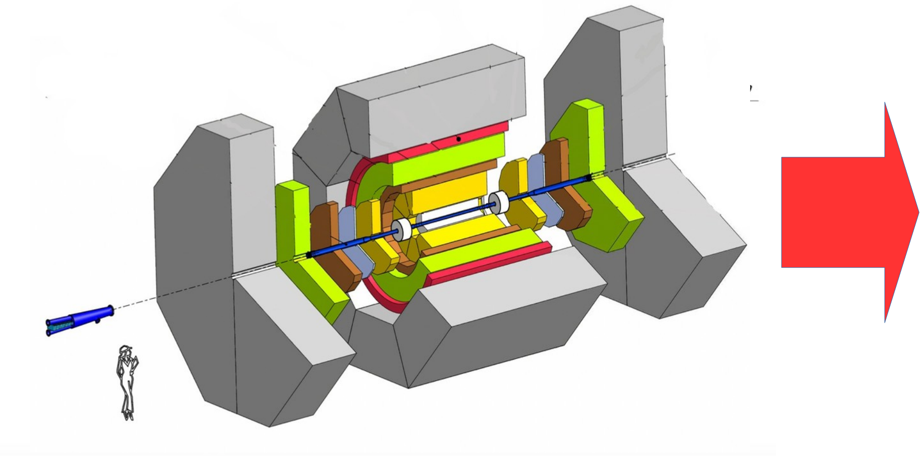
SPD
DAQ & Computing & Software

Alexey Zhemchugov
SPD Software Coordinator
zhemchugov@jinr.ru

SPD as a data source



- Bunch crossing every 76.3 ns = crossing rate 13 MHz
- ~ 3 MHz event rate (at 10^{32} $cm^{-2}s^{-1}$ design luminosity)
- 20 GB/s (or 200 PB/year (raw data), $3*10^{13}$ events/year)
- Selection of physics signal requires momentum and vertex reconstruction → no simple trigger is possible

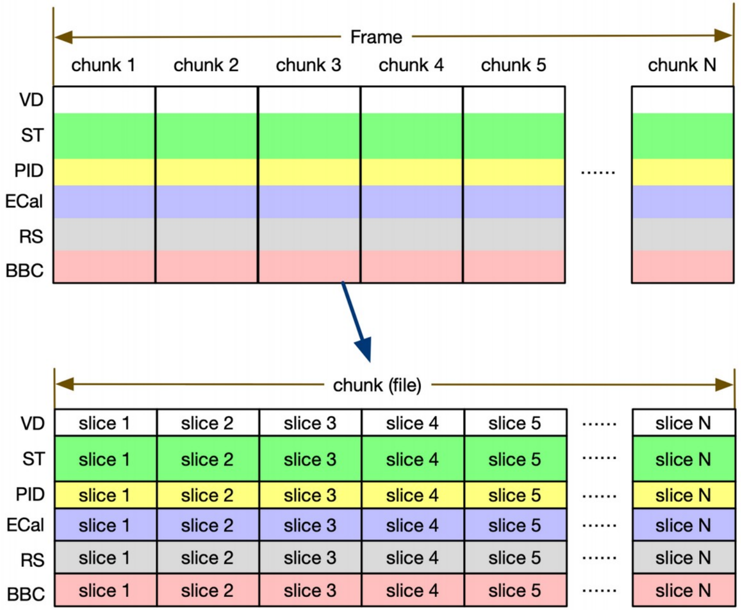
The SPD detector is a medium scale setup in size, but a large scale one in data rate!

Input data

- RAW event size 7 kB
- RECO event size 15 kB
- Time for Reconstruction (1 ev) 100 HepSPEC
- Time for Simulation (1 ev) 500 HepSPEC
- Event rate at maximum luminosity 3000 kHz
- Event rate after online data filter 150 kHz
- Operation time 50000 seconds/day
- Operation time 200 days/year

