A preliminary look at energies of VDG data at EM

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Outline

- Modification in tkrRecon which affects reconstruction of low energy gammas at EM
- Describe how energies of the gammas at EM were estimated
- Test the reconstruction method on various MC data
- Test the reconstruction method on VDG data
- Summary and plan
Reconstruct VDG data, run 031007191651, 70304 events

Settings in TkrRecon: TkrControl.cxx

\[
\begin{align*}
    m\text{\_minEnergy} &= 30.0; \quad \text{// Min tracking energy (MeV)} \\
    m\text{\_fEneParticle} &= 0.8; \quad \text{// Fraction of Cal energy to use in PR.}
\end{align*}
\]

<table>
<thead>
<tr>
<th>Reconstruction settings</th>
<th>No of reconstructed events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default settings:</td>
<td></td>
</tr>
<tr>
<td>( m_\text{minEnergy} = 30 )</td>
<td>39526</td>
</tr>
<tr>
<td>( m_\text{fEneParticle} = 0.8 )</td>
<td></td>
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<tr>
<td>Change settings:</td>
<td></td>
</tr>
<tr>
<td>( m_\text{minEnergy} = 4 )</td>
<td>60756</td>
</tr>
<tr>
<td>( m_\text{fEneParticle} = 1 )</td>
<td></td>
</tr>
</tbody>
</table>

Threshold in CAL energy used in TkrRecon seems to be too high, especially for low energy gamma reconstruction. Can we change it to a low value? Need to investigate impacts for high energy gammas.
A simple way to estimate energy

- Total estimated energy = TkrEnergy + CalEnergy
  
  - TkrEnergy is estimated according to number of hits in the tracker, corrected by the event direction.
  
  - CalEnergy is estimated by summing up all calibrated energies recorded in each crystal. Need to correct for threshold effects since each crystal only “produces” an energy if it is > 2 MeV.
**TKR Energy reconstruction (MC)**

Event selection: $n\text{TkrTracks} \geq 1 \land z\text{Dir} < -0.9$ (25 deg from vertical) \land max\text{Cal} > 4 \text{MeV}

Error = spread

Use this curve to calculate the TKR Energy

Error = spread/sqrt(N)

Use this curve to calculate the TKR Energy
Threshold effect causes bias on measured CAL energy

Error = spread

Error = spread/sqrt(N)

Event selection: nTkrTracks>=1
zDir < -0.9 (25 deg from vertical)
maxCal>4MeV
Test energy estimation on various MC data
(monochromatic $\gamma$ beam)

- **17.6 MeV straight down gammas**
  
  - Histogram
  - Entries: 4326
  - Mean: 17.15
  - RMS: 3.054

- **30 MeV straight down gammas**
  
  - Histogram
  - Entries: 8540
  - Mean: 27.49
  - RMS: 4.141

- **50 MeV straight down gammas**
  
  - Histogram
  - Entries: 10204
  - Mean: 45.42
  - RMS: 5.501
Cosmic Background

Gammas: 66% 17.6 MeV, 34% 14.6 MeV, FWHM = 1.5 MeV

Not a monochromatic beam!

Electrons are produced by gamma conversions in the iron shield in front of the accelerator.
Reconstructed Energy Spectrum of VDG DATA

Event selection: nTkrTracks>>=1 && zDir < -0.9 (25 deg from vertical) && maximal energy deposited in any single crystal>4MeV

Expected $\gamma$ Spectrum
Delta function (17.6 MeV)
Breit-Wigner (mean 14.5, width=1.5MeV)
Reconstructed energy (MC VDG)

All events

Events converted in iron shield upstream

Estimated energy (MeV)
Reconstructed energy (MC VDG data)

Events converted in top layer of tracker

Estimated energy (MeV)
Bias on the energy estimation

- Potential reasons that fitted energy is a bit lower than known gamma energy
  - At least half of the signal is actually made of electrons produced upstream in the Fe shield
  - Some particles could deposit energy in inactive regions of the detector
  - Tracker loses sensitivity to high energy when nhits >= 12
  - Large uncertainty in calculating TKR energy
Summary

• A simple energy estimator based on number of hits in the tracker and sum energy in all CAL crystals has been developed to reconstruct low energy gammas at EM
  – We have applied it on various MC and VDG data with reasonably good performances.

• VDG data generate lots of useful information to study performance of the EM, especially at low energy.
Future plan

• Following topics are under investigation:
  – Use multiple scattering to estimate tkrEne (KF result)
  – More parameters can be used to correct threshold effect in CAL such as number of hit crystals
  – Investigate off axis performance
  – Investigate full tower scenario
• Problems need to be solved in next EM data taking
  – Reject background electrons