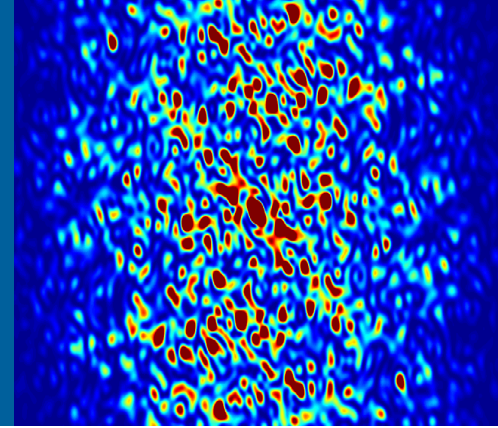


APS COMPUTING AND DATA MANAGEMENT INFRASTRUCTURE

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APS BEAMLINE COMPUTING INFRASTRUCTURE

- APS: 67 beamlines today (42 XSD, 25 CAT)
- Separate network infrastructure for XSD and CAT beamlines
- All beamlines have some local computing and storage resources
- Centrally managed infrastructure:
 - Beamline NetApp Storage
 - Voyager: medium/long term storage system
 - Virtualization clusters
 - Orthros: HPC cluster
 - Database applications (ESAF DB, BSS)
 - Data Management System

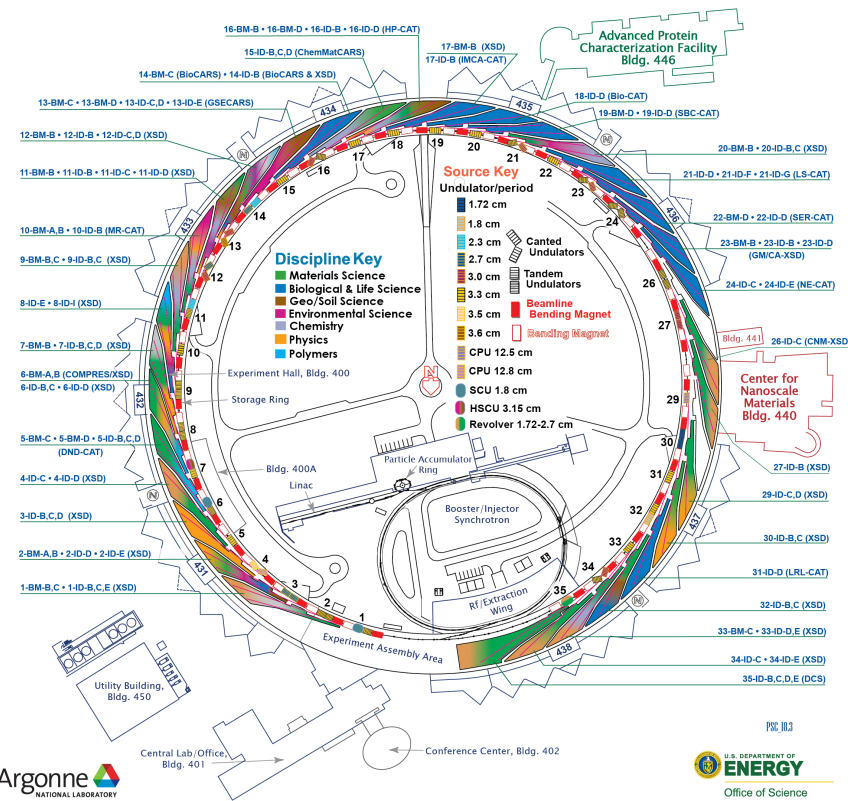
ARGONNE NATIONAL LABORATORY 400-AREA FACILITIES

ADVANCED PHOTON SOURCE

(Beamlines, Disciplines, and Source Configuration)

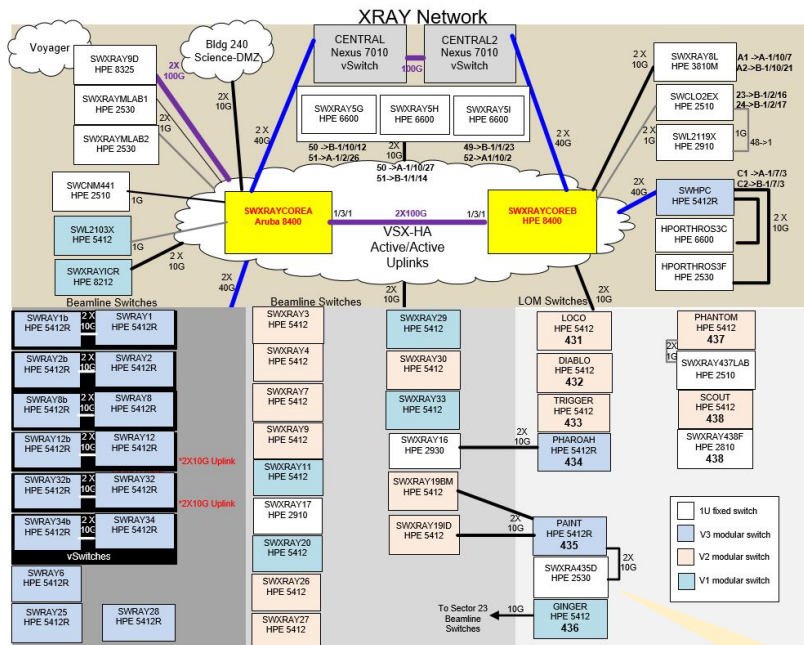
ADVANCED PROTEIN CHARACTERIZATION FACILITY

CENTER FOR NANOSCALE MATERIALS



NETWORK INFRASTRUCTURE

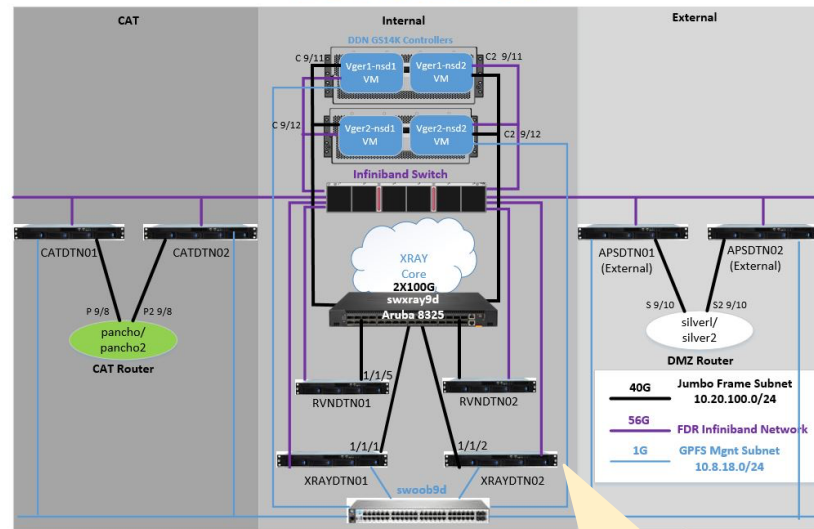
- Separate networks for XSD and CAT beamlines



