



INLINE ION GETTER PUMP FOR PARTICLE ACCELERATORS

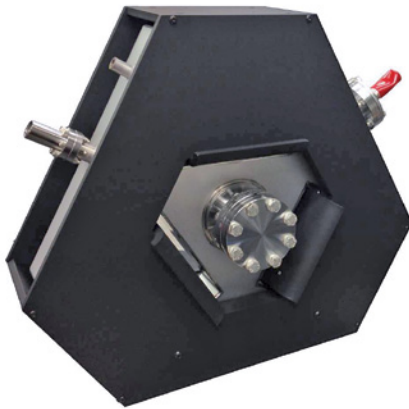
**INNOVATIVE ION PUMP
WITH INTERNAL RF SHIELDING
AND EXTERNAL B-FIELD SHIELDING**



Agilent Technologies



Inline Ion Getter Pump with Internal RF Shielding and External B-Field shielding



Introduction

Ion getter pumps (IGPs) are particularly appropriate for use in modern accelerator facilities because of their high reliability, cleanliness and the absence of vibration that could disturb the trajectory of the beam. Normally T-pieces are used to connect the pumps to the beam tube. These reduce the effective pumping speed and require the use of radiofrequency (RF) shielding which is complicated and expensive. Moreover, very often the accelerated particles are sensitive to stray magnetic fields and the impedance of the surrounding vacuum tube. Magnetic fields generated by the ion pump magnets, which are asymmetrically oriented to the beam tube, can be a major drawback. To overcome these problems we have developed, in collaboration with the Deutsche Elektronen-Synchrotron (DESY), an innovative in-line ion getter pump which can be mounted directly into a beam line without a T-piece and which has a symmetrical arrangement of the magnets around the beam tube. Additionally, RF shielding can be easily integrated inside the in-line pump.

Using this innovative in-line concept (Patent EP2 431996A1) ion pumps will become an integral part of the beam tube for the first time when installed on the X-FEL system at DESY. The use of ion getter pumps in such a configuration is very attractive, as they maximize pumping speed efficiency. But conventional IGPs also require that the particle beam must be protected from magnetic stray fields and from any possible contamination (for example, titanium sputtered by the cathodes). To address this challenge, a large cross-functional team worked in close cooperation to develop this solution. The arrangement of the magnets and the geometry of the pole piece, used to guide the magnetic field lines, were designed to minimize any disturbance on the beam trajectory. Moreover, the element location inside the pump has been optimized to “self- shield” the beam, without requiring the addition of expensive and complex optical shields. Finally, thanks to the in-line solution, a simple RF shield (a copper coated tube with pumping slits) can now be easily installed directly inside the pump at the accelerator site. installed directly inside the pump at the accelerator site.



