Miniball PPAC

Contents

[1] Nigel Warr August 2007

1 Caveat

This manual was originally written for the PPAC in its original state, where it was mounted directly downstream of the target chamber and could not be moved. That was the configuration used until the end of 2006. From 2007, we have an actuator, which allows the PPAC to be moved in and out of the beamline. Unfortunately, Darmstadt have provided us with a system, which is much more complicated than the old one, with numerous ways of making mistakes and very few safety features, other than those added in the past. The operation of the motor is highly unsatisfactory and the whole assembly far too cumbersome.

Moreover, they did not update the documentation or provide new documentation. This manual has been updated from information gleaned from information provided by Jarno van de Walle, who had to figure things out by trial and error. There are various things, which are not completely certain, so they could easily be wrong. So check everything and think before doing!

Furthermore, the present state of the PPAC actuator is not satisfactory for long term use and will have to be improved, which means this documentation will rapidly become out of date. So use it at your own risk, but please don't use it at the risk of the PPAC!

2 The PPAC

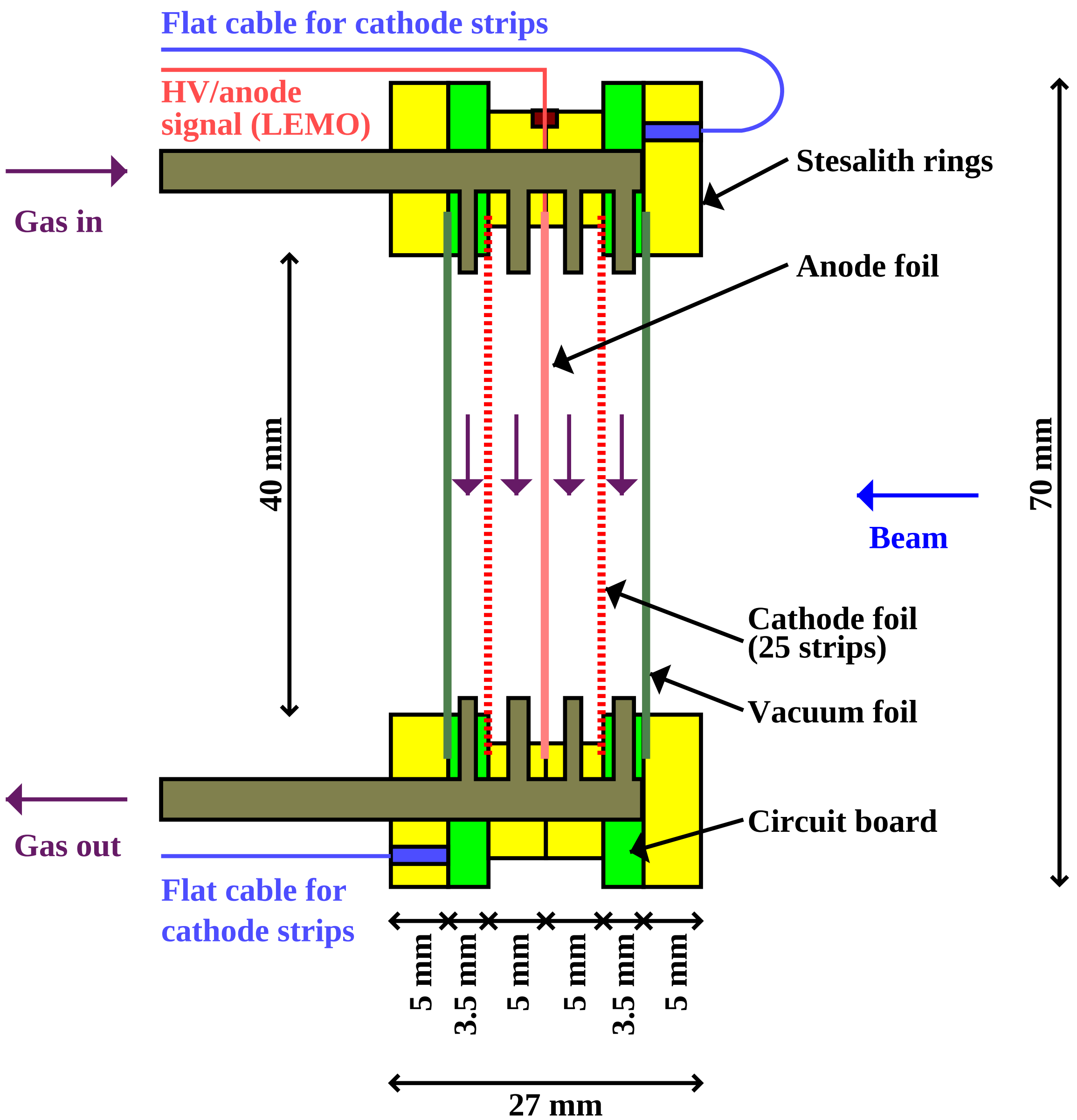

Figure 1: The construction of the PPAC

The Miniball parallel plate avalanche counter is a gas-filled detector with 25 strips in the X direction and 25 strips in the Y direction. In passing through the PPAC, the beam passes through five foils in the following order:

- Vacuum foil: 1.5 μm mylar foil evaporated on both sides with 40 μg/cm^2 Al.
- Cathode strip foil: 1.5 μm non-evaporated mylar foil for the strips with twenty-five strips in the X direction of about 500 nm of Al. The strips are at 1.6 mm pitch.
- Anode foil: A 2.0 μm mylar foil evaporated with Al.
- Cathode strip foil: 1.5 μm non-evaporated mylar foil for the strips with twenty-five strips in the Y direction of about 500 nm of Al. The strips are at 1.6 mm pitch.
- Vacuum foil: 1.5 μm mylar foil evaporated on both sides with 40 μg/cm^2 Al.

