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Na^{22} PRODUCTION CROSS SECTION IN SOIL

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This note presents an estimated macroscopic cross section for production of Na^{22} by nucleons in soil as a function of energy. The macroscopic cross section is defined as $\Sigma n_i \sigma_i$ where n_i is the number of atoms (species i) per gram of soil and σ_i is the corresponding Na^{22} production cross section.

The quantities n_i were taken from Awschalom, et al.[1] for moist NAL soil. They are similar to other assumed soil compositions[2].

The cross sections σ_i are based mainly on experimental data[3-28]. Some calculated values obtained from ORNL[29] (by Monte Carlo methods) were also taken into consideration. All σ_i were assumed to be constant above ~ 10 GeV. The literature search for the σ_i was not exhaustive. Some existing compilations[14,30-32] were helpful.

Figs. 1-6 show the data for the various elements. The solid curves represent our estimates of the excitation functions. Error bars (as reported in the literature) have been

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omitted. The scatter in σ_i values at nearly identical energies provides perhaps a better measure of the true errors. In view of the paucity of data for potassium and calcium (and since their Na^{22} production cross section is expected to be similar) the available data were combined (Fig. 5). Only proton and neutron induced Na^{22} production are reported here. The data in Figs. 1-6 refer to protons unless otherwise indicated in the legend. In our estimates of the excitation functions protons and neutrons were not distinguished. Pion data are virtually nonexistent while data for production by d, α, etc. are of lesser interest in shielding problems.

The resulting macroscopic excitation function for soil is shown in Fig. 7. A small amount of remaining detailed structure was smoothed out.

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Legend ---(Ref. 9, n, many measurements), ● (11,n), ■ (3), ▲ (4,n), Δ (8,n), × (6,7), o (10), ∇(5), + (29,n)

