III. RESULTS

According to the considerations developed up to now, it is clear that, in order to examine the physical region relevant for light neutralinos with a sizable elastic neutralino-nucleon cross section efficiently, one has to set up a scan of the supersymmetric parameter space focused on low values of M_1, restricted ranges of m_A and μ close to their minimal values as allowed by present experimental lower bounds, and a range of $\tan\beta$ delimited from above by the bounds from the neutral Higgs decays into a tau pair and from $\mathrm{BR}(B_s \to \mu^+ + \mu^-)$. The LEP limits on $\tan\beta$ and m_A are taken into account through the bounds derived from the Higgs-strahlung of the Z boson [21]. The selection of the parameters' ranges has also to allow small values of the tau slepton, to take care of the cosmological bound for neutralinos with $m_\chi \gtrsim 28$ GeV (see previous discussion in Sec. II A).

For these reasons, the scan of the parameter space adopted in the present paper is the following: $1 \leq \tan\beta \leq 15$, $100\ \mathrm{GeV} \leq \mu \leq 200\ \mathrm{GeV}$, $10\ \mathrm{GeV} \leq M_1 \leq 100\ \mathrm{GeV}$, $100\ \mathrm{GeV} \leq M_2 \leq 2000\ \mathrm{GeV}$, $700\ \mathrm{GeV} \leq m_{\tilde{q}_{12}} \leq 2000\ \mathrm{GeV}$, $100\ \mathrm{GeV} \leq m_{\tilde{t}} \leq 1000\ \mathrm{GeV}$, $70\ \mathrm{GeV} \leq m_{\tilde{l}_{12,L}}$, $m_{\tilde{l}_{12,R}}$, $m_{\tilde{\tau}_L}$, $m_{\tilde{\tau}_R} \leq 150\ \mathrm{GeV}$, $90\ \mathrm{GeV} \leq m_A \leq 160\ \mathrm{GeV}$, $0.5 \leq A \leq 3$.

We turn now to the discussion of the physical results as obtained by our numerical scans of the supersymmetric parameter space. First, we analyze the generic population of light neutralinos within the LNM which takes into account all the constraints listed in the previous Sec. II C, then we will discuss the impact of the excess seen by the ATLAS and CMS Collaborations at the LHC.

A. The light neutralino population within the LNM

A first result of our scans is shown in Fig. 1. From the scatter plot displayed here, one sees that the lower bound on the neutralino mass turns out to be about 18 GeV. The depopulation in the domain with $\tan\beta \gtrsim 12$ and $90\ \mathrm{GeV} \lesssim m_A \lesssim 100\ \mathrm{GeV}$ with respect to our previous analyses [3] is due to the new bound $\mathrm{BR}(B_s \to \mu^+\mu^-) < 1.08 \times 10^{-8}$ [31].

In Fig. 2, we display the correlation between m_A and m_h, m_H, because this will be useful for the discussions to follow. From the left panel of Fig. 2, one can derive the values of the ratio m_A/m_h which enters into the approximate estimate of the neutralino-nucleon elastic cross section due to the h-exchange contribution [see Eq. (9)].

Figures 3 and 4 give the size of the various channels contributing to the neutralino pair annihilation and to the neutralino-nucleon elastic cross section, respectively. From Fig. 3, we observe in the neutralino pair annihilation cross section a dominance of the A-exchange contribution for $m_\chi \lesssim 28$ GeV, and a possible dominance of the $\tilde{\tau}$ exchange for larger values of m_χ, as anticipated in Sec. II A (the contribution of the Z exchange is largely subdominant compared to the other two and is not shown). Figure 4 shows that in the direct detection cross section the contributions from the h and H exchanges are largely dominant over the squark exchange, with a sizable dominance of the h exchange over the H one.

The scatter plot for the quantity relevant for the comparison with the direct detection experimental results,

