

Characteristics of Activated Carbon Fiber on NOx Purification and Concept of Wide-area NOx Purification Technology



○Takaaki Shimohara¹⁾, Satoko Yamashiro¹⁾, Shunji Niiya¹⁾, Masaaki Yoshikawa²⁾, Jin Miyawaki³⁾, Seong-Ho Yoon³⁾ and Isao Mochida³⁾

¹⁾ Fukuoka Institute of Health and Environmental Sciences

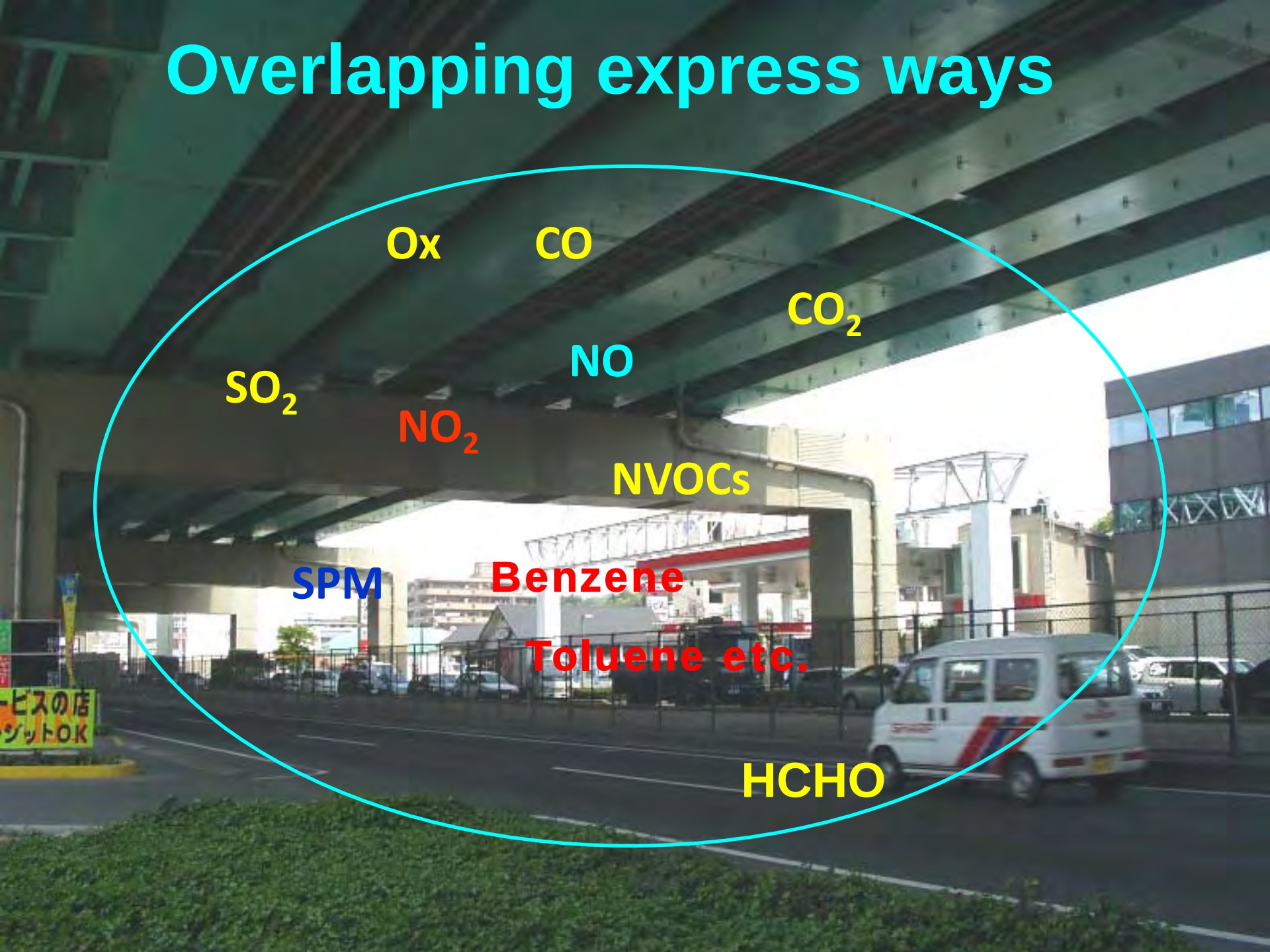
²⁾ Energy Technology Laboratories, Osaka Gas co., Ltd.

³⁾ Kyushu University

ACF mounting



Overlapping express ways



Ox **CO**

CO₂

NO

SO₂ **NO₂**

NVOCs

SPM **Benzene**

Toluene etc.

HCHO

Vehicle emissions monitoring station

Annual average

NO 89ppb, NO₂ 48ppb

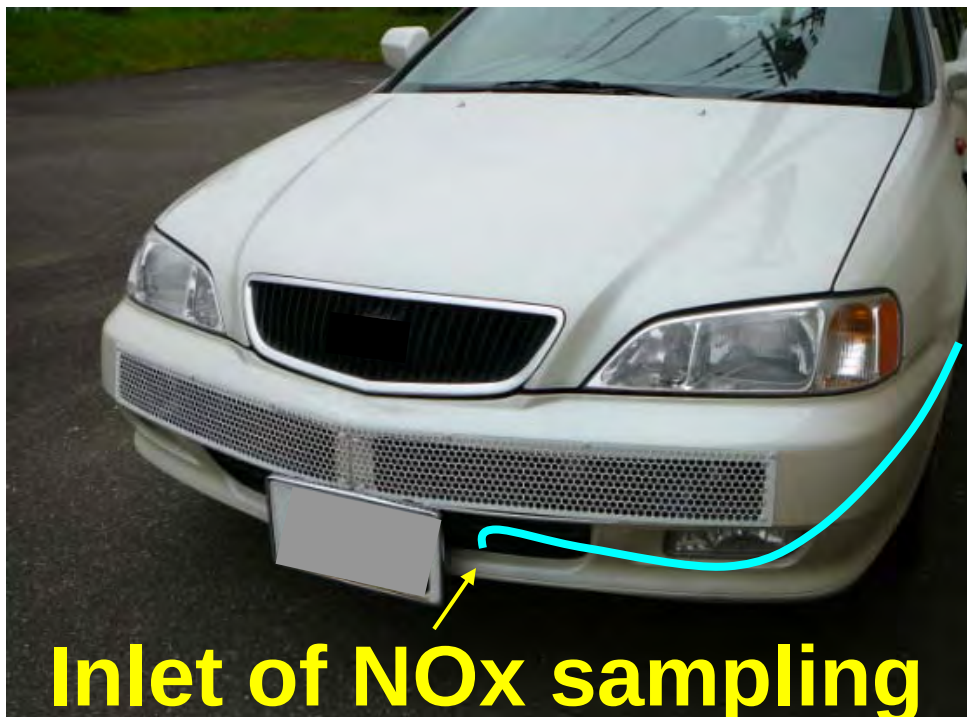
Max of hourly value

NO 384ppb, NO₂ 80ppb



Automatic NOx analyzer





Real-time NOx concentration on a road

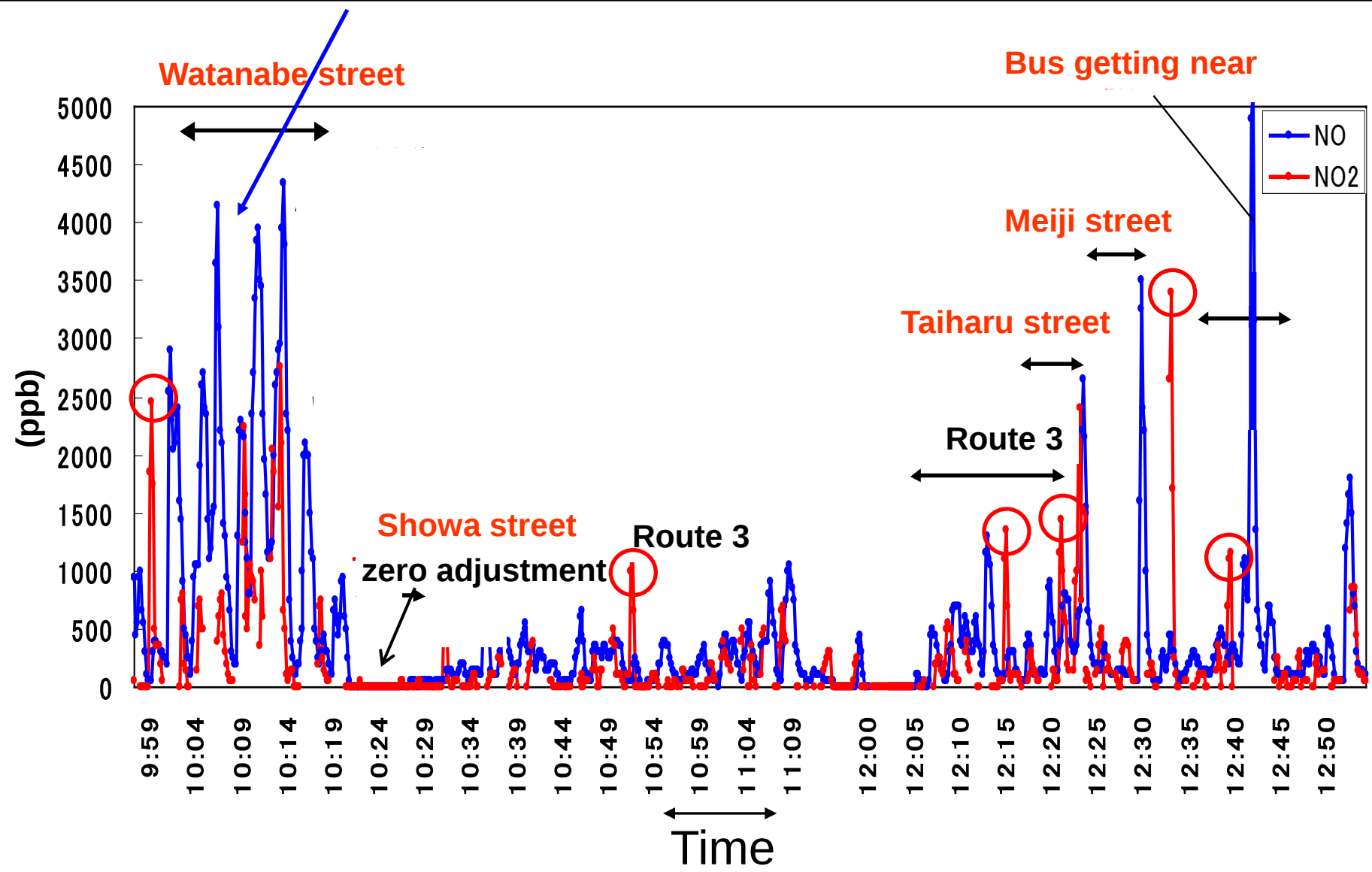




Photo catalyst (TiO_2)

Incomplete oxidation

NO is oxidized and released as NO_2
Sunlight (UV)

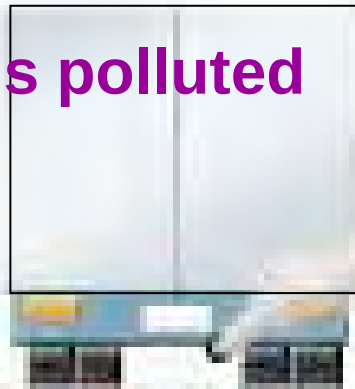
Relative humidity is high

Unknown VOC's

Wind speed is strong

(Contact time is shorter than 3 seconds)

Surface is polluted



NO

NOx

Cleanup

NO_2

Decomposed
Oxidized

Fixed as HNO_3
Washed out

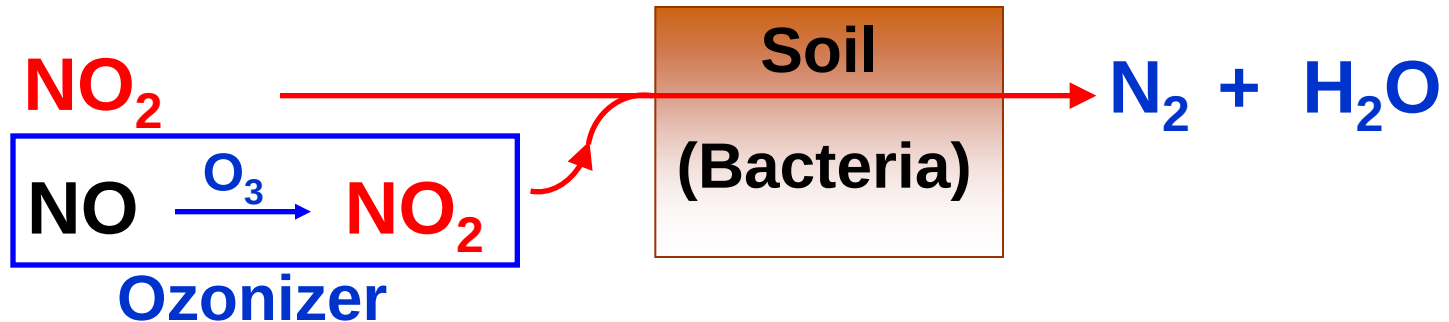
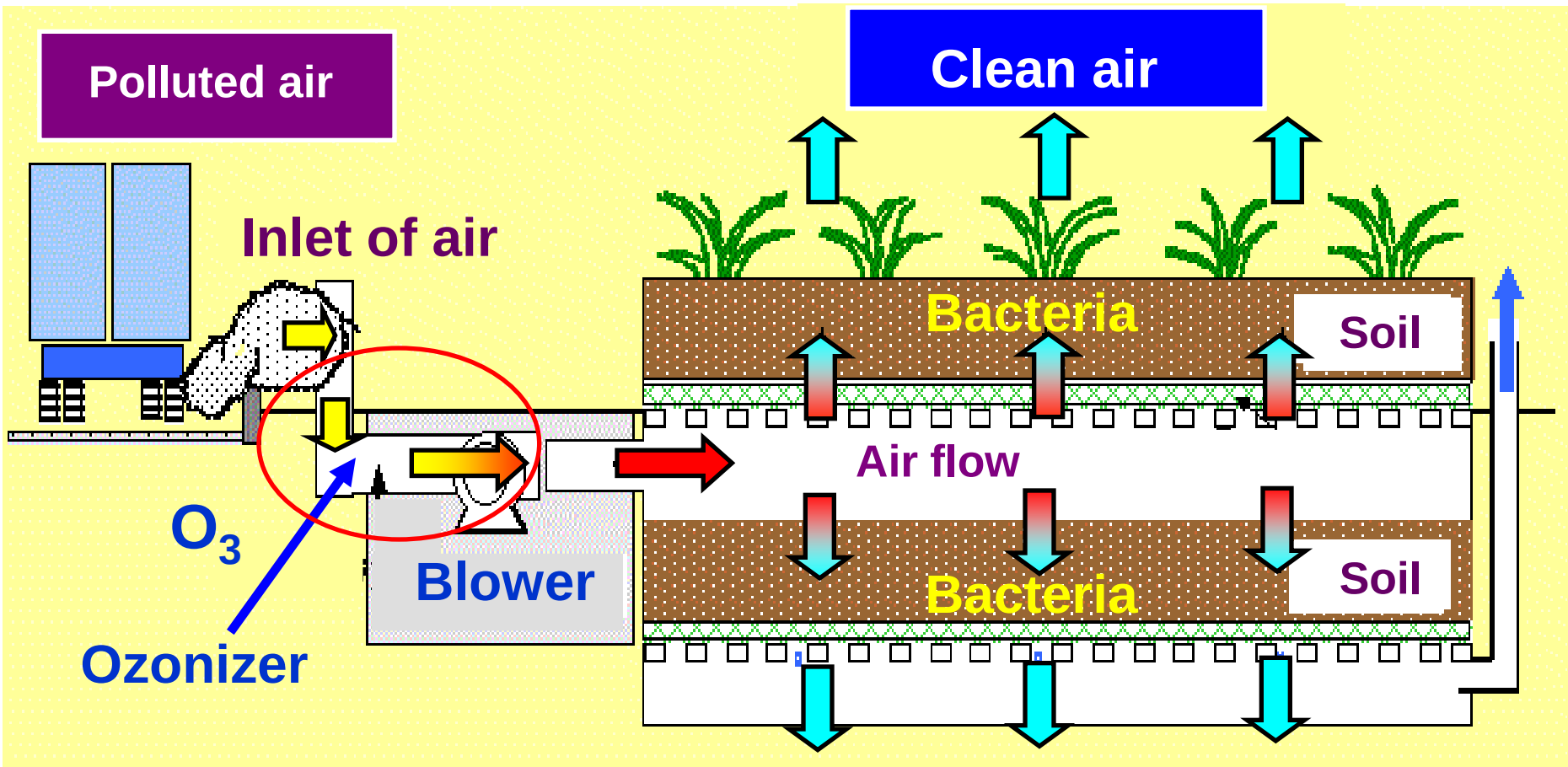
Disadvantage of TiO_2

De-NOx works in day time only.

NOx purification rate is fairly low.

There is rising a worry that NO_2 and unknown toxic chemical substances are generated from the walls by an incomplete oxidation.

De-NOx system using soil



Disadvantage of de-NOx system using soil

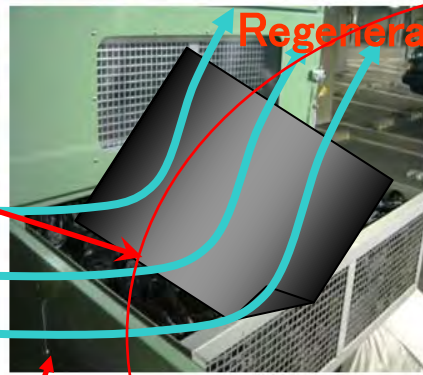
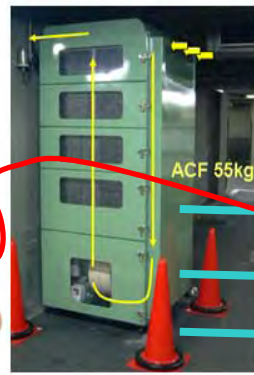
The land price is too expensive.

Air sucking area is so limited.

