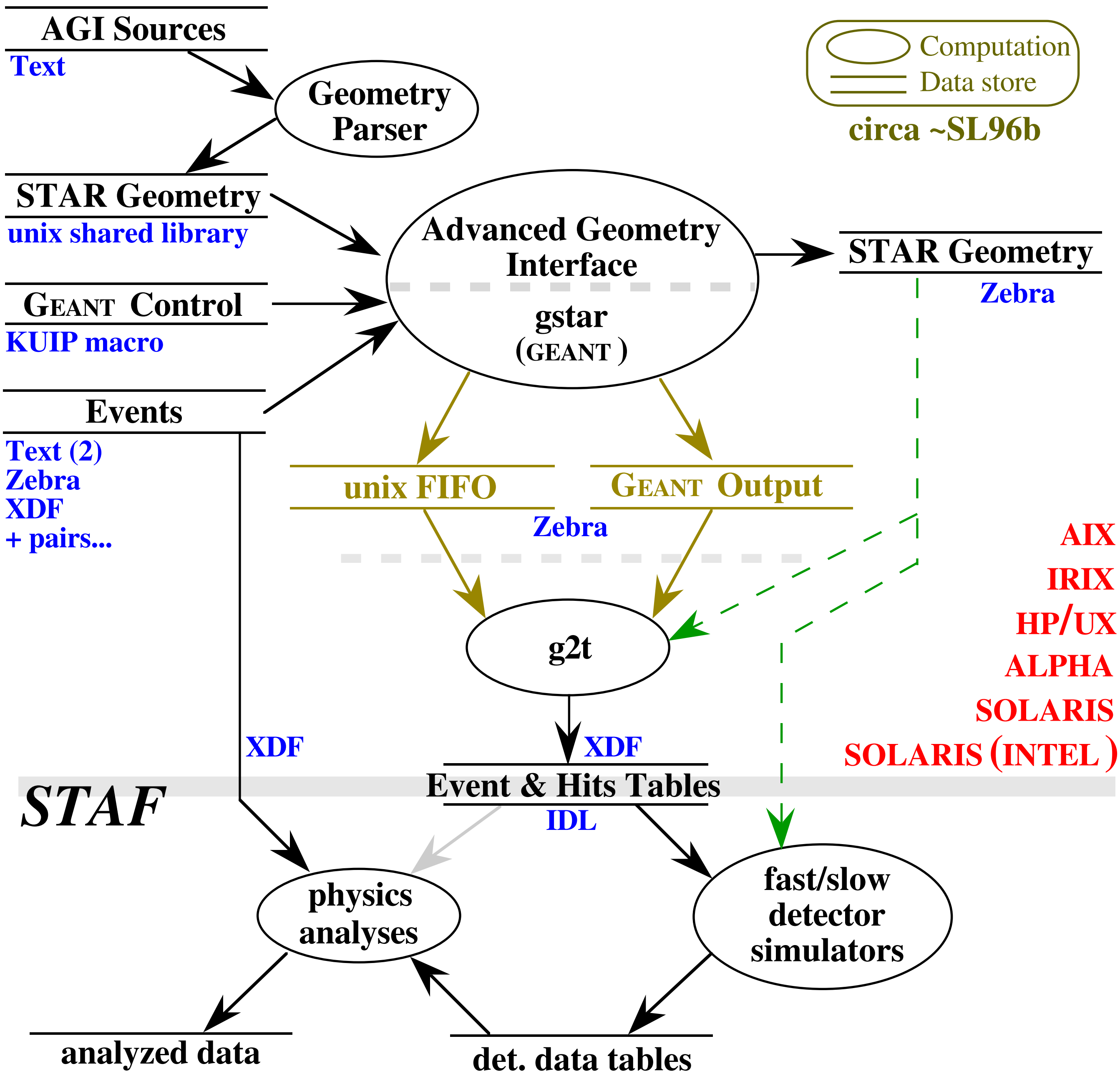
STAR Detector Simulators

Fortran or C/C++ codes run as PAMs in STAF...



GEANT crossings → detector signals, ADCs, TDCs, ...

