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# Nanoparticle generation potential of summer and winter tyres at varying ambient temperatures

29th NPC 02.06.2026 Carsten Neukirchen

der Bundeswehr
Universität München

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Zentrum für Digitalisierungs- und Technologieforschung der Bundeswehr

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# Introduction

Formerly Tyre wear was associated with producing mainly large particles

- Difficult to capture without proper enclosure of tyre and road interface
- Specialized measurement instrumentation needed (former CPC standard at 23 nm cutoff not suffiecient)
- Proper testing conditions play a vital role


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# Tyre dynamometer

- Add-on to existing infrastructure (Brake dynamometer)
- Roller from chassis dynamometer is pressed against tyre from the side
- Surface of roller consists of sintered metal, but can be  exchanged in the future to mimic road interface more accuratly
- Second enclosure around roller to minimize background concentrations


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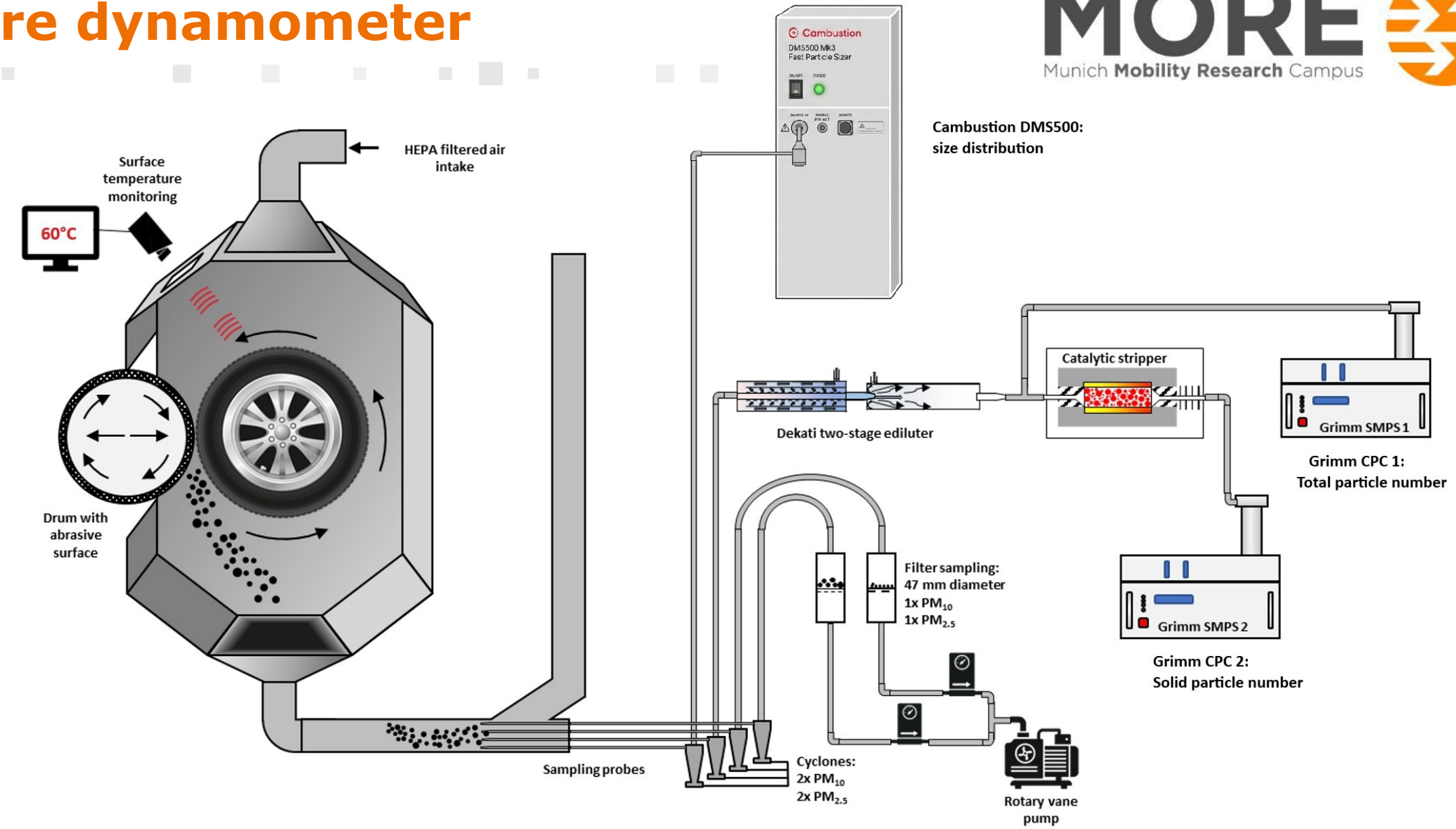
# Tyre dynamometer





