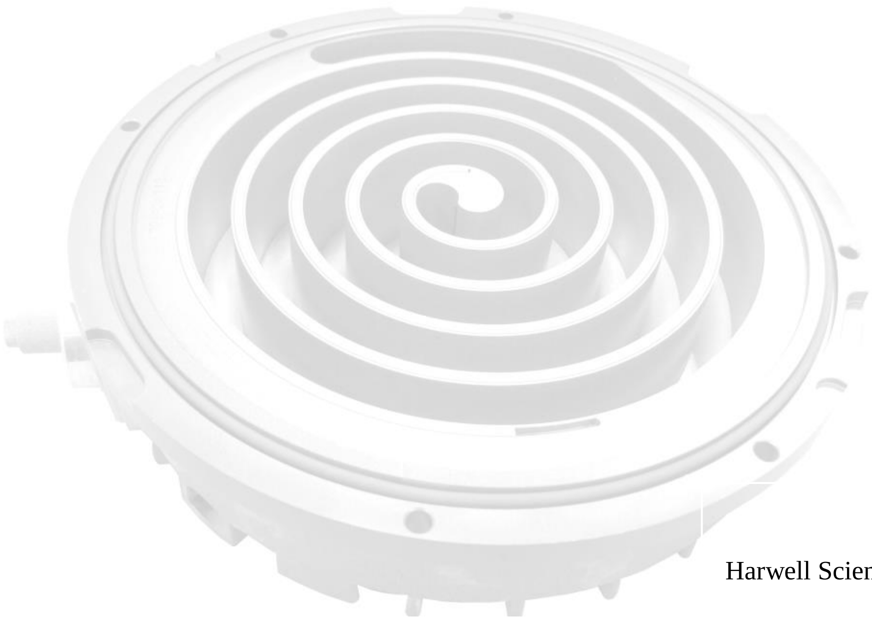
Diamond Vacuum System Manual



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1. VACUUM AT DIAMOND

1.1 Vacuum Overview

A vacuum is needed in the Diamond synchrotron beam pipes and vessels to allow the electrons free passage without too many losses. At atmospheric pressure the electrons would quickly collide with gas molecules, be scattered or lose too much energy and be lost from the beam. In fact, to achieve relatively free passage for the electrons we need to reduce the gas pressure in the beam spaces to 1/1,000,000,000,000 of an atmosphere or lower.

A vacuum is defined as a pressure below, often considerably below, atmospheric pressure, which we can display pictorially as below

Better Vacuum = Lower pressure

0-100 mbar	100-200 mbar	200-300 mbar	300-400 mbar	400-600 mbar	500-600 mbar	600-700 mbar	700-800 mbar	800-900 mbar	900-1000 mbar

We are interested in the pressures at the very end of this ruler, in fact if a ruler length representing atmosphere was 1 million kilometres long then we are interested in achieving a pressure which is represented by the first mm of the ruler.

At Diamond we want to keep the pressure in the beam pipes around 10^{-9} mbar or lower even when the beam is on. Even at these pressures we still have some 10^{13} molecules per metre cubed, although the molecules are so small that they have to travel an average of 66 kilometres before colliding with another gas molecule, at these densities.

The average distance between gas molecule collisions is an important concept in vacuum. We look at the way the gas in the vacuum behaves in 3 distinct regions. These regions are based around a mean free path (L), which is the average distance a gas molecule has to travel before hitting another gas molecule.

1. Viscous or continuum flow, this is where the gas-to-gas collisions dominate over gas-to vessel-wall collisions, L << D (where D is the dimension of the vessel)
2. Transitional flow, this where the mean free path of the gas is approximately equal to the dimensions of the vessel. L=D
3. Molecular flow, collisions are dominated by gas-to-vessel-wall collisions, L >> D

In viscous flow, gas collisions dominate so that the motion of gas molecules is collective and the gas behaves like a continuous fluid, whilst in molecular flow there are very few gas collisions so the flow of gas is more like a random diffusion process of independent molecules. To achieve a high flow rate of gas in molecular flow we need to have large pipes with good conductance. Generally in the molecular flow region we need pumping and conductances to be in the order of 100 to 1000 l/s whilst in viscous flow we can work with conductances and pumping in the order of 1 to 10 l/s or less.

Following is a table showing the relationship between pressure, density of molecules and mean free path. Mean free paths of electrons are just estimated by scaling the nitrogen molecule mean free path by an approximate size ratio. Diamond operates with high-energy relativistic electrons and they will only be significantly affected by interaction with atomic nuclei, which will reduce the cross sectional areas further and so increase the electron mean free paths.

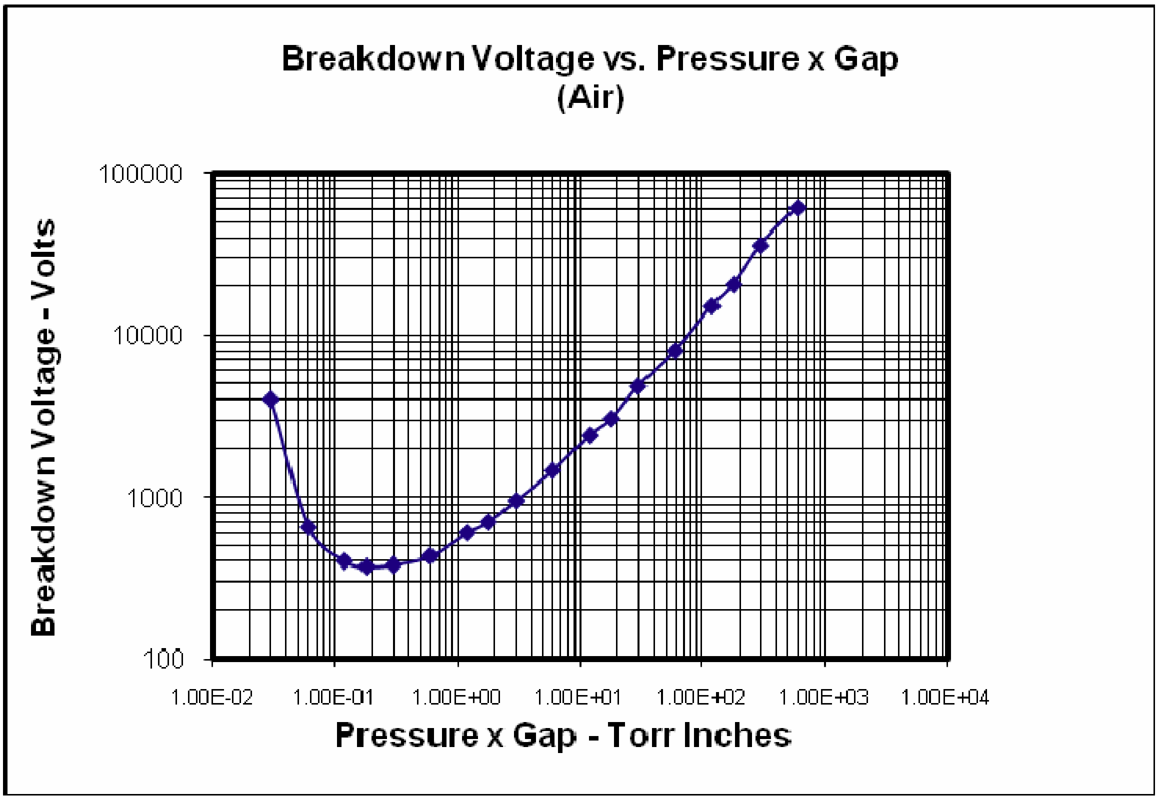
Pressure in mbar	Number molecules/ m^3	Mean free path Nitrogen in metres	Mean free path of electron in metres	Flow regime
1000	2.50E+25	6.60E-08	6.60E-04	Viscous
1	2.50E+22	6.60E-05	6.60E-01	Viscous
1.00E-01	2.50E+21	6.60E-04	6.60	Transitional
1.00E-03	2.50E+19	6.60E-02	6.60E+02	Molecular
1.00E-06	2.50E+16	6.60E+01	6.60E+05	Molecular
1E-10	2.50E+12	6.60E+05	6.60E+09	Molecular

1.2 Breakdown voltage vs pressure

In 1889, F. Pashchen published a paper which set out what has become known as Paschen's Law. The law essentially states that, at higher pressures (above a few mbar) the breakdown characteristics of a gap are a function of the product of the gas pressure and the gap length, usually written as V= f(*pd*), where *p* is the pressure and *d* is the gap distance.

The curve following is for voltage breakdown between two flat parallel copper electrodes, separated by 1 inch, for pressures between $3x10^{-2}$ torr and 760 torr. As the pressure is reduced below a torr (as shown in the following diagram) the curve of breakdown voltage versus pressure reaches a minimum, and then, as pressure is further reduced, rises steeply again.

It can be concluded from this breakdown curve that it is essential not to apply high voltage to electrodes in a pressure range 10^{-2} mbar to 300 mbar. Interlocks on Diamond need to take into account this phenomenon recorded by Pashchen.



1.3 Achieving vacuum at Diamond

To achieve a vacuum in Diamond we must first pump the majority of the atmospheric air out using mechanical displacement roughing pumps, such as scroll pumps and then turbomolecular (turbo) pumps.

Roughing pumps, and in particular in Diamond's case scroll pumps, are used in the viscous range. These types of mechanical pumps have pumping speeds that tend to be quoted in m^3 per hour. A scroll pump typically has a pump speed of around 10 m^3 per hour, which is equivalent to around 2 l/s. Pumping speeds are relatively small in the viscous range and the flow of the gas is quite different from lower pressure vacuum. These pumps need to expel large amounts of gas to the atmosphere so have to work hard and need fairly powerful motors.

Turbomolecular pumps need to be backed by roughing pumps to operate. These pumps can be started at atmosphere but do not start pumping effectively until below 10^{-2} mbar. These pumps are effectively differential pumps and work by producing a differential pressure from their inlet to the outlet pipes. Fast moving blades deflect incoming gas molecules to the outlet pipe and create the pressure difference. Normally the inlet of a turbomolecular pump is working in the molecular flow region whilst the outlet is working in the transitional flow range, hence the inlet pipe needs to be of the widest dimension possible whilst the outlet can be relatively narrow. The pumping speed of the turbomolecular pumps on the pump carts, utilised by

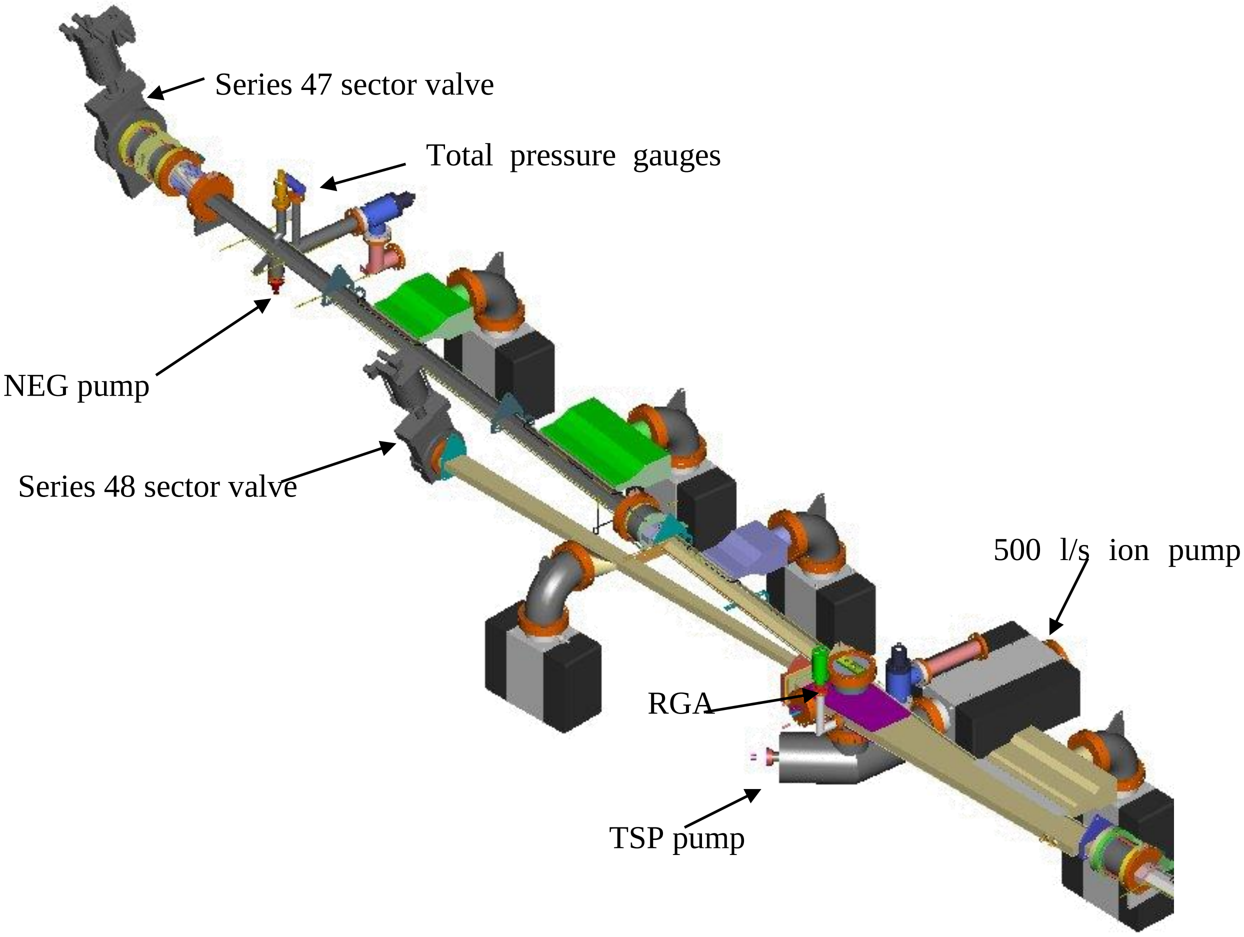
Diamond, is around 250 l/s. However the pump cart inlet valve has a conductance of around 125 l/s which limits their efficiency.

Once we reach pressures of 10^{-5} to 10^{-6} mbar we can isolate the mechanical pumps and use capture pumps (ion pumps, titanium sublimation pumps (TSPs) and non-evaporable getter (NEG) pumps). The capture pumps effectively work by trapping the gas inside the pump by using a reactive metal surface. In the case of TSPs and NEG pumps these continue to pump reactive gases until saturation without application of external power. In the case of ion pumps the pumping mechanism involves the application of a high voltage combined with a permanent magnetic field - if the high voltage is removed the ion pumps will soon stop pumping. All capture pumps will effectively become heavier with time, although the increase will be tiny. At 10^{-6} mbar we are working at 1/1,000,000,000 of an atmosphere.

If there are no leaks in a vessel then the pressure will reach a steady state when the pumping rate of gas is equal to the flow of gas from the chamber walls. The release of gas from materials within a vacuum is termed as outgassing. Gas will always be desorbed (outgassed) from every solid material and so will contribute to the ultimate vacuum of a vessel. To get the best vacuum (lowest pressure) inside a sealed vessel we can:

1. Use clean materials with the lowest outgassing values, such as stainless steel
2. Reduce the gas absorbed in and adsorbed on materials exposed to the vacuum by baking the vessel to deplete the gas reservoirs in an on the wall, this will lower the outgassing rate of the wall.
3. Use larger pumps.

These steps have been used on Diamond and the total nominal pumping speed applied to each storage ring arc is some 3000 l/s or though due to conductance limitation of the pipe the effective pumping speed is reduced to only about 2/3 of this value. A picture of a typical vacuum string is shown on the next page.

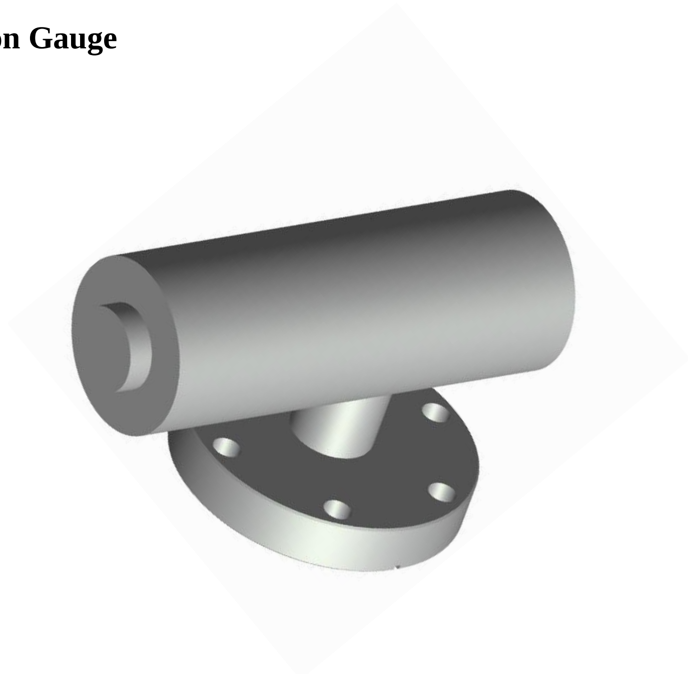


Series 47 sector valve
Total pressure gauges
NEG pump
Series 48 sector valve
500 l/s ion pump
RGA
TSP pump

2. TOTAL PRESSURE GAUGING

On the Diamond vacuum system there is a requirement to read pressures from atmosphere, 1000 mbar, down to around 10^{-11} mbar. To do this we need to use a combination of 2 gauges. A Pirani Convection Gauge reads from atmosphere down to 10^{-3} mbar, whilst the Inverted Magnetron Gauge reads from 10^{-2} mbar down to 10^{-11} mbar.

2.1 Pirani Convection Gauge



Diamond uses the Pirani convection gauge from MKS, pictured above. A Pirani convection gauge works by sensing thermal convection and conductance of the remaining gas in the vacuum. The Pirani uses a heated filament, the resistance of which is measured using a Wheatstone bridge device. The resistance of the filament is related to the temperature of the filament, which in turn is related to the heat loss through the gas, which in turn is related to the gas pressure.

A conventional Pirani (Which doesn't rely on convection) works well between the pressures of 10 mbar down to 10^{-3} mbar. This is the region where gas to wall collisions dominate but is above the pressure where the carrier numbers have been reduced to a level where other heat losses, such as radiation losses and conduction through the filament wires, dominate.

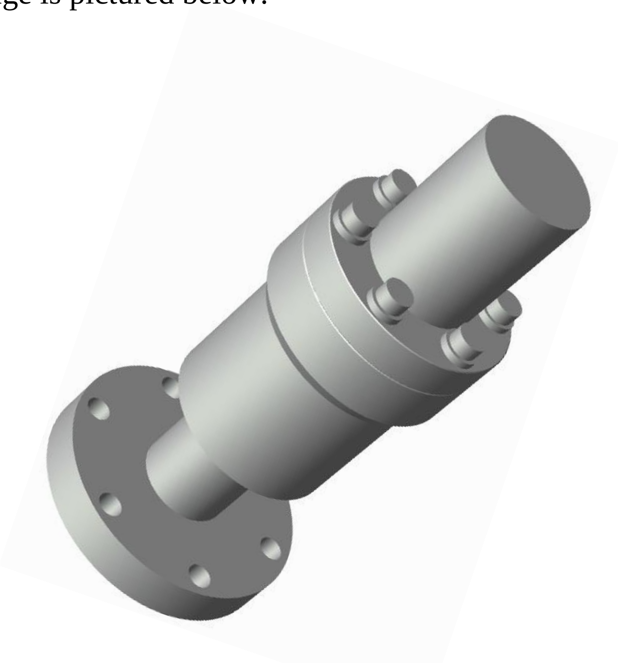
To achieve a pressure indication from 10 mbar to atmosphere the gauge must work on heat loss from the filament by convection. The heat loss from conduction through the gas in the region 10-1000 mbar is constant in this region; this is because although there are many more carriers these carriers cannot travel so far due to gas to gas collisions. In the convection region of the gauge there is accuracy of the order of +/-50 mbar.

Because the gauge works on convection between 10 mbar and atmosphere it is important to have the filament (main axis of the gauge) orientated horizontally. Obviously if you position the gauge vertically the convection will occur along the filament which will seriously affect the calibration.

Once the pressure has been lowered enough such that the gas to wall collisions start to dominate over the gas to gas collisions then the conductivity becomes proportional to the gas pressure but also has a dependence on the composition of the gas.

2.2 Inverted Magnetron Gauge

Diamond utilises the MKS **I**nverted **M**agnetron **G**auge (IMG), sometimes referred to as a Cold Cathode Gauge. This gauge is pictured below.



The IMG works on the principle of ionising gas with spiralling electrons in a strong electric and magnetic field cell. The electron molecule collision produces ions along with more electrons which maintain the ionisation process. The resultant ions are attracted to a cathode (collector); the current from the cathode is then directly related to the number of gas carriers. The cathode in this device is held near earth potential whilst the Anode is held around 3kV.

This type of gauge works well between pressures of 10^{-4} mbar to 5 x 10^{-11} mbar. At pressures much above 10^{-4} mbar the glow discharge resulting from the ionising gas is so strong that it starts to etch and contaminate the gauge. The gauge will work for a short time from 10^{-2} mbar to 10^{-4} mbar, but the gauge should only be used in this region during a pump down so that the gauge only sees this pressure for a short period of time.

In a dry atmosphere it is possible to turn the gauge on at atmosphere and it will indicate a pressure of 10^{-5} mbar, this situation should be avoided as it can lead to permanent damage to the gauge. Interlocks are provided from the Pirani gauge to avoid this situation.

Below the 5 x 10^{-11} mbar the discharge in the gauge has a tendency to extinguish as there are not enough electrons being produced to ensure ionisation of the remaining gas molecules. In a conventional gauge the ionisation process is started by free electrons, however this process can be unreliable so to improve the efficiency of starting the process Diamond gauges are fitted with field emitters, which produce electrons in the strong electric field. However even with a small constant supply of electrons from a field emitter it is found that at pressures below 5 x 10^{-11} mbar the number of molecules is still too low to guarantee the discharge and the gauges can become unreliable.

2.3 937a controller

The 937a, shown below is designed to drive various vacuum gauges. At Diamond the unit is used to drive both Pirani gauges and IMGs.

Front view

Back view

2.3.1 Gauge relay interlocks

The 937a has 3 gauge card slots and can be assembled with the following combination of gauge drivers and interlocks.

Slot CC – IMG card (1 IMG, 1 interlock)
Slot A- Pirani card (2 Pirani gauges, 2 interlocks) *or* IMG card (1 IMG, 2 interlocks)
Slot B- Pirani card (2 Pirani gauges, 2 interlocks)

Diamond's normal configuration is 2 IMG cards and 1 Pirani card. This gives a total of 5 interlocks; all interlocks levels can be set from serial port or front panel. All 5 interlocks can be over ridden to be switched **OFF**. These interlocks are output from the accessory connector, see back view above.

In addition there is an independent zero volt interlock on each IMG card factory set at 10^{-4} mbar. These interlocks have been added to the cards specifically for Diamond and are used to protect RGA filaments. These interlocks come from pins B&C of the remote socket on the IMG cards, see back panel picture. Pins A&D of the remote socket turn off the IMG when linked; this function is used on the pump carts to control the operation of the gauge remotely.

2.3.2 Controller internal interlocks

<u>Pirani enable of IMGs</u>

There are 2 internal interlocks, which provide enable signals from the Pirani gauges to the IMGs. (Pirani B1 is linked to IMG in slot CC, Pirani B2 is linked to IMG in slot A) These interlocks are there to make sure that the IMGs are not switched on at high pressures. The level of these interlocks can be set from the serial port or front panel. At Diamond we set this interlock at 10^{-2} mbar however they may be over ridden to be forced **ON** for the particular case of there being no related Pirani or the related Pirani has become damaged.

<u>IMG over pressure</u>

Once turned on the controller may use the pressure reading from the IMG to interlock itself with an over pressure interlock. So if the pressure increases above a set value the gauge will turn off. The value set for the over pressure interlock at Diamond is 5×10^{-4} mbar. This interlock set point can be set from serial port or front panel.

A table of the way these interlocks are used on Diamond is given in section 2.3.4.

2.3.3 Pressure output

There are various outputs of pressures from the 937a.

a) The pressure is output to the front panel. There are up to 5 digital display values for 5 gauges. Diamond uses just 4 gauges; the central output is not used.

b) The pressures can be read by querying the serial port. Diamond uses the RS-232 port for this purpose which is linked directly to the IOC and so to EPICS. The IOC queries the pressures every second.

c) There are various analogue outputs from the analogue socket; these are 0 to 10 volts. (The higher the voltage the higher the pressure). There is a combined Pirani and IMG signal, which gives a reading from 1000 mbar to 10^{-11} mbar, a log output for each IMG and a buffered output from each gauge. In Diamond we use the combined signal, which is transmitted directly into EPICS via an A/D converter in the IOC, and the Log IMG signals, which are used with the RGAs for calibration. The pin outs for the connector are given in the table below.

d) For a description of the formulae used to calculate the pressure from voltages please see the MKS manual, referenced in the end section of this manual

Pins	Analogue output descriptions	Diamond Use
1	Combination channel CC & B1	EPICS reads for trending
2	Buffered Channel CC	Not Used – except RF straight for fast monitoring
3	Buffered Channel A1	Not Used – except RF straight for fast monitoring
4	Buffered Channel A2 (For case of dual Pirani boards)	Not Used
5	Buffered Channel B1	Not Used
6	Buffered Channel B2	Not Used
7	Log Channel CC	Used by RGA electronics for calibration
8	Log Channel A1	Used by RGA electronics for calibration
9	Combination channel A & B2	EPICS reads for trending
10	Log Channel B1	Not used
11	Log Channel B2	Not used
12	Not used	Not used
13	Cold Cathode disable, Slot CC	Not used
14-24	Analogue ground	Used for ground signals above
25	Cold Cathode disable return, Slot CC	Not used

2.3.4 Gauge Set points

Gauge	Slot	Control requirement		Set Point Pressure Requirement	Active 937A set point	Adjustable Set Point Range
IMG1	CC	Sector valve, vacuum healthy		$1x10^{-6}$mbar	SP1	$1.2x10^{-2}$ to $2.7x10^{-10}$mbar
		RGA		$1x10^{-4}$mbar	Fixed, on IMG1 card	Factory set
		IMG Overpressure		$1x10^{-4}$mbar	IMG over pressure protection	$1.2x10^{-2}$ to $2.7x10^{-10}$mbar
IMG2	A	Sector valve, vacuum healthy		$1x10^{-6}$mbar	SP2	$1.2x10^{-2}$ to $2.7x10^{-10}$mbar
		MPS		1 x 10^{-7}mbar	SP3	$1.2x10^{-2}$ to $2.7x10^{-10}$mbar
		RGA		$1x10^{-4}$mbar	Fixed, on IMG2 card	Factory set
		IMG Overpressure			IMG over pressure protection	$1.2x10^{-2}$ to $2.7x10^{-10}$mbar
Pirani 1	B1	Ion pump, on/off		$1x10^{-2}$mbar	SP4	120 to $2.7x10^{-3}$ mbar
		IMG1 enable		$1x10^{-2}$mbar	IMG1 off if pressure > B1 IMG enable	1 to $2.7x10^{-3}$ mbar
Pirani 2	B2	Ion pump, on/off		$1x10^{-2}$mbar	SP5	120 to $2.7x10^{-3}$ mbar
		IMG2 enable		$1x10^{-2}$mbar	IMG2 off if pressure > B2 IMG enable	1 to $2.7x10^{-3}$ mbar

Note: Interlocks have 10% hysteresis.

2.3.5 Use of interlocks

As shown in the interlock table we use the interlocks at Diamond as follows:

1. Use IMG 1 & 2 for valves
2. Use IMG 2, spare interlock for MPS
3. Pirani and IMG for ion pump and TSP interlocks. We need to OR the IMG interlocks with the Pirani interlocks because:

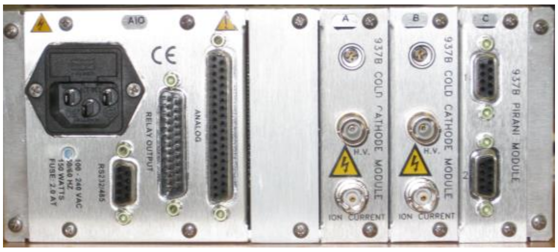
   - During bakeout the Pirani gauges need to be disconnected
   - If a Pirani gauge fails in a section then the only way to override this interlock to allow the ion pumps to stay on is to override the Pirani IMG enable and then use valve interlock to keep ion pumps on.

2.3.6 Pin outs for accessory relay connector

15 Pin Accessory connector				
Set	Channel	Normally open	Normally closed	Common
1	CC	2	1	9
2	A1	10	3	11
3	A2	12	4	5
4	B1	13	6	14
5	B2	7	8	15

2.4 937b controller

The 937b shown below will supersede the 937a. It is has some advantages to the user as well as being an easier unit to have its firmware upgraded.



The number of controllable relay interlocks is 12, 4 for each board. This means 4 associated with IMG1, 4 associated with IMG2, a total of 4 for the Pirani board which is 2 for Pirani 1 and 2 for Pirani 2. The Pirani interlocks can be activated either in the up or downwards direction whilst the IMG interlocks can only be activated downwards.

The interlocks come with programmable hysteresis which allows for UHV conditions to be met, 10^{-9} mbar region, before any valve is open although closing can be still kept at the 10^{-6} mbar region. The minimum hysteresis is 10% but a hysteresis of 50% is more common. If the hysteresis is set too small you may get chattering of the relays

The Diamond 937b also has a fast switching opto-coupler which we can utilise to drive the fast valves and flaps. This means that we don’t need to drive them with the VAT electronics which has a substantial cost and foot print saving. When the opto-coupler is not being used to drive the fast valves it may be used for some other purpose. The gauge set points for the 937b are shown on the table following.

The RS232/RS485 connection which is now a standard part of the power module and not an option in a separate slot has a different pin out to the 937a
The pin outs have changed for this connector to

Pin 2 – RS232 TxD.
Pin 3 – RS232 RxD.
Pin 5 – Ground.

The 937b has a 937a emulation mode and with the use of some Y cables the 937b can be backwards compatible.

Note: Because the 937b has the ability to set hysteresis of the setpoints all beamline first gauge controller units will be replaced with 937b's so that a stringent setting may be applied to allow the beamline to open but less stringent for it to close

<u>Setup of 937b</u>

The 937b needs to have its serial address set before it can be accessed by EPICS. In addition it needs to have the combination of gauges set so that the analogue output can be driven. Setting these functions is done from the front panel of the 937b. Instructions on doing this are given below with the default Diamond settings are follow these instructions.

<u>Setting serial address</u>

This must be done on all newly installed controllers.
Press <system setup> on the 937b
Move the cursor to the address box using the up down keys.
Press <Enter>
Move the up down cursor keys to set the address to 001
Press <Enter>

<u>To setup the combination gauges manually</u>

(This only has to be done if you are not loading from the EPICS menus or and not rebooting the IOC)
In system setup move the cursor to Set Combination Channels
Press <Enter>
Use Up down keys to change to ON
Press<Enter>
On combination 1 use side key to move to column marked Middle
Press<Enter>
Use up down keys to change to C1
Use side keys to move to Low column
Use Up down keys to change to A1
Use side keys to move to enable column.
Use up down keys to change to enable.
Press<Enter>
Use keys to move to combination 2 then adjust for
C2 B1 Enable
Press<Enter>

System Setup			
P Unit	MBAR	**Comm Type**	RS232
Address	1	**Baud Rate**	9600
Com Mode	937B	**Parity**	NONE
Set Param	Enable	**User Cal**	Enable
PID Recipe	Edit	**Ratio Recipe**	Edit
PID Ctrl Stup		Edit	
Combination Setup		Edit	
DAC Parameter Setup		Edit	
System FV Info		Display	

Set Combination Channel Parameter				
	High	**Middle**	**Low**	**Enable**
Combo #1	NA	C1	A1	Enable
Combo #2	NA	C2	B1	Enable

Setup CC Gauge A1					
GT	N2	**UCAL**	1.0E+00	**AO Delay**	3
Fast Relay SP		1.0E-05		**Prot SP**	5.00E-04
Relay		**Enable**	**Dir/Ch**	**Set SP**	**Hyst**
Relay 01		ENABLE	BELOW	1.0E-06	1.0E-06
Relay 02		ENABLE	BELOW	1.0E-07	1.1E-07
Relay 03		ENABLE	BELOW	1.0E-07	1.1E-07
Relay 04		ENABLE	BELOW	1.0E-04	1.1E-04
Control SP		SAFE	C1	1.0E-02	1.5E-02

Setup CC Gauge B1					
GT	N2	**UCAL**	1.0E+00	**AO Delay**	3
Fast Relay SP		1.0E-05		**Prot SP**	5.00E-04
Relay		**Enable**	**Dir/Ch**	**Set SP**	**Hyst**
Relay 05		ENABLE	BELOW	1.0E-06	1.0E-06
Relay 06		ENABLE	BELOW	1.0E-07	1.1E-07
Relay 07		ENABLE	BELOW	1.0E-07	1.1E-07
Relay 08		ENABLE	BELOW	1.0E-04	1.1E-04
Control SP		SAFE	C2	1.0E-02	1.5E-02

Setup convection Pirani Gauge C1					
Sensor	CP	**Gas Type**	N2	**FD**	NO
Auto Zero	NA		**Manual Zero**		No
ATM Value	1.0E+03		**ATM Cal**		NO
Relay		**Enable**	**DIR**	**SET SP**	**Hyst**
Relay 09		ENABLE	BELOW	1.0E-02	1.1E-02
Relay 10		ENABLE	ABOVE	9.5E+02	8.5E+02

Setup convection Pirani Gauge C2					
Sensor	CP	**Gas Type**	N2	**FD**	NO
Auto Zero	NA		**Manual Zero**		No
ATM Value	1.0E+03		**ATM Cal**		NO
Relay		**Enable**	**DIR**	**SET SP**	**Hyst**
Relay 11		ENABLE	BELOW	1.0E-02	1.1E-02
Relay 12		ENABLE	ABOVE	9.5E+02	8.5E+02

37 pin AIO D connection for 937b

Pins	Analogue output descriptions	Diamond Use
1	Buffered Channel A1	Not Used – except RF straight for fast monitoring
2	Buffered Channel A2	Not Used
3	Buffered Channel B1	Not Used – except RF straight for fast monitoring
4	Buffered Channel B2	Not Used
5	Buffered Channel C1	Not Used
6	Buffered Channel C2	Not Used
7	Log/Lin A1 (Switchable between Log and Lin)	Used by RGA electronics for calibration
8	Log/Lin A2 (Switchable between Log and Lin)	Not Used
9	Log/Lin B1 (Switchable between Log and Lin)	Used by RGA electronics for calibration
10	Log/Lin B2 (Switchable between Log and Lin)	Not used
11	Log/Lin C1 (Switchable between Log and Lin)	Not used
12	Log/Lin C2 (Switchable between Log and Lin)	Not used
13	Combination signal A&C1(Programmable selection)	EPICS reads for trending
14	Combination signal B&C2(Programmable selection)	EPICS reads for trending
15	Power A1	Used on pump stations, shorting to earth turns off gauge
16	Power A2/Degas A1	Not used
17	Power B1	Used on pump stations, shorting to earth turns off gauge
18	Power B2/Degas B1	Not used
19	Power C1	Not used
20	Power C2 Degas C1	Not used
21-37	Analogue ground	Used for ground signals above

Pin out for 937b relay O/P including standard levels

Pins	Descriptions	Diamond Use	I/L On
1	Relay 1 N/O	IMG 1, Valve interlock	1 E-6
2	Relay 1 Common	IMG 1, Valve interlock	
3	Relay 2 N/O	IMG 1 MPS 1 interlock	1 E-7
4	Relay2 Common	IMG 1 MPS 1 interlock	
5	Relay 3 N/O	IMG 1 MPS 2 interlock	1 E-7
6	Relay 3 Common	IMG 1 MPS 2 interlock	
7	Relay4 N/O	IMG 1 RGA interlock	1 E-4
8	Relay 4 Common	IMG 1 RGA interlock	
9	Relay 5 N/O	IMG 2, Valve interlock	1 E-6
10	Relay 5 Common	IMG 2, Valve interlock	
11	Relay 6 N/O	IMG 2 MPS 1 interlock	1 E-7
12	Relay 6 Common	IMG 2 MPS 1 interlock	
13	No connection	Not used	
14	Relay 7 N/O	IMG 2 MPS 2 interlock	1 E-7
15	Relay 7 Common	IMG 2 MPS 2 interlock	
16	Relay 8 N/O	IMG 2 RGA interlock	1 E-4
17	Relay 8 Common	IMG 2 RGA interlock	
18	Relay 9 N/O	PIRG 1 Ion pump interlock	1 E-2
19	Relay 9 Common	PIRG 1 Ion pump interlock	
20	Relay 10 N/O	PIRG 1 MPS I/L	900
21	Relay 10 Common	PIRG 1 MPS I/L	
22	Relay 11 N/O	PIRG 2 Ion pump interlock	1 E-2
23	Rely 11 Common	PIRG 2 Ion pump interlock	
24	Relay 12 N/O	PIRG 2 MPS I/L	900
25	Relay 12 Common	PIRG 2 MPS I/L	

2.4.1 Gauge Set points for 937b

Gauge	Slot	Relays	Control requirement	Set Point Pressure Requirement/adjustable	Direction for Change/allow change	Hysterisis/Adjustable	Adjustable Set Point Range
IMG1	A	1	Sector valve, vacuum good	1x10-6mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
		2	MPS I/L1	1x10-7mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
		3	MPS I/L2	1x10-7mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
		4	RGA I/L	1x10-4mbar	Below	Minimum/no	1.2x10-2 to 2.7x10-10mbar
		Internal	Overpressure	5x10-4mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
On CC card			Fastvalve	1x10-5mbar	Below	Minimum	
IMG2	B	5	Sector valve, vacuum good	1x10-6mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
		6	MPS I/L1	1x10-7mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
		7	MPS I/L2	1x10-7mbar	Below	Minimum/yes	1.2x10-2 to 2.7x10-10mbar
		8	RGA I/L	1x10-4mbar	Below	Minimum/no	1.2x10-2 to 2.7x10-10mbar
		Internal	Overpressure	5x10-4mbar	Below		1.2x10-2 to 2.7x10-10mbar
On CC card			Fastvalve	1x10-5mbar	Below	Minimum	
Pirani 1	C1	9	Ion pump, on/off	1x10-2mbar	Below	Minimum/yes	120 to 2.7x10-3 mbar
		10	MPS I/L	900 mbar	Above/yes	Minimum/yes	120 to 2.7x10-3 mbar
		Internal. Safe mode	A control	1x10-2mbar	Below	Minimum/no	1 to 2.7x10-3 mbar
Pirani 2	C2	11	Ion pump, on/off	1x10-2mbar	Below	Minimum/yes	120 to 2.7x10-3 mbar
		12	MPS I/L	900 mbar	Above/yes	Minimum/yes	120 to 2.7x10-3 mbar
		Internal Safe mode	B control	1x10-2mbar	Below	Minimum/no	1 to 2.7x10-3 mbar

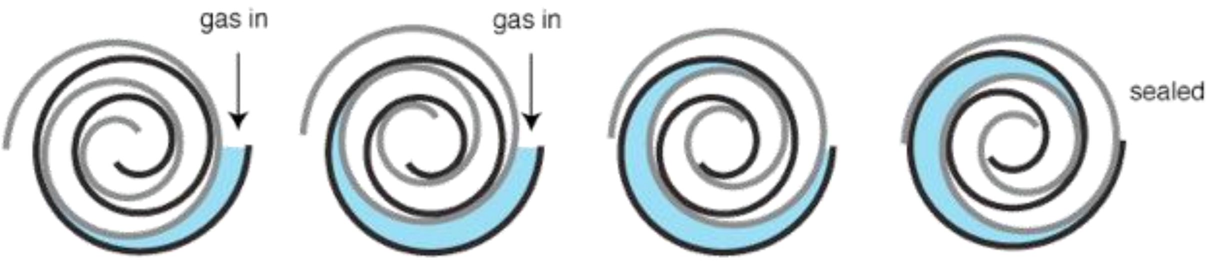
3. MECHNICAL PUMPS

To achieve the vacuum on Diamond we initially utilise mechanical pumping systems to remove the atmosphere from the chamber. The first style of pump needed is a “roughing” pump which mechanically removes the gas from the chamber. This style of pumps works by compressing a volume of gas to above atmospheric pressure such that the gas can be exhausted out of a non-return valve. The compression ratio of these pumps typically varies from 1000 to 100,000 and so they may achieve a pressure down to 10-2 mbar. Traditionally these style of pumps were oil rotary pumps but now in an environment such as Diamond are usually dry scroll pumps

To achieve lower pressures than 10-2 mbar a differential style pump needs to be placed between the volume being evacuated and the roughing pump. Traditionally these pumps were oil diffusion pumps but now are turbo molecular pumps in the main.

3.1 Scroll Pumps

Scroll pumps uses two interleaving spirals one of which is fixed and the other orbits eccentrically without rotating. This traps pockets of gas and compresses them so that they may be exhausted from the centre of the scroll. The scroll pump depends on the machining tolerance of the 2 spirals and the PTFE seals which are utilised.



Scroll pumps can and do produce small amounts of CF4 gas which may back stream into a vacuum chamber. This gas has a detrimental effect on some getter materials. So it has been advised not to leave these pumps continually pumping directly on vacuum chambers containing getters without a differential pump such as a turbo pump in line.

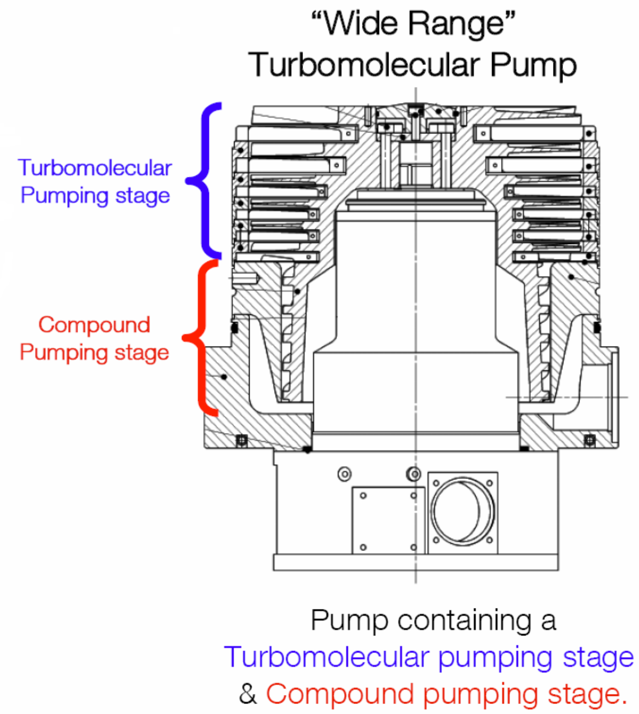
Scroll and roughing pumps in general are usually quoted in volumes they sweep per hour. So a moderate sized scroll will sweep 10 M^3 per hour which is the same as 2.8 l/s.

3.2 Turbo Pumps

Turbo molecular pumps work by causing a compression from the top of the turbo to the base. The gas at the back of the turbo is then expelled to the outside using a roughing style pump such as a scroll, roots or diaphragm pump.

Morden Turbo molecular pumps generally now consist of 2 stages, a turbo stage and a drag stage. The turbo stage consists of rotating angled blades interleaved with stationary blades called stators. When operating at their optimum the blades travel at approximately the average speed of the molecules being pumped. The blades are angled so they deflect the gas molecules down to stator blades below which in turn deflect the molecules down again to the next rotary stage the stator also acts as a restriction for gas molecules travelling against the flow from the low vacuum to the high vacuum end of the pump. At the compressed end of the turbo the gas molecules are directed to the backing pump by a drag stage which usually takes form as a rotating disc which gives the molecules directional momentum.

Turbo pumps are defined in terms of pumping speeds and compression ratios. Usually a mid size 300l/s turbo pump will have a relatively high compression ratio for N_2, 10^7, but rather a low compression ratio for H_2, 10^4. A pump can be designed for high throughput but low compression ratio or vice versa by varying the angle and opening of the rotators and stators as well as changing the design of the drag stage.



3.3 Turbo pump connections

Generally we turn the turbo pumps on at Diamond by shorting 2 pins together, and read back when the pump is at speed by looking at a relay "n/o" contact which is made when the turbo is at 80% or so of maximum speed. The pin outs for the SL80 (Oerlikon) and the VT301 (Agilent) is described below:

We do also have EPICS drivers for the Edwards nEXT80, nEXT300 & nEXT400 Turbo pumps which give speeds, temperatures, and service interval warnings.

SL80 turbo connections

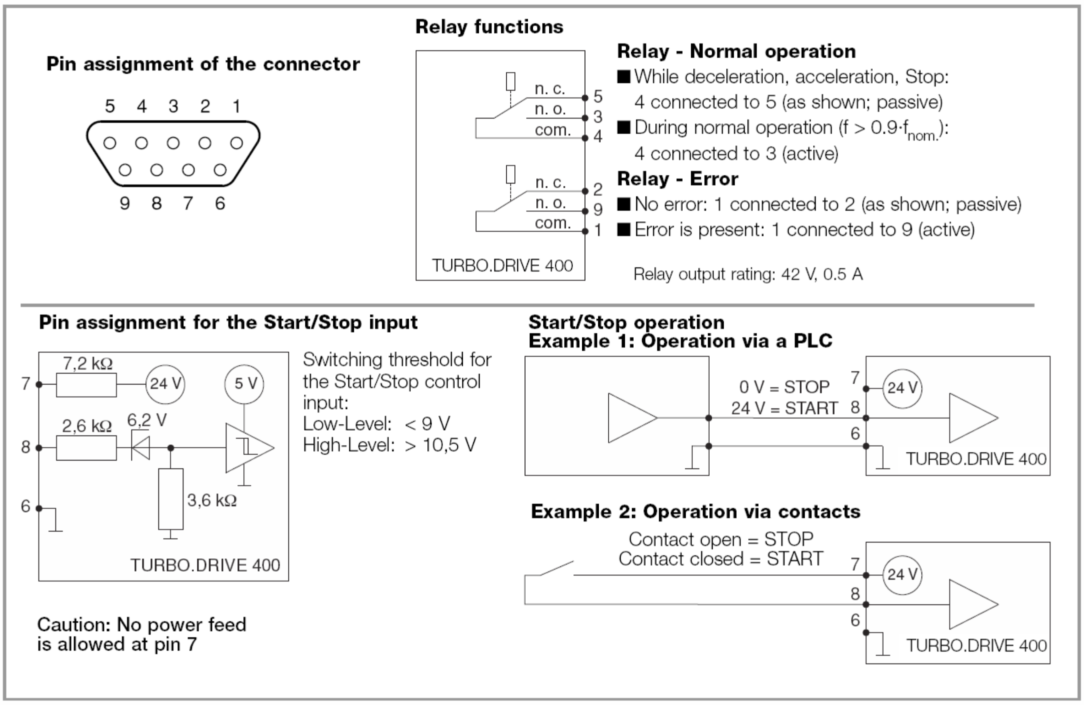
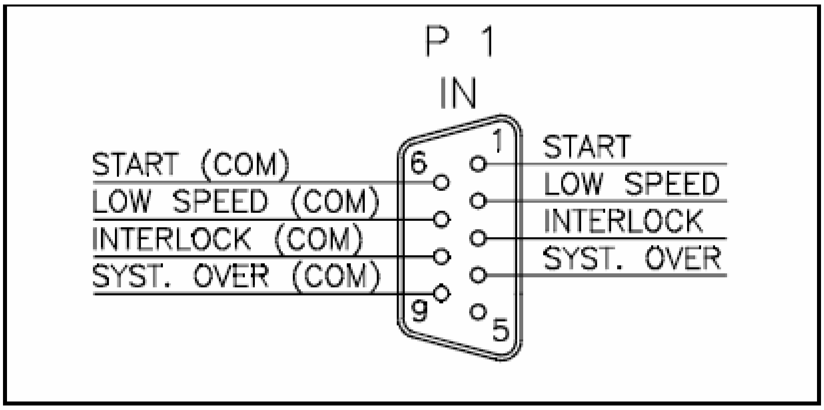


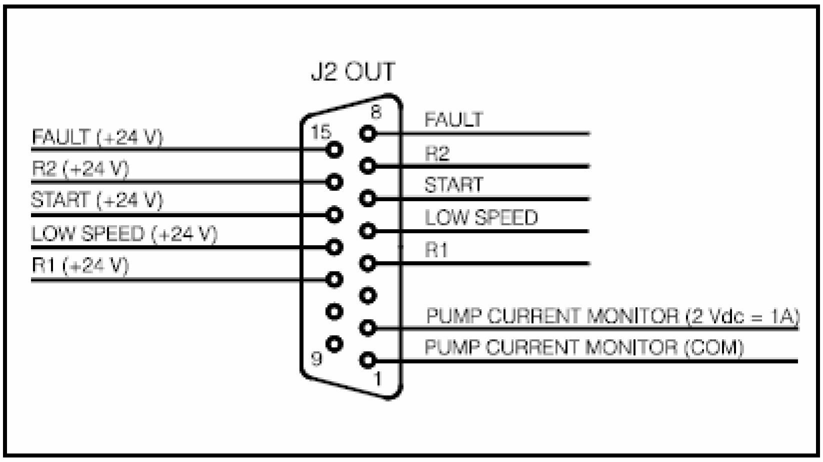
Fig. 3.20 Pin assignment of the REMOTE (X1) connector

VT301 Rack mounting controller connections



P1 Input Connector

Connection J2 - Logic Output Interconnections



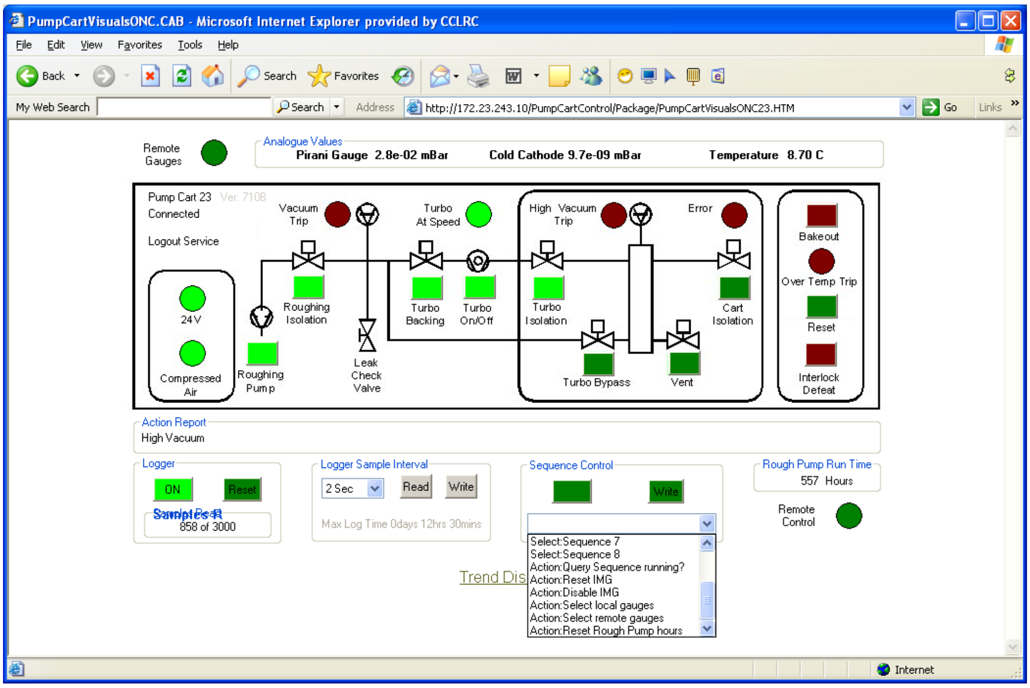
Logic Output Connector

3.4 Pump carts.

Diamond uses 2 types of pump carts manufactured by MKS and Edwards. Both types of cart contain a roughing/backing pump as well as a turbo pump. The MKS carts are generally used on the machine and have a PLC controlled system. The top chamber is bakeable to 120 ^{0}C and a RGA is installed as standard. The cart also has the ability to have a leak detector fitted to the back of the turbo for leak detecting.

MKS CART

We have developed a webpage device driver for the MKS cart which allows us drive the cart remotely.



MKS cart webpage

The Edwards pump cart is used in the main for the beamlines, and each beamline will have at least one of these carts, if not more. The cart is controlled through the Edwards TIC controller, and contains some automatic functions which will shut the cart off in the case of a vacuum failure. There is the ability to fit an RGA to the Edwards cart if required and it allows a leak detector to be fitted to the back of the turbo as in the MKS cart. This Edwards cart has now be supersede by our own in-house cart which has a PLC & touch screen control:

<u>Edwards Cart</u>

<u>Diamond in-house cart</u>

Diamond Desktop pumping station

The pumping station above shows an in-house built device which utilises pumps and gauges supplied by different manufacturers. This unit has an active gauge supplied from MKS. These gauges are useful for off line work as they only require 24volts to operate and all the electronics is on board the gauge. These gauges are not suitable for high radiation areas.

3.5 Active Gauges

The MKS Denmark gauges shown below are active gauges with the electronics on the gauge head they only need 24V DC to power them and can give,

1. On board display of pressure,
2. Up to 3 relay outputs
3. 1 analogue output
4. Serial communications

Gauge		Type		Range
901		Micro Pirani+Piezo gauge		1000 to 1 e-5 mbar
902		Piezo		1000 to 1 mbar
910		Mirco + absolute Piezo		1500 to 1 e-5 mbar
925		Micro Pirani only		down to 1 e-5 mbar
972		Micro Pirani+ CC		1000 mbar to 1 e-9 mbar

EPICS drives for the gauges have been written:

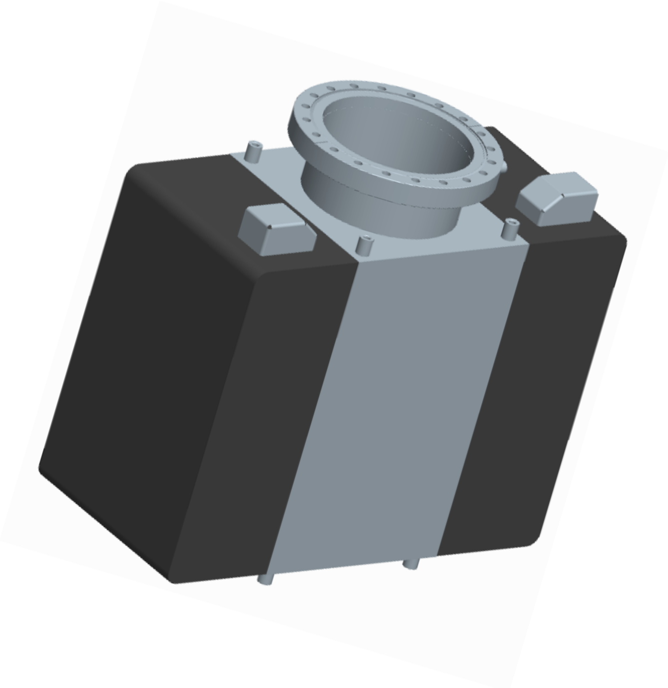
4. CAPTURE PUMPS

4.1 Ion Pumps

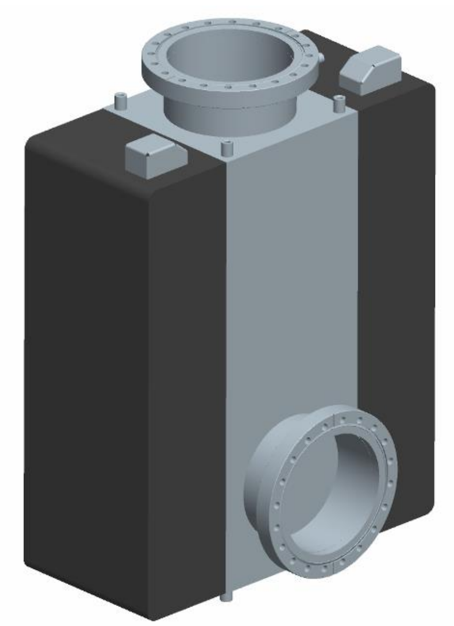
Ion pumps pump gases from 10^{-4} mbar to 10^{-11} mbar by capturing the gas into the body of the pump. Ion pumps are made up of a honeycomb of cells which operate in a similar way to a cold cathode gauge, namely electrons spiral in a strong magnetic and electrical field. When the electrons collide with a gas molecule they produce more electrons and an ion, the ion is accelerated towards the cathode whilst the electrons are spiral in the applied fields and produce in turn more ions and electrons. In conventional ion pumps the cathodes are made from titanium, ions impinging on the cathode sputter fresh titanium molecules off which coat the anode cells. Molecules coming into the ion pump may be trapped and are effectively pumped by either

1. Impinging on freshly coated reactive titanium surfaces or
2. Being ionised and then accelerated and buried in the cathode.

Ion pumps used on Diamond are manufactured by Gamma Vacuum they are made from a combination of honeycombed cells. Pictures of a 300 L/S pump and a 500 L/S pump are shown below. The 500L/S pump shown has an extra port to allow for additional pumps to be fitted to it. Ion pumps are sometimes used in combination with TSPs and NEG pumps described in following sections.



300 L/S Pump



500 L/S pump with addition port

Each honeycombed element has an effective pumping speed of 50 l/s. A 300 l/s pump will contain 6 cells; a 500 l/s pump 10 cells etc.

Running an ion pump at too high a pressure may damage the pump by producing a glow discharge which etches away the pump or arcing in the pump which can cause overheating and metallise internal ceramics etc.

The pumps used at Diamond have +7 kV applied to the anode, whilst the cathode is at earth potential. Each 7 kV supply has a 1 kW capability this makes the supplies potentially lethal. Safety precautions to protect personnel are discussed in a later section covering the power supplies.

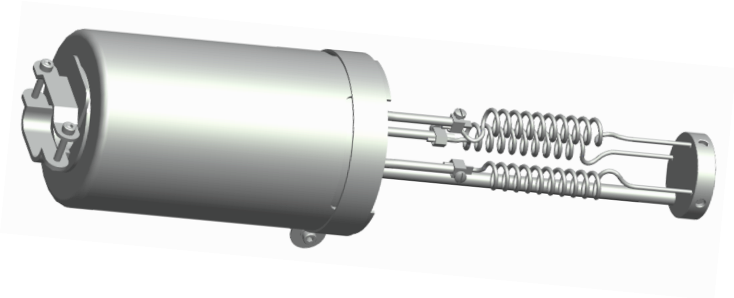
4.1.1 Ion pump internal heaters

The ion pumps have internal heater elements, hidden under the pole piece covers. These heaters are connected to a terminal block, which can be connected directly to the mains. The heaters are used to condition the pumps if they become contaminated or need degassing after a system vent. If additional thermal insulation is fitted during bakeout care has to be taken not to overheat the pump magnets as they can be damaged above 200°C. The power output for the heaters for a particular ion pump is given in the table following.

Ion Pump	***Heater Power (Watts)***	***Heater current in Amps at 240 VAC***
600LS	2400	10
500T	1600	6.7
300T	800	3.3
150T	600	2.5
100L	800	3.3

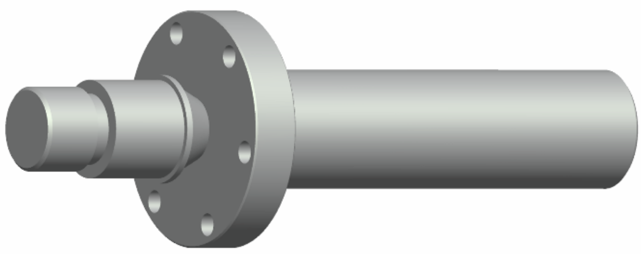
4.2 TSPs

Titanium **S**ublimation **P**umps (TSP) are used to provide temporary additional pumping. They work by heating a filament made from a titanium alloy. Titanium is evaporated from the filament and coats the internal wall of the pump. Gas impinging on the surface of the freshly coated surface may react with the metal and become trapped. This pump will pump until a monolayer of gas has been trapped on the surface. This will take a few seconds at 10^{-5} mbar and several hours at 10^{-9} mbar.



Filament assembly of TSP

4.3 NEG Pumps



NEG Cartridge

NEG cartridges as shown above have been utilised at the ends of the storage ring arcs. These pumps are to give extra pumping where there was insufficient space to fit ion pumps.

The NEG pump is made from a porous metal alloy which has a huge surface area which has to be activated by baking it into a mechanical pump, normally in Diamond's case using a pump cart. Gas, which has previously been trapped into the pump, migrates to the bulk of the metal alloy. This frees fresh sites, which can adsorb new gas molecules. After bakeout the pump is sealed from the pump cart and allowed to pump passively until it is once again saturated.

4.4 Controllers

Ion Pumps and TSPs are controlled via the MPC (Multiple Pump Controllers) The MPC has 2 high voltage supplies and the ability to have fitted a serial port which can drive a TSP power supply.

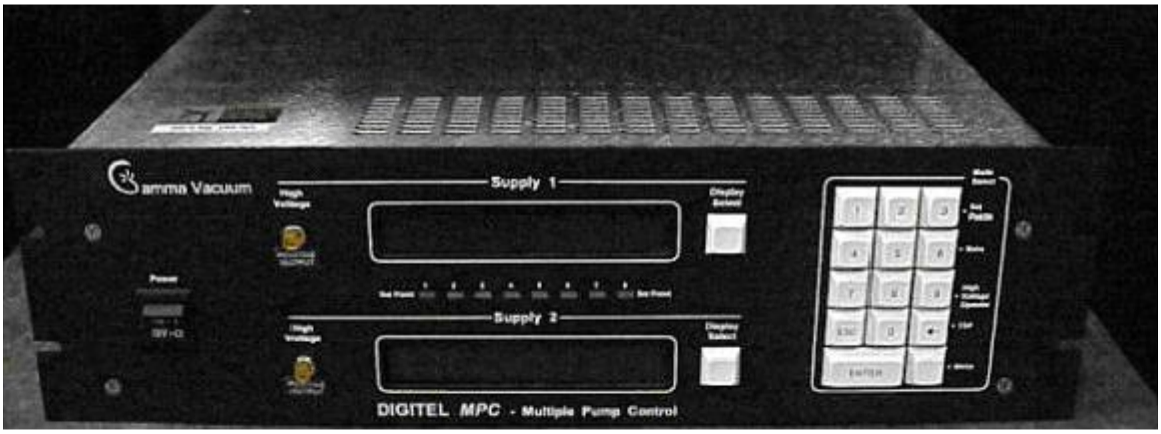
Diamond current incorporates 2 types of MPC namely a MPC II and a MPCe. The MPCe is the new version and in the main differs from the MPC II by

1. Using a touch screen
2. Have the TSP function incorporated on the main CPU board
3. New versions of MPC firmware may be downloaded using the serial connection.

In Diamond TSPs are controlled via MPCe’s.

4.4.1 MPC II

Front MPC II



Back Panel

MPC II controls ion pumps and TSPs. The TSPs are controlled via a TSP brick (power supply) which is located near the pump itself. The MPC II power supply used by Diamond has two independent 1 kW supplies, and the output voltage is 7kV, unless current limited by the pump drawing too much current. (At 10^{-5} mbar a 500 l/S pump will draw around 100 mA. This means that at pressures higher than this the power supply will be current limited and the output voltage will drop.)

