



Training in Vacuum Technology for JUAS 2014 Students

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Technology Department

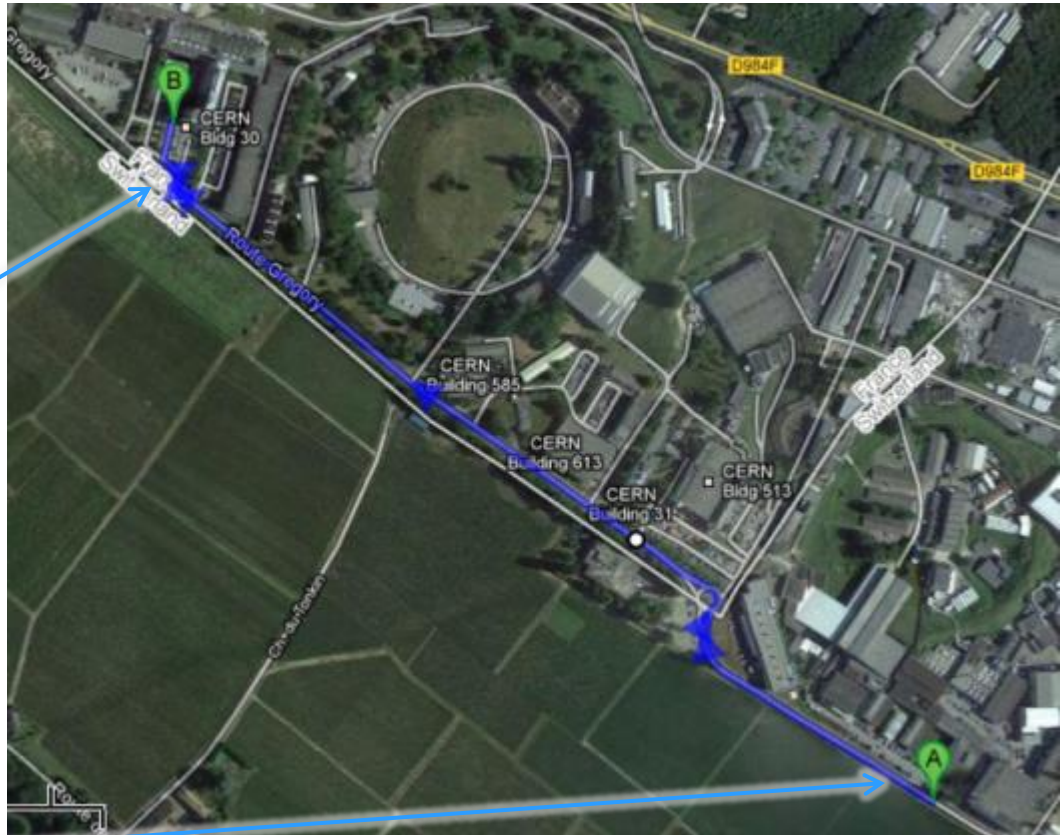
Vacuum Surfaces and Coatings Group

CERN, CH-1211 Geneva

1. **Vacuum @ CERN**
2. **Material and Surface Science: Activity 1**
3. **Mechanical Engineering**
4. **Instrumentation: Activity 2**
5. **Simulation: Activity 3**
6. **Operation: Activity 4 and 5**

The Circuit in the CERN's Meyrin Site

B. 30 and 113

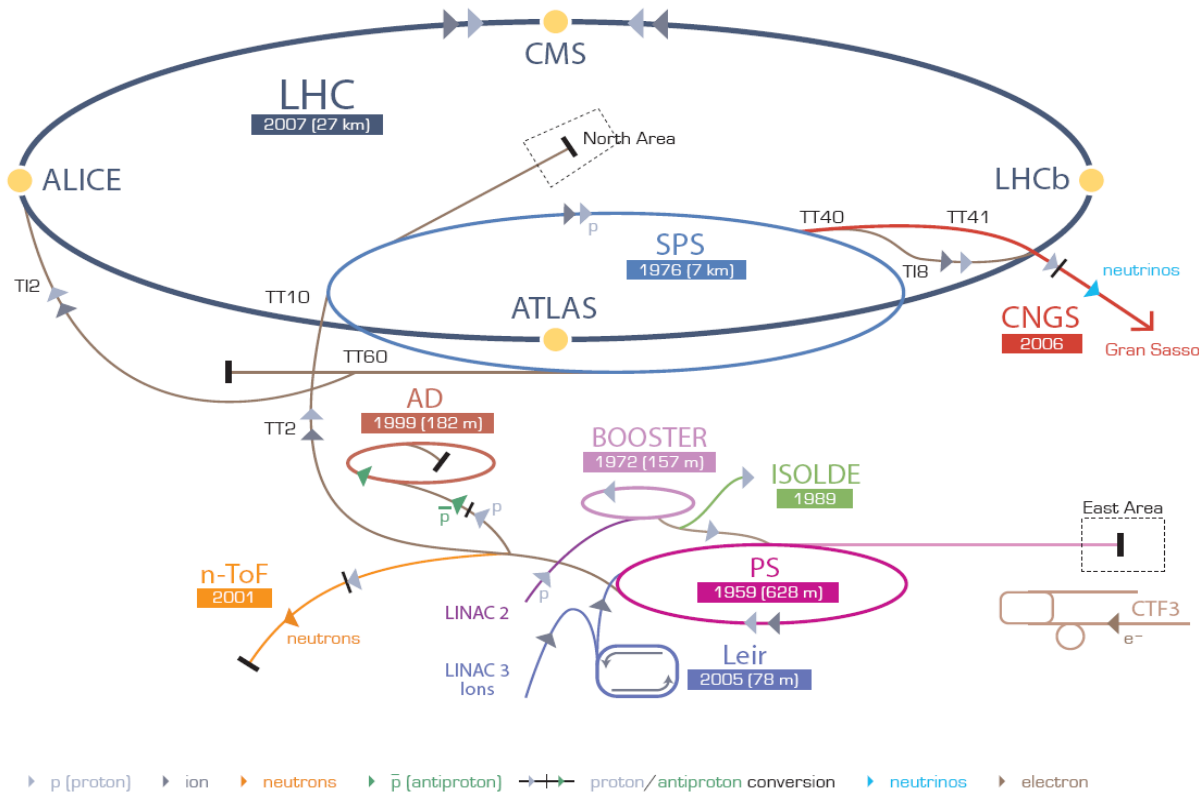


B. 101

1 Km from B. 30 to B. 101

Vacuum @ CERN

CERN Accelerator Complex



Vacuum is necessary for the free circulation of beams.

