COMPASS Analysis Models

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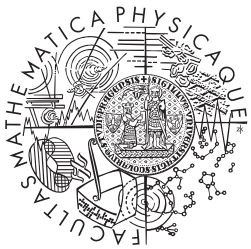

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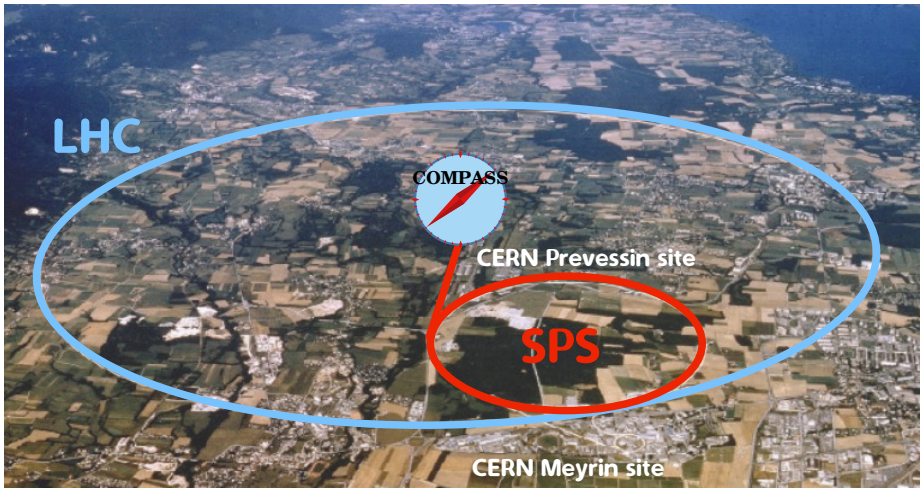
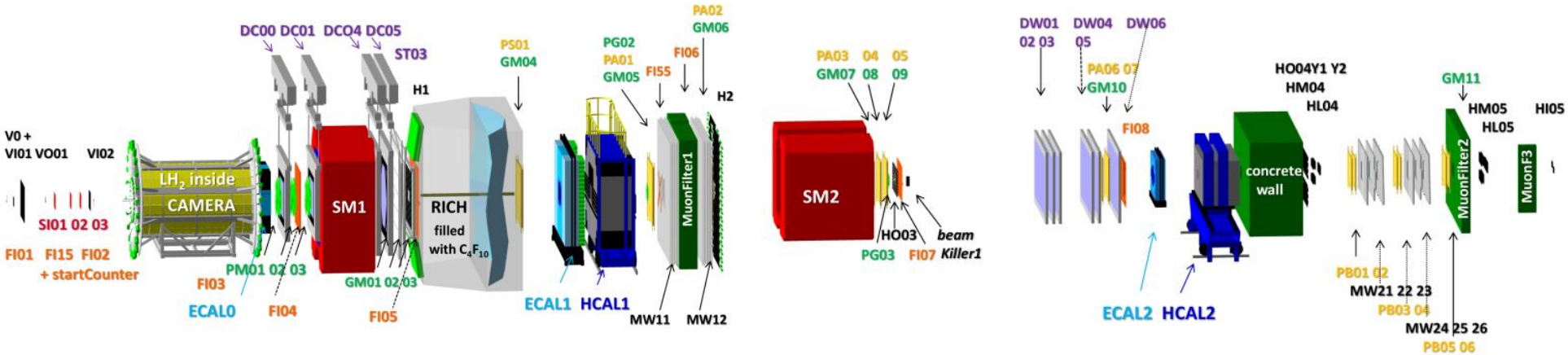
Outline

COMPASS Experiment



It is located at M2 beamline of CERN's SPS.

- 24 institutes, 13 countries, cca 250 people.
- Fixed target, multi-purpose.
- Muon or hadron beam at $\approx$ 100–200 GeV/c.
- 2-stage magnetic spectrometer.
- Calorimetry.
- Muon filters.
- Ring-imaging Cherenkov detector (RICH).



