First considerations of the online filter

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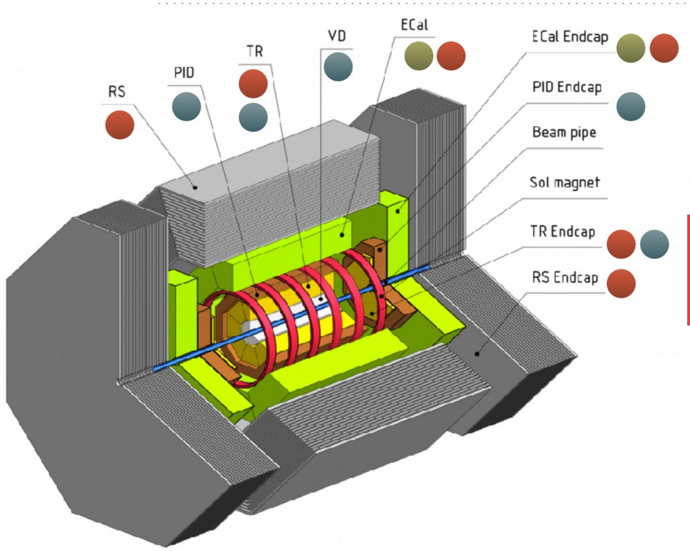
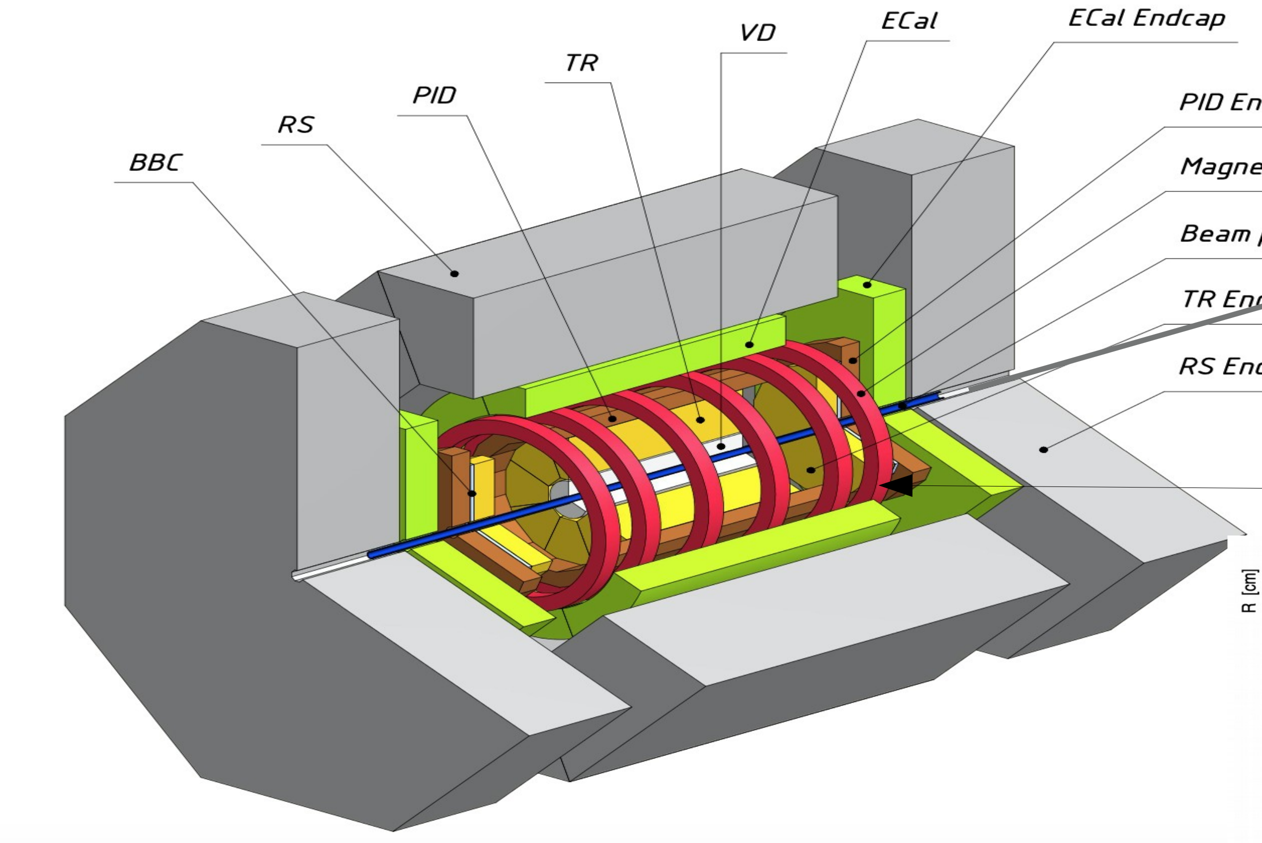
SPD as a data source

