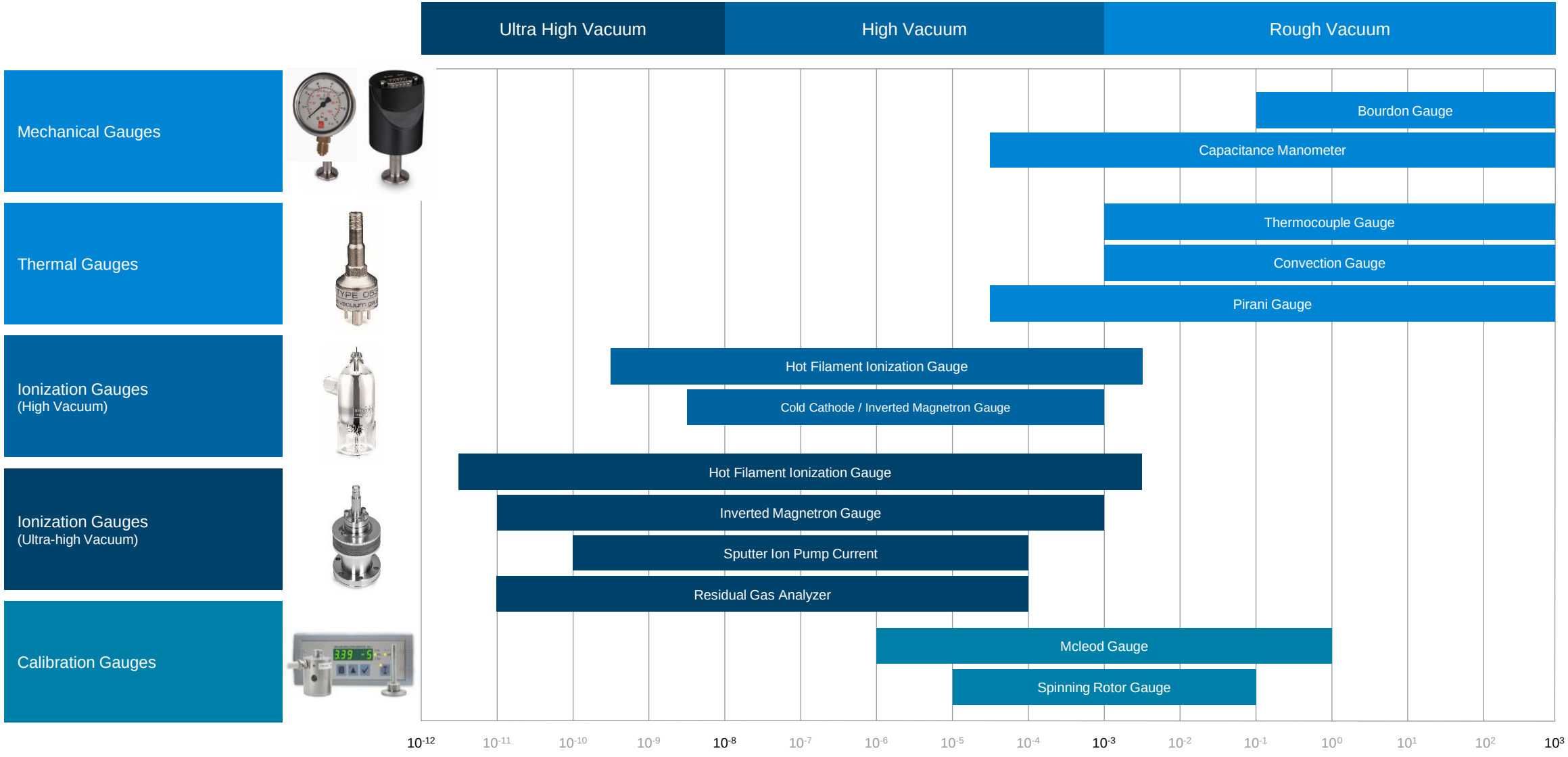
Vacuum Control & Measurement

- Hardware

- Valves

- Gauges and controller

Measuring Vacuum Technologies



Agilent Vacuum Gauges

Active Gauges

- Active vacuum gauges include both the control unit electronics and the actual sensor.
- These gauges typically require 24 V DC and then provide a 0 - 10 V output related to pressure.
- Linearized output signal, either analogue or digital, means that there are no transmission errors on the cable. The gauge cables are standardized and there is no influence of the line on the measured pressure value.
- Wide range gauges

Passive Gauges

- passive gauges only the sensor is included, while the electronics are excluded.
- Passive gauges offer direct measurement of the sensor signal and the cable has an influence on the measuring signal. They require particular cables according to indicator type.
- The controller is also the measuring device, so that the power supply only comes from the controller. In a similar fashion, the display is located uniquely on the controller.

