Size distribution of aerosols attached by cosmogenic nuclide Be-7 in the atmosphere at the TA telescope station

[1]Dept. of Physics, Yamagata University
[2]Dept. of Earth and Environmental Sciences, Yamagata University
[3]Institute of Cosmic Ray Research, University of Tokyo

S. Kikuchi[1], H. Sakurai[1], S. Gunji[1], F. Tokanai[1], F. Yanagisawa[2], S. Udo[3]

Motivation

- We have been studying a behavior of the cosmogenic nuclides in the atmosphere.

- Topics
  - Observation of aerosols and Be-7 at TA telescope station
    - The relationship between Be-7 and aerosols size
    - The attachment rate of Be-7 to aerosols
    - The relationship between the Be-7 concentrations and the solar radiation.

Cosmogenic nuclide Be-7 and aerosols

- Production

$^{14}N(n,x)^7Be$
$^{14}N(p,x)^7Be$
$^{16}O(n,x)^7Be$
$^{16}O(p,x)^7Be$
$^{40}Ar(n,x)^7Be$
$^{40}Ar(p,x)^7Be$

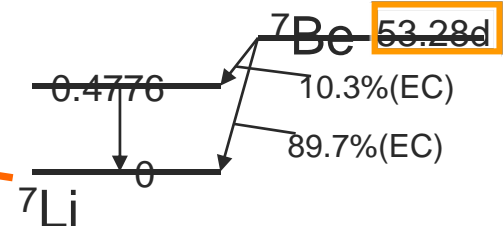Cosmic rays collide with the atmospheric elements

Be-7 is produced

Be -7 is oxidized and attaches to aerosols.

Aerosols with Be-7 fall down to the ground.

- We collect the aerosols and measure the radioactivity of Be-7.

^7Be 53.28d

0.4776   10.3%(EC)

89.7%(EC)

detection

0

^7Li

Gamma ray: 477 keV

Observation

- Location: On the roof of telescope building (13m above the ground) of "Telescope Array project" at Utah($39°$ N, $112°$ W, Alt.:1400m), USA (We contribute to the TA experiment of the highest energy cosmic rays by the study of aerosols in that area.)

- Aerosol sampling： May.2006

- Daily sampling of Be-7: From Oct. 2005

The telescope building of TA project

Method

- **Collection**

Andersen air sampler has 5 stages to classify aerosol sizes.

•Range of classification on the each stage
F1: 7.0 μm~
F2: 3.3~7.0
F3: 2.0~3.3
F4: 1.1~2.0
BC: <1.1 μm

◆The measurement of aerosols
  •Concentration
  •Size distribution

- **Measurement**

  ○ The low-level radioactivity measurement of Be-7 by HPGe detector in the underground lab.
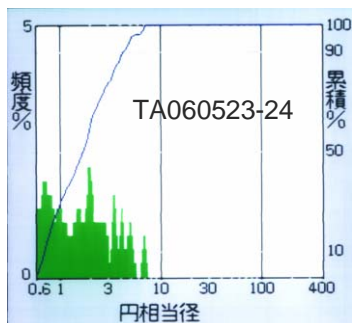

20 m under the ground
(ICRR, Univ. of Tokyo)

Background Level:
0.006 cpm
(on 1 equivalent channel
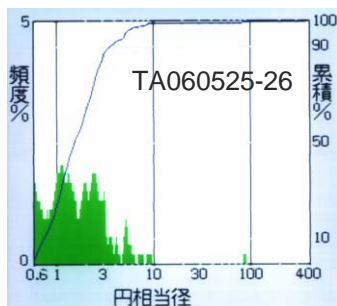to Be-7's 477 keV)

Size distribution of aerosols

Aerosol particle imaging

20um

Measurement range: 0.60≤equivalent diameter≤400.0 [μm]
The machine can't measure water-soluble particles.

