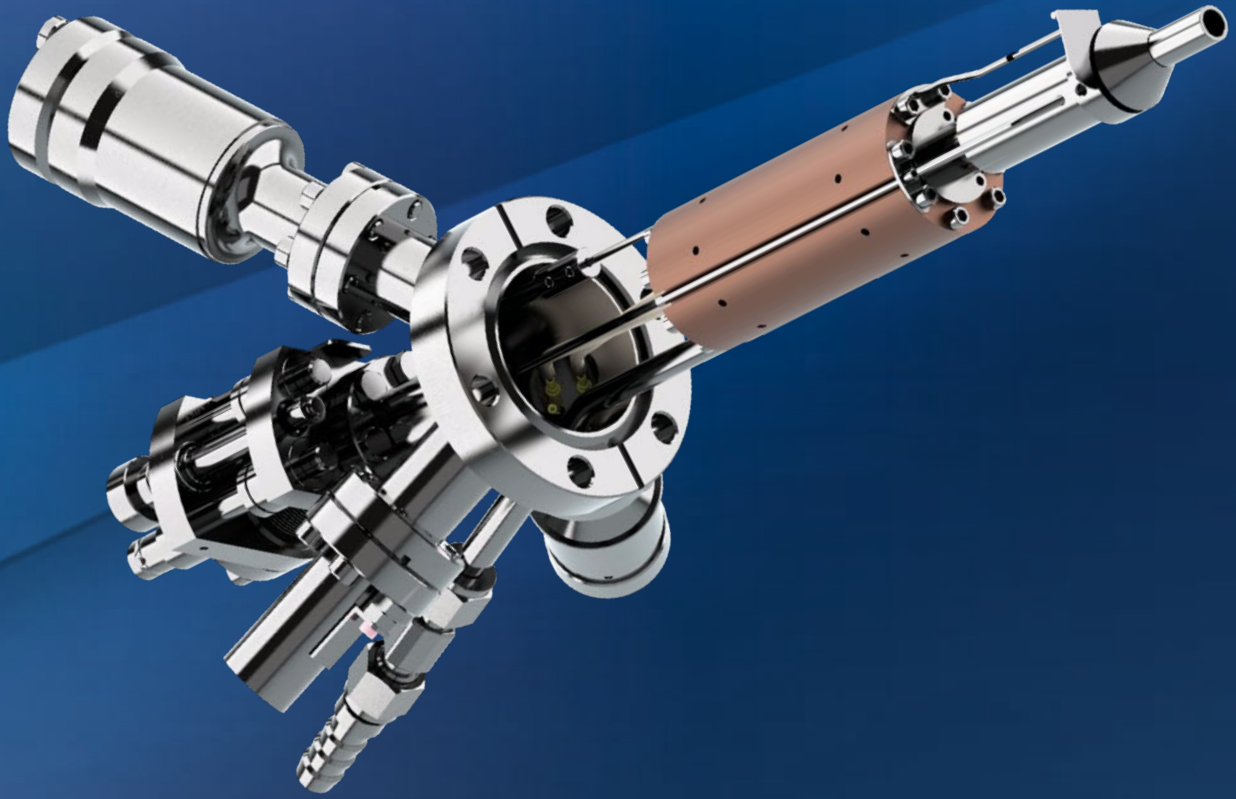
EFM Series

FOR ULTRA-PURE SUBMONOLAYER AND
MULTILAYER THIN FILM GROWTH

KEY FEATURES

- Ultra pure evaporation
- Reliable and proven design
- Rod or crucible operation
- Rear loading with line of sight for alignment
- Flexible configuration
- Temperature 100 °C – 3300 °C



Focus™

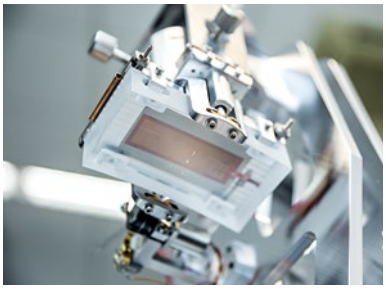
A member of SPECSGROUP

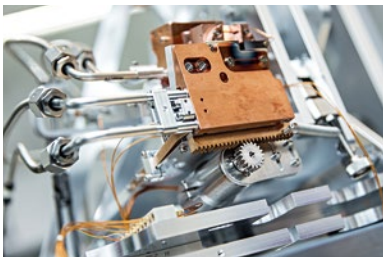
SPECS™

Innovation in Surface Spectroscopy
and Microscopy Systems

Innovative components and systems for groundbreaking new surface analysis tools – that's SPECS.

