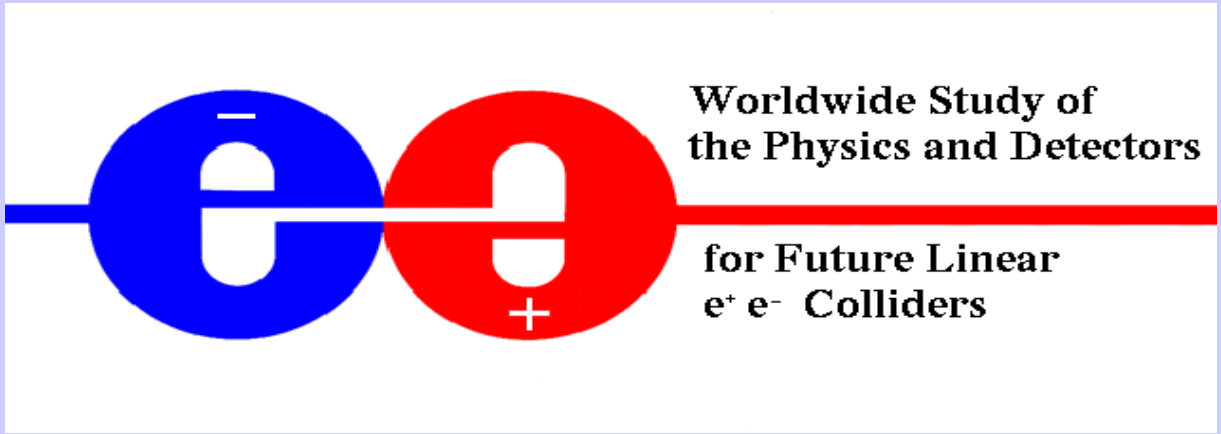
Further Developments of RERECO Vertex and Kink Finding Particle Propagation to IP



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Motivation

- Pflow concept : reconstruction of every primary particle produced in e^+e^- interactions

- Primary particles may decay and interact with detector material giving rise to V0's and kinks $\rightarrow$secondary objects (pieces of tracks and additional calorimeter clusters) : problem of double counting arises

- Dedicated procedure of V0 and kink ID must be worked out to facilitate Pflow algorithm

Algorithm Strategy and Definitions

- Strategy
  1. Finding V0's and kinks
  2. Identification of basic reconstructed objects (track segments, calorimeter clusters) associated with V0's and kinks
  3. Correct propagation of particles to IP and exclusion of secondary tracks and calorimeter clusters
- V0's
  - ✔ Decays of neutral strange particles (Λ^0, K^0_S, ...)
  - ✔ Photon conversion
- Kinks
  - ✔ Decays of charged particles
  - ✔ Bremstrahlung
  - ✔ Multiple scattering at large angle
  - ✔ Artificial kinks due to tracking procedure

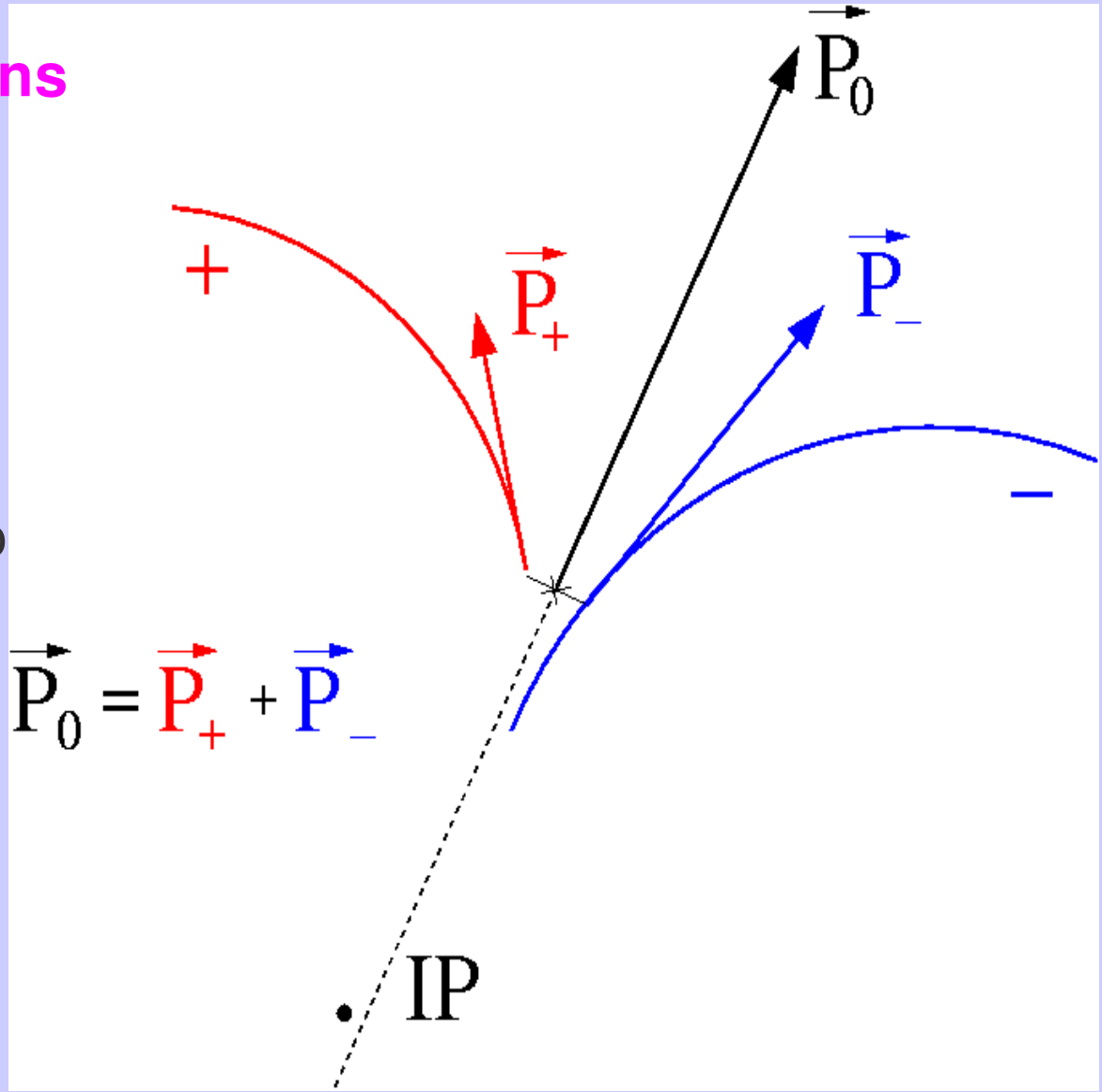
V0 (Neutral Vertex)

