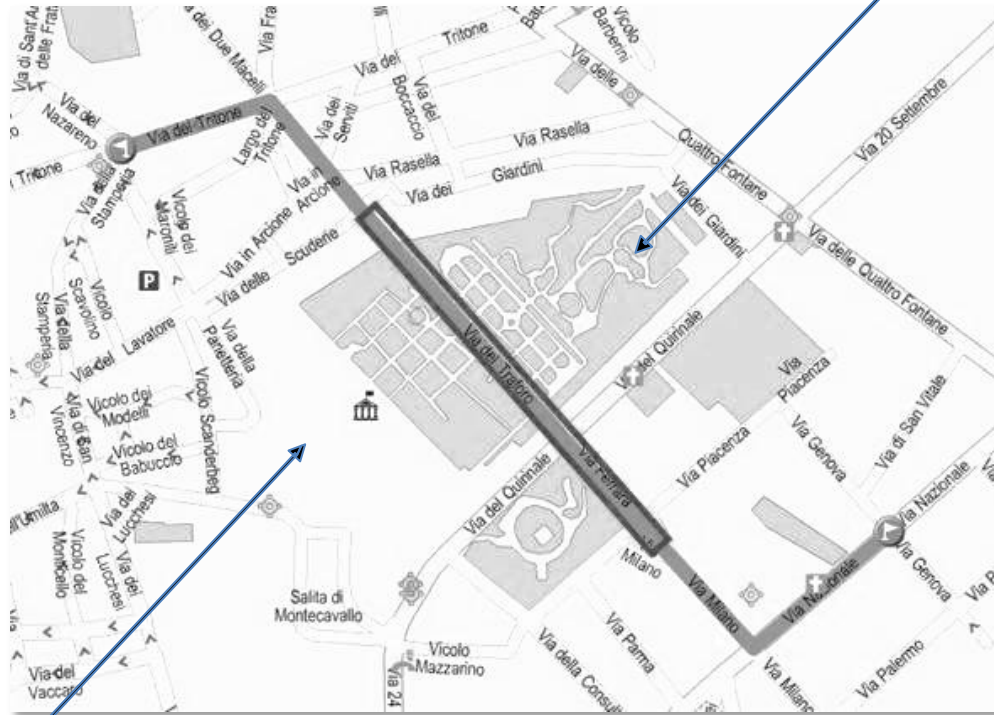


 **airlite**<sup>®</sup>



- History and description of the tunnel
- Materials: paint
- Materials: lighting system (lamps)
- Phases of the renovation work
- Description of the monitoring program
- Remarks
- Preliminary evaluation of the results
- Conclusions

## The Quirinale Hill (gardens)



Presidential Building



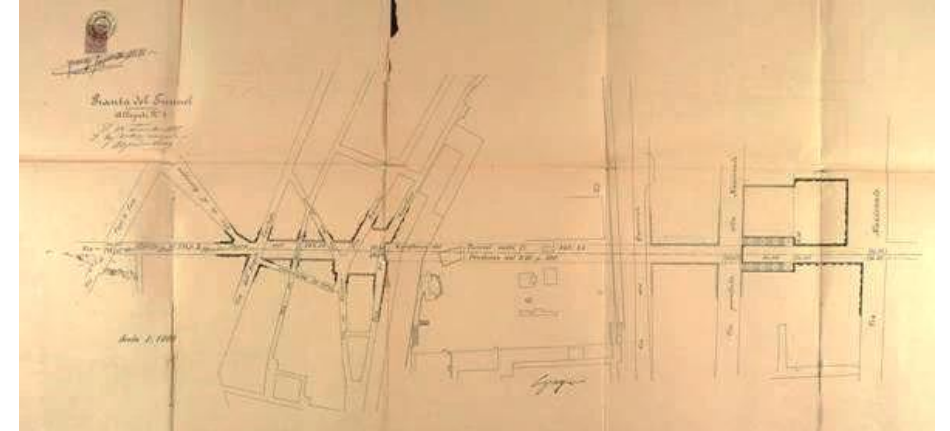
Entrance - via del Tritone



Entrance - via Nazionale



- To facilitate the road circulation in the centre of Rome
- To build a direct connection between via nazionale and Piazza di Spagna
- To improve the circulation between the Esquilino district and the Flaminio district
- To make the circulation more efficient between the central station (Termini Station) and the hystorical centre of Rome

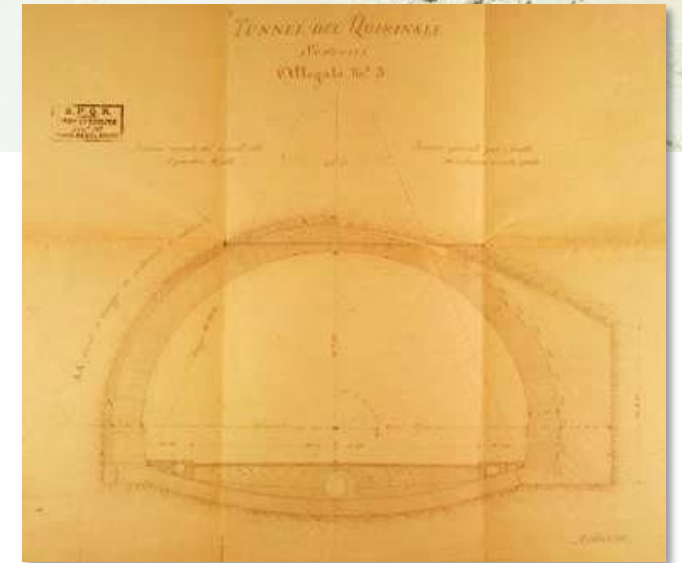
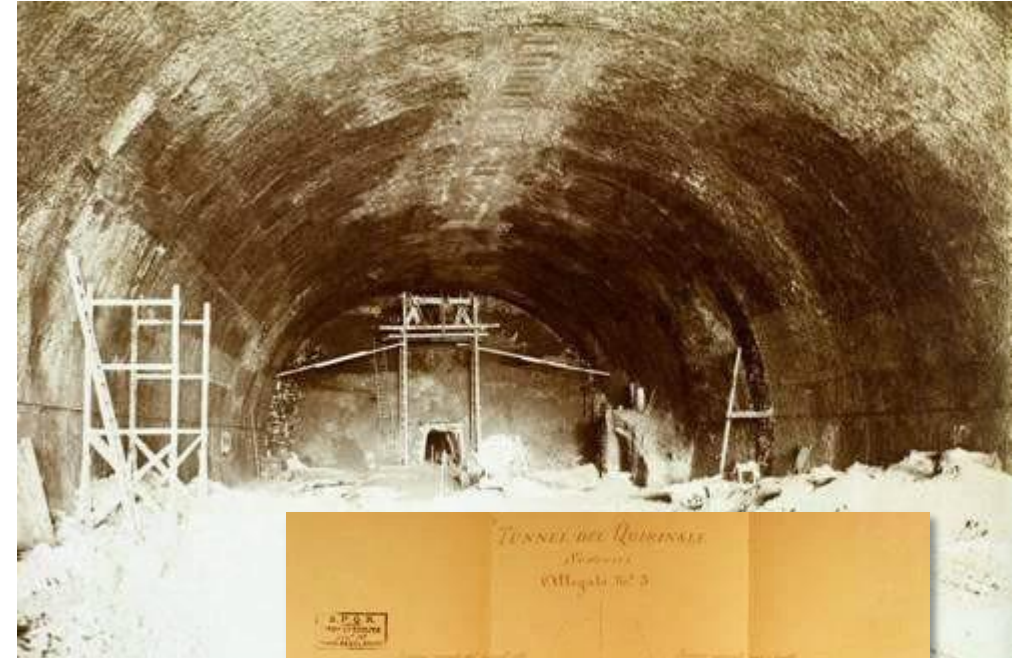


Original Project



## Some information:

- Start of the works: June 1900
- Earth to be extracted: 87.000 cubic meters
- Official opening of the tunnel:  
October 20, 1902
- Total cost of the work: £. 3.842.364,32
- Length: 347,70 m
- Width: 17 m
- Height: 8,5 m



Original Project

- the existing lighting system was no more acceptable, according to the current regulations and safety rules.
- anyway, it was not appropriate for the activation of the photocatalytic effect
- the vault was very dirty, coated with a oily thickness of smog.



## An official decision concerning the tunnel renovation was taken in May 2007

After which, a monitoring program in order to evaluate the current pollution condition, was immediately defined before the starting of the works (programmed in the summer period, in order to minimize the traffic problem in that very congested zone of Rome).

According to the plan, works lasted 1 month (the whole month of August 2007).

The tunnel was officially opened in September 8th, 2007, at 18.00 with the participation of the Mayor of Rome.





A surface of 9.000 m<sup>2</sup> has been clean and then coated with a photocatalytic cement-based paint.