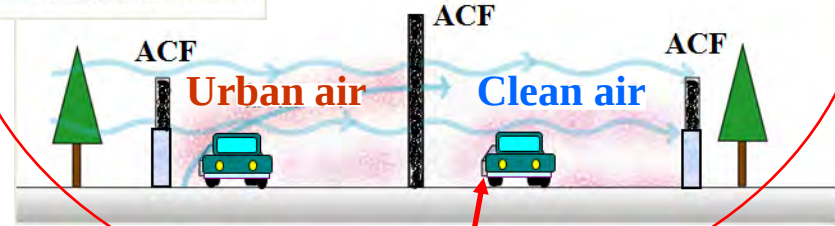
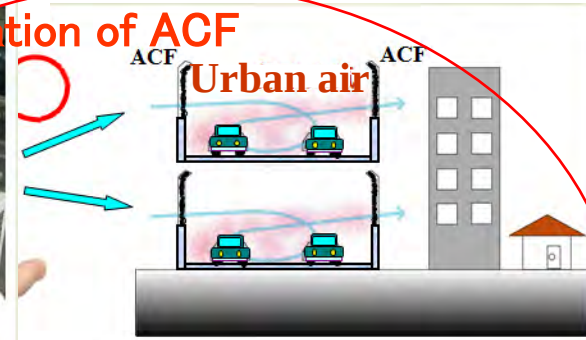
(Air speed passing soil-layer is 3-4 cm / sec.)

Blower for air sucking, and ozonizer require plenty of electric energy.

Water sometimes splays on the soil for keeping alive a bacteria.



Regeneration of ACF



Forced ventilation
Natural ventilation

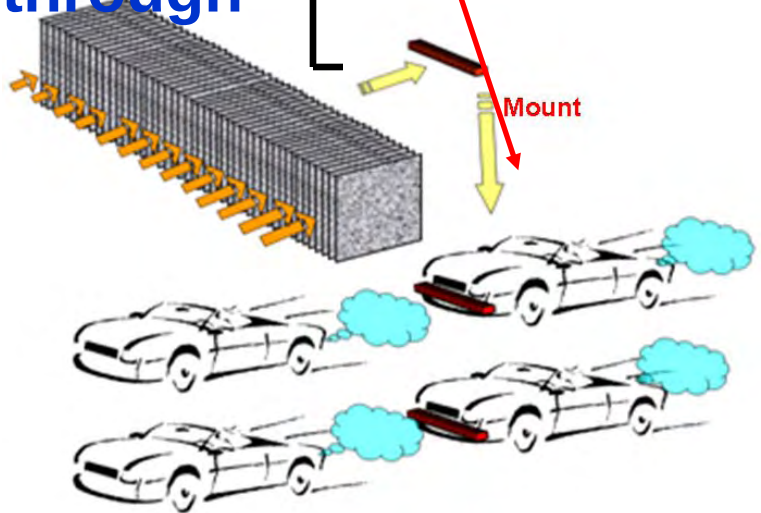
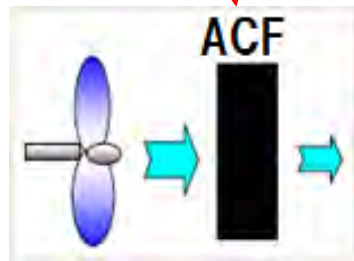
Electric energy is need

Natural air convection

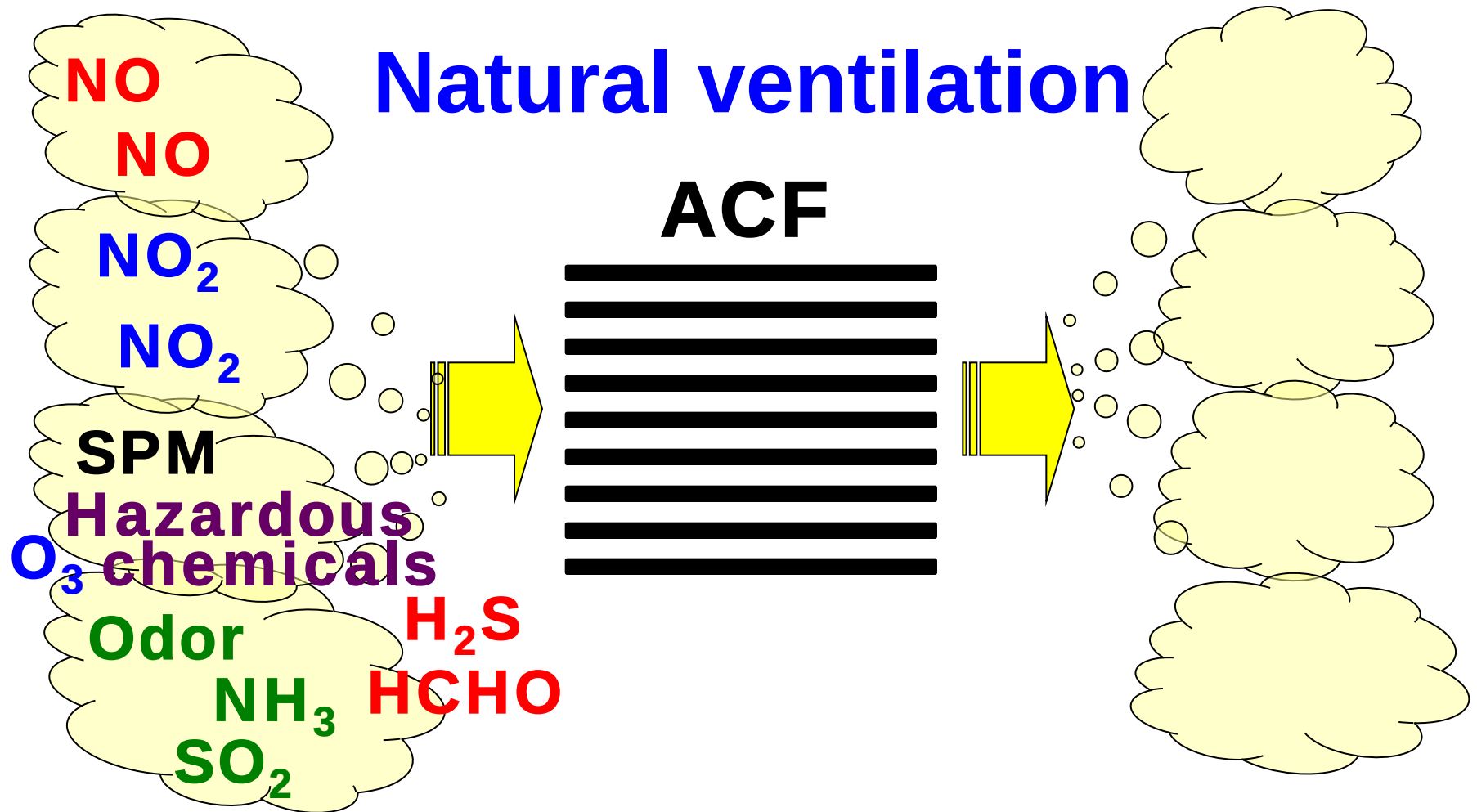
Passing through

Electric energy is no need

Fixed type
Mobile type

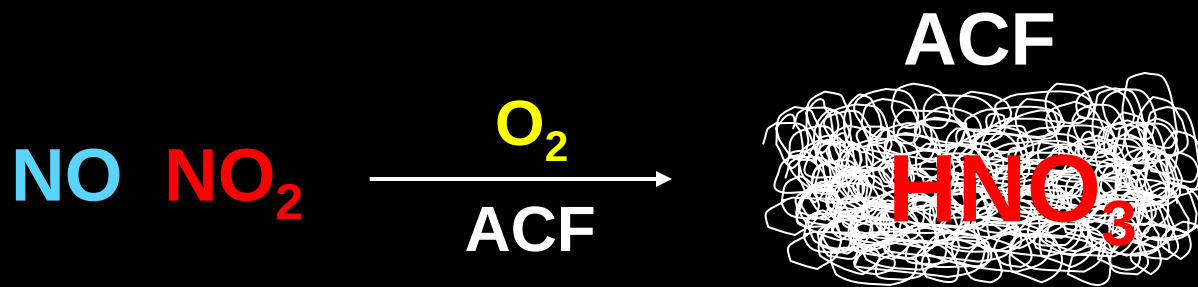


Characterization of ACF purification



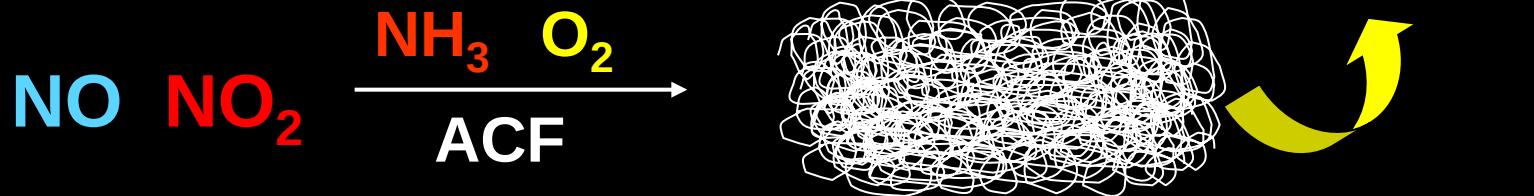
**Room temperature, ozonizer is no need,
no light irradiation, compact design**

I . Oxidation and fixing as HNO_3 in ACF

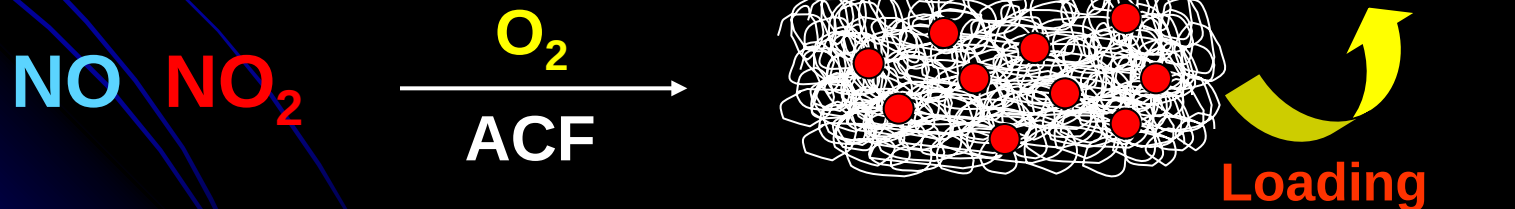


II . Reduction and harmlessness

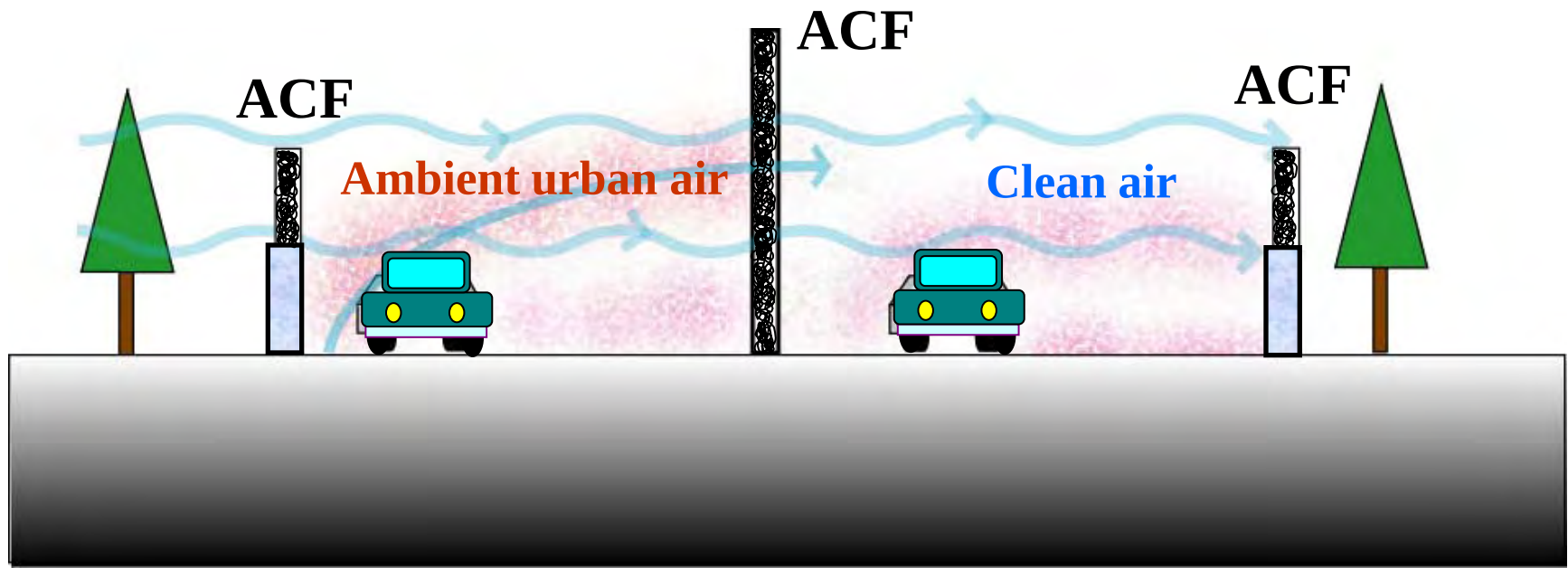
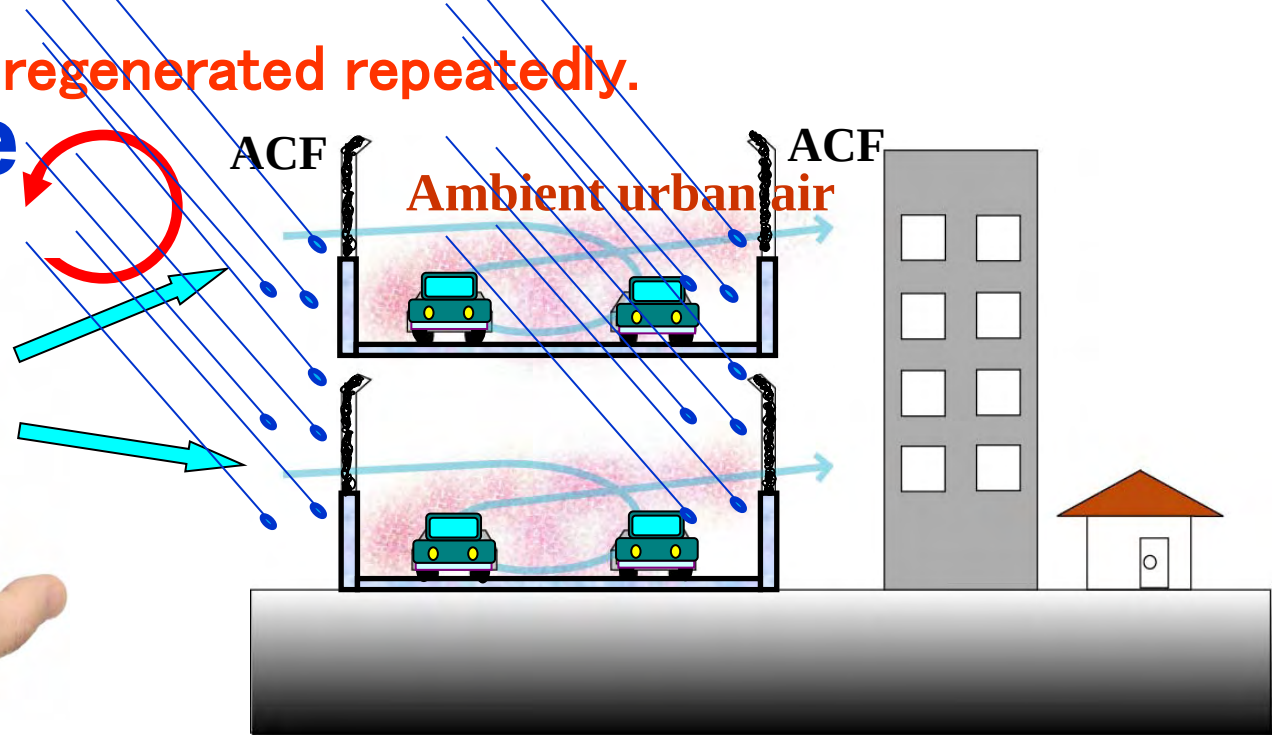
① Ammonia