6 XSD beamline switches have 40G links to core switches

Most beamline/LOM switches have 10G links to core switches

DTN DATA/Network Connections



Each data transfer node for the central storage system has 40G link

BEAMLINE NETAPP STORAGE

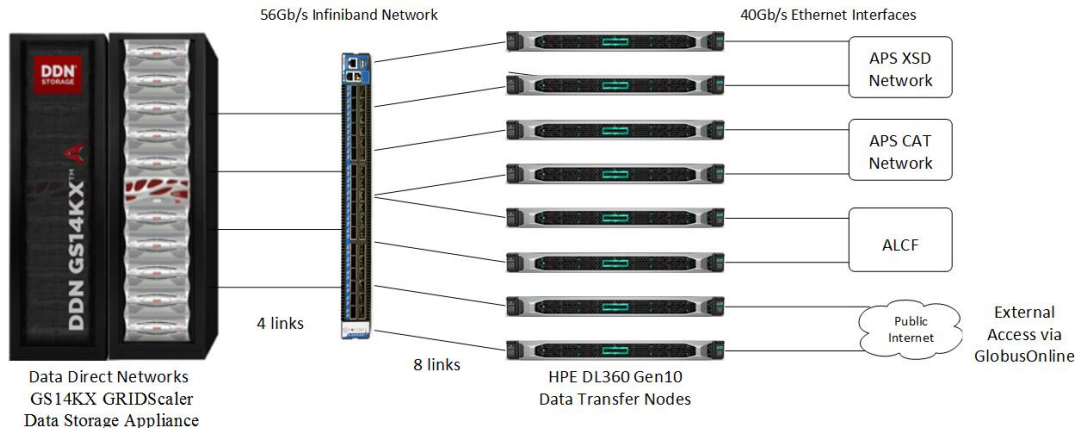
- Used as primary NAS storage for beamline users and data
- Four 2-node appliances in a cluster:
 - 3 appliances provide SATA storage (FAS 8040 & FAS 8200, 750 TB)
 - 1 appliance provides SSD storage (AFF-A300, 15 TB)
- Supports NFS and CIFS
- No predetermined storage allocation per beamline
 - Storage is allocated on a first come, first served basis
 - Each beamline has its own Storage Virtual Machine
- Using thin provisioning, deduplication, compression, snapshots



NetApp FAS 8200

VOYAGER: APS DATA STORAGE SYSTEM

- GridScaler GS14KX file storage appliance
 - IBM Spectrum Scale (formerly GPFS) high performance filesystem
 - 2 controllers, each controller running 2 VMs (GPFS servers)
- 430 12TB disks, 4.1PB of usable storage
- Current system has 10 enclosures, room for 900 disk drives (8.5PB of storage)
- It can be expanded up to a total of 20 enclosures (1800 drives, about 17PB of storage)

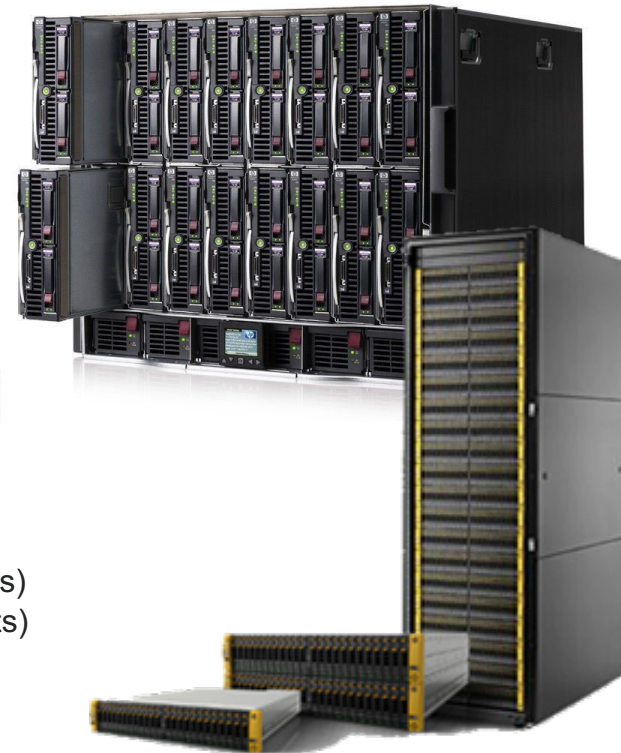


- Data Transfer Nodes: 1 Intel Xeon 6144 3.5GHz CPU, 128GB RAM, 40 Gbps ethernet link, 56 Gbps Infiniband, 2 x 400GB SSD drives (mirrored):
 - 2 for APS XSD beamlines
 - 2 for APS CAT beamlines
 - 2 for APS to ALCF data transfers
 - 2 for External access via Globus Online
- External users/collaborators retrieve data using Globus Online

VIRTUALIZATION RESOURCES

- HPE ProLiant Blade System: 2 x c7000 chassis in an active/active H/A configuration)
- 26 hypervisors: HPE ProLiant BL460c blade servers, gen 8, 9, 10
 - Dual CPU, 36 hyper-threaded cores per CPU
 - Between 128 GB and 512 GB RAM
- Two HPE 3Par storage arrays (each has two controllers):
 - Model 7440c, 110TB SAS and 10TB tiered SSD storage, used as primary SAN storage for virtual servers
 - Model 8440, 40TB SSD storage, used as boot drives for virtual servers
- Hypervisor nodes support 8 virtual clusters:
 - General purpose (2 hosts)
 - BCDA (beamline control system support; 2 hosts)
 - XSD dserv cluster (distributed network services for XSD beamlines; 6 hosts)
 - CAT dserv cluster (distributed network services for other beamlines; 2 hosts)
 - XSD Data Management cluster (4 hosts)
 - CAT Data Management cluster (2 hosts)
 - DMZ cluster (Internet-accessible services for XSD beamlines; 2 hosts)
 - Development cluster (6 hosts, including warm spares for all clusters)