In particular:

- A grey paint for the vault until 1,80m of height
- A white paint in the remaining surface of the vault







According to the specific Italian standard (UNI 11247), this paint has a very high photocatalytic activity (NO<sub>x</sub> abatement higher than 90%, after 60min).

### Principle:

Measurement of the NO<sub>x</sub> abatement when a polluted continuous gas flow is put in contact with a cement based material surface during UV exposure

#### Test conditions:

HR = 50 %

10 T = 27 ± 2°C

I = 2 mW.cm<sup>-2</sup>

C(NO<sub>x</sub>) = 550 ppb

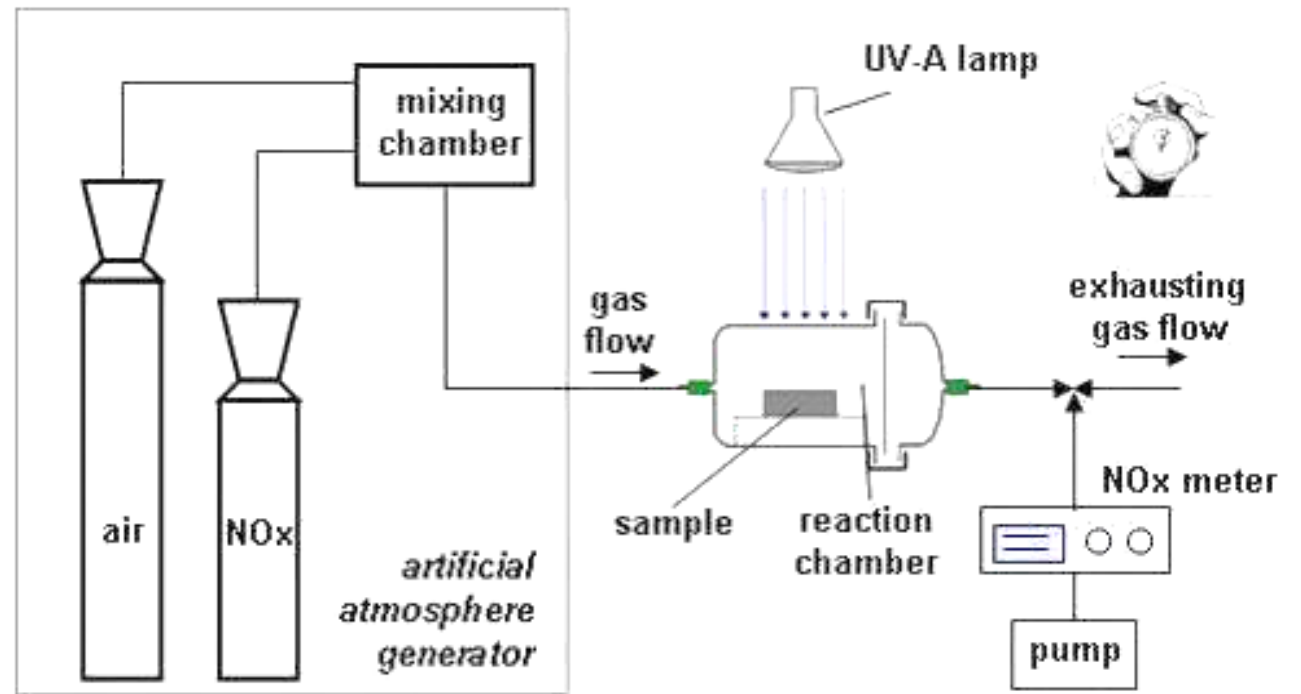
C(NO) = 450 ppb

F = 5 L.mn<sup>-1</sup>

V = 3 L ± 20%

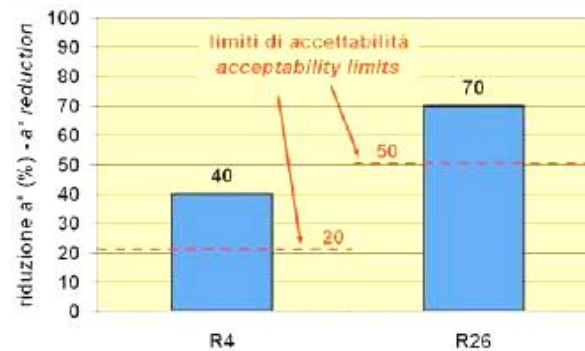
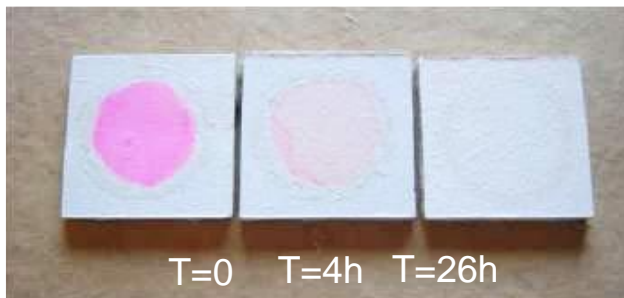
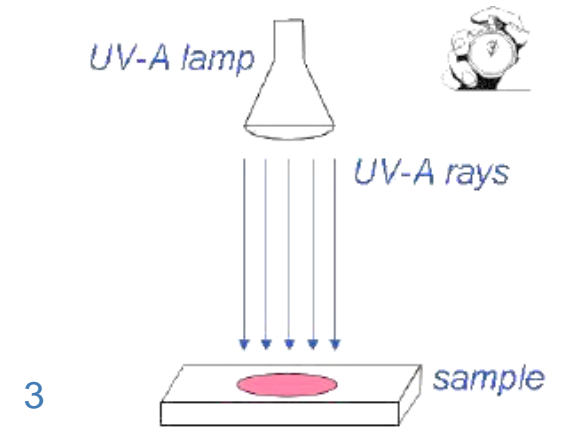
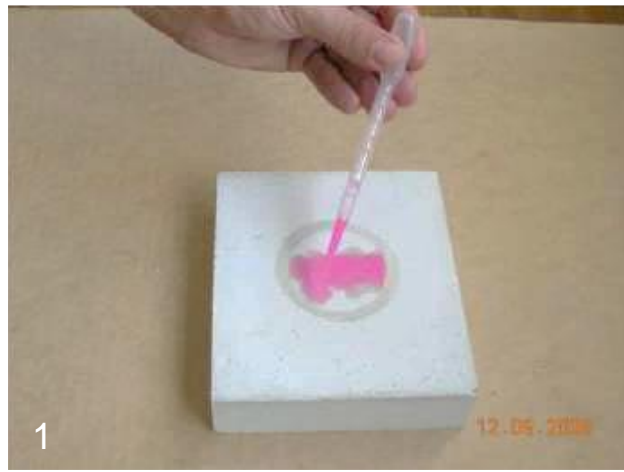
#### Sample:

Curing time > 10 days S = 65      2 cm<sup>2</sup>



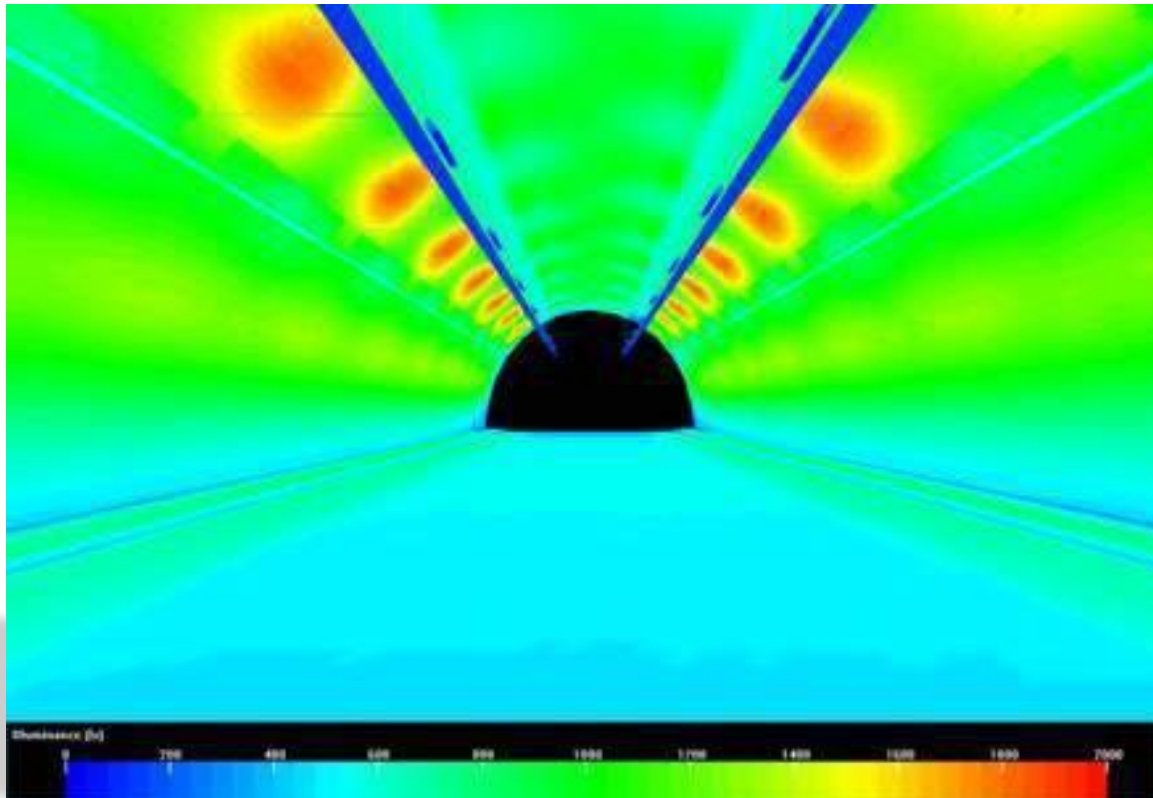


Besides, this paint presents a very good performances in terms of self-cleaning capacity (determined by means of the colorimetric test method based on Rhodamine-B – Draft Italian Standard)

