Event Classification with TWIST

Blair Jamieson
University of British Columbia

~ 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 $\mu$
  - 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

Blair Jamieson
Beam Positrons in TWIST

Particle characteristics

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

Blair Jamieson
Delta Electrons in \textit{TWIST}

Particle characteristics

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

Blair Jamieson
Cosmic Rays in \textit{TWIST}

Particle characteristics

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

Blair Jamieson
Complex Events in *TWIST*

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

Blair Jamieson
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

Blair Jamieson
Use of Hit Times Simplifies Event Classification

Blair Jamieson
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.

Blair Jamieson
Event Classification

For $8 \times 10^7$ 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

Blair Jamieson
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?

Blair Jamieson
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