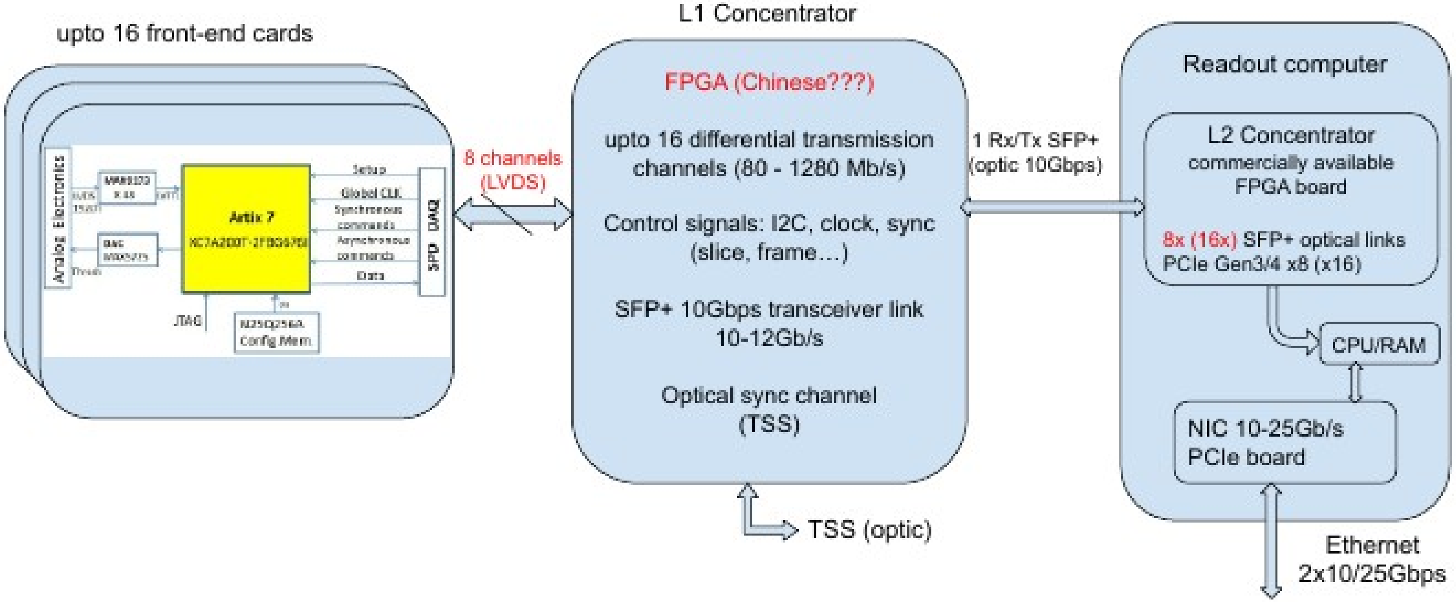
Free running DAQ

No trigger = No classical events anymore

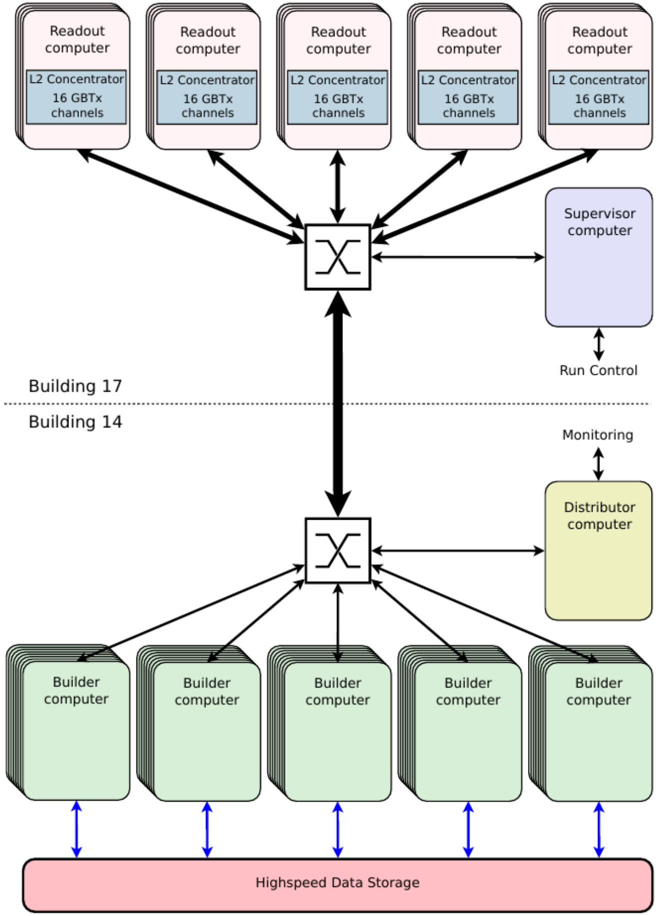


- Primary data unit: **time slice** (1 us — 8.3 ms)
- Time slices combined in **time frames** (up to 549 s, 16 GB max, < 160 MB to fullfil 20 GB/s limit)
- Intermediate units — **time chunks** of 0.1-0.2 s (2-4 GB or ~10^5-10^6 events) are being discussed now
-
- Every time slices will contain signals from a few to many collisions (events)
- Event building have to unscramble events from a series of time slices.

