CHA EVAPORATOR

User guidelines

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Introduction.

The CHA evaporator has the following characteristics:

1. 2 independent resistive power supplies.
2. 1 Electron Beam Gun (E.B. Gun) with 4 automatic crucible holders.
3. Two 4 inch (100 mm.) round targets.
4. IC/5 Automatic Deposition Controller
5. A mechanical pump with a roots blower and a cryopump.

Allowed Materials are:

- Ag, Au, Cr, Ge, Ni, Mo, Pd, Pt, Ti, W

Allowed uses:

- Only approved users may operate this system.
- The CHA evaporator has been assigned for thin films. No deposition should be thicker than 5000 Å. (Even if you use multiple metals the total thickness per evaporation session should be less than 5000 Å)
- Do NOT make initial melts of material on this system. USE THE NRC EVAPORATOR FOR THIS PURPOSE.

Procedure:

The CHA evaporator is divided into 16 different panels. These panels are labeled on the machine with a number and/or a description. This procedure will use this labels to refer to the panels. See the appendices at the end of this procedure for images of the panels.

PUMPING, VENTING AND LOADING.

PANEL NO. 1 AUTO TECH II is the controller for the pumping cycle and the bell jar for the system. See Appendix I for pictures of the panels and Appendix II for pictures of the inside of the Bell Jar.

Vacuum Gauges:

Panel NO. 13 VACUUM GAUGE CONTROL controls the pressure gauges in the machine. The CHA evaporator has two ion gauges and two convectron gauges. Convectron gauges can read pressures from atmosphere to 10^{-4} Torr. Ion Gauges can read pressures lower than 10^{-4} Torr. Ion Gauges will turn themselves off if pressure rises above 10^{-4} Torr. Convectron Gauges will read 0 for pressures below 10^{-4} Torr. The format for the displays is given by a 2-digit mantissa and 1 digit exponent. So 2.3 –5 means $2.3*10^{-5}$ Torr.

The display labeled IG will display the pressure for 1 of the Ion gauges at a time. Please notice that it's not possible to have both ion gauges on at the same time. If you are not reading a pressure of an Ion gauge, this means that gauge is off.

- Convectron gauge A reads the pressure behind the roughing valve on the roughing pump side. This pressure can be read on the "A" display.
- Convectron gauge B reads the pressure at the chamber. This pressure can be read on the "B" display.

- Ion Gauge #1 reads the pressure on the cryopump. Display labeled IG.
- Ion Gauge #2 reads the pressure at the chamber. Display labeled IG. THIS GAUGE SHOULD BE ON AT ALL TIMES DURING EVAPORATION. This gauge is interlocked to the E.B. Gun and resistive power supplies, if you turn this gauge off during evaporation it will TURN YOUR POWER SUPPLIES OFF. (Crash the E. Beam)

Green indicator lights:

There are six green light indicators on the vacuum gauge controller, when either of these lights go on they mean:

1. Chamber pressure is below 10^{-6}. You may begin your evaporation
2. Not used
3. Not used
4. Not used
5. The Roots blower is on.
6. Cold Water is on, you may turn the E.B. Gun on.

Venting the system:

1. Make sure the Water Lines for the E.B. Gun, the Thermal sources and the Crystals are open. (Room temperature water flows through these during the vent cycle to prevent water condensation when the bell jar is open)
2. In PANEL NO. 1, make sure the knob selector is on AUTOMATIC. The Selector may have to be unlocked to move it. The Selector is locked and unlocked via the key on that same panel.
3. The 4 Manual switches should be off (down position)
4. Switch the Auto Control switch (Underneath the Selector knob) to RAISE/VENT (up position) position. The System should automatically vent itself and open the chamber.

