



Toxicity of biomass combustion generated ultrafine particles: evidence from stack-sampled and airborne UFPs

Giovanni LONATI¹, Paola FERMO², Marina MARINOVICH³, Roberta VECCHI⁴

¹Dept. of Civil and Environmental Engineering - Politecnico di Milano

²Dept. of Chemistry, Università degli Studi di Milano

³Dept. of Pharmacological and Biomolecular Sciences, Università degli Studi di Milano

⁴Dept. of Physics, Università degli Studi di Milano



POLITECNICO
MILANO 1863

Background and scope

TOBICUP (TOxicity of Biomass COmbustion generated Ultrafine Particles) project designed to assess the toxicological responses of UFP samples from:

- stack emissions of residential wood combustion units
- airborne UFP samples collected where biomass burning for residential heating is widely used.

UFP sampling

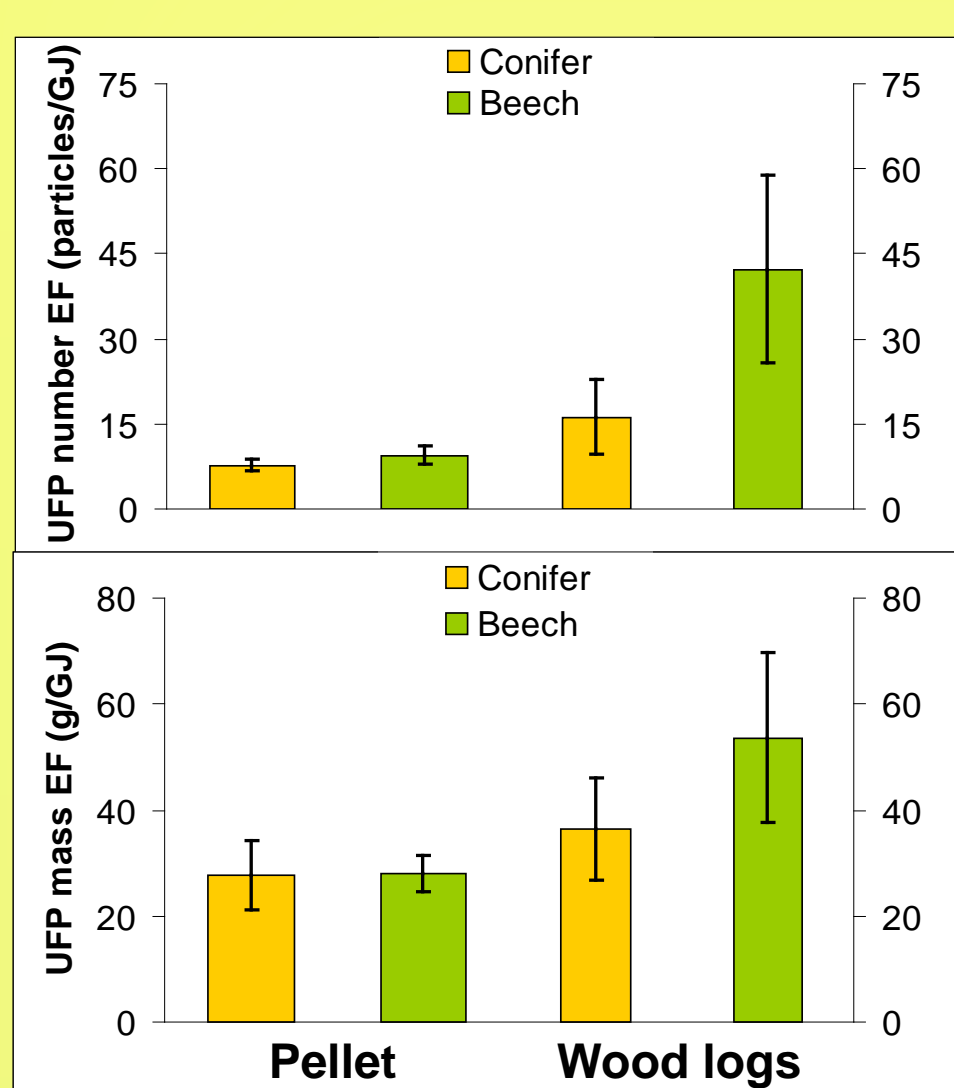
- UFP stack samples generated by wood (beech and fir) combustion in a 11 kW pellet stove (automatically stoked) and in a 8 kW wood log stove (manually stoked) collected during combustion tests intended to simulate real-world combustion cycles
- Airborne UFP samples collected during monitoring campaigns carried out at a small alpine town (Morbegno) in Northern Italy, where wood burning is largely diffused for domestic heating in winter. Integrated UFP samples were collected both in wintertime (over three/four days) and summertime (seven days).
- Parallel multistage impactors equipped with different collection substrates, depending on the subsequent analysis to be performed.

