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Evolution of Traffic-Related Atmospheric Pollutants Near Roadways

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Background

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- Traffic-related atmospheric pollutants (TRAP) are believed to adversely impact the health of populations living and working near roadways.
- Approximately 4 million (~13%) Canadians live within 100 m of a major road.
- Estimation of the exposure of these populations to TRAP in challenging as concentrations of TRAP vary both spatially and temporally.

Objectives

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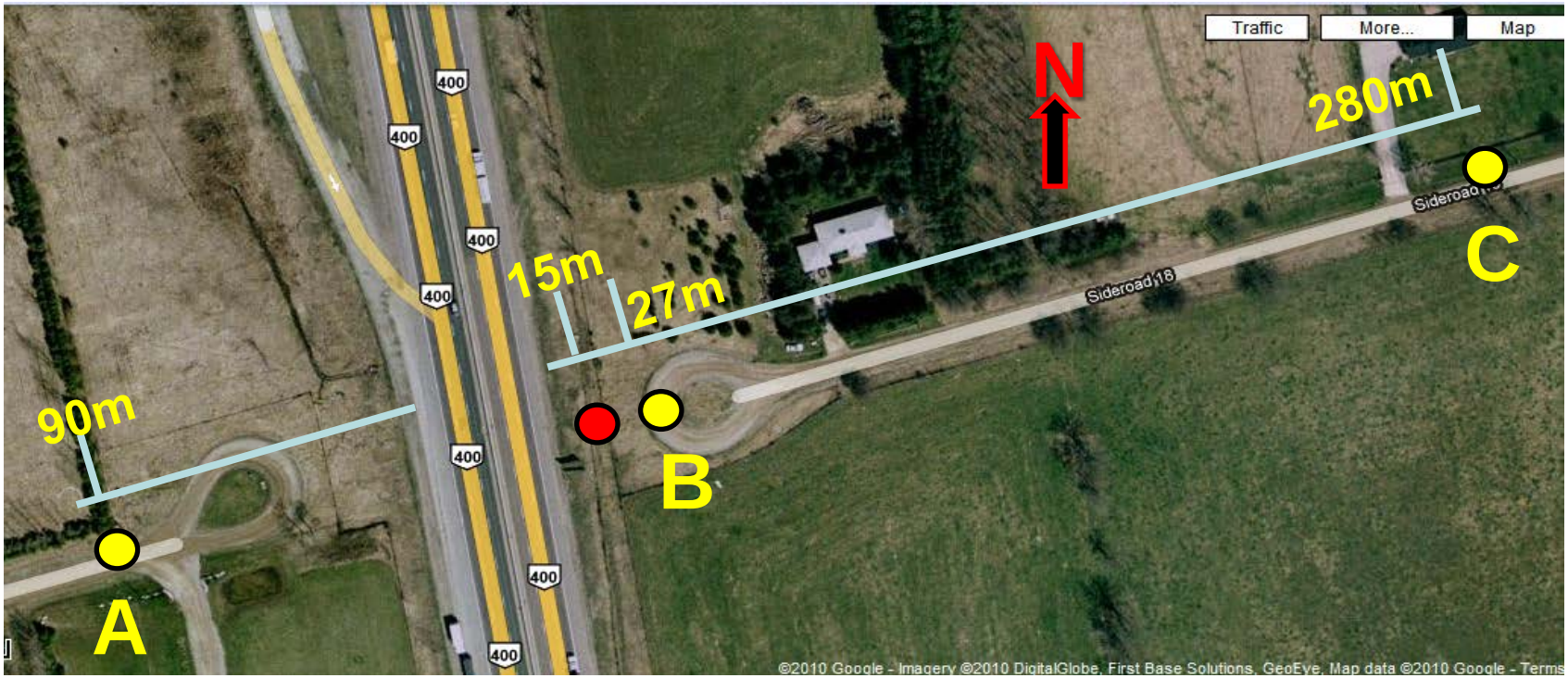
- To evaluate concentration gradients of traffic-related pollutants as a function of distance (3-280m) from a highway
- To characterize size evolution of ultrafine particles (UFP) from the highway
- To quantify the number size distribution of non-volatile particle cores using a thermodenuder (TD) system
- To identify chemical properties and mixing status using a single particle mass spectrometry

Measurements

- **Thermodenuder (TD)** at 250°C
- **FMPS/TD-FDMS** (5 min interval)
- **ATOFMS/TD-ATOFMS** (5 min interval)
- APS
- DustTrak (PM2.5 and PM1)
- Aethalometer (Black carbon, BC)
- Particle bound PAH monitor
- Gas analyzers
- Met system (WD, WS)
- GPS & Webcam



