Status of the offline computing system

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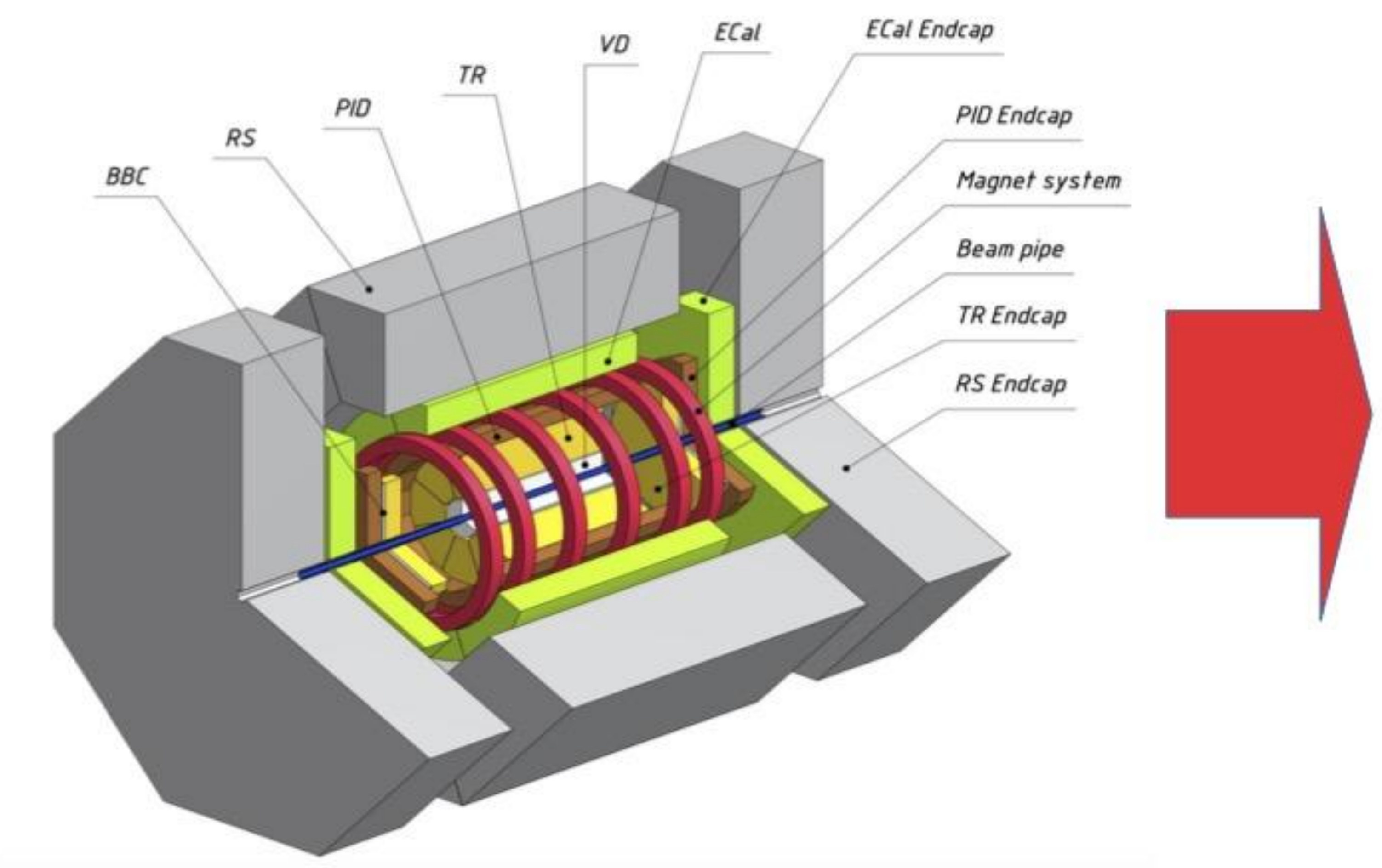
SPD data amount



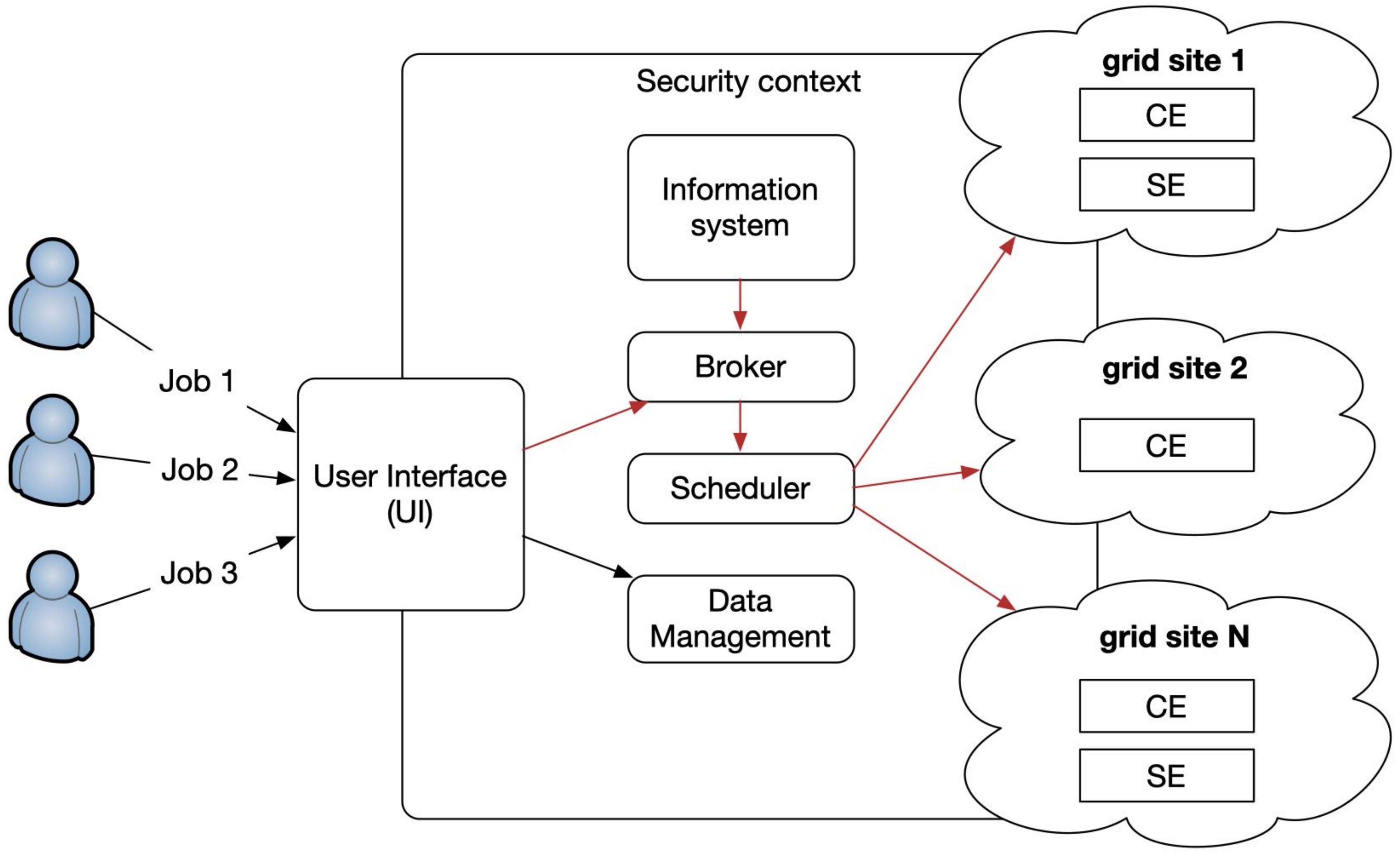
- Bunch crossing every 76.3 ns = crossing rate 13 MHz
- ~ 3 MHz event rate (at 1032 cm- 2s-1 design luminosity) = pileups
- **Estimated data rate:** 20 GB/s (or 200 PB/year (raw data), $3*10^{13}$ events/year) before On-line filter
  - *We still have no full understanding of realistic, expected data rate: frontend electronics and DAQ on initial design step*
- Required number of simulated events will be in order of magnitude comparable with collected.

