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# **Instruments for on-site control of particle number concentration**

2<sup>st</sup> VERT-Forum, March 25<sup>th</sup> 2011

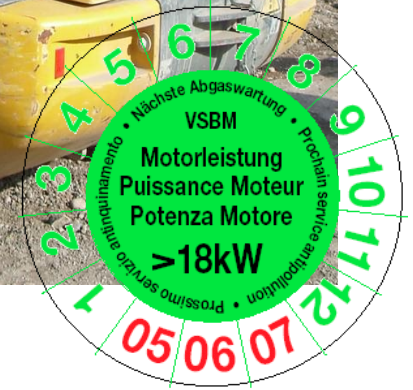


# Outline

- Smoke Test for Construction Machines**
  
- Nanoparticle measuring instrument**
  
- Comparison of prototype instruments**
  
- Outlook**



# Smoke test for construction machines

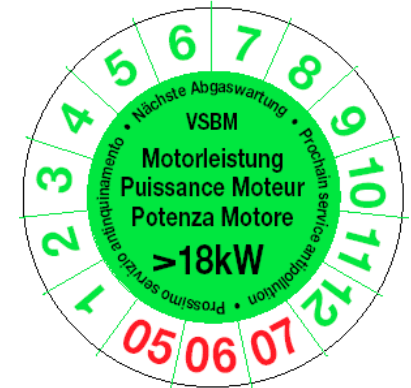




# Smoke test for construction machines

## Current system

- Opacimeter
- Measurand: Light extinction coefficient
- Free acceleration test
- Limit: extinction coefficient  $k < 0,15 \text{ m}^{-1}$



## Disadvantages

- insensitive for small particles and low concentrations
- revolution measurement mandatory
- heavy instruments (not for field measurements)

## Advantages

- same instruments as for diesel vehicles,
- known technique



# Smoke test for construction machines

## Future system

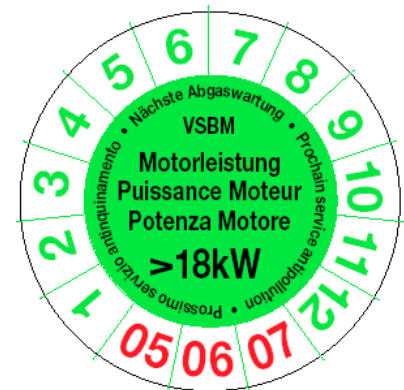
- Nanoparticle measuring instrument
- Measurand: Number concentration
- Steady state measurement at high revolution
- Limit: Number concentration  $C < 10^7 \text{ cm}^{-3}$  (to be defined)

## Disadvantages

- risk of new technology
- new instruments needed (investment)