SPD Readout Chain

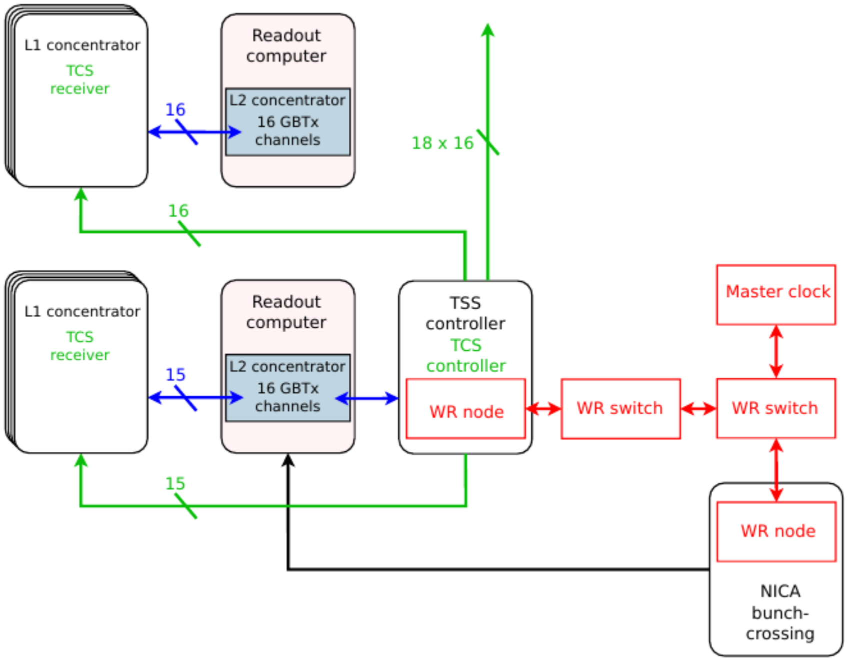


Slice building

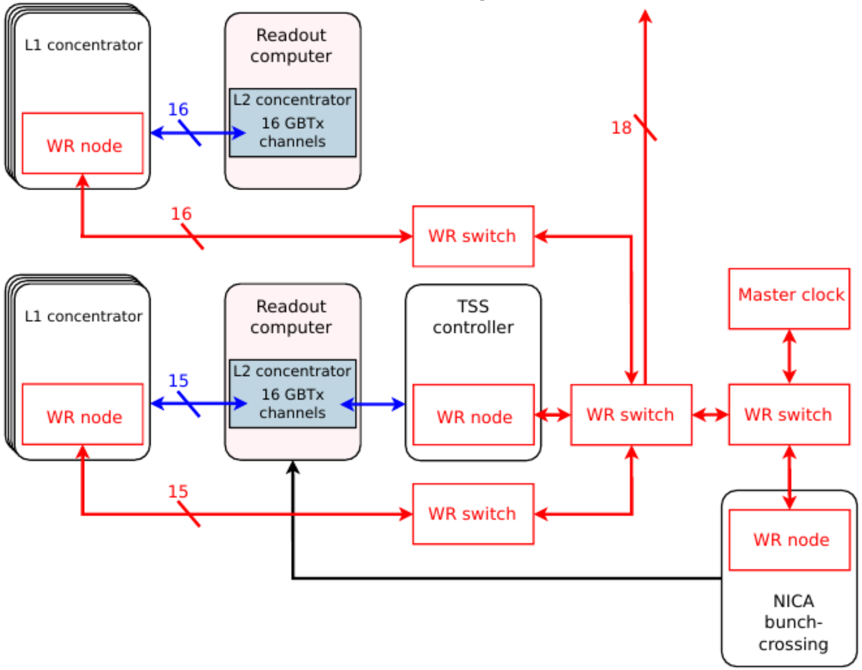


Timing and synchronization

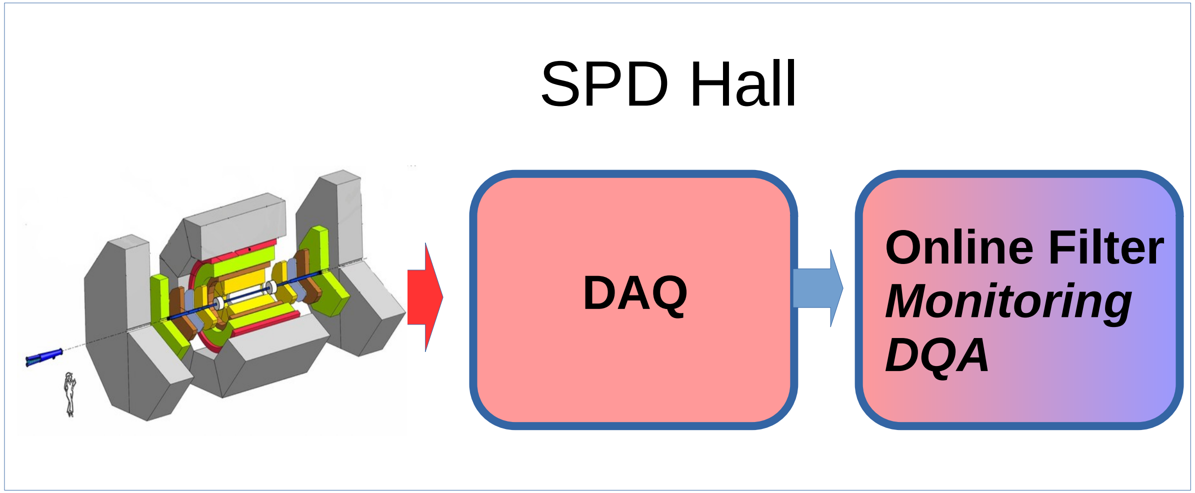
TCS based sync

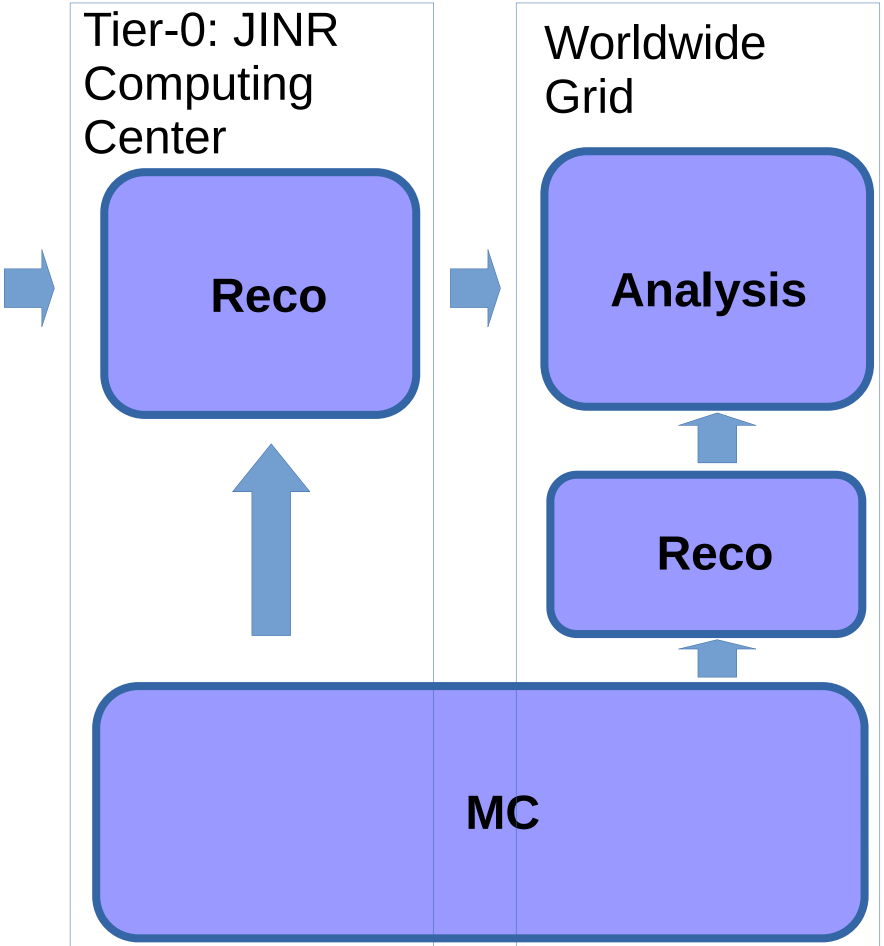


WR based sync



Data workflow





Continuous data reduction:

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

Online Data Filter

High-performance heterogeneous computing cluster

