The SAES Group

making innovation happen, together

saes getters

SAES Group activity in accelerator technology

Paolo Manini SAES Getters SpA, Italy ,

Advanced Low Emittance Rings Technology (ALERT) 2016 Workshop

Outline

- A few words on the SAES Group
- NEG pumps for accelerators
- NEG coating for light sources
- A new company : SAES RIAL Vacuum

70 years of World Wide leadership

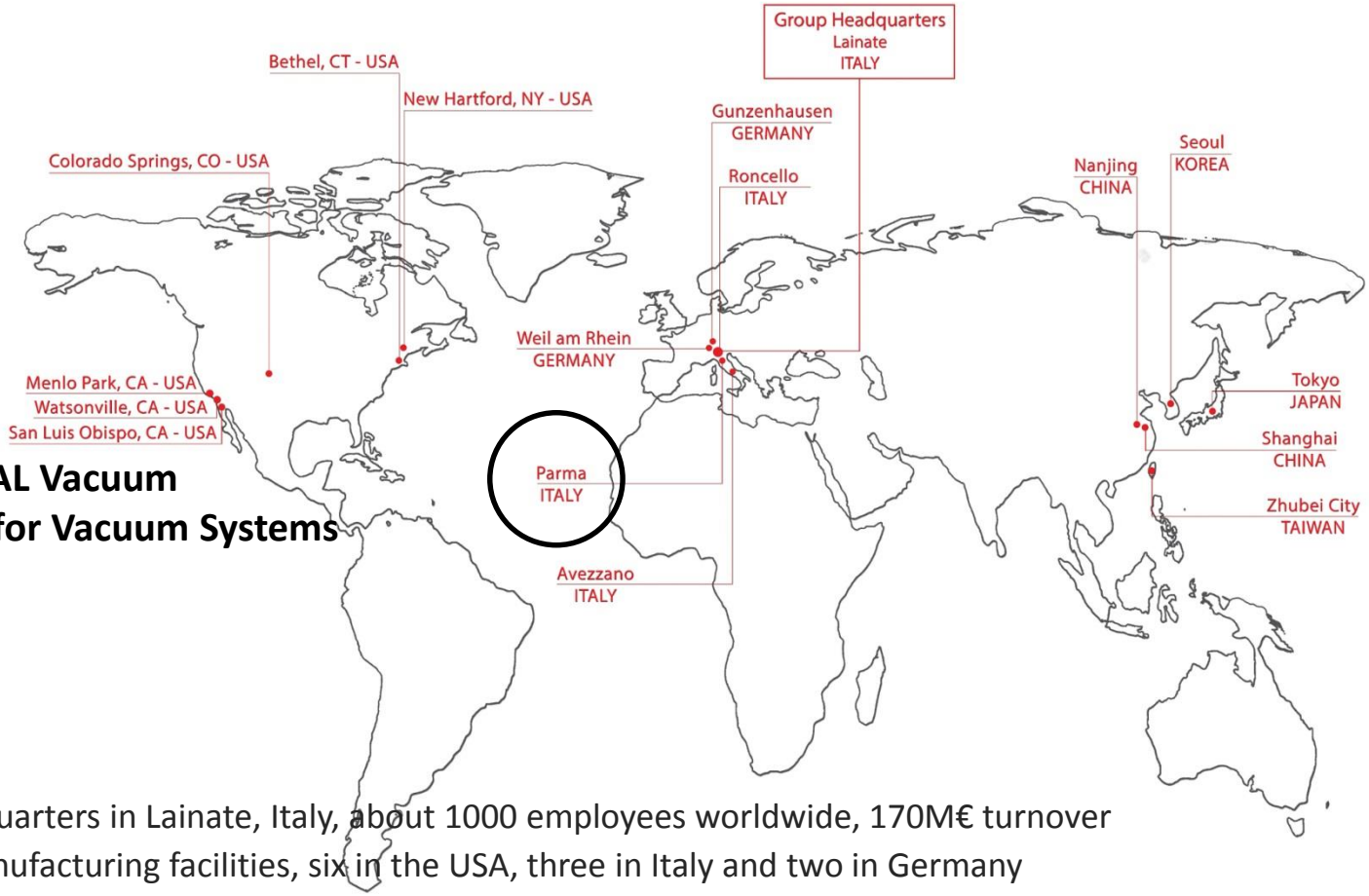
SAES Getters is an Italian company established 70 years ago in Milano. Since then it has pioneered getter technology and advanced materials for :

- Information and Displays industry,
- Lamp industry,
- **Vacuum and Ultra-high Vacuum applications**,
- Vacuum tubes and electronic devices industry,
- Ultra-high gas purification for Semiconductors,
- Renewable Energies area.

Since 2004 our **NiTi smart materials solutions** have been innovating:

- the Medical devices industry,
- the Consumer electronics industry,
- the Automotive industry,
- the White Goods and Domotic industries.

The SAES Group



SAES-RIAL Vacuum
New JV for Vacuum Systems

- Headquarters in Lainate, Italy, about 1000 employees worldwide, 170M€ turnover
- 10 manufacturing facilities, six in the USA, three in Italy and two in Germany
- Asian subsidiaries located in Japan, China, South Korea and Taiwan
- Authorized distributors worldwide
- Technological innovation sustained by more that 10% of turnover investments in R&D

Our Research and Innovation

Key Figures

- **11%** of net sales allocated to R&I every year
- State-of-the-art corporate laboratories covering a surface of over 3,300 sq. m.
- More than 150 highly skilled people engaged in RDI activities world-wide. Almost 17% of the total workforce of the Group:
  - about 50% are graduated (mainly in Physics, Chemistry, Engineering and Material Science)
  - 20% of graduated are PhD
- 233 Scientific Papers and Conference Proceeding published in the last 20 years
- Strong cooperation with Universities and R&D centers

In-house Core Competencies

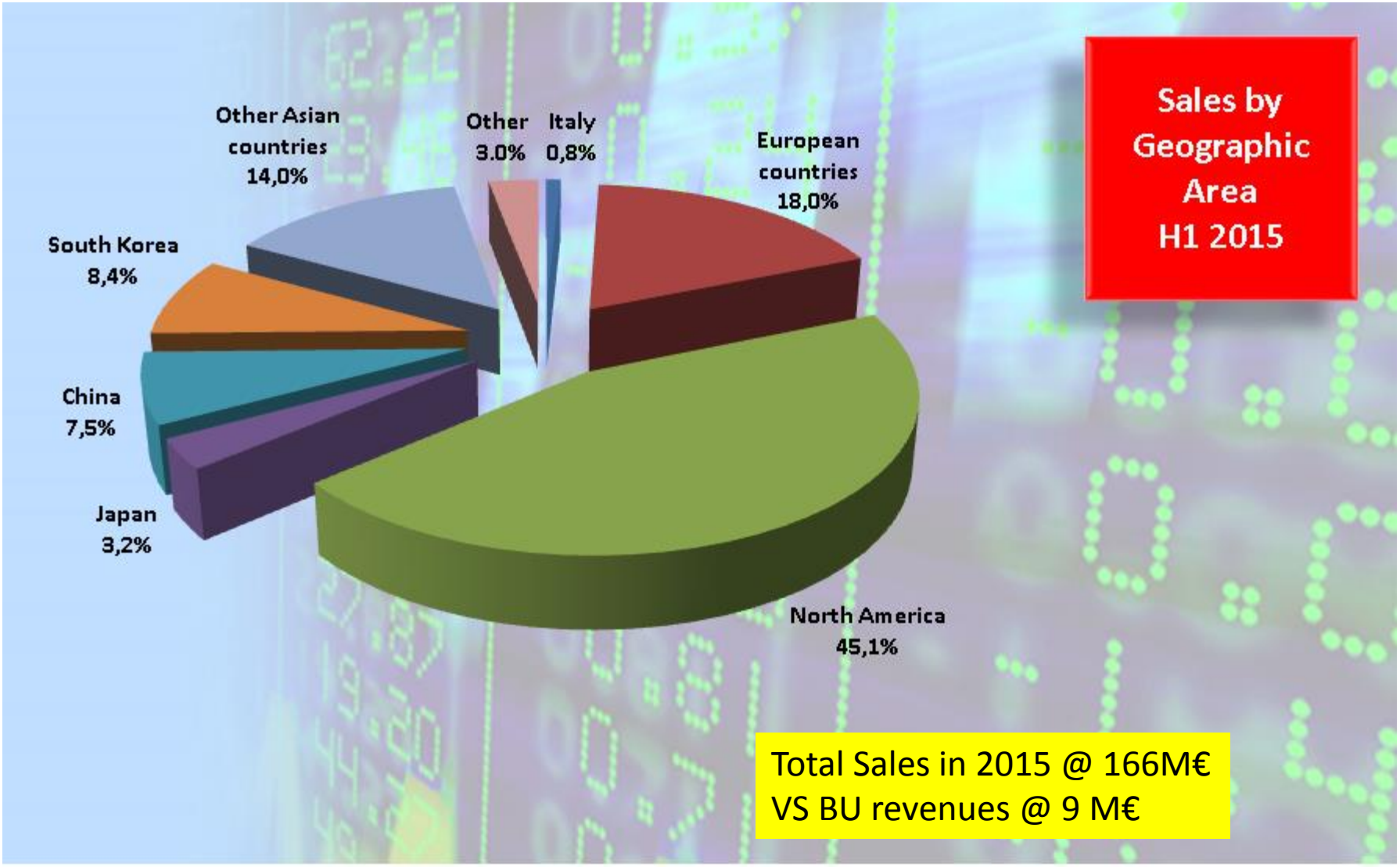
- Vacuum Metallurgy for Getters
- Fine Powders Metallurgy
- Thin Film Deposition
- Metals Dispensing
- Ultra-high vacuum science & technology
- UHP Gas Handling