Our headquarter is situated in the center of Germany's capital Berlin with subsidiaries in Hünstetten, Switzerland, USA and China. SPECS has attracted a talented team of scientists and engineers who have dedicated their knowledge and experience to the development, design, and production of instruments for





surface science, materials research, and nanotechnology for almost 30 years. In order to continuously improve performance and to make available latest developments, we are in contact with numerous scientists, users and customers from all over the world. Reliable quality control (ISO 9001 certified) and excellent fast service, both remote and on-site, ensures maximum uptime and long-term operation and reliability of SPECS instruments over many years.

Focus™

EXPERTS FOR UHV-COMPONENTS AND MOMENTUM MICROSCOPY

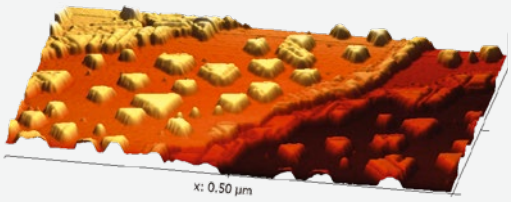
Preparing clean and functional surfaces using UHV electron beam deposition techniques

Thin film deposition and surface preparation

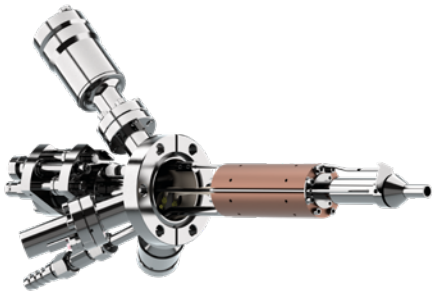
Electron beam (e-beam) evaporation is a physical vapor deposition technique used to create thin films of materials by heating them with a focused electron beam. This method allows for the deposition of high-purity films, including metals and semiconductors, in ultra-high vacuum conditions. It is widely applied in surface science, materials research, and nanotechnology for producing coatings, electronic components, and optical devices. The precise control over deposition rates and material purity makes it ideal for applications requiring high-quality thin films, such as in microelectronics and photonics.

The FOCUS EFM e-beam evaporator was designed for the evaporation of magnetic materials such as Fe, Co, Cr, Mn, and Ni, producing ultra-pure sub-monolayer and multilayer thin films. Additionally, materials like Pt, Ag, Au, Al, Ti, Ta, W, and semiconductors (e.g., silicon) and organic molecules can be evaporated with highly controlled purity. The careful selection of materials used in the EFM, along with its proprietary cooling concept and an integrated T/C controlled degassing capability up to 250°C, facilitates evaporation in ultra-high vacuum conditions (down to below 10^{-10} mbar) while minimizing cross-talk between sequentially evaporated substances.

The robust and compact design, coupled with high manufacturing standards, positions the EFM series as a valuable long-term investment. The EFM-series evaporators, including the EFM 3, EFM 3s, EFM 4, and EFM 3Ts, are well-suited for thin film evaporation and as doping cells in classical MBE growth. Currently, over 2000 instruments are utilized in various surface science research laboratories, providing a comprehensive set of parameters and recipes for nearly every evaporation process. The EFM has been referenced in hundreds of publications, indicating the scientific relevance of its specialized design for surface science. FOCUS offers service, spare parts, and support for all EFMs built since 1991. The EFM 3 was the first commercial evaporator to include an integrated flux monitor, enabling reproducible real-time control of the deposition rate. Once calibrated, this feature removes the need for a quartz thickness monitor, offering more accurate and controlled initiation of evaporation compared to temperature measurement.