② Reducing agent loading



ACF could be regenerated repeatedly.
Fixed type



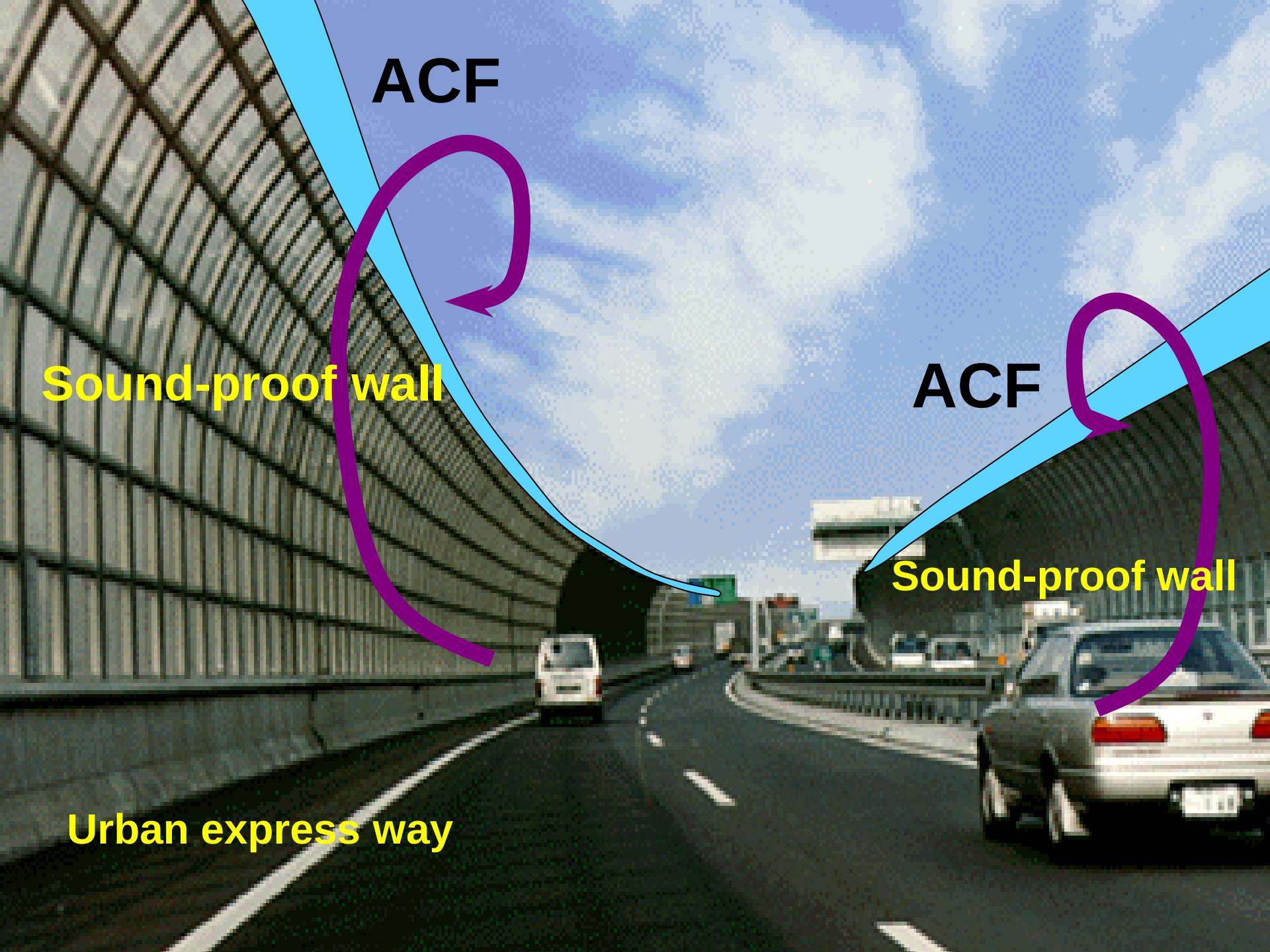
ACF

ACF

ACF







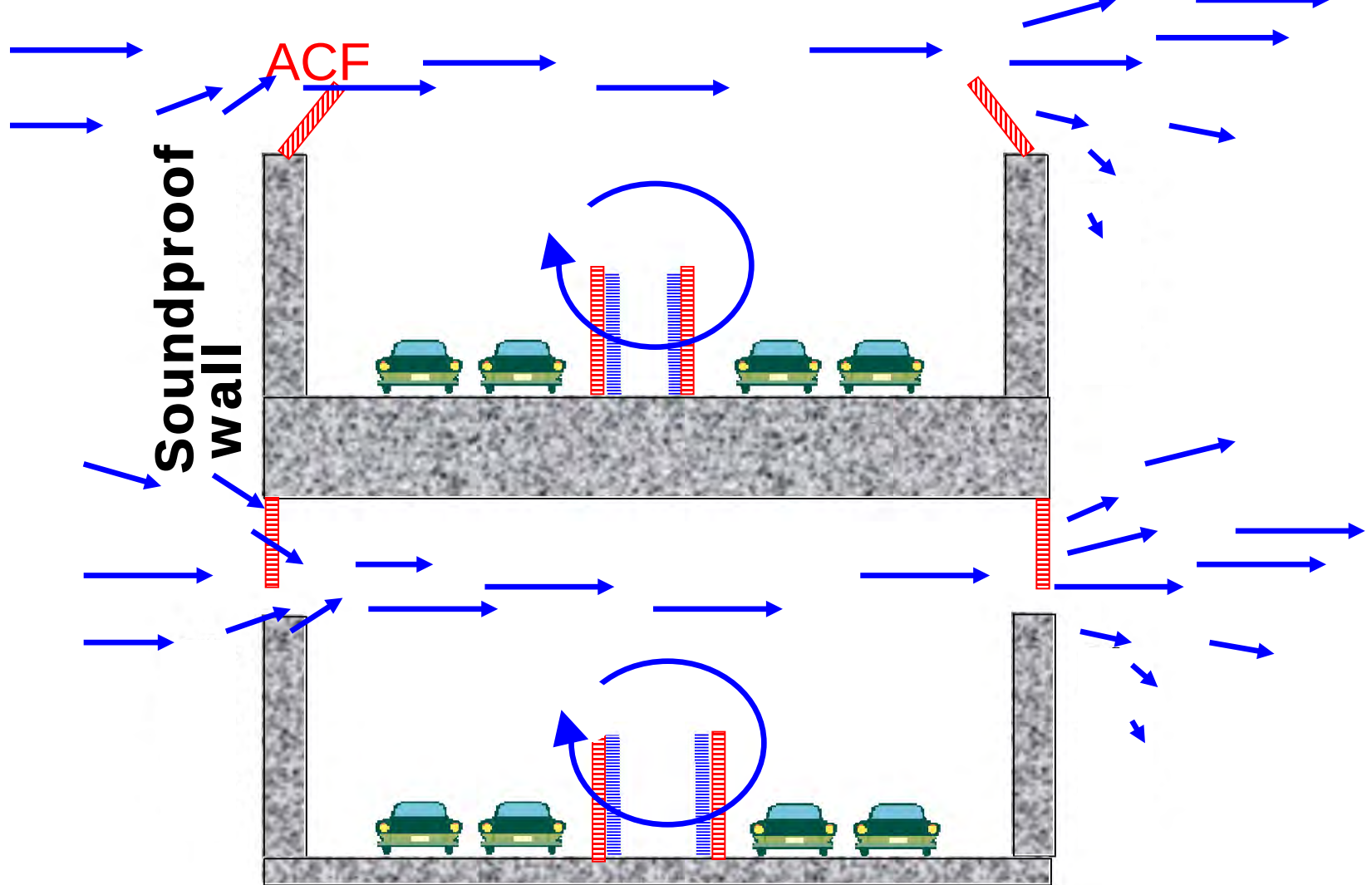
ACF

Sound-proof wall

ACF

Sound-proof wall

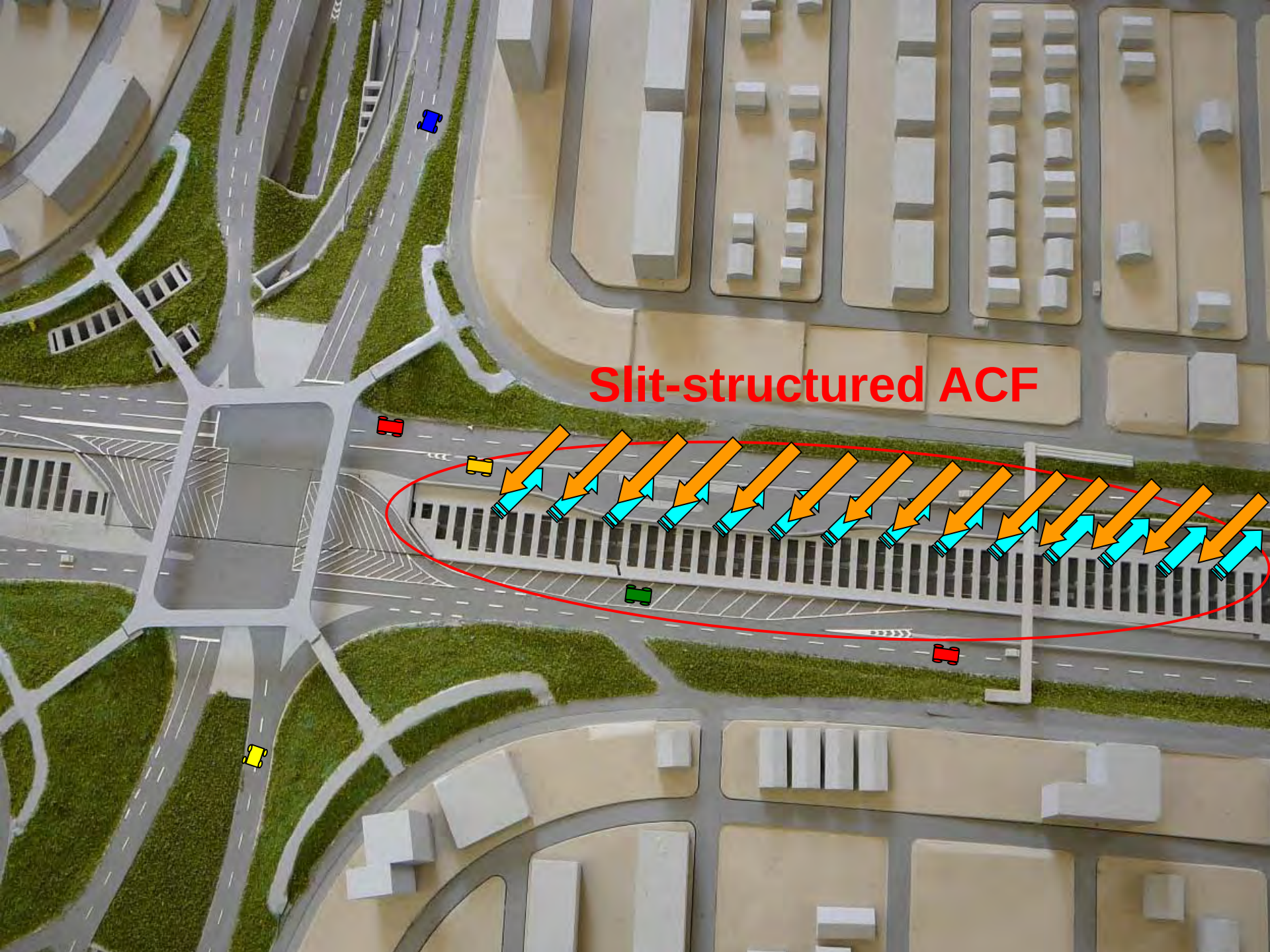
Urban express way



**Overlapping express way (cross section)
Fixed type purification technology**

**Utilizing of natural wind.
(Slits type and/or fiber-form type ACF)**

Slit-structured ACF



Demonstration of NO_x purification ability on a medium strip



ACF fence

Prefabricated lab.

Teflon booth

青森の
よごれた空気をきれいにしよう
よごれた空気
きれいな空気
熱風を利用した大気浄化
ACF
阿鼻保健環境研究所、福岡県環境部、豊橋技術科学大学、九州大学、環境物質化学研究所
が技術開発は独立行政法人 環境再生保全機構の委託研究により行われています

In actual installation

- (1) Compact size**
- (2) Low-cost**
- (3) Maintenance-free**

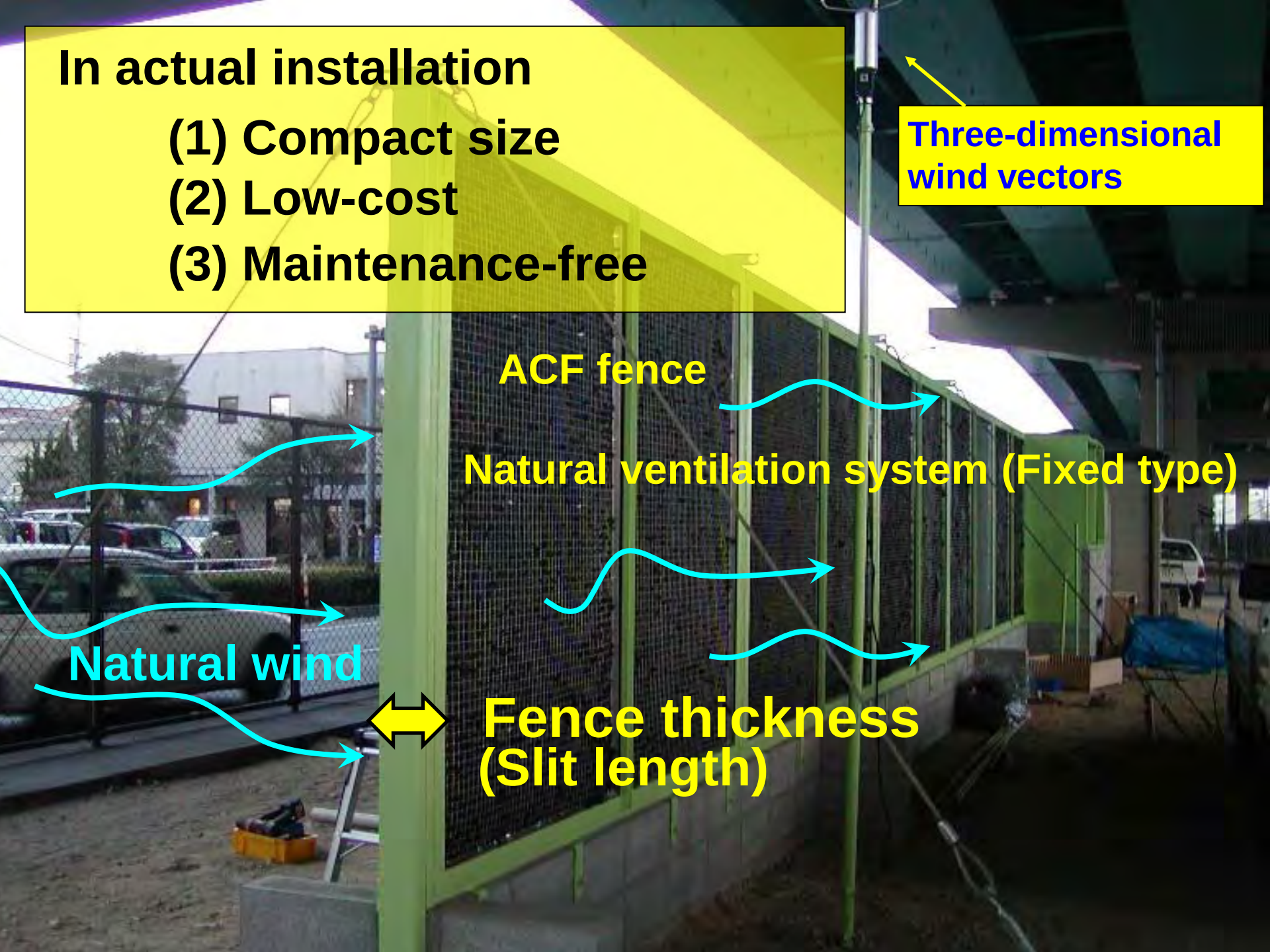
**Three-dimensional
wind vectors**

ACF fence

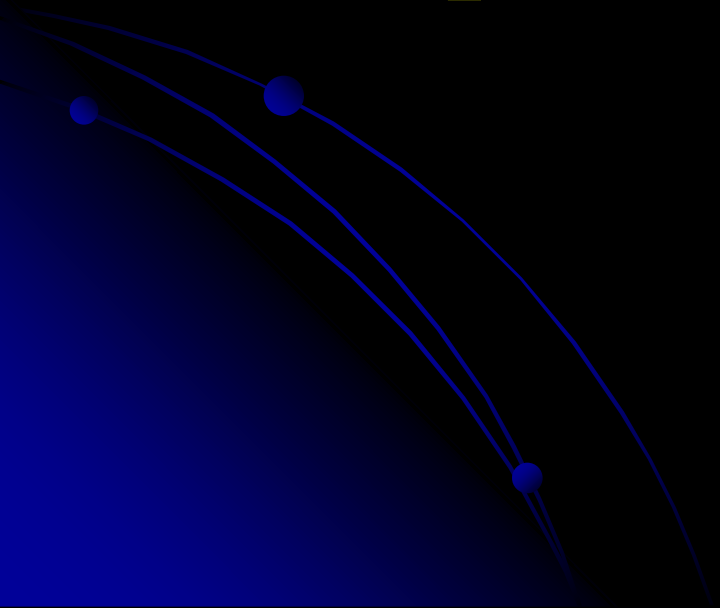
Natural ventilation system (Fixed type)

Natural wind

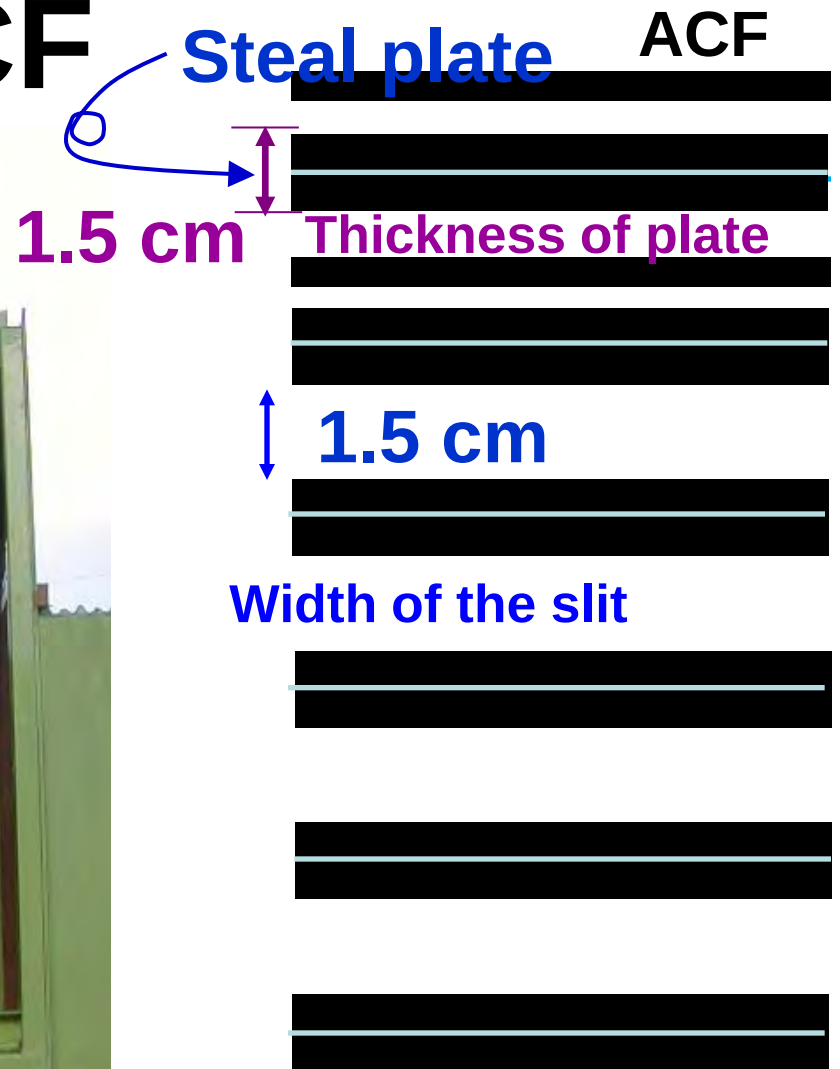
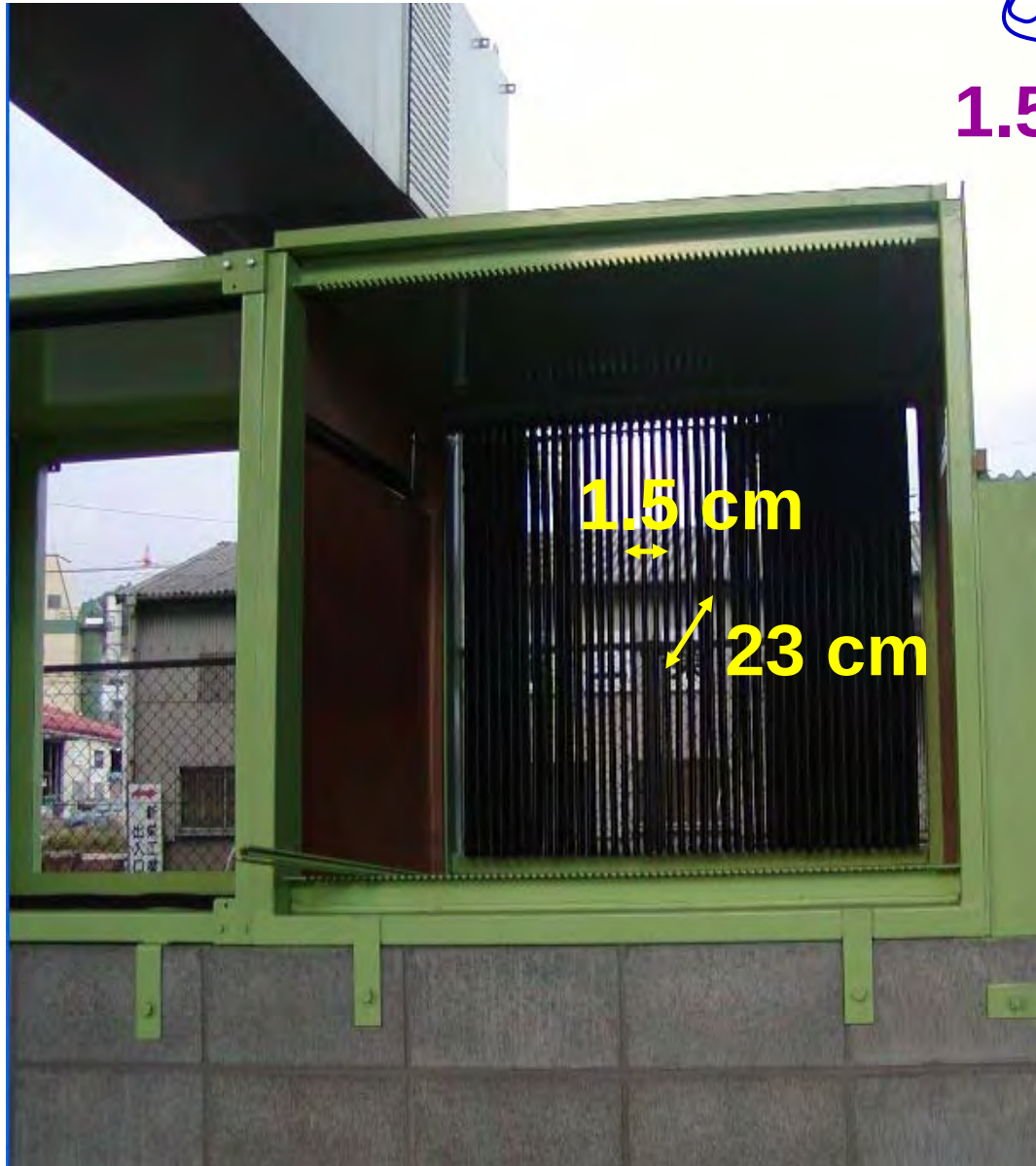
**Fence thickness
(Slit length)**



