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Investigation of The Particle Number Emissions Measurement Proposed by PMP

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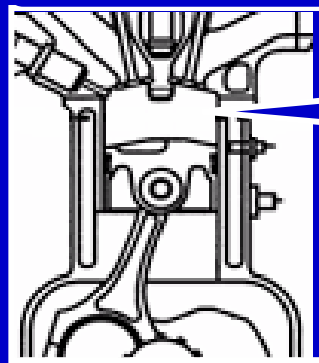
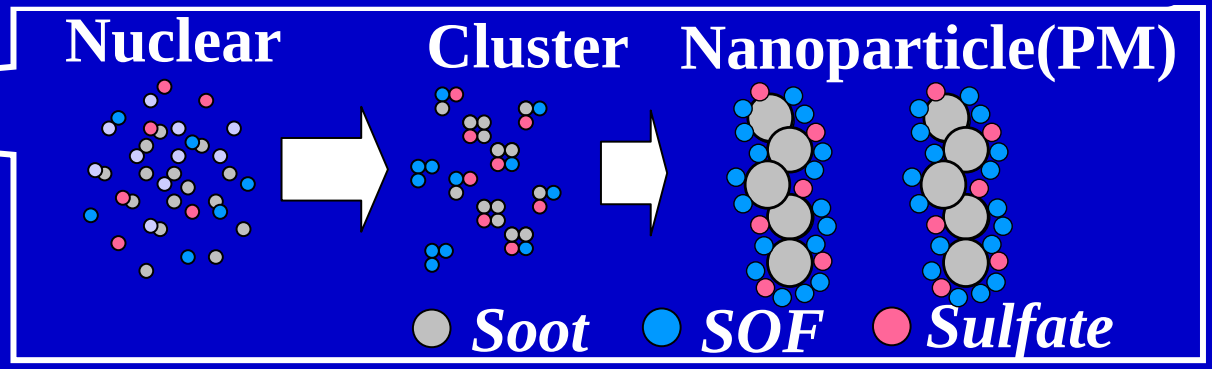
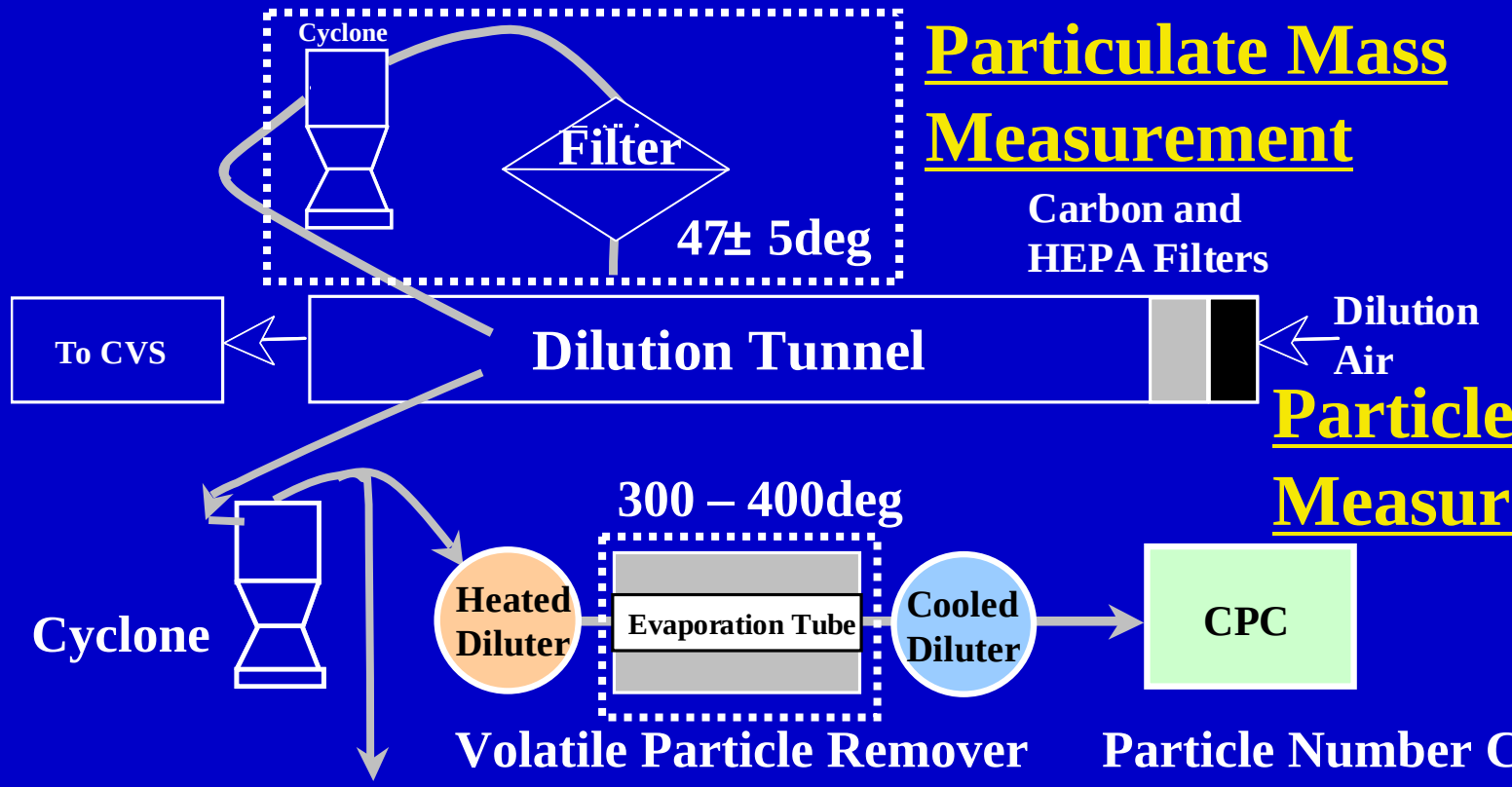
1-1. Measurement of Particulate Matter