- The SPD offline data processing system should be able to deal with trillions of events per year.
- Dozens of thousands of CPUs will be required

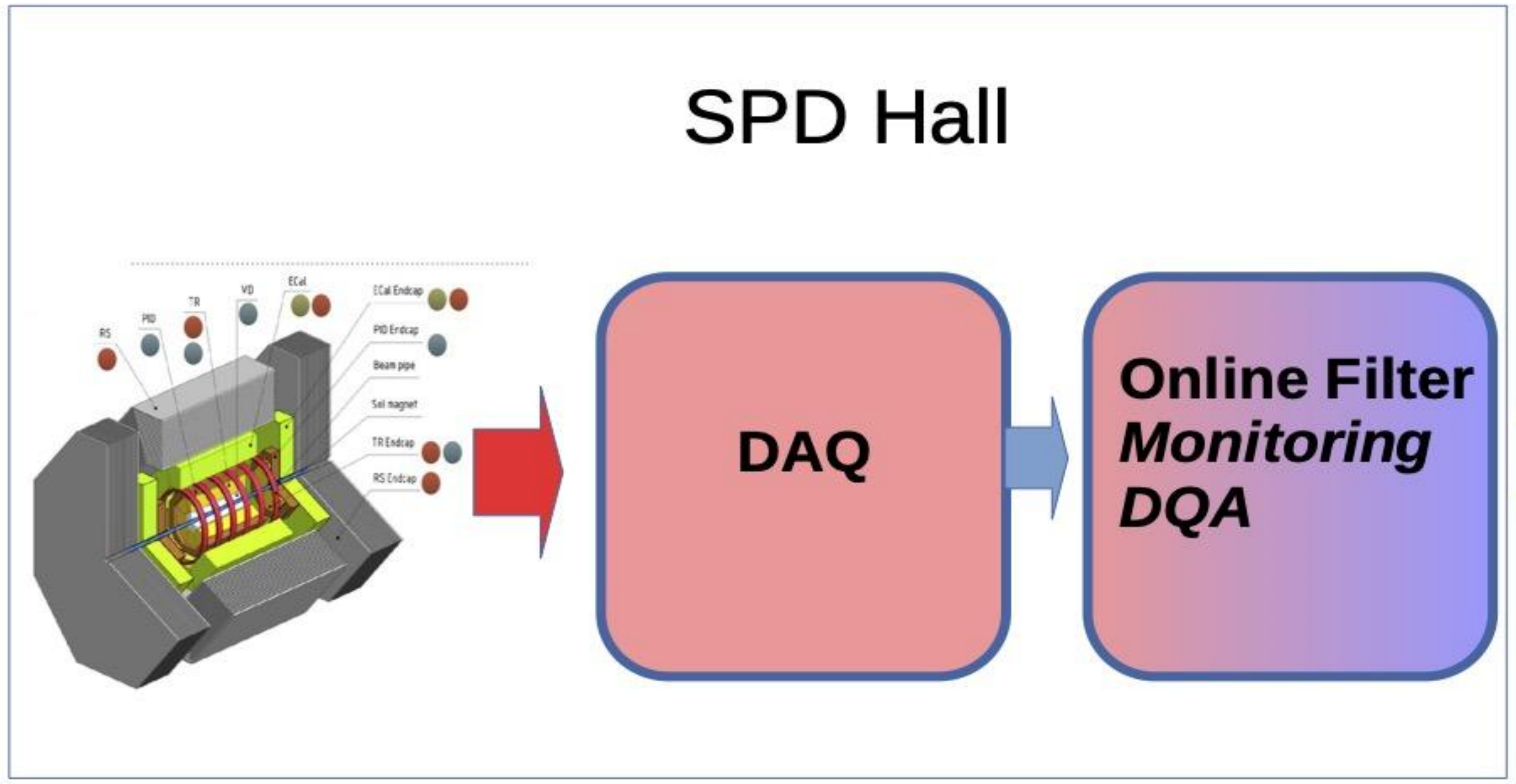
HTC: grid computing

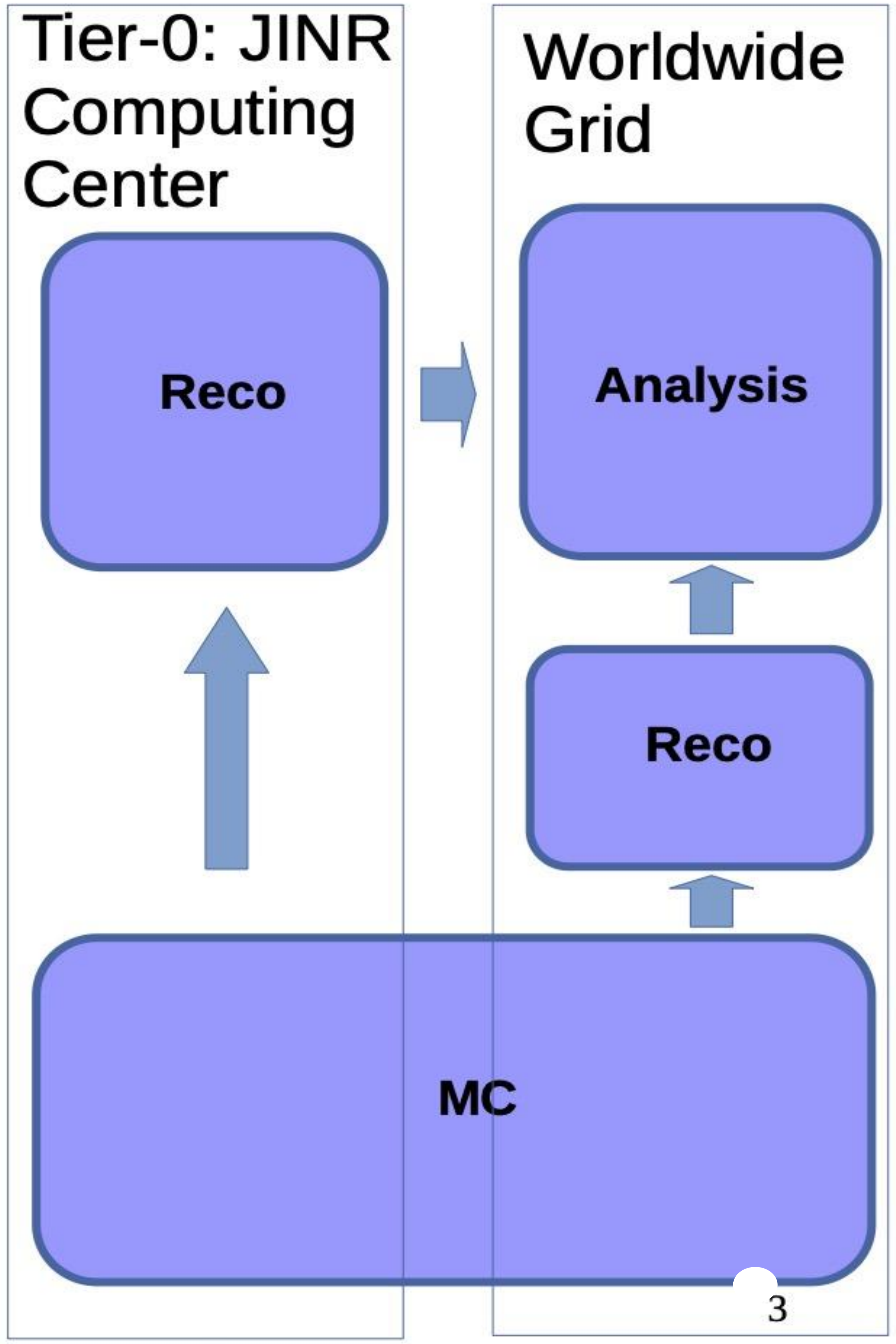
Grid computing is the collection of computer resources from multiple locations to reach a common goal. The grid can be thought of as a distributed system with non-interactive workloads that involve a large number of files. Grid computing is distinguished from conventional high performance computing systems such as cluster computing in that grid computers have each node set to perform a different task/application.

