Technetics Group Presentation – UHV – Labs

October 14th 2016

ENGINEERED SOLUTIONS FOR DEMANDING ENVIRONMENTS®

Technetics GROUP

EnPro Industries companies

EnPro Industries

Sealing Products	Engineered Products	Engine Products & Services
Technetics Group	GGB Bearing Technology	Fairbanks Morse Engine
Garlock	CPI	
Stemco — A Higher Standard of Performance.™		

Revenue: $ 1.2 B (2015) / 6,200 employees / 37 primary manufacturing locations

Amounts shown include the deconsolidated operations of Garlock Sealing Technologies LLC and its subsidiaries

Technetics Group Overview

Locations: 13 global manufacturing locations

Employees: Over 1000 employees worldwide

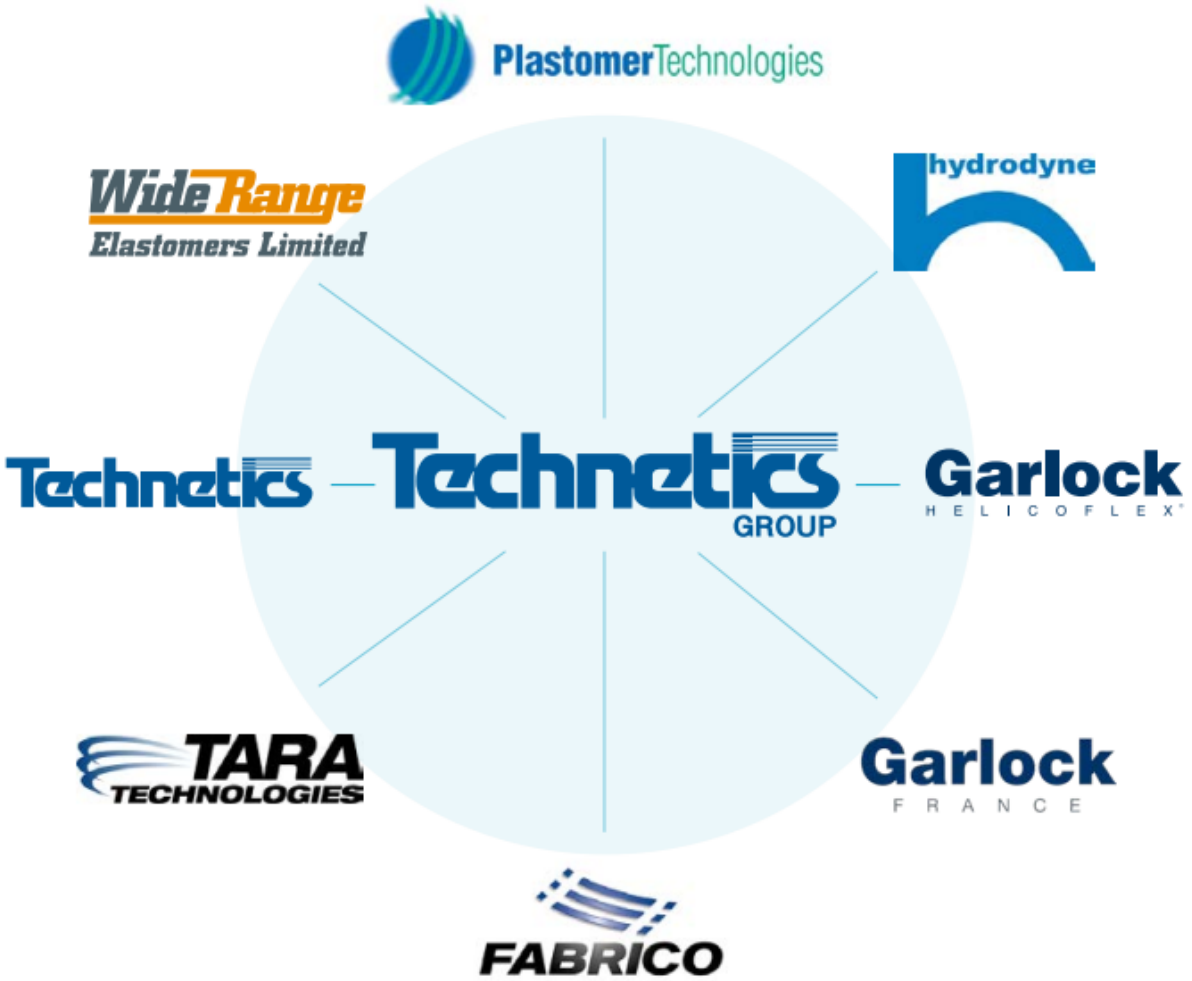
More than 115 engineers and technical sales persons

1 R&D center and 9 Laboratories

A coming together of the world's top-performing businesses…

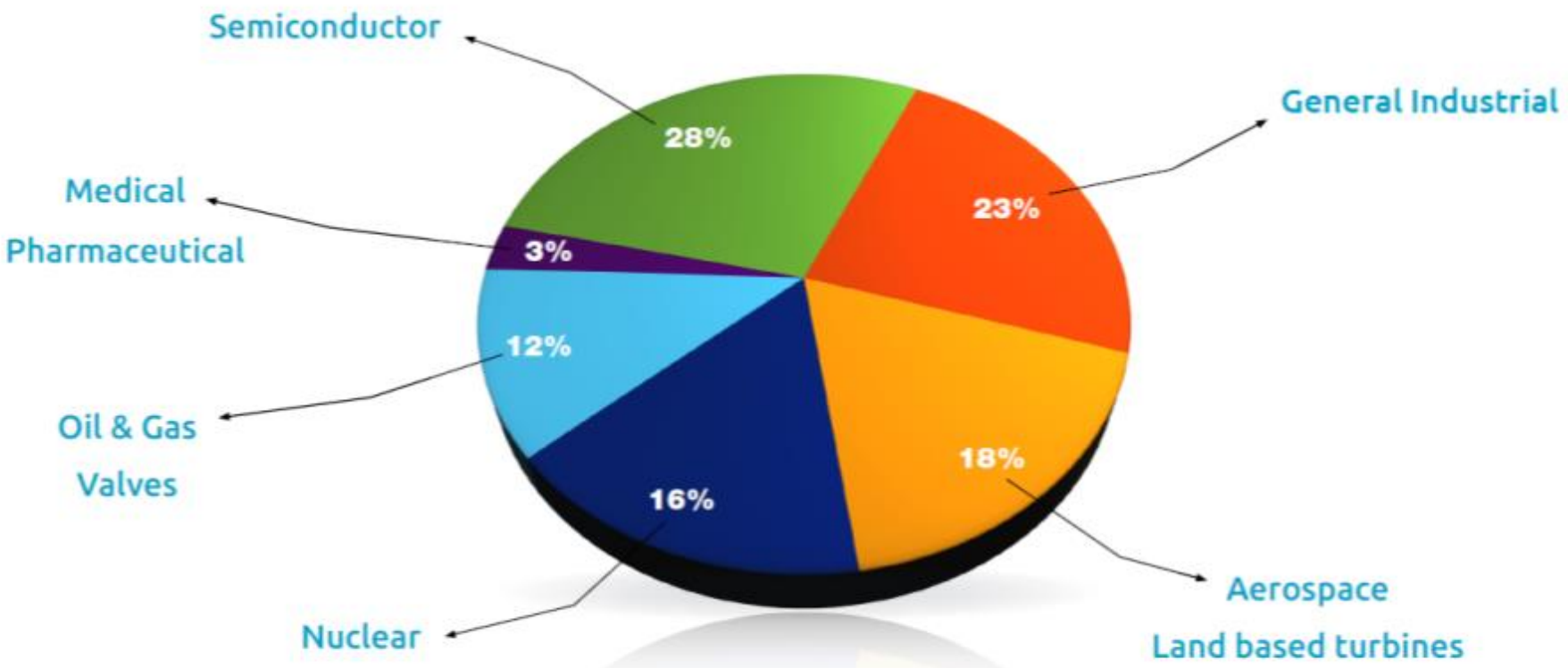
Technetics Group is the combination of eight of the world's best-known sealing and critical component design and manufacture businesses: Helicoflex, Garlock France, Tara Technologies, Technetics, Wide Range Elastomers, Plastomer Technologies, Hydrodyne and Fabrico.

Technetics Group brings together brand names that are used throughout the world in critical markets: HELICOFLEX® resilient metal seals, BELFAB® edge-welded metal bellows, FELTMETAL™ abradable seals and acoustic media, BIO-GUARDIAN® elastomer seals and ORIGRAF® graphite seals.



Technetics Group Overview

Sales per market



maestral® Sealing Laboratory

The laboratory that uses science to serve sealing

Collaboration between Technetics Group & CEA since 1969

SEALING LABORATORY MISSIONS

- **QUALIFICATION:** Simulation of actual working conditions in order to qualify sealing solutions in specific environment.
- **CHARACTERISATION:** Fundamental tests aiming at understanding in detail the seal behaviour.
- **EXPERTISE:** Physical, mechanical and numerical analysis aiming at understanding sealing mechanisms or at explaining failure.
- **DEVELOPMENT:** Complete projects utilizing all equipments and resources to design, characterize and qualify new products.