The particle number regulation will be newly introduced to Euro5



Fuel
Lubricant





Particulate Mass Measurement

Carbon and HEPA Filters

Particle Number Measurement

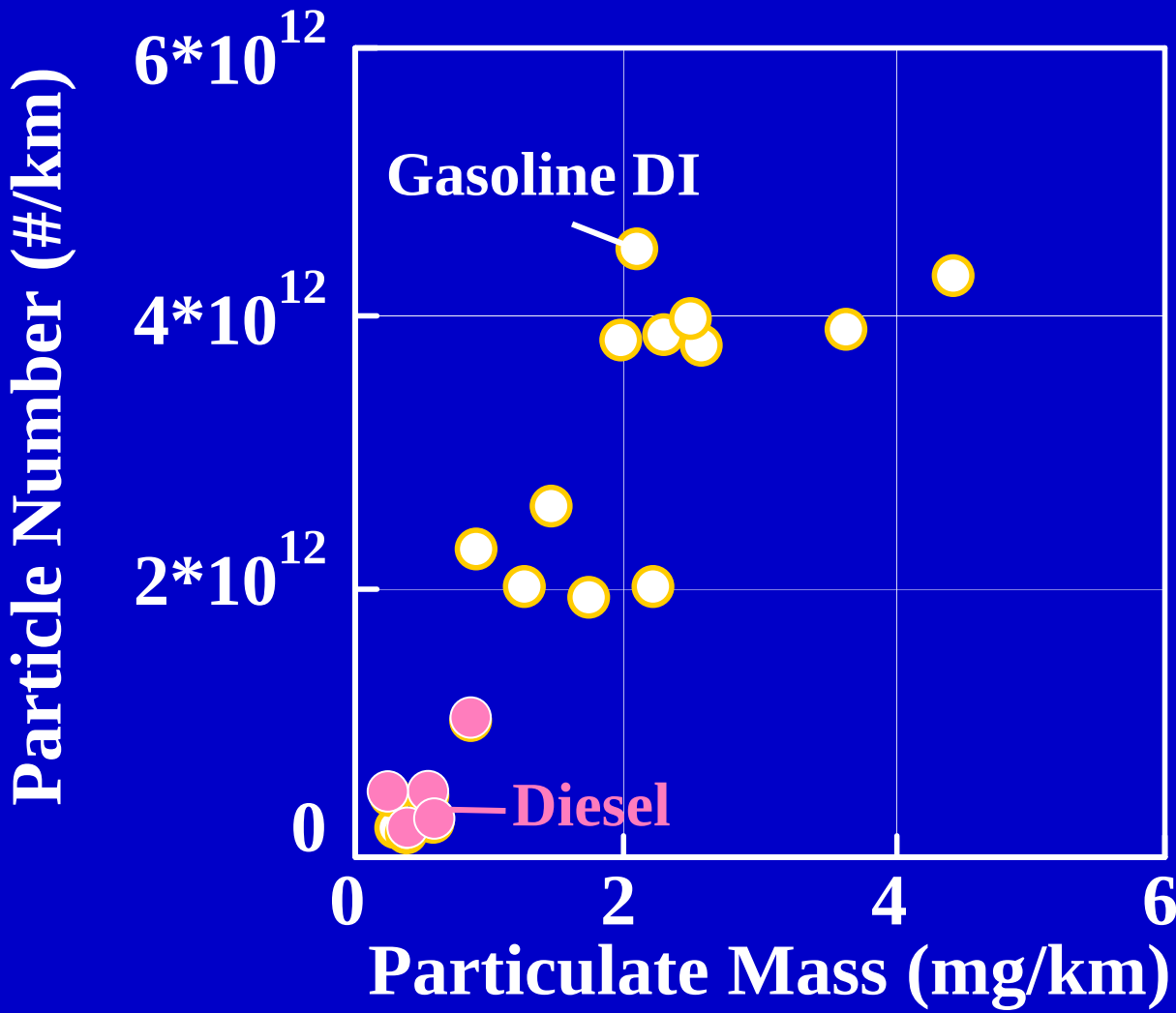
1-2. Regulations

		EURO5		EURO6
		2009 ~	2011 ~	2014 ~
Particulate Mass (mg/ km)	Diesel	5.0	4.5	4.5
	Gasoline	5.0	4.5	4.5
Particle Number (#/ km)	Diesel	-	6.0×10^{11}	6.0×10^{11}
	Gasoline	-	-	To be defined

Contents

2. Variability of PM and PN Measurement

These measurement variability is large



Test Mode : NEDC
Test Vehicles : 19
5 Diesel
13 Gasoline DI
1 Gasoline MPI

Reference
ECE/TRANS/WP.29
/GRPE/62 10 April 2008

Contents

3-1. Influence of PNC's Sensitivity

$$N = \frac{k \cdot V \cdot C \cdot pcrf \cdot 10^3}{d}$$

N : particle number emission (#/km)

k : PNC's sensitivity for electrometer

V : Volume of the diluted gas at standard conditions(L/test)

C : Corrected concentration of particles (#/cm^3)

pcrf: mean particle concentration reduction factor of the VPR at the dilution setting used for the test

d : distance corresponding to the operating cycle (km)

3-2. PNC Calibration Requirement

There is no description of material

		Linearity	Cut off Diameter Performance
Particle	Diameter	50 - 100nm (50 nm suggested)	23nm , 41nm
	Material	-	-
	Concentration	・5 points (2000 ~ Limit of Single Count) ・0 point	-
Monodisperse		GSD≦ 1.2	GSD≦ 1.1
Evaluation		± 10%, R2≧ 0.97 (for Electrometer)	38 ~ 62%@23nm ≧ 90%@41nm

3-3. PNC Calibration Method

$$\textit{PNC's Sensitivity} = \frac{\textit{PNC Reading}}{\textit{Electrometer Reading}}$$

