PRESSURE VARIATION IN THE INNER TRIPLETS DURING BEAM OPERATION

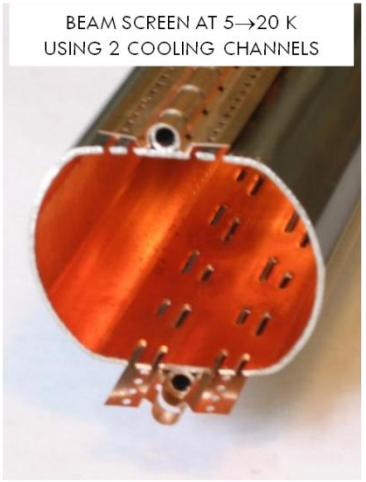
Outline

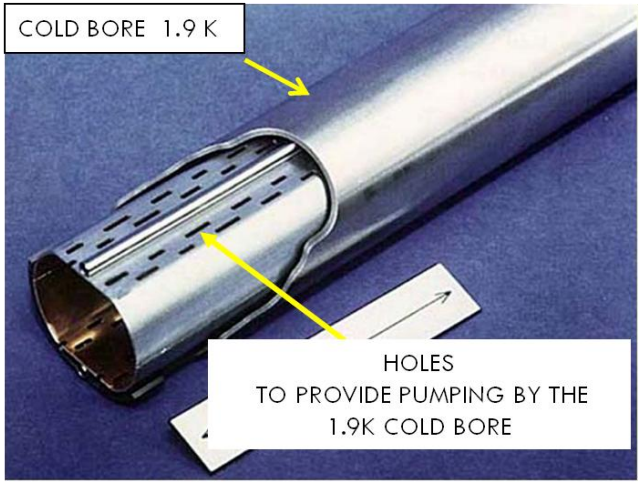
- Introduction: Inner triplet pumping characteristic;
- Pressure in the inner triplet:
  - Scrubbing Run;
  - Technical Stop;
  - Beam Operations;
- Summary

Beam Screen & Cold Bore

Innovating conceptual design with a “beam screen”
Beam screen inserted inside cryomagnet cold bore

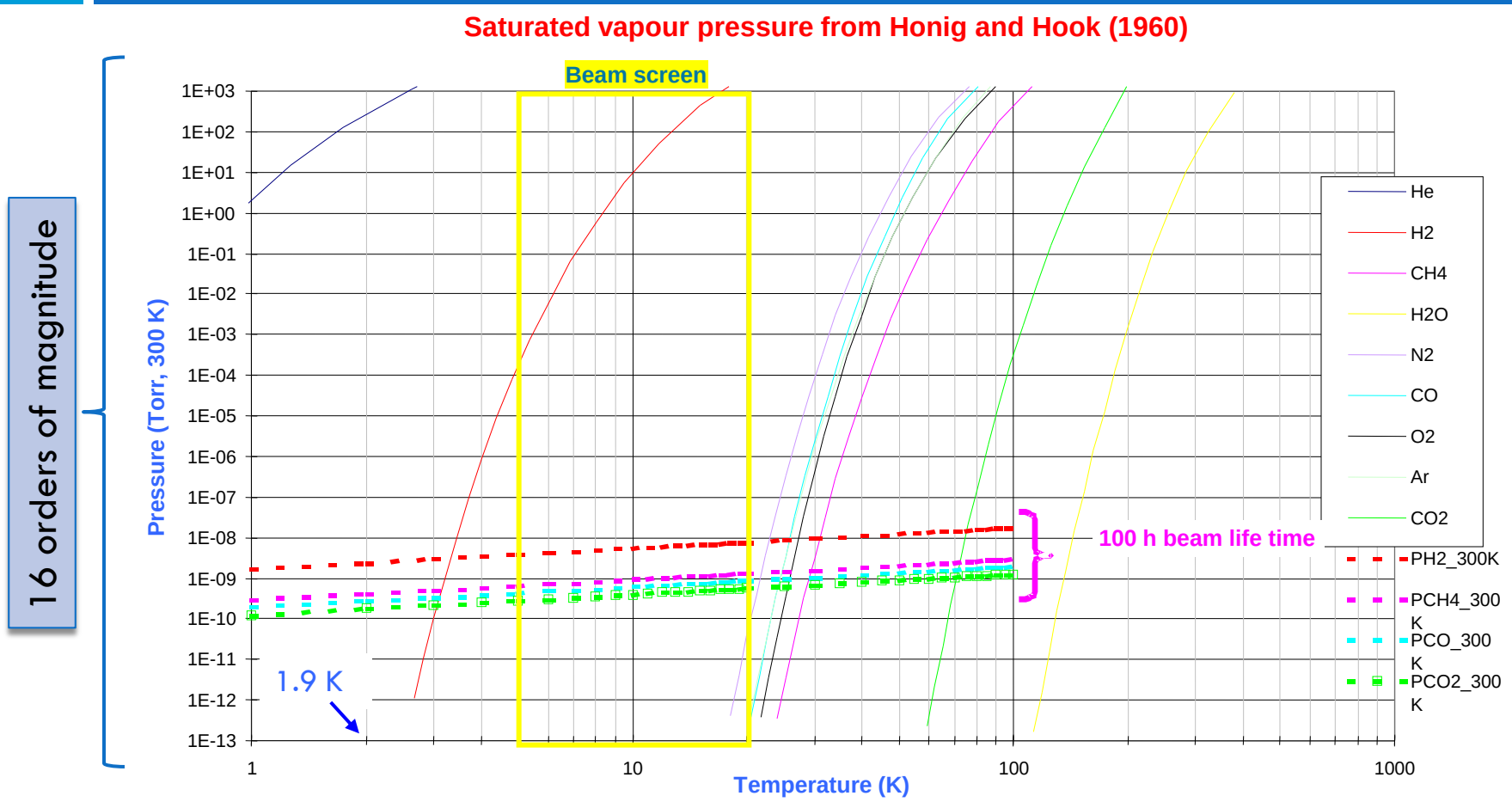
- **Intercept the heat loads**
  - Synchrotron light,
  - Energy loss by nuclear scattering,
  - Image currents,
  - Electron clouds.
- **Provide vacuum pumping**
- **Low photo-electron reflection**
- **Optimize the beam aperture**





