Estimation of aerosol particle deposition in the Respiratory Tract in West African populations

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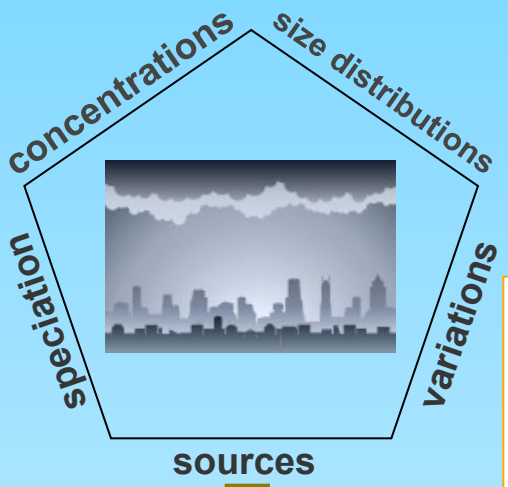
4th AMMA International conference

Toulouse 2-6 July 2012

Context ?

Characterization of West African urban aerosol and its health impacts: Dakar and Bamako

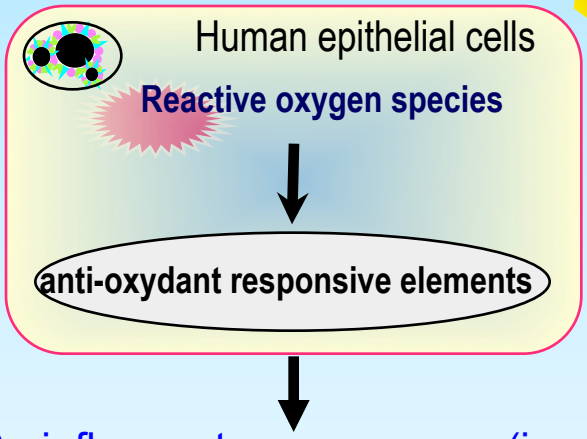
(POLCA & AMMA 2)



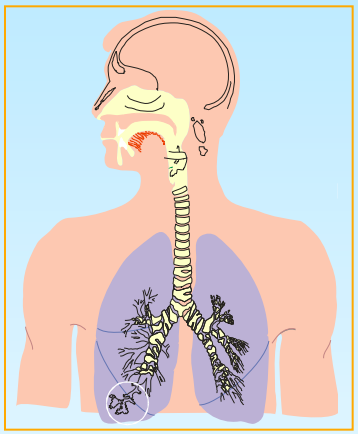
Health Impacts

I. Modified ICRP Respiratory Tract Model (DEPCLUNG)
1. model implementation
2. respiratory system / morphometry
3. input parameters

II. Compartmental particle deposition
1. deposition efficiency
2. west african vs caucasians
3. mass deposition



Proinflammatory responses (in vitro)
(collaboration A. Baeza, Univ. Paris 7)



Deposition in lungs
(collaboration A. Didier, CHU Larrey)