- Organic Chemistry
- Hybrid Polymer Technology
- Ultra High Porosity Sintering
- Impregnated Sintered Metals
- Nano Powder Technology
- Shape Memory Alloys science
- & technology
- Vacuum Metallurgy for NiTi
- Chemical and physical analysis
- Materials science

Quality, Environment, Safety & Ethics

Total Quality Management is our key approach for ***innovative, safe and environmentally friendly*** products development

SAES Group Consolidated Sales



Total Sales in 2015 @ 166M€
VS BU revenues @ 9 M€

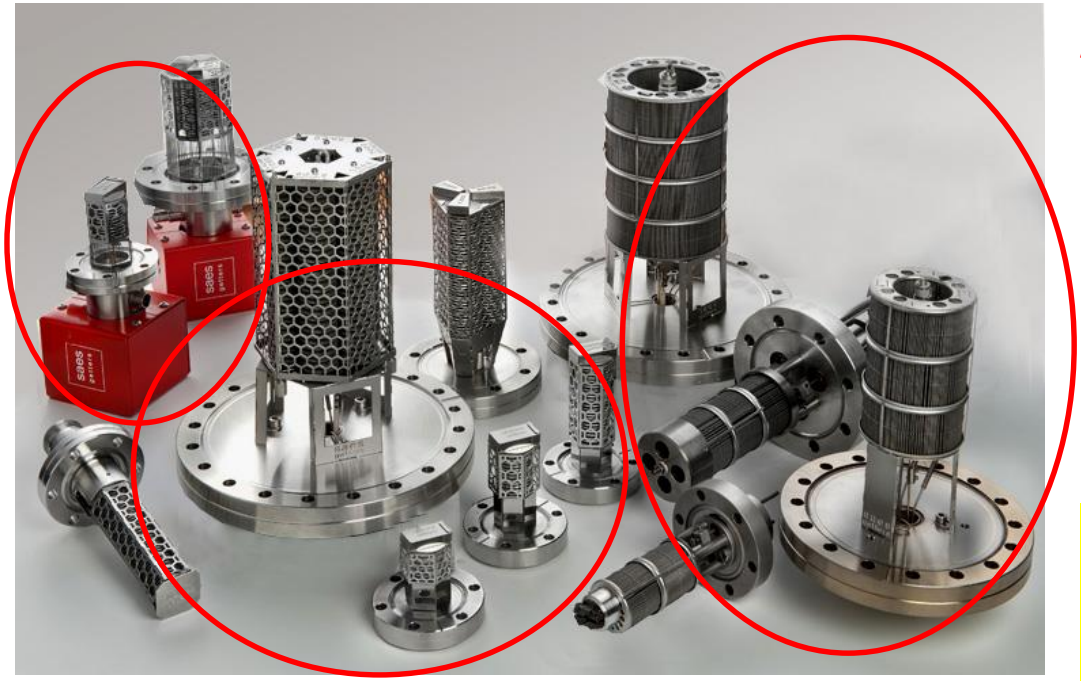
SAES and the accelerators

- The accelerator market is a strategic one for SAES (Colliders, FEL, light sources, spallation sources…)

- SAES is active in this market since 50 years with a large range of products :
  - NEG pumps for HV-UHV-XHV
  - NEG coating solutions
  - Analytical support
  - Vacuum chambers & integrated systems (SAES RIAL Vacuum)

- SAES is active worldwide in particle accelerator projects (Asia, Europe, US).

NEG (Non Evaporable getter) pumps for light sources

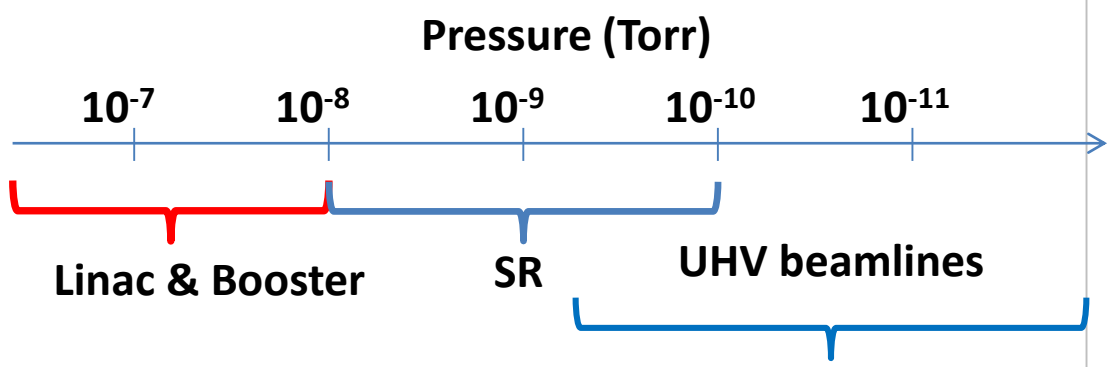


Advantages of NEG pumps

- Best pumps for hydrogen
- Extremely compact, light weight
- No need of power for operation
- No maintenance costs
- No vibration, no magnetic interference

- ***Capacitorr pumps***
  - sintered getter materials
  - Pumping speed from 50 l/s to 4000 l/s (H2).
- ***Capacitorr HV pumps***
  - based on the ZAO® getter
  - High Vacuum application (up to 1x10-8 mbar)
- ***NEXTorr pumps,***
  - combine ion & NEG technology
  - Pump all gases (active & inert)

NEG in Synchrotron Radiation source



LINAC & Booster

Storage Ring

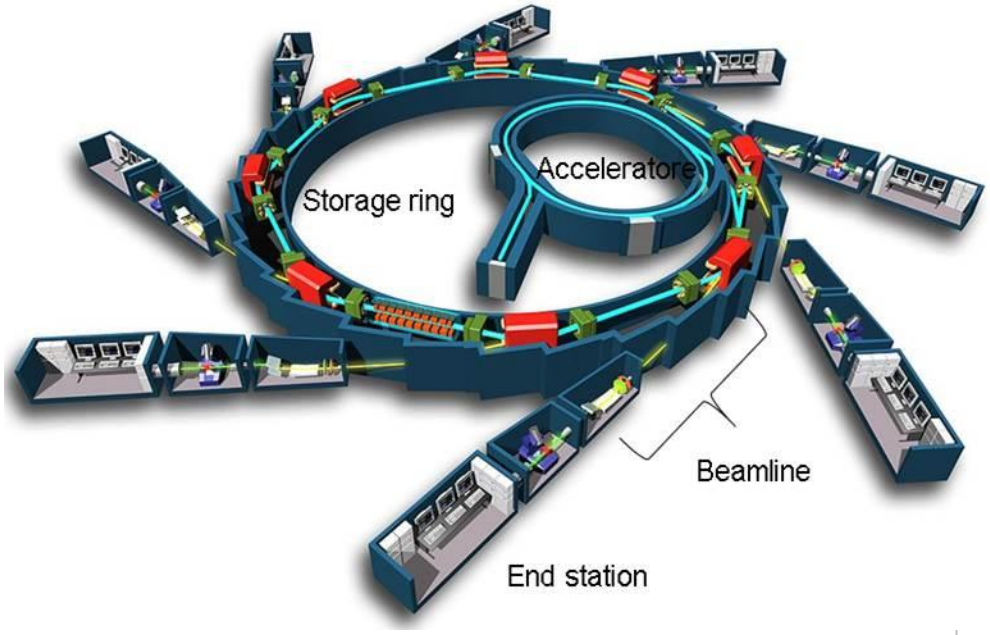
- In the ring AND in the absorbers, the Undulators, between magnets (quadrupoles, sextupoles…), bending chambers

