Activity size distribution of radioactive ^{7}Be aerosols at different environments in Northern Italy

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Radioactive aerosols

Following their production by gas-phase nuclear transformation, the isotopes condense on the aerosol particles, growing by condensation of non-radioactive species and the fate of radionuclides will become the fate of the carrier aerosols.

Natural: terrestrial origin, decay products of ^{222}Rn, ^{220}Rn, ^{210}Pb
or cosmogenic, ^{7}Be, ^{14}C,^{3}H, ^{32}P, ^{35}S

Artificial: nuclear weapons or nuclear accident, ^{137}Cs, ^{90}Sr, ^{131}I, ^{106}Ru

Radioactive aerosols are of specialist interest

in studying environmental process

^{7}Be (55.3d) and ^{210}Pb (22.24y) *have been proven powerful tools studying cloud scavenging and precipitation, aerosol transit and residence times in the troposphere, aerosol deposition velocities, and Simulated Global Climate Models. (Brost, Feichter)*

for health implications

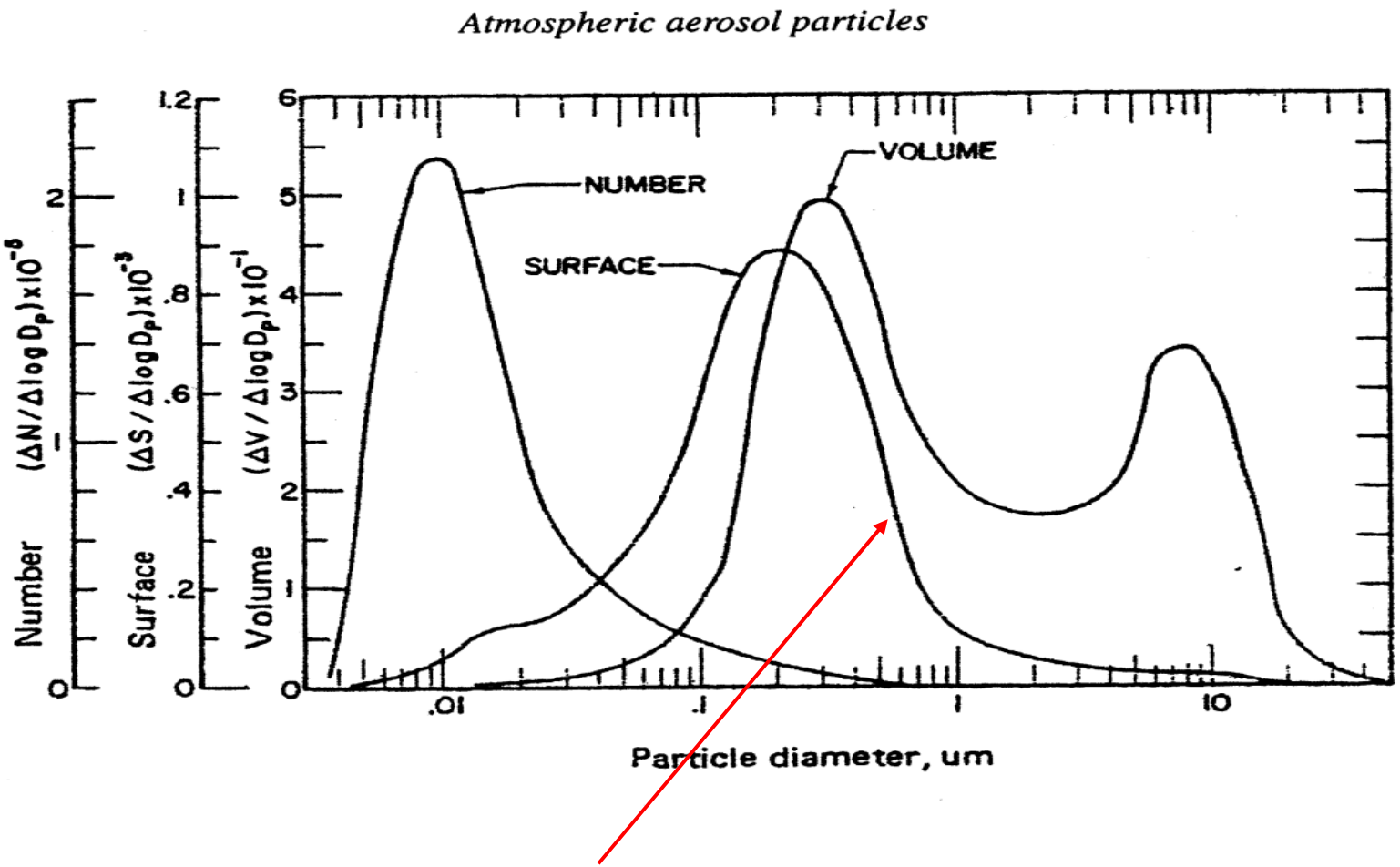
radon (^{222}Rn), thoron (^{220}Rn) and their decay products

The greatest fraction of the natural radiation exposure in humans results from inhalation of the radon short-lived decay products, which occur in the free atmosphere and in higher concentrations in the room air of buildings.

The "radonproblem" was first recognized among workers in mines.

Inhalation exposure via smoking by ^{210}Pb, ^{210}Po

Radioactive aerosols



The activity size distribution of radioactive aerosols follows the **surface distribution**.

