SPD Offline Computing System

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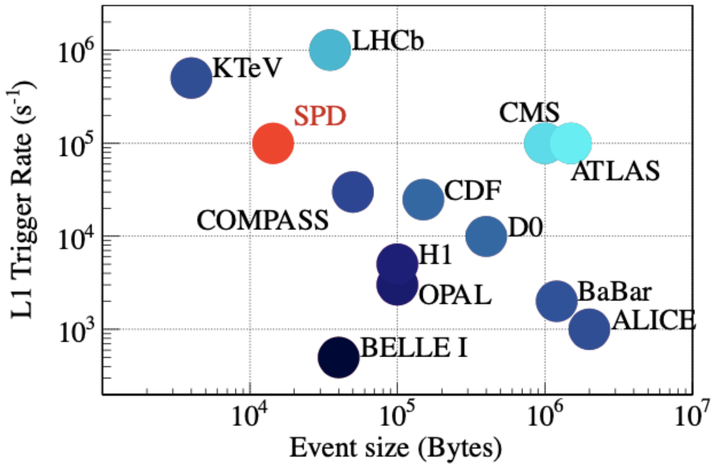
Introduction

The expected event rate of the SPD experiment is about 3 MHz (pp collisions at $\sqrt{s}$ = 27 GeV and 10^{32} $cm^{-2}s^{-1}$ design luminosity). This is equivalent to a raw data rate of 20 GB/s or 200 PB/year, assuming a detector duty cycle is 0.3, while the signal-to-background ratio is expected to be on the order of 10^{-5}. Taking into account the bunch-crossing rate of 12.5 MHz, one may conclude that pile-up probability cannot be neglected.