Sub Monolayer of CaF2 on Si(111) - P Brahe, P Moriarty, University of Nottingham



EFM 3

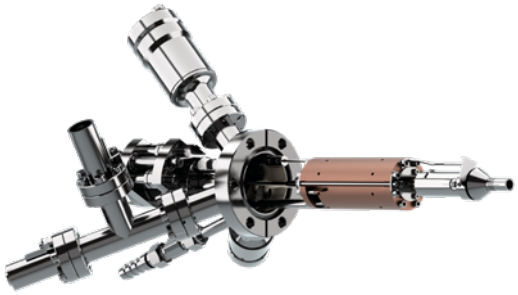
- Ultra pure evaporation
- Reliable and proven design
- Rod or crucible operation
- Flux monitor
- Integrated shutter

The Classic

The EFM 3, the first model in its family, is specifically engineered for thin film growth and molecular beam epitaxy. It can produce both sub-monolayer and multilayer systems, with evaporation rates ranging from 1/10 of a monolayer per minute to several monolayers per second. The precisely defined evaporant beam profile ensures highly uniform deposition on the sample.

The deposition area can be adjusted by selecting from three different, easily exchangeable exit apertures, as well as by varying the distance from the source to the sample. Rods and crucibles can be adjusted using the integrated z-shift to optimize the distance between the evaporant and the filament.

Additionally, the integrated flux monitor and shutter enable precise reproducibility of previous evaporation rates before the sample is exposed to the evaporant, even with the shutter closed. When paired with the EVC 300/300s, the flux monitor signal can be utilized to fully control the evaporation process through the integrated flux regulation.



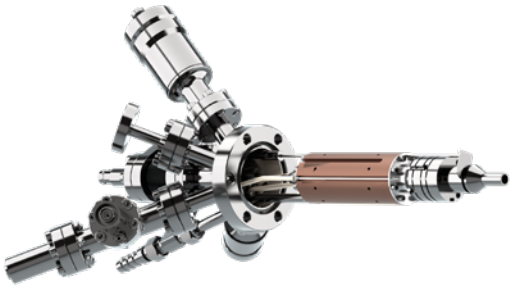
EFM 3s

- Ultra pure evaporation
- Ion suppression for defect free evaporation
- Rod or crucible operation
- Flux monitor
- Integrated shutter

Suppressing Ions

By incorporating an ion suppressor the EFM 3s expands the original EFM 3 model. In electron beam evaporators, a fraction of the evaporant beam is ionized due to electron bombardment during the heating process. Most of these ions are captured by the flux monitor electrode.

However, because the evaporator operates at a high voltage relative to the grounded sample, some ions are not captured and may lead to undesirable defects on the substrate surface. The implementation of the ion suppressor guarantees the highest quality of deposition, while protecting the surface from surface damage.



EFM 3i

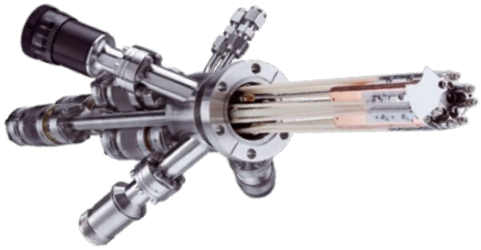
- Ion-Beam-Assisted-Deposition (IBAD)
- Ultra pure evaporation
- Rod or crucible operation
- Flux monitor

Ion Beam Assisted Deposition

The EFM 3i is designed to enable layer-by-layer growth in situations where natural progression may not take place. It allows for the controlled evaporation of the target material while generating ions to induce additional surface defects as nucleation centers through Ion-Beam-Assisted Deposition (IBAD). These ions can come from either an intrinsic process involving the evaporated target material or from inert gases, facilitated by an integrated gas inlet.

