TEL AVIV UNIVERSITY אוניברסיטת תל-אביב

Search for Heavy Displaced Vertices at ATLAS

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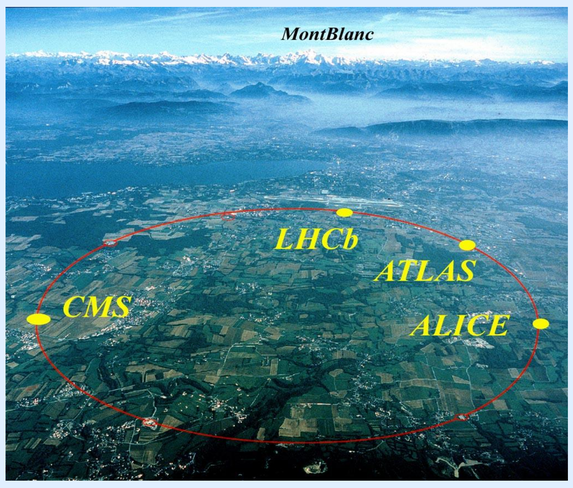
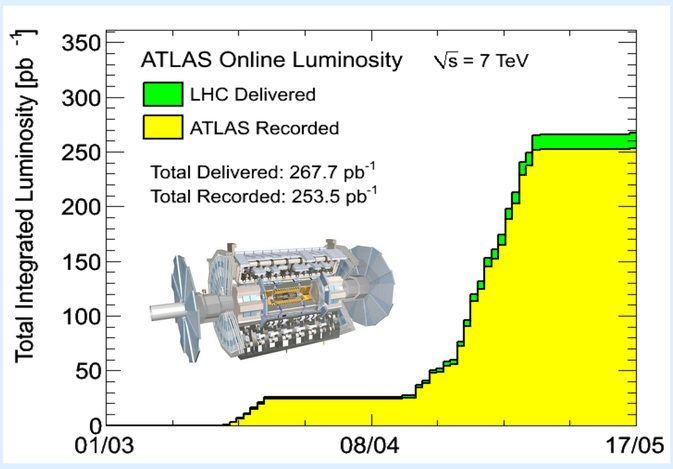
The Large Hadron Collider (LHC)



LHC is a discovery facility for new physics at the TeV mass scale.

ATLAS is one of the four large detectors that study the products of high-energy proton-proton Collisions at LHC.

The LHC luminosity so far is 253.5 pb^{-1}. This will grow to at least 1 fb^{-1} by the end of 2011.

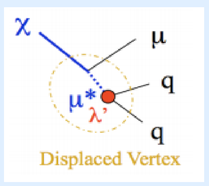


ATLAS integrated luminosity in 2011 so far (May 17)

Search for New, Long-Lived Particles

Many new-physics scenarios predict new, massive particles with long lifetimes. Examples include supersymmetry models or models with hidden sectors. The decay vertices of particles with lifetimes of order 10 ps to 10 ns can be efficiently identified by the ATLAS detector.

Our initial signal model is supersymmetry with R-parity violation (LSP decays to a muon + 2 jets).

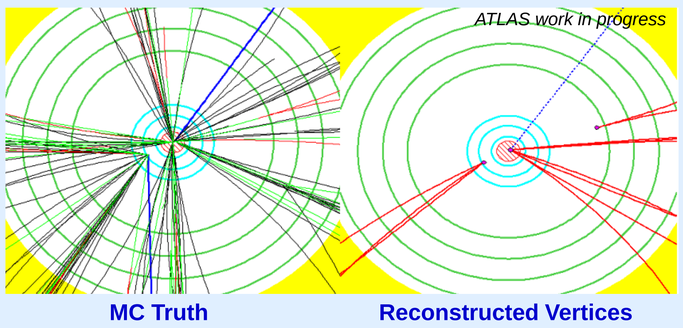


Trigger and Vertex Reconstruction

Events are required to pass a high-p_T muon trigger.

We form displaced vertices from charged-particle tracks with high impact parameter (d_0) with respect to the beampipe. If a track is associated with several vertices, it is assigned to the vertex for which it has the lowest χ^2.

