

## NATIONAL ELECTROSTATICS CORPORATION

Operations Manual (2LT022260) for the  
**NEC RC43 Analytical Software** (2RS025574)  
Version 4.6  
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## **ELECTRICAL AND PRESSURE EQUIPMENT** **SAFETY INSTRUCTIONS**



**IMPORTANT SAFETY INFORMATION  
READ BEFORE OPERATION AND SERVICE**



**SHOCK HAZARD WARNING  
THIS UNIT USES AC MAINS POWER  
THIS UNIT CONTAINS DANGEROUS VOLTAGES AND ENERGY**

**This unit must only be operated and serviced by qualified personnel who have read the instruction manual and are familiar with the hazards associated with dangerous voltages. Proper care and judgment must always be observed.**

### **ELECTRICAL WARNINGS FOR OPERATION:**

- 1. Before connecting input AC power, ensure that all covers are in place and securely fastened. Ensure that the required safety ground to the chassis is installed and sufficient cooling is supplied.**
- 2. Proper grounding from the input AC power is required to reduce the risk of electric shock and to comply with safety agency and code requirements.**
- 3. Use caution when connecting input AC power. Only apply the input voltage specified on the rating label.**
- 4. Use caution when connecting any high voltage cables. Never handle any output cables when the unit is operating.**
- 5. After the unit is switched off, dangerous voltages may remain on the outputs. Allow sufficient time for self-discharge before handling anything connected to an output. The user's load must be taken into consideration when determining the time required.**
- 6. When user serviceable fuses are present, always replace fuses with the same type and volt/amp rating.**
- 7. Never attempt to operate the unit in any manner not described in the instruction manual.**
- 8. Never remove warning labels from the unit. Replace lost or damaged labels immediately. Contact NEC for replacement labels.**

### **PRESSURE WARNINGS FOR OPERATION:**

- 1. Before connecting lines to be pressurized, ensure that all gas/liquid connectors, tubes and components are in place and securely fastened.**
- 2. Use caution when connecting pressurized input/output lines. Only apply pressurized lines for the gas/liquid at the rating specified for this unit.**
- 3. Ensure the correct gas/liquid is connected to the correct point on the unit.**
- 4. When operating unit under pressure, ensure all connectors, lines and components are leak tight.**
- 5. Never attempt to operate the unit in any manner not described in the instruction manual.**

### **SERVICE:**

**The following safety labels apply to this unit:**



**CAUTION - Risk of electrical shock**



**Protective Ground Conductor**

- 1. When pressurized inputs are turned off and/or the unit is shut off, dangerous pressures may remain in the equipment. Follow a proper pressure relief procedure before unfastening any pressurized component.**
- 2. Service is best done by NEC trained technical personnel, either at the site during installation or by returning the unit to the NEC factory. Call NEC at 608-831-7600 for a Return Materials Authorization (RMA) number and ship unit to 7540 Graber Road, Middleton, WI 53562.**
- 3. If service of this unit is to be done at the user's site, this service may only be performed by trained and qualified personnel and must follow instructions from this manual or from NEC technical personnel.**
- 4. Consult NEC supplied assembly drawings, parts lists, circuit board drawings and schematic diagrams for service details.**

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## I. INTRODUCTION

This manual covers the installation and operation guidelines of the NEC RC43 analytical endstation. The complete endstation includes one bay of electronics, including a personal computer, located in the control console, and the analysis chamber, vacuum system, etc., located at the endstation itself. It does not cover the ion sources, accelerator, or any beam focusing components.

The RC43 analytical endstation is capable of Rutherford Backscattering Spectroscopy (RBS) with channeling. Options also include Nuclear Reaction Analysis (NRA), Forward Recoil Spectroscopy (FRS), and Particle Induced X-Ray Emission (PIXE) with an EDS or WDS detector, and HRBS High Resolution RBS. The ability to add other materials analysis techniques also exists. To optimize these techniques the experimenter can use any ion species at any available energy for an analysis beam. Multiple samples can be inserted into the chamber via a load lock and oriented with respect to the beam with a five axis manipulator. The entire chamber is electrically isolated. This makes possible absolute beam current measurements.

The complete endstation is shown in the "Endstation, RBS Assembly" drawing. Installation is straightforward only involving mounting items, connecting cables, and alignment of the collimator with ion beam axis. Operation of the vacuum system and sample load lock are automated via a user friendly vacuum interlock controller. The detection system has high energy resolution beginning with a detector with  $E$  of  $\sim 11$  keV. The data, once collected using RC43.EXE, can be easily stored and or analyzed with the personal computer and analysis software (RUMP, GUPIX). The source code for RC43.EXE is in Visual Basic. The source code can also be customized for special experiments upon request.

## A. POWER and FACILITIES REQUIREMENTS

### Electrical Power

Console	7 Amps, 115 VAC, Single Phase
Endstation	20 Amps, 115 VAC, Single Phase
	6 Amps, 220 VAC, Single Phase

Water (Turbo Pump) 8.0 l/hour (~2 gal/hour)

Compressed Air 80 psi

Dry Nitrogen 5 cfm @ 5 psi  
(Venting Vacuum System)

Rough Pump Exhaust 1" base, oil resistant

## B. LIST of OEM MANUALS

Computer	PC Operating System (Windows XP)
Current Integrator	Windows
Vacuum Monitor	Printer
Detector Amplifier	Camera and Monitor
Nim Bin	Valves
Multichannel Analyzer - ADC	Manipulator Local Controller
Manipulator Controller	Manipulator Indexer Units
Turbo Pump Controller	Ion Gauge Controller
Vacuum Interlock Controller	RC43 Data Collection Software
Detector and Preamplifier S.S.B.	GUPIX PIXE Analysis Software
Detector and Preamplifier Nal.	
Detector and Preamplifier SiLi	
Specimen Temperature Controller	
Faraday Cup	
Beam Profile Monitor	
Turbo Pump	
Rough Pump	
Manipulator	
RUMP RBS Analysis Software	
MCA Software	

### C. LIST of DRAWINGS

14-0-2226	Endstation, RBS Assembly
14-0-2077	Sample Holder Assembly
8-0-5562	Manipulator Controller Assembly
8-0-6443	Local Manipulator Controller Assembly
14-0-2109	Manipulator, 5 Axis CBM Assembly



#### D. LIST of TOOLS REQUIRED

Adjustable precision telescope or theodolite for alignment

General purpose hand tools:

Box-end/Open-end wrenches to 1"; English (2 each) Metric (1 each)

Screwdrivers

Allen wrenches; English and Metric

Wire strippers, crimpers, D-pin tool

Hammers

Flashlight

Ethanol

Acetone

Lint-free rags e.g., kimwipes

Multimeter

D-Pins; Male and Female

Hand drill with bits

Files

Small taps

Gloves

Sample Sticky Pads

Sample Tweezers

#### E. LIST of CABLES

See Cable Schematic (2XA055190).

## F. DEFAULT FILES LOADED

### RBS.CFG

```
"@ U of C Berkeley","Lab"
5000,"XA"
5000,"YA"
10000,"ZA"
2000,"THETA"
3000,"PHI"
0,"PSTAGE"
100,"PHI Steps/Deg"
1,"Manip Port#"
"none","Client"
6100,"Client Port#"
"c:\program files\internet explorer\iexplore.exe c:\rbs\v46\rc43v46.htm","Manual"
2,"Number of Cards"
"ims","Sample Stage Type"
"123","Current Integrator Type"
"1150","Counter Card Base Address"
2048,2048,2048,2048,"MCA Gain Settings"
"AccelNET", "Parameter Control AccelNET or RBS400"
60,4350,9555,2715,"Main"
2820,4350,9525,6400,"Angle"
0,1005,8925,8985,"Open"
2835,4380,9525,8250,"Image"
5805,45,4200,5670,"Manip"
0,4380,4320,5865,"RC43toAccelNET"
2130,5610,9885,2940,"Position"
2400,2760,11150,4350,"Rate"
3705,4320,10500,9000,"RBS"
2310,15,4245,2640,"ROI"
0,750,3420,3390,"PTable"
2100,1995,5880,5850,"CounterI/O"
"c:","Drive"
"C:\rbs\data","Path"
0,0,1845,510,"Element"
"RBS rbs normal angle"
0,"Slope 0"
0,"Y Int"
"RBG rbs grazing angle"
0,"Slope 1"
0,"Y Int"
"PIX pixe x-rays"
0,"Slope 2"
0,"Y Int"
"NRA nuclear reaction"
0,"Slope 3"
0,"Y Int"
1000,"BIC Timing Delay"
1,2,4,"BIC I/O Defaults"
"10","150","Beam to Detector Angles"
"5.0","0.863","Detector Solid Angles"
"General","General","Scattering Geometries"
"101","300"," 1","200","400"," 2","300","499"," 3","400","599"," 4","597","805"," 1","ROI
Channels"
```

400,"Counts/Bar for Ratemeter"  
 0,"Moveable Detector Position"  
 "RBS rbs normal angle","Spectra Description"  
 "RBG rbs grazing angle","Spectra Description"  
 "PIX pixe x-rays","Spectra Description"  
 "NRA nuclear reaction","Spectra Description"  
 .1,"Moveable Detector Degrees/Step"

## REGISTER.CFG

Thomas J. Pollock ext 247	Person and phone extension for software registration
c:\rbs\rc43.bmp	Background picture displayed in registration window
2700	Blue dot vertical position

## CS.CFG

none  
 RBS FC, PosSC, Beamline FCup Position  
 RBS FC, CR, Beamline FCup Current  
 TPS TK-1, GvmVR, Terminal MV Read  
 TPS TK-1, TrvVC, Terminal MV Set  
 SETUP, TotPartE, Beam Energy  
 SETUP, ChgState, Beam Charge State  
 SETUP, Ospecies, Beam Mass  
 DET ES-1, CR, End Station Cup Current  
 LMP ES-1, PwrSC, End Station Lamp Control  
 DET ES-1, ZoomDC Zoom Camera Control

These are control codes sent to the accelerator control computer to do the indicated tasks.

## G. STEPPER MOTOR INITIALIZATION

Plug RS232 into motor to download to.

All other motors must have rs232 unplugged.

Power up stepper controller.

On computer start IMS software.

Check it is communicating.

Open \*.lxt file into edit window.

Check for communications in Terminal Window by typing in **"pr a"** followed by a return and look for answer.

Download edit window commands.

On context popup window click radio button for "edit window" then click download

Type **"py=1"** return

Type **"CNTR J"**

Type **"\*s CNTRL J"**

Where \* represents the motor name defined in the download file.

Power down and up stepper controller and IMS software.

Try to communicate with motor using name and check downloaded parameters.