The output from these power supplies is potentially lethal therefore some protection has to be made. The output of the supplies is protected from energisation unless connected by an interlocked "Safeconn" connection to the actual pump. The "Safeconn" connection is a low voltage signal that must be made to allow the high voltage to be turned on. The low voltage signal is made via two brushes on the ion pump cable connector making contact with a metal ring on the feedthrough when the cable is fitted to the pump.

Diamond uses a short bakeable cable (typically 1.5 m) with a "Safeconn" connection. To make the connection to this cable we utilise a Fischer connector set. This connector set has 2 low voltage connections for the "Safeconn" connection and one high voltage connection for the pump power. To make this connection safe the low voltage breaks before the high voltage. If the connection is broken when the pump is energised, the safety interlock is lost first so the power supply will automatically shut down and the power in the lead will be discharged in the pump. This connection style is to provide extra safety. However users should not rely on it - rather they should ensure that they turn off the supplies before disconnecting cables.

Power supplies are interlocked using the total pressure gauge interlocks. These interlocks come into the pump via the interlock plug shown above. There are 4 interlocks required for the MPC. There is one interlock for each ion pump supply and two interlocks for the TSP controller see next section.

Ion pump power supplies have additional over pressure protection - once a pump is successfully started, if the current drawn is too high then the supply will turn itself off. The trip is pump size related. For instance if a 500 l/s pump draws 100mA at 10^{-5} mbar whilst a 10 l/s pump will draw 100mA at 10^{-3} mbar. Therefore if the power supply is to switch off at a particular pressure the correct pump size must be input into the controller. On Diamond, EPICS normally does this on the reboot of an IOC. However if a new controller is fitted and the user doesn't want to reboot the IOC then the settings should be input through direct intervention. (See section on EPICS)

EPICS talks to the MPCs through the RS-232 serial interface. An MPC working with EPICS needs to have its address set to 1. This is set on the front panel of the MPC through the configure menu. High voltage, currents drawn and pressures are read from the serial port of the MPC every 1 second.

MPCs do also have setpoint relays, which can be used to interlock separate equipment. These Setpoints have a hysteresis setting such that the off point may be a higher pressure than the on point, thus preventing relay chattering. The setpoint relays from the MPC are not generally used on Diamond; the exception however is the RF cavities where they are used by the Accel to control their equipment.

4.4.2 Interlocks

The MPC can be interlocked with external contacts, which are input on J506 on the MPC. The pin contacts details for this socket are given in the table below

Interlock description	**Interlock purpose**	**Pin number on socket**	
HV1	Allows ion pump 1 on	1 & 3	Used on all MPCs
HV2	Allows Ion pump 2 on	7 & 9	Used on all MPCs
TSPL	Interlock for too high pressure for TSP	6 & 8	Used on MPCs on SR
TSPH	Interlock for too lower pressure for TSP	2 & 4	Not used, always shorted

4.4.3 Interlocks Out

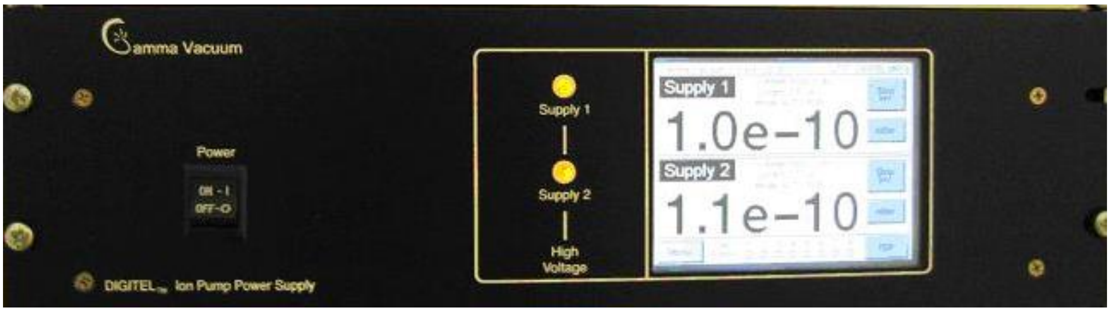
The MPC also has 8 interlocks outputs, 4 of which are zero volt relay outputs, the pin outs for these relay outputs are shown below which can be setup to be driven from either

37 Pin Interlock/analogue connector			
Set	Normally open	Normally closed	Common
1	3	2	1
2	6	5	4
3	9	8	7
4	12	11	10

The Setpoints can be associated with either of the two HV outputs. The interlocks have a Setpoint on and a Setpoint off function. This means that you can program in a hysteresis with these interlocks. It is normal to program the Setpoint on as a low pressure interlock to the setpoint off.

4.5 MPCe

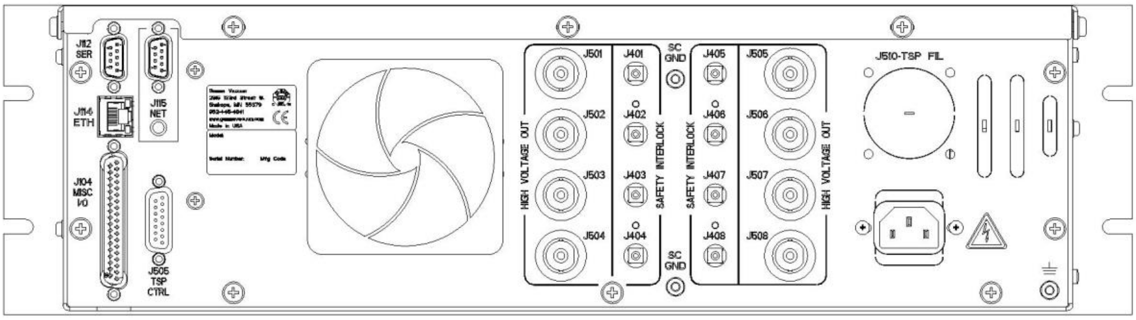
MPC II is now obsolete and new units will be MPCe which is easily differentiated by its touch screen panel. The MPCe has all the functionality of the MPC II therefore from the controls point of view there will be no difference.



The MPCe has been found to been superior in driving the TSP units, so all MPC IIs in the storage ring which are used to drive TSPs have been exchanged for the MPCe version.

4.6 MPCq

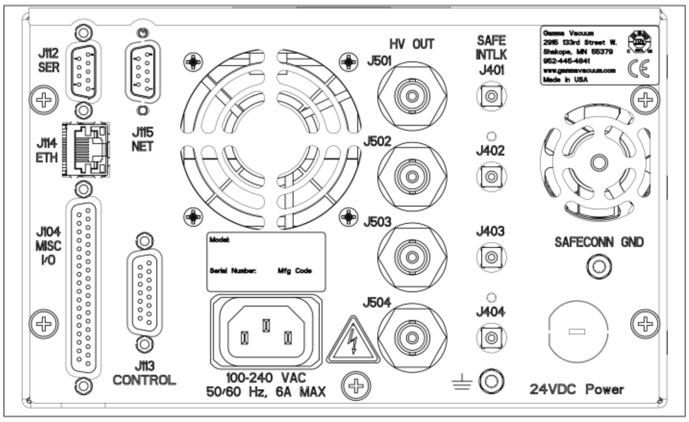
The MPCe is now obsolete and the new version is the MPCq with its updated colour screen and its change of interlock inputs such that all the inputs and outputs are made on one connector namely J104 as described in the table following. Note that to put a MPCq in a position which had a MPC II or MPCe an adapter cable as shown below will be needed.



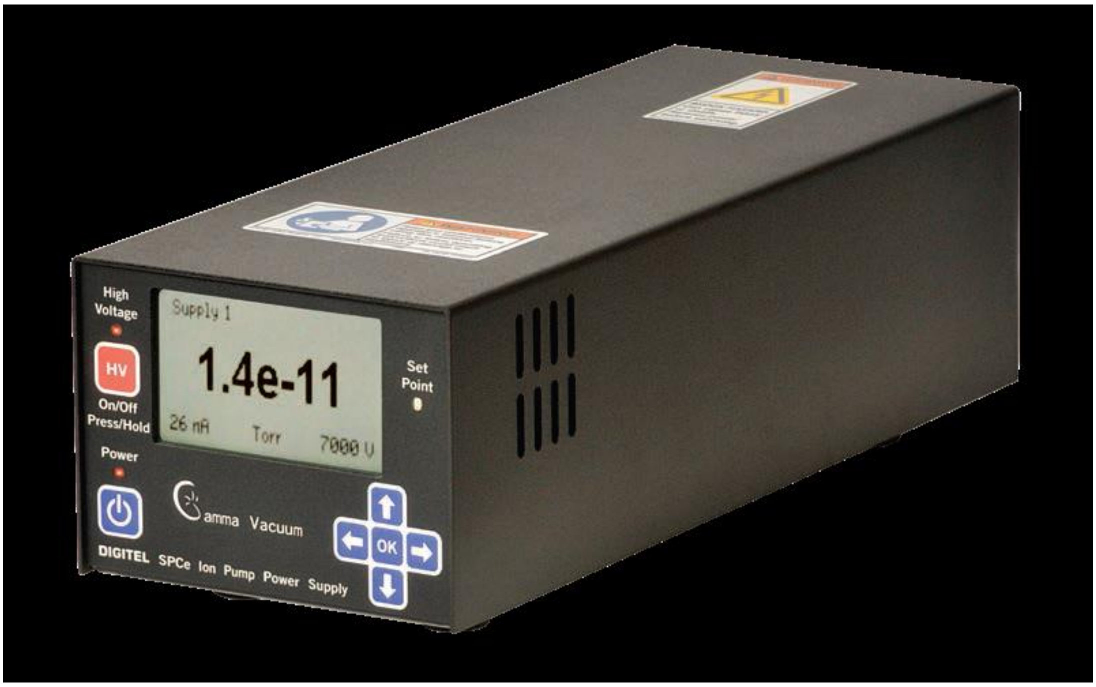
2.1 Pin	2.2 Description
1	Relay 1 Common *
2	Relay 1 NC
3	Relay 1 NO
4	Relay 2 Common *
5	Relay 2 NC
6	Relay 2 NO
7	Relay 3 Common *
8	Relay 3 NC
9	Relay 3 NO
10	Relay 4 Common *
11	Relay 4 NC
12	Relay 4 NO
13	Reserved - do not use, ground
14	Reserved - do not use, ground
15	DIGITAL OUT 1 - output, digital, 0/+5VDC, 7mA max
16	Reserved - do not use, ground
17	DIGITAL OUT 2 - output, digital, 0/+5VDC, 7mA max
18	Reserved - do not use, ground
19	DIGITAL OUT 3 - output, digital, 0/+5VDC, 7mA max
20	Reserved – do not use, output, digital, 0/+5VDC, 7mA max
21	Reserved – do not use, output, digital, 0/+5VDC, 7mA max
22	DIGITAL IN 1 - input, pulled-up internally to +3.3V, ground to activate assigned function
23	DIGITAL IN 2 - input, pulled-up internally to +3.3V, ground to activate assigned function
24	DIGITAL IN 3 - input, pulled-up internally to +3.3V, ground to activate assigned function
25	DIGITAL IN 4 - input, pulled-up internally to +3.3V, ground to activate assigned function
26	+12Vdc - supply, regulated, 80mA max
27	Not connected
28	Not connected
29	Reserved - do not use, ground
30	ANALOG OUT 1 - output, analog, range 0 to +10VDC
31	Ground
32	ANALOG OUT 2 - output, analog, range 0 to +10VDC
33	Ground
34	ANALOG OUT 3 - output, analog, range 0 to +10VDC
35	Ground
36	ANALOG OUT 4 - output, analog, range 0 to +10VDC
37	DIGITAL OUT 4 - output, digital, 0/+5VDC, 7mA max

4.7 QPC

The QPC (Quad power supply controller) is a switched mode power supply type device. It can have up to 4 High voltage boards, powered by 2 off power supplies, feeding four separate ion pumps. As this is a switched mode power supply it has the ability to have the output voltage set, the range for the output is 3,000 to 7,000 volts.



4.8 SPCe



A SPCe is a 3 to 7kV 40mA with a maximum power output of 50 watts which can control one ion pump. This device is special useful for controlling the smaller ion pumps as they will run at 5kV. It is also useful as a portable supply due to its light weight and compactness. The SPCe has a high pot mod allowing the voltage to ramp to 10 kV

4.9 TSP

The TSP power supply (termed brick by Gamma) is mounted within 3 metres of the TSP itself. This is because the high current bakeable lead from the brick to the pump is only 3 metres long. The TSP power supply/brick is controlled via a serial connection from the MPC. A picture of the TSP brick is given below

The New TSP, pump and controller, have different style connector interface which allows the short high current cable to be easily attached. As shown in the cable below.

5. VALVES AND CONTROLLERS

5.1 Standard

The standard Diamond pneumatic valve operates using 5.5 to 7 bar of air. This is controlled via a 24 volt DC solenoid which switches the air from the open chamber to the closed chamber of the pneumatic cylinder of the valve, thus operating the valve. The standard valve has 2 open position micro switches and 2 closed position micro switches, in addition to an air pressure switch which is factory set at 5.25 bar +/- 0.25 bar. All switch contacts and solenoid contacts are supplied via a 12 way plug. The drawing of this is given in the appendix of this document.

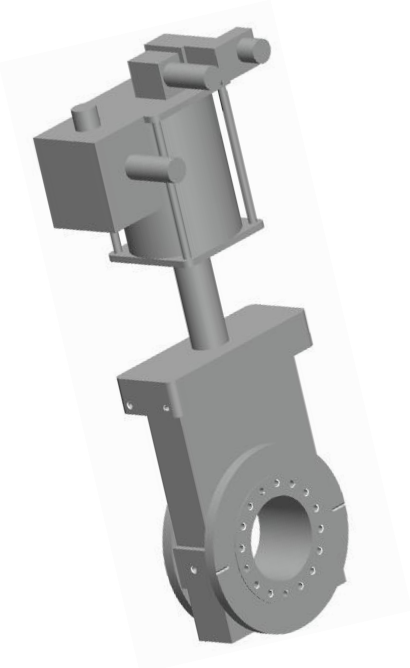
The valves generally shut within 2-3 seconds, they are designed such that the initial 90% of the stroke happens very quickly with the final 10% of the stoke being slowed down using an air restrictor so as not to damage the valve. The initial 90% of the stroke may take one second whilst the final 10% part of the stroke may take up to 2 seconds.

Valves are operated via the PLC valve crate, which is documented later.

An arrow style mark is ▷ always etched on the valve flange which has the sealing surface. Usually this flange will be on the vacuum side of the valve so any air pressure is supports the closed position and doesn’t try to open the valve. In beamlines which use viton sealed valves there is a preference to always have this flange furthest away from the storage ring, i.e. towards the experimental station, as this will mean that the Viton seal will always face away from the light and so will be less susceptible to damage during valve closures when the beam is on.

5.2 Standard All metal valve

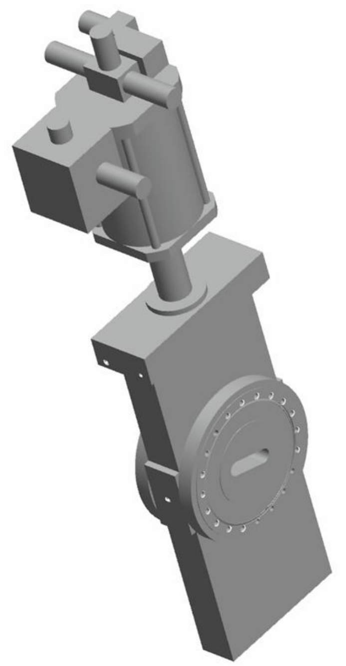
The standard all metal valve used on Diamond is the VAT series 48 valve. This valve utilises the VAT wet seal. This seal is very sensitive to dust/contamination.



5.3 All metal RF valve

The all metal RF valve is designed so that when open the valve takes on the shape of the beam tube and the any gaps are filled with an RF foil. The RF valve effectively has two shut plates. (See picture below)

In the lower of the two plates the shape of the beam tube has been machined out. When the plates open up then a RF foil springs out between the plates which have the race track/ beam tube shape.



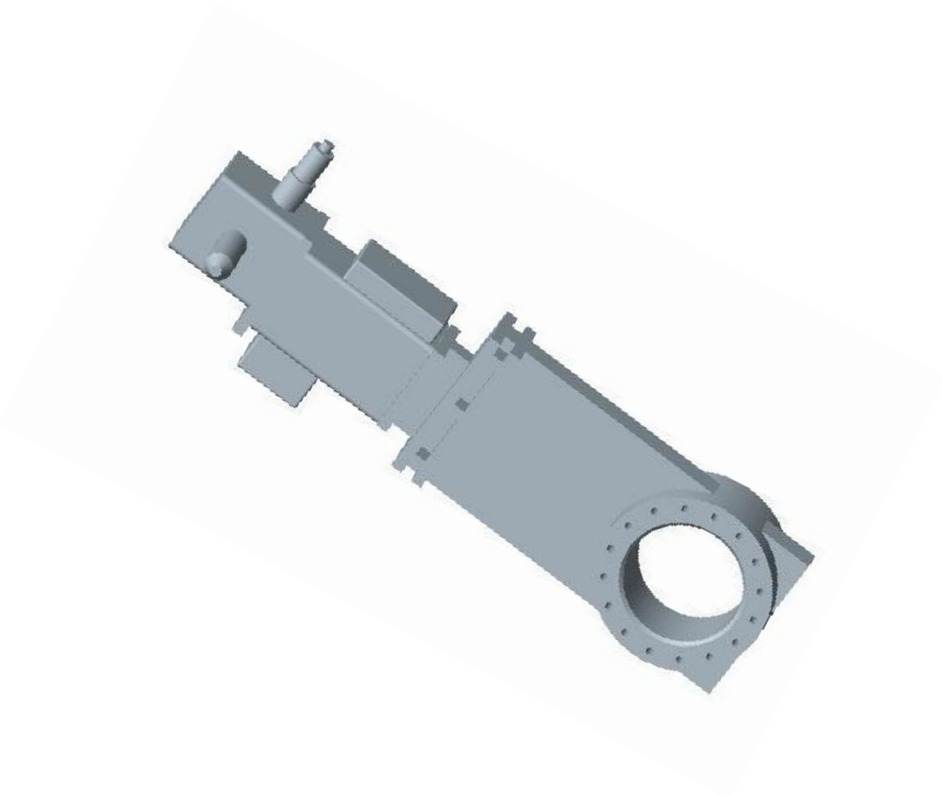
The higher of the two plates is identical to an ordinary metal valve and creates a vacuum seal in the same way that a series 48 valve does, described in the previous section.

(Note: The Diamond Storage ring RF valve is a DN100 valve but with a DN160 flange, the DN 160 flange is used to be compatible to the Storage ring flanges.)

5.4 Series 10 valve used on the beamlines.

This valve has the same electrical interface, but the valve itself uses a viton seal. This seal requires a much lower force to be applied to close it, and so as can be seen from the valve itself the pneumatic cylinder is much smaller. The sealing face as with all the other models is indicated by the arrow style mark. The flange that this mark is on is the side of the sealing face. The sealing sides should point away from the storage ring so that the beam never sees the Viton seals.

The force used to close the valve is much lower than with the all metal valve which means that the valve will not open if there is atmosphere on the opposite side to the sealing face and vacuum on the other side. VAT recommend <30mbar as a differential pressure at opening.



Series 10 DN100

5.5 Fast valves

The fast valve is designed to shut within 10 to 13 milliseconds of the gauges controlling the valve registering a pressure increase. Diamond uses two types of fast valve; one operates with a leak-tight closure using a Viton seal. This valve has a manufacturer name of Series 75.0 and 75.2 and may be used on its own to produce a vacuum isolation of two sections. The other type of valve is an all metal valve, Series 77.3 and 77.1, and closes to less than 1 l/s constriction; this valve needs to be used in conjunction with a normal valve to provide a leak-tight isolating seal.

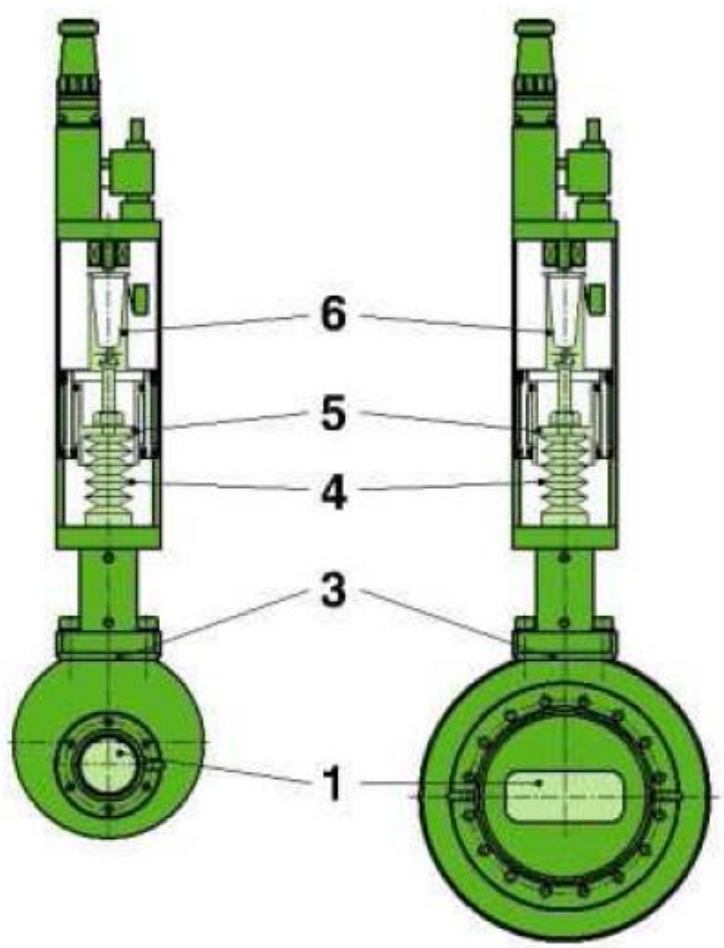
The pneumatic control of the valves differs depending on the size of opening required. The smaller valves are as shown below and have a relatively simple pneumatic mechanism. To open them air is supplied to the open side of the actuator for a set time or until the valve hits the open limit, the valve is then held open by a mechanical latch. The open solenoid is then closed and the air is directed to the closed cylinder which is filled ready for shutting the valve this is rather like setting a spring. To shut the valve the mechanical latch is opened and the already full close cylinder slams the valve closed.

Series 75.2
Valve type

Series 77.3
Shutter type

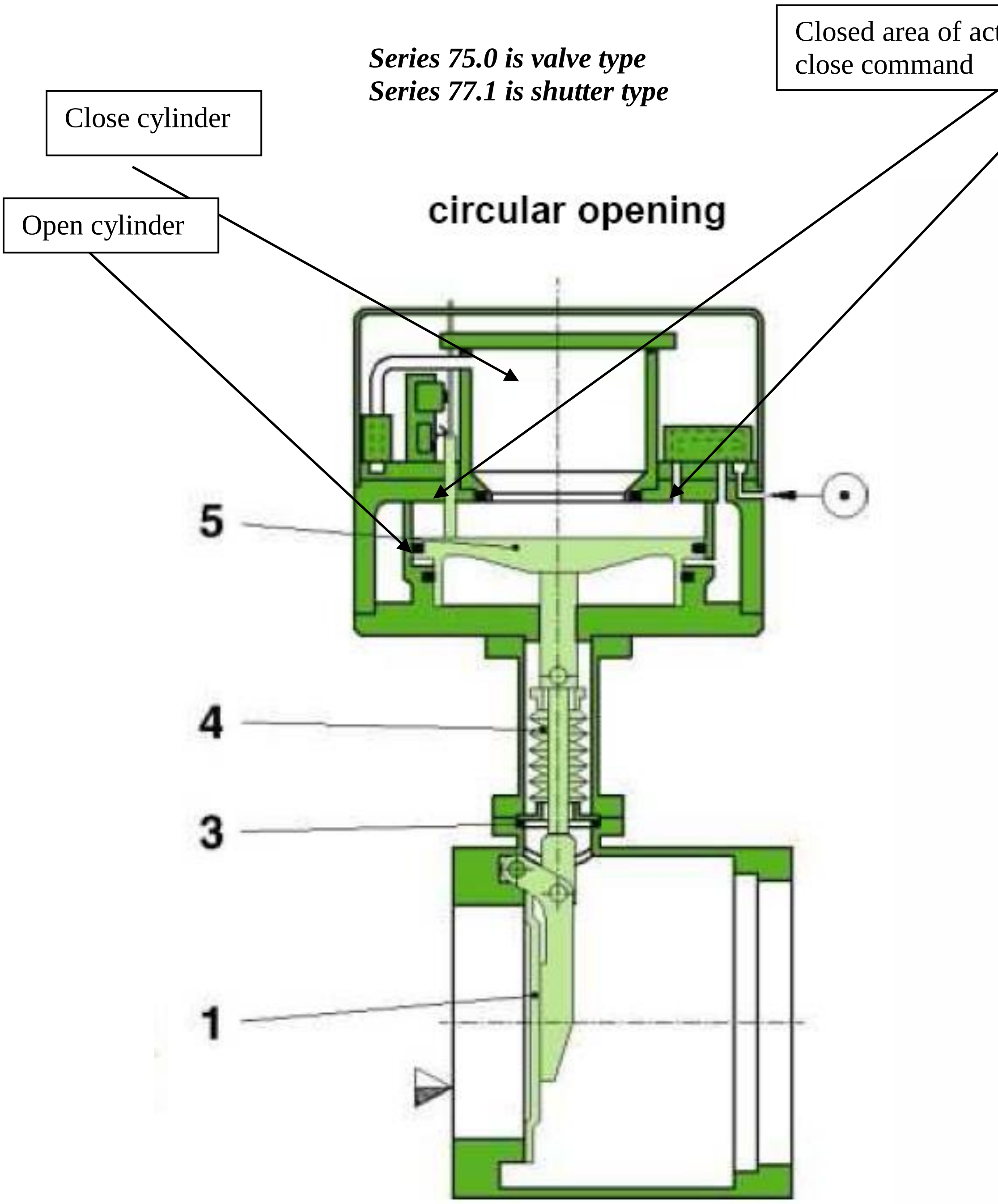
circular opening

(slot opening)



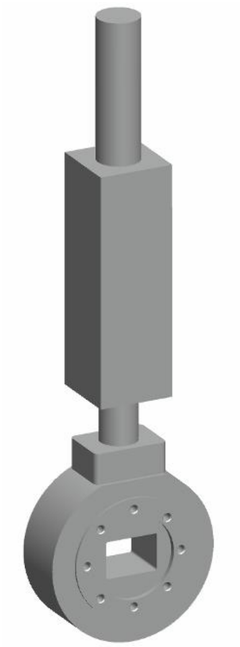
The larger fast valves and flaps are held open by air pressure on the open side of the actuator. After opening the valve the open interlock micro switch directs power to the solenoid which allows the closed cylinder to fill with air at the same time that the open is still being kept at pressure. The area on the actuator plate from the open cylinder is larger than the closed cylinder so the valve stays open. When you want to close the valve the controller stops air to both open and closed cylinders, it then leaks air into an area which allows the closed cylinder to gain a much larger area of the actuator plate to act on. The closed cylinder then can act like a coiled spring and slams the valve closed.

Series 75.0 is valve type
Series 77.1 is shutter type



To open Series 75.2 and 77.3 solenoid current is supplied for only a limited time (10/15 seconds). To shut the valve a few seconds' needs to have elapsed since the open current has been stopped to allow the close cylinder to fill then 100 volts can be discharged through the electromagnetic trigger clamp releasing the valve to close.

To open series 75.0 and 77.1 solenoid current needs to be continually supplied. To shut the valve the open current is stopped and 100 volts is discharged through the closed solenoids.

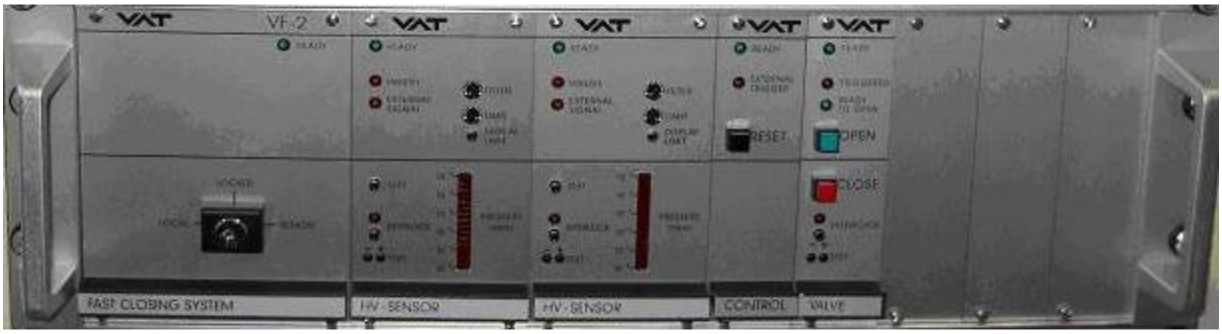


Fast Shutter

5.5.1 Fast Valve controllers

5.5.1.1 VAT controller

The initial fast valve controller used by Diamond is a VAT product, it senses the pressure using a set of dedicated IMGs (of a different type from the IMGs used elsewhere on Diamond) and uses a particular set point for the gauges to turn the gauges off and shut the fast valve or shutter. The controller is designed around a bus, which may carry into several units. The following units plug into the bus: power supplies, IMG supplies, control supplies and valve supplies. By setting different dip switches on the units the fast valve electronics can be configured for different needs. Diamond uses 2 basic type of configuration, one where the fast valve is controlled by 2 gauges "AND-ed" together and another where 2 pairs of such gauges are "OR-ed" together to act independently to shut a fast valve/flap. For the valves to trip shut both gauges of a pair need to trip off. The gauges are only activated to trip when areas to be protected are opened up to volumes to be protected against, for example beamline to storage ring.



VAT fast valve controller

The first type of control with 1 pair of gauges is used in two locations one to protect the Linac with a Series 75 and two a Series 77 to protect the storage ring from the BTS.

The second type of configurations, of 2 pairs of 2 gauges, is used on all the front ends to protect the storage ring from the front end itself and when the beamline-to front-end-valve is open to protect the storage ring from the beamline.

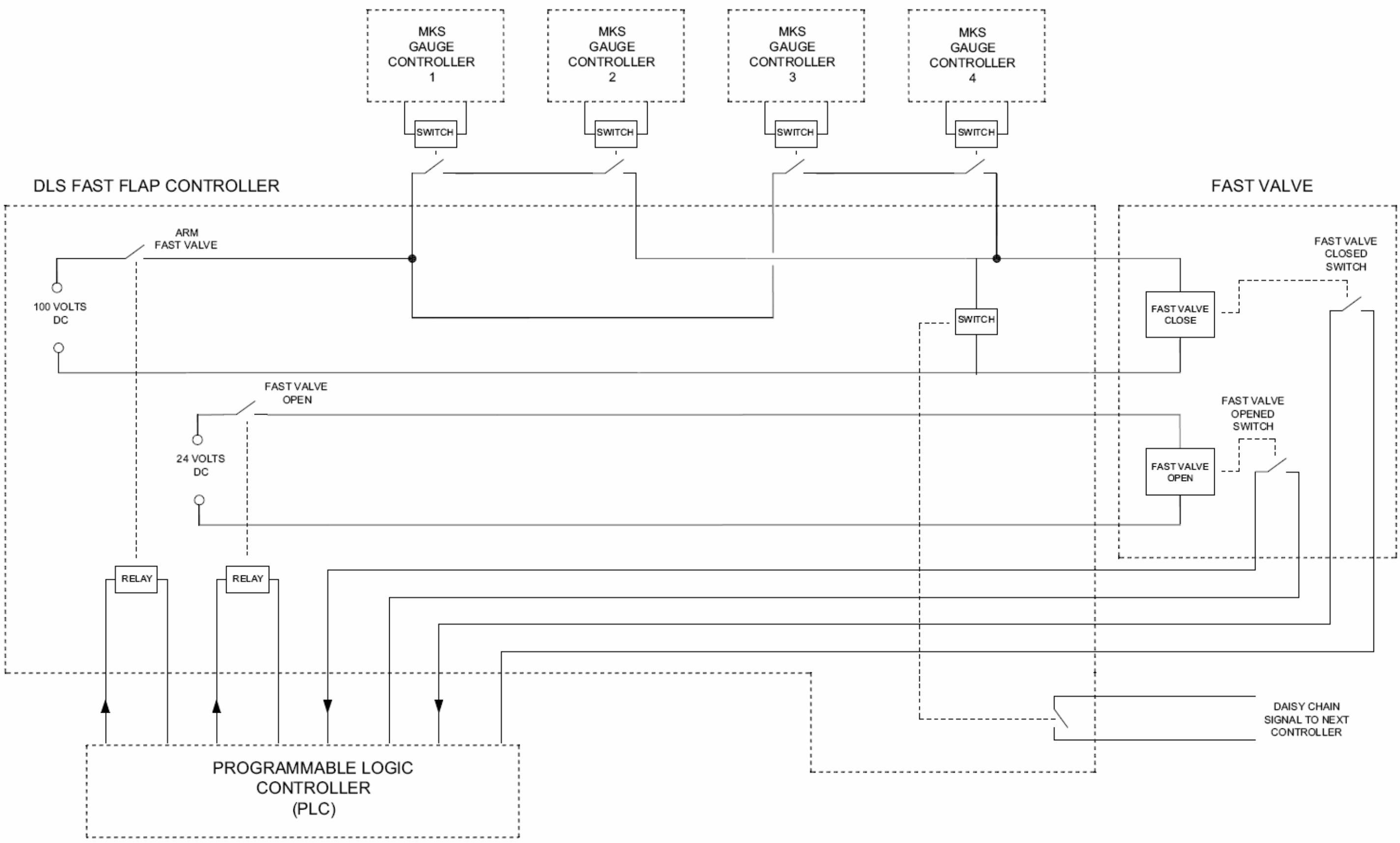
The dip switch settings for the controllers are given in the appendix.

5.5.1.2 Diamond developed controller

The fast valve controller recently developed by Diamond uses closing outputs from CC cards in the new gauge controller the 937b. If the pressure rises above a set value then 24 volt signals are returned to the fast valve controller which will activate the fast valve if has been set to arm by the PLC. Dip switches are available in the controller to allow latching of the gauge signal and to select the type of fast valve under controller. The dips switch settings are given in the appendix

DLS Fast valve controller

A simplified schematic of the fast valve electronics is given in the diagram below. The X5 socket can be used to daisy chain fast valve controllers together, so that more than one fast valve may be shut, or a fast acting absorber may be shut in front of the fast valve to protect it from the power of the beam before an absorber at the start of the frontend is closed.



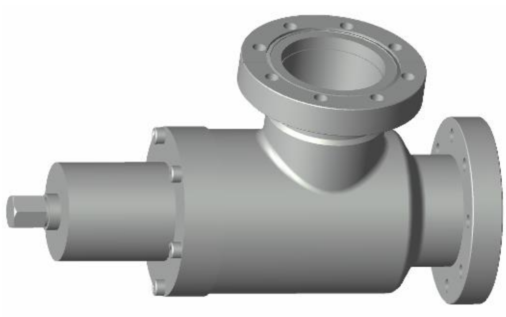
5.5.2 *Fast Mask*

B13I has white/pink light which travels down the length of the beamline so a fast mask made from Glidcop was developed so that valves further down the beam line can be shut quickly in the event of a vacuum failure without the need to worry about radiation damage. The valves are protected from beam damage by closing the fast mask in front of them within 100mS. This protects components against the beam for the critical 3 seconds whilst the frontend absorber closes. The fast mask is driven by a signal from X5 in the case of a fast valve and from the loss of the open limit in the case of the normal valve.

A picture of the prototype fast mask device is shown on the following page.

5.5.3 Right Angle Manual valves

A DN63 Right angle valve all-metal valve is pictured following. On Diamond this style of valve is used to connect to pump carts for venting sections, mechanical pumping out from atmosphere and for use during conditioning of NEG pumps, TSPs and bakeout of vessels. The valve uses the VAT wet seal which is prone to damage from dust particles. Therefore on Diamond these valves are further protected with the use of a cover plated with a self-sealing Swagelok fitting. The space between the plate and the valve is pumped out using a small mobile pumping system such as a leak detector. There is also a smaller DN40 version of this valve which is used in some places on Diamond.



DN63 RA valve

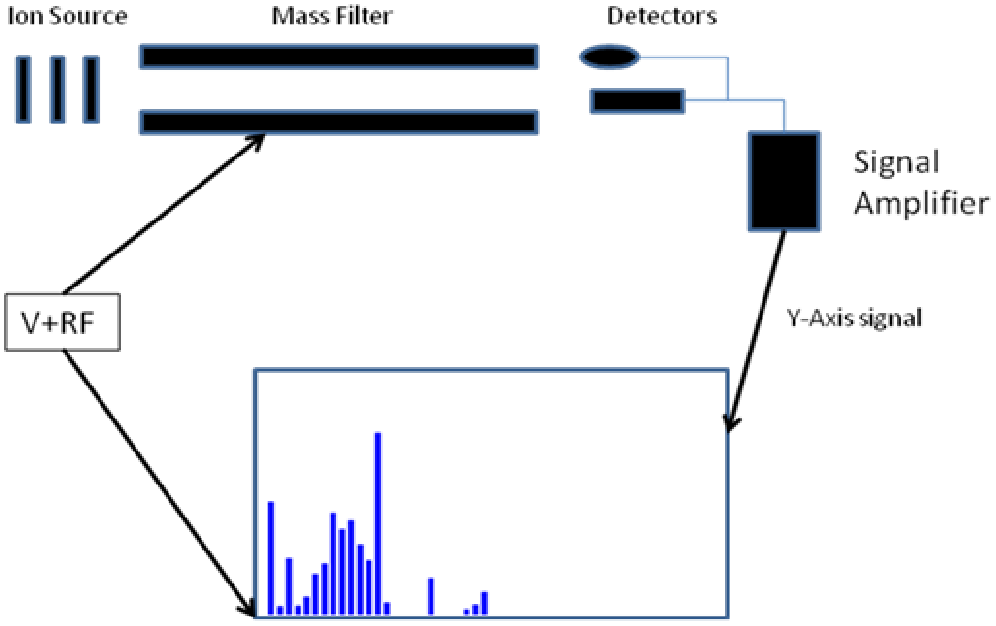
5.5.4 Leak valves

A VAT motorised leak valve incorporated with an Oxygen cylinder to leak oxygen into the vacuum system as required on some beamlines. The step motor is driven via the PLC valve controller. A manual version of the valve exists and is used on easily accessible applications

6. RESIDUAL GAS ANALYSERS (RGA)

RGAs used on Diamond are compact quadrupole mass spectrometers, which work using a hot filament, an ionisation cage, mass filter, a Faraday plate detector and a channel plate multiplier. Gas molecules are ionised by the electrons produced by the filament and cage. The resultant ions are accelerated towards the quadrupole assembly which is a mass filter. The mass filter works by putting a combination of DC and RF voltages on the rods, different values of which allow particular M/e ratios to traverse the filter and impinge on one of two detectors - channel plate or Faraday plate.

Quadrupole Analyser: Principle of Operation

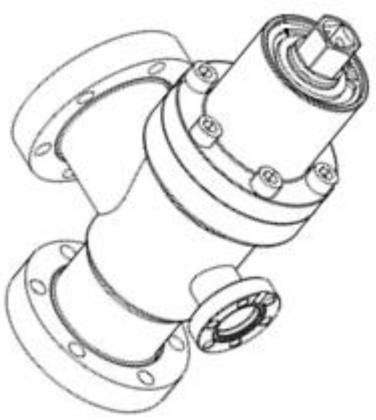


6.1 RGA heads

RGA heads on Diamond are single filter devices from MKS Spectra. These devices have been placed around the ring at places of particular interest, such as crotch vessels, ID chambers etc. There is always a total pressure gauge close to an RGA. Outputs from the total gauge controller are used to trip the RGA off in case of a vacuum failure and to supply a total pressure reading to the RGA to provide a calibration point.

MKS RGA

Because of the need to service the RGA heads it is advisable to put the RGA source behind a right angle pump-able valve such as the one shown below. This will allow for independent venting of the RGA head.

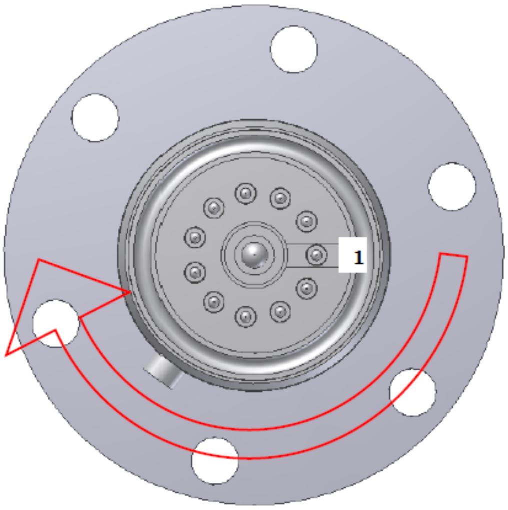


VAT P/N 54132-GE02-AB01

6.2 RGA Pin configuration

The pin configuration is as shown in the table below. The earth pin is the one with the copper strip and the other pins are numbered in ascending order clockwise around the feed through until pin 11. Pin12 is the central pin.

Pin	Connection
1	Earth
2	Source Plate
3	Electron Multiplier
4	Filament 1
5	Extraction plate
6	Suppressor plate
7	R.F.1
8	Filament common
9	No connection
10	Filament 2
11	R.F.2
12	Collector



6.3 RGA MV+ electronics

RGA electronics on Diamond accelerators and beamlines phase 1 and phase 2 are MV+ units. These MV+ units are connected to heads using a 3-metre extension cable. The electronics units are individually tuned for particular heads and cables and so need to be kept together. As such they are serial numbered together. The electronic boxes need to be kept away from radiation as much as possible so they have been located beneath the machine girders where possible. Also the heads need to be protected from radiation or else an unwanted background signal is observed. To achieve this on the storage ring we use a lead shield around the head. Please see pictures at the end of this section:

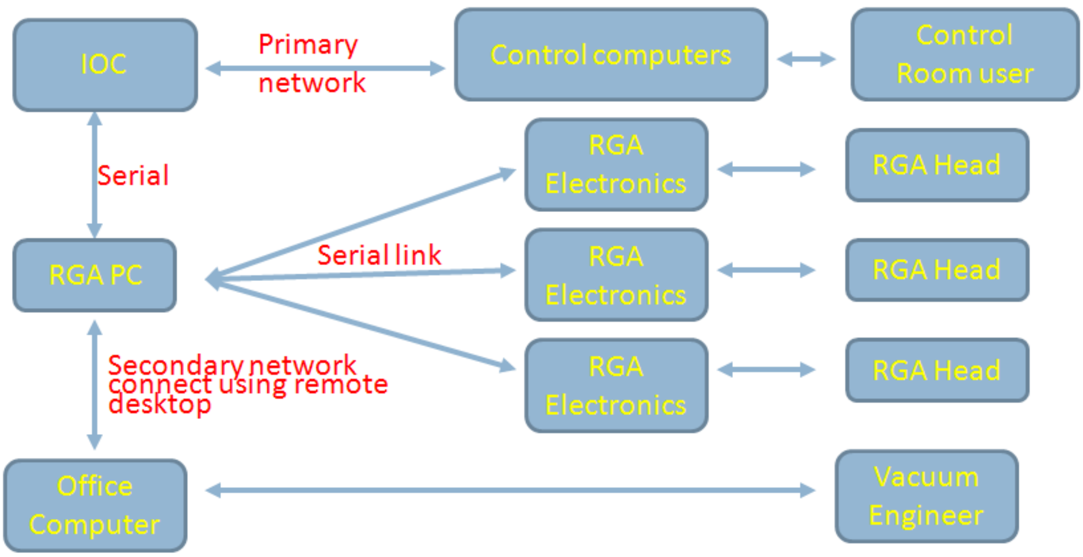
The electronics outputs and inputs to the RGA head. Input controls to the electronics included

1. 24 volt power supply
2. Analogue input from a local IMG gauge, this signal is used for calibrating and the head.
3. Interlock from a local gauge
4. RS-422 connections to an RGA computer. (*It is worth noting that the pin out of the 422 connections on the Serial board of the RGA PC differ from manufacturer to manufacturer so you need to check the manual before wiring/drawing up.)*

6.4 RGA Computers and Process eye

The RGAs are driven by the manufacturer's Windows based software called Process Eye. Each sector contains an RGA PC which is a 1U rack mounted PC which has been connected to the secondary controls network. IP addresses for the PCs are given in the Appendix. The PCs have an RS-422 extension card installed in them, which can run up to 8 RGA heads. On the PC this runs with comms ports 3 to 10. Communications between the RGA PC and EPICS is done via the PC serial RS-232 port, comms port 1. The RGAs can be controlled locally or via EPICS. When run under EPICS they constantly run bar graphs of 1-50 AMU scans under 2 multiplier settings. When EPICS asks for a partial pressure Process Eye sends back the last valid unsaturated peak height taken from the scan. EPICS can archive these partial pressures.

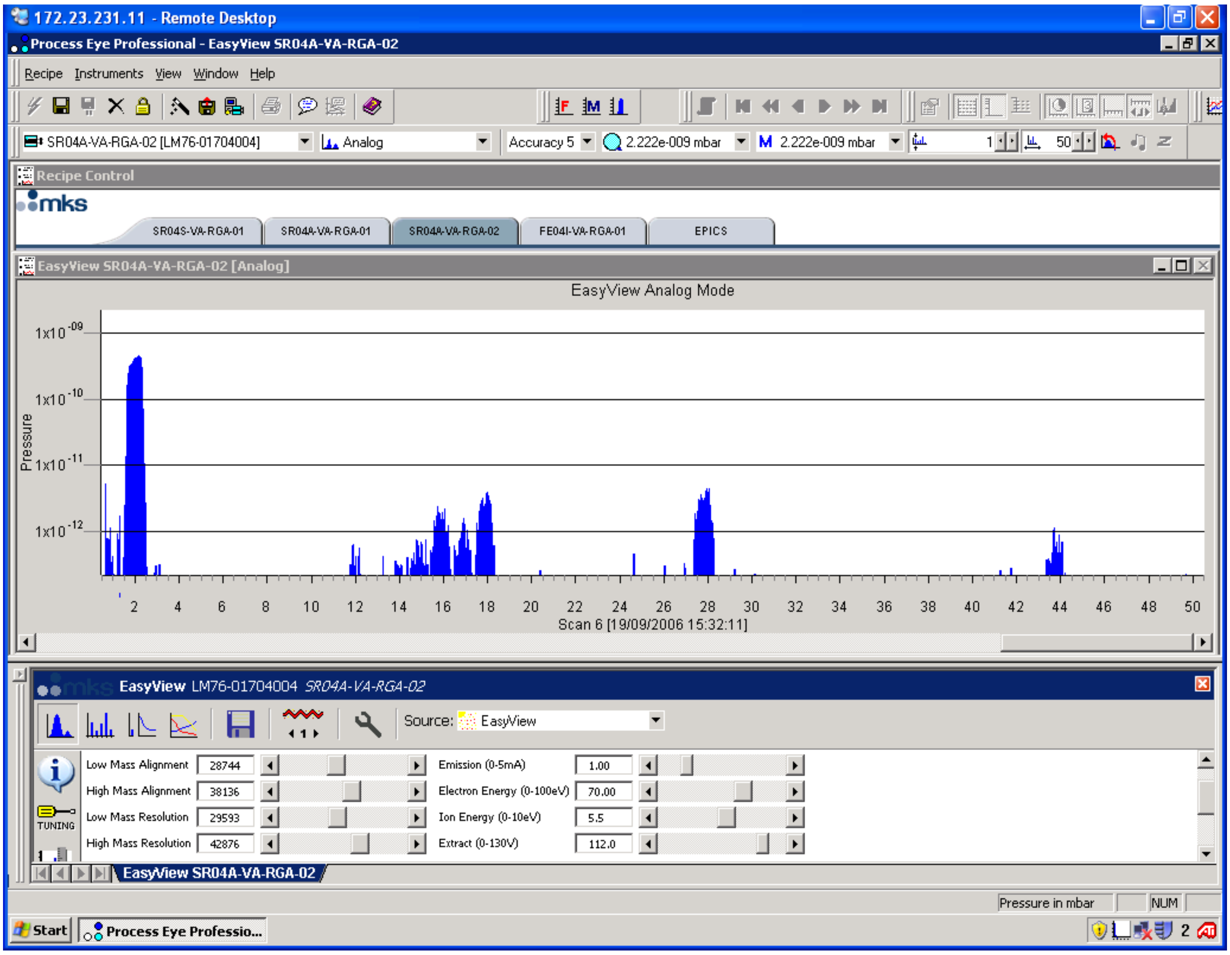
The control of the RGAs is shown in diagram form below.



6.4.1 Process Eye User interface

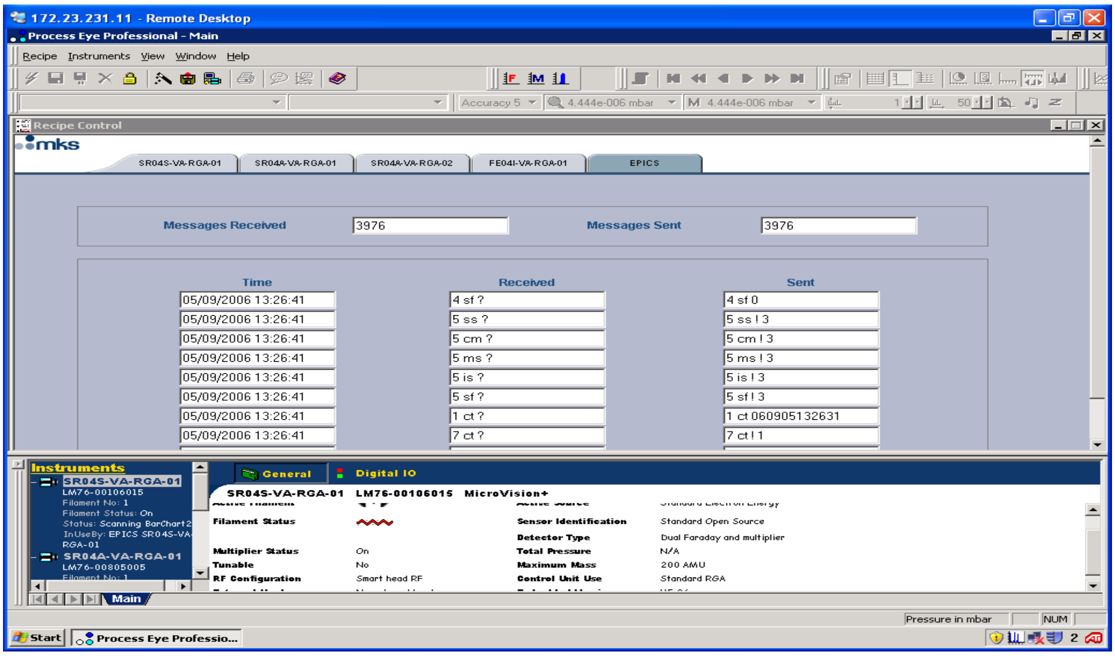
The picture below shows the Process Eye “Easy view” interface, via the remote desktop. Remote desktop may be opened for a RGA computer by using the IP address, or computer name as shown in the appendix. To take control of individual RGAs the EPICS control of the RGA must be set to Local.

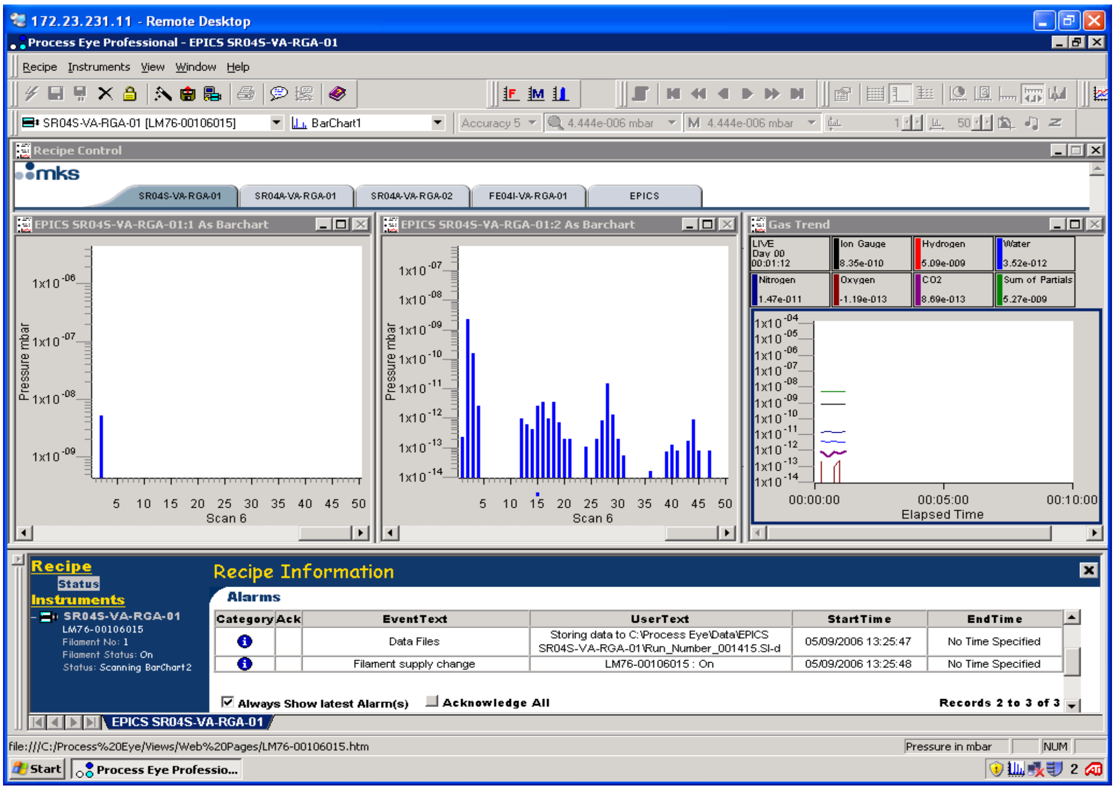
The password for connecting to the RGA computers is : **Supermicro2**



Picture of remote desktop of RGA computer

Pictures below show the serial interface page between the RGA computer and EPICS and display of RGA when under EPICS control



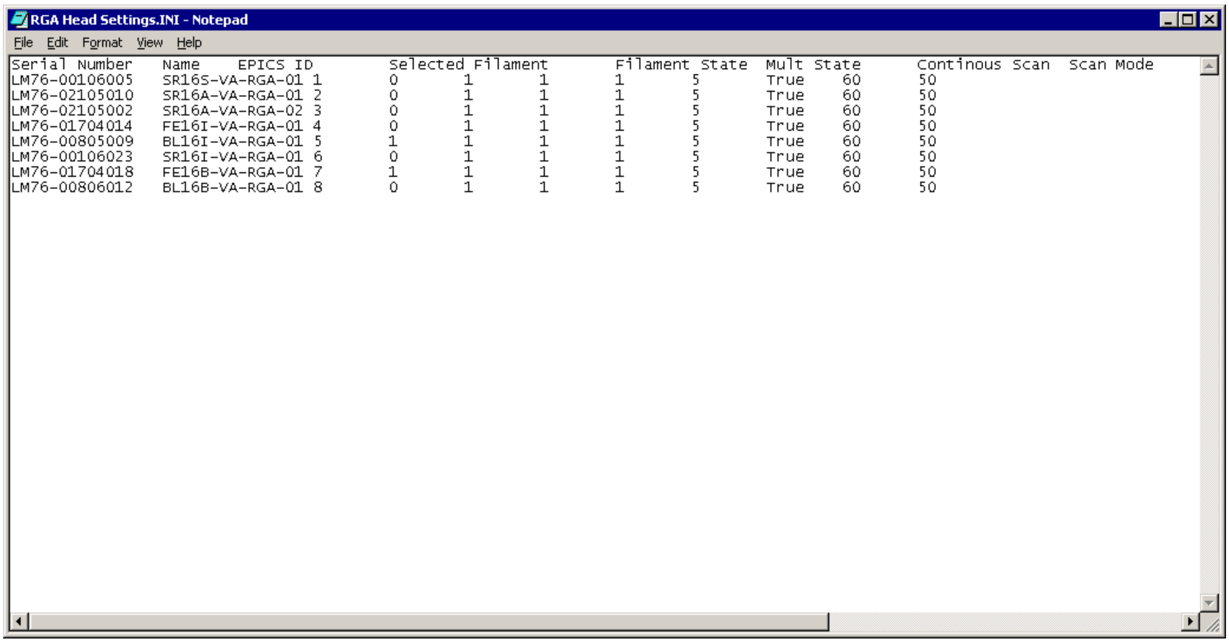


6.4.2 *EPICS ID for RGAs*

EPICS has ID's for particular RGA heads in the storage ring. These are shown in the table below. This table needs to be setup on the windows PC during the initial installation of the system. The relevant file can be found at C:\Processeye\Logs\RGAHeadSettings.INI

EPICS Name	EPICS ID
SRXXS-VA-RGA-01	1
SRXXA-VA-RGA-01	2
SRXXA-VA-RGA-02	3
FEXXI-VA-RGA-01	4
BLXXI-VA-RGA-01	5
SRXXI-VA-RGA-01	6
FEXXB-VA-RGA-01	7
BLXXB-VA-RGA-01	8

The INI file is shown below and can be edited in WordPad

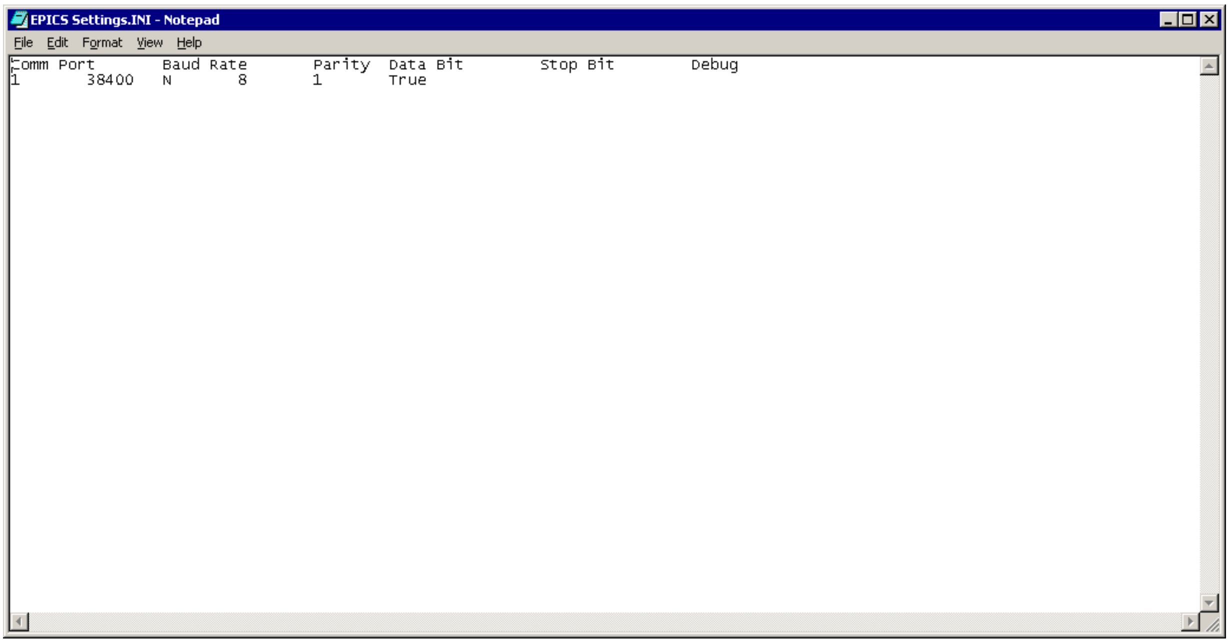

RGA Head Settings.INI - Notepad
File Edit Format View Help

```
Serial Number    Name     EPICS ID       Selected Filament        Filament State   Mult State      Continous Scan   Scan Mode
LM76-00106005    SR16S-VA-RGA-01 1       0        1        1        1        5        True    60      50
LM76-02105010    SR16A-VA-RGA-01 2       0        1        1        1        5        True    60      50
LM76-02105002    SR16A-VA-RGA-02 3       0        1        1        1        5        True    60      50
LM76-01704014    FE16I-VA-RGA-01 4       0        1        1        1        5        True    60      50
LM76-00805009    BL16I-VA-RGA-01 5       1        1        1        1        5        True    60      50
LM76-00106023    SR16I-VA-RGA-01 6       0        1        1        1        5        True    60      50
LM76-01704018    FE16B-VA-RGA-01 7       1        1        1        1        5        True    60      50
LM76-00806012    BL16B-VA-RGA-01 8       0        1        1        1        5        True    60      50
```

It is possible to set the EPICS scan mode by changing the scan mode state in this file and restarting process eye. It should be noted that you can only do this if process eye has already been halted as this file is re-written every time process eye is terminated. Scan mode 5 gives you a barchart 1-50 mode. Scan mode 1 sets the head into local control and you can then operate the head in "Easymode".

6.4.3 EPICS Settings

Epics settings are saved in C:\Processeye\Logs\EPICS Settings.INI. The Baud Rate is generally set to 38400, although other Baud Rates can be used if required.




```
Comm Port        Baud Rate        Parity  Data Bit         Stop Bit         Debug
1        38400   N        8        1       True
```

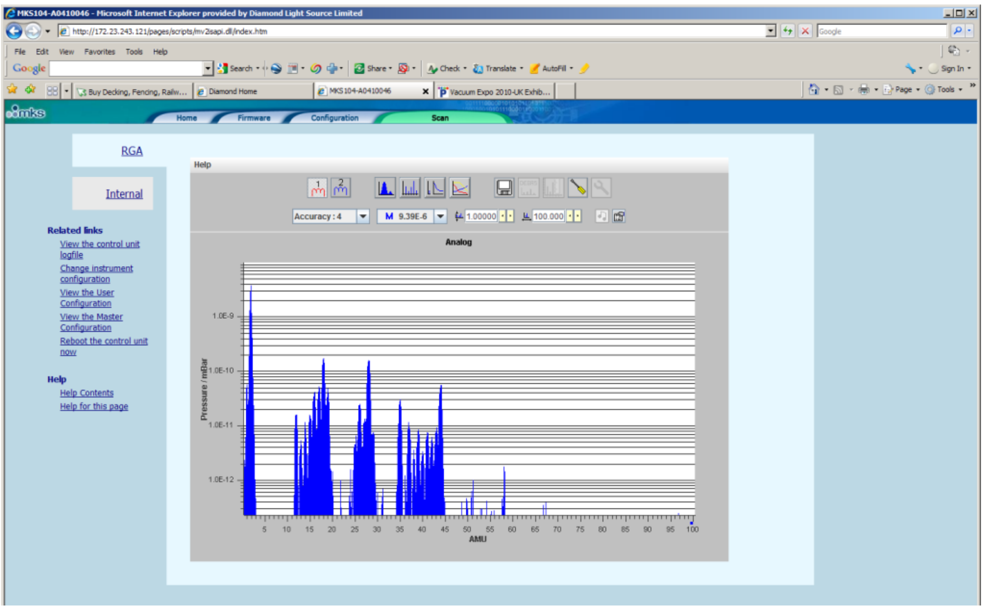
6.5 MV2 RGA units for Phase 3

The MV+ RGA controller has become obsolete and replaced with the Microvision 2 (MV2) RGA controllers also made by MKS. Diamond has moved to using the new MV2 controllers from phase 3 beamline onwards. This change does not affect new IDs and Frontends which will continue to use the MV + controllers. To that end 30 MV + units have been purchased to allow frontends and IDs to continue to use the MV+.

