New Sampling and Exposure Techniques for Investigating the Effects of Combustion Sources

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Concentrator Features:

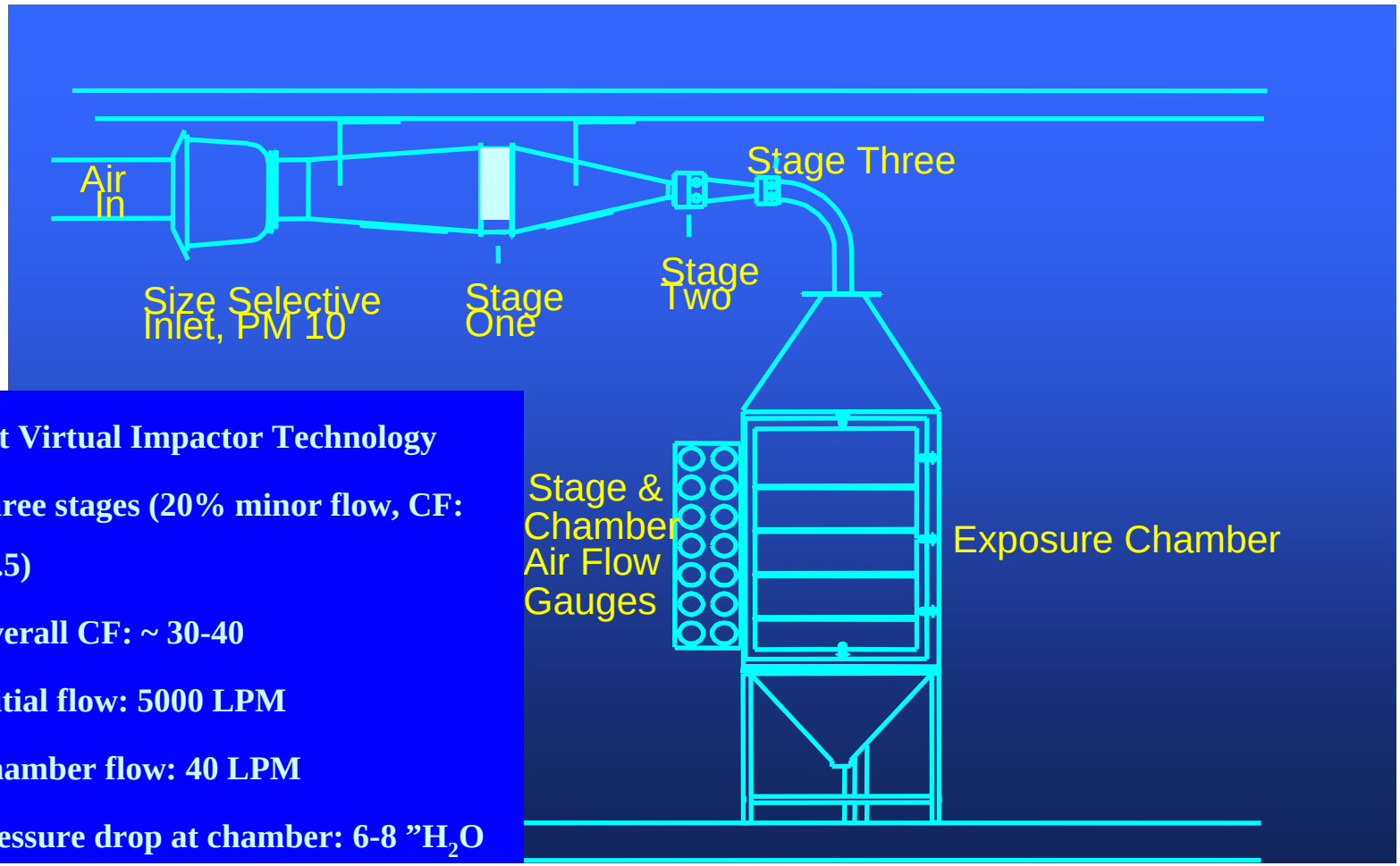
- Real particle exposures
  - Dose and chemistry
- Realistic exposure gradients
  - High-end of atmospheric concentrations
- Variability of exposure mixtures
- Flexibility of particle size
  - Fine, coarse and ultrafine
- Investigate gaseous co-pollutants

Concentrator Shortcomings:

Variability of exposure mixtures
Attribution to specific sources

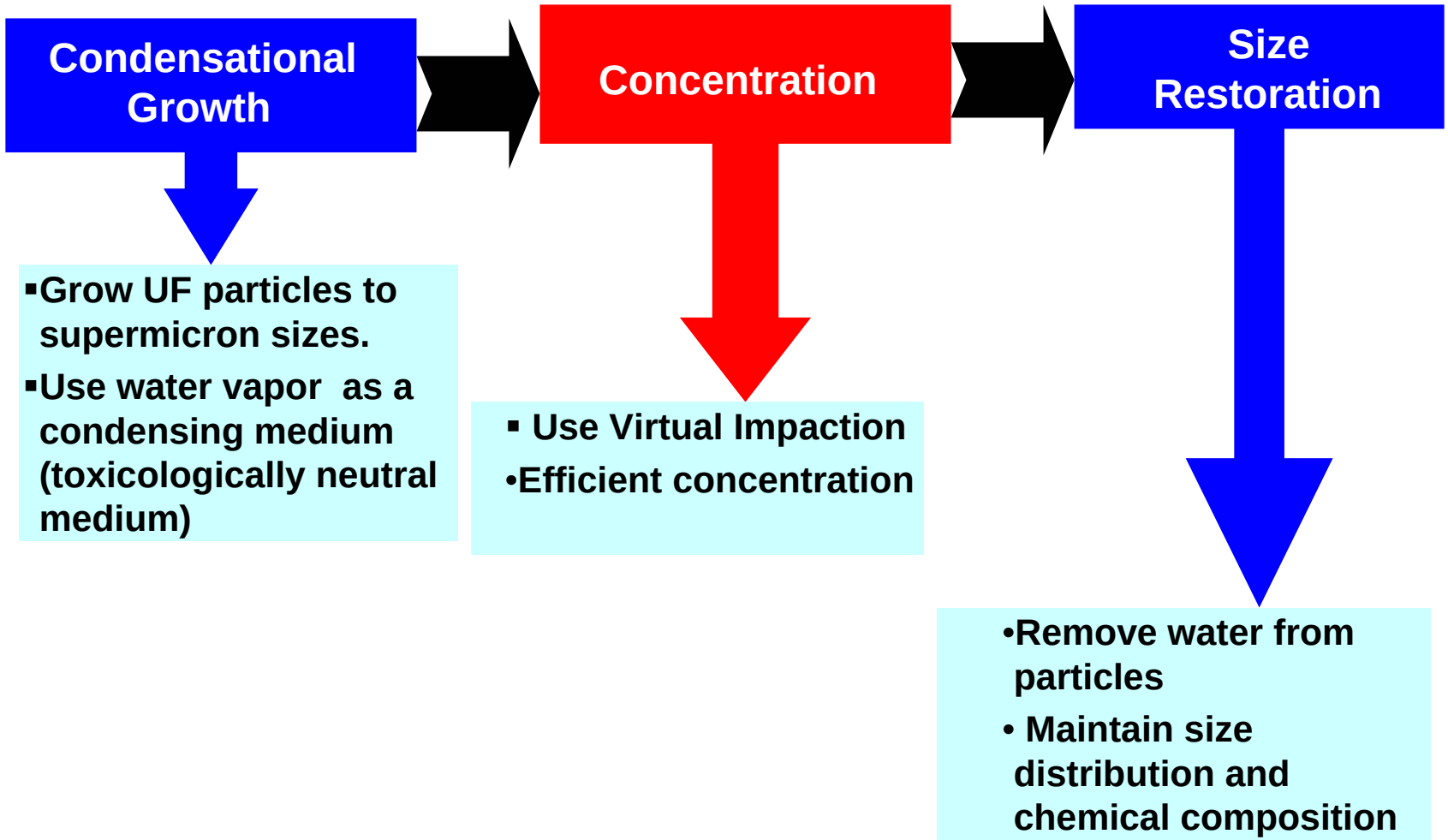
Fine Particle Concentrator (0.1-2.5 µm)

(Sioutas et al., 1995, *Environmental Health Perspectives*)