Chemical and biological analyses

- Determination of elemental composition (ICP-AES), inorganic ions (IC), anhydrosugars (HPAEC-PAD), total organic carbon (TOT), PAHs (GC-MS)
- Investigation of pro-inflammatory cytokine interleukin-8 (IL-8) induction in two human cells lines (THP-1 and A549), used as surrogates of alveolar macrophages and lung epithelial cells
- UFP-induced oxidative stress and genotoxicity investigated in A549 cells by alkaline comet assay and γ -H2AX
- NIES certified diesel exhaust particles (DEP) used as reference for biological effects

Results – UFP stack samples

UFP emission factors

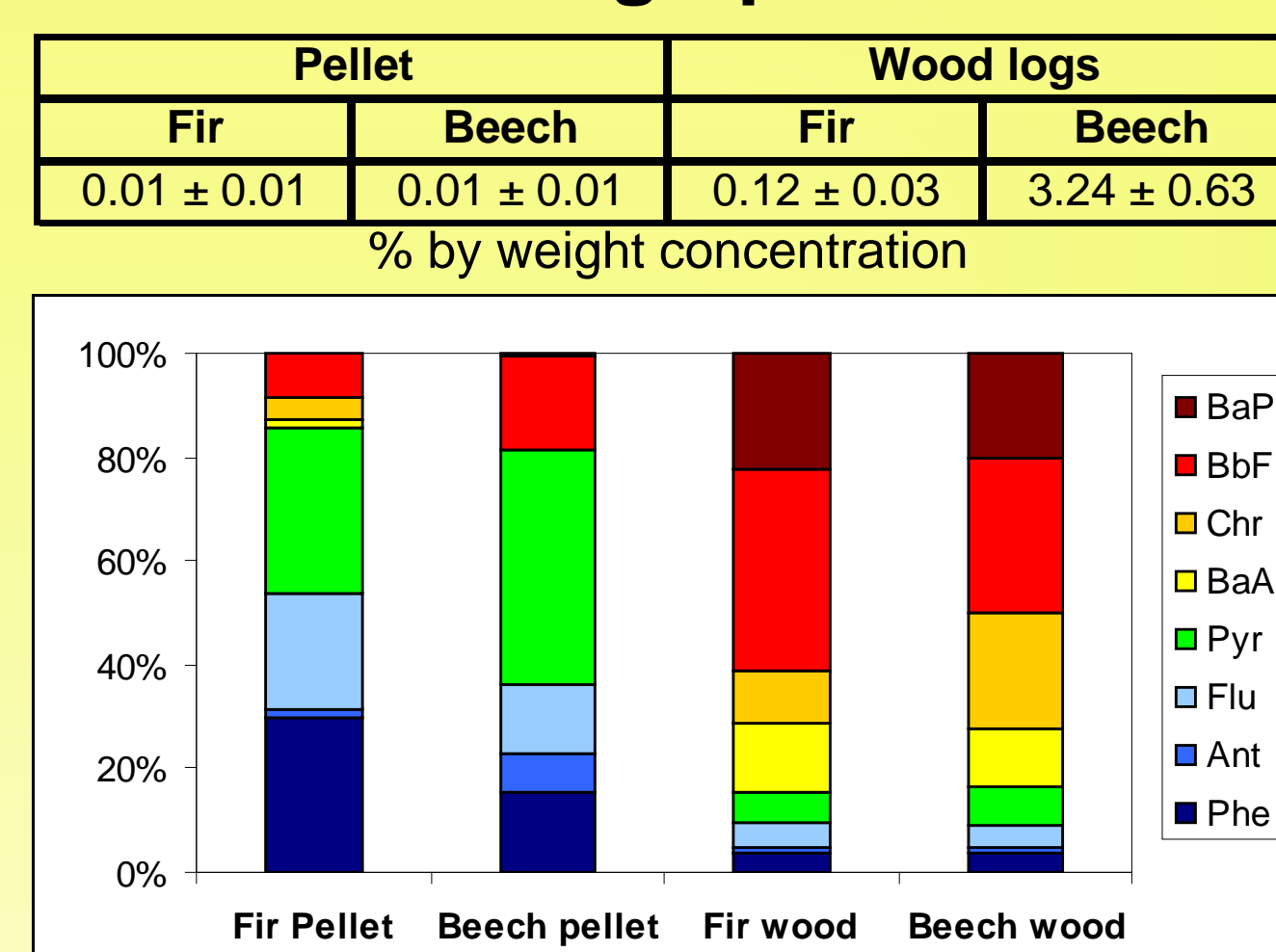


Flue gas concentrations (@NTP,13% O₂)

Pellet
12-56 mg/m³
5-16 · 10⁷ #/cm³
MGD 35-71 nm

Wood logs
32 - 107 mg/m³
23-60 · 10⁷ #/cm³
MGD 51-107 nm

PAHs concentrations and fingerprints



Results – airborne UFP samples

UFP ambient concentrations

Winter Average: 2.2 μ g/m³
Range: 1.6-3.2 μ g/m³

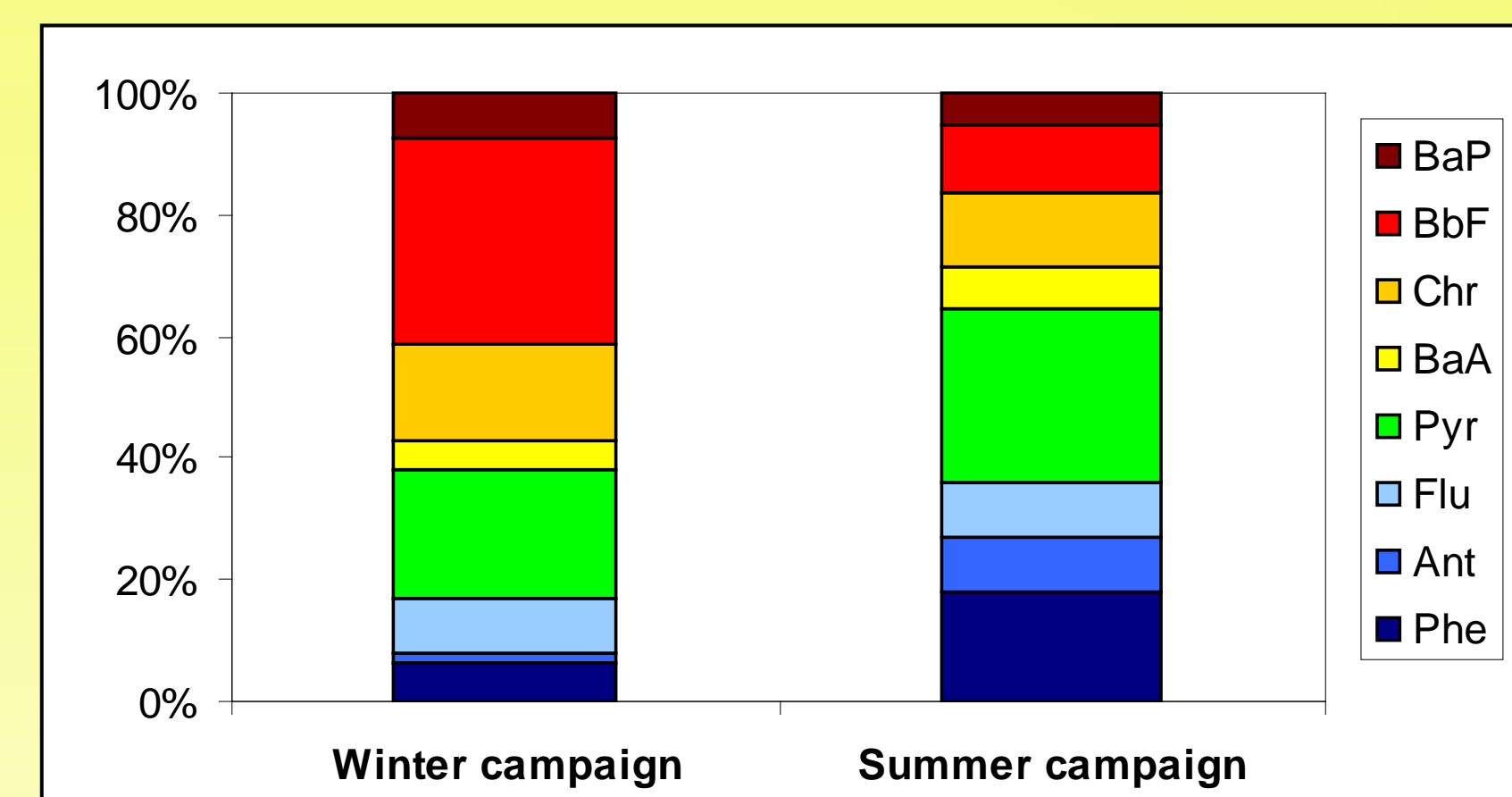
Summer Average: 2.0 μ g/m³
Range: 1.0-3.1 μ g/m³

