

AVL 

# Dual particle counter for measuring simultaneously automotive exhaust solid particle number emissions larger than 10 nm and 23 nm

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- 1 Introduction and Methodology
- 2 Effect of the Catalytic Stripper on the SPN23, using APC Dual (10 & 23nm)
- 3 Conclusion



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# Introduction – Background

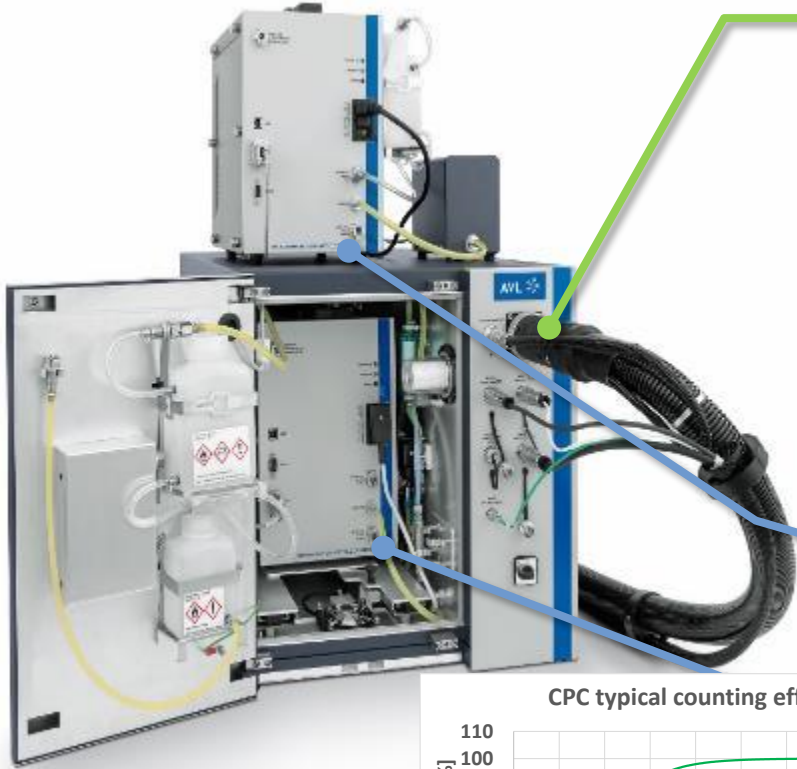
## Global Technical Regulation 15 Amendment 6 for SPN23