128 Km long vacuum system: the longest in the world.

All vacuum degrees and all vacuum technologies are employed at CERN

LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron

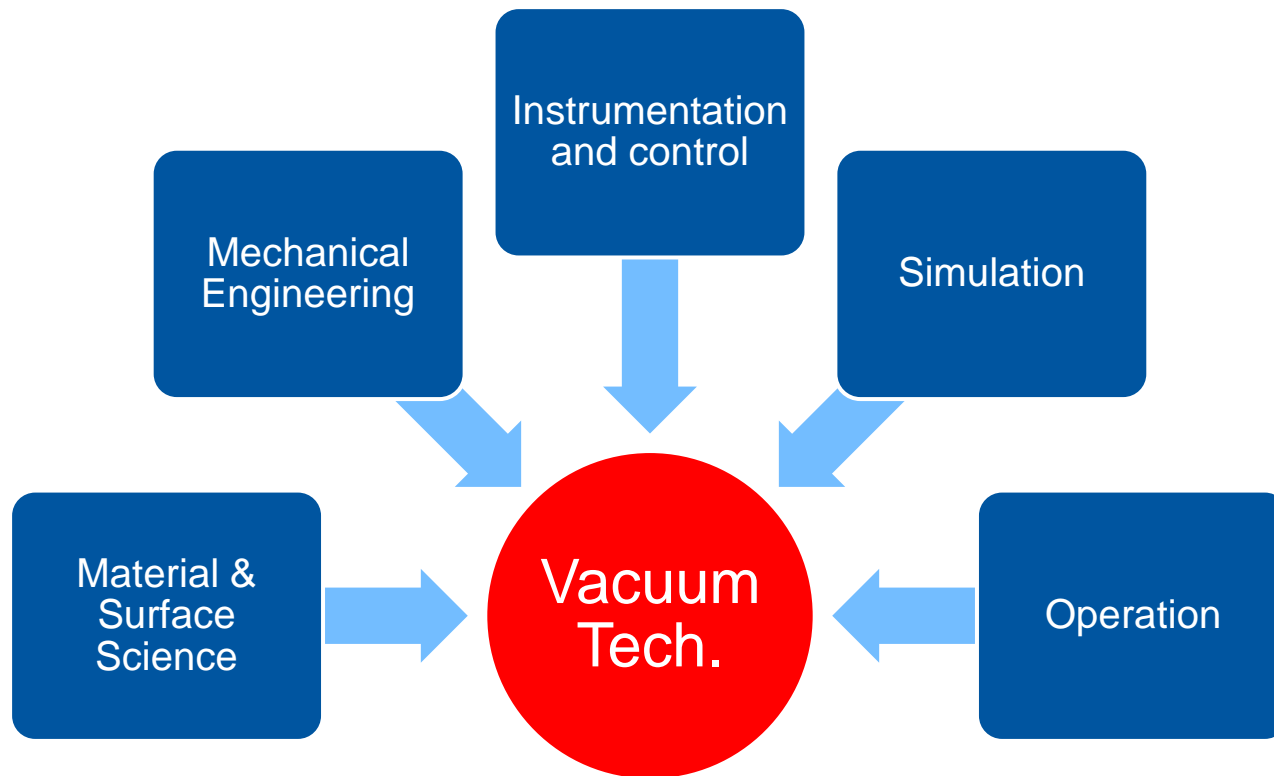
AD Antiproton Decelerator CTF3 Clic Test Facility CNGS CERN Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice

LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight

Vacuum @ CERN

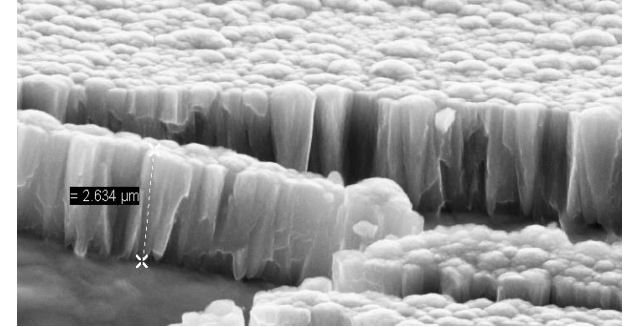
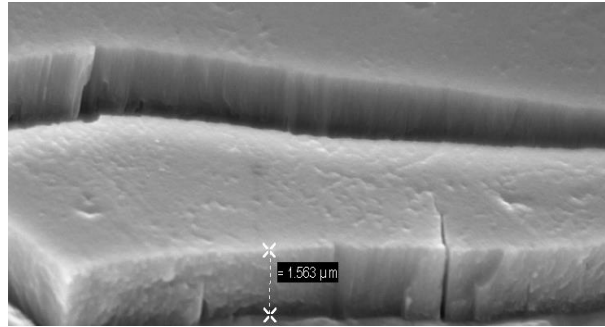
Machine	Type	Year	Energy	Bakeout	Pressure (Pa)	Length	Particles
Linac, Booster, ISOLDE, PS, n-TOF and AD Complex						2.6 km !	
LINAC 2	linac	1978	50 MeV	Ion pumps	10 ⁻⁷	40 m	p
ISOLDE	electrostatic	1992	60 keV	-	10 ⁻⁴	150 m	ions: 700 isotopes and 70 (92) elements
REX-ISOLDE	linac	2001	3 Mev/u	partly	10 ⁻⁵ - 10 ⁻¹⁰	20 m	
LINAC 3	linac	1994	4.2 MeV/u	Ion pumps	10 ⁻⁷	30 m	ions
LEIR	accumulator	1982/2005	72 MeV/u	complete	10 ⁻¹⁰	78 m	pbar, ions
PSB	synchrotron	1972	1-1.4 GeV	Ion pumps	10 ⁻⁷	157 m	P, ions
PS	synchrotron	1959	28 GeV	Ion pumps	10 ⁻⁷	628 m	P, ions
AD	decelerator	?	100 MeV	complete	10 ⁻⁸	188 m	pbar
CTF3 complex	linac/ring	2004-09		partly	10 ⁻⁸	300 m	e
PS to SPS TL	Transfer line	1976	26 GeV	-	10 ⁻⁶	~1.3 km	P, ions
SPS Complex						15.7 km !	
SPS	synchrotron	1976	450 GeV	Extractions	10 ⁻⁷	7 km	p, ions
SPS North Area	Transfer line	1976		-	10 ⁻⁶ - 10 ⁻⁷	~1.2 km	
SPS West Area	Transfer line	1976				~ 1.4 km	
SPS to LHC TI2/8 Line	Transfer line	2004/2006				2 x 2.7 km	
CNGS Proton Line	Transfer line	2005				~730 m	
LHC Accelerator						~109 km !	
LHC Arcs (Beam x2, Magnets & QRL insul.)	collider	2007	2 × 7 TeV	-	< 10 ⁻⁸	2 × (2 × 25 km)	p, ions
LSS RT separated beams				complete		2 × 3.2 km	
LSS RT recombination						~ 570 m	
Experimental areas						~ 180 m	
Beam Dump Lines TD62/68	Transfer line	2006	7 TeV	-	10 ⁻⁶	2 × 720 m	
				High Vacuum		~20 km	~128 km !
				UHV w/wo NEG		~ 57.5 km	
				Insulation vacuum		~ 50 km	

