GEM TN-92-226

# Physics Simulation Group Meeting - SSCL

October 20, 1992

Abstract:

Agenda, attendees, and presentations of the GEM Physics Simulation Group Meeting held at the SSC Laboratory on October 20, 1992.

Physics | Simulation Group Meeting SSCL 10/20/92

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Physics/Simulation Meeting of Oct. 20th 1992

Agenda

1:00 pm Agenda -- K. McFarlane (5 mins)

1:05 pm gemfast on PDSF (how to) -- I. Sheer (10 mins)

1:15 pm Overall status -- T. Skwarnicki (15 mins)

1:30 pm Reports and discussions (led by T. Skwarnicki) on parameterizations (implemented, planned, tested?). (20 mins each)

- -- Tracker (20 mins)
- -- Central Calorimetry (20 mins)
- -- Forward Calorimetry (20 mins)
- -- Muon system (20 mins)

2:50 pm Break (cafeteria closes at 3 pm) 10 mins

3:00 pm -- Trigger (10 mins)

3:10 pm Generator issues -- F. Paige, I. Sheer... (10 mins)

3:20 pm Reports by physics groups (experience with Baseline 1 version, any problems, suggestions) 5 mins each

- -- Standard Model Higgs -- CalTech group
- -- Heavy Flavor -- Chiaki Yanagisawa, J. Antos
- -- Jet Physics -- R. Carey, A. Savin
- -- Physics at 10^34 -- T. Wenaus, B. Zhou, K. Lane
- -- Missing E_T -- F. Paige, A. Vaniachine, M. Shupe

3:45 pm Uniform format for final presentation (Paige, Lane?)

4:00 pm Reports of Physics Results

4:30 pm Discussion of tasks for each group (parameterization and physics)

6:30 pm Adjourn

## Assignments for Physics Simulations for the GEM TDR

(B. Barish)

This outlines work to be done for the physics section of the TDR (it is a summary of the Physics/simulation meetings of Wednesday Oct. 7-8th). Responsibilities are defined; people who are identified should note the time table below and respond to B. Barish if there is any difficulty. Additional participation in physics studies is encouraged; communicate with K. Lane. You are asked to familiarize yourself with the structure of the baseline 1 version of gemfast (can be found on PDSF in /gem/demo/gemfast). Suggested improvements to gemfast should be sent immediately to T. Skwarnicki. (Email addresses are given below.)

There will be a meeting at SSCL on October 20th (1pm till ?) to receive progress reports.

### Topics to be studied

The topics to be studied for the TDR, and the groups (or nuclei of the groups) are (see Responses to the DEC. 1991 PAC report, GEM TN-92-131):

1. Standard Model Higgs -- CalTech group (Zhu, Yamamoto, Shi, Mrenna)
   All!

2. Heavy flavor -- Chiaki Yanagisawa, Jaroslav Antos
   a. ttbar production for m_t = 250, 140 GeV.
   b. polarization in t -> Wb.
   c. Single technieta production, gg -> eta_T -> ttbar

3. Jet Physics -- R. Carey, A. Savin
   a. Quark substructure
      (Need program for measurement of structure functions at low luminosity.)

4. Physics at 10^34 -- T. Wenaus, B. Zhou, K. Lane
   All in TN-92-131

5. Missing E_T -- F. Paige, A. Vaniachine, M. Shupe
   a. Gluinos via missing E_T, like-sign dileptons
   b. Squarks
   c. Missing E_T requirements

### Method of study

All groups WILL USE a new fast parameterized simulation derived from FAST1 and modelling Baseline II, called 'gemfast' for TDR calculations.

The responsibilities for gemfast are as follows:

Overall integration -- T. Skwarnicki
Directory structure and generator interfaces -- I. Sheer

Tracker parameterization -- M. Brooks, S. McKee, I. Sheer
Central Calorimeter parameterization -- H. Ma, A. Savin, J. Womersley
Forward Cal. parameterization -- M. Shupe
Muon parameterization -- P. Dingus, T. Wenaus, B. Zhou
Trigger parameterization -- C. Allen, H. Uitjerval

The subsystem contacts are responsible for:
1. Providing parameterizations of their subsystem
2. fixing bugs in any code that they provide
3. Running 'gemfast' to verify that their system is appropriately described.

### Schedule

1. Initial definition of capabilities of gemfast (OCT. 8th)
2. Tests of, and familiarization with, Baseline 1 version by physics groups leading to further definition of gemfast capabilities needed ( responses from groups by OCT. 14TH to Tomasz)
3. Organization by the gemfast group of work to produce new parameterizations ( to be described at SSCL on OCT. 20TH)
4. Final definition of gemfast at SSCL meeting (OCT. 20TH)
5. Gemfast V1 ready for use NOV. 7TH.
6. Studies completed DEC. 31ST 1992.

## Communications

Announcements will be sent out to a mailing list that will be updated occasionally. They will also go to the newsgroup ssc.pdsf.gem.
Participants not on the mailing list are encouraged to:
1. Read the Unix newsgroups ssc.pdsf.gem and ssc.gem.news. To do so on pdsf type rn -q gem or xrn.
2. Send your INTERNET address to K. McFarlane to be added to the mailing list. This is an address of the form user@xxx.yyy.zzz.aaa. Systems on BITNET and DECNET almost always have internet addresses and these are more universal.

Email addresses:
B. Barish: barish@cithe1.cithep.caltech.edu (CITHEX::BARISH)
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The distribution list used to mail this out is
SSCVX1::USER3:[MCFARLAN]TDRPHYS.DIS

FAST MC SIMULATION FOR TDR
Tomasz Skwarnicki, Oct 13.

The purpose of this note is to trigger further discussion on how we should upgrade the fast MC program, so it can serve as physics simulation tool for TDR. We should all realize that WE DO NOT HAVE working fast MC program since the design has changed from the integrated liquid calorimeters to the hybrid option. We should also keep in mind how much damage poor physics part can do to the whole GEM project (see past PAC reviews).

We already had some discussions on Oct. 8th, but we need more to have a clear picture on Oct. 20th what the detector people are supposed to provide. This note is mostly addressed to the people who are responsible for detector parameterizations, though other people, especially those who took responsibility for physics simulations, are also encouraged to participate in the discussion.

My understanding of the responsibility of the people who are supposed to provide detector parameterizations (named in the E-mail from Oct.10th) is as follows:

1. Participate in discussion on the upgrade of the code concerning the detector part you are responsible for.

   This may also require some interaction between you and other people involved in designing this subdetector who are not directly responsible for parameterizations (people designing hardware, doing full simulations or coordinating the group).

   Understand by Oct.20th what you are supposed to provide by first days of November.
   In addition to fortran code, this may include providing some specifications of the detector used in the existing code. If these specifications are not yet known it will be your job to work out the official line which will be used in physics simulations.

2. Make sure that what was agreed by Oct.20th is delivered by first days of November (actually as soon as possible - if you know what you are supposed to do you may do it already now).
   If fortran code is delivered it must be well debugged in stand alone mode.
   You may get other people (not named on the responsibility list) to do the parametrization job, but you are responsible for making sure that the job is done right and on time.

3. Test simulation of your detector after your code has been integrated with the overall framework (e.g. produce plots of resolution vs Pt or eta with the fast MC program).

Below I am going through each detector component and describe how the present simulation works, specify what we will need to update, or open discussion if the upgrade strategy is not clear.

People should think about the job they are supposed to do now. E-mail discussion is welcome. The meeting on Oct.20th is only to summarize what has been discussed before. You know very well that not much is getting done at meetings themselve.

Before I get on specific detectors let me propose three other things:

Common problem of people starting physics analysis is how to set up PYTHIA and ISAJET properly. Could generator experts (Frank Paige, Ken Lane, Hiro Yamamoto) work out a set of official steering cards for the generators for all the physics processes

people are supposed to study. Or, at least, provide some guidelines for inexperienced users. We saw people wasting analysis time on wrong generator set-up before. It may happen again.

Fast simulation contains some utility routines e.g. jet finding, cone energy etc. Could someone look at improve them before people start doing analysis? Please share with other people any other utility routines which you may write in course of your analysis.

Some kind of visualization of generated events and detector responses would play important role in debugging and understanding signal and background signatures. Does anybody have ideas how we could get cheap visualization in a short time scale?

Since this note becomes detailed below, you may skip it to the part relevant to your responsibility.

To find relevant detector codes in the existing fast MC library ( /gem/src/gemfast/libfsi ) look at fsi_frspXX.f, where XX=CT, EC, HC, FC, MU (they are all called by fsi_evt).

CT=Central Tracker
EC=Electromagnetic Calorimeter
HC=Hadron Calorimeter
FC=Forward Calorimeter
MU=Muon system
TR=Trigger system

L0= absorption length
X0= radiation length

EM= electromagnetic

## CENTRAL REGION CALORIMETERS

PRESENT CODE: (produced by Hong Ma and Tomasz S.)

Particles are transported to the front face of EC. In the transport code, the calorimeters are assumed to be cylinders with eta coverage limit.
No preshowering in CT. No multiple scattering.
Electrons and gammas shower immediately (i.e. no fluctuations in the shower origin). Exponential fluctuations in depth of the interaction point for hadrons. Helical path for charged hadrons in the calorimeter before the interaction point (or stopping point). Constant dE/dX along this path.
Total energy of the shower is smeared (gaussian) according to energy dependent formula: a/sqrt(E) |+| b (a is a function of eta for the present EC code).
EM showers are smeared according to EC resolution. Hadronic showers according to HC resolution.
Bock's formulae for longitudinal and transverse shower profiles are turned into grid's in L0 or X0 (longitudinal - is actually not a grid but energy dependent integral table in L0, transverse - 2 dimensional differential grid). No fluctuations in the shower profiles.
No correlation between transverse and longitudinal shower profiles.
Showers develop always radially.
Shower energy is split among EC and HC (there may be also energy leaking from back side of HC) according to eta-dependent thickness of EC and HC using longitudinal Bock's tables. The table goes up to 1 TeV (of E not Et). No other longitudinal segmentation is simulated.

Then the energy is distributed transversely to the cells integrating the transverse grid within the cell limits. Cell sizes are constant in phi and eta.

Transverse leakage from the edge of the central calorimeter is assumed to be detected in FC with 100 % efficiency and no additional smearing.

Whole volume of calorimeter is "active".
Non-projective cracks in EC (old Baseline-I cracks) are simulated by worsening the energy resolution in this region.
Effect of cryostat walls not simulated (except for contribution to gaussian energy resolution).

