Reconstructing Boosted Top Decays
A Window on New Physics at ATLAS
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**Beyond the Standard Model with tf**
High $p_T$ top quark processes at ATLAS could shed light on exotic new phenomena, including Warped Extra Dimensions. New states such as Kaluza-Klein excitations of gravitational gravitons may couple strongly to the top quark and reveal themselves through high-mass $t\bar{t}$ pair production.

**Overlap and Isolation – Fun with Boosted Tops**
High momentum top quarks present interesting reconstruction issues. Due to collimation of the final-state particles from the decay, calorimeter signatures tend to overlap and the reliability of standard isolation definitions decreases. Care must be taken when reconstructing tops from leptons and jets in such events.

**A New Measure of Isolation**
Isolation defined by spatial separation ($\Delta R = \sqrt{(\Delta \eta)^2 + (\Delta \phi)^2}$) or surrounding calorimeter energy ($E_{T-Cone}$) is prone to particle collimation effects in high $p_T$ top events. The mass ratio $\Psi = M(jet)/M(jet+jet)$ provides a good alternative. Muons from boosted tops are reliably distinguished from those originating in jet fragmentation.

**The Muons: Reconstructing Boosted $t \rightarrow b W \rightarrow b\mu\nu$**
Muon isolation plays an important role in the reconstruction of top quark decays to $b\mu\nu$, especially so for tops with high transverse momenta. As the $p_T$ of the top quark increases, the angular separation between the muon and $b$ jet decreases. The standard isolation criteria ($\Delta R$ and $E_{T-Cone}$) are not very efficient in the high-$p_T$ region. The mass ratio $\Psi$ provides an alternative definition for identifying the muon from such boosted decays.

**Signatures in the ATLAS Detector**

**The Electrons: Reconstructing Boosted $t \rightarrow b \nu W \rightarrow b e\nu$**
Even in very highly boosted $t \rightarrow b e\nu$ decays the electron is generally reliably identified and reconstructed. However, its close proximity to the associated $b$ quark means that it is often also included as a constituent of the corresponding reconstructed jet. Since the reconstructed top quark is taken to be the four-momentum sum of the candidate jet, electron, and neutrino solution, the electron momentum contribution is double-counted. This broadens the resolution of the reconstructed top quark mass.

**Boosted Hadronic Top Decays**
As with $t \rightarrow b\ell\nu$ decays, the signatures of a boosted $t \rightarrow b W \rightarrow b\nu j$ decay can become entangled with each other, effectively resulting in a top "monojet." Fortunately, the substructure of such a collimated top jet can still be used to distinguish boosted top quarks from single high energy jets. The $Y_{n\rightarrow n-1}$ split-merge scales for combining $n \rightarrow n-1$ protojets (calorimeter clusters) used in the $k_t$ jet algorithm provide a promising tool for identifying top monojetss. Cuts on various combinations of the jet splitting scales and jet mass improve high-mass $t\bar{t}$ event selection.

**Future Studies**
How do background processes affect reconstruction of boosted top decays? How does reconstruction of boosted tops vary for different jet algorithms? What are the trigger efficiencies in boosted $t\bar{t} \rightarrow b\nu j j (\ell = e, \mu)$ decays? How can a $\Psi$-based muon isolation definition affect MET resolution?