Understanding, Measuring and Regulating Sub-23 nm Particle Emissions from Direct Injection Engines Including Real Driving Conditions

Project status

A. Tsakis

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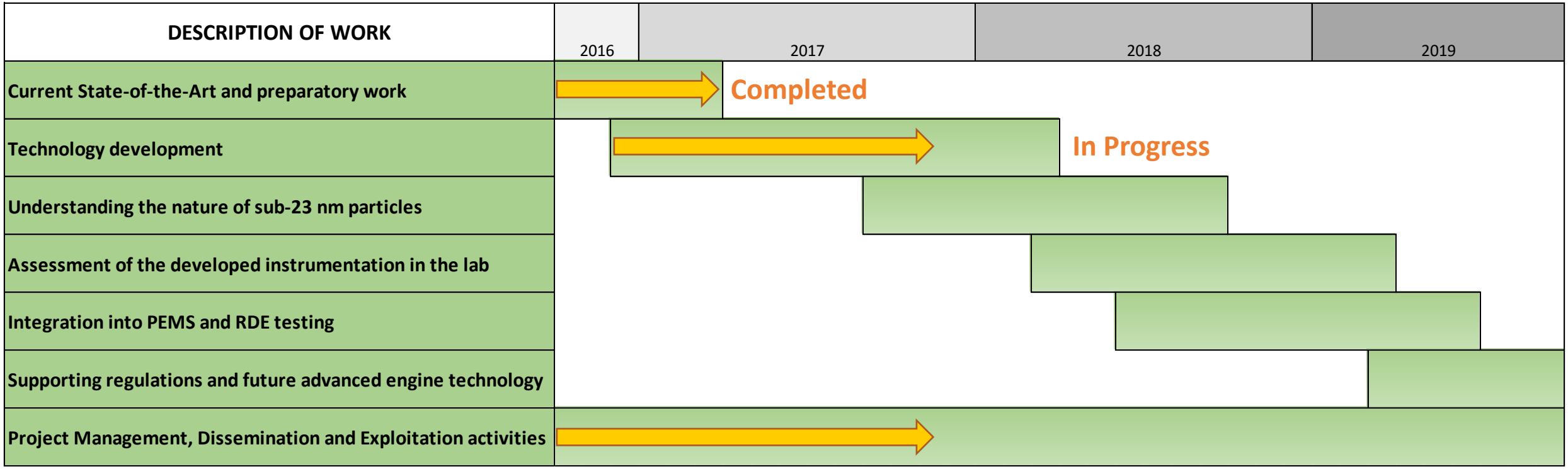
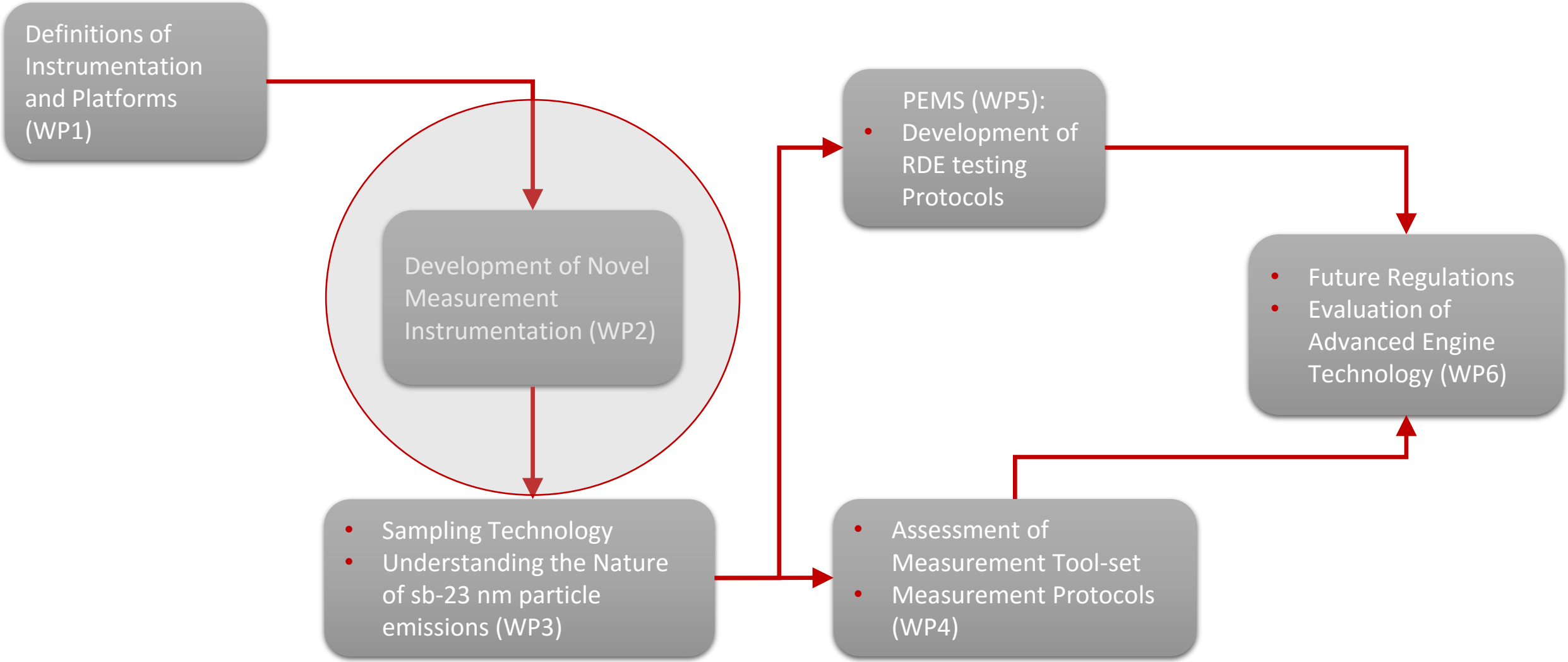


- Deliverables are on schedule.
- Two measuring technologies are in the evaluation phase. Another two at prototyping phase.