W.J. Llope
Rice University

Generalities:

* Detector simulators needed for each of the eight active subsystems...
  TPC, CTB/TOF, MWC, VPD, ZDC, FTPC, SVT, EMC/SMD

* They start with geant "hits" information from crossings and may simulate each detector's
  collection of ionization electrons or scintillation light...
  conversion of these into electronic signals...
  electronic conversion of these into digital data...
  including noise, inefficiencies, and all other "real-life" effects...

* They should be "linked" to geometry, calibration, & run databases...

* They should be as fast as possible and reliable...

* They should be *as realistic as necessary*...

"Fast" versus "Slow" Simulations

More detailed descriptions are generally more CPU-intensive...
The most detailed description is not always necessary...
May need several variants/detector...

Fast Simulators - *parameterize overall detector response and sample from appropriate distributions...*

Slow Simulators - *describe in software each step in the signal development, processing, & digitization...*

Realistic detector descriptions are needed to
extract realistic efficiencies, backgrounds, & biases...
understand specific details of the actual performance...

For high track densities/high rates, and/or for analysis-critical detectors:
A "slow" description may be necessary...

Otherwise:
"Fast" descriptions may suffice...

STAR Detectors and their Software Simulators

- ❑ Running outside STAF (*i. e.* port to STAF in progress)
- ■ Running in STAF (TAS→STAF port or new package)
- ● Released as official package (cvs controlled, AFS reference area)
- ▼ Example kumacs & documentation (on www)

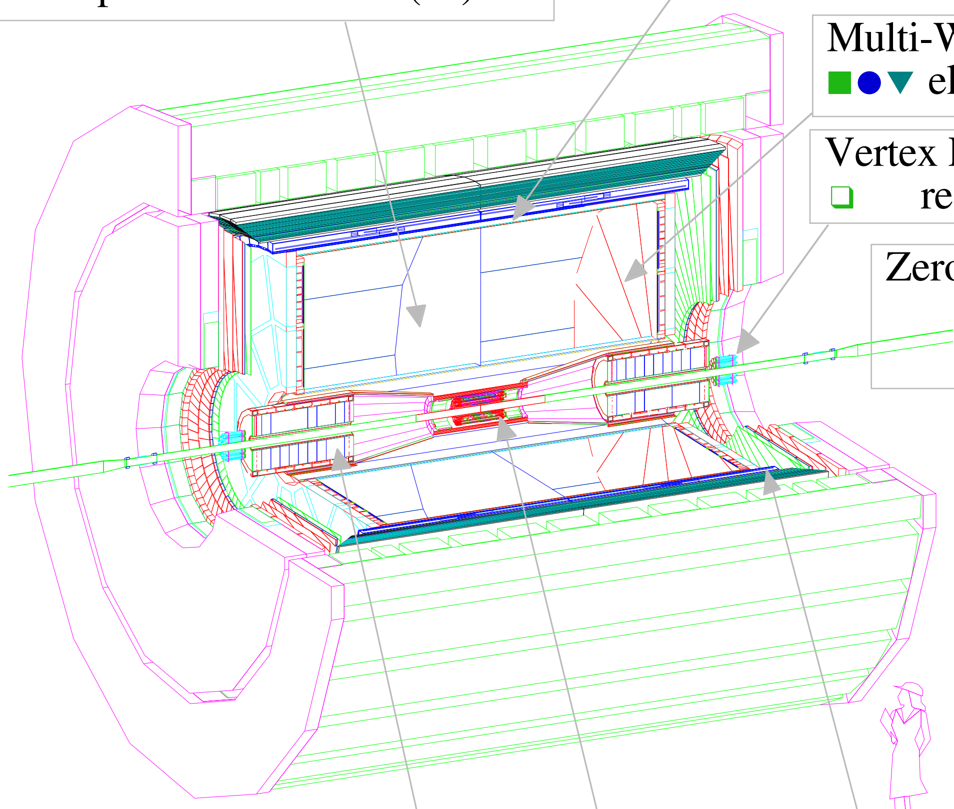
Time Projection Chamber (TPC)
■●▼ Tpc Slow Simulator (tss)
■●▼ Tpc Fast Simulator (tfs)

Central Trigger Barrel (CTB)
Time of Flight (TOF)
■●▼ resolution simulator (ctf)

Multi-Wire Chamber (MWC)
■●▼ electronics simulator (mws)

Vertex Posn. Detector (VPD)
❑ resolution simulator (vps)

Zero Deg. Calorimeter (ZDC)
fast simulator (zfs?)
slow simulator (zss?)