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# Test parameters

| Emission source | Tyre wear |
|---|---|
| Simulated vehicle | SUV (1895 kg) |
| Test cycle | Custom cycle |
| Duration | 4.3 h |
| Total distance driven | 350 km |
| Average speed | 80.8 km/h |
| Temperature | 12 °C / 23 °C |
| Test components | Summer + Winter tyres from same premium brand |


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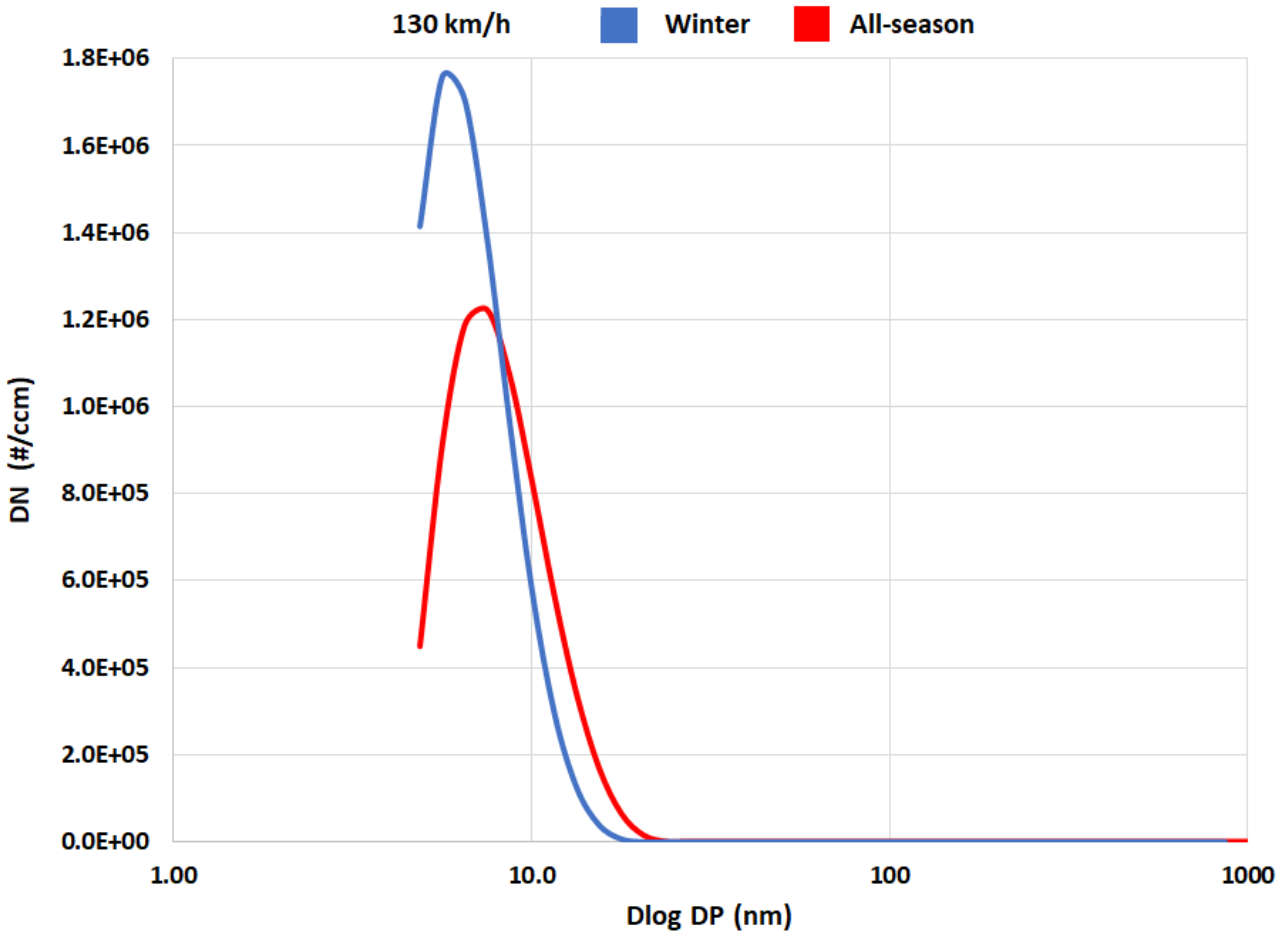
# Tyre wear - Nanoparticles

- For lower speeds also PN modes at 50 nm - 110 nm visible
- Both winter and all-season tyres show peaks around 10 nm at 23°C
- Warmer winters have led to increased share of all-season tyres, which are prone to produce NP during summer





