Quadrant ionization chamber with low scattering and models for normal and flash operation

Features

- Compact and cost-effective
- 3 cm diameter sensitive area
- Thin film foils for minimal scattering; < 100 µm WET
- Quadrant readout electrode pattern for beam centring or flatness measurement
- Dual electrode gaps for improved signal to noise
- Gold electrode coatings for improved reliability
- Models available for regular dosimetry and flash dosimetry
- Internal sensing of temperature, pressure and humidity with internal desiccant to ensure stable operation at high gap fields
- Atmospheric air or flow gas fill
- Bias voltage loopback verification

Applications	• Proton and electron beam measurement , including flash beam currents • Dose delivery control and monitoring • Beam trajectory monitoring
Options	• Electrode spacing 5 mm (ICQ-3) or 1 & 1.3 mm (ICQ-3SG)

Specifications

General	
Detector type	Parallel plate transmission ionization chamber with dual gap quadrant readout.
Beams	Ionizing radiation transported in air: protons > 5 MeV, heavy ions > 1 MeV/u, electrons > 1 MeV
Beam current range	Up to 100 nA cm-2 (particle current) recommended for ICQ-3, up to 10 µA cm-2 for ICQ-3SG
Sensor	
Sensitive area	3 cm diameter
Active gaps	ICQ-3: 2 x 5.0 mm ICQ-3SG: 1 & 1.3 mm
Readout electrode	Quadrant pattern

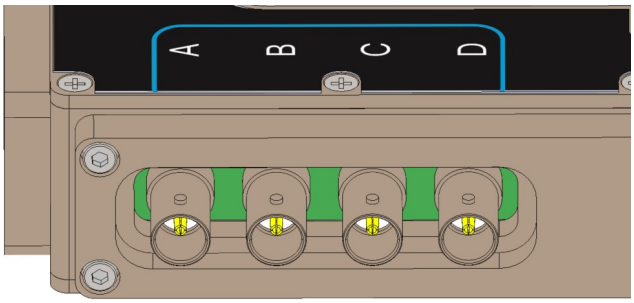
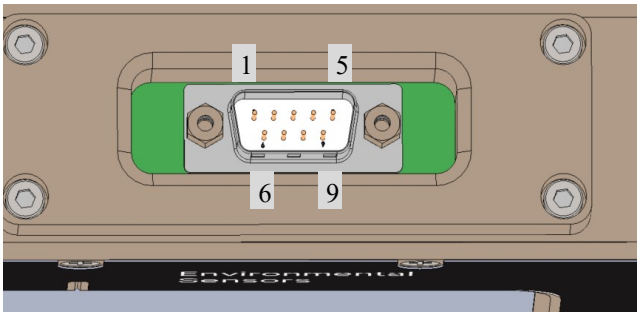
Specifications

Sensor (continued)	
Bias voltage	ICQ-3: Up to 1500 V ICQ-3SG: Up to 1000 V
Electric field in gaps	ICQ-3: Up to 3 kV cm^{-1} ICQ-3SG: Up to 10 kV cm^{-1} / 7.7 kV cm^{-1} (gap 1 / gap 2)
Typical ion transit time	ICQ-3: 140 µsec at 1000 V, air fill gas at STP ICQ-3SG: 7 µsec and 12 µsec at 800 V, air fill gas at STP
Typical gain	ICQ-3: 87 for 150 MeV protons, air fill gas at STP ICQ-3SG: 20 for 150 MeV protons, air fill gas at STP
Gain uniformity	ICQ-3: Better than +/-2% for beams within the sensitive area. ICQ-3SG: Better than +/-5% for beams within the sensitive area

Chamber gas	
Operating gas	Dry atmospheric air or flow gas such as nitrogen, argon/CO_2
Desiccant	One sorb sachet, user replaceable in situ.
Flow gas connections	To suit 1/8” tube push fit. Sealing plugs provided for atmospheric air operation.

