Vertexing Degradation

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2005/Apr/21  @Hawaii
Near Future

~x3 BG study is needed
What will happen?

Red : x3 BG
Blue : nominal

SVD x3 BG ~25%

Occupancy will increase upto ~25% in 1st layer!

~8%

Vertexing is OK?!
Performance Prediction

Procedure

$B \rightarrow J/\Psi \ \text{Ks, } B \rightarrow \text{generic MC event (Detector Simulation)}$

$+$

Random-trigger real Background event (as of 2004)

Nominal BG $\rightarrow$ Tracking/Vertexing $\rightarrow$ Performance Check

$x3 \ \text{BG}$

Some Assumptions

- PID is perfect,
- Lepton/Kaon tagging only,
- Current Hardware/Software
Vertex Resolution

\( \Delta V_{\text{cp}}(=V_{\text{cp}}^{\text{MC}} - V_{\text{cp}}^{\text{Rec}}) \)

- \( \sigma \approx 36\mu m \) (Nominal)
- \( \sigma \approx 44\mu m \) (x3 BG)

\( \Delta V_{\text{tag}}(=V_{\text{tag}}^{\text{MC}} - V_{\text{tag}}^{\text{Rec}}) \)

- \( \sigma \approx 67\mu m \)
- \( \sigma \approx 79\mu m \)

\( \Delta V_{\text{dif}}(=V_{\text{dif}}^{\text{MC}} - V_{\text{dif}}^{\text{Rec}}) \)

- \( \sigma \approx 86\mu m \)
- \( \sigma \approx 104\mu m \)

\( s_{\text{nominal x3 BG}} \approx 20\% \) degradation
Reconstruction Efficiency

**Nominal:** ~67%

**x3 BG:** ~58%

**TAG side**
- Track finding + Quality (tag vtx/cp vtx)
  - Nominal: ~49%
  - x3 BG: ~46%

**CP side**
- Track finding in CDC (cp vtx/L0 trig)
  - Nominal: ~67%
  - x3 BG: ~58%

- Track Quality (SVD+CDC)
  - Nominal: ~67%
  - x3 BG: ~58%

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- Track finding in CDC
  - Nominal: ~67%
  - x3 BG: ~58%
## Most Responsible Part?

**B → J/Ψ Ks, B → generic : 10,000 events**

(σ = single gaussian)

<table>
<thead>
<tr>
<th></th>
<th>1st : Nominal 2,3,4 : x3BG</th>
<th>1,2 : Nominal 3,4 : x3BG</th>
<th>1st : x3BG 2,3,4 : Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta V_{cp})</td>
<td>(~36,\mu m) 3321 events</td>
<td>(~36,\mu m) 3382 events</td>
<td>(~44,\mu m) 3381 events</td>
</tr>
<tr>
<td>(\Delta V_{tag})</td>
<td>(~66,\mu m) 1531 events</td>
<td>(~66,\mu m) 1558 events</td>
<td>(~72,\mu m) 1568 events</td>
</tr>
<tr>
<td>(\Delta V_{dif})</td>
<td>(~89,\mu m)</td>
<td>(~85,\mu m)</td>
<td>(~99,\mu m)</td>
</tr>
</tbody>
</table>

Resolution is not so different from nominal BG case

1st layer!
SVD Cluster Classification

- $(S, S)$: True cluster
- $(B, B)$: Background (BG) cluster
- $(B, S)$, $(S, B)$: Fake cluster
- $(S+B, S)$: Distorted cluster

BG/Fake/Distorted clusters smear hit position affect tracking/vertexing
CP side ($J/\Psi$ Ks)

CP vertex = Vertex ( $J/\Psi \rightarrow \mu^+ \mu^-$)

x3 BG, 1st layer

Distorted cluster is the main cause
Distorted Cluster

1st lyr.

2nd lyr.

3rd lyr.

4th lyr.

Tracking seems to be fine upto 2nd layer

Clustering should be improved!
TAG side

x3 BG, 1st layer

μ momentum

Red: True
Blue: Distorted
Green: Background
Yellow: Fake

Fraction of BG/Fake cluster increases

cls energy diff. of 1st lyr

$|E_z| - |E_{r\phi}|$ (elec)
2 of 3 remaining layers have no hit.

Track seed itself in CDC is not good!
Fake Cluster

1st lyr.

2nd lyr.

3rd lyr.

4th lyr. hit (True ~100) (Fake ~550)

NO hit

~700

NO hit

~700

hit (True ~300) (Fake ~200)

~600

1316

NO hit

~700

hit

~600

2354

hit

~300

1038

NO hit

~300

NO hit:hit (2:3)

hit (1:1)

hit

~700

hit

~600

Good track + poor cluster in 1st lyr ?
(worsens the track quality)

Poor track seed ?
B → D*⁺D*⁻ Case

x3 BG, 1st layer

mom. of CP-side part.

Red : True
Blue : Distorted
Green : Background
Yellow : Fake

mom. of TAG-side part.

B → D*⁺D*⁻ (D*⁺ → D(Kπ)π), B → generic

CP side → High mom.
TAG side → Low mom.

