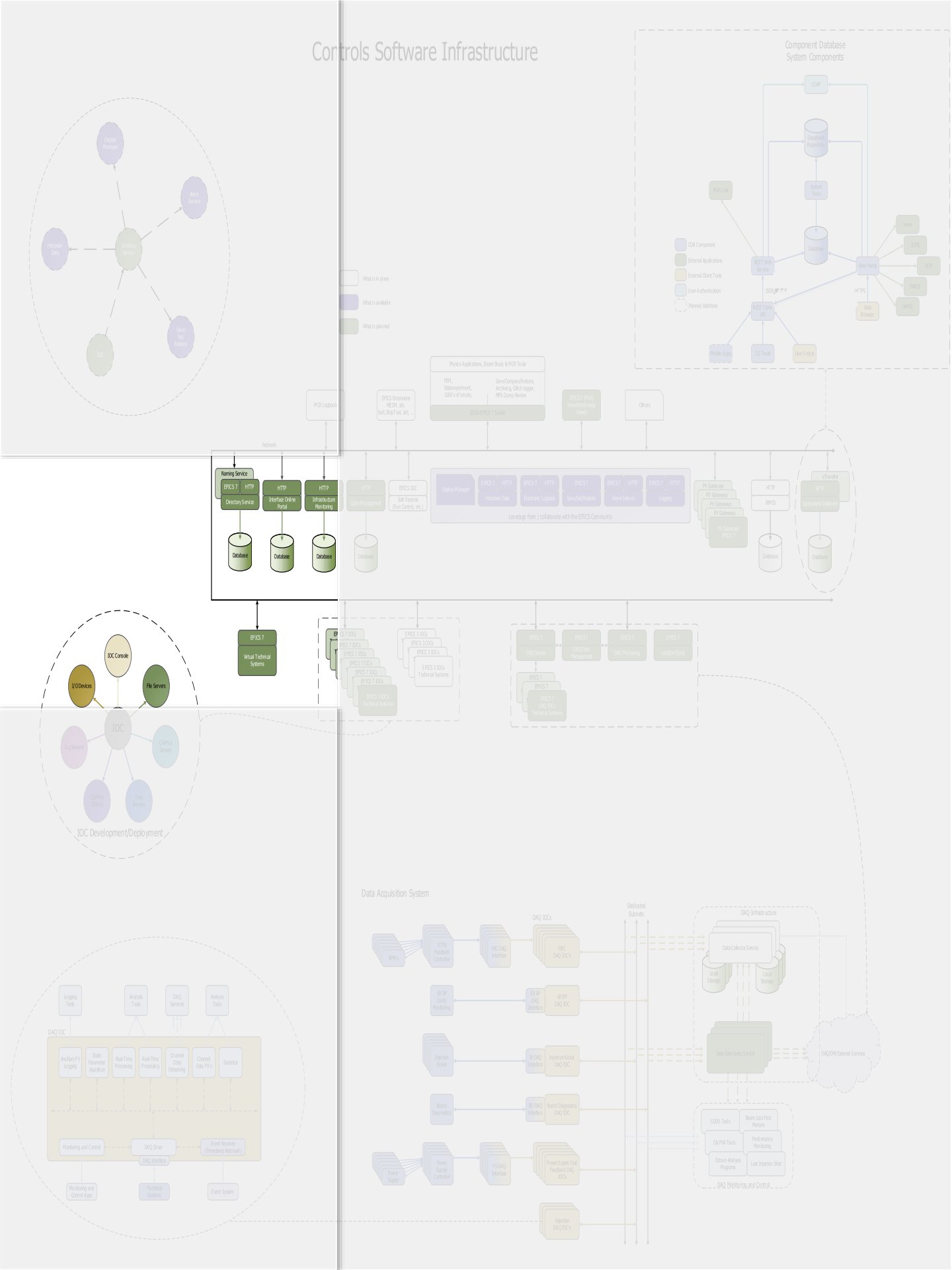
EPICS7 and Digital Video System

- Next Plan
  - Plan to take 100 seconds data per experiment/study
  - 3Gbps data rate per camera (or more) to be saved/transferred
    - Local HD solution does not sound reasonable
    - 10GigE Network infrastructure available to use
  - Integrate with DAQ Data Management (DM) system
    - Directly stream data into DM with new area detector streaming plugin