PAHs concentrations

Winter 2.3 ng/m³

Summer 0.3 ng/m³

PAHs fingerprints



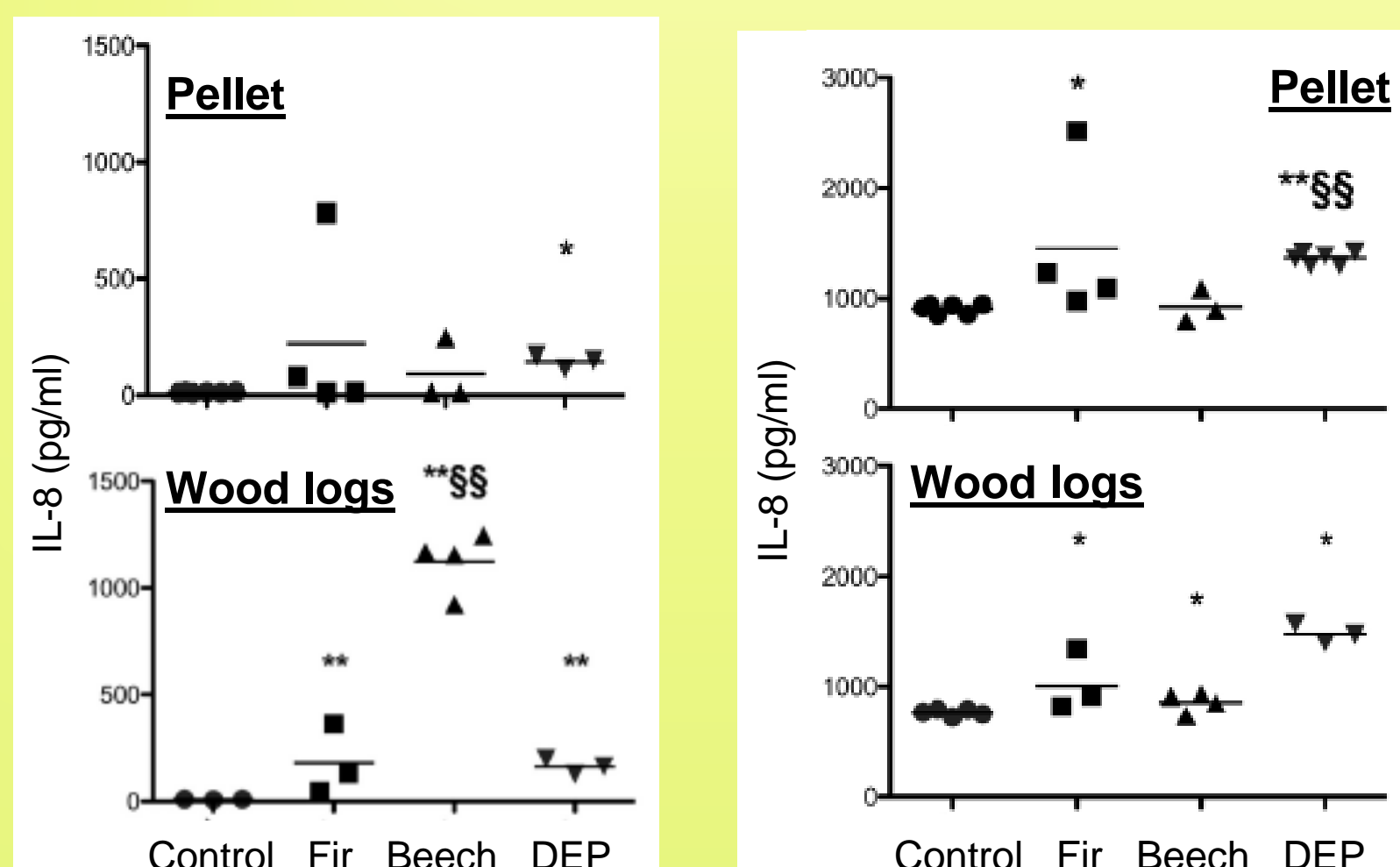
Cyto- and genotoxic effects (A549)