Variation of aerosol size distribution
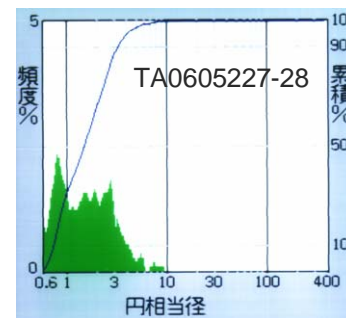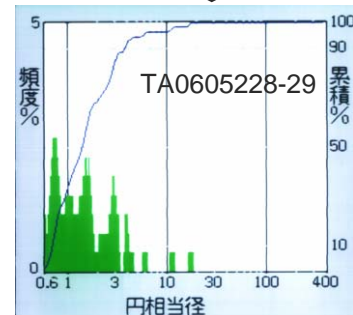
TA060523-24

23-24.May

TA060525-26

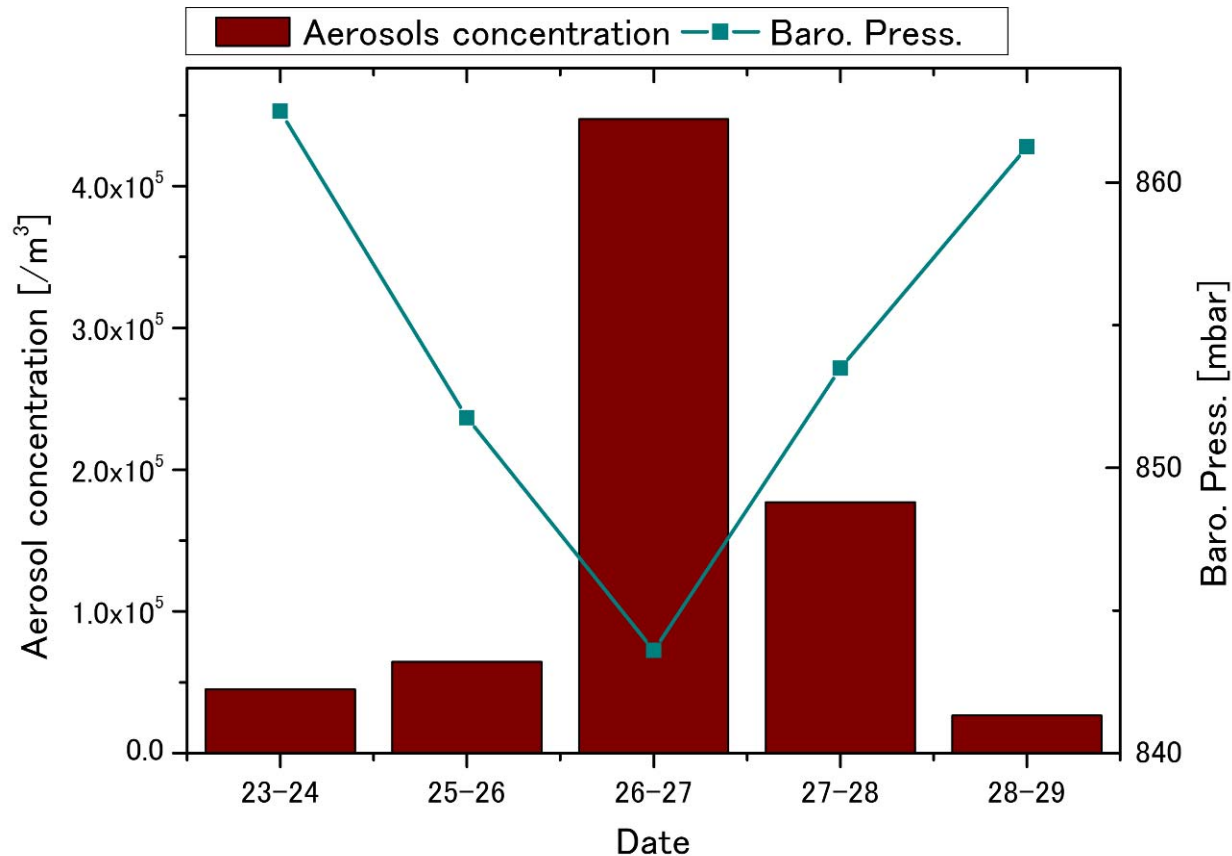25-26.May

TA0605226-27

26-27.May

TA0605227-28

27-28.May

TA0605228-29

28-29.May

The sizes of all particles is less than $\phi\, 10\mu m$.
Each distribution has 2 peaks at about $1\mu m$ and $3\mu m$.