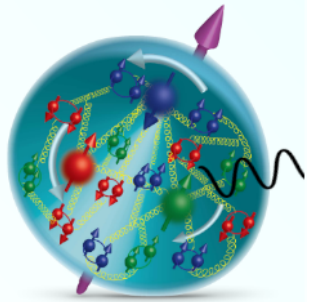
The COMPASS setup is about 60 m long.

How do quarks & gluons, and their dynamics, make up proton spin?

$$\tfrac{1}{2} = \tfrac{1}{2}\Delta\Sigma + \Delta G + L_g$$

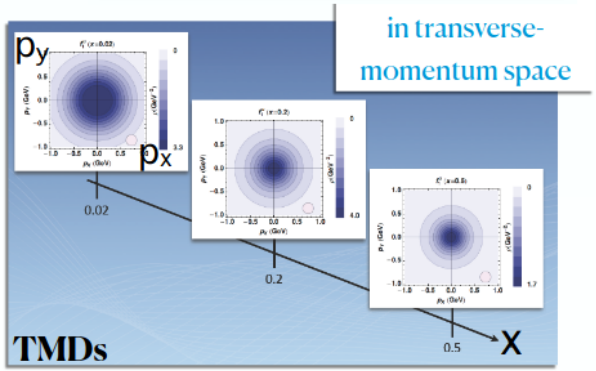
quark spin | gluon spin | orbital angular momenta of quarks and gluons

Spin puzzle



Nucleon tomography

How is the proton spin correlated with the motion of quarks/gluons?



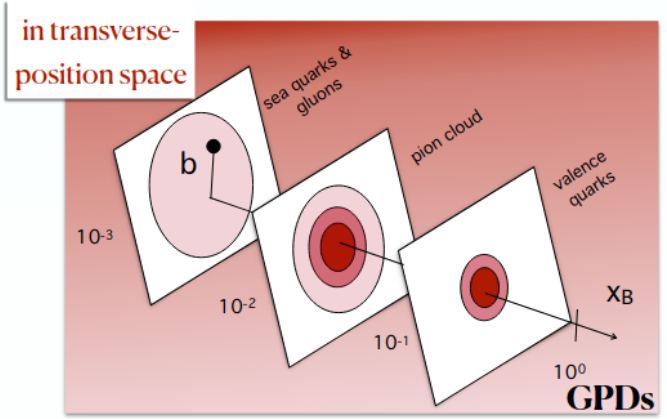
Transverse Momentum Dependent PDFs	Generalized Parton Distributions
TMDs $f(x,k_T)$	GPDs $H(x,\xi,t)$