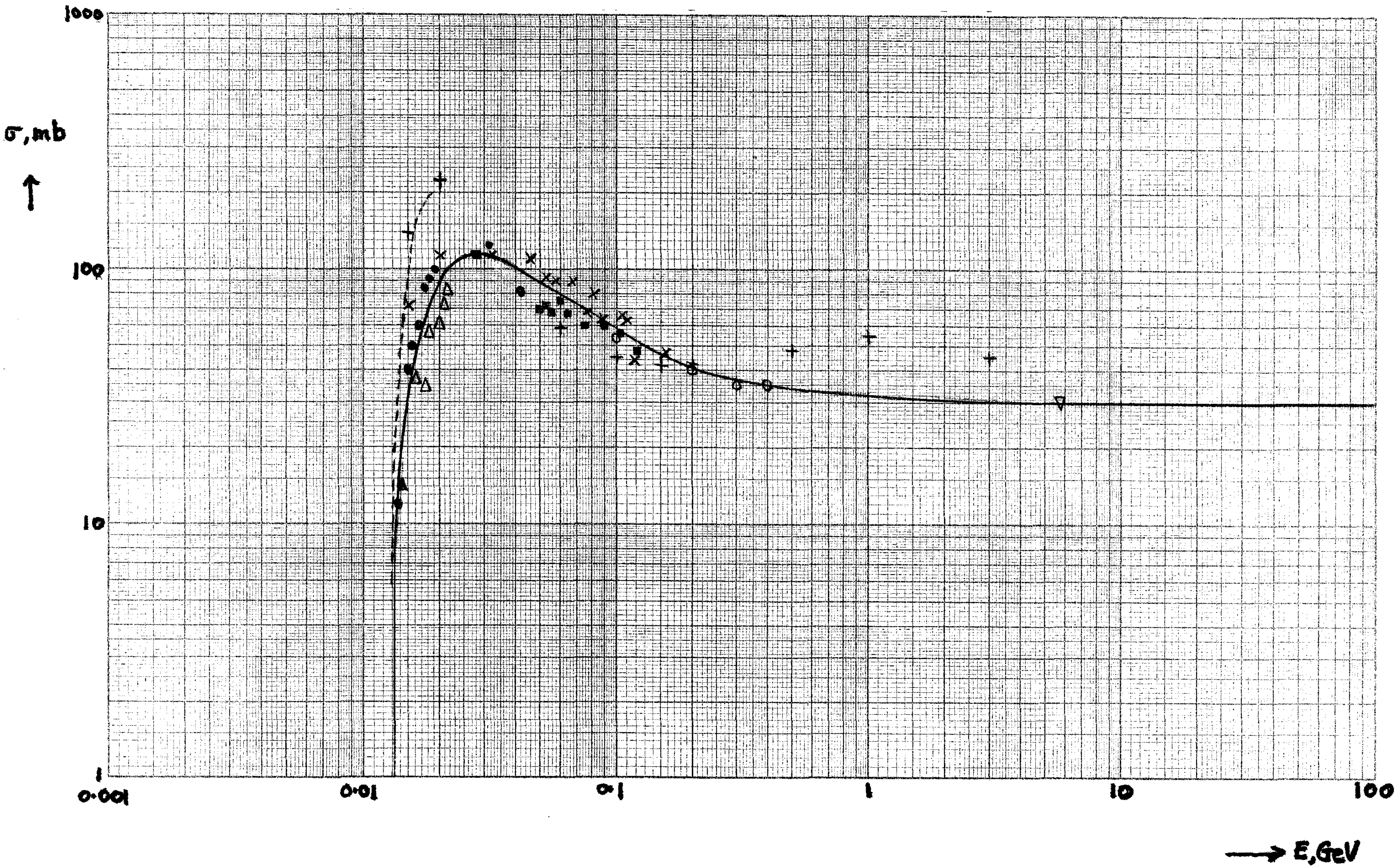

Fig. 1. Na^{22} excitation function for Na.

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Legend ---(Ref. 12, many measurements), o(10), □(13), +(29,n)

