Vertex Detector Studies

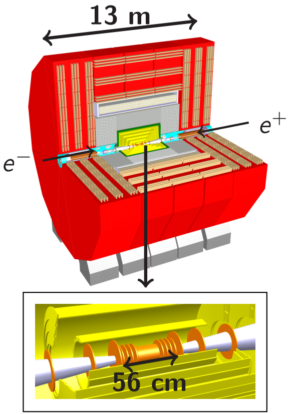
Niloufar Alipour Tehrani (CERN & ETH Zürich), Philipp Roloff (CERN)

On behalf of the CLIC Detector and Physics Study

CLIC Detector and Physics Collaboration Meeting 2014
CERN
10 June 2014

Introduction

- CLIC_SiD_CDR vertex detector :
  - 5 layers in barrel.
  - 4 disks in endcaps.
- Previously, the flavour-tagging performance for new vertex detector geometries have been studied which allow the use of:
  - airflow cooling for the heat removal. ▸ "spirals" geometry

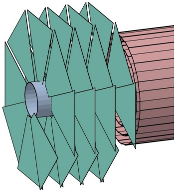


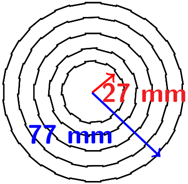
- Now :
  - The effect of a lower magnetic field (B=4.5 T instead of 5 T) on the performance of the CLIC detector is under study.
  - For lower B-fields, the inner radius of the vertex detector needs to be increased to reduce the background due to the incoherent e^+e^- pairs.
  - This talk studies the effect of an increase of the inner radius on the flavour-tagging performance. ▸ "spirals_radius31" geometry

Reminder: the *spirals* geometry

- Spiral arrangement of the sensors in the forward region (instead of disks) to allow for airflow cooling.

- The same barrel as the CLIC_SiD_CDR geometry.
- Material budget: 0.11% X_0 per layer.



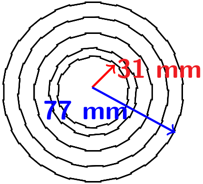


- The *spirals* geometry shows very similar beauty and charm-tagging performances to the CLIC_SiD_CDR geometry.

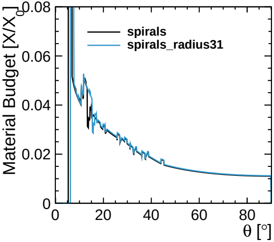
cf. LCWS13 workshop Physics performance studies for different CLIC vertex detector geometries.

The *spirals_radius31* geometry

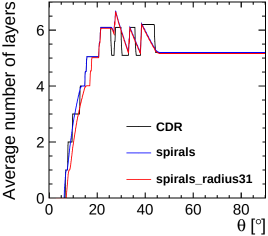
- For *spirals_radius31*, the radius is increased to r_{in}=31 mm which corresponds to the inner radius of CLIC_ILD for 4 T (r_{in}=27 mm for CLIC_SiD).



- The first barrel layer contains 20 modules (18 for CLIC_SiD).
- Spiral arrangement of the sensors in the forward region.
- The simulated material budget for the vertex detector (including the beam pipe) averaged over ϕ:



- Number of sensitive layers averaged over ϕ:



Simulations strategy

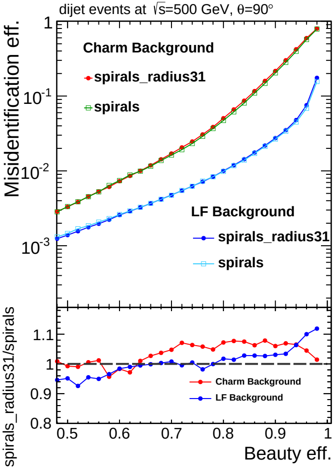
- The impact of the new geometry is evaluated using the flavour-tagging performance based on the full simulation of the detector (cannot be done analytically).
- Dijet events (without ISR and Beamstrahlung) at center-of-mass energies of $\sqrt{s}$ =200 GeV and 500 GeV with polar angle $\theta = 90^{\circ}$ are considered.
- 80000 events are considered for each process:
  $e^+e^- \rightarrow b\bar{b}$
  $e^+e^- \rightarrow c\bar{c}$
  $e^+e^- \rightarrow u\bar{u}, d\bar{d}, s\bar{s}$ $\Rightarrow$ light-flavoured (LF) jets
- 50% of the events are used for training the Boosted Decision Trees (BDTs) classifier and 50% for testing. The mass and the decay length significance of the vertices are the most important input variables.
- B-field=5 T

Software versions used:

- SLIC v3r0p3
- org.lcsim 2.5
- LCFIPlus v0.52

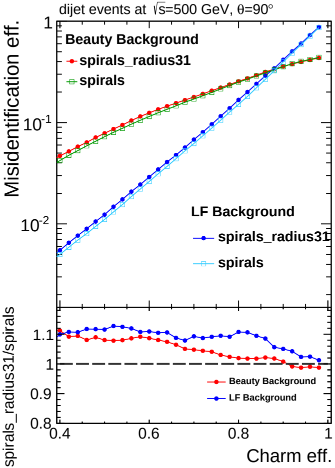
Comparison of the *spirals* and the *spirals_radius31* geometries (1)

- $\sqrt{s}$=500 GeV
- The b-tagging efficiency vs. the probability to misidentify c/LF jets as b jets.
- Very similar b-tagging performance.



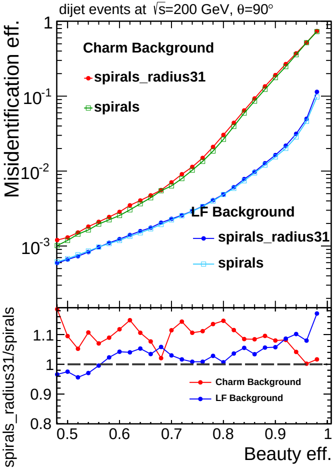
Comparison of the *spirals* and the *spirals_radius31* geometries (2)

- $\sqrt{s}$=500 GeV
- The c-tagging efficiency vs. the probability to misidentify b/LF jets as c jets.
- Fake rates increase by up to 10% for *spirals_radius31*.



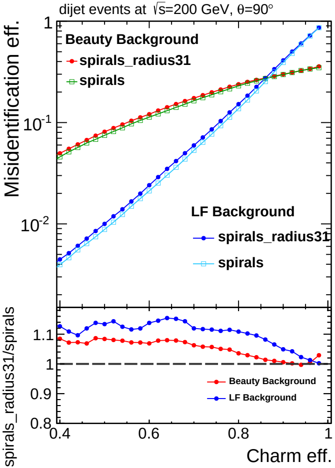
Comparison of the *spirals* and the *spirals_radius31* geometries (3)

- $\sqrt{s}$=200 GeV
- The b-tagging efficiency vs. the probability to misidentify c/LF jets as b jets.
- For lower jet energies, up to typically 10% increase in fake rates for the *spirals_radius31* compared to *spirals*.



Comparison of the *spirals* and the *spirals_radius31* geometries (4)

- $\sqrt{s}$=200 GeV
- The c-tagging efficiency vs. the probability to misidentify b/LF jets as c jets.
- Up to typically 10% increase in fake rates for the *spirals_radius31* compared to *spirals*.



Conclusions

- The effect of a larger inner radius of the vertex detector on the flavour-tagging performance has been studied with the *spirals_radius31* geometry.
- In general, the performance is very similar to the *spirals* geometry. The impact is more visible on jets at lower energies.
- The impact is bigger for charm vs. LF separation as there is no decay after the first layer and the precision gets better with a smaller inner radius.