Project Work Plan



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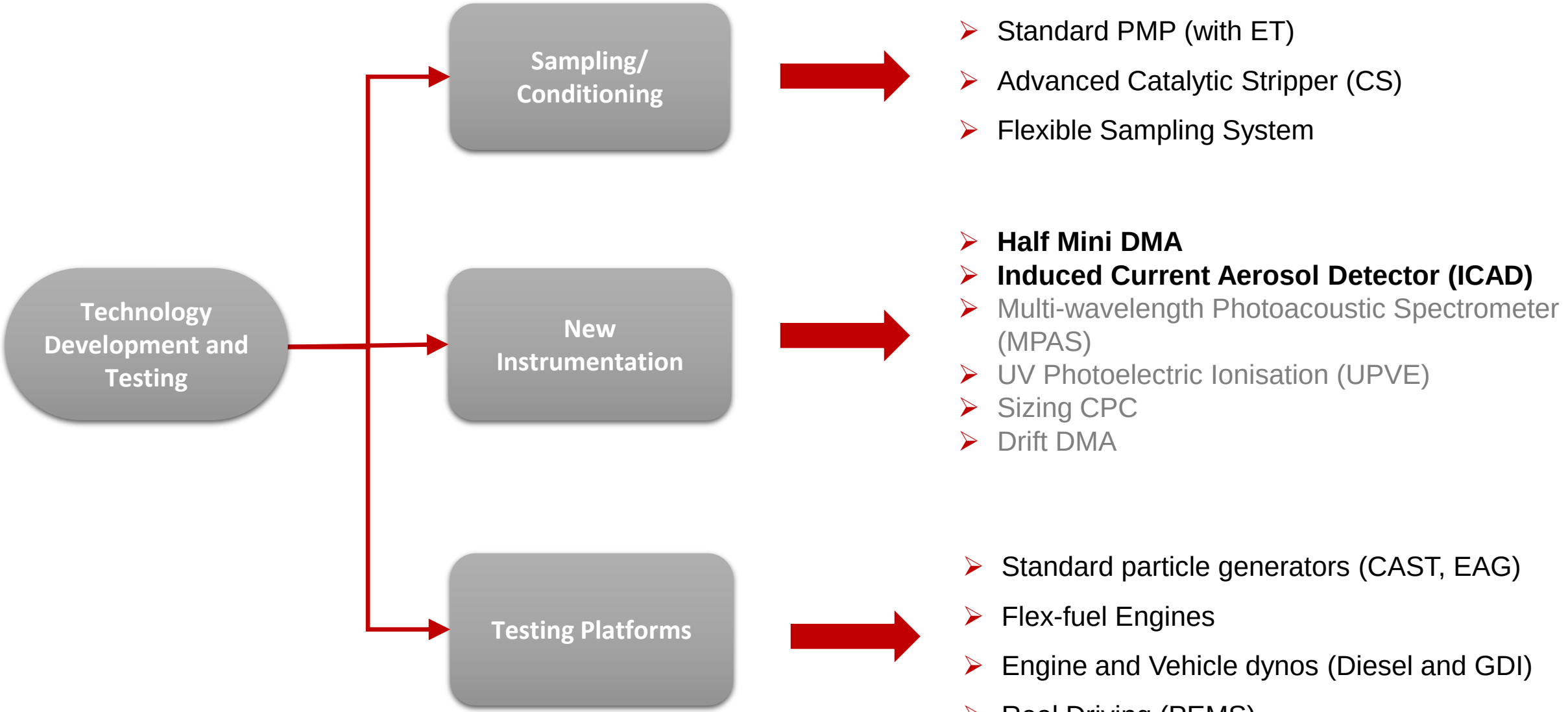
Measurement technology development



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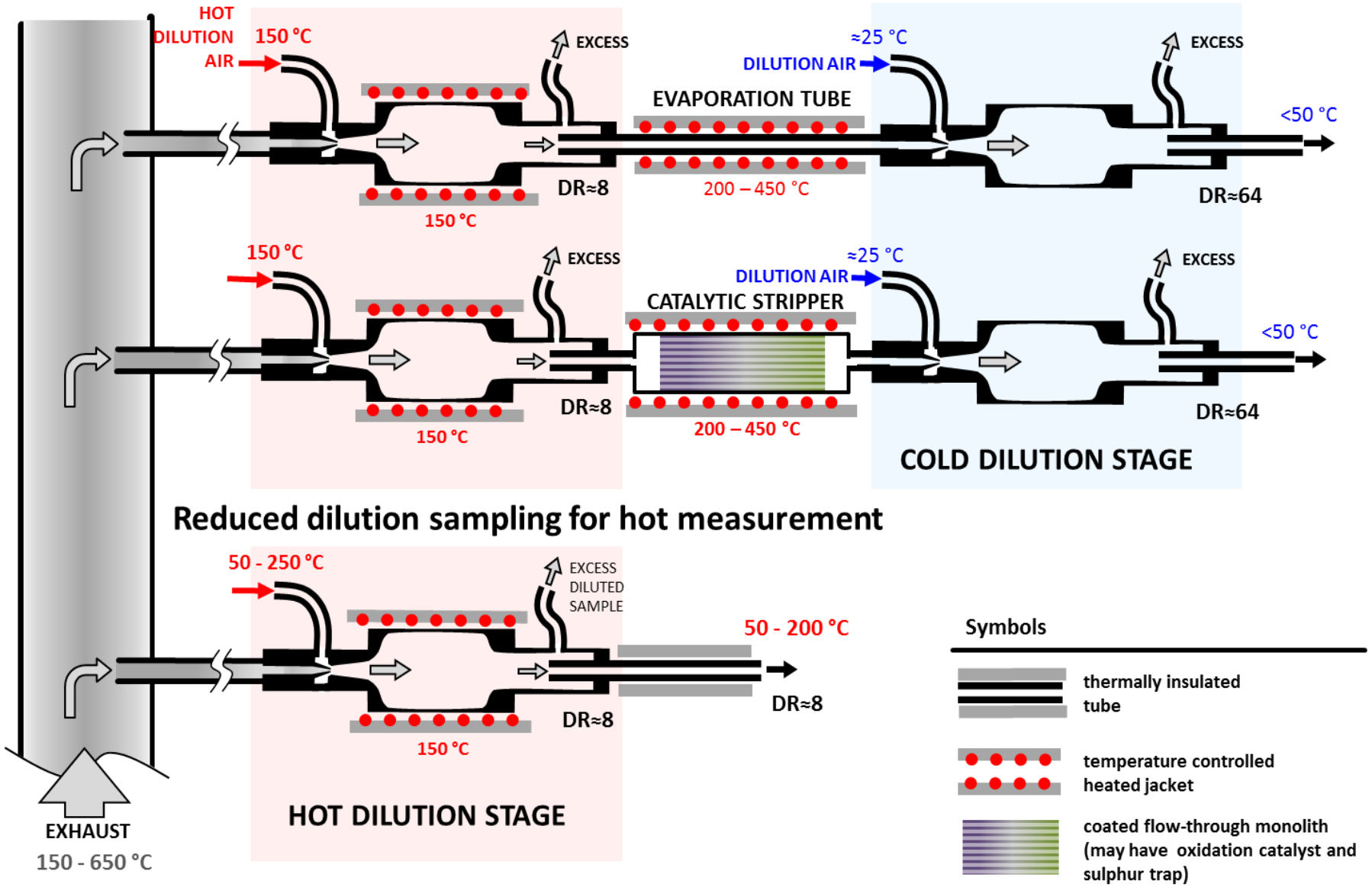
Sampling / Conditioning