Pedestal fluctuations (thermal noise) by gaussian smearing of cell energies - assumed to be the same even though physical cell sizes change.

Pile-up is simulated by summing up in each cell energies from showers in the past and future minimum bias events with appropriate time dependent weight.

User accesses cell energies directly or by utility routines (cone energy, jet finding, clustering program).

PRESENT PARAMETERS: (separate set for EC and HC)

Geometry: radius, half length in z, and eta limit of the effective cylinder.
Average L0 (absorption length) and X0 (radiation length) in cm.
Average ionization per unit radiation length for charged hadrons before interaction.
Parametrization of gaussian energy resolution as a function of energy (and eta for EC).
For HC, need EM resolution in addition to hadronic resolution.
Thickness of calorimeter vs. eta (in both L0 and X0, for both EC and HC).
Segmentation: delta(phi), delta(eta).
Sigma of gaussian energy noise in single transverse cell.
Time dependent weight for pile-up simulation (weight=1 by definition for on-time showers).

MINIMAL UPGRADE PLAN

Update of all of the above parameters.
+
Simulation of the projective crack in EC at eta=0.
+
Parametrization of angular resolution for photons (vs. energy, vs. eta) (assuming vertex perfectly known)
+
Parametrization of EM shower pointing.

Simulation of the projective crack in EC
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Energy lost in the crack (important for missing Et and isolation cuts) cannot be easily simulated in the present framework. The parametrization should take into account also effects of the calibration procedure on the measured energy in this region.

I think that an effect of this crack on the physics analyses is likely to get attention of many reviewers of TDR.

We need people to think about this problem now, so we can come up with a solution by Oct.20th.

OTHER PROBLEMS WHICH WE SHOULD DISCUSS

Segmentation
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Constant cell sizes in eta make them unrealistically small at large eta. In consequence showers spread among many more cells at larger eta (this makes simple shower energy algorithms like e.g. 5x5 inconvenient).

Some studies of the isolation cuts impose minimum cell energy cut-off, thus are affected by the improper cell sizes.
Thermal noise in a cell is kept constant which is wrong for decreasing cell size, but may be unimportant since pile-up noise dominates at large eta.

In principle, our transverse shower profile algorithm can work with unequal cell sizes. In practice, unequal cell sizes would require major re-writing of the code because the trivial mapping of cell indices into geometrical location must be replaced by the complicated one.
This is also likely to result in significant slow down of the MC program (remember GEANT is slow mostly because of exact treatment of geometry).
Effect of the equal cell sizes on shower energy can be fixed by using algorithm which sums different number of cells at different eta.
I have no good ideas how to fix isolation cone energy with cell energy threshold and how to fix unrealistic clustering at large eta with too good granularity.

## Non-gaussian energy resolution

Missing Et physics is sensitive to non-gaussian tails in the resolution. Dead material in front of the calorimeter (CT + cryostat) and in between EC and HC (cryostat) will generate such tails (also longitudinal leakage from HC, which is already simulated).
This is in addition to the projective crack effect.
In principle, we could simulate these effects explicitly by estimating fractions of energy lost e.g. in cryostats on shower-to-shower basis using the existing parametrization of the longitudinal shower profiles. This is not a trivial change but can be done.
This will not help if there are tails in the energy distribution for other reasons (e.g. fibers in SPACAL).
Since we do not have fluctuations in longitudinal shower development this cannot be exact in any case.
The other solution is to use non-gaussian smearing of shower energies. I know convenient analytical parametrization which combines gaussian with power law tail. Detector people would need to parametrize not only gaussian sigma but also tail parameters.

## Shower fluctuations

Is there an easy way to fluctuate shower development?
E.g. keeping total shower energy constant (total shower energy is smeared explicitly by the parametrized energy resolution) we could redistribute energy among cells (or do it earlier on the grid level). We would need somebody to work out parametrization of the fluctuations.

## Pile-up at different luminosities

Present scheme of pre-calculated pile-up cell energy arrays stored on external file takes a lot of disk space and is difficult to implement for more than one luminosity. Using the same idea of pile-up simulation we could make the simulation more flexible by moving the time weighting of minimum-bias events to the analysis job (or run concurrently as separate UNIX process and use fifo's to pass pile-up arrays).
This may significantly slow down the MC.

# FORWARD CALORIMETER

PRESENT CODE: (provided by M. Shupe)

FC parametrization code (FCSMEAR) is called for particles which exit HC cylinder with eta in appropriate limits.
The acceptance at the high eta edge is not a step functions but ramps from 1 to 0 between eta=6.2 and 6.8 (random number generator used to decide whether the particle was actually detected in this region).
Energy and direction of the particle is smeared according to W/LAr simulation. Individual calorimeter cells are not defined.

Vectorial sum of all smeared particle energy-vectors detected in FC is calculated. This sum includes also the energy which leaked transversely from EC and HC calorimeters.

FCSMEAR was designed to be called with the particle four-vector at the detector origin. It is now called with particle four-vector at the entrance to FC which probably double-counts direction smearing due to magnetic field effects in front of FC.

MINIMAL UPGRADE PLAN

Update FCSMEAR to FC design in the hybrid option and larger beam-pipe:
- new eta limits
- new energy and direction smearing
- direction smearing must exclude curving of charged particles in magnetic field in front of FC

+

Pile-up simulation.

Pile-up simulation
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We can simulate pile-up in FC in the way equivalent to what we do for individual cells in the central calorimeters. We need to know time dependent weight function for off-time minimum bias events.

*OTHER PROBLEMS WHICH WE SHOULD DISCUSS*

Non-gaussian energy resolution
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Missing Et physics is very sensitive to non-gaussian tail in detector response. I don't know much about FC. Is it long enough to catch even late developing showers? What about transverse leakage especially on the beam-pipe side ? Can tails be neglected ?

If we do not simulate shower development in FC the only way to take tails into account is to apply non-gaussian smearing (see comments for the central calorimeters).

Shower development ?
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In principle we could simulate FC in the same way as we do for the central calorimeters. Define cell structure and develop showers transversely and longitudinally (explicit leakage simulation).
The code can be adopted from the central calorimeter part.
Detector people would need to provide the same parameterizations as for the central calorimeters (see above).

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CENTRAL TRACKER
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PRESENT CODE: (provided by Shawn McKee and Melynda Brooks)

Every charged track originating from the interaction point region (cylinder R=0.4 cm, z=+-5 cm) with |eta|<2.5 and some minimum momentum

is considered to be reconstructed. No efficiency simulation.

Momentum and track origin resolutions are parametrized as function of P and eta (results of full simulation of single tracks).

No CT information is provided on tracks originating beyond the interaction region.

The simulation is the present shape is applicable only physics relying on high Pt isolated charged tracks.

MINIMAL UPGRADE PLAN

Accept the present resolution code (CT design has not changed).

+

Simulate converted photons.

Converted photons.

There are two aspects of photon conversions. High energy converted gammas give background to electron sample. Converted photons of any energy may help gamma/jet separation (residual jet background comes from multi-photons). For the first problem early conversions are relevant. For the second point all conversions before the last IPC layer matter. We will need parametrization of CT material at least before the last IPC layer and after the first silicon layer.

Conversions can be simulated by making gamma "decay" to e+e-, with electrons added to /hepevt/ and tracked by the fast simulation from there. CT people should not only provide material parametrization but also conversion code.

OTHER PROBLEMS WHICH WE SHOULD DISCUSS

Standard set of guesses

Many important aspects of CT functionality are not simulated at all (reconstruction efficiency for high Pt tracks, dependence on the luminosity, efficiency and accuracy of the primary vertex reconstructions, low Pt track reconstruction for isolation cuts etc.).
Taking into account complexity of the problem there is no hope to obtain parameterizations of these aspects from the full simulations on the time scale relevant for the TDR physics simulations.
Fast MC user is left to make his own guesses and assumptions.
I think this is a dangerous situation which will result in inconsistent assumptions used in different physics analyses. I would be nice if CT group provided standard set of assumptions. Perhaps in three different versions: 1. optimistic 2. likely 3. pessimistic.

CT "calorimeter"

The other solution to the apparent lack of CT simulation in the fast MC is to follow idea of Frank Paige:

- using the cylindrical tracker of the fast MC find intersections of the charged trajectories with layers of silicon and IPCs
- define cell structure of each layer:
  strips for silicon, pads for IPCs
- count tracks in each cell
- may simulate detector inefficiency and dead time due to the pile-up
- for each track calculate number of layers intersected and number of layers with isolated hits

Making some assumptions on how many (isolated) hits must be recorded for track to be reconstructed and having its momentum measured (also on the largest gap allowed), we could actually simulate efficiency taking into account event and pile-up environment. Systematics of this

kind of approach could be controlled by varying the above assumptions (e.g. requiring three isolated hits puts absolute upper limit on the reconstruction efficiency, whereas requiring all hits to be isolated puts absolute lower limit on the efficiency).
Pile-up could be treated exactly.
One could also study use of IPC alone at high luminosity.
I believe such a tool would be useful not only for physics simulation but also for understanding of the limitations of the CT design.

This kind of code could substantially slow down the simulation. It also requires a dedicated person for code development and further application studies.

## MUON SYSTEM

PRESENT CODE: (provided by Roger McNeil,J.D. Sullivan, P. Dingus and T.S.)

Muons loose their energy in the calorimeter according to the parametrization by Roger McNeil, which depends on P and total calorimeter thickness. It includes catastrophic energy loss. It was obtained using BaF2 + SPACAL model.

The total energy loss is split into ionization and EM shower parts by using momentum dependent fraction (which, however, does not flactuate and is not correlated to the actual energy loss). Shower part is put into the calorimeter by adding "photon" to /hepevt/ which is then processed by the fast MC code in usual way. Ionization energy is deposited uniformly in the intersected cells.

To be measured muon must reach the muon system with exclusion of the geometrical acceptance gaps in eta and phi (at the entrance to the muon system). Momentum resolution was parametrized by J.D.Sullivan as a function of Pt, eta and phi.

Reconstruction and trigger efficiencies were parametrized as a function of Pt and theta at the detector origin by Peter Dingus.

Note that muons from decays in flight are simulated by the fast MC.
No simulation of muon efficiency in jet and shower leakage environment.
No simulation of fake muons due to the secondary punch through (i.e. tracks from shower leakage) /an old fast1 code exists which perhaps could be adopted/.

