SPD
DAQ, Software and Computing

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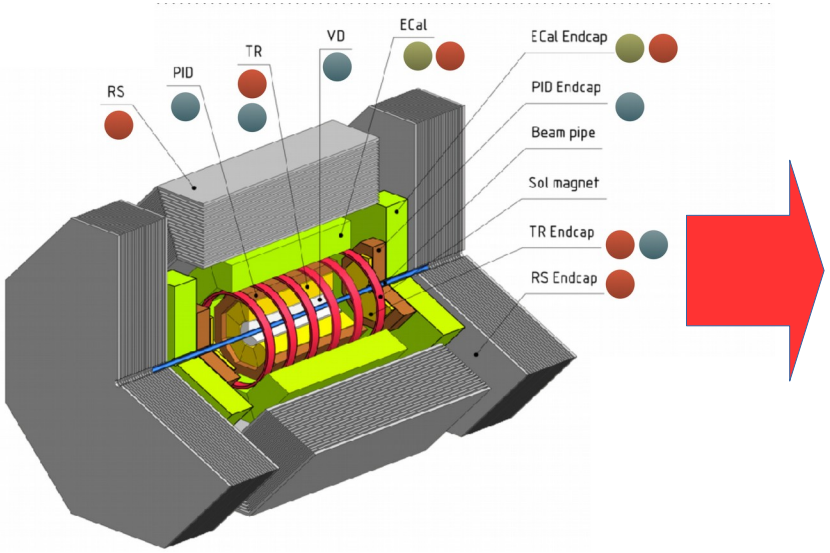
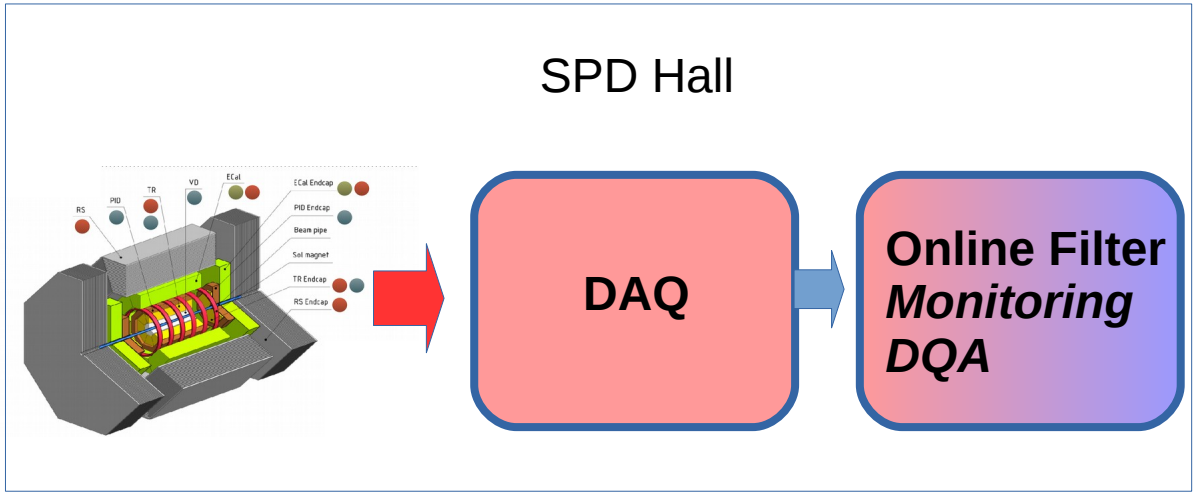
SPD as a data source