## Advantages

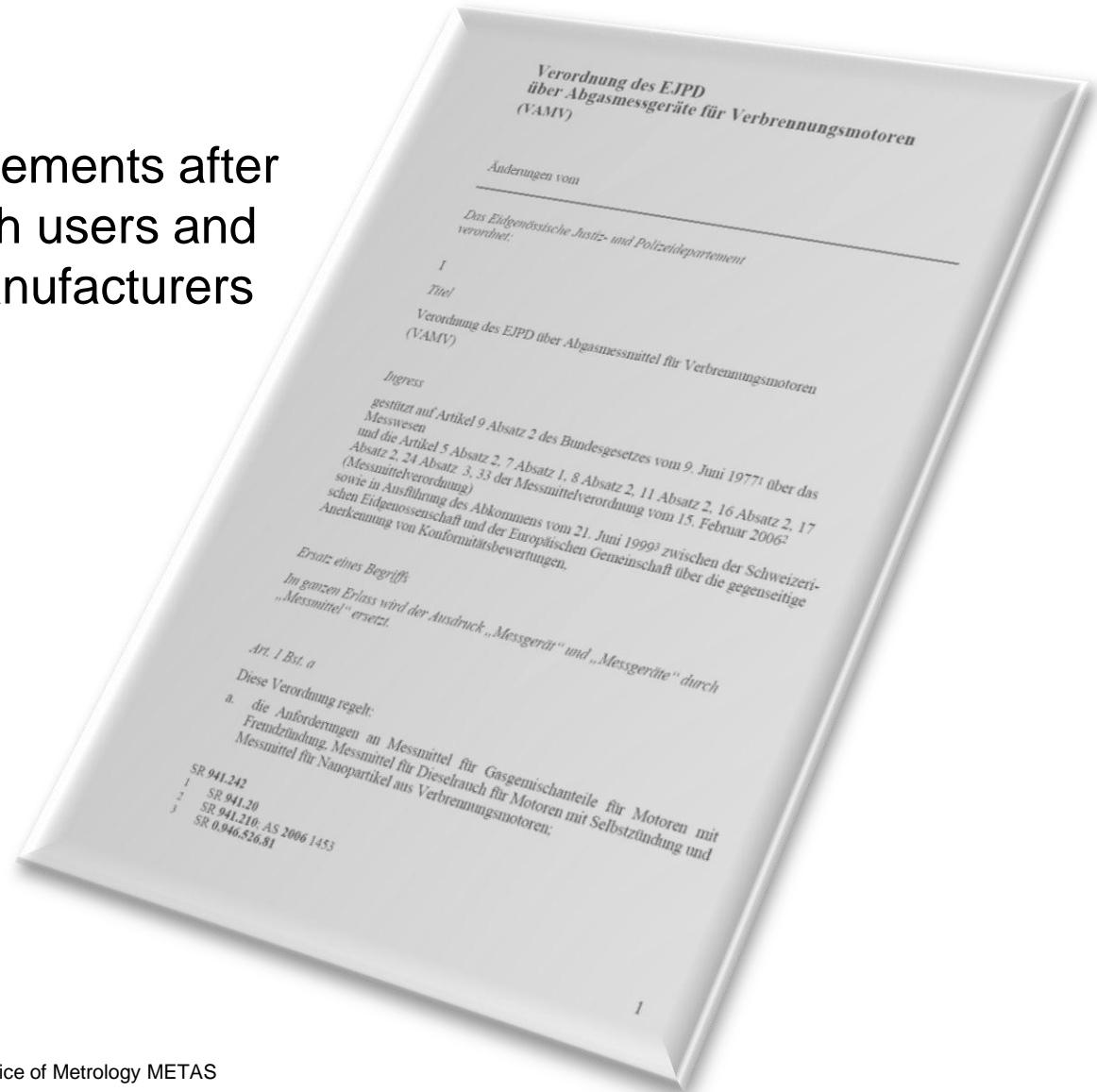
- more sensitive
- easy handling
- faster procedures





# Nanoparticle measuring instrument

Refined requirements after discussion with users and instrument manufacturers





# Nanoparticle measuring instrument

## Number concentration measurement

The measuring range shall be from  $10^5 \text{ cm}^{-3}$  to  $10^7 \text{ cm}^{-3}$ .

Values below measuring range shall be indicated as „below  $10^5 \text{ cm}^{-3}$ “, values above as „above  $10^7 \text{ cm}^{-3}$ “.

The reference conditions for the result shall be actual ambient conditions.



# Nanoparticle measuring instrument

## Error limits for number concentration measurement

As a function of particle size and particle composition the counting efficiency  $E$  shall be within following limits:

<b>Particle (mobility) diameter</b>	<b>Permitted range for <math>E</math></b>
23 nm solid particle	$E < 50 \%$
41 nm solid particle	$50 < E$
80 nm solid particle	$70 < E < 130 \%$
200 nm solid particle	$E < 200 \%$
30 nm tetracontane droplets	$E < 5 \%$

