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Feature Story

## Explore

INNER **VIEW**

### Hideaki Motoyama

Professor of National Institute of Polar Research

### Let Things Work Themselves Out

～Exploring Earth's Past and Present Through Ice



RION CO., LTD.

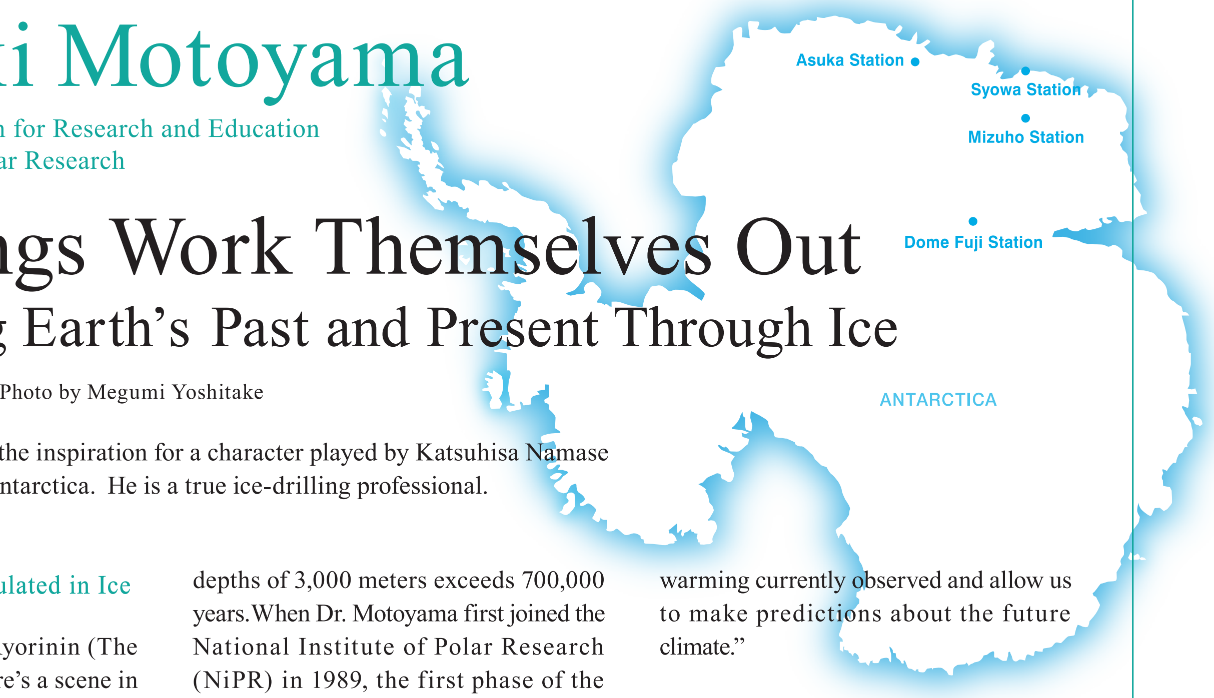
Dr. Hideaki Motoyama

Born in Niigata prefecture in 1957, Dr. Hideaki Motoyama became an assistant researcher at the National Institute of Polar Research in 1989. In 1997, he was promoted to the position of Assistant Professor, and then in 2006 to the rank of full professor. He has participated 12 times in the Japanese Antarctic Research Expedition (including three times as a member of the wintering party), from the 31st expedition in 1989 to the 57th expedition in 2015. At the Dome Fuji Station, he directed and oversaw ice-core drilling. His favorite author is Masanori Hata.

**Inter-university Research Institute Corporation Research Organization of Information and Systems**
**National Institute of Polar Research**
10-3, Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan
http://www.nipr.ac.jp/english/

# Hideaki Motoyama

Professor of the Division for Research and Education
National Institute of Polar Research




# Let Things Work Themselves Out

## ～Exploring Earth's Past and Present Through Ice

Text by Michinari Okazaki / Photo by Megumi Yoshitake

Professor Motoyama was the inspiration for a character played by Katsuhisa Namase in a recent movie set in Antarctica. He is a true ice-drilling professional.

### The Earth's Past Encapsulated in Ice

In the movie Nankyoku Ryorinin (The Chef of the Antarctic), there's a scene in which the character Moto-san listens on his birthday to his child sing "Happy Birthday to You" over the phone.

"The movie has many scenes I'm tempted to point out just aren't true. No one runs around outdoors in Antarctica, for instance. But that's one scene I have to point out is pure fiction," says Dr. Motoyama with some amusement. "I don't have any children."

Needless to say, unlike the Arctic, the Antarctic is located on a continent, meaning there's solid land underneath. Over countless years, snow has accumulated on the ground and solidified under its own weight, forming ice (ice sheets). And that's the current surface of the continent of Antarctica. Much like geological stratifications, the ice sheet can be studied to reveal the environment of the Earth in the past. This is precisely the purpose of Dr. Motoyama's duties: ice-core drilling. The drilling site is the Dome Fuji Station, located 1,000 kilometers inland from Syowa Station on the coast of Ongul Island. As the name implies, the Station is on a mountain with elevation of 3,810 meters, comparable to Mt. Fuji. The high elevation means the ice is thicker here, and the thicker ice means that the past recorded in the ice goes back to far more ancient times. The deposition age of the ice at depths of 3,000 meters exceeds 700,000 years. When Dr. Motoyama first joined the National Institute of Polar Research (NiPR) in 1989, the first phase of the full-scale ice-drilling project had just begun.

"It was the first time a Japanese team was attempting this task, so there were debates on whether we should use foreign-made drills or not. Ultimately, four types of test drills were produced domestically based on drills manufactured by a Danish company. When I first participated in the 31st Japanese Antarctic Research Expedition (JARE) in 1989, I took them with me to test them on glaciers in Antarctica."

In the second phase of the Deep Ice Coring Project, the ice sheet was drilled 3,035 meters down, almost to bedrock. Drilling was completed in January 2007. The ice collected from the deepest part is 720,000 years old. Currently, the ice cores are stored at a low-temperature storage room at NIPR at -50°C and subject to analysis in a wide range of aspects.

"Unlike sediment cores taken from the seafloor or ground strata, this ice contains ancient air. We can measure the concentration of greenhouse gases like carbon dioxide by analyzing the air trapped in the ice, which would show the relationship between climate change and greenhouse gas concentrations in the past. That will help clarify the association between greenhouse gases and the global warming currently observed and allow us to make predictions about the future climate."

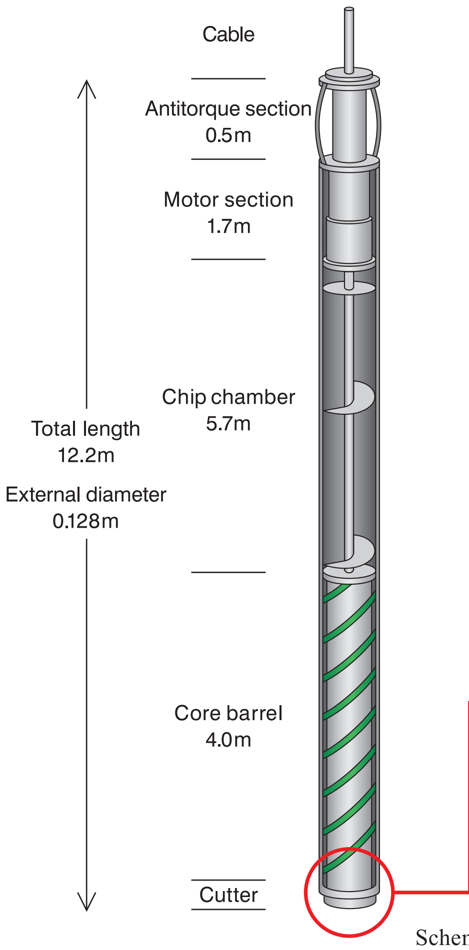
### The drill is a key technical development

The deep ice coring system for drilling ice features a long pipe structure. The cutter located at the tip creates a circular incision in the ice. The columnar cores of the ice sheet are stored within the pipe and raised to the surface. This process is repeated over and over. But things don't always go smoothly.

"While I was on my way to Antarctica for the 38th expedition (in 1996), the drilling had reached a depth of 2,500 meters. But then, when there was just 500 meters left to bedrock, the drill got stuck midway and couldn't be raised. The team did their best to recover the drill, but nothing worked."

Even after encountering these problems, Dr. Motoyama and others drew up a plan for another drilling project lest their efforts to accumulate technological know-how be in vain. Their plan was accepted. The second phase of the Deep Ice Coring Project began in 2001, and, for this, a new drilling system was developed.