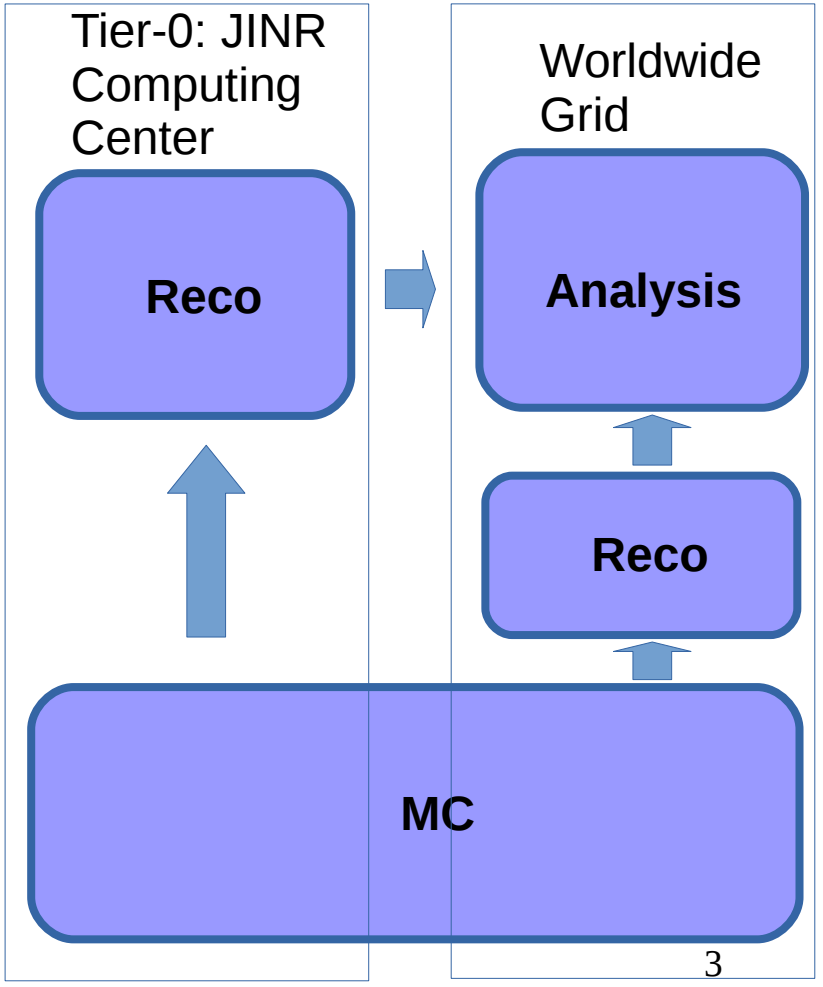


- Bunch crossing every 80 ns = crossing rate 12.5 MHz
- ~ 3 MHz event rate (at 10^{32} $cm^{-2}s^{-1}$ design luminosity) = pileups
- 20 GB/s (or 200 PB/year (raw data), $3*10^{13}$ events/year)
- Selection of physics signal requires momentum and vertex reconstruction → no simple trigger is possible

