Event Classification with *TWIST*

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~ Motivation ~

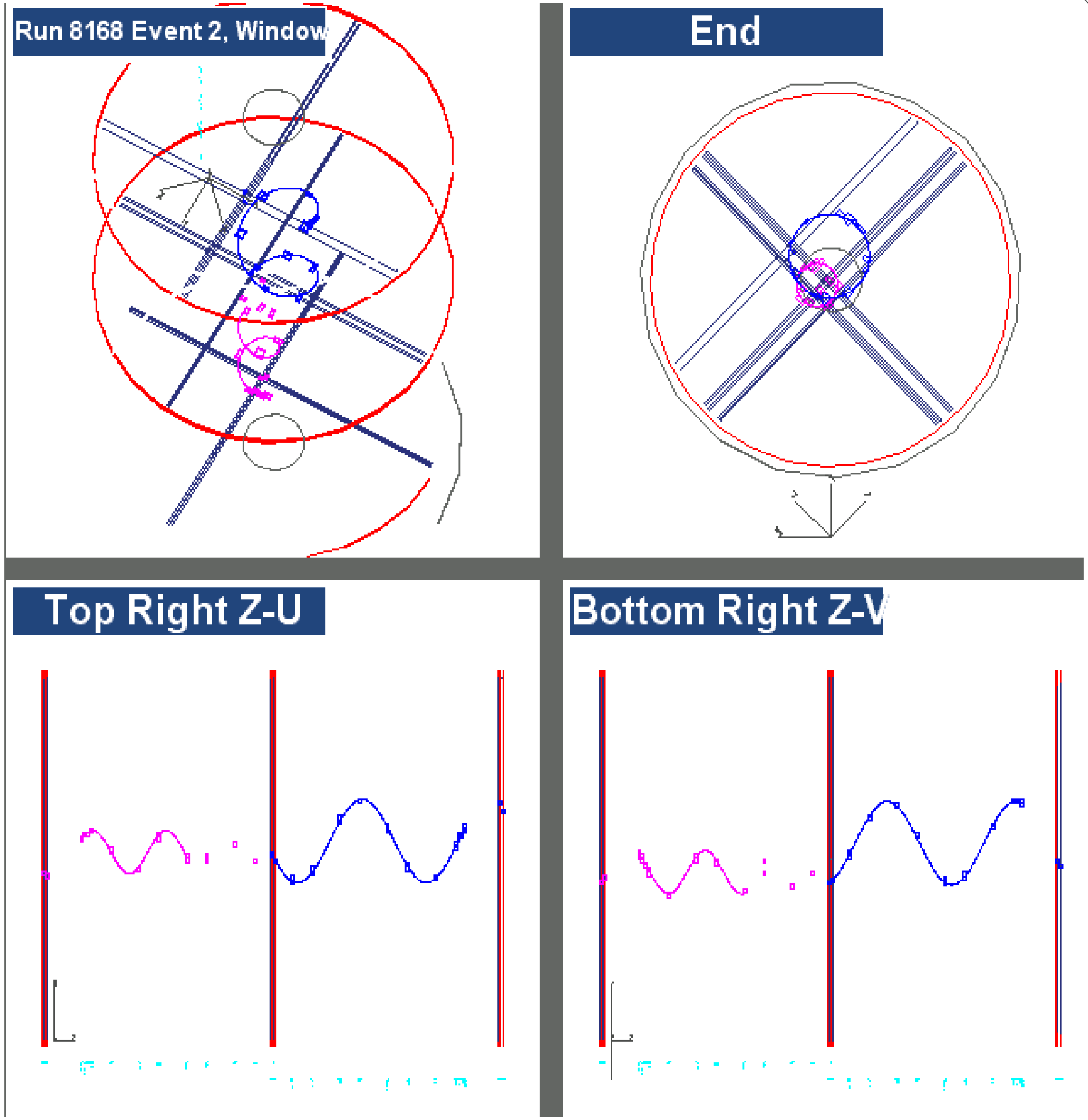
Why is event classification important to *TWIST*?

