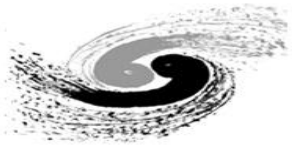


中國科學院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

高能所計算中心
IHEP Computing Center

Perspective and Strategy of IT Development at IHEP

Qiulan Huang

on behalf of Computing Center, IHEP, Chinese Academy of Sciences

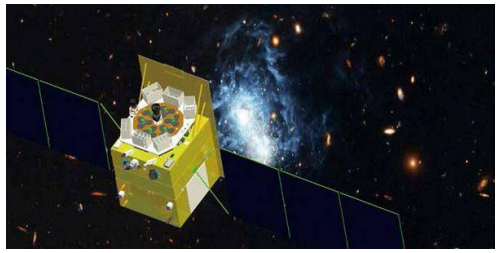
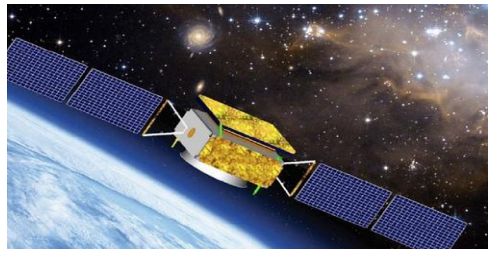
Grid 2021 at Dubna

July 6, 2021

Outline

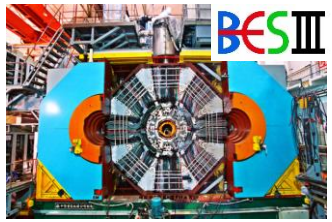
- Introduction and Objective
- Strategic plans
- Main activities and progress
- Challenges
- Conclusions

Experiments at IHEP

~550KM

~4400M

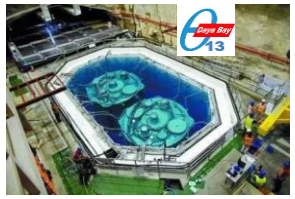
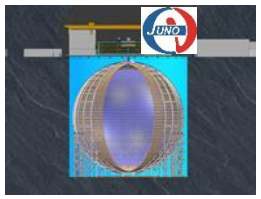


CEPC

中国散裂中子源
China Spallation Neutron Source

高能同步辐射光源
High Energy Photon Source | HEPS

~-5M

~-300M

Astro Physics Experiments

HXMT: 0.2PB/year, 2000 CPU cores,2017-2023
GECAM:0.2PB/year, 2000 CPU cores,2021-2025

High Latitude Cosmic Ray Observatory

LHAASO: 6 PB/year,10000 CPU cores 2020-
YBJ:0.1PB/year, 1990-
HEAD: 3PB/year, in plan
eXTP: 0.3PB/year, in plan

Collider Experiments

BESIII: ~1 PB/year, 10000 CPU cores,2010-2027
CEPC prototype: 0.3 PB/year, 2014-

Neutron/Photon Sources

CSNS: 1PB/year 2000 CPU cores (current)
100 PB/year, 10000 CPU cores (future)
HEPS: 150 PB/year, 10000CPU cores, 2025-

Neutrino Experiments

DayaBay： 0.3 TB/year, 3000 CPU cores,2012-2020
JUNO： 3 PB/year, 10000CPU cores 2022-2032


新疆
黑龙江
吉林
HEPS
BEPCII/BESIII
北京
天津
Jinan Branch
宁夏
山西
河北
山东
青海
甘肃
陕西
河南
安徽
江苏
上海
浙江
湖北
四川
重庆
江西
湖南
贵州
云南
CSNS
JUNO
DayaBay
海南
南海诸岛
Ali Primary Gravitational Wave Observation
YBJ
LHAASO

Distributed Resources

- Remote sites have good network to IHEP
- Remote sites is fully managed by IHEP-CC
- Data transfers is managed by SPADE
- CPUs can not be shared in a global pool
- No unified user authentication and authorization

	CPU Cores	Disk Storage	Tape Storage	Network	Experiments
IHEP-CC	38000	Lustre,20 PB EOS, 10 PB	30 PB	100G/10G/1G	All
IHEP-Dongguan Guangdong Province	~4000	Oceanstor 3 PB	1 PB	10G-100G to IHEP	CSNS
IATAMS Shandong Province	~15000	Lustre 2.5 PB		1G-10G to IHEP	AMS
IHEP-Daocheng Sichuan Province	~1800	EOS 1.6 PB		2G to IHEP	LHAASO
USTC, Anhui Province	1920	Lustre 4 PB		Internet	BESIII, ATLAS
LZU Gansu Province	180			Internet	BESIII
PKU Beijing	288			Internet	BESIII
Shandong Uni. Shandong Province	472			Internet	JUNO,LHAASO,BESIII,ATLAS
Huawei Cloud	~20000	3 PB		10G to IHEP Dongguan	CSNS
IHEP Huairou Branch (ready by 2025)	~10000	Lustre 30 PB		100G to IHEP	HEPS

It's essential to R&D in distributed computing technologies

IT Requirements

- Large Scale storage and powerful computing requirements
  - BEPCII/BESIII: ~1PB/year, 10000 CPU cores
  - Nutrino experiments
    - DayaBay: 0.3 TB/year, 3000 CPU cores
    - JUNO: 3 PB/year, 10000CPU cores, 2022-2023
  - LHAASO: 6 PB/year,10000 CPU cores 2020-
  - Astro physics experiments
    - Hundreds of TB/year
  - Neutron/Photon Sources
    - CSNS: 1PB/year 2000 CPU cores (current)
      100 PB/year, 10000 CPU cores (future)
    - HEPS: 150 PB/year, 10000CPU cores, 2025-
  - LHC: 50 PB/year, 3~5PB/year transferred to IHEP
    - ATLAS, CMS, LHCb, BelleII
- Multifunctional Information and Computing platform: High performance, High availability and High Efficiency
  - Computing system
    - HTC, HPC, real-time computing, Heterogeneous computing, distributed computing
  - Data storage
    - Provide hundreds of PB data storage service
  - Network(Data Center and Internet)
    - Bandwidth: 100Gbps
  - Software framework
    - Different experiments use different softwares
  - Data Management system
    - Scientific data management, data policy
  - Information Service
    - Videoconference, database, docdb, Indico, Twiki, Gitlab, etc
  - Cyber Security
    - Safe and reliable security environment for critical infrastructure
  - Open data service

International Collaborations

- BEPCII/BESIII
  - 72 institutions, ~500 collaborators
  - 7 countries and regions
- LHAASO
  - 20 institutions, ~250 collaborators
  - 4 countries
- DayaBay
  - 40 institutions, ~250 collaborators
  - 6 counties and regions
- JUNO
  - 71 institutions, ~500 collaborators
  - 16 countries
- HEPS & CSNS
  - Public scientific research facilities
- Tier-2 of ATLAS, CMS, LHCb, BELLE II
  - Hope to strive to establish Tier1 to deepen international collaboration