The ions are directed onto the substrate using an electrostatic lens, which allows for the adjustment of the ion-to-neutral ratio within the deposition area at the target. This adjustment has a direct impact on the density of the induced defects. For sensitive substrate materials, protection against ion bombardment can be achieved by applying a repelling lens voltage (refer to EFM3s).

It is important to note that due to the specialized design of the ionization region, the maximum crucible size is limited in comparison to the EFM 3.



EBE-4

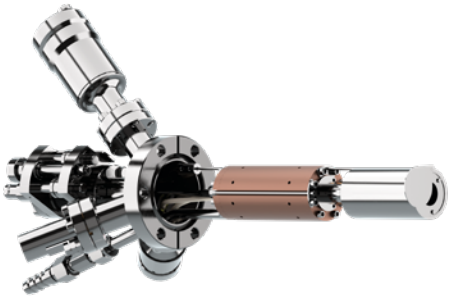
- Up to four individual pockets
- Configurable pockets with crucibles or rods
- Co-evaporation of up to 4 materials
- Extremely high power densities
- Unique, highly reliable design

Four Pocket Co-Evaporator

The SPECS EBE-4 is a versatile, fully UHV-compatible multipocket mini e-beam evaporator designed for the evaporation of small quantities of nearly any material. The material, whether in crucible or rod form, is heated through electron bombardment from a surrounding filament, achieving temperatures exceeding 3000 K.

The system can accommodate up to four pockets, each fitted with either a fixed-length holder or a linear drive, allowing for a rod feed of up to 25 mm. Users also have the option to upgrade this feature later. Each pocket can operate independently or in various combinations, enabling true co-evaporation.

This flexibility makes the EBE-4 particularly well-suited for a broad spectrum of surface science applications. When paired with the EBE-M Power Supply, which can control each pocket individually or in conjunction with others, the EBE-4 facilitates optimal evaporation and co-evaporation processes by managing filament current and regulating emission and flux current.



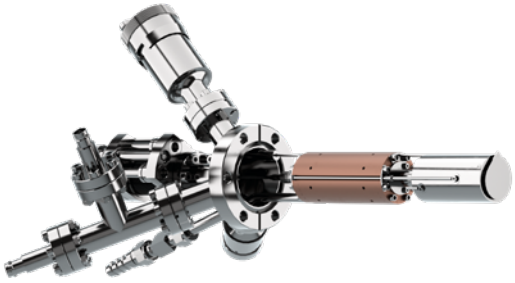
EFM 4

- Large area deposition
- Rod or crucible operation
- Flux monitor
- Integrated shutter

For Larger samples

The EFM 4 retains all the features of the EFM 3 but is specifically designed for deposition on substrates with a larger diameter, accommodating sizes up to approximately 50 mm. It offers three different exit apertures, allowing for precise adaptation of the evaporation area to match the sample size. Evaporation rates can be adjusted, ranging from 1/10 monolayer per minute to over 1000 monolayers per second, depending on the selection of the appropriate crucible and e-beam power.

The EFM 4 supports crucible capacities of up to 700 mm³. Its effective water-cooling system ensures a low background pressure, typically in the 10^{-10} mbar range, even during extended operation at high evaporant temperatures.

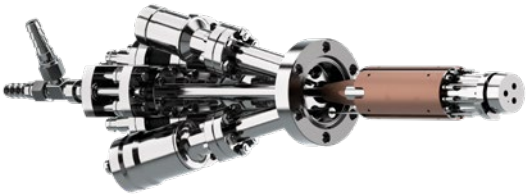


EFM 4s

- Large area deposition
- Ion suppression for defect free evaporation
- Rod or crucible operation
- Flux monitor
- Integrated shutter

Suppressing Ions

The EFM 4s expands the original EFM 4 model by incorporating an ion suppressor. In electron beam evaporators, a fraction of the evaporant beam is ionized due to electron bombardment during the heating process. Most of these ions are captured by the flux monitor electrode. However, because the evaporator operates at a high voltage relative to the grounded sample, some ions are not captured and may lead to undesirable defects on the substrate surface. The implementation of the ion suppressor guarantees the highest quality of deposition, while protecting the surface from surface damage.