k_T-integration

$\Delta_T=0, t=0$

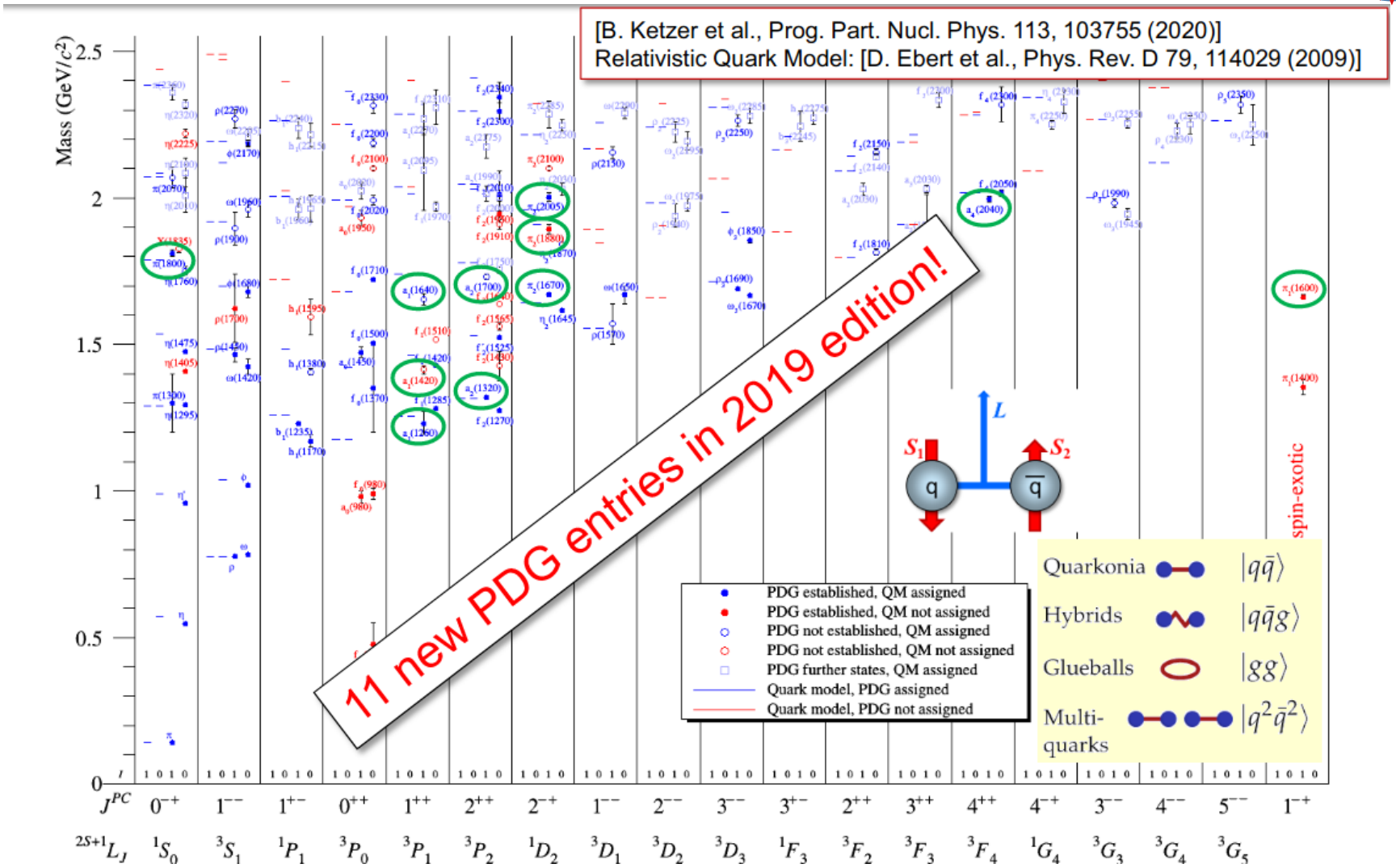
(collinear) PDFs $q(x)$, 1D

How does the proton spin influence the spatial distribution of partons?



[Courtesy of C. Riedl]