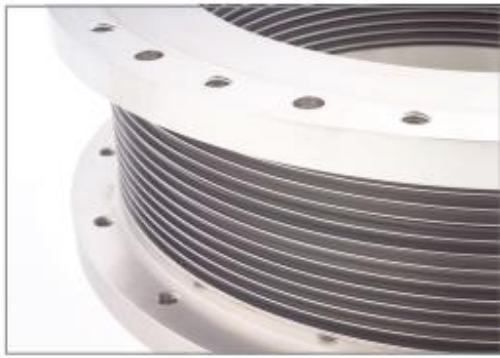
Equipment

Hydraulic presses *(up to 2500kN)*
Ovens and furnaces *(up to 1100°C/2012°F)*
Test benches
Gas booster pressure unit *(2000 bar)*
Measuring instruments & data acquisition systems
(measurement column, computer-controlled microscope, microdurometer, helium-mass spectrometers, 3D laser profilometer)
CAD-CAM design tools, finite elements calculation, 3D simulation

Technetics Products in UHV & Cryogenic (Labs)

- Metals seals
  - HELICOFLEX®
  - CF
  - Machined
- Elastomer seals
- Quick Connection Systems (QDS®)
- Bellows



Typical UHV & Cryogenic Sealing Problems

- Aluminum flanges / Dissimilar materials
- Light weight flanges / Insufficient bolting
- High temperature bake out
- Cryogenic temperatures
- Odd shaped chamber - port
- Large chamber - port
- Outgassing / Permeability
- Virtual leaks
- Radio Frequency (RF) compatible

Metal Seal Selection

Application Information	SEAL TYPE					
						
	Helicoflex®	Delta®	O-Flex™	C-Flex™	E-Flex™ U-Flex™®	Machined Seal®
Ultra High Vacuum	●	▲▲	■	■	■	▲
Low Pressure	▲▲	●	▲	▲	▲	▲
High Pressure	▲▲	■	▲	▲▲	●	▲
Cryogenic Temperature	▲▲	▲	●	●	●	■
High Temperature	▲▲	▲	▲	▲	▲	■
Spring Back	●	●	●	▲	▲▲	■
Shaped Seals	▲	▲	▲	●	■	■
Axial Sealing	▲	■	●	▲	■	■
QDS Compatible	▲	▲	■	■	■	■
Seating Load	High	Moderate	High / Moderate	Moderate / Low	Low	High / Moderate
Leak Rate Approximation	Helium	Ultra-Helium	Helium / Bubble	Helium / Bubble	Low Bubble	Helium

Leak Legend	Approximate Leak Rates per meter of circumference
Ultra-Helium	≤ 1 x 10^{-11} std.cc/sec He
Helium	≤ 1 x 10^{-9} std.cc/sec He
Bubble	≤ 1 x 10^{-4} std.cc/sec He
Low Bubble	≤ 25 cc/sec @ 0.345 MPa Nitrogen per 25.4 mm of diameter

Actual leak rate in service will depend on the following:

Seal Load: Wall Thickness or Spring Load

Surface Finish: Seal and Cavity

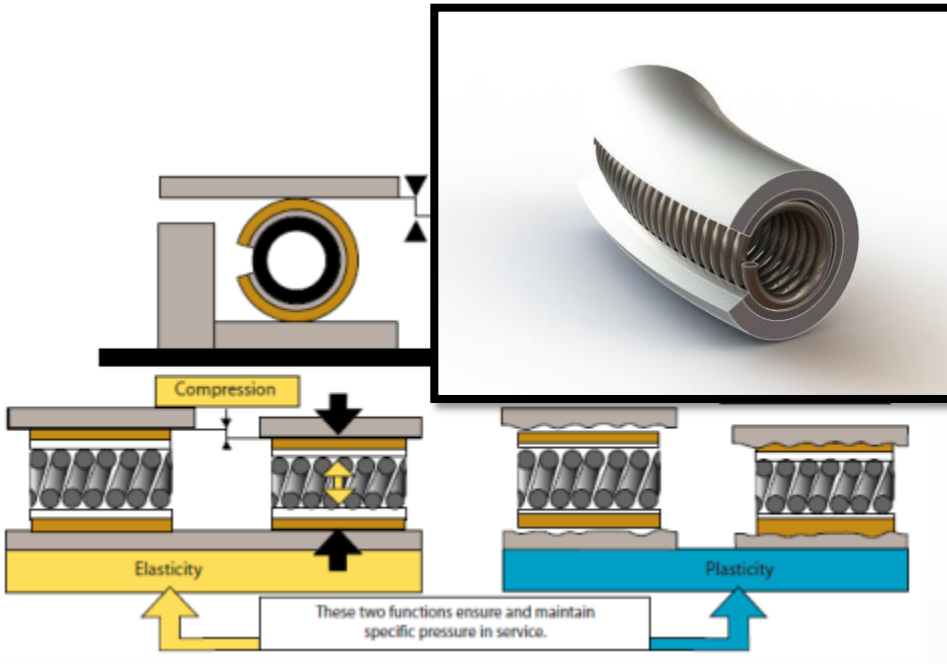
Surface Treatment: Coating/Plating/Jacket Material

Application Legend	
Recommended - Excellent	▲▲
Recommended - Good	▲
Optional - Special Design	●
Not Recommended	■

HELICOFLEX® Principle

The sealing principle of the HELICOFLEX® family of seals is based upon the plastic deformation of a jacket of greater ductility than the flange materials.

This combination of elasticity and plasticity makes the HELICOFLEX® seal the best overall performing seal in the industry.



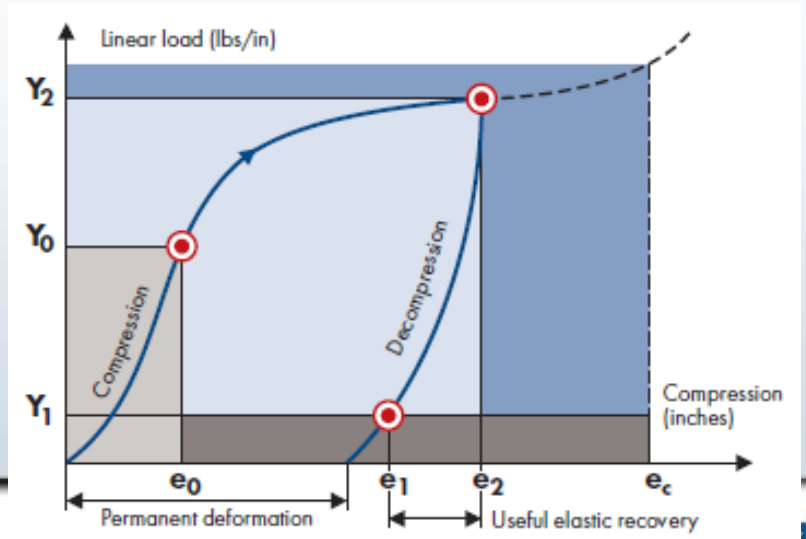
Y_0 = load on the compression curve above which leak rate is at required level

Y_2 = load required to reach optimum compression e_2

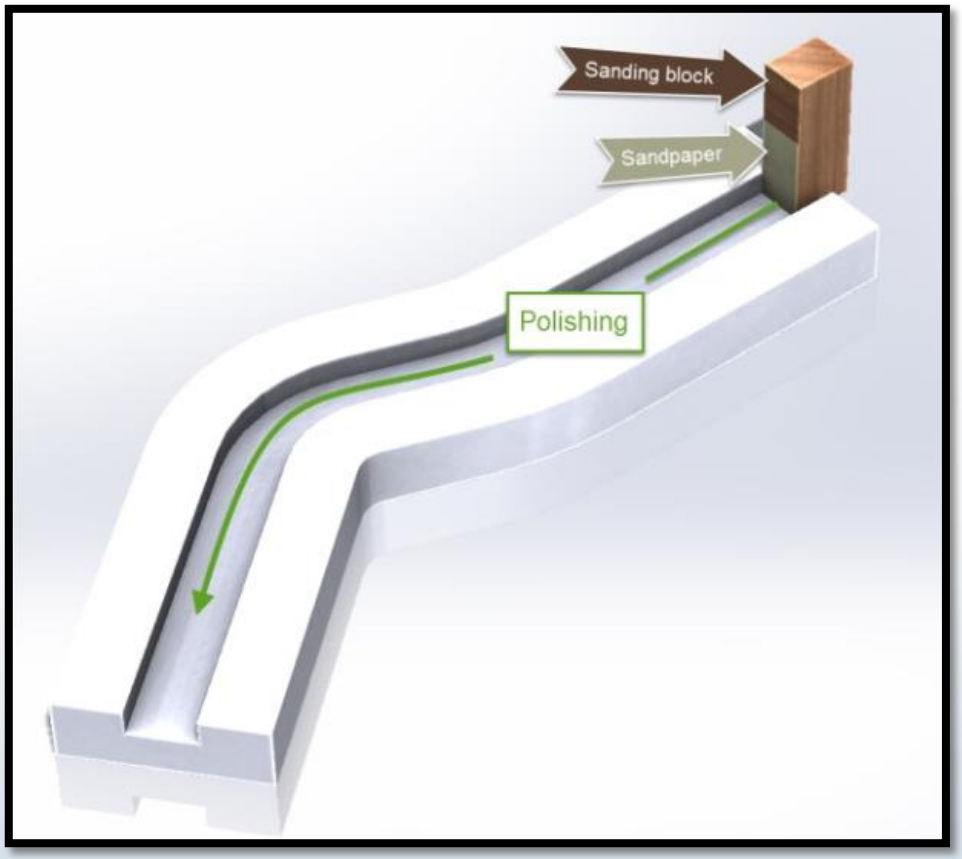
Y_1 = load on the decompression curve below which leak rate exceeds required level

e_2 = optimum compression

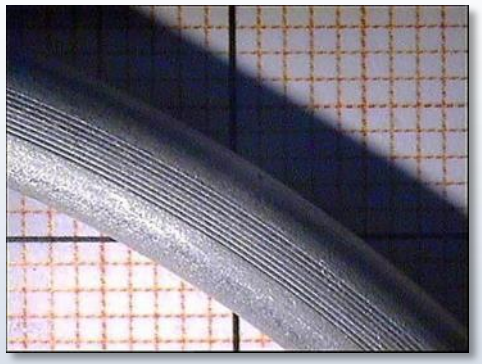
e_c = compression limit beyond which there is risk of damaging the spring



