# The MEGHA Manual

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**The Charissa Collaboration**

# Preface

This document is intended as a guide to the MEGHA facility and associated equipment for running charged particle experiments at the Australian National University Canberra. The following pages describe procedures for operating an evolving system. Some sections will inevitably have reached their "use by date" by the time you read this. Please refer to documentation local to the ANU and the latest version of this manual on the Charissa server at Daresbury for updates to the procedures described herein. ***If the procedures change during your experiment or you find an error UPDATE this manual by WRITING in it!*** Space has been provided at the end for additional comments. Most importantly, be careful out there and use the force!

*Steve Chappell.*

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# Chapter 1

# The Target Chamber

The full mechanical design specification for the MEGHA target chamber can be found in the document *"Multi Element Gas Hybrid Array", S.J. Metcalfe, Mechanical design office, Daresbury Laboratory (1994) and related updates.* Brief notes concerning usage of the chamber are given below.

## 1.1 Beamline

The MEGHA chamber is mounted on "Line A" of the Linac Hall (experimental area 2) at the ANU. It may utilize beams accelerated by the 14UD tandem Van de Graaff at this facility with or without post acceleration in the Linac booster.

## 1.2 Targets & Target Ladder

The target drive, guide tube and loading mechanism are located in the front portion of the target chamber. At present it consists of a manual drive which raises/lowers a "target rod" and the target frame attached to it. Up to five standard ANU targets may be loaded onto the frame. Targets are replaced by lowering the target ladder into the "target loading tube" located below the beamline entrance to the chamber. This allows targets to be replaced when the chamber is under vacuum.

## 1.3 Collimation System

Collimators and antiscatter apertures are mounted on ceramic inserts inside the "collimator tube". These inserts may be placed at any position within the tube. This tube is mounted inside a guide which is fixed to the chamber entrance. The collimator tube slides freely within the guide such that apertures may be placed at the desired position with respect to the target. The collimator tube is loaded through the "collimator box" at the chamber entrance. This "box" has a removable lid and contains feedthroughs for connecting the apertures to a current meter. A "standard set" of Daresbury type apertures is available.

## 1.4 Detection Systems

Two detection systems have been developed for use in the MEGHA chamber. These consist of:
**1)** A "Gas–Hybrid" array of up to 44 close packed Scintillator–Solid State Position Sensitive Detector–Ionisation chamber telescopes. These are mounted in nine-telescope modules, five modules comprising the full array. The modules plug into ports at the rear of the chamber.
**2)** A Silicon Strip detector array catering for up to 10 detectors. These mount on a removable

support placed inside the front portion of the chamber.
These systems are described in the following chapters of this manual.

# Chapter 2

# The Hybrid Detector Array

## 2.1 Overview

The basic module of the array consists of a self-contained vacuum-sealed unit of nine telescopes, each containing three detection elements; an ionization chamber, a solid state position sensitive detector (PSD) and a scintillating CsI(Tl) crystal, operating within the same volume of propane gas. An exploded view of these components is shown in Figure 2.1. The front of the module is sealed by a single sheet of aluminized mylar (typically a few $\mu$m thick) glued to a frame and bolted, against an 'O'-ring seal, to the main body. This forms nine windows with aluminized surface facing inward, effectively earthed via the module casing, to provide the gas section cathode. Signals, power, bias and gas flow are passed to the relevant components through the stainless steel module base plate. Five modules arranged in a Maltese cross (Fig. 2.2), with PSD centres tangent to a 600 mm radius sphere centered on the target, comprise the full array of 44 telescopes. Un-scattered beam passes through a narrow beam pipe, which replaces the central telescope in the zero degree module, to the downstream beamline and onto a Faraday cup for monitoring current.

The characteristics of the individual detection elements are discussed in the following three sections.

### 2.1.1 Gas Ionization Chamber

The axial field gas ionization chamber has evolved as a natural extension of designs developed at the Nuclear Structure Facility, Daresbury. We use a central gridded anode and shield grid constructed from Au-W wires (typically 20 $\mu$m diameter at a pitch of 1 mm) soldered onto a PCB frame in nine 50 mm $\times$ 50 mm sections . A common bias is applied to the anode grids (typically using the relation 2.5 V torr$^{-1}$ cm$^{-1}$) so that, depending upon experimental application, operation is typically in the range +500-1500 V for gas pressures of 50-150 torr. Individual signals from each anode section allow for the coincident detection of ions in different volumes of the gas.

### 2.1.2 Position Sensitive Detector

The PSD's used in MEGHA are of the large area resistive sheet variety and deliver both energy and position information through just five contacts (Fig. 2.5). These detectors are manufactured by implanting boron into $n$-type silicon and forming a thin resistive layer for charge division that also serves as the front anode of the detector. Additional ion-implanted strip lines border this electrode in a "low resistance ring" to compensate for the "pin cushion" distortion that is usually a characteristic of such devices. Signals derived from each of the front face corners of the (50 mm $\times$ 50 mm sensitive area) PSD's used in MEGHA localize event position with a remarkable degree of linearity (better than 1%) and show little evidence of distortion. Reverse bias is maintained across the PSD by application of a positive voltage to the rear face cathode or "energy" contact. The present stock of PSD's include similar designs manufactured by Hamamatsu Photonics and

Eurysis. The bulk of detectors are of 380 $\mu$m wafer thickness with a nominal operating bias of +80–100 V. See section 2.2.2.

### 2.1.3 CsI(Tl) Scintillator and Photodiode

The detector (supplied by Quartz & Silice) consists of a solid piece of CsI(Tl) crystal, wrapped in 5 $\mu$m thick aluminized mylar, with a 50 mm $\times$ 50 mm square front face and an active depth of 10 mm. The crystal is tapered, acting as a light guide, over a further 15 mm to a 18 mm $\times$ 18 mm square and glued onto a photodiode (Hamamatsu S3204-03). The two pins of the photodiode are soldered onto a PCB, where a high-gain hybrid FET preamplifier is mounted together with other passive components. Signal connections, bias and the $\pm$12 V power supply, are via a 14-pin ribbon cable socket (Fig. 2.4).

Operation of these scintillators at 2 $\mu$s shaping time and +30 V bias gives the best resolution for charged particle detection. The detector provides a gain of $\sim$ 6 mV/MeV and a full face energy resolution of 300 keV for 5.5 MeV $\alpha$-particles. An investigation of the point resolution of the CsI gave resolution values between 150 and 250 keV with a variation of pulse height across the detector face. Experiments requiring precise energy calibration may necessitate spline correction, for example, of this behaviour. See the document *N.M.Clarke, Charissa Report CH/Tech/92/08* for more details.

### 2.1.4 Preamplifiers

The pre-amplification of signals from the gas anodes and PSD's is performed using Charissa designed "surface mount" charge sensitive preamps. These are housed in groups of 18 in "preamp cans" mounted on the rear of each module, three cans per module. The "low gain" preamps are nominally $\times 1$ and used for the PSD's. The modified "high gain" variety are approximately $\times 5$ and used for the gas anode signals.

## 2.2 Module Construction

Notes on the construction of the MEGHA modules from their component parts (as shown in figure 2.3) and the routing of signals can be found in this section. A complete inventory of module parts is given in appendix A.

***When building the modules please remember to:***

***1) Check and include the many O-rings.***

***2) Use high vacuum techniques (gloves and a clean bench!) to help minimise pump down times.***

***3) Test for signal continuity BEFORE installing the module.***

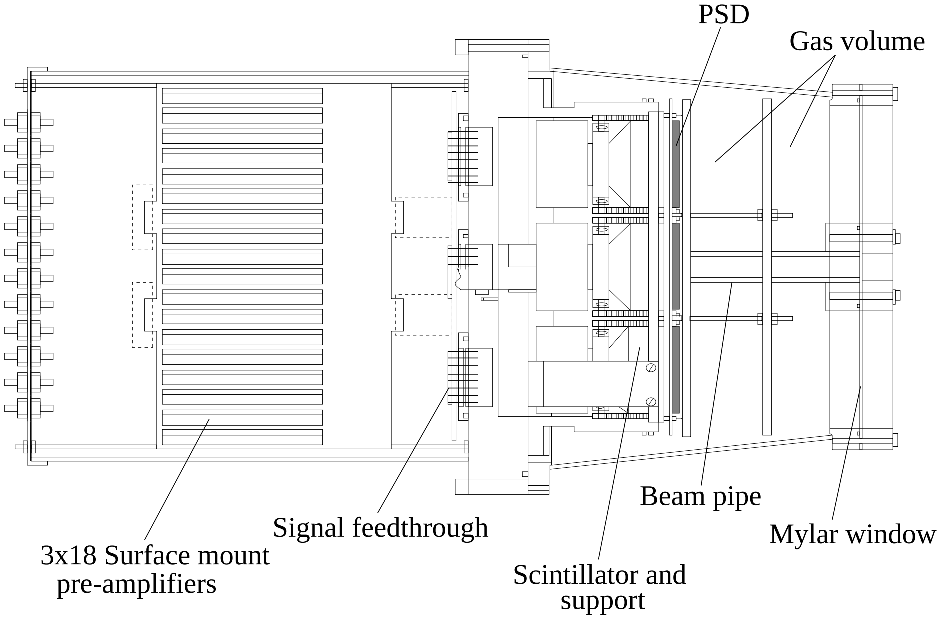
***4) Cover any exposed 16-pin feedthroughs. They are transparent and allow a significant amount of light to strike the detectors.***

***5) Protect the feedthroughs from damage. They are fragile and the most common source of leaks.***

***6) The length of screws is critical. Washers must be used on all screws. Refer to "Screw details for Module Assembly" in the technical drawings.***

### 2.2.1 The CsI Array

Each scintillator unit is cradled by a support, which is attached to the scintillator mount by two springs. ***Note that the relative orientation of the mount and scintillators is important and must follow that shown in Fig. 2.4.*** A clamp screwed to the scintillator frame at the four corners then keeps these springs and the scintillators in position. A single ribbon cable, attached as shown in Fig. 2.4, delivers power and bias to the scintillator unit and passes signals to the baseplate feedthrough shown in Fig. 2.7. ***Note that this ribbon cable has been modified to route signals from the same signal output pin along different lines.*** A common test input