Mechanical	
Overall size	230 mm by 215 mm by 38 mm approx (see figures)
Insertion length	37.3 mm
Orientation	Normal to beam, beam may enter via either face.
Fiducials	Electrode pattern tolerance build-up relative to fiducial features on body +/- 0.3 mm nominal, < +/- 0.1 mm typical .
Weight	1.3 kg (2.8 lb) excluding any added mounting brackets .
Operating environment	Clean and dust-free, 0 to 35 C (15 to 25 C recommended , < 70% humidity, non-condensing, minimum vibration (< 0.1g all axes 1 to 50 Hz). Temperature and pressure compensation of chamber gain must be performed for full accuracy.
Shipping and storage environment	-10 to 50 C, < 80% humidity, non-condensing, vibration < 1g all axes, 1 to 20 Hz

Connectors

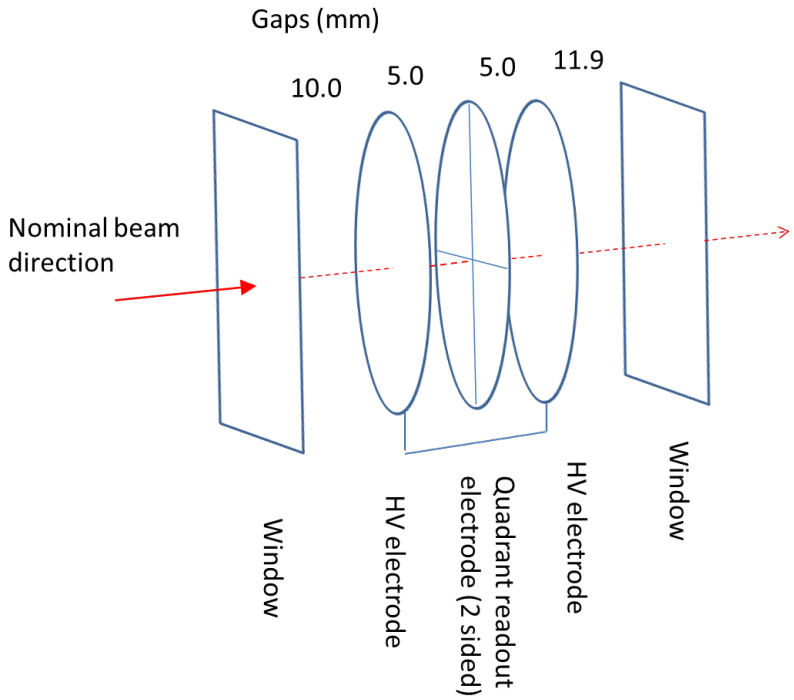
Quadrant readout	Four BNC receptacle 
HV in / out	Two SHV (connection order is not critical) 
Environmental sensors	One DSub 9 pin male 

1	Chassis	6	Analog out +
2	Analog out -	7	Select bit 0
3	Select bit 1	8	Device ID 2
4	Device ID 1	9	+ 5VDC in
5	DGnd		

Beampath materials	ICQ-3

Layers in beam path

1	7.5 µm	Polyimide foil aluminized both sides 0.1 µm (window)
2	10.0 mm	Fill gas (non-active gap)
3	7.5 µm	Polyimide foil gold coated both sides 0.02 µm (HV electrode)
4	5.0 mm	Fill gas (active gap)
5	12.5 µm	Polyimide foil gold coated both sides 0.04 µm (quadrant electrode)
6	5.0 mm	Fill gas (active gap
7	7.5 µm	Polyimide foil gold coated both sides 0.02 µm (HV electrode)
8	11.9 mm	Fill gas (non-active gap)
9	7.5 µm	Polyimide foil aluminized both sides 0.1 µm (window)



Sequence shown is for nominal beam direction, entering on decal face. Beam can enter instead on the other face without affecting performance. Connections between the faces of the readout electrode allow two gaps to provide signal for each quadrant.