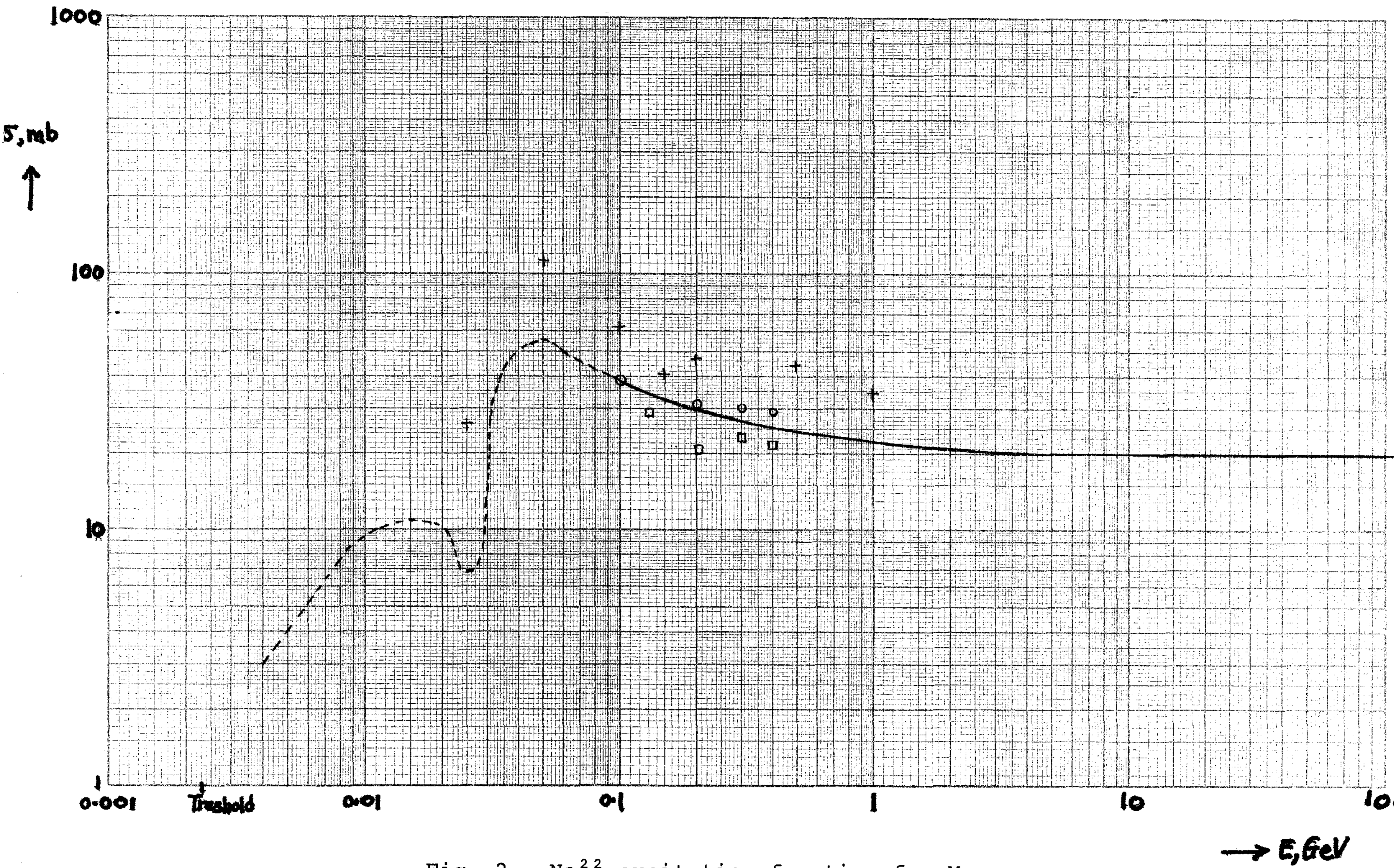

Fig. 2. Na^{22} excitation function for Mg
(Below 0.1 GeV the assumed excitation function
coincides with the curve from Ref. 11)

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Legend ♦(Ref. 14), ■(17,18), ▲(19), ▽(20,21), ✕(22), ●(15,16), △(5), ⊕(29), +(29,n)

