
CERN

Practical Days
Vacuum Systems

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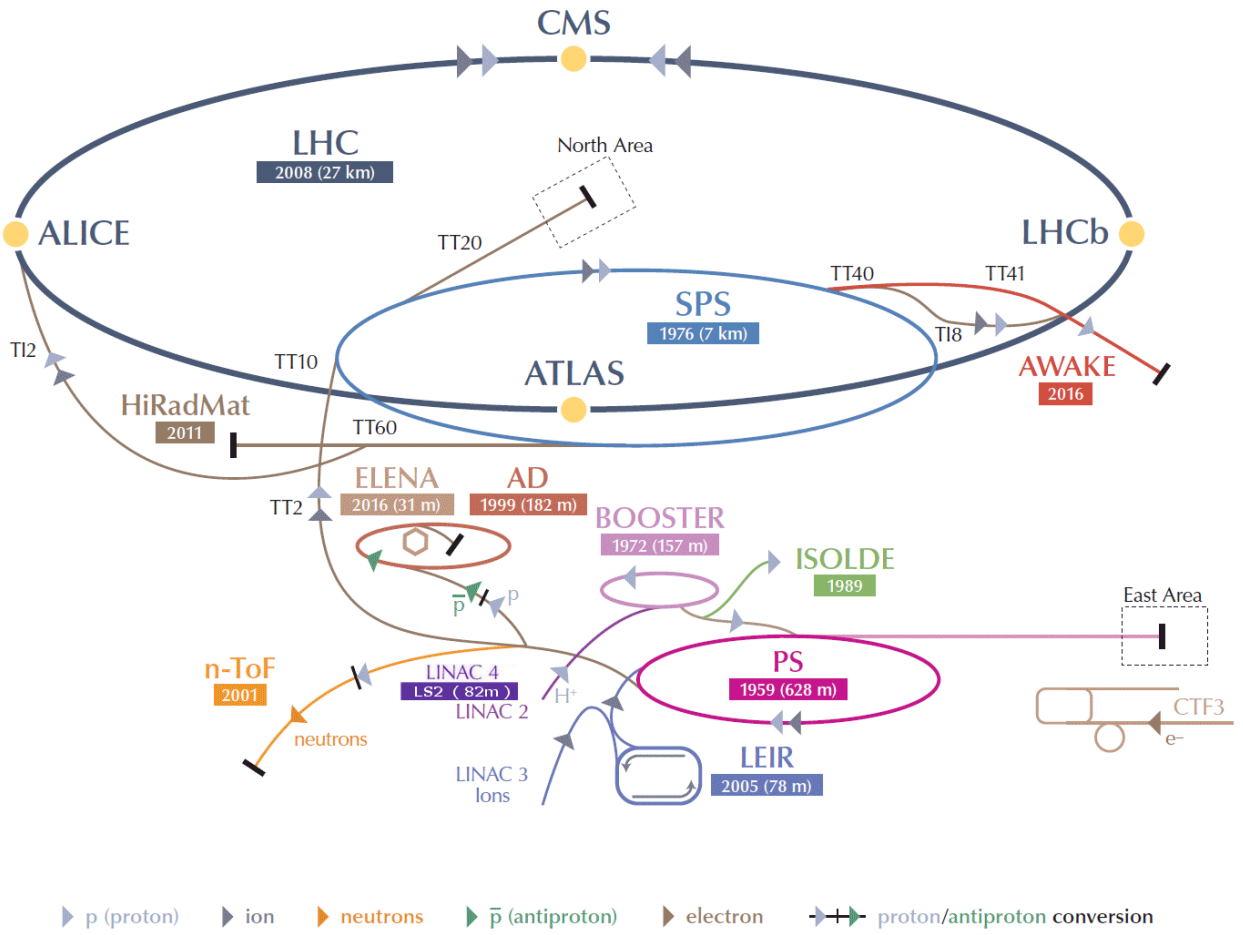
CERN accelerators complex



CERN vacuum systems

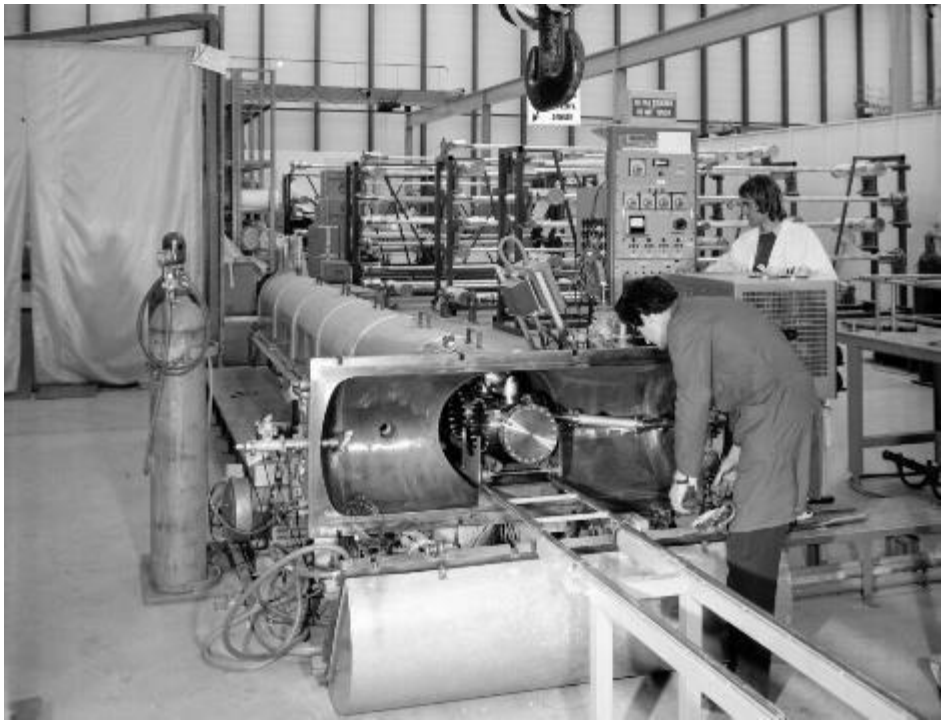
Machine	Type	Year	Energy	Bakeout	Pressure (Pa)	Length	Particles
Linac, Booster, ISOLDE, PS, n-TOF and AD Complex						**2.6 km !**	
LINAC 2	linac	1978	50 MeV	Ion pumps	10^{-7}	40 m	p
ISOLDE	electrostatic	1992	60 keV	-	10^{-4}	150 m	ions: 700 isotopes and 70 (92) elements
REX-ISOLDE	linac	2001	3 Mev/u	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 x (2 x 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