2850 ion pumps, **450** turbomolecular pumps, **325** Ti sublimation pumps,...
6 Km of NEG coated beam pipes, **2750** pressure gauges, **40** leak detectors
and **100** RGAs, **1930** roughing valves and **510** gate sector valves





Thin Films: TiZrV



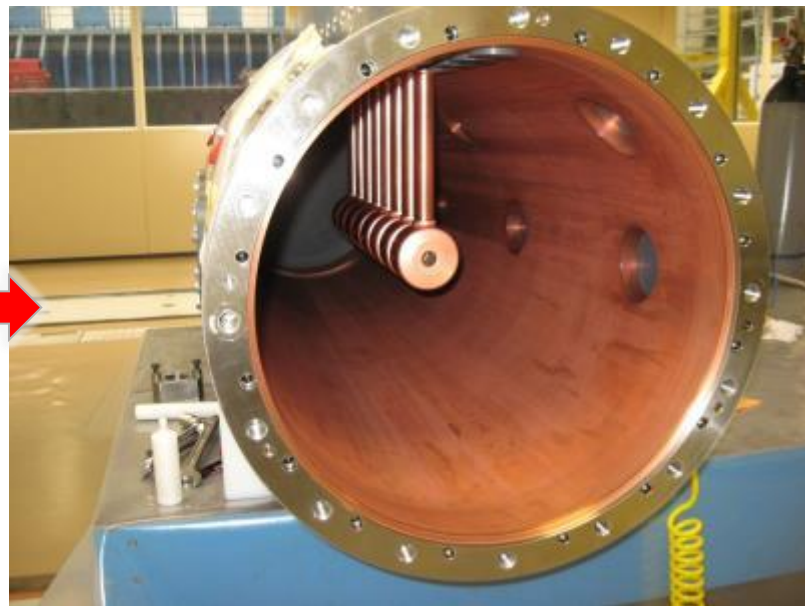
Thin Films: Amorphous Carbon



Thin Films: Nb



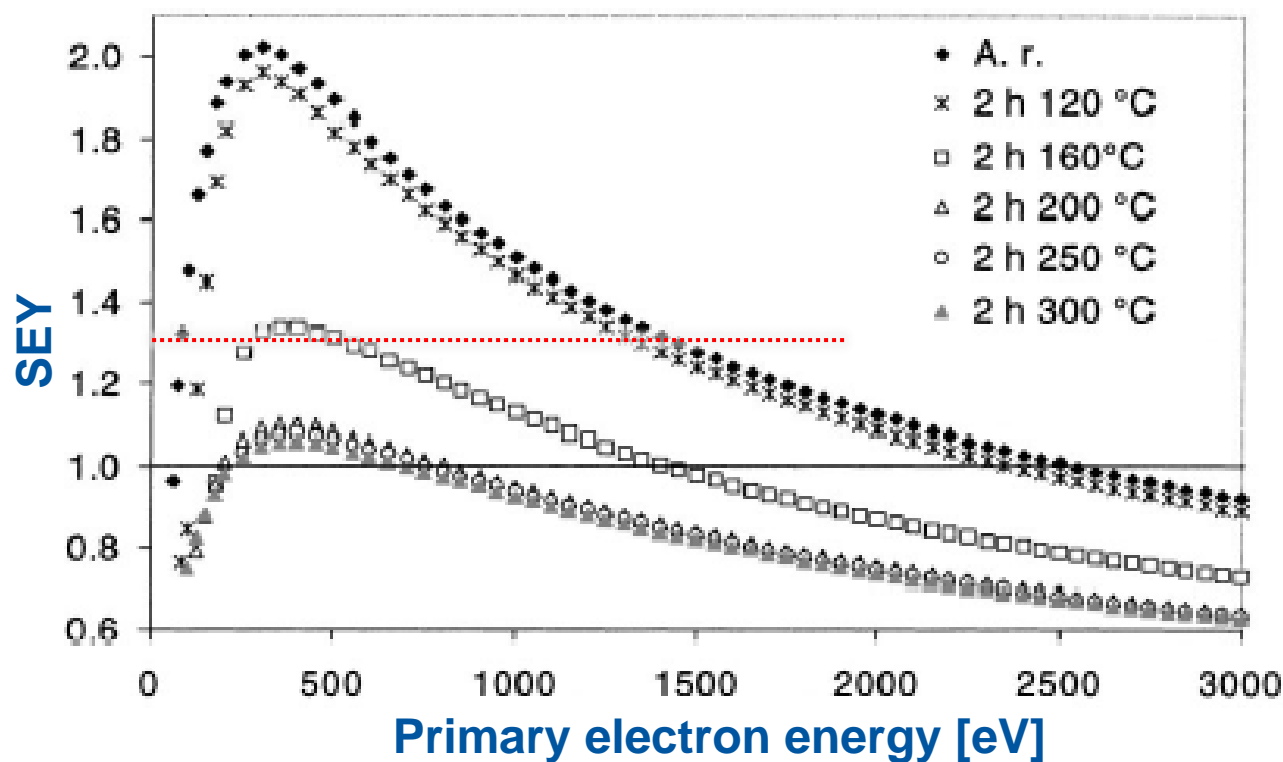
Electroplating



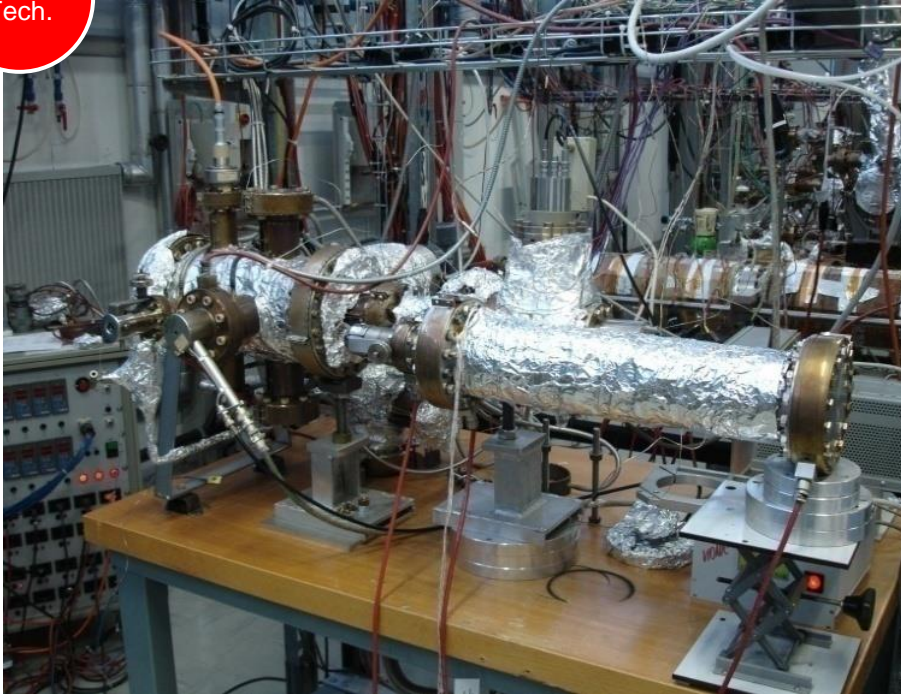


Beam induced surface modification. Surface analysis.