EFM 3T

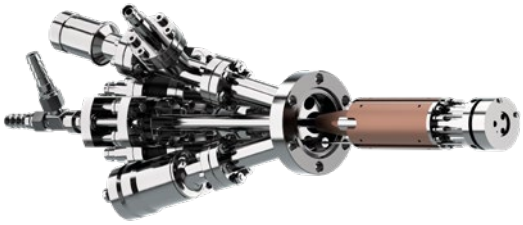
- Consecutive or co-evaporation
- Ultra pure evaporation
- Rod or crucible operation
- Flux monitor
- Integrated shutter

Three Independent sources at once

The triple evaporator EFM 3T is based on the design concept of the EFM 3 evaporators and features three independent cells, allowing for the evaporation of a diverse range of materials. Each of the three individual cells is designed with crossing beams positioned approximately 93 mm from the exit aperture to maximize the overlap of the evaporation area.

To ensure optimal performance, each cell is equipped with its own filament and high-voltage supply, effectively preventing any crosstalk between the cells. Additionally, three independent flux monitors facilitate the controlled stoichiometric growth of compounds. The integral multi-position shutter allows for precise dosing and enables either simultaneous or consecutive evaporation, making it possible to produce structures such as superlattices or multilayers.

Independent z-shifts allow for an indipendent choice of materials and evaporation method (e.g. rod/crucible). The target materials can be conveniently refilled from the rear (3x DN 16 CF). Notably, a single power supply can operate all three cells sequentially; however, in the case of co-evaporation, each material will require its own dedicated power supply.

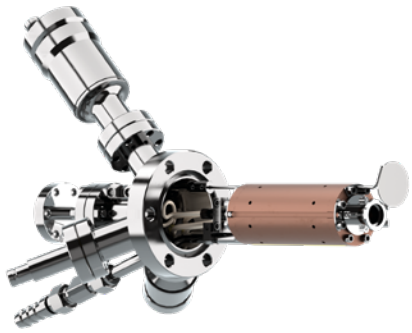


EFM 3Ts

- Ion suppression for defect free evaporation
- Consecutive or co-evaporation
- Rod or crucible operation
- Flux monitor
- Integrated shutter

Triple Source with Ion Suppressor

The EFM 3Ts expands the original EFM 3T model by incorporating an ion suppressor. In electron beam evaporators, a fraction of the evaporant beam is ionized due to electron bombardment during the heating process. Most of these ions are captured by the flux monitor electrode. However, because the evaporator operates at a high voltage relative to the grounded sample, some ions are not captured and may lead to undesirable defects on the substrate surface. The implementation of the ion suppressor guarantees the highest quality of deposition, while protecting the surface from surface damage.



EFM-H

- Highly efficient hydrogen source
- Ideal for cleaning and etching
- Simple and robust design
- Integrated shutter

Atomic Hydrogen Source

The EFM-H is a highly efficient atomic hydrogen source, particularly well-suited for cleaning and etching semiconductor surfaces, including silicon (Si), gallium arsenide (GaAs), germanium (Ge), and indium phosphide (InP). Additionally, it aids in surface passivation, enhances thin film growth, and supports other applications that utilize atomic hydrogen.

The EFM-H has a cracking efficiency of nearly 100%, a smooth and sharply defined spot profile and a low background pressure. This hydrogen flow capillary is heated via electron beam bombardment, producing hydrogen atoms with a typical kinetic energy of approximately 250 meV. The heated area is effectively shielded by the EFM's distinctive copper cooling shroud, resulting in negligible outgassing.

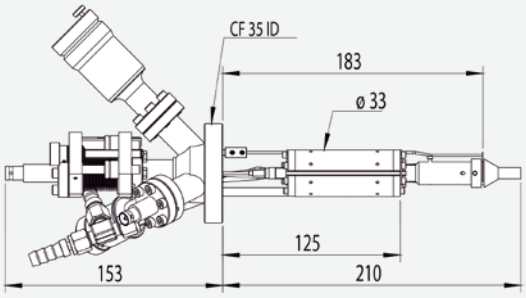
The design of the EFM-H allows for precise alignment of the hydrogen beam onto the sample, achieving an atomic hydrogen flux of $2x10^{15}$ cm^{-2} s^{-1} with an adjustable beam profile.

