LHC VACUUM SYSTEM: 2012 REVIEW AND 2014 OUTLOOK

G. Lanza, V. Baglin, G. Bregliozzi, J.M. Jimenez

EVIAN 2012

Outline

- Vacuum integrity protection
- Vacuum beam dumps 2012
- Vacuum interventions 2012
- 2015 LHC vacuum outlook

Vacuum Integrity Protection

The vacuum interlocks trigger the sector valves closure

A high pressure limit is set for the LHC: **VACUUM AND EQUIPMENTS PROTECTION**

- Fast reaction to sudden beam pipe air venting
- Minimise the propagation of the effects of a leak
- Reduce beam downtime

Different priorities for Warm / Cold systems

- Warm vacuum system: Reduce the recovery time dominated by bake-out
- Cold vacuum system: Minimise gas contamination onto the beam screen to avoid the need of a magnet warming up

Definition of Vacuum Interlock threshold

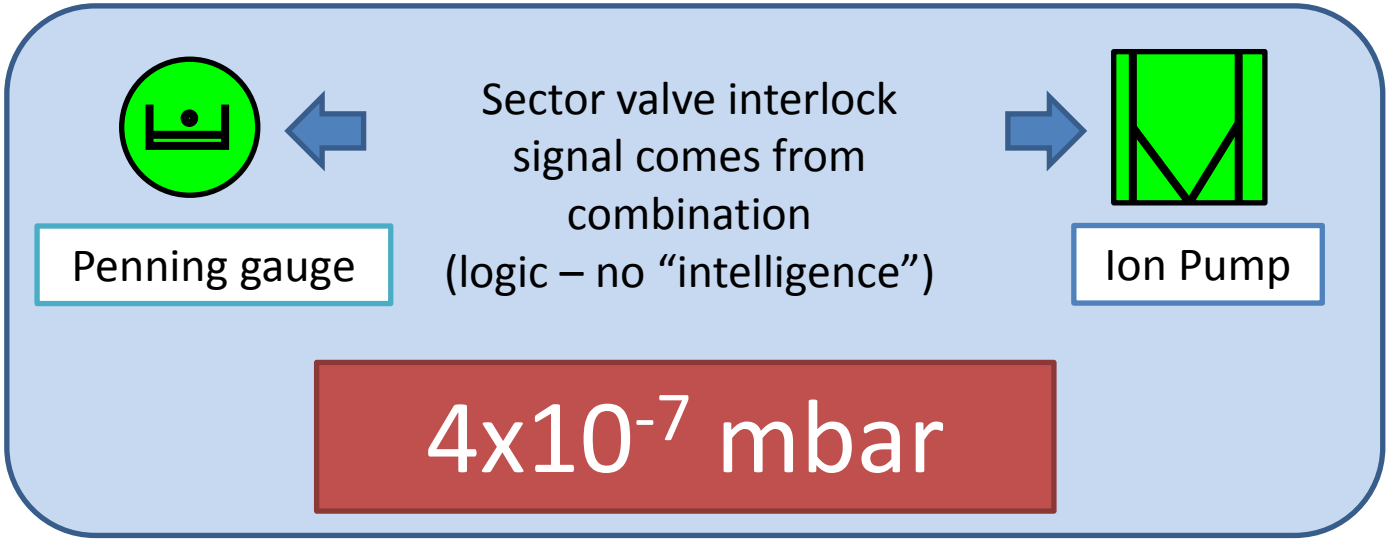
Critical gas density over 1m to induce a quench at 7TeV
1.7×10^{17} molec./m^3 (7×10^8 protons/m/s lost in the cold mass)

4×10^{-7} mbar

Maximum gas density to grant 100h beam lifetime in the arcs: H_2molec/m^3 = 1×10^{15}

V. Baglin, LHC Project Workshop – Chamonix XIV

Vacuum Interlocks Rules



Redundancy N=3

N-1 elements above the limit or off dump the beam

Interlock levels as set by "clients"

