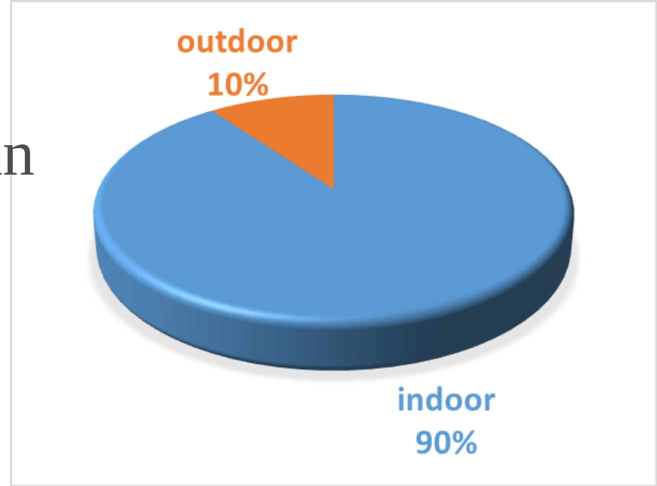
Photocatalytic nanomaterial as a remediation technology for indoor environment

Vincent Bartolomei, Adrien Gandolfo, Elena Gómez Alvarez, Sasho Gligorovski, Henri Wortham

LABEX-SERENADE

Atmos'Fair Aix*Marseille université cnrs

Context



- Indoor air pollution: People stay more than 90% time within indoor environment

- Low energy building

Air exchange rate lower in order to save the energy.

❖ Problem: indoor pollution increases

✓ Solution: ventilation ; but electric cost …

✓ Alternative : Photocatalytic paint

Solar activation, cost: application.

Context

- Previous study of our group show that interactions between NO_2 and surface in presence of light can induce Nitrous Acid formation.

Gómez Alvarez *et al.*, 2014

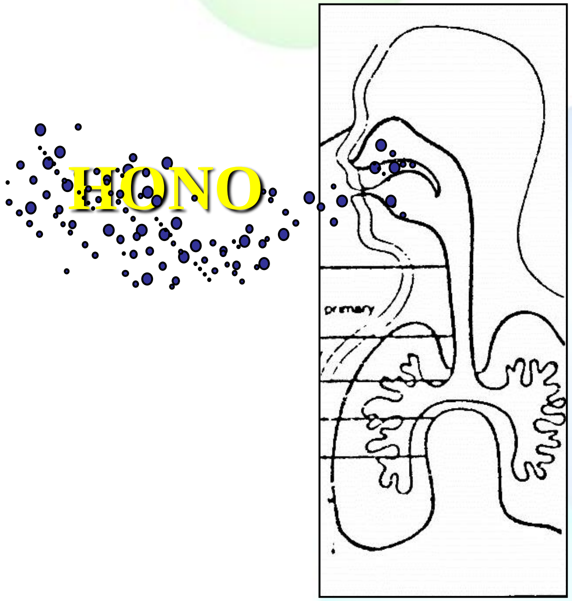
Bartolomei *et al.*, 2014

- Nitrous Acid (HONO) is a precursor of harmful pollutant like:

❖ Nitrosamine

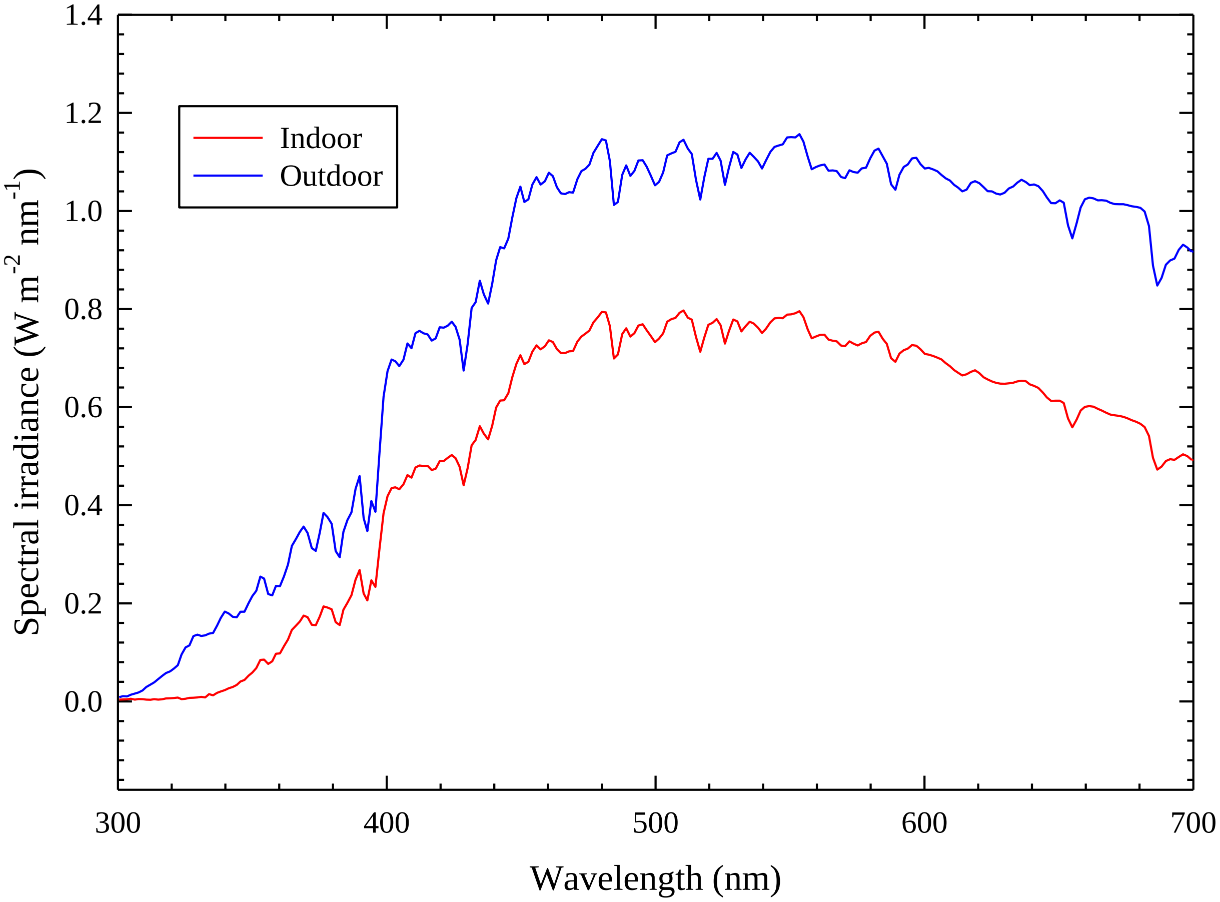
❖ Hydroxyls radicals

HONO + hν → OH + NO



Objectives

Comparison of light intensity



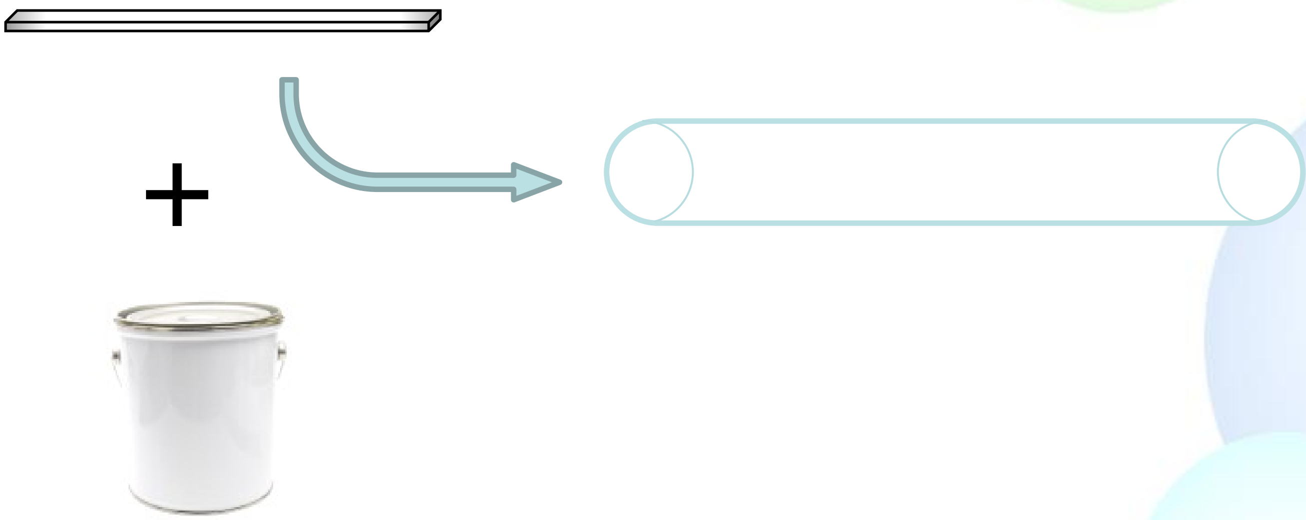
Integrated Irradiance from 300 to 400 nm (near UV) :

Indoor : 9.7 W.m^{-2}

Outdoor: 22.2 W.m^{-2}

Preparation of the paint layers

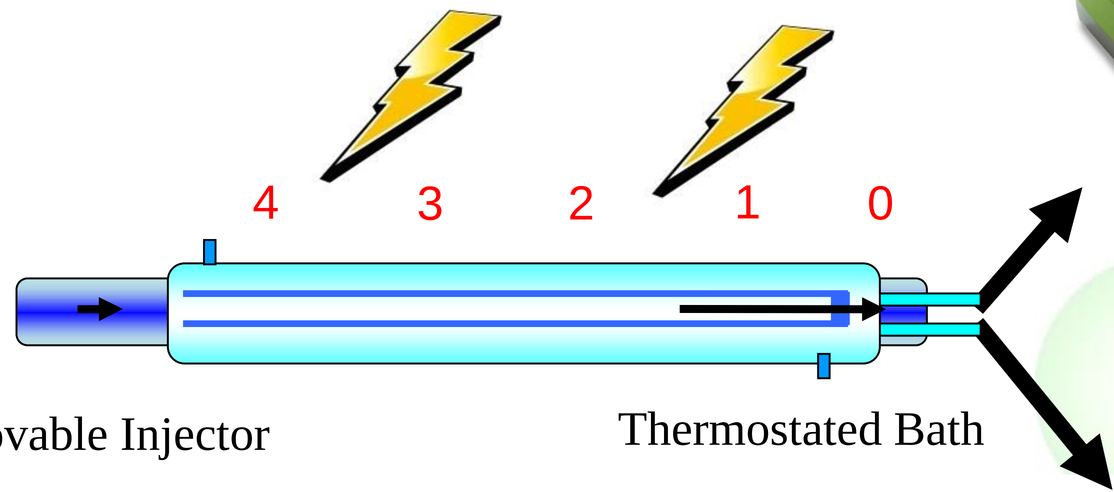
- The paint has been especially formulated to respond to our research objectives.
- It have been applied on a thin glass plate, in a homogeneous paint film.
- A typical paint drying condition have been followed at 23 °C and 55 % RH in obscurity during 21 days.