I. DEPCLUNG Respiratory Tract Model

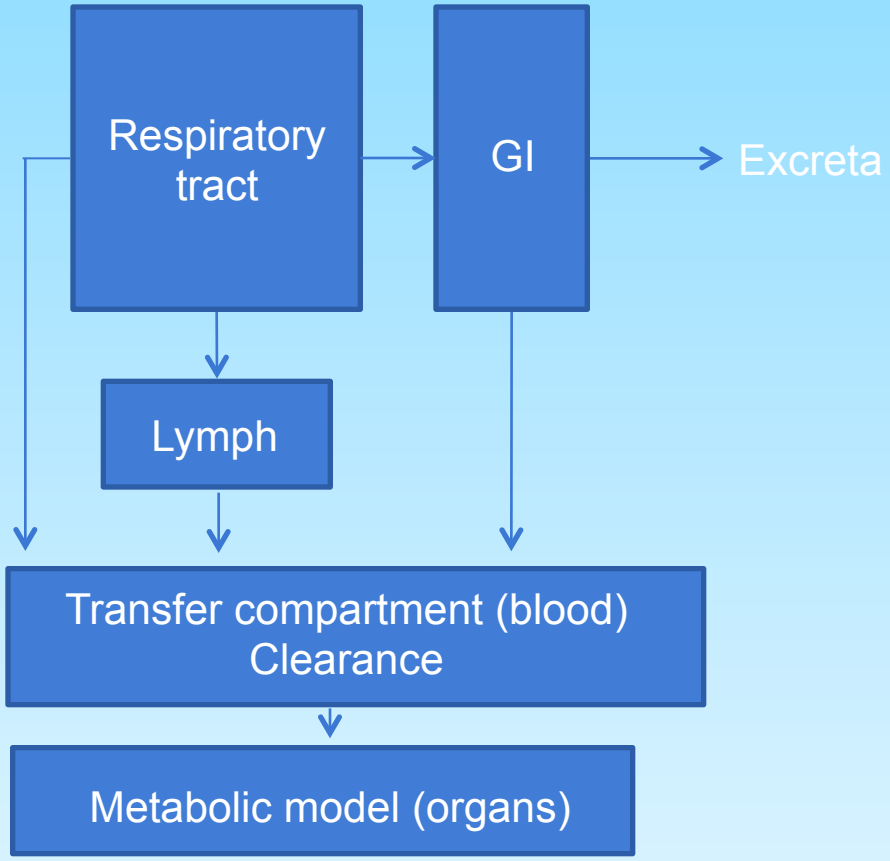
I.1. Model implementation

Historical

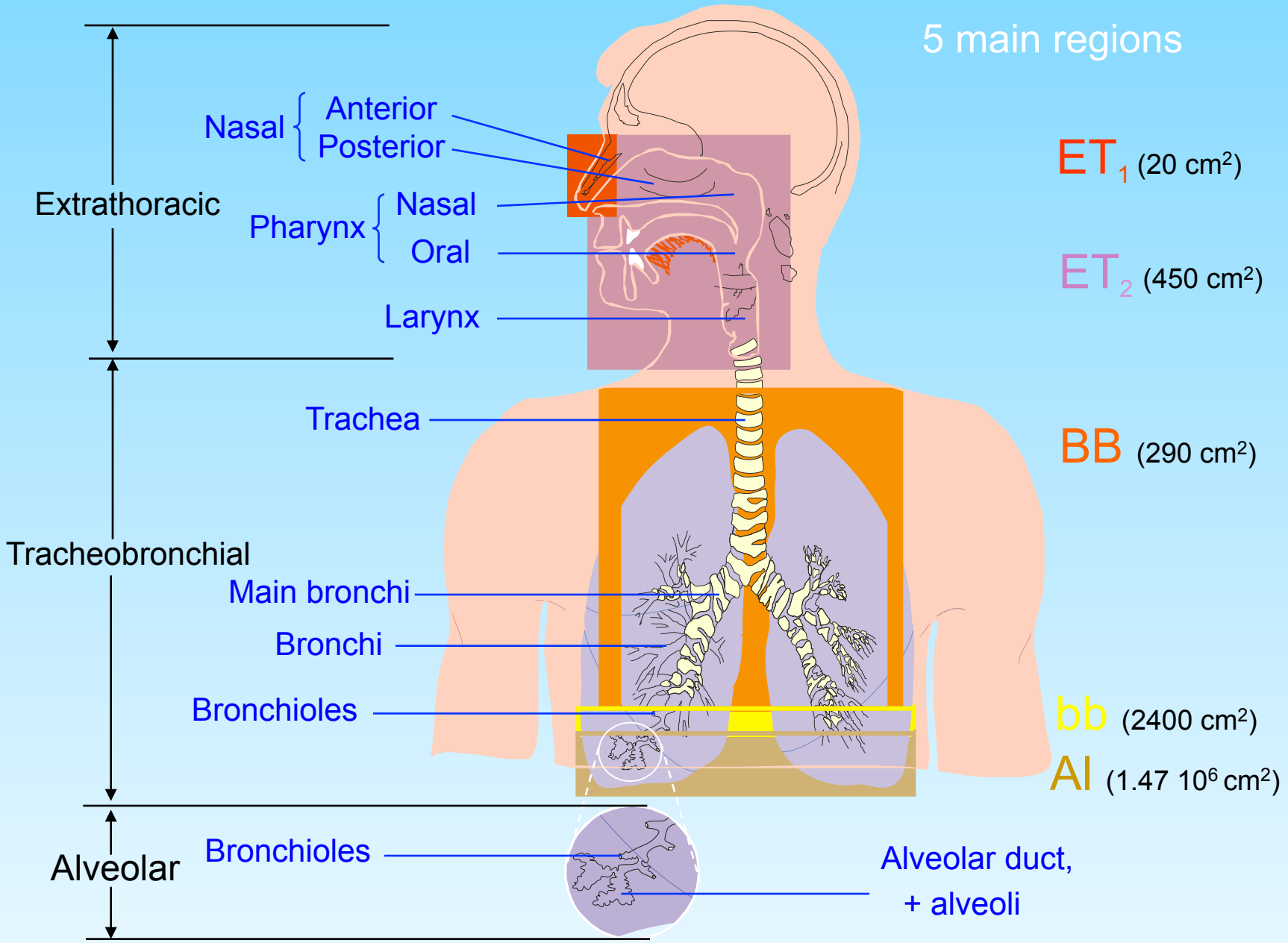
- 1959: simple lung model (ICRP 2) for adults radioactive workers

- 1994: new RTM (ICRP 66) for environmental pollution, smoking and lung disease and applied to all population

- 2010: ICRP adapted: DEPCLUNG



I.2. Respiratory Tract System



I.3. Input parameters

Subject parameters

	Adult males			Adult females			10-year old children		
	Caucasians[a]	West Africans	Ratio	Caucasians[a]	West Africans	Ratio	Caucasians[a]	West Africans	Ratio
H (cm)	176	177[b]	1.006	163	165[b]	1.012	138	136[c]	0.985
W (kg)	73	68[b]	0.932	60	63[b]	1.050	33	28[c]	0.848
TLC (L)	6.98	5.64[e]	0.808	4.97	3.95[e]	0.795	2.87	2.17[d]	0.756
FRC (L)	3.30	2.6[f]	0.788	2.68	1.82[f]	0.679	1.48	1.12*	-
VC (L)	5.02	4.20[b]	0.837	3.55	3.00[b]	0.845	2.33	1.71[c]	0.734
V (ml.s^{-1})	833	673*	-	694	552*	-	317	325[d]	-
VT (L)	1.25	1.01*	-	0.99	0.79*	-	0.58	0.65[d]	-
VR (m^3.h^{-1})	1.5	1.2[b]	0.800	1.25	0.96*	-	1.12	0.792*	-
Light exercise									