"The new drill was 12.2 meters in total length. It allowed us to collect a four-meter ice core in a single run. The chips (drill cuttings of ice) produced by the drilling are also stored inside the pipes. After cutting the 4-meter core and raising it to the surface, we remove both the core and the chips, and



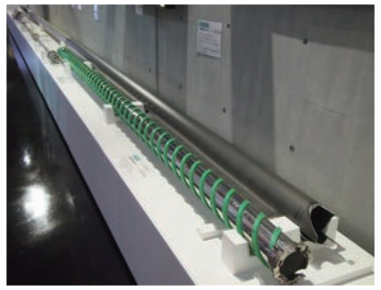
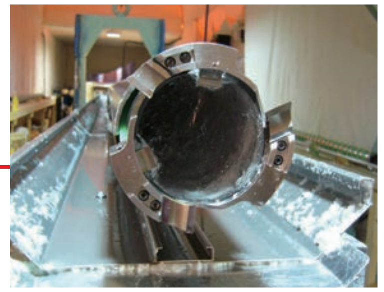



Photo of actual drill
© National Institute of Polar Research



The cutter section
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Schematic diagram of the deep ice coring system

the drill and pipes are cleaned and lowered once again. The drill system has a pipe-within-a-pipe structure and was ingeniously designed to allow the chips to rise up between the two pipes for storage in the chip chamber, with a 100% recovery rate."

With good reason, Dr. Motoyama is proud of his system. Recovery rates with foreign-made drilling systems are 60-70% at best. The chips that aren't recovered remain inside the hole; a separate procedure is needed to remove them before the next run. The drilling system made in Japan eliminates the need for this extra step. Drilling efficiency is high, and the drilling rate, 160 meters per week, unrivalled anywhere in the world. But, understandably, the development of this system posed numerous issues. One was where to procure such long pipes.

"The total length of the pipes was 12 meters. Even the slightest warping means that they would get stuck. We consulted with major companies on producing such high-precision pipes, but most of them turned us down. Finally, an aluminum pipe manufacturer in Fukushima prefecture with special expertise in tube drawing agreed to produce the pipes we needed. Even so, only one or two of any of ten pipes given had the precision required for use in drilling. These pipes made it possible to drill 3,000 meters. We're incredibly grateful to this company."

Beyond the pipes, an abundance of unique, sophisticated technologies from numerous small- to medium-scaled companies can be found in the production of the cutters for the ice drilling and drill motors. One company offered to supervise the final assembly and testing of the drilling system. Thus, his drilling system is a purely made-in-Japan system.

"I'm not too obsessed with having the system made in Japan. But no such systems were being marketed anywhere in the world, and research institutions and universities in foreign countries were each developing their own unique system. So, with foreign-made systems, we couldn't make requests for detailed customization. A system had to be imported as a whole set. But there were technologies available in Japan that made it possible to achieve the performance we needed. Now, with the admirable record achieved with our system, many foreign teams are purchasing complete sets of our drilling system."

## Recruited to the NiPR on the Himalayas

Dr. Motoyama was born and raised in the Niigata prefecture countryside. He walked about barefoot, looking for bees'nests to eat the grubs and enjoyed catching dragonflies and frogs.

"I always loved nature. I'd watch things no one else seemed interested in, like Venus appearing in the daytime sky. After school, I used to go bird watching or watch the stars at night. When the supernova appeared in Cygnus, I climbed up on our roof every night and compared its brightness against other stars to determine the magnitude and draw a plot."

When he was young, he says, his interests didn't focus on Antarctica. Instead, he attended Hokkaido University to study animal ecology, to follow in the footsteps of Masanori Hata, a figure he respected. But circumstances kept him from joining any biological laboratories, and he chose to pursue studies in a geophysics department. The Institute of Low Temperature Science (ILTS) at Hokkaido University, which he attended as a graduate student, was his third choice. Even then, he never expected to go to Antarctica.

"I was a student in the snowmelt science division at the ILTS. The field work didn't bother me, since I grew up in a place where we had three to four meters of snow on the ground in winter. I was studying the relationship between weather and the runoff from the snowmelt originating at the surface of the snowcover that flows into streams and rivers through the snowcover."

During the course of his studies, he was invited to a scientific expedition to the Himalayan glaciers in Nepal. He participated three times. During one of these expeditions, he met a researcher from NIPR. Dr. Motoyama recalls this with a smile. If he hadn't been invited to join the NIPR by that individual, he would never have ended up in Antarctica.

"Even before I joined NIPR, I'd been asked several times, 'Why don' t you come on the Antarctica expedition?' But there were things in the Nepal Himalayan observation only I could do, so I'd always turned down the offer."

After earning his PhD at the ILTS, he remained there for two years as a researcher until joining the NIPR in 1989. It's been 30 years since he first joined the JARE as an NIPR researcher. His life has focused on the study of ice.

## Maintaining the on-site feeling

Dr. Motoyama has had brushes with death.

"In Antarctica, we get all of our water by melting snow or ice. There's an endless amount of that, of course. Because the temperature is too cold above ground, we dig a hole to make water beneath the snow surface. But once, the hole was too wide, I guess. When I entered the hole, the ceiling collapsed on me. And once you're trapped in snow, you lose your sense of orientation. I heard someone call out for me, and that's when I knew which way I had to move to get out. I got out alive because I was near the edge of the hole."

Another time, when returning from Antarctica, he stopped in Sydney and went swimming at a beach. He then discovered the tide had become too strong to return to shore.

"Then I heard a voice saying, "Calm down." Maybe it was someone speaking to me over a speaker, or maybe it was just in my head. And I gathered my wits and slowly made my way back to the beach."

Ice core storage facility at Dome Fuji Station
© National Institute of Polar Research

Dr. Motoyama doesn't panic in the face of danger. His motto is to let things work themselves out. He wears the same clothes year round, regardless of season.

"I'm alright in the cold. Humans are tough. I think our bodies learn to cope with the cold. When I was interviewed here (at NIPR), I took the interviewers on a tour of the low-temperature room at -50 °C, only in my T-shirt and wearing sandals on bare feet. I know from experience that four or five minutes in there won't do any harm, so I'm fine with that."

Research at the NIPR is mostly based on fieldwork. Researchers go out to sites to collect data to complete their study.

"Of course, there's research that involves objective analytical data and satellite observations you get from the Internet. But if one isn't aware of the fundamental processes involved in a phenomenon, it's easy to arrive at the wrong interpretation. That's why I want researchers to see what's actually out there in the field. It's a way to remind yourself that things in nature aren't so simple."

For example, he explains, if you hear someone say, "There's ten centimeters of snow cover," you tend to picture an even accumulation of snow. But snow doesn't accumulate evenly in Antarctica. A researcher has to understand what's actually happening and consider ways to assess the depth data from the observations to identify the essential nature of the phenomenon.

"There's a lot from the past we can reconstruct from ice cores, but the most important thing is establishing a precise timeline. In other words, if we can create a climate model that accurately reconstructs past climate change, the model should improve the reliability of our predictions of the future climate. Will temperatures rise 2 °C or 8 °C over the next 100 years? An accurate model will make it possible to narrow the range of our predictions."

From the interviewer:
At the end of the interview, I asked Dr. Motoyama how he felt when he arrived in Antarctica only to hear that the drill was stuck in ice. He responded, "I had one less responsibility, so I felt a bit relieved." I would certainly like a portion of his stoicism and toughness. (M.Okazaki)

Feature Story

# Explore

The more we learn about something,the more we want to know.
That's characteristic of the human search
for knowledge beyond our grasp.
The journey to explore the world is never-ending.

01 Research

## The Singing Aurora ～establishing the mechanism that generates the pulsating aurora

A pulsating aurora is an aurora that pulsates for brief periods. Dr.Satoshi Kasahara (University of Tokyo)'s group has observed and established the mechanism that generates this phenomenon.

What are pulsating auroras? Pulsating auroras are auroras that pulsate for short periods ranging from several seconds to several tens of seconds. It's long been theorized that they result from intermittent changes in the behavior of electrons within the Earth's magnetosphere. But, until now, no direct observations of this mechanism have been possible.

### Observing electrons: The key to establishing the mechanism

Auroras are mystical and fantastic displays of light. Most of you picture an aurora as curtains of light, slowly swaying in the sky. An aurora is a kind of electromagnetic phenomena caused by the excitation of atoms and molecules in the Earth's atmosphere by electrons precipitating from space. However, there's a lesser known type of aurora, one that pulsates for short periods. This phenomenon, called a pulsating aurora, is caused by intermittent changes in the amount of electrons precipitating into the atmosphere. Explanations posed in the past posit that the generating mechanism involves resonant interactions between electrons in oscillating motion on the N-S axis along the magnetic field lines and chorus waves*, a type of electromagnetic wave, within the magnetosphere, at great distances from the atmosphere (Fig.1). The key to confirming this theory was observing electrons oscillating along the N-S axis.