HELICOFLEX® Seal: Performance



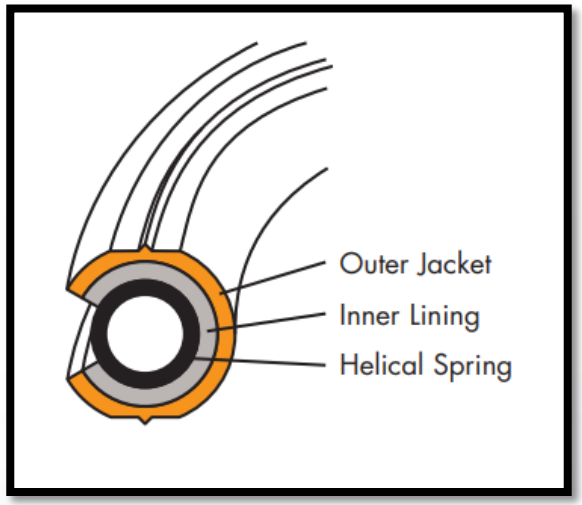
Poor Flange Finish:
Radial Marks



Good Flange Finish:
Concentric Marks

DELTA® Seal: Performance

- DELTA® seals can provide Helium leak rate performance of $< 1 \cdot 10^{-11}\ \mathrm{mbar} \cdot \mathrm{L} \cdot \mathrm{s}^{-1}$ (per meter of seal circumference)
- Actual leak rate will depend on seal jacket, cavity/flange finish, bolting, hardware robustness and cleanliness level
- Aluminum jacket: seals well on Aluminum flanges
  - Ex: Flange = 6061 with T6 Heat Treatment
  - Min Flange Hardness: 65 HV

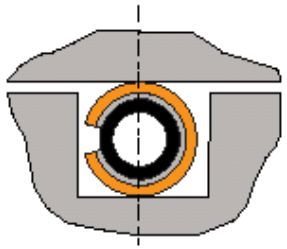


Dimensions:	(Ø 3.8 to Ø 2000mm)
	Ø 0.150 in. to Ø 80 in.
Temperature:	- 272 to 700°C
	- 458 to 1292°F
	+1.8 to 973°K
Helium sealing level:	$Q \leq 10^{-13}$atm cm^3 s^{-1}
Seal Classification Type:	HNV

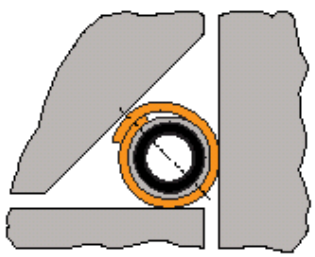
HELICOFLEX® Assembly Possibilities

TYPICAL CONFIGURATIONS

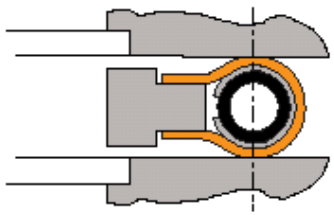
HN200
Groove assemblies



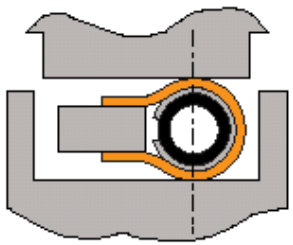
HN240
3 face compression



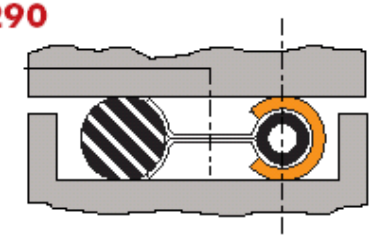
HN208
Raised face flanges - ANSI B16.5



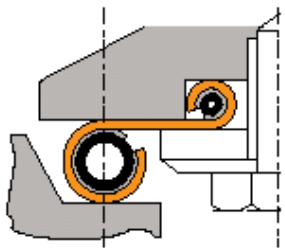
HN203
Tongue & groove



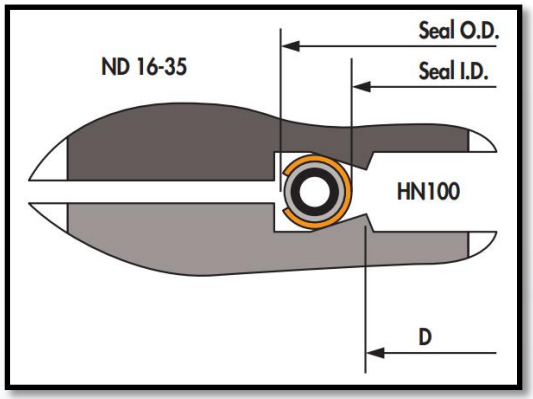
HNDE290
Leak check - inert gas purge

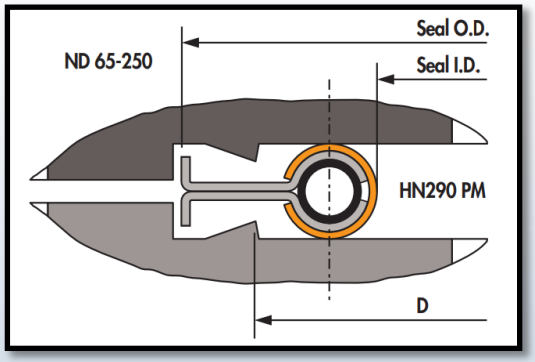


HND229
Valve seats

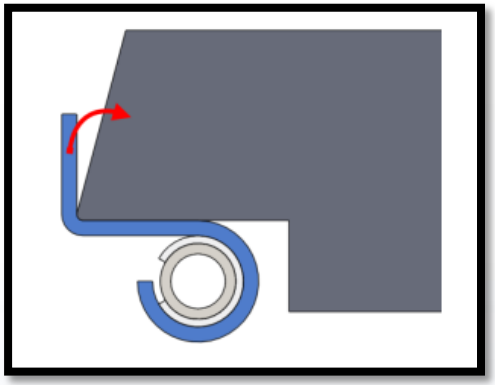


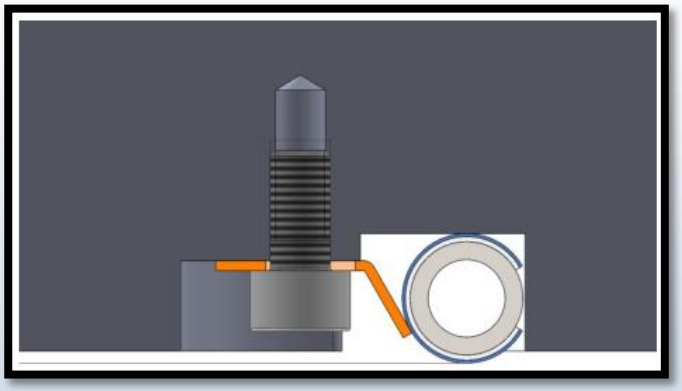
Also as CF Flange Upgrade

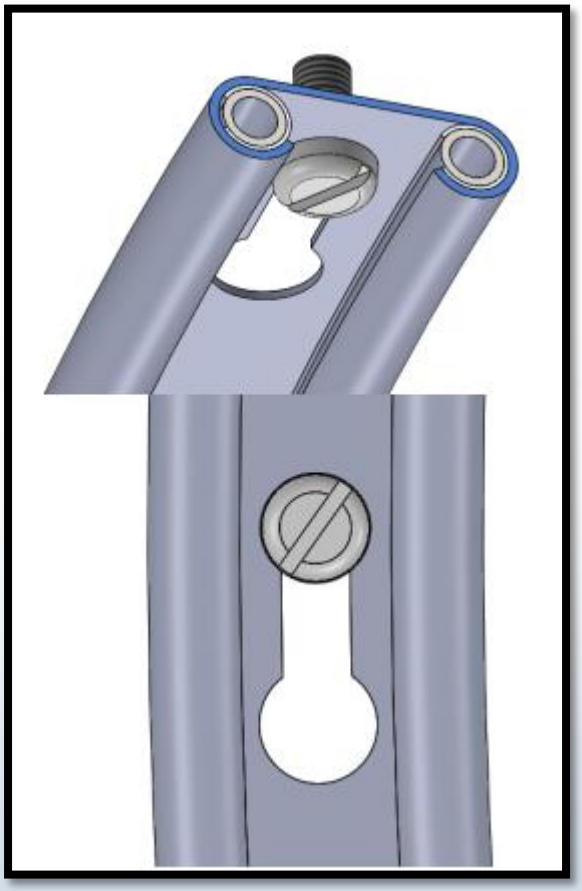




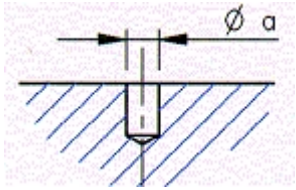
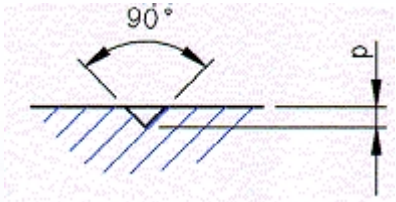
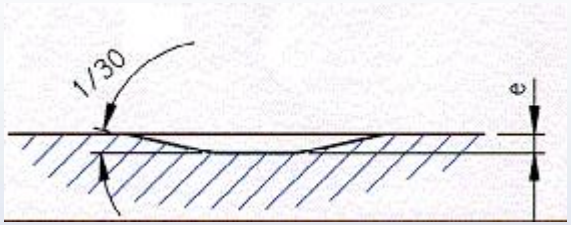
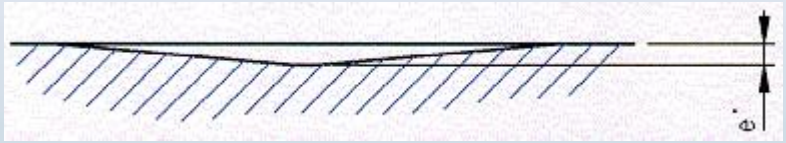
HELICOFLEX® Fixing systems