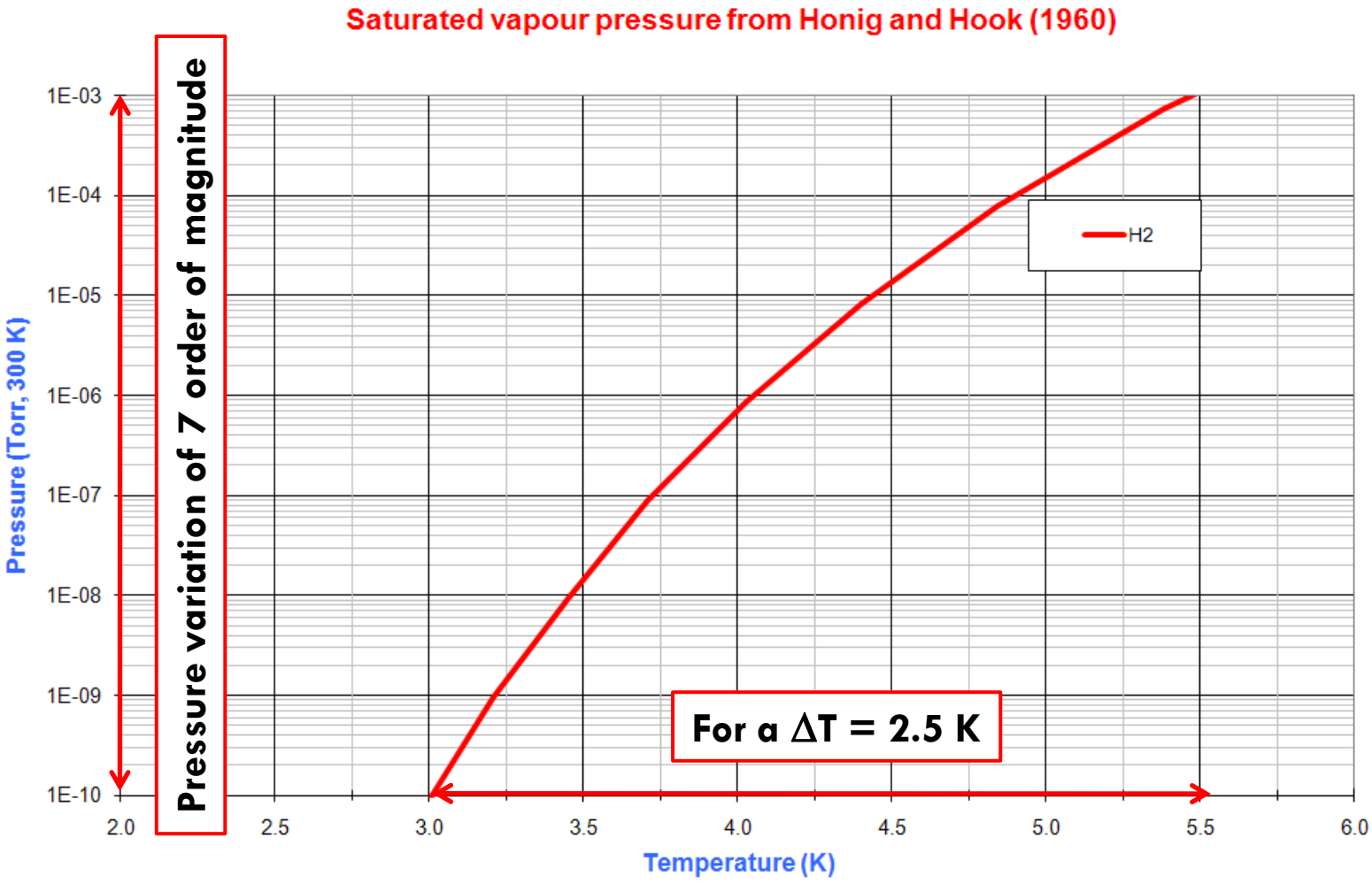
A cryopump is a vacuum pump that traps gases and vapors by condensing them on a cold surface

Beam Screen & Cold Bore



- At 1.9K all saturated vapor pressure of the most important gas are negligible.
- Beam screen operates between 5 – 20K: H_2 vapor pressure could be very large.
- Above 25 K, CO vapor pressure could be also significant.

Hydrogen adsorption isotherm



- Saturated vapour pressure for at least one monolayer of gas condensed on the surface

Vacuum Transient

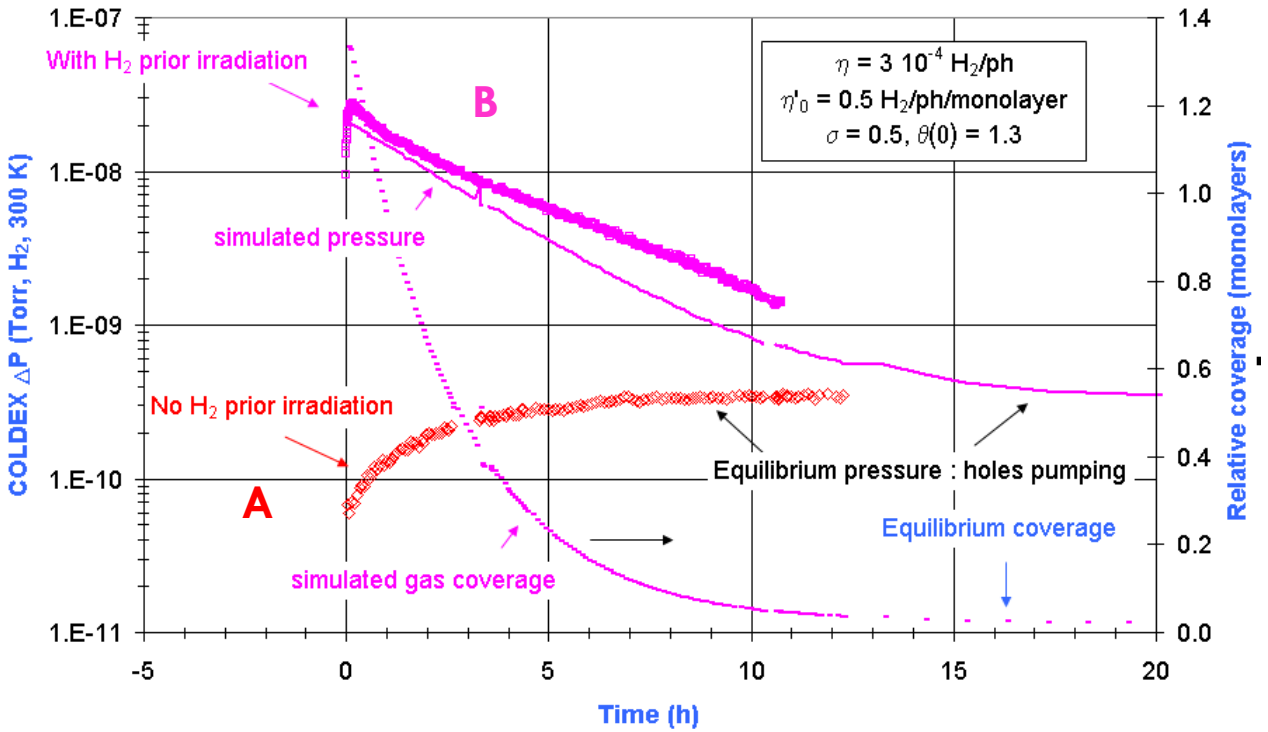
In presence of beam, undesirable vacuum transient could appears when the BS coverage is larger than the required equilibrium coverage.
The equilibrium coverage decreases from a few to ~ 0.01 monolayer

Effect of ~ 1 monolayer of H_2 condensed onto the BS subjected to synchrotron radiation