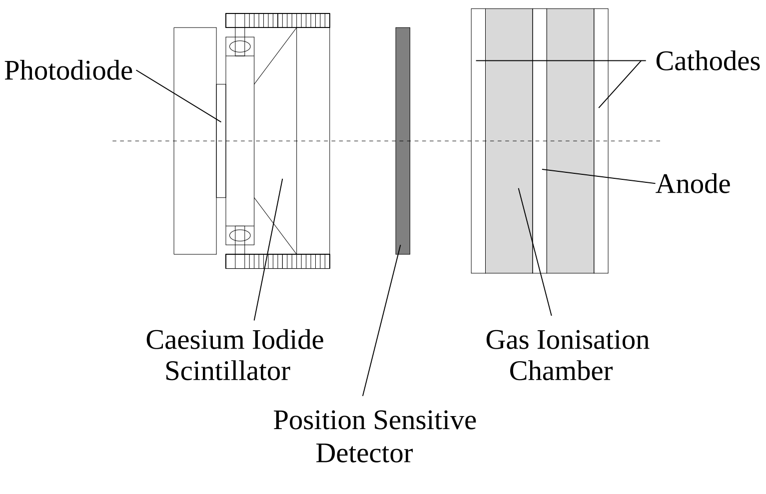




***Figure 2.1**: Components of the nine 3-element telescope MEGHA Module.*

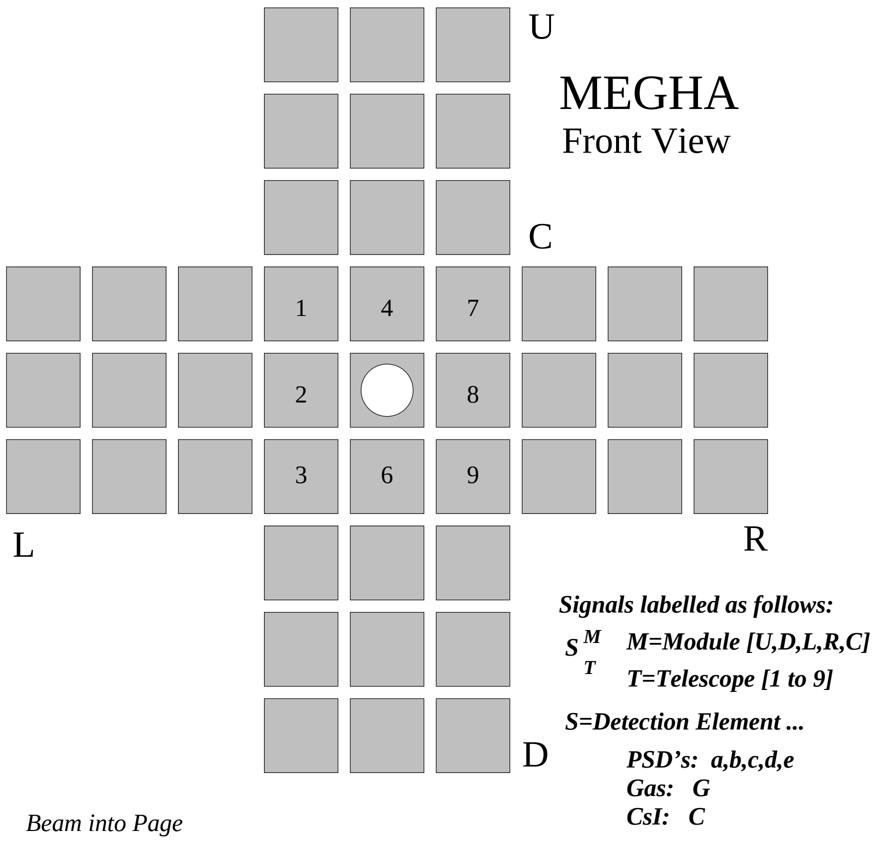



***Figure 2.2***: *MEGHA Array: Convention used for telescope and signal labelling.*

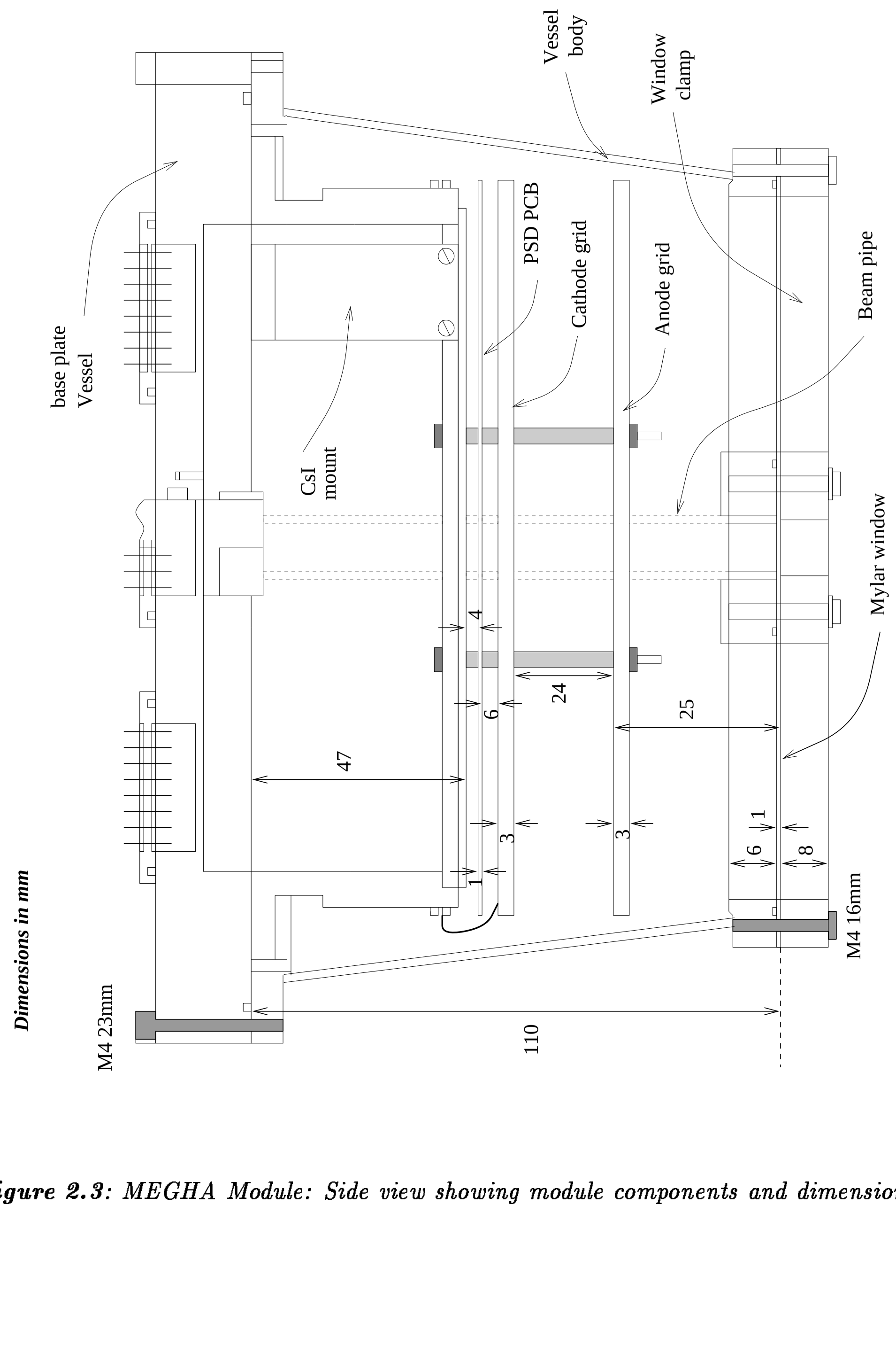



***Figure 2.3:*** *MEGHA Module: Side view showing module components and dimensions.*

line takes pulses to the test circuit of all the photodiode preamps in the module. A summary of the pin allocations for the CsI array is given in the figure.

### 2.2.2 PSD Array

Four 4 mm PTFE spacers separate the scintillator clamp from the PSD PCB board. The PSD's simply plug into this board which must be oriented as shown in Fig. 2.5. ***Note that two possible orientations connect each PSD to the PCB board. However, only one orientation connects the rear face energy signal (e)! Look for the central pin with a connection to the Si wafer.*** Three ribbon cables take the PSD signals a to e and pass them to the baseplate PCB inserts. These then route the signals to the baseplate feedthrough pins as described in Fig. 2.7.

The "offset" and "pull-down" resistors connected to the PSD position contacts (p in Fig. 2.5) are in the form of plug-in packs so that these resistances may be varied according to the experimental application. The resistor packs are located on the PCB board that mounts directly onto the module baseplate inside the preamp can. ***Note that the orientation of these resistor packs on the PCB board is important!***

### 2.2.3 Ionisation Chamber

The shield (cathode) grid of the ionisation chamber is mounted immediately above the PSD's, separated from them by four 6 mm PTFE spacers. The grid wires go on the top side of the PCB frame and are oriented to lie horizontally. Four 24 mm spacers then separate the shield from the anode grid. The whole assembly is then secured by nuts. Individual anode signals are extracted along cables (bundled as three sets of three) which plug into each of the baseplate PCB's. A single common bias is applied to the anode grid via direct connection through the conhex feedthrough on the module baseplate (Fig. 2.7) The bias cable is fed from the baseplate around CsI No. 1 to the anode grid. This grid is oriented with wires running horizontally and on the underside of the PCB frame. Connections to the individual telescope grids are shown in Fig. 2.6.

### 2.2.4 Windows & Calibration Grids

The front face of the module is sealed by a thin mylar window. This is secured between two frames (the window clamp) then bolted to the module casing. A calibration grid may be attached to the front of the module using four screws. Location pins determine the orientation of the grid. ***Nb. The mylar windows are usually attached when the modules are in place (bolted to the rear flange) via the access ports on either side of the chamber. Before sealing the modules ensure that all of the gas flow pipework is connected and the gas system valves set to equalize the pressure to atmospheric throughout the module and chamber volumes. The required valve settings are described in the evacuation procedure given in section 4.5.2.***

### 2.2.5 Connections to the Module Baseplate

#### Preamp Cans

Three preamp cans attach to each module. The front of each of these cans plugs into the three baseplate feedthroughs serviced by the preamps. Four screw thread rods support the corners of each preamp-can, screwing directly into the baseplate. Four long screwthreads are provided for attaching the module handles. The preamp cans deliver signals on conhex connectors as shown in Fig. 2.7. Each preamp can also has 3 SHV connectors for PSD bias and a plug for the preamp power supply. The three inputs eT, GT and pT allow a pulser to be connected to the test circuit of the preamps. eT drives the three PSD "energy" preamps, GT the three "gas" preamps and pT the 12 PSD "position" preamps. The telescope numbering convention is given in Fig. 2.2.

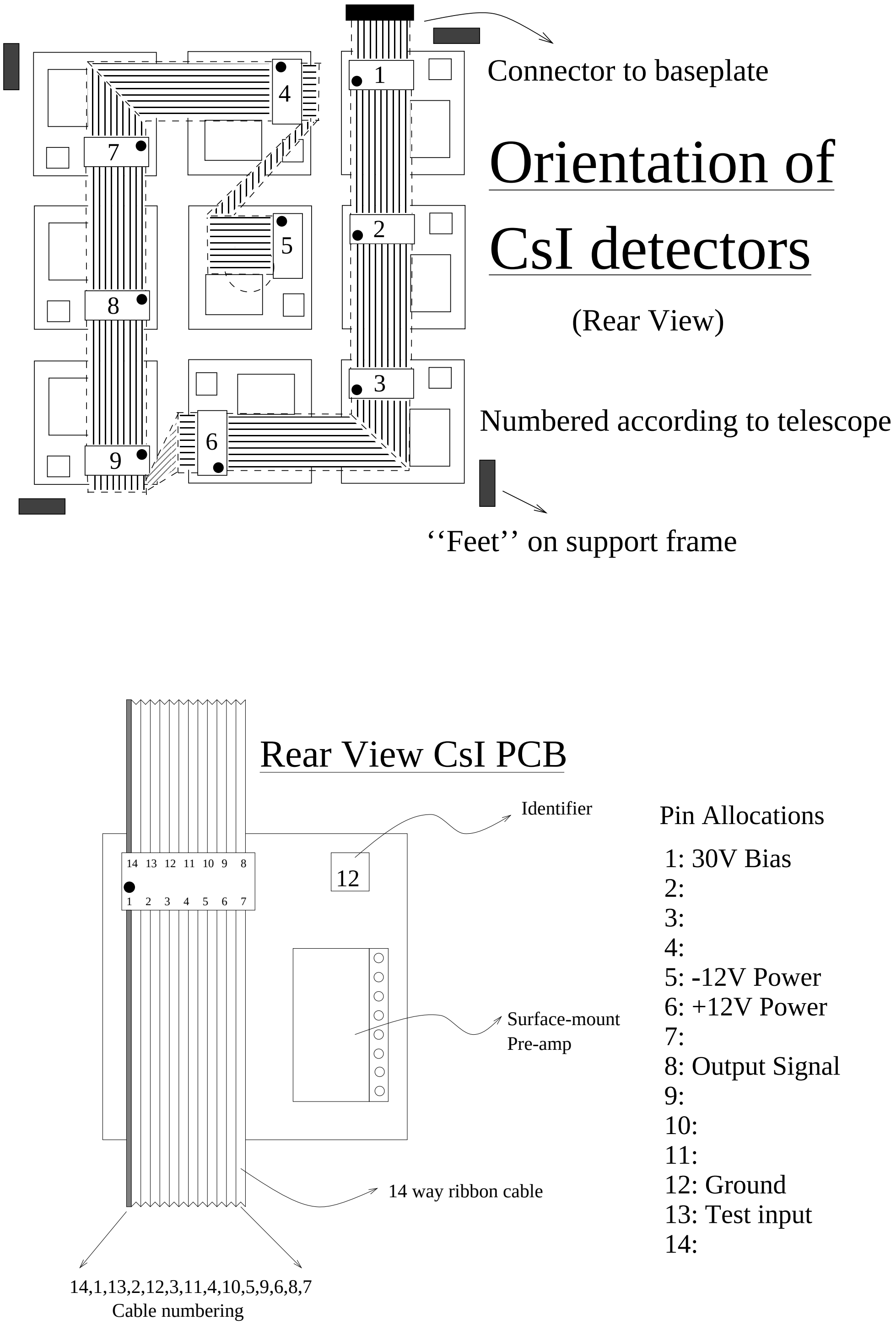
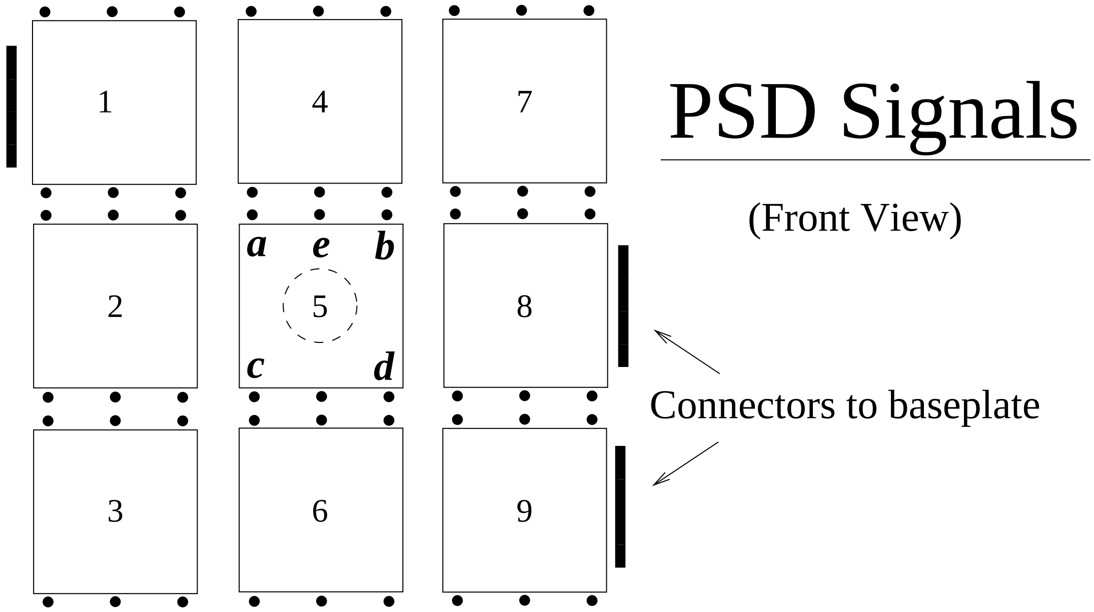



***Figure 2.4:*** *CsI Array: Orientation of detectors, & Signal routing.*



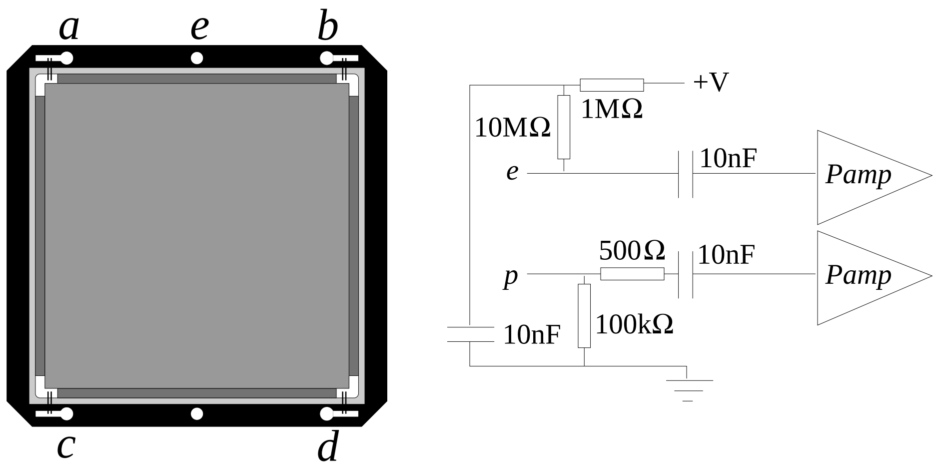




***Figure 2.5**: PSD Array: Orientation of detectors, & Signal routing.*

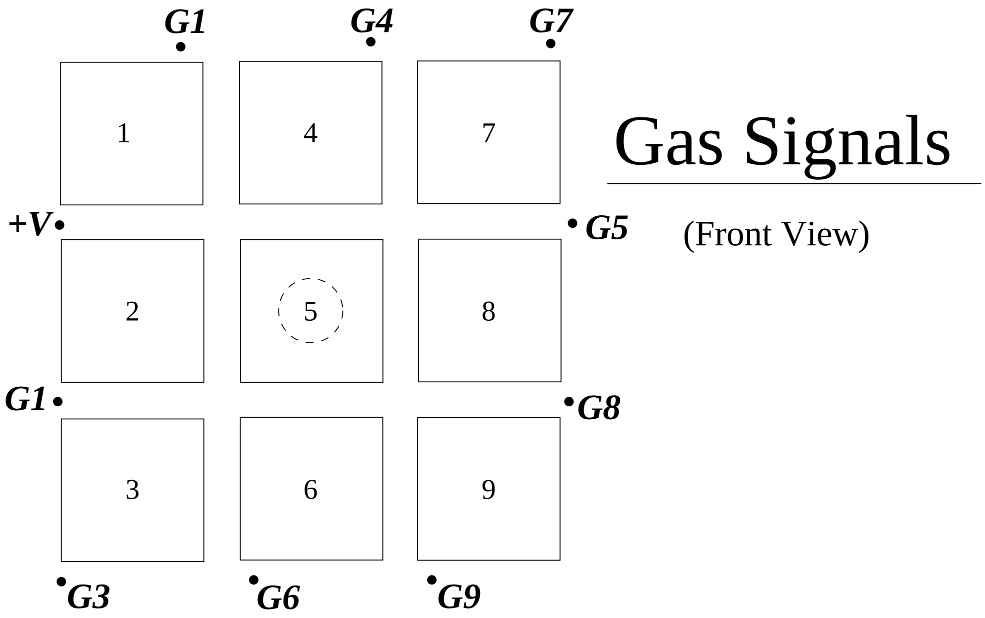



*Figure 2.6: Orientation of the gas anode grid.*

**CsI Connector**

Connections to the CsI array are made directly to the module baseplate feedthrough shown in Fig. 2.7 via the BNC to 16 pin conversion box.