Technical Data

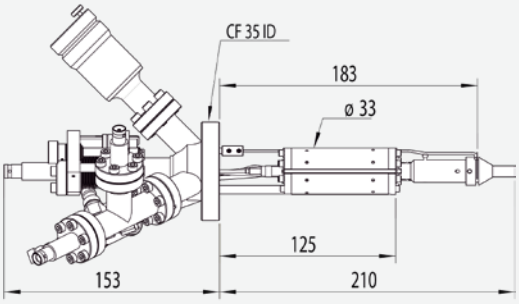
Configuration
typ. Working Distance in mm
standard Insertion Depth in mm
optional Insertion Depths in mm
typ. Flange to Sample distance in mm
Evap. Area Diameter in mm
Mounting Flange
Evap. from Wires
max. Crucible Capacity in mm^3
max. Crucible Diameter in mm
z-shift 25mm
z-shift 50mm
Rear Loading
Shutter
Shutter drive
Flux Monitor
Ion Suppressor
IBAD
Co-Evaporation
Nickel coating (of Cu parts)
Port aligner (±3°)
upgrade/retrofit options

	EFM3	EFM 3s	EFM 3i	EFM 3T	EFM 3 TS	EFM 4	EFM 4s	EFM-H	EBE-4
	50-300	50-300	50-300	93	93	50-300	50-300	>60	60-95
	210	210	210	161	161	210	210	140	231
	190-600	190-600	190-600	161-411	161-411	190-600	190-600	120-250	-
	260-410	260-410	260-410	254	254	260-410	260-410	>200	291-326
	4-30	4-30	4-30	8.5, 11, 14	8.5, 11, 14	10-133	10-133	±6° to ±15°	10
					DN40 CF				
	✓	✓	✓	✓	✓	✓	✓	-	-
	700	700	250	250	250	700	700	-	70
	11	11	8	8	8	11	11	-	4
	✓	✓	✓	✓	✓	✓	✓	-	configurable
	optional	optional	optional	-	-	optional	optional	-	-
	✓	✓	✓	✓ (3x)	✓ (3x)	✓	✓	-	✓
	✓	✓	✓	✓ (multiple)	✓ (multiple)	✓	✓	optional	✓
					optional				✓
	✓	✓	✓	✓ (3x)	✓ (3x)	✓	✓	-	✓
	-	✓	✓	-	✓	-	✓	optional	-
	-	-	✓	-	-	-	-	-	-
	-	-	-	✓	✓	-	-	-	✓
					on request				-
					optional				-
	3s, 4, H	4, H	-	3Ts	-	-	-	pumping by-pass	z-shifts