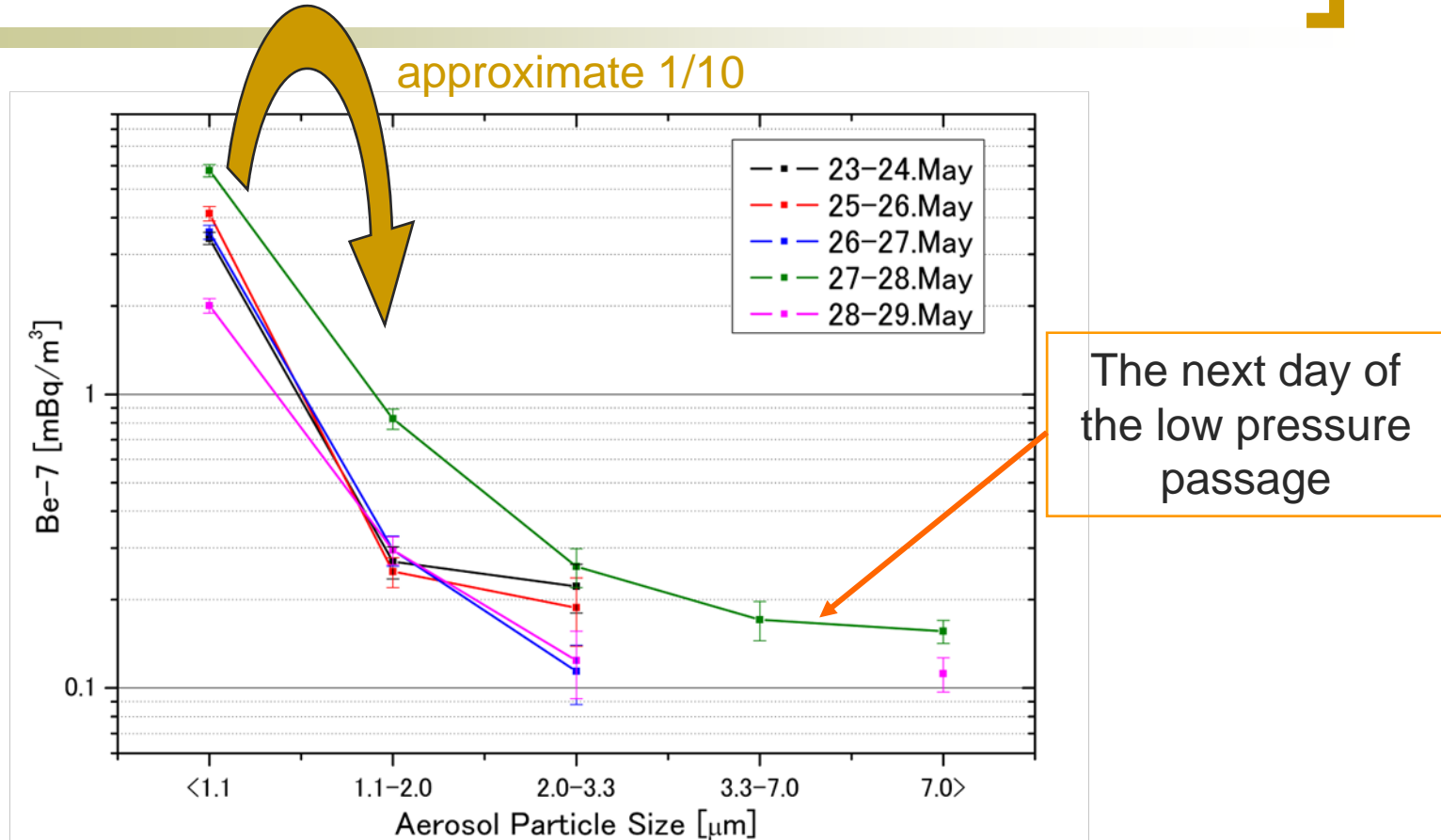| Aerosol concentration [particles/m^3]	$2.7\times10^4 \sim 4.5\times10^5$

The range of size distribution is similar to each other for any aerosol concentrations.

Aerosols concentration and barometric pressure

The aerosol concentration increased by the low pressure passage.

Be-7 concentrations at each size classification stage

approximate 1/10

The next day of the low pressure passage

The radioactivity of each sample is very low.

