RADIONUCLIDES IN THE ENVIRONMENT AND THEIR APPLICATIONS

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Nuclear Physics Lab-Radiation Physics Group

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PART A

- Infrastructure - Instrumentation
- Research Activities – Collaborations

PART B

- Radioactive aerosols

Nuclear Physics Lab

Laboratory Equipment on Radiation Measurements

2 HPGe (42%)

1 HPGe (20%)

1 Ge-planar

Nuclear Physics Lab

Laboratory Equipment on Radiation Measurements

alpha-system (2000 mm^2)

Radon system (air, water, soil)
Lucas cells

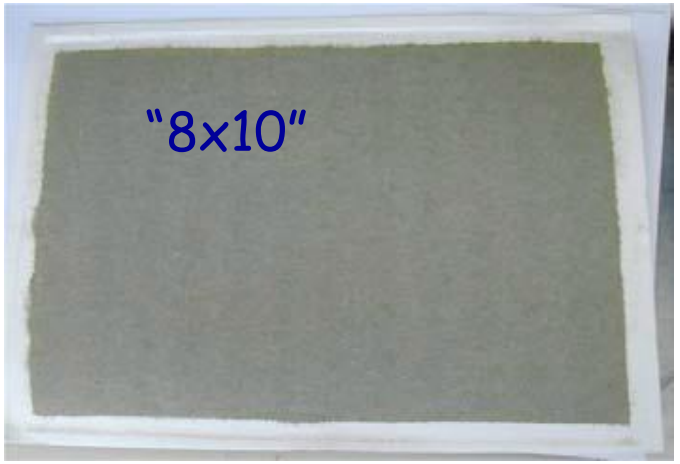
Aerosol sampling

HV air Sampler (Staplex TFIA-2)

Flow rate: 1.6-1.7 m^3/min (60cfm)
Sampling duration: 23 h
Total Volume: 2400-2700 m^3
Air Volume Uncertainty (2σ): 30-50 m^3

Glass Fiber Filters TFAGF810

Very high retention of fine particles. 99.98% retention efficiency of 0.3 micron particles.

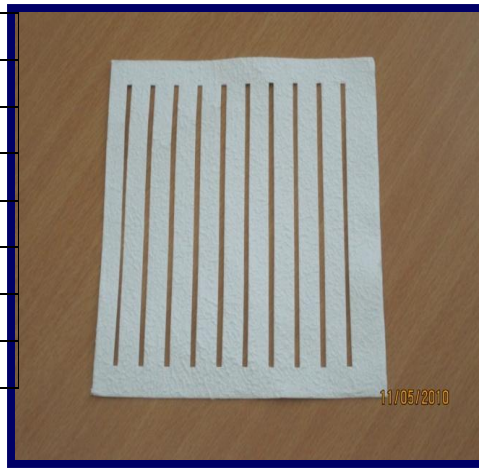


Aerosol sampling by Impactors

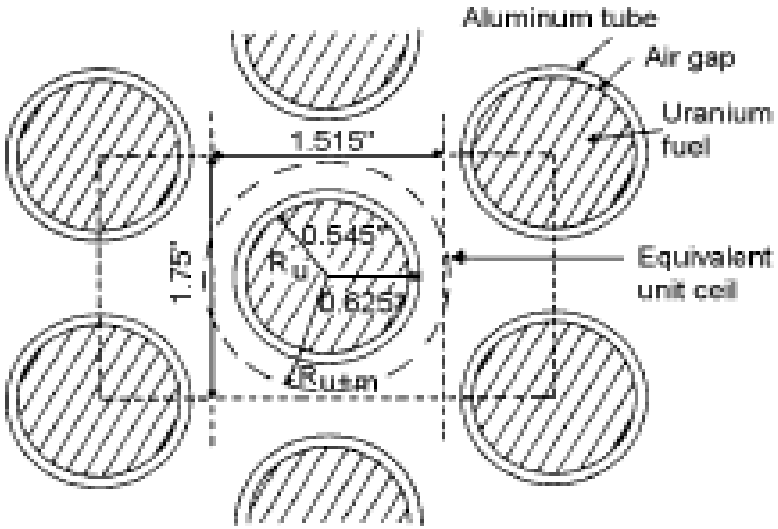
1ACFM Cascade Impactor
8-stage and a backup Filter

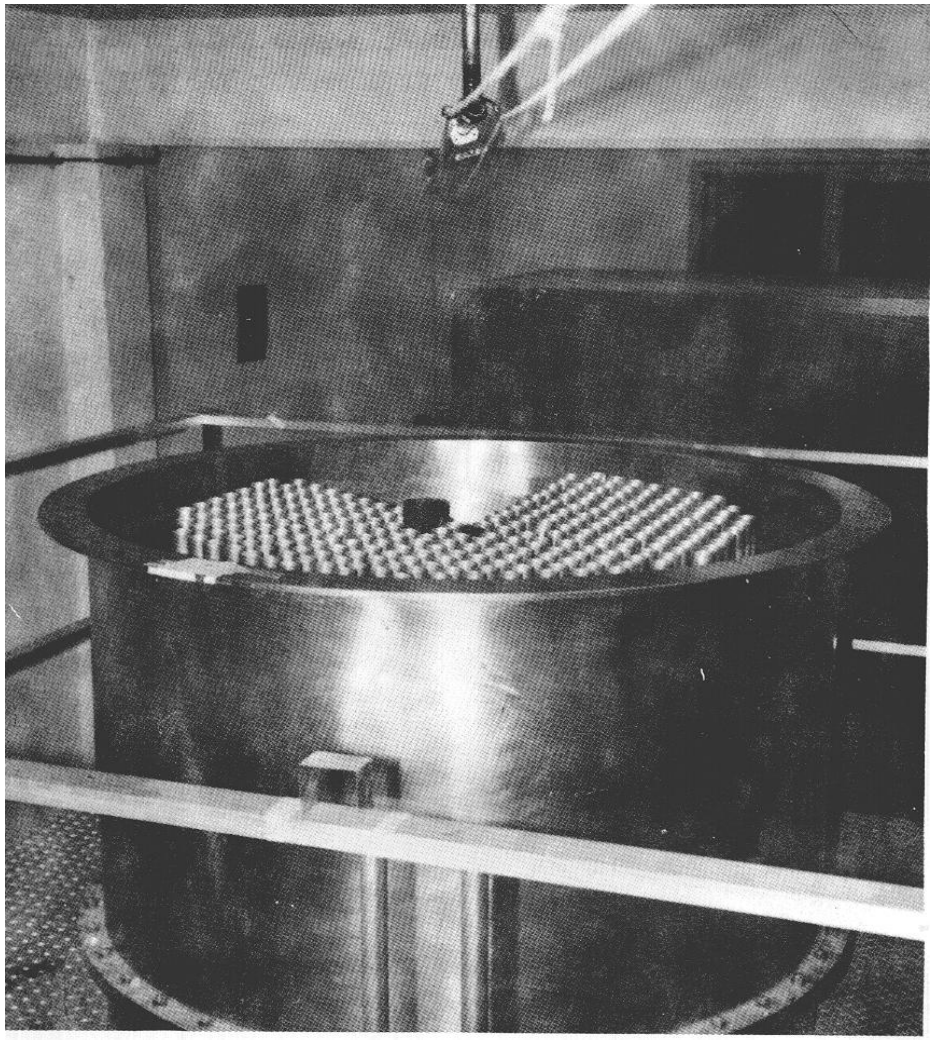
20 cfm six-stage Cascade Impactor

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



Subcritical Nuclear Reactor





Nuclear Reactor
Subcritical nuclear reactor, Model 9000, Nuclear Chicago

is installed and operating in the Nuclear Physics Laboratory.