Two types of V0's

1. decays of neutral hadrons

2. photon conversion

- Signature : two **charge conjugate** tracks with small distance between them
- Minimal distance is searched for using helix model for the two tracks
- Neutral particle momentum is calculated as vectorial sum of charged particle momenta @ the reconstructed decay point
- The two tracks and associated clusters are replaced by new object : V0

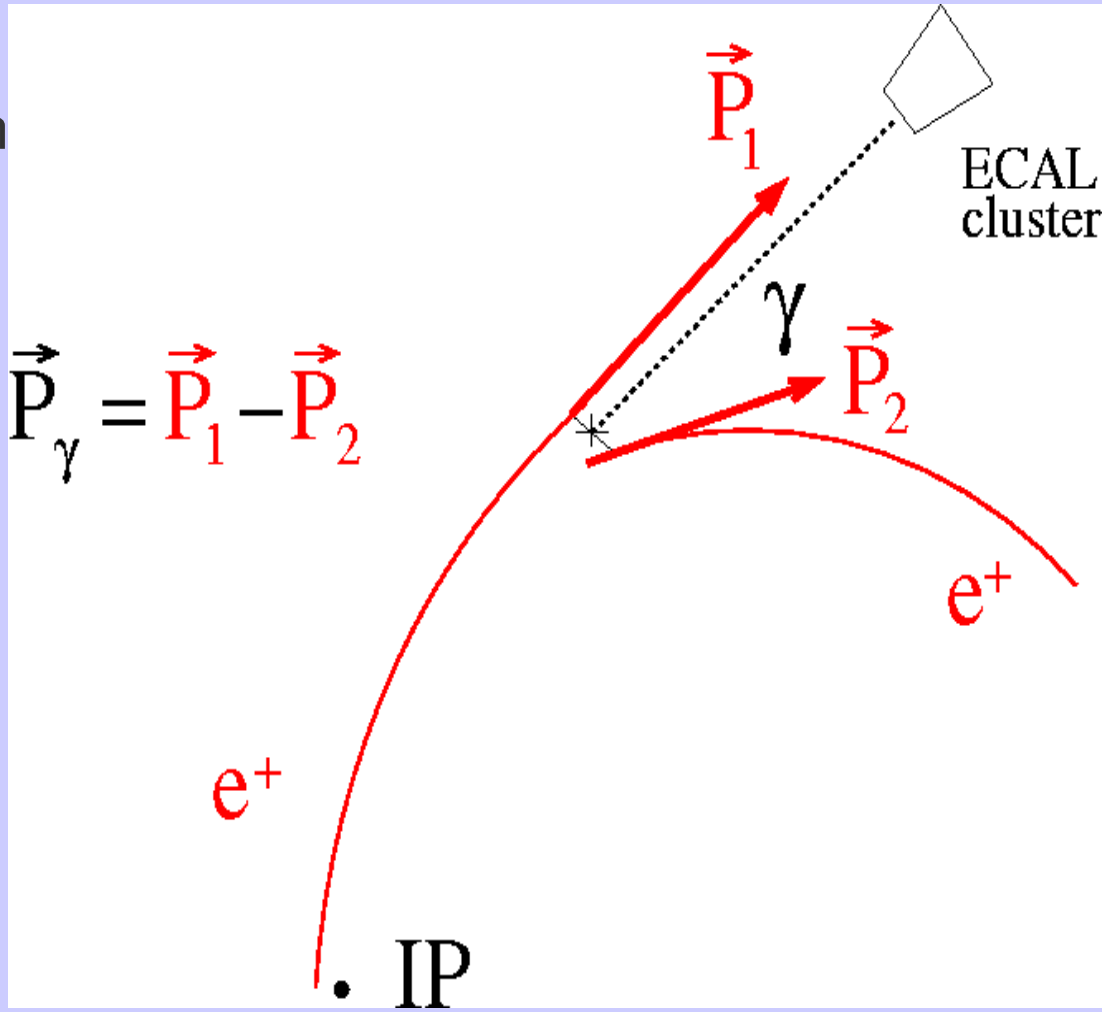


Kinks

Two types of kinks

1. Kinks with associated neutral clusters (bremstrahlung, $\Sigma^- \rightarrow n\,\pi^-$, $\Sigma^+ \rightarrow p\pi^0$)
2. Kinks without neutral clusters (scattering at large angle, $K \rightarrow \mu\nu$, $\pi \rightarrow \mu\nu$, ...)