**Gas Bias**

Bias is applied to the anode grid via connection to the conhex feedthrough indicated in figure 2.7. The remaining feedthroughs are unused.

### 2.2.6 The Zero Degree Module

A beampipe replaces the central telescope of the zero degree module. Apart from the notes below the construction of this module is identical to the others.
When constructing the zero degree module:
**1)** Use the zero degree mylar window/calibration grid/window clamp.
**2)** Remove the plug on the baseplate to allow passage of beam.
**3)** Use the zero degree baseplate PCB's.
**4)** Use the zero degree preamp can.
**5)** Remember that telescope number 5 doesn't exist!

### 2.2.7 Summary of Pin Allocations for each Module

Figure 2.7 summarises the pin allocations on the rear of the module baseplate. The telescope numbering convention is given in Fig. 2.2.

### 2.2.8 MEGHA Patch Panel

Most of the cabling for each module goes via a patch panel mounted above and behind the target chamber. The patch panel layout mimicks the *front view* of the 44 telescope array shown in Fig.

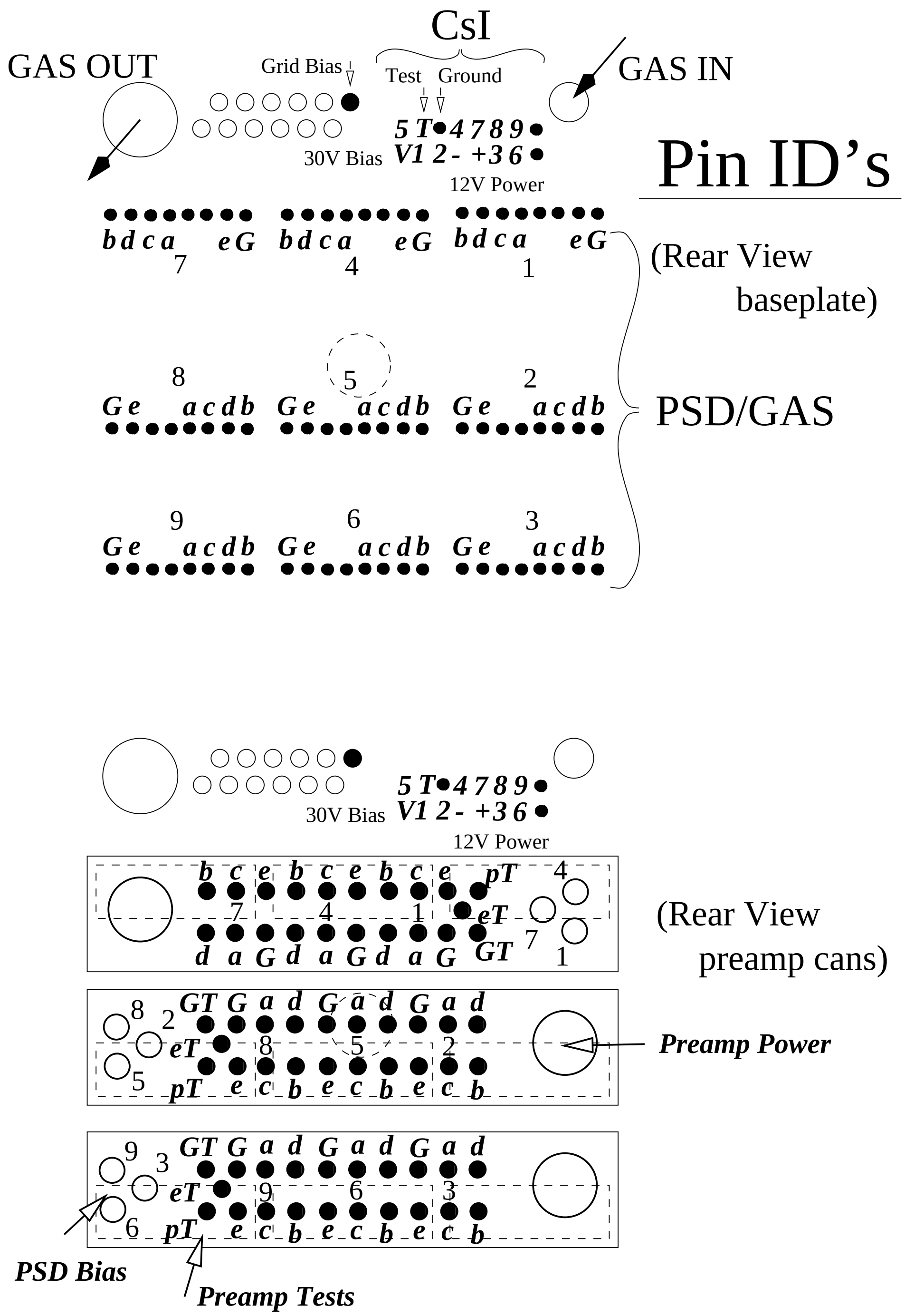



***Figure 2.7:*** *Summary of pin allocations on the baseplate and preamp cans of each Module.*

2.2. The complete patch panel layout is included here for reference (Fig. 2.8).

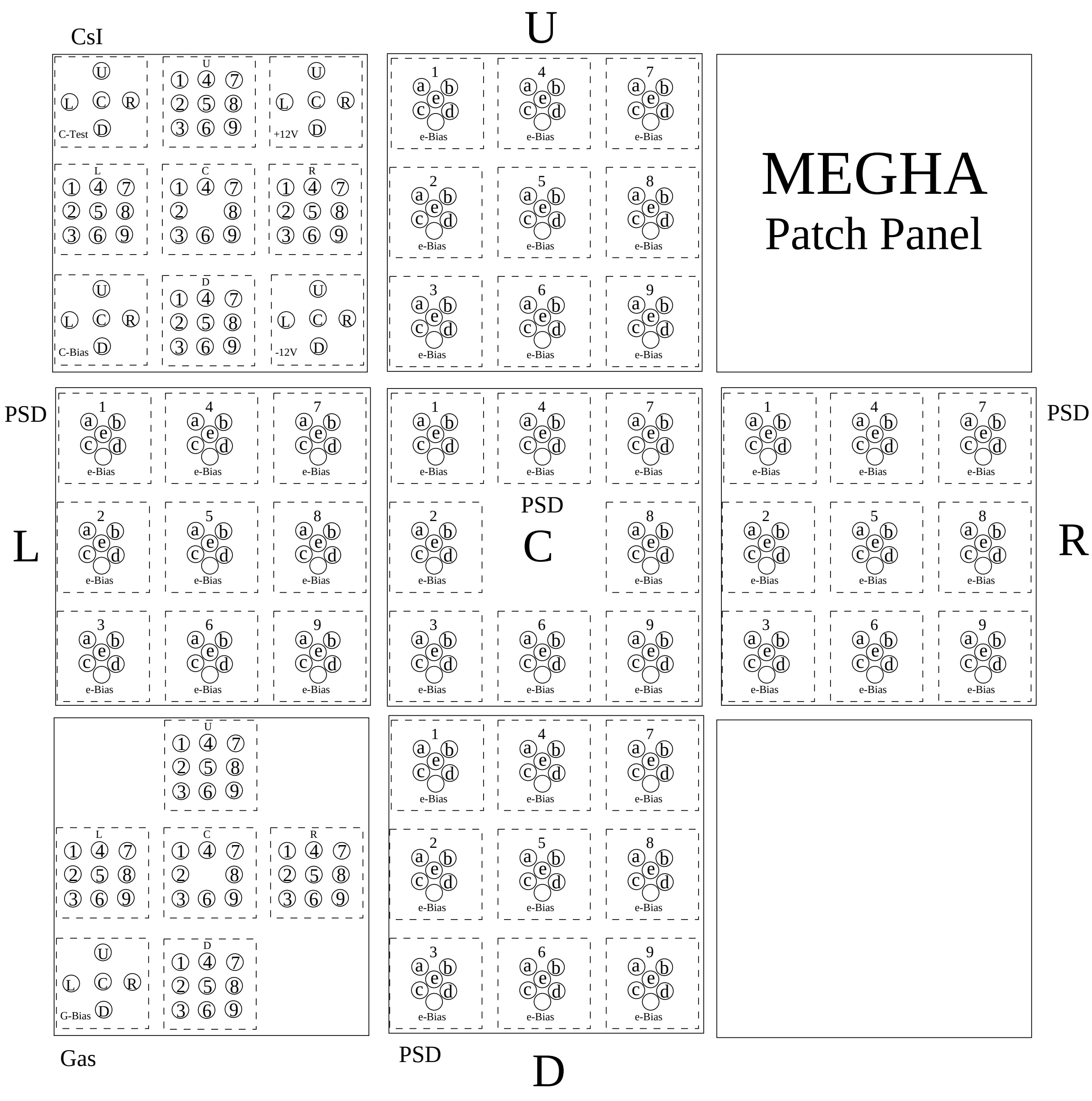



***Figure 2.8:*** *Layout of the MEGHA patch panel.*

# Chapter 3

# The Strip Detector Array

## 3.1 Empty!

When its built I'll write something!

# Chapter 4

# The Gas & Vacuum Handling System

## 4.1 Overview & System Description

These notes are designed to give an outline of the procedures to be followed at the ANU when operating the MEGHA gas & vacuum handling system. Due to the complexities of the system there are of course a number of different ways of achieving the same result when cycling MEGHA. Indeed, the inbuilt flexibility that allows for many different modes of operation means that only certain of the procedures below will be applicable to any one experiment. ***It is therefore advised that operators of this system use these notes only as a guide and use their own logic when making command decisions!***

The gas rack is formed from two 19" racks which are bolted together to form one continuous internal space. This contains the vacuum control and gas handling systems. The main electrical power enters the rack on the right hand side via a 30A connector. It then goes to a power control unit for distribution. This unit contains three contactors and associated connectors to run the three vacuum pumps plus a 13A connector for the mains distribution board. The Programmable Logic Controller (PLC), vacuum gauges and pump controllers are powered from this board.

Figure 4.1 shows the schematic diagram of the gas & vacuum handling system that appears on the front panel of the control rack[1]. MEGHA consists of three distinct volumes: The target chamber A and the volumes made up by the detector modules B & C. Each of the modules can be connected in parallel as belonging to either volume B or volume C using the gas manifold mounted to the rear of the chamber. Any modules not required may be replaced by a blanking plate attached to the vessel A. The two volumes B and C may be operated independently to give, for example, two different gas pressures in two sets of modules simultaneously. If only one gas pressure is required then all modules may be connected in parallel to form one volume B or C. On the schematic diagram the module volumes are connected across the two sets of boxes "B/C Vacuum" and "B/C Gas". The former (B/C Vacuum) indicates connection to the backing pressure which draws gas from B/C Gas through the modules. The vacuum and gas pipework in the figure is indicated by solid lines and the electrical wiring by dashed lines. Logical control of the pneumatic valves and pumps is provided by pushbuttons on this panel labelled with the valve identifications VA1 to VA20. VA1, VA2 and VA3 are the large plate valves connecting the chamber to the beamline and turbo pump "units" TPU1 and TPU2. These units consist of a turbo pump plus rotary backing pump. RP3 is the backing rotary pump.

The Programmable Logic Controller forms the heart of the system separating the pushbuttons and the user from the solenoid operated pneumatic valves. The PLC uses "Ladder Logic"[2] to process status information before allowing the valves and pumps to be switched. If the user

[1] Please remember that this diagram *is* schematic and does *not* always show the physical location of pipework connections. For example, the roughing line is usually connected to the top of the chamber

[2] Further information on Ladder Logic and programming the PLC can be found in the appendices to this manual.