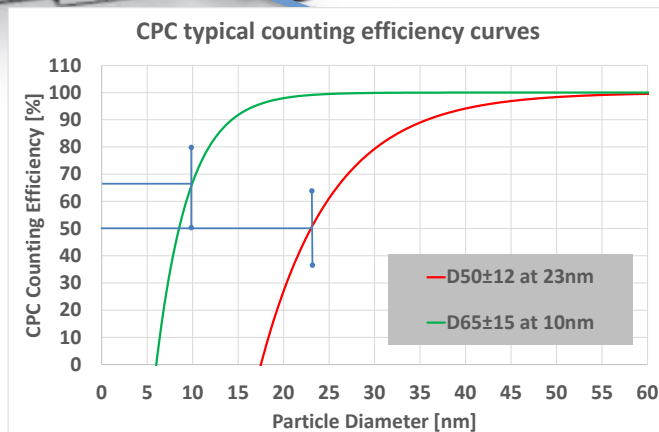
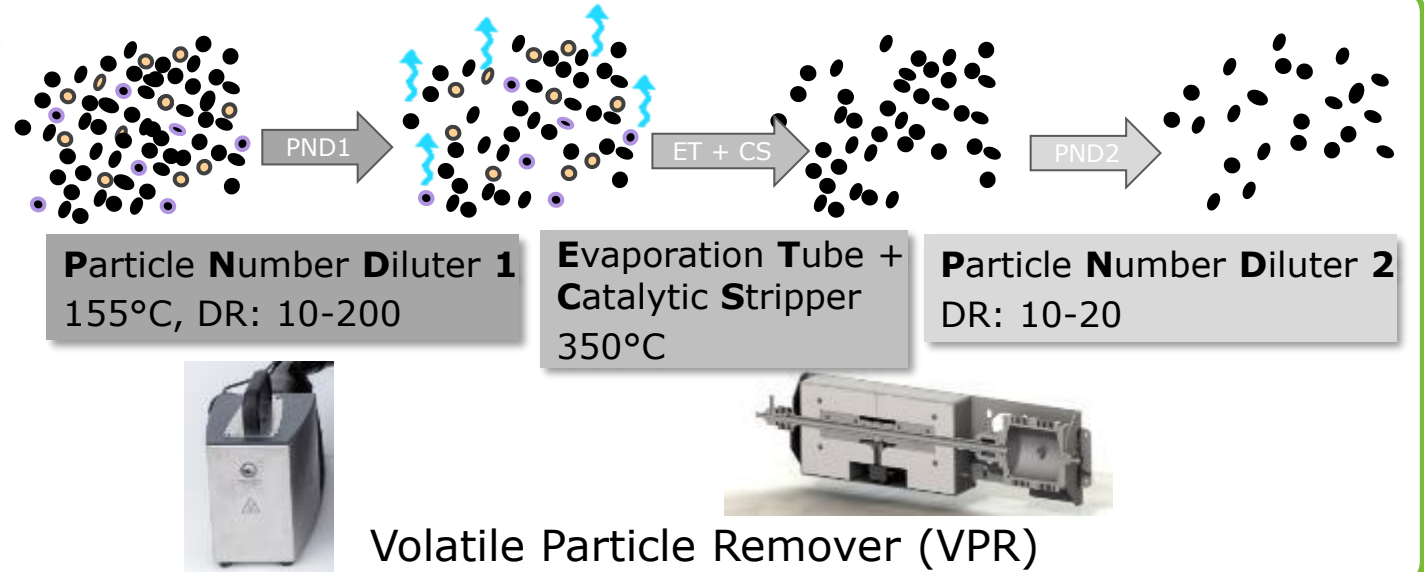
- Current GTR15 (Amendment 5) does not allow a Catalytic Stripper (CS) in the Volatile Particle Remover (VPR) of Solid Particle Number (SPN) counters with cutoff 23 nm (SPN23) (*device parts should not react with the exhaust gas components*)
- The latest amendment of the GTR15 (Amendment 6) allows a CS as optional at the VPR for SPN23, while the CS is mandatory for SPN10.
- An AVL Particle Counter (APC) Dual for simultaneous measurements of SPN23 and SPN10 incorporates a CS in its Evaporation Tube (ET), and is compared vs an APC with a VPR without a CS (only ET - SPN23).



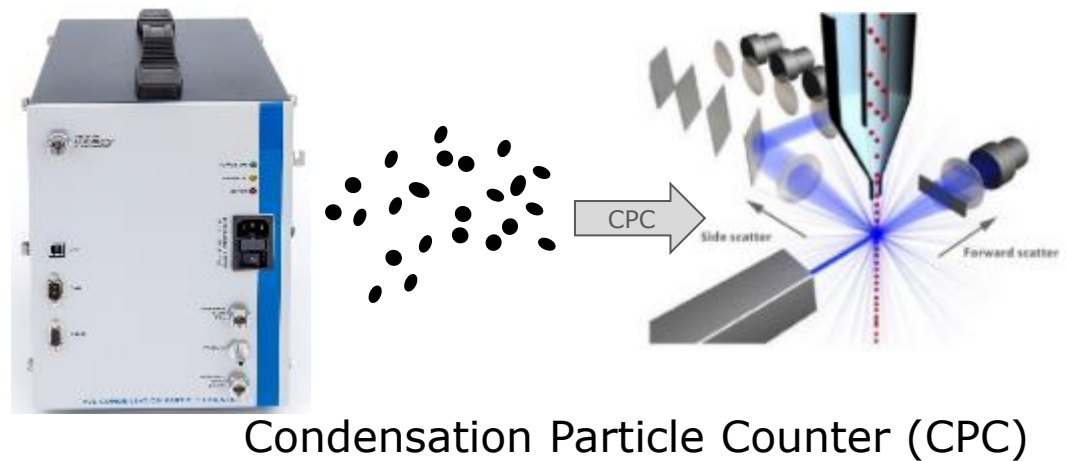
# AVL Particle Counter (APC) Dual: Overview



