pressure rise induced by the electron cloud in the LHC

general context:

is scrubbing needed in LHC?

- pressure ?
- heat load (no?)
- fast TMCI-like instabilities (no?)
- long-term emittance growth ?

Vincent Baglin; see W. Turner, PAC93

$$\eta_{tot} = \eta + \eta'$$ desorption yield

strongly bound molecules, varies with e- dose!, cleaning rate is a function of material, cleanliness, temperature

"recycling desorption yield", varies with surface coverage, pressure, sticking coefficient

$$\eta < \eta'$$ usually

in equilibrium:

$$n = \eta \frac{\dot{\Gamma}}{C}$$

$$V \frac{dn}{dt} = (\eta + \eta')\dot{\Gamma} - Cn - Sn$$

hole pumping

BS pumping speed

$$A \frac{d\theta}{dt} = Sn - \eta' \dot{\Gamma}$$

surface coverage

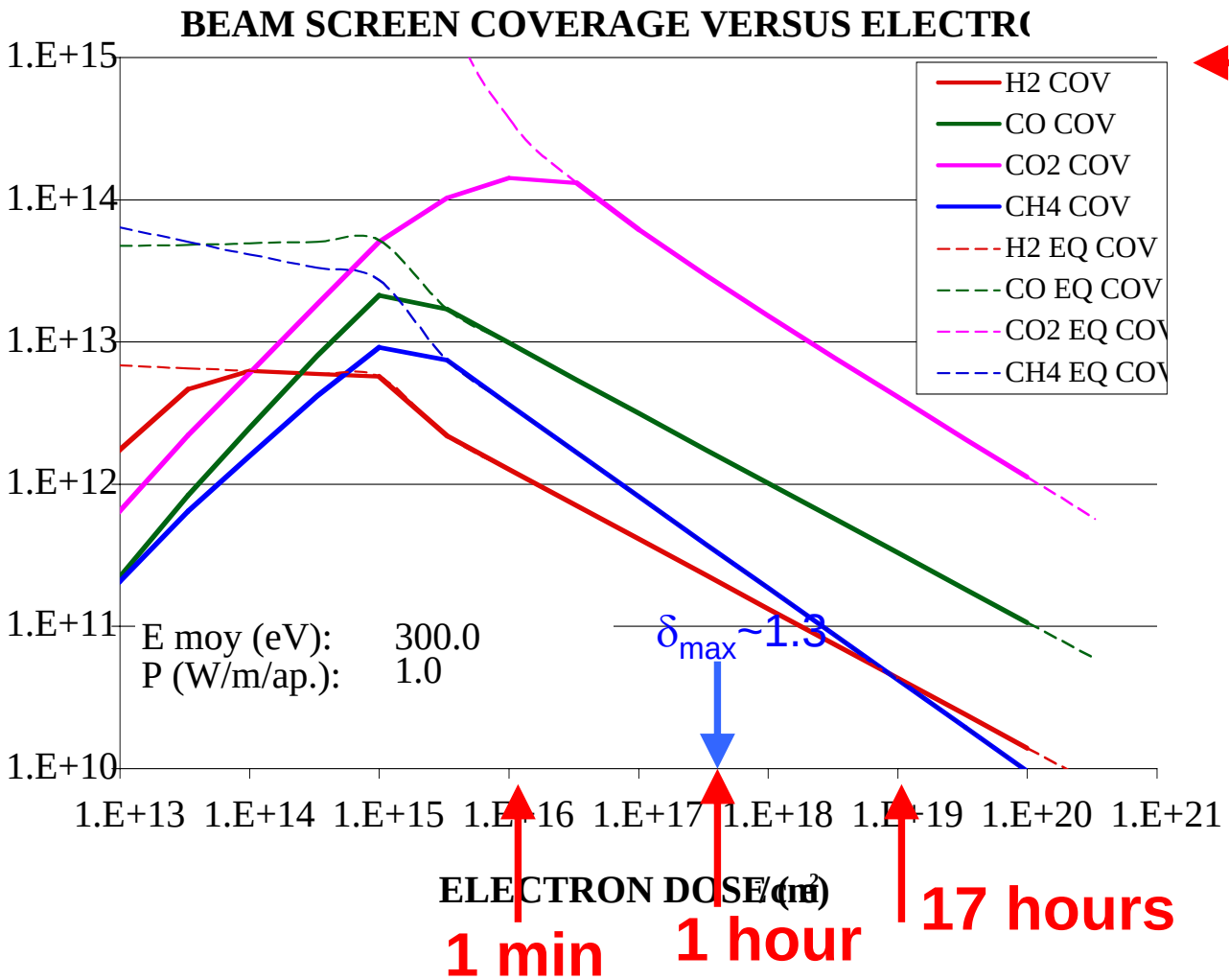
e- flux

Vincent Baglin

pressure effects

Information from Vincent Baglin

AT-VAC (V.Baglin, N.H.) has simulated the LHC pressure evolution.
According to Noel's lab measurement, for E> 30 eV, the e- recycling yield is large.
Therefore, under electron bombardment the BS will have a bare surface without any monolayers. Monolayers will be only on the cold bore.