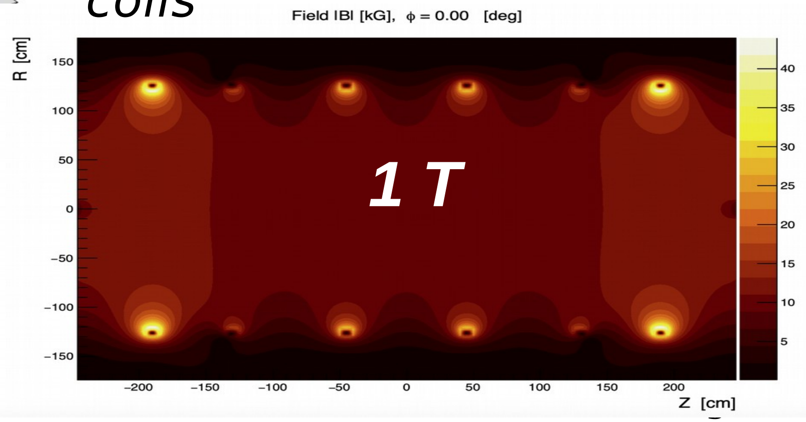


- Bunch crossing every 80 ns = crossing rate 12.5 MHz
- ~ 3 MHz event rate (at 10^{32} $cm^{-2}s^{-1}$ design luminosity) = pileups
- 20 GB/s (or 200 PB/year (raw data), $3*10^{13}$ events/year)
- Need to reduce data rate by a factor of 50-100
- Selection of physics signal requires momentum and vertex reconstruction → no simple trigger is possible

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

Detector overview



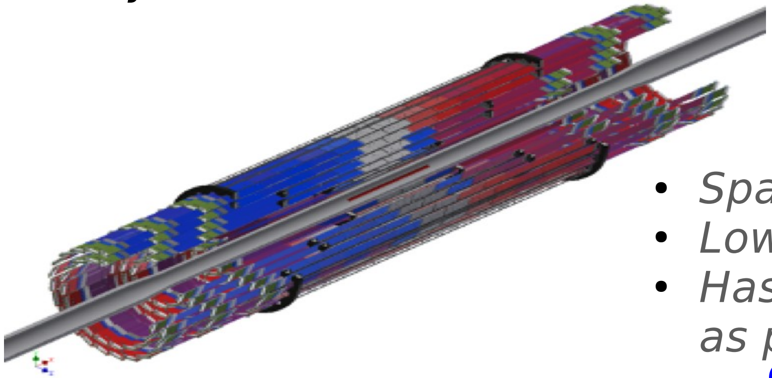


Tracking system

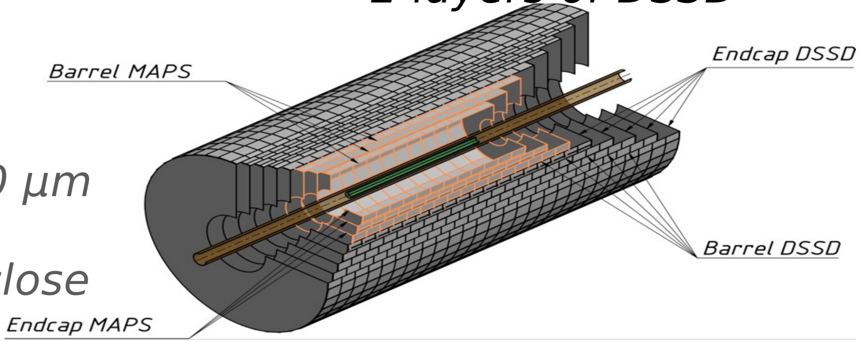
Vertex detector

two options:

5 layers of DSSD

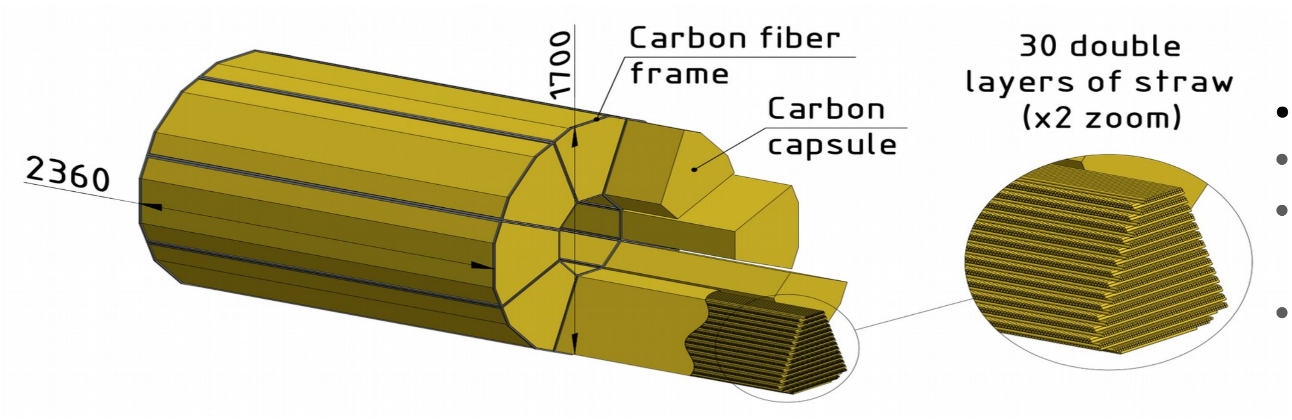


3 layers of MAPS +
2 layers of DSSD



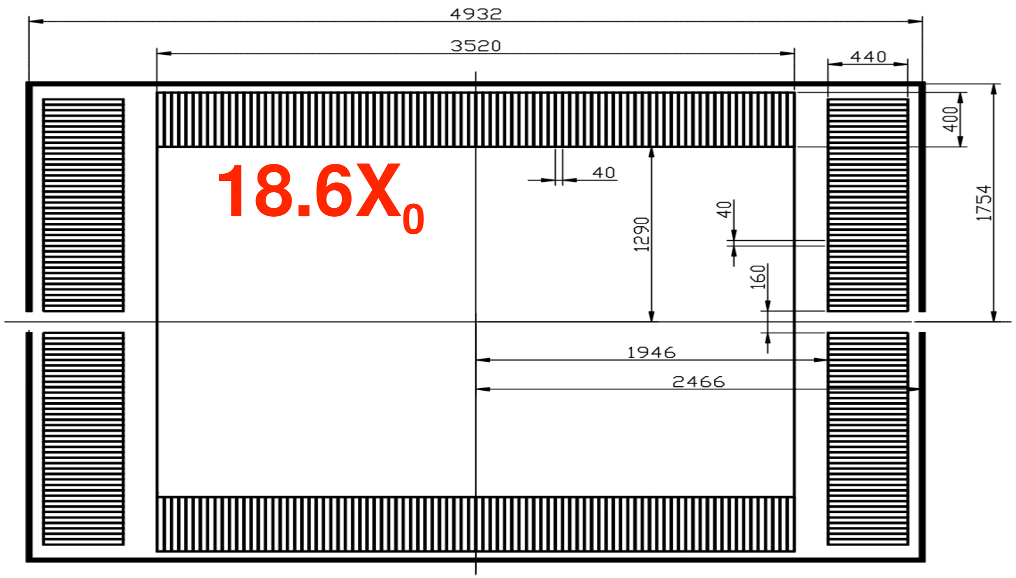
- Spatial resolution <100 μm
- Low material budget
- Has to be installed as close as possible to the IP