Activity Median Aerodynamic Diameter

AMAD

AMAD value tell us how big is the diameter of the radioactive particles

Is the diameter of aerosol particles where below and above this value exist the 50% of the activity of aerosol particles

AMAD, Activity Median Aerodynamic Diameter

Is useful

- to define the mean residence time of radioactive particle and any other particle with similar behavior in the atmosphere
- in dosimetric models, the calculated dose principally depends on AMAD
- on models of aerosol transport in the atmosphere

Size of particles deposited decrease with increasing altitude of debris cloud, wind velocity and distance downwind.

Residence Time

is a function of various removal processes,

dry deposition — by impaction, diffusion, sedimentation

wet deposition

Residence Time

can be estimated

by means of radioactive nuclides as tracers, which become attached to aerosol particles and are removed with them

Method based on the ^{7}Be aerosol particle growth rate

$$\tau_R = \frac{AMAD_{mean} - Size_{Aitken\ nuclei}}{Mean\ particle\ growth\ rate}$$

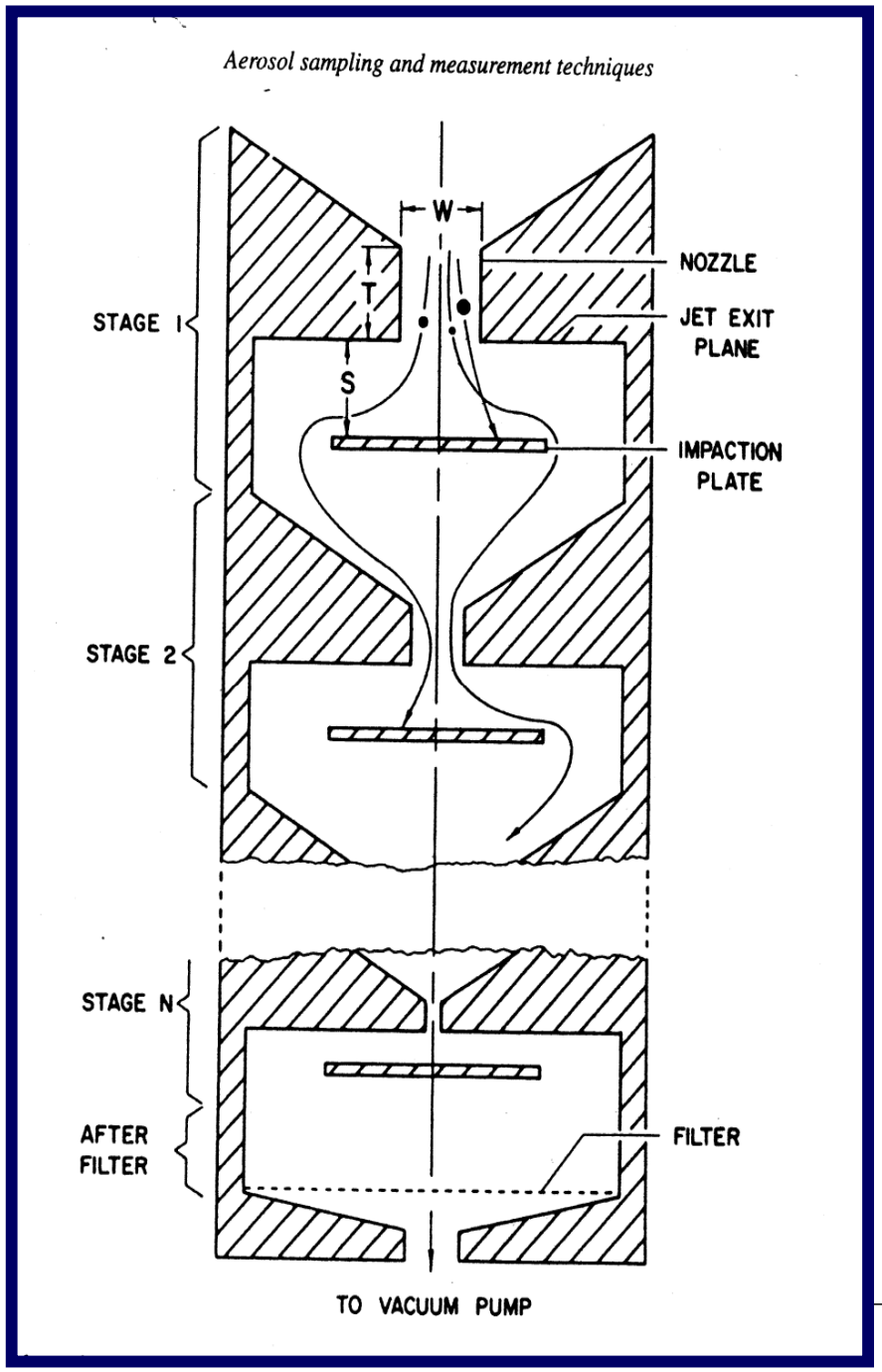
Mean particle growth rate = 0.004 or 0.005 $\mu m\ h^{-1}$

$Size_{Aitken\ nuclei}$ = 0.0015 μm

AMAD ^{7}*Be* = 0.54 – 1.05 μm (0.80 μm)