We encourage to organize a GRID computing system for offline processing of SPD data by incorporation of resources of experiment collaborators.



Data workflow



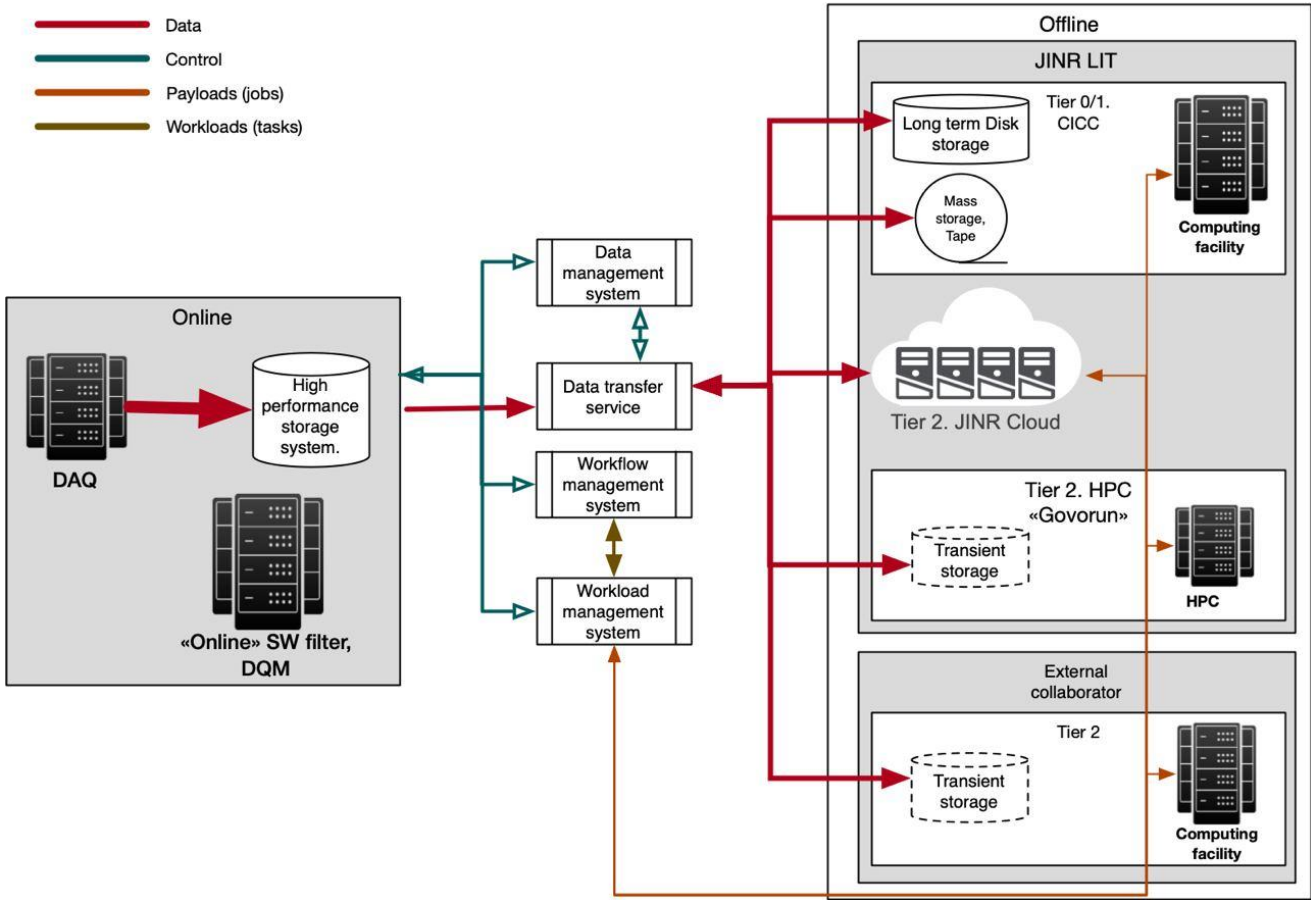


Continuous data reduction:

- DAQ: noise suppression
- Online filter: event building, partial reconstruction, software trigger
- Offline computing: data analysis and long term storage