Experimental set-up

(UV/Vis lamps 340-400 nm)

NO_2



Movable Injector

Thermostated Bath

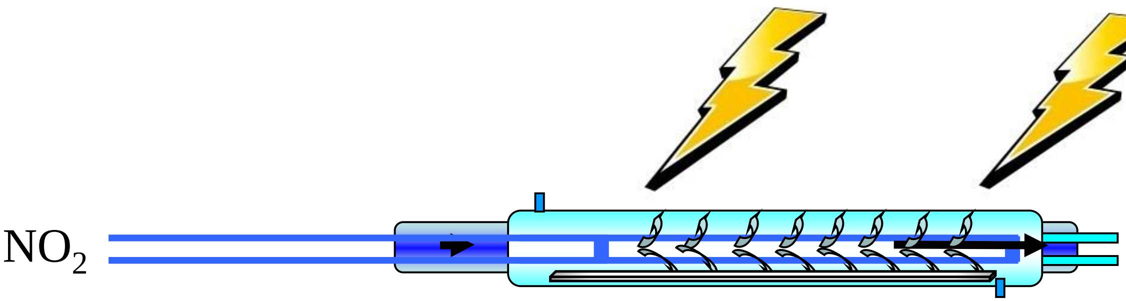
NOx Analyzer

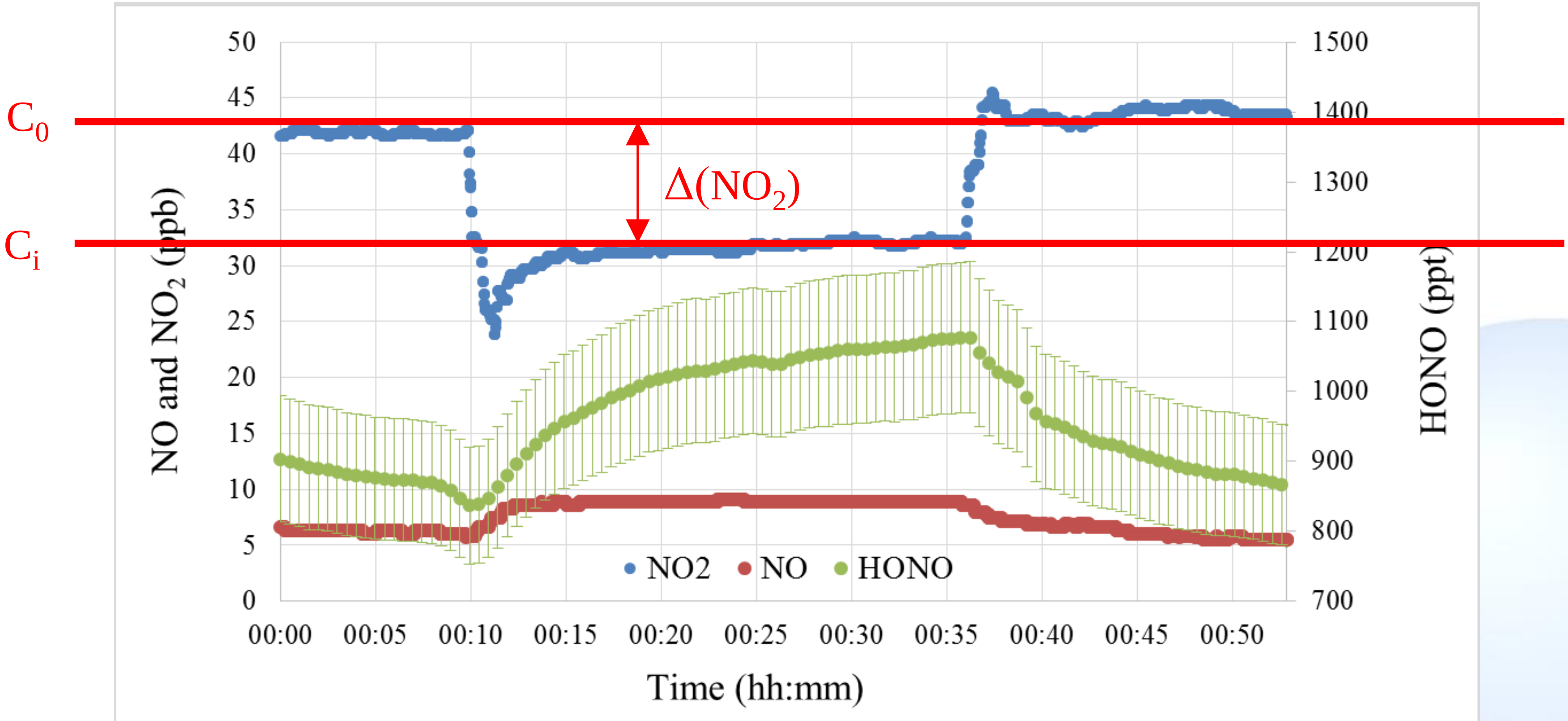
HONO monitor

Three parameters were evaluated:

- TiO_2 quantities
- Light intensity
- Relative Humidity (RH)

