

# Air Filters Components Activity Measurements with HpGe Gamma Spectrometer

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## *Abstract*

Authors present the results of radioactive nuclides identification in the air filter materials, collected at the territory of Pohang city (Republic of Korea) one month after the Fukushima nuclear power plant accident.

## **Introduction**

Experiment on air filters activity measurements have been conducted at POSTECH University located at Pohang city on the east side of the Republic of Korea one month after the devastating earthquake and tsunami demolished many small cities and villages at Japan as well as severely damaged several blocks of the Fukushima nuclear power plant. Air filters were collected approximately one month after the earthquake at a distance of about 1000 km to the South-West from Fukushima.

There are several kinds of detectors that detect the gamma rays emitted from radioactive samples, but High-Purity Germanium detector (HPGe) is widely used because of the high resolution and efficiency.

We used the HPGe detector (ORTEC, GEM-30180) with 20% efficiency for our measurements. The detector is p-type, which can measure the energy spectrum range of 100 keV to 10 MeV, and the energy resolution (FWHM) is 1.63 keV with 1.33 MeV <sup>60</sup>Co gamma line. To accumulate pulse height spectra we used the computer based DAQ system with Gamma-Vision 32<sup>[1]</sup> software from ORTEC. The detector location is the first floor of Neutron laboratory at Pohang accelerator laboratory. Detector shielding consists of about 20 cm thick lead and 5 cm copper. Detector and shielding are shown at Fig.1.



Fig.1. Detector and shielding box view

### **Samples collection and preparation**

To collect necessary amount of the sample, we need a filtering system because an amount of the radioactive nuclides of interest is too small in the air to be directly detected. The filtering system collects the dust assumed that the radioactive nuclides are included in atmosphere. The system was set up on the open roof of RIST building located at Pohang city (Republic of Korea) around 18 meters above the ground (Fig.2).

The collector consists of two parts, namely: pump and filter. The pump sucks the air into the filter. The pumping rate is about  $1 \text{ Nm}^3/\text{min}$  at constant rate.



Fig.2. Air filtering system location at the roof of the RIST building

We collected two different filter samples using same pumping equipment. It took one day per sample to be sufficiently collected for this research. First filter sample in paper form was made by QMA (Quartz Microfiber Filters, Cat No. 1851-865, particle retention (0.3  $\mu\text{m}$ ): minimum 99.95%) and had the following sampling time: 13.04.2011, 14:00 ~ 14.04.2011, 14:00 (around 24 hours). As the result of sampling, the weight of collected particulates was 0.161 g and the total flow was 1440.1  $\text{Nm}^3/\text{day}$ . The average concentration of particulates representing the amount of the dust in air is 111  $\mu\text{g}/\text{Nm}^3$  (Fig.3).

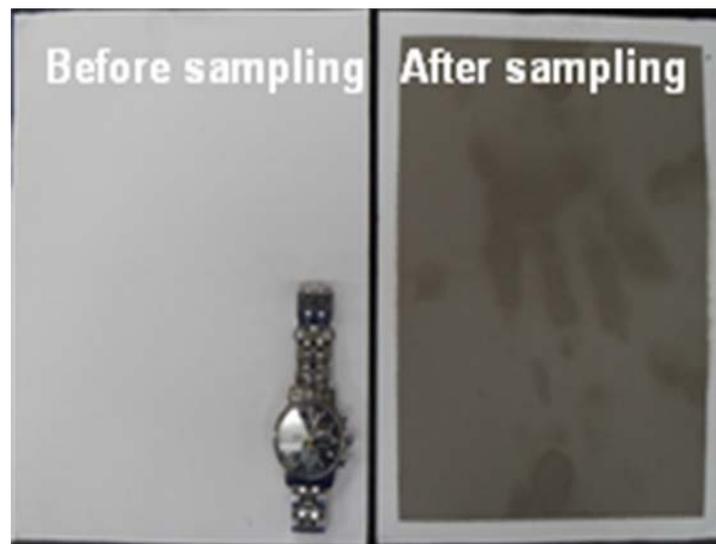


Fig.3. QMA paper before and after sampling

Second sample was different from QMA filter in many ways. In case of second, it is comprised of 3 layers of foam rubber, AC (Absorbent Coal) and foam rubber in order (Fig.4). The AC filter was also collected below the same condition of QMA filter.



