Measuring efficiency using 3 particle final state events

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HPS Collaboration Meeting
3 May 2017
Outline:

• Rate effects and Ecal-only data
• 3 particle final state event selection
• Topologies
• Efficiencies
• Summary
2016 SVT data has rate dependency
Effect is not clear in Ecal-only selection
## Ecal Only Selection - 2015

<table>
<thead>
<tr>
<th>Run</th>
<th>Run Current (nA)</th>
<th>Fcup livetime</th>
<th>Q (nc)</th>
<th>Q (nc) x livetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>5749</td>
<td>30</td>
<td>0.97</td>
<td>14631</td>
<td>14193</td>
</tr>
<tr>
<td>5754</td>
<td>40</td>
<td>0.938</td>
<td>15330</td>
<td>14380</td>
</tr>
<tr>
<td>5755</td>
<td>60</td>
<td>0.87</td>
<td>17288</td>
<td>15041</td>
</tr>
<tr>
<td>5772</td>
<td>50</td>
<td>0.8822</td>
<td>333139</td>
<td>293895</td>
</tr>
</tbody>
</table>

- All used v7tb-Lat147 trigger
- 5749, 5754 had unique pedestals for specified current
- 5755 and 5772 used 50 nA pedestals
2015 running

Loose selection (dominated by WABs):
- $E < 0.8$ GeV
- Time difference $< 1.6$ ns
- Pairs1
- Trigger time window
- 1 cluster in top, 1 in bottom
- 1 cluster left half, 1 cluster right half

This wab-beam-tri MC uses MG5
Here’s the same loose selection I showed in November where wab-beam-tri was using MG4.

→ Not very different from now.
2015 running

Tight selection (reduce WABs):
• $E < 0.8$ GeV
• Time difference $< 1.6$ ns
• Pairs1
• Trigger time window
• 1 cluster in top, 1 in bottom
• 1 cluster left half, 1 cluster right half
• clusters within $+/- 200$ MeV
• Coplanar 180 $+/-$ 10 deg

This wab-beam-tri MC uses MG5
Here's the same tight selection I showed in November where wab-beam-tri was using MG4.

→ Low Esum in MG5 looks much better!
→ High Esum in MG5 unchanged
3 Particle Final State Event Selection

• Tracks:
  • $P < 850 \, \text{MeV}$ (to avoid FEE)
  • Tracks can share no more than 3 hits with other tracks
  • GBL tracks (5+ hits)
  • 3rd track in fiducial region (see next slide)

• Clusters:
  • Cluster $E < 850 \, \text{MeV}$ (to avoid FEE)
  • Energy-Distance Cut (shown 2 slides from now)
  • Clusters in trigger time window $[40, 50]$
  • Choose clusters at least $\frac{3}{4}$ crystal away from edge
  • Cluster energy sum $> 0.9 \, \text{GeV}$

• Track-Cluster Matching:
  • Matching within 10 sigma, based on position

• After matching, check matched clusters are in time. Choose the best, unmatched cluster as one that is in time, has smallest time difference, and energy sum of all clusters $< 1.2 \, \text{GeV}$

• Pairs1 trigger
3rd track Fiducial Cuts, from flat MC

Electron

Positron

$P_x/P_z$

$P_y/P_z$

$P_x/P_z$

$P_y/P_z$
Results of final event selection

Energy-distance cut
Positron, 3 matched tracks

Energy-distance cut
Electron, 3 matched tracks

Psum of Tracks

Esum of Clusters
Consider these topologies:

- e- (close), e+
- e- (far)
- e- (close)
- e- (far), e+
- e+
- e- (close), e- (far)

- Disambiguate the e- cluster using the cluster position in y.
- Consider each of these three cases with e+ top/bottom.
Tag and probe (slide shows 1 topology):

- Consider all combinations and keep top/bottom separate.
Tritrig-wab-beam-tri
(wab-beam-tri had not enough statistics)