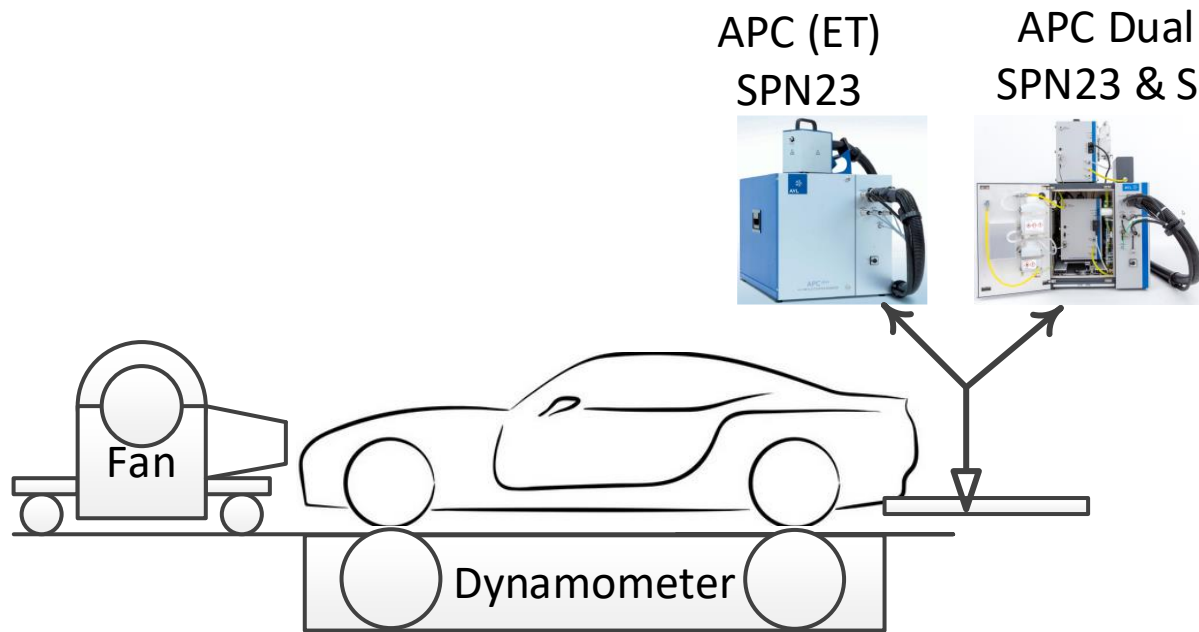
1) Sample Pre-Treatment



2) Sensors



# Experimental setup on Light-duty vehicle chassis dyno



APC: AVL Particle Counter

CS: Catalytic Stripper

ET: Evaporation Tube

FTP: Federal Test Procedure

LD: Light-Duty

NEDC: New European Driving Cycle

RDE: Real Driving Emission

SFTP: Supplemental Federal Test Procedure

SPN: Solid Particle Number

WLTC: Worldwide harmonized Light vehicles Test Cycle

- Various tests (WLTC, NEDC, FTP75, SFTP-SC03, RDE) were conducted at a LD vehicle chassis dyno bench:
  - 2 tests with Diesel vehicles
  - 13 tests with Gasoline Direct Injection vehicles.
- 2 APCs were used at the same sampling location (raw exhaust gas, tailpipe): APC (ET) and APC Dual (CS)

