VICKSI-STATUS REPORT

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Abstract.- A description of the VICKSI-facility, its operation and the improvements made during the last three years is given. The ongoing improvement of VICKSI by the addition of an 8 MV tandem which should be in operation in 1984 as alternate injector is outlined.

1. Introduction.- The VICKSI (Van-de-Graaff-Isochron Cyclotron Kombination für Schwere Ionen) accelerator facility is a combination of a single ended 6 MV CN-Van-de-Graaff and a four fold symmetry separated sector isochronous cyclotron with K = 128, built by Scanditronix, Uppsala, Sweden (fig. 1). It is in operation since spring 1978. As reports on design, specification and running in of the system have been given elsewhere[1,2] we will give in this report only a brief description of the main parameters. Positive ions ($1^+ \le q_i \le 4^+$) with mass $1 \le A \le 86$ are extracted from an axial Penning ion source. After charge selection, prebunching and optical adaption to the accelerator tube of the Van-de-Graaff the beam is accelerated with terminal voltages between 2.5 and 6.2 MV. The Van-de-Graaff and the cyclotron are connected through a 35 meter long beam line which contains two bunchers and a stripper besides all the necessary optical elements to transport the beam to the cyclotron and match it to the cyclotron acceptance. In the cyclotron the energy of the incoming beam is increased by a factor of about 17, thus the maximum energy is $E_{max} \le q_i \times 6 \times 17 \approx q_i \times 100$ (MeV). A second limit is given by the bending limit of the cyclotron magnet $E_{max} \le 128 \times q_s^2/A$ with q_s = charge state out of the stripper. Presently the highest energy beams available from VICKSI are a 25 MeV/A ^{12}C beam and a 20 MeV/A ^{20}Ne beam. The prebuncher in the terminal and the two beam line bunchers allow to compress about 60% of the ion source dc-output into 6° phase width of the cyclotron rf. With the given stripping ratios about 10% of the ion source output is available for experiments.

2. Operating experience and development.- The beam time statistic for 1979 and 1980 and for the first six months of 81 is shown in tab. 1. Operating- and service-time has nearly been constant during this period. Much effort has been given to reduce downtime and time for setting a beam. The downtime of the different subsystems is tabulated in tab. 2.

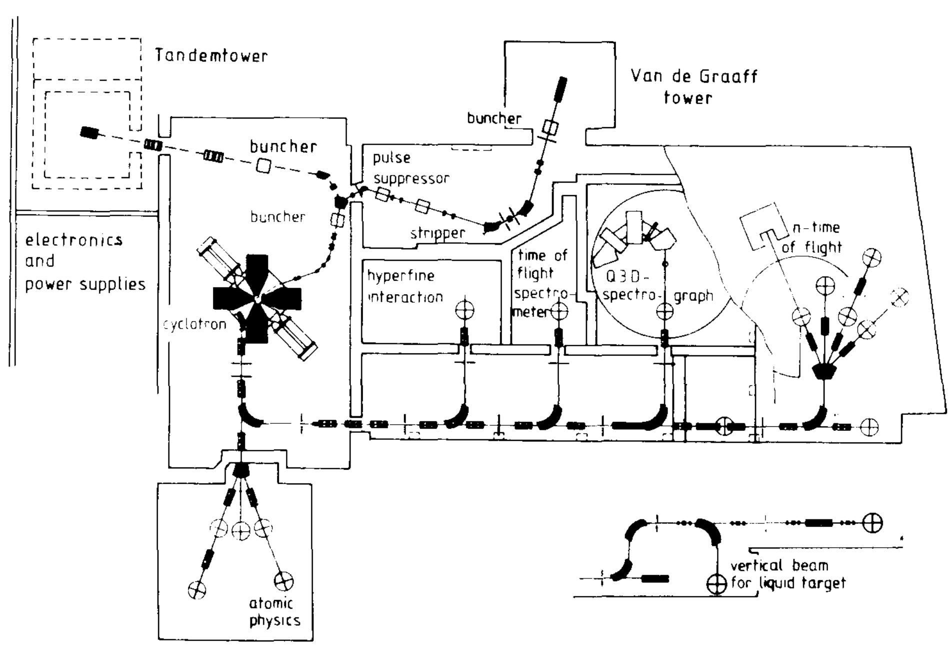

Fig. 1: Layout of the VICKSI facility. The dashed lines indicate the planned beam line between tandem and cyclotron and the location of the tandem tower.