Fwd. Time Proj. Chambers (FTPCs)
■● Ftpc Fast Simulator (ffs)
❑ Ftpc Slow Simulator (fss)

Electromagnetic Calorimeter (EMC)
Barrel, End-caps, and Shower Max. Detectors
Emc Fast Simulator (efs)
Emc Slow Simulator (ess)

Silicon Vertex Tracker (SVT)
■●▼ Svt Resn. Simulator (srs)
❑ Svt Signal Simulator (sss+ssf)

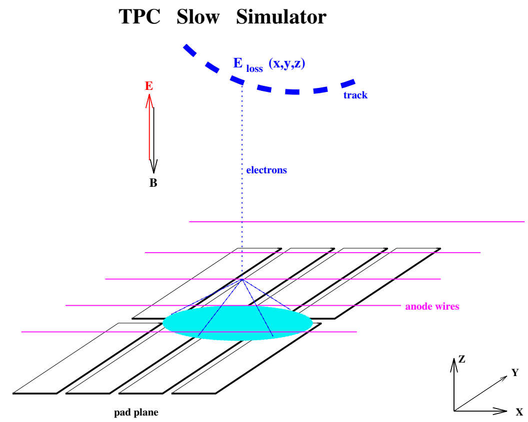
TPC Simulators

- **Tpc Fast Simulator (tfs)**

Dhammika Weerasundara
Iwona Sakrejda

GEANT pad-row crossings → TPC space points
sample Gaussians for pad response (SN 33) & pad resolution (SN 34)
path across pad-row, longitudinal diffusion, & shaper response
merges and flags overlapping hits

STAF compliant, released,
CVS control, documented



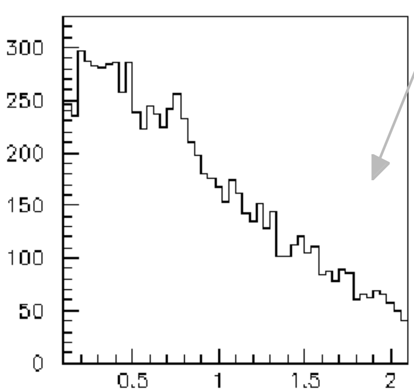
- **Tpc Slow Simulator (tss)**

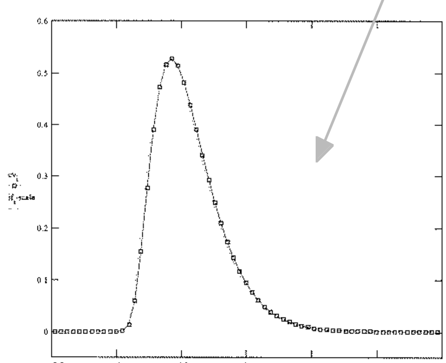
GEANT e- clusters → TPC pixel data
(→cluster/hit finders→TPC space points)
$n_e = \Delta E / I_0$
cloud transported w/ diffusion
gas gain fluctuations via Polya function
pad response and pad resolution
shaper response
signal sampled at the SCA clock frequency
shaper-filtered white noise added in time buckets
pixels above threshold digitized to ADC counts