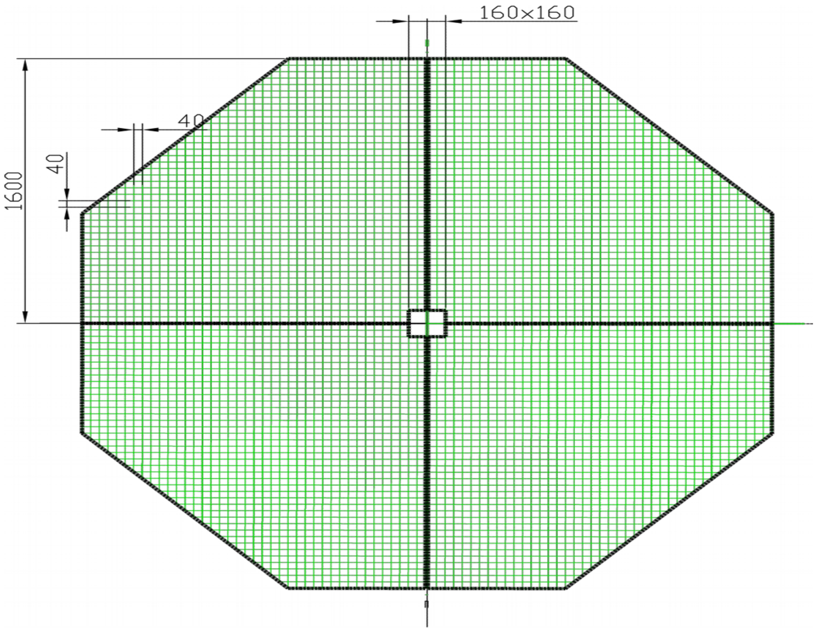
Straw tracker



- Spatial resolution ~150 μm
- Low material budget
- Operation in magnetic field of about 1 T
- dE/dx measurement

Electromagnetic calorimeter





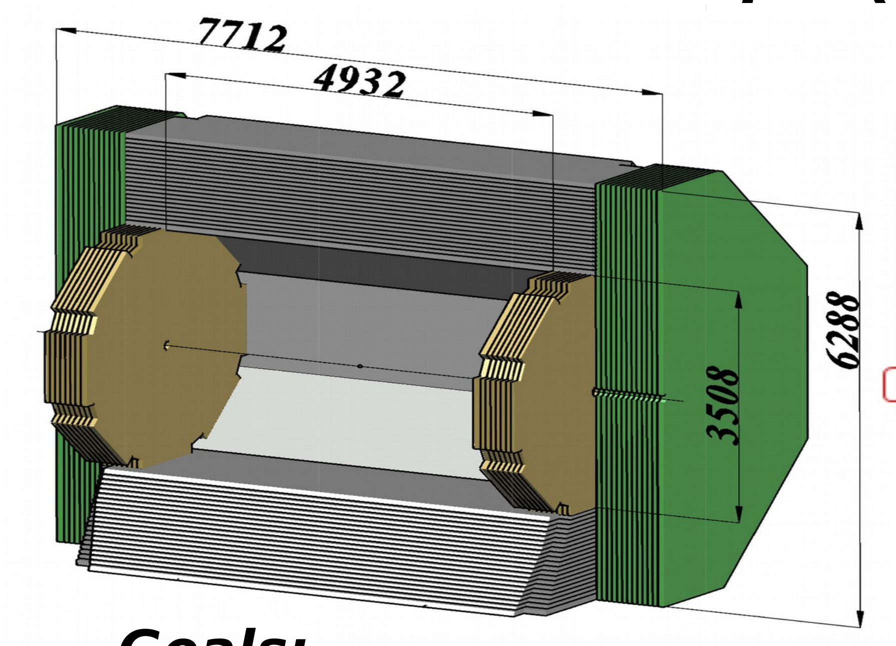
Goals:

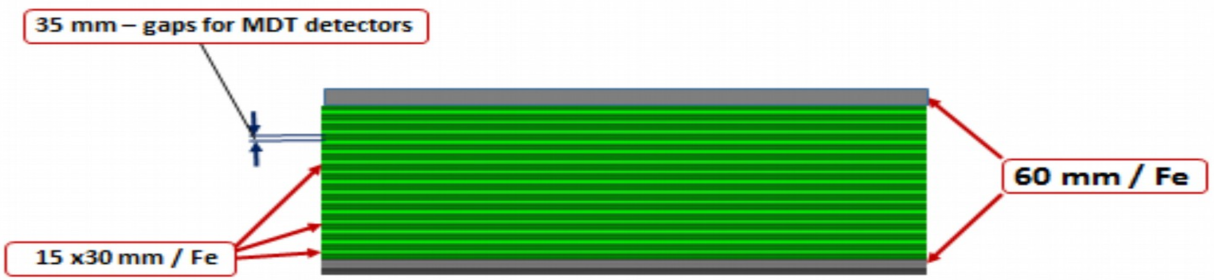
- *Detection of prompt photons, photons from π^0, η and χ_c decays*
- *Identification of electrons and positrons, participation in muon identification*