100 h life time limit →

A: Beam Screen with Bare surface

B: Beam Screen with significant surface coverage

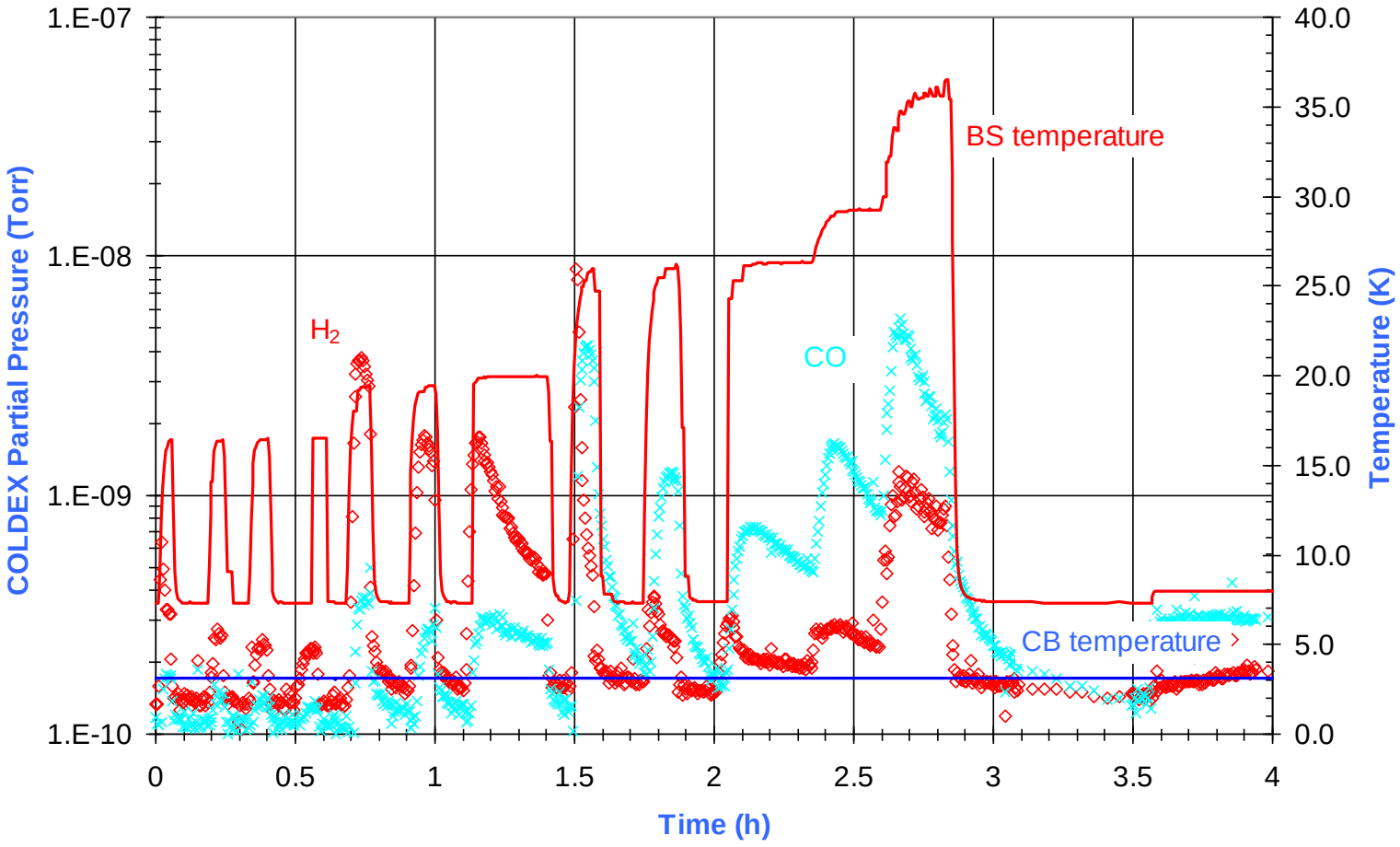


Beam Screen at 10K – Cold Bore at 3K

Data from: Vincent Baglin - LHC Performance Workshop CHAMONIX XIII - 2004 - 19/23 January

Impact of BS temperature oscillations

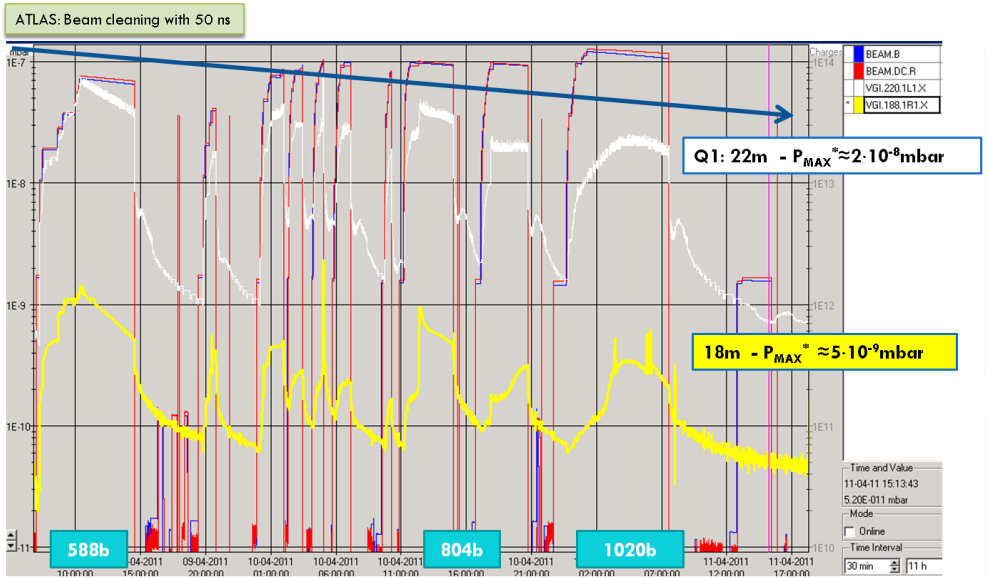
Effect of less than a monolayer of CO physisorbed onto the BS subjected to temperature oscillations : pressure increases and flushing towards cold bore

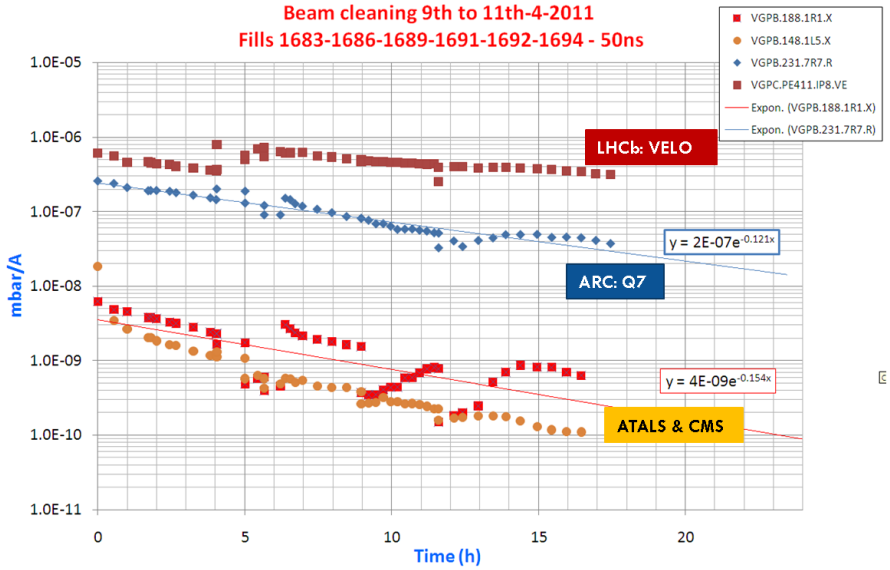


Data from: Vincent Baglin - LHC Performance Workshop CHAMONIX XIII - 2004 - 19/23 January