The total effective thickness is approximately 1 mg/cm^2.

The four stesalith rings each 5 mm thick and the two electronic circuit boards parts are 3.5 mm thick, so the total thickness is 27 mm. The outer diameter is 70 mm and the active inner diameter is 40 mm.

The tubes for the gas supply are 20 mm long 4 mm diameter aluminium tubes.

The PPAC can be operated with CF_4 or iso-butane. In the past we used iso-butane, but because of CERN safety rules, we switched to CF_4.

3 The PPAC actuator

Originally, the PPAC was placed immediately downstream of the target chamber, so that it was between the target chamber and the CD feedthroughs. Its own feedthroughs were in a flange immediately downstream from the CD feedthroughs. This had the disadvantage, that the PPAC and CD cables and tubes interfered with each other somewhat.

From 2007, the PPAC is mounted on an actuator, placed further downstream beyond the connection for the downstream turbo pump. This actuator allows the PPAC to be moved in and out of the beamline. A valve can be closed when the beam is out of the beamline, allowing the PPAC to be pumped and vented independently of the main beamline. Note that this valve is different to the other valves, in that it does not close automatically if the compressed air fails. This is to prevent it closing when the PPAC is in the beamline, as this would damage the actuator. It also means, that you have to press down the open or close button for several seconds in order for the valve to open or close.

The PPAC has two gas connections (inlet and outlet), one HV connection (LEMO) and two sets of twenty-five signal connections (D-sub) which connect to the outside world via feedthroughs. In addition to these, there is a further connection to the chamber, which is used to connect the PPAC to the chamber while pumping down or venting.

The old PPAC flange had proper Swagelock fittings for the gas tubes, which could be plugged and unplugged without breaking the vacuum. The new actuator has crude rubber tubes with clamps. Also, the old system was properly colour coded, so it was clear what was what. The new system is clearly a step backwards.

The high voltage (typically about 400 volts) is applied via a CSTA 2 preamplifier box to the LEMO connector on the top of the actuator. The voltage is applied to the central electrode and a signals are picked off this line by the preamplifier for energy and timing signals. The preamplifier takes ± 12 V power which are applied over two wires from a D-sub connection which goes to the Miniball preamp power box upstairs. However, it seems that the central anode signal has not been connected in 2007.

Unfortunately, the 50-pin D-sub connectors used for the X and Y signal feedthroughs have been known to leak in the past. We tried using atmosit to plug the leak, but found that this tended to short the pins together. This was the biggest single problem with the PPAC in the past, but it seems this wasn't changed. It also seems that it is no longer clear which feedthroughs are for X and which are for Y. Now, however, there are other worse shortcomings.

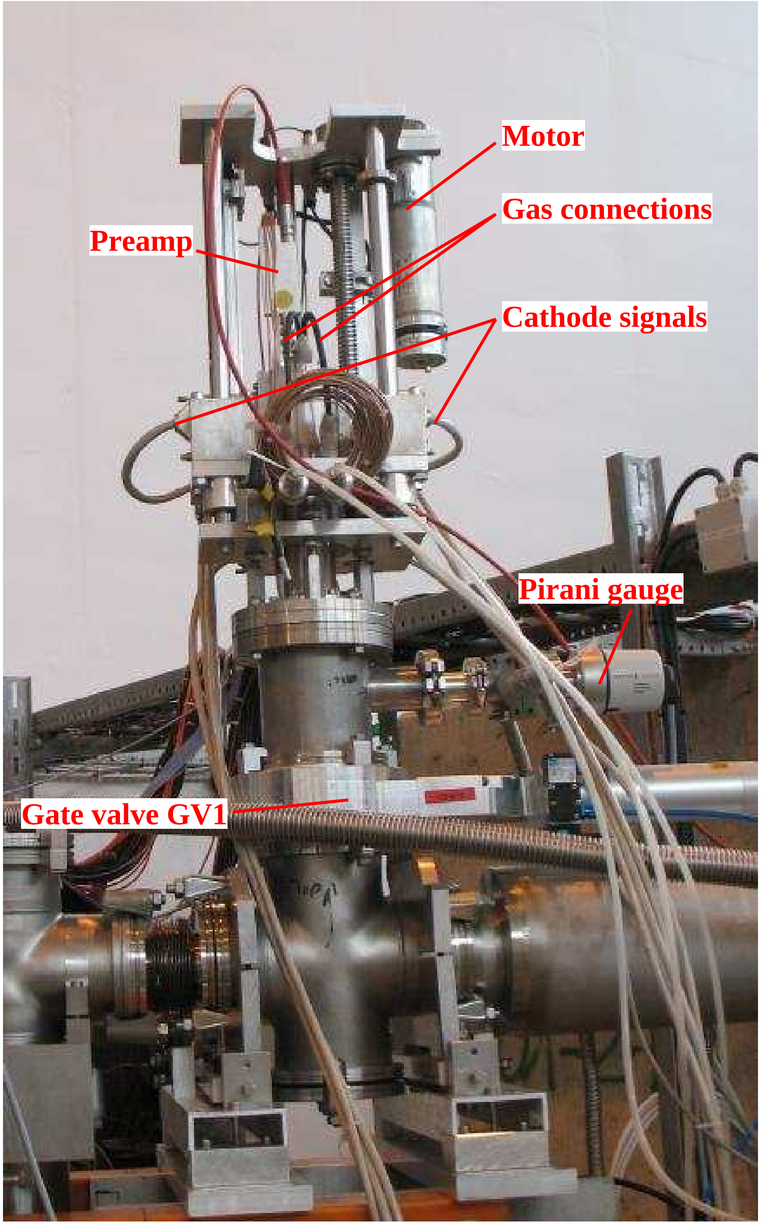

Figure 2: The PPAC actuator, which allows the PPAC to be moved in and out of the beamline. In this picture, the PPAC is in place in the beamline.