Insertion Devices & Undulators

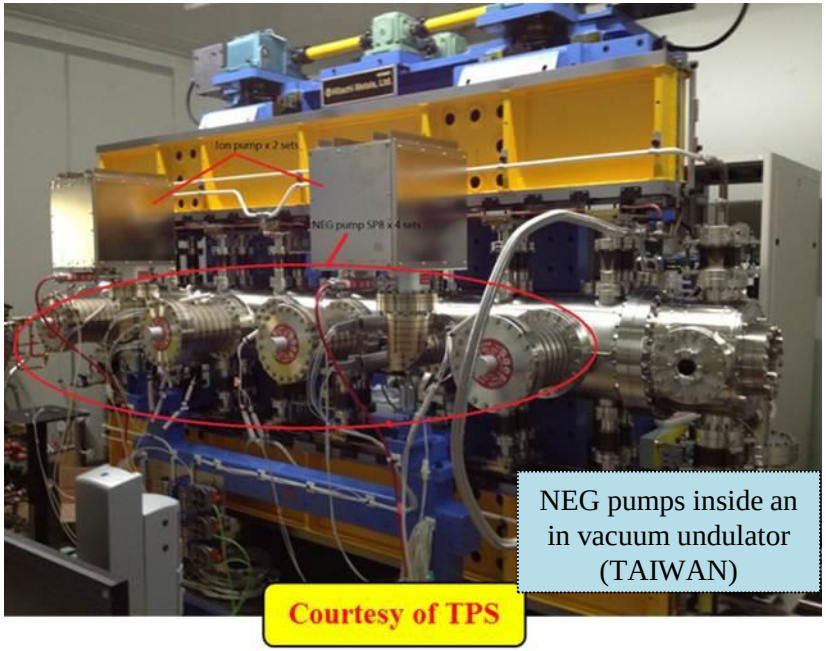
- NEG coating, due to the small aperture

BEAMLINES

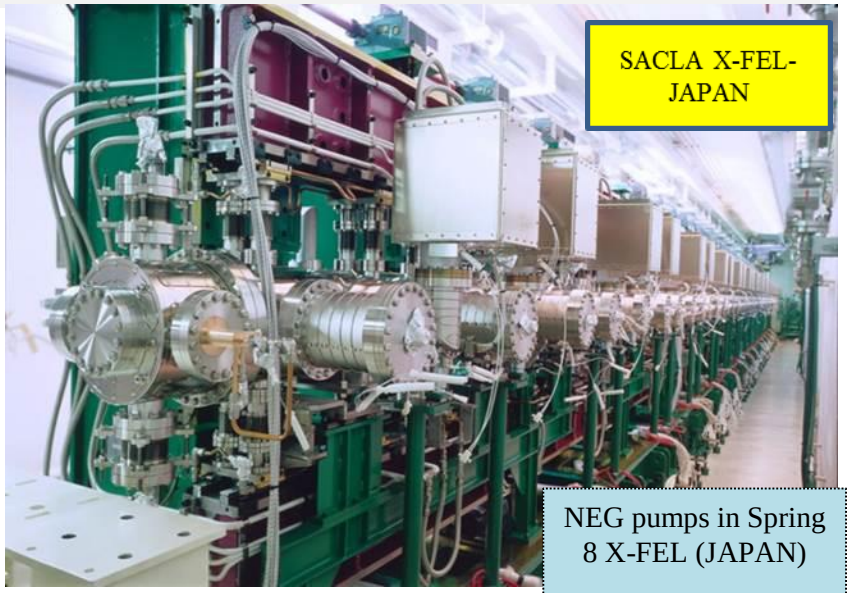
- In UHV end-stations (space, vacuum, uimproved design)



Examples of application of NEG pumps

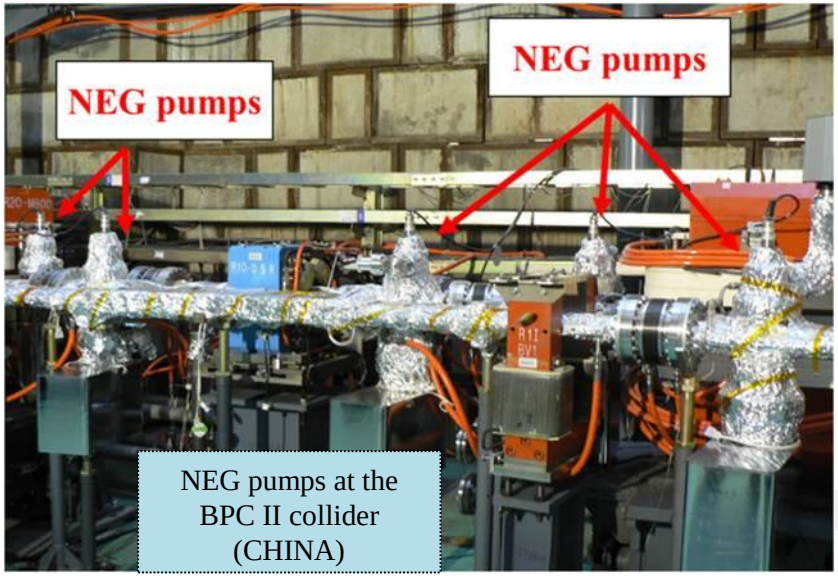


NEG pumps inside an in vacuum undulator (TAIWAN)

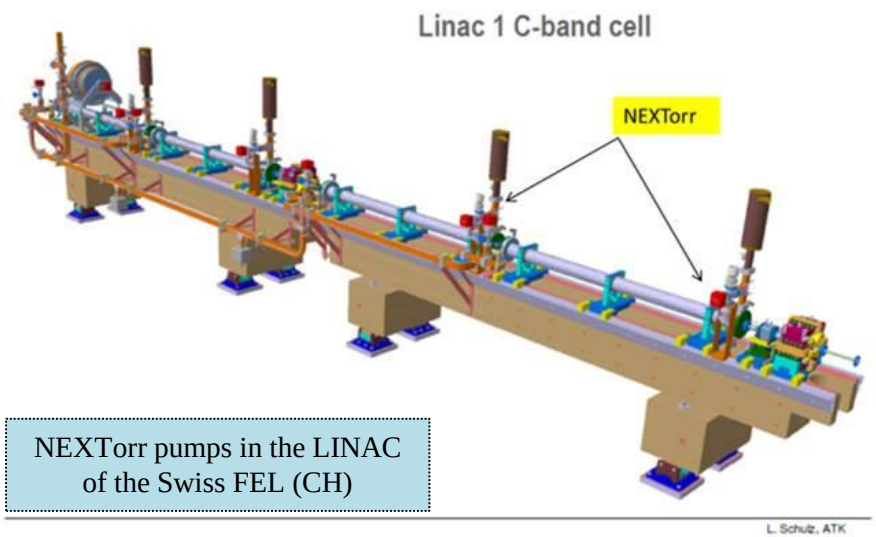


SACLA X-FEL-JAPAN

NEG pumps in Spring 8 X-FEL (JAPAN)