Requirements:

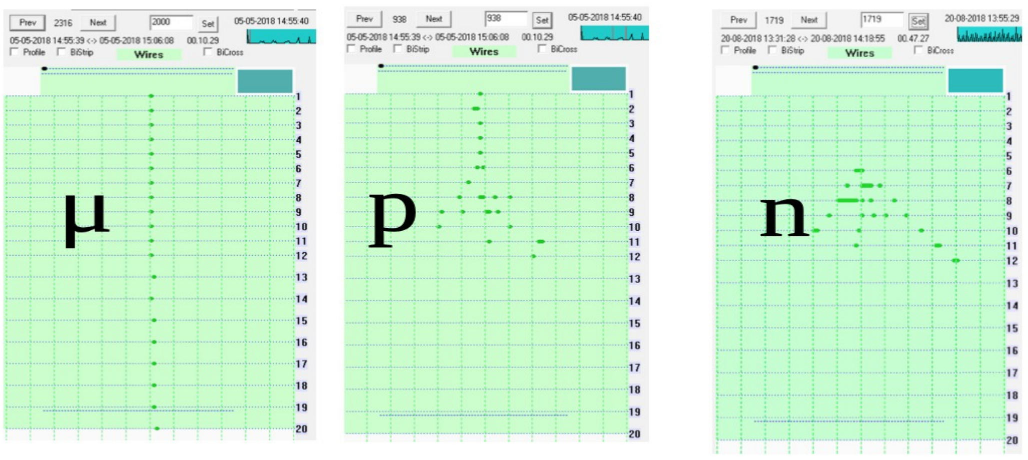
- *Granularity ~4 cm*
- *Low energy threshold (~50 MeV)*
- *Energy resolution*

Range (muon) system





Event examples at 5 GeV/c



Goals:

- *Muon identification*
- *Rough hadron calorimetry*

Requirements:

- *should have at least $4\lambda_I$*

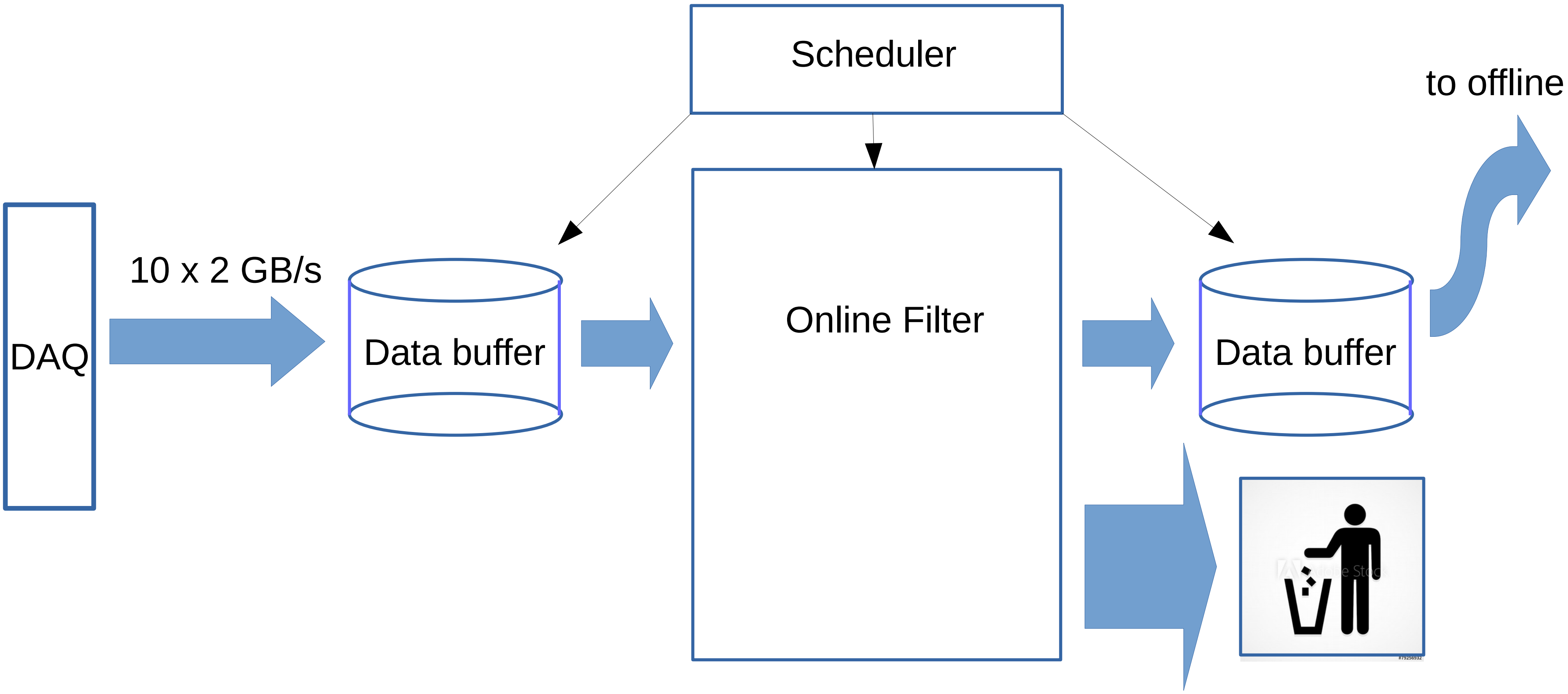
Online Filter

High-performance heterogeneous computing cluster

- Partial reconstruction
  - Fast tracking
  - Fast ECAL clustering
- Event unscrambling
- Software trigger
  - several data streams
- Monitoring and Data quality assessment
- Local polarimetry

Machine learning is a key technology

Online Filter Layout



Input data structure

No trigger = No classical events anymore

Primary data unit: **time slice** (1 us — 8.3 ms)

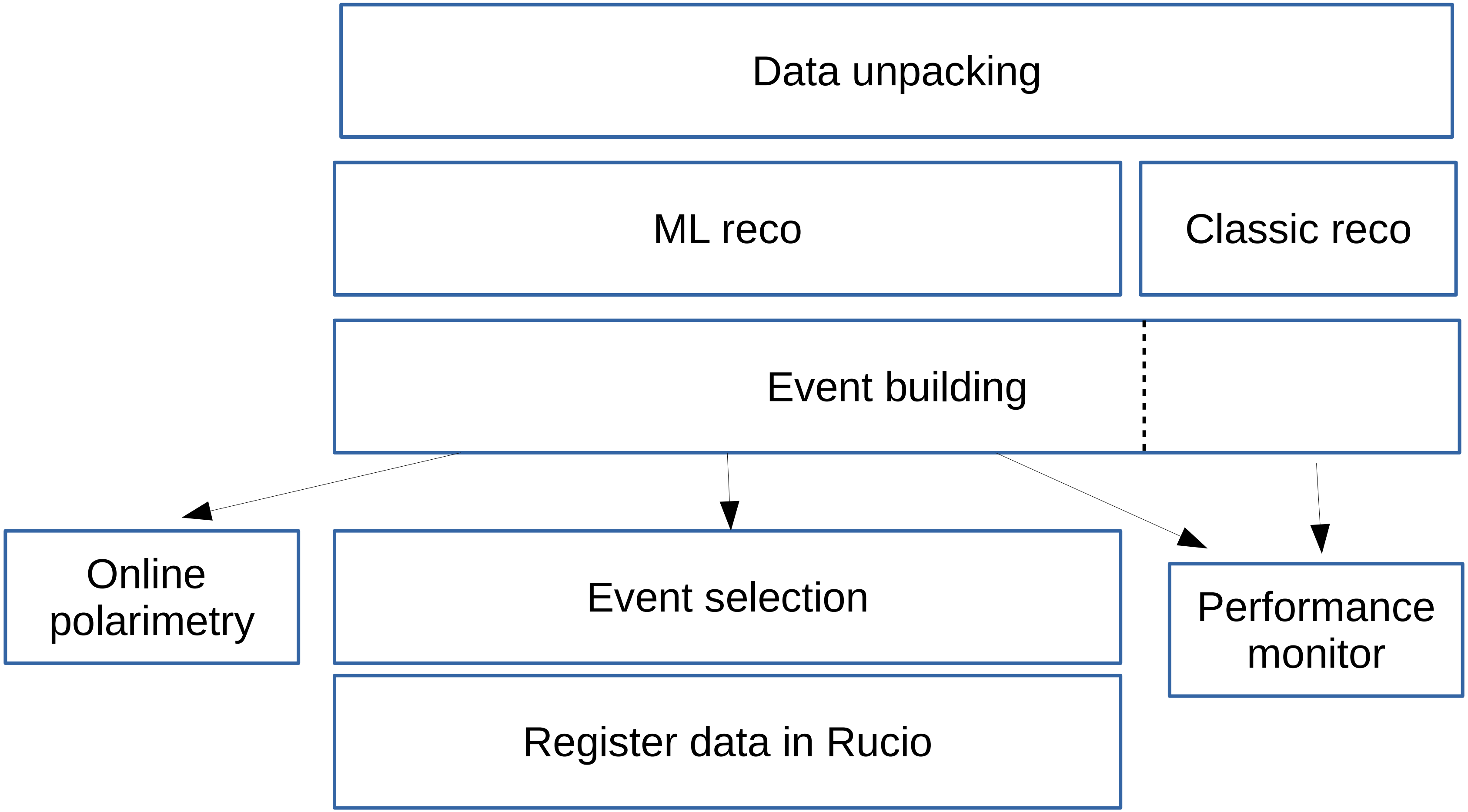
Time slices combined in **time frames** (up to 549 s, 16 GB max, < 160 MB to fullfil 20 GB/s limit)