B. Henrist et al./Applied Surface Science 172 (2001) 95–102



Activity 1: gas from metals

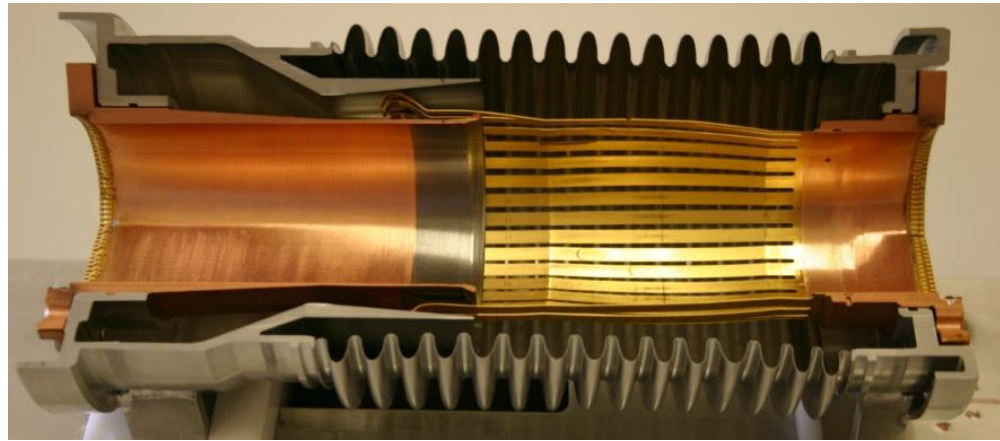


- Thermal and particle induced outgassing
- Gas permeation in polymers and metals
- Assessment of vacuum components
- Thin film coatings for the reduction of material outgassing

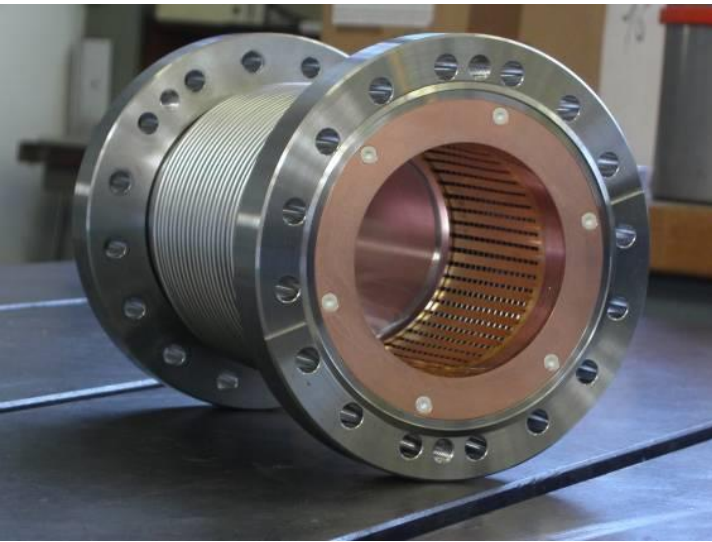
Mechanical
Engineering



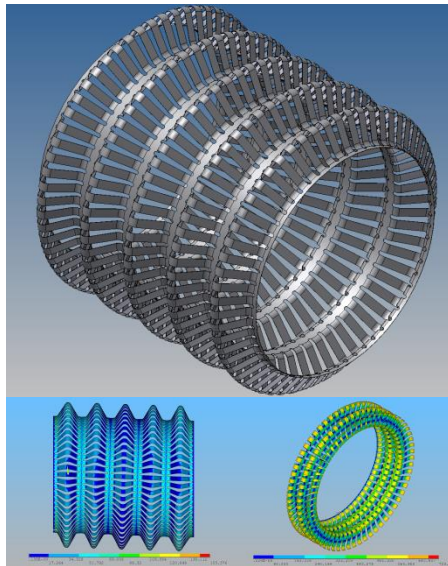
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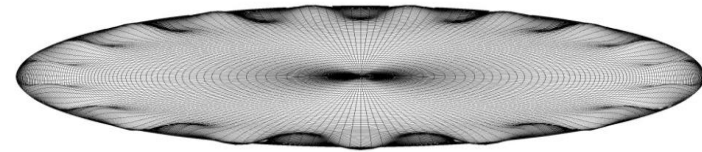
Design