Objective

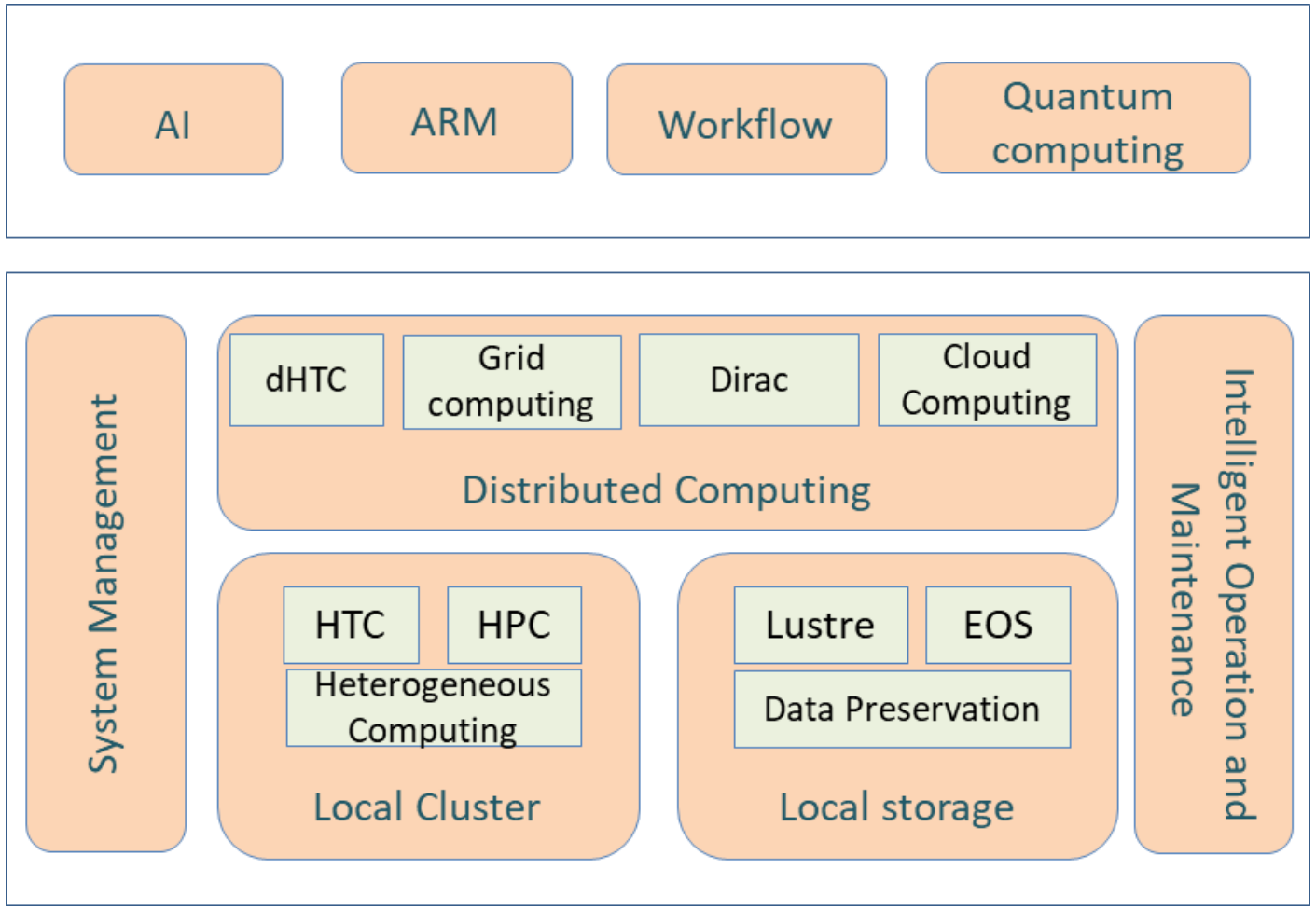
- Provide IT Service
  - Scientific computing service for essential scientific activities for particle physics and Neutron/Photon source
    - Scientific diversity programme; theory; detector R&D; LQCD and so on
    - Future colliders; accelerator R&D
  - Scientific research management and information service
- IT R&D
  - Scientific computing and data platform: computing, data storage, network, security
  - Software: Scientific software framework, Scientific data management software, Information software
  - AI technology: AI platform, Intelligent operation and maintenance, Data processing
  - Deepen international cooperation

Strategic plans

(1) Data and Computing Platform

- Vision and main goals
  - Achieve a high performance computing platform with “One platform, multi-centers” architecture
  - Realize the expansion and integration of cross-domain heterogeneous resources
  - Provide the most suitable computing services for all experiments
- Missions
  - Establish user committee to collect experiments’ demand and supervise operation quality
  - Build a high level data center infrastructure for HEP experiments
  - Lead in establishing Scientific Computing Alliance to export technology, software, standard specifications in relevant demostic fields
  - Focusing on JUNO, LHAASO and CEPC, leading the construction of its own distributed computing platform, and joining the wider HEP grid computing platform (such as WLCG/EGI), and establishing strategic cooperation with more experiments such as SKA
  - Improve IT contribution to WLCG (matching physical contribution)

Computing R&D

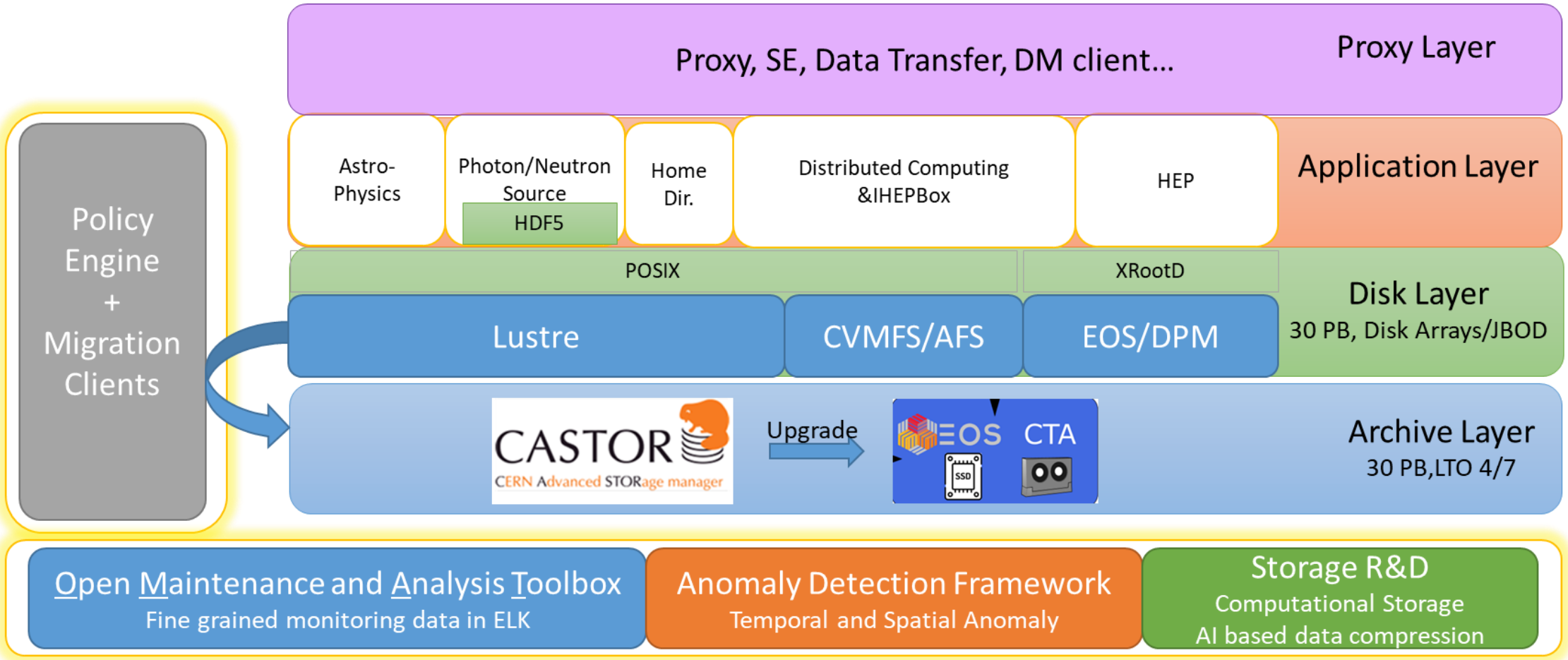


- To support million CPU cores scale : Qos
- Need to coordinate and cooperate with multiple centers in various fields to construct “One Platform, multi-centers”
- Implementation of distributed computing framework for JUNO and LHAASO
- Apply novel IT technologies like Quantum, AI , ARM etc.