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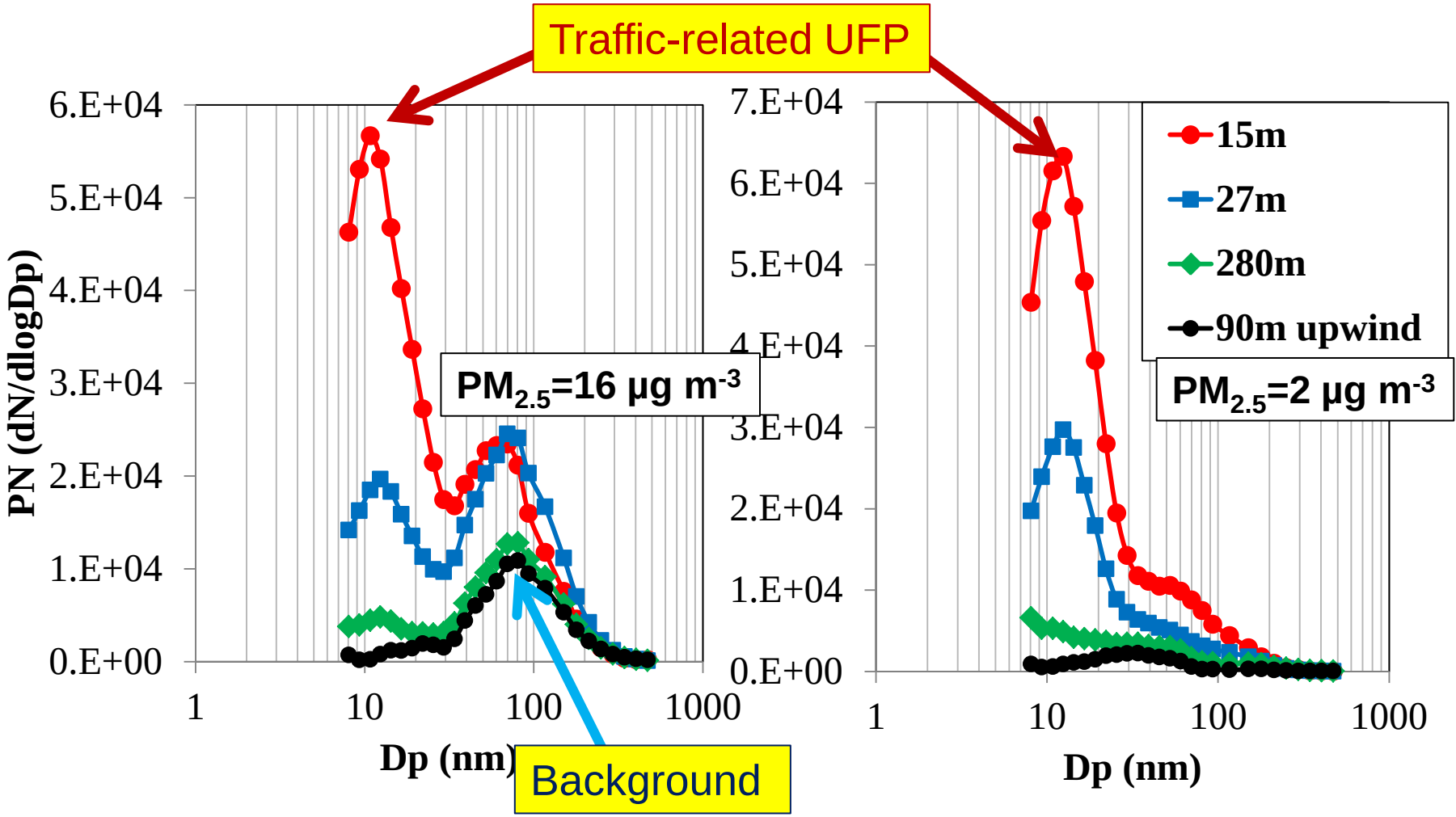
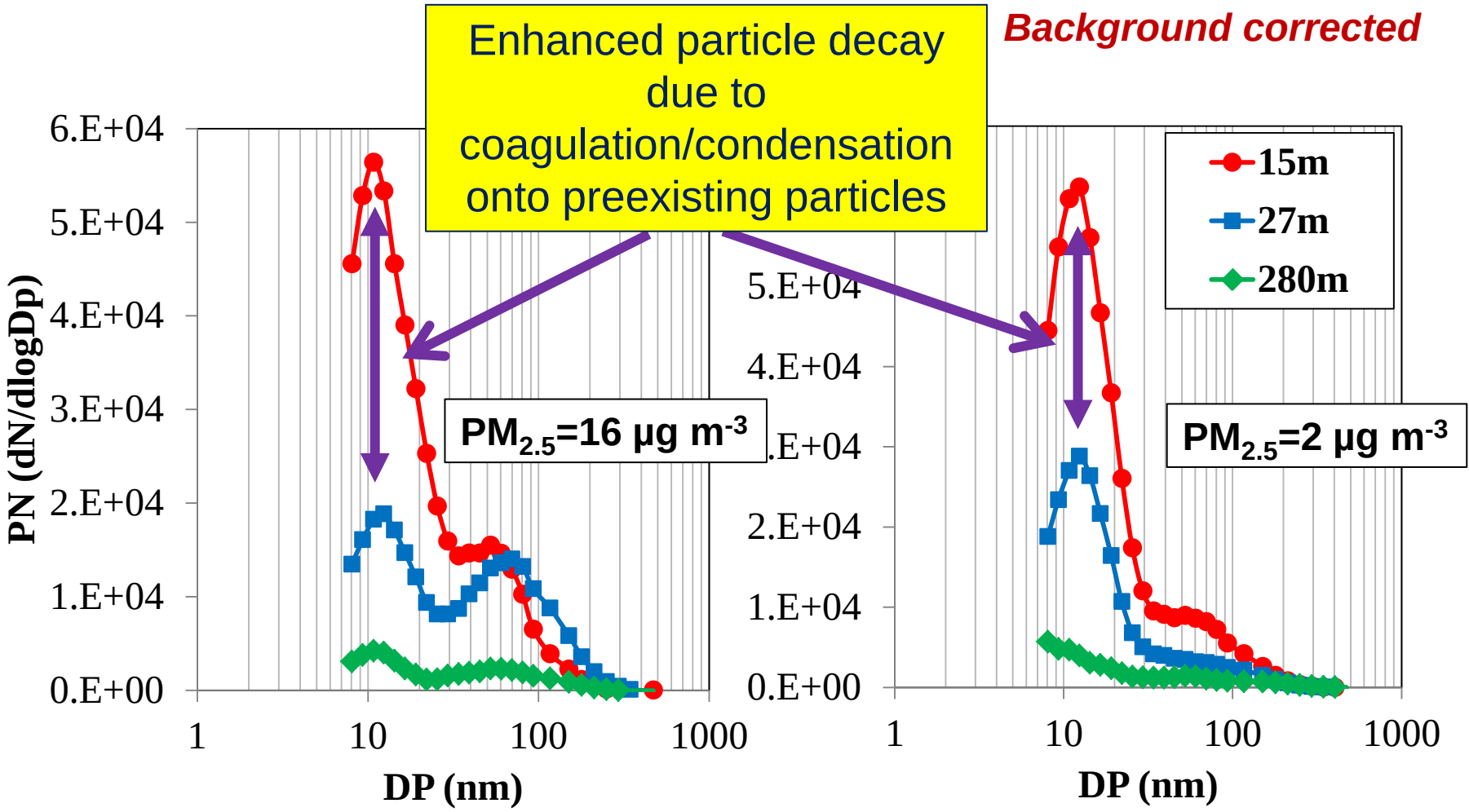
Evolution of UFP Size Distribution



