Square Tank Pseudo-Normal Incidence Reflectivity Measurements

Measurement Overview

General Procedure:

1. **Set up SQ tank**, **identify** incident and reflected **positions**, then configure in incident position.
2. Verify light source using 161 nm deuterium line, use peak up procedure (find max/2 in both dimensions)
3. Scan Monochromator from 120 – 220 nm measuring incident count rate at PMT.

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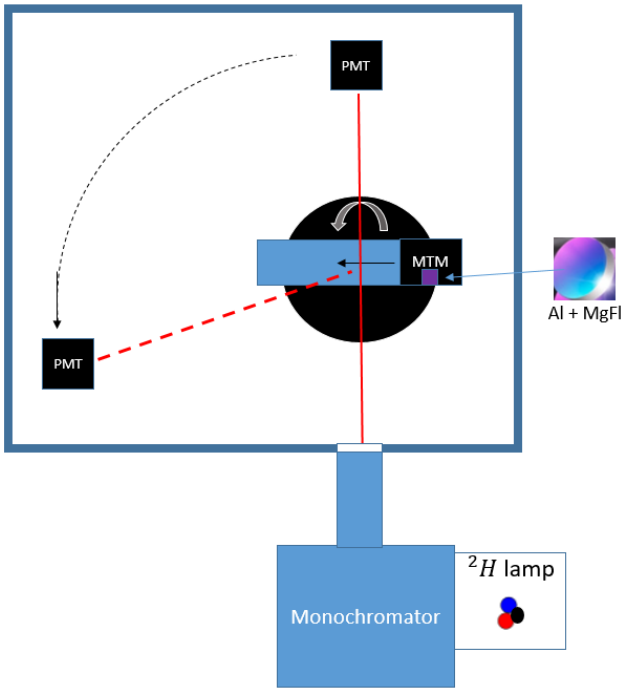
4. Configure set up in reflected position
5. Repeat peak up procedure
6. Scan Monochromator from 120 – 220 nm measuring reflected count rate at PMT.
7. Repeat steps 1-6 with MCP instead of PMT, and hollow-cathode instead of deuterium lamp, with scans conducted from 90 – 128nm



Set up SQ Tank and Systems

SQ Tank pump down procedures

1. Plug in exhaust fan
2. Turn on water chiller for rough
3. Ensure SQ Tank is closed and all systems isolated!!!
4. Press ‘start’ on rough pump to turn on
5. At 80 mT, turn on power strip. This powers the first two solenoids on manifold and closes the vent valve on clean room side of manifold.
6. At 80 mT again, open to chamber.
7. At 80 mT in chamber: close chamber rough -> turn off power strip -> turn off rough pump -> unplug exhaust fan. Leave chiller on if using monochromator, else, turn off rough water chiller
8. Make sure unnecessary systems are off and chamber is isolated!
9. If cryo temp ~ 12 K and its compressor is on, open up the cryo gate valve.
10. After ~ 30 secs you should be in the low -5’s and can operate the ion gauge. Wait till -6’s to operate MCP.

SQ Tank back to air

1. Make sure all systems off and cryo gate valve closed (stages can be left on)
2. Change back fill timer to ~10 min
3. Turn on chamber purge.

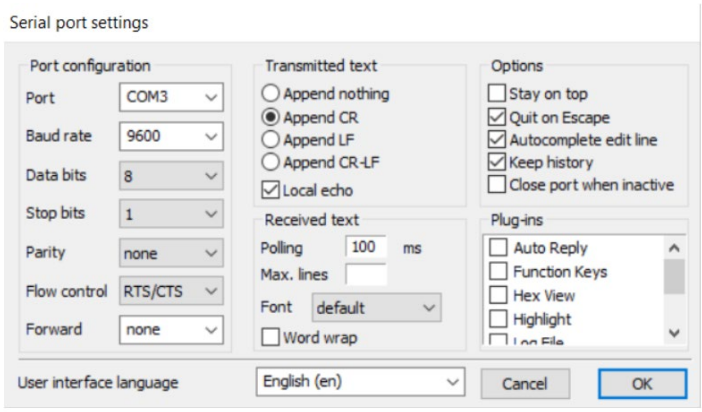
4. If going to partial, turn off at 200 Torr.