Simulated supersymmetry signal event

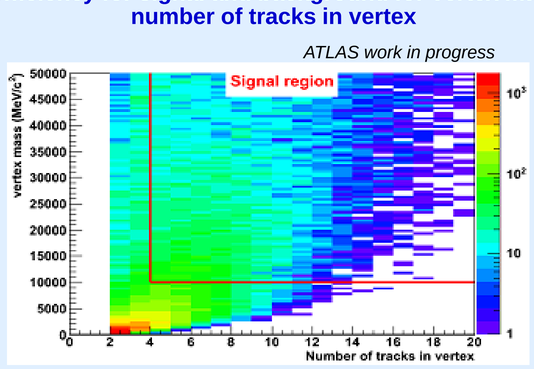


MC Truth **Reconstructed Vertices**

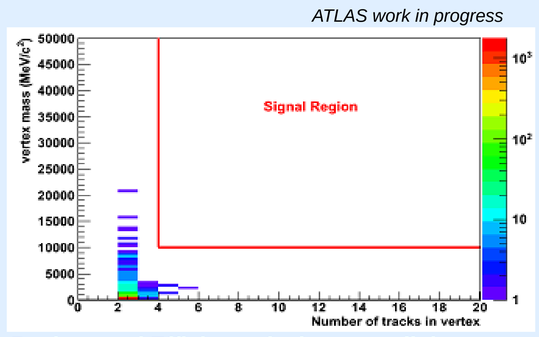
Event Selection

Background is strongly suppressed by requiring that vertices have a high mass and high track multiplicity.

Cut efficiency for signal and background for vertex mass vs. number of tracks in vertex



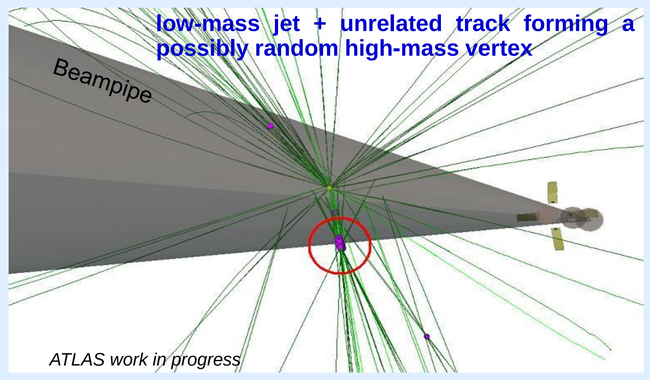
Signal Efficiency



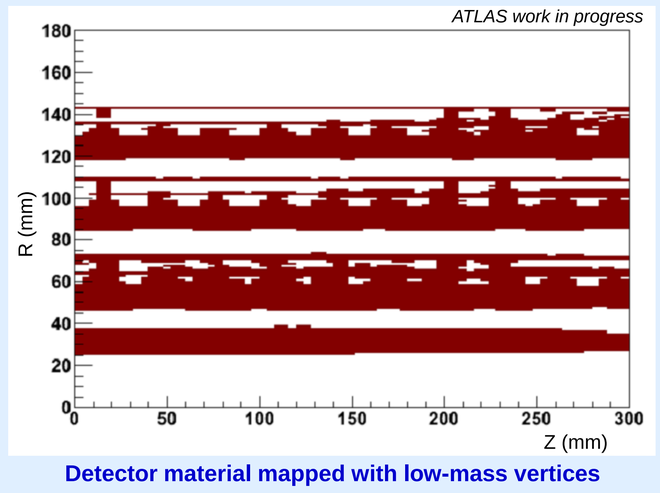
Background Efficiency (using a small data control sample with different triggers)

Background Estimation

A random combination of tracks may pass the cuts if a high-p_T track passes near a low-multiplicity, low-mass vertex caused by particle-material interaction.



To suppress this background, we veto vertices occurring in high-density material, mapped using low-mass vertices in data and Monte Carlo (MC).

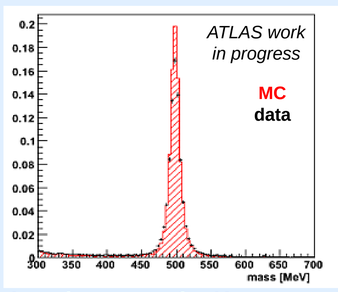


Detector material mapped with low-mass vertices

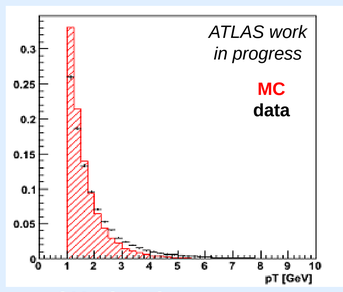
Using MC, we estimate the number of background vertices that pass the cuts in the remaining air volume. We validate the MC prediction using data, by studying the number of low-mass vertices in detector material and in adjacent air gaps.