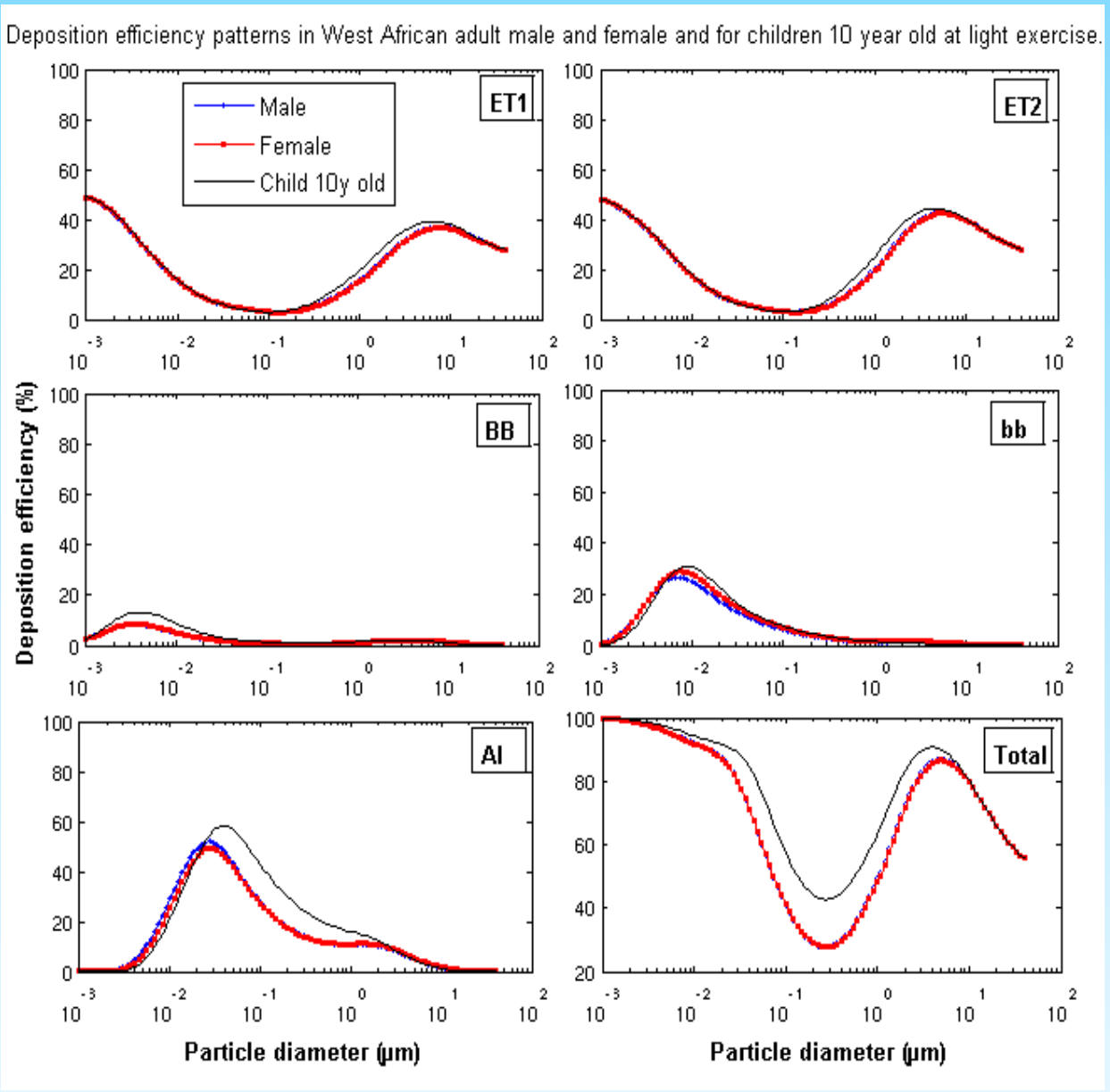
[a]ICRP publication 66, [b]Dufetel et al., 1989 and 1990, [c]Seck et al., 1990, [d]Miller et al., 1977, [e]Lapp et al., 1974, [f]Roy et al., 1991
*estimated value

Particle parameters

	Diameter type	Diameter size	Shape factor	Density	GSD
Range/choices	AMTD, AMAD d_{th} , d_{ae}	0.0006 – 100 µm	1 - 2	0 – 22.57 g.cm^{-3}	formula or custom value (< 1)
Default	AMAD	5 µm	1.5	3.0 g.cm^{-3}	formula

II. Compartmental particle deposition

II.1. Deposition efficiency (DF)



- DF peak upper of 40% in the ET region at the lowest and upper size range

- In the BB, bb and Al regions peak increase and shift, with maximum of 60% in the Al at size less than 0.1 µm

- DF higher in 10 year old children and especially on the Al region for size range of 0.01-0.1 µm.

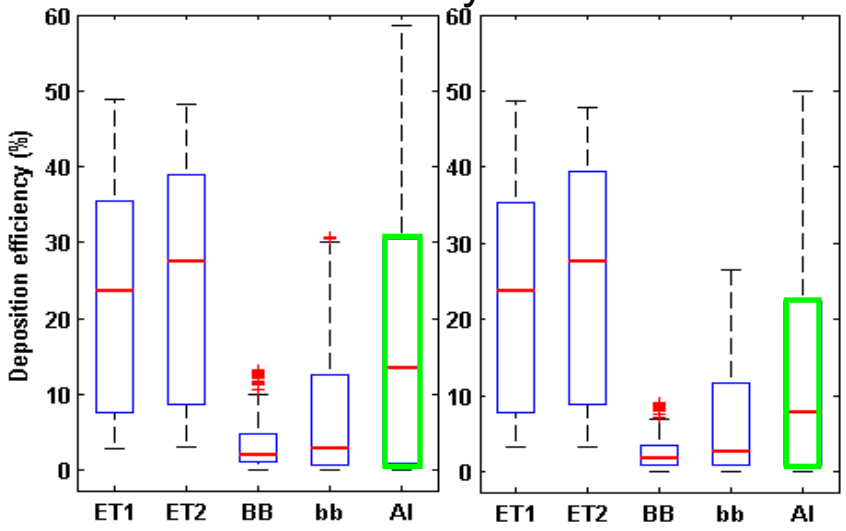
II.2. West Africans vs Caucasians

Adult males

Caucasians

- In adult males, no difference in
- In adult males, no difference in compartmental deposition between West Africans and Caucasians (1 – 2 %), while in children difference rise to 27 % in the AI