- Signature : two tracks of **the same charge** and small distance between them
- Kink can be accompanied by detectable neutral object
- Hypothesis of accompanying neutral particle is tested by searching for neutral cluster matching “reconstructed” trajectory of neutral object
- Secondary track and neutral clusters associated with kink are removed from the list of Pflow objects
- Initial track is retained in the list of Pflow objects



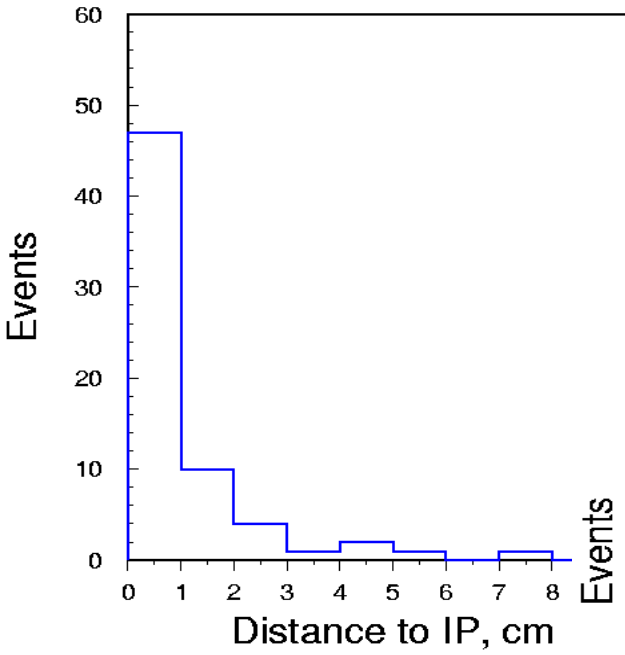
Checking Algorithm on Single Particles

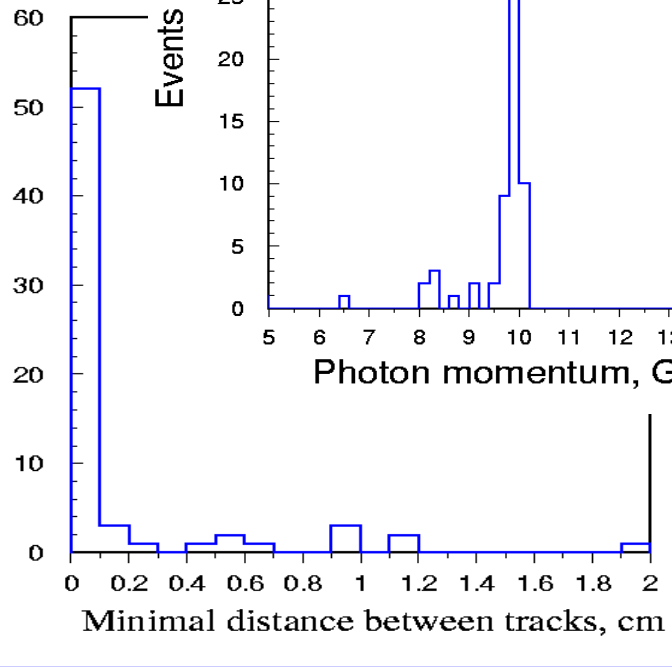
- Basic checks are performed using samples of events with single particles
- Reference samples : photons, electrons, K_S^0's and Λ^0's
- Particle are generated at fixed position (0.,0.,0.) with fixed energy and momentum vector isotropically distributed over solid angle
- Simulation of detector response is done with BRAHMS
- Reconstruction is performed by SNARK

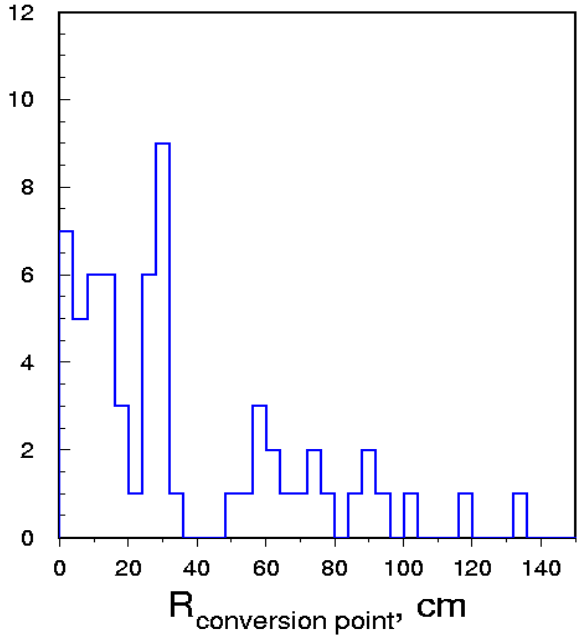
Control Distributions for Events with Single Photon

- 1000 single photon events
- conversion occurs in 7% (70 events)
- photon energy is 10GeV

