

Flavor-tagging studies with different vertex-detector geometries

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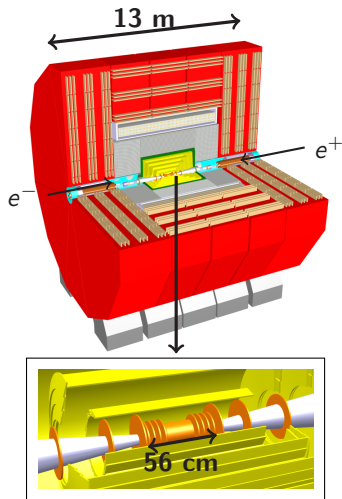


- Reminder on the CLIC_SiD vertex detector geometry
- Implementation of new vertex detector geometries
- Physics performance studies
- Conclusions

Reminder on the CLIC_SiD vertex detector geometry



- CLIC_SiD vertex detector (default geometry):
 - 5 layers in barrel.
 - 4 disks in endcaps.
- A more realistic model for the vertex detector is under development in which:
 - Airflow cooling is used for the heat removal.
 - Double-layered sensors are considered to reduce the mechanical support material.
- Goal: compare the performance of different vertex detector models for jet identification (flavor tagging).

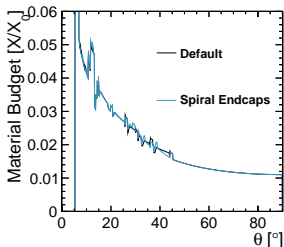
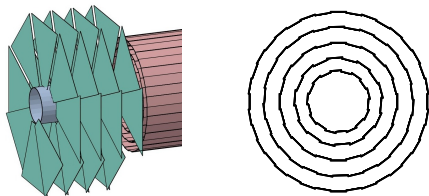


Implementation of new vertex detector geometries

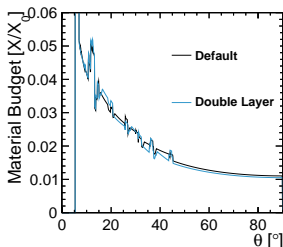
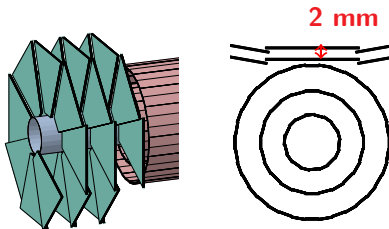


Implemented geometries

- Spiral endcaps geometry:
 - Allows airflow cooling with the same barrel as the default geometry.

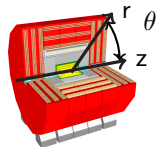
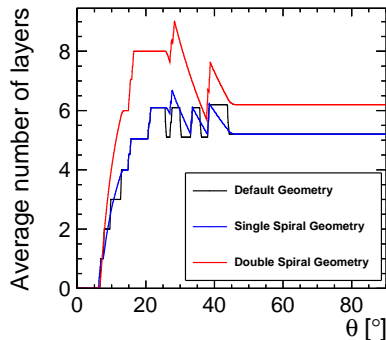


- Double layer geometry:
 - Double-layered sensors.
 - 3 layers in the barrel and 3 layers in the endcaps.



The Coverage of the Vertex Detector

- Average number of sensitive layers (averaged over the azimuthal angle ϕ).



Physics Performance Studies



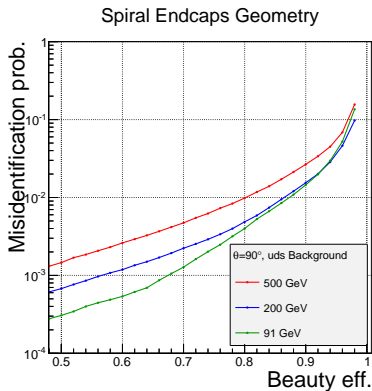
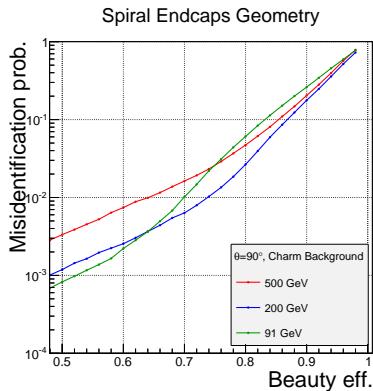
Simulations strategy

- The impact of the new geometries on the jet identification requires full simulation of the detector (cannot be done analytically).
- Software versions used:
 - SLIC v3r0p3
 - org.lcsim 2.5
 - LCFIPlus v0.52
- Dijet events at center-of-mass energies of $\sqrt{s} = 91$ GeV, 200 GeV and 500 GeV with polar angles $\theta = 10^\circ, 20^\circ, \dots, 90^\circ$ are considered.
- 80000 events are considered for each process:
$$e^+e^- \rightarrow b\bar{b}$$
$$e^+e^- \rightarrow c\bar{c}$$
$$e^+e^- \rightarrow u\bar{u}, d\bar{d}, s\bar{s}$$
- 50% of the events are used for training the BDTs and 50% for testing.



b jet identification and energy dependence

- The spiral endcaps geometry is used for dijets at different energies with the polar angle $\theta = 90^\circ$.