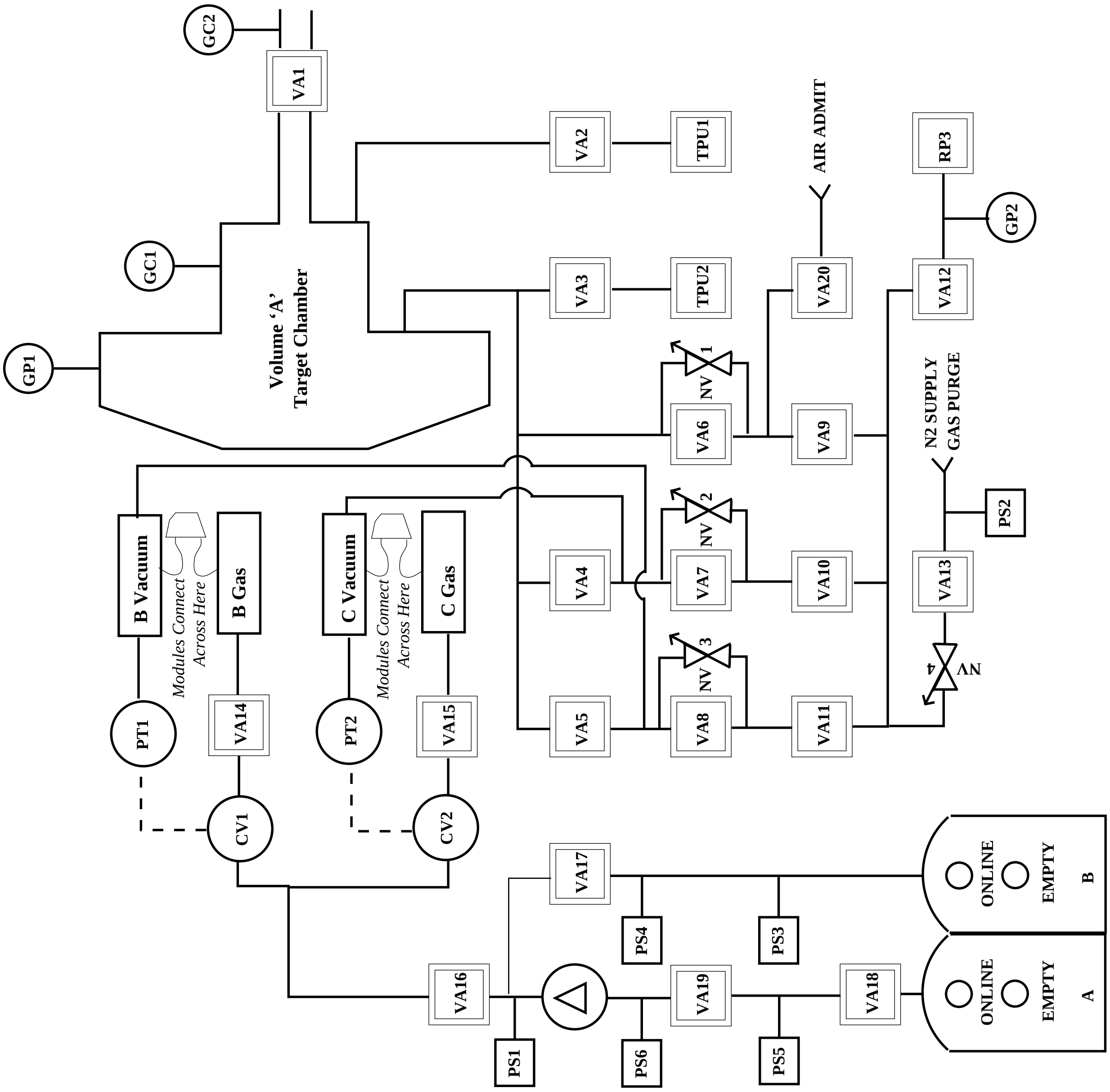



***Figure 4.1:*** *MEGHA gas & vacuum flow logic.*

attempts to open or close a valve or switch a pump using the pushbuttons when it is foolish to do so they will be rewarded with a beep from the gas control alarm and no operation will be performed. Once a valve has been opened succesfully *i.e. confirmed to have ACTUALLY opened by the PLC monitoring the status of switch sensors at the valve*[3] the relevant pushbutton will be lit. The pump control buttons (TPU1, TPU2 and RP3) are latched with distinct on (pressed in) and off (out) positions. These buttons do not connect to the PLC. They simply connect the pumps directly to the power control unit which turns the pumps on or off.

**Note that no protection is implemented for the pumps other that that provided by the turbo pump control units.**

The system also incorporates four manual needle valves NV1 to NV4. The controls for NV1 to NV4 are mounted immediately below the schematic diagram. NV4 is used to regulate the flow of the $N_2$ "gas purge" from the modules. If there is insufficient pressure at the pressure switch PS2, VA13 will not open. NV2 and NV3 allow adjustment of the pumping pressure and $N_2$ admit to the module volumes and NV1 a similar function on the chamber volume. Needle valves NV1 to NV3 may be bypassed using the valves VA6 to VA8.

Two gas bottles are indicated on the diagram labelled A and B with a set of status lights under PLC control. Bottle A is the "Master" cylinder and B the "Slave". Gas is delivered to the gas flow system through VA14 to VA19. The PLC automatically selects which bottle to place "on-line" by inspecting the status of the pressure switches PS3 to PS6. If there is insufficient pressure at PS1 VA16 will not open. If the gas pressure in bottle A is not above the threshold set on PS2, VA18 will not open. If it is not below the threshold set on PS6, VA19 will not open. Similarly, the pressure provided by bottle B must fall between the limits set by PS3 and PS4 before VA17 will open. Pressure transducers PT1 and PT2 measure the gas pressure and feedback to control valves CV1 and CV2 which adjust the gas flow supply.

Four pressure gauges are included in the system. GP1 and GP2 are of the Pirani type and measure the target chamber and backing pressures respectively. GC1 and GC2 are cold cathode sensors monitoring the target chamber and beamline at high vacuum.

The gas flow controls, pressure readouts and Turbo pump status indicators are mounted in the left hand side of the control rack.

## 4.2 Important Notes

**1)** A vacsorb unit is required for roughing.
**2)** The small turbo pump (TPU1) is now mounted on the downstream beamline.
**3)** The target chamber, downstream beamline and upstream beamline to the valve VA1 form a single volume, albeit with large impedances to gas flow through the collimation system and the chamber exit pipe.
**4)** The beamline valve VA1 is controlled by a unit adjacent to the beamline where it is designated as "Valve A". The status of this valve is given by the Normally Open pair connected to terminals 7 and 8 of the protection unit. This is indicated by the LED behind the VA1 button on the MEGHA gas rack.
**5)** A Normally Open Pair connects to the Valve A and beamline protection unit terminals 3 and 4. This pair closes and indicates "Good" Target Vacuum for GC1 pressures below the set point on the MEGHA vacuum gauge controller.
**6)** Undesirable pressure fluctuations were found when attempting to rough the MEGHA system with carbon vane pumps. It is therefore inadvisable to use them for roughing when modules with mylar windows are in place.
**7)** At the time of writing no provision had been made to connect gauge GC2 to the beamline. The beamline pressure can be calculated by reading the appropriate ion pump currents.
**8)** The Automatic Bottle change system was also found to be highly sensitive to slight changes in gas flow. The system should be set to manual and Bottle B used in preference to Bottle A until

[3] Note that VA13, VA16, VA17, VA18 and VA19 do not have switch sensors at the valve. VA2 and VA3 have two switches, one closes on valve open, the other on valve close. The status of VA1 is given by the control unit adjacent to the beamline. The remaining valves have a single switch which makes contact on valve open.

further notice.
**9)** There is no mesh over the chamber port sealed by VA3. To prevent screws flying into the turbo pump when this valve is opened ensure that none are left loose in the chamber!

## 4.3 Alarms

If a failure occurs the control system will automatically attempt to shut ALL valves. The failsafe for the pneumatic valves VA4 to VA20 is in the shut position. They require compressed air pressure to remain open so will always close on a compressed air fail. Unfortunately, this is NOT true of the large area plate valves VA1 to VA3 which require compressed air to *change* position and CAN remain in the open OR closed position on a compressed air fail.

### 4.3.1 Procedure on Hearing the Alarm

All valves should have been closed automatically. The user is prevented from operating the valves at this point.

On hearing the buzzer press the reset button ONCE to inhibit the annoying buzzer noise unless you like it! Take note of the panel display. Valves that were open when the failure occured will flash. If you are satisfied that the problem has been resolved press the reset button again to clear the alarm condition. If all is well the panel LED's will stop flashing, the gas supply system will activate and you can start opening valves again. If not the alarm will persist.

Please Remember to:
***1) Protect the beamline!***
***2) Ensure biases are off all the detectors!***
***3) Check pumps!***
***4) Always turn off the Vacuum Gauge Controller before disconnecting gauges.***
***5) Leave the Turbo Pump Controller Units switched on at the units themselves.***

## 4.4 Gas Control Power Up

When starting the system from scratch,

***Ensure that...***
***1) Mains Power is Connected and ON.***
***2) The Compressed Air Line is attached and ON.***
***3) $N_2$ Supply pipework is connected and ON.***
***4) Pumps TPU1 and TPU2 (both turbo and rotary) are connected with switches OFF on the gas rack panel but ON at the pumps and controllers themselves.***
***5) Air supply to VA2 and VA3 is connected and ON. Note VA1 is now connected to the controller adjacent to the beamline. The connections on the gas rack should always be blanked off.***
***6) Water switch cables from VA2 and VA3 are connected. No connections are required to the VA1 sockets.***
***7) Backing Pump RP3 is OFF on the gas rack panel but ON at the pump.***
***8) A Vacsorb unit is available.***
***9) Pressure Guages are present and cabling is attached.***
***10) Gas flow manifold and Module pipework is connected.***
***11) Gas bottles are connected (open hand valves and check pressure reading).***
***12) Manual Override is DEACTIVATED.***
***13) The PLC RUN key is set to STOP.***

Note the status of:

***a) Downstream beamline! : Is beamline there?!, Pumps ON?, Pressure?***
***b) Upstream beamline! : Pumps ON?, Pressure?, CLOSE VALVES.***

*Go Ahead press the green power ON button.*
All fuse lights on the PLC front panel should illuminate.
*Now start the PLC program by turning the PLC RUN Key to RUN.*
ALL control panel LED's should light and the buzzer sound. ***If this does not happen Seek Help BEFORE proceeding: the incorrect software may be loaded into the PLC or some LED's/the buzzer may be faulty.***
In the unlikely event that everything has worked the control display should indicate:
**1)** which gas bottle has been automatically placed on-line by opening either VA18 and VA19 or VA17.
**2)** that all other valves are closed.
**3)** that the compressed air supply is connected.

You can be sure that if there is a problem lights will flash and the alarm will sound!

## 4.5 Gas & Vacuum Cycling Procedures

The general procedures described in this section assume a standard setup where modules are operated with both gas control channels B and C. It should be clear that for experiments using only channel B, that the channel C controls and valve operations can be ignored. Similarly, for measurements not requiring gas control at all one can follow these procedures and ignore all reference to operations of the gas cycling system. Some of the possible variations and corresponding amendments to the standard procedure are listed below.

### 4.5.1 Variations on the Standard Procedure

#### Gas Channel C NOT in Use

e.g. All modules connected in parallel as volume B.
Valves VA4, VA7, VA10, VA15 and NV2 should always remain closed.
Gas control valve CV2 should be kept closed.

#### Gas Channel B NOT in Use

e.g. All modules connected in parallel as volume C.
Valves VA5, VA8, VA11, VA14 and NV3 should always remain closed.
Gas control valve CV1 should be kept closed.

#### No Gas Volumes Required

e.g. For MEGHA strip detector array experiments.
Apply the above two amendments ensuring that VA16 also remains closed.
Disconnect the gas bottles by closing the regulator hand valves.

### 4.5.2 Evacuation

***Ensure biases are off all the detectors!***
***Protect the beamline!***
***Ensure chamber is sealed!***

**1) Starting from:**
VA4, VA5, VA6, VA7, VA8, VA9, VA10, VA11, VA20 Open.
Remaining valves closed including needle valves!

*Nb: VA17 to VA19 are controlled by the automatic gas feed. The pipework from VA14 to CV1 and VA15 to CV2 should be at good vacuum from the previous gas purge.*
Connect the rotary pump RP3.
***Monitor the backing pressure on GP2 and the chamber pressure on GP1 then GC1.***

**2) At the Atmospheric Pressure of the day:**
Make a note of the various gauge readings. You will need to vent the chamber back up to within a few torr of these values.
Close VA6, VA7, VA8, VA10, VA11, VA20.
Only the volume A-B-C pressure equalisation valves VA4 and VA5 and the roughing line valve VA9 should be open.
Start RP3, Open Hand Valve and open VA12.
Slowly open NV1 to pump the combined volumes A, B and C ***at a rate of 0.1 to a few times 0.1 torr per second*** to prevent significant pressure differences between the volume A and volumes B and C. Pumping in this manner will cause the evacuation of B and C to lag behind that in A, keeping the windows pressured in the right direction (i.e. outward).
Open NV1 further as the pressure drops to maintain the rate of decrease. **If the pressure differential between the volumes becomes greater than a few torr, close NV1, wait for the pressure to equalize, then proceed.**

**3) At $< 50$ torr:**
Close NV1, VA12 and RP3 Hand valve.
Open the needle bypass valve VA6.
Open VA12.
Slowly Open RP3 using it to control the rate of decrease.

**4) At $< 1$ torr:**
Switch from RP3 to vacsorb. Close VA12 and RP3 Hand valve. Open Vacsorb. Open VA12.

**5) At $< 10^{-1}$ torr:**
Close the pressure equalisation valves VA4 and VA5.
Close VA6, VA9 and VA12.
Ensure small turbo unit TPU1 is operational and at speed.
Open the small turbo valve VA2.
Ensure large turbo unit TPU1 is operational and at speed.
Open the large turbo valve VA3.

**6) Continue to pump modules using the backing line:**
Open RP3 hand valve then VA12.
Open VA10 and VA11.
GP2 should be $< 10^{-1}$ torr before opening VA7 and VA8.

**7) At chamber pressure $< 10^{-5}$ torr:**
Ensure that the pressure in the beamline is Good. Check GC2 and ion pump gauges.
Open the beamline VA1.

### Example Pump Down Curves

An example evacuation sequence for the MEGHA system is shown in Table 4.1 and Fig. 4.2. These data were measured for 3 modules connected as volume B. The pressure transducer PT2 (normally connected to volume C) was connected so as to monitor the chamber pressure in the range: atmosphere to zero torr. Note that a confident user may well be able to evacuate faster than this *hopefully* foolproof scheme!

