Study Of Single Particle And Jet Response With the SiFCC Detector

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Outline

• Introduction of the SiFCC detector at a 100-TeV pp collider
• Single particle response and resolution
• Jet response and resolution
• Comparison of weighted generator-level energy with calorimeter jet energy
• Conclusion
SiFCC Detector For Performance Studies

- Re-purpose SiD (ILC) detector and SLIC software

SiFCC: multipurpose, high granularity, compact detector

- 30% smaller than ATLAS (D=25 m vs D=19 m)
- 30% larger than CMS (D=14.6 m vs D=19 m)
Characteristics Of SiFCC Detector

- 5 T solenoid outside HCAL

- Pixel and Outer trackers:
  - 20 µm pixel (inner), 50 µm (outer)

- ECAL (Silicon+W): 2x2 cm, 32 layers, ~35 $X_0$

- HCAL (Scint+Fe)
  - 5x5 cm cells: $\Delta \eta \times \Delta \phi = 0.022 \times 0.022$
  - CMS: $\Delta \eta \times \Delta \phi = 0.087 \times 0.087$
  - ATLAS: $\Delta \eta \times \Delta \phi = 0.1 \times 0.1$
  - Longitudinal: 64 layers, 11.3 $\lambda_i$
  - 27.5 mm Steel, 5 mm Polystyrene active material, 2.5 mm G10 (3.1% sampling fraction)
  - > 150 million cells, non-projective
Event Display Of 1 TeV Single Charged Pion

- 7300 calorimeter hits, 440 SiTracker hits
- 1 reconstructed PFA object ($\pi^+$)=998 GeV
- 1 reconstructed CaloCluster at 1058 GeV
- Many back-splash interactions
Single-Pion Response And Resolution

- Resolution for CaloClusters is better than tracks for $E > 3$ TeV
• Response and resolution for single-neutron are similar to those of single-pion
Photon Response And Resolution

- More results of single electron/KLs in the backup slides
The jet response is much worse than what we expected. The resolution gets worse with increasing jet pT for jet pT > 1 TeV.
Jet Energy Response And Resolution With \(Z' \rightarrow qq\) Samples

- Larger jet radius recovers the charged particles that fall outside of jet cone due to the strong magnetic field

- Similar trend is observed in the \(Z' \rightarrow qq\) samples
What Is Inside A Jet?

- Generator-level jets clustered with anti-\( k_T \) algorithm and \( \Delta R=0.4 \) (\( Z' \rightarrow qq \) sample)

- Neutrinos are excluded in the calculation of \( E_{\text{true}} \)

- Overall fractions
  - \( \pi^\pm \): 40%
  - \( \gamma \): 24%
  - \( K^\pm \): 11%
  - \( p, n, K_s, K_L \): 5% each
  - Rest (\( \Lambda, \Xi, \Sigma \)): 5%
Comparison Of Energy Response

- Weight generator-level particles with single-particle response and smear with single-particle resolution

- response = 0 for charged particles with E < 8 GeV, ey response mean=1, RMS/Mean = 0.15/√E ⊕ 0.01

- gen (charged + γ): include only charged particles and photons

1-TeV $Z' \rightarrow qq$

- Jet radius=0.4
- gen response (no γ)
  - Mean = 0.840
  - RMS = 0.087
- gen (charged + γ)
  - Mean = 0.900
  - RMS = 0.133
- gen response (charged + γ)
  - Mean = 0.701
  - RMS = 0.165
- Calo
  - Mean = 0.866
  - RMS = 0.068

40-TeV $Z' \rightarrow qq$

- Jet radius=0.4
- gen response (no γ)
  - Mean = 0.981
  - RMS = 0.045
- gen (charged + γ)
  - Mean = 0.904
  - RMS = 0.106
- gen response (charged + γ)
  - Mean = 0.838
  - RMS = 0.134
- Calo
  - Mean = 0.857
  - RMS = 0.114
Conclusion

- We present a study of the single particle and jet response/resolution with the SiFCC detector using full GEANT4 simulation

- Response and resolution of single particles follow the expected performance of the designed detector

- Resolution of calorimeter jet energy increases with jet energy for jet energy above 1 TeV

- For low energy, the distribution of the weighted generator-level jet energy matches that of the calorimeter jet

- Suggestions, comments, or collaborators are always welcome!
Backup Slides
• Response and resolution for single-$K_L$ are similar to those of single-pion.

![Graphs showing response and resolution for single-$K_L$ compared to single-pion.](image)
• Response and resolution for single-photon are similar to those of single-electron
• Response and resolution for single-pi0’s are similar to those of single-photon
SiD detector for ILC

- Multi-purpose detector for the ILC
- The key characteristics of the SiD detector:
  - 5 Tesla solenoid
  - Silicon tracker: 50 um readout pitch
  - ECAL: (0.35 cm cell size, W / silicon)
  - HCAL:
    - 1x1 cm cell size (RPC)
    - 40 layers for barrel (HCAL) ~4.5 $\lambda_i$
- Optimized for particle-flow algorithms (PFA)
- Fully configurable using SLIC software