Note about a second "evidence" for a WIMP annual modulation

G. Gerbier\textsuperscript{a}, J. Mallet\textsuperscript{a}, L. Mosca\textsuperscript{a}, C. Tao\textsuperscript{b}

\textsuperscript{a} DSM/DAPNIA/SPP, C.E.A. Saclay, F-91191 Gif-sur-Yvette, France
\textsuperscript{b} CPPM,IN2P3/CNRS and Université Aix-Marseille II, 163 av. de Luminy, case 907, F-13288 Marseille cedex 09, France

1 Introduction

This note is intended to contribute to a clarification about a claimed "evidence" by the DAMA group of an annual modulation of the counting rate of a Dark Matter NaI(Tl) detector as due to a neutralino (SUSY-LSP) Dark Matter candidate \cite{1}. A first "evidence" \cite{2} had already given rise to a note of comments \cite{3}.

As the information given in this paper \cite{1} refers only to the result of a theoretically constrained fit, it is difficult to estimate the relevance of the claimed evidence.

Answers to the following 5 questions would be essential to enable the scientific community to correctly appreciate the relevance of the claimed effect to the search for WIMPs, which has been under way for several years, in a number of experiments over the world.

2 Questions

1) What are the experimental values, and the corresponding experimental errors of the modulation amplitude $S_m$? This amplitude can be calculated from the daily counting rates \cite{4}, without any fit or maximum-likelihood procedure, for each energy interval. The experimental errors should include both statistical and systematical contributions and be given separately. Statistical errors for a given exposure can be calculated with good approximation by anybody: in this case they are definitely larger than the errors from the maximum likelihood procedure presented in the last DAMA paper (see figure 1 of this note).

How can the strong difference between the distributions of the modulation amplitudes $S_m$ in the two papers \cite{1,2} be explained (see figure 2 of this note)? The only difference between the two approaches is the explicit presence of the WIMP hypothesis in the maximum likelihood fit giving the $S_m$ values in the second paper, while in the previous paper the $S_m$ values were obtained before introducing this theoretical hypothesis.

2) What is the experimental distribution of the modulation amplitude $S_m$ for the individual NaI modules? We remind that for the first data set (1/3 of the new statistics), this distribution, given in one of the DAMA reports \cite{2}, was very unlike a "physical" distribution (there was an effect for 3 detectors while the 6 others did not show any deviation), as stressed in a note of comments \cite{3} about this paper.

3) Concerning possible systematic effects, can the "separation-plot" between physical events and PMT noise be shown for the 2-6 keV energy interval relevant to the claimed
Figure 1: Modulation amplitude $S_m$ distribution from the second exposure [1], constrained by the WIMP hypothesis. The corresponding errors coming from this DAMA fitting procedure are compared to the statistical contribution to the experimental errors, calculated by us, assuming a continuous acquisition.

Second DAMA report 14 962 kg.d $S_m$ and error values constrained by the WIMP hypothesis

$\sigma_{S_m} = \sqrt{\frac{2R}{M \Delta t}}$

$R =$ counting rate (evts/ kg/d/keV)
$M =$ mass (kg), $\Delta t =$ run time (d)

$R \approx 1$ evts/kg/d/keV in 2-3 keV
$R \approx 2$ evts/kg/d/keV in 3-6 keV

effect (and not for the large 2-20 keV interval as in figure 1 of ref [1] or figure 16 of ref [5])?

How can the strange behaviour of the 2-6 keV energy distributions of the nine crystals (figure 2 of ref [1]) be explained? The total counting rate in the 2-3 keV bin is typically a factor 2-3 smaller than the counting rates in the following bins. How can the even more important drop of the residual background (obtained after subtraction of the ”signal” coming from the maximum likelihood fit) be accounted for?

2-3 keV : 0.5 evts/keV/kg/day
3-4 keV : 1.8 evts/keV/kg/day
4-5 keV : 1.9 evts/keV/kg/day
5-6 keV : 2.0 evts/keV/kg/day

4) The 2-6 keV region is affected by PMT noise which is partially rejected by software cuts. How is the stability of the efficiency correction and contamination level proven to be not worse than 1%, as absolutely needed for the claimed effect, in a region where the efficiency is strongly varying with energy (figure 17 of ref [5])?

5) In the presented maximum-likelihood procedure, which gives as output simultaneously an “evidence” for a rate modulation and the values of the two basic parameters caracterising the neutralino candidate (mass and cross section on proton), what is the influence of the applied constraint on the mass (neutralino mass $\leq 25$ GeV)? In other words, if this constraint is removed, does at least one additional solution show-up in this maximum likelihood fit?
Figure 2: Modulation amplitude $S_m$ values, constrained by the WIMP hypothesis, from the second exposure [1] are compared with the $S_m$ values from the previous paper, not constrained by the WIMP hypothesis [2].

References
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