

# Developing a Displaced Vertex Trigger for Dark Matter Searches

Elia Schmidt

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## I: Motivation



- Search windows largely closed
- Third Signature:

$$e^+e^- \rightarrow l^+l^- + \text{invisible}$$

- Solution: Displaced Vertex Trigger (DVT)

### Inelastic Dark Matter (iDM)

Two natural scenarios:



Signature (same for many more dark sector models):

- Two leptons from displaced vertex + missing energy



- Hits in the transversal plane (2D)
- Demand two tracks from a common vertex



- Probe ~400 reference vertices (=Macrocells) using
  - Hough transform



### Hough Transform



Geometrical Space — Parameter Space Hit in GS Curve in PS Intersection in PS -----Track in GS

- Physical assumption about track shape to reduce lacksquarecomplexity
- Build Hough matrix with all hits  $\bullet$
- Find Peaks

Problem: Simple Thresholding is imprecise for multiple Vertex candidates

# II: Basic Strategy

#### **1: Weighted Hough Transform**



- Thresholding too imprecise
- Select 10 promising candidates from peak heights in Hough Matrix

#### **2: Neural Clustering**



- Iterative Clustering (5 iterations)
- Cluster parameters —> Neural Net







## III: Clustering



- Seeded Clustering Algorithm
- Scan Neighbours to increase cluster size
- Stop after five iterations
- Compute parameters:
  - Center of gravity
  - Sum of all values
  - Peak value
  - Extent & Angle
  - Waist

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#### Neural Net

• Demand 2 clusters for each event



- Monte Carlo data used for Training
- Flat lifetimes to be model independent
  - Clusters obtained from true vertex (MC):
  - Clusters from wrong vertices:
  - Clusters found in single track events:

dent ex (MC): target target

target value 1
target value 0
target value 0

#### Parameter discrimination





10

#### Separation plot after training



- Blue: Real Tracks
- Orange: Fake Tracks
- Black line: Median value
  - Correct assignment: 93.5%
  - False positives: ~6.5%
- Red line: Preliminary Threshold

# IV: (Preliminary) Results

- Full algorithm:
  - Preselection of 10 candidates
  - Neural Clustering
- Signal only (background stable version on the way)
- Metric plots:





# IV: (Preliminary) Results



Efficiency: 69.1% Resolution: 4.44cm

Estimate - True value

# Conclusion

- Fully working DVT algorithm
- Within UT4 capabilities (further tests needed)
- Reasonable Efficiency & Resolution

- Further improvements in efficiency, resolution and rejection needed
- Stabilize against background
- Test on real data (  $K_0 \rightarrow \pi^+ \pi^-$ )



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