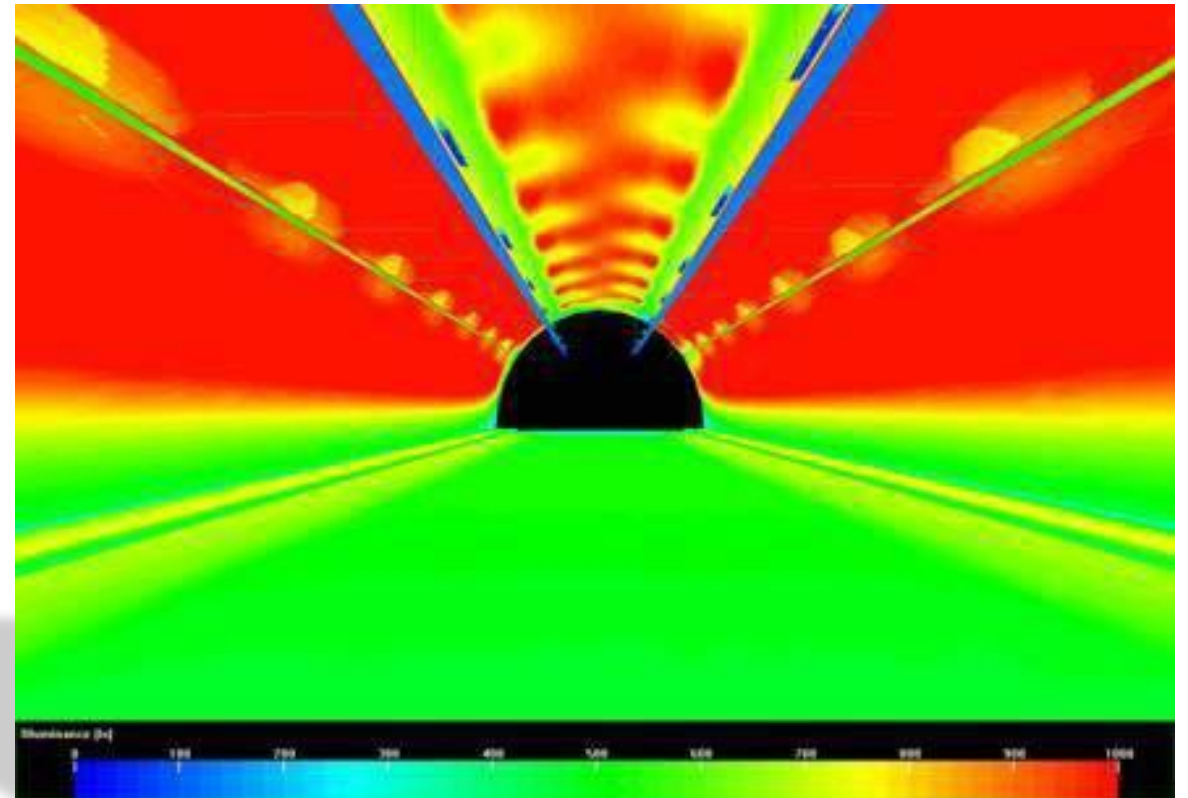




A specific lighting design work was carried out

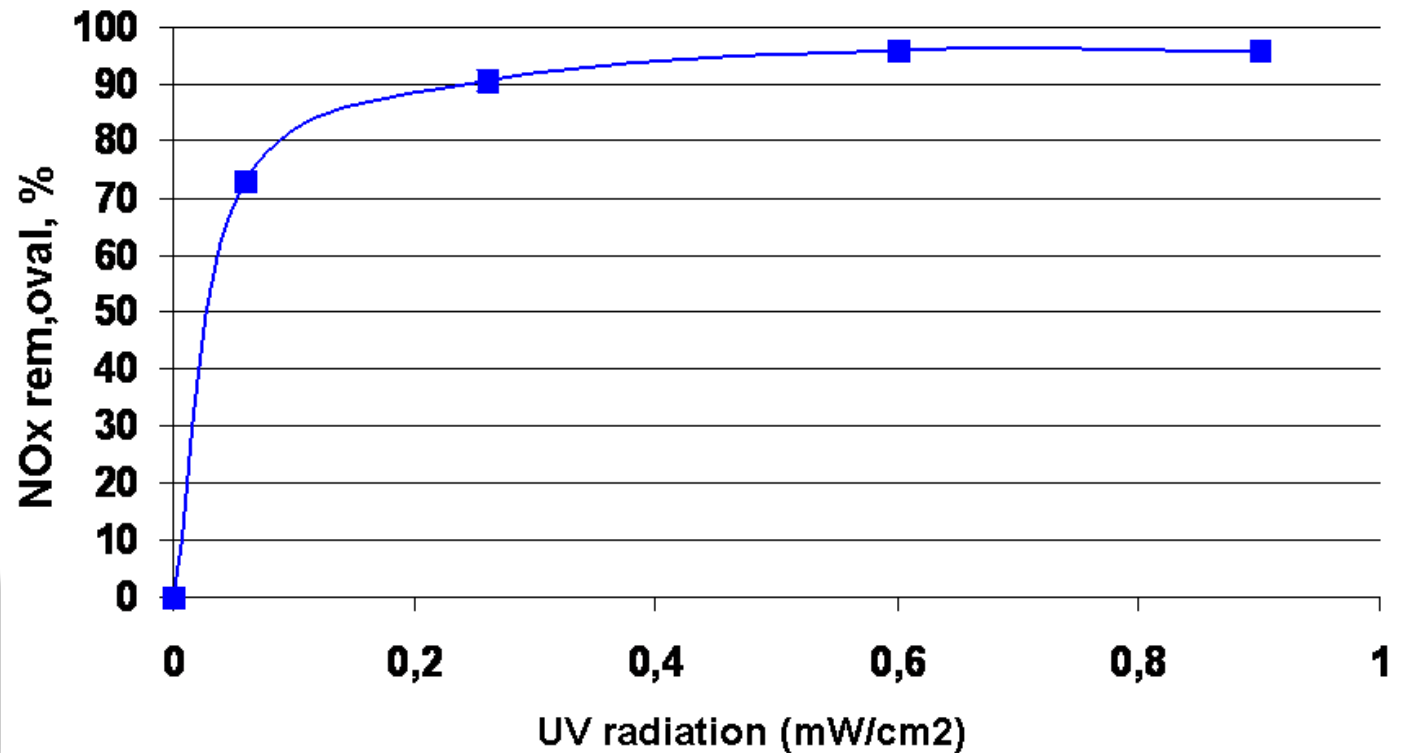


Visible light irradiation



UV light irradiation

The choice of the lamps was made by taking into consideration a reference curve, derived from experimental tests for the determination of the photocatalytic abatement of cement-based materials, as a function of the abatement degree of NO<sub>x</sub>



