CLEO III track finding uses cell level information in the initial phase, does not depend on intrinsic device resolution, is ideal for high (radial) density, low precision, information.

CLEO III track finding was developed for a small-cell drift chamber but is applicable to any detector with similar cell-level information.

The goal of the initial phase is to find segments that one would see by eye, isolated anywhere in the chamber, in contrast to algorithms seeded by arcs defined by widely spaced (in radius) sets of hits.

A TPC is a 3-dimensional device. However, after clustering of the pad signals in r-φ, and assigning the cluster position to the closest pad center, projected TPC cell-level information is similar to that of a small-cell drift chamber.

This algorithm is readily applicable to a TPC. (Course Z information can be used to reduce track and noise density that is projected onto the 2-D view.)

The found track segment, in yellow, is interrupted by the noise created by the looping track.
An important feature of CLEO III track finding is the diagnostics package providing information on the conditions encountered & decisions met in selecting track candidates at intermediate steps in the algorithm.

It is used for program development and provides the ability to visually diagnose problems and pathologies.

Graphics features would translate well into JAVA.

Zoom feature

Cell information can be displayed for each cell. This can be device dependent.
The diagnostics package includes a logging feature that provides information on the successes and failures of the algorithm during the growth of a segment.

The chart below provides details on the conditions that lead to stopping the short segment.
I will describe some of the features of the algorithm before applying it to a TPC.

Segment-finding can start at any layer and run outward or inward. It proceeds by adding cells satisfying tunable conditions of continuity and isolation.

Here, the latter half of the track is found as a second segment.
CLEO III Track Finding... Overcoming Noise

"extend" and "merge"

Two segments can be merged into another segment.

Merge provides compensation for the tight hit selection requirements used in initial segment-finding.

After all clean segments are found (within the z-projection road for a TPC application), well established segments can be extended into noisier regions.
Segments are be selected, by order of quality, for **further processing**.

Processing starts by fitting the **cell locations** to a hypothesis function (helix).

Here, only the isolated cells (in white) are included in the fit.

The **orange** cells are in a road but not yet in the fit.

At this level, TPC data could be treated much like drift chamber data.
The residual display is used for diagnostics and development of the latter phases.
Application of CLEO III Track Finding to a TPC

...differences in the second phase

A **small-cell drift chamber** has
time information for precise r-φ measurements,
a drift distance **sign ambiguity**, and
pulse height information.
Stereo layers provide the z information.

A **TPC** has
time information for precise z measurements
and pulse height and shape information.

r-φ – z hit information in **both** applications.

In a **TPC**, the **z projection is not coupled** with r-φ
because there is no sign ambiguity.
Second phase hit selection is less complicated.

The Z-projection. Both applications use a z fit to
discriminate against bad initial-phase segments.
CLEO III track finding, using fitted track segments in self selected isolated regions, is highly successful in extending tracks into complicated noisy regions.

You see into the crowns of the trees because the trunks tell you where to look.
In a third phase, the track can be extended from the TPC into the silicon vertex detector.

The 4 silicon hits have been selected as a “group” with the characteristic that the hits have a small residual spread within the group but may have a larger average residual relative to the established track.

Silicon hits shown in the residual display.
“TPC event”

idealized detector, 100 layers, 2m o.r.
5mm x 15mm cells
single pad “hits”, no clustering, no noise, no Z clustering, only 1 hit/cell

20 tracks in the jet, +/- .3 in $\phi$, +/- .3 in cot$\theta$

Tracks are found, but there are many short segments. **Yellow** indicates current track, **Pink**, a previous track, **Green**, valid hits for pattern recognition.

Reason for premature end of current track is indicated in the log. (The track was found to the last layer but the single hits look like stragglers.)

No changes to the basic pattern recognition. No Z information is used, yet
“TPC event”, selected Z-projection road

Hits are pre-selected to come from a z-projection cone.

Yellow indicates current track, Green, valid hits for pattern rec., Purple, invalid, out-of-time.

Tracks are resolved.
Short segments may be ignored; they will be resolved in another projection.
Note: the curler falls out of the road.

Plan:
scan through the z projection roads.
Convert to a format that is compatible with an existing Linear Collider detector simulation.

Optimize the method of selecting/scanning the Z projection roads.

Add TPC detector specific information to the 2nd stage pattern recognition.

Add clustering in r-ϕ and Z. Add noise.

Add read-out specific (anode wire vs. GEM/MicroMegas) signal spreading characteristics.

Build robustness into the algorithm against signal pathologies through tuning with the aid of the graphical diagnostics,

Provide detailed, robust, analysis of track separation and pattern recognition efficiency (as a function of readout characteristics, segmentation (r-ϕ and Z), track density, and noise level) required to evaluate the (world) hardware development.

First year expenditures: student support $44,000
computer 2,000
travel 10,000

$56,000