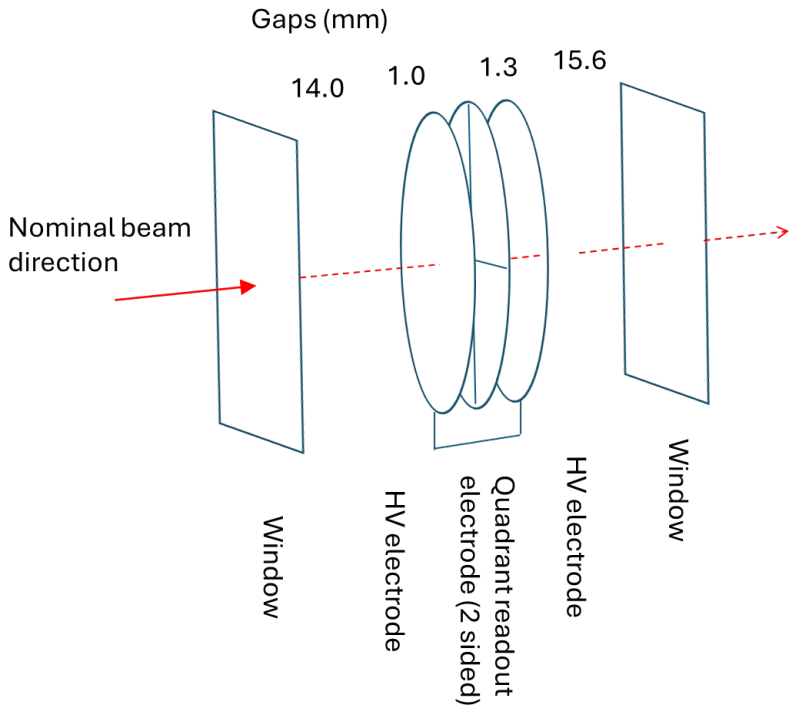
Total effective thickness 98 µm water equivalent including air fill gas.

CAUTION	Do not expose the device to ionizing radiation beams unless all connections to readout electronics and bias supplies are made, or otherwise grounded. Charge build-up and subsequent arcing damage can occur if this instruction is ignored.

Beampath materials	ICQ-3SG

Layers in beam path

1	7.5 µm	Polyimide foil aluminized both sides 0.1 µm (window)
2	14.0 mm	Fill gas (non-active gap)
3	7.5 µm	Polyimide foil gold coated both sides 0.02 µm (HV electrode)
4	1.0 mm	Fill gas (active gap)
5	12.5 µm	Polyimide foil gold coated both sides 0.04 µm (quadrant electrode)
6	1.3 mm	Fill gas (active gap
7	7.5 µm	Polyimide foil gold coated both sides 0.02 µm (HV electrode)
8	15.6 mm	Fill gas (non-active gap)
9	7.5 µm	Polyimide foil aluminized both sides 0.1 µm (window)



