CDF detector simulation framework

and its performance

Elena Gerchtein
Carnegie-Mellon University
(for CDF collaboration)

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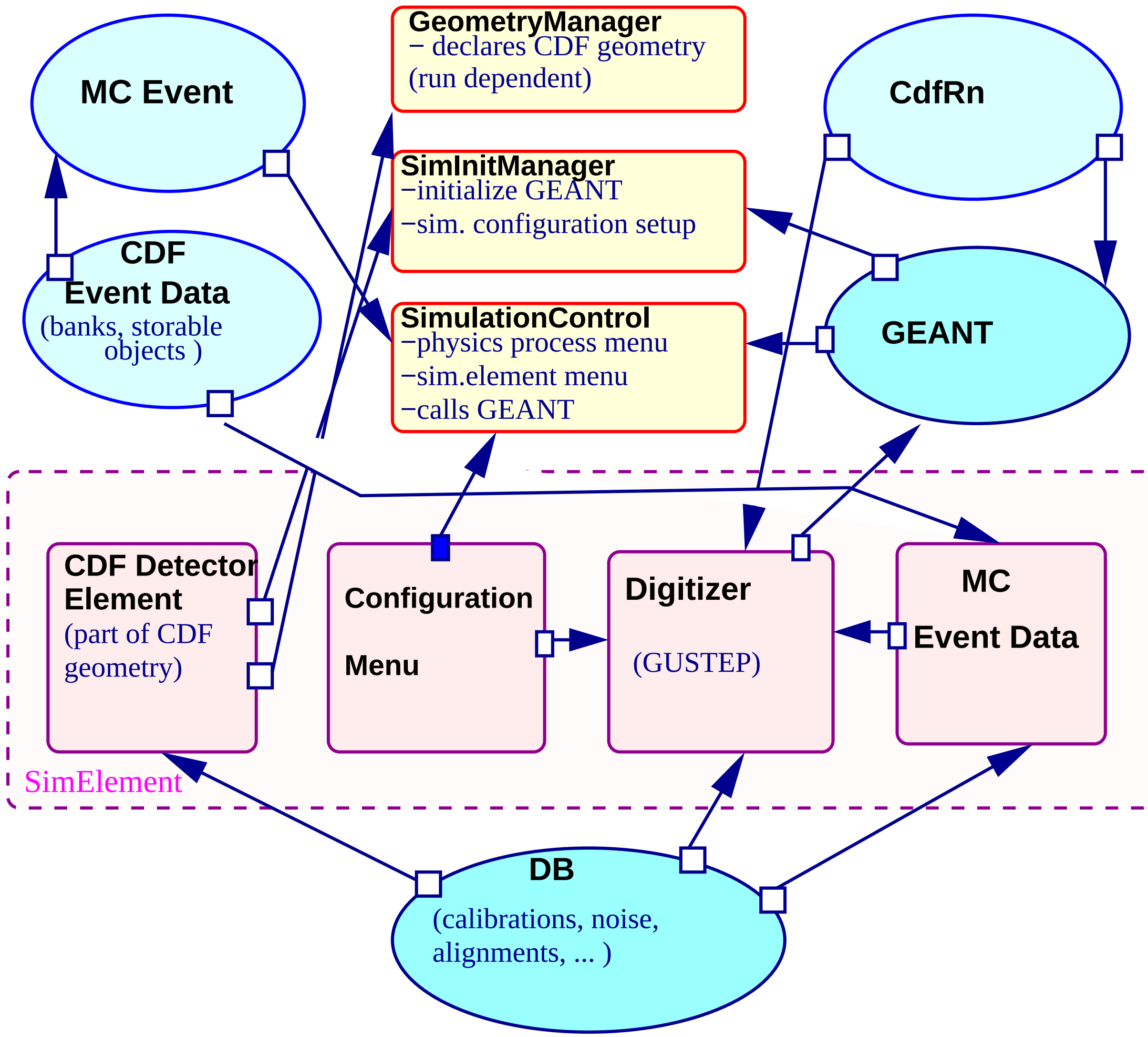
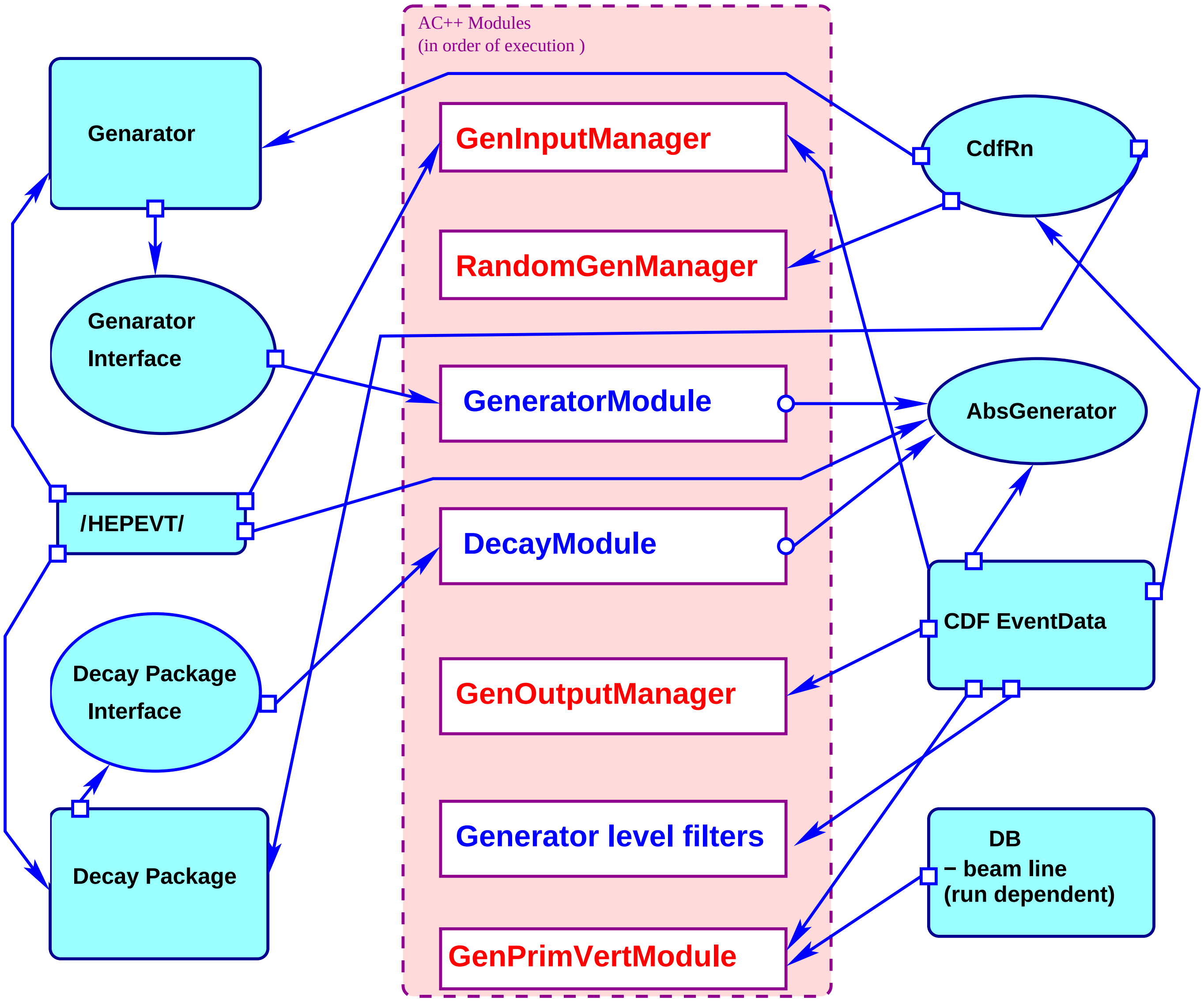
Simulation framework(SF): design and infrastructure