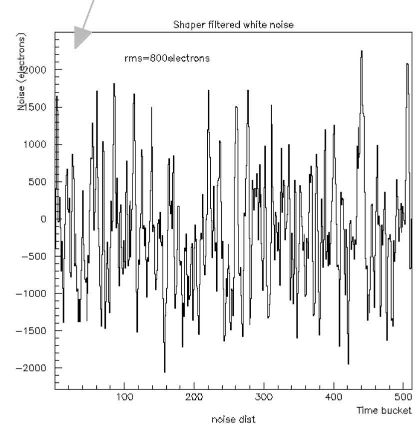
Mike Lisa
Iwona Sakrejda

STAF compliant, released, CVS control, documented

$$S(x_p,y_p,t) = n_e\, G\, F(x_p,x_0)\, F(y_p,y_0)\, F(t,t_z) + N_t$$

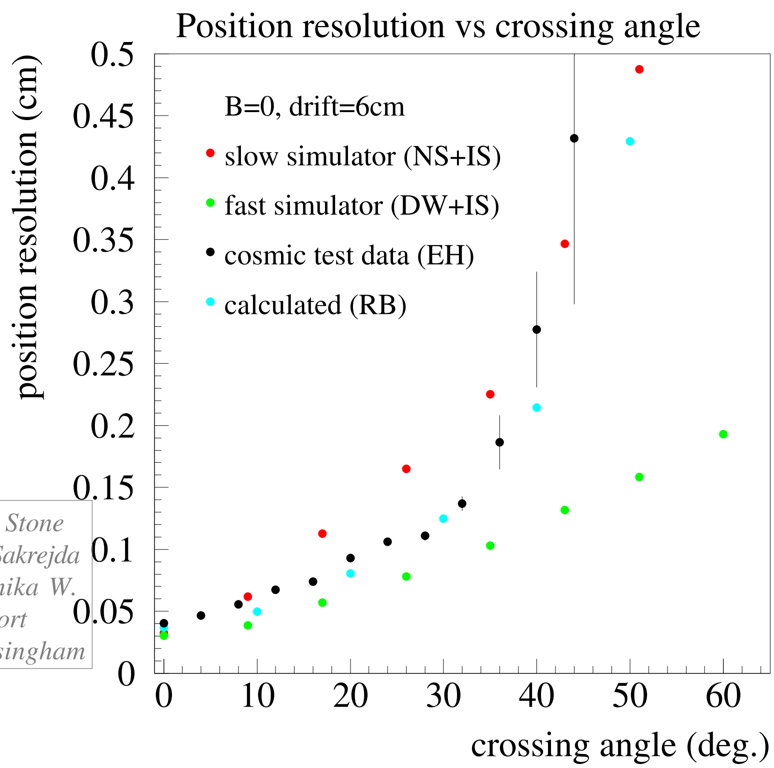




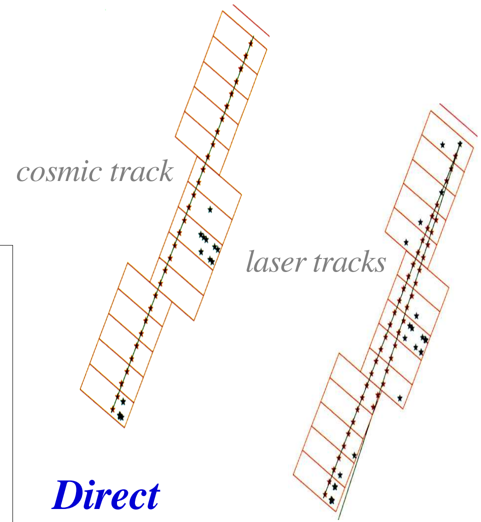


recently: speed increases, laserino support, output for System Test

TPC Cosmic and Laser Tests



Nathan Stone
Iwona Sakrejda
Dhammika W.
Eric Hjort
R. Bossingham



Direct comparison of the TPC Simulators to data from the actual TPC...

Calculation: (SN 247)

- I_0 = 29.8 eV/pair...
- 3-pad algorithm...
- hit-finding helps...

Tpc DIstortions (**tdi**):

Peter Jones

Simulate effects of E-field distortions for (zero B-field) cosmic/laser tests
Evaluates radial distortion integral for various E-field non-uniformities
Selective straight-line fits to reconstructed tracks & space pt. residuals

Centroid displacement from cross-talk

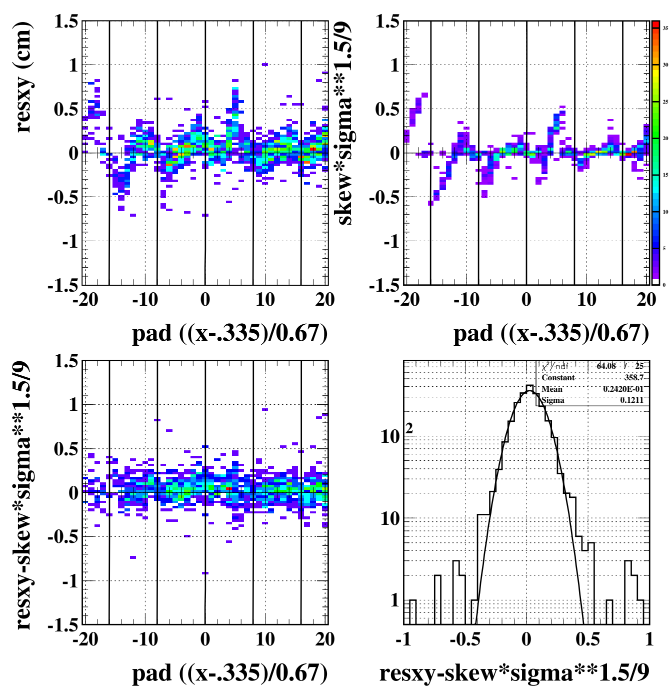
cross-talk displacement of cluster centroids only weakly dependent on the track angle...