Events with gamma conversion



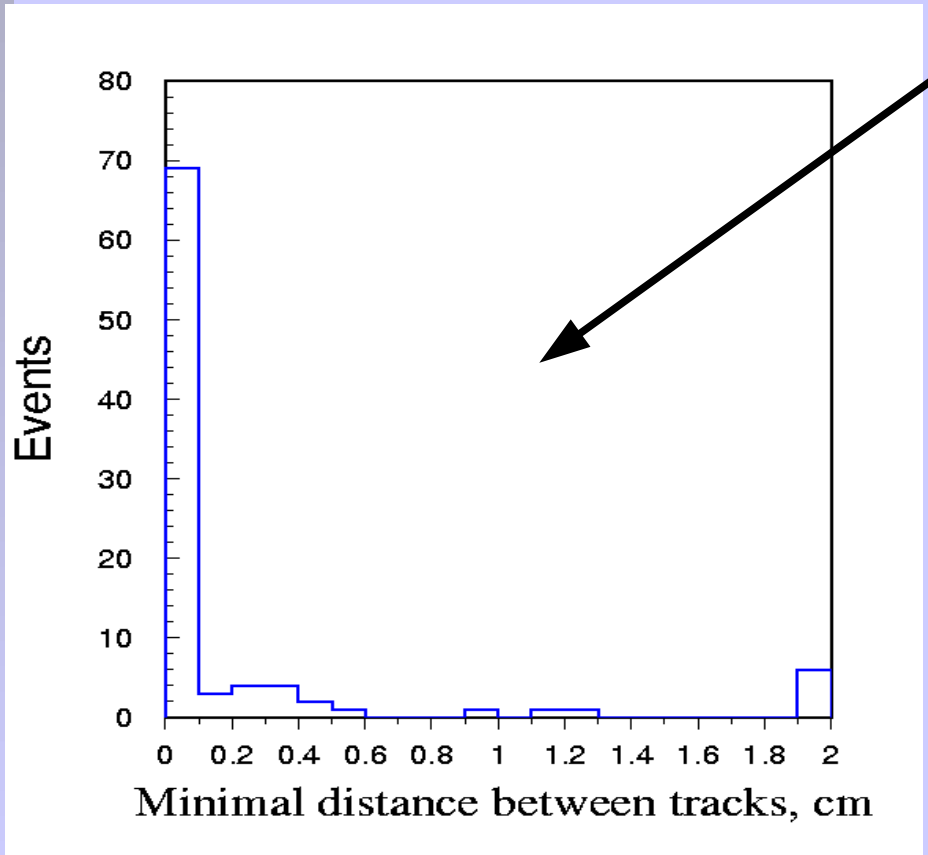


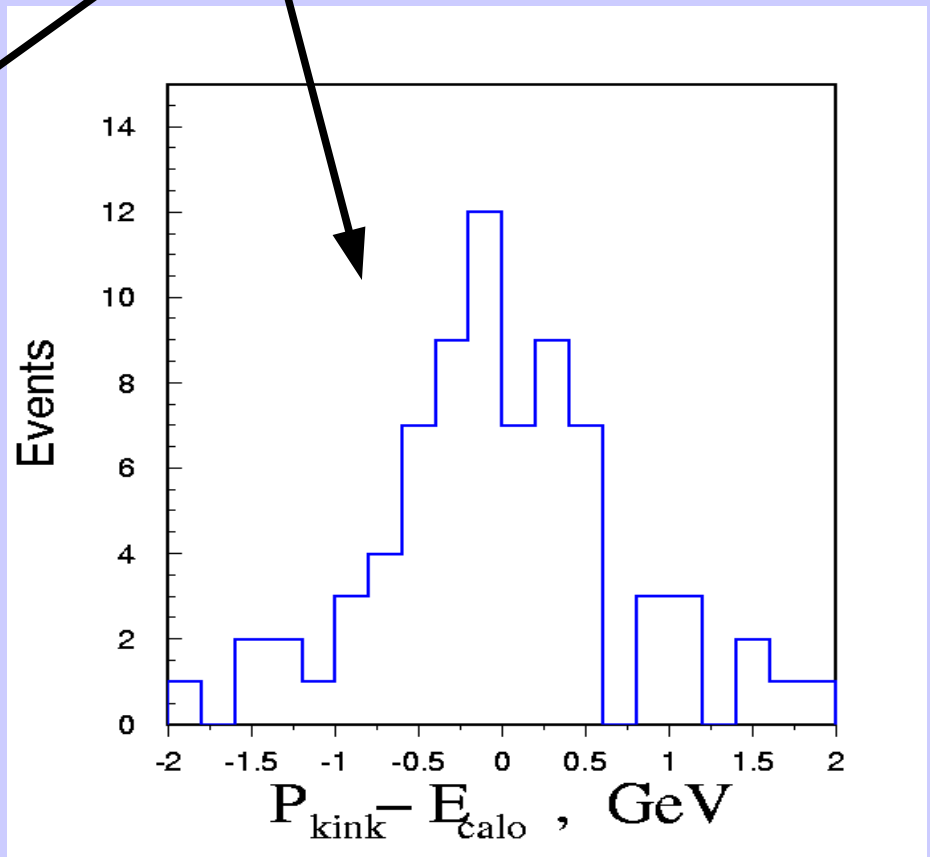


Control Distributions for Events with Single Electron

- 1000 single electron events
- Bremstrahlung occurs in 9% (90 events)
- Electron energy is 10 GeV