Inline Ion Getter Pump with Internal RF Shielding and External B-Field shielding

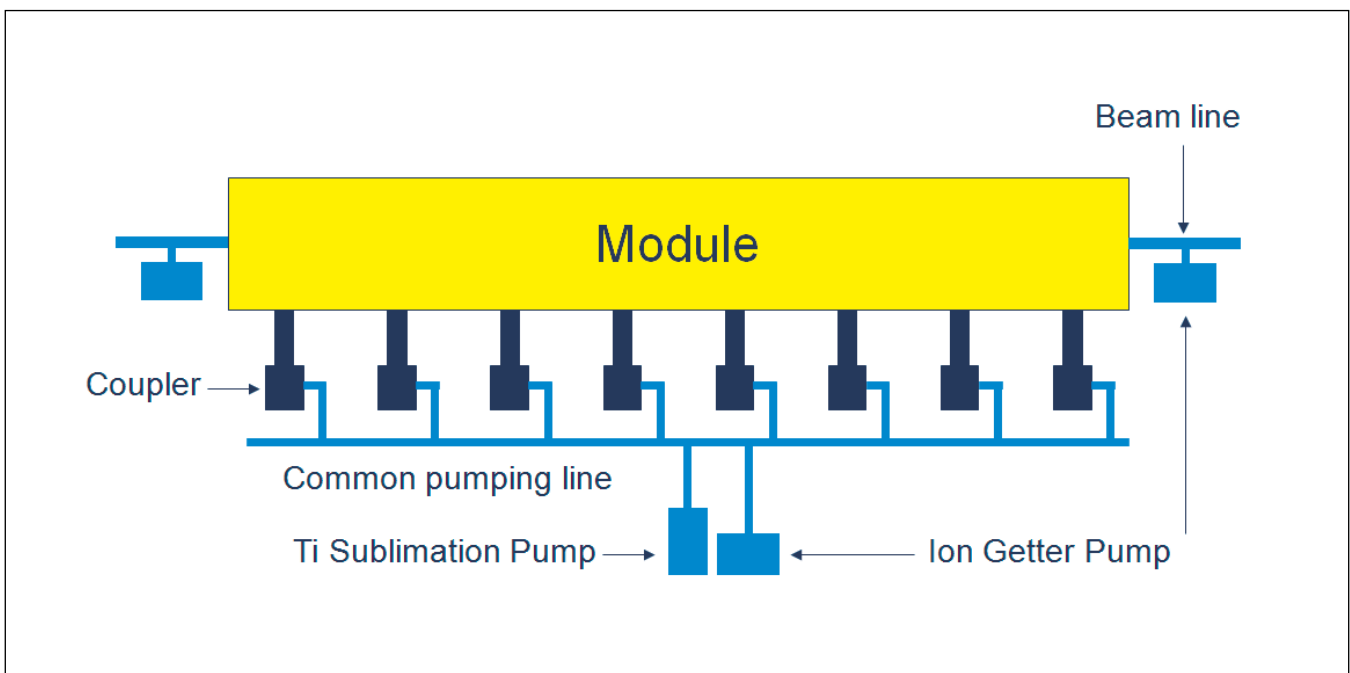
Ion getter pumps are a well known and established technology. Nevertheless, the in-line pump described in this document represents a **new and innovative solution** to simplify the application of IGPs in a highly-demanding environment such as an accelerator facility, with added value for the customer.

The use of Agilent in-line ion pumps at DESY XFEL will support cutting-edge scientific research, giving us additional visibility and highlighting our position as a technology leader in ultra-high vacuum.

The in-line construction is poised to become the standard for similar applications, opening new opportunities in worldwide laboratories.

Accelerators: Traditional technology

In a traditional configuration, ion pumps are placed along the accelerator chamber, which is made up of modules as shown below. Normally T-pieces are used for connection. They reduce the effective pumping speed and require radio frequency (RF) shielding which is complicated and expensive.





Inline Ion Getter Pump with Internal RF Shielding and External B-Field shielding

Main drawbacks of traditional technology

The traditional technology is affected by two drawbacks:

Stray magnetic field

In modern accelerator facilities very often the accelerated particles are sensitive to stray magnetic fields, and in particular to the influence of components which are transverse to the direction of the beam. In a typical configuration the magnets are asymmetrical with respect to the beam tube, thus preventing a self-compensating effect of the components.