How can we accumulate gas in the BS?
April 2011 - Scrubbing Run

Vacuum during scrubbing run





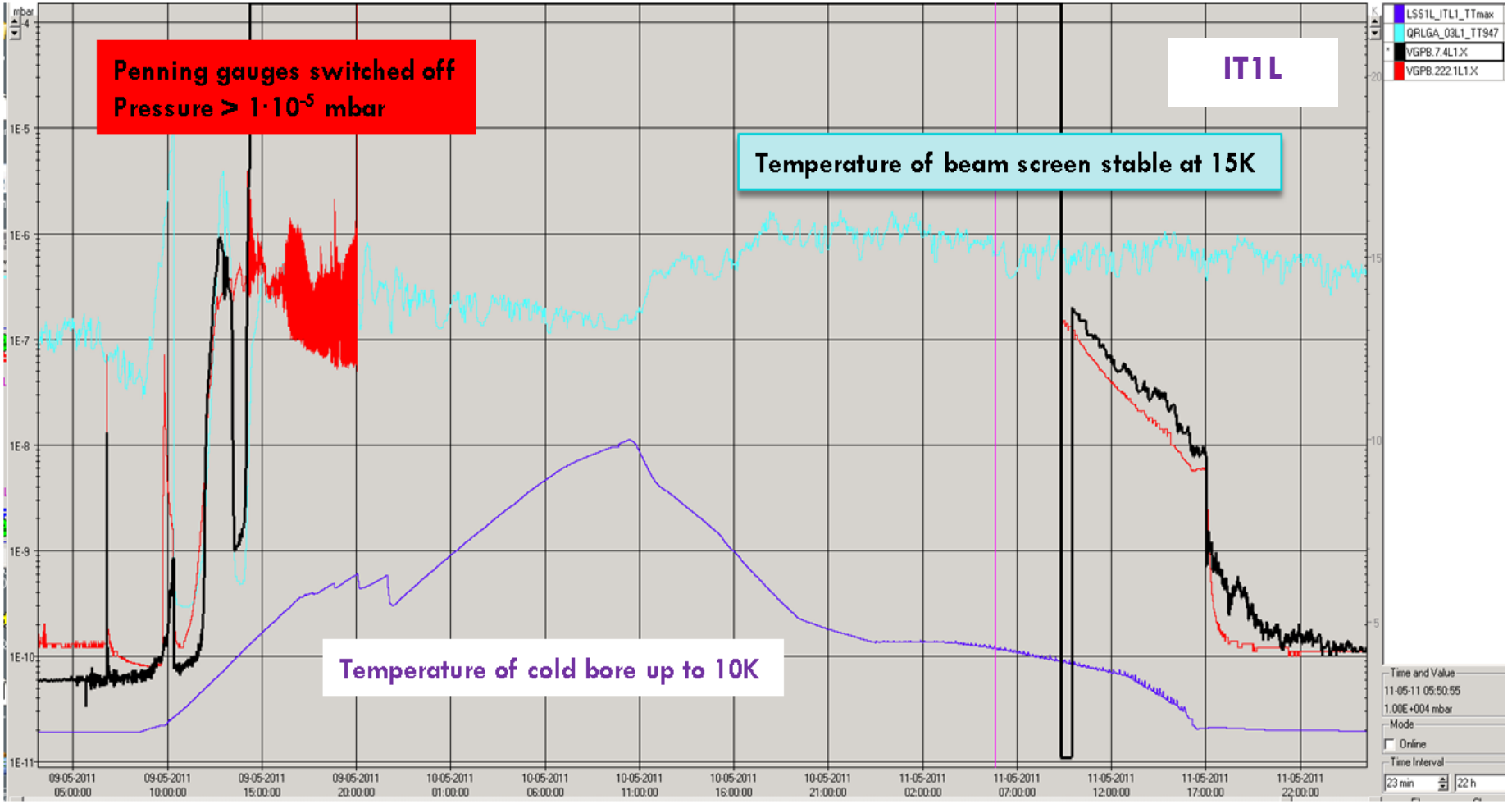
Scrubbing run:
Increase beam current
Pressure decrease due to vacuum cleaning & scrubbing

For ATLAS and CMS reduction of one decade in about 17h (periods with constant number of bunches)

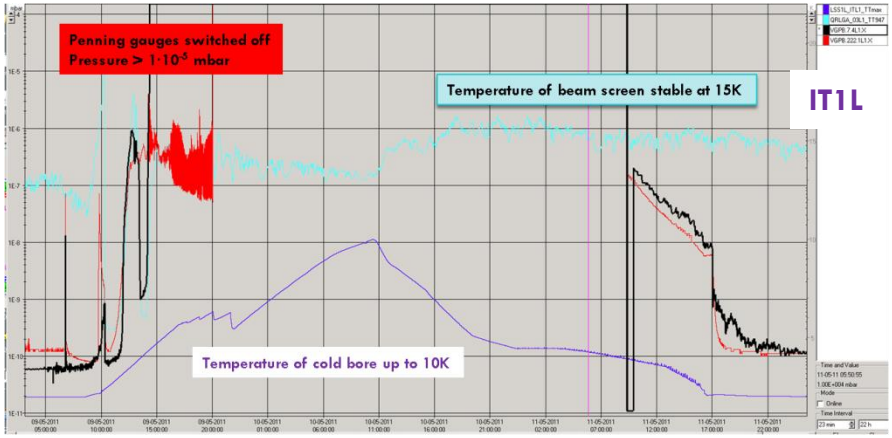
All the desorbed molecules are chemisorbed on NEG and physisorbed on the beam screen

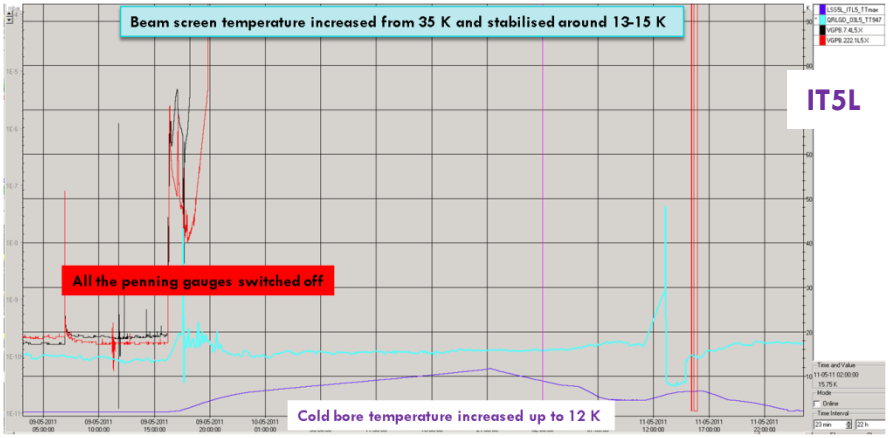
How can we modify the coverage of gas in the BS ?
Example : May 2011- Technical Stop

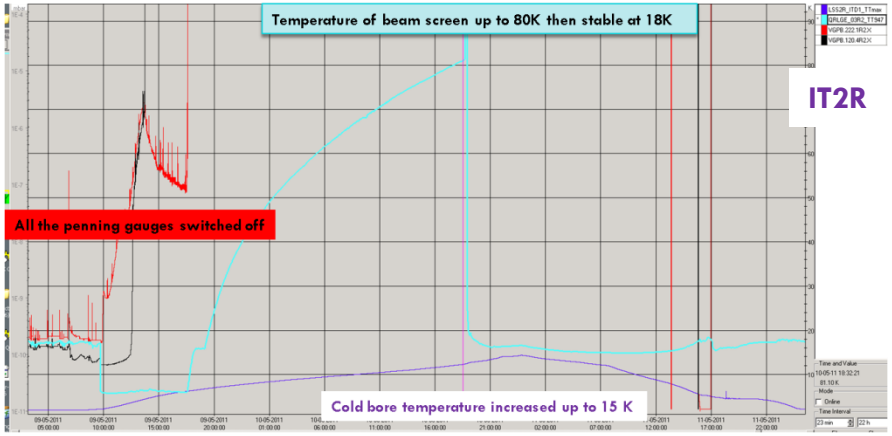
Pressure Variation during Technical Stop: IT 1L

