OPERATION OF HIMAC AND CANCER THERAPY

Chihiro Kobayashi, Hideki Fujiwara, Tomihiro Nishimura, Yoshinobu Sano, Hirotsugu Ogawa
Accelerator Engineering Corporation (AEC), Chiba 263-0043, Japan
Eiichi Takada
National Institute of Radiological Sciences (NIRS), Chiba 263-8555, Japan

Abstract
The operational status of HIMAC is reported.

1. INTRODUCTION

HIMAC, Heavy Ion Medical Accelerator in Chiba, has been used for cancer therapy application since June 1994. Accumulated number of treated patients is about 1,000 at present. The results of local control rate of tumor and survival rate are good.

The accelerator characteristics are summarized in Table 1. Beams of various ion species are supplied for physics and biology experiments during nights and weekends.

Table 1: Outline of Himac

OUTLINE OF HIMAC

Ion Source

PIG	Solid materials ions such as Si, B
10GHz ECR	Mainly C used for cancer treatment
18GHz ECR	Heavier ions such as Ar, Fe, Kr, Xe

Linac

RFQ	100MHz, 300kW, q/A=1/2∼1/7, 0.8MeV/u
DTL	100MHz, 1.4MW, q/A=1/2∼1/7, 6.0MeV/u

Synchrotron

Upper Synchrotron	42m dia., 130m circumference,
Lower Synchrotron	100MeV/u∼800MeV/u each
	Beam intensity ex. C 2.0E+9 pps