(2) Data Storage

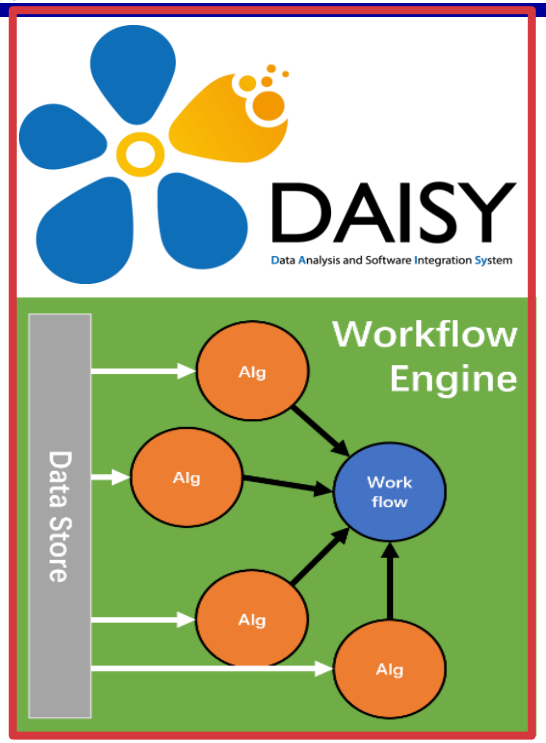
- Goal: Overcome the technical challenges of data storage from the three key areas of HEP, Radiation science and Space astronomy
  - ZB-level cost effective storage capacity
  - TB/s- level linearly scalable data access performance
  - Safe and reliable long-term data preservation
  - Efficient remote data access in distributed computing framework
- Missions
  - R&D of hierarchical storage and intelligent storage technology for HEP computing
  - R&D of tape management for Long-term data preservation
  - R&D of remote data access through WAN

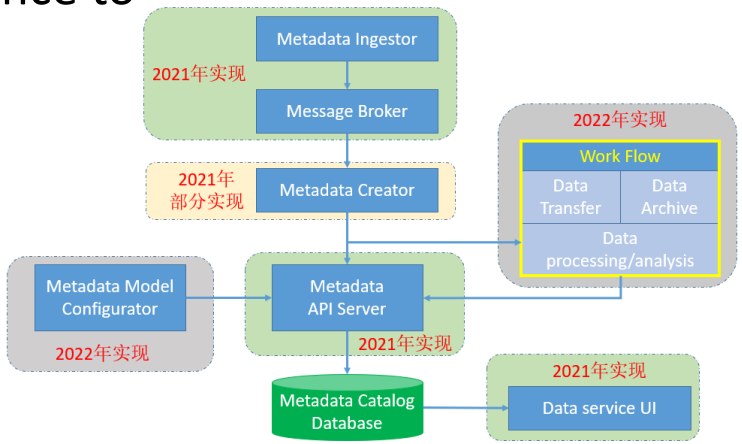
Storage at IHEP



(3) Software framework

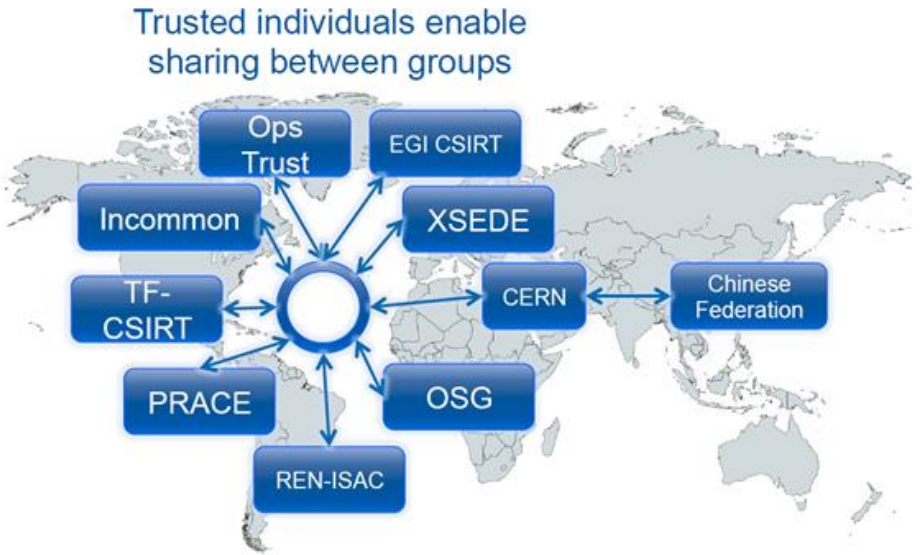
- Goal: Development two kinds of software frameworks
  - DAISY: Data processing software framework for HEP and photon sciences
  - Scientific Data Management framework
- Missions
  - Form the data processing framework particularly for photon science and astronomy projects
  - Form the scientific data management and data policy for photon science to manage and annotate data and publish as open data
  - Develop workflow and dataflow engine
  - Form an ecology contains a framework and discipline software by collaborating with discipline software team