Titanium contamination

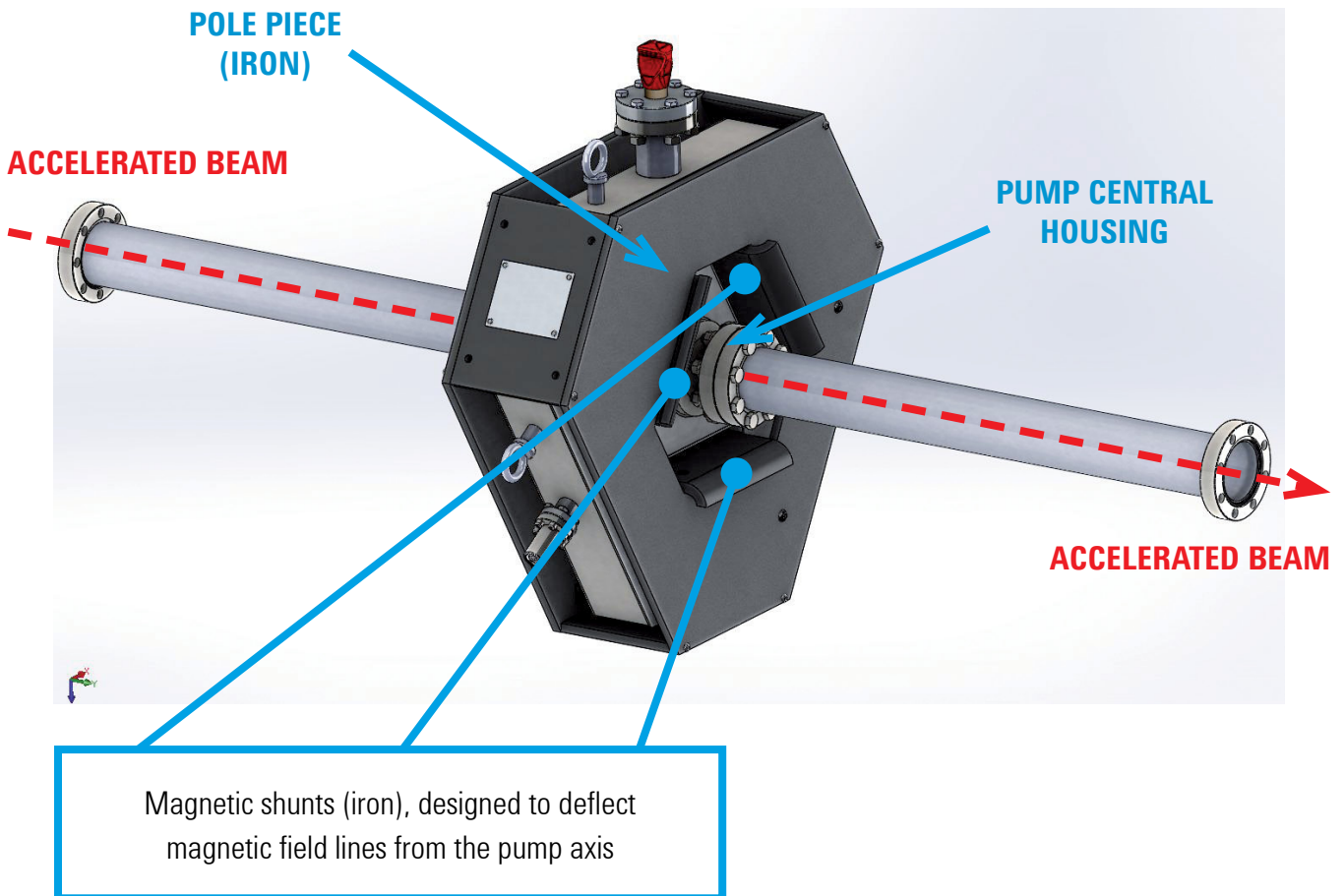
The beam of charged particles must be protected from the titanium sputtered by the ion pump cathodes and also from titanium debris coming from possible «peeling» phenomena. Typically this issue is overcome with the addition of complex optical shields, that further reduce the effective pumping speed.



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Solution: Diode In-line pump with optimized magnetic field