- design is based on a mixture of generic programming and OOP => SF is easily extensible and time efficient
- Four elements of SF
  - geometry description. CDF uses the same geometry for reconstruction and simulation (was not the case in run I)
  - configuration menu
  - digitizer
  - event data object. It is in the same format as for reconstructed data + MC truth information
- tracking of particles through matter is based on GEANT3 tracking
- SF is integrated into AC++ application framework

Simulation framework(SF): design and infrastructure (II)



Generator sequence



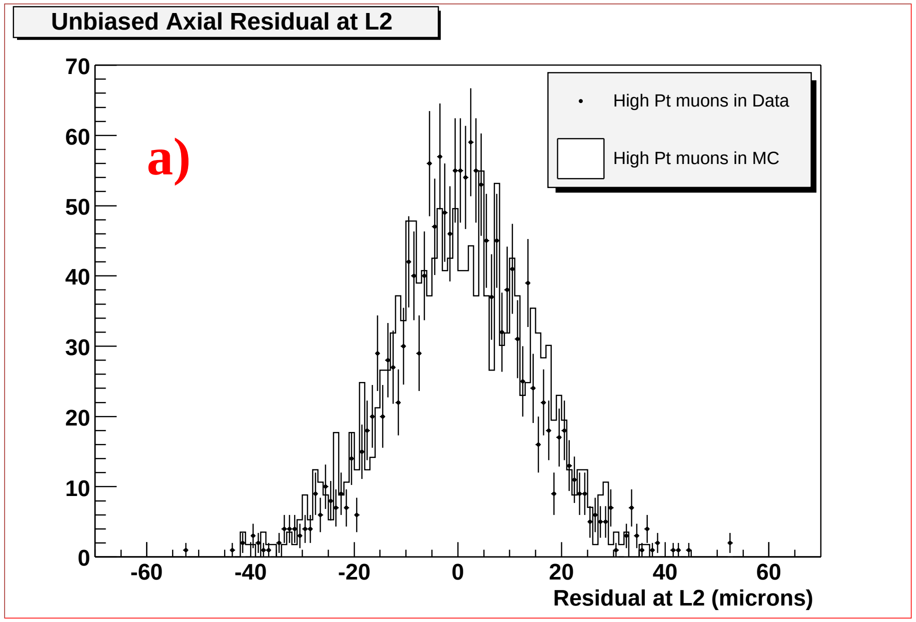
Simulation executable functionality

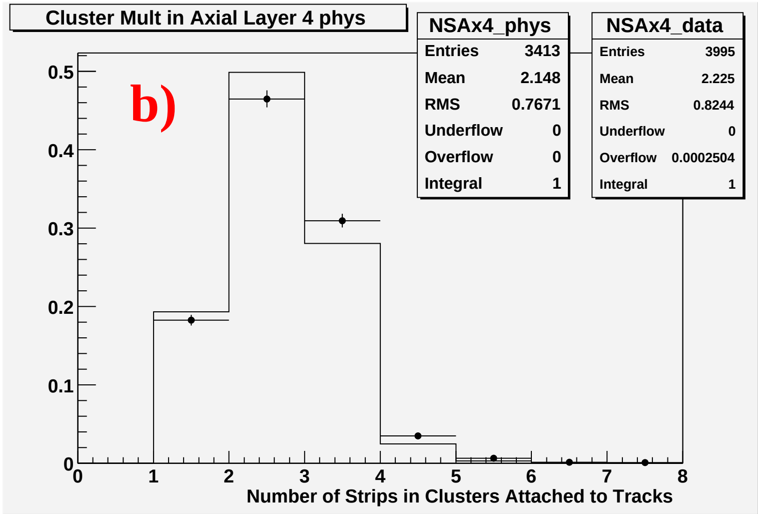
- Allows to generate physics event with different generators
  - Herwig 6.4 - PYTHIA 6.2 - ISAJET 7.51 - WGRAD - WBBGEN - GRAPPA(GRACE for ppbar) - VECBOS - BGenerator - MinBiasGenerator - Single Particle
  - Les Houches Accords - universal interface between matrix element generators and MC programs - implemented in PYTHIA and GRAPPA