ADT

MKB

Each equipment receive a signal from one gauge and/or one or two Ion pumps

Upper threshold: 5×10^{-7} mbar
Lower threshold: 1×10^{-7} mbar

Upper threshold: 2x10-5 mbar
Lower threshold: 1x10-5 mbar

MKI

RF Cavities

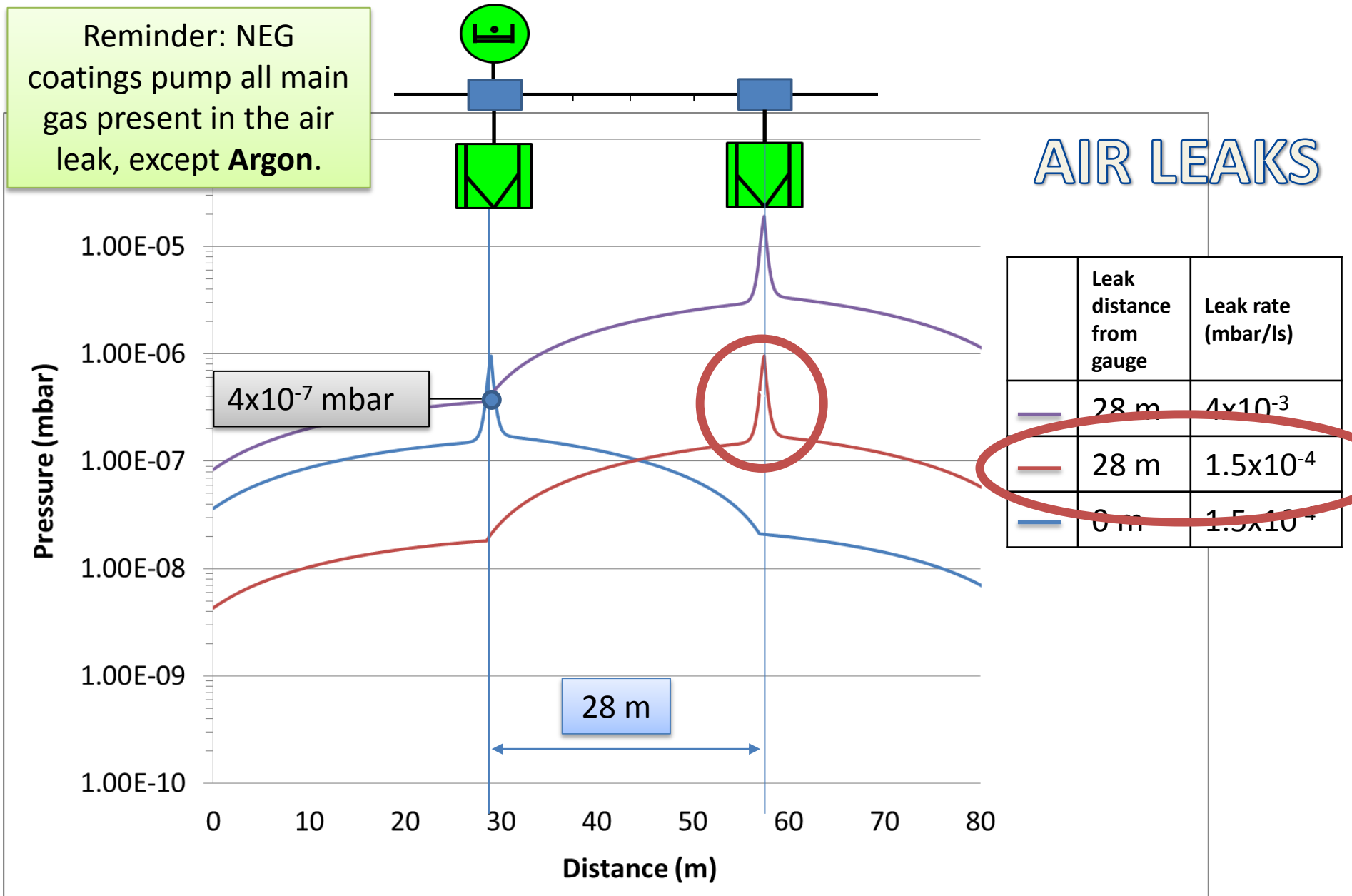
Each equipment owners decide the thresholds and choose how to use the signal

Upper threshold: 2x10-8 mbar
Lower threshold: 1x10-8 mbar

Upper threshold: 4x10-7 mbar
Lower threshold: 1x10-7 mbar

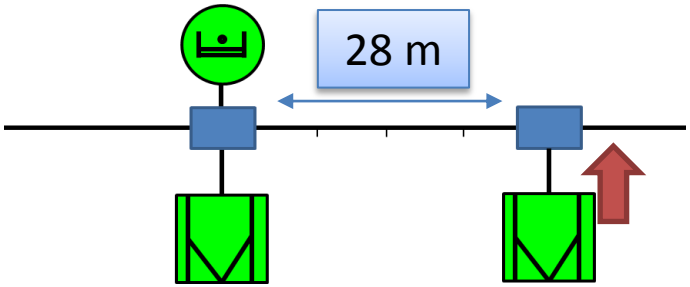
Threshold impact on Recovery Time

Reminder: NEG coatings pump all main gas present in the air leak, except **Argon**.



	Leak distance from gauge	Leak rate (mbar/ls)
	28 m	$4x10^{-3}$
	28 m	$1.5x10^{-4}$
	0 m	$1.5x10^{-4}$

