Vacuum Performances and Lessons for 2012

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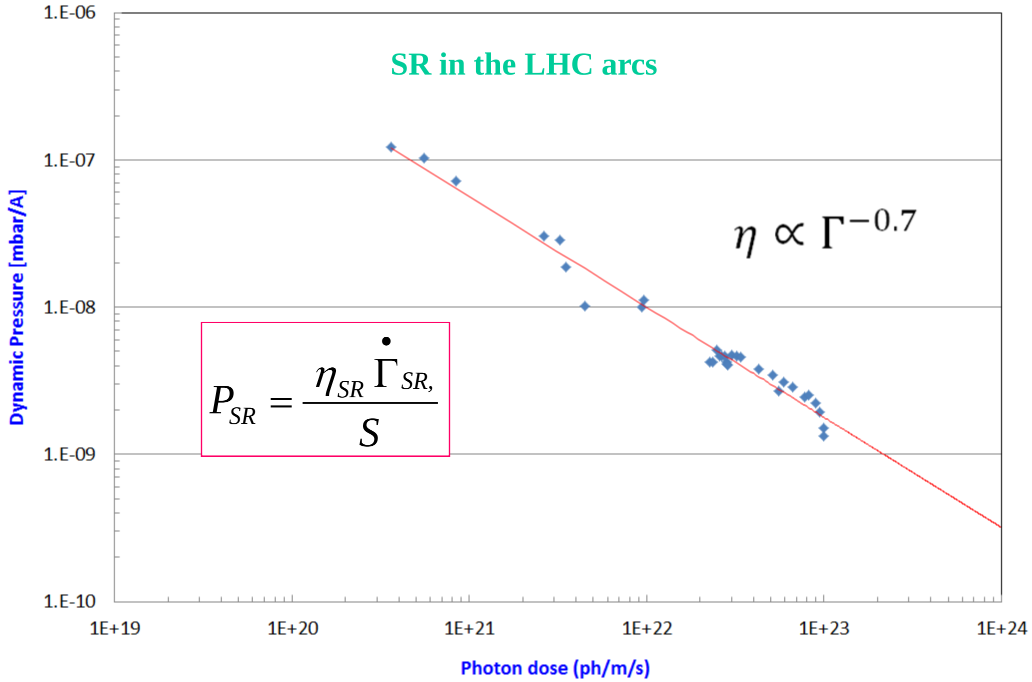
1. Dynamic effects
2. Unexpected pressure rise
3. Recommendations & Expectations
4. Conclusions

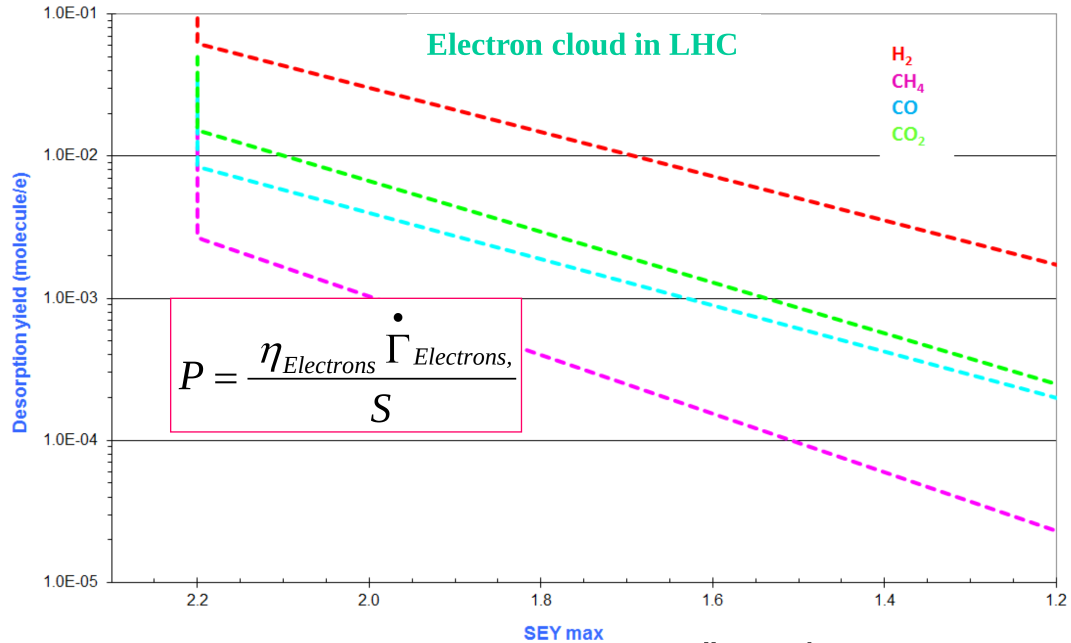
1. Dynamics Effects

Dynamics effects

- In the LHC, the circulating protons stimulate **gas desorption** which is:
  - induced by synchrotron radiation => always present during LHC life
  - induced by electron cloud => absent in NEG coated vacuum chambers, the electron flux in other areas decreases with beam scrubbing

- The result of the continuous bombardment is a reduction of the desorption yields *i.e.* a reduction of the LHC pressure





N. Hilleret *et al.*, LHC PR 472 2001

- The desorbed gas is pumped by the NEG coating, by ion pumps and by the cryogenic surfaces (beam screens)

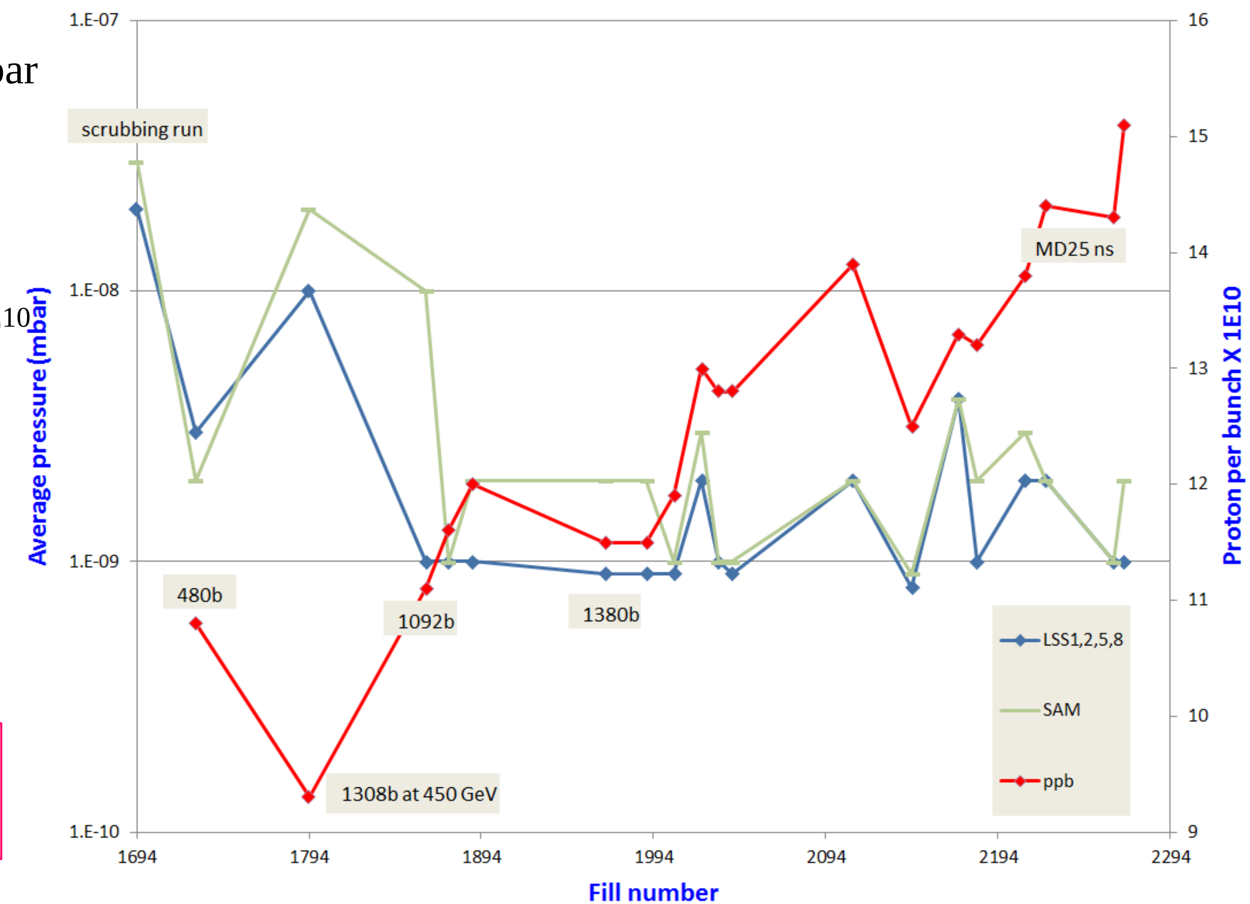
- The LHC vacuum system has been designed to be stable and to cope with these gas load (O. Gröbner, Vacuum 60 (2001) 25-34)