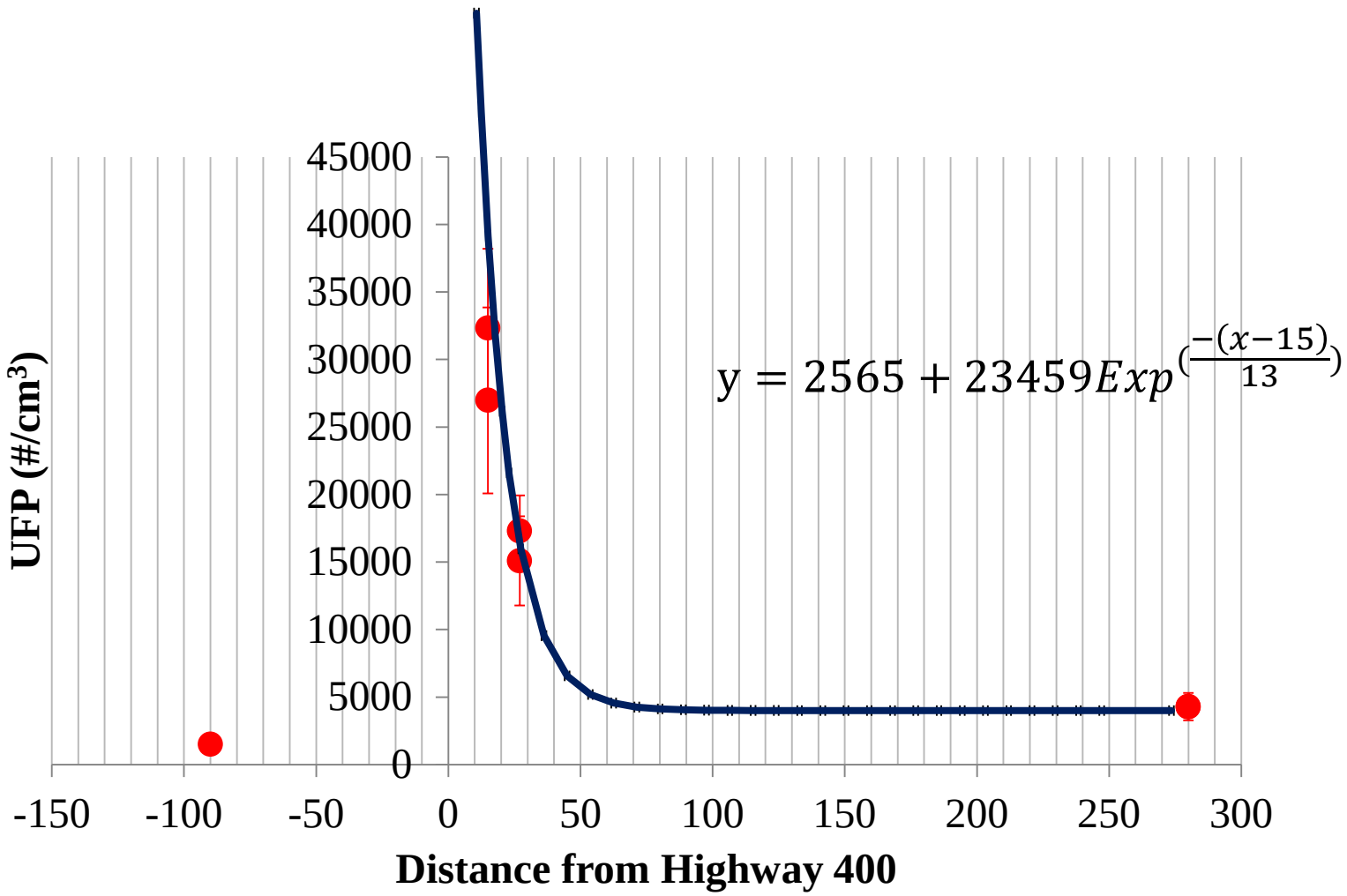
- On average, ~53% of total UFP number concentration decayed between 15m and 27m, while most (~90%) of traffic-related UFP (< 25nm) disappeared at 280m from the highway

Evolution of UFP Size Distribution



- ~90% of traffic-related 10 nm UFP decayed exponentially with increasing distance (15m to 280m).
- 55~67% decay of 10 nm particles between 15m and 27m