Outdoor demonstration of slit structured ACF-unit on NO_x purification ability

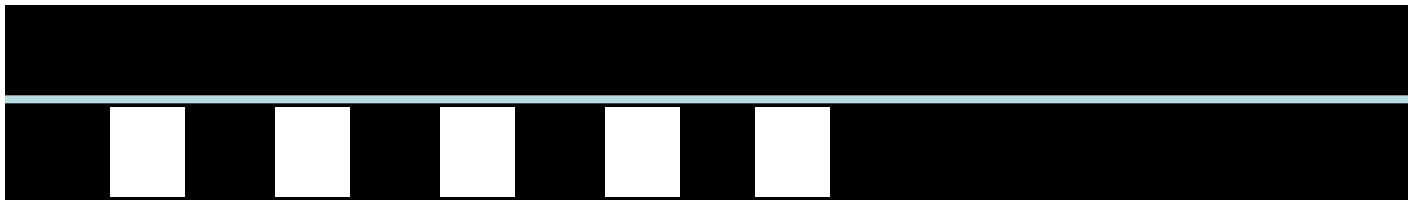


Slits type ACF



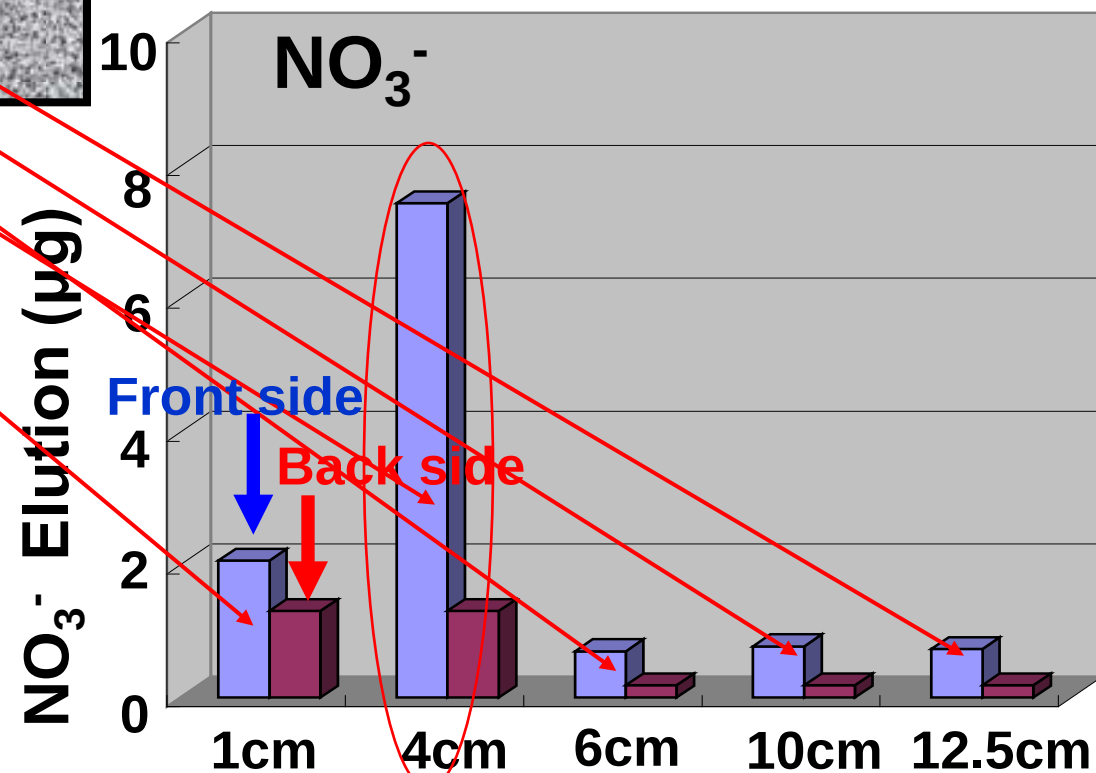
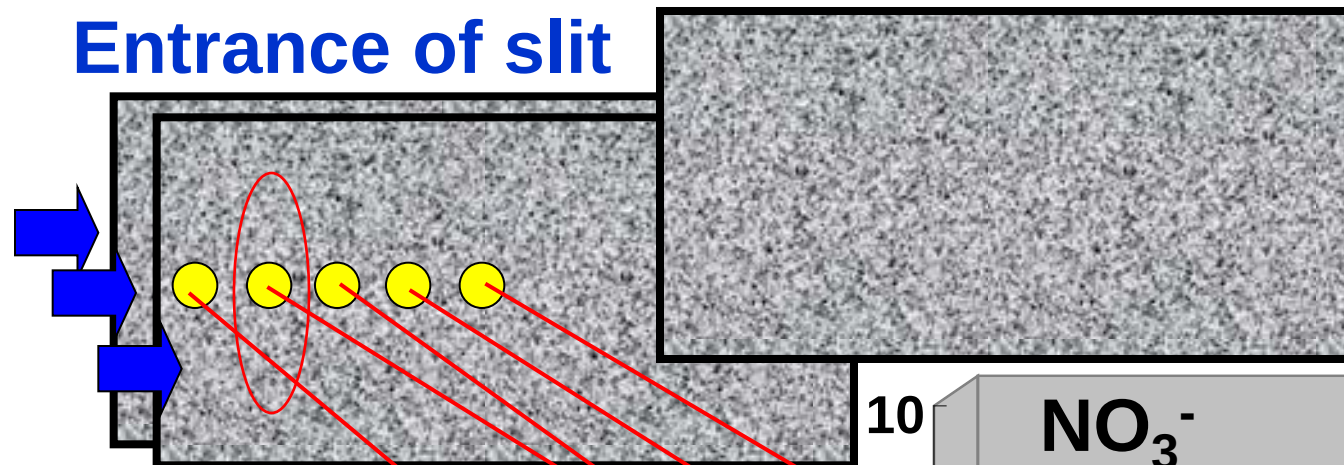
ACF

1.5cm

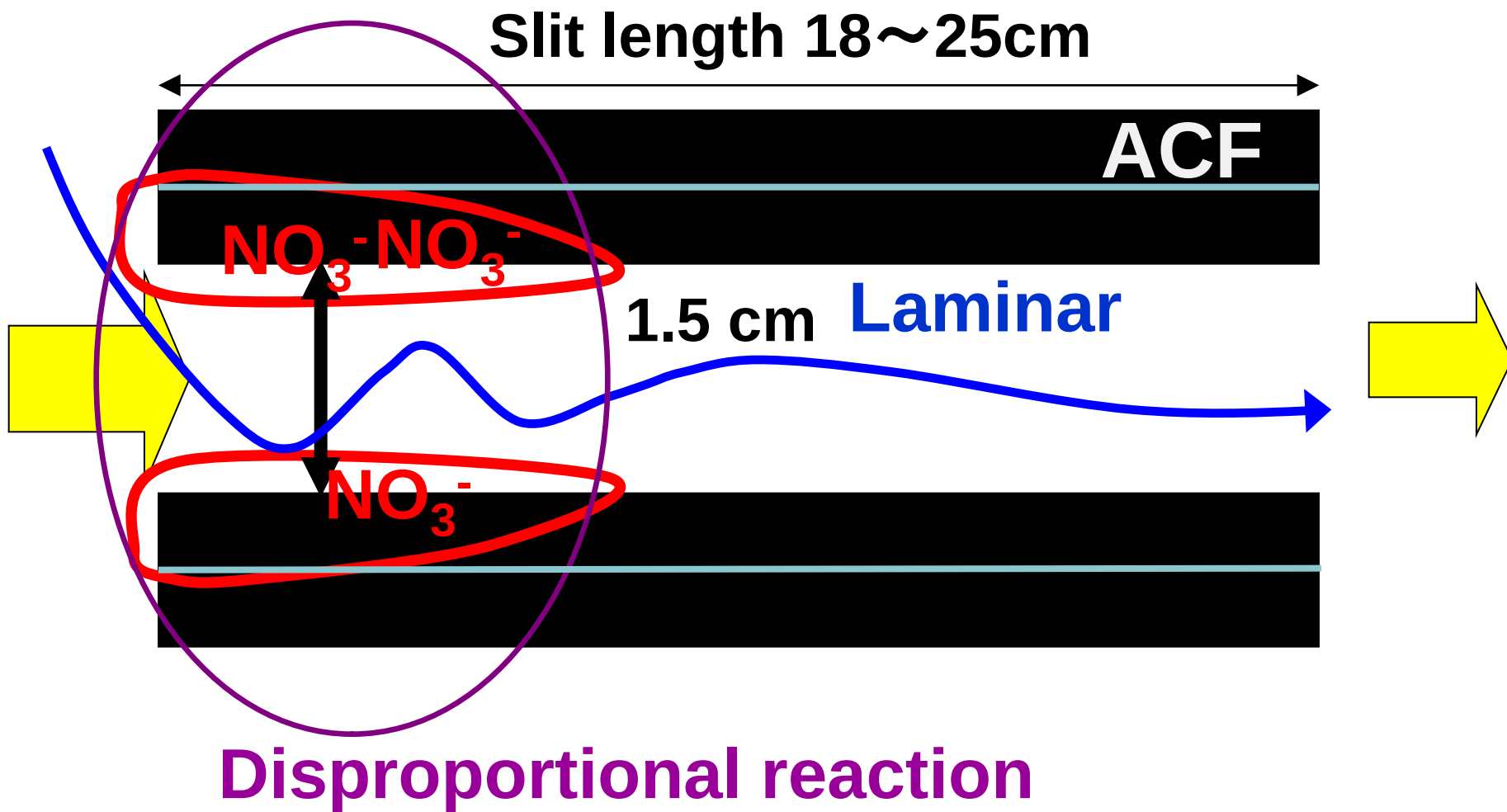


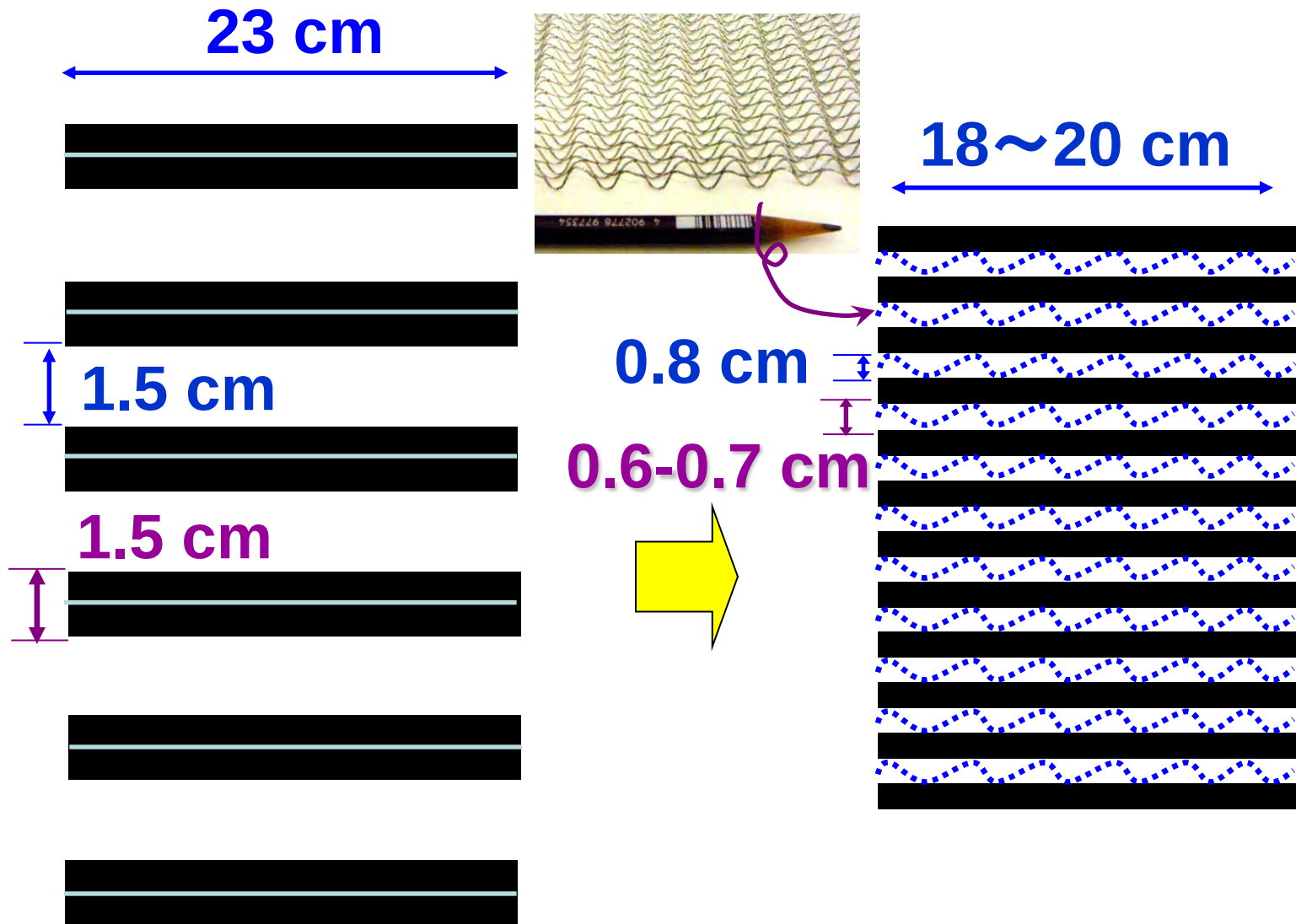
Air flow

Entrance of slit

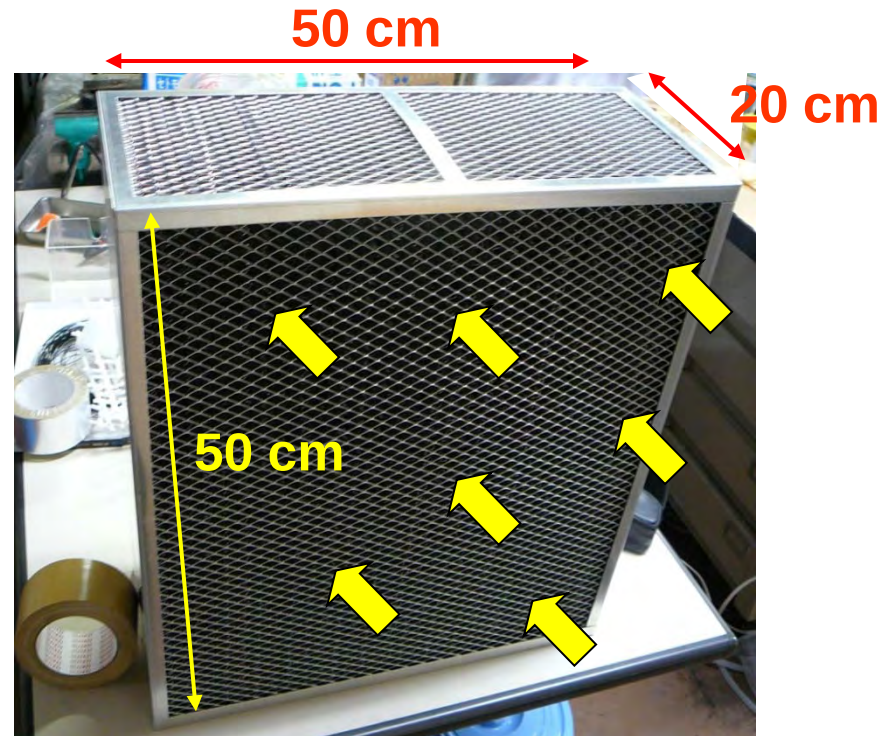
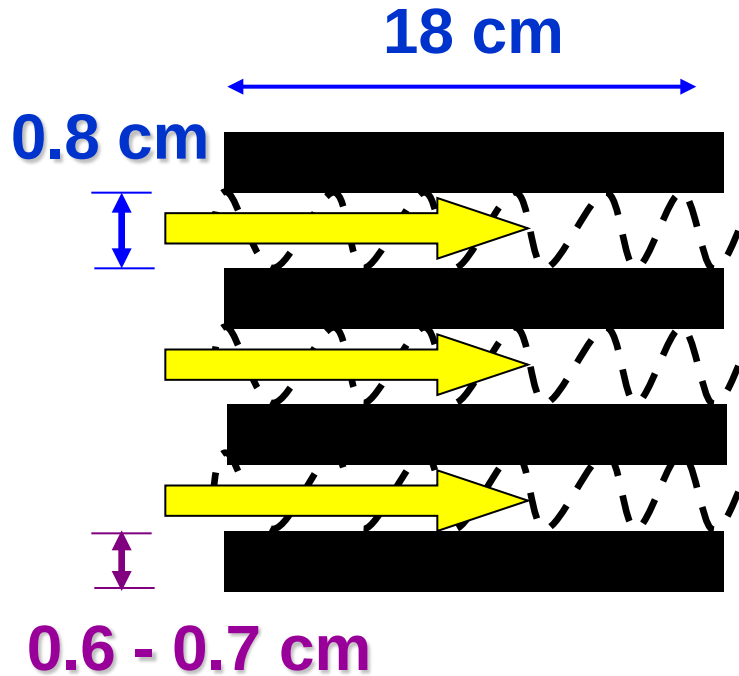


