Note on a hint for an annual modulation signature of a 60 GeV WIMP

2. 2. No reason to select the particular 2-12 keV region where the effect is observed.

The observed effect depends on the crystal.

about the statistical treatment

2.1. The effect is not distributed among the crystals as expected.

Introduction

The energy distribution and several experimental checks which could easily mimic the observed signal were published but not discussed in detail. The observed distribution comes from the expected experimental measured value. The distribution over the nine crystals in the 2-12 keV energy interval is found to be the weighted average value over the nine crystals.

The main evidence of the "hint" comes from the weighted average value over the nine crystals constituting the detector. A variable quantifying the modulation is found to be 0.034 ± 0.008 events/kg/day/keV. This is considered as a significant signal and interpreted as the hint for a modulation.

However, the distribution of the statistical significance per crystal (weighted excess) shows that the observed distribution is drastically different from the expected one. In the case of an homogeneous distribution of the effect among the crystals, the mean deviation comes from the weighted average value over the nine crystals.

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It depends on the nature of the considered WIMP. In the case of Spin Independent interacting WIMP, the expected interactions on NaI occur mostly on the Iodine nuclei because of the $A^2$ factor ($(127/23)^2 \approx 30$) and of the reduced mass factor $(\mu^2(W,I)/\mu^2(W,Na) \approx 6$ for a WIMP (W) mass of 60 GeV). Then the upper value of the energy window which would keep 90% of the modulation of a signal above 2 keV from any WIMP mass is 6 keV (taking into account the quenching factor, the form factor effect and the energy resolution). Would it be the Spin Dependent case, interactions occur mostly on Sodium and this upper value is around 25 keV.

So there is no physics grounds in considering a priori a 2-12 keV region which seems to have been chosen ”ad hoc” to enhance the statistical significance of the ”hint of signal”. Anyway, the 3 first data points (2-5 keV region), divided by the corresponding statistical errors (from the table 3 of ref 2), are respectively 0.62 $\sigma$, 0.57 $\sigma$ and 1.3 $\sigma$ away from zero, showing no significant excess, and so no hint of a 60 GeV WIMP signal. This is illustrated on figure 2 where the experimental Sm energy distribution is shown together with the signal from a 60 GeV WIMP, the integral of the signal being normalised to the total excess in the 2-12 keV region. This normalisation, imposed by the data, corresponds to a cross section larger than the claimed one by more than one order of magnitude, incompatible with published limits. If, alternatively, a normalisation to $\sigma_p = 10^{-5}$ pb is assumed, then more than 90 % of the observed effect would be unexplained. So the interpretation of the excess as being due to a 60 GeV WIMP does not fit the data.
2.3 No discussion on the selection of the time windows

The June time window is very short, only 12 days. On the other hand, the quoted spread of the winter time measurements, about 70 days, corresponds to twice the time needed for an exposure of 3368 kg.d with a 115 kg setup. So, either there were a shutdown of the experiment or data removal. How does the effect vary with lengths and positions of time windows? All these points have direct consequences on the significance of a possible effect.

3 About the systematic effects

3.1 Large subtraction of the PMT noise in the 2-6 keV region not under control

With such a set up (underground conditions, each crystal seen by 2 PMT’s) and trigger (the coincidence of the two PMT’s), the photomultiplier noise (random coincidences) dominates the counting rate in the 2-6 keV region and extends up to 10 keV. As indicated in [3], this noise (with characteristic shape) is removed by software cuts. There is however an overlap between the noise pulse shape distribution and true NaI(Tl) pulse shape distribution.

The uncertainty in the removal of this noise, for data taken at six months time interval, should not exceed the level of 1% of the signal (as absolutely needed in any annual modulation analysis). This implicit hypothesis of stability is here out of control, a priori not realistic, in any case not discussed.

Correlatively, the efficiency for applying these cuts, that is the fraction of true NaI(Tl) events kept, ”varies from 30-40 % (depending on the crystal) up to 100 % between 2 and
12 keV” [3]. The uncertainty on these selections and corrections should also be taken into account.

3.2 Other systematic effects

There are other systematic effects such as the variation in time of the energy normalisation, and the decay rate of the residual contaminations which must be evaluated and the corresponding uncertainties taken into account before talking about any possible hint of modulation.

4 Conclusion

Using information available from the papers themselves, it has been shown that in no way the result presented in [1,2] can be considered as a hint of a WIMP annual modulation.

References
1. P. Belli, talk at TAUP97, Gran Sasso Laboratory, September 7-11, 1997
2. R. Bernabei et al., preprint ROM2F/97/33 - August 1st, 1997