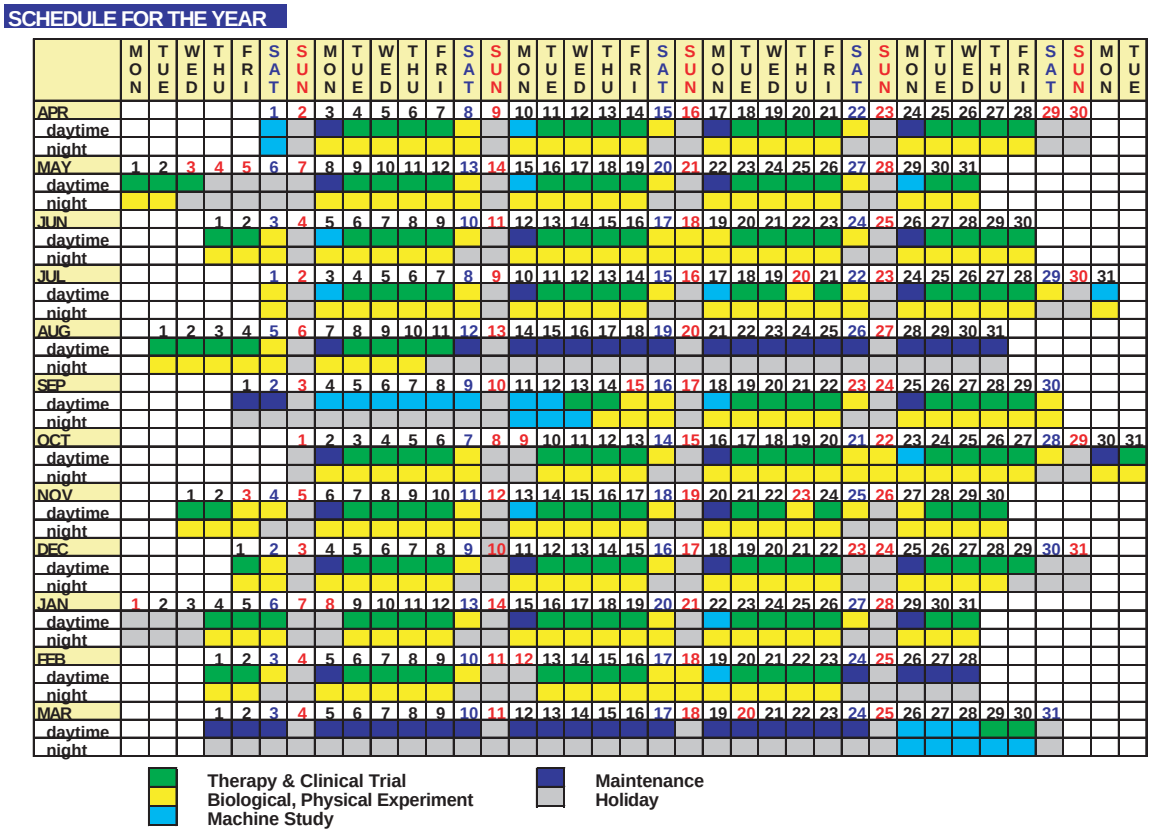
Treatment and Irradiation Facilities

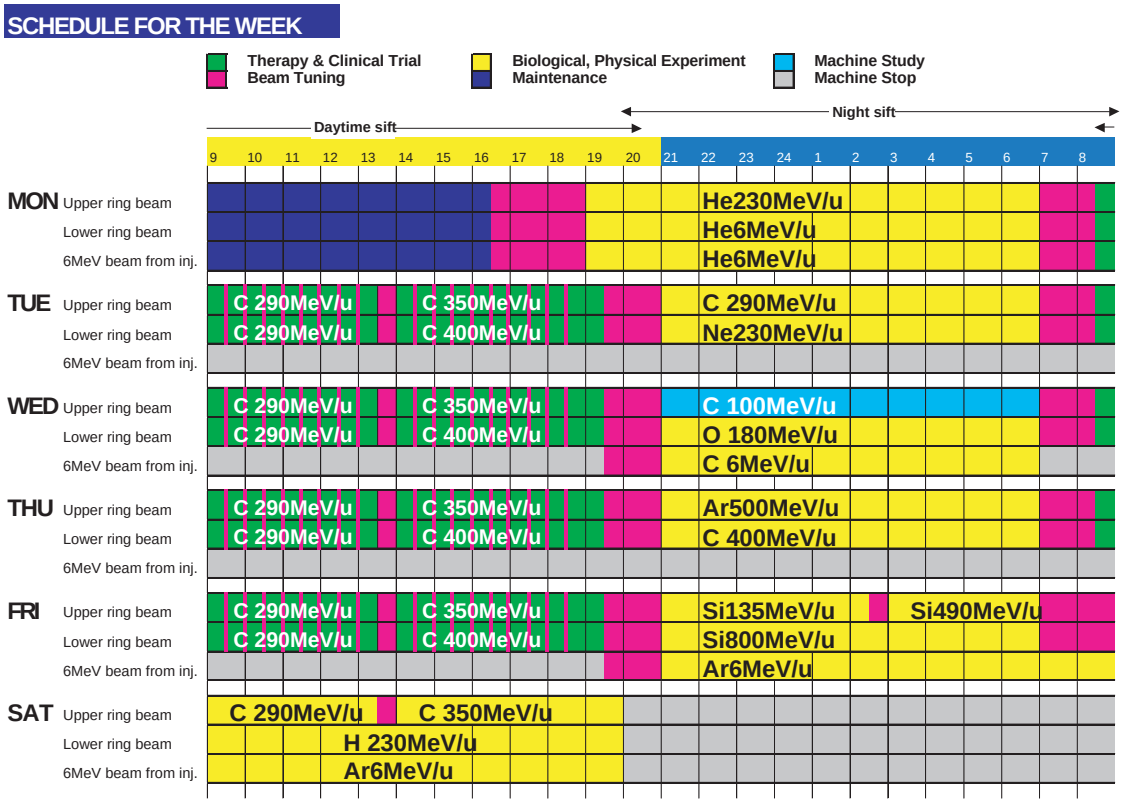
Treatment room A	(Vertical beam)	Max. field size 22cm dia.
Treatment room B	(Horizontal & Vertical beam)	Dose rate 5Gy/min
Treatment room C	(Horizontal beam)	Penetrating range 30cm in tissue
Biological experiment room		Wobbler method used
Physical-general experiment room		
Secondary beam experiment room		(Radioisotope beam such as ^{11}C)
Medium energy experiment room		(0.8 `∼ 6MeV/u beam from Linac)

2. SCHEDULE

HIMAC schedule for the present fiscal year is shown below. From April to early August and from September to February are the two semesters of running. Periodic maintenance, as well as installation of new devices for improvement and research, is concentrated into the shutdown period of August or March.