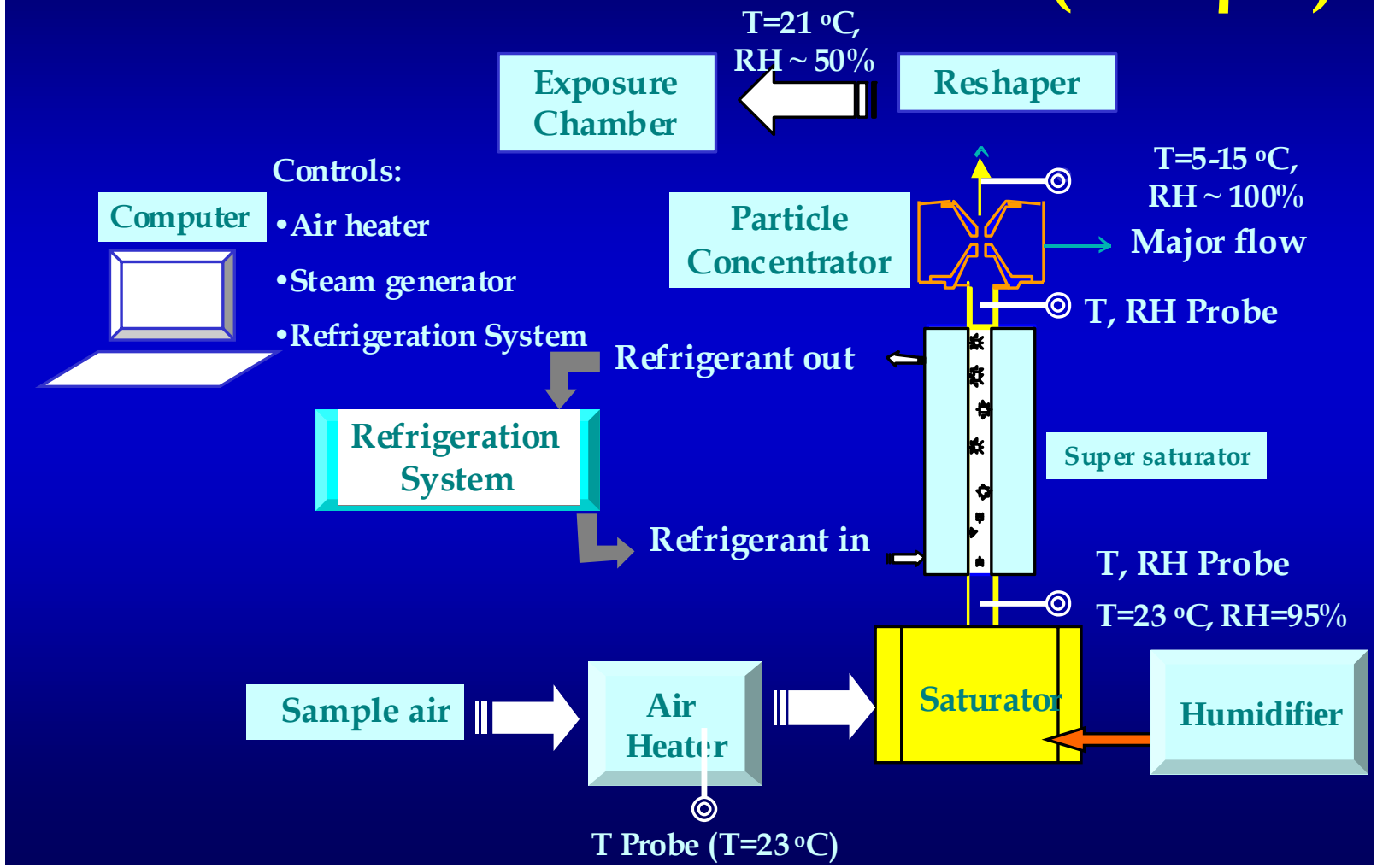


- **Slit Virtual Impactor Technology**
- **Three stages (20% minor flow, CF: ~3.5)**
- **Overall CF: ~ 30-40**
- **Initial flow: 5000 LPM**
- **Chamber flow: 40 LPM**
- **Pressure drop at chamber: 6-8 ”H_2O**

Can we apply the CAPS method to concentrate UF particles?



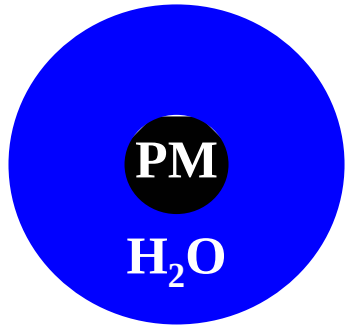
Ultrafine Particle Concentrator (<0.2 μm)



Demokritou et al. (2001)

Condensational Growth → **Concentration** → **Size Restoration**

- Well known atmospheric phenomenon
- At supersaturation conditions water vapor condenses on UF particles
- Cloud formation

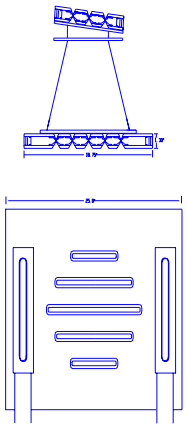


Technical Challenges:

- Grow ALL particles above supermicron sizes regardless of surface and chemical properties
- Minimize UF Particle losses
- Build a high volume system (5,000 lpm)

Condensational Growth → **Concentration** → **Size Restoration**

Virtual Impactor

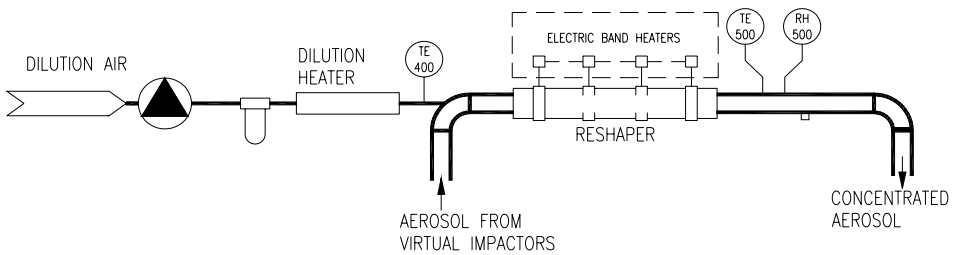


- **VI technology: Cutpoint : 1.0µm**
- **High concentrated aerosol output (50 lpm)- High Volume system (5,000 lpm)**
- **High concentration enrichment (40 to 60 times)-2 VI stages**
- **Low particle losses- No size distortion between sampled and concentrated aerosol**
- **Low pressure drop in the minor flow (inside chamber)**

