EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

May 28, 1962

Proposal for a measurement of the rate of the muon capture process $\mu^- + He^3 \rightarrow H^3 + \nu$

C. Rubbia, E. Zavattini

The capture rate of muons in He^3 going to H^3 has been measured recently by a Dubna group with the help of a diffusion cloud chamber. Their results, based on 26 events, give a capture probability of about 1 capture every 300 stops. A number of authors have emphasized that such an experiment can be analysed in terms of coupling constants almost as accurately as the capture in liquid hydrogen. Calculations by Wolfenstein and by Werntz indicate a capture rate of $1.51 \cdot 10^3$ sec^{-1} with an accuracy of better than 5% (given the ft value for H^3 β decay).

A precision measurement of the capture rate of muons going to H^3 is an essential complement to the determination of the total capture rate in liquid hydrogen. In the case of the experiments performed until now with liquid hydrogen, the muon and the proton are, at least during 80% of the time, in a singlet state. On the other hand, the hyperfine states of the mesic atom of He^3 are populated statistically with no relaxation during the muon lifetime, with the triplet three times more likely than the singlet state. By combining the two experiments one can separate out the capture rates in the singlet and triplet states. The values of the Gamow-Teller and Fermi coupling constants can also be worked out.

The experiment proposed here is a counter experiment. The expected counting rate is of several hundred good counts per hour, and it is hoped to reach an accuracy in the result of the order of the theoretical uncertainties ($\sim$ 5%). μ mesons are brought at rest (Fig. 1) in a container filled up with He^3 gas at high pressure (20 atm). For He^3, scintillation properties are assumed similar to those for He^4. This is an assumption which needs experimental checking. In case of insufficient light output, a mixture of He^4 and He^3 can be tried out. The capture, going on in an H_3 state, is identified by the energy of the charged fragment(s) produced in the target counter. According to the findings of the Dubna group, the captures to an unbound final state give rise to a broad, flat spectrum, quite small and easy to subtract out (see Table I).