Electron Track Efficiency

- e- efficiency when alone in top half
- e- efficiency when alone in bot half
- e- efficiency when e+ in same top half
- e- efficiency when e+ in same bot half
- e- efficiency when e- in same top half
- e- efficiency when e- in same bot half
Positron Track Efficiency

- • e+ efficiency when alone in top half
- ○ e+ efficiency when alone in bot half
- ■ e+ efficiency when e- in same top half
- □ e+ efficiency when e- in same bot half

**Y-axis:** Matched 3 tracks/Matched 2+ tracks

**X-axis:** Momentum of third (missing) track [MeV]

The graph shows the efficiency of positron tracking under different conditions.
Electron Track Efficiency

- e- efficiency when alone in top half
- e- efficiency when alone in bot half
- e- efficiency when e+ in same top half
- e- efficiency when e+ in same bot half
- e- efficiency when e- in same top half
- e- efficiency when e- in same bot half

Positron Track Efficiency

- e+ efficiency when alone in top half
- e+ efficiency when alone in bot half
- e+ efficiency when e- in same top half
- e+ efficiency when e- in same bot half

Y position of third cluster [mm]
Electron Track Efficiency

Matched 3 tracks/Matched 2+ tracks vs Momentum of third (missing) track [MeV]

- Blue circles: e- efficiency when alone in top half
- White circles: e- efficiency when alone in bot half
- Red squares: e- efficiency when e+ in same top half
- Orange squares: e- efficiency when e+ in same bot half
- Green triangles: e- efficiency when e- in same top half
- Blue triangles: e- efficiency when e- in same bot half
e+ efficiency when alone in top half
•
e+ efficiency when alone in bot half
○
e+ efficiency when e- in same top half
■
e+ efficiency when e- in same bot half
□

Positron Track Efficiency

3 tracks matched

Positron in top, alone

- h_Eep_3trk_top_0
  - Entries: 309
  - Mean: 0.4803
  - Std Dev: 0.06547

Positron in bottom, alone

- h_Eep_3trk_bot_0
  - Entries: 192
  - Mean: 0.316
  - Std Dev: 0.0703
Positron Track Efficiency

- ● e+ efficiency when alone in top half
- ○ e+ efficiency when alone in bot half
- ■ e+ efficiency when e- in same top half
- □ e+ efficiency when e- in same bot half

Plots showing matching efficiencies and distributions for positron tracks in top and bottom halves with and without matching third tracks.
Electron Track Efficiency

- Efficiency when alone in top half
- Efficiency when alone in bot half
- Efficiency when $e^+$ in same top half
- Efficiency when $e^+$ in same bot half
- Efficiency when $e^-$ in same top half
- Efficiency when $e^-$ in same bot half

Positron Track Efficiency

- $e^+$ efficiency when alone in top half
- $e^+$ efficiency when alone in bot half
- $e^+$ efficiency when $e^-$ in same top half
- $e^+$ efficiency when $e^-$ in same bot half

5772
Electron Track Efficiency

- e- efficiency when alone in top half
- e- efficiency when alone in bot half
- e- efficiency when e+ in same top half
- e- efficiency when e+ in same bot half
- e- efficiency when e- in same top half
- e- efficiency when e- in same bot half

Positron Track Efficiency

- e+ efficiency when alone in top half
- e+ efficiency when alone in bot half
- e+ efficiency when e- in same top half
- e+ efficiency when e- in same bot half

5772
WAB

Electron Efficiency

Positron Efficiency

5772:
Electron Efficiency

WAB MC:
Positron Efficiency

5772:

WAB MC:
Conclusions:

- Three particle final state events probably mostly WABs
- Efficiencies could be systematically low in regions by 5-10%
- Don’t see huge top/bottom difference
- Need to run over more data
- Difficult to find clear correction with 3 prong events
- Being able to vertex 3 tracks could help (and useful to vertex analysis tail studies)