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 1 or few collisions (events)

Event building have to unscramble events from a series of time slices.

Online filter operation



Data unpacking

- **Input:** bytestream from the DAQ
- **Output:** raw hits (channel-signal) grouped by time slices, with a timestamp

We do not need to reproduce the bytestream in the MC for future developments, but we do need time slices with raw hits (and possible pile-ups)

ML reconstruction

- Track reconstruction => Ntrk, Pt[Ntrk], Pz[Ntrk]?
- Primary vertex reconstruction => Vtxx, Vtxy, Vtxz
- ECAL => Ncluster, Energy[Ncluster], Position[Ncluster]
- RS clusters
- π^0 reconstruction in ECAL ?
- ZDC, BBC for online polarimetry ??
- PID ???

Classic reconstruction

- The same as ML reconstruction but using traditional algorithms
- Assume that calibration constants and alignment are not available
- Assume that noise level is not known *a priori*

Event building

- **Input:** several (2 or 3) consecutive time slices selected by a sliding window, with reconstructed data
- Event building is based on timing and reconstructed primary vertex position
- **Output:** event structure, consisting of a set of raw hits and reconstructed information (primary vertex, tracks, clusters)

Event selection

- We need a preliminary set of physics criteria to select interesting events, and relevant pre-scale factors for the output data streams
  - *more details from M. Zhabitsky*
- Decision of the event selector is an input for the data management system (datasets, metadata)
- Shall we consider HDF5 as an output data format?

Preliminary task list

- Data reading and unpacking — subdetectors + DAQ group
- Physics selection criteria and data streams, physics requirements, performance monitoring - Mikhail Zhabitsky
- Dedicated MC simulation (time slices with labels for ML training, noise) - Igor Denisenko?
- Framework - Anna Belova + ??
  - Scheduler, Core framework (Allen-like?), Workflows AB + Danila Oleynik + ??
  - ML implementation (C++)
  - Event selector
  - HDF5 IO
  - Interface to Rucio AB + Danila Oleynik
- ML reconstruction - group of Gennady Ososkov
  - Tracking and Primary vertex - Pavel Goncharov, Egor Schavelev, Anastasiya Nikolskaya, Ekaterina Rezvaya
  - ECAL - Beograd univ ?
  - RS
- Classic reconstruction (+GPU ?)
  - Tracking and Primary vertex
  - ECAL
  - RS
- Event building
- Local polarimetry