The fuel is about natural uranium metal (U_3U_8), the moderator light (tap) water, H_2O and the reflector is also light water, H_2O.

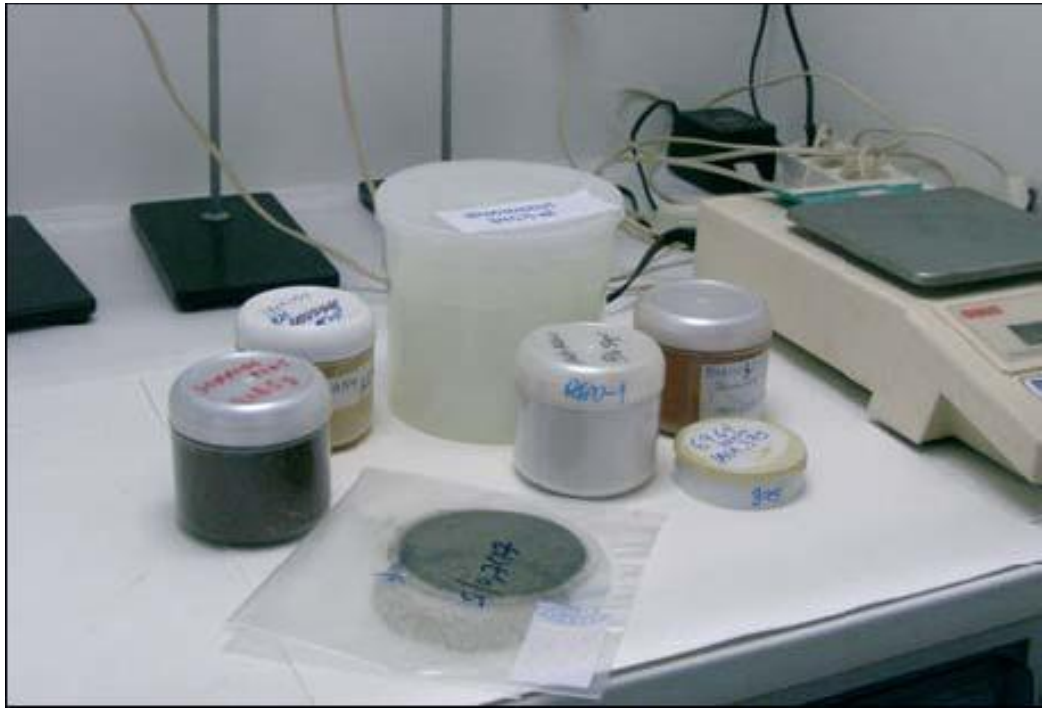
The lattice core is hexagonal, 42 inches (1.07 m) high and of 35 inches (88.90 cm) maximum diameter.

The neutron source at the core is ^{241}Am-Be 5 curies (185 GBq), $1.1.10^7$ n s^{-1}.

The reactor is used for
the activation of various materials by neutrons such as indium
the determination of the thermal neutrons flux
the horizontal and the vertical distribution of the neutron flux

Under the auspices of
Greek Atomic Energy Commission and IAEA

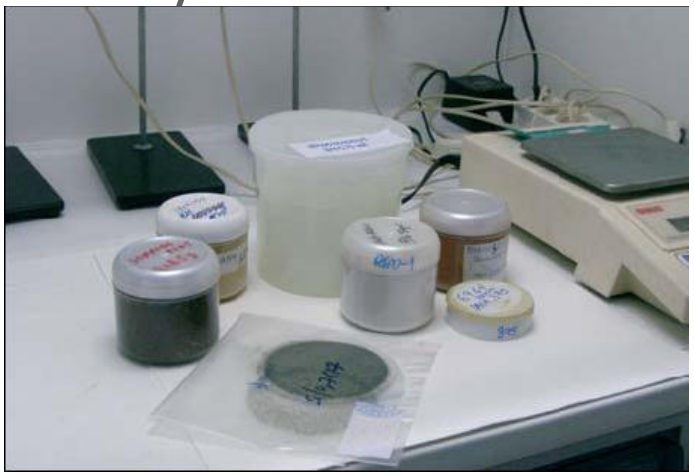
Participate in Intercomparison and Intercalibration tests



Research Activities

- Environmental radioactivity - radioecology
- Natural and man-made radionuclides in the environment
- Environmental radioactivity from Chernobyl and Fukushima accident
- Escaping Radioactivity from Coal Power Plants
- Radioactivity of building materials
- Radon exposure in dwellings and caves
- Radon soil gas variations due to seismic activity
- Radioactive aerosols

more than 100 publications
more than 600 references



Concentrations of Radionuclides in ambient air

A number of publications on defining the concentrations of natural and artificial radionuclides and the parameters that affect their concentrations in environments have been published.

Our lab has a good experience on nuclear accidents, Chernobyl and Fukushima and a number of publications have been published too.

ENVIRONMENTAL Science & Technology

ARTICLE

pubs.acs.org/est

Tracking of Airborne Radionuclides from the Damaged Fukushima Dai-Ichi Nuclear Reactors by European Networks

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Erasmus Agreements - Collaborations of the members of Nuclear Physics Lab

- University of Cyprus, Physics Department
- University of Cyprus, Chemistry Department
- University of Upsalla, Physics Department
- Universita degli Studi di Milano, Physics Department
- University of Salamanca, Spain, Physics Department
- University of Salzburg
- FMI (Finnish Meteorological Institute), Helsinki Finland
- STUK, (Radiation and Nuclear Safety Authority), Helsinki Finland

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Uranium in ground water samples of Northern Greece

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Yiannis Pashalidis
University of Cyprus

Flavia Groppi
INFN, Universita degli Studi di Milano, Italy

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journal homepage: www.elsevier.com/locate/jenvrad

Fukushima fallout at Milano, Italy

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^{7}Be aerosols in the Arctic atmosphere – modelling of air mass trajectories

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EPJ Web of Conferences **24**, 05004 (2012)
DOI: 10.1051/epjconf/20122405004

Time lag between the tropopause height and the levels of ^{7}Be concentration in near surface air