Intersecting Storage Rings

- Discovery of :
  - Vacuum stability and pressure runaway
  - Beam induced multipacting (electron cloud)

- Developments of laboratory studies and cleaning methods

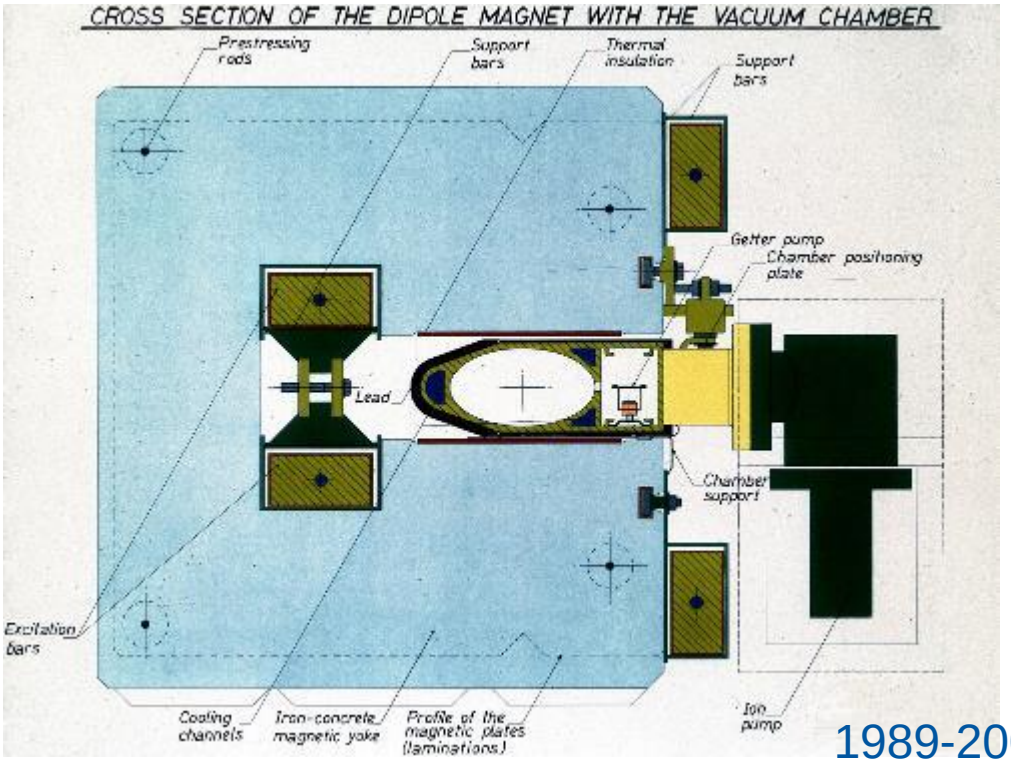


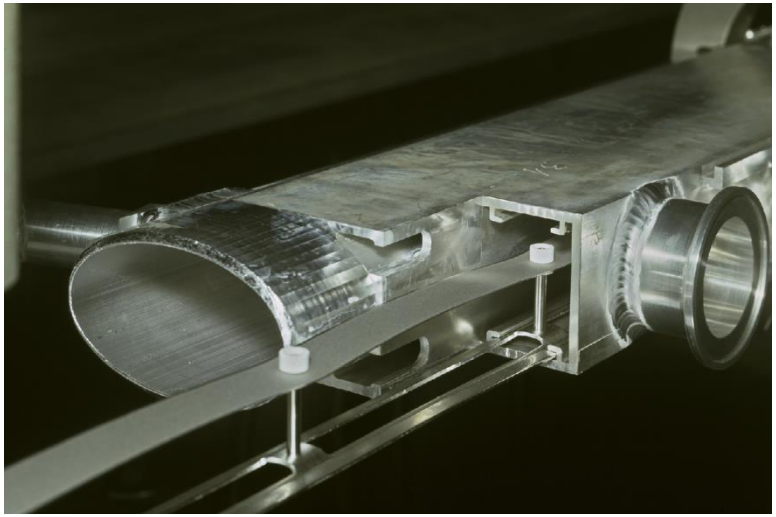
1971-1984

Large Electron Positron Collider

- Synchrotron radiation in LEP:
  - From 6 to 660 keV critical energy
  - Gas desorption studies

- Innovative pumping system
  - Antechamber with NEG pumping strip
  - Water cooled and lead shielded