Not appropriate
Points so far

Causes of the vtx-resolution degradation

**High Momentum**  (Distorted cluster)
- Tracking (upto 2nd lyr) is fine
- Distorted cluster in 1st lyr worsens trk-quality

**Low Momentum**  (Background cluster)
- Poor seed track in CDC

**Low Momentum**  (Fake cluster)
- Poor seed track in CDC  (~a half)
- Fine tracking (upto 2nd lyr) +Bad cluster in 1st lyr.
How to Recover ... Current Attempt

Energy balance cut

\[ | |E_z| - |E_{r\phi}| | > 15,000 \text{ el} \]

Cut

Not used for tracking in SVD
(for 1st, 2nd layer)

Quality of track

w/o Bad clst > w/ Bad clst
(esp. 1st lyr)

Better vtx resol.
# Recovered Vtx Resolution

$B \rightarrow J/\Psi K_s$, $B \rightarrow$ generic : 10,000 events  

<table>
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<tr>
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<th>Nominal BG</th>
<th>x3 BG</th>
<th>x3 BG w/ ene. balance</th>
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<tr>
<td>$\Delta V_{cp}$</td>
<td>~36 $\mu$m 4197 events</td>
<td>~44 $\mu$m 3115 events</td>
<td>~42 $\mu$m 3120 events</td>
</tr>
<tr>
<td>$\Delta V_{tag}$</td>
<td>~67 $\mu$m 2038 events</td>
<td>~79 $\mu$m 1436 events</td>
<td>~75 $\mu$m 1423 events</td>
</tr>
<tr>
<td>$\Delta V_{dif}$</td>
<td>~86 $\mu$m</td>
<td>~104 $\mu$m</td>
<td>~96 $\mu$m</td>
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Better vtx resol.
Other Attempts...

For High-momentum tracks

To avoid using Distorted cluster in the 1st layer

Is it possible to optimize clustering?

or cluster selection?

cluster width,
clustering threshold,
incident angle of particle,
layer correlation of charge

.....

(by Heffernan)

1st lyr. 1BG, N-side

1-strip

2-strip

3-strip

4-strip

5-strip

incident angle(deg)
Other Attempts...

For Low-momentum tracks

To get more reliable low-momentum tracks
SVD self-track finding is difficult ...

Eff. by Trabelsi@U of Hawaii

Tracks without enough CDC hits for usual pattern recognition

SVD+sCDC track finding?

Still working on

(SVD 4 lyrs + sCDC)
Possible Hardware Updates

Optimizing shaping time of readout chip in SVD
(Background ↓~30%@max )

Or replace the readout chip on the 1st layer
  VA1TA → APV25 (shaping time 800nsec → ~50nsec)

Pixel-type detector can reduce Distorted/Fake cluster

Replace the readout electronics in CDC
  Deadtime can be reduced (2.2μ → 0.8μsec)

Key point is to reduce room for BG to sneak in
Summary

Vertex Resolution deteriorates by ~20% under x3 BG

Causes of deterioration

for High mom. track
  Track finding/quality (upto 2nd lyr) seems to be OK
  Distorted cluster in 1st lyr makes track quality worse

for Low mom. track
  Track seed itself in CDC is poor
  SVD true cluster can not be used correctly

Way of Recovery

Energy balance cut  ➔  Better vertex resolution

But many things to do (low-pt tracking, better clustering, hardware...)
Reconstruction Efficiency $(\pi^+ + \pi^-)$

**CP side**
- Track finding in CDC
  - Nominal: $\sim 88\%$
  - $x3$ BG: $\sim 82\%$
  - $\sim 6\%$
- Track Quality (SVD + CDC) (cp vtx/L0 trig)
  - Nominal: $\sim 48\%$
  - $x3$ BG: $\sim 47\%$
  - $\sim 1\%$

**TAG side**
- Track finding + Quality (tag vtx/cp vtx)
  - Nominal: $\sim 48\%$
  - $x3$ BG: $\sim 47\%$
  - $\sim 1\%$↓
CP side($\pi^+\pi^-$)

CP vertex = Vertex ($B \rightarrow \pi^+\pi^-$)

x3 BG, 1st layer

Situation is the same. Distorted cluster!

### π momentum

<table>
<thead>
<tr>
<th>E_z</th>
<th>-</th>
<th>E_rφ</th>
<th>(elec)</th>
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Yellow : Fake

Situation is the same. Distorted cluster!
### Recovered Vtx Resolution

**B → π⁺π⁻, B → generic**: 10,000 events

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<tr>
<td>ΔV&lt;sub&gt;cp&lt;/sub&gt;</td>
<td>~26 μm 7023 events</td>
<td>~32 μm 5775 events</td>
<td>~30 μm 5867 events</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;tag&lt;/sub&gt;</td>
<td>~59 μm 3356 events</td>
<td>~72 μm 2725 events</td>
<td>~71 μm 2754 events</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;diff&lt;/sub&gt;</td>
<td>~71 μm</td>
<td>~97 μm</td>
<td>~88 μm</td>
</tr>
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Better Efficiency?! Better Vtx Resol.