- **According to the size of particle, Be-7 concentration decreases.**

The observation of Be-7 concentrations is useful for the monitoring of aerosols with the size smaller than $2~\mu m$.

Calculation of the attachment rate of Be-7 to aerosol at each stage

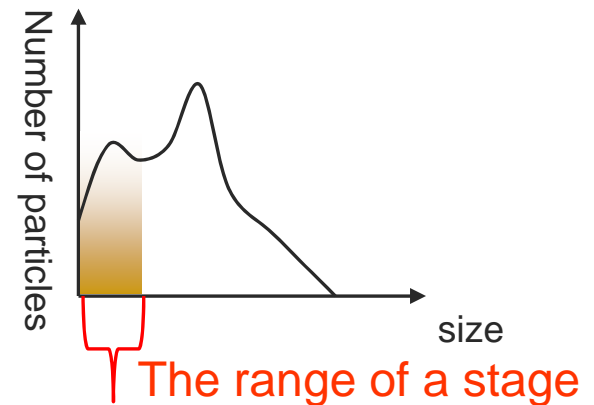- Calculation of the number concentrations of Be-7 at each stage

A [mBq/m³]: From the measured value of the radioactivity

N [particles/m³]: The number concentrations of Be-7.

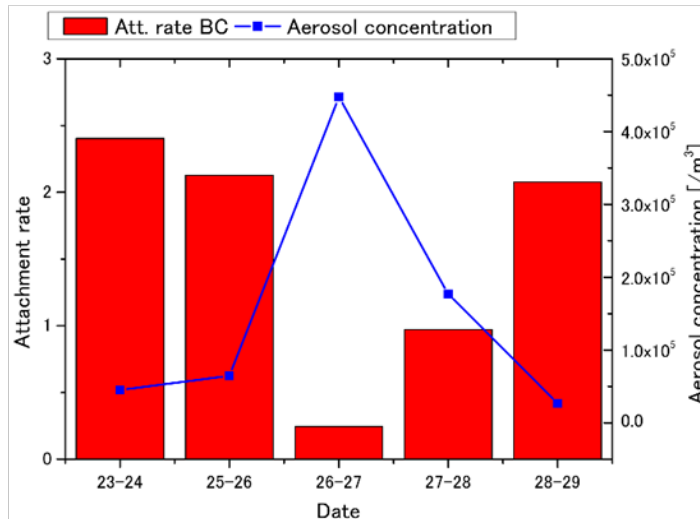λ**[1/sec]:**The disintegration constant of Be-7.

$$A = \lambda \cdot N$$

- Calculation of the number concentrations of aerosols from the size distribution corresponding to the each stage of Be-7
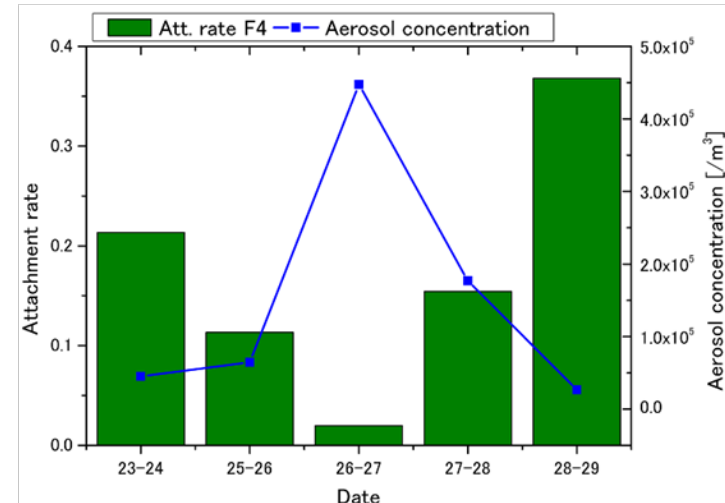

Number of particles

size

The range of a stage

$$\text{Attachment rate} = \frac{\text{Number concentrations of Be-7s [particles/m}^3]}{\text{Number concentrations of aerosols[particles/m}^3]}$$

Attachment rate of Be-7 to aerosol

Size: smaller than 1.1 μm

Size: 1.1-2.0 μm

The attachment rate of the day without influence of the low pressure
smaller than 1.1 μm: approximately 2
1.1-2.0 μm: approximately 0.3

At the low pressure, as the aerosol particles near to the ground surface flow up, they presumably prevent the falling down of the aerosols from the upper atmosphere.
This phenomena indicates that the aerosol particles attached by Be-7 come down from the upper atmosphere.