The major difference between the MV+ and MV2 is the change from serial communication to an Ethernet connection. An EPICS driver has been developed at Diamond to communicate with the MV2 via the Ethernet link. However the unit can also be controlled offline by connecting it directly to a PC via the Ethernet link.

6.5.1 Connecting directly to MV2 RGA from a PC

The MV2 hosts a webpage internally (as shown below) which can be accessed by typing the unit's serial number (eg "*http://MKS104-A1412025"*) or IP address (eg "*http://172.23.231.66*") into the address bar of a browser.
The serial numbers of MV2 units are normally found on a sticker affixed to the side of the unit. The IP addresses of RGA units currently installed on Diamond beamlines and configured on the Diamond network is listed in section 14.5 of this document.



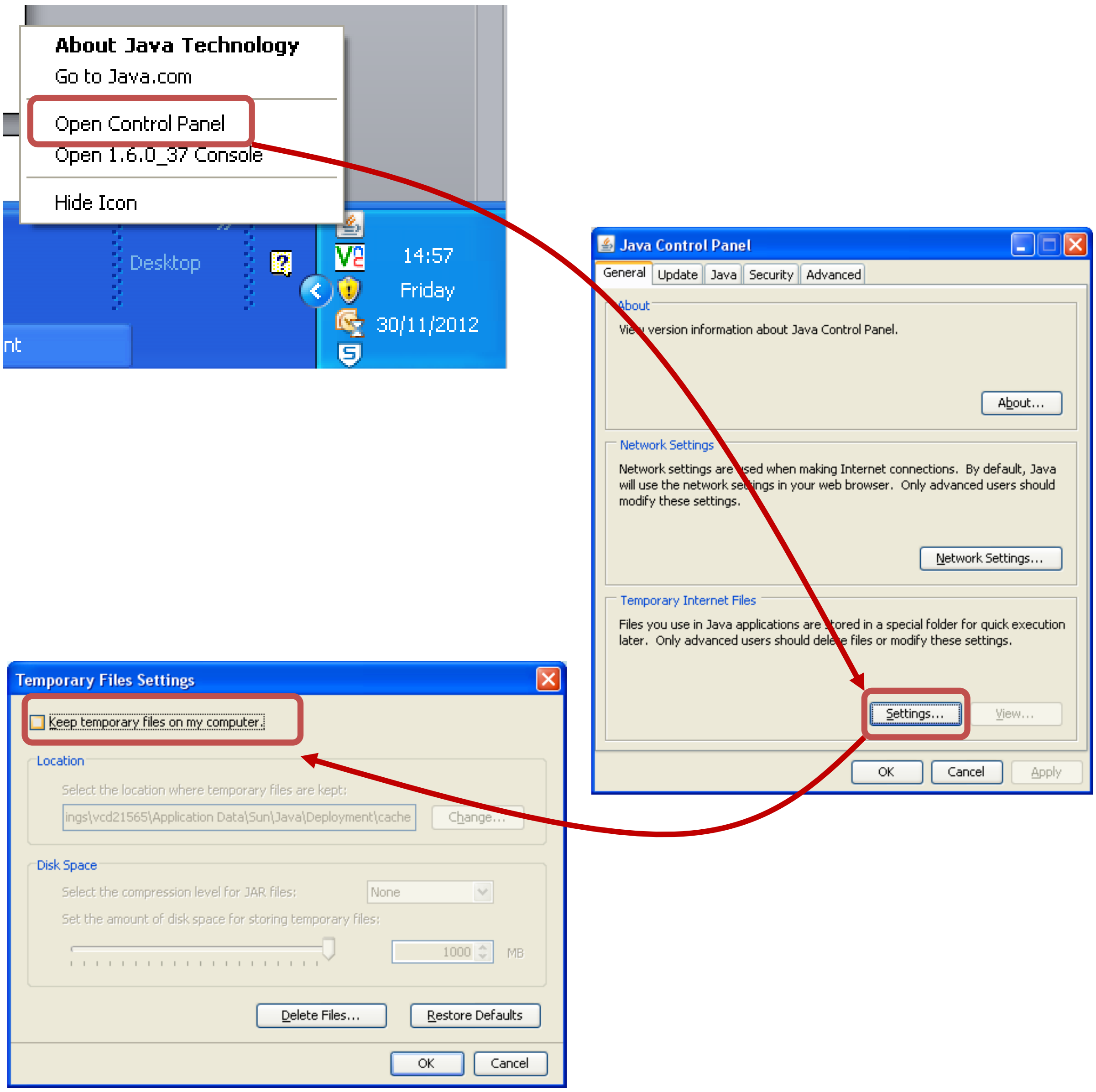
If you are unable to connect to a MV2 unit, it is likely due to a mismatch in the IP configuration of the unit and the host PC. The MKS default static IP address for the MV2 is in the range "*169.254.xxx.xxx*". By setting the host PC IP configuration to "static" and an address in the range "*169.254.xxx.xxx*" you should be able to connect with a MV2 unit assuming the unit is using the default MKS IP settings.

6.5.2 Steps on setting up MV2 based on above section

1. Connect laptop directly to the RGA controller
2. Right click on network icon and click on 2 open Network and Sharing Centre
3. Click on "Change adapter settings" can be seen on list on the left.
4. Right Click on Local area connection and click on "*Properties*"
5. Right Click on "*Internet Protocol Version 4 (TCP/IPv4)*"
6. Set to Obtain an IP address automatically and obtain a DNS server address automatically.
7. Should now be able to connect to RGA unit through internet explorer.

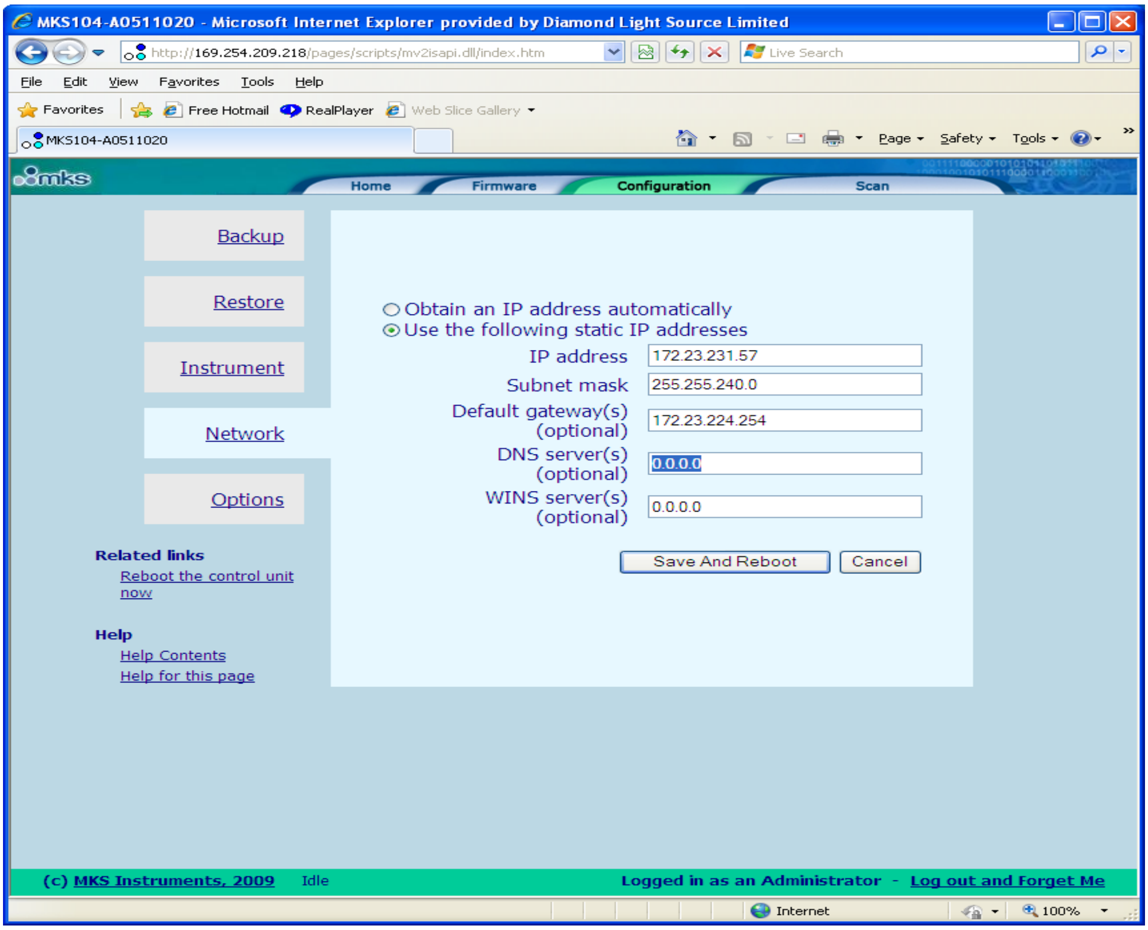
8. Once connected and logged in change the IP address to the one given and change Subnet mask to 255.255.240.0 & gateway to 172.23.224.254.
9. After this should be able to log in over the secondary network.
10. If there are problems connecting then you can choose a IP address on your laptop to be near what you suspect the RGA controller to have. By default the IP address on the controller is 169.254.?.? so use on the PC something like 169.254.100.100

Once connected, the password to log in is: “mksrga1”. Please note that only one user can be in control of the MV2 RGA unit at one time. If the unit is in use by another user, you can force the unit into “idle” state by reboot it then take control.
Once logged in, the user is able to control the instrument and take RGA scans.
The MV2 internal webpage runs a Java appelet which sometimes fails to load. To overcome this problem, you need to stop Java from keeping temporary files on your PC. This can be done by opening the Java control panel by right clicking on the Java icon is the status area of your windows machine as shown below.



6.5.3 Connecting MV2 RGA controller to Beamline or Secondary network

To setup an MV2 controller to be used remotely, for example on a beamline, it needs to be assigned a static IP address. To do so a new IP address needs to be obtained from the network administrator. For beamlines, this will be the relevant beamline controls Engineer. For the secondary network, this will be IT. The network administrator will require the Mac address of the unit, this can be found labelled on the unit itself. The network administrator will also require a name for the unit. By convention, if the unit is to be on a beamline, we use the PV for that RGA as the name. For example: "BL21B-VA-RGA-02". This name is then used by network administrator as the alias for the RGA controller.
The assigned IP address needs to be inputted into the unit by connecting to the unit directly and via the internal webpage as shown below. The Subnet mask and gateway can also be obtained from the network administrator.
Once the network details have been updated, the unit needs to be rebooted and connected to the relevant network port. From then on the internal webpage can be accessed by typing the unit's IP address or name into the address bar.

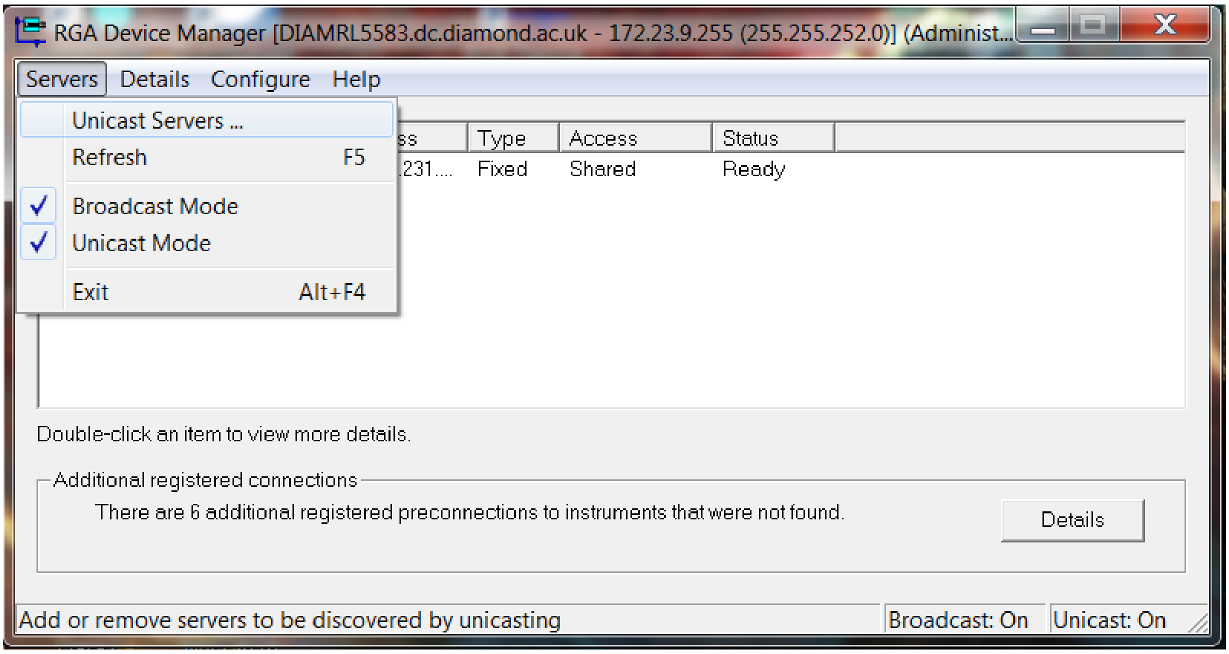


If an MV2 unit is in use by EPICS, to gain control via the webpage, the unit need to be put into local control in EPICS.

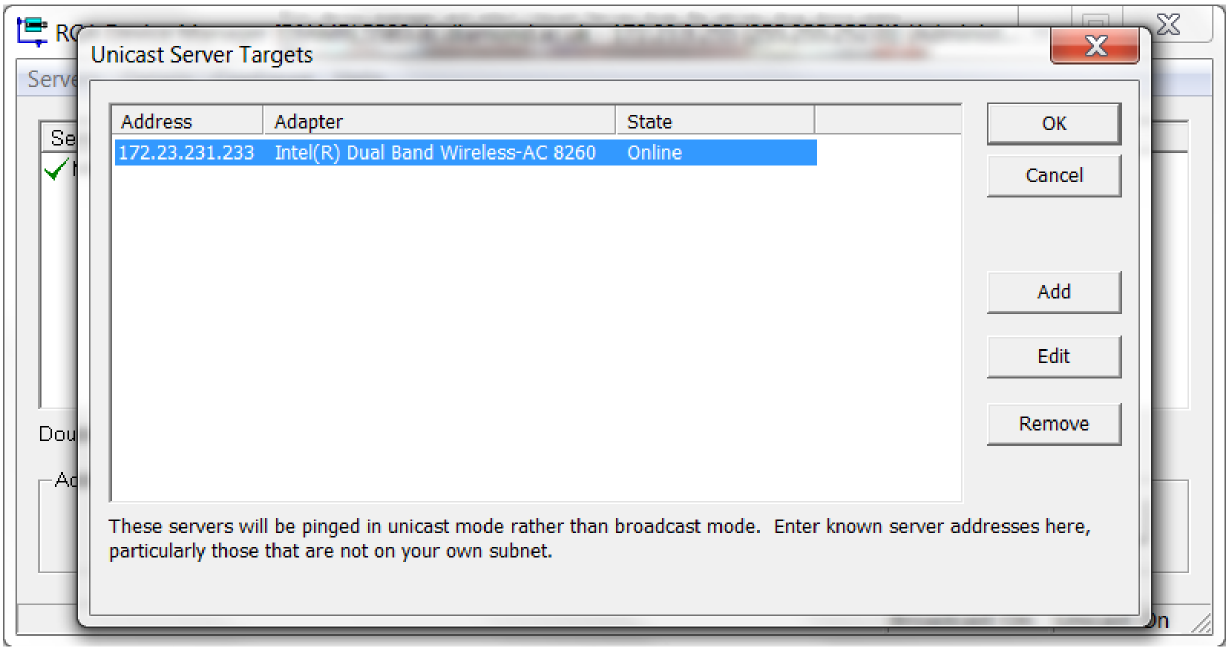
6.5.4 Replacements for broken MV+ units in the storage ring

Due to the dwindling supply of operational MV+ units, provisions have been put in place to allow these units to be replaced with MV2 units. With the exception of the 24V power supply and the serial connection, the wiring for the other ports on the MV2 control units are the same as for the MV+ so when replacing a MV+ for a MV2 these connections can simply be plugged in the equivalent ports. The 24V power supply connector can either be rewired to the configuration for the MV2 or a simple adapter can be used between the two types (a small supply of these adapters should be available in the vacuum laboratory). As for the network connection, in preparation for this reassignment, IP addresses have been pre-allocated for all of the RGAs in the storage ring which can be found here: S:\Technical\Vacuum\Vacuum_Data\RGA Upgrades\Copy of RGAsIPaddresses-with-IPs.xlsx. In the event that unit is not listed in the aforementioned spreadsheet, contact IT support to assign a secondary network IP address for this unit. The MV2 control unit will need to have this static IP address assigned to it before it is installed (see previous sections on how to do this). Once installed, the MV2 units will need to be connected to the secondary network via Ethernet cable. In the storage ring any even numbered network ports should connect to the secondary network and there should be two such ports per cell. In the event that more than two MV2 units are required in one cell, an Ethernet switch can be installed (hooked up to the secondary network) to provide additional access.

To communicate with the newly installed MV2 units, the RGA PCs will need to be configured to look for the assigned IP address of the new unit. To do this, open the RGA device manager and select Unicast Servers from the servers drop down menu:



From here a list of IP addresses that the RGAPC communicates with should be given as shown below. Simply add the IP of the newly installed RGA into the list and close the menu.



With this complete, the MV2 RGA should now appear in the device list and can be configured appropriately to have exclusive access from this PC. From here the "EPICS Head Settings" file in C:\Process Eye\Logs folder will need to be adjusted to match the new unit and then the new MV2 RGA should be able to operate on the RGAPC alongside the MV+ units. This is not an ideal solution and there are presently efforts to gradually replace the MV+ units with MV2 units so that all of the RGAs can be networked and remove the necessity for the RGAPCs, but this replacement method can serve as a stopgap until that can be realised.

7. VACUUM INTERLOCKS

Relay contacts are taken from the gauge controllers and used to control the operation of valves, ion pumps and other machine components. The logic for this is implemented in the PLC valve control crates. As discussed in the section 2 the 937a gauge controller has 5 separate relay contacts. These contacts are input directly into the valve control unit. The valve crate works on these inputs to provide outputs to drive the valves and to provide interlocks to the MPC ion pump controllers. A detailed description of the valve control crate is given in the next section. (When using the 937b on more recent beamlines and frontends the number of interlocks has increased to 12 per unit however the accelerator sections continue to use the 937a only.)

7.1 Valve logic

The logic to control the operation of valves can be described in a table format; the tables for the valves are given in the Appendix.

For the valves we use an “Initial vacuum” setting and a “Run Vacuum” setting. The initial vacuum setting is typically more stringent than the run vacuum setting. In some cases, such as in the booster ring, the initial and run vacuum conditions are identical.

The initial vacuum condition is used for opening the valves whilst the run vacuum condition is used for keeping the valves open. Typically all the interlocks required for the operation of a valve need to be made to open it, however to keep a valve open we may choose to have a less stringent condition where more than one interlock needs to fail before we lose the "maintain open" condition. Having these two states gives us the ability to reduce the number of spurious trips due to hardware failures or electrical noise. In most cases the run vacuum condition allows two interlocks to fail whilst still keeping the condition healthy. As a gauge controller runs 2 gauge sets, a controller on the storage ring and front ends can fail without tripping the valves closed.

7.2 Service & Operational mode

The valve control crate has a key switch to change the crate from "service mode" to "operational mode".

7.2.1 Operational Mode

The valve control crates will normally be in operational mode. In this state

1. The valves are controlled by a combination of IMG interlock logic.
2. The Pirani signals are not forwarded onto adjacent valve control crates, so that valves cannot be opened between sections where one valve control crate is in service mode and the other is in operational mode.
3. There is a separate Initial vacuum and Maintain Open vacuum condition.

7.2.2 Service Mode

Service mode is generally only used when maintenance is carried out on the machine. In service mode the following come into operation

1. The valves are interlocked to the Pirani gauges on either side of the valve.
2. The IMG interlocks to adjacent crates are lost so that a valve cannot be opened between operational area and service area as noted above.

7.3 Vacuum MPS

As discussed previously there is a spare interlock on the IMG in the A1 slot. In general this has been used as a MPS interlock and is set at 10^{-7} mbar. The MPS interlock is used for various purposes, for example in the storage ring it is normally linked to the beam dump function. In the storage ring the MPS interlocks are taken straight through the valve crate and into the MPS card. To allow for the fact that a gauge might fail the MPS interlocks are in general paralleled interlocks from a gauge and an associated ion pump.

7.4 Beamline Non Critical Vacuum MPS

To reduce the amount of shutdowns of the machine caused by a failing Beamline MPS signal a non-critical MPS signal has been created. This signal is sent back to frontend and is used to shut the last absorber in the front end, if the absorber does not shut within 10 seconds then the frontend MPS will be lost and the beam will be dumped.

The non-critical MPS on the vacuum system is more stringent than the conditions to close the vacuum valves and create a beam trip. Where there are 2 gauges in the first vacuum space of the beamline then we have generally set a condition that once the valve is open both “valve” gauge interlocks need to break to close the end frontend valve. In the non-critical MPS condition only one of the gauge interlocks has to break to loose the non-critical MPS and so close the absorber.

Where there is only one vacuum gauge in the first vacuum space, or the condition for opening the last frontend valve relies on more than just the initial beamline vacuum space then we can use the spare interlock on the A slot IMG, which is generally termed as the MPS interlock on the machine, this has been done on BL18 as shown in section 10, beamline non-critical MPS.

The table in the section 10 shows the vacuum part of the beamline non-critical MPS, other parts of the Beamline non-critical MPS include the water flows and temperatures.
In general:

All valve closures after a DCM will be non-critical and will not cause a beam trip. All valve closures before a DCM are critical as we do not want the valves to cross the white light the beam has to be dumped.

8. VALVE CONTROL CRATES

8.1 Valve crate overview

The diamond Valve Controller chassis has been designed to protect the vacuum integrity in the accelerators, front ends and beamlines. It does this by closing vacuum valves in the event of a vacuum incident thus isolating the affected area and warning neighbouring vacuum sections of the problem allowing preventative action to be taken as required.
Each SR, Booster, Front end or Beamline sector has either one or more valve controllers installed in the associated vacuum rack which monitor all associated parameters within the sector.
The valve controller consists of a 3 U chassis containing an OMRON CJ1 PLC system complete with all associated IO wiring. There are two main varieties; a four valve and a six valve unit. There is also a special unique crate designed for the LINAC. The crate provides interconnectivity with the standard valve interface, previous and next cell valve controllers, EPICS communications, MPCs interlocking, gauge controllers relay signals and generic IO via dedicated back panel mounted connectors.
Each valve control crate is programmed to provide protection relating to the condition of its various interlocks. This means that in beamline applications the code stored in the PLC is specific to the location

<u>4 valve Controller</u>

<u>6 Valve Controller</u>

8.2 Operation

The valve control crate operates independently of the VME based IOC and is unaffected by reboots or network problems. The unit interfaces to the IOC via an RS-232 connection. Data is transferred to and from the IOC in blocks. Information indicating interlock and valve status, operational modes and numbers of valve operations can all be obtained. Requests can be made by EPICS to open or close a valve. The valve controller will only service these if the interlocks associated with the valve in question are 'healthy'. Requests are sent to the valve controller in the form of a set value in a memory location. The value is tested by the PLC and serviced if interlocks allow. The request is immediately overwritten to an idle command to ensure that there are no queued commands. This happens regardless of whether the request was serviced or not.

All interlocks are latching and so must be reset before a request to open a valve is sent. The EPICS display shows the current, latched and initial status of each interlock bit. Unless the current status is bright green it is not useful to issue a reset as the interlock is not available.

The initial yellow Interlock bit will trap and hold the initial cause or first interlock to fail. The red latched status bits will hold this along with any subsequent failures until a reset request is made.

The interlocks are made up of confirmation of safe vacuum levels either side of a valve or in neighbouring sectors (derived from the various gauge relay set points) and status of other valves, absorbers and shutters if there is a dependency.

It is impossible to open a valve if the interlocks are not in a healthy condition. The operator cannot inadvertently do any damage unless someone has overridden the gauge controller set points. Even if a valve control crate is in service mode and operating on a reduced set of interlock conditions there is still protection from inadvertent opening of valves between the sector in service mode and neighbours in normal operational mode.

8.3 Non-valve-related IO.

The valve controller also provides enable signals out to ‘Multiple Pump controllers’. These are dependent on either of the IMGs and Pirani gauges situated within the vacuum space occupied by the MPCs Ion pump.

The 6-Valve Controller can also be configured to interface to a multitude of other equipment via generic IO and can be programmed to provide control as required. In front end and some beamline applications it provides the enabling signals to the VAT Fast Valve Control Crate and becomes the interface between EPICS and the VAT crate. Requests to open and arm the fast valve are sent to the valve controller and forwarded as direct IO to the VAT crate.

The valve controller can also read the status of flow switches and trip amps and combine these signals into any Machine Protection Permit that it generates.

If other equipment in and around the vacuum area requires enable signals or interlocking to signals either already read by the valve controller or compatible with the IO these can also be generated as required.

8.4 Previous and next cell connections.

Every valve controller has the ability and connectivity to send and receive vacuum status signals to neighbouring crates. For example the four valve crates in the storage ring connect to neighbouring sectors via the previous and next connectors. Six valve control crates used for front-end valve control send signals to the beamlines via the next cell connector and also to the storage ring via the previous cell connector. This previous cell connection from the front end to the storage ring sector crate is fed into the four valve control crate via one of the two aux sockets reserved for front end communications.

When designing beamline vacuum systems that require multiple valve controllers it is essential to put the gauge signals into the correct control crate to allow valves to be interlocked. This is especially important when the valve is controlled by one crate but requires forwarded interlocks from another crate. This is because the six valve controller passes five interlocks to the previous crate but only receives one back. So it is better to put the two gauges on the right hand side of the valve in the next control crate and allow this controller to retransmit these signals to the previous crate because the next valve along in the vessel will also require both IMG and Pirani signals in its interlock chain (see drawing 1072118 BL15I).

The signal list and implementations is as follows:

8.4.1 Storage Ring

Previous connector	Signal
Previous In1:	Run Vacuum from SRn-1 (contact made when condition healthy).
Previous In2:	Initial Vacuum from SRn-1 (contact made when condition healthy).
Previous In3:	Valve 4 closed from SRn-1 (contact made when valve 4 closed).
Previous Out1:	IMG-01 & Operation mode to SRn-1 (contact made when condition healthy).
Previous Out2:	PIRG-01 & Service mode to SRn-1 (contact made when condition healthy).
Previous Out3:	Run Vacuum to SRn-1 (contact made when condition healthy).
Previous Out4:	Initial Vacuum to SRn-1 (contact made when condition healthy).

Next connector	Signal
Next In1:	IMG-01 & Operation mode from SRn+1 (contact made when condition healthy).
Next In2:	PIRG-01 & Service mode from SRn+1 (contact made when condition healthy).
Next In3:	Run Vacuum from SRn+1 (contact made when condition healthy).
Next In4:	Initial Vacuum from SRn+1 (contact made when condition healthy).
Next Out1:	Run Vacuum to SRn+1 (contact made when condition healthy).
Next Out2:	Initial Vacuum to SRn+1 (contact made when condition healthy).
Next Out3:	Valve 4 closed from SRn+1 (contact made when valve 4 closed).

8.4.2 Front End – Storage Ring

Previous connector	Signal
Previous Out1:	FE healthy Run Vacuum (5 out of 6 gauge signals healthy, contact made when condition healthy).
Previous Out2:	FE healthy Initial (6 out of 6 gauge signals healthy, contact made when condition healthy).

Previous Out3:	FE healthy IMG & Operation mode
Previous Out4:	FE healthy PIRG & Service mode
Previous Out5:	Not used.
Previous In1:	Storage ring – FE valve open (Storage ring Valve 2 on ID FE's and Valve 3 on bending magnet FE's).

Next connector	Signal
Next In1:	IMG-01 from FE to be used with FE-IMG-06 for FE-VALVE-02
Next In2:	Non Critical MPS from Beamline (to be used in ABSB interlock chain, made when healthy).
Next In3:	Run vac from Beamline (used for FE-VALVE-02, made when healthy)
Next In4:	Initial vac from Beamline (needed to open FE-VALVE-02, contact made when condition healthy).
Next In5:	Critical MPS from Beamline (to be used in both FE MPS & ABSB interlock chain, made when healthy). This will trip the machine if lost whilst FE is open.

Next Out1:	One or both FE Absorbers closed (contacts made when either or both absorbers are closed).

8.4.3 Beam Line to Front End

Previous connector	Signal
Previous Out1:	IMG-01 and Operation Mode (contact made when condition healthy).
Previous Out2:	Non Critical MPS (used to trip absorber. Contact made when condition healthy).
Previous Out3:	Run Vacuum (contact made when condition healthy).
Previous Out4:	Initial Vacuum (contact made when condition healthy).
Previous Out5:	Critical MPS (used to trip Machine when lost. Contact made when condition healthy)
Previous In1:	One or both FE Absorber closed (contact made when either closed, used to stop valves from transiting the beam).

Next connector	Signal
Next In1:	Usually next IMG along beamline.
Next In2:	Usually next PIRG along beamline.
Next In3:	User defined
Next In4:	User defined
Next In5:	User defined
Next Out1:	FE Absorber or beamline shutter status to be used to stop valves from transiting the beam.

8.4.4 Beam Line to Beamline

Previous connector	Signal
Previous Out1:	IMG-** and Operation Mode (contact made when condition healthy).
Previous Out2:	PIRG-**
Previous Out3:	User defined
Previous Out4:	User defined

Previous Out5:	User defined
Previous In1:	User defined

Next connector	Signal
Next In1:	User defined
Next In2:	User defined
Next In3:	User defined
Next In4:	User defined
Next In5:	User defined
Next Out1:	User defined

8.5 Aux sockets to front ends from storage ring

The storage ring 4-valve controllers have 2 aux sockets are all linked to front ends in their section. Aux1 is in general for insertion device front end whilst Aux2 is for the bending magnet front end. In turn these crates connect to the beamline controllers giving the crates the ability to take preventative action in the event of a vacuum incident.

The signal list and implementations is as follows:

Aux socket 1	Signal
Aux1 In1:	FEI Run Vacuum (Contact made when condition healthy).
Aux1 In2:	FEI Initial Vacuum (Contact made when condition healthy).
Aux1 In3:	FEI-IMG-01 & Operation mode (Contact made when condition healthy).
Aux1 In4:	FEI-PIRG-01 & Service mode (Contact made when condition healthy).
Aux1 Out1:	SR VALVE-02 Open (Contact made when condition healthy).

Aux socket 2	Signal
Aux2 In1:	FEB Run Vacuum (Contact made when condition healthy).
Aux2 In2:	FEB Initial Vacuum (Contact made when condition healthy).
Aux2 In3:	FEB-IMG-01 & Operation mode (Contact made when condition healthy).

Aux2 In4:	FEB-PIRG-01 & Service mode (Contact made when condition healthy).
Aux2 Out1:	SR VALVE-03 Open (Contact made when condition healthy).

Every valve controller has the ability and connectivity to send and receive vacuum status signals to neighbouring crates. For example the four valve crates in the storage ring connect to neighbouring sectors via the previous and next connectors. Six valve control crates used for front-end valve control send signals to the beamlines via the next cell connector and also to the storage ring via the previous cell connector. This previous cell connection from the front end to the storage ring sector crate is fed into the four valve control crate via one of the two aux sockets reserved for front end communications.
When designing beamline vacuum systems that require multiple valve controllers it is essential to put the gauge signals into the correct control crate to allow valves to be interlocked. This is especially important when the valve is controlled by one crate but requires forwarded interlocks from another crate. This is because the six valve controller passes five interlocks to the previous crate but only receives one back. So it is better to put the two gauges on the right hand side of the valve in the next control crate and allow this controller to retransmit these signals to the previous crate because the next valve along in the vessel will also require both IMG and Pirani signals in its interlock chain (see drawing 1072118 BL15I).

8.6 Valve status local display

The front panel of each valve controller has a number of LEDs used to represent the status of each valve. The normal first powered up display (provided that vacuum valves are connected) should indicate that the valve is in the closed position (green closed LED illuminated). If the valves associated fault light is flashing at 0.2 Hz then there is an air pressure fault. If the LED is flashing at 1Hz then an opening valve has failed to complete its move due to a loss of one or more of its interlocks or a valve has been forced to shut due to the loss of an interlock required to maintain it in the open position. If the solenoid yellow lamp is illuminated and the open LED is flashing then this denotes a valve moving from a closed limit towards and open. The LED will stop flashing and illuminate permanently as soon as the limit is reached.

8.7 PLC Coding

The PLC code is based around a standard architecture. All valve controllers have a number of common drivers. Each has an area in memory for general housekeeping. This area holds the unique CPU number required for inventory. There is also a register, which contains a number relating to which location the unit is installed in and another that lists the version of code running. There is also an hours and days run block logging information for mean time between failure predictions.

There is then a section for signal conditioning. This allows filtering to be performed on air pressure and water flow inputs. This allows momentary drop outs due to instantaneous pressure drops to be ignored.

Next there are EPICS drivers for each pneumatic device. These are identical for all devices and provide the common open, close, reset, number of operations, operation mode, interlock status signals to be processed. There are then a set of interlock words for each device driver. These are un-populated in the un-programmed state except for several standard interlocks such as air pressure, valve movement timeout and unexpected loss of limits. This is the area that the PLC engineer fills in with the interlock requirements as agreed with the vacuum engineer.

The next set of drivers actually handle the normal opening and closing commands and generate the drive signal for the front panel indication.

Lastly there is a section for generating interlocks to be forwarded to other systems as required.

8.8 Remote IO Valve Control Crate

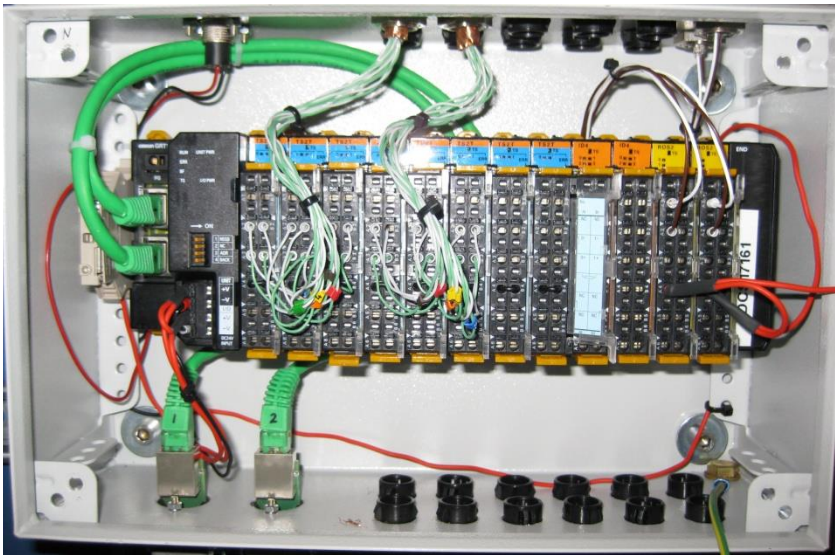
8.8.1 Additional features

The new Remote IO PLC supports both Ethernet Communications and Remote IO. EPICS can talk to the unit using UDP (User Datagram Protocol) via TCP rather than the old method of FINS commands over RS232. This is very much faster allowing a much greater amount of data to be transferred continuously. The valve control crate sits on a private network behind the IOC which also acts as a port forwarding device allowing remote programming of the PLC to take place.

UDP uses a simple transmission model without implicit handshaking dialogues for providing reliability, ordering, or data integrity. Thus, UDP provides an unreliable service and Datagrams may arrive out of order, appear duplicated, or go missing without notice. UDP assumes that error checking and correction is either not necessary or performed in the application, avoiding the overhead of such processing at the network interface level. Time-sensitive applications often use UDP because dropping packets is preferable to waiting for delayed packets, which may not be an option in a real-time system.

The valve control crate also contains a Profinet Master IO unit which allows a secondary totally hidden private network of remote IO to be connected to each valve control crate. The remote modules have been built up into thermal and generic inputs and outputs junction boxes which can be selected depending upon the application.

8.8.2 Remote IO Junction Box



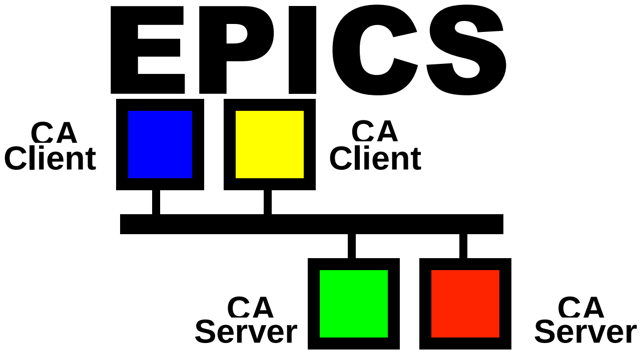
The Remote IO boxes connect back to the Valve controller over Cat5 Ethernet patch leads and so can be expanded to suit a changing application quickly and simply.

8.8.3 Remote IO Inputs and Outputs

Temperatures, flowmeter interlocking switches, anti-collision limits for Motion stages and RGA enables can now all be wired to locally mounted Remote IO junction boxes. The associated inputs signals appear within the PLC in high address registers. Data is validated as being current via a system of watch dog signals and then mapped down into usable memory addresses within the PLC allowing the information to be used directly in the PLC software. This allows critical temperature monitoring to be added and interlocked to the relevant device as required.

9. EPICS

The **E**xperimental **P**hysics **I**ndustrial **C**ontrol **S**ystem (EPICS) is the control system being used at Diamond. This is a fully distributed system not running on any central device but using the **Channel Access (CA)** architecture to allow easy communication between **Clients** and **Servers** over a control network. It is a flat architecture of controllers and operator workstations that communicate via TCP/IP and UDP protocols.



EPICS logo showing clients and servers each side of a control network.

At the field end, vacuum EPICS CA servers are **Input Output Controllers** (IOC) that interface directly with vacuum device controllers. Operators Interfaces, which run on Linux and Windows platforms, are clients accessing **Process Variables** (PVs) provided over the network by the EPICS CA servers.

9.1 EPICS GUI in use

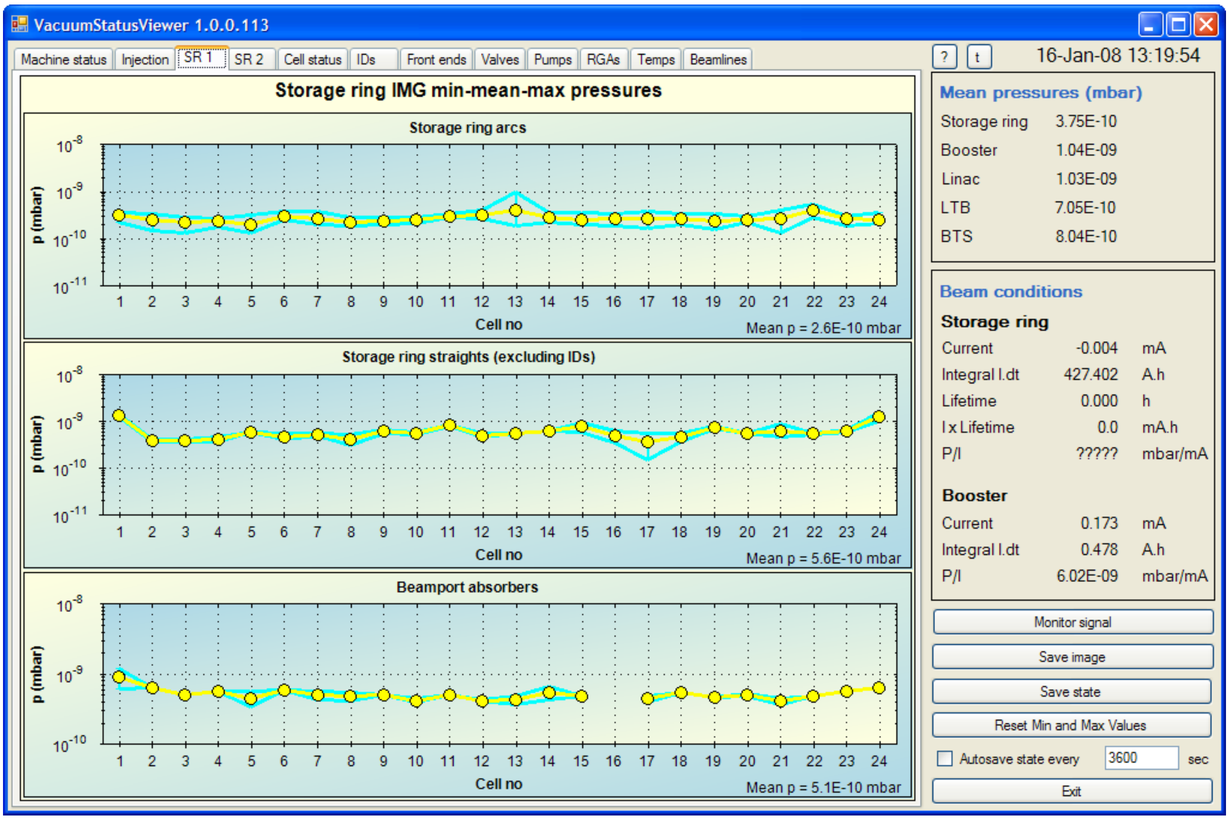
Several GUI (Graphical User Interface) type have been developed for EPICS. They provide interactive friendly displays on computer screens to control and monitor machine equipment. The main EPICS GUI in use at Diamond is called EDM, standing for Extendible Display Manager. Files are saved with the .edl extension and an architecture using macros allows one to set easily the same display widget for a given device type all around the machine. Each widget and icon will be detailed later.

EDM will become unsupported/obsolete so there is a move away CSS platform. Beamlines I14 and I21 currently run on this platform and a team of controls engineers having been producing replicas of the machine EDMs in CSS which will be rolled out in the coming years.

Other displays such as MEDM, Java and python interfaces, as well as Matlab GUI have also been developed at Diamond. Dedicated windows software such as the VacuumStatusViewer, displayed at the end of this section, have also been written in Visual Basic to provide remote vacuum monitoring from a Windows desktop computer on the office network through the EPICS gateway.

To finish, other GUI part of the EPICS package are in use (Striptool, Alarm Handler, Channel Archiver, etc…). They are described briefly below.

Main applications are available from the launcher, accessible by entering 'launcher' in a Linux terminal window, they are then found under Utilities.



Vacuum Status Viewer written in Visual Basic.

9.1.1 EDM / MEDM

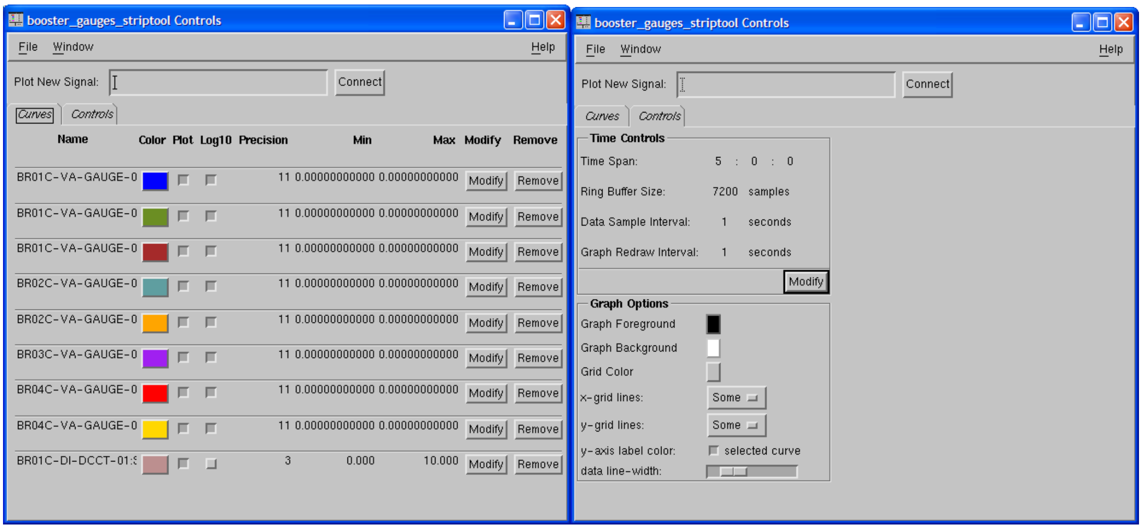
EDM, standing for Extendible Display Manager, is the real time graphical interface mainly used at Diamond. EDM is a very flexible display that allows simple control and read back of the Process Variables in use on the Channel Access network. Macros are used to generate similar displays for the same instrument all around the machine.

9.1.2 Striptool

Striptool is the basic trending tool for the EPICS package. It allows one to record and trend up to 10 PVs, with different scales for each, against time. It is fully scalable and the buffer size as

well as the sampling rate can be defined in the "controls" panel (note it cannot be faster that the initial sampling at the IOC level!).
Striptool is available from the launcher => utilities => striptool, or by directly clicking on “Graph” on some vacuum EDM.

<u>For trending pressures, use logarithmic scales.</u>



Striptool – property panel – Curves and Controls options.

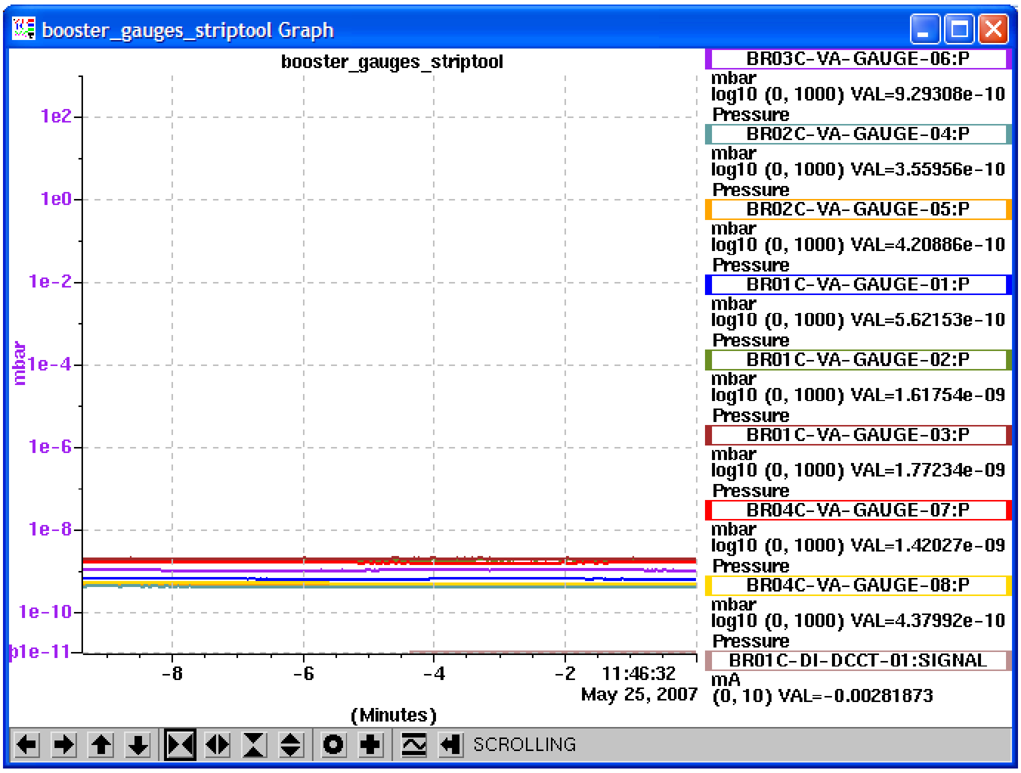


Fig. Striptool screen

9.1.3 Channel archive Viewer

The archive viewer may be used to look at data which is 20 minutes old or older. The viewer is accessible from any office computer as long as the correct applications have been loaded. The channel archive viewer at Diamond is a JAVA based application available from the launcher: Utilities => Channel archiver viewer - R3.14.7. It can also be found on the S:// drive under S:\Technical\Controls\Tools\archiver\archiveviewer.jar but will need the Java platform installed on your computer to be able to run.

There are two archivers running namely a primary one and a standby one. They need to be connected to the following addresses to be accessed form the Java viewer:
Standby: http://archiver.pri.diamond.ac.uk/archive/cgi/ArchiveDataServer.cgi
Primary: http://archiver.cs.diamond.ac.uk/archive/cgi/ArchiveDataServer.cgi

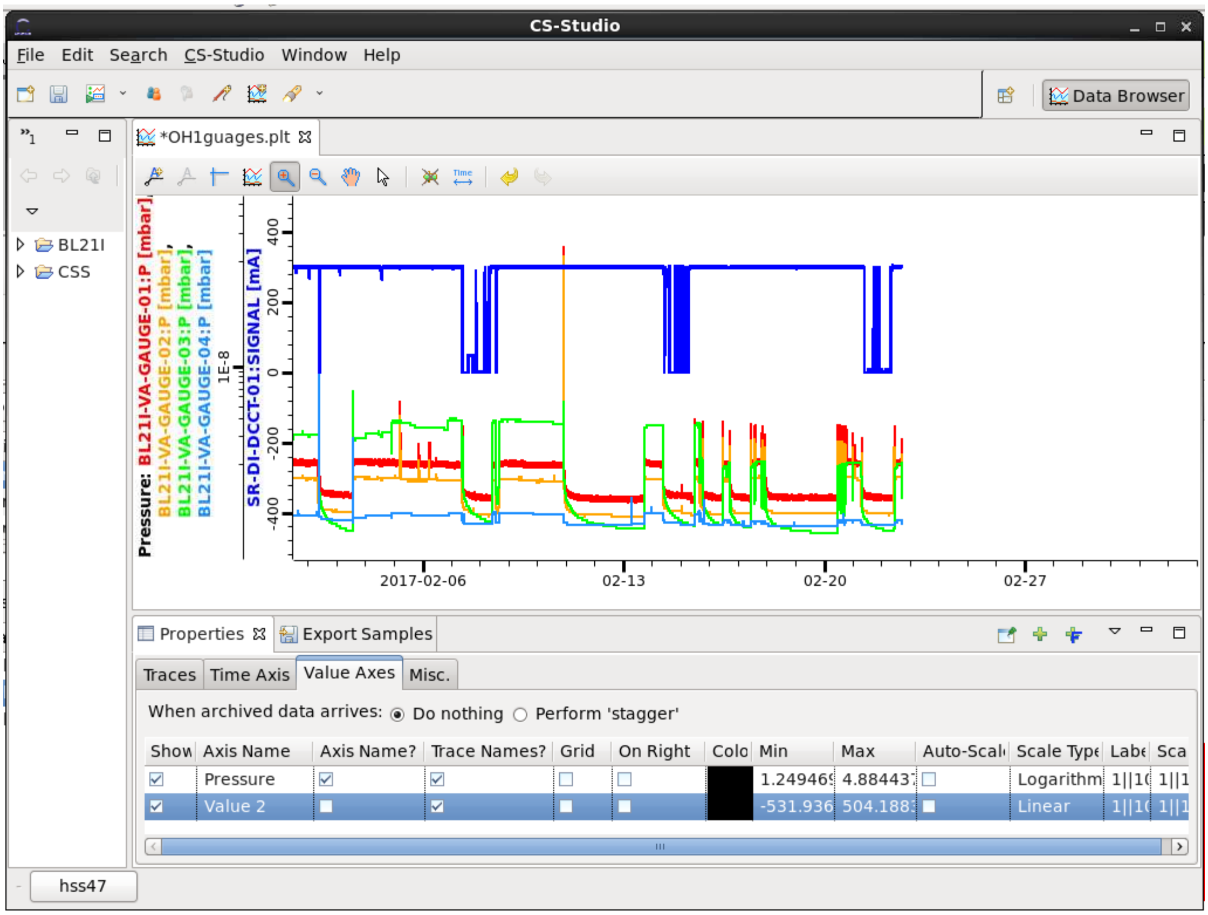
After connection to the archiver, simply select the Archiver Directory (e.g. VA for vacuum, FE for Front end… etc…), type in the PV to retrieve and the search date, then plot. Please always use LOG scale for pressure PVs. Display or archived waveforms is also possible.

For more information, please refer to the archive viewer manual (S:\Technical\Controls\Tools\archiver\manual.pdf)

Example of. Java archive viewer screen.

9.1.4 CSS plots

In addition to using the archive viewer there is a CSS tool in the launcher under UTILITIES/(C)ontrol (S)ystem (S)tudio which gives a strip tool style device which also will display the archiver data. This in many ways is easier to use than the archive viewer so is worth experimenting with. A snap shoot of the combined strip tool/archiver is given next.



Example of. CSS plotter.

9.1.5 Probe tool

The probe tool allows to monitor or/and control a single PV value. It also provides extra information on the PV including listing possible values (if any list available) and showing alarm status as well.

Probe screen

9.1.6 Alarm handler

Allows setting up of soft alarms on PV status/values. If the PV value exceeds a threshold value, an alarm is activated (The alarm handler will sound and an e-mail can be automatically sent to defined e-mail addresses etc).

9.2 Control room computers

Control room computers are standard PC Linux stations, dual homed on both primary and office network. They run a special Diamond release of the Redhat Linux.

Vacuum Operator Interfaces (OPI) are mainly EDM based GUIs that easily allow control and monitoring of vacuum instrumentation. Python and Matlab scripts are also in use as mentioned earlier. These computers are running several open source software packages, as well as a number of computer specific Matlab licences.

As the computer are dual homed, they have direct access to the primary network for channel access and control of the machine via EPICS. Furthermore, they are connected to the office network: U:/drive and S:/drive can thus be mounted on for direct access to personal or shared files:

- Mount the U:/drive:
  - Create a sub-directory named ‘U’ in your home directory
  - type in ‘mountwindows’ in a terminal windows
  - Use your Windows password

- Mount the S:/drive:
  - Create a sub-directory named ‘S’ in your home directory
  - type in ‘mountwindowsS’ in a terminal windows
  - Use you Windows password

9.2.1 Terminal window and Linux basics

Once logged onto one of the Linux control computers in the control room you need to start the “Launcher” (as mentioned earlier in this chapter) in order to get access to the desired EPICS

EDMs. To start a terminal window, simply right click on the desktop wallpaper, and choose 'Open Terminal'. In the new window that opens, type in "launcher" or "launcher&" to start the application.

Below is a list useful LINUX commands which may be used in the terminal window.

- Change directories (cd)
- Where am I ? (pwd)
- Viewing and manipulating the shell command history list (history)
- List files within the current directory (ls)
- Edit text file (nedit)
- Copy file (cp)
- Delete file (rm)
- Create a directory (mkdir), remove an empty directory (rmdir)
- Move or Remame file (mv)
- Fine a file (find, locate et which)
- Find text in file (grep)
- Remote connection to window pc (rdesktop)
- Secure shell connection (ssh)
- Terminal server connection (telnet)

Within a terminal window, previous commands input can be viewed by using the arrow keys. If you wish to repeat a command use the arrow keys to return to it. Once the command has been selected use the <enter> key to start it.

Using the '&' at the end of a command line allows one to run the command in the background, thus leaving the terminal window active for launching other applications. To exit a running application (will close it), use Ctrl + C.

Information on commands can be obtained using the 'help' function or 'man –k'. (This link provides basic information on Linux) (http://www.er.uqam.ca/nobel/r10735/unixcomm.html)

9.2.2 Remote desk top Windows computers

It is possible to remote desktop to a Windows computer from a Linux machine at Diamond using the rdesktop command in a terminal window:

To a personal computer knowing the computer name:

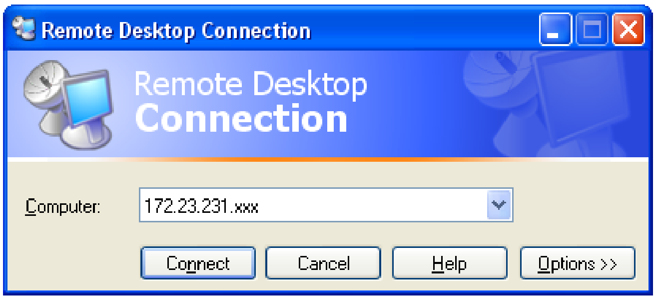
- rdesktop -u *username* -k en-gb -g 1280x1024 -K computername.diamond.ac.uk &

To a RGA computer knowing its IP address:

- rdesktop -u *rgauser2* -k en-gb –K –a 16 -g 1280x1024 172.23.231.xxx &
- IP table available in appendix. (shortcuts also available from RGA overview edm)

- Login as to be local to the RGApc machine using:
  - Username: rgauser2
  - Password: Supermicro2

From a windows machine use the remote desktop connection that can be found in:
Start → Programs → Accessories → Communications → Remote Desktop Connection



9.2.3 Secure Shell

Due to the network/gateway architecture, it is sometime useful to Secure Shell (ssh) to a machine hosted on a different network in order to have control access over EPICS or connect to some instrumentation.

The Shh command allows one to connect onto another linux machine on the network. Under Window, ssh server/client software such as Exceed can be used. From a linux machine, the syntax for the ssh command to be entered in a terminal window is:

ssh –l username computername.diamond.ac.uk

Connection to computers hosted on the secondary network and development network are normally available from the office network. During shutdown, a special server homed on both secondary and primary network is available to allow easy shutdown work. To connect to this sever from a linux or windows machine running exceed, the login syntax is:

ssh ops-username@login.pri

Vacuum Lab Linux machine is pc0002.cs.diamond.ac.uk. It can be connected to if needed from Office network and beamlines but has limited performances. The following machine should be preferred: pc0011.cs.diamond.ac.uk.

9.2.4 Linux accounts

There have been various Linux accounts namely a development account, an ops account and a standard Linux account. New users will only have a standard linux account which has the same

ID and password as their windows account. With a Linux account you can only connect into linux.diamond.ac.uk. with your standard password.

To connect directly to the operations PCs you require an ops account. To connect to the pc0011 you need a development account which is currently being phased out.

9.2.5 Short cuts in home directory: Bashrc file

It can be useful to create some short cuts in your profile file in your Linux home directory. After which it is possible just to type shortcut name at the command prompt. Below is an example of creating a short cut to an office PC

Log on to your home directory then use an editor to edit the bashrc file for example:

Gedit .bashrc

Type in your short cut

Alias windows = ‘Rdesktop –u username –k en-gb –K –a 16 –g 1280x1024 –K computername.diamond.ac.uk’

Save and close the file. Then to apply the changes type

Source .bashrc.

After this you can just type Windows at a command prompt when you are logged in and you will be directed to your computer. If you are using a computer that somebody else is logged into then you may open a terminal and login as a supper user with the command

SU user name

From which point you will be able to use your alias/shortcuts that you have created.

9.2.6 Connecting to Diamond from home

It is possible to remotely connect to diamond computer systems from home. This is often useful when “on-call” to support machine or beamline operation. There are several ways to do this depending on the Diamond system you want to connect to.

To access your outlook email, use: *https://webmail.diamond.ac.uk*

To connect to the Office Network, setup a new VPN network connection using the hostname:

pptp.diamond.ac.uk

The login details are the same as your diamond windows login. Once logged in, you will then be able to remote desktop to your office windows machine, map to the S: & U: network drives and access the diamond intranet site.

To connect to a Office or Beamline linux machine, follow the link below to an article on the controls wiki.

http://www.cs.diamond.ac.uk/cgi-bin/wiki.cgi/How_to_remotely_control_an_office_or_beamline_Linux_machine_(VNC)

IOC's

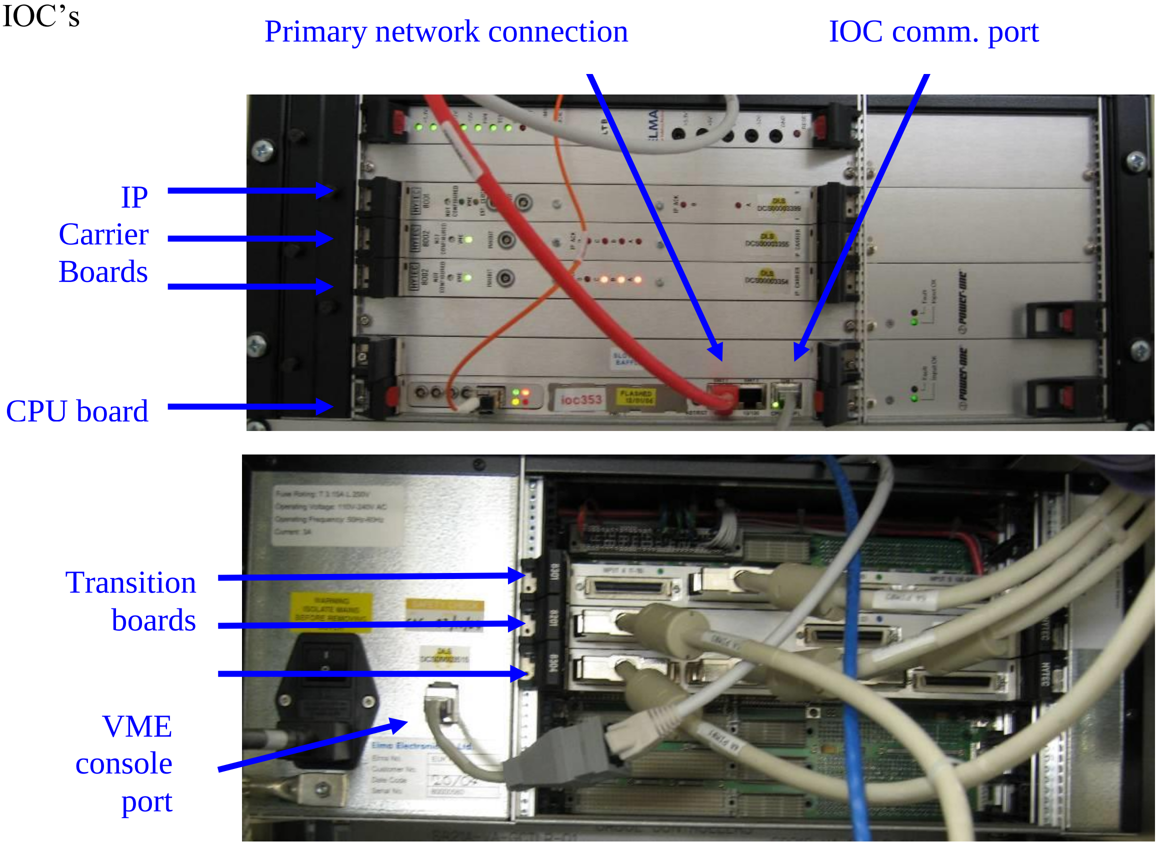


Fig. Vacuum IOC front and back view.

Input Output Controllers (IOC) in use at Diamond are VME hardware crate based and running VxWorks real-time Kernel. One or more IOCs are located in each CIA and act as CA servers to access vacuum Process Variables assigned to allocated vacuum instruments/controllers. Each storage ring cell hosts one main vacuum-dedicated IOC, located in vacuum Rack-01 in each CIA. Furthermore, vacuum devices will also be controlled from general IOCs such as Front-End and ID IOCs. A list of vacuum related IOCs is available in the appendix. Depending of the location, vacuum instruments and controllers will be different, therefore both database and hardware configurations will be location dependant. Each IOC always includes one CPU board running the EPICS database and several I/O cards.

9.2.7 Cards and PIMS

- The CPU board. The CPU board host the intelligence of the IOC which runs the EPICS database. Network and timing modules are located on this board.