"With conventional observation instruments," says Dr.Satoshi Kasahara, Associate Professor at the Department of Earth and Planetary Physics of the University of Tokyo, "the resolution of the angle of incidence is too coarse to distinguish the target electrons from other electrons. So we chose to construct, on our own, an observation instrument that would have the angular resolution we needed."

In short, the observation that established the cause of pulsating aurora generation relied not just on Dr. Kasahara's role as a researcher in planetary science, but as a developer of his observation instruments.

*Chorus waves : Electromagnetic waves along the Earth's magnetic field lines whose intensity changes between 1 kHz and several kHz. Since their frequencies are within the audible range, the sound created by the waves resembles the chirping of birds when amplified; hence the name. (See p.14 for a related article.)

### The idea : Improve angular resolution

As a university student, Dr.Kasahara chose to major in earth and planetary physics based on his interest in auroras. Another draw was the appeal of acquiring data using self-made instruments. He

Dr. Satoshi Kasahara, Associate Professor (University of Tokyo)

began developing the instrument used in his present research in 2008, while still a student.

The biggest problem he faced in developing the instrument, he says, was the management part: managing the schedule and negotiating with manufacturers."The fun part of technical design ended up being less than 20% of the effort. After the project was officially accepted, a new problem seemed to crop up every day. I felt like I was surfing forever on a sea of problems."

How did he manage to achieve his goal to improve angular resolution? It wasn't a technological breakthrough, he says, but the conception of an idea. The story goes like this:The sensors used in conventional observation systems for capturing incoming electrons were large and lacked precision in terms of detecting the direction of incidence. The ideal solution is to use tightly laid-out small sensors, but this approach would have been too cost and labor intensive. Dr. Kasahara came up with the idea for a method for laying down small sensors with some space between them (Fig.2).

"The space between the sensors creates a dead angle within which we can't capture electrons. But reducing the size of the sensors improves the angular resolution at which we capture the incident electrons. In other words, I decided to improve the precision with which we captured electrons for the electrons I could capture, even if that meant there were electrons I wouldn't be able to capture."

### His passion for the project

If the satellite launch fails, nearly 10 years of hard work is instantly lost. "Launching a satellite is a high-risk, high-reward project that allows for no repeated trials. Developing a project like this requires researchers and manufacturers from their respective fields devoting their entire time and effort as professionals, or even their whole lives. That's the reason for the enormous thrill among everyone involved when these efforts culminate in success in gathering data. So many faces came to mind as I wrote my paper of the people I wanted to thank. That's the true joy of participating in this project."

Interview and photos by:
Yuichiro Fuse (music technical writer)

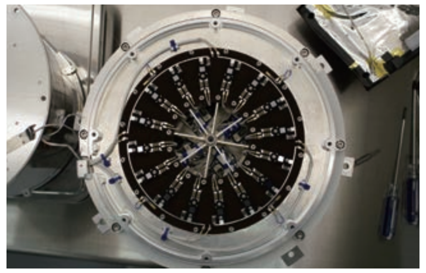
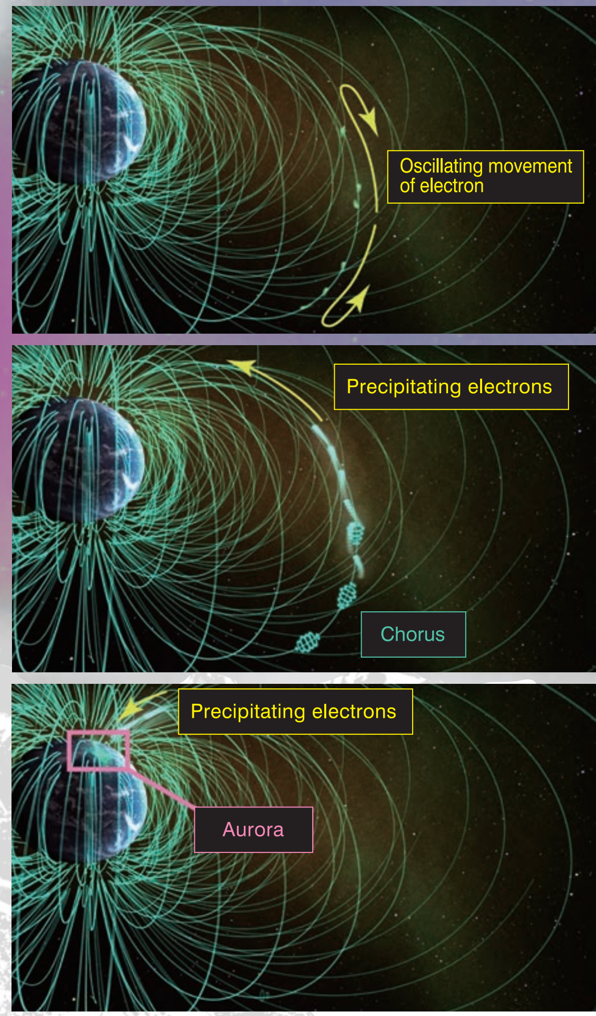


Photo of the Medium-Energy Particle Experiments -Electron Analyzer, MEP-e, actual observation instrument (courtesy of Satoshi Kasahara)




❶ Electrons are in oscillating motion along the Earth's magnetic field lines.

❷ Electrons energized by resonance with intermittently generated chorus waves precipitate into polar regions.

❸ The intermittent precipitation of electrons generates pulsating auroras.

Fig.1. Mechanism generating pulsating auroras
© ERG science team

Movie
http://vimeo.com/255272730
(with BGM and subtitles in Japanese)

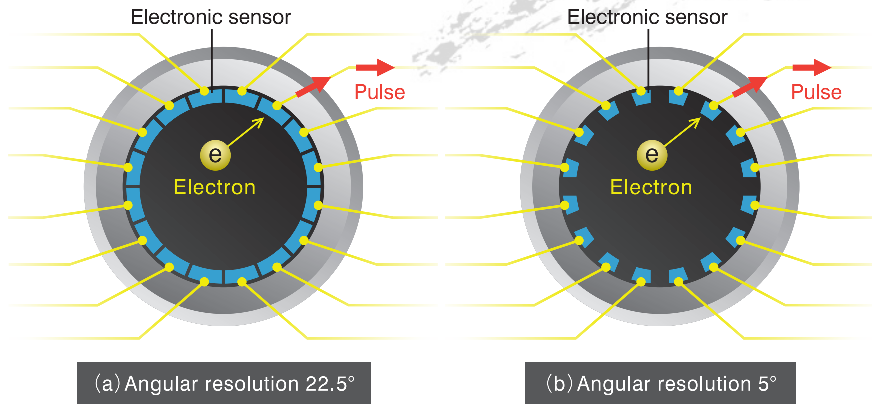



Fig.2. Schematic image of electronic sensors
(a) Conventional sensor:16 sensor elements are laid out, packed tight along the circumference.
(b) Modified sensor :To improve angular resolution, the size of the sensors has been reduced, and the array of sensors has interval spaces.

02 A Case of Measurement

# The Story of Air, Clouds and Meteorological Effects

## ～Measuring aerosols

Global warming, acid rain, PM2.5 — these are all currently major global environment issues. Aerosols are one major factor associated with all these phenomena. We interviewed Associate Professor Masataka Shiobara (PhD, National Institute of Polar Research) on aerosol observations in Antarctica.

### The bizarre and complex nature of aerosols

Many potential factors contribute to global warming or cooling. Aerosols, minute particles suspended in the atmosphere, are one factor, as are the clouds that form with aerosol particles as their nuclei. Aerosols are key to understanding the mechanism of various global meteorological phenomena and climate change.

Fine aerosol particles can scatter or absorb light. Global cooling occurs if they scatter sunlight and reflect it away from the Earth. Global warming occurs if they absorb sunlight and heat the air. Clouds form when water vapor condenses onto the fine particles of aerosols that serve as nuclei. This means no clouds will form without aerosols and that the type of aerosol involved in a cloud's formation will affect both how it forms and its characteristics. Since clouds also block sunlight, cloud formation affects surface temperatures. The effect of aerosols on surface temperature due to light scattering or absorption is called the direct effect; the effects due to clouds are called an indirect effect.

There are two general aerosol types: anthropogenic aerosols, including smoke exhaust and gas emissions, and naturally occurring aerosols, like volcanic smoke, airborne soil particles, and ocean spray. In general, since all these particles reflect light, they were originally believed to contribute to cooling. But later studies have shown that the carbon (soot) generated by combustion has heat absorption properties and has the opposite effect of warming. Clearly, then, aerosols have complex effects on the climate (Fig.1).

Among scientists, the current general consensus is that the mean global temperature has risen by about 0.7°C in the past 100 years. Taking into consideration the increase in greenhouse gases, the temperature should have risen more than it actually has. It's been claimed, as early as in the 1995 IPCC* report, that this suppression may be attributable to the cooling effects of light scattered by aerosols. Along with Vice President Al Gore of the United States, the IPCC was awarded the 2007 Nobel Peace Prize for raising awareness of the issue of global warming. The IPCC has released reports at five year intervals since. The next report will be its sixth.