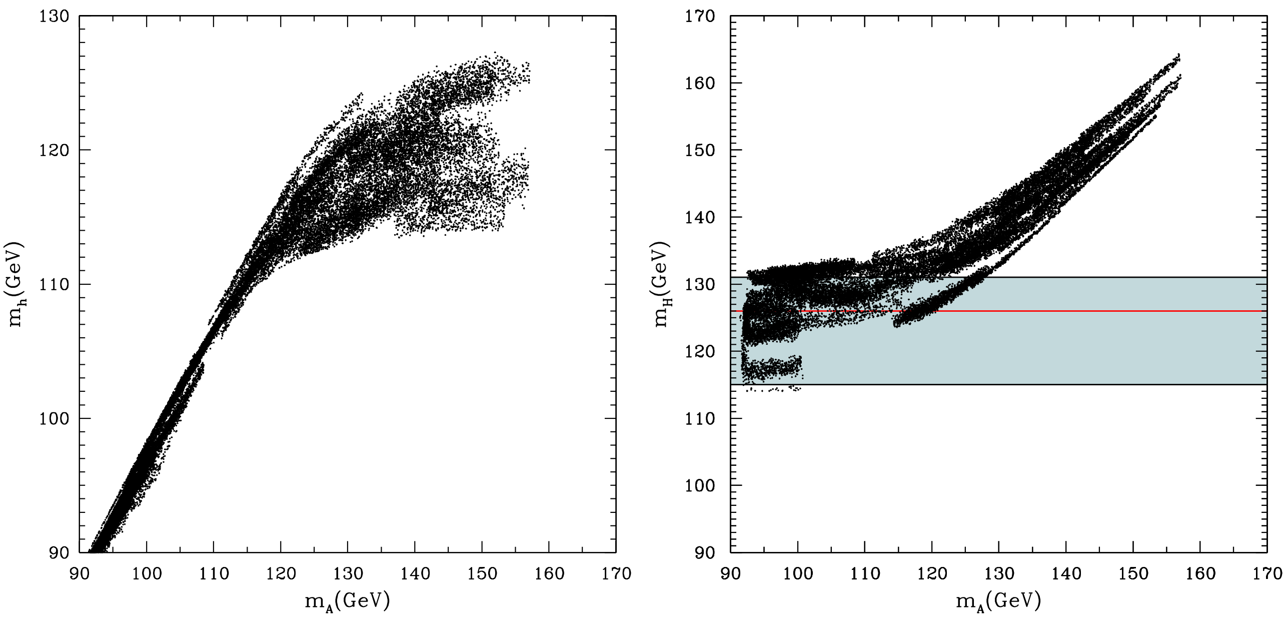

FIG. 2 (color online). Relation among the Higgs masses in the LNM. In the left panel, the correlation between m_h and m_A is shown. In the right panel, the correlation between m_H and m_A is given. The horizontal (red) line and the shaded band around it denote the value of 126 GeV for the Higgs mass (and the 95% C.L. region between 115.5 GeV and 131 GeV) compatible with the excess of events observed by ATLAS [11] and CMS [12].

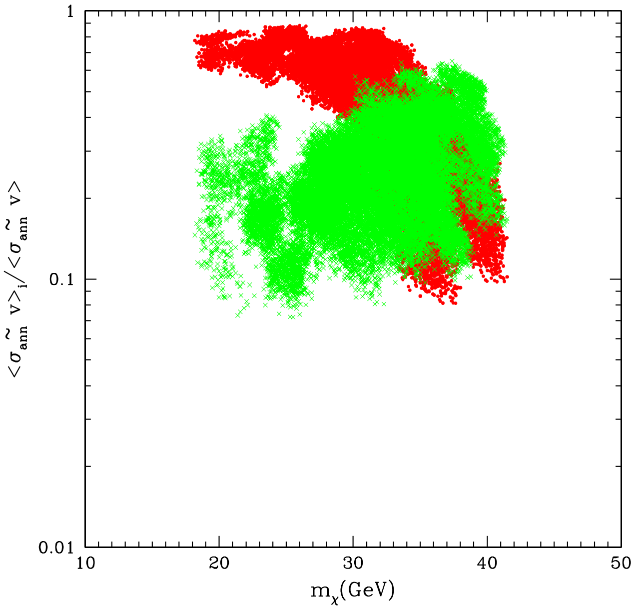

FIG. 3 (color online). Fractional relevance of channels in the neutralino self-annihilation cross section $\langle \widetilde{\sigma_{\rm ann} v} \rangle$ appearing in Eq. (2) as a function of the neutralino mass in the LNM. The (red) points refer to annihilation through A exchange; (green) crosses to annihilation through $\tilde{\tau}$ exchange.

$\xi\sigma^{(\rm nucleon)}_{\rm scalar}$, is displayed in Fig. 5. It is noticeable that our population of light neutralinos fits quite well a region of compatibility of the DAMA/LIBRA data with the CRESST results in the $m_\chi - \xi\sigma^{(\rm nucleon)}_{\rm scalar}$ plane.