- I/O cards: Several configurations of IP carrier boards, IP modules and transition boards can be used on vacuum IOCs. Two types of I/O are widely used to interface the IOC to instrumentation: Serial RS-232 and analogue input/output connections.

- Serial RS-232 configuration: 8515 IP modules with a 8904 PIM will be used to provide 8 Channels of RS232. Depending of the number of serial connections required, either 8001 or a 8002 IP carriers will be use to accept respectively two or four IP modules per card. Straight through transition card (ex: 8304) will be used with 50 ways SCSI cables to connect to the serial PIM.

- Analogue Input/output configuration: In order to read back combined analogue signal from vacuum gauges, ±10V analogue signal will be read by the IOC. These go onto an 8002 IP carriers with 8401 and 8402 IP modules and a 8202 transition card. 8401 are 8 channels ADC for analogue inputs.

9.2.8 Networks connections

Several networks are in place at Diamond. They are either directly interconnected or using the EPICS gateway to allow Process Variable to be read through.

- IOCs are homed on the ***Primary network*** through a 1Gb Ethernet connection. This connection is used to load the latest database into the IOC at boot up and interact with other EPICS clients and servers (other IOCs). The primary network can thus be defined at the primary Channel Access network. The primary network is physically isolated from other networks by the EPICS gateway. All process variables going through the gateway are READ-ONLY. It is thus impossible to get direct control over a machine PV from any other network (except by polling to mirror a PV from a network to another – this is currently done for ID control from beamlines).

- The IOC communication port and the VME crate console port are both connected to the console network. CRATE Crate Monitor Adapter, and MVME Console Adapter are respectively necessary between the RJ45 connections to the patch panel. A similar type of communication is under development to allow remote programming of the valve control crates. These connections are used to communicate with the IOC in a terminal window by addressing the correct port on the corresponding terminal server in the CIA.

- The secondary network is in used for devices other than IOCs that do not need channel access. Furthermore, it is privileged that non Linux machines are not connected directly to the primary network. For these reasons, RGA computers are thus connected onto the secondary network. They can be accessed at any time by remote connection from any location –this process is described in the remote connection section.

- Also to mention is the office network, mainly used for Windows machine, as well as the development network mainly used by Controls Group.

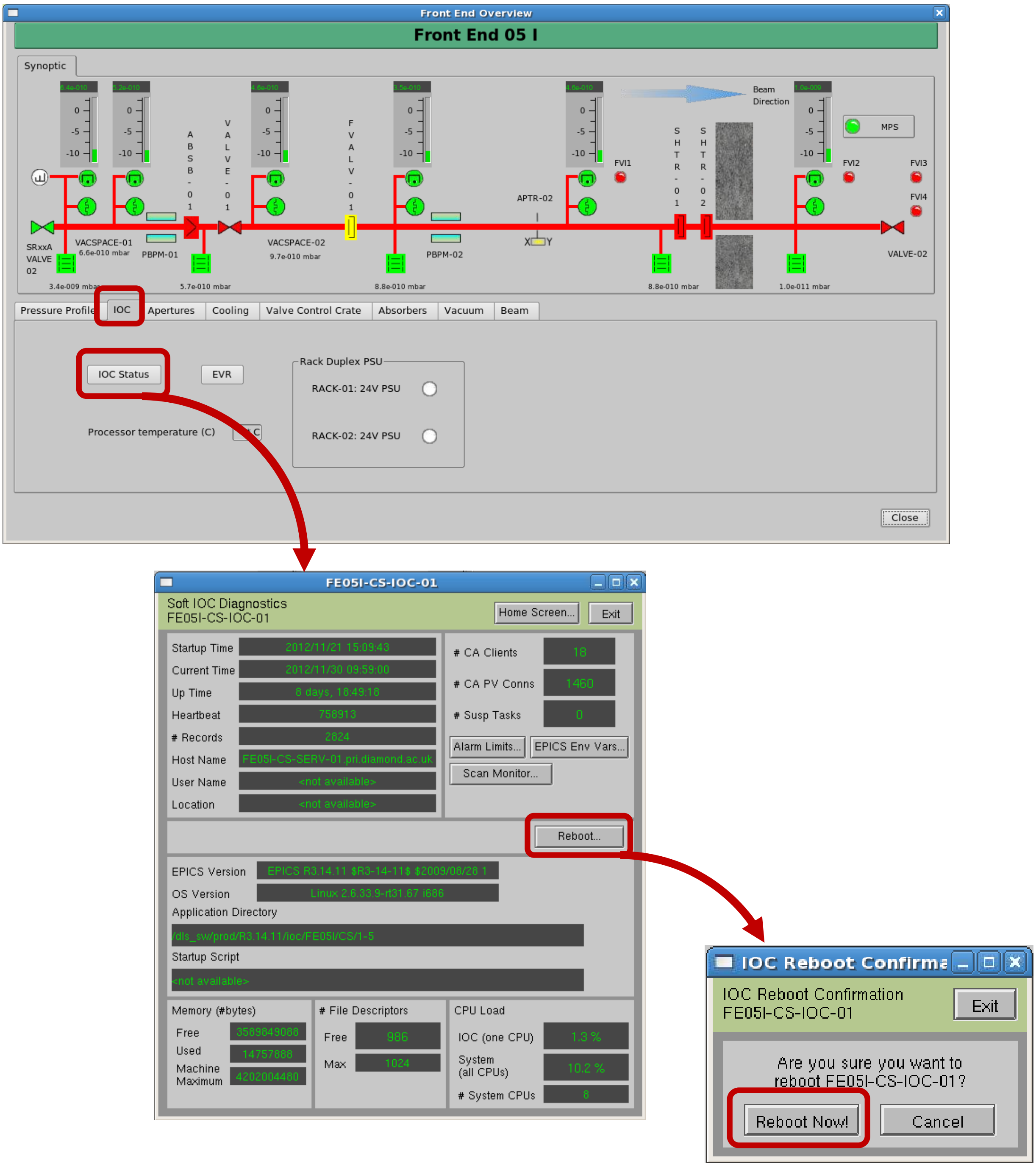
- Finally, each beamline has its own network sitting behind a gateway.

9.2.9 REBOOTING IOCs

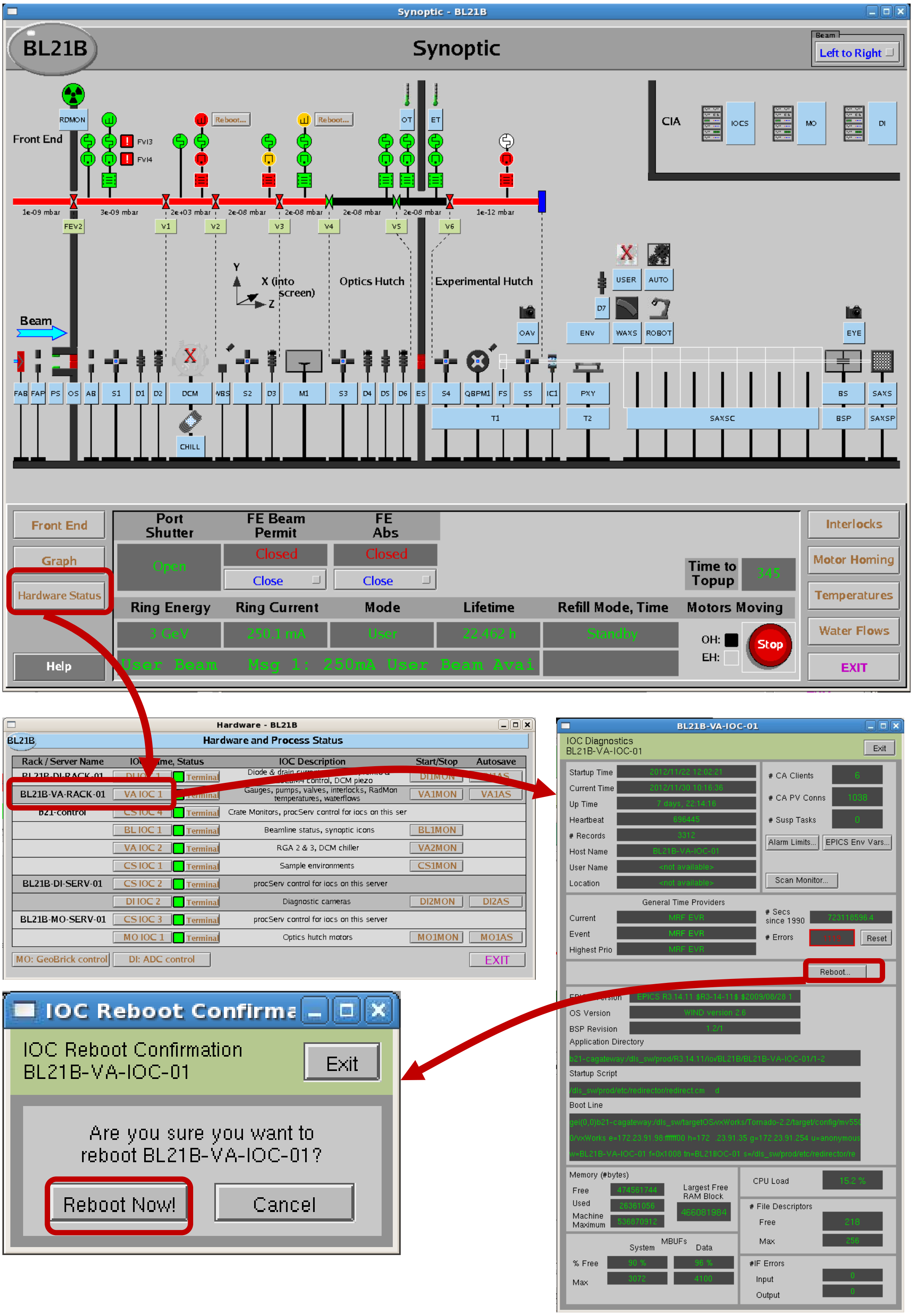
There are several ways to reboot an IOC: either soft or hard reboot, physically or remotely. There are also two types of IOCs: the VME crate IOC used on the Phase 1 and 2 Vacuum racks and the newer Virtual IOCs used on Phase 3 frontends and beamlines. The virtual IOC is hosted on 1U rack linux PCs capable of hosting multiple Virtual IOCs simultaneously. A hard reboot of one of these IU PC will cause a reboot of all the virtual IOCs hosted on it. Therefore a hard reboot is not advisable as it may cause an undesired effect.

9.2.9.1 Virtual IOC soft reboot

Each IOC has a status EDM which displays vital statistics of the IOC and also allows a soft reboot of the IOC. For phase 3 frontends, a link to the IOC status EDM can be found on the frontend vacuum synoptic as shown below for FE05I.



For phase 3 beamlines, the IOC status EDM can be found on the beamline vacuum synoptic as shown below for BL23B.



9.2.9.2 Rebooting VME Crate IOCs

Vacuum IOCs are not directly part of any protection system, therefore, rebooting a vacuum IOC does not normally change the status of any pump/valve/gauges, and does not directly drop any MPS or PSS signal. However, one must be aware that several parameters such as pressure interlock settings, pump size and MPC/TSP configuration are reinitialised to defaults at IOC boot-up. Therefore, if any interlock has been forced on a controller to allow beam operation, rebooting the corresponding IOC will reset the interlock to its default value and might thus have indirect knock-on effects.

<u>IMPORTANT:</u>

- an IOC reboot does not directly kill the MPS but will reinitialise all default interlock settings and may have unexpected effects. Please check status and advise OPS <u>before</u> rebooting any IOC.

- If rebooting ID IOC, trim coils table will be erased and need to be reBURTed with the last BURT file for this ID. (Ask ID group if not sure which file to use, better to let them know before intervention).

9.2.9.3 Boot up

Vacuum IOCs boot up from primary network. The correct start-up script is directly downloaded from the correct directory location automatically deduced from the IOC name.

(Done with the following start-up script: */home/diamond/R3.13.9/prod/ioc/st.cmd)*

Boot parameter will look like as following:

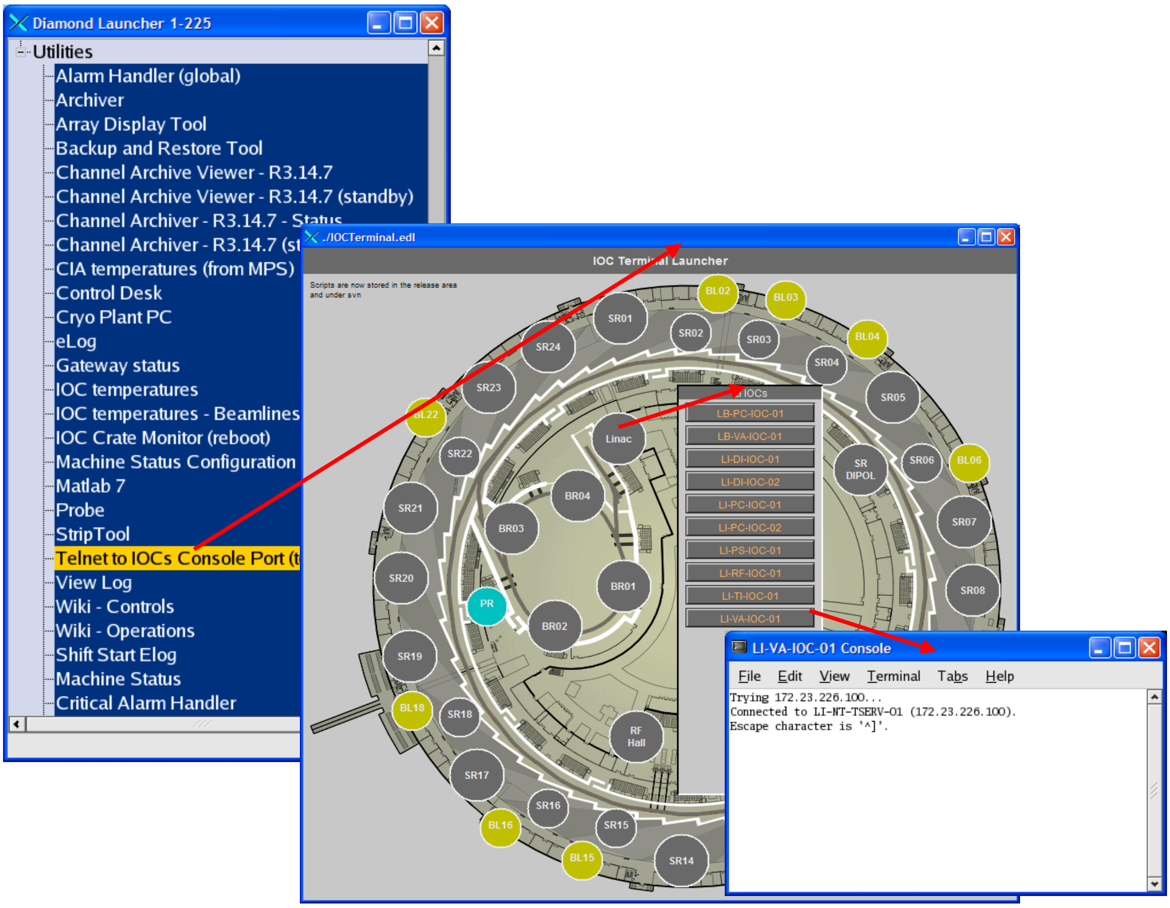
boot device : gei0
processor number : 0
host name : cs03r-cs-serv-07
file name : /home/Tornado2.2/target/config/mv5500/vxWorks
inet on ethernet (e) : 172.23.200.66:fffff000
inet on backplane (b):
host inet (h) : 172.23.194.7
gateway inet (g) : 172.23.192.23
user (u) : epics
ftp password (pw) (blank = use rsh): ^scipe123
flags (f) : 0x0
target name (tn) : SR23C-VA-IOC-01
startup script (s) : /home/diamond/R3.13.9/prod/ioc/st.cmd
other (o) :

9.2.9.4 VME IOC Soft boot

The first possibility to reboot a still healthy IOC is through EPICS using the IOC panel. It operates a soft reboot that will reload the database from a predefined network location. This kind of reboot will be needed following an update in the EPICS database to be implemented or following the loss of communication with one or a few vacuum devices.

Vacuum IOC reboot panels can be accessed from the Vacuum rack view by clicking on the IOC crate, or from the vacuum IOC overview panel (Diamond => Vacuum => Vacuum IOCs).

IOC can also now be access via the “Telnet to IOC console port” edm directly from the launcher (under #Utilities).



Telnet to IOC console port edm

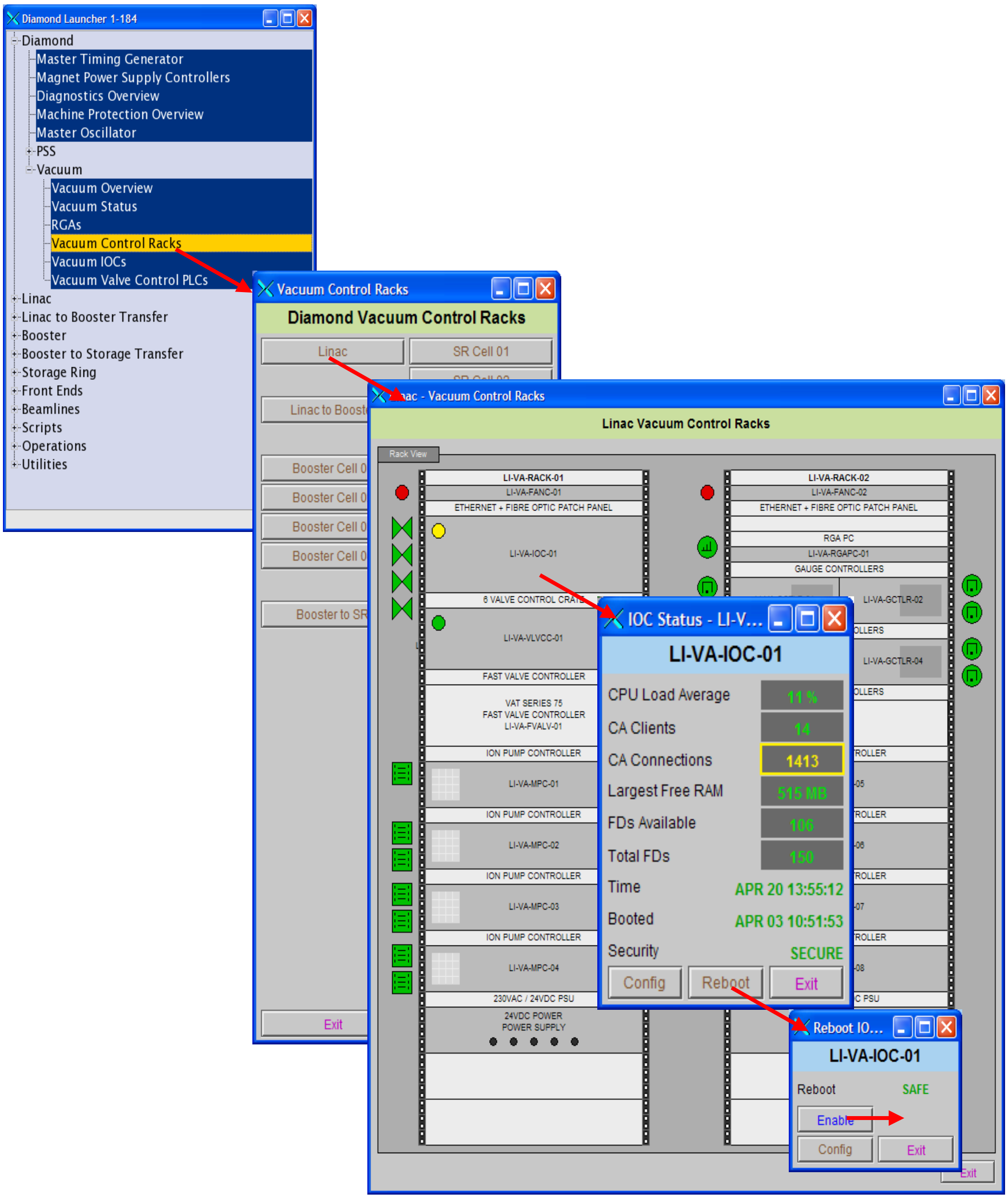


Fig .Vacuum IOC soft reboot form rack panels – example for LINAC IOC.

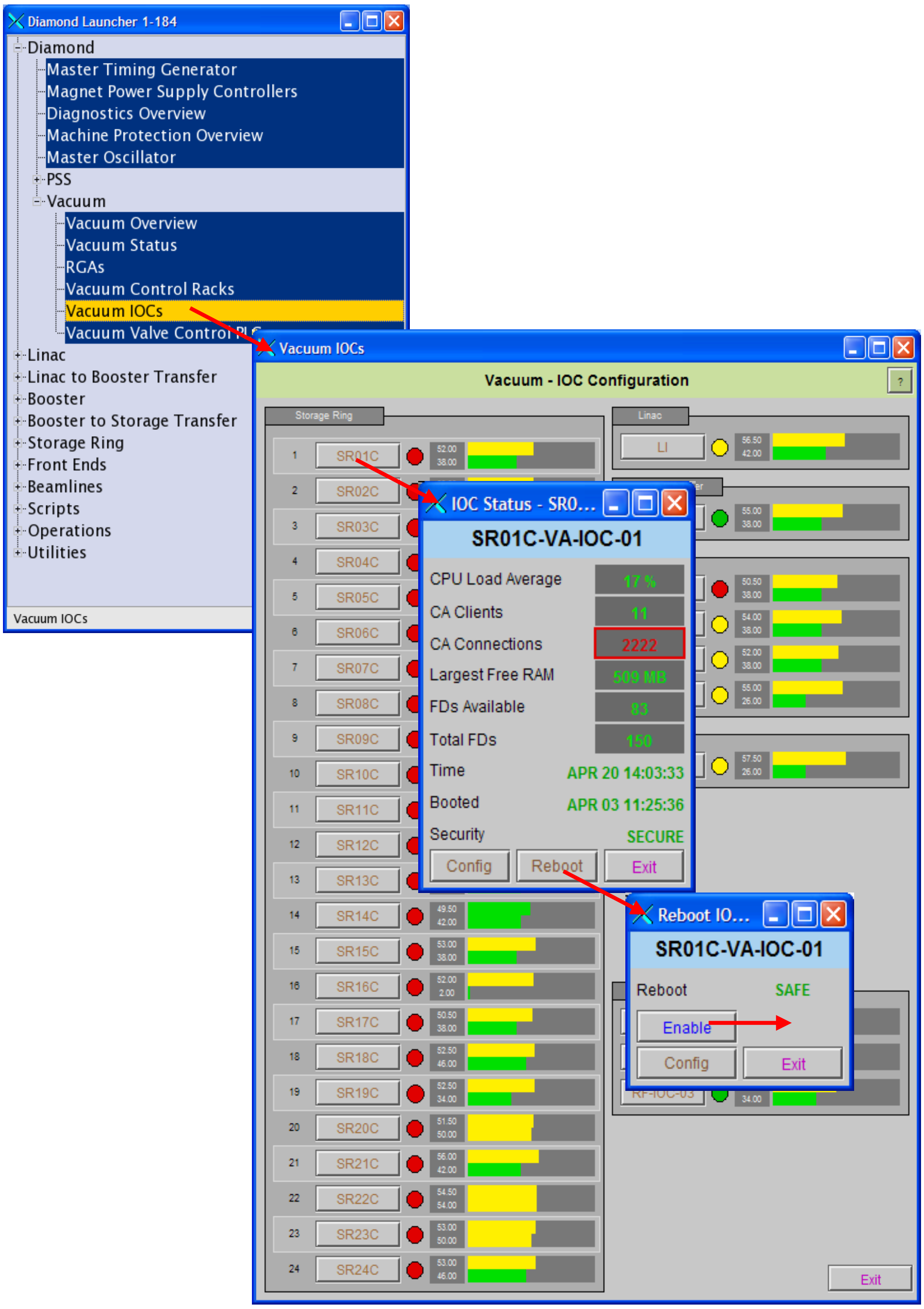
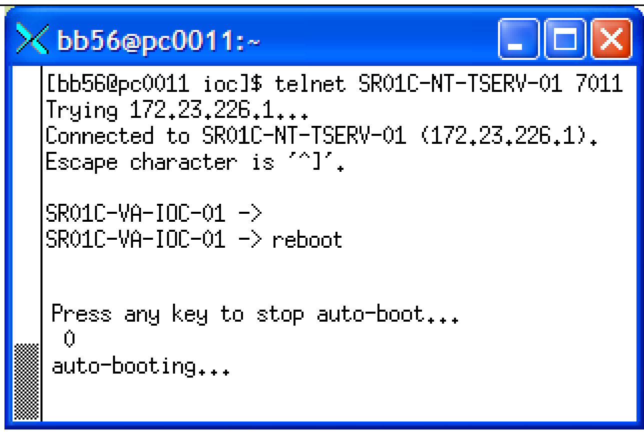


Fig. Vacuum IOC soft reboot from Vacuum – IOC Configuration EDM.

The second way to soft reboot an IOC is to connect to the IOC communication port using a telnet connection from a terminal window. One needs to select the correct network switch and port to connect to. This information can be found in the Vacuum IOCs list available in appendix.

<table>
<tr>
<td>For example, the following command will be used to connect to cell 01 vacuum IOC: telnet SR01C-TSERV-NT-01 7011

Once connected to the IOC, one should see ->SR01-VA-IOC-01: (need to press enter a few time to make it appear)

To reboot the IOC, enter the command "reboot" (or press CTRL x)</td>
<td>
</td>
</tr>
<tr>
<td colspan="2">After a few 10 seconds, the IOC should reboot and the starting script should run on the screen.</td>
</tr>
</table>

There is also a tool available on the launcher/utilities/Telnet to IOCs Console Port (terminal launcher) to start telnet sessions.

Always remember to terminate a session with “<CTRL>]”

Otherwise the telnet port will remain blocked.

9.2.10 VME IOC Hard boot

If an IOC is fully crashed and does not respond to soft reset command, it might be necessary to perform a reset of the hardware. IOC hard reboot can be operated at several levels: One can firstly reset the CPU board by holding the reset button on the front panel for a couple of second. Secondly the VME crate can be reset over EPICS or via telnet to the VME console port. Thirdly and finally, a power cycle of the VME crate can be done using the power switch on the back of the crate this however should only be done only as a last resort!

Hard reboot of IOCs can be performed through the EPICS IOC Crate Monitor Utility as following. This will perform a reset and reconfigure of each VME board. Following the cpu board reset, the database will load automatically onto the ioc.

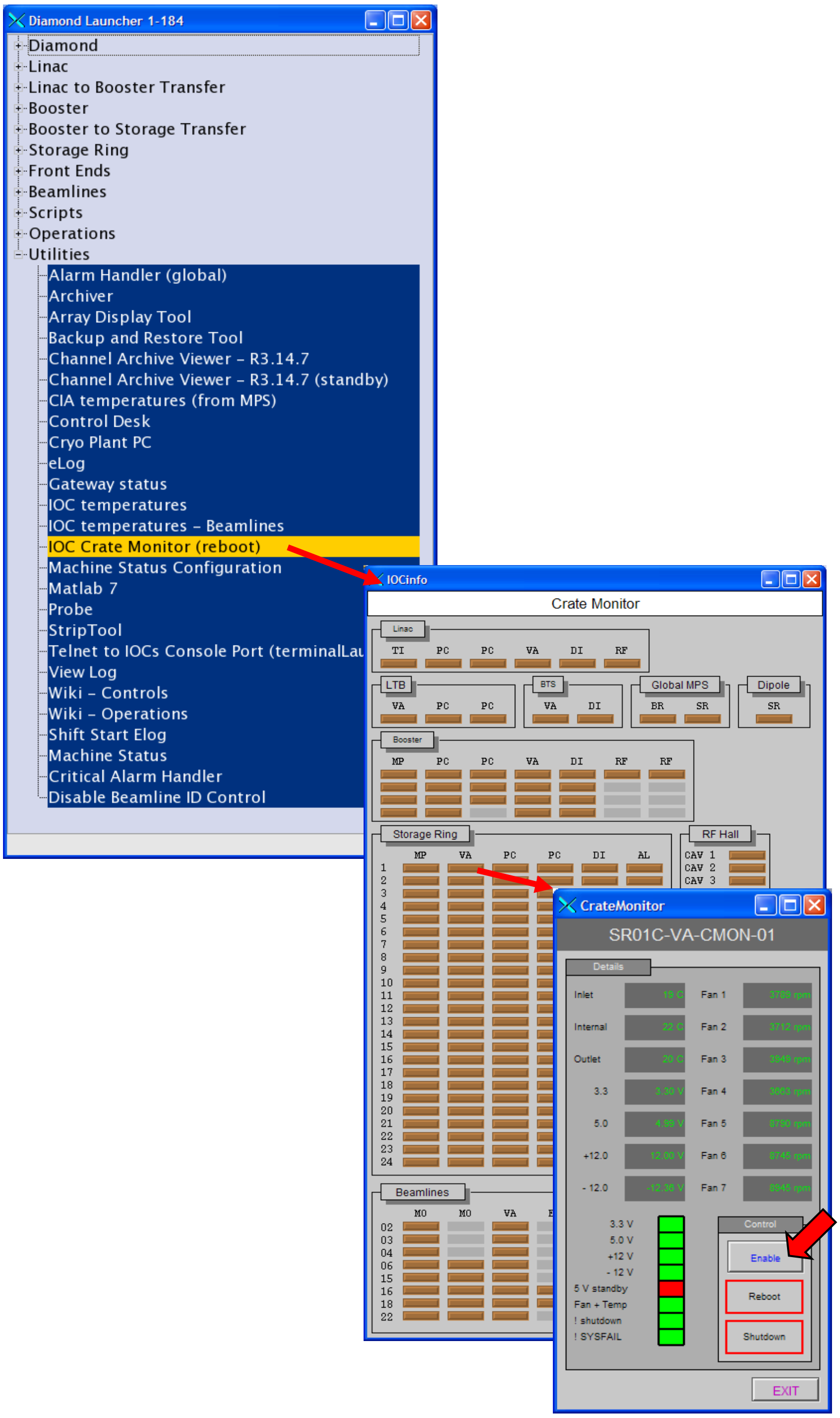


Fig. Vacuum IOC hard reboot using crate monitor edm

The same function can be operated by connecting to the VME console port using telnet. The port used to access the IOC communication port has to be used. Once connected, enter the command R,7E for power reset. The rack will reply r,5e and perform a reset of the power supply.

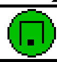
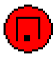
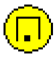
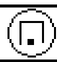
9.3 Basic Vacuum PVs

9.3.1 Status PV

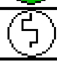
Status PV is always available on vacuum equipment and reflects the overall status of the device. This PV is also in use to set the colour of the Icon symbolising the device, thus giving fast information about instrument status.

In EPICS colour code:
- White means no communication
- Green means operating normally / within range.
- Yellow means operating outside of range.
- Red means device OFF or not working properly.

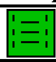
IMG Status:

PV	Value	meaning	Icon display
xxxxx-VA-IMG-xx:STA	**OK**	**HV on – normal operation**	
	OFF	**HV OFF** ○ **no Pressure reading.** ○ **No interlock**	
	Below Range	**HV on – gauge not striking** ○ **no Pressure reading** ○ **Interlock provided**	
	Anything	**No EPICS connection to gauge**	

Pirani Status:

PV	Value	meaning	Icon display
xxxxx-VA-PIRG-xx:STA	**OK**	**normal operation**	
	Anything	**No EPICS connection to gauge**	

ION PUMP Status:

PV	Value	meaning	Icon display
xxxxx-VA-IONP-xx:STA	**OK**	**Normal operation**	
	Anything	**No EPICS connection to MPC**	
	STANDBY	**HV OFF – pump can be re-started**	
	ERROR	**Error on pump – check error code before restarting**	
	SAFE-CONN	**Cable not properly connected to pump or MPC back panel.**	

Titanium sublimation pumps Status:

PV	Value	meaning	Icon display
xxxxx-VA-TSP-xx:STA	**TIMED**	**TSP FIRING in timed mode (autofiring on time)**	Ti
	CONTINUOUS	**TSP firing for 2min – from request to fire**	
	DEGAS	**TSP firing in degas mode**	Ti
	Anything	**No EPICS connection to MPC / TSP**	Ti
	OFF	**TSP OFF – normal status**	Ti

RGA Status:

PV	Value	meaning	Icon display
xxxxx-VA-RGA-xx:STA	**0**	**RGA OFF or filament off**	
	1	**RGA in LOCAL CONTROL**	
	2	**RGA in Degass mode – not to use -**	
	3	**RGA calibrating Faraday – not to use -**	
	4	**RGA calibrating Multiplier – not to use -**	
	5	**RGA on, filament on, normal operation under EPICS control. BARCHART 0-50 mode**	
	6	**RGA on and OK, under EPICS control BARCHART 0-100 mode**	
	7	**RGA on and OK, under EPICS control BARCHART 0-200 mode**	
	Anything	**No EPICS connection to MPC / TSP**	

Vacuum Valves Status:

PV	Value	meaning	Icon display
xxxxx-VA-VALVE-xx:STA	**OPEN**	**Valve opened (open contact made)**	
	OPENING	**Valve in motion**	
	CLOSING		
	CLOSED	**Valve closed (close contact made)**	
	Anything	**No communication with Valve Control Crate**	
	FAULT	**Valve fault – check interlocks (air pressure – limits)**	

Vacuum FAST Valves/Flaps Status:

PV	Value	meaning	Icon display F.Flap – F.Valve	
xxxxx-VA-FVALV-xx:STA xxxxx-VA-FFLAP-xx:STA	**OPENING**	**Valve opening – in motion**		
	OPEN DISARMED			
	OPEN Partially armed			
	OPEN ARMED			
	CLOSING	**Valve closing - in motion. Not in use, fast valve !!!**		
	CLOSED	**Valve closed (close contact made)**		
	Anything	**No communication with Valve Control Crate**		
	FAULT	**Valve fault – check interlocks (air pressure – limits)**		

Vacuum Space Status:

The vacuum space status is special as it is both function of the pressure and devices' status. For a vacuum space to be healthy (green), all the valves need to be opened, all pumps on, and all gauges within range

Global PV have been set for overview panels, they are preceded with a "G". As an example, SR01C-VA-GIMG-01:STA is the global status of all IMGs in SR cell 01. Global status will upgrade to 'bad' value if any of the parameter is not within operation range.

PV numbers to status

IONP:STA	
PV Value	***Meaning***
0	Unknown
1	Waiting
2	Standby
3	Safe-Conn
4	Running
5	Cool Down
6	Pump Error
7	HV Switched Off
8	Interlock
9	Shut Down
10	Calibration
11	Invalid
12	
13	
14	
15	

PIRG:STA + IMG:STA (MKS 937A + B)	
PV Value	***Meaning***
0	OK
1	OK
2	Above Range
3	At Atmosphere
4	Low Emission
5	Filament Off
6	HV Off
7	Startup Delay
8	Below Range
9	Controlled
10	Protected State
11	No Gauge
12	Not Connected
13	Wrong Gauge
14	Bad Command
15	Locked Out

TSP:STA	
PV Value	***Meaning***
0	Unknown
1	Off
2	Ramping
3	Firing
4	Armed
5	Pressure Interlock
6	No Interlock
7	Degas
8	Auto Config
9	Re-Sync
10	Disconnect
11	Invalid
12	
13	
14	
15	

RGA:HEADSTA	
PV Value	***Meaning***
0	Idle
1	Local Control
2	Degas Filament
3	Cal Faraday
4	Cal Multiplier
5	Barchart 1-50
6	Barchart 1-100
7	Barchart 1-200
8	Analogue 1-200
9	No RGA
10	Peak Jump
11	Invalid
12	
13	
14	
15	

VALVE:STA	
PV Value	***Meaning***
0	Fault
1	Open
2	Opening
3	Closed
4	Closing

FVALV:STA/FFLAP:STA	
PV Value	***Meaning***
0	Fault
1	Open Armed
2	Opening
3	Closed
4	Closing
5	Open Disarmed

10. OPERATORS GUIDE TO VACUUM CONTROLS

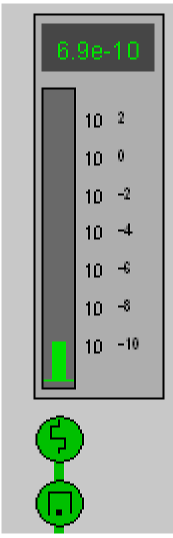
10.1 EDMs & Controls

When we consider controls of the vacuum system we think of vacuum spaces. A vacuum space is a volume between two or three closing valves. Instruments within a section or vacuum space should operate in a similar fashion. Therefore we have built up from the particular control of a unit to the control of all identical units within an area. So from individual gauge and pump controls we go to controls of vacuum spaces for such devices and onto control of whole areas such as the storage ring. EPICS colours have the following meanings

Colour	Meaning
Green	Healthy, in range, Go
Red	Stop
Yellow	Out of range, warning
White	No communications

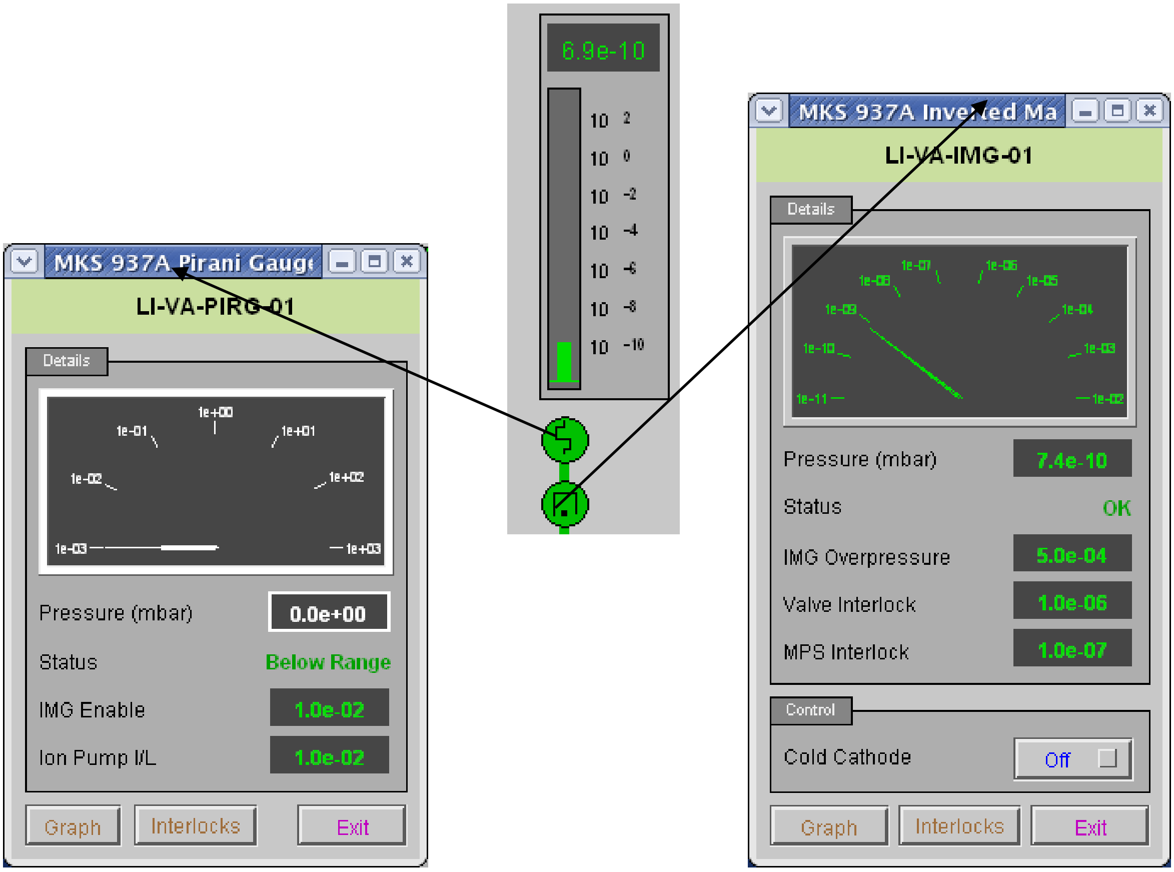
10.1.1 Total pressure Gauges with 937a

As discussed previously the full scale pressure range is made up of a combination of a Pirani and an IMG. The pressure range for these two gauges is from Atmosphere to 10^{-11} mbar. The analogue combination signal is taken from the gauge controller straight into an A/D converter in the IOC. Then in EPICS the combination gauge is displayed as below. The sampling of this gauge is done up to a maximum of 10 times a second or 10 Hz.



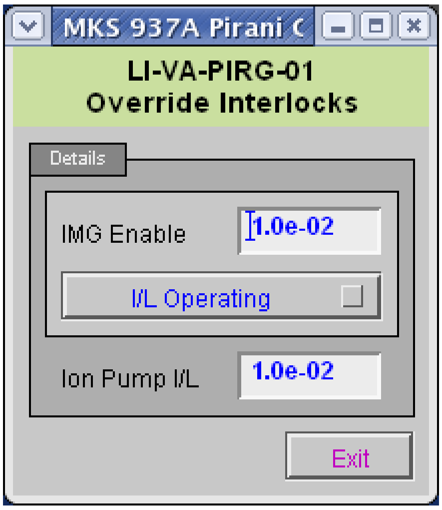
The analogue signal uses the Pirani signal from Atmosphere to 10^{-3} mbar and then the IMG signal from 10^{-3} mbar to 10^{-11} mbar. The Pirani signal takes priority so if the Pirani drifts up above the 10^{-3} mbar limit then the Pirani signal is displayed, even if the IMG is showing a good pressure. If this happens the Pirani can be reset at the controller, see fault finding section.

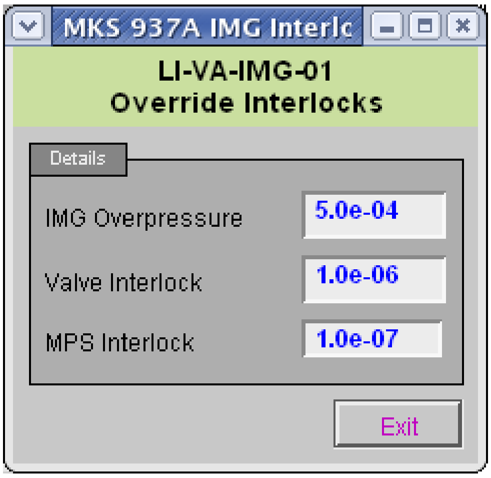
If we click on the Pirani gauge, displayed with a filament above, or alternatively the IMG, displayed as cup with a dot in then we will bring up the following EDMs.



As the Pressure displayed by the IMG is in the 10^{-10} mbar range this obviously means that the Pirani, that only reads down to 10^{-3} mbar, will show "below range". The pressure as measured on specific gauge panels is taken from the serial communications line to the gauge and is once a second (1Hz).

Clicking on the interlock buttons above brings up the interlock levels. The standard settings are shown as shown in the windows following





10.1.2 Total pressure Gauges with 937b

937b IMG Overrides

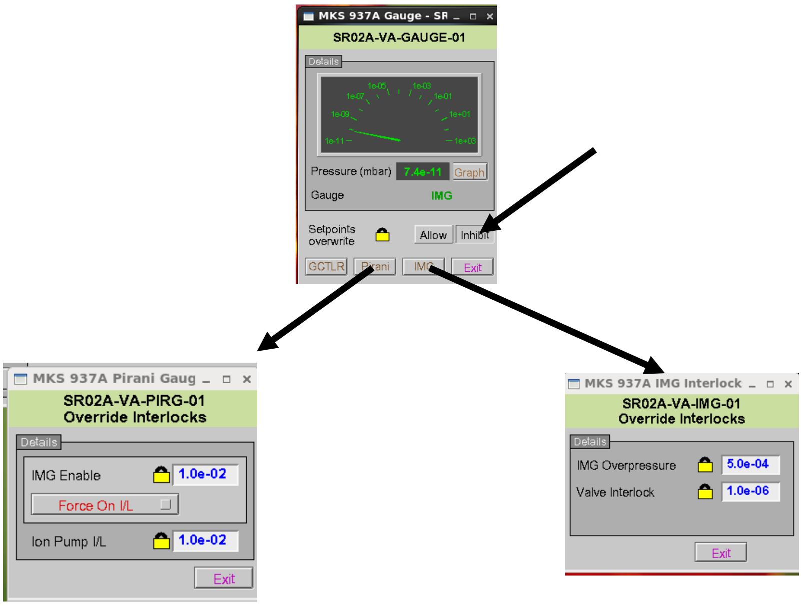
937b PIRG Overrides

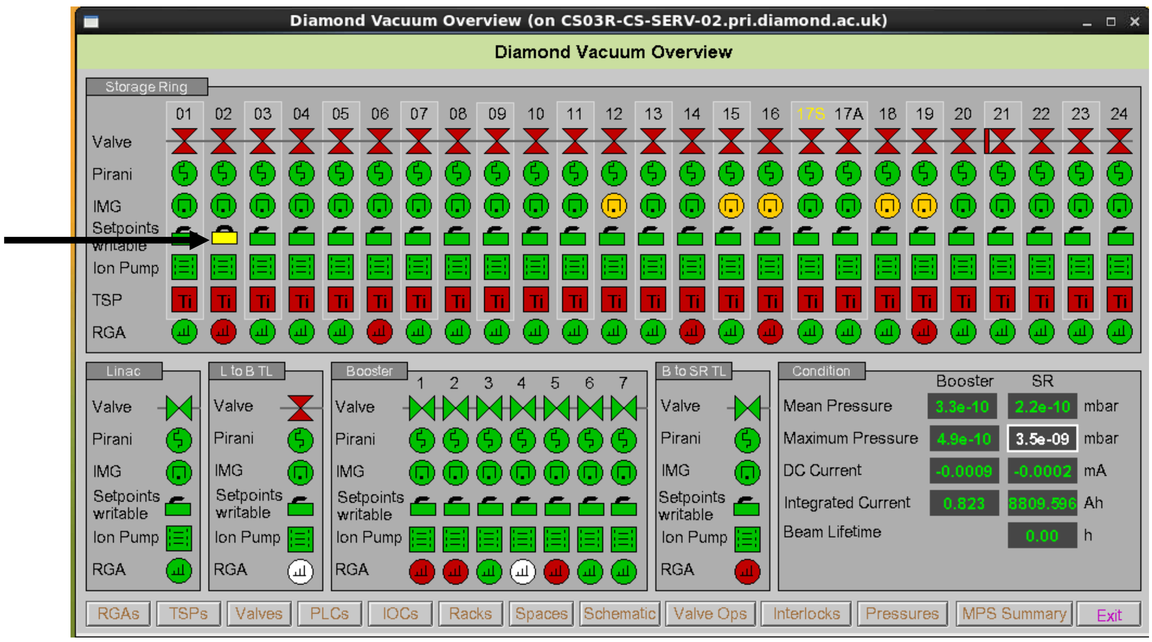
*10.1.3 **Locking interlock setpoints:***

During IOC reboots the default interlock values are written to the gauge controllers. There are certain situations where we would like to lock the interlock levels at higher, or sometimes lower values, and we do not want the values changed during an IOC reboot. A new PV has been introduced which allows us to stop writing to gauge controller setpoint values effectively locking into the last programed setpoint value. The PV has the format XXXXX-VA-GAUGE-XX:ILKSETSP:NOWRITE. If the PV is set then a padlock is shown displayed locked. In a group of gauges, such such as a storage ring sector when any gauge within the group has a locked setpoint the group is displayed as locked.

To get to a gauge setpoint writable PV click on "the gauge section" of the display as in the EDMs displayed below.

Clicking on the “Inhibit” button of the gauge will lock all the interlocks of that particular gauge set. It will not be possible to write to any of the interlock setpoint values of a particular gauge which is locked with the setpoint inhibit button. The vacuum overview will show a locked padlock for the whole sector of which the gauge belongs to as a warning, this is shown below.

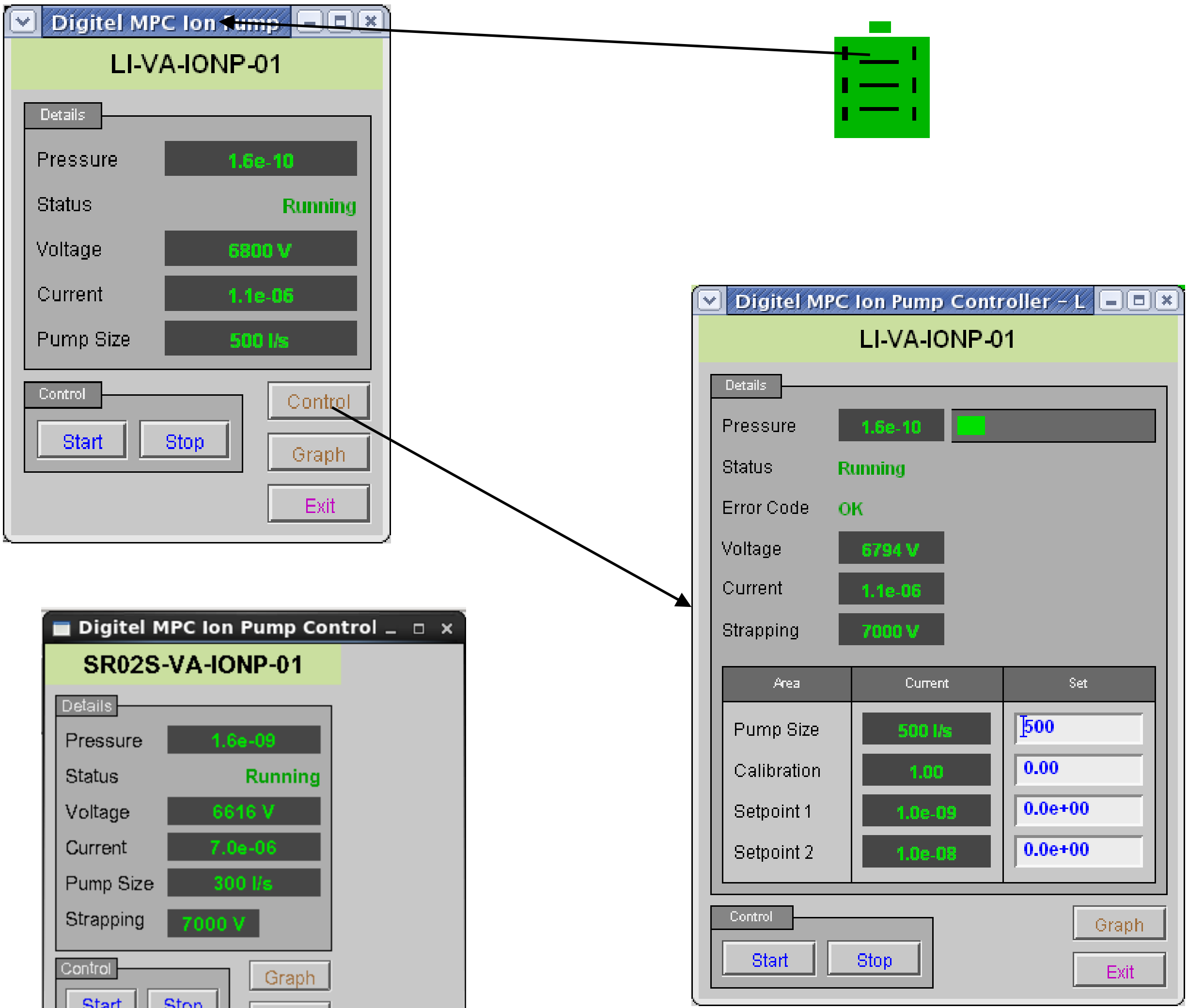


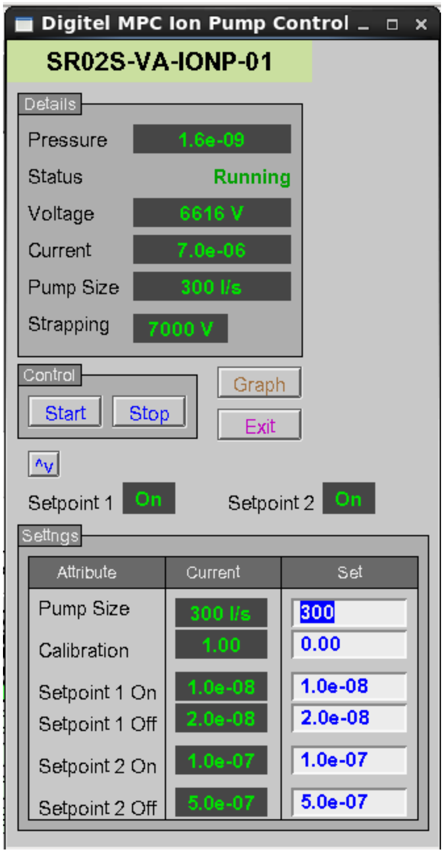


Currently this inhibit function has only been rolled out to the SR, booster & Linac gauges and not yet to the ID's of Frontends.

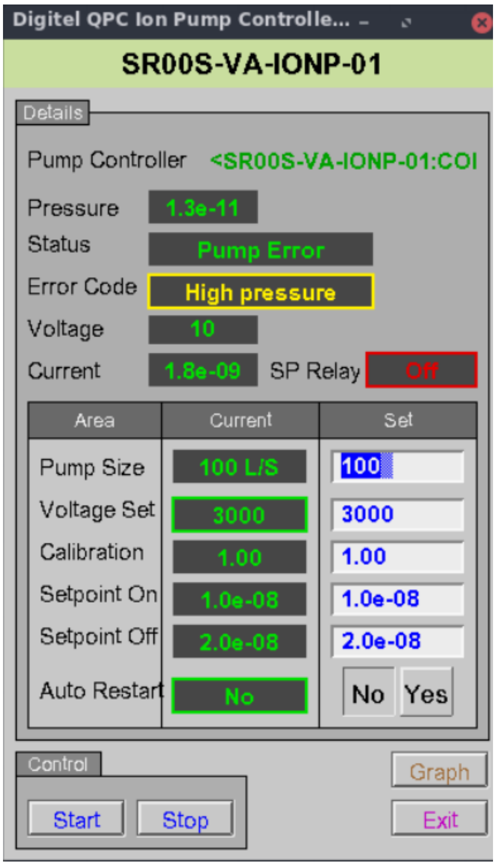
10.1.4 Ion Pumps

Ion pumps are displayed, as below, clicking on an ion pump will bring up the control of the ion pump window.



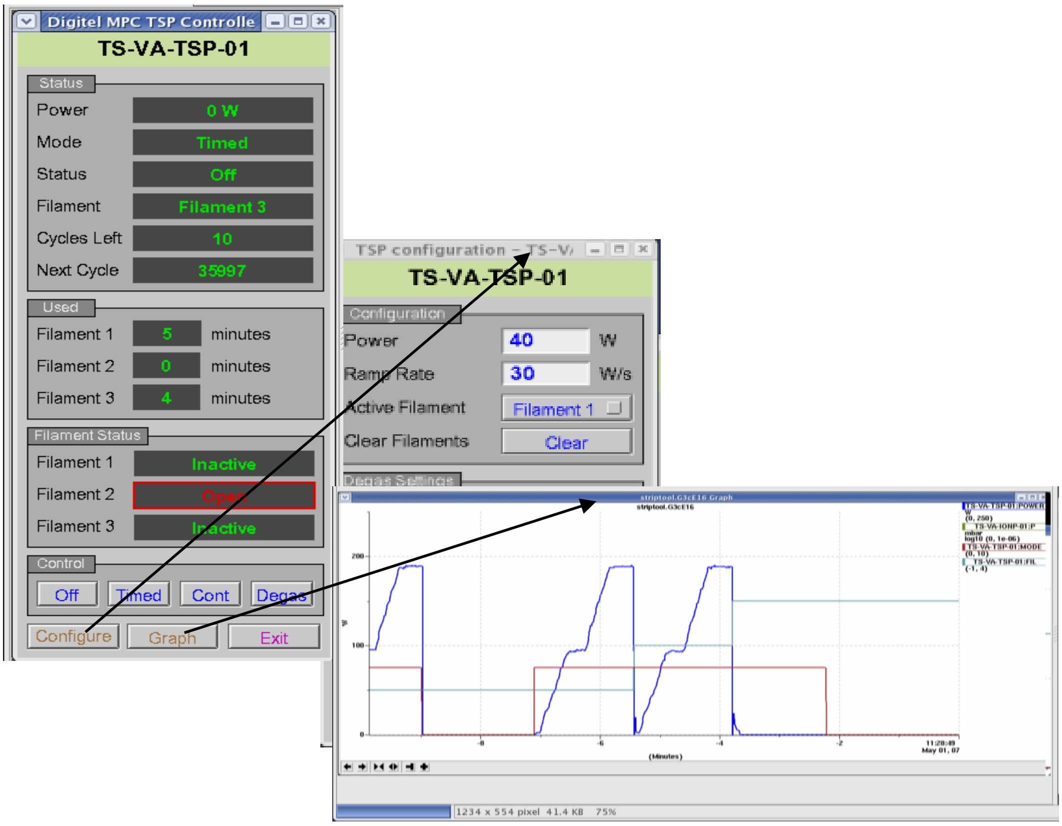


On the left is the newer GUI which displays two sets of interlocks, the first interlock is the generic MPS interlock and the second interlock is the Generic valve interlock.



The new QPC controller GUI is shown on the left hand side. As this is a switch mode power supply it allows for setting the voltage from 3000-7000 volts.

10.1.5 TSP



The panels above are fairly easy to understand. Basically to run a TSP filament we need to put around 45 Amps through one of the filaments for around 60 to 120 seconds. This will make Titanium evaporate from the filament and coat the wall of the TSP chamber. We can set the filament to come on every few hours to help pump downs.

We have various modes of operation

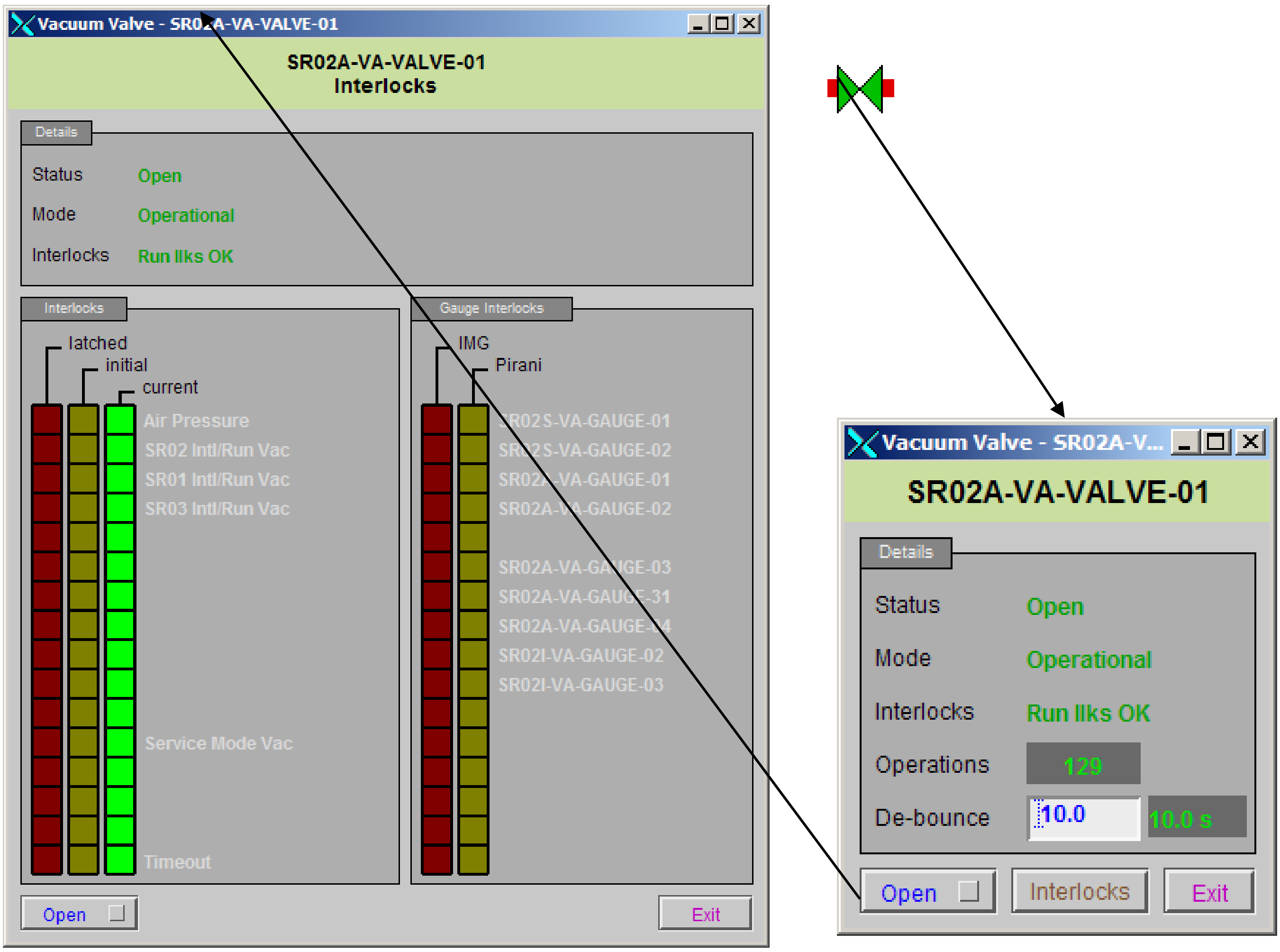
a. Timed mode, this mode will switch the filament on for set amount of time every defined by the user period.

b. Degas mode, this mode switches on the filament and ramps it to half power for a user defined period of time, it then ramps up the filament to full power.

c. Continuous mode switches on a filament for a 120 seconds.

As they have limited capacity and potentially can make the pressure worse if not used correctly, TSPs should only be operated by the Vacuum Group.