Threshold impact on Recovery Time



AIR LEAKS

1.5×10^{-4} mbar/ls

t= 1 h

6 cm of NEG saturated

t= 10 h

60 cm of NEG saturated

t= 4 day

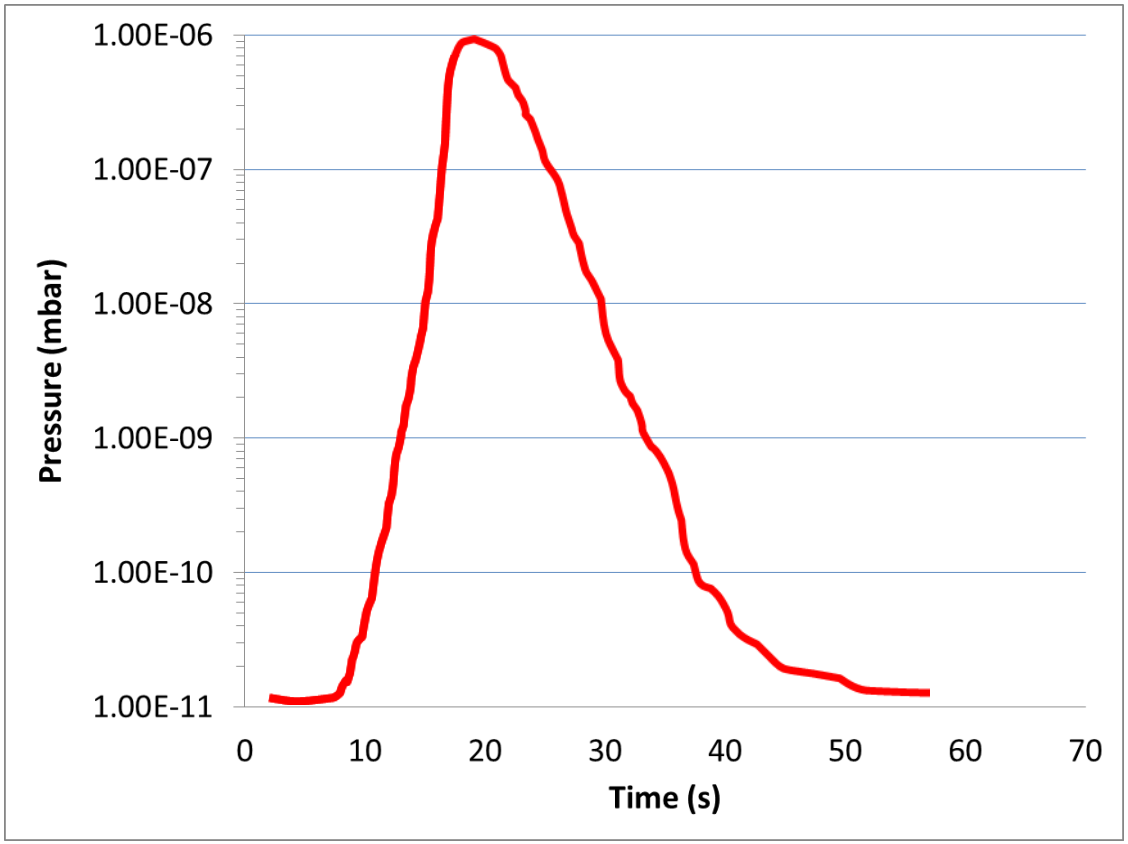
6 m of NEG saturated

t= 8 days

11 m of NEG saturated

Distributed pumping speed reduction → Distributed pressure increase → Background, Increase recovery time

Dealing with pressure spikes



Pressure gauge controllers and ion pump power supplies have “no intrinsic intelligence”
Interlock chassis is only “logic” based i.e. no possible signal treatment

Pressure spikes over the high interlock limit will always trigger **sector valves fast closure**, as requested after sector 3-4 incident.

Interlock during scrubbing

To allow the conditioning of the machine, the interlock can be temporarily increased.

As the beam lifetime during scrubbing is shorter, a smaller vacuum beam lifetime limit remains negligible as compared to beam lifetime

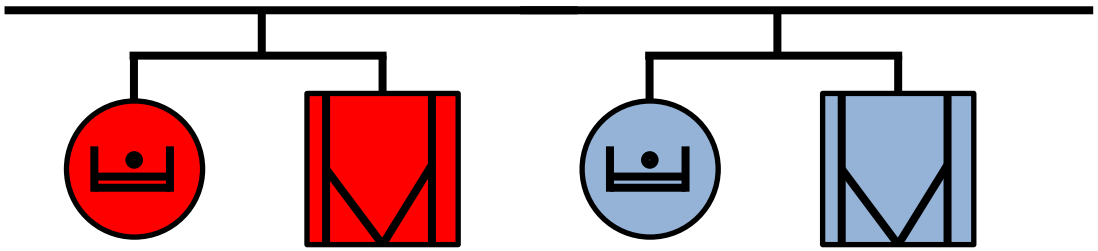
Interlock for non conformity

Each case has to be evaluated with Owners of surrounding equipment before taking the decision of relaxing the interlocks