The new actuator is extremely heavy and cannot be lifted without the crane, so changing the PPAC is an even worse job than before.

4 The gas system box

The gas control system is in the box above the beam line. It contains the valves and signals to operate the gas system. It has five connections and six electronic connections.

We have had the problem in the past that the four electrovalves heat up a lot, so it is important to use metal not plastic tubing at this point. For the other connections, the plastic tubing is fine.

4.1 The gas connections

The gas connections are:

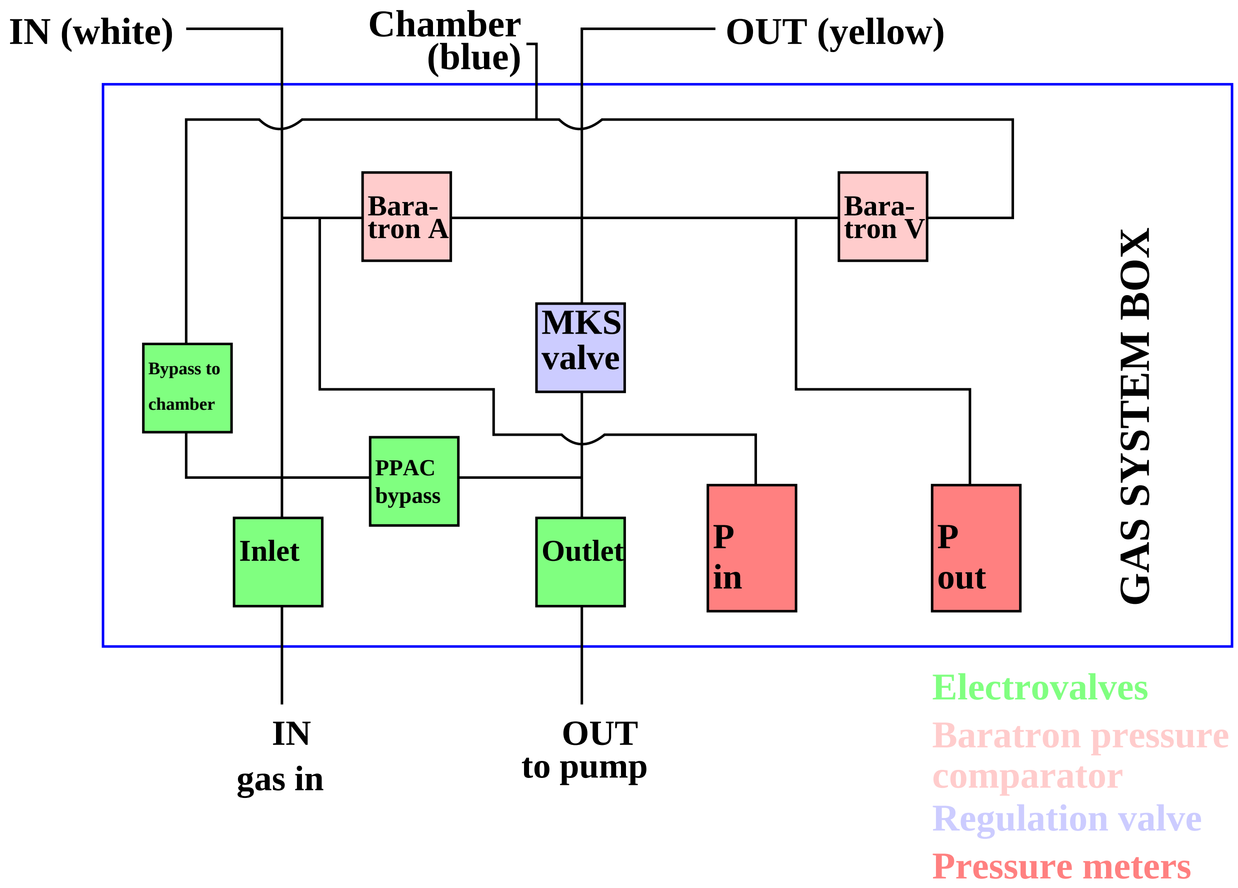

Figure 3: The PPAC gas system box schematics.