Distance Decay Gradient in UFP



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Decay gradients (**%/10m**) of TRAPs

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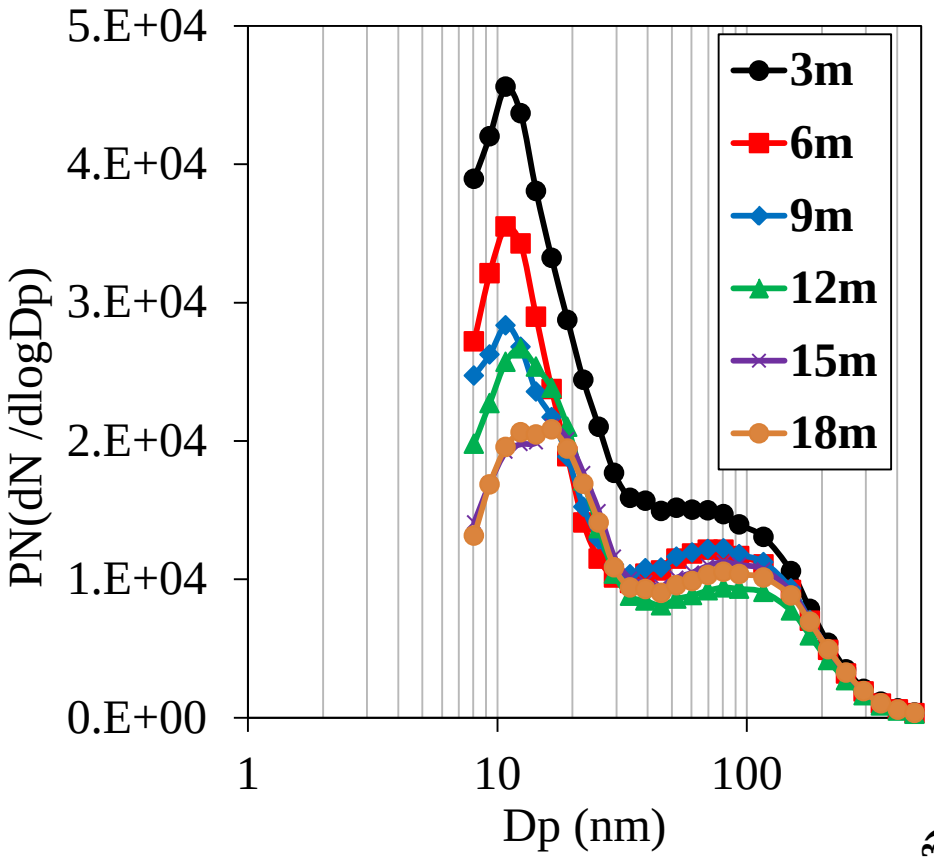
	Aug. 26		Aug. 19	
	15-27m	27-280m	15-27m	27-280m
UFP_{25} (<25 nm)	**45**	3.6	53	3.6
UFP (25-100nm)	**43**	3.0	8	2.2
UPF(100-500nm)	**32**	2.4	(26)	0.6
UFP(8-500nm)	44	3.4	35	3.0
Black Carbon	na	2.8	na	1.7
p-PAH	na	3.2	na	2.3
$PM_{2.5}$	na	0.7	na	0.6
$PM_{2.5}$ ($\mu g\ m^{-3}$)	2		**16**	
Average WD (º)	280		240	
Average WS (m/s)	**5.1**		3.4	

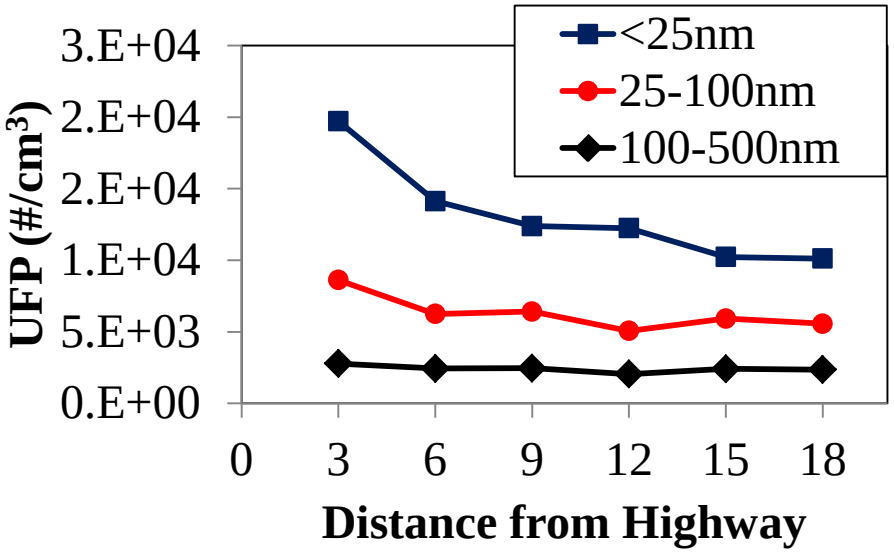
Micro-Scale UFP Gradients within 20m



- Overall 31%/10m decrease in the total UFP number
- Highest decay rate for nuclei mode particles (Dp ~10nm)
  - ~39%/10m for 10nm
  - ~24%/10m for 20nm