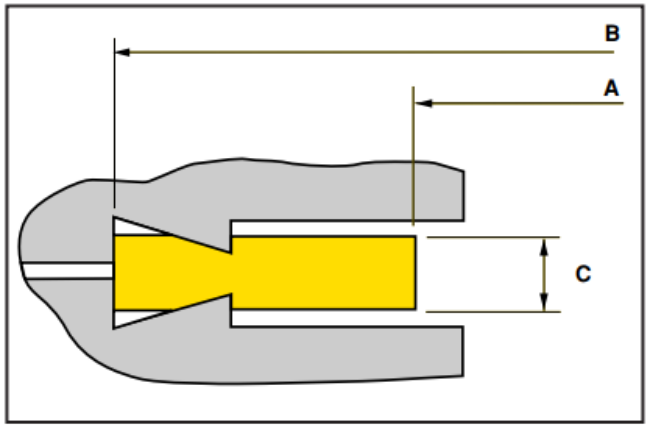


Surface defects

		Torus *Ø12,7mm*	*Ø2,5mm*
• Stitching		OK <= Øa=2,7mm	
• Scratch		<= p=0,18	
• Local		<= e=0,28	
• Wide		<= e'=0,56mm	0,05mm

Copper Flat Seals for CF Flanges

- Cost-effective solution in UHV application unless
  - Too high temperature transient
  - Too big dimensions
  - No shape seal possible
  - High load required
  - Damaged flanges



ND	Dimensions mm A B C	Code
16	16,2 x 21,3 - 2	157414
25	25,4 x 32,8 - 2	157447
35	36,8 x 48,1 - 2	157413
36	39,2 x 48,1 - 2	157412
50	50,8 x 61,6 - 2	157452
63	63,6 x 82,4 - 2	157435
64	72 x 82,4 - 2	157436
75	76,2 x 91,4 - 2	157453
100	101,7 x 120,4 - 2	157454
125	127 x 141,4 - 2	157437
150	152,5 x 171,3 - 2	157455
200	203,3 x 222,1 - 2	157456
250	254 x 273 - 2	157438

Note: Other dimensions available on request.

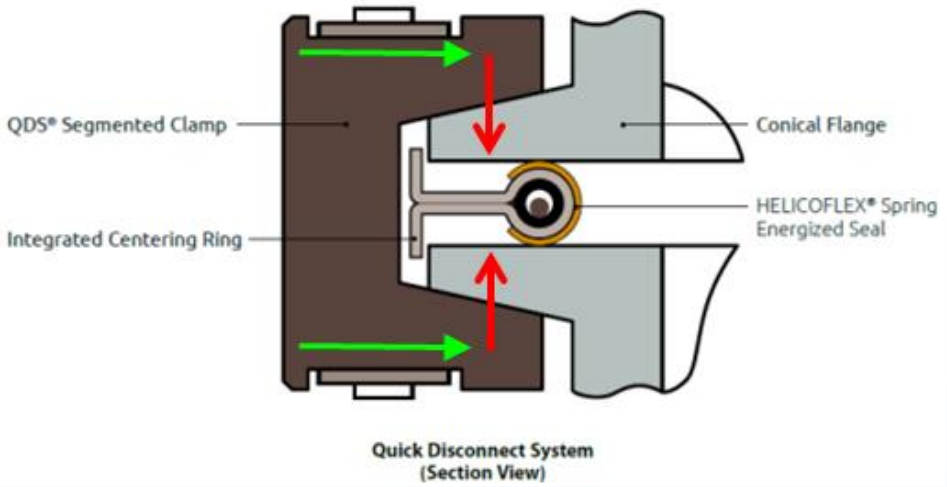
Typical ISO KF System

- **Typical UHV KF clamps are NOT strong enough to compress HELICOFLEX® seals (High seating Load)**
- **QDS clamp and HELICOFLEX® seals can be used with standard ISO KF or PNEUROP flanges.**
- **QDS system**
  - Higher temperature
  - No outgassing
  - No permeation
- **ISO Compatible QDS series**
  - Class 150
  - Class 300

Sizes: KF10 – KF50

QDS Quick Disconnect System

- **Class 150 - Standard**
  - Aluminum clamp segments
  - Non magnetic
  - Vacuum and ultra-vacuum applications
  - Limited to 200°C
  - **Compatible with ISO KF flanges**
- **Class 300 - Standard**
  - Stainless steel clamp segments
  - Carbon steel screw (Stainless on request)
  - Vacuum and low pressures
  - Adapted to metal seal soft jackets
    - Aluminum, Silver, Copper
  - Usable up to 300°C
  - Cryogenic temperatures: < 1.8° K
  - **Compatible with ISO KF flanges**



Quick Disconnect System
(Section View)

Machined Seals

- All metal – Designed to Have Spring Back
- Ideal for Small Diameters
- Typical Materials
  - Aluminum
  - Nickel
  - Stainless Steel
- Retainer Assembly
  - Can hold multiple seals
  - Easy installation

Typical UHV Applications

Particle Accelerators

- Beam tube connections
- Target chambers
- RF Connections
- Cryogenic (Superconducting)

Fusion Reactors/Devices

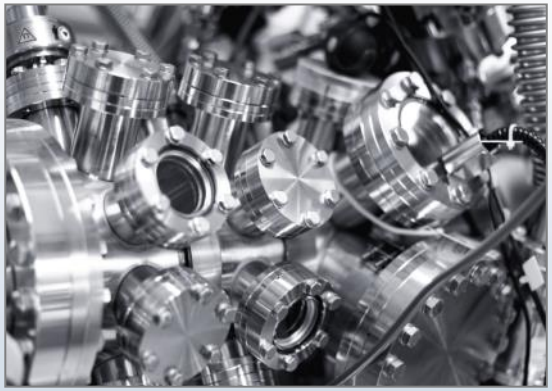
- Chambers
- Pumping
- Neutron beam injection

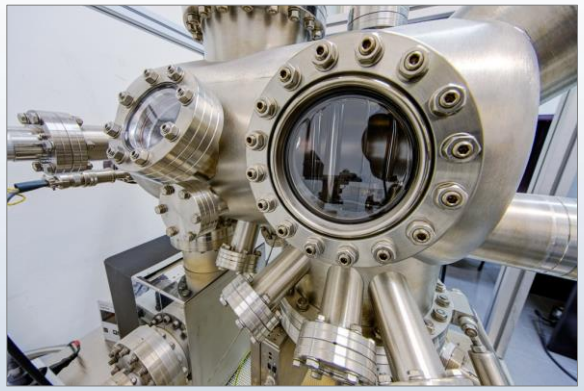
Physics – Nuclear & Med Research

- Custom shapes/chambers
- Target chambers
- RF Connections

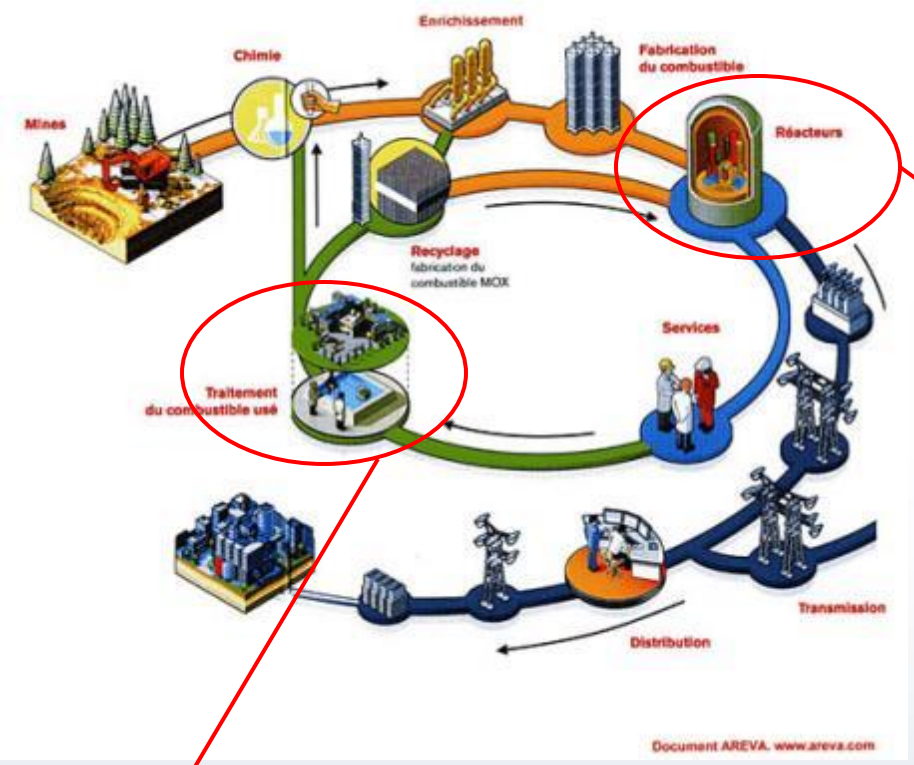
Semiconductor

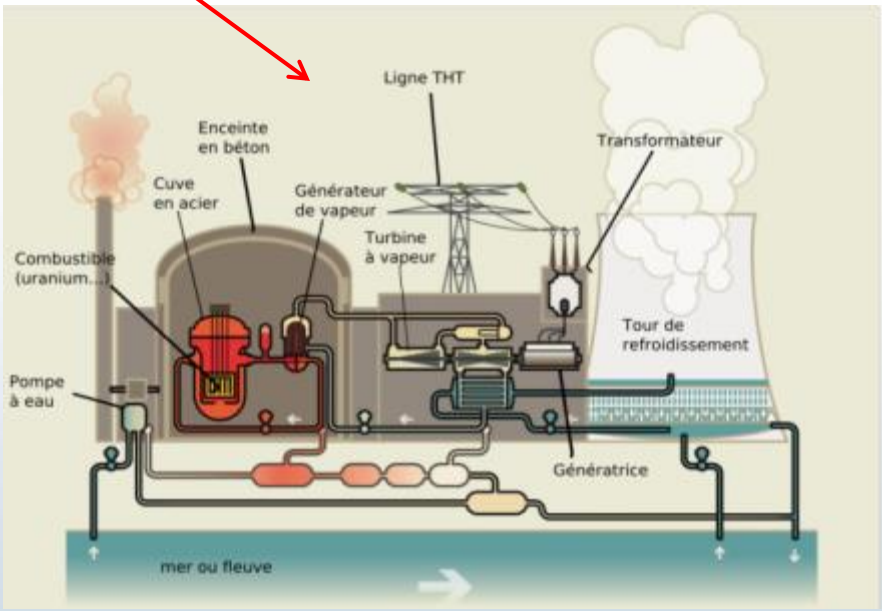
- PVD Chambers
- Cluster tools, Valves





Technetics Group is involved all along the Nuclear cycle… From Production to Recycling.