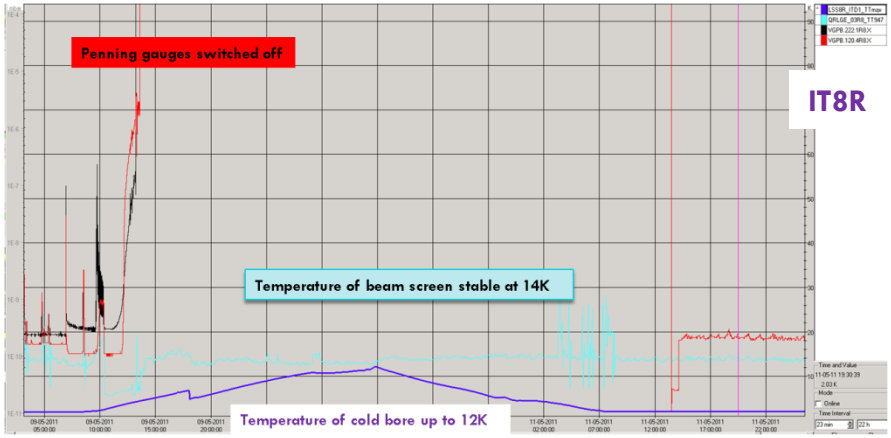


Pressure Variation during Technical Stop: IT 1L









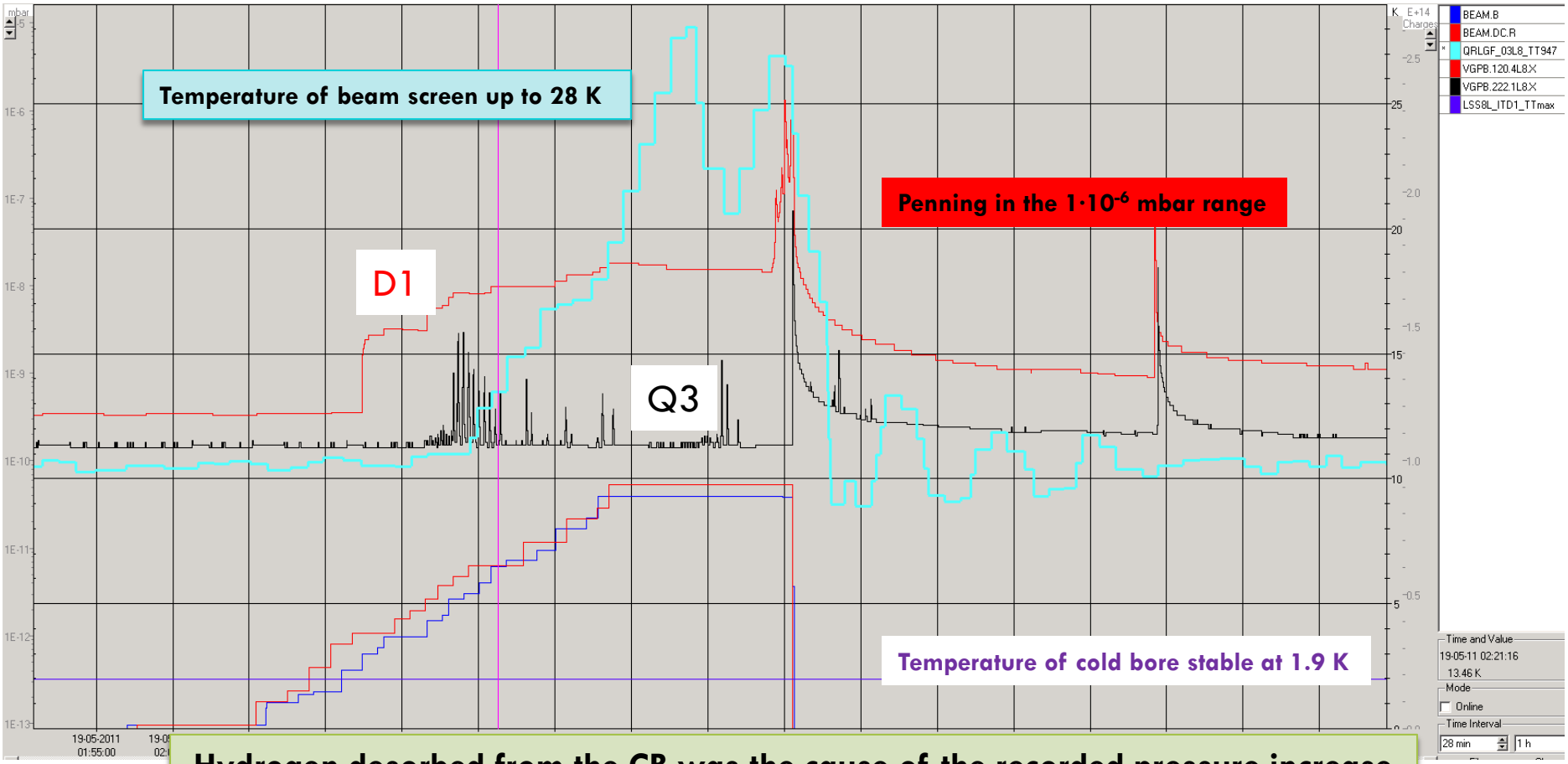
Pressure Variation during Technical Stop: IT 1L

- Temperature of the cold bore increased up to 10 ÷ 15 K
- All the penning gauge switched OFF: $P>1\cdot10^{-5}$ mbar
- Beam screen at variable temperature between 15 ÷ 20 K
- Part of the hydrogen desorbed from the CB was condensed on the beam screen.

Some Example of Pressure Variation During Beams Operation

Beam Dump due to Vacuum: 19.05.2011

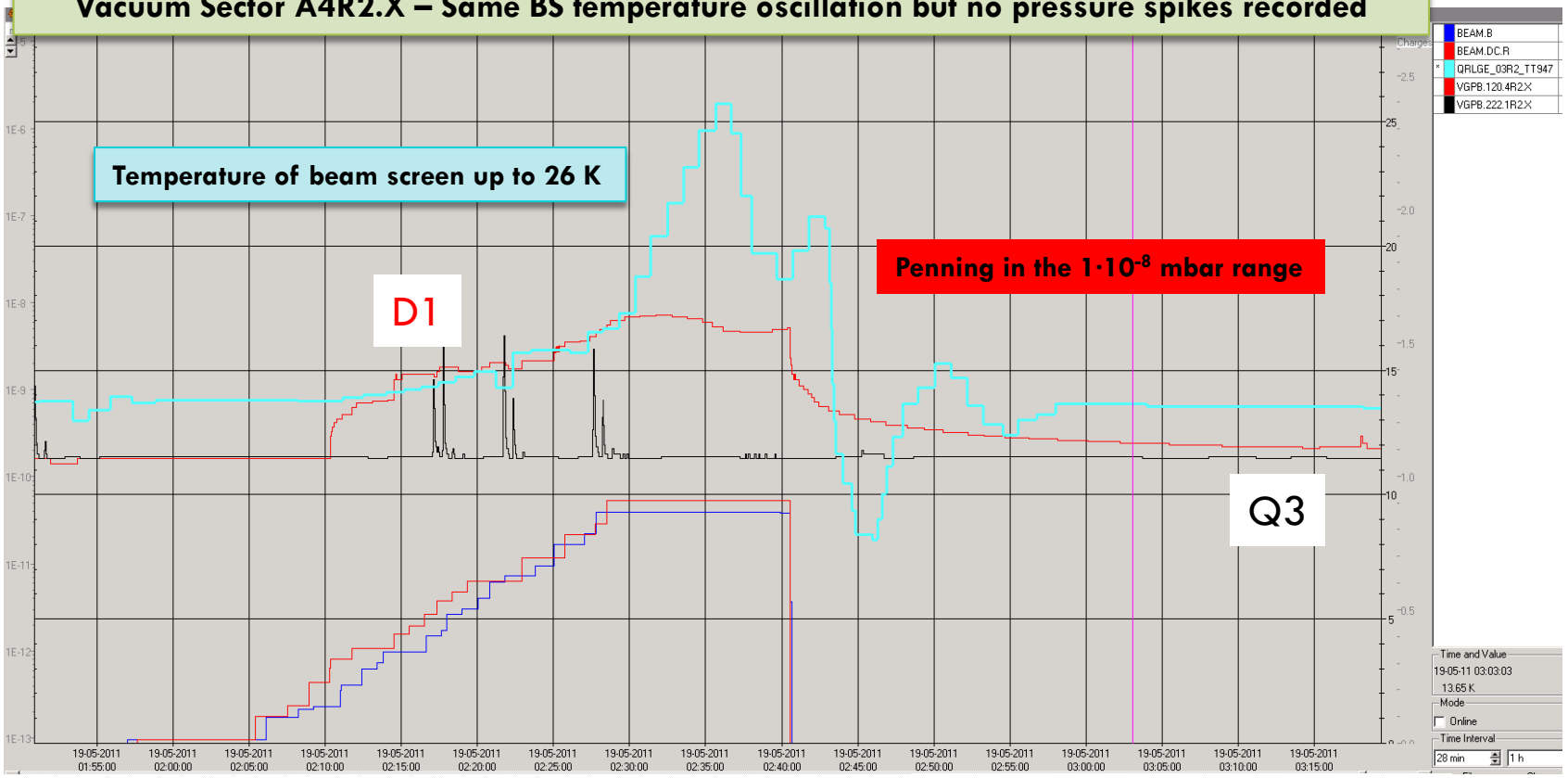
Beam dump at 02:40:32 – fill number 1789 – Vacuum Sector A4L8.X