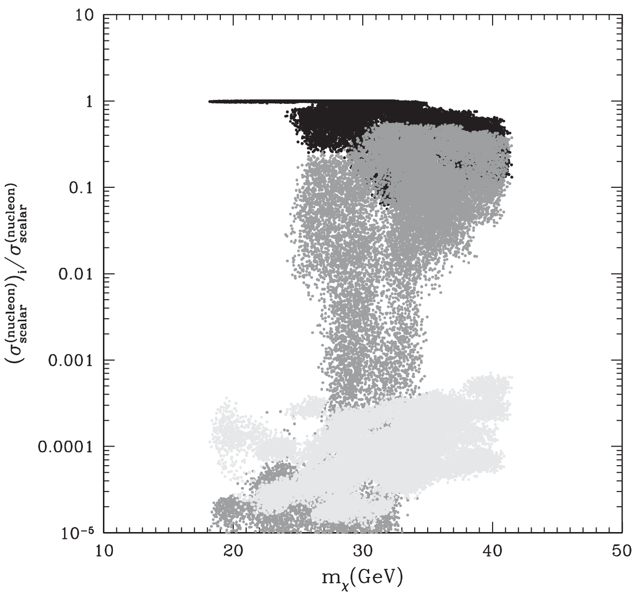

FIG. 4. Fractional relevance of channels in the neutralino-nucleon elastic-scattering cross section as a function of the neutralino mass in the LNM. From darker to lighter points: h exchange, H exchange, $\tilde{q}$ exchange.

Some comments are in order here:

(a) The scatter plot shown in Fig. 5 is obtained with a specific set of values for the hadronic quantities which establish the coupling between the Higgs boson and the nucleon (i.e., $g_d = g_{d,\rm ref} =$ 290 MeV). As mentioned in Sec. II B, the quantity g_d suffers from large uncertainties [19], so that the scatter plot of Fig. 5 could actually move upward by a factor 3 or downward by a factor 0.12.

(b) The experimental region of each individual experiment is sizably affected by uncertainties due to the estimate of the quenching factor. In the case of the DAMA/LIBRA experiment, the two regions are illustrative (but not exhaustive) of the large effect introduced by different evaluations of this factor [10].

(c) The position of the experimental regions $m_\chi - \xi\sigma^{(\rm nucleon)}_{\rm scalar}$ strongly depends also on the DM galactic

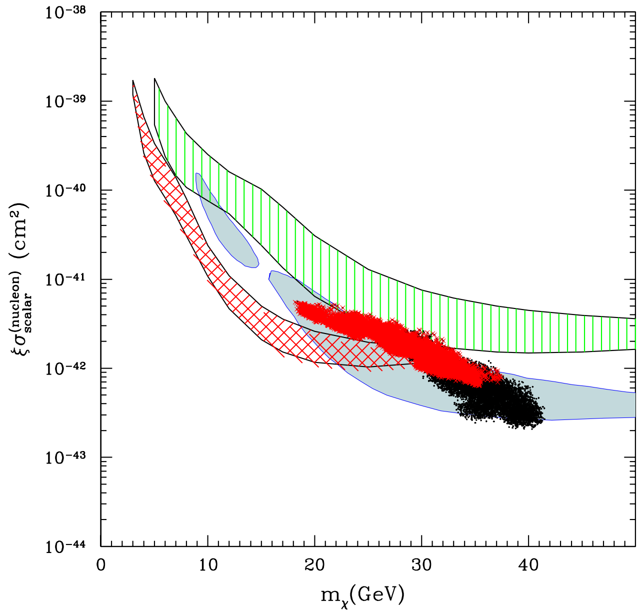

FIG. 5 (color online). Neutralino-nucleon cross section $\xi\sigma^{(\rm nucleon)}_{\rm scalar}$ as a function of the neutralino mass for the LNM scan and for $g_{d,\rm ref} = 290$ MeV. The (red) crosses denote configurations with a heavy Higgs mass in the range compatible with the ATLAS [11] and CMS [12] excess at the LHC. The shaded areas denote the DAMA/LIBRA annual modulation regions: the upper area (vertical shade; green) refers to the case where constant values of 0.3 and 0.09 are taken for the quenching factors of Na and I, respectively [10]; the lower area (cross hatched; red) is obtained by using the energy-dependent Na and I quenching factors as established by the procedure given in Ref. [55]. The gray regions are those compatible with the CRESST excess [7]. In all cases, a possible channeling effect is not included. The halo distribution functions used to extract the experimental regions are given in the text.