cluster *skewness* a better indicator of cross-talk displacement than residuals?

new results - not yet in simulators or cluster-finder...

resid. σ ~ 2.9mm before correction
σ ~ 2.2mm after correction

Tom Trainor
Dhammika W.
Iwona Sakrejda



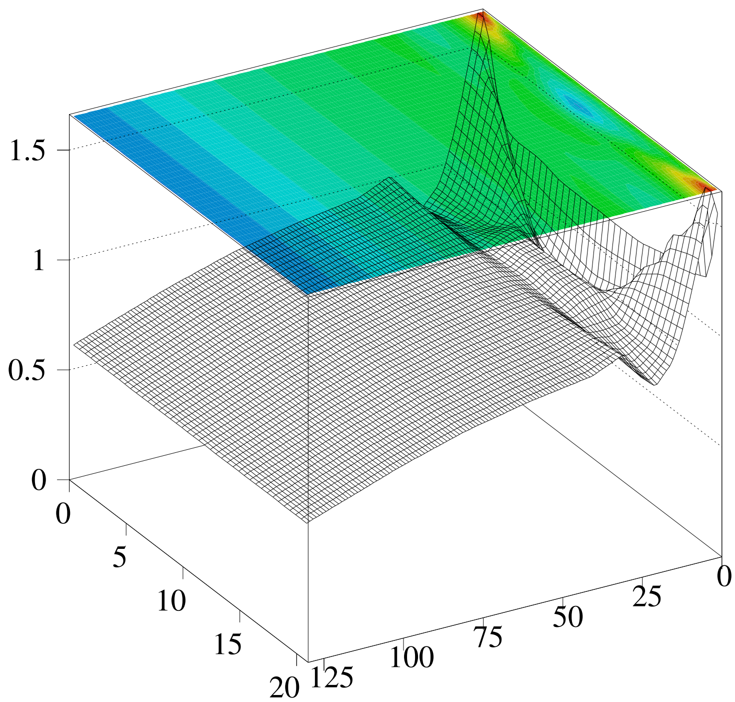
CTB/TOF Simulator

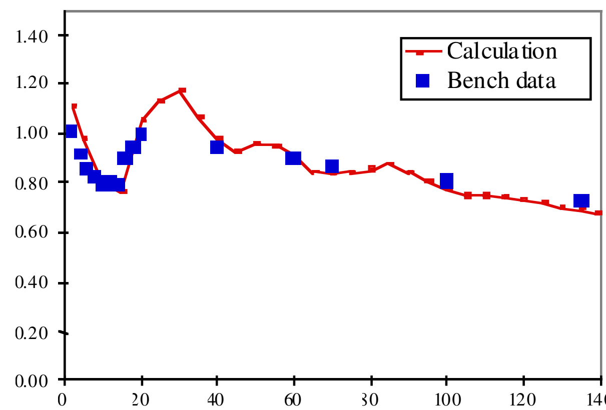
CTB and TOF are simulated as a common *software* detector (CTF)

- **Ctb/Tof Simulator (cts)**
  geant crossings ($\mathbf{x}$, ΔE) $\rightarrow$ ADC (and TDC) values

Pablo Yepes

convert deposited energy to $N\gamma$ in the scintillator
parameterize photon attenuation
Option 1: simple exponential attenuation
Option 2: mapped PH response versus hit x_{local} & y_{local}





Geary Eppley
Gordon Mutchler
Pablo Yepes
WJL

cathode surface efficiency, quantum efficiency
parameterization of PMT line shapes
integration of all signals in gate $\rightarrow$ overall ADC values
addition of pedestals with defined moments