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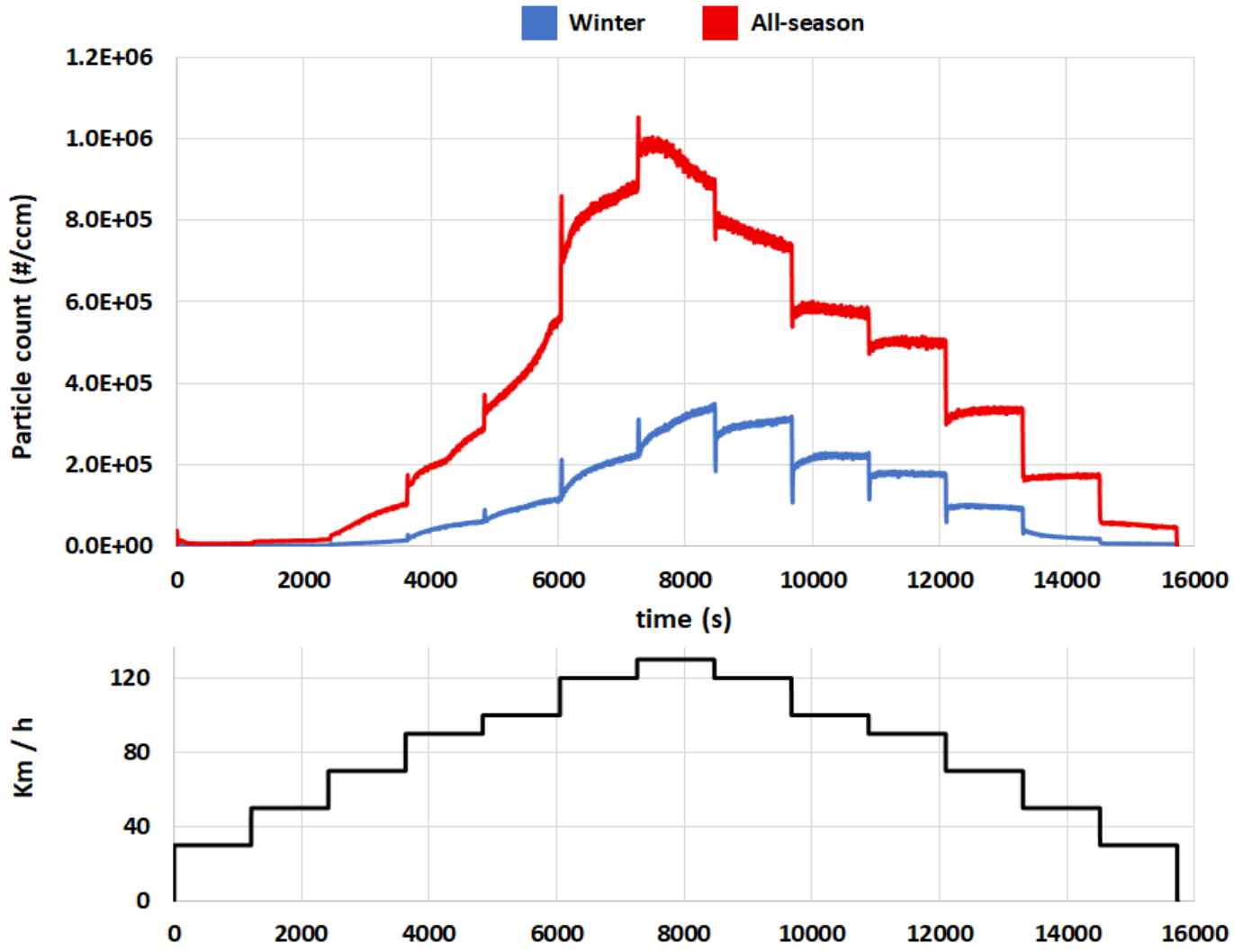
# Tyre wear - PN

- 3 orders of magnitude increase in PN from 30 – 130 km/h
- PN emissions unstable until thermal equilibrium is reached
- All-season tyre showed ~ 3 times higher PN