Also shown is a weekly schedule. Cancer treatments are performed during the daytime of Tuesday through Friday, with carbon beams, while physics and other experiments have beams during the rest. A half day preventive maintenance is scheduled bi-weekly.





3. ORGANIZATION

The operation of HIMAC is done by AEC. AEC is a company founded at the time of HIMAC commissioning, and now has a contract from NIRS on HIMAC operation and maintenance. Accelerator operation personnel is 28 people, average 30 years old, experiencing 4 to 5 years of operation, whose backgrounds are various and usually not accelerator-related. Shift schedule is rotating with 7 teams, each consisting of three-operators. About 40% of the working time is consumed with the half-day shifts, and the rest of the time is used for maintenance and improvement work. by individual operators.

4. OPERATIONAL PERFORMANCE

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. Nevertheless, other ions are also accelerated, ranging from H to Xe.

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. Ion source improvement is also effective for heavier ions such as Fe, Kr, Xe, etc.

Although the collection of data is incomplete, machine failure is controlled to a level of 1% or less. This is depicted by the fact that unscheduled down-time of more than 30 minutes accumulates about 50 hours only for each year. RF and control (including PLC, VME and other computers) system are major source of the down. The present year sees more trouble in control domain than the recent years. This is due to both initial malfunctioning of a new system and weared-out hardware of an old computer.

Accelerator operation group organization

Operation staff from AEC

	Number of staff
Manager	2
Operator	26

(Ave. Age 30.6 Ave. Career 4.6)

Operator's maintenance work

	Number of staff
Ion source	6
RF system	4
Vacuum	3
Power supply & Magnet	7
Beam monitor	6
Control system	7
Cooling	2

(several works per person)T

Operators meeting

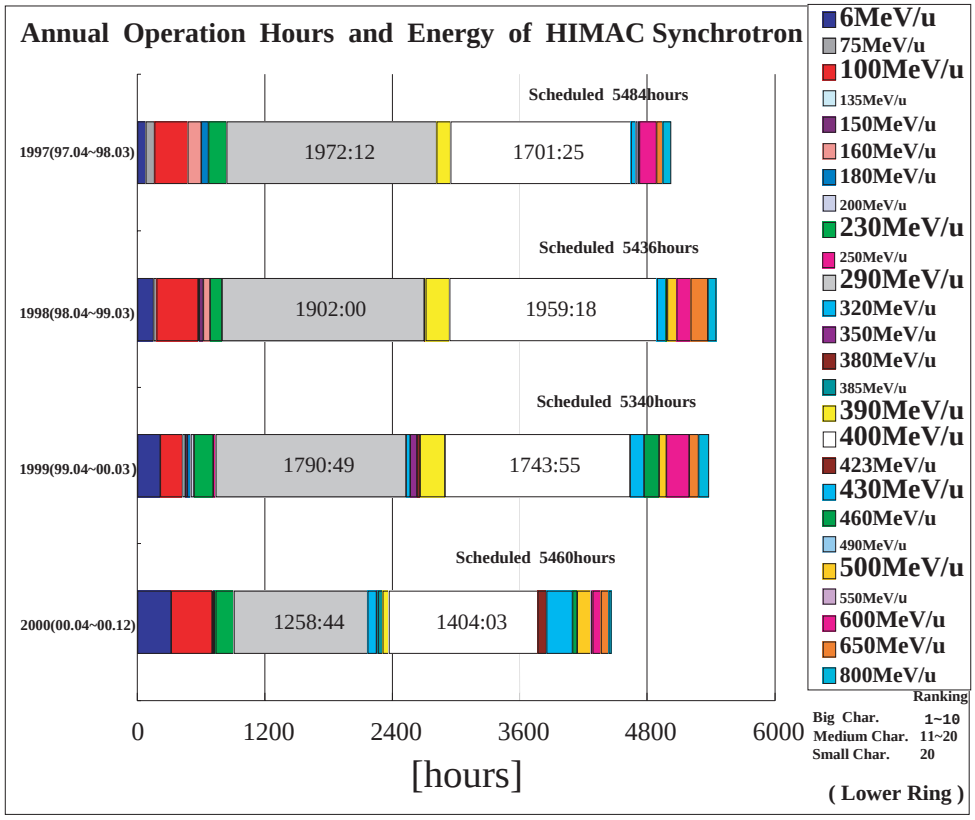
Date Thursdays (?1hr)
Participant Team-leader & Manager
Subject - Review operation of the previous week
(Beam reliability etc.)
- Follow-up machine problems
- Confirmation of the next week schedule