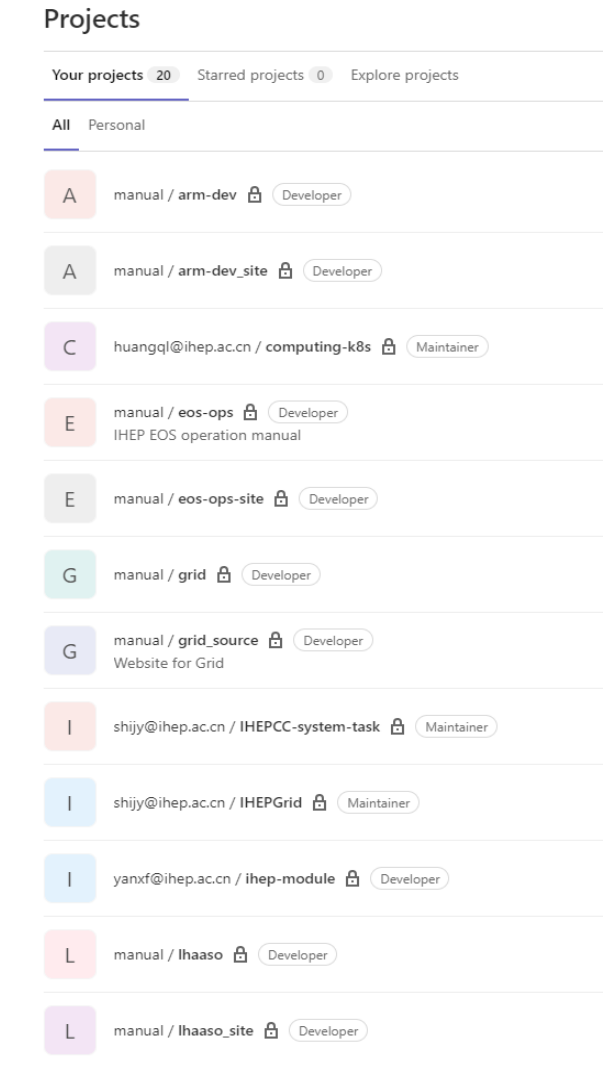
(4) Network and Security

- Provide on-demand high performance network infrastructure
- IHEP has collaborated with CERN in
  - WAN performance improvement: LHCONE (LHC Open Network Environment)
    - China has joined LHCONE since March 2018
  - Supporting IPv6 in computing environment
    - IHEP became one of the WLCG Tier-2 sites who supported IPv6 since the end of 2017
  - Cyber security
    - IHEP established the Chinese cyber security federation in June 2016
    - Sharing the workflow, experiences and knowledge on WLCG security
- Foreseeable further collaboration
  - More research and development in LHCONE and SDN/NFV/RoCE to provide higher performance in data transferring and sharing between collaborators
  - Establish more comprehensive and practical scheme in Cyber security
  - Research on the new network techniques to provide stable and high performance in network connectivity



(5) Information Service

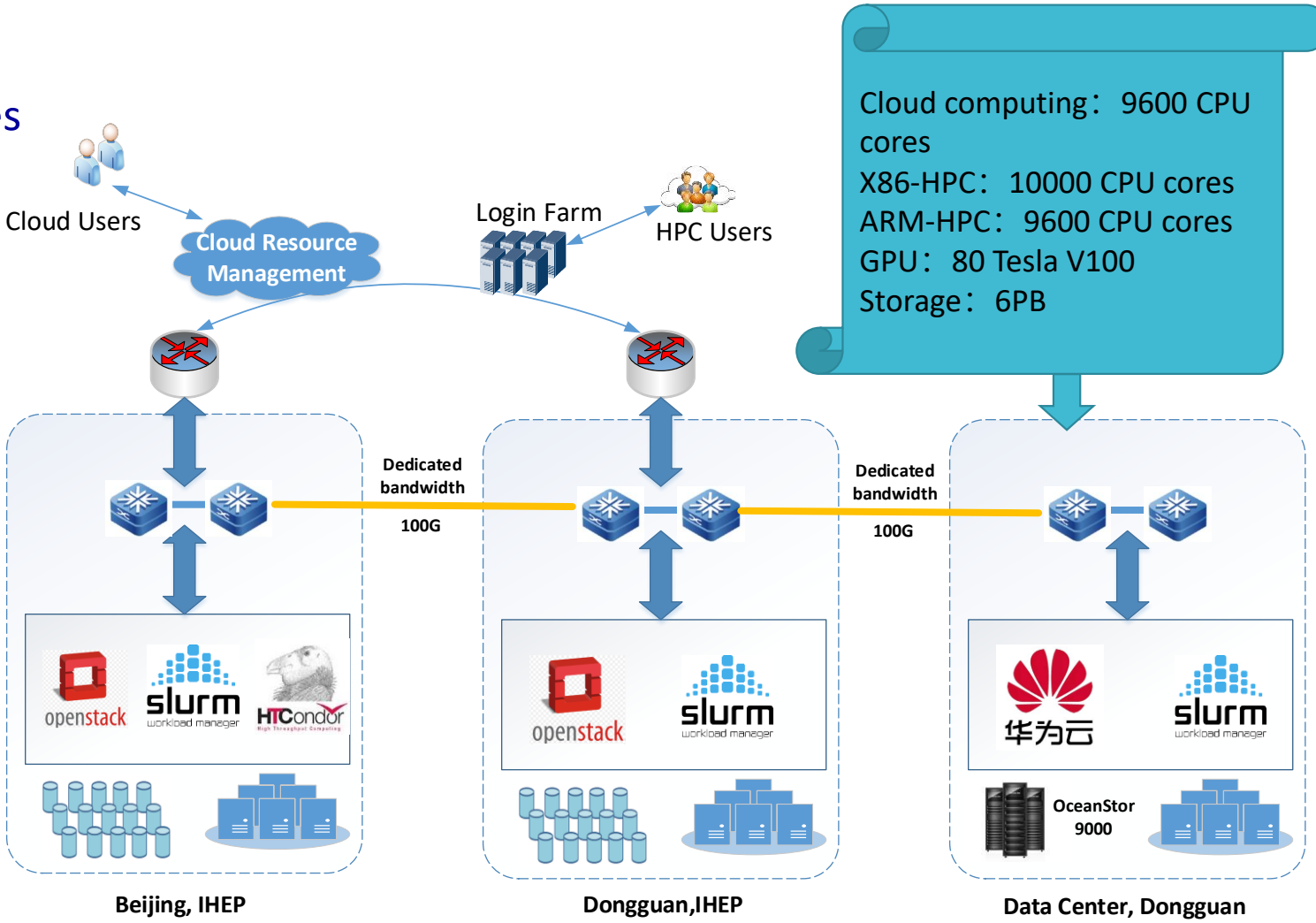
- 2021-2023 new planning and construction start
  - Increasing and diversified demands from scientific research
  - Respond to the development of IHEP
- Design, develop, and release new information systems based on new requirements
  - Institute-level OA system (daily affairs management, personnel resignation, leave,...)



Main Activities and Progress

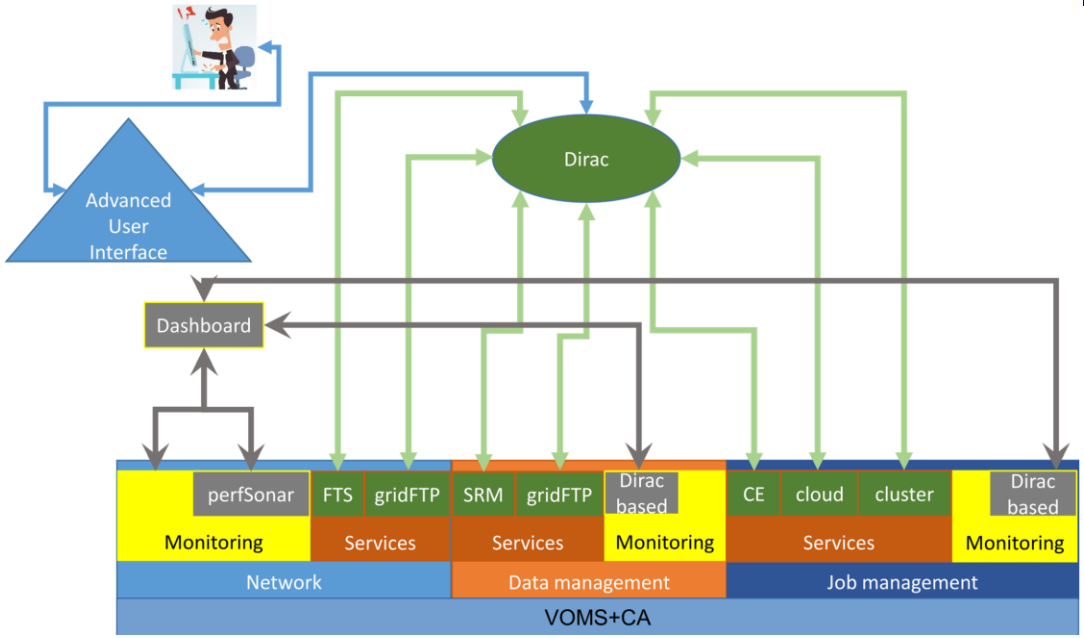
One Platform multi-centers

- Develop dHTC (Distributed High Throughput Computing) to integrate cross-border resources
  - Keep same usage mode as IHEP local cluster and transparent to users
- July, 2021 One platform multi-center (Beijing, Dongguan) come to online
  - CPU cores: up to 70,000
  - Storage capacity: >35PB
  - Network (Beijing-Dongguan):1Gbps --> 6Gbps
- Heterogenous hardware
  - X86 CPU、GPU、ARM