- *TWIST* is a high precision measurement of the Michel Distribution for muon decay
- High precision requires that event classification is unbiased in:
  - Identifying different particles
  - Tagging events that do not need to be fit

Muon Decay Events in *TWIST*

Particle characteristics

- Beam μ
  - Maximum ionizing – want to see stop in target
  - Have lots of multiple scattering – small 'radius'
- Decay e+
  - Starts where a muon stopped
  - Wide range of 'radius' (exits detector at ~60 degrees)
  - High angle and low energy can have lots of scattering



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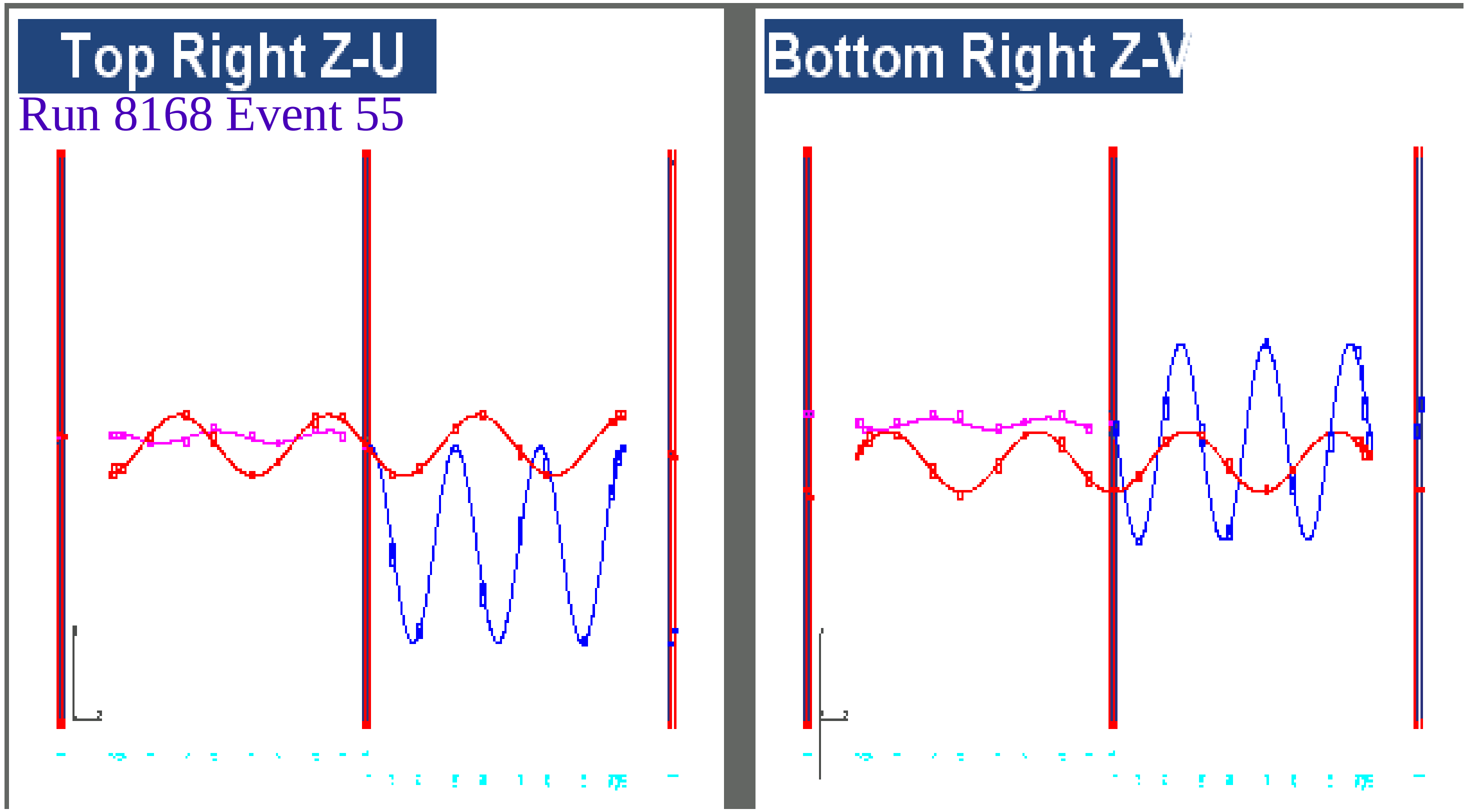
Beam Positrons in *TWIST*