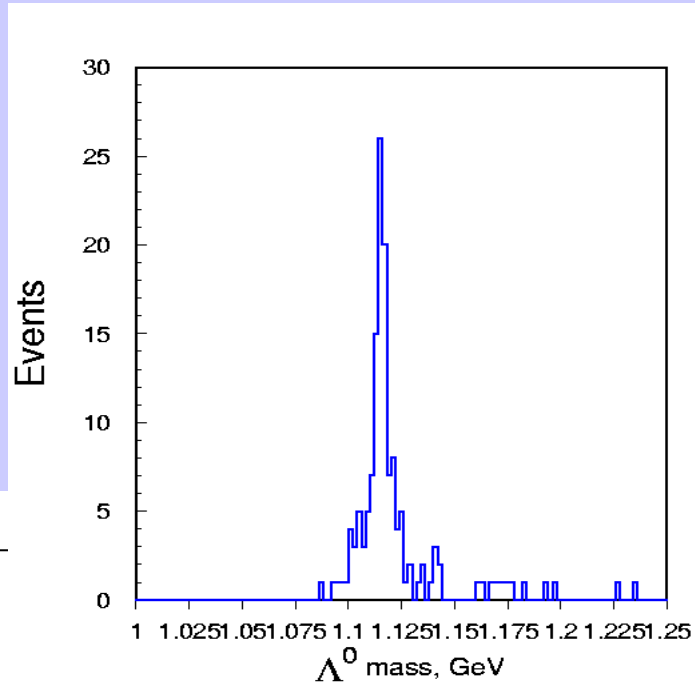
Events with bremstrahlung

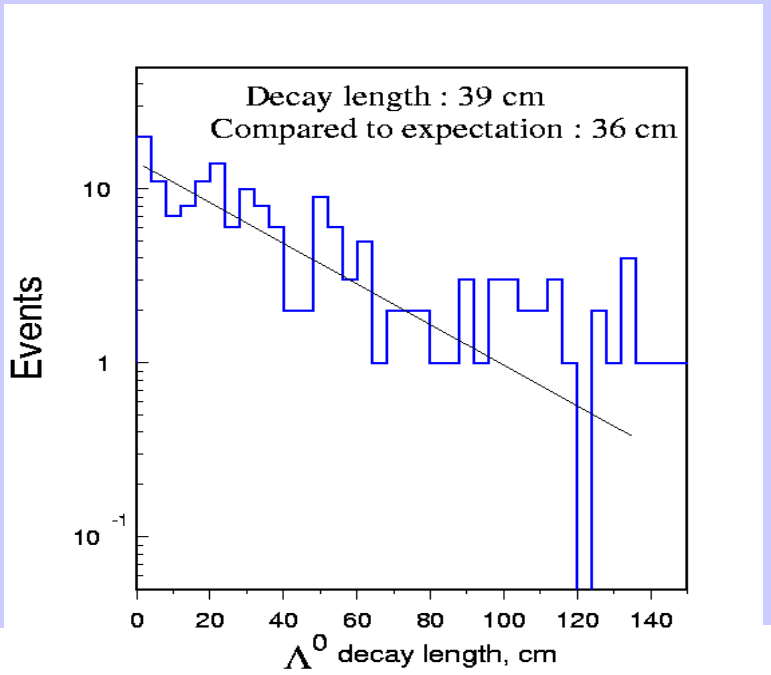


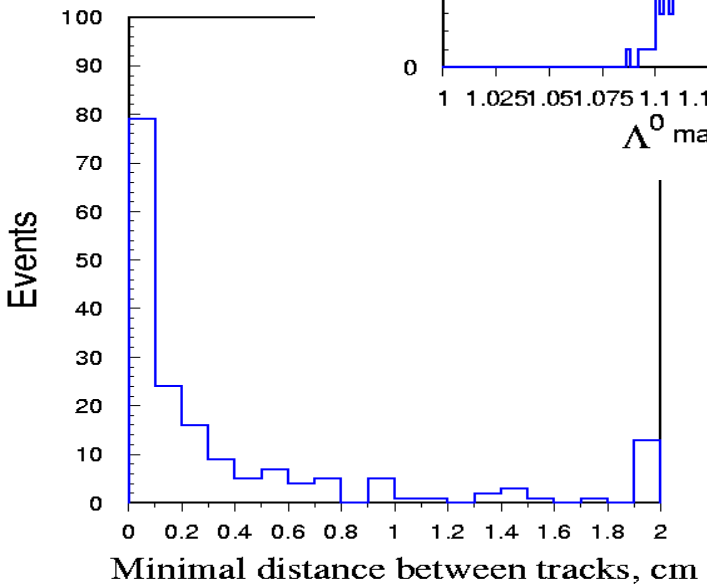


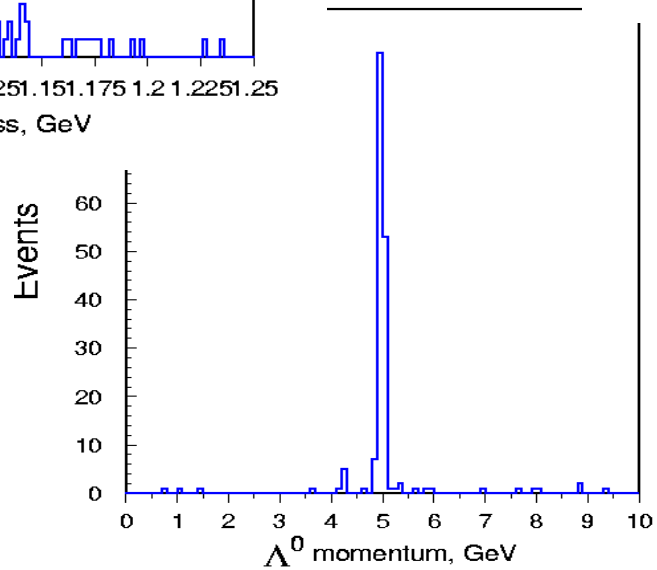
Control Distributions for Events with Single Λ^0

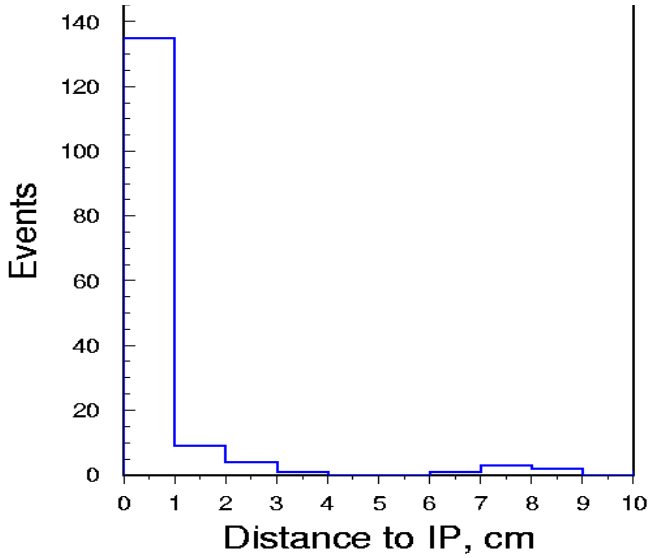
- 150 events with $\Lambda^0 \rightarrow p\pi^-$