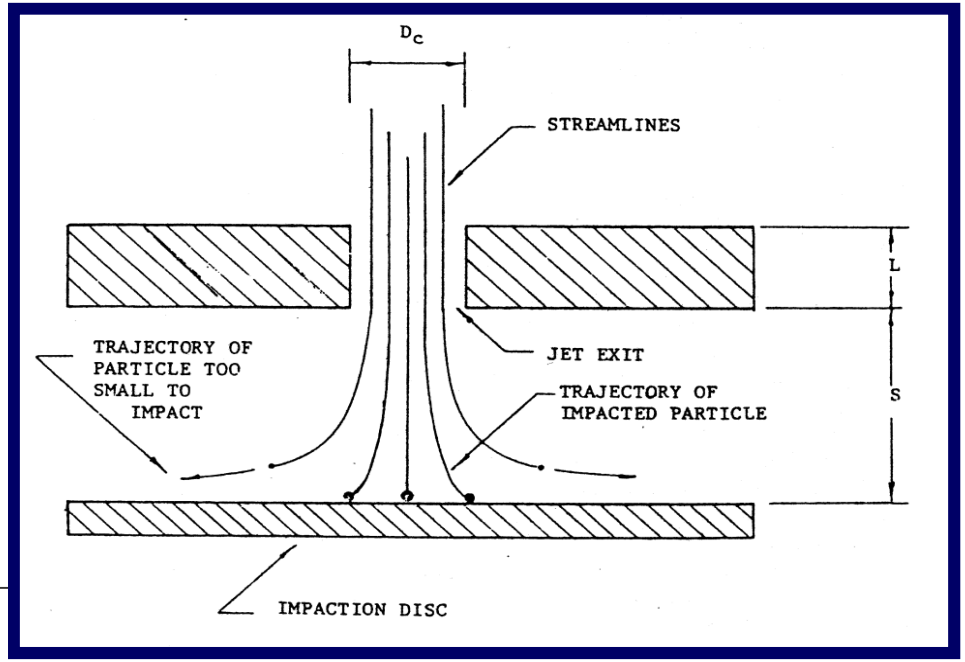
$$\tau_R = 4.5 - 10.9\ d$$

$$\tau_R = 7.5\ d$$

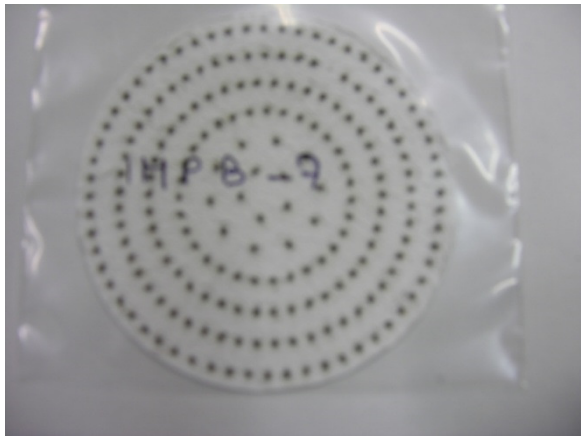


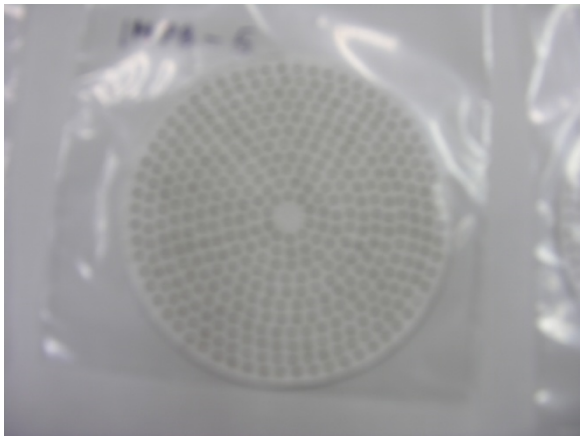
Physics behind the cascade impactor

By subsequently making the orifice diameter smaller on each Stage of the Cascade Impactor, the particles are increased in velocity and the aerodynamic separation of particles over a large range can be determined.



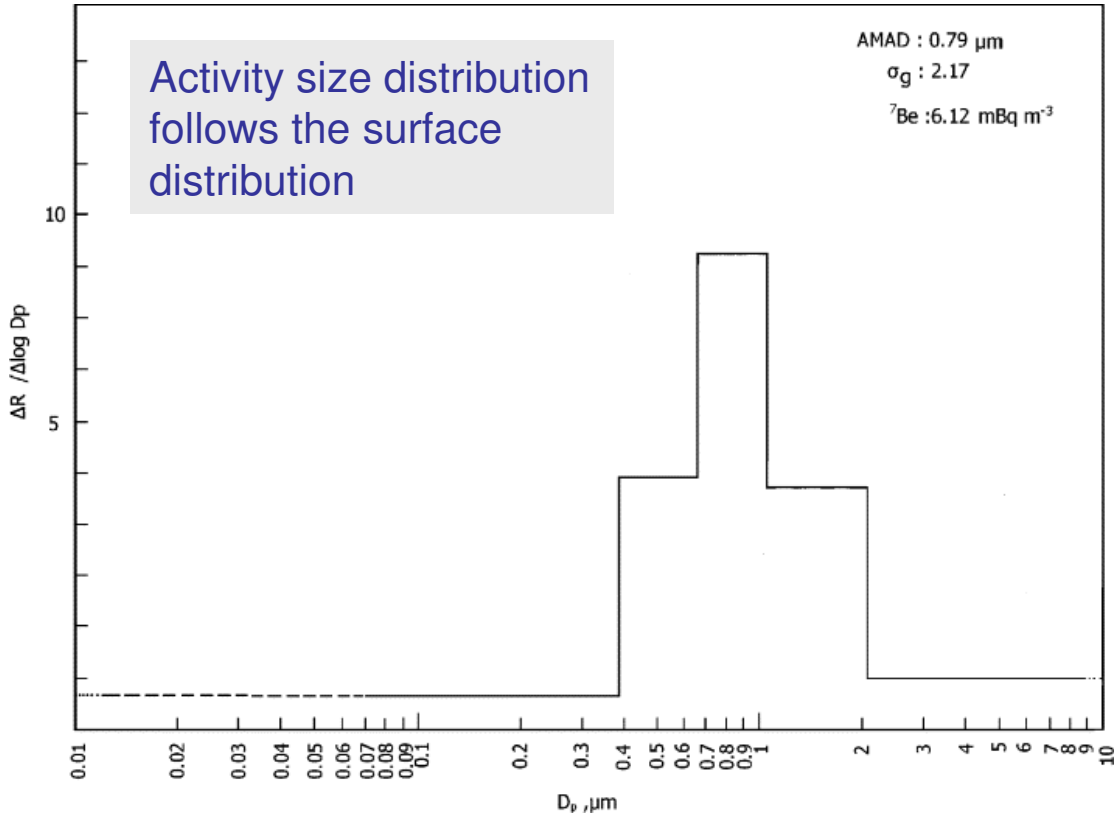
Filter Samples Acetate Cellulose Filters