MINIMAL UPGRADE PLAN

Update geometry
+
Update energy loss routine to LKr+SPCAL design.
+
Update momentum resolution to the technology choice (produce two until final choice is made).
+
Improve reconstruction and trigger efficiencies and make them dependent on the muon parameters at the entrance to MU rather than at the detector origin.

OTHER PROBLEMS WHICH WE SHOULD DISCUSS

### Muon efficiency in jets

The present code is valid only for isolated muons.
Can we parametrize detector efficiency for muons in jets?

### Fake muons from punch through

Use old fast1 code ?

Transforming momentum vector measured in MU
to one at the interaction vertex
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There are two issues here:

- extrapolating trajectory back to the vertex point.
  (remember - fast code transports muons in magnetic field before they reach the MU system. Also decays in flight!)
  Can curvature be neglected ? Should we multiple-scatter muons ?
- adding back the energy loss.
  We need utility routine which will calculate average energy loss for given calo thickness.
  If somebody wants to put measured energy back we may improve on how this energy is deposited in the calorimeter.

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TRIGGER
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Muon system has its own trigger code.
Calorimeter trigger code was written by C. Allen but not officially integrated with the fast MC.
It is not quite clear to make what the trigger code is supposed to do for each analysis. If anything needs to be done here, it should be worked out by direct interaction of the physics simulation people with Charles Allen and Henk Uitjerval, who are willing to help with the fast simulation.

# GEMFAST PHYSICS SIMULATIONS FOR THE TECHNICAL DESIGN REPORT

## 1. Standard Model Higgs Physics

1.1 $H^0 \to \gamma\gamma$ ($M_H = 80 - 150\,\mathrm{GeV}$). This and the associated production process should be studied for couplings smaller than standard model (as in the minimal supersymmetric standard model) to determine the limits of intermediate-mass Higgs detectability.

1.2 $t\bar{t} + H^0 \to \ell\gamma\gamma + X$ ($M_H = 80 - 150\,\mathrm{GeV}$). This process will be studied at luminosities $\mathcal{L} = 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ and $10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$.

1.3 $H^0 \to Z^0 Z^0 \to \ell^+\ell^-\ell^+\ell^-$ for $\ell = e, \mu$ ($M_H = 140 - 800\,\mathrm{GeV}$). For the 800 GeV Higgs, this process will be studied at $\mathcal{L} = 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ and $10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$.

1.4 $H^0 \to Z^0 Z^0 \to \ell^+\ell^-$ jet jet ($M_H = 800\,\mathrm{GeV}$).

1.5 $H^0 \to Z^0 Z^0 \to \ell^+\ell^-\nu\bar{\nu}$ ($M_H = 800\,\mathrm{GeV}$).

## 2. Heavy Flavor Physics

2.1 $t\bar{t}$ production for $m_t = 140\,\mathrm{GeV}$ and $250 - 300\,\mathrm{GeV}$ in standard ($t \to W^+ b$) and non-standard ($t \to H^+ b$ for $m_t \geq 200\,\mathrm{GeV}$) decay modes and mass measurement via the $M_{\ell\mu}$ and multijet distributions. Tagging the $t\bar{t}$ events by an isolated lepton *plus* an inclusive muon from $b$-decay is a major test of GEM's abilities. The charged Higgs mass will be $M_{H^+} = 150\,\mathrm{GeV}$ and we shall assume the decay modes $H^+ \to c\bar{s}$ and $\tau^+\nu_\tau$ with variable branching ratios. Identification of $W^+$ and $H^+$ in dijet decay modes is an important consideration here.

2.2 If time permits, we shall study the $W$ polarization in $t \to W^+ b$ decay. This involves measuring the angular distribution, in the $W$ rest frame, of the dijet from $W$ decay relative to the $W$ direction in the $t$-quark rest frame.

2.3 Single technieta production, $gg \to \eta_T \to t\bar{t}$. The object is to see a peak in the $t\bar{t}$ invariant mass or in the $p_T$ distribution of the top quark.

## 3. Jet Physics

3.1 Quark substructure in high-$p_T$ and invariant mass jet production (deviation from QCD cross sections at $p_T \gtrsim 4\,\mathrm{TeV}$).

3.2 Devise a program for measurement of the parton distribution functions in experiments at low luminosity and carry out typical simulations (if time permits).

## 4. Physics at Ultrahigh Luminosity

4.1 Signal and backgrounds for quark – lepton substructure at the scales $\Lambda \gtrsim 25\,\mathrm{TeV}$ in the Drell-Yan process $\bar{q}q \to \mu^+\mu^-$.

4.2 Signal and backgrounds for quark – lepton substructure at the scales $\Lambda \gtrsim 25\,\mathrm{TeV}$ in the Drell-Yan process $\bar{q}q' \to \mu^\pm\nu$. Chiral structure of the contact interaction will be probed via the $\eta_\mu$ distribution.

4.3 Signal and backgrounds for $Z'^0 \to \ell^+\ell^-$, with $\ell^\pm = e^\pm, \mu^\pm$. Precision measurements of the mass and width (via $e^+e^-$) and asymmetries (via $\mu^+\mu^-$); determination of the reach in $M_{Z'}$.

4.4 Signal and backgrounds for $W'^\pm \to \ell^\pm\nu_\ell$. Precision measurements of the mass, width and asymmetry; determination of the reach in $M_{W'}$.

4.5 Signal and backgrounds for color-singlet $\rho_T^\pm \to Z^0W^\pm \to \ell^+\ell^-\ell^\pm + \not{E}_T$ and $\ell^+\ell^-$ jet jet.

## 5. Missing-$E_T$ Physics

5.1 Missing-$E_T$ requirements on the detector.

5.2 $\widetilde{gg}$ detection via the $\not{E}_T$ signature.

5.3 $\widetilde{gg}$ detection via the likesign dilepton signature. Although not strictly a missing-energy process, this complements the preceding search.

5.4 Squark production and detection via the $\not{E}_T$ signature. (Is squark-gluino production useful and/or interesting?)

[illegible] HC

The only good news:

Sasha Vanyashin volunteered to take care of pile-up simulation.
(should include FC)

Because of lack of (?)
manpower:

accept constant segmentation
no shower fluctuations
neglect tails in energy resolution ← cannot if large

MUST GET:

new geometry
average absorption and radiation length in cm
minimum ionizing energy per radiation length
average segmentation
thermal noise per cell (neglect size depend[illegible]
signal time-shapes for pile-up simulation

[illegible] physics [illegible]ulation [illegible]ple take [illegible]e of this [illegible]nselves?

( parametrization of angular resolution
parametrization of pointing )

[illegible]d full simulation

energy resolution vs E
energy resolution vs $\eta$, cracks
thickness of calorimeters vs $\eta$ (rad. length and abs. length)

PROJECTIVE CRACK SIMULATION ($\eta = 0$) ?

TR

Henk Uitjerval updated Charles Allen's code.
(need to discuss organization of code)

Henk and Charles should interact with people people doing physics simulation to see what the trigger issues are.

CT

Shawn McKee (f company) promised
- to update momentum resolution and track origin resolution to current design
- to provide primary vertex resolution for minimum bias and $H \to \gamma\gamma$ events
- to provide routine checking whether track is isolated (generator level?)

converted photons ?
do not quite see the use in the present framework which neglects all secondary charged tracks in CT
(need to discuss, what $H \to \gamma\gamma$ people want)

CT "calorimeter" i.e. naive hits simulation
did not see much interest from people simulating physics
CT people not willing to work on it
→ not going to do it

what we have is ≈ no CT simulation
are people happy with it ?
standard set of guesses ?

MU

Peter Dinqus asked Larry Rosenson for updated momentum resolution and geometrical acceptance.

Torre Wenaus will work on momentum resolution and geometrical acceptance in parallel using GEANE ? (need to talk)

Peter Dinqus promises updated energy loss, (reconstruction and trigger efficiencies

T.S. asked Jim Sullivan for update of the momentum resolution routine and Roger McNeil for update of the energy loss routine (no response so far)

Should we resurrect Roger McNeil's punch through code ? (need to discuss)

FC

Mike Shupe promised to work on it.

My guess is that we will get updated fsi-fcsmear from him.