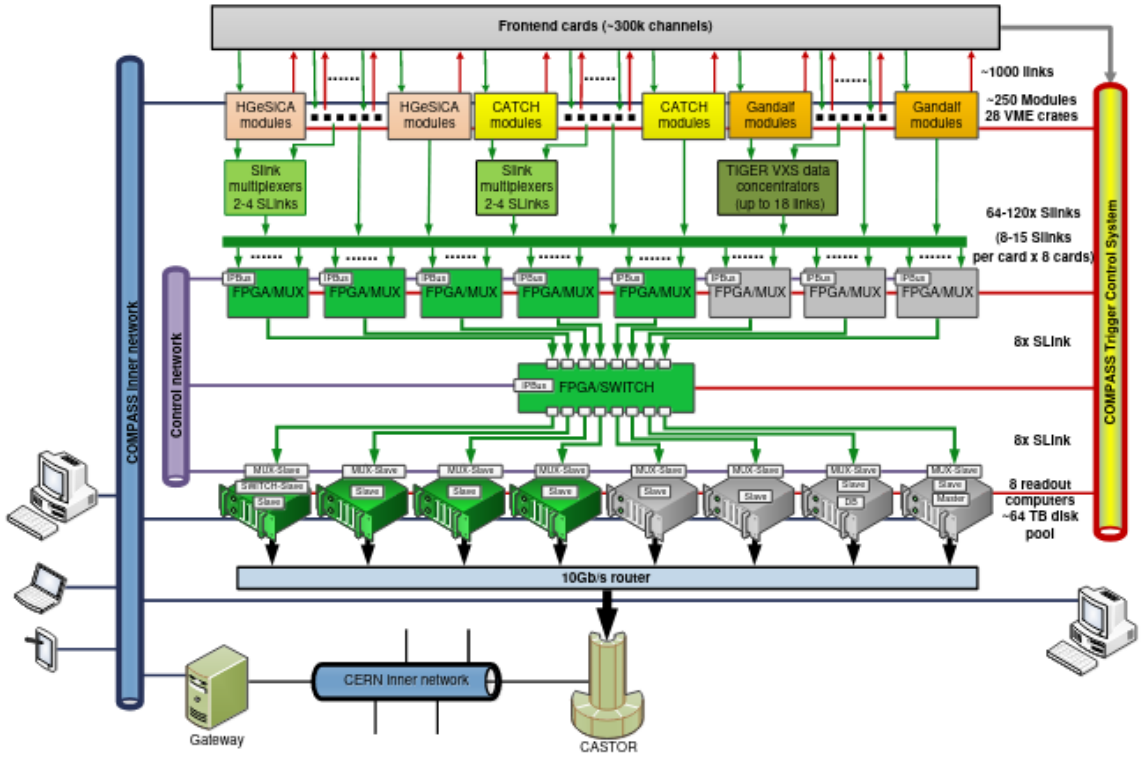
- Semi-inclusive deep-inelastic scattering: μ^+ beam and polarised targets.
- Drell–Yan: π^- beam, $p^\uparrow$, W, Al targets.
- Deep-virtual Compton scattering: $\mu^\pm$ beam and liquid H_2 target.



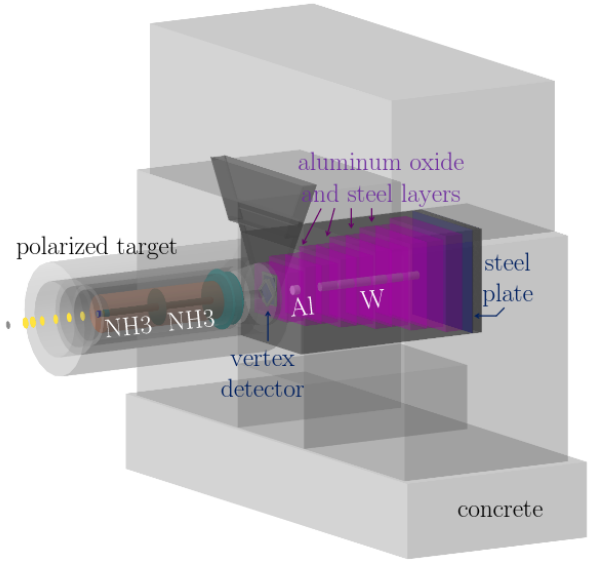
[Courtesy of B. Ketzer]

- Light hadron spectroscopy: hadron beams and nuclear targets.

