PROCEDURE FOR OPERATING THE RU 12-INCH CYCLOTRON

By Tim Koeth

The following are “nominal” instructions for turning on the cyclotron. The operator may not need to or be interested in turning on all components, but can still use this document to follow the outlined procedure in operating any of the cyclotron sub-systems.

Each subsystem is described and illustrated on the cyclotron’s web page. The student should thoroughly review this document as well as the web page descriptions (http://www.physics.rutgers.edu/cyclotron/) and of course visit the cyclotron itself to become familiar with the equipment before operating any portion of the cyclotron.

I. PRE-OPERATION CHECK LIST – CHECK EVERY TIME!
   a. Ensure AC mains power to control rack is on (typically always left on)
   b. Ensure AC mains power to magnet table is on (typically always left on)
   c. Ensure city cooling water main valve is open (valve located on wall near sink)
   d. Ensure two “Tarzan” cooling fans located in rear of control rack are running.

II. STARTING CONTROL COMPUTER
   a. Turn on All GPIB Equipment (see photo below for identification):
      i. HP3497A in control rack
      ii. Keithly 197A DMM
      iii. HP3427? Bias voltmeter meter
      iv. HP3022 Filament Heater
      v. HP8165A Signal Generator (AKA Synthesizer)
      vi. National Instruments GPIB extended located in the rear of the control rack
      vii. National instruments GPIB extender locate in the magnet table
      viii. HP3497A located in the magnet table
   b. Turn on the AC power to the IG3
   c. Once PC is booted, run latest version of Cyclotron Controls (cyclotroncontrols_v8.5.vi as of this writing)
   d. With Cyclotron Controls VI loaded click on the continuously running button – this starts the VI and the operator will see the GPIB equipment begin remote operation. i.e. the HP3497 begin to scroll through their MUX channels.
III. TURNING ON COOLING WATER:
In the VI, on the bottom of the control panel click on the button to turn on the water flow. The red button should turn green, and the red water flow “lamp” on the annunciator panel should also turn green. The operator should inspect the four VISUAL indicators that positively show water flow.
   i. The proteous flow controller on the underneath of the magnet table
   ii. The proteous flow monitors on the top magnet coil
   iii. The proteous flow monitors on the bottom magnet coil
   iv. The graduated water flow indicator for the diff pump (0.2 GPM)

IV. TURNING ON THE VACUUM SYSTEM (the operator should visit http://www.physics.rutgers.edu/cyclotron/12inchvacsys.shtml to become familiar with the vacuum system components) At the time of writing this version, the vacuum system is manually controlled, but there are provisions to operate the vacuum system in the Cyclotron Controls VI.
a. Ensure Cyclotron Vacuum chamber is installed in the magnet (see chamber installation procedure)
b. Ensure Hydrogen leak valve is closed
c. Ensure Mass Flow Controller is powered down, or set for 0 flow
d. Turn on mechanical fore-pump (pump will be heard)
e. Open Safety Valve (if system was at atm pump loading will be heard)
f. Open Main Chamber Valve (once open yellow lamp on valve housing will illuminate)
g. Wait for entire system to pump to 2E-2 Torr or lower (as measured on Sensor 1?)
h. **ENSURE** cooling water to Diff pump is 0.2GPM
i. Once system is has been pumped to 2E-2 Torr or lower turn on Diffusion pump. The diffusion pump Variac should be set to 110VAC. The diff pump turn-on process will take about ½ an hour. As the diffusion pump is heating up, the foreline pressure will rise slowly up to hundred of milliTorr. As the Diffusion pump starts to pump the foreline pressure will begin to once again drop.
j. Once chamber pressure is below 1E-2 Torr quickly add Liquid Nitrogen (LN2) to the cold trap. If LN2 is much above 1E-2, any air or moisture will be frozen out instead of pumped out. Frozen moisture will sublimate and outgas for a long time (days) and may be confused for a slow leak). If the LN2 is not added soon after 1E-2 Torr is reached, back streaming oil from the diffusion pump will contaminate the cyclotron chamber

k. The thermocouple mounted on the Diffusion pump will read about 250°C.
l. After the LN2 is added the operator should go to the Inficon IG3 and turn on Ion Gauge by depressing the EMIS (for emission) button [the magnet should be off at this point]. The filament in the ion gauge should illuminate and the IG3 display should read the pressure. If the pressure is about 1E-3Torr the IG3 will shut itself off. The operator should wait for the pressure in the chamber to to fall below 1E-6 Torr (5E-6 Torr if really impatient).