Overview of 2011

- Scrubbing run with interlock levels set to 10^{-6} mbar
- Increase number of bunch from 480 b to 1380b and 11.5 10^{10} ppb
- Continuous increase of bunch density till 14.5 10^{10} ppb:

  average pressure below 5 10^{-9} mbar

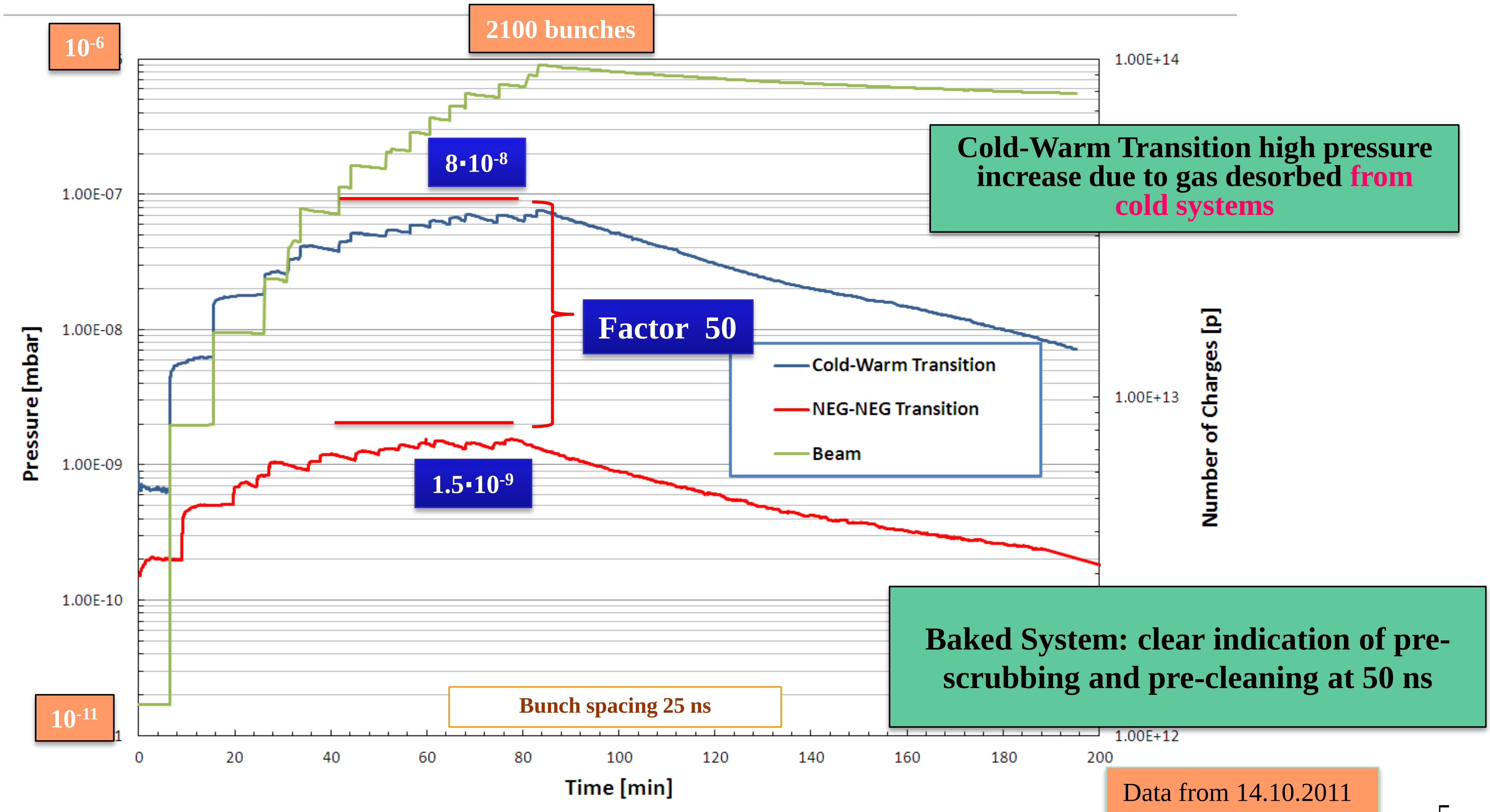
Scrubbing and beam conditioning of the whole vacuum system



Pressure with 25 ns Beams

- Pre-scrubbed parts (field free) do not show significant pressure increases
- Pressure is dominated by desorption from cold parts (~1 W/m is measured in field areas)

=> arcs and stand alones magnets are not fully scrubbed

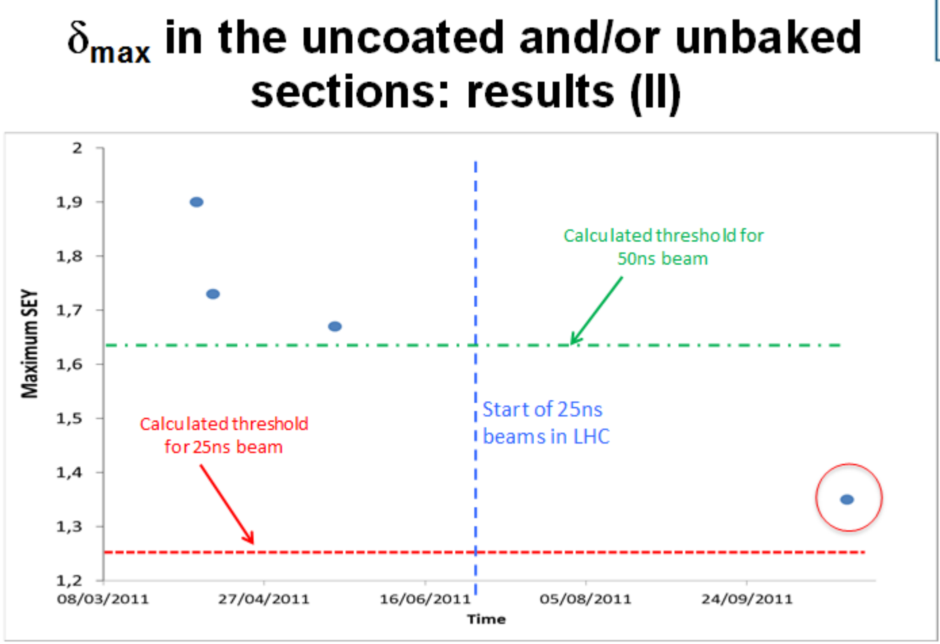


LSS: Evolution of Vacuum Scrubbing

Threshold with 1.1 10^{11}ppb	450 GeV	3.5 TeV
50 ns	1.63	1.58
25 ns	1.25	1.22

G. Rumolo *et al.*, Evian 2011

- After scrubbing run with 50 ns:
  $\delta = 1.7$
  - 19-05-11:
    $\delta = 1.65$
    - After MDs with 25 ns beam (24-10-11) :
      $\delta = 1.35$



