B.3 Front-Ends

3.1 INTRODUCTION

The aim of this section is to describe in general terms the front-ends of DIAMOND. The specification will look at the different issues that affect the front-end and cover the major design problems to be solved. The document will define a typical overall layout of the front-end and the design philosophies to be used. The result will be a document that can be used in discussion with suppliers or can be expanded to provide tight specifications for individual components.

On DIAMOND's storage ring there are 48 dipole magnets, 18 x 5m 'straights', and 6 x 8m 'straights'. The front-ends are the section of the synchrotron that runs between the storage ring and the shield wall (see Figure 3.1-1). The front-ends in effect connect the storage ring to the beamlines. There is provision for 48 front-ends. 24 front-ends will be used for synchrotron radiation created from dipoles (BM front-ends) and 22 will be used for synchrotron radiation created from the insertion devices in the 'straights' (ID front-ends). There will be special arrangements in 'straights' 1 and 17 which are used for injection and RF.

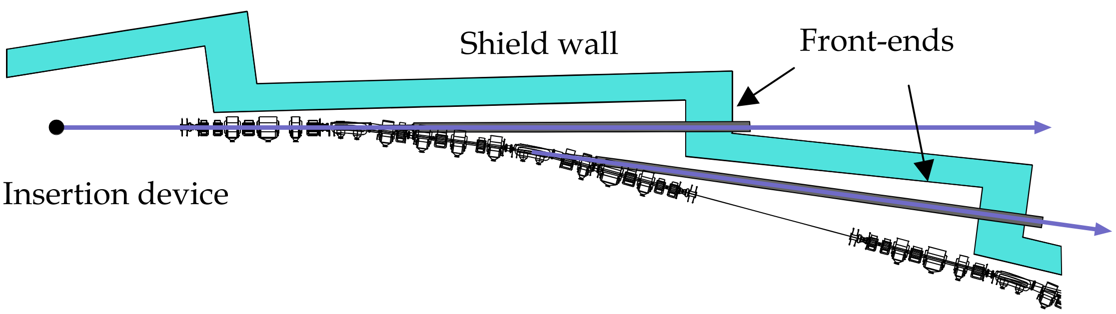


Figure 3.1-1 Front-end position

The front-ends then, interact with the beamlines, the storage ring, and insertion device radiation and are affected by the design of all these sections. Other factors also affect the design, issues that are common to the whole machine, for example the quality of the services within the building. In section 3.2 these outside factors are looked at and described in detail.

After establishing design constraints common throughout the whole machine, we can look at ones more specific to the front-ends. A major factor that affects the design is the location within the building of the front-ends. The physical constraints so to speak.

In section 3.3 the space constraints of the front-end and the required beam apertures through the front-end are given.

Section 3.4 looks more specifically at the functions to be carried out by the front-ends. It looks individually at the components used to carry out these functions and discusses issues particular to each component. This leads on to section 3.5, which looks at design issues that apply to the front-end as a whole. Section 3.6, looks at the proposed layout of the standard insertion device front-end with respect to the issues raised in section's 3.4 and 3.5 and goes through the design rationale of the solution proposed.

Section 3.7 lists some of the front-ends on the ESRF and other machines so that a comparison may be made between the front-end in section 3.6 and other 3rd generation front-ends.

Finally, section 3.8 goes on to look at the procurement method for the front-ends.

3.2 GENERAL SPECIFICATIONS

This section describes services required and other information that will be required in order to design the front-ends.

3.2.1 MACHINE SPECIFICATIONS

(a) AIR SERVICE

Level of Lubrication:	Oil free air
Level of filtration:	10 micron minimum
Pressure:	9 bar

All solenoids for pneumatic equipment must be compatible with oil-free air.

(b) WATER SERVICE

There are to be two water supplies. The demineralised supply is used to provide water to the magnets on the storage ring, as well as general cooling on the front-ends and beamlines. Aluminium components will not be connected to this circuit and will have a local system connected through a heat exchanger.

Demineralised water system

Inlet Pressure:	10 bar
Water inlet temperature:	22°C
Electrical isolation:	0.1 mS/m or Grade 2 BS ISO 3696:1995
Oxygen level:	To be de-oxygenated

Wetted surfaces:	Oxygen free Copper or stainless steel

All solders to be demineralised water compatible. No joints allowable inside vacuum.

Non-demineralised cooling water supply

Inlet Pressure:	10 bar
Water inlet temperature:	22°C
Water quality	Bio-inhibited water.
Wetted surfaces:	Aluminium.

No joints are permisible inside vacuum.

(c) ELECTRICITY SERVICE

Three phase Voltage:	400V
Single phase Voltage:	230V
Frequency:	50Hz
Control Voltage:	24Vdc

All equipment supplied must be CE marked and conform to BS 7671:1992 and the Electricity at Work Regulations and where appropriate must comply with The Low Voltage Directive (73/23/EC). Wire/cabling sizes and colours are to meet the requirements of the current edition of the IEE Regulations and must comply with the EMC regulations for emision of noise in sensitive environments.

(d) SERVICE ACCESS

The main service routes through the shield wall to the front-ends are shown in Figure 3.2-1.

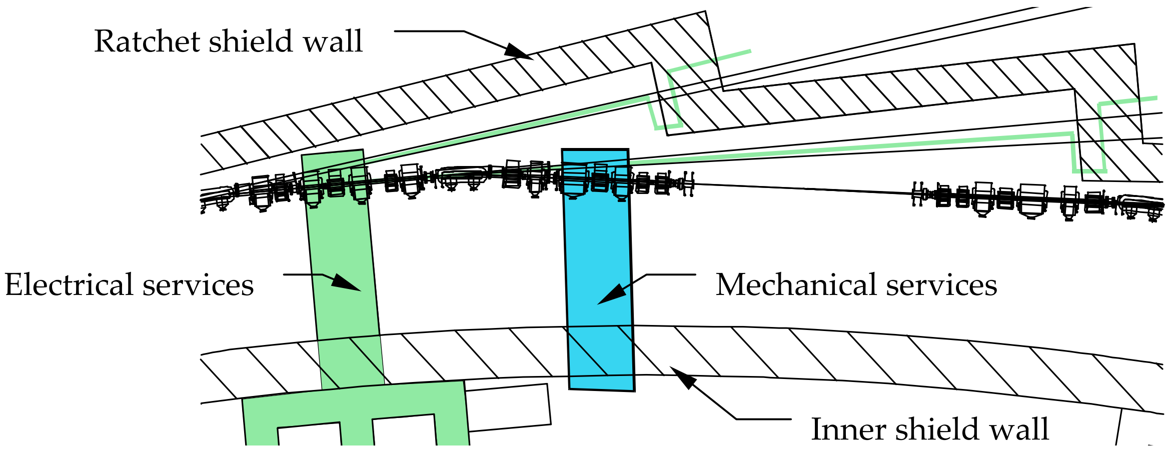


Figure 3.2-1 Service routing

The main services will come through the inner shield wall although there is also limited access for cables through the ratchet shield wall.

(e) ELECTRON BEAM

Beam energy actual:	3	GeV
Beam current initial:	300	mA
Total Dipole Power Initial:	300	kW
Total Dipole Power Initial Design:	330	kW (design)
Single Dipole Power Initial:	6.3	kW
Single Dipole Power Initial Design:	7	kW (design)
Beam Current Future:	500	mA
Total Dipole Power Future:	500	kW
Total Dipole Power Future Design:	550	kW (design)
Single Dipole Power Future:	10.5	kW
Single Dipole Power Future Design:	11.6	kW (design)

Beam Current Future is an upgrade route for DIAMOND. Beam Current Initial is the initial current that will be run on DIAMOND. The difference in cost between the two options will determine if the front-end components will be designed to the Beam Current Initial figures or the Beam Current Future.

(f) STANDARD BM RADIATION SOURCE APERTURES

Dipole Vertical aperture	3	mrads (+1.5 to –1.5 mrads)
Dipole Horizontal aperture	20	mrads (+5 to +25 mrads)
Single Dipole Power Initial	48	W/mrad
Single Dipole Power Initial (+10%)	52.8	W/mrad (design)
Single Dipole Power Future	80	W/mrad
Single Dipole Power Future (+10%)	88	W/mrad (design)
B – Field	1.4	T
Bend radius	7.1429	m

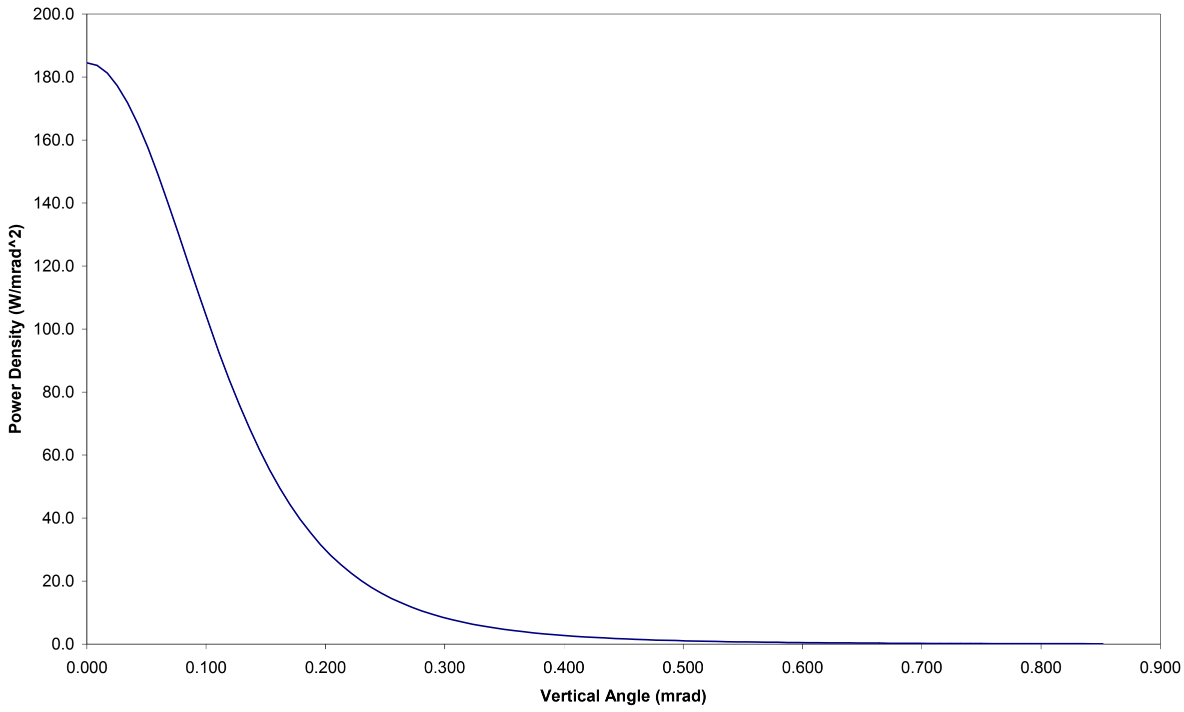


Figure 3.2-2 Dipole Power Density Graph Initial:

(g) SPECIAL BM RADIATION SOURCE APERTURES

CD BM Radiation Source Apertures

Dipole Vertical aperture	8	mrads (+4 to –4 mrads)
Dipole Horizontal aperture	35	mrads (0 to +35 mrads)
Single Dipole Power Initial	48	W/mrad
Single Dipole Power Initial (+10%)	52.8	W/mrad (design)
Single Dipole Power Future	80	W/mrad
Single Dipole Power Future (+10%)	88	W/mrad (design)

IR BM Radiation Source Apertures

Dipole Vertical aperture	30	mrads (+15 to –15 mrads)
Dipole Horizontal aperture	35	mrads (0 to +35 mrads)
Single Dipole Power Initial	48	W/mrad
Single Dipole Power Initial (+10%)	52.8	W/mrad (design)
Single Dipole Power Future	80	W/mrad
Single Dipole Power Future (+10%)	88	W/mrad (design)

(h) STANDARD 5m STRAIGHT ID RADIATION SOURCE APERTURES

Undulators

Undulator Vertical aperture	1	mrad (+0.5 to –0.5 mrads)
Undulator Horizontal aperture	1	mrad (+0.5 to –0.5 mrads)

A typical Undulator output is between 1 and 6kW at 300mA
A typical Undulator output is between 2 and 10kW at 500mA
A typical max power density for an undulator is 22kW/mrad^2.