V. **TURNING ON THE ELECTROMAGNET**

a. Ensure all metal objects are outside of the “safety zone” (Black/Yellow Tape barrier)
b. Ensure cooling water is flowing (input pressure should be above 10 PSI and both Proteous flow controllers should be in motion) *In the future the proteous flow monitors will be monitored by an interlock chassis.*
c. Turn on to HP6269B power supplies located in the bottom left of the control rack. Typically magnet control is executed through the lab view VI, but at the time of this document’s writing, magnet control is performed from the front panel of the Upper HP6269B (the primary supply).

d. Slowly adjusting the coarse and fine current knobs, set the magnet current to the desired value. CAUTION when turning down the magnet current, do so slowly to prevent back-emf from damaging the power supply. Only when the current is down to 0 shut the mains off.

VI. TURNING ON THE RF POWER (50 WATT REGIME)

a. ENSURE that the chamber vacuum is below 1E-3 before turning on RF
b. ENSURE that the chamber is properly connected to the matching box
c. ENSURE that the matching box lid is securely fastened
d. ENSURE that all RF cables are connected
e. Turn on the Tektronix 2213 oscilloscope (located above the LCD monitors)
f. Turn ON the HP8165A Signal Synthesizer
g. Set HP8165A’s amplitude to 10mv:
   i. On the HP8165 Press the “LOCAL” button
   ii. On the HP8165 Press the “AMPLITUDE” button
   iii. On the HP8165 type in 10 and then press the “mV” button
   iv. On the HP8165 press the “RF ON/OFF” button, the Amplitude display will extinguish
h. Turn on the ENI 350L Amplifier
i. Press the “RF ON/OFF” Button on the HP8165 – the drive amplitude will be displayed
j. Set the RF frequency in the range of resonance (~ 14.900MHz is low)
   i. On the HP8165 press the “FREQUENCY” button
   ii. On the HP8165 key-pad enter 14.900 then press the “MHZ” button
   iii. Press the “FINE” button several time to highlight the 1kHz place
k. Sweep the RF frequency to find the cyclotron resonance
   i. On the HP8165 press the “FREQUENCY” button
   ii. While pressing the “↑” button on the HP8165 watch the TEK 2213 scope channel 1 for maximum response. Maximum response occurs at resonance.
l. Slowly increase the RF drive amplitude in steps of 10mV
   i. On the HP8165 press the “AMPLITUDE” button
   ii. Enter 20 on the HP8165 key-pad
   iii. Press the “mV” button, and the drive amplitude of 20mV will be displayed
   iv. Repeat steps ii. and iii until 50 Watts of FWD power is achieved (DO NOT exceed a setting of 250mV amplitude on the HP8165)
m. The operator can determine the DEE peak-to-peak voltage from the calibration curves in the log book or the RF DEE Voltage Studies paper located on the cyclotron web page.

VII. TURNING ON THE ION SOURCE

a. Ensure vacuum system is satisfactorily running
b. Ensure IG3 Ion Gauge is OFF
c. Ensure Cooling water is flowing
d. Ensure Magnet has at least 10 Amps of current flowing (the magnetic field suppresses arcing in the ion source)
e. Turn on AC power to Kepco HV [Bias] power supply
f. Turn on AC power to HP3022? [filament heater] power supply
g. Turn Kepco’s HV switch from STANDY to HV ON (-200V)
h. With filament biased slowly begin to heat the filament by increasing the current through the filament with the HP3022 power supply. As the filament heats up, an incandescent glow will be seen through the cyclotron chamber view ports. While heating the filament, watch the bias current (filament emission current). Heat the filament until the emission current is between 50 and 70mAmps (as read by the Keithly 197 DMM) As of this revision, a voltage of 5.50 V and a current of 22.5 to 22.7 Amps was optimal for operation. CAUTION increasing the filament heater current much higher quickly erodes the Th-W filament, a current of 27 amps will almost instantly destroy the filament. The filament is designed to be replaced, as it often will have to be, but replacement is a tedious process that consumes several hours. NOTE if arcing occurs, the fuse in the front panel of the Keithly may blow, replace only with the rated value fuse)
i. Open the Hydrogen bottle, note that the high pressure gauge reads 100PSI or more. SHUT THE HYDROGEN BOTTLE, there is enough gas “charge” for several hours of running.
j. Adjust the regulator (turning knob CW) to increase the low pressure side to 10PSI.
k. Bypassed as of this revision. In the VI click on the “Hydrogen Valve” to open the Hydrogen safety valve.
l. For manual operation, slowly increase the “variable leak” to a setting of 106. As you approach a leak setting of 95, watch both the pressure as read on the GP ion gauge and emission current as read on the Keithly 197.
m. Visual inspection through the smaller cyclotron chamber view port should show a plasma jet exiting the ion source’s chimney aperture that faces the DEE.

VIII. CONTACT INFO: CYCLOTRON EXPERTS

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