Topological Vertex Finder
- secondary vertex reconstruction in jets -

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Overview

- Topological vertex reconstruction method

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- Reconstruction of secondary vertices in jets

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- Topological variables

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- Application to b-tagging

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- Topological vertex reconstruction method
- Reconstruction of secondary vertices in jets
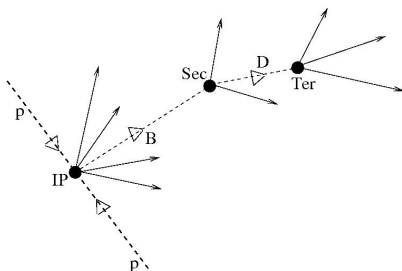- Topological variables
- Application to b-tagging
- Outlook

Requirements on a vertex reconstruction algorithm

- good primary vertex reconstruction
    - signal & pile-up events
        - ~4 low lumi
        - ~20 high lumi
- good secondary vertex reconstruction
    - e.g. for b-tagging:
        - decay vertex of B/D-hadron
        - flight distance
        - track multiplicity
        - invariant vertex mass
- reconstruction (and rejection) of gamma-conversions & V0-decays
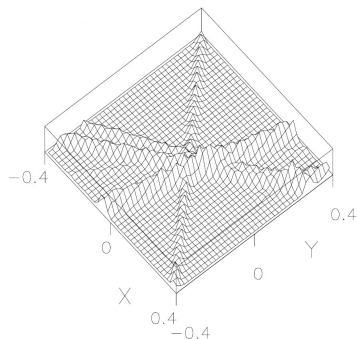   - event 'clean-up'

Reconstruction method

▷ David J. Jackson,
  Nucl.Instrum.Meth.A388: 247-253,
  1997

▷ reconstruction of a set of vertices &
  associated subset of the charged
  tracks

▷ association accords to a vertex
  probability function which is based
  on the trajectories and position
  resolution of the tracks

▷ track ambiguities are allowed
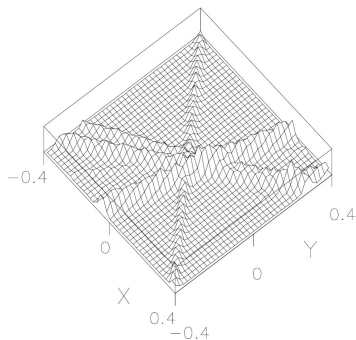
Construction of a Gaussian tube around a track

▷ p - residual to a track

▷ V - covariance matrix

▷ using of the track perigee parameterization

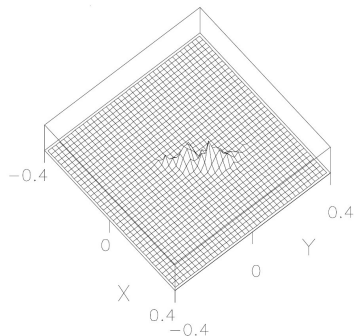Track Gaussian tube function:
$$f_i(\vec{r}) = exp(-\tfrac{1}{2} p^T V^{-1} p)$$

Track- & Vertex functions

Track Gaussian tube function:
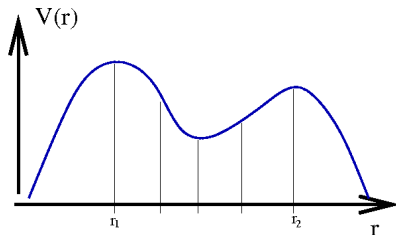$$f_i(\vec{r}) = exp(-\tfrac{1}{2}pV^{-1}p^T)$$

Vertex probability function:
$$V(\vec{r}) = \sum_{i=0}^{N} f_i(\vec{r}) - \frac{\sum_{i=0}^{N} f_i^2(\vec{r})}{\sum_{i=0}^{N} f_i(\vec{r})}$$
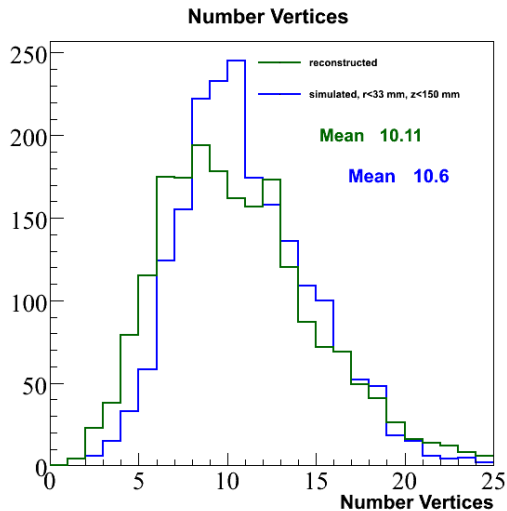
Vertex clustering