Support LHAASO and LQCD

Distributed Computing Facility



Core
- DIRAC
  - File Catalog
  - Job Management

Basic
- VOMS: authentication and authorization
- CernVMFS: SW and small data sharing
- Network monitoring

Storage
- Local Storage Element, as DCACHE, XROOTD, STORM
- Data transfer: FTS
- Book-keeping

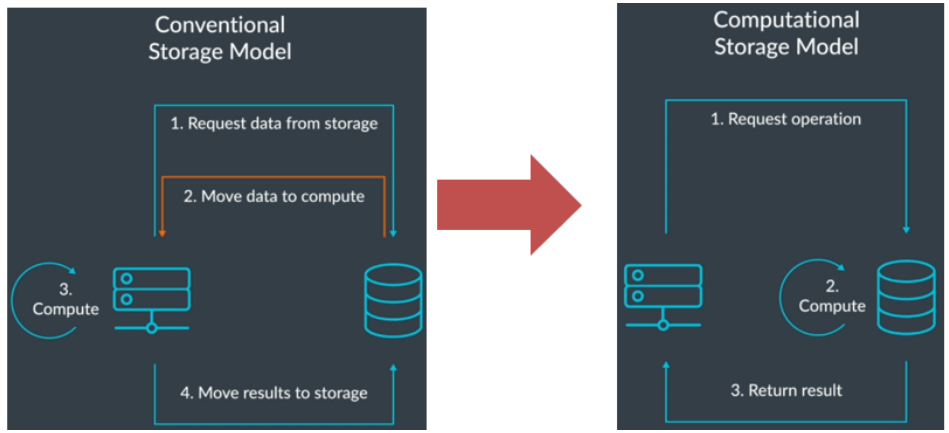
Sites (cores)	Normal	Resource type
CNAF	400	HTCondorCE
IN2P3	210	HTCondorCE
JINR*	2000	OpenNebula->HTCondorCE
Padovana	100	OpenStack
IHEP*	2000+500	OpenStack/HTCondor/HTCondorCE
SDU	50	HTCondor
Total*	5260	

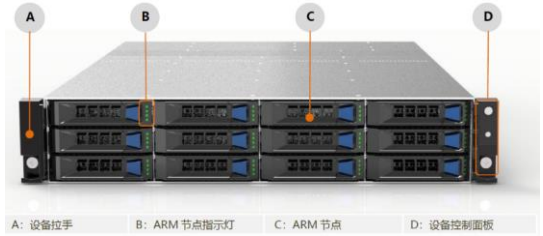
Site	SiteType		MaskStatus
GRID.IN2P3.fr	GRID		Active
CLUSTER.SDU.cn	CLUSTER		Active
CLOUD.IHEPCLOUD.cn	CLOUD		Active
GRID.IHEP.cn	GRID		Active
CLOUD.INFN-PADOVAN...	CLOUD		Active
GRID.JINR-CONDOR.ru	GRID		Active
GRID.INFN-CNAF.it	GRID		Active

Support JUNO and BESIII

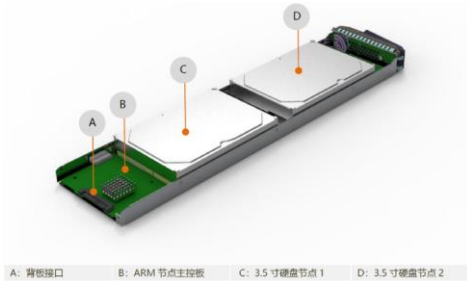
R&D: (CSS)Computational Storage System

- CSS “move process to data” paradigm to its ultimate boundaries by deploying embedded processing engines inside storage devices to process data
- Reduce data movement and improve computing efficiency
- Developed CSS based EOS and XROOTD for HEP computing
  - Integrated general computing algorithm, data compression, etc
- Status
  - Coding XRootD plugin based EOS storage
  - Hardware：ARM, customized PCIe（not decided）
  - Plan to support LHAASO at the beginning