Tab. 1: Beam Time Statistic

	1979	1980	first six months 81
Operating time	6.462 100 %	6.463 100 %	3.508 100 %
% of Calendar time	73.8	73.6	80.7
Service time	450 7 %	452 7 %	186 5.3 %
Downtime	594 9.2 %	982 15.2 %	304 8.7 %
Tests	231 3.5 %	136 2.1 %	78 2.2 %
Cond. time	224 3.5 %	86 1.3 %	142 4.1 %
Setting time	1.183 18.3 %	1.493 23.1 %	545 15.5 %
Setting time per beam	--	21	13
Beam on target	3.780 58.5 %	3.314 51.3 %	2.253 64.2 %

Van de Graaff-Injector

During the last two years the performance of the injector has been steadily improved. The axial Penning ion source has now a life time of about 500 h and is able to produce 4^+ ions from noble gases and 3^+ ions from Carbon with reasonable intensities (3-6 pnA). After extensive heating and conditioning of the acceleration tube, the injector runs at voltages up to 6.3 MV with about one spark per day at this voltage, at lower voltages essentially no sparks occur. The relatively high downtime of the injector is caused by the fact that in case of a failure in one of the elements of the very complex terminal at the high voltage end of the machine, one has to open the pressure tank, to close it after repair, and to dry the pressurized gas. The opening and closing and drying cycle needs at least 10 h.

Tab. 2: Unscheduled Downtime

	1979		1980		first half year 1981	
	h	% of oper. time	h	% of oper. time	h	% of oper. time
Injector	414	6.4	368	5.7	193	5.5
Beam Line System	24	0.4	62	1	29	0.8
Cyclotron	83	1.3	385	6	24	0.7
RF-Systems			76	1.2	9	0.3
Computer Control Syst.	11	0.2	20	0.3	8	0.2
Cooling etc.	62	0.9	13	0.2	16	0.5
Other			58	0.8	25	0.7
	594	9.2	982	15.2	304	8.7

Beamline System

When VICKSI came into operation in 1978, only a few target places were available. During the last 2.5 years the main task was to complete the beamline system. Now 17 target positions are available. Due to the increasing number of magnets and vacuum elements the downtime of the beam transport system increased from 0.4% to about 1% of the operating time.

To extend the lifetime of the stripper foil and to get a more homogeneous illumination of the foils by the beam a new stripper with a wobbling mechanism was built and is in operation.

Computer Control System

With about 0.2% downtime of the operating time the VICKSI control system[3,4] is very reliable. Only the analogue acquisition system causes some problems. We hope to solve these by an exchange of the CAMAC multiplexer through scanning ADC's next year. During the last 2 years the main developments of the control system were

a) to connect all new beamline elements to the control computer,
b) to provide special routines alleviating the operation of the machine,
c) to install a new PDP 11/44 in exchange for the PDP 11/40 to enlarge the available core memory.

Cyclotron

Comparing the cyclotron downtimes for the last two and a half years, it is obvious that in 1980 the downtime was essentially higher than during the rest of the period. One reason was, that we had an unscheduled opening of the vacuum chamber which was caused by a large vacuum leak. By accident one pick up of the phase measurement device was hit by a high intensity beam (~10μA) and destroyed. The repair work took about 165 h. An other reason was, that we reached the lifetime limit of a lot of electronic devices which had to be exchanged. An analysis of the downtime (tab. 3) gives an indication where improvements to cyclotron components which will affect the reliability of the whole machine should be implemented.

Tab. 3: Cyclotron Downtime

		h
1979		
1)	Instabilities of magnet power supplies	28
2)	Sparking of rf-anode-power supplies	32
3)	Problems with phase measurement	8
4)	Problems with the setting of the cyclotron	9
	Other	6
		Σ 83
1980		
5)	Destroyed pick up of the phase measurement device	165
6)	Problems with the variac of the main magnet power supply	87
7)	Defect phaseprobe electronic	11
8)	Instabilities of trim coil power supplies	15
9)	Problems with radial probes	9
	Other	98
		Σ 385
1981 (first half year)		
	no specific failures	Σ 24

Therefore the following improvements have been made:

- a modification of the control electronics and better cooling increased the reliability of the power supplies
- in the anode power supplies of the rf-system the high voltage transformers have been exchanged against transformers with better insulation and better cooled rectifier boxes have been installed
- increased cooling of the variac and new variac drive electronic for the main magnet power supply
- more rigid and better protected pick ups of the phase measurement device
- more powerful power boosters for the stepping motors of the radial probes have been built.