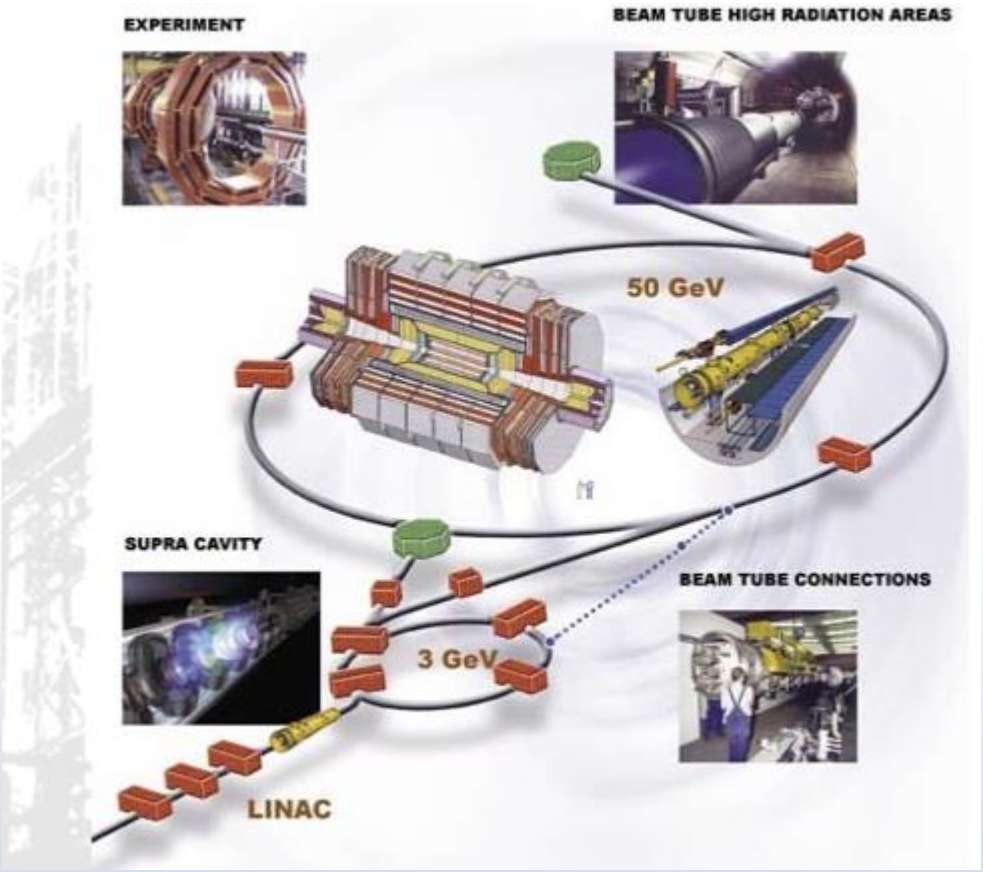


Reprocessing and storage

- Areva NC reprocessing plant
- Reprocessing research
- Cask containers for storage

(300-years simulation ongoing)

R&D Labs: Particles Accelerators



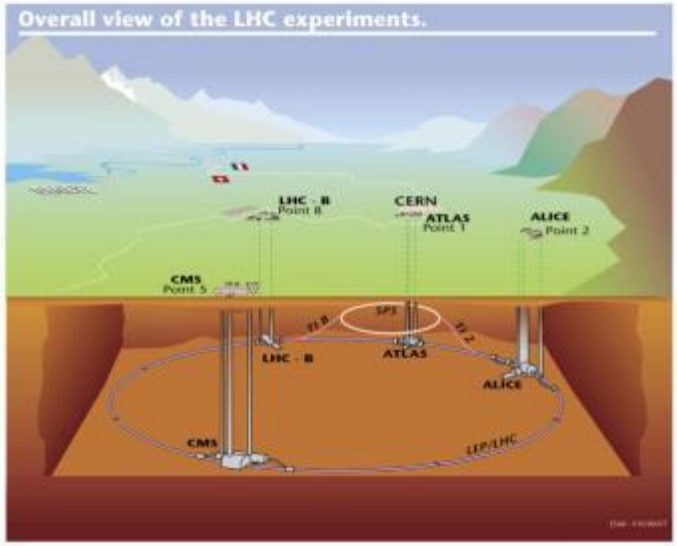
Main projects

- LHC / CERN (Switzerland)
- B-Factory (Japan)
- J-Park (Japan)
- Fair (Germany)
- US/DE Universities
- …

R&D Labs: CERN LHC

- 52 000 HELICOFLEX® seals in multiple configurations
- 6 000 quick-disconnect systems
- 70 000 of the more standard CF seals (OFS copper)

- Cryogenic applications: 1,6 K - supercritical Helium systems
- Sealing performance: $< 10^{-11}$ mbar · L · s^{-1}.
- Large rectangular sizes of over 2m length



600mm Quick Disconnect System on Beam Dump

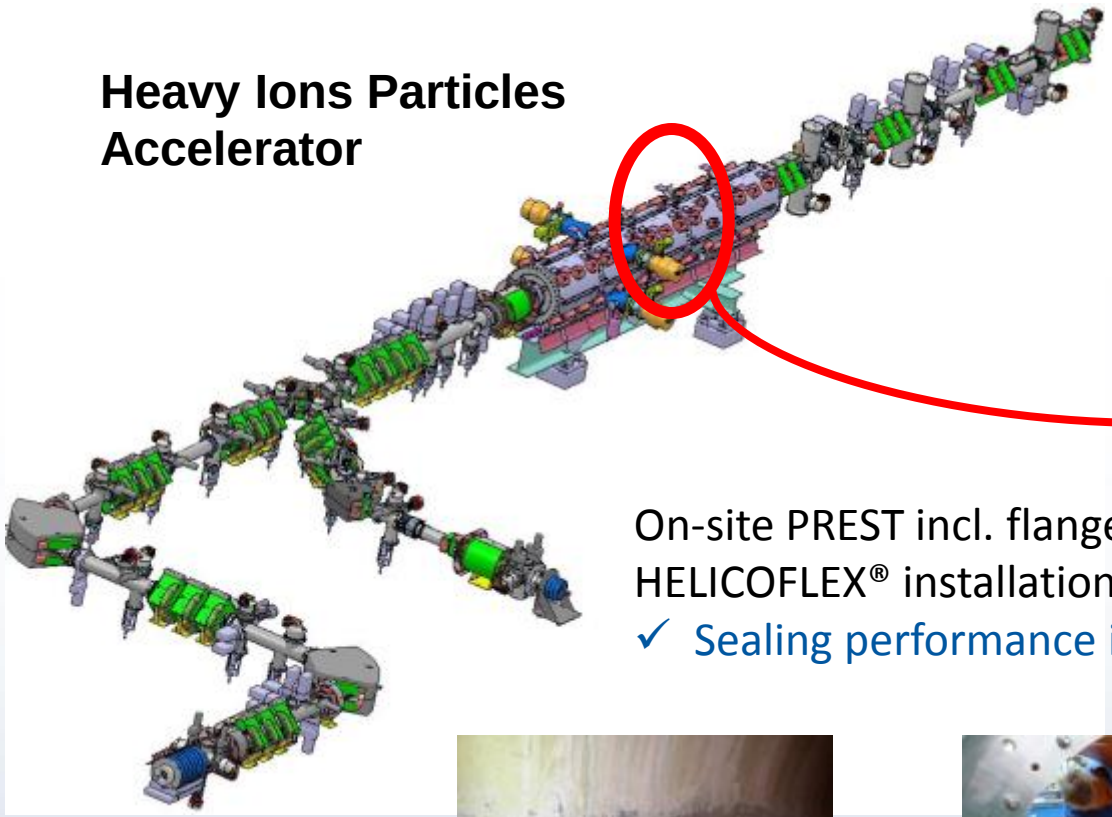
Partial view of the 17 miles-long racetrack