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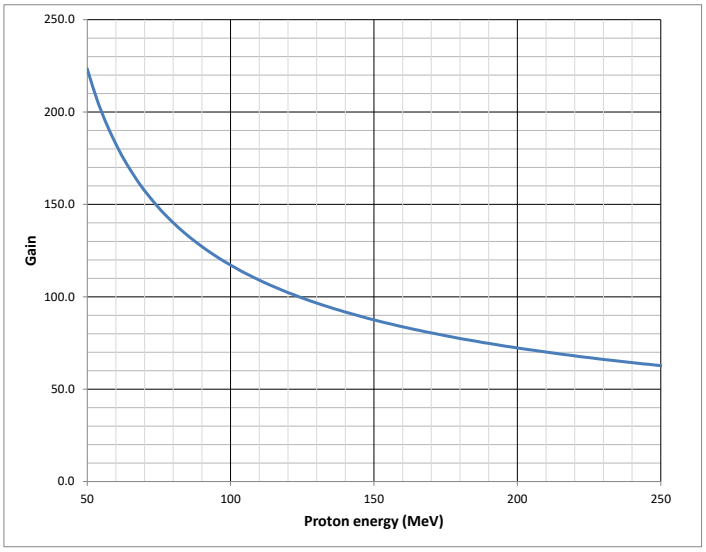
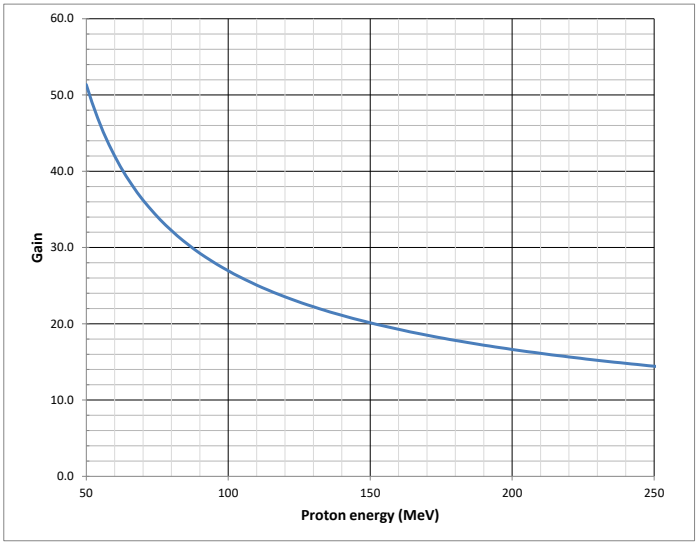
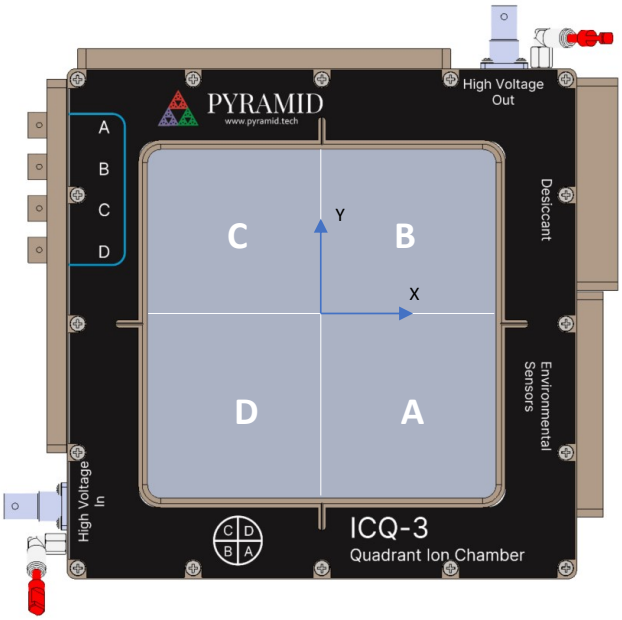
Detector gain

Nominal gain curves ICQ3	Protons, air gas filling at STP calculated by Geant4 
Nominal gain curves ICQ3-SG	Protons, air gas filling at STP calculated by Geant4 
Gain correction	The nominal gains shown at standard ambient temperature and pressure ($Temperature_{SATP}$ = 298.15 K, $Pressure_{SATP}$ = 100000 Pa), must be corrected for measured temperature and pressure. In general if the gain is known at reference temperature and pressure, then the corrected gain at particular measured temperature and pressur is given by $Gain_{CORR}$ = $Gain_{REF}$ / [($Pressure_{REF}$ / $Pressure_{MEAS}$) * ($Temperature_{MEAS}$ / $Temperature_{REF}$)] where temperatures are in Kelvin and pressures in Pascal. For accurate dosimetry, the gain must be established against traceable reference devices and corrected for temperature and pressure.