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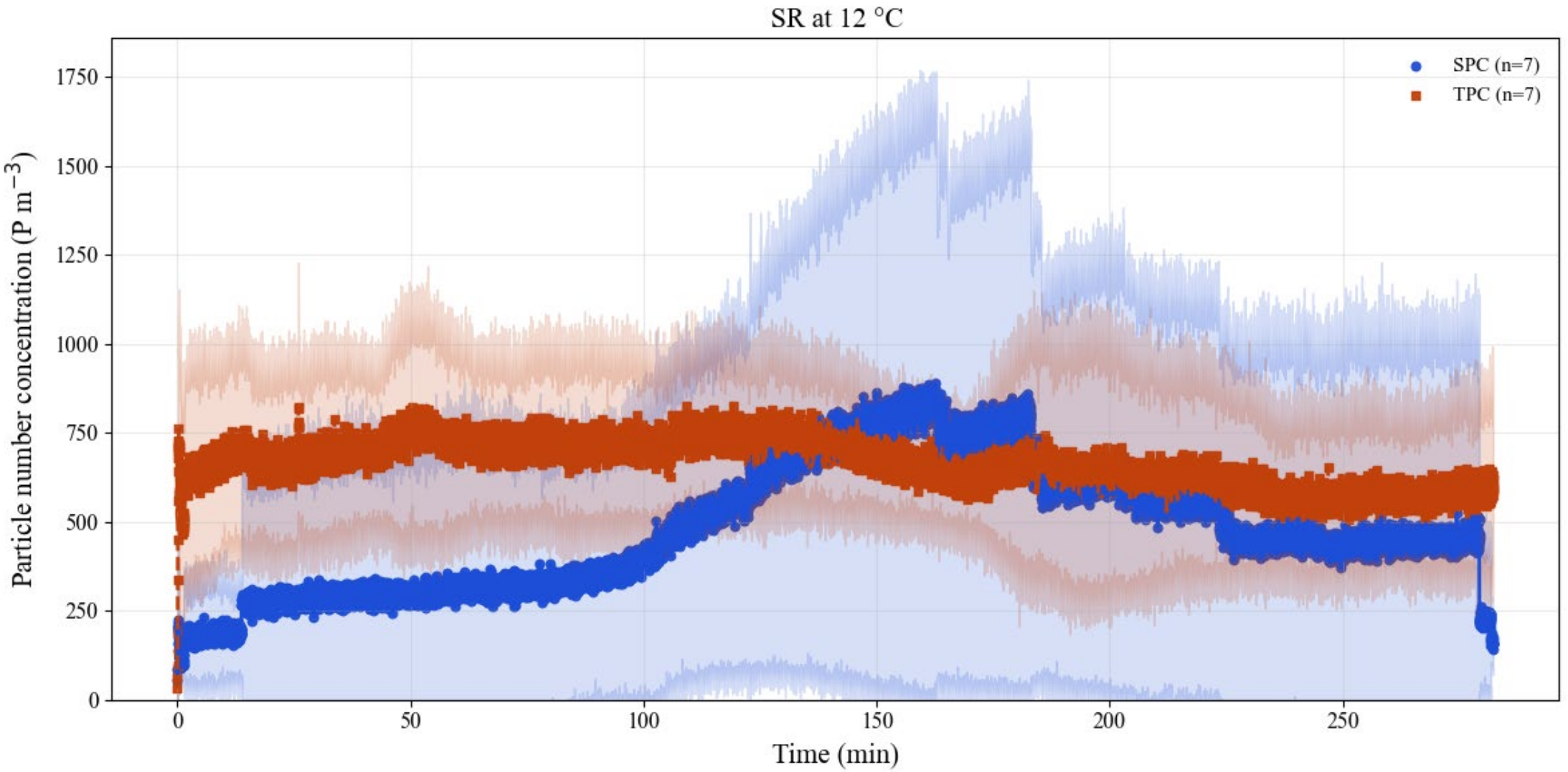
# Tyre wear - Overview