*IPCC : Intergovernmental Panel on Climate Change

### Measuring aerosols in Antarctica

Syowa Station uses Rion's particle counters to monitor the size and count of fine particles in the atmosphere throughout the year. This monitoring measures aerosols near the ground. To minimize the effects of human activity near the station on monitoring results, the particle counter is placed inside an atmospheric observation room for clean air (aerosol observation hut or AOH) located some distance from the station, and air is drawn in from the outside for measurements (Fig.2).

The atmosphere over Antarctica is extremely clean. Due to the absence of airborne nuclei that would promote moisture condensation, the air we exhale doesn't turn into visible mist. The aerosol observations performed in Antarctica involve various instruments. In addition to collecting data on particle size and counts, these measurements track and analyze aerosol species, as well as the intensity of the solar radiation and brightness of the sky.

"Since Antarctica originally had no inhabitants, there's essentially no anthropogenic aerosols there. But we do observe combustible aerosols sometimes. One important goal of our research is to determine where these aerosols came from and how they were carried to Antarctica. Right now, it's becoming apparent that most have marine origins." (Dr.Shiobara)

The research vessel Shirase, which sails between Japan and Syowa Station, carries another particle counter. As the Shirase navigates the waters of the Pacific Ocean and off the coast of the Philippines, Indonesia, and Australia, it measures aerosols to assess interregional differences. Observations en route to and from Antarctica are just as important as the observations made in Antarctica.

### The latest topic in aerosol research

Among the hot topics in aerosol research now is the question of the relationship between aerosol types and the cloud types they generate. Unlike their anthropogenic counterparts, much remains to be learned about naturally occurring aerosols. Studies have shown that pollen, bacteria, and other bioaerosols play an important role in cloud formation. Research on the issue continues to intensify.

"We want to make a quantitative measurement of how many particles are present in one cubic centimeter of atmosphere. To do that we have to perform flux measurements and precise measurements of particle size. Rion's instruments are ideal for their reliable calibration services. It's one of the reasons we have the utmost confidence in your company." (Dr. Shiobara)

Interview made with the cooperation of the Polar Meteorology and Glaciology Group of the National Institute of Polar Research

Dr. Masataka Shiobara, Associate Professor (National Institute of Polar Research); photo by Megumi Yoshitake

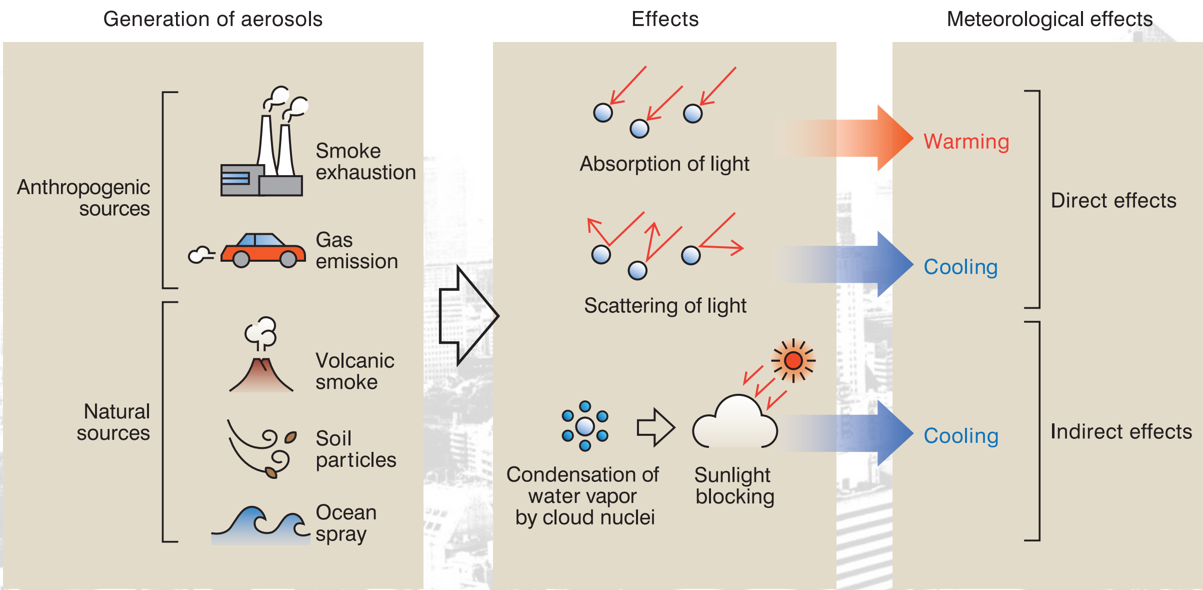



Fig. 1. Schematic diagram of aerosols and their effects on the climate

Fig.2. The atmospheric observation room for clean air (AOH) at the Syowa Station, where aerosol observations are carried out. Air is drawn in from the top parts of the tower on the left.




Fig.3. A particle counter of the same model as the one installed inside the AOH (Rion KC-01E)

TECHNICAL REPORT

# Faster and More Accurate

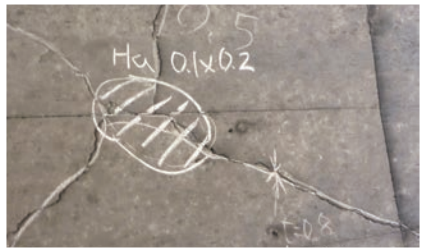
## A more efficient method for tunnel hammering inspections

**Japan has almost 10,000 tunnels totaling a distance of 4,000 km. Here we'll discuss some of the renewed efforts* to inspect these tunnels with greater precision and efficiency.**

*Joint research by West Nippon Expressway Engineering Kyushu Co., Ltd., Elwing Co., Ltd. and Rion.

### Issues related to tunnel inspections

Japan has numerous bridges and tunnels built after 1960. Thirty years from now, around 60% of all tunnels will be more than 50 years old. As tunnels age, the risk grows that portions of tunnel walls or ceilings will come loose. Given concerns about the shortage of inspectors, an important issue is how to continue performing maintenance accurately and efficiently well into the future.



Example of an abnormal section (crack) in the tunnel wall

Tunnels are currently inspected by workers standing on the deck of an inspection vehicle. A worker either visually inspects every inch of the surface of the tunnel, from the walls to the ceiling, or uses a hammer to tap the walls to check for abnormal sections (Fig.1). In the hammering inspection, the inspector depends on his ears to assess the sounds produced by these taps as vehicles rush by, even if traffic flows in one direction only. The effectiveness of such subjective assessments depends on the experience and the skill of the inspector.

To eliminate personal differences in these assessments and enable quantitative determination and record-keeping, we performed an experiment to validate the setup of an inspection system based on a rotary hammering inspection device. This device must satisfy the following conditions: The device is compact and readily portable; it performs inspections efficiently; and it allows the operator to tell the difference between normal and abnormal sections, even in the presence of noise from passing vehicles.

Fig.1. Inspecting the walls inside a tunnel from the deck of an inspection vehicle

### Enhancing the efficiency of the hammering inspection

The commonly-used hammering inspection generates just one single-point result per hammer tap. Multiple strikes are required to inspect a wide section of the wall. With the hammering inspection device used here, the rotary part is pressed against the wall and rolled along the surface to generate a continuous series of hammer taps. This allows a wide section of the wall to be inspected rapidly. However, due to the nature of the design, the hammer tap generated is quieter than the sound generated by conventional inspection hammers. Thus, noise from passing vehicles is more likely to pose problems.

To explore the feasibility of using the present hammering inspection device to assess the soundness of walls, a microphone (Rion UC-59 + NH-22) was attached to the device. Another microphone was used to simultaneously measure the noise generated by passing vehicles. All data was stored on a data analyzer (a Rion SA-A1). Fig. 2 shows how the measurement system was configured.

### Is rotary hammering an effective inspection method ?

◎Won't the noise generated by passing vehicles drown out the rotary hammer taps ?

Fig.3 compares the analyzed 1/3-octave band levels. As the figure shows, the hammer taps are stronger than the noise generated by passing vehicles at frequency bands above 1 kHz. This means the hammer taps won't be drowned out by vehicle noise and that measurements should be possible.

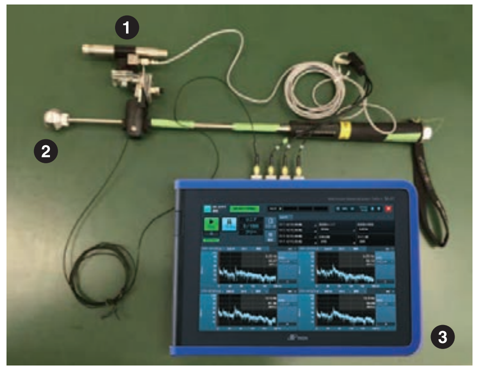
◎Can the system of rotary hammers distinguish between normal and abnormal sections of a wall ?