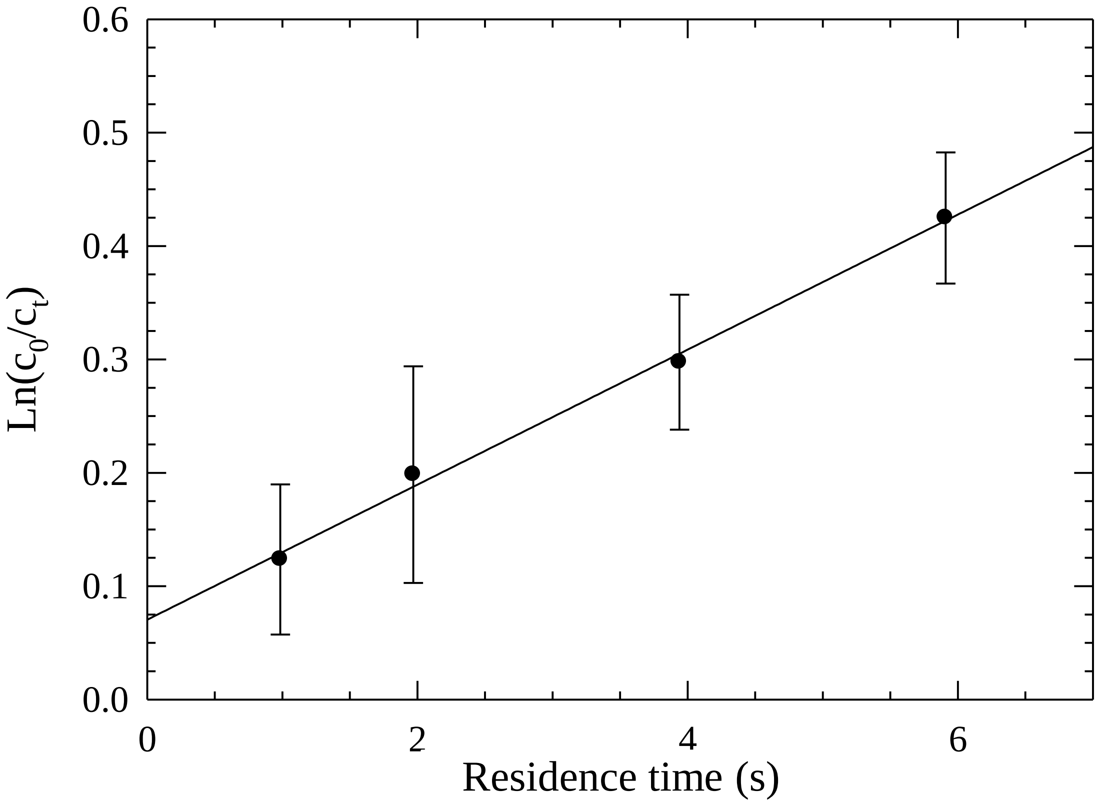
Typical signals of NO, NO_2, HONO





The uptake coefficient

From ΔC to uptake coefficient γ



$$\ln \frac{c_0}{c_i} = k_{1st} t$$

Slope = k_{1st}

$$\gamma = \frac{4k_{1st}}{\bar{\upsilon}} \frac{V}{S}$$

V/S : Surface to volume ratio of the reactor

$$\bar{\upsilon} = \sqrt{\frac{8RT}{\pi M}}$$

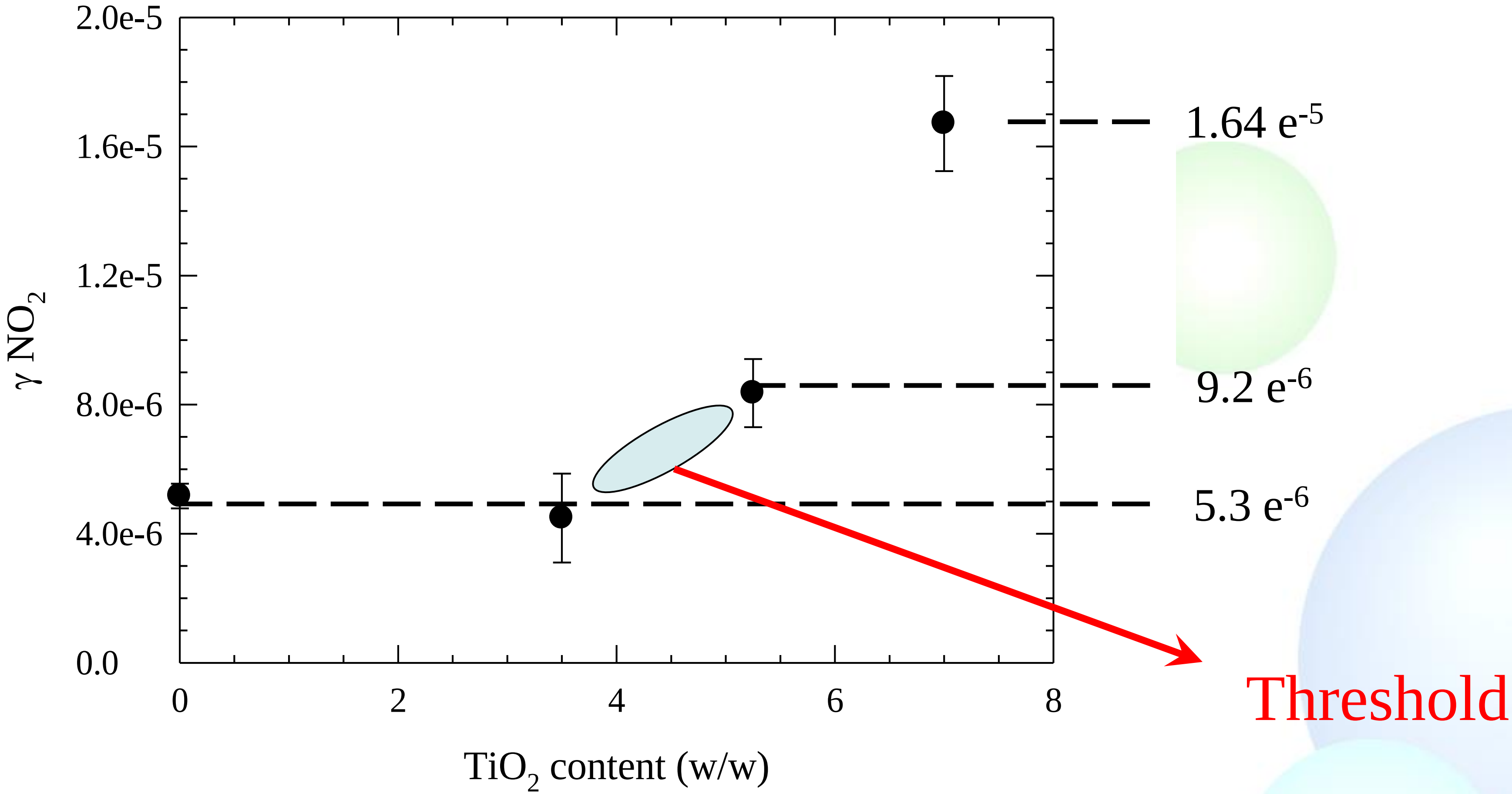
γ **<u>is used to define the probability of reaction</u>**