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

Data workflow





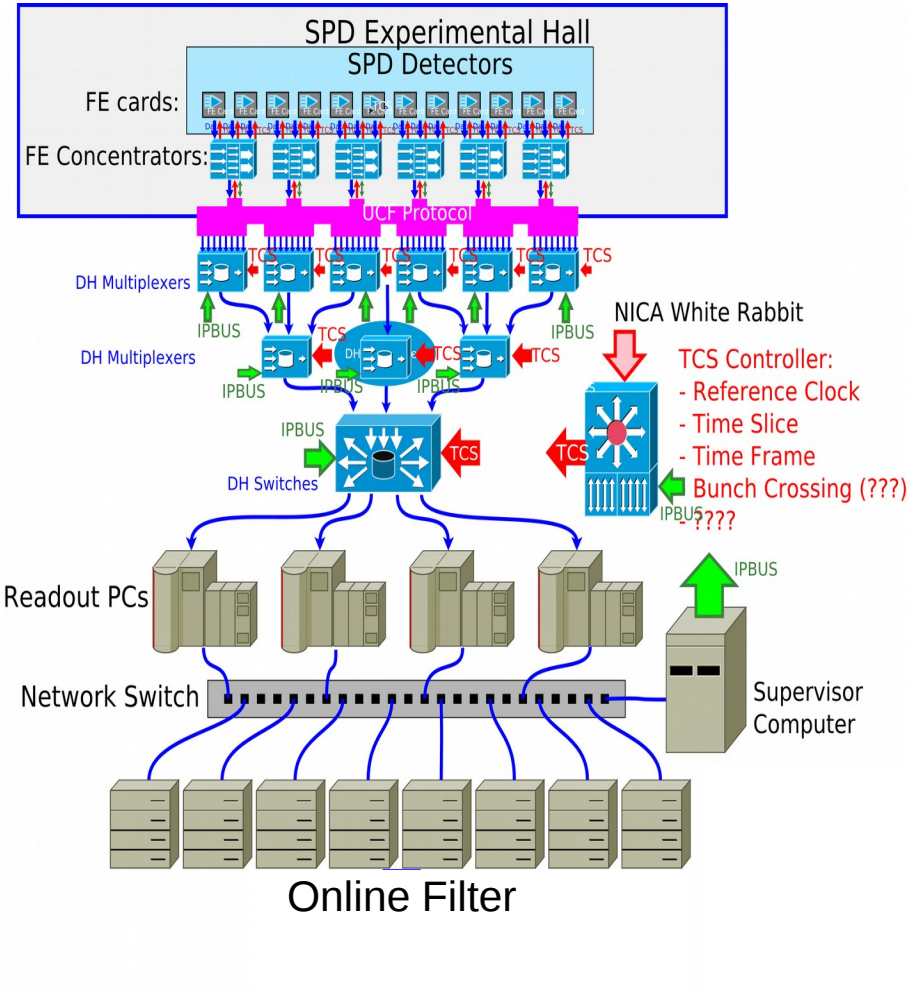
Continuous data reduction:

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

Free-running DAQ

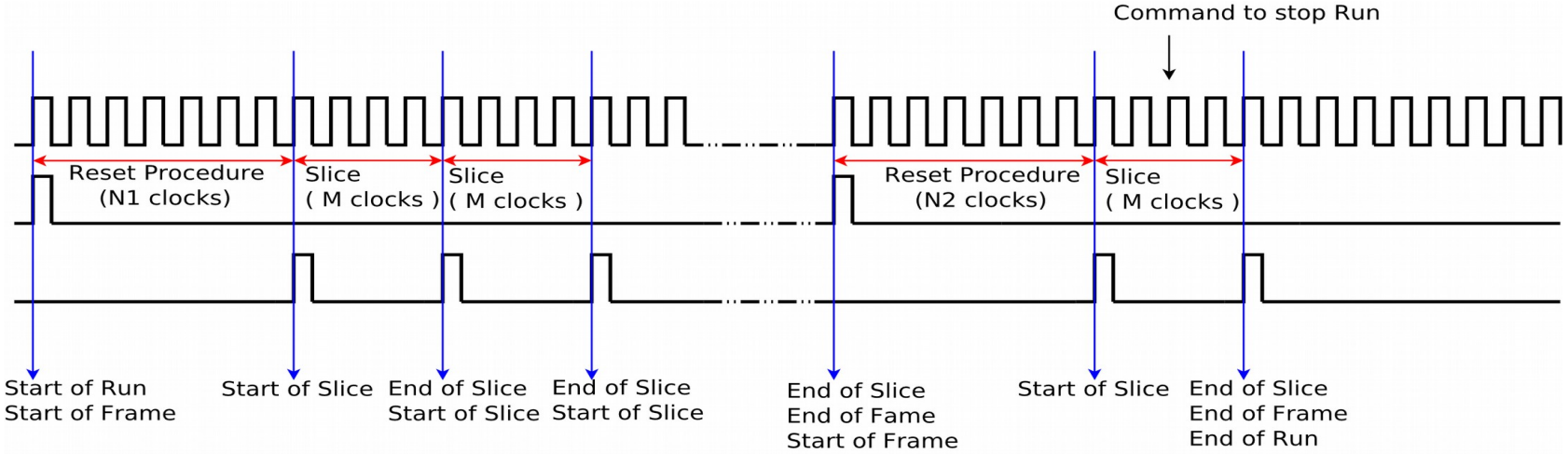
- No global trigger
- Self-triggered FEE digitizes data and sends it to DAQ
- Zero suppression
- Timestamp added
- Several FEE options are being considered, using experience of PANDA and COMPASS projects
- Data from FEE is collected and managed by FPGA-based DAQ system

