The Atlas Vertex Reconstruction

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A Toroidal LHC Apparatus
Vertices

- Primary vertex
- Pileup vertices
- Vertices from conversions
- Vertices from long lived particles
- Vertices in jets and from decay chain
Fig. 1. Vertex topologies important for physics analyses in ATLAS: primary and pile up vertices, vertices from conversions and long-lived particles, vertices in jets and vertices from decay chains.
Heavy Ion Collision Event with 2 Jets
Alignment

**Pixel**: 50 x 400 microns  
**SCT**: 80 micron pitch  
**TRT**: 4mm dia tube
ATLAS Preliminary

Pixel barrel

\( \sqrt{s} = 7 \text{ TeV} \)

- Autumn 2010 Alignment
  - FWHM/2.35=19 \( \mu \text{m} \)
- Monte Carlo
  - FWHM/2.35=17 \( \mu \text{m} \)

Hits on tracks / 4 \( \mu \text{m} \)

Local x residual [mm]

SCT barrel

\( \sqrt{s} = 7 \text{ TeV} \)

- Autumn 2010 Alignment
  - FWHM/2.35=36 \( \mu \text{m} \)
- Monte Carlo
  - FWHM/2.35=34 \( \mu \text{m} \)

Hits on tracks / 12 \( \mu \text{m} \)

Local x residual [mm]

TRT barrel

\( \sqrt{s} = 7 \text{ TeV} \)

- Autumn 2010 Alignment
  - FWHM/2.35=138 \( \mu \text{m} \)
- Monte Carlo
  - FWHM/2.35=138 \( \mu \text{m} \)

Hits on tracks / 12 \( \mu \text{m} \)

Local x residual [mm]
Software package flow

**Figure 3-7** Tracking reconstruction chain. The boxes on the top represent data objects, whilst the boxes on the bottom show the algorithms which work on them. The arrows show the direction of data flow.
Primary vertex reconstruction

• Adaptive MultiVertex Finder
  – Finding through fitting
  – Starts with track reconstruction
  – Outliers go and form new vertex

• VKalman Vertex Fitter
  – Think of Kalman filter
  – Outliers with high $\chi^2$ value gets rejected
  – Fitting after finding
TABLE I
Efficiencies (in %) of reconstruction of signal primary vertices with different approaches.

<table>
<thead>
<tr>
<th></th>
<th>AMVF</th>
<th>VKalVrt</th>
<th>Fast fitter</th>
<th>Full fitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$WH, H(120) \rightarrow b\bar{b}$</td>
<td>95.35</td>
<td>96.25</td>
<td>89.38</td>
<td>89.39</td>
</tr>
</tbody>
</table>

TABLE II
Resolutions on the transverse positions of signal primary vertices reconstructed using different approaches.

<table>
<thead>
<tr>
<th></th>
<th>AMVF</th>
<th>VKalVrt</th>
<th>Fast fitter</th>
<th>Full fitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$WH, H(120) \rightarrow b\bar{b}$</td>
<td>11.21</td>
<td>11.34</td>
<td>12.69</td>
<td>12.69</td>
</tr>
<tr>
<td>$WH, H(120) \rightarrow w\bar{w}$</td>
<td>10.02</td>
<td>10.03</td>
<td>10.68</td>
<td>10.68</td>
</tr>
<tr>
<td>$H \rightarrow 4l$</td>
<td>9.81</td>
<td>9.72</td>
<td>10.4</td>
<td>10.4</td>
</tr>
<tr>
<td>$t\bar{t}$</td>
<td>10.33</td>
<td>10.33</td>
<td>12.55</td>
<td>12.55</td>
</tr>
</tbody>
</table>
Fig. 3. Distribution of residuals of the transverse position of primary vertices in $t\bar{t}$ events reconstructed with the Adaptive Multi Vertex Finder.

Fig. 4. Distribution of pulls of the transverse position of primary vertices in $t\bar{t}$ events reconstructed with the Adaptive Multi Vertex Finder.
Vertex Kinematic Fitter

- Mass constraint
- Improved resolution

Fig. 5: Momentum resolution of the muon track parameters at the vertex reconstructed with the default vertex fitter and the VertexKinematicFitter with mass constraint, using simulated $J/\psi \rightarrow \mu^+\mu^-$ events.
Conversion photon, Long lived particle

- Constrained vertex fitting
- Track pairs preselection
- Track selection using particles IDs

Fig. 6. Track, track-pair and vertex reconstruction efficiency for converted photons originating from 120 GeV $H \rightarrow \gamma\gamma$ decays, as a function of distance from the beam axis.

Fig. 7. Reconstructed vertex radial position resolution (in mm) for converted photons from a 120 GeV $H \rightarrow \gamma\gamma$ decay. For comparison the two cases where the participating tracks have lost $> 20\%$ (< 20\%) of their energy due to bremsstrahlung are also shown separately.
$K_S \rightarrow \pi^+ \pi^-$

Fig. 9. Reconstructed vertex radial position resolution (in mm) of $K_S \rightarrow \pi^+ \pi^-$ decays as a function of the radial distance from the beam axis.

Fig. 8. Reconstructed vertex radial position resolution (in mm) of $K_S \rightarrow \pi^+ \pi^-$ decays.
Vertices in Jets

• Track Selection
  – Selection of displaced tracks
  – Reconstruction of all 2 tracks vertices
  – Removal of vertices compatible with γ, long lived particles

• Types
  – Inclusive vertex finder
    • Form a common geometrical vertex
  – Topological / JetFitter
    • Assume that all tracks intersect a common PV → b → c flight axis
Figure 1. The ATLAS default secondary vertex finder fits all displaced tracks to an inclusive vertex.

Figure 2. JetFitter performs a multi-vertex fit using the b-hadron flight direction constraint.
Fig. 10. Radial position resolution (in mm) of the secondary vertex, for the *inclusive vertex finder* (BTagVrtSec in the figure) and for the *topological vertex finder* (JetFitter in the figure). In the latter case, only the first vertex in the decay chain is considered if more than one displaced vertex is found.

Fig. 11. Light quark rejection as a function of $b$-tagging efficiency for various algorithms: the *inclusive vertex finder* (green triangles), the *topological vertex finder* (full red circles) and, for comparison, the impact parameter only based algorithm (blue empty circles).
References


• P. Billoir and S. Qian, Nucl. Instr. and Meth. A311 (1992) 139-150.