Fuel & Stove	Mass dose based relative toxicological responses				
	genotoxicity		oxidative stress		cytotoxicity
	γ H2AX	comet test	ROS	RNS	MTT
Fir pellet	1.6	1.1 *	1	1.1	1
Beech pellet	1.3 **	1 ***	1.6	1	2.3 **
Fir Wood	1.7 **	2 ***	1.2	1.1 *	2.6 *
Beech Wood	1 **	1.1 **	1.4 *	1.2 *	2.1 *

Fuel & Stove	Energy-weighted relative toxicological responses				
	genotoxicity		oxidative stress		cytotoxicity
	γ H2AX	comet test	ROS	RNS	MTT
Fir pellet	1.4	1.3	1.2	1.3	1
Beech pellet	1	1	1	1	2
Fir wood	1.8	2.9	1.1	1.5	3.2
Beech wood	2	3.1	2.5	3.2	4.8

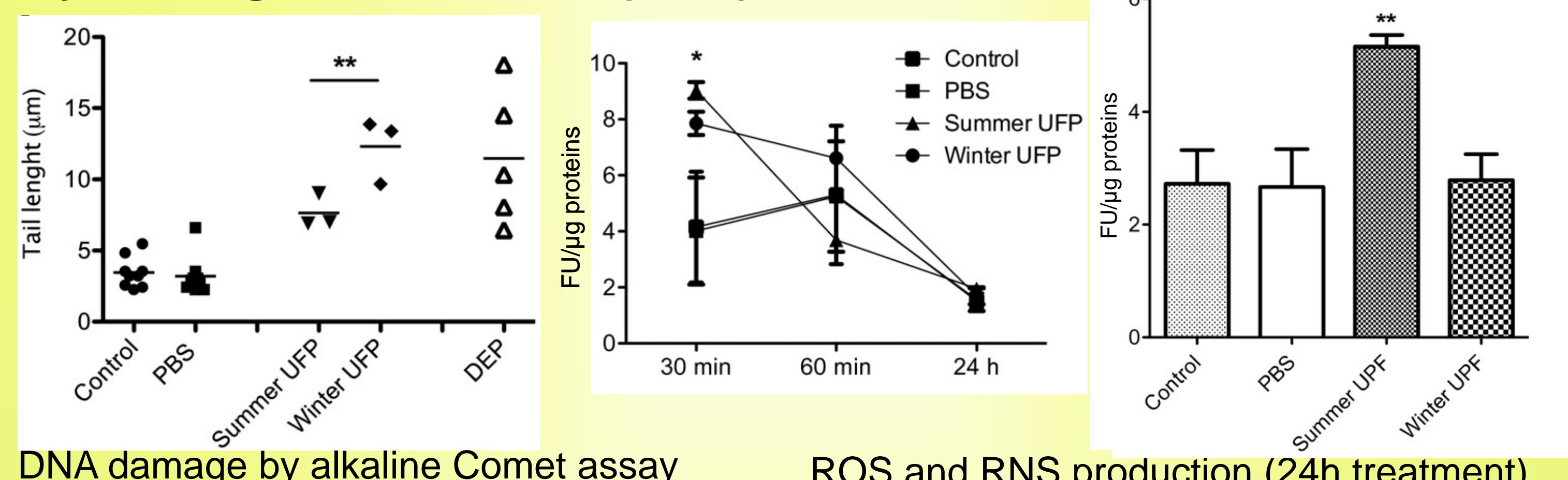
* p<0.05
** p<0.01
*** p<0.001
vs. control
Cells treated for 24h with 100 μ g/ml_{medium}

Inflammatory effects (THP-1, A549)



