Aerosols into Suspension Collectors, a New Approach for and Efficient Collection of Airborne Particles for Toxicological Studies

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BACKGROUND

- Accurate information on the toxicological responses to ambient aerosols in needed for human exposure models and risk assessment studies

- In vitro exposure studies are widely used as a model to assess the interactions between air pollutants and cells

- They are more economical than animal studies

- Responses either in the cells or in the supernatant provide fast information regarding the toxicological properties of ambient aerosols

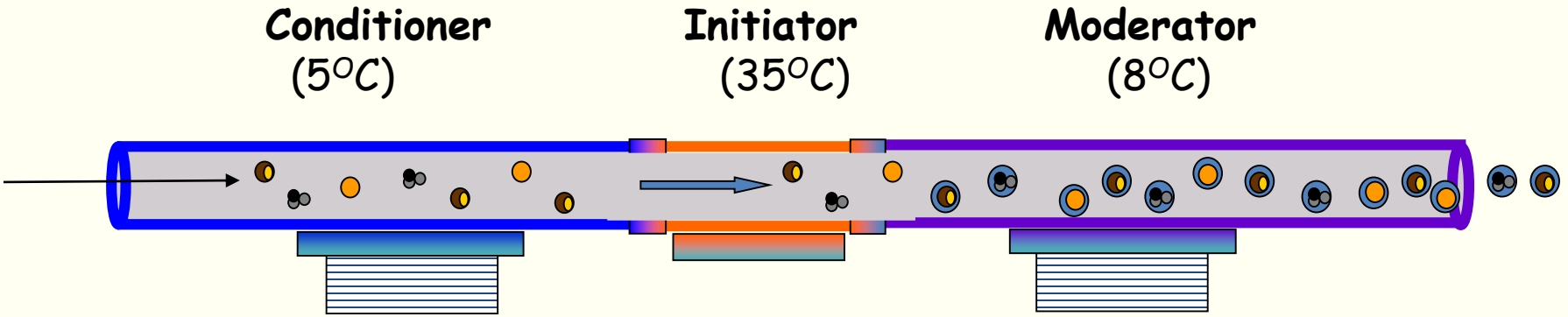
- Conventional in vitro assays cannot assess accurately the toxicity of aerosols as exposure studies are limited by the sample collection system:
  1. loss of physical and chemical integrity of the particles during collection
  2. transformations during extraction and resuspension

OUR APPROACH

To eliminate the need for filter-base collection, are reduce sampling artifacts we have developed two new devices that collect ambient aerosols directly:

1) into liquid as concentrated suspension
2) into cell culture systems

These systems use the three-stage, moderated laminar flow water condensation technology develop by Hering et al. (2014) to grow and collect particles down to 6 nm in liquid



AEROSOL INTO SUSPENSION COLLECTORS

Advantages of the ASCs:

1. *Direct collection* into liquid reduces sampling artifacts

2. *No need* for extraction and resuspension steps

3. Collects *soluble particle-phase* components, and *insoluble particles* suspended in the collection liquid

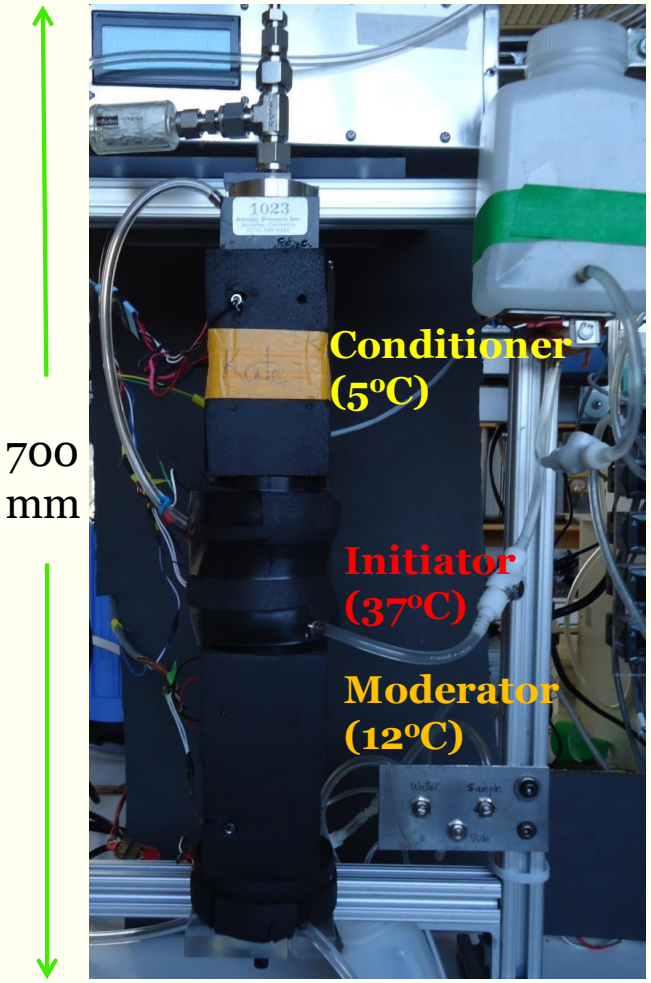
4. The *concentrated nature* of the collection allows reducing sampling times