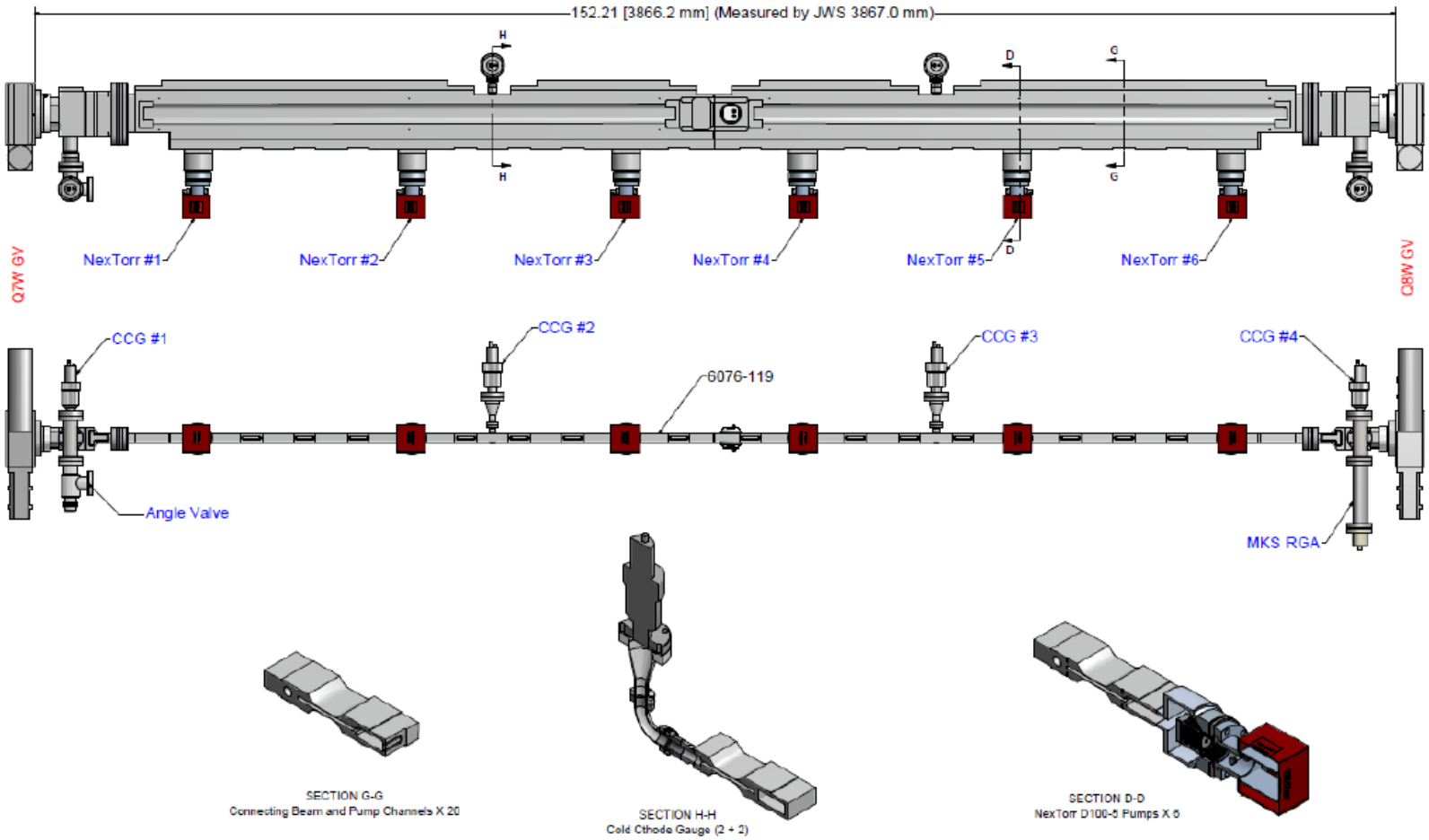


NEG pumps at the BPC II collider (CHINA)



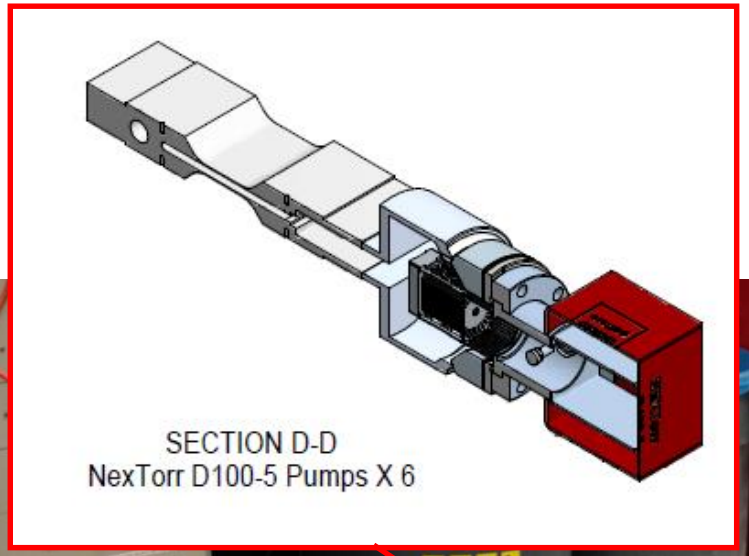
NEXTorr pumps in the LINAC of the Swiss FEL (CH)

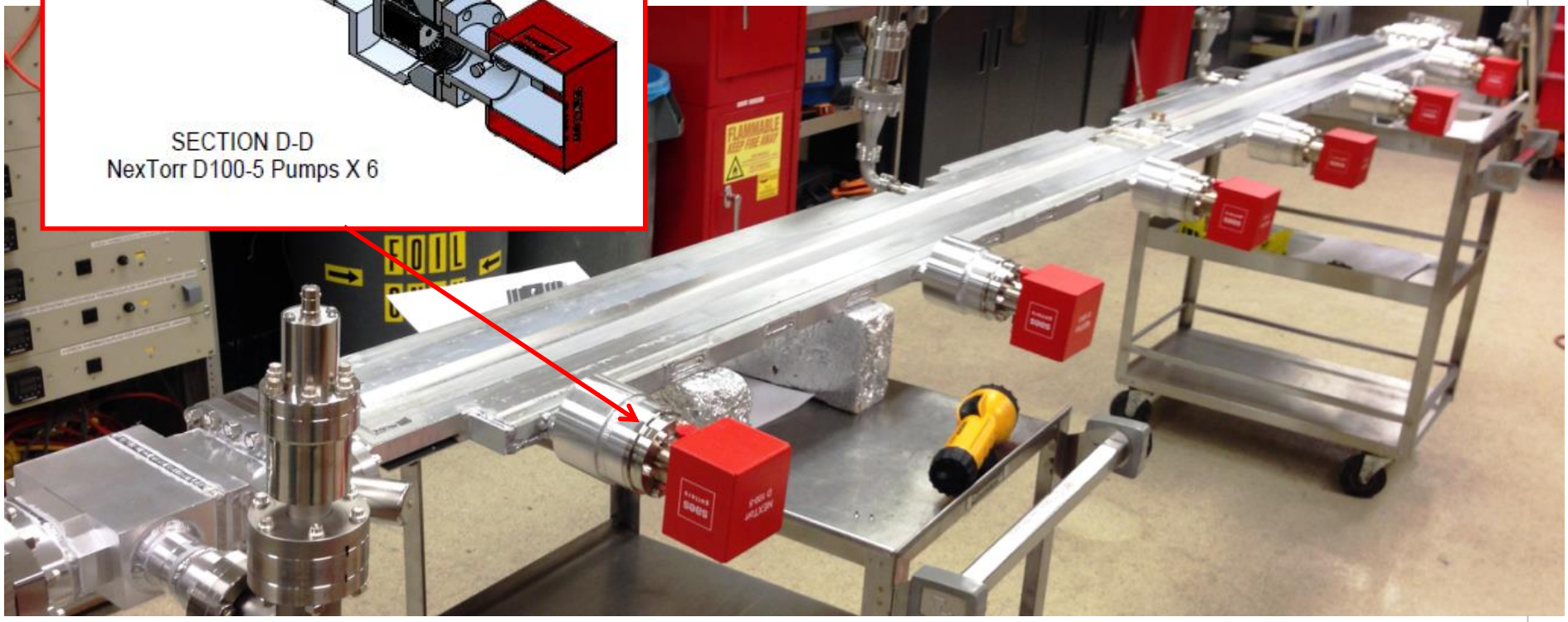
Undulator vacuum test chamber



Courtesy of Wilson Laboratory, Cornell

Six NexTorr D100-5 Pumps on Undulator Chamber





NEG coating solutions for accelerators

- SAES is CERN licensee since 2001 of the NEG coating technology which complements the product portfolio based on lumped NEG pumps.

- A substantial R&D and NEG coating activity has been done to :

  - industrialize the process
  - assess the feasibility of NEG coating of complex shape chambers, including narrow gap insertion devices.