Position response or beam flatness



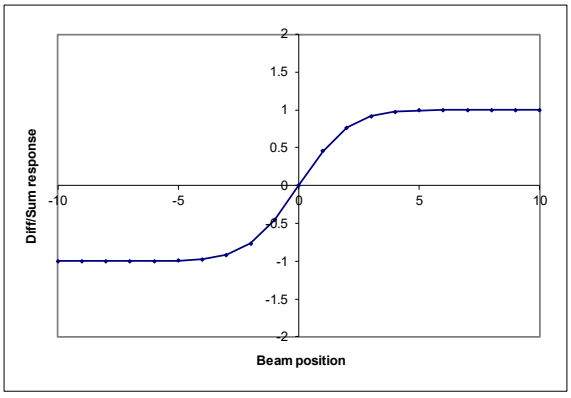
The decal is applied to the nominal beam entrance face. The ICQ-3 has no actual preferred beam entrance side (the beam can enter in either direction) so the direction is arbitrary to suit a particular installation. Designation of the sensing axis as X / Y, or horizontal / vertical is also arbitrary, as it depends upon the orientation of the IC with respect to the beamline, and of the beamline relative to any other reference coordinate system.

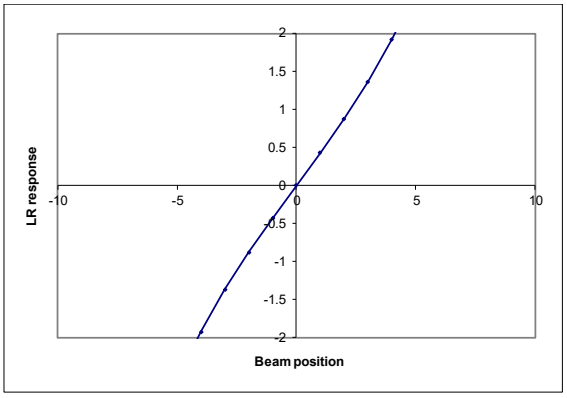
Four channel electronics often include built-in real-time position functions such as difference over sum. The functions below give the axis directions shown above.

X = ((A+B)-(C+D))/(A+B+C+D) Y = ((B+C)-(A+D))/(A+B+C+D)

The plot on the left below shows the position function curve for a 2 mm sigma beam crossing the sensor. The log ratio position function shown in the right hand plot below may be preferred for some applications:

X = log((A+B)/(C+D)) Y = log((B+C)/(A+D))

