# AERIAL PLATFORM EQUIPPED FOR NUCLEAR EMERGENCY MEASUREMENTS

E. CISBANI,[1,2] S. FRULLANI,[1,2] F. GARIBALDI,[1,2] M. IODICE,[1,2] A. MOSTARDA,[1]
L. PIERANGELI,[1,2] G.M. URCIUOLI,[1,2] A. AMBROSINI,[3] C. BERTEOTTI,[3] G. STELLATO,[3]
U. DELPRATO[4]

[1]Physics Laboratory, Istituto Superiore di Sanita', Rome
[2]Sezione Sanita', Istituto Nazionale di Fisica Nucleare, Rome
[3]ALENIA-FINMECCANICA, Unita' di Telerilevamento, Rome
[4]ELECOS, Divisione Ricerca e Sviluppo, Rome

## INTRODUCTION

Aerial Radiological Measuring Systems (ARMS) developed in the late 1950s for uranium ore prospecting have also provide an invaluable tool in environmental surveillance of nuclear power plants and nuclear processing facilities as well as in emergency response for large-scale radiological accidents. Historically the international concern of the potentialities of such systems was triggered in 1978 by the search and partial recovery of radioactive debris scattered over an estimated area of about 100,000 km$^2$ as a consequence of the impact in the Northwest Territories of Canada of the nuclear powered Soviet "COSMOS-954" satellite(1). Less than 10 years after, in occasion of the Chernobyl accident, many countries had developed such systems and maps of surface contamination have been collected over several European countries showing a large diffusion of the radioactive fallout originated by the release from Chernobyl nuclear plant (2,3). Also in Italy an ARMS mounted on Agusta-Bell 412 helicopter having as detector large NaI(Tl) counters was used by the group of Physics Laboratory of Istituto Superiore di Sanita' to map the ground surface contamination over the central-southern part of the country(4). From that experience it was deduced that aerial platforms without air sampling and air radioactive contaminants measurement capability can only give quantitative information on ground contamination when the air contamination is negligible and then, in the more critical period when the radioactive plume is passing over the country, it can only be used for qualitative assessments. We have now equipped a fixed wing aerial platform with sampling and measurement capability that can be used to give fully quantitative information on the plume as well as on the ground radioactive contamination in a far field emergency situation.

## PARTENAVIA OBSERVER P68 AERIAL PLATFORM

In early nineties, ALENIA and ELECOS (5) have developed a measuring system ( called SNIFFER ) mounted on Observer P68 aircraft to monitor air quality, with respect to aerosol and gaseous pollutants, at flight height variable between 50 and 1000 meters. Observer P68 is a light two-engined plane with the whole structure in aluminium but the front cap that is made of Plexiglas.

The sampling unit is installed in this cap and the sampling probe goes out from the front part ( see Fig. 1 ). Aerosol is collected on a filter positioned along the sampling line. A meaningful sampling of aerosol is provided through a control system that regulates the air flow according to the aeroplane speed and compensates for temperature and pressure variations as well as for the filter progressive cloggage. In this way an active isokinetic sampling is maintained assuring an entrance flow velocity equal to the aeroplane translation velocity. The entrance flow can be regulated within an error of 1% in the range 35-70 l/minute.

The rotating filter holder has four filter locations, one for each of the possible independent aerosol collections during the same flight mission. Behind the filter that is aligned with the suction line ( see Fig. 2 ), a Geiger counter ( external diameter 1 cm ) and a small ( 1x1x1 cm$^3$ ) BGO counter, allow real-time measurements of gross-beta activity, total gamma activity and low resolution gamma spectra. Beta counter scaler and gamma spectra are stored in predetermined time intervals that can be as short as 1 minute and that can be changed during the flight mission according to the actual contamination levels. Results of measurements are continuously presented on the on-board monitor. The aircraft is equipped with an advanced Global Positioning System that allows the correlation of stored data with the spatial and temporal localisation. In this way the final result of the mission can be presented mapping out the measured values on the mission path flight.

The smallness and intrinsic poor resolution of the BGO counter makes that the gamma spectrum measured, even when only one radioactive contaminant is present, is very broad ( see Fig. 3 left ) allowing then a valid assessment only on the presence of the radioactive contamination but hardly the identification of the radionuclide can be attempted. When a mixture of contaminants, as is always the case for a release from a nuclear plant, is present the identification of gamma emitters is out of any realistic possibility.