- Decay packages
  - QQ 9.1 - EvtGen - Tauola
- Allows configuration of subdetectors with different geometry levels and different physics processes (depending on desired accuracy vs. time efficiency):
  - Silicon detector (SVX,ISL)
  - Central Open-cell Tracking chamber (COT)
  - Muon detectors (CMU,CMP,CMX,IMU)
  - Time-of-flight system
  - EM and HAD calorimeters
  - Cherenkov luminosity counters (CLC)
  - Very forward detectors (Miniplug,BSC,RPS)

Silicon detector simulation

- Silicon microstrip detector with double sided readout.
- Charge deposition models (CDM) (affects cluster's efficiency and intrinsic resolution)
  - Geometric
  - Parametric
  - Physical
- Complicated detailed geometry, alignment, and beam parameters are important to get impact parameter right
- a) Intrinsic resolution (layer 2, cluster width 2, calculated using unbinned likelihood fit) and b) cluster profiles (layer 4 shown) MC (single particles) compared to 15 GeV/c muons data $(50pb^{-1})$ are in good agreement

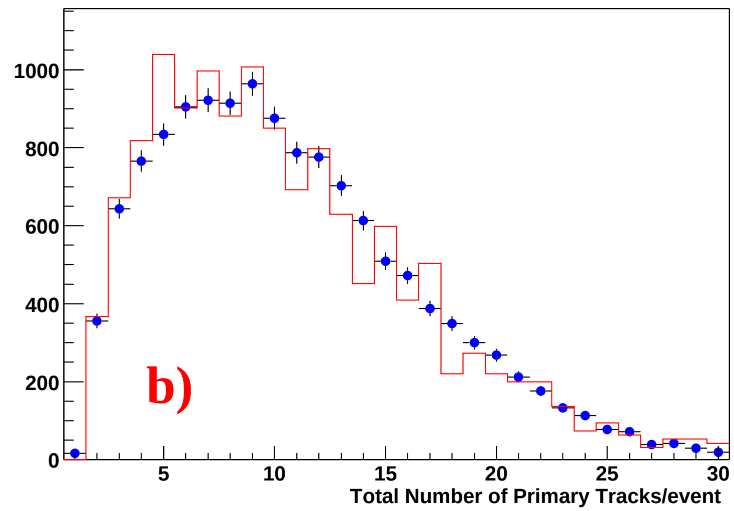


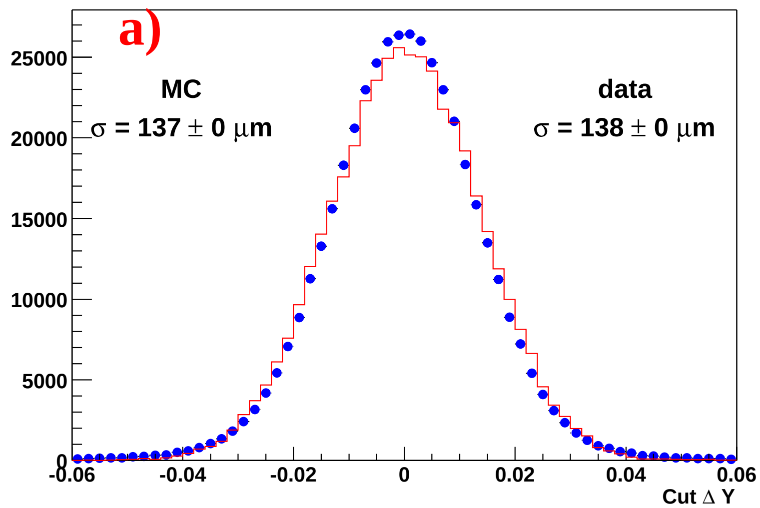


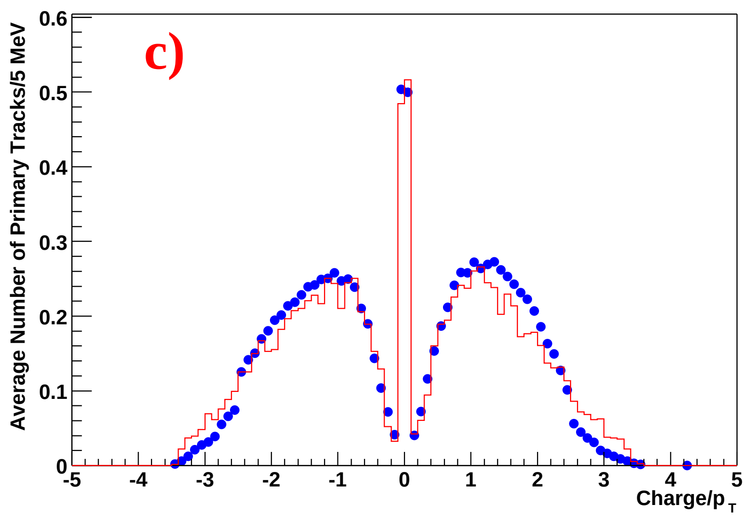
COT simulation

- COT - drift chamber
- Drift models (DM)
  - GARFIELD, Penn
- $W \rightarrow \mu\nu$ MC agrees well with data

  - MC-PYTHIA, DM GARFIELD(tuned)
  - data - high Pt muons $> 18\ GeV/c$
  - a) - Residual ΔY
  - b) - Track multiplicity of primary tracks
  - c) - Charge/Pt of primary tracks