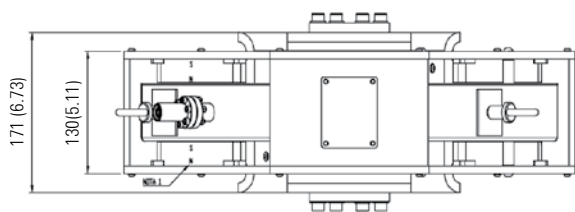
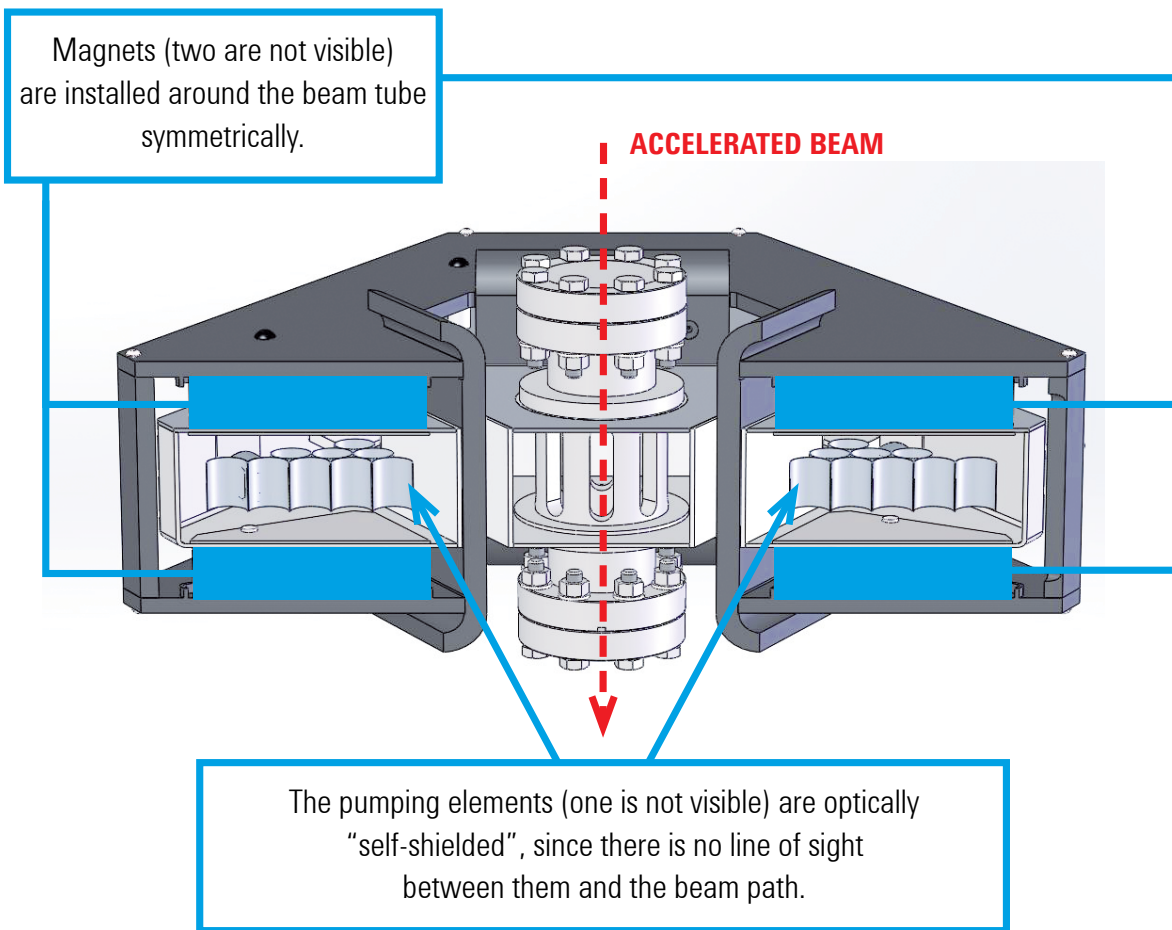
In-line vacuum pump which can be mounted directly into a beam line without T-piece, developed by Agilent Technologies in collaboration with "Deutsches Elektronen Synchrotron" (DESY).



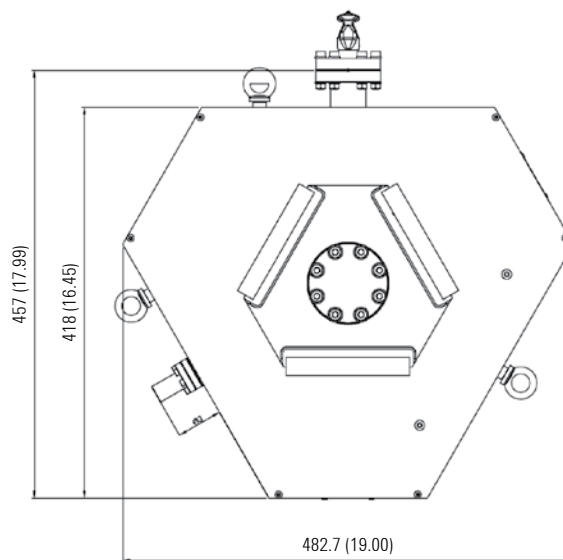
With the pump mounted in this position, any possible titanium debris will be collected at the bottom of the pump, without affecting the beam.