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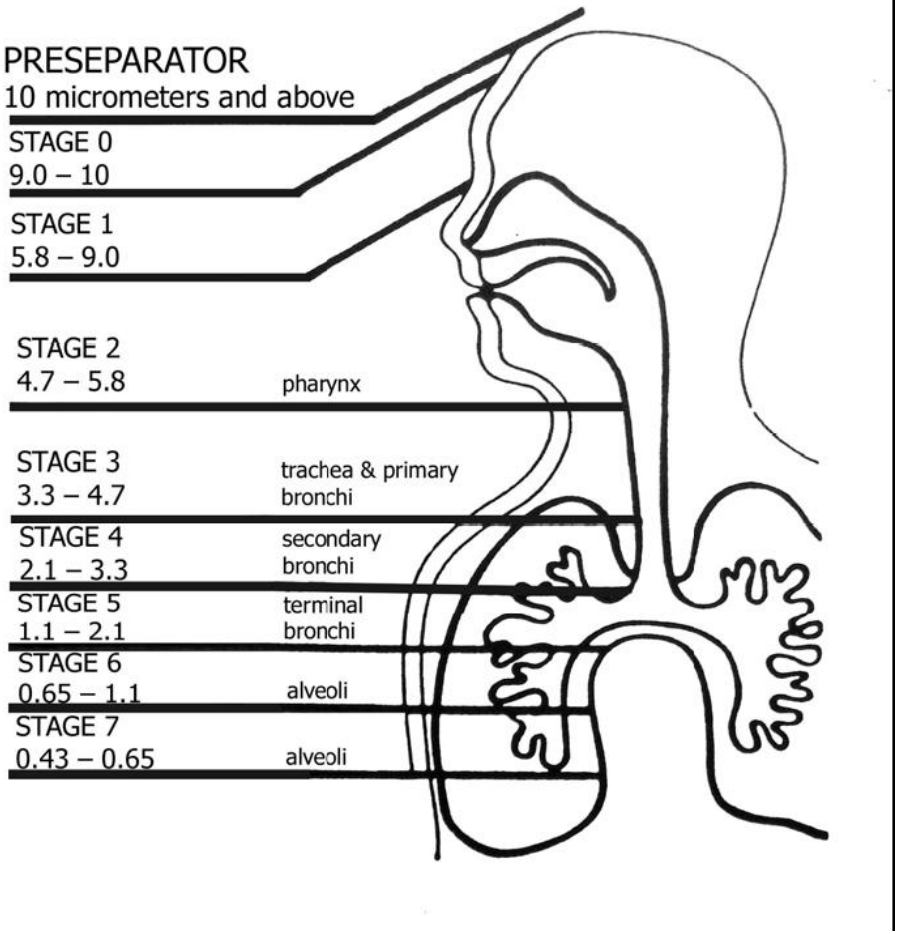
Melas Dimitris
Laboratory of Atmospheric Physics

PART B

Radioactive Aerosols

1ACFM Cascade Impactor 8-stage and a backup Filter



The Impactor is designed as a substitute for the human respiratory tract to collect and separate particulate matter according to its aerodynamic size and property.

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
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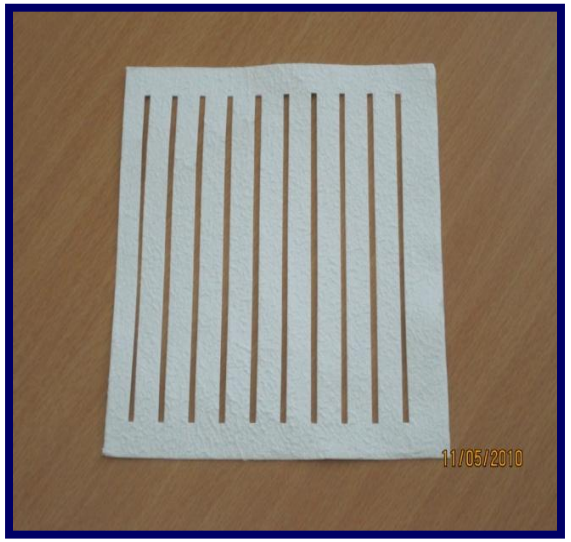
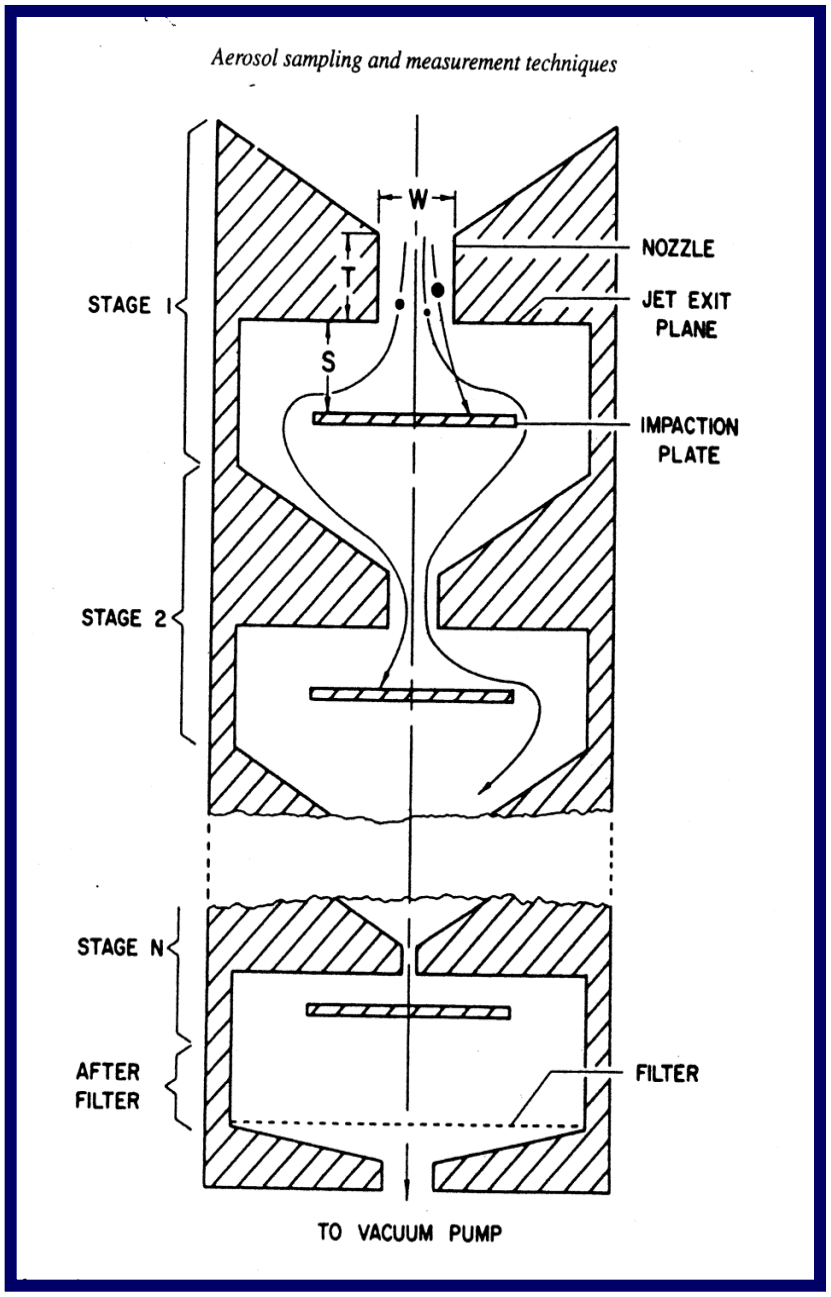
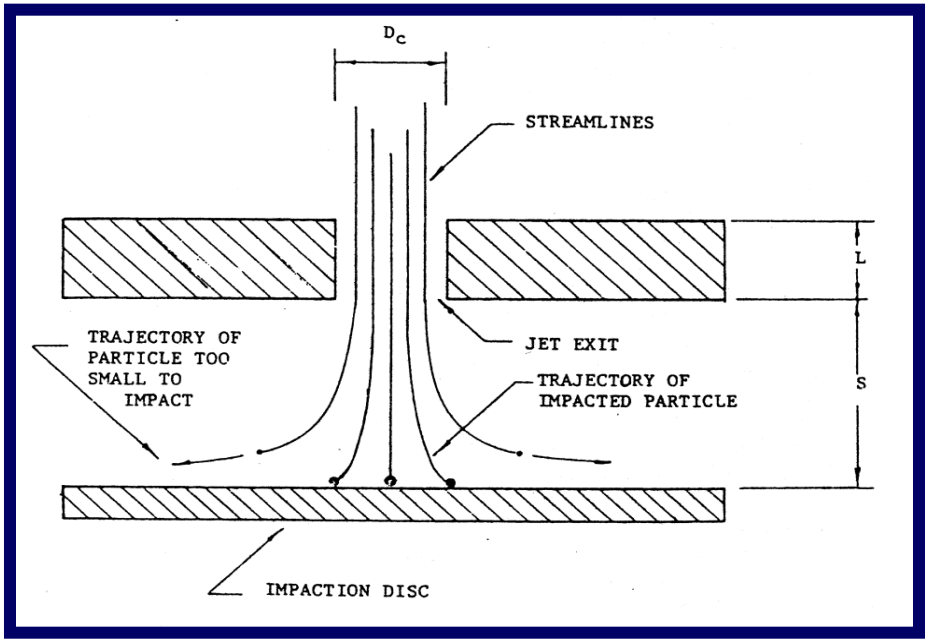