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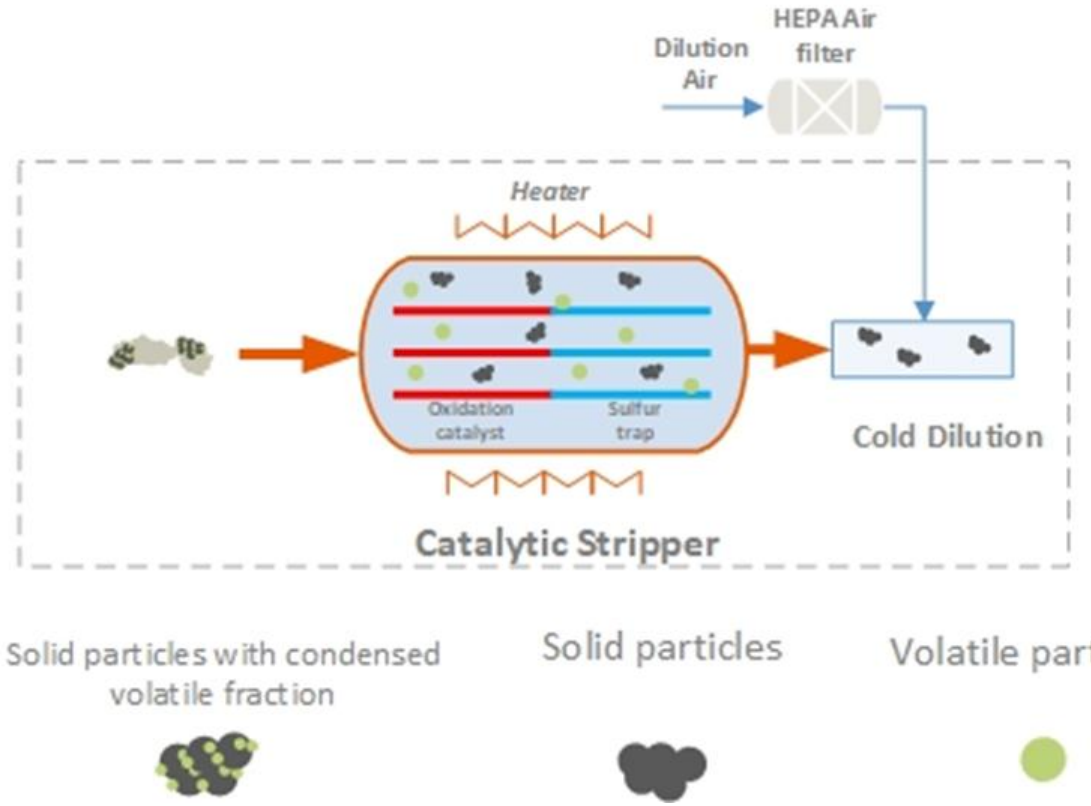
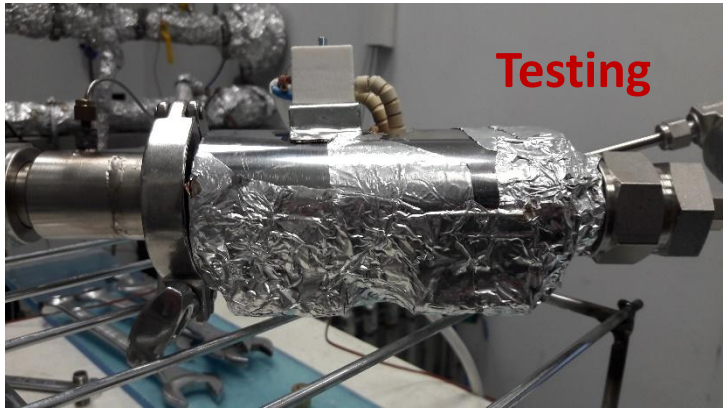
Catalytic stripper development



- A plethora of mixed oxides were synthesized and tested for their SO_2 adsorption capacity
- A double function monolith was impregnated with the most efficient powders and addition of Pt



- C40 removal efficiency
- SO_2 adsorption
- Solid particle penetration

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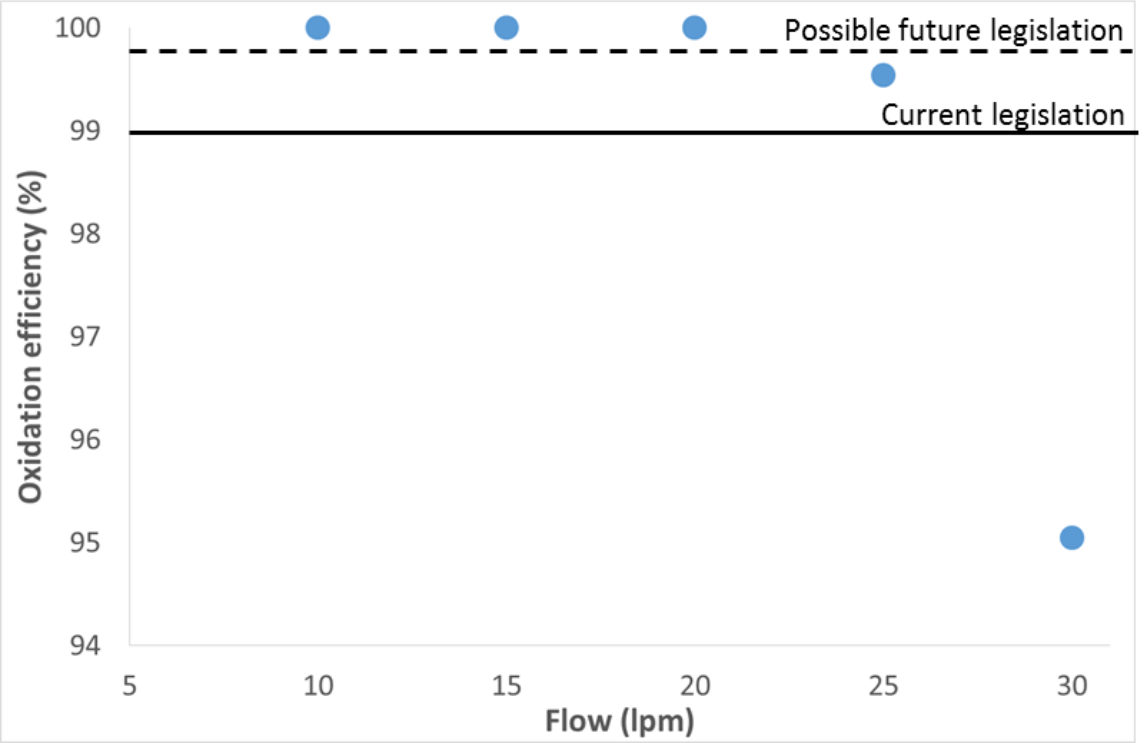
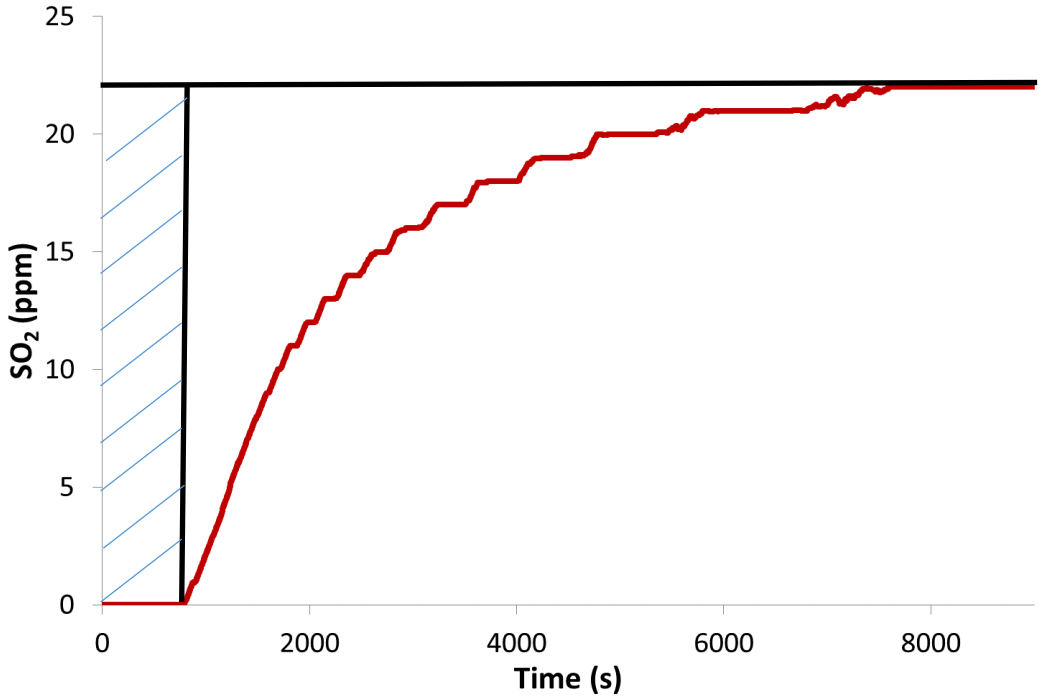
Catalytic stripper development



The catalytic stripper meets the current but also possible future PMP demands with **>99.9% oxidation efficiency** up to Q=20 lpm for concentrations >10^6particles/cm^3.