Relationship between the daily Be-7 concentration and the solar radiation

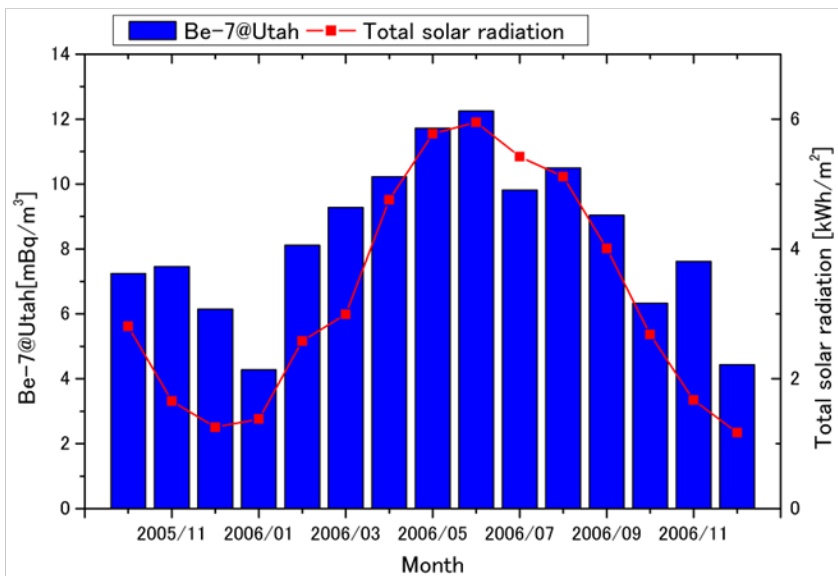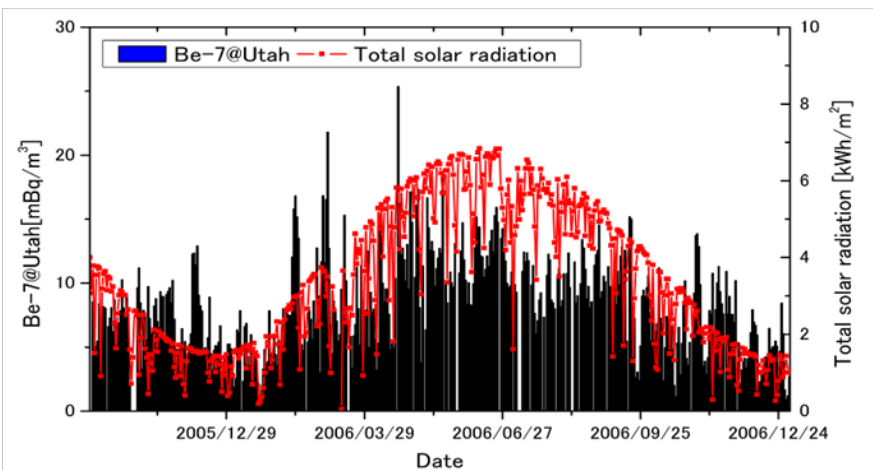**The concentrations have been continuously observed since Oct. 2005.**

Comparison of daily variation

correlation coefficient : **0.63**

Comparison of monthly variation

correlation coefficient : **0.91**

$$1.27\left[\frac{\text{Be - 7[mBq/m}^3]}{\text{solar radiation[kWh/m}^2]}\right]$$

Solar radiation data: CEMP (Community Environmental Monitoring Program)

Summary

- We have studied the behavior of cosmogenic nuclides in the atmosphere.
- We have been observing Be-7 concentration in Utah since Oct. 2005.
- Aerosol concentration [particles/m^3] : $2.7\mathrm{x}10^4 \sim 4.5\mathrm{x}10^5$
- Most of Be-7 attaches for the aerosols less than 1 μm
- Attachment rate:
    - ϕ < 1.1 μm : approximately 2
    - 1.1 < ϕ < 2.0 μm : approximately 0.3
- Solar radiation is good correlated to Be-7 concentration.