Fig.4. Second sample: foam rubber (top and bottom) and AC layer in the middle

## Measurements

Sample measurements were performed three times according to the type of filter sample material. The first was of AC filter a couple of days later after filter collection. After conducting the pretests, energy calibration, peak identifications and background measurements, it was carried out in the Pb-Cu shielding structure by HpGe detector for 100300sec. The beaker of AC was parallel to the axial of the detector and was put close by the end of the detector head as possible so that the activity calculation of the nuclides of interest can be more convenient. Secondly, two paper filters, which were respectively collected on the different days, March 14 and April 13, were measured after the AC filter measurement. Since they are very thin and wide compare to the AC sample, it is difficult to achieve the detector count rate, which should be large to identify the signal of interest in given time. Therefore, we have to compress the paper filters by folding it in four layers and then the folded paper filters were put on the surface of the detector head. Measurement time duration was 156139 sec for April's sample and 170060 sec for March's sample respectively. The next measurement was conducted with the foam rubbers. They were collected at the same time with AC filter. Since each of foam rubber was inserted at the top and bottom of

the collecting rod with AC filter as the center, the position of two foam rubbers make difference. As the result, we just measured the bottom rubber. We supposed that the accumulated amount of the dust on top rubber is a negligible quantity because the top rubber plays the role as the inlet of airflow and the bottom rubber play the role as the outlet.

## Results

Before sample measurements, the detector background was carefully investigated. First, we measured experimentally the efficiency of our passive background shielding.

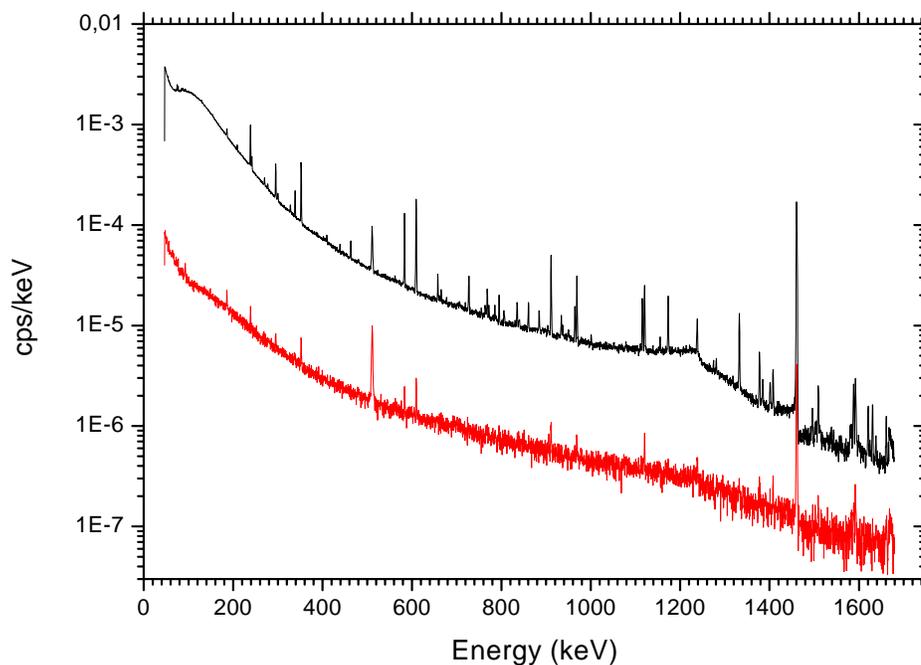


Fig.5. Detector background without shielding (upper spectra) and inside the shielding box (lower spectra)

At Fig.5 one can see the detector background count rate expressed in **cps/keV** for unshielded and shielded detector.