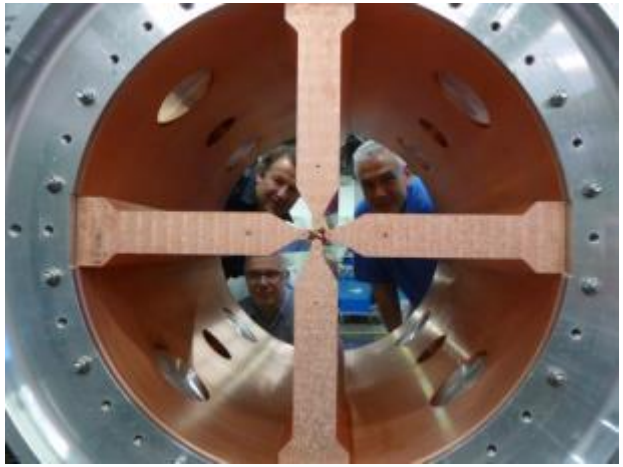
LHC : collider expected to accelerate protons to energies of seven trillion electron volts, smash them together, recreating conditions in the primordial fireball only a trillionth of a second after the Big Bang

March 2013: CERN discovers Higgs Boson particle, purpose of LHC construction

R&D Labs: GANIL Spiral 2

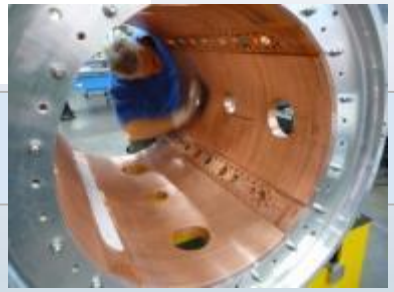
Heavy Ions Particles Accelerator

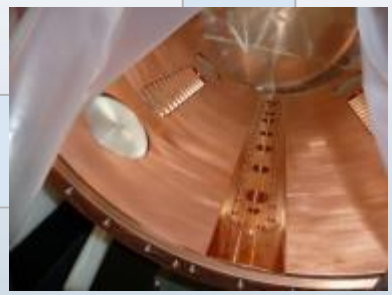




On-site PREST incl. flange polishing and HELICOFLEX® installation

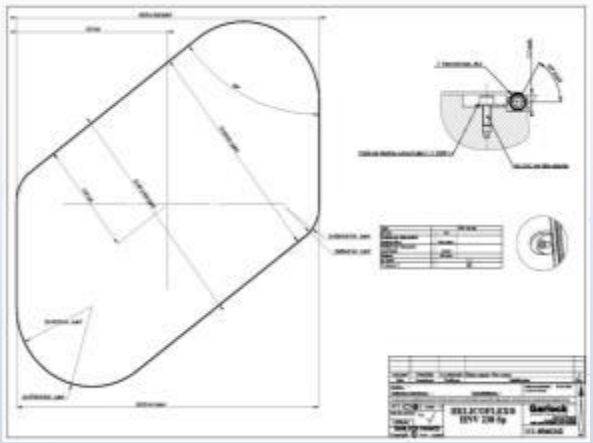
✓ Sealing performance increased by 30%



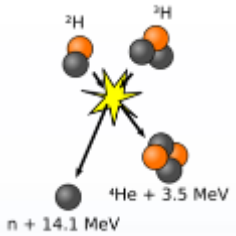


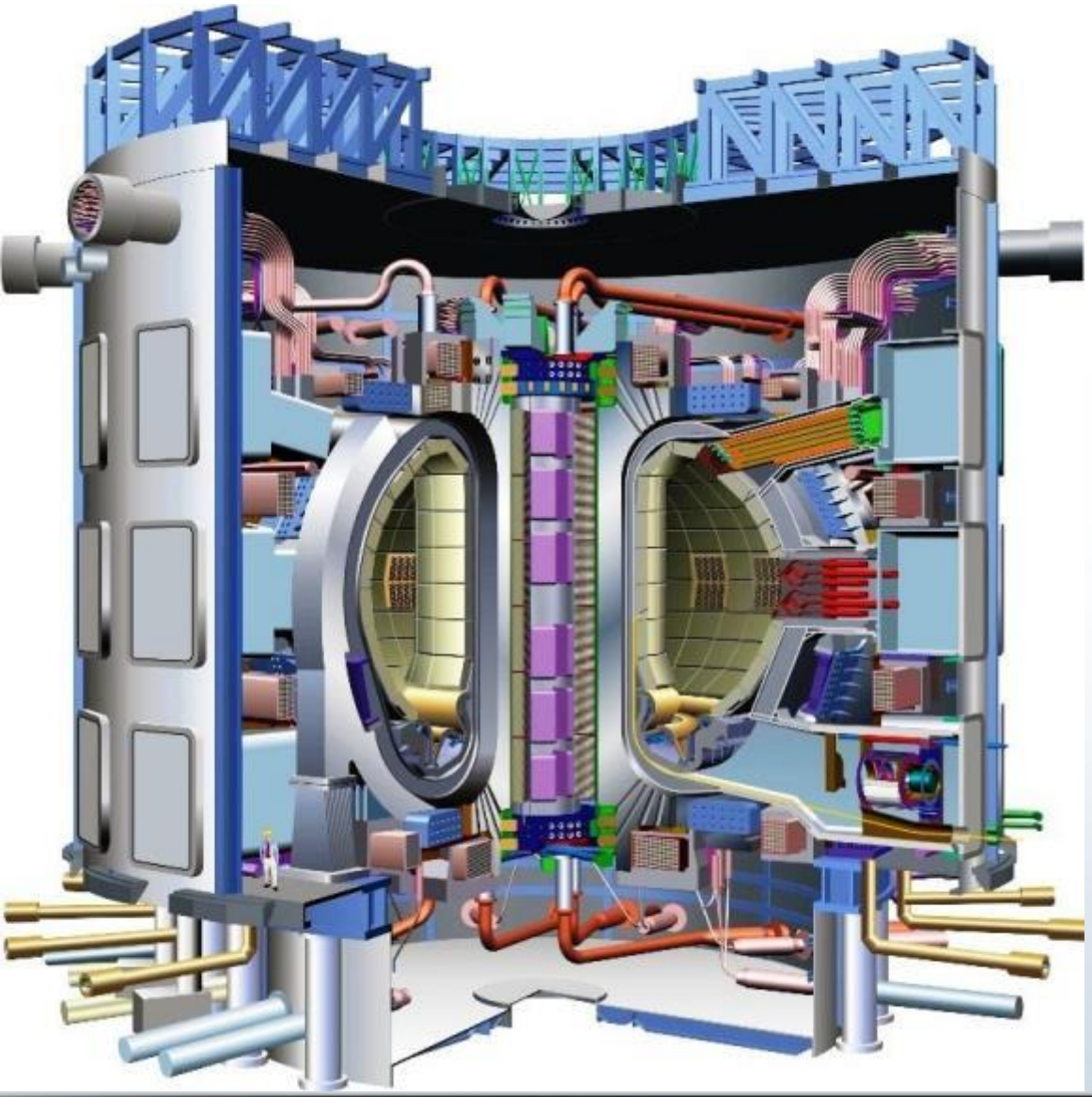
R&D Labs: Laser Mega Joules

- Nuclear fusion simulation laboratory, to avoid “real” nuclear tests
- Delivered
  - Complex design shaped Helicoflex
  - Silicone seals : Special compound developed with CEA
  - On-site PREST



Target:
Deuterium 0,4 mg +
Tritium 0,6 mg

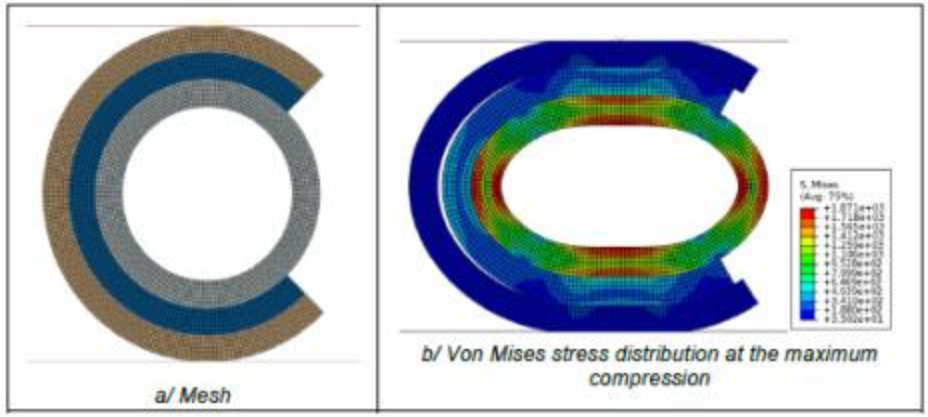


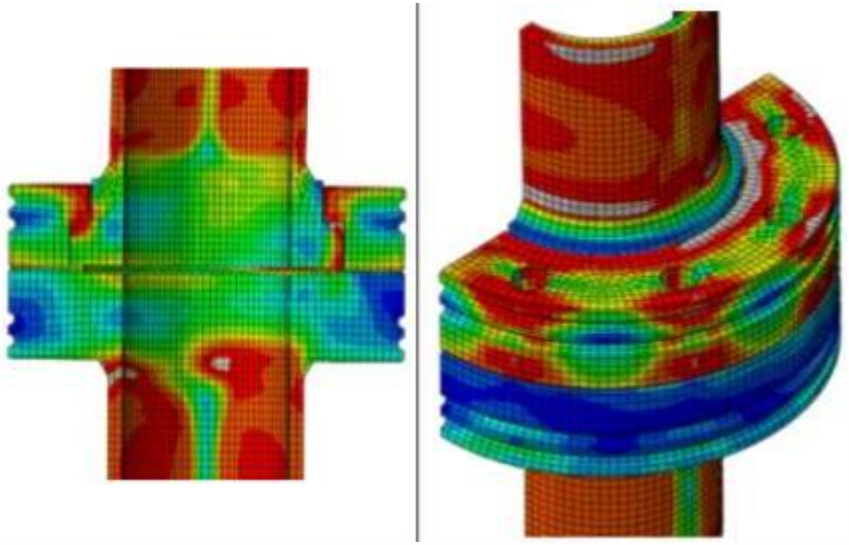


ITER Project Update

Vacuum Section Update

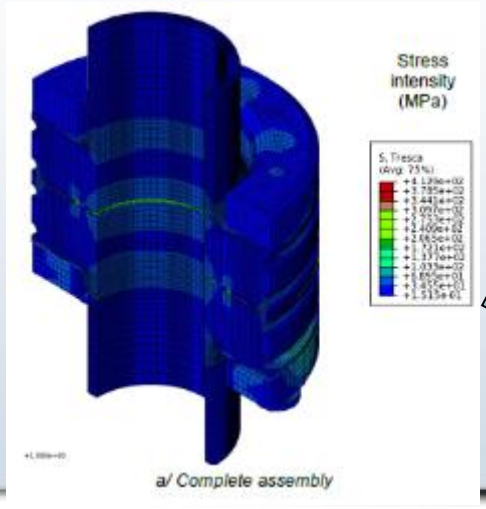
- Finite Element Analysis (FEA)