- The complete **S adsorption** capacity is 3.5mg or 0.27g/l of catalyst volume while the overall 11.8mg or 0.91g/l.
- CS completely adsorbs SO2 for approximately **250 NEDC cycles in raw exhaust** (no dilution).

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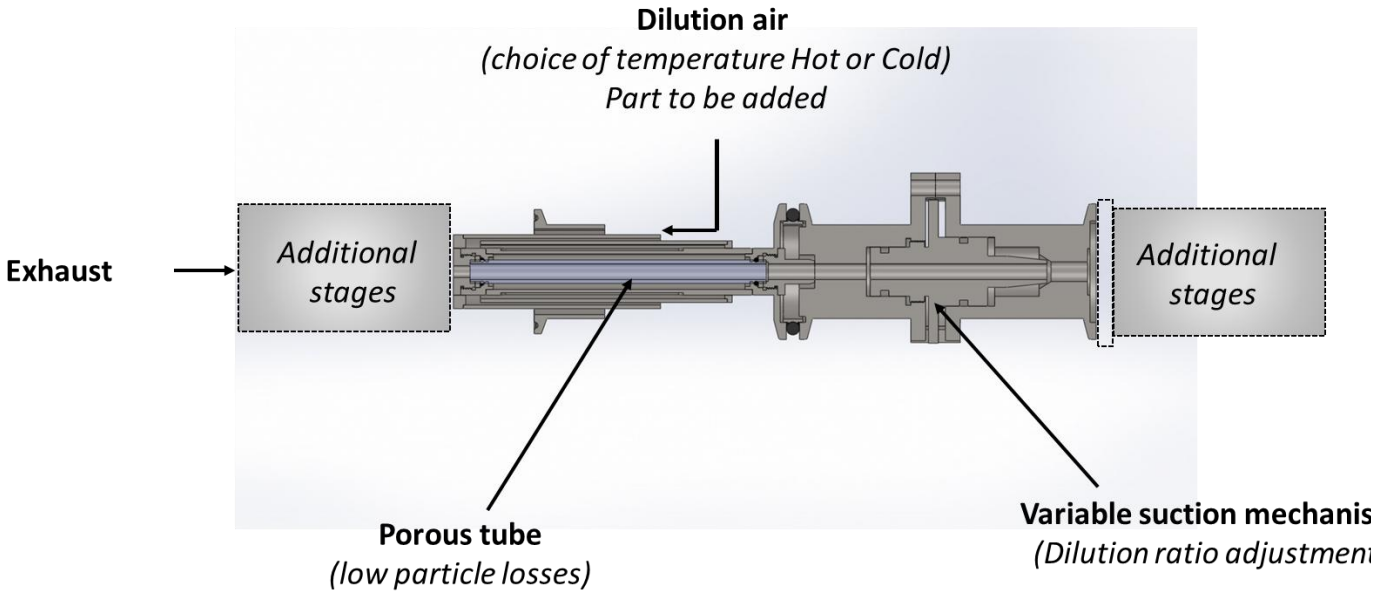
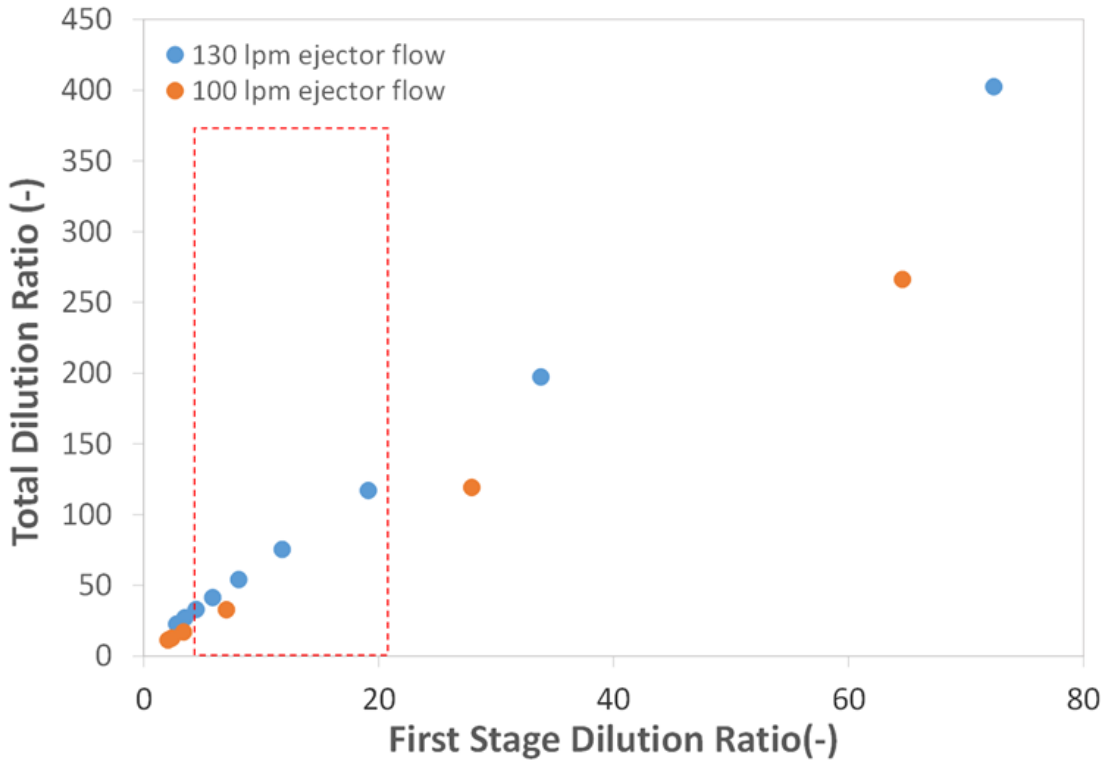
Dilution system with variable DR

The system developed can operate in a wide variety of DRs (10-400) and can host additional dilution stages and/or volatile treatment devices.