Use an Active Gauge when:

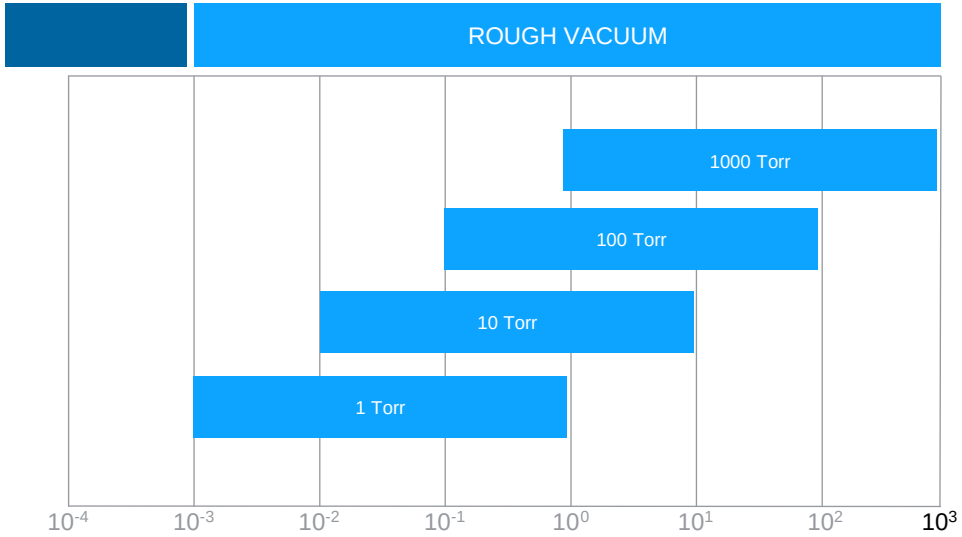
- Wide range gauges is needed
- Customer does not want a controller (power supply still required)
- To save money on cabling
- Low baking temperature range

Use a Passive Gauge when:

- Many gauges are required (system cost can be less with passive gauges)
- Radiation is present
- When baking or UHV measurement is needed