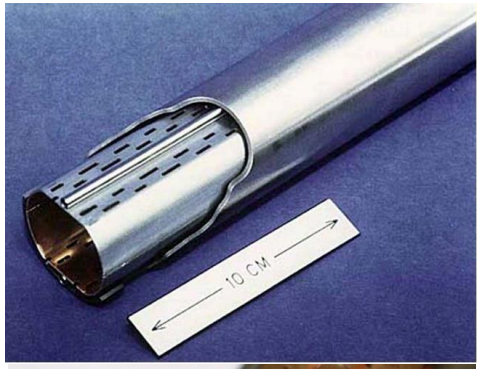




1989-2000

Large Hardon Collider

- Cold bore (CB) at 1.9 K which ensures leak tightness
- Beam screen (BS) at 5-20 K which intercepts thermal loads and acts as a screen



Started in 2008 – to be upgraded by 2025-27 and operated until 2040…

Vacuum, Surface and Coatings group

Design, construction, operation, maintenance and upgrade of high & ultra-high vacuum systems for Accelerators and Detectors.

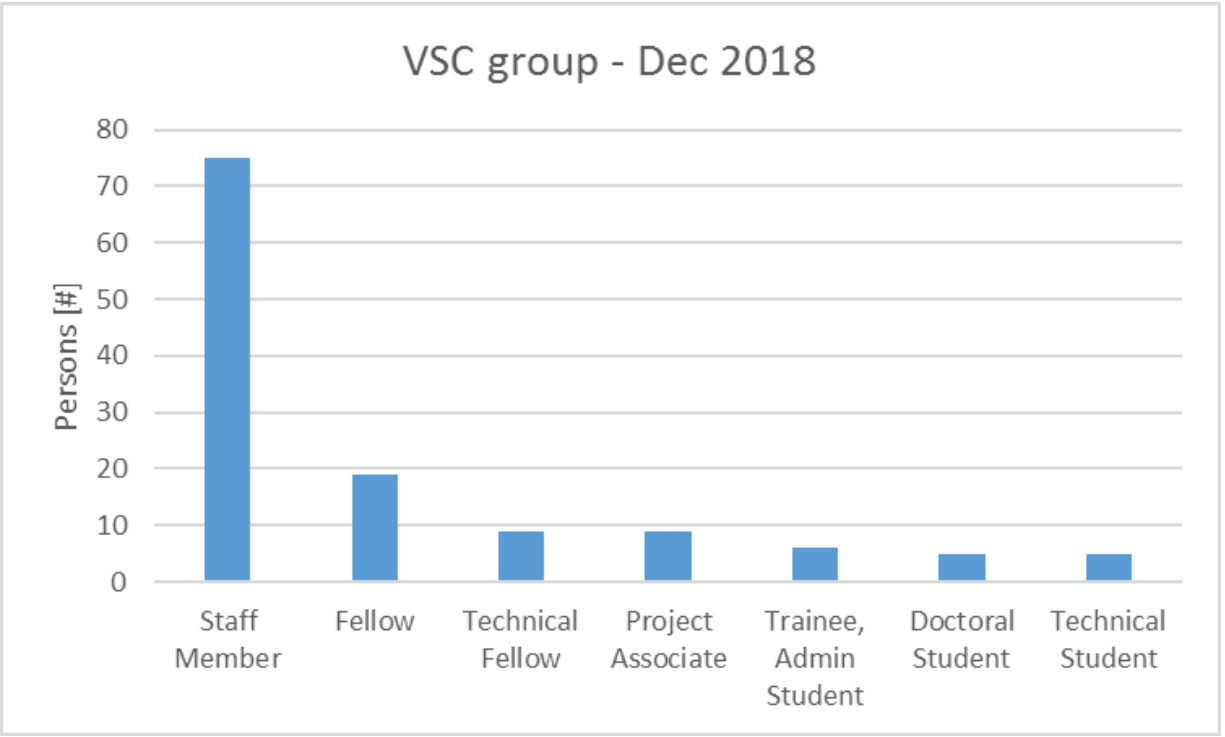
- Expertise and support on thin-walled vacuum chambers, windows and bellows compensation systems
- Expertise in vacuum sealing and leak-tightness technology
- Expertise in dynamic vacuum phenomena
- Management of the industrial support contract for vacuum work in accelerators
- Expertise in vacuum control systems, vacuum interlocks and monitoring tools

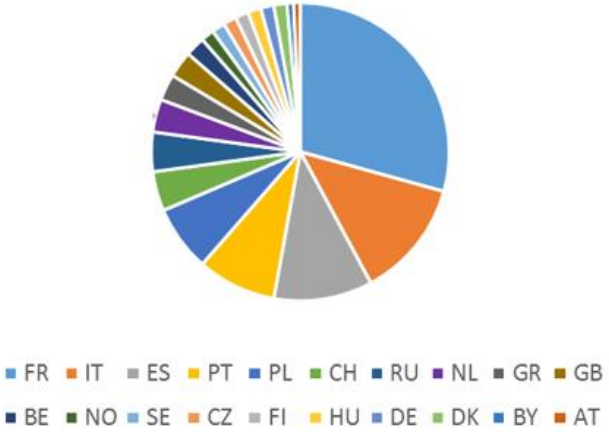
Coatings, surfaces treatments, surface and chemical analysis for Accelerators and Detectors. Expertise and support in the fields of:

- Coatings, electroplating and surface cleaning techniques
- UHV characterization and of material and surfaces
- Degassing analysis and treatments