Shift schedule

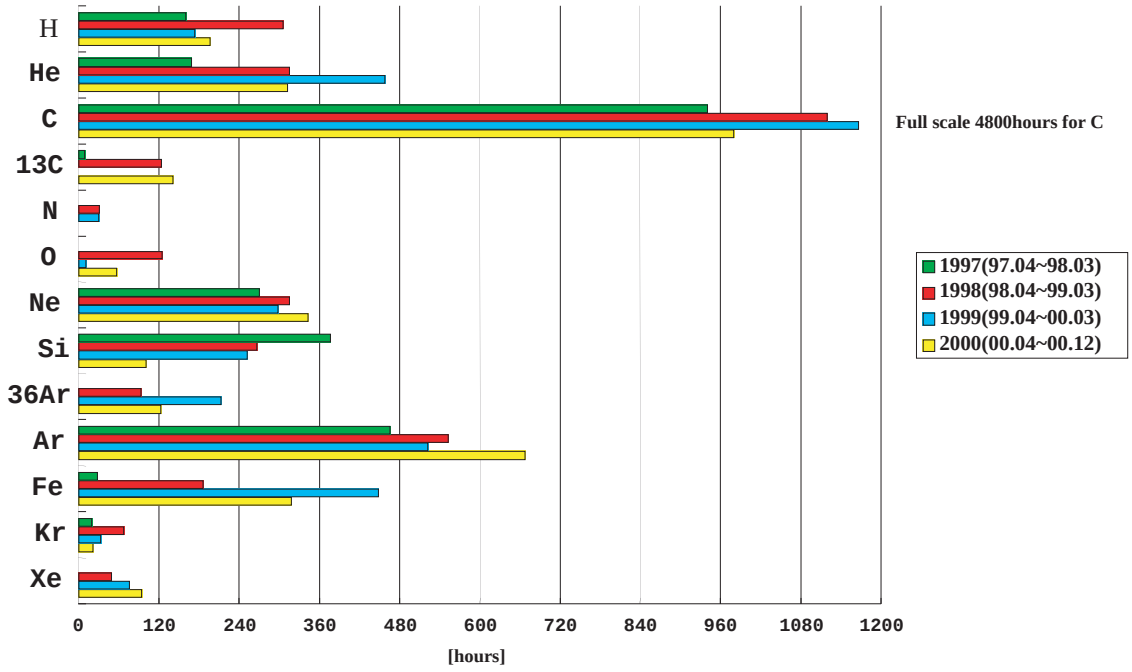
Number of operators per shift(team) 3
Number of team 7

D : Daytime shift(8:30 - 20:30)
N : Night shift (20:00 - 9:00)
M : Maintenance (8:30 - 17:30)
H : Holiday