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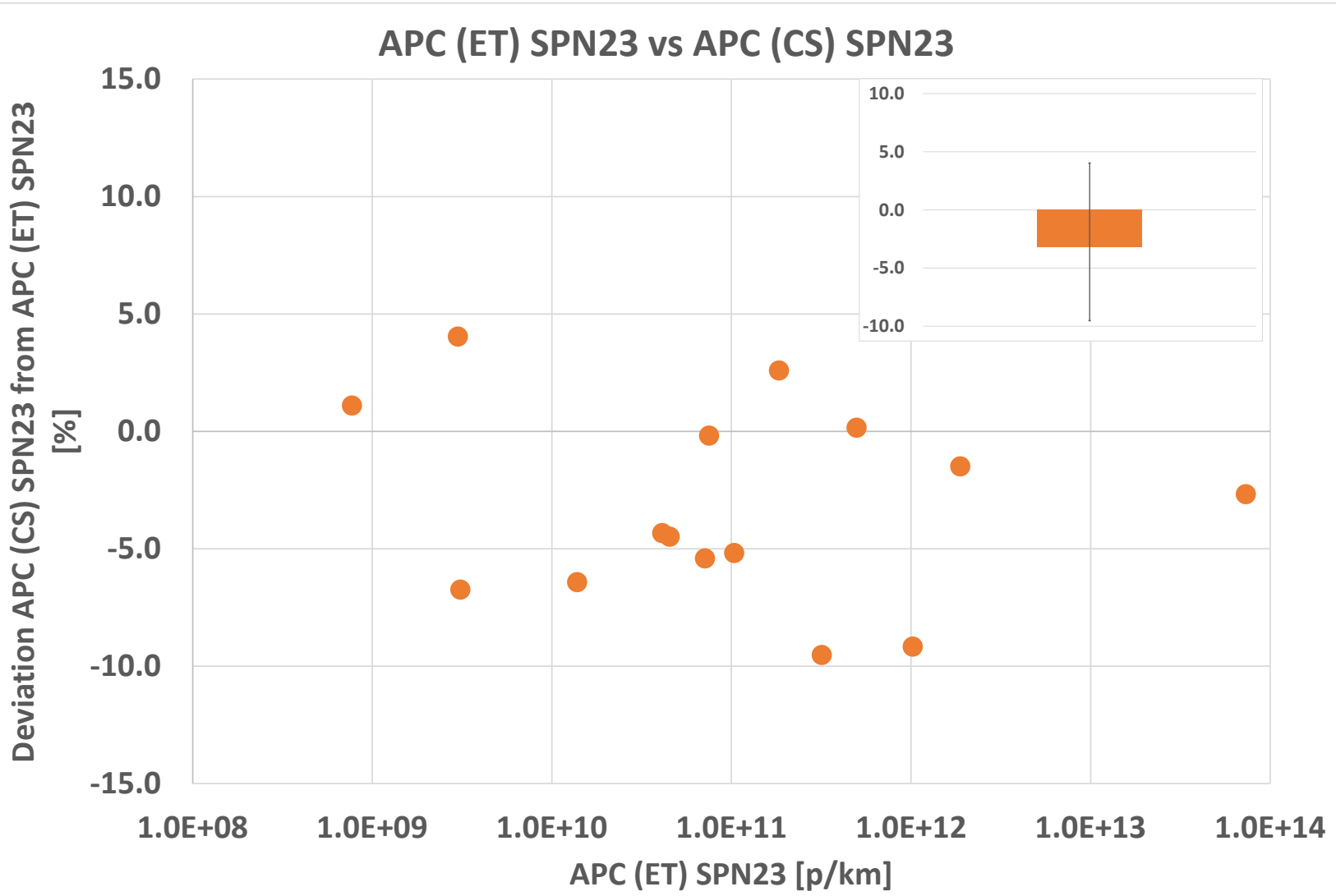
1 Introduction and Methodology