Below are the \*.lxt file used for initialization for each motor:

<b>Xaxis.lxt</b>	<b>Yaxis.lxt</b>	<b>Zaxis.lxt</b>	<b>Taxis.lxt</b>	<b>Paxis.lxt</b>
a=1000	a=1000	a=1000	a=1000	a=100
d=1000	d=1000	d=1000	d=1000	d=100
ms=5	ms=5	ms=5	ms=2	ms=2
Vi=100	Vi=100	Vi=100	Vi=100	Vi=50
Vm=1000	Vm=1000	Vm=2000	Vm=800	Vm=500
hc=20	hc=20	hc=20	hc=20	hc=10
rc=50	rc=50	rc=50	rc=50	rc=60
s1=2,0	s1=2,0	s1=2,0	s1=2,0	s1=2,0,0
s2=3,0	s2=3,0	s2=3,0	s2=3,0	s2=3,0,0
s3=7,0	s3=7,0	s3=7,0	s3=7,0	s3=7,0,0
s4=8,0	s4=8,0	s4=8,0	s4=8,0	s4=8,0,0
je=1	je=1	je=1	je=1	s9=16,0,0
Dn="X"	Dn="Y"	Dn="Z"	Dn="T"	s10=16,1,1
				cw=100
				s7=49,0
				s8=49,0
				de=1
				cm=0
				je=1
				Dn="P"
				pg 1
				lb su
				h 10
				o9=1
				e
				pg

## II. INSTALLATION

### A. UNPACKING

The NEC RC43 analytical endstation is shipped with the control console and endstation partially assembled. Items packed individually for protection include: computer, computer monitor, vacuum monitor, vacuum interlock controller, turbo pump controller, vacuum gauge, printer, manipulator, turbo pump, detectors, detector electronics, load lock assembly, rough pump and rough lines, camera & monitor, bellows, ion gauge, gate valves, and cables. The control console is a single bay. Typically it is with the Pelletron control console.

The endstation typically is shipped with the chamber mounted to a frame. A beamline insulator, gate valve, Faraday cup, and beam profile monitor (if ordered) are connected as one piece. Bolted to the chamber are insulating weldments for the turbo pump and manipulator. Unpack all items and inspect everything thoroughly. If any part appears damaged (gasket surfaces) notify NEC immediately. Failure to do so could seriously delay installation. Also included will be a box of manuals and documentation, which should be reviewed before operating any piece of equipment. The assembly drawings; "RBS 17" chamber", and "Endstation, RBS" will be very helpful during assembly.

### B. MOUNTING

Begin mounting by positioning the control console and endstation in their designated places. Mount the computer, current integrator, printer, etc. in the console. Coarsely align the chamber with the high energy beamline. Bolt the turbo pump and gate valve to the chamber, then bolt the manipulator to the chamber. For correct orientation see "Endstation, RBS Assembly" drawing.

Exercise care when handling the ceramic insulators. Mount the load lock on the chamber lid. Refer to "RBS 17" Chamber Assembly" drawing. Insert sample transfer rod in endstation load lock. Mount the sample change switch to the nylon plate on the lock flange. Rack mount endstation electronics as shown in assembly drawing. Complete endstation beamline by bolting on bellows. Align endstation and high energy beamline from machine by eyesight and bolt together with bellows. Insert rough pump below turbo pump and assemble roughing lines. Bolt on the ion gauge and thermocouples (3). The vacuum system should now be sealed from atmosphere. Connect all electrical cables as they are marked, connect the air lines, water lines and N<sub>2</sub> line with the facilities sources. Keep detector cables away from other cables. Leave cables and lines to load lock long to facilitate easy chamber lid removal via the lid lift mechanism.

## C. ALIGNMENT

The endstation is now operational. Complete the installation by accurately aligning the chamber, chamber collimator or microprobe, and beamline with an alignment scope ( $\pm 1$  mm). If the alignment is not going to be done for two or more days then read the section on vacuum operation and start the vacuum system.

For alignment remove the port at the end of the chamber. Remove the beam collimator inside the chamber. The ion beam should follow the horizontal center line of the chamber. Screw in four bolts in the rear port. Properly twine string around each bolt to form a cross hair. Keeping the chamber level, align this cross hair with the center of the prealigned beamline. The horizontal and vertical adjustments for the chamber are located at the upper corners of the chamber stand. Reinstall the collimator checking that both of the apertures are aligned with the scope and thus on beam center. If the collimator is not aligned then align it by moving it around in its mount. If it can not be aligned this way then also move the chamber. It is the beam collimator or microprobe which is most important to have aligned with the beam!

Finally, check the electrical isolation of the chamber with the current integrator cable disconnected. The whole chamber is used as a non suppressed Faraday cup and is thus electrically isolated. During operation however, it is very important to keep the chamber either connected to the current integrator or ground.

### **Warning:**

**If the chamber is left to float electrically, potentially fatal voltages could develop. There is a small possibility the chamber can be electrically connected, by a plasma, to the ion gauge thus resulting in voltage being applied to the chamber. Failure to keep the chamber electrically connected to ground or the current integrator could result in INJURY to the operator.**

### **Warning:**

Also, the collimator or microprobe, and sample holder are insulated from the chamber. The collimator current should be measured or ran to ground by bringing the current out via a multi-pin feedthru. The sample holder is used to collect primary beam current. The sample holder current is brought out of the chamber via a multi-pin feedthru. The chamber current and sample current can then be connected together using a BNC tee. With this configuration absolute current measurements can be made with the current integrator.

The feedthrus used to bring out of the vacuum collimator current, sample holder current, SSB detector signal, and chamber light power are mounted on a flange. This flange bolts onto the chamber by the 0° port. It typically has two floating double ended BNC feedthrus and two 4 pin feedthrus.

### III. OPERATION

The operation of the NEC analytical endstation can be divided into these four subsystems; vacuum, detection, computer, and manipulator subsystem. Operation of each subsystem should only be done by qualified personnel.

#### A. VACUUM SYSTEM

The vacuum system is composed of; three gate valves, two 1" KF rough valves, vent valve, Turbo pump, rough pump, turbo pump controller, three thermocouples, ion gauge, convectron gauge monitor, ion and thermocouple gauge monitor, vacuum interlock controller, and all evacuated space. The vacuum interlock controller controls the position of all valves. It uses as input information from the two vacuum monitors, the turbo pump controller, and the vacuum status of the high energy beamline. The interlock controller assumes the vacuum volume of the high energy beamline gauge to be the same as the volume on the other side of the chambers beamline valve. If there is a valve between this gauge and the chambers beamline valve, extreme caution should be taken in using the interlock controller when this middle valve is closed. The controller could be told there is good vacuum on the other side of the chamber beamline valve when it is really bad vacuum due to the upstream valve being closed.

**Caution:**

**Operation of the RBS vacuum controller with a closed valve between the endstation beamline valve and the high energy beamline vacuum gauge is not recommended. Operation of the controller with this valve closed could result in damage to the vacuum system.**

**Caution:**

On the front panel of the interlock controller there are switches which have an auto and closed position for each valve. On the valve itself there is also a remote control and open switch. Using this switch on the valve the interlock controller can be overridden and the valves manually opened and closed. In case of vacuum failure or power failure the controller will protect the chamber and pumps by closing valves. The controller will also prevent oil backstreaming from the rough pump into the chamber when the turbo pump is off by closing the rough valve between the turbo and rough pump. The turbo pump is automatically vented during power failure after a delay using it's own vent valve.

On the front panel of the vacuum interlock controller all valve positions are displayed along with the vacuum status from the gages, i.e. bad, good rough vacuum ( $\sim 50$  torr) or good high vacuum ( $\sim 10^{-6}$  torr) using red and green LED's. The gauges monitor three vacuum spaces; chamber, high pressure side of turbo, and the load lock chamber. The turbo pump condition (i.e. up to speed) is also monitored. Drawings show the front and rear panel layout of the controller. Also the logic is shown in schematic 8-0-5501. For more information on the controller see "RBS Vacuum Controller" manual.

## 1. Vacuum System Startup Operation

Before starting the turbo or rough pump check that the volume to be evacuated is completely sealed off. Air pressure lines to the valves should be charged and cooling water running through the turbo pump. Also the rough pump and or turbo pump oil level should be checked. Check all electrical connections on the vacuum interlock controller, and on the two vacuum monitors. On the interlock controller, switch all valves to CLOSE position and make sure the valves themselves are in REMOTE control. Also check that the Sample Change switch located on the load lock flange is in the OFF position. Read thru the RBS Vacuum Controller manual before using it.

Turn on the two vacuum monitors and the vacuum interlock controller. Look at the front panel of the interlock controller and understand what it is telling you. All valves should be closed (red light). Vacuum conditions will be bad (red light). Enable the valves. The rough pump switch on the right of the interlock controller should be turned to TURBO. Start the rough pump and look for bad seals in the rough lines up to the two right angle valves. Switch RV1 to AUTO mode and switch TURBO NLK to BYPASS. RV1 should open and the rough pump will start roughing the turbo. Turn on the turbo. The setpoint for TC1 should be checked and or set at ~1 torr. Refer to manuals for help. When the setpoint for the turbo pump is reached VAC/TC1 LED will turn green.

The chamber can be roughed while the turbo is coming up to speed. Switch RV2 and LV to AUTO and ROUGH PUMP to LOCK/CHAMBER. RV1 should close and RV2 and LV open. You will here the rough pump as it evacuates the chamber. Set and/or check TC2 VAC status at ~110 mtorr and TC3 VAC status at ~100 mtorr. When TC2 setpoint is reached LV valve will close and when TC3 setpoint is reached RV2 will close. The LED lights on the front panel will show this.

The turbo should be up to speed; TURBO light on. Switch ROUGH PUMP to TURBO. If the vacuum condition of the chamber is still good switch PV to AUTO. The pump valve will open and the turbo will now start pumping on the chamber. The system should now be heading for high vacuum,  $\sim 10^{-6}$  torr. Once high vacuum is reached in the chamber and in the beamline, the beamline valve can be switched to AUTO and will open.

To operate the vent valve switch VV to AUTO. Switch ROUGH PUMP to TURBO. Vent only the lock by pushing the right VENT switch to LOCK. Hold the VENT switch until the light comes on. Check or set the ATM setpoint at atmospheric pressure.

### **Caution:**

**For different gases the atmospheric setpoint differs. Do not pressurize the vacuum system. Pressurization could result in damage to the system.**

### **Caution:**

To vent the chamber, switch the left VENT button to LOCK/CHAMBER and hold until light comes on. It is best to turn off the ion gauge previous to venting the chamber. When the ion gauge goes off the Beamline Valve will close. To reestablish vacuum after venting, switch ROUGH PUMP to LOCK/CHAMBER and when roughing is done back to TURBO.



## 2. Sample Change Operation

To insert a sample via the load lock first vent the lock. Remove the 2" quick flange with quick disconnect. Attach the sample holder to the sample transfer rod and replace the KF fitting to the load lock. Tighten the clamp. Rough out the lock by switching ROUGH PUMP switch to LOCK/CHAMBER on the vacuum controller. When the lock VAC light on the controller turns green, turn the sample change switch to ON. This switch is located on the load lock flange. The sample change light on the controller will come on along with the chamber light. This switch opens the lock valve and the sample can now be attached to the manipulator. Switch ROUGH PUMP back to TURBO before inserting sample.

