Camera vacuum flanges for high energy detection

In order to efficiently detect photons with energy in the vacuum & extreme ultraviolet and soft & hard x-ray range, an environment free of particles that could interfere with the useful photon signal is generally created between the high energy radiation source and the detector. This is achieved by pumping out of the experimental chamber the atomic or molecular species that would absorb the useful radiation and be ionised, hence creating ‘pollutant’ species.

The present document highlights the key vacuum flange interfaces available for connecting Andor CCD detectors to vacuum chambers or spectrographs for a range of applications including x-ray plasma diagnostics, extreme ultraviolet (EUV/XUV) imaging & microscopy, x-ray diffraction imaging or spectroscopy, or high harmonic generation (HHG).

Energy range considerations

A high energy photon can be absorbed by molecules or atoms present in the experiment environment, and ionise these species at the higher energies. The regions relevant for the present discussion are defined as follow [1]:

Radiation domain	Wavelength range (nm)	Photon energy range (keV)	Comments
Ultraviolet			
Vacuum UV (VUV)	10 – 200	0.124 – 0.006	Absorbed by atmospheric oxygen, increasingly pronounced <~180 nm, potential ionising radiation
Extreme UV (EUV)	10 - 121	0.124 – 0.1	
Soft X-Ray			
Extreme UV (XUV)	0.1 – 10	12.4 – 0.124	Ionising radiation
Hard X-Ray	0.001 – 0.1	1,240 - 12.4	Strongly ionising radiation

Table 1 – High energy radiation energy range definition

Vacuum considerations

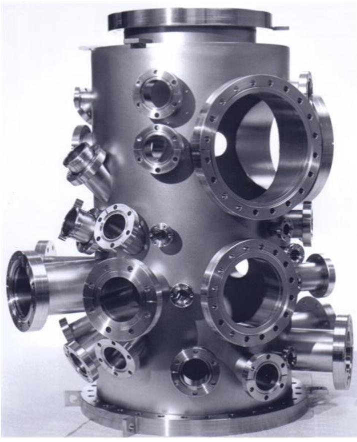
The magnitude of the absorption and scattering of useful x-ray / electrons signal by gas particles depends on the ‘quality’ of the vacuum of the experiment environment.

Vacuum regime	Pressure range[2]			
	mbar	bar	Pascal (Pa)	Torr
Atmospheric pressure	$1.013 \times 10^{+3}$	1.013	$1.013 \times 10^{+5}$	$7.6 \times 10^{+2}$
High vacuum	1×10^{-3} to 1×10^{-9}	1×10^{-6} to 1×10^{-12}	1×10^{-1} to 1×10^{-7}	7.5×10^{-4} to 7.5×10^{-10}
Ultra high vacuum	1×10^{-9} to 1×10^{-12}	1×10^{-12} to 1×10^{-15}	1×10^{-7} to 1×10^{-10}	7.5×10^{-10} to 7.5×10^{-13}
Extremely high vacuum	$<1 \times 10^{-12}$	$<1 \times 10^{-15}$	$<1 \times 10^{-10}$	$<1 \times 10^{-13}$

Table 2 – Vacuum regime definition

Vacuum chambers detector coupling considerations

Examples of vacuum environments onto which Andor 'open front' 'SO' detectors can be attached are shown on fig. 1.



Vacuum Chamber

Vacuum Ultraviolet (VUV) spectrograph

Extreme Ultraviolet (EUV/XUV) spectrograph

Figure 1 – Example of vacuum assemblies accepting Andor 'SO' detectors

Material considerations and bake-out

Materials for use in vacuum should:

- Exhibit low rate of outgassing (release of adsorbed gas or water molecules trapped in the material)
- Be carefully machined to minimize the amount of cracks / defects that could trap unwanted gas or moisture
- Be tolerant to bake-out temperatures

A bake-out process is used to force impurities out of the surfaces exposed to the vacuum, as these could cause outgas and impact on the quality of the vacuum. This could in turn affect the detector minimum cooling temperatures.

Andor vacuum flanges are machined from stainless steel 304 grade.

Flange standards considerations

There are 3 main flange standards used to couple cameras to vacuum enclosures. These formats are described in the following sections:

1. **CF (Conflat™) standard**
2. **ISO standard** (including **ISO-F** and **ISO-K**)
3. **KF standard**

Other flange standards, such as Japanese 'JIS'[3] or Korean 'KS', can be considered through Andor Customer Special Request (CSR) process. Please contact your local Andor representative for further information.

Connecting to VUV/EUV/XUV spectrographs

Andor detectors can be integrated on a number of 3rd party VUV, EUV or XUV spectrographs, including McPherson[4] or H+P Spectroscopy[5]. However these spectrographs may not be designed with the connection standards listed above.

Please refer to the McPherson spectrograph section of this document for further details on available options. For any other option, please contact your local Andor representative for further information.

1. CF (or ConFlat^{TM}) / ICF format

This flange format is based on a metal-to-metal sealing by mean of a **knife-edge** interface. It is suitable for operation in environments ranging from atmospheric pressure to ultrahigh vacuum (< 10^{-13} Torr or < 1.3×10^{-13} mbar) - Research-grade 'direct detection', open-front cameras are compatible with pressure environments down to 10^{-8} / 10^{-9} mbars.

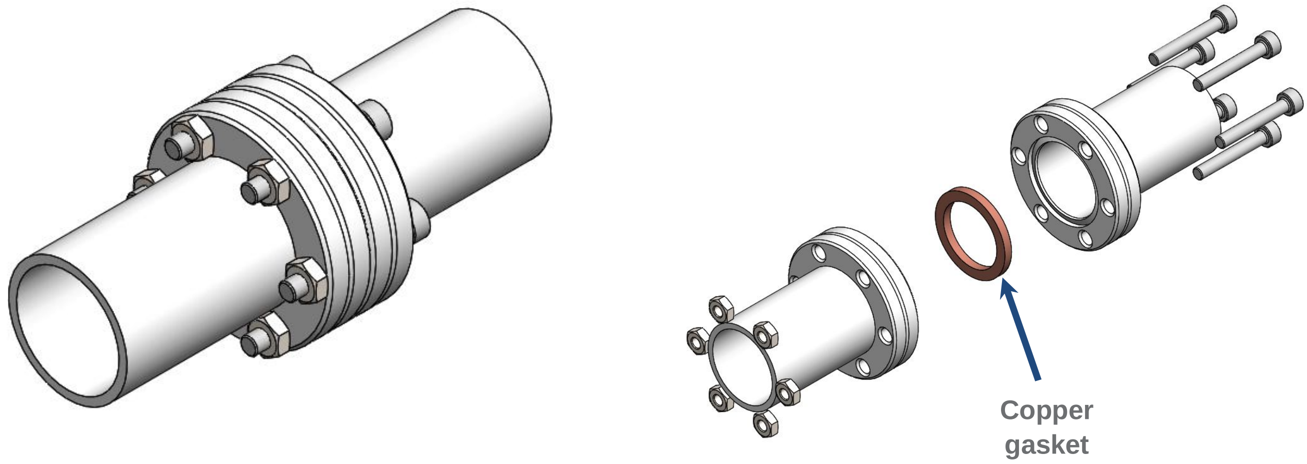


Figure 2 – Typical CF flange interface, with soft metal gasket shown on the drawing on the right