Children 10 year old



West Africans Caucasians

➔ this large difference in children is due to differences in lung capacities more important for children (26 % in children and 21 % in Adult males) ?

➔ or uncertainties in subject parameters for children from West Africa, ?

II.3. Mass deposition calculation

$$DM_i = DF_i * N(t) * TV * VR$$

DM : deposited mass per exposure per time per person
DF : deposition fraction
N : aerosol concentration in $\mu g.m^{-3}$ or m^{-3}
TV : tidal volume in ml
VR : ventilation rate in $m^3.h^{-1}$

By replacing ”per person” with “per body-weight” or “per lung-volume (per TLC)”, two more indexes were also evaluated:

- deposition per body-weigth DW ($\mu g\ h^{-1}\ Kg^{-1}$)
- deposition per lung-volume DL ($\mu g\ h^{-1}\ L^{-1}$)

Regarding mass deposition using three results:

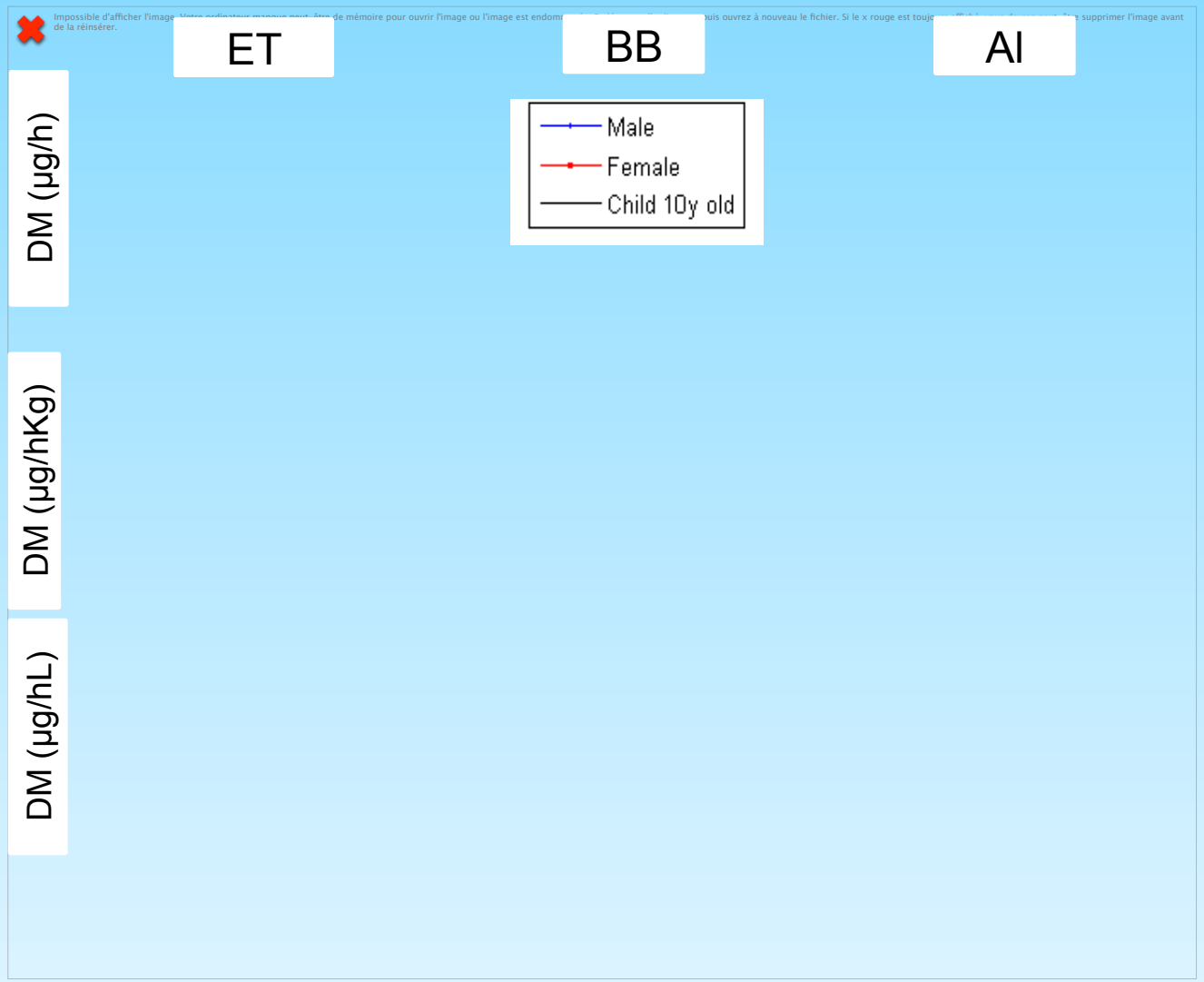
1. inhalation of 1 $\mu g.m^{-3}$

2. measured mass size distribution

3. measured chemical mass distribution

II.3.1. Compartmental mass deposition

1. inhalation of 1 µg.m^{-3}

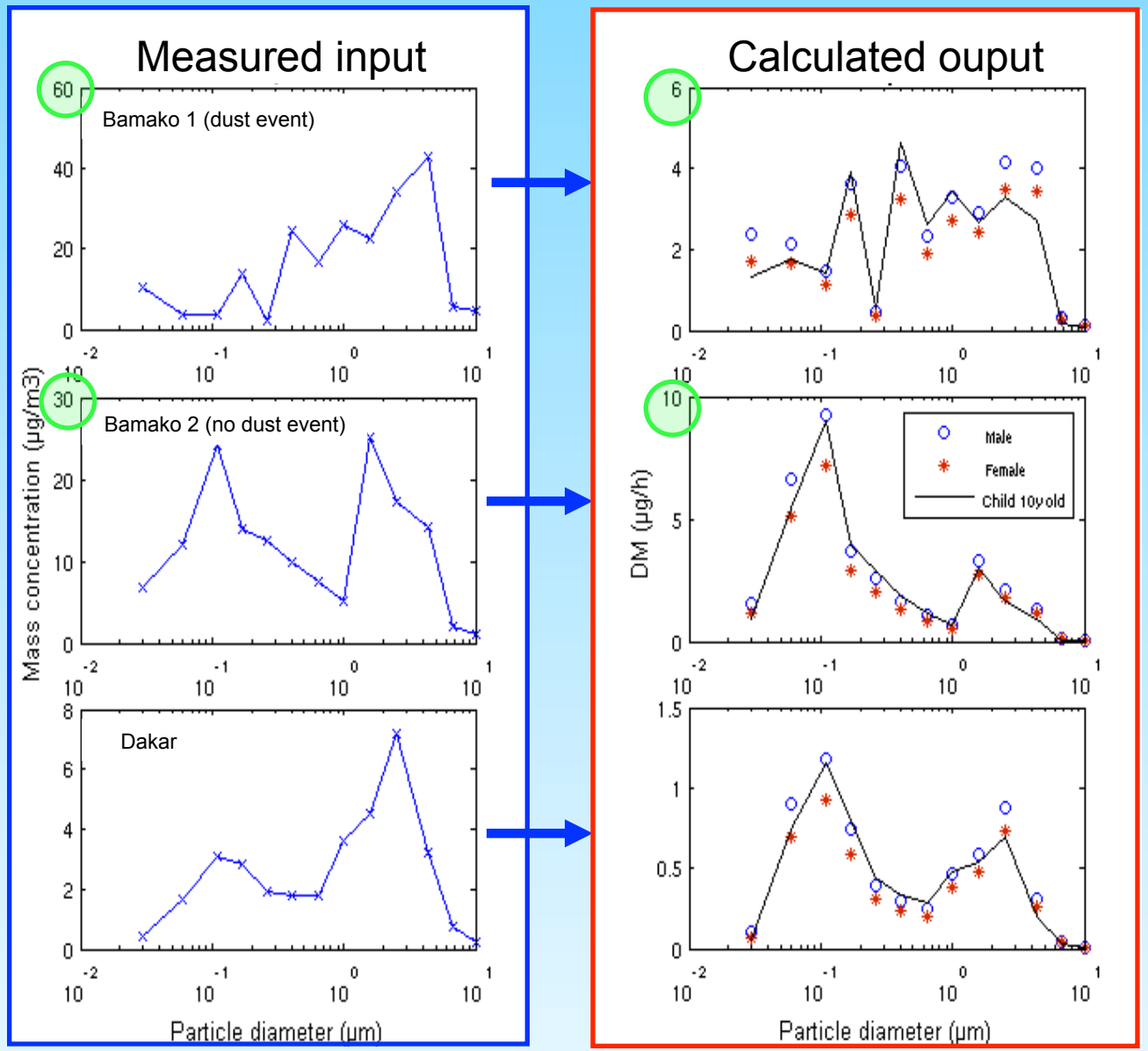


Clear difference is observed between adult males, females and children 10 year old, when changing evaluation indexes

(⚠ units in ordinates !)

II.3.2. Mass distribution deposition

2. Measured mass size distribution



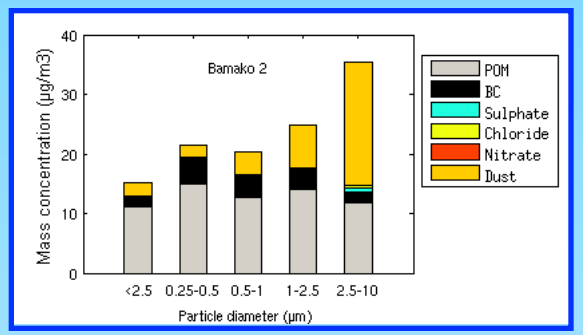
- Mass distribution
- Mass distribution measured with 13-stage impactor (Dekati) at Bamako 1 (dust event),

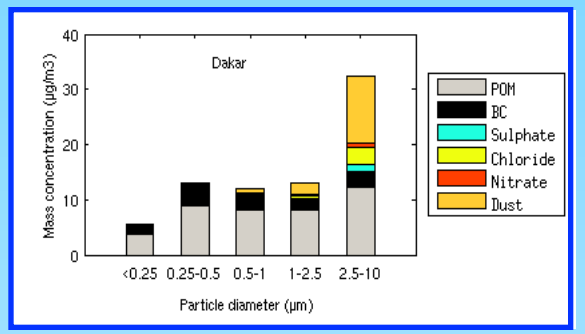
- Calculated deposited
- Calculated deposited mass (DM) in the Al regions and children, females and children 10

