The lifetime frontier: search for displaced hadronic jets in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

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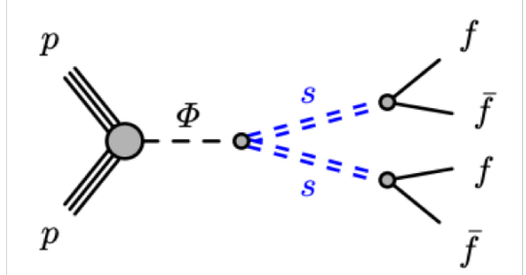
INTRODUCTION

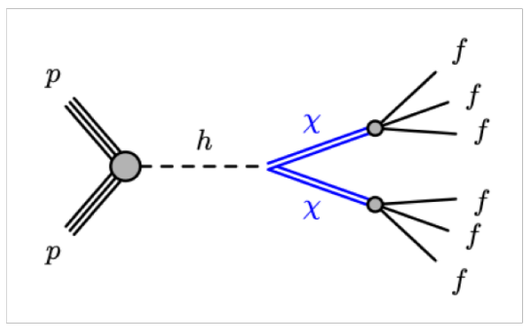
Many Beyond the Standard Model theories addressing open questions such as dark matter, matter-antimatter asymmetry, neutrino masses, the hierarchy problem, etc, either explicitly predict or allow for long-lived particles (LLPs). Neutral LLPs decaying to hadronic jets in the Muon Spectrometer (MS) of the ATLAS detector would leave the distinct signature of a highly displaced vertex with no preceding activity in the inner detector or calorimeters.

BENCHMARK MODELS

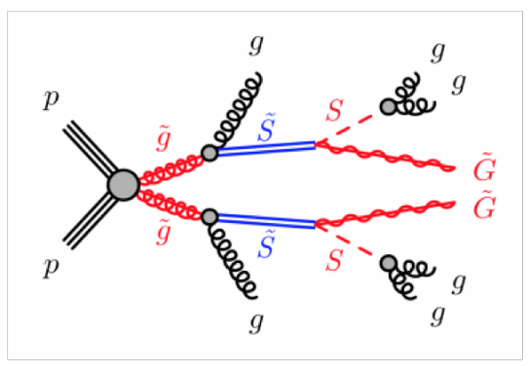
I. SCALAR PORTAL



II. BARYOGENESIS



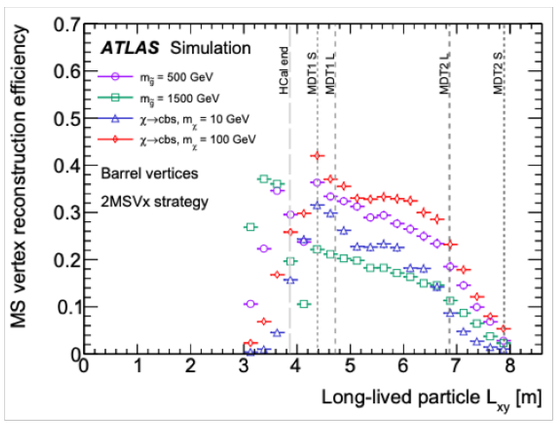
III. STEALTH SUSY

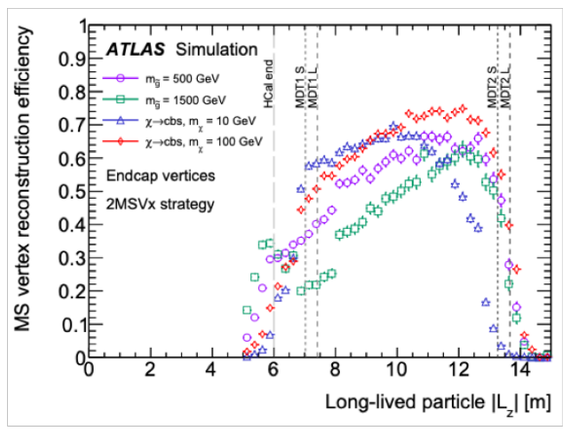


SIGNAL SELECTION

- Passes Muon RoI Cluster Trigger [1]
  - Dedicated, signature-driven trigger HLT_j30_muvtx_noiso
  - "Cluster" – at least 3 (4) muon RoIs within $\Delta R = 0.4$ in the barrel (endcaps)
- Contains a primary vertex (PV) with at least two tracks with $p_T > 400$ MeV
- Contains at least one MS vertex [2] that "matches" to triggering muon RoI cluster $\Delta R(\text{clus,vtx}) < 0.4$
- Hit requirements on tracking chambers: $300 \leq n_{MDT} \leq 3000$ and on trigger chambers: $n_{RPC(TGC)} \geq 250$ in barrel (endcaps)
- MS vertices removed in the region $0.7 < |\eta| < 1.3$ (MS barrel/endcaps transition region and calorimeter crack region)