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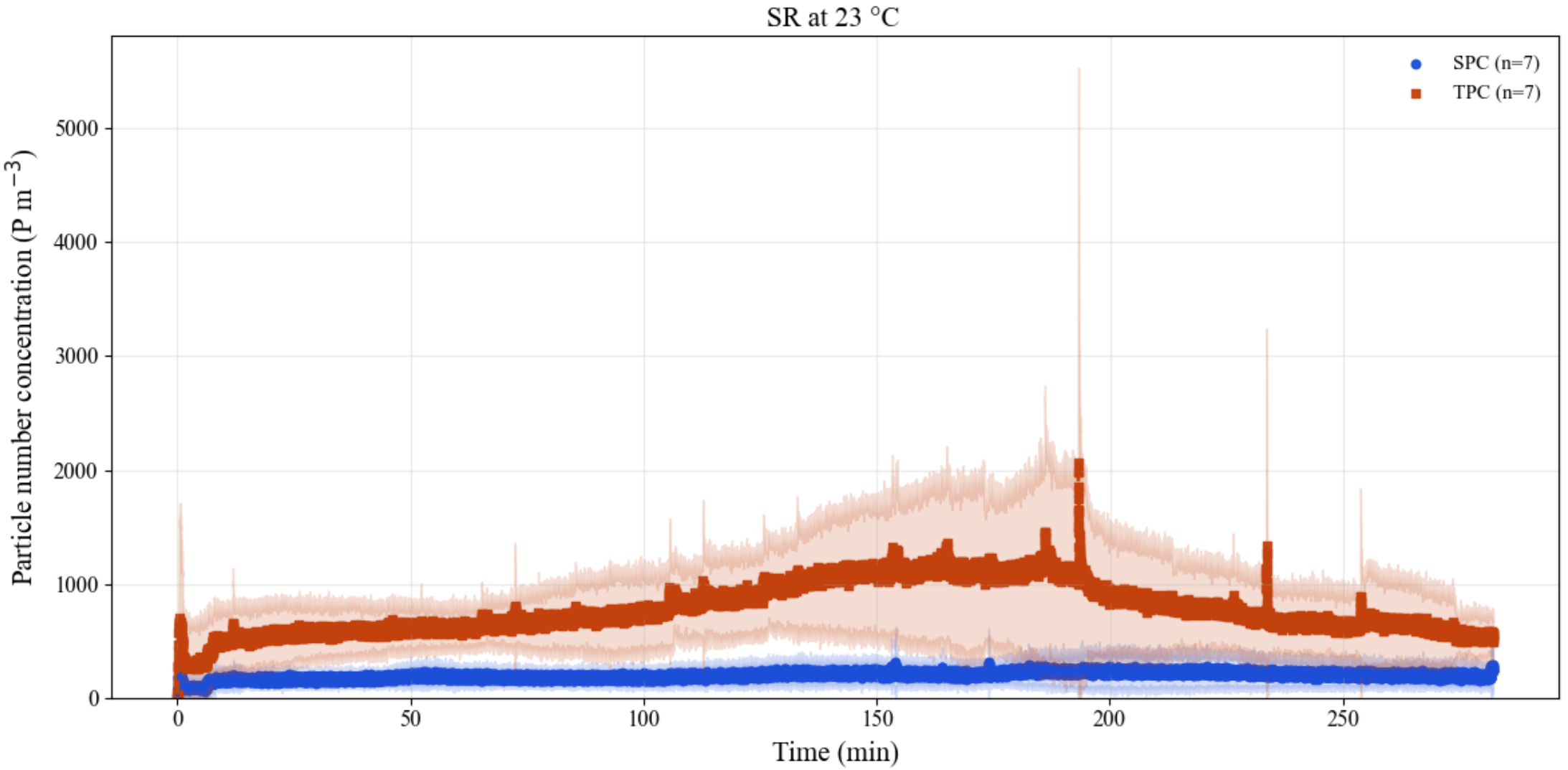



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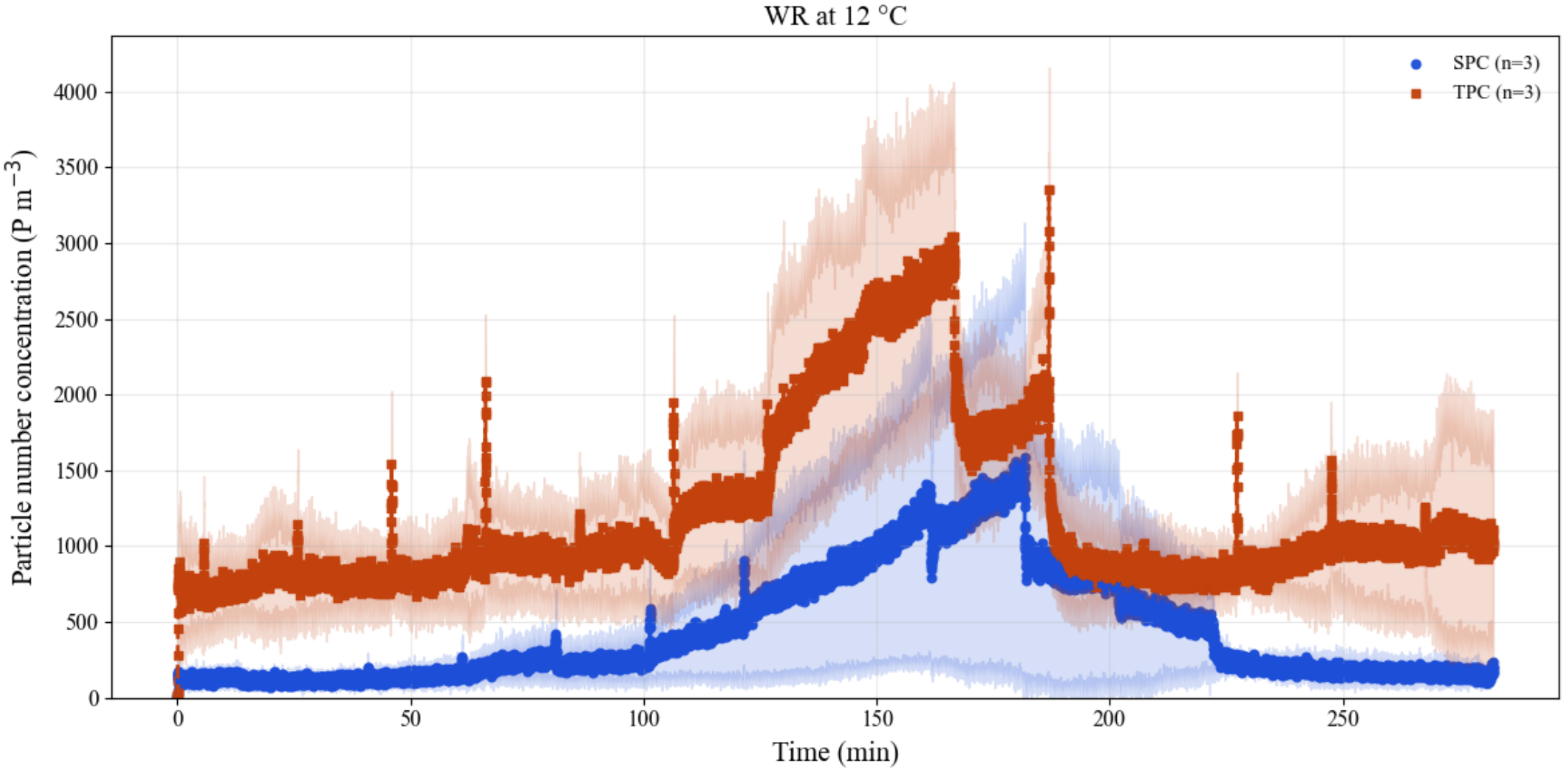



