MESON SCIENCE RESEARCH WITH PULSED MUONS

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§1 Introduction

In 1980, new Meson experimental facility BOOM (Booster Meson Facility) was constructed in our laboratory at KEK-BSF (Booster Synchrotron Utilization Facility). Utilizing pulsed proton beam from 500 MeV booster synchrotron, intense (> 10^4 μ/pulse) and sharply pulsed (50 ns width and 20 Hz repetition) muon beam is generated in a main decay muon channel with a large superconducting solenoid (6m long, 12cm bore and 50kG field) and parasitically in a surface muon channel. The basic layout of experimental area is shown in Fig.1.

There are two important features in muon experiments with this world's strongest pulsed beam: 1) Capability of long time range measurement of μe decay and μSR without any background contributions from accidental coincidences between incoming muons and emitted $e^{\pm}$: 2) Effectiveness for the beam to be coupled with extreme experimental conditions of a low duty factor such as high r.f. field, high power laser, etc.

Since the first operation of the muon channel, new types of experiments have been carried out with the emphasis on these features[1)]. Typical examples are described in the followings.

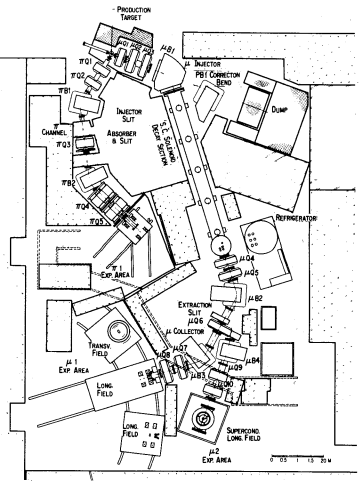

Fig.1.

§2 Pulsed Muon Experiments : Long time range Measurement of μSR

The μSR method, utilizing asymmetric $e^{\pm}$ emission along polarized muon spin, can be used to probe the local magnetic field and its fluctuation felt by the muon inside condensed matters as well as, muonium (Mu, hydrogen like neutral bound state) chemical reactions, etc. Using pulsed muons which have strong advantage for long time range measurement, one can now measure low frequency muon spin rotation, slow μ^+ relaxation, fast and slow diffusion, etc. The following new results have been obtained. Experiments were performed mainly with backward muons from the superconducting muon channel.

a) There have been a large number of experiments on the chemical reaction rates of Mu in a wide variety of aqueous solutions. However, the existing data for the most basic standard, namely, the reaction rate of Mu in pure water, had been controversial. In order to clarify this situation by measuring weak relaxation rate, it is essential to use intense pulsed muons under very weak field (∿ 3G) with a good field homogeneity. The long-lived character of Mu in water has been revealed by the pulsed μSR method and a new upper limit is place on the chemical reaction rate of Mu with diamagnetic compounds[2].

b) Pulsed μSR is particulaly effective for the measurement of a very slow spin rotation, which enables us to measure critical phenomena under very weak external transverse field, without destroying critical behaviour of magnetic ordering. The experiments have been done on μ^+ in Ni.[3] The typical μSR spectra are shown in Fig.2, demonstrating a long time range measurement capability (normally 5μs for DC muons). The obtained critical indexes for paramagnetic Knight shifts and ferromagnetic local fields are more or less consistent with magnetization measurements. The critical index in paramagnetic correlation time obtained from dipolar relaxation is consistent with neutron scattering but inconsistent with nuclear probe measurements by PAC method.

§3 Pulsed Muon Experiments : Coupling with extreme experimental conditions

The high power pulsed r.f. source (peak power 20 kW and 2 x 10^{-3} duty factor) was applied for the muon spin resonance studies coupled with pulsed muons. The first observation of time differential pattern in muon spin resonance have been realized[4].

The muon spin resonance technique will be applied powerfully to various problems that cannot be studied by the spin rotation method. Typical examples are as follows; a) local field measurment under strong decoupling field; b) measurement of time dependent change of muon local fields; c) establishment of zero-polarization reference for delicate polarization phenomena in muon capture now applied in polarization transfer studies in $^{12}C(\mu,\nu)^{12}B$ reations[5]

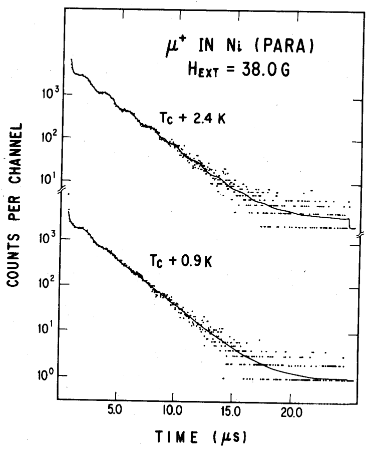

Fig.2.

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1) UT-MSL News Letter No.1(May, 1981) and NO.2 (May 1982) ed, K. Nagamine and Yamazaki. 2) K. Nagamine et al, Chem. Phy. Lett. 87(1982)186.
3) K. Nishiyama et al, Contribution to ICM 82. 4) Y. Kitaoka et al, Hyperfine Interaction 12 (1982) 51. 5) Y. Kuno et al, to be published.