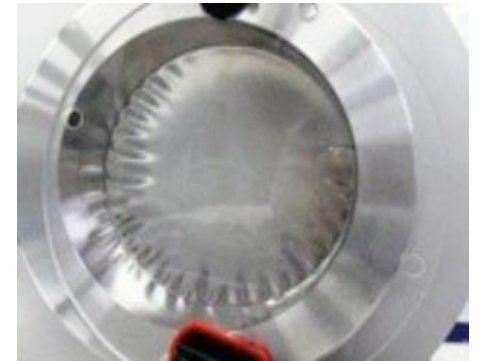
Production



Computation



Thin walls

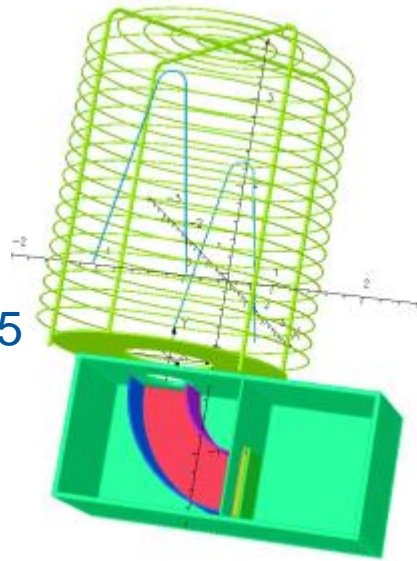


Instrumentation

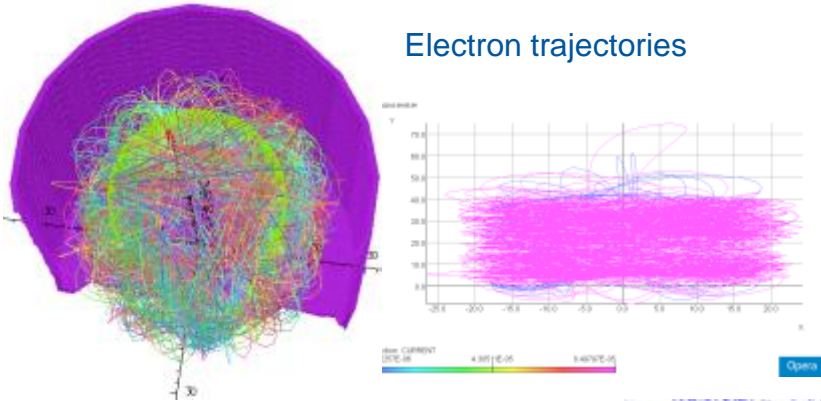


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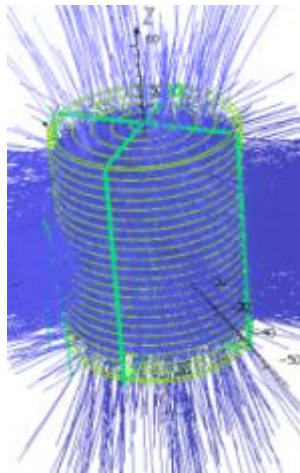
SVT 305



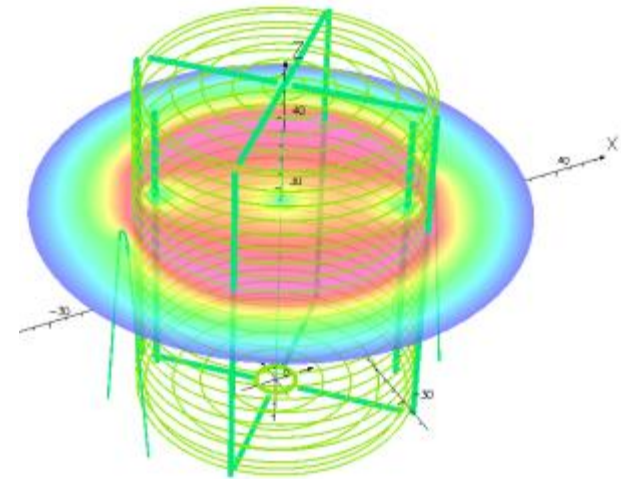
Electron trajectories



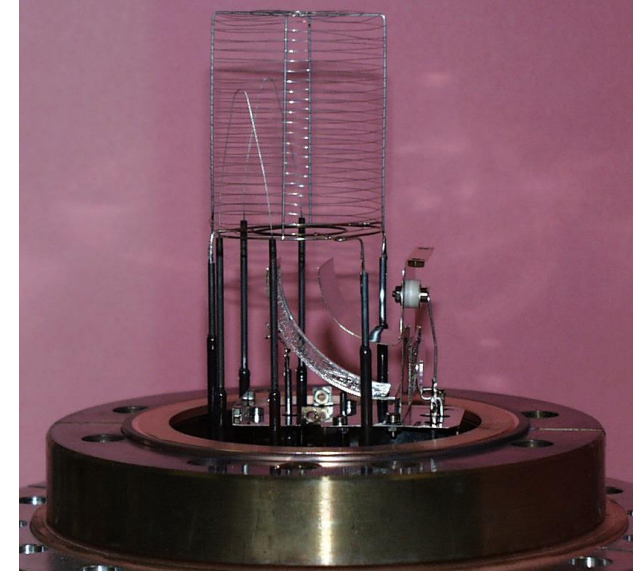
Ion trajectories
(here illustration of
ion losses)



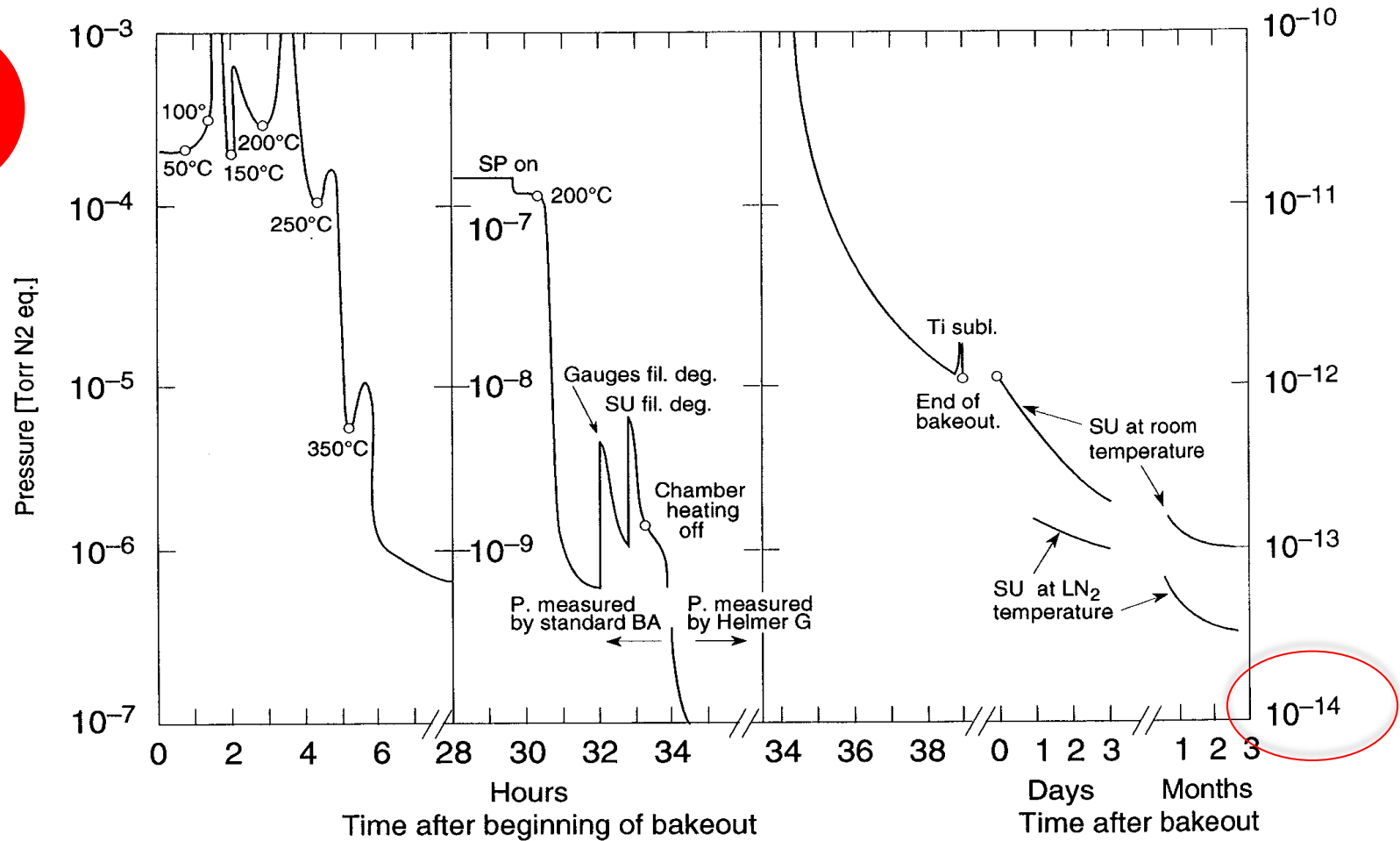
Electrical
potentials
(here during
modulation)