Beam dumps 2012

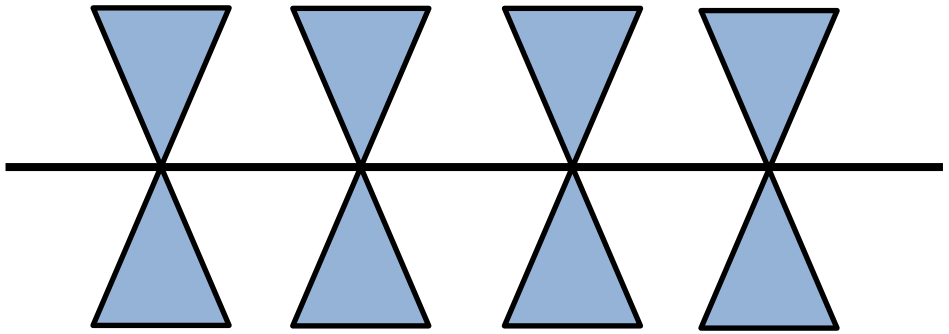
related to vacuum

Beam dumps 2012 related to vacuum



Vacuum gauges switch off or in undefined status

PLC switch lost connection



Vacuum valves in undefined position

LS1: follow all recommendation given by R2E

Beam dumps 2012 related to vacuum

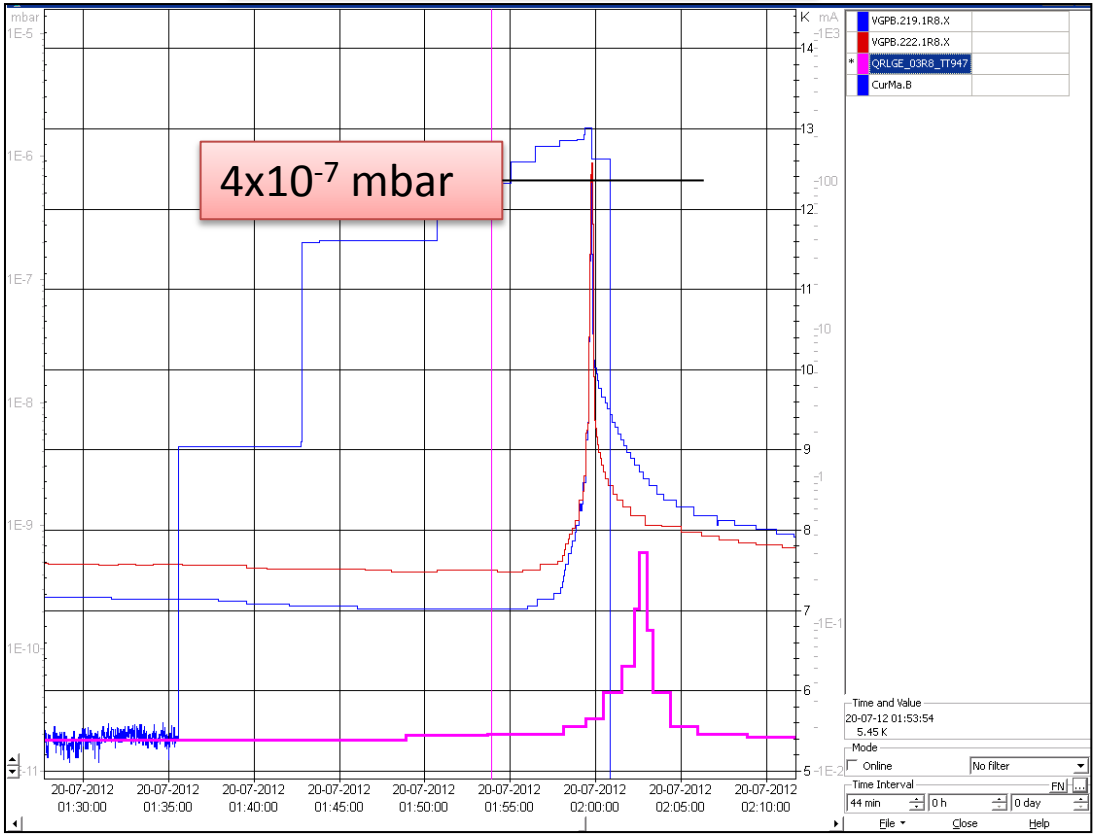
Equilibrium surface coverage depends of parameters such as:

- beam parameter
- Beam screen temperature.

If the surface coverage exceeds its equilibrium value, pressure excursion or transient due to cryogenics appears when the beam is injected.

