# Cool down

## Room temperature preparations

- Check the wiring (bananas not connected until the magnet is up): Wiring (file updated 20.4.2012) (change file name to .xlsx)

- Mount radiation shields
  - smaller: see through the hole in the bottom that the nuclear stage is in the center, remember the touch detector
  - bigger: remember the touch detector

- lift vacuum can: clean In-surfaces and seal by indium o-ring
  - pump vacuum can: turbo can be started when $p < 1$ mbar

- leak testing: pump vacuum can by turbo, use leak detector as backing pump, appropriate background level $10^{-9}$
  - spray helium to all flanges
  - pot:
    - pump pot (pot mech), make sure that the backside of the pump is open (to the return line or to the ambient).
    - pressurize the pot from helium bottle, to about 1.2 bar
  - dilution unit:
    - close connection between still and condenser (small valve at the roof)
    - make sure that the pumping line (bypass pumping line of the still) is closed (bigger valve right next to the small one)
    - let mixture to the still (without traps), control the flow by valves on the gas handling panel. Increase pressure in controlled way up to 400 mbar, wait for reaction from the leak detector. Open the connection between condensing side and still. Wait more.
    - Pump the mixture back to tanks by still mech and roots pumps.
  - remember to test all the additional experimental cells

- attaching first magnet
  - lift up the dewar
  - attach the first magnet by screws, remove four lead blocks from the counterweight
  - lower the dewar, be careful, wires inside the magnet can be loose
  - remove the "ears" of the magnet
  - attach and tighten the centering/fixing pieces and fix the magnet to vacuum can
  - connect rest of the wiring and the extension for the syphone (use tape to fix firmly)
  - attach to bottom plate for the magnet
  - attach the extension of the bottom syphone
  - check all wires, now everything should be connected Wiring

- raise dewar
    - attach dewar to platform by screws on the roof
    - pump dewar (using the pots pump, make sure that the backside of the pump is arranged properly)
    - leak test the dewar by pressurizing to 1 bar with helium

## Cooling by LN

- Pump the pot and pressurize it to about 1.2 bar from a storage dewar

- Insert heat exchange gas to the vacuum can
    - Stop the turbo pump and the leak detector
    - The valve for inserting the heat exchange gas is situated on the top of the cryostat, near the turbo pump.
        - Remove the blind flange
        - Insert the Neon container
        - Open the valve and pump the tubes by the mechanical pump
        - Stop pumping vacuum can
        - Insert about 20-30 mbar of Ne to vacuum can
        - Close the valve and replace the blind flange

- Transfer nitrogen
    - Make sure that the syphone goes to the bottom hole
    - Make sure that the dewar's exit line is open to the ambient
    - Start blowing nitrogen to dewar, keep the overpressure below 0.2 bar and the pressure of the pot above 1.2 bar
    - It takes about 12 hours to put about 100 liters of nitrogen through the line

- When the Pt-100 value is below 30 Ω start blowing nitrogen out
    - Change straight syphone to the roof (bottom flange)
    - Use silicon tube (try to keep the tube as straight as possible) to make a line to a nitrogen dewar (it's wise to start filling the nitrogen trap dewar)
    - Pressurize the exit line, keep the overpressure below about 0.2 bar. Keep pressurizing the pot by helium to keep it above 1.2 bar.

- As nitrogen blowing is started pump vacuum can empty.
    - make sure that the valve for heat exchange gas is closed and sealed
    - pump by mechanical pump, below 1 mbar start turbo pump
    - at some point replace the nitrogen trap dewar with another dewar, fill the nitrogen trap dewar and cool the nitrogen trap
        - if the trap is empty (you can see this by observing the pressure after the pumps while opening the traps valves), no need for pumping the trap at this point.