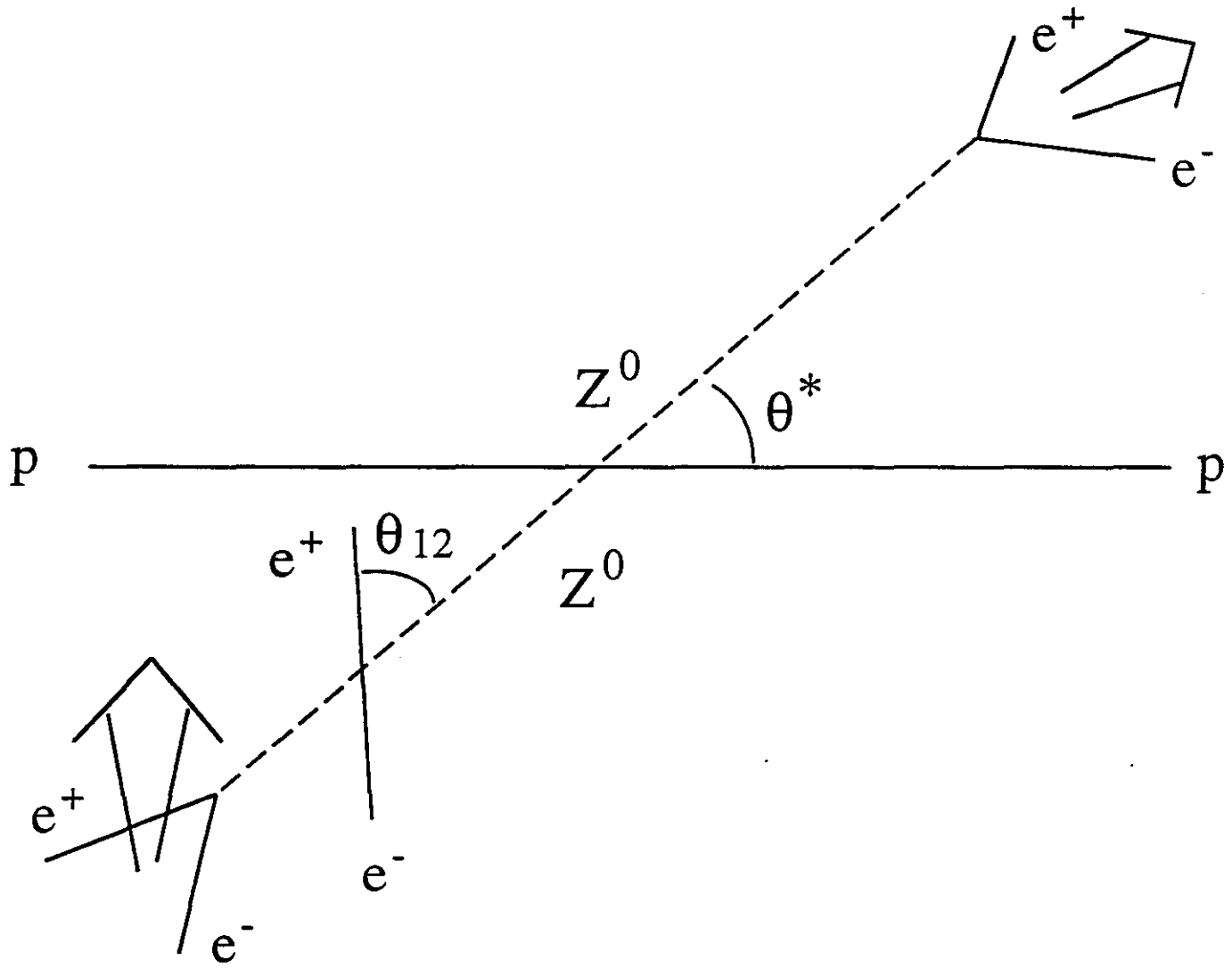
H. Yamamoto

- Process
  - tt H0 -> $\gamma + \gamma$
    - Higgs mass
    - pt range
    - top decay mode
      - leptonic decay
  - H0 -> $\gamma + \gamma$
  - H0 -> Z Z*
    - Higgs mass
    - Z and Z* mass range
    - decay mode of Z and Z*
      - 4 e, 2e2μ, 4μ
  - H0 -> Z Z
  - Z+Z
  - Z + W
  - W+ + W-
  - W+ + W+
  - jet + jet
  - $\gamma$ + jet
  - $\gamma + \gamma$
  - Minimum bias event
  - t t
  - Heavy Z0'
  - Drell-Yang
- In all dataset
  - Final State QED radiation ON
  - Peterson function for heavy quark fragmentation function
  - Top quark = 140 GeV
  - Updated Z and W decay table
  - Min bias - best fit by SDC
  - other...

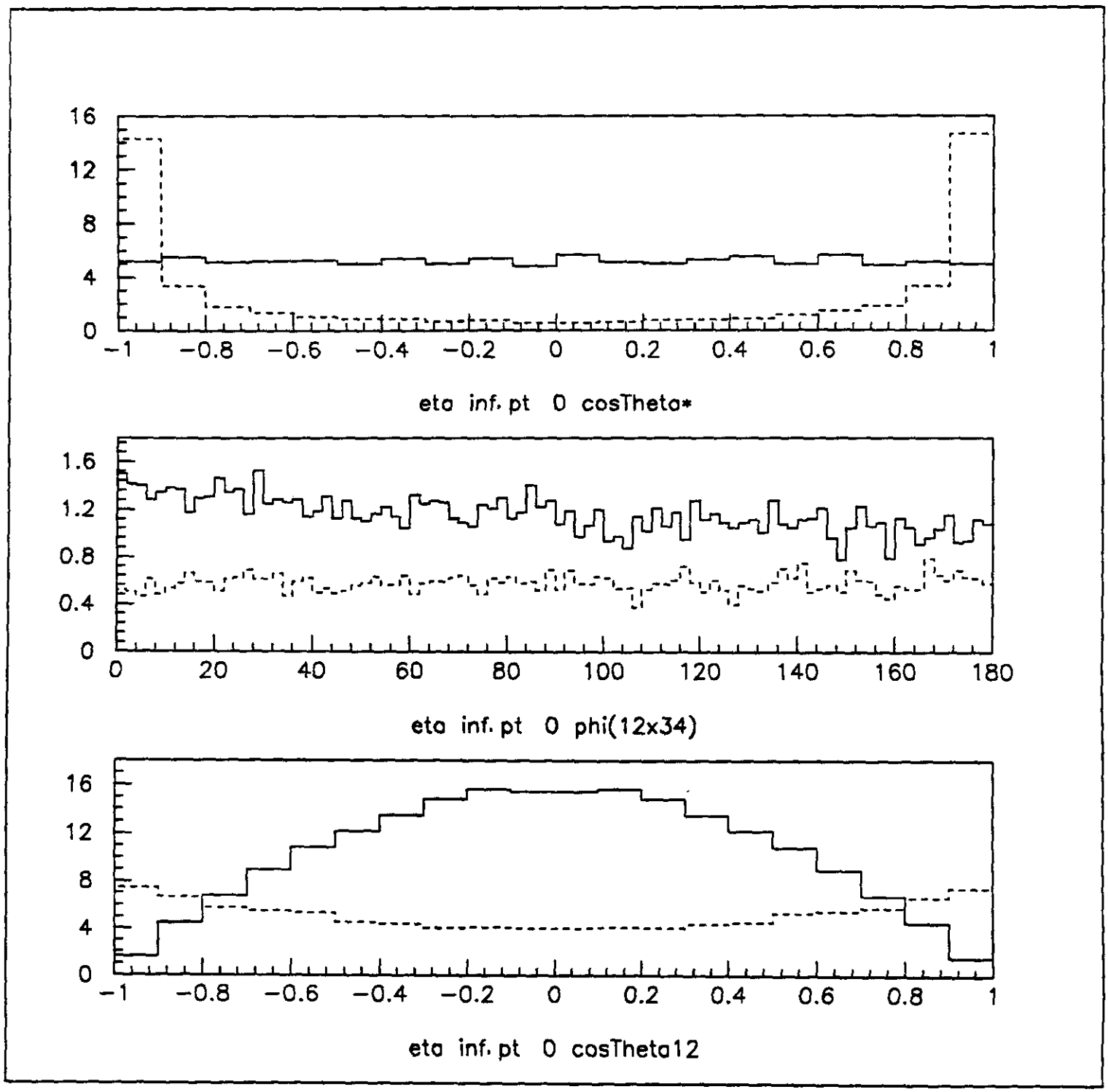
```
*****************************************************
*                                                   *
*                 S S C    A N A                    *
*                                                   *
*      Version: 2.01   26 Jul 1991                  *
*                                                   *
*****************************************************

*** ANL will now initialize ALL the available Sub-Processes...
Initialization of LUINP
Initialization of PY5X

   *** Default Initialization of PYTHIA parameters  *****
**********************************************
Following parameters are changed from default
Top Quark Mass (140 GeV)
Photon radiation in parton shower
Peterson function for heavy quark fragmentation
Z and W decay table
**********************************************
Initialization of PYTRIT
*** End of initialization ***

 Available Sub-Processes are:
 LUINP                 PY5X                  ZZBCK
 LUSAV

*** Please select active Sub-Processes, terminate by OK

 Submodule name(s)  ?
py ok
...... Selected thus far:
 PY5X
  1 selected entries which are different:
   2 PY5X

 ANL:  Select COM entries or GO or REDEFINE SubProcesses

 PY5X                      GO                        REDEFINE

 ANL: Select  1 option
 ANL>
py
 Lulist PRINTOUT (Y/N):  N ?

 fill ISAJET array (Y/N):  N ?


     *****  Initialization of PYTHIA parameters  *****

 PYH:  PYINIT ARGUMENTS and SHMin

FRAME     CMS
BEAM      P
TARGET    P
WIN       40000
QTMIN     10
QTMAX     -1
SHMIN               2.0
SHMAX     -1

 PYH: Hit <Return> to accept
 PYH>
```

```
 PYH:  parameter type

 MSTP                    PARP                    MSTI
 PARI                    MSEL                    MSUB
 KFIN                    CKIN                    JETSET
 SEED                    KFPR                    GO

 PYH: Select  1 option
 PYH>
jetset

          *****  Initialization of JETSET74 parameters  *****

 LND:  parameter type

 MSTU      PARU      MSTJ
 PARJ      DECAY     MASS
 LIFE      GO

 LND: Select  1 option
 LND>
decay

 particle id in KF code (0:exit):  0 ?
25

DCY: DECAY DATA of H0

 MODE#  DC  BRRAT    DECAY PRODS
 +   1   1  0.000   d           d~
 +   2   1  0.000   u           u~
 +   3   1  0.010   s           s~
 +   4   1  0.080   c           c~
 +   5   1  0.820   b           b~
 +   6   1  0.000   t           t~
 +   7  -1  0.000   l           l~
 +   8  -1  0.000   h           h~
 +   9   1  0.000   e-          e+
 +  10   1  0.000   mu-         mu+
 +  11   1  0.090   tau-        tau+
 +  12  -1  0.000   chi-        chi+
 +  13   1  0.000   g           g
 +  14   1  0.000   gamma       gamma
 +  15   1  0.000   gamma       Z0
 +  16   1  0.000   Z0          Z0
 +  17   1  0.000   W+          W-

 DCY: MODE #(0:exit,-1000:SetStable,-MODE#:SelOne,                1000:ShowMe,20
0
-14

DCY: Only Mode   14 is enabled

 DCY: MODE #(0:exit,-1000:SetStable,-MODE#:SelOne,                1000:ShowMe,20
0
0

 particle id in KF code (0:exit):  25 ?
0

 DCY:  parameter type

 MSTU      PARU      MSTJ
```