Particle characteristics

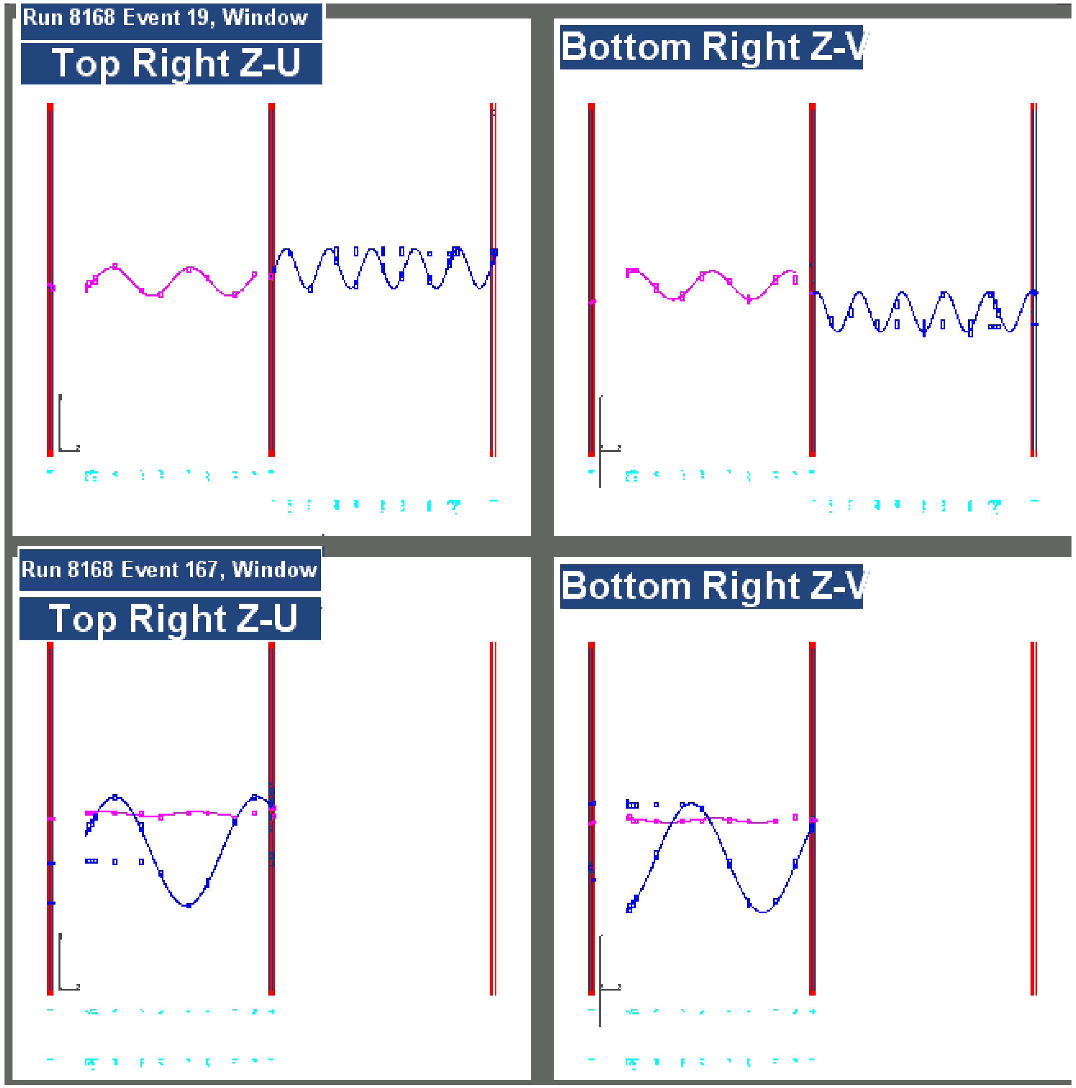
- Beam e+
  - >10:1 beam e+ per muon
  - Minimum ionizing – pass through the detector
  - Small 'radius'