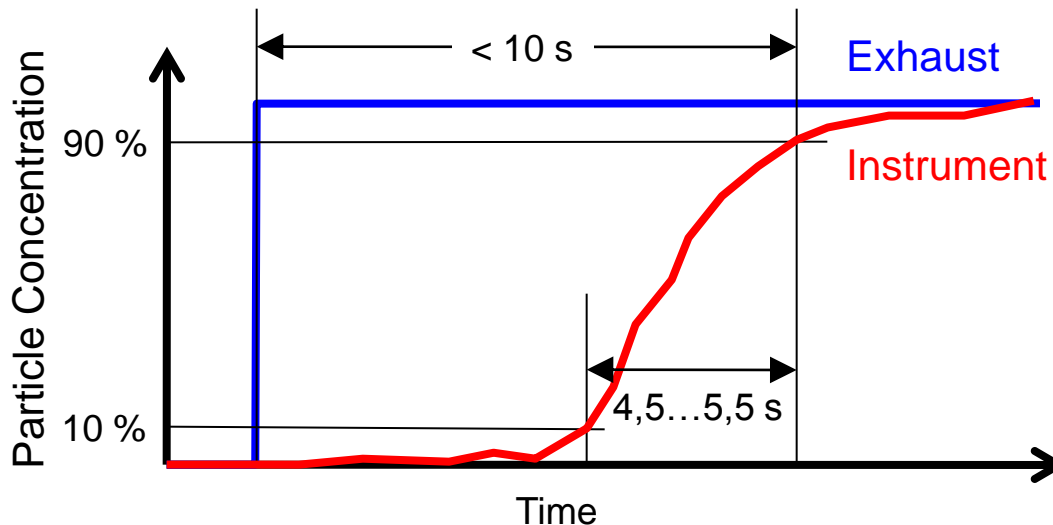


# Nanoparticle measuring instrument

## Requirements for time constants

**Response Time:** During the official measurement the instruments response from 10 % to 90 % of an instantaneous change of the particle number concentration (upward and downwards) shall last between 4,5 s and 5,5 s.

**Delay Time:** The duration between the entry of aerosol at the sampling line and the 90 % indication of the number concentration shall be below 10 s.