Tracking Efficiency for High Impact Parameter (d_0) Tracks

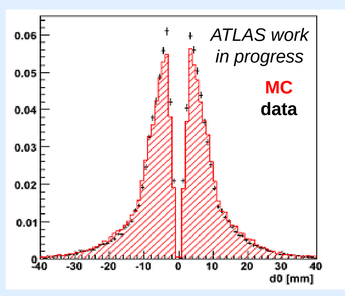
We validate the inner-detector tracking efficiency for tracks with high d_0, by comparing the d_0 distributions of K_S daughters in data and MC.



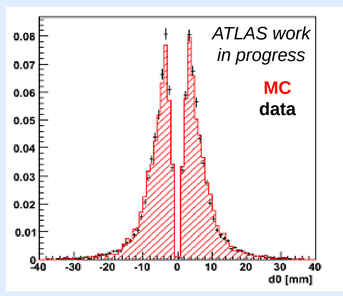
Invariant mass for K_s candidates



p_T of K_s daughters

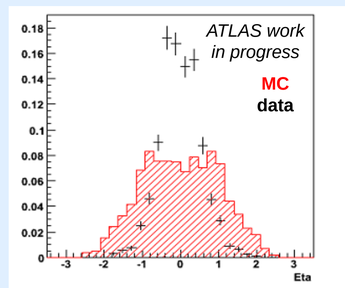


d_0 of K_s daughter tracks

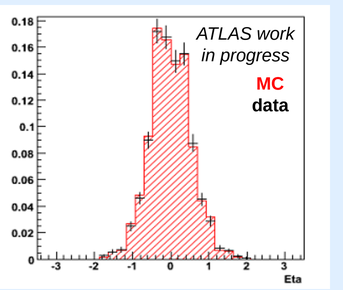


d_0 of Ks daughter tracks, with $p_T > 2$ GeV

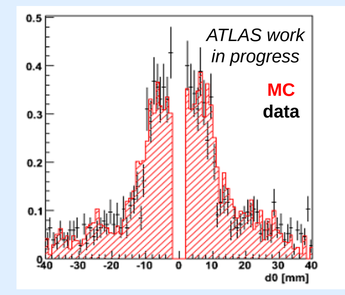
To validate the muon efficiency for high-d_0 tracks, we use the fact that over a small range of d_0 the true cosmic-muon d_0 distribution is flat. Then the reconstructed cosmic-muon d_0 distribution gives the muon reconstruction efficiency as a function of d_0.



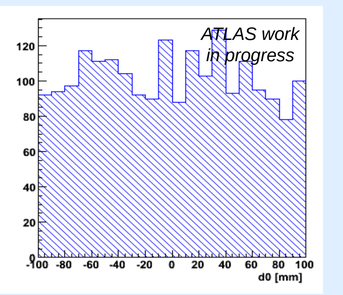
η distributions of signal-MC and cosmic-data muons.



η distributions after shaping the cosmic-muon sample with the accept -reject method.



Signal-MC muon efficiency overlayed with the d_0 distribution of cosmic-muon tracks.



Cosmic MC true d_0 distribution

The muon trigger efficiency is determined using Z^0 decays.

Using the good agreement between the data and MC, we estimate the error due to the muon reconstruction efficiency.

Results

We estimate that with an integrated luminosity of 1 fb^{-1}, we will be able to set a 90% CL upper limit on the production cross section of R-parity violating supersymmetry events as low as several fb, depending on the SUSY spectrum and on the lifetime of the lightest supersymmetric particle.

A first analysis is under way with 2010 ATLAS data.

Future improvements:

- A dedicated displaced-vertex trigger will increase the efficiency of the analysis and make it more model independent.
- Improved track reconstruction for tracks with high d_0 will increase sensitivity for highly displaced tracks and will provide a better vertex mass measurement.