Fig.4 shows the differences in levels measured for the abnormal and normal sections for each frequency band. Compared to the normal sections, the abnormal sections record signals approximately 6 dB higher at 2.5 kHz, and 1-2 dB lower in the 10-20 kHz band. In the frequency distribution graph plotted from the levels recorded at each frequency band, we see the characteristic distributions for a normal section, an abnormal section, and for passing vehicles. Fig.5, for example, shows the frequency distribution plot for 2.5 kHz.

These results suggest that even in the presence of noise from passing vehicles, it may be possible to distinguish between normal and abnormal sections.

In future studies, measurements will be taken in other tunnels. The goal is to put into practical use the new hammering inspection system.


Yuichi Yonemoto
(S&V Measuring Instrument Development Section)

➊Microphone(UC-59+NH-22)
➋Rotary hammering test device
➌Analyzer for data storage(SA-A1)

Fig.2. Architecture of the system for measuring the rotary hammering test device

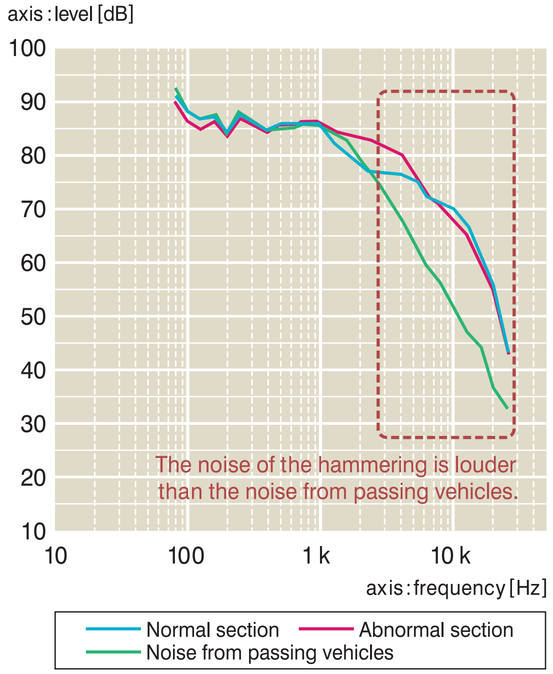



Fig.3. Comparison of 1/3-octave band levels

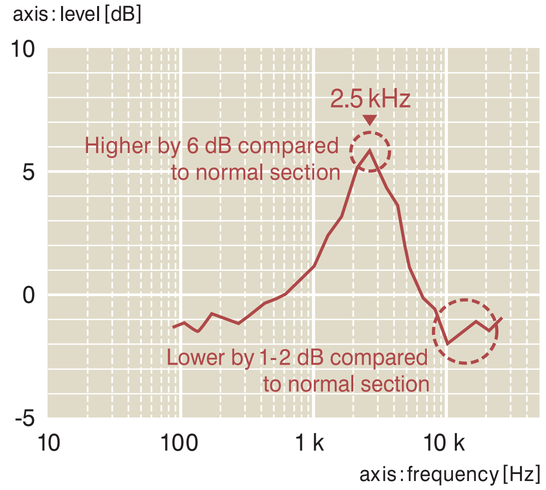



Fig.4. Difference in 1/3-octave band levels (abnormal section vs. normal section)

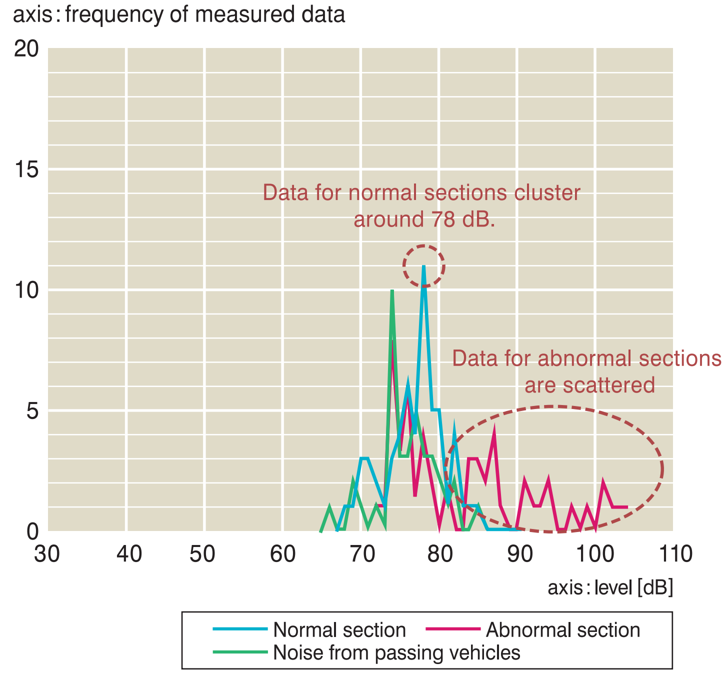



Fig.5. Frequency distribution at 2.5 KHz band

# Understanding Measuring Instruments

**We will explain a measuring instrument from various angles in a three-part series**

## Clean Room Standards and Monitoring (#2)

# The Multipoint Monitoring Method

**This is the second part in a series introducing pharmaceutical cleanrooms that require high cleanliness and methods for monitoring cleanliness. Here we'll describe how a method based on multiple sensors, called the multipoint monitoring system, works.**

### Need for multipoint monitoring

The previous issue stated routine monitoring during the manufacturing of pharmaceuticals had to be performed according to the guidelines stipulated in GMP.*1

The cleanrooms used in pharmaceutical manufacturing processes must meet rigorous standards for cleanliness. Different grades of cleanrooms are often used for different processes. Multipoint monitoring is a method for controlling cleanliness even in cases like this. Multipoint monitoring systems allow the operator to set threshold values and particle sizes separately for the grade required for each controlled environment. Alarms or warning lamps can be installed at measurement locations to notify site workers if the particle count exceeds the set threshold value.

Multipoint cleanliness monitoring systems come in two general types, based on differences in component devices and measurement methods: multipoint tube monitoring systems and multipoint sensor monitoring systems.

Multipoint tube monitoring systems have a manifold (switching device) connected to the particle counter used to measure cleanliness. Multiple sampling tubes connected to this manifold extend to each point to be measured. Measurements are taken by switching from point to point.

Multipoint sensor monitoring systems have multiple particle counters, one for each point being measured. Thus, they offer more freedom in measurement, and an independent monitoring schedule can be set for each measurement location.

**Fig.1** shows an example of how a multipoint monitoring system can be connected. The section below introduces multipoint sensor monitoring systems, and the advantages of the two different types.

*1 GMP (Good Manufacturing Practice): Ministerial Order for the Standards Concerning the Management of Manufacturing and Quality of Pharmaceuticals and Quasi-Pharmaceutical Products

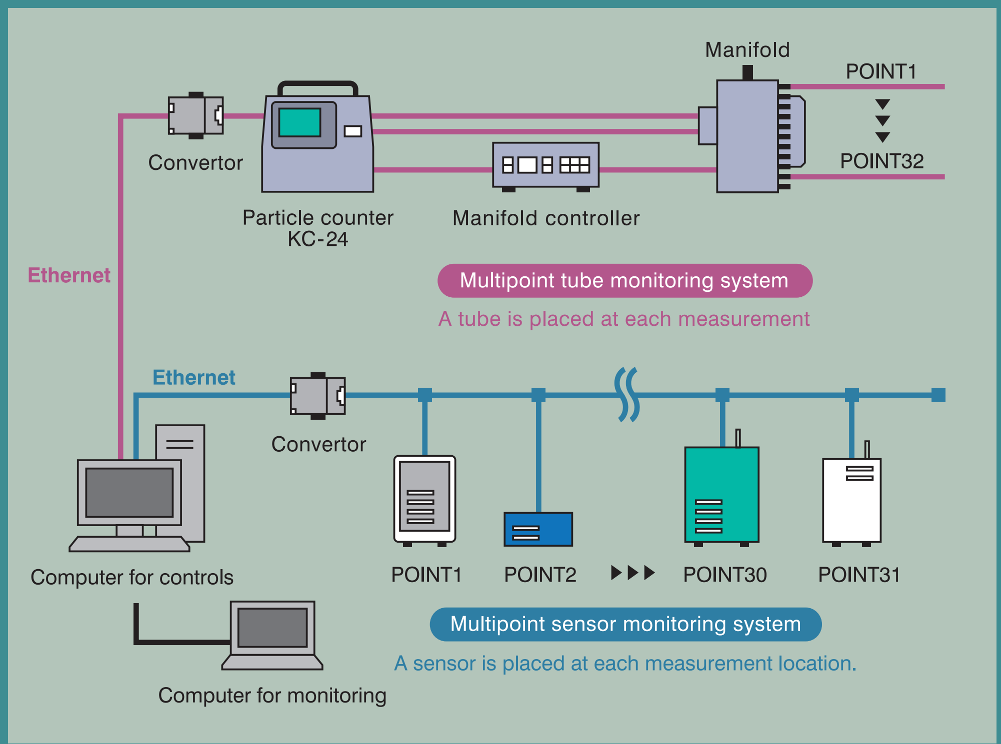



Fig.1. An example of a multipoint monitoring system configuration

### Multipoint sensor monitoring systems

In multipoint sensor monitoring systems, all measurement locations can be monitored constantly and continuously. This makes it more likely that a problem will be discovered soon after it occurs, allowing fast identification of circumstances and efficient investigation of causes.