Hydrogen desorbed from the CB was the cause of the recorded pressure increase

Beam Dump due to Vacuum: 19.05.2011

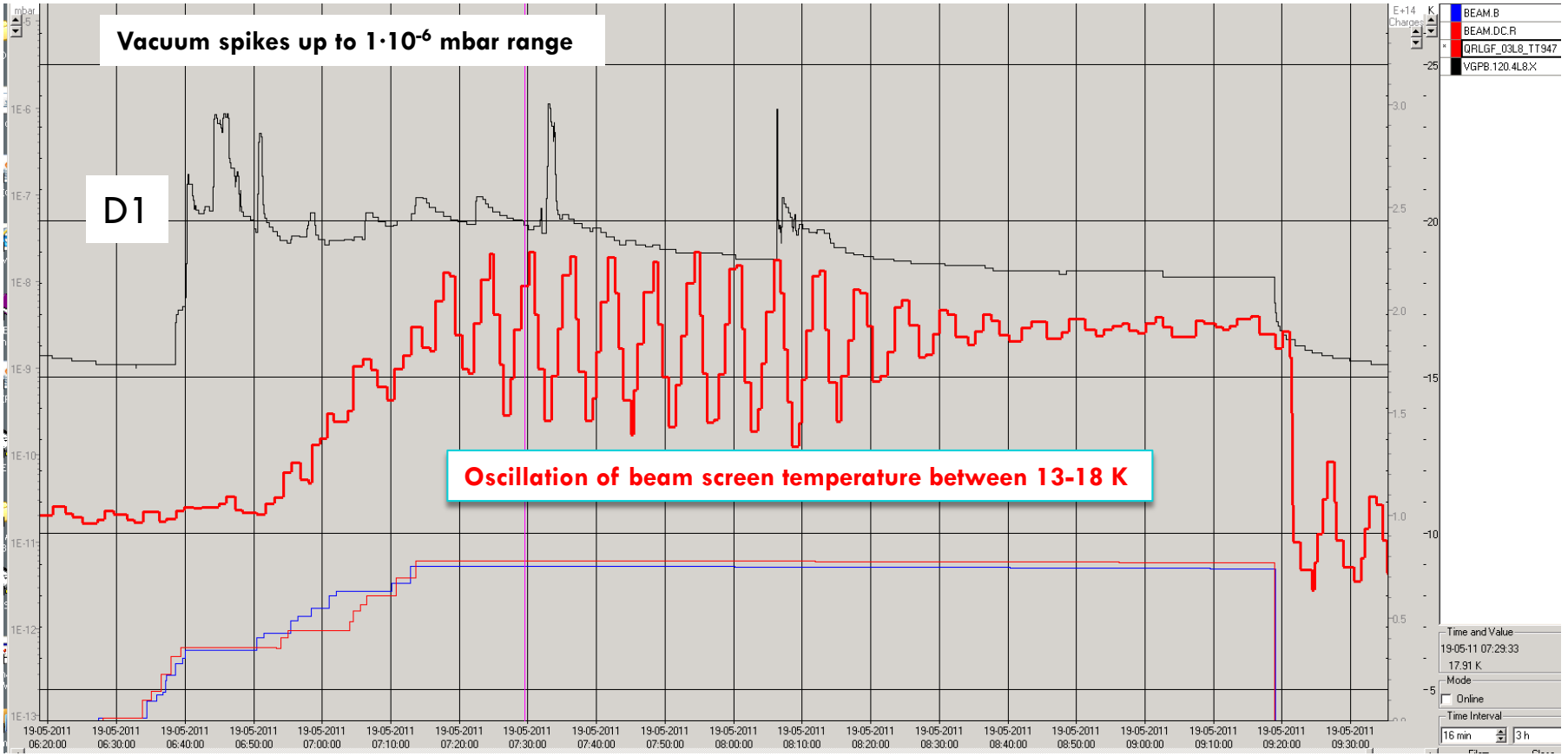
Vacuum Sector A4R2.X – Same BS temperature oscillation but no pressure spikes recorded



Temperature of cold bore stable at 1.9 K

Pressure increase just due to electron cloud activity – No pressure spikes recorded
Same beam orbit and/or same lost as in IT8L?