FPGA-based free-running DAQ



- The concept is confirmed at Belle2 and COMPASS
- White Rabbit is used for time reference
- Identical DAQ modules (TCS, data concentrators, MUXs and switches) for all subsystems
  - only FPGA firmware is different
- Simple data treatment (e.g. noise removal) is possible

Time structure



Tclock = 8ns (125 MHz) from White Rabbit;
Reset Procedure <= 300 ms (depends on electronics);

Slice Number: 24 bits (1 us - 8.3ms)
Data Size: max 16GB (real size < 160MB (20GB/s limit));

Frame: starts by Reset procedure, width 16 bits (min: 65ms, max: 549.7s),
Data Size: max 1PB (real size < 10TB (20GB/s limit))

No classical events anymore. Event building have to unscramble events from a series of time slices.

Online Filter

High-performance heterogeneous computing cluster

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

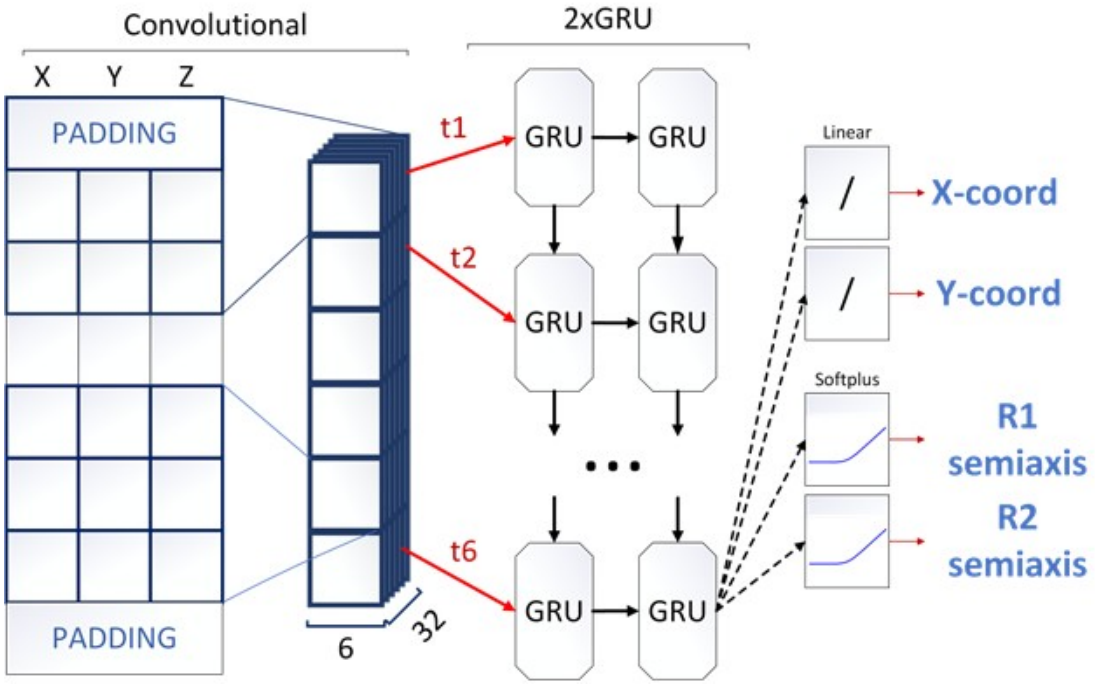
Machine learning is a key technology

- Monitoring and Data quality assessment
- Local polarimetry

Example: TrackNETv2

P.Goncharov, G. Ososkov et al.
1812.03859

Model Architecture



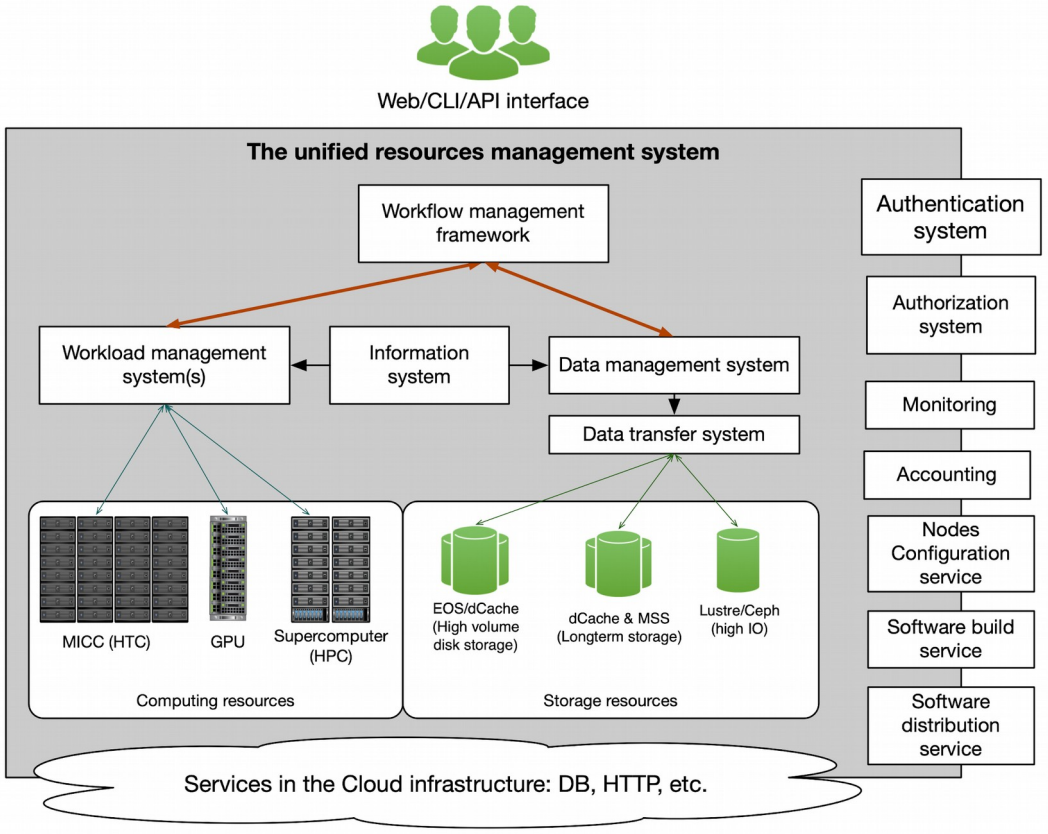
- works like learnable version of the Kalman filter
- for the starting part of a track predicts an elliptical area at the next station where to search for the continuation
- if there is not continuation candidate track is thrown away

Results (BM@N experiment, NICA):

- 12K tracks/sec on Intel Core i3-4005U @1.70 Ghz
- 96% of tracks were reconstructed without any mistake

Continuous monitoring of the NN performance is needed to keep control of systematics