A **knife-edge** sealing involves a sharp-edged wedge of hard material on one side of the flange that cuts into a soft metal gasket on the mating part as the attachment bolts are tightened. The ductility of the soft metal (e.g. oxygen-free copper) gasket is used to fill small defects in the flange, providing an extremely leak-tight seal while also compensating for potential thermal expansion mismatch during bake-out up to ~ 450^{o}C. Note that detectors cannot be exposed to such temperature – the maximum sustainable bake-out temperature for Andor cameras is +55^{o}C.

Two different definition standards exist to specify this flange formats – equivalences are shown in table 3:

- **European/Asian standard** uses the letters 'DN' followed by the **inner** diameter (ID) of the flange in mm, e.g. DN10 denotes a flange with 10 mm internal diameter.
- **American standard** uses a number to define the **outer** diameter (OD) of the flange in inches.

Europe, Asia [ID, mm]	America [OD, inches]	Notes
DN10CF	*1*	(1)
DN16CF	*1⅓ ("mini")*	(1)
DN25CF	*2⅛*	(1)
DN40CF	*2¾*	(1)
DN50CF	*3⅜*	(1)
DN63CF	*4½*	(2)
DN75CF	*4⅝*	(1)
DN100CF	6	(3)
DN125CF	6¾	(5)
DN160CF	8	(4) (5)
DN200CF	10	(5) (6)
DN250CF	12	(5) (6)

(1) Not suitable for Andor cameras

(2) Suitable for Newton and iKon-M

(3) Andor standard CF configuration for Newton, iKon-M and iKon-L platforms

(4) Andor standard CF configuration for iKon-XL

(5) These I.D. can also be accommodated for Newton, iKon-M and iKon-L. Please contact your local Andor representative for further information.

(6) These I.D. can also be accommodated for iKon-XL. Please contact your local Andor representative for further information.

Table 3 – Equivalence of common CF flange formats

The following table summarises Andor's standard flange interface technical characteristics. Please contact your local Andor representative for alternative formats:

Camera platform (a)	Vacuum chamber standards compatibility	Outer diameter (OD) (b)	Inner diameter (ID) (b)	Knife-edge diameter (KD)	Mounting holes PCD	Mounting holes format	Bolt mounting direction	Flange orientation	Flange to sensor plane distance (nominal)	Filter holder type
Newton DO920P-*xx*	DN100CF / 6" CF / CF-152	5.96" [151.6 mm]	1.97" [50.0 mm]	4.52" [114.9 mm]	16 x ø8.5 mm thru on PCD ø130.3 mm	Clearance for M8 or 5/16 UNC bolts	From camera to vacuum chamber	Rotatable (11.25º increments)	0.13" [3.2mm]	Bayonet (d)
iKon-M DO934P-*xx*	DN100CF / 6" CF / CF-152	5.96" [151.6 mm]	1.97" [50.0 mm]	4.52" [114.9 mm]	16 x ø8.5 mm thru on PCD ø130.3 mm	Clearance for M8 or 5/16 UNC bolts	From camera to vacuum chamber	Rotatable (11.25º increments)	0.13" [3.2mm]	Bayonet (d)
iKon-L DO936N-*0W-*xx* (c)	DN100CF / 6" CF / CF-152	5.96" [151.6 mm]	2.68" [68.0 mm]	4.54" [115.3 mm]	16 x threaded on PCD ø130.3 mm	Threaded holes (c)	From vacuum chamber to camera	Fixed (mounting hole at 12 o'clock)	0.24" [6.1mm]	Screw-in (e)
iKon-XL XLO-EAyy-C0	DN160CF / 8" CF / CF-203	7.97" [202.4 mm]	4.41" [112 mm]	6.525" [165.7 mm]	20 x ø8.5 mm thru on PCD ø181.1 mm	Clearance for M8 or 5/16 UNC bolts	From camera to vacuum chamber	Rotatable (11.25º increments)	0.24" [6.1mm]	Screw-in (e)

Table 4 – Andor standard CF interfaces definition

(a) xx = sensor code, e.g. BN, BR-DD; yy = sensor code identifier (iKon-XL only)

(b) The O.D. is used to describe the camera flange, while the I.D. is specified according to the sensor size

(c) There are 3 specific threaded hole options for iKon-L:

a) M8 thread built into the flange - camera code *= **M0W**
b) 5/16 UNC thread built in to flange - camera code *= **I0W**
c) Encapsulated nut (either M8 or 5/16UNC) – camera code *= **00W** [nuts can be removed and replaced if thread is worn]

(d) Included with camera

(e) Optional

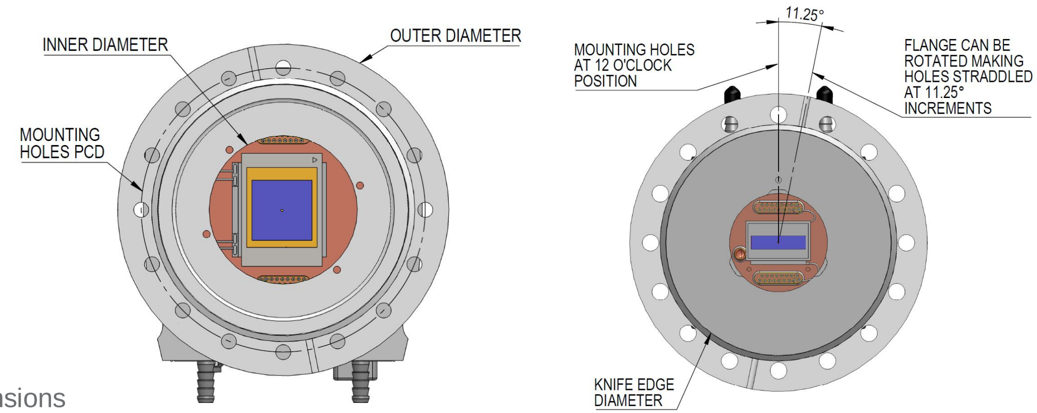


Figure 3 – Details of flange characteristic dimensions

2. ISO format (ISO-K and ISO-F)

This flange format is based on an **O-ring** seal. It is suitable for operation in environments ranging from atmospheric pressure to high vacuum (10^{-8} Torr or $1.3x10^{-8}$ mbar). - Research-grade 'direct detection', open-front cameras can work with pressure environments down to 10^{-6} / 10^{-7} mbars. The ISO format includes two main variations:

- **ISO-F**, using conventional bolt/nuts to secure the flange mating parts
- **ISO-K**, using claw clamps to secure the flange mating parts

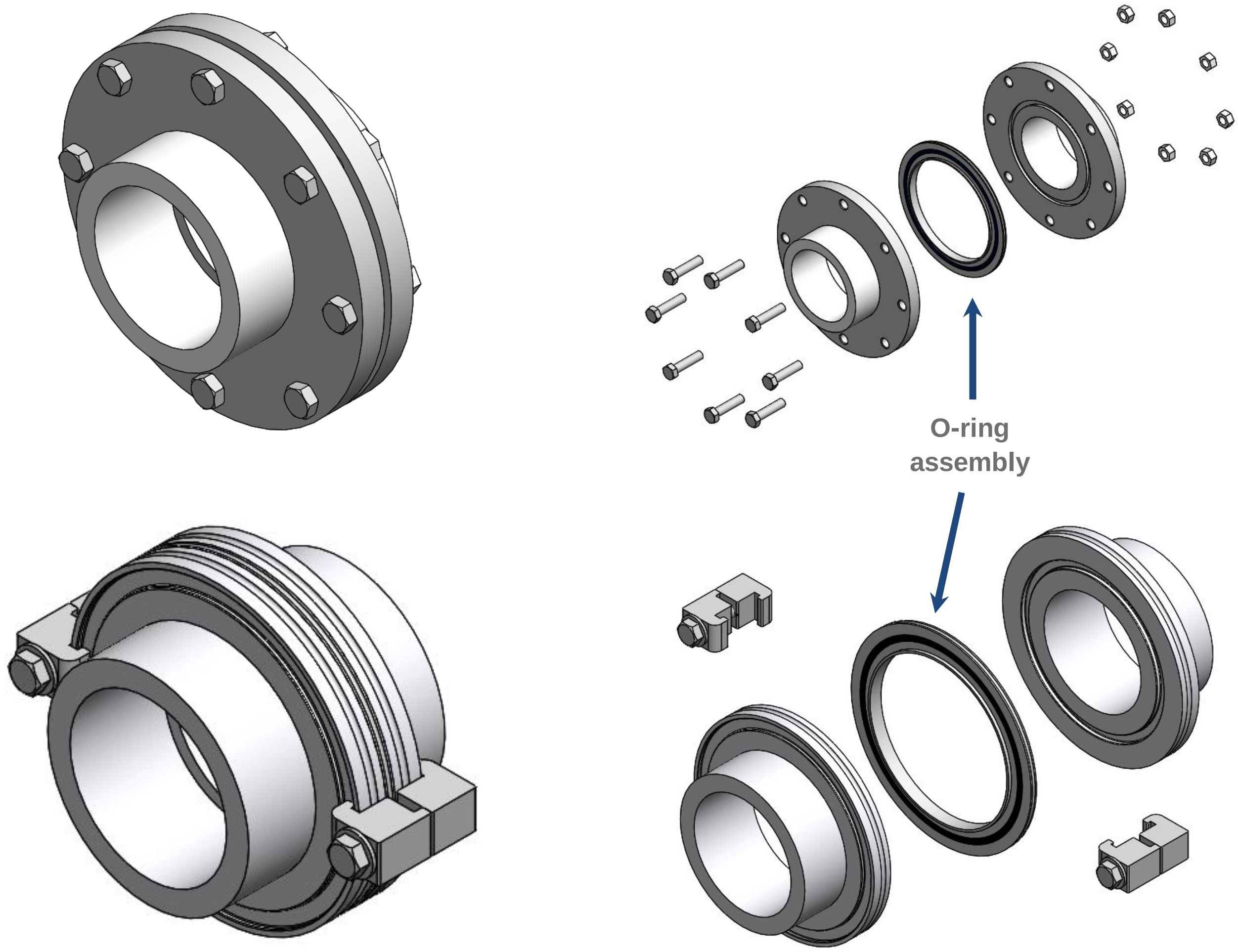


Figure 4 – ISO-F (top) and ISO-K (bottom) flange interface with assembled (left) and exploded view (right)

The **O-ring** assembly consists of a centring metal ring and an O-ring wrapped around it. The two flange mating parts are designed with a groove that is used to centre the O-ring assembly while tightening the attachment bolts or clamps.

This interface can sustain bake-out temperatures up to ~ 150°C. Note that detectors cannot be exposed to such temperature – the maximum sustainable bake-out temperature for Andor cameras is +55°C.

ISO flange formats are identified by the nominal internal diameter (I.D.) in millimetres, e.g. an ISO-K 100 or ISO-F 100 have an internal diameter of 100 mm. The standard sizes range from ISO-63 to ISO-630[6].

ISO-K 100 or **ISO-F 100** are recommended for Newton and iKon-M series, but can also be provided for iKon-L. Other larger O.D. can however be accommodated. Please contact your local Andor representative for further information.

3. KF format

This flange format – also known as Klein Flange (or KF) - is also based on an **O-ring** seal. It is suitable for operation in environments ranging from atmospheric pressure to high vacuum (10^{-8} Torr or $1.3x10^{-8}$ mbar).

