The LHC “under pressure”

- Dynamic Pressure in the LHC - Detection of parasite ions and investigation of surface conditioning

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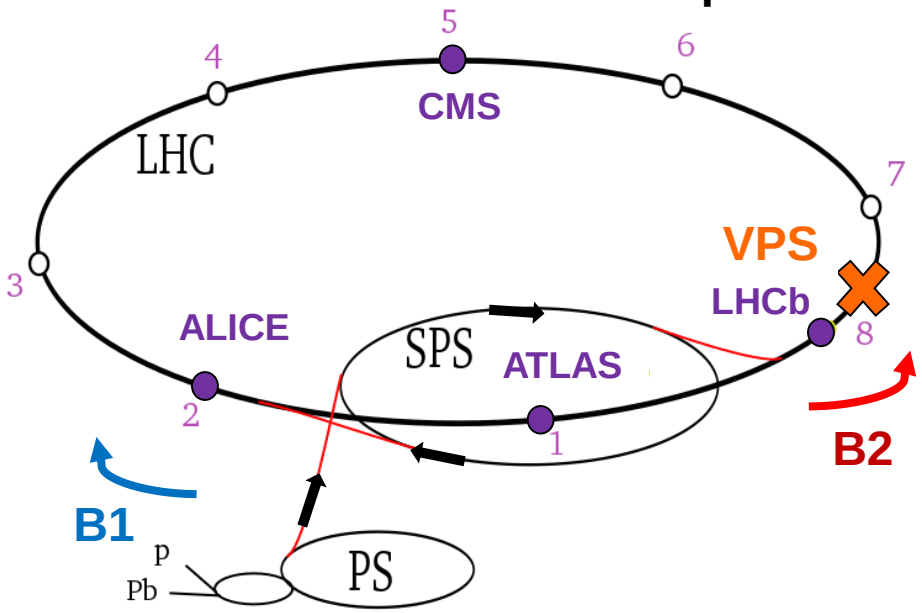
LHC RUN II Statement

CERN's accelerator complex



LHC characteristics

- World's largest and most powerful particle accelerator (27 km ring).
- Proton beam- PS- SPS- injection in LHC- energy ramp-collision at IP.
- CERN's mission: helps to uncover what the universe is made of and how it works.

LHC RUN II

- Beam emittance increases
- Deterioration of the luminosity factor
- Premature dumps with occurred due to beam divergence and instabilities.

To stay operational during 2018, the LHC was limited to fewer than the nominal number of bunches

LHC
27 km, 8.33 T
13 TeV, 2556 b

→

LHC
27 km, 8.33 T
14 TeV, 2808 b

→

FCC-hh
80 km, 20 T
100 TeV, 10600 b

Dynamic pressure : **Stimulated desorption? Secondary particles? collective effects ? Electron cloud? Ions ? Influence of surfaces?**