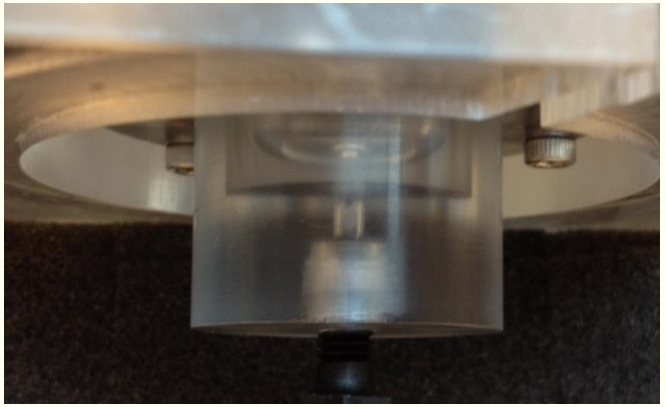
5. Provides concentrated aerosol/particle samples ready to be characterized using *in-vitro and in-vivo* assays

1. AEROSOL INTO SUSPENSION COLLECTOR (ASC)

Specifications:

1.5, 3 or 5 lpm sampling flow rate
200-500 µL collection volume



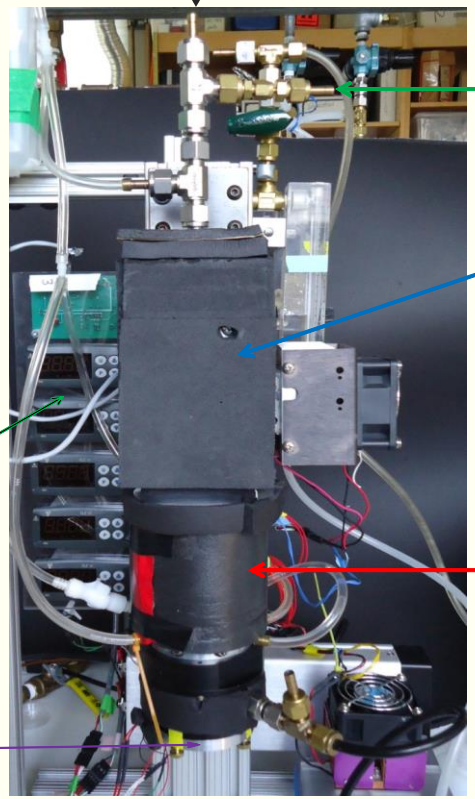


Collection vial

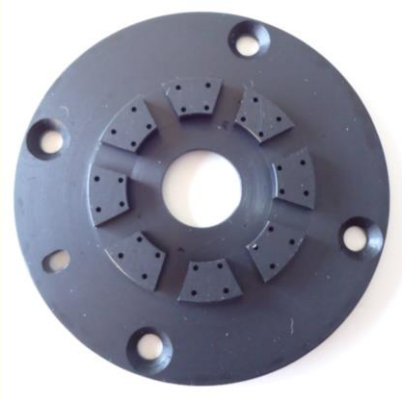
2. DIRECT *IN-VITRO* EXPOSURE SYSTEM (DIVE)