Condensational Growth → **Concentration** → **Size Restoration**

Technical challenges:

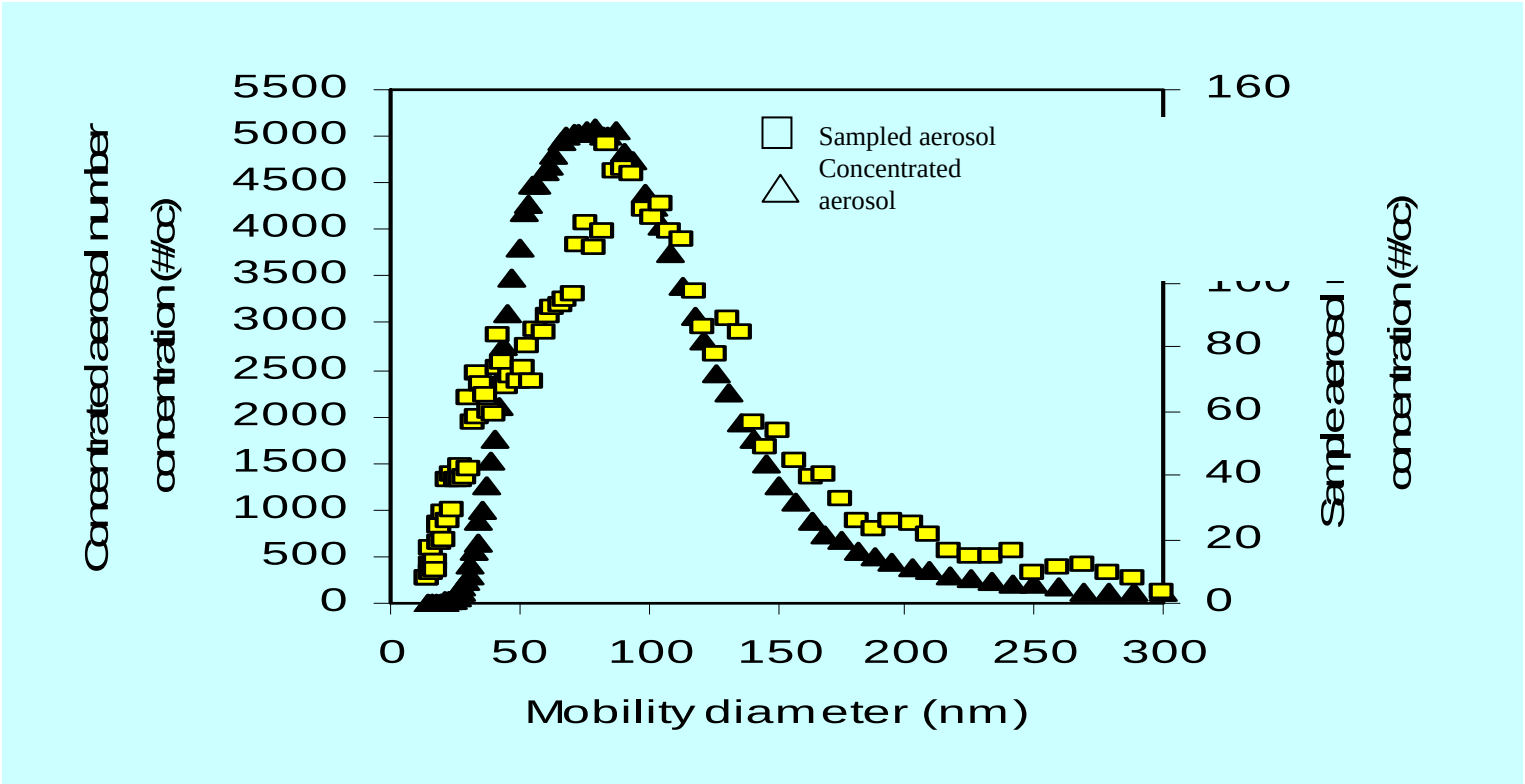
- **Remove water in short residence time (seconds)**
- **No UF losses**



Thermal size restoring Method:

Methods:

- **Remove water using a diffusion dryer system?**
- **Remove water by using a thermal drying method?**



Mobility diameter (nm)	Sampled aerosol	Concentrated aerosol
Mean Median Modal	84 75 79	84 76 85
Concentration factor = 42		
Dilution airflow=16LPM, Total outlet low=66LPM		