Inlet of slit





Corrugated plate of wire gauze was inserted into the slit



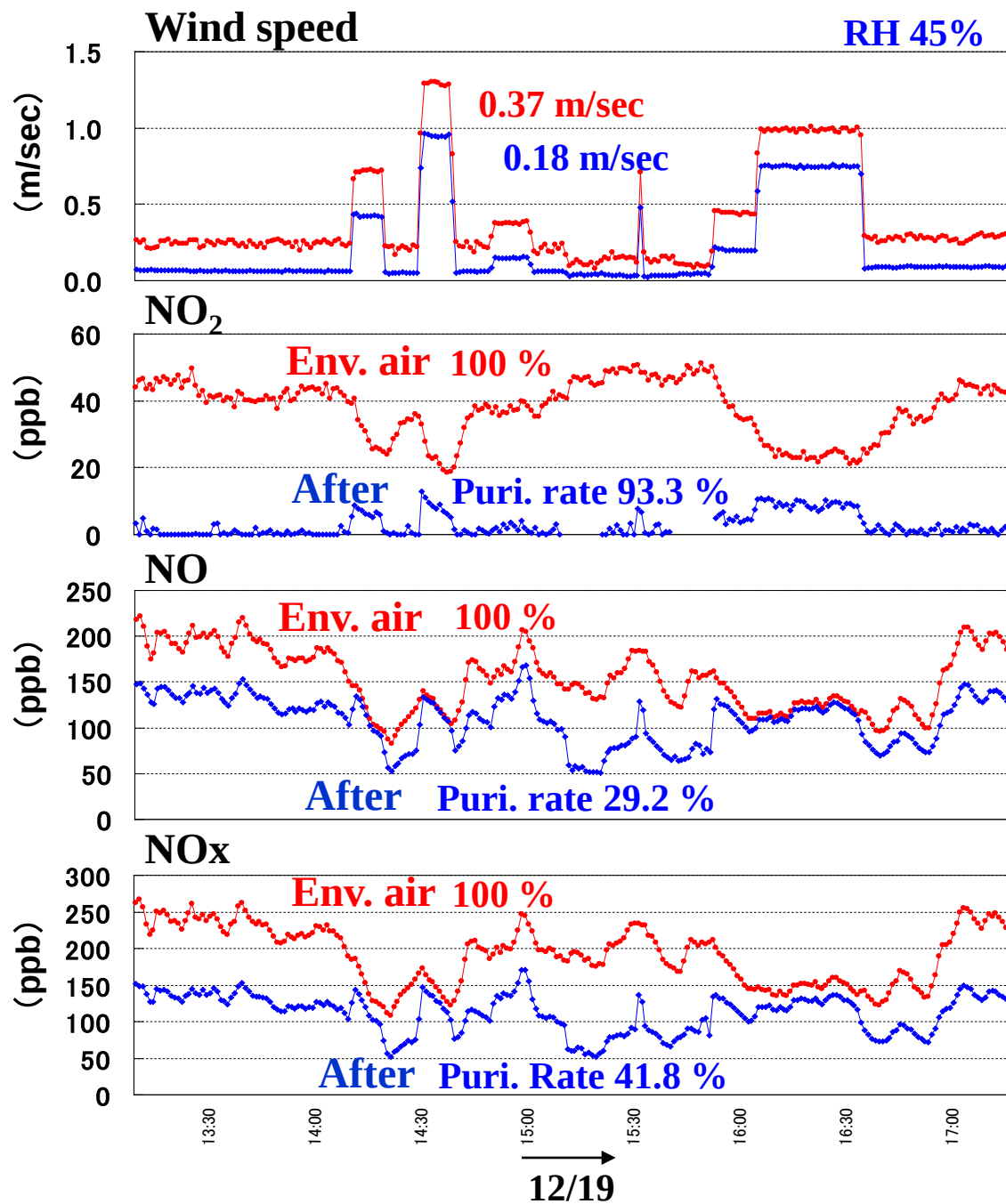
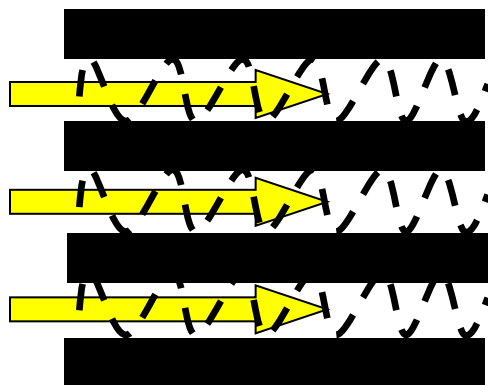
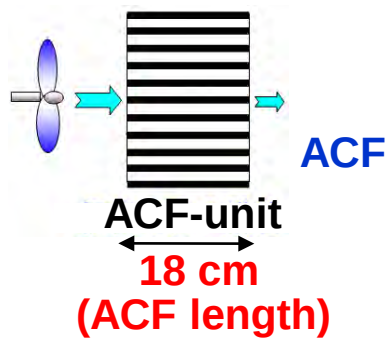
ACF-unit
(Board-type slit-structured ACF)

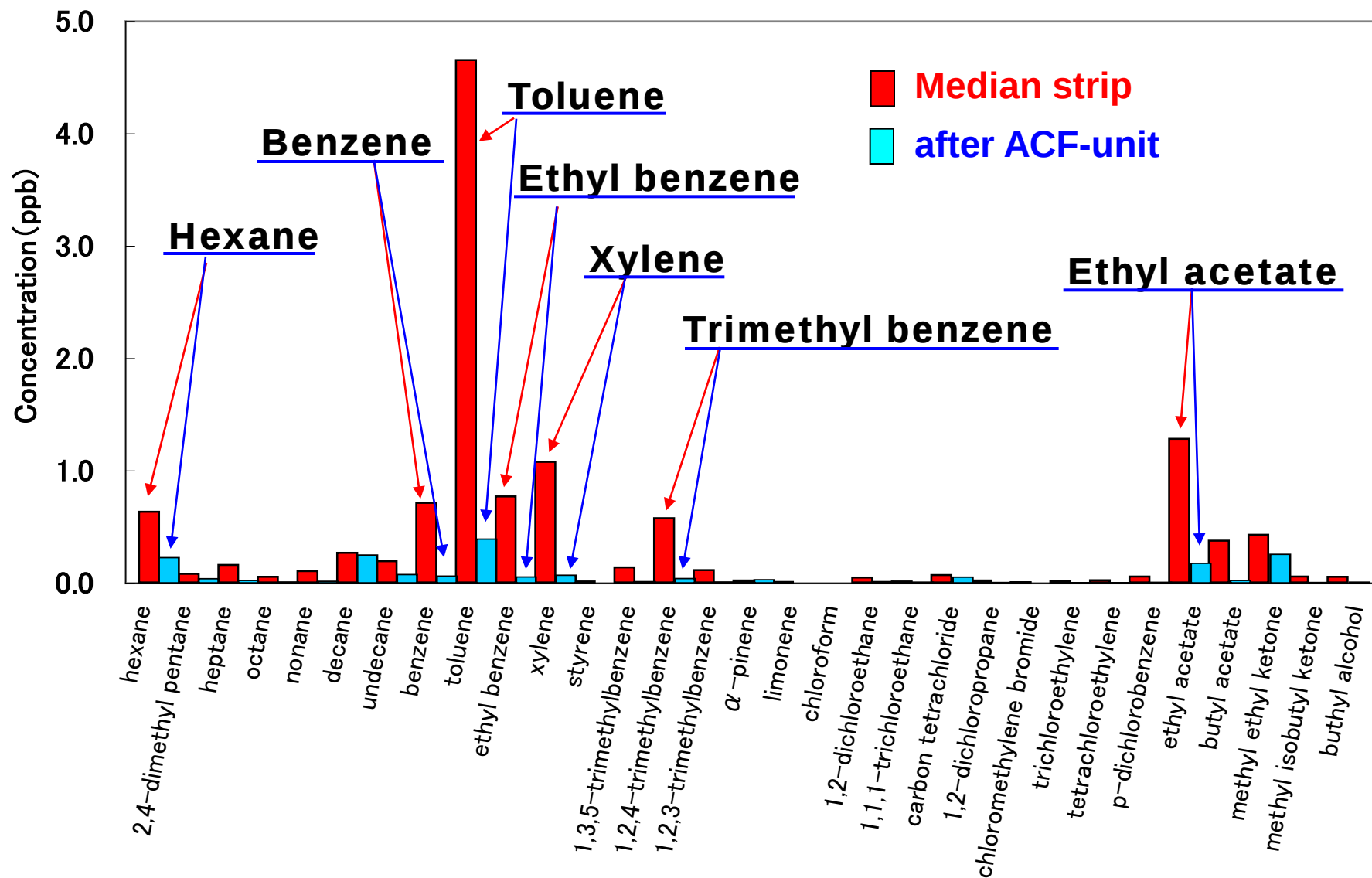
3.0 - 3.5 kg

by Dr . Yoshikawa of Osaka Gas Corporation

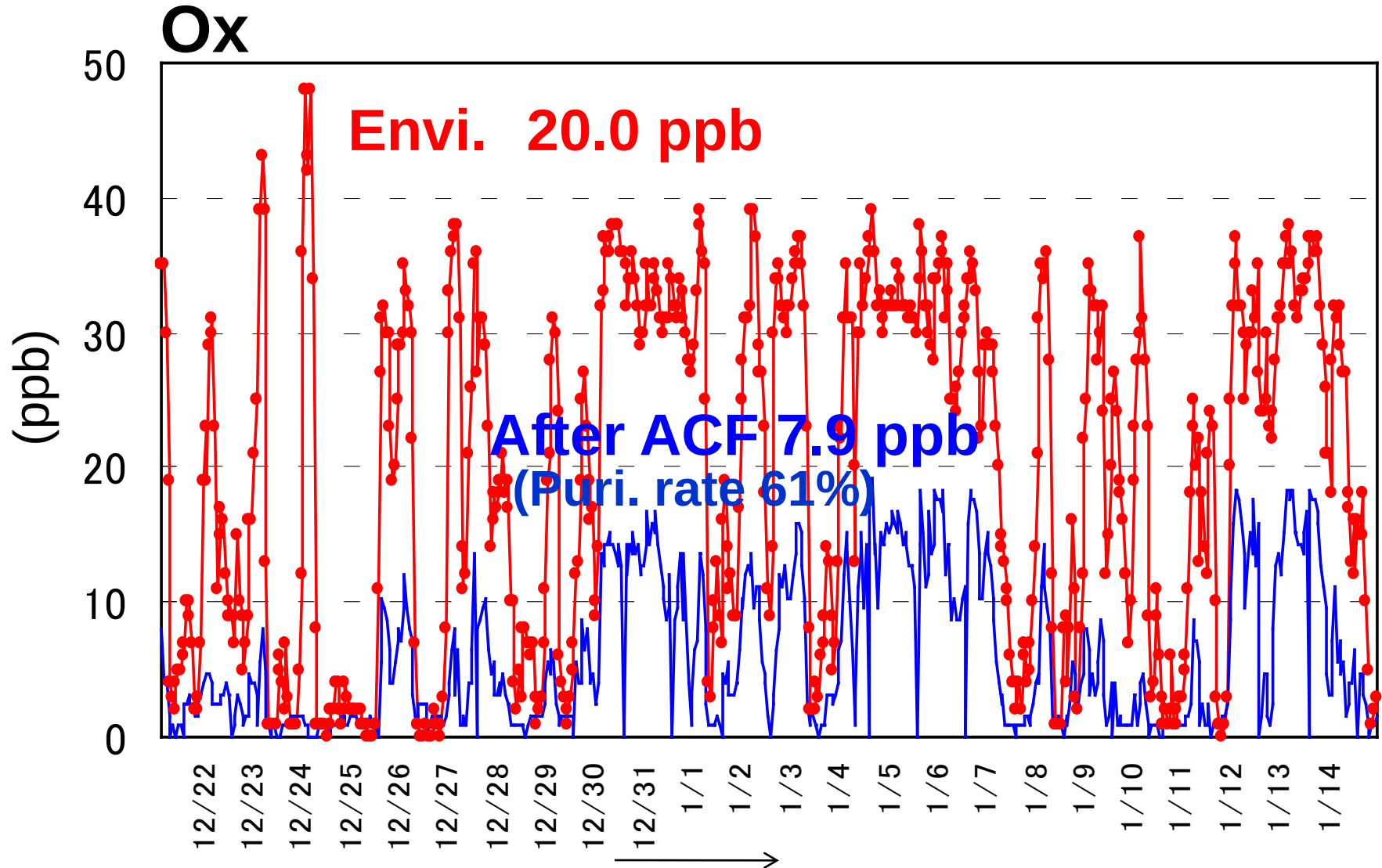
Demonstration of NOx purification ability using natural Wind.



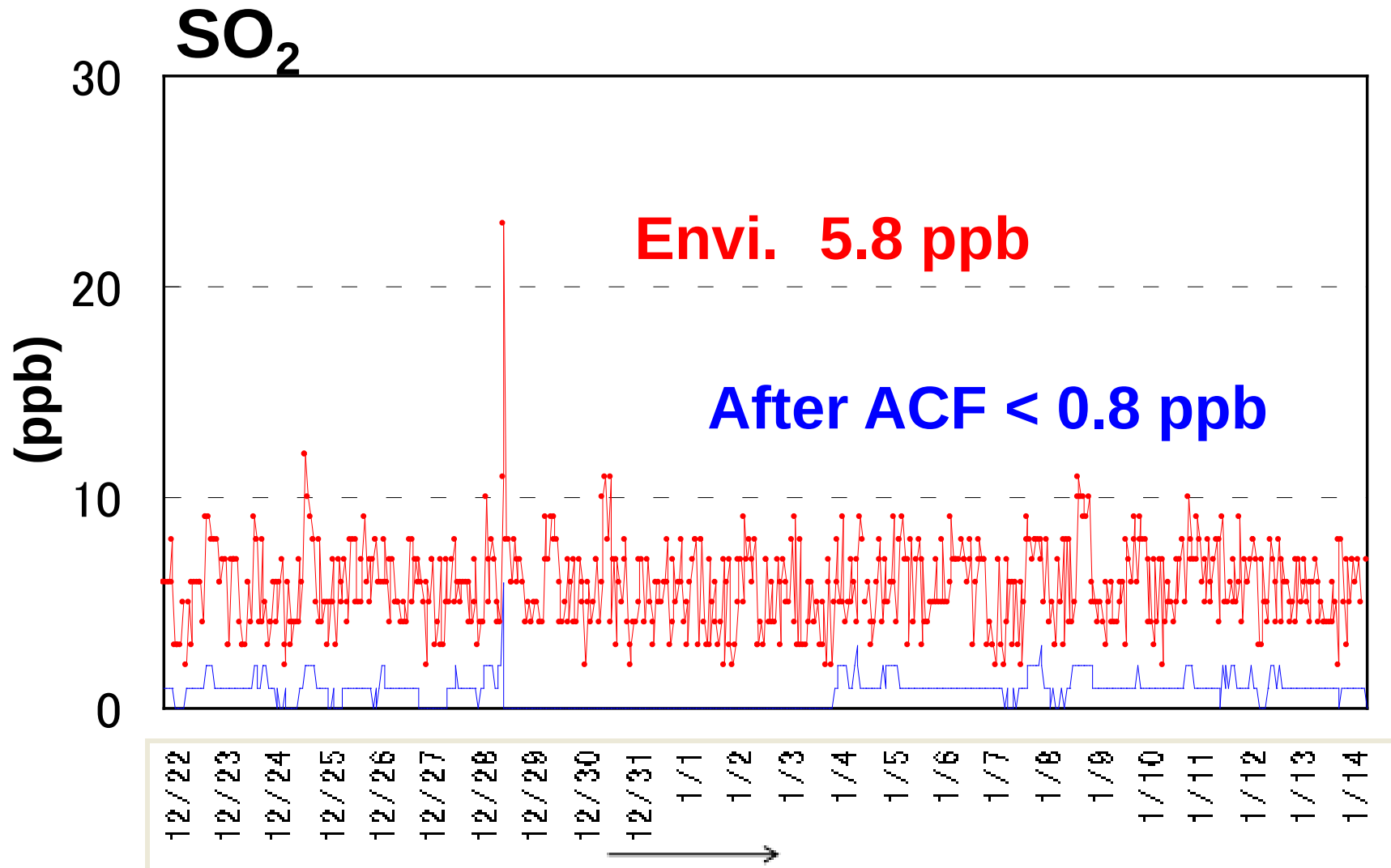




The oxidants scavenging efficiency of ACF-unit with natural wind



The SO₂ scavenging efficiency of ACF-unit with natural wind





稚内

旭川

札幌

釧路

函館

青森

秋田

盛岡

仙台

新潟

福島

宇都宮

東京

横浜

長野

名古屋

三河

京都

大阪

神戸

松山

高松

岡山

北九州

福岡

熊本

鹿児島

伊豆諸島

Nishi-Yodogawa of Osaka prefecture in Japan

ACF fence (21 m)

2.1 m

(16m)

Fence thickness (20cm)

Nishi-Yodogawa of Osaka prefecture in Japan

ACF fence (21 m)