2 **Effect of the Catalytic Stripper on the SPN23, using APC Dual (10 & 23nm)**

3 Conclusion



# APC (CS) SPN23 vs APC (ET) SPN23



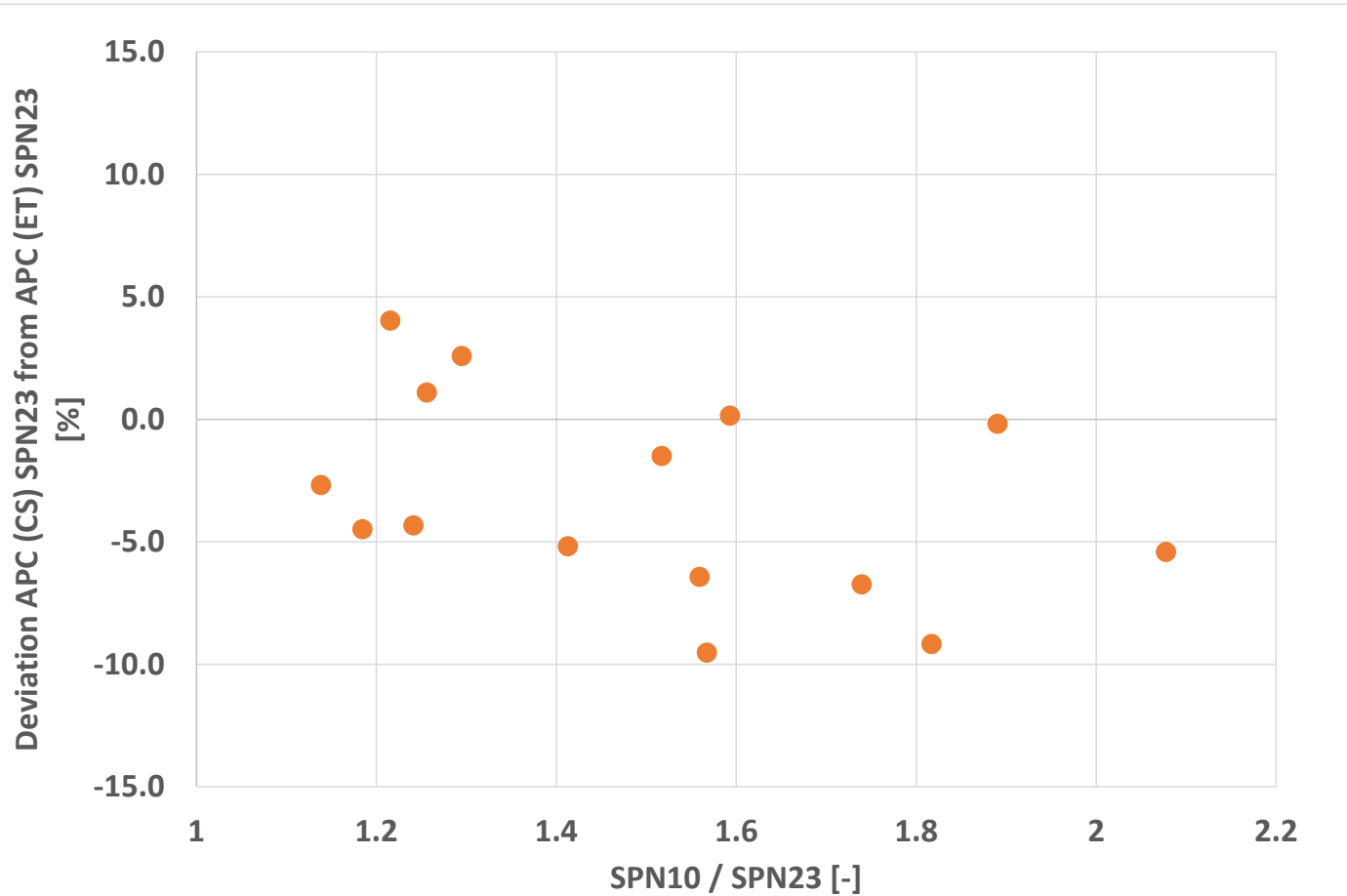
**Deviation** APC (CS) SPN23 from APC (ET) SPN23 for 15 Driving Protocols ranged from -10% to +5%, with an average of -3%

Such levels are similar to experimental uncertainties observed with existing ET-based PMP systems of the same design ( $\approx \pm 10\%$ ).

→ **No significant deviation** between APC (CS) and APC (ET) for **SPN23** noticeable!