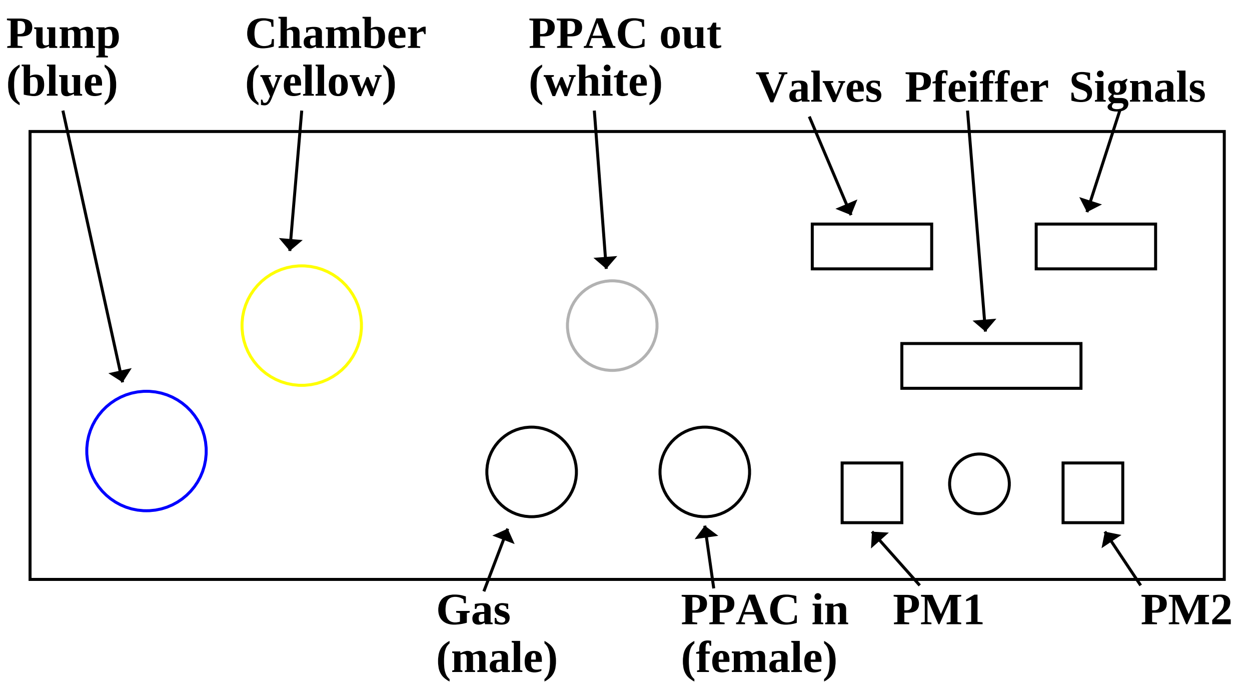

Figure 4: The PPAC gas system box connectors.

Inlet/outlet of box	Colour/type	Connected to
Pump	Blue	To roughing pump
Chamber	Yellow	Blue feedthrough on flange
PPAC out	White	White feedthrough on flange
PPAC in	Female	Yellow feedthrough on flange
Gas	Male	Gas bottle via pressure reducer

Note that the colour coding is not logical. Blue on the box is for the pump, while blue on the flange is for the chamber and yellow on the box is for the chamber, but yellow is the inlet on the flange!

This might, however, have changed since 2006!

4.2 The electronic connections

- Flat cable "valves" going to electronic control panel.
- Flat cable "signals" going to electronic control panel.
- D-sub cable "Pfeiffer" going to Pfeiffer RVC200.
- LEMO multicable going to Pfeiffer RVC200.
- PM1 going to Pfeiffer dual gauge (gauge 1).
- PM2 going to Pfeiffer dual gauge (gauge 2).

5 The control devices

The three devices in figure 5 are:

- MKS 250 pressure regulator. This is used to control the valve between the gas system and the pump. We use two operation modes: auto and manual. In manual mode, the valve is fully open (as long as the manual setting is set to 10.0), so all the gas is pumped out of the system as fast as possible. In automatic mode, the MKS 250 regulates the valve to maintain the desired pressure inside the system. We operate with phase lead set to 8 s, gain to 50 %, input to 1 volt and manual setting to 10.0

- Pfeiffer RVC 200 flow regulator. This is used to regulate the flow of gas into the system. We either have it closed (with the green LED above the close button lit) or open to 10^{-2} mbar l/s.
- Pfeiffer dual pressure gauge. This displays the pressure either at the inlet or the outlet side of the system. You press the "CH" button to toggle between P1 (inlet side) and P2 (outlet side).

6 The control logic panel

The PPAC system has three modes: "standby", "running" and "emergency". In running mode, we have gas flowing through the PPAC with the flow regulated by the Pfeiffer RVC 200 and the pressure regulated by the MKS 250. In standby mode, the two bypass valves are open and the inlet and outlet valves are closed. The control electronics manages the switching between these two modes and also monitors the pressure difference between the PPAC and the target chamber, switching into emergency mode if this pressure difference increases too much.

Valve	Standby	Running	Emergency
Inlet	Closed	Open	Closed
Outlet	Closed	Open	Closed
Bypass to chamber	Open	Closed	Open
PPAC bypass	Open	Closed	Closed

The control panel has a schematic diagram of the gas system, with LEDs to indicate the state of each valve and switches to change the state of those valves when in manual mode. Normally, when we are running in automatic mode, we should set the valve switches into the positions corresponding to the PPAC's standby mode.