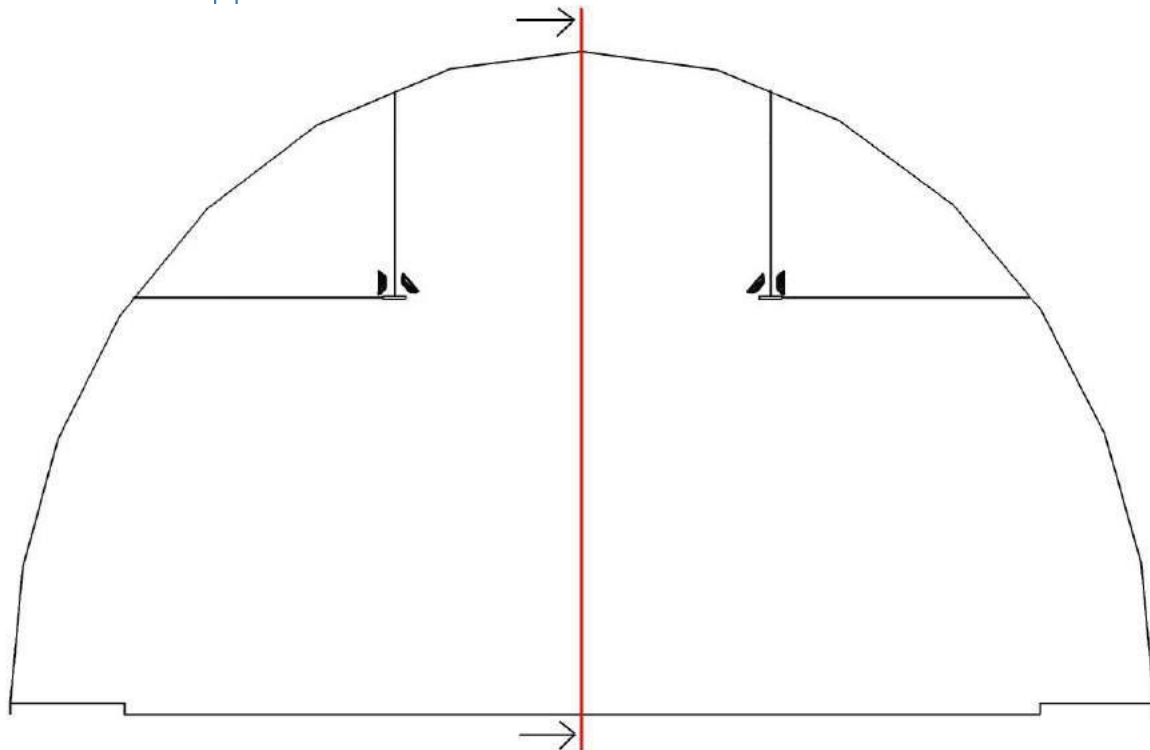
Height of the gallery = 8,7 m

Width of the gallery = 15 m

Height of the installation of the devices = 5,5 m

The distance between the wiring  
canals and the device support = 7 m

Gallery section with  
the position of the devices



Combined lamp Visible + UV



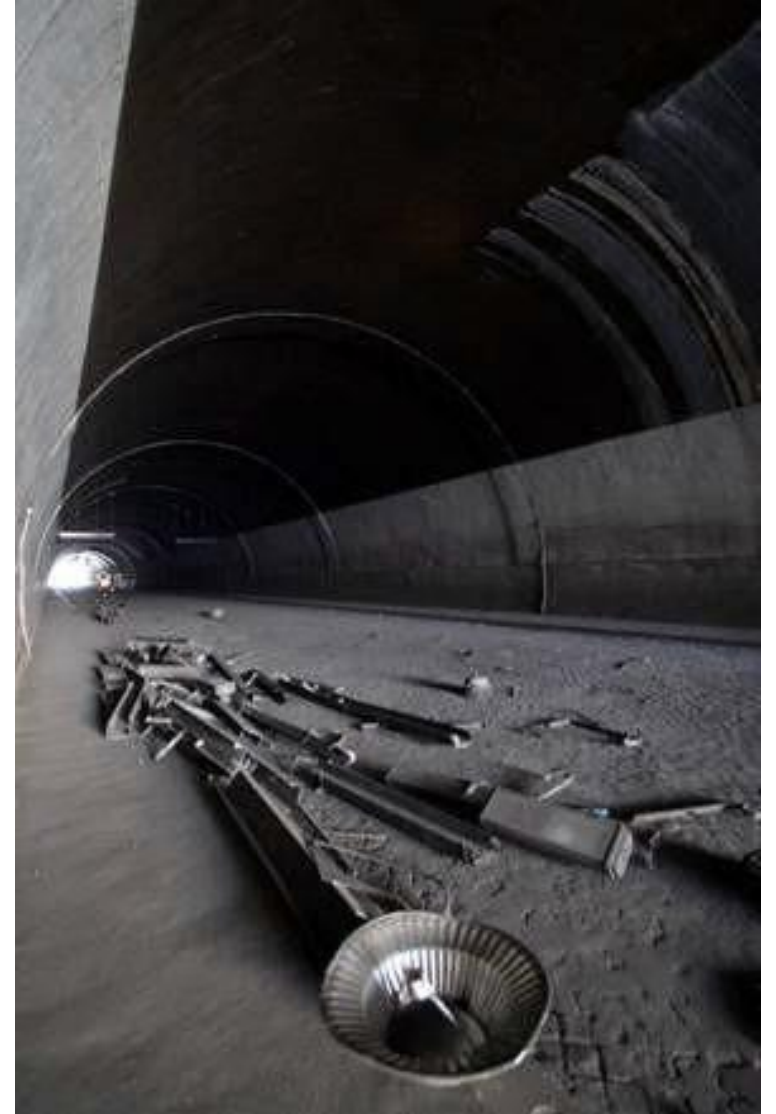
Only UV lamp





# Phases of the renovation work

(August 2007)







Application by airless spraying technique  
Two layers: (1) primer (2) paint



Application by airless spraying technique  
Two layers: (1) primer (2) paint





The new lighting system is able to activate the photocatalytic process  
White light is directed towards the vault (diffusion),  
in order to obtain a homogeneous lighting effect





Reopening of the renovated tunnel in occasion of the “Sleepless Night” in Rome (afternoon, 8 September, 2007).

Press conference and official ceremony, with the participation of the Mayor of Rome (Mr. W. Veltroni)



Roman citizen can freely walk along the tunnel, before the circulation of the cars



A very impressive comparison between the rendering of the tunnel, simulated in the design phase by Disano (left) and the real situation of the tunnel, after the renovation work (right)







# Monitoring Program

The monitoring approach was defined by CTG in agreement with some managers of the Municipality of Rome (Department for the Environmental Activities).

Due to the particular situation in terms of both:

- monitoring approach (use of NOx meters along the day),
- needs of collecting some relevant data in a manual way (Traffic, light conditions, wind speed)
- this monitoring has required the presence of almost three resources/day.

The monitoring was generally carried out during the daytime (period 8.00-18.00), from Monday to Friday. One nocturnal monitoring was also carried out, for each campaign.

## TIMING:

Before the renovation: from 3 July, 2007 to 20 July, 2007

After the renovation: from 25 September, 2007 to 10 October, 2007

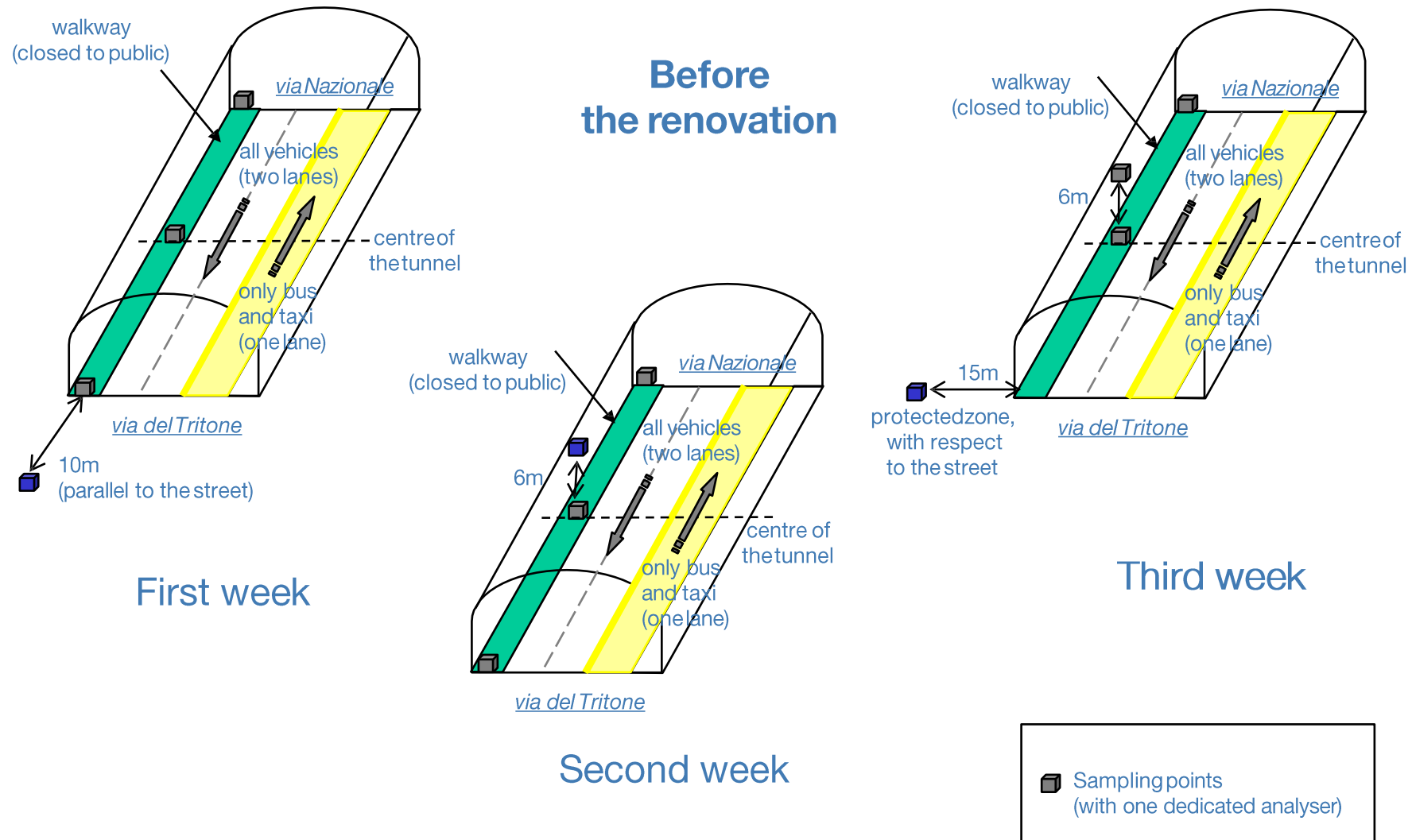
## REGISTERED DATA:

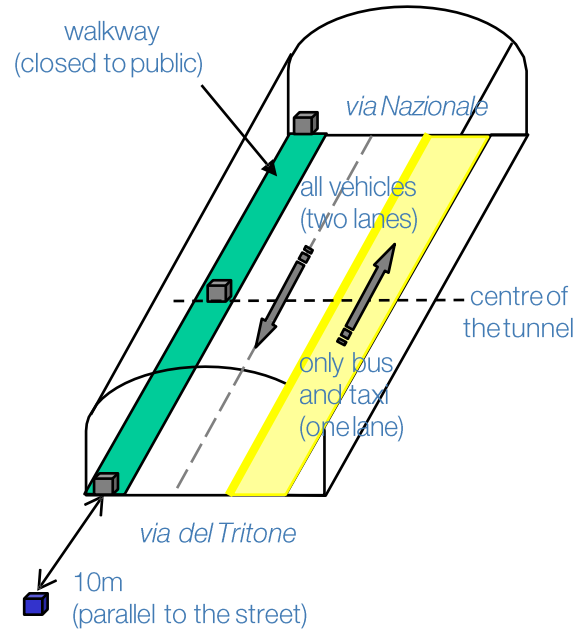
- NO, NO<sub>2</sub> and NO<sub>x</sub>
- Weather conditions and Light situation (T, HR, P, wind speed, UVA, UVB, RAD, Lux)
- Traffic situation, vehicles/hour



## Main equipment used for the monitoring campaigns:

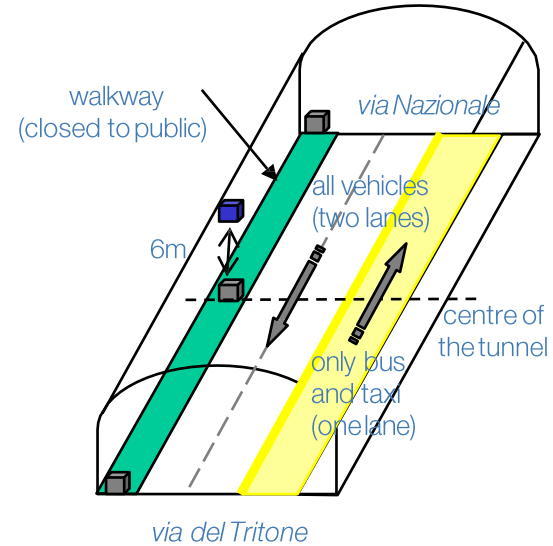
- 4 chemiluminescence NOX analyzers (ENVIRONNEMENT)
- 1 calibrating system (ENVIRONNEMENT)
- 1 Thermo-hygrometer (TESTO)
- 1 Luxmeter – TESTO
- 1 UVA/UVB/RAD meter (Delta OHM)
- 1 Anemometer






first week

after renovation



second and third week

 Sampling points (with one dedicated analyser)





CTG working site, next to the tunnel  
(via del Tritone)



Position of one analyser  
(via del Tritone)



Measurement  
of wind speed



Position of one analyser  
(via Nazionale)



Positions of two analysers, in the centre of the tunnel (before the renovation)

- Due to the specific application (tunnel, instead of open place, or road), we can consider that the lighting conditions as steady.
- however, due to the large dimensions of the tunnel, a certain amount of sunlight could reinforce the photocatalytic action, in addition to the artificial light (in some hours of the day)
- the most relevant parameters which could influence the monitoring results the traffic (number of vehicles per hour) and the wind speed.
- a nocturnal data collection was decided, along the two periods:
  - from 8.00 of 11/7 to 18.00 of 12/7 (before the renovation)
  - from 8.00 of 10/10 to 18.00 of 11/10 (after the renovation)

- Data collection of analysers positioned just outside
- the entrance “via del Tritone” was strongly influenced by local traffic, due to the temporary parking (few minutes) of touristic buses (the tunnel is some hundred meters from the famous “Fontana di Trevi” monument
- this phenomenon is seasonal, from spring period
- to the end of summer period). It is particularly evident in the central part of the day (from 10.00-11.00 to 16.00-17.00, according to the days)

The tunnel is quite windy, as:

- It is large, in dimensions;
- The volume of the traffic is predominant in one direction (from via Nazionale to via del Tritone), due to the two lanes (in the opposite direction the circulation is allowed only to public vehicles (buses, taxi) service vehicles and “official cars” (no private vehicles)

The tunnel is slightly downhill, from via Nazionale to via del Tritone



- The mean daily NO<sub>x</sub> values increase, passing from via Nazionale to via del Tritone, probably due to the above mentioned windy situation in the tunnel and to the pollution effects derived from the other entrance.
- The mean NO<sub>x</sub> values are very high: daily values of 400-800 ppb (Rome)
- an increase of NO<sub>x</sub> values during the afternoon was almost regularly observed, due to the tourist traffic above described (especially for the positions next to the entrance “via del Tritone”) and very high pollution peaks were sometimes registered



# Preliminary Results

## Type of station:

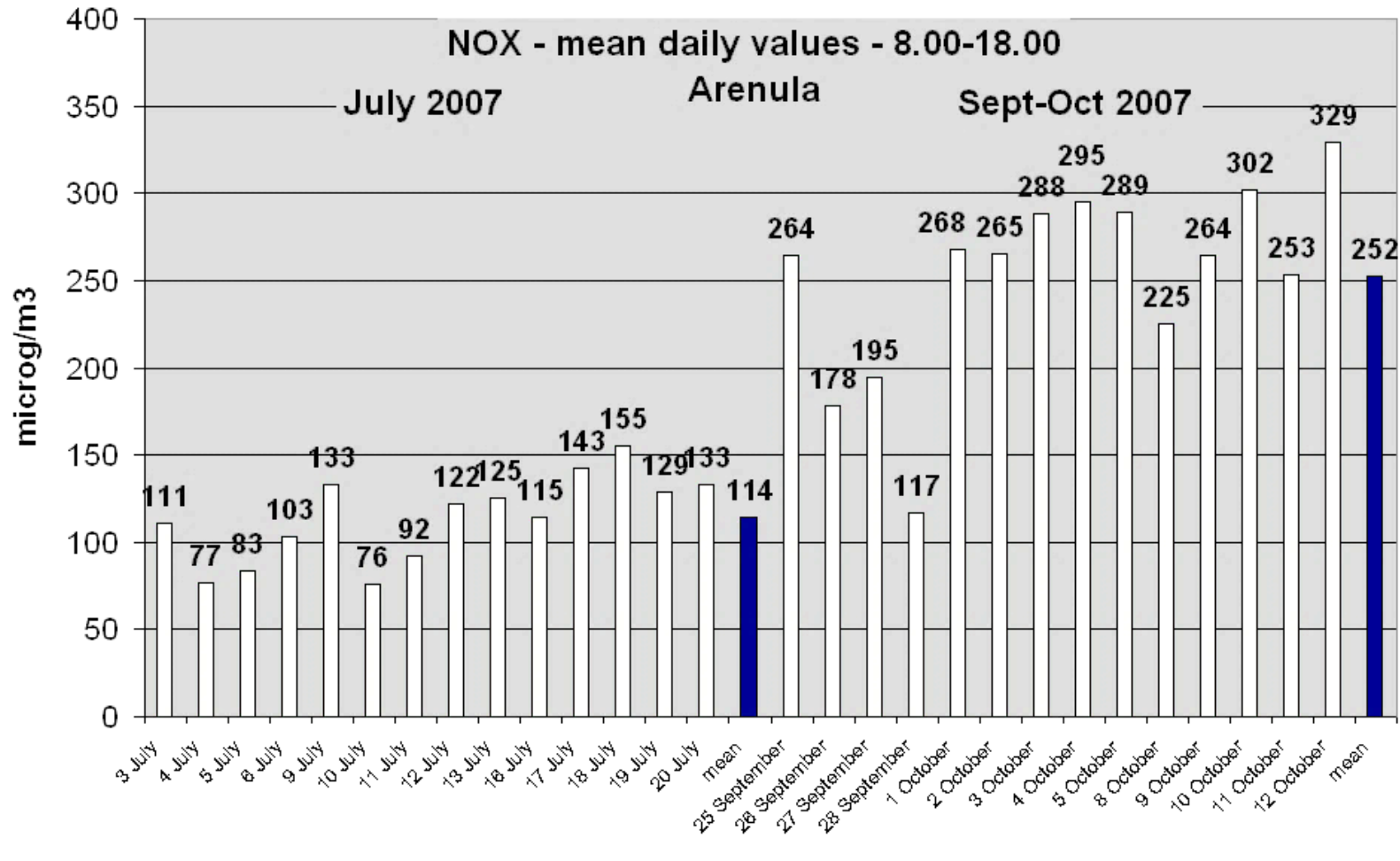
- Arenula: traffic
- Fermi: traffic
- Villa Ada: background