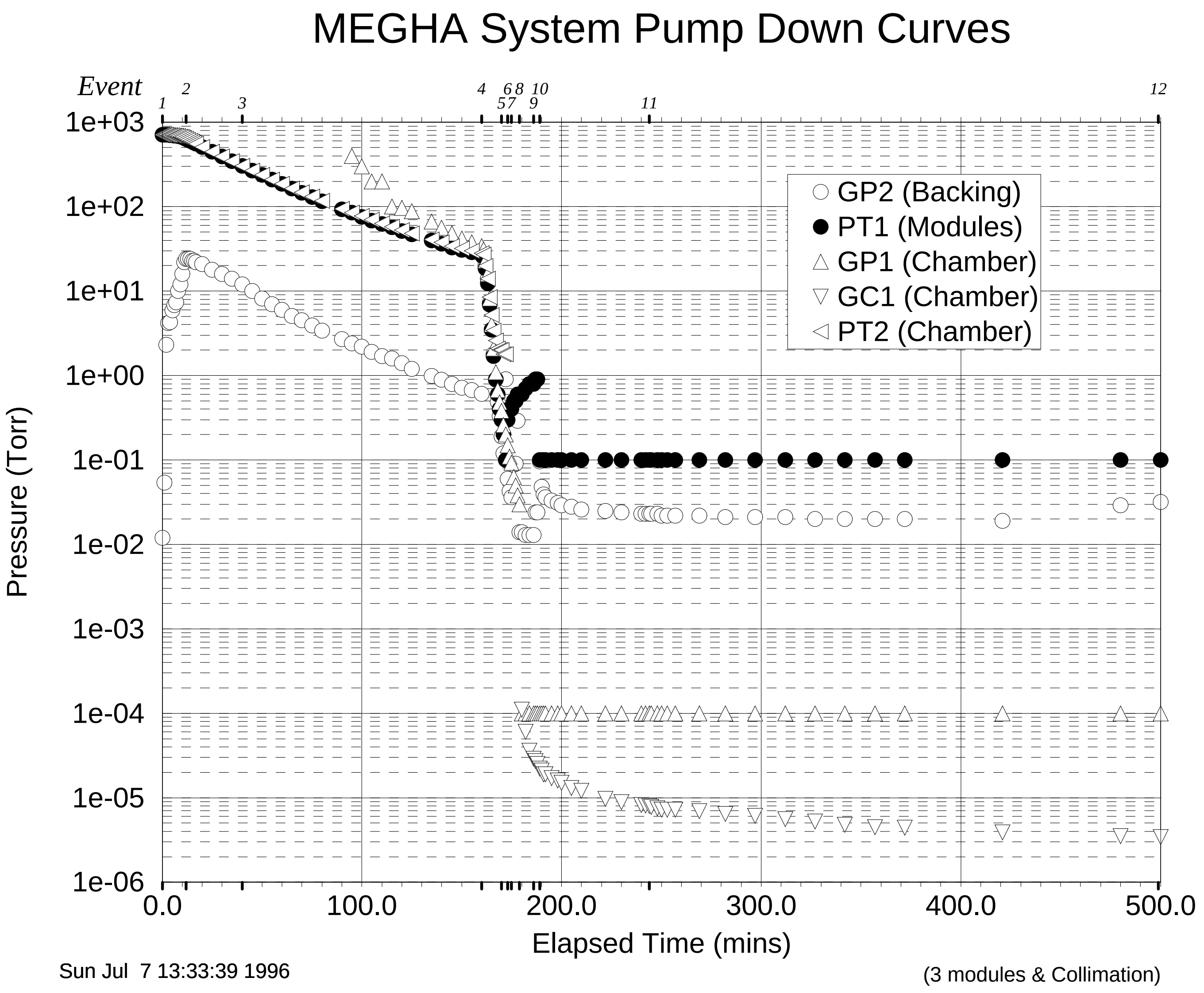



*Figure 4.2: Example Pump Down Curves.*

| Event No. | Time (mins) | Operations |
|---|---|---|
| 0 | Start Point | VA5, 6, 8, 9, 11, 17, 20 OPEN. Rest Closed. |
| | | Turbo's at Full speed. RP3 On. |
| 1 | 0 | Open RP3 Hand Valve. |
| | | Close VA6, VA8, VA11, VA20. |
| | | Open VA12. Crack Open NV1. |
| 2 | 12 | NV1 Now Fully Open. |
| 3 | 40 | PT1 and PT2 equal. |
| 4 | 160 | RP3 Hand Valve Closed. |
| | | VA6 Open. Crack Open RP3 Hand Valve. |
| 5 | 170 | Switch from RP3 to Vacsorb. |
| 6 | 173 | Close VA5. |
| 7 | 175 | Close Vacsorb Hand Valve. |
| | | Close NV1, VA6, VA9, VA12. |
| | | Open RP3 Hand Valve. |
| | | Open VA11, VA12. |
| 8 | 179 | Open VA2 then VA3. |
| 9 | 186 | Open NV3 Fully. |
| 10 | 189 | Close NV3. Close RP3 Hand Valve. |
| | | Open VA8. Crack Open RP3 Hand Valve. |
| 11 | 244 | Open VA1 (Valve A to beamline). Valve B in closed position. |
| 12 | 499 | Open Valve B to the accelerator. |

***Table 4.1:*** *Event list for Example Evacuation Sequence.*

### 4.5.3 Introducing Gas

***Ensure biases are off all the detectors!***
***Protect the beamline Close VA1!***
***Protect the turbo pumps Close VA2 and VA3!***

**1) Starting from Evacuated Volumes A,B and C.**
Valves as at end of Evacuation procedure and the above precautions: VA7, VA8, VA10, VA11 and VA12 are open. Rest CLOSED including needle valves! *Nb: VA17 to VA19 are controlled by the automatic gas feed.*
***Monitor the backing pressure on GP2 and the chamber pressure on GC1.***

**2) Check the Gas feed system.**
The gas feed valves VA14 and VA15 should be closed.
VA18 and VA19 or VA17 should be open. VA16 should be closed.
Ensure Gas Controller 1 is operational and CV1 is CLOSED.
Ensure Gas Controller 2 is operational and CV2 is CLOSED.
The controllers should be set to INT and on the 10V range. Their potentiometer dials should be wound to zero. The Phase lead and gain are typically set to 6 secs and 95%, respectively.
Open VA16.

**3) Admit gas to volume B:**
***Monitor Gas B pressure on PT1.***
Close VA8.
Open the gas admit valve VA14.
Dial in the required set point pressure.
Switch Gas Controller 1 to MANUAL. Use the potentiometer to slowly open CV1 and bleed gas into volume B.

***The flow rate should not exceed 0.1 to a few times 0.1 torr per second.***
***Watch closely PT1 and GC1 for any indication of a gas leak across the intermediate window. e.g. a rise in volume A pressure.***

**4) At a torr or so above the required Gas B pressure:**
Switch CV1 to CLOSE. Wind potentiometer to zero.
Check backing pressure GP2.
Adjust NV3 for a suitable pump out rate measured on PT1.
***The flow rate should not exceed 0.1 torr every few seconds or so.***
At approximately the desired pressure. Turn Gas Controller 1 to AUTO. The pressure should quickly settle down to cycle about the required set point value.

**5) Admit gas to volume C:**
***Monitor Gas C pressure on PT2.***
Close VA7.
Open the gas admit valve VA15.
Dial in the required set point pressure.
Switch Gas Controller 2 to MANUAL. Use the potentiometer to slowly open CV2 and bleed gas into volume C.
***The flow rate should not exceed 0.1 to a few times 0.1 torr per second.***
***Watch closely PT2 and GC1 for any indication of a gas leak across the intermediate window. e.g. a rise in volume A pressure.***

**6) At a torr or so above the required Gas C pressure:**
Switch CV2 to CLOSE. Wind potentiometer to zero.
Check backing pressure GP2.
Adjust NV2 for a suitable pump out rate measured on PT2.
***The flow rate should not exceed 0.1 torr every few seconds or so.***
At approximately the desired pressure. Turn Gas Controller 2 to AUTO. The pressure should quickly settle down to cycle about the required set point value.

**7) Ready to Run?!**
Open the chamber to the small (VA2) then large (VA3) turbo pumps.
Ensure that the chamber pressure GC1 is $< 10^{-5}$ torr.
Ensure that the pressure in the beamline is Good. Check GC2.
Open chamber to the beamline (VA1).

### 4.5.4 Venting

***Ensure biases are off all the detectors!***
***Protect the beamline Close VA1!***

**1) Starting from Evacuated volume A, Gas filled volumes B & C.**
Valves as at end of Introducing Gas procedure: VA2, VA3, VA10, VA11, NV2, NV3, VA12, VA14, VA15, VA16 open. Rest CLOSED including remaining needle valves! *Nb: VA17 to VA19 are controlled by the automatic gas feed.*

**2) Shut off Gas Supply:**
Set Gas Controller 1 and 2 to CLOSE CV1 and CV2.
Close VA16.

**3) Evacuate volumes B and C**
Adjust NV2 and NV3 to evacuate gas from B and C.

**4) At Volumes B & C $< 10$ torr:**
Open VA7 and VA8.
Close NV2 and NV3.

**5) At Volumes B & C $< 10^{-1}$ torr:**
Close VA14 and VA15.
Close VA7 and VA8.
Close VA10 and VA11.
Close VA12.
Close the turbo pump valves VA3 and VA2.
Open the volume A-B-C pressure equalisation valves VA4 and VA5.
Open VA9 and VA13.
Slowly open NV4 and NV1. **NV4 is not a needle valve in the present system so care must be taken not to open this valve too fast.** Admit $N_2$ into the combined volume A-B-C. ***Ensure no large pressure differential occurs across the thin windows.*** The rate of pressure increase should not exceed a few 0.1 torr a second, i.e. the reverse of the evacuation procedure.

**7) At Volumes A-B-C $1-3$ torr above atmospheric:**
Close NV1 and NV4.
Close VA13.
Open VA20.
Slowly Open NV1 then the bypass valve VA6 to allow pressure to decrease to atmospheric.
You may now open the chamber.

### 4.5.5 Changing Targets

Close VA1 before winding the target mechanism up or down to the required target.

### 4.5.6 Replacing Targets Under Vacuum

***Protect the beamline Close VA1!***
***Protect the turbo pumps Close VA2 and VA3!***

**1) Starting from Evacuated volume A, Gas filled volumes B & C.**
Valves as at end of Introducing Gas procedure and the above precautions: VA10, VA11, NV2, NV3, VA12, VA14, VA15, VA16 open. Rest CLOSED including remaining needle valves! *Nb: VA17 to VA19 are controlled by the automatic gas feed.* As a further precaution you may wish to remove the gas from the modules before proceeding.
***Monitor the chamber and gas pressures on GC1, PT1 & PT2.***

**1) Venting the target tube assembly:**
Ensure that a carbon vane/vacsorb unit is connected to the exchange tube before evacuating the chamber!
Wind target ladder to its lowest setting.
Connect $N_2$ supply line to the carbon vane/vacsorb unit.
Bleed $N_2$ into the target tube until it reaches atmospheric pressure.
Open the target tube & remove the target ladder.
Reload the target ladder & replace inside the target tube.
Close target tube.

**2) Returning target ladder to Evacuated volume A:**
Evacuate target tube using carbon vane/vacsorb unit.

**3) At target tube pressure $< 10^{-2}$ torr:**
Isolate from the carbon vane/vacsorb unit.

Wind target ladder up to operating position.
Open chamber to the turbo pumps. Open VA2 and VA3.

**4) At chamber pressure GC1 $< 10^{-5}$ torr:**
Ensure that the pressure in the beamline is Good. Check GC2.
Open to the beamline VA1.

## 4.6 The Gas Bottles

These are located behind the lower left panel of the gas control rack. For access to the bottles undo the screws on the front and remove this panel.

If the master gas bottle A empties, VA16 will automatically close. VA18 and VA19 will then shut and the empty LED will light. Bottle B will go on-line if it is present and contains gas. Should you wish to change a gas bottle follow the procedure below.

***Note that it is advisable to close VA16 before changing the gas bottles. Adjustments to the needle valves NV2 and NV3 and gas control potentiometers may also be needed during automatic or manual bottle changes.***

### 4.6.1 Changing the Slave bottle B

Bottle B may be replaced providing VA17 is shut. Check the pressure reading from the bottle. The pressure switches and indicator lights may be trying to fool you into believing that the bottle is empty! Close the hand valve on the bottle regulator. Replace the bottle. Open hand valve. Check pressure reading.

### 4.6.2 Changing the Master bottle A

Bottle A may be replaced providing VA18 and VA19 are shut. Procedure the same as for bottle B.

*Nb: The PLC will automatically select which gas bottle to place on-line after opening the hand valve if running in the AUTO mode.*

## 4.7 Shutdown

**1)** Purge Gas from the modules and vent the chamber.
**2)** Ensure that all valves are closed, especially VA1 to VA3. *Nb: VA17 to VA19 are controlled by the automatic gas feed and may remain open.*
**3)** Deactivate the pumps TPU1, TPU2 and RP3.
**4)** Turn the PLC RUN key to STOP.
**5)** Press the red power OFF button.

The remaining valves should shut automatically. If the system is to be left for some time close the hand valves on the gas bottle regulators, the compressed air and $N_2$ inlets. Isolate the control rack and pumps TPU1, TPU2 and RP3 from the mains supply.

## 4.8 Manual Override

This key allows the automatic gas feed to be set to manual. The level of protection for the rest of the system remains the same. Particulary strange requests such as venting the beamline will still not be granted. You'll just have to rewrite the software to do that!

# Chapter 5

# Operating Procedures at the ANU

... or: How to succesfully create a beam and accelerate it onto the right target. As always, refer to guidelines at the ANU.

## 5.1 Ion Sources

### 5.1.1 Startup procedure (Sputter Source)

**1)** Turn on the 4 breakers (2, 3, 5 and 6) on front of source rack. The extract volts should come on.
**2)** Over a *30 minute period* run the ionizer up to 20 A.
**3)** Keep restoring the ionizer to 20 nA from time to time as it falls.
**4)** Remove earthing hook from sputter rack and close perspex gate. Hang hook on door handle.
**5)** On vacuum control racks that span the perspex door:
Check green "Good" lights are on.
Check ion gauge reads $\sim 4 \times 10^{-7}$.
**6)** Check 14UD tube pressures $\sim 10^{-8}$ (See rack near door leading to lift).
**7)** Open level 5 isolation valve – Press two buttons together on rack above $90^o$ inflection magnet.
**8)** Press ON switch on Box Voltage control panel (Top of rack near door leading to lift). Blue light next to switch should come on. Set Box volts to required value (usually 128.6 kV).
**9)** Check ionizer — get it stable at 20 A.
**10)** Over a *15 to 20 minute period* run ionizer up in 3 Amp steps *(every few minutes and NO faster)* to about 30 A — Check value logged in 14UD log.
**11** Switch LE cup current monitor to control room. Go to remote! Check image slits OK (usually 1mm). Go downstairs and wait for beam to build up on the LE cup. When pill is hot enough, turn the reservoir on. Build up reservoir to previously logged value over *30 mins.*
**12** Scan $90^o$ magnet strength to optimize for required beam species.

Typical values for the source are:
15 kV extractor.
4-6 V (8-9V max) ionizer.
30V (60V max) Reservoir.