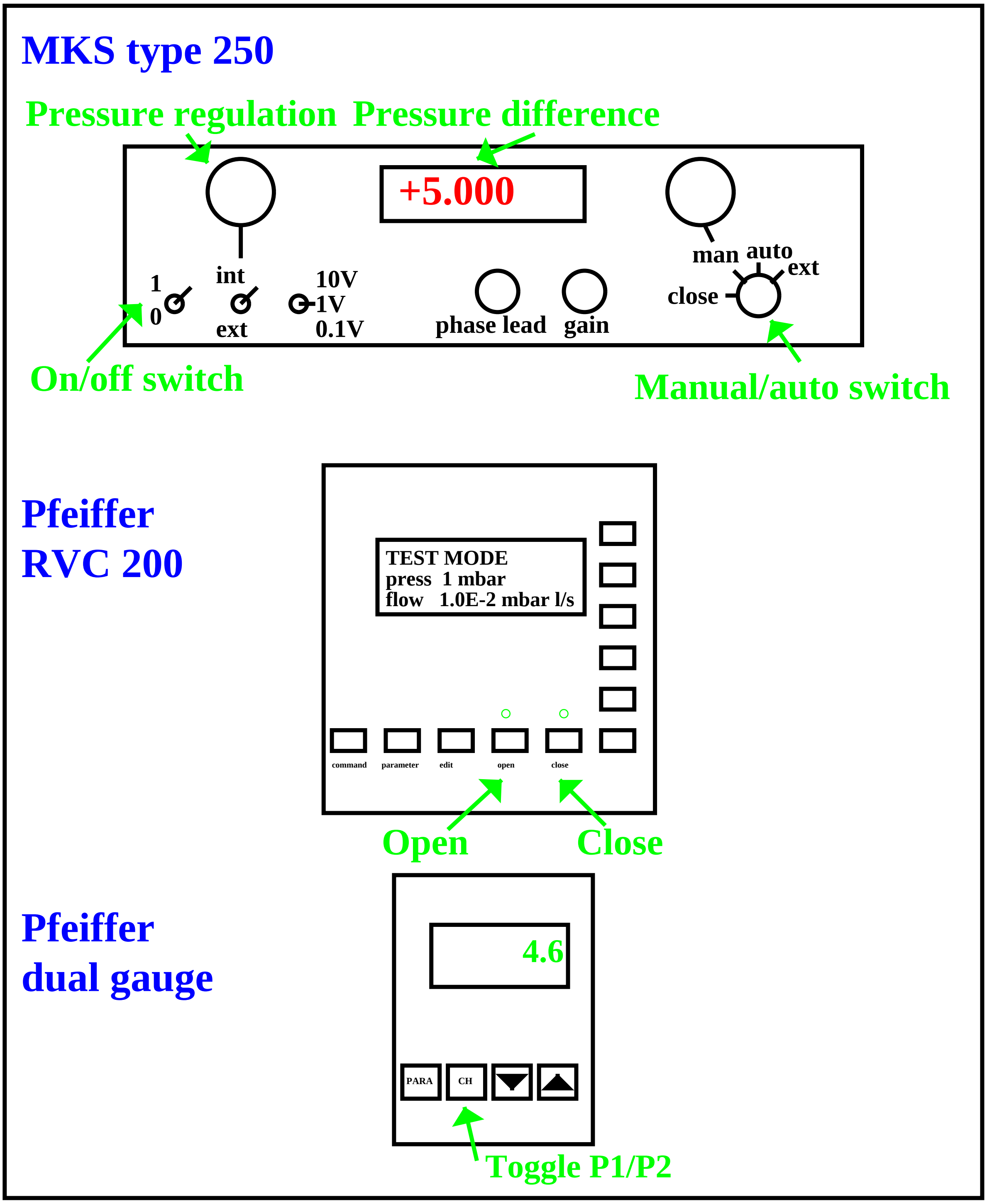

Figure 5: The PPAC control devices located at the base of the downstream orange beamline support.

There are two LEDs to indicate the state of the system. The red one lights if an error occurs and the green one lights in running mode.

Below, there are two buttons and two switches. The green "START" button is used to switch into running mode and the red "RESET" button is used to switch into standby mode. Note that it is the user's responsibility to make sure that the target chamber and PPAC are pumped down before pressing "START" and that gas has been removed from the PPAC before pressing "RESET".

The first switch switches the control electronics between automatic mode (i.e. the system switches between running and standby when the user presses start or reset.) and manual mode (the user operates individual valves with their switches). The second switch turns the baratron on and off.