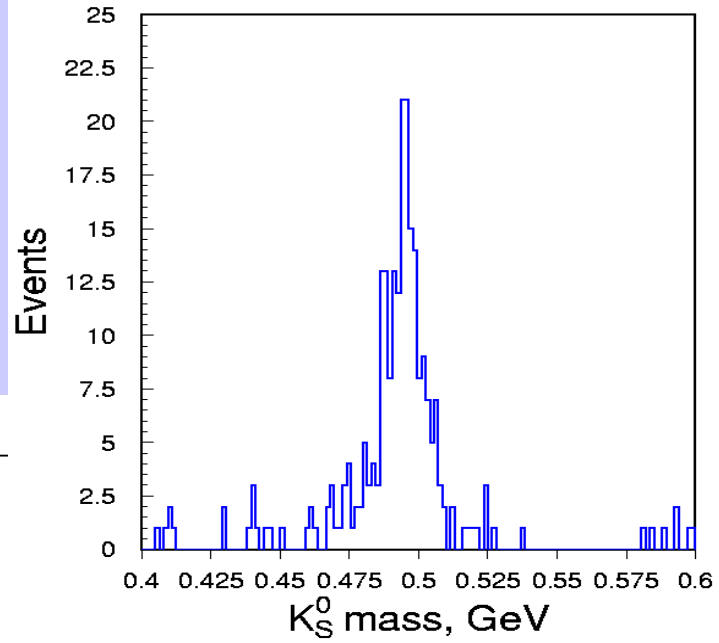


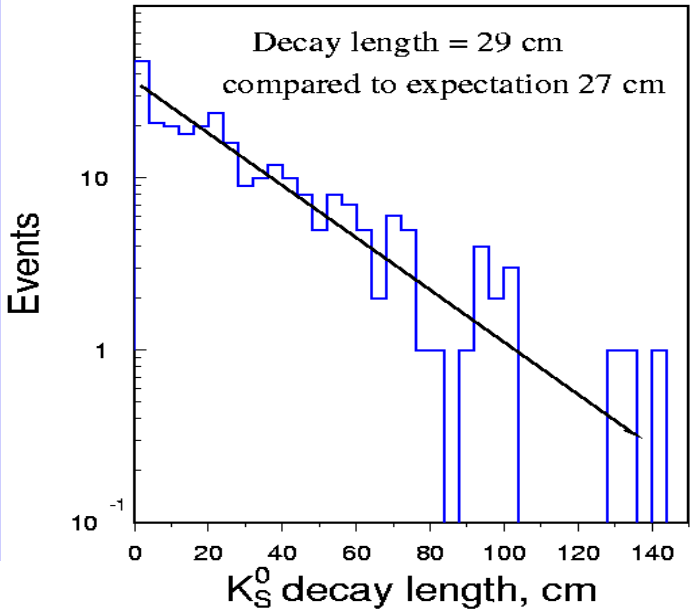


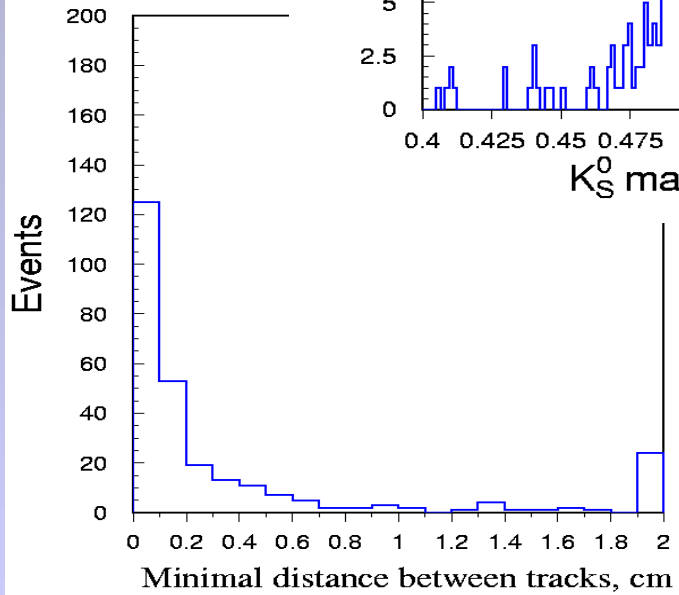


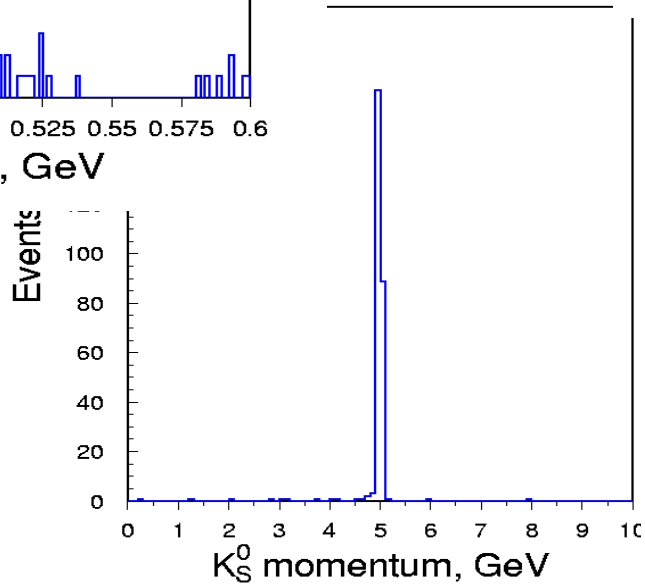
Control Distributions for Events with single K^0

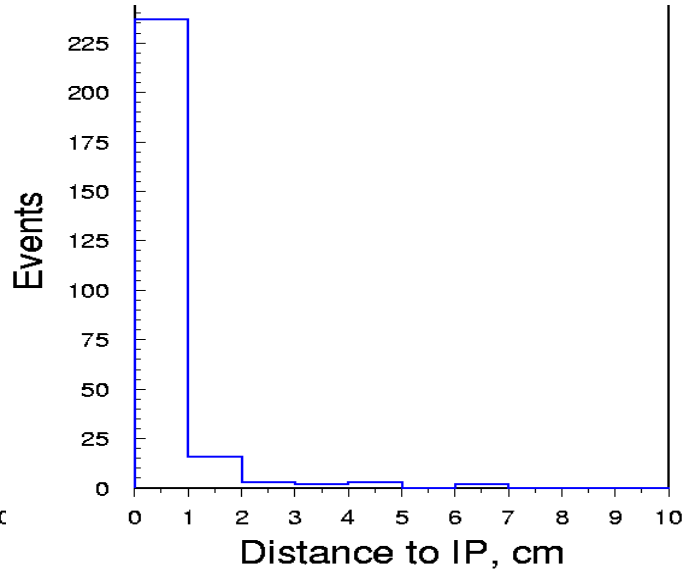
- 260 events with $K^0_S \rightarrow \pi^+ \pi^-$