HPE ProLiant c7000 Enclosure

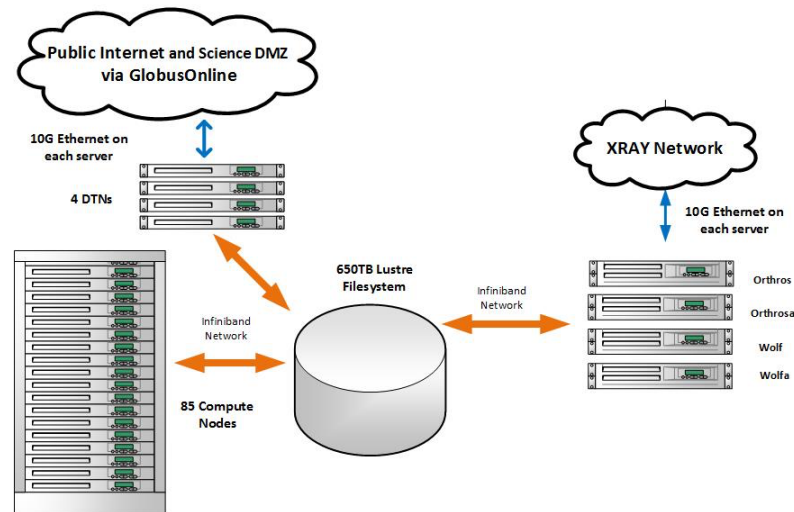


HPE 3Par Family

ORTHROS: APS ON-DEMAND ANALYSIS CLUSTER

- SGE batch scheduler
- 85 compute nodes, 1060 CPU cores
- Each node has a minimum of 64GB RAM, newer nodes have 128-192GB RAM
- Compute nodes dedicated to each user/beamline
 - Provides instant access for fast job turnaround
 - Allows scientists to adjust experiment parameters in near real-time
 - Compute nodes are configured for specific analysis techniques (e.g., more memory and/or more cores)
- External users/collaborators retrieve data using Globus Online
 - 2 DTNs for Public Internet access
 - 2 DTNs for the Science DMZ
- 650TB Lustre Filesystem
 - Enterprise class storage with redundant controllers
 - Supported by NFS, SMB and GridFTP

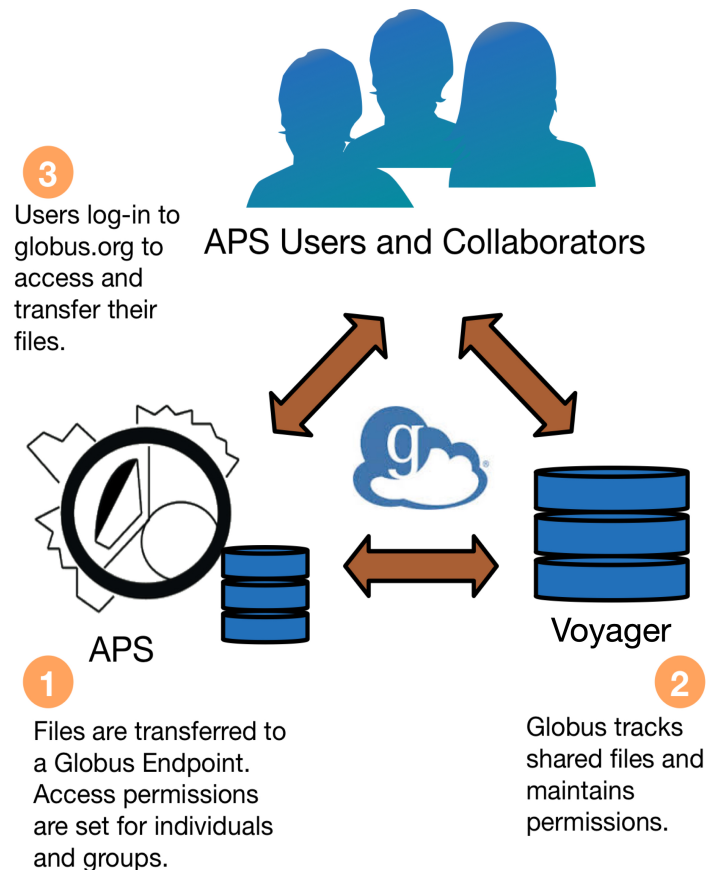
Orthros Configuration



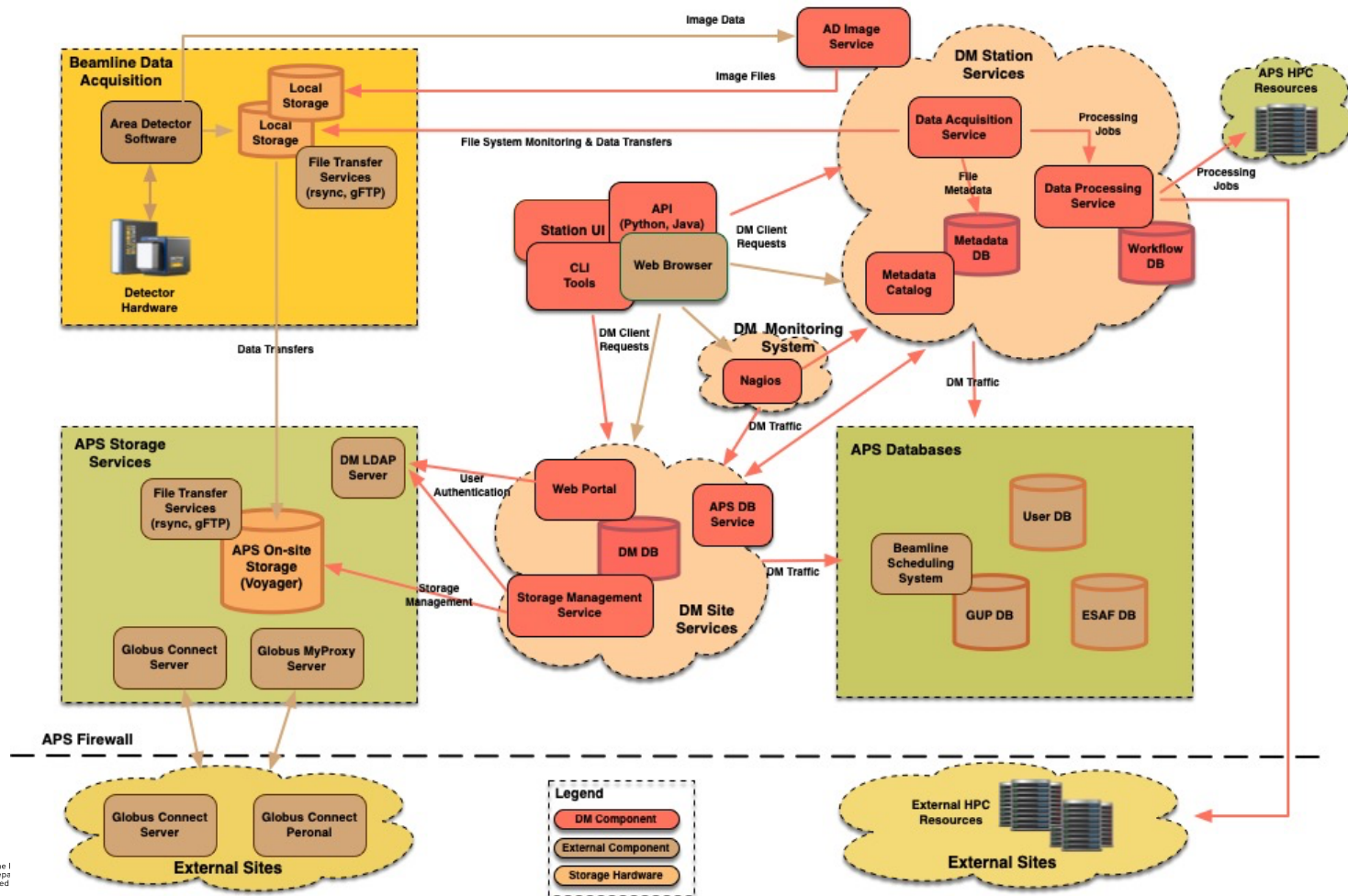
- Example Usage: 8-ID-I
 - 11 dedicated nodes
 - running about 100 jobs per day over the last 4 months (from 10/19 through 01/20)