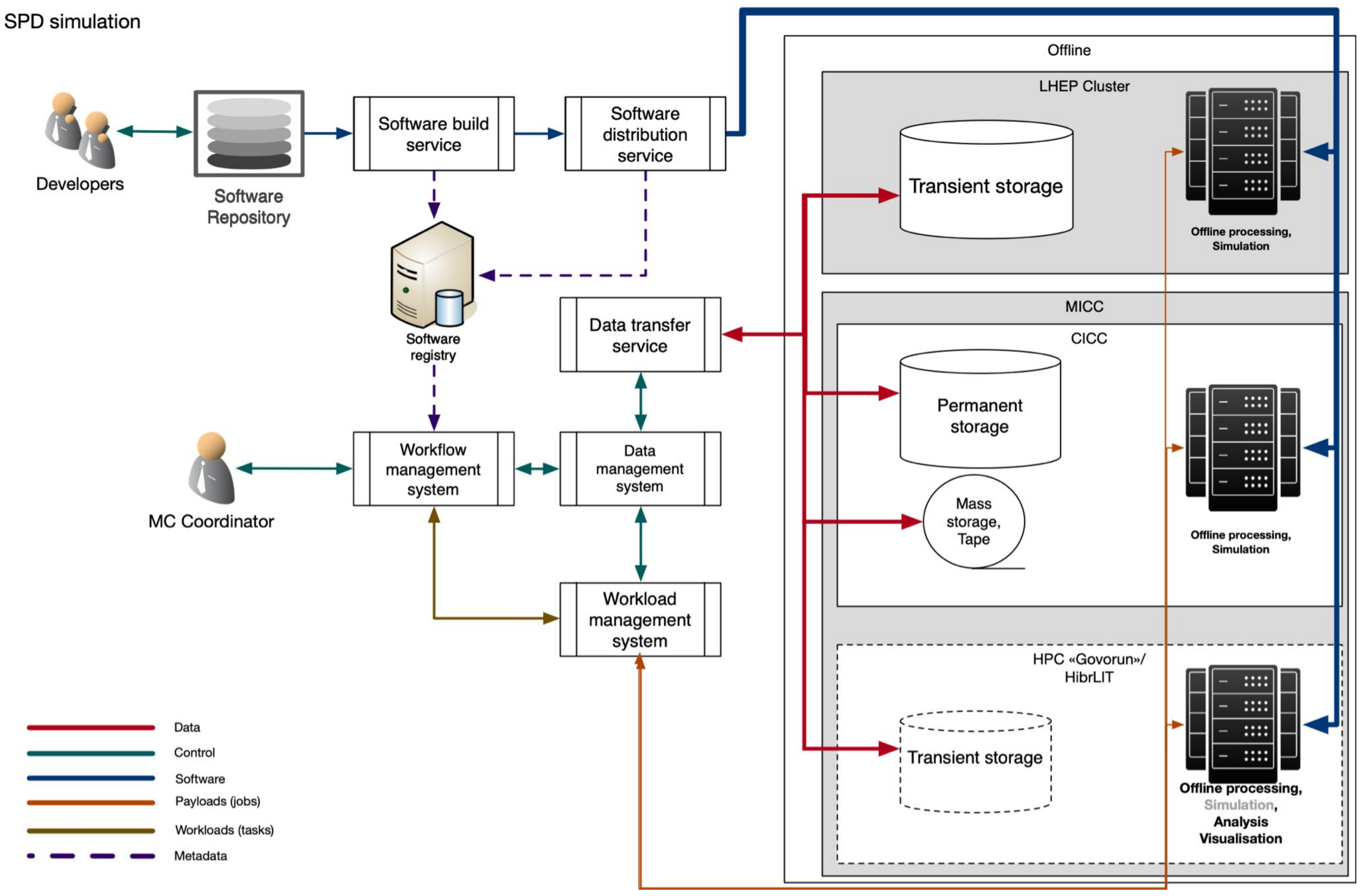
Use case: mass data processing

- The main consumer of distributed computing resources
- It is very important to find the most optimal ratio of the size and number of files to be processed by the system for the most efficient use of the available computing infrastructure
- Key components:
  - WFMS
  - WMS
  - DMS & DTS
  - Software distribution service - service which allow automatic deployment of new versions of SW in heterogeneous environment



Use case: simulation

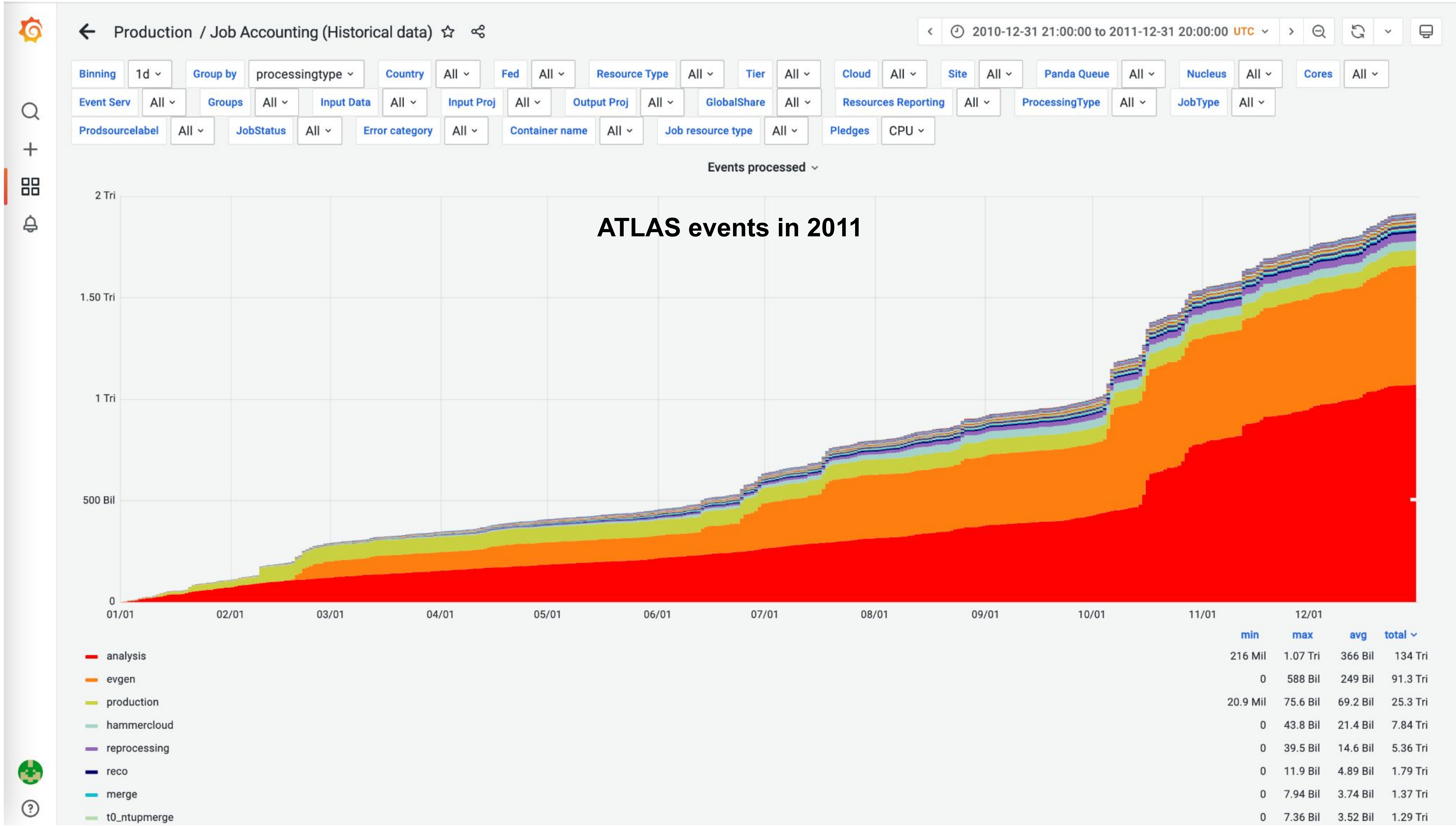
- Simulation – another huge consumer of computing resources
- Can be (should be) started before facility will be ready to collect data
- Accompanied by intensive software development
- Key components:
  - WFMS
  - WMS
  - DMS & DTS
  - Software build service – required for automation of building of new releases of SW
  - Software distribution service - service which allow automatic deployment of new versions of SW in heterogeneous environment