10.1.6 Valves



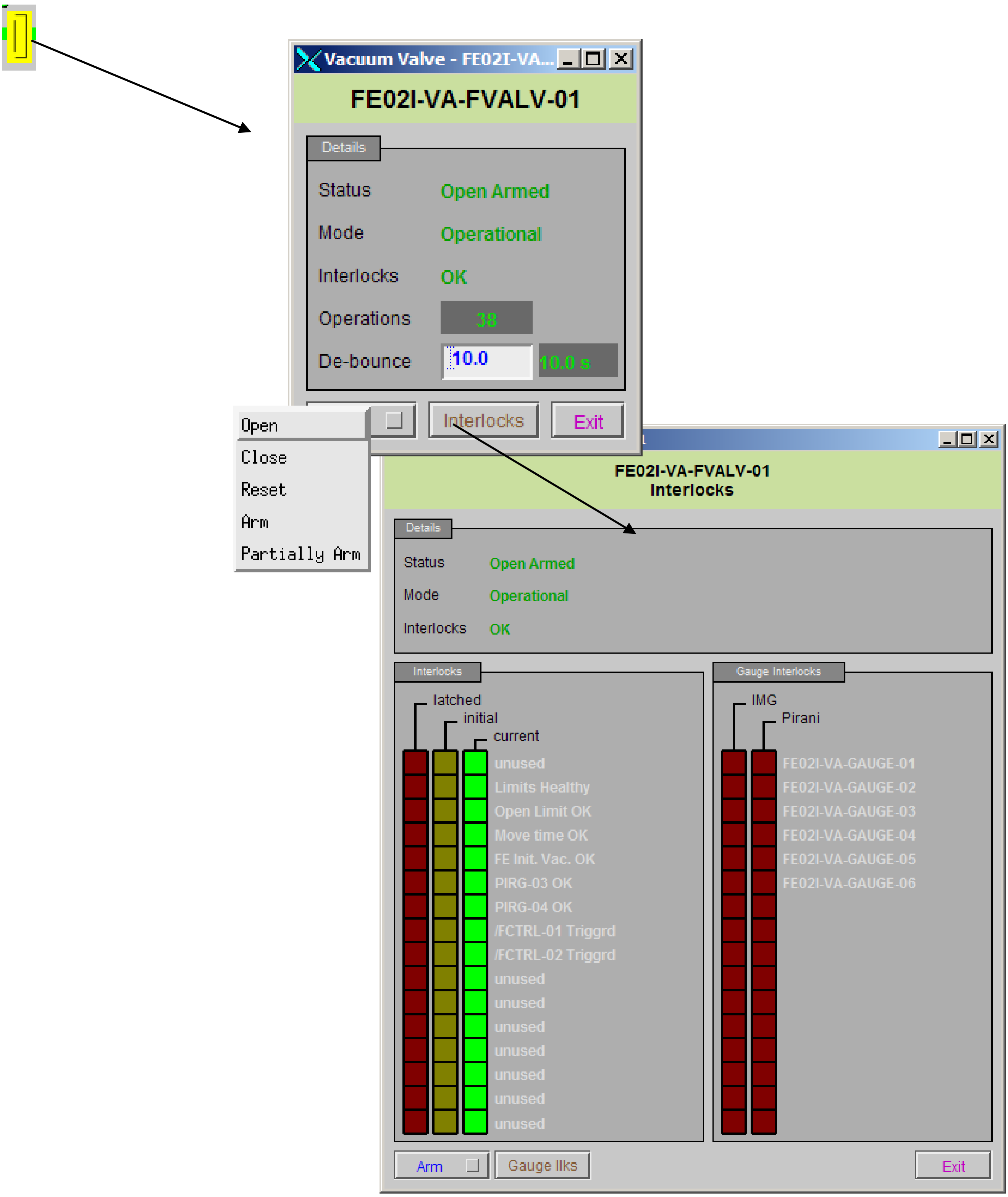
Clicking on the valve symbol above opens up the valve GUI, which shows the status of the valve, the mode of the valve control unit (Operational or Service), status of the interlocks, the total number of times the valve has been operated since its last service, and the De-bounce setting. The De-bounce time is the time that the valve has to reach an open or closed position along with the total time it can allow the pressure interlock to drop before an error is reported and an attempt to close the valve is made.

The close/open button also has a function to reset the interlocks. If an interlock has dropped out then as well as the interlock being remade it also requires the interlocks to be reset. This is because the interlock is latched.

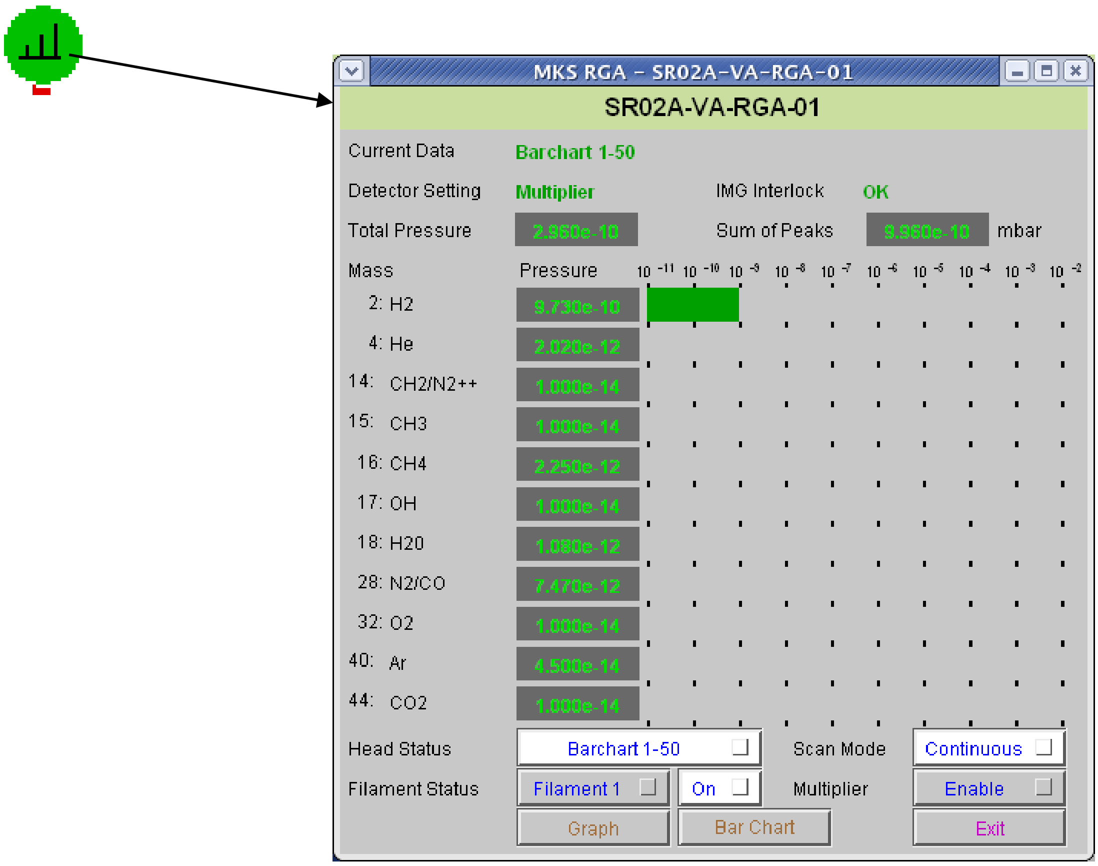
To see what interlocks have been lost the interlock button can be pushed which opens up the interlock panel. The initial and run vacuum conditions for a section are made up of a combination of gauges. To display the status of the gauges we need to pres the gauge button. Once a gauge interlock has been lost the gauge indicator (cherry) will be latched off and the interlock will have to be remade and the valve reset to lose the latch.

10.1.7 Fast Valves

The fast valve symbol is shown below. The fast valve is coloured yellow when open and not armed, brown when open and partially armed with gauges in front end, green when open and fully armed and red when closed



10.1.8 RGAs



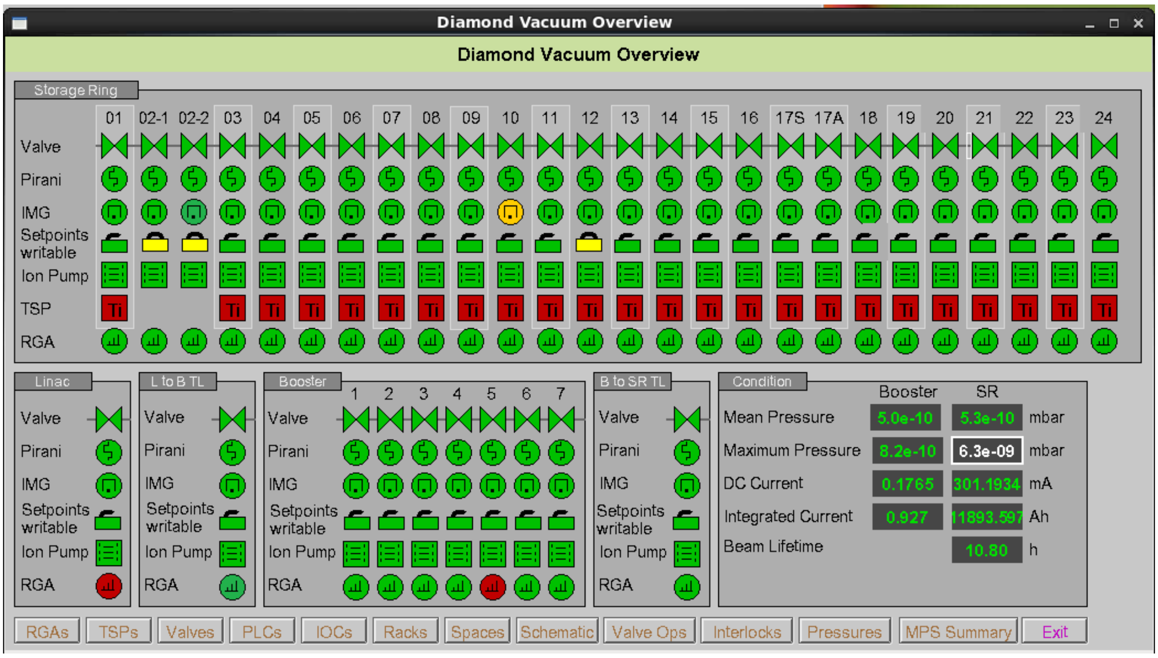
Clicking on the RGA panel gives an RGA display. Usually the RGAs run continuously in barchart 1-50 mode and the data is archived by EPICS.

The other main mode of operation is local mode. This mode gives control of the RGA back to the user through the MKS Spectra software. The RGA can then be operated directly with the manufacturer's software, on a Windows based computer. <u>Mode changes and use of local control on the machine/accelerator RGAs should normally only be done by the Vacuum Group.</u>

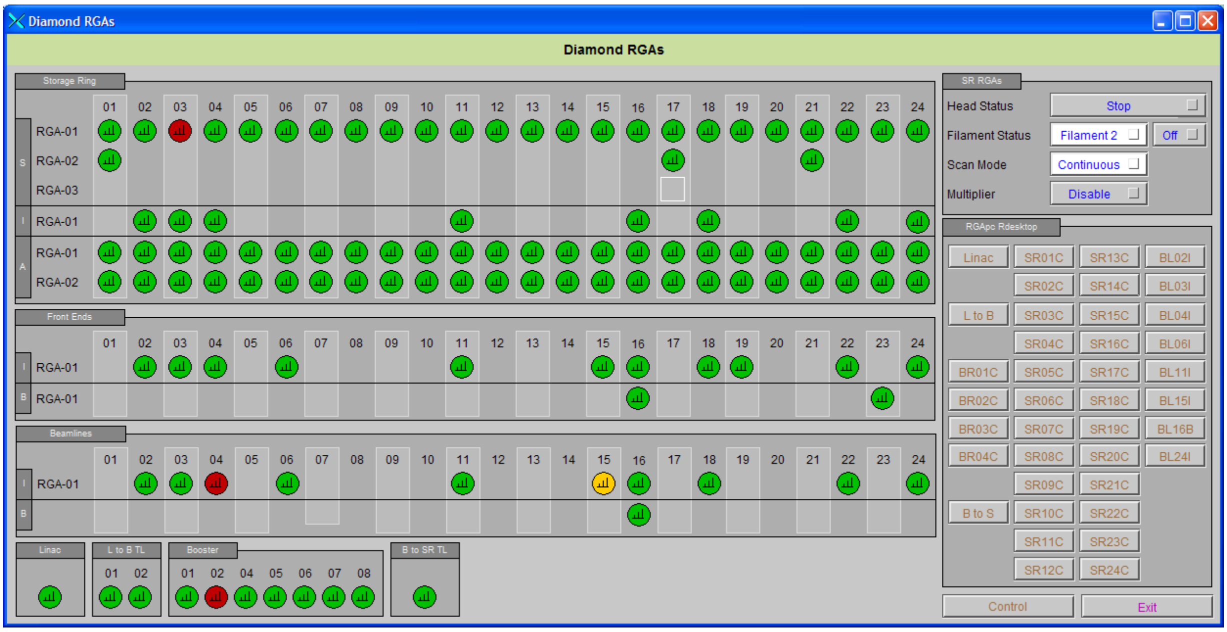
The total pressure reading and the sum of peaks shown at the top of the EDM should be nearly identical if the head is well calibrated. The total pressure is derived from the analogue signal coming from a total pressure gauge located next to the RGA head whilst the sum of peaks is the sum of the partial pressures.

10.1.9 Overview panels

On the overview panels click on the section/component that you want to drill down to and view in more detail.



Vacuum overview

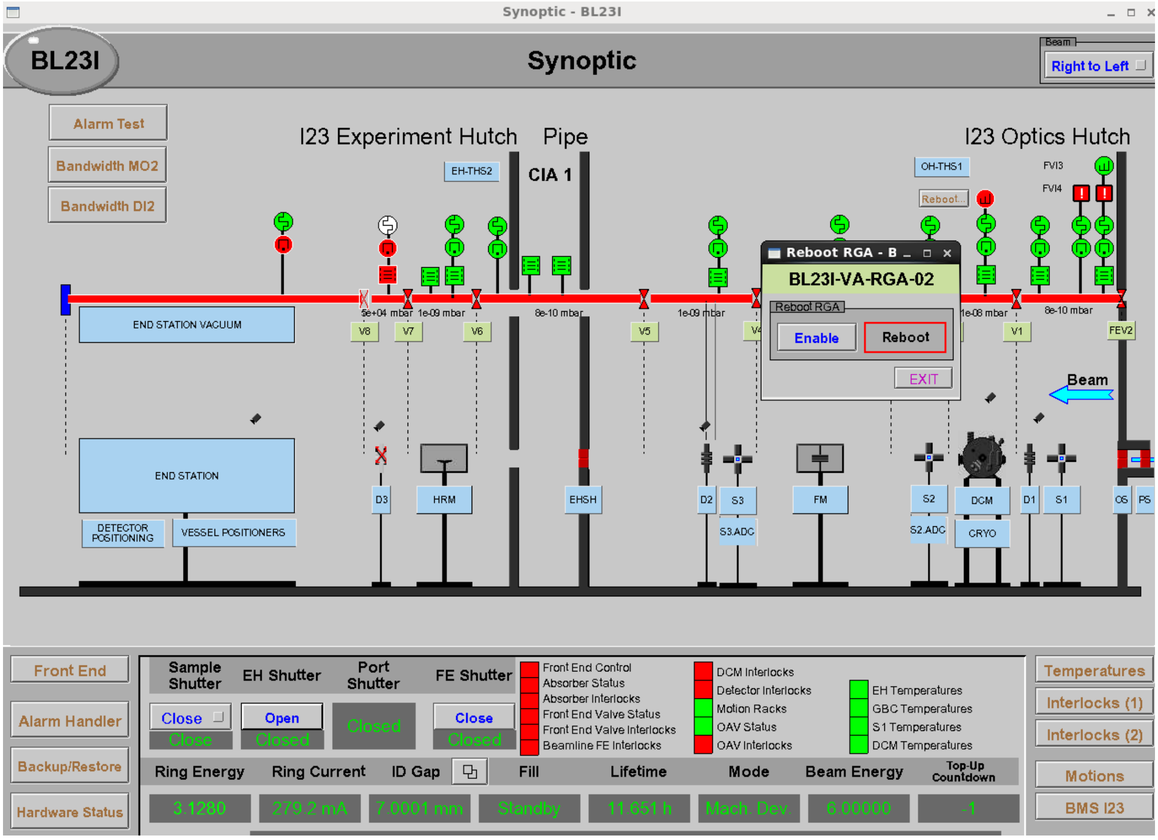


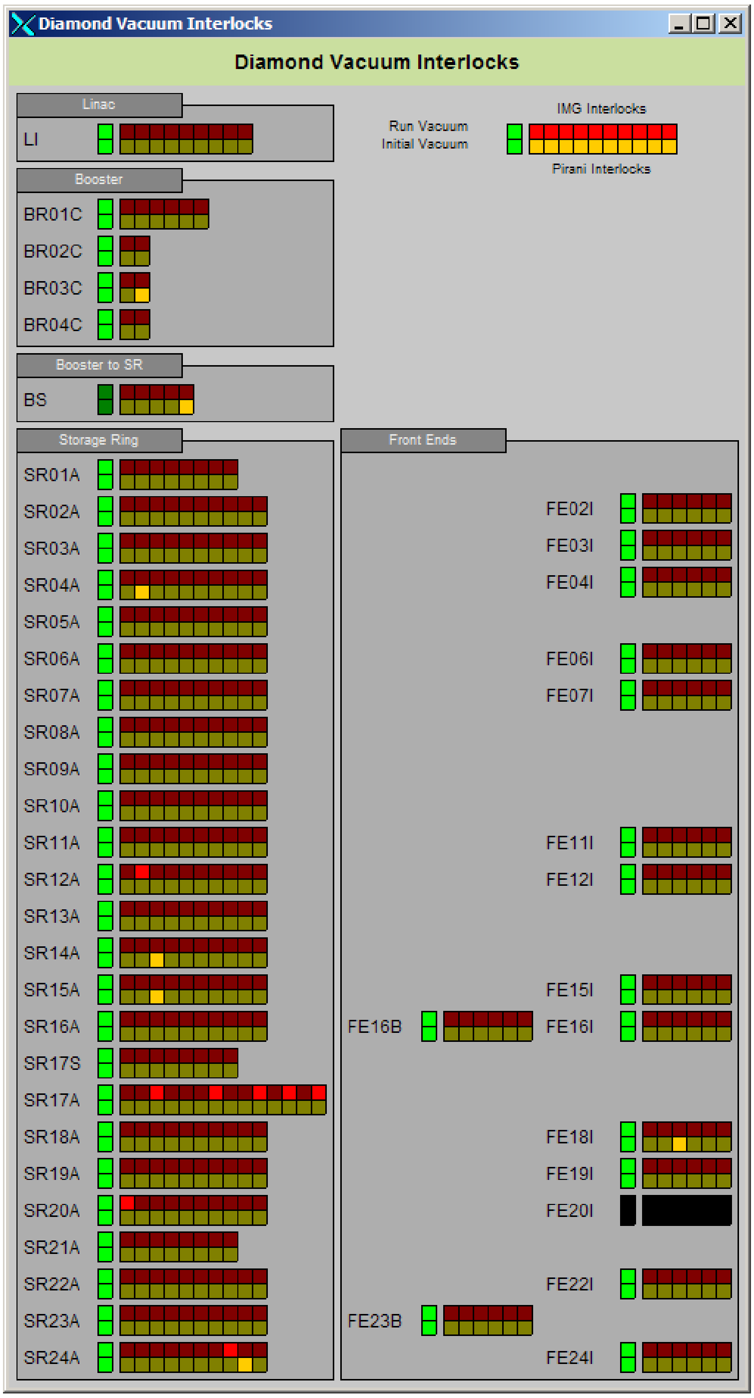
Diamond RGAs overview

Rdesktop connections to RGA computers are available on this page.

10.1.10 Control of MV2

To enable taking control of the MV2 a power supply interrupt has been installed with the units which will drop the DC supply to the unit for some seconds. The unit will then reboot whence you may take over control. This is shown in the GUI below.

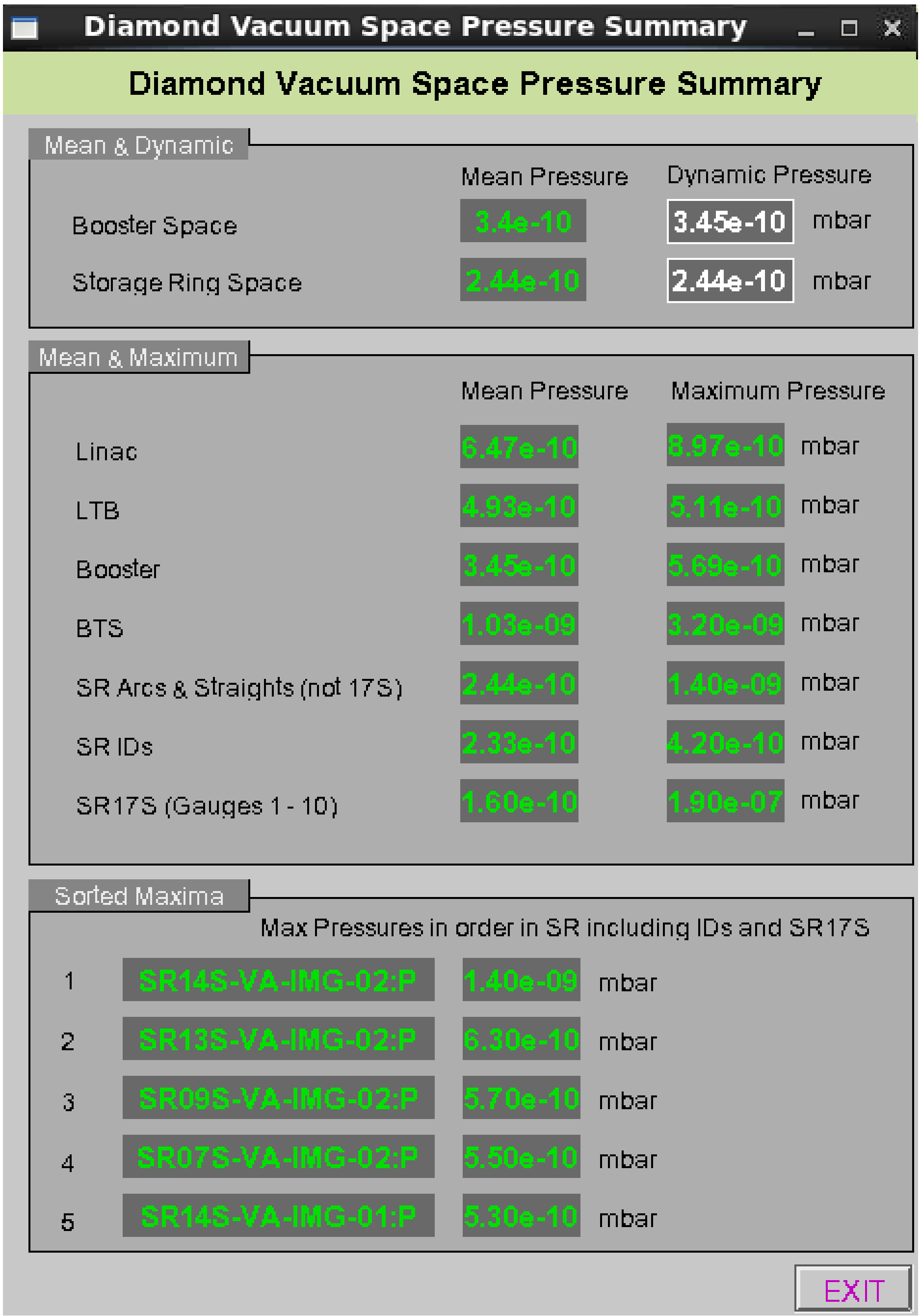




Interlocks at a glance around the ring.

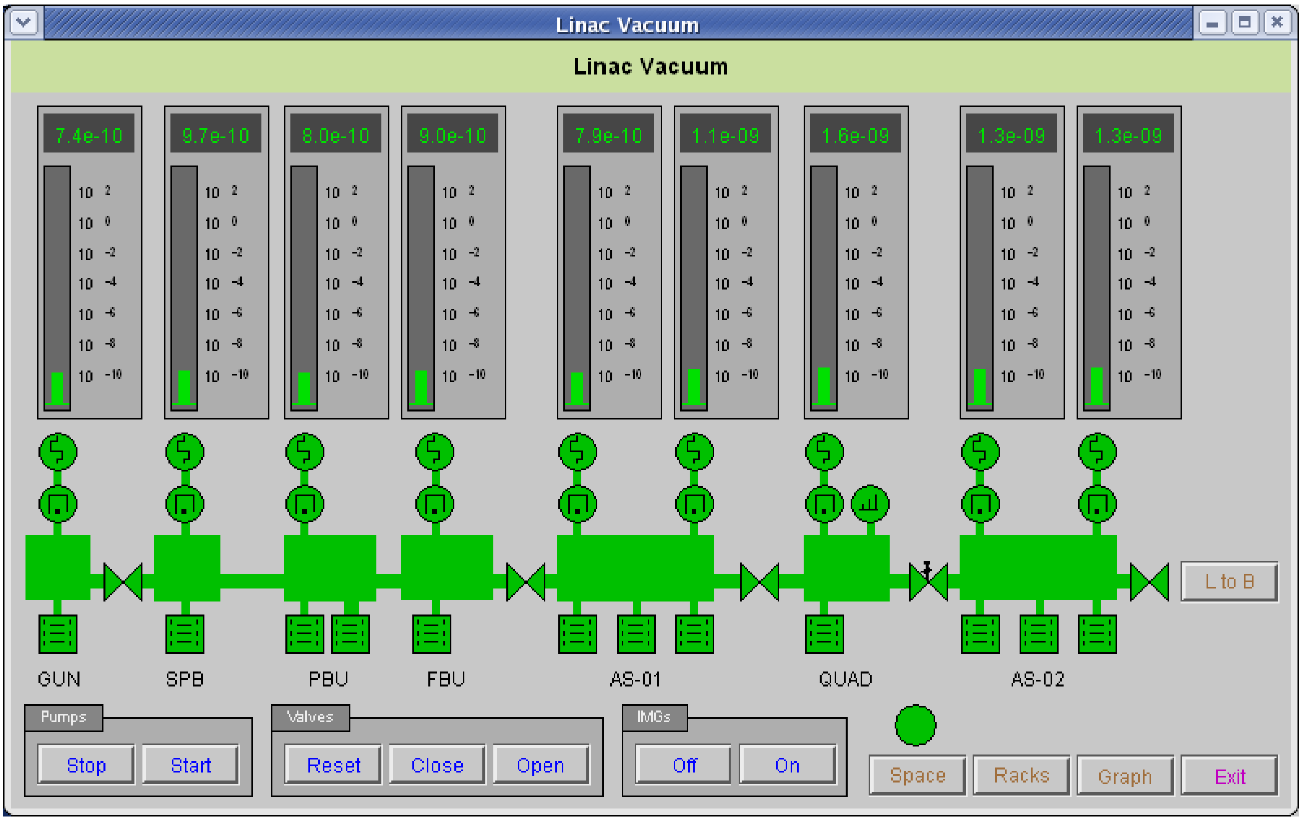
Note that the interlocks shown here are the valve interlocks which are latched, the valves interlocks need to be reset to clear them even when they are good.

We have a vacuum space summary which will display the maximum pressures around the ring. This is a useful function for the operators when some new equipment has been installed during a shutdown and they can observe at a glance any trouble some areas.



10.1.11 Linac

The Linac EDM displays all the valves, gauges, and pumps on one display. The fourth valve is a fast valve, (VAT Series 75) with a Viton seal. The EDM has a spring on this valve to indicate is different. This valve is also different in its use and generally it is only shut due to a vacuum failure or inrush of air or for maintenance.
On this EDM we can see that we can control individual gauges and pumps as well as all the LINAC pumps and gauge controllers in one action. To see details of a gauge, pump or valve click on the appropriate symbol as previously described.

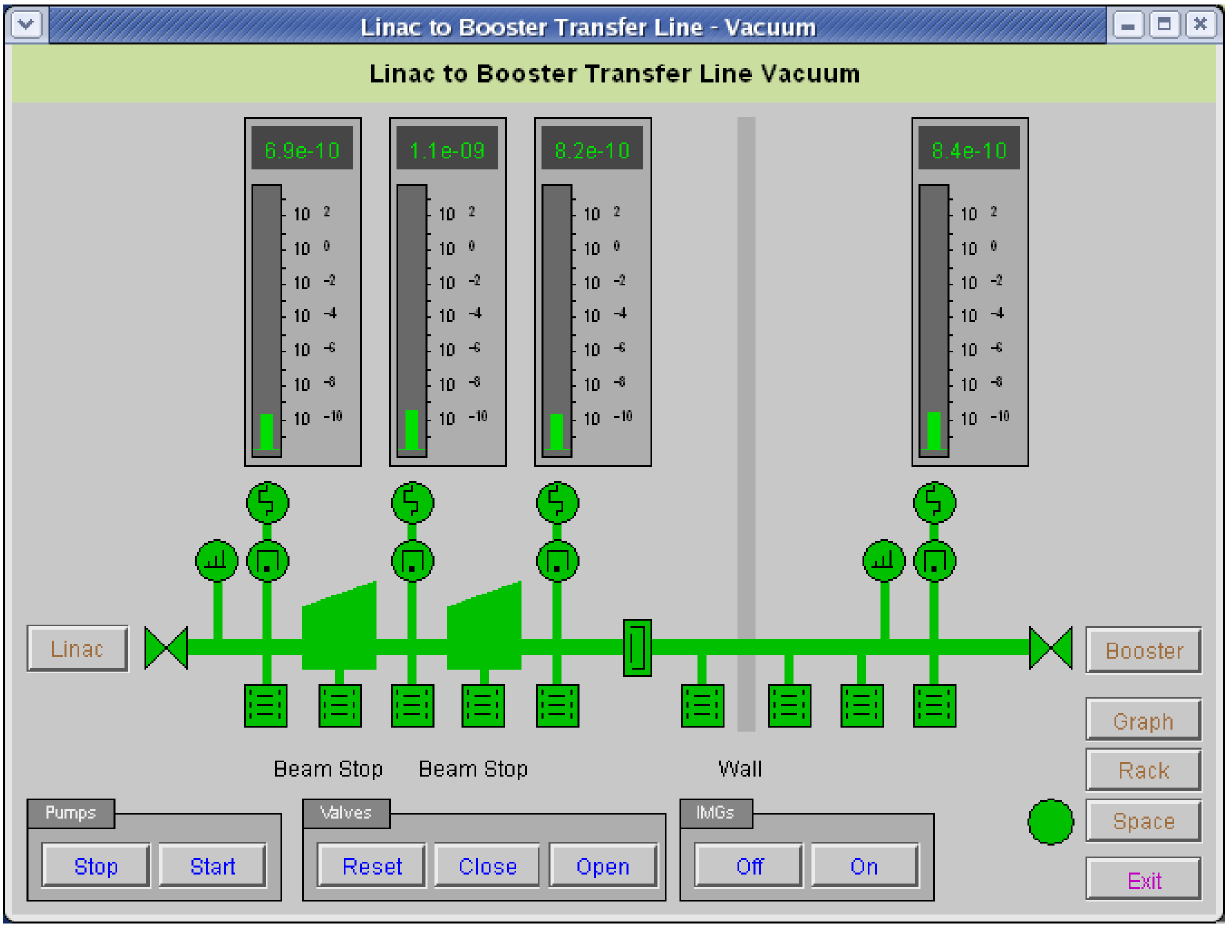


To open the valves in the LINAC all the gauges have to be healthy. Once the **<u>fast</u>** valve is opened then it will not shut unless by a command during the arming or by being triggered by the fast valve gauges. All other valves will close if the run vacuum is lost. The run vacuum is dependent on all gauges being healthy except one. (Note the run vacuum condition was put into the LINAC because of spurious trips from the gun vacuum)

10.1.12 LTB

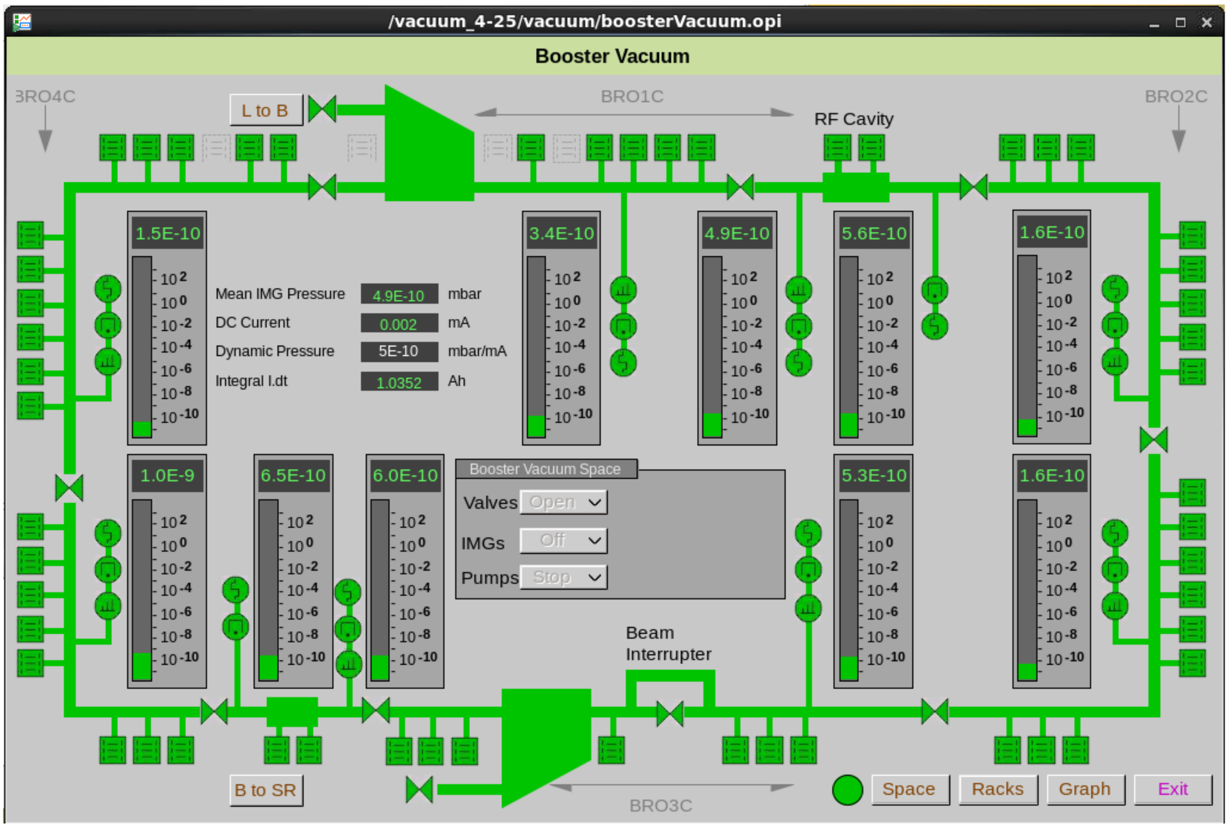
The LTB EDM is shown next. The LTB travels through a wall separating the LINAC from the Booster. The vacuum electronics for the part of the LTB in the LINAC area, referred to as LTB1, is housed in the LTB1 vacuum rack in the LINAC CIA. The electronics for LTB2, the section in the booster tunnel, is housed in the Booster 1 CIA (BR01C). From a valve controls point of view the LTB is considered to be part of the Booster, and so all PLC controls for this area come from the valve control crate in BR01C.

There is a valve control unit in the LTB1 rack which drives a radiation shutter, this is independent of the vacuum system so does not need to be considered here.



10.1.13 Booster

The EDM for the booster is shown below. It is shown as a rectangle to clearly show the sections which are controlled by different CIAs, there being 4 CIAs in the booster.

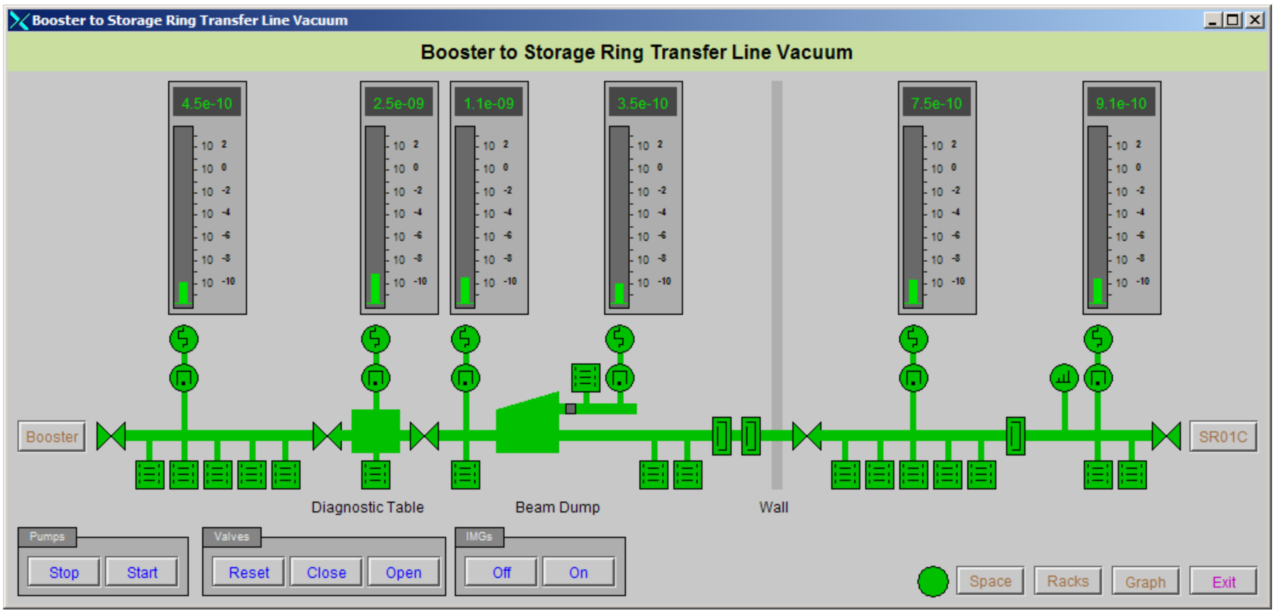


The booster is treated as one vacuum section in the control of its valves. This means that if any one gauge interlock is lost, all valves of the booster will close.

10.1.14 BTS

The electronics for the BTS is housed in CIA 24. The vacuum equipment is interlocked via a 6-valve control crate, which monitors the straight of cell 1 of the storage ring. A 6-valve crate is used, as this is the Diamond standard control crate capable of interfacing with the electronics for a fast valve.

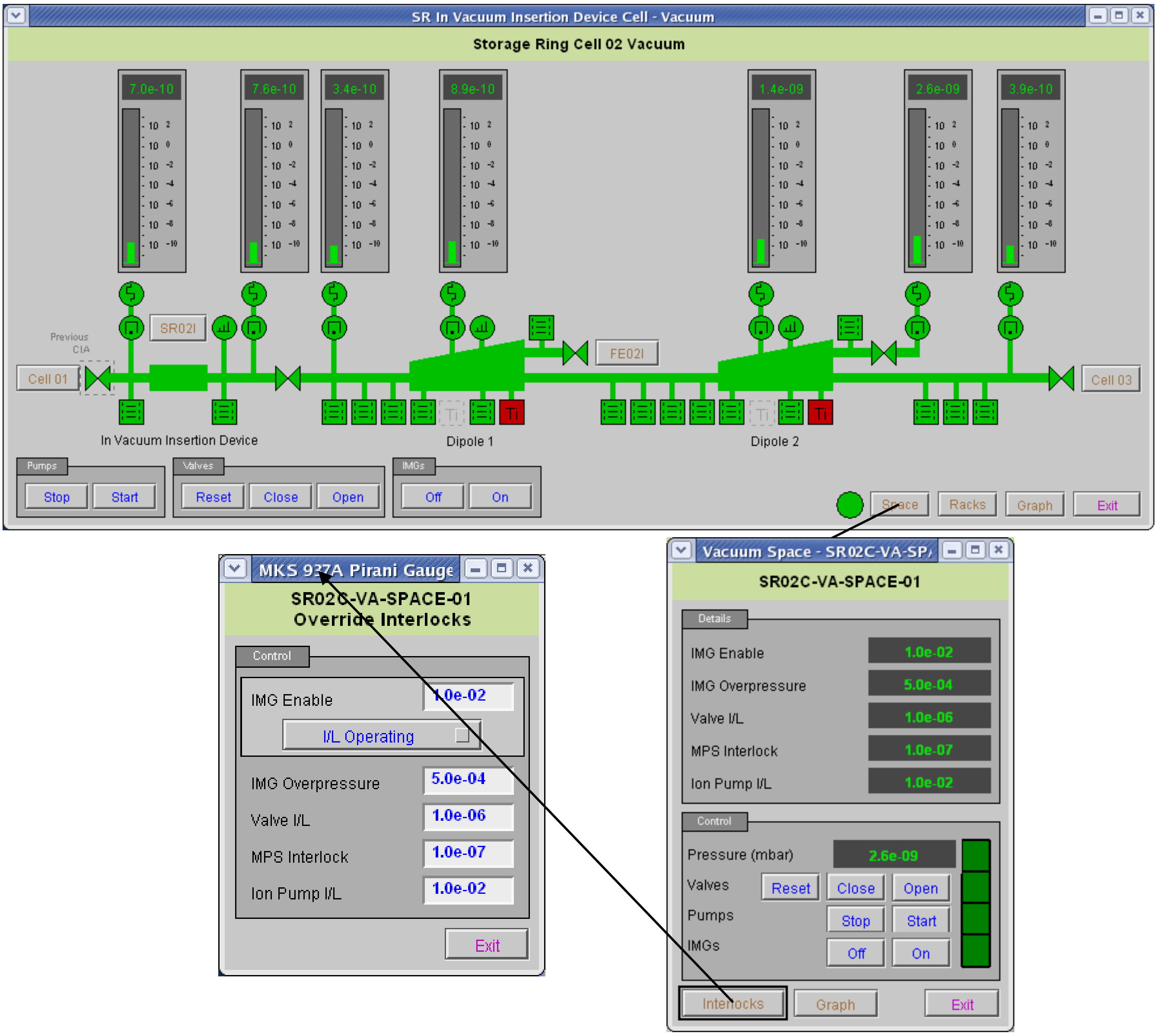
The fast valve is to protect the storage ring and works in conjunction with valve 2 of the BTS



10.1.15 Storage Ring

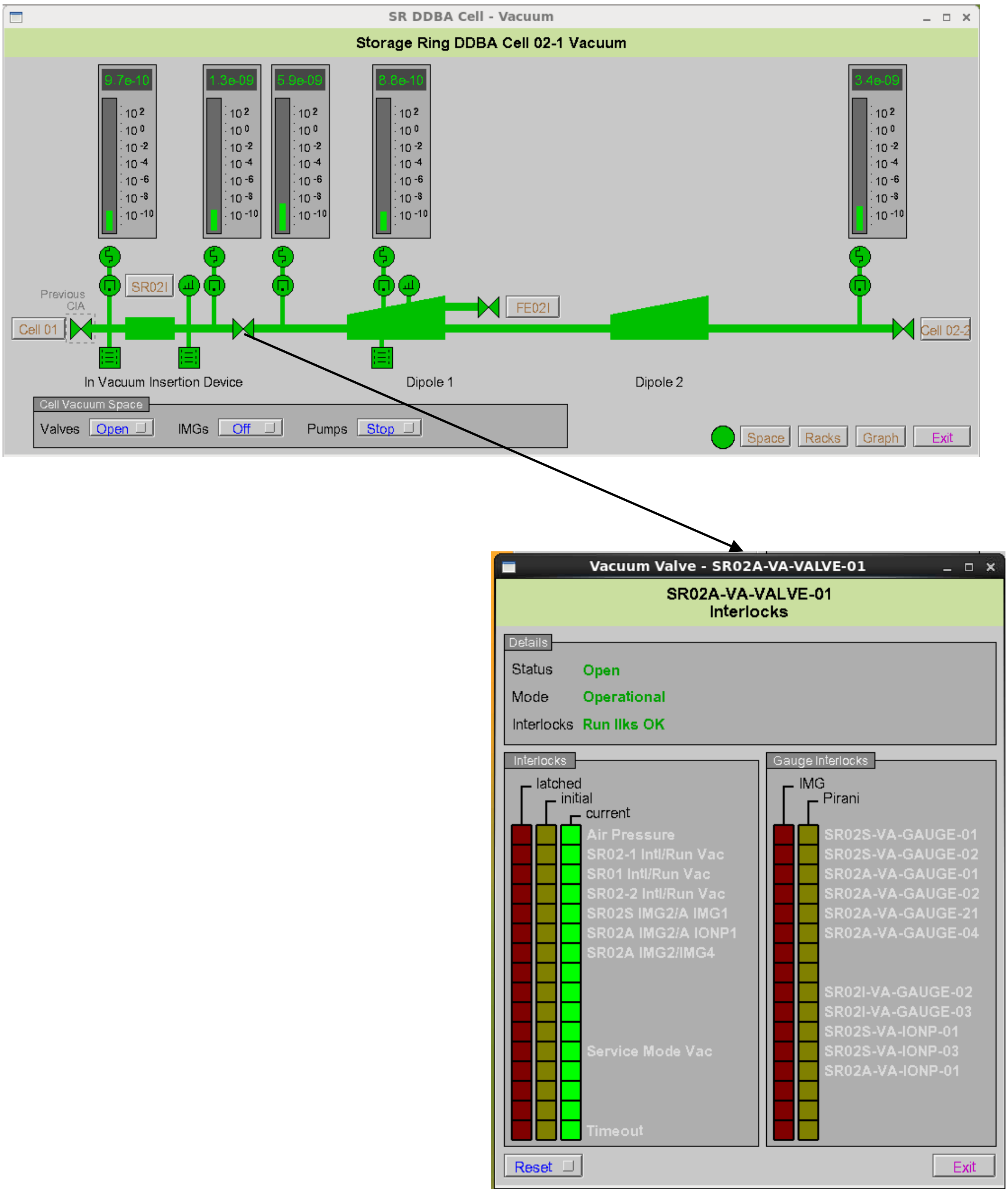
A typical EDM for the storage ring is given below. You can navigate from one cell to another with the "next cell" and "previous cell" buttons.

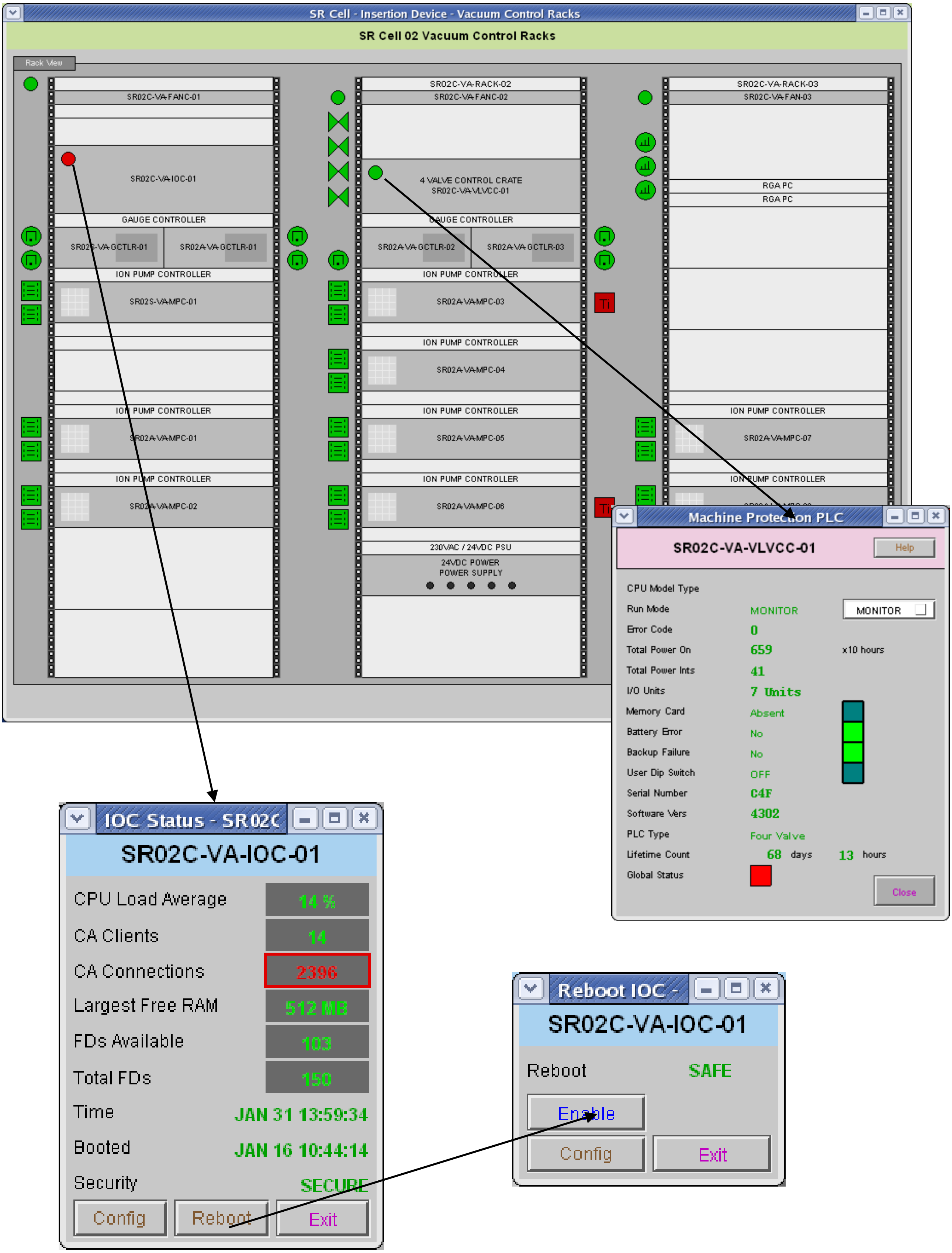
Vacuum operations can be carried out on the whole cell or on vacuum spaces within the cell. Clicking on "space" gives the whole cell, whilst clicking on the vacuum pipes will give you functions for the vacuum subsection within the cell.



Clicking on the Racks display shows the EDMs following:

The new DDBA shown below section uses the ion pump setpoint 2 levels to double up on the gauge interlocks, allowing us to keep the 3 interlocks to fail principle which allows for a gauge controller to fail without tripping the beam. We have kept the vacuum sections as 2 dipole sections, which mean splitting sector 2 into to two, so that we can keep the identical valve logic based on our 4 valve controllers.



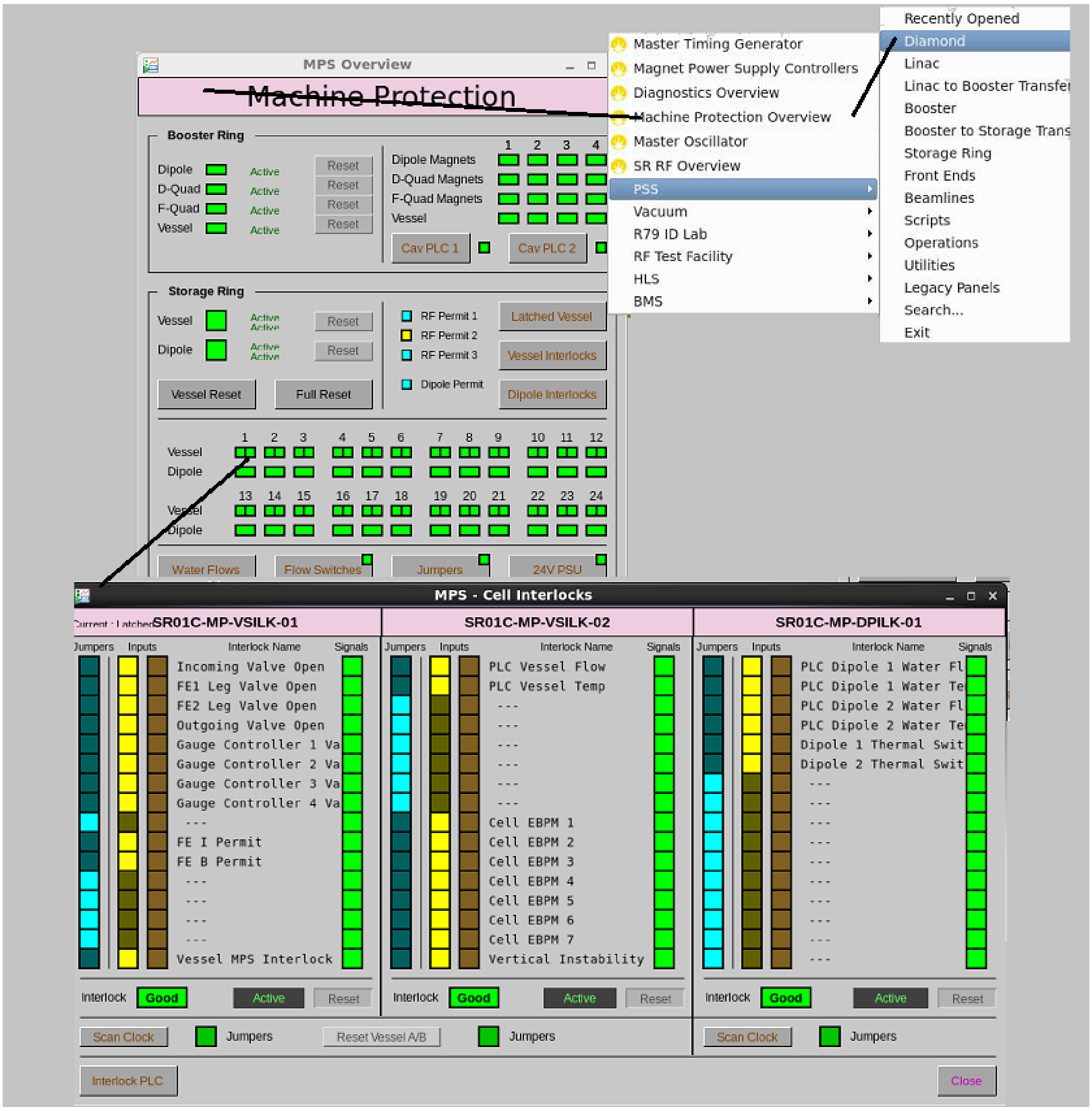


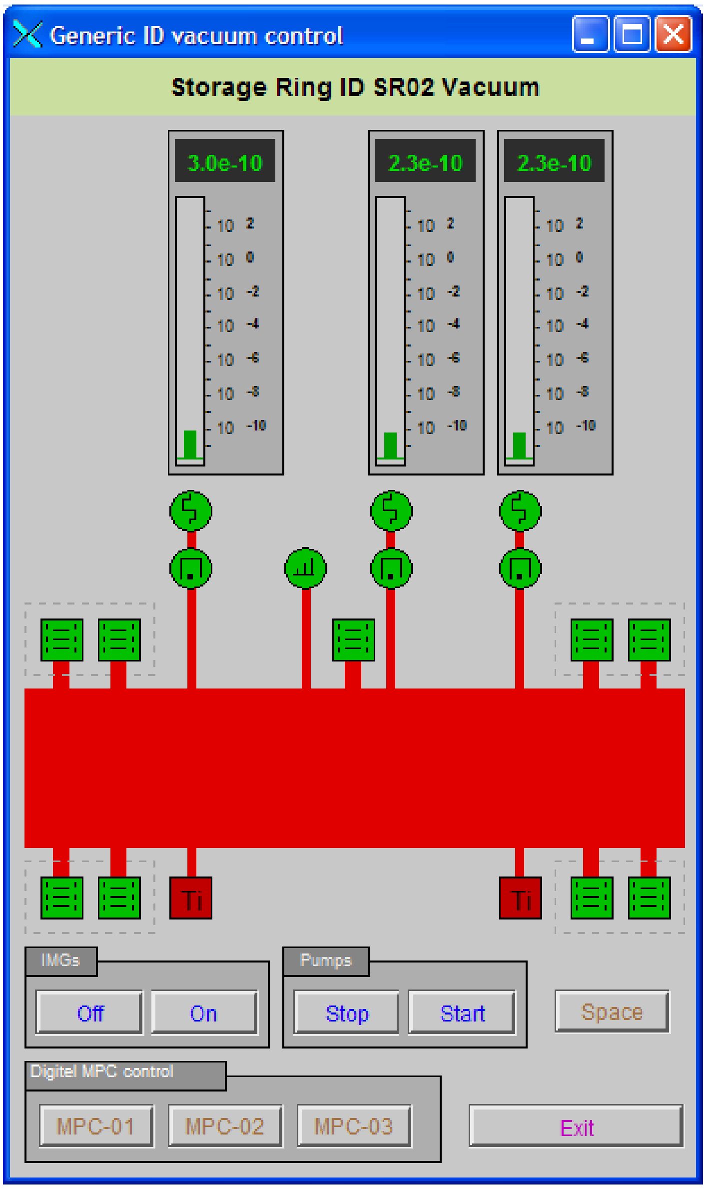
SR Cell - Insertion Device - Vacuum Control Racks
SR Cell 02 Vacuum Control Racks
Rack View
SR02C-VA-FANC-01
SR02C-VA-IOC-01
GAUGE CONTROLLER
ION PUMP CONTROLLER
SR02C-VA-RACK-02
SR02C-VA-FANC-02
4 VALVE CONTROL CRATE
SR02C-VA-VLVCC-01
SR02C-VA-RACK-03
SR02C-VA-FAN-03
RGA PC
230VAC / 24VDC PSU
24VDC POWER
POWER SUPPLY
Machine Protection PLC
SR02C-VA-VLVCC-01
Help
CPU Model Type
Run Mode
MONITOR
Error Code
0
Total Power On
659
x10 hours
Total Power Ints
41
I/O Units
7 Units
Memory Card
Absent
Battery Error
No
Backup Failure
No
User Dip Switch
OFF
Serial Number
C4F
Software Vers
4302
PLC Type
Four Valve
Lifetime Count
68 days 13 hours
Global Status
Close
IOC Status - SR02C
SR02C-VA-IOC-01
CPU Load Average
14 %
CA Clients
14
CA Connections
2396
Largest Free RAM
512 MB
FDs Available
103
Total FDs
150
Time
JAN 31 13:59:34
Booted
JAN 16 10:44:14
Security
SECURE
Config
Reboot
Exit
Reboot IOC -
SR02C-VA-IOC-01
Reboot
SAFE
Enable
Config
Exit

10.1.16 MPS interlocks

To check the MPS interlocks for a section in the storage ring go to <Launcher> <Diamond> < Machine Protection Overview> as shown below. The vacuum MPS interlocks are as below.

Gauge Controller 1 vacuum	SRXXS-IMG-02 MPS I/L or SRXXS-IONP-03
Gauge Controller 2 vacuum	SRXXA-IMG-02 MPS I/L or SRXXA-IONP-05
Gauge Controller 3 vacuum	SRXXA-IMG-03 MPS I/L or SRXXS-IONP-12
Gauge Controller 4 vacuum	SRXXA-IMG-04 MPS I/L or SRXXS-IONP-16



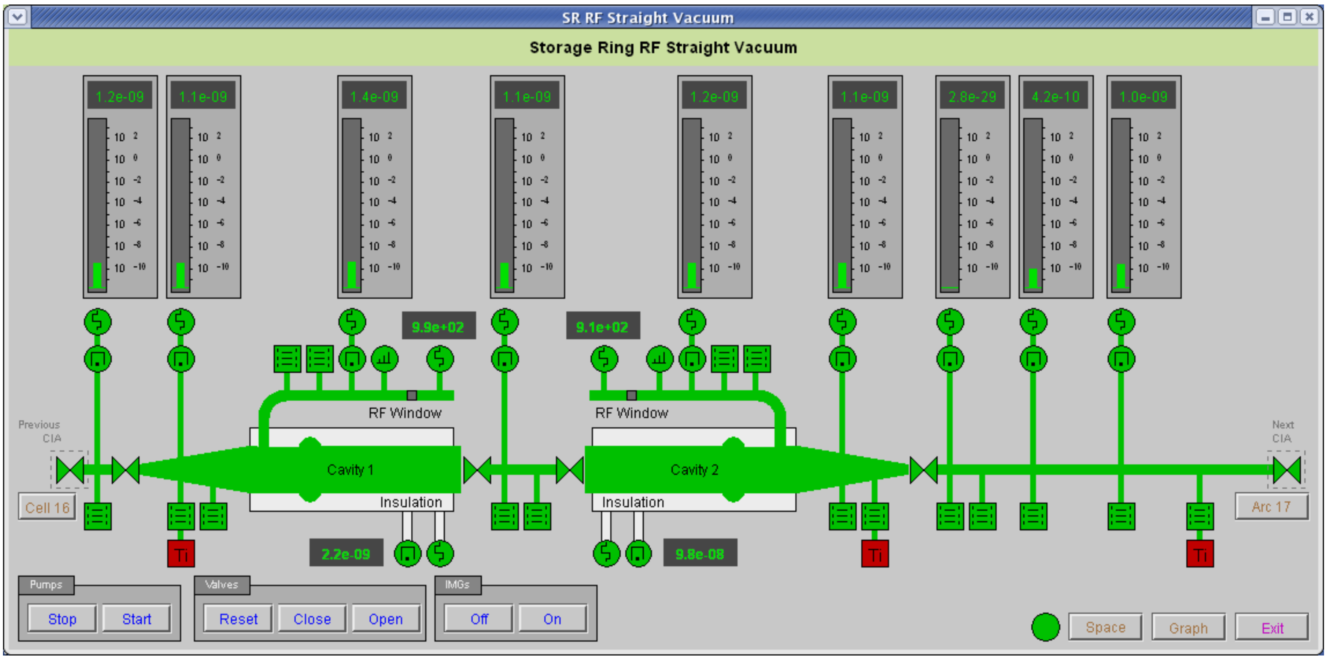

Generic ID vacuum control
Storage Ring ID SR02 Vacuum
3.0e-10
2.3e-10
2.3e-10
Ti
Ti
IMGs
Off
On
Pumps
Stop
Start
Space
Digitel MPC control
MPC-01
MPC-02
MPC-03
Exit

10.1.18 SR17S, RF straight

The RF straight is a special straight with the ability to hold up to 3 superconducting RF cavities. Each cavity is housed between its own 2 isolation valves. Therefore the RF straight has to have up to 6 extra sector valves with 3 cavities fitted. Each cavity has its own IOC, which interfaces to the RF instrumentation and the vacuum equipment. There is a 6-valve control crate which interfaces with the sector 17 4-valve control crate via gauge connector 1 (on other straights used for the straight gauge I/P) and the Gauge connector 5 (on other straights connected to ID electronics).

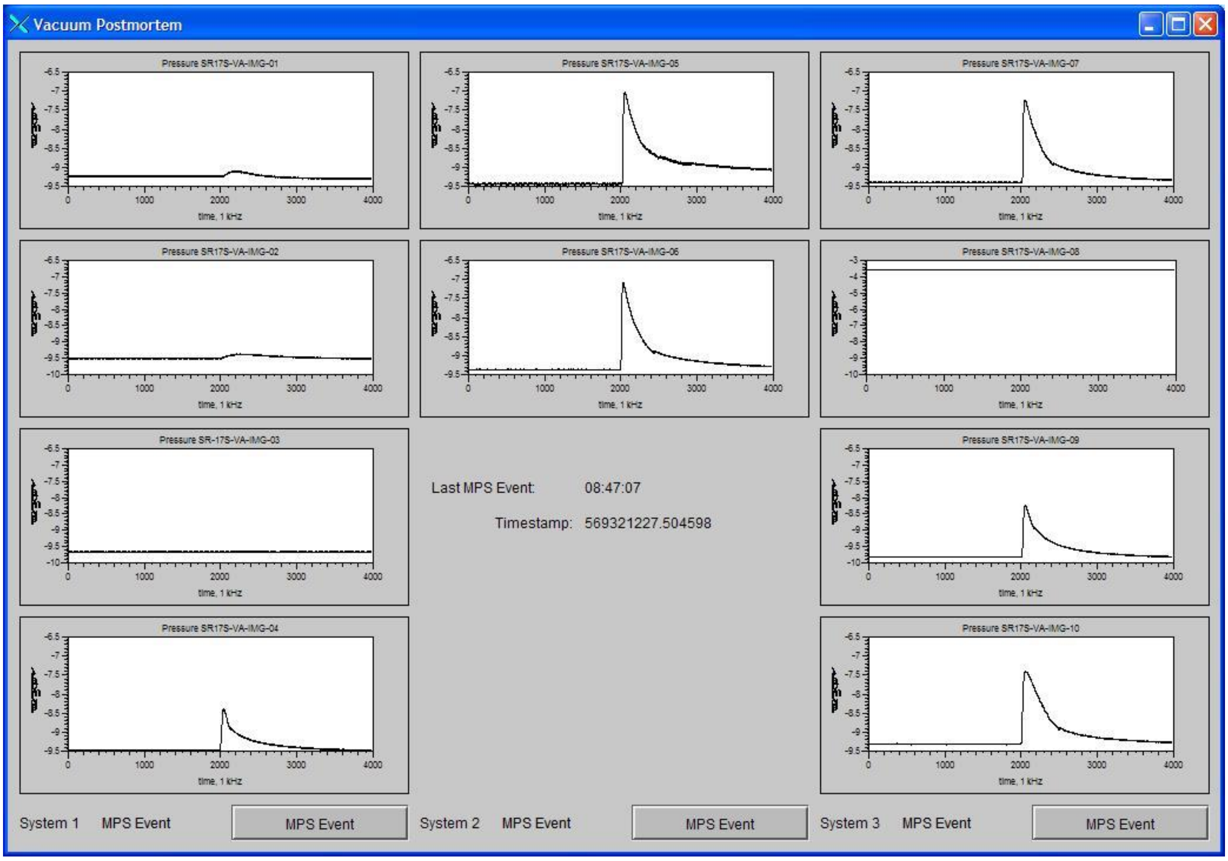
Four of the sector valves in the RF straight are large DN250 valves. These valves take some 30 seconds to open and shut and have large pneumatic cylinders, because of this the air pressure switch is only used to stop operation if the air pressure is not there. It does not shut the valve in case of the air pressure switch not making during an operation

SR17S-VA-VALVE-04 is orientated on its side and because of this it has a very limited number of operations. It has been designed because of limited operation so that after closing the valve a switch needs to be reset just under the 6-valve controller in the CIA17 before it can be reopened. This valve will only close on an operator's demand and not automatically on a vacuum failure.