Loading the system: (See Appendix II)

1. On PANEL 6. SHUTTER AND TARGET ROTATION CONTROL. Turn the Target switch to FIXED. (Note that you must gently pull on the switches while switching them).
2. Turn the knob to SUBSTRATE 1 SOURCE 1. This will bring Target No. 1 to the front of the machine. Load your holder. Turn the knob to SUBSTRATE 2 SOURCE 1. This will bring Target No. 2 to the front of the machine. Load the other holder here. This holder should be loaded even if it has no samples on it to keep the weight on the turret balanced.
3. On PANEL NO. 6 open the necessary shutters using the three shutter switches. Load the metals on the resistive sources. **The Source #3 (the one on the right side of the machine) is reserved for Gold.** Source #2 may be used for all other materials. If you will be changing the boat then remove the shield and use the Allen key to carefully load the boat. Make sure to properly replace the shield when you are done. To load metals on the **E.B. GUN SOURCE** select the appropriate pocket by changing in PANEL NO. 2. E.B. GUN ROTATION CONTROL the switch to MANUAL position and changing the source selector knob to the desired location. **Pocket #1 is reserved for the Ti house source, pocket #2 is reserved for Pt.** Pockets #3**,** and #4 can be used for all other materials. Close all the Shutters and place your Samples on the correct position for evaporation.

Pumping the system.

1. Check that the 3 shields are in position. Check that the 3 shutters are closed. Check that the position of the mirrors are such that you can see all 3 sources by looking at them with your eyes leveled with the E.B. Gun shutter. Make sure the knob on PANEL # 1 is set to AUTOMATIC.

2. On PANEL #1 Switch the Bell Jar switch to START/LOWER Position (switch all the way down).
3. After 20 seconds the bell jar will lower and the pump cycle will start.
4. Once the pressure in the chamber reaches 100 mT (See PANEL NO. 13 display B) the machine will change from the Mechanical pump to the Cryopump (crossover).
5. If after 1 second the pressure is too high for the cryopump, the high-vac valve will automatically close. In PANEL NO. 1 The standby light will go on and the "H" light will go on. This means an error on the high-vac valve. On PANEL NO. 1. switch the Bell Jar switch to STOP/STANDBY position for 3 seconds (middle position), then back to START/LOWER position to repeat the cycle (down position).
6. If the high vac error persists after 3 attempts at cycling it then it may be necessary to **MANUALLY PUMP THE SYSTEM.** Check the pressure at the chamber (PANEL 13 DISPLAY "B"). If it is not below 100 mT. (Display should read below 1.0 –1) contact the SUPERUSER. If the pressure is below 100 mT. then on PANEL NO. 1 switch the AUTO CONTROL switch to STOP/STANDBY and change the knob to MANUAL mode. From the manual switches, turn the HIGH VAC switch on. On Panel NO. 13, turn ion gauge 2 on and verify that the pressure is below 10^{-4}. If it is not IMMEDIATELY CLOSE THE HIGH VAC VALVE AND CONTACT THE SUPER USER.
7. If there is no error then the HIGH VAC on PANEL NO. 1 AUTO TECH II will remain on and on PANEL NO. 13 IG2 (Ion Gauge 2, chamber pressure) will automatically turn on. If the ion gauge does not automatically turn on you may turn it on manually.

8. While the machine pumps down program the deposition controller and check your recipes.
9. When the pressure is lower than $4*10^{-6}$ degas ion gauge 2 for 10 minutes by pressing the Degas button on PANEL NO. 13.

Thermal Evaporation.