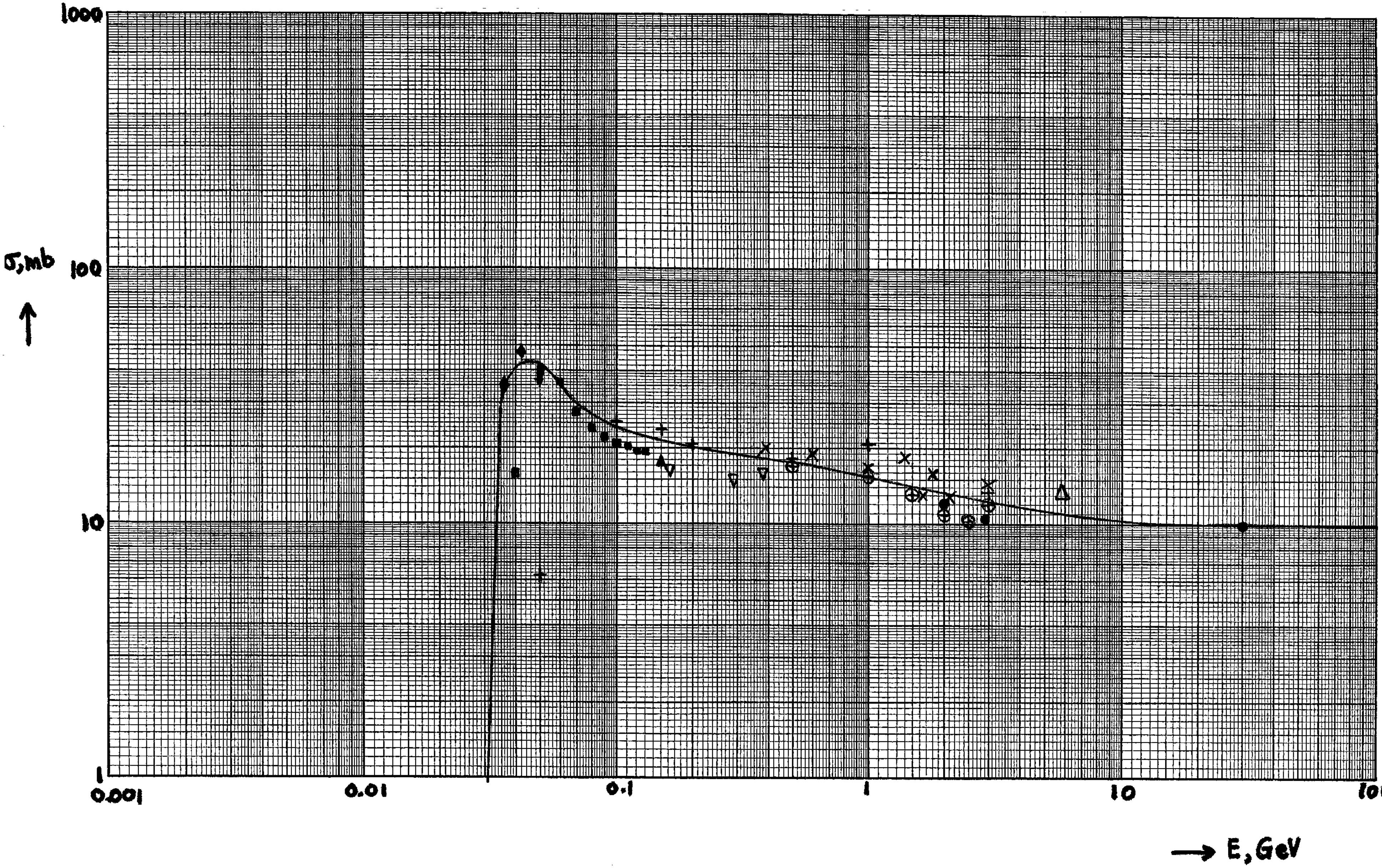

Fig. 3. Na^{22} excitation function from Al.