Inner triplets LSS 8 - 20 July

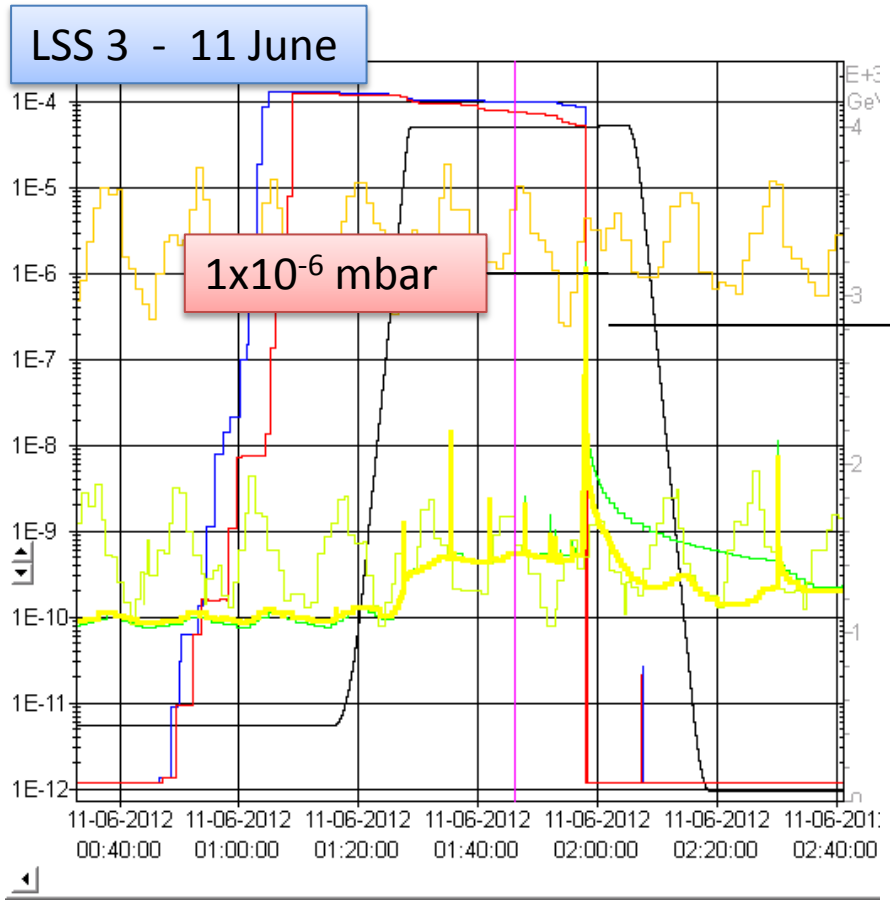
After 10h SMOG injection



V. Baglin, LHC Project Workshop – Chamonix XIII

G. Bregliozzi, LBOC presentation, 31.05.2011

Beam dumps 2012 related to vacuum

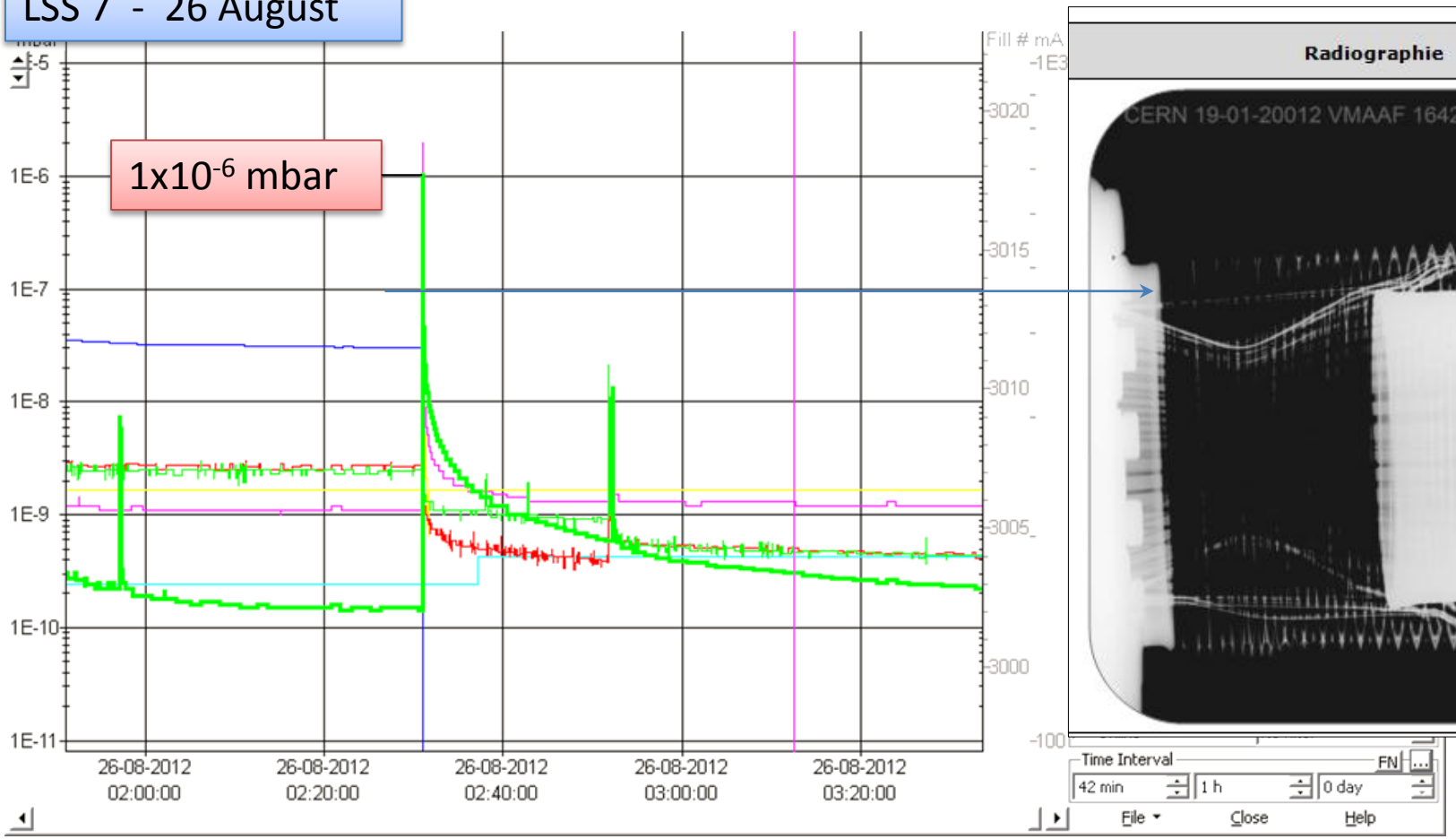


Gauge signal

- Proton induced desorption
- Ionization of the cable (seen in ISRs)

Beam dumps 2012 related to vacuum

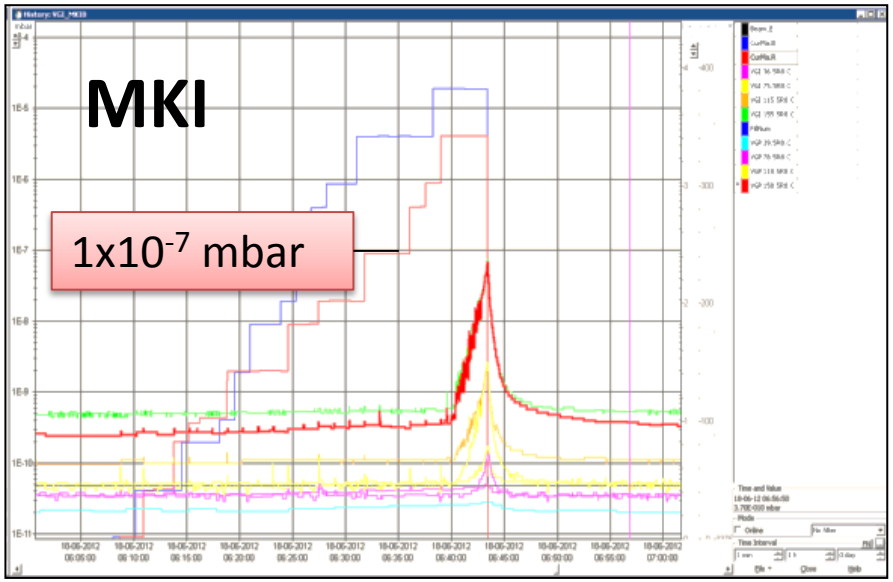
LSS 7 - 26 August



Typical signal of mechanical non conformity: all positions are known.

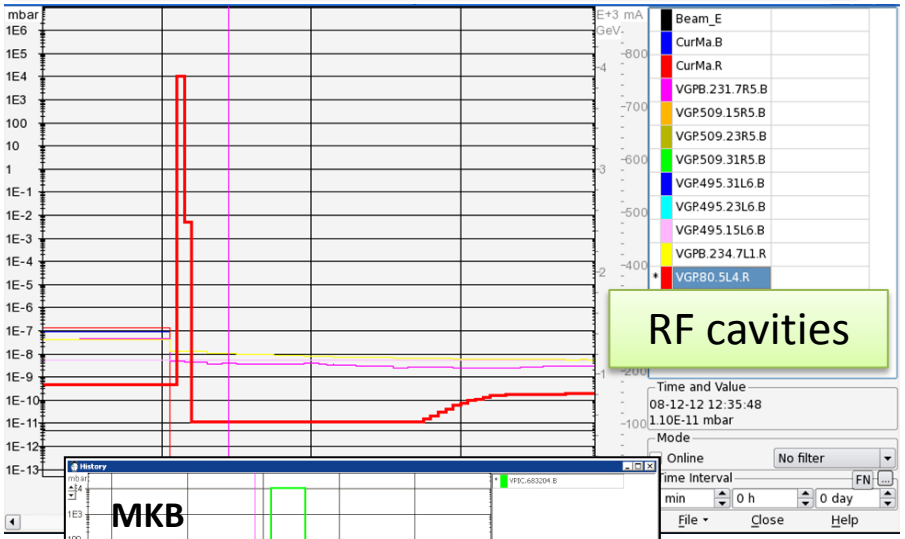
LS1: reparation of **ALL** RF non-conform RF inserts