- NEG coating is now being considered in light sources not only in insertion devices but also as the main pumping system in the storage ring (e.g. Soleil, MAX IV)

SAES can coat elliptical ID down to 7 mm gap and circular pipes down to 6 mm diameter

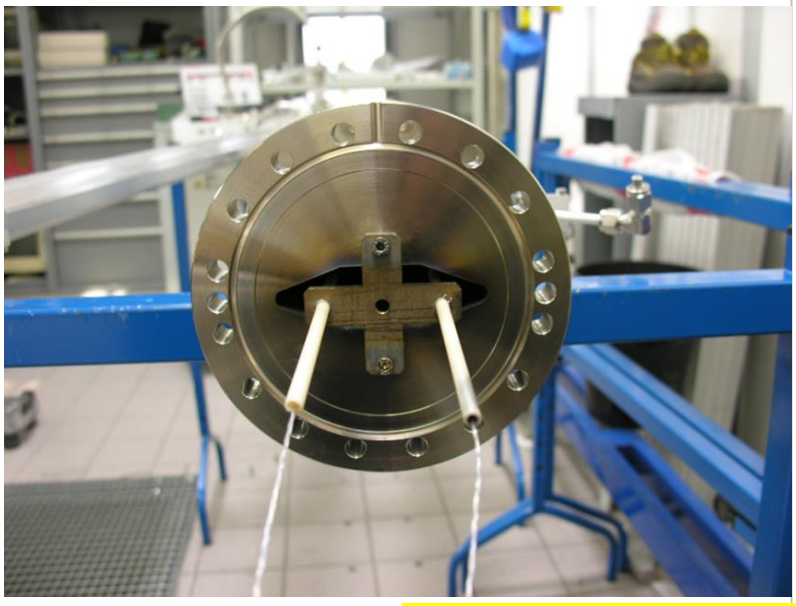
Trends in narrow gap chambers…

- The first large synchrotron project using relatively small section chambers was the SOLEIL ring, the first light source to adopt NEG coating extensively (> 55% of the ring circumference).

- For SOLEIL chambers, cathode wires could be suitably positioned inside the cross section of the chambers as this was reasonably large.

- Depending on the required film specifications, 2 or even 3 cathodes were used in the assembly.

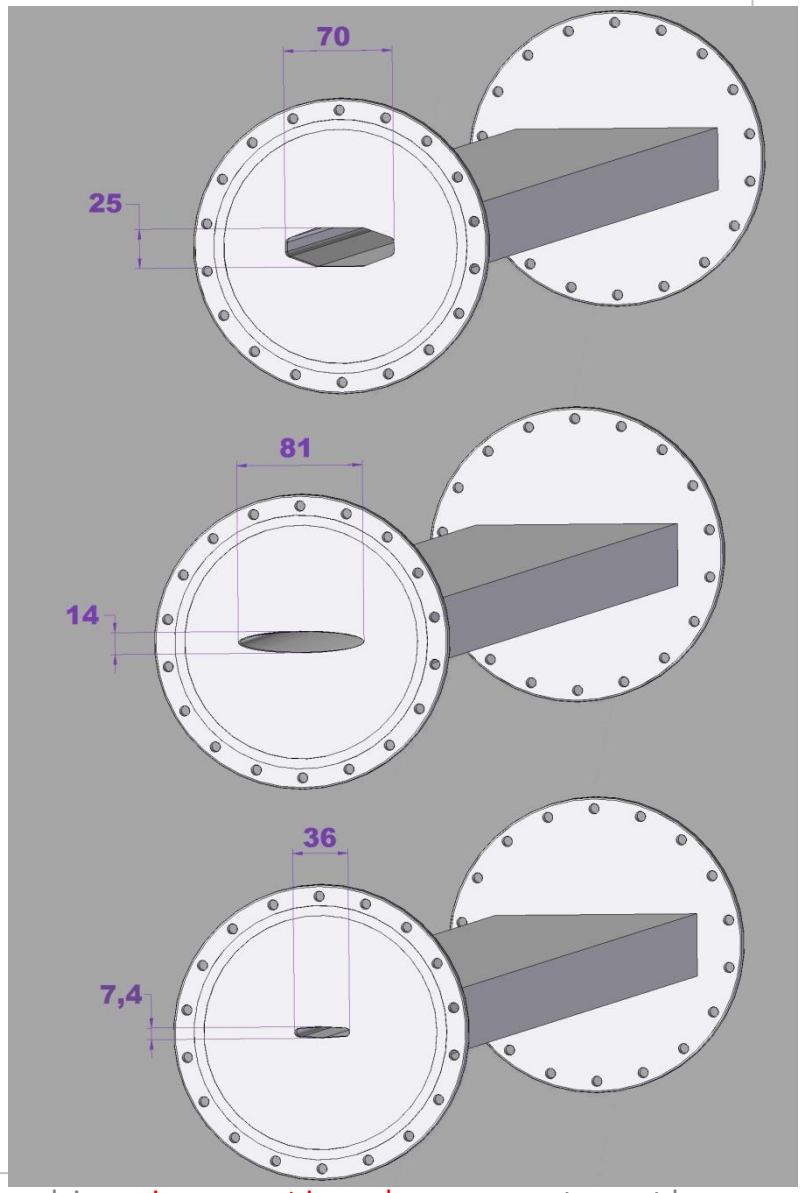
- Spacing among cathodes was modeled to ensure that the thickess distribution was as close as possible to user's requirements.



Courtesy of SOLEIL

Trends in narrow gap chambers…

- In parallel with SOLEIL, several other facilities (DLS, MAX, NSRRC, PSI…) started to use NEG coated IDs with gaps in the range between 12 and 9 mm.
- In the following years gaps have decreased in size down to 7 mm. Sections were also accordingly reduced (from 70 mm to 35 mm, typically)
- The combination of both effects make the coating much more difficult as
  - **Inserting and mounting the cathodes is more critical**
  - **the plasma volume is pretty much reduced which may cause plasma instabilities and/or dis-uniformities unless properly addressed.**
  - **Plasma adjustments may require higher working pressures**



Small diameter pipes

- Since a few years now, pipes with internal diameter as small as 4 mm are increasingly considered as insertion devices for high emittance light sources. There is therefore a growing interest in the scientific accelerator community in understanding the coating process and feasibility.

- As of now we have coated and characterized stainless steel pipes with diameter of
  - 10 mm
  - 8 mm
  - 6 mm

- Pipes with 4 mm diameter have been prepared but not successfully coated yet.

NEG coating projects delivered by SAES

- ESRF, France
- ELETTRA, Italy
- SOLEIL, France
- MAX II-III, Univ. of Lund, Sweden
- Diamond, UK
- NSRRC, Taiwan
- SLS, Switzerland
- ASP, Australia
- ISA, Denmark
- APS, LBNL, USA
- Indus II (India)
- Solaris (Poland)

Synchrotrons are not the only machine using NEG coating

- 600 m of warm straight section of RHIC at BNL.

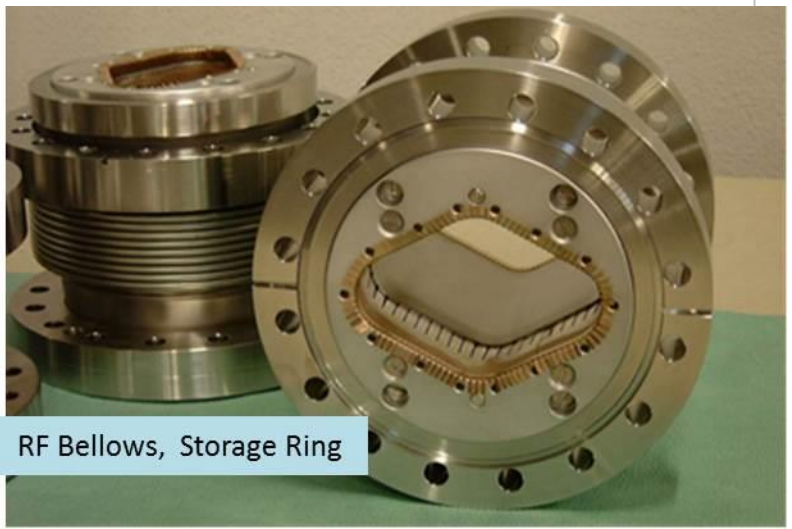
A new company : SAES RIAL Vacuum

- In decembre 2015 SAES Getters and Rodofil established a new company , SAES RIAL Vacuum, which is partecipated by the two mother companies.

- Mission : create a high level technological and manufacturing pole finalized to the design, manufacturing and testing of vacuum systems and integrated components for a variety of research and industrial applications.