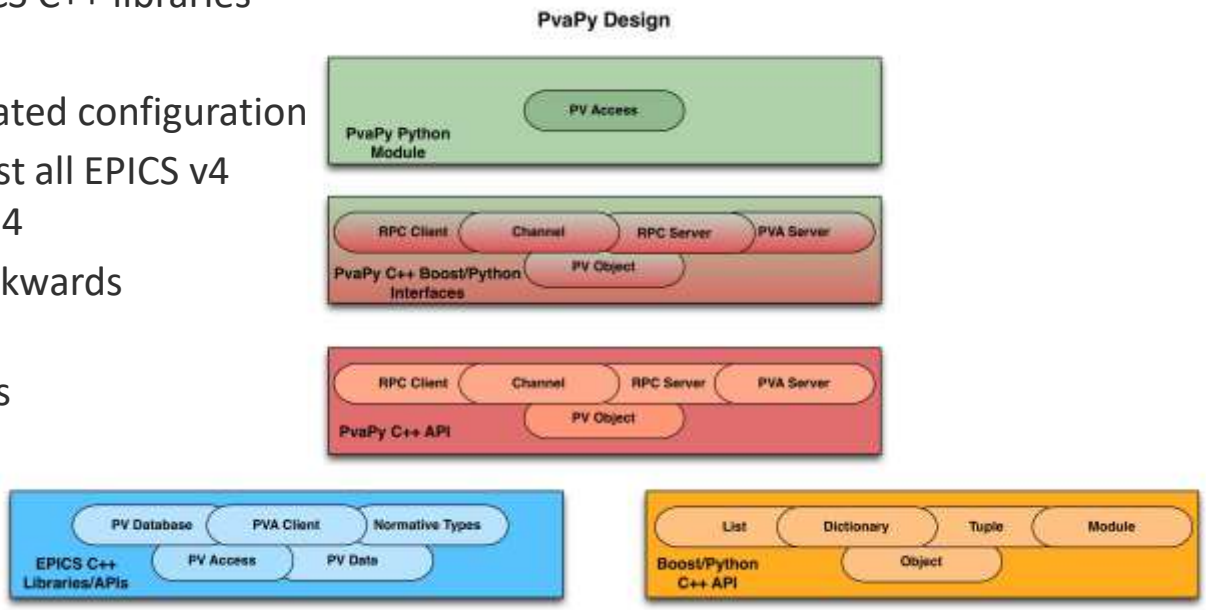
PVAPY: A EPICS7 PYTHON LIBRARY

Controls Software Infrastructure



PvaPy – Python API for PV Access

- Uses boost.python to wrap EPICS C++ libraries
- Works for both CA and PVA
- Utilizes EPICS build with automated configuration
- Builds against EPICS7 and against all EPICS v4 versions starting with release 4.4
- Maintains stable interfaces, backwards compatibility
- Easy installation for Conda users
- Works on Python 2/3
- Works on OSX and Linux
- Very good performance



Functionality

- Support for scalars, structures and unions (both variant and restricted)
- Support for channel monitors, get(), put(), putGet() and getPut() operations
- Support for numpy arrays
- PVA Server
- RPC server/client

Getting Software

- Sources: **https://github.com/epics-base/pvaPy**
- Online Documentation: **https://epics.anl.gov/extensions/pvaPy/production**
- Conda packages (Python 2 or 3): **epics::pvapy** (packages contain documentation)

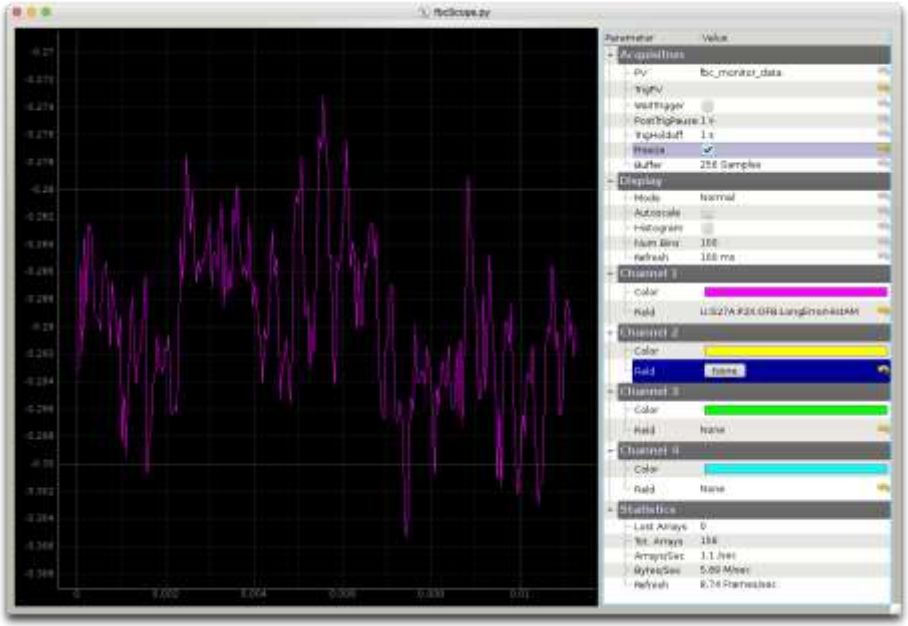
More Info in lighting talks:

- PvaPy Status Update, S. Veseli
- From Zero to EPICS7 in 5 minutes, T. Fors

PvaPy Use Cases

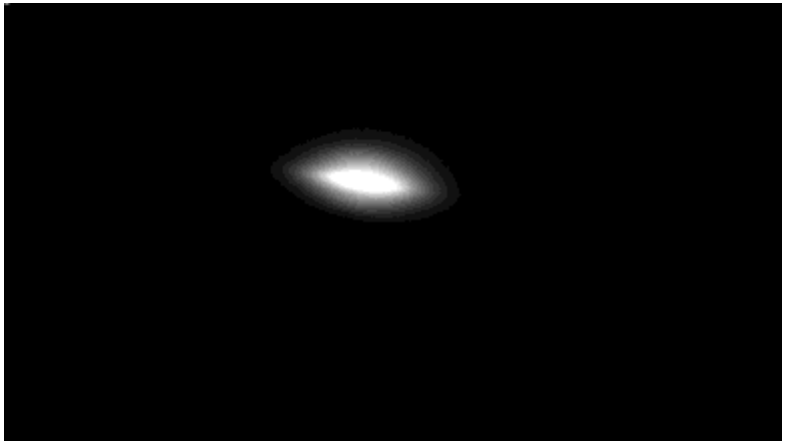
Scope Application

- Monitor fast data from DAQ FOFB, PS, BPM TxT, LLRF, ...



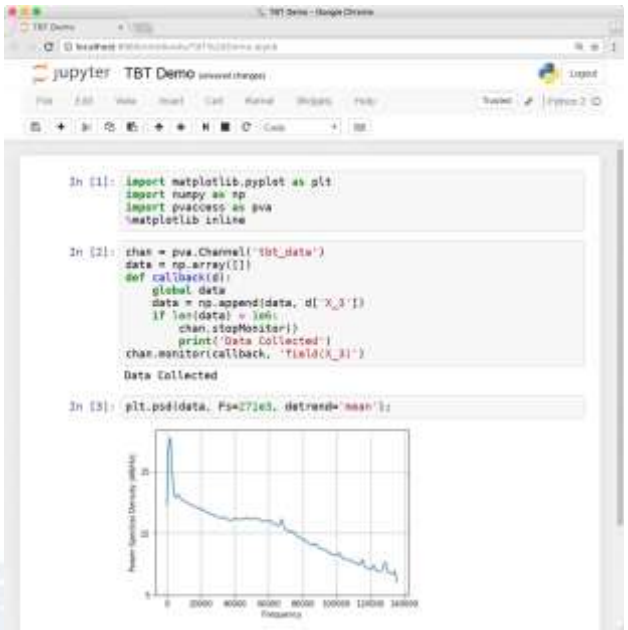
Video image

- Desktop testing 45fps @1920x1200 (~800Mbps)
- To be merged with scope application



Python jupyter notebook

- Online data analysis, machine controls



Conclusion

- APS/APSU software infrastructure clarified, and development strategy established to deliver a modern APS/APSU control system
- High performance DAQ system based on EPICS7 in production over year
- Digital video system primarily uses EPICS7 for its image data, and planning to develop an area detector plugin to stream image data to DAQ Data Management system directly for post use
- EPICS7 Python binding, pvaPy, under active development, and its 1.1.0 version released on 4/30/2018
- Client application under active development on top of pvaPy

Thanks

- Mark Rivers for all his supports in area detector and various productive discussions
- Tim Mooney for his help in assembling synApp modules
- Tim Madden @ RF group for his valuable discussions and contributions on the EPICS7 Scope application
- Bingxin Yang @ Diagnostics group for his various discussions on digital video system development
- All colleagues at Controls Group for their contributions, discussions, helps, and suggestions