Beam dumps 2012 related to clients system

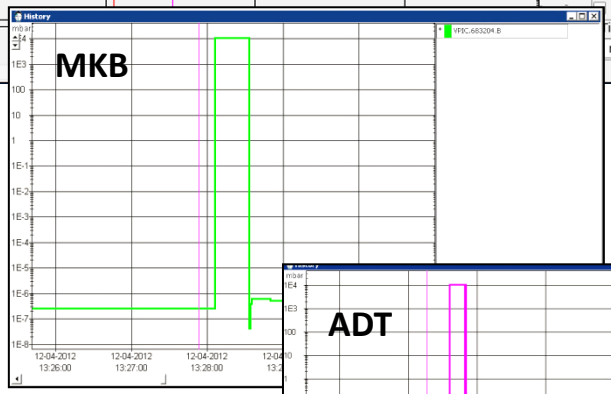


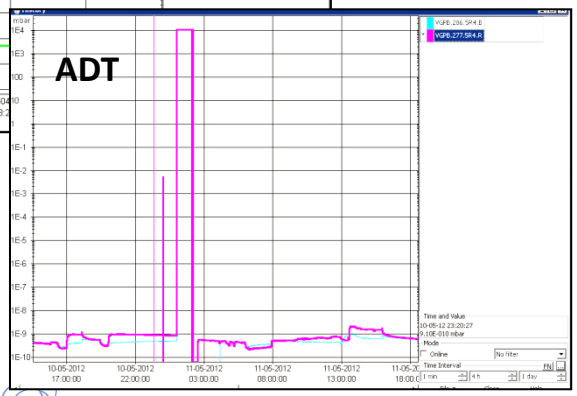
Real pressure signal

Gauge or Controller fault or EMI



RF cavities





2012 Vacuum Interventions

Type of vacuum intervention

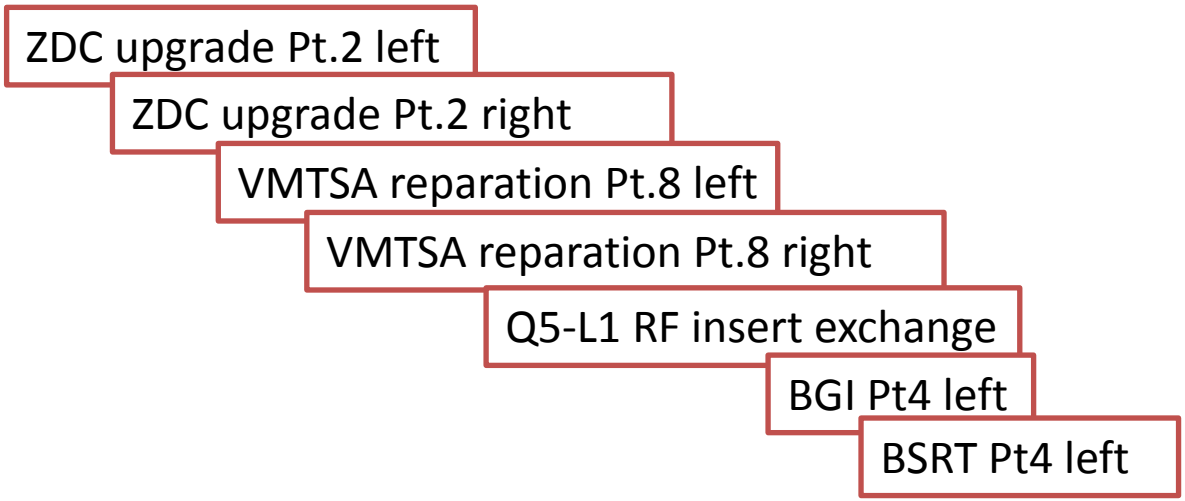
The baseline is bake out and NEG activation

- At the end of the intervention the sector recovers the previous static pressure
- The intervention should have no impact on the LHC operation, the beam lifetime or the background on the experiments
- An exceptional, alternative intervention, that has to be evaluated by the vacuum group experts, is Neon Venting → will be harmful for operation with high intensity and high energy beams

Venting and Bake out

Usually a **3 weeks** intervention (typical of any baked vacuum system) depending on the sector complexity:

- Venting the sector to air
- Mechanical intervention
- Pumping
- Bakeout installation
- Bakeout and NEG activation
- Bakeout removal