CAPACITANCE MANOMETER

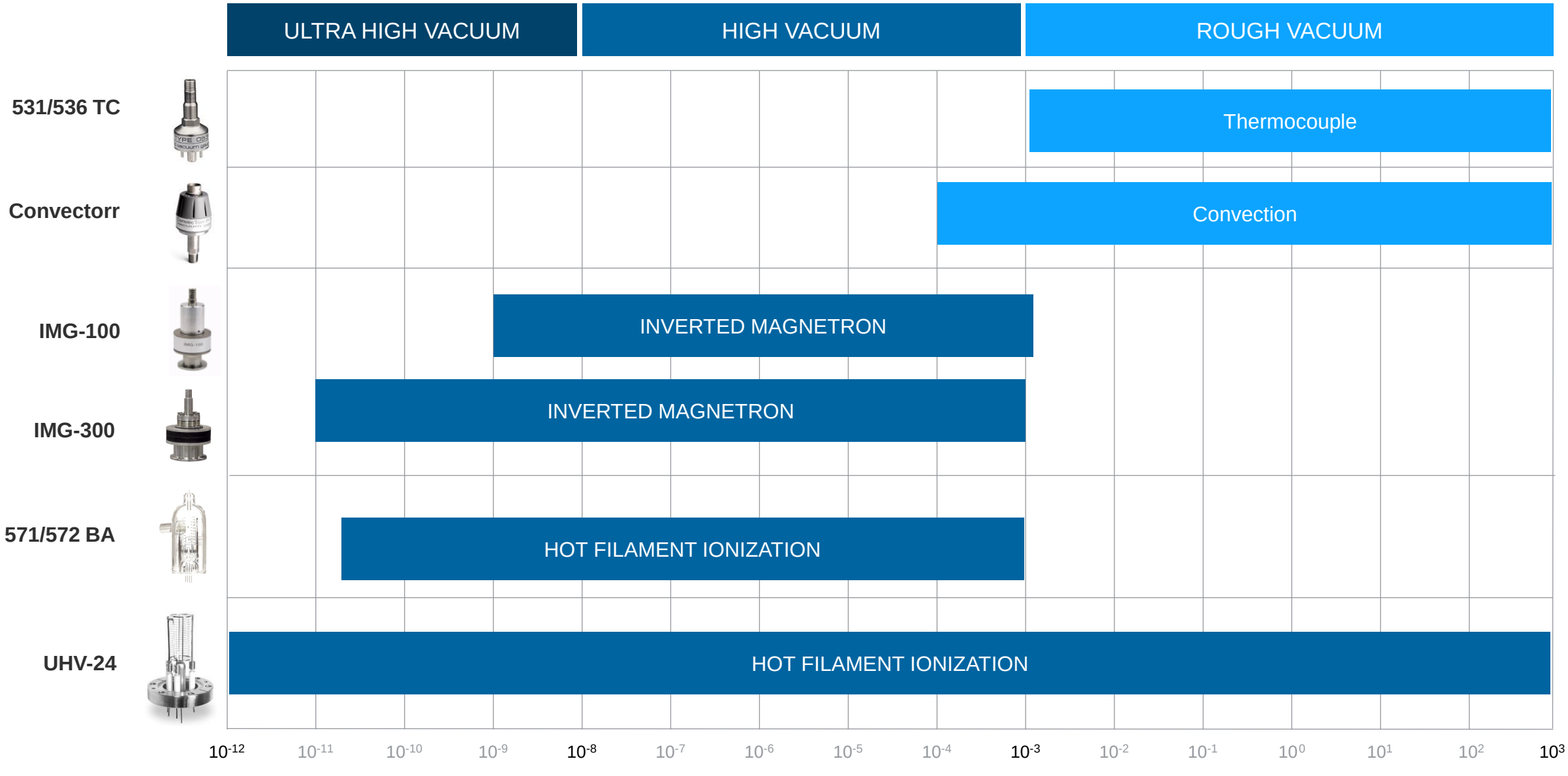
- Diaphragm forms one plate of a capacitor (deflection changes spacing which alters the capacitance)
- MOST ACCURATE and FASTEST RESPONSE gas independent gauge;
- Limited dynamic range (≈ 3.5 decades) per gauge



		ADVANTAGES	DISADVANTAGES
	CAPACITANCE MANOMETER	• Very accurate from Atmosphere to a few Torr	• Relatively expensive

APPLICATION	• Thin Film vacuum process • Semiconductor production process

Agilent Passive Gauges



Rough Gauge Controllers

XGS-600 Vacuum Gauge Controller

Operation of up to 12 gauges and display readings for up to 8 gauges at a time from ATM to UHV/XHV

AGC-100/AGD-100 Controller

User selectable units (mbar, Torr, Pascal), setpoint control, and interface options

HGC-536 Portable Gauge Controller

Accurate pressure readings and graphing in the field, Bluetooth-smartphone capabilities

☐ Compare

RGC-100 Rough Vacuum Gauge Controller

Precalibrated gauge controller for pressure measurements in the 1 x 10 -3 to 760 Torr...

☐ Compare

RGC-100T Radiation Resistant Rough Vacuum Gauge Controller

Radiation resistant pre-calibrated TC vacuum gauge controller

☐ Compare

RGC-150 Rough Vacuum Gauge Controller

Pre-calibrated gauge controller for pressure measurements in the 1 x 10 -3 to 760 Torr...

AGC-100/AGD-100 (For active gauge)

AGC-100 (Controller)

- Single channel controller
- FRG-700/702, FRG-720/730, PVG-5xx, PCG75x, and CDG-500
- Analog output, USB and ethernet port
- 2 setpoints
- mbar, Torr, Pascal
- USB Datalogger

AGD-100 (Display)

- Single channel display
- FRG-700/702, PVG-5xx, and PCG-75x
- Analog output
- mbar, Torr, Pascal

RGC100/100T

- 536 Thermocouple Gauge Tube
  - *Pipe thread/VCR/KF/CFF flange*
- Atm – 1mTorr
- Torr or mbar with difference part number.
- set point (optional)
- RS-232 communication interface (Optional)
- RGC-100T
  - *radiation-resistant using radiation-hardened components*
  - *Target applications include high energy physics, linear accelerators, and other high-radiation environments in the rough.*

RGC150

- 536 Thermocouple Gauge Tube
  - *Pipe thread/VCR/KF/CFF flange*
- Atm – 1mTorr
- 2 set points
- Analog output
- RS-232 communication interface