To transfer the sample from the load lock to the sample holder on the manipulator loosen the knurled knob on top of the load lock quick disconnect approximately one half a turn or less. Watch the vacuum while loosening the knurled knob. Slowly slide rod and sample down into the chamber. Orient sample mount so it will slide into the sample mount holder on the manipulator. Looking through the chamber window, move the manipulator with the local controller so the sample holder lines up with it's matting piece mounted on the manipulator. Carefully slide the sample holder into the manipulator holder. Unscrew the rod from the sample mount and retract as far as possible. Tighten the knurled knob so the vacuum improves and the rod stays totally retracted. Use vacuum grease on sample rod for smooth movement. Turn off the sample transfer switch.

### **Caution:**

**The sample rod must be clear of the LV when operating the sample change switch. Failure to maintain proper clearance will result in damage to the sample transfer rod and the LV.**

### **Caution:**

To remove a sample from the chamber first rough out the lock chamber. Open LV using sample change switch. Switch ROUGH PUMP back to TURBO. Remove the sample from the chamber. Turn off the sample transfer switch. Vent the lock, and remove the sample from the lock.

## B. DETECTION SYSTEM

The detection system begins with a silicon surface barrier particle detector and optional detectors such as a second SSB detector, 2" sodium iodide or HpGe gamma-ray detector and, SiLi or Wavelength Dispersive X-Ray detector. Also, high depth resolution magnetic spectrometers have been incorporated with a \*.MCP file extension. The SSB detector is mounted below the collimator. This gives a scattering angle of 170°. A second SSB detector can be positioned at any angle from outside the vacuum system.

Each detector has a preamp and from there the signals are fed into a spectroscopy amplifier. From the detector amplifier the signal goes to the multichannel analyzer/analogue to digital converter. The 2000 channel MCA/ADC is a board located inside the computer with inputs in the rear. To collect a full energy spectrum connect the amplifier output to the main input. This input is designed for a TTL level pulse. If counts which normally would generate a pulse of  $\sim < 2$  volts are to be counted then turn the gain up.

The MCA can be gated (turned on and off) by the current integrator. To do this connect

the +5 volt output gate of the integrator to the gate input of the MCA. The gate must also be enabled as “coincident” in software. This allows the spectra collection length to be determined by beam current and not time. This gate is very slow to go off and so the delay between off and on cycles must be > .5 seconds. This gate signal can also be daisy chained if more than one MCA card is present.

Typical operating beam currents are 50 to 100 particle nanoamps for RBS and 10 to 40 particle nanoamps for channeling. An amplifier gain of 40 uses two-thirds of the available channels when the incident beam is 3 MeV He<sup>++</sup>. Consult the detector data sheets for high voltage settings.

For specific instructions on adjustments consult the appropriate manual. For best energy calibration results of the MCA mono-energetic sources of alpha particles and gamma rays are suggested. Recommended sources are: Thorium 230 4.69MeV, or Americurium 241 5.486MeV (smoke Detector) for alphas and Cobalt 60, 1.173 and 1.332MeV for gamma rays. These sources offer absolute energy calibration of the detection system and can be repeatedly used.

## C. COMPUTER SYSTEM

The user can use three software programs to do some of the endstation control, data collection and data analysis of the NEC RC43 analytical system. All 3 programs have icons displayed on the desktop when the computer is turned on under windows 95/98/XP. To make a selection just double click your choice. Once the program is running, choices are listed at the top with pull down menus and toolbars.

The first program, (MAESTRO), can be used to only collect spectra. This program comes with the data collection card, located inside the computer, and gives the user total control of the cards' parameters. Here a growing spectrum can be observed and when collection is complete, the spectrum can be saved to disk in a variety of formats. The second, (RC43.EXE) does sample manipulation, controls the data collection card(s), and interfaces to the current integrator, and does qualitative analysis. It has automatic data collection for doing channeling, NRA, ERD, PIXE, RBS, and Probe work. It has several live data displays and writes data to an ascii file for disc storage. The third, (RUMP.EXE or GUPIX.EXE) is the RBS quantitative data analysis program. It has a screen display and menus. All 3 can print to system printers. Other quantitative data analysis programs, such as Gupix, may be provided depending on what optional detectors were purchased.

The operating system is Windows XP. For questions on the computer refer to the computer hardware manual, or the Windows XP manual.

### 1. MCA board Software (MAESTRO.EXE)

The actual Maestro software operation is thoroughly covered in it's own manual and should be read previous to use. Covered here will be the interaction of the software and the computer.

The Maestro software can communicate to the MCA board even if the board is located in another computer once the MCB server software is loaded and running. After the software is correctly configured, the state of the board can be accessed through the icon on the desktop. On the top is a menu bar. Click on the top menu bar to display the drop down menus.

To store a spectrum on disk click on FILE, SAVE. Please note that none of the Maestro file formats are supported by RC43 or by RUMP.

To close this application click on the X in the upper right corner. This program can be operated simultaneously with RC43 even though it is not healthy to have two applications trying to control the same MCA card at the same time.

### 2. Qualitative Data Collection Software (RC43.EXE version 4.6)

RC43.EXE is used for qualitative analysis and automation of data collection for the RC43 endstation manufactured by NEC. It is also used as an upgrade package for other endstation types. The user can display several windows. Each window allows control for a specific data collection mode. Some of the those modes are; automatic full energy spectra collection without operator intervention, linear scanning, 2 dimensional crystal and uprobe imaging and, ratemeter. These windows and associated routines automate data collection which would otherwise be very time consuming. Within each window most buttons and text boxes have a help box which will pop up if the mouse cursor is left over it for ~1 second. The windows can be moved around and resized to suit the user. When RC43 is Quit, the windows

position and size as well as other default information can be written to disk. This information is then loaded at run time so the windows will appear as they were left.

RC43.EXE is written in Visual Basic™. It interfaces with an io card for current integration(PCI bus), the manipulator controller (RS232 com port), and the TRUMP data collection card (PCI bus).

To run this program double click on it's icon located on the desktop, or using Windows Explorer double click on RC43.EXE in the C:\RBS directory. Once RC43.EXE is loaded a copyright panel will be displayed on top of a picture of the endstation. If you have not registered yourself here please do so. To remove this from the screen click on "continue" with the left mouse button. A menu bar will be displayed. To use the menu bar to control the sample manipulator for example, move the mouse cursor to MANIPULATOR and click the left button. This displays the manipulator control window.

a. Registered Window

This is the first window to appear as shown on the title page. It displays the NEC copyright notice as well as the user this product is registered to at your site. If no user information has been entered some will be requested. The background here is any BMP or JPG file the user desires. Located in the C:\RBS directory is a file REGSTER. This file contains registration information and the name of the file which gets displayed at startup as shown in the section on default files. If registration information has been entered the main menu will be displayed, otherwise clicking on continue prompts the user to register. While the main menu window is being displayed many defaults are loaded from the file RBS.CFG. A description of the contents of this file is found in the introduction under default files.

b. Main Menu Window

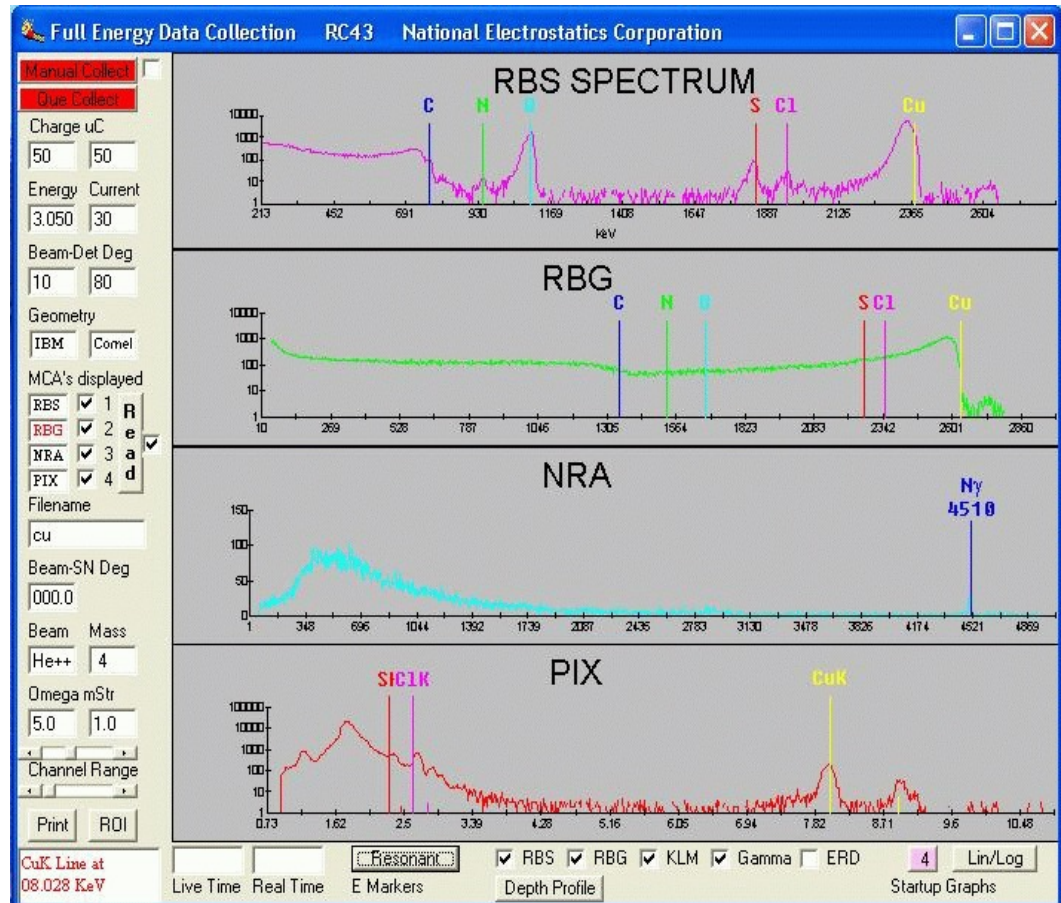


This window has a menu bar across the top, a message box on the left, the time and date are displayed with the ability to change fonts for printed spectra, etc and create new data directories. A list of MCA's available is also in the center. On the right is a file listing box. The context sensitive button help can be toggled on and off from the HELP menu. By clicking on the menu items other control windows are displayed. Messages are displayed in the message box during program operation which the user will want to read. At this time a message appears indicating what MCA data collection cards have been installed in the PC.

The user can send commands to and receive information from the accelerator control computer over the network. Communications are established at the startup of this window. If a connection is not made the beam mass, charge state, and energy displayed on the left are defaults. The computer name and port number for communications with AccelNET are parameters in RBS.CFG and CS.CFG. The accelerator control commands listed in the file CS.CFG are already configured for the system to use.

The default directory where data will be saved/read from through out the entire program is listed in the file box. This has C:\RBS\DATA as the startup default. This can be changed at any time. The program will remember what it was at quitting time since this information is saved in RBS.CFG and used as the new startup default the next time RC43 loads. The QUIT menu must be used to save the configuration. Use windows X when you do not want to save.