Pumping down monochromator

1. Make sure the correct light source is connected and all other ports are closed, if using HCL, ensure second scroll pump is attached and cooling input should come from below b/c bubbles flow up, also ensure a pressure gauge us hooked up to the HCL.
2. Turn on scroll pump connected to turbo. If using HCL, also turn on scroll pump to lamp.
3. Let pump down to 1e-1 Torr (ideally, can work with < 2e-1), then turn on turbo. On startup, power will go to 175W. It should settle with: P ~ 19W, I ~ 0.24A, T ~ 21 deg C, and 56 kRPM.
4. Turn on monochromator's water chiller, the hollow cathode lamp (HCL) water tubing must be connected for water to flow.
5. **Wait** till monochromator is at P = 1e-5 (bottomed out) and SQ Tank is pumped down before opening the light source isolation gate valve. And in general **wait** to do this step until you're ready to commence testing.

Using Monochromator

1. Make sure monochromator is off
2. Plug in RS-232 9-pin dsub into monochromator
3. Plug other end of RS-232 into your computer
4. Open Termite
5. Confirm settings and press okay.:



6. Confirm port is open on Termite.
7. Turn on monochromator. Both monochromator and Termite screens should confirm connection. i.e. Monochromator -> "computer control", Termite -> "Acton Rsch…" in green
8. Two main Termite commands:
   - 121.6 goto # sends out 121.6 nm
   - ?nm # returns current wavelength
9. You can go to the desired wavelength and disconnect the Termite connection. If using PMT, you can verify everything's working with the 161.0nm deuterium line.

Setting up PMT

1. Go inside SQ tank and hook up PMT if not already installed. Unplug A,B,C, or D (just one!) from pre amp box and plug it into the PMT. Also, unplug the HV power supply from the MCP and plug it into the PMT.

2. In the control room, make sure the corresponding signal wire (A,B,C or D) is unplugged from the position analyzer and instead plugged into the 'input' of the Hammamatsu preamp.
3. Set the pre-scalar on Hammamatsu to 1.

Setting up MCP

1. Ensure MCP is installed into detector holder and PMT is in purge box.
2. A,B,C, and D should be plugged into the associated pre amp.
3. 4 signal wires from MCP should be plugged into back-end of pre-amp. The wire with the least number of zipties on it goes on top, the second least is second from the top, and so on.
4. Plug HV power into MCP detector
5. Ensure A,B,C, and D are plugged into corresponding ports on the position analyzer box in the control room.

Setting up Universal Counter (UC)

1. If using MCP, plug the rate output from the position analyzer into channel 1 on UC. If using PMT, plug Hammamatsu output into channel 1 on UC.
2. Plug an RS-232 into the UC. Plug the USB end of this cable into computer.
3. In computer: Control panel -> view devices & settings -> hardware & sound -> scroll to the bottom and check COM ports. RS-232 connections should show up ports 3-5 (4-9 for Nick K's labtop)
4. Turn on UC, push 'recall', then push 'enter'.
5. Press the 'save and print' button 3 times until print screen is on.
6. Use the up or down arrow to select print 'on', then hit 'enter'.
7. Check that light next to 'save and print's is on
8. If using MCP, set impedance to 1 mega-ohm, if using PMT set to 50 ohms.

Finding incident positioning

1. Have SQ tank and monochromator at local atmospheric pressure.
2. Hook up 'Dragon's Flame' or other visible light source to monochromator.
3. Send beam into the tank and verify spot size & shape is acceptable at far end of SQ tank, i.e. it will fit onto the detector.
4. Adjust slit sizes on monochromator as necessary. Be careful as you could open to wide and affect the vacuum.
5. Move the MTM so that mirror sample is not obstructing light path. Sending the MTM to its maximum positive value is a recommended procedure for ensuring repeatability.
6. Move the swing arm and UTM100 such that the light is incident on the detector.
7. Zero the swing arm and UTM100.
8. Record the positioning of: Swing arm, UTM, and MTM. These are the only three stages you should move once you begin the test.