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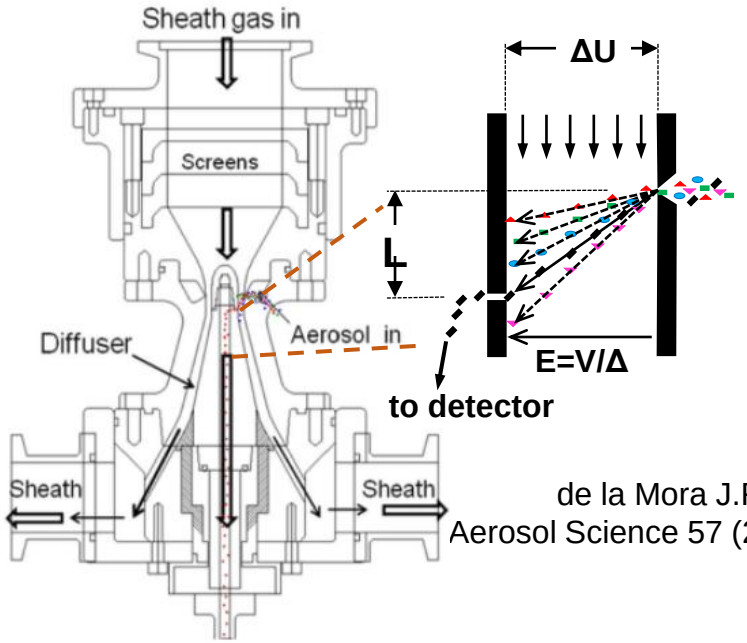
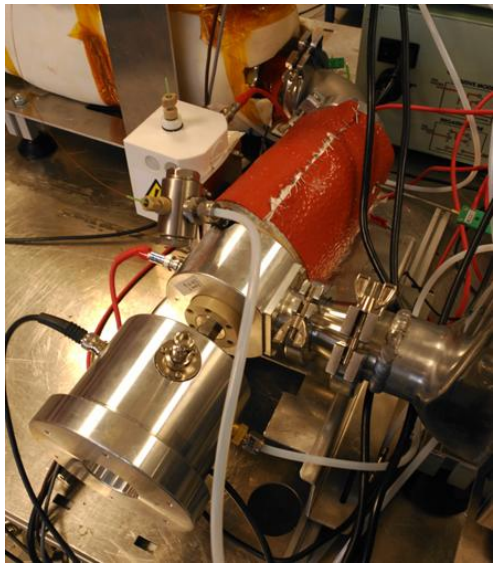
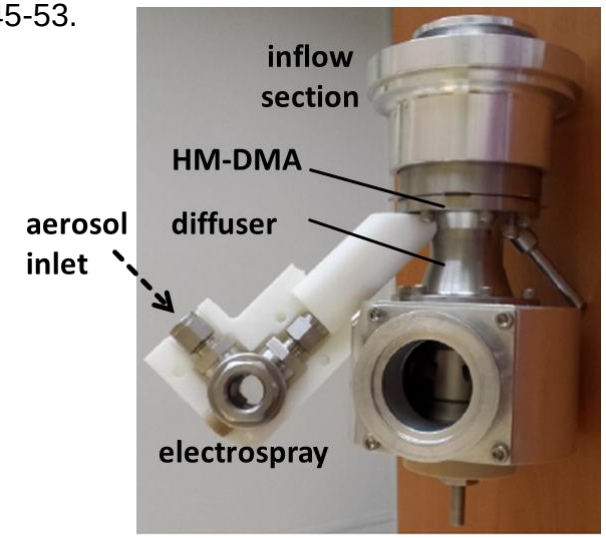
The Half-Mini DMA



de la Mora J.F., Kozlowski J., Aerosol Science 57 (2013) pp.45-53.

- Capable of operating up to 200 ° C.
- High resolution below 20 nm.





- **Reduced exhaust aerosol conditioning**:
  - Less dilution (cold dilution obsolete)
  - Fewer / smaller / lower power consuming devices for sample conditioning
- **Practical advantages**:
  - Easier to detect low sub-23 nm particle concentrations.
  - Fewer diffusive particle losses.
  - Measures both positively and negatively charged particles.

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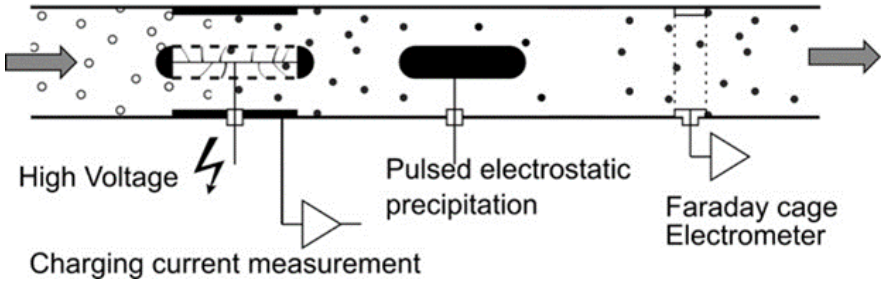
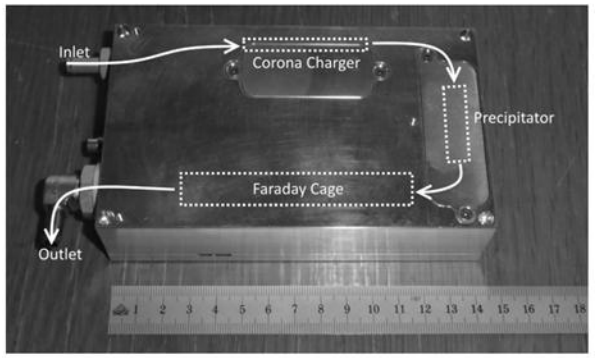
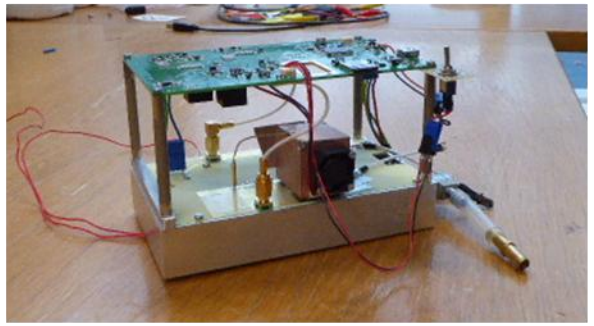
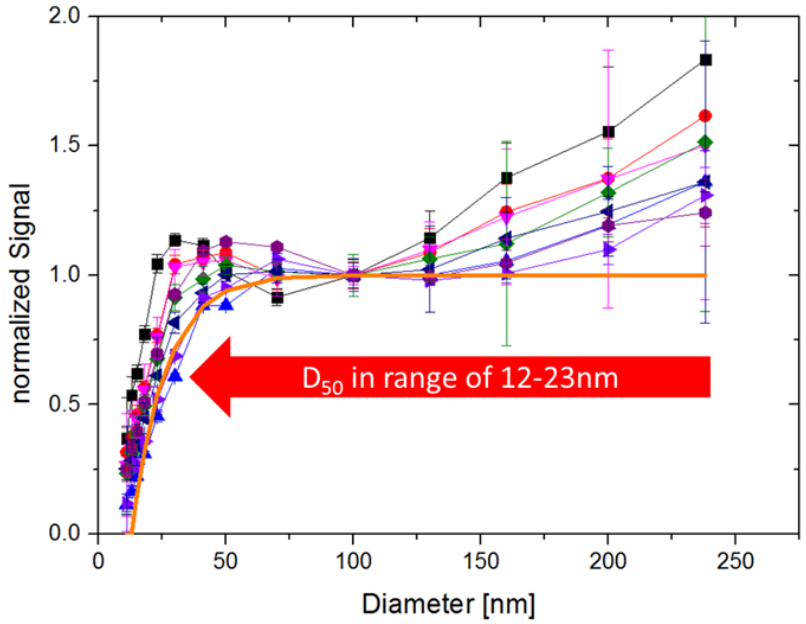
Automotive Induced Charge Aerosol Detector (ICAD)

The concept of Diffusion Charging



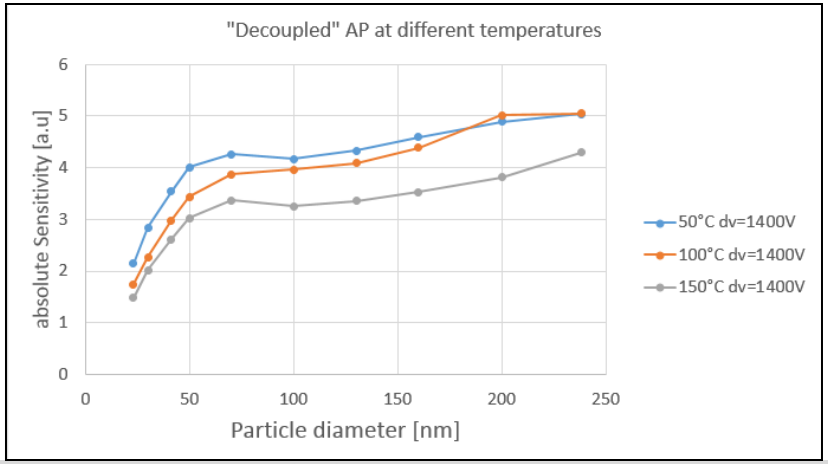






The goals achieved

- Operate at high temperature (150^{0}C) to allow minimum dilution
- 50% counting efficiency at 11.5nm
- Absolute sensitivity increased