### c. Data Collection Window



Clicking on Data Collection in the main menu displays this window. Collection and ion beam parameters are listed on the left. At the upper left is a MANUAL COLLECT button and QUE COLLECT button. To collect data from the sample presently in the beam, click the MANUAL button and data will begin to appear in the graph area of the window. If you want to append new data to the existing data click the box to the right of the MANUAL button. To collect data from samples whose positions etc. have been entered in the sample position table click the QUE COLLECT button. The first sample in the run list and tagged (C, R, A, M, P in column 8) in the sample position table will be moved into the beam and data collection will begin. All subsequent samples in the run list and tagged in the sample position table will sequentially get run which are within the run number bounds shown at the lower left of the sample position table. The duration of each run is determined by the charge entry in the table if this capability is enabled. Data will be saved to disc using the filename listed in the position table.

The beam energy and beam current is initially received from the accelerator control computer. The beam charge, beam to detector angles theta1 and theta2, scattering geometry, detector solid angles can be changed by the user or left to the defaults read in from the configuration file RBS.CFG. The integrated current left to go is displayed in a text box next to the total set for the sample. Under MCA's displayed are either the data collection cards found installed in the PC at

startup or the number of startup graphs. Up to 4 spectra can be displayed. By clicking the check box you can select which graphs are displayed. Even though a graph is not displayed, data is being collected. The Filename is displayed for saving data. This filename gets appended with the extension listed above it for the specific card. If the filename is left blank NO data will be saved. The Beam to Sample Normal angle, Beam species, beam Mass, and detector solid angles, Omega1 and Omega2 are also shown and should be checked by the user so they agree with present experimental conditions. This information is stored as a header with the spectra on disk.

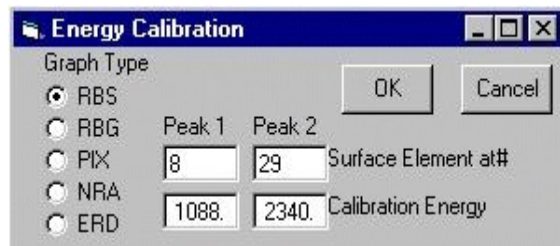
The READ data button is located to the right of the MCA's displayed and calls a file read dialogue box. The user selects the desired data file which is displayed in the active spectral graph. To make a graph the active one just click on it, preferably to the left of the vertical axis, with the mouse. Selecting the active graph also sets the default file extension for the file read box. The file read box then displays only those files with that extension. Due to the need to append extensions to the filenames, the filename box is used to store data only and not read data. This button also disables reading current accelerator parameters like beam energy.

At the lower left are a Channel Range selector for the active graph, and a Print button which prints the graphs shown to the default system printer, and a message box. The ROI button displays the ROI table and the ROI's already set by placing a colored line at the appropriate channel number in the appropriate spectral graph. ROI's are set by left clicking in the spectral graph. The channel number is entered in the active cell of the ROI table and a blue line is placed on the graph. The message box tells the user when data collection is on, what sample is being run etc.

At the bottom of the spectral graphs there are several buttons and text boxes. The live time and real time are displayed for the last graph updated. To display the live time and real time for a particular spectral graph make it the active one being displayed by clicking to the left of the graph axis. The MCA displayed box text turns red to indicating the active graph.

The "E Markers" button displays markers on the selected graphs for elements and gamma energies listed in the element table window. To have elemental markers displayed in a graph, click in the check box to the left of the appropriated graph type. The first time the "E Markers" button is pressed the element list is displayed. If the "E Markers" button displays "Active" the markers will be displayed during data collection. To change the number of startup graphs click on the "Startup Graphs" button. Once the number of startup graphs has been changed RC43 must be Quit and restarted or errors will occur. Since the graphs are loaded at program startup, changes do not take affect until the next time the program is loaded. Lastly, a Lin/Log button toggles the vertical display axis from linear to logarithmic for the active graph.

Energy calibration is accomplished via the window at the right. Use the right mouse button to select calibration peaks. Cyan colored vertical lines are displayed at the selected channels. After right clicking twice on a graph the energy calibration window will pop up. Here



The image shows a software window titled "Energy Calibration". It has a "Graph Type" section with radio buttons for RBS (selected), RBG, PIX, NRA, and ERD. To the right of these are two input fields labeled "Peak 1" and "Peak 2", containing the values "8" and "29" respectively. Further right is a label "Surface Element at#". Below the "Peak 1" and "Peak 2" fields are two more input fields containing "1088" and "2340", with a label "Calibration Energy" to their right. At the top right of the window are "OK" and "Cancel" buttons.

a radio button tells the calibration routine what type of graph ie RBS, PIXe etc. Then atomic numbers of the peaks selected in the graphs are entered in the Surface Element at# text boxes labeled Peak1 and Peak2. The window automatically calculates the energy of the peaks when focus is moved away from either atomic number boxes and displays the energy in the Calibration Energy text boxes. Once Peak1 and Peak2 boxes have numbers in them click on the OK button and the graph will then be redisplayed with the x-axis converted to an energy scale. The energy calibration is also stored in the RBS.CFG file when Quit is selected from the main menu. If the user desires to use the old energy calibration just click the CANCEL button. To return to Channels as the X axis display, enter an energy equal to the channel number which was clicked in the graph. Each X axis tick equals 100 channels. So click on the second and fourth X axis tick mark and enter 200 and 400 for the energy in the Energy Calibration window.

Some energy calibration sources are:

#### Alphas (MeV)

AM <sup>241</sup>	5.544 (.3%)	5.486 (85%)	5.443 (13%)	Available from smoke detector
Th <sup>230</sup>	4.689 (75%)	4.621 (25%)		

#### Gammas (MeV)

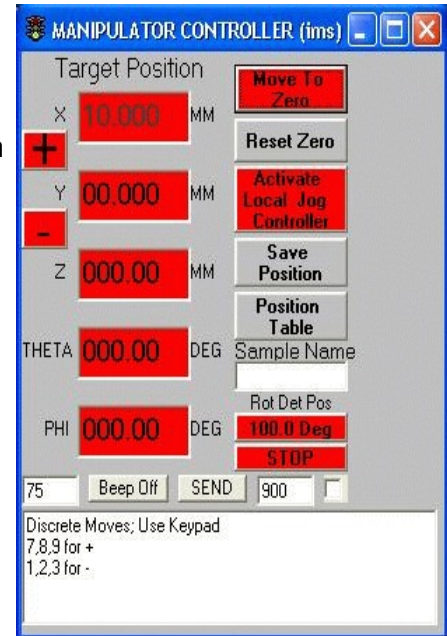
Cs <sup>137</sup>	0.662	
Co <sup>60</sup>	1.173	1.332
Na <sup>22</sup>	0.511	1.275



#### d. Manipulator Window

The manipulator window displays the sample position at which the ion beam is hitting. At program start up this position is read from C:\RBS\RBS.CFG. If the manipulator has been moved by means other than the program, this position may need to be adjusted. In some cases the position is also read from the controller

There are five manipulator axes: X, Y, Z, Theta, and Phi. Also, in some cases a rotatable detector is controllable. X translates horizontally perpendicular to the beam. Y translates horizontally parallel to the beam. Z is vertical translation. Theta rotates about the Z axis and Phi rotates about the Y or beam axis. The position is in millimeters for X, Y, and Z, with a minimum move of .001mm. For Theta and Phi it is in degrees with a minimum move of .01°. Translation ranges for X and Y may be as small as  $\pm 8$  mm. For Z the range is  $\pm 50$  mm or greater. Rotational range for Theta is  $\pm 160^\circ$  and Phi is  $\pm 90^\circ$  or continuous with in vacuum stepper motor. Each axis has adjustable limit switches. These limit switches may reduce the above ranges and should be checked and adjusted periodically. Caution must be exercised when the heated and cooled sample holder is used when rotating Theta and Phi to their maximum value.



In the window the position of each axis is displayed in a text box as well as the rotatable detector position. Any button or text box which actively moves the manipulator is in red. Select or activate an axis to move by clicking on the appropriate text box. When numbers are entered directly from the keyboard, hit enter to make the manipulator move. Also, the keypad keys have predefined moves associated with them. In the message box, information is displayed occasionally which defines each keypad key. Movements are all relative. For each move the manipulator makes, a relative check is made.

On the left of the position boxes are command buttons + and -. These buttons move the active axis an amount determined by how long you hold down the left mouse button. When you let up on the button the final position is displayed in the position box. Once again to activate an axis click on its position box and the background color of the box will turn green.

A local manipulator controller box, which is located at the endstation, can be made active for local use. To move all axes to their zero position click on the MOVE TO ZERO button. To zero all the text boxes without moving the manipulator click on the RESET ZERO button. Communications use serial port 1 on the PC to the manipulator controller. The communications control is on this

form. If you close this window communications to the manipulator controller will also be closed. This window can be minimized to the toolbar but do NOT close it!

The buttons SAVE POSITION and POSITION TABLE call up the sample position table window. The first also loads the next open row in the position table with the current sample position and sample name listed. The sample name is then used as a file name when the spectra are stored on disk. These buttons log sample positions in the table for later use with queued sample data collection. The position table window is covered in detail later in the manual.

The box on the lower left displays the communications delay. The default is 75 milliseconds. A beep can be turned off or on with the next button. The "SEND" button sends the text in the message window to the manipulator. For the correct syntax consult the motor/controller manual. Next to the send button is the duration which the in vacuum motor is active after the local jog button is depressed. This prevents the motor from overheating. The last checkbox turns on the eucentric move software feature for angle and image scans.

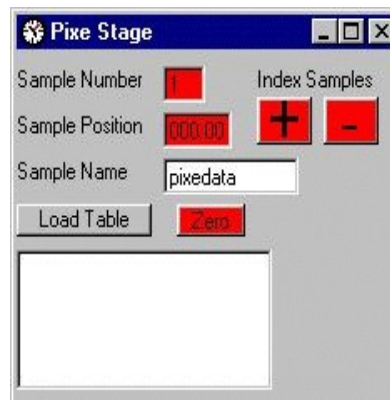
If an error condition occurs, an explanation will appear in the message box at the bottom of the window. For example, if the manipulator controller is not turned on, and a move is requested, the error window will appear with: COMMUNICATIONS ERROR: NO RESPONSE ON CONTROLLER INDEXER # ?. Also, if a hard limit switch on the manipulator is hit text will appear indicating which axis. To abort a move use the STOP button. To change the holding current to the in vacuum motor use the PHI IDLE 0% current button.