Vacuum, Surface and Coatings group

Design, construction, installation and operation of the CERN vacuum systems
75+53 = 128 persons





Several collaborators from different countries and institutes

TE-VSC organisation

Group management
+ 5 sections:

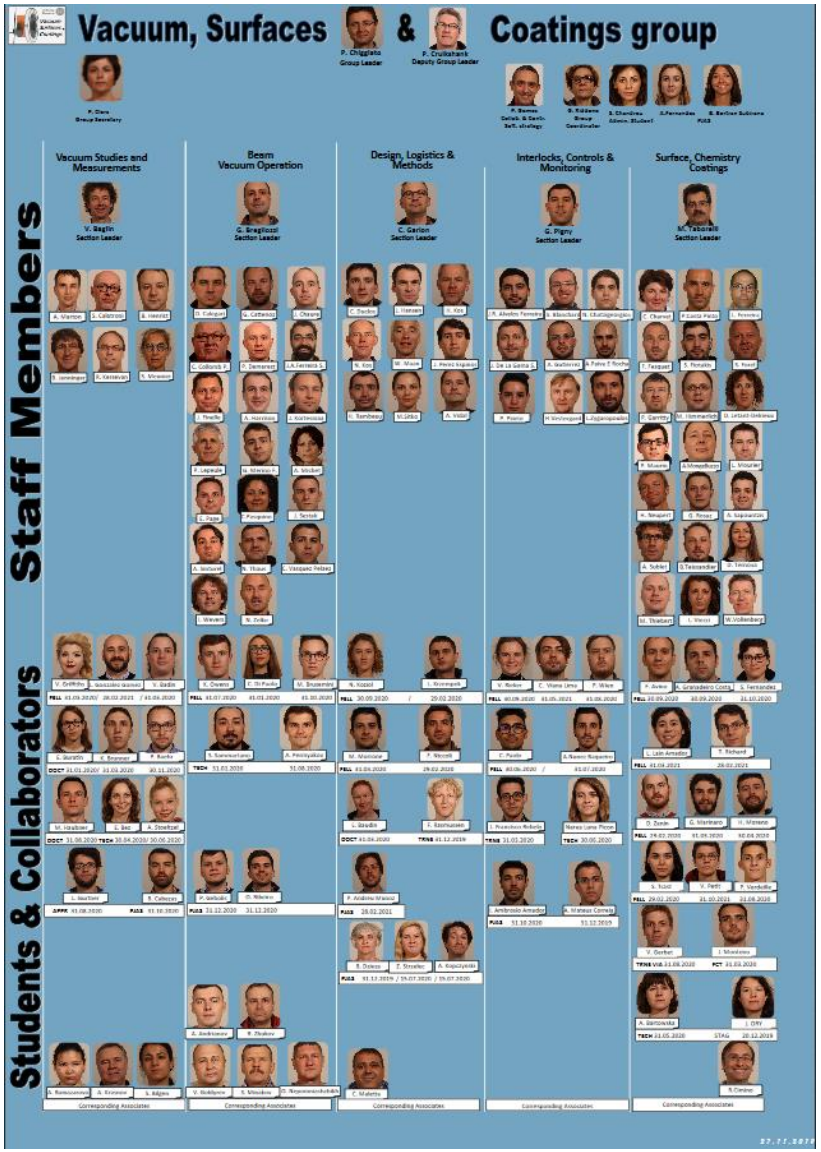
Vacuum studies and measurements

Beam vacuum operation

Design, logistics & methods

Interlock, controls & monitoring

Surface, chemistry & coatings



Organisation of practical days

The group is split in two smaller group (~ 6):

Laboratory activities

Modelling activities

2x2 tutors

Two half day sessions

Lunch with tutors

Bring your own laptop, or we can loan one to you for the session if needed

Laboratory activities: pump down

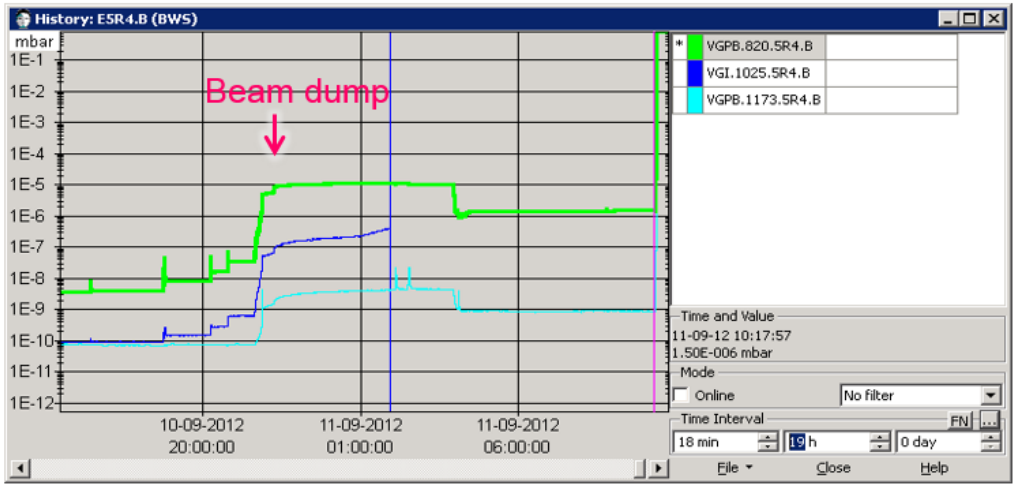
- Pump down of a vacuum system:
  - start pumping
  - open roughing valve
  - expected pump down curve