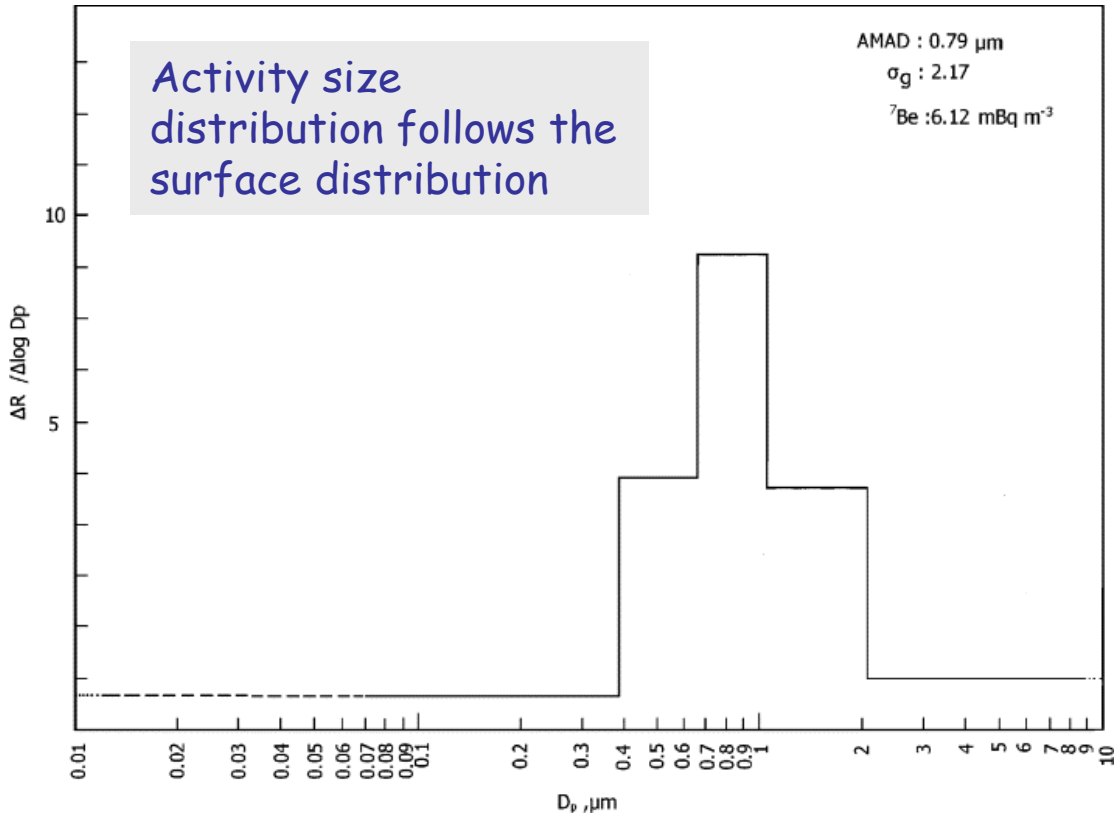
Physics behind the cascade impactor

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.