Geometric mode of a
Helmer gauge



Lowest pressure ever measured at room temperature





Activity 2: pressure measurement

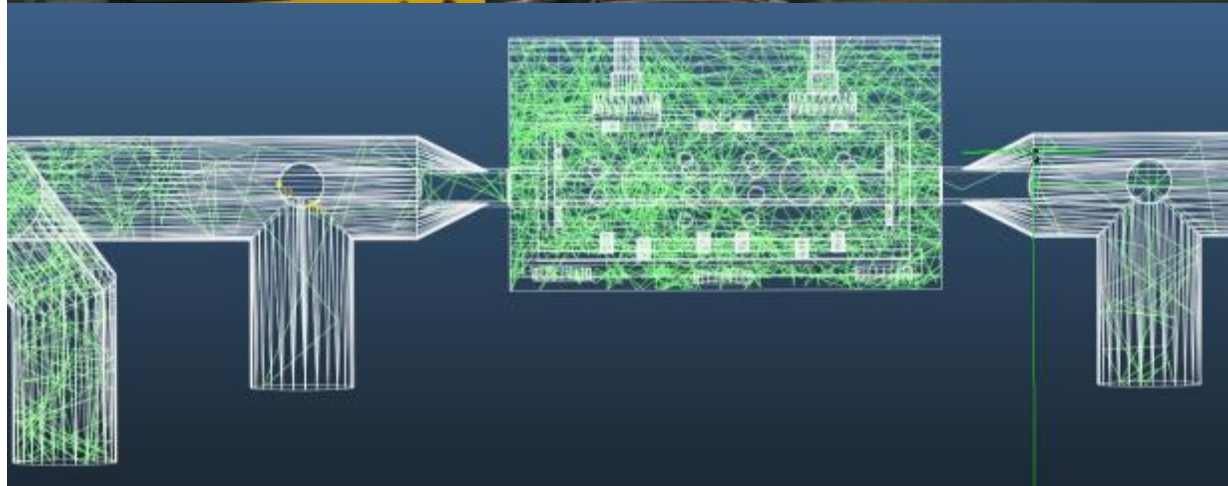


- Pressure measurement by gas ionization
- Quadrupole gas analyzers and partial pressure measurement
- The training lab
- Calibration of instruments

Simulation



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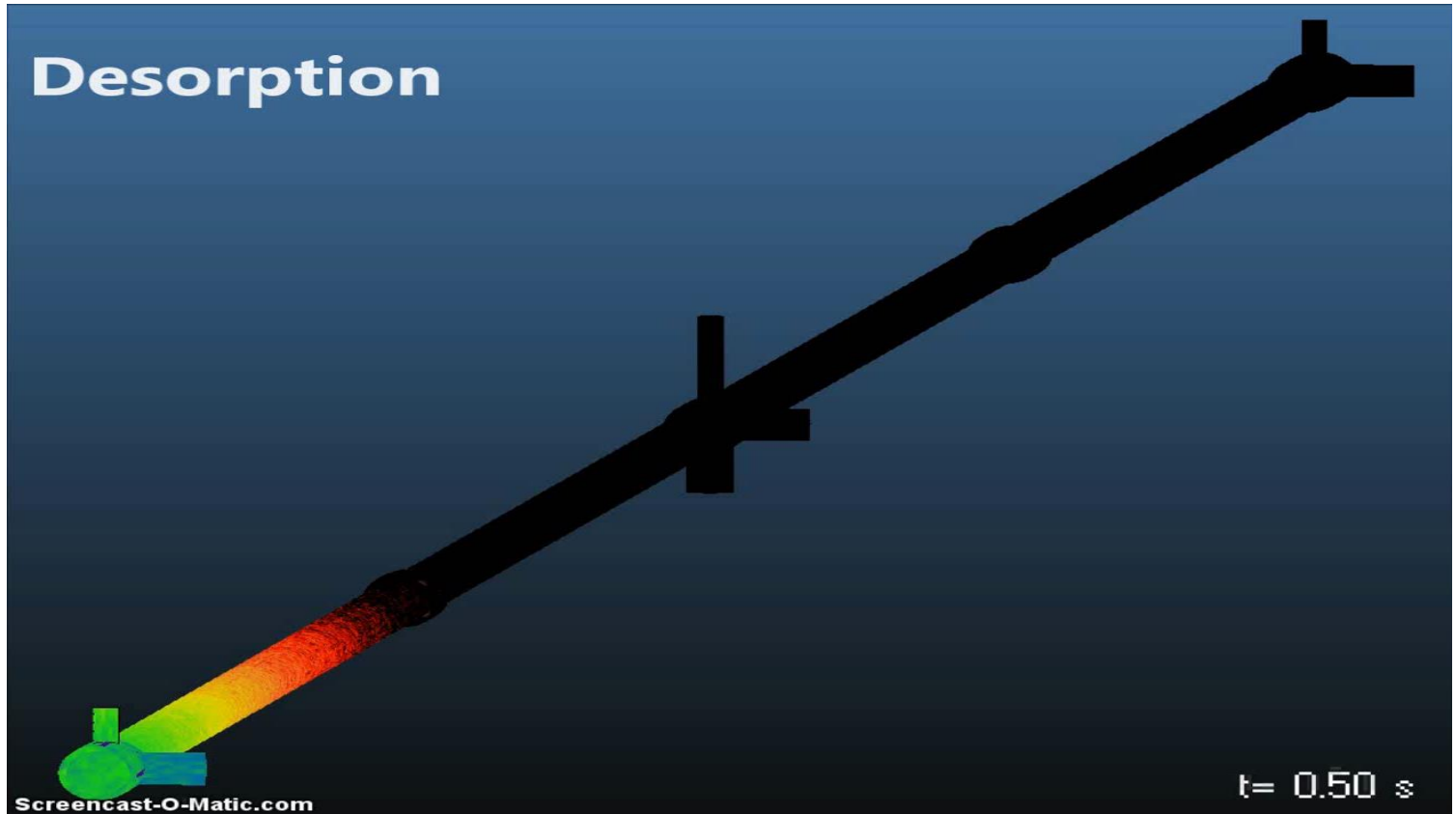