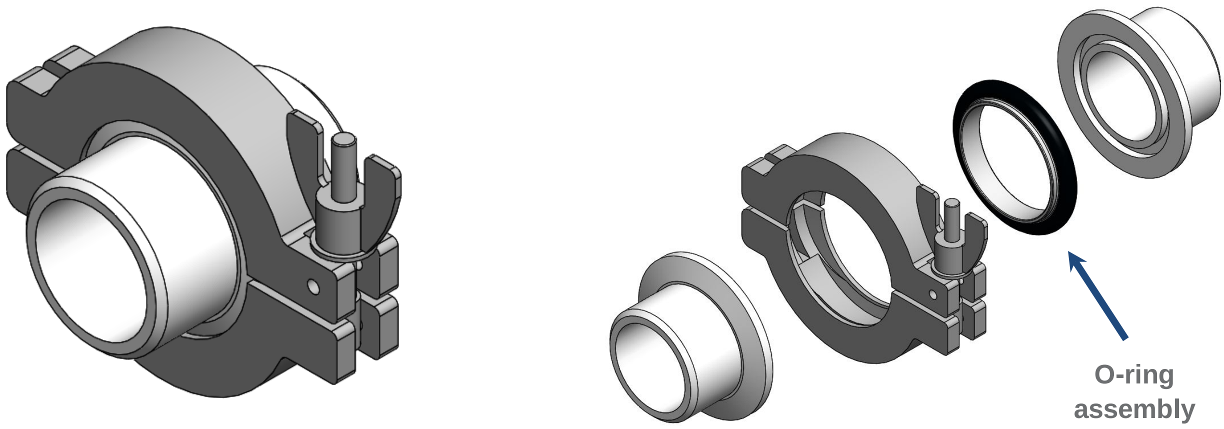


Figure 5 – KF flange interface with assembled (left) and exploded view (right)

The **O-ring** assembly consists of a centring metal ring and an O-ring wrapped around it. The two mating parts of the flange are designed with a chamfered lip and an interface to locate the O-ring assembly. A circular claw with a wing-nut (or thumbscrew) is used to compress the O-ring assembly and the two flange parts to create the seal.

This interface can sustain bake-out temperatures up to ~ 150°C. Note that detectors cannot be exposed to such temperature – the maximum sustainable bake-out temperature for Andor cameras is +55°C.

KF flange format is identified by the nominal internal diameter (I.D.) in millimetres, e.g. an KF100 has an internal diameter of 100 mm. The standard sizes range from KF10 to KF50[6].

Please contact your local Andor representative for further information on options available.

4. McPherson spectrographs

Andor Newton CCD detectors options ***-995*** can connect readily to the spectrographs listed in table 5.

The Newton -995 cameras (e.g. DO920P-BN-995 or DO940P-BN-995) coupling interface is an O-ring sealed flange, designed with the sensor image plane sitting 5.4 mm behind the faceplate front and with a 38 x 25mm aperture. Please refer to[7] for software control of these spectrographs, and see appendix A for further details on the cameras.

Model number	Wavelength Range (nm)		Focal length (mm)	Spectral resolution (nm)	Multi-track	High vacuum	Optical design
234/302	VUV	30 to 550	200	0.1	-	Yes	Concave Holographic
225	VUV	30 to 1,200	1,000	0.015	Yes	Yes	Normal Incidence
248/310G	Soft X-ray EUV, XUV	< 1 to 310	1,000	0.018	-	Yes	Grazing Incidence

Table 5 – Main VUV/EUV/XUV spectrographs compatible with Andor *-995* flange variation

Filters

Andor open-front 'SO' cameras can be coupled to filters to remove the unwanted contribution of low energy radiations on the useful signal.

For x-ray experiments with useful information in the energy range 3-30 keV ('direct' x-ray detection with a silicon-based detector), thin foils of Beryllium (Be) or Aluminium (Al) are typically used. Typical transmission characteristics of Beryllium filters as a function of thickness are shown on fig. 6.

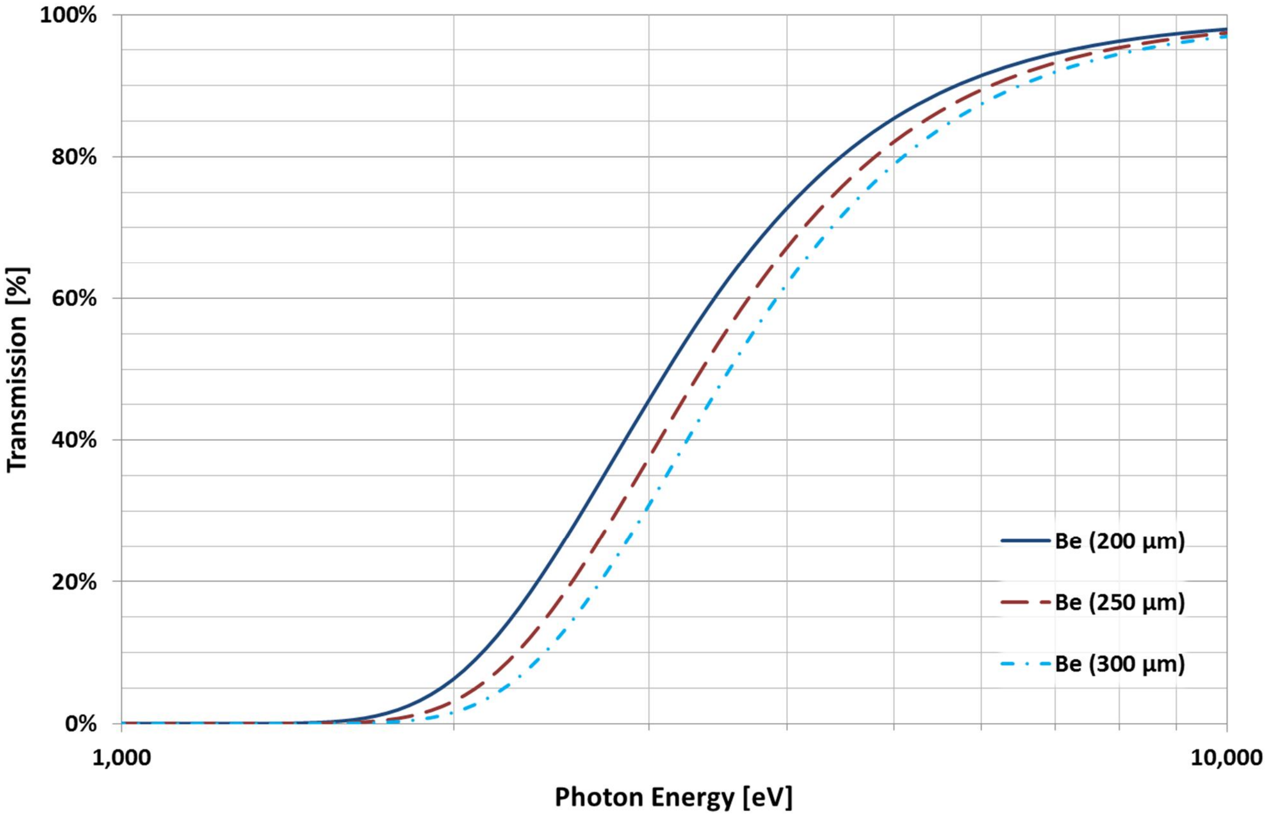


Figure 6 – Typical Beryllium filters transmission curves versus material thickness