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

AMAD

Activity Median Aerodynamic Diameter

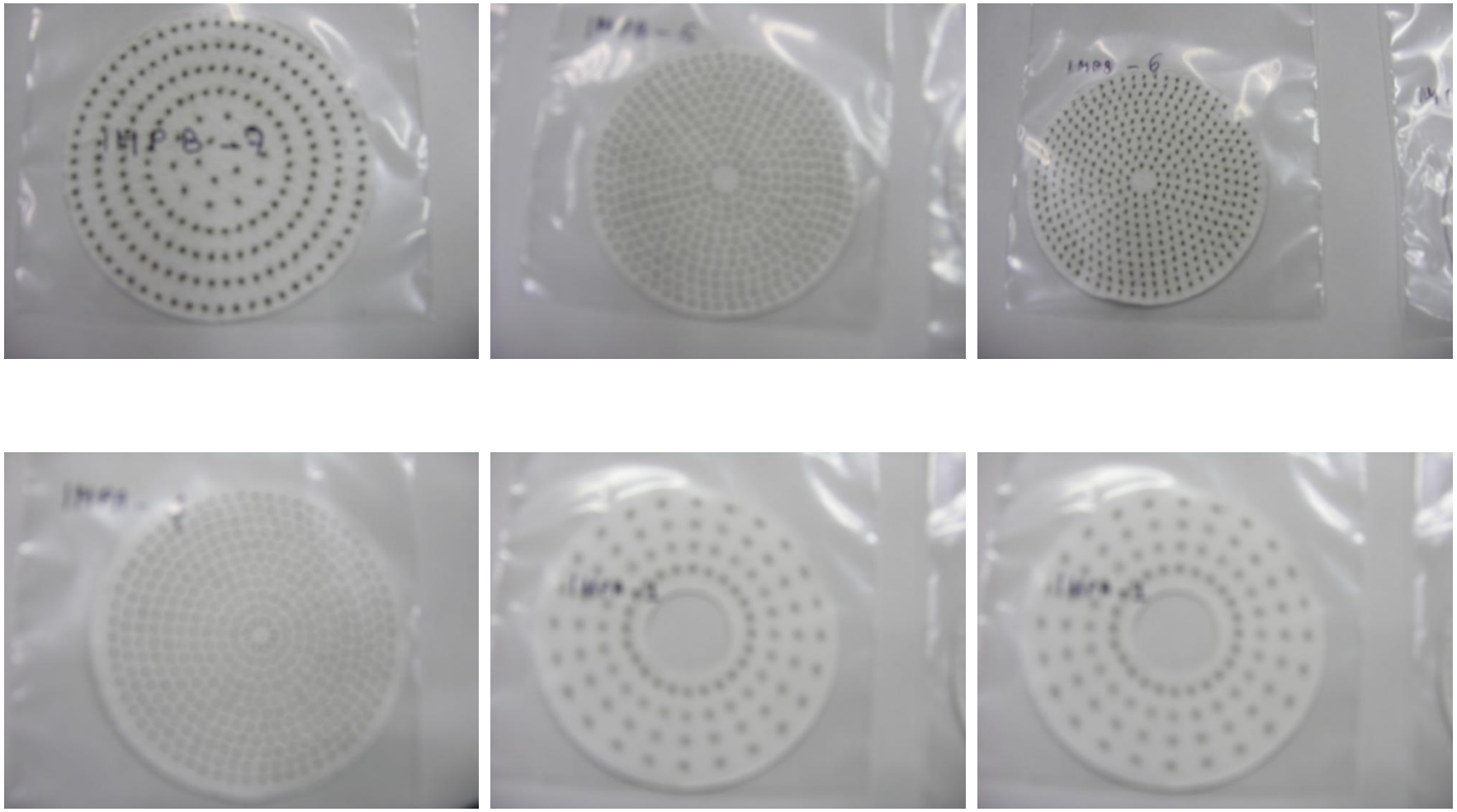
AMAD value tell us how big is the diameter of aerosol particles

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

We can calculate the mean residence time of radioactive particle and of any other particle with similar behavior in the atmosphere

Setup of the two 1ACFM cascade impactors

Filter Samples Acteate Cellulose Filters



Experimental Results

AMAD values during different Seasons			
	Winter	**Spring**	**Summer**
	24/02/11 - 03/03/11	24/05/11 - 01/06/11	18/07/11 - 26/07/11
L.A.S.A	0.66	0.66	
University	0.70	0.66	
	04/03/11 - 11/03/11	21/04/11 - 30/04/11	08/07/11 - 16/07/11
L.A.S.A.	1,05	0.73	0.47
Macugnaga	0.52	0.61	0.52
	14/03/11 - 21/03/11	05/05/11 - 15/05/11	26/06/11 - 04/07/11
L.A.S.A	0.77	0.55	0.47
ISPRA	0.40	0.50	0.69

Similar AMAD values in L.A.S.A and University during wniter and spring

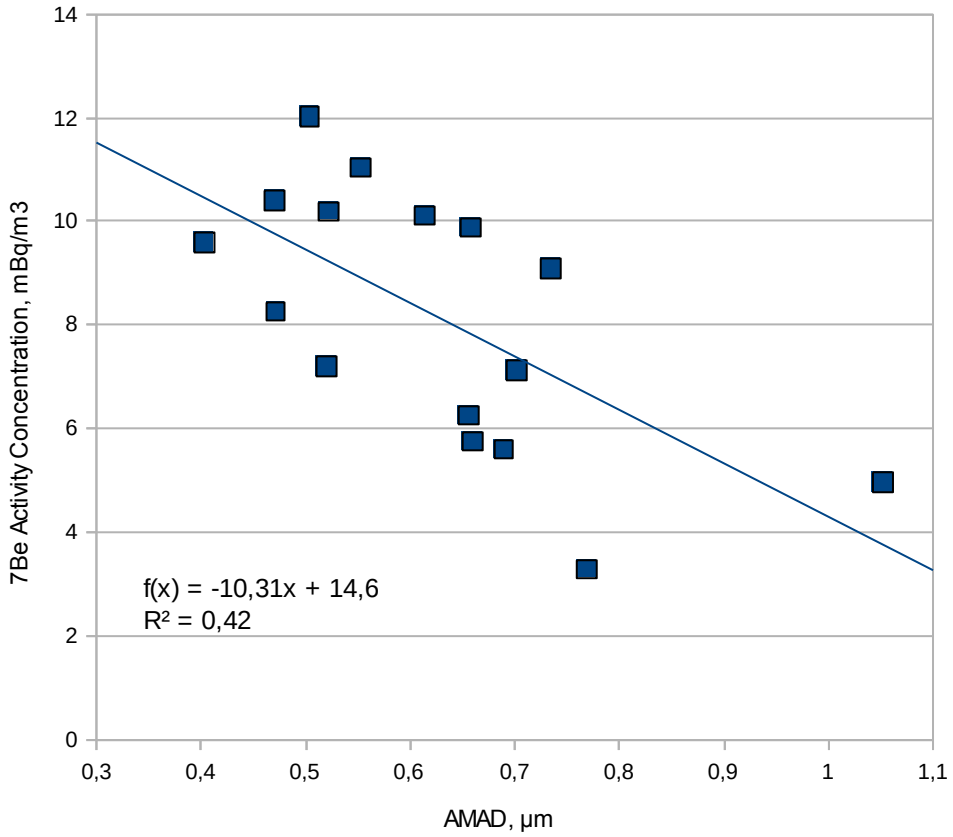
In L.A.S.A. in most poluted environment the AMAD values are greater

During winter period the AMAD value in ISPRA is the lowest

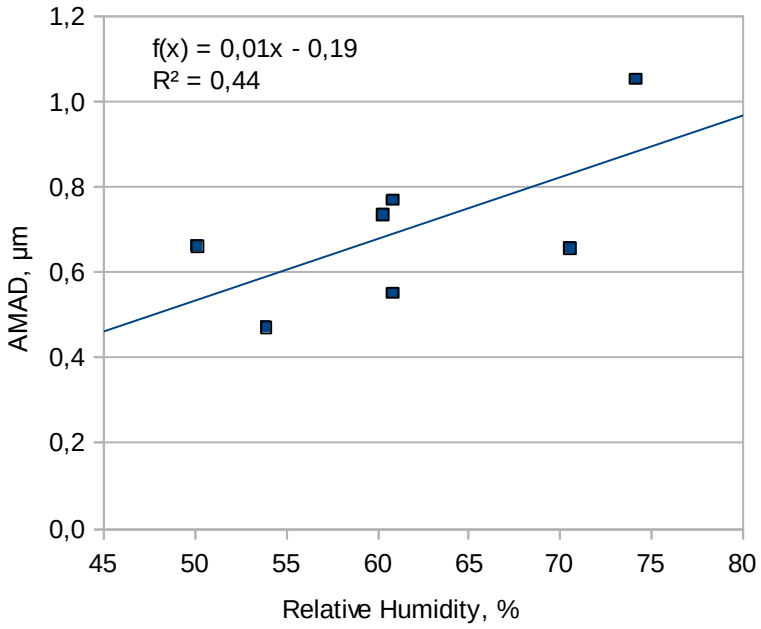
Lower AMAD values in the clean environments of ISPRA and Macugnaga

