UPPER LIMIT ON MAGNETIC MONOPOLE FLUX FROM BAKSAN EXPERIMENT

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No indication of slowly moving penetrating particles in cosmic radiation unerground was found during two years observation. Particle velocity and pulse shape are main criteria for search. Probability of the imitation of slow particles (β<0.1) by atmospheric muons is negligible. Our upper limit on superheavy magnetic monopole flux is now $1.86\cdot10^{-15}cm^{-2}sr^{-1}s^{-1}$ (90% c.l.) for velocity range $2\cdot10^{-4}<\beta<0.1$.

Resent years activity in the search for magnetic monopole has been increasing[1] in spite of negative results of all performed experiments. However, limit on monopole flux achieved so far is still larger than bound set from astrophysical consideretion. At present Baksan underground telescope[2-4], having the largest acceptance for monopole (1850 m^2sr), accumulates data for more than two years live time. In this paper we represent new limit on flux of superheavy magnetic monopoles set from Baksan experiment.

1.EXPERIMENTAL DETAILS. Following characteristic features of Baksan telescope make it most suitable detector for monopole searches: i) big size (16m×16m×11m); ii) 3200 scintillators arranged in 8 layers separeted by concrete absorber; iii) timing registers to measure particles velocity; iv) recording of pulse shape for each layer.

In order to select slowly moving particles special trigger is used. Its logic can be understood from time diagram presented in Fig.1. Signal (a) arises when only one from six external layers is hitted. This signal opens time gate (b) of 50μs duration with 50ns delay for delayed signal from any two internal layers(c). Initial signal triggers the memory for 1.5μs to record co-ordinates of hitted scintillators(d). Delayed coincidence signal triggers memory again now for 50μs and also triggers oscilloscope to record pulse shape. The delays of the signals from all layers relative to initial one are measured up to 50μs. All the signal thresholds for trigger logic, detector co-ordinates and timing cor-

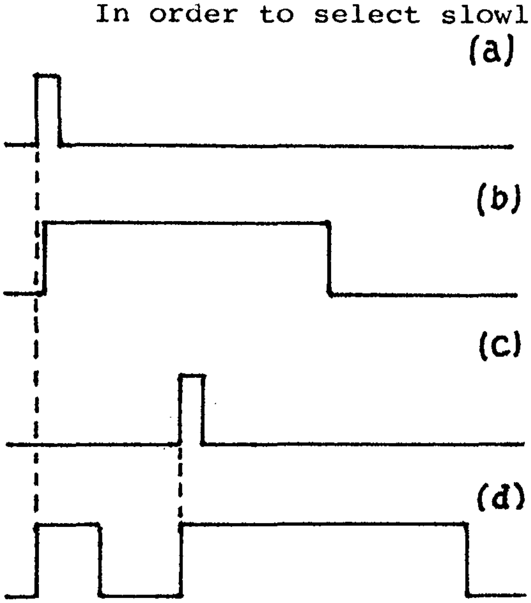

Fig.1 Time diagram of trigger logic.

respond to 0.25 of amplitude of minimal ionizing particle. The trigger rate is 237 per day.

2.RESULTS AND DISCUSSION. Two types of events are selected by the trigger. The first is when there are signals from two scintillator layers one external and one internal and second is when there are signals from more than two layers. The rate of events of the first type 82.6/day is due to chance coincidences with a single internal pulse, secondaries from muon interactions outside of telescope and stopping muons. In the last case muons are stopped in absorber between scintillator layers so that decay electrons produce a signal in internal layer. Second type of events is due to chance hit of fast muon in time gate 50μs (152.1/day) and muons with time of flight between external and internal layers bigger than 50ns(2.3/day)

Two criterions are chosen to select candidates for further analysis of time of flight, amplitudes and pulse shape. In order to exclude firs type of events we required signals from at least three layers. Second type of events was excluded by requirement of time intervals no less than 0.1us between successive layers. During live time 18,546 hours analazed so far no candidates has been recorded.