Specifications:

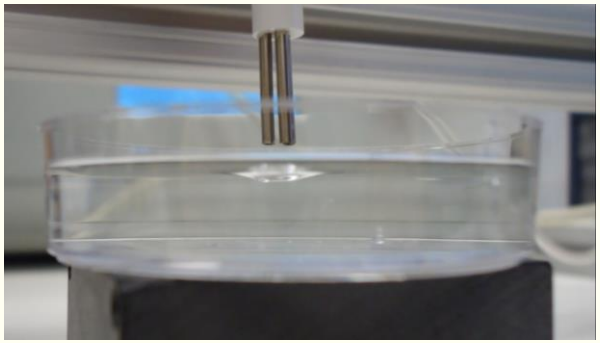
8 lpm sampling flow rate
32 impaction nozzles to minimize disruption of the cell culture medium
CO_2 introduced to the incoming flow (5%)
Temperature (37°C) and RH (>90%) maintained in the collection chamber



Impaction Nozzles

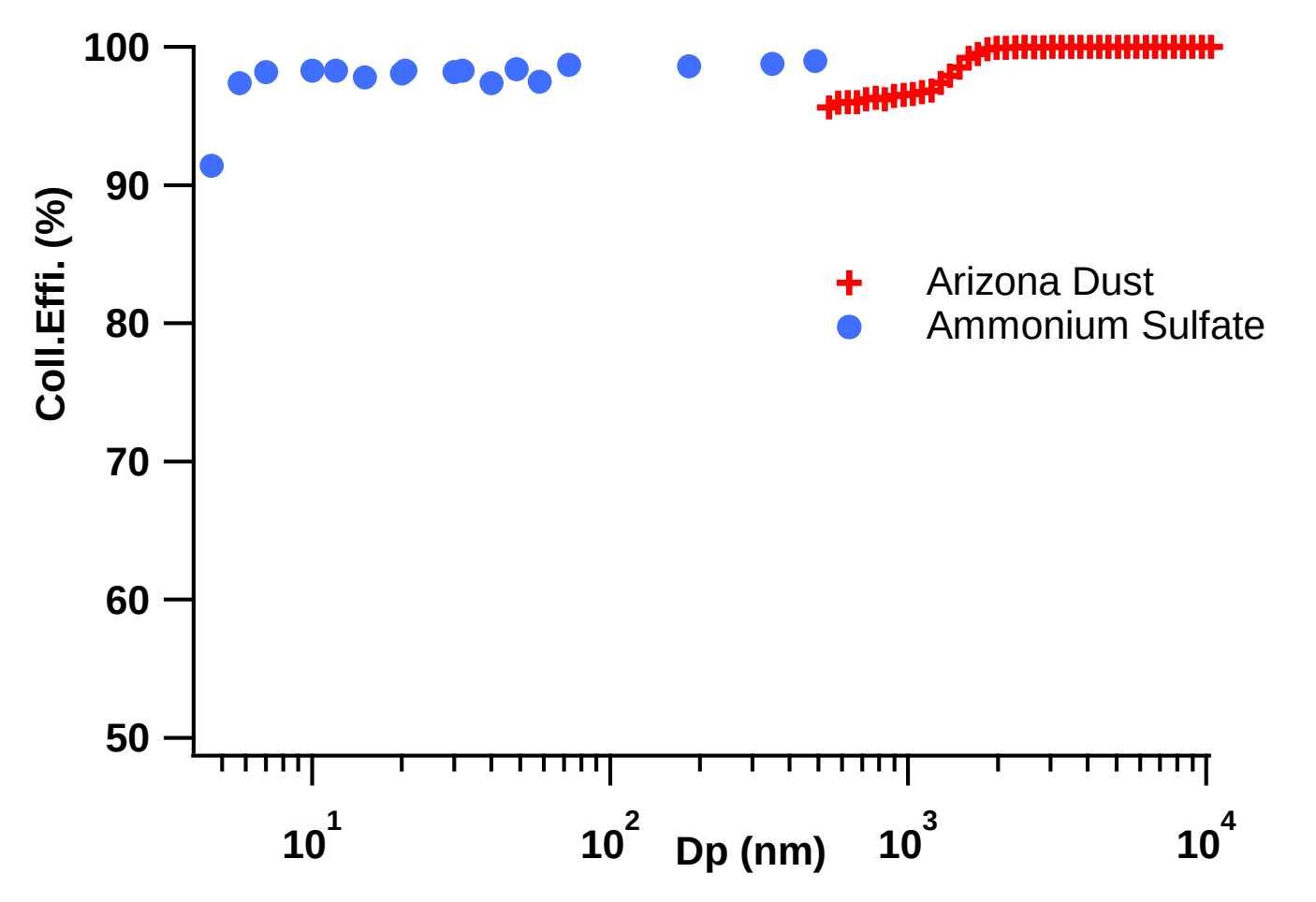


Sample delivery



COLLECTION EFFICIENCY

Collection efficiencies **>90%** for particles sizes between **5 nm** and **10 µm** at moderated temperatures



FIELD DEPLOYMENT: *Michigan State University*

a) Indoor (Lab testing) - March 2014