The XGS-600 – Design Features

Advantages
One controller for all - Support Active and Passive gauges - Support measurement range from Atmosphere to UHV
Flexibility of design - most customizable controller on the market
Operate up to maximum 12 gauges (depend on card configuration)
Fully programmable RS-232/485 serial communications
Analog output
8x setpoint with fast signal response < 20msec

H card

M card

C card

A card

UHV/HV Vacuum Gauges

Bayard-Alpert Hot-Cathode Ionization Gauge (hot filament)

- UHV24 - Measures down to 5 x 10^{-11} Torr
  - Most popular UHV gauge
- UHV24P - Measures down to 2 x 10^{-12} Torr
  - UHV gauge providing the highest vacuum reading
- 571//563 Glass BA
  - Thoria-coated Iridium Filament
  - 1 x 10^{-3} to 2x 10^{-10} Torr
  - High X-ray limit
  - bakeable up to 450°C
- 572Glass BA
  - Dual tungsten filament
  - 1 x 10^{-3} to 2x 10^{-10} Torr
  - High X-ray limit
  - bakeable up to 450°C

Inverted Magnetron (cold cathode)

- IMG-100
  - 1 x 10^{-3} to 5 x 10^{-9} Torr
  - 150 °C maximum lower case: cable disconnected
- IMG-300
  - Most durable and fastest responding UHV gauge
  - 1 x 10^{-3} to 1 x 10^{-11} Torr
  - Radiation-resistant and bakeable to 250°C during operation
  - Long cable lengths available

Bayard-Alpert Hot-Cathode Ionization Gauge (hot filament)

UHV-24 / 571 / 572

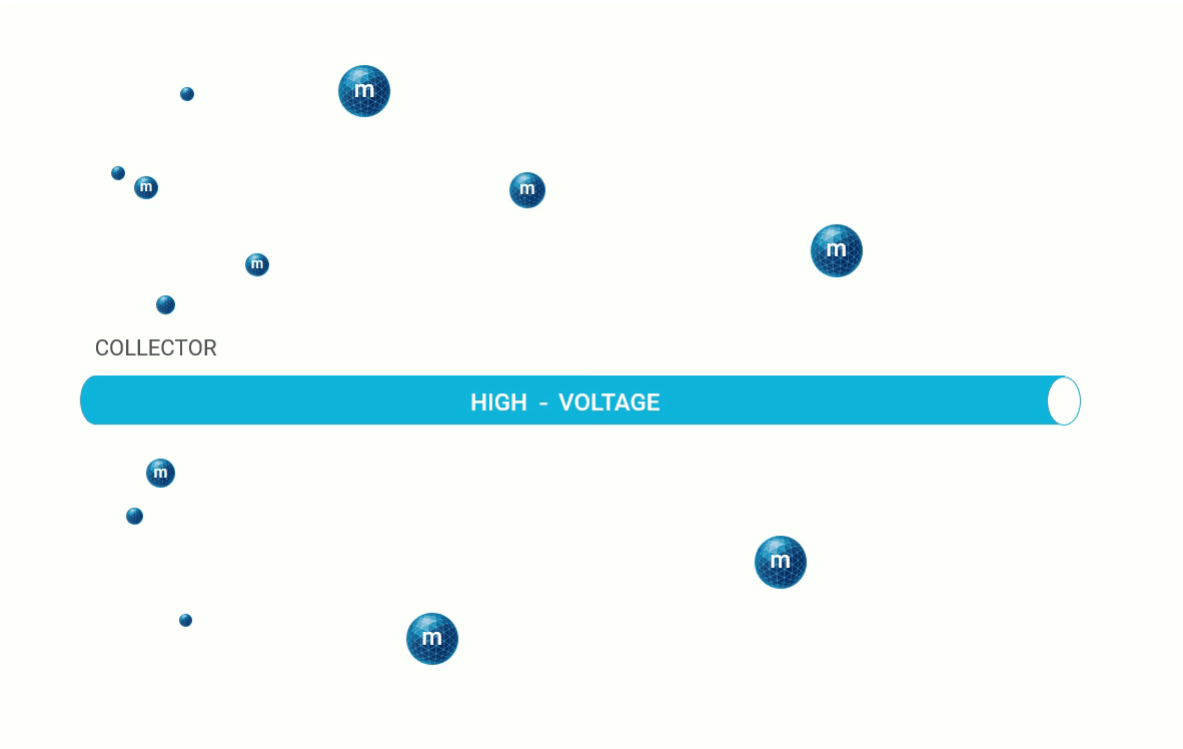
- Accuracy ±20%
- Bakeout Temperature 450 °C with cable connected
- Operating temperature 0 °C to 250 °C
- Tungsten and yttria-iridium filament