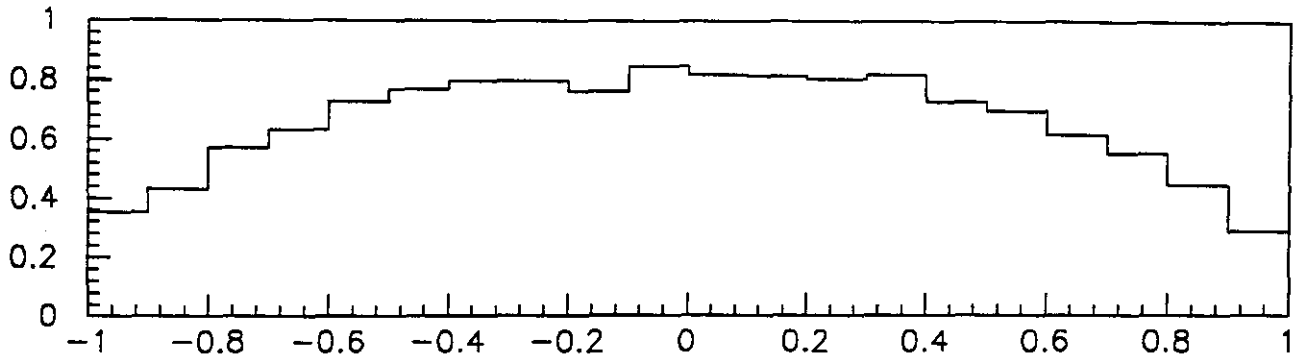
```
 PARJ      DECAY     MASS
 LIFE      GO

 DCY: Select  1 option
 DCY>
decay

 particle id in KF code (0:exit):  0 ?
101

%ERROR -- BAD PARTICLE ID

 particle id in KF code (0:exit):  101 ?
621

DCY: DECAY DATA of T0

 MODE#  DC  BRRAT    DECAY PRODS
 +   1   1  1.000   Wvirt+      b           specflav
 +   2   1  0.000   Wvirt+      s           specflav
 +   3  -1  0.000   H+          b           specflav

 DCY: MODE #(0:exit,-1000:SetStable,-MODE#:SelOne,                1000:ShowMe,20
0
86

 DCY:  decay table of T0

BR_RATIO     0.
CONTROL      0.
MATRIX       0.
1ST_DAUGH    0.
2ND_DAUGH    0.
3RD_DAUGH    0.
4TH_DAUGH    0.
5TH_DAUGH    0.

 DCY: Hit <Return> to accept
 DCY>


 DCY: MODE #(0:exit,-1000:SetStable,-MODE#:SelOne,                1000:ShowMe,20
0
0

 particle id in KF code (0:exit):  621 ?
86

DCY: DECAY DATA of t-hadron

 MODE#  DC  BRRAT    DECAY PRODS
 +   1   1  1.000   Wvirt+      b           specflav
 +   2   1  0.000   Wvirt+      s           specflav
 +   3  -1  0.000   H+          b           specflav

 DCY: MODE #(0:exit,-1000:SetStable,-MODE#:SelOne,                1000:ShowMe,20
0
```


e+
e-
Z0
θ*
p
p
e+
θ12
Z0
e+
e-
e-

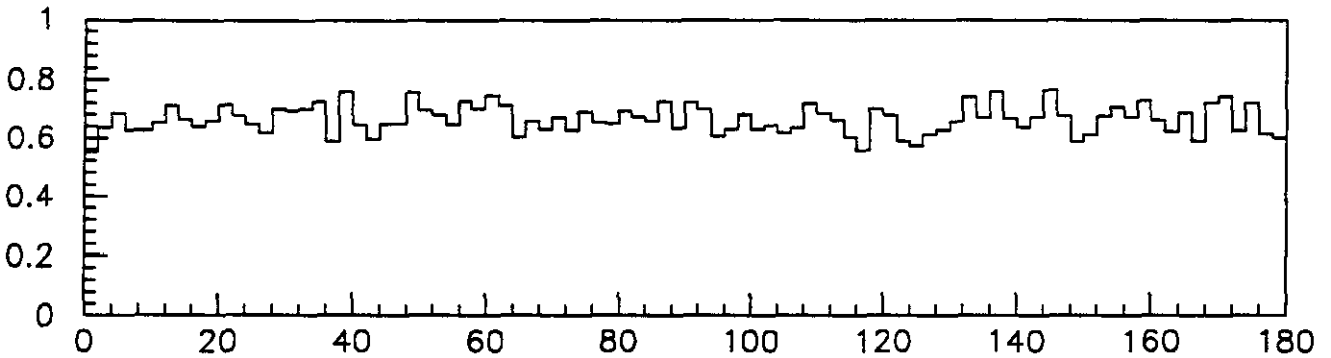
Generated


16
12
8
4
0
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
eta inf. pt 0 cosTheta*
1.6
1.2
0.8
0.4
0
0 20 40 60 80 100 120 140 160 180
eta inf. pt 0 phi(12x34)
16
12
8
4
0
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
eta inf. pt 0 cosTheta12

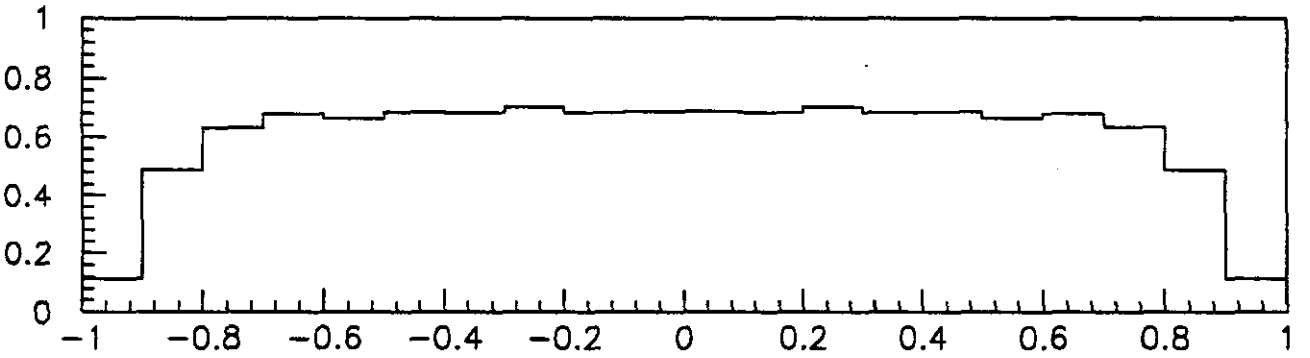
# Acceptance




acceptance for cosTheta*

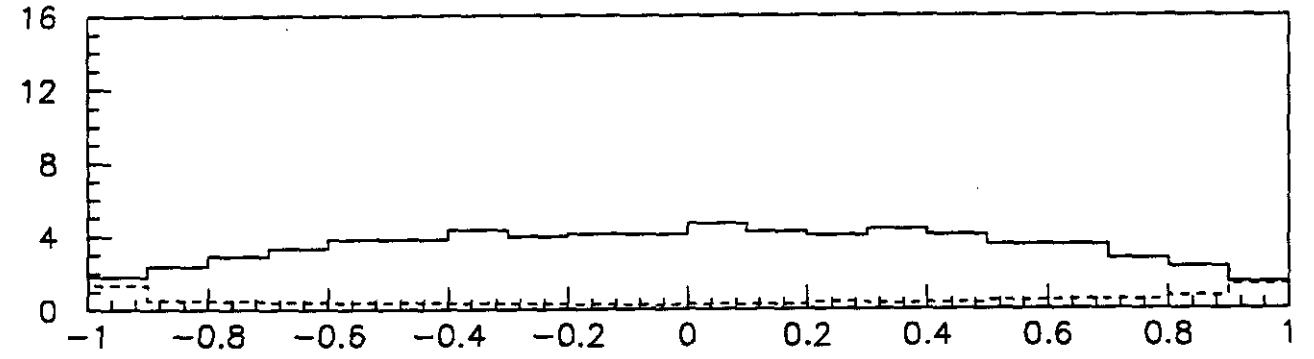



acceptance for phi(12x34)

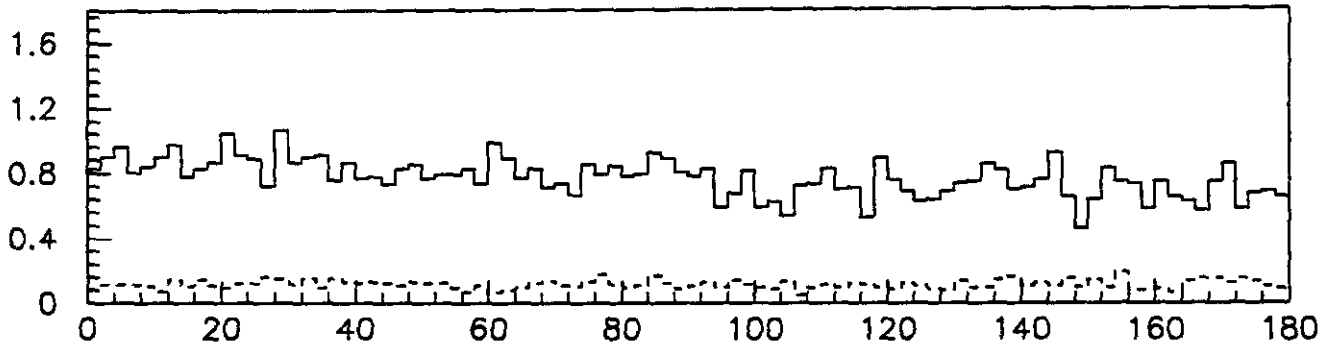



acceptance for cosTheta12

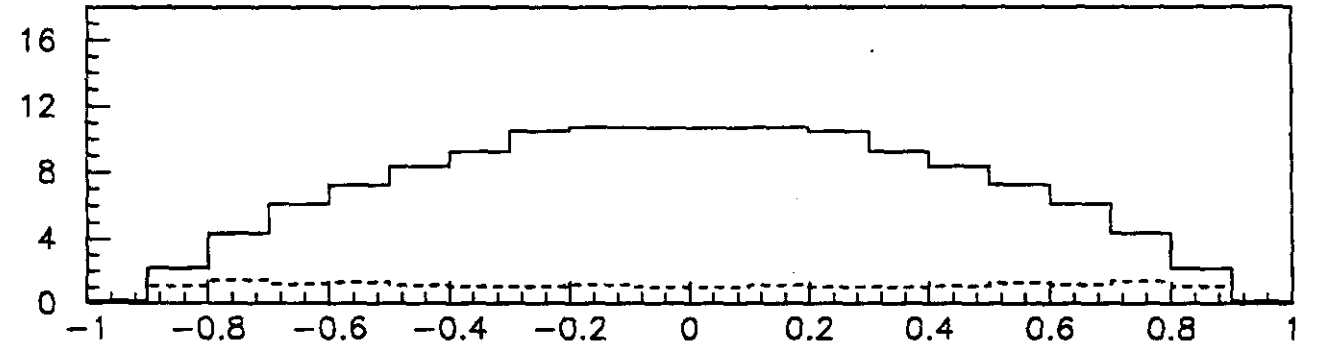
Observed ($\eta < 2.5$ $p_T^e > 20$)