time-dependent processes

Simulation



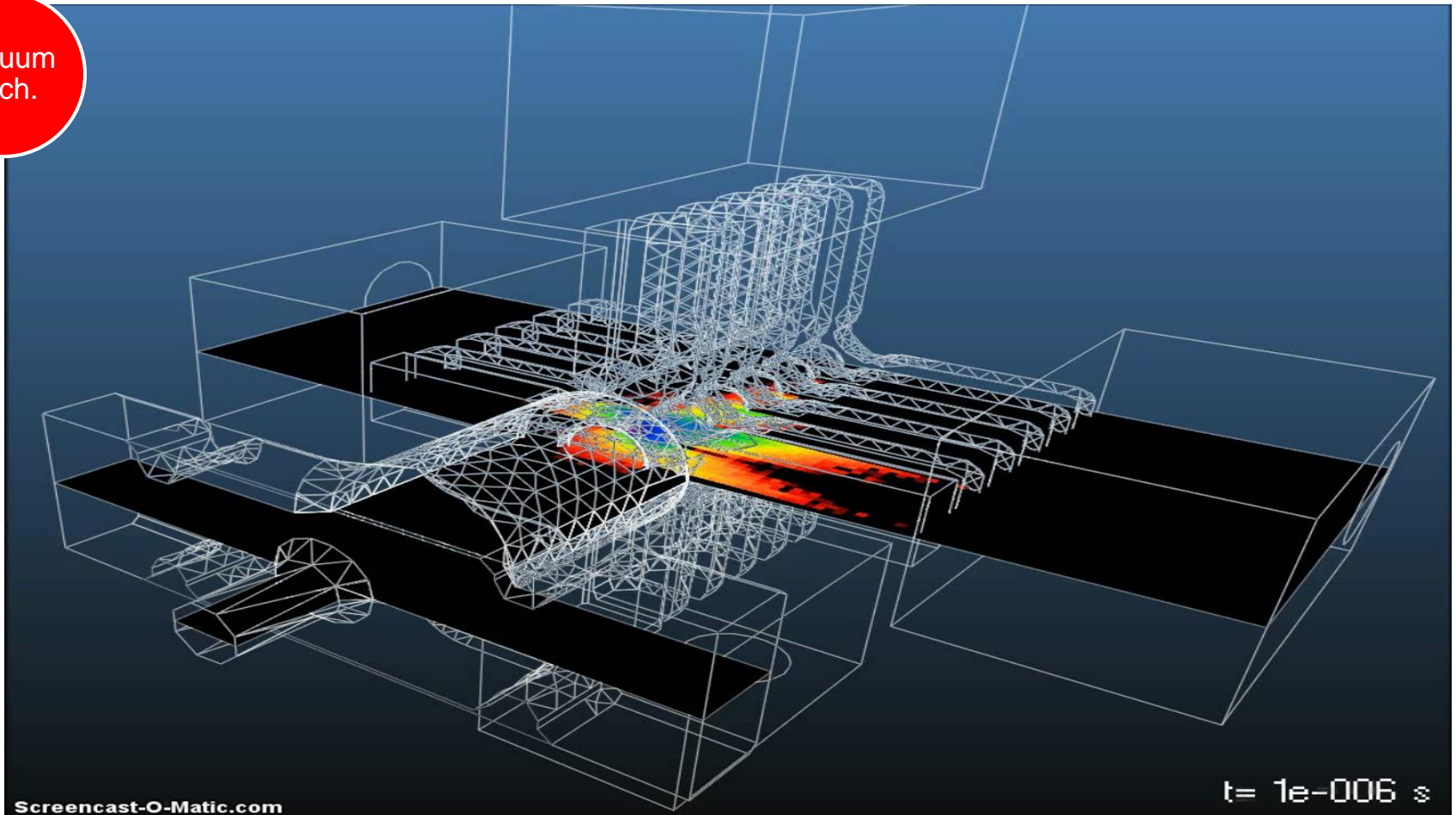
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Simulation

Activity 3: MC simulation

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Operation

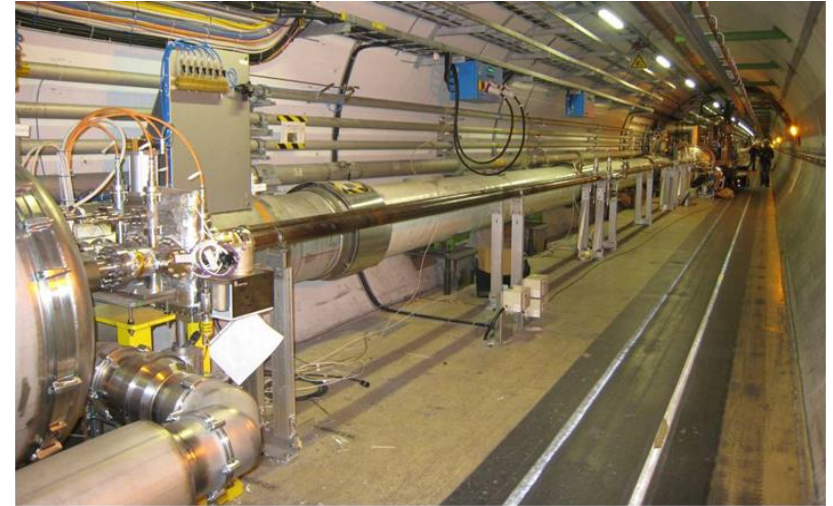
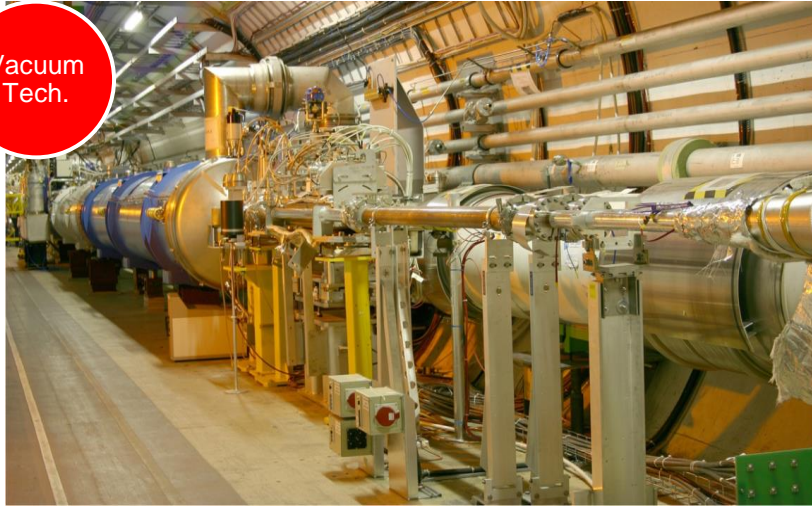


