CHEP 2016 Conference, San Francisco, October 8-14, 2016

Contribution ID: **243** Type: **Poster**

Evaluation of clustering algorithms at the < 1 GeV energy scale for the electromagnetic calorimeter of the PADME experiment

Tuesday, 11 October 2016 16:30 (15 minutes)

The long standing problem of reconciling the cosmological evidence of the existence of dark matter with the lack of any clear experimental observation of it, has recently revived the idea that the new particles are not directly connected with the Standard Model gauge fields, but only through mediator fields or ‘’portals”, connecting our world with new ‘’secluded” or ‘’hidden” sectors. One of the simplest models just adds an additional U(1) symmetry, with its corresponding vector boson A’.

At the end of 2015 INFN has formally approved a new experiment, PADME (Positron Annihilation into Dark Matter Experiment), to search for invisible decays of the A’ at the DAFNE BTF in Frascati. The experiment is designed to detect dark photons produced in positron on fixed target annihilations ($e^+e^- \to \gamma A'$) decaying to dark matter by measuring the final state missing mass.

The collaboration aims to complete the design and construction of the experiment by the end of 2017 and to collect $\sim 10^{13}$ positrons on target by the end of 2018, thus allowing to reach the $\epsilon \sim 10^{-3}$ sensitivity up to a dark photon mass of ~ 24 MeV/c^2.

One of the key roles of the experiment will be played by the electromagnetic calorimeter, which will be used to measure the properties of the final state recoil γ, as the final error on the measurement of the A' mass will directly depend on its energy, time and angular resolutions. The calorimeter will be built using 616 2x2x22 cm^3 BGO crystals recovered from the electromagnetic calorimeter end-caps of the L3 experiment at LEP. The crystals will be oriented with the long axis parallel to the beam direction and will be disposed in a roughly circular shape with a central hole to avoid the pile up due to the large number of low angle bremsstrahlung photons.

The total energy and position of the electromagnetic shower generated by a photon impacting on the calorimeter can be reconstructed by collecting the energy deposits in the set of crystals interested by the shower. This set of crystals is not known a priori and must be reconstructed with an ad hoc clustering algorithm.

In PADME we tested two different clustering algorithms: one based on the definition of a squared set of crystals centered on a local energy maximum, and one based on a modified version of the ‘’island” algorithm in use by the CMS collaboration, where a cluster starts from a local energy maximum and is expanded by including available neighboring crystals.

In this talk we will describe the implementations of the two algorithms and report on the energy and spatial resolution obtained with them at the PADME energy scale ($<$ 1 GeV), both with a GEANT4 based simulation and with an existing 5x5 matrix of BGO crystals tested at the DAFNE Beam Test Facility (BTF).

Tertiary Keyword (Optional)

Secondary Keyword (Optional)

Reconstruction

Primary Keyword (Mandatory)

Algorithms

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Session Classification: Posters A / Break

Track Classification: Track 5: Software Development