G. Rumolo *et al.*, Evian 2011

→ **1) No more electron cloud at 50 ns is expected (up to 1.45 10^{11} ppb at least, fill 2267)**
2) Requires further scrubbing to operate with 25 ns

NB: In the arcs, after MDs with 25 ns, $\delta = 1.5$

Dealing with Beam Screens : Example of ITs

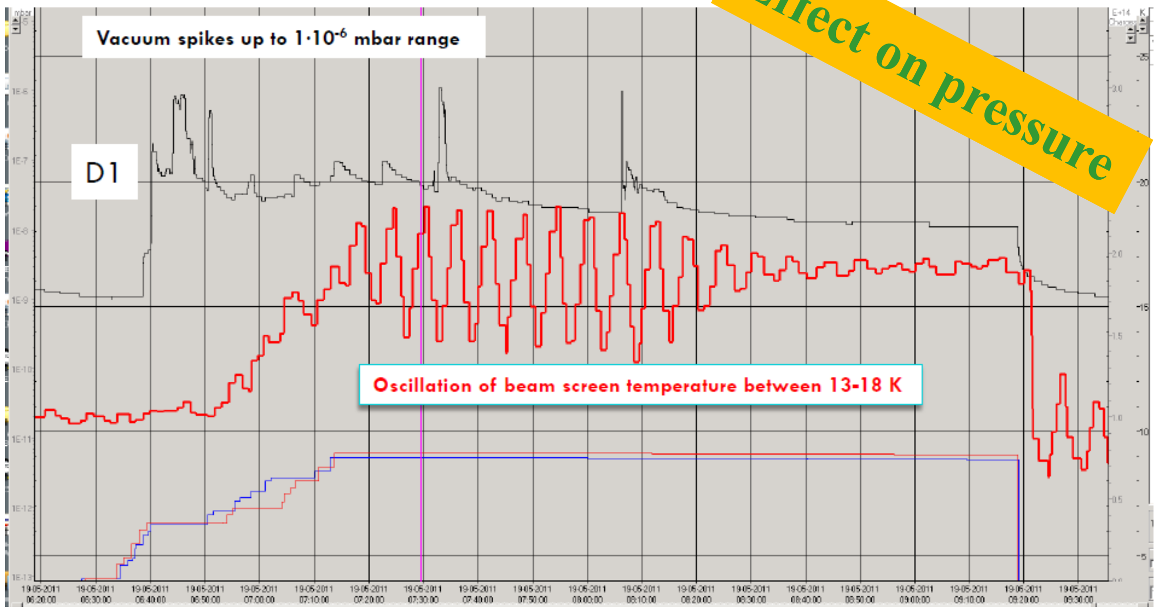
- During beam injection, the heat load onto the BS increases : as expected, gas transients appeared

1) Cool down sequence: CB 1st, BS 2nd
=> Keep a bare surface on the BS

2) Optimisation of ITs cooling loops to keep temperature increase below 25 K
=> avoid crossing adsorption isotherms

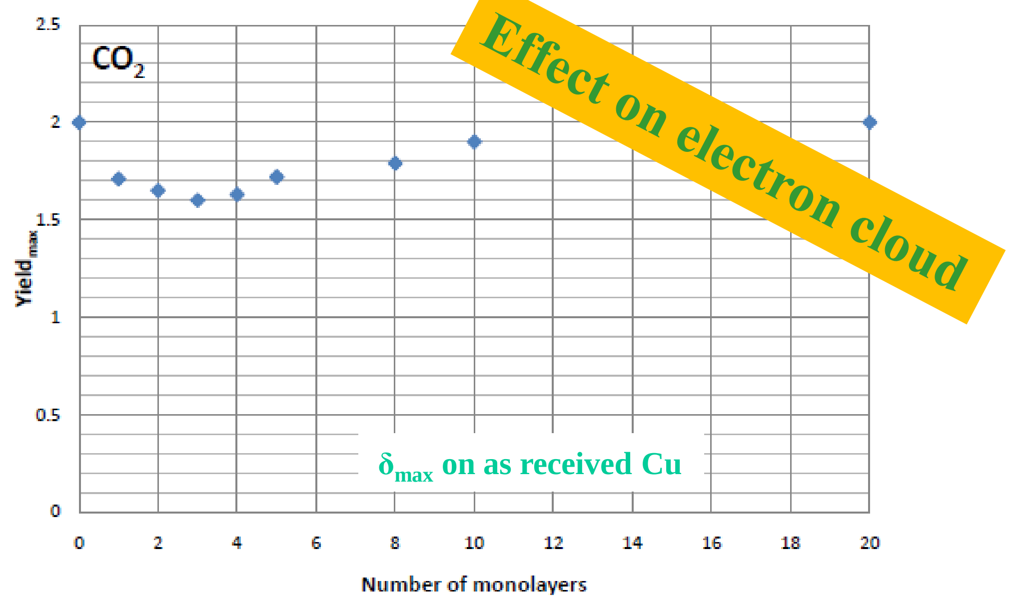
3) Flushing the gas from the BS towards the cold bore by appropriate warm up to > 90 K
=> when a lot of gas is accumulated (scrubbing run)

4) Evacuation of condensed gas during TS/Xmas-break while ITs cooling is stopped
=> definitive removal of gas from the vacuum system



G. Bregliozzi, LBOC 31-5-2011

Monolayers on as received Cu	CH_4	CO	CO_2
@ 50 ns, δ_{max} <1.6	< 20	-	< 3
@ 25 ns, δ_{max} <1.3	<1	< 1	< 1



A. Kuzucan, PhD Thesis, 2011

- Gas physisorption on cold surface increases the SEY
- Minimise the surface coverage of physisorbed gas is a must
- 25 ns beams are much sensitive than 50 ns ones

