PROCEEDINGS OF SCIENCE

Dark Matter searches at LHC

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The origin of the Dark Matter (DM) is a puzzle that particle physics is trying to understand. Physics at the collider has a unique potentential to produce the DM candidate in laboratory. In this contribution we present the latest results of the searches for DM at the ATLAS and CMS experiments, using $\sqrt{s} = 7$ TeV and $\sqrt{s} = 8$ TeV data. Emphasis is given to the arguments addressed in the discussion session, in particular on the models used to interpret the experimental results.

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1. Introduction

Dark matter (DM) is required to explain numerous astrophysical measurements. However, since none of the known Standard Model (SM) particles are adequate DM candidates, the existence of a new particle is hypothesised, with properties suitable to explain the astrophysical measurements. One of the best candidates for DM is a stable weakly interacting massive particle (WIMP). These particles may be pair-produced at the LHC, provided their mass is less than half the parton centre of mass energy. These particles are expected to couple to SM particles through a generic weak interaction, which could be the known weak interaction of the SM or a new type of interaction. Several new particle physics models designed to solve the hierarchy problem also predict WIMPs.

Because WIMPs do not interact with the detector material, their production leads to signatures with missing transverse momentum. The final states with one jet or a photon originating from initial/final state radiation (ISR/FSR) provide a powerful signature sensitive to DM scenarios. In model independent approaches, the interaction between the DM and SM particles is usually assumed to be mediated by a particle too heavy to be produced directly, such that the resulting interaction can be treated as a contact interaction [1, 2]. Within such models,g the interaction between DM and SM particles are described by two parameters, the mass of the DM candidate m_χ and a suppression scale Λ [1], where the DM candidate is assumed to be a Dirac fermion. Several operators that describe this interaction can be written depending on the nature of the couplings (e.g. scalar, vectorial, axial, etc.). In this framework it is possible to compare the results coming from direct, indirect and collider experiments [3]. The latter can be then used to set limits on the parameters m_χ and Λ and also on the DM-nucleon scattering cross-section as a function of the DM candidate mass m_χ.

2. ATLAS and CMS Results

We presented the results from the ATLAS and CMS Collaborations. Both experiments have the analysis of mono-photon [4, 5] and mono-jet [6, 7] topologies with the additional requirement of a large missing transverse momentum. Currently, CMS reports results for the entire $\sqrt{s} = 8$ TeV data-set ($L_{int} = 19.5$ fb $^{-1}$) for the mono-jet topology, while ATLAS used half ($L_{int} = 10.5$ fb $^{-1}$) of the available data-set. For the mono-photon final state, both experiments analysed the $\sqrt{s} = 7$ TeV data-set ($L_{int} = 5$ fb $^{-1}$) only.

The search strategies for both topologies are similar for the two experiments. They require the presence of significant missing transverse momentum balanced by a hard-p_T jet (or photon), possibly accompanied by an additional jet close to the leading-p_T jet (or photon). Other activities in the events are vetoed (jets and leptons). For more details see [4, 5, 6, 7].

For the mono-jet analysis, the observed and expected limits at the 90% CL on the DM-nucleon scattering cross section are shown in Fig. 1. We displays CMS limits because they are the most updated ones, and hence more stringent. Comparing data-sets with the same size, ATLAS and CMS have similar performance. In figure 2 we show the 90% CL upper limits on the nucleon-DM cross section as a function of m_χ, for the mono-photon analyses. The searches at the colliders have

[1] In ATLAS papers Λ is named M_*

more stringent limits than direct and indirect experiments, in the low m_χ region (1-4 GeV), for spin-independent interactions, and up to 300 GeV, for spin-dependent interactions.

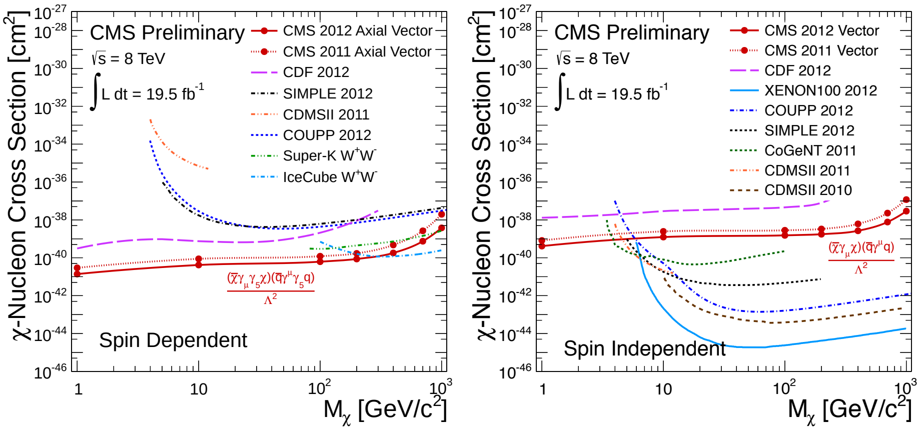

Figure 1: 90% CL upper limits on the DM-nucleon cross section versus DM candidate mass m_χ, for the mono-jet search. The results from several experiments refer to the axial-vector (left) and vector effective operators (right).

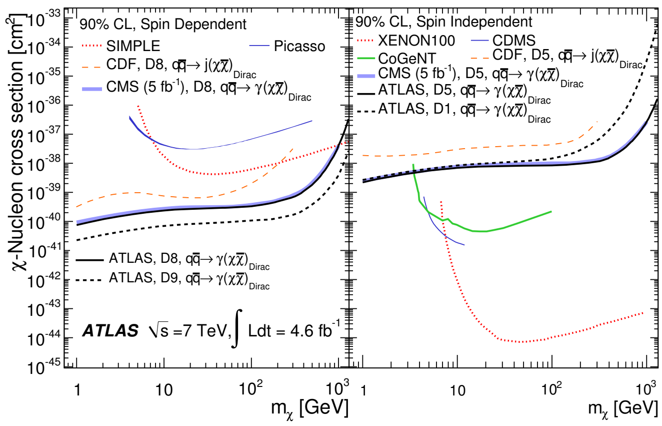

Figure 2: 90 %CL upper limits on the DM-nucleon cross section as a function of the DM candidate mass m_χ, for the mono-photon analysis. The results from several experiments refer to the spin-dependent (left) and spin-independent (right) interactions.

3. Discussion

Several experiments [8, 9, 10, 11, 12, 13, 14] that look for direct or indirect DM detection have discrepancies between data and theoretical predictions, that may point towards a possible interpretation of the DM as a new particle. Recently, several constraints have been set from direct and indirect DM searches and from pair production at the LHC. We believe that the LHC physics program should put the DM search as one of its top priorities. The LHC experiments have already produced a large number of results in final states that can be interpreted in the context of the DM search. On a fertile ground there are the searches developed to find Super-Symmetry (SUSY), or the decay of the Higgs in invisible particle. A systematic approach must be adopted to depict the characteristics of the DM particle candidate. The interpretation of the experimental results is a hot topic for this subject, as the paradigm at the basis of the effective theory ($\sqrt{\hat{s}} << M$) may be broken at the LHC scale, especially when LHC will move to 13-14 TeV in the centre of mass energy. A new model or a set of models, following the Simplified-Models (SMS) approach used for SUSY [15, 16], is needed to serve as the starting point for building more complex theories and for their comparison with the experimental results. This effort to be effective needs close collaboration between the theory and experimental communities, which will be possible only if DM search will become a top priority at the LHC.

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