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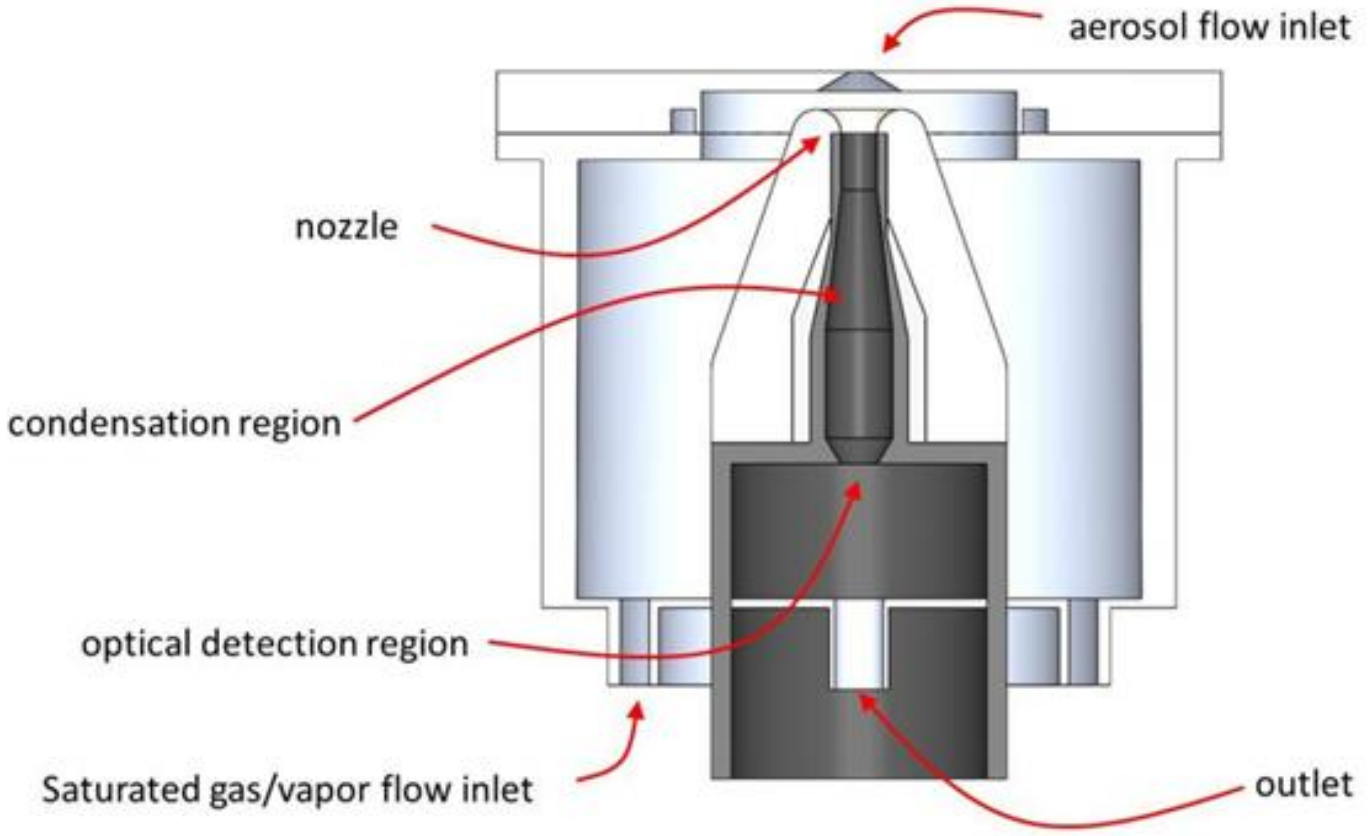
Sizing CPC (S-CPC)

- Real-time measurements of number concentration and size.
- Cumulative particle concentration measurement.
- Support/advisory help from Yale University.
- Design finished
- Manufacturing has started.
- Fist check with monodisperse samples.



S-CPC schematic (SEADM)

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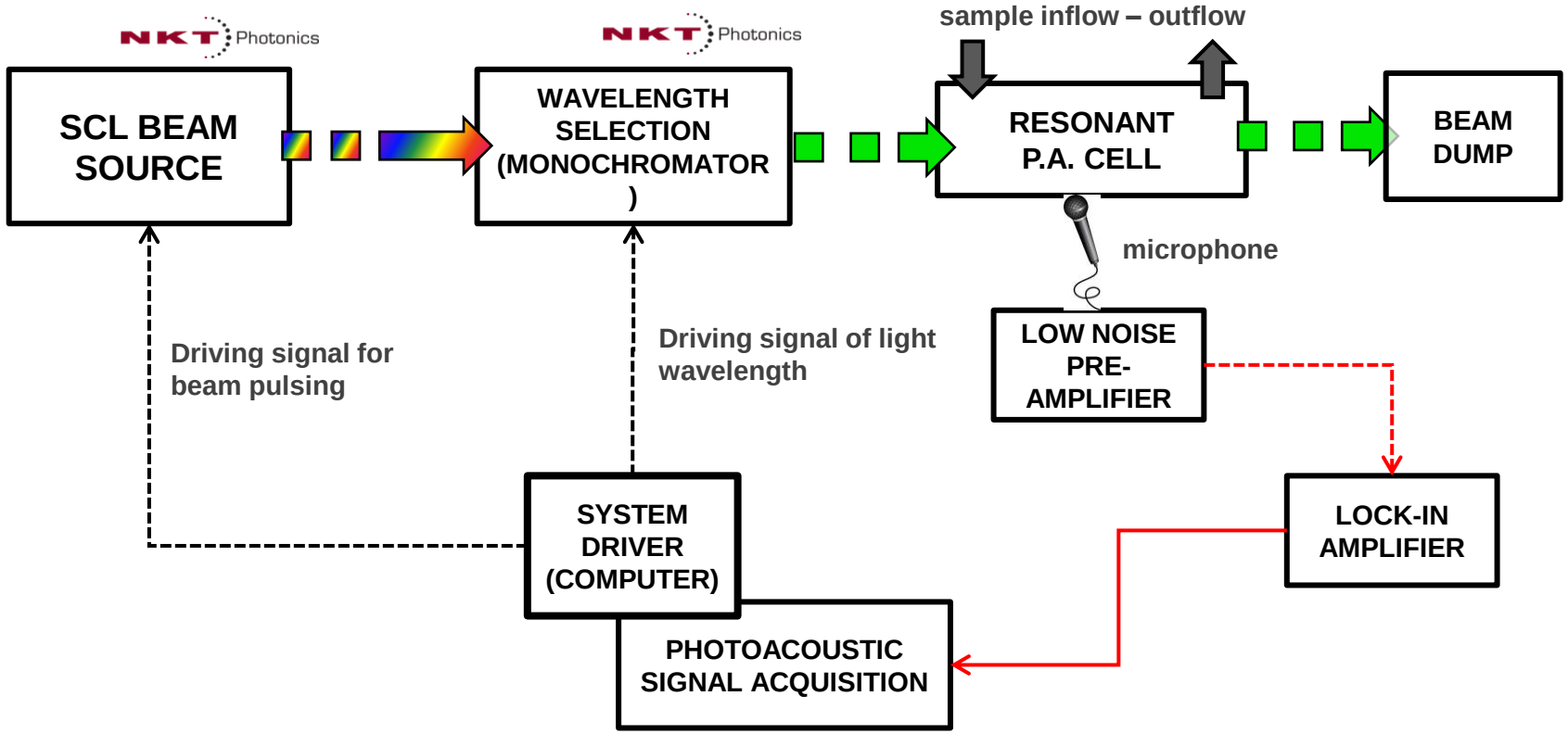
Supercontinuum laser multi-wavelenght photoacoustic aeroslosspectroscopy (SCL-MPAS)