ProFlow

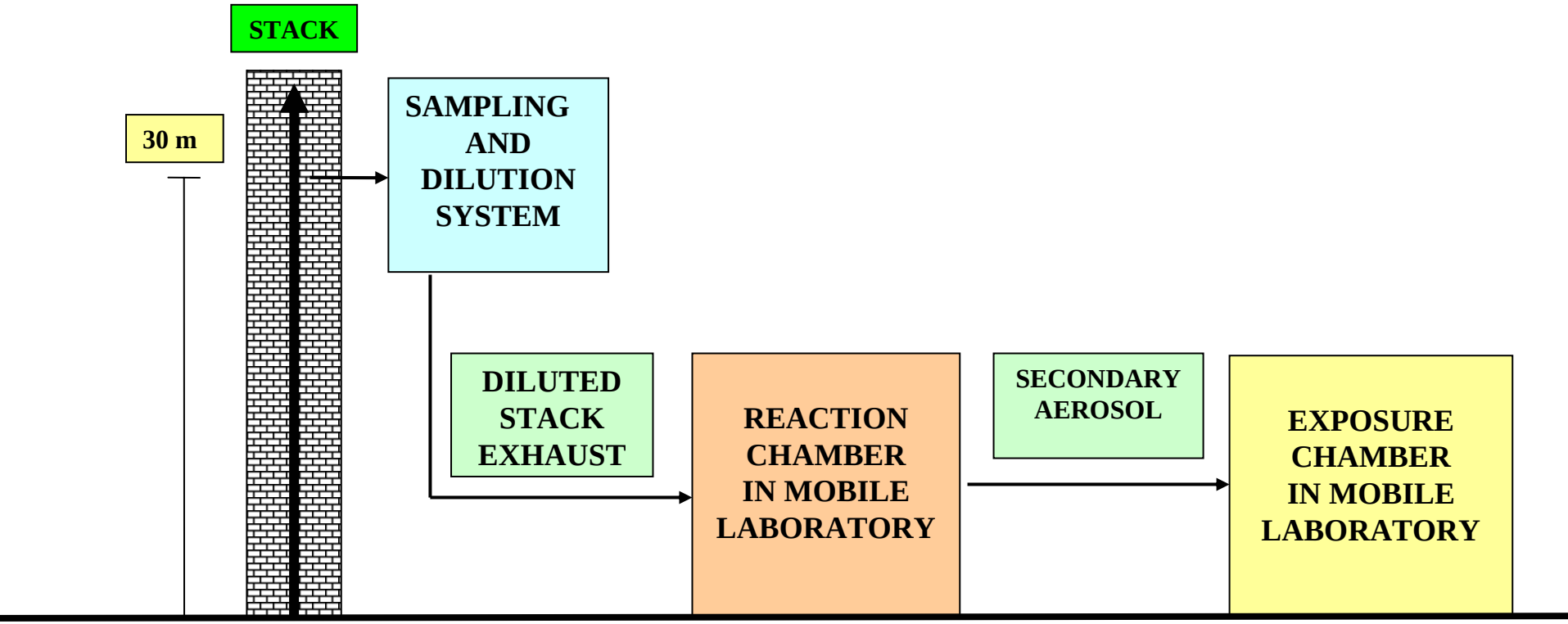
Concentration Technology

- Fine particle concentrators
  - Six in US (3 funded by HEI)
  - Brazil, Japan, Netherlands and Canada
- Coarse Particle concentrators
  - One at US EPA (human studies)
- Ultra-fine particle concentrators
  - Two for US EPA (human and animal studies)