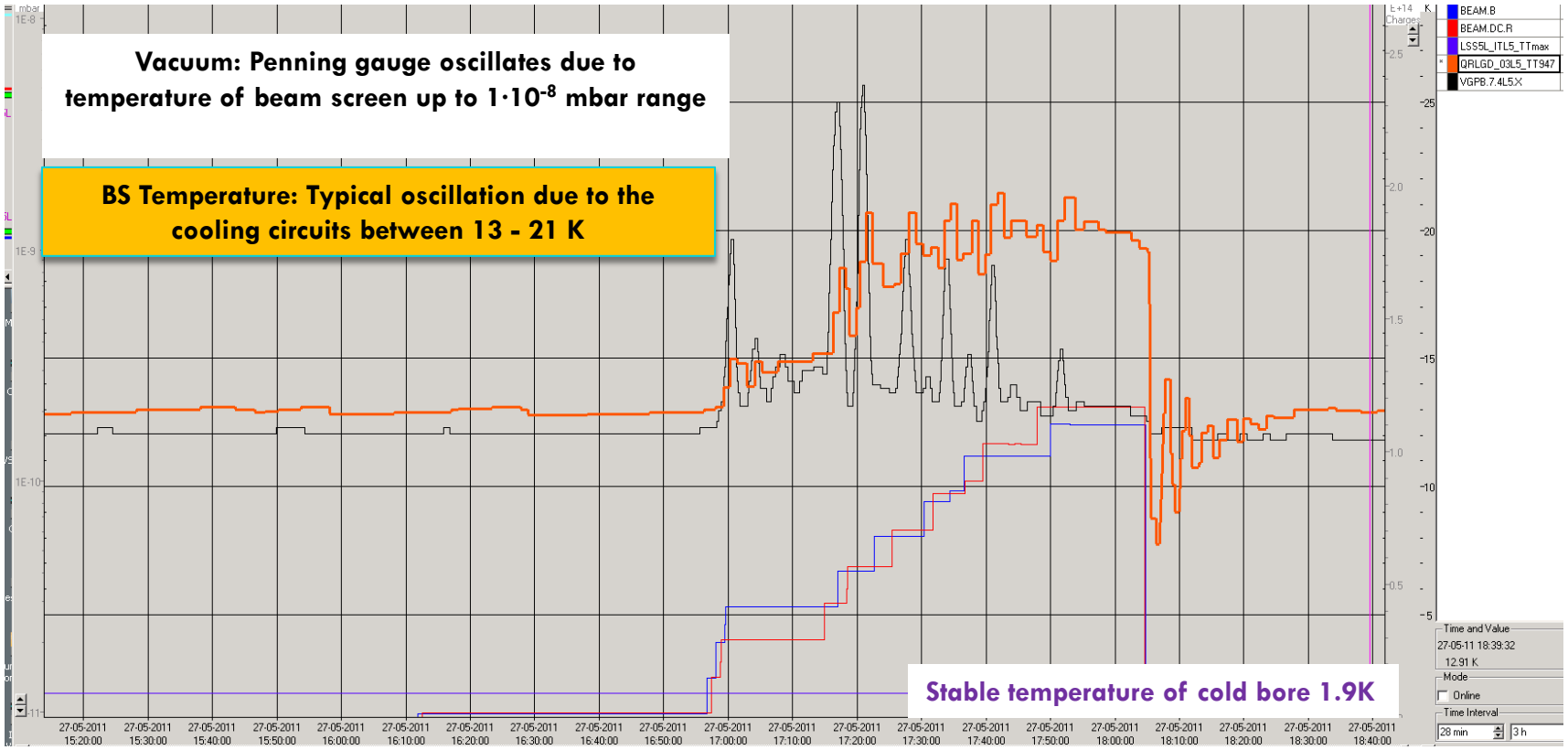
Pressure Variation during Beam Operation: : IT8L