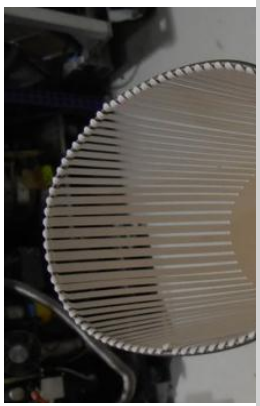
2. Unexpected Pressure Rises

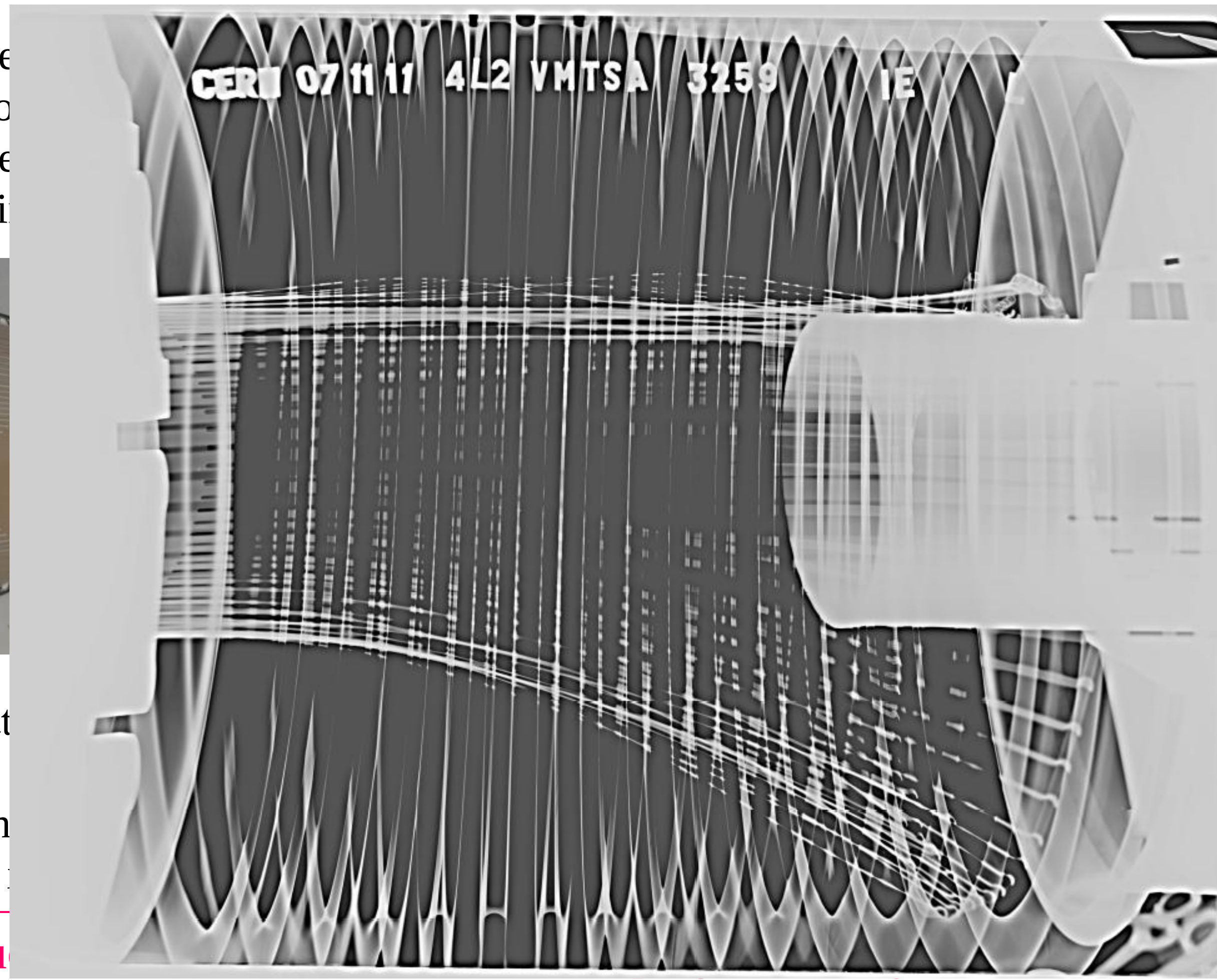
Pressure spikes: LSS2 – LSS8

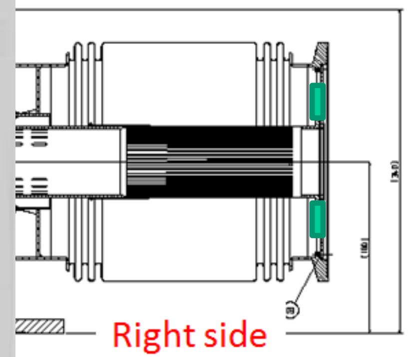
- Frequent pressure spikes, some up to 10^{-6} mbar, were observed in the vicinity of D1s during injection and stable beams
- Increasing the interlock level to 2 10^{-6} mbar avoided the vacuum valves closure but not the radiation induced by the beam

- The origin of spikes are VAMTF vacuum modules (LMC 9-16/11/2011). There are 8 modules in the ring.
- Under beam heating, the spring become lose causing a large opening of the RF contact and creating sparks
- These VAMTF must be re-design for LS1

- During Xmas break, the ... ndations were:
    - Improve the co
    - Decrease the le
    - Insert ferrites i ... ose 180/70







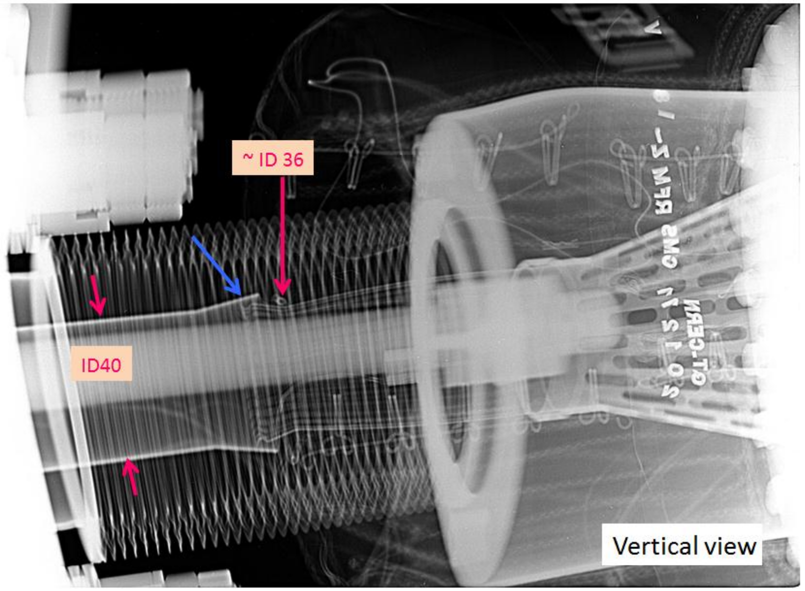
- The proposed modificat

- Further RF studies with
- An acceptable solution

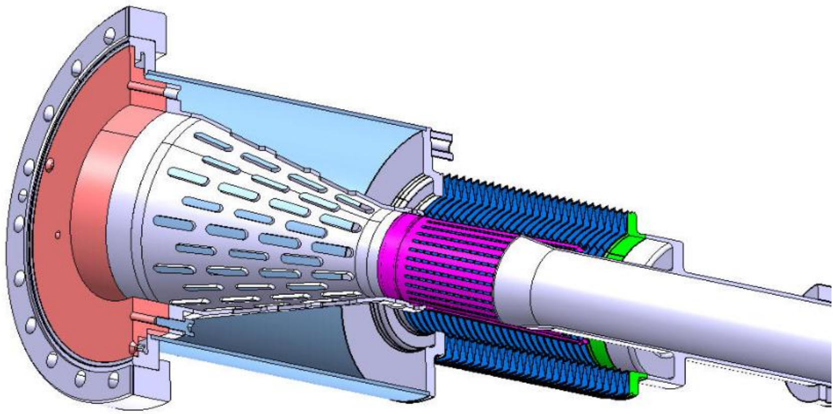
The issu

Pressure spikes: CMS

- Frequent pressure spikes, some up to 10^{-6} mbar, were observed at CMS, 18 m, right.
- When the local pressure was above 10^{-8} mbar, CMS background was larger than 100 %