Part 1

TiO_2 content

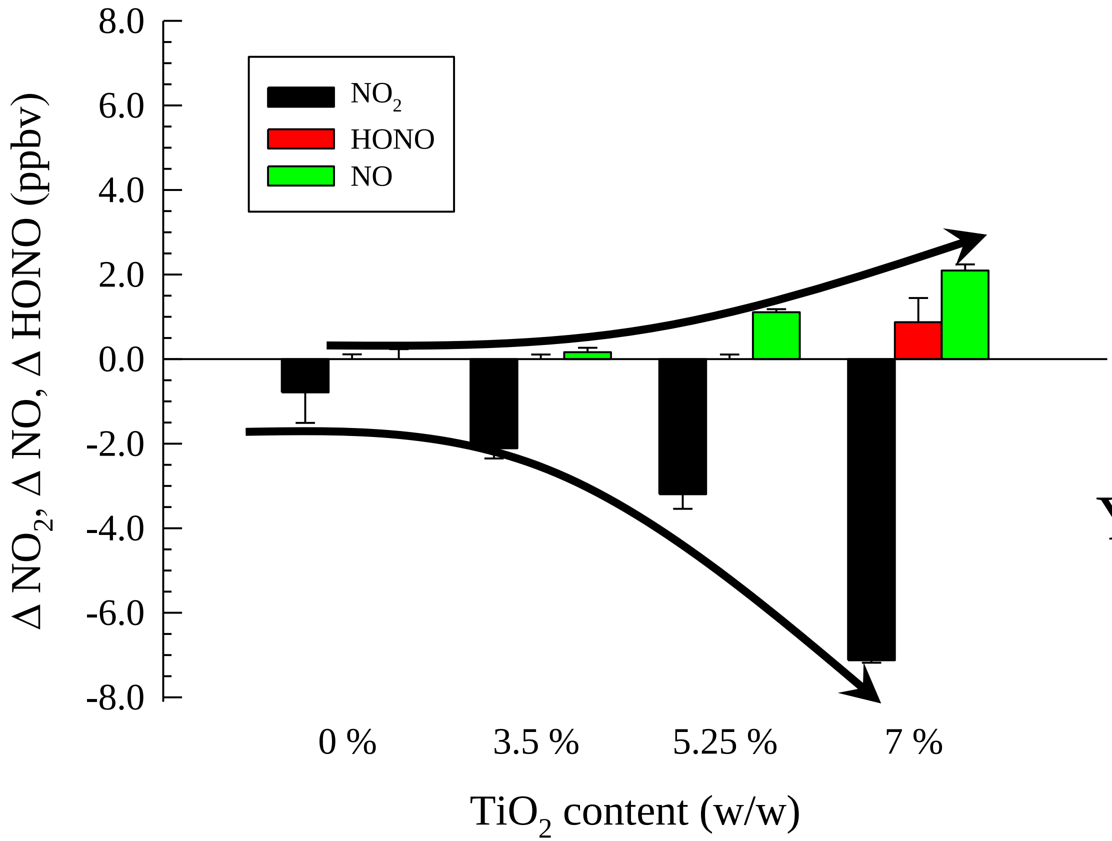
γ (NO_2) in function of TiO_2 content

<u>Experimental conditions:</u> [NO_2] 40 ppb, RH 40 %, 20 $W.m^{-2}$



NO and HONO production

Experimental conditions: [NO_2] 40 ppb, RH 40 %, 20 $W.m^{-2}$



$Yield_{max}(NO) = 35\ \%$

$Yield_{max}(HONO) = 12\ \%$

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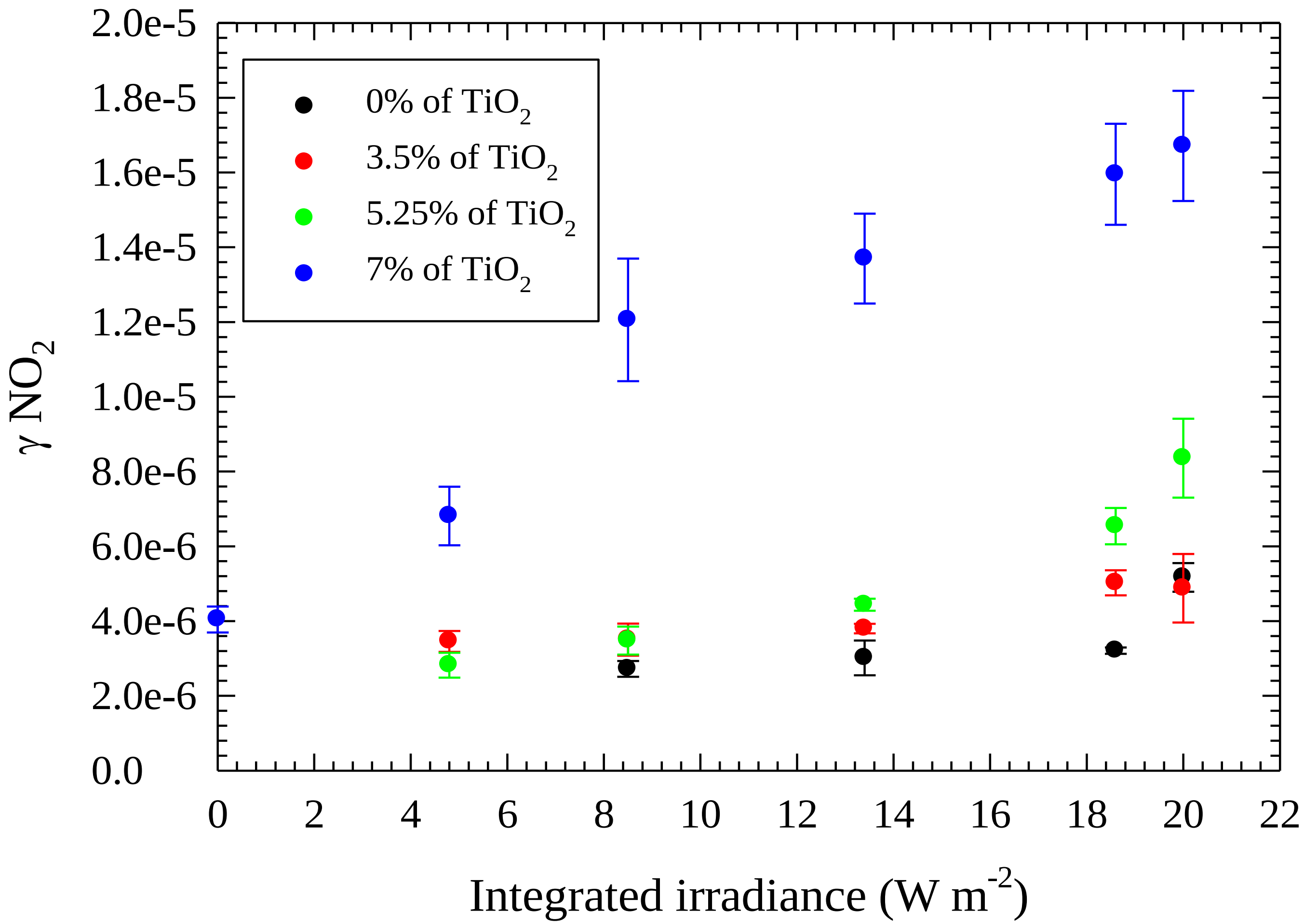
Light Intensity dependance