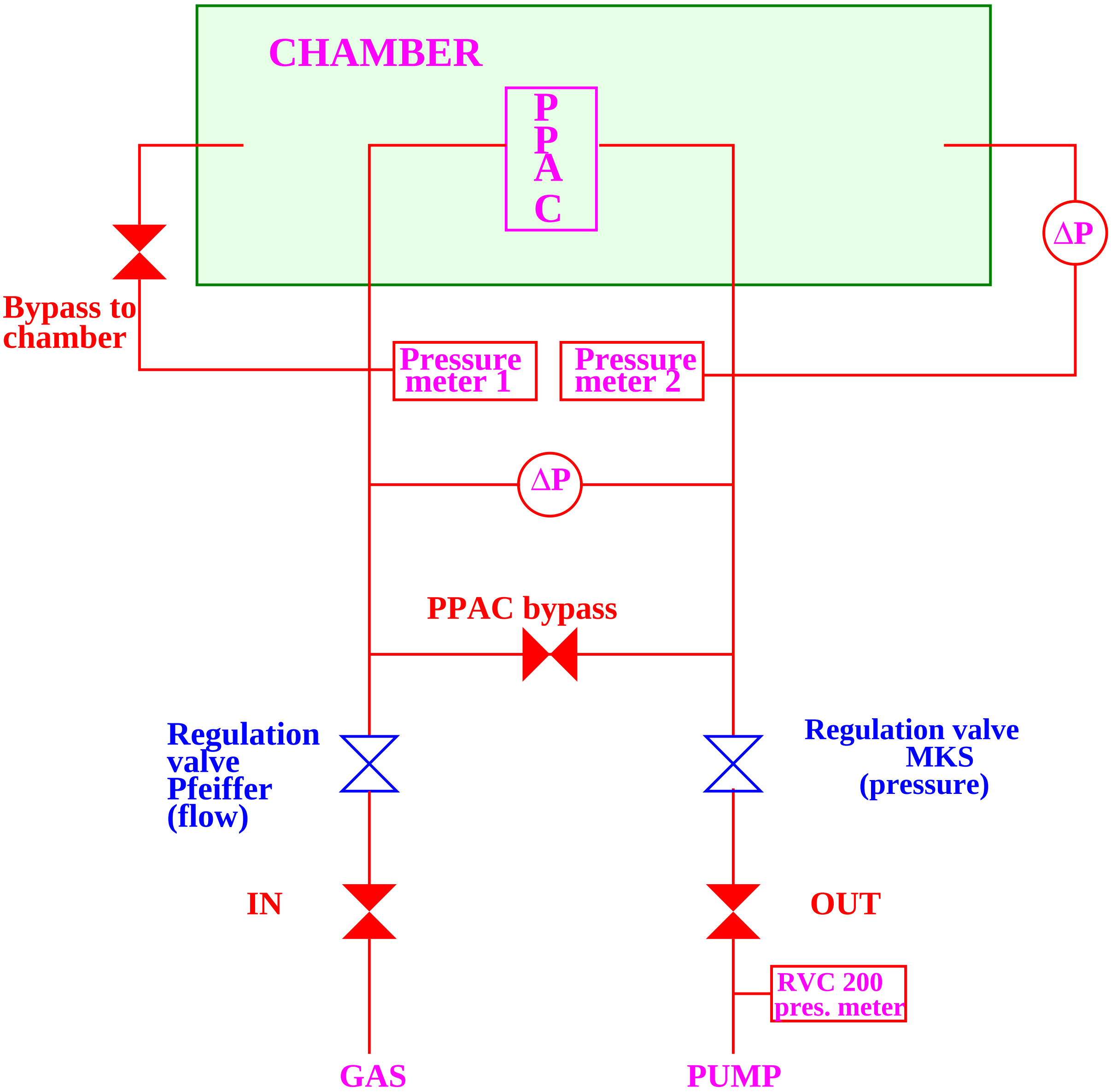

Figure 6: The PPAC gas control system

7 The readout electronics

The PPAC flange has two 25-pin D-sub connectors (the lower one for the X strips and the upper one for the Y strips) which are connected to a special adapter which maps the 25 signals from one 25-pin D-sub connector to four 15-pin D-sub connectors, where the first 7 pins of three D-sub connectors are used and only 4 pins of the last one.

From the adapter, the signals go into the CF161 current digitizer box (mounted on top of the gas system box), which converts the currents into pulses which are sent by long ECL cables to the VME scalers upstairs.

In addition to the signals from the strips, we have a LEMO connector on the PPAC flange to which we apply the high voltage via a CSTA 2 preamplifier, which also provides us with the timing and energy signals from the high-voltage electrode.