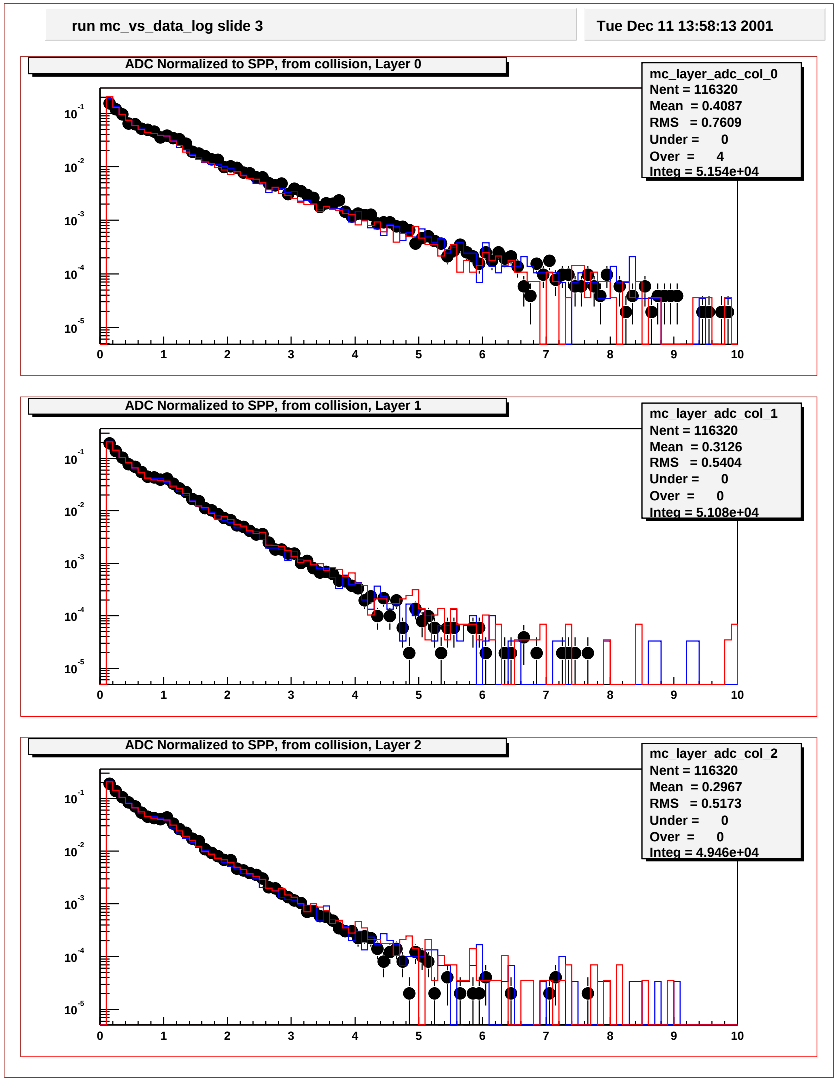






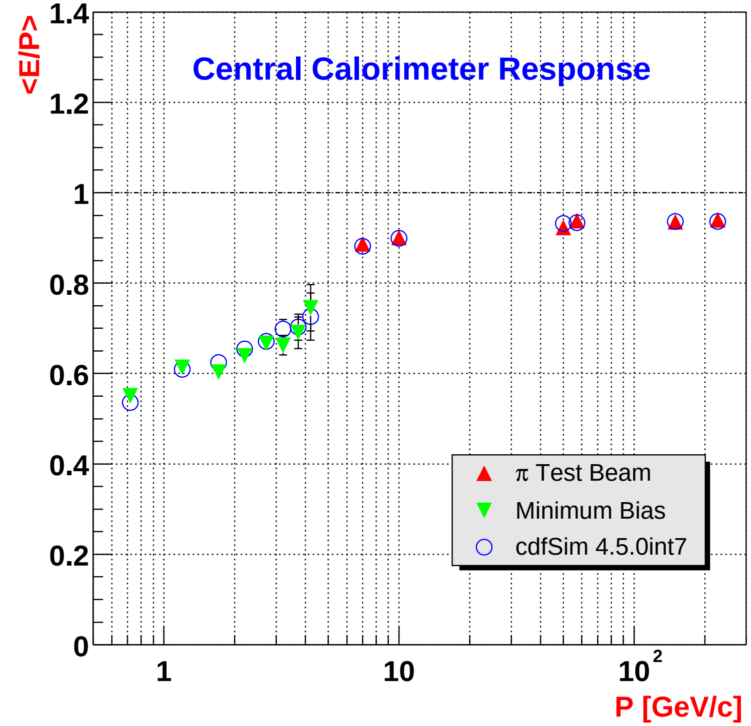
CLC simulation

- Cherenkov luminosity counters
- CLC is used to measure luminosity at CDF. CLC acceptance to ppbar inelastic process is estimated from the simulation and gives major contribution to lumi uncertainty => CLC simulation performance is critical.
- Generation and propagation of cherenkov photons is simulated by GEANT. Geometry in front and around CLC is described with high detail level.
- MC and data are in good agreement
  - plot - amplitude distributions in CLC counters (3 layers); dots - MC; red and blue - data (west and east sides)
- Uncertainty due to CLC simulation in the luminosity measurement is less then 4%