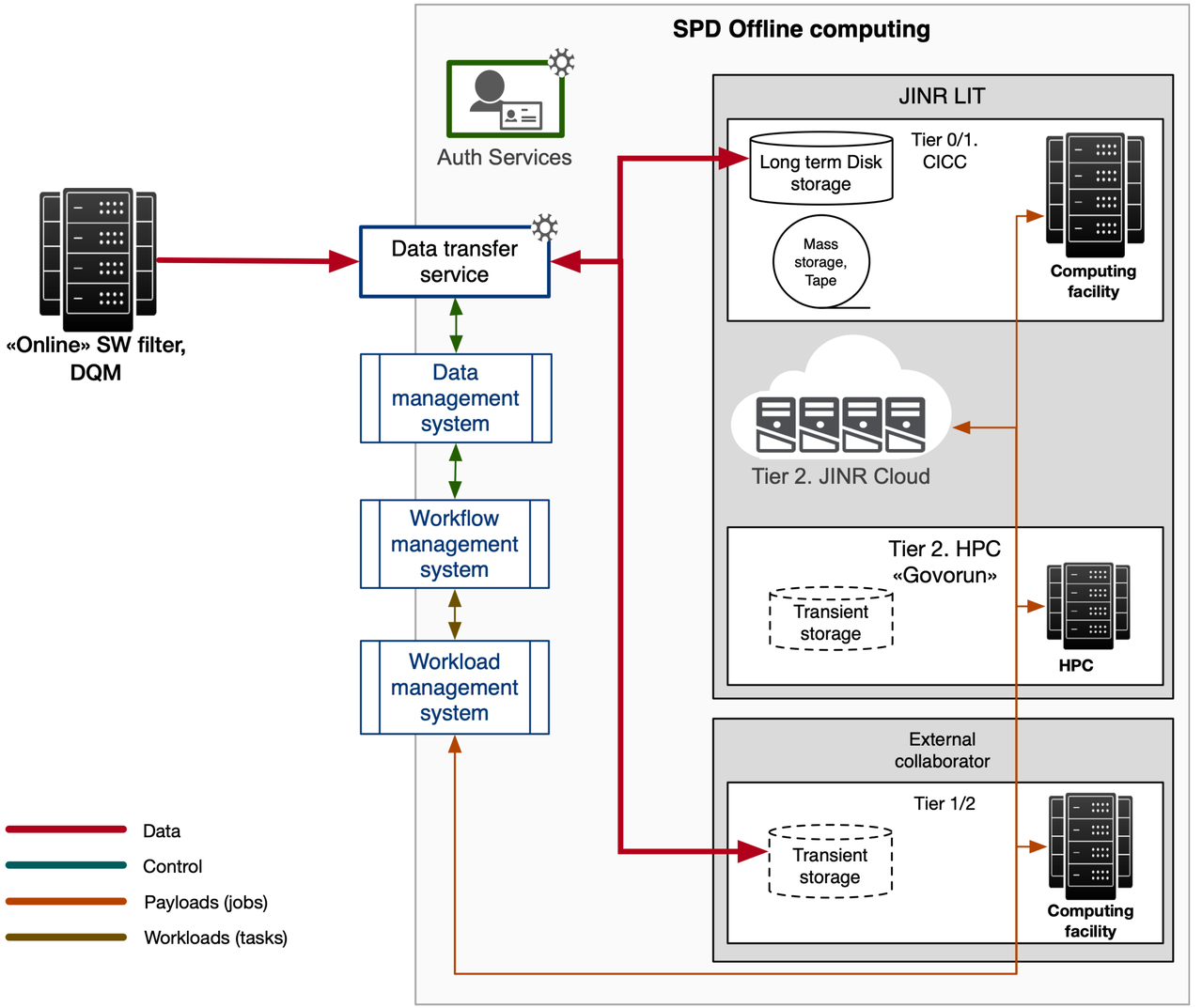
- SPD TDR



The goal of the online filter is at least to decrease the data rate by a factor of 20, so that the annual growth of data, including the simulated samples, stays within 10 PB. Then, data are transferred to the Tier-1 facility, where a full reconstruction takes place and the data is stored permanently. The data analysis and Monte-Carlo simulation will likely run at the remote computing centres (Tier-2s). Given the large data volume, a thorough optimization of the event model and performance of the reconstruction and simulation algorithms are necessary.