Wavelength Shifter

Wavelength Shifters Vertical aperture	1	mrad (±0.5 mrads)
Wavelength Shifters Horizontal aperture	10	mrads (±5 mrads)

A typical Wavelength Shifters output is 8kW at 300mA
A Typical Wavelength Shifters output is 14kW at 500mA

Superconducting Multipole Wigglers

Multipole Wiggler Vertical aperture	1	mrad (±0.5 mrads)
Multipole Wiggler Horizontal aperture	10	mrads (±5 mrads)
B-Field	3.5	T
No. of periods	24	
Period length	60	mm

Typical Superconducting Wiggler output is 31kW at 300mA

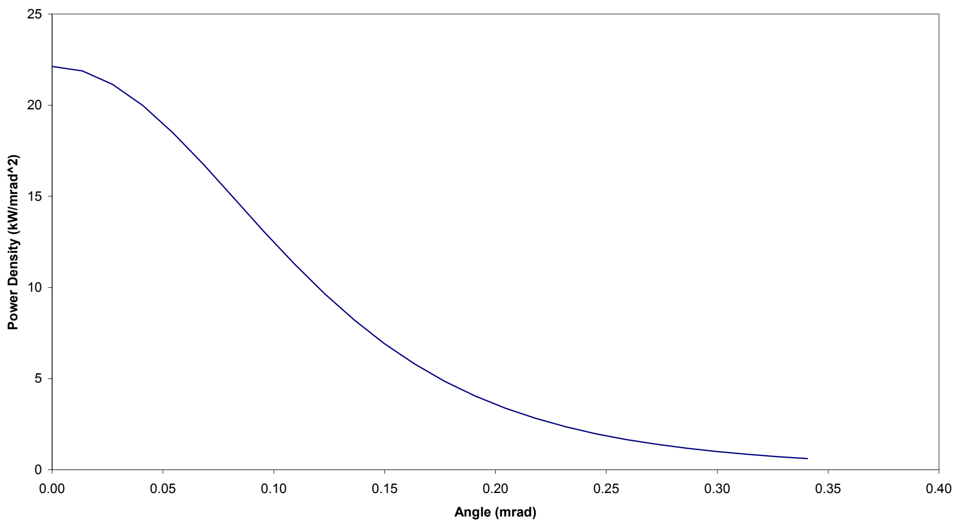


Figure 3.2-3 Power density on vertical axis

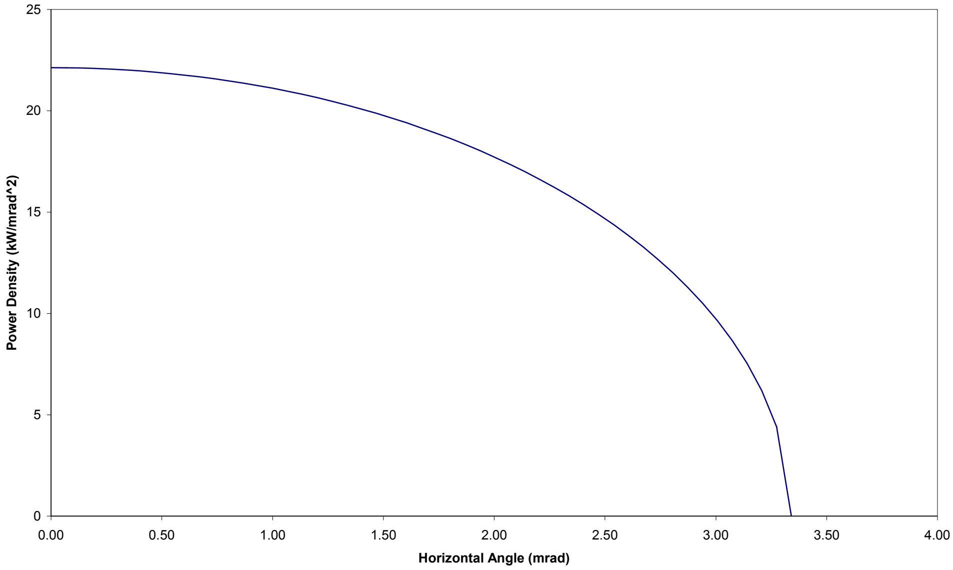


Figure 3.2-4 Power density on horizontal axis

Permanent Magnet Multipole Wigglers

Multipole Wiggler Vertical aperture	1	mrad (±0.5 mrads)
Multipole Wiggler Horizontal aperture	10	mrads (±5 mrads)
B-Field	2.25	T
No. of periods	24	
Period length	200	mm

Typical Wiggler output is 43kW at 300mA

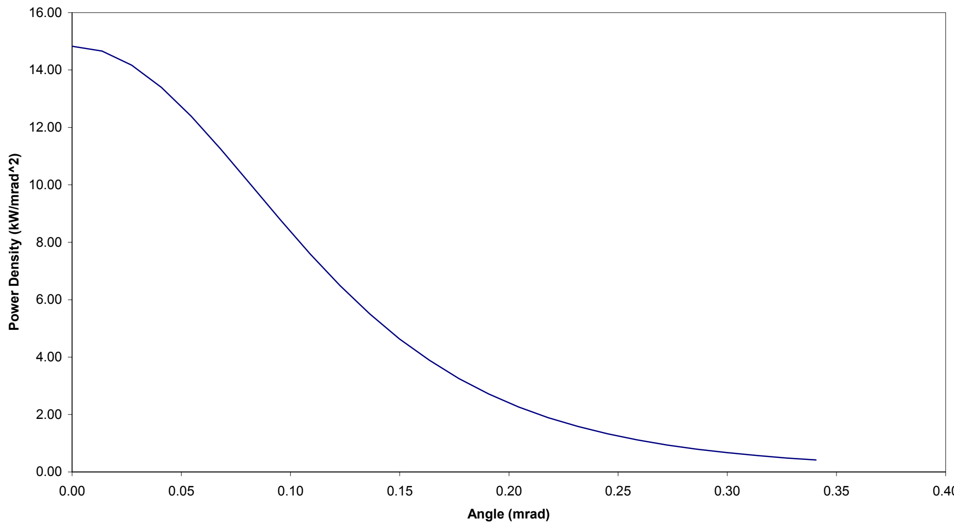


Figure 3.2-5 Power density on vertical axis

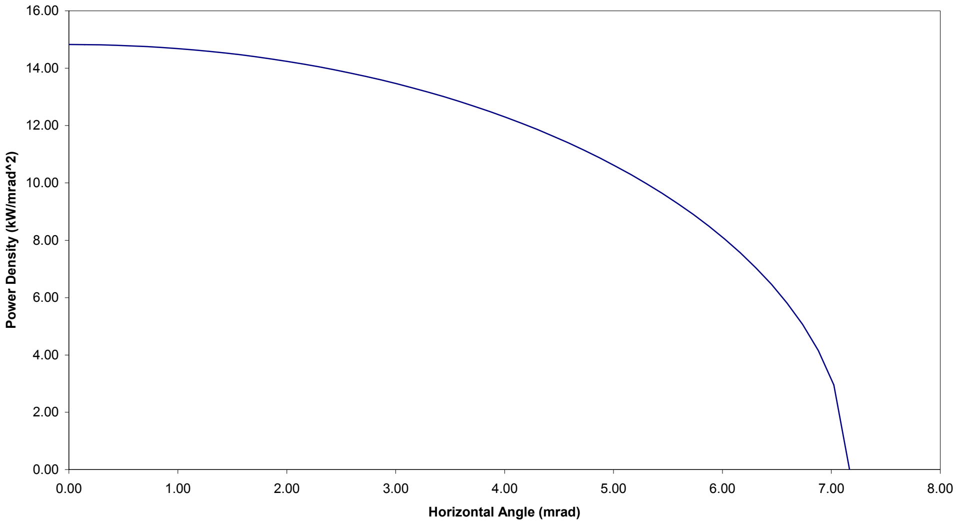


Figure 3.2-6 Power density on horizontal axis

(i) VACUUM LEVELS

Static pressure in storage ring and front-ends:	10^{-10}	mbar
(To be achieved after 100Ahr of beam conditioning.)		
Dynamic vacuum level in storage ring and front-ends:	$<10^{-9}$	mbar

(j) BEAM HEIGHT

Height of electron beam above floor:	1400	mm

3.3 FRONT-END SPACE CONSTRAINTS

There are two basic space constraints on the footprint of the front-end: the ratchet shield wall and the acromat. This is true for all types of front-ends. This section will look at a number of different front-end types, all of which have to fit into one of two positions: BM front-ends, or ID front-ends.

3.3.1 BM FRONT-ENDS

Each of the bending magnets on DIAMOND produces 131mrads of synchrotron radiation. 35mrads of radiation go into the entrance of every BM front-end via the connection flange on the storage ring. There are two different types of BM front-ends. Standard BM front-ends and Special BM front-ends. The majority of the front-ends will be Standard BM front-ends; these then should be a standard design. The Special BM front-ends have to be individually designed for each beamline and so will only be introduced in this specification.

(a) STANDARD BM FRONT-ENDS

Standard front-ends require the delivery of 20mrads of uncollimated synchrotron radiation up to the shield wall. There is the possibility of passing this 20mrads of radiation through the shield wall to the optics and experimental areas.

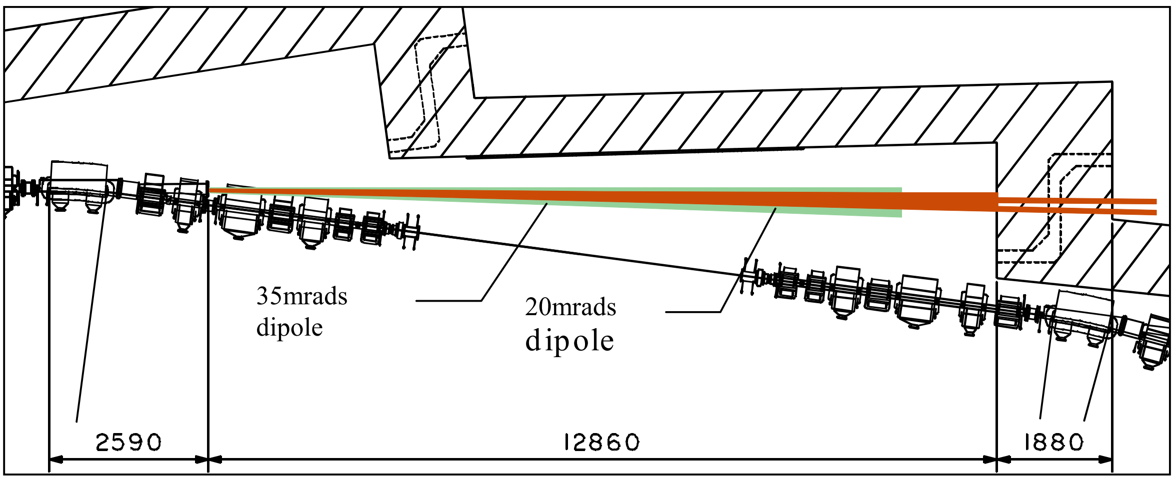


Figure 3.3-1 Space constraints of Standard Bending Magnet (Dipole) front-ends

Although the standard BM front-end only passes 20mrads of radiation, 35mrads enter the front end and so 15mrads must be absorbed. The first 5mrads that enter are poor quality due to end effects from the dipole magnet and must be absorbed. The next 20mrads of synchrotron radiation are suitable for the standard BM front-ends and can be used in experiments. The final 10mrads do not fit through the shield wall thus must be removed. This is shown in Figure 3.3-1.

(b) SPECIAL BM FRONT-ENDS

The special BM front-ends are those that will have no standard design. These include front-ends for CD and IR beamlines. CD front-ends require 35mrads horizontal by 8mrads vertical of BM radiation. This has to be extracted through the front-end. IR Front-ends require 35mrads horizontal by 30mrads vertical, this is taken out in a specially constructed dipole chamber.

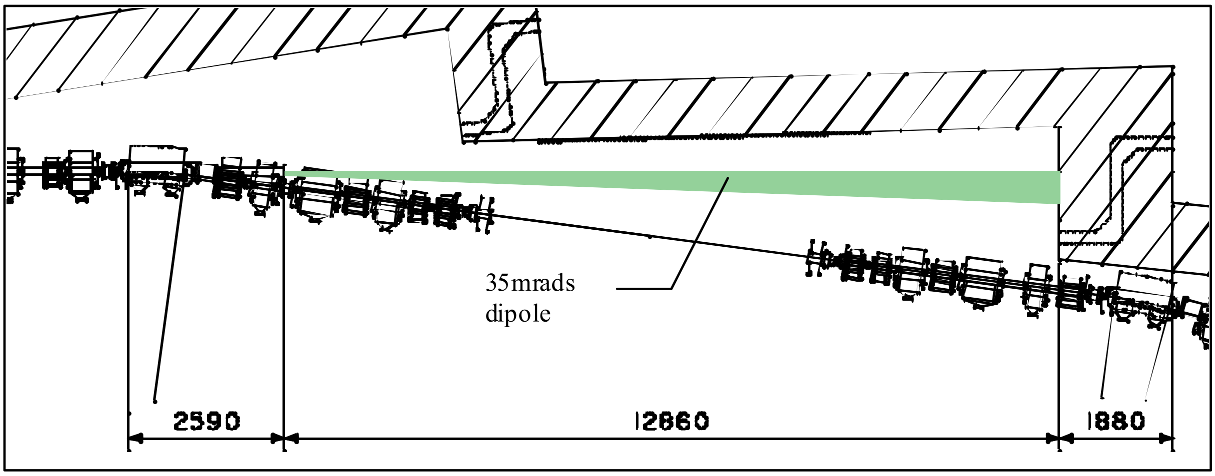


Figure 3.3-2 Space constraints of Special Bending Magnet (Dipole) front-ends.