1. Check on PANEL NO. 16 (Behind the evaporator on the wall) that the water lines for Thermal sources and Crystal monitors are open.
2. Verify on PANEL NO. 13. That the green LEDs numbered 1, 5 and 6 are on. On that same panel, make sure that Ion Gauge #2 (chamber pressure) is on.
3. On PANEL NO. 6. make sure that your samples are on the correct source.
4. On PANELS NO. 11 OR 12. Make sure the power supply is in REMote mode. Make sure the dial is reading AMPS. Turn the power supply on.
5. On PANEL NO. 10 select and run the correct procedure/s. See section "IC/5 DEPOSITION CONTROLER" in this document for more details.
6. When finished with the deposition, turn the power supplies OFF.
7. Wait 10 minutes before venting the Bell Jar.
8. After unloading your samples, pump the bell jar down to $5*10^{-6}$ Torr. Leave the system in STANDBY MODE (On PANEL NO. 1. Knob selector in AUTOMATIC and the Bell Jar switch on STOP/STANDBY: middle position). This should take about 10 minutes.
9. Close the water Lines

E. Beam Evaporation.

1. Check on PANEL NO. 16 that the water lines for E. Beam source and Crystal monitors are open.
2. Verify on PANEL NO. 13. That the green LEDs numbered 1, 5 and 6 are on. On that same panel, make sure that Ion Gauge #2 is on.

3. On PANEL NO. 6. make sure that your samples are on the correct source.
4. On PANEL NO. 2. Make sure that the Switch is in the AUTOMATIC position and that the correct pocket is selected. (If it's not change it from the IC/5 controller)
5. On PANEL NO. 15. (Big Power supply to the right of the evaporator) Turn the E.B. Power supply ON. Notice that the fan on the side of the power supply should be unobstructed.
6. On PANEL NO. 9 Turn the High Voltage ON Adjust the voltage to 10,000 Volts. Turn the Emission current ON.

   Notes on PANEL NO. 9: There are six knobs on the right side of the panel. The top row of the knobs controls the longitudinal motion of the beam, the bottom row controls the lateral motion of the beam. The left most buttons control the position of the beam. The middle knobs control the frequency of the beam sweep: TURNING THESE KNOBS COUNTERCLOCKWISE INCREASES THE FREQUENCY OF THE SWEEP. The right most knobs control the amplitude of the beam sweep: TURNING THE KNOBS CLOCKWISE INCREASES THE AMPLITUDE OF THE SWEEP. Please make sure that BOTH the frequency and amplitude of the sweep are set to a minimum when you are done with your evaporation: (Frequency knobs fully clockwise, Amplitude knobs fully counterclockwise).
7. On PANEL NO. 10 select and run the correct procedure/s. See section "IC/5 DEPOSITION CONTROLLER" in this document for more details.
8. When finished with the deposition, turn the power supply OFF. PANEL NO. 15.
9. Wait 10 minutes before venting the Bell Jar.
10. After unloading your samples, pump the bell jar down to $5*10^{-6}$ Torr. Leave the system in STANDBY MODE (On PANEL NO. 1. Knob selector

in AUTOMATIC and the Bell Jar switch on STOP/STANDBY: middle position)

11. Close the water Lines

PANEL NO. 10. IC/5 Deposition Controller

Note: For a complete reference see the IC/5 Thin Film Deposition Controller USER GUIDE sections 3 – 6.

The IC/5 Deposition Controller can automatically control the E. Beam and thermal power supplies, the shutters and the E. Beam crucible selector. It CANNOT control the position and sweep of the E. Beam nor the position of the target (samples).

IC/5 Front panel: The Y and N keys stand for YES and NO. The E and keys stand for ENTER and CLEAR. The PRINT key should NOT be used. The F1 to F6 keys are used to navigate through the IC/5's menus. Their function is context dependent and can be read on the right margin of the DISPLAY. The MENU key is used to access a user-friendly navigation menu. It accomplishes the same purpose as the F# keys.

IC/5 status: The IC/5 can be in 3 different basic states: READY, STOP or Running. The READY state is the state the IC/5 will be in when it's ready for operation or programming: The word READY will be on the main OPERATE display. The IC/5 will be in STOP state after finishing a process or when the user manually hits the STOP button on the front panel or on the handheld remote. Note: In STOP mode some programming features are disabled. To Get from STOP to READY press the RESET button on the front panel. The Running state can be a variety of states the IC/5 will be in during a process execution. Press the STOP key on either the remote or the front panel to stop execution of the current process.