The best beam transmission is for 60% on Einzel lens up/down control. Then adjust inflection magnet.

### 5.1.2 Shutdown (Sputter Source)

**1)** Turn "Quick Cool" on (See control rack near source $\sim$ 35 cm from top). Hear gas come on.
**2)** Adjacent to the Quick Cool is the reservoir control. Press down and run to zero (see bottom left gauge on inside rack.)
**3)** When reservoir temperature $< 50^o$, lower ionizer by about 20%.

**4)** Find Box Volts control (Rack near door leading to lift). Turn volts down using "−" button and switch off.
**5)** Lower ionizer another 30% or so.
**6)** Close level 5 isolation valve (On rack above $90^o$ magnet).
**7)** Take hold of earthing hook. Open cage and attach hook to ring below amonia bottle on source.
**8)** Halve the ionizer current.
**9)** After a couple of minutes halve the ionizer current again.
**10)** Wait a minute then run ionizer current to zero.
**11)** Wait around 3 minutes.
**12)** Turn off breakers 2, 3, 5 and 6 ONLY using switches on front of source rack. The extract volts should go off.
**13)** Turn Quick Cool off.
**14)** Write anything to report in the appropriate source log book.

## 5.2 Target Station

**1)** Set the analyzing magnet to direct beam into the Linac Hall or main experimental area.
**2)** Prepare the target station and beamline.
MEGHA is on Line A in the Linac Hall.
The 2m Chamber is on Line 3 in the main area.

## 5.3 The 14UD

### 5.3.1 Startup

**1)** Check that the (mid section) sublimer currents are zero before turning on shafts.
**2)** Move charge voltage switch to on.
**3)** Switch shafts key to on.
**4)** Hit start on upper and lower shafts.
**5)** Switch charging motor key to on and hit start buttons.
**6)** Switch GVM terminal voltage stabilizer (TVS) to slits.
**7)** Turn up charging voltage control. Current will start running through the resistors and is measured on low and high energy tube ammeters.
**8)** Increase charging voltage to about 10 kV.
**9)** Adjust GVM voltage error to approx required potential.
**10)** Switch TVS to GVM.
**11)** Move triode needles inward. The triode current should increase and the terminal voltage should rise to the GVM setting. If not adjust charging voltage and triode needle positions. Keep in the green and out of the red on triode current meter.
**12)** Check hand valve above analyzing magnet is open.
**13)** Check image slits OK (usually 1mm).
**14)** Select appropriate line to control (e.g. line 3 in Area 1).

The terminal potential corona stabilizer is usually set to "stabilize". If running at high MV it is usual to "condition" the machine for a while.

If the machine sparks, lower the charging volts, wait for vacuum to recover, then put volts back on.

### 5.3.2 Shutdown

**1)** Switch TVS to GVM.
**2)** Set zero volts on GVM.
**3)** Move triode needles out and reduce charging voltage to zero. Turn off panel switch

**4)** Stop the charging motors. Turn key to off.
**5)** Run down terminal and mid section sublimers.
**6)** Stop upper and lower shafts. Turn key to off.
**7)** Move charge voltage switch to off.
**8)** Turn $90^o$ magnet and switching magnet controls down to less than 50 A.
**9)** Leave all steerers, Quads and NMR as you have been using them.
**10)** Record all troubles/failures relating to the 14UD in the fault log.

### 5.3.3 Beam Transport

**1)** Identify the distribution of charge states following stripping at the central terminal for the required beam using the ANU code STRIP. Access to the local computers is via account name "charissa".
**2)** Identify the precise analyzing magnet B-field for the required beam using the ANU code UD-FREQ. Set the NMR probe (An $H_2O$ sample irradiated with an R.F. field at a frequency determined by the NMR gaussmeter tuning pot.) to the exact value given by the code then adjust the B-field using the coarse and fine controls until resonance is observed on the scope (The B-field induced energy level splitting of the sample now matches the R.F. frequency.) *Please remember that electromagnets follow a hysteresis loop. If reducing the field, cycle the magnet by winding to max then min then to the required setting.*
**3)** The other machine settings (for the quadrupoles etc.) are approximate. They will need adjusting to give the optimum beam transport. In practise it is often more effective to take the machine parameters from previously recorded settings (in the 14UD log book) and scale according to the magnetic rigidity:

$$BR = \left(\frac{2M_bE_b}{q^2}\right)^{\frac{1}{2}} \tag{5.1}$$

*i.e. NEW Magnet setting = OLD Setting X NEW NMR/OLD NMR.*
**4)** Tune all machine parameters to their approximate settings.
**5)** Ensure LE F.Cup is in place. Assuming source running OK and that inflection magnet is set: Adjust Einzel lens, control focus and steering to maximise current (set console metering to LE cup.) *Nb. Low Energy Iris may be used to reduce beam current.*
Tune beam with electrostatic quad controller.
Make fine adjustments to the inflection magnet control.
**6)** Remove LE cup and tune beam onto Tank cup.
**7)** Tune onto HE cup. *(Nb. The terminal lens may be used at this point but make a note of the original settings.)*
**8)** Once beam is on the analyzing slits, the terminal voltage may be stabilized by switching the charging voltage control from GVM to slits and setting the appropriate feedback threshold.
**9)** Proceed with tuning the beam down the appropriate line.
**10** Use apertures/scintillator at the target position to do the final focussing of beam and to determine the maximum beam spot size.
**11)** Record machine settings in the 14UD parameter log.
*(Nb. It is not necessary to record every energy setting for a 100+ step excitation function measurement in the 14UD parameter log, but wise to keep a record in the run book!)*
**12)** During the experiment record any unusual/interesting events (e.g. sparks) in the 14UD log.

## 5.4 The Linac

**1)** The 14UD analyzing magnet is swung around and connected to the Linac Line.
**2) The $90^o$ Magnet or "Big Red" in the Linac Hall:**
If no post-acceleration is required in the Linac booster, the $90^o$ magnet is set such that the beam is bent directly towards the switching magnet and appropriate beamline (Line A for MEGHA) on entry to the Linac Hall.

If using the booster this magnet is set such that the beam drifts straight through, is accelerated around the Linac, then drifts through the magnet again at $90^o$ to the original direction and on towards the switching magnet and target station.

**2) How does it all work again?!**

# Appendix A

# Inventory of module parts

## A.1 Vessel

- Base plate
  - 3 x outer PCB - attached to pre-amp. motherboard
  - 3 x inner PCB
  - 16 x M4 allan cap screws 23mm with washers
  - 12 x conhex feed-through
  - 10 x metal-glass feed-through with 'O'-rings
  - Blanking flange for beam pipe exit
- Body
- Window clamp - 16 x M4 allan cap screws 16mm with washers, vac. relieved
- 1 x large and 1 x small 'O'-rings
- Calibration grid
  - 4 x M4 allan cap screws 8mm with washers, vac. relieved
- 4 x feet
- 2 x handles
  - 8 x ?mm screwed rod
  - 4 x ?mm screwed rod
- 1 x large and 1 x small swagelok connector with 'O'-rings
  - both with blanking caps and pipe connectors
  - Blanking plate – aluminium

## A.2 CsI mount

- Legs x 4 [A2-32 / 8052]
  - 8 x M2.5 allan screws 8mm, vac. relieved
  - 8 x M2 screws 6mm, vac. relieved
- Base [A0-32 / 8045]
- Clamp [A0-32 / 8046]
  - 4 x screws for corners

## A.3 PSD and Gas Detector mounts

- 4 x M4 screwed rods 60mm
- 8 x M4 nuts
- Spacers
  - 4 x 4mm spacers
  - 4 x 6mm spacers
  - 4 x 24mm spacers
- PSD printed circuit board with
  3 x 15-way ribbon cables attached
- Gas section
  - Cathode grid
  - Anode grid
- CsI detectors (per detector)
  - 2 x brackets
  - 2 x springs
  - 2 x allan cap screws 47mm
  - 2 x nuts/washers

## A.4 Cabling

- 3 x 3-way gas cables to anode grid
- Gas bias line to anode grid
- Cathode grid grounding cable to CsI mount
- 9 port CsI ribbon cable (8 for central module)

## A.5 Gas window

- Mylar window glued to frame
- Beam pipe (for central module)
  - 4 x allan cap screws

## A.6 Detectors

- 8/9 PSD's
- 8/9 CsI scintillators with preamps

## A.7 Miscellaneous

- Resistor packs for outer base plate PCB

# Appendix B

# The PLC Gas & Vacuum System Controller

This appendix describes aspects of the Programmable Logic Controller (PLC) peculiar to the MEGHA system. Operators are referred to the documentation that is supplied with the PLC and the software "Melsec Medoc" for further information.

## B.1 Hardware

The PLC system has two components:
**1)** The front panel control which occupies the top half of the right hand rack of the Gas Control System.
**2)** The PLC unit which is in the left hand rack. Two ribbon cables connect this unit to the control panel.
The PLC consists of a master (FX80) plus a slave (FX48) unit manufactured by Mitsubishi. Together these units provide for up to 64 inputs (labelled X) and 64 outputs (labelled Y). The inputs are taken from the front control panel, the valve switches and vacuum gauges. The outputs go to the front panel LED's and solenoid valves. These have been wired according to the scheme shown in tables B.1 to B.6. Note the PLC numbering system X/Y 0,1,2,3,4,5,6,7,10 etc. Six connectors (A to F) take signals to/from the PLC and the system hardware. The allocation of these pins is also shown in tables B.1 to B.6, where the pin labelling for connectors C,D and E is given in Fig. B.1.

After power-up of the gas rack, the PLC control begins when the "Run/Stop" key is switched to RUN. This is the normal mode for operating the system. When this key is in the STOP position all pneumatic valve operations are inhibited and the system is effectively "OFF".

## B.2 Software

The inputs and outputs of the PLC are separated from one another by a Ladder Logic control program residing in the master FX80 unit. In this case the program may contain up to 2000 Ladder Logic steps and is loaded/monitored through a connection on the front panel of the control rack. A PC may be used to download new software or monitor the active program in real time by connecting it to this socket using the adaptor supplied. A smaller designated hand held interface may also be used to inspect the ladder logic instead of the PC. These two interfaces may not be used at the same time. The PC software "Melsec Medoc" has been used for programming the current system. ***Please DO NOT attempt to modify the core PLC program without proper training or discussion. Corruption of this program or loading of a new module without due notification to ALL other users could result in a SERIOUS failure of the system! Note that Ladder "Logic" suffers from a number of unusual quirks that***

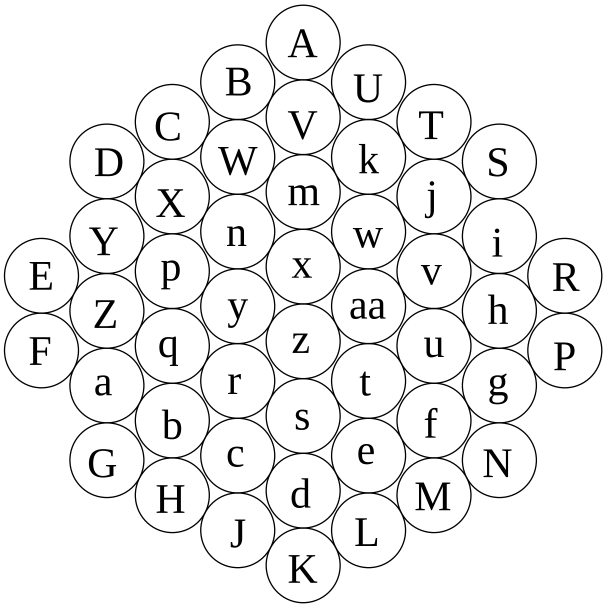



***Figure B.1:*** *Pin allocations for connectors C,D, and E on PLC box rear panel.*

***combined with the MEGHA system can at times appear incredibly illogical.*** The core program may be changed by an experienced user when the PLC is STOPped.

**The following PLC programs are available:**
*MEGHA1:* Default Master program giving fully protected system.
*VATST:* Bare valve operation tests.
*PBTST:* Bare pushbutton tests.
*TEST:* The latest TEST version of the Master program.
**Please DO NOT erase, overwrite or otherwise modify these programs.**

| PIN ID | PLC IN | PLC OUT | FROM | TO |
|---|---|---|---|---|
| 1 | X0 | | VA1 PNL SW | |
| 2 | X1 | | VA2 PNL SW | |
| 3 | X2 | | VA3 PNL SW | |
| 4 | X3 | | VA4 PNL SW | |
| 5 | X4 | | VA5 PNL SW | |
| 6 | X5 | | VA6 PNL SW | |
| 7 | X6 | | VA7 PNL SW | |
| 8 | X7 | | VA8 PNL SW | |
| 9 | X10 | | VA9 PNL SW | |
| 10 | X11 | | VA10 PNL SW | |
| 11 | X12 | | VA11 PNL SW | |
| 12 | X13 | | VA12 PNL SW | |
| 13 | X14 | | VA13 PNL SW | |
| 14 | X15 | | VA14 PNL SW | |
| 15 | X16 | | VA15 PNL SW | |
| 16 | X17 | | VA16 PNL SW | |
| 17 | X20 | | VA17 PNL SW | |
| 18 | X21 | | VA18 PNL SW | |
| 19 | X22 | | VA19 PNL SW | |
| 20 | X23 | | VA20 PNL SW | |
| 21 | X24 | | TPU1 SW ‘A’ | |
| 22 | X25 | | TPU2 SW ‘A’ | |
| 23 | X26 | | RP3 SW ‘A’ | |
| 24 | X27 | | ALARM RST SW | |
| 25 | RUN | | RUN KEY SW | |
| 26 | NONE | | TPU1 SW ‘B’ | PWR CTRL TPU1 RELAY |
| 27 | NONE | | TPU2 SW ‘B’ | PWR CTRL TPU2 RELAY |
| 28 | NONE | | RP3 SW ‘B’ | PWR CTRL RP3 RELAY |
| 29 | X77 | | MAN KEY SW | |
| 30 | | | | |
| 31 | | | | |
| 32 | | | | |
| 33 | | | | |
| 34 | | | | |
| 35 | | | 24V PSU IN PWR CTRL | TPU1,2&RP3 SW |
| 36 | | | 24V PSU IN PWR CTRL | TPU1,2&RP3 SW |
| 37 | | 24V | 24V P/S ON PLC | P/S COMMON |
| 38 | | 24V | 24V P/S ON PLC | P/S COMMON |
| 39 | | 0V | 0V LINE-PLC & 24V P/S | PNL LED COMMON |
| 40 | | 0V | 0V LINE-PLC & 24V P/S | PNL LED COMMON |