Systems can use one of two particle counter types: The first type incorporates an internal pump for drawing in air samples. The second type lacks the pump.

The latter type requires a separate external pump unit or a vacuum source. Since a single pump can provide the suction needed by multiple particle counters, depending on actual conditions, it's possible to construct cost-efficient systems.

For particle counters with internal pumps, the counter may be detached from its current location and carried elsewhere to make measurements. These particle counters offer convenience when making temporary measurements.

### Factors that prevent accurate measurements

Particle counters don't require pretreatment processes for the samples. Their strength lies in the ability to take real-time measurements immediately after sample collection. To obtain accurate particle counts, care must be taken to prevent loss of the particles during sample intake or transfer. The major obstacles to precise measurements are given below.

**(1) Effects of air intake rate**

The relationship of the airflow rate at the target environment to the air intake rate of the particle counter affects particle concentration measurements. **Fig.2** shows schematic images of the air intake through sampling tubes. When airflow and intake rates are equivalent, as in case (a), the measured particle concentration and the actual particle concentration of the controlled environment may be considered to be equal. When the air intake rate exceeds the airflow rate, as in case (b), some particles may not be carried with the airflow into the sampling tube due to inertial force. Conversely, when the air intake rate is lower than the airflow rate, as in case (c), some particles that should have remained outside may enter the sampling tube. To prevent the latter two cases, each sensor is equipped with a probe for taking in sample air at the same rate as airflow. Measurements are made using the probe.

**(2) Effects of sampling tube material**

In certain cases, particles can be affected by the material of the sampling tube through which they pass. Tube materials that tend to generate static electricity, like Teflon and silicone polymer, will attract particles and may prevent accurate measurements. These materials should be avoided.

**(3) Effect of air intake angle**

In cases in which the sampling tube is placed at an angle to the airflow, this angle will affect counting efficiency. **Fig.3** presents a schematic image of particle behavior in an angled configuration. If angle θ is large, particles that fail to follow the curved airflow may not enter the sampling tube. This effect will be more pronounced for larger particles. If θ is 30° or less, accurate measurements should be possible for particles up to about 10 μm.

The theme of the final part of the series presented in the next issue will be validation, or the procedures applied to ensure measurement accuracy.

Shuhei Nezu
(Particle Counter Development Section)

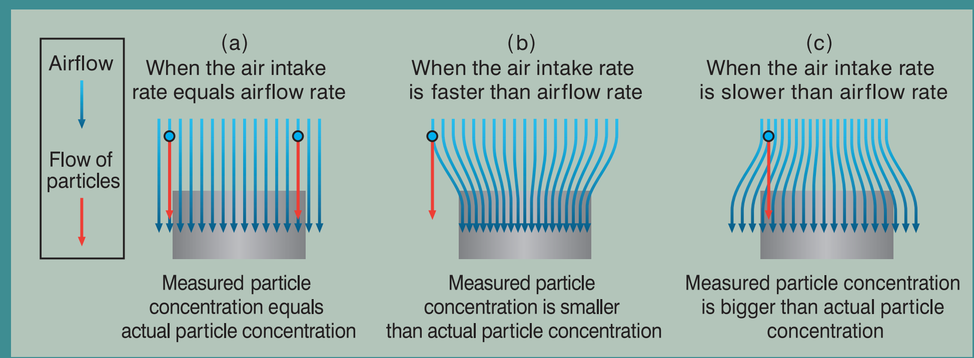



Fig.2. Effect of air intake rate

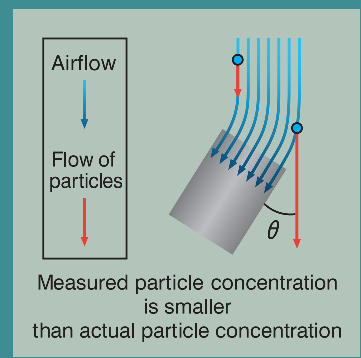


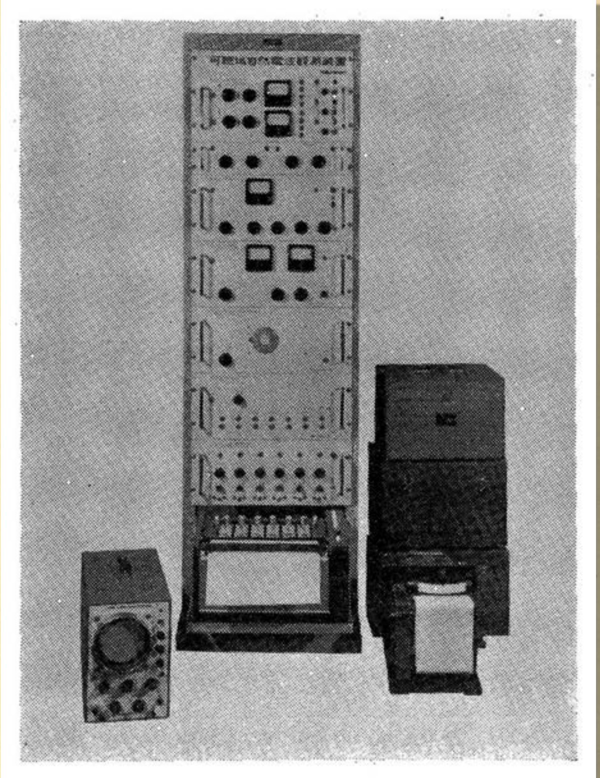

Fig.3. Effect of air intake angle

Rion's History of Technology

# LEARNING from our Past Products

## Custom Instruments that Proved Their Mettle in Antarctica

# An instrument for natural VLF radio emissions observations



Rion has a surprisingly long history with Antarctic research, mainly through an instrument installed there for analyzing the sound of auroras. We spoke with Mr.Shigenori Kawasaki, who participated in the development of this instrument.*

* During the development of this instrument, Mr. Kawasaki worked in Engineering Department Section 1.

——Natural VLF radio emissions is an unfamiliar term. What does it mean?

The term refers to static noise generated in the Earth's atmosphere, which can be heard as sound. One example is thunder, an atmospheric radio phenomenon, which is often from an electrical discharge between clouds. The target of the actual observation is the secondary sound generated by the aforementioned phenomena, called whistlers (see below). These are clear tones like those made by a whistle.

——Why are such sounds observed in Antarctica?

Because atmospheric radio phenomenon are more frequent in polar regions like Antarctica, which means more favorable conditions for observation. Auroras are one example. I've heard that the instrument was deployed at Syowa Station during the 7th Japan Antarctica Research Expedition in 1965.

——Can you share some of the development background?

The instrument was a custom-ordered one developed at the request of the Department of Earth and Planetary Physics at the University of Tokyo, which was in charge of observations of the ionosphere and so forth in Antarctica. The instrument was basically a modified sound spectrograph widely used in voice analysis.

——What part of the development did you oversee?

I was in charge of developing the filter module, the part in the center with the large dial. Immediately after I was assigned to the Engineering Department, my supervisor told me to build a filter having such and such properties. And so I did. The module is used to enhance the S/N ratio of the processed signal. The dial is used to select the center frequency of the passband. Since the lower the frequency of the analyzed signal, the larger the inductance has to be, we had to increase the number of turns on the coil. For frequencies of 100 Hz or less, the coil had to be larger than 10 cm. It wasn't just large — it was quite heavy, nearly 10 kg.

——How much wire is wrapped to make a coil?

For the low frequency range, maybe 3,000 to 4,000 turns. The wire had to be carefully wrapped around a bobbin. Otherwise you'd get bulges, which would make it impossible to fit the coil in the ferrite core.

——Do you mean it wasn't wrapped by machine?