Finding reflected position

1. Move the rotation stage and MTM such that the light reflects off the center of the sample to the desired angle.
2. A.O.I. = $\frac{180 degrees - Swing\_Arm\_degrees}{2}$. Swing arm moves 98.31 steps per degree. This angle may have to be adjusted to ensure no cable/hardware is obstructing the light path. Get as small an

angle as workable, convert swing arm steps to degrees and plug into equation to calculate the angle of incidence.

3. Record positioning of: Swing arm, UTM, and MTM. The rotation stage should be able to be left at this value.
4. Move MTM to its maximum positive value to ensure the light path is unobstructed with new rotation stage position. Adjust positioning and repeat steps 1-3 as necessary to satisfy a) reflection angle b) unobstructed light path in incident position.

Measuring 120 – 210 nm with the PMT

0. Identify incident and reflected positions using instructions above.
   Steps 1-6 are setting up systems and pumping down
1. Follow **setting up PMT** above.
2. Attach deuterium lamp to monochromator.
3. Follow **pumping down monochromator** steps above
4. Cover deuterium lamp to shield from harmful radiation.
5. Deuterium lamp should be warmed up for 30 min prior to test so turn on the deuterium lamp.
6. Follow **SQ tank pump down procedure** above.
   Steps 7-16 are turning on and using the PMT
7. Plug output from Hammamatsu into channel 1 of the Universal Counter.
8. Turn on power supply (BK precision), should be outputting 5V on both outputs.
9. Follow **Setting Up Universal Counter (UC)** steps above.
10. Ensure Universal Counter impedance to 50 ohms.
11. Follow the **Using Monochromator** steps from above to set up the monochromator, leave isolation valve closed.
12. When pressure in monochromator is 1e-5 (4e-4 w/ current gauge) and tank is at vac, open light source isolation valve, check for change on ion gauge.
13. Make sure ion gauge is off and UC is on.
14. Turn on HV (silver toggle at bottom of rack on 'ORTEC' stack), should see power red light turn on.
15. Zero the voltage knob and turn on DMM to DC voltage monitoring
16. Turn on silver HV and triphold toggles for det 1, check that red LED between these two toggles is turned on. It will turn of if the circuit is tripped.
17. Turn up voltage to 1.451 VDC (this is really kv), should start to see counts at 0.8v
    Steps 17 – 24 are obtaining measurement data with PMT
18. Using the 161.0nm deuterium line, verify the SQ Tank is in the incident position.
19. Disconnect from monochromator on termite so your python code can connect.
20. Perform peak up in the incident position with UTM (go to max counts / 2 in both directions, settle at average of these two positions)
21. Set code parameters and wavelength range (PMT_scan.py) in Spyder.
22. Open Anaconda Powershell Prompt and run the PMT_scan.py (shown as lamp_monitor.py below), keywords are the monochromator port, counter port, and csv to save data. (e.g. python

PMT_scan.py COM4 COM5 incident_dat.csv)

```
(base) C:\>cd Users\pahi9557\Desktop\Pollux

(base) C:\Users\pahi9557\Desktop\Pollux>python
Python 3.7.3 (default, Apr 24 2019, 15:29:51) [MSC v.1915 64 bit (AMD64)] :: Anaconda, Inc. on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> exit()

(base) C:\Users\pahi9557\Desktop\Pollux>python lamp_monitor.py COM4 COM5 junk.csv
Monochromator Port: COM4
Counter Port: COM5
Saving to file: junk.csv
Saving dakrs to file: junk_darks.csv
b'0 \r\n'
?NM 102.6  ok
```

23. This will save the incident flux and corresponding darks at each wavelength.
24. Change SA, UTM and MTM to reflected position.
25. Repeat steps 19 and 21 in the reflected position.
26. Reverse order relevant steps for shutdown procedure.