eta 2.5, pt 20 cosTheta*

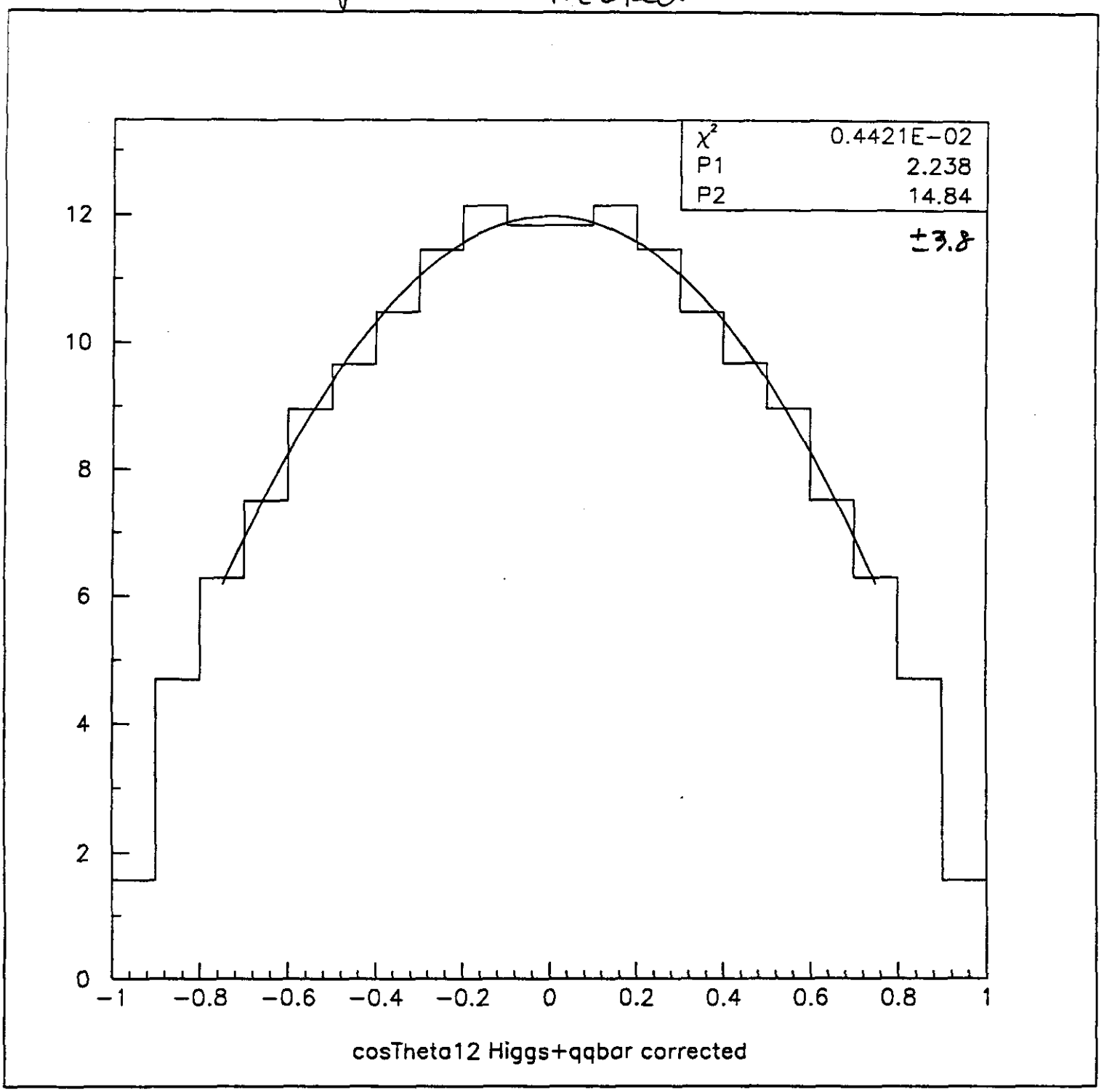


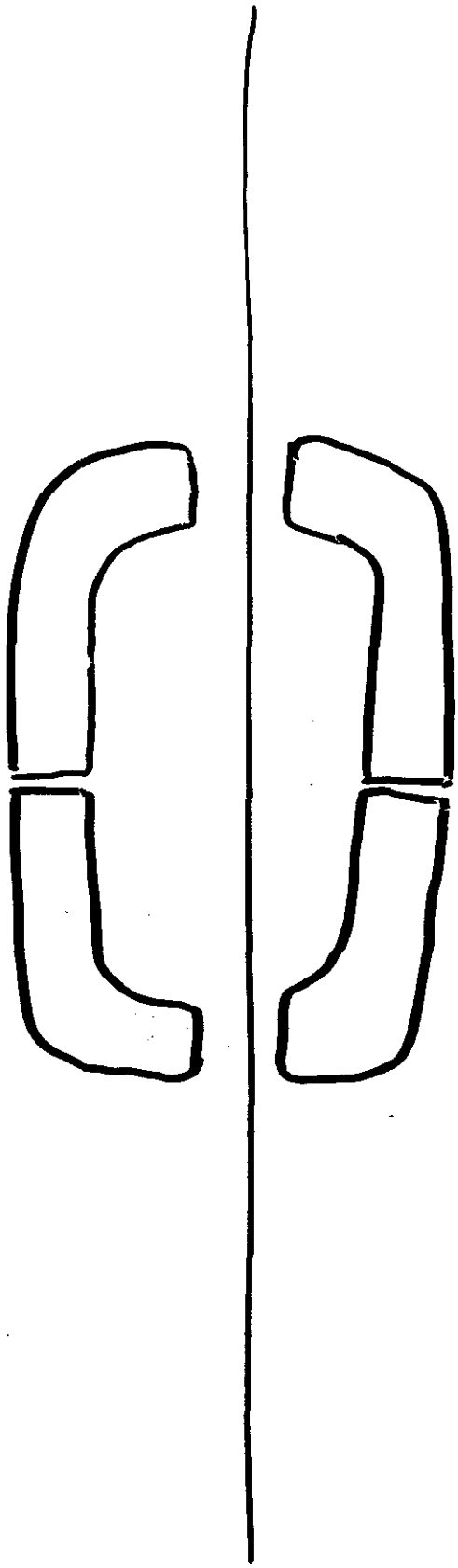

eta 2.5, pt 20 phi(12x34)