Camera platform	Standard Be filter thickness	Standard Be filter diameter [clear aperture]	Min. recommended thickness *
Newton SO	250 µm	Ø45.5 ±0.2 mm [Ø35.0mm]	200 µm
iKon-M SO	250 µm	Ø45.5 ±0.2 mm [Ø35.0mm]	200 µm
iKon-L SO	250 µm	Ø60.0 ±0.2 mm [Ø45.0mm]	250 µm
iKon-XL SO	250 µm	Ø105.0 ±0.2 mm [Ø95.0mm]	250 µm

Table 6 – Standard filter thickness for Andor open-front 'SO' platforms
* available through CSR – thinner windows carry increased risks of breakage, long-term stress

Other filter options[8] may be considered through Andor's CSR process. Please contact your local Andor representative for further information. See Appendix B for further information on filters and filter holders.

There are two options for coupling filters to Andor open-front ‘SO’ cameras:

1. A **vacuum chamber-compatible filter holder** than can be attached to the camera through a bayonet or a screw-in interface (depending on the camera interface, see table 4)
2. A filter mount that allows the camera to be decoupled from a vacuum chamber and be used as a **standalone** detector (or ‘SY’). Note that this configuration cannot be attached to another vacuum chamber

Vacuum chamber-compatible filter holder

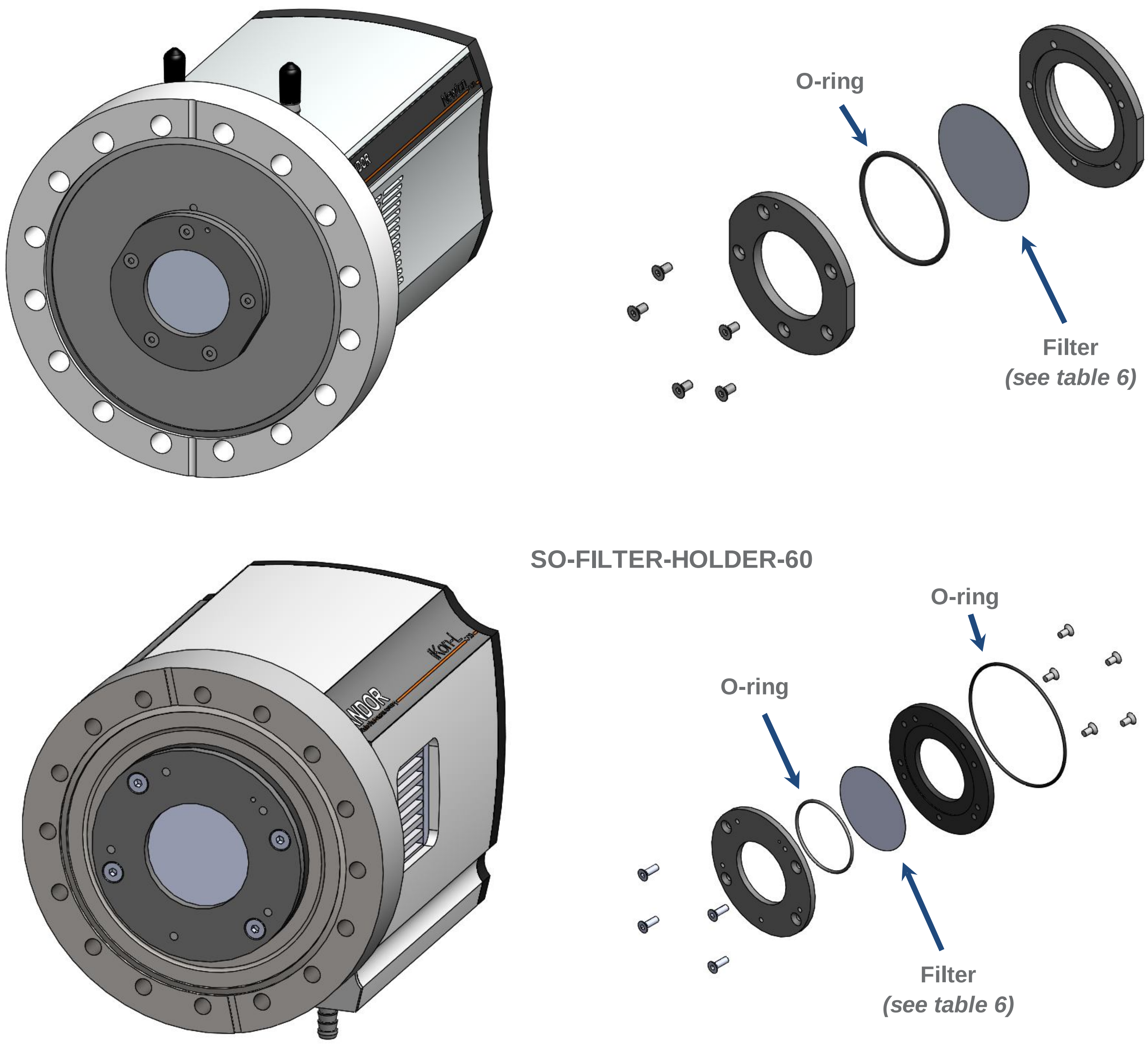


Figure 7 – Newton and iKon-M (top) and iKon-L (bottom) vacuum chamber-compatible filter holders

The filter holders SO-FILTER-HOLDER-xx have a built-in pumping channel to ensure pressure equilibrium on either side of the filter, hence minimizing the risk of mechanical stress and damage to the filter.