- Check the wiring: Wiring

- leak testing: pump vacuum can by turbo use the leak detector as backing pump, appropriate background level $10^{-9}$
    - pot:
        - there is some helium inside the pot, if it is leaking the signal should appear when the leak detector is connected to the vacuum can
    - dilution unit:
        - close connection between still and condenser (small valve at the roof)
        - make sure that the pumping line is closed (bigger valve right next to the small one)
        - let mixture to the still through the traps, control the flow by the needle valve. Increase pressure in controlled way up to 400 mbar, wait for reaction from the leak detector. Open the connection between condensing side and still. Wait more.
        - Pump the mixture back to tanks by still mech and roots pumps.
    - dewar (when all nitrogen is out):
        - see that the bath resistor has a smaller value than the liquid nitrogen value.
        - pump dewar empty
        - pressurize to one bar by helium from the bottle

## Inserting helium

- Insert syphone to the bottom position

- Open back of the dewar to the return line

- Connect the 3He bottle (on the roof) to the valve for the heat exchange gas (near the turbo pump)
    - pump tubing (the 3He bottle must be closed)
    - first just by mechanical pump, as pressure goes down also with the turbo

- Pushing 4He gas to dewar
    - Pressurize storage dewar from a helium bottle to about 0.05 bar overpressure
    - When helium gas is going in put 2-3 mbar of 3He to vacuum can
    - After 3-4 hours, when R_bath $\approx$200 Ω and NbTi wires are superconducting (T $\approx$10 K) start pumping vacuum can, continue helium transfer for about another 1-2 hours

- If resistance values are showing that liquid helium is condensing to the dewar stop transfer (after approximately 100 liters of helium from the storage dewar)

- After about 3-4 hours of pumping, when the pressure in the vacuum can is low enough (??):
    - Leak test

        - Dewar is has plenty of 4He, pot also. To test the dilution unit put some mixture in. From the gas being pumped out from the vacuum check 3He and 4He levels
            - There should be much more 3He than 4He coming out
    - Continue transfer

- When liquid helium level is above 7 cm pot can be started
    - see that the back side of the pump is connected to the return line
    - wait until pot is full (35.5 pF)
    - at first both of pot's impedances can be open (second impedance can be adjusted using small valve on the roof)

- remember to change the syphone to the upper position

## Starting the dilution fridge

- Condensing dilution gases can be started when helium level is high enough (more than 7 cm on the level meter) and pot is full. Pot should be running at full power.

- Cool helium trap

- Make sure that the valve connecting condensing side and still is closed

- Pump the still by mechanical pump (no roots).

- Open the line from behind the mechanical pump through the traps to the condensing side

- Let helium from the tanks (start from the bigger, yellow, one) through the magnetic valve and the needle valve and the bypass line to the front of the mechanical pump.
    - Control the flow by the needle valve and by the magnetic valve
    - At the beginning the flow rate should be at the range 400-600 µmol/s
    - When mixture starts to condense the flow rate can be increased to 1000-1500 µmol/s

- When the tanks are empty and the dilution unit in running turn on the roots pump

- Starting the diffusion pump
    - Before starting the pump, pump the lines
        - Open the valve on the backside of the diffusion pump (in the cellar)
        - Pump the line for some time (how long??)
        - Check that the cooling water line is working
    - When the pressure on the still side is at $10^{-1}$ mbar level start the diffusion pump
        - Open the big valve on the still pumping tube
        - Close the valves of the bypass pumping line (first the one on the top of the cryostat platform, then the one at the cellar)
        - It takes several hours for the pump to start running full power

- It is best to regenerate the nitrogen trap when dilu starts to run smoothly

- Before first nuclear stage magnetization, remove all magnetic materials near the cryostat!

# Normal operation

### Helium transfers

- make visual measurements

- Precool syphone
    - Connect syphone to the return line by silicon tube
    - Insert syphone to the storage dewar (slowly)
    - Open the valves of the syphone and the return line
    - Close the valve of the storage dewar

- When the silicon tube is frozen almost to the return line's valve
    - Open storage dewars valve
    - Close syphone's valve
    - Remove silicon tube

- Insert syphone to its place on the roof
    - open syphone's valve
    - close storage dewars valve
    - start pressurizing the storage dewar from the helium bottle
        - suitable overpressure is 0.2-0.3 bar
        - see that the gas meter is revolving at reasonable speed

- As liquid starts to flow into to dewar the gas meter stops momentarily
    - Adjust overpressure of the storage dewar if needed
    - Turn on the level gauge