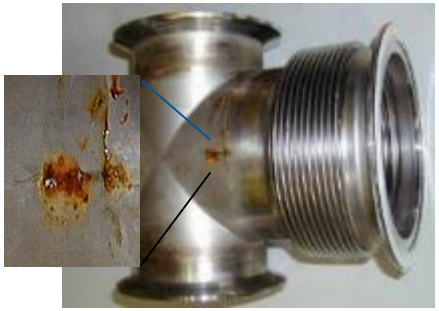
Laboratory activities: pumping speed measurement

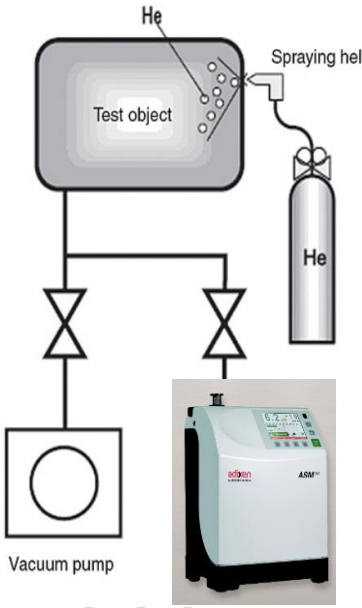
- Pumping speed measurement

Laboratory activities: leak detection

- How to locate / identify leaks in a vacuum system ?