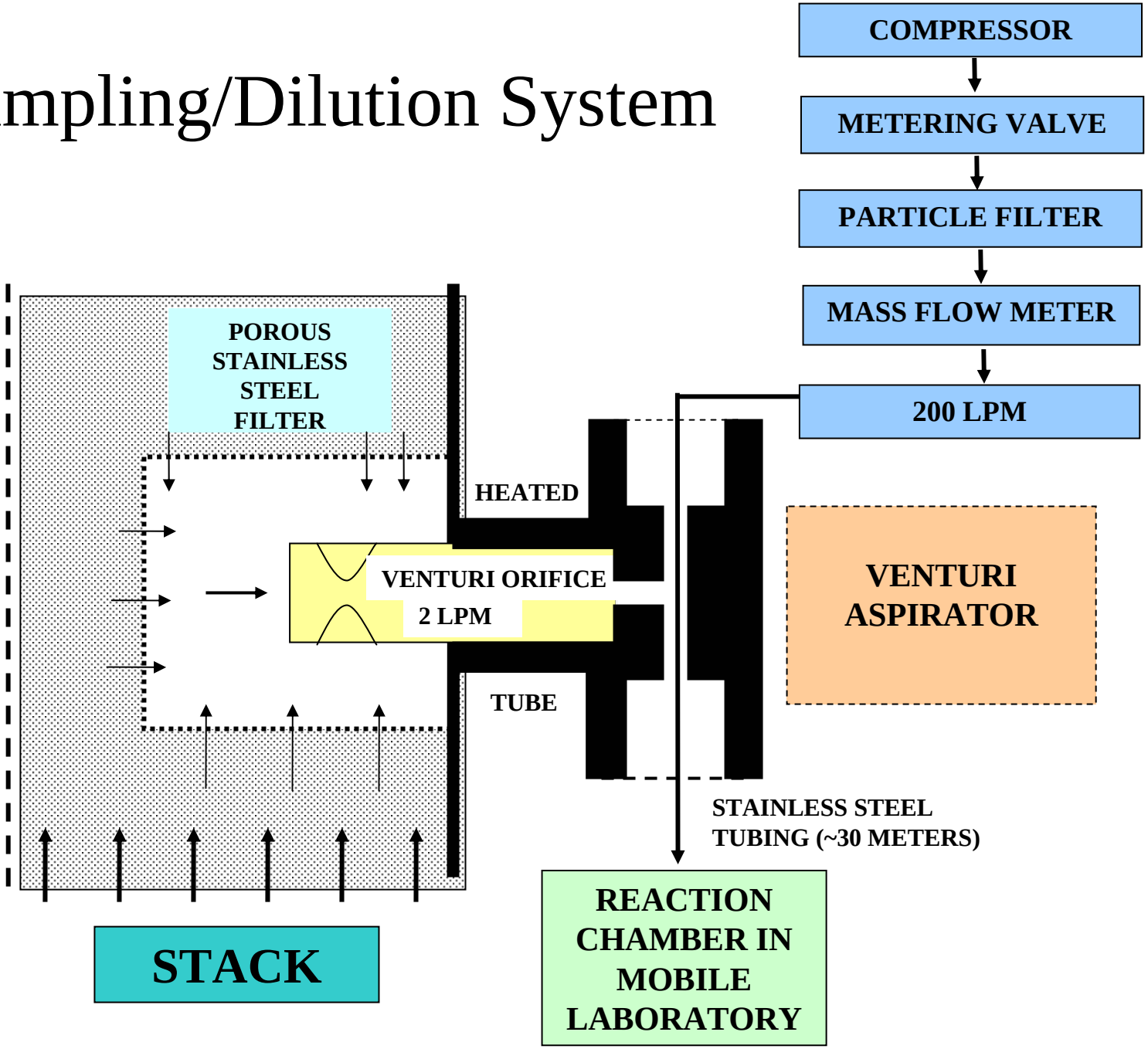
TERESA: Toxicological Evaluation of Realistic Emissions of Source Aerosols

- Investigate the toxicity of *primary* and *secondary* coal combustion emissions at multiple power plants in the U.S. by exposing laboratory rats to a variety of simulated atmospheric scenarios