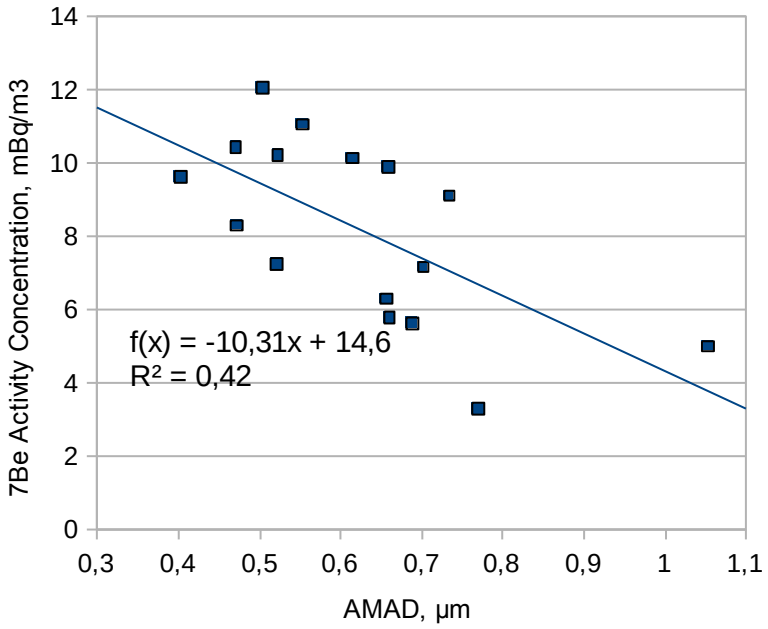
During summer the lowest AMAD values were observed in L.A.S.A

Anticorellation between AMAD values and Activity Concentrations



^{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.

Acknowledgment

European Community - Research Infrastructure Action under the FP6 “Structuring the European Research Area” Programme, LAPBIAT (RITA-CT-2006-025969)

in the cold and dark Arctic atmosphere they are expected relative longer aerosol residence times

Arctic Research Centre of the FMI at Sodankylä

Location: 67.37° N, 26.65° E, 180 m asl

Offers unique possibilities for carrying out research on atmospheric radioactivity in the northernmost continental Europe.

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)
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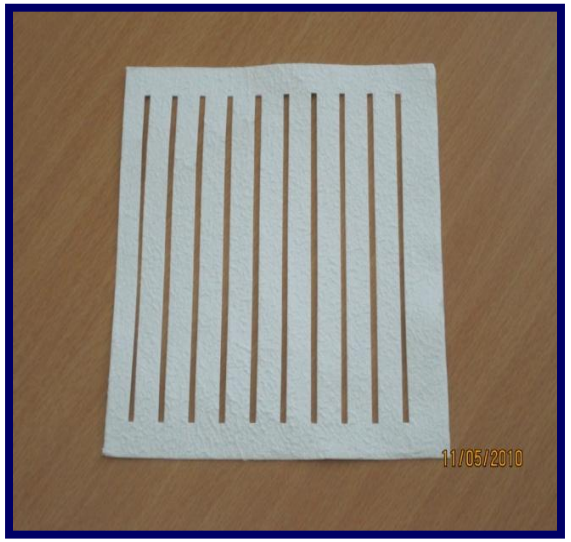
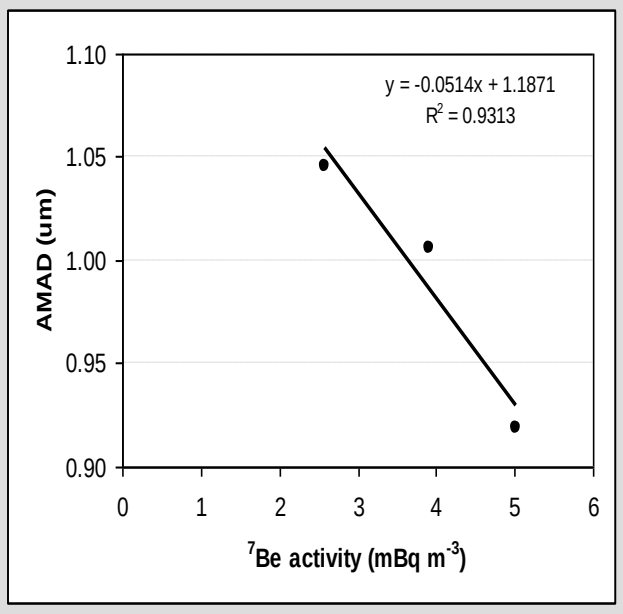


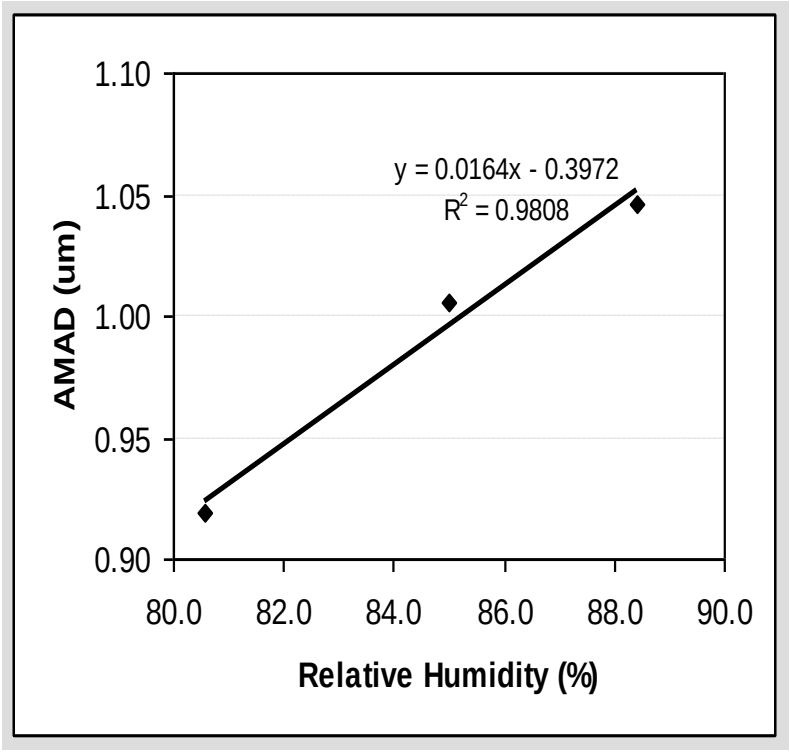
Activity Concentrations and Activity Size Distributions of ^{7}Be

