# TIME STRUCTURE OF THE ACCELERATED BEAM AT THE RCNP CYCLOTRON

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## Abstract

Time structure of an accelerated beam is measured with two different types of phase-measuring devices. A charge-induction type phase meter is developed and a microscopic time structure is measured with sampling method. RF-$\gamma$ timing method is also successful to obtain a phase and time structure of the beam.

## Non-intercepting phase probe

An older type of phase measuring devices was intercepting one. Non-intercepting capacitive or inductive beam pick-up heads are developed at several laboratories. However, continous observation at any position can not be attained. A direct-reading type phase-meter system is developed in our laboratories. It consists of a capacitive beam pick-up head, frequency doublers, mixers, crystal oscillators and a low frequency Wiltron phase-meter. The super-heterodyne technique is used to get excellent signal to noise ratio(S/N). As the second harmonic component of the beam signal is used, very good S/N is obtained at the presence of still high field of RF oscillation. The phase-meter is sensitive even at small beam current of about 80nA over the wide frequency range(6-18MHz). In order to observe a microscopic beam structure, a sampling technique was applied to the same pick-ups.

## RF-$\gamma$ timing method

There are another ways to measure both phase and time structure of the beam simultaneously. At the SIN injector cyclotron, a time structure of the extracted proton beam was measured by TOF method using elastically scattered protons. The same procedure is used at Milan and at TRIUMF. Instead of elastically scattered protons, reaction gamma rays can be used to obtain the time structure of the internal beam. Reaction gamma rays at the beam probe(copper) and trigger pulse from RF signal are used as for a start and a stop pulse of a time to amplitude convertor. Block diagram is shown in fig. 1. In this method, very fast gamma·transitions must be chosen not to make an additional error due to delayed components from isomeric gamma transitions. Due to this consideration, we generally chose the high energy gamma transitions ( >1.5MeV), though these gamma transitions yield decrease at rather smaller radius (r=60cm). A 75MeV proton phase history was obtained from r=70cm to the outermost radius. It is noted that the beam can be accelerated at the same phase up to r=90cm, though at outer radius than r=90cm, the beam reaches later than the RF phase. RF-γ timing method are also useful to resolve the microscopic beam structure. This is more feasible than the sampling method and this is very reliable. The effect of the phase slit to select the beam with narrow phase angle can be assertained using this method. The relation between energy and time structure were examined by measuring momentum distributions with analyzing magnet. It is more confident that the beam with narrow energy spread can be obtained using phase slit at initial motion region of the cyclotron.

The time structure of the polarized beams of proton and deuteron were measured. Beam spills of polarized proton are shown in fig. 2. The effect of beam buncher located at injector line is clearly shown.

The time calibration in RF-γ timing method was done as to measure a time interval of succesive beam burst. The measurement are compared withthat obtained by sampling method. These different ways remarkably agree with each other. For example, fine structure obtained by sampling method shows a several peculiar time distribution, non-symmetric or saw-tooth which are also obtained in RF-γ timing method. These structures can not be derived from a spurious effect of electric circuits.

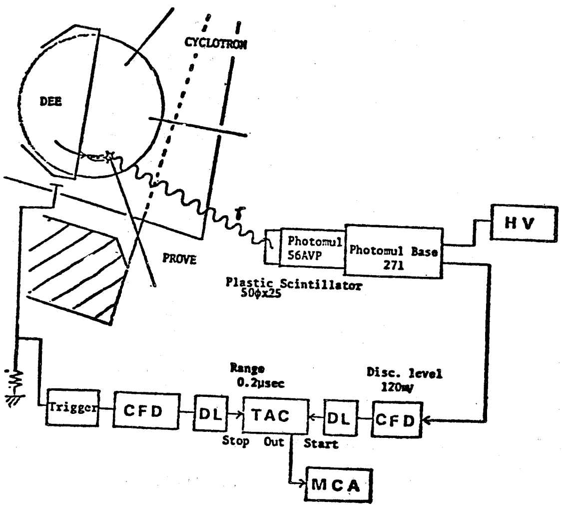


Fig. 1. Block diagram of RF-γ timing method

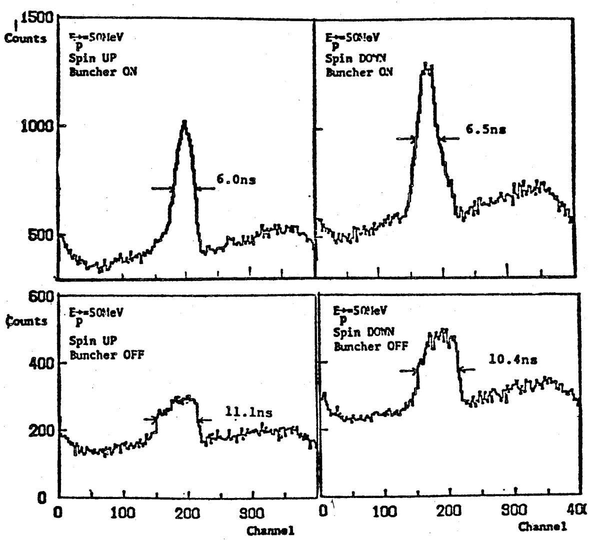


Fig. 2. Time structure of polarized proton