IC/5 Menu Structure: The IC/5 has a hierarchical menu structure with 2 main levels: The OPERATE and the PROGRAM Menu.

The OPERATE menu is used to run a procedure. It will display all the information about the current process. Refer to page 3-12 of the IC/5 users guide for a complete description. To get to the program menu from anywhere in the IC/5 hierarchy press the MENU key and then F6.

The PROGRAM menu gives you access to the Material Directory and the Process Directory. More information on these can be found on the section "Programming the IC/5"

IC/5 Floppy Disk:

The IC/5 uses standard 3.5'' floppy disks. Please use only NEW IBM formatted floppies.

Using the IC/5 Deposition Controller

1. Select the process you will run. To do this make sure the IC/5 is in READY state.
2. If you will be loading your process from a floppy disk then load the process from the PROGRAM-I/O-FLOPPY DISK directory
3. If you know the process number you will run and you know it needs no adjustments (and it's a number less than 8) you can use the PROCESS SELECTOR in PANEL NO. 2 to select the active process
4. If you want to verify the content of the process then select the active process from the PROGRAM-PROCESS menu. That menu will show you all the current processes on the IC/5. Use the arrow keys to navigate to the process you want. Press F4 to make it the active process.
5. To Specify the desired thickness press the F5 PROCESS key. You may now specify the Final Thickness and desired Deposition Rate for each layer of your process. NOTE: It's assumed here that the process has been previously characterized and that the RISE and RAMP times as well as the CONTROL GAINS have been correctly adjusted.

6. Press MENU and then F6 to get back to the OPERATE menu. Verify on the top middle section of the screen that the process and material selected are what you expect.
7. If the first Layer will be an E. Beam deposition and the current E. Beam crucible is not the right one you have to do a CRUCIBLE SWITCH. **BEFORE TURNING ON THE POWER TO THE EBEAM.** To do this press START on the IC/5 PANEL 10. The IC/5 should display SOURCE SWITCH and the RISE 1 stage will start. This is OK you have NO power to your ebeam. Once the pocket is in correct position press STOP. Press RESET. Turn the E. Beam ON.
8. In PANEL NO. 6 make sure the Shutter switches and Target position are in the right location. Shutters should be in Automatic and Target position should be in SUBSTRATE 1 (OR 2) - SOURCE 1. (Source 1 is the Ebeam)
9. Press START on the front panel of PANEL 10 IC/5 controller.
10. You can manually reset the thickness monitor pressing F1.
11. At any time during the process you can override the automatic operation by pressing F3. This will automatically open the shutter and the source power control will then be controlled from the handheld remote. Once you have achieved the deposition rate you want you can return to automatic control by pressing F3 again.
12. When the Deposition is done, turn the power supplies off and wait 10 minutes before venting.

Programming the IC/5 Deposition Controller

Programming a recipe for the IC/5 involves 2 steps:

- Defining the Material Properties. Here are the suggested values.
  1. Menu PROGRAM-MATERIAL DIRECTORY-MATERIAL.
  2. There you can select the material to add from the material library.
  3. Select the material you want and press F5 MATERIAL