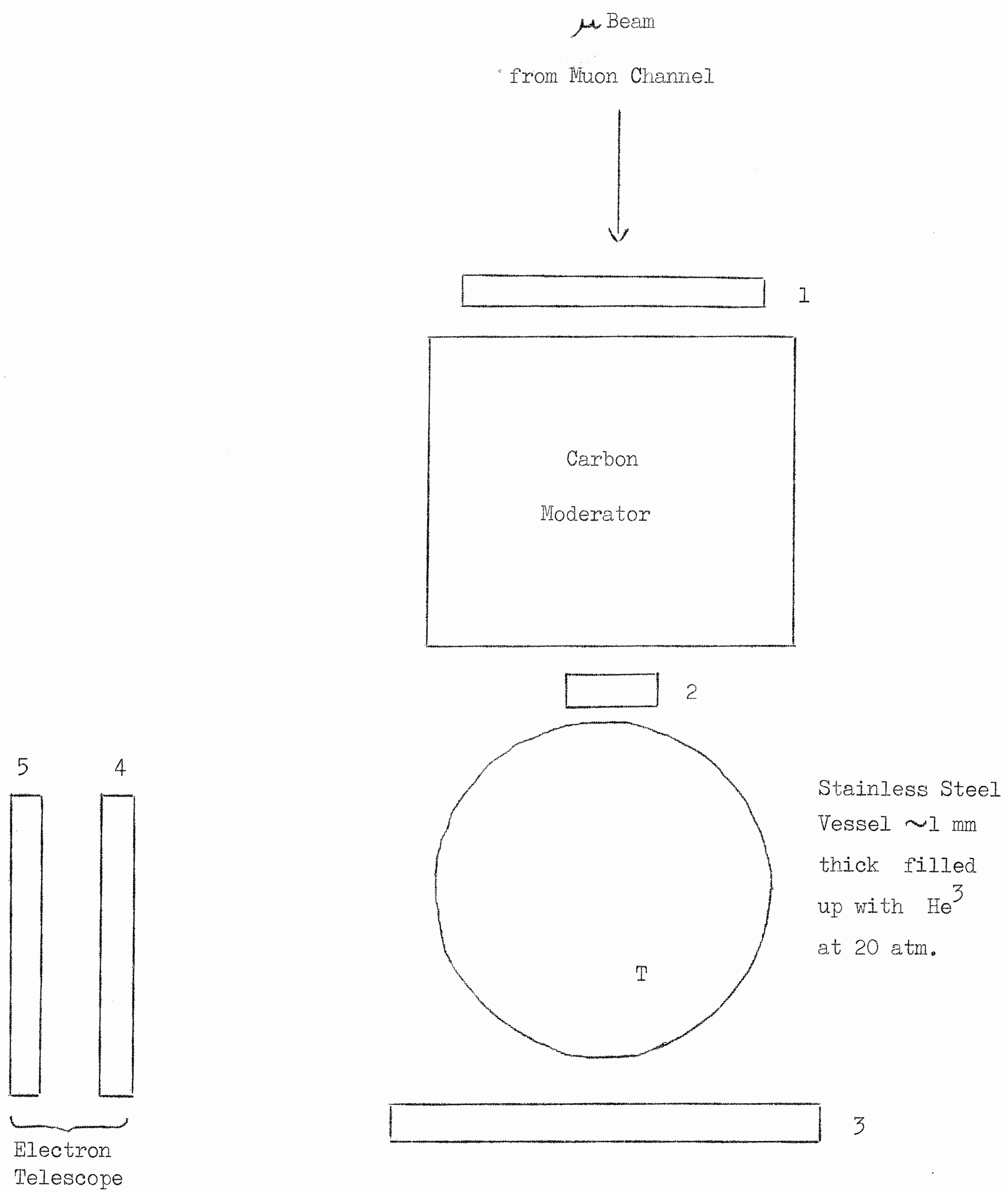
The various kinds of background to be expected are summarized in Table I. The capture rate is then determined by comparing the number of captures recorded with the number of decay electrons recorded by the telescope (45). The decay electrons coming from the walls are about three times more than the ones coming from the gas. The time dependence, however, being quite different, they can be separated out unambiguously (1 μs after the stop, the wall effects are already less than 1% !). The solid angle for the decay electrons can be calculated with a Monte Carlo. The electronics needed is quite simple and already exists. The time between the stop (signature : $12\bar{\bar{T}}\bar{3}$) and the capture ($\bar{\bar{T}}\bar{1}$) or the decay (45) is recorded in one 100-channel pulse height analyser, while in another 100-channel pulse height analyser the energy released by the capture is stored. At the same time, energy and time of each event are recorded on a punched tape. The tape is then read by the Mercury computer in which the results are stored in the form of a 100 x 100 matrix.

Table I

Corrections to the Searched Effect

Process	Magnitude of the effect	Way of correcting for it
Unbound final states	$<$ 10% (for 30% counter resolution)	Flat energy distribution; easy to subtract out, the resolution of counter being known.
Wall effects:		
a) charged prongs from captures in the walls	~ 100% (less than 0.2% after 1 μs)	Negligible after 1 μs.
b) loss of good events due to finite target size	$\ll$ 11%(o)	Measurements at different pressures. Monte Carlo calculation.
Accidentals	$\ll$ 100%	Difficult to predict. Quite small extrapolating from Dubna results. Paralysis circuit requiring only 1 muon incident on the apparatus at less than 15 μs from capture.

(o) Monte Carlo calculation for uniform stop distribution (pessimistic assumption).


μ Beam
from Muon Channel
1
Carbon
Moderator
2
5
4
Stainless Steel
Vessel ~1 mm
thick filled
up with He3
at 20 atm.
T
3
Electron
Telescope

4049/p