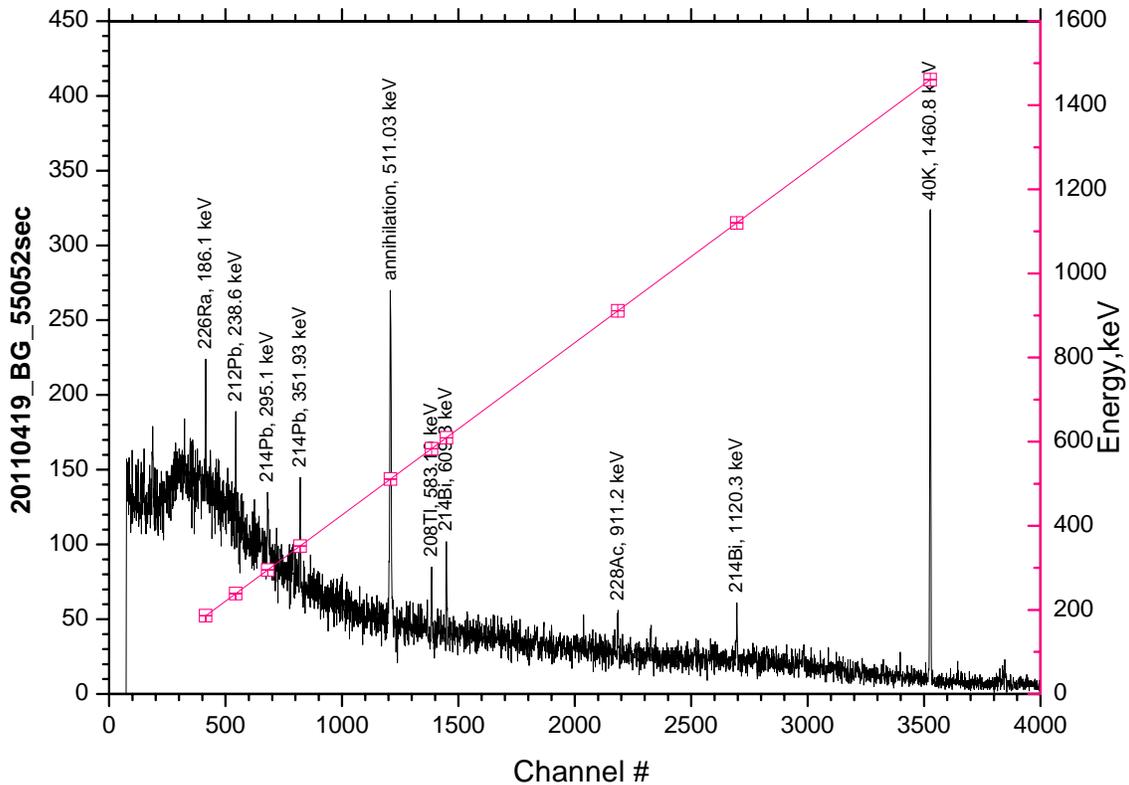


Fig.6. Shielded detector background spectra accumulated during 55052 seconds with nuclides identification and energy calibration

Fig.6 demonstrates one of the shielded detector background spectra accumulated during our measurements with gamma lines identification and energy calibration.

The QMA filter samples measurements did not reveal any nuclides different from the background except for gamma line with measured energy 477.662(9) keV that we are identifying as the line from cosmogenic origin nuclide  $^7\text{Be}$ , produced by GCR particles spallation reaction at oxygen and nitrogen in the atmosphere.

AC filter in its turn also did not reveal any gamma lines different from background ones except the gamma line with identified energy 364.4 (1) keV which potentially could be the  $^{131}\text{I}$  line (reference energy 364.489 keV). AC filter material spectrum with background one in corresponding energy range are shown at Fig.8.