Standalone camera filter holder (SO-to-SY camera type converter)

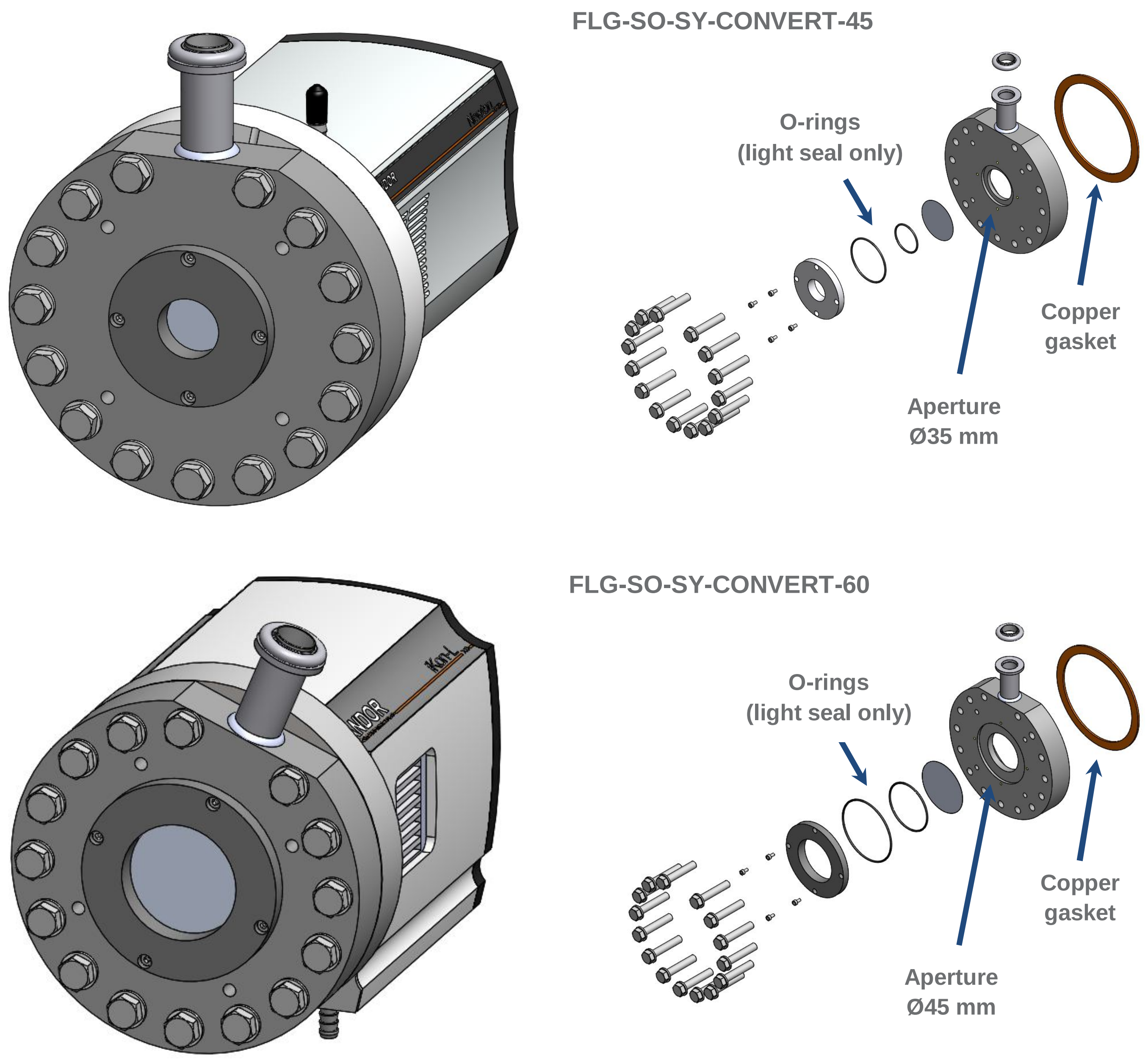


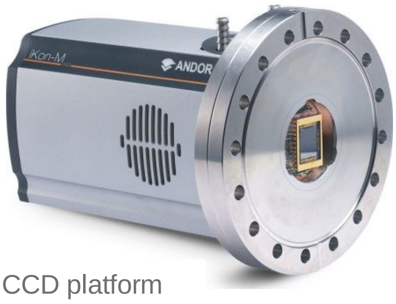
Figure 8 – SO-to-SY filter holder assembly for Newton & iKon-M (top) and iKon-L (bottom) open-front 'SO' platforms

FLG-SO-SY-CONVERT-45 mounts onto the Newton and iKon-M 'SO' camera series. FLG-SO-SY-CONVERT-60 mounts onto the iKon-L 'SO' camera series. The vacuum sealing interface is a knife-edge.

The vacuum between the filter and the sensor is achieved by connecting a pump to the interface highlighted on fig. 7, which is fitted with a KF16 interface. Note that since this interface relies on an O-ring vacuum seal, pressure down to 10^{-6} mbar can be achieved. Continuous pumping is recommended to maintain the highest degree of vacuum, and also ensure access to the lowest camera cooling temperature.

Appendix A – Andor 'open-front' 'SO' detectors for VUV / EUV / XUV imaging and spectroscopy

