OPERATIONS

K1200 OPERATING EXPERIENCE

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K1200 Operation

Table I shows operating time statistics for the K1200 in 1991, and table II shows the various beams which were run on the K1200. There were 73 beams with 120 different beam changes, giving a beam change for every 46 hours of operation, or every 36 hours of research time.

The year 1991 showed a considerable increase in K1200 operation time versus 1990. There were 3553.5 hours of research time in 1991 against 952.5 hours in 1990. The category of operation, or (research + development + overhead), which represents the time that the cyclotron was running, went from 1752.25 hours to 5587.25 hours in 1991. This increase is due in large part to the completion of the phase II beamlines.

TABLE I K1200 Time Distribution 1991

	Hours	Percentage
Operation		
Research	3553.50	48.21
Development	578.50	7.85
Overhead	1455.25	19.75
	5587.25	75.81
Maintenance	493.25	6.69
Breakdown	1289.75	17.50
TOTAL	7370.25	100.00%
OFF	1313.25	

EFFICIENCY = E = (R + D + O) / (TOTAL - MAINTENANCE)

E = 5587.25/6877.0 = .812 = 81.2 %

Tuning time from the cyclotron to the target has been decreasing, due to an effort to use the code TRANSPORT to predict beamline magnet settings. Correspondence between theory and reality was initially poor, so much examination was done of actual distances and dimensions in the beam transport system. Also, there were improvements made in magnet current calibrations. Predicted beam envelops are now close enough to reality to give a good initial setup.

The project to replace the dee stem indium seals with silicone rubber O-rings has gone forward. These are vacuum seals on the fifteen inch diameter, hatbox shaped insulators which provide for penetration of the dee stems into the cyclotron vacuum chamber. The indium seals would begin

TABLE II

K1200 BEAMS Jan.-Dec. 1991

Ion	E/A [MeV/u]	Hours	% Time
4 He 2+	155.0	6.0	0.1
4 He 2+	140.0	11.8	0.3
4 He 1+	60.0	6.0	0.1
4 He 1+	40.0	103.8	2.4
5 (H-He) 1+	34.9	89.0	2.1
5 (H-He) 1+	30.0	5.0	0.1
6 Li 2+	90.0	8.8	0.2
6 (D-He) 1+	22.0	2.0	0.0
7 Li 2+	70.0	40.3	0.9
7 Li 2+	65.0	33.8	0.8
7 Li 2+	50.0	171.5	4.0
11 B 2+	25.0	61.0	1.4
12 C 6+	155.0	20.5	0.5
12 C 6+	145.0	11.5	0.3
12 C 6+	140.0	15.8	0.4
12 C 5+	125.0	76.5	1.8
12 C 4+	95.0	3.0	0.1
12 C 4+	75.0	25.0	0.6
12 C 3+	40.0	106.8	2.5
12 C 2+	22.0	2.8	0.1
12 C 2+	20.0	10.0	0.2
14 N 4+	70.0	30.0	0.7
14 N 4+	50.0	4.0	0.1
15 N 6+	100.0	1.5	0.0
15 N 5+	90.0	9.8	0.2
16 O 8+	155.0	22.5	0.5
16 O 6+	75.0	31.0	0.7
16 O 4+	60.0	30.8	0.7
16 O 4+	40.0	198.3	4.7
17 O 3+	28.4	25.0	0.6
17 O 3+	25.0	175.5	4.1
17 O 3+	20.0	36.5	0.9
18 O 6+	80.0	836.8	19.7
20 Ne 10+	140.0	25.0	0.6
20 Ne 9+	125.0	15.8	0.4
20 Ne 9+	115.0	30.5	0.7
20 Ne 8+	100.0	26.3	0.6