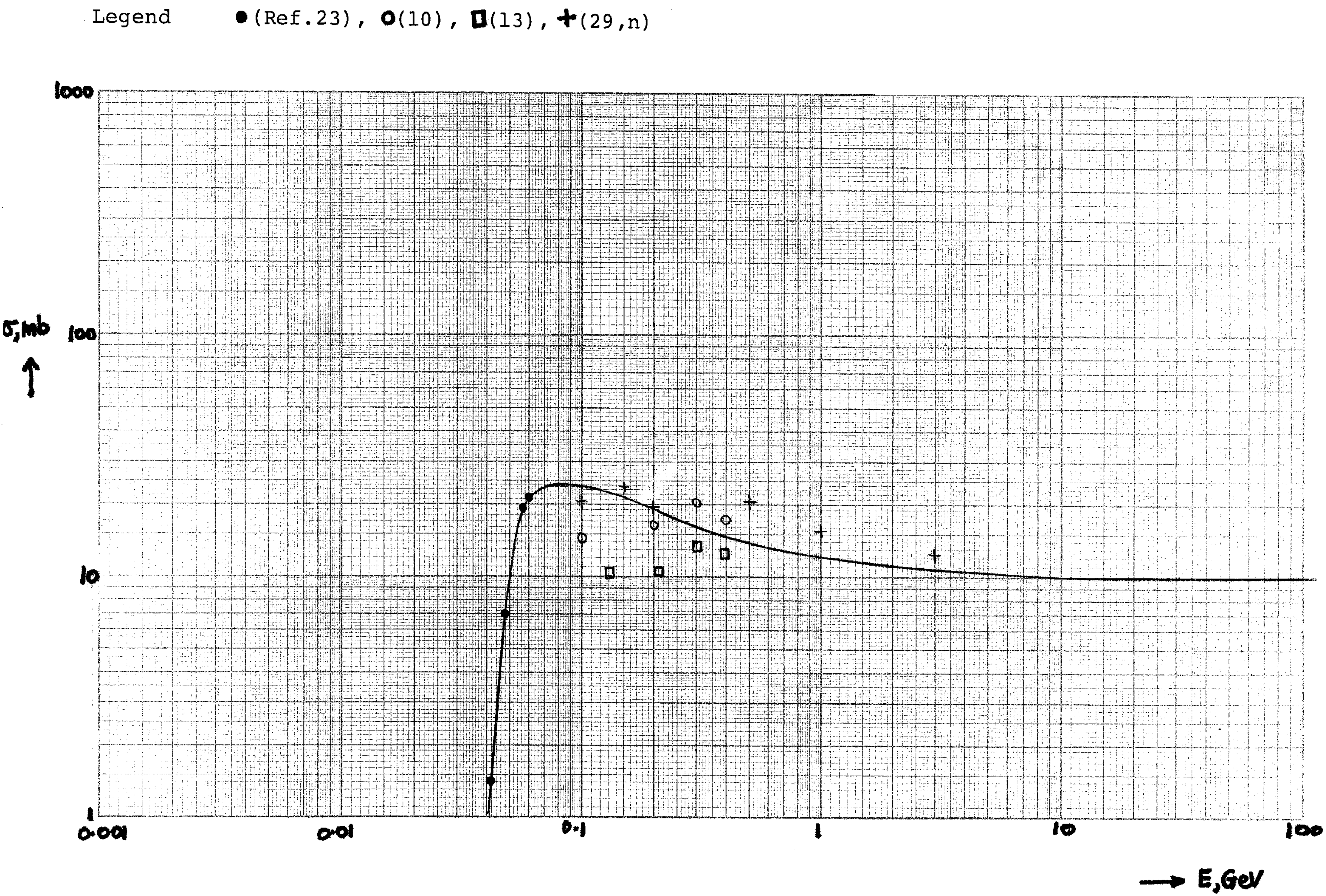

Fig. 4. Na^{22} excitation function for Si.

Legend ● (Ref. 10), + (29,n), o (Ref. 10,K)

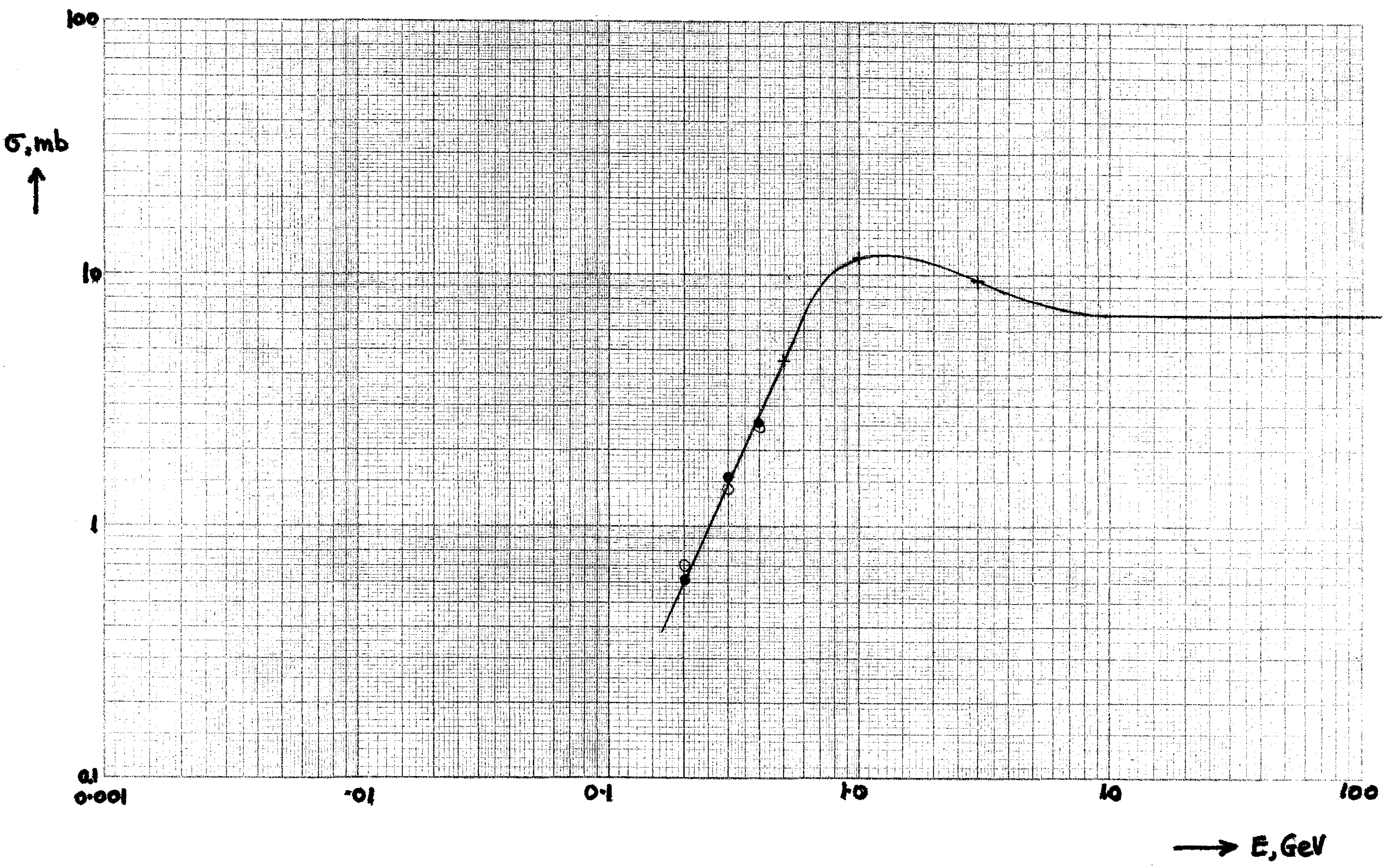

Fig. 5. Na^{22} excitation function for Ca(K).

