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Search for long-lived neutral particles in ATLAS detector

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Summary. — A number of extensions of the Standard Model results in particles that are neutral, weakly coupled and have macroscopic decay lengths comparable with LHC detector dimensions. In the Hidden Valley (HV) models long-lived neutral particles that decay to heavy flavors or pairs of boosted leptons (lepton-jets) can be produced in SUSY processes, Z' decays and Higgs boson decays. Results are presented of a study of the ATLAS Detector performance for the Higgs decays $h^0 \to \pi_v^0\pi_v^0 \to b\bar{b}b\bar{b}$, and $h^0 \to \pi_v^0\pi_v^0 \to UUUU \to 4(l^+l^-)$, where both π_v^0 and U are neutral and can have a displaced decay. Triggers for processes with such non-standard signatures have been developed and are now included in the trigger menu for data taking.

PACS 12.90.+b – Miscellaneous theoretical ideas and models.
PACS 14.80.Ec – Other neutral Higgs bosons.

1. – Monte Carlo signal samples

The following parameters were used to simulate the process $h^0 \to \pi_v^0\pi_v^0 \to b\bar{b}b\bar{b}$: $E_{cm} = 7\,\text{TeV}$, $m_{h^0} = 120\,\text{GeV}$, $m_{\pi_v} = 40\,\text{GeV}$ and $c\tau_{\pi_v} = 1.5\,\text{m}$. For $h^0 \to \pi_v^0\pi_v^0 \to UUUU \to 4(l^+l^-)$, $E_{cm} = 7\,\text{TeV}$, $m_{h^0} = 120\,\text{GeV}$, $m_{\pi_v} = 4\,\text{GeV}$ and $c\tau_{\pi_v} = 0\,\text{m}$, $m_U = 0.6\,\text{GeV}$ and $c\tau_U = 80\,\text{mm}$ with $BR(l^+l^-) = 45\%\ e, 45\%\ \mu, 10\%\ \pi$. Both processes have been generated using PYTHIA and then processed with ATLAS simulation. With these parameters approximately 40% of the decays occur in the Inner Detector (ID), 48% in the Calorimeters (ECal and HCal) and the remaining 12% in the Muon Spectrometer (MS) system.

2. – Detector signatures and triggers

A simulation of typical HV [1] Higgs decays in the ATLAS Detector is shown in fig. 1. Hidden Valley events are characterized by highly displaced decays, leading to jets appearing throughout the volume of ATLAS. The standard ATLAS high level triggers [2] are able to select only a small fraction of these events. But it is possible to use the displaced vertex signature to design signature driven triggers to increase the fraction of

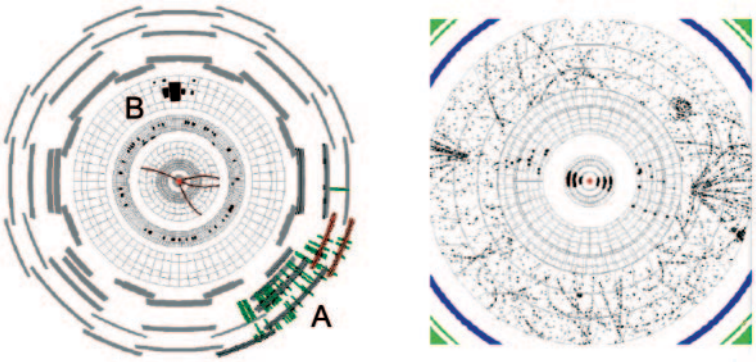

Fig. 1. – Event display for typical $h^0 \to \pi_v^0 \pi_v^0$ decays. Left: decay in the MS (A) and in HCal (B) Right: decay in the ID.

events accepted. Decays occurring near the end of the HCal and before the first muon trigger plane result in a large number of charged hadrons traversing a narrow (η, ϕ) region of the MS. The first level of the ATLAS muon trigger will return several Regions of Interest (RoI) clustered in a small R(η, ϕ) area (see decay A in fig. 1 left). Moreover, little to no energy is deposited in the calorimeters and no visible track connects the RoI cluster with the Interaction Point (IP). A RoI cluster event signature can be used as a high level trigger object to select these decays. If the decay occurs in or beyond the ECal the ratio of energy deposited in the HCal to that in the ECal is larger than the one which is normally observed for jets originating at the IP. Decay B in fig. 1 (left) illustrates this decay topology. Such jet feature plus isolation in ID is used as the trigger object. Decays in the ID, far from IP, lead to jets with no connecting track to the IP (trackless jets). Figure 1, right shows two π_v decays in the ID. A trackless jet with a muon in the jet cone (to reduce QCD background) is the trigger object. Lepton-jets produced far from the IP are characterized by several very narrow two lepton final states. Multi-muons triggers MS-only (measurement only in MS without matching with tracks in ID) associated with neutral elecrtomagnetic clusters, can be used to select these decays. A three muons MS-only and a two MS-only muons + one gamma cluster have been found to give a substantial contribution in the selection of this type of final states.

Details about triggers are given in [3]. They have been implemented in the ATLAS trigger software framework and they are presently running in the trigger menu for data taking. In the process $h^0 \to \pi_v^0 \pi_v^0 \to b\bar{b}b\bar{b}$ (assuming standard Higgs production cross section and 100% BR decays to hidden sector), for a lifetime of 1.5 m, our signal acceptance times cross-section is 5.5 pb and for a lifetime of 20 m, is 3 pb.

REFERENCES

[1] Strassler M. J. and Zurek K. M., *Phys. Lett. B*, **651** (2007) 374; Falkowsky A. *et al.*, *JHEP*, **1005** (2010) 077.
[2] Aad G. *et al.* (The ATLAS Collaboration), *JINST*, **3** (2008) S08003.
[3] Aad G. *et al.* (The ATLAS Collaboration), ATL-PHYS-PUB-2009-082.