- Transfer takes about 1 hour

### Changing He-trap dewar

- Reduce the circulation by reducing still heating

- Close the valve before traps (black handle)
    - Observe the pressure behind pumps during exchange

- Close the valve "to dilution refrigerator"

- Opening a way from the volume after the traps to the pumping line
    - close tanks
    - close escape line

    - start opening valves from the low pressure side (starting from the needle valve then magnetic valve, then the rest)

- Take helium trap out from the old dewar and put it to the new one

- Start circulating mixture through the traps (open the black valve)
    - After a while close the way from behind the traps to pumping line
        - Close valves in opposite order to opening
        - After every valve wait a little to get the tubes pumped

- Open the "to the dilution refrigerator valve"

- Remember to open tanks and escape line!

## Regenerating traps

- If the pressure in front of the traps (behind pumps) starts to raise, even though pressure behind the traps stays low (p_cond), it is time to regenerate traps

- Reduce the circulation by reducing still heating

- Close the valve before traps (black handle)
    - Observe the pressure behind pumps during exchange

- Close the valve "to dilution refrigerator"

- Open a way from the volume after the traps to the pumping line
    - close tanks
    - close escape line
    - start opening valves from the low pressure side (starting from the needle valve then magnetic valve, then the rest)

- Pump the traps while they are still cold (in their respective dewars)
    - Observe the pressure after the mechanical pump
    - When no more stuff (mixture) is coming from the traps stop pumping (close the valve after traps)

- Pump "log" empty (service mech)
    - Stop pumping "log" and open a way from the traps to the "log"
        - Make sure that only the traps, no other parts of the system, is connected to the "log"

- Warm up traps, remove He trap from the dewar first then LN trap (use heat gun)
    - Observe the pressure of the "log"
    - Mind also the pressure behind the pumps (mixture is slowly being pumped from the still)
        - There is about 1 hour to do the regeneration before the pressure behind the pumps reaches the level that stops the pumps

        - Remember that escape line is closed!!
    - Normally the pressure of the log rises to some hundreds of millibars
    - When traps are warm close the line to the "log"
        - You can pump the log empty, make some note of how much stuff came out
        - Pump traps also!

- Cool the traps, LN trap first

- Start circulating mixture through the traps, flow max 2 mmol/s (reopen the way from behind the traps to the pumping line open the "black" valve before the traps)
    - After a while close the way from behind the traps to pumping line
        - Close valves in opposite order to opening
        - After every valve wait a little to get the tubes pumped

- Open the "to the dilution refrigerator valve" (Slowly)
    - See that everything starts to work normally again

- Remember to open tanks and escape line!

## (De)magnetization

**Magnetization**

Assume field is 0.1 T and the final field 9 T. External shunt should be always open and wires connected.

- --POWER ON-- Power on from Oxford Magnet Power Supply.
- --HOLD-- internal shunt open
- --CURRENT FIELD-- change to TESLA
- --MAGNET STATUS-- current magnet status before magnetization (0.1 T)
- --SET POINT-- should be the same as "magnet status" (0.1 T)
- --HOLD + RAISE-- fast mode, display FAST
- --SET RATE + RAISE/LOWER-- set rate (100 mT/min)
- --GOTO SET-- current goes quickly up from 0 to "set point" (to current which corresponds 0.1 T)
- --HEATER-- depersist the magnet, follow "output voltage" which should be constant
- WAIT 30 seconds
- --SET POINT + RAISE-- raise set point to final field (9 T).
- WAIT for hours

Continue when "set point" reached

- --HEATER-- switching heater off persists the magnet
- WAIT for 30 s
- --GOTO ZERO-- power supply current goes quickly to zero
- --POWER OFF-- power off

**Demagnetization**

Assume magnet is magnetized to 9 T. External shunt should be always open and wires connected.