- The main markets are research, industrial and accelerator vacuum systems

- SAES RIAL Vacuum combines the deep knowledge in vacuum and material science of **SAES Getters** with the expertise in vacuum design and fine machining of **RIAL VACUUM** (established in the 70s)

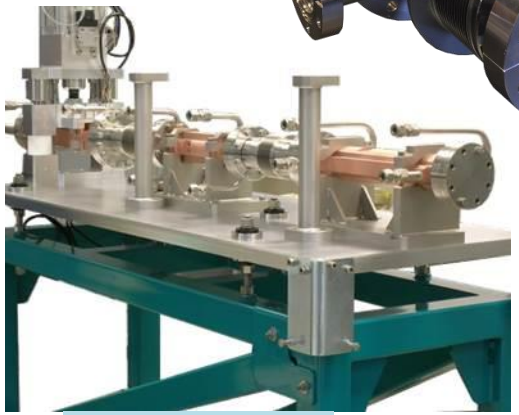


RF Bellows, Storage Ring

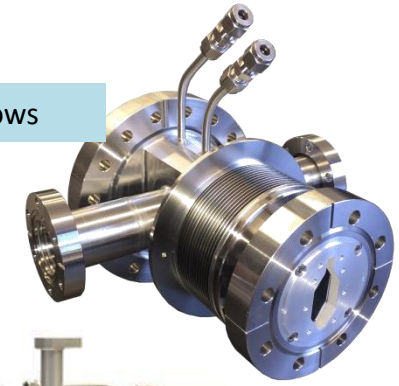
Vacuum technology for synchrotrons

- Typical products/solution for accelerators& synchrotrons are :
  - Chamber for in vacuum & in air-undulator
  - Chambers for the storage rings and special chambers
  - Mirror chambers
  - Crotch absorbers, BPM, taper, RF bellows
  - Bunch compressors…