Data taking

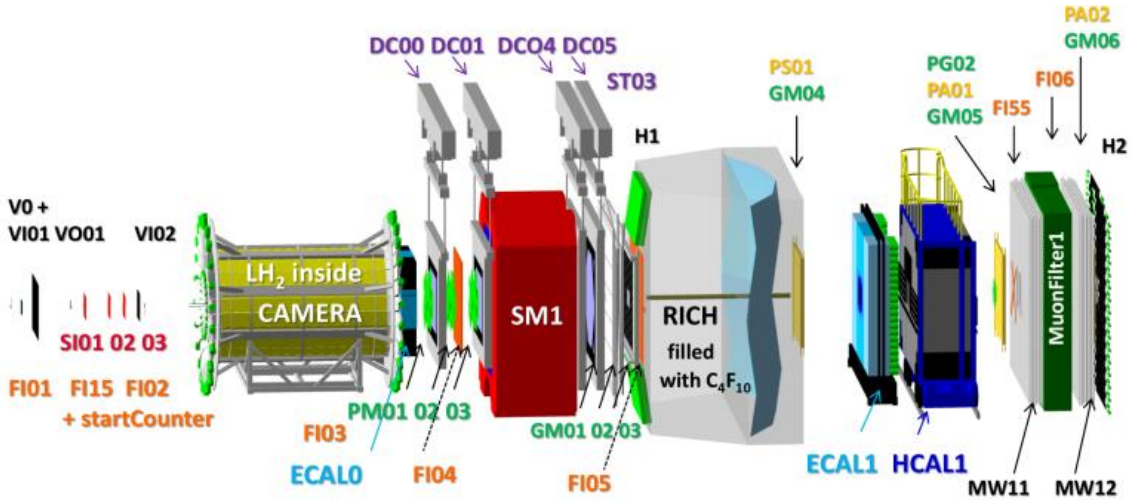


- Trigger rate up to 40 kHz, event size up to 50 kB.
- In-spill data rate 1.5 GB/s, sustained rate 500 MB/s.
- Over one year $\approx$ 600 TB, saved to CERN Tape Archive.
- Hardware-based event-building.
- Custom ‘raw’ data format.
- ROOT is used for data quality and stability monitoring (mostly histograms).



Visualisation from TGEANT

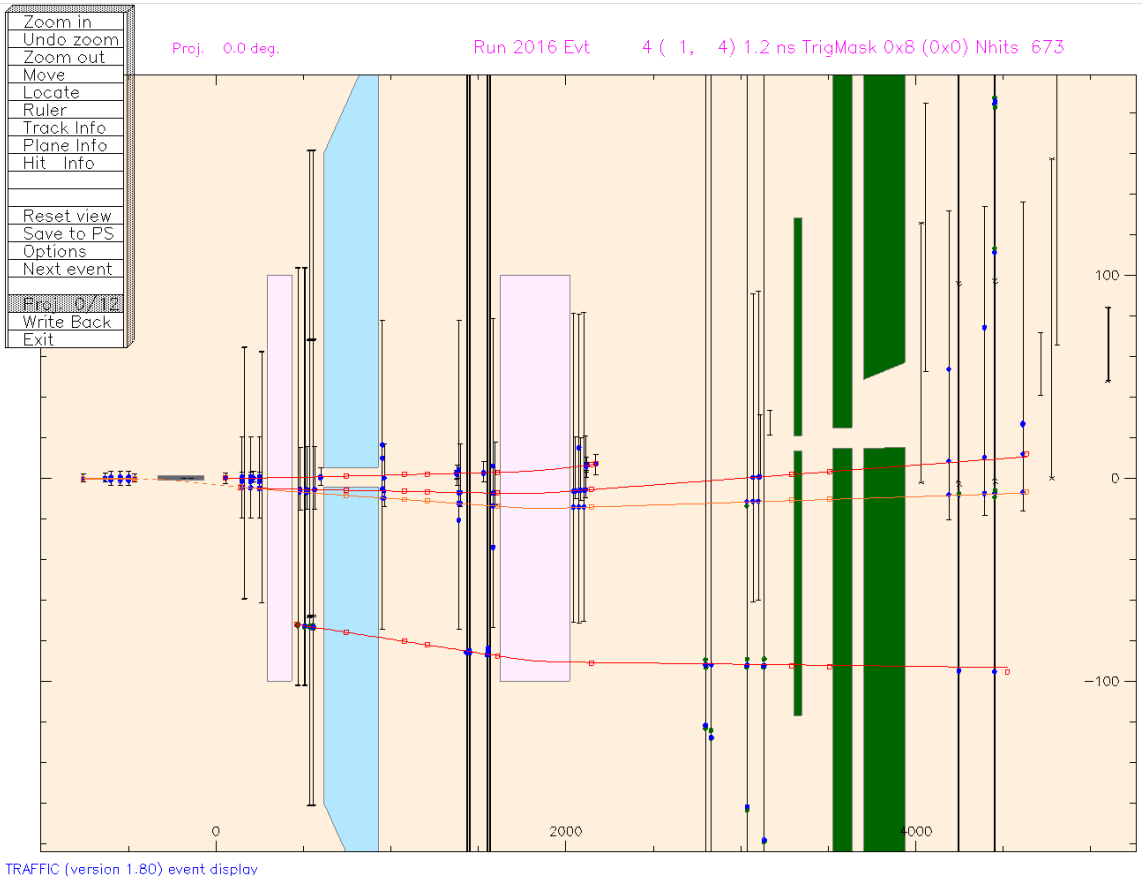
[Courtesy of T. Szameitat]