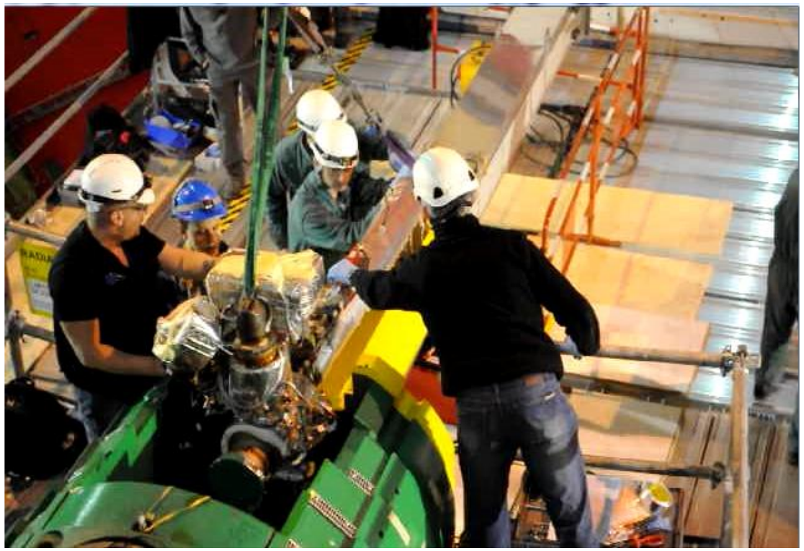


- During X-mas break, a non-conform vacuum module was identified
- The current understanding of the origin of this NC is due to a mis-positionning of the TAS-56 vacuum chamber
- To avoid the risk of further aperture reduction, a repair under Ne atmosphere was done
- This method avoided the full bake out of the CMS vacuum sector which would have meant dismounting the central detector !
- A new RF insert, with an additional 20 mm thick copper ring was made

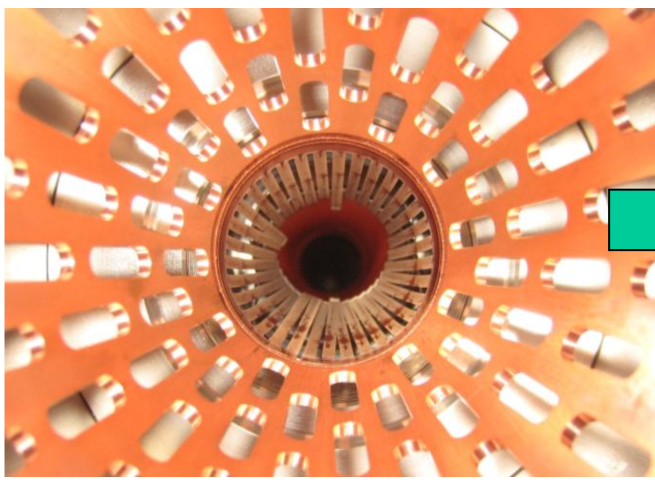


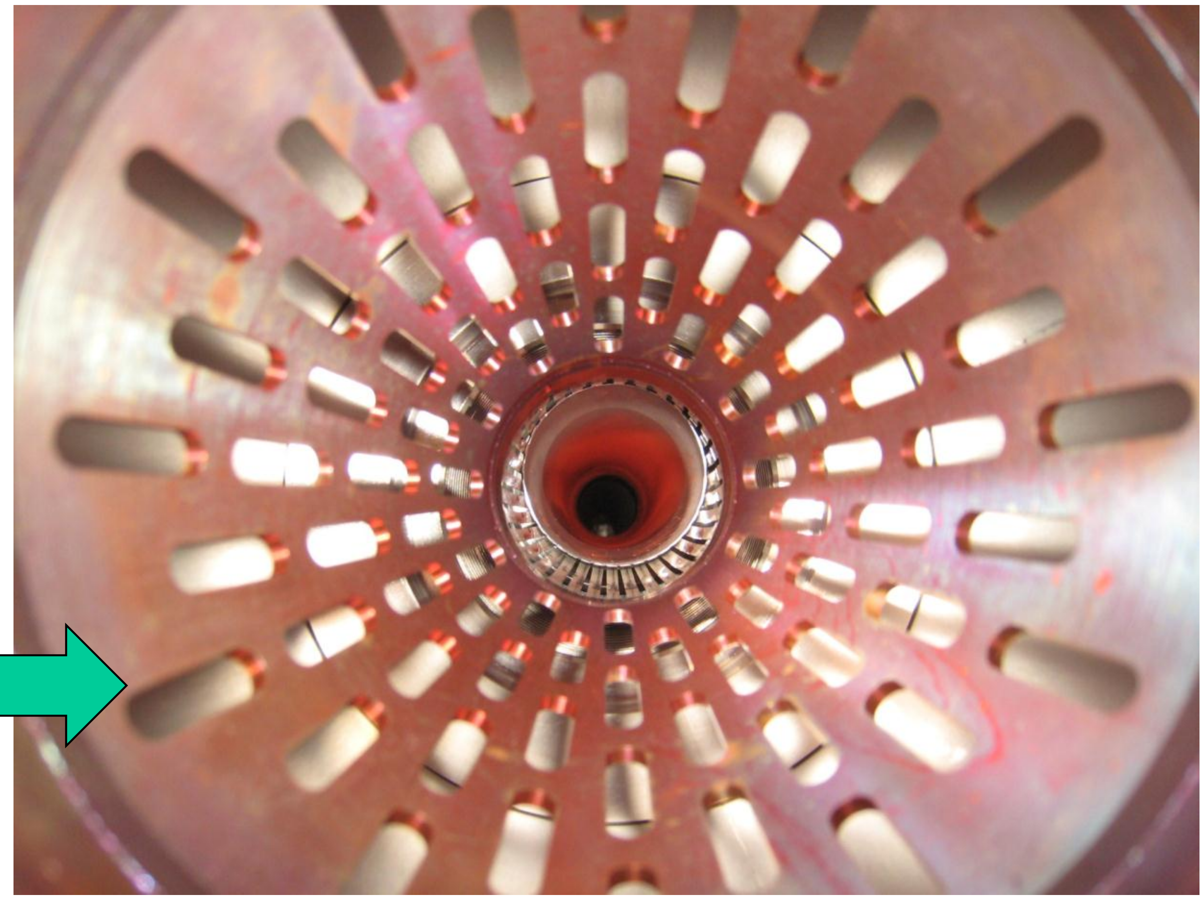
CMS – Repair under Ne

- The vacuum system was over pressurised to + 200 mbar to minimised air backstreaming into the NEG chambers
- The CMS forward vacuum chamber was opened and moved away for inspection