Computing system

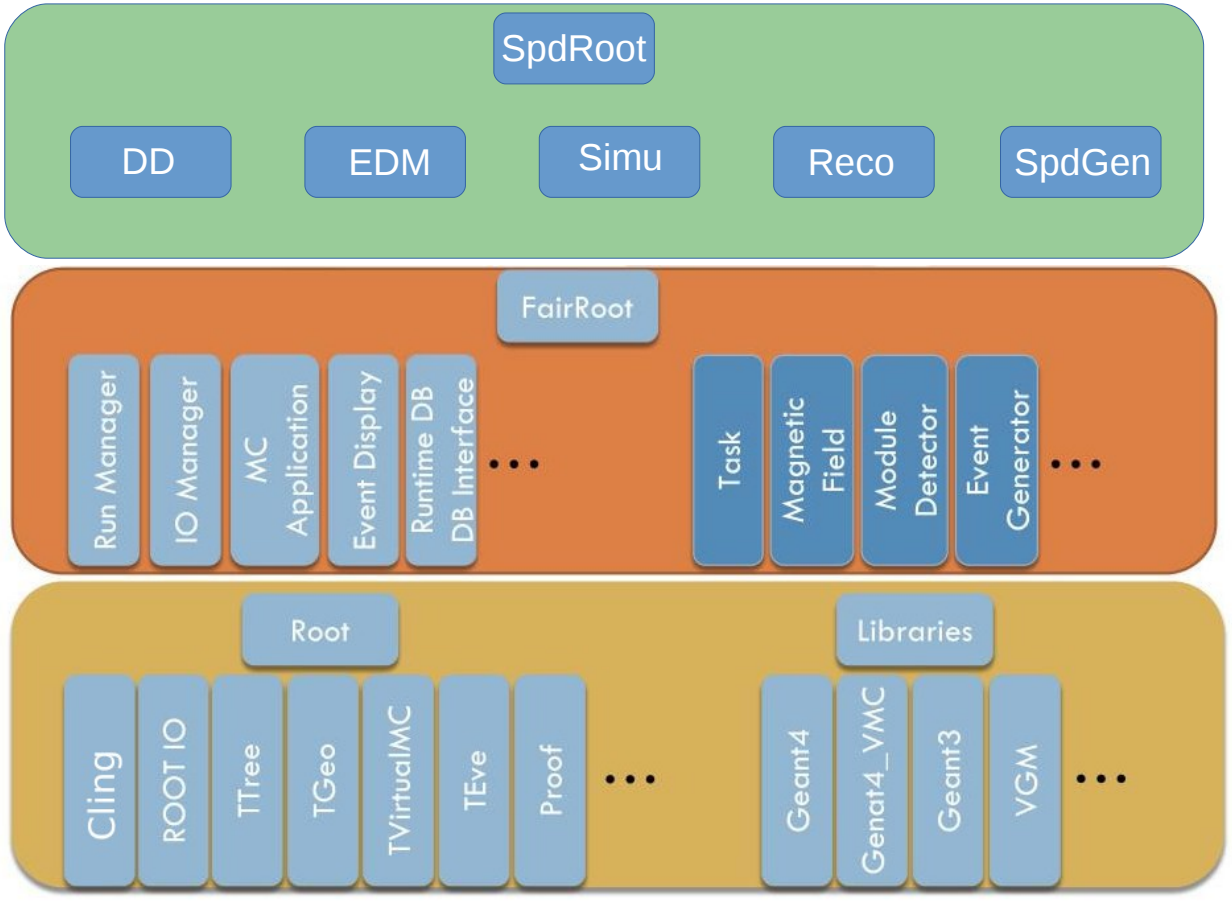


All basic components are already available from LHC experiments:

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

Adaptation to operate with the SPD event model and offline software is needed

Offline Software



- Based on FairRoot
- Current SpdRoot 4.0.0 allows simulation and detector performance study for CDR
- For the TDR preparation and the data taking more complicated and robust tool is needed (ALFA? Key4HEP?)

Development Infrastructure

- Git repository: *http://git.jinr.ru/nica/spdroot*
- Documentation Wiki: *https://git.jinr.ru/nica/spdroot/-/wikis/home*
- Software distribution: CVMFS (*Ubuntu, CentOS7, SL6*) + Docker containers

Slow control

- Standard Detector Controls
  - HV, LV
  - Gas (ST, RS)
  - Magnetic field
  - Temperature, pressure
- Safety and interlocks
- Interface to the accelerator

TANGO Controls is now considered as a solution.
Development is at an early stage yet.

Possible areas of common R&D

- **DAQ**
  - FPGA firmware development, noise suppression
  - Performance study and architecture optimization
  - Online software and monitoring
- **Online Filter**
  - Machine learning algorithms for fast reconstruction, event building and software trigger. Performance monitoring.
  - Cluster simulation and optimization
- **Computing system**
  - Orchestration of distributed computing services. SPD-specific workload and data management.
  - Deployment at remote Tiers
- **Offline Software**
  - Evaluation of a Day-1 software framework: ALFA, Key4HEP. SpdRoot migration.
  - Concurrent simulation and reconstruction algorithms
- **Slow control**