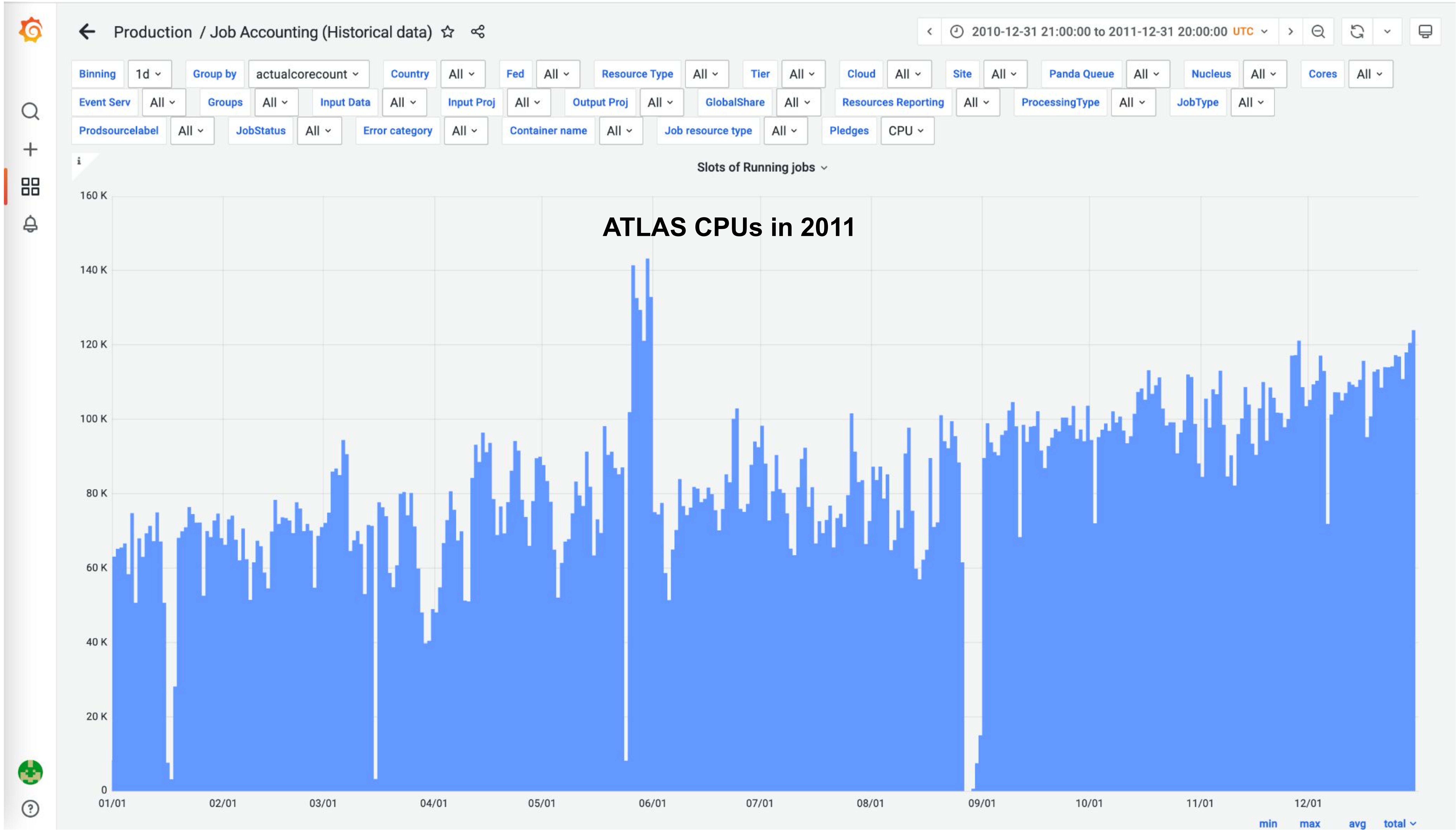
Data volumes in numbers

- Now we expect that facility will generate $2*10^{12}$ events per year (EPY)
- We expect to process one event per one second
- There are 31536000 seconds per year (SPY)
- EPY/SPY = 63419 fully loaded CPUs
- Now we spend ~5-6 seconds to process one event, it is a crucial point – serious improvements of the applied software must be done to reduce this number
- At the moment in LIT we have ~8000 CPU shared between many experiments
- To handle load of such level we need to be ready to process our data at any available computing resource like remote cluster, cloud or HPC

Existing experiments with similar data volumes 1/2



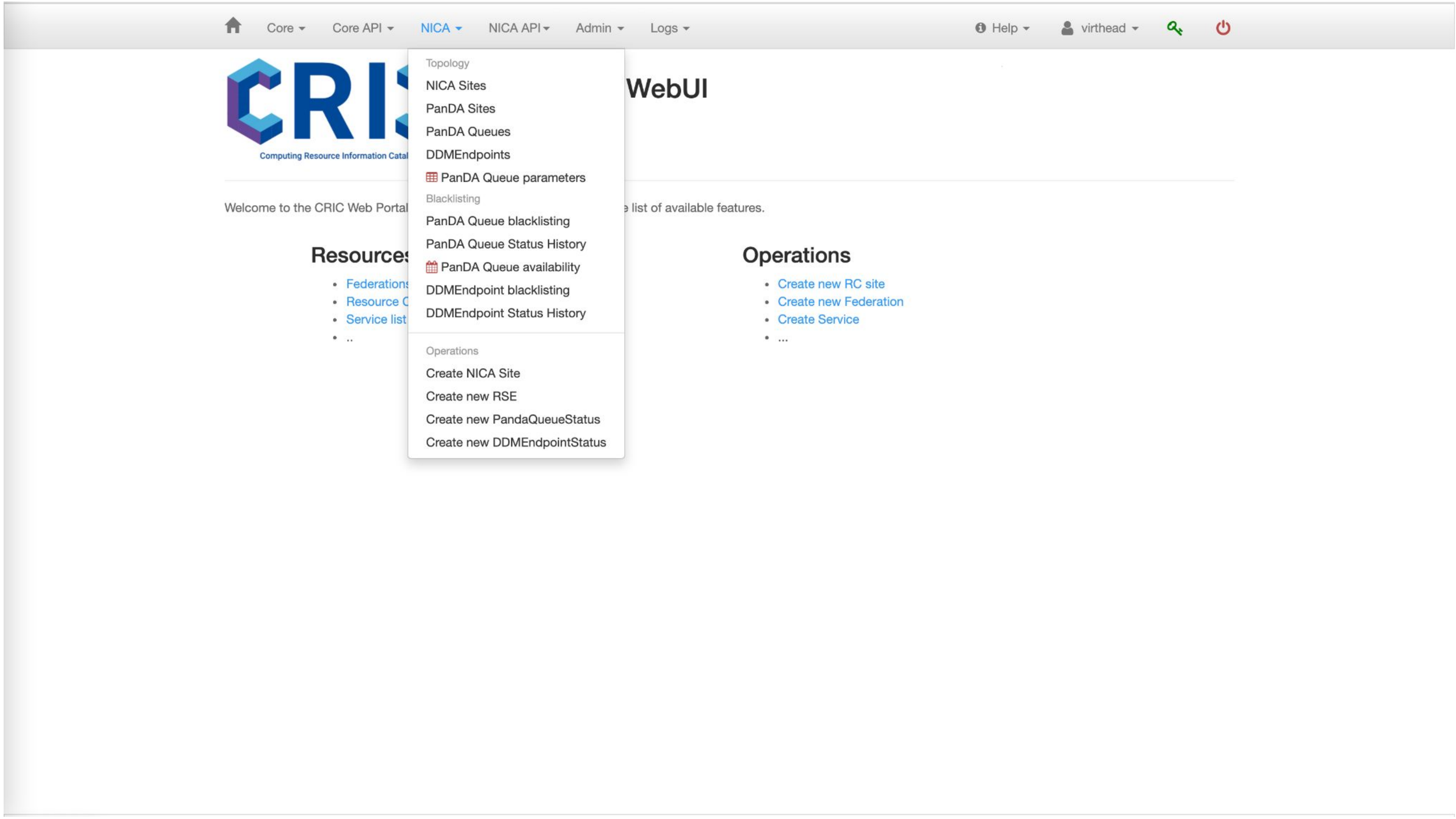
Existing experiments with similar data volumes 2/2