Reference Electrometer

Aerosol Generator

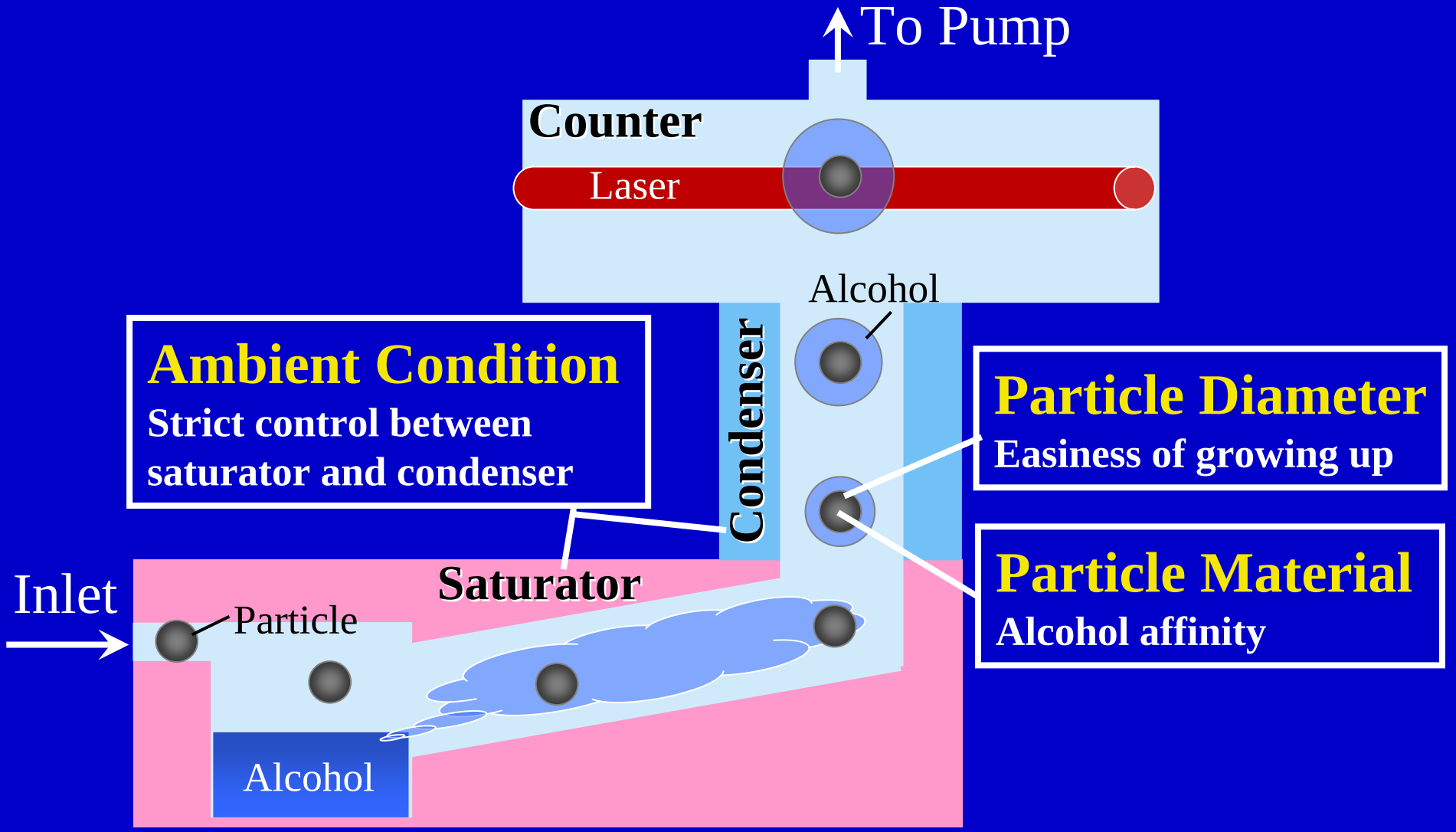
Neutraliser

Electrostatic Classifier

PNC Under Calibration

3-4. Concern Items about PNC

For growing particle, PNC uses alcohol and is required strict control



3-5. Objectives

Clarification of The Issues for
PNC Calibration Method

1. Influence of Ambient Condition
   (Temperature , Pressure , Humidity)
2. Influence of Particle Diameter
3. Influence of Particle Material

3-5. Objectives

Clarification of The Issues for
PNC Calibration Method

1. Influence of Ambient Condition
   (Temperature , Pressure , Humidity)
2. Influence of Particle Diameter
3. Influence of Particle Material

3-1-1. Influence of Ambient Condition

Influence of Ambient Condition
(Temperature, Pressure, Humidity)