MS VERTEX RECONSTRUCTION EFFICIENCY





TWO-VERTEX SEARCH

➢ Effectively background-free ➢ Limited sensitivity to longer lifetimes

MS vertices must be isolated from both tracks and jets

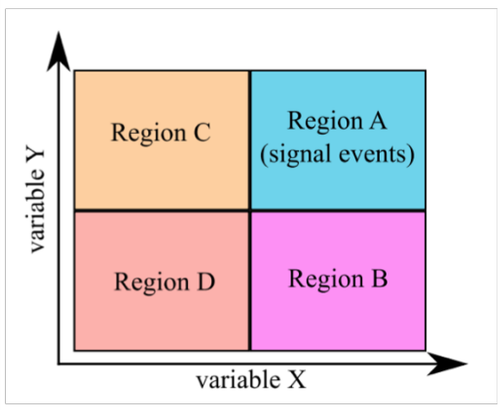
Data-driven background estimation uses events passing either the Muon RoI cluster trigger or a zero-bias trigger to quantify how often the MS vertex algorithm reconstructs non-signal vertices

$$N_{2\text{Vx}} = N^{1\text{cl}} \cdot P^{\text{Vx}}_{\text{noMStrig}} + N^{2\text{cl}}_{1\text{UMBcl}} \cdot P^{\text{Vx}}_{\text{Bcl}} + N^{2\text{cl}}_{1\text{UMEcl}} \cdot P^{\text{Vx}}_{\text{Ecl}}$$

ONE-VERTEX SEARCH

➢ Higher backgrounds ➢ Higher sensitivity to longer lifetimes

Background estimation with ABCD method



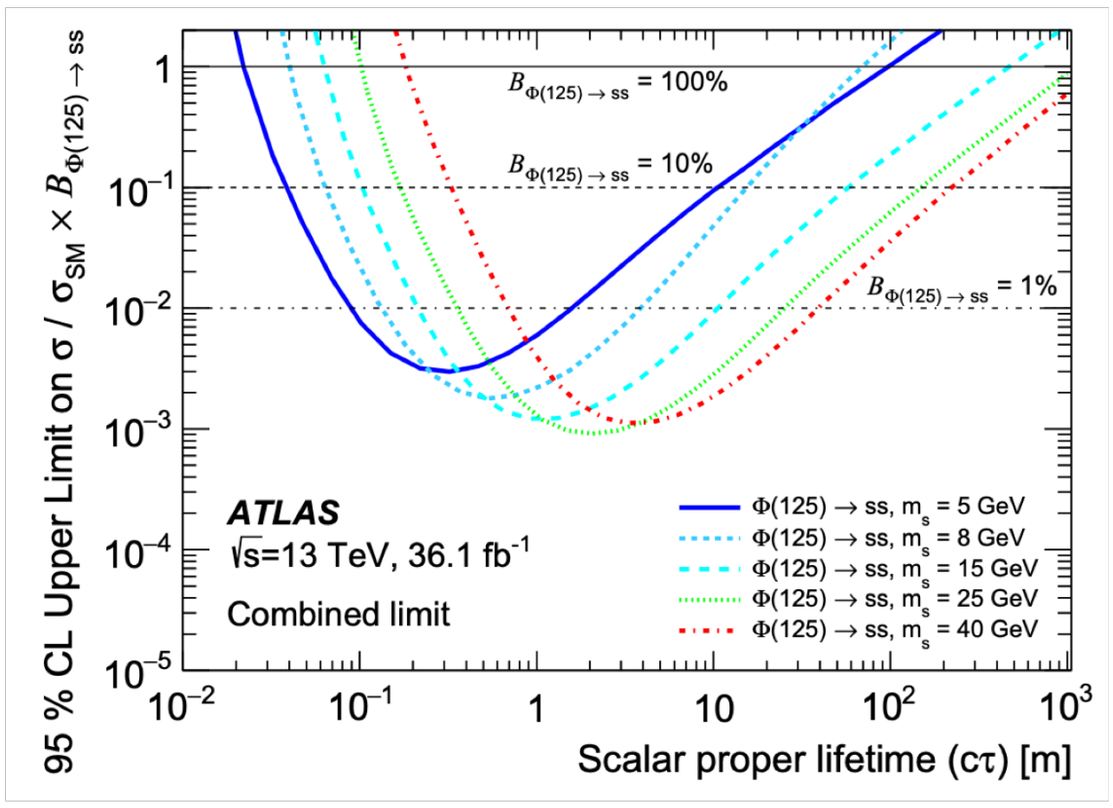
Variables X and Y are good discriminating variables such that signal events are clustered in region A. X and Y are uncorrelated, so expected background events entering region A is given by:

$$N_A^{\text{expected}} = N_B \times \frac{N_C}{N_D}$$

All benchmark models: $X = \min(\Delta R(\text{closest jet}), \Delta R(\text{closest track}))$
Scalar portal/Baryogenesis: $Y = |\Delta\phi(\text{MET, vtx})|$
Stealth SUSY: $Y = \text{vertex}(\text{nMDT} + \text{nTrig hits})$

RESULTS

No excess is observed, and 95% CL exclusion limits are set for all mass points of all benchmark models. Limits set from the combination of the one- and two-vertex searches are shown below for select mass points of the scalar portal benchmark model.



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[1] arXiv:1305.2284 [2] arXiv:1311.7070