- Partial reconstruction
  - Fast tracking and vertex reconstruction
  - Fast ECAL clustering
- Event unscrambling
- Software trigger
  - several data streams

Machine learning is a key technology

Control of systematics?

- Monitoring and Data quality assessment
- Local polarimetry

Reconstruction workflow

- **Tracking in the vertex detector (at the second stage)**
  - Vertices
  - Track seeds

- **Tracking in the straw tracker (+ MCT at the first stage)**
  - T0s (crude, ~10 ns) → bunch crossing time
  - Tracks
  - Unassociated straw hits

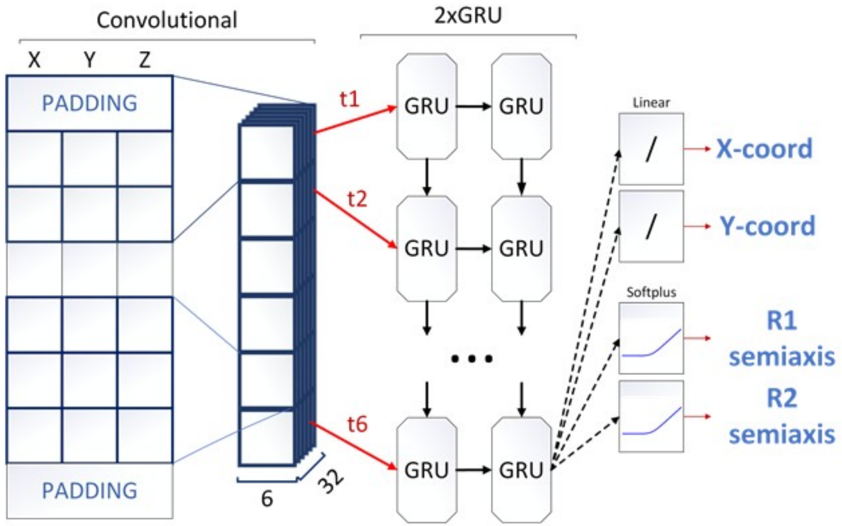
- **ECAL reconsruction**
  - Clusters
  - π^0 candidates

- **RS reconstruction**
  - Clusters
  - Muon candidates

- **Association of tracks, RS and ECAL clusters to vertices (event unscrambling)**
- **Copy raw data from PID, BBC, ZDC to events according to bunch crossing time**