* p<0.05
** p<0.01
§ p<0.05
§§ p<0.01
vs. UFP or DEP treated cells

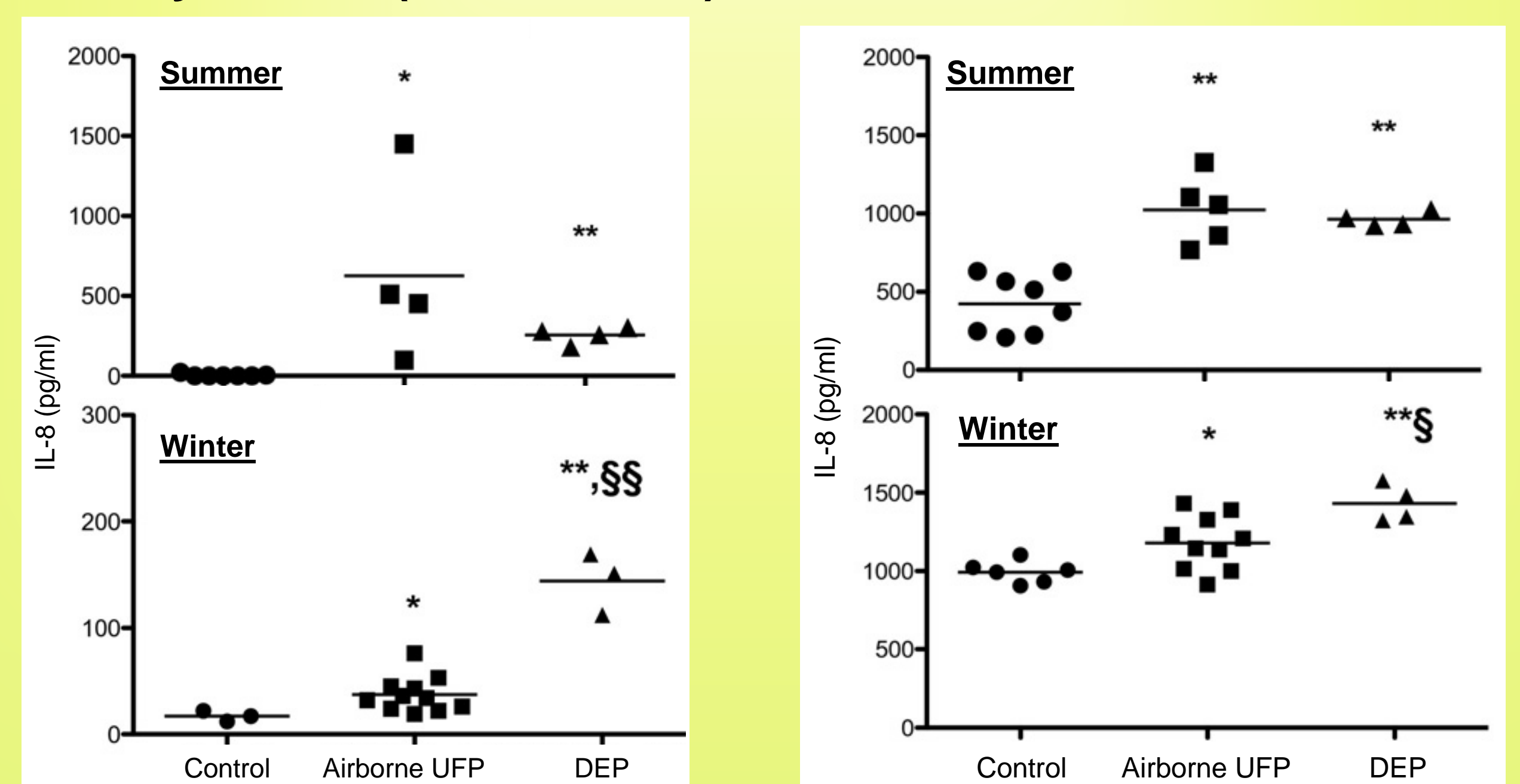
Cyto- and genotoxic effects (A549)



DNA damage by alkaline Comet assay

ROS and RNS production (24h treatment)

Inflammatory effects (THP-1, A549)



Conclusions

- UFPs from wood logs combustion displayed stronger genotoxic and inflammatory effect than UFPs from pellet combustion
- Beech wood logs induced higher IL-8 release in THP-1 cells
- Airborne UFPs were able to stimulate an inflammatory response: summer UFPs more active in inducing IL-8 release in both cells lines, but the release was overall similar to the one observed with DEP
- Genotoxic effects induced by winter UFPs were higher than those induced by UFPs sampled in summer
- Genotoxic effects driven by PAHs both in stack and airborne UFP samples