No, it wasn't. That's because the instrument wasn't a mass-produced model. Ideally, to achieve a high number of turns, you would use thinner wires. But thinner wire means high DC resistance, which results in high insertion losses. In other words, the level of the signal after passing though the filter would be reduced. From that perspective, thicker wires are better. So the issue became identifying the right wire thickness. Thin wires are also more prone to break. I would start wrapping wire into a coil all day from the start of a workday. You can imagine my disappointment when the wire broke midway. Also, if you touch the wire with your bare hands, the sweat from your hands can corrode the insulation on the wire material. I had to wear gloves. If the instrument were mass-produced, I could have outsourced the job. But since it was a custom order, I had to do it myself.

——Why didn't you use an op amp?

Because a coil is much simpler in terms of structure and gives better S/N ratios because there's no noise source. A filter available on the market at that time as a standard Rion product also proved useful. Most filters back then were designed along the architecture of constant-K filters.

——Was the work interesting?

Sometimes. At other times, it was excruciatingly difficult. If a job is too interesting, you find yourself too absorbed in it. That's not good if you have to do it later as a commercial venture. You'll find you've left your team behind. That might be acceptable when you're still low in the ranks, but once you become a supervisor, you have to keep reminding yourself that you're developing human resources.

——What can you do to develop human resources?

It's important to allow someone to work hard on their own, but a superior can't leave a worker completely alone. It's important to give advice in a timely manner. It's important to say: "Hey, there's another way to do this." If a subordinate is struggling for ideas, his supervisor should search for a solution, too, but without intervening too much. Keeping the appropriate distance is what's essential in training someone.

Interviewer : N.Sekijima

Mr.Shigenori Kawasaki

**[ Whistler ]**

Of the atmospheric radio disturbance phenomena that occur near the ground, phenomena that produce sounds in the audible range, heard by humans as whistling sounds over the telephone line, are often called whistlers. Since whistlers can be used to determine the state of the ionosphere above the Earth and even in the magnetosphere beyond, studies of whistlers have been active since the 1950s. Instruments for natural VLF radio emissions observations are used to analyze this phenomenon.
Chorus waves, which resemble a bird chirping and are associated with the generation of pulsating auroras, are a type of whistler (see p.6 of this issue).

Model using constant-K filters, SA-2704 (1959)

The research vessel Fuji, which carried the 7th JARE team to Antarctica

© National Institute of Polar Research

Hello From the Office
Greetings from the Office in Kokubunji

# “Rion Hall” and “Rion Square”

## Both located in *cocobunji Plaza* at the Kokubunji Station north exit

In April 2018, a public facility called cocobunji Plaza opened in the station building at the north exit of Kokubunji Station, the station closest to the Rion offices.

In June 2019, our company will celebrate the 75th anniversary of its founding. To commemorate the milestone, we’ve acquired naming rights to the facilities and given them the names “Rion Hall” and “Rion Square”.

“Rion Hall” is an open space designed mainly for communicating information and promoting interaction among the people of Kokubunji. The multi-purpose hall has a maximum capacity of 260 seats. The adjacent outdoor space, “Rion Square”, offers a place where people of various ages can relax and find refreshment among the greenery.

At the opening event of cocobunji Plaza, Rion held a commemorative event to formally announce the naming. Our Measurement Instrument Brach set up nine booths under the theme “Let’s Experience Sound and Vibrations!” The activities included a Shouting Contest judged by a sound level meter and a Stamp Your Feet Contest judged by a seismometer.

**From the Shouting Contest booth operator**

At our booth, we used indicators for the sound levels we encounter in our everyday lives. We found one woman who could shout at helicopter-class levels (approx. 110 dB). An especially creative person, a young boy, tried shouting in several different pitches to get the best result.

**From the Stamp Your Feet Contest booth operator**

We measured seismic intensity by having participants jump up and down on a board. The adult participants were a little reserved. The children were a little more unrestrained about bouncing on the board. One youngster recorded a seismic intensity of seven, which is the highest point of the scale. I think the experience provided some sense of how intense an actual earthquake can be.

View inside Rion Hall, with Rion Square seen from its window (courtesy of Kokubunji City)

A boy participating in the shouting contest held in Rion Square (The score shown is before his try.)

リオンホール

*cocobunji Plaza* (Note: The plaza is a public facility; it is not owned by Rion.)
Location : *cocobunji WEST* 5F, 3-1-1 Honcho, Kokubunji City, Tokyo
Contact : +81-42-325-6330





SCIENCE COLUMN

# Making things smaller

In 1965, an advertisement for a certain chocolate product had the tagline, “Bigger means better.” The phrase suited the environment in Japan at the time, which was developing economically at a rapid pace. Nevertheless, the book *Chijimi Shiko no Nihonjin* (Smaller Is Better) by Lee O-Young claims that the Japanese mind operates better in making things smaller than in expanding more. Starting with the story of *Sukuna-Bikona*, a tiny divinity in Japanese mythology who assisted *Ōkuninushi* in building Japan, the Japanese have believed small things hold supernatural powers —thus, heroes young and small like *Issun-Boshi*, *Momotaro*, and *Ushiwakamaru*.

Rion produces automated monitoring instruments to monitor aircraft noise. The dimensions of the latest NA-39A model have been reduced to 1/3rd those of conventional models. If you take into account the functions newly added, including frequency analysis, you could argue that the overall system is at most 1/6th the size such a device would have had to be in the past. The model is less than 1/12th the size of products marketed 30 years ago. The spacing of the microphone array, which detects the direction from which sounds arrive, has also been reduced from 2 meters to 1 meter, then to 50 centimeters, and now to 25 centimeters. Making things smaller lies at the core of product development for Japanese industries, a spirit reflected strongly in Rion’s products.

As things continue to be made smaller and smaller, it may one day be possible to construct a palm-sized automated monitoring instrument. That, of course, won’t be easy. All technologies develop and eventually become mature. The important thing, then, is making a technological breakthrough that will make such an instrument possible. Following *Sukuna-Bikona*’s example, it may be wise simply to ask for the deity’s help. After all, he is the god of sowing, of hot springs, of medicine, and of knowledge.

Dr. Ichiro Yamada
(Advisor, Executive Director of the Airport Environment Improvement Foundation)

*Issun-Boshi*
by R.Tada (S&V MIME Section)

Japanese scenery

At the Gion festival in Ueda City, Nagano Prefecture (July 2017)
Photograph by: Masahiro Sunohara (Business Technology Development Section)

A *matsuri* (festival) is a summer tradition in Japan.
The locals carry the *mikoshi* (portable shrine) though the streets, shouting “*Wa-shoi, wa-shoi!*”

# ShineView!

Introducing one of Rion's shine workers, someone who shines, on and off duty.

Makoto Hosono Production & Sales Control Section

## Caves Filled with New Discoveries

Mr. Hosono belongs to a caving organization that explores caves of limestone and other types of rock, and creates detailed maps. He was a leader on the team that discovered a previously unknown subterranean lake in Ryusendo cavern, one of Japan's three best-known limestone caves.

—— What first got you interested in caving?

I joined the Boy Scouts when I was in the third grade. I went on my first caving tour when I was a university student. After that, I founded a caving group at my university with another student. But it wasn't until I graduated that I really started to cave actively.

—— What does caving actually involve?

The main part of caving is exploring and surveying uncharted passages. Sometimes, you make your way hammering anchors to hook a rope and climb up or down for several tens of meters.

—— Do you like enclosed spaces?

Not exactly. [laughter] It's like how a child enjoys moving his body. I enjoy the sensation of using my whole body when I'm outside.

—— I heard you made a major discovery once.

Yes. In 2007, on a survey expedition to the famous Ryusendo cavern (in Iwaizumi Town, Iwate Prefecture), our team discovered a previously unknown subterranean lake. The discovery was covered by many media outlets.

—— What's the appeal of underground adventures?

It's probably about not knowing what lies ahead. You' re elated when you find new passages and spaces. Once you' ve found them, you survey and chart them. Since your name remains on the charts, a person may come to you some day in the future to ask about the history. I really look forward to that possibility.

—— This has to present some hazards, right?

Yes. Once, I'd forgotten to do the usual procedure of tying the end of a rope in a knot while I was descending down into a 30-meter deep vertical passage. If I hadn't realized my mistake midway, the rope would have come loose from the descender, and I would have fallen from a height of 10 meters.

—— Would there be help if you fell?

To prevent secondary disasters, the rule is that no one should go assist another person until they've secured their own safety. Team work is important, but the fundamental rule is to be responsible for yourself first.

—— Do you have any advice for anyone interested in caving?

I'm cautious about recommending it, since it's not exactly the safest sport. But some caves don't require special skills to explore. Those might be good starting points.