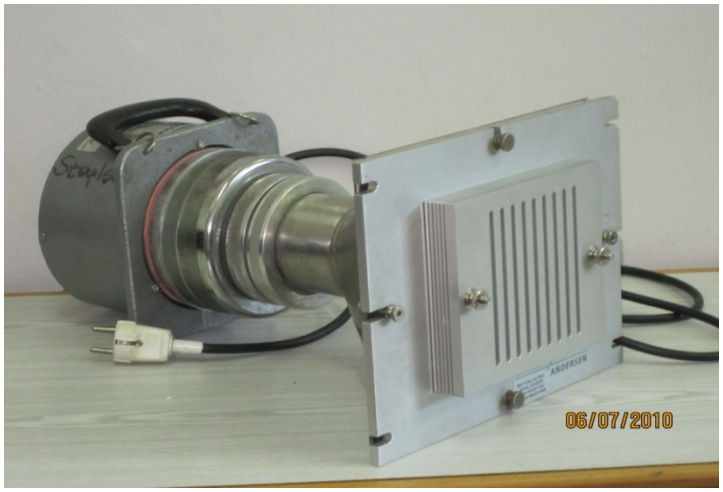
Activity size distribution of ^{7}Be aerosols

The activity median aerodynamic diameter (AMAD) of the aerosol particles is determined upon the measurement of the activities of the aerosol-associated radioactive nuclides.



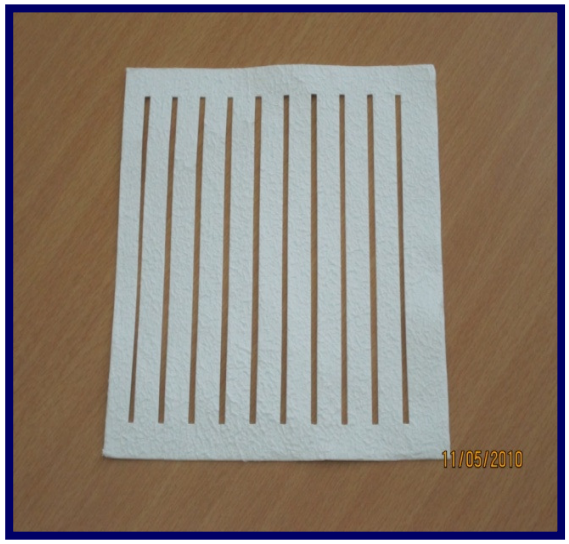
Activity size distribution of ^{7}Be aerosols by 20-CFM cascade impactor

Sampling Procedure
20cfm six-stage Cascade Impactor



Observation and Measurement can be done with a six stage HV Cascade Impactor. A device that sucks air in order to collect and divide radioactive aerosols by size. This classification occurs due to the different cuts of the metal plates and the way they affect the air streamline passing throw. The filters we use are made of fiberglass material.

Stage	Cutpoints (μm)
1	10.2
2	4.2
3	2.1
4	1.4
5	0.73
6	0.41
F	<0.41



Activity size distribution of ^{7}Be aerosols in different environments

In the literature exist publications about radioactive aerosols but there no works done simultaneously in different environments

To use radioactive aerosols as an index of air pollution conditions
by different AMAD values
by different composition of air pollutants

Sampling Procedure -Sites of Investigation

Four different sites for investigation were chosen

- L.A.S.A. Lab, INFN, Segrate, Milano
- University degli Studi di Milano
- ISPRA(near the lake)
- Macugnaga, Monte Rosa Mountain(1300m asl)

L.A.S.A. Lab was the reference station

Each one measurement campaign included two simultaneous measurements, one in LASA lab site (reference station) and one in of the rest sites.

Four different Seasons (3 simultaneous measurement in each season)

Winter Campaign (starting in February 2011)
Spring Campaign
Summer Campaign
Autumn Campaign (has been done yet)