RF cavities as cryo-systems operating at 4.2K, and therefore feature 2 vacuum spaces: the beam vacuum and the insulation vacuum. Beam vacuum is UHV, as the rest of the Storage Ring, whereas insulation vacuum is only HV and pumped by cryo-sorption only. Cavity interlocks are controlled by 3 independent PLC, one for each cavity. Each one will integrate vacuum interlock, cryogenics interlock and power interlocks to protect the cavities.

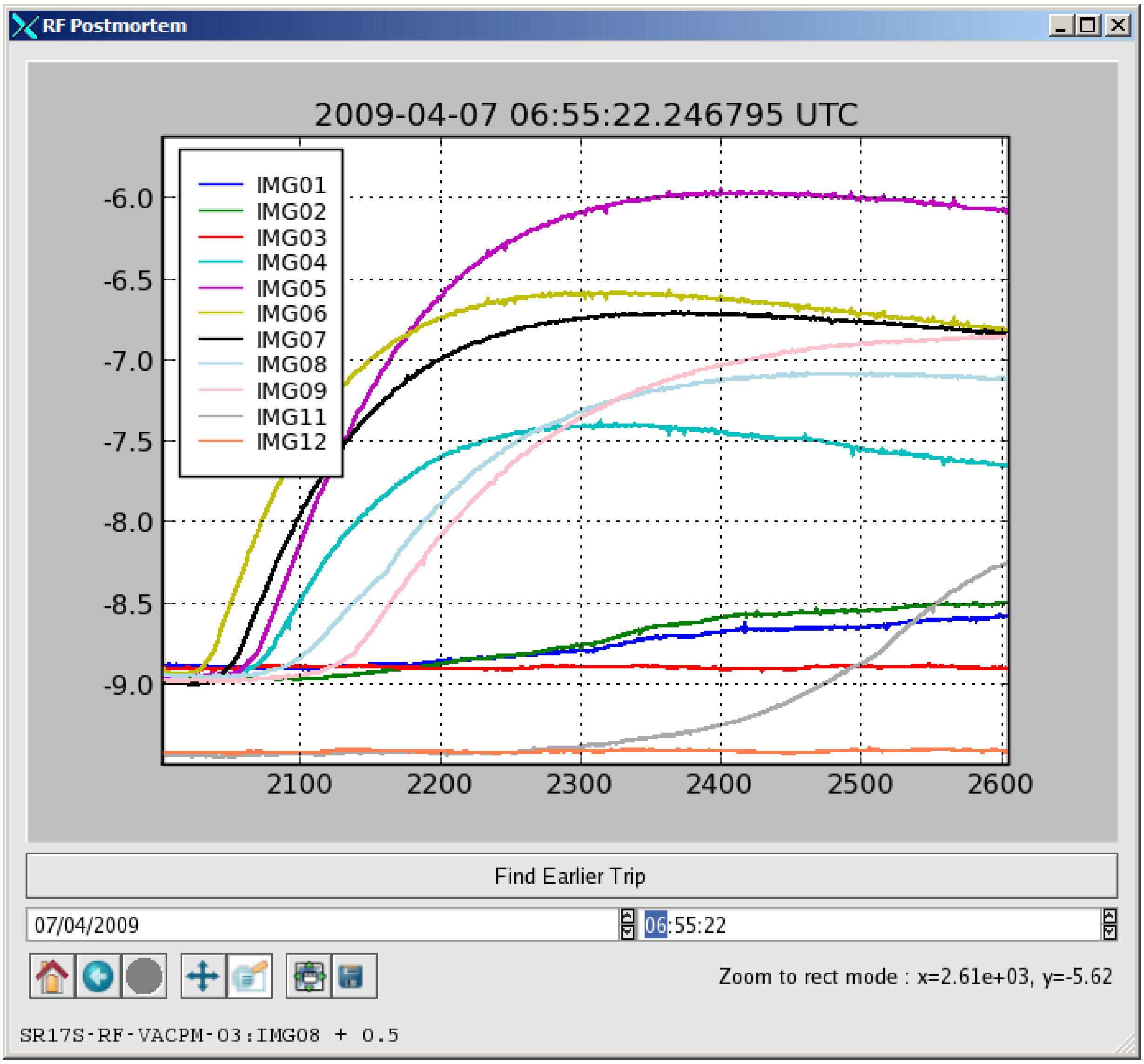
As cavities are very important for operation, some specific fast vacuum monitoring has been implemented to diagnose their vacuum behaviour. The buffered analogues from the IMG exposed to beam vacuum are therefore monitored at 1 kHz on a rolling buffer triggered by MPS event. ±2s of data is thus recorded and archived for each beam trip that occurs thus giving us a vacuum signature of the cavities event.



RF cavities vacuum post mortem

The cavity gauges and the first 2 SR17A gauges have now been connected to one system so that we can record when all the gauges respond to the pressure burst with respect to each other. If we plot the time they respond against their actual X position we can find out exactly where a vacuum event occurs. The next plot shows an event occurring around IMG-06 of the cavities (this is the taper of cavity 2) and propagating down the cavities and arc.

This system can be found from the launcher, storage ring, ring RF, VAC post-mortem GUI.



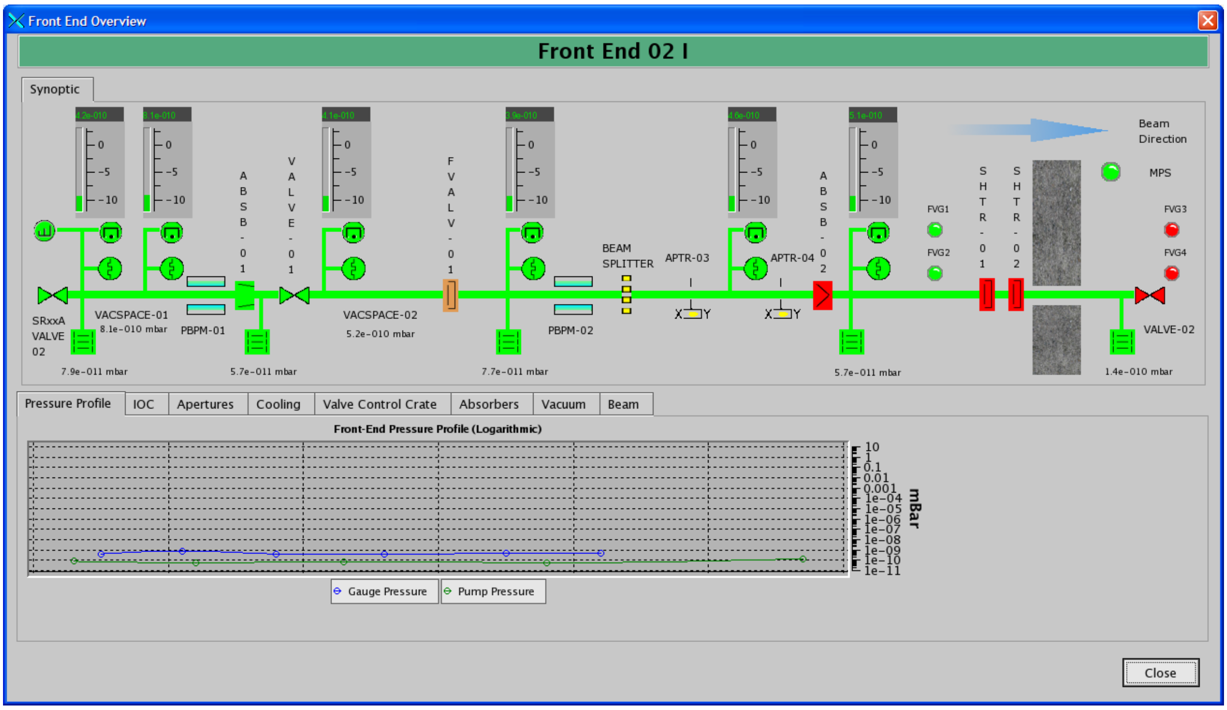
RF Postmortem
2009-04-07 06:55:22.246795 UTC
IMG01
IMG02
IMG03
IMG04
IMG05
IMG06
IMG07
IMG08
IMG09
IMG11
IMG12
-6.0
-6.5
-7.0
-7.5
-8.0
-8.5
-9.0
2100
2200
2300
2400
2500
2600
Find Earlier Trip
07/04/2009
06:55:22
Zoom to rect mode : x=2.61e+03, y=-5.62
SR17S-RF-VACPM-03:IMG08 + 0.5

10.1.19 Front ends

Front ends are the most complicated part of the vacuum system from a controls point of view. This is because the vacuum system needs to be linked to the cooling system and the operation of the absorbers along with the operation of the machine so that valves are not closed across the beam. It should be noted that the interface to the valve crate for the absorbers and the shutters is identical to the interface to the valves. The interlock chains for these devices are shown in much the same way as the valves.

The shutter has one difference to the other devices in the fact that the operation signals go through the PSS (personnel safety system). This means that PSS can override all operations to the shutters.

A mimic of the front end is shown below



Modes of operation for the front end may be summarised as follows:

10.1.19.1 As beamport absorber 1

The front end may be operated as a beam port absorber in the sense that the Absorber 1 is closed and V1 is closed, all the power is stopped by the absorber. What happens downstream of V1 is not linked to the machine.

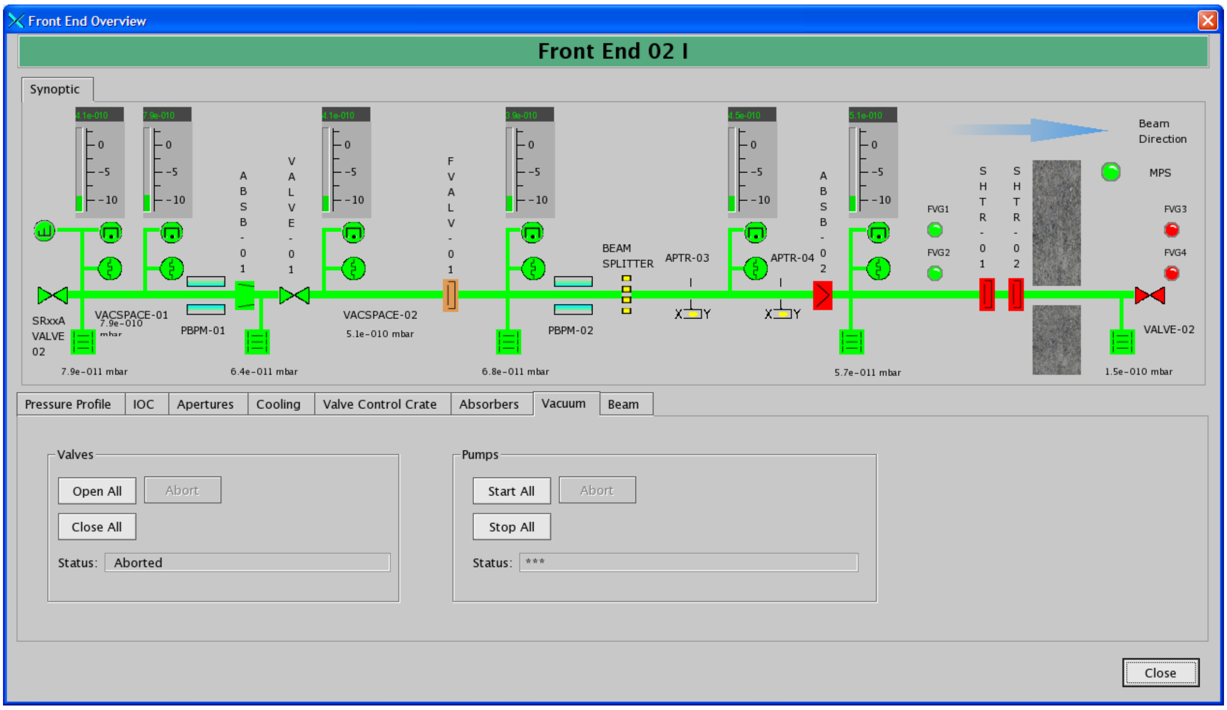
10.1.19.2 As beamport absorber up to absorber 2

The front end can be opened up to Absorber 2. In this case, Absorber 1, Valve1 and Fast valve 1 need to be open. To open V1 the fast valve must be open and partially armed, this means that the fast valve is ready to shut if the first set of fast valve gauges are ready to trip.

10.1.19.3 Open to beamline

To open the front end up to the beamline, the beamline has to be ready to take beam. Then absorber 1 & 2, shutter 1 & 2, V1 and the fast valve has to be open. The fast valve must be fully armed to open V2, this means that the 4 Fast valve gauges (FVG) must be on. Two of the gauges are in the front end and two of the gauges are in the beamline.

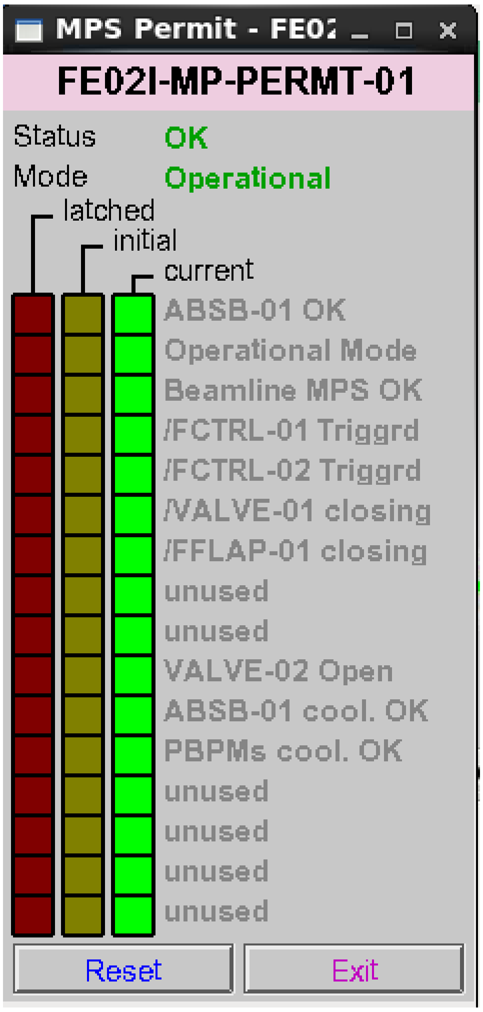
There are pages in the mimic which will allow the opening and closing of the valves and shutters automatically, as shown below.

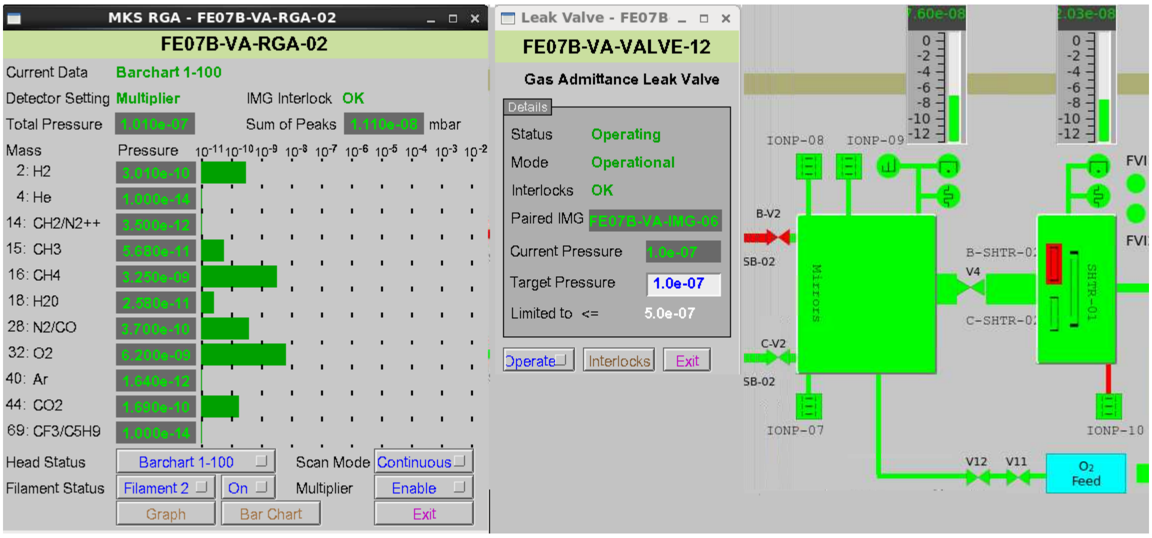


Note: The fast valve gauges (FVG) status is now shown on the mimic. The gauges turning green when on and Red when off.

10.1.19.4 Front end permit

For the beam to run in the storage ring a front end permit has to be generated. This is to make sure that the x-ray beam cannot impinge on any vacuum valves, and that the water flow to x-ray absorbers is satisfactory, also that beam lines are protected with either the optics hutch being locked up or and x-ray shutters are down along with the appropriate absorber.

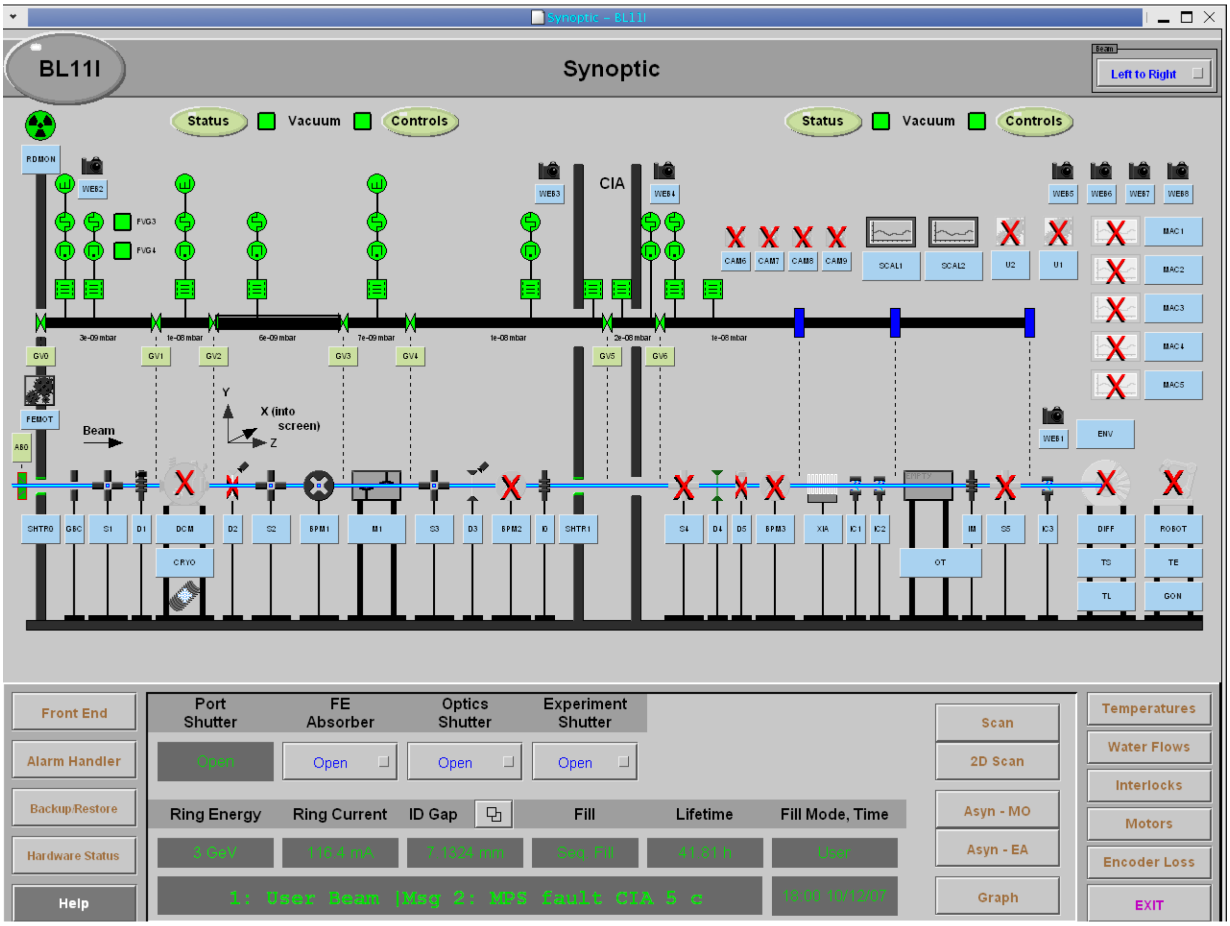




Above is the leak valve control of the mirror box. The required pressure can be set and then the valve is driven to this pressure. The mass spectrometer shows the partial pressure of the oxygen leaked into the system.

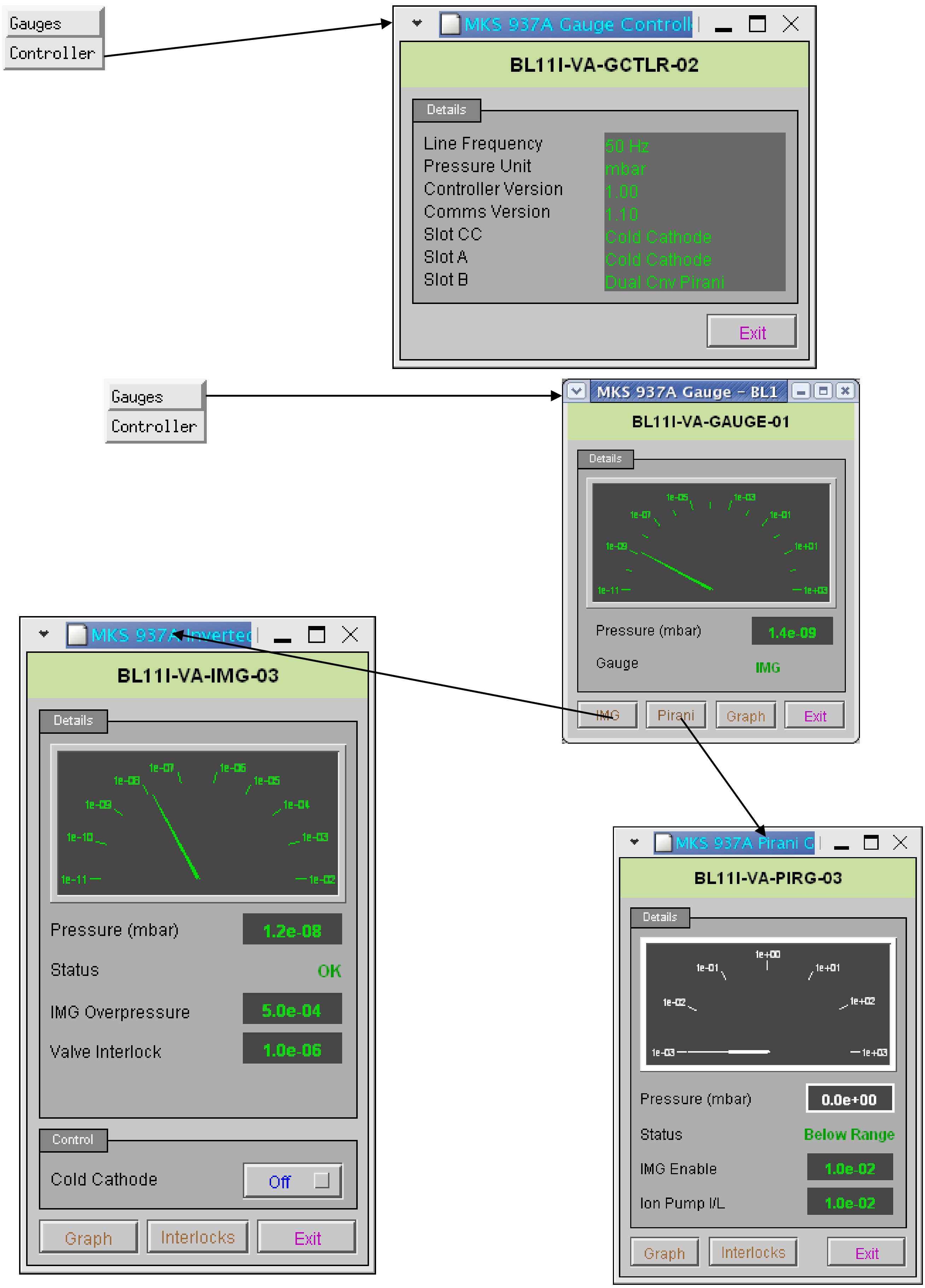
10.1.20 Beamlines

The vacuum overviews and gauge details are a little different on the beamlines as they have been developed from the first concepts to actuality by a different set of controls software engineers. A typical synoptic of a beamline is given below.



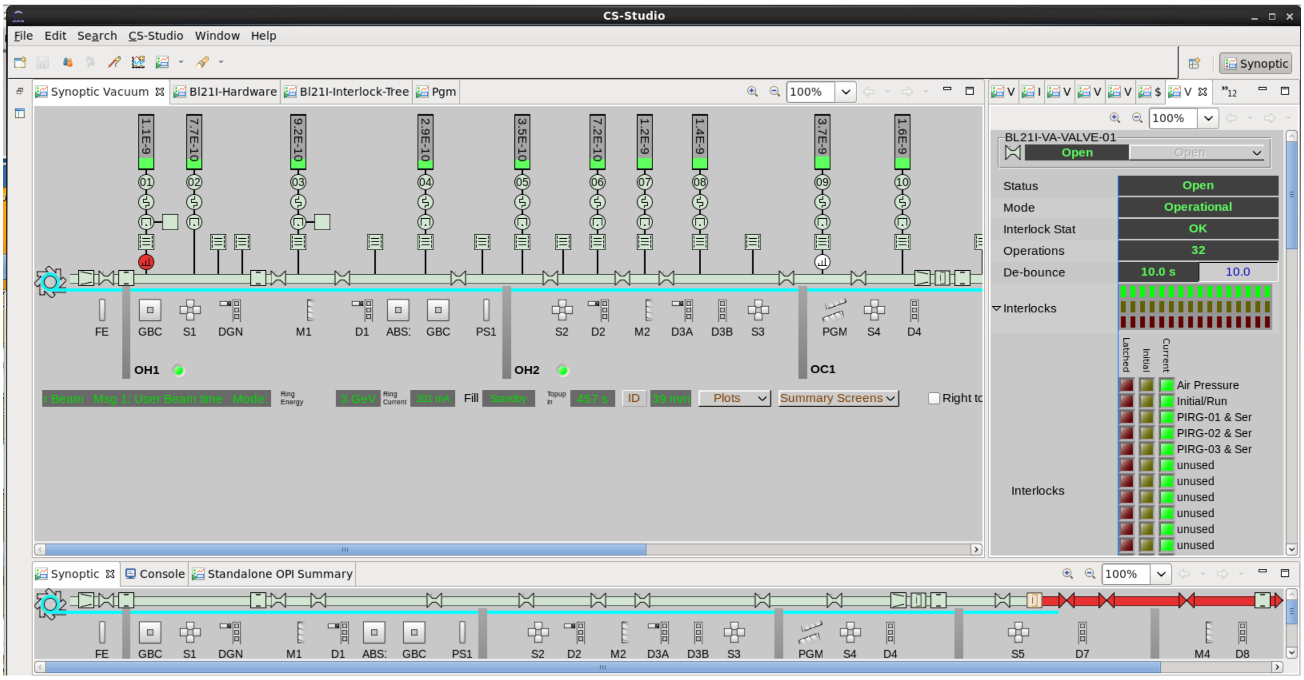
The black beam pipe is demonstrating ready for beam. If a valve is closed then the beam pipe will go red.

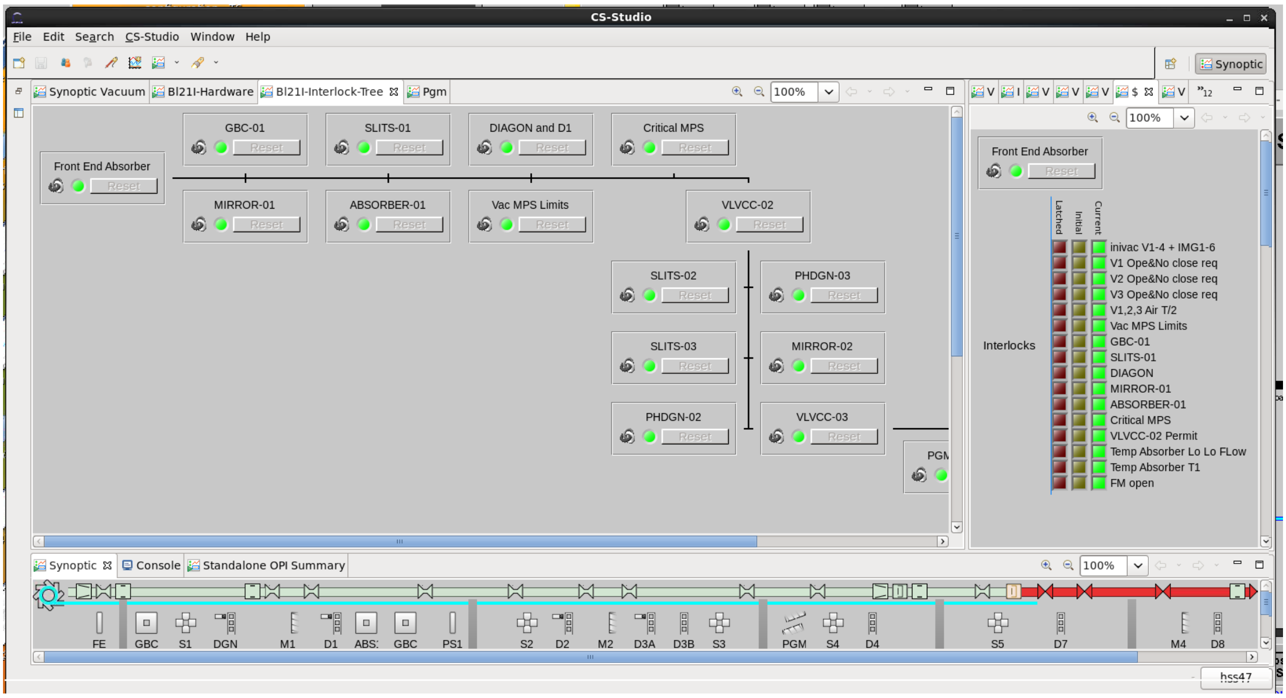
Clicking on IMG or Pirani brings up the following gauge/ controller button


Gauges
Controller
MKS 937A Gauge Controll
BL11I-VA-GCTLR-02
Details
Line Frequency 50 Hz
Pressure Unit mbar
Controller Version 1.00
Comms Version 1.10
Slot CC Cold Cathode
Slot A Cold Cathode
Slot B Dual Cnv Pirani
Exit
Gauges
Controller
MKS 937A Gauge - BL1
BL11I-VA-GAUGE-01
Details
Pressure (mbar) 1.4e-09
Gauge IMG
IMG
Pirani
Graph
Exit
MKS 937A Inverted
BL11I-VA-IMG-03
Details
Pressure (mbar) 1.2e-08
Status OK
IMG Overpressure 5.0e-04
Valve Interlock 1.0e-06
Control
Cold Cathode Off
Graph
Interlocks
Exit
MKS 937A Pirani G
BL11I-VA-PIRG-03
Details
Pressure (mbar) 0.0e+00
Status Below Range
IMG Enable 1.0e-02
Ion Pump I/L 1.0e-02
Graph
Interlocks
Exit

10.1.21 Beamlines using CSS

A typical example of a CSS interfaced beamline is shown below. The main user advantages are the tidiness of the captured GUI's, within a cell, and the graphing/plotting function which enables the combination of archive data with current data to be displayed.





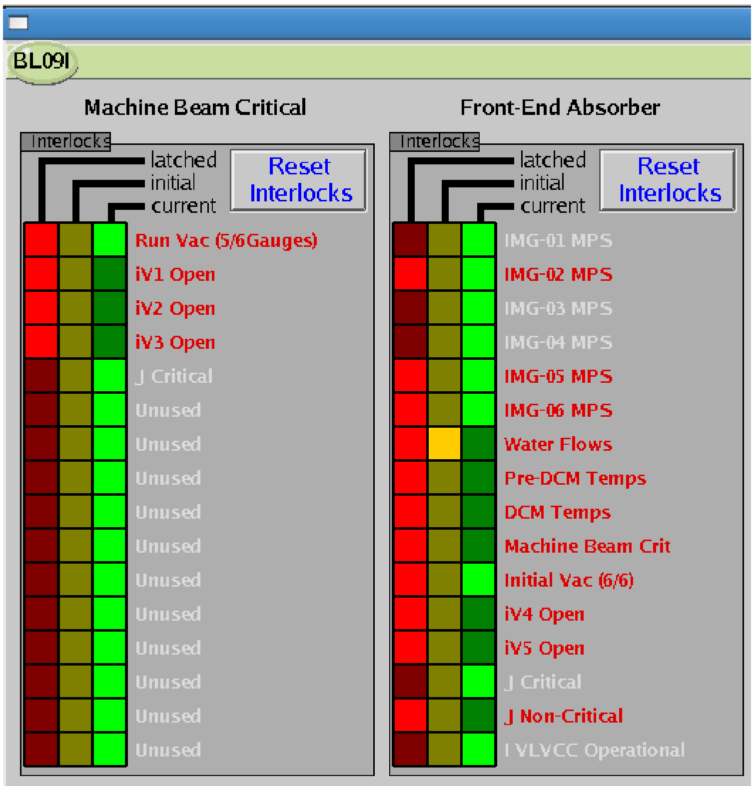
As in the case with the machine, clicking on interlocks gives the interlock set points for the IMGs and the Pirani gauges.

The pressures as described under the vacuum pipes or in the vacuum spaces are taken from the analogue signals. The pressure as shown on the gauge EDM is taken from the combination of analogue signals. The pressures as shown on the actual IMG EDM and Pirani EDM are taken from the serial reading from the Gauge.

10.1.22 Reducing trips

In an attempt to reduce trips a number of actions have been carried out.

1. The first gauge controller of all beamlines has been exchanged for a 937b. This is so we can set an interlock on pressure much below an interlock off pressure this ensuring the vacuum in the beamline is good before opening to the machine.
2. The interlock system between the beamlines and the machine has been made transparent by dividing out 2 of the interlocks going to the frontend into **"Machine beam critical"** and **"Front-end Absorber".** The Front-end absorber interlocks are set to be far more stringent than the machine beam critical interlocks so that the frontend absorber is closed before anything in the beamline develops into something that will warrant the machine being turned off. This has been applied to all beamlines.



3. We have started to change the interlocks on the storage ring and frontend such that a gauge controller can be powered off or fail and the beam will not trip as long as adjacent gauge interlocks are healthy. A run vacuum condition will be healthy until more than 2 gauge interlocks have failed. This has meant some slight alterations to the PLC code and EPICS displays as well as some minor rewiring. These have now all been completed.

11. INTERLOCK TABLES

11.1 Machine interlocks

Linac

LI-VA-VALVE-01	Open	Initial vacuum Linac									Air press
	Maintain open	Run vacuum Linac									Air press
LI-VA-VALVE-02	Open	Initial vacuum Linac									Air press
	Maintain open	Run vacuum Linac									Air press
LI-VA-VALVE-03	Open	Initial vacuum Linac									Air press
	Maintain open	Run vacuum Linac									Air press
LI-VA-FVALV-01	Open										
	Maintain open										
LI-VA-VALVE-05	Open	Initial vacuum Linac	LB-VA-IMG-01	LI-VA-FVALV-01 OPEN	LI-VA-FVALV-01 Armed						Air press
	Maintain open	Run vacuum Linac	LB-VA-IMG-01								Air press

Initial Vacuum all Linac Gauges healthy, LI-VA-IMG-01 to LI-VA-IMG-09
Run Vacuum all Linac Gauges bar one healthy, LI-VA-IMG-01 to LI-VA-IMG-09

Booster & LTB

LB-VA-VALVE-01	Manual Valve										
LB-VA-VALVE-02	Open & Maintain Open	Booster IMG 1 to 11 Healthy	LB-VA-IMG 04								Air press
BR01C-VA-VALVE-01	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR01C-VA-VALVE-02	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR02C-VA-VALVE-03	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR3C-VA-VALVE-04	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR03C-VA-VALVE-05	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR04C-VA-VALVE-06	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR01C-VA-VALVE-07	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BR01C-VA-VALVE-08	Open & Maintain Open	Booster IMG 1 to 11 Healthy									Air press
BS-VA-VALVE-01	Open & Maintain Open	Booster IMG 1 to 11 Healthy	BS-VA-IMG 01								Air press

BS

BS-VA-VALVE-??	Manual Valve										
BS-VA-FFLAP-02	Open	BS-VA-IMG-03	BS-VA-IMG-04								
	Maintain open	BS FVG01 & 02 Not triggered									
BS-VA-VALVE-02	Open	BS IMG 01 to 04	BS-VA-FFLAP-01 OPEN	BS-VA-FFLAP-01 armed							Air press
	Maintain open	BS IMG 01 to 04	BS-VA-FFLAP-01 OPEN								Air press

Storage Ring

SRXXA-VA-VALVE-01	Open	Initial vacuum sector(xx-1)	Initial vacuum sector(xx)	Initial vacuum sector(xx+1)	SRXXS IMG2/A IMG1	SRXXA IMG2/A IMG3	SRXXA IMG3/A IMG4				Air press
	Maintain open	Run vacuum sector(xx-1)	Run vacuum sector(xx)	Run vacuum sector(xx+1)	SRXXS IMG2/A IMG1	SRXXA IMG2/A IMG3	SRXXA IMG3/A IMG4				
SRXXA-VA-VALVE-02	Open	Initial vacuum sector(xx)	Initial vacuum FE(xx)I	SRXX-VA-VALVE-01 Closed	SRXX-VA-VALVE-04 Closed						Air press
	Maintain open	Run vacuum sector(xx)	Run vacuum FE(xx)I	IMG21&FE(XX)I-IMG1							Air press
SRXXA-VA-VALVE-03	Open	Initial vacuum sector(xx)	Initial vacuum FE(xx)D	SRXX-VA-VALVE-01 Closed	SRXX-VA-VALVE-04 Closed						Air press
	Maintain open	Run vacuum sector(xx)	Run vacuum FE(xx)D	IMG31&FE(XX)D-IMG1	SRXXS IMG2/A IMG1	SRXXA IMG2/A IMG3	SRXXA IMG3/A IMG4				Air press
SRXXA-VA-VALVE-04	Open	Initial vacuum sector(xx-1)	Initial vacuum sector(xx)	Initial vacuum sector(xx+1)	SRXXS IMG2/A IMG1	SRXXA IMG2/A IMG3	SRXXA IMG3/A IMG4				Air press
	Maintain open	Run vacuum sector(xx-1)	Run vacuum sector(xx)	Run vacuum sector(xx+1)	IMG4&SR(XX+1)S-IMG1						

Initial vacuum: SRXXS-VA-IMG-01, SRXXS-VA-IMG-02,SRXXA-VA-IMG-01,SRXXA-VA-IMG-02,SRXXA-VA-IMG-21,SRXXA-VA-IMG-03,SRXXA-VA-IMG-31,SRXXA-VA-IMG-04,SRXXI-VA-IMG-02,SRXXI-VA-IMG-03
Run Vacuum: Allows two of the above to be unhealthy
If no ID, or SRXXA-VA-IMG-21/31 then interlock is shorted out

RF

SR17S-VA-VALVE-01	Open	Straight Initial vacuum									Air press
	Maintain open	Straight run vacuum									
SR17S-VA-VALVE-02	Open	Straight Initial vacuum									Air press
	Maintain open										
SR17S-VA-VALVE-03	Open	Straight Initial vacuum									Air press
	Maintain open	Straight run vacuum									
SR17S-VA-VALVE-04	Open	Straight Initial vacuum									Air press
	Maintain open	Straight run vacuum									
SR17S-VA-VALVE-05	Open	Straight Initial vacuum									Air press
	Maintain open	Straight run vacuum									
SR17S-VA-VALVE-06	Open	Straight Initial vacuum									Air press
	Maintain open	Straight run vacuum									

Initial Condition for SR17S is following gauges healthy, SR17S-VA-IMG-01, SR17S-VA-IMG-02, SR17S-VA-IMG-04, SR17S-VA-IMG-06, SR17S-VA-IMG-07, SR17S-VA-IMG-09, SR17S-VA-IMG-10.
Run Condition for SR17S allows one of the above gauges interlocks to be lost. Initial Condition for SR17S is all gauges in sector healthy,
Note :2010, Pump out box gauges at 10-7mbar added with time constant debounce of 5 seconds.

Frontend

FEXXI-VA-ABSB-01	Open	5 of 6 IMG	VALVE-01 open limit switch	FEXXI Upstream coolant OK	FVALV-01 Open	SHTR01&2 open limit switch	VALVE-02 open limits	Beamline MPS OK	V2 Air Debounce/2	Beamline MPS non Critical OK	Air press
	Maintain open	5 of 6 IMG	VALVE-01 open limit switch	FEXXI Upstream coolant OK	FVALV-01 Open	SHTR01&2 open limit switch	VALVE-02 open limits	Beamline MPS OK		Beamline MPS non Critical OK	Air press
FEXXI-VA-VALVE-01	Open	FE Initial vacuum (6of6)	FVALV open & partial armed	IMG-02/IMG-03	IMG-04/IMG-05	ABS not clsd/5of6 IMG					Air press
	Maintain open	FE Run vacuum (4of6)	FVALV open & partial armed	IMG-02/IMG-03	IMG-04/IMG-05	ABS not clsd/5of6 IMG					Air press
FEXXI-VA-FVALV-01	Open	FE Initial vacuum									Air press
	Maintain open	FVG-01 & 02 Not tripped	FVG-03 & 04 Not tripped								Air press
FEXXI-VA-SHTR-01(Port)	Open	Guard line A	Guard line B								Air press
	Maintain open	Guard line A	Guard line B								Air press
FEXXI-VA-SHTR-02(Optics)	Open	Guard line A	Guard line B								Air press
	Maintain open	Guard line A	Guard line B								Air press
FEXXI-VA-VALVE-02	Open	FE Initial vacuum (6of6)	BL Initial vacuum	Valve1 open, FVALV fully arm	GRD A or not V2 Close	GRD B or not V2 close					Air press
	Maintain open	FE Run vacuum (4of6)	BL Run vacuum	Valve1 open, FVALV fully arm	GRD A or not V2 Close	GRD B or not V2 close	IMG06+BLIMG01				Air press

Front end initial vacuum FEXX-VA-IMG-01 to 06 healthy
Front end run vacuum, allows two of the above gauge interlocks to be lost.

11.2 Beamline interlocks

11.2.1 Phase 1 Beamline initial and run conditions

BL02I		**BL03I**		**BL04I**		**BL06I**		**BL15I**		**BL16I**		**BL18I**		**BL22I**	
Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run
BL02I-VA-IMG-01	BL02I-VA-IMG-01 **OR** BL02I-VA-IMG-02	BL03I-VA-IMG-01	BL03I-VA-IMG-01 **OR** BL03I-VA-IMG-02	BL04I-VA-IMG-01	BL04I-VA-IMG-01 **OR** BL04I-VA-IMG-02	BL06I-VA-IMG-01	BL06I-VA-IMG-01	BL15I-VA-IMG-01	BL15I-VA-IMG-01	BL16I-VA-IMG-01	BL16I-VA-IMG-01 **OR** IMG-02	BL18I-VA-VALVE-01 OPEN	BL18I-VA-VALVE-01 OPEN	BL22I-VA-IMG-01	BL22I-VA-IMG-01 **OR** BL22I-VA-IMG-02
BL02I-VA-IMG-02		BL03I-VA-IMG-02		BL04I-VA-IMG-02		BL06I-VA-IMG-02	BL06I-VA-IMG-02	Note: Vacuum break after IMG01		BL16I-VA-IMG-02			BL18I-VA-VALVE-02 OPEN	BL18I-VA-VALVE-02 OPEN	
						BL06I-VA-IMG-04	BL06I-VA-IMG-04					BL18I-VA-VALVE-03 OPEN	BL18I-VA-VALVE-03 OPEN		
						BL06I-VA-IMG-05	BL06I-VA-IMG-05					BL18I-VA-VALVE-04 OPEN	BL18I-VA-VALVE-04 OPEN		
						BL06I-VA-VALVE-01 OPEN	BL06I-VA-VALVE-01 OPEN								
						BL06I-VA-VALVE-02 OPEN	BL06I-VA-VALVE-02 OPEN								
						BL06I-VA-VALVE-03 OPEN	BL06I-VA-VALVE-03 OPEN								

11.2.2 Phase 1 Beamline Non-Critical and Critical MPS

BL02I		BL03I		BL04I		BL06I		BL15I		BL16I		BL18I		BL22I	
Non-critical	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*
BL02I-VA-IMG-01	BL02I-VA-IMG-01/02	BL03I-VA-IMG-01	BL03I-VA-IMG-01/02	BL04I-VA-IMG-01	BL04I-VA-IMG-01/02	All temps ok All flows ok IMG-01 To IMG-07	V1	BL15I-VA-IMG-01	BL15I-VA-IMG-01	BL16I-VA-IMG-01 BL16I-VA-IMG-02	BL16I-VA-IMG-01/02	BL18I-VA-IMG-02, MPS signal Water Flow Cryo Running	V1 open	V1 Open	V1 Open
BL02I-VA-IMG-02		BL03I-VA-IMG-02		BL04I-VA-IMG-02		Valve 1 to 5 open	V2	IMG1 MPS	Note: Vacuum break after IMG01			DCM temp 1 DCM temp 2 Fast valve	V2 Open	V2 Open	V2 Open
Downstream Valves & temps		Downstream Valves & temps		Downstream Valves & temps		IMG2 A2	V3	Temps					V3 Open	V3 Open	
						IMG5 A2	V4	Water flows					V4 open	V4 Open	
						IMG7 A2	IMG1						Run vac	V5 Open	
							IMG2							Bl wflow	
							IMG4							Cryo OK	
							IMG5							Temp PLC	
							IMG6							IMG1	
														IMG2	

11.2.3 Phase 2 Beamline initial and run conditions

BL07I		BL11I		BL12I		BL16B		BL19I		BL20I**		BL23B		BL24I		BL04.1J		BL10I	
Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run	Initial	Run		Initial	Initial	Run	Initial	Run
IMG-01	V1 Open & Run Vac (2 out of 3 Gauges, IMG-01,02,03)	IMG-01	IMG-01 or IMG-02	IMG-01	IMG-01	V1 Open	V1 Open	V1 to V3 open limits	V1 to V3 open limits	IMG-01	IMG-01	IMG-01	IMG-01	V1 Open	V1 Open	IMG-11	IMG-11		
IMG-02		IMG-02		IMG-01 A2 Relay		IMG-01	IMG-01	IMG1	4 out of 5 gauges IMG1 to IMG5	IMG-01 A2 Relay 1e-7		Not Service	Not Service	IMG-01	IMG-01 or IMG-02	IMG-12	IMG-12		
Not Service		Not Service		IMG-02		IMG-02	IMG-02	IMG2						IMG-02					
				IMG-03		Not Service	Not Service	IMG3						Not Service	Not Service				
				Not Service				IMG4											
								IMG5											

11.2.4 Phase 2 Beamline Non-Critical and Critical MPS

BL07I		BL11I		BL12I		BL16B		BL19I		BL20I**		BL23B		BL24I		BL04.1J	
Non-critical	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*	*Non-critical*	*Critical*
Water flow OK	V1 Open or D1 in beam	Water Flow OK	V1 Open	GBC-01 Temps OK	IMG-01	IMG-01 A2 Relay	V1 Open	Water Flow OK	V1 Open	V1 Open	V1 Open	GC1 A2 Relay	No Critical condition	All Water flows	V1 Open	Slits Temps OK	No Critical as linked to MX4
V1 Open		V1 Open	IMG-01 or IMG-02	Diamond Win Temps OK	IMG-02 or Diamond Window presence detector	V1 Open		IMG-01	V2 Open	V2 Open	V2 Open			V1 Open	V2 Open	Mono Temps OK	
D1 in beam or V2,V4 & V5 op	Run Vac	IMG-01, 02 & 03		Shutter-01 Temp OK		V2 Open		IMG-02	V3 Open	V3 Open	V3 Open			V2 Open	V3 Open	Water flows OK	
		Cryo Running		Water Flow OK		V3 Open		IMG-01 A2 Relay		V4 Open	V4 Open			V3 Open		IMG-11 & 12 OK	
Cryo On		GBC Temps OK		IMG-01 A2 Relay		V4 Open or PHDGN-01 in beam		V1 Open		J Branch V1 Open	J Branch V1 Open			V4 Open			
Cryo Hlthy		Slits Temps OK		Diamond Window detector		V5 Open or PHDGN-01 in beam		V2 Open		IMG-01 A2 at 1e-7				GBC-01 Temps OK			
Init Vac OK		PHDGN-01 Temps OK		IMG-01		V6 Open or PHDGN-01 in beam		V3 Open		Water Flow OK				IMG-01 & 02 and A2 Relay			
Run Vac OK		DCM Temps OK		IMG-02		Water Flows OK		Beamline Temps OK		Cryo On				GBC-02 Temps OK			
IMG-01 A2 at 1e-7		Laser in safe position				DCM Temperatures OK		Cryo Running		Cryo Hlthy				DCM Brag Temps OK			
OH1 Temps OK		V2 Open				TM Temperatures OK		Cryo Temps OK		OH1 Temps OK				DCM XTAL 1 Temps OK			
		V4 Open				MLM Temperatures OK											
		V5 Open				Shutter Temps											
						Chiller Temp Low											

12. STORAGE RING VALVE OPERATION

12.1 Overview

12.1.1 Opening valves at the beginning of a run

a. Open valves SRxxA-VA-VALVE-02 and SRxx-VA-VALVE-03 in all 24 cells where not already open. Some of the -02 valves and all the -03 valves will already be OPEN.

b. Open valves SRxxA-VA-VALVE-01 and SRxx-VA-VALVE-04 in all 24 cells, finishing with SR16A-VA VALVE-04 and SR17A-VA VALVE-01. These will all be closed to start with.

c. Open the beam interrupter valve in cell 21

12.1.2 Closing valves at the end of a run

a. Close valves SRxxA-VA-VALVE-01 and SRxx-VA-VALVE-04 in all 24 cells.

b. Close valves SRxxA-VA-VALVE-02 in cells 2, 3, 4, 6, 15, 16, 18 and 22 only. Leave open in all other cells.

c. Close valves FExxI-VA-VALVE-01 and FExxI-VA-VALVE-02 in cells 2, 3, 4, 6, 15, 16, 18 and 22. (Do not close Fast Valves!)

d. Leave valves SRxxA-VA-VALVE-03 open in all 24 cells.

DO NOT CLOSE any SR17S valves (RF straight valves)

e. Close the beam interrupter valve in cell 21

12.1.3 Correcting an interlock value to allow opening

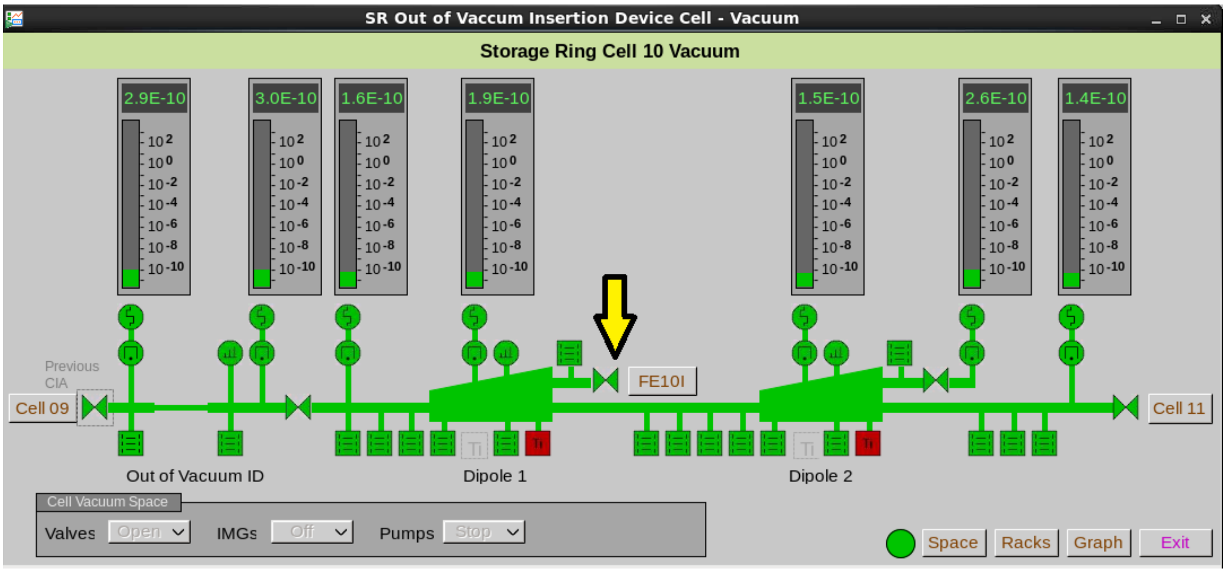
⇨ Need supervision from a vacuum group member or suitably experienced person.

12.2 Opening valves at the beginning of a run

FE and BPA valves (02 and 03) are interlocked with cell isolation valves (01 and 04) to control the way the vacuum system is opened up. The premise is that the storage ring vacuum needs to be safe, therefore opening up to the storage ring vacuum needs to be controlled.

=> VALVES 02 & 03 must be opened before cell isolation valves can be opened**.**

If cell isolation valves have been opened previously to FE/BPA ones, please refer to CLOSING VALVES AFTER A RUN for the closing procedure.

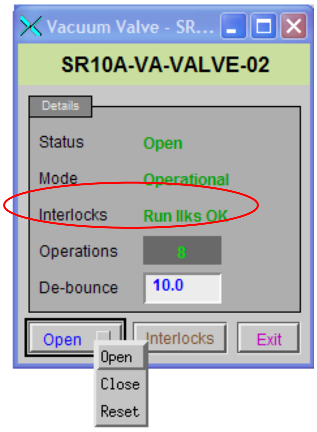


12.2.1 *To open a valve:*

- click on the Reset Button to reset the interlocks (left click)

- Then click on the valve to open.
- Check that the interlock is Run Ilks OK –

⇨ If the interlock is Failed, go to the checking and correcting interlocks section.



- click on bottom left button => Open (the valve should turn and go orange, then green)

12.2.2 Opening cell isolation valves (VALVE-01 & VALVE-04) in all sectors.

⇨ SR16A-VA VALVE-04 and SR17A-VA VALVE-01 must be the 2 last valves to be opened.

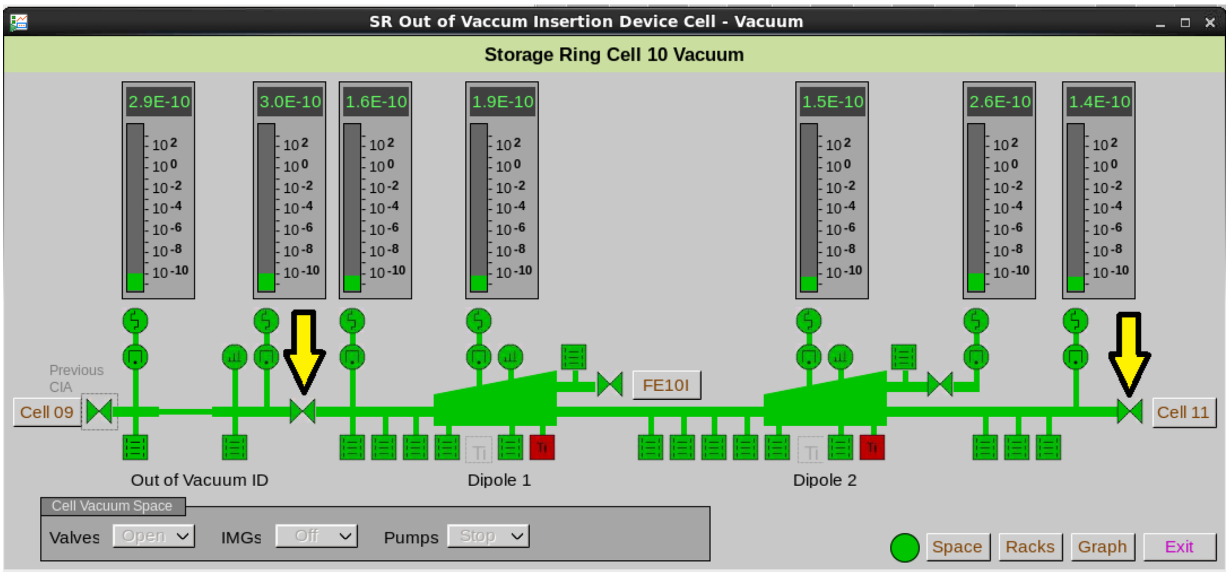
⇨ please use the same procedure

Do not forget to OPEN the beam interrupter in cell 21 before circulating the beam !

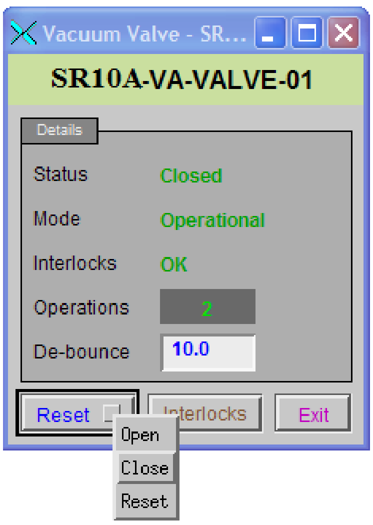
12.3 Closing valves at the end of a run

1) All cell isolation valves should be closed after run ended (VALVE-01 & VALVE-04)

- click on the valve (left click)



- click on bottom left button => CLOSE

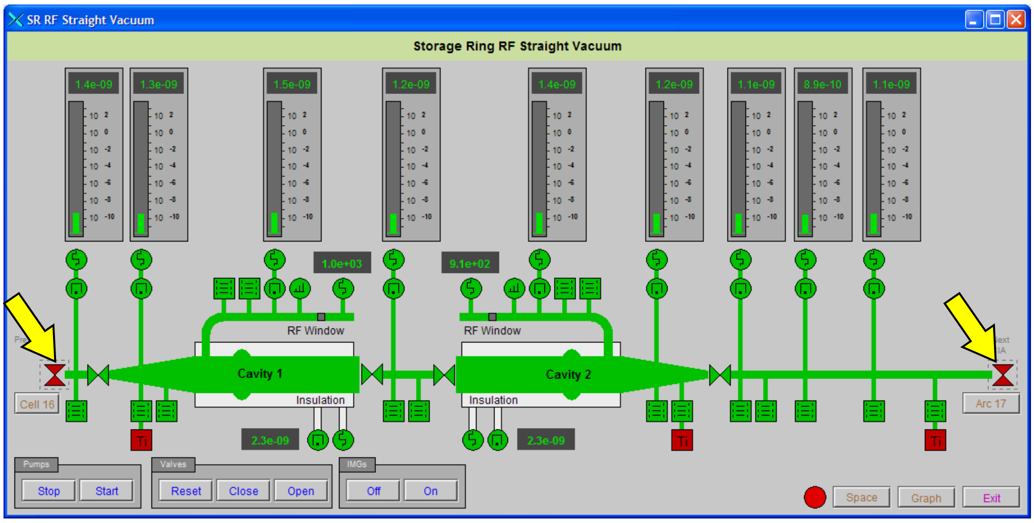


2) The first Spool piece in the RF section is now a pumped volume. However, the RF section is considered as a unique vacuum space, and valves should not be closed.

RF section valves are effectively operation limited to 10,000 operation for V2, V3 and V5. Due to its horizontal orientation, SR17S-VA-VALVE-04 is limited to ~100 operations only.

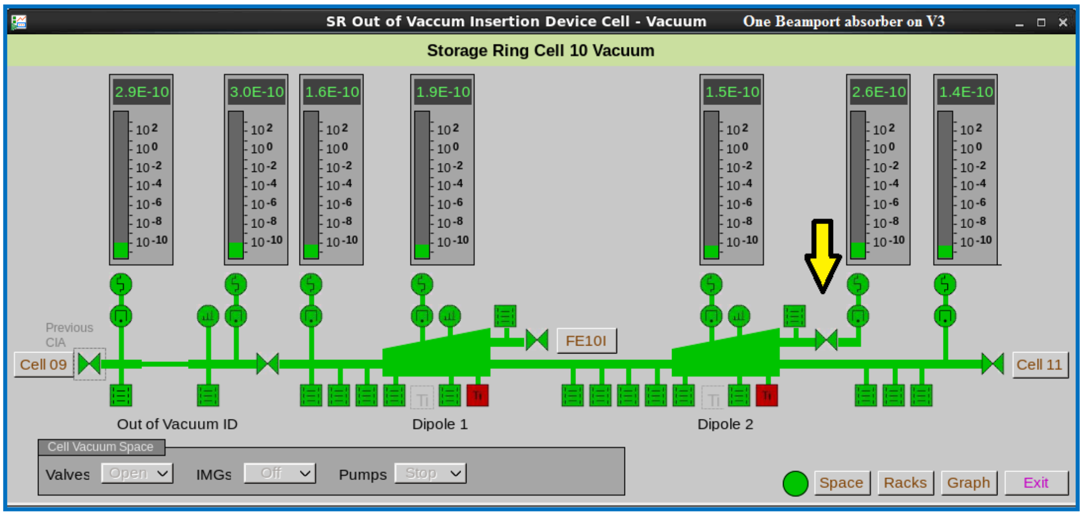
RF section valves(=> between SR16A-VA-VALVE-04 and SR17A-VA-VALVE-01)

must NOT be closed as a standard procedure at the beginning of a shutdown.



3) ALL valves to Beam Port Absorbers (BPAs) should be kept OPEN all the time.