	Tungsten	Thoria/Yttria-coated Iridium
Accidental exposure to atmosphere	No tolerance	High tolerance
High Oxygen partial pressure	Easily oxidized	Resists oxidation
Chemical reaction with operating gas	Higher filament temperature, higher reaction rate	Lower filament temperature, lower reaction rate
Outgassing	More power required for given emission – tendency to outgas	Lower power consumption, less outgassing
Particulate generation	Low particulate generation	Generates particulates as the thorium coating flakes off over time
Others		Shorter life when expose to hydrogen and gallogen gases

Ionization Principle

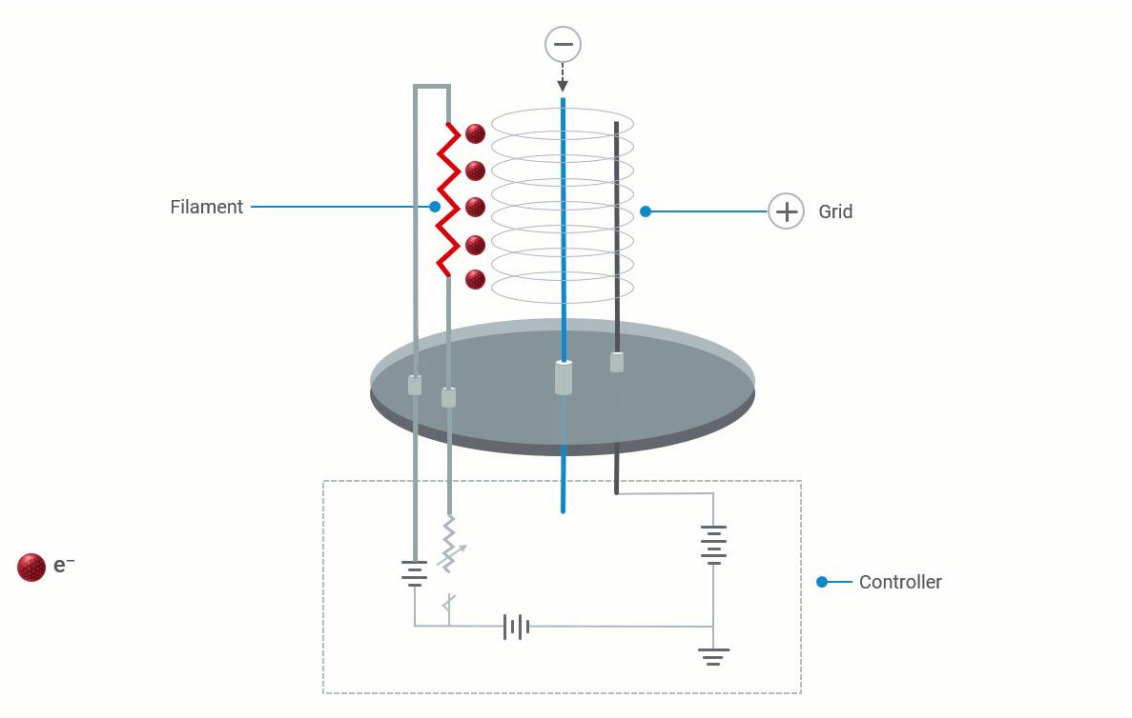
Ions created by bombarding background gas molecules with free electrons are attracted to a collector.

Measuring the resulting current provides a measurement of the gas density or pressure.



Hot Filament Ionization Gauge (BA)

M^+ Ions are attracted to the negatively charged collector resulting in a measurable current.



Hot Filament Ionization Gauge (BA)