APS DATA MANAGEMENT SYSTEM

- DM software is designed to help beamlines with various data management tasks
- *Storage area management*: movement of acquired data from local storage to a more permanent location, data archival, etc.
- *Enabling users and applications to easily find and access data*: metadata and replica catalog, remote data access tools
- *Facilitating data processing and analysis with automated (in real-time) or user-initiated processing workflows*

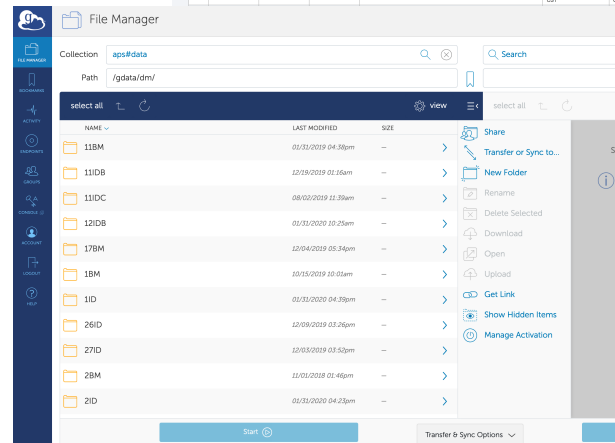
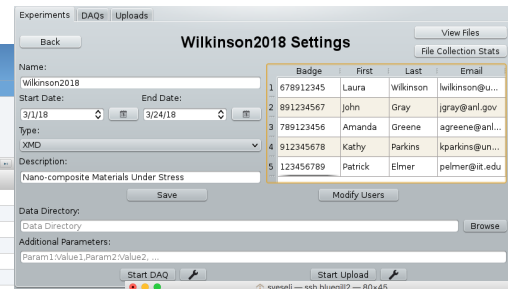
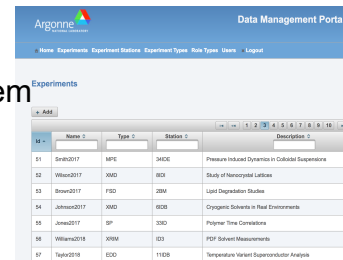
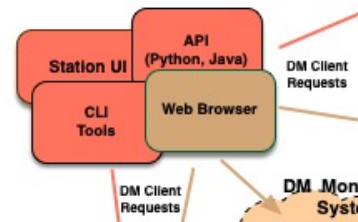


APS Data Management System



DM USER INTERFACES

- Web browser access to the DM Web Portal, Nagios web pages, beamline Metadata Catalog, and Globus Online (for remote data access)
- Python REST services are accessible via DM Python and Java APIs
 - DM Python modules available as Conda packages
 - Easy access to ESAF DB and Beamline Scheduling System
- Workflow engine provides OMQ interfaces for job submission
- Extensive set of command line tools
 - Built on top of Python APIs
 - Session based
 - Fully scriptable
 - Online usage documentation (--help option)
- DM Station GUI
 - Implemented in PyQt
 - Uses Python REST APIs
 - Easiest way to start using the system



```
dm-6m-daq --experiment=EXPERIMENTNAME --data-directory=DATA DIRECTORY
[--duration=DURATION]
[--dest-directory=DEST DIRECTORY]
[--upload-data-directory-on-exit=UPLOAD DATA DIRECTORY ON EXIT]
[--upload-dest-directory-on-exit=UPLOAD DEST DIRECTORY ON EXIT]
[--process-hidden]
[--process-existing]
[--workflow-name=WORKFLOWNAME --workflow-owner=WORKFLOW OWNER]
[--workflow-job-owner=WORKFLOW JOB OWNER]
[--workflow-args="key1:value1 key2:value2 ..."]

[--skip-plugins=SKIP PLUGINS]
[--type=TYPE NAME]
[--description=DESCRIPTION]
[--start-date=START DATE]
[--end-date=END DATE]
[--user=USERS]
[--esaf-id=ESAF ID]
[--proposal-id=PROPOSAL ID]
[--run=RUN NAME]
[key1:value1, key2:value2, ...]

Description:
Run DAQ for experiment on station 609A. If experiment does not exist, it will
be added to the DM database. If list of users or proposal id is specified, this
command will also add roles for all users listed on the proposal.

Options:
--experiment=EXPERIMENTNAME Experiment name.
--data-directory=DATA DIRECTORY Experiment data directory.

DAQ Options:
--dest-directory=DEST DIRECTORY Destination directory relative to experiment root
path.
--duration=DURATION DAQ duration; it must be specified in hours (h) or
days (d). Examples: "8h", "14d".
--upload-data-directory-on-exit=UPLOAD DATA DIRECTORY ON EXIT
```

DM WORKFLOWS

- Can be used to fully automate data acquisition and processing pipelines on APS beamlines
- Generic framework that can handle both automated real-time processing, as well as user-initiated processing and analysis of data
- Seamless integration with the rest of the DM system components
- Workflow definitions are described as Python dictionaries and kept in Mongo DB
- DM workflow is a collection of processing steps executed in order
- Each processing step is associated with an (arbitrary) executable
- Support for input/output variables
- Processing steps are automatically parallelized if possible
- Support for batch jobs
- Support for processing multiple files with a given workflow
- Job monitoring is done by polling the service and generating web pages