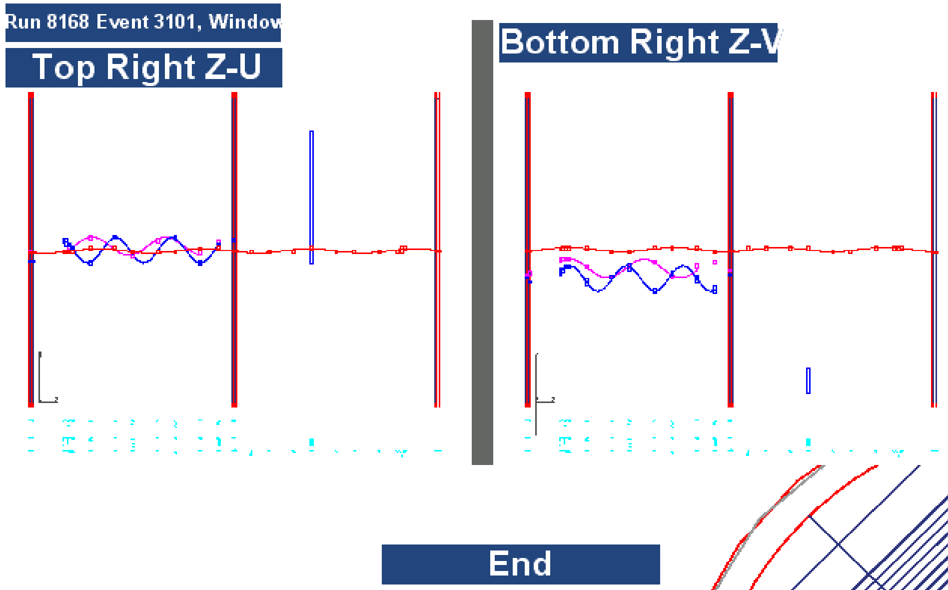
Delta Electrons in *TWIST*

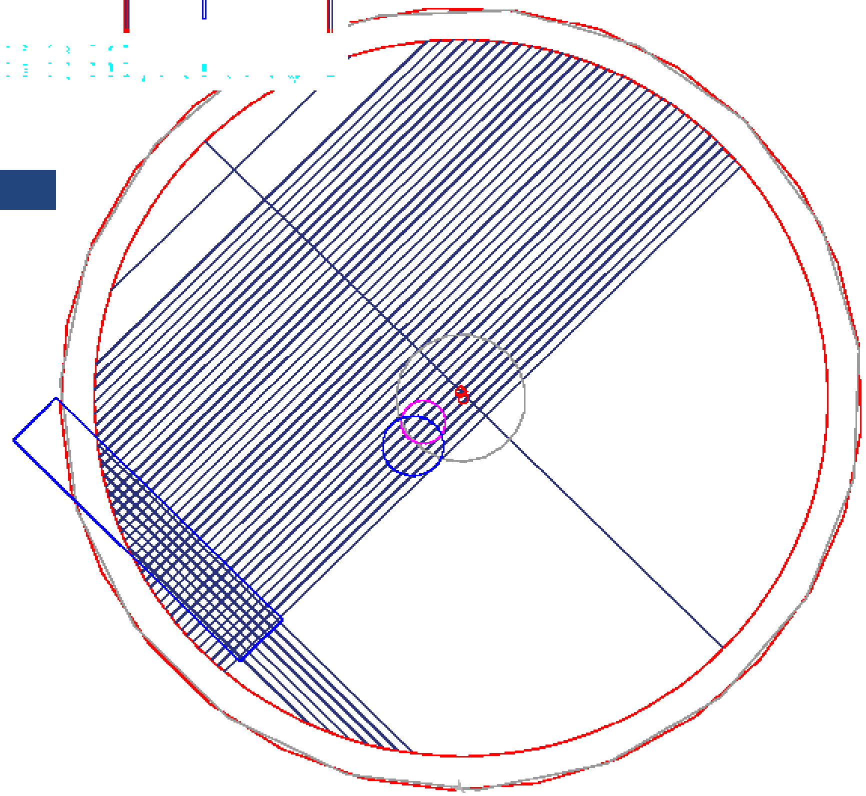
Particle characteristics

- Delta electrons
  - Knocked out of material by μ, Beam e+, or Decay e+
  - Low energy electron tracks in time with μ, Beam e+, or Decay e+
  - Look like straight lines in detector