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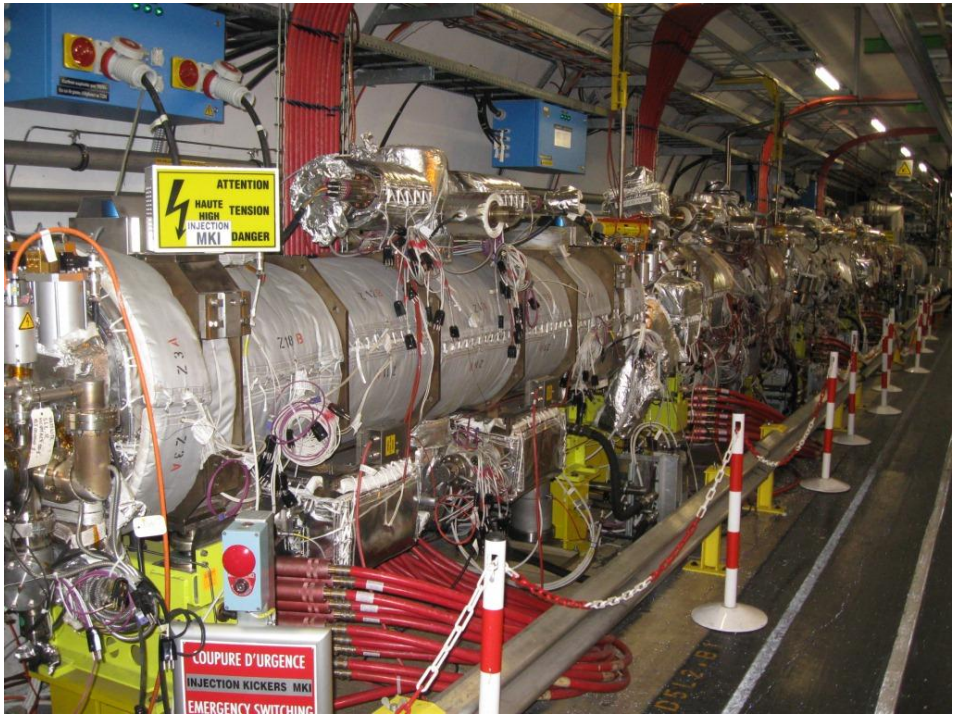
Exception

MKI exchange

- **5 days** of Technical Stop continuous days and nights work
- **3 weeks of preparation** of the kicker on surface
- At least a week for the scrubbing of the new component



Neon venting

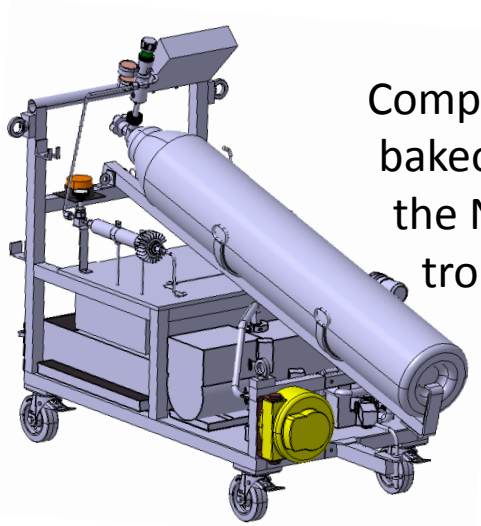
No bake out

5 days intervention

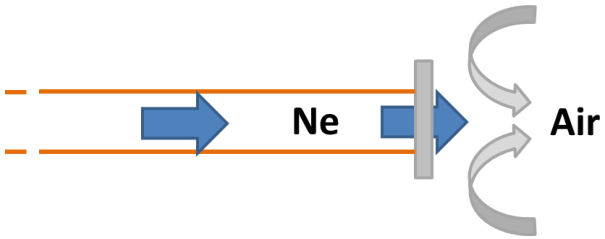
Avoid major NEG saturation but possible local saturation close to the exchanged piece

Zone that can stand **over pressurization** +100mbar

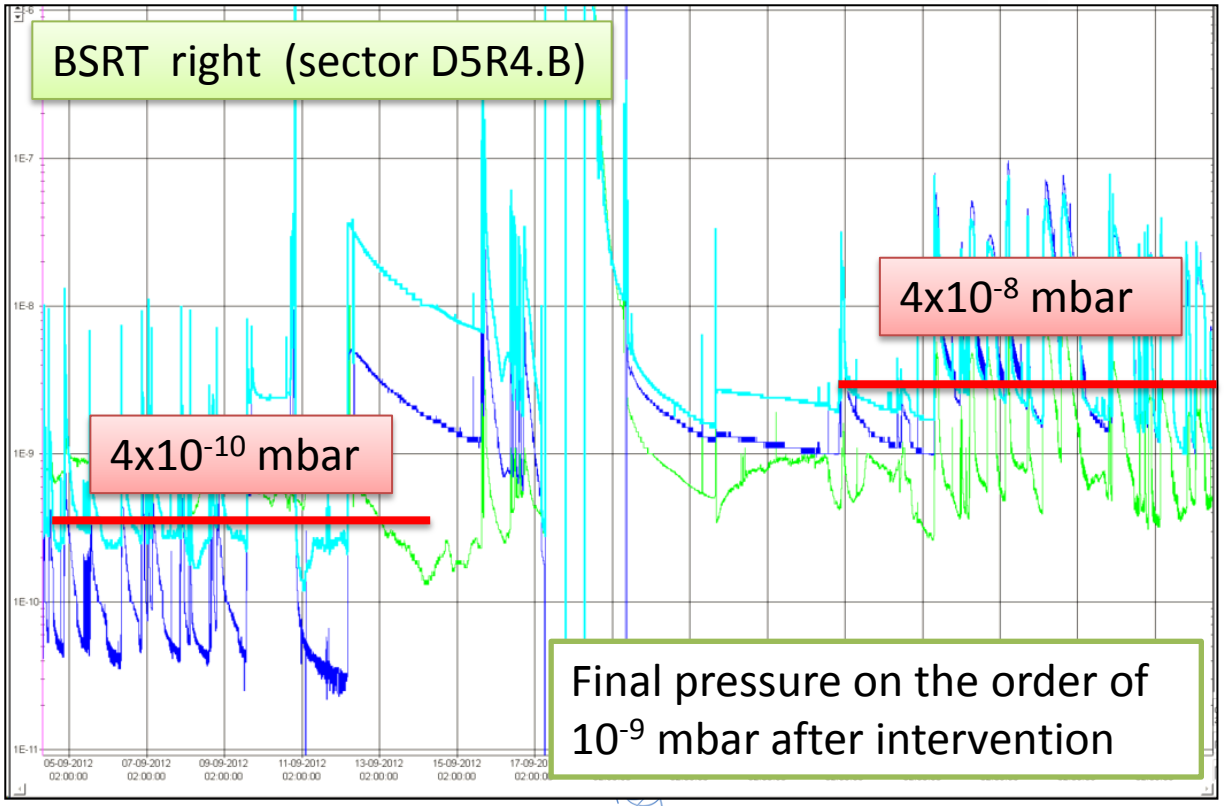
Preparation to minimize the mechanical intervention time