Beside this the main task of development was:

1) more sensitive beam diagnostic for low intensity beams
2) quicker and simpler setting of the cyclotron.

Therefore a new capacity phase probe head with preamplifier which can be mounted on the existing radial probe drive, had been built and successfully tested with beam intensities down to 1 enA. A new more sensitive phase measuring electronic is being build and will be tested by the end of this year. To alleviate the setting of the cyclotron a computer program for switching on and tuning of the rf-systems has been installed and is in operation. A standard procedure for tuning the cyclotron has been developed. To ease centering and extraction of the beam, amplitude and phase of a first harmonic field perturbation are now available as machine parameters on the control console. These improvements for setting of the cyclotron have dramatically reduced the beam development time. In the first part of 1981 the time needed for setting a beam was on the average only 13 hours compared the over 20 hours during 1980.

3. Future Plans.- From the beginning of the VICKSI project it was planned, to add a second injector for the cyclotron. The improvements for the existing facility by the addition of a suitable second injector are

- an increase of the maximum particle energy. Due to the energy limit of the present injector the bending limit of the cyclotron of 32 MeV/A cannot be reached.
- an increase of variety of elements which can be accelerated with VICKSI. Presently only ions out of gaseous materials can be accelerated.
- an increase of the available beam time by alternate use of two injectors.

Considering all aspects like available money, time and manpower we came to the conclusion, that the best alternate injector for VICKSI would be an 8 MV tandem. With the tandem we will be able to produce ion beams of 32 MeV/A up to mass 40 with an intensity of 1 pnA on target. The energy per nucleon to mass characteristic of the 8 MV tandem and K = 128 cyclotron combination is shown in fig. 2. Target intensities of 1 pnA or more can be expected. This has been estimated using known ion source currents, bunching efficiency, stripping efficiencies and transmission through tandem, beam line and the VICKSI cyclotron.

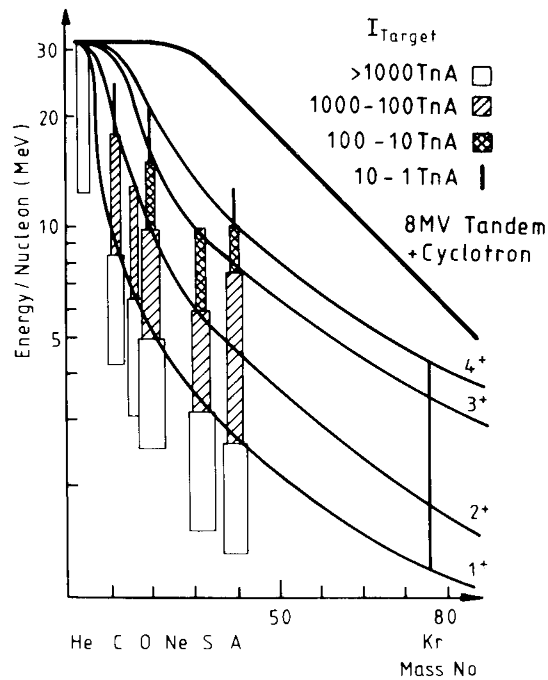

Fig. 2: Energy per nucleon versus mass number for the existing CN-cyclotron and the tandem-cyclotron combination. For some typical ions the intensities at the target for different energies and charge states out of the ion source are indicated.

Due to building limitations a vertical tandem has to be used which will be housed in a 35 m high tower near the cyclotron hall. The coupling of the tandem to the cyclotron will be done via quadrupole telescopes and small bending magnets into the existing beam line (fig. 1). Before the bending magnets the second buncher for tandem injection is positioned. This configuration allows to preserve the features and specifications of the existing injection system for the cyclotron. The tandem injector will be connected to the existing control system.

The final approval for the tandem project has been given in February of this year. First elements for the tandem have already been ordered. The ion source platform will be delivered by the end of the year. The planning for the building is finished. We hope to place the order for the tandem within the next few weeks. The tandem should be in operation by the end of '83 and beams will then be available from VICKSI with the tandem in the first half of 1984.

References

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