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Dimensions: millimeters (inches)

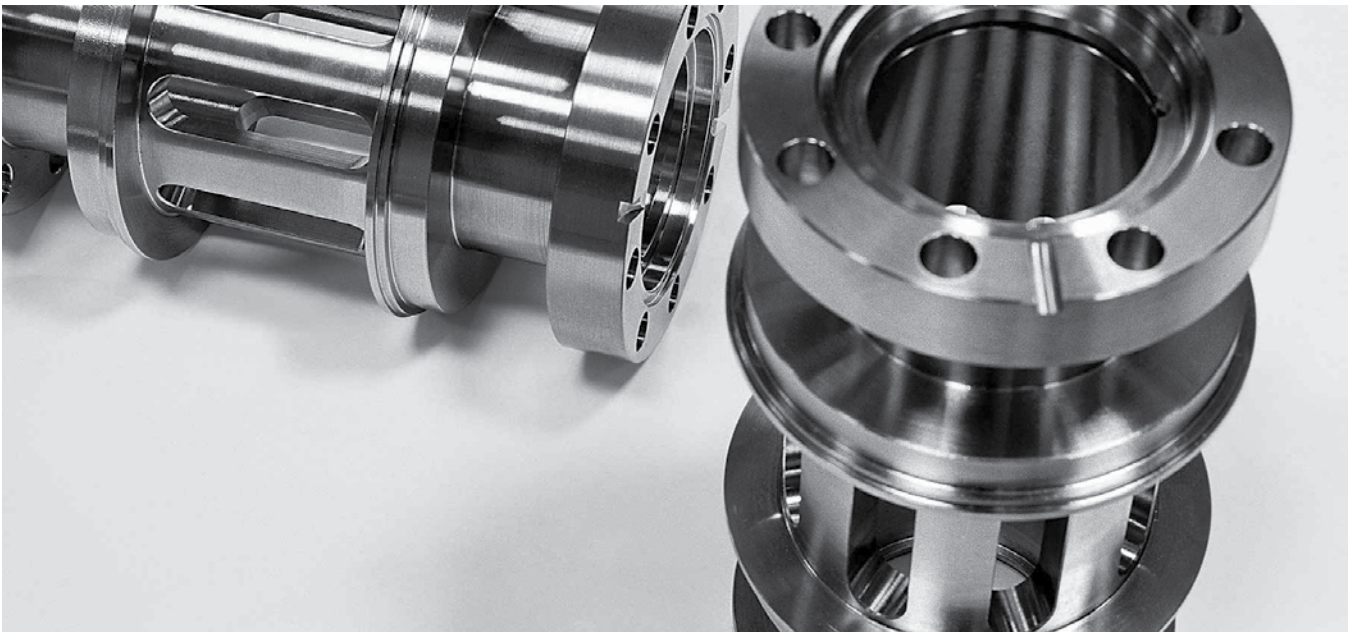




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Diode In-line: Internal housing

The core of the pump is constituted by an internal housing. Since it will become part of the beam tube, its design must satisfy very strict requirements both for dimensions and tolerances.



This internal housing is matched, directly at the customer site, with a RF shield of similar construction. The number and the geometry of the slits can be adapted to the required physics specification to ensure a minimal distortion of very sensitive beams.

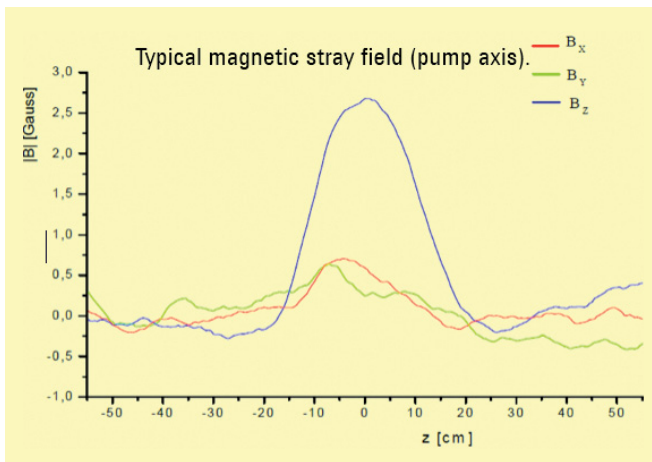


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Reduced magnetic Stray Fields

The stray magnetic fields of this pump are greatly reduced in comparison with a standard ion pump of the same pumping speed.