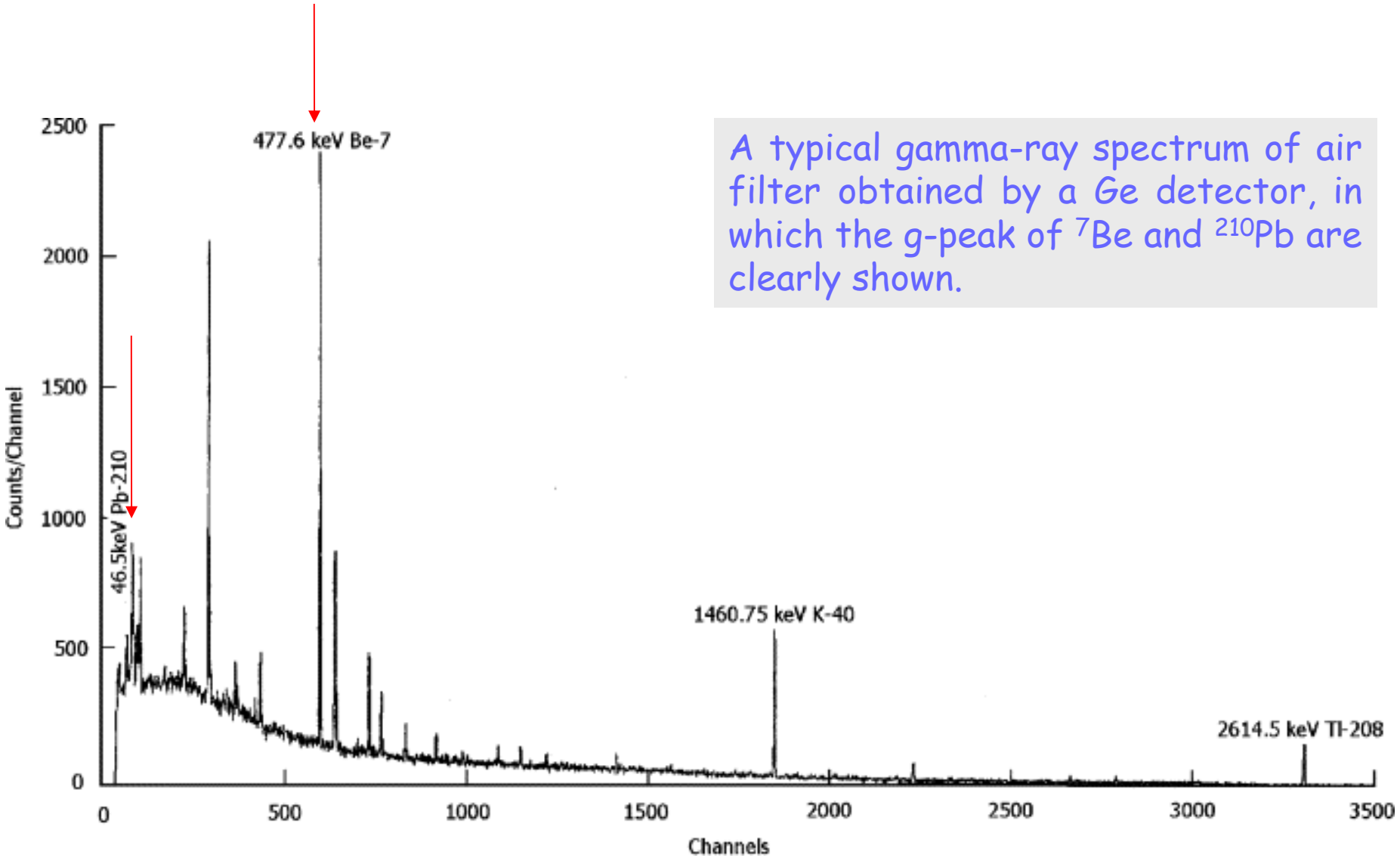
1 week of sampling →10 days of measurement

(2x9)x3x4 = 216 air filter samples

Setup of the two 1ACFM cascade impactors

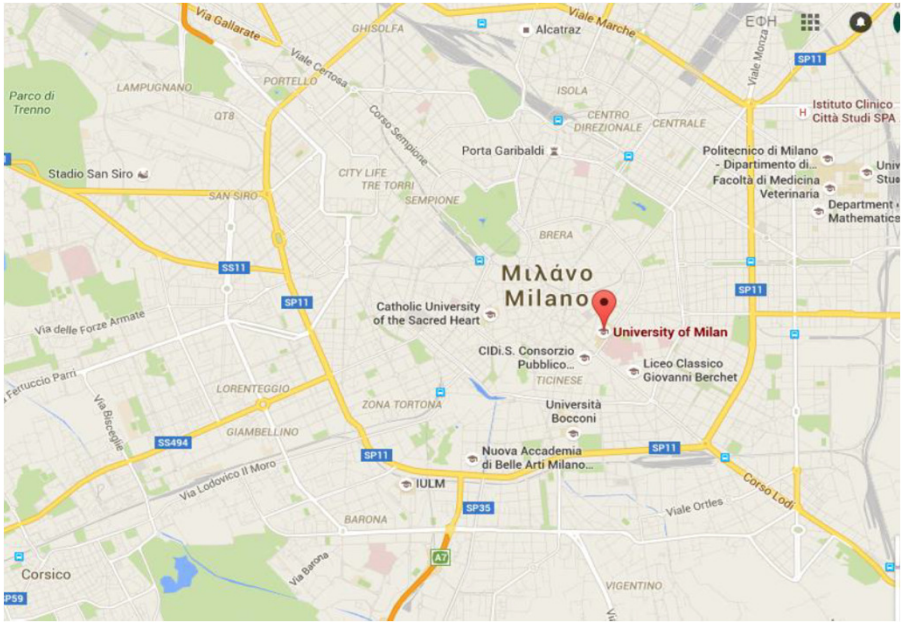
L.A.S.A. Lab, INFN and Physics Dept. of University of Milano