Figure 3.3-2 shows that it would be possible to have 35mrads horizontally of radiation up to the shield wall. Due to shielding constraints only the first 25mrads could pass through the shield wall. It is much more likely that the 35mrads would be collimated or focussed at an earlier stage to allow more beam through the shield wall while reducing the size of the optical elements required.

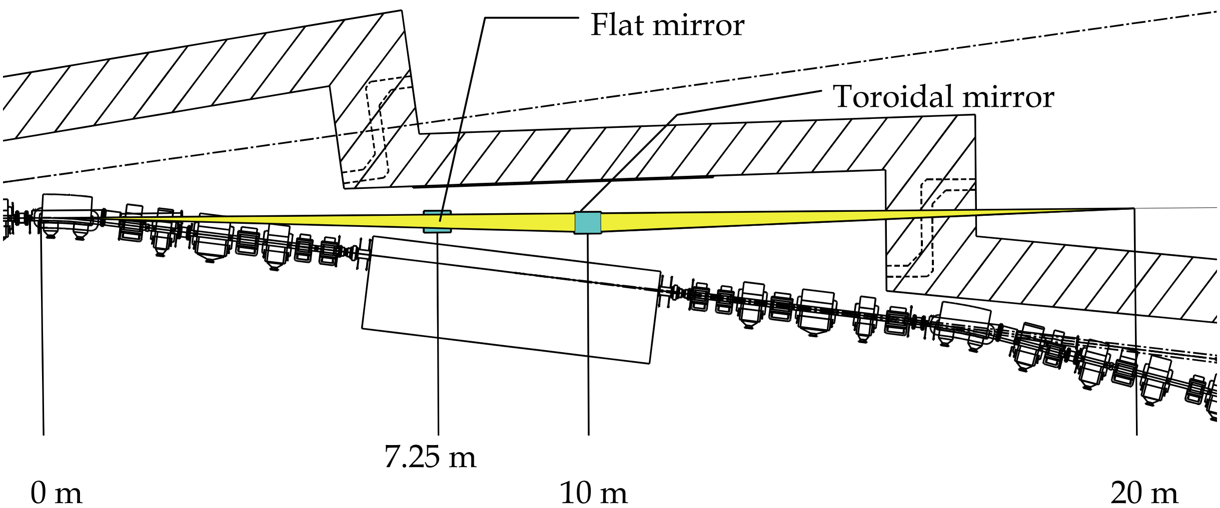


Figure 3.3-3 Example CD schematic plan

Figure 3.3-3 shows a plan view of an example CD line that could fit within the imposed space constraints. It consists of: a plain mirror and a toroidal mirror. The plain mirror is at a 10° angle vertically (400mm wide [across the beam] by 500mm long [along the beam]) and deflects the beam vertically by 20° and is placed at 7.25m from the source. The toroidal mirror, placed 10m from the source is at a -10° angle vertically (400mm by 500mm) it deflects the beam back to horizontal and provides 1:1 focussing. This gives a focus at 20m from tp. Provision is to be made for a toroidal grating of similar size to mirror 2 placed beside mirror 2 and able to slide into place to replace mirror 2. The mirror is to be used for dispersive CD and the grating for monochromatic CD.

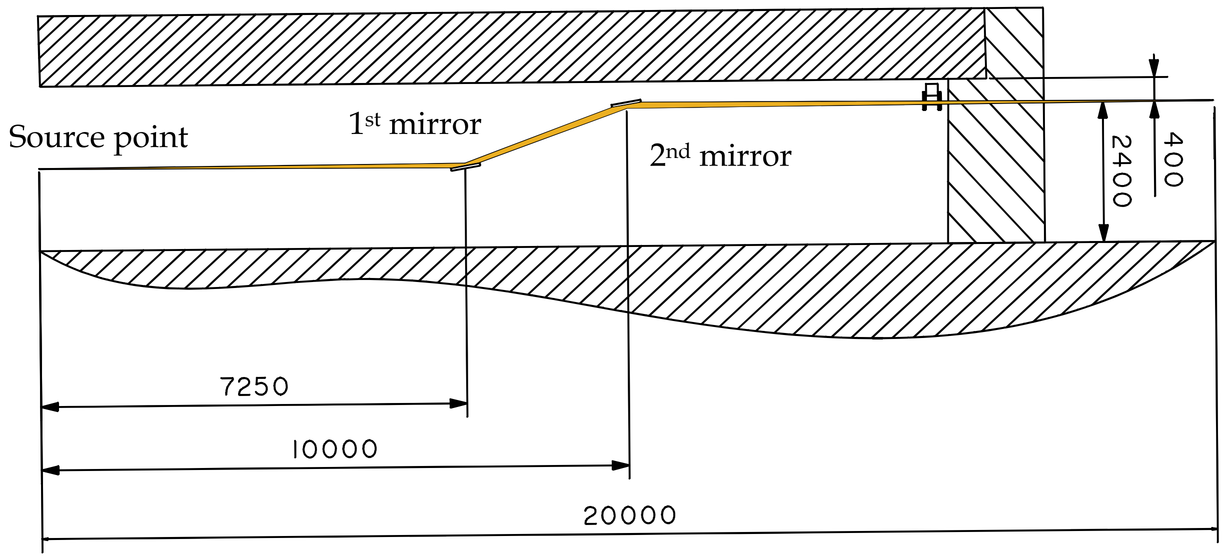


Figure 3.3-4 Example CD schematic elevation

Figure 3.3-4 Shows the beam height in order to show how much room there is between the beam and tunnel roof. This may affect the design of some of the components forcing them to become more compact.

IR Beamline

IR front-ends require 35mrads horizontal by 30mrads vertical of dipole radiation. This necessitates a mirror in the dipole vessel that will extract the radiation vertically and collimates or focuses it at an early stage.

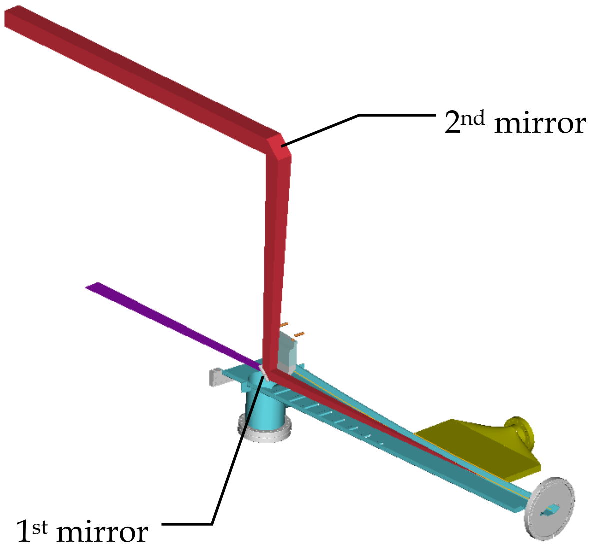


Figure 3.3-5 Example IR beamline schematic

Figure 3.3-5 shows a mirror arrangement that would be positioned within a specially designed dipole vessel. The 1st mirror is a flat mirror with a slit in the middle to let the x-rays continue on while deflecting the longer wavelength beam upwards. The 2nd mirror is a toroidal mirror that collimates or focuses the diverging beam, whilst bringing the beam back to the horizontal.

3.3.2 ID FRONT-ENDS

Each ID front-end has an aperture of 10mrads from the front flange on the crotch vessel. This 10mrads will contain both synchrotron radiation from IDs in the 'straights' and some unwanted BM radiation from the dipoles. Only the ID radiation is desired, however, and so as much as possible of the BM synchrotron radiation is absorbed. The space constraints for all ID front-ends are the same for both the 8m and 5m 'straights'. Many different types of insertion device can be fitted into a 'straight'; these are listed as follows:

- Undulators
- Wigglers
- Wavelength shifters
- Combinations

It is proposed to design a Standard ID front-end that will cater for as many cases as possible, though special designs will be used when the standard design is not practical.

(a) STANDARD ID FRONT-ENDS

It is proposed to have a standard front-end layout that can cater for single Undulators, single Wigglers, single wavelength shifters and multiple co-linear Undulators. This is to be achieved by allowing 10mrads of radiation to pass through to the shield wall in every standard ID front-end (See Figure 3.3-6). A further advantage of this is that if a single Undulator beamline is altered to a multiple Undulator beamline in the future, it may be possible to have the same front-end.

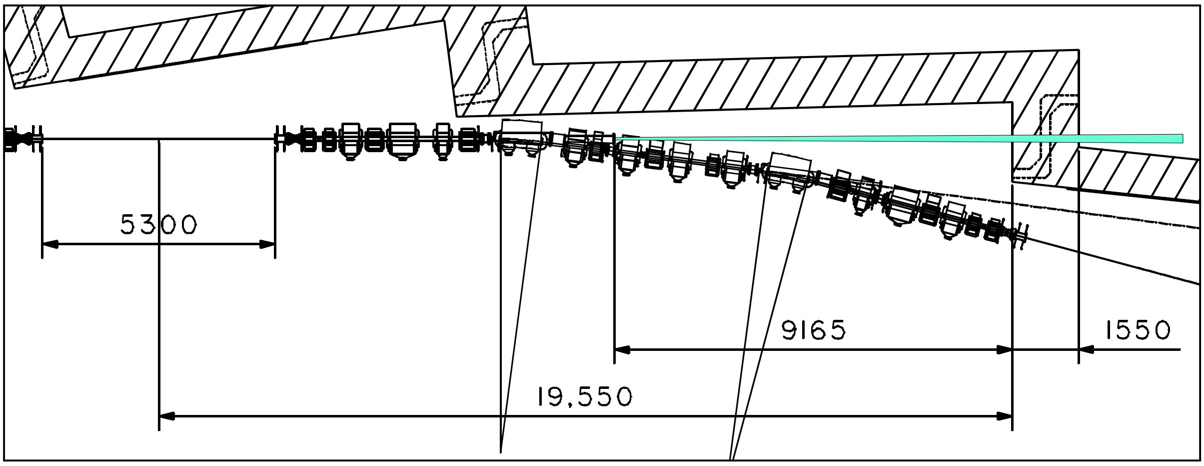


Figure 3.3-6 Space constraints of Insertion Device front-ends

Figure 3.3-6 shows a space acceptable for a front-end from a 5m straight. It is similar for an 8m straight.

(b) SPECIAL ID FRONT-ENDS

Special ID Front-ends are those where there are multiple insertion devices in a 'straight' that are not co-linear. A number of possibilities are available: Multiple Undulators, combination of Undulator and Wiggler, combination of Undulator and Wavelength shifter and further possibilities that may be developed in the future. The combination of insertion devices required depends upon the experiment being carried out. This cannot be foreseen and thus the front-ends may not be of a standard design for these cases.

The term Multiple Undulators is used when there is more than 1 Undulator in a straight. A maximum of 3 Undulators could be positioned in a 5m straight. Individually these would be less powerful than a single 5m Undulator would, as the power output is linear to Undulator length. The advantage of using multiple Undulators is that a number of beams could be obtained from the same front-end. The multiple beams can be split into three groups: Co-linear multiple beams, Parallel and offset multiple beams, and Angular offset multiple beams.

'Co-linear multiple beams' is a combination consisting of multiple beams travelling down the same centre line, these can be treated similar to a single Undulator and thus come under the Standard ID front-end.

'Parallel and offset beams' describes the situation of multiple beams travelling parallel to each other but offset by a small distance (1mm or so). The beams are so close to each other that this situation can be treated similar to a single Undulator design.

'Angular offset multiple beams' describes the situation of multiple beams diverging from one another. For example, it is proposed that 3 Undulators could be positioned in the same straight, and between the insertion devices dipoles would be placed. This diverts the electron beam so that it takes an angled path through the insertion device thus producing angular offset beams as shown in Figure 3.3-7.

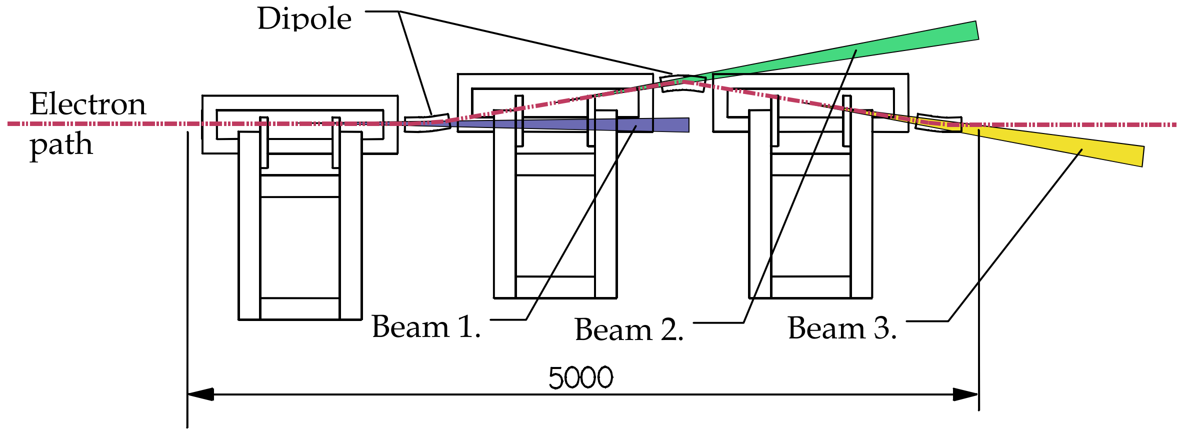


Figure 3.3-7 Angular offset beam production

It should be noted that the angles are exaggerated for clarity.