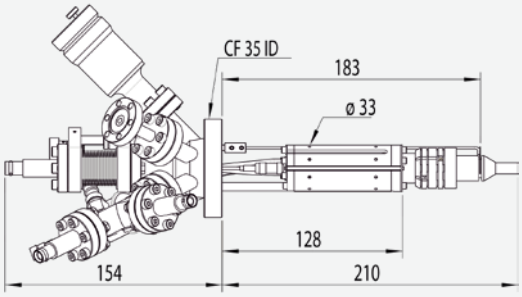
Dimensions



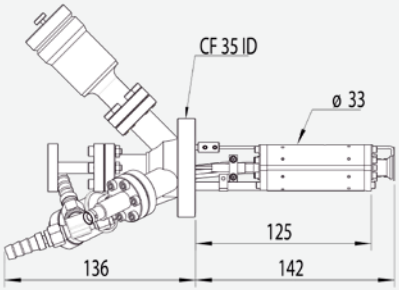
EFM 3 – the classic



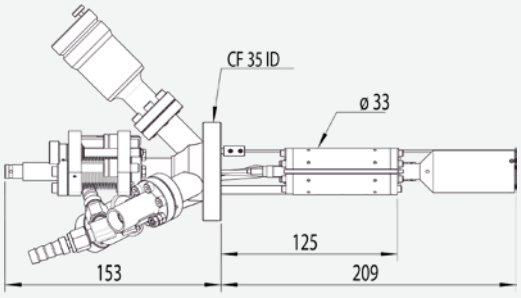
EFM 3s – suppressing ions



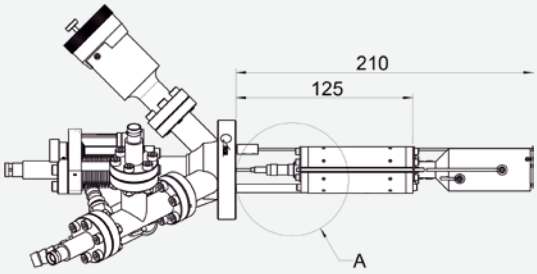
EFM 3i – ion beam assisted deposition



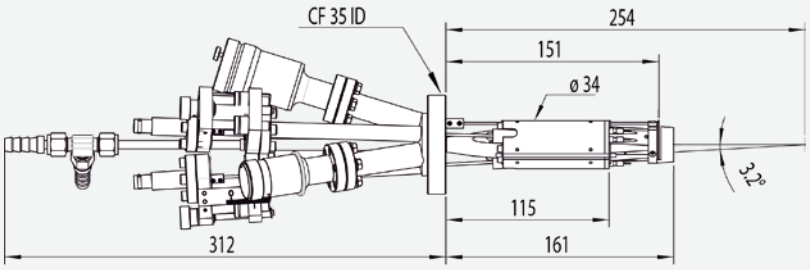
EFM H – atomic hydrogen source



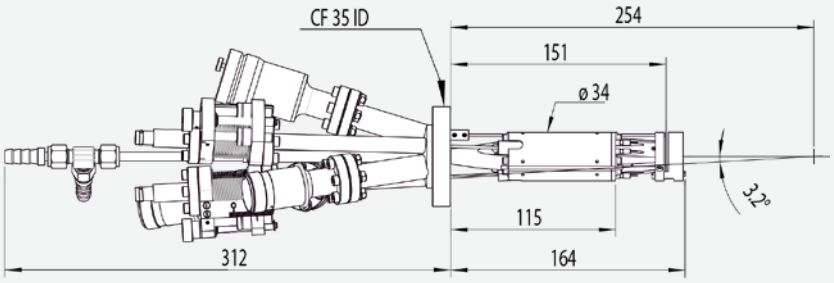
EFM 4 – for larger samples



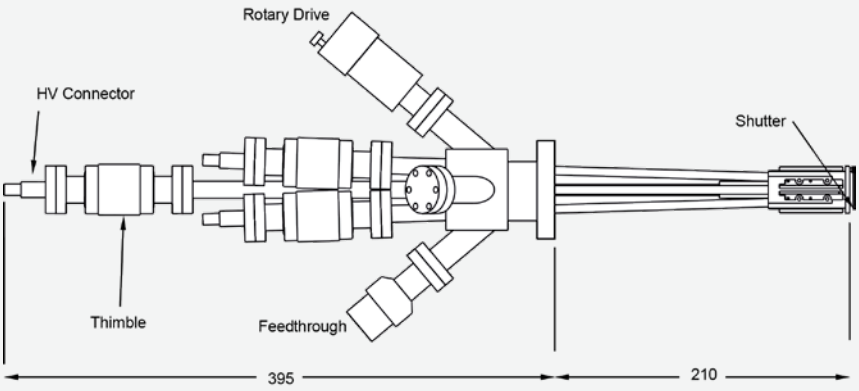
EFM 4S – suppressing ions



EFM 3T – three independent sources at once



EFM 3TS – triple source with ion suppressor



EBE 4 – four pocket co-evaporator

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