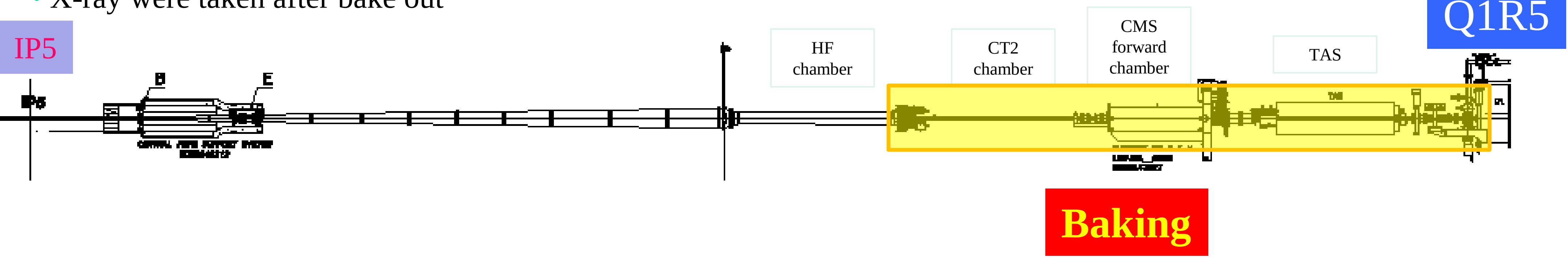
- And the RF insert exchanged





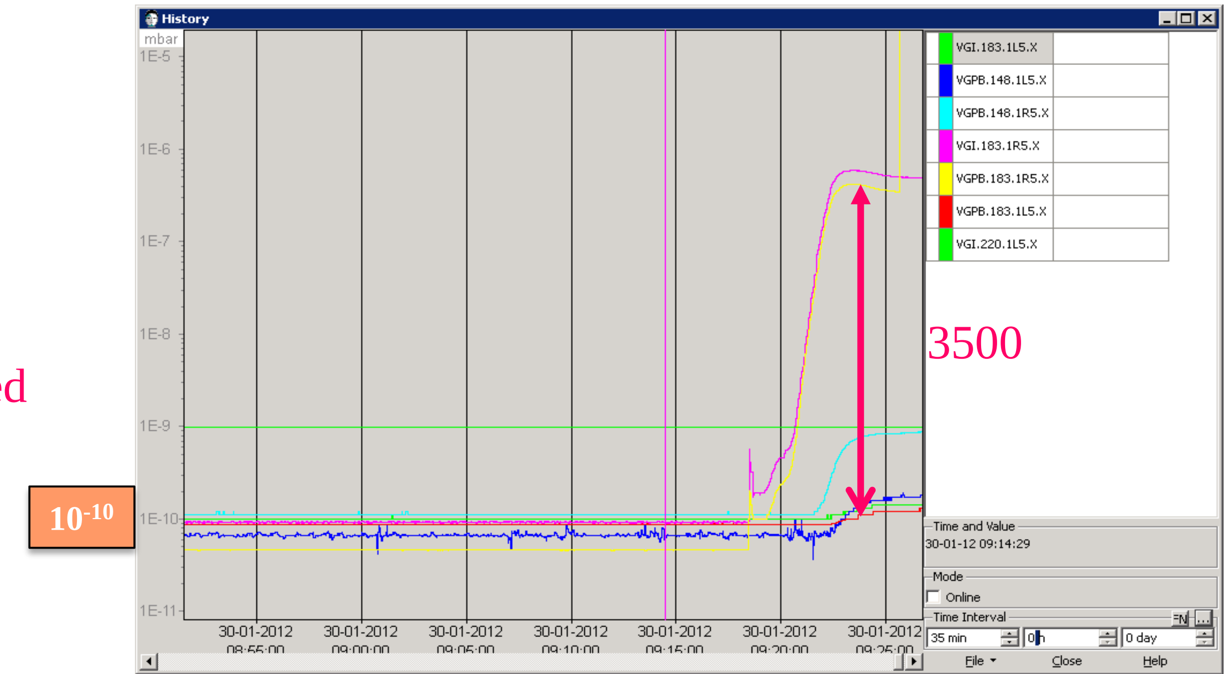
CMS –Ne pump down and NEG activation

- Once the flanges closed, Ne was evacuated by a mobile pumping group located at Q1R5
- 10^{-9} mbar was reached after 2 days indicating that NEG chamber located at the IP were still pumping
- CMS forward chamber and vacuum chambers located upstream and downstream were re-activated
- X-ray were taken after bake out



- Achieved pressure are < 1 10^{-10} mbar
- Transmission from – 18 till + 18 m equals 3500

→ The CMS IP chambers are still activated
The vacuum performance are restored

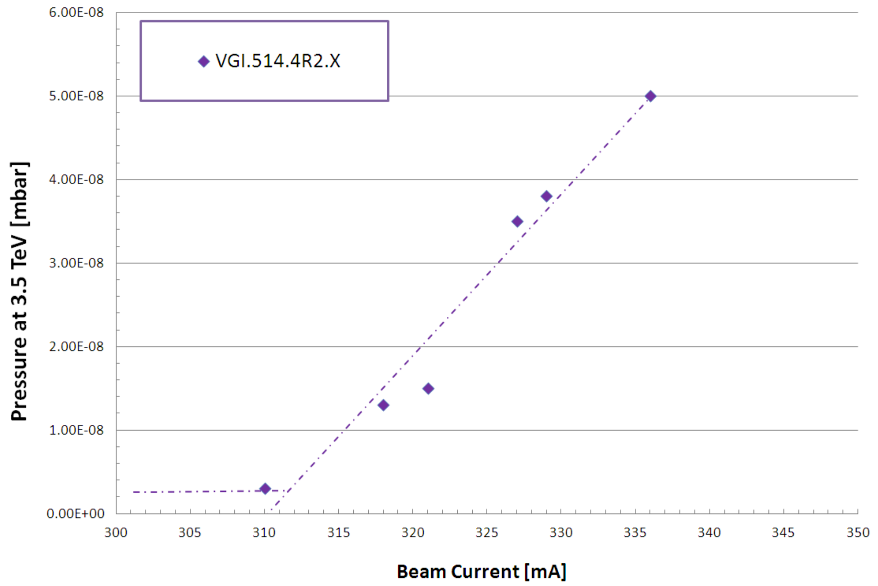


ZDC Upgrade

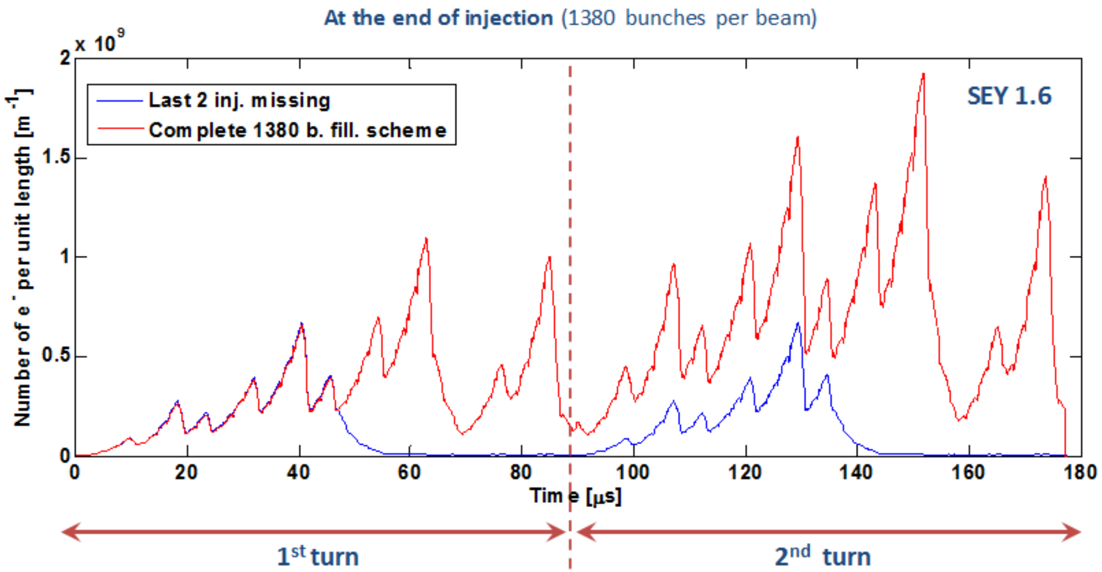
- In order to reduce the shadowing to the ZDC, the TCTVB was replaced by a TCTVA and the recombination chamber shifted by 1.36 m towards the IP (ECR 1153295)
  - => a new vacuum chamber ID800 of 2.9 (2.0) m was inserted on the left (right) side of LSS2
  - => as agreed with ALICE, the scrubbing of this new vacuum chamber could worsen the background in the experiment

- With 50 ns beams, pressure increase (> 10^{-8} mbar) have been observed along the ID800 vacuum chamber (~ 15 m long). => it produced significant background to ALICE

- Despite the large diameter, experimental observations as well as theoretical studies confirm the presence of an electron cloud in the ID800 vacuum chamber due to a multi-turn effect.