Using two FMPSs

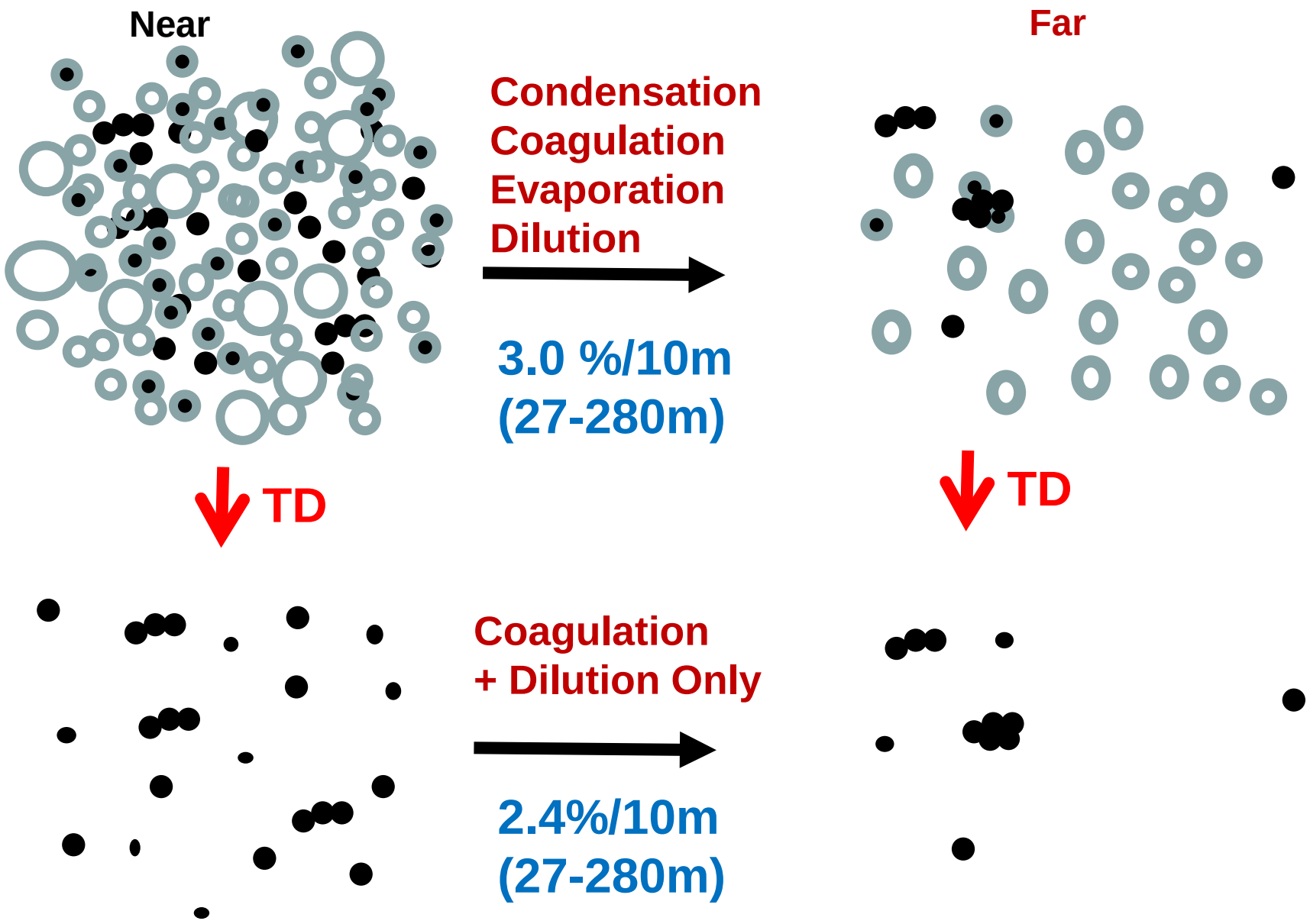
6-run average at each location



Decay Gradients (**%/10m**) of UFP

%/10m	Sep. 1		Aug. 26	
	3-9m	9-15m	15-27m	27-280m
UFP (<25 nm)	**59**	29	45	4
UFP (25-100nm)	39	23	43	3
UPF(100-500nm)	16	14	32	2
UFP(8-500nm)	50	25	44	3
$PM_{2.5}$ (µg m^{-3})	45		2	
Average WD (º)	260		280	
Average WS (m/s)	6.7		5.1	