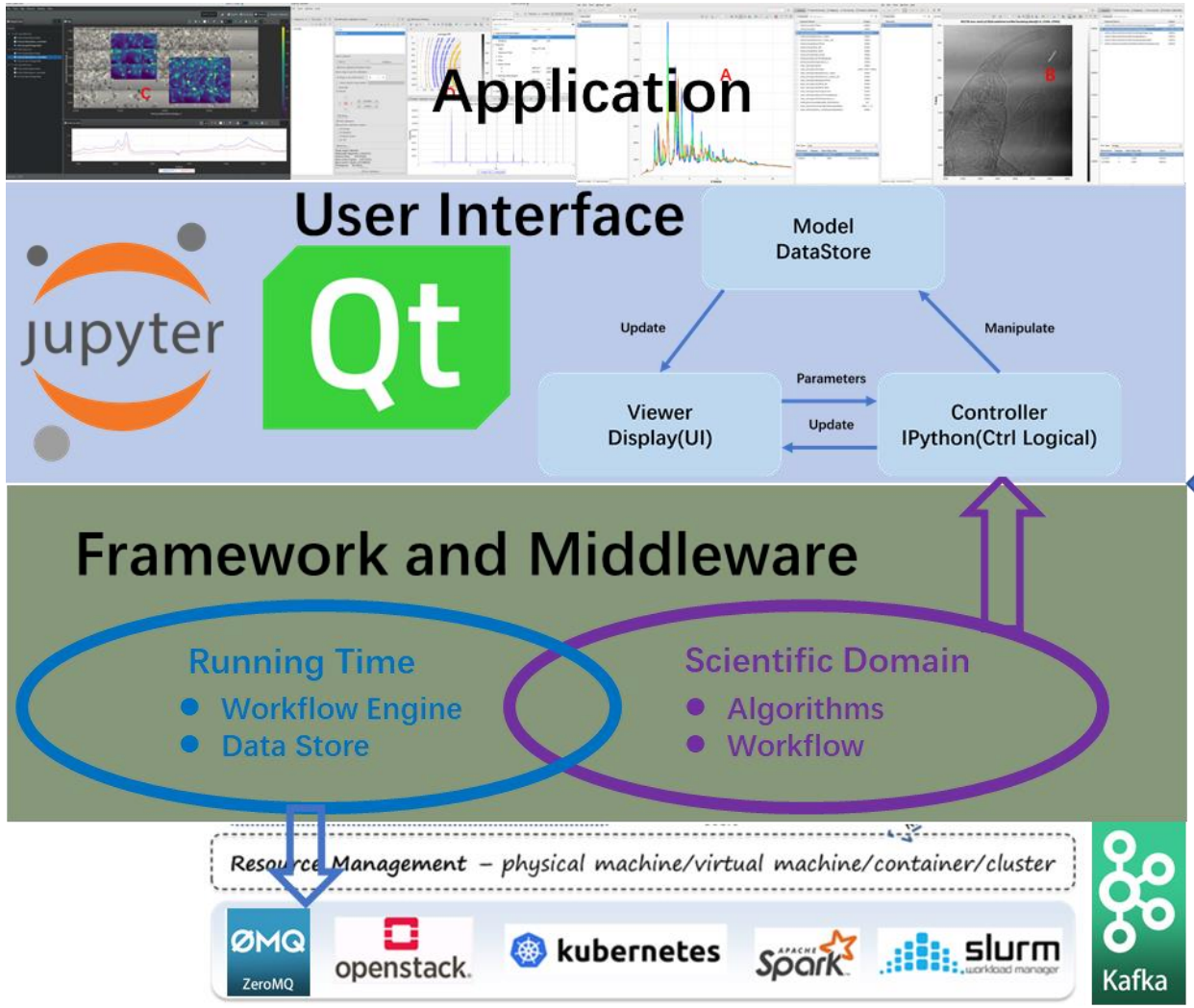


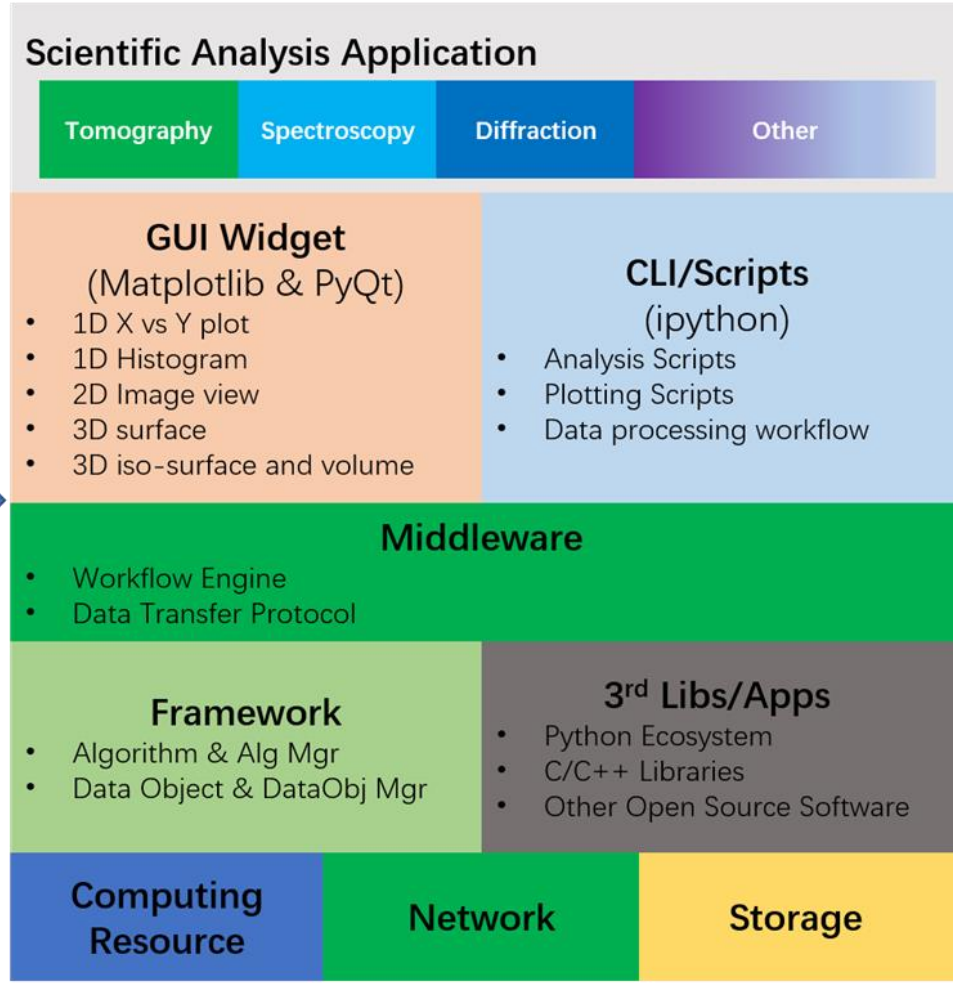
Rack



ARM

Daisy: Data processing software framework





Testbed for HEPS

jupyterhub Home Token liuzhibin Logout

1. Login (JupyterHub)

Server Options

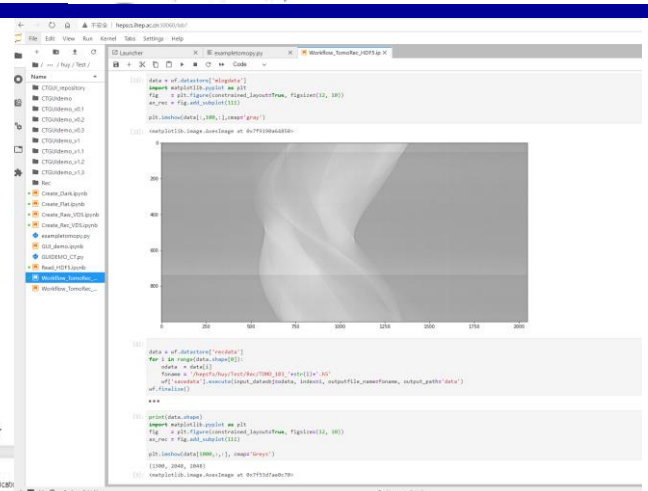
CT 3D reconstruction
CT 3D reconstruction service based on tomopy.

Deep Learning
Mainstream deep learning framework, contains tensorflow, pytorch, keras

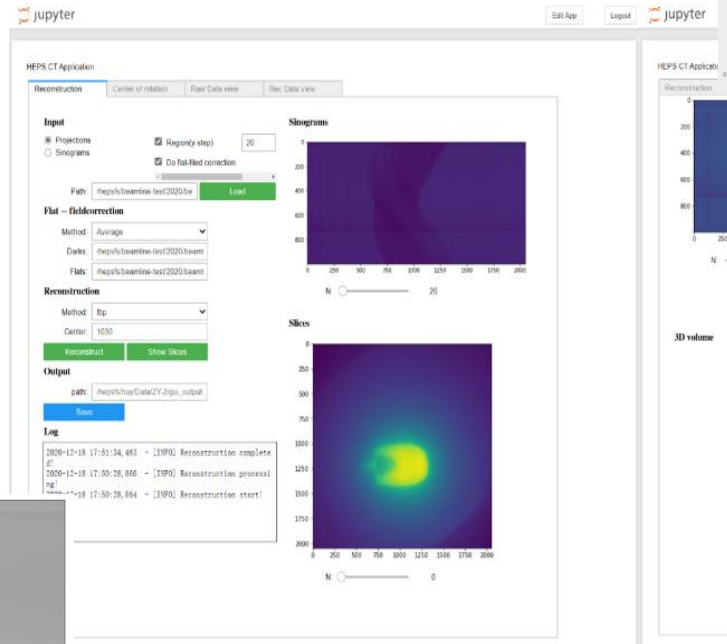
Spark
Jobs can be submitted to the spark cluster