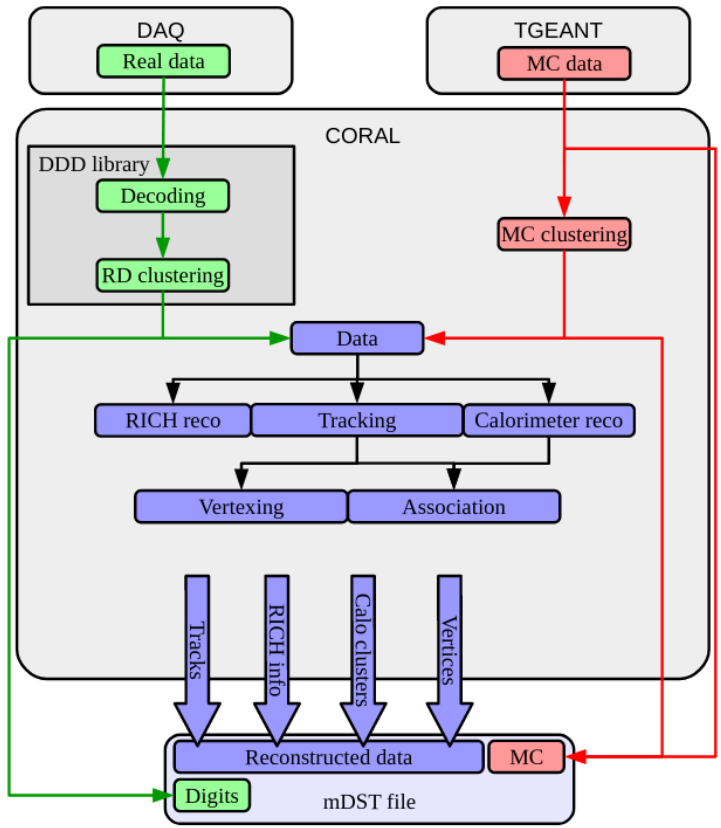
Another TGEANT visualisation.

- TGEANT software – Geant 4 based simulation of COMPASS apparatus.
- Interface to several event generators (LEPTO, Djangoh, Pythia 6, Pythia 8, HEPGEN)
- Independent from ROOT.
- The geometry can be exported to GDML, convertible later into ROOT format.

Data reconstruction



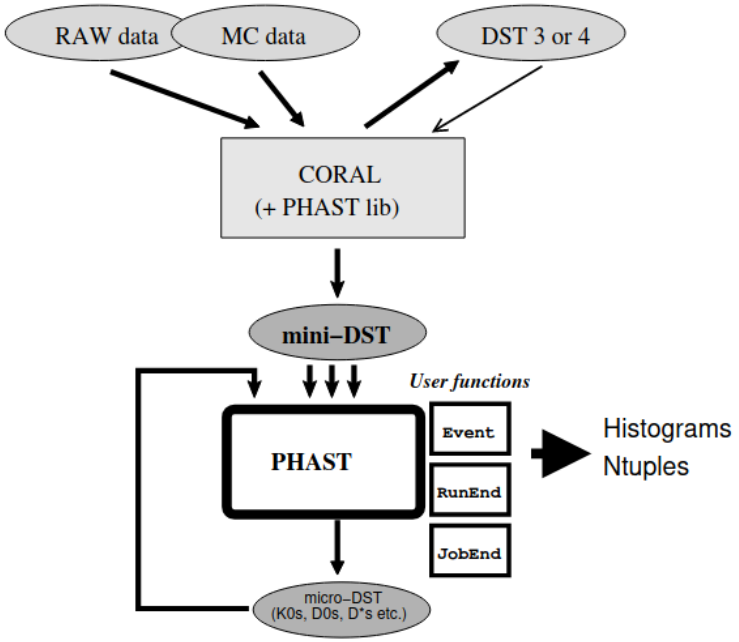
CORAL (TRAFFIC) event display.