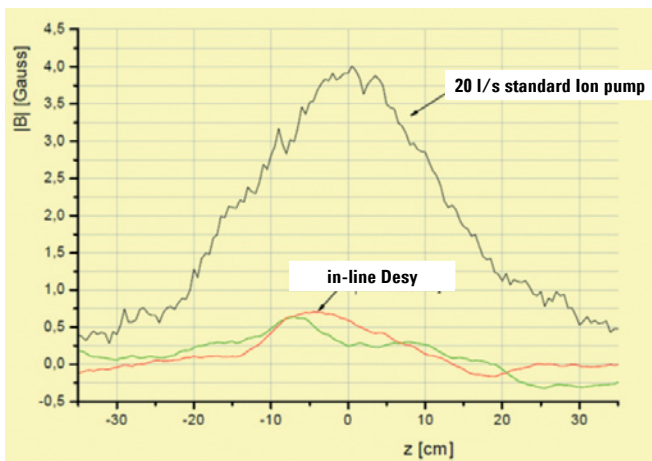
The transversal field components have maximal field strength of about 1/2 Gauss. The longitudinal field component, which does not affect charged particles travelling along the beam tube, has a maximum of about 3 Gauss.



Courtesy of DESY

The arrangement of the magnets and the geometry of the pole piece, used to guide the magnetic field lines, order are designed to **minimize any disturbance on of the beam trajectory.**

Magnetic stray field comparison



Courtesy of DESY

Comparison between a standard 20 l/s Ion pump vs the in-line DESY pump clearly demonstrates the reduced magnetic field of the in-line pump.



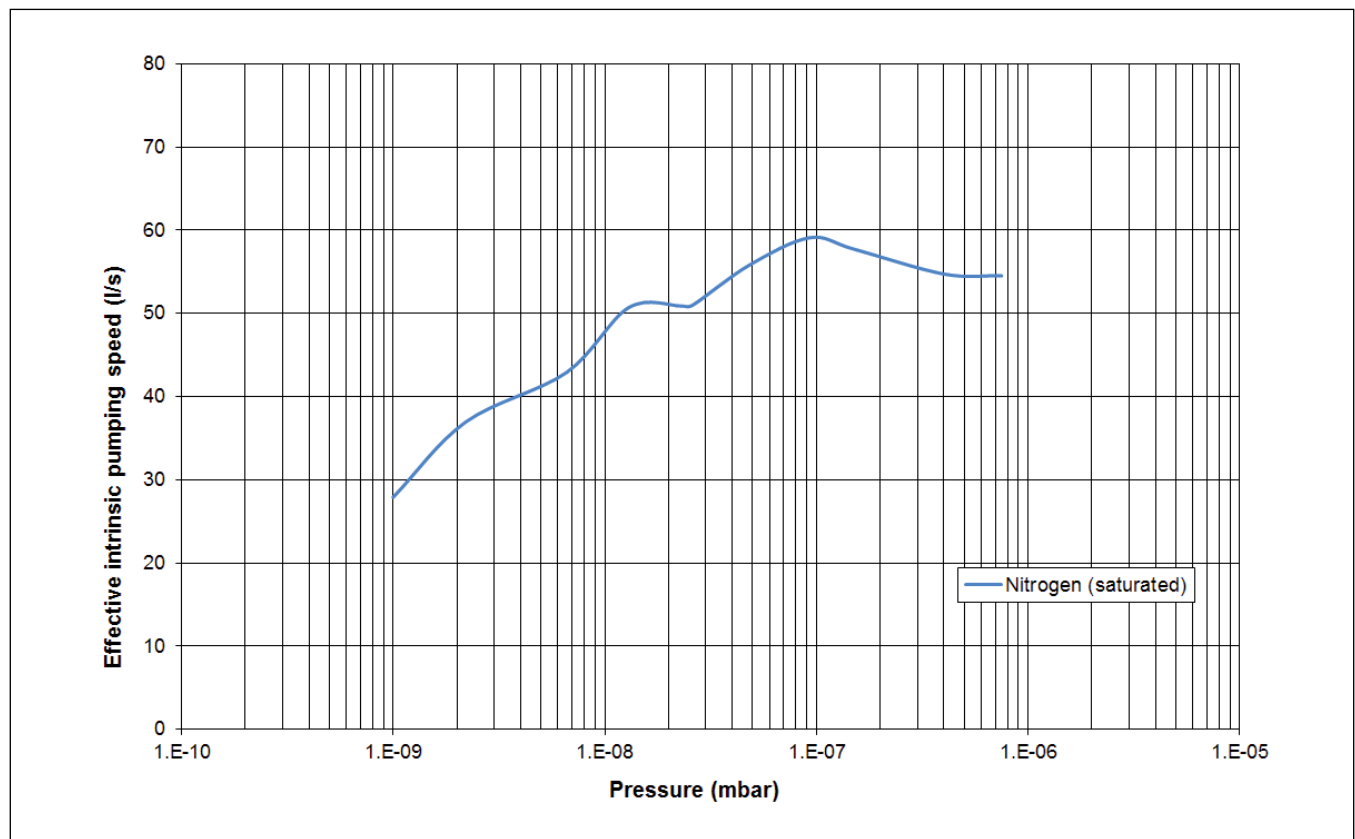
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Pumping Speed