In order for three beams to pass through the same front-end, the front-end has to have a 10mrads H x 1mrad V aperture (see Figure 3.3-8). This allows three beams spaced as follows: one down the centre and the others at 4mrads to either side. This is the same aperture size as for a wiggler and so 10mrads H x 1mrad V will be the standard aperture size for both undulator and wiggler front-ends.

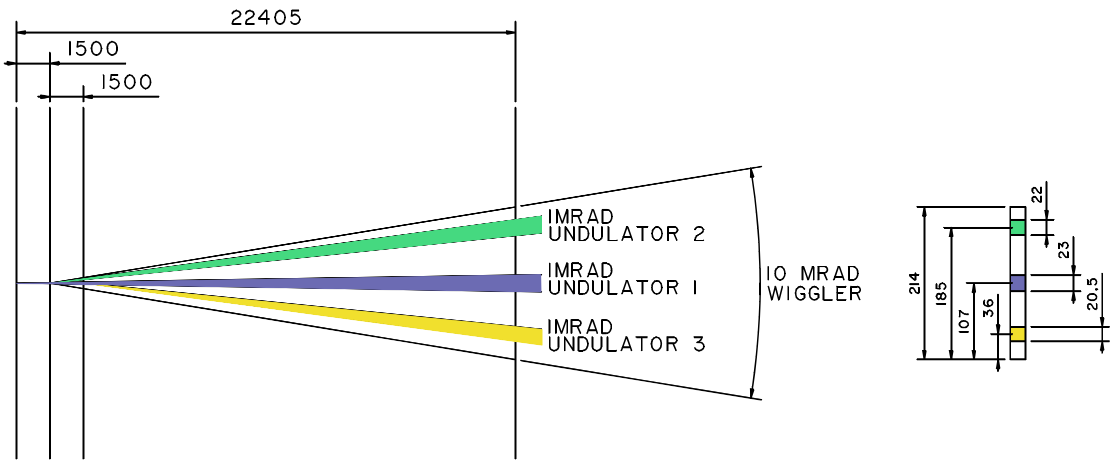


Figure 3.3-8 Undulator beam layout

When an Undulator and Wiggler or wavelength shifter are positioned together in the same straight, the front-end will have to be designed around the exact positioning of the ID beams. This can vary over a large range and so unless the devices are co-linear, there will be no standard design for these cases.

3.4 FRONT-END FUNCTIONS

This section will look at the different functions carried out by the front-end, the components that carry out these functions, and the issues that will need to be taken into account when designing these components.

The main functions that will be looked at in this section are:

3.4.1 Beam Quality
3.4.2 Beam Diagnostics
3.4.3 Defining the beam
3.4.4 Optics heat loading
3.4.5 Achieving and protecting vacuum
3.4.6 Radiation Safety and Operations

3.4.1 BEAM QUALITY

It is essential that beam quality be preserved through the front-ends. This involves preserving the beams' coherence and its polarisation. As far as the front-end design is concerned, this means interfering with the beam as little as possible.

3.4.2 BEAM DIAGNOSTICS

The primary purpose of beam diagnostics is to monitor the beam position and to provide the required information to the global feedback system to stabilise the beam.

The DIAMOND synchrotron radiation source is being designed as a 'low emittance high brightness' source. In order for the experiments to take advantage of the small source size, it will be necessary for the positional and angular stability of the source to be maintained to a sufficient extent that the beamline optics can deliver a stable photon beam to the sample. Beamline optics will produce an image of the source at the sample (or detector) position. Defining the required stability of this image as 10% of the image dimension leads to a required source stability of 10% of the source size. Single photon beam monitors in a beamline allow the photon beam to be measured at a given point along the beamline. Two such monitors are required to establish the position and angle of the photon beam thereby establishing the source position.

The current FWHM predicted source sizes for DIAMOND are (see table A2 3.4-1)

ID straight 5 m	15	290 microns (v x h)
ID straight 8 m	30	421 microns (v x h)
Bending Magnet	56	127 microns (v x h)

Beamline optics contain both focussing and monochromating elements which may be combined into a single optical element or distributed over several elements. The wavelength (or energy) resolution of the monochromator depends on the angular range of the light accepted, hence angular movements will degrade this resolution. Angular movements also result in changes of the position of the photon beam.
Changes in the source position will be reflected by the optical elements and result in a changed focal spot position. The extent of this movement depends on the magnification factor of the optical arrangement. This is true for vertical and horizontal movements for both undulator and wide fan (bending magnets, multipole wigglers and wavelength shifter) sources leading to similar stability requirements irrespective of the source type.

Typical ID beamline layouts will have optical elements at around 25 metres and the focus at 50 metres. In a bending magnet beamline optical elements can be at around 20 metres. The front-end will allow space for beam position monitors in the region 10 to 15 metres for ID beamlines and 5 to 10 metres for bending magnet beamlines.

Simple geometrical considerations imply, for an ID beamline, ± 0.3 micron vertical positioning of the beam will be required at monitors at both 10 and 15 metres to give the required 10% source stability. Horizontally 3 microns will be adequate. For a bending magnet with monitors at 5 and 10 metres 1.25 microns vertical positioning is required and again 3 microns horizontally. These requirements have implications for the stability and vibration isolation of the position of the photon monitors, optical elements and sample position.

Consideration will have to be given to minimising the vibration of the floor and the support columns of the PBPMs and to minimising the drift and thermal movement of the systems if the required accuracy is to be achieved. The mechanical design and accuracy of encoders, motors and electronics need to be consistent with the required sub-micron resolution.

The two devices that define the path of the photon beam need not be identical (e.g. two tungsten vane monitors, or a pinhole and an imaging screen). The most appropriate system should be chosen to match the source properties being monitored. A study into the present state of photon beam position monitors is underway and will report shortly.

Whatever the exact nature of the photon beam position monitoring system chosen, the above requirements imply that that space be provided in the front ends for these devices. This is shown in the schematic diagrams. This also implies that there are no optical elements between the photon beam position monitors and the source.

If the PBPM are to be included in the fast feedback, thought has to be given to the placement and interlock arrangements of valves, absorbers etc. As far as possible these devices should be placed downstream to avoid interruption of the feedback due to port crashes caused by whatever reason. The upstream valves (if any) should be operated manually or triggered only by vacuum problems. They should also provide a trigger to the feedback system so it can take the PBPM out of the servo loop before the valve actually closes.

Photo-emision based monitors are excellent for vertical diagnostics of the photon beams. Typical systematic intrinsic and extrinsic effects that can lead to errors are (not exhaustive):

1. Intrinsic effects :Stray radiation on the blades
   Blade misalignment
   Electronics thermal drift
   Gap dependent effects

2. Extrinsic effects :Magnet power supply noise/ripple
   Mechanical vibration
   Thermal effects
   Insertion device gap changes
   Ground motion

Each effect will have its own noise spectrum which will contribute to the overall performance of the system.

Despite the above, resolutions that can typically be achieved are 1 µm at 100 Hz and 0.1 µm at 1 Hz. PBPMs included in the fast feedback system, which will be operating at several kHz update rate, will require careful optimization.

In general with photo-emision based monitors, there is a problem with dipole radiation contaminating ID radiation. Proper consideration of this effect is required before producing a detailed design for the PBPMs.

There may be more than one ID operating in each straight. Depending on detailed design and source specifications it may or may not be possible to supply independent beam diagnostics for each ID.

3.4.3 DEFINING THE BEAM

There are two main types of aperture proposed for experiments. The BM (standard) aperture which defines a “low power density” beam of 20mrads x 3mrads, and the ID beam aperture which defines a “high power density” beam within a 10mrads x 1mrad aperture. These beams are the outputs of the front-ends. The input to the front end is the crotch vessel aperture. The crotch vessel aperture for a BM front-end is 35mrads x 8mrads of BM radiation. The crotch vessel aperture of an ID front-end is 10mrads x 8mrads of BM radiation.

Several different components are used to define the beam along the length of the front-end. These will be described as follows:

(a) Absorbers
(b) Cooled fingers
(c) Defining apertures
(d) Slots

(a) ABSORBERS

The absorber is a cooled plate that may be dropped into the path of the photon beam. This is done in order to stop the photon beam from reaching the sample, thus allowing work to be done in the sample area. The design of absorber is set by the heat loading and heat profile it has to absorb. The heat loading depends on the beam type.

Further work needs to be done to assess the number of absorber designs required on the ID front-ends. The ESRF absorber design described in ‘Design and Performance of ESRF high power Undulator front-end components’ by Jean Biasci, Bernard Plan and Lin Zhang will form the basis of this work.

(b) COOLED FINGERS

When an experiment that is taking place over a long period of time only requires a set percentage of the maximum aperture size of the photon beam, cooled fingers can be used to remove the rest of the aperture. These are not adjustable, however, and once an aperture has been selected, it cannot be changed without installing a different finger.

These can also be used for instance when absorbing the BM radiation from the ID front-end. The position of the fingers within the front-end (and therefore the heat loading on them) is dependent upon the layout of the other components. After a beam line concept has been decided, it will be necessary to do further work on the design of the fingers. For instance, the fingers may have to be angled to the photon beam to decrease the maximum thermal loading on them.

(c) DEFINING APERTURE

When the beam enters the front-end it is larger than that required out the exit. The component that resizes the beam is called a defining aperture. Effectively this cooled fixed picture frame sizes the beam vertically and horizontally simultaneously. This defines a maximum beam aperture very accurately.

A design similar to that used on the ESRF could be used for the BM front-ends and for the single Undulator and Wiggler front-ends. The multiple Undulator lines need further work.

An option is to split the defining aperture into two halves vertical, and horizontal. This would allow a design similar to the slits to be used and would allow a variable aperture size. The ESRF are looking at such a design for their own use. It should be possible to have a standard range of these variable defining apertures in the beginning, although more options could be derived depending on the position, size, and number of Insertion devices to be used.

The ESRF experience is that in order to reduce heat loading on any single defining aperture or slit assembly it is best to split the heat loading between a number of similar components.

(d) SLITS

Sometimes photon beams of varying power levels are required for an experiment. In this case, moving slits can be used to absorb some of the energy in the beam. This gives the user a useful tool for controlling power.

Further work needs to be done on the design of these slits, in principle they could be similar to the design discussed for the defining aperture.

The slits would be used to help spread the heat load from the defining aperture in such a way that the defining aperture would take half the loading and the slits half the loading.

Special attention needs to be paid to the multiple Undulator front-ends. This will require careful modelling and again may need to be designed according to size, position and number of Undulators.

3.4.4 PROVISION FOR FRONT-END OPTICS

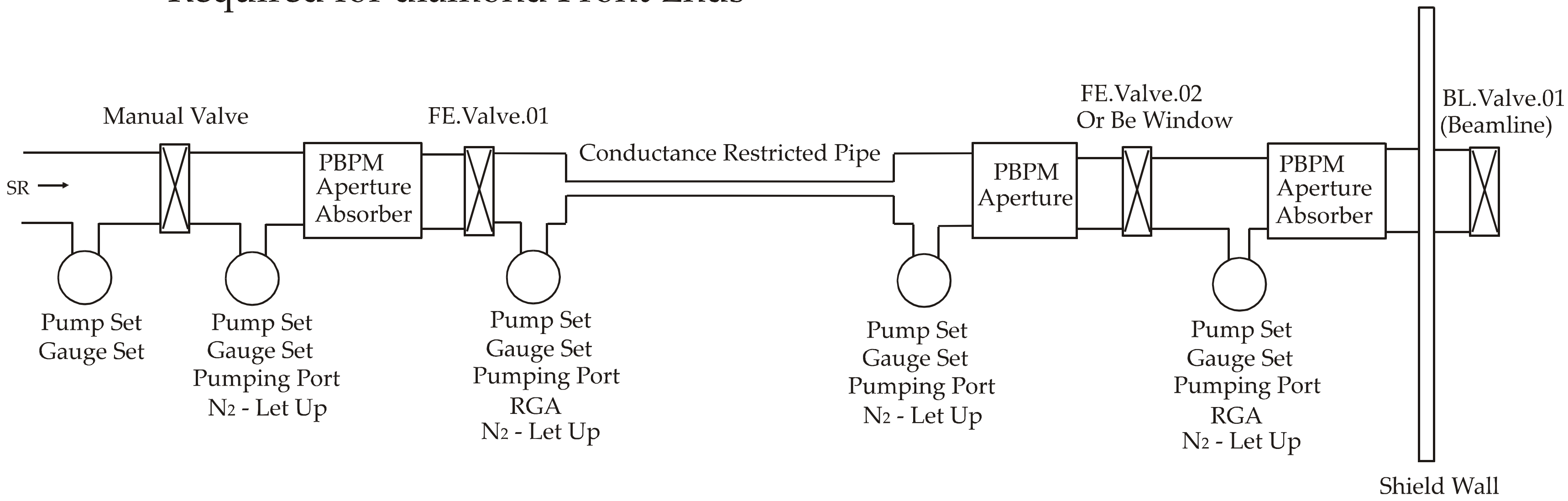
Optics and filters are used to filter out the longer wavelengths from the photon beam before it reaches any delicate components. This works as when the longer wavelengths are removed a lot of power is removed with them. However, the filters in themselves are quite delicate and have maximum power loadings. This means that there is a limit to how close they can be positioned to the insertion device. Provision should be made for an optic that can be lifted in and out of the radiation beam.