4. Source: Ebeam: 1, Thermal: 2 (3 is for Gold)
5. Control Loop: Use 2 for automatic control.
6. Process gain: The lower the gain the faster the system will respond to meet the specified rate. Be careful: IF YOU SPECIFY TOO LOW A GAIN, THE SYSTEM WILL BECOME UNSTABLE. Suggested value: ebeam: 5, Thermal: as low as 4.
7. Master tooling: Ebeam:77%, Thermal: 70%. If you find that these values do not yield very precise results you can tune this with the following formula: Tf=Tfi(Tm/Tx). Where Tf is the new tooling factor. Tfi is the initial tooling factor. Tm is the actual thickness, Tx is the nominal thickness. Let the Superuser know if you plan to alter this parameter
8. Recorder Output, Function, Crystal quality and stability = 0
9. Page 2. Maximum power: Ebeam: 65%, Thermal 85%.
10. Soak Power 1. Ebeam: 27% (this is when the E. Beam actually turns on), Thermal: 45% (This is where gold melts, adjust as necessary)
11. Rise Time 1. Ebeam: 1 minutes, Thermal 3 minutes.
12. Soak Time1. Ebeam: 3 minutes, Thermal 3 minutes.
13. Soak power 2, rise time 2, soak time 2. To be determined depending on the boat and material. EXPERIMENT ON MANUAL MODE BEFORE GUESSING. It's safer to go very slowly and then adjust as necessary.
14. Auto-Soak 2? Yes. This will let the IC/5 change the soak 2 parameters based on the last run of this material.
15. Rest of parameters on second page: 0.
16. Page 3. Crystal to be used. Crystal = 1 is for EBEAM, Crystals 2 and 3 are for Thermal. (3 is for GOLD only) Adjust only 1 crystal with these 3 parameters: Option = 4, Weight = Tooling = 100 %

- Defining the Layer Structure. Here are the suggested values:

1. Menu PROGRAM - PROCESS DIRECTORY. Select a slot and press F5 PROCESS.
2. Specify the materials for each successive layer. NOTE: *When programming a composite recipe with E. Beam and Thermal evaporations it may be a good idea to have separate processes for each.* The reason is that you have to manually switch the Target.
3. Specify the Number corresponding to the metal to evaporate.
4. Specify the Rate of deposition
5. Specify the Final Thickness.
6. Thickness limit = 0.
7. Co-Deposition: NO
8. Ratio control = 0.
9. Rate Watch time= 0.
10. Ratewatch accuracy = 5.
11. Crucible: EBEAM: Crucible where you put the metal, Thermal = 1.

Appendix I. Evaporator Panels.

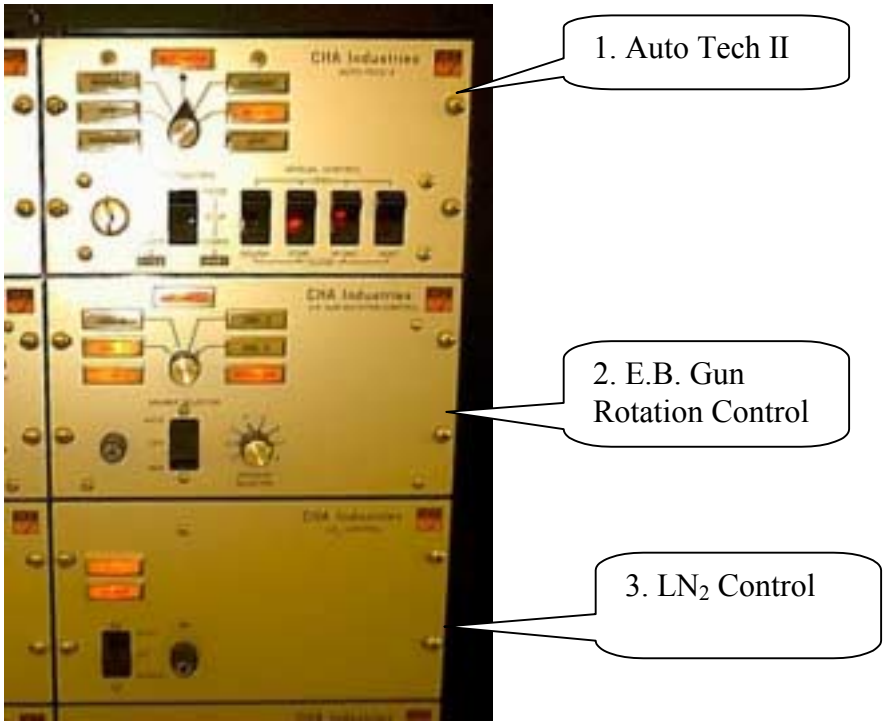

Figure 1. Top: Auto Tech II controller, Middle: 2. E.B. Gun Rotation Control. Bottom: 3. LN2 Control, Always leave on AUTO position.