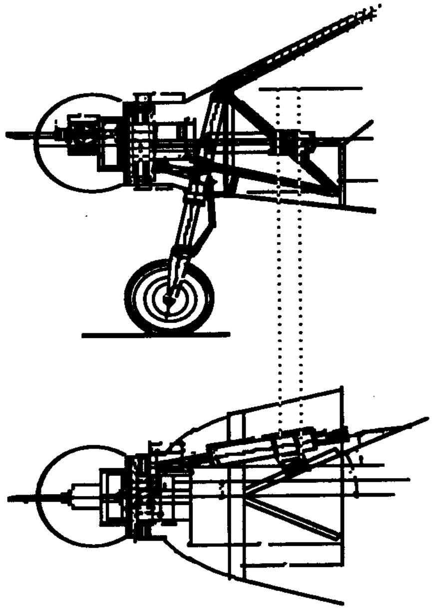


Fig.1 OBSERVER P68 with air sampling unit and HPGe detector

To overcome this failure of the radioactive contaminant measurement, the whole mechanism of the filter holder and connected services has been completely redesigned in a different way in order to allow the insertion of a 20% efficiency, high resolution HPGe detector. A new SNIFFER system with the redesigned mechanical parts was built. In Fig. 2 the scheme of the new system with the insertion of the HPGe detector is shown.

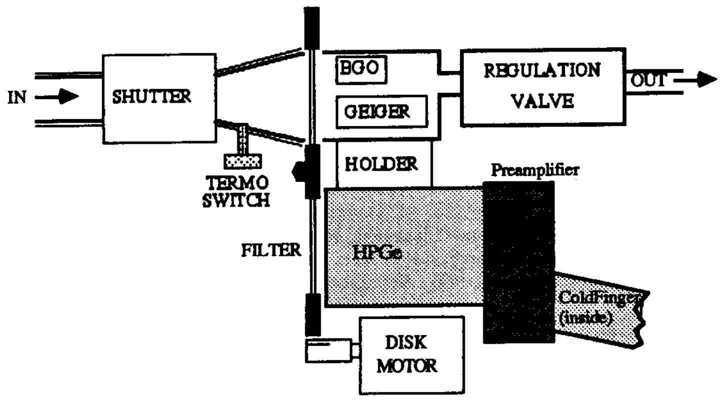
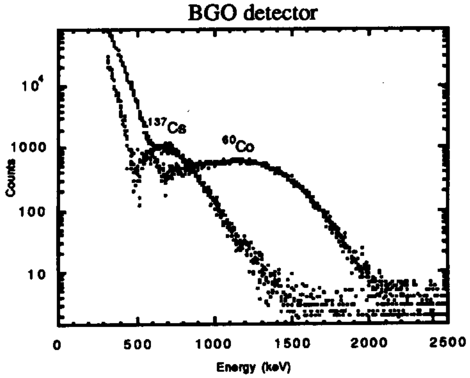



Fig. 2 Schematic diagram of sampling line with radioactive contamination detectors.



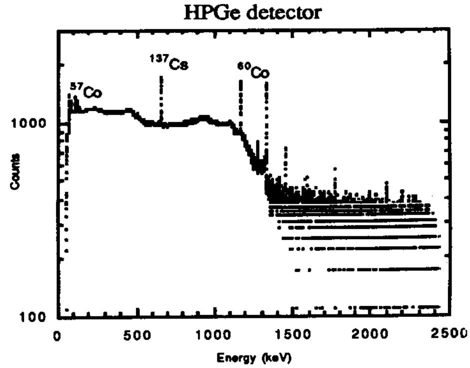




Fig. 3 Left: Separate Gamma Spectra obtained with BGO detector for $^{60}Co$ and $^{137}Cs$ sources
Right: Total Gamma spectrum obtained with HPGe detector for the three sources added together

In this way at the end of one sampling period, after the rotation of the filter holder, it is possible to face the filter, that was placed before the rotation along the suction line, to the high resolution detector that allows the identification of each gamma emitting radioisotope in the aerosol sample previously collected. The HPGe detector was specially designed in collaboration with Canberra Semiconductor N.V. to take into account the particular application and the geometrical constraints imposed by the installation of the whole system in the aircraft. A slim Canberra type ACT-1 dewar is used with 12 hour holding time that is well compatible with a flight time duration of 4-5 hours for a single mission. To reduce microfonicity deterioration of the resolution the preamplifier is mounted as close to the crystal as possible. A 20 cm. long cold finger provides the low temperature to the crystal. The resolution of the detector is 2.0 KeV for the 1.33 MeV line of $^{60}Co$ and 1.28 KeV for the 122.06 line of $^{57}Co$. In Fig. 3 right, the spectrum obtained when three sources ( $^{57}Co$, $^{137}Cs$ and $^{60}Co$ ) are faced to the HPGe is shown. It is possible to see how the improved resolution allows the clear identification of different contaminants. Moreover while with the BGO the minimum detectable energy is little less than the energy of the $^{137}Cs$ source ( 661.66 KeV ), with the new detector this limit can be lowered up to 100 KeV.

On board of the aircraft, large surface NaI(Tl) counters, which have a much better resolution than the small BGO counter spectrum shown in Fig. 3, and also HPGe high efficiency and high resolution counters are placed to collect gamma spectra from the total environment. From the information collected by these counters after the subtraction of the contribution whose source is in the air, that has been inferred from the air sampling measurements, assessments on the ground contamination can be deduced even in the early phase when the plume, coming from a far field release, cross over the interested country.

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