#### one. Pixe Stage Window

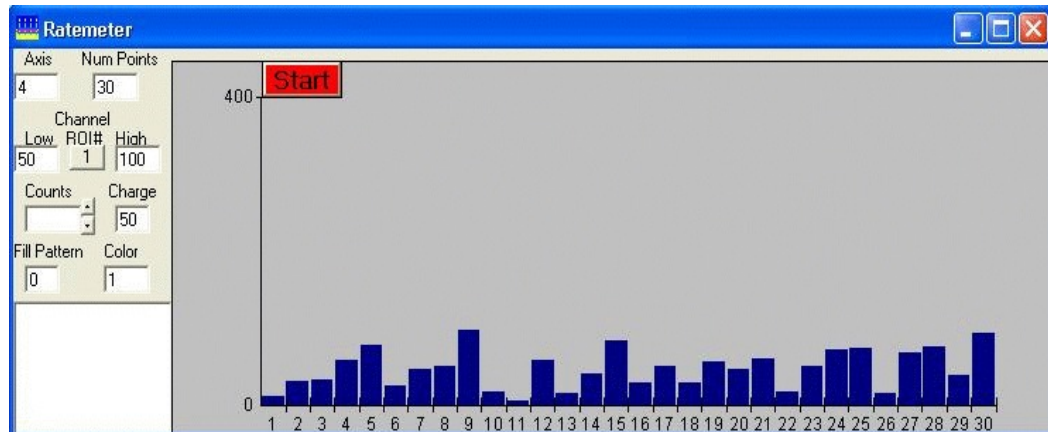
This window computer controls a forty sample stage designed specifically for mounting thin or thick PIXE samples. The sample number (1 to 40) is displayed at top. Below it is the angular position. Both of these boxes will take input and when the return key is pressed the stage will move to the corresponding position. The + and - buttons will index the stage one sample position in the positive or negative direction. A sample name can be entered in the Sample Name box.

This name is then entered in the sample position table as a filename to store the spectral data when the Load Table button is pressed.

The Load Table button loads the sample position table with forty positions and sample names and using the sample name as a base and appending the numbers 1 thru 40. Through using the sample position table queued data collection is available to the user for the PIXE stage. The Zero button moves the stage to sample number 1.



e. Channeling Ratemeter Window



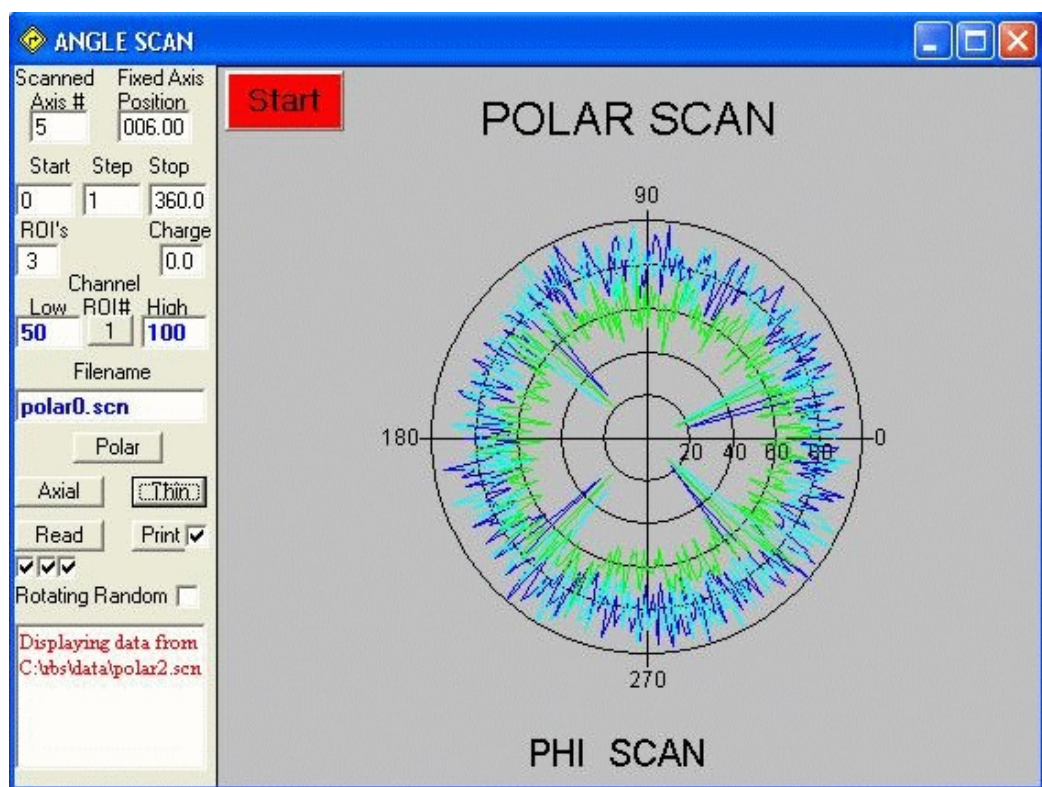
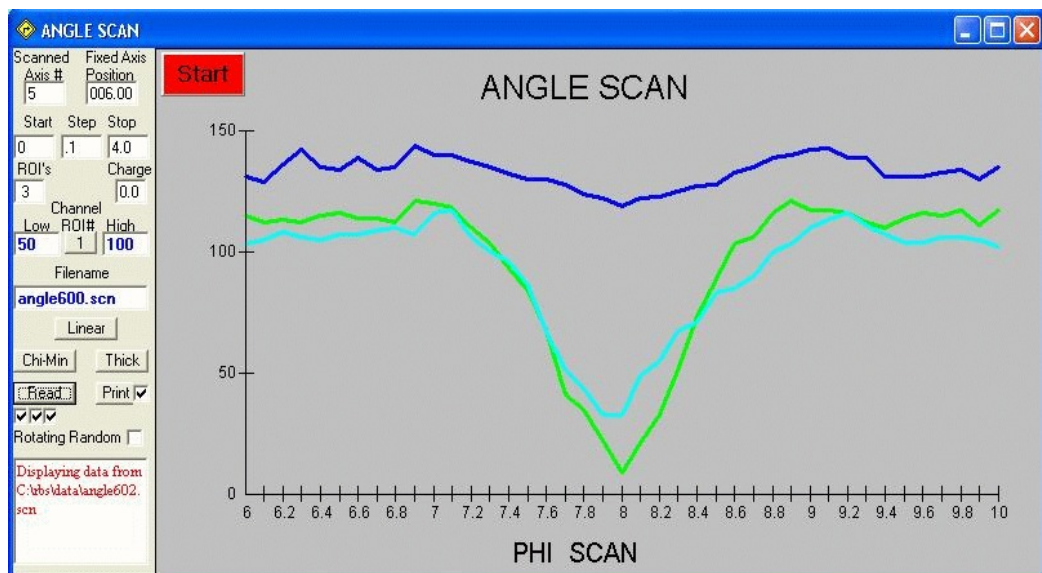
The operator can use this window to manually locate the crystal axis of a sample or to fine tune the position from the polar scan axial button. The parameters associated with this window are on the left. The axis number (X=1, Y=2, Z=3, Theta=4, Phi=5) being manually scanned and number of data points in the histogram (maximum 100) are displayed at the top. The ROI number follows with the corresponding high and low channel numbers. The channel numbers can be edited and when the user clicks somewhere else on the window the changes will go into affect. The integrated current per data point is entered in the charge text box.

The scrolls next to the counts window change the graphs full scale by a factor of 2. The full scale value is saved when the program is quit and loaded at startup. For clarity the number of counts for the first data point or histogram bar is displayed in the counts text box. Selection boxes for the graphs histogram bar color and fill pattern are last. Once again a message box alerts the user of required action or problems. Errors with manipulator communications are sent to the manipulator window. The message box must have focus to activate the keypad keys. When the START button is clicked it changes to STOP. Clicking on this button again stops the ratemeter.

Click on the START button to start data collection. The duration for each point is entered in the charge text box and should be set prior to starting and may be changed at any time during the run. Data will begin to be displayed in the graph area in histogram form. Hot keys are listed in the message box. To move the sample using the keypad keys listed in the message box click in the message box and turn Num Locks OFF. Now keypad keys 4 and 6 will select an active axis and 7, 8, 9, 1, 2, & 3 will move the selected axis discrete amounts in the positive and negative directions.

To manually align the crystal axis with the beam, rotate Theta and Phi until the counts being displayed go through a minimum. Once the counts minimum has been located quit this routine with the Q command and collect a full energy spectrum or do an angle scan to determine the Chi-min and half angle of the crystal channel. There will be more than one minimum. Planar channels will also generate a minimum in the counts being displayed. This minimum will not be as wide or as significant as an axial channel minimum.

f. Channeling Angle Scan Window



These windows allow the user to set up to 9 regions of interest. They then display the total number of counts for each region as a function of position or angle depending on which axis is being scanned. The data can be displayed in

Linear or Polar format with Thick or Thin line type. If the operator does an angle scan through an axial channel the Chi-Min and Half angle of the crystal can be calculated using the Chi-Min button. Likewise, the axial channel orientation can be calculated for a polar scan using the Axial button. Also, with multiple regions of interest, impurities can be determined to be interstitial or substitutional.

The window is set up with the scanned axis number (X=1, Y=2, Z=3, Theta=4, Phi=5) and fixed axis position for a polar scan, displayed at the top left in editable boxes. Below that is the start, step, and stop positions (MM or °) for the scan. These positions are relative to the current manipulator position. The number of ROI's to display is next with integrated current for each pointing the charge text box. The number of ROI's is determined by the rows in the ROI table which have a value in the first column. Adding values to the ROI table will automatically add another ROI here. Consequently, editing the channel regions displayed here will change those in the ROI table. The channel numbers come from the ROI table or defaults if there are no values in the table. The channel numbers and filename are displayed in the same color as the data on the graph. One file for each ROI is generated. The filename gets appended with the ROI number for uniqueness and ".scn". The filename text box is editable. By editing the filename for ROI number 1 all the filenames can be changed.

Below the filename box are a Linear/Polar graph type button. Next is a Thick/Thin line type button and a button labeled Chi-Min/Axial. Next a Read data button and a print button to get a hard copy of the graph. In Linear mode the Chi-Min button calculates the chi-min and half angle of a crystal channel. In Polar mode it (Axial) calculates an axial channel position from planar minima. When polar plots are displayed the axial button will locate the 4 minima and calculate the axial channel orientation. However, the minima must be separated by at least 10 channels. This orientation is displayed and loaded in the sample position table. However, upon return from the sample position table if all the roi's are not loaded in the roi table, as the case when reading in data, then the number of roi's may get altered. This may result in being unable to print all the spectra until the ROI table is edited.

The Read button will sequentially display a read file dialogue box for each ROI listed in the number of ROI text box. Click the check box corresponding to the ROI number to display the data before clicking the read button. A message box is on the lower left to prompt the user or to display relevant instructions. On the very bottom left is a check box labeled Rotating Random. If this box is checked during a scan the full energy spectrum will also be displayed and saved. When the user is collecting polar scans this will automatically collect a rotating random spectrum for the sample.