Viewing Collection: 8idiuser-workflows

_id	owner	stages	description	name
5a0395b2441dc3d393a96	8diuser	[{"1-Staging": "...", "2-Setup": "..."}]	XPCSB-01 Workflow	xpcsb-01
5b80571384221d0a7aa74a48	8diuser	[{"2-APCS": "...", "3-Staging": "..."}]	XPCSB-04 NERSC Workflow	xpcsb-04-NERSC
5a6649e83441dc4e99f1c321	8diuser	[{"6-Monitor": "...", "7-File": "...", "8-Monitor-File": "...", "9-APCS": "...", "4-CopyBack": "..."}]	XPCSB-02 Workflow	xpcsb-02
5a6a77203441dc337ab9575	8diuser	[{"1-Staging": "...", "6-CopyBack": "..."}]	XPCSB-03 Workflow	xpcsb-03

Output timestamp: 2018/09/26 17:57:21 CDT

Number of processing jobs: 144

startTimestamp	endTimestamp	speJobName	speJobId	status	stage	runTime	id
2018/09/26 17:56:06 CDT		R137_P12_hetero_1_step2_10mm_Strain010_atto_Lq0_055	192755243	running	5-Monitor	69.58	57023b6
2018/09/26 17:22:45 CDT	2018/09/26 17:24:07 CDT	R137_P12_hetero_1_step2_10mm_Strain010_atto_Lq0_055	192755221	done	6-CopyBack	82.02	1637058
2018/09/26 16:54:41 CDT	2018/09/26 16:55:21 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_054	19275503	done	6-CopyBack	39.42	5678860
2018/09/26 16:52:26 CDT	2018/09/26 16:53:11 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_053	19275498	done	6-CopyBack	45.59	bec3a6a
2018/09/26 16:42:35 CDT	2018/09/26 16:43:08 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_051	19275466	done	6-CopyBack	33.48	a7ef69a
2018/09/26 16:37:19 CDT	2018/09/26 16:37:58 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_050	19275437	done	6-CopyBack	39.20	18e164d
2018/09/26 16:33:59 CDT	2018/09/26 16:34:39 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_049	19275428	done	6-CopyBack	39.41	ffcdde18
2018/09/26 16:30:15 CDT	2018/09/26 16:31:09 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_048	19275416	done	6-CopyBack	53.32	087a76c
2018/09/26 16:11:45 CDT	2018/09/26 16:12:30 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_047	19275378	done	6-CopyBack	84.78	d132211
2018/09/26 12:22:38 CDT	2018/09/26 12:23:44 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_046	19275345	done	6-CopyBack	75.74	806926c
2018/09/26 12:10:59 CDT	2018/09/26 12:12:15 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_045	19275321	done	6-CopyBack	75.59	99fec5b
2018/09/26 11:48:26 CDT	2018/09/26 11:49:45 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_044	19275307	done	6-CopyBack	78.84	395c9ae
2018/09/24 15:56:08 CDT	2018/09/24 15:57:19 CDT	A021_sample8_GI_Ion45deg_2kev_F3_1p0EN4_0p26deg_043	19275295	done	6-CopyBack	71.11	4856023

Output timestamp: 2018/09/26 17:57:21 CDT

PROCESSING @ 8-ID-I

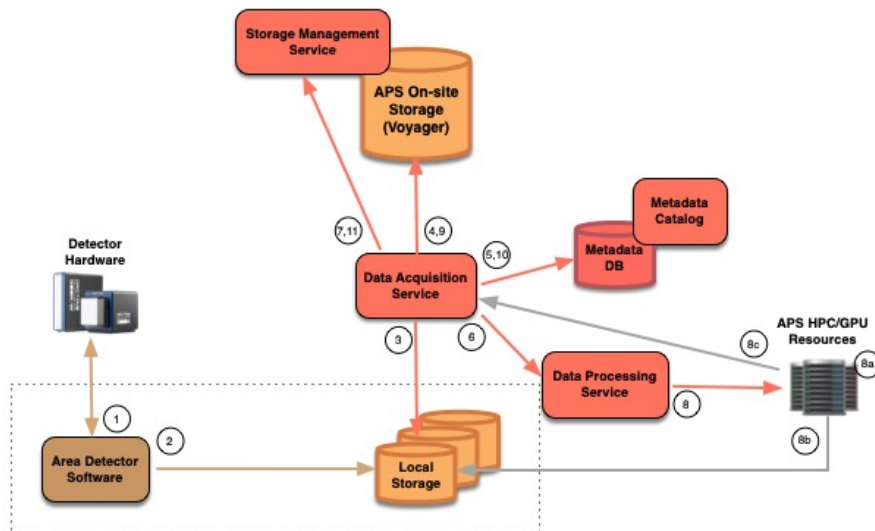
- 8-ID-I uses X-ray Photon Correlation Spectroscopy technique (XPCS) for the studies of equilibrium fluctuations and fluctuations about the evolution to equilibrium in condensed matter in the Small-Angle X-ray Scattering (SAXS) geometry
- SPEC software is used for instrument control and data acquisition
- For every raw data file SPEC scripts start DM processing job based on one of the implemented workflows
- Beamline has 35+ different workflows
- In a high throughput mode, new file is processed every 4-5 seconds, with up to 5K jobs per day
- NERSC Workflow:
 - Acquires auth tokens
 - Copies needed data files from APS to NERSC
 - Prepares/submits/monitors Slurm job
 - Copies results back
 - Cleans up

```
{
  'name': 'nersc-example',
  'owner': '8iduser',
  'description': 'NERSC Example Workflow',
  'stages': {
    '01-START': {
      'command': '/home/dm/workflows/nersc-example/start-workflow.sh $filePath $id',
      'outputVariableRegexList': [
        'INPUT DIRECTORY: (?P<inputDir>.)',
        'WORKFLOW DIRECTORY: (?P<workflowDir>.)',
        'NERSC SLURM SCRIPT: (?P<nerscSlurmScript>.)',
      ]
    },
    '02-AUTH': {
      'command': '/home/dm/workflows/nersc-example/get-nersc-ssh-proxy.sh $nerscUsername $nerscPasswordFile $nerscMfaSecretFile $nerscSshProxyFile',
    },
    '03-PREP-JOB-DIR': {
      'command': 'ssh -q -i $nerscSshProxyFile $nerscUserAccount "mkdir -p $nerscResultsDir"'
    },
    '04-COPY-SLURM-SCRIPT': {
      'command': 'rsync -ar -e "ssh -q -i $nerscSshProxyFile" $workflowDir/$nerscSlurmScript $nerscDtnAccount:$nerscJobDir'
    },
    '05-COPY-INPUT-HDFS': {
      'command': 'rsync -ar -e "ssh -q -i $nerscSshProxyFile" $orthrosResultsDir/$inputHdf5File $nerscDtnAccount:$nerscResultsDir'
    },
    '06-COPY-INPUT-IMM': {
      'command': 'rsync -ar -e "ssh -q -i $nerscSshProxyFile" $immDir/$immFile $nerscDtnAccount:$nerscJobDir'
    },
    '07-SUBMIT-CORR': {
      'command': 'ssh -q -i $nerscSshProxyFile $nerscUserAccount "sbatch -J $nerscJobName -e $nerscJobDir/$nerscJobName.err -o $nerscJobDir/$nerscJobName.out $nerscJobDir/$nerscSlurmScript $nerscResultsDir/$inputHdf5File $nerscJobDir/$immFile",
      'outputVariableRegexList': [
        'Submitted batch job (?P<nerscJobId>.)',
      ]
    },
    '08-MONITOR-CORR': {
      'command': '/home/dm/workflows/nersc-example/get-nersc-job-status.sh $nerscSshProxyFile $nerscUserAccount $nerscJobId $nerscJobName',
      'outputVariableRegexList': [
        'Job . state: (?P<nerscJobState>.)',
        'Job . exited: (?P<nerscJobExited>.)',
        'Job . exit status: (?P<nerscJobExitStatus>.)',
      ]
    },
    'repeatPeriod': 60,
    'repeatUntil': '$nerscJobExited' == 'True',
    'maxRepeats': 120,
    '09-COPY-AUTH': {
      'command': 'ssh -q $orthrosUserAccount "mkdir -p $orthrosJobRunDir" && rsync -ar $nerscSshProxyFile $orthrosUserAccount:$orthrosJobRunDir'
    },
    '10-COPY-RESULTS': {
      'command': 'ssh -q $orthrosUserAccount rsync -ar -e \\'ssh -i $orthrosSshProxyFile\\' $nerscDtnAccount:$nerscResultsDir $orthrosUserAccount:$orthrosJobRunDir'
    },
    '11-CLEANUP': {
      'command': 'ssh -q -i $nerscSshProxyFile $nerscUserAccount "rm -rf $nerscJobDir"'
    }
  }
}
```