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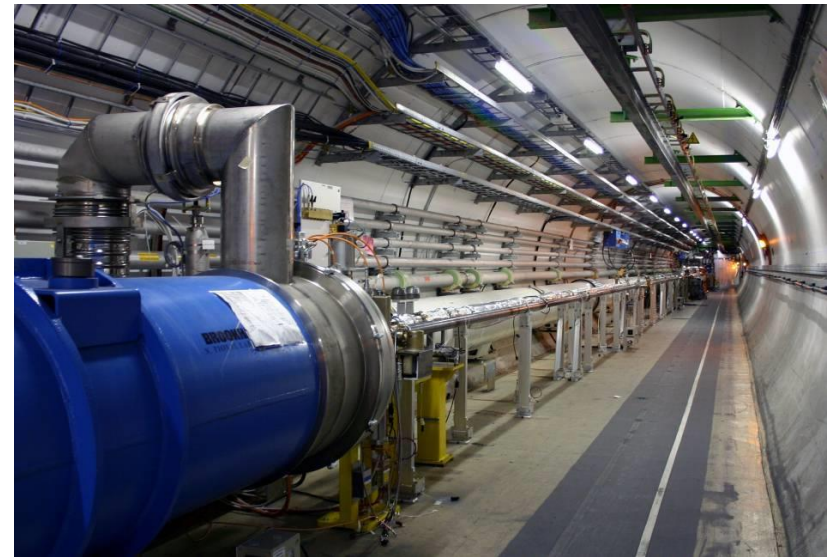
Operation

Examples of vacuum systems in the LHC

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LHC



Examples of vacuum systems in the LHC

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Vacuum technicians
installing part of the
beam pipe support
system

Interventions in controlled areas

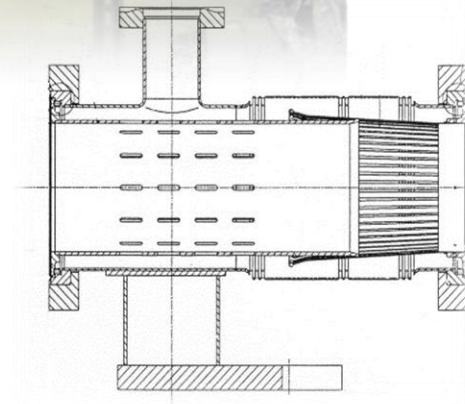
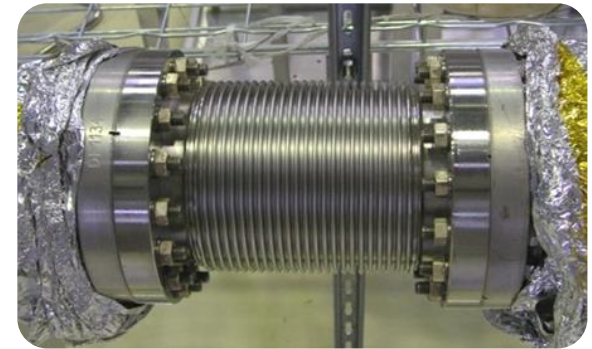




Remote interventions in controlled areas



Activity 4: LHC vacuum system with NEG

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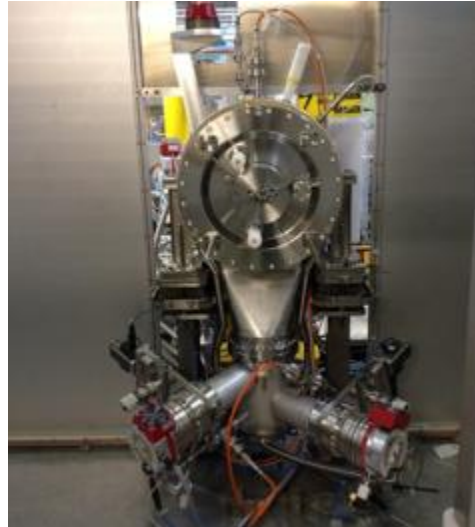
- Thin film coating for the LHC
- LHC vacuum components
- The LHC collimators and their vacuum system
- Bakeout and NEG activation

Activity 5: leak detection

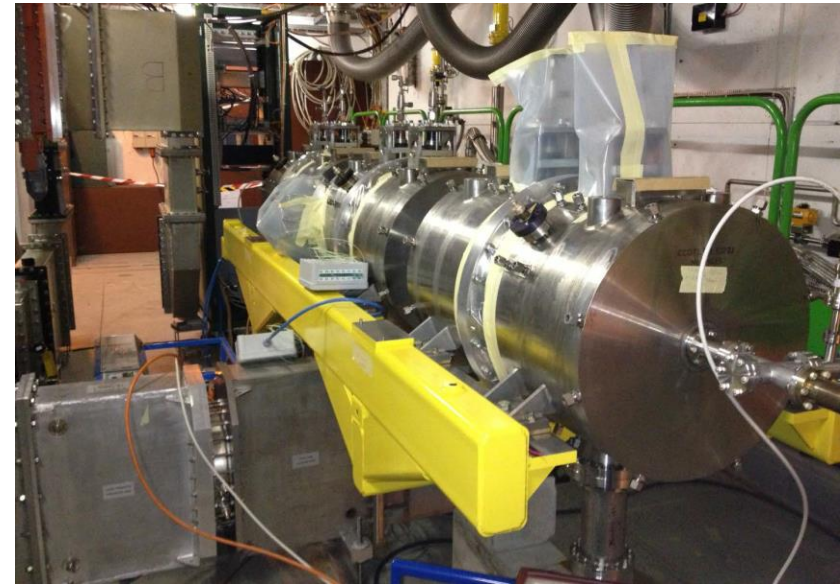
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Leak and pressure test of PIMS disks



Leak test of new source



Acceptance test of CCDTL module



Leak test of DTL Drift tubes.

This is just a few of the leak, pressure and acceptance test done in 2013 for the new material to be installed in Linac 4.

**We are looking forward to
sharing our work with you at
CERN !**



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