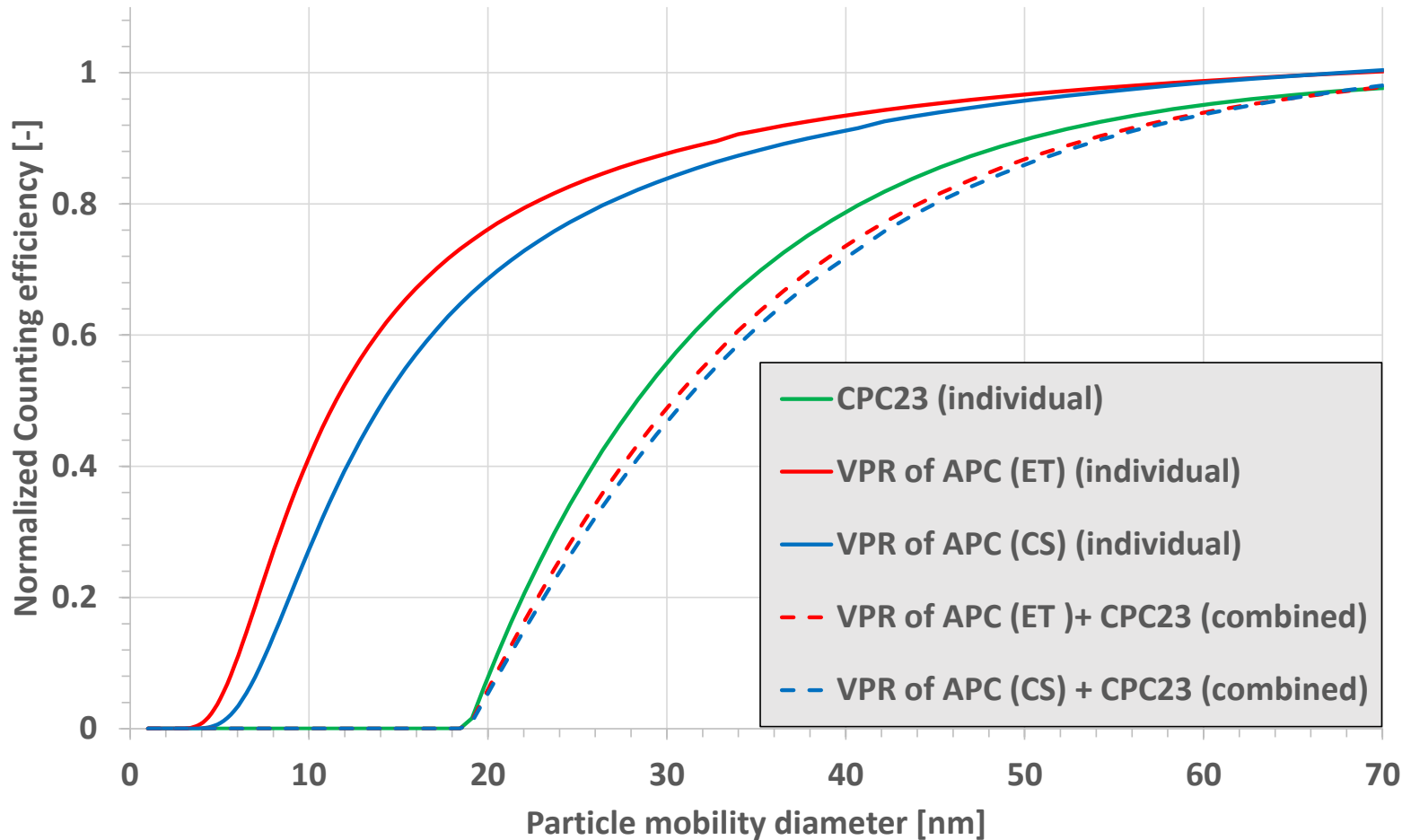
# Effect of CS on SPN23 vs the ratio SPN10 / SPN23



- The ratio of SPN10 to SPN23 offered by the dual APC provides some information on the size of the emitted particles over the cycle. A large ratio indicates smaller particles.
- No clear trend of the deviation on the SPN10/SPN23 ratio could be identified.
- ➔ This further suggests that the effect of the CS on SPN23 does not depend on underlying particle size

# Theoretical Effect of CS on 23 nm systems

Theoretical counting efficiency vs particle diameter for APCs



Combined efficiency of a **23nm** PN system is dominated by the detection efficiency of the 23nm CPC.

**Differences** due to sampling losses between Systems with **CS and ET are marginal**, irrespective of the particle size.

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# Conclusions

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## APC (CS) vs APC (ET):

- The effect of the CS on SPN23 was experimentally verified to be within the experimental uncertainties ( $< \pm 10\%$ ).
- The deviation remained small even at very high SPN10/SPN23 ratios implying that the effect does not depend on the underlying size distribution. This is because overall system counting efficiency is dominated by the CPC detection efficiency curve.
- The results justify the latest GTR15 amendment, allowing CS as an option for measuring SPN23.

Thank you



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