DATA ACQUISITION & REAL-TIME PROCESSING

Data Acquisition & Real-Time Processing Flow

- 1 : Receive Image Data
- 2 : Write Raw Image File to Local Storage
- 3 : Monitor DAQ Folder
- 4 : Transfer Image File to APS Storage
- 5 : Catalog Image File Metadata
- 6 : Submit Processing Job
- 7 : Image File Notification
- 8 : Run Processing Workflow
- 8a: Process Raw Image Data
- 8b: Write Processed File
- 8c: Request Upload of Processed File
- 9 : Transfer Processed File to APS Storage
- 10: Catalog Processed File Metadata
- 11: Processed File Notification



Alternative Setup 1: AD to AD

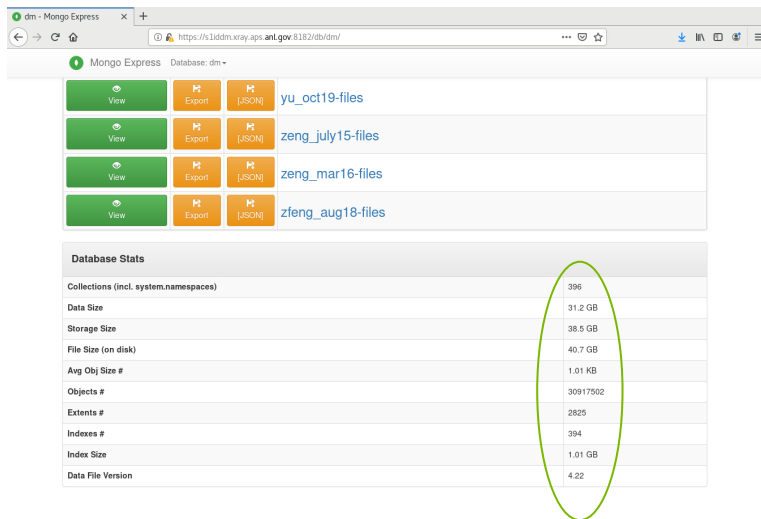


Alternative Setup 2: AD to Image Service

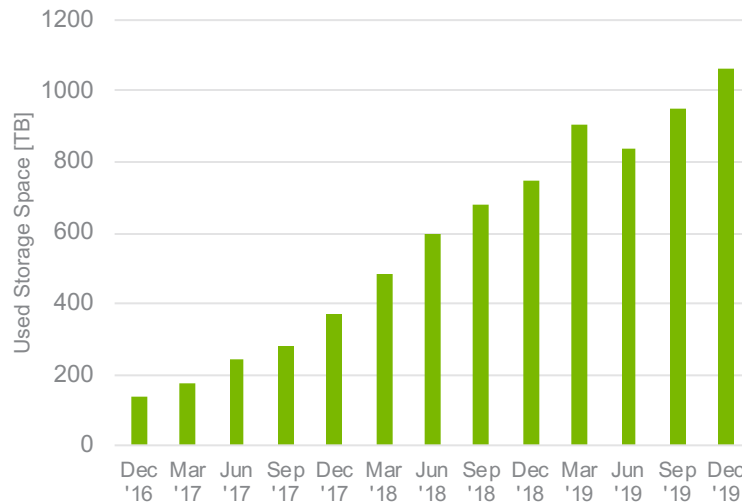


DM SYSTEM AND VOYAGER STORAGE USAGE

- October 2015: First DM software deployment at 6-ID-D
- December 2016: 5 beamline deployments, about 150 TB used storage
- January 2020: more than 35 beamline deployments, about 1.1 PB of used storage space, over 2400 experiments in DM DB
- 1-ID Beamline: over 300 experiments in DM DB, about 300TB storage space used (mostly compressed), over 30M cataloged files