Compulsory bakeout of the Neon trolley



The new not NEG coated piece/chamber would need **conditioning** : temporary local pressure rise when a new piece is installed



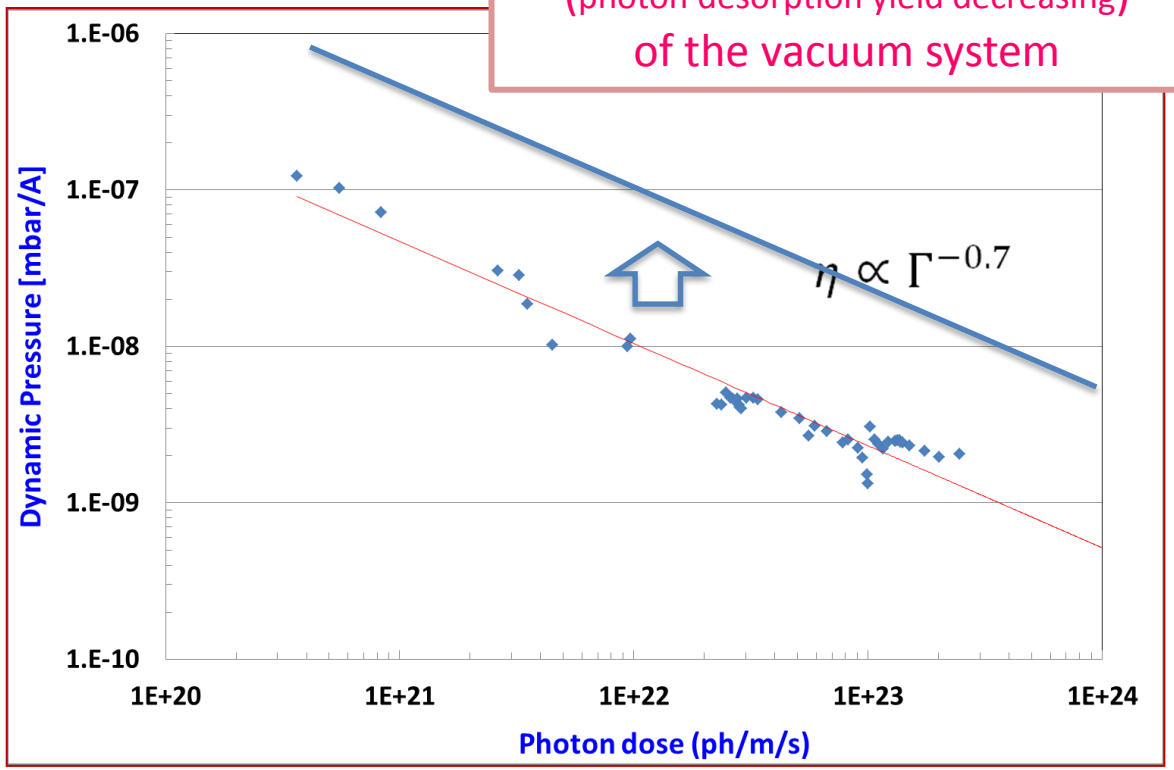
2015 vacuum outlook

2015 vacuum outlook

Pressure increases due to synchrotron light irradiation

$$P = \frac{\eta_{ph,g} \cdot \dot{\Gamma}_{ph}}{S}$$

Vacuum cleaning
(photon desorption yield decreasing)
of the vacuum system



2015 vacuum outlook

After LS1:

The secondary electron yield and the electron stimulated gas desorption will be reset during LS1. Since previously scrubbed and air exposed surface scrubs 10 times faster than as received surface, the “old” chambers and components conditioning will be faster.

New components will need a complete conditioning.

Proton stimulated gas desorption at 6.5 TeV from collimators will be larger than what we had at 4TeV

Possible pressure excursion related to beam screen temperature regulation following operation with 25 ns beams.

LS1 consolidation

- Reparation all non-conformities
- Follow all recommendation of R2E
- E-cloud mitigation: NEG coating of inter-module experimental zone
- E-cloud mitigation: NEG coating of 150 module in the LSS
- Optimization of pumping layout all around the machine where it was considered to be a potential limitation for the machine nominal operation : MKI, collimators and TDI where we need more pumping speed to have a built-in operational contingency

Conclusions

- The standard vacuum interlock were designed to **protect the integrity of the vacuum system.**
- The **standard interlock value is 4x10^{-7}** mbar, that has been relaxed during beam pipe conditioning and in special cases *i.e.* non –conformity.
- The baseline for vacuum intervention include **bakeout and NEG activation** (from 5 days with shifts to 3 weeks)
- **Neon venting** interventions can be carried out in special cases (5 days intervention)
- The operation experience from 2012 run confirmed that **scrubbing and beam pipe conditioning approach** (baseline) is a valid option for beam operation in 2015