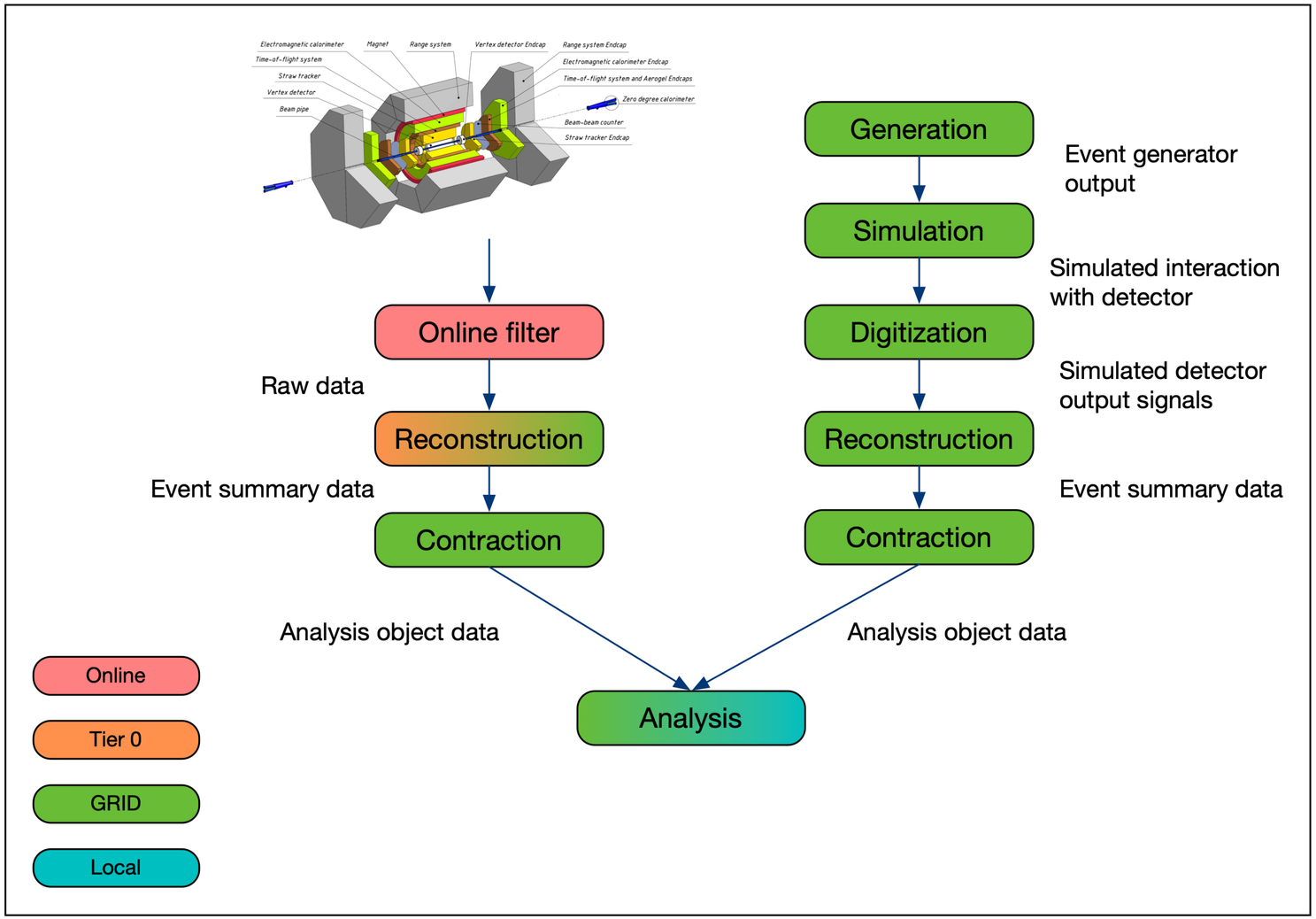
Computing system components

- CRIC information system — the main integration component of the system: gathers info about all computing and storage resources, access protocols, entry points, and many other things in one place and distributes this info via API to all other components mentioned below
- PanDA WFMS/WMS — manages data processing at the highest level of chains of tasks and datasets or periods and campaigns, finds the best computing resource for task to be executed on, manages individual jobs (usually 1 job means 1 input file) processing
- Rucio DMS — responsible for data management, including data catalog, data integrity and data lifetime management strategies
- FTS DTS — enables massive data transfers



Processing steps distribution over computing resource types

- Execution of events reconstruction and reprocessing jobs is accompanied by intensive I/O operations and will be done mostly on the dedicated farms on JINR site as Tier 0 component of the distributed computing system
- The use of Tier 0 is dictated by huge amount of initial data, gathered by the physics facility — data must be reduced as much as possible in order to be ready for distribution
- Less I/O intensive steps, especially Monte-Carlo production, can be performed on the remote computing centres
- User analysis can be run on every close to user resource



Resources and services provided by MLIT

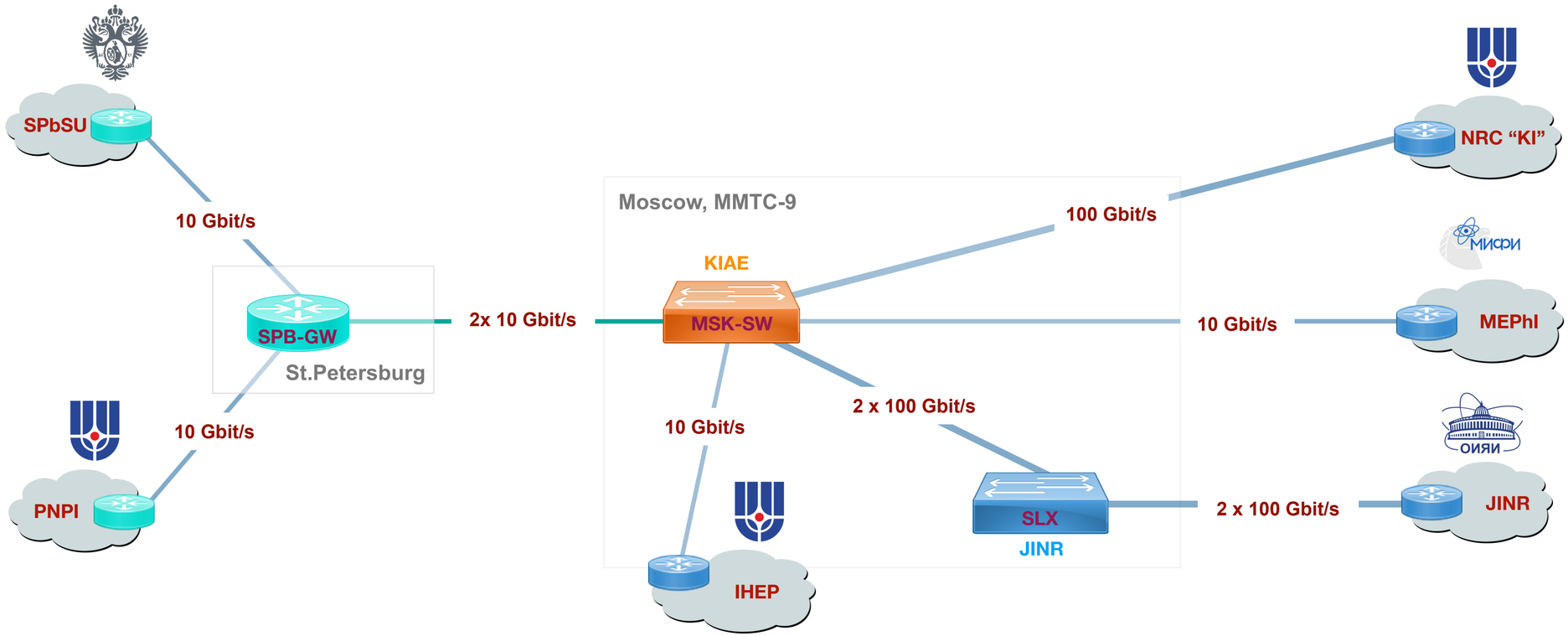
- CA, VOMS/IAM, CVMFS
- MICC
  - Cloud (IaaS, dedicated VM, spinning disks and SSD)
  - CICC (Slurm batch, grid ARC6 CE)
  - Govorun HPC, HybriLIT
- Disk and tape storage (EOS, grid SE)
- GitLab, Indico, docdb, video conference, project management, etc.
- It would be great to organize a DBOD (Database On Demand) service at MLIT with support of popular RDBMS systems, for example, PostgreSQL and MariaDB