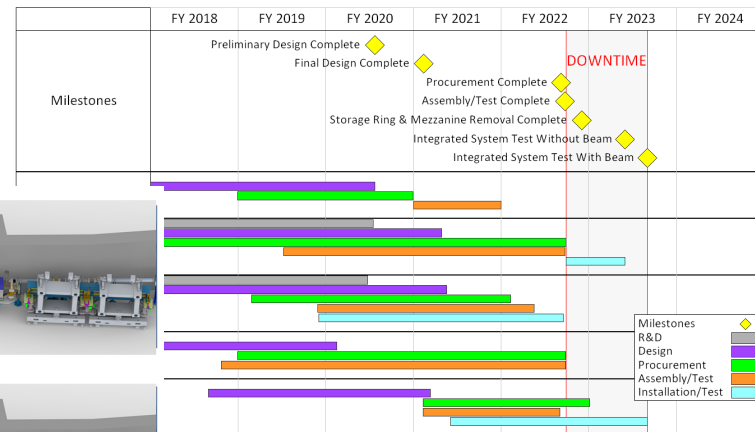
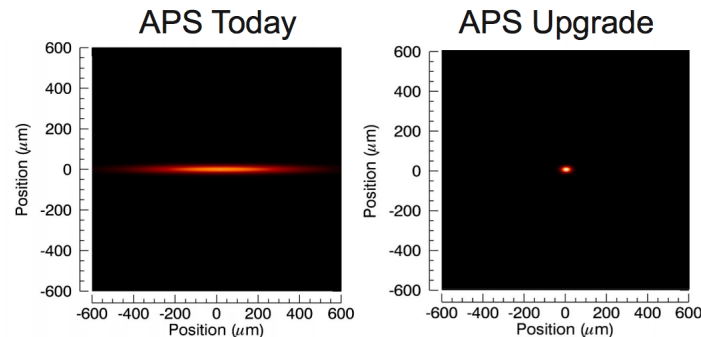


Voyager Storage Usage



APS UPGRADE

- X-ray detector capabilities are constantly improving: bigger frames, higher frame rates => more raw data
- APS Upgrade: Higher brightness => more x-rays can be focused onto a smaller area => more raw data in greater detail and less time
- 8-ID-I Beamline (XPCS):
 - Lambda 750K detector, 1.5MB frame, 2000 fps => about 300 MB/s data rate (about 10% non-zero pixels)
 - Production rates today: 1-2TB/week on the average, 8-10TB/week maximum (compressed data)
 - Rigaku 500K detector: 50K frames per second, can sustain 1GB/s data rate

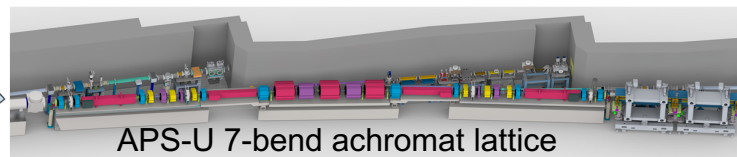
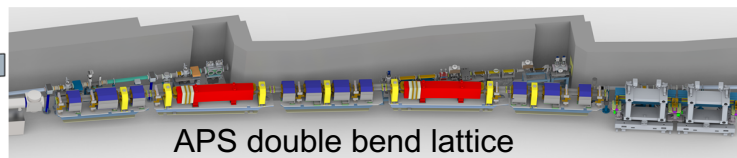


APS-U Schedule

$$\varepsilon \propto \frac{E^2}{(N_D N_S)^3}$$

N_D = # dipoles/sector
 N_S = # sectors

~70-fold
reduction in
horizontal
emittance



CAN ANALYSIS KEEP UP WITH DATA?

Ptychography data rates and data volumes

	Today	1-3 years	5-10 years
Diffraction pattern size (MB)	2 ^a	3 ^b	3
Acquisition rate (frames/s)	100	1000	50000 ^c
Compression rate	10	10	10
Data rate (MB/s)	20	300	15000
Detector duty percentage (%)	50 ^d	50	50
One day(TB)	0.82	12.36	617.98
One run (days)	45	45	66
Data per run (TB)	37.08	556.18	40786.74
Data per year (PB)	0.11	1.63	119.49

Ptychography @ APS-U:
Anticipated data volume of over 600TB per day

- Use the current Eiger 500K detector, 32 bits per pixel.
- Use 1.5M detector, 16 bits per pixel.
- Considering ~100x increase flux provided APS-U, and faster detector (e.g., 50 kHz) will be available at that time.
- Considering the time spent on the experiment set up, changing sample, and beam down, etc.

Analysis Estimates

Scanning	200 x 200 um	300 x 300 um	500 x 500 um	1000 x 1000 um
Chip Area (um ²)	20	20	20	20
Target Resolution (nm)	0.2	0.2	0.2	0.2
Step size (um) (10 probe modes)	1000000	2250000	6250000	25000000
Number of scan points/projection	512	512	512	512
Diffraction pattern (pixels)	32	32	32	32
Bits per pixel	1.05E+12	2.36E+12	6.55E+12	2.62E+13
Data size/projection (Bytes)	100	100	100	100
Projections	95.4	214.6	596.0	2384.2
Raw data size (TB)	0.4	0.9	2.4	9.6
Total exposure time (days, 3 kHz)	0.5	1.0	2.9	11.6
Total scan time (plus 20% overhead)				
Computation				
FLOPs/iteration/diffraction/mode (ePE)	9.44E+07	9.44E+07	9.44E+07	9.44E+07
Peak Single Precision FLOPs/Sec/GPU (GTX1080 Ti)	1.15E+13	1.15E+13	1.15E+13	1.15E+13
Utilization rate	0.05	0.05	0.05	0.05
Time/iteration/diffraction/mode (Sec) (Theoretical)	1.64E-04	1.64E-04	1.64E-04	1.64E-04
Time/iteration/diffraction/mode (Sec) (Workstation)	2.00E-04	2.00E-04	2.00E-04	2.00E-04
Number of probe modes	10	10	10	10
Iterations	100	100	100	100
Time/diffraction (s)	0.20	0.20	0.20	0.20
Total time using one GPU (days)	231.5	520.8	1446.8	5787.0
The number of GPUs	200	200	200	200
Parallel scaling efficiency	0.5	0.5	0.5	0.5
Reconstruction time (days)	2.3	5.2	14.5	57.9

Over 2 days needed to reconstruct 95TB dataset using 200GPUs

SUMMARY

FUTURE WORK

- Challenges ahead:
 - Increasing data rates and volumes
 - Increasing need for faster algorithms, more computing power, and more efficient utilization of existing resources
- Many APS beamlines are working on improving their reconstruction code (D. Gursoy)
- Ongoing effort to understand computing and data requirements for APS-U beamlines (N. Schwarz)
- This will provide crucial input into facility plans for computing and data management after APS-U machine comes online
- Computing:
 - Ongoing work towards understanding how to make best use of external computing resources (ALCF, NERSC, etc.)
 - Consolidate APS HPC/GPU cluster resources
 - Develop better cluster configuration: enable resource sharing, job preemption
 - Deploy cluster monitoring tools
 - Invest into user training to enable more effective usage of cluster resources
 - More effort for automating beamline data acquisition and real-time processing pipelines
- Data Management:
 - Add support for data archiving (ALCF); automate movement of older data to archive
 - Enhance workflow and processing job management capabilities (DM Station GUI, Web Portal)
 - System monitoring enhancements (provide easy real-time access to system usage information)
 - Packaging/installation improvements (Conda-based), better user documentation