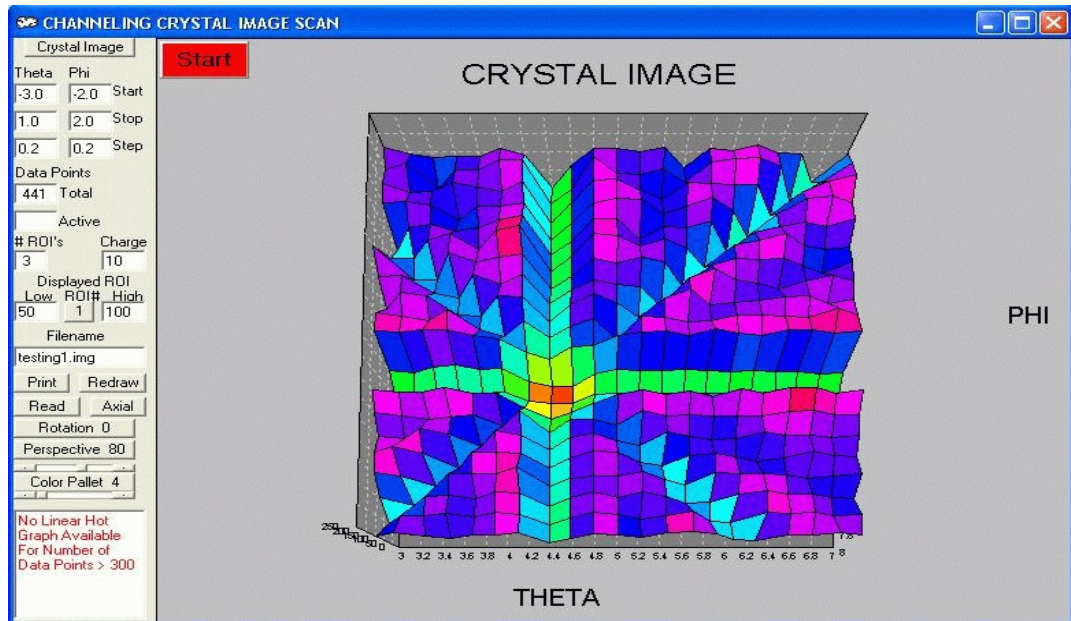
To begin a scan click the START button. The button caption changes to STOP. To abort the scan before completion click the STOP button. The x axis of the graph displays the region to be scanned and the y axis will auto-scale with the number of counts. The total number of counts is displayed on the graph for each ROI.

At the beginning of the scan the manipulator will move to the starting position. Before starting, set the charge text box to the desired amount of integrated beam



current for each data point. The first data point(s) will appear on the graph after the charge preset is reached. The manipulator will move to the next position, the current integration will begin again, and data collection will start again. When the scan is complete each ROI is saved with it's respective file name. Data is saved in an ascii file in a macro format which RUMP can read using the XEQ command. Data can then be further analyzed and plotted with the RUMP analysis software.

g. Channeling Image Scan Window



This window is used to collect 2 dimensional angle oriented images for channeling and translational oriented images for lateral elemental profiles using a microprobe. At the top left is a button with default label Crystal Image. Clicking on it changes the label to Micro Image. This lets the user select the type of image desired. The Crystal Image will do a 2 dimensional scan in theta and phi and label the graph accordingly. The Micro Image likewise does a 2 dimensional scan in Z and X with these labels on the graph.

The surface graph has the number of counts, or intensity, coming out of the page. The user can adjust the perspective and rotation angles. The intensity is mapped to a selectable color range. The graph surface can be viewed from a perspective position between 0 and 100 and a rotational angle of 0 to 120. Zero is with the data intensity displayed vertically on the screen ie looking at the edge of the surface, while 100 is looking down on the surface. The color pallet as well as the range of colors used from a specific pallet are user selectable.

When the window first comes up there are several editable text boxes which define the imaging parameters. There is a START, STOP, and STEP box for both axes to be scanned. These parameters define the starting, stopping and step size for each axis. The starting and stopping positions are relative to the position displayed in the manipulator window for the scanned axes. The remaining 2 axes are not changed. The total number of data points is calculated and displayed to give the user some idea of the time required to collect the data. Also, if the number of data points is over 300 the hot hit one dimensional graphing is unavailable. The active data point number is displayed in the active text box during imaging.

The number of ROI's desired is displayed in the # ROI box. To the right is the user set able integrated current per data point in the Charge box. Just below this is the ROI being displayed with the corresponding high and low channel

numbers. By clicking on the ROI# button, data for that ROI will be displayed in the surface graph and the active roi high and low channel numbers will also be shown and can be edited. A filename under which each ROI data will be saved is listed with a default name. The filename can be edited. If ROI #1 filename is edited then all other filenames are changed to this with the ROI number and ".img" appended for uniqueness. The other filenames can be edited and only ".img" will get added.

Buttons to Print, Redraw, and Read data are also available. Print will send the surface graph to the default system printer with some annotation. If the linear graph is displayed it too will get printed. Redraw is used to clean up any fuzziness of the display caused by the vertical scale being auto-scaled during data collection or remove the linear graph. Read will load and display data from the file selected in the file read dialog box. It will display internally generated data if the file listed does not exist.

At the bottom left a message box lets the user know what is expected of them and will inform them of warning and error messages. As an example the first and then second cell positions of the mouse hot-hit are displayed in the message box when generating a linear graph.

As indicated above a one dimensional graph can be extracted from the surface graph by clicking the mouse in two locations on the surface graph. A line is drawn on the surface graph and the nearest data point is extracted and graphed in a pop up graph at the bottom. The axis of this graph is determined by the most grid lines crossed by the line displayed on the surface graph. The one dimensional data is not saved to disk but is printed with the image.

Once all parameters have been set, clicking on the START button begins data collection for the defined image scan and ROI's. As indicated by the button helps, to stop data collection before scan completion just click on the same button again. Data collection will then be aborted at the next cycle. During data collection the user can view the different ROI's and change the perspective angle, display color, and filename. Once data collection is complete the image spectra will be saved to disk as an ascii file.

#### h. Micro Scan Window

The user can scan a sample collecting and saving on disk full energy spectra for each point. The RBS data collection window and sample position table are displayed. Spectra are saved on disk with a filename appended with information indicating position in the scan. If the user is only interested in ROI data then use the image scan window. A Micro Scan is set up using the position window. See the sample position window description for more information on how to set up a microprobe scan



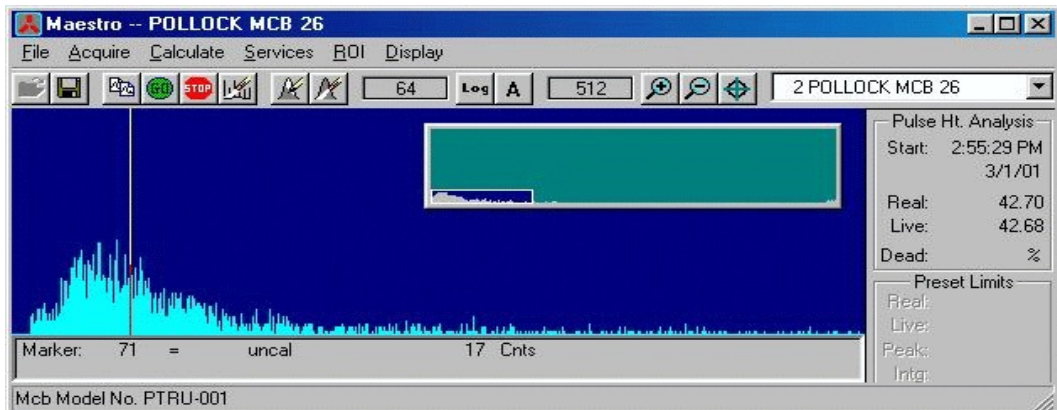
i. Help Window

The RC43 manual is displayed using internet explorer. This gives the user an easy way to access the manual on line with search capabilities. The manual also has html links which can be used for viewing! If internet explorer is not available or it is desired to put the manual in a different directory the corresponding line in RBS.CFG can be edited as desired.

j. Testing

These windows are used to test communications with the PCI cards in the computer or with other hardware like the accelerator control computer. There is a window for the MCA, AccelNET computer, & I/O card.

one. MCA Communications



This is the standard window for the MCA card. This routine checks communications with the MCA card. The MCA window can be used to set ADC Gain, gating etc values to something other than the default 2048 channels assuming the data collection card has more than 2048 channels.

two. Test BIC

There is also a test routine specifically for the BIC. Use this to check communications with the BIC. The message text box on the main menu tells the user what to do and lists the results of the BIC test.

three. Test RC43 to AccelNET

The RC43 to AccelNET communications window, shown at right, gives the user a windows interface to AccelNET for control of all parameters. This window can be displayed on its own or brought up in the RC43 program by clicking on the TEST menu button and then on RC43toAccelNET item in the drop down list. At program startup the AccelNET host and configuration information is loaded from the file /rbs/cs.cfg. The host name must be resolvable to a valid internet address by a name server or listed in the hosts file. The following line must also be in the services file "AcDBserv 6100/tcp #AccelNET to RC43" To allow RC43 to communicate to the Accelerator Control System AccelNET.

At the top of the window the menu items **BUTTONS**, **CONFIG**, and **HELP** are listed. When these menu items are selected, via a left click of the mouse, a drop down list is shown. Below the menu items are several buttons and text windows. Two buttons located on the upper left are labeled **Beamline Fcup** and **Beam Parameters (MeV =)**. These buttons are predefined. The first controls the position and reads a beamline Faraday Cup. The second reads the ion beam parameters (Energy, Mass, Charge State). Several other text boxes and buttons can be seen below which will be covered later.

On the **BUTTONS** drop down list are **Add**, **Define**, **Delete**, **Move**, and **Size**. **Add** will add a button to the window and ask for text to be displayed on the button face. A button will then appear with the entered text displayed on the button face. This button is automatically associated with the parameter listed in the parameter Label and RefName text box, located in the upper right corner under the menu. From now on to read this parameters' value just click the button. To select a new parameter in the Label and RefName text box, click on the arrow on the right side of the text box. A drop down list of all available parameters is displayed. Click on one to select it and close the list. Now you are ready to add another button.

**Define** allows the user to change the text and parameter associated with a button. Once again the parameter selected is the one displayed in the Label/RefName text box. **Delete** removes the selected button. To select a button right click it. A text box below the buttons shows which button is the selected one. **Move** and **Size** allow the user to position and change the size of the selected button.

The Label and RefName text box is loaded from the Desc.lst file at program startup. If this file changes on the AccelNET PC then a fresh copy should be put on the RC43 PC in the \rbs directory. Desc.lst is found in the /AccelNET/pg/contract\_name/tools/ directory on the AccelNET PC.

On the **CONFIG** drop down list is **Save** and **Restore**. The **Save** item will save the configuration of all shown buttons to the file csbut.cfg in the /rbs directory. This includes the parameter associated with a button as well as it's size and position. The next time the window is loaded **Restore** can be used to bring back the button configuration previously saved.