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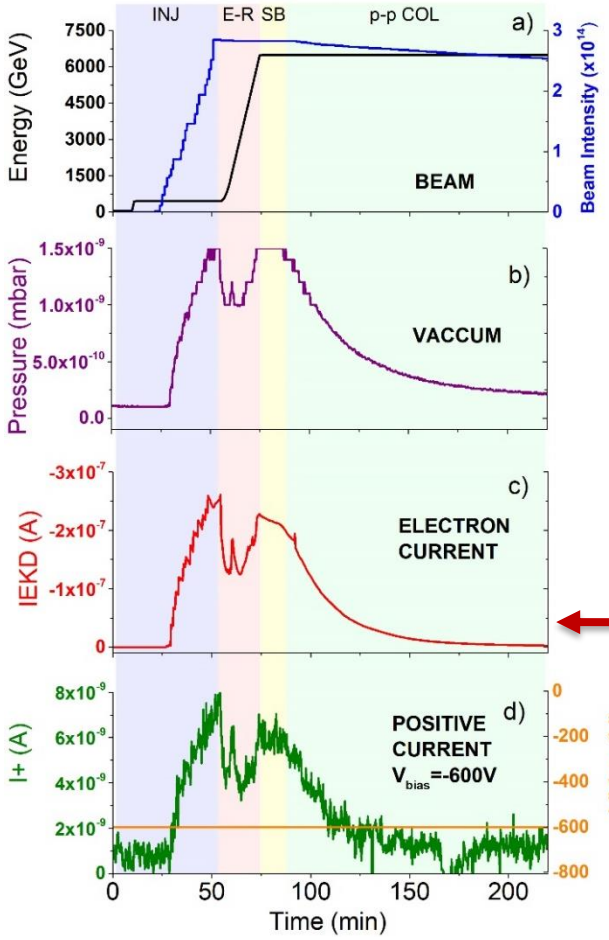
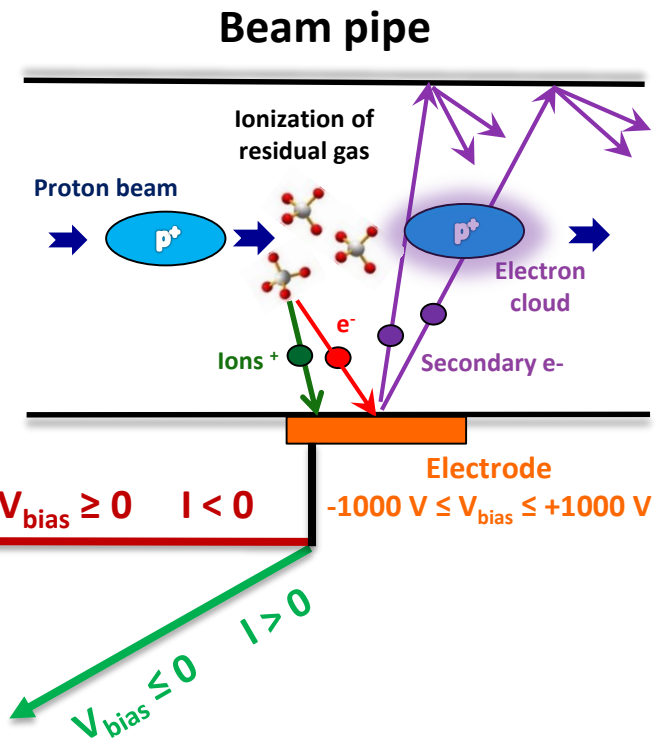
Results

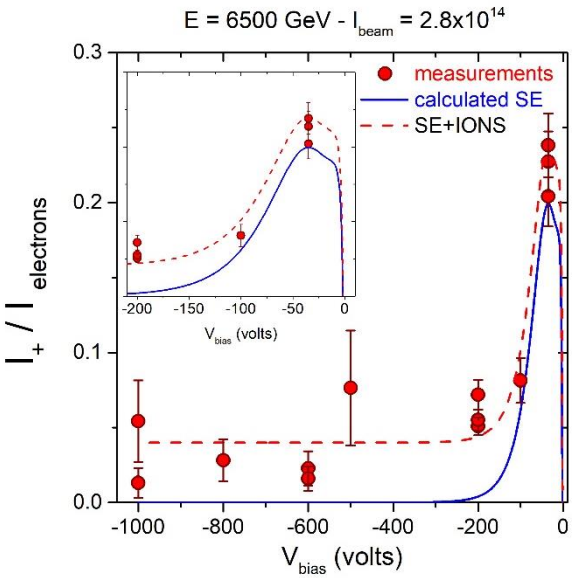
Ionic current measured in the VPS of the LHC during RUN II

Standard fill for physics





Measurements with V_{bias} scanning compared to calculated SE contribution



② The ion current represents 4% of the electron current.

① A positive ion current was detected.

Results

DYVACS - DYnamic VACuum Simulations

Analytical model of the dynamic pressure based on VASCO code

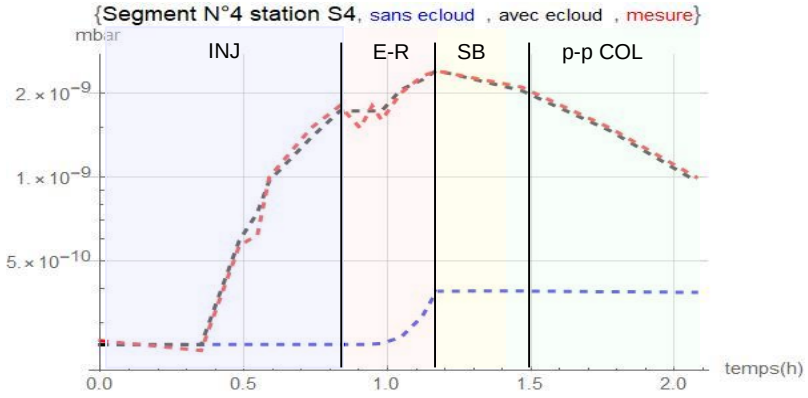
n=1D gas density

Residual gas ionization (by p beam, by EC) | Photon Desorption | Thermal Desorption

$$C\frac{\partial^2 n}{\partial x^2} + \eta_i\left(\sigma_{i-p}\cdot\frac{I_{beam}}{e} + \sigma_{i-e}\cdot\Gamma_e\cdot L\right)\cdot n + \eta_e\Gamma_e + \eta_{ph}\Gamma_{ph} + a\cdot q_{th,} - S\cdot n = 0$$