Cosmic Rays in *TWIST*



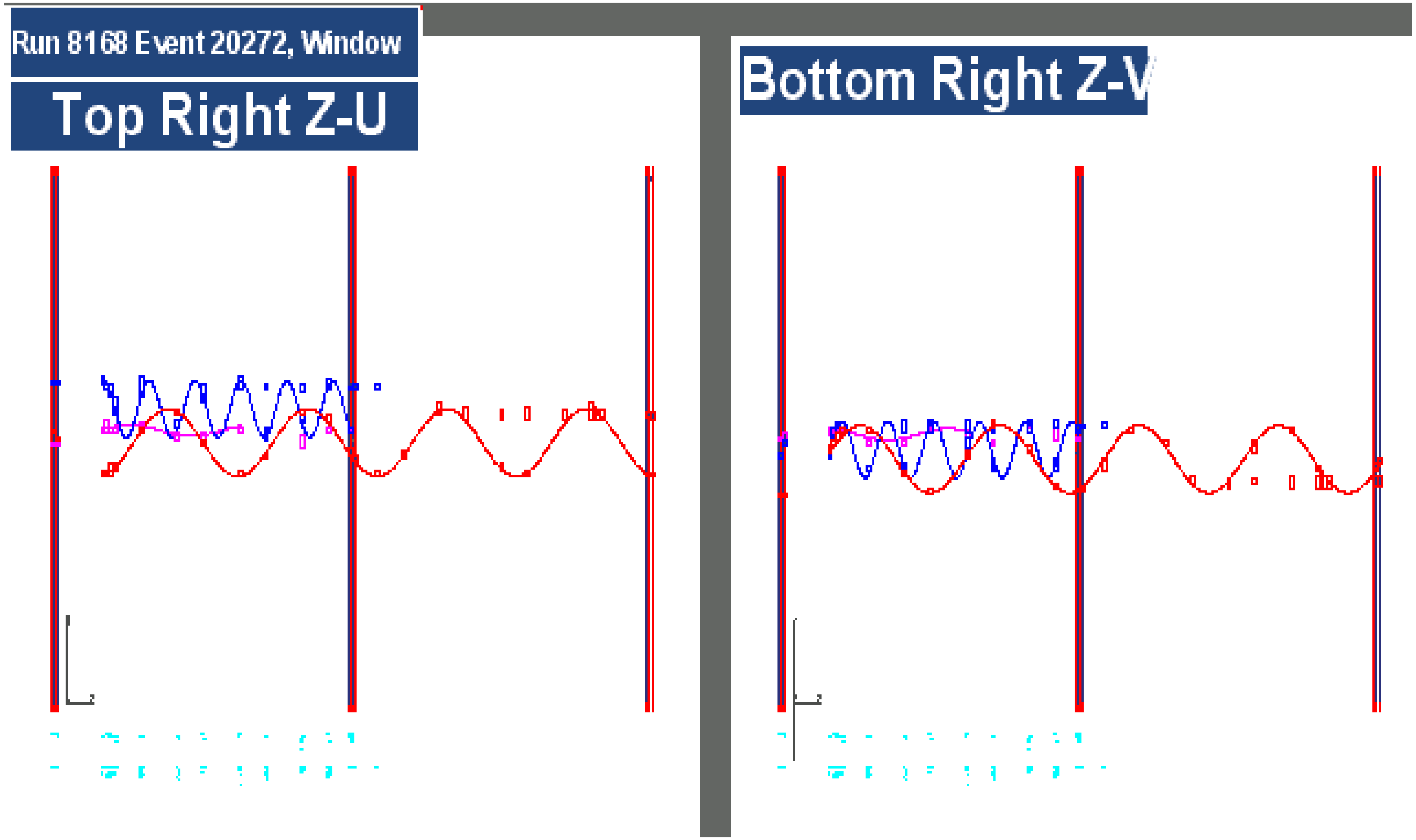


Particle characteristics

- Cosmic rays
  - Low rate (2/second or ~1/1000 events)
  - Hit very few planes – lots of hits in planes passed through

Complex Events in *TWIST*