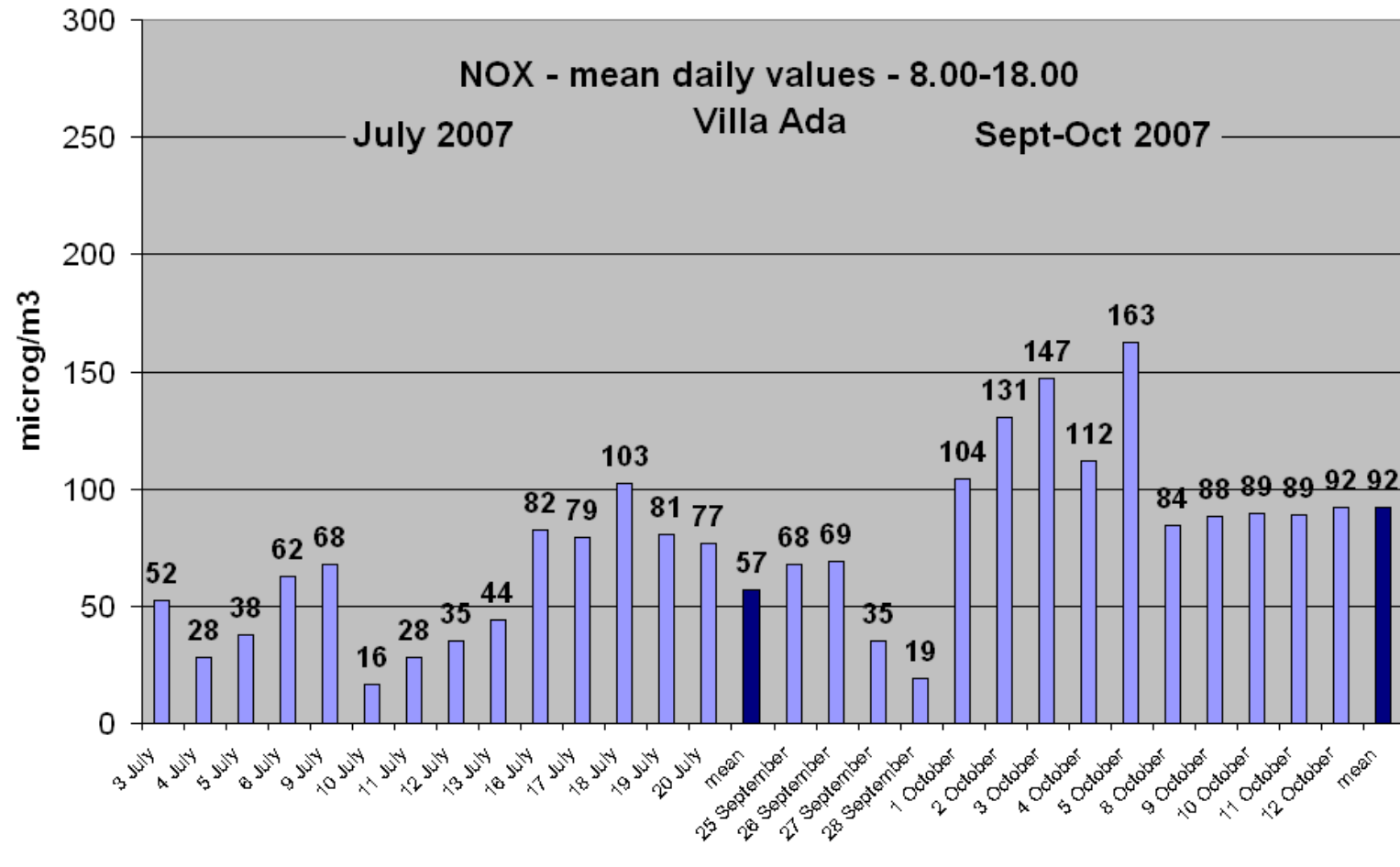
During daylight (8.00-18.00), in the city of Rome, the daily values registered by means of official fixed stations were higher in the period of three-weeks monitoring campaign (September-October 2007), with respect to the three-week period of July 2007 - official data from ARPA Lazio (\*).

(\*) ARPA Lazio is the Regional Environmental Agency for the Lazio region, which is in charge of the pollution monitoring, in Rome.





Largo Arenula – centre of Rome (traffic)



Villa Ada – Centre of Rome (background)

During the monitoring campaign after the renovation works, some measurements of light were carried out in different points of the tunnel, both at 1.8 m and 6 m of height.

These measurements confirmed the mean light values, previewed in the design phase.



Number of vehicles per hr (mean hourly value) was (manually) registered in occasion of the two monitoring campaign.

Mean values are similar, in July 2007 and in September-October 2007 1100 vehicle/hr, about

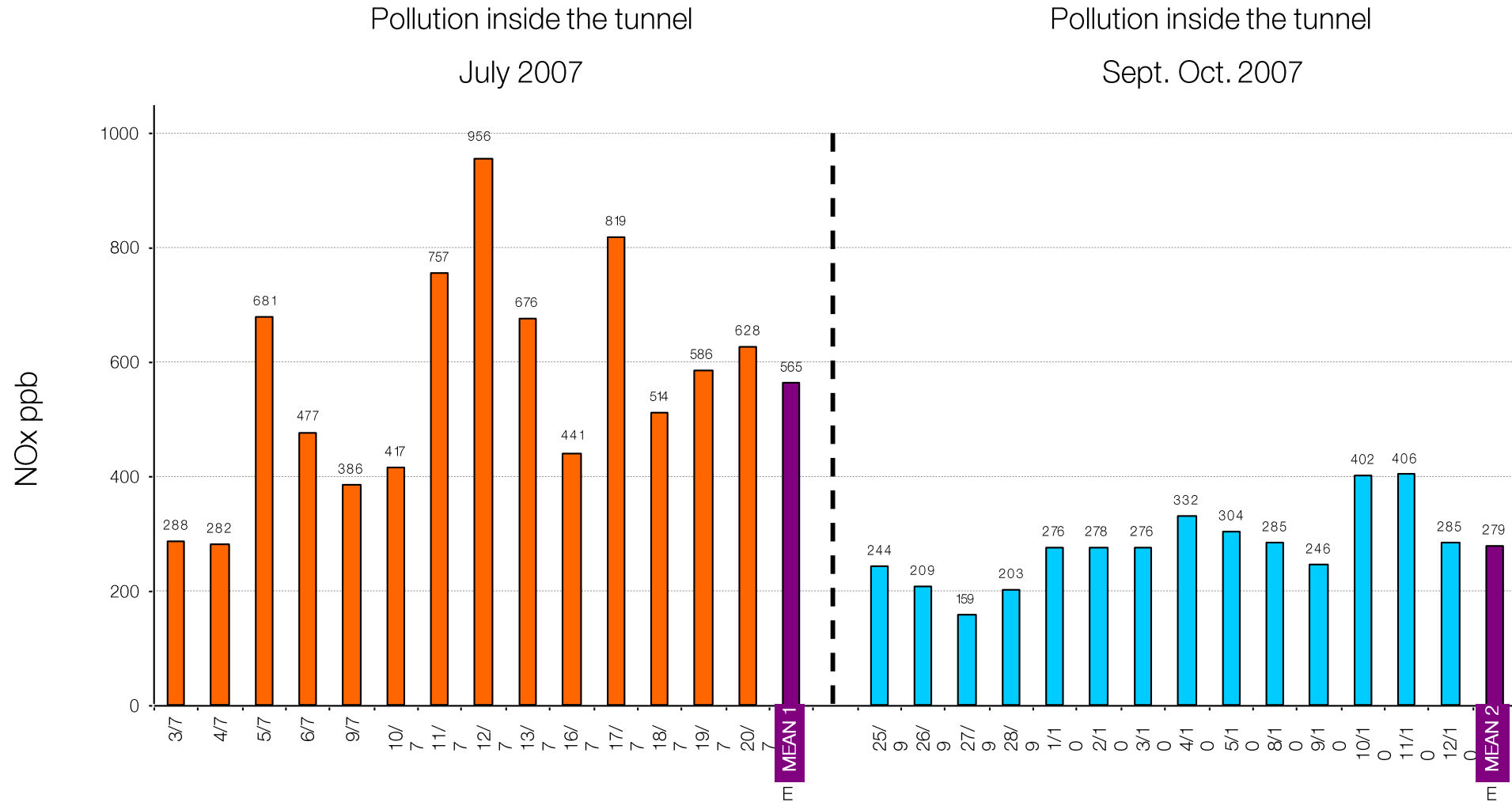
A large number of tourist buses was observed along the day, mainly in the range: 10.00-16.00 (both in July and in Sept-Oct period).