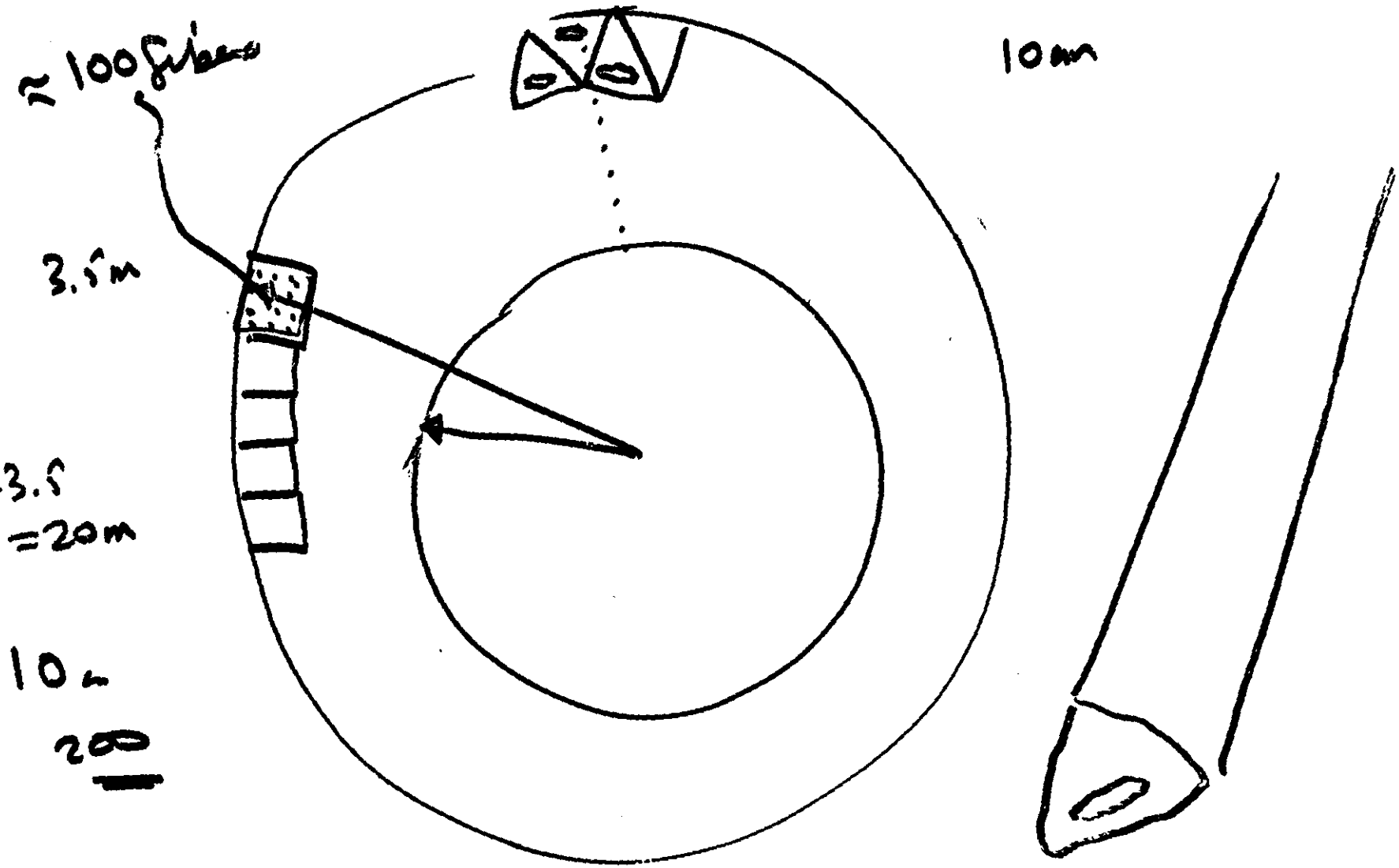

eta 2.5, pt 20 cosTheta12

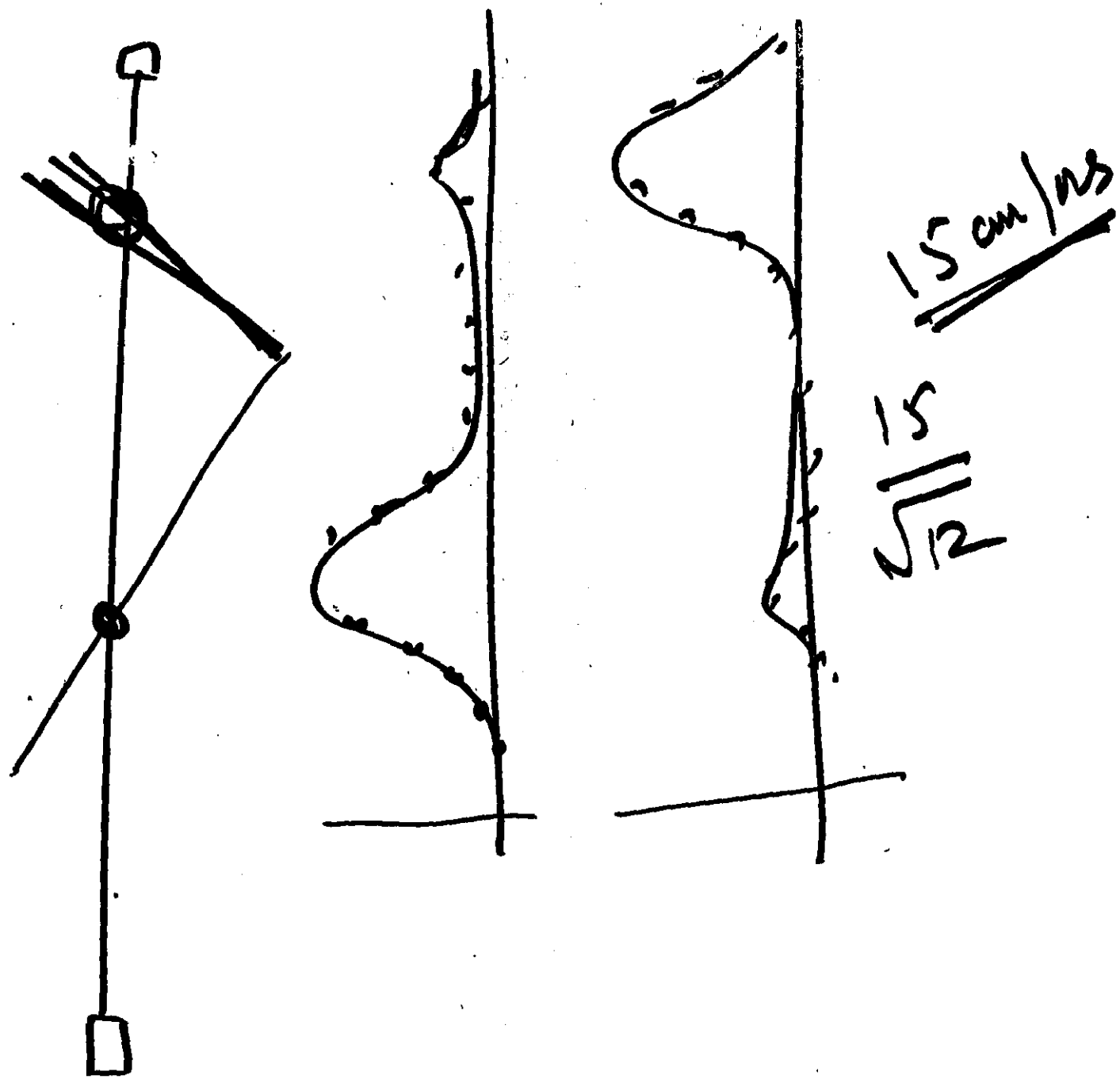
Acceptance Corrected





6 mm × ~~100~~ 240 = 1 m




15 cm/ns
15
√12

# How to get started with gemware

(1) Setup your environment

add to the end of your .cshrc

source /gem/etc/gemsetup.csh

(2) Look at the demo's

/gem/demo/...

(3) Read the instructions

man pages

README files



J. Shear

25/[illegible]/92

# gemgen

generic generator interface package

Programs:

gempyt - PYTHIA 5.6 interaction generator

gemisa - ISAJET 646 interaction generator

gemspg - JETSET 7.2 based single particle generator

gemgfa - event builder

libraries:

- libutg - generator utility library
- libpyt - PYTHIA 5.6 interface routines
- libisa - ISAJET 646 interface routines
- libspg - JETSET 7.2 based single particle generator
- libgta - event builder routines

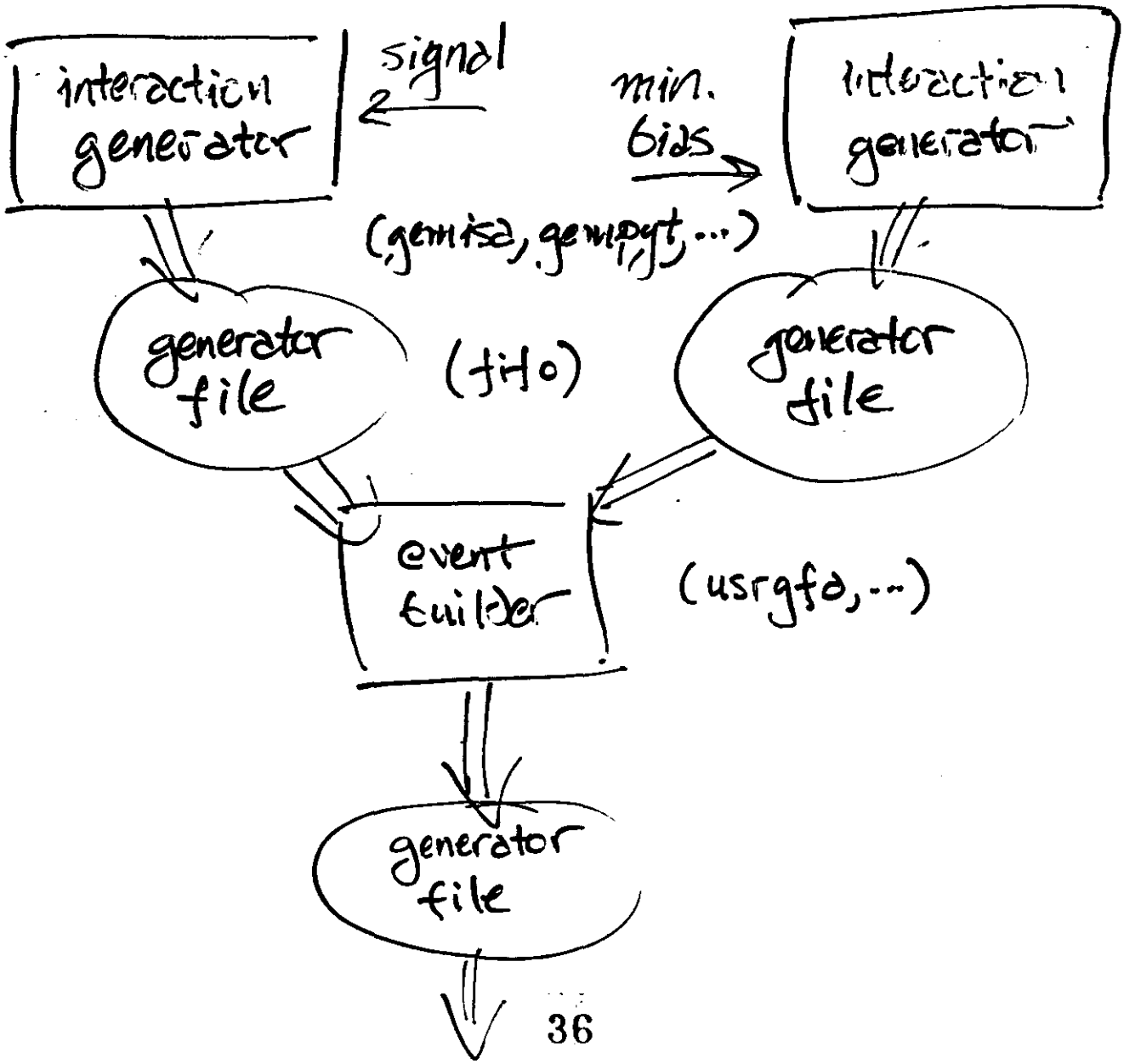
demos:

- usrpyt - user analysis of PYTHIA 5.6 interactions
- usrisa - user analysis of ISAJET 646 interactions

## Demos (cont.)

usrspg – user analysis of interactions made from single particles

usrgfa – user event analysis



Documentation: manpages - gemgen(5)
gempyt(1)
gemisa(1)
gemspg(1)
gemgfa(1)
libutg(3)
libpyt(3)
libisa(3)
libgfa(3)
libspg(3)

README's - /gem/demo/
gemgen/
usrpyt/
usrisa/
usrspg/
usrgfa/

How do you get programs to do what you want?