- Biosafety level 2 (BSL-2) lab - HEPA filter
- Low #/cc (~$4x10^3$) – lab ambient ai

b) Ambient - May 6-9, 2014
- Empty office room on the first floor
- 100-150m back side of the parking lot
- 3 hr samples, morning and afternoon

FIELD DEPLOYMENT: *In-vitro assays*

Cells:

- Mouse leukaemic monocyte macrophage cell line (**RAW 264.7)**
- Human Bronchial Epithelial cell line ***(BEAS-2B)***
- Normal Human Bronchial /Tracheal Epithelial cell line **(*NHBE)***

Cytotoxicity:

- Trypan Blue
- MTS Assay

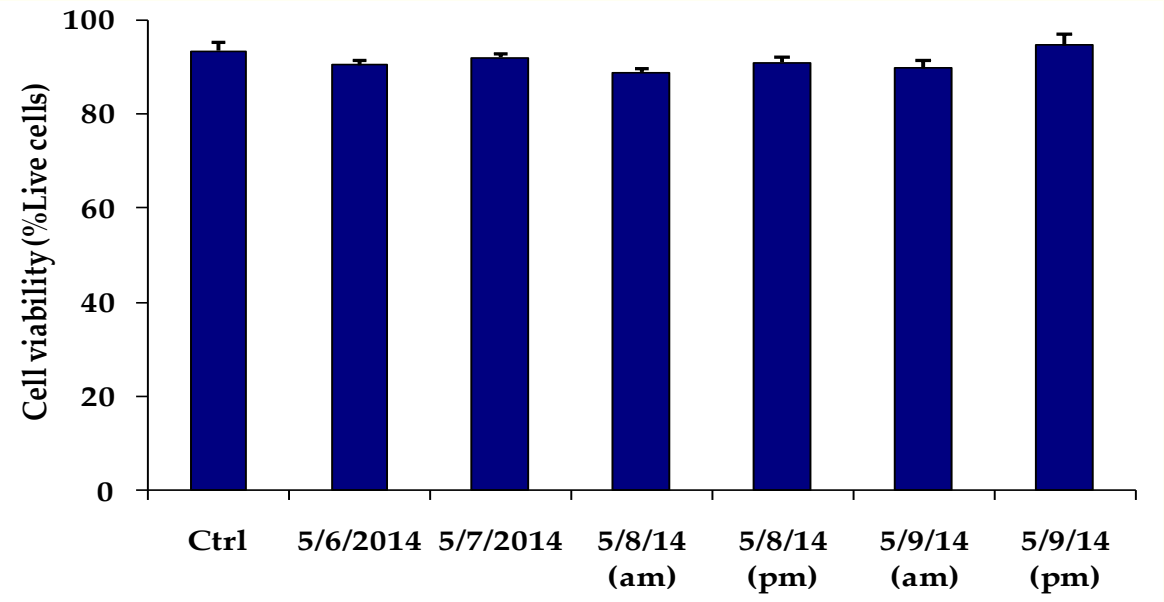
Stimulation:

- **Plating**: 30,000 cells/well, 24-well plates, 1 mL BEGM, 24 hr
- **Stimulation**: **0.001 m^3** air/mL (incense burning), 300 µL/well, 16hr
  0.05 m^3 air/mL (outdoor), 300 µL/well, 16 hr

Endpoints:

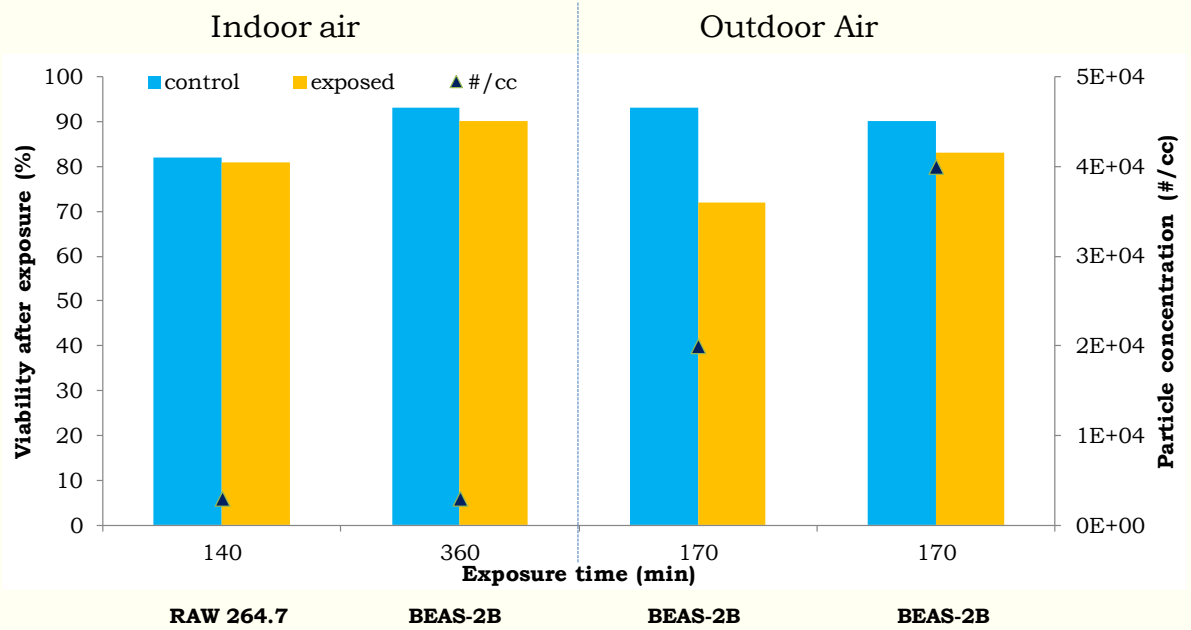
- **Pro-inflammatory markers**: interleukin 6 (IL-6)
  interleukin 8 (IL-8)

