ECal Reconstruction and Photon Results with GEANT4

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Introduction

- Requirements from future linear collider
  - very good jet energy resolution
  - needs energy flow method
    - typical multi-jet event
    - chrg. part. carry 64% E $\rightarrow$ tracker
    - photon carry 25% E $\rightarrow$ EM cal.
    - neut. Had. carry 11% E $\rightarrow$ HAD cal.

- Calorimeter must be optimized for energy flow. need full simulation study (GEANT4)
Photon reconstruction
(by Dr. Iwasaki)
\( \gamma \) selection by transverse information

- Extrapolate charged tracks to the cluster radius.
- Associate the nearest track to the cluster.

\( \gamma \) selection:

\[ \Pi = 48\% \]

\[ \varepsilon = 98\% \]
γ selection by longitudinal information
γ selection by longitudinal information (cont.)

We determine the longitudinal γ shape by fitting.
\( \chi^2 \) for the \( \gamma \) assumption

- Overall \( \gamma \) selection performance with other selection: 
  \( \Pi = 85\% \)
  \( \varepsilon = 85\% \)
Mass reconstruction (no kin. con.)

<table>
<thead>
<tr>
<th>GEANT4</th>
<th>W mass</th>
<th>error</th>
<th>Top mass</th>
<th>error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track + (\gamma)</td>
<td>67.1±15.9 GeV</td>
<td>(28%)</td>
<td>141.0±33.5</td>
<td>(24%)</td>
</tr>
<tr>
<td>Track + (\gamma) (true)</td>
<td>70.2±16.9</td>
<td>(24%)</td>
<td>147.0±31.7</td>
<td>(22%)</td>
</tr>
<tr>
<td>Track + (\gamma) (true) + h(^0) (true)</td>
<td>77.2±15.1</td>
<td>(20%)</td>
<td>159.7±30.7</td>
<td>(19%)</td>
</tr>
</tbody>
</table>

- True-\(\gamma\)/selected-\(\gamma\) difference ... 2~4%
- → very good \(\gamma\) selection performance
- Adding the neutral hadron clusters
  - can improve mass resolution 3~4%
Calorimeter tracking

- Fine granularity of SD calorimeter (5X5mm²) makes enable tracking.
- Calorimeter may help track finding with tracking device and can significantly contribute to physics analysis (GMSB,…)
- We have checked the tracking performance using $Z \rightarrow \mu\mu$ and single photon events.
Charge separation

Sample is $Z \rightarrow \mu\mu$ @ $E_{cm}=91.26\text{GeV}$
Impact parameter resolution

- Impact parameter and momentum resolution must improve when the tracks link to hits in outer layer of tracking device.
Line fitting of photon clusters
DOCA resolution

10GeV gamma from I.P.
A new calorimeter geometry

Toshinori Abe, Uriel Nauenberg, and Joseph Proulx

- A very fine granular calorimeter shows excellent performance.
- But it is very expensive!
- U. of Colorado proposes a new calorimeter geometry to give energy flow calorimeter with reasonable cost.
Staggered geometry
Benefit of this geometry

**Measured position (no staggered)**

- RMS = 0.2858

**Measured position (staggered)**

- RMS = 0.1444
GEANT4 setup
Position resolution (LD base)

- No staggered: $\sigma_\phi = 0.0066$
- Staggered: $\sigma_\phi = 0.0037$
Position resolution (SD base)
Energy vs. position resolution
Direction resolution (LD base)

-no staggered
\( \sigma = 0.082 \) (rad.)
\( \phi_{MC} - \phi_{rec} \)

-staggered
\( \sigma = 0.063 \) (rad.)
\( \phi_{MC} - \phi_{rec} \)
Direction resolution (SD base)
Current SD detector design gives very good photon reconstruction.

Calorimeter tracking is promising for SD.

U. of Colorado starts study of a new calorimeter design.

full simulation and hardware study