Molecular Diffusion | Ionic Desorption | Electronic Desorption (e⁻ Cloud) | Pumping Flux

- Considering EC build-up: ↗ Electronic desorption
- Residual gas ionized by EC: ↗ ionic desorption

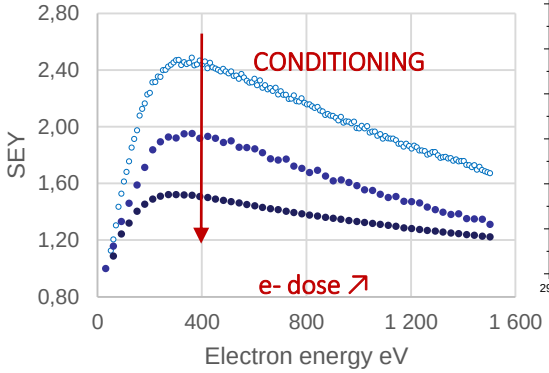


③ DYVACS simulations are in good agreement with measurements performed in the VPS of the LHC.

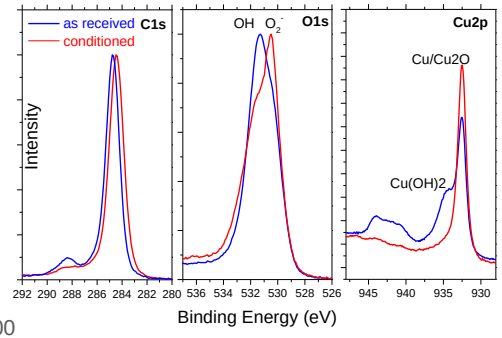
④ DYVACS can be used to predict dynamic pressure of future accelerators.

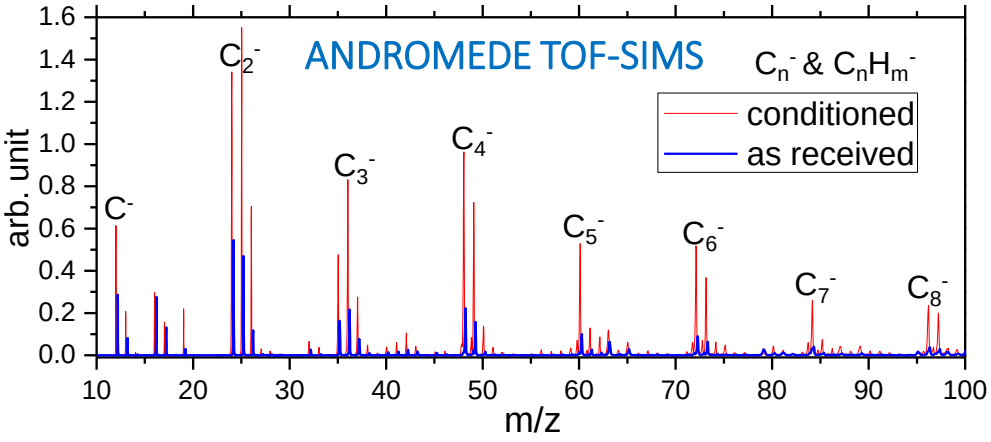
Surface Analysis

SEY of LHC Beam Screen



XPS





⑤ Conditioning effect and graphitization: Beam pipe surface chemistry is modified by interactions with electrons (EC).

Highlight

Issue

Dynamic phenomena as stimulated desorption, secondary particle creation and some collective effects induce a beam quality degradation and limit accelerator performances.

Results

- ① A positive ion current was detected.
- ② The ion current represents 4% of the electron current.
- ③ Simulations are in good agreement with measurements performed in the VPS.
- ④ DYVACS can be used to predict dynamic pressure of future accelerators.
- ⑤ Conditioning: Beam pipe surface chemistry is modified by interactions with e-.

Perspectives

- ➢ Further investigations of Conditioning & stimulated desorption (e- and ions) are necessary.
- ➢ Experimental data needed as input for DYVACS.
- ➢ Prediction of dynamic pressure for the FCC project.

Thank you for your attention !

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