**HELP** has the two drop down items **OnLine** and **Manual**. **OnLine** shows helpful suggestions on the use of the RC43toAccelNET window via a message box. **Manual** displays this help file via notepad. This manual page is in the file /rbs/rc43toaccelnet.txt

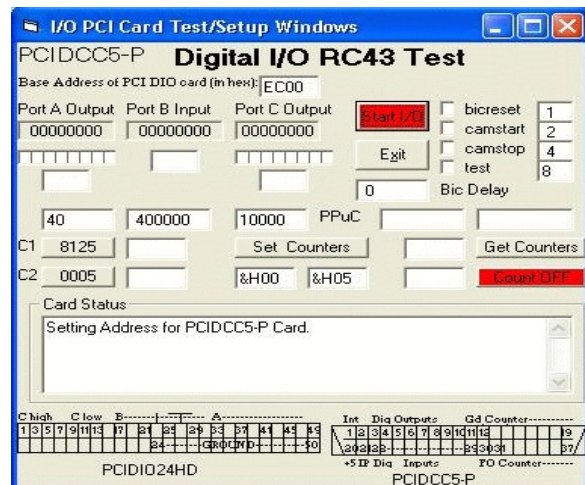
For communications setup the Host is listed on the left side of the window. This is the PC where AccelNET is running. It is read from the initialization file at startup, but can be changed via this window at any time. To change the Host, first use the **Close Conn.** Button, edit the Host name, and use the **Open Conn.** Button. For permanent changes edit the initialization file cs.cfg. The port number being used is shown between these two buttons.

This number should be a positive number. A negative number indicates failure of the open command!

Listed to the right of the Host in is the Parameter Label, RefName, and Value. These text boxes show the current parameter and its value and are editable. Below these text boxes are the buttons **Get Parameter Value** and **Set Parameter Value**. **Get Parameter Value** will read the value of the parameter listed. **Set Parameter Value** will set the parameter to the value listed in the Value text box. To change the value edit the contents of the Value text box. The remaining boxes calculate the time it takes to complete a command and can be used for troubleshooting.

#### four. Test I/O & Counter Card

The Digital I/O card primarily communicates with the current integrator. It can be configured by the user to send TTL signals to other devices as well as use on board counters. Use this screen to activate other I/O lines to control devices accepting TTL signals as indicated on the right side of the window below. Also, the delay for communicating to the CI can be seen and adjusted by the user. For more specific instructions on this I/O card please see the manual located on the Kontron CD. Make sure the dll and sys files from pcid24/win32/drivers get copied to windows/system32 and windows/system32/drivers respectively.



#### k. Quit

To exit from RBS.EXE click on the QUIT button in the main menu. A box will appear asking if you want to quit. Click on OK to exit. Clicking on CANCEL will return you to the program main menu. Information on the manipulator position, window positions etc is written to rbs.cfg file before the program stops. Also communications ports are closed. If the user clicks on the windows X to close RC43 then no configuration information will be saved to disk, ie RBS.CFG will not be overwritten.

## I. Position Table Window

Up to 300 sample positions can be saved from the manipulator window to this table with sample filenames. This row of information is then used by the QUE COLLECT data collection button in the rbs window to define the position, filename, integrated current, etc for the next sample. Use the SAVE POSITION

#	X	Y	Z	THETA	PHI	Energy	Chg	Filename	R
1	50.000	1.000	000.00	006.00	006.00	2.400	40	rbsdata1	R
2	50.000	2.000	000.00	006.00	006.00	2.400	40	rbsdata2	R
3	50.000	3.000	000.00	006.00	006.00	2.400	40	rbsdata3	R
4	50.000	4.000	000.00	006.00	006.00	2.400	100	rbsdata4	C
5	50.000	5.000	000.05	006.00	006.00	2.400	40	rbsdata5	R
6	50.000	6.000	000.10	006.00	006.00	2.400	100	rbsdata6	A
7	50.050	7.000	000.00	006.00	006.00	2.400	100	rbsdata7	M
8	50.050	8.000	000.05	006.00	006.00	2.400	100	rbsdata8	P
9									
10									

Below the table, there are buttons: 'Move To #', 'UProbe Load', 'Save', 'Hot Key Help', 'File', 'Load', and 'Clear'. There are also 'Start' and 'Stop' input boxes.

button in the manipulator window to load the next empty row with the current manipulator position and Sample name displayed in the Manipulator window. If the Sample name in the manipulator window is blank then the filename comes from the rbs window. To edit any cell in the position table double click it. For an explanation of valid data for the columns in the table use the Hot Key Help button.

If the user double clicks in the Run column (8) then R in that column gets inserted/deleted. An R in column 8 is needed to collect RBS data for this sample position. An A can be entered in column 8 to tell the Que Collect routine to collect an angle scan as defined in the angle scan window. Also, a P is for polar scan, C is for crystal image, and M is for microprobe image.

**NOTE:** If the current integrator is a BIC then during automated data collection when the Run type changes from R or back to R a message box is displayed and waits for the user to click OK. This message box gives the user an opportunity to change the preset on the BIC. This preset is almost always different for full energy data collection and scanning data collection.

Once the table is loaded with sample positions the positional accuracy can be checked using the MOVE TO # button. The # indicates the table row, or sample number, which was last clicked on. By clicking on this button the manipulator will move to this (#) position. The Start and Stop boxes hold the start and stop sample numbers for queued data collection. If the user wants to run sample numbers 1 through 4 but not sample number 3 then the Run state of sample number 3 can be toggled to off, or a blank, by double clicking in column 8. This removes the R, or whatever, from that column for that sample and queued data collection will skip it.

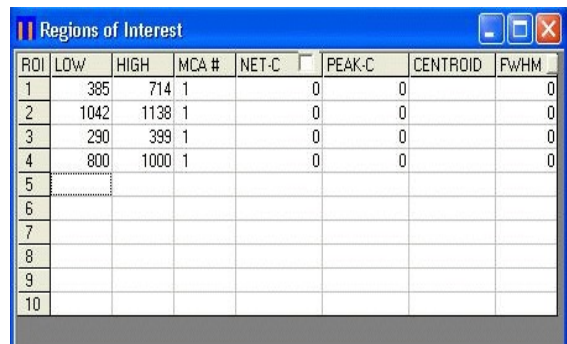
The UPROBE LOAD button loads the table with a grid of sample position points for full energy spectra data collection using queued data collection. The starting position is the currently active table row. Under the UPROBE LOAD button are two rows with manipulator axis labels Z and X. The first column defines the range of the grid for each axis. The second column defines the step size for

each axis. For example, if the currently active row has all 0's in it with a filename of "circuit", and both Z and ROT rows contain 0.1 and 0.02, clicking on UPROBE LOAD button will fill the next 36 rows in the table with position values and filenames. The first 6 table rows would contain Z positions from 0 to 0.1 and filenames "circuit00" to circuit05". The 7<sup>th</sup> row would have an X position value of 0.02 and Z back to 0 with filename "circuit10". The last position value for Z and X would be 0.1 with filename "circuit55". This feature saves the user much time over moving the sample a small amount and then saving the position etc.

The SAVE and LOAD buttons allow the user to save and load sample position tables from disk via a file save and file open dialog box. This could also be used to clear the Sample Position Table by loading an empty table. The default path used comes from the main window.

#### m. ROI Table Window

This table holds up to 10 regions of interest. Each row in the table is comprised of the ROI #, low channel, high channel, MCA number, Net counts, Peak counts, and a course peak Centroid calculation. The Peak counts are the Net counts minus background. Background is calculated by the sum of the counts in the low roi plus high roi divided by 2, times number of channels. The centroid calculation is the sum of the number of counts in a channel times the channel number divided by the total number of counts. The ROI's are used by the Ratemeter, Scanning, and Imaging windows to define channel number ranges in the MCA cards from which counts are summed. The ROI's can be set directly from a spectral graph in the rbs data collection window. The ROI table is automatically displayed when the ratemeter, angle scan, and image windows are shown. The ROI table can also be displayed by clicking on Initialize ROI from the channeling menu or by clicking on the ROI button in the rbs data collection window. This button will also display lines in the rbs spectra showing the current ROI's which are in the table.



ROI	LOW	HIGH	MCA #	NET-C	PEAK-C	CENTROID	FWHM
1	385	714	1	0	0		0
2	1042	1138	1	0	0		0
3	290	399	1	0	0		0
4	800	1000	1	0	0		0
5							
6							
7							
8							
9							
10							

In the rbs data collection window the user can click on the spectral graph to load this channel number in the ROI table in the active row. A single click on a row makes that row the active row. The values in this table can be edited by double clicking on the desired table element. A text box pops up in which the new value is typed. Also, the arrow keys will move between cells in the table. The "u" and "d" keys will scroll the channel number in the active cell up and down for fine adjustments.

There is a check box on the top row in the NET-C column. This box, if checked, will update the peak counts etc. every 2 seconds. A second button located in the FWHM column converts the channel values to energy assuming a valid energy conversion has previously been completed.

If this window is closed with the X in the upper right corner the information in the table is not saved! The ROI #s in the first 5 rows are saved in RBS.CFG.



#### n. Element Window

Elements in this window are displayed on the full energy spectral graphs by clicking the "Markers" button on the data collection window. Up to 10 elements can be added by using the slider or typing the atomic number in the text box. The position where the markers are displayed on the graph is dependent upon the energy calibration of the graph and what type of graph it is. For example the element Cu would be displayed on the RBS and RBG graphs according to backscattering kinematics which take into account the incident ion mass, energy, target mass, and theta scattering angle. On a PIXe graph the position would be at the K and or L x-ray energy of Cu.

The next column contains the energy at which gamma-rays will be displayed on an NRA graph. Values must be typed into these text boxes. Tab will move from one box to the next. The box labeled ERD energy loss contains the energy lost by the recoiling ion traversing the filter foil. The position of an ERD elemental marker is determined by the recoiling energy minus the energy lost in the foil. The Description box allows the user to annotate the Gamma markers. Each marker has its' own Description box. Markers are displayed in all graphs in which they are valid and within range.

The screenshot shows a window titled "Element Table" with a table of elements and their gamma-ray energies. The table has two columns: "ATOMIC #" and "Gamma KeV". The first row shows element 7 (N) with a gamma energy of 4510. The second row shows element 6 (C) with an empty gamma energy box. The third row shows element 8 (O) with an empty gamma energy box. The fourth row shows element 16 (S) with an empty gamma energy box. The fifth row shows element 17 (Cl) with an empty gamma energy box. The sixth row shows element 29 (Cu) with an empty gamma energy box. Below the table, there are two more boxes: "ERD Foil KeV Energy Loss" and "Description". The "ERD Foil KeV Energy Loss" box is empty, and the "Description" box contains the letter "N".

ATOMIC #	Gamma KeV
7 N	4510
6 C	
8 O	
16 S	
17 Cl	
29 Cu	

ERD Foil KeV Energy Loss:

Description:

### 3. Data Analysis Software (RUMP.EXE)

The RUMP manual gives an explanation of all the commands, over 150 in all. Here only some of the more important ones will be covered. Some of the commands listed in the manual do not apply to a P.C. and Windows operating system. Commands listed here will be referenced to the manual by page number.