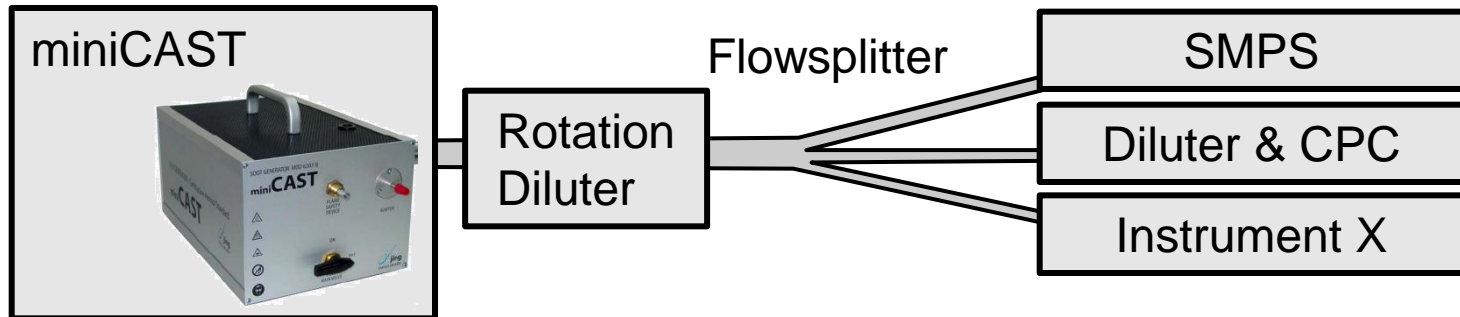
# Laboratory comparison of instruments





# Laboratory comparison of instruments

## Measurement setup

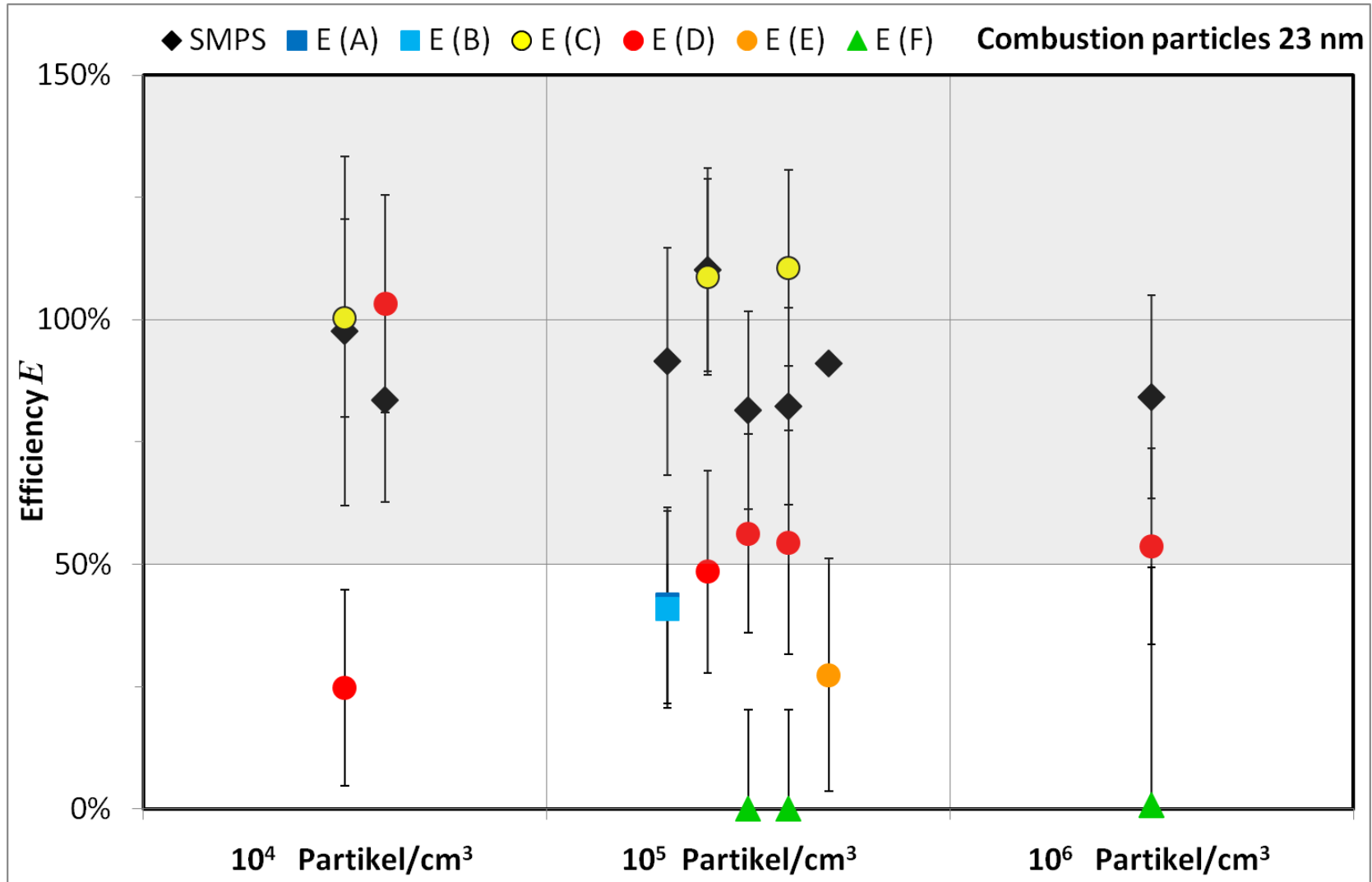


## Instrument descriptions

- A** Condensation particle counter (identical to B)
- B** Condensation particle counter (identical to A)
- C** Diffusion battery (prototype)
- D** Diffusion battery with thermodilution (prototype 1)
- E** Diffusion battery with thermodilution (prototype 2)
- F** Scattering light instrument (prototype)