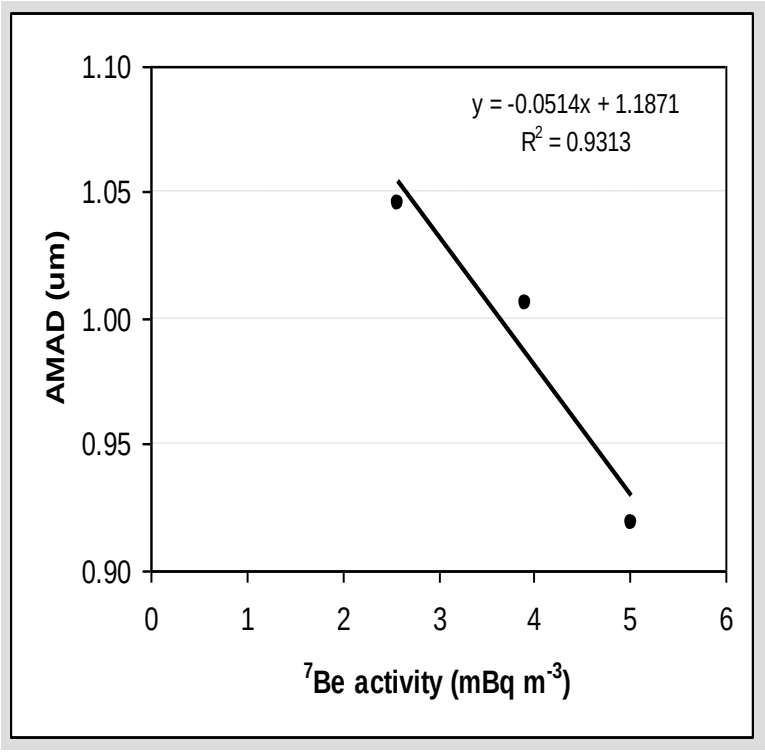
Start of sampling	^{7}Be (mBq m^{-3})	AMAD (μm)	σ_s
26-Mar-10	5.01	0.92	2.00
29-Mar-10	2.57	1.05	1.87
1-Apr-10	3.91	1.01	2.09
4-Apr-10	0.70	0.54	1.81
7-Apr-10	2.37	0.73	1.94
20-Jul-10	3.72	0.87	2.86
27-Jul-10	6.88	0.90	2.19
3-Aug-10	2.93	1.05	2.95
10-Aug-10	1.20	0.82	3.06
17-Aug-10	3.89	0.63	2.48
24-Aug-10	3.69	0.86	2.35
7-Sep-10	7.46	0.63	2.43



The mean activity concentration during summer (4.3 mBq m^{-3}) is 50% higher than that at the end of winter (2.9 mBq m^{-3})

^{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.

But this association with possibly higher scavenging rates of aerosols does not necessarily alone explain the anticorrelation between the AMAD and the ^{7}Be activities.

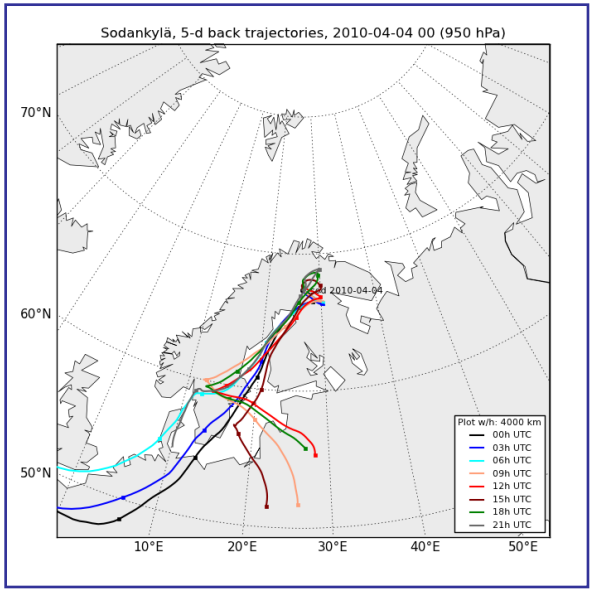
The air mass origin associated with synoptic scale weather phenomena may contribute to that.

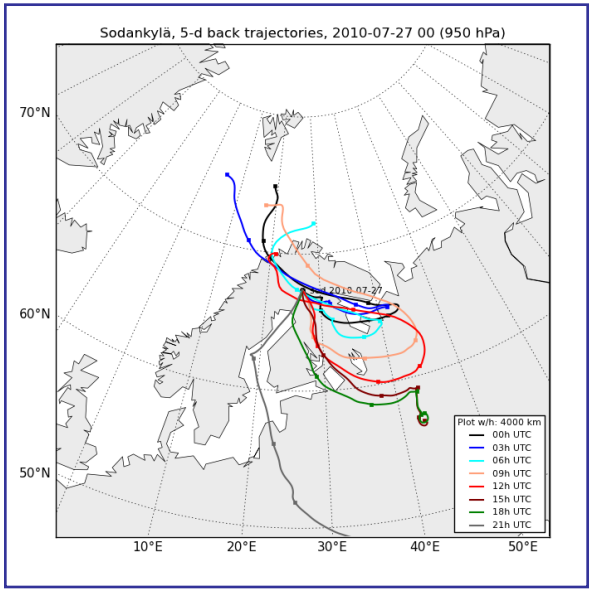
Experimental Data of ^{7}Be in Combination with Air Mass Origin

TABLE I. EXPERIMENTAL DATA OF ^{7}BE AEROSOLS IN COMBINATION WITH AIR MASS ORIGIN

Start of sampling	^{7}Be (mBq m^{-3})	AMAD (μm)	Back trajectories
		Winter Campaign	
26/03/10	5.01	0.92	Arctic
29/03/10	2.57	1.05	Arctic
01/04/10	3.91	1.01	N. Atlantic & Continental
04/04/10	0.70	0.54	N. Atlantic & Continental
07/0410	2,37	0.73	Continental
		Summer Campaign	
20/07/10	3.72	0.87	Arctic and N. Atlantic
27/07/10	6.88	0.90	Continental (and Arctic)
03/0810	2.93	1.05	N. Atlantic, Arctic & Continental
10/08/10	1.20	0.82	Arctic (and Continental)
17/08/10	3.89	0.63	Arctic
24/08/10	3.69	0.86	Arctic
07/09/10	7.46	0.63	N. Atlantic

Air Mass Back Trajectories analysis





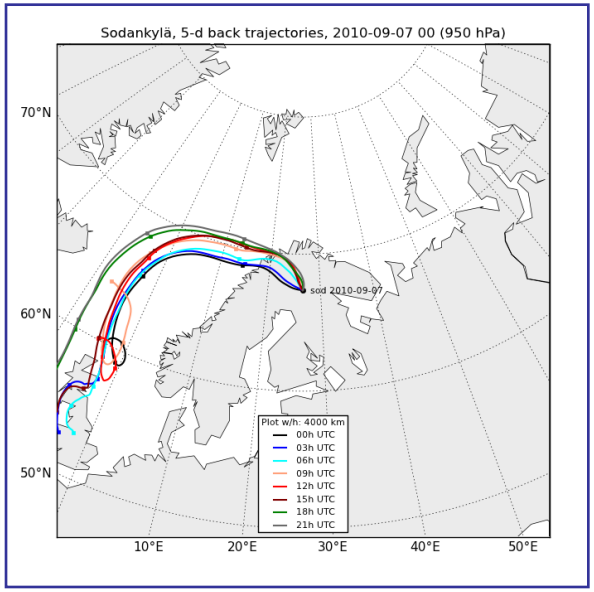


Fig. 1
Five-day long air mass back trajectories, arrival to Sodankylä 4 April 2010, 950 hPa pressure level, arrival times 00, 03, 06, 09, 12, 15 18, and 21 UTC