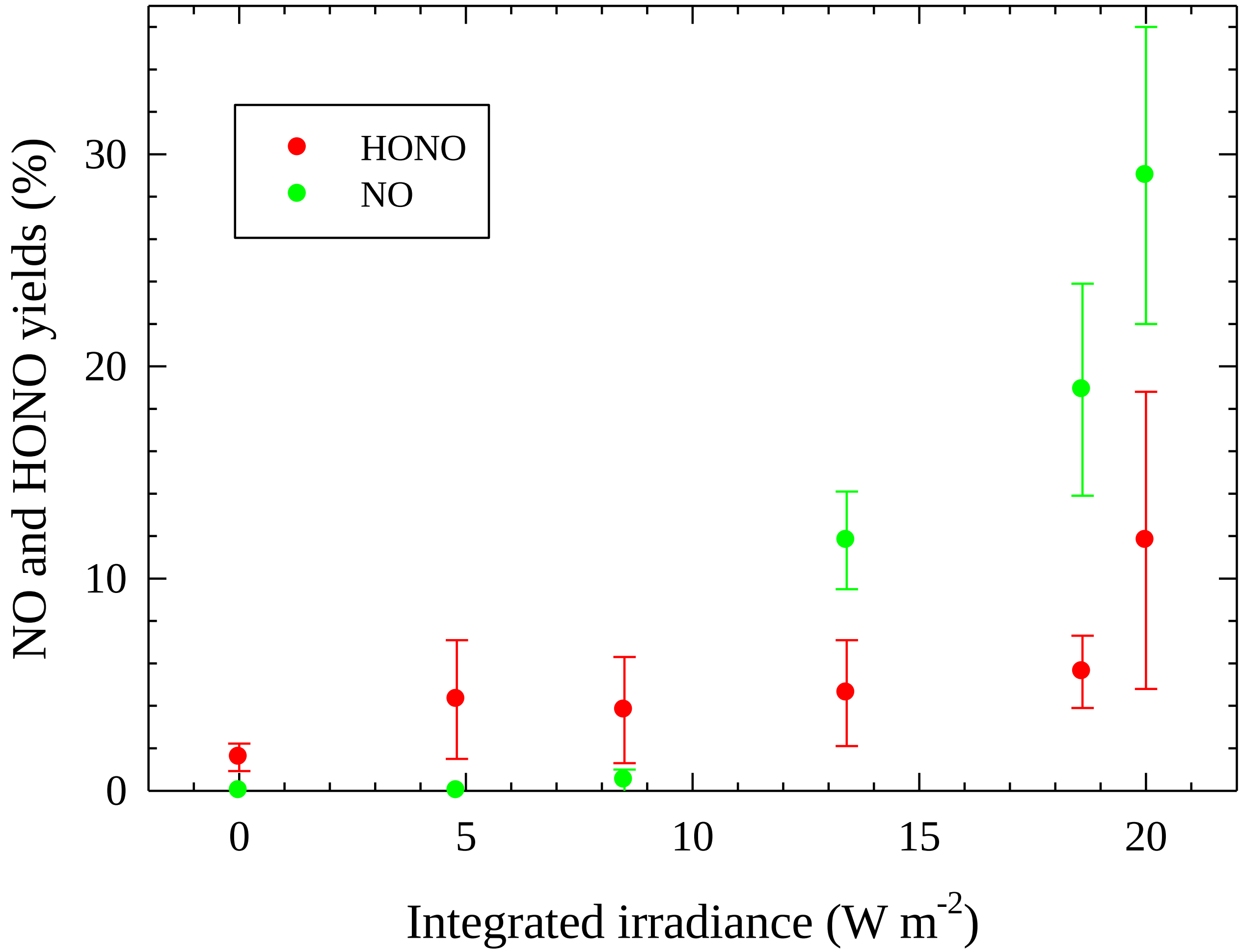
γ (NO_2) depending of Light Intensity

Experimental conditions : NO_2 = 40 ppb ; 40 % RH



NO and HONO production in function of light intensity

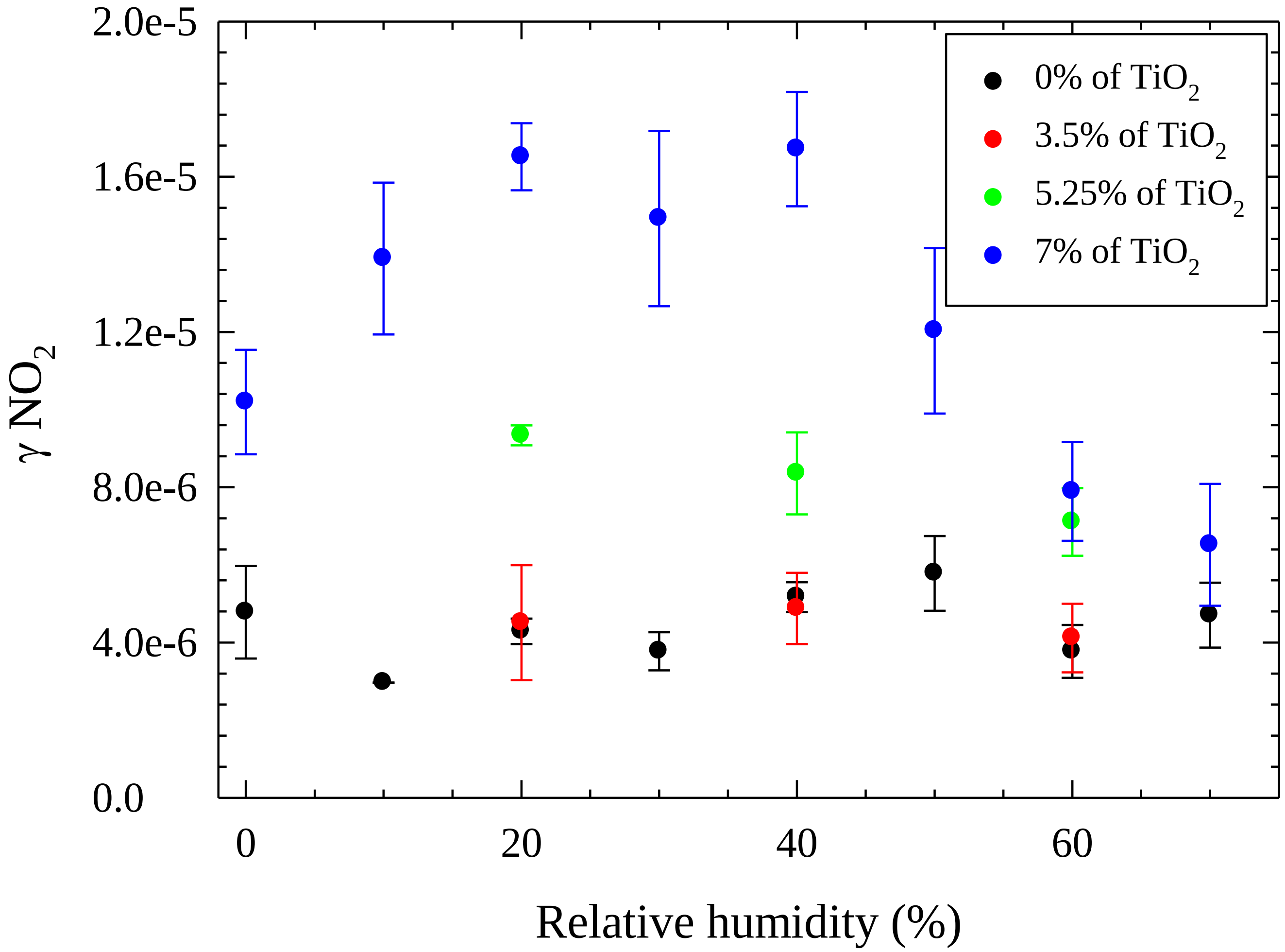
Experimental conditions : NO_2 = 40 ppb ; 40 % RH; 7 % Nano TiO_2