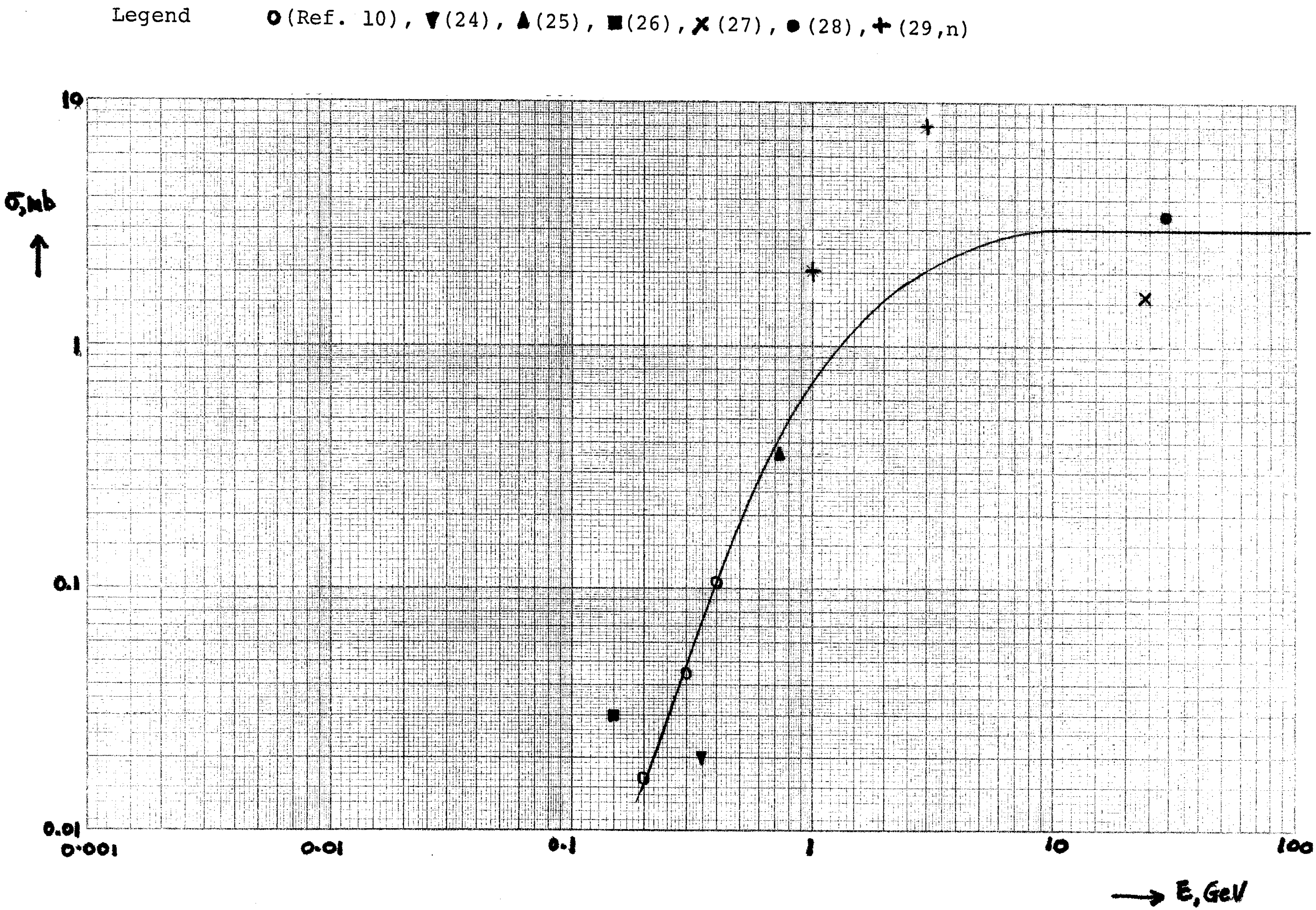

Fig. 6. Na^{22} excitation function from Fe.