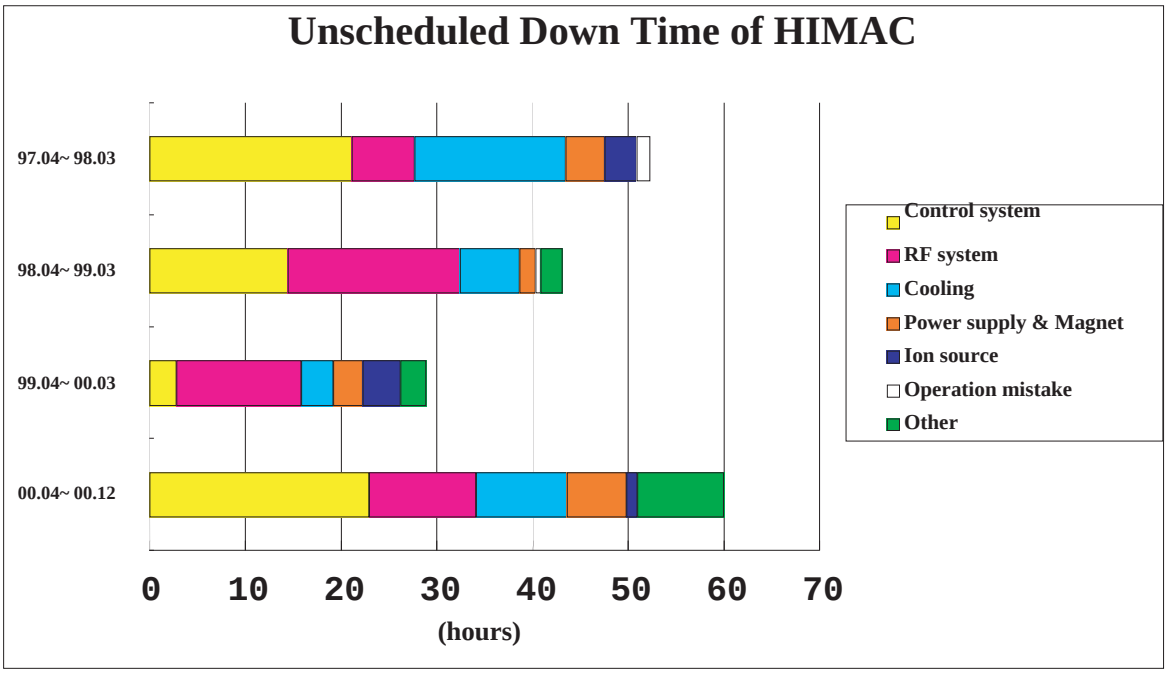
	Team1	Team2	Team 3	Team 4	Team 5	Team 6	Team 7
MON	D	MM		M	HH		N
TUE	N	D	MM		MM		H
WED	H	N	D	MM		MM	
THU	M	H	N	D	MM		M
FRI	MM		H	N	D	MM	
SAT	HH		HH		N	D	H
SUN	HH		HH		HH		H
MON	MM		M	HH		N	D
UE	D	MM		M	HH		N
WED	N	D	MM		MM		H
THU	H	N	D	MM		MM	
FRI	M	H	N	D	MM		M
SAT	HH		HH		D	HH	
SUN	HH		HH		HH		H
Working Hour/week	39.0	39.0	43.0	41.0	41.0	39.5	37.5
% of time operators on shift	44.9	59.0	53.5	41.5	41.5	29.1	30.7



Annual Operation Hours for Various Ions



Unscheduled Down Time of HIMAC



	Total time of unscheduled down	Number of fault	Mean time to repair	Long (>3hours) down	
97.04 ?98.03	52:14	24	2:10	24:30	2
98.04 ?99.03	43:04	21	2:03	16:39	3
99.04 ?00.03	28:51	17	1:41	12:38	3
00.04 ?00.12	59:57	33	1:49	18:59	5

5. PROBLEMS

The trouble occurrence has decreased from the initial years. This is in the line of our objective of reducing machine trouble and reducing the down-time when trouble occurs. However, trouble-shooting is a very good opportunity to train and educate operators in our case. Stable operation may end up incapable operators. Establishing the training method of operators is one of the problems we need to solve.

A phenomenon of concern is the fact that more than 20% of the operators suffer lumbago symptom. This is much higher rate of occurrence than the average of similar age-group. Although the present average age of the operators is 30 years, the symptom may show another shift-work problem, and apparently not everyone is able to continue the shift after 10 years from now.

6. ACKNOWLEDGEMENT

The authors are grateful to all the members of AEC and staffs of Accelerator Division of NIRS.