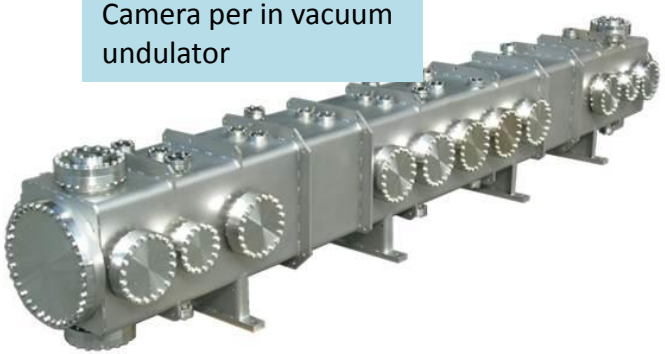
Mirror chamber



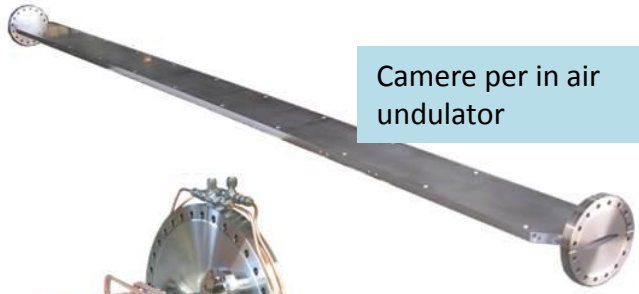
Soleil absorber



RF Bellows



Camera per in vacuum undulator



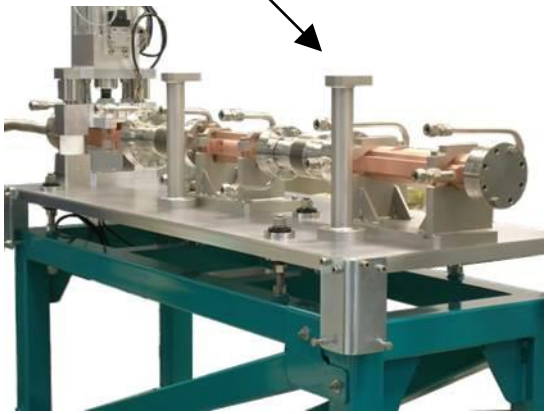
Camere per in air undulator

Taper

SAES group offer for synchrotron light sources

NEG Pumps

NEG Coated Chambers



Integrated Vacuum Systems

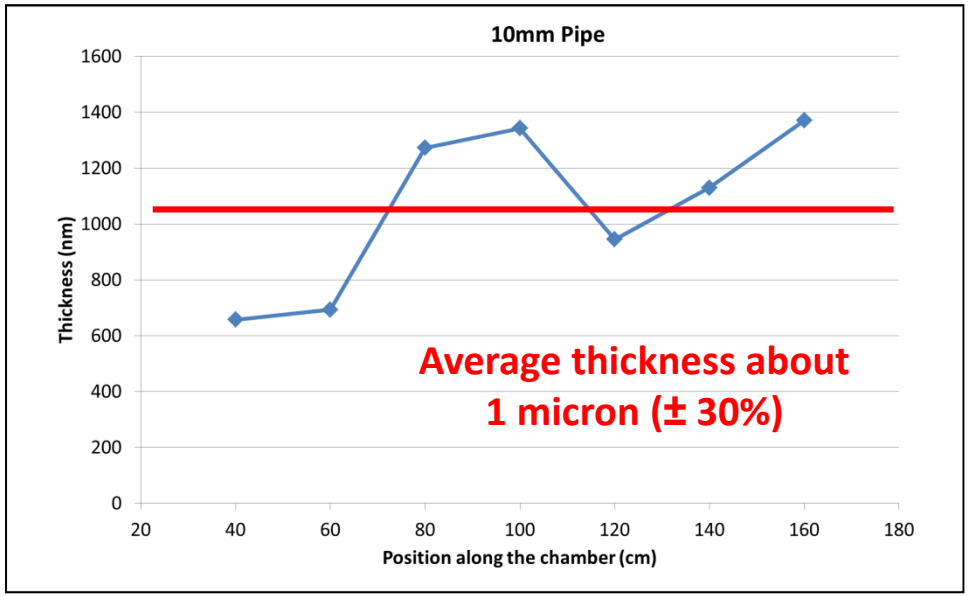
Thank you for your attention

saes group

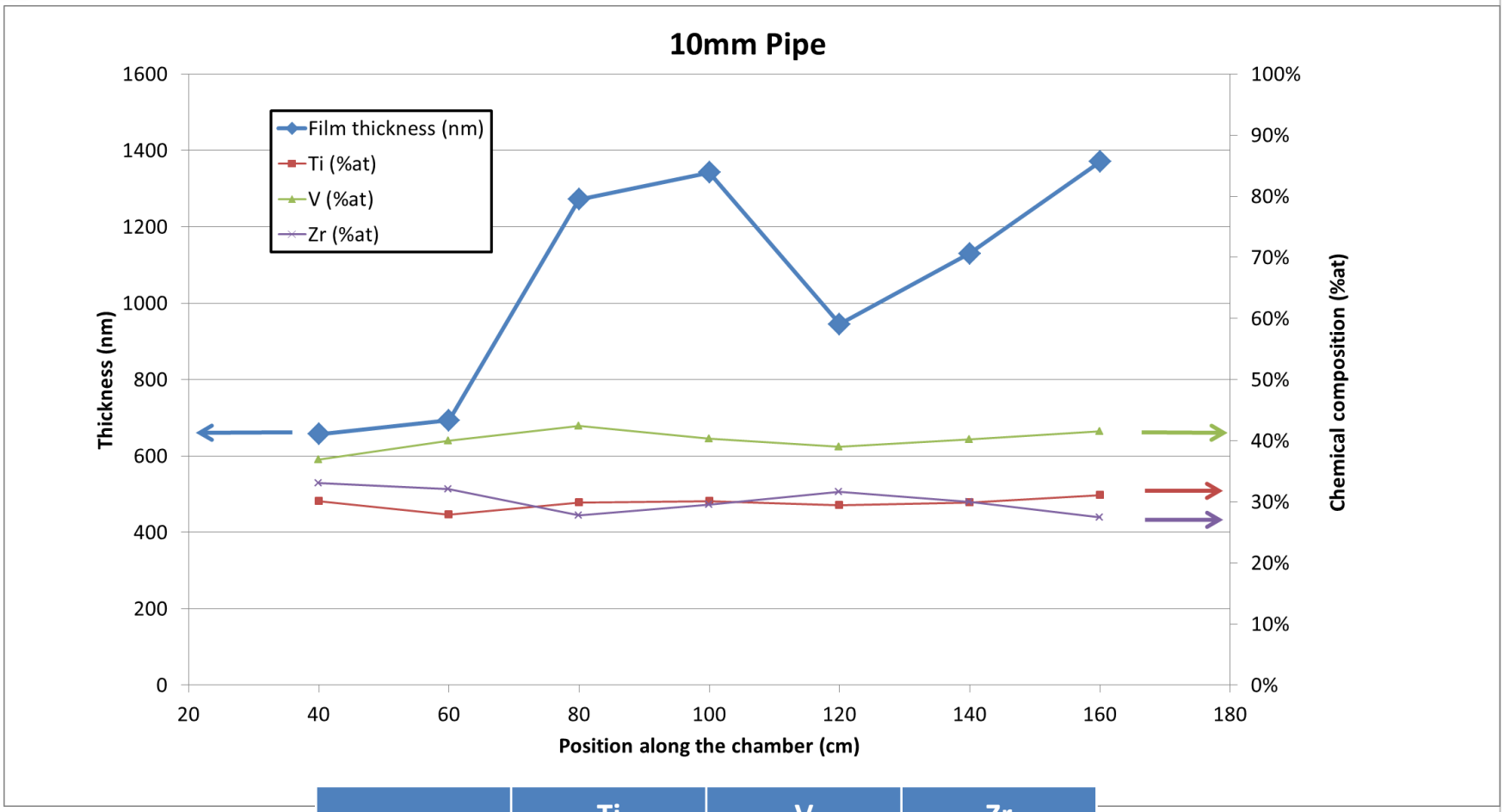
www.saesgroup.com

Small diameters pipes: 10mm

- Pipes lenght **2m**, internal diameter 10mm, stainless steel
- Plasma could be ignited without major issues and coating process was smooth with coating parameter recorded and stable
- The pipes were cut and opened and visually and SEM inspected to check for uniform presence of the film → Covered area: 100%
- Thickness measurement were carried out by EDS analysis



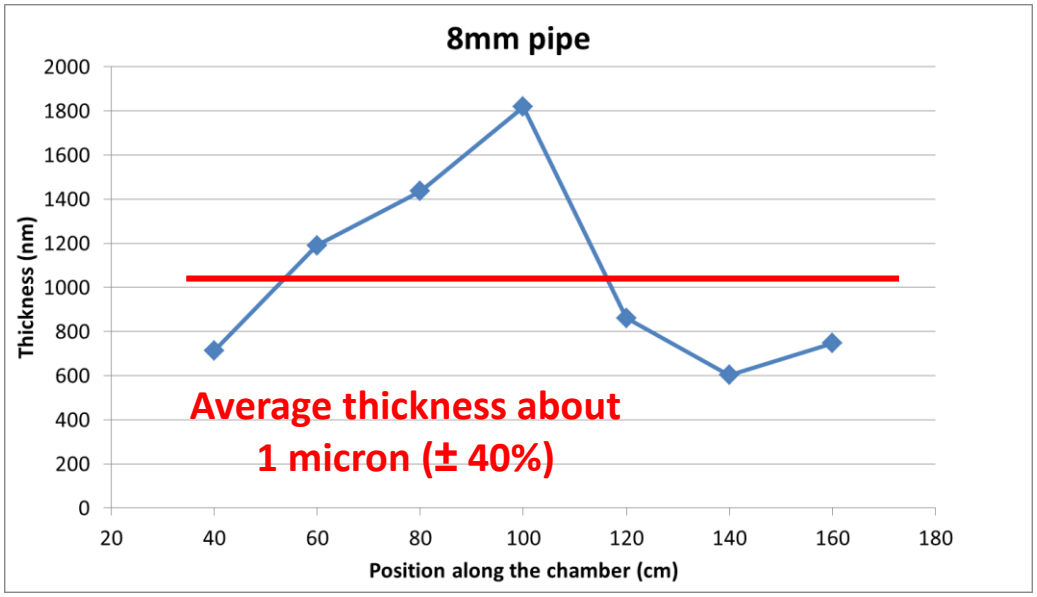
Small diameters pipes (10mm): chemical composition uniformity



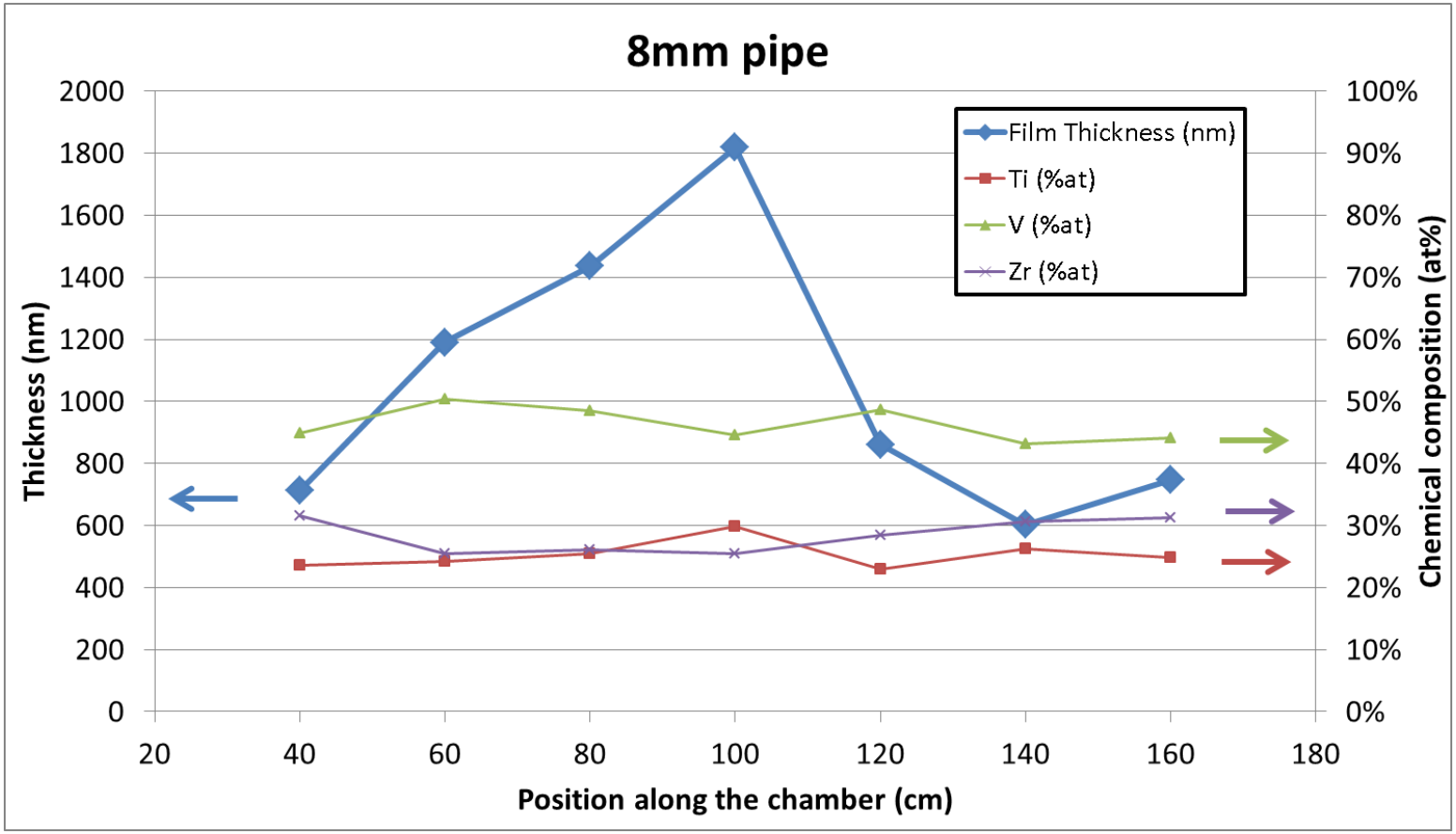
	Ti	V	Zr
Nominal composition	**30 %at**	**40 %at**	**30 %at**
Experimental Average	**29,8 %at**	**40,0 %at**	**30,2 %at**

Small diameters pipes: 8mm

- Pipes lenght **2m**, internal diameter 8mm, stainless steel
- Also in this case plasma ignited without issues and the coating process was smooth with coating parameter recorded and stable
- The pipes were cut and opened and visually and SEM inspected to check for uniform presence of the film → Covered area: 100%
- Thickness measurement were carried out by EDS analysis.