With reference to preliminary considerations concerning:

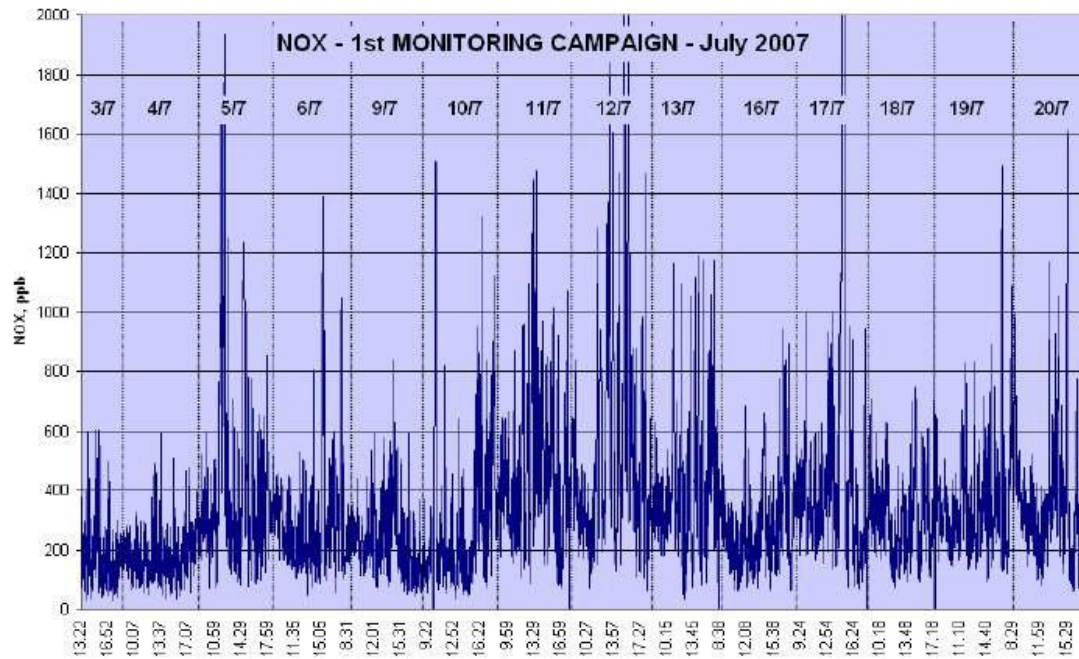
- daily trends of NO<sub>2</sub> values (see previous graph)
- geometry and local conditions of the tunnel;
- possible origin of pollution in the tunnel (traffic + external buses),

in the following graphs, the data referred to the centre of the tunnel (1m) will be taken as the most representative, for this first preliminary evaluation.

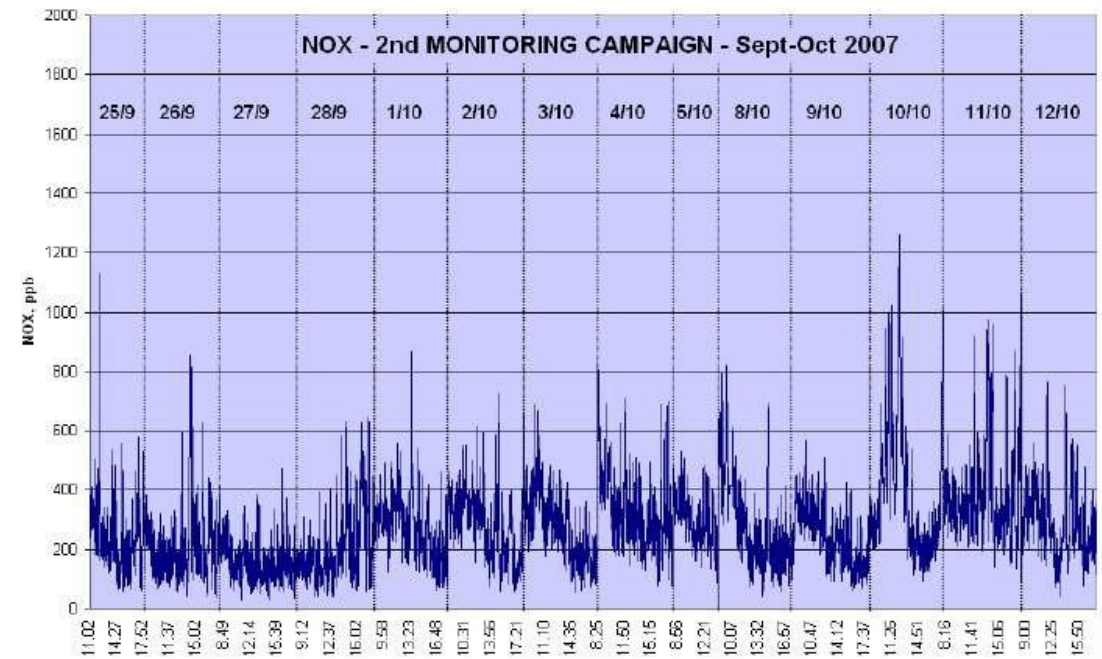


In the center of the tunnel – 1m

before the renovation



after the renovation



Clear reduction of instantaneous peaks,  
in presence of the photocatalytic coating

