GlueX Particle ID

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Overview

- Sources of PID information:
  - Drift Chambers:
    - χ^2 from track reconstruction (charged)
    - χ^2 from dE/dx in the drift chambers (charged)
  - TOF/BCAL/FCAL:
    - χ^2 from time-of-flight (charged and neutral)
    - χ^2 from dE/dx in the TOF (BCAL?) (charged)
- Calculate total χ^2, FOM for each PID hypothesis
- Particle ID: Hypothesis with highest FOM
- All information saved: User can perform custom PID

Track Reconstruction χ^2

* For each track candidate, create a track hypothesis for each PID
* Wire-based and time-based track reconstruction of each hypothesis
* Use track reconstruction χ^2 from time-based fit

$$\chi^2 = r C_r r^T$$

(r: Kalman-filtered residual, C: covariance matrix)

Drift Chamber dE/dx χ^2

* Calculate the measured dE/dx for each CDC/FDC hit used for the track
* Ignore the hits with largest dE/dx: keep ~half (int(#hits)/2 + 1) the hits
  * Gas: dE/dx is Landau-distributed, ignore tail to approximate Gaussian
* Compare the total dE/dx's, calculate χ^2

$$\chi^2 = \frac{\left(\sum \frac{dE}{dx}_{Hit} - \sum \frac{dE}{dx}_{Probable}\right)^2}{\sigma^2_{\Delta \frac{dE}{dx}}}$$

Charged Particle TOF χ^2

* Position-match the SC & TOF/BCAL/FCAL hits to each track hypothesis
* Calculate the TOF (BCAL?) dE/dx chi-squares (Detail: later slide)
* Calculate initial PID FOMs from the chi-squares calculated thus far
* Select the RF beam bunch corresponding to each track (Detail: next slide)
* For each RF beam bunch, reconstruct the vertex positions using the track hypotheses with the largest FOM
* Project RF & TOF/BCAL/FCAL times to reconstructed vertices, calculate χ^2

$$\chi^2 = \frac{(t_{RF} - t_{Hit})^2}{\sigma^2_{\Delta t}}$$

(Times projected to reconstructed vertex)

Selecting the RF beam bunches

* For each track hypothesis:
  * Project the SC hit-time & RF times to the beamline (POCA)
  * Select the RF beam bunch that is closest to the projected SC time
* Select the RF beam bunches that match the tagged photons
* Of the photon-matched RF bunches, select the one with the most matched tracks (matched track: at least one matching hypothesis)
* Group these matched tracks together with that RF beam bunch
* Repeat grouping until no remaining tracks
* NOTE: In case true photon wasn't tagged: if 3+ tracks, select RF beam bunch with the most matched tracks

Charged Particle TOF: Misc.

- If no SC hit, use DC time to select RF bunch
- If no BCAL/FCAL/TOF hit, use DC time instead
- If track hits in multiple systems: use BCAL, then TOF, then FCAL hits
  - TOF: best time resolution, but BCAL: hits sooner, significant energy loss
- If > 1 BCAL/FCAL/TOF position-matched hit in the chosen system
  - If none are > 3σ apart in time, hit-time = weighted average
  - If at least one is > 3σ apart in time, use reconstructed DC time instead
- If missing both SC hit and BCAL/FCAL/TOF hit:
  - Choose RF bunch with most tracks, use DC time for TOF
    - If > 1 RF bunch with the most tracks, pick the one with a matching photon
      - If more than one has a matching photon, then use the DC time of the track hypothesis with the largest FOM to choose the RF bunch

TOF dE/dx χ^2

* Calculate the measured and most probable dE/dx
* Compare the total dE/dx's, calculate χ^2
* Can this be done for the BCAL as well?

$$\chi^2 = \frac{\left(\frac{dE}{dx}_{Hit} - \frac{dE}{dx}_{Probable}\right)^2}{\sigma^2_{\Delta\frac{dE}{dx}}}$$

Charged Particle PID

- Perform PID (weighted chi-squared)
  - Weight each χ^2 so that each source has equal weight
  - Calculate the FOM for each track hypothesis
  - Select the track hypothesis with the largest FOM
- Calculate the vertex times from the weighted average of the track times (projected from BCAL/FCAL/TOF)

Neutral Particle PID

* Neutral Track: each BCAL/FCAL shower that is not matched to **EACH** PID hypothesis of any charged track
* For each neutral track, create a hypothesis for each ID (γ , n) & vertex combination
  * Vertices: if no charged tracks, then use target center
* Project BCAL/FCAL shower time to vertex, compare to vertex time: calculate χ^2
* Calculate the FOM (confidence level), select the hypothesis with the largest FOM.

$$\chi^2 = \frac{(t_{Vertex} - t_{Shower})^2}{\sigma^2_{\Delta t}}$$

(Shower time projected to vertex)

Particle Classes

* Particle classes detailed at: http://www.jlab.org/Hall-D/software/wiki/index.php/Mattione_Particle_Classes

* PID information is saved at:
  * χ^2 from track reconstruction: DTrackTimeBased
  * χ^2 from dE/dx in the drift chambers: DTrackTimeBased
  * χ^2 from time-of-flight: DChargedTrackHypothesis and DNeutralTrackHypothesis
  * χ^2 from dE/dx in the TOF: NA, will be in DChargedTrackHypothesis
  * FOM: DChargedTrackHypothesis and DNeutralTrackHypothesis
  * PID: First DChargedTrackHypothesis in DChargedTrack, and first DNeutralTrackHypothesis in DNeutralTrack

* Vertex-independent data: DVertexIndependentResults
  * Contains DChargedTrack & DNeutralShowerCandidate