Fill Number 1790 – Thursday 19/05/11 at 7:00 AM

Pressure Variation during Beam Operation: : IT5L

No electron cloud activity due to the CMS magnetic field

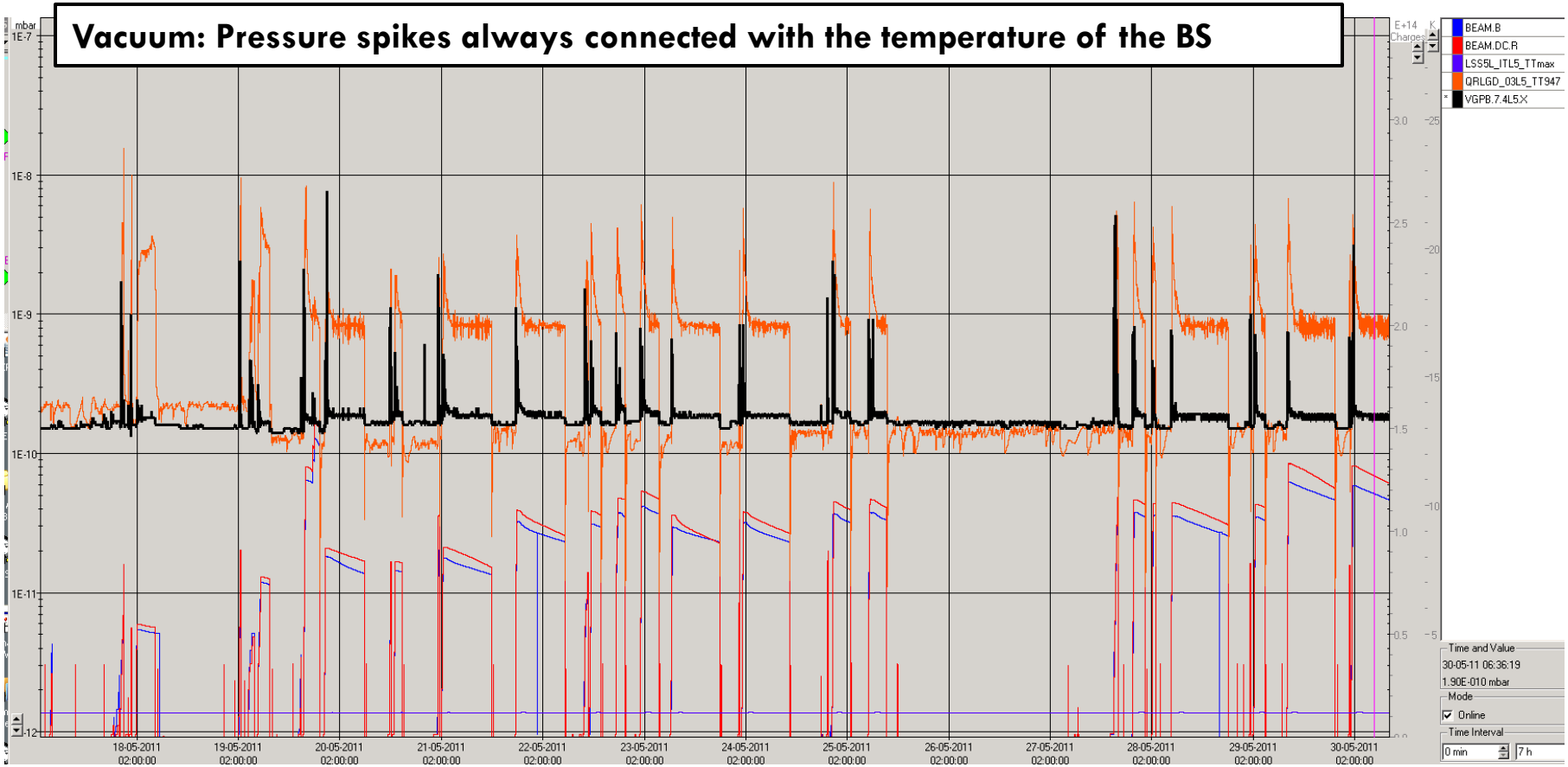


Fill Number 1808 – Friday 27/05/11 at 17:00

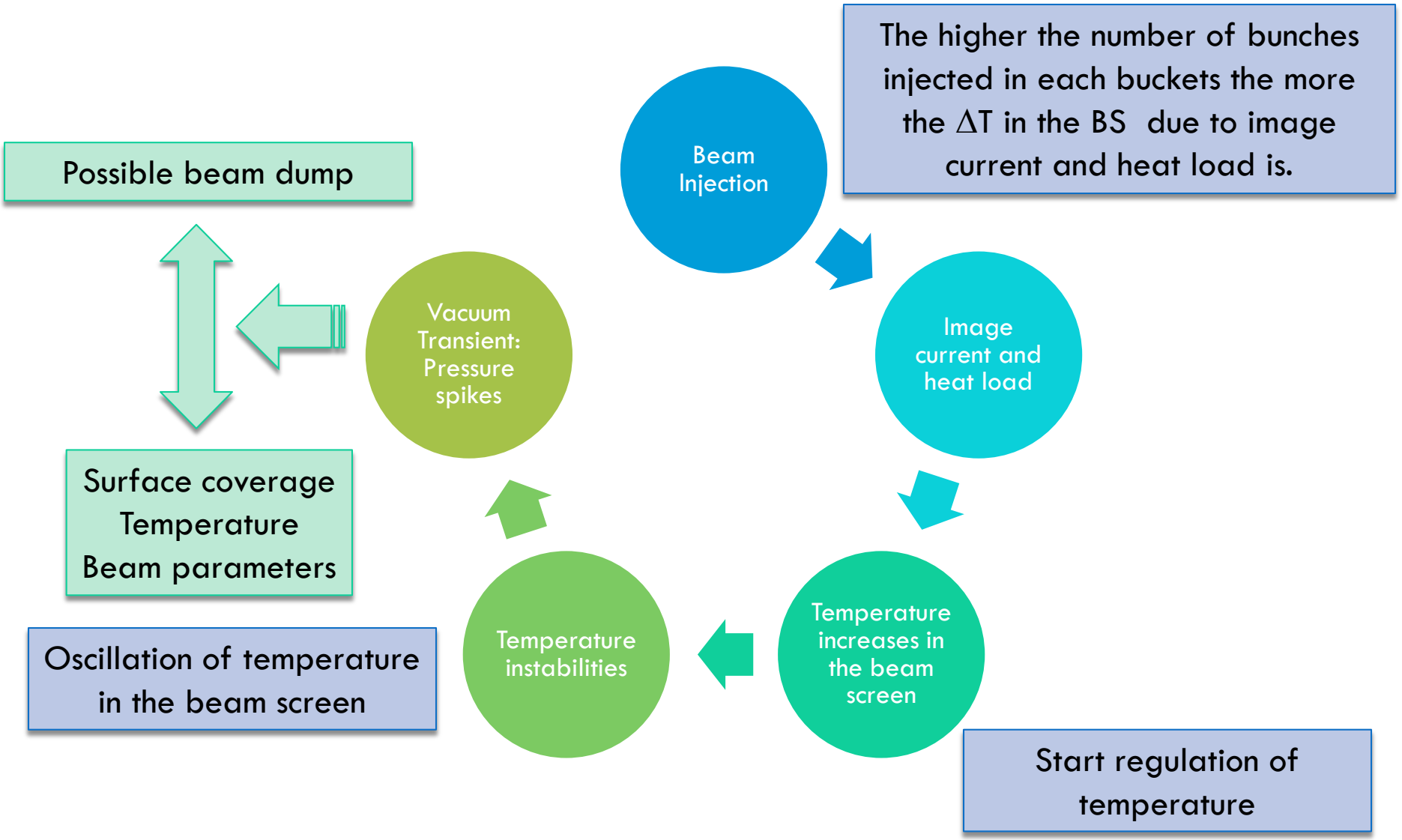
Pressure Variation during Beam Operation: : IT5L

Beam Screen: Temperature spikes at the end of injection, then stable .

Vacuum: Pressure spikes always connected with the temperature of the BS

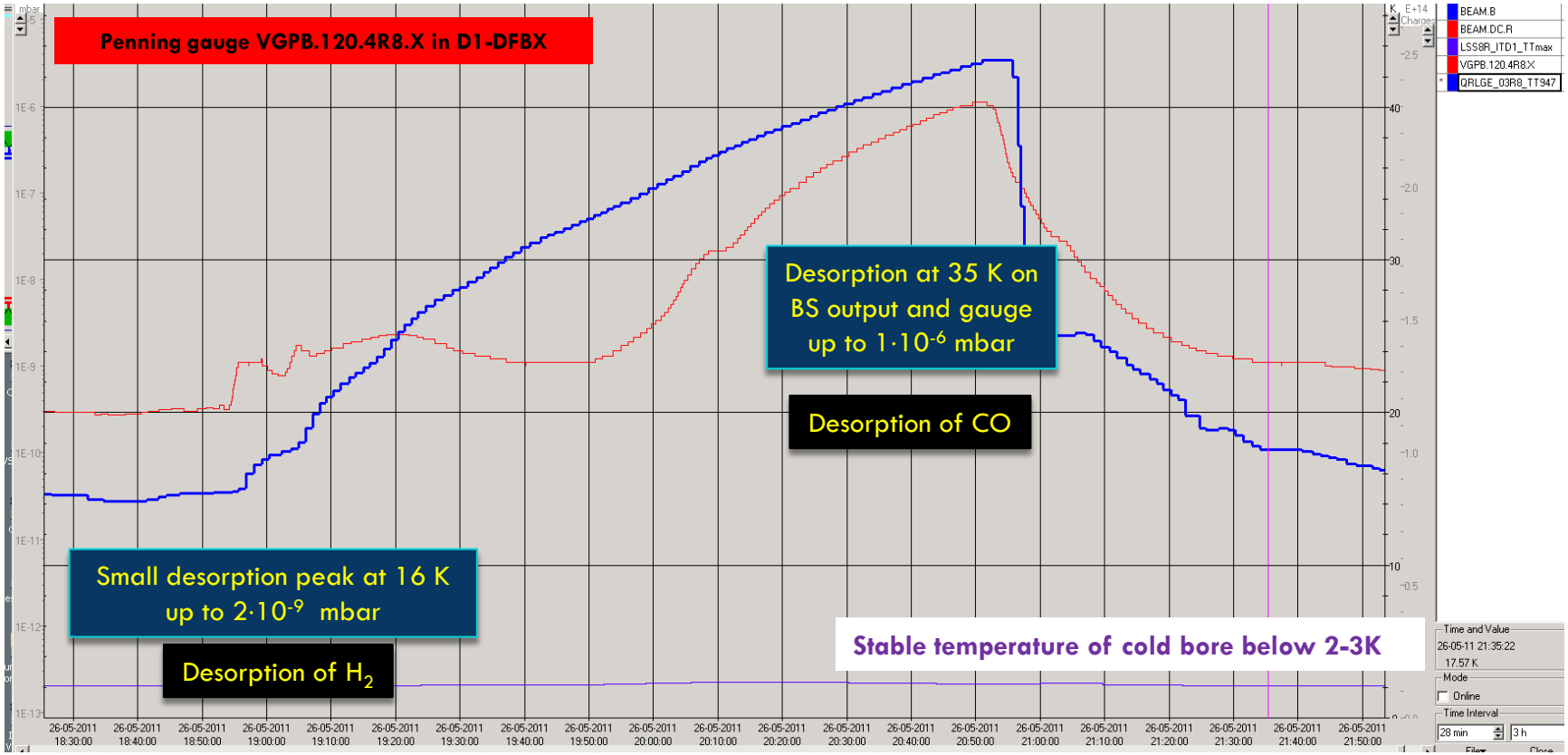


Cause & Effect



Possible Remedy (Tested last week)

Flushing of the gas in excess on the beam screen inner surface onto the cold bore to avoid transient



We flushed this large quantity of CO to the CB and then cool down

Test performed the 26/05/2011 at 19:00

Summary

- Scrubbing run : beam conditioning => gas desorbed and chemisorbed on NEG and physisorbed on beam screens.
- Gas accumulated onto the beam screens up to equilibrium coverage
- During technical stop in may 2011: redistribution of the surface coverage along beam screens
- If we have an excess surface coverage: possible vacuum transient
- Vacuum transient might induced beam dump, background and even quench at 7 TeV/beam
- Vacuum transients could be avoided by an adequate BS warming up: the gas is flushed towards CB
- Warming up has been tested last Friday on IT8I&R (up to >30K) and IT1L (up to 20 K)
- If successful, warming up of other IT should be done.