Ion	E/A [MeV/u]	Hours	% Time
20 Ne 7+	100.0	4.0	0.1
20 Ne 7+	80.0	38.8	0.9
20 Ne 6+	75.0	18.3	0.4
20 Ne 5+	60.0	14.8	0.3
20 Ne 5+	50.0	16.0	0.4
22 Ne 7+	75.0	83.3	2.0
22 Ne 6+	70.0	3.3	0.1
28 Si 8+	50.0	8.0	0.2
36 Ar 13+	80.0	43.5	1.0
36 Ar 12+	80.0	208.3	4.9
36 Ar 8+	45.0	18.8	0.4
36 Ar 6+	22.0	2.0	0.0
40 Ar 13+	80.0	48.8	1.1
40 Ar 12+	80.0	22.8	0.5
40 Ar 12+	65.0	245.0	5.8
40 Ar 7+	25.0	19.3	0.5
51 V 13+	50.0	98.8	2.3
58 Ni 13+	50.0	2.0	0.0
78 Kr 22+	75.0	178.0	4.2
84 Kr 19+	50.0	81.3	1.9
84 Kr 14+	22.0	60.3	1.4
86 Kr 23+	75.0	18.5	0.4
86 Kr 22+	70.0	41.0	1.0
86 Kr 19+	45.0	36.3	0.9
92 Mo 25+	70.0	63.3	1.5
129 Xe 31+	65.0	2.0	0.0
129 Xe 30+	60.0	5.8	0.1
129 Xe 28+	50.0	74.3	1.8
129 Xe 29+	50.0	24.0	0.6
129 Xe 30+	50.0	219.5	5.2
129 Xe 26+	40.0	37.8	0.9
129 Xe 21+	26.0	28.5	0.7
129 Xe 21+	25.0	10.0	0.2
136 Xe 24+	28.4	144.0	3.4
238 U 39+	25.0	6.0	0.1
238 U 35+	20.0	5.5	0.1
		4240.5	100.0

leaking after several months of use, causing a significant maintenance problem. All dee stems except one now have O-rings, a total of ten O-rings in five dee stems. The other stem has so called Delta seals, a type of metallic artificial O-ring. The O-rings seem to be a success, in that they have not failed in the approximately one year that they have been in the cyclotron. The pair of Delta seals has likewise been trouble free.

The anode power supply for the K1200 is made up of a 1200 KW power transformer and rectifier, with separate crowbar units, controls and a distribution system. The 1200 KW subsection has experienced failures in the transformer, choke and rectifiers, so the cyclotron ran mainly with K500 subsection in 1991; about 95% of the time. The 1200 KW transformer, choke and rectifier of this subsection have been redesigned, and new units ordered. This should be both more rugged and more accesible than the old, as it will not be immersed in oil.

A Phase slit system was installed this year to allow narrowing the beam time structure. The system consists of two pins, each eccentrically mounted on the end of a rotatable rod, at a distance of seven inches from the cyclotron center. Rotating a rod moves the pin in a circle, so it moves in and out in radius. The two pins are in different valleys in the cyclotron, but they may be used in concert to narrow both edges of the beam.

Deflectors are less troublesome than in the past. At present, the E1 deflector will run at about 60 KV, while E2, being shorter and less complex, may reach 80 KV, with shoe to septum gaps of 6 mm. A glass coating has been tried on the shoes with some success, and this has led to trying anodized aluminum shoes. The E2 deflector has been running for some months with an anodized aluminum shoe, and a project is in motion at this writing to replace the more complicated E1 shoe with the same type.

K500 Operation

The K500 cyclotron was run a total of 241.25 hours in 1991, in only the first and third quarters of the year. It is kept full of liquid helium and under vacuum, but left off most of the time. Table III shows the beams run in 1991 by the K500.

TABLE III K500 Beams 1991

MeV/u	Ion	Month
30	12 C 4+	Jan.
13	4 He 1+	Feb.
30	7 Li 2+	Feb.
16.7	4 He 1+	Aug.

CURRENT STATUS OF THE K1200 RF SYSTEM

F. Pigeaud, J. Brandon, and J. Vincent

The K1200 RF System operated for approximately 5500 hours during the 1991 calendar year as shown in Figure 1. The system has undergone few changes since the completion of the new transmitters in 1990, though several small-scale improvements were made to various transmitter elements. The largest ongoing project involves the redesign and upgrade of the final anode power supply which began in early 1991. Improvements to the vacuum seals on the dee stem insulators also continued into 1991.