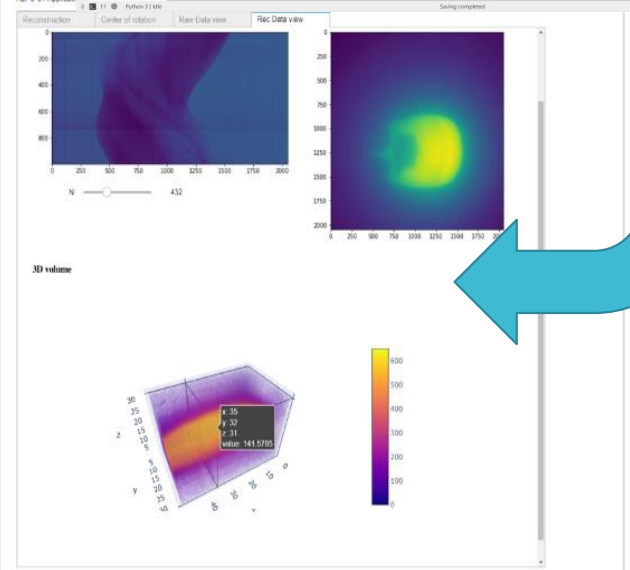
Start

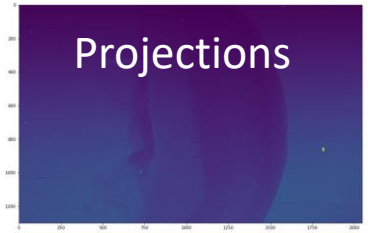
2. Workflow (JupyterLab)



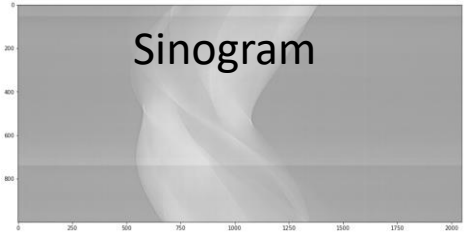
3. Visualization (Jupyter notebook widget)