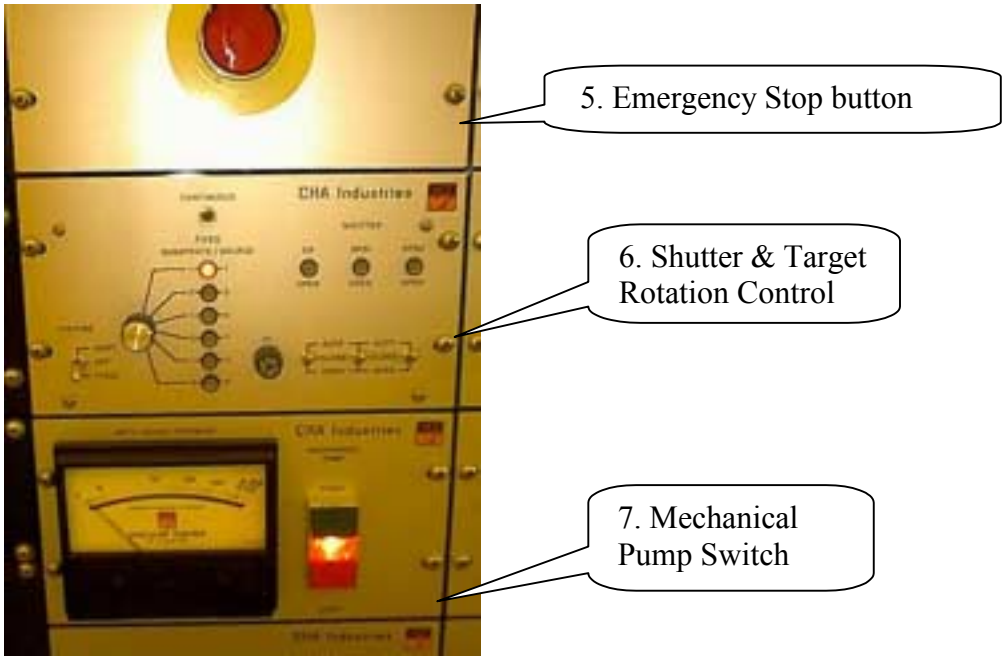

Figure 2. Top: 5. Emergency Stop, Middle: 6. Shutter and Target Rotation Control, bottom: 7. Mechanical pump Power Switch, this should always be on.

Figure 3.: 9. E.B. Gun Control. Source #1

Figure 4: 10. IC/5 Deposition Controller

Figure 5: 11 and 12. Resistance Power Supplies.

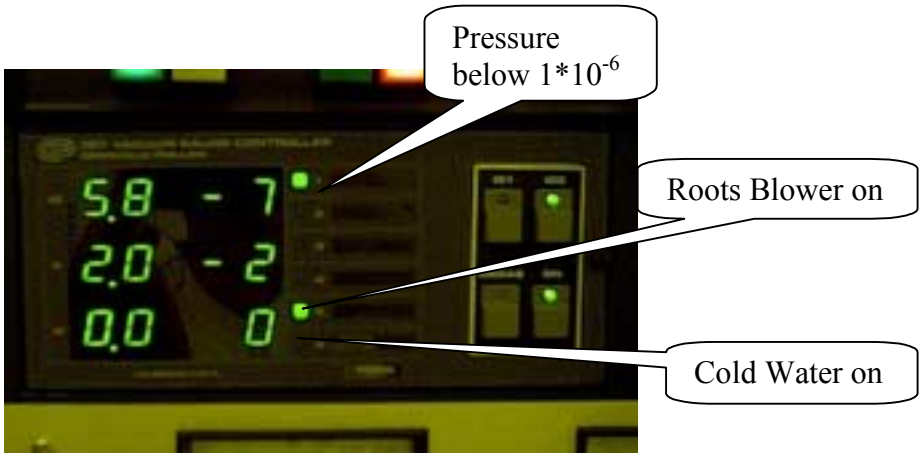

Figure 6: 13. Vacuum Gauge Control

Figure 7: 14. Cryopump Control. Don't press the BLUE button.