- Higher influence of
- Higher influence of size distribution than

II.3.2. Chemical mass distribution deposition

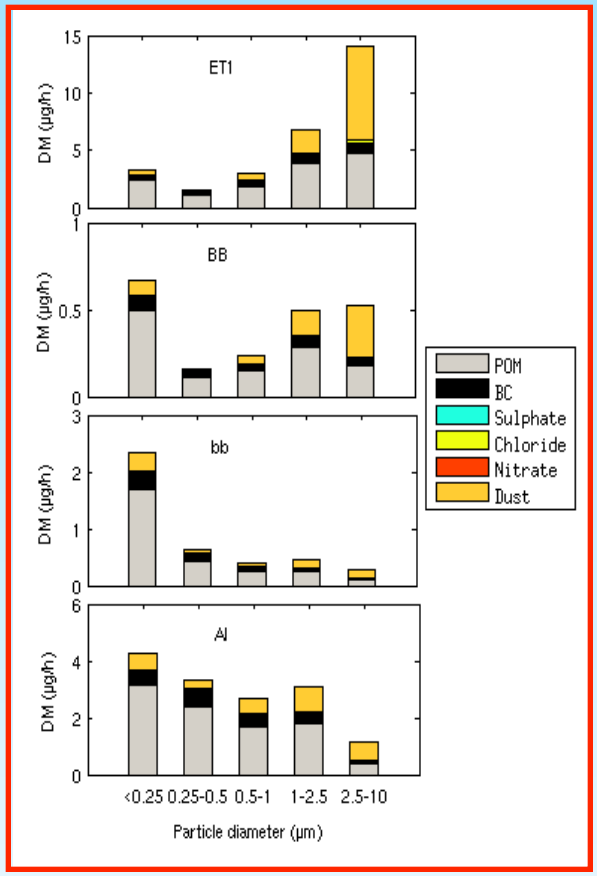
3. Measured chemical mass distribution

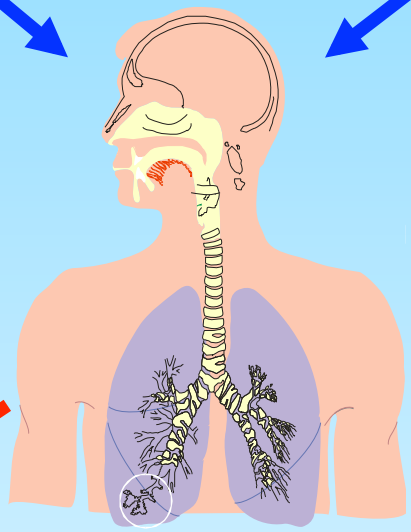




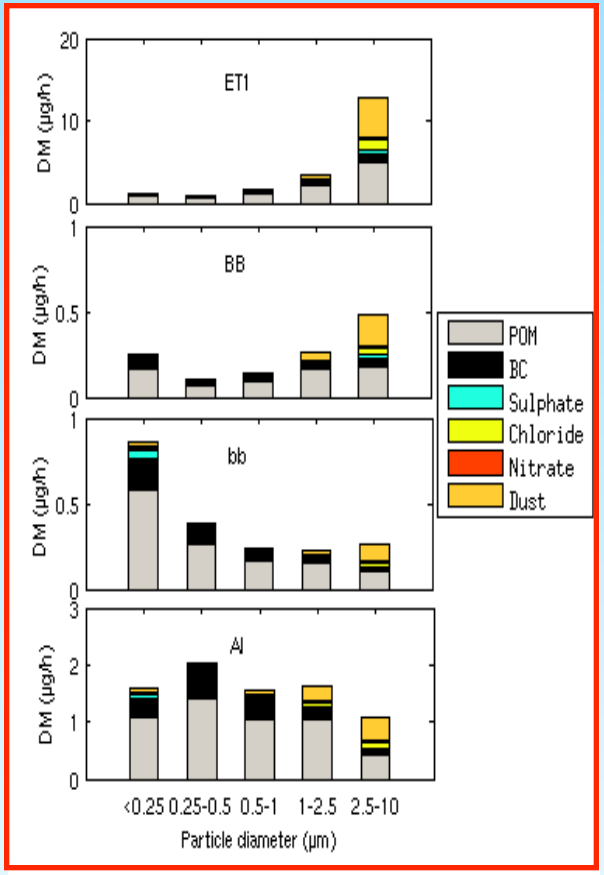
Aerosol chemical mass distribution in Bamako 2 and Dakar