▷ bild two track pairs and calculate the vertex seed for each pair

▷ determine the vertex probability for each seed

▷ cluster the vertex seeds together to bild vertex candidates

▷ fit all vertex cluster

Two spatial points $\vec{r}_1$ and $\vec{r}_2$ can be solved if:
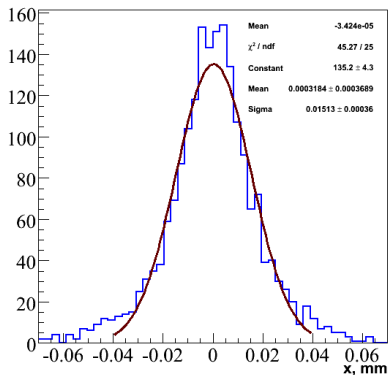$$\frac{min\{V(\vec{r}):\vec{r}\in\vec{r}_1+\alpha(\vec{r}_1-\vec{r}_2),0\leq\alpha\leq1\}}{min\{V(\vec{r}_1),V(\vec{r}_2)\}} < R_0$$
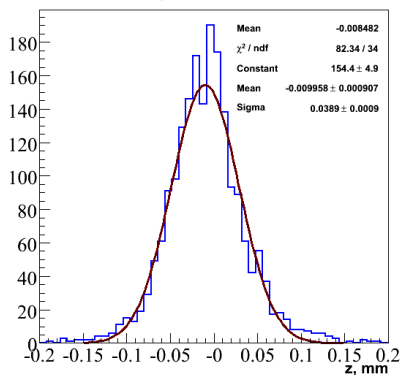
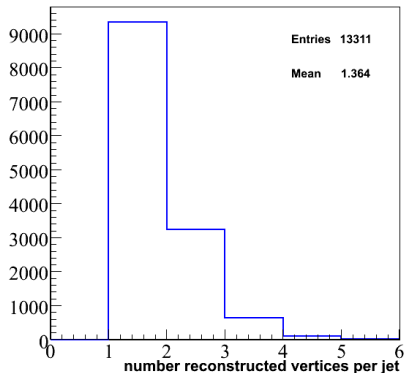# Vertex Reconstruction in $t\bar{t}$ events

Vertex Reconstruction in $t\bar{t}$ events

Secondary Vertex Reconstruction in Jets, $t\bar{t}$ events

Number Vertices

Entries 13311

Mean   1.364

number reconstructed vertices per jet

Number Tracks

Entries 18159

Mean   2.343

number associated tracks per vertex

Secondary Vertex Resolution, $t\bar{t}$ events
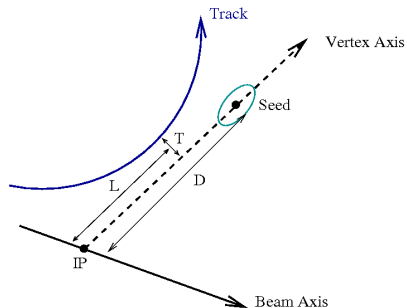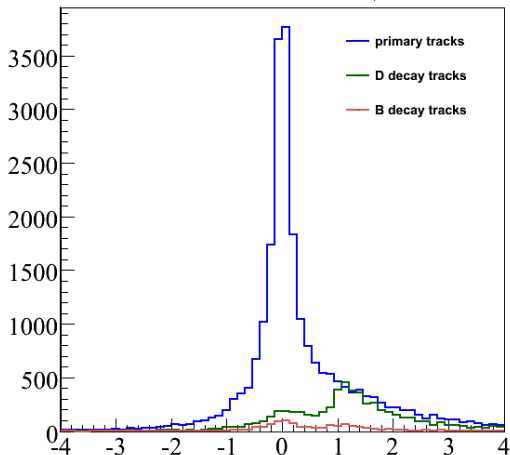
Topological Variables

▷ all non-primary vertices found
must be n-prong with n $\geq$ 2

▷ for primary vertex $\rightarrow$ B $\rightarrow$ D
decay chain can have one-prong
vertices

▷ consider furthest found vertex as
a seed, calculate distance of
closest approach and
longitudinal distance to point of
closest approach for each
isolated track

Longitudinal Distance at Point of Closest Approach

Correction to the Invariant Vertex Mass

▷ some decays produce only one track at vertex

▷ thus tracks should have small T and large L/D values
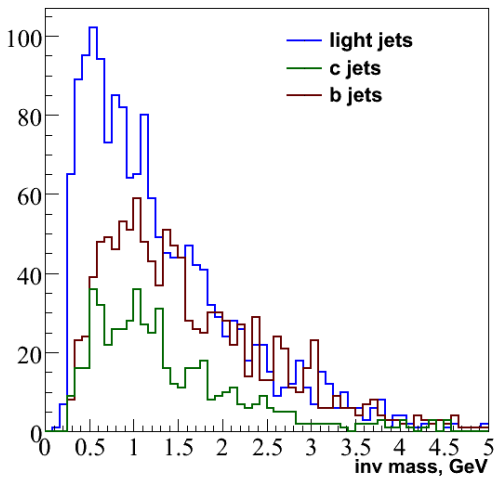
▷ attach such tracks to the seed vertex

$$\text{Define: } M_{p_T} = \sqrt{M^2 + p_T^2} + |p_T|$$

- M is the invariant vertex mass
- $|p_T|$ is the transverse component of the total momentum to the flight direction

▷ use the L/D and corrected vertex mass variables to determine likelihood functions

Corrected Invariant Vertex Mass

Conclusions & Outlook

- topological vertex finder can be used to reconstruct vertices on RDOs (primary vertex and futher vertices) and for vertex finding on AODs (secondary vertices in jets) as well
- new topological variables for b and c jet tagging
- improvement of the separation power of these topological variables needed:
  - significance of L/D
  - improvement of primary and secondary vertex resolution & track association needed
- ongoing work on implementation of the new jet-tagger based on discussed variables