Generic Algorithm Used in High Multiplicity Events

- Algorithm utilizes SNARK package which performs clustering and associates track segments with clusters

- Track categorization (4 categories)
  1) Track segments with attached starting and end points
  2) Track segments with disconnected starting point and attached end point
  3) Track segments with disconnected end point and attached starting point
  4) Track segments with disconnected starting and end points

Generic Algorithm Used in High Multiplicity Events

- Initial categorization
  1) Tracks having hits in the 1st or 2nd layer of vertex detector and reaching calorimeter
  2) Tracks starting beyond 2nd layer of vertex detector and reaching calorimeter
  3) Tracks having hits in the 1st or 2nd layer of vertex detector and ending within TPC volume
  4) Tracks starting beyond 2nd layer of vertex detector and and ending within TPC volume
- Tracks of 1st category are assumed to originate from IP
- Tracks from categories 2) – 3) are tested for their inter-relations

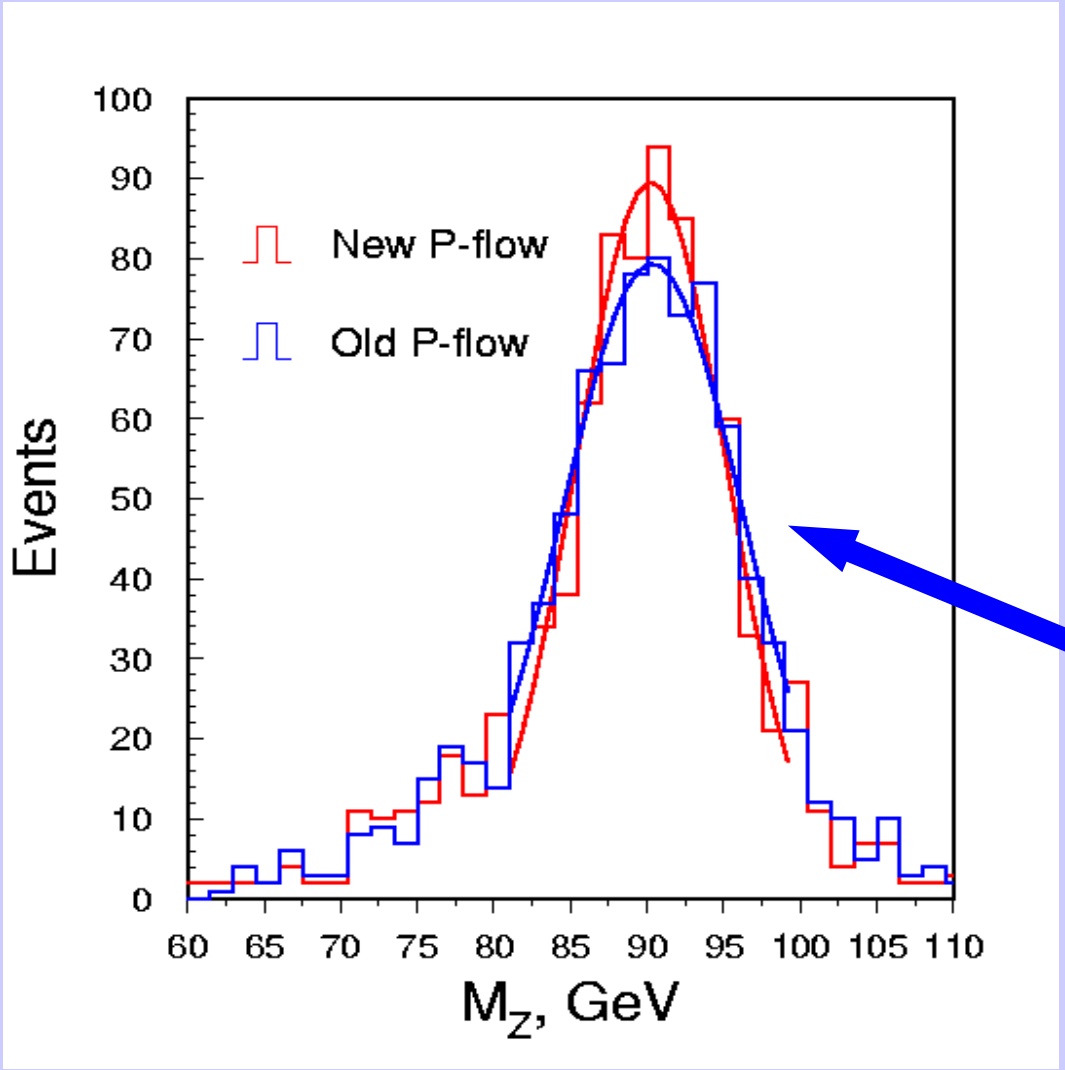
Generic Algorithm Used in High Multiplicity Events

- Minimal distance between tracks from categories 2) – 4) is calculated for those pairs which fulfill the following requirements
  - ✔ Only tracks with opposite charges and disconnected starting points are allowed to form V0
  - ✔ Only tracks with the same charge are allowed to form kink, one of the tracks must have disconnected end point (primary track), another – disconnected starting point (secondary track)
  - ✔ Reconstructed decay point of V0 (reconstructed point of kink) are required to have distance to beam axis greater than 3cm to reduce number of faked V0's/kinks due to high hit density in the proximity of IP
  - ✔ DCA to IP of neutral object associated with V0 must be less than 3cm
- Track pair with minimal distance is chosen
  - ✗ V0 : track starting points are regarded to be attached and track categories are redefined accordingly
  - ✗ Kink : end point of primary track and starting point of secondary track are regarded to be attached and track categories are redefined accordingly