STAF compliant, released, CVS control, documented

Other Trigger Detector Simulators

- **MWc Simulator (mws)**

  James Whitfield

  GEANT crossings ($\mathbf{x}$, ΔE) $\rightarrow$ MWC trigger quantities

  wire counting or charge integration

  STAF compliant, released, CVS control, documented

- **VPd Simulator (vps)**

  Zoran Milosevich

  GEANT crossings ($\mathbf{x}$, ΔE) $\rightarrow$ VPD TDC values

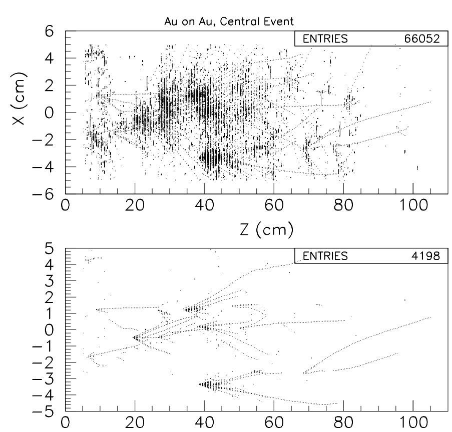
  examine all charged secondaries, keep those with β>2/3
  calculate N_γ produced in quartz and time response
  smear time response (σ = 75 ps, according to E878)

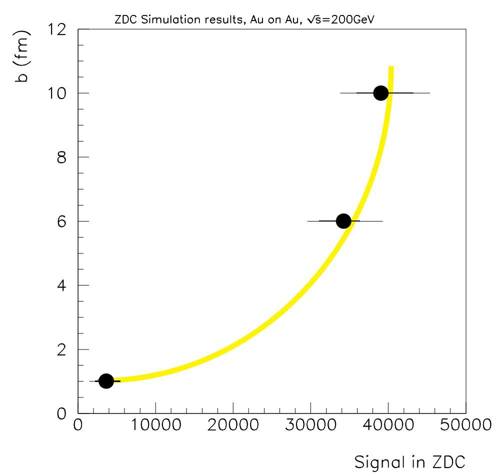
  running in STAF, not yet released

- **ZDC response simulators**

  Bill Christie

  Detector still in design phases, test run at CERN two weeks ago
  Detailed gstar geometry file exists
  gstar-based simulations with fragment afterburner have been done
  GEANT-showering used (similar approach matches performance seen in NA49)





impact parameter resolution dominated by event fluctuations
probably only needs a reasonable fast simulator...
good £ measurements require good single neutron efficiency
probably needs a slow simulator to understand response...

FTPC Simulators

- Ftpc Fast Simulator **(ffs)**

  GEANT crossings ($\mathbf{X}$, ΔE) $\rightarrow$ FTPC space points

  parameterize cluster moments

  radial drift (SN 214)

  pad response, & shaper width

  angular effects, pad-lengths

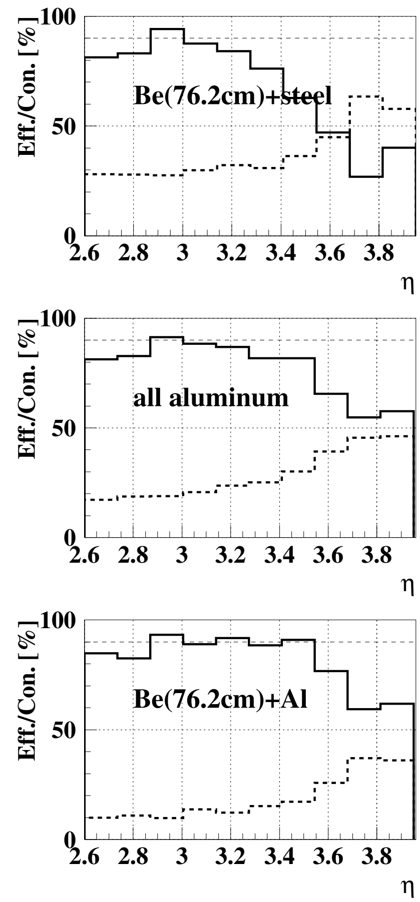
  merge overlapping clusters

  based on NA35 and NA49 experience

  in STAF, released, CVS control, documented

  improved version in progress...