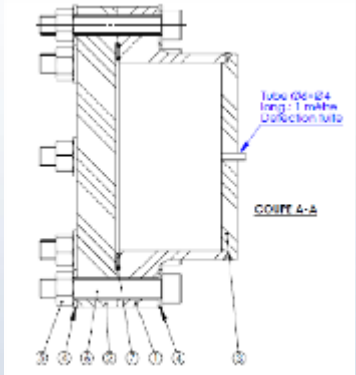


Bending Simulation

- Vacuum Flanges Design, Validation and Testing

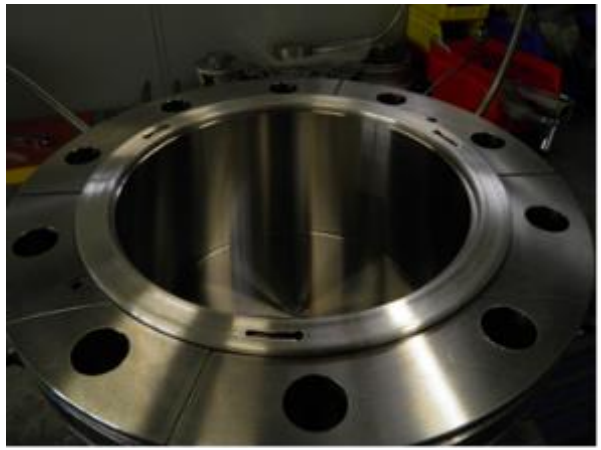


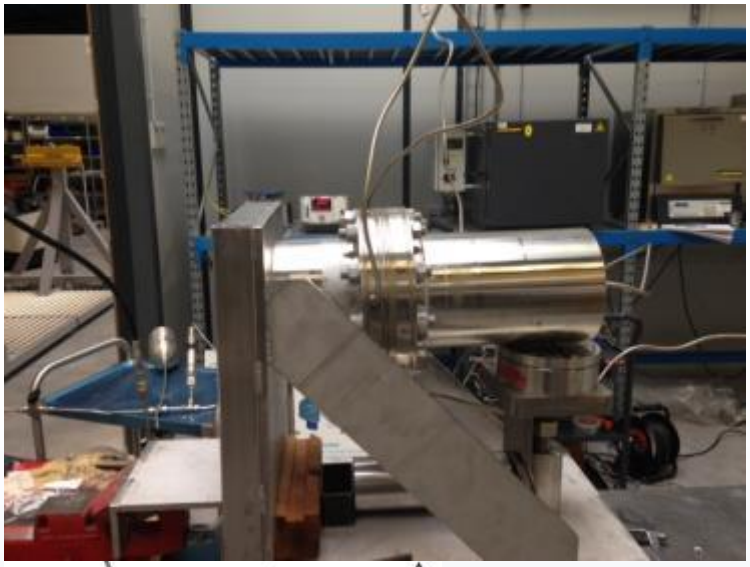
Design

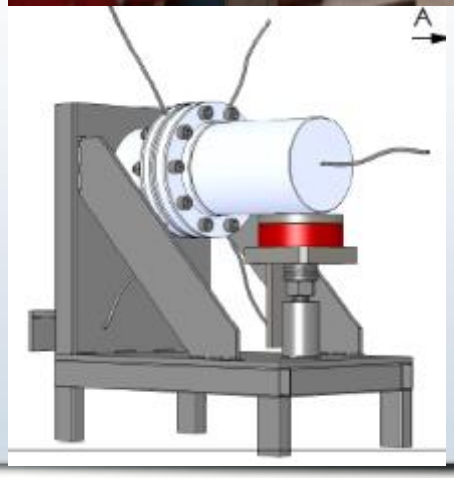


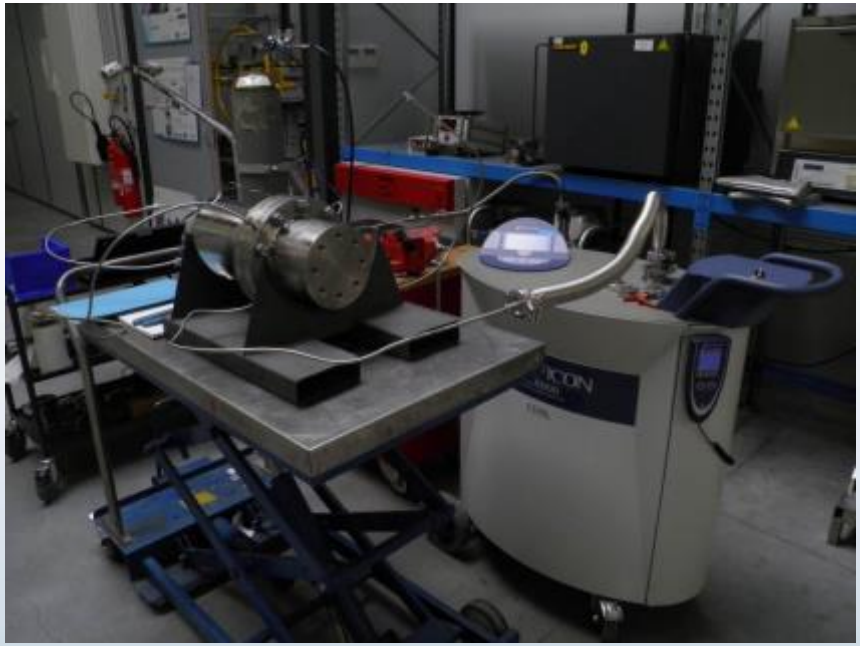
Testing

Vacuum flanges Phase II









Project: NBI front end Components

- HELICOFLEX® design improvement allowing **advanced remote handling** solution
- Possibility to duplicate design to other ITER application

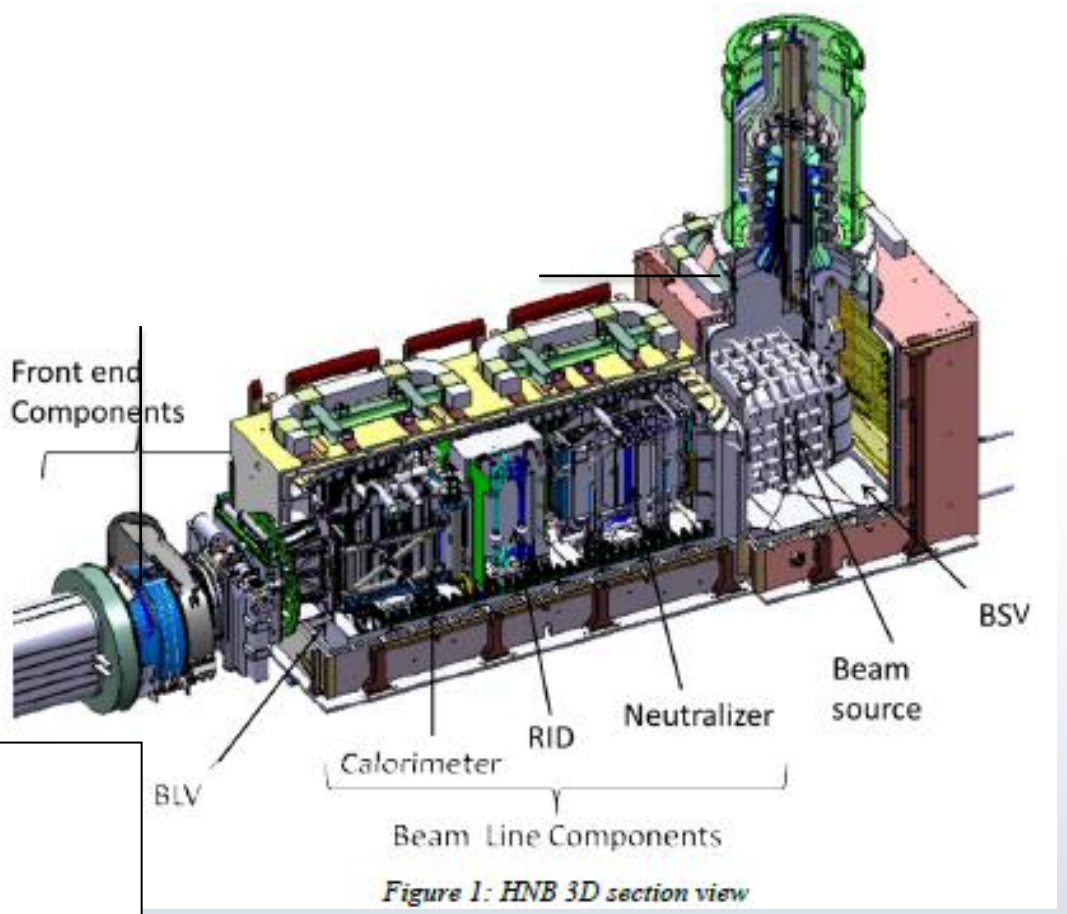
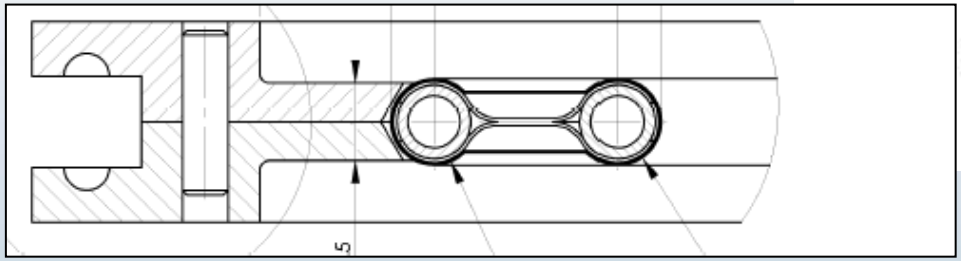
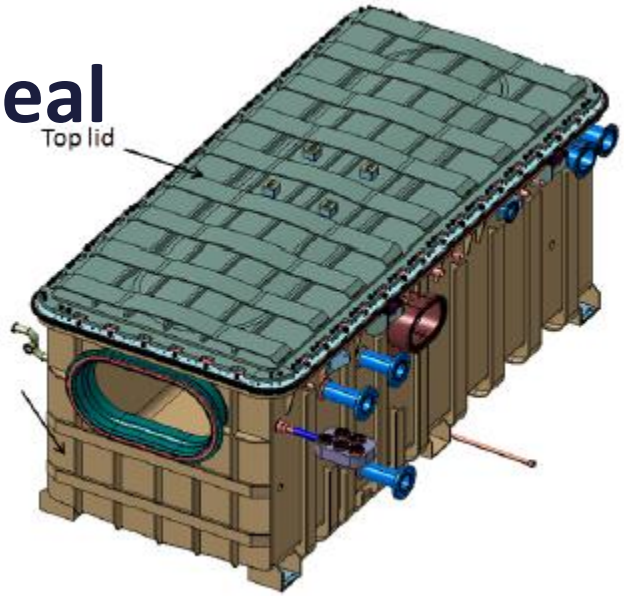