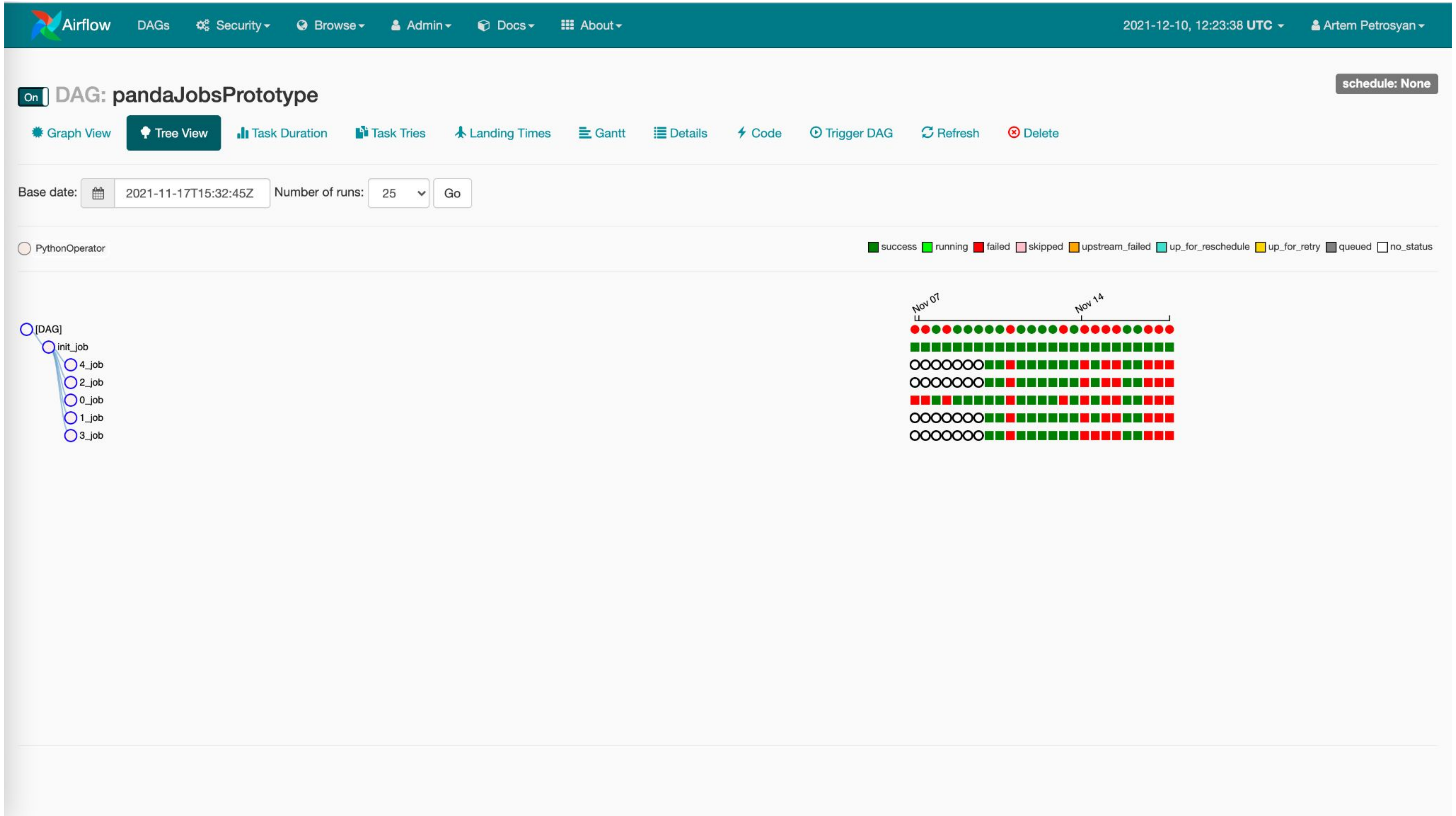
Services of the offline computing system

- Some services, like authorization/authentication, VOMS and CVMFS were already in place and supported by LIT as central and common services for JINR
- Information system (CRIC): deployed, integrated with JINR SSO, being filled with data
- WFMS (Apache Airflow): deployed, integrated with JINR SSO, integrated with WMS
- WMS (PanDA): deployed, integrated with CRIC
- WMS monitoring: deployed, integration with JINR SSO is ongoing
- Pilots delivery to the computing resources (Harvester, HTCondor): deployed, integrated with CRIC, deliver pilots to the computing resources (LIT MICC)
- Pilots, pilot wrappers: container-ready, adopted to our environment, integrated with CRIC, tested on work with JINR EOS, ready to run payloads with real data

NICA CRIC Web UI



Apache Airflow Web UI



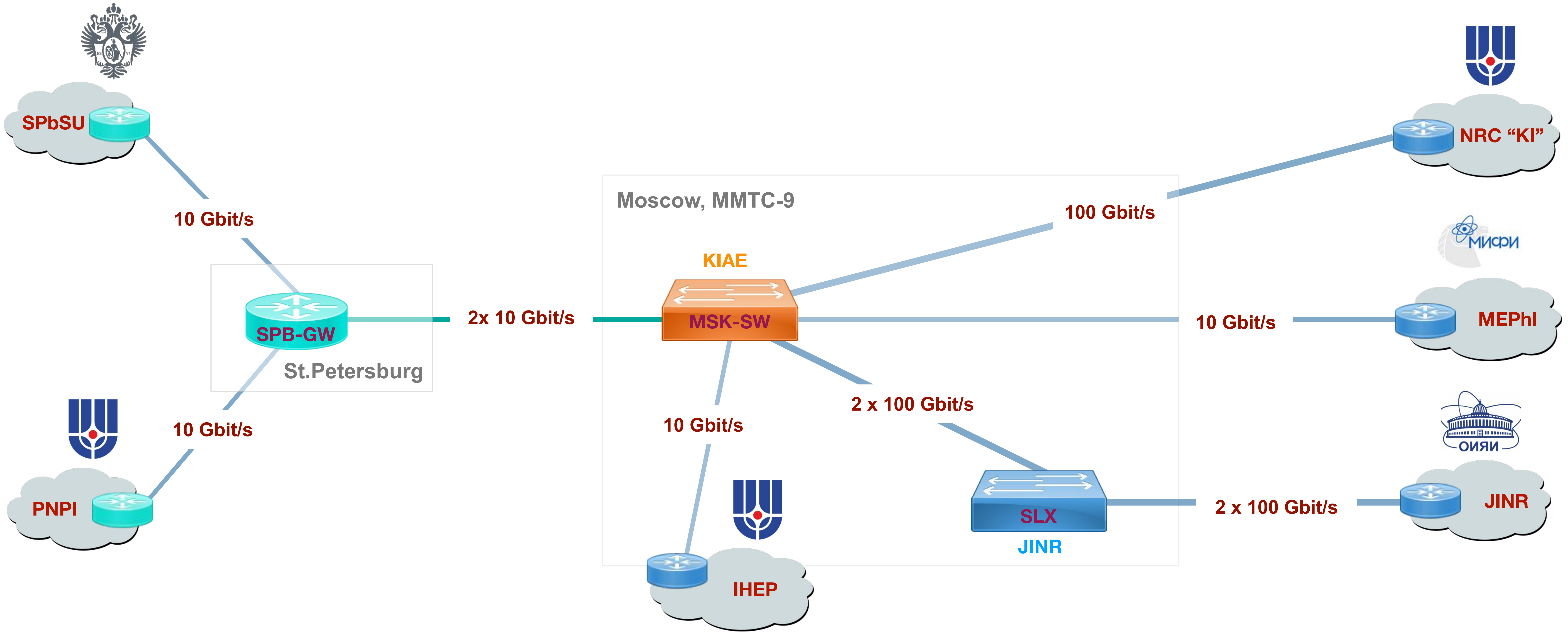
Distributed computing for HEP in Russia

JINR, PNPI, SPbSU, IHEP – already have experience of supporting own Data Processing Centers and participation in the distributed computing for LHC

- *JINR – Data Center for LHC with ~23000 CPU and 25PB Disk storage and 55PB Tape storage*
- *PNPI – Data Center for own experiments and LHC with ~15000 CPU and 5Pb Disk storage*
- *SPbSU – Tier2 ALICE Computing facility*
- *IHEP – Tier2 WLCG site*

Russian network infrastructure for Megascience projects

JINR, PNPI, SPbSU, IHEP data centers already settle high throughput network, which is one of the keys for creation of distributed system



Status and plans

- A prototype, based on the components, which have proven their ability to handle expected data volumes, is ready for real data
- We’re ready to start implementing workflows
- Integration with Korolev HPC at Samara University now is in technical stage: we’re working on the resource
- Several institutes, like PNPI and SPbSU, are considering the possibility of participating in data processing
- We’re looking forward to integrate external computing and storage resources, which members of our collaboration will be ready to provide

Thank you!