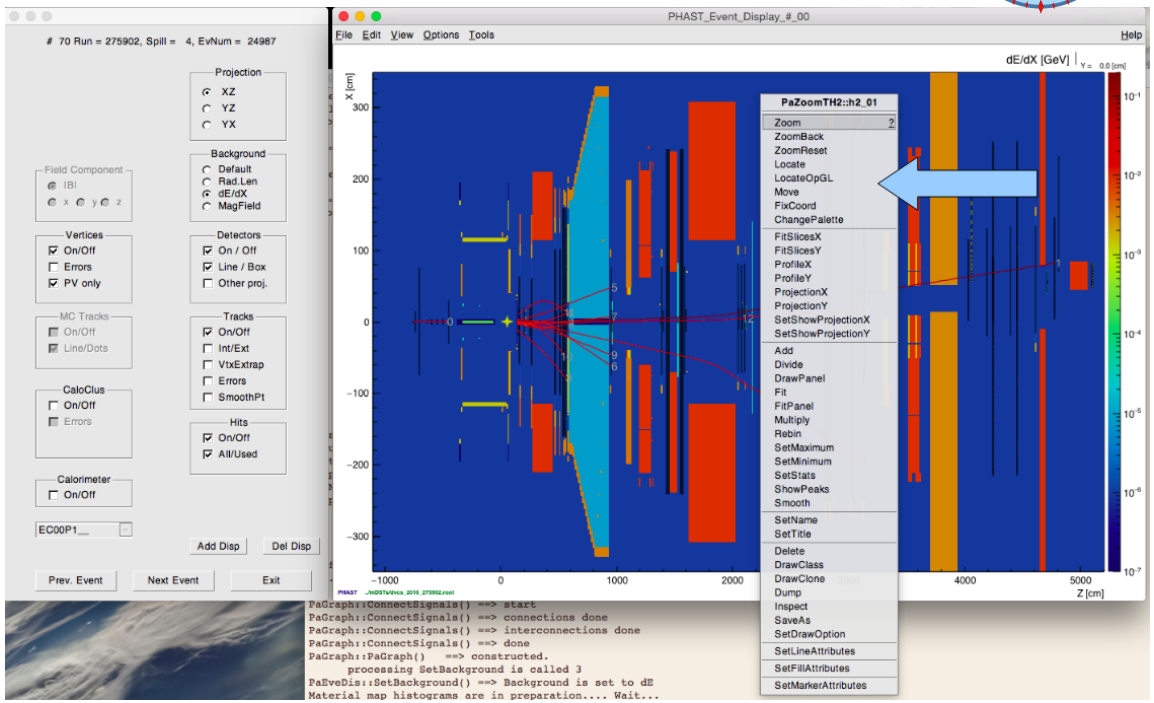
[Courtesy of C. Regali]

- COMPASS Analysis and Reconstruction – CORAL.
- Using ROOT, CLHEP and also CERNLIB. (dates back to pre-2000).
- ROOT geometry is used to estimate energy losses in materials.
- Can be used directly for analysis – save users-defined ROOT histograms and trees.
- More efficient: centralized reconstruction, results saved in ‘mDSTs’.

