Present Status of HIMAC

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Abstract

HIMAC has been supplying carbon beams for clinical trial of charged particle therapy since 1994. It also provides various ion beams from H to Xe for collaborative study in physics, biology, and relevant field of research. Present status of HIMAC is described in the report.

1. INTRODUCTION

HIMAC, Heavy Ion Medical Accelerator in Chiba, is an accelerator complex that consists of an injector system (ion-sources and linacs), two synchrotron rings (called the upper ring and the lower ring), high-energy beam transport lines, and an irradiation system for cancer therapy and for relevant experiments.

It is the first ion-synchrotron built for medical treatment. As such, priority of the machine operation and development efforts is focussed on reliable and stable beam supply and improvement for matching into hospital-type environment.

The number of patients treated by HIMAC carbon ion has been increasing, more than tripled from the previous report[1], as shown in Table I. A few words would be in order on clinical result, although we need more experience in time and cases to establish the modality in an "evidence based" manner, and to advance to the phase where it becomes covered by medical insurance or equivalent scheme.

Table I

HIMAC CARBON-ION CANCER-THERAPY PATIENTS ACCUMULATION ('94.6-'01.8)

Site (per Protocol)	FY94		FY95		FY96		FY97		FY98		FY99		FY00		FY01		Total	
Head & Neck	7		10		19		31		22	*1*	38		29		20		176	*1*
Cent. Nerve System	6		8		10		6		9		7		15		4		65	
Lung	6		11		27	*1*	17		28		33	*1*	45		20		187	*2*
Liver	—		12		13	*1*	19		25	*2*	17	*1*	22	*1*	11		119	*5*
Prostate Gland	—		9		18		10		30		30		31		16		144	
Uterus	—		9		13		11		10		11		13		2		69	
Bone & Soft Tissue	—		—		9		13	*1*	19	*6*	18		25		7	*1*	91	*8*
General	—		24		16	*1*	30		17	*2*	32	*3*	14	*7*	5	*2*	138	*15*
Skull Base	—		—		—		6		4		2		2		2		16	
Pancreas	—		—		—		—		—		—		3		3		6	
Eye	—		—		—		—		—		—		0		4		4	
Rectum	—		—		—		—		—		—		—		2		2	
Esophagus	—		—		1		16		4		—		2		—		23	
Tongue	2		—		—		—		—		—		—		—		2	
Annual Total	21		83		126	*3*	159	*1*	168	*1*	188	*5*	201	*8*	96	*3*	1042	*31*

Note: Number of "extra" (multiple) tumor target within the registered patients is shown in *italic*.

The local control rate in 2 years after treatment, and the 3-year survival rate are deduced from the subset of tabulated number of patients, and show considerably better results. In Liver, e.g., local control is more than 80 %. For further updated detail, see the relevant pages of http://www.nirs.go.jp.

2. ION SOURCES AND LINACS

There are two ECR-type and one PIG-type sources in use at HIMAC. 10GHz ECR routinely provides C^{2+} beam for treatment and other experiments, while 18GHz one runs for Fe and heavier noble gasses. PIG covers Si, for example. Recent topics of the sources are reported at ICIS, held at Oakland, by the respective authors.[2]

In Fig.1, the statistics of accelerated ion species in HIMAC injector is shown for the last four and a half years. Since April 1998, the Time-Sharing-Acceleration in the injector linac system has been in operation, and the effective beam supply time has been increased about 20 %. TSA can provide three different beams to each destination, two rings and a 6 MeV/A experiment course.