- --POWER ON-- Power on from Oxford Magnet Power Supply.
- --HOLD-- internal shunt open
- --CURRENT FIELD-- change to TESLA
- --MAGNET STATUS-- current magnet status before demag (9 T)
- --SET POINT-- should be the same as "magnet status" (9 T)
- --HOLD + LOWER-- slow mode, display SLO
- --GOTO SET-- current goes quickly up from 0 to "set point" (to current which corresponds 9 T)
- --HEATER-- depersist the magnet, follow "output voltage" which should be constant
- WAIT 30 seconds
- --SET POINT + LOWER-- first lower set point slowly, "Sweep limiting" should appear. Lower set point to final field (0.3 T).
- WAIT for hours:

9.0 T -> 4.0 T  30 mT/min  2 h 47 min
4.0 T -> 2.0 T  20 mT/min  1 h 40 min
2.0 T -> 0.5 T  10 mT/min  2 h 30 min
0.5 T -> 0.2 T  5 mT/min  1 h
0.2 T -> 0.1 T  2 mT/min  50 min
0.1 T -> 0.0 T  1 mT/min  1 h 40 min

Continue when "set point" reached

- --HEATER-- switching heater off persists the magnet
- WAIT for 30 s
- --GOTO ZERO-- power supply current goes quickly to zero
- --POWER OFF-- power off

# Warm-up

## Collecting dilution gases

- Switch off booster pump
- Put about 8 mA to still heater and about 10 mA to mixer heater
- Start collecting dilution gases
    - Collect through traps (you can see the flow)
    - Appropriate flow rate about 1000µmol/s
    - The 3He rich stuff comes out first put it to the smaller (blue line) tanks
- At some point still dries (takes ~ 1h, p tanks <100 mbar)
    - Reduce still heating 8 mA -> 4 mA
    - Stop pot
- Dilution gases continue to come out as irregular bursts at first

    - When mixer temperature has risen to about 1.2 K gas flow becomes more steady
- Remember to switch to big tank (yellow line) when smaller ones are full

### Warming to room temperature

- Empy experimental cell
    - Pump helium gases out of the experimental cell before cryostat's helium bath dries
    - Switch all heaters off
    - Open pot bypass

- Wait for LHe bath to dry and the cryostat to warm up
    - Observe pot pressure

- When bath is dry the cryostat warms to LN temperature in ~1 day, then
    - Close pot bypass and pressurize pot (if you want to cooldown again very soon)
    - Lowering dewar
        - Free the counterweight (remove the jack)
        - Open bolts on top of the cryostat (outer ones 7 pcs)
        - Lower dewar slightly, lower gradually more

- Don't pump VJ
    - Some remnant gases will evaporate and act as heat exchange gas
    - VJ can be opened when T is above 0 degrees celcius (see Pt-100 inside, water not condensing outside)

