very detailed measurement of the breakup channels [5] and an upper limit for the admixture of heavy neutrinos [6]. Limits on capture from the 2S mesic level as well as the transition rate between the mesic hyperfine levels were also obtained.

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MEASUREMENT OF THE BREAKUP CHANNELS IN NUCLEAR MUON CAPTURE BY ^{3}He AND ^{4}He

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The rates of the breakup reactions $\Lambda_B(^3\mathrm{He})$, $\Lambda_B(^4\mathrm{He})$ in nuclear muon capture by ^{3}He and ^{4}He have been measured. The experiments were performed in the muon beam of PSI with a multi-anode high pressure ionization chamber filled with isotopically pure ^{3}He or ^{4}He at 120 bar. The chamber was used as a target and detector for both the incoming muons and for the charged reaction products (tritons, deuterons, protons). When a negative muon is captured by a helium nucleus, the following reactions occur:

$$
\begin{array}{llll}
^3He + \mu \rightarrow & t + \nu_\mu & (1) & \\
& d + n + \nu_\mu & (2) & \\
& p + n + n + \nu_\mu & (3) & \\
^4He + \mu \rightarrow & t + n + \nu_\mu & (4) & \\
& d + n + n + \nu_\mu & (5) & \\
& p + n + n + n + \nu_\mu & (6) &
\end{array}
$$

Reactions (2-6) represent muon captures that result in an unbound triton or ^{4}H nucleus and are referred to as the breakup reactions. Our experiment aims primarily to measure the absolute rate of the $^3\mathrm{He} \longrightarrow {}^3\mathrm{H}$ partial muon capture transition $\Lambda_C(^3\mathrm{He})$, with high preci-

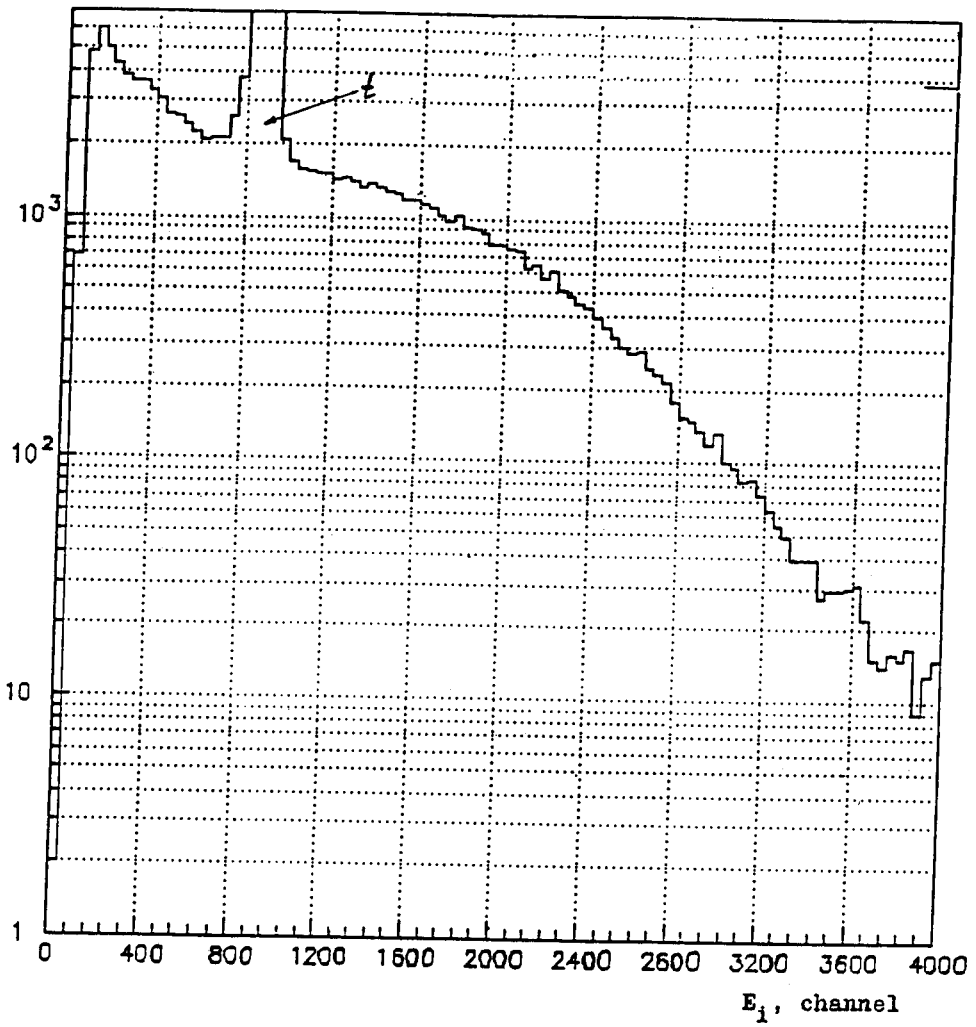

Fig.1. The energy spectrum of the muon capture events by ^{3}He (1 ch=1.6 keV)

sion [1]. The breakup capture rates $\Lambda_B(^3\mathrm{He})$, $\Lambda_B(^4\mathrm{He})$ are also measured in this experiment. It is interesting to compare the probabilities of capture from the same nucleus into various channels (reactions (1) and (2-3)), and the rates $\Lambda_B(^3\mathrm{He})$, $\Lambda_B(^4\mathrm{He})$ of similar breakup reactions in helium isotopes.