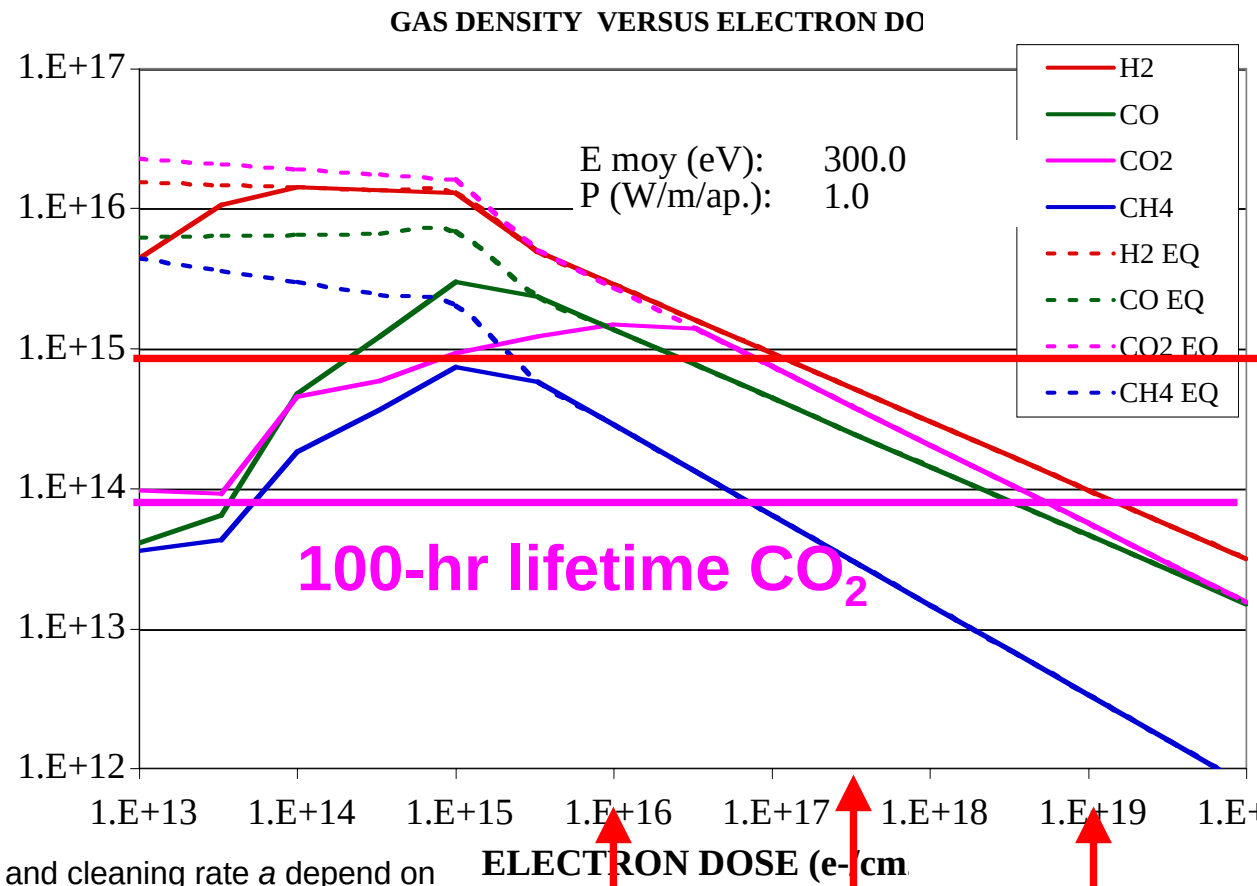
1 monolayer =
1E15 molecules/cm2

for 2E16 e/m/s
i.e. 3 mA/m

N. Hilleret,
LHC MAC Dec 2004

Information from Vincent Baglin

Pressure increase due to e-cloud. Level is a linear function of the electron flux. It depends only on the electron dose



for 2E16 e/m/s i.e. 3 mA/m

100-hr lifetime H_2

$$P = \Phi \frac{\eta}{S} = \Phi \eta_0 \left(\frac{D}{D_0} \right)^{-a} \frac{1}{S}$$

e- flux

dose

η and cleaning rate *a* depend on the e- energy; if the energy decreases from 300 eV down to 100 eV, the eta decreases by a factor 3, similarly, the cleaning rate decrease as well. V.B. expects the pressure of Noel's plot will be about the same for 300 eV or 100 eV.