The pumping speed of the in-line ion pump has been measured as per DIN28429.

Since the pump is 3" flanged, a conical adapter was used in order to connect the ion pump to the Fischer-Mommsen dome. In this configuration, the measured pumping speed for nitrogen was approximately 45 l/s in the range 1E-6/1E-8 mbar, as validated by DESY tests.

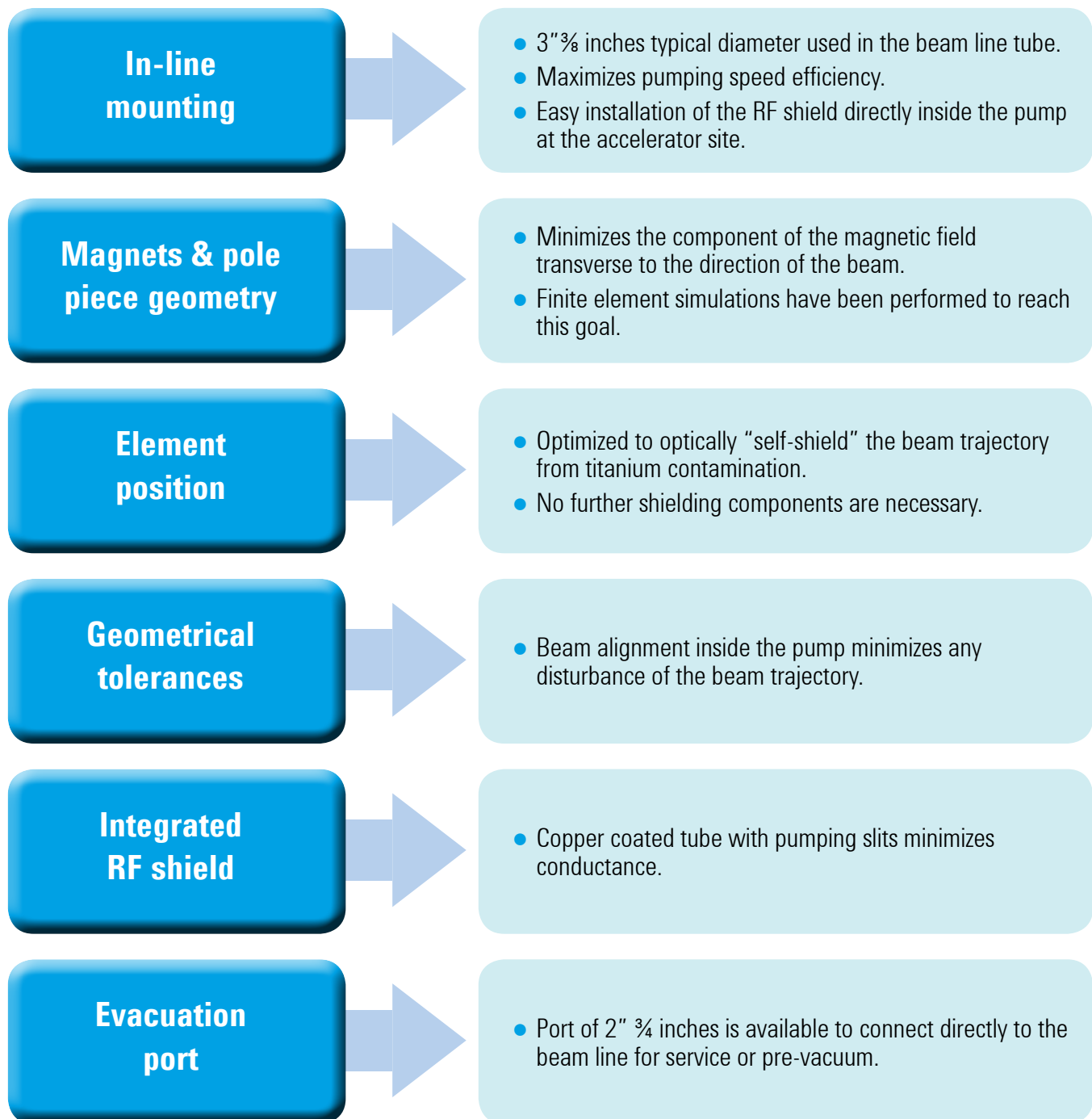
The graph below shows the intrinsic (effective) pumping speed for nitrogen of the in-line ion pump, evaluated by taking into account the conductance of the conical adapter and its transmission probability.





