Many thanks to Laura Fields and Anders Ryd for help with their track stub code

OUTLINE

- Why taus?
- Phase-I Calorimeter Tau Trigger
- Phase-II Tracker
- Tau Trigger with Tracks
- Full Simulation Samples and Tools
- First Results
- Summary and Plan
“Why Tau’s?” and Tau Trigger

- Physics with hadronically-decaying taus in Higgs and SUSY
- Access for Z events as the SM candle
- Calorimeter-based tau triggers at higher luminosity will be very difficult in an environment with huge QCD production cross sections with large amounts of overlapping pileup (PU) events.
- This requires that we will need to re-design and validate the trigger for both Phase I and II
Phase-I Calorimeter Tau Trigger

- Khotilovich, Mason, Safonov: Full calorimeter/muon simulation framework for simulating events in the high PU environment

**Trigger Rate for QCD events**

- $L_1 \equiv$ Level 1 trigger
- $\text{Tau} \equiv$ Tau (original config.)
- $\text{Tau(new)} \equiv$ New tau trigger

$\text{Tau} \approx L_1$ at PU50
$\text{Tau} > L_1$ at PU100
$\text{Tau(new)}$ … degrading at PU100

We need further reduction of the trigger rate by requiring a track trigger primitive.
Phase-II Tracker

- Weinberger and Kamon - Full Simulation Package for Tracker (Long Barrel Geometry) - emphasis on improving tau triggering - in the SLHC Tracker Simulation Group

Baseline upgrade design presented at Fermilab workshop 21\textsuperscript{th} November 2008
Stubs and Tracklets

Andrew W. Rose

$r-z$ view

$\phi$ view

Stub

Tracklet (vector!)

M. Weinberger

Figure 3a.
Current Long Barrel Geometry in 226

In this study, the 4th inner pixel is not included.
Tau Trigger with Tracks

Assuming the matching of the seed track and a cluster can be done like in “electron” trigger, our focus is to test several isolation (ISO) quantities:

1) \( N_{sub} = \# \text{ of stubs in ISO cone for layer } k \)
2) \( N = \# \text{ of tracklets in ISO cone} \)
3) \( I = [\Sigma p_T \text{ for tracklets in ISO cone}] \)
4) \( I_\theta = \Sigma (p_T \Delta \theta) / \Sigma p_T \)
5) ...

where

- ISO cone = between \( R_S \) and \( R_I \)
- \( R_S = \text{Signal cone radius} \)
- \( R_I = \text{Isolation cone radius} \)
Full Simulation Samples and Tools

(1) Full simulation package for Long Barrel Tracker (M. Weinberger) + Calorimeter (V. Khotilovich) in 226
   ✓ ½ detector (to offset memory problems)

(2) Test samples
   ✓ Ditau ($p_T = 10\sim200$ GeV, $\eta = 0\sim2.5$) + PU0
   ✓ Ditau ($p_T = 10\sim200$ GeV, $\eta = 0\sim2.5$) + PU200 [2900 events]

(3) Analysis codes
   ✓ Laura Fields’s track stub finder in 226; Clustering of stubs to remove multiple counting not ready.
   ✓ Michael Mason’s Phase-1 tau calo-cluster reconstruction in 1.6.12 → under migration to 226 (not fully tested yet)

Today, we focus on $N_{\text{sub}}$. 

M. Weinberger
First Look: Hits and Stubs

Hits

<table>
<thead>
<tr>
<th>Layer Number</th>
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<tbody>
<tr>
<td>1</td>
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<td>1200</td>
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Hit Position

A circular graph showing the distribution of hit positions along the x, y, and z axes.

Stub Position

Graphs showing the distribution of stub positions for different values of \( \eta \).

\( \eta = 0 \)

\( \eta = 2.5 \)

M. Weinberger
First Look: Stub Rates (PU200)

- However these rates count every pixel for use in stub creation.
- So many stubs will be created from a single track
- Need clustering to remove the extra stubs
Crude Calculation: $N_{\text{stub}}$

1. Find the average rate of subs per area by layer.
2. Find area of ISO cone ($\Delta \theta = 10^\circ \sim 30^\circ$) for a track at $45^\circ$.
3. Combine to find the average number of stubs in the ISO cone.

$$N_{\text{stub}} = \text{Area} \times 2 \times \text{Rate} / 40 \text{ MHz}$$
$N_{stub}$ in $10^\circ$-$30^\circ$ Cone

![Graph showing $N_{stub}$ in $10^\circ$-$30^\circ$ Cone vs. Layer Number. The graph displays a steady increase from Layer 1 to Layer 10.]
$N_{\text{stub}}$ in $10^\circ$ Cone

- Can not compare stubs to simStubs as Fullsim does not have PU in sim path
- Fastsim does, so look at 50pu events and see how many stubs versus the simstubs to get estimate of overcounting
- Factor of $\sim 10$

- Scale down from counting all stubs calculated from 25pu fastsim sample
Summary and Plan

(1) We created a full simulation package for Long Barrel Tracker + Calorimeter in 226 and tested a fully simulated sample of Dijet + PU200 events.

(2) We plan to have:
- A full production sample of QCD events
- A complete analysis package
  - Laura Fields’s track stub finder in 226
  - Clustering – to be prepared.
  - Michael Mason’s tau cluster reconstruction in 1.6.12 → migration to 226
- A complete performance evaluation
  - Isolation
  - Track-cluster matching
Backup
**Calculation: $N_{\text{stub}}$ in 10°-30° Cone**

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<th>angle</th>
<th>tan angle</th>
<th>layer1</th>
<th>layer2</th>
<th>layer3</th>
<th>layer4</th>
<th>layer5</th>
<th>layer6</th>
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<th>layer8</th>
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<td>86.3</td>
<td>100.5</td>
<td>104.0</td>
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| area of 10 |        |        |        |        |        |        |        |        |        |        |         |         |
| area of 30 | 481.1  | 601.0  | 1040.5 | 1213.6 | 1829.4 | 2056.8 | 2818.9 | 3099.6 | 4203.5 | 4501.4 |         |         |
| isoarea   | 4338.1 | 5418.9 | 9381.7 | 10942.8 | 16495.7 | 18546.1 | 25418.0 | 27948.9 | 37903.1 | 40589.1 |         |         |

| Sim Stub rate | 0.0011 | 0.0010 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |         |         |
| Stub Rate    | 0.2050 | 0.1700 | 0.0800 | 0.0800 | 0.0600 | 0.0500 | 0.0400 | 0.0400 | 0.0400 | 0.0400 |         |         |

<table>
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<td>Number in 10</td>
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<tr>
<td>StubRate</td>
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<tr>
<td>---------</td>
</tr>
<tr>
<td>Number in iso</td>
</tr>
<tr>
<td>Number in 10</td>
</tr>
</tbody>
</table>

M. Weinberger