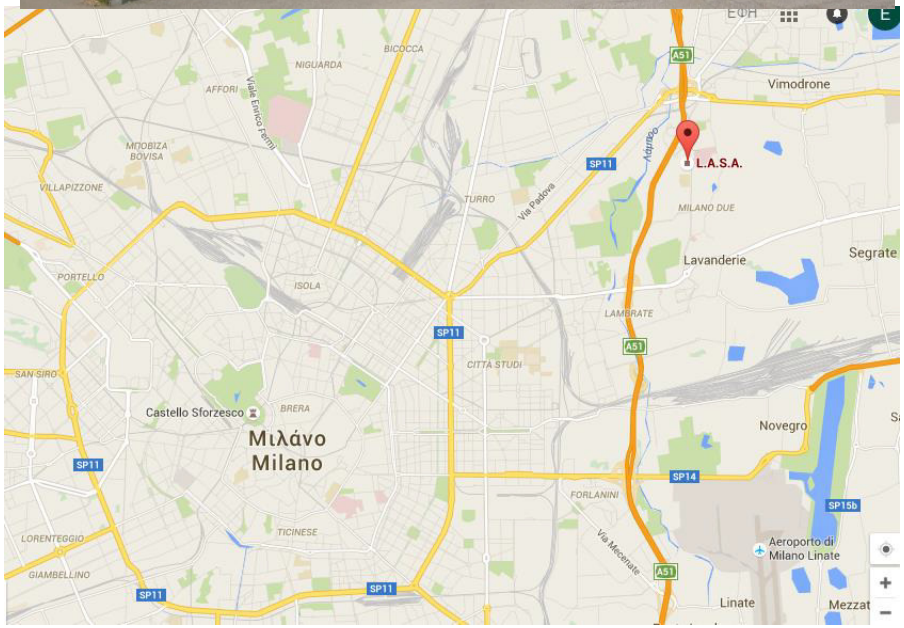
The filters, used as plane radioactive sources were measured for ^{7}Be activity ($E\gamma$ = 477keV) by γ-spectrometry, using low background HPGe detector.



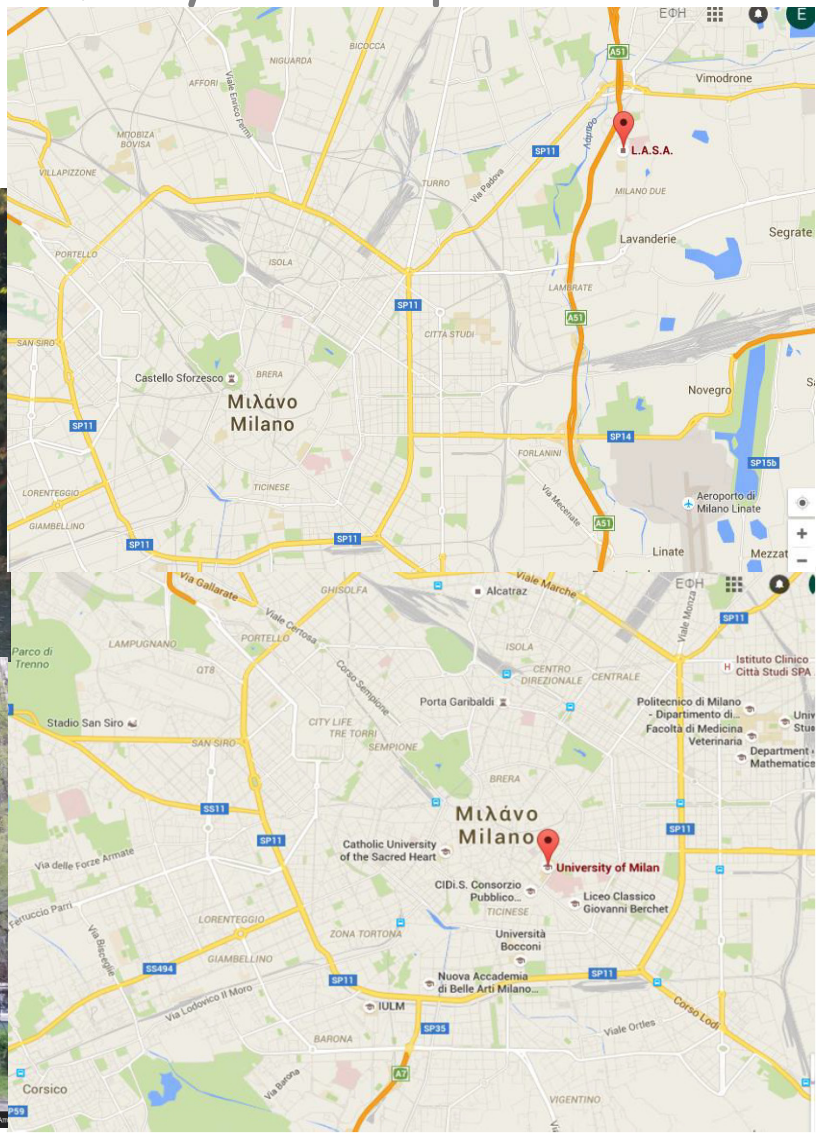
A typical gamma-ray spectrum of air filter obtained by a Ge detector, in which the g-peak of ^{7}Be and ^{210}Pb are clearly shown.