***Table B.1****: Pin allocations and PLC wiring. Connector A.*

| PIN ID | PLC IN | PLC OUT | FROM | TO |
|---|---|---|---|---|
| 1 | | Y30 | | ALARM RESET LED |
| 2 | | Y31 | | |
| 3 | | Y32 | | |
| 4 | | Y33 | | |
| 5 | | Y34 | | |
| 6 | | Y35 | | |
| 7 | | Y36 | | |
| 8 | | Y37 | | |
| 9 | | Y40 | | VA1 LED |
| 10 | | Y41 | | VA2 LED |
| 11 | | Y42 | | VA3 LED |
| 12 | | Y43 | | VA4 LED |
| 13 | | Y44 | | VA5 LED |
| 14 | | Y45 | | VA6 LED |
| 15 | | Y46 | | VA7 LED |
| 16 | | Y47 | | VA8 LED |
| 17 | | Y50 | | VA9 LED |
| 18 | | Y51 | | VA10 LED |
| 19 | | Y52 | | VA11 LED |
| 20 | | Y53 | | VA12 LED |
| 21 | | Y54 | | VA13 LED |
| 22 | | Y55 | | VA14 LED |
| 23 | | Y56 | | VA15 LED |
| 24 | | Y57 | | VA16 LED |
| 25 | | Y60 | | VA17 LED |
| 26 | | Y61 | | VA18 LED |
| 27 | | Y62 | | VA19 LED |
| 28 | | Y63 | | VA20 LED |
| 29 | | Y64 | | TPU1 LED |
| 30 | | Y65 | | TPU2 LED |
| 31 | | Y66 | | RP3 LED |
| 32 | | Y67 | | AIR PRESS LED |
| 33 | | Y70 | | ALARM BUZZER |
| 34 | | Y71 | | ALARM LED |
| 35 | | Y72 | | GAS 'A' ONLINE LED |
| 36 | | Y73 | | GAS 'A' EMPTY LED |
| 37 | | Y74 | | GAS 'B' ONLINE LED |
| 38 | | Y75 | | GAS 'B' EMPTY LED |
| 39 | | Y76 | | MAN MODE LED |
| 40 | | | | |

***Table B.2:*** *Pin allocations and PLC wiring. Connector B.*

| PIN ID | PLC IN | PLC OUT | FROM | TO |
|---|---|---|---|---|
| A | | Y0 | | VA1 LIVE |
| B | | COM1 | | VA1 NEUTRAL |
| C | | Y1 | | VA2 LIVE |
| D | | COM1 | | VA2 NEUTRAL |
| E | | Y2 | | VA3 LIVE |
| F | | COM1 | | VA3 NEUTRAL |
| G | | Y3 | | VA4 LIVE |
| H | | COM1 | | VA4 NEUTRAL |
| J | | Y4 | | VA5 LIVE |
| K | | COM2 | | VA5 NEUTRAL |
| L | | Y5 | | VA6 LIVE |
| M | | COM2 | | VA6 NEUTRAL |
| N | | Y6 | | VA7 LIVE |
| P | | COM2 | | VA7 NEUTRAL |
| R | | Y7 | | VA8 LIVE |
| S | | COM2 | | VA8 NEUTRAL |
| T | | Y10 | | VA9 LIVE |
| U | | COM3 | | VA9 NEUTRAL |
| V | | Y11 | | VA10 LIVE |
| W | | COM3 | | VA10 NEUTRAL |
| X | | Y12 | | VA11 LIVE |
| Y | | COM3 | | VA11 NEUTRAL |
| Z | | Y13 | | VA12 LIVE |
| a | | COM3 | | VA12 NEUTRAL |
| b | | Y14 | | VA13 LIVE |
| c | | COM4 | | VA13 NEUTRAL |
| d | | Y15 | | VA14 LIVE |
| e | | COM4 | | VA14 NEUTRAL |
| f | | Y16 | | VA15 LIVE |
| g | | COM4 | | VA15 NEUTRAL |
| h | | Y17 | | VA16 LIVE |
| i | | COM4 | | VA16 NEUTRAL |
| j | | Y20 | | VA17 LIVE |
| k | | COM5 | | VA17 NEUTRAL |
| m | | Y21 | | VA18 LIVE |
| n | | COM5 | | VA18 NEUTRAL |
| p | | Y22 | | VA19 LIVE |
| q | | COM5 | | VA19 NEUTRAL |
| r | | Y23 | | VA20 LIVE |
| s | | COM5 | | VA20 NEUTRAL |
| t | | | | |
| u | | | | |
| v | | | | |
| w | | | | |
| x | | | | |
| y | | | | |
| z | | | | |
| aa | | | | |

***Table B.3:*** *Pin allocations and PLC wiring. Connector C.*

| PIN ID | PLC IN | PLC OUT | FROM | TO |
|---|---|---|---|---|
| A | X30 | | VA1 SW OPEN | |
| B | | 24V | VA1 SW COMMON | |
| C | X31 | | VA1 SWITCH CLOSED | |
| D | X32 | | VA2 SW OPEN | |
| E | | 24V | VA2 SW COMMON | |
| F | X33 | | VA2 SWITCH CLOSED | |
| G | X34 | | VA3 SW OPEN | |
| H | | 24V | VA3 SW COMMON | |
| J | X35 | | VA3 SWITCH CLOSED | |
| K | X36 | | VA4 SW | |
| L | | 24V | VA4 SW COMMON | |
| M | X37 | | VA5 SW | |
| N | | 24V | VA5 SW COMMON | |
| P | X40 | | VA6 SW | |
| R | | 24V | VA6 SW COMMON | |
| S | X41 | | VA7 SW | |
| T | | 24V | VA7 SW COMMON | |
| U | X42 | | VA8 SW | |
| V | | 24V | VA8 SW COMMON | |
| W | X43 | | VA9 SW | |
| X | | 24V | VA9 SW COMMON | |
| Y | X44 | | VA10 SW | |
| Z | | 24V | VA10 SW COMMON | |
| a | X45 | | VA11 SW | |
| b | | 24V | VA11 SW COMMON | |
| c | X46 | | VA12 SW | |
| d | | 24V | VA12 SW COMMON | |
| e | X47 | | VA14 SW | |
| f | | 24V | VA14 SW COMMON | |
| g | X50 | | VA15 SW | |
| h | | 24V | VA15 SW COMMON | |
| i | X51 | | VA20 SW | |
| j | | 24V | VA20 SW COMMON | |
| k | X52 | | PS1 SW | |
| m | | 24V | PS1 SW COMMON | |
| n | X53 | | PS2 SW | |
| p | | 24V | PS2 SW COMMON | |
| q | X54 | | PS3 SW | |
| r | | 24V | PS3 SW COMMON | |
| s | X55 | | PS4 SW | |
| t | | 24V | PS4 SW COMMON | |
| u | X56 | | PS5 SW | |
| v | | 24V | PS5 SW COMMON | |
| w | X57 | | PS6 SW | |
| x | | 24V | PS6 SW COMMON | |
| y | X60 | | AIR SW | |
| z | | 24V | AIR SW COMMON | |
| aa | | | | |

***Table B.4**: Pin allocations and PLC wiring. Connector D.*

| PIN ID | PLC IN | PLC OUT | FROM | TO |
|---|---|---|---|---|
| A | X61 | | GP2 PRESS SW | |
| B | | 24V | GP2 SW COMMON | |
| C | X62 | | GC2 PRESS SW | |
| D | | 24V | GC2 SW COMMON | |
| E | X63 | | GP1 PRESS SW | |
| F | | 24V | GP1 SW COMMON | |
| G | X64 | | Valve A status | |
| H | | 24V | Valve A COMMON | |
| J | X65 | | TPU1G | |
| K | | 24V | TPU1G COMMON | |
| L | X66 | | TPU2G | |
| M | | 24V | TPU2G COMMON | |
| N | X67 | | | |
| P | | 24V | | |
| R | X70 | | | |
| S | | 24V | | |
| T | X71 | | | |
| U | | 24V | | |
| V | X72 | | | |
| W | | 24V | | |
| X | X73 | | | |
| Y | | 24V | | |
| Z | X74 | | | |
| a | | 24V | | |
| b | X75 | | | |
| c | | 24V | | |
| d | X76 | | | |
| e | | 24V | | |
| f | | | | |
| g | | | | |
| h | | | | |
| i | | | | |
| j | | | | |
| k | | | | |
| m | | | | |
| n | | | | |
| p | | | | |
| q | | | | |
| r | | | | |
| s | | | | |
| t | | | | |
| u | | | | |
| v | | | | |
| w | | | | |
| x | | | | |
| y | | | | |
| z | | | | |
| aa | | | | |

***Table B.5:*** *Pin allocations and PLC wiring. Connector E.*

| PIN ID | PLC IN | PLC OUT | FROM | TO |
|---|---|---|---|---|
| 1 | X24 | | SEE CONN A24 | CONTACTOR1(TPU1) |
| 2 | X25 | | SEE CONN A25 | CONTACTOR2(TPU1) |
| 3 | X26 | | SEE CONN A26 | CONTACTOR3(TPU1) |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | 24V PSU IN PWR CTRL | TPU1,2&RP3 SW |
| 9 | | | 24V PSU IN PWR CTRL | TPU1,2&RP3 SW |

***Table B.6**: Pin allocations and PLC wiring. Connector F.*

# Appendix C

# The 2m Chamber at ANU

Experiments requiring specific configurations of MEGHA modules, gas hybrid telescopes, strip detectors and large area PSD's etc. may use the 2m scattering chamber on "Line 3" of experimental area 1 at the ANU. Detector signals can be patched to the MEGHA data acquisition system in the Linac Hall. In total 128 signals may be transferred to/from the MEGHA DA and the patch panel adjacent to the 2m chamber. Operating procedures relevant to using the 2m chamber are described in this appendix.[1]

## C.1 The Gas & Vacuum Handling System

The 2m chamber is pumped by a combination of carbon-vane pumps, which take pressure down from atmospheric to around 40 mbar, vac-sorbs which take pressure to 35 microns ideally and finally a cryo-pump which maintains the operating pressure in the $10^{-7}$ torr range. The gas handling is done by a unit similar in principle to the Daresbury units (although a fraction of the size!) backed by a small rotary pump. The layout of the system is shown figure C.1.

### C.1.1 Evacuation

***Ensure biases are off all the detectors!***
***Ensure hand valve is open & beamline connected!***
*The hand valve is open when the handle is pointing towards the chamber and the bellows are UN-compressed.*

**1) Starting from:**
2 valves to chamber (A and B) OPEN.
2 valves to vacsorbs CLOSED.
Valve D below transducer OPEN so that digital gauge reads pressure.
Ensure that the vacsorbs are cool or at least on the way.

**2) The gas-handling valves should be in the following configuration:**
Gas-in valve (GD) on chamber wall CLOSED.
Chamber equalisation valve (GH) OPEN.
Detector input valve (GE) OPEN.
Gas out valve (GF) to left of roughing line CLOSED.
Beamline valves A and B SHUT. Beam hand valve OPEN.

**3) Lower the chamber lid:**
*Make sure everything is clear and no plastic etc. has been left in the chamber.*

[1] Gas & Vacuum cycling procedures adapted from the document "2m Chamber Vacuum Cycling...", M.J. Leddy, S.J. Hall & C.D. Jones.

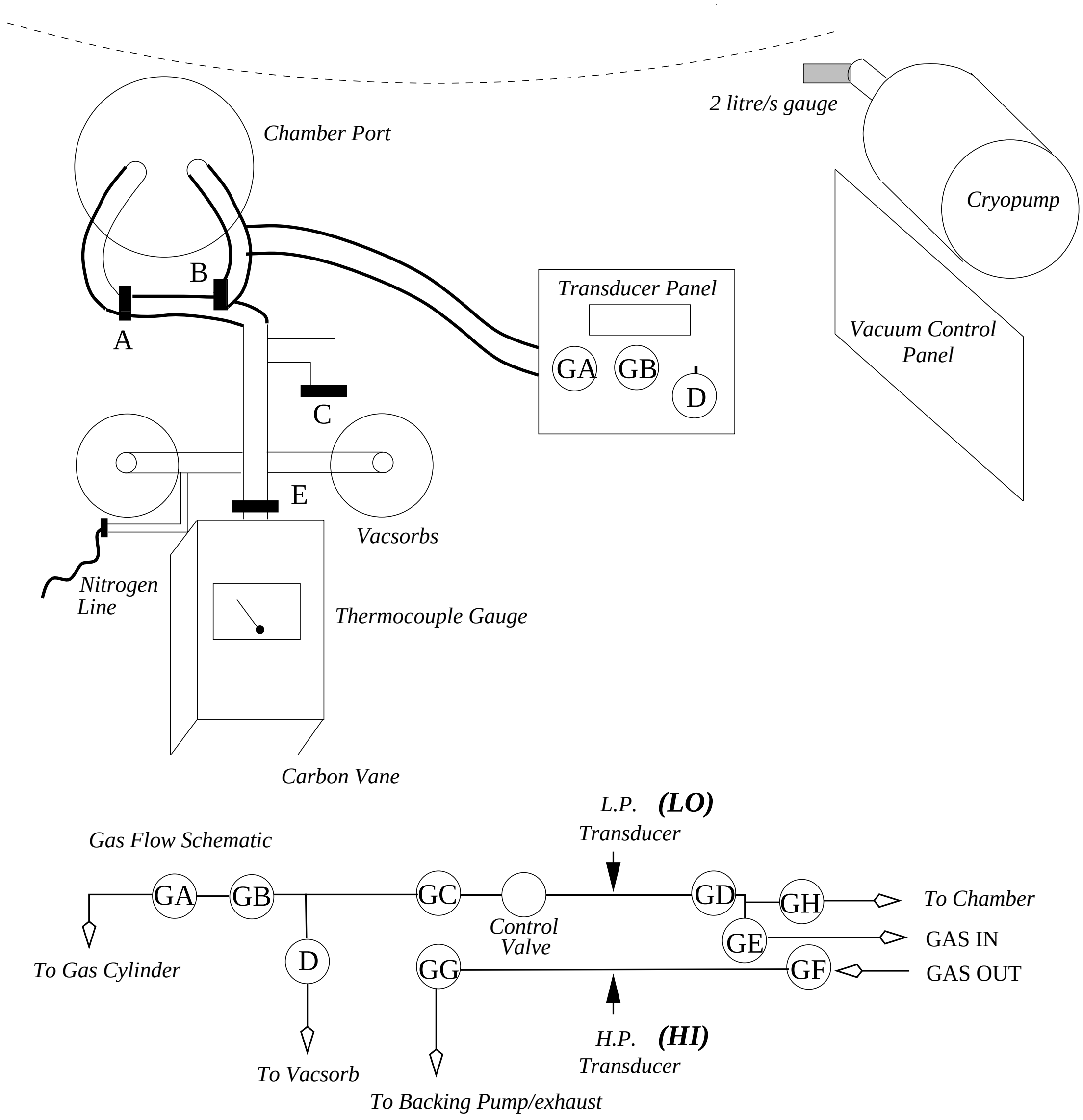



***Figure C.1***: *Layout of the 2m chamber gas & vacuum handling system.*

Switch control to Down (no surprises there) and the lid will lower to within 1 inch of closing. Check the O-ring is seated and all is clear, then hold down the "inch" button until the motor stops itself—*don't just stop because the lid looks like it is down.*

**4) Close valve C:**
*If the airlock over the target region is to be used, ensure that the large bore tube leading from the middle of the chamber lid is connected to the roughing line (in front of the large plastic valve handle on the right hand side of the line—valve C in the figure) and valve C open. Two bolts is enough. If the airlock is not to be used, close valve C.*

**5) Switch on carbon vane and open valve E:**
The thermocouple gauge should start to drop and the gas rack transducer reading should also fall. *If hybrid gas detectors are being used then do not exceed 1mbar/sec pumping rate.*

**6) When the gas rack transducer reads less than 40 mbar:**
Close valve E.
Switch off carbon-vane.
Open valve on small vacsorb. *If the vacsorb is active you should hear a hissing sound and the pressure should drop quite rapidly.*
Close valve D. This isolates the gas rack transducer from the system. Note that the transducer reading may rise at this point due to a small leak in the gas lines.