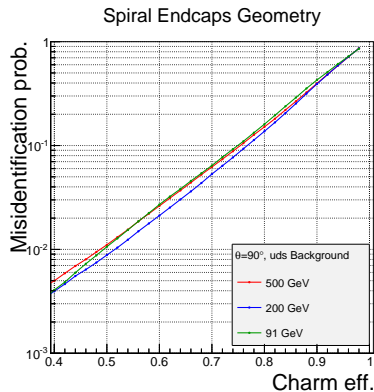
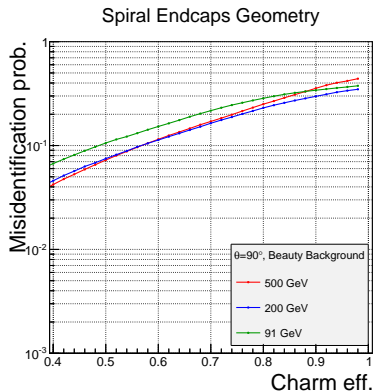


In general, b jet identification gets better for jets at lower energies.



c jet identification and energy dependence

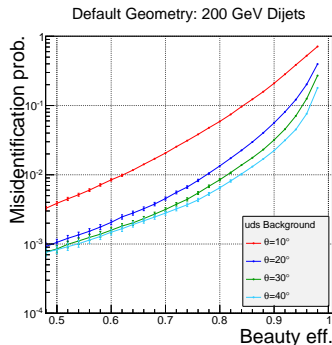
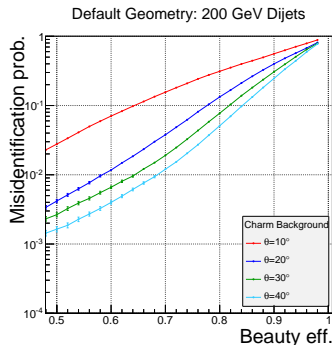
- The spiral endcaps geometry is used for dijets at different energies with the polar angle $\theta = 90^\circ$.



In general, b jet identification has a better performance than c jet identification.

b jet identification and jet angle dependence

- For the default geometry, b jet identification evaluated with dijets at 200 GeV in the forward region.

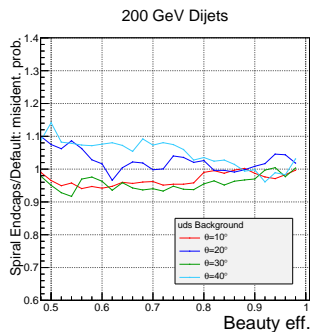
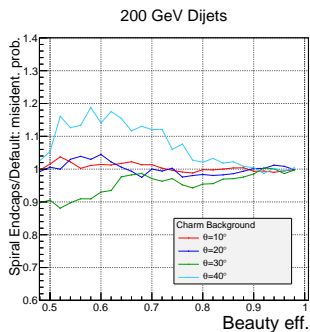


For low polar angles, the performance decreases due to several factors:

- Losses in the beam pipe.
- Low number of detecting layers.
- Low impact parameter resolutions.

Spiral endcaps vs. default geometry

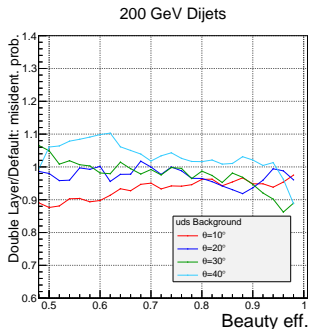
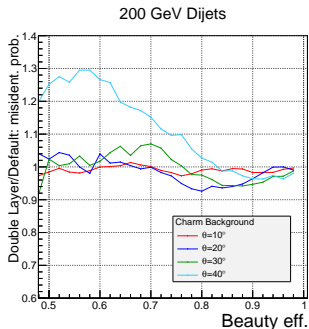
- To compare the two geometries, the ratio between the misidentification probabilities of the spiral endcaps over the default geometry is computed.



Both geometries have similar b jet identification performance except at $\theta = 40^\circ$ (cf. slide 17).

Double layer vs. default geometry

- Dijets in the forward region are considered.