Heated Filament

- Emits high energy photo-electrons

Grid

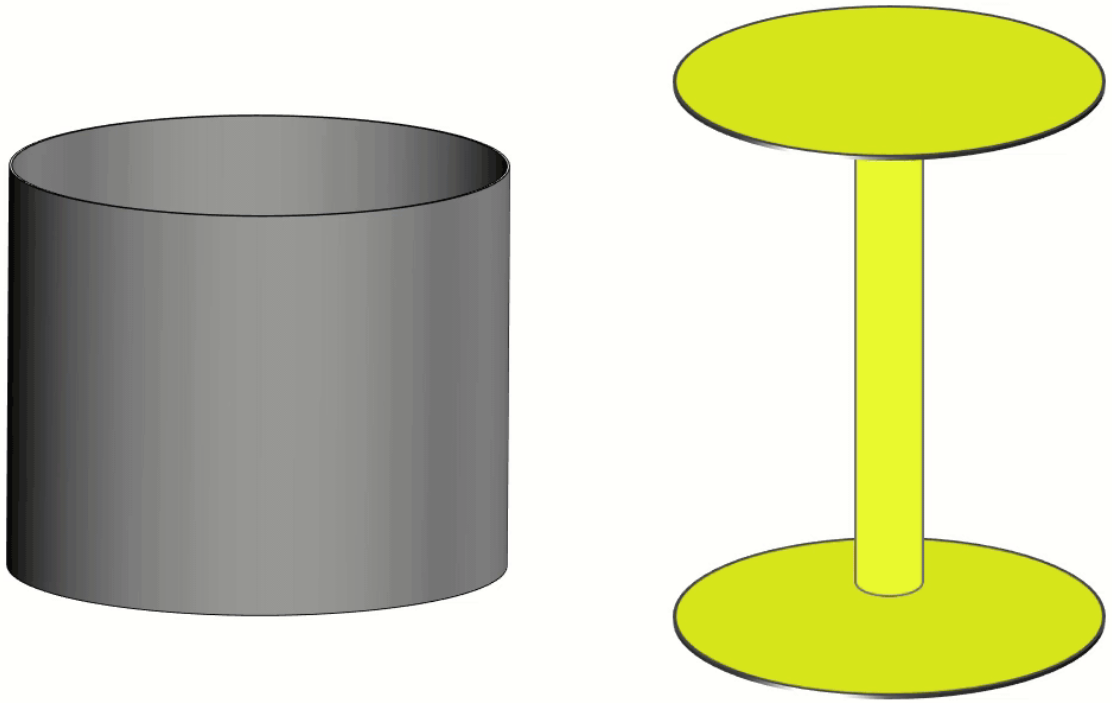
- Accelerates electrons promoting collisions with (neutral) gas molecules creating M+ ions

Collector

- Attracts M+ ions with high negative potential: Resulting current is proportional to gas density or pressure

Cold Cathode Ionization Gauge

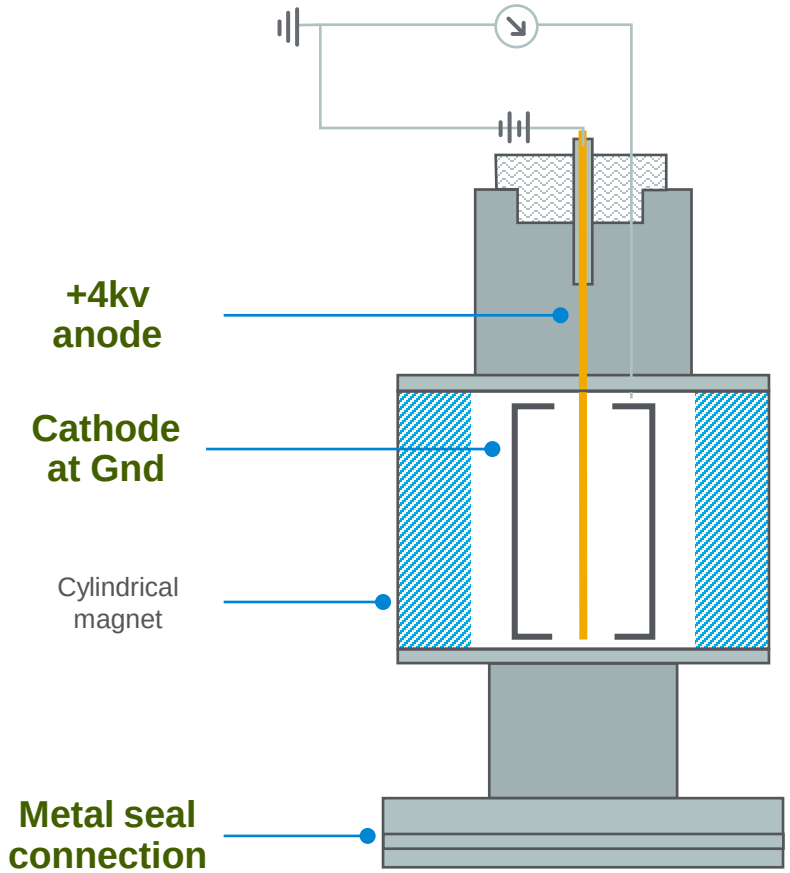
Electric and Magnetic Fields create PLASMA within a partially closed cylinder.