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Features & Benefits





Inline Ion Getter Pump with Internal RF Shielding and External B-Field shielding

Success Story: XFEL – X-Ray Free Electron Laser

Linear Accelerator of 3,4 km length at DESY, Hamburg, Germany.

Extremely short coherent X-ray flashes (fs) will be produced for research on biological cells, chemical reactions and nano particles on atomic scale.



DESY X-FEL Installed Base

➔ #350 in-line pumps



* DESY's XFEL is a groundbreaking X-ray research site under construction in Germany, based in Hamburg. It will generate X-ray flashes with brilliance 1 billion times higher than that of the best conventional X-ray radiation sources. It is expected to open up completely new research opportunities for scientists and industrial users. In-line ion pumps help make this possible.



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Summary

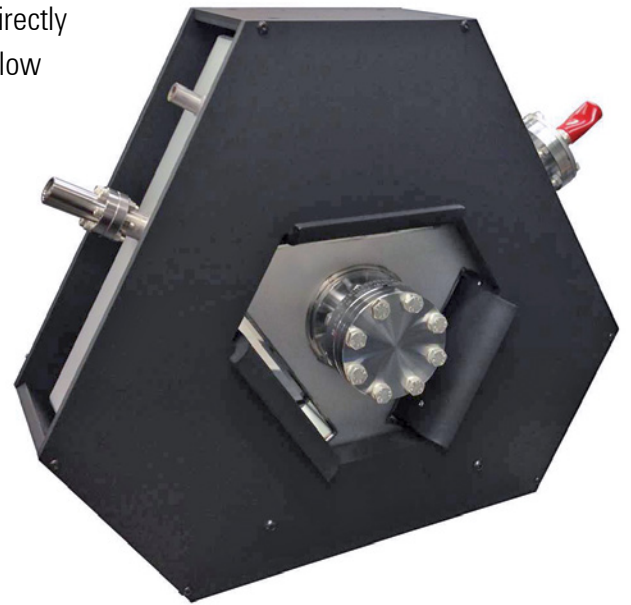
Diode In-line Ion Pump were designed specifically to be mounted directly in a beam line. The pump's magnetic circuit is optimized to provide low values of the stray field along the pump axis.

The pump operates in a pressure range from 10^{-5} to below 10^{-11} Torr (mbar). Pumping speed may vary depending on the system pressure, gas type and the applied operating voltage. Pumps can be optimized by using Agilent 4UHV Controllers to achieve the lowest possible operating pressure.

A positive polarity high voltage supply is required to operate Diode pumps.

For more information:

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Agilent In-line Ion pumps integrated into a transport beam-line at X-FEL/Desy