Example: TrackNETv3 for track recognition

JINST 17 (2022) 12, P12023
D. Rusov et al, talk at PCT'2023



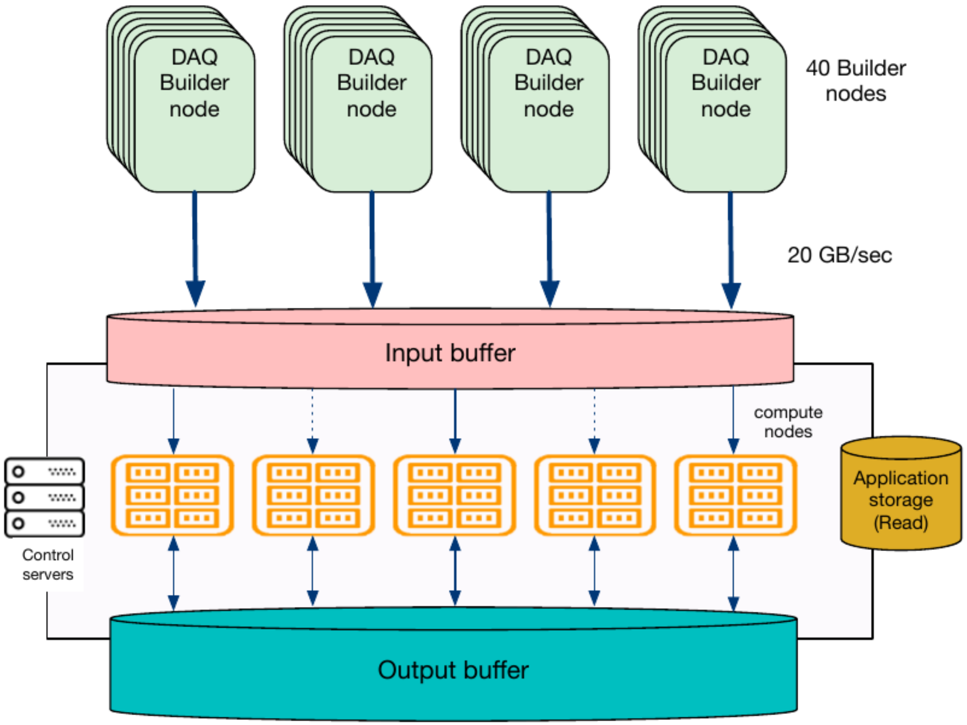
- Network predicts an area at the next detector layer where to search for the track continuation
- If continuation is found the hit is added to the track candidate and the procedure repeats again
- Essentially reproduces the idea of the Kalman filter: track parameters are predicted by synaptic weights determined by network training
- Generalization? Stability?

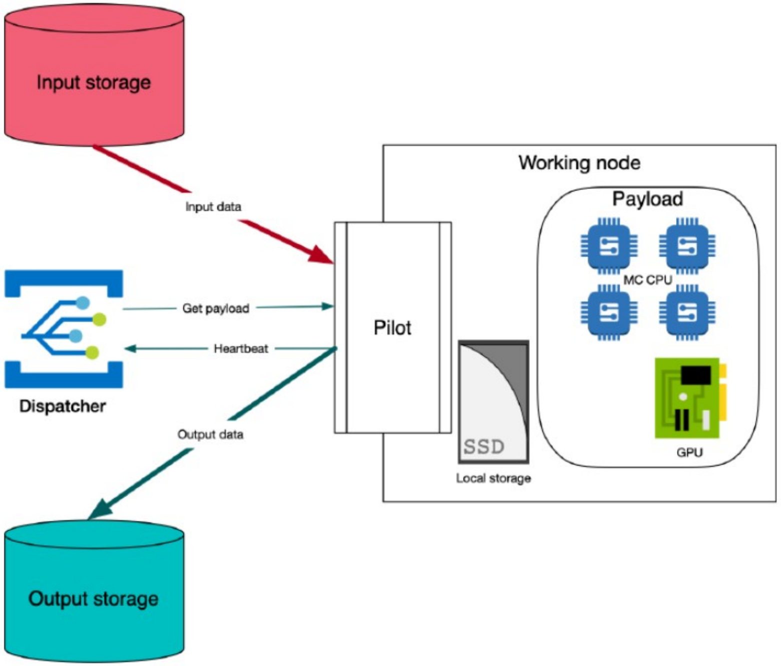
	Time slices of 40 events
Track efficiency (recall) (%)	96,54
Track purity (precision) (%)	94.75
Time slices / sec	63.74 (*40 = 2549.6)