Inverted Magnetron Gauge (for UHV)

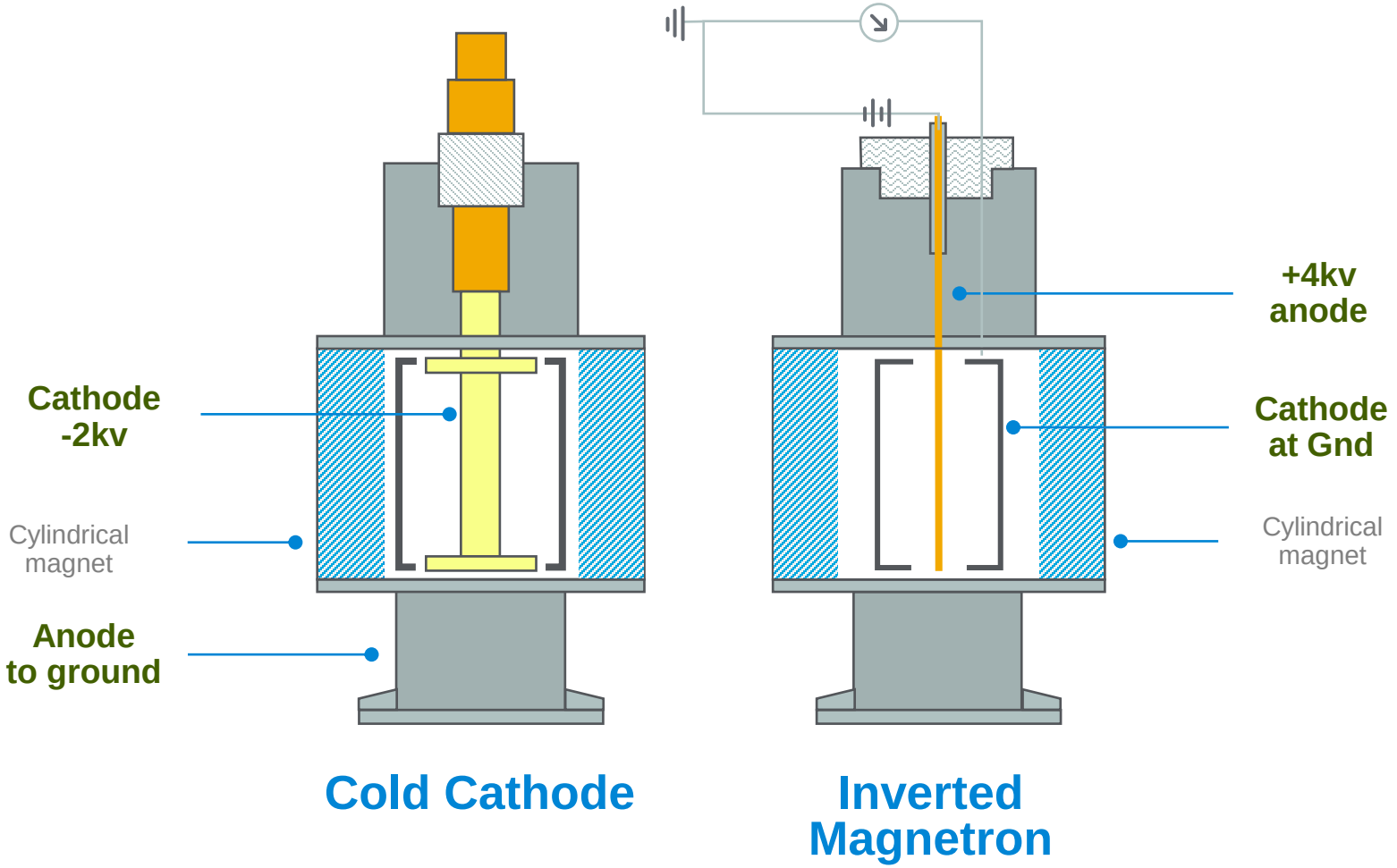
Higher ‘strike’ voltage improves ability to ignite and sustain plasma (esp. at UHV pressure).

All metal seal better suited to UHV applications.



Cold Cathode / Inverted Magnetron Gauge

Inverted Magnetron design uses HIGHER voltage (to initiate and sustain plasma) and INVERTS the voltages (ions created at High Voltage and attracted to Grounded cathode).