(16m)

2.1 m

Fence thickness (20cm)

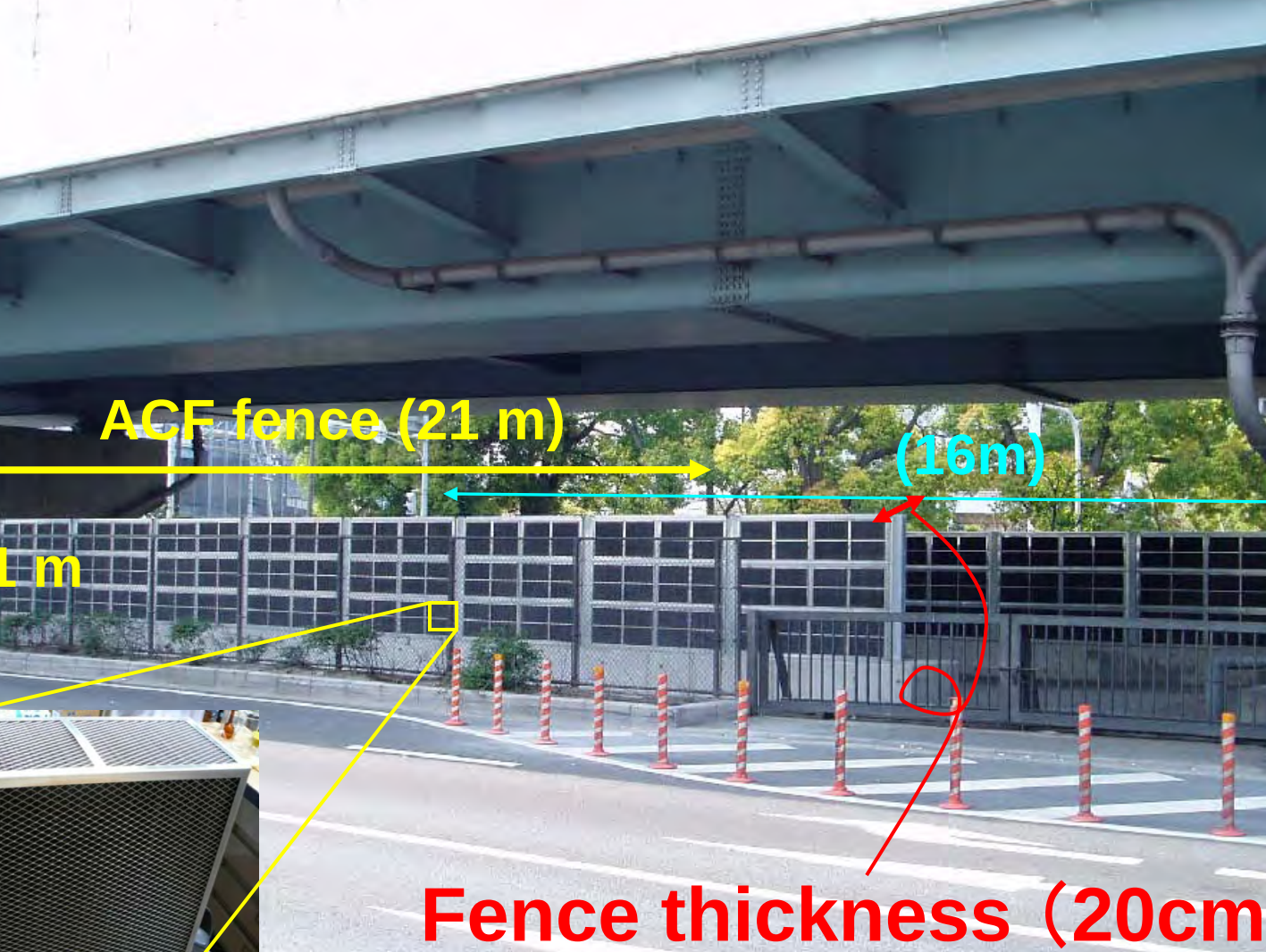
Nishi-Yodogawa of Osaka prefecture in Japan

ACF fence (21 m)

(16m)

2.1 m

Fence thickness (20cm)



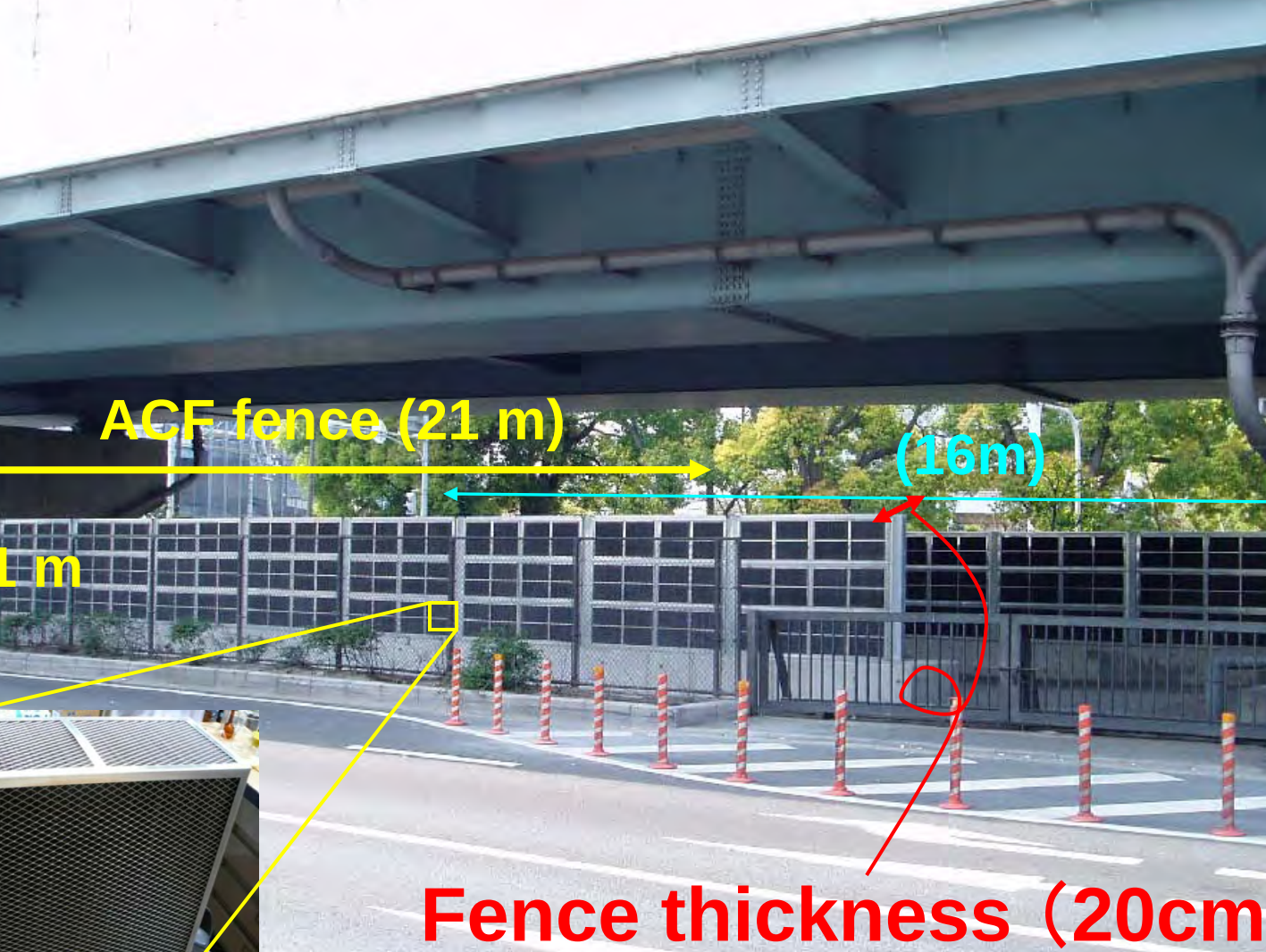
Nishi-Yodogawa of Osaka prefecture in Japan

ACF fence (21 m)

2.1 m

(16m)

Fence thickness (20cm)



Nishi-Yodogawa of Osaka prefecture in Japan

ACF fence (21 m)

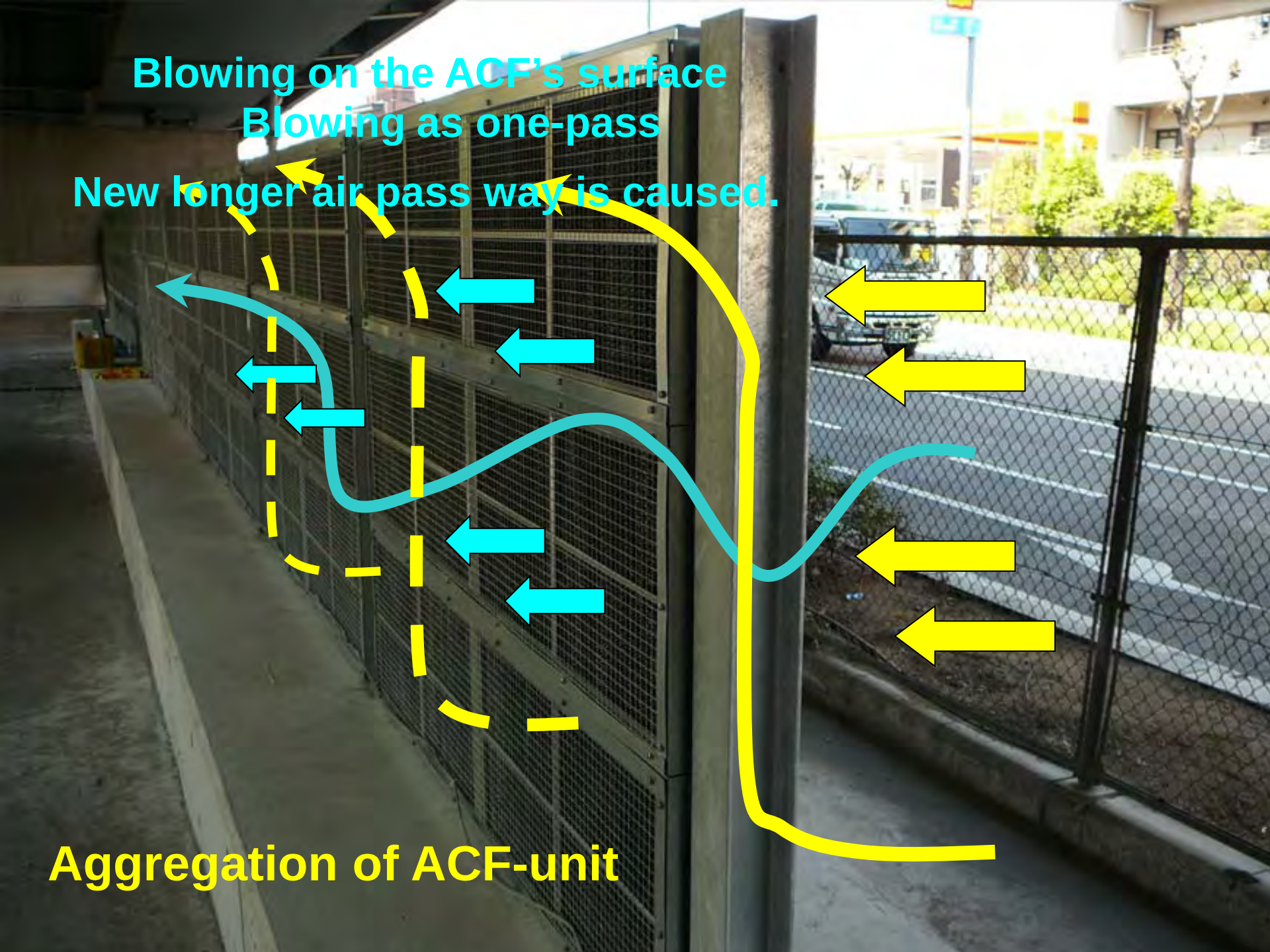
2.1 m

(16m)

Fence thickness (20cm)

Blowing on the ACF's surface
Blowing as one-pass
New longer air pass way is caused.

Aggregation of ACF-unit



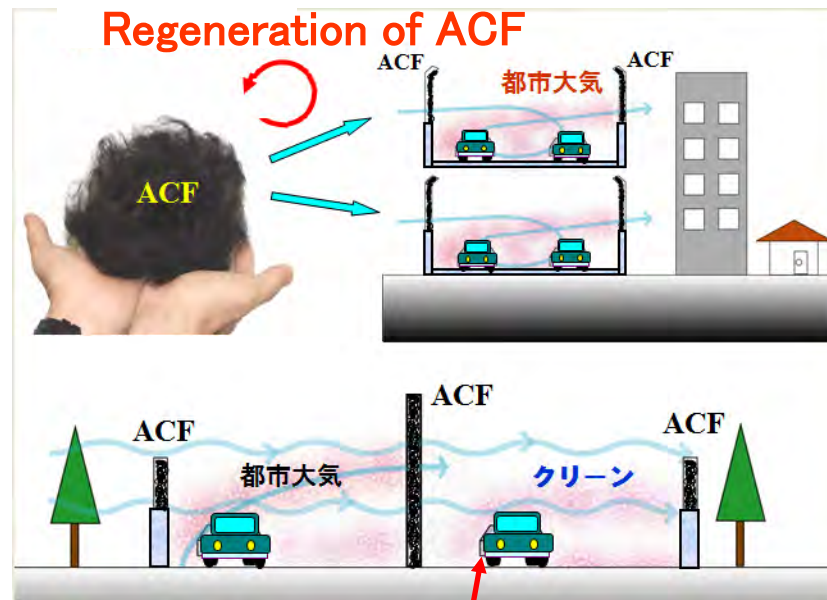
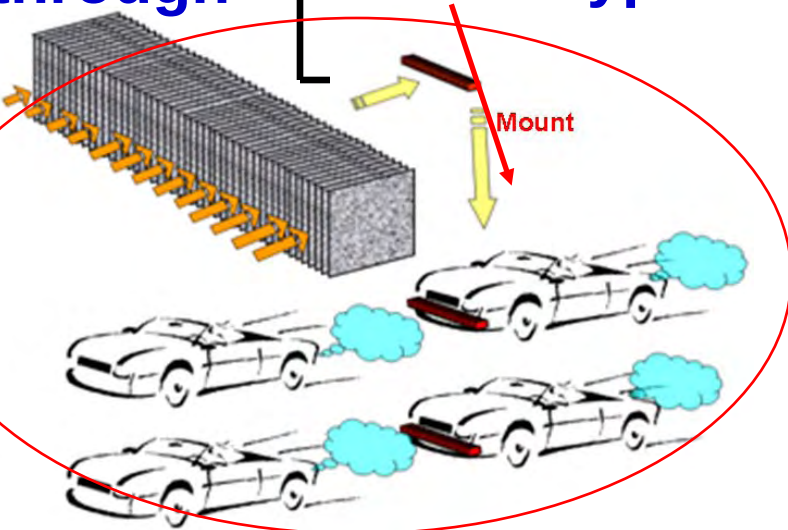
Forced ventilation
Natural ventilation

Natural air convection

Passing through

Fixed type

Mobile type



Mobile type

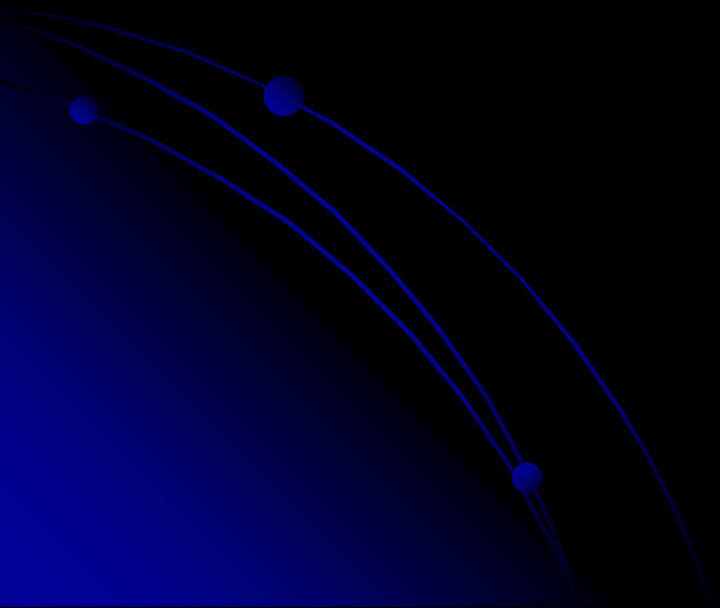
No electric energy

ACF

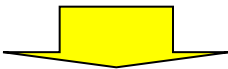
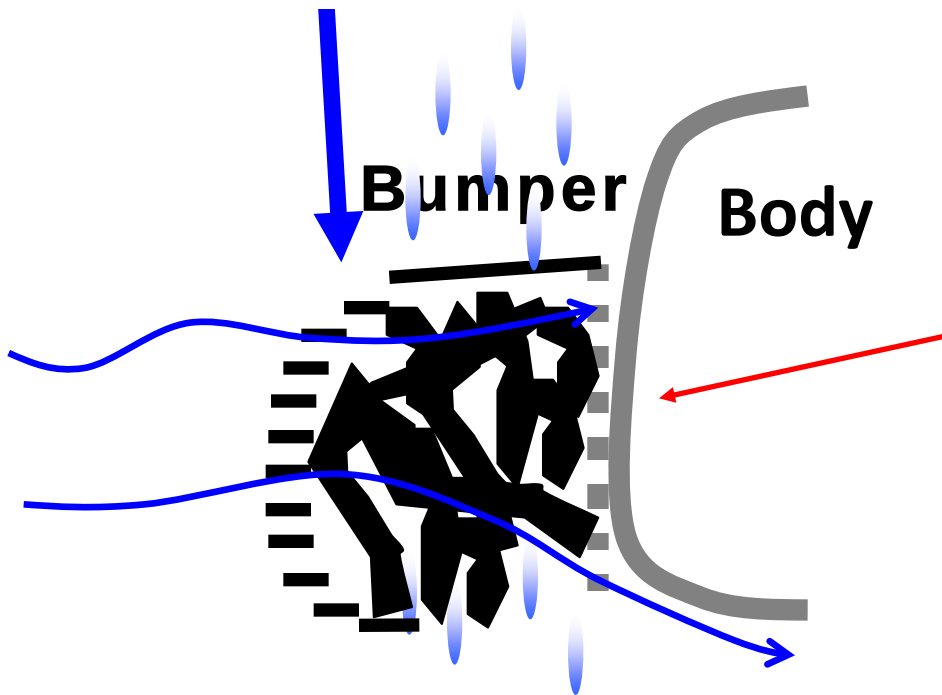
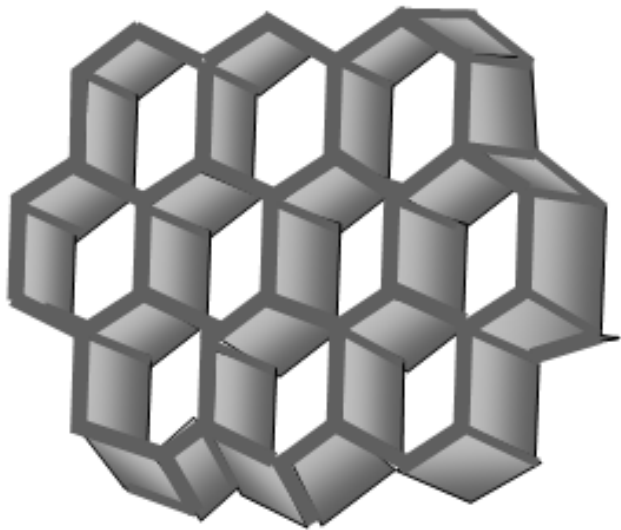
using vehicle running wind