1. L.A.S.A. INFN Milano, Italy

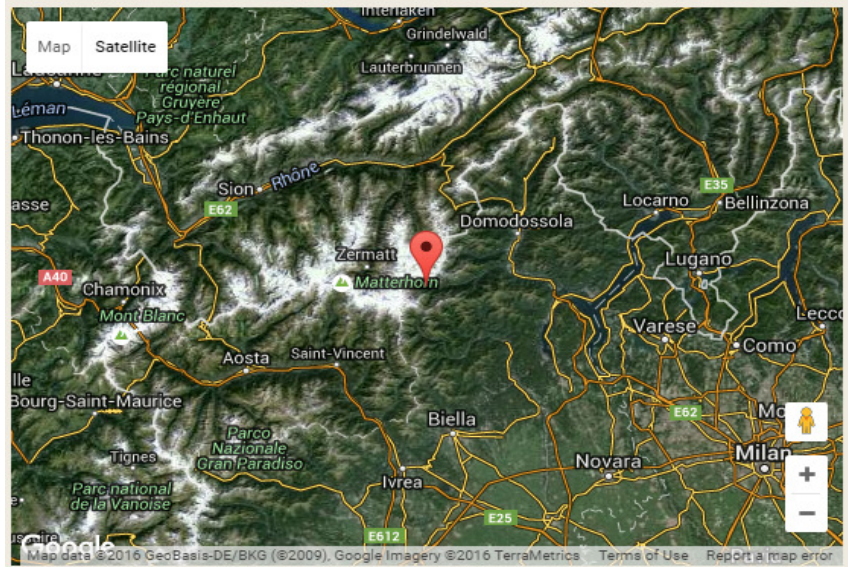




2. Universita Degli Studi di Milano, Physics Department



3. Monte Rosa, Macugnaga

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4. ISPRA


Brovello
SS33
Belgirate
ΠΙΕΜΟΝΤΕ
ΛΟΜΒΑΡΔΙΑ
Besozzo
SP50
Gavirate
Bardello
SP69
Brebbia
SP35
Malgesso
SP18
SP50
SS629
Massino
Visconti
Lesa
SS33
SP63
Biandronno
Ispra
SP32
SP36
Travedona
Monate
SP36
SP69
Barza
Ranco
Cadrezzate
SS629
Uponne
Osmate
Meina
Barzola
SP33
Ternate
Map data ©2016 Google

^{7}Be activity and AMAD values

^{7}Be activity concentrations (mBq m^{-3}) during different seasons

	Winter	Spring	Summer	Autumn
	24/02/11-03/03/11	24/05/11-01/06/11	18/07/11-26/07/11	22/11/11-02/12/11
LASA	4.52	3.55	----	1.08
University	3.99	4.68	----	2.10
	04/03/11-11/03/11	21/04/11-30/04/11	08/07/11-16/07/11	02/11/11-12/11/11
LASA	3.66	5.11	5.67	2.73
Macugnaga	5.36	4.03	4.23	0.79
	14/03/11-21/03/11	05/05/11-15/06/11	26/06/11-04/07/11	22/10/11-30/10/11
LASA	2.34	4.87	5.07	1.84
ISPRA	1.32	5.12	5.80	4.60
mean LASA	**3.51**	**4.51**	**5.37**	**1.88**
Mean all	**3.53**	**4.56**	**5.19**	**2.19**

At all stations the ^{7}Be activity concentrations present lower values during winter and higher values during summer, which is consistent with the general trend of ^{7}Be activity concentrations in Northern hemisphere throughout a year.

Difference in sunspot number, double during autumn 2011 (90 instead of 45)

^{7}Be AMAD values (μm) during different seasons

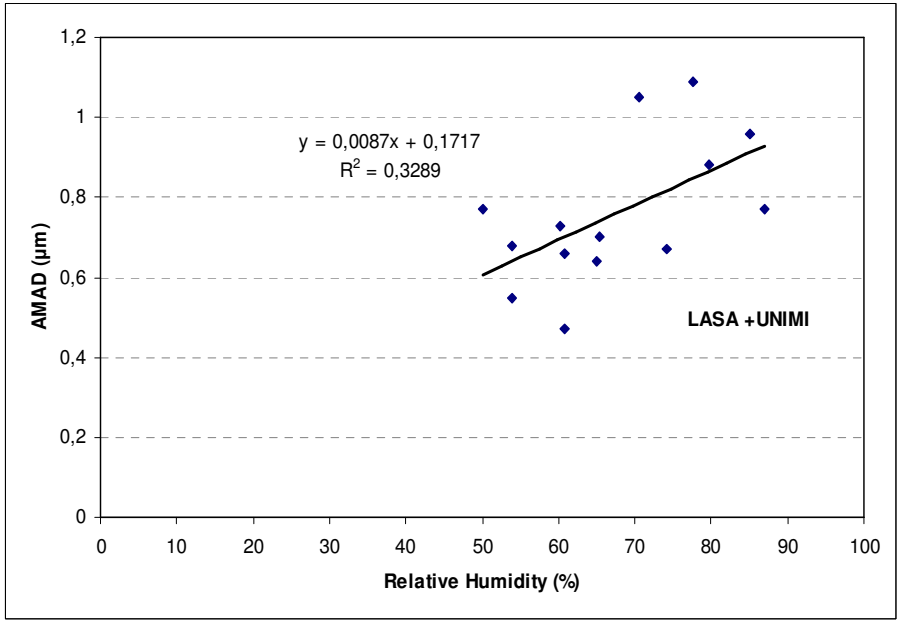
	Winter	Spring	Summer	Autumn
	24/02/11-03/03/11	24/05/11-01/06/11	18/07/11-26/07/11	22/11/11-02/12/11
LASA	0.67	0.66	----	0.88
University	0.70	0.66	----	1.09
	04/03/11-11/03/11	21/04/11-30/04/11	08/07/11-16/07/11	02/11/11-12/11/11
LASA	1.05	0.73	0.64	0.77
Macugnaga	0.49	0.61	0.48	0.40
	14/03/11-21/03/11	05/05/11-15/06/11	26/06/11-04/07/11	22/10/11-30/10/11
LASA	0.77	0.55	0.47	0.96
ISPRA	0.40	0.50	0.69	0.49
MEAN	**0.68**	**0.62**	**0.57**	**0.77**