Aerosol Generator

Neutraliser

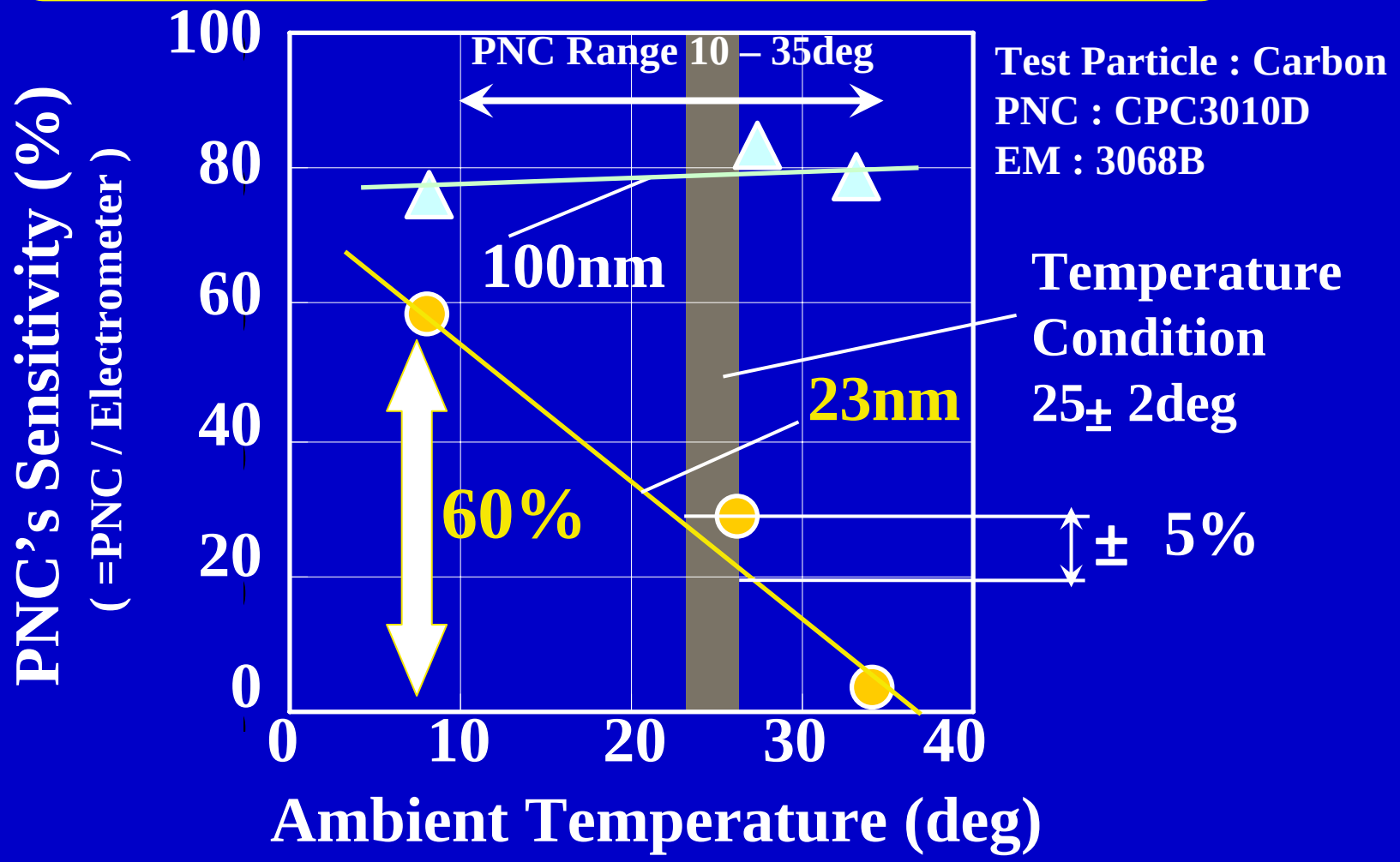
Electrostatic Classifier

Electrometer

PNC

3-1-2. Influence of Ambient Temperature

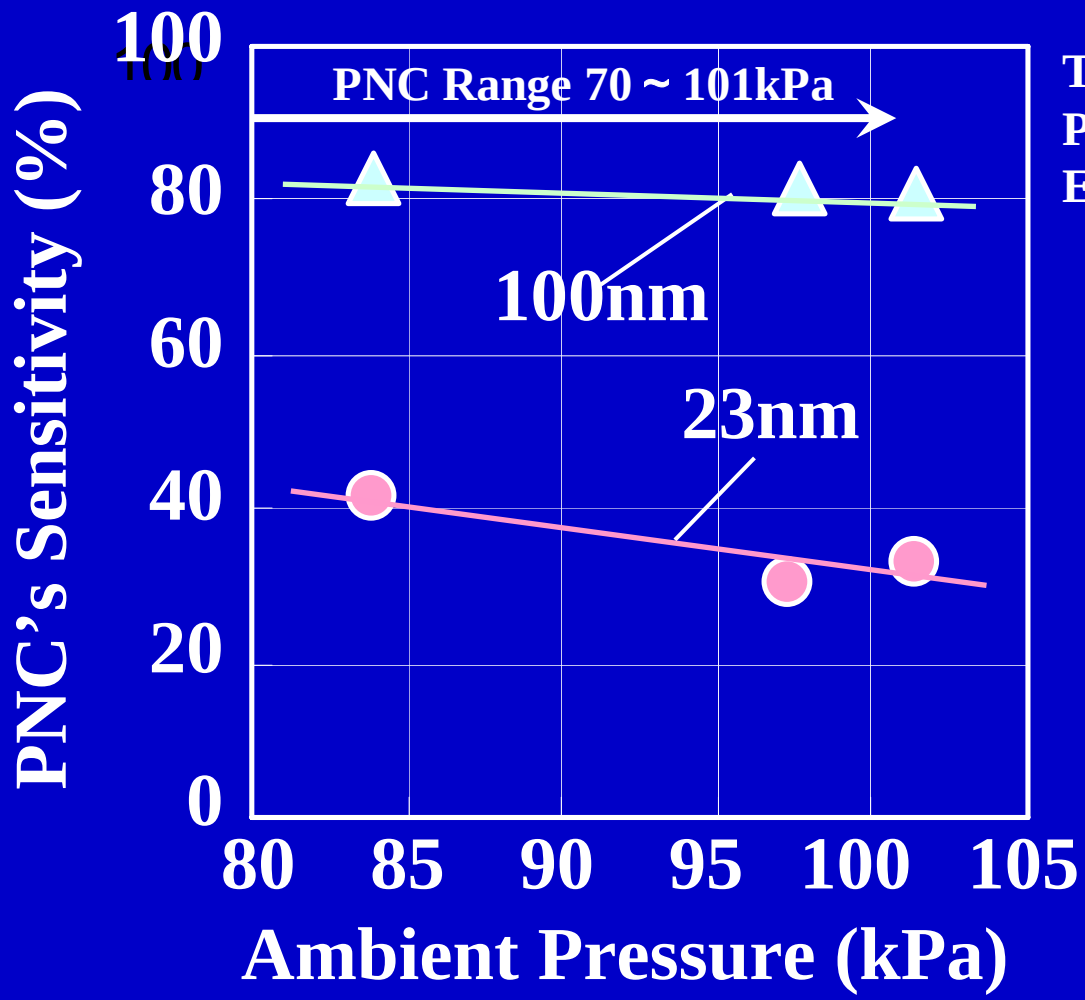
In 23nm particle, the higher temperature, the lower PNC's sensitivity



→ **Temperature condition should be controlled**

3-1-3. Influence of Ambient Pressure

There is little influence

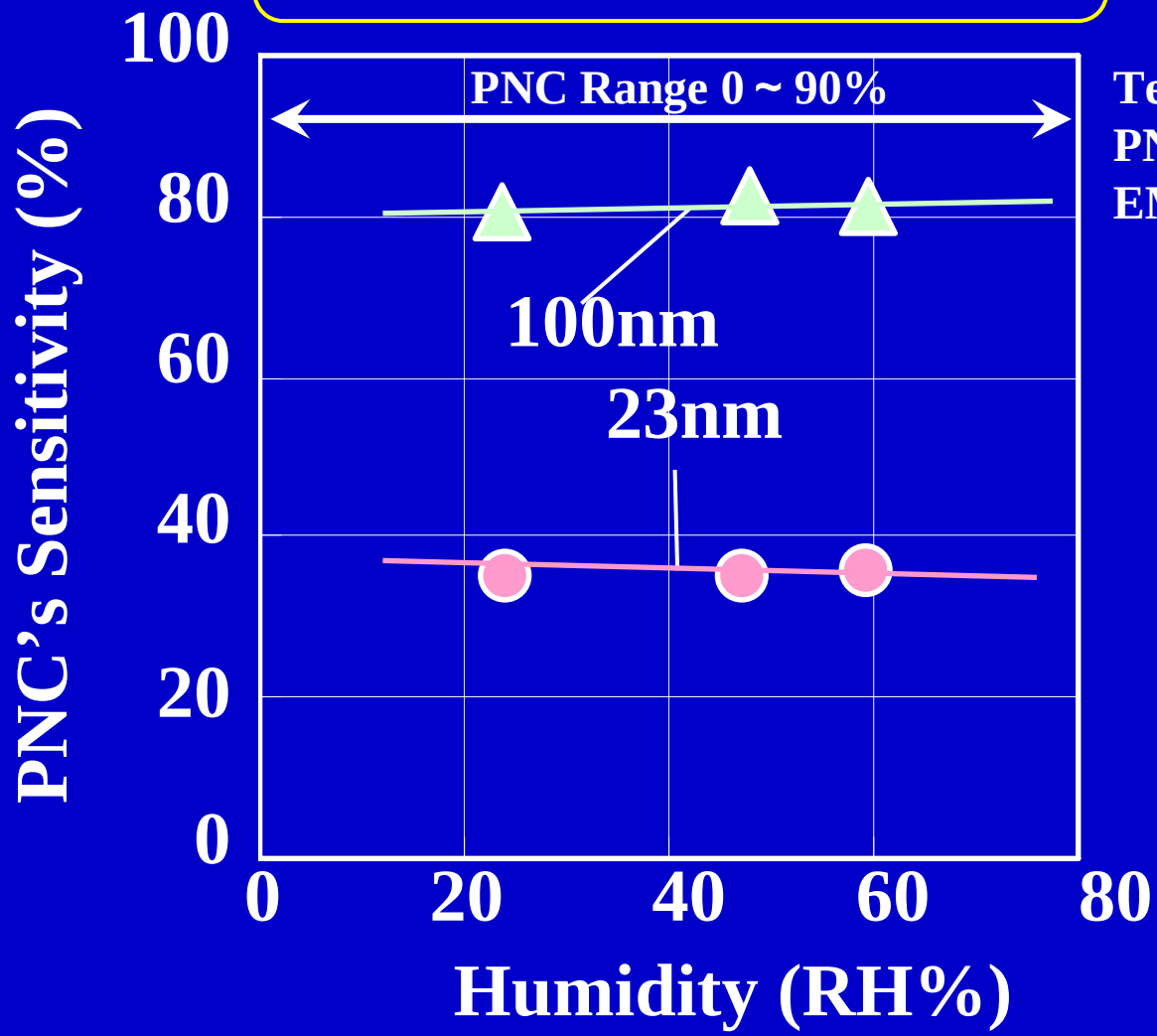


Test Particle : Carbon
PNC : CPC3010D
EM : 3068B

→ **Pressure control isn't needed**

3-1-4. Influence of Ambient Humidity

There is no influence



Test Particle : Carbon
PNC : CPC3010D
EM : 3068B

→ **Humidity control isn't needed**

3-1-5. Proposal for Ambient Condition

		Linearity	Cut off Diameter Performance
Ambient	Temperature	**Unification**	**Unification**
	Pressure	-	-
	Humidity	-	-