⇨ **All valves 02 and valves 03 kept OPEN except where Front end is fitted.**



4) Valves to Front-Ends should be CLOSED after the run:

5) All front end (FE) valves should also be closed to isolate beamlines during shutdowns

12.4 Checking and correcting interlocks

1. If the interlock is still failed after a reset on the valve control panel, then click on interlock to access the interlock status details:

   ⇨ a Bad interlock will have the GREEN LED (■) off (=> ■)

   ⇨ a Latched (previous) interlock will have the RED LED ON (■)

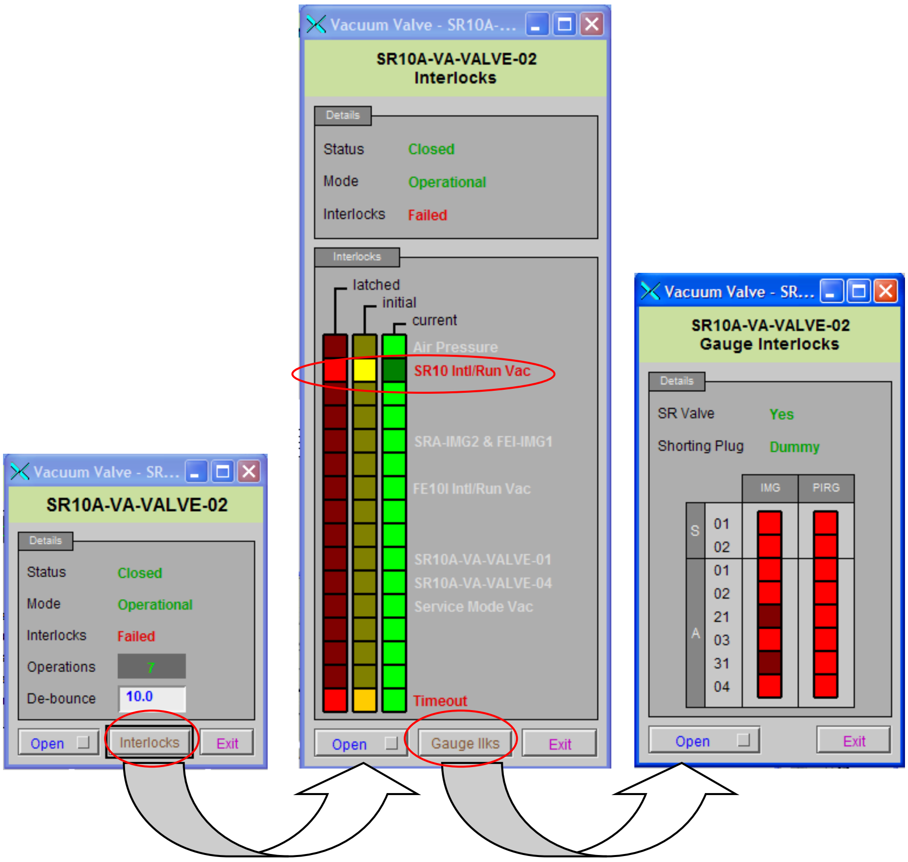
   ⇨ The first occurring bad interlock will be marked with the yellow LED ON (■)

   From this panel, you can see where the problem actually is.

   In the example below, we can see that the vacuum condition is not good in cell 10.

   By clicking on ***Gauge Ilks*** button, we get that the interlock from gauges 21 and 31 of this cell are not healthy. (go to 2)) (Note in the new valve GUI the gauge interlock page is displayed along side the valve interlocks.)

   In the same example, we can also see a timeout of the valve observed (valve un-expectedly slow to operate or previously temporarily disconnected).



The interlocks needed will vary depending of the type of valve.

2. In the case the pressure is raised above 10^{-6} on a BPA gauges (gauges 21 or 31) but is still below 10^{-4}, it is possible to modify the interlock pressure level to open a BPA valve (this can happen if the BPA remains isolated too long since there is no pumping on it)

   Supervision from a vacuum group member or a suitable experienced person is requested for this action.

   To restore a healthy interlock signal from a gauge:

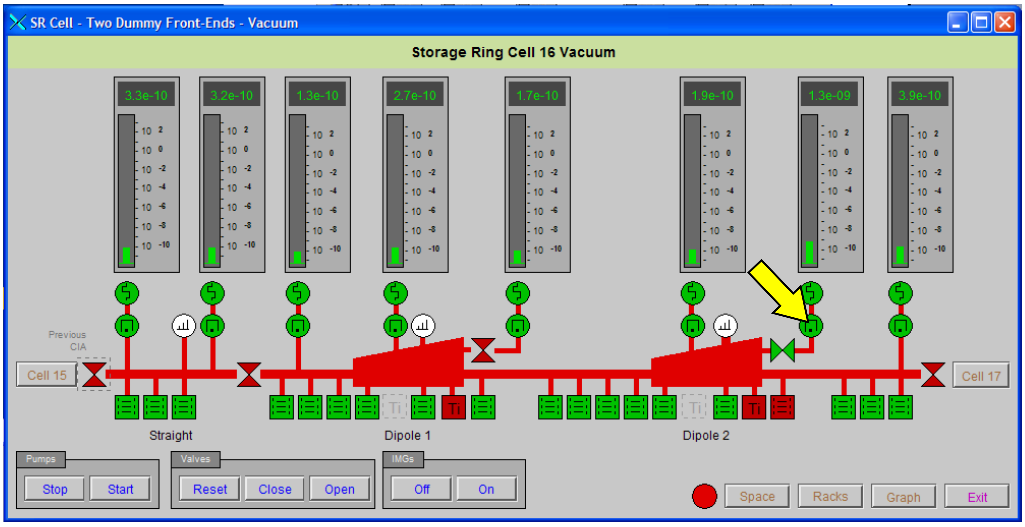
   ⇨ click on the gauge with non healthy interlock

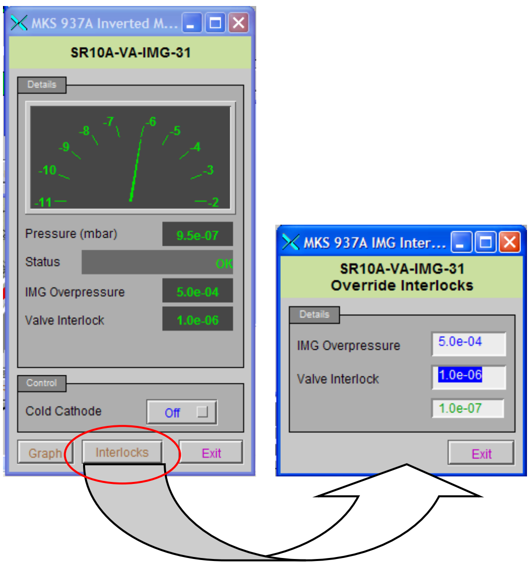
   ⇨ click on interlocks

   ⇨ modify the valve interlock value above the actual pressure

   ⇨ reset the valve to open and open it

   ⇨ restore the gauge interlock value at 1.0e-06 mbar after opening the valve





13. COMMON FAULTS

13.1 Vacuum equipment

13.1.1 Total pressure gauges

1. 937a does not operate from front panel. Reboot the 937a by turning on and off .

   ⚠ **This will kill all interlocks assigned to this controller!** ⚠

   Note that Epics control may still work if power cycling controller is not possible

2. Pirani gauge not showing – on front panel: Check connections through to gauge
3. Pirani gauge showing $1.1x10^{-1}$ mbar on front panel, check potentiometer box has been refitted to gauge. If yes, check pirani filament as it may be broken.
4. IMG reading lo: IMG not striking because vacuum too good
   - 4.1. IMG not striking because vacuum too good
   - 4.2. Cables not connected, check connections
   - 4.3. Short in cables, test with dummy gauge at the end of the cables. Replace short bakeable cables.
   - 4.4. Short inside gauge, check resistance between Cathode, Anode and Earth. Should all be infinite.
   - 4.5. IMG HV board damaged, check with dummy gauge directly at the back of the controller. If gauge reading stay “Lo”, replace HV board or controller.

13.1.2 Ion pumps

1. No communication from MPC to EPICS, white display EPICS
   - 1.1. Check serial address of MPC, this is through config menu, should be set to 1.
   - 1.2. Reboot MPC by switching on and off.
2. Pressure from ion pump showing much higher than nearby IMG
   - 2.1. Check that pump size is correct for pump
   - 2.2. Power supply needs calibrating, recalibrate
   - 2.3. High leakage current in pump, spot knock pump
   - 2.4. Leakage in cable, Replace short bakeable cable.
3. Ion pump is noisy, shown by unstable pump pressures

3.1. Check cables for leakage

3.2. Check for pump reading high pressure which can be an indication of leakage in pump, pump will need spot knocking.

4. Can not switch Ion pump High Voltage on.

4.1. Check that there is no Safeconn error, if so check cable

4.2. Check there is no interlock error, if so check connection from valve control crate, check Pirani pressures for system

4.3. Check errors on front panel of MPC, Reset MPC by cycling power off and on.

4.4. HV board may be damaged. Disconnect HV cable on back of the pump controller and put blank connector on back of MPC for safety issues. Then connect a shorted safe-conn connector and turn HV on. If HV does not turn on, HV board needs to be replaced. Please consult Vacuum Group before doing this.

4.5. CPU board damaged. MPC Unit needs to be replaced.

13.1.3 Valves

1. Pneumatic air leaking from valves

1.1. Check compressed air pipes into valve, repair if possible

1.2. Check to see if air is continual venting from brass fittings on pneumatic solenoid if so the leak is likely to be the solenoid itself, replace solenoid

2. Air pressure interlock missing for valve operation.

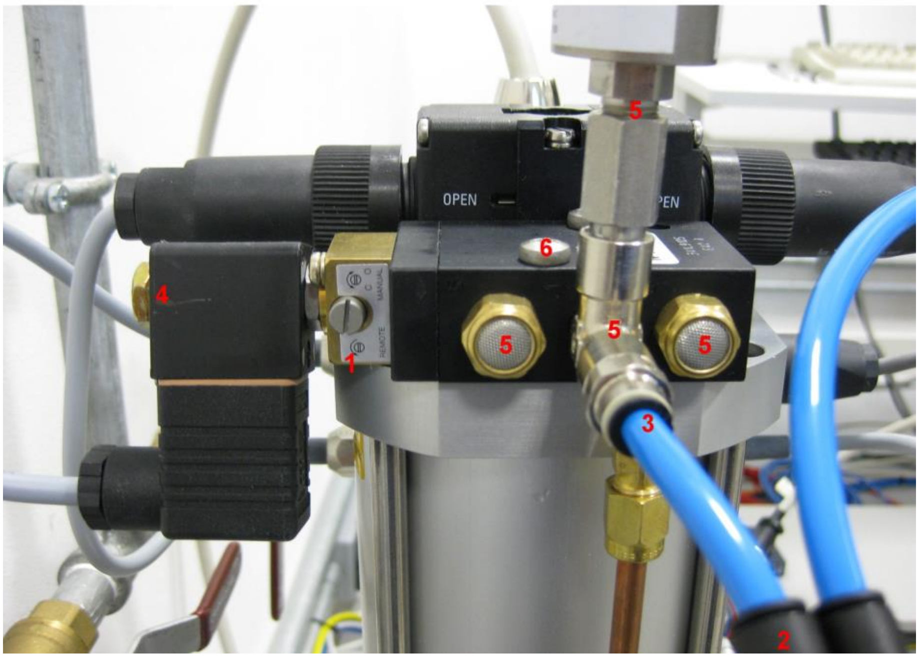
2.1. Check compressed air pipes into valve.

2.2. Check that no air supply manifold is closed.

2.3. If other valves on the same supply have air, check air pressure switch with MultiMate. Replace Switch if needed.

2.4. If pressures switch is giving proper signal, check cabling to PLC.

13.1.4 Removal and replacement of valve Pneumatic solenoid



1. The solenoid over ride screw, labelled 1 in the picture should be in the closed/automatic position.

2. Remove the 13 pin valve cable coming from the control system. This will close the valve if it is open. Remove the air pressure switch cable from the valve box.

3. Turn off Air to solenoid, item 3. (Trace air line to make sure that only solenoid is affected).

4. Disconnect air line from solenoid at the push in connector on the solenoid.

5. Disconnect power plug from solenoid, item 4.

6. Remove the air pressure transducer, and air filters, items 5. (This may also be done after step 7.)

7. Using a Phillips screwdriver remove the two screws on top of the solenoid assembly items 6.

8. The solenoid assembly should now lift off.

<u>Replacing new solenoid</u>

1. Check that the sealing faces are clean and dust free

2. Screw new solenoid into position.

3. Fit air filters and Air pressure transducer (put twist in wire before screwing transducer in place so the action of fitting transducer un-twists the wire).

4. Push Air line into solenoid assembly

5. Turn air on slowly checking for air leaks.

6. Check that the solenoid is in Closed/automatic position.

7. Connect power to solenoid, item 4

8. Try to activate the valve through the control system. The valve should open and there should be no leaks. If after opening the valve there is a large air leak through solenoid which is indicated by a constant leak through the filters, item 5 then you will need to take some further actions.

Air leaks on new solenoids

1. Check that you can open and shut the valve in the control system and that doing so causes no problems.

2. Close the valve in the control system.

3. Close the air to the valve and take the line, item 3 from the diagram, out to drain the system of air.

4. Force the valve open in the control system or use the valve override switch to open the valve. The valve will not actually open as there is no air on it.

5. Connect the air line and very slowly open the air to the valve. This should take some minutes. With the airline now open and the valve now open, close and open the valve a few times and check for air leaks.

6. If there are still air leaks you may need to replace the solenoid again or to service the pneumatic cylinder itself.

13.1.5 RGAs

1. RGA not seen on RGA computer

1.1. Check RGA is correctly connected and powered.

1.2. Check RGA is correctly installed on RGA computer. Please consult Vacuum Group for installation

1.3. Reset RGA ECU unit and process-eye software if needed. Please consult Vacuum Group before doing this.

2. RGA not seen on EPICS edm

2.1. Check that RGA is correctly installed and working on the RGA computer

2.2. Check if Process-eye software has crashed on RGA computer.

2.3. Check that RGA computer and EPICS IOC are correctly communicating by opening the EPICS tab on process-eye.

2.4. Check that ID in IOC database match with RGA EPICS ID in C:\Process Eye\Logs\RGA Head Settings.INI. ID numbers are detailed in RGA table in appendix.

2.5. Check RS232 cable between RGApc and IOC is damaged or wrong.

3. Filament will not turn on

3.1. Check the interlock cable is connected correctly at both ends

3.2. Check that the IMG is on and below 1 x 10^{-4} mbar

3.3. If you are sure the pressure is good, removing the interlock jack plug from the power supply will override the interlock. Please consult Vacuum Group before doing this.

3.4. Check continuity of filament

3.5. Change RGA power supply

4. Total pressure from associated IMG and total peaks don't match

4.1. Check to see that error is out by more than 30 % as some errors are inevitable

4.2. Try to recalibrate the RGAs using Process Eye. Please consult with Vacuum Group before doing this

4.3. If the head will not calibrate then try putting some default values for the calibration directly into software. Values should be manually adjusted to match pressure.

5. Peaks not on correct AMU

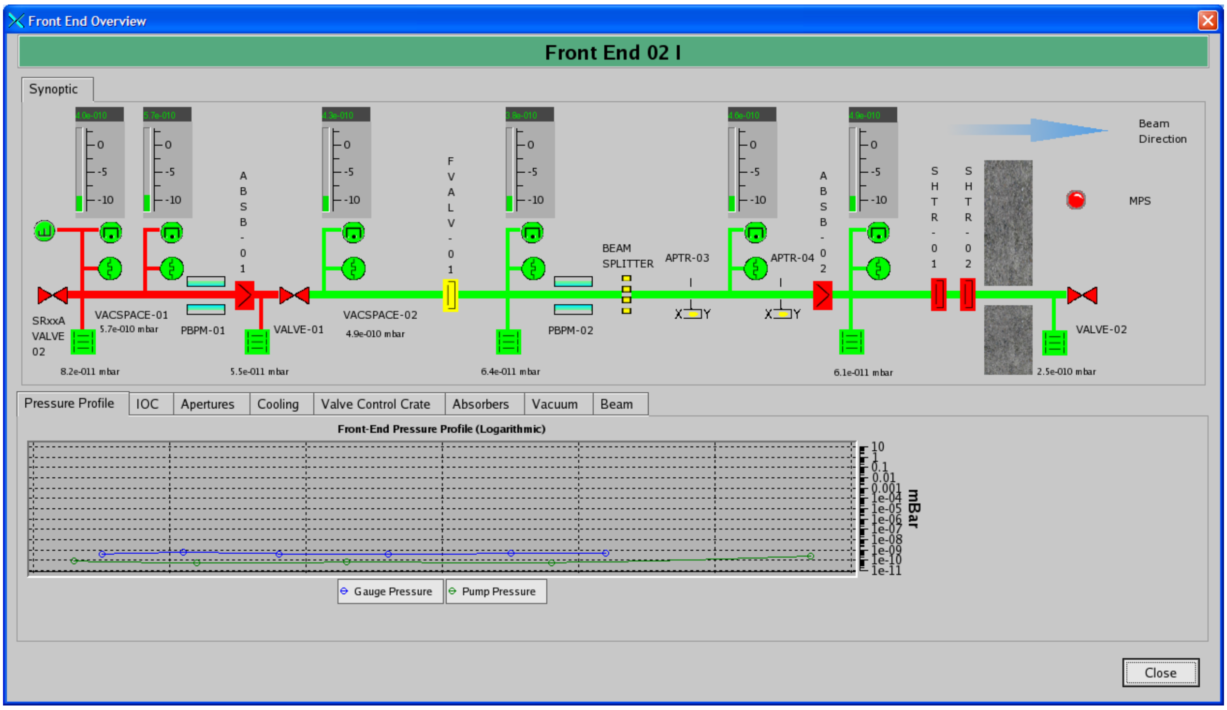
5.1. Calibrate the head using the software in Easy View. Remember to save to all after calibration. Please consult with Vacuum Group before doing this

6. RGA scan is noisy and filament turns off when high masses are reached during scan

6.1. Check that serial number on the ECU and analyser do match. If matched units are available, swap units to get matched set when possible.

6.2. If matched units are not available for some reason, RGA will require RF filter tuning. Please consult Vacuum Group

13.2 Front End Valve controller Faults.

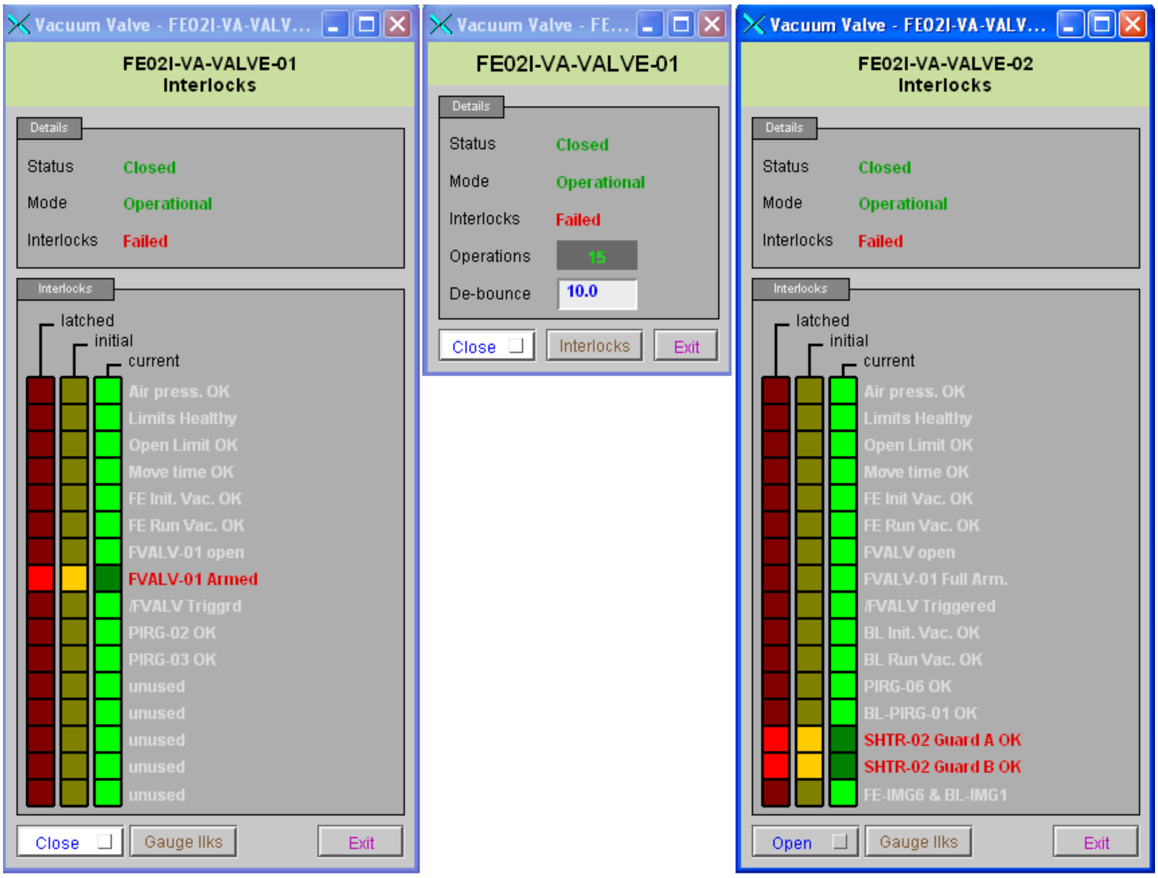


The front end Mimic for the vacuum system is as above. The example is for FE02 but all phase one front ends look very similar.

Different screens can be accessed by clicking the tab style buttons arrange horizontally across the middle of the screen.

It is also possible to drill in to see more information relating to each of the pneumatic devices as well as the MPS interlock status.

13.2.1 Vacuum Valves



The first click on any pneumatic device brings up the box in the centre. This shows the current status of the device, its interlocks, number of operations and the last EPICS command sent to it which in the above case was a command to close the valve. It also has a user adjustable de-bounce value. This sets the timeout value for the device to complete a movement before a fault is indicated. It also provides a delay value which sets a timer to allow for variations in air pressure. This means that the system can stand the air pressure dropping below the interlock set level for the indicated number of seconds before an air pressure fault is triggered and a close command is issued to the device.

The current state of an interlock is represented by the green bit (column). A bright green colour represents a healthy interlock where as a dark green shows one not available upon reset. The bright yellow bit (column) represents the initial failure (useful if more than one fault is showing) whist the red bit (column) shows all of the latched interlock bits until reset. A current interlock bit showing dark green might not mean that the system is in fault, it may just show that there is a pre-requisite condition required to allow opening. In the above case this is showing that valve 1 cannot open unless the fast valve is armed. For valve 2 to open both of the PSS shutter guard lines need to be available indicating that the Optics hutch has been searched and locked up.

13.2.2 Common vacuum valve faults.

(What to try if green current interlock is not available).

- Air Pressure: There is a 10-second delay as described above. If the valve is a large one then it is possible for it to take quite a long time to complete its move effectively reducing the measure air pressure at the cylinder. If adjusting this value does not recover the situation then it will be necessary to go down to the air manifold and check and adjust the air pressure as required. If this still fails to make the interlock then either the air pressure switch on the valve is faulty or there is a problem with the cabling back to the PLC.
- Limits healthy. This is an integrity check, which ensures that there is not a short across the cable making it appear that a valve is open when not. It checks to make sure that the valve is not sending both open and closed limits simultaneously. If this interlock is in fault then expect to find a damage cable or connector, or that the limits on the valve are damaged or have fallen off.
- Open limits OK checks that the open limit is only made when the solenoid is engaged. If this interlock bit illuminates then the limit contact must have jammed or welded itself together and tunnel intervention will be required.
- Move time. If this interlock fails then the valve did not get from a closed to open position within the time set in the debounce. It is worth increasing the time to see if this cures the problem. If it doesn’t reach an open limit within the timeout value then the valve returns to the closed position. It may be that the limit switch is not set up correctly or has fallen off. Again tunnel access is required.
- Front end initial vacuum OK. This interlock requires all 6 IMGs in the front end to be healthy to allow the valve to open. This interlock is masked out when the valve is open. If this interlock is not present check all gauge controllers and ensure that all IMGs are enabled and that the setpoint is correct. If it is still not present then check each of the three GC cables attached to the PLC via sockets GC1, GC2 and GC3. Often these cable crimps fail or push back into the connector. The best solution is to remove the offending end and solder a new connector on.
- Front end run vacuum. If this interlock fails then the valve will shut if open. To clear it requires at least 5 of the 6 IMGs to be below the vacuum setpoint. Check using same method as before.

13.2.3 *Possible faults common to front end valve 01*

(What to try if green current interlock is not available).

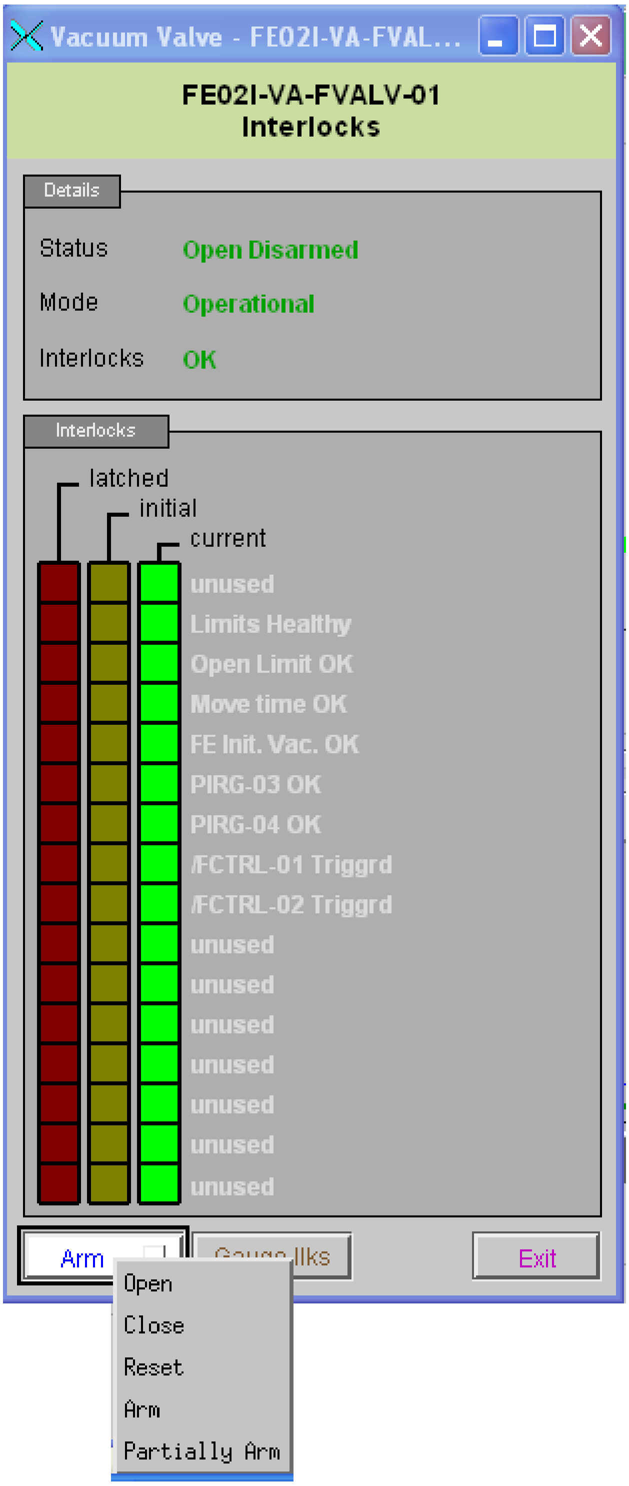
- Fast Valve open. The fast valve being open is a pre-requisite for valve 1 opening.
- Fast Valve armed. The fast valve must be armed to ensure vacuum protection for the storage ring. The fast valve can be partially or fully armed depending upon the status of FE valve 02. To arm it go to its drop down on the mimic,

ensure that it is open and then click on full or partial arm. If it will not arm then either it is missing the interlock from the front end or beamline vacuum gauges or the controller has been switched into local mode down in the CIA. Failure to arm and immediate trip can usually be attributed to the fast valve high voltage gauges threshold being set lower than the actual pressure.

- Pirg-02 OK. This interlock is only monitored if the crate is in service mode. If it is not present then either the Pirani gauge is faulty or the pressure is too high.
- Pirg-03 OK. This interlock is only monitored if the crate is in service mode. If it is not present then either the Pirani gauge is faulty or the pressure is too high.
- FCTRL-01 & 02 triggered. This is caused by the fast valves being turned on when the vacuum level is too close to their trip level threshold. Reset and raise the trip point locally on the fast valve controller and try to arm again.

13.2.4 Fast Valve controller.

The fast valve can only be opened if the front end initial vacuum is good. However once open this condition is no longer monitored unless the fast valve is armed and ready to fire. The fast valve uses air to open but has a magnetically held spring to shut it in the event of a vacuum incident. Once open it must be armed before any of the vacuum valves can be opened. It can be partially or fully armed dependent upon which valve the operator needs to open. To arm it, the PLC upon receipt of the request from EPICS, check to see that the IMGs situated nearest to the fast valve gauges are sensing acceptable vacuum (this is normally the Initial vacuum for that particular vacuum space). If this is the case the high voltage enable is turned on to the Fast valve Gauges. Once the gauges have struck the PLC sends a reset pulse to the fast valve control card and enables the closing interlock. This arms the fast valve ready to fire. Failure to open the associated vacuum valve within 50 seconds disarms the fast valve and returns it back to open disarmed status. If the associated valve is opened and then closed for any reason this also disarms the fast valve by removing the close interlock and switching off the high voltage. If the fast valve does trigger then the vacuum valves also close to help protect the vacuum.



Vacuum Valve - FE02I-VA-FVAL...
FE02I-VA-FVALV-01
Interlocks
Details
Status
Open Disarmed
Mode
Operational
Interlocks
OK
Interlocks
latched
initial
current
unused
Limits Healthy
Open Limit OK
Move time OK
FE Init. Vac. OK
PIRG-03 OK
PIRG-04 OK
/FCTRL-01 Triggrd
/FCTRL-02 Triggrd
unused
unused
unused
unused
unused
unused
unused
Arm
Exit
Open
Close
Reset
Arm
Partially Arm

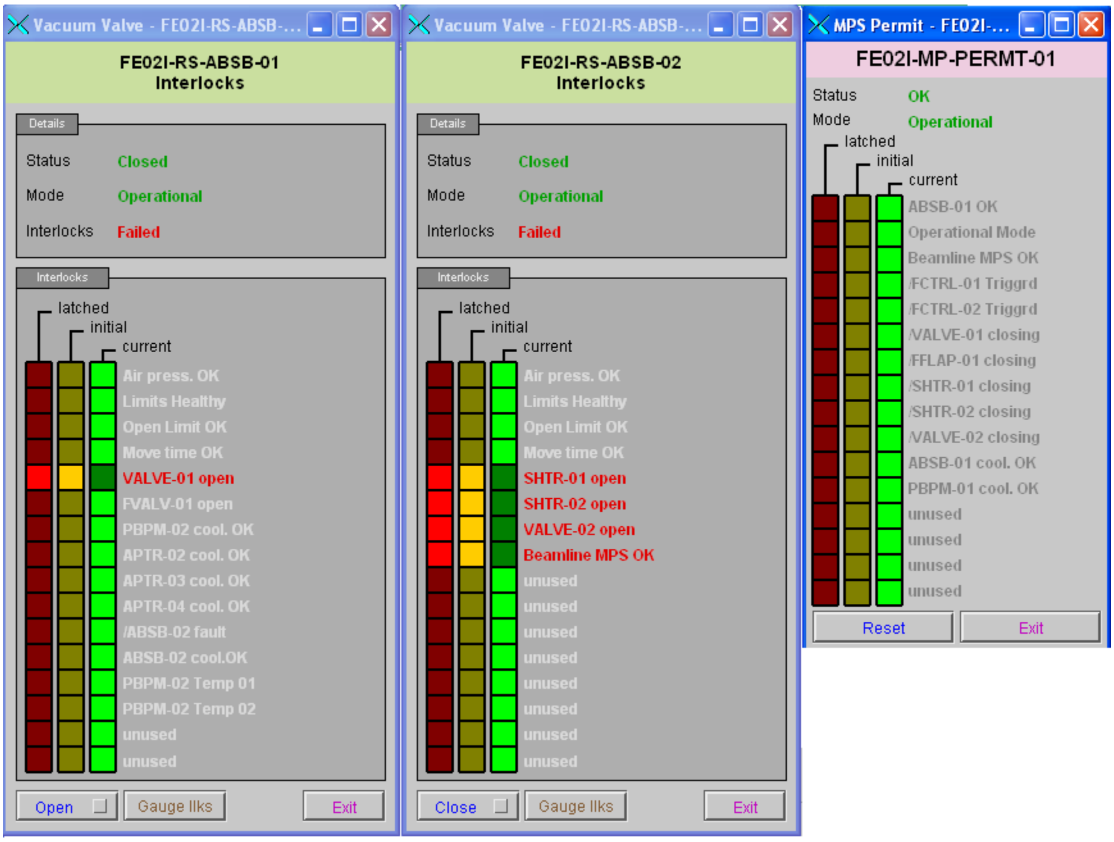
13.2.5 Possible faults specific to front end Valve 02

(For generic faults common to all vacuum valves see above).

- Beamline initial vacuum OK. This interlock requires all IMGs in the first vacuum space in the beamline to be healthy to allow the valve to open. This interlock is masked out when the valve is open. If this interlock is not present check all gauge controllers and ensure that all IMGs are enabled and that the setpoint is correct. If it is still not present then check the 12 pole Souriau connector from the next cell to the valve control crate is present. If this is ok check the synoptic for the beamline.
- Beamline run vacuum. If this interlock fails then the valve will shut if open. To clear it requires at least 1 of the IMGs to be below the vacuum setpoint. Check using same method as before.
- Pirg-06 OK. This interlock is only monitored if the crate is in service mode. If it is not present then either the Pirani gauge is faulty or the pressure is too high.
- Beamline Pirg-01 OK. This interlock is only monitored if the crate is in service mode. If it is not present then either the Pirani gauge is faulty or there is insufficient vacuum present. This interlock comes in via the 12 pole Souriau connector from the next cell to the valve control crate is present.
- Guard Lines A and B OK. To allow Valve 2 to open both of the PSS shutter guard lines need to be available indicating that the Optics hutch has been searched and locked up. This is to ensure that it is not possible for accidental venting due to personnel intervention to occur. If they are not available then check that the hutch is locked. If it is then there may be a problem with the PSS.

13.2.6 Absorbers and MPS Permit.

The next EDMs representing the absorbers and machine protection interlock feed to the MPS rack to allow the beam to run. Most interlock bits required by the absorbers are really pre-requisite conditions from other devices. The only other interlocks to the absorbers are from water flow switches and over temperature alarms from trip amps.



13.2.7 Possible faults specific to Absorber 01

(For generic faults common to all vacuum valves see section a).

- PBPM-02, APTR-02, 03 & 04 and ABSB-02 coolant OK. If any of these are missing then either the flow has reduced to below the setpoint or the limit switch has been knocked. Each trip point has been set up and recorded so tunnel intervention will be required to check that the switch is set at the 70% full flow limit. If this is not the case then an adjustment of flow and or limit switch position will be required.
- If an Absorber 02 fault comes up it is necessary to navigate to the window for absorber 02 and reset it. It will most likely be due to a movement timeout or air pressure problem.

- PBPM-02 temps 01 & 02. If these interlocks are missing then either the temperature detected is too high or there is a problem with the trip amps that read the temperature and convert to a relay set point. Check the two lower trip amps in the chain of 4. The green power light should be on and the burn out LED off. If the temperature is ok then the relay b amp should be lit. Check for continuity across the terminals. If there is a problem with the trip amp then expert backup will be needed as the unit will possibly need reconfiguring which requires a programming device and interface.

13.2.8 Possible faults specific to Absorber 02

(For generic faults common to all vacuum valves see section 12.2.1).

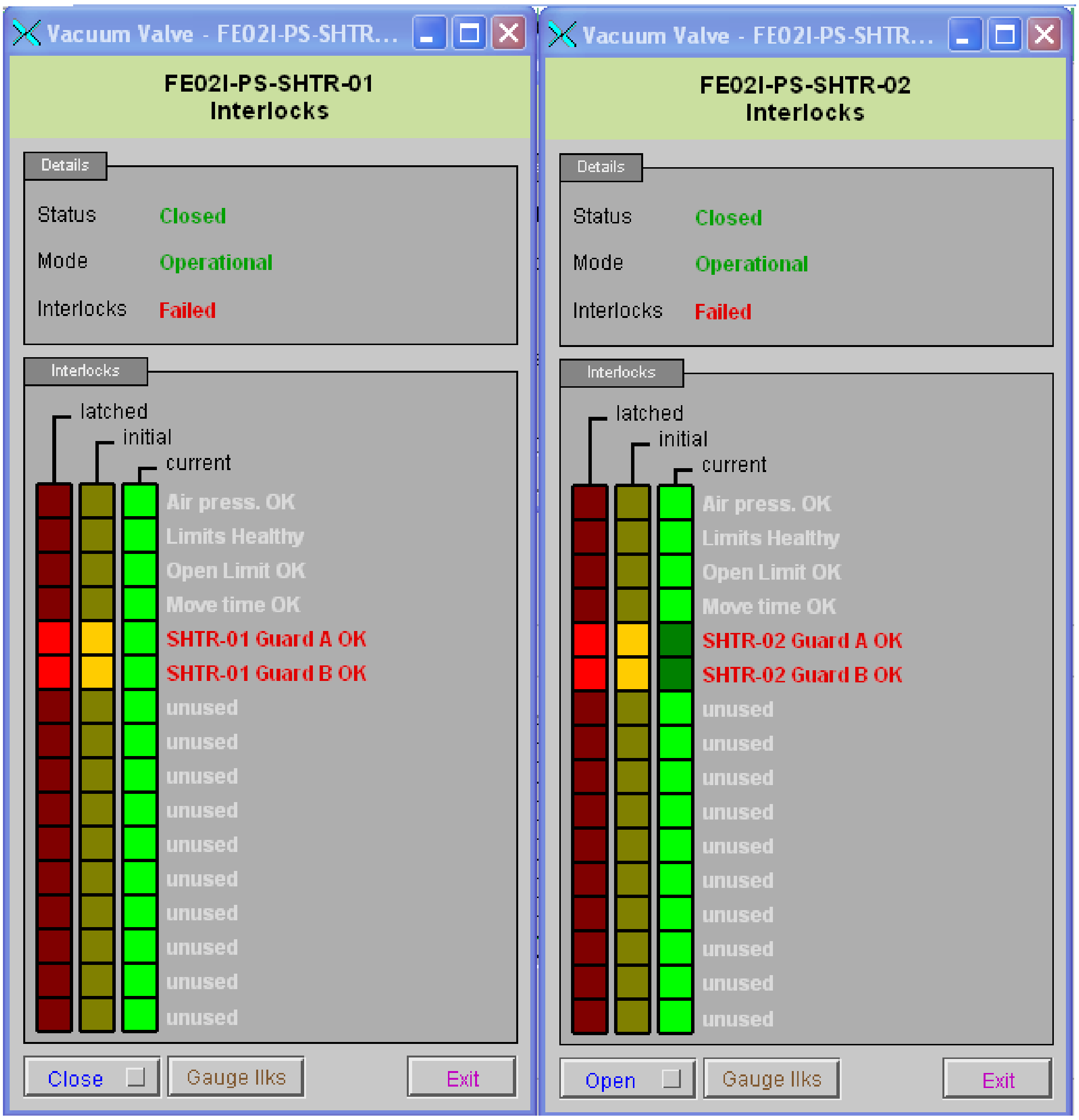
- Beamline MPS. If the beamline is unable to provide the interlock permit required to allow the second absorber to open or, if already open to close the absorber, this LED will be off. Depending upon the beamline it will relate to critical temperatures or flows or vacuum conditions within the beamline. The interlock would only trip the absorber to close in most cases. It would not become a full MPS trip (see MPS panel next to ABSB-02) unless the absorber failed to shut within the timeout specified by the operator in EPICS.

13.2.9 Possible faults specific to the MPS interlock

(For generic faults common to all pneumatic devices see above).

- Valve controller not in operation mode. The crate has been switched to service to allow intervention and has not been returned to operational mode. This will require visiting the CIA and manually selecting operation mode.
- FVALVE controller 1 & 2 triggered. This would indicate that the fast valve HV gauges either in the middle of the front end or start of the beamline have detected a rapid rise in pressure and so triggered the fast valve to protect the vacuum.
- Fast valve closing. See above.
- Any other pneumatic device closing unexpectedly. Either the global air supply has failed and all devices are shutting or there has been a vacuum incident and the fast valve has not operated properly. Either way recovery will be required. The fast valve can only fail to trigger if it loses the close interlock from the PLC. Suspect inter-rack wiring.

13.2.10 PSS Shutters



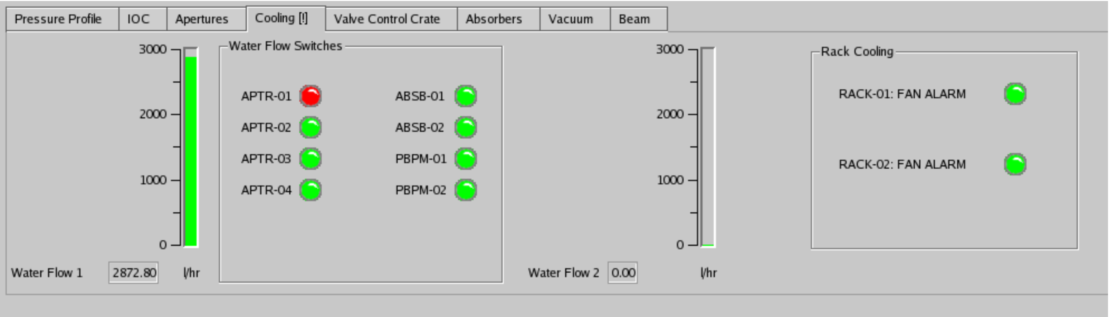
13.2.11 Possible faults specific to the PSS interlock

(For generic faults common to all pneumatic devices see above).

- Guard Lines A & B for shutter 01. These are only available when the tunnel is locked and the Linac enable key is removed.

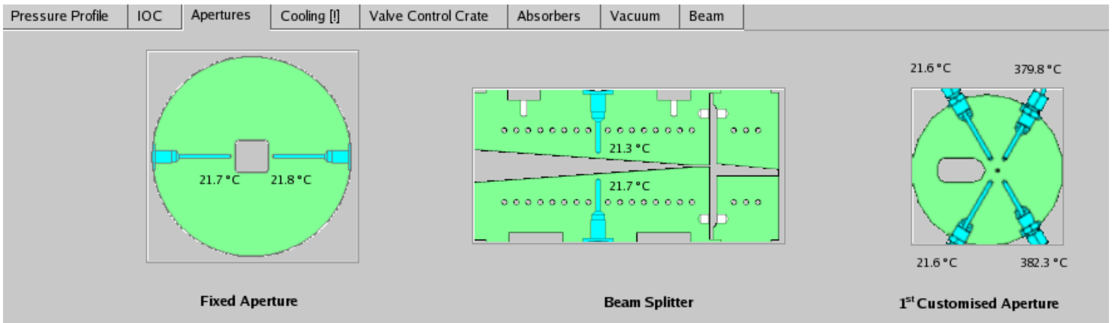
- Guard Lines A & B for shutter 02. These are only available when the optics hutch is searched and locked. These devices must be open to allow absorber 02 to be opened.

13.2.12 Water Interlocks



If any of the water interlocks have failed then there will be red inidicators warning of the fact on the above EDM. Also the flow rate will be at zero like the display for water flow 2. If any of the flow interlocks are missing with the exception of the first absorber, beam can still operate. This is because ABSB-01 is closed and protecting the un-cooled surface from the heat of the beam. The interlock bits would also be out on the associated ABSB-02 interlock word.

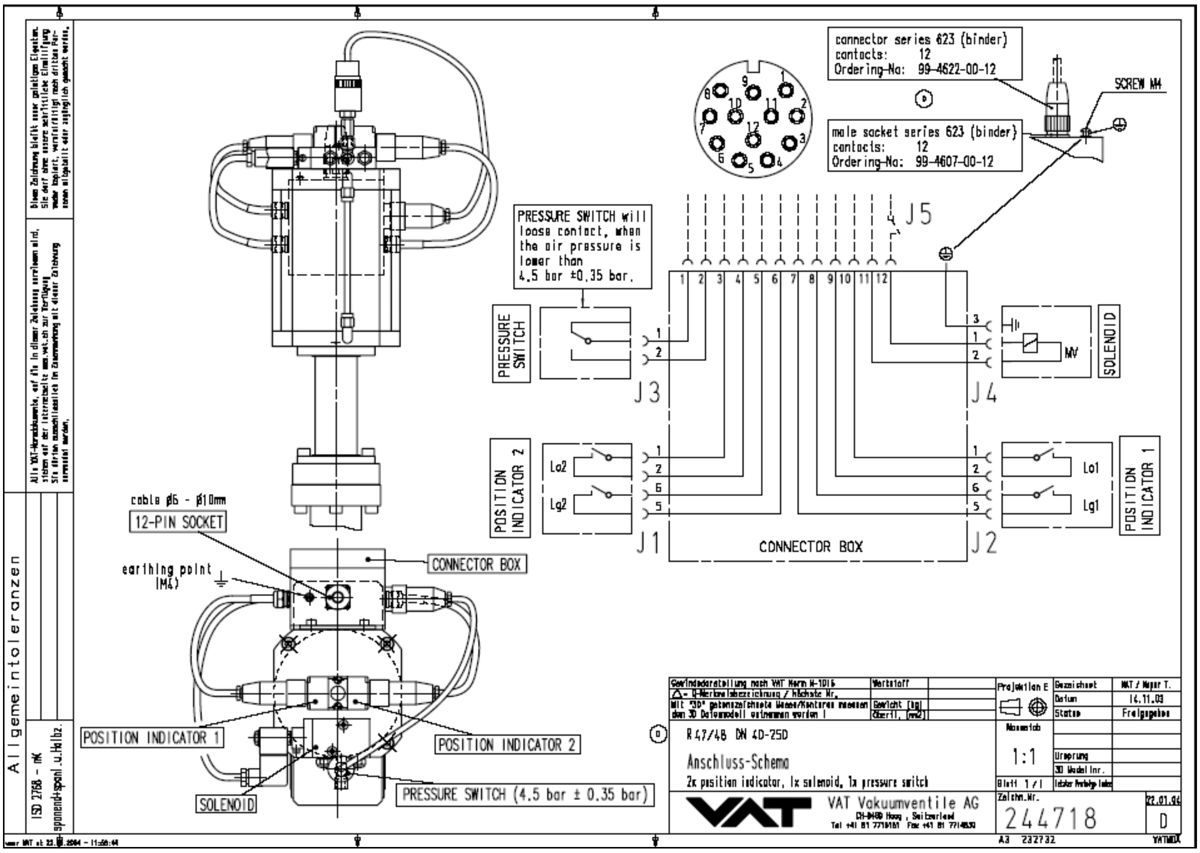
13.2.13 Temperatures



The above temperatures are not critical to the operation of the front end but provide diagnostic and warning information. If any are reading erroneously then please warn the responsible person to allow repair during the next shutdown.

14. APPENDIX

14.1 Valve box wiring



14.2 Vacuum IOCs

IOC Name	Terminal server	IOC Console Port	VME port
LI-VA-IOC-01	LI-NT-TSERV-01	7011	7012
LB-VA-IOC-01	LI-NT-TSERV-01	7007	7008
BR01C-VA-IOC-01	BR01C-NT-TSERV-01	7008	7009
BR02C-VA-IOC-01	BR02C-NT-TSERV-01	7008	7009
BR03C-VA-IOC-01	BR03C-NT-TSERV-01	7008	7009
BR04C-VA-IOC-01	BR04C-NT-TSERV-01	7008	7009
BS-VA-IOC-01	SR24C-NT-TSERV-01	7030	7031
SR01C-VA-IOC-01	SR01C-NT-TSERV-01	7011	7012
SR02C-VA-IOC-01	SR02C-NT-TSERV-01	7011	7012
SR03C-VA-IOC-01	SR03C-NT-TSERV-01	7011	7012
SR04C-VA-IOC-01	SR04C-NT-TSERV-01	7011	7012
SR05C-VA-IOC-01	SR05C-NT-TSERV-01	7011	7012
SR06C-VA-IOC-01	SR06C-NT-TSERV-01	7011	7012
SR07C-VA-IOC-01	SR07C-NT-TSERV-01	7011	7012
SR08C-VA-IOC-01	SR08C-NT-TSERV-01	7011	7012
SR09C-VA-IOC-01	SR09C-NT-TSERV-01	7011	7012
SR10C-VA-IOC-01	SR10C-NT-TSERV-01	7011	7012
SR11C-VA-IOC-01	SR11C-NT-TSERV-01	7011	7012
SR12C-VA-IOC-01	SR12C-NT-TSERV-01	7011	7012
SR13C-VA-IOC-01	SR13C-NT-TSERV-01	7011	7012
SR14C-VA-IOC-01	SR14C-NT-TSERV-01	7011	7012
SR15C-VA-IOC-01	SR15C-NT-TSERV-01	7011	7012
SR16C-VA-IOC-01	SR16C-NT-TSERV-01	7011	7012
SR17C-VA-IOC-01	SR17C-NT-TSERV-01	7011	7012
SR18C-VA-IOC-01	SR18C-NT-TSERV-01	7011	7012
SR19C-VA-IOC-01	SR19C-NT-TSERV-01	7011	7012
SR20C-VA-IOC-01	SR20C-NT-TSERV-01	7011	7012
SR21C-VA-IOC-01	SR21C-NT-TSERV-01	7011	7012
SR22C-VA-IOC-01	SR22C-NT-TSERV-01	7011	7012
SR23C-VA-IOC-01	SR23C-NT-TSERV-01	7011	7012
SR24C-VA-IOC-01	SR24C-NT-TSERV-01	7011	7012

14.3 Other Vacuum related IOCs

IOC Name	Terminal server	IOC Console Port	VME port	
FExxI-CS-IOC-01	SRxxC-NT-TSERV-01	7016	7017	(Front end IOC)
SRxxI-CS-IOC-01	SRxxC-NT-TSERV-01	7022	7023	(Insertion Device IOC)

14.4 RGA PC addresses.

Nos	CIA	Area	I/P Address	Computer name	EPICS ID	EPICS names RGAs	RGA S/N
1	LINAC	LINAC	172.23.231.1	LI-VA-RGAPC-01	1	LI-VA-RGA-01	LM76-01904012
	LINAC	LT	172.23.231.51	LT-VA-RGAPC-01			
2	LINAC	LTB	172.23.231.2	LB-VA-RGAPC-01	1	LB-VA-RGA-01	LM76-80004006
3	BR01C	Booster1	172.23.231.3	BR01C-VA-RGAPC-01	3	LB-VA-RGA-02	LM76-01904007
4					1	BR01C-VA-RGA-01	LM76-81604001
5					2	BR01C-VA-RGA-02	LM76-00805010
6	BR02C	Booster2	172.23.231.4	BR02C-VA-RGAPC-01	1	BR02C-VA-RGA-04	LM76-81604010
7					2	BR02C-VA-RGA-05	LM76-80004018
8	BR03C	Booster3	172.23.231.5	BR03C-VA-RGAPC-01	1	BR03C-VA-RGA-06	LM76-80004007
9	BR04C	Booster4	172.23.231.6	BR04C-VA-RGAPC-01	1	BR04C-VA-RGA-07	~~LM76-80004003~~
10							LM76-00506007
11					2	BR04C-VA-RGA-08	LM76-81604006
12	SR24C	BTS	172.23.231.7	BS-VA-RGAPC-01	1	BS-VA-RGA-01	~~LM76-00106013~~
13							LM76-01904015
14	SR01C	Sector1	172.23.231.8	SR01C-VA-RGAPC-01	1	SR01S-VA-RGA-01	LM76-00106026
15					6	SR01S-VA-RGA-02	LM76-00305017
16					2	SR01A-VA-RGA-01	LM76-00805017
17					3	SR01A-VA-RGA-02	LM76-00105009
18	SR02C	Sector2	172.23.231.9	SR02C-VA-RGAPC-01	1	SR02S-VA-RGA-01	LM76-00106006
19					2	SR02A-VA-RGA-01	LM76-01704008
20					3	SR02A-VA-RGA-02	LM76-00305005
21					4	FE02I-VA-RGA-01	LM76-80004015
22					6	SR02I-VA-RGA-01	LM76-81604007
23					5	BL02I-VA-RGA-01	LM76-01904004
24	SR03C	Sector3	172.23.231.10	SR03C-VA-RGAPC-01	1	SR03S-VA-RGA-01	LM76-02105003
25					2	SR03A-VA-RGA-01	LM76-00905010
26					3	SR03A-VA-RGA-02	LM76-00105007
27					4	FE03I-VA-RGA-01	LM76-01904009
28					6	SR03I-VA-RGA-01	LM76-00805006
29					5	BL03I-VA-RGA-01	LM76-01904003
30	SR04C	Sector4	172.23.231.11	SR04C-VA-RGAPC-01	1	SR04S-VA-RGA-01	LM76-00106015
31					2	SR04A-VA-RGA-01	LM76-00805005
32					3	SR04A-VA-RGA-02	LM76-01704004
33					4	FE04I-VA-RGA-01	~~LM76-01704019~~
34							LM76-00106001
35					6	SR04I-VA-RGA-01	LM76-01904010
36					5	BL04I-VA-RGA-01	LM76-01904006
37	SR05C	Sector5	172.23.231.12	SR05C-VA-RGAPC-01	1	SR05S-VA-RGA-01	LM76-00106022
38					2	SR05A-VA-RGA-01	~~LM76-00305001~~
39							LM76-01904001

40					3	SR05A-VA-RGA-02	~~LM76-01904001~~
41							LM76-00805001

42	SR06C	Sector6	172.23.231.13	SR06C-VA-RGAPC-01	1	SR06S-VA-RGA-01	LM76-00106003
43					2	SR06A-VA-RGA-01	~~LM76-00305003~~
44							LM76-00905003
45					3	SR06A-VA-RGA-02	LM76-00305009
46					4	FE06I-VA-RGA-01	LM76-01105010
47				*analyser*	5	BL06I-VA-RGA-01	LM76-02105006
48				*ecu*			LM76-01705006
49	SR07C	Sector7	172.23.231.14	SR07C-VA-RGAPC-01	1	SR07S-VA-RGA-01	~~LM76-00305097~~
50							LM76-00305011
51					2	SR07A-VA-RGA-01	LM76-00305018
52					3	SR07A-VA-RGA-02	LM76-20704004
53	SR08C	Sector8	172.23.231.15	SR08C-VA-RGAPC-01	1	SR08S-VA-RGA-01	LM76-00305015
54					2	SR08A-VA-RGA-01	LM76-01904017
55					3	SR08A-VA-RGA-02	LM76-00805013
56	SR09C	Sector9	172.23.231.16	SR09C-VA-RGAPC-01	1	SR09S-VA-RGA-01	LM76-00305014
57					2	SR09A-VA-RGA-01	LM76-01705003
58					3	SR09A-VA-RGA-02	LM76-01705008
59	SR10C	Sector10	172.23.231.17	SR10C-VA-RGAPC-01	1	SR10S-VA-RGA-01	LM76-81604009
60					2	SR10A-VA-RGA-01	LM76-01705010
61					3	SR10A-VA-RGA-02	LM76-01705005
62	SR11C	Sector11	172.23.231.18	SR11C-VA-RGAPC-01	1	SR11S-VA-RGA-01	LM76-01704011
63					2	SR11A-VA-RGA-01	LM76-80004019
64					3	SR11A-VA-RGA-02	LM76-01705002
65					4	FE11I-VA-RGA-01	LM76-00106027
66					5	BL11I-VA-RGA-01	LM76-01605010
67					6	SR11I-VA-RGA-01	~~LM76-00307005~~
68							LM76-00505006
69	SR12C	Secto12	172.23.231.19	SR12C-VA-RGAPC-01	1	SR12S-VA-RGA-01	LM76-01705004
70					2	SR12A-VA-RGA-01	LM76-80004009
71					3	SR12A-VA-RGA-02	LM76-00305003
72	SR13C	Secto13	172.23.231.20	SR13C-VA-RGAPC-01	1	SR13S-VA-RGA-01	LM76-00905005
73					2	SR13A-VA-RGA-01	LM76-20704014
74					3	SR13A-VA-RGA-02	LM76-00805004
75	SR14C	Sector14	172.23.231.21	SR14C-VA-RGAPC-01	1	SR14S-VA-RGA-01	LM76-80004016
76					2	SR14A-VA-RGA-01	LM76-01704005
77					3	SR14A-VA-RGA-02	LM76-02105009
78	SR15C	Sector15	172.23.231.22	SR15C-VA-RGAPC-01	1	SR15S-VA-RGA-01	LM76-00106007
79					2	SR15A-VA-RGA-01	LM76-01705009
80					3	SR15A-VA-RGA-02	LM76-00805007
81					4	FE15I-VA-RGA-01	~~LM76-00105010~~
82							LM76-00805016
83					5	BL15I-VA-RGA-01	LM76-20704004

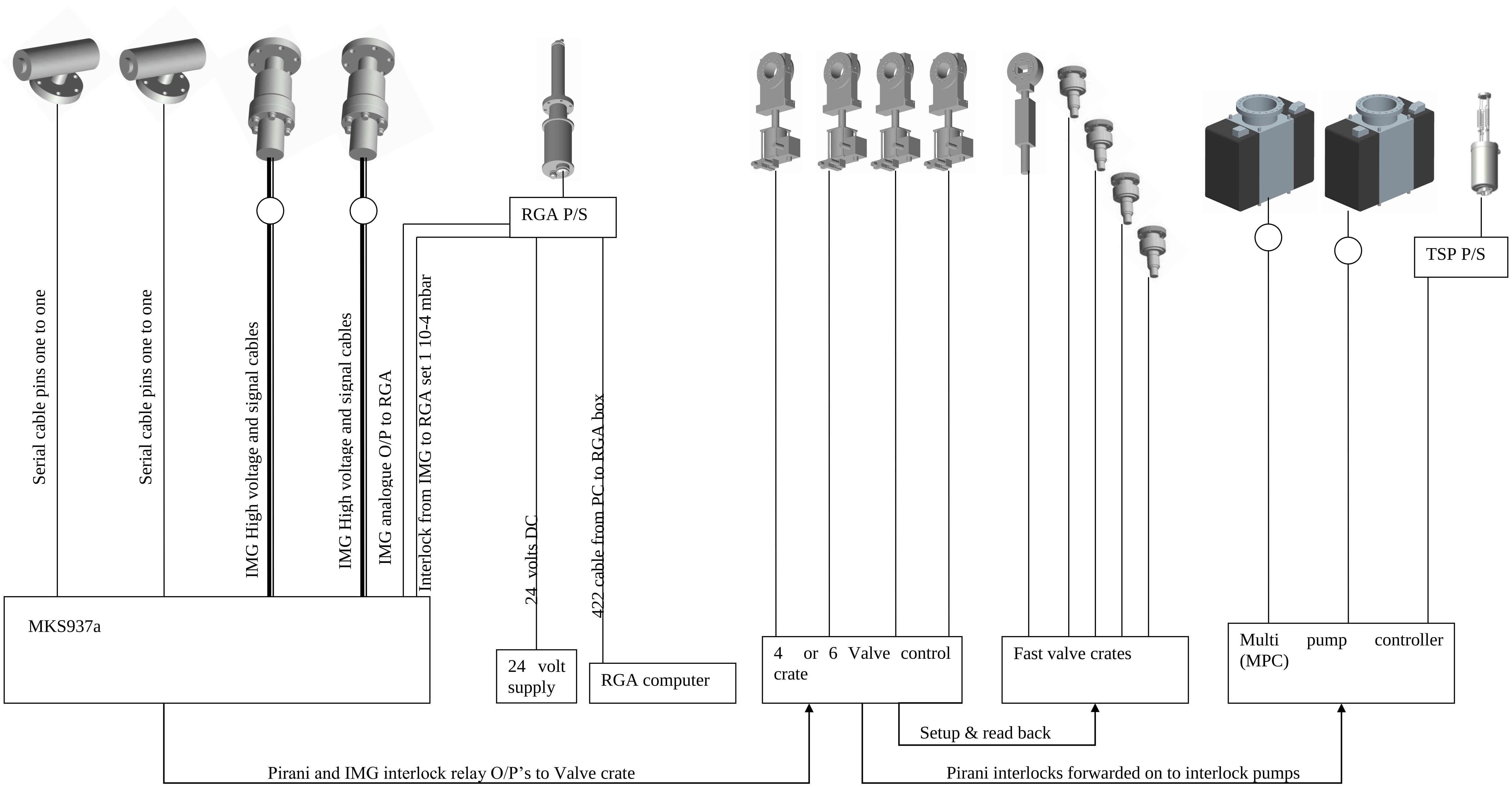
84	SR16C	Sector16	172.23.231.23	SR16C-VA-RGAPC-01	1	SR16S-VA-RGA-01	LM76-00106005
85					2	SR16A-VA-RGA-01	LM76-02105010
86					3	SR16A-VA-RGA-02	LM76-02105002
87					4	FE16I-VA-RGA-01	LM76-01704014
88					6	SR16I-VA-RGA-01	LM76-00106023
89					5	BL16I-VA-RGA-01	LM76-00805009
90					7	FE16B-VA-RGA-01	LM76-01704018
91	SR17C	Sector17	172.23.231.24	SR17C-VA-RGAPC-01	5	SR17S-VA-RGA-01	LM76-20704002
92					6	SR17S-VA-RGA-02	LM76-20704008
93					7	SR17S-VA-RGA-03	
94					1	SR17A-VA-RGA-01	LM76-20704009
95					2	SR17A-VA-RGA-02	LM76-01705001
96	SR18C	Sector18	172.23.231.25	SR18C-VA-RGAPC-01	1	SR18S-VA-RGA-01	LM76-00106002
97					2	SR18A-VA-RGA-01	LM76-80004017
98					3	SR18A-VA-RGA-02	LM76-00905008
99					4	FE18I-VA-RGA-01	LM76-01704016
100					6	SR18I-VA-RGA-01	LM76-01604002
101					5	BL18I-VA-RGA-01	LM76-00106024
102	SR19C	Sector19	172.23.231.26	SR19C-VA-RGAPC-01	1	SR19S-VA-RGA-01	LM76-01704015
103					2	SR19A-VA-RGA-01	LM76-00305013
104					3	SR19A-VA-RGA-02	LM76-00805012
105					4	FE19I-VA-RGA-01	LM76-00106004
106	SR20C	Sector20	172.23.231.27	SR20C-VA-RGAPC-01	1	SR20S-VA-RGA-01	LN76-01704007
107					2	SR20A-VA-RGA-01	LM76-01904005
108					3	SR20A-VA-RGA-02	LM76-20704012
109	SR21C	Sector21	172.23.231.28	SR21C-VA-RGAPC-01	1	SR21S-VA-RGA-01	LM76-00805020
110					6	SR21S-VA-RGA-02	LM76-00106016
111					2	SR21A-VA-RGA-01	LM76-01904008
112					3	SR21A-VA-RGA-02	LM76-01904002
113	SR22C	Sector22	172.23.231.29	SR22C-VA-RGAPC-01	1	SR22S-VA-RGA-01	~~LM76-00305002~~
114							LM76-00106009
115					2	SR22A-VA-RGA-01	LM76-00305019
116					3	SR22A-VA-RGA-02	LM76-01704010
117					4	FE22I-VA-RGA-01	LM76-01704017
118					6	SR22I-VA-RGA-01	LM76-00905009
119					5	BL22I-VA-RGA-01	LM76-00805008
120	SR23C	Sector23	172.23.231.30	SR23C-VA-RGAPC-01	1	SR23S-VA-RGA-01	LM76-00305008
121					2	SR23A-VA-RGA-01	LM76-01704009
122					3	SR23A-VA-RGA-02	LM76-00805019
123					7	FE23B-VA-RGA-01	LM76-00806004