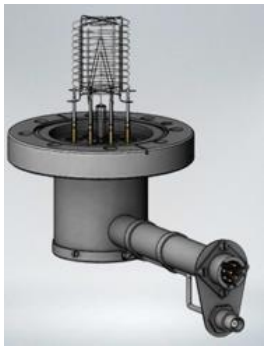


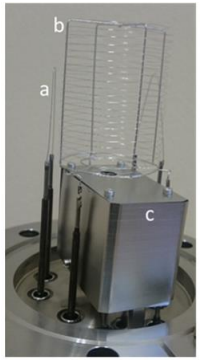


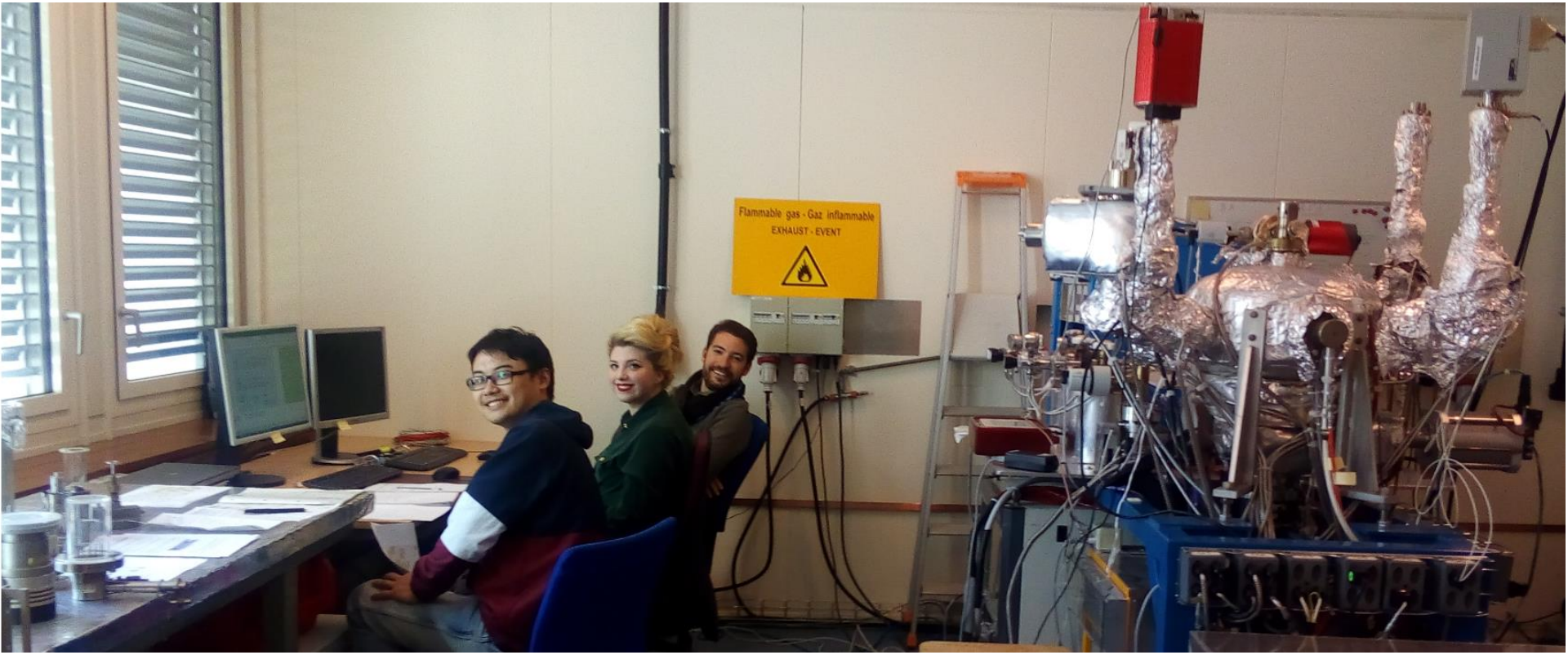
He leak detector

Laboratory activities: vacuum gauge

- Vacuum gauges description
- Vacuum gauge calibration

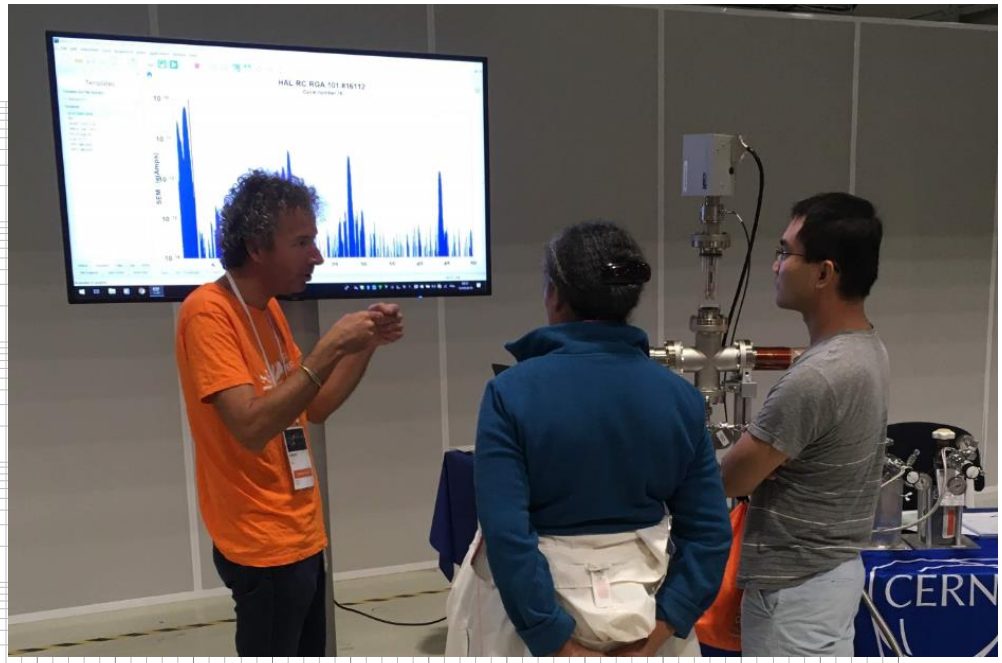






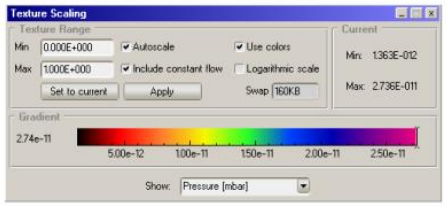
Laboratory activities: gas analysis

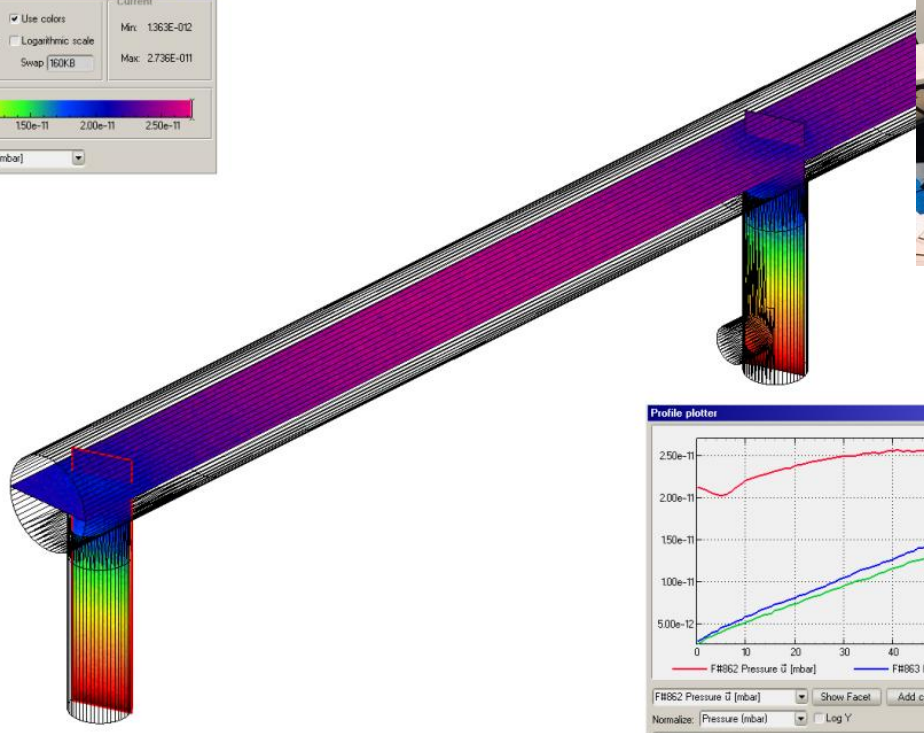
- is my residual gas composition reasonable ?
- Estimation of the partial pressure

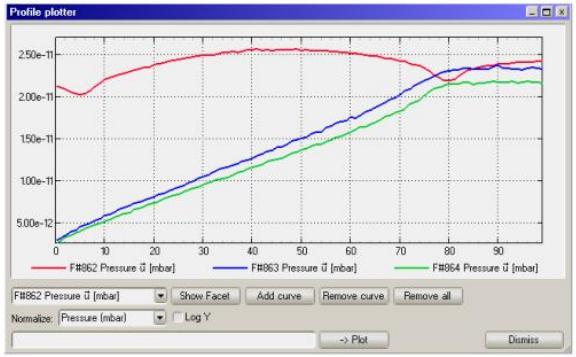


Design of vacuum systems

- A test particle Monte-Carlo code for molecular flow
- http://molflow.web.cern.ch/
- R. Kersevan – M. Ady