Generic Algorithm Used in High Multiplicity Events

- Objects constituting V0 or kink are handled as follows
  - ✔ Tracks constituting V0 are removed from the list of Pflow objects and substituted by new object V0
  - ✔ Secondary track belonging to kink and calorimeter clusters (if any) associated with kink are removed from the list of Pflow objects
  - ✔ Primary track belonging to kink is retained in the list of Pflow objects
- Procedure is repeated for tracks remaining in categories 2) – 4)
- Track pairing procedure is terminated if distance between tracks for any selected pair exceeds certain optimized threshold (currently 5mm)
- Remaining tracks with disconnected starting point are added to the list of primary tracks if DCA < 3cm
- Final list of Pflow objects : primary tracks, neutral clusters, V0's

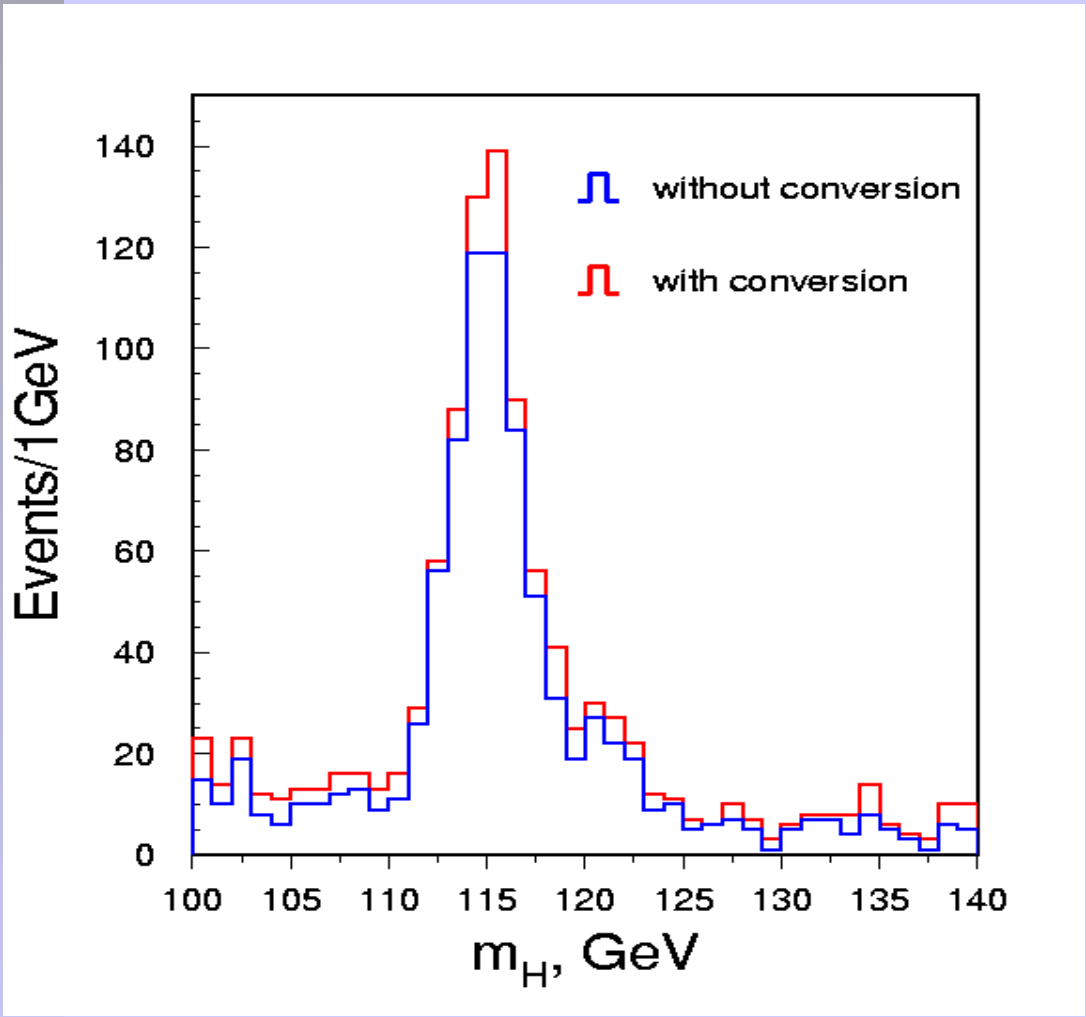
Reconstruction of Z^0 Mass



Algorithm is tested on hadronic decays of Z^0 at Z pole energy (91.2 GeV) (u,d,s,c,b)

Resolution on Z mass is improved from 5.4 to 4.4 GeV

Reconstruction of Photonic Higgs Decays



- Algorithm is tested on $HZ \rightarrow \gamma\gamma qq$ events @ 500 GeV
- In ~ 20% of events at least one photon undergoes conversion
- 17% efficiency recovery for this channel with dedicated V0 finding procedure

Summary and Outlook

- Dedicated procedure of V0 and kink finding is necessary to facilitate Pflow algorithm
- First steps in this direction are taken. Preliminary version of V0 and kink finding procedure is developed
- Sizable improvement of Pflow performance is demonstrated on samples of $Z^0 \to q\bar{q}$ and $HZ^0 \to ggq\bar{q}$ events
- Yet current version of package have weak points leaving room for further improvements
  - ✔ Helix model for tracks does not take into account energy loss, more sophisticated track model must be employed
  - ✔ Steering parameters (cut on distance between tracks, cut on distance of neutral objects to IP *etc*) need further optimization
  - ✔ Conversion of bremstrahlung photon, cascade decays (like $\Omega^- \to \Lambda^0 K^-$, $\Xi^- \to \Lambda^0 \pi^-$) are currently not taken into account, should be properly treated
  - ✔ Neutral particles may decay into neutrals ($K^0_S \to \pi^0 \pi^0$, $\Xi^0 \to \Lambda^0 \pi^0$), currently not taken into account, challenge for calorimetry