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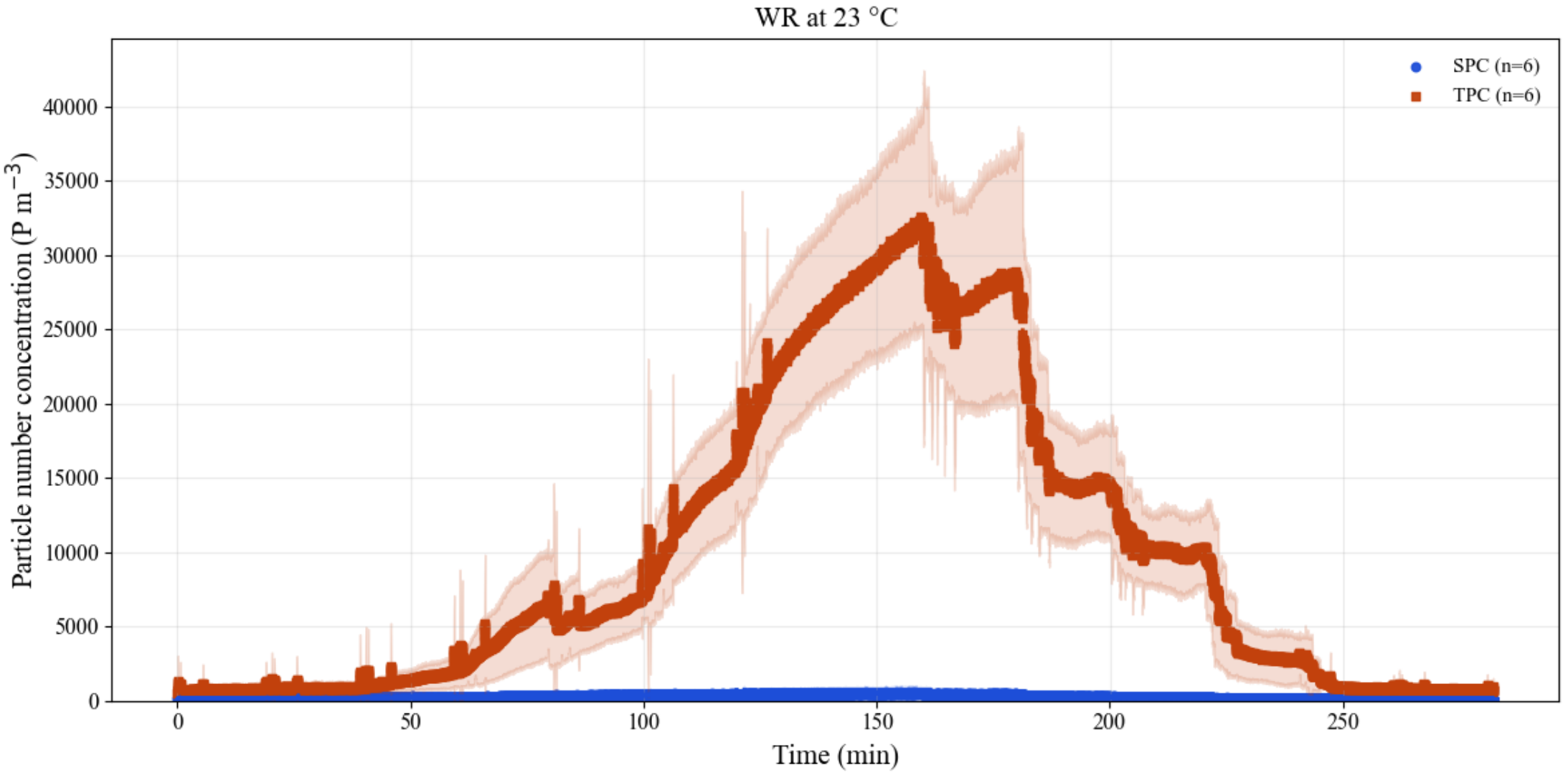