During 5 weeks of data taking about $4.8{\cdot}10^5$ and $4.6{\cdot}10^4$ breakup events have been recorded, respectively, in ^{3}He and in ^{4}He. At the same time, with a special prescaling trigger, about $3.4{\cdot}10^5$ and $3.7{\cdot}10^4$ single muon-stop events have been registered in these two gases, for precise absolute monitoring of muon stops. The Figures 1 and 2 display the energy spectra of muon capture events in ^{3}He and in ^{4}He as seen by the ionization chamber. The energy spectrum in ^{3}He shows a clean triton line of the reaction (1), but in other aspects the spectra are very similar.

Finally we obtained: $\lambda_B(^3\mathrm{He}) = (720 \pm 6(stat) \pm 65(syst))\ \mathrm{s}^{-1}$ and
$\lambda_B(^4\mathrm{He}) = (415 \pm 5(stat) \pm 40(syst))\ \mathrm{s}^{-1}$.

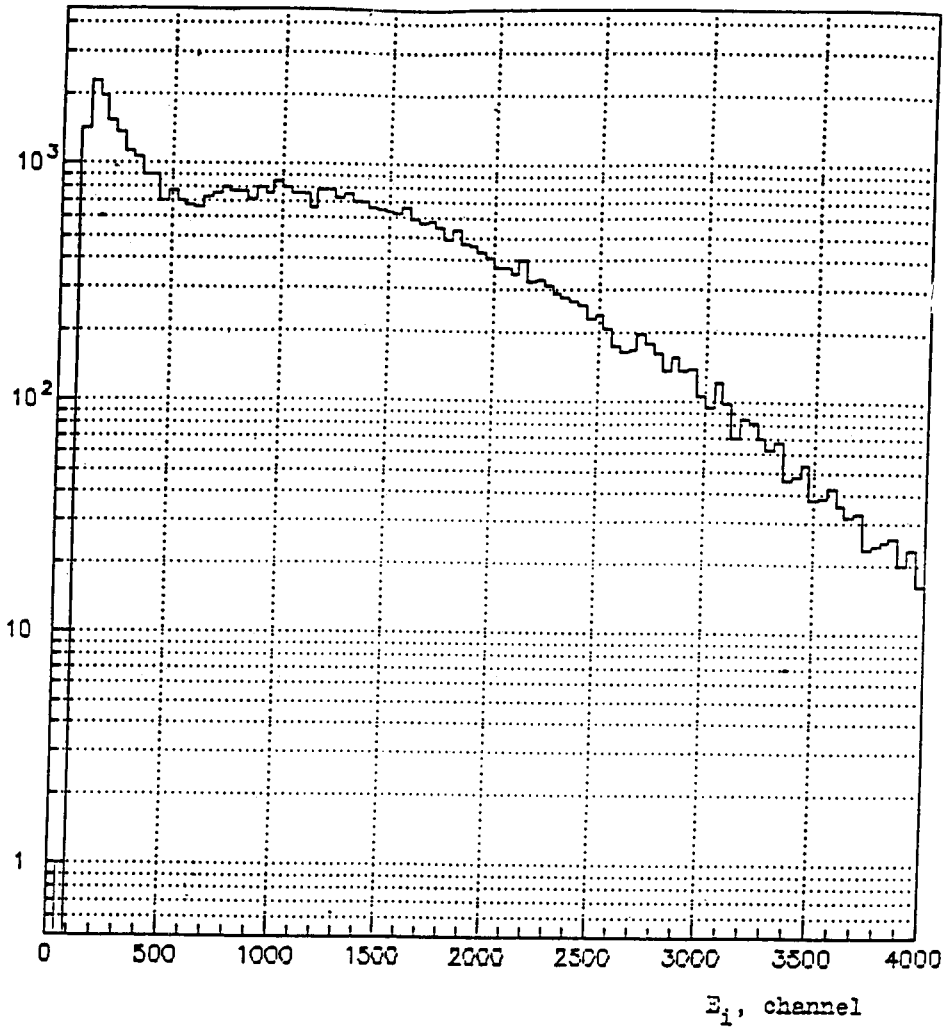

Fig.2. The energy spectrum of the muon capture events by ^{4}He (1 ch=1.6 keV)

With our result on $\Lambda_C(^3\mathrm{He})$ [1] we can estimate the value of total capture rate of muons by ^{3}He, including all capture channels: $\Lambda_C^{tot}(^3\mathrm{He})=\lambda_C(^3\mathrm{He})+\Lambda_B(^3\mathrm{He}) = (2216 \pm 70)\ \mathrm{s}^{-1}$. Our investigation of muon capture by ^{3}He and ^{4}He yielded three independent rates: breakup for both isotopes, and total capture rate by ^{3}He.

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