RF Amplifiers and Electronics

The new transmitters came on line during the summer of 1990, so most testing and adjustments to the system were completed by mid-1991. The only significant component problems we experienced were associated with the anode filter choke. As mentioned in the previous annual report, the anode choke possessed high-Q self-resonant modes in our band of operation, so the transmitter housing and filter choke were redesigned to alleviate this difficulty. Since the completion of this upgrade there have been no recurrences of choke failures.

The other alteration to the transmitters involved the driver anode tuning stem which overheated during high-frequency, high-power operation. This component has been water-cooled in anticipation of even higher power demands in the coming year.

New control electronics were added to the K1200 to allow experimenters to shut the beam off in a matter of milliseconds with a TTL pulse which de-phases one of the RF signals. This is used to prevent a mis-tuned beam from damaging sensitive detectors.

Final Anode Power Supply

The NSCL Phoenix Power Supply Control Cabinet and High-Voltage Distribution Cabinet were brought on line in May of 1991, and have greatly improved the reliability of the system. The final stage of the Phoenix upgrade is now underway and should be completed by the end of the summer of 1992. The remaining elements of the power supply system are the indoor Power Converter Cabinet and the spare 1358 kVA transformer. These components are discussed in more detail under the title "Phoenix Power Supply Upgrade."

Dee Stem Insulators

Changes to the dee stem vacuum seals had been initiated in 1990 because the previously employed indium seals tended to wear out and become unreliable over the period of a year. Alternative vacuum seals are now installed in all the insulators. At present, five of the six dee stem insulators have silicone rubber seals which appear to be working very well. The other stem has a metal seal which has been installed for comparison purposes, and is also working satisfactorily.

Conclusion

Several small upgrades to control electronics are expected in the coming year, primarily to improve the ease of operation. Due to regularly scheduled maintenance periods, the K1200 RF system has been operating very reliably, with no significant breakdowns occurring after the transmitter changes listed above were implemented. This reliability should be further enhanced by the completion of the Phoenix Power Supply, and the addition of the spare transformer.

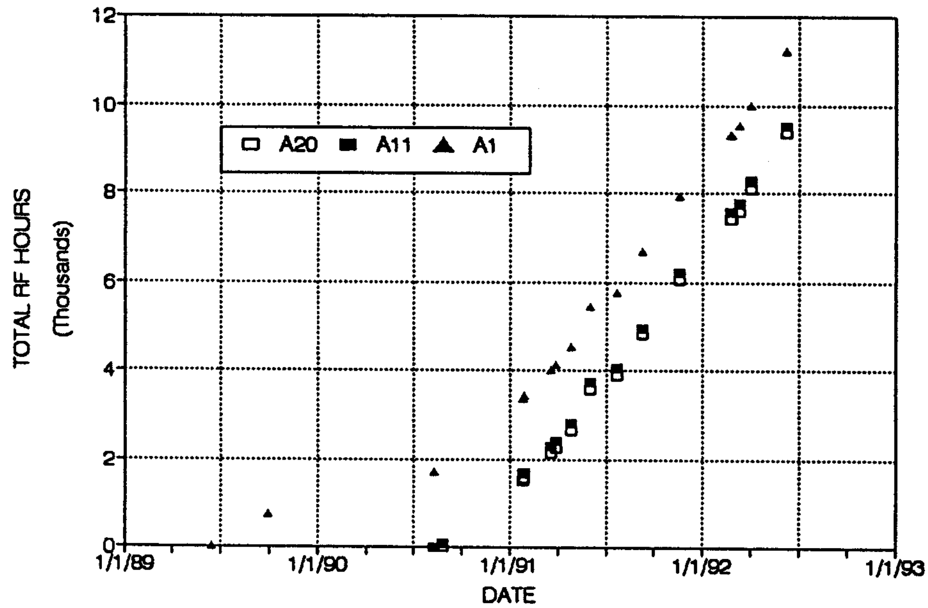

Figure 1: Total K1200 RF hours for each TH555 tetrode. The tubes are plotted by serial number, where A1 is the unit used during development. A11 and A20 are the numbers of the two other tubes used. The three tubes have been interchanged between transmitters, so the graph reflects RF hours of tetrode, not transmitter, operation.