0.70 mBq m^{-3}, 0.54 μm

Fig. 2
Five-day long air mass back trajectories, arrival to Sodankylä 27July 2010, 950 hPa pressure level, arrival times 00, 03, 06, 09, 12, 15 18, and 21 UTC

6.88mBq m^{-3}, 0.90 μm

Fig. 3
Five-day long air mass back trajectories, arrival to Sodankylä 7Sept. 2010, 950 hPa pressure level, arrival times 00, 03, 06, 09, 12, 15 18, and 21 UTC

7.46 mBq m^{-3}, 0.63 μm

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Ioannina, 8 Sep,2012

Air Mass Back Trajectories analysis

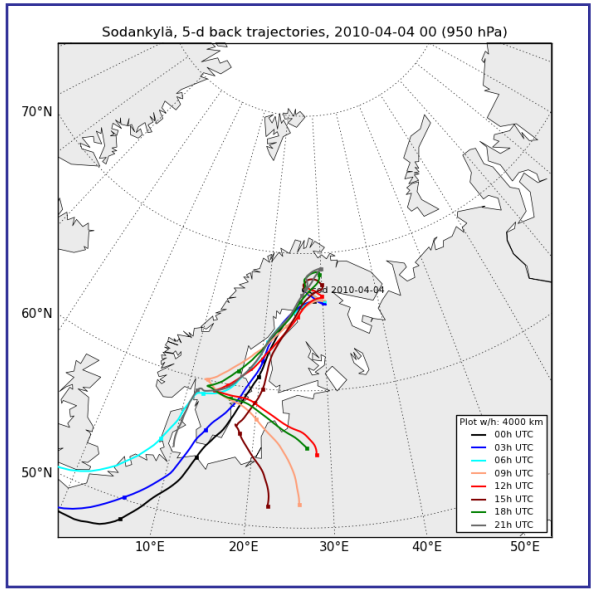

Fig. 1
Five-day long air mass back trajectories, arrival to Sodankylä 4 April 2010, 950 hPa pressure level, arrival times 00, 03, 06, 09, 12, 15 18, and 21 UTC

0.70 mBq m^{-3}, 0.54 μm

- Air masses coming from the North Atlantic Ocean usually have a low ^{7}Be activity concentration due to the frequent occurrence of precipitation (Paatero and Hatakka, 2000).
- Also the upward motion of air masses in the low-pressure system, reduces the transport of ^{7}Be from the upper troposphere close to the ground.
- Air masses transported over the ocean are usually moist thus enhancing the particle growth by condensation. It seems that actually air masses come most of the time from the continent.
- The complex meteorological situation including front passages during the sample collection makes, however, a detailed analysis difficult.

Air Mass Back Trajectories analysis

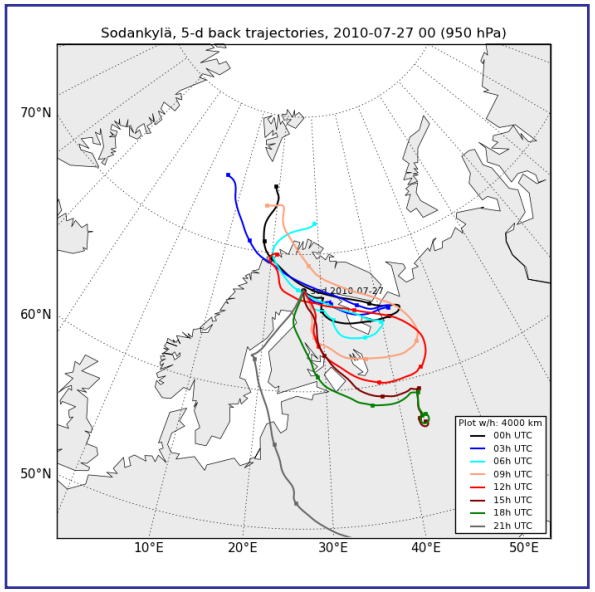

Fig. 2
Five-day long air mass back trajectories, arrival to Sodankylä 27July 2010, 950 hPa pressure level, arrival times 00, 03, 06, 09, 12, 15 18, and 21 UTC

6.88mBq m^{-3}, 0.90 μm

- The air masses came from south-east. High ^{7}Be concentration levels are often encountered with these air masses.
- These situations, as in this case too, are associated with high-pressure systems, in which the downward motion of the air masses brings ^{7}Be from the upper troposphere to the surface.
- Also the moisture content of these continental air masses is low, and the lack of precipitation prevents the removal of ^{7}Be by wet deposition.
- On the other hand, as the removal rate of these aerosol particles is low the particles have had time to grow with various atmospheric coagulation and condensation processes.

Air Mass Back Trajectories analysis

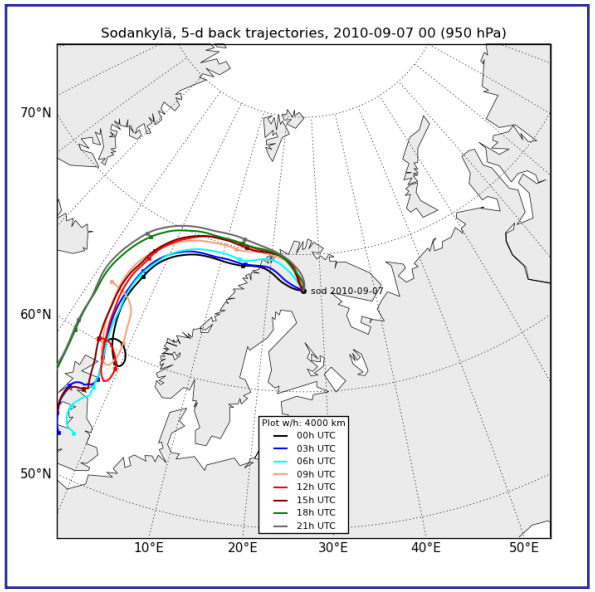

Fig. 3
Five-day long air mass back trajectories, arrival to Sodankylä 7Sept. 2010, 950 hPa pressure level, arrival times 00, 03, 06, 09, 12, 15 18, and 21 UTC

7.46 mBq m^{-3}, 0.63 μm

- Apparently, the opposite seems to have happened during summer period.
- The air masses that are coming from North Atlantic Ocean have a high ^{7}Be activity concentration (7 Sep. 2010, 7.46 mBq m^{-3}). The AMAD value, on the other hand, is lower than average, 0.63 μm.
- In this case a high-pressure system with its centre located over Southern Finland and Estonia drove continental air masses anticyclonally across the North Atlantic Ocean.
- Judging from the low AMAD value the age of these aerosol particles is less than during the previous case.

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