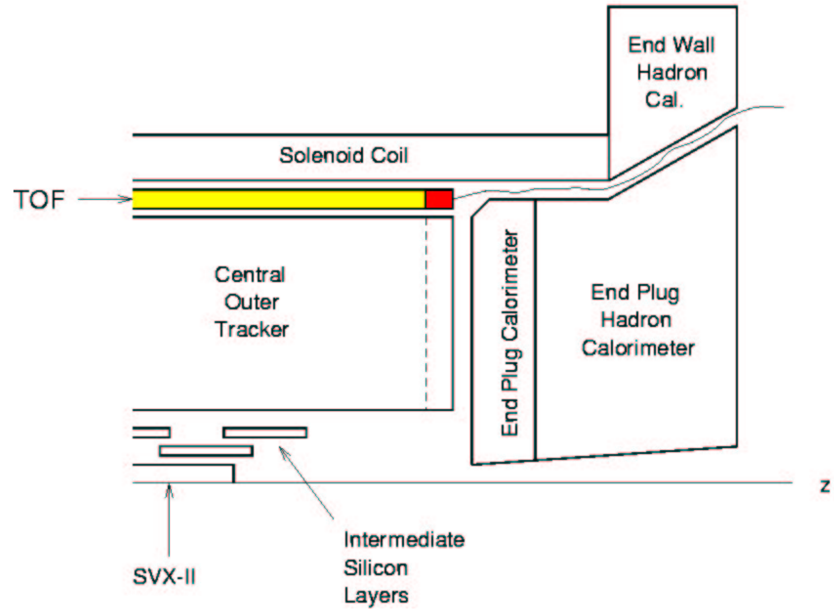
Calorimeter simulation

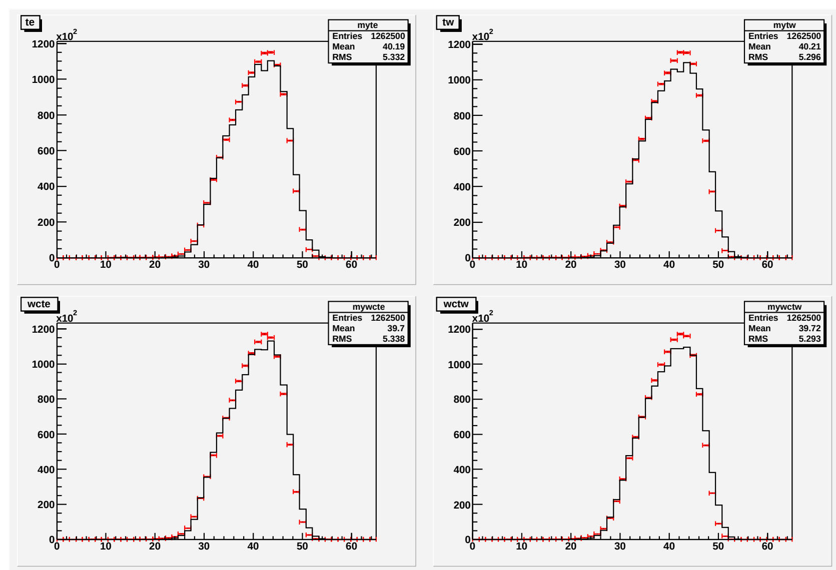
- **Parameterized shower simulation (GFLASH) tuned to data.**
- **EM - scale and resolution are checked using E/p**
- **HAD - testbeam data are used to tune shower shape**
  - **high Pt tuning - high Pt pions (central: 7-227 GeV testbeam (mainly 57 GeV), plug: testbeam 8-227 GeV)**
  - **low Pt tuning - low Pt isolated tracks (min.bias data)**
  - **for WHA: no testbeam data => set E scale of WHA to CHA**