1 min

1 hour

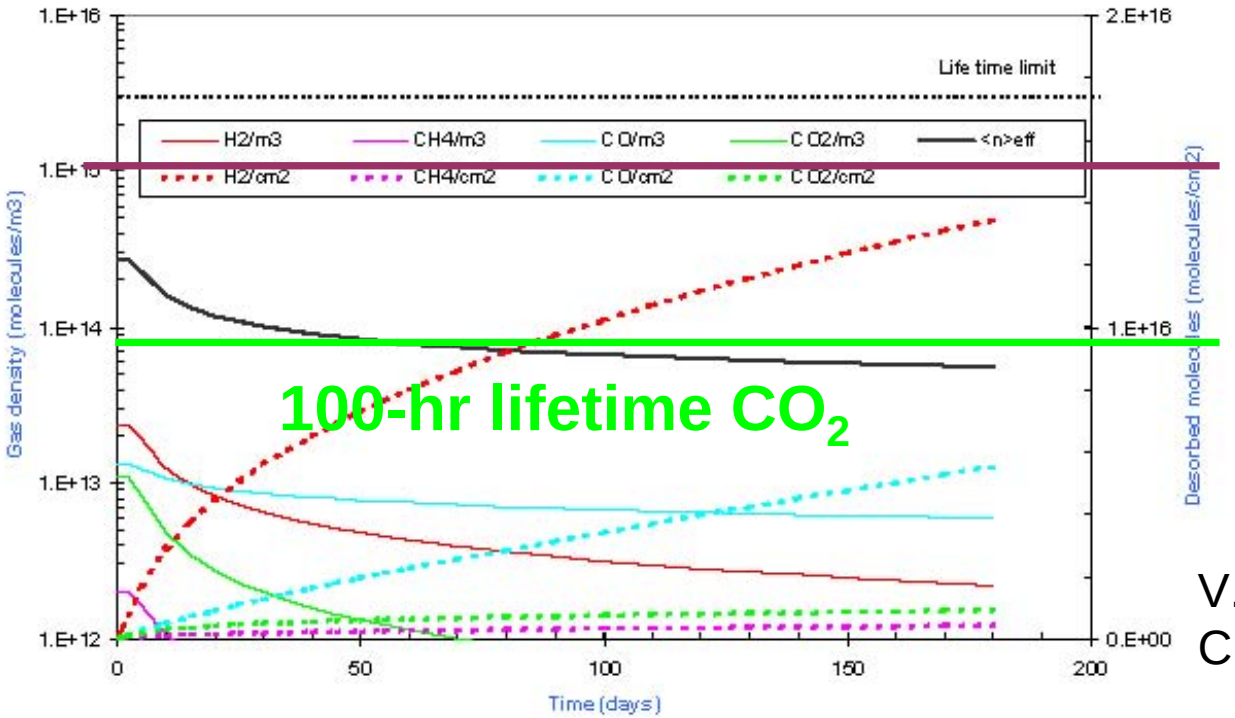
17 hours

(assuming 2 stripes of 3 mm each)