1. rtp (run time parameter) file
   read from stdin

2. generator setup file
   filename is rtp

   gempyt, gemspg } file parsed to lugive

   gemisa - regular isajet setup

```
*(+doc.)
*************************************************************************
*
* Project    :  gemgen
* Purpose    :  example rtp file for PYTHIA generator job
* Author     :  I.Sheer <sheer@sscvx1>
* RCS info   :
*  $Source: /tmp_mnt/home/dssg1/gemlib/gem_hp/ins/gemgen/demo/gempyt/vdev/RCS/H0_2g
*  $Revison$, $Date: 1992/09/24 22:34:03 $
*  $Author: sheer $, $Locker:  $, $State: Exp $
*  $Log: H0_2gamma.rtp,v $
*  Revision 1.1  1992/09/24  22:34:03  sheer
*  Initial revision
*
*   Revision 1.3  1992/09/21  15:58:46  sheer
*   inserted all possible runtime parameters
*
*   Revision 1.2  1992/09/16  14:05:23  sheer
*   added RCS header
*
*************************************************************************
*(-doc.)
*
* utg runtime parameters
*
idebug_utg = 1              ! debug level
nprint_utg = 2              ! events to print using heplst
nskip_utg = 10              ! events to skip
mlist_utg = 1               ! heplst list mode
mxerr_utg = 10              ! maximum number of generator errors
iozeb_utg = 0               ! FZ i/o flag
mxsel_utg = -1              ! maximum number of events to select
timel_utg = 300             ! cpu time limit
iosel_utg = 1               ! select all events by default
ofile_utg = 'H0_2gamma.out' ! event output file
*
* pyt runtime parametes
*
sqrts_pyt = 40000.          ! center-of-mass energy
irun_pyt = 5000             ! starting run number
nevnt_pyt = 10              ! events to generate
nprint_pyt = 0              ! events to print using lulist
nskip_pyt = 0               ! events to skip
mlist_pyt = 1               ! lulist list mode
iseed_pyt = 19780503        ! random number seed
rnget_pyt = ' '             ! random number generator state get file
rnput_pyt = 'random.dat'    ! random number generator state put file
jfile_pyt = 'H0_2gamma.pyt' ! pythia job file
end
```

rtp file for gempyt

```
*(+doc.)
*********************************************************************
*
* Project    :  gemgen
* Purpose    :  example H0 -> gamma gamma PYTHIA setup
* Author     :  I.Sheer <sheer@sscvx1>
* RCS info   :
*  $Source: /tmp_mnt/home/dssg1/gemlib/gem_hp/ins/gemgen/demo/gempyt/vdev/RCS/H0_2g
*  $Revison$, $Date: 1992/09/24 20:38:12 $
*  $Author: sheer $, $Locker:  $, $State: Exp $
*  $Log: H0_2gamma.pyt,v $
*  Revision 1.1  1992/09/24  20:38:12  sheer
*  Initial revision
*
*********************************************************************
*(-doc.)
*
MSEL=16            ! H0 production
*
MDME(184,1)=0      ! supress H0 -> d d~
MDME(185,1)=0      ! supress H0 -> u u~
MDME(186,1)=0      ! supress H0 -> s s~
MDME(187,1)=0      ! supress H0 -> c c~
MDME(188,1)=0      ! supress H0 -> b b~
MDME(189,1)=0      ! supress H0 -> t t~
MDME(190,1)=-1     ! supress H0 -> l l~
MDME(191,1)=-1     ! supress H0 -> h h~
MDME(192,1)=0      ! supress H0 -> e- e+
MDME(193,1)=0      ! supress H0 -> mu- mu+
MDME(194,1)=0      ! supress H0 -> tau- tau+
MDME(195,1)=-1     ! supress H0 -> chi- chi+
MDME(196,1)=0      ! supress H0 -> g g
MDME(197,1)=1      ! allow H0 -> gamma gamma
MDME(198,1)=0      ! supress H0 -> gamma Z0
MDME(199,1)=0      ! supress H0 -> Z0 Z0
MDME(200,1)=0      ! supress H0 -> W+ W-
*
PMAS(C6,1)=140.    ! top quark mass
PMAS(C25,1)=80.    ! H0 mass
*
MDCY(C111,1)=0     ! inhibit pi0 decays
*
MSTJ(22)=4         ! particle decayed only if in cylinder (for later tracking)
PARJ(73)=20.       ! cylinder radius (cm)
PARJ(74)=10000.    ! cylinder length (cm)
END
```

setup file for gempyt

"$H^0 \to \gamma\gamma$"

```
*(+doc.)
*************************************************************************
*
* Project    :  gemgen
* Purpose    :  example minimum bias PYTHIA setup file
* Author     :  I.Sheer <sheer@sscvx1>
* RCS info   :
*  $Source: /tmp_mnt/home/dssg1/gemlib/gem_hp/ins/gemgen/demo/gempyt/vdev/RCS/minbi
*  $Revison$, $Date: 1992/09/24 20:38:12 $
*  $Author: sheer $, $Locker:  $, $State: Exp $
*  $Log: minbias.pyt,v $
*  Revision 1.1  1992/09/24  20:38:12  sheer
*  Initial revision
*
*************************************************************************
*(-doc.)
*
MSEL=0            ! full user control of subprocesses
MSUB(92)=1        ! include single diffractive subprocess
MSUB(93)=1        ! include double diffractive subprocess
MSUB(95)=1        ! include low pt subprocess
*
PMAS(C6,1)=140.   ! top quark mass
PMAS(C25,1)=100.  ! H0 mass
*
MDCY(C111,1)=0    ! inhibit pi0 decays
*
MSTJ(22)=4        ! particle decayed only if in cylinder (for later tracking)
PARJ(73)=20.      ! cylinder radius (cm)
PARJ(74)=10000.   ! cylinder length (cm)
END
```

setup file for gempyt

" min bias "

```
*(+doc.)
*************************************************************************
*
* Project    :  gemgen
* Purpose    :  example rtp file for gemisa demo
* Author     :  I.Sheer <sheer@sscvx1>
* RCS info   :
*  $Source: /tmp_mnt/home/dssg1/gemlib/gem_hp/ins/gemgen/demo/gemisa/vdev/RCS/minbi
*  $Revison$, $Date: 1992/09/24 23:18:11 $
*  $Author: sheer $, $Locker:  $, $State: Exp $
*  $Log: minbias.rtp,v $
*  Revision 1.1  1992/09/24  23:18:11  sheer
*  Initial revision
*
*************************************************************************
*(-doc.)
*
* utg runtime parameters:
*
idebug_utg = 1              ! debug level
nprint_utg = 5              ! events to print using heplst
nskip_utg = 10              ! events to skip
mlist_utg = 1               ! heplst list mode
mxerr_utg = 10              ! maximum number of generator errors
iozeb_utg = 0               ! FZ i/o flag
mxsel_utg = -1              ! maximum number of events to select
timel_utg = 300             ! cpu time limit
iosel_utg = 1               ! select all events by default
ofile_utg = 'minbias.out'   ! event output file
*
* isa runtime parameters
*
irun_isa = 5000             ! starting run number
nprint_isa = 0              ! events to print using prtevt
nskip_isa = 0               ! events to skip
idtpf_isa = 0               ! decay table print flag
cseed_isa = '225694492122301.0' ! random number seed
rnget_isa = ' '             ! random number generator state get file
rnput_isa = 'random.dat'    ! random number generator state put file
dtble_isa = 'decay.table'   ! isajet decay table
jfile_isa = 'minbias.isa'   ! isajet job file
end
```

rtp file for gemisa

```
SAMPLE HIGGS JOB FOR SSC
40000,10,0,0/
HIGGS
QMW
400,1600/
HMASS
800/
JETTYPE1
'Z0'/
JETTYPE2
'Z0'/
WMODE1
'MU+','MU-'/
WMODE2
'E+','E-'/
PT
50,20000,50,20000/
END
STOP
```

setup file for gemisa

" $H^0 \rightarrow Z^0 Z^0 \rightarrow \mu^+\mu^-$ "
$\hookrightarrow e^+e^-$

```
SAMPLE MINBIAS JOB
40000.,100,0,0/
MINBIAS
END
STOP
```

Setup file for gemisa

"min bias"

```
*(+doc.)
*************************************************************************
*
* Project    :  gemgen
* Purpose    :  example rtp file for gemgfa demo (H0 -> gamma gamma at
*               10**34 using pythia for signal and isajet for pileup)
* Author     :  I.Sheer <sheer@sscvx1>
* RCS info   :
*  $Source: /tmp_mnt/home/dssg1/gemlib/gem_hp/ins/gemgen/demo/usrgfa/vdev/RCS/usrg:
*  $Revison$, $Date: 1992/09/26 07:48:45 $
*  $Author: sheer $, $Locker:  $, $State: Exp $
*  $Log: usrgfa.rtp,v $
*   Revision 1.4  1992/09/26  07:48:45  sheer
*   name changes
*
*   Revision 1.3  1992/09/26  04:41:34  sheer
*   increased debug level to 2
*
*   Revision 1.2  1992/09/26  02:32:10  sheer
*   10**34 luminosity
*
*  Revision 1.1  1992/09/16  15:39:48  sheer
*  Initial revision
*
*************************************************************************
*(-doc.)
*
* utg runtime parameters:
*
idebug_utg = 2              ! debug level
nprint_utg = 1              ! events to print
nskip_utg = 10              ! events to skip
mlist_utg = 1               ! listing mode
mxerr_utg = 10              ! maximum number of generator errors
iosel_utg = 1               ! select all events by default
iozeb_utg = 0               ! output format switch
mxsel_utg = -1              ! maximum number of events to select
timel_utg = 300             ! time limit in cpu seconds
ofile_utg = 'usrgfa.out'    ! output file name
*
* gfa runtime parameters:
*
nevnt_gfa = -1              ! number of events to read
irun_gfa = 725              ! starting run number
iozeb_gfa = 0 0             ! input format switch
iseed_gfa = 65539           ! random number seed
vertx_gfa = 0. 0. 0.        ! mean vertex position (mm)
sigma_gfa = 0. 0. 70.       ! Gaussian spread on vertex position (mm)
avemb_gfa = 16.             ! mean value of poisson dist
rnget_gfa = ' '             ! random number state get file
rnput_gfa = 'random.gfa'    ! random number state put file
signal_gfa = 'H0_2gamma.out' ! input file for signal interactions
mnbias_gfa = 'minbias.out'   ! input file for minimum bias interactions
end
```

rtp file for gemgfa

## User Handles:

usrdefs - set defaults

usrinit - initialize

usrbofr - beginning-of-run

usrevnt - processes event

usreofr - end-of-run

usrdone - job termination

# GEMFAST

Uses gemgen framework (usrgta)

libraries: libfsi - fast simulation routines

libfxb - fast clustering routines

demo: fsi_demo - näive $H \to \gamma\gamma$ search

documentation: man pages - gemfast(5)
libfsi(3)
libfxb(3)

README - /gem/demo/gemfast/

How to Build your own version of GEMFAST:

(1) cp /gem/demo/gemfast/* .
copies demo files to your current directory.

(2) customize fsi_demo.F

(3) make demo

# gemfast

usrdefs: call fsi_ini

usrinit: call fsi_ipr (optional)

usrevnt: call fsi_evt

call fsi_addpile (optional)

call fxb_xb (optional)

call fxb_fixtec (optional)

call fsi_epr (optional)

call fxb_xbpr (optional)

fsi_cacone
fsi_eccone
fsi_hccone
fsi_cajets
fsi_etoeta
fxb_gtoec
fxb_gtoca

} utilities

# Improvements in the pipeline

1. improved coordination for multitasking (better gfaexam2.)
2. signal handling to allow for graceful termination
3. rewrite of stdhep i/o routines to allow use of fifo's on platforms other than hp/sun