CURRENT STATUS OF THE NSCL CONTROL SYSTEM

J. Priller and L. Foth

Structure and Configuration

Hardware

The current control system at NSCL is based on VAX GPX/II color graphics workstations, clustered around a MicroVAX II that acts as a disk server. Actual data collection and device control is handled by some 20 distributed VME stations, which respond to requests for device readings and settings by the VAX workstations and also allow device control via their local knobs and keyboards. Data transmission between the VAX workstations and the VME stations is provided through Arcnet.

Most of the VAX workstations at NSCL have attached VME-to-QBUS knob/toggle and meter panels, which allow operators to control and monitor many devices simultaneously. Several workstations lack the attached control panels and have keyboard device control and on-screen monitoring only.

Software

The VAX workstations for the NSCL control system run under the VMS 5.3 operating system, with DEC UIS as the graphics subsystem. Arcnet is provided to the workstations through device drivers (provided with the QBUS arcnet boards), with additional software written at NSCL to provide a high-level applications interface and multiple-process arcnet access. The NSCL arcnet software is written primarily in Pascal, with a few small 'C' routines to perform tasks that are difficult (or impossible) to code in standard Pascal. Applications interfaces are provided for Pascal and FORTRAN programs.

Additional software exists to allow the VAX workstations to communicate with the VME knob/toggle and meter boards. This consists of device drivers written in VAX Macro (assembly language) and higher-level access functions written in Pascal.

Strengths

The multitasking provided by the VMS operating system is the primary advantage of the current workstation-based system. It allows operators to execute multiple control and monitoring programs simultaneously, and to have detached programs run invisibly in the background. One such background program at NSCL intercepts VME, Modicon and radiation safety alarms and sends these messages to a dedicated printer in the control room.

Another advantage of the workstations comes from having them in a cluster arrangement with a single disk server. This enables them to use the same data and program files and ensures that any software or configuration changes made are available to all workstations immediately. It also allows the workstations to be used fairly interchangeably, should one be down for repairs or be being used for other purposes.

Weaknesses

The one serious weakness of the current system is the relatively low level of computing "horsepower" in the VAX GPX workstations. Most of the workstations have older CPU boards, and find it difficult to run the graphics-intensive control programs with the responsiveness necessary for real-time control. While it is possible to upgrade the CPU boards to faster models, this is not inexpensive and has been put off over the last several years.

Recent Upgrades

The pSOS upgrade to the VME stations was finished this past year. This upgrade enhanced the features of the VME stations and also included "cleaning up" the databases and system software.

Also added was software to bring the older K500 cyclotron fully into the NSCL control system. It had been using CAMAC as its primary means of data transmission, with a VAX PDP/11 running specialized assembly-language control software. A CAMAC board was added to the VME system, and VME software written to make the older CAMAC devices appear as regular VME devices to the VAX workstations. Some specialized VAX software was written to control the K500's deflectors and its main probe, both of which have rather complicated geometries.

Future Plans

In an effort to expand access to control system data, a new type of control console is under development at NSCL. This console will be based on Intel X86-architecture personal computers, using the Microsoft Windows graphical environment. Support for the multitasking IBM OS/2 2.x and forthcoming Microsoft NT environments may be added when development tools for them become more available. See "A Control Station Based on Microsoft Windows" by J. Vincent, also in this volume, for further details on this project.

CURRENT STATUS OF NSCL PHASE II BEAMLINE ELECTRONICS

A. McGilvra

The electronics for the Phase II beamline that connects the K1200 cyclotron to all the experimental vaults have been running for well over a year now (see NSCL Phase II Beamline Electronics from the 1988, 89, 90 Annual Reports for a complete description and previous status reports). Phase II electronics basically consists of controls, power supplies, and instrumentation.

The electronics are grouped into two major installations: one controls the Analysis Hall (A1200), which is a single S-shaped beamline at the exit of the K1200 cyclotron; the other controls the Transfer Hall, which is a multiple beamline switchyard that connects the K1200 (via the A1200) and the K500 cyclotrons to five experimental vaults.