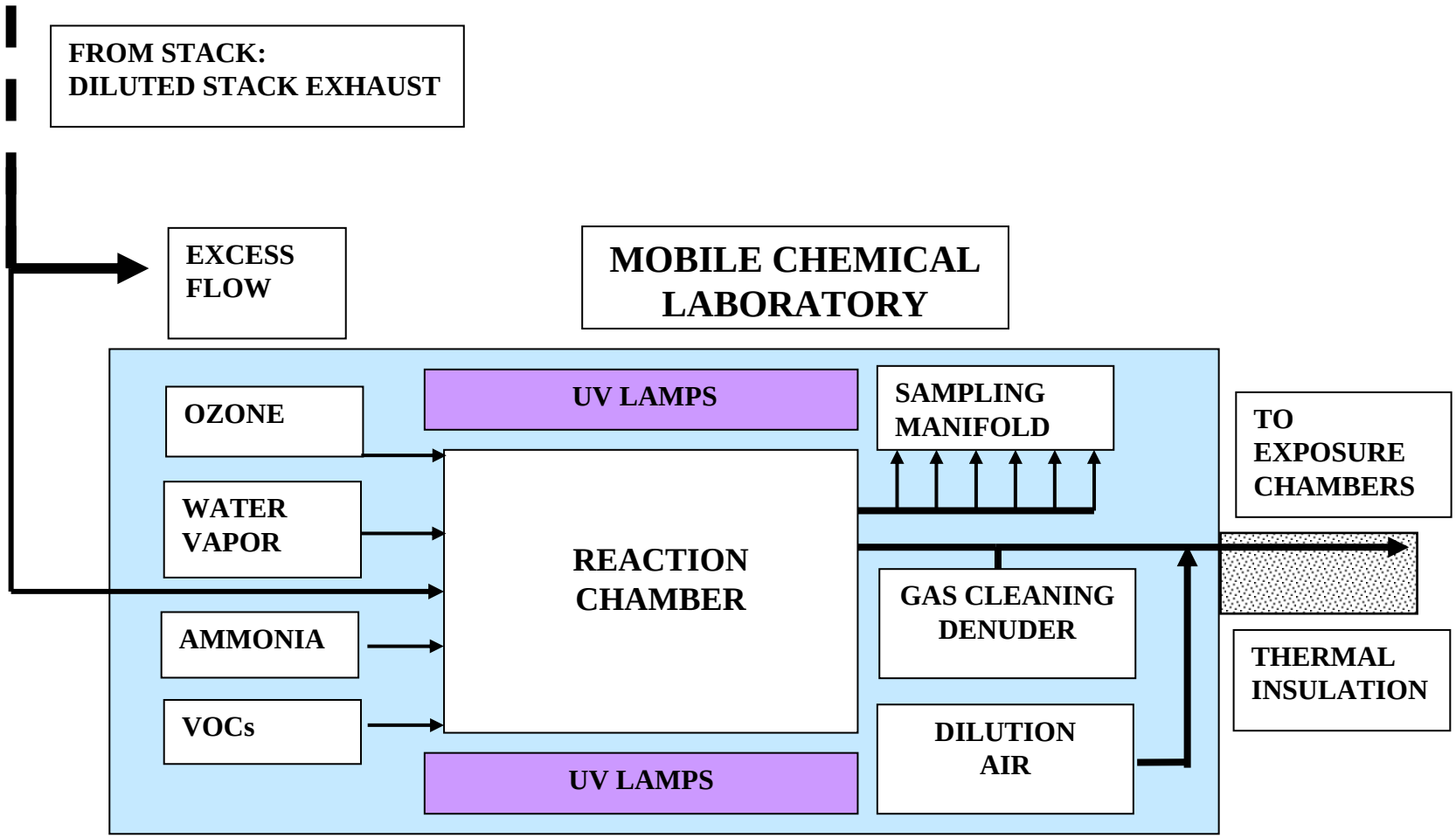
Field Layout



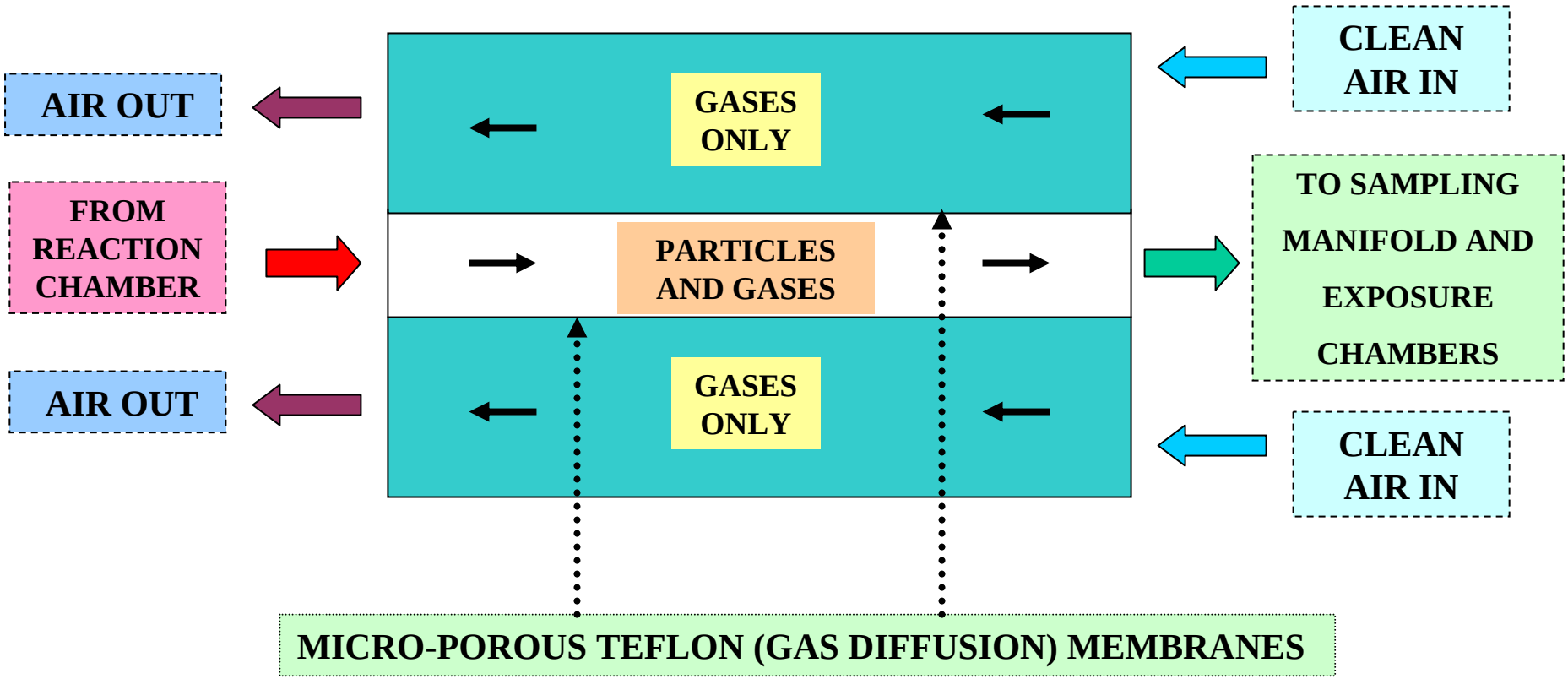
Stack Sampling/Dilution System



Reaction Chamber



Diffusion Denuder/Gas Cleaner



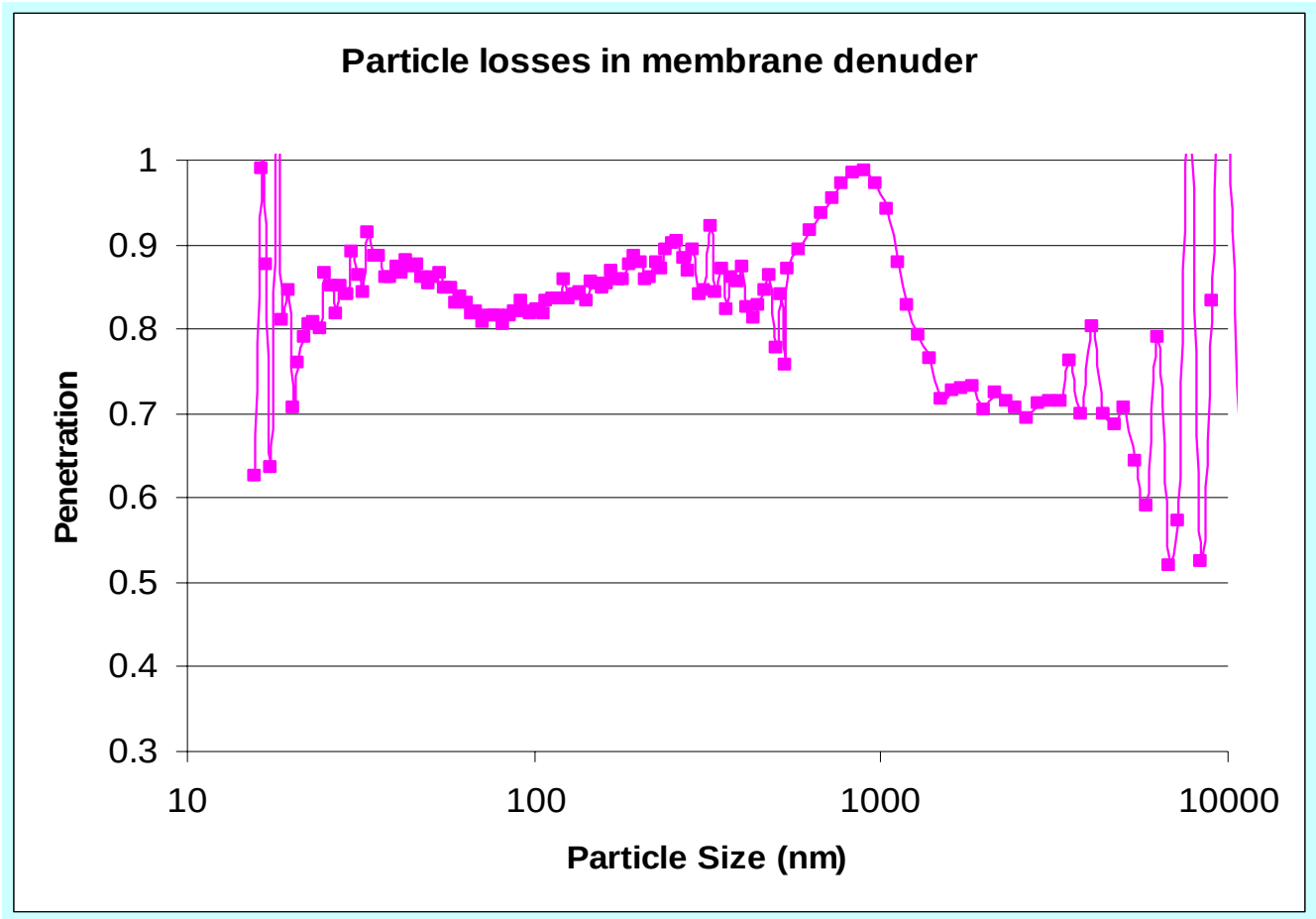
Denuder Characteristics

- Teflon Membrane: pore size 1 um, porosity 30%, thickness 5 mm
- Denuder: length 100cm, height 1 cm, width 10 cm
- Flows: sample air 3.5 Lpm, clean air 4 x 3.5 Lpm

Denuder Performance

	Flush 2:1	Flush 4:1
CO	1.1	0.58
SF6	N/A	9.91

Performance of membrane denuder



Tested with a NaCl artificial aerosol