Aerosol Dynamic Processes



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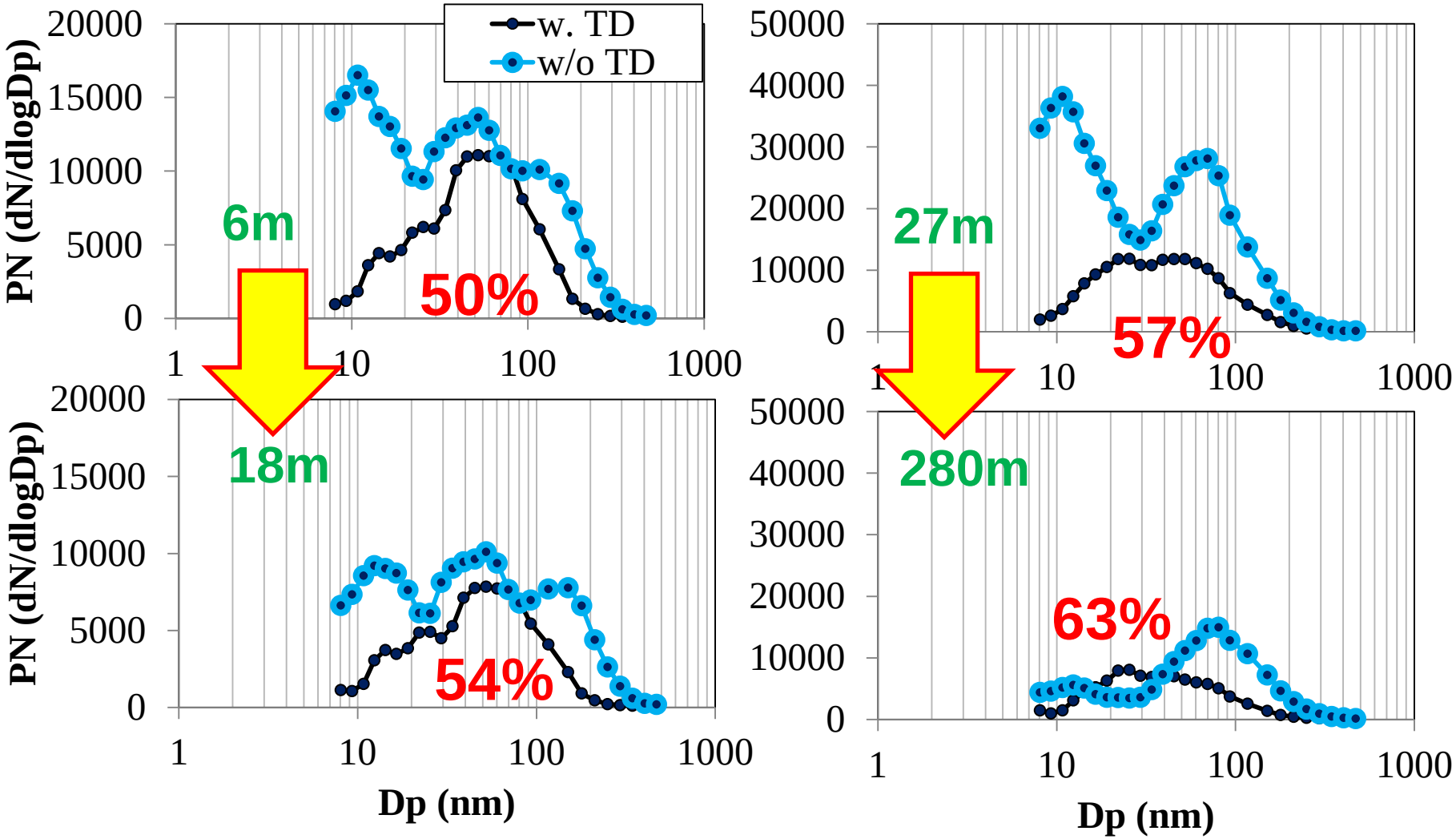
Size Distribution of Non-Volatile UFP



- Mostly no shift in the size distributions of non-volatile UFP
- Mode of non-volatile particles : 20-30nm, 70-80m (aggregates)

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Traffic-related Particle Type Profiles

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- Aerosol conditioned with a TD and without TD
- Collected from 5:30 am to 9:30 am
- At Sites B (27m) and C (280m)
  - AB : Non-TD particles at Site B (27 m from the highway)
  - AC : Non-TD particles at Site C (280 m from the highway)
  - TB : TD particles at Site B (27 m from the highway)
  - TC : TD particles at Site C (280 m from the highway)
- ART-2a Clustering Analysis