BAMAKO 2





DAKAR



Importance of size chemical composition

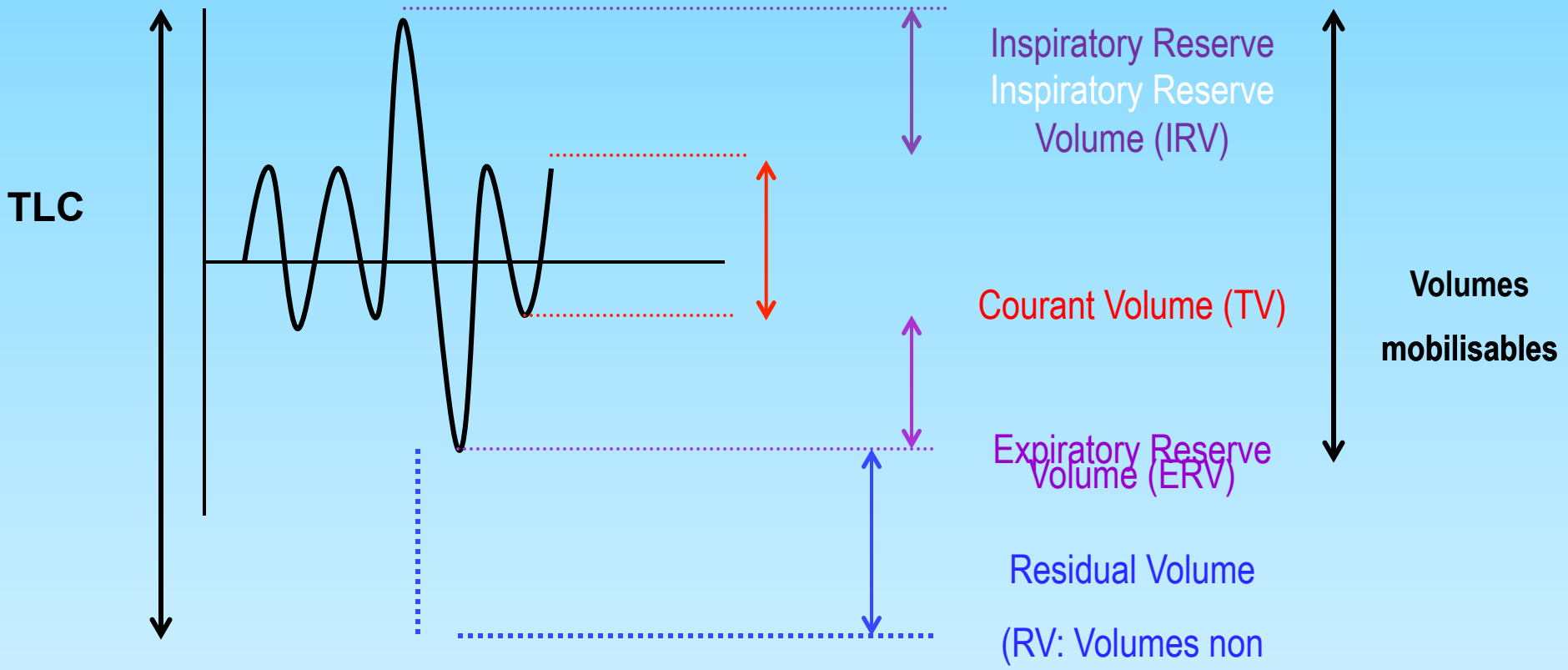
Conclusions

- Particle deposition on lungs is strongly influence by the age of subjects, their lung characteristics and their respiratory capacities
- Large differences in deposition were observed between males, females and children when changing deposition indexes. However, deposition fraction is practically identical in adult West Africans and Caucasians
- Lung particles deposition depend not only on size distribution of aerosols but also on their chemical composition.