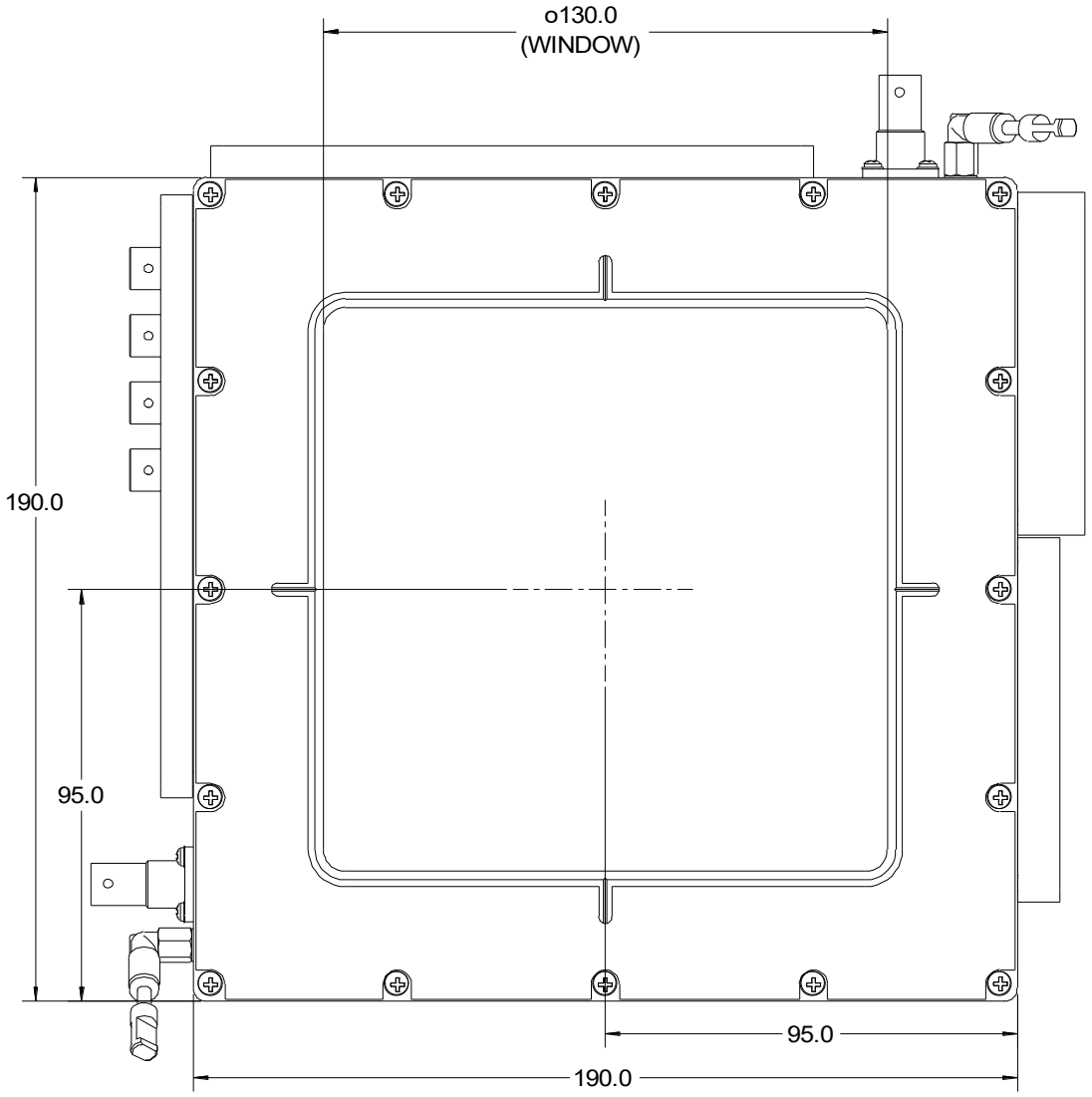




Similar position functions can also be used for broad beams such as passively scattered proton therapy beams, in which case they indicate beam flatness rather than centroid location.