- **Plot shows central calorimeter response MC (open circle) compared to data (test beam and min.bias) - achived exellent calorimeter response**



TOF simulation

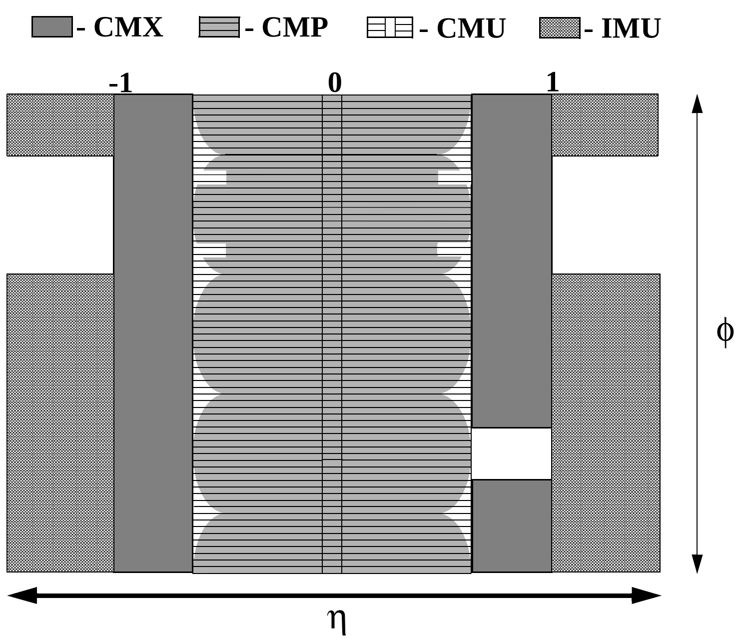
- Time-of-flight
- Figure shows a comparison of measured Tof distributions between MC and data events.
  - data - store 832, tracks which hits single bar are selected
  - MC - BB-bar events generated with PYTHIA
  - cross with bar - data; hist. - MC; upper and lower plots are comparisons of time distribution for the east and west channels before and after the time-walk corrections.
- Data and MC agrees reasonably.