To load RUMP click on the RUMP icon on the desktop. This will load RUMP into memory and set the buffer size. The buffers, 11 total, each hold a spectrum and a description of that spectrum. The description contains things like incident beam energy, scattering geometry, integrated beam current, and channel to energy conversion. These individual parameters determine how RUMP "looks at" the data and must be correctly set to get an accurate analysis of the data. The data goes from a file on disk into a buffer and so the buffers are what get plotted, analyzed, etc.

After the setup RUMP will display a prompt, one of ten, and wait for a command. A "?", or HELP, p.1, will list all commands accessible from the main command processor. There are three subcommand processors; ANNOTE, SIM, PERT, pgs. 18, 12, 16. ANNOTE is for labeling plots of spectra. SIM is used to simulate an imaginary sample which is divided into layers. Each layer has a thickness and is composed of at least 1 element.



PERT compares a simulated spectrum, made up by the operator, to an actual spectrum, collected by the detection system and then adjusts the layer thickness, composition, etc., until the two spectra overlap when plotted. Also under the ANNOTE subcommand processor is the SAMPLE sub-subcommand processor p. 18. These commands are used to draw a picture on the plot which represents a section of the sample.

In the subcommand processors a ? or HELP will give you a list of the possible commands. HELP will also give a short explanation of the command which follows it. RETURN will move control back to the main command processor.

Before any plotting of spectra, simulated or real, can be done RUMP needs to be told what type of device the spectra are to be plotted on. The DEV LIST command, p. 5, will display a list of devices which can be activated. Choose one which corresponds to your system (EGA or VGA). Now all plotting is done to your screen. To plot to the printer the device for the HP 660C is DJET550C. Many more devices are listed with the RUMP manual. Also, in the file Devices.Dat the line for the DJET550C must have an LPT port number associated with it. The system printer which is to be used must also have the same LPT port associated with it.

When a spectrum is read from disk by RUMP using the GET command, p. 8, it is assumed the spectrum file name ends in ".RBS". If this is not the case, as with PCA3 .SPT files then the filename extension must be used. To load spectra stored with RC43.EXE use the XEQ command. When a spectrum gets read from disk by RUMP, it acquires a description from RUMP. If the parameters of this description are not correct they should be changed. The ACTIVE command, p. 9, will display the parameter values. Other commands can be used to change them. The parameters associated with a file should be reviewed often to insure correct analysis. Note that spectra saved using the Maestro software cannot be read directly into RUMP. They must be stored in ASCII with either the correct header format or possibly no header at all.

When a spectrum gets simulated it acquires a list of parameters from buffer number 1. These parameters should also be checked to insure they are the ones which match the experimental spectrum. The simulated spectrum always gets put in buffer zero. To check the parameters of buffer 0 key in POINT 0, p. 8. The ACTIVE command will then display the parameters associated with the simulation, buffer 0, since it is the active buffer.

To analyze an experimental spectrum one must match the simulated spectrum to it. The layer thicknesses and compositions, etc. of the simulated spectrum are altered, manually by you or automatically by PERT, until the two spectra trace out the same line when plotted on top of each other. The concentrations and thicknesses of the simulated spectrum are then the same as those describing the experimental spectrum. The layer thicknesses and concentrations of the constituents of the layer can be displayed using the command SHOW, p. 12, when in the SIM subcommand processor.

Some other helpful commands are ELEMENT, WID THICK, WHATISIT, and PROFILE, p. 11, 13. ELEMENT will plot, on the screen, the surface scattering energy of any element. The cursor is used to define the peek and an element must

be entered. WID THICK will display the thickness of a peak displayed. WHATISIT will display the five elements whose surface scattering energy is around the position defined by the cursor. PROFILE will rescale the simulation in units of concentration vs. depth. Also, while doing simulations, equations can be used for depth dependent concentration profiles, p. 14.

Use of the MACRO command, p. 17, makes complicated plotting very easy. Macros can be easily edited with the EM command. The command processor will also accept a full line of commands. This drastically increases the efficiency of commands which require input. Finally RUMP is a very large interactive program which requires an alert operator.

## D. MANIPULATOR

First read the operation manuals for the controller and the manipulator. Be familiar with the software, RC43.EXE, used to control the manipulator.

**Caution:**

**Before operating the manipulator remove all shipping braces. The X and Y slides are braced and the bellows are protected with plastic. Read the shipping instructions for the manipulator. Failure to remove the braces will result in damage to the manipulator.**

**Caution:**

**Caution:**

**Before operating the controller connect all electrical motor leads. Never disconnect a motor cable while the controller is on. A disconnected lead could cause damage to the controller.**

**Caution:**

When all braces have been removed and all electrical motor cables connected physically check and or adjust all limit switches. To do this move the motor by hand until you feel it start to become difficult to move. Move it in the opposite direction about one full turn and set the limit switch at this point. Do this for all the axes with limit switches.

Once all cables are connected and limit switches adjusted turn on the controller. Confirm that the controller and manipulator have ground cables connected to them. When the controller is power up each motor runs a stored program to set step rate etc. Each motor has a different program loaded. For backup the programs are stored in rbs/ims directory. The ims\_term program is used to download and save the stored program. The hand held controller is also activated. If equipped with a moveable detector motor, this motor is activated at power up for axis 5 rather than the in vacuum motor for the phi axis.

To established communications between the computer and controller, run the RC43.EXE program. The program will initialize communications with the controller. The step rate etc will get set at program startup. Now select an axis and move it. If the axis which moved is different from that specified by the computer then troubleshooting is required. Move all axes to their zero position. Use the reset command button to set this as the software zero position in the manipulator window. Now the computers zero position and the manipulators physical zero position are the same. The software manipulator position gets read from the manipulator controller at startup of the RBS program. The zero position may coincide with the sample transfer position. This allows the user to easily position the manipulator for sample transfer by hitting the Move To Zero button.

When a travel limit switch is tripped by the manipulator, motion is stopped for that axis. Now, this axis can only be moved away from the limit switch using the hand held controller or the software manipulator window.

Each motor has a power up program loaded. This program sets the step and acceleration rates, limit switches etc. How to download these programs and what they are see the stepper motor initialization section of this manual.

## E. SAMPLE ALIGNMENT CAMERA

The sample alignment camera is used to define the position of the beam spot of ~2 mm on the sample. Through the camera the sample is seen at 5X magnification on the monitor located in the console. To initially align the camera with the beam, focus and center the sample mount on the monitor screen by adjusting the camera in it's holder. Mount on the sample holder something which will fluoresce or burn when beam hits it. A glass slide works well. Run beam into the chamber and mark the beam position on the monitors screen using an erasable felt pen.

The camera can be swung out of the way to see inside the chamber if need be. When swinging it back into position the beam alignment described above must be checked and or redone. If you have an alignment scope then there is a ball plunger which is used for repositioning. Packing around the camera should be used to prevent light from getting into the chamber.

To swing the camera away from the window first loosen the screw which attaches the camera to the bar. Slide the camera away from the chamber until it can be swung without hitting the chamber. Move the camera out of the way and tighten the screw.

## F. OVERALL SYSTEM OPERATION

First check the vacuum system. If the system has not been used for ~12 hours the vacuum should be better than  $10^{-6}$  torr. Start the accelerator and focus the desired amount of beam into the chamber. Mark the beam spot on the sample monitor. Remove beam to the Faraday cup before the chamber. Insert samples into the chamber. If the load lock is used, the local manipulator controller can be used to align the manipulator sample holder to accept samples from the load lock.

Start the computer and load RC43.EXE program into memory. To do unattended RBS data acquisition log each sample position etc in the sample position table. Turn on the detection system. Before turning on the high voltage check the high voltage connection on the rear of the bias supply. For a silicon surface barrier detector the cable should be connected to the lower voltage output if it exists (0 to 100 volts). Slowly turn up the high voltage to the recommended operating voltage. See the detector sheet or detector container for the recommended operating voltage.

Connect the current integrator to the sample holder feedthru and to the chamber at the endstation if not already done. To use the integrator to determine spectrum run times connect "dumps out" output to the Counter card input. Also connect the GATE output on the counter card to the Gate input on the back of the MCA board (computer). Daisy chain if more than one MCA board is going to be used. Connect the data output from the amplifier to the main input for pulse height analysis. Set the required dose on the charge text box.

In the RC43 program click on DATA COLLECT menu item to display the Data Collection window. Allow beam to hit the sample or let the program take out the beamline faraday cup. Then push the MANUAL COLLECT button. A spectrum should start growing on the computer display. Edit the beam parameters if necessary. Once a spectrum is collected store it on disk. RC43.EXE will do this automatically at the end of the run. In RC43.EXE the filename extension used can be set. To read these files into rump use the "XEQ" command.

While a second spectra is being collected, run RUMP (RBS) to analyze spectra already on disk. Hard copies of analyzed spectra can then be plotted and annotated for future reference. To plot spectra use the plot button in on the RUMP window. It is strongly recommended to put all the plotting commands in a macro file and then run the macro file eg. "XEQ filename" for annotated plots. When all the samples have been analyzed just reverse the above process to shut things off.

#### IV. REFERENCES

##### **RBS:**

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Materials Analysis by Ion Channeling, L. C. Feldman, J. W. Mayer, S. T. Picraux, (Academic Press, N.Y. 1982)

Empirical Stopping Powers For Ions in Solids, J.F. Ziegler, J.P. Biersack, and U. Littmark, IBM Research Report RC9250 (1982).

A paper written on the data analysis software (RUMP) is:

"A Semiautomatic Algorithm for Rutherford Backscattering Analysis", L. R. Doolittle, Nuclear Instruments and Methods in Physics Research B15 (1986) 227-231 North-Holland, Amsterdam.

##### **Resonant Scattering processes and Nuclear Reaction Data:**

Handbook of Modern Ion Beam Materials Analysis, J.R. Tesmer, M. Nastasi, Materials Research Society, Pittsburgh, Pennsylvania 1995.

##### **PIXE reference:**

PIXE A Novel Technique for Elemental Analysis, Sven A. E. Johansson, John L. Campbell, Wiley & Sons, 1986

##### **Multi-Analysis:**

Fundamentals of Surface and Thin Film Analysis, Leonard C. Feldman, James W. Mayer, North-Holland, 1986

Encyclopedia of Materials Characterization, C. R. Brundle, C. A. Evans Jr. S. Wilson, (Butterworth-Heinemann, Boston, 1992).

High Energy and Heavy Ion Beams in Materials Analysis, 1989 MRS Proceedings, J. R. Tesmer, C. J. Maggiore, M. Nastasi, J. C. Barbour, J. W. Mayer, (Materials Research Society, Pittsburgh, Pennsylvania, 1990).

## **V. DOCUMENTATION INCLUDED**

14-0-2226	2LA022260	Endstation, RBS Assembly
14-0-2077	2LA020771	Sample Holder Assembly
14-0-2109	2LA021091	Manipulator, 5 axis, CBM Assembly