Newton CCD platform



iKon-M CCD platform

Sensor quantum efficiency (QE) considerations

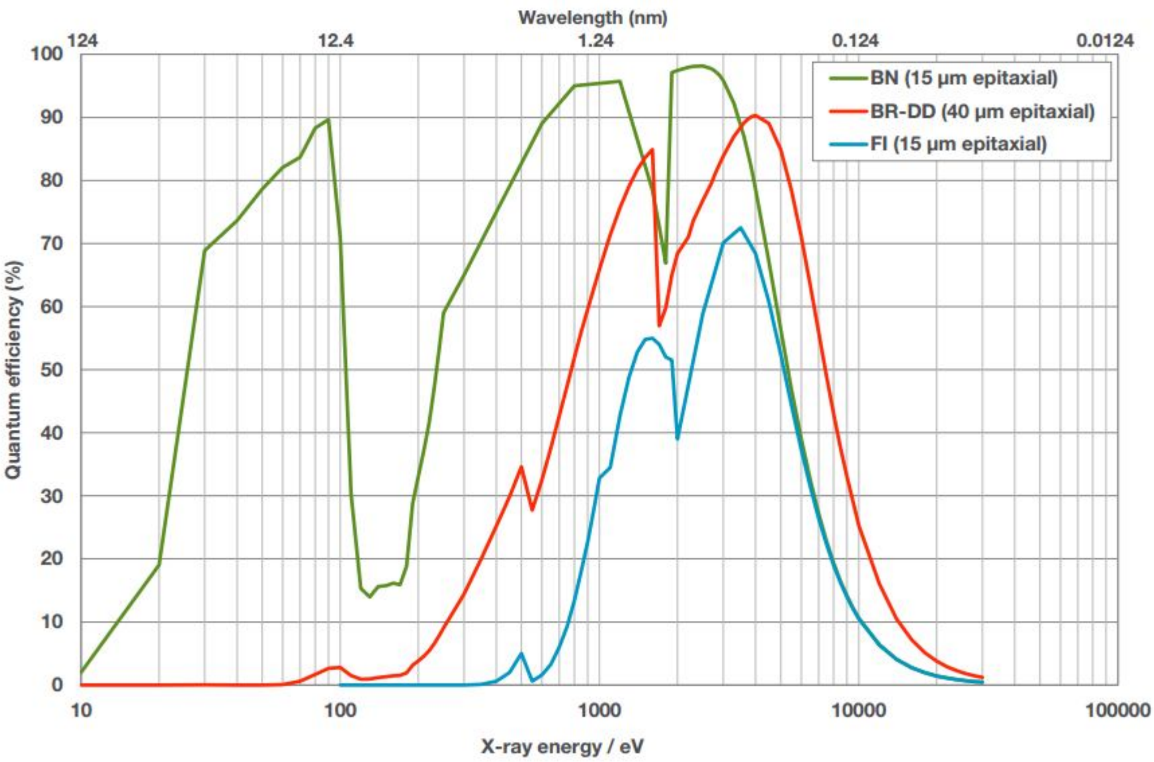


Figure 9 – Typical sensor quantum efficiency (QE) at room temperature for Andor standard offer

Sensor type key:

BN: Back-illuminated un-coated sensor
BR-DD: Back-illuminated AR coated deep-depletion sensor
FI: front-illuminated

Note that other sensors could be considered for integration into Andor 'open-front' 'SO' platforms – please contact your local Andor representative for further details.

BN-DD: Back-illuminated deep-depletion un-coated sensor – increased higher energy QE versus -BN type
FI-DD: Front-illuminated deep-depletion sensor – increased higher energy QE versus -FI type

Detectors for Spectroscopy

	Newton DO920P-*XX*	Newton DO920P-BN-995	Newton DO940P-*XX*	Newton DO940P-BN-995
Sensor format	1024 x 255 matrix 26 µm pixels e2v CCD 30-11		2048 x 512 matrix 13.5 µm pixels e2v CCD 42-10	
Sensor size	26.7 x 6.7 mm		27.6 x 6.9 mm	
Sensor options (-*XX*)	BN, BR-DD, FI	BN	BN, FI	BN
Minimum TE-cooling temperature	-100 °C	-100 °C	-100 °C	-100 °C
Maximum spectral rate	273 sps (>1,580 with crop mode)		122 sps (>940 with crop mode)	
Pixel well depth	500,000 e-		100,000 e-	
Register well depth	1,000,000 e-		150,000 e- (HS mode) 600,000 e- (HC mode)	
Readout noise	4 e- @ 50 kHz readout		3.5 e- @ 50 kHz readout	
PC interface	USB 2.0			
Flange interface	DN100CF / 6" CF / CF-152	O-ring seal, sensor 5.4 mm behind faceplate, 38 x 25 mm aperture	DN100CF / 6" CF / CF-152	O-ring seal, sensor 5.4 mm behind faceplate, 38 x 25 mm aperture

Detectors for Imaging

Detectors for imaging	iKon-M DO934P-*XX*	iKon-L DO936N-*0W-*XX*	iKon-XL 230 XLO-EAxx-C0	iKon-XL 231 XLO-EAxx-C0
Sensor format	1024 x 1024 matrix 13 µm pixels e2v CCD 47-10	2048 x 2048 matrix 13.5 µm pixels e2v CCD 42-40	e2v CCD 230-84 4096 (H) x 4112 (V) matrix 15 µm pixels	e2v CCD 231-84
Sensor size	13.3 x 13.3 mm	27.6 x 27.6 mm	61.4 x 61.7 mm	
Sensor options (-*XX*)	BN, BR-DD, FI	BN, BR-DD, FI	BN	BN, BR-DD
Minimum TE-cooling temperature	-100 °C	-100 °C	-75 °C	
Maximum image rate	4.4 fps	0.95 fps	>0.5 fps	>0.35 fps
Pixel well depth	100,000 e^-	100,000 e^- 150,000 e^- [BR-DD]	150,000 e^-	350,000 e^-
Output node capacity well depth	250,000 e^-	1,000,000 e^-	450,000 e^- [HS] 900,000 e^- [HC]	600,000 e^-
Readout noise	2.9 e^- @ 50 kHz 3.3 e^- @ 50 kHz [BR-DD]	2.9 e^- @ 50 kHz 4.3 e^- @ 50 kHz	4.5 e- @ 100 kHz	2.1 e- @ 100 kHz
PC interface	USB 2.0		USB3.0, fibre-optic	
Flange interface	DN100CF / 6" CF / CF-152	DN100CF / 6" CF / CF-152	DN160CF / 8" CF / CF-203	

Table 7 – Andor 'Open-front' cameras key specifications

Appendix B – 'Open-front' 'SO' cameras accessories

Camera platform	Filter holder part number	Standard Be filter dimensions (Ø x thickness)	Standard filter part number (order seperatly)	Min. recommended thickness *	Max. recommended thickness
Newton	Included with camera	Ø45.5 mm x 250 µm	ACC-OPT-02839	200 µm	500 µm
iKon-M	Included with camera	Ø45.5 mm x 250 µm	ACC-OPT-02839	200 µm	500 µm
iKon-L	SO-FILTER-MNT-IKONL	Ø60.0 mm x 250 µm	ACC-OPT-03838	250 µm	500 µm
iKon-XL	SO-FILTER-MNT-IKONXL	Ø105.0 mm x 250 µm	ACC-OPT-10395	250 µm	500 µm

Table 8 – Standard filter and holder references for Andor open-front 'SO' platforms
* available through CSR – thinner windows carry increased risks of breakage, long-term stress

Note: Copper gasket for CF Conflat™ flanges can be sourced from a number of vendors. This part can also be ordered from Andor under the reference **ACC-FLG-SO-GSKT-CU**.

Appendix C – Q&A

Q1: Does the vacuum chamber pressure impact the minimum cooling temperature achievable by an 'open-front' 'SO' camera?