→ Need to control ambient temperature

3-2. Objectives

Clarification of The Issues for PNC Calibration Method

1. Influence of Ambient Condition (Temperature , Pressure , Humidity)
2. Influence of Particle Diameter
3. Influence of Particle Material

3-2-1. Influence of Particle Species

PAO; polyalphaolefin (by Electrosplay)
Carbon (by Spark)
NaCl (by Atomizer)

Aerosol Generator

Neutraliser

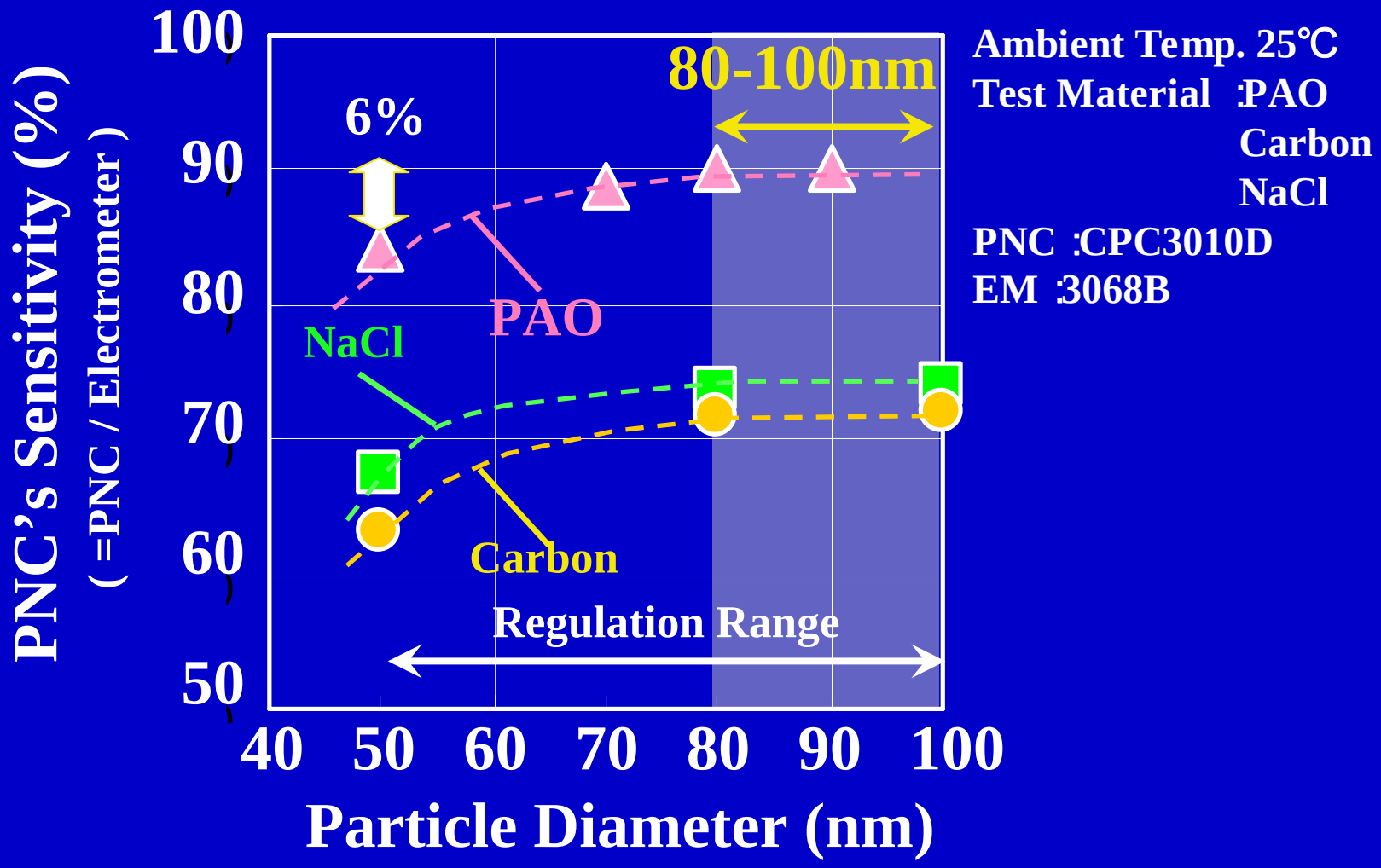
Electrostatic Classifier

Electrometer

PNC

3-2-2. Influence of Particle Diameter

The smaller particle diameter, The lower PNC's sensitivity



→**80-100nm is recommended for linearity check**

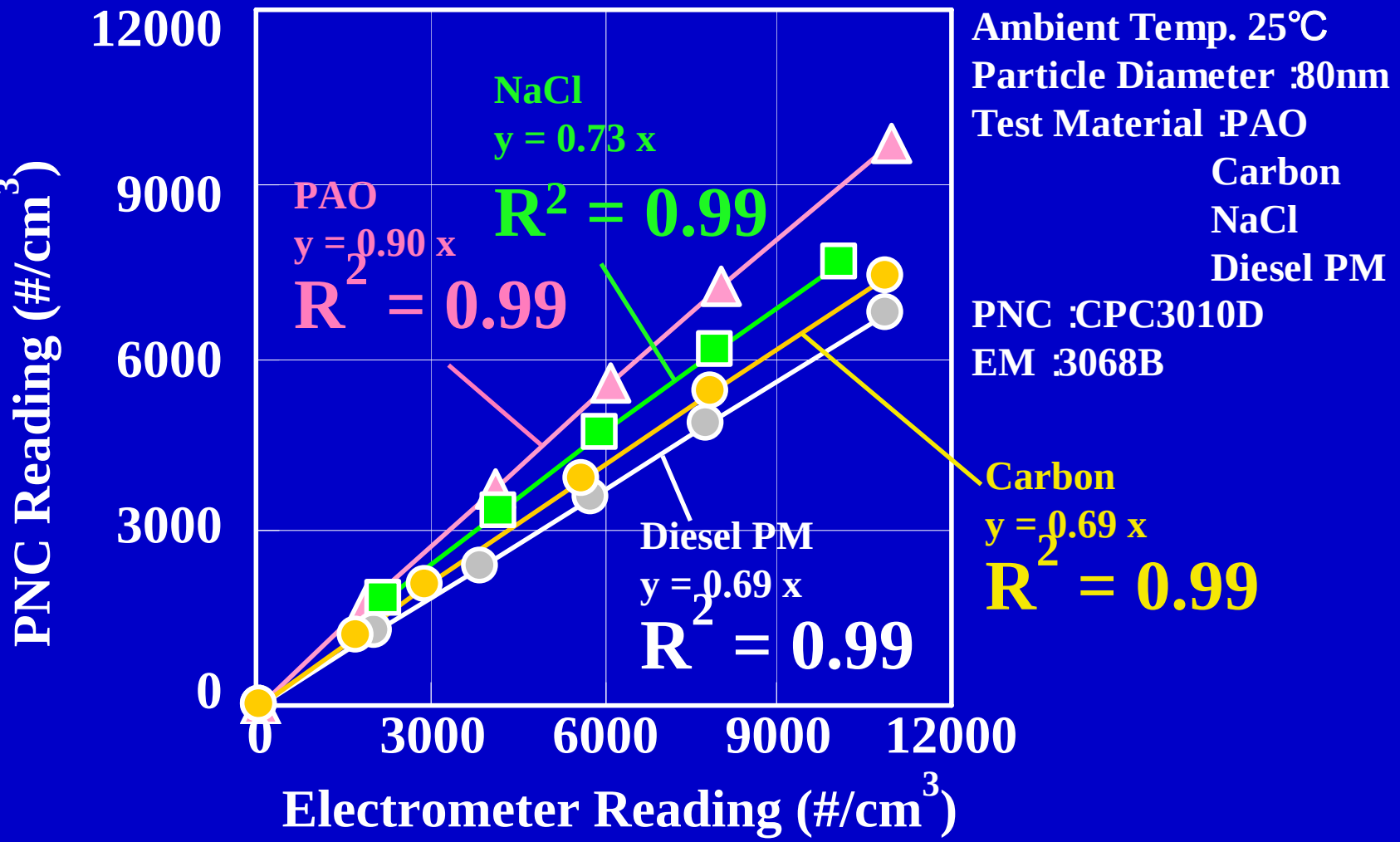