G. Bregliozzi, LBOC 22-7-2011



G. Iadarola, G. Romulo, 25-1-2012

→ Solenoids were added at each conical chamber during this Xmas break
Scrubbing with 25 ns beams will help to reduce further the pressure level

ID800 chambers are not fully scrubbed => still pressure rises could be expected around ZDC in 2012

3. Recommendations

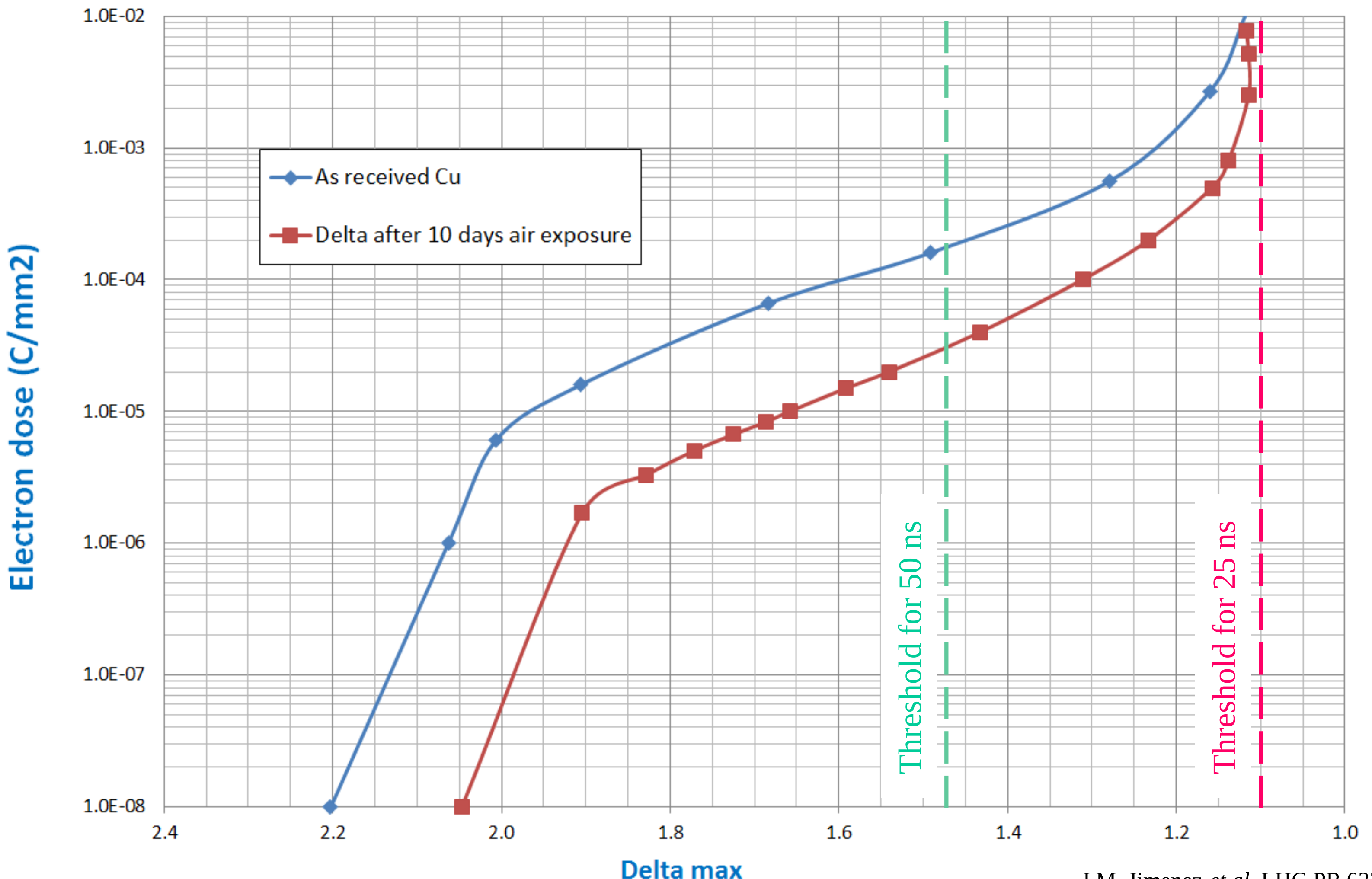
&

Perspectives

Effect of Air Venting on Vacuum Scrubbed Surface

- For as received Cu, ~ 0.2 mC/mm^2 is required to reach the 50 ns threshold
- For pre-scrubbed Cu and exposed to air, the dose needed to reach the 50 ns threshold is 0.03 mC/mm^2

→ Previously scrubbed and air exposed surface scrubs 10 x faster than as received surface



J.M. Jimenez *et al*, LHC PR 632, 2003

Re-commissioning of Vacuum

- During this Xmas break, 6 vacuum sectors were vented to air and 4 experimental sectors vented to neon
- The NEG in all these vacuum sector is re-activated
- 5 m of new vacuum chamber were installed in LSS2

⇩

- 50 ns operation:

  - immediate start up to 1.45 10^{11} ppb should be possible while scrubbing in the shadow of the intensity ramp up
  - immediate start up to 1.6 10^{11} ppb will requires a couple of days of scrubbing with 25 ns beams

- 25 ns operation:

  - Requires a dedicated scrubbing run with 25 ns

Conclusions

- The LHC vacuum system for NEG coated parts and cryogenic parts behave as expected

  - With 50 ns beams, electron cloud builds up in non-NEG coated parts of the long straight sections. Now, these parts are almost fully scrubbed

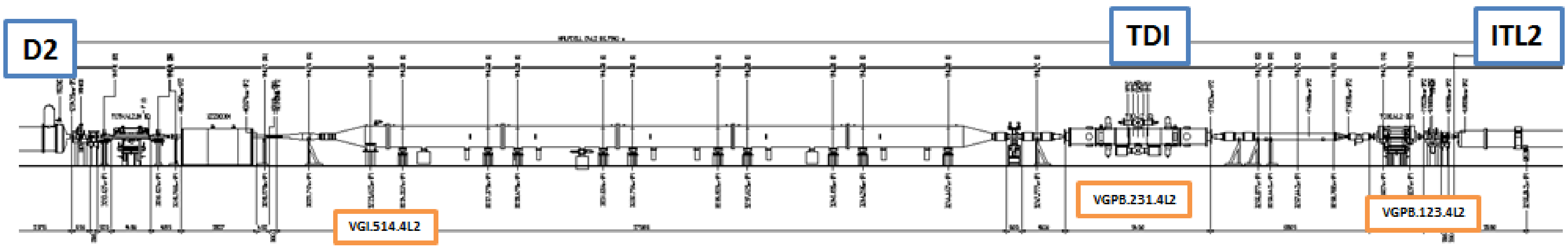
  - Arcs and stand alone magnets show large electron cloud activities

=> Scrubbing and vacuum conditioning in RT and cryogenic part works as planned

- All unexpected pressure behaviour are understood but not all effects could be fully fixed during this Xmas break.