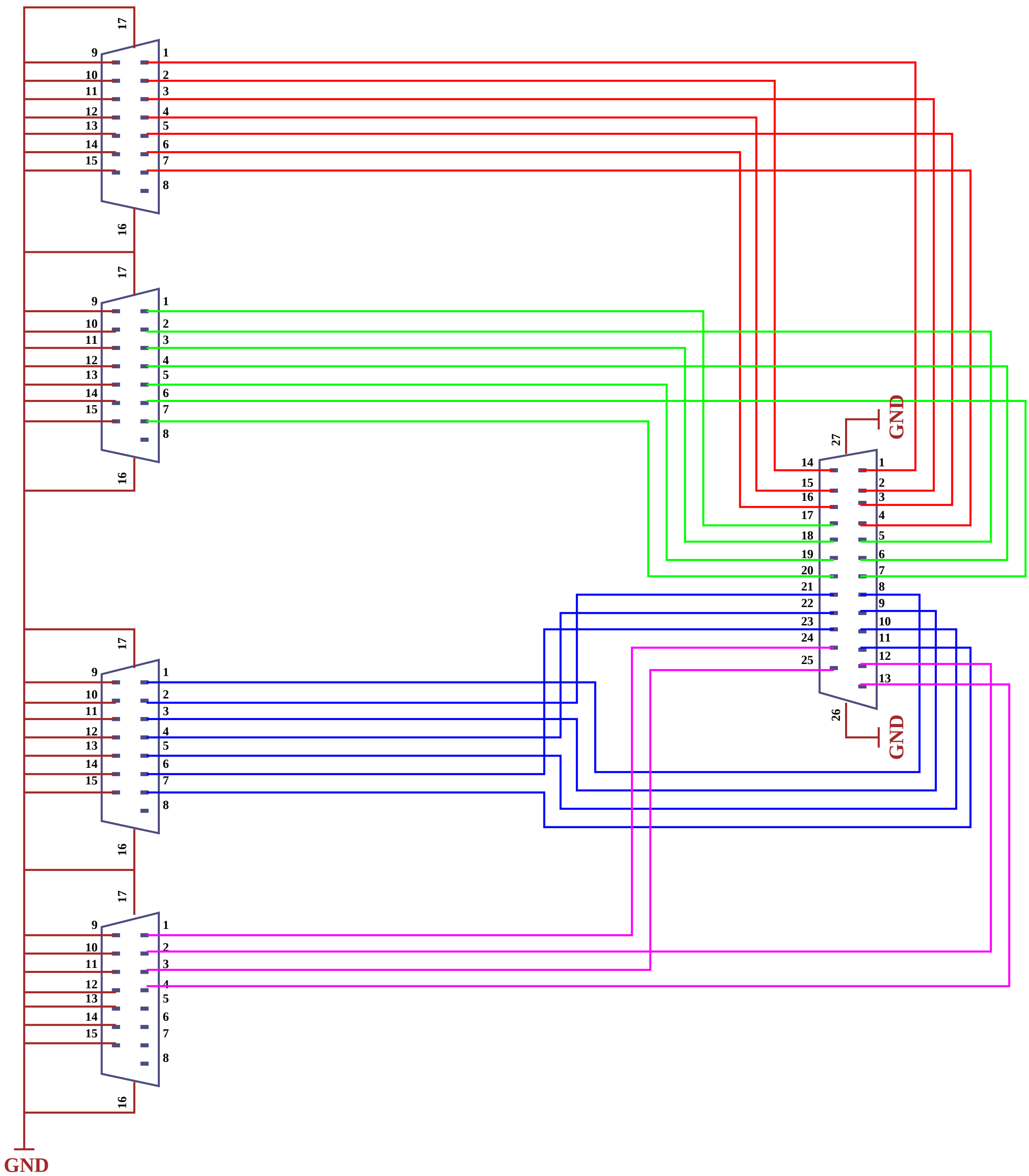

Figure 7: The splitter/adapter which converts a 25-pin D-sub connector to four 15-pin D-sub connections

8 Typical values

The following are typical values. Actual values for a given experiment may vary. Increasing the voltage increases the sensitivity of the PPAC, but care should be taken that it doesn't spark.

Parameter	Where	Value
Gas	Under beam stop	CF_4
Bottle pressure	Under beam stop	120 bar
Pressure of gas in PPAC	In beam line	5 mbar
Gas flow rate through PPAC	Pfeiffer RVC 200	0.01 mbar l/s
HV	Upstairs on platform	+400 volts
Pressure set point	MKS 250	5.00 mbar
Input	MKS 250	1 volt
Phase lead	MKS 250	8 s
Gain	MKS 250	50 %
Manaul setting	MKS 250	10.00

9 The actuator's vacuum system

When the PPAC is retracted into the actuator, the actuator may be isolated from the main beamline by closing valve GV1. Note that this is an impulse activated valve, so you have to hold the open button for the duration of the opening and similarly for the close button when closing. Don't just press the button, hold it down for at least 3 seconds!

This valve is different from most of the other valves in that it will not close automatically if the compressed air fails. This is to prevent damage to the PPAC arm, if the PPAC is in the beamline at the time. Such a loss of compressed air occurs several times a year due to power outages.

There is an orange roughing pump with a hand operated valve labelled RPA which connects directly to the actuator. This valve should be closed when GV1 is open and the turbo pumps are pumping on the main beamline, otherwise the turbo pumps will suck the oil out of the roughing pump. There is no way of interlocking this!

If GV1 is closed, it is possible to pump on the actuator with this roughing pump by opening RPA. However, care should be taken if there is not already vacuum in the actuator, not to create too large a pressure difference in the PPAC. The pressure difference is shown on the MKS type 250 pressure regulator located at the base of the orange downstream beamline support. The PPAC can withstand a pressure difference of 5 mbar comfortably if the internal pressure is higher than the external (i.e. like it is when there is gas flowing) but the internal pressure should not be more than 1 mbar less than external pressure. Here, internal refers to the pressure in the PPAC and external to that in the actuator.

Furthermore, the PPAC has its own roughing pump, which is connected to the PPAC gas system. The valves of the gas control system are used to regulate it, so it should be on at all times, except when the PPAC and actuator are vented for long periods.

The vacuum inside the PPAC can be read from the Pfeiffer dual gauge. The two channels correspond to the inlet and outlet sides. The pressure difference between the PPAC and the actuator is shown by the MKS pressure regulator. Finally, there is a direct measurement of the pressure in the actuator on channel 2 of the dual gauge in the rack next to the yellow beam dump stand.

10 Pumping down the PPAC and actuator

To pump down the PPAC, it must first be retracted inside the actuator and GV1 must be closed. The PPAC should be in standby mode, with the inlet and outlet valves closed, and the PPAC bypass and bypass to chamber valves open. The MKS pressure regulator should be set to manual mode, so the valve is always open and the Pfeiffer flow regulator valve should be closed. The PPAC grey pump should be running, though it will not be used until we put gas in. The manual RPA valve should be closed, but the orange roughing pump should be running.

We will pump both the PPAC and the actuator simultaneously by pumping on the actuator with the bypass to chamber valve open. In this way we can prevent pressure differences between the actuator and the PPAC. However, the diameter of the bypass to chamber line is much less than that of the line to the roughing pump, so if we pump too fast, we could still build up a pressure difference, which would destroy the PPAC. So we must pump very slowly, watching the pressure difference displayed on the MKS pressure regulator. This should never exceed 5 mbar.