Evolution of Particle Types

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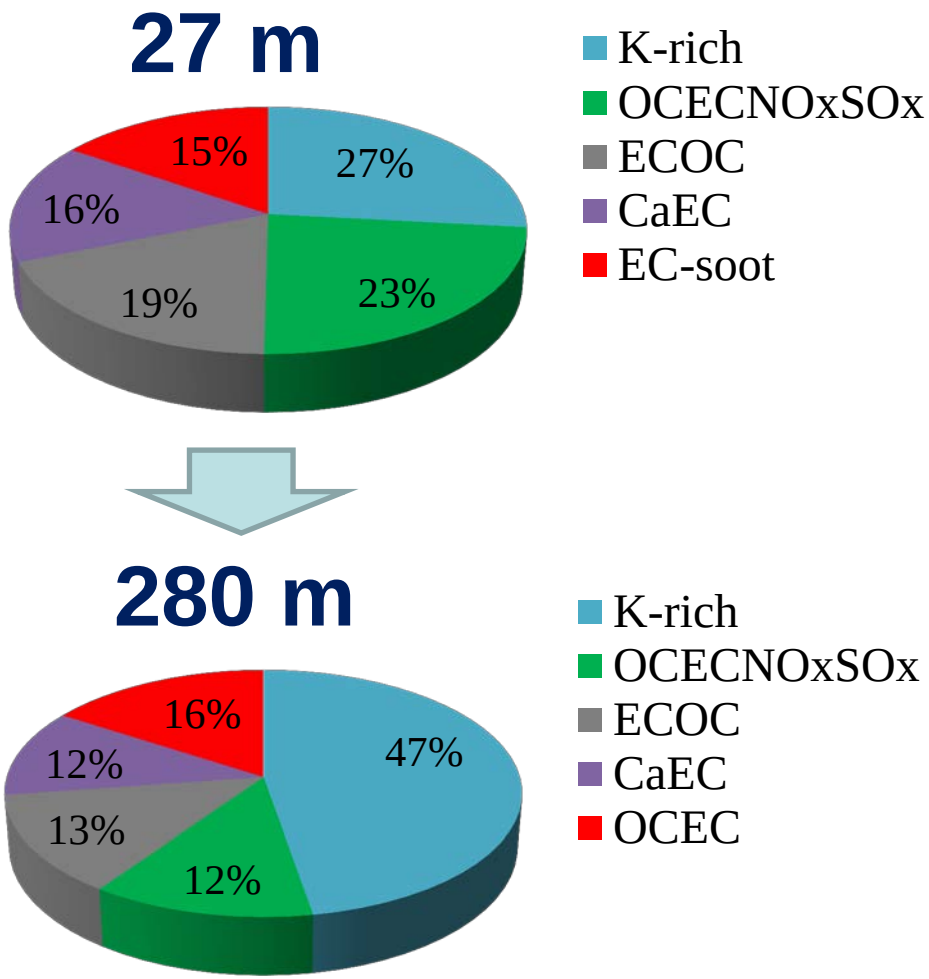
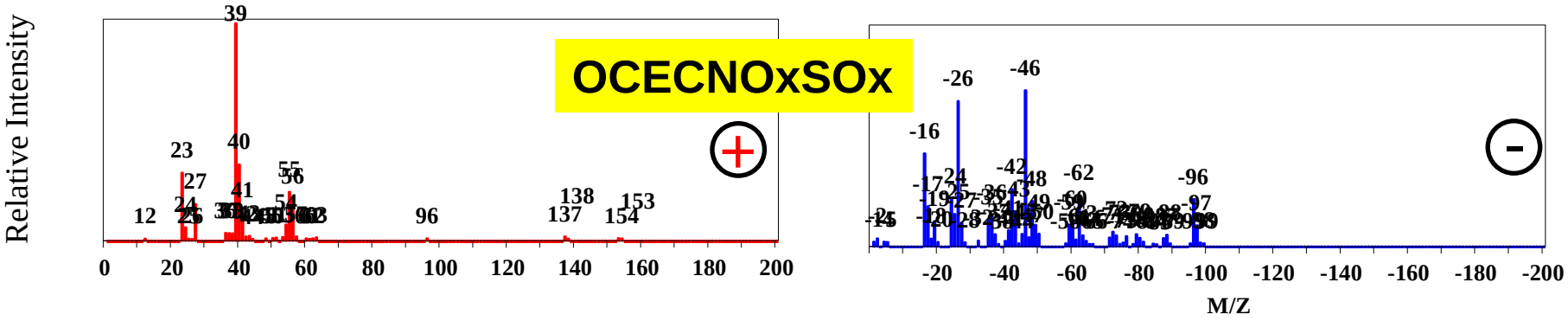
- Common particle types
  - K-rich
  - OCECNOxSOx
  - ECOC
  - Ca-rich
- Unique particle type
  - EC-soot (only at 27m)
  - OCEC (only at 280m)

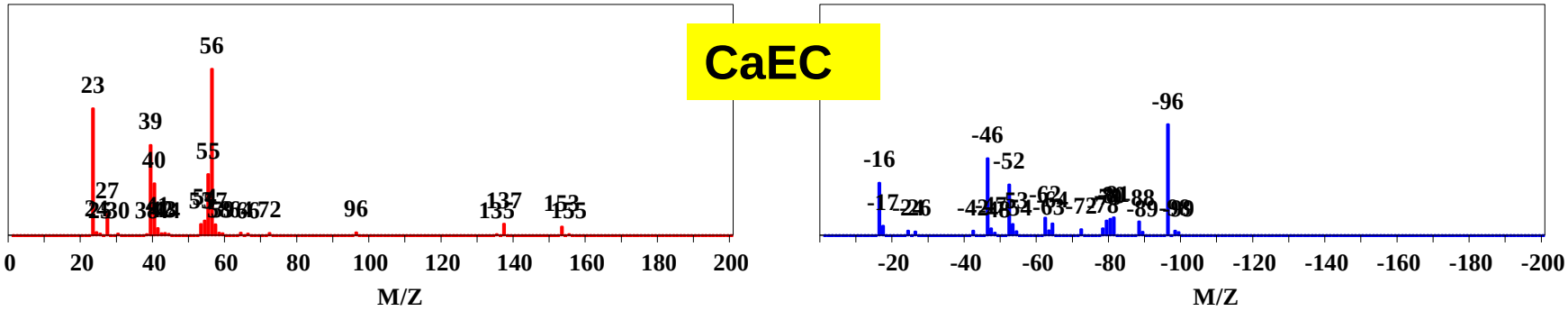


Background particle types : K-rich

Common Particle Types



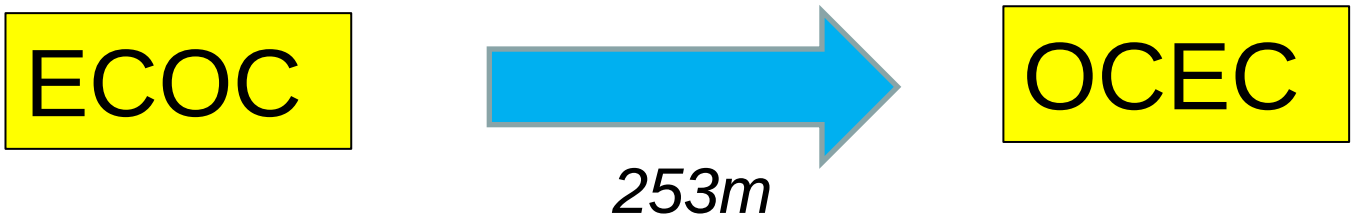
- OC fragments (m/z 43, 44, 53, 55), C12n+, C12n-, Ba137/138, Ca, organic nitrogen, phosphate, nitrate, sulphate
- Diesel-like particles