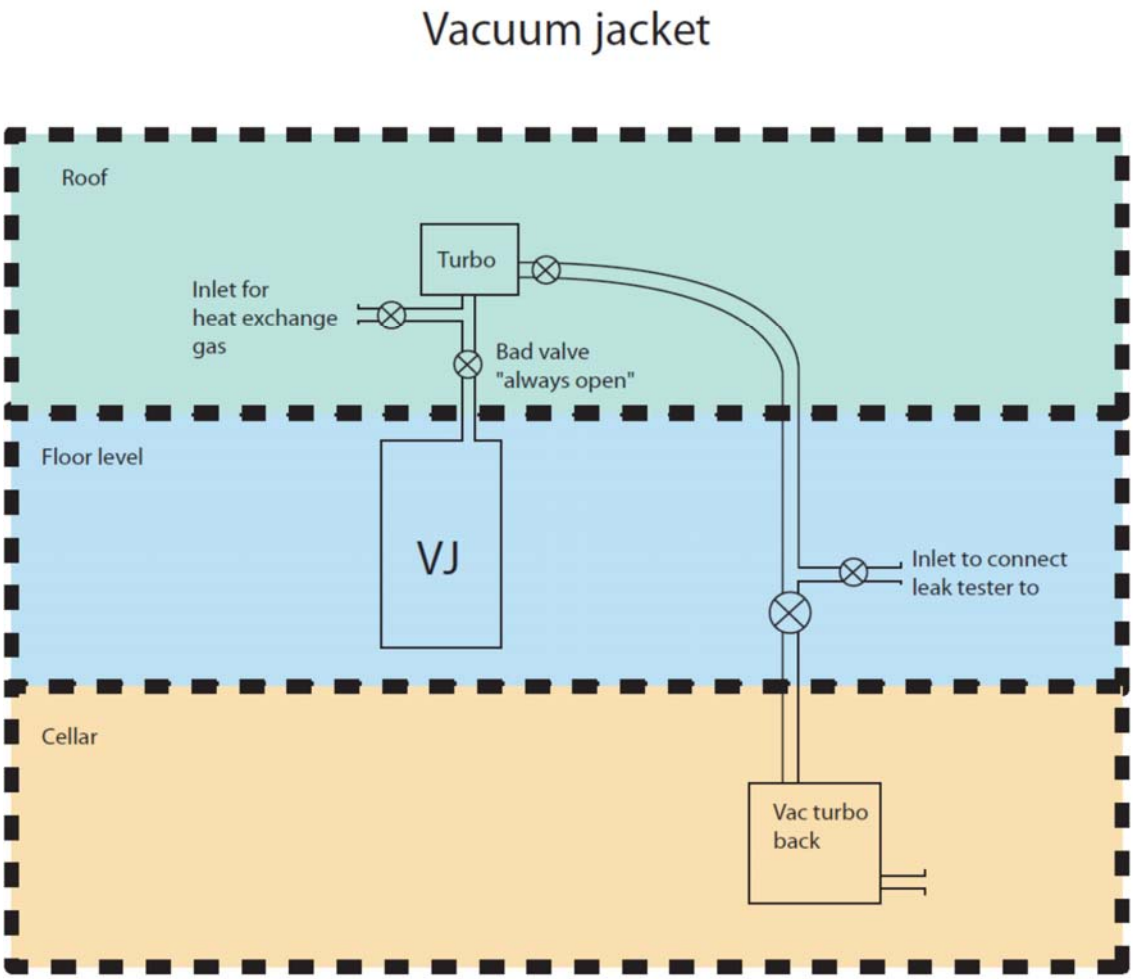
- Removing magnet
    - Disconnect wiring related to the magnet (fix loose ends)
    - Remove syphone extension
    - Remove the locking/centering pieces (bottom and sides)
    - Attatch the supporting pieces ("ears")
    - Carefully lift the dewar
        - When the magnet rests on the dewar by the supporting pieces remove four lead tiles form the counterweight
        - Open nuts that hold the magnet on the cryostat platform
        - Carefully lower the dewar with the magnet inside

- Removing radiation shields
    - Disconnect touch detector wires, and remove sheilds
- Removing VJ
    - Loose bolts, let air in, open bolts.