PRELIMINARY

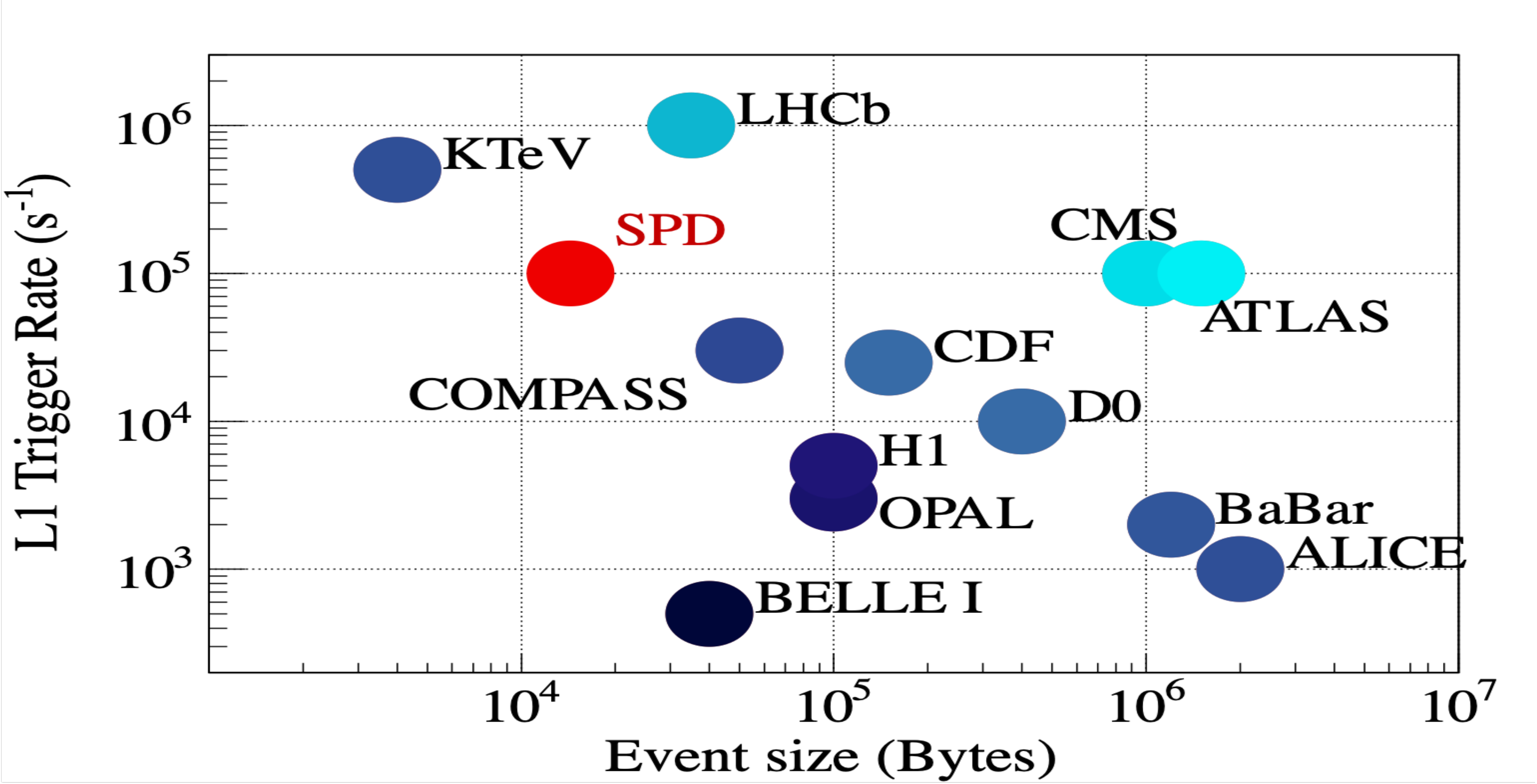
Intel(R) Xeon(R) Gold 6148 CPU @ 2.40GHz + GPU Nvidia V100 32Gb