External participants

- Data volume mandates some baselines
  - >10 Gbps network per site (from TDR)
  - >500 TB storage capacity per site (not from TDR, but might be added to the next version)
- Try to use existing free software as much as possible
  - Experience comes form large LCG experiments
- Optimize management and operation effort
  - Do not deploy home-grown solutions that are different from site to site
  - Provide a reasonable guidelines for interfacing physical resources with central data management services

Russian WLCG network backbone

- Network bandwidth, amount of CPU and storage capacity is a combination of factors which allow to take part in SPD computing
- Russian “old school” WLCG computing centres are the most likely candidates for this role



Principles of the computing system

- Jobs -> tasks -> trains of tasks -> workflows
- Files -> datasets
- Gather and keep metadata of each workflow/task/job, dataset/file and event
- Advanced strategies for managing data lifetime: some files to be deleted immediately, other will be kept till the end of the production, another will be stored for some period after being gathered, and the most important data must be kept forever
- Concentrating on the use of containers as a universal response to the variety of software versions on computing centres: we publish tagged version of SpdRoot at CVMFS so that anyone can use it
- We keep in mind multiprocessor, multithreading and non x86 architectures of the modern hardware — there is ongoing development of Gaudi based framework for SPD, which will replace SpdRoot, based on ROOT framework