Appendix II. Inside the Bell Jar.

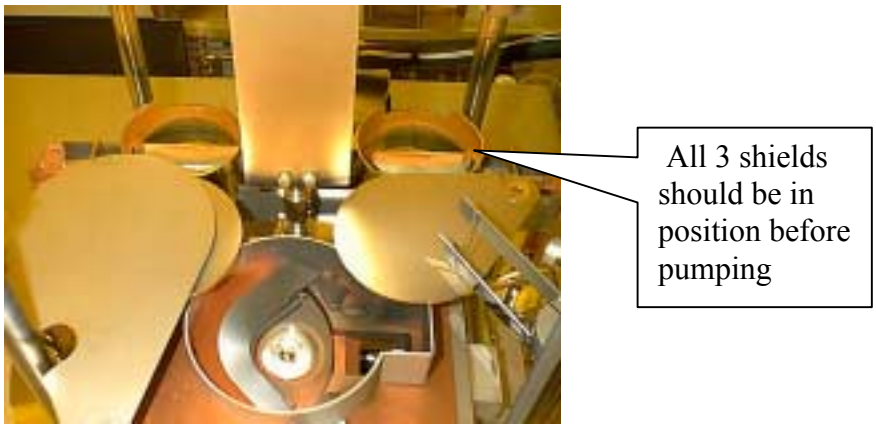

Figure 8: E.B. Sources and Thermal sources.

Figure 9: Side View of the Sources. Notice the shields and view mirrors.

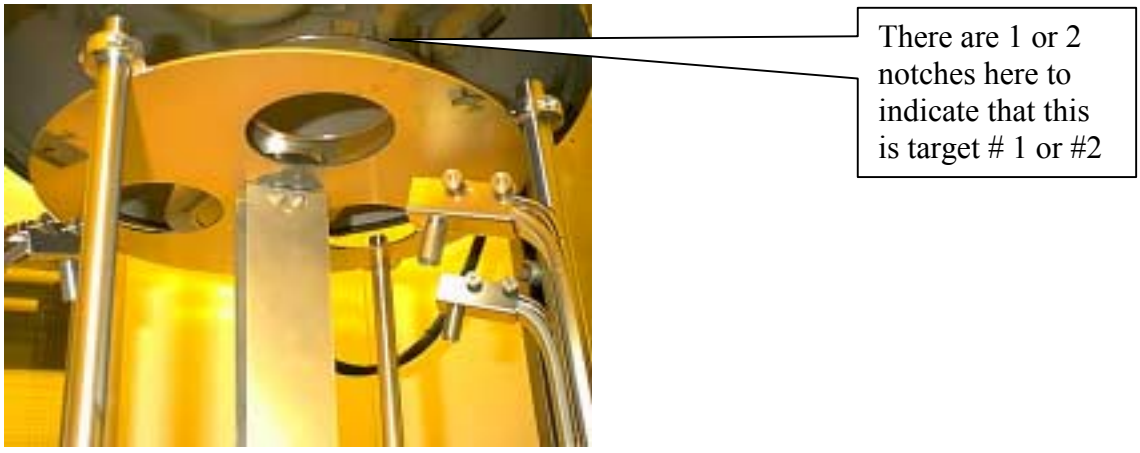

Figure 10: Target Turret. There are 3 openings for each source, one crystal monitor for each source and 2 targets.