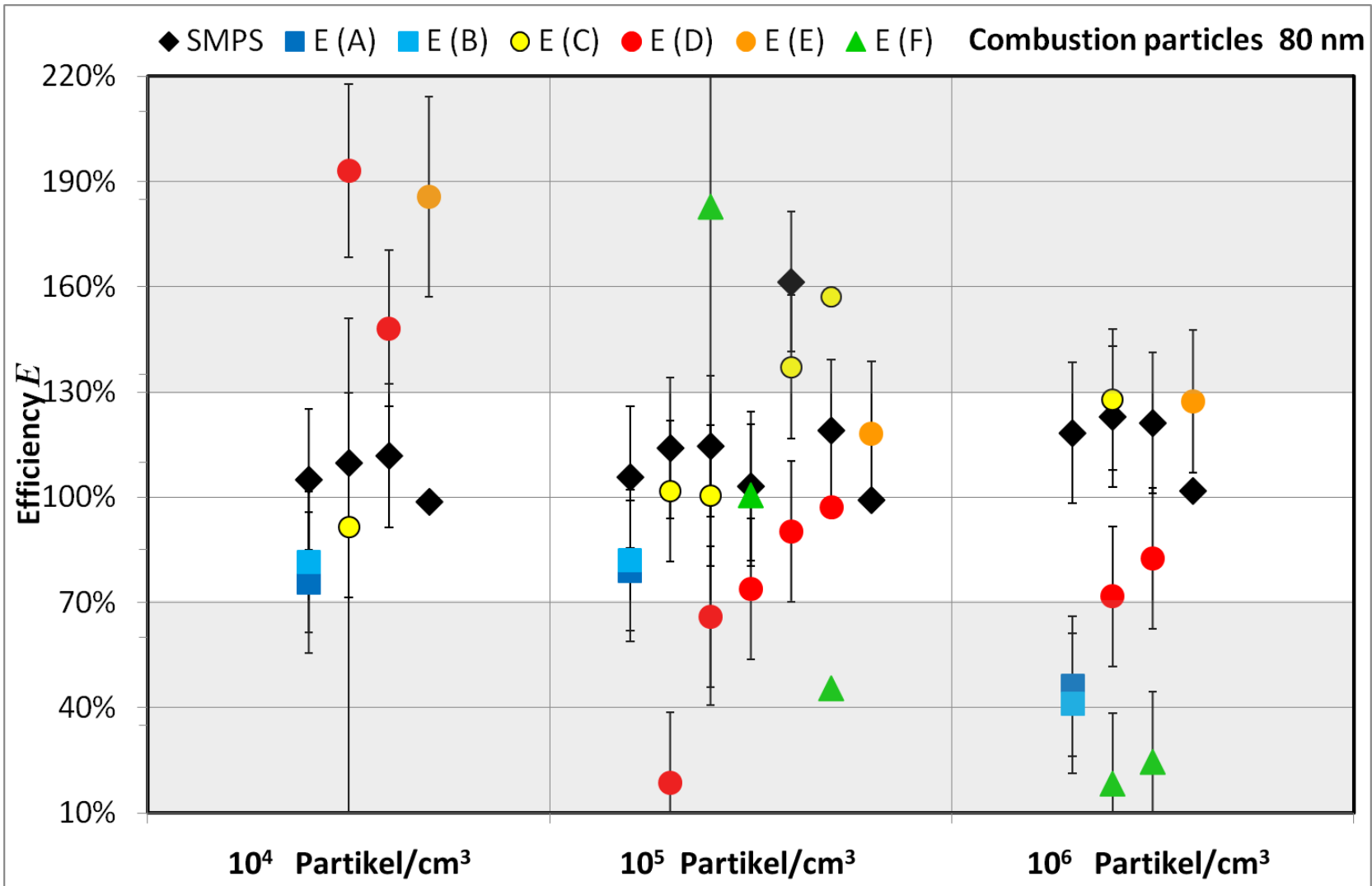


# Laboratory comparison of instruments



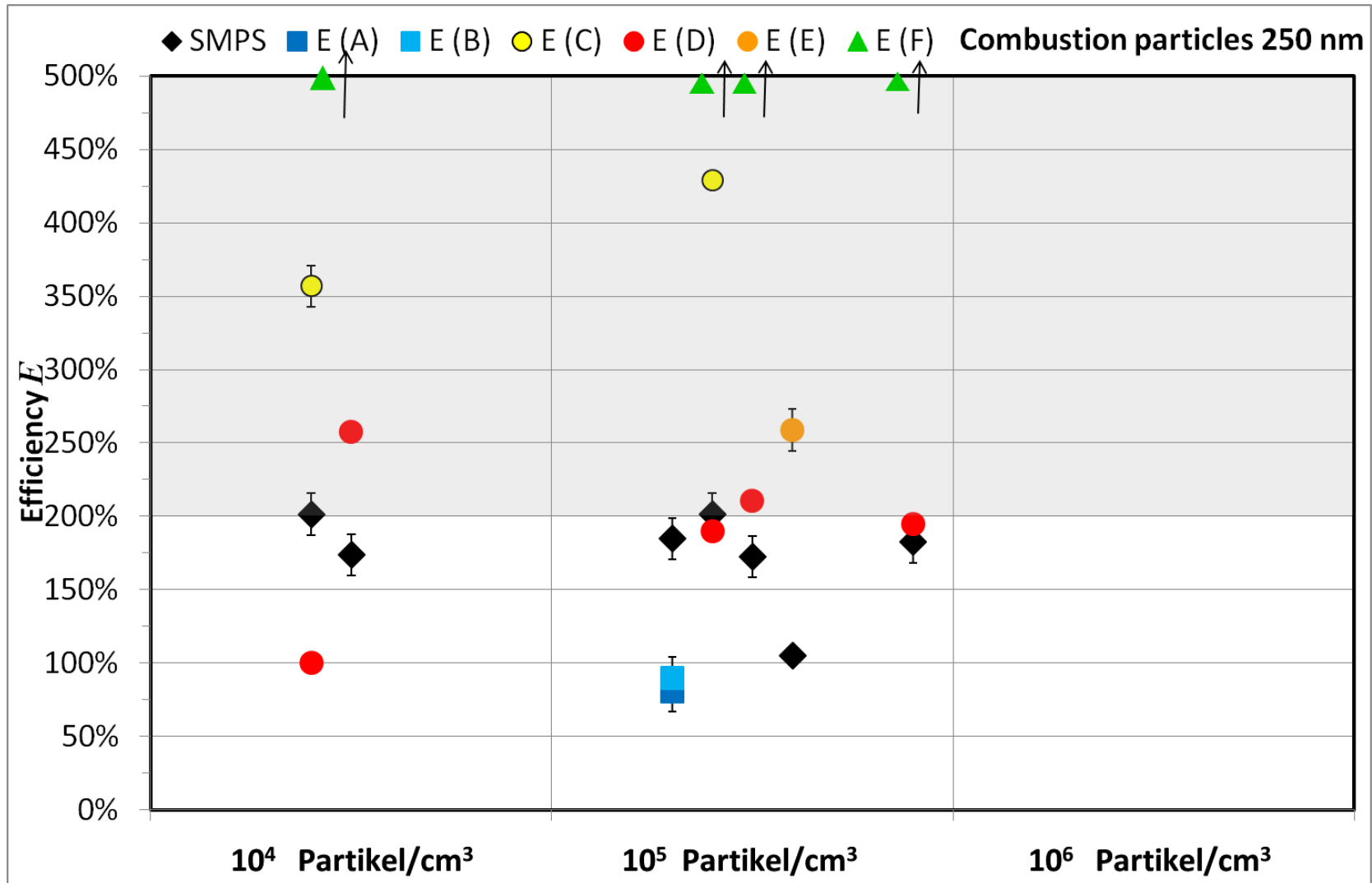


# Laboratory comparison of instruments





# Laboratory comparison of instruments





# Outlook

- ❑ Particle number concentration is the measurand for emission measurements
- ❑ Instrument technology is ready
- ❑ Legislation for “nanoparticle measuring instruments” is in discussion within Swiss administration
- ❑ Further applications for the “nanoparticle measuring instrument” is evaluated



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# Thank you

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