A complex event can have any combination of particle types:
Beam μ , Beam e+, Decay e+, Delta electrons, and Cosmic rays



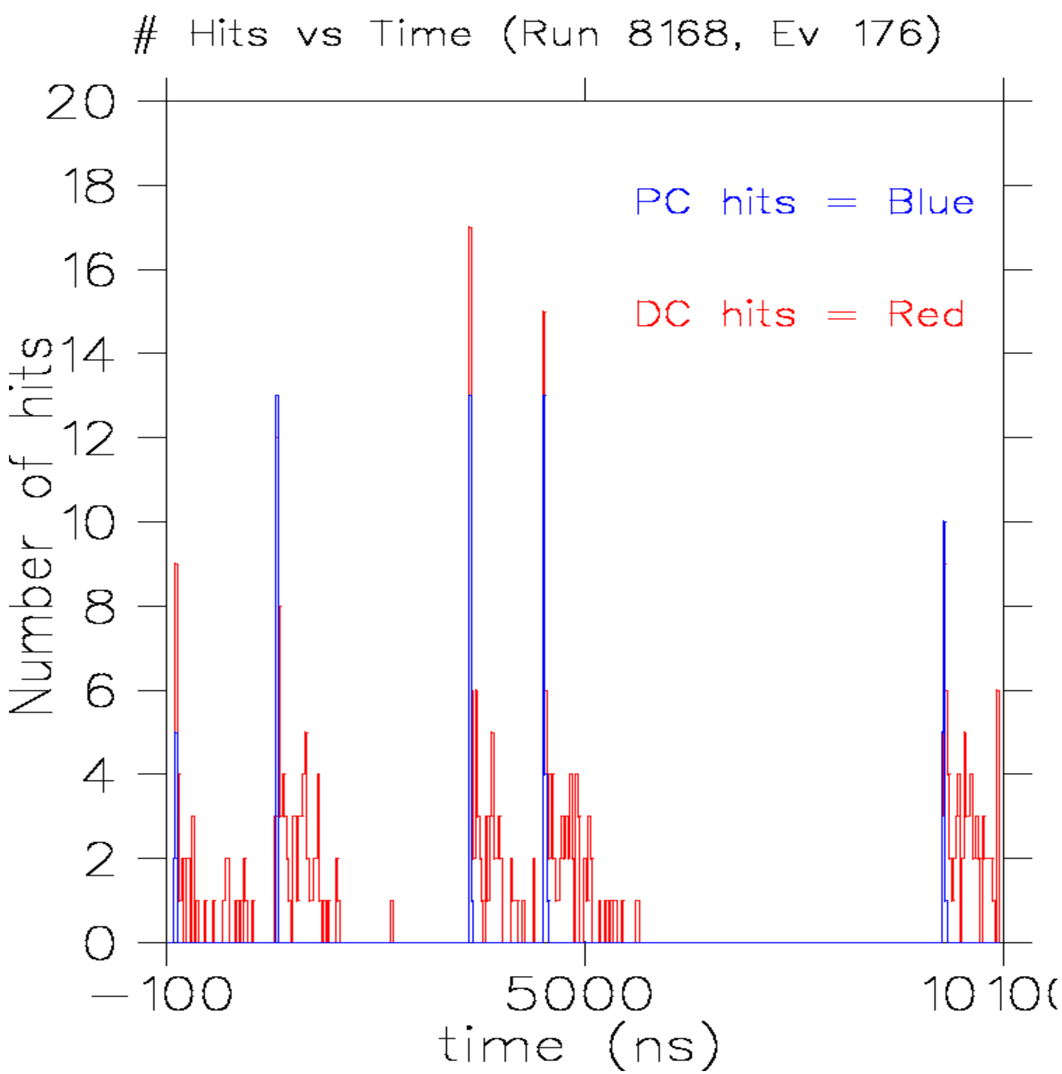
How Events are Classified in *TWIST*

Event Classification Steps:

- Sort hits into different time bins (time windows)
- Identify what particles are in the windows
- Decide on an overall event type

Sorting Hits in Time (Windowing)

- Proportional chambers (PC) used to set times
- Drift chambers (DC) have drift time < 1000 ns
- How overlaps are handled
- Trigger time at zero ns



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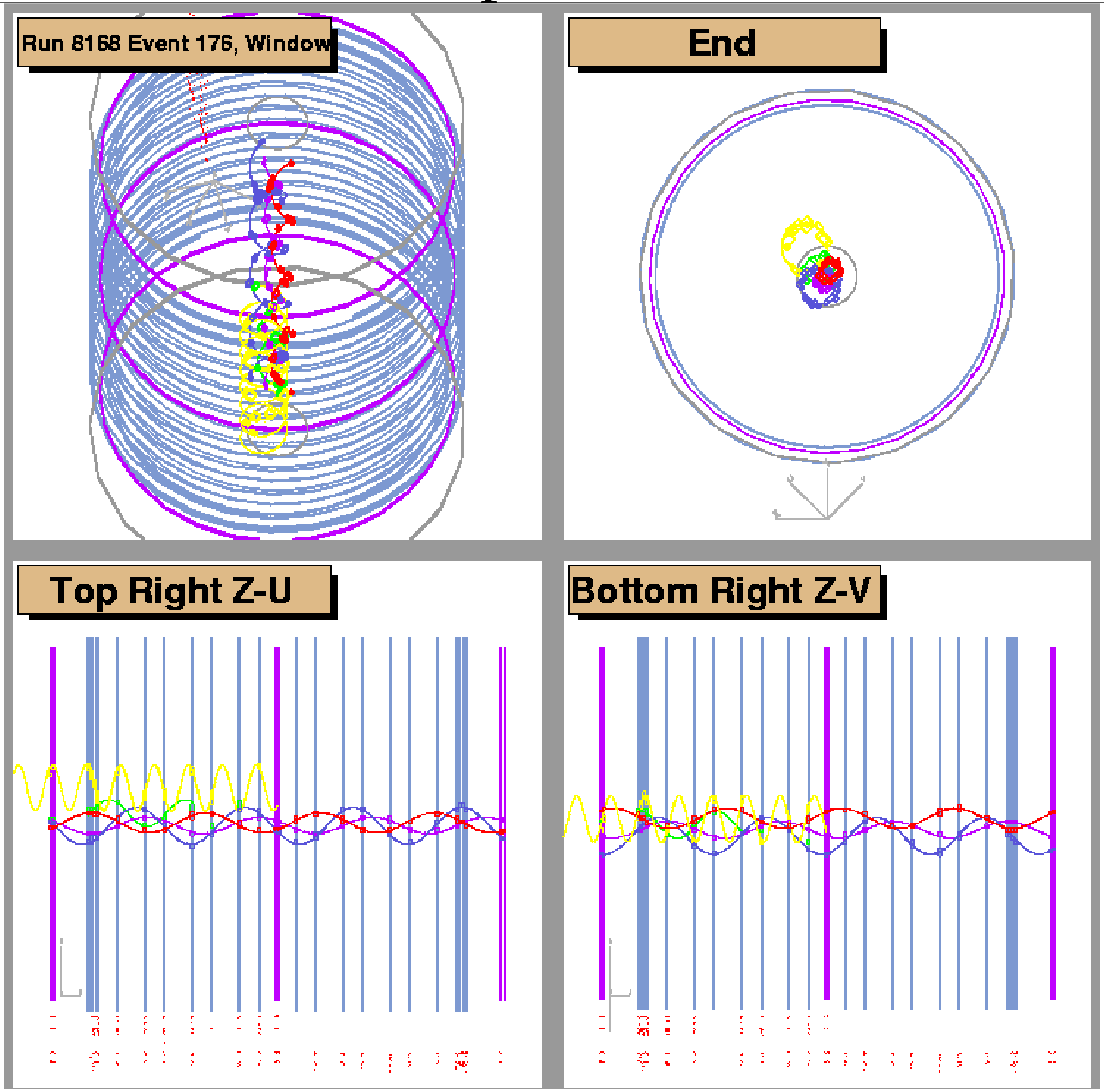
Use of Hit Times Simplifies Event Classification