To pump down, open RPA very slowly, watching the pressure difference. Don't go above 5 mbar pressure difference. Once the pressure in the PPAC shown by the Pfeiffer dual gauage is below 5 mbar, you can open RPA all the way.

To summarize:

- Make sure PPAC is retracted into actuator.
- Make sure GV1 is closed.
- Make sure PPAC is in standby (Inlet and outlet closed. Both bypass valves open, MKS on manual, Pfeiffer valve closed).
- Make sure RPA is closed.
- Make sure the venting valve is closed.
- Make sure orange roughing pump is running.
- Make sure grey PPAC pump is running.
- Slowly open RPA to pump down both PPAC and actuator simultaneously.
- Do not let pressure difference shown on MKS exceed 5 mbar.
- When PPAC pressure is less than 5 mbar, open RPA fully.

11 Moving the PPAC in and out

Make sure the PPAC and actuator are pumped down. The vacuum in the actuator (see the second channel of the dual gauge in the rack) needs to be less than 5 $\times 10^{-2}$ mbar. If not, pump some more with the orange roughing pump, by opening RPA.

Then we must close RPA, and open GV1. Don't have these two valves open at the same time, or oil will be sucked out of the roughing pump. RPA is a hand operated valve, while for GV1 there is an "open" button on the vacuum control system. Note that you have to hold this button down until the valve is completely open (at least 3 seconds).

There are two connections for the motor. The first is used to unblock it. If more than about 8.3 Volts is applied to this wire, it is possible to operate the motor, otherwise it won't move. Between 5 and 15 Volts is applied to the other wire to move the motor. Note that the polarity determines the direction the motor moves in! Be careful not to catch the cables and tubes, when the motor is moving.

This is a truly awful system. It is not really possible to do it safely without having one person up the ladder keeping the cables safe and another operating the system from the ground. Be very careful, that the cables don't catch! Moreover, the fact that you have to plug and unplug connectors to change the motor direction is highly unsatisfactory.

If you just want to bring the PPAC in and out of the beam, you can leave GV1 open all the time and leave the PPAC gas and HV on.

12 Letting gas into the PPAC

Once the actuator and PPAC are both pumped down, we want to close the bypass to chamber (otherwise we can't build up a pressure difference), and the PPAC bypass. We also want to open the inlet valve to let gas in and the outlet to let gas back out. All this is done simply by pressing the "START" button and waiting for the system to switch from standby to running state. The last part of this state change is to close the PPAC bypass, so wait for that valve to close before going on to the next step. Obviously, the flow regulator should still be closed before we do this and the MKS should be set to manual (i.e. the valve is always open).

With the MKS valve fully open, the pump is pumping on the PPAC, so we need to switch the MKS from manual to automatic, so that it starts trying to regulate the pressure to the desired value (e.g. 5 mbar). Switching the MKS to automatic causes the valve to close until the pressure reaches that value and then it opens and closes as necessary to maintain that pressure.

Clearly, we won't get any pressure build up until we let gas into the system. Make sure that the valve on the gas bottle is open and then open the flow regulator (typically to something like 10^{-2} mbar l/s) by pressing the "open" button on the Pfeiffer flow regulator. Caution, pressing once increases by one unit of whatever scale it is on, but it switches scale automatically when it goes from 9×10^{x} to $1\times10^{x+1}$ and the next press is a factor of ten more than the previous one. From then on, gas should start flowing into the PPAC and when the pressure reaches the desired pressure (i.e. 5 mbar), the MKS valve should start regulating.

To summarize:

- Make sure flow regulator is closed and pressure regulator on manual and beamline and PPAC are pumped down.
- Press "START"
- Switch pressure regulator to automatic.
- Open flow regulator and set it to 10^{-2} mbar l/s. It seems that this is now slightly broken and needs to be increased up to 10^{-3} mbar l/s first and then very slowly to 10^{-2} mbar l/s, only when the pressure in the PPAC is at 5 mbar. Otherwise the control system goes into "fault" state. This is a new problem in 2007. In 2006, it was possible to go straight up to 10^{-2} mbar l/s.
- The PPAC is now in running mode.

13 Letting gas out of the PPAC

First make sure the high voltage is off. The HV supply is located at the top of rack 1 of the electronics.

Essentially we need to reverse the steps for putting gas in. That means we need to close the Pfeiffer flow regulator valve so that no more gas enters the PPAC, turn the MKS pressure regulator to manual, so that its valve opens fully letting the pump pump on the PPAC. Then when the pressure is better than about 1 mbar, we can press "RESET" to open the bypass to chamber.

Note that the PPAC can comfortably withstand a pressure inside 5 mbar greater than outside, but not the other way round. So you need to vent more slowly than you pump down.

To summarize:

- Make sure the PPAC high voltage is off.
- Press the "CLOSE" button on the Pfeiffer flow regulator until the green LED comes on indicating it is fully closed.
- Turn the pressure regulator to manual, so that its valve is fully open. This should cause the pressure to drop.
- When the pressure is below 1 mbar, press "RESET" to close the inlet and outlet valves and open the bypass valves.
- The PPAC is now in standby mode.

14 Venting the PPAC and actuator

First of all we have to take gas out of the PPAC and go into standby mode, with the inlet and outlet valves closed and the bypass valves open, the pressure regulation on manual and the flow regulation closed.

Valve RPA must be closed and then we can slowly vent the PPAC and actuator simultaneously using the needle valve. Go very slowly. At no time should the actuator pressure exceed that of the PPAC by more than 1 mbar.