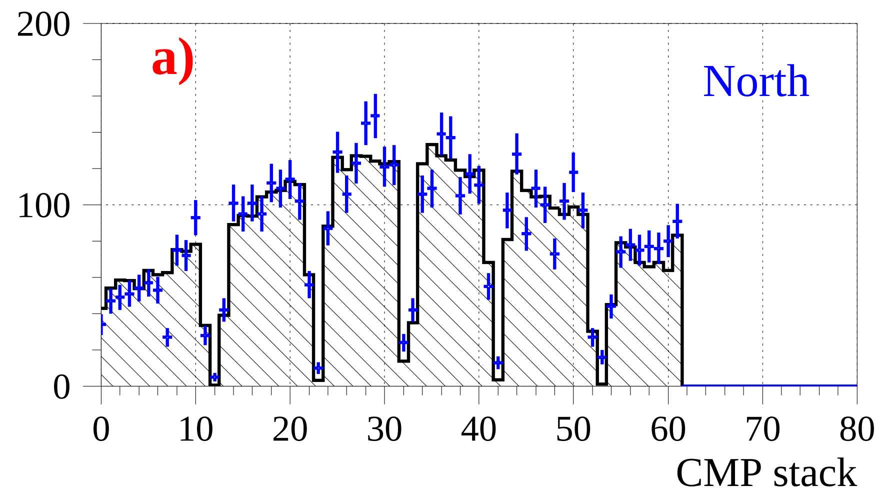


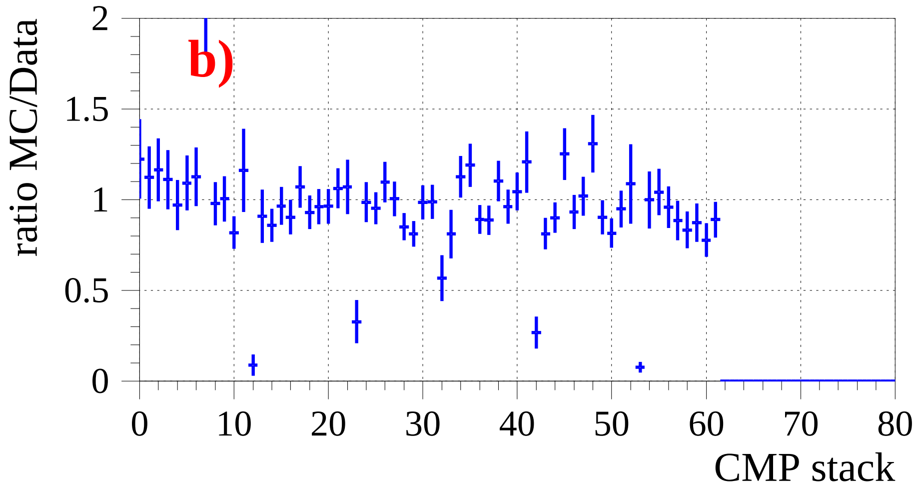


Muon system simulation

- **CDF Muon System - geometry description is challenging. Plot below shows location of the central muon component in azimuth ϕ and pseudorapidity η**
- **Data and MC agrees well.**
  - $W \to \mu\nu$ **data; MC - single muons**
  - **a) number of CMUP muons for each stack in the north wall; (MC - hist.; data - points))**
  - **b) ratio MC/data**







Status and conclusions

- CDF Simulation Framework is proven to be flexible, easily extensible, and efficient, hiding complex infrastructure details from a user and providing convenience for large MC production.
- Sub-detectors are sucessfully implemented in the CDF Simulation Framework
- Monte-Carlo simulation of physics events is in a good agreement with data.

- This talk summarizes a collective effort of many CDF institutions working on implementing and tuning simulation for many CDF sub-detectors.