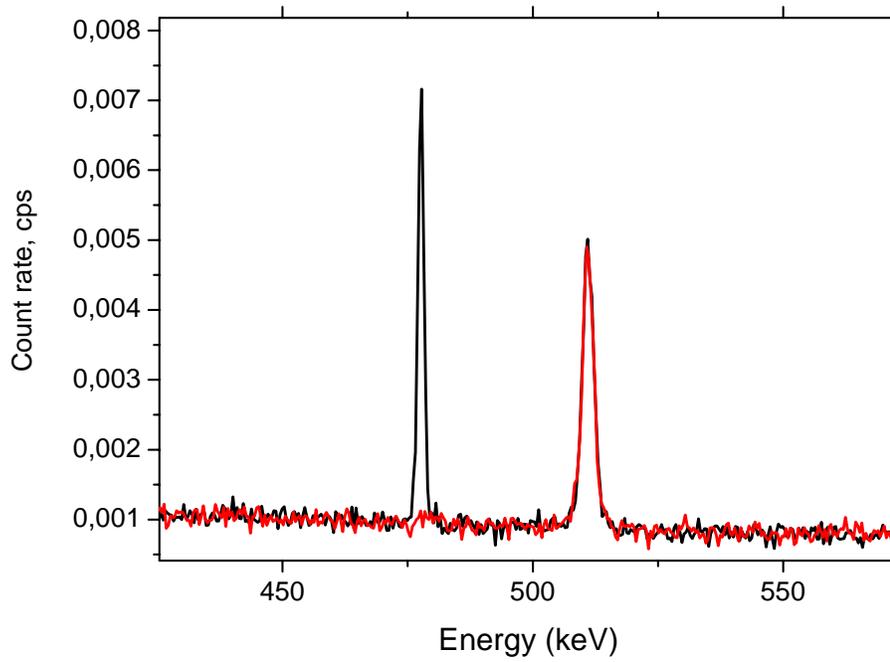


Fig.7.  ${}^7\text{Be}$  gamma line 477.6 keV (left) registered from QMA filter

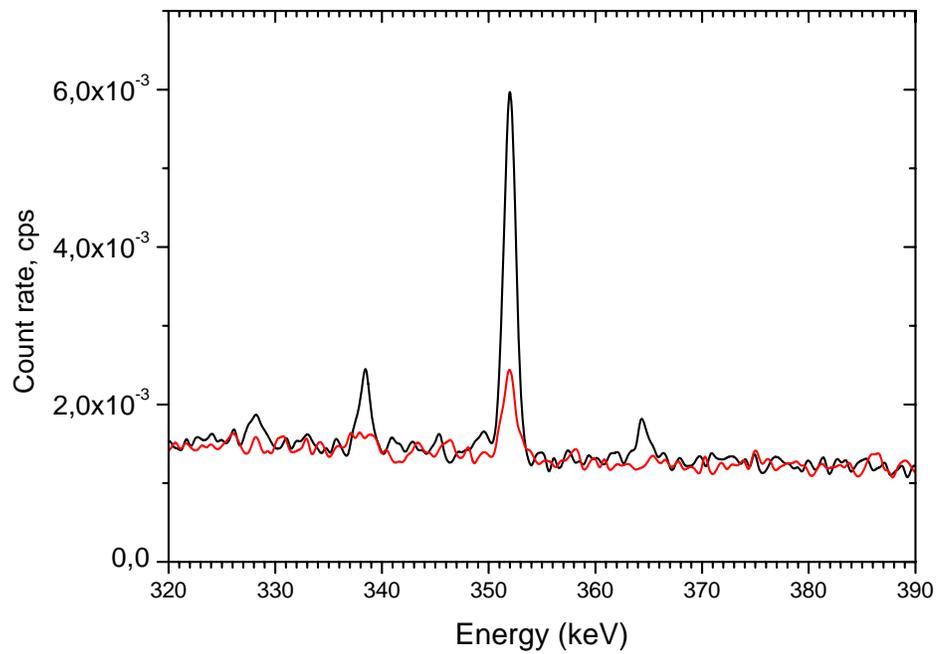


Fig.8. AC filter material spectra compared to the background spectra

To clarify the nuclide identification in the latter case we repeat the measurements with AC

filter material approximately one month after the sample collection. Having in mind the  $^{131}\text{I}$  lifetime that is 8 days, we supposed that corresponding peak would disappear one month after collection.

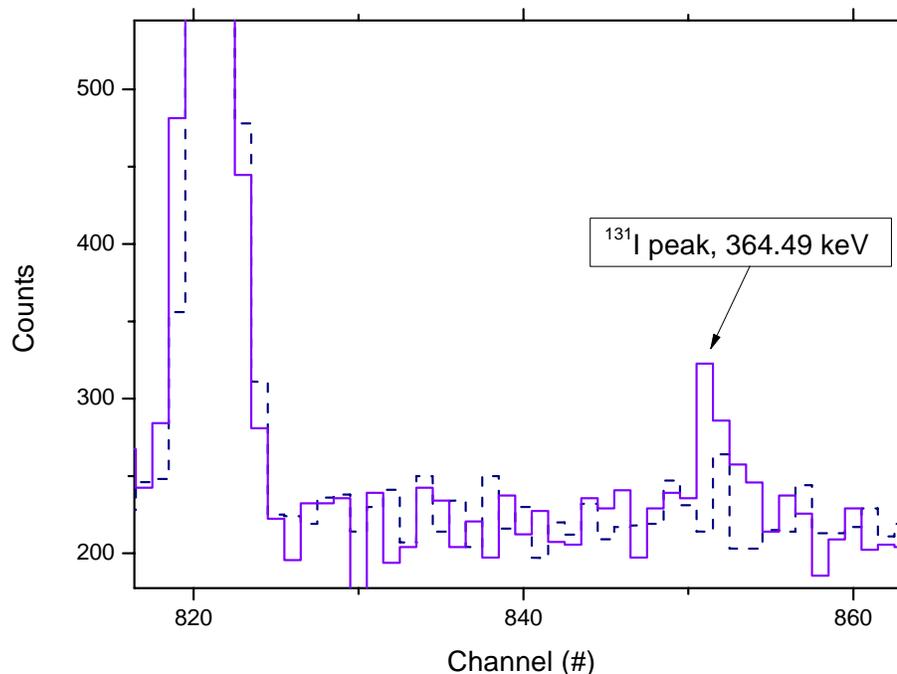


Fig.9.  $^{131}\text{I}$  peak disappear 1 month after sample collection. Solid line – "fresh" sample, dashed line – one month later.

Fig.9 demonstrates comparison of the two gamma spectra from AC filter material collected immediately after filter collection and one month later. Numerical analysis of the data obtained gives an activity estimates for the  $^{131}\text{I}$  accumulated in AC material during 1 day of the air filter system operation ( $1440 \text{ Nm}^3$  of air) equal to  $0.6 \pm 0.1 \text{ Bq}$ .

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<sup>1</sup> <http://pdf.directindustry.com/pdf/ortec/a66-b32-gammavision-32-gamma-spectrum-analysis-software/50423-143328.html>