PanDA Workload Management System

- The PanDA workload management system was developed for the ATLAS experiment at the Large Hadron Collider
- A new approach to distributed computing
  - A huge hierarchy of computing centres and opportunistic resources working together
  - Main challenge – how to provide efficient automated performance
  - Auxiliary challenge – make resources easily accessible to all users
- Core ideas :
  - Make hundreds of distributed sites appear as local
    - Provide a central queue for compute jobs – similar to local batch systems
  - Reduce site related errors and reduce latency
    - Build a pilot job system – late transfer of payloads
    - Crucial for distributed infrastructure maintained by local experts
  - Hide middleware while supporting diversity and evolution
    - PanDA interacts with middleware – users see high level workflow
  - Hide variations in infrastructure
    - PanDA presents uniform ‘job’ slots to user (with minimal sub-types)
    - Easy to integrate grid sites, clouds, HPC sites …
  - Data processing, Production and Analysis users see same PanDA system
    - Same set of distributed resources available for different processing types
  - Highly flexible – instantaneous control of global priorities by experiment

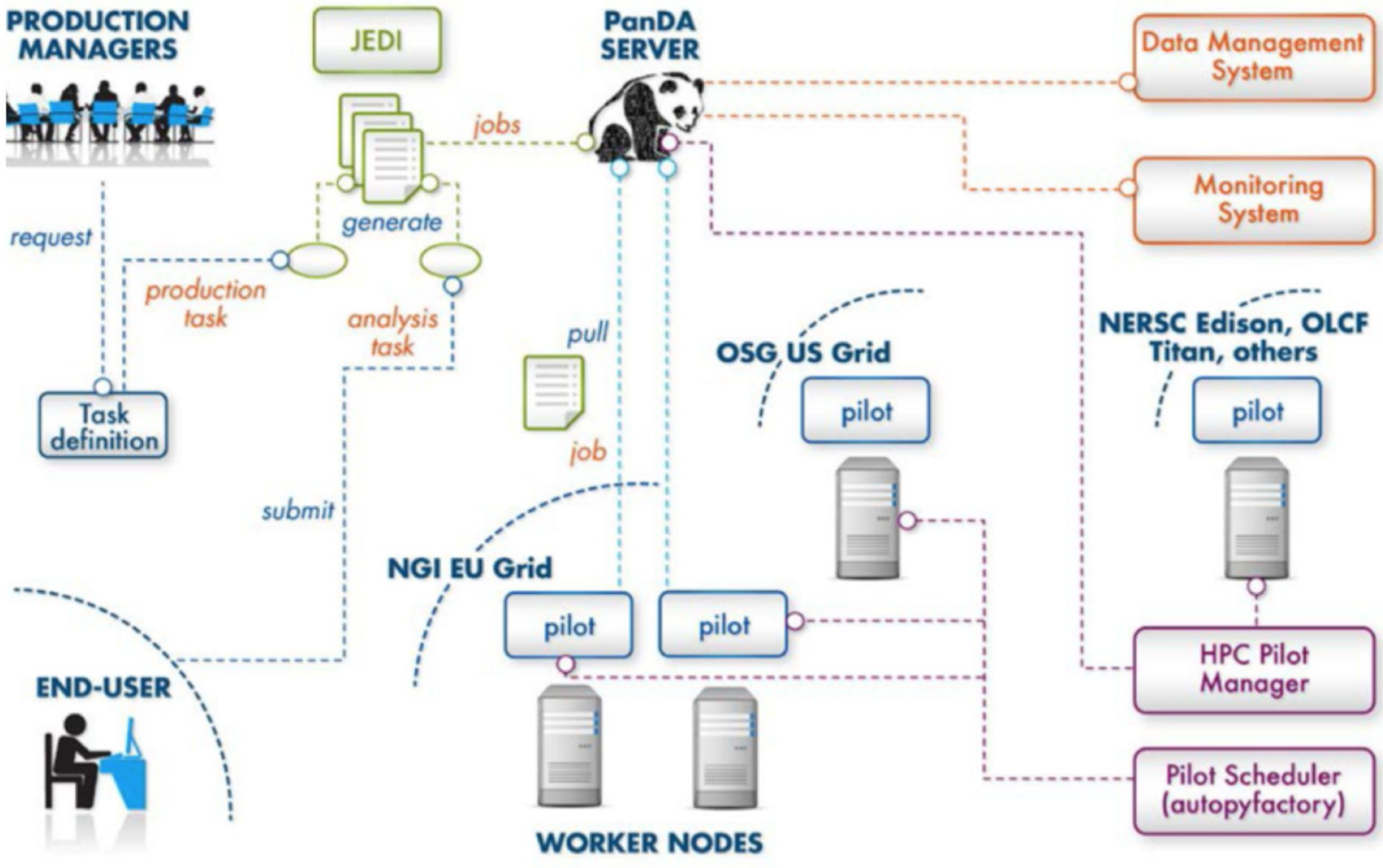
PanDA Workload Management System

- The PanDA Production ANd Distributed Analysis system has been developed by ATLAS since summer 2005 to meet ATLAS requirements for a data-driven workload management system for production and distributed analysis processing capable of operating at LHC data processing scale. ATLAS processing and analysis places challenging requirements on throughput, scalability, robustness, efficient resource utilization, minimal operations manpower, and tight integration of data management with processing workflow.

- PanDA throughput has been rising continuously over the years. In 2009, a typical PanDA processing rate was 50k jobs/day and 14k CPU wall-time hours/day for production at 100 sites around the world, and 3-5k jobs/day for analysis. In 2017, PanDA processes about a 1,2M jobs per day, with about 120,000 jobs running at any given time. The PanDA analysis user community numbers over 1400.

PanDA at nutshell

- Pilot based job execution system
  - Pilot manages job execution on local resources, as well as data movement for the job
- Payload is sent only after pilot execution begins on Compute Element
  - Minimize latency, reduce error rates



Brief PanDA History

2005: Initiated for US ATLAS (BNL and UTA)

2006: Support for analysis

2008: Adopted ATLAS-wide

2009: First use beyond ATLAS

2011: Dynamic data caching based on usage and demand

2012: ASCR/HEP BigPanDA project

2014: Network-aware brokerage

2014: Job Execution and Definition I/F (JEDI) adds complex task management and fine grained dynamic job management