**7) After 10-15 minutes:**
Close small vacsorb.
Open large vacsorb.
***The pressure must fall below 75 microns on the vacsorb transducer before it is safe to open to the cryo pump and usually the large vac-sorb can bring it down to about 35 microns.***
Wait for thermocouple to drop below 60 microns and vacuum good/bad lights to turn to green.
If this does not happen and you are impatient the protection on the thermocouple can be switched off by moving the 2m thermocouple toggle switch on the Target Line Vacuum Protection Unit to bypass—***Only if the Roughing line Thermocouple is < 75 microns.***

**7) At pressure < 75 microns:**
Close chamber valves A and B.
Close vacsorb valves.
Switch the 2 litre per second to *bypass* on the target line vacuum protection unit (TLVPU).
Turn the range switch on the 2 litre per second gauge to start.
*The orange vacuum fail light will illuminate on the 2l/s ion pump control unit.*
Open the valve to the cryo-pump, called valve A on the TLVPU.
*The Thermocouple control unit should shoot down and the vacuum good light come on. The 2 l/s ion pump control unit gauge should follow and the range can be set to 10 mA or 1 mA as needed.*

**8) When all vacuum good lights on TLVPU turn green:**
Switch all bypass switches to protect.
Ensure chamber 2l/s pressure < 70 $\mu$A and beamline valves A, B are shut.
Open beamline valve B between chamber and beamline.
*Note that it is possible to hurry things along if necessary. In this case ensure that the chamber 2l/sec gauge reads < 120$\mu$A. Then on the line valve control unit (near quads) swith the line 2l/sec to bypass and open valve B between chamber and beamline. The vac fail light may come on but the line 2l/sec should read < 120$\mu$A which is OK. Pressure should continue to drop and the vac fail light should go out. At this point switch back to protect. Open valve A to beamline.*
***The line 2l/sec pump is located just upstream of the line A quads. The reading is taken from a meter underneath the quads. If reading goes higher than 10mA then***

***shut valve B and let the pump recover. If this is not done the pump can overheat.***

**9) With the system operational the following readings are typical:**
Gas rack transducer: 020 (nb - This is isolated from the chamber).
Thermocouple control unit: 3 microns. Vacuum good light on.
TLVPU: Valve A open. Valve B shut. All vacuum good lights on.
2 l/s ion pump control unit: $\sim$30 $\mu$a on 100$\mu$a setting.
Mains light on.
Carbon vane pressure transducer: 0. Thermocouple: full left (<1000 $\mu$m).

### C.1.2 Venting

***Ensure biases are off all the detectors!***

**1) Starting from Evacuated Chamber:**
Shut beamline valves A and B.
Shut hand valve to beamline and insert holding pin if you want to leave this under vacuum. If not leave open.
*This valve is shut when the handle is pointing away from the chamber and the bellows are compressed.*
Close cryo-pump valve (valve A on vacuum control unit).
Ensure gas in valve (GD) and gas out valve (GF) on chamber wall are shut and the chamber equalisation valve (GH) is open.
Open transducer valve D.
Check pressure in roughing line indicated on the thermocouple above the carbon-vane. If at atmospheric, rough out the line using the carbon-vane. If the target line is attached, make sure the valve (C) is open so that this line is roughed out as well. If the line is not attached make sure that C is shut.
If necessary attach nitrogen line to the roughing line.

**2) Open valves A and B SLOWLY:**
Allow nitrogen to enter the roughing line and chamber.
*Keep an eye on the transducer reading—approximately 1 mbar per second seems the usual rate to vent at.*
*Watch the transducer reading and stop nitrogen flowing when it reads approx 900 mbar (local atmospheric pressure).*
***If nitrogen is allowed to flow beyond this pressure, the chamber lid will lift and the O-ring may be damaged.***

**3) At Atmospheric pressure:**
Slowly open the valve to the target line (valve C), assuming the line itself is not attached, so that the chamber is open to the atmosphere.
*If the line is attached, the valve should be open so that the target line is at the same pressure as the roughing line. If this has not been done, open the valve now, slowly. Then DISCONNECT the line, or it will be torn out when the lid is lifted!*
Lift the lid by about an inch, then check that the O-ring has not lifted with it. This usually happens, so run a steel ruler above the O-ring and let it drop back into place.
Raise the chamber lid to the required height.

### C.1.3 Replacing Targets Under Vacuum

***Protect the beamline! Close beamline hand valve and beamline valve A.***

**1) Starting from Evacuated Chamber:**

Ensure that the chamber valve on top of the chamber is shut, that valve D is shut and the vacsorbs are cool.
Connect the target line to valve C and the $N_2$ line on top of the chamber.
Use carbon vane to pump out the target line up to the chamber lid valve.
The Pressure can be measured on the gauge on top of the chamber.
Close valve E and open vacsorb valve.
This will have removed most of the gas from the system. The vacsorb should be left open at this point as a safety.
Place the 2l/sec pump on the cryo on bypass and open the valve on top of the chamber.
The pressure in the chamber will rise but should stay below 1mA before starting to drop again.

**2) Replace target using target rod:**
Remove target rod and shut valve on top of chamber.
Shut the vacsorb valve and valve C.
Place the target at 90° to the pumping line.
Open the $N_2$ line to the target replacement system and take line up to atmosphere.
Open flange on top of chamber and remove target.
*As long as the vacuum is good then the chamber 2l/sec ion pump can be placed back on protect and the scale changed back to 100μA.*
The pressure in the chamber may now be slightly worse than the pressure in the beamline. Therefore, put the beamline 2l/sec ion pump on bypass before opening up the handvalve.
Wait for beamline 2l/sec ion pump to recover. Put beamline 2l/sec to protect and open valve A to tandem.

### C.1.4 The Gas Handling system

The gas flow is from a bottle behind the cryo-pump, through the *transducer* panel to the control unit, through the gas-in and detector in valves on the chamber wall, through the detectors, out via the gas-out on the chamber wall and through a rotary pump. There are 2 sensors in the control unit, one labelled HI, in the output line which ranges up to atmospheric pressure, and one labelled LO in the input line which reads up to about 10 torr. For our purposes the HI sensor will always be used assuming we are running at pressures $> 10$ torr.

**While the chamber vacuum is being cycled the valves should be in the following status:**
2 valves before the transducer (GA and GB) CLOSED.
Transducer valve CLOSED (valve D).
Gas-in on control unit CLOSED (GC).
Exhaust valve on control unit CLOSED (GG).

**In the triangle of valves on the chamber wall:**
Gas-in CLOSED (GD).
Detector in OPEN (GE).
Chamber valve OPEN (GH).
Gas out valve to the left of the roughing line CLOSED (GF).
Proportional control valve set to 'close'.

Valve below gas-out is redundant but should be closed.

### C.1.5 Introducing Gas

***Gas should only be introduced into the detectors after the chamber pressure has dropped below 250μA on chamber 2l/sec ion pump.***

**1) Starting from Evacuated Chamber:**
Shut beamline valves A and B.
Turn on rotary pump below gas control panel and open gas out (GG) on control panel. This pumps from the rotary pump, through exhaust valve (GG), to chamber gas out valve (GF).
Shut gas bottle valve and gas regulator valve just above bottle.
Switch on carbon vane and open valve E.

**2) After lines pumped out:**
Close valve E and switch off carbon vane.
Switch proportional valve to LO.
Open vacsorb valve and transducer valve D. This evacuates between the propane bottle and the chamber gas-in valve (GD).
The proportianal valve readout should read 0 by the end of pumping.

**3) At the end of pumping:**
Open valve GA.
Open valve GB.
Open valve GC.
Switch the proportional valve rotary pot to OPEN.
*You should see -ve gas flow in the flow rate meter at this stage.*
Set proportional valve toggle switch to HI.

**3) When lines have been roughed out:**
Close transducer valve (D).
Close valves (GA and GB).
Leave vacsorb open for emergencies.
Close chamber (GH) valve on chamber wall.
Check that exhaust valve (GG) is open.
Open gas-out valve (GF) and then slowly open gas-in valve (GD).
*Recheck that proportional valve is reading 0, that the proportional valve is on the 10 V full scale setting and that the HI setting has been selected.*
Put the control switch on *AUTO* on the control box and ensure i/p line pressure is approx zero and the green status light is lit, as opposed to the red one.
Close valve GC as a safety.

**4) The system should now be in its equilibrium state:**
*This means that the proportional valve is fully closed. This valve is adjusted using the rotary pot, which may not read zero for fully closed but probably will be near.*
Fully open the valve on the centre of the gas cylinder lid.
Open the pressure regulator on the side of the gas bottle until the 200 line can be read.
Open the left hand valve on the *transducer* panel one turn or less (GA).
Open the valve (GB) very slowly. *This is the needle valve which controls the gas supply pressure (eventually you will want this to give a reading of about 1000 mbar (usually 1077 mbar) on the transducer valve's digital read out). If the transducer won't go up to ~1077 mbar then open GA a bit further.*
Open GC fully.
*The flow meter should register but the green status light remain lit. Pressure in the detectors is then controlled by the control pot. The central digital meter on the gas control box gives you the pressure in VOLTS (where for the HI range 10 V = 1 atmosphere, approximately 760 torr, and on the LO range 1 V = 1 torr ).*
***Do NOT touch the toggle switch when the control is set to auto. If the toggle is changed, the proportional valve will go crazy.***

**5) Ready to Introduce Gas into the detectors:**

*Monitor the digital pressure readout of the proportional valve, the flow rate meter and also the 2l/sec readout below the vacuum protection unit. This 2l/sec readout is important as it monitors the pressure in the chamber.*
Open proportional valve slightly using the control pot.
*The status light on the proportional valve should remain green. If it goes red then you are opening too fast, stop and wait for it to recover.*

**6) With some gas in detector (~0.2 V on digital readout):**
Close the gas exhaust valve (GG) until flow meter ~100 scc/min.
Introduce more gas by opening proportional valve control pot until required pressure is reached *(while continually checking 2l/sec pressure, if this goes very bad then wind down the proportional valve control pot and open valve D to the vacsorb). As you do this keep closing exhaust valve (GG) to keep flow rate at ~100 scc/min.*
*If the flow rate goes off scale and the control pot status light remains green then no worries! It just means that you should shut GG slightly.*

**7) After reaching the required pressure (eg. 1 V $\equiv$ 76 torr):**
Ensure that the flow rate is ~40-60 scc/min.
Close vacsorb and switch gas control, on bottom of gas control unit, to protect.

**8) During the run monitor:**
Gas flow rate (~40-60 scc/min).
Detector gas pressure (~1 V Digital readout on gas control).
Transducer Pressure (~1077 mbar).
Chamber pressure (~70 $\mu$A 2l/sec gauge below vacuum protection unit).
Status green on proportional valve control pot.

### C.1.6 Removing Gas & Venting the Chamber

***Protect the beamline! Close valves A and B to the beamline.***

**1) Starting from Evacuated chamber, Gas filled detectors:**
Close valve A to the cryopump on Target Line Vacuum Protection Unit (TLVPU).
Switch from protect to bypass on gas control lower unit (below proportional control valve).
Close the proportional valve by winding down the control pot to 0 and switching it from auto to close.
Close GC and open GG fully.
*This should pump the gas out of the detectors until eventually the flow rate is very low.*

**2) When the digital pressure readout is ~0 (usually ~0.05):**
Close GB and GA to stop any more gas entering the gas control system.
Close gas bottle valves.
Close GF and GG to stop pumping of gas from detectors.
Switch 2l/s ion pump to bypass on TLVPU. (Otherwise it tries to shut valve A to the cryo.)
Open GH to couple the detectors with the chamber.
*The transducer will still be reading ~1077 mbar. The gas from here can be pumped out using the carbon vane.*

**3) Ensure that chamber valves A and B are shut as well as GA, GB and GC.**
Switch on carbon vane and open valve E (on carbon vane) and valve D.
*This will pump out the carbon vane line down to ~40 mbar.*
Close valve E and switch off carbon vane.
*If you've got a working vacsorb then you can pull more gas out of the carbon vane line, otherwise the remaining gas can be let into the chamber.*

Check that GF and GD are closed and that GH is open.
Slowly open valve A on chamber wall to release the gas into the chamber through the detector.

**4) After pressure in transducer has dropped to 0:**
Slowly open chamber valves A and B.
The $N_2$ can now be let into the chamber and detectors.
Slowly open $N_2$ valve on plastic tube and then open $N_2$ valve on pumping rig.
Transducer pressure should start to increase from 0 to 900 at a rate of $\sim$1 mbar/sec.

**5) When transducer pressure reaches 900 mbar:**
Shut $N_2$ valves.
Open valve C.
Lift the lid.
Turn off rotary pump below gas control.

# Appendix D

# Additional Notes & Revisions