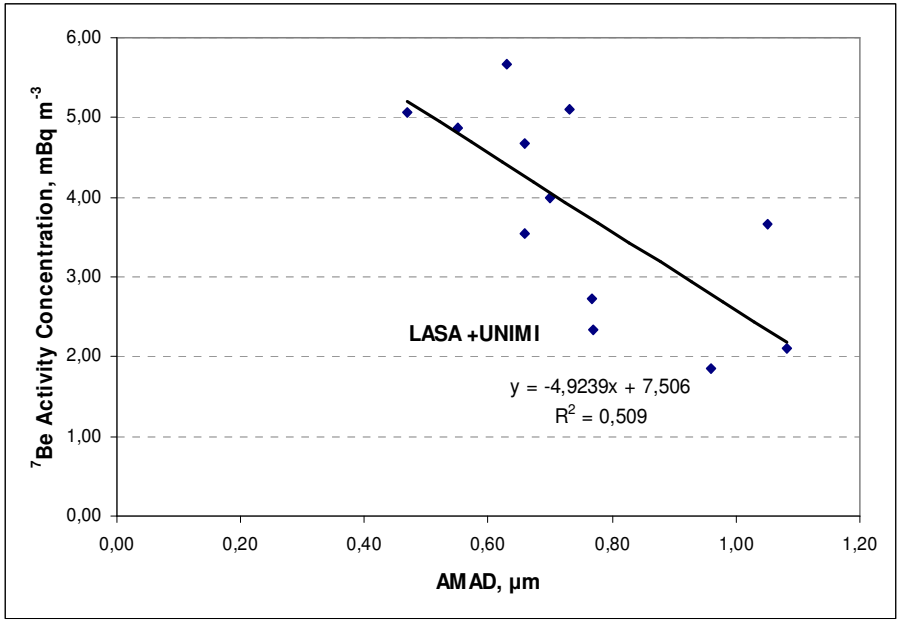
Greater AMAD values in polluted environments

Not in ISPRA

Lower AMAD values during summer

^{7}Be AMAD in correlation with activity concentration and RH%

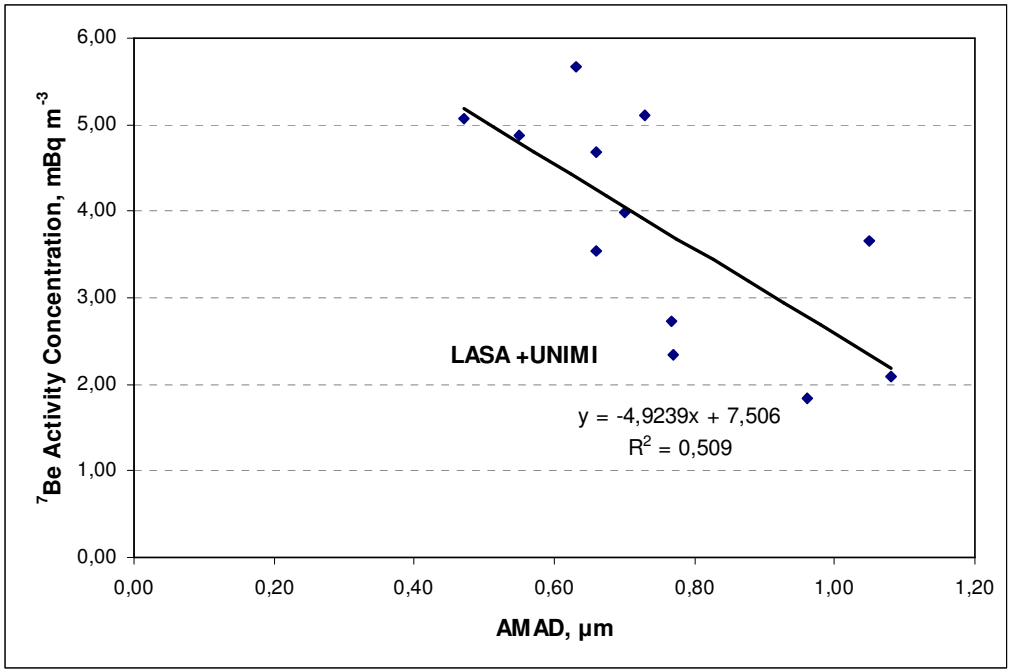




During high RH% conditions, condensation processes become more intense, resulting in increased particle sizes of atmospheric aerosols.

But, greater aerosol particle sizes means higher scavenging rates of aerosols and as a result lower activity concentration of ^{7}Be in the atmosphere.

Anticorellation between AMAD values and Activity Concentrations



$$\tau_R = \sim 7\ d$$


Lithotopos, Serres

Collection substrates


Neo Petritsi, Serres


Fteri, Pieria


Ano Poroia, Serres

Conclusions

- To the best of our knoweledge, this is the first study of the activity size distribution of a radioactive nuclide taken simultaneously at two different environments
- An anticorellation exists between AMAD values and activity concentrations of ^{7}Be
- A positive corellation exists between AMAD values and RH%
- Greater AMAD values are observed during warm summer months
- Greater and similar AMAD values were observed in polluted environments (L.A.S.A and University) and lower AMAD values in clean environments (Macugnaga and ISPRA)

Thank you!