Michael Konrad



- Ftpc Slow Simulator **(fss)**

  GEANT crossings ($\mathbf{X}$, ΔE) $\rightarrow$ FTPC pixel data

  drift & diffusion in highly non-uniform fields

  simulation of read-out processes

  avalanche

  pad-response

  shaper-response

  digitization

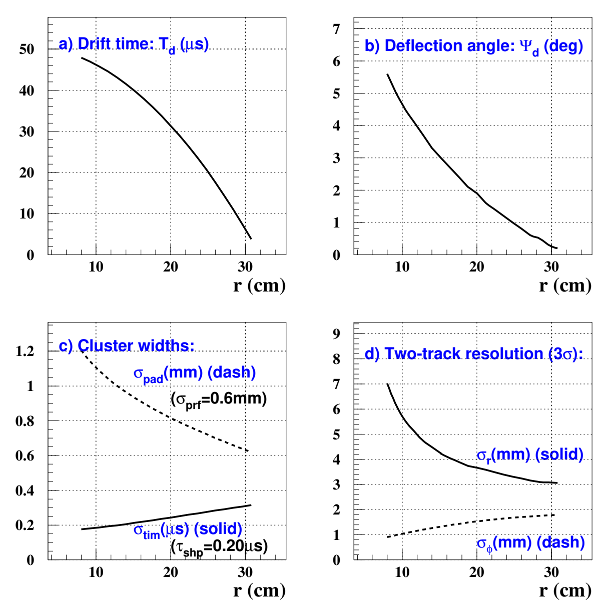
  compression (not yet implemented)

  Running outside of STAF (FTPCSIM)

  Port to STAF in progress...

Wen Gong
Janet Seyboth

FTPC: Ar-CO$_2$(50%) in $\vec{E}\perp\vec{B}$ (V_c=10kV, B=5kG, L_{pad}=2cm)



SVT Simulators

- Svt Resolution Simulator **(srs)**

  Ken Wilson

  GEANT crossings (**x**, ΔE) → SVT space points
  parameterizations based on explicit transport calculations
  Coulomb repulsion, diffusion
  1. direct mode (simple table translation, no resolution effects)
  2. Gaussian smearing (RMS independent of drift distance)
  3. Realistic simulator (translation, smearing, hit merging)

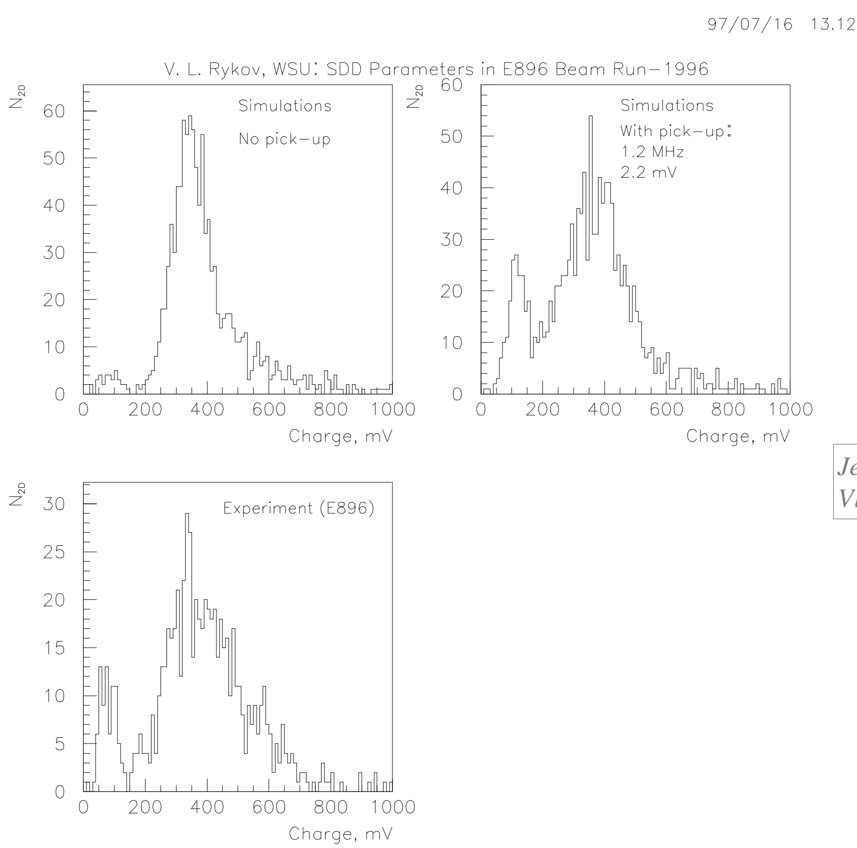
  STAF compliant, released, CVS control, documented
  Option 3 operational but in need of more tuning...