3.4.5 ACHIEVING AND PROTECTING VACUUM

Much of the information contained in section E5 (Vacuum) of this document is applicable to the front-end design and reference should be made to it for design details.

The front-ends are coupled directly to the storage ring which is necessary to allow synchrotron radiation to pass down the front-ends and on into the experimental stations. Because of this direct coupling, it is essential that the front-end vacuum system does not compromise the operation of the storage ring. Therefore, a similar approach is made in designing the vacuum system for the front-ends as is used for the storage ring. See references[1];[2];[3].

Schematic Layout of Vacuum Equipment Required for diamond Front Ends



Notes:

Manual Valve = All Metal, Manually Operated Gate Valve with valve protection switches incorporated into the control system.
(The inclusion of this manual valve has not yet been agreed by the storage ring design group)

Pump Set = Not yet defined but large ion pump with integral TSP can be assumed as minimum requirement.

Guage Set = A combination of inverted magnetron cold cathode and pirani gauge.

Pumping Port = A right angle all metal valve with DL type 5 CF flanges, connected by manifold into Rough Pumpng Station..

RGA = Residual Gas Analyser for partial pressure analysis.

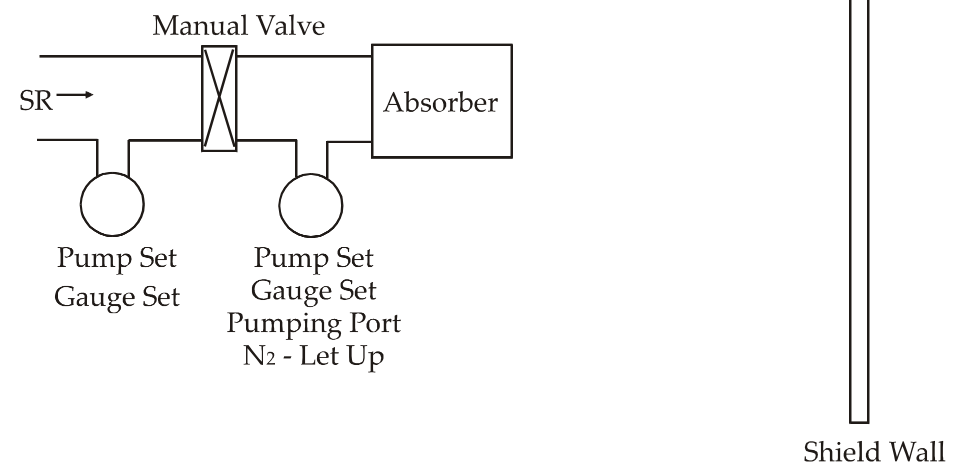
N_2-Let Up = All metal valve connected into a dry nitrogen system for letting up the vacuum system to atmospheric pressure.

FE.Valve.01 = All metal gate valve - pneumatic operation

FE.Valve.02 or Be Window = In this position either an all metal gate valve (pneumatic operation) will be required or a Beryllium Window.

BL.Valve.01 (Beamline) = This will be the first beamline vacuum gate valve, it may need to be all metal but will probably be viton sealed - Pneumatic operation

Schematic Layout of Vacuum Equipment Required for unused Front Ends



Notes:

Manual Valve = All Metal, Manually Operated Gate Valve with valve protection switches incorporated into the control system.
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Guage Set = A combination of inverted magnetron cold cathode and pirani gauge.

Pumping Port = A right angle all metal valve with DL type 5 CF flanges, connected by manifold into Rough Pumpng Station..

N2 Let-up = All metal valve connected into a dry nitrogen system for letting up the vacuum system to atmospheric pressure.

The vacuum levels in the front-end are set to have no deleterious effect on the storage ring vacuum while maintaining effective transfer of synchrotron radiation. This specification requires that the following total pressures be met:

$P_{\text{with SR}} < 1\text{x}10^{-9}$ mbar

$P_{\text{without SR}} \leq 1\text{x}10^{-10}$ mbar

To achieve these vacuum levels in the front-end it will be necessary first to rough down the system using an installed network of vacuum pipes that couple into rough pumping stations. The rough pumping stations could be those installed on the storage ring (fixed stations) or could be mobile roughing stations located outside the shield wall (See reports: VAC-SR-rpt-004 and 005). It is likely that the former scenario will be adopted, as this will be the cheapest option, the simplest to implement and allow greater control thus reducing the possibility of contamination. Written instructions will be in place to define the pump down process and suitable control interlocks will be installed to prevent vacuum failure. When appropriate, the main system pumps will be used to bring the total pressure down to the desired levels. It is likely that these main pumps will be a combination of Ion Pumps and Titanium Sublimation or Non-Evaporable Getter pumps.

It will be necessary to carry out a review of available ion pump designs before selecting those most suitable for the diamond front-ends. It is likely that some form of differential diode (noble diode) ion pump will be used. It may also be possible to include in-line ion pumps in some pump locations if there is a clear benefit to the project. This will be assessed in the ion pump review that will be carried out in the next phase of the diamond project.

The main contribution to the gas load in the front-ends will be from synchrotron radiation that strikes components such as absorbers, moving slits, and defining apertures. When designing these components it will be necessary to pay particular attention to their vacuum performance. It is likely that the main system pumps will be located as close to these components as possible to be able to deal with the gas load effectively.

The vacuum level will be measured using a combination of inverted magnetron cold cathode gauges and Pirani gauges in the same way as for the storage ring. If the total pressure is above a set limit then the beamline front-end isolation valve will be closed automatically to protect the storage ring vacuum. It is expected that the storage ring vacuum will be protected from any sudden inrush of gas, caused by catastrophic component failures on the front-ends, by installing suitable differential pumping, fast closing gate valves and a conductance restricted vacuum pipe.

A partial pressure gauge will also be installed in the first part of the front-end to monitor the particular gas species present in the vacuum system so that the status of the vacuum system can be better understood. If a high concentration of high mass gas species is present, then indications of serious beam mis-steer or a serious vacuum leak is identified in a front-end, and the isolation protection valve will be closed. The front-end control system will automatically provide some of this protection by direct communication with the RGA.

A series of isolation gate valves will be present in the front-ends to provide adequate protection to the storage ring vacuum system as well as simplifying operations and maintenance programmes. Because of the vacuum levels required and the presence of high levels of electromagnetic radiation, these isolation valves will be of an All-Metal design. In some front-end designs, it is likely that some of the isolation gate valves will be replaced with Beryllium windows.

All vacuum components will be specified to handle a bakeout of up to 250^0C. The components will be pre-conditioned before installation and will need to meet strict vacuum criteria before acceptance. The acceptance criteria for these components will be determined at a later date. After installation, it may be necessary to carry out an in-situ bake before the front-end can be operated. At this stage of the design, it is necessary to assume that a bakeout system will be installed. A final decision on bakeout will be taken after a detailed calculation of the front-end vacuum system has been carried out.

When it is necessary to make a vacuum intervention, the rough pumping stations will be used to control the let up to atmospheric pressure with the permanently installed dry nitrogen gas supply.

The final component of the front-ends is the first beamline isolation gate valve. It is likely that this valve will be subjected to a sufficiently reduced synchrotron radiation level to facilitate a significantly cheaper design of gate valve – viton sealed rather than metal. However, if there is no Beryllium window in the front end then all components up to and including this valve will have to be all metal.

3.4.6 RADIATION, SAFETY AND OPERATIONS

The operation of the storage ring and beamlines will create significant radiation problems. Control measures must be applied to ensure that the health and safety of all personnel is guaranteed at all times.

(a) BREMSSTRAHLUNG

High energy electrons lost from the electron beam will interact with any material or component that they strike by releasing energy in the form of gamma radiation. High energy electrons can also interact through the bremsstrahlung effect producing high energy photons. These photons will subsequently interact with material through pair production resulting in the creation of a positron and an electron. The positron will annihilate causing more photons and the electron, if having sufficient energy will again interact through the bremsstrahlung effect. The number of particles will increase whilst the mean energy of the particles decreases. This is the electromagnetic cascade. Eventually, the mean energy decreases so that other reactions can occur. The cascade is then progressively attenuated. The photon (gamma) dose rate is extremely high at small angles to the electron beam and is less at wide angles. Gamma radiation is attenuated efficiently by dense or high z materials such as lead or concrete.

(b) GAS BREMSSTRAHLUNG

A particular form of bremsstrahlung is ‘gas’ bremsstrahlung. This is produced when electrons interact with the residual gas molecules within the vacuum chamber. This radiation is experienced as a narrow beam of energetic photon radiation that passes down the beamline.

(c) NEUTRON RADIATION

Some of the bremsstrahlung photons will create high energy neutrons by the giant resonance, pseudo-deuteron and photon-pion reactions. The neutron dose rate is much less than the photon, but the neutrons are more difficult to attenuate. Concrete is a cheap shield hydrogenous material that attenuates neutrons in the MeV energy range efficiently. Higher energy neutrons may need denser materials such as barytes concrete, iron or lead.

(d) SYNCHROTRON RADIATION

The synchrotron radiation that passes down the beamlines is electro-magnetic radiation which spans the spectrum from infrared to ultraviolet and x-rays. The x-rays have energies up to around 100keV in shielding terms. The dose rate in the beam and the dose rate scattered from beam shutters, collimators, apertures, etc. is highly dangerous to people.

(e) SHIELD WALL

The accelerator and beamline front ends will be located in a shielded tunnel (see Figure 3.4-1 Shield wall). The Operations Team will ensure that no one will be present in the tunnel by means of a search and interlock procedure. People will enter the tunnel through labyrinths. All cables and services will enter the tunnel through shielded ducts.

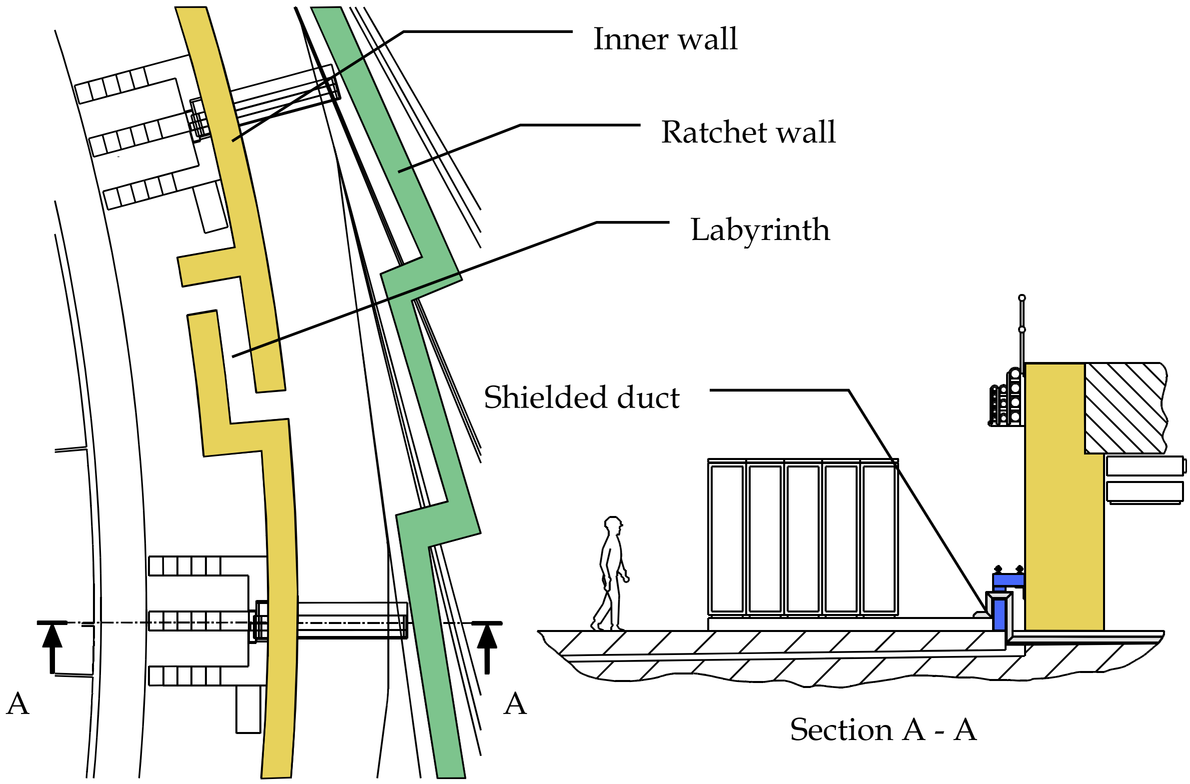


Figure 3.4-1 Shield wall

The wall has to be thick enough to absorb all the radiation from the synchrotron. If any part of the wall is to be made of blocks, special care must be taken to ensure that no radiation can escape through the cracks between the blocks.