Measuring 90 – 128 nm with the MCP

0. Identify incident and reflected positions using instructions above.
1. Follow **setting up MCP** above.
2. Plug the rate output from the position analyzer into the channel 1 on UC.
3. Follow **Setting Up Universal Counter (UC)** steps above.
4. Ensure impedance is set to 1 Mega ohm on UC
5. Attach HCL to monochromator. Bubbles flow up, so cooling input should be come from below.
6. Attach 2nd scroll pump to HCL.
7. Follow **pumping down monochromator** steps above
8. Follow **SQ tank pump down procedure** above.
   Steps 9 - 21 are turning on and using the HCL
9. Make sure turbo has settled to nominal settings (see pumping down monochromator).
10. Make sure gas cylinder and regulator are correct and open.
11. Make sure water chiller for HCL is turned on.
12. Plug in HV to the HCL.
13. Open gas valve to lamp, can spark at 1e-1 Torr, can be jumpy, keep an eye on this value.
14. Turn on bertran series 105 high power supply, make sure knobs are 0'd, then turn on HV switch. Ensure HV on LED lights up. If not check that cable is plugged in on the lamp and that water chiller interlock is green.
15. Turn up voltage on Bertran series 105 to something high (0.4kv) so it's current limited.
16. Turn up current to spark it, 41.5 mA should be stable.
17. May have to kink tubing (interrupt flow) and start at once to ignite (simulating a step function startup).
18. Bring lamp down to operating pressure ~ (3to6)e-2 Torr.
19. Once pressure in chamber is mid -6's, open light source isolation gate valve. Make sure MCP **is not** on before you unisolate since it can cause the chamber pressure to rise.
20. Lyman Beta at 102.6nm is a good line to start on, then verify the lines you want to use.
21. Follow the **Using Monochromator** steps from above.

22. Turn on MCP GUI:
    -23.1 Turn on white Dell computer with Sun monitor, usr: xray pass:xray
    -23.2 Click on ‘Shortcut to Detector’
    -23.3 Select ‘Quantar Rae Detector’
    -23.4 Click ‘Monitor’, this begins the GUI’s monitoring process.
23. **If pressure still in mid e-6s, you may continue**
24. Turn on Position Analyzer, set ‘Meter Function’ to ‘Input level (gain)’.
25. Turn on HV (silver toggle at bottom of rack on ‘ORTEC’ stack), should see power red light turn on.
26. Zero the voltage knob and turn on DMM to DC voltage monitoring
27. Turn on silver HV and triphold toggles for det 1, check that red LED between these two toggles is turned on. It will turn of if the circuit is tripped.
28. Increase voltage at ‘Det 1’ until input level is in black box on position analyzer, also monitor the GUI and the count rate. First counts seen at ~2.4kv, should end up somewhere around 4kv.
29. Adjust gas needle valve to maintain operating lamp pressure (3to6)e-2 Torr, keep an eye on cryo temp (ion gauge should be off!), make sure it stays around 13 K.
30. Carefully adjust monochromator slit sizes if needed, though this should be dialed at air with a visible light source (do not exceed “25” this *may* be near the limit).
31. Verify gain on the HCL’s power supply is adjusted so that needle is in black box on analog screen.
32. Verify the SQ Tank is in the incident position.
33. Run reflected and incident at the same detector voltage!
34. Set code parameters and wavelength range (monomcpscan_finer.py) in Spyder.
35. Open conda terminal and run the monopmtd2scan_finer.py (shown as lamp_monitor.py below), keywords are the monochromator port, counter port, and csv to save data.

```
(base) C:\>cd Users\pahi9557\Desktop\Pollux

(base) C:\Users\pahi9557\Desktop\Pollux>python
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Monochromator Port: COM4
Counter Port: COM5
Saving to file: junk.csv
Saving dakrs to file: junk_darks.csv
b'0 \r\n'
?NM 102.6  ok
```

36. This will save the incident flux and corresponding darks at each wavelength.
37. Change SA, UTM and MTM to reflected position.
38. Repeat data taking steps in the reflected position.