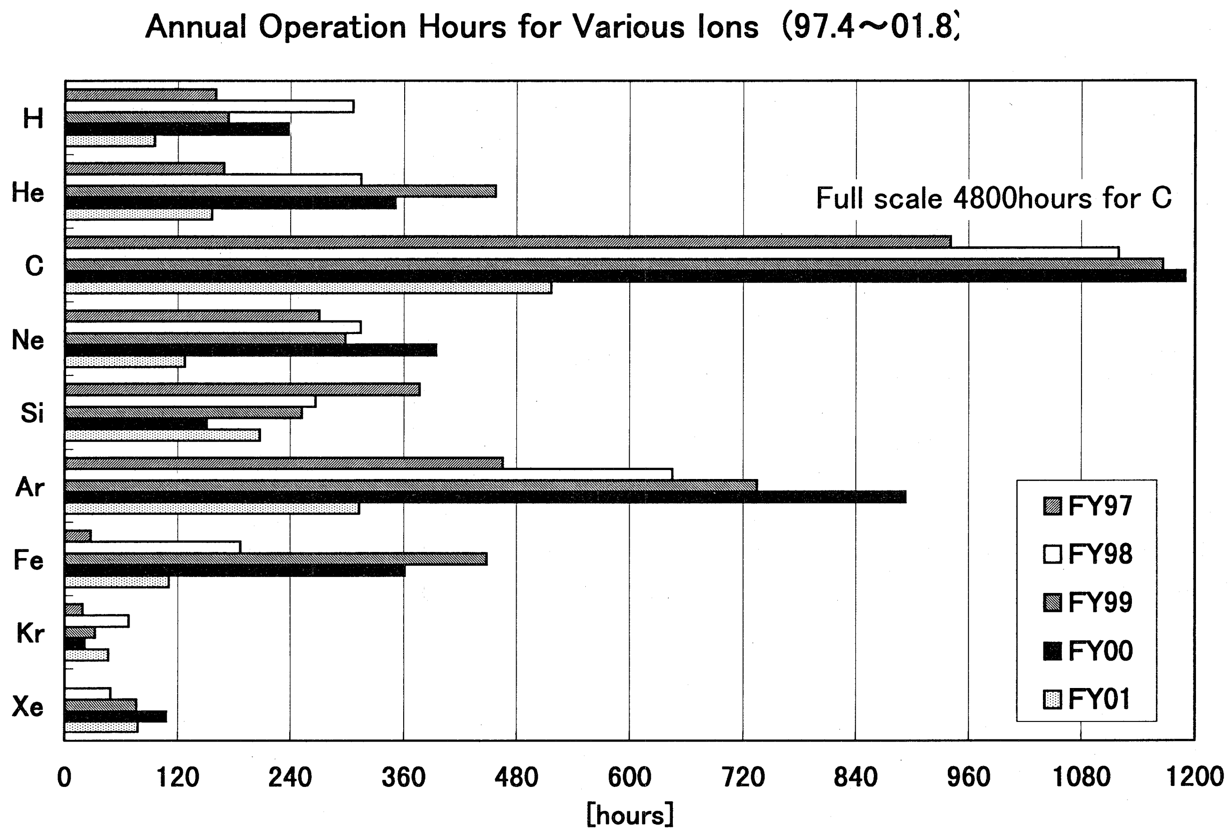

Fig. 1. Acceleration Statistics of injector of HIMAC. As indicated, data for FY01 are from April to August only.

3. SYNCHROTRONS AND HIGH-ENERGY BEAM TRANSPORTS

The synchrotron ring of HIMAC can accelerate ions of q/m = 1/2 up to 800 MeV/A, although the clinical practice is concentrated to carbon beams of 290 to 400 MeV/A, at present. In Fig. 2, the annual operation hours of the lower ring are shown with information on flat top energy. The annual operation hours are about 5,500 hours, of which major part is for therapy and relevant measurements. It can be seen that carbon ion acceleration (for 290 and 400 MeV/A) prevails more than 60 % of the operational time of a ring. It is to be noted that low energy operation share reflects the activity for EC (electron cooling) installation in the ring.[3] Beam Profile Monitor using MCP is developed and employed in the ring.[4]

Since the last year, beam intensity for therapy irradiation was elevated to, typically, 2.0×10^9 particles per sec. in order to expedite the irradiation time. This change was made possible by the development of "quasi-non-destructive" beam monitor at the end of transport lines for clinical ports, while the response of dose monitoring system in the clinical port limits the possible use of even higher intensity. It is also instrumental in the change that the beam interlock system works excellently.[5]