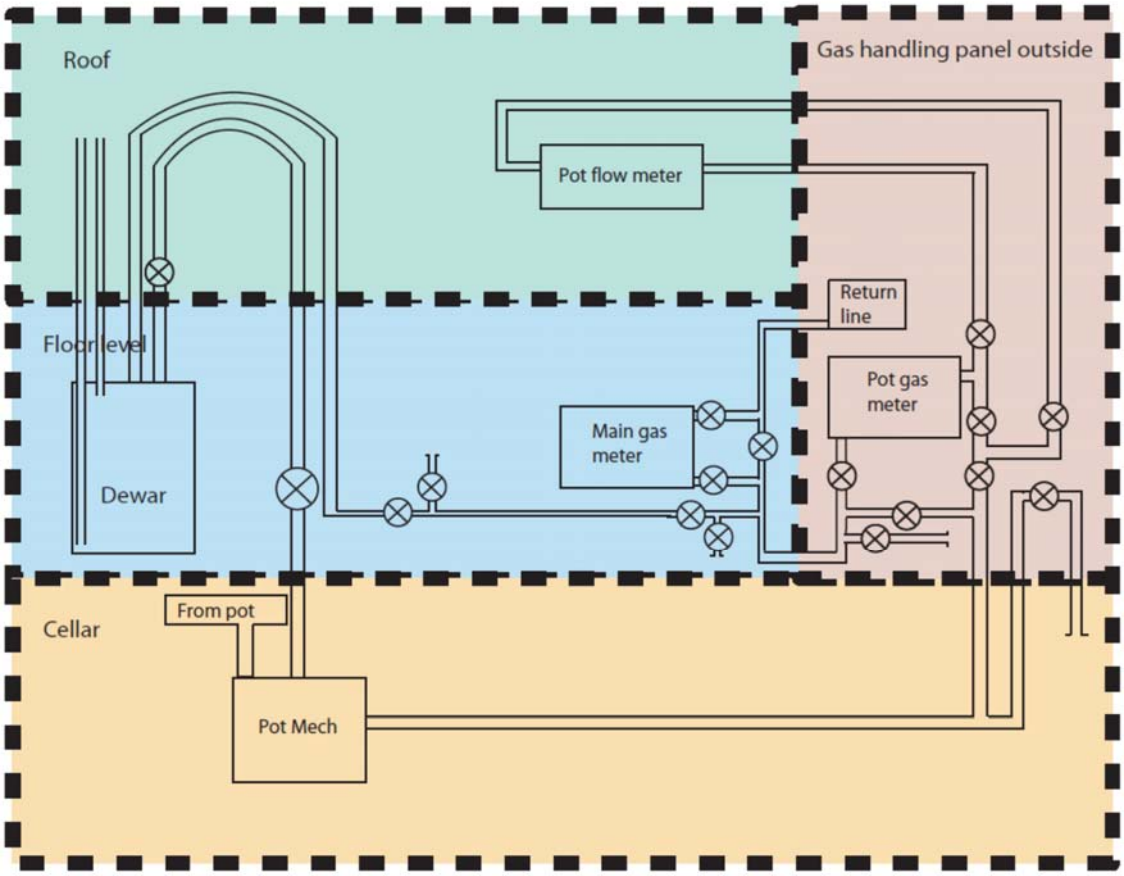
## Misc

### Pumps

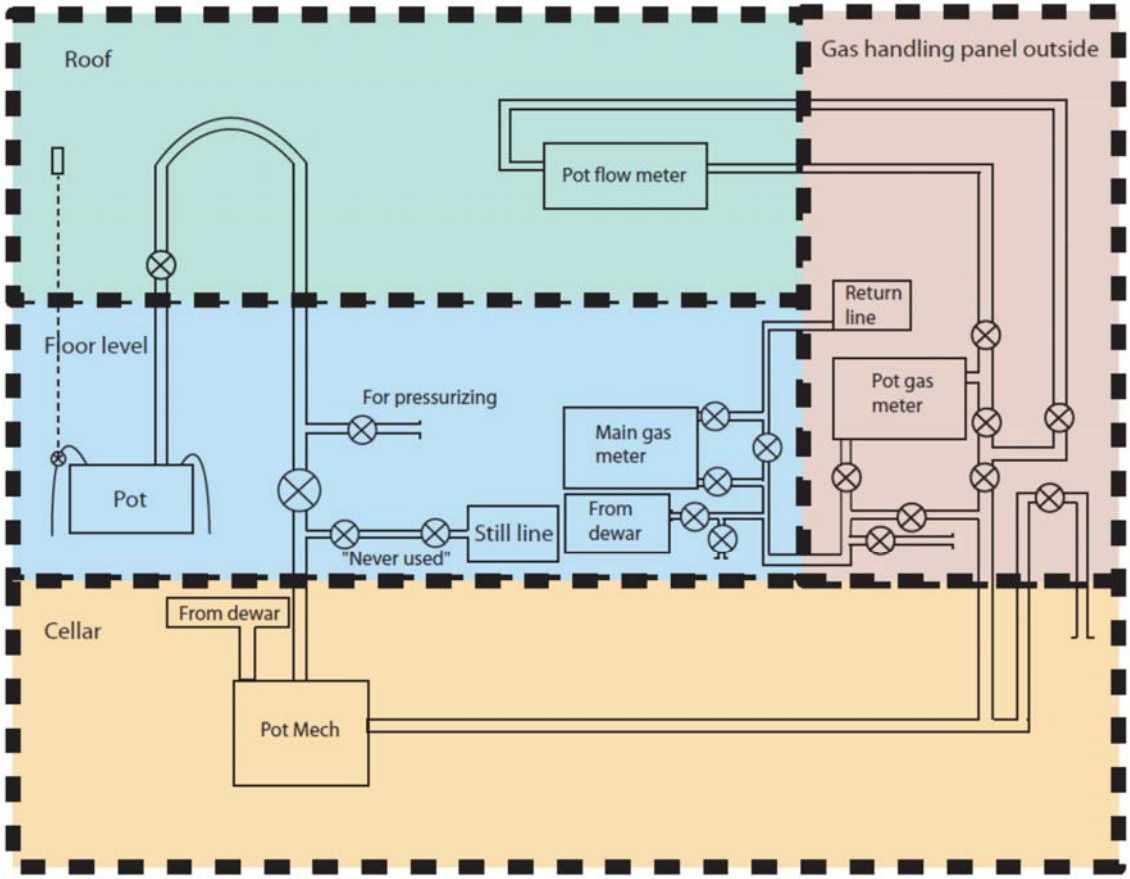
**Figures**


Vacuum jacket
Roof
Turbo
Inlet for
heat exchange
gas
Bad valve
"always open"
Floor level
VJ
Inlet to connect
leak tester to
Cellar
Vac turbo
back

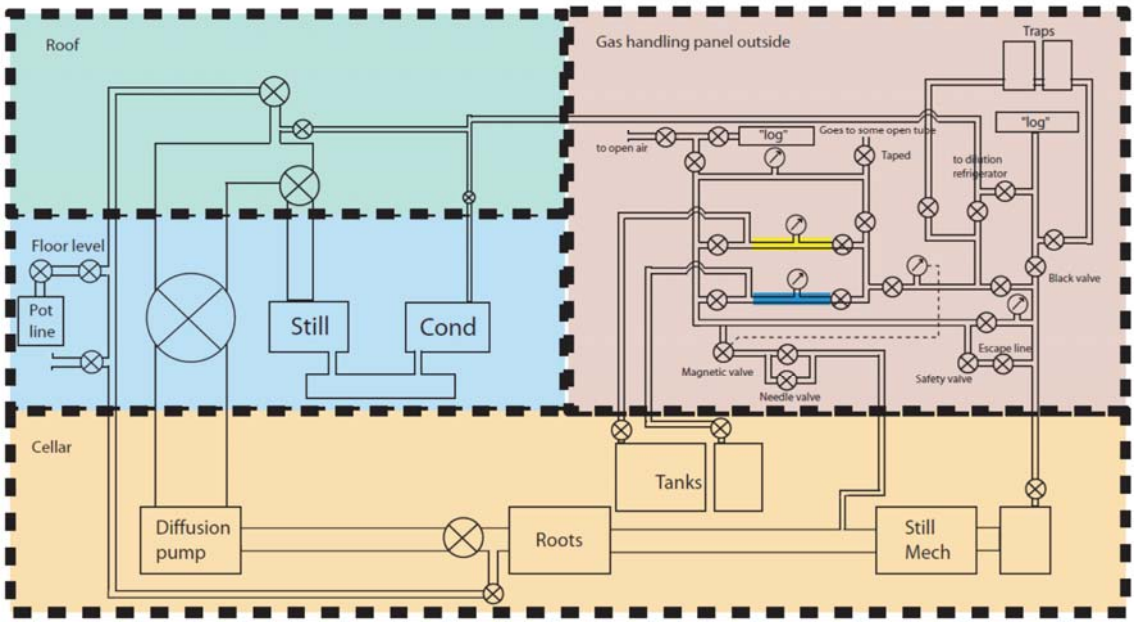
# Dewar


Roof
Gas handling panel outside
Pot flow meter
Return line
Floor level
Pot gas meter
Main gas meter
Dewar
Cellar
From pot
Pot Mech

# Pot


Roof
Gas handling panel outside
Pot flow meter
Return line
Floor level
Pot gas meter
For pressurizing
Main gas meter
Pot
From dewar
Still line
"Never used"
Cellar
From dewar
Pot Mech

# Dilu


Roof
Gas handling panel outside
Traps
"log"
Goes to some open tube
to open air
Taped
"log"
to dilution refrigerator
Floor level
Pot line
Still
Cond
Black valve
Escape line
Magnetic valve
Needle valve
Safety valve
Cellar
Tanks
Diffusion pump
Roots
Still Mech