- Laser pulsing controlled electronically via the super-continuum laser source
- Wavelength controlled electronically via the monochromator
- Acoustic excitation frequencies ≈ 2 – 4 kHz considered.
- Wavelength range considered: 400 – 840 nm (700 – 840 nm is in IR spectrum)



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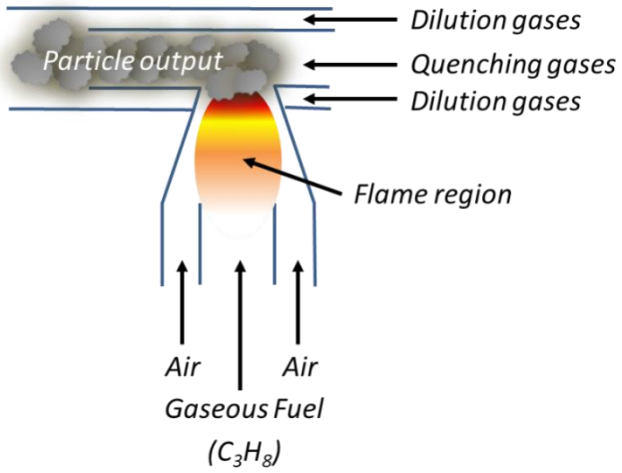
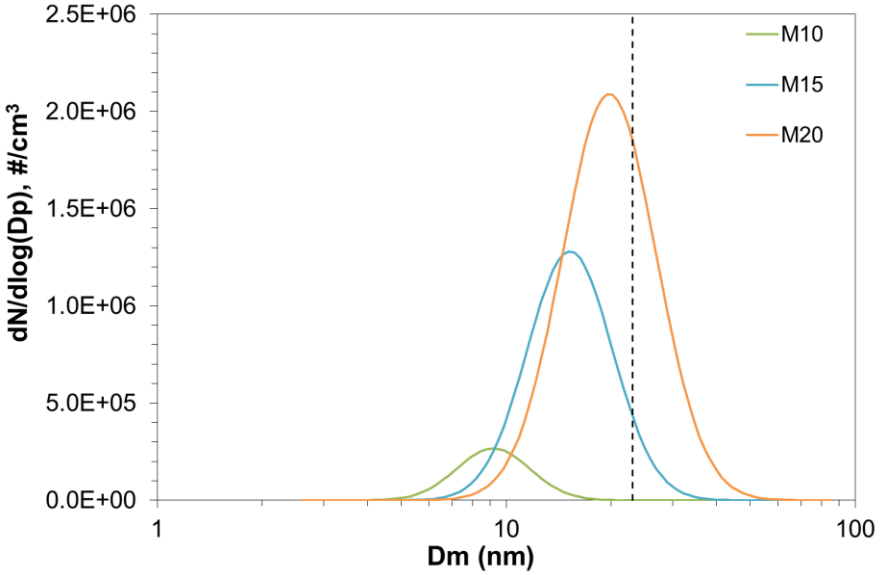
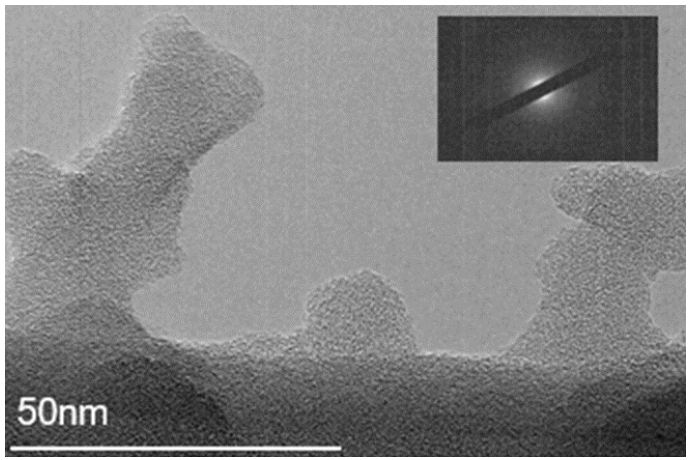
Testing with CAST Particle Generator

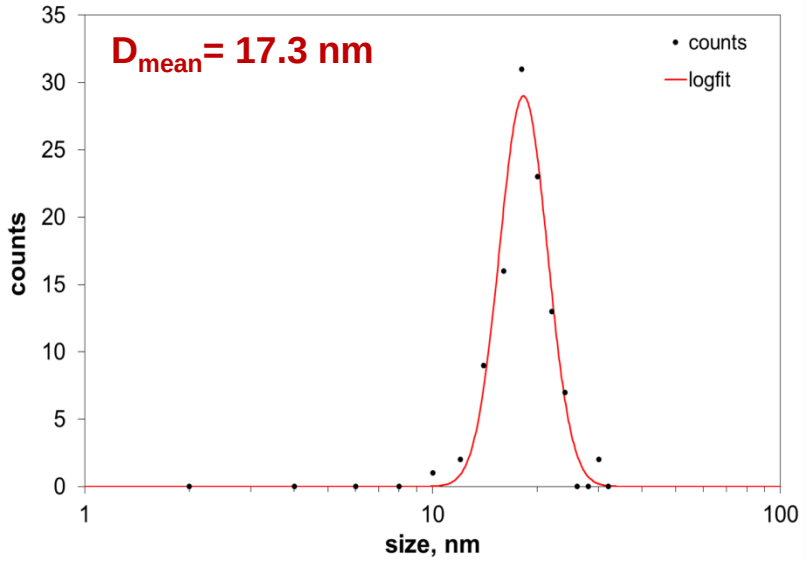
- CAST produces aerosols with user tailored characteristics by fine tuning the flow rates of the oxidation/quenching gas mix





- Nanoparticles are amorphous, lacking a well defined perimeter, exhibiting a semi-solid nature of elliptical/spherical shape
- Image analysis showed that particle sizes lie in the range of 10-30nm, with a mean value of 17.3nm