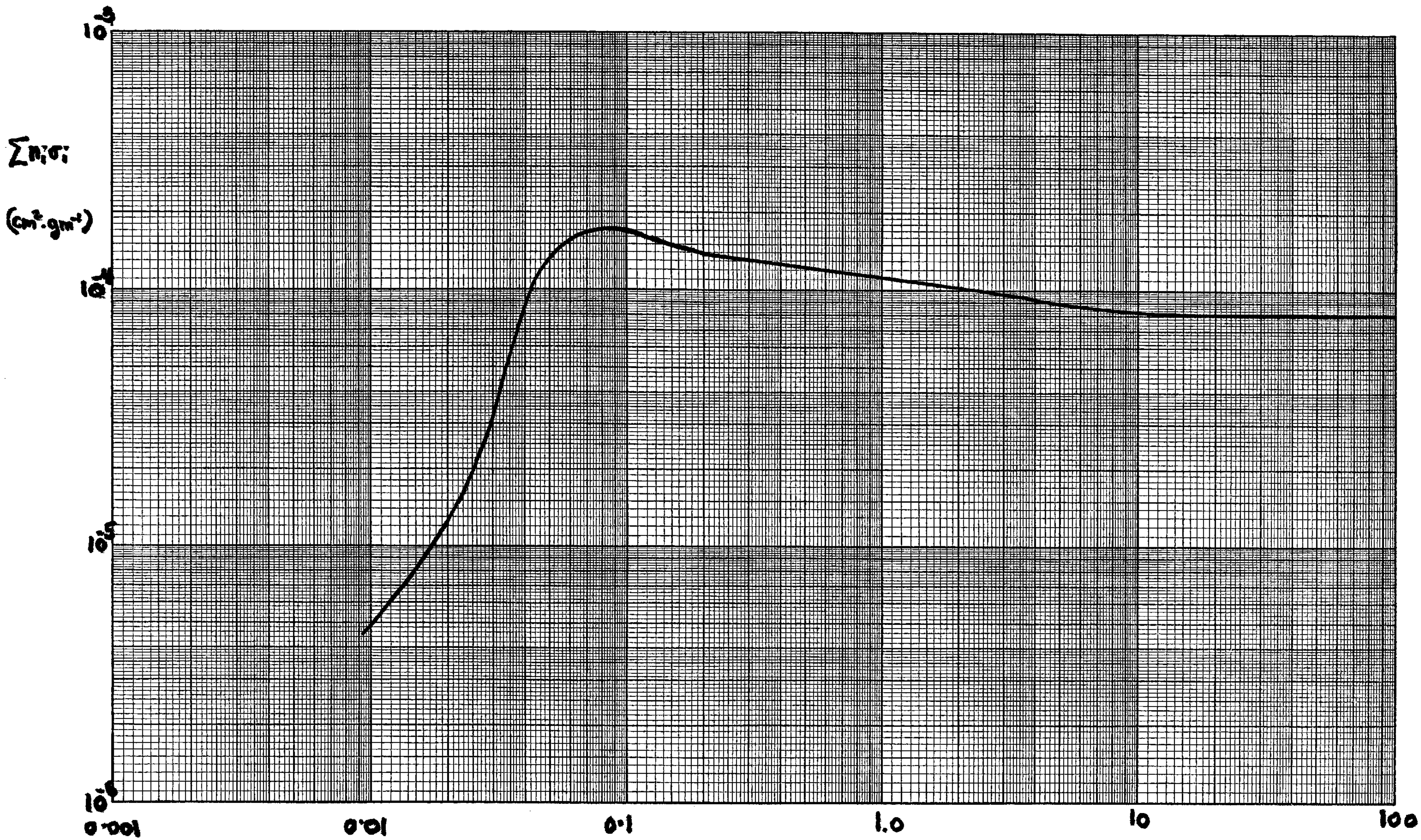

Fig. 7. Macroscopic Excitation Function for Na^{22} in Soil → E (Gev)