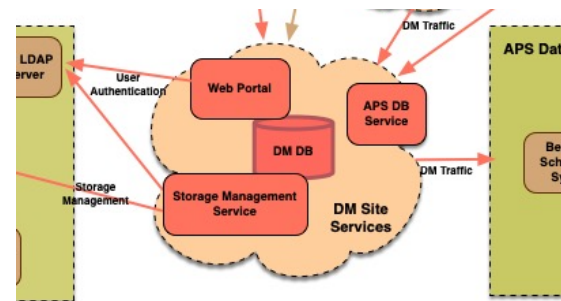
ACKNOWLEDGEMENTS

- APS IT group (R. Sersted, D. Wallis, D. Leibfritz, M. Westbrook, and T. Lutes) for their work on building and maintaining the APS On-site Storage, networking, and virtual machines used to host beamline DM services
- APS IS group (F. Lacap and Y. Huang) for their help and cooperation with accessing APS databases, and their recent development work on ESAF DB API (Y. Huang)
- APS SDM group for many useful discussions (B. Frosik, A. Glowacki, and F. Khan), and help with the system support and development (D.P. Jarosz, J. Hammonds)
- APS 1-ID (J.-S. Park and P. Kenesei), 6-ID-D (D. Robinson), and 8-ID-I (S. Narayanan) beamlines for their patience, support and help with DM system testing and troubleshooting since the early prototype versions.
- Ptychography Group (T. Bicer, J. Deng, D. Gursoy) and HT-HEDM beamline (J.-S. Park, C. Zhang) for useful discussions about their data rates and computing needs
- All of those who are using, have used, or attempted to use the DM system in any way

ADDITIONAL SLIDES

DM SITE SERVICES

- DM Database (PostgreSQL)
 - Maintains information about users, experiments, and beamline deployments
- Storage Management Service (Python, REST)
 - Runs on storage head nodes
 - Controls storage file system permissions, which enables data access for remote users
- APS DB Service (Python, REST)
 - Enables easy access to APS ESAF and GUP information
- Web Portal (Java EE, Glassfish)
 - Experiment management
 - Support for beamline deployments
- Automated utilities for synchronizing DM user information with APS User Database

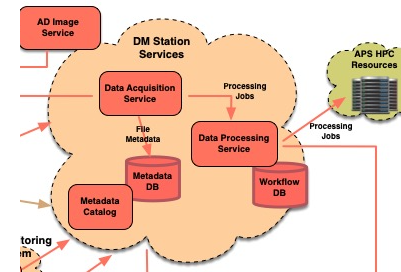


The screenshot shows the Argonne Data Management Portal interface. The header includes the Argonne logo, the title 'Data Management Portal', and a user login 'User: dm Role: Administrator'. Below the header is a navigation bar with links: Home, Experiments, Experiment Stations, Experiment Types, Role Types, Users, and Logout. The main content area is titled 'Experiments' and features a table with columns: Id, Name, Type, Station, Description, Start Date, End Date, and Actions. The table contains 10 rows of experiment data.

Id	Name	Type	Station	Description	Start Date	End Date	Actions
51	Smith2017	MPE	34IDE	Pressure Induced Dynamics in Colloidal Suspensions	10/08/2017 10:36 PM CDT	10/18/2017 08:52 PM CDT	
52	Wilson2017	XMD	8DI	Study of Nanocrystal Lattices	11/08/2017 11:11 PM CDT	11/13/2017 12:05 AM CDT	
53	Brown2017	FSD	28M	Lipid Degradation Studies	12/25/2017 01:44 PM CDT	12/25/2017 02:25 PM CDT	
54	Johnson2017	XMD	6IDB	Cryogenic Solvents in Real Environments	06/27/2017 01:46 PM CDT	06/27/2017 12:25 PM CDT	
55	Jones2017	SP	33D	Polymer Time Correlations	01/07/2017 08:35 AM CDT	01/15/2017 01:43 PM CDT	
56	Williams2018	XRIM	8D3	PDF Solvent Measurements	01/05/2018 08:32 AM CDT	01/23/2018 11:07 PM CDT	
57	Taylor2018	EDD	11IDB	Temperature Variant Superconductor Analysis	01/16/2018 08:24 AM CDT	01/16/2018 01:20 PM CDT	
58	Evens2018	EDD	11IDC	DNA Degradation Probes	01/28/2018 01:59 PM CDT	02/02/2018 11:35 AM CDT	
59	Brown2018	MPE	7ID	X-ray Measurements of Biological Surfactants	01/30/2018 03:53 PM CDT	02/07/2018 05:15 AM CDT	
60	Daves2018	FSD	68M	Micro-diffraction of Porous Building Materials	02/15/2018 05:06 PM CDT	02/27/2018 07:24 PM CDT	
61	Wilkinson2018	XMD	1ID	Nano-composite Materials Under Stress	03/01/2018 07:31 AM CDT	03/24/2018 08:22 AM CDT	
62	Johnson2018	XRIM	8D3	Rare Earth Ions Near Interfaces	03/01/2018 10:31 AM CDT	03/14/2018 05:33 PM CDT	

DM STATION SERVICES

- Each beamline deployment (“DM Station”) includes several Python services: DAQ Service, Metadata Catalog, AD Image Service, Workflow Engine
- Data Acquisition Service
 - Responsible for data uploads and for monitoring local file storage
- Metadata Catalog (Mongo DB)
 - File metadata are arbitrary key/value pairs
 - Each experiment has its own file metadata collection
- AD Image Service
 - Attaches a PV Access monitor to Area Detector PVA Server plugin channel
 - Can save images in JPEG, HDF5, SDDS formats; more can be added if needed
 - Uses PvaPy (EPICS7 Python API that wraps C++ libraries)
 - Can keep up with a fully saturated 10Gbps link
 - Actual data rates depend on storage capabilities and the chosen image format (i.e., the efficiency of the underlying Python libraries)
- Workflow Engine provides support for managing user-defined workflows, as well as for submitting and monitoring processing jobs based on those workflows
 - Generic framework that can handle both automated real-time processing, as well as user-initiated processing and analysis of data



- Every DM service has a set of monitoring interfaces that enable external applications to find out about its state
- These are used by the custom Nagios plugins that provide up-to-date information about the health of the DM station deployments

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