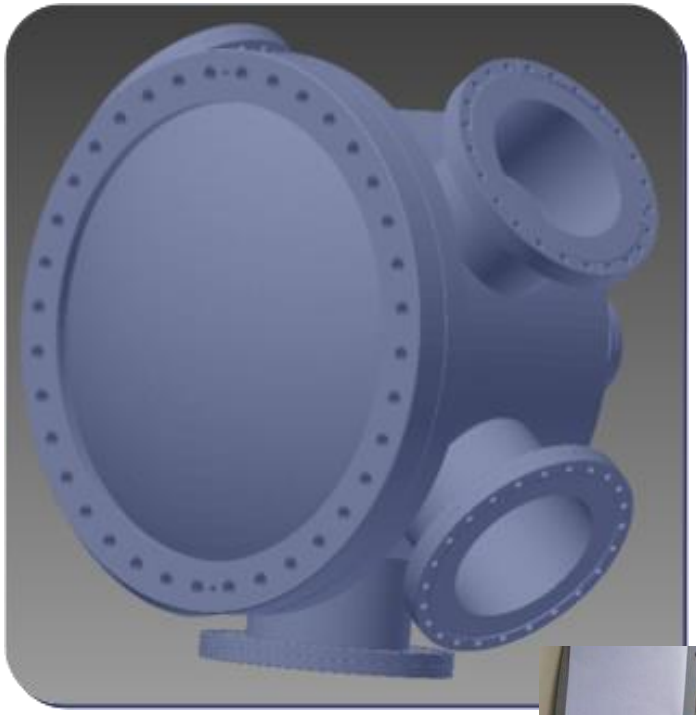


A simple accelerator part with a pumping port

Step 1: creating geometry

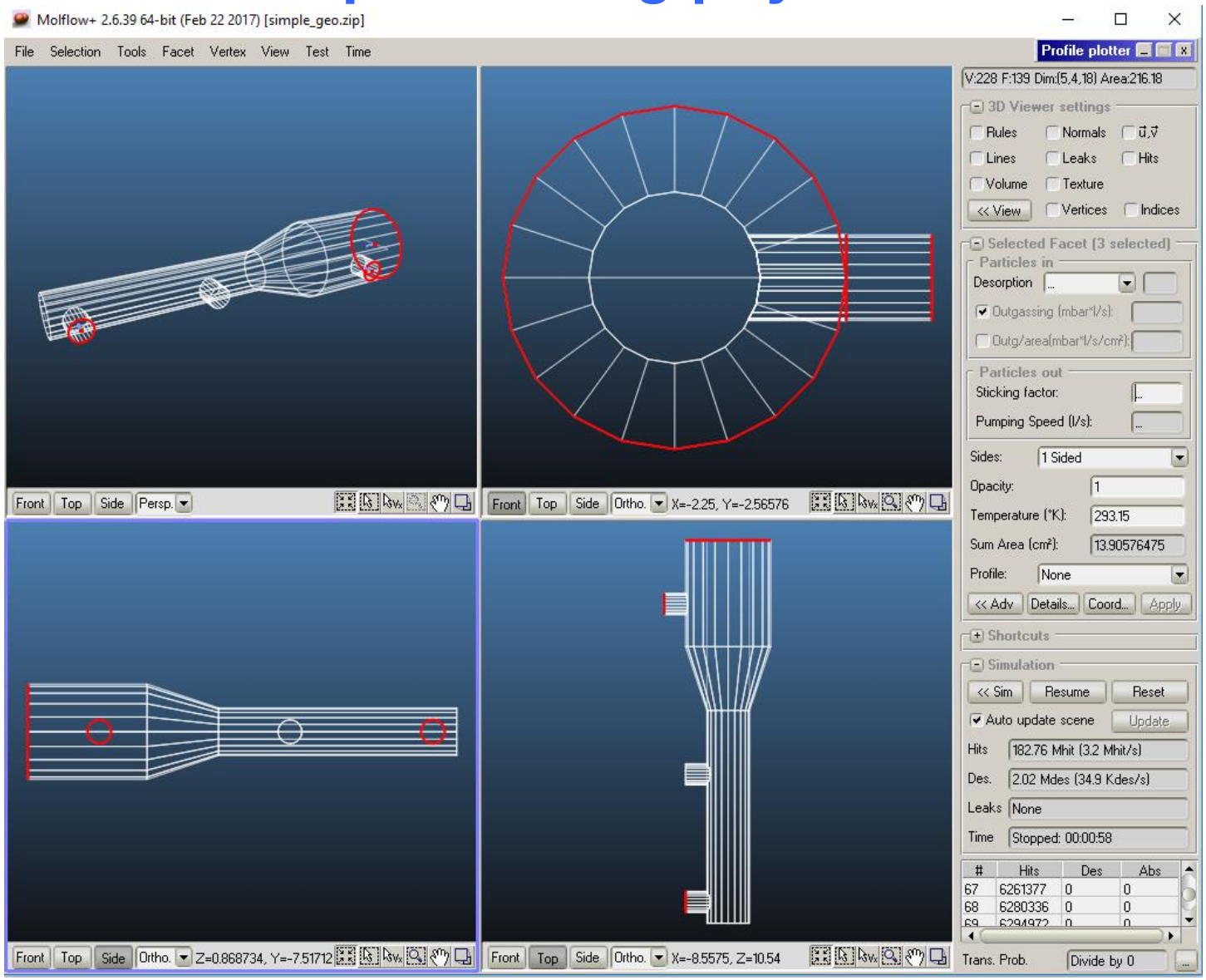
CAD

Molflow+

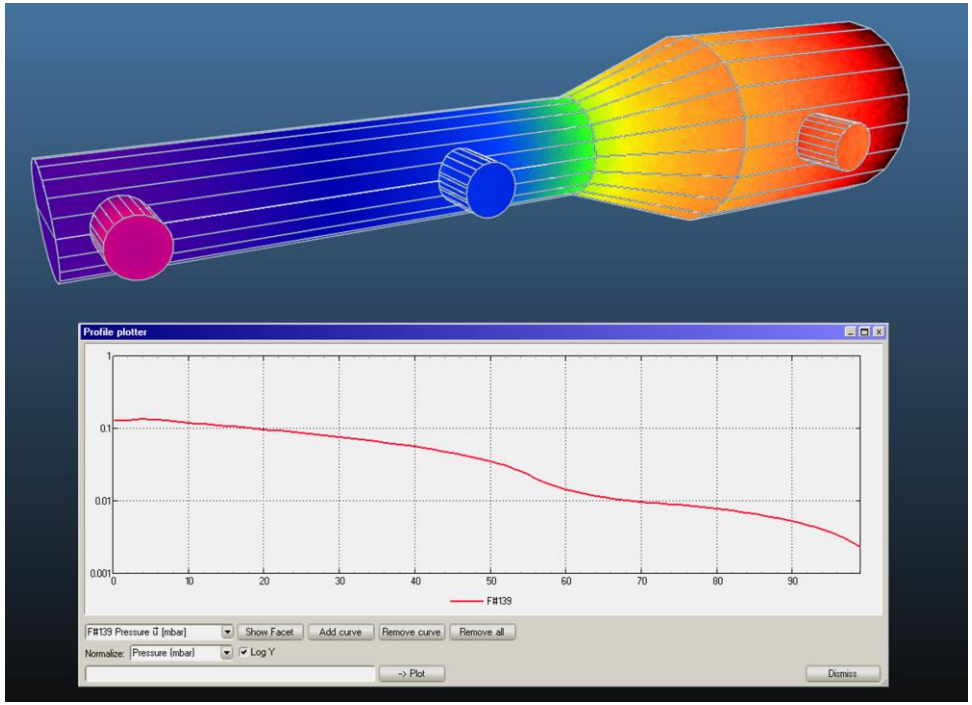


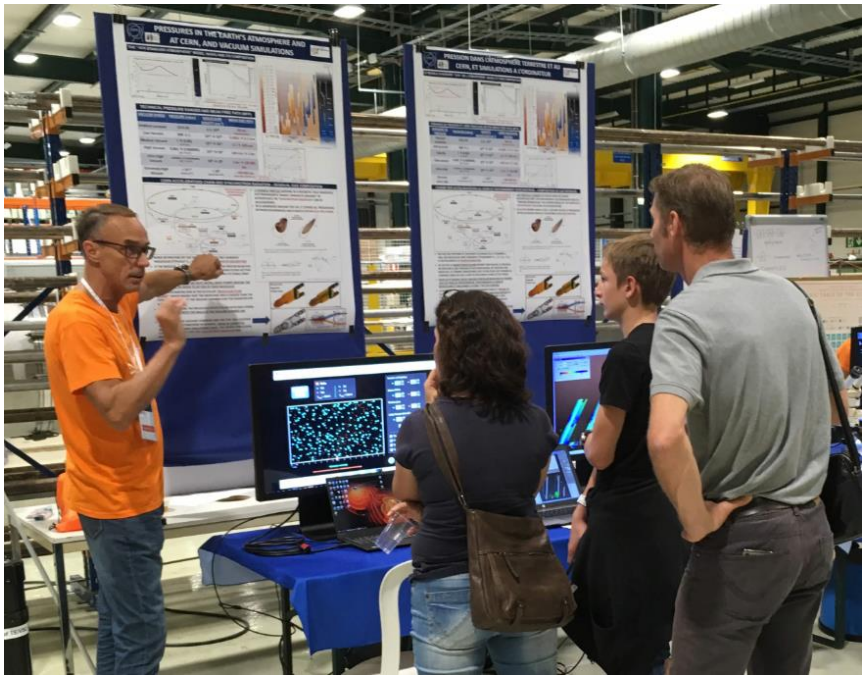
STL format

Step 2: adding physics



Step 3: simulation and results

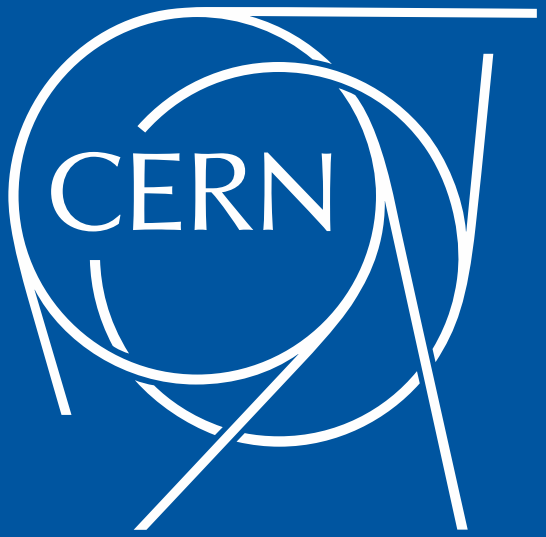




100k molecules

You are welcome to join our group for the practical days !

Thank you for your attention !!!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