Online Filter operation





After the online filter

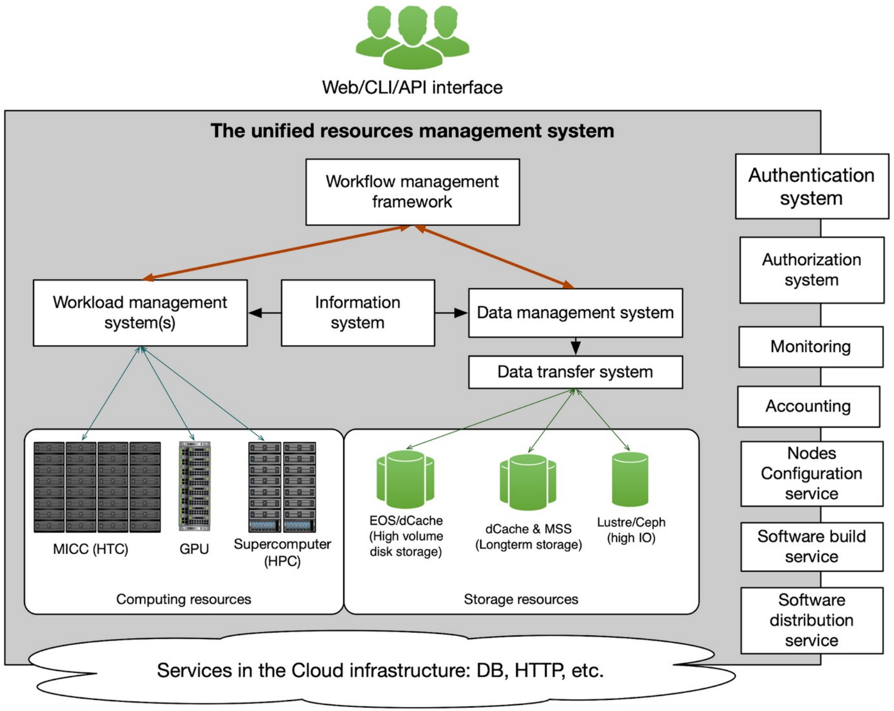


Expected data volumes

- **Preparation for the experiment.**
  - Monte Carlo simulation from 2024 to 2028 will provide 2 PB per year.
  - Total per stage: 10 PB.
- **Stage I: running at low luminosity of the NICA collider.**
  - Monte Carlo simulation and real data taking from 2028 to 2030 will provide 4 PB per year. Reprocessing: 2 PB per year.
  - Total per stage: 18 PB.
- **Upgrade of the setup for operation at high luminosity.**
  - Monte Carlo simulation from 2031 to 2032 will provide 2 PB per year. Reprocessing: 2 PB per year.
  - Total per stage: 8 PB.
- **Stage II: running at maximum design luminosity of the NICA collider.**
  - Monte Carlo simulation and real data taking from 2033 to 2036 will provide 20 PB per year. Reprocessing: 10 PB per year.
  - Total per stage: 120 PB.

Total for all stages: 156 PB.

Distributed computing system



All basic components are already available from LHC experiments:

- *Workload management: PANDA*
- *Data management: RUCIO and FTS*
- *Software distribution: CVMFS*

Databases

- Several databases are needed:
  - Data taking conditions and calibration data
  - Physics metadata (including MC input configurations)
  - EventIndex: catalog of physics events, both collected from the detector and simulated
  - Hardware database and mapping
  - Monitoring and logging
  - Collaboration management data.
- Designed as a complex information system that includes data collection and transfer tools, APIs for access from the production and analysis software, client software, supervisors, and monitoring.
- A PostgreSQL RDBMS is considered as a database platform

Offline Software

- A Gaudi-based software framework is being developed:
  - Geometry description: GeoModel
  - Generators: Pythia8, FTF, UrQMD + capability to add more generators
  - Simulation: Geant4
  - Reconstruction: ACTS or GenFit for tracking, Kfparticle for vertex reconstruction, own algorithms for other subsystems
- Current simulation and performance studies are done by another framework SpdRoot, based on FairRoot software

Required SPD computing resources

	CPU [cores]	Disk [PB]	Tape [PB]
Online filter (Stage I)	3000	2	none
Offline computing (Stage I)	20000	5	6 per year
Cost estimate (Stage I) [k$]	5750	616	42 per year
Online filter (Stage II)	6000	4	none
Offline computing (Stage II)	60000	15	30 per year
Cost estimate (Stage II) [k$]	16500	1672	210 per year

Total for Stage I: 6.4 M$

Total for Stage II: 18.2 M$ + 0.2 M$ per year

Tier-0 at JINR will provide about 25-30% of all computing resources
Tier-1 at Gatchina is going to contribute about 25%
The rest should be distributed between the participating institutes