3-3. Objectives

Clarification of The Issues for
PNC Calibration Method

1. Influence of Ambient Condition
   (Temperature , Pressure , Humidity)
2. Influence of Particle Diameter
3. Influence of Particle Material

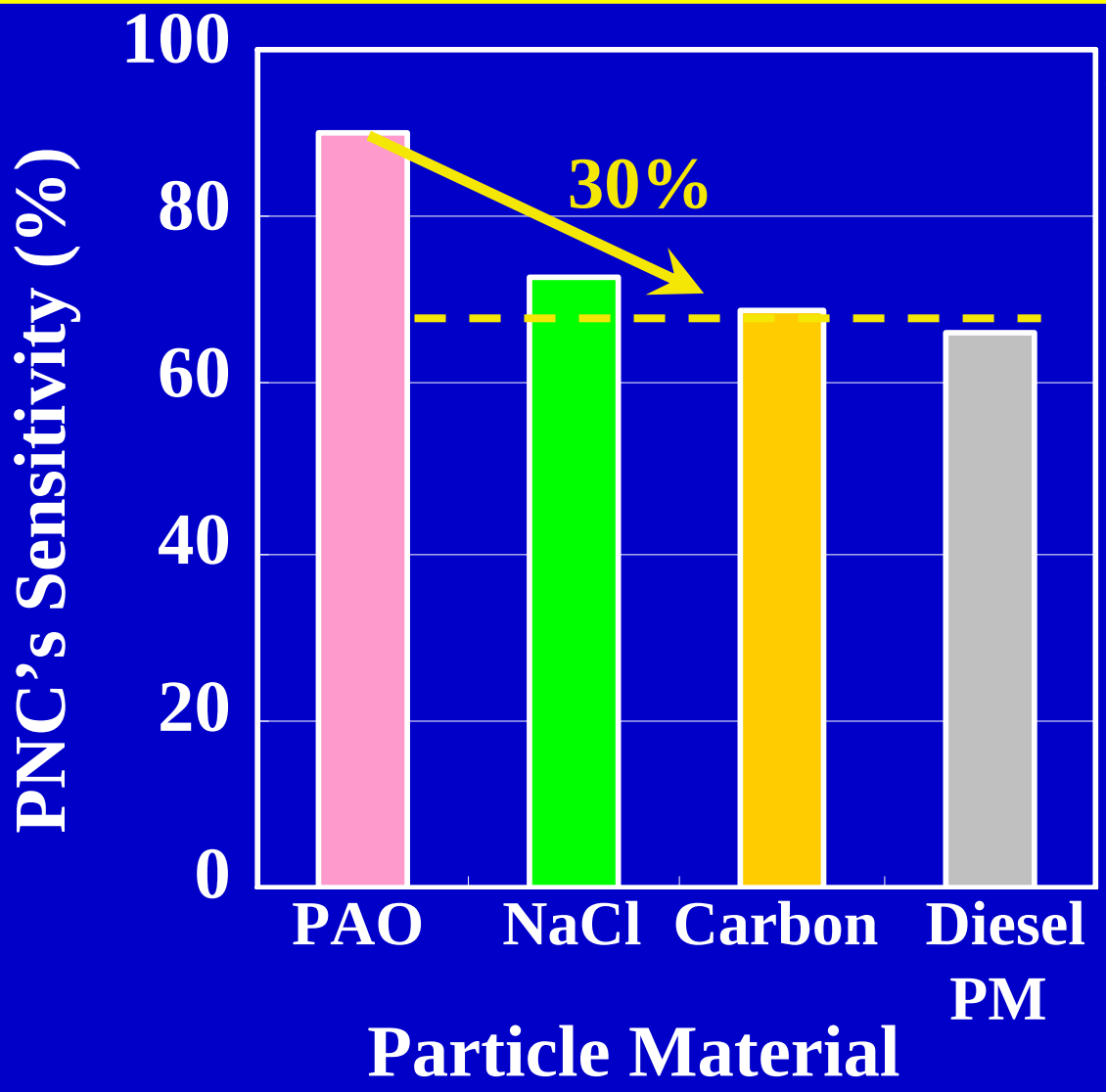
3-3-1. Influence of Particle Material for Linearity

All of test particle materials meet the current PMP regulation (R^2 more than 0.97)



3-3-2. Difference of PNC's Sensitivity According to Particle Material

PNC's sensitivity is different 30% according to materials



Ambient Temp. 25℃
Particle Diameter :80nm
Test Material :PAO
Carbon
NaCl
Diesel PM
PNC :CPC3010D
EM :3068B