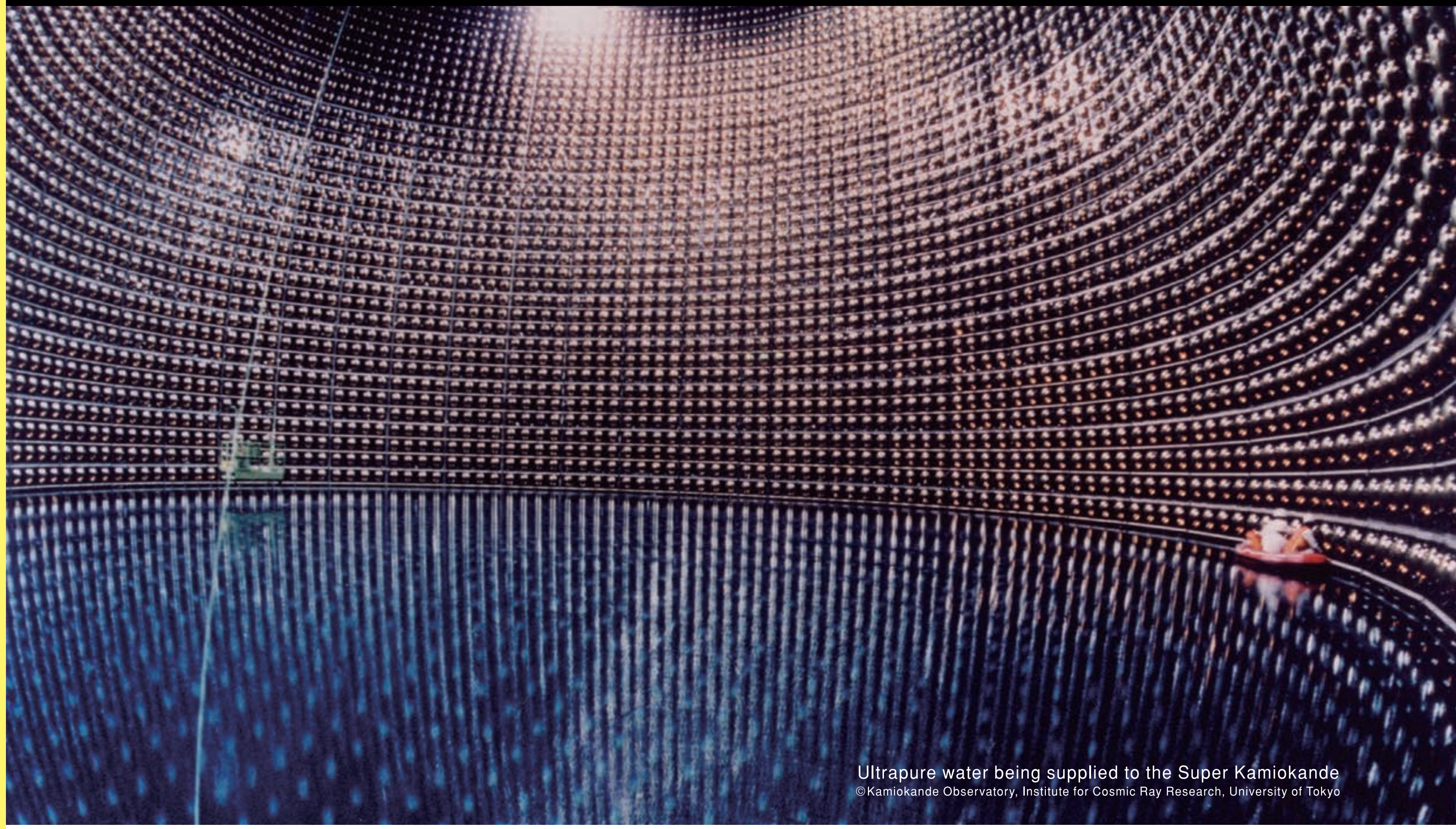
Mr. Hosono surveying a narrow cave

Climbing down a slope using ropes

From the interviewer: Finally I asked him " Would you be interested in going to Antarctica?", and he answered "I don't like the cold, so, no [laughs]." (H.Tomizawa)



# Launching a Validation Experiment for a Bioparticle Counter at Super Kamiokande, the World's Largest Underground Neutrino Observation Instrument

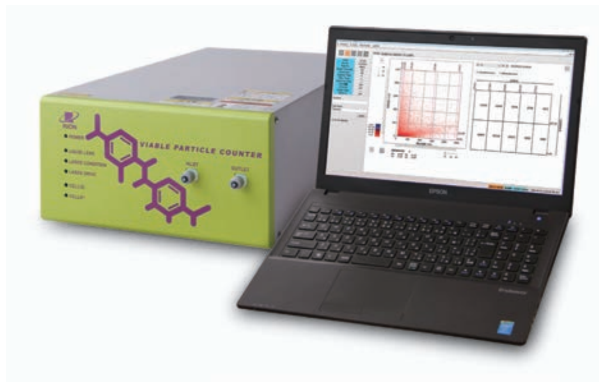


Ultrapure water being supplied to the Super Kamiokande
©Kamiokande Observatory, Institute for Cosmic Ray Research, University of Tokyo

## Monitoring massive volumes of ultrapure water

The Super Kamiokande is the world's largest observation instrument dedicated to the capture of the elementary particles called neutrinos. To detect the extremely faint radiation given off by neutrino interactions, it's filled with 50,000 tons of ultrapure water.

To maintain high detection performance for this light, the water inside the tank is constantly being circulated for purification. In January 2018, a validation experiment was launched to investigate the effects of the bacteria occurring in the ultrapure water on the transmissivity of light. The instrument used in the experiment is Rion's bioparticle counter.



Bioparticle counter

Bioparticle counters measure the size and numbers of bioparticles by instantly evaluating particles as nonbiological or biological. They do this by detecting the autofluorescence of riboflavin, a metabolic activator (and a type of vitamin $B_2$).

An article in Shake Hands, vol. 4, introduced the mechanism by which the Super Kamiokande captures neutrinos. To view past issues, go to the Shake Hands page at the end of this issue.

## TOPICS Research presentations, articles, etc.

**【Related to sound and vibration measuring instruments】**

◎Acoustical of Japan 2018 Spring Meeting (March 13-15, Nippon Institute of Technology)

- Study on methods for localization of the infrasound / T.Doi*1, K.Iwanaga*1, T.Kobayashi*1, Y.Nakajima (in Japanese)
- Sound source identification and it's evaluation by means of "Timbre Similarity Index" of environmental noise / H.Suzuki*1, Y. Nakajima (in Japanese)

◎The Journal of the Acoustical Society of Japan Vol.74, No.5 (2018)

- Measuring system for wind turbine noise (in Japanese)

◎The Journal of the INCE of Japan Vol.43 No.3 Jun.,'18

- An Introduction of Measurement of Ground Propagation Characteristic for the Road Traffic Vibration / H.Umayahara, R. Kazama, K.Yamashita, T.Ozaki, N.Okamoto, T.Hasumi (in Japanese)

*1 Kobayasi Institute of Physical Research

**Exhibitions**

S Related to sound and vibration measuring instruments
P Related to particle counters

- S Acoustical Society of Japan 2018 Autumn Meeting (September 12-14, Oita University)
- S Automotive Testing Expo China 2018 (September 25-27, Shanghai, China)
- S The Institute of Noise Control Engineering of Japan 2018 Autumn Meeting (October 13-14, Kanagawa University)
- S Measurement & Control Show 2018 OSAKA (November 7-9, Grand Cube Osaka)
- P SEMICON Taiwan 2018 (September 5-7, Taipei, Taiwan)
- P Regenerative Medicine JAPAN 2018 (October 10-12, Pacifico Yokohama)
- P SEMICON Japan 2018 (December 12-14, Tokyo Big Sight)
- P SEMICON Korea 2019 (January 23-25, Seoul, Korea)

**Seminars**

We conduct seminars on sound and vibration across the country. Please visit the web site (http://rion-sv.com/event/all) for dates, venues, programs and other details.

## About the Front Cover

A significant portion of an iceberg is underwater. Only a small portion is visible above the surface. In research targeting natural phenomena, only a portion of all the information can be obtained as data. This is why imagination is a major factor in trying to understand any phenomenon in its entirety. (M.Oana)

## Editorial Postscript

Many explorers are active in our world: explorers of the universe, frontiers, skies, oceans, and even shapeless things. The joy in finally finding what one set out to find must be immeasurable. For my part, I'm going to do my best to find a place to have lunch today. (H.Sagawa)

A Polar Science Museum is located on the premises of the National Institute of Polar Research. One can come here to see truly exciting images and exhibits on auroras. Antarctica is a place where the Earth meets space. (M.Okazaki)

**Past issues of *Shake Hands* are available here:**
**http://rion-sv.com/shakehands/**

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Environmental Instrument Division, Rion Co., Ltd.
3-20-41 Higashi-motomachi, Kokubunji, Tokyo 185-8533, Japan

Contact

Planning Section, Environmental Instrument Division
TEL +81-42-359-7860 FAX +81-42-359-7458
Email : shakehands@rion.co.jp

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