124	SR24C	Sector24	172.23.231.31	SR24C-VA-RGAPC-01	1	SR24S-VA-RGA-01	LM76-01704006
125					2	SR24A-VA-RGA-01	LM76-00305006
126					3	SR24A-VA-RGA-02	LM76-01904020
127					4	FE24I-VA-RGA-01	LM76-00705002
128					5	BL24I-VA-RGA-01	LM76-01605009
129					6	SR24I-VA-RGA-01	LM76-00307006
130	BL02I		172.23.231.32	BL02I-VA-RGAPC-01		BL02I-VA-RGA-02	LM76-01904011
131						BL02I-VA-RGA-03	LM76-01904014
132	BL03I		172.23.231.33	BL03I-VA-RGAPC-01	1	BL03I-VA-RGA-02	LM76-01904019
133					2	BL03I-VA-RGA-03	LM76-01904013
134	BL04I		172.23.231.34	BL04I-VA-RGAPC-01		BL04I-VA-RGA-02	LM76-01904016
135						BL04I-VA-RGA-03	LM76-01904018
136	BL06I		172.23.231.35	BL06I-VA-RGAPC-01	1	BL06I-VA-RGA-02	LM76-00106020
137					2	BL06I-VA-RGA-03	LM76-01705007
138					3	BL06I-VA-RGA-04	LM76-01705006
139					4	BL06I-VA-RGA-05	LM76-02105005
140	BL15I		172.23.231.36	BL15I-VA-RGAPC-01	2	BL15I-VA-RGA-02	LM76-00106028
141					3	BL15I-VA-RGA-03	LM76-00106008
142					4	BL15I-VA-RGA-04	LM76-
143					5	BL15I-VA-RGA-05	LM76-00106010
144	BL16B		172.23.231.37	BL16B-VA-RGAPC-01	1	BL16B-VA-RGA-02	LM76-00707007
145					2	BL16B-VA-RGA-03	LM76-01704011
146	BL11I		172.23.231.38	BL11I-VA-RGAPC-01	1	BL11I-VA-RGA-02	LM76-01704019
					2	BL11I-VA-RGA-03	LM76-00806006
147	BL24I		172.23.231.39	BL24I-VA-RGAPC-01			
148	BL19I		172.23.231.40	BL19I-VA-RGAPC-01			
149	BL18B		172.23.231.41	BL18B-VA-RGAPC-01			
150	BL12I		172.23.231.42	BL12I-VA-RGAPC-01			
151	BL07I		172.23.231.43	BL07I-VA-RGAPC-01			
152	BL20I		172.23.231.44	BL20I-VA-RGAPC-01			
153	ME01 Bl net		172.23.231.45	ME01D-VA-RGAPC-01			
154	ME01 Dev net		172.23.243.199	ME01D-VA-RGAPC-01			
155	BL12I external		172.23.231.46	BL12I-VA-RGAPC-01			
156	RFTF		172.23.231.47	RT-VA-RGAPC-01	1	RT-VA-RGA-01	LM76-02105008
	BL10I		172.23.231.48	BL10I-VA-RGAPC-01			
	BL13I		172.23.231.49	BL13I-VA-RGAPC-01			
	BL13I external		172.23.231.52	BL13I-VA-RGAPC-02			
	BL09I		172.23.231.50	BL09I-VA-RGAPC-01			
	BL09I		172.23.231.53	BL09I-VA-RGAPC-02			
	Vac Lab		172.23.4.97	Diamrg0001.dc.diamond.ac.uk			

14.5 MV2 RGA

RGA's running MV2 are connected directly to the beamline secondary network.
Subnet 255.255.240.0 & gateway to 172.23.224.254

Nos	Area	I/P Address	MAC Address
1	BL21B-VA-RGA-02	172.23.231.54	00:05:51:03:E9:FA
2	BL21B-VA-RGA-03	172.23.231.55	00:05:51:03:12:B1
3	BL23I-VA-RGA-02	172.23.231.56	00:05:51:03:12:DA
4	BL23I-VA-RGA-03	172.23.231.57	00:05:51:03:12:6B
5	BL23I-VA-RGA-04	172.23.231.58	
6	BL05I-VA-RGA-02	172.23.231.59	00:05:51:03:13:5C
7	BL05I-VA-RGA-03	172.23.231.60	00:05:51:03:13:3D
8	BL05I-VA-RGA-11	172.23.231.62	00:05:51:05:8A:DD
9	BL05I-VA-RGA-12	172.23.231.63	00:05:51:05:8A:E8
10	BL05I-VA-RGA-04	172.23.231.64	00:05:51:03:13:2A
11	BL05I-VA-RGA-21	172.23.231.65	00:05:51:05:8A:6C
12	BL08I-VA-RGA-02	172.23.231.66	00:05:51:05:8A:76
13	BL08I-VA-RGA-03	172.23.231.67	00:05:51:03:12:F6
14	BL05I-VA-RGA-05	172.23.231.68	00:05:51:04:32:27
15	BL24B-VA-RGA-02	172.23.231.70	00:05:51:05:8C:75
16	BL05J-VA-RGA-71	172.23.231.71	
17	BL05J-VA-RGA-72	172.23.231.71	
18		172.23.231.72	
19		172.23.231.73	
20	BL07C-VA-RGA-01	172.23.231.74	00:05:51:04:4A:60
21	BL07C-VA-RGA-02	172.23.231.75	00:05:51:04:4A:C2
22	BL07C-VA-RGA-03	172.23.231.76	00:05:51:04:49:75
23	BL21I-VA-RGA-02	172.23.231.78	00:05:51:07:85:7E


Serial cable pins one to one
Serial cable pins one to one
IMG High voltage and signal cables
IMG High voltage and signal cables
IMG analogue O/P to RGA
Interlock from IMG to RGA set 1 10-4 mbar
RGA P/S
24 volts DC
422 cable from PC to RGA box
MKS937a
24 volt supply
RGA computer
4 or 6 Valve control crate
Fast valve crates
TSP P/S
Multi pump controller (MPC)
Setup & read back
Pirani and IMG interlock relay O/P's to Valve crate
Pirani interlocks forwarded on to interlock pumps

14.6 Fastvalve electronic dipswitch settings

VAT Fast valve crate controller (Frontend controls beam line gauges and Fastflap)

		Switch 1	2	3	4	5	6
Power supply	s1	0	0	0	0		

Note: Fast valve stays open on power off

		Switch 1	2	3	4	5	6
HV-Sensor module	s1	1	0	0	1	0	0
	s2	1	0	0	0		
	s3	1	0	0	0	0	0
	s4	0	0	0	0		

Note: S4.1=0 allows disconnection of CC cable without triggering fast valve shut.
Potentiometer Filter: Left stop 1mS, Right Stop 7mS

		Switch 1	2	3	4	5	6
HV-Sensor module	s1	1	0	0	1	0	0
	s2	1	0	0	0		
	s3	0	1	0	0	0	0
	s4	0	0	0	0		

		Switch 1	2	3	4	5	6
Control module	s1	1	0	0	0		
	s2	1	0	0	1	0	0
	s3	1	1	0	0	0	0
	s4	0	0	0	0		

Note: S4.1=0 Gauge signals AND together to make control trip

		Switch					
		1	2	3	4	5	6
Valve module	s1	1	0	0	1	0	0
	s2	1	0	0	0		
	s3	1	1	1	0		
	s4(series77)	1	0	0	1		
	s4(Series75)	0	0	0	1		

<u>Fast valve crate controller (Frontend controls frontend gauges)</u>

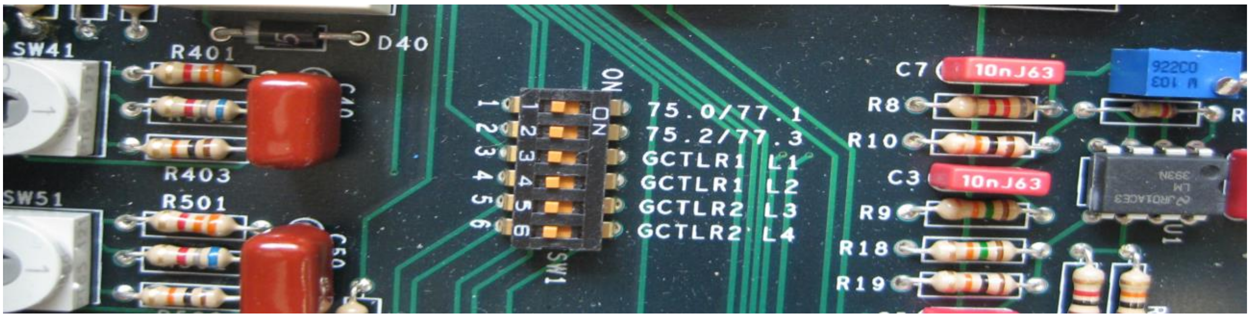
		Switch					
		1	2	3	4	5	6
Power supply	s1	0	0	0	0		

		Switch					
		1	2	3	4	5	6
HV-Sensor module	s1	1	0	0	1	0	0
	s2	1	0	0	0		
	s3	0	0	1	0	0	0
	s4	0	0	0	0		

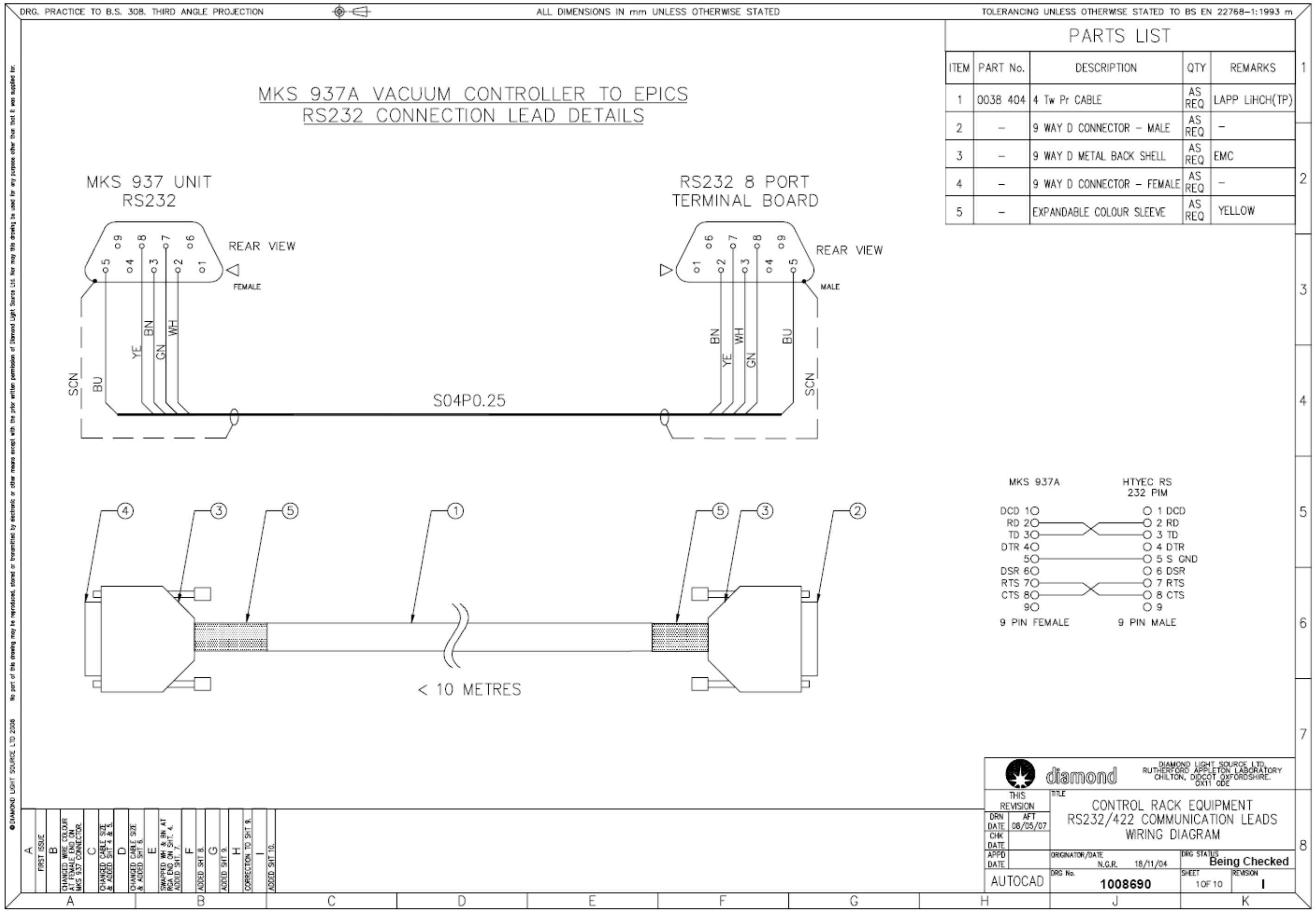
		Switch					
		1	2	3	4	5	6
HV-Sensor module	s1	1	0	0	1	0	0
	s2	1	0	0	0		
	s3	0	0	0	1	0	0
	s4	0	0	0	0		

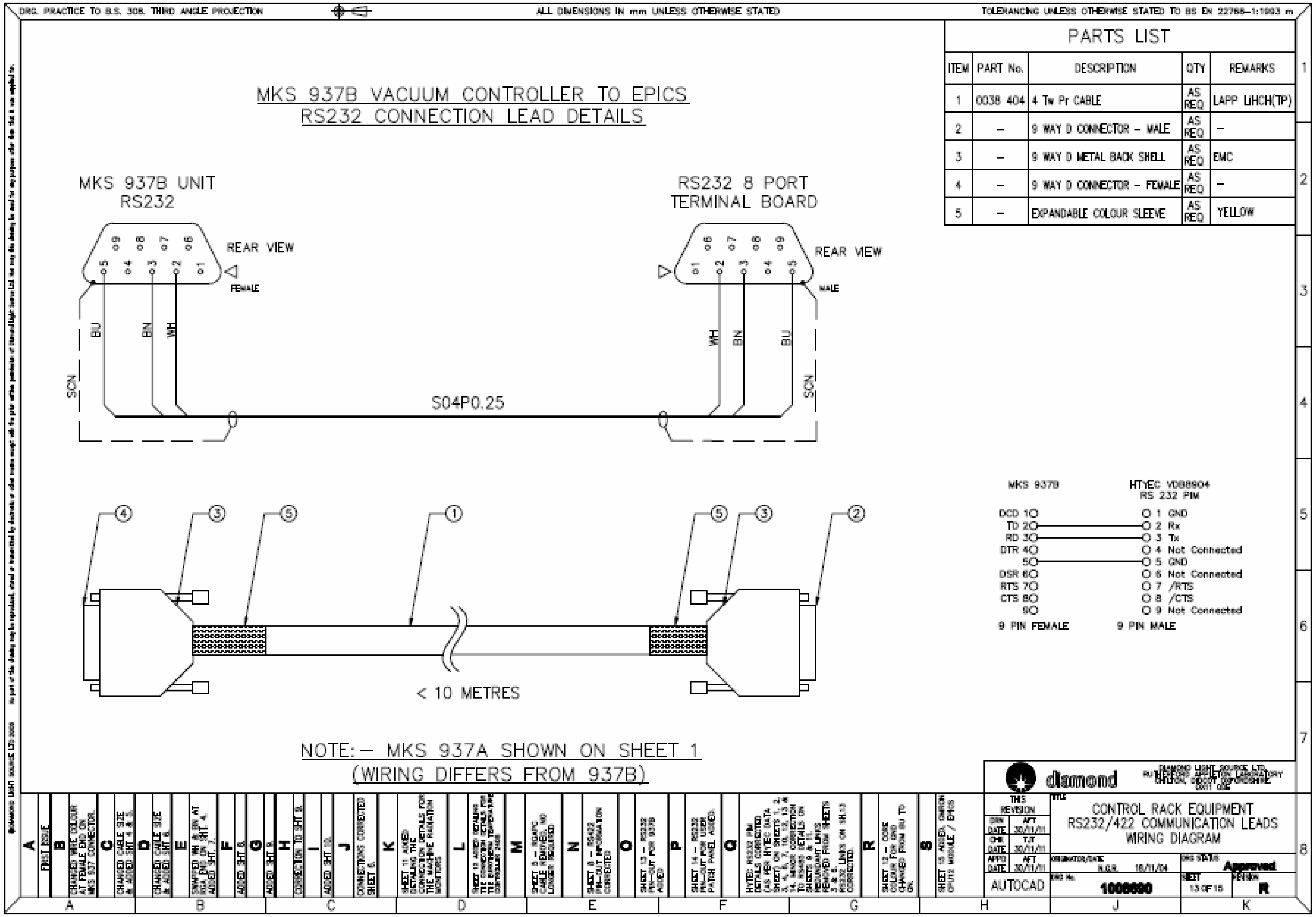
Control module	Switch 1	2	3	4	5	6
s1	1	0	0	0		
s2	1	0	0	1	0	0
s3	0	0	1	1	0	0
s4	0	0	0	0		

DLS fast controller dip swirches

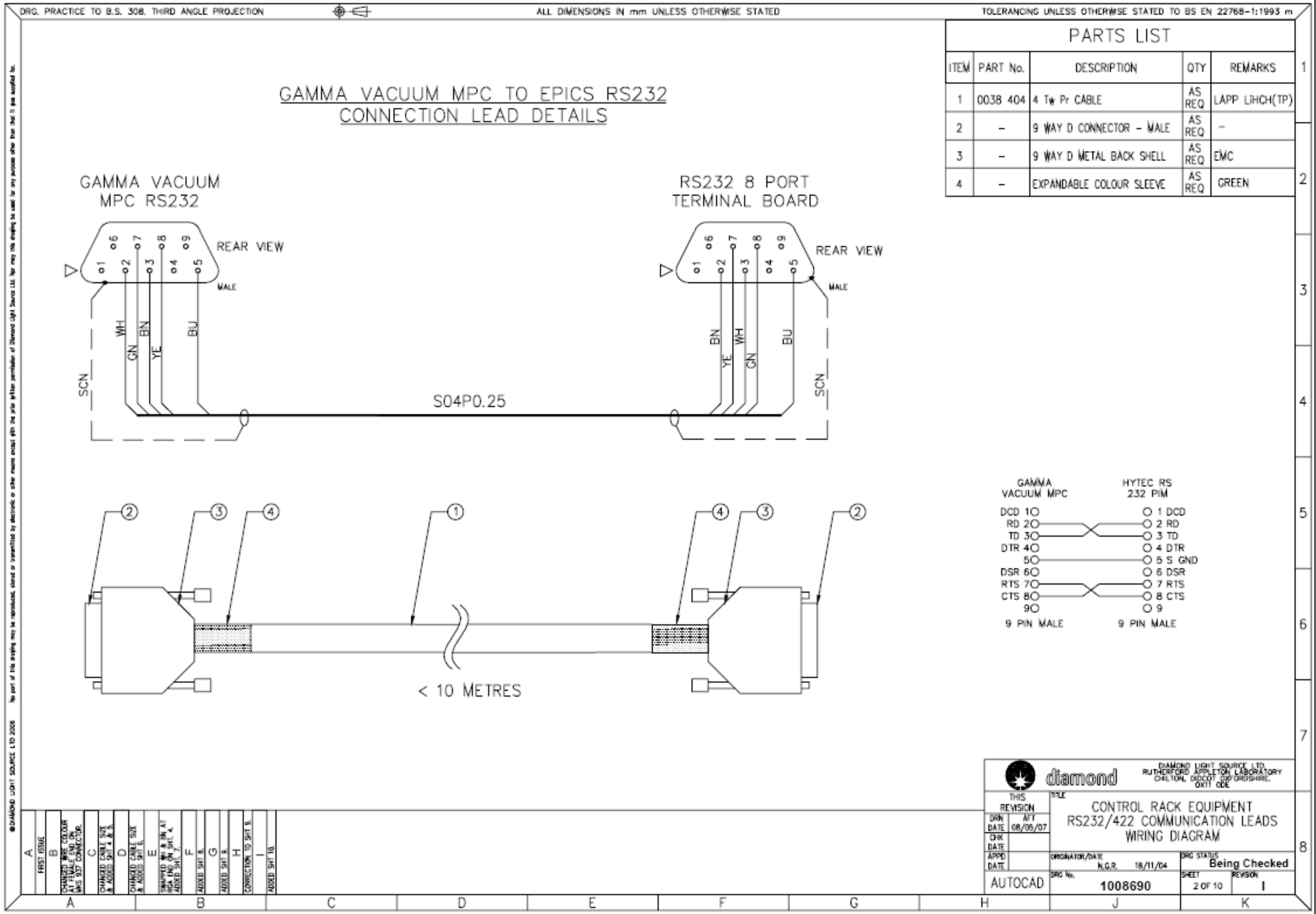


14.7 RS232 wiring details for vacuum devices





MKS 937B VACUUM CONTROLLER TO EPICS
RS232 CONNECTION LEAD DETAILS
MKS 937B UNIT
RS232
REAR VIEW
FEMALE
RS232 8 PORT
TERMINAL BOARD
REAR VIEW
MALE
BU
BN
WH
SCN
S04P0.25
< 10 METRES
NOTE:— MKS 937A SHOWN ON SHEET 1
(WIRING DIFFERS FROM 937B)
PARTS LIST
ITEM | PART No. | DESCRIPTION | QTY | REMARKS
1 | 0038 404 | 4 Tw Pr CABLE | AS REQ | LAPP LIHCH(TP)
2 | – | 9 WAY D CONNECTOR – MALE | AS REQ | –
3 | – | 9 WAY D METAL BACK SHELL | AS REQ | EMC
4 | – | 9 WAY D CONNECTOR – FEMALE | AS REQ | –
5 | – | EXPANDABLE COLOUR SLEEVE | AS REQ | YELLOW
MKS 937B
HTYEC VD88904
RS 232 PIM
DCD 1
TD 2
RD 3
DTR 4
5
DSR 6
RTS 7
CTS 8
9
1 GND
2 Rx
3 Tx
4 Not Connected
5 GND
6 Not Connected
7 /RTS
8 /CTS
9 Not Connected
9 PIN FEMALE
9 PIN MALE
CONTROL RACK EQUIPMENT
RS232/422 COMMUNICATION LEADS
WIRING DIAGRAM
AUTOCAD
Approved
R


DRG. PRACTICE TO B.S. 308. THIRD ANGLE PROJECTION
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED
TOLERANCING UNLESS OTHERWISE STATED TO BS EN 22768-1:1993 m
GAMMA VACUUM MPC TO EPICS RS232
CONNECTION LEAD DETAILS
PARTS LIST
ITEM | PART No. | DESCRIPTION | QTY | REMARKS
1 | 0038 404 | 4 Tw Pr CABLE | AS REQ | LAPP LIHCH(TP)
2 | – | 9 WAY D CONNECTOR – MALE | AS REQ | –
3 | – | 9 WAY D METAL BACK SHELL | AS REQ | EMC
4 | – | EXPANDABLE COLOUR SLEEVE | AS REQ | GREEN
GAMMA VACUUM
MPC RS232
REAR VIEW
MALE
RS232 8 PORT
TERMINAL BOARD
REAR VIEW
MALE
WH
GN
BN
YE
BU
SCN
S04P0.25
BN
YE
WH
GN
BU
SCN
< 10 METRES
GAMMA
VACUUM MPC
HYTEC RS
232 PIM
DCD 1
RD 2
TD 3
DTR 4
5
DSR 6
RTS 7
CTS 8
9
9 PIN MALE
1 DCD
2 RD
3 TD
4 DTR
5 S GND
6 DSR
7 RTS
8 CTS
9
9 PIN MALE
diamond
DIAMOND LIGHT SOURCE LTD.
RUTHERFORD APPLETON LABORATORY
CHILTON, DIDCOT, OXFORDSHIRE.
OX11 0DE
CONTROL RACK EQUIPMENT
RS232/422 COMMUNICATION LEADS
WIRING DIAGRAM
Being Checked
AUTOCAD
1008690
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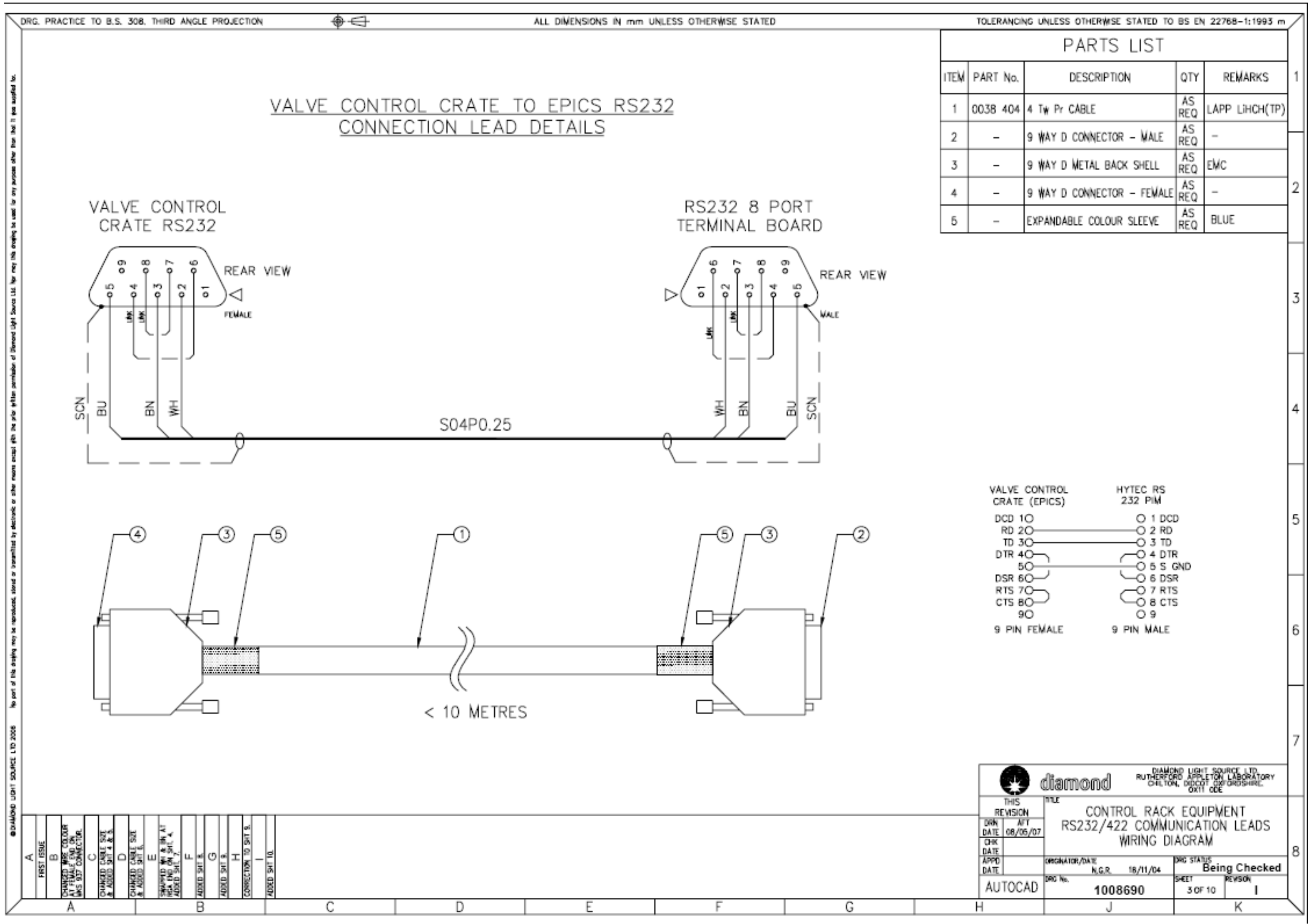
I
A
B
C
D
E
F
G
H
J
K



DRG. PRACTICE TO B.S. 308. THIRD ANGLE PROJECTION
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED
TOLERANCING UNLESS OTHERWISE STATED TO BS EN 22768-1:1993 m
VALVE CONTROL CRATE TO EPICS RS232
CONNECTION LEAD DETAILS
VALVE CONTROL
CRATE RS232
REAR VIEW
FEMALE
RS232 8 PORT
TERMINAL BOARD
REAR VIEW
MALE
SCN
BU
BN
WH
S04P0.25
< 10 METRES
PARTS LIST
ITEM | PART No. | DESCRIPTION | QTY | REMARKS
1 | 0038 404 | 4 Tw Pr CABLE | AS REQ | LAPP LiHCH(TP)
2 | – | 9 WAY D CONNECTOR – MALE | AS REQ | –
3 | – | 9 WAY D METAL BACK SHELL | AS REQ | EMC
4 | – | 9 WAY D CONNECTOR – FEMALE | AS REQ | –
5 | – | EXPANDABLE COLOUR SLEEVE | AS REQ | BLUE
VALVE CONTROL
CRATE (EPICS)
HYTEC RS
232 PIM
DCD 1
RD 2
TD 3
DTR 4
5
DSR 6
RTS 7
CTS 8
9
9 PIN FEMALE
1 DCD
2 RD
3 TD
4 DTR
5 S GND
6 DSR
7 RTS
8 CTS
9
9 PIN MALE
diamond
DIAMOND LIGHT SOURCE LTD.
RUTHERFORD APPLETON LABORATORY
CHILTON, DIDCOT, OXFORDSHIRE.
OX11 0DE
CONTROL RACK EQUIPMENT
RS232/422 COMMUNICATION LEADS
WIRING DIAGRAM
AUTOCAD
N.G.R. 18/11/04
Being Checked
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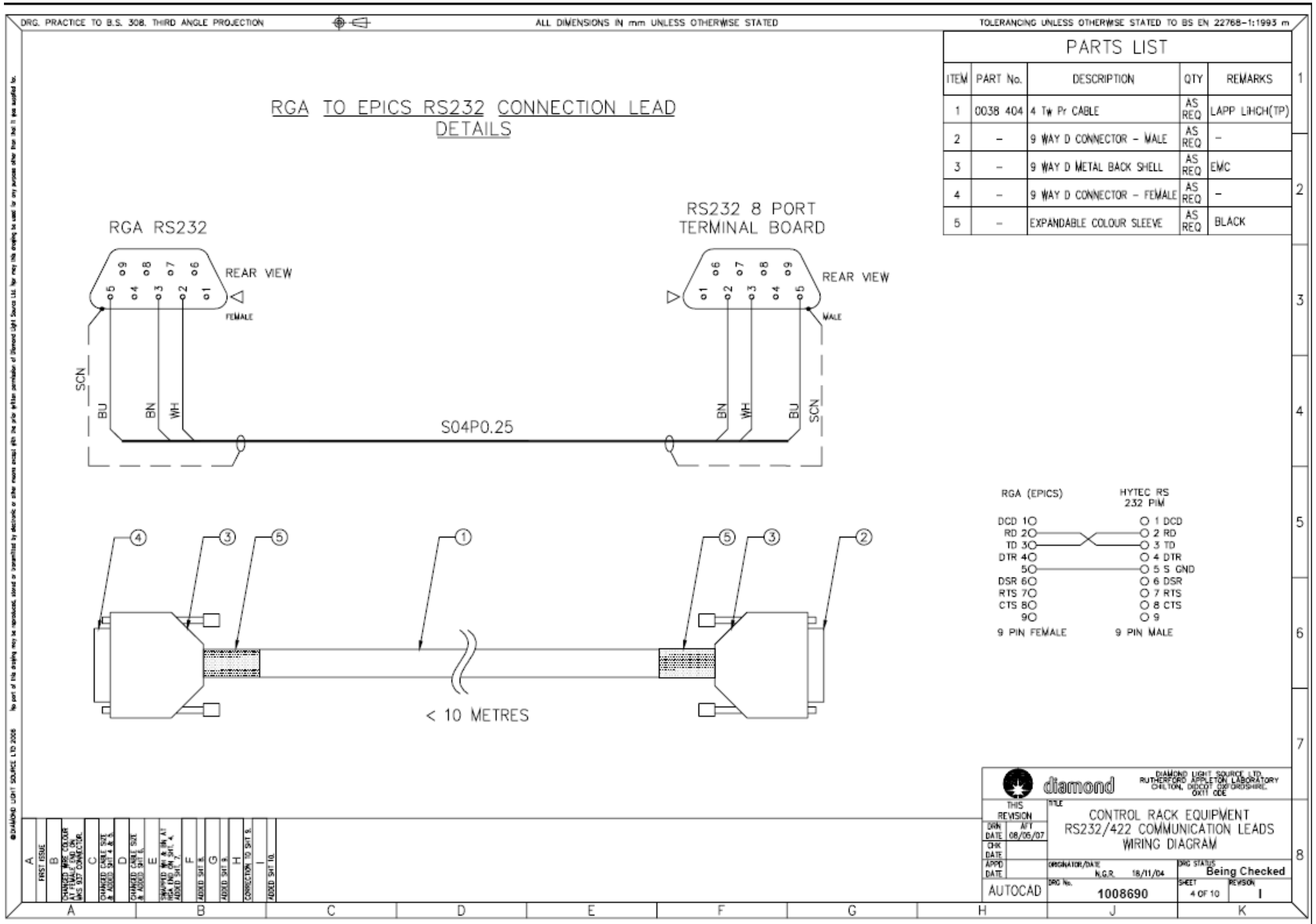
DRG. PRACTICE TO B.S. 308. THIRD ANGLE PROJECTION
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED
TOLERANCING UNLESS OTHERWISE STATED TO BS EN 22768-1:1993 m
RGA TO EPICS RS232 CONNECTION LEAD DETAILS
RGA RS232
REAR VIEW
FEMALE
RS232 8 PORT TERMINAL BOARD
REAR VIEW
MALE
SCN
BU
BN
WH
S04P0.25
< 10 METRES
PARTS LIST
ITEM | PART No. | DESCRIPTION | QTY | REMARKS
1 | 0038 404 | 4 Tw Pr CABLE | AS REQ | LAPP LIHCH(TP)
2 | – | 9 WAY D CONNECTOR – MALE | AS REQ | –
3 | – | 9 WAY D METAL BACK SHELL | AS REQ | EMC
4 | – | 9 WAY D CONNECTOR – FEMALE | AS REQ | –
5 | – | EXPANDABLE COLOUR SLEEVE | AS REQ | BLACK
RGA (EPICS)
HYTEC RS 232 PIM
DCD 1
RD 2
TD 3
DTR 4
5
DSR 6
RTS 7
CTS 8
9
9 PIN FEMALE
1 DCD
2 RD
3 TD
4 DTR
5 S GND
6 DSR
7 RTS
8 CTS
9
9 PIN MALE
diamond
DIAMOND LIGHT SOURCE LTD.
RUTHERFORD APPLETON LABORATORY
CHILTON, DIDCOT OXFORDSHIRE.
CONTROL RACK EQUIPMENT
RS232/422 COMMUNICATION LEADS
WIRING DIAGRAM
Being Checked
AUTOCAD
N.G.R. 18/11/04
1008690
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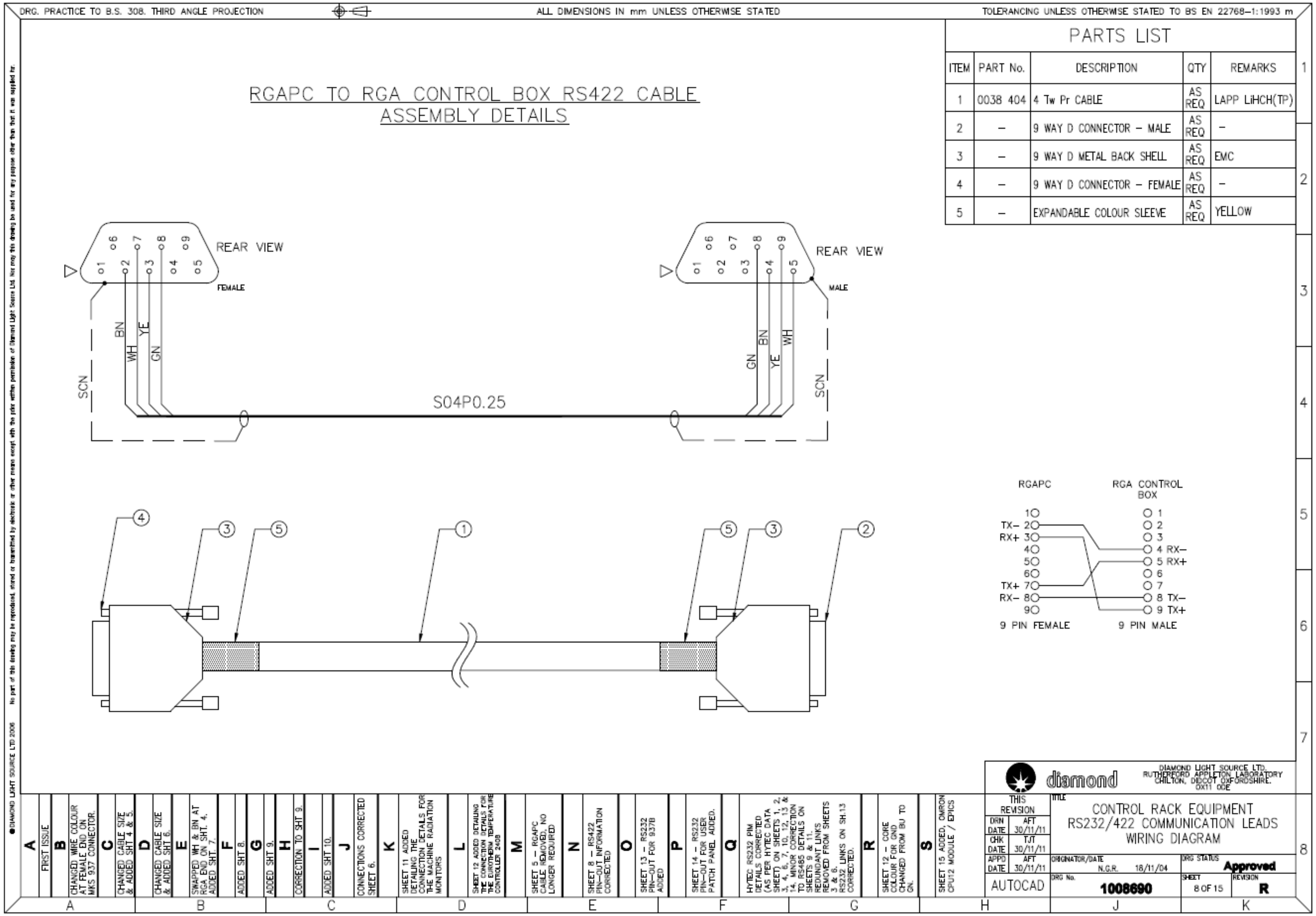
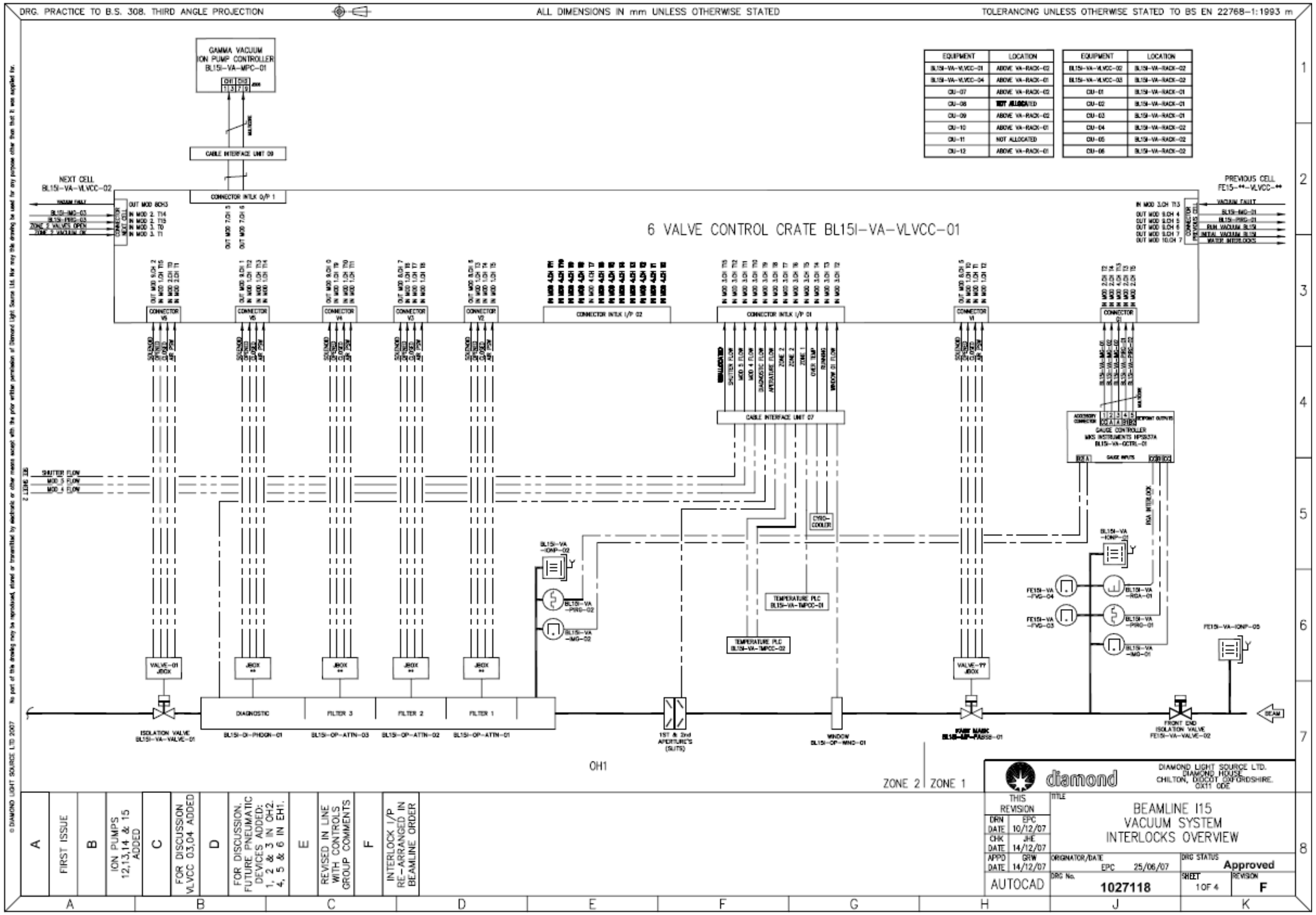
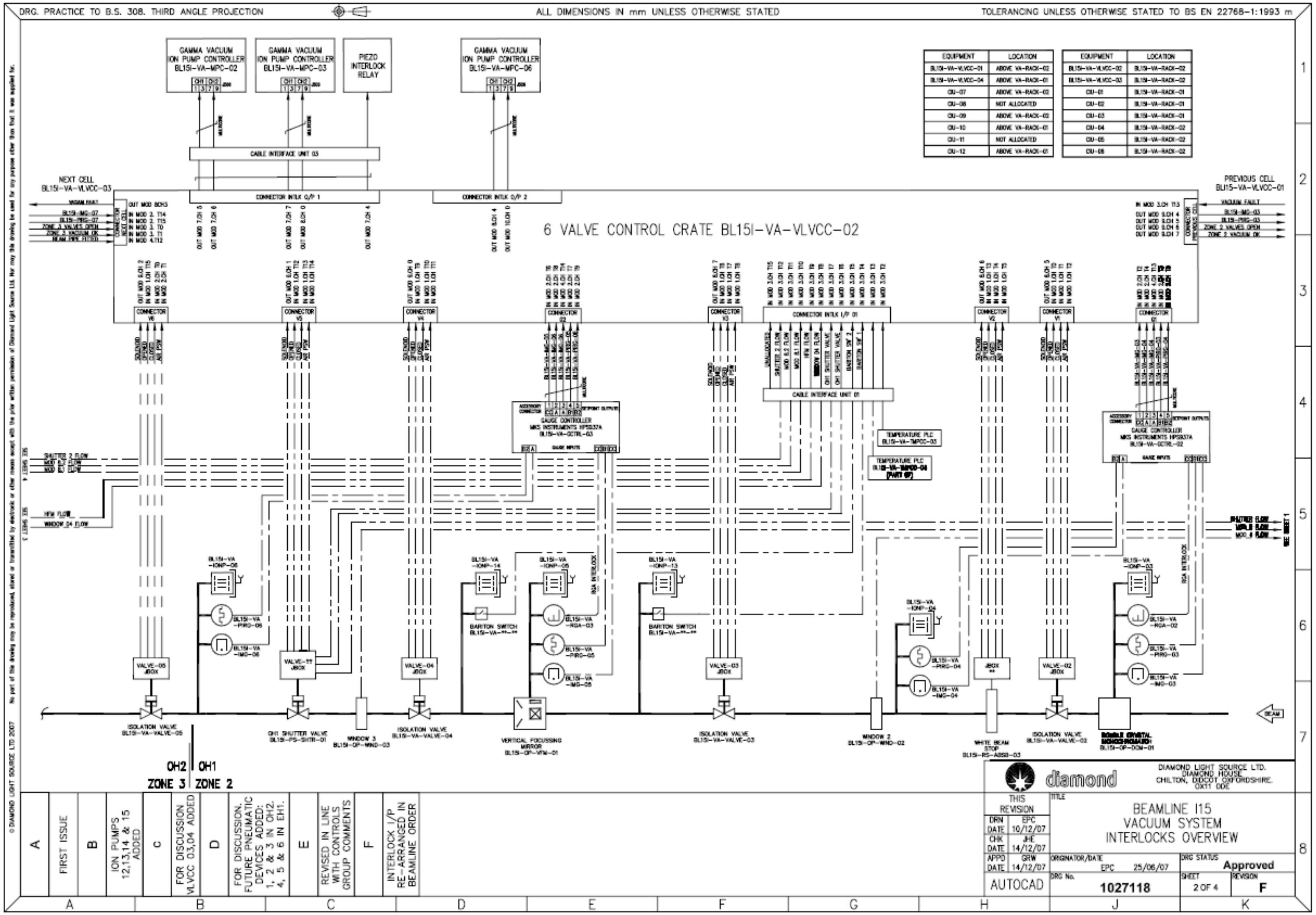
A B C D E F G H J K



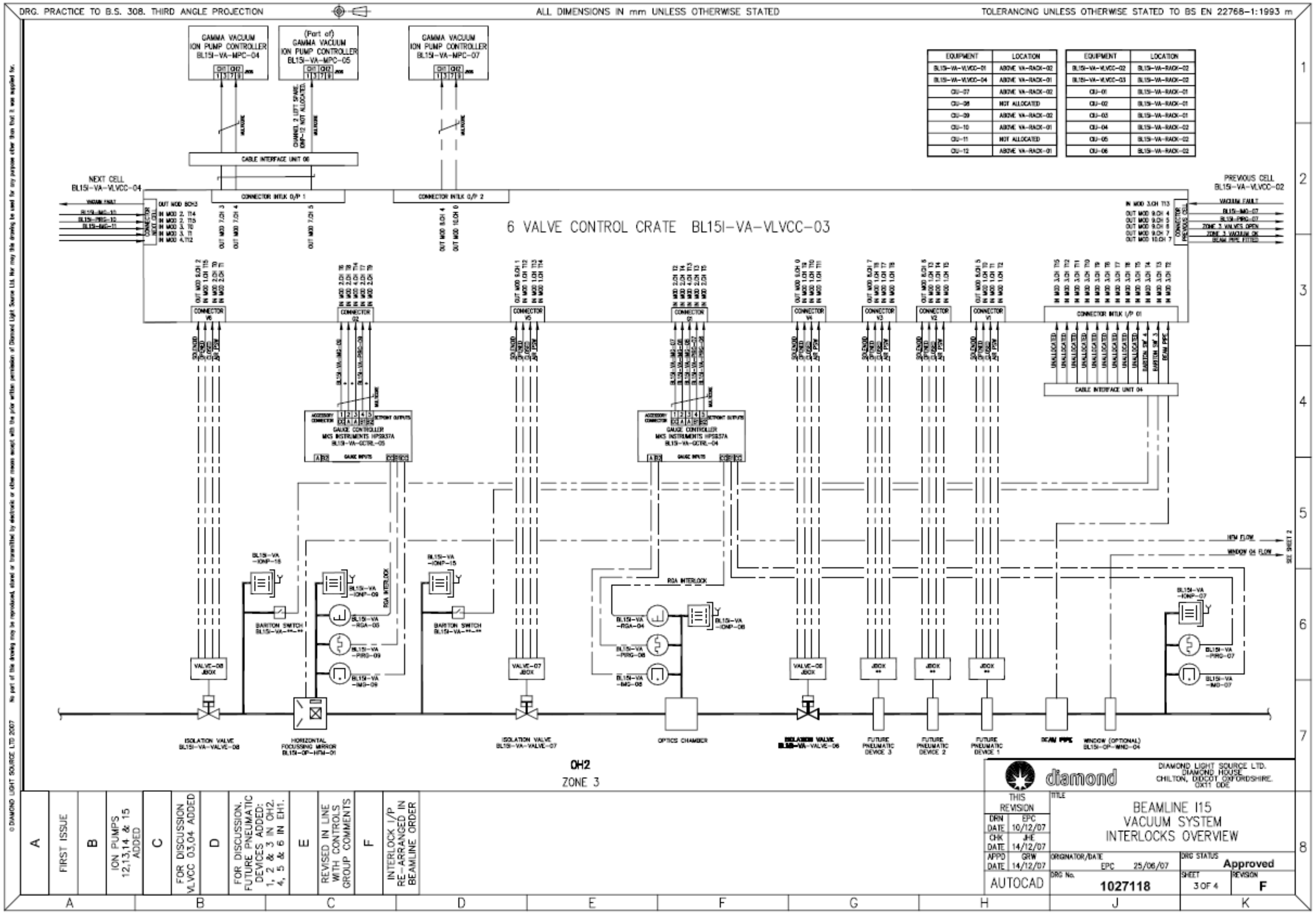
DRG. PRACTICE TO B.S. 308. THIRD ANGLE PROJECTION
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED
TOLERANCING UNLESS OTHERWISE STATED TO BS EN 22768–1:1993 m
RGAPC TO RGA CONTROL BOX RS422 CABLE
ASSEMBLY DETAILS
PARTS LIST
ITEM | PART No. | DESCRIPTION | QTY | REMARKS
1 | 0038 404 | 4 Tw Pr CABLE | AS REQ | LAPP LiHCH(TP)
2 | – | 9 WAY D CONNECTOR – MALE | AS REQ | –
3 | – | 9 WAY D METAL BACK SHELL | AS REQ | EMC
4 | – | 9 WAY D CONNECTOR – FEMALE | AS REQ | –
5 | – | EXPANDABLE COLOUR SLEEVE | AS REQ | YELLOW
REAR VIEW
FEMALE
MALE
BN
WH
YE
GN
SCN
S04P0.25
RGAPC
RGA CONTROL BOX
TX– 2
RX+ 3
TX+ 7
RX– 8
4 RX–
5 RX+
8 TX–
9 TX+
9 PIN FEMALE
9 PIN MALE
DIAMOND LIGHT SOURCE LTD. RUTHERFORD APPLETON LABORATORY CHILTON, DIDCOT OXFORDSHIRE. OX11 0DE
CONTROL RACK EQUIPMENT
RS232/422 COMMUNICATION LEADS
WIRING DIAGRAM
AUTOCAD
N.G.R. 18/11/04
Approved
1008690
8 OF 15
R

14.8 6 Valve interconnections on I15





DRG. PRACTICE TO B.S. 308. THIRD ANGLE PROJECTION
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED
TOLERANCING UNLESS OTHERWISE STATED TO BS EN 22768-1:1993 m
GAMMA VACUUM ION PUMP CONTROLLER BL15I-VA-MPC-02
GAMMA VACUUM ION PUMP CONTROLLER BL15I-VA-MPC-03
PIEZO INTERLOCK RELAY
GAMMA VACUUM ION PUMP CONTROLLER BL15I-VA-MPC-06
CABLE INTERFACE UNIT 03
CONNECTOR INTLK O/P 1
CONNECTOR INTLK O/P 2
NEXT CELL BL15I-VA-VLVCC-03
PREVIOUS CELL BL15-VA-VLVCC-01
6 VALVE CONTROL CRATE BL15I-VA-VLVCC-02
CABLE INTERFACE UNIT 01
GAUGE CONTROLLER MKS INSTRUMENTS HPS937A BL15I-VA-GCTRL-03
GAUGE CONTROLLER MKS INSTRUMENTS HPS937A BL15I-VA-GCTRL-02
TEMPERATURE PLC BL15I-VA-TMPCC-03
SHUTTER 2 FLOW
WHITE BEAM STOP
BEAM
ISOLATION VALVE BL15I-VA-VALVE-05
OH1 SHUTTER VALVE BL15I-PS-SHTR-01
WINDOW 3 BL15I-OP-WIND-03
ISOLATION VALVE BL15I-VA-VALVE-04
VERTICAL FOCUSSING MIRROR BL15I-OP-VFM-01
ISOLATION VALVE BL15I-VA-VALVE-03
WINDOW 2 BL15I-OP-WIND-02
ISOLATION VALVE BL15I-VA-VALVE-02
DOUBLE CRYSTAL MONOCHROMATOR BL15I-OP-DCM-01
OH2 OH1
ZONE 3 ZONE 2
A FIRST ISSUE
B ION PUMPS 12,13,14 & 15 ADDED
C FOR DISCUSSION VLVCC 03,04 ADDED
D FOR DISCUSSION. FUTURE PNEUMATIC DEVICES ADDED: 1, 2 & 3 IN OH2. 4, 5 & 6 IN EH1.
E REVISED IN LINE WITH CONTROLS GROUP COMMENTS
F INTERLOCK I/P RE-ARRANGED IN BEAMLINE ORDER
DIAMOND LIGHT SOURCE LTD. DIAMOND HOUSE CHILTON, DIDCOT, OXFORDSHIRE. OX11 0DE
BEAMLINE I15 VACUUM SYSTEM INTERLOCKS OVERVIEW
DRN EPC DATE 10/12/07
CHK JHE DATE 14/12/07
APPD GRW DATE 14/12/07
ORIGINATOR/DATE EPC 25/06/07
DRG STATUS Approved
AUTOCAD
DRG No. 1027118
SHEET 2 OF 4
REVISION F


DRG. PRACTICE TO B.S. 308. THIRD ANGLE PROJECTION
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED
TOLERANCING UNLESS OTHERWISE STATED TO BS EN 22768-1:1993 m
GAMMA VACUUM ION PUMP CONTROLLER BL15I-VA-MPC-04
(Part of) GAMMA VACUUM ION PUMP CONTROLLER BL15I-VA-MPC-05
GAMMA VACUUM ION PUMP CONTROLLER BL15I-VA-MPC-07
EQUIPMENT | LOCATION
BL15I-VA-VLVCC-01 | ABOVE VA-RACK-02
BL15I-VA-VLVCC-04 | ABOVE VA-RACK-01
CIU-07 | ABOVE VA-RACK-02
CIU-08 | NOT ALLOCATED
CIU-09 | ABOVE VA-RACK-02
CIU-10 | ABOVE VA-RACK-01
CIU-11 | NOT ALLOCATED
CIU-12 | ABOVE VA-RACK-01
EQUIPMENT | LOCATION
BL15I-VA-VLVCC-02 | BL15I-VA-RACK-02
BL15I-VA-VLVCC-03 | BL15I-VA-RACK-02
CIU-01 | BL15I-VA-RACK-01
CIU-02 | BL15I-VA-RACK-01
CIU-03 | BL15I-VA-RACK-01
CIU-04 | BL15I-VA-RACK-02
CIU-05 | BL15I-VA-RACK-02
CIU-06 | BL15I-VA-RACK-02
NEXT CELL BL15I-VA-VLVCC-04
PREVIOUS CELL BL15I-VA-VLVCC-02
6 VALVE CONTROL CRATE BL15I-VA-VLVCC-03
GAUGE CONTROLLER MKS INSTRUMENTS HPS937A BL15I-VA-GCTRL-05
GAUGE CONTROLLER MKS INSTRUMENTS HPS937A BL15I-VA-GCTRL-04
RGA INTERLOCK
ISOLATION VALVE BL15I-VA-VALVE-08
HORIZONTAL FOCUSSING MIRROR BL15I-OP-HFM-01
ISOLATION VALVE BL15I-VA-VALVE-07
OPTICS CHAMBER
FUTURE PNEUMATIC DEVICE 3
FUTURE PNEUMATIC DEVICE 2
FUTURE PNEUMATIC DEVICE 1
BEAM PIPE
WINDOW (OPTIONAL) BL15I-OP-WND-04
OH2
ZONE 3
A FIRST ISSUE
B ION PUMPS 12,13,14 & 15 ADDED
C FOR DISCUSSION VLVCC 03,04 ADDED
D FOR DISCUSSION. FUTURE PNEUMATIC DEVICES ADDED: 1, 2 & 3 IN OH2. 4, 5 & 6 IN EH1.
E REVISED IN LINE WITH CONTROLS GROUP COMMENTS
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DIAMOND LIGHT SOURCE LTD. DIAMOND HOUSE CHILTON, DIDCOT OXFORDSHIRE. OX11 0DE
TITLE
BEAMLINE I15
VACUUM SYSTEM
INTERLOCKS OVERVIEW
THIS REVISION
DRN EPC DATE 10/12/07
CHK JHE DATE 14/12/07
APPD GRW DATE 14/12/07
ORIGINATOR/DATE EPC 25/06/07
DRG STATUS Approved
AUTOCAD
DRG No. 1027118
SHEET 3 OF 4
REVISION F
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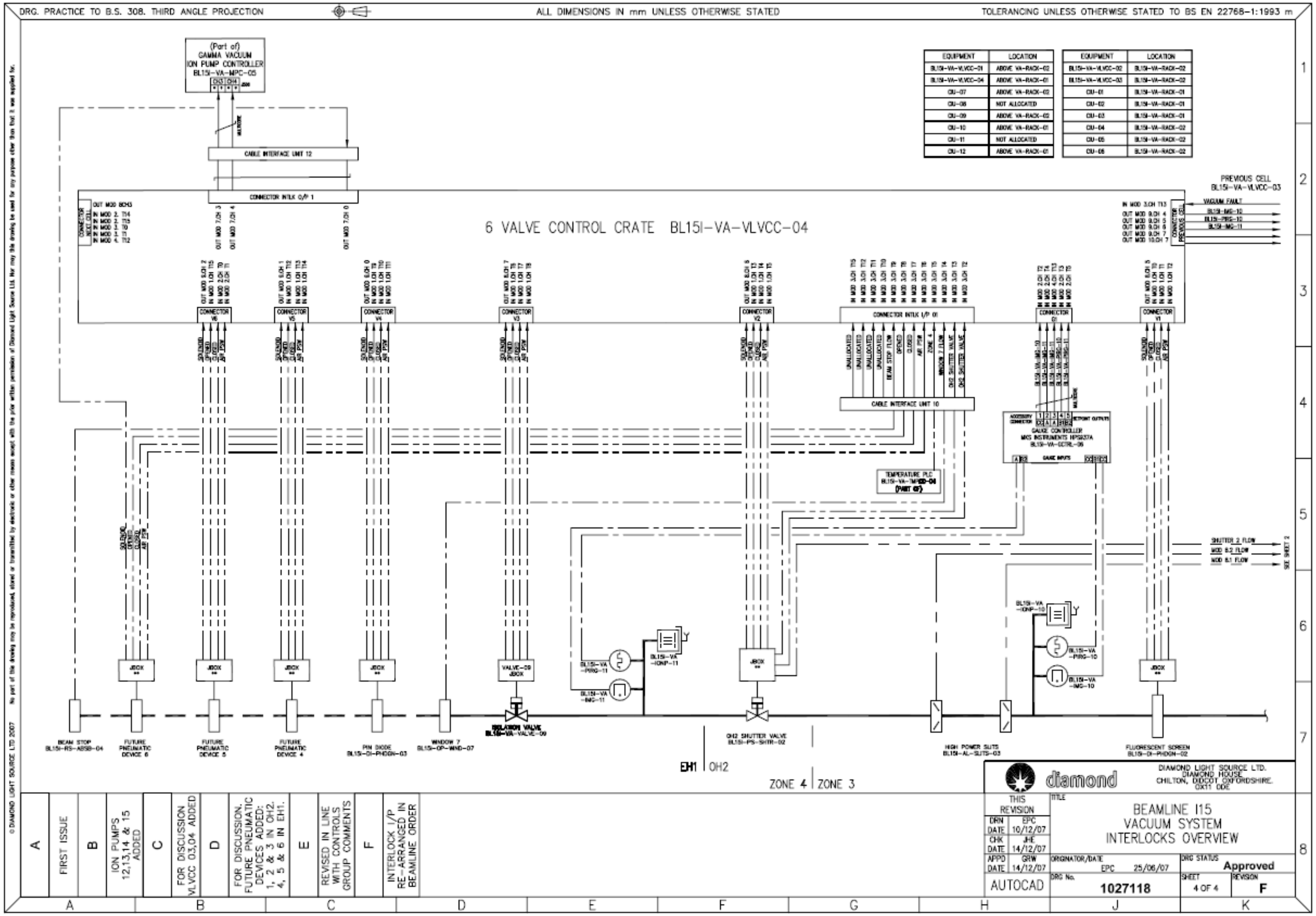

EQUIPMENT	LOCATION
BL15I-VA-VLVCC-01	ABOVE VA-RACK-02
BL15I-VA-VLVCC-04	ABOVE VA-RACK-01
CIU-07	ABOVE VA-RACK-02
CIU-08	NOT ALLOCATED
CIU-09	ABOVE VA-RACK-02
CIU-10	ABOVE VA-RACK-01
CIU-11	NOT ALLOCATED
CIU-12	ABOVE VA-RACK-01

EQUIPMENT	LOCATION
BL15I-VA-VLVCC-02	BL15I-VA-RACK-02
BL15I-VA-VLVCC-03	BL15I-VA-RACK-02
CIU-01	BL15I-VA-RACK-01
CIU-02	BL15I-VA-RACK-01
CIU-03	BL15I-VA-RACK-01
CIU-04	BL15I-VA-RACK-02
CIU-05	BL15I-VA-RACK-02
CIU-06	BL15I-VA-RACK-02

15. REFERENCES

15.1 Specifications

[1] TDI-VAC-CTRL-001-VACUUM CONTROL.doc
[2] TDI-VAC-CTRL-002-LTB BOOSTER.doc
[3] TDI-VAC-CTRL-003-LINAC.doc
[4] TDI-VAC-CTRL-004–RGA
[5] TDI-VAC-CTRL-005-Frontend.doc
[6] TDI-VAC-CTRL-006-Fastvalve
[7] TDI-VAC-CTRL-007-BTS.doc
[8] TDI-VAC-CTRL-008-RF.doc
[9] TDI-VAC-CTRL-010-Storage ring
[10] CTRL-XX-rpt-010 Proposal for a DIAMOND Control System Naming Convention
[11] TDI-VAC-CTRL-011-BL021.doc

15.2 Diamond manuals

[1] Archive viewer manual (S:\Technical\Controls\Tools\archiver/manual.pdf)

[2] NEG PUMP SYSTEM TDI-VAC-SDQ-MS-0042

[3]Fast valve tests for frontends TDI-VAC-VL-PRJ-ADL-001

15.3 Manufacturers' manuals

[1] TDI-VAC-VEQ-VEM-001 MPC

[2] TDI-VAC-VEQ-VEM-002 MPCe

[3] TDI-VAC-VEQ-VEM-003 937a

[4] TDI-VAC-VEQ-VEM-004 939a 232 485

[5] TDI-VAC-VEQ-VEM-005 RGA MKS Microvision

[6] TDI-VAC-VEQ-VEM-006 Fastvalve75

[7] TDI-VAC-VEQ-VEM-007 Fastvalve77

[8] TDI-VAC-VEQ-VEM-008 Fast valve electronics