Drawings

Nominal entrance face

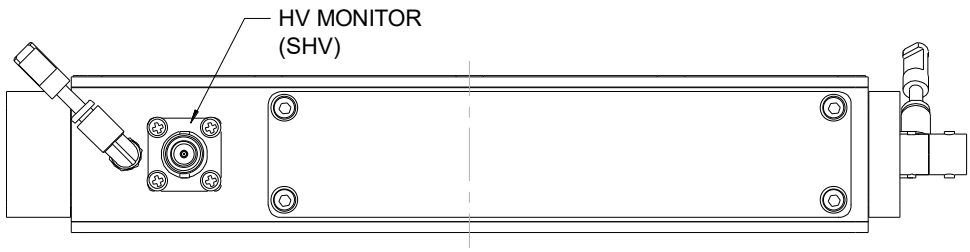


ICQ-3 and ICQ3-SG external features are identical

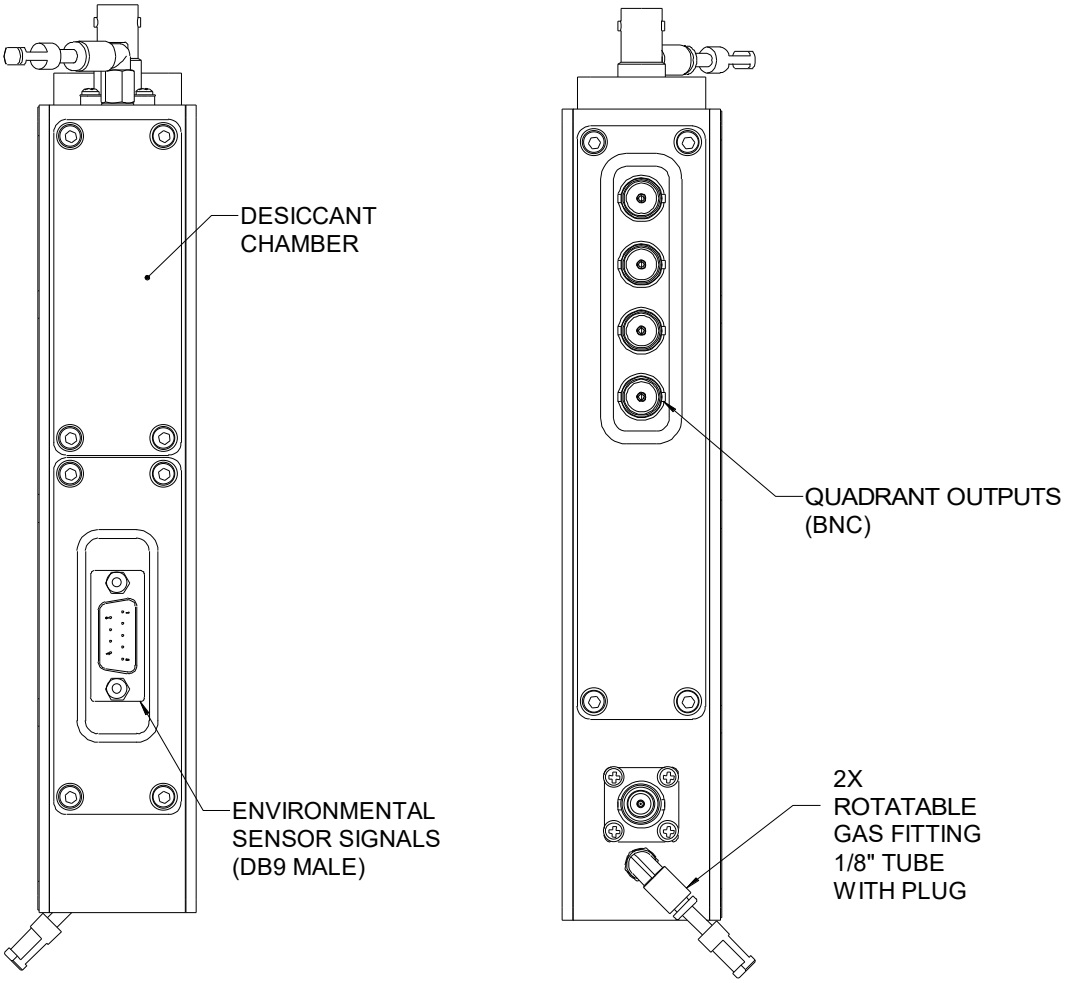
Dims: mm

Drawings

Top surface

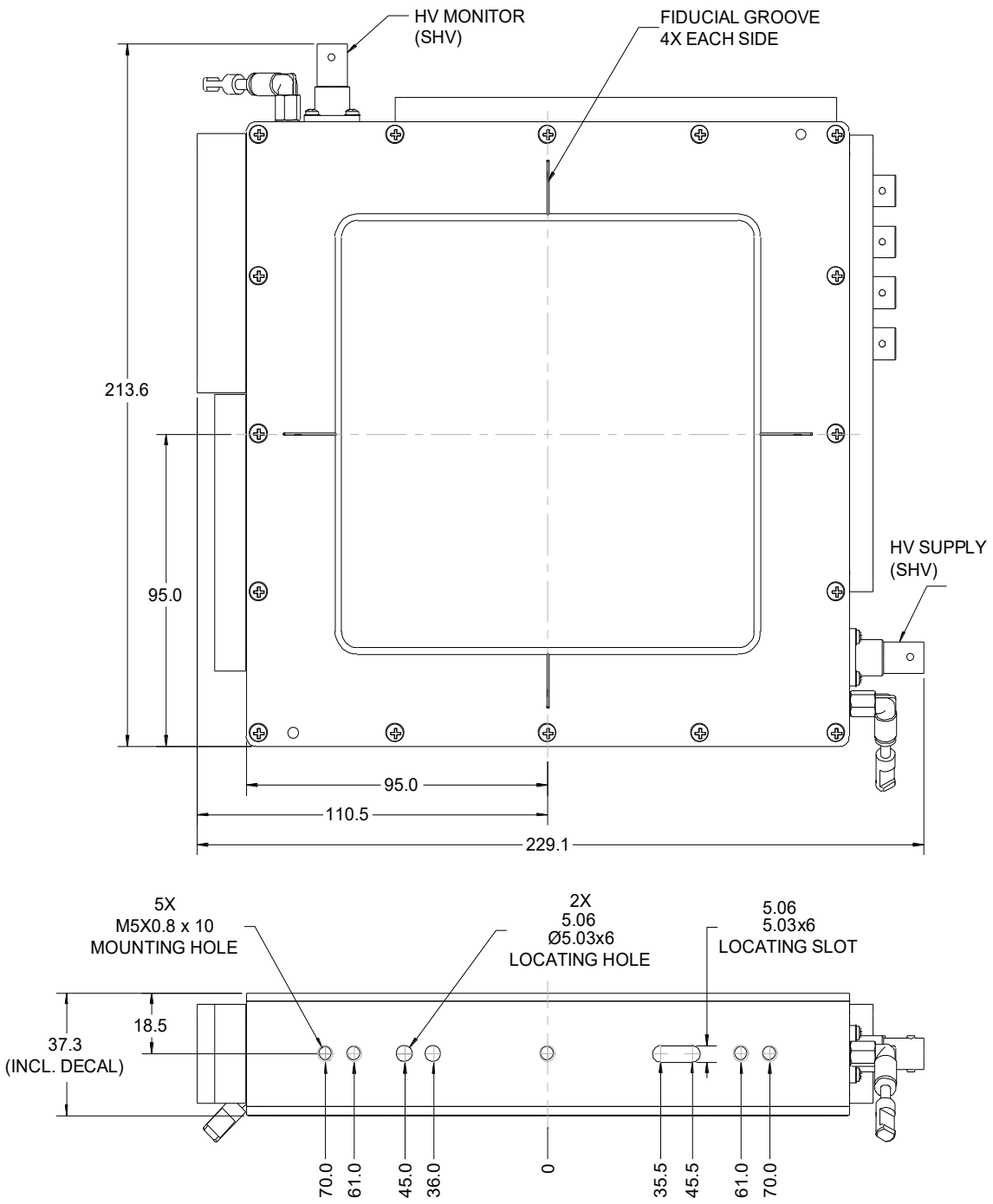


Side elevations



Drawings

Nominal exit face and underside mounting surface



Dims: mm

Ordering information

Sales code	Description
ICQ-3	Quadrant ionization chamber with 5 mm electrode gaps
ICQ-3SG	Quadrant ionization chamber with 1 and 1.3 mm electrode gaps

Sales code - related items	Description
FX4-XP20	Four channel current electrometer with +2 kV bias supply
CAB-BNC-xx-BNC	Cable coaxial, BNC terminated, xx feet long for signals.
CAB-SHV-xx-SHV	Cable coaxial, SHV terminated, xx feet long for bias voltage.
CAB-D9F-xx-D9M	Cable, 9-way screened, 9-pin DSub female to male, xx feet long for environmental sensors.

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