Demonstration of NO_x purification



Making holes to create an emblem



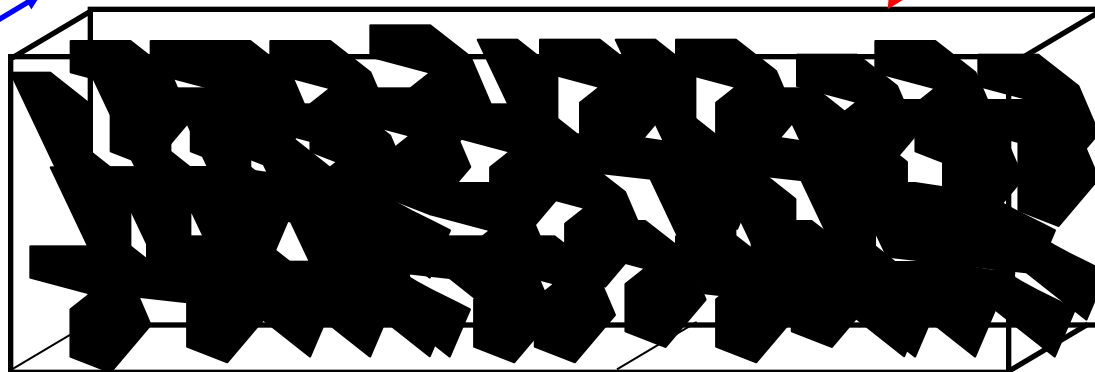
NOx purification by use of ACF unit packed into the bumper of vehicle

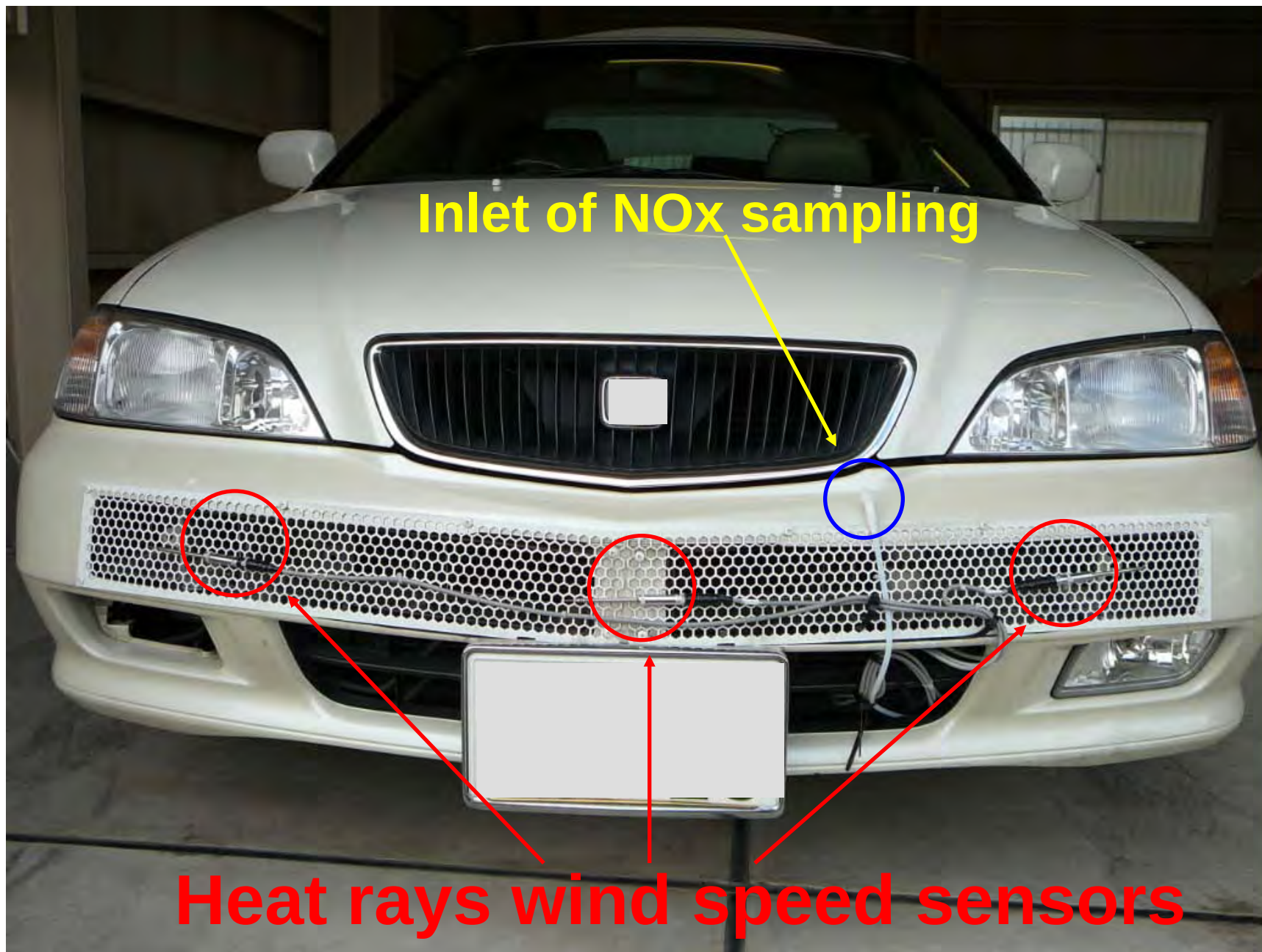


ACF density
 0.048 g/m^3

9 cm

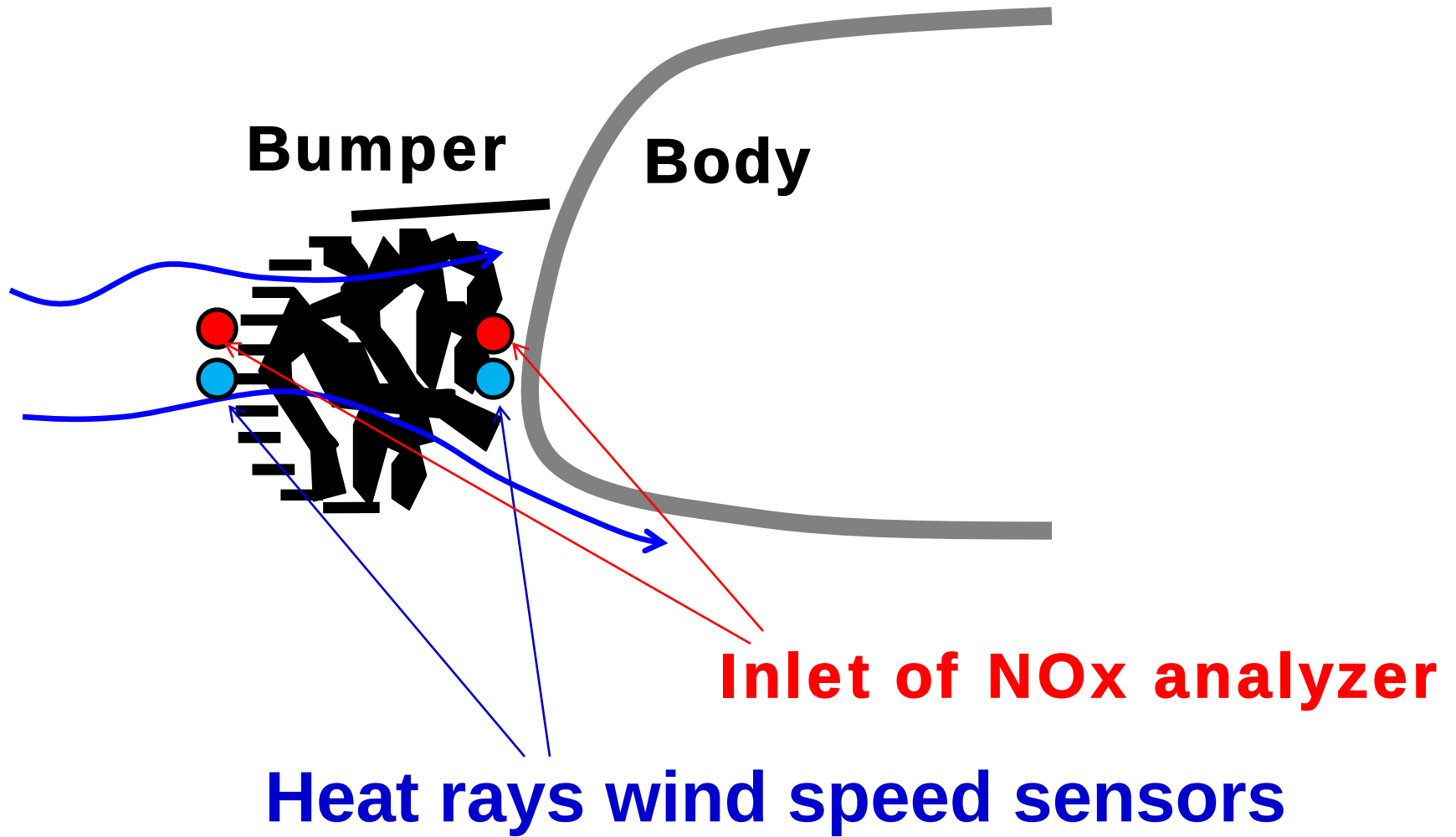
8 cm



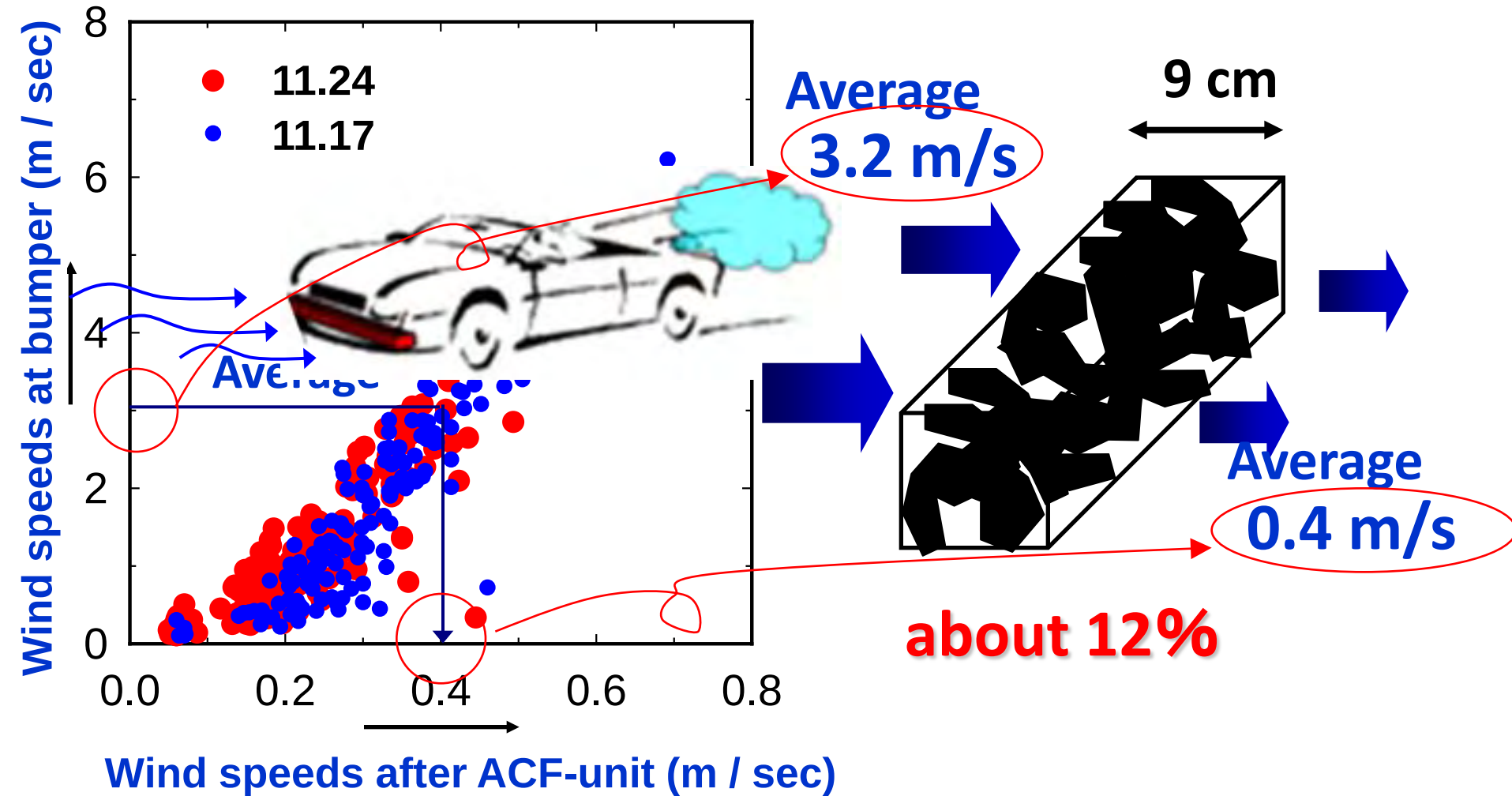


Inlet of NOx sampling

Heat rays wind speed sensors

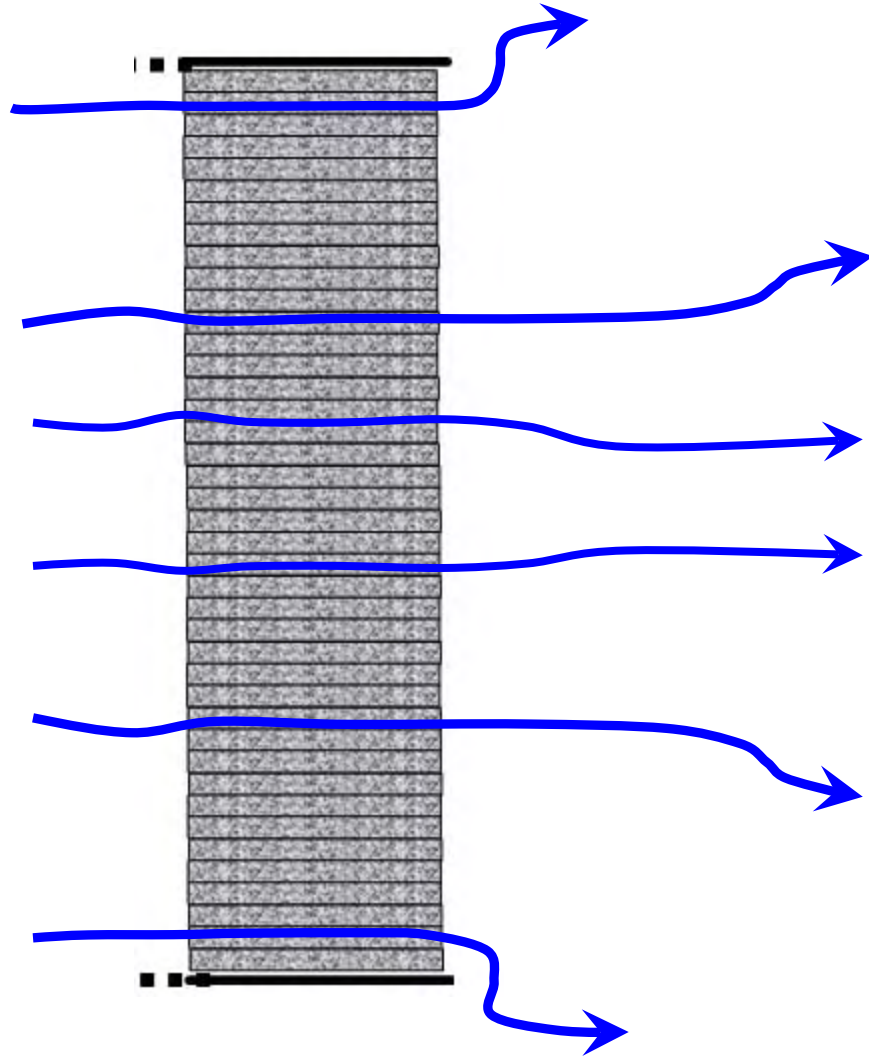


Wind volume passing through ACF at bumper



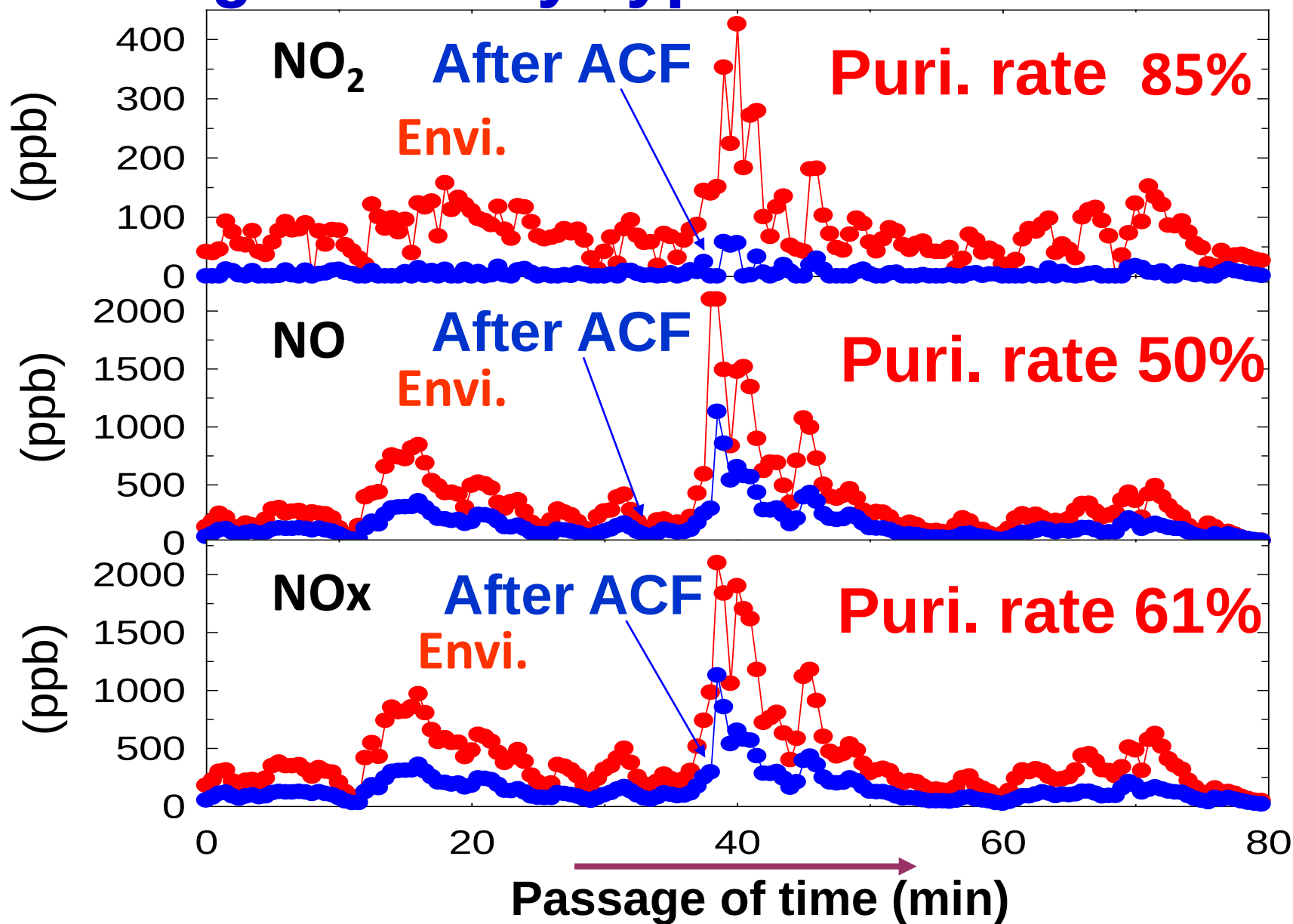
On high-speed running vehicle

High-density ACF type works well with high winds

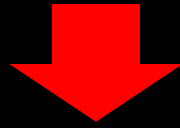


On high-speed running vehicle

High density type



Simple question



When vehicle running speed is fairly low at idling operation or in traffic snarl, the NO_x concentrations increase.