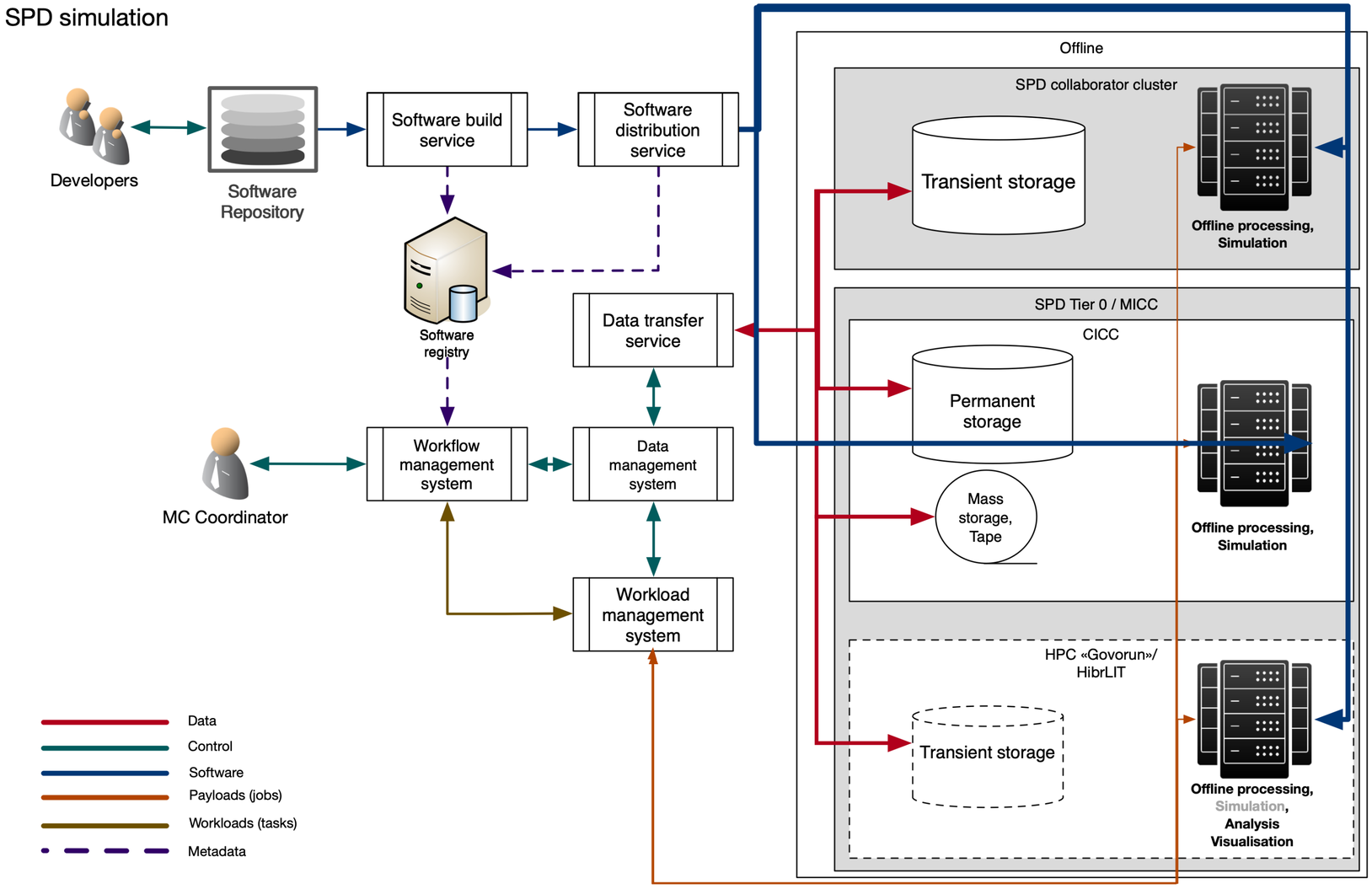
How do we use computing resources

- Personal computers and laptops: development, initial testing
- JINR cloud service: development, testing in the environment, profiling, testing with containers
- Batch service: personal analysis, small tasks
- Production system over the distributed computing resources: large (thousands jobs) tasks over large datasets, chain of tasks and workflows, mass productions in the interest of the collaboration

Production setup

- CVMFS as an entry point to the “official” versions of SpdRoot
- Production setups on the CVMFS in form of frozen sandboxes
- Each new production means new directory with all dependencies on CVMFS
- Each production on CVMFS corresponds to path with the same name on EOS
- Production role in VOMS for users who run mass production
- Directory to store results of the production on EOS with strict access rights in order not to be deleted accidentally

MC workflow example



Summary

- MLIT provides all the necessary services for building data processing system of our experiment, we work in close contact
- All SPD middleware services deployed on MLIT cloud service
- We expect that JINR will not cover more than 25% computing needs of the experiment and thus finding external collaborators for data processing is one of the highest priority tasks
- External participants demonstrate interest and intention to participate in software development and data processing, we work with each of them: for example, an agreement of collaboration in computing with PNPI has just signed, grid queues of PNPI and INP BSU were connected to the distributed computing infrastructure of the experiment in 2022
- A prototype of SPD computing system ready to test mass production
    - First production (samples of D-meson decays and min. bias) is now ongoing
- Working on automatic image building at CI/CD of SpdRoot
- Our next steps will lay in the field of data management and databases: geometry versions, calib&align, magnetic field, etc.

Thank you!