Possibilities of Using the KEK 500 MeV Booster Synchrotron for Cancer Therapy

Chiri Yamaguchi, Kazuaki Katoh

Most of the high or medium energy accelerators in the world are being built mainly for the research in physics. Some of them, however, provide biomedical facilities. Table 1. gives a comparison of such accelerators, which are known as meson factories[1].

The KEK 500 MeV booster synchrotron is operated with the repetition rate of 20 Hz and is planned to provide a beam current of 5 uA. The intensity of 0.7 uA is obtained so far. It is only 9 pulses out of 40 in every two seconds that are injected into the main ring and accelerated to 12 GeV. About three quarters of the booster pulses, therefore, can be used for other purposes by extracting them outside a booster hall.

It would be possible to use proton beam from the booster in medical science. Here, however, the possiblities of using the secondary beam of negative pions in cancer therapy are described.

The negative pion yields from 450 MeV proton synchrotron are shown in the figure. This was calculated from the cross section data of ref. 2. This shows that more than 10^4 pions of energies between 70 and 100 MeV with 1 MeV energy spread are produced per sec over a solid angle of 1 msr. The pions of above described energies are said to be convenient for cancer therapy, (ref. 3.)

If we construct a large acceptance ($\sim$ 100 msr) pion channel and use a thick target (5 $\sim$ 50 g), we will obtain $10^9 \sim 10^{10}$ pions/MeV/min with energies of about 90 MeV. If above number of pions are captured uniformly in the small target volume of 2×2×1 cm^3, the corresponding dose rate of such a pion beam is 100 $\sim$ 1000 rad/min. This was calculated based on the fact that nearly 30 MeV of the pion rest mass of 140 MeV appears in the form of kinetic energy of the charged particles such as protons, alpha particles, and heavier particles that are absorbed locally, resulting a "star" (ref. 3.)

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References :

1) Phys. Today, Feb. (1975) P. 17

2) E. Lilluthun, Phys. Rev. 125, 665 (1962)

3) M. R. Raju and C. Richman, Current Topics in Radiation Research Quarterly 8, 159-233 (1972)

Table 1. Comparison of meson factories (ref. 1)

Facility	Type of Machine	Range of Proton energy (MeV)	Maximum beam intensity Planned (10^{-6} amp)	Reached	Macro duty factor (%)
SIN	Sector focusing Cyclotron	590	100	12	100
TRIUMF	"	180-520	100-200	0.01	100
LAMPF	Proton Linac	600-800	100-1000	10	6
Nevis	Synchrocyclotron	560	10-40	-	60
Dubna	"	700	25-50	-	50?
CERN	"	600	7	0.3	>50
KEK Booster	Fast cycling Synchrotron	500	5	0.7	0.16