RESULTS: *Cell viability*



ASC

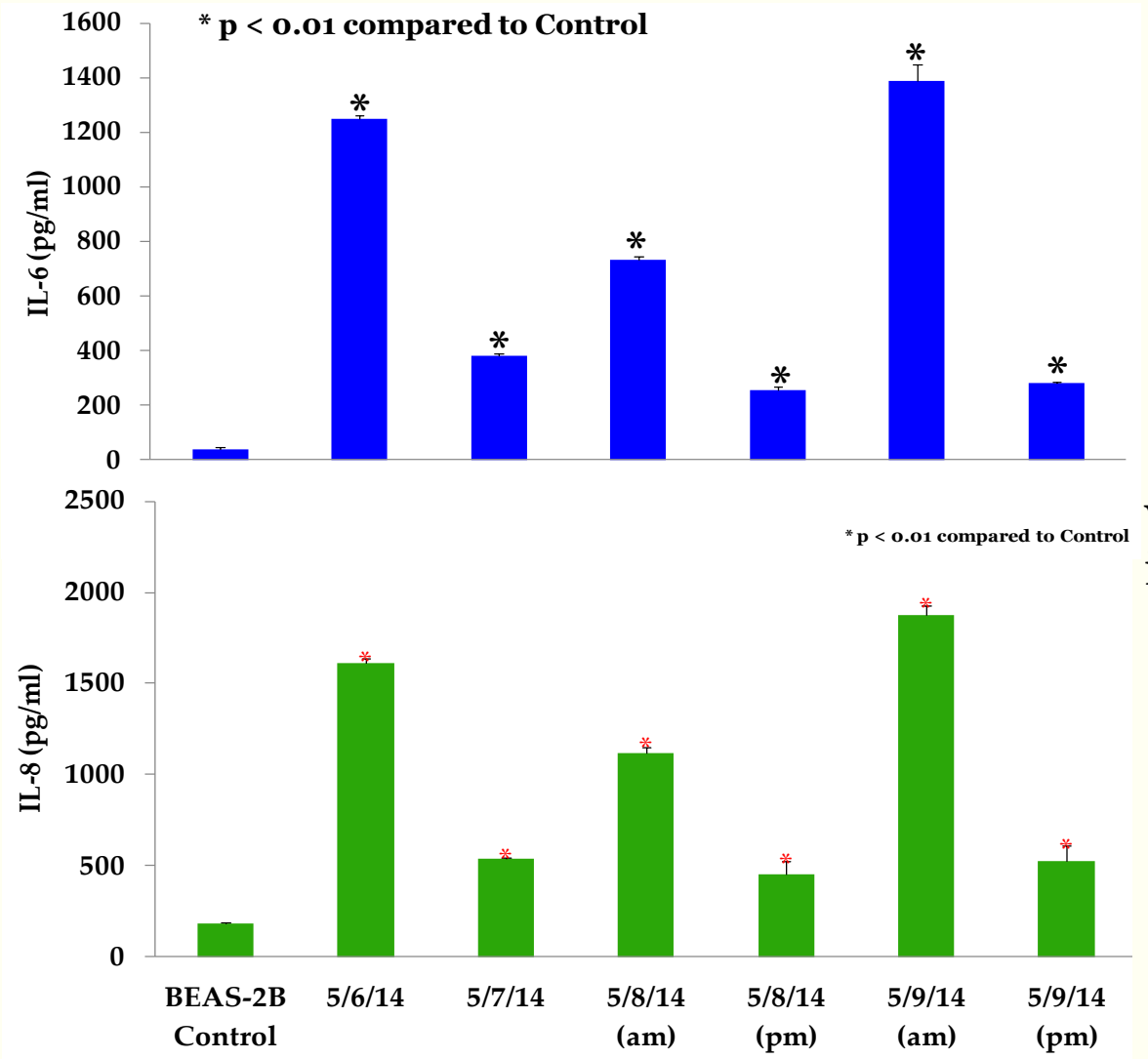
Exposure to 0.05 m^3/mL of outdoor PM did not have a significant impact on BEAS-2B cell viability



DIVE

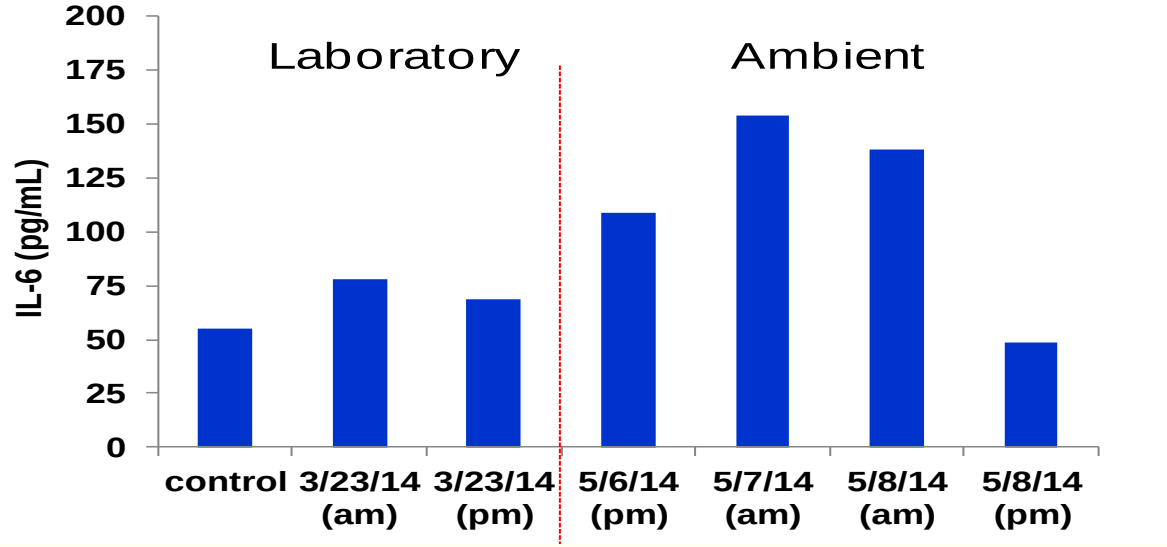
No major differences in viability were observed between the control and exposed cells