(f) SHUTTERS

A port shutter will close off each beamline during normal injection of the Ring. Eventually, it might be possible, in the right circumstances, to use top-up injection with the port shutter open. Extra shielding will be positioned to prevent any cross over radiation penetrating down the beamline. Beamline shutters will allow access into the optics and experimental hutches. All shutters must be designed according to the requirements of the defined standard[4].

The Front-end design group has debated the number of Hutch Shutters required for each beamline.

The issue is whether it is necessary to operate with a Port Shutter, Optics Hutch Shutter and Experimental Hutch Shutter. The other option would be to use the Port Shutter to perform the function of the Optics Hutch Shutter as well as its own function and operate with the Port Shutter and Experimental Hutch Shutter only.

By using 'available' health & safety, maintenance, reliability and financial information an attempt has been made to determine the necessity of the Optics Hutch Shutter to perform a specific function, and the impact or consequences of excluding it from the Diamond design. Consideration of other synchrotron light sources has been included in the discussions and it is understood that although the APS and SRS use a Port Shutter, Optics and Experimental Hutch Shutters the ESRF use a Port Shutter and Experimental Hutch Shutter only.

It is the opinion of the group that, because of the implications of this decision on other departments, the discussion should be introduced to a wider audience of participants. This audience would include the JVC Technical Director and Beamline Scientists, to enable the discussion to be brought to a satisfactory conclusion.

(g) ACCESS TO FRONT-ENDS

Access to the front-ends can only be permitted when the electron beam is stopped. Entry routes into the shield wall will be interlocked so that when the synchrotron is producing radiation it will not be possible to enter. Refer to machine safety document.

When the radiation is stopped normal access to the front-ends will be via a set of ladders that will go over the storage ring similar in principle to that on the current SRS. The ladders will be attached to the floor separate from the girder.

In order to ensure that it is not possible to be trapped within the shield wall when the machine is operating a search within the shield walls must be carried out before the machine can be activated. For safety reasons there will be a button at each of the front-ends. Before the machine can be started this button must be depressed. (Refer to machine safety document). There is to be one ladder per front-end to provide access as shown in Figure 3.4-2.

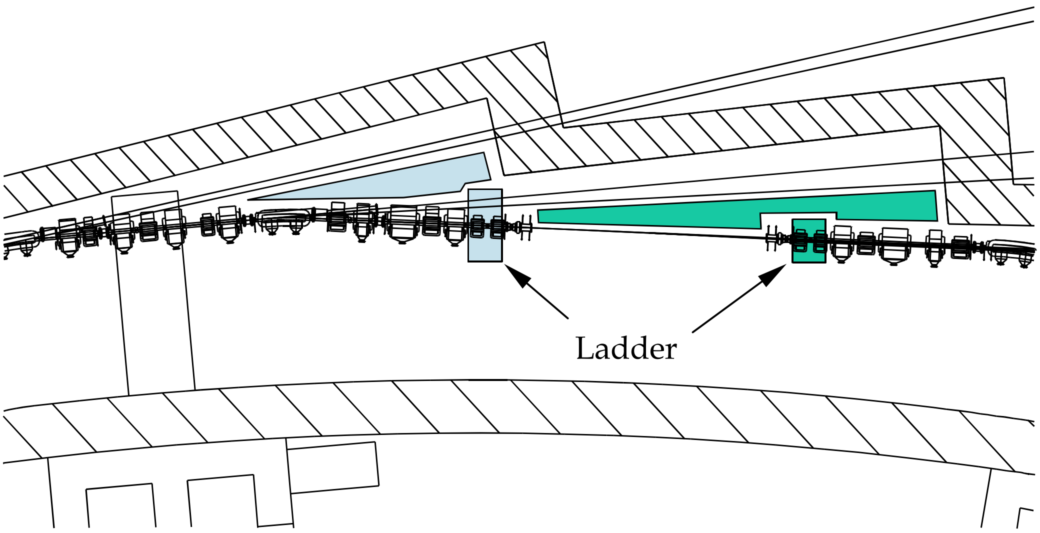


Figure 3.4-2 Plan view of Front-end access

A second method of access for maintenance and installation is via removal of the roof. This will be required when larger components (such as the vacuum chamber) have to be extracted or installed as a crane can be used to aid with lifting.

3.5 FRONT-END DESIGN CONSTRAINTS

This section looks at issues that are common to all of the components in the front-end.

3.5.1 MODULARITY

There are two standard front-end types: BM front-ends and ID front-ends.

Due to the fact that there will only be one front-end per dipole, it should be possible to include a degree of modularity in the design. This would reduce the design time required, and because of economies of scale will reduce the individual cost.

There are 2 main types of beamline: BM beamlines, and ID beamlines. ID beamlines can further be split into single Undulators, Wigglers, and Wavelength Shifters.

BM beamlines require a 20mrads spread of radiation to be carried to the shield wall. This will be split into smaller arcs before passing through the shield wall. It should be possible to have common components as far as the beam splitter. Thus most of the components for all BM front-ends should be identical, those that are not identical should be modular so that they can easily be changed to suit different beam splits.

ID beamlines are more complex due to the different types of ID device that can be installed. Undulators require only 1mrad of vertical and horizontal radiation, Wigglers, and Wavelength shifters require 10mrads horizontal and 1mrad vertical. It is proposed that in order to leave open the possibility of upgrading single Undulator lines all ID front-ends are to give 10mrads horizontal by 1mrad vertical.

The main difference between Undulator, Wigglers, and Wavelength shifters is power distribution. A wavelength shifter gives a broad band of energy with a 'moderate' overall power distribution and 'low' peak power. A Wiggler gives a broad band of energy with a 'high' overall energy level but 'low' peak power. An Undulator gives a 'low' overall energy level but a 'high' peak power. The arrangement of components in the two lines should be similar, where possible components should be designed for use in either line. Other components such as the defining apertures, absorbers, and slots may be designed in such a way that only a small part of them has to be replaced in order to accommodate the different beams. Other components such as the PBPM may need to be completely different.

The ID front-ends then should all have a similar layout. Some of the components that carry out similar functions may have to be different, however, in order to cope with the differing beam types. These different components may have to be unique depending on the beamline. In this case, a modular design of components should be pursued so that they are easy to remove or replace. For instance all apertures could be fixed at 1m long, thus allowing different apertures to be slotted into position if different beam shapes are required.

3.5.2 RADIATION

All of the components within the front-end will be subject to x-rays of varying powers. Electrical components should be placed as far away from the vacuum vessel as possible. If possible, rubber hoses or cables should not cross beam height close to the storage ring or beamline vacuum vessel as they can be embrittled by the synchrotron radiation.

3.5.3 ALIGNMENT

The components must be very accurately aligned to each other, to the storage ring and to the beam lines. In order to achieve this, two fiducial points must be accurately positioned on each component. See the alignment document.

Each component should be capable of being adjusted without affecting the position of the others.

In order to align the front-ends with the beamlines without removing the tunnel roof, survey holes will be located 2.4m from the floor level, and on beam centre horizontally.

3.5.4 HEAT LOADING

The components subjected to intense heat loading must be carefully modelled to ensure problem free operation. Care should also be taken to ensure that no component could be damaged due to beam mis-steers.

3.5.5 BAKE-OUT

Provision must be made to bakeout all the vacuum components to 250^{0}C in situ. A final decision on whether to use in-situ bakeout for the front-ends will be taken after a detailed calculation of the front-end vacuum system has been carried out. However all vacuum components will be baked during pre-conditioning and it is anticipated that sections of front-end components will be built up off line and baked as assemblies.

3.5.6 VACUUM

Much of the information contained in section E5 (Vacuum) of this document provides details of design constraints for example material choice and specification.

Detailed quality assurance documentation for the diamond vacuum system will be written covering aspects such as cleaning, material handling and specification as well as manufacturing guidelines. To achieve the necessary vacuum levels for the project it will be essential that the quality assurance documentation is adhered to and so will need to be policed rigorously. This documentation will need to be written early in the next phase of the diamond project.

These documents will be required for all the diamond facility vacuum systems including the front-ends. It is likely that existing CLRC specifications will form the basis of these quality assurance documents. Typical examples include:

- General manufacturing specification[5].
- Cleaning specification[6].
- Leak testing specification LT/02/88/A.

For bakeout considerations see section 3.5.5 of this document.

The levels of synchrotron radiation gas desorption will have a major influence on the design of the vacuum system (including chambers and pipes). It will be necessary to carry out detailed calculations of gas desorption before the design can be finalised.

3.5.7 TEST AND ASSEMBLY

The front-end should be designed in such a manner that it can be assembled and tested off the synchrotron and then lowered into position with the minimum of installation time. All systems including water, electrical and vacuum integrity should be tested before the front-end is lowered into position to ensure a short shutdown period.

3.5.8 VIBRATION

Each component must be checked to ensure that when it is operated it does not cause vibration in any of the adjoining components. Attention must be paid during detailed design to reduce the production and transmission of vibration to the ground and neighbouring sensitive components.

3.6 FRONT-END COMPONENT LAYOUT

The previous sections have defined the functions of the front-end components. They have also looked at any limitations on the arrangement of these components. This section will first look at a block diagram of these components that meet the set criteria and then will examine the physical constraints.

3.6.1 UNUSED FRONT-ENDS

Before front-ends are installed, an assembly of parts is required to absorb the radiation produced from the dipole magnets. This will be done as shown below. A decision on whether to install this isolation valve will be taken following detailed development of the operational philosophy of the front-end early in the next phase of the design study.