3-3-3. Influence of Different PNC's Sensitivity

Measurement value is directly corrected by PNC's sensitivity

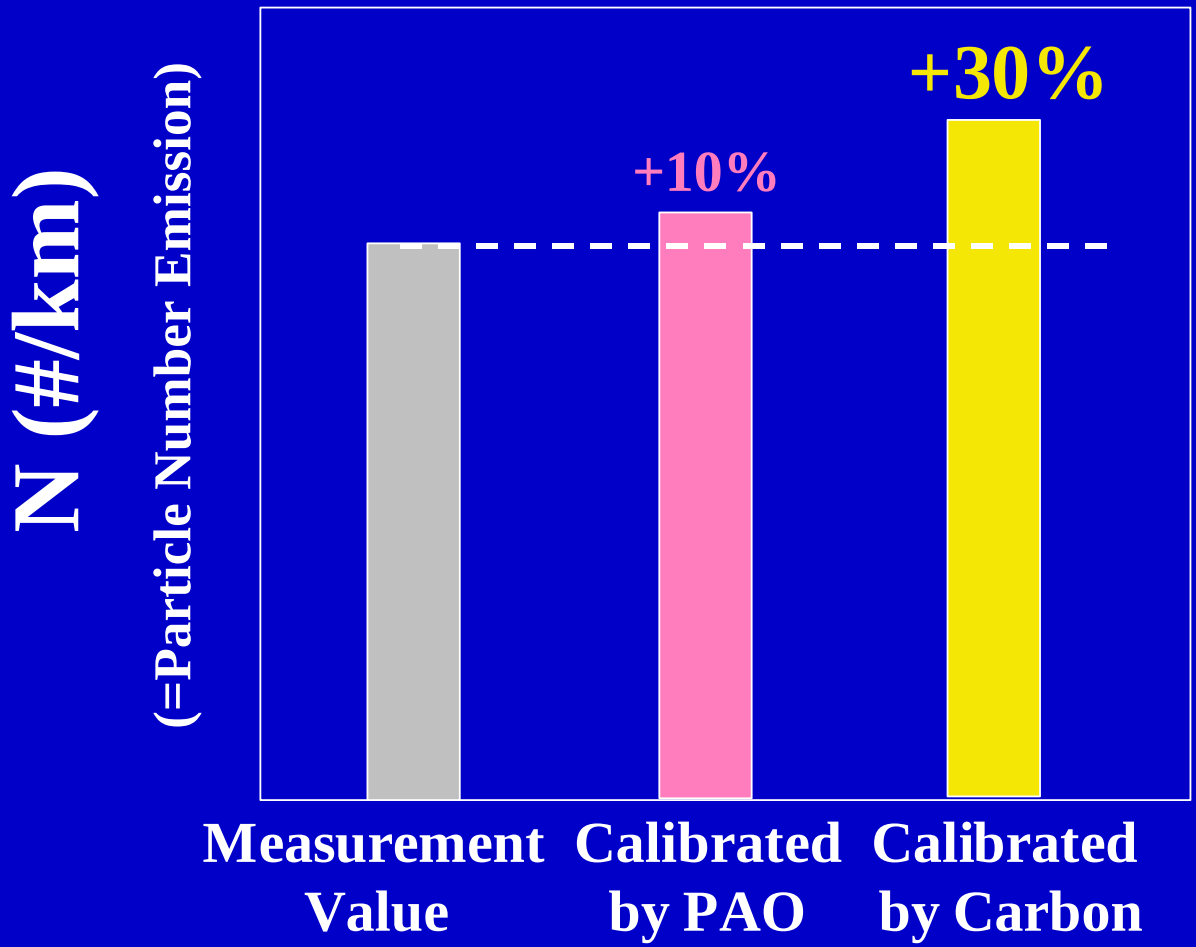
$$N = \frac{k \cdot V \cdot C \cdot pcrf \cdot 10^3}{d}$$

N : particle number emission (#/km)