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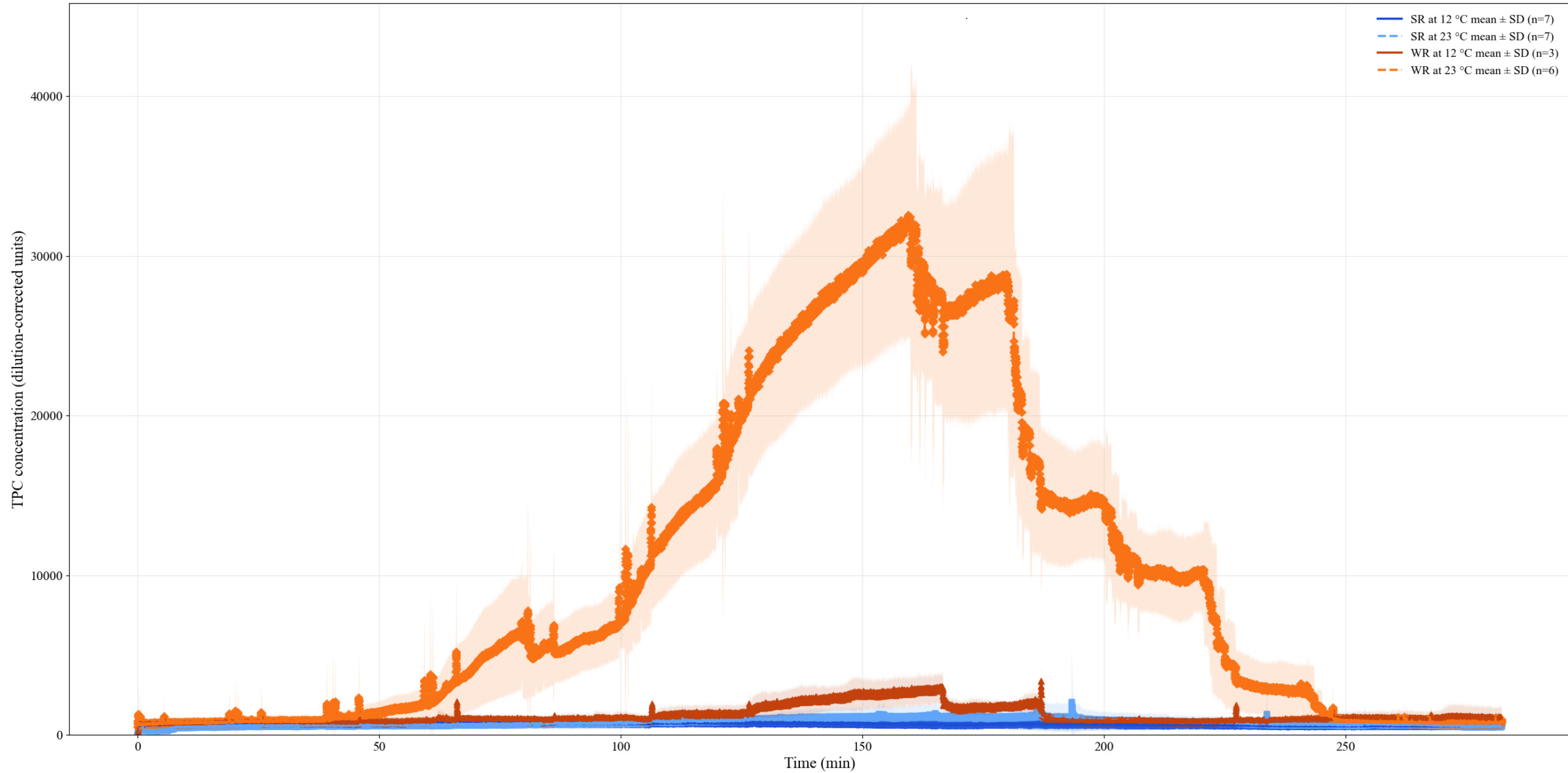