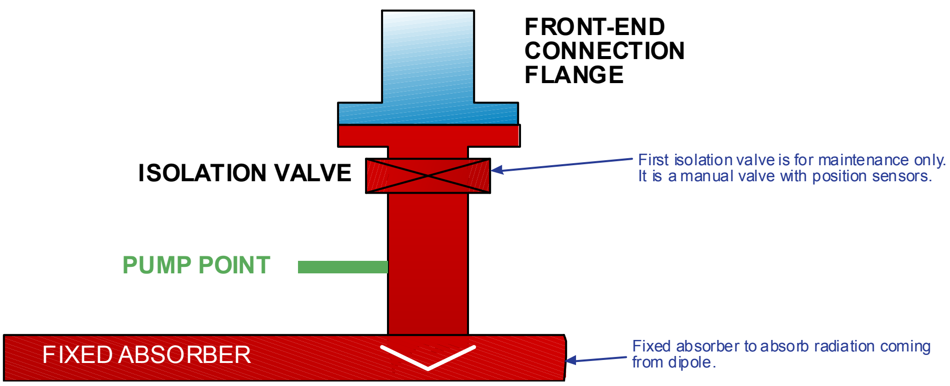


Figure 3.6-1 Dipole absorber assembly for unused front ends

3.6.2 STANDARD ID FRONT-END BLOCK DIAGRAM (UNDULATOR)

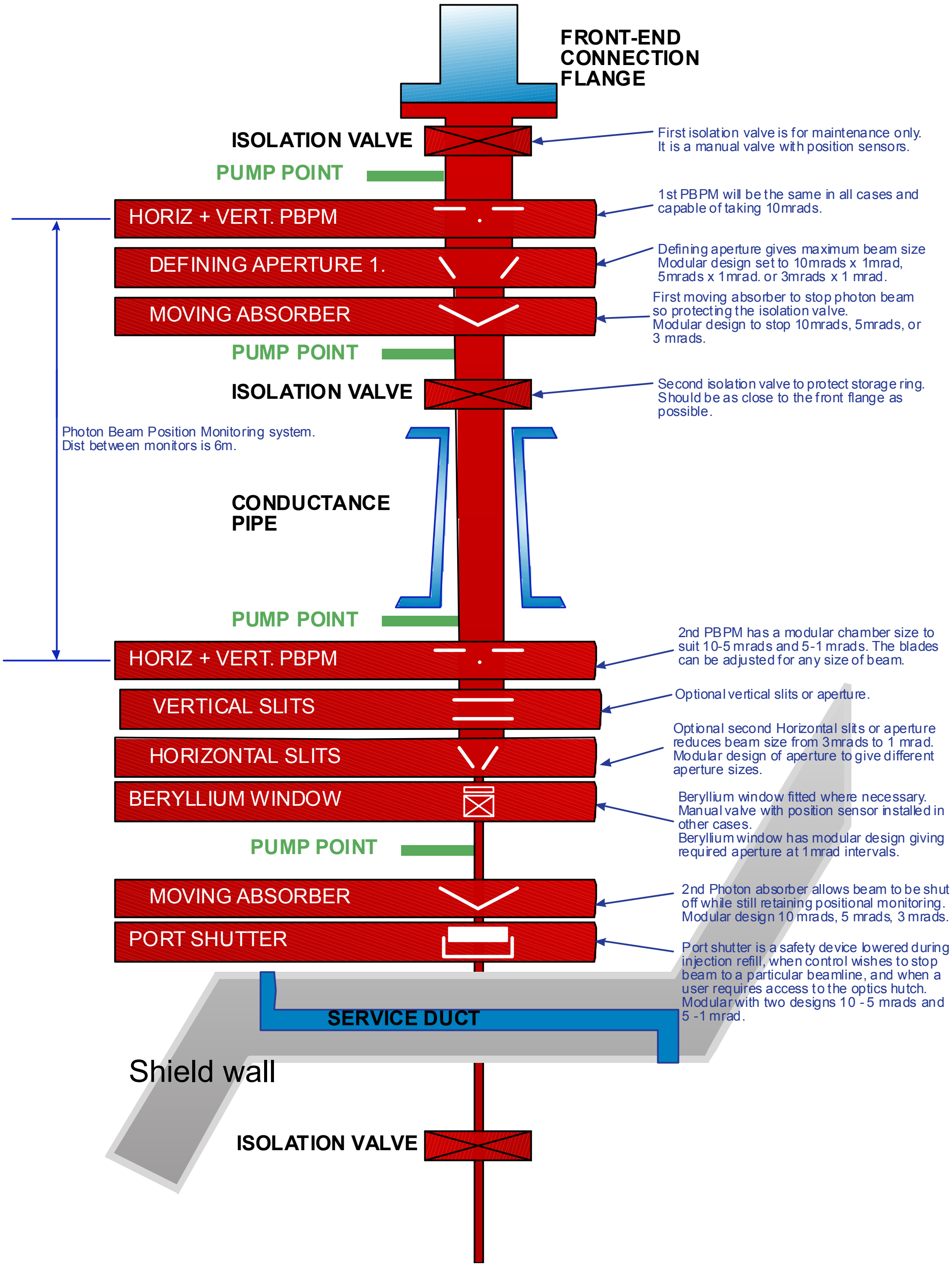


Figure 3.6-2 Standard front-end block diagram (undulator)

See section 3.6.7 for an explanation of design rationale.

3.6.3 STANDARD ID FRONT-END BLOCK DIAGRAM (W/S AND MPW)

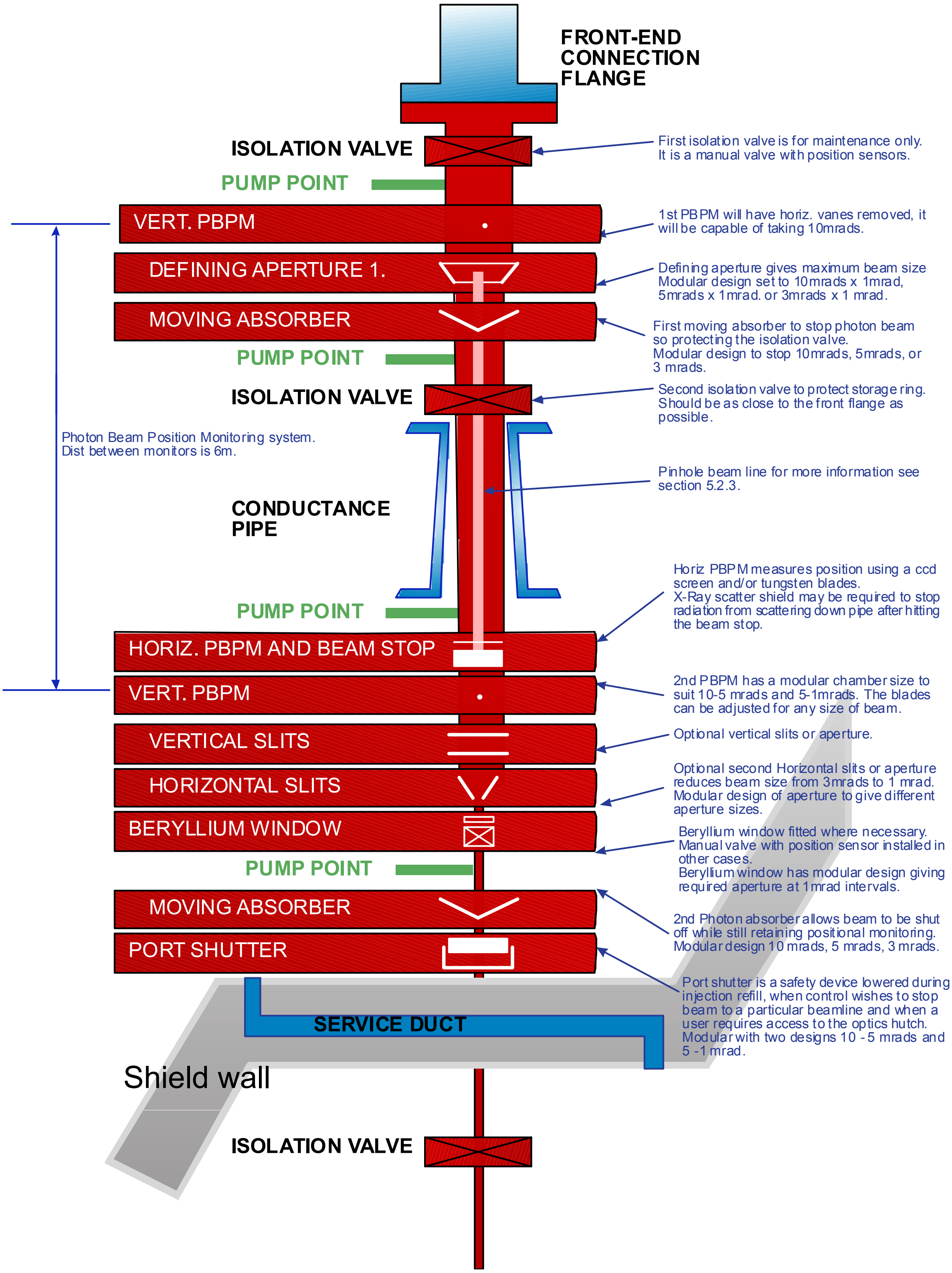


Figure 3.6-3 Standard ID front-end block diagrams (W/S and MPW)

See section 3.6.7 for an explanation of design rationale.

3.6.4 STANDARD BM FRONT-END BLOCK DIAGRAM

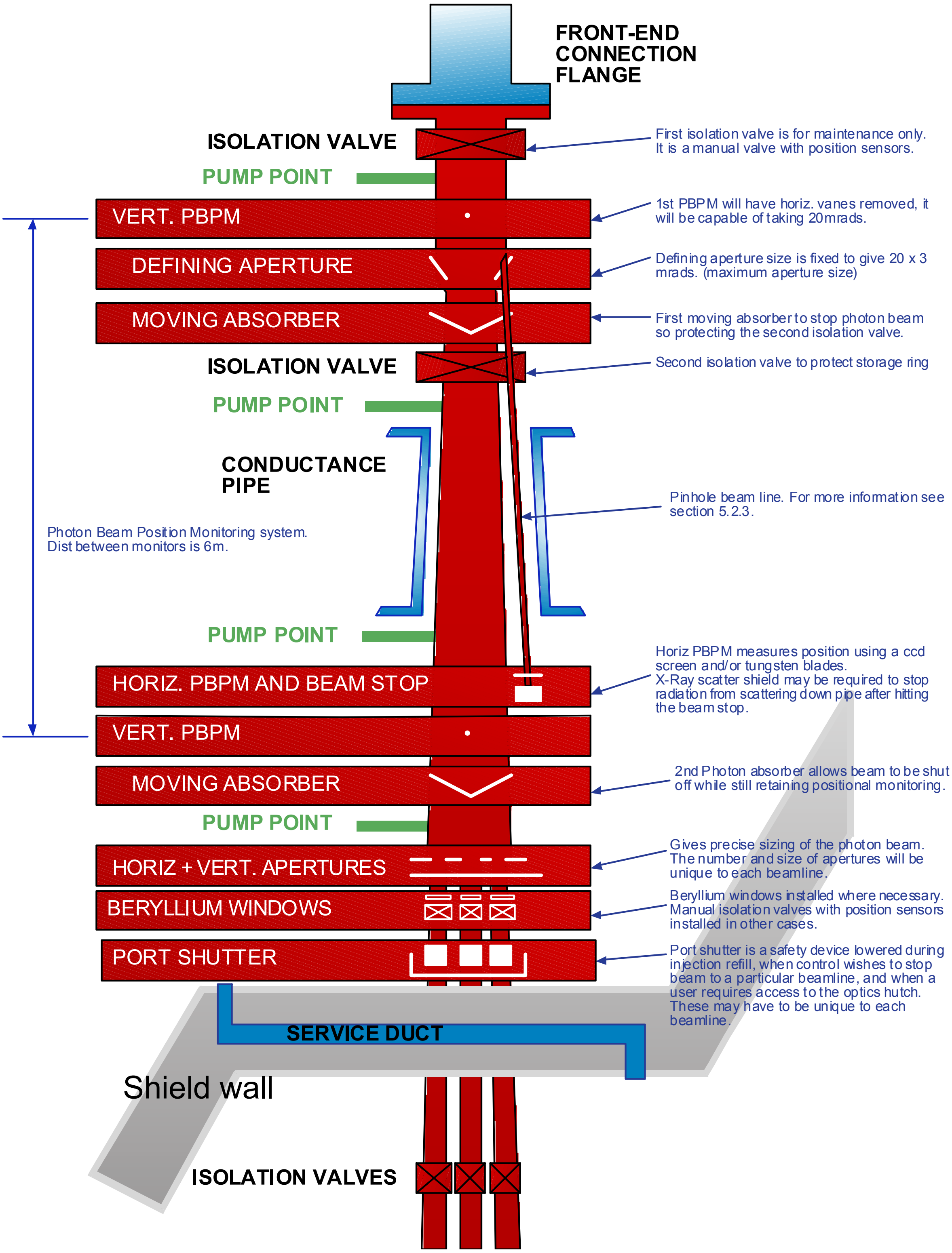
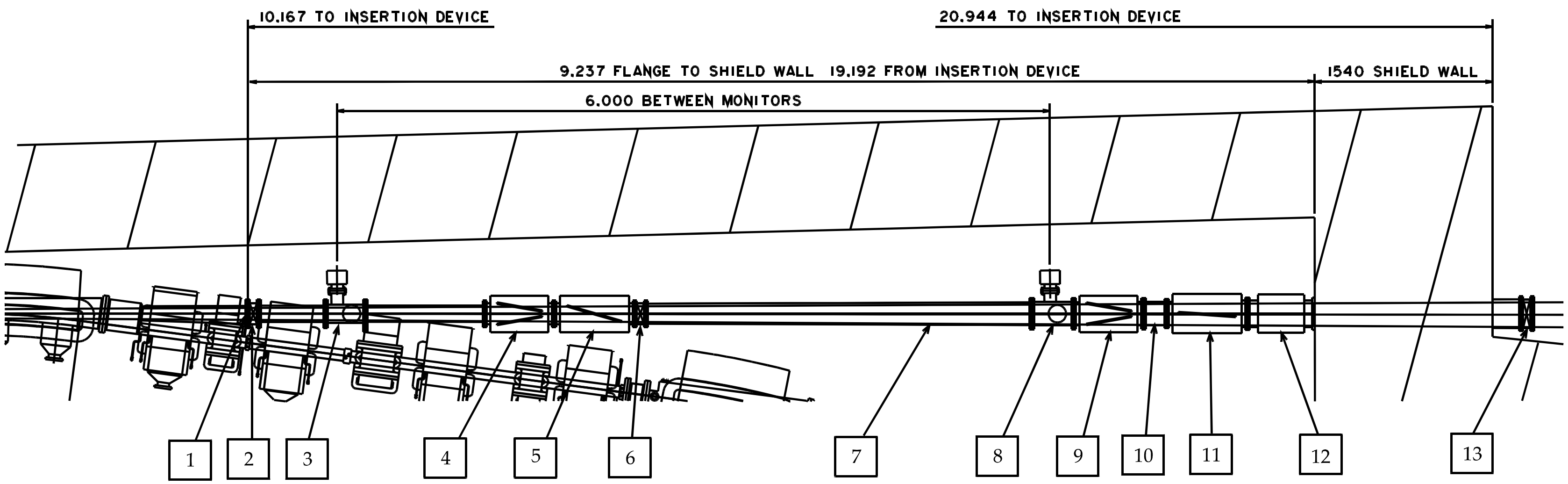


Figure 3.6-4 Standard BM front-end block-diagram

3.6.5 PHYSICAL STANDARD ID FRONT-END LAYOUT



3.6.6 STANDARD ID FRONT-END PARTS LIST

The following table lists the front-end components with their distance to the insertion device (5m straight)

No.	Item	Dist X	No.	Item	Dist X
1.	Front Flange	10.169m	8.	Horiz + Vert PBPM	17m
2.	Isolation Valve	10.2m	9.	Horiz + Vert slits/apertures	17.8m
3.	Horiz + Vert PBPM	11m	10.	Beryllium window (option)	18m
4.	Defining aperture	12.6m	11.	Absorber	18.5m
5.	Absorber	13.2m	12.	Port shutter	19.2m
6.	Isolation valve	13.6m	13.	Isolation valve	21.3m
7.	Conductance pipe	14m			

3.6.7 ID FRONT-END DESIGN RATIONALE

This section will look at the proposed design and explain its features. It will start at the downstream side of the front-end and work upstream explaining each component in turn.