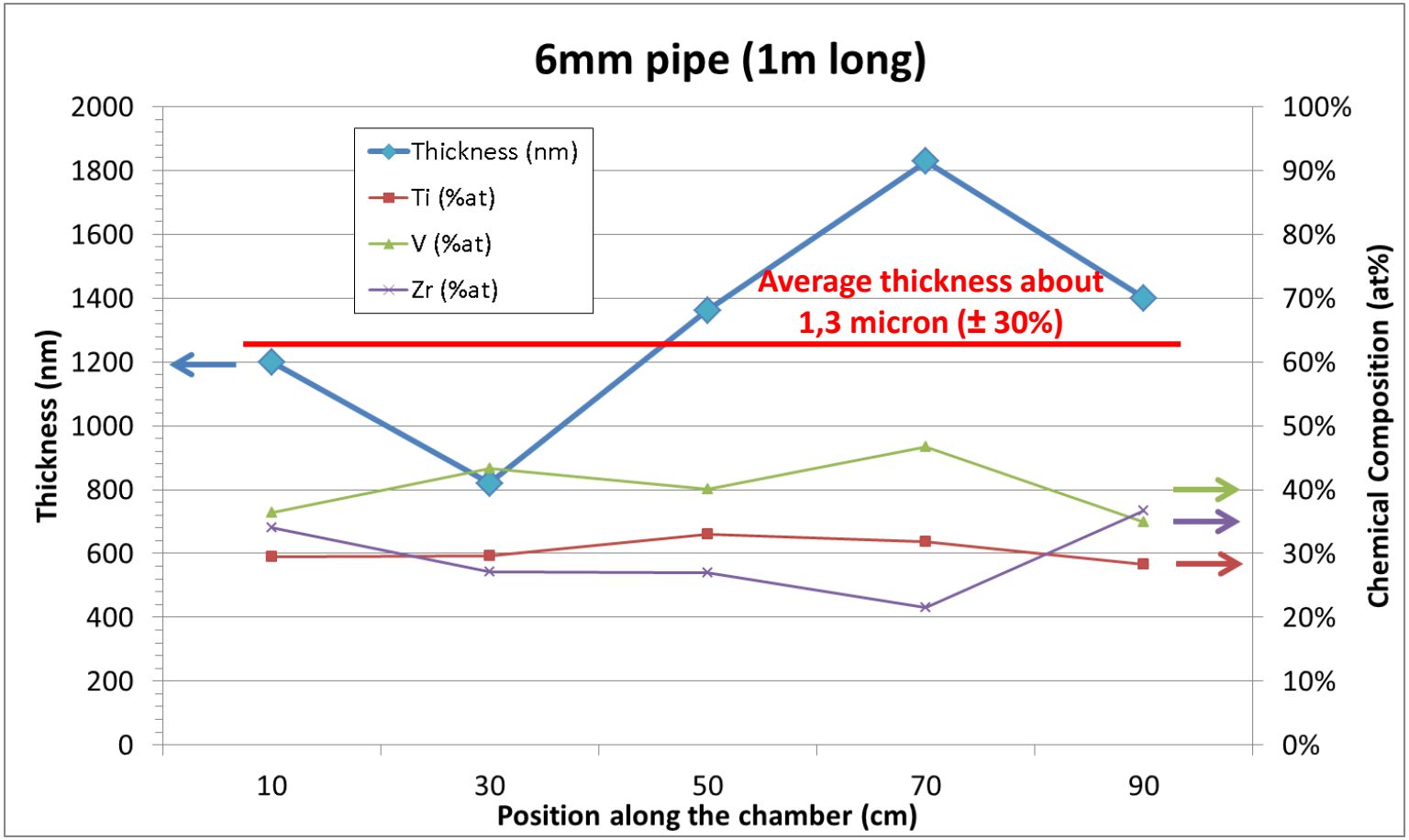


Small diameters pipes (8mm): chemical composition uniformity



	Ti	V	Zr
Nominal composition	**30 %at**	**40 %at**	**30 %at**
Experimental Average	**25,3 %at**	**46,3 %at**	**28,4 %at**

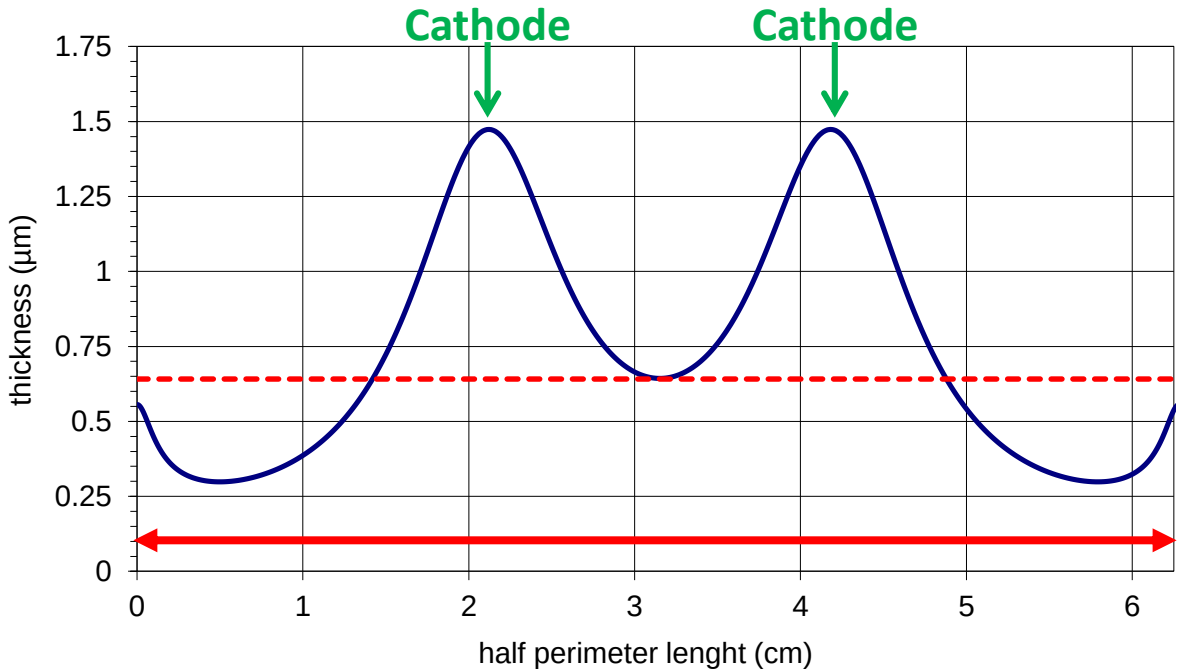
Small diameters pipes (6mm): chemical composition uniformity

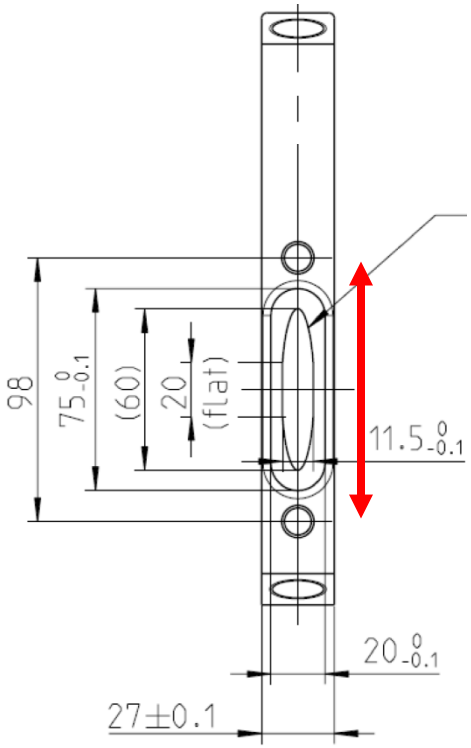


	Ti	V	Zr
Nominal composition	**30 %at**	**40 %at**	**30 %at**
Experimental Average	**30,5 %at**	**40,3 %at**	**29,2 %at**

Typical thickness variation in a narrow ID

- A typical thickness distribution is showed in the chart below for the ID section given in the picture.
- Average film thickness is about 0,6 micron, however thickness can move from a 0,3 micron minimum to a 1,5 micron high, depending on the area.
- This is unavoidable as there is no way to prevent sputtered atoms to deposit and grow a film closer to the emitting source (the cathode).
- Use of three cathodes can mitigate the issue and smooth somewhat the thickness distribution.





Typical thickness variation in a narrow ID