Phast



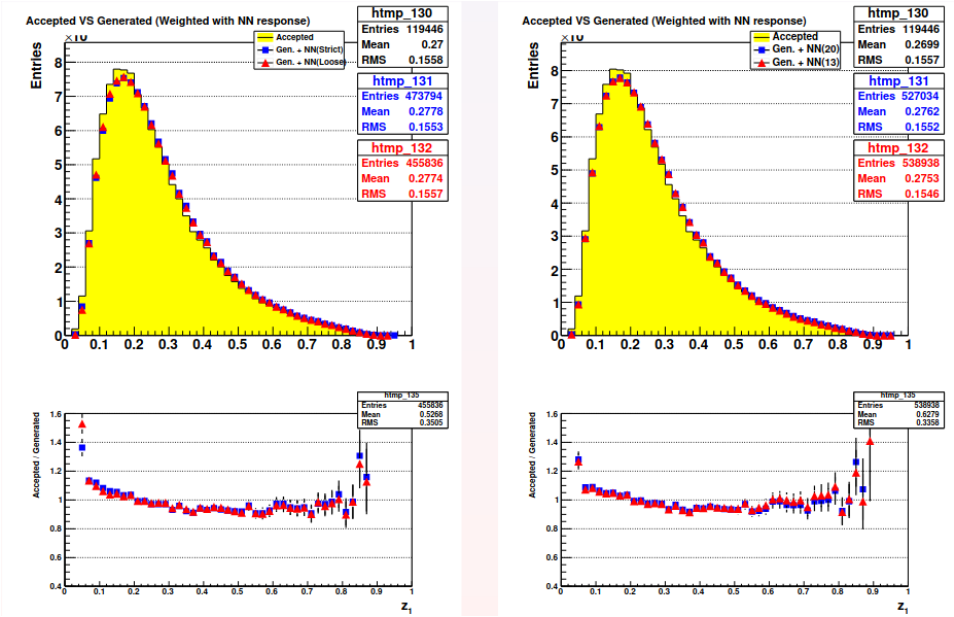
[PHAST, S. Gerassimov]

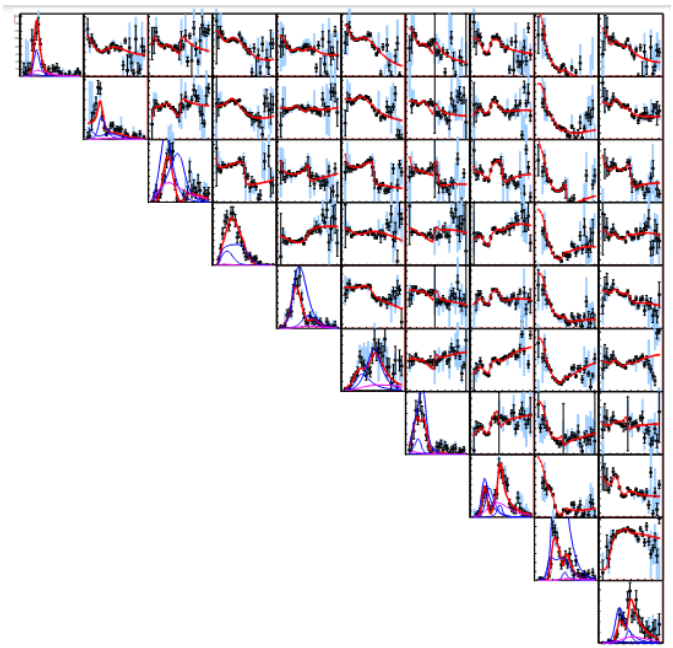


PHAST event display

- PHysics Analysis Software Tools (PHAST).
- Data structure and file format – mDST, size about 1/10 of the raw files.
  - ROOT tree containing custom C++ objects.
  - PaSetup – geometry, magnetic fields...
  - PaEvent – vertices, tracks, calo clusters (cross-referenced).
- Software for event filtration and analysis in C++
  - User event functions called for every event, user-written classes.
  - Output into ROOT trees and histograms.
- Event display.

Data analysis





- Within PHAST,
- ROOT macros,
- ROOT-linking C++ programs,
- Python, Jupyter notebooks etc.

- Mostly de-centralized, everyone chosing according to personal preference.
- Recently some efforts for archiving the code on GIT at least.

- Simple filtering, histogramming.
- Fitting (usually Minuit or Migrad) binned and UML.
- Spectroscopy – partial wave analysis [ROOTPWA]
- Neural networks – parametrization of CEDAR response, discriminating underlying physics process [arXiv]