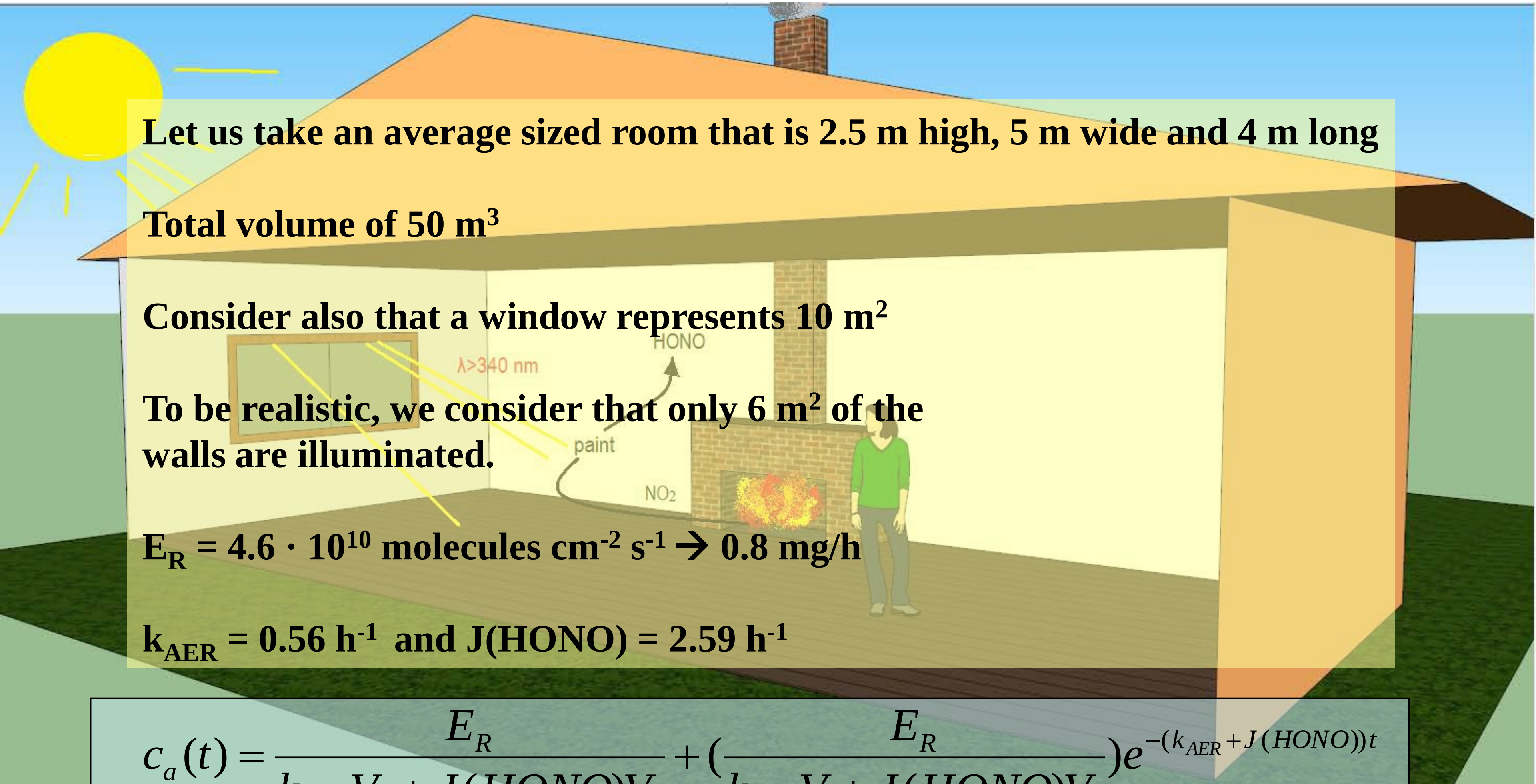
Relative Humidity dependance

γ (NO_2) in function of RH

Experimental conditions : [NO_2] 40 ppb, 20 $W.m^{-2}$



Atmospheric implication



Let us take an average sized room that is 2.5 m high, 5 m wide and 4 m long

Total volume of 50 m^3

Consider also that a window represents 10 m^2

To be realistic, we consider that only 6 m^2 of the walls are illuminated.

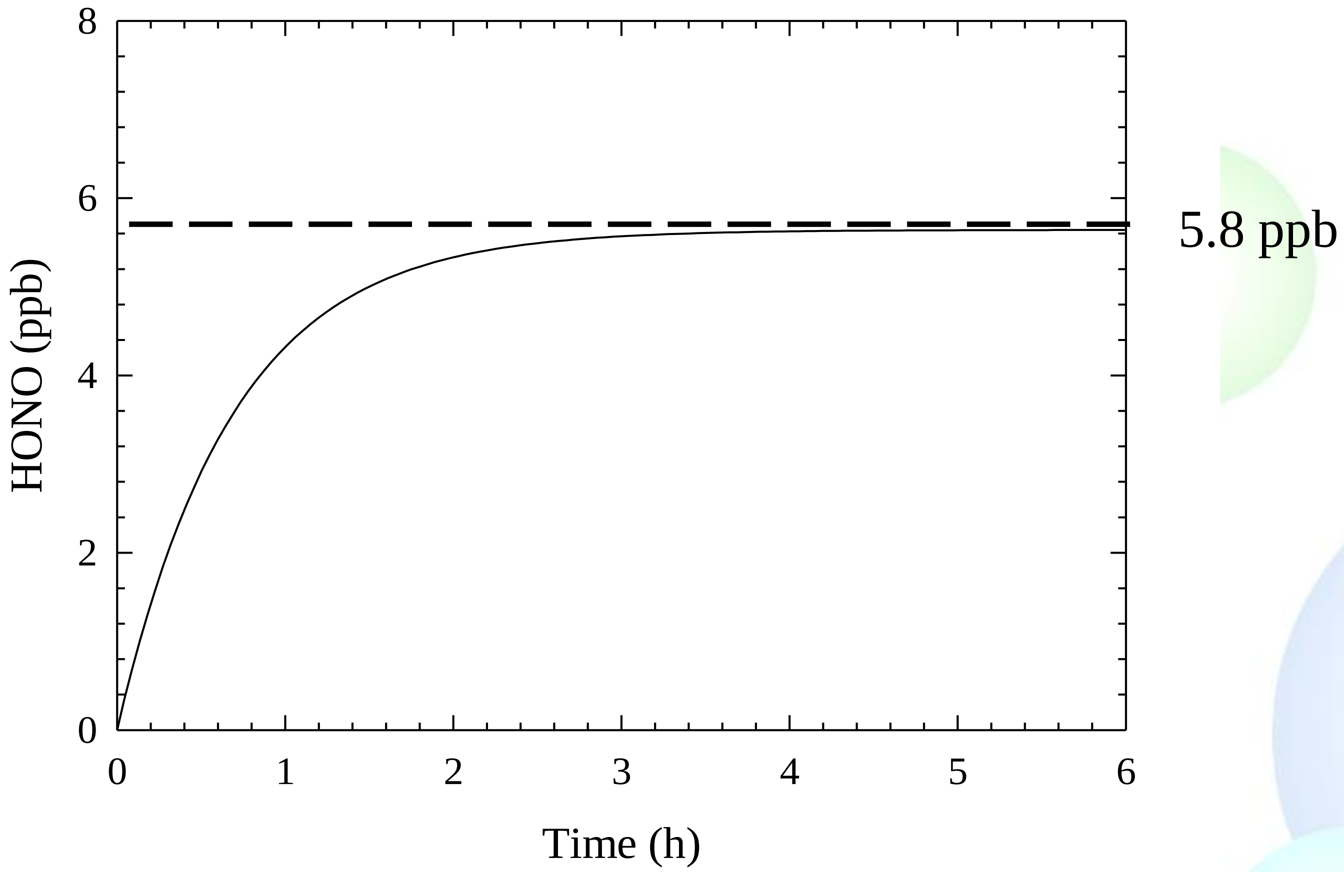
E_R = 4.6 · 10^{10} molecules cm^{-2} s^{-1} → 0.8 mg/h

k_{AER} = 0.56 h^{-1} and J(HONO) = 2.59 h^{-1}

$$c_a(t) = \frac{E_R}{k_{AER}V + J(HONO)V_1} + \left(\frac{E_R}{k_{AER}V + J(HONO)V_1}\right)e^{-(k_{AER}+J(HONO))t}$$

Atmospheric implication

Modeled HONO values considering only the source of HONO



Conclusion

•The uptakes of NO_2 vary in function of the quantity of TiO_2 nanoparticles and NO/HONO conversion yields as well.

•7% TiO_2 content is too high with respect to the HONO production

•5.25% TiO_2 seems more appropriate regarding both Nox and HONO levels

•The laboratory measurements are still ongoing : porosity and pigment content of paints will be tested soon.

Thank you for your attention