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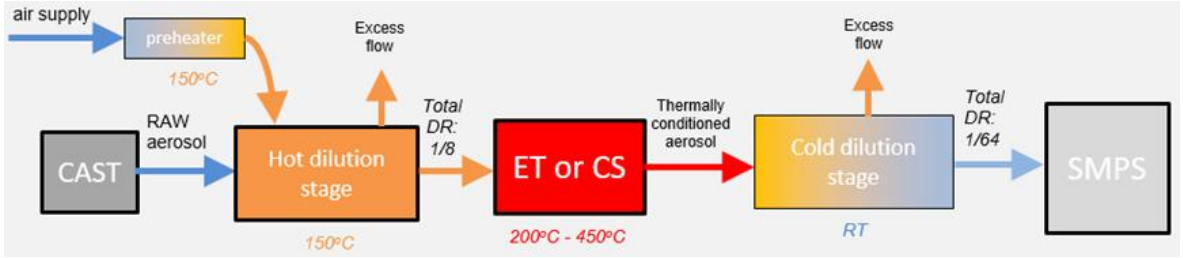
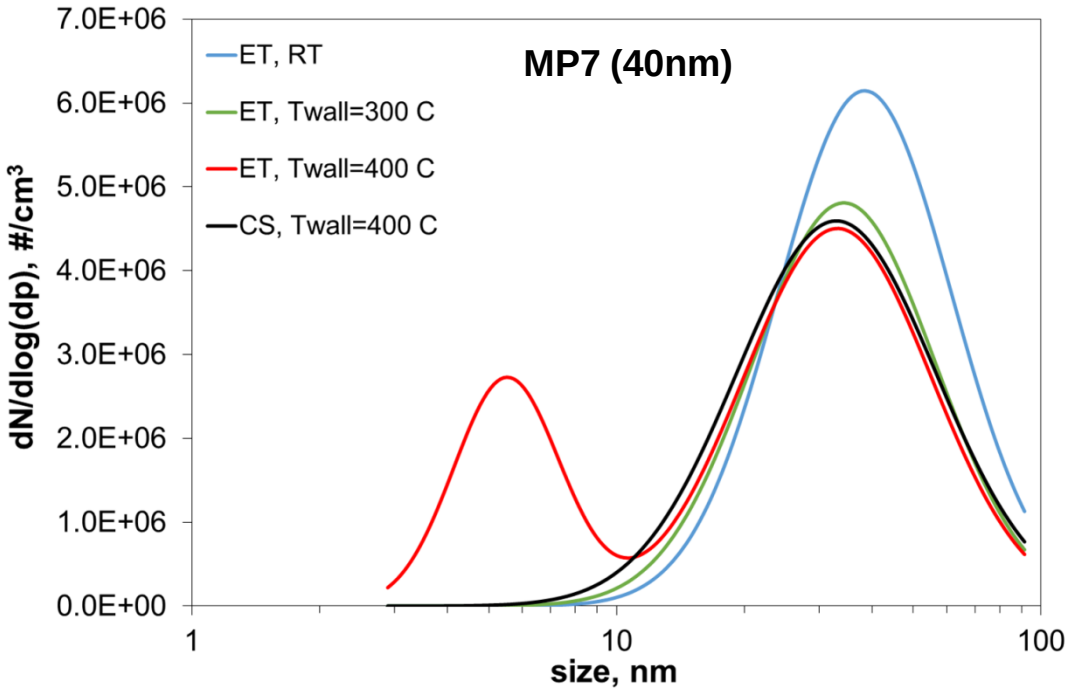
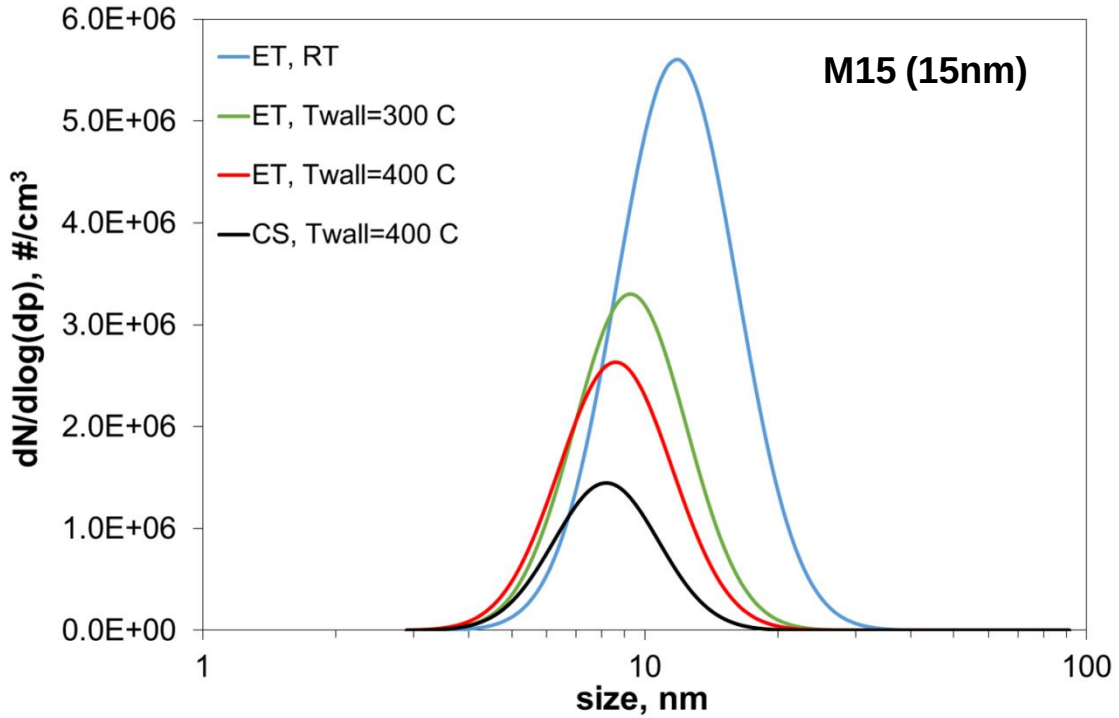
Testing with CAST Particle Generator





With ET a mode occurs at ~6nm for T_{wall}>350°C (artefact?)



More severe particle shrinkage (reach up to 1/3 of the initial particle size) than for bigger sizes

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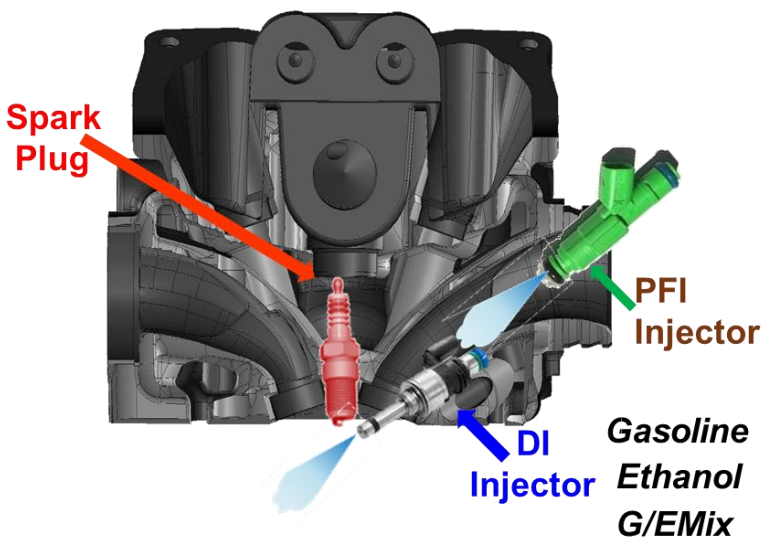
Testing platforms for instrument evaluation

- **Vehicle Testing on chassis dyno**
  - Euro 6 Diesel
  - Euro 6 Gasoline with Direct Injection
  - Euro 6 Gasoline with Direct and Indirect Injection



- **Vehicle Testing on road**
  - Euro 6 Diesel
  - Euro 6 Gasoline Direct Injection Engine

- **Portable emissions measurement system (PEMS) instrumentation**

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Next steps

- Finish developments for all proposed instruments.
- Perform measurements to a variety of testing platforms (Test Matrix).
- Chose among best solutions for PEMS application.

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Thank you for your attention!

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