The trigger and criterions of selection make acceptance dependent on velocity. The calculations show that for velocity range $2\cdot10^{-4}<\beta<0.1$ acceptance is nearly constant $185\mathrm{0m^2sr}$. So we can set upper limit on monopole flux as:

$$1.86\cdot10^{-15}\mathrm{m^{-2}sr^{-1}s^{-1}}$$

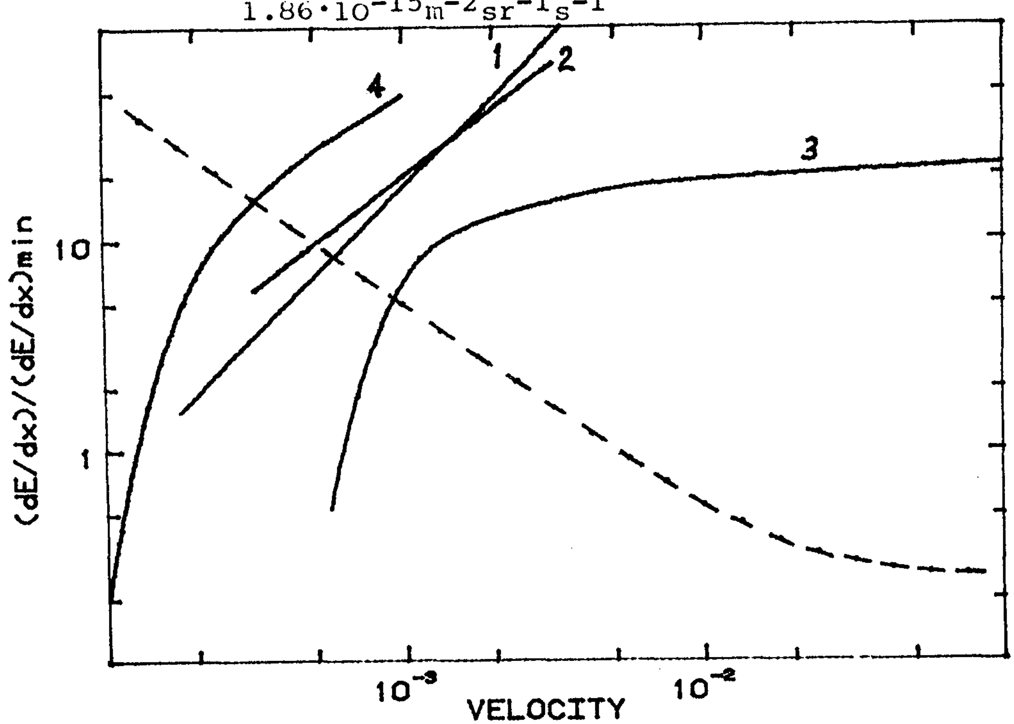

Fig. Ionization losses of monopole as function of velocity; curves 1-[3], 2-[5], 3-[6], 4-[7]

However, there is problem of ionization losses of energy by slowly moving monopoles. Number of estimates and calculations has been made. They are shown on Fig.2. Curve 1 is estimate of ionization losses[3] made from ionization power of slowly moving protons taking into account peculiarities of interactions of moving magnetic charge with electrons. Curve 2 was calculated for magnetic monopoles in a degenerated Fermi gas[5]. Curve 3 is calculation of light emitted of organic scintillator with the energy gap 5 eV[6]. In calculation of curve 4 it has been taken into consideration possible excitation of atoms due to shift of atomic levels by magnetic field of monopoles[7]. These calculations are made for atoms of helium and it is not clear if there is contribution of this effect to excitation of scintillator. It is seen from Fig.2 that for $\beta > 10^{-3}$ there is no problem in sensitivity of usual ionization detectors to magnetic monopoles. For velocity range 10^{-3}-10^{-4} the possibilities of such kind of detectors are quite uncertain and for $\beta < 10^{-4}$ there is no hope to detect monopoles using ionization technique. Besides amplitude of monopole signal can be reduced due to stretch of pulse if time of traversing through detector is bigger than integrating time of the circuit. Really this effect results in increase of threshold. On Fig.2 dashed curve shows dependence of real threshold of recording of slowly moving particle on velocity for Baksan telescope. So, ionization power of monopoles limit velocity range of our experiment to $\beta \sim 10^{-3}$.

However we can use hypothesis[8] on catalysis of proton decay by monopoles to set limit on monopole flux for $\beta < 10^{-3}$. For proton decay taking place inside the concrete absorber or scintillator the mean detection efficiency is 0.56. If the catalysis cross section is 50mb then the efficiency of Baksan telescope to record monopoles trough catalysis process is more than 0.9.

Therefore, our limit is model independed for monopole velocity $\beta > 10^{-3}$ and is valid for $\beta > 2 \cdot 10^{-4}$ if catalysis cross section is >50mb.

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