k : PNC's sensitivity for electrometer

3-3-4. Influence of Different PNC's Sensitivity

Particle number emission is different by calibrated material



→ Need unification of particle material

3-3-5. Presumptive Cause of Particle Material Influence

1. Influence of Multiple Charged Particle
2. Influence of Alcohol Affinity

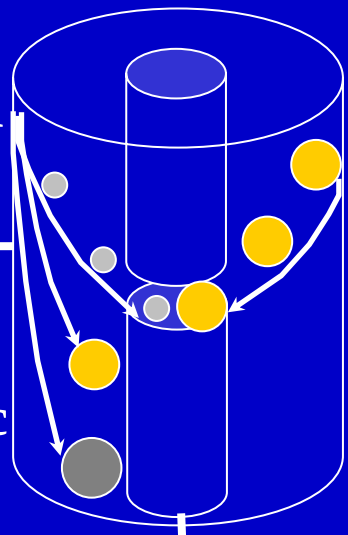
Aerosol Generator

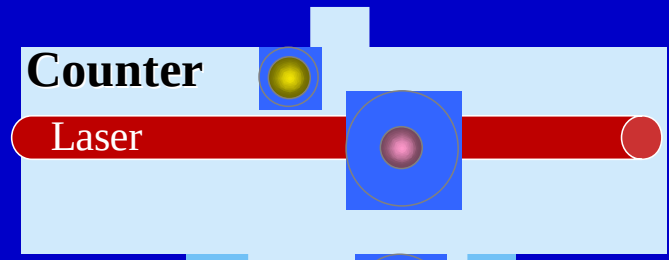
Neutraliser

+1 charged

+2 charged

Electrostatic Classifier





Condenser

1.Multiple Charge

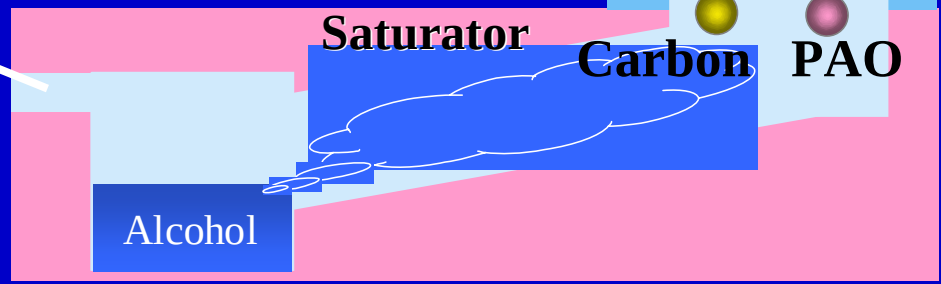
+1 Count → 1

+2 → 2

Electrometer

PNC

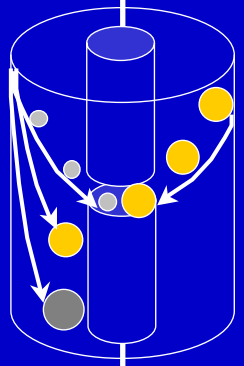
2.Alcohol Affinity



3-3-6. Number of Multiple Charged Particle

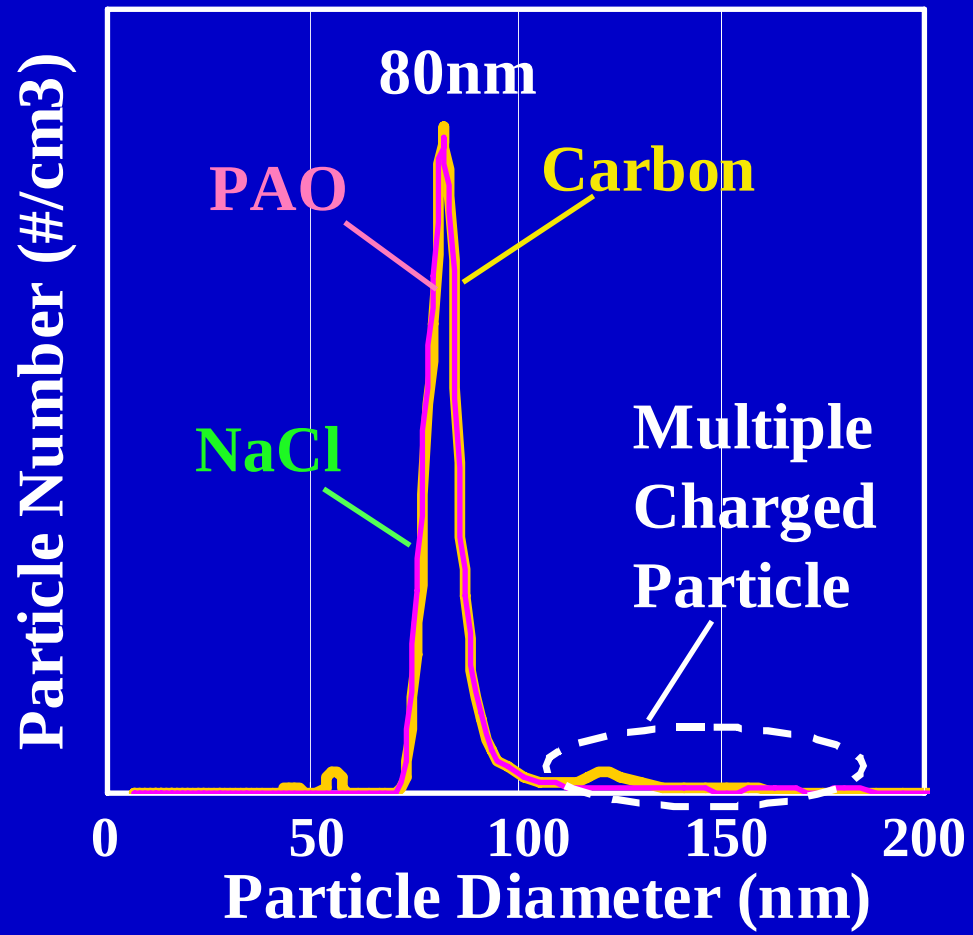
There are few multiple charged particles

Neutraliser



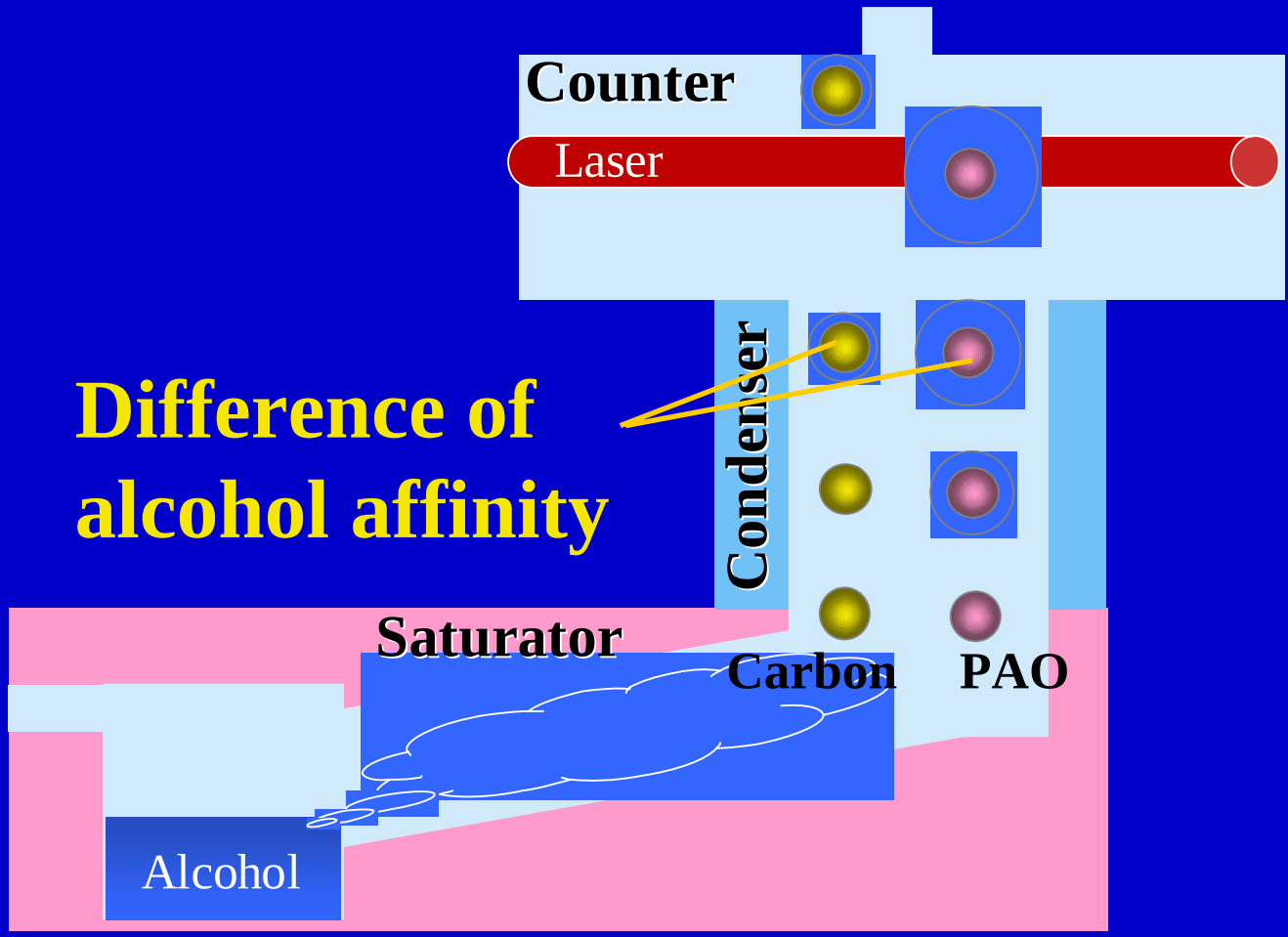
Electrostatic Classifier

Size Distribution Analyzer



→ **Influence can be ignored**

3-3-7. Influence of Alcohol Affinity



Guess that PNC's sensitivity deference is influence of alcohol affinity and now investigating

3-3-8. Proposal for PNC Calibration Condition

		Linearity	Cut off Diameter Performance
Particle	Diameter	80- 100 nm	23nm , 41nm
	Material	Unification	Unification

→ **80-100nm particle is recommended for linearity check**

→ **Need unification of particle material**

4. Conclusion

1. Need to control ambient temperature for PNC calibration and measurement.

2. 80-100nm particle is recommended for linearity check.

3. Need unification of particle material for PNC calibration.

Thank you for your attention