Cold Cathode / Inverted Magnetron Gauge

Electric and Magnetic Fields

- Create plasma within a hollow stainless steel (typ.) cylinder
- Accelerate electrons to collide with (neutral) gas molecules creating M+ ions

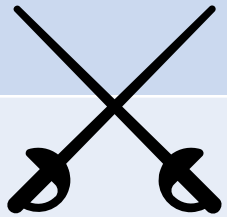
Collector

- Attracts M+ ions with high negative potential
- Resulting current is proportional to gas density i.e. **pressure**

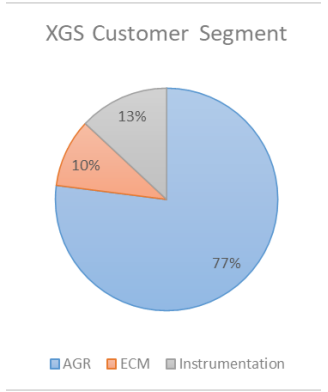
Inverted Magnetron Gauge (for UHV)

	IMG-100	IMG-300
Measurement range	1 x 10-3 Torr to 5 x 10-9 Torr	1 x 10-3 Torr to 1 x 10-11 Torr
Bake out temperature	150 °C maximum with Cable Disconnected	250 °C maximum with cable and magnet attached
Materials exposed to vacuum	300 series stainless steel, nickel, glass (feedthrough)	Stainless steel, nickel, glass, nickel alloy 52
Sensitivity	2.7 A / Torr + 20% at 5 x 10-6 Torr	2 A / Torr + 20% at 5 x 10-6 Torr

Selecting High Vacuum Passive Gauges

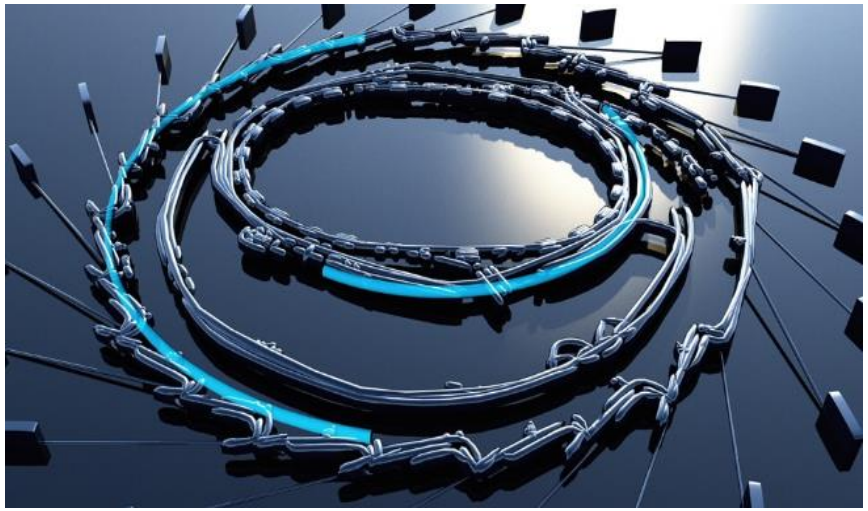
	Selection guide
Hot Filament Ion Gauge	• Measurement precision is the most important • Stability is needed • Lowest cost needed when gauge must be replaced frequently • Magnetic field is not allowed • Gauge must be able to start in HiVac and UHV
 Inverted Magnetron Gauge	• Fast response is required • Gauge must tolerate shock and vibration • Gauge is exposed to dirty processes • Application can not tolerate heat or light

Applications where the XGS-600 controller excels



Physics research & development
(Accelerators, Synchrotrons, and Other Large Facilities)

- *Fast - <20ms response time*
- *Compact - half-rack size support up to 5x IMG gauges*
  - *Intuitive menu, clear view, simply & quick setup*
- *Support long cable*
- *Fully programmable serial communications*
- *Support both passive and active gauges*



Laboratory

(Nanotechnology research)

- *Easy to use – Intuitive user interface for quick setup and operate*
- *Flexibility: post-sale reconfigures*
- *Display up to 12 gauges*
- *Enlarge screen enable view from distance.*
- *Support both active and passive gauges*

Industrial processes/ OEM Equipment

(semiconductor manufacturing, Molecular Beam Epitaxy)

- *Performance – programmable*
- *CE and CSA certify and RoHS Compliance*
- *Worldwide universal power input*
- *Reliable (very low annual failure rate)*
- *Up to 8 set points and contact relay*