Figure 1: HNB 3D section view



Challenging Project: NBI top lid seal

- R&D contract signed 42 k€
- Unknown HELICOFLEX® **scale (9m x 3m)**
- Challenging manufacturing process
- Mock-up under process



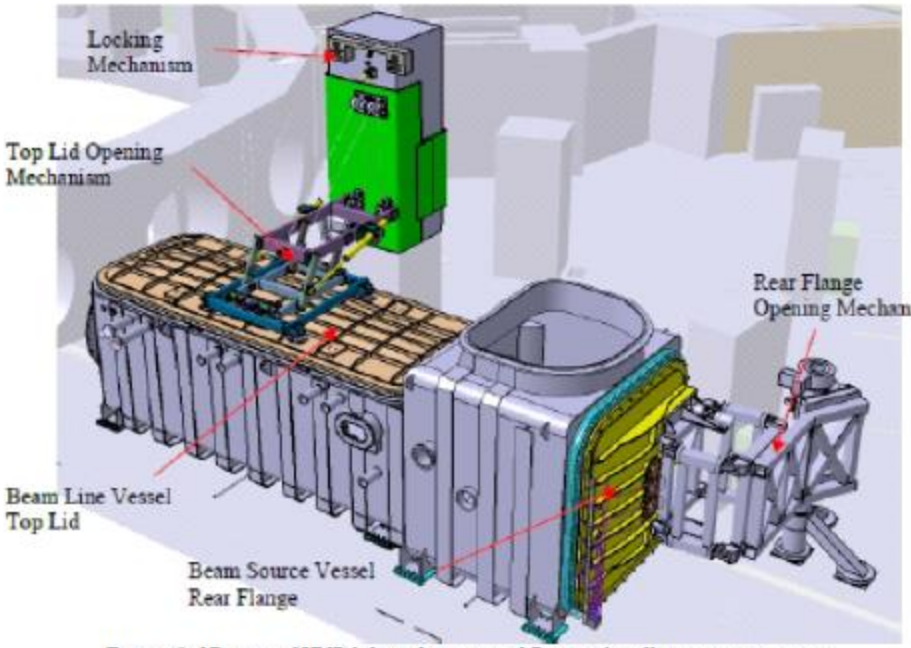
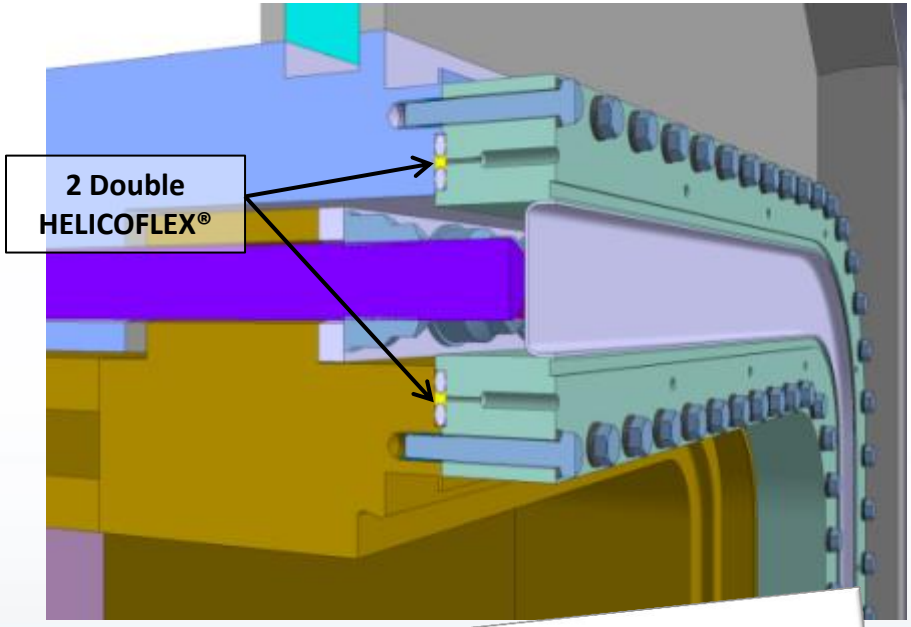


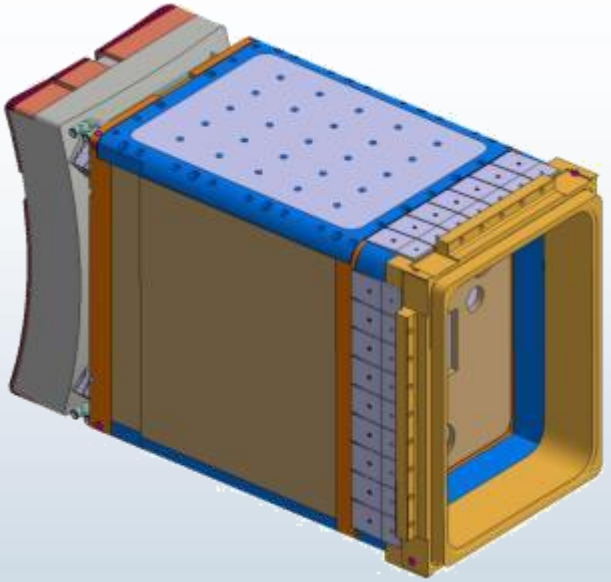
Figure 6: 3D view of HNB lids and associated Remote handling opening systems

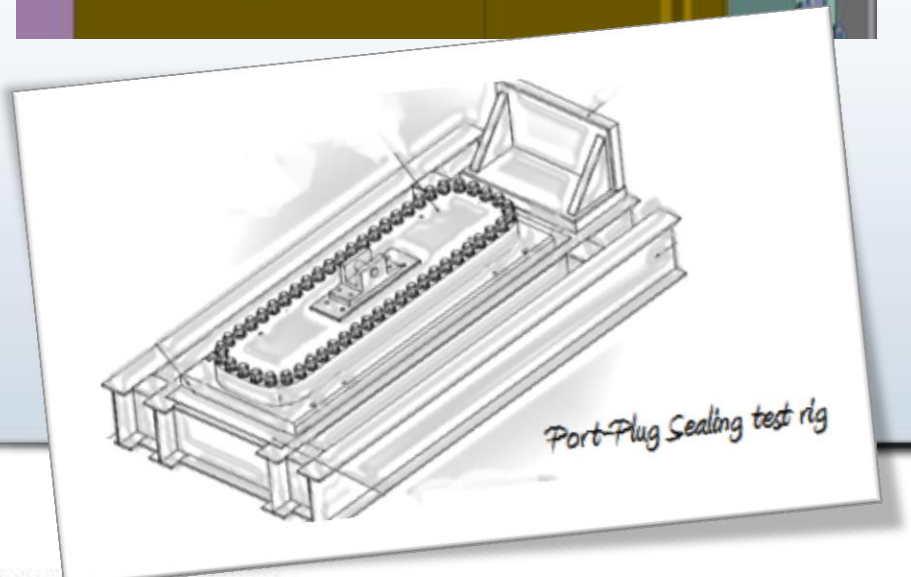
Current development

Project: Helicoflex vs. lip seals on Port-Plugs



- Port-Plug sealing solutions vs. lip-seals solution
- Quantities: 18 upper / 15 equatorial / 5 divertor ports





SPIDER Project – Kenol Flanges

- ITER SPIDER Project - Italy
- Conditions :
  - Pressure : 30 bars
  - Temperature : 180°C
  - Sealing criteria: $< 10^{-8}\ \mathrm{mbar \cdot L \cdot s^{-1}}$
  - Calcul code : DESP97/23/CE