A1: No impact on cooling temperatures for pressure below ~10^{-5} mbar

Q2: What information should be provided for custom Conflat™ flange design?[6]

Parameter	Value	Notes
Vacuum chamber standards compatibility?		e.g. DN200CF or 12" (if applicable)
Outer diameter?	*mm or inches*	
Inner diameter?	*mm or inches*	this can refer to the clear aperture around the sensor
Knife-edge diameter?	*mm or inches*	
Mounting holes pitch circle diameter (PCD)?	*mm or inches*	
Mounting hole format?		e.g. M8 or ⅜
Bolts mounting direction?		this is the direction from which the screws should inserted from, e.g. camera flange-to-vacuum chamber, or vacuum chamber-to-camera flange
Flange rotation?		e.g. Yes/No, step granularity (in degrees)
Flange to sensor plane distance (nominal)	*mm or inches*	from the front face of the camera to the sensor plane
Filter holder requirement		e.g. Yes / No, filter type / material / thickness

Q3: Can Andor 'SO' cameras accommodate existing vacuum chamber setups designed with 'straddled' flange configuration?

Platform	6" flange 'straddled' configuration	4.5" flange 'straddled' configuration
Newton 'SO'	✓ **YES** Newton 'SO' models can accommodate 11.25º step rotation as standard Flange to sensor plane distance = 0.13" [3.2mm] Compatible with standard Newton 'SO' bayonet filter holder configuration [included]	**! More information required** Please contact your local Andor representative do discuss your specific VUV/EUV/XUV spectrograph focal plane configuration
iKon-M 'SO'	✓ **YES** iKon-M 'SO' models can accommodate 11.25º step rotation as standard Flange to sensor plane distance = 0.13" [3.2mm] Include standard iKon-M 'SO' bayonet filter holder	✓ **YES** Variation **'-9NP'** (e.g. DO934P-BN-**9NP**) can accommodate straddled configuration Flange to sensor plane distance = 0.23" [5.9 mm] Include bayonet filter holder
iKon-L 'SO'	✓ **YES** Variation **'-9OW'** (e.g. DO936N-*0W-BN-**9OW**) can accommodate straddled configuration Flange to sensor plane distance = 0.24" [6.1 mm] Include standard iKon-L 'SO' screw-in filter holder	✗ **Not available**

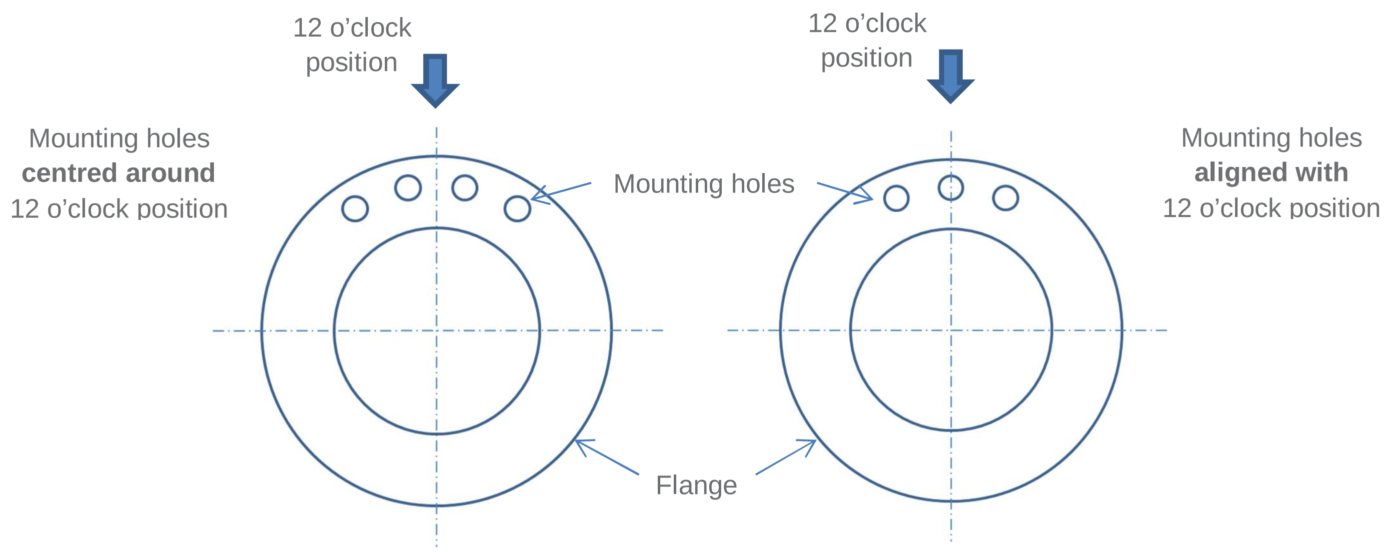


Figure 10 – Illustration of vacuum flanges with 'straddled' configuration (left) and Andor standard configuration (right)

Q4: What information should be provided for ISO flange design?[6]

Parameter	Value	Notes
Vacuum chamber standard compatibility (if any)?		e.g. ISO-F 100 or ISO-K 100
Tube outer diameter?	*mm or inches*	
Flange outer diameter?	*mm or inches*	
Flange thickness?	*mm or inches*	
Number of bolts (ISO-F)?		e.g. 8x Ø9 mm on Ø145 mm
Centring O-ring assembly characteristics?		e.g. ISO 100 format, or alternatively define the lip internal and external diameter (mm or inches) and the thickness (mm or inches)
Flange to sensor plane distance (nominal)?	*mm or inches*	from the front face of the camera to the sensor plane

Appendix D - Useful documents and links

[1] ISO 21348 Definitions of Solar Irradiance Spectral Categories, http://www.spacewx.com/pdf/SET_21348_2004.pdf

[2] Pressure conversion tool http://www.unit-conversion.info/pressure.html

[3] Japanese flange standard JIS: http://www.baleng.com.au/flanges-japanese-standard.php

[4] McPherson Vacuum Ultraviolet Soft X-ray & Extreme Ultraviolet spectrographs
http://www.mcphersoninc.com/spectrometers/xuhvvuvuv/xuhvvuvuv.html and
http://www.mcphersoninc.com/spectrometers/vuvuvvis/vuvuvvis.html

[5] H+P flat-field XUV / EUV / VUV spectrographss http://www.hoerlein-partner.com/

[6] Lesker website http://www.lesker.com/newweb/menu_flanges.cfm

[7] Andor software control for 3rd party spectrograph technical note available at MyAndor

[8] Beryllium and Aluminium filters transmission http://henke.lbl.gov/optical_constants/filter2.html

Other useful references

[9] Andor High Energy Detection product brochure
http://www.andor.com/pdfs/literature/Andor_High_Energy_Detection_Brochure.pdf

[10] Tips for CF vacuum flange coupling / installation
http://www.lesker.com/newweb/flanges/flanges_technicalnotes_conflat_1.cfm#CF_Installation