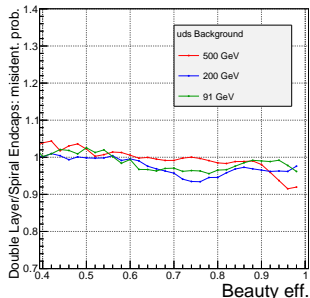
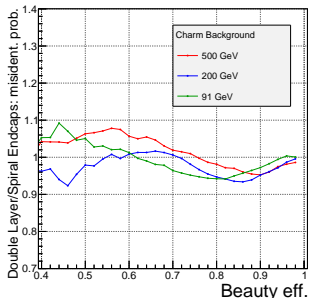


Both geometries have similar b jet identification performance except at $\theta = 40^\circ$ (cf. slide 17).

Double layer vs. spiral endcaps geometry

b jet identification

- For a global comparison of the single and double layer approach, a mixture of polar angles is considered.

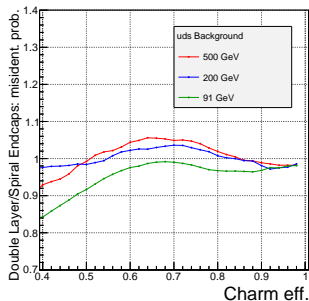
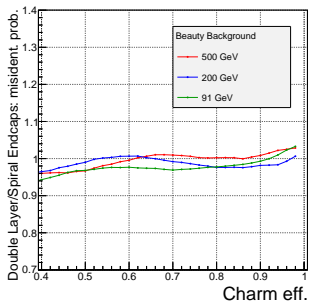


Both geometries have similar b jet identification performance.

Double layer vs. spiral endcaps geometry

c jet identification

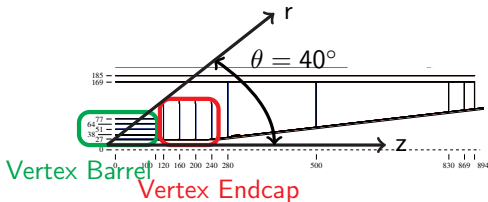
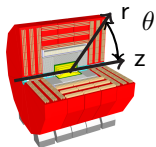
- For a global comparison of the single and double layer approach, a mixture of polar angles is considered.



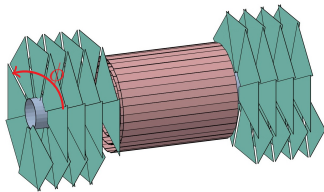
The double layer geometry improves the misidentification probability of uds-jets at 91 GeV.

Jet identification at $\theta = 40^\circ$

- The b jet identification at $\theta = 40^\circ$ has higher background for the spiral geometries (up to 30% for the double layer geometry).
- At this angle, there is the transition between the vertex endcaps and the barrel. Less sensitive layers are hit in the spiral for certain ϕ angles.



- This effect can be potentially improved by using a ϕ dependent optimization of the track reconstruction.



Conclusions

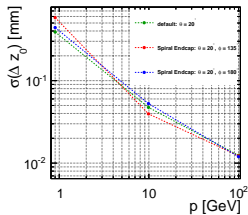
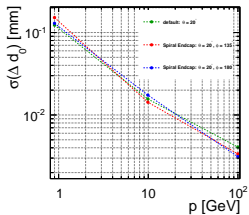
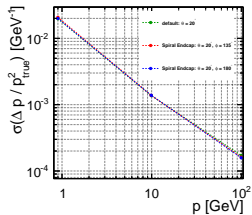
- Two new concepts for the CLIC vertex detector have been implemented: spiral endcaps and double layer geometries.
- The impact of the new geometries on the physics performance is too complex to be estimated analytically as it depends on many factors \Rightarrow full simulation is needed.
- In general, the performance of the different geometries is rather similar.
 - The single and double layer geometries have very similar performances.
 - For jets at 40° , the default geometry shows better b jet identification performance than the spiral geometries \Rightarrow the track reconstruction should be optimized.
 - Double-layered sensors reduce the background for the c jet identification at low energy.



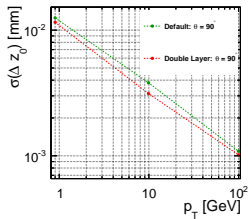
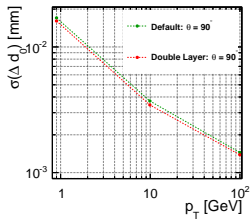
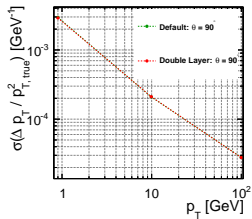
Backup Slides



Impact parameter resolutions: spiral endcaps geometry

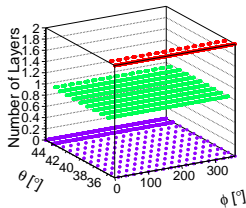


Impact parameter resolutions: double layer geometry

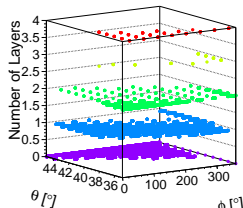


Number of Layers at $\theta = 40^\circ$

Default geometry



Spiral endcaps



Double layer