2014: JEDI-based Event Service

2014: megaPanDA project supported by RF Ministry of Science and Education

2015: New ATLAS Production System, based on PanDA/JEDI

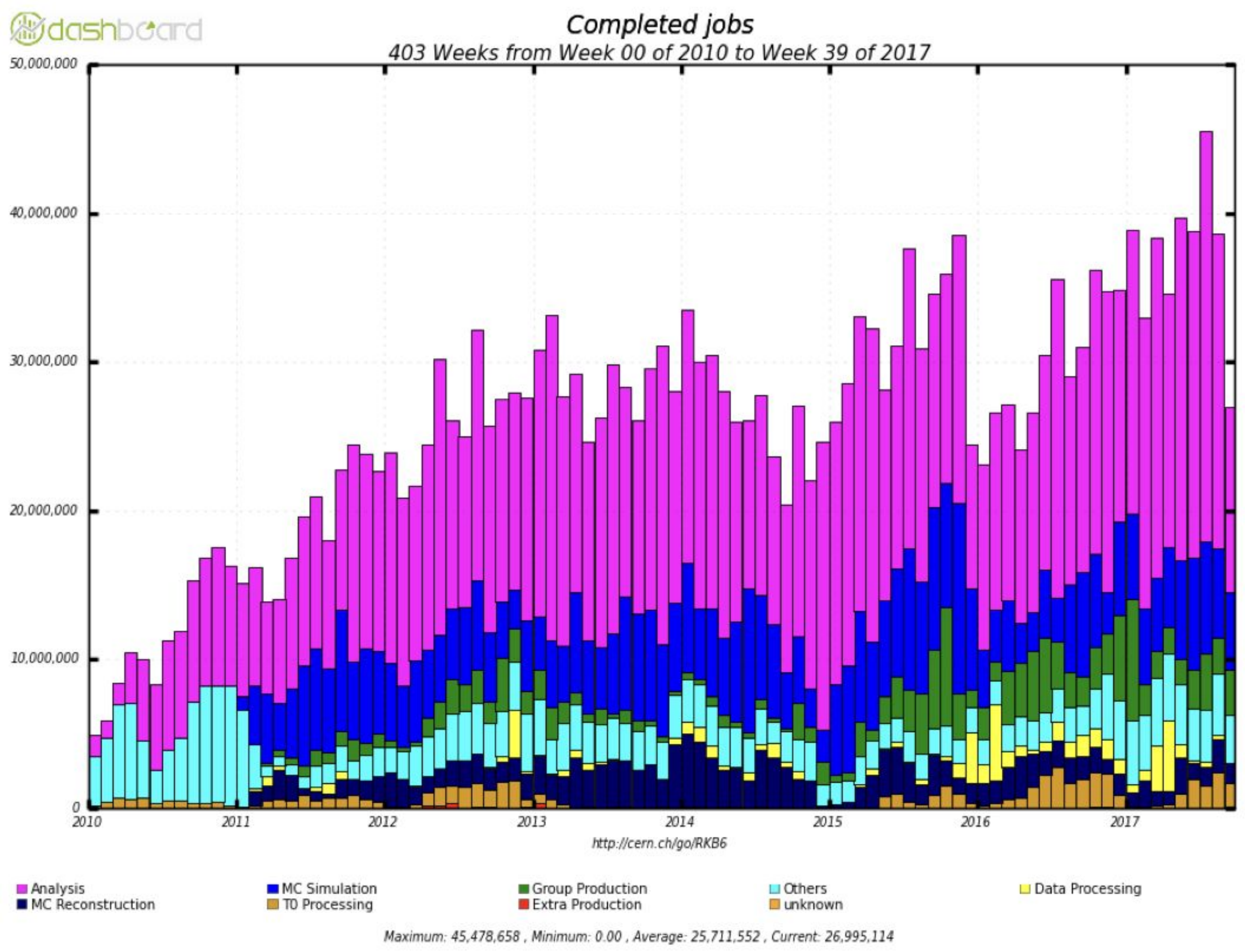
2015: Manage Heterogeneous Computing Resources

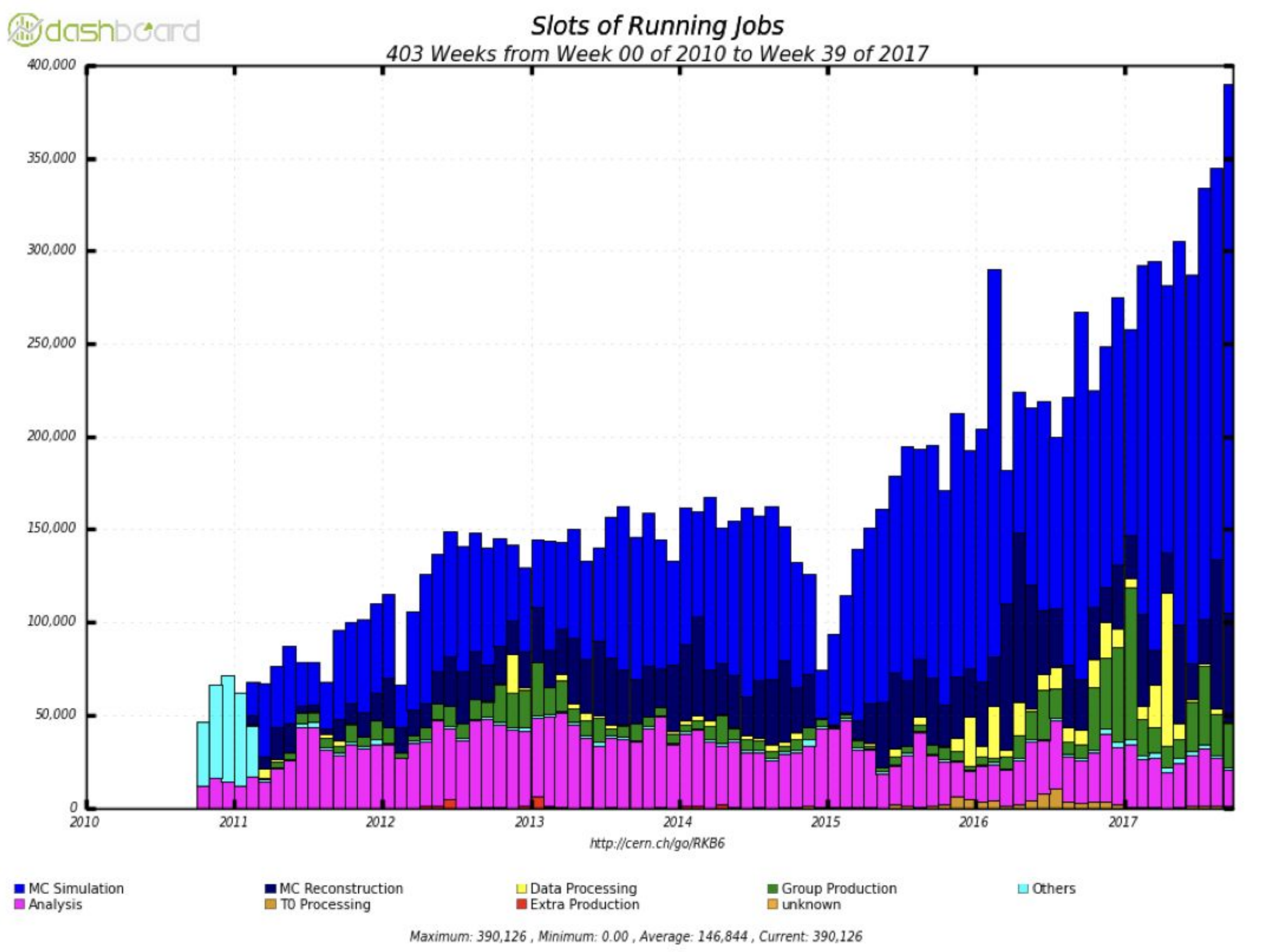
2016: DOE ASCR BigPanDA@Titan project

2016: PanDA for bioinformatics

2016: COMPASS adopted PanDA (JINR, CERN, NRC-KI), PanDA beyond HEP : LSST, BlueBrain

2017: PanDA instance at OLCF: PanDA for IceCube





Computing Resource Information Catalog (CRIC)

CRIC is the framework to design high-level information systems which describe the topology of the Computing model(s), providing unified description of resources and services used by Experiment applications.

CRIC was chosen to realise the information system for SPD Offline computing infrastructure