(a) 1ST ISOLATION VALVE

This valve is not included in the cost breakdown but is included here as a recommendation to improve the operational ease of front-end maintenance and to allow the installation of the initial front ends without storage ring venting. If agreed, the valve could be fitted at all ports to allow the installation of future front ends without storage ring venting. A manually operated all metal gate valve is proposed although the cost/benefits of pneumatic operation need to be considered in detail. The valve will require special position indicators to be fitted similar to those used on personnel safety valves. This is to ensure that the valve cannot be closed by accident during operations. The facility control system will generate the necessary interlocks. A decision on whether to install this isolation valve will be taken following detailed development of the operational philosophy of the front-end early in the next phase of the design study.

(b) 1ST PBPM

The second component then is a PBPM. The two PBPM's need to be as far apart as possible and this is achieved by positioning the first one close to the front flange. This is similar to the approach taken by the ESRF.

To cope with the different beam sizes and types it may be necessary to motorise the blades so that they can be moved close together to measure Undulator beams and far apart to measure MPW beams. This would allow easier alteration of beamlines. It is also possible to have a non-motorised blade that has to be changed manually after venting up a section of the front-end.

The two devices that define the path of the photon beam need not be identical (e.g. two tungsten vane monitors, or a pinhole and an imaging screen). The most appropriate system should be chosen to match the source properties being monitored.

However, it would be convenient to use as small a group of device types as possible.

(c) DEFINING APERTURE

The defining aperture is positioned next in order to keep the size of the vacuum chambers as small as possible. This may define the horizontal aperture separately from the vertical one and so effectively become slits. This would allow a standard design that could also be used for the slits further upstream. It is envisaged to fix standard horizontal aperture sizes; say 10mrads, 5mrads and 3mrads. This would mean that components downstream of the aperture would be no larger than necessary.

A further advantage of defining the horizontal aperture separately from the vertical one is that it may be practical to design a "Christmas tree". This would allow one design of aperture to cater for all three aperture sizes simply by moving the horizontal aperture in the vertical plane.

With the Wigglers and wavelength shifters a pinhole may need to be positioned in the defining aperture in order to create the monitoring beam. This could be done by drilling a 2 or 3mm diameter hole in the defining aperture and positioning a thin tungsten plate with a 50micron hole further downstream to filter out the excess beam.

(d) 1ST ABSORBER

The absorber comes next. The ESRF design of absorber is unconventional but appears very good. There is no possibility of a water leak inside the vacuum and it is more efficient than the standard design. It is proposed to have 3 different heads on the absorber to cope with a 10mrads, 5mrads or 3mrads beam from the defining aperture. The design would allow utilisation of the same framework and adjustment mechanism on every option with different heads to suit the 3 power loadings. This is as close to the storage ring as practical to give the isolation valve as much time as possible to close.

The absorber comes after the defining aperture in order to reduce the heat loading on this component so making it easier to design.

(e) 2ND ISOLATION VALVE

The second isolation valve is used to provide protection to the storage ring vacuum system and the front-end vacuum system in the event of a failure of either of the two systems. The 1st absorber protects this valve from synchrotron radiation. The total pressure and partial pressure measuring systems will provide interlocks to facilitate the opening/closing of this valve.

(f) CONDUCTANCE PIPE

The conductance-restricting pipe forms part of the vacuum protection system. It will be designed to have the smallest internal dimensions that will allow a beam of 10 mrads of synchrotron radiation through. It is envisaged that IR and CD beamlines will be added to the diamond project at some stage. These beamlines require optics to be located in the front-end and will preclude the use of a conductance-restricting pipe. These front-ends will be considered as specials and will be the subject of individual front-end design.

(g) 2ND PBPM

The second photon absorber is positioned next. This is before the second absorber the idea is that the location of the beam is known before it is allowed to enter the optics hutch. It is positioned before the slots in order to eliminate any possibility of shadowing.

It would be envisaged to provide a 10-5mrads PBPM design and a 5-0.2mrads PBPM design in order to reduce the size and cost of the components. These two designs would use the same blades and mechanisms, just have different casing sizes. The design and type of PBPM has yet to be fixed, but one can envisage a modular system with two designs (one for 10mrads of horizontal beam and one for ca. 1mrad of horizontal beam).

(h) HORIZ. + VERT. SLITS

The horizontal and vertical slits come next. These could either be of fixed size, so becoming a second defining aperture or a “Christmas tree” design could again be used allowing for an adjustable beam width of say 3mrads, 2mrads or 1mrad. If a fixed size was used this would be unique to every experiment. For instance if 1mrad was required the beam would initially be reduced to 3mrads by the defining aperture and then to 1mrad in this later section. If 4mrads were required the beam would initially be reduced to 5mrads in the defining aperture and then to 4mrads in this later section. The component could be tabled meaning that no extra design time would be required after the initial design.

(i) BERYLLIUM WINDOW OR 3RD ISOLATION VALVE

The beryllium window is fitted after the PBPM so that it does not affect the accuracy of beam positioning. Alternatively, a diamond or CVD coated window could be used with the possibility that the window could be motorised. For front-end designs that don’t require a window, a 3rd Isolation valve will be installed. The criteria for the 2nd Isolation valve apply. The purpose of the valve would be to provide isolation between different parts of the vacuum system for added protection and for ease of maintenance and operation. If a beryllium window is fitted onto a beamline that utilises the coherence of the source, then it will have to be highly polished.

(j) 2ND ABSORBER

The second absorber will be identical in principle to the first although dimensions may be different to allow for larger size of beam at this point.

(k) PORT SHUTTER

The port shutter prevents radiation from passing down the beamline during injection, and when the optics hutch has not been searched and interlocked. It should be designed to comply with the standard [7]. The ESRF design and new SRS design should be considered for this application. It is recommended that 2 sizes be catered for 10mrads and 5mrads. The 5mrads design will be comparable to the ESRF but the 10mrad design will be much larger. For safety reasons, a dual control system will need to be looked at.

(l) 4TH ISOLATION VALVE

The last component is an isolation valve located after the shield wall. This valve provides front-end/beamline isolation for protection to each vacuum system and for satisfactory operation of both vacuum systems. This valve will be a gate valve but may not need to be all metal, this will be determined after the completion of the detailed front-end vacuum system calculations. If there is no beryllium window in the beamline then it is likely that this valve will need to be all metal.

(m) BEAM SIZES

It should be noted that 10mrads was chosen as it is the maximum beam size, 5mrads as this is similar to the ESRF maximum beam size, 3mrads as this would suit an Undulator and spread the heat loading better. There may be more optimal sizes, which will be obtained after thermal simulation.

3.6.8 STANDARD ID FRONT-END SPECIAL OPERATIONS

(a) VACUUM FAILURE ON BEAMLINE

The control system will close the 1st absorber and all the isolation valves.

(b) VACUUM FAILURE ON STORAGE RING

Electron beam is stopped and all the isolation valves close.

(c) VACUUM FAILURE ON FRONT-END

The control system will close the 1st absorber as well as all the isolation valves.

(d) BEAMLINE SHUT DOWN FOR MAINTENANCE

Electron beam is stopped and all isolation valves close.
The 1st isolation valve can be closed manually to isolate the front-end from the storage ring.
Any component in the front-end can be worked on without having to bring the storage ring up to atmosphere.

(e) USER STOPS THE PHOTON BEAM

Second absorber closes allowing the beam position to be constantly monitored by the 1st and 2nd PBPM. Station shutter in the optics hutch drops into position.

(f) CONTROL STOPS THE PHOTON BEAM

2nd absorber closes allowing the beam position to be constantly monitored by the 1st and 2nd PBPMs. Port shutter drops into position.
This turns both control circuit and user circuit red

(g) USER STARTS THE PHOTON BEAM

Beam position constantly monitored. So Port shutter (providing the control circuit is green) is removed then 2nd absorber. If Port shutter cannot be opened, control has closed the shutter

(h) CONTROL STARTS THE PHOTON BEAM

Control turns control circuit green. This allows the user to turn the user circuit green and thus a User start beam can then proceed.

3.7 SIMILAR FRONT-ENDS

This section will look at front-ends constructed to do similar jobs to the front-ends on DIAMOND but on other machines.

3.7.1 BEAMLINE 6 AND 10 SRS

Beamlines 6 and 10 on the SRS are very similar to each other. They both have Multipole Wigglers for sources and they both contain similar components in a similar order. Below are listed the components of the front-ends for beamlines 6 and 10 in order from the storage ring to the beamline.

Cooled absorber
Defining aperture
Isolation valve
Pumping and Instrumentation point
PBPM
Port shutter

3.7.2 BEAMLINE 14 SRS

Beamline 14 is slightly different from 6 and 10. It has a 2 Tesla Multipole Wiggler as an insertion device. This beamline intersects the transfer path into the storage ring. Below are listed the components on this front-end in order from the storage ring to the beamline.

Cooled absorber
Defining aperture
Isolation valve

Pumping and instrumentation point
Beamtube (1.65m long)
Finger absorber
Fixed mask with pumping
PBPM
Finger absorber
Fixed mask
Pumping port
Beryllium window
(Transfer path intersects at this point)
Beryllium window
Port shutter
Station shutter

3.7.3 BEAMLINE 16 SRS

Beamline 16 is different in that it uses a cryogenic wiggler for its insertion device. Below are listed the components on this front-end in order from the storage ring to the beamline.

Cooled absorber
Defining aperture
Isolation valve
Pumping and instrumentation point
Beryllium window
PBPM vessel
Kratky aperture
Isolation valve
Port shutter
Station shutter

3.7.4 ESRF STANDARD ID FRONT-END ASSEMBLY

The ESRF break up a front-end into 3 parts. Module 1 is closest to the storage ring, Module 2 is closest to the shield wall, and the transition module lies between the two. Listed below are the components in the module 1 ID standard assembly starting from the storage ring side.

Isolation valve
X-BPM sensor
Pumping tee
Fixed absorber assembly (270mm flange to flange)
Moveable absorber assembly (800mm flange to flange)
Isolation valve
Fast closing shutter

Continuing with the transition module

Approx. 3m of pipe
Acoustic delay chamber (2.4m long)

Continuing with module 2

Absorber
X-BPM sensor (14m from 1st)
Slit filter (800mm flange to flange)
Beryllium window
X-BPM sensor (2m from 2nd)
Port shutter

3.7.5 ESRF HIGH POWER STANDARD ID FRONT-END ASSEMBLY

Listed below are the components in Module 1 High Power ID Standard assembly starting from the storage ring side

Isolation valve
X-BPM sensor
Pumping tee
Fixed absorber assembly (270mm flange to flange)
Mask dia 8mm (265mm flange to flange)
Isolation valve.
Defining aperture
Absorber
Valve
Fast acting valve

Continuing the transition module

Pumping chamber
Straight chamber (2.6m flange to flange)
Acoustic delay chamber (2.4m flange to flange)

As shown in the general layout this line has the standard module 2 assembly. There is also a second option as listed below :-

Starcell pump (in-line Ion pump)
Vertical slit (270mm flange to flange)

Isolation valve
Pumping tee
Horizontal slit (270mm flange to flange)
Cooled window
X-BPM Sensor (11m from 1st)
Port shutter (510mm flange to flange)

3.8 FRONT-END PROCUREMENT

It is likely that the front-end will be broken down into sub-sections with a high level specification pulling all the component specifications together.

Sub-sections would include:

PBPM's
Absorber assembly
Defining Aperture and slits assemblies
Port shutter assembly

These would be tied together with a high level specification detailing:

Physical layout of front-end
Max. Size flange-flange of each component
Construction standards
Quality assurance requirements
Deliverables
Numbering systems to be used
CAD Drawing standards
Time schedule
IPR and Confidentiality agreements.

REFERENCES

[1] DIAMOND internal report: VAC-SR-rpt-006

[2] DIAMOND internal report: VAC-SR-rpt-008

[3] DIAMOND internal report: VAC-XX-rpt-010

[4] HPR91/178, rev 2002

[5] Daresbury Laboratory internal report: DL/UHV/01/90

[6] Daresbury Laboratory internal report: CS/05/95

[7] HPR91/178, rev 2002