Event Classification – Window Types

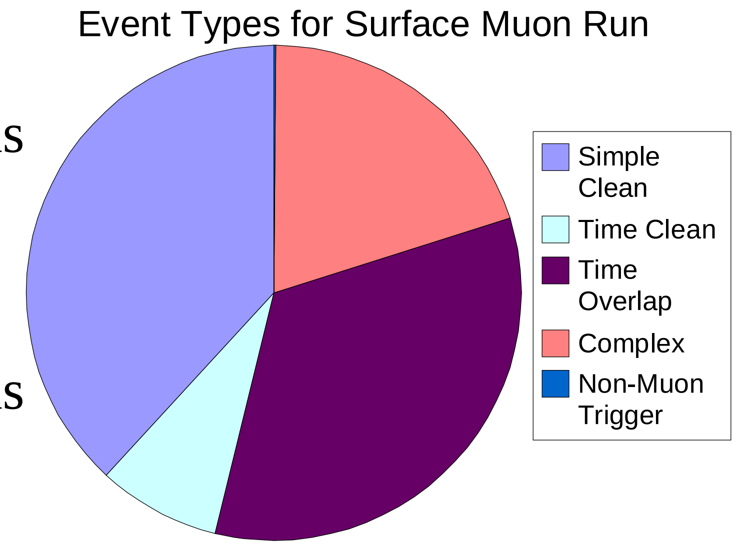
- Muon
- Upstream Decay Positron
- Downstream Decay Positron
- Beam Positron
- Empty
- Overlap involved

- Trackable Upstream, a few Downstream Hits
- Trackable Downstream, a few Upstream Hits
- Trackable Upstream after "muon" and "decay"
- Trackable Downstream after "muon" and "decay"
- Trackable Downstream prior to muon

- Pass through the detector, but not beam positron
- DC clusters but no PC clusters.

Event Classification

For 8×10^7 Surface Muon Events (2 kHz Trigger rate)



Simple Clean Events

- Have just a muon and a decay positron
- Tracks are separated in time by > 1000ns

Time Clean Events

- Have a muon, a decay positron and one or more beam positrons
- Tracks are separated in time by > 1000ns

Time Overlap Events

(Close to 34% imposed by time structure)

- Have one or more tracks separated by < 1000ns

Complex Events

- Events which do not appear to have a muon and decay positron
- Could be just beam positrons
- Fast decays downstream
- Decay positrons with deltas and/or scattering

Non-Muon Trigger Events

- Muon and a decay positron but not triggered by the muon

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Validation of Event Classification

Two methods have been developed for validation of event classification:

- Validating classification by eye
  - ➔ Looking at 500 data events revealed largest challenges:
    - ✗ ~2% of events misclassified due to delta electrons
    - ✗ ~1% of events misclassified because of scattering
- Validating classification using GEANT data
  - ➔ GEANT knows what was thrown
  - ➔ How to handle knowledge of delta electrons in GEANT?

Summary

- High precision requires that event classification is unbiased in:
  - ➔ Identifying different particles
  - ➔ Tagging events that do not need to be fit
- Event classification is simplified by sorting hits into time bins (time windows)
- Validation of event classification shows that work needs to be done to:
  - ➔ Handle delta electrons
  - ➔ Understand scattering