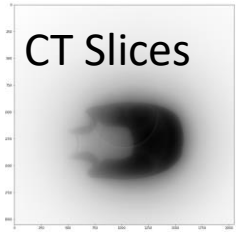




preprocessing

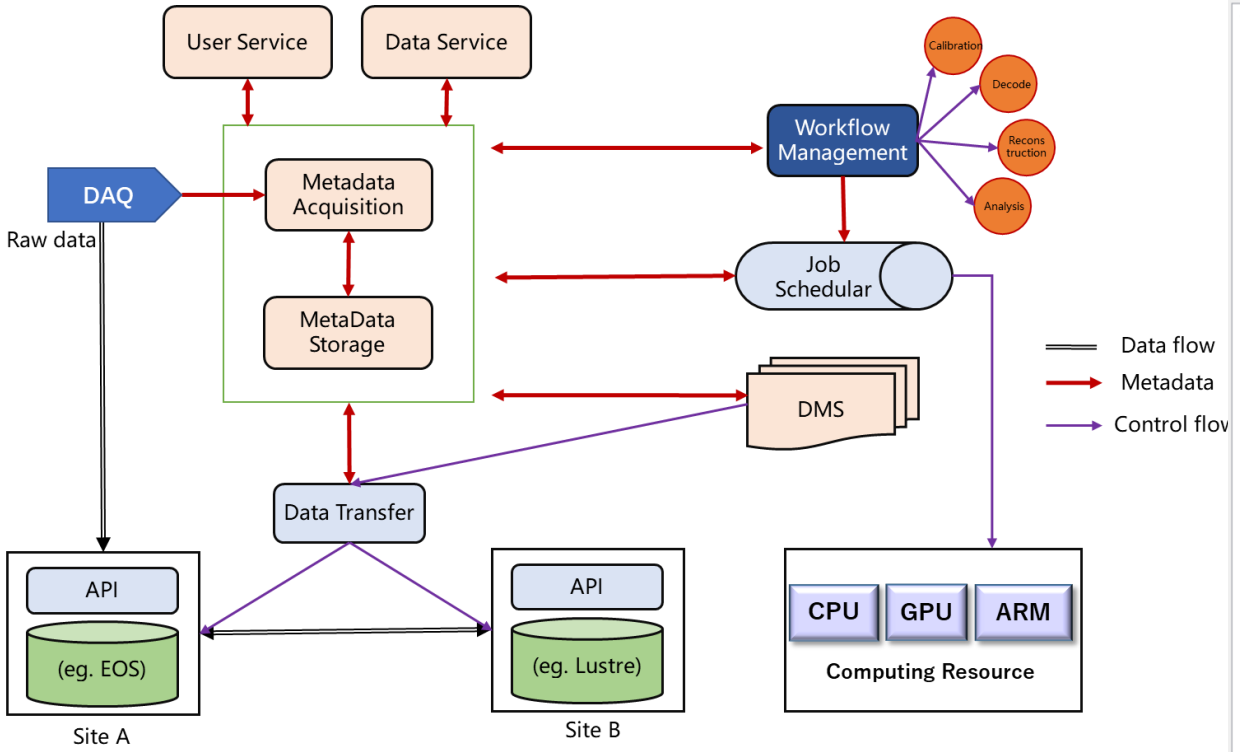


reconstruction



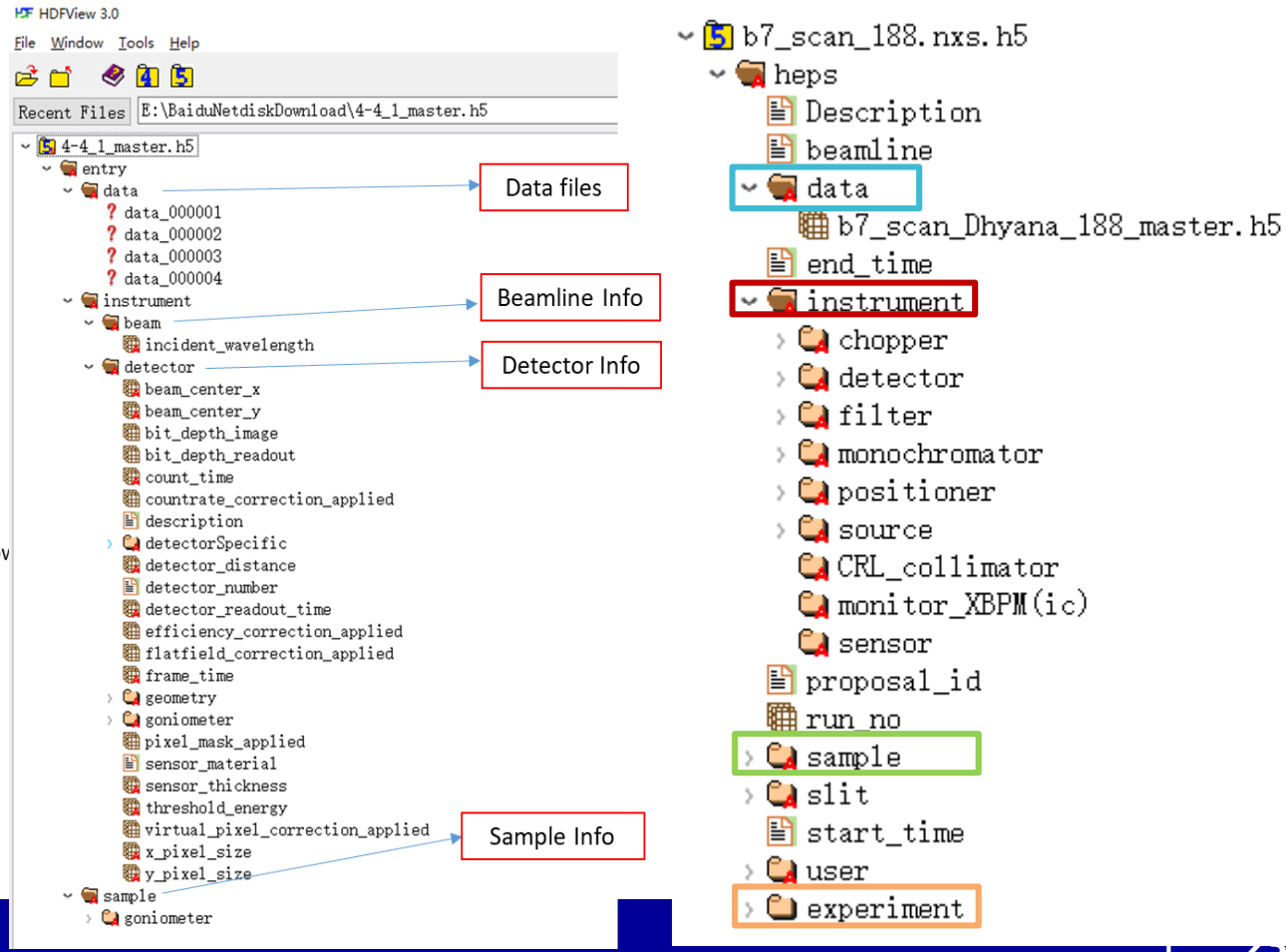
Data Management framework

- Design and develop metadata acquisition approach
- Developed Metadata catalogue framework
- Data format standardization
  - HDF5 file format design for B7 beamline(**Hard X-Ray Imaging**)
- Draft version of Data Policy for HEPS is finished



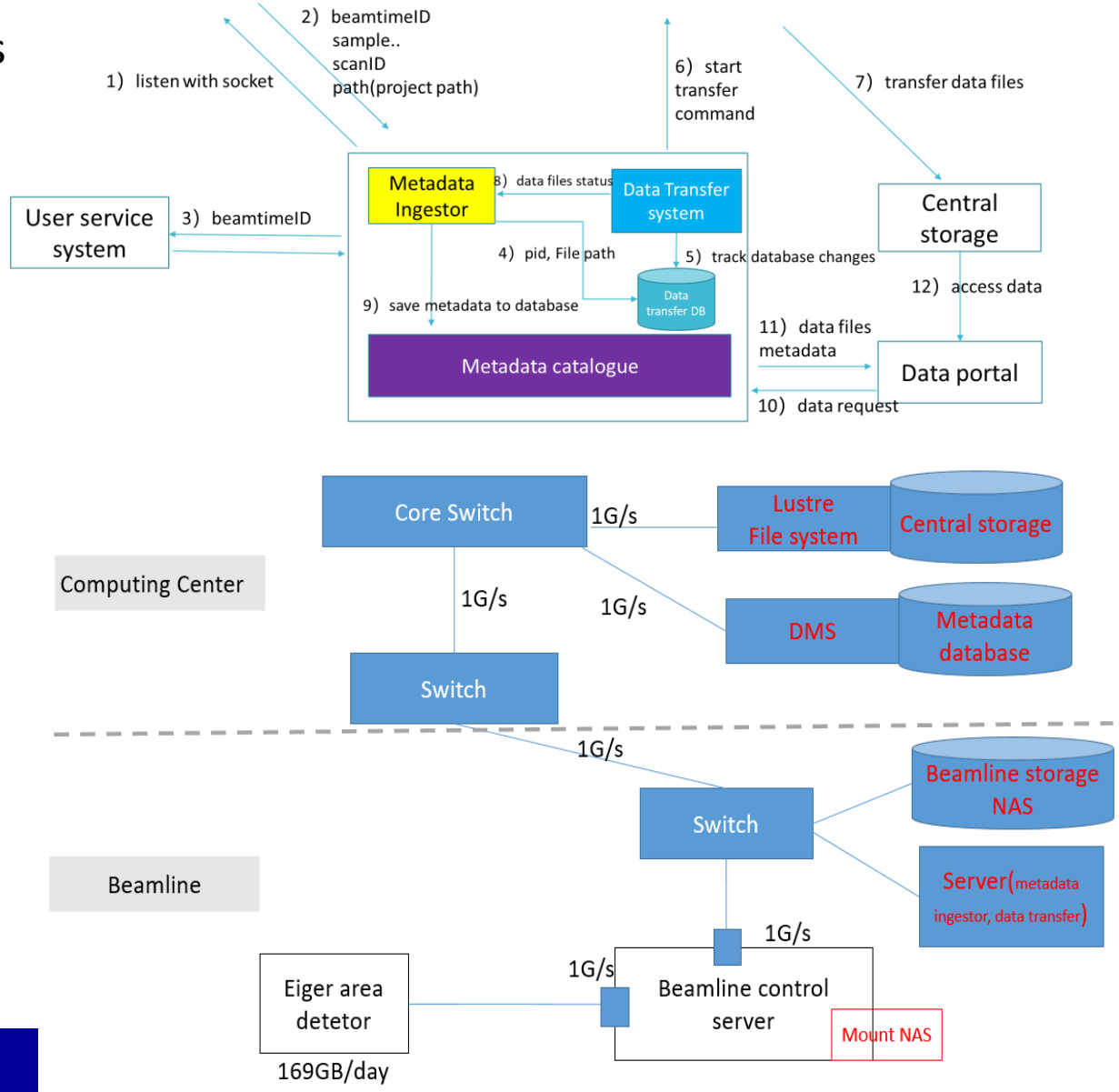
HDF5 is entirely agnostic about what data is stored!

Nexus is a set of rules how data should be organized in an HDF5 file.



DMS Testbed for HEPS

1. Network bandwidth is upgraded from 100Mb/s to 1Gb/s
2. Beamline storage: **2TB** NAS, Dell EMC NX3240, NFS file system
3. Central storage: **80TB** disk array, Lustre file system, located at Computing Center
4. A server located at the beamline, responsible for
    - metadata ingesting
    - data transferring
5. DMS API server and database server, located at Computing Center
6. Data service web portal
    - authorized users and administrators
    - access data, download data files



Main Challenges

- Manpower
  - 30+ staffs current
  - Difficult, not many suitable candidates(such as software technology and development talents)
- International Collaborations
  - Broader international cooperation, such as opening up the direction of international disciplines

Conclusions

- This is recognized and reviewed by IHEP as the 2020-2025 strategy plan, which provides a realistic and prudent IT support to ambitious and visionary scientific objectives
- Scientific data and computing platform capabilities and services are the foundation of the development of IHEPCC
- The information service at IHEP is one of the important tasks of IHEPCC
- Strengthen collaboration with experiments and integration of scientific research activities
- Welcome talents to join IHEPCC

Thank you!

Any Questions?