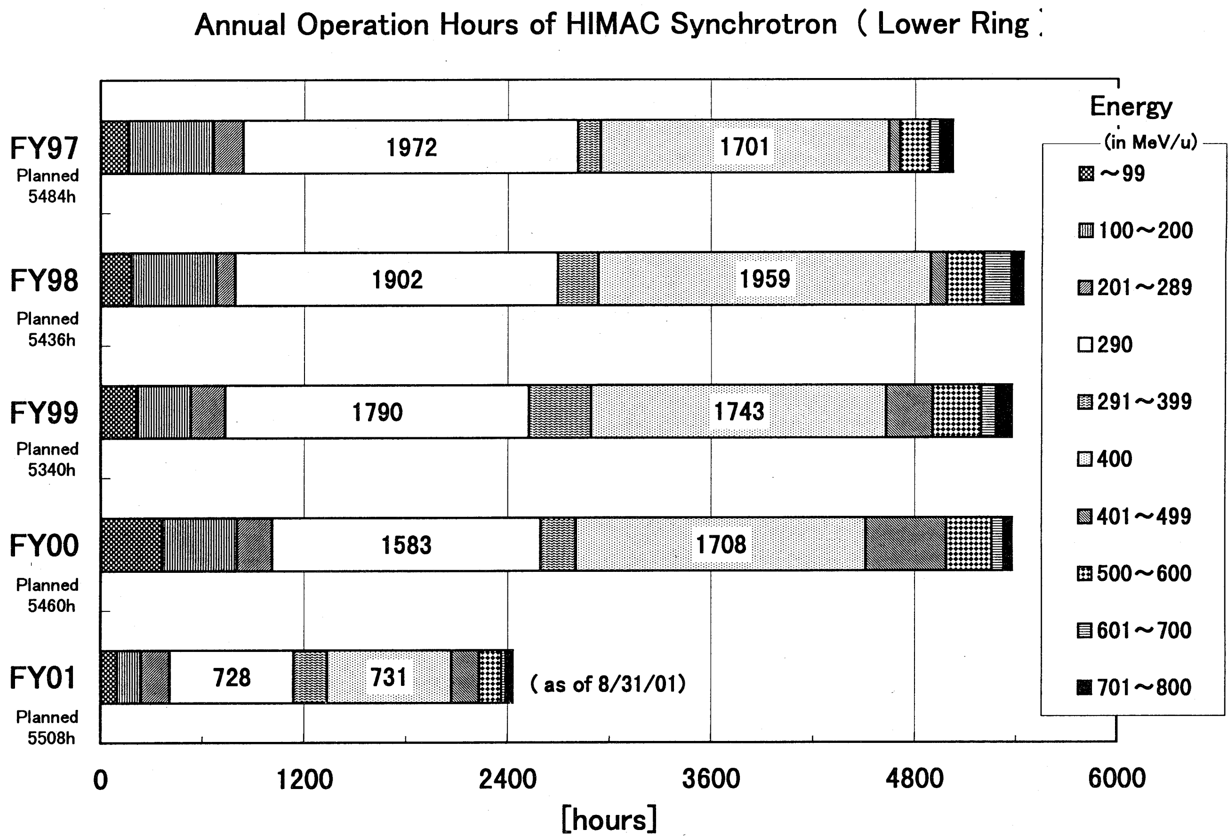

Fig. 2. Acceleration Statistics in terms of accelerated beam energy from HIMAC synchrotron lower ring.

Although the collection of data is incomplete, machine failure is controlled to a level of about 50 hours only for each year, i.e., 1 % or less of the scheduled operation time. RF and control (including PLC, VME and other computers) system are major source of the down. The last and present years see more trouble in control domain than the previous years, due to both initial malfunctioning of a new system and weared-out hardware of an old computer.

4. IRRADIATION SYSTEM AND OTHER R&D ACTIVITY

In quest of confirming the irradiation range in the treatment, the secondary beam line with clinical irradiation facility is constructed.[6] To advance medical application of accelerated beam, various studies are being carried out; a high field permanent magnet, a 7T wiggler for medical use of SR, and a sheet beam profile monitor, which are reported in the present symposium, by the respective authors.

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