Is the ACF-unit ineffective on de-NO_x?

Light winds hardly pass through the high density of ACF.

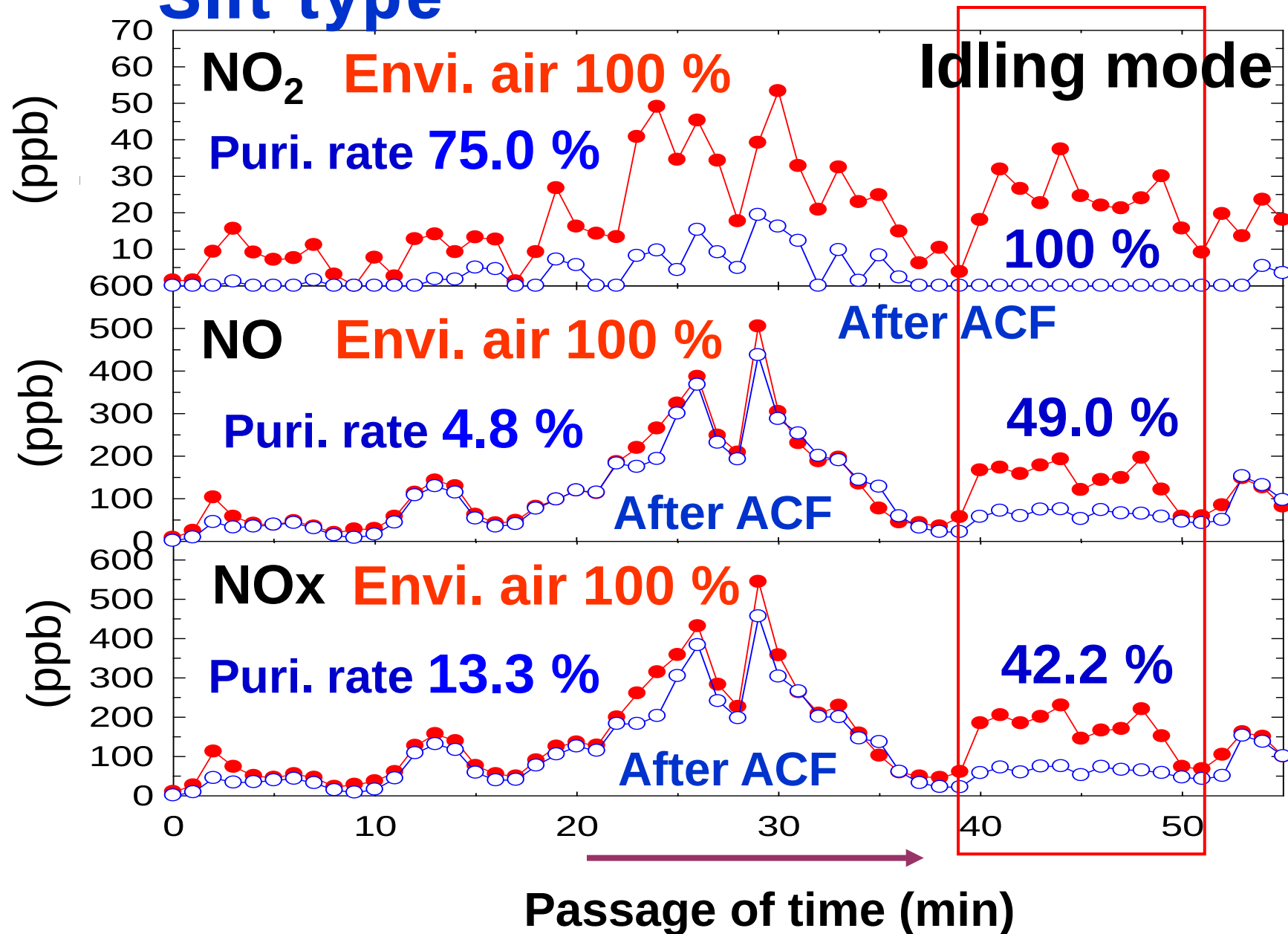
On low-speed running vehicle

Slit type works well with slow winds



On low-speed running vehicle

Slit type

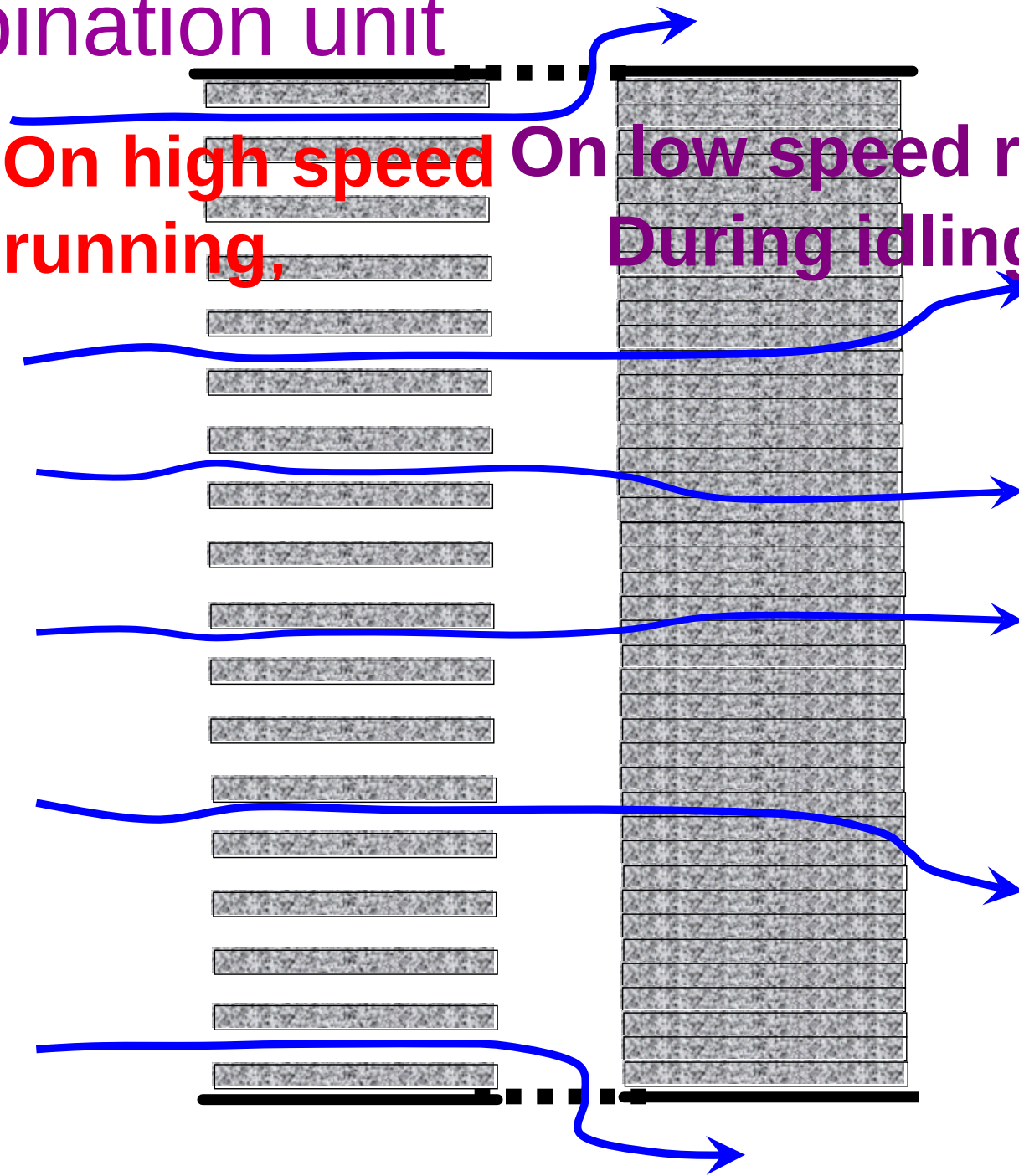




Combination unit

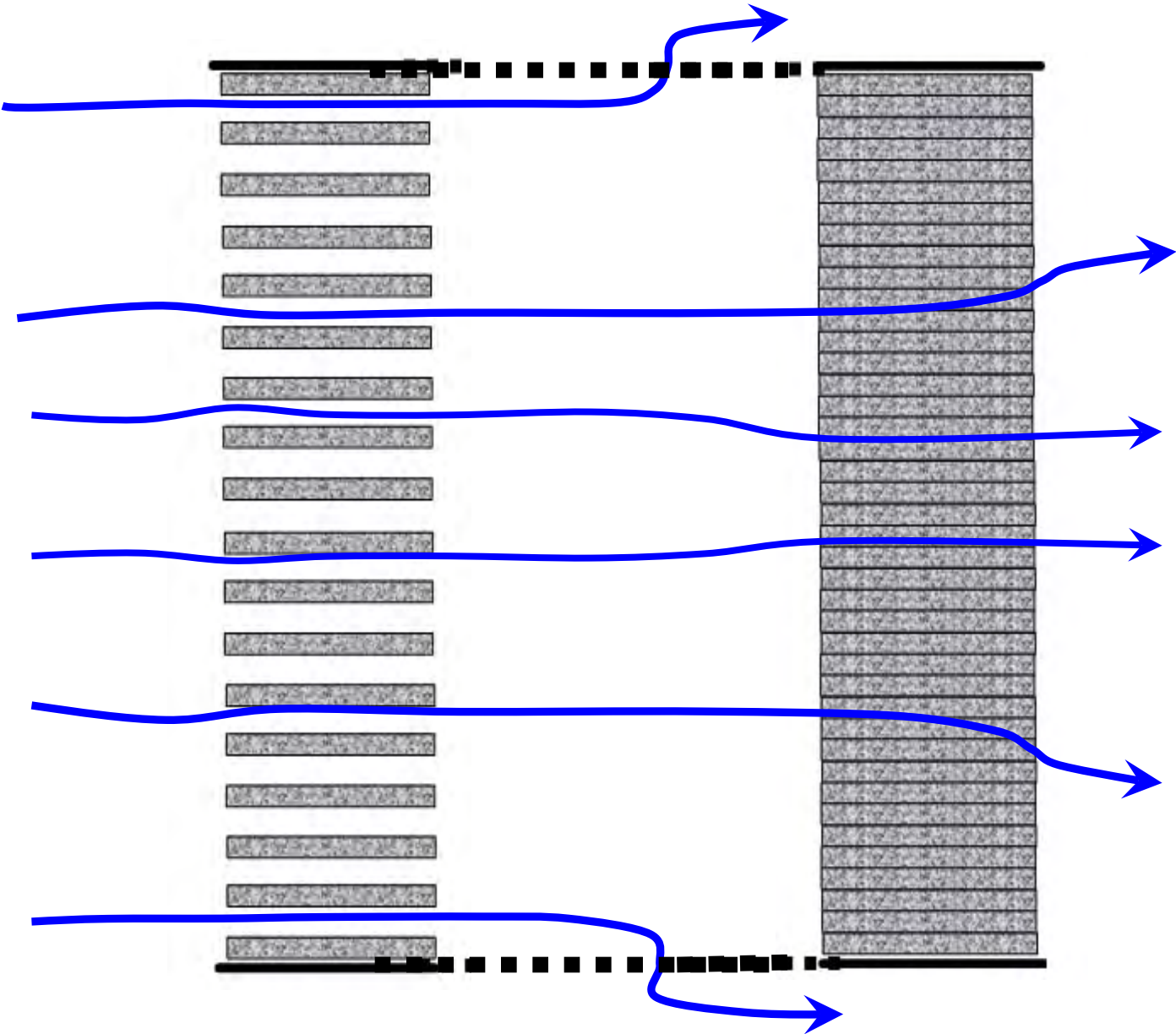
On high speed running,

On low speed running,
During idling mode,





Combination unit



Average weekday traffic: 53,600 vehicles

(large vehicles: 12.7%)

Mean concentration **NOx 98 ppb**

Treatment airflow: 600 m³ /min

Construction cost: **2,500,000 US\$**
Calculated solely on daytime
measurement

6.7 m³ /min /car × 74.4 vehicles /min = 500 m³ /min

Frontal Installation

At 35 km /h, Wind speed: **9 m /sec**

Assumed air flow into the 20 x 50 cm slits at **1.1 m /sec.**

Five to several hundred times high concentration NOx can be purified, no electricity required.

NOx 100~5000ppb

NOx 50~100ppb



<http://www.engelhard.com/documents/Premair%20BroREV031405.pdf>

PremAir Green

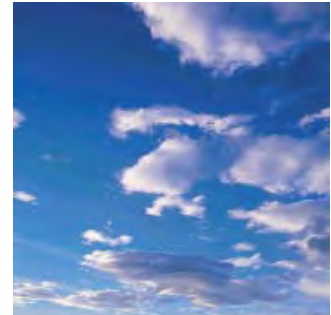
Where regulatory compliance is not needed, PremAir Green Image is a cost-effective option for vehicle manufacturers to demonstrate commitment to a clean environment and a responsible environmental policy.

PremAir® catalyst now part of The Sharper Image's Ionic Breeze® Air Purifiers



...catalysts before they enter the ambient air. In 2001, Engelhard received the J. Dean Sensenbaugh Award from the Air & Waste Management Association (AWMA) for its development and commercialization of PremAir.

...in the air, PremAir offers a novel way to combat ozone pollution and holds the promise of cleaner, healthier air for everyone.



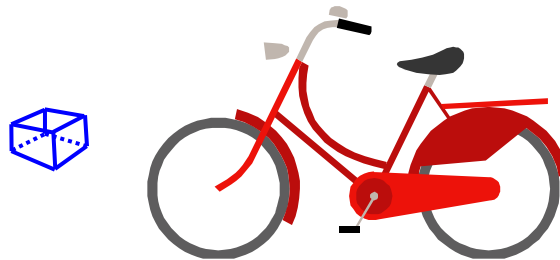
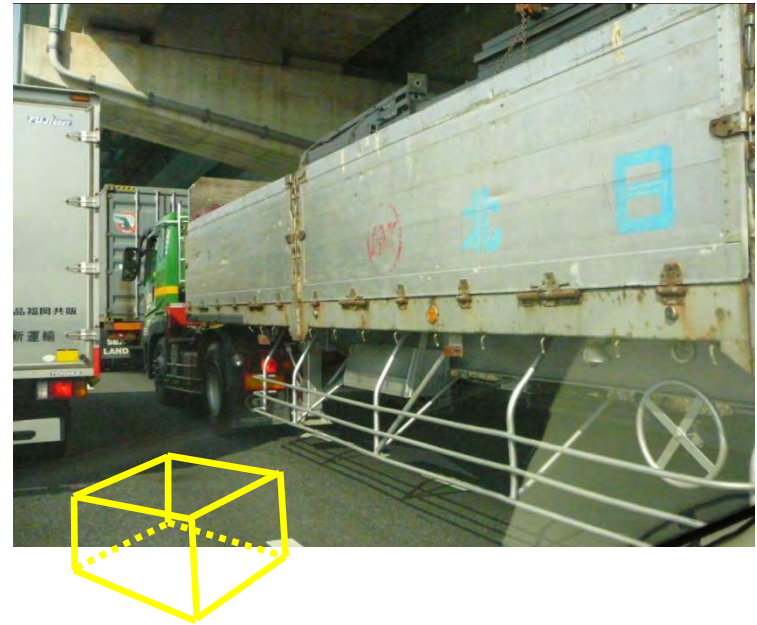
PremAir



Ozone destruction catalyst of Engelhard 「PremAir」

BMW, Volvo, Ford etc.

Installation part



Mobile system can sweep running through each road, continuously.



Scavenging of NO_x, SO₂, NH₃, chemical substances such as benzene, xylenes etc.

Advantage of mobile type system

Mobile system can sweep running through each road, continuously.

Even if 10% of vehicles are loading ACF system, high concentration of NO_x, SO₂, NH₃ and VOC's can be purified without electric energy.



Thank you very much for kind attention

**Fukuoka Institute of Health & Environmental
Sciences, Environmental science part
atmospheric section**

Takaaki Shimohara