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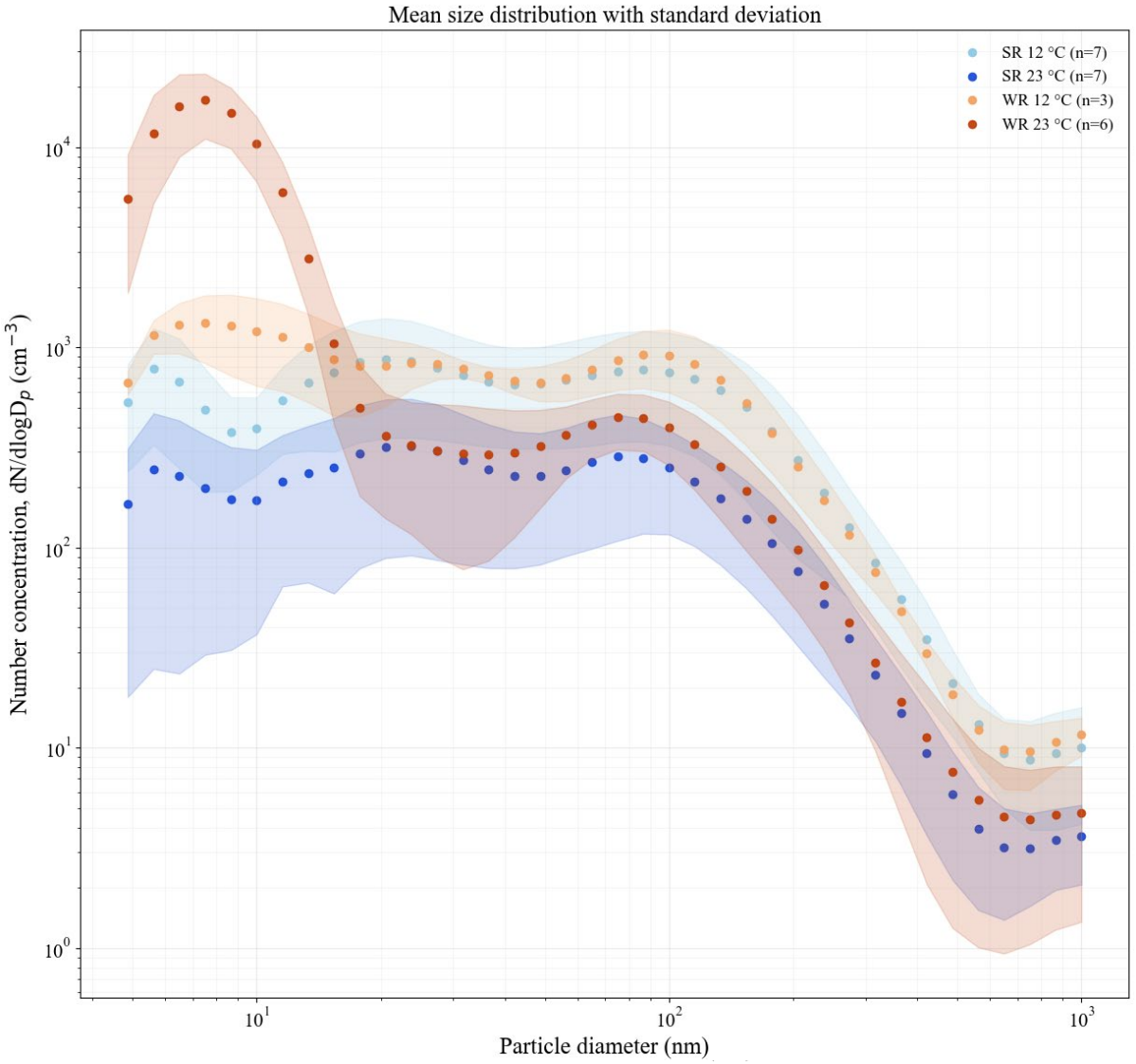


- 10 nm peak increases by 2-3 orders of magnitude above critical temperature
- Coarser modes higher for 12°C
  - change from abrasion to evaporation?


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# Outlook – Next steps

Dual approach:

Dynamometer :

- Identification of temperature dependance (Ambient & tyre surface)
- Influence of both temperatures on emitted PN and size distributions

Lab setup :

- Measurement of generated particle number and sizes under controlled heating rates
- Comparison of complete tyres, raw materials (e.g. NBR or SBR) and additives (6-PPD) to appoint individual potential to generate volatile NP


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# Conclusion

- NP potential of tyres is heavily dependent on temperatures
- Critical temperature needs to be studied in more detail
- High numbers of NP can be generated under environmental relevant conditions
- Generated particles are predominantly volatile
- Increasingly hotter summers and milder winters in combination with growing percentage of all-season tyres could enhance the problem


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# Thank you for your attention!

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