RESULTS: *Pro-inflammatory effects of PM (ASC)*

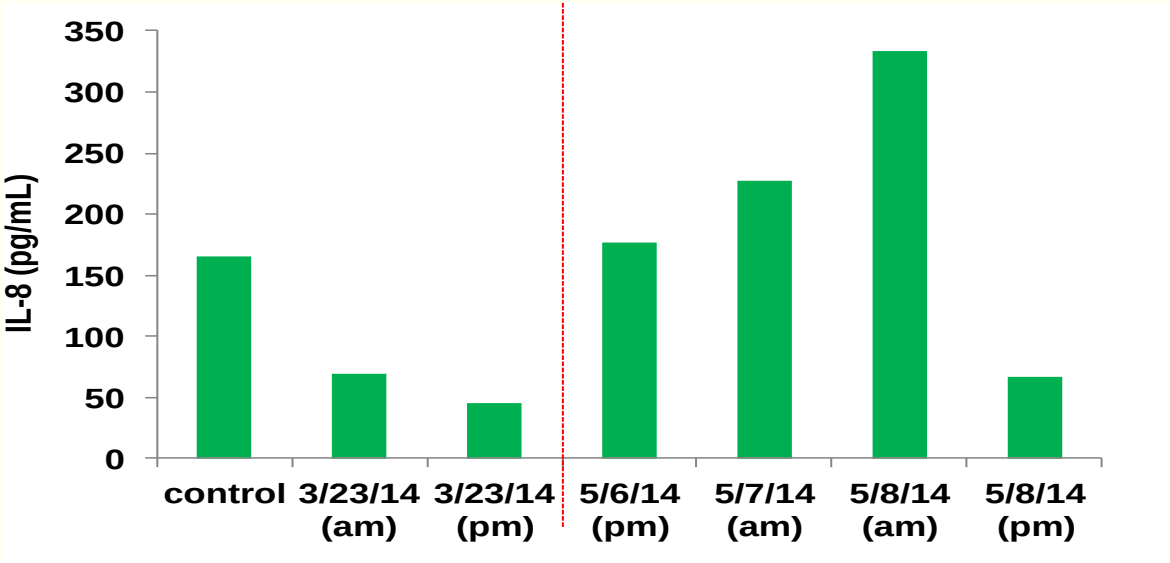


- Ambient PM induced a:
  - 10- to 34-fold increase in IL-6
  - 5- to 25-fold increase in IL-8
- Important diurnal and daily variability in the pro-inflammatory capacity of PM
- Higher effect observed in morning periods

RESULTS: *Pro-inflammatory effects of PM (DIVE)*



- Differences between control and exposed cells were observed
- Higher difference for ambient PM



- A significant increase in IL-8 production was only observed in 2 of the days
- Different behavior for different days

SUMMARY

A. We have developed a new collection system for collecting ambient aerosols directly into highly concentrated liquid suspensions (ASC)

B. DIVE prototype provides the means to assess aerosol toxicity using *in-vitro* assays under realistic ambient and physiological conditions

C. Collection Efficiencies for both systems were higher than 90% for particles sizes ranging from 5 nm to 10 µm

D. Cell viability after exposure to ambient PM was similar to control

E. Inflammatory responses measured as IL-6 and IL-8 production were observed for exposures to ambient particles down to 3 hrs

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