In the centre of the tunnel – 1m

Three weeks data

values > 400 ppb

values > 300 ppb

Before the renovation

27%

46%

After the renovation

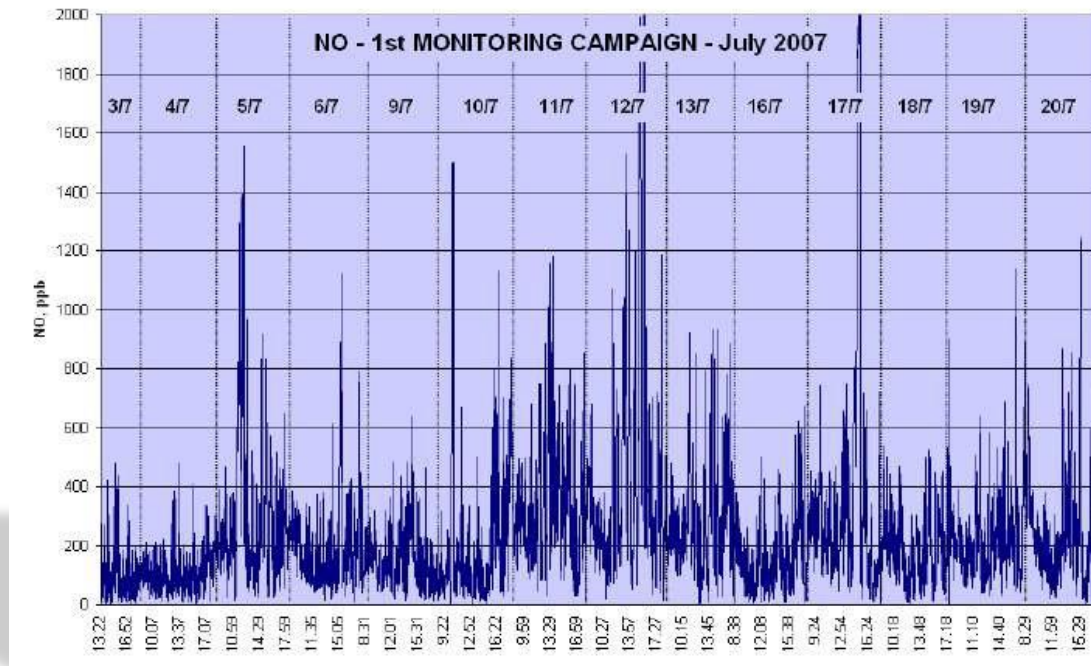
16%

37%

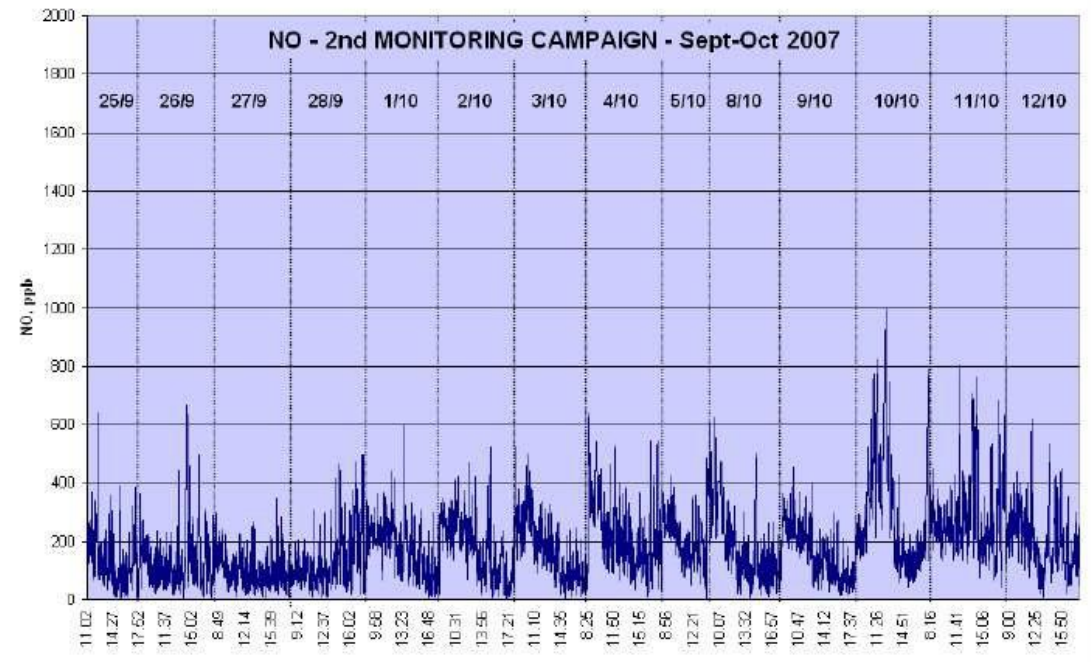


In the center of the tunnel – 1m

before the renovation



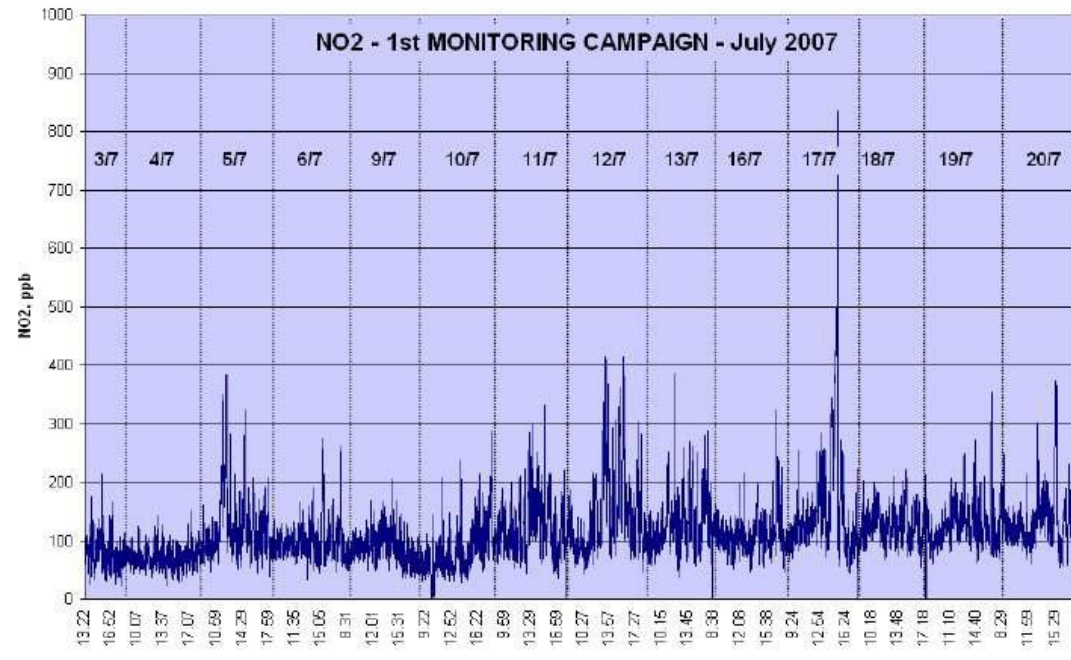
after the renovation



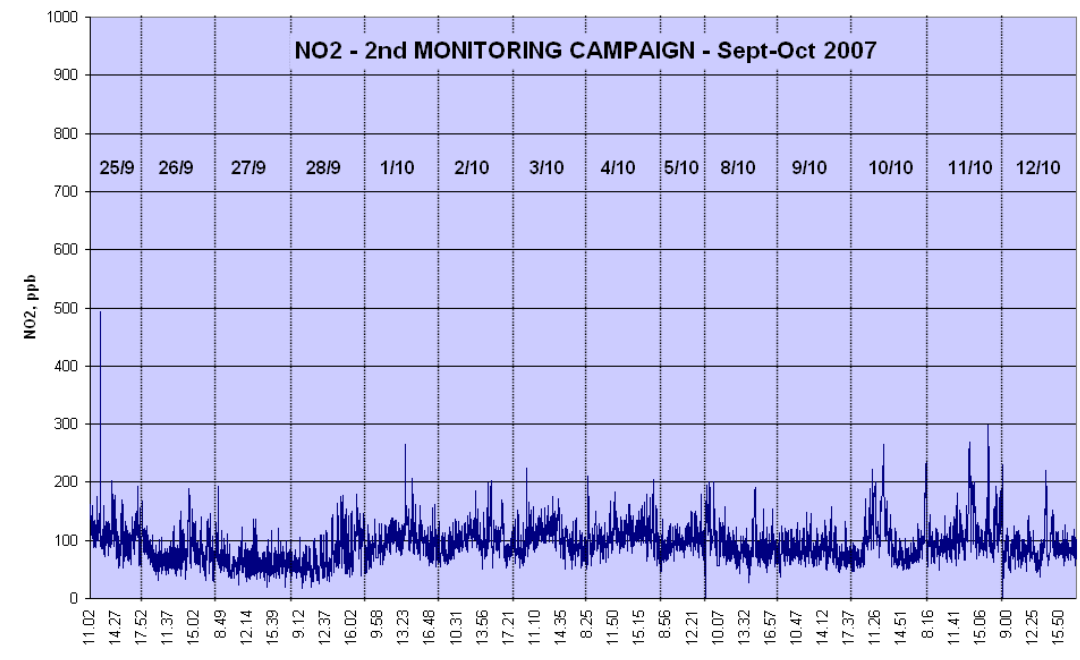
Clear reduction of instantaneous peaks,  
in presence of the photocatalytic coating

In the center of the tunnel – 1m

before the renovation



after the renovation



Clear reduction of instantaneous peaks,  
in presence of the photocatalytic coating

- The renovation work has allowed to obtain a relevant result, from the architectural point of view;
- a broaden NOx monitoring programme, was carried out by CTG before and after the work;
- this preliminary evaluation of collected data seems to confirm the **photocatalytic depollution activity** of the cement-based paint applied on the vault of the tunnel.

- a 51% reduction of NO<sub>x</sub> values has been calculated, too.
- a 25% reduction of NO values in the centre of the tunnel has been calculated.
- a clear reduction of pollution peaks was observed, after the renovation (pollution peaks are considered very dangerous for the human health).



As preliminary, general comment to these results we can say that:

the photocatalytic action allows to maintain the pollution levels under certain limits.

In particular, a reduction on NO<sub>2</sub> values (official reference for the Environmental Agency) was obtained.

With reference to the **geometry** and **local conditions** of the tunnel:

- The tunnel is very large and volumes of air to be treated are very high;
- the **contact time** for the absorption effect, needed for the depollution reaction of cement-based material could also be influenced by the air speed in the tunnel;
- this effect is more evident, in case of relatively short tunnels;

- we must consider that the efficiency of the photocatalytic effect decreases, with the increase of the distance from the wall;
- according to our experience, considering a transversal section of the tunnel, 50% about of the whole air volume should be treated;

These results correspond to the expected values calculated from the lighting system design, based on the NOx calibrating curve and considering the dimensions of the tunnel (length, width)

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