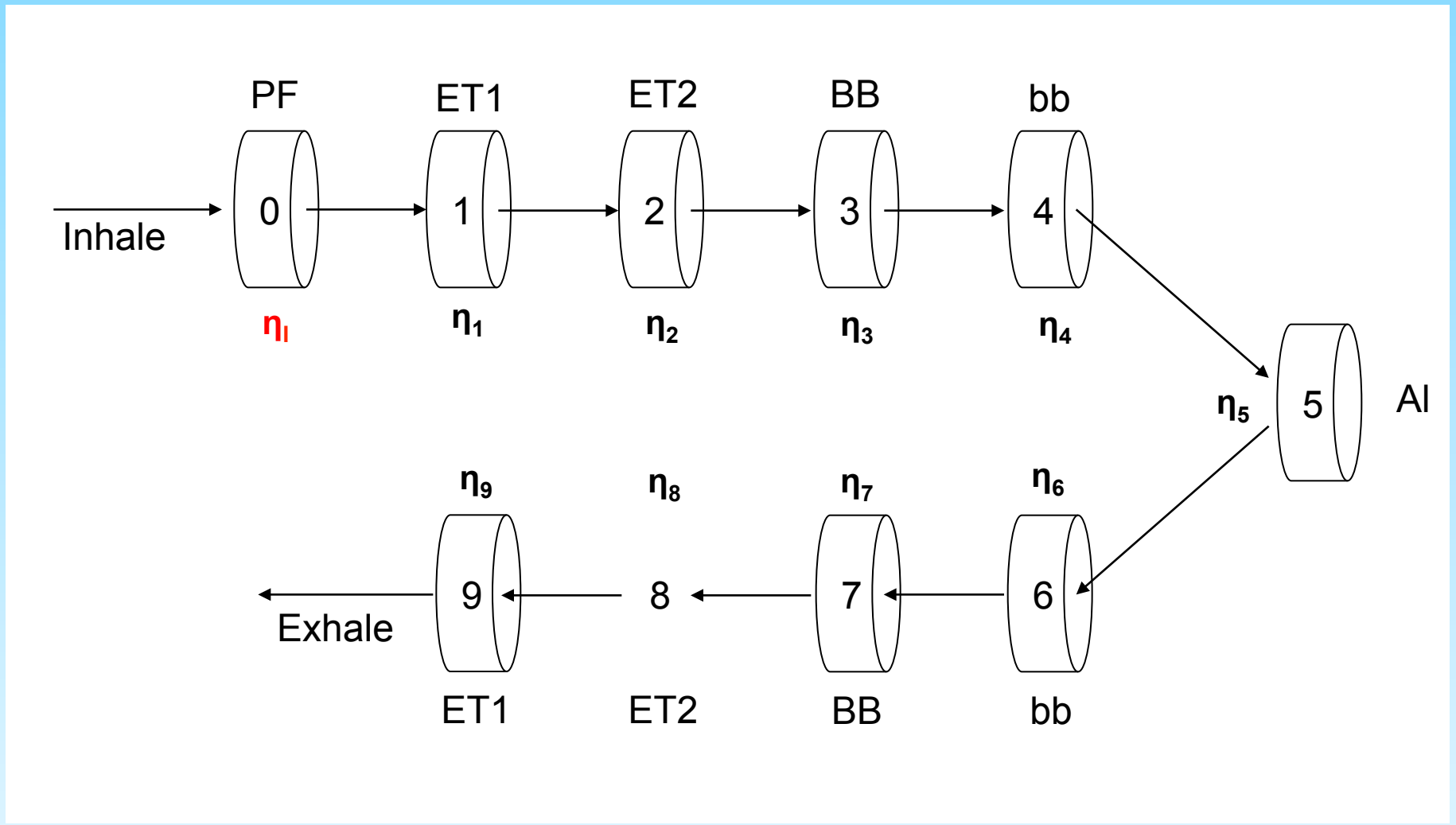
Perspectives

- This study is limited by a lack of data on lung capacities for African, particularly for children and more investigations are needed
- Role of particle solubility and hygroscopicity need to be taken into account
- Differences between characteristics of inhalable particles and that are found in bb region need to be taken into account in toxicological analyses.

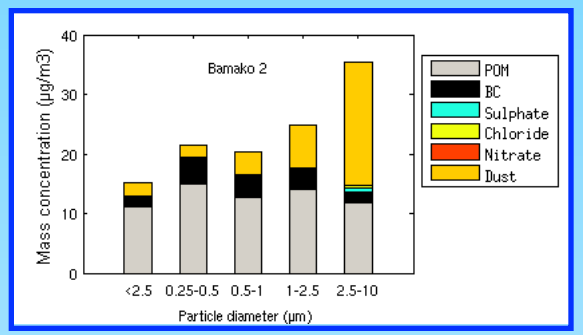
THANKS

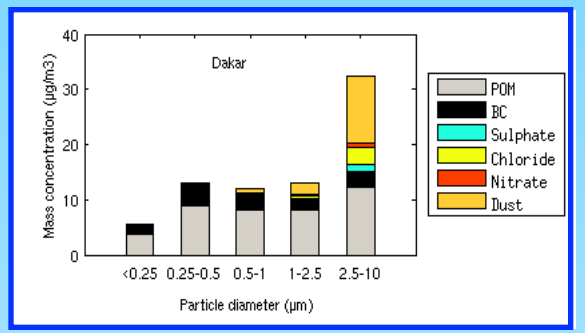


IC (Inspiratory Capacity) = VC + VRI

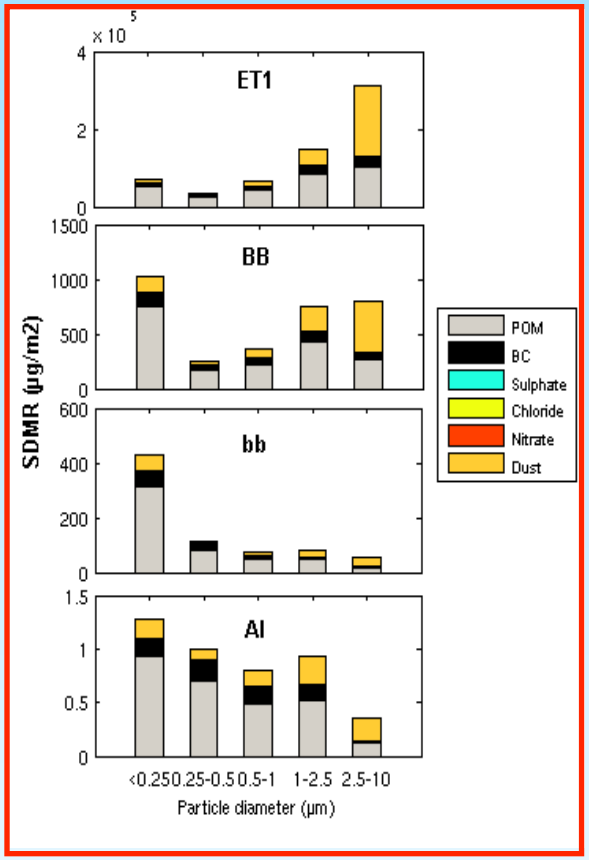


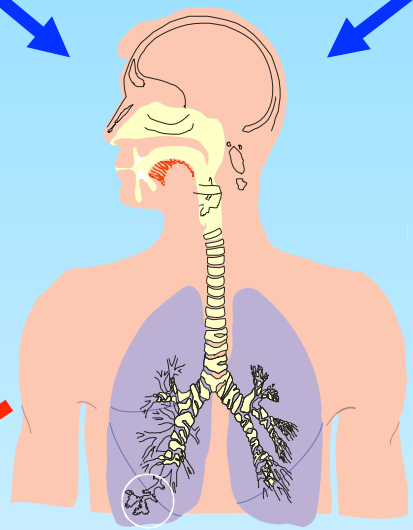
Each filter is characterized by an filtration efficiency (η) and a volume (v)





BAMAKO 2





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