Performance and occupancies in a CCD vertex detector with endcaps

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Introduction

- Motivation:

  Extend barrel tracking philosophy forward

1. Better vertexing at forward region
2. Extrapolate tracks to forward disks for momentum measurement and reliable extrapolation to the calorimetry.
3. Pattern Recognize in 5 Layers of CCD
4. Global Pattern Recognition to follow
Current working issue

- We need to make sure the feasibility of this idea.
- At this point, we are working on the following issues.
  1. Endplate layout
  2. Performance
  3. Occupancies and radiation damage
Endplate layout
Design concept

- Extend 5 layer tracking over max $\Omega$
  
  $\Omega$ Coverage
  - 5 CCD layers: 0.97 (vs. 0.90 TDR VXD)
  - 4 CCD layers: 0.98 (vs. 0.93 TDR VXD)

- Minimize CCD area/cost
  
  - Shorten Barrel CCDs to 12.5 cm (vs. 25.0cm)

- Thin the CCD barrel endplate
  
  - a single 300 $\mu$m Si disk for self supporting
Performance study

- Full detector simulation for reality.
- Generate single muon track for 2GeV, 20GeV, and 200GeV as a function of cosθ.
- Do Kalman filter fit.
- Study momentum resolution, impact parameter resolution, and dip angle resolution.
Almost same performance.

Momentum and dip angle resolution

- \( \log(1-\cos \theta) \) vs \( \tan \theta \) at \( p = 0.00 \text{ GeV} \)

200 GeV

20 GeV

2 GeV

20 GeV

2 GeV
Impact parameter resolution

Better performance at the forward region.
Tracking performance with endplate

- Momentum and dip angle resolutions are same as previous design.
  - These resolutions are dominated by lever arm than VXD.

- Impact parameter resolutions are significantly improved both of low and high momentum region.
  - Do we get better heavy flavor jet tagging at forward region than before?
B-tag performance

- $Z^0 \rightarrow q \bar{q}$
- Topological vertexing at $E_{cm} \sim 91$ GeV
- $P_T$ corrected mass tag (no optimization)
- Better b-tag performance at the forward region
Occupancy study setup

- One big question for endplate vertex detector is occupancy (and S/N ratio).
- We study it taking account to the following signal and backgrounds at $\sqrt{s}=500\text{GeV}$:
  1. $e^+e^- \rightarrow t\bar{t}$ (Pandora Pythia)
  2. Photons (Takashi)
  3. $e^+e^-$ pairs (Takashi)
  4. $\gamma(\ast)\gamma(\ast) \rightarrow$ hadrons (Tim)
    (Backgrounds are overlaying per a train.)
- We use full detector simulation with NLC beam condition (192 bunches per train).
Endplate occupancies

**VXD Endcap occupancies**

- Signal + backgrounds
- Signal (t\bar{t})
- \gamma s
- e^+e^-
- \gamma\gamma \rightarrow \text{hadrons}
- Backgrounds

![Graph showing occupancies](image)

- Occupancy (1/layer/track)
- Layer number
Occupancies vs. R

10^{-3} at inner radius
Occupancy with endplate

- **Good news:**
  Occupancy rate (~$10^{-5}$ and $10^{-3}$ *at inner radius*) is not terrible.
  (Thanks to very fine granularity of CCD)

- **Bad news:**
  S/N ratio is very small.
  (Small number of signal tracks and most of backgrounds are $e^+e^-$ pairs which are real tracks.)

→ How difficult detector understanding?
→ How cost track finding?
→ How pollute signal tracks?
Radiation damage per month

About ~5 Gy/month at inner radius
How severe is it?

- I have collected opinions by two vertex detector experts.
  1. First opinion: John → Green light.
  2. Second opinion: Chris → Grey…
     (should be careful about machine environment, clock time, etc…)
- Currently we can not say 5Gy/month indicates green, yellow, or red light.
  We need more opinion about it.
Summary

- We just start a study of vertex detector with endcaps.
- The endcaps significantly contribute to improve impact parameter resolution and b-tag performance at forward region.
- The occupancy is not a problem but S/N ratio. (Is time stamp needed?)
- We are looking forward to hear expert’s opinion about radiation damage.