- Svt Signal Simulator + FEE/ASIC simulator **(sss+ssf)**

  Claude Pruneau

  GEANT crossings (**x**, ΔE) → SVT raw ADC data
  apply Coulomb repulsion and diffusion via parameterizations
  optional charge loss
  simulate anode signals with actual response of bipolar PASA
  translate anode output into ADC values including ASIC response

  Running outside of STAF, port to STAF in progress...

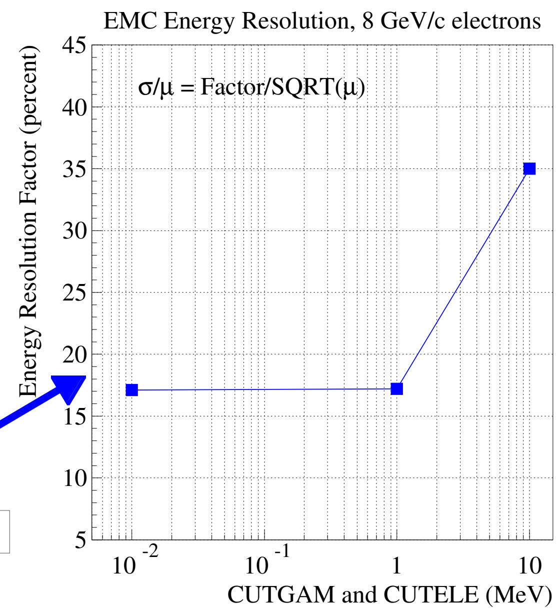


Jeff Sheen
Vladimir Rykov

EMC Simulations

- GANT showering
  GEANT crossings ($\mathbf{x}$, ΔE) $\rightarrow$ tower/depth/SMD Σ's (in a.u.)
  simply set GEANT `CUTS` low enough to make reasonable showers
  showers may not be realistic enough
  no description of ORC or FEE
  not very fast

  Present method...



Value seen in SPEMC Test Runs

WJL

- Emc Slow Simulator **(ess)**
  GEANT crossings ($\mathbf{x}$, ΔE) $\rightarrow$ ADC values
  accumulate geant information in small cells (~20-100/tile)
  apply map of facial dependence of N_{pe} measured on bench
  time dependence, PMT line shapes, application of ADC gate
  FEE dual-range integration, calculate trigger bits

  Doesn't exist yet.
  Lots of bench data available...

- Emc Fast Simulator **(efs)**
  GEANT crossings at EMC Front plate ($\mathbf{x}$) $\rightarrow$ ADC values
  in gstar - save incidence info (PID, p, dir. cosines) & kill particle
  sample shower depth
  sample Gaussian for ADC values from non-showering particles
  parameterize $e^{\pm}$, γ, and $h^{\pm}$ showers matching test-beam ADC data
  sample from these parameterizations and include fluctuations

  Doesn't exist yet. May need several variants...
  Lots of Test Run data available...

Joblist for Detector Simulators

Specific...

- vps, fss, sss
  finish port to STAF, complete documentation, and release...

- BEMC/BSMD & EEMC/ESMD
  fast simulator(s) needed now...
  slow simulator less urgent at the moment, but "easier"...

- ZDC
  study new test beam results...
  fast simulator once design finalized, then slow simulator...

- PMD, SSD, ...

General...

◊ not all simulators compile on all platforms...

◊ w/ SAS and SOFI, reach consensus on structure of geometry, calibrations, and other databases...
  modify simulators to make use of this information...

◊ Continue to push to production simulations of large event samples...
  insure code is stable and optimize for speed...
  optimize algorithmic detail...
  benchmarking...

◊ Investigate inclusion of certain detector sim. algorithms in gstar...

◊ Maintenance and Evolution...
  keep up with the evolution of STAR detectors...
  continue to bench-test simulator codes against data...
  database I/O...