The electronics that control the Analysis Hall beamline are housed in a set of control racks in a room above the Analysis Hall called the A1200 Balcony. The electronics that control the Transfer Hall are housed in a set of control racks in the South Wall Alcove just outside the Transfer Hall. The 10-volt, 100-amp power supplies and the instrumentation units described are not in the control racks; instead, they reside in the halls close to the devices they are controlling or monitoring. Description and status of the controls, power supplies, and instrumentation are given below.

Controls

VME Crates

Description: Used for controlling power supplies and instrumentation via analog I/O and serial communications for set points and readings.

Status: Installed and operational.

Changes since last year: Installed 16-bit A/D and D/A boards in the A1200 Balcony VME crate to control the A1200 20V/20A power supplies (see below). These power supplies were previously controlled by 12-bit boards. The change to 16 bits was needed for higher resolution readability and setability which was necessary for some experiments. The Transfer Hall 20V/20A power supplies' readings and settings are sufficient at 12 bits for the time being.

Gould-Modicon PLC (Programmable Logic Controller) Modules

Description: Used for interlock logic control: turning devices on and off, telling status of water flow switches, etc.

Status: Installed and operational.

Changes since last year: Added auto-fill logic to automate the cryogenic liquid filling cycles of the superconducting magnets. Modbus+ communication network was installed, greatly enhancing responsiveness of PLC user-interface devices.

Power Supplies

20 Volt, 20 Amp DC Power Supplies

Description: Four-quadrant (+V/+I, +V/-I, -V/+I, -V/-I) supplies used to power the quadrupole focusing magnets. Controlled via VME analog I/O points and the Modicon PLC. Quantity required is 49.

Status: Installed and operational.

Changes since last year: New circuit added for improved temperature and time drift of the current feedback. This project is in progress now; the new circuit will be added to all A1200 20V/20A power supplies first because the A1200 beamline is where the long-term drift performance of the power supplies is most critical. Eventually the Transfer Hall power supplies may receive the same upgrade. Also, a safety shorting device has been developed and is in testing to prevent personnel from getting shocked by incorrectly disconnecting a superconducting magnet from its power supply. The device will be put on all 20V/20A and 10V/100A power supplies.

10-Volt, 100-Amp DC Power Supplies

Description: Four-quadrant supplies used to power the dipole steering magnets. Controlled via VME serial communications and the Modicon PLC. Quantity required is nine.

Status: Installed and operational.

No changes.

Instruments

Beam Current Meters

Description: Used to read beam currents from 10 pA to 300 uA at several points on the beamline via VME serial communications.

Status: Installed and operational.

Changes since last year: Five more constructed and in testing; will be used to augment existing beam diagnostic system.

Bang-Bang Servos

Description: Used to control motor drives for moving beam diagnostic apparatus and experimental apparatus. Controlled via VME serial communications.

Status: Installed and operational.

Changes since last year: The addition of several beamline devices requiring motor control has created a shortage of bang-bang servos. Five more are near completion. In the meantime we have been swapping with existing installations.

Cryogenic Monitor Unit

Description: Used to monitor health signals of the magnet cryostats: helium pressure, helium level, and magnet lead voltage drop. Output signals are read by VME analog inputs, Modicon PLC, the LED Panel described below, and the Cryogenic Dual Meter Selector Panel described below.

Status: Installed and operational.

Changes since last year: Several more were taken from stock and used on new magnets.

Dual Channel Thermocouple Vacuum Gauge Controller

Description: Used to read vacuum from two thermocouple vacuum sensors. Output signals are read by the Dual Meter Selector Panel described below. Quantity required is 19.

Status: Installed and operational.

No changes.

Local Monitoring Devices in the Control Racks

LED Panel

Description: Used to monitor the cryostat status signals that come from the Cryogenic Monitor Unit. Two are required.

Status: Installed and operational.

No changes.

Cryogenic Dual Meter Selector Panel

Description: Used to read the cryostat helium level and helium pressure signals that come from the Cryogenic Monitor Unit described above. Two are required.

Status: Installed and operational.

No changes.

Vacuum Dual Meter Selector Panel

Description: Used to read the vacuum signals that come from the Dual Channel Thermocouple Vacuum Gauge Controller described above. Eight are required.

Status: Installed and operational.

No changes.