N. Hilleret, LHC MAC Dec 2004

shortest lifetime ~ 10 hr

pressure in/de-crease from photons - prediction based on COLDEX results



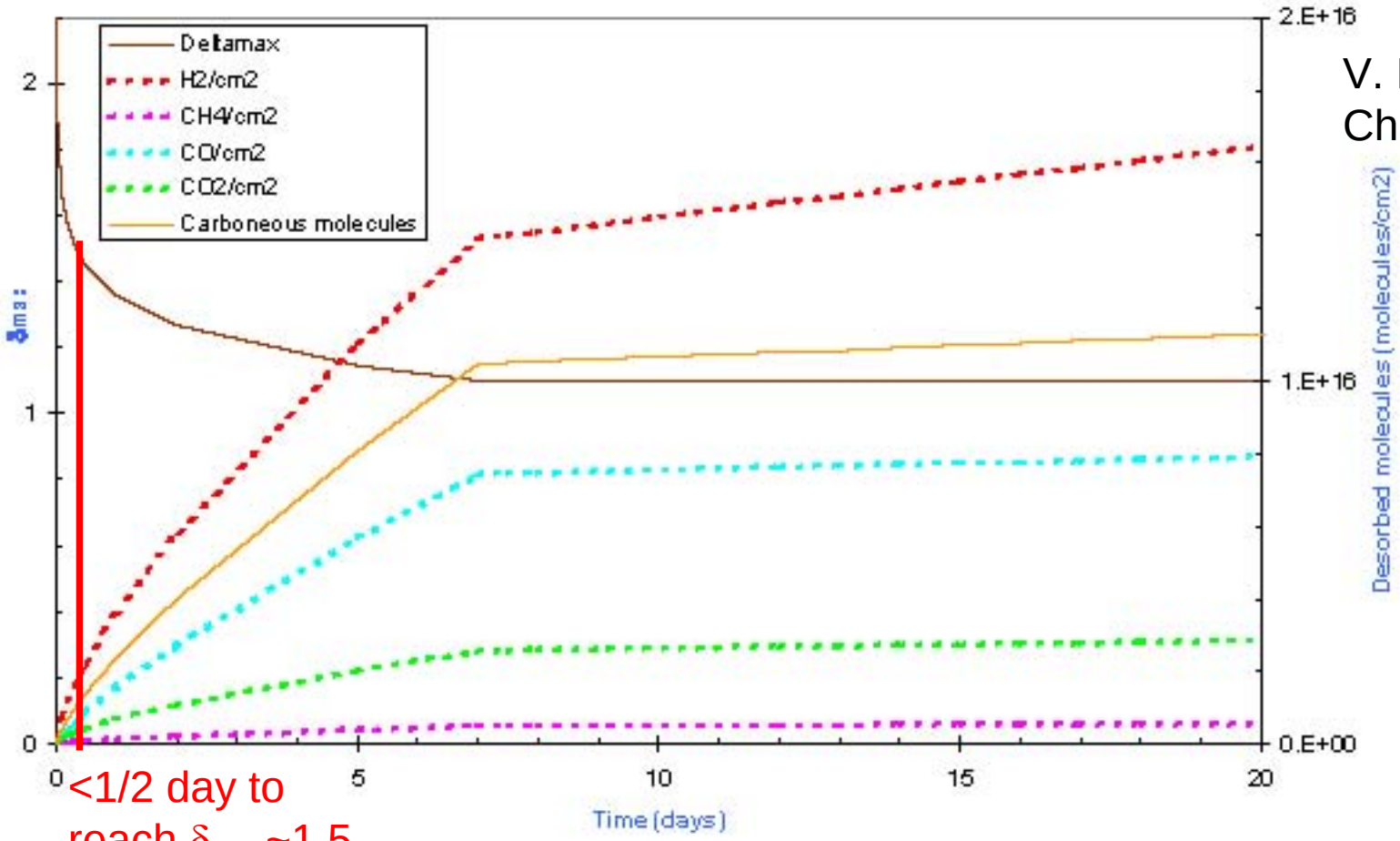
100-hr lifetime H_2

lifetime ~ 10000 hr

V. Baglin
Chamonix 2003

Figure 1 : Gas densities and desorbed molecules during the first year of LHC operation

"Desorption yield of electrons is about 2 orders of magnitude larger than photons. For similar fluxes (2E16 e/m/s against 1E17 ph/m/s) we are dominated by electron gas load. *The cleaning rate is measured to be small for photons. For electrons, to my knowledge, there is no measurement and Noel always assumed that its cleaning rate is faster than for photons* (0.5 vs. 0.6 for H2 and 0.5 vs. 0.2 for CO)."



V. Baglin
Chamonix 2003

<1/2 day to reach δ_{max}~1.5

Figure 2 : Maximum of SEY and desorbed molecules during the conditioning of a LHC dipole.

can we condition with the TOTEM beam?

consider:

40 bunches, 10^{11} protons per bunch, only accelerated photo-electrons, assume rate of photo-electron production 0.00123 (initial surface), take only 2% hitting the top and bottom of chamber, full width 4 cm, and assume that only ½ is accelerated to energies > 30 eV

then

$$\frac{\dot{N}_e}{A} = \frac{0.00123\times10^{11}\times40\times0.02\times1/2\times11\times10^3}{2\times0.02\,\mathrm{m^2 s}} \approx 1.2\times10^{13}\,\frac{1}{\mathrm{m^2 s}}$$

to get a total dose 1e16 cm^{-2} or 1.6 mC/cm^2 we need 96 days of continuous 40-bunch TOTEM beam operation, or 20 days with 200-bunch operation

how long an operation is planned?