Thank you for your attention !!!

ZDC Layout

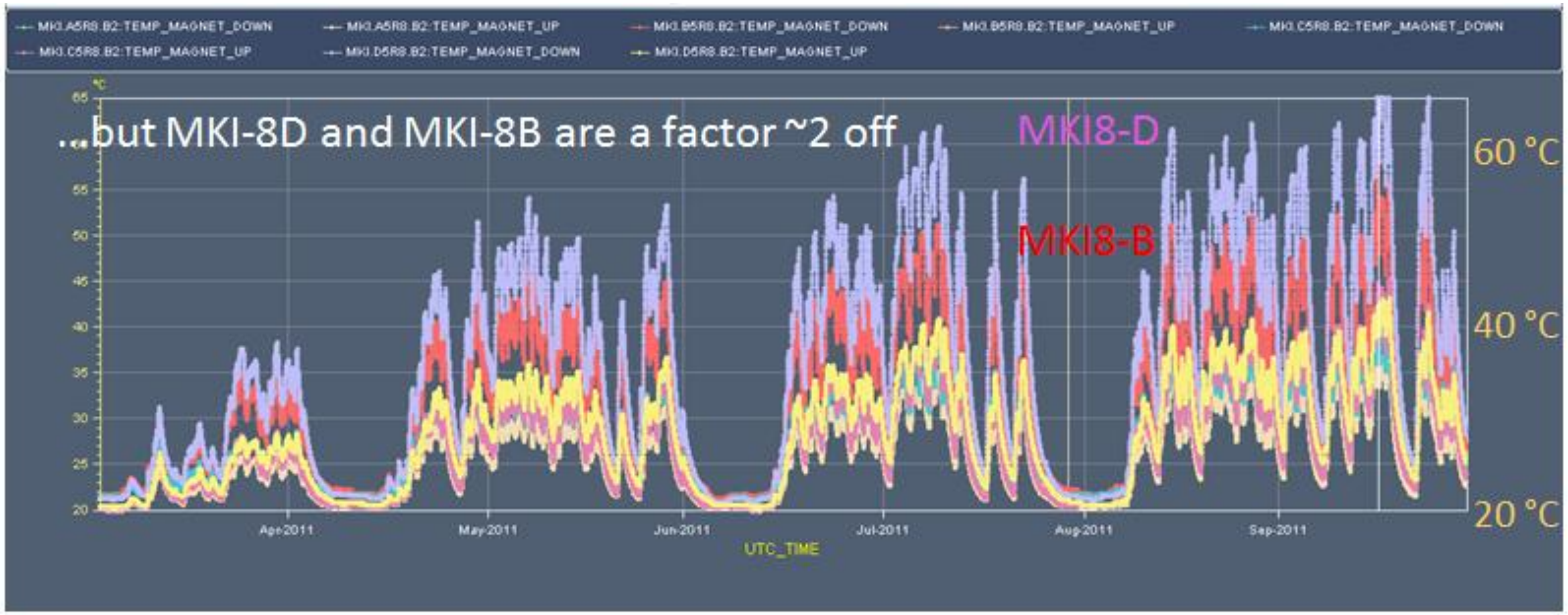


MKI outgassing

- With 50 ns beams, the MKI tank pressure is in the range 1-2 10^{-10} mbar, except MKID.4R8 at 5 10^{-10} mbar

→ MKID.4R8 was re-baked during this X-mas break

MKI
in point 8



B. Salvant *et al.*, Evian 2011

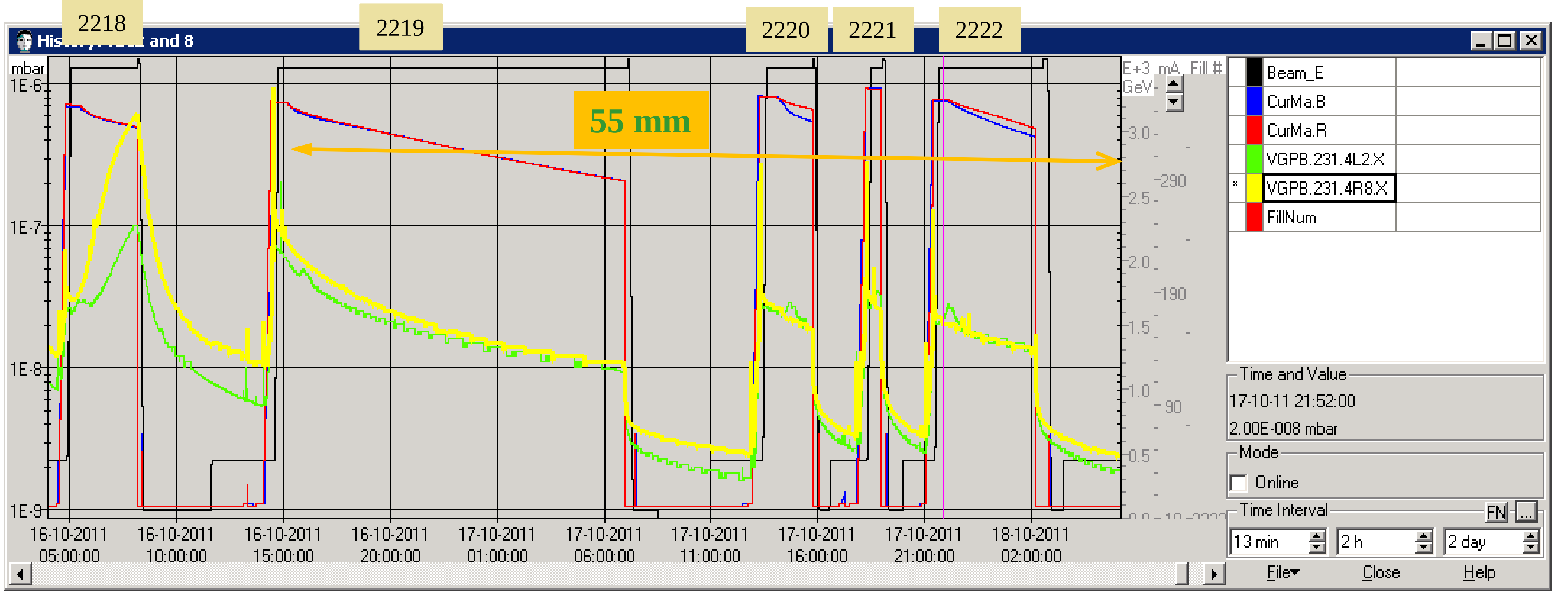
- With 25 ns beams, the MKI operation is limited by pressure level (3 10^{-9} mbar) in interconnects, copper chamber and ceramic chambers

→ Solenoids were added at each MKI interconnects during this X-mas break

All issues related to MKI are not solved => still pressure rises around MKI in 2012

TDI outgassing

- During stable beams, pressure at TDI increased up to 10^{-6} mbar due to thermal outgassing (slow pressure rise)
- Increasing the parking gaps from 22 till 55 mm decrease the pressure level in the 10^{-8} mbar range



- During X-mas break, NEG cartridge were added at the TDI
- A gain of a factor 2 is expected in pressure