- Strong Ca/CaO, Na, organic fragments (m/z 55), Ba1375/137, C12n-, Phosphate, nitrate, no sulphate
- Fuel additives (i.e., Ca, Ba) and lubricant oil (Phosphate) from likely gasoline

Observed at both sites, 27 m and 280 m from the highway

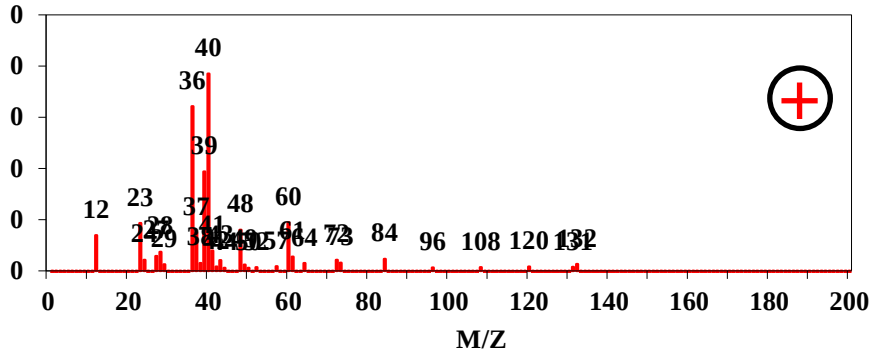
Transformation of Particle Types

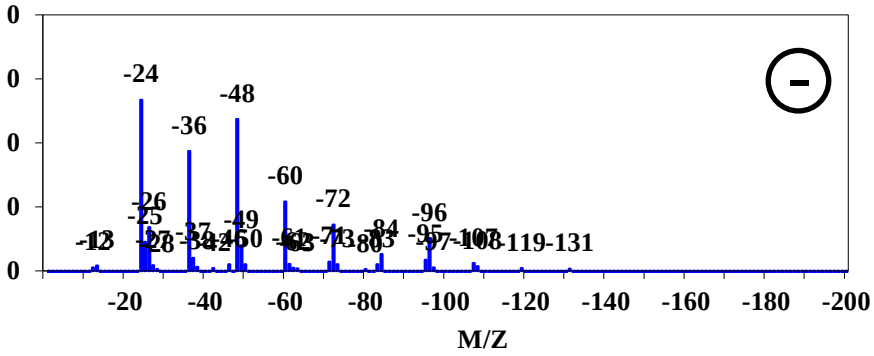


- Clearer C12n+, weak C12n-, organic fragments, weak negative spectra, less sulphate
- Gasoline-like particles

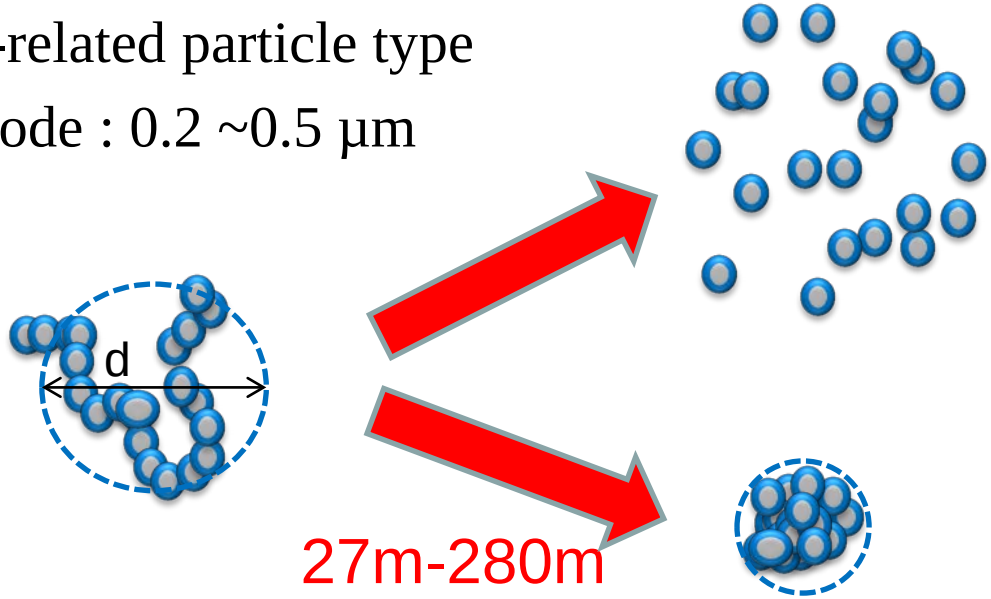
- Strong similarity in the positive spectra with the ECOC type
- Many organic fragments in both pos. and neg. spectra
- Increase of condensable vapors and/or coagulation of organics

EC-soot (soot aggregates)





- Only observed at Site B (at 27m) w/o TD
- Fresh soot aggregates formed from small soot monomers coated with volatile matters, i.e., water layers
- Diesel-related particle type
- Size mode : 0.2 ~0.5 μm



Summary

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- On average, the decay rates of the total traffic-related UFP number concentrations from a highway were found to be ~50%/10m (3-15m), ~40%/10m (15-27m), and 3%/10m (27-280m).
- The decay rates varied by particle sizes, pre-existing particles, and wind speeds.
- There was no significant shifts in the size distributions of non-volatile UFP, except for possible break-down of fresh soot aggregates.
- The ATOFMS/TD-ATOFMS system identified non-volatile traffic-related particle types, OCECNOxSOx, ECOC, Ca-rich and a unique type, EC-soot only at near highway.

Acknowledgements

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