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EDGAR, A NEW PLANT RADIATION MONITORING SYSTEM

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INTRODUCTION

The EDGAR system is a new radiation monitoring system for nuclear power plant, reprocessing plant and nuclear research reactor for radioactive contamination, gamma and neutron field monitoring.
Developed by French Atomic Energy Agency,this system provides not only complete functions of standard RMS ,also allows spectroscopy level detection of alpha and beta particles based on a patented collimator unit.
A complete computerized approach has been taken,allowing full installation control in a single PC based display and communication unit.

STANDARD SYSTEM

When designing an alpha continous air monitoring system,which will be able to detect very low level of Pu 238 and Pu 239 aerosols,the standard method is using alpha spectrometry.

We can monitor all the "interfering" energies coming from radon and his daughters (Bi 212, Bi 214 and Po 218) and apply mathematical algorithms to correct the interference with the Pu 238 and Pu 239 expected peak locations.In order to obtain good statistical data ,the source to detector distance is minimized.This allows high efficiency of counting but degrades greatly the resolution of the detector due to the greatly different distances traveled by the alpha particles.

The accuracy required using this method is affected greatly by the thickness of the "dust" deposit in the filter since part of alpha trajectory is through the deposit plus through the aluminium coating of the detector.

Additionally,when detecting very low levels of Pu aerosols at the level of 1-2 DAC.h (approximately 0.08- 0.16 Bq/m^3),the statistical laws do not apply on the Pu contamination.
This phenomenon creates uncertainty on the real Pu contamination based on Pu and radon contribution counts.

Moreover, a minimum of 30 to 60 minutes counting is needed to create the statistical base from which we can derive the contamination levels.Every time the concentration changes or the radon concentration is affected by air flow changes in the vinicy of the detector head,we need the above time lapse in order to make an intelligent decision on the actual contamination level at the filter sampling area.

The main difficulties are coming from bad energy resolution and high concentration of natural alpha background Ra A (Po-218, 6MeV) and its variation versus time from 0.2 Bq/m^3 to 50 Bq/m^3 provides interference inside the Pu-238 window (E=5.49MeV) as shown in Figure 1.

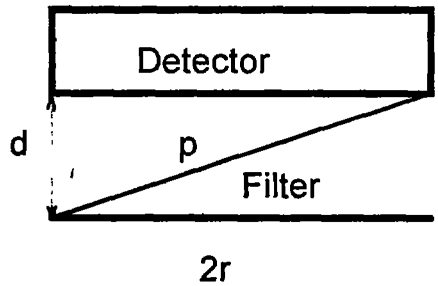
EDGAR SYSTEM.

The EDGAR system uses a complete different approach.By intelligent use of distance and collimator,we are able to reduce the radon and daughters

contribution in the plutonium area of interest by a factor of 200 to 300.
When α particles move in the air, they lose energy.This energy loss is proportional to the distance that has been covered.According to the Geiger's formula,the energy left to the α is:

$$E_d = [\sqrt{E_0^3} - d/0.32]^{2/3}$$

where:
E_0 is the α initial energy in MeV
d is the distance in cm covered by the α
E_d is energy left to the α after the distance d.



d=distance filter-detector
2r=diameter of the filter

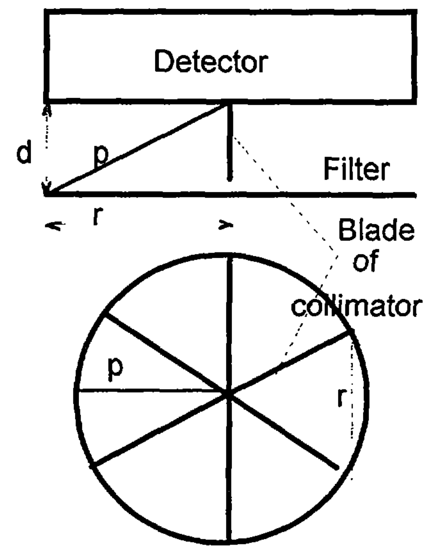
Figure2-Maximum Travel Distance for an α Particle Without Collimator.

The minimum travel distance for an α is:d
The maximum travel distance for an α which still meets the detector is:

$$p=[d^2+(2r)^2]^{1/2}$$

Figure.2 shows the standard design without collimator and obviously the distance d between detector and filter shall be short.Let us suppose that d=1cm and
r = 1.2cm .We can calculate E_d for artificial and natural α radioisotopes
Without collimator,in the worse case,we can get

- Pu 238 at E_d=4.56 MeV if its α goes from the filter to the detector using the shortest distance.
- Ra A at E_d =3.51 MeV if its α goes from the filter to the detector using the longest distance.



r=Radius of the filter
d=Distance filter-detector

Figure 3-Maximum Travel Distance for an α Particle With Collimator.
The minimum travel distance for an α is:d.
The maximum travel distance for an α is:

$$p=[d^2+(r)^2]^{1/2}$$

and should be true for all direction.
That means the collimator must limit the travel of α particles in an equilateral triangle with an edge equal to "r".
The different blades of the collimator must be located at an angle of 60 degrees between consecutive blades.

In this case,the Ra A is in the Pu 238 window and then the discrimination is not good.

With collimator,in the worse case,we can get(Figure.3)

- Pu 238 at E_d =4.56 MeV if its α goes from the filter to the detector using the shortest distance.
- Ra A at E_d =4.59 MeV if its α goes from the filter to the detector using the longest distance.

In thiscase,the Ra A cannot enter in the detection window,and then the discrimination is very good.

The logic behind the method is to prevent the need for algorithms based on a reading somewhere else in the spectrum and an assumed energy degradation which will induce a certain percent of those counts in the plutonium(or other desired isotope) area of interest.The specially designed distance/collimator structure prevents any alpha which has lost more than approximately 1.5 MeV to reach the detector and be counted at the wrong window.Additionally,the small angle of acceptance prevents a major influence of the thickness of the dust collected on the filter.

In the case of the Po 218 (E=6.0 MeV, $T_{1/2}$=3mn) which is the closest contaminant to the Pu 238/239area,its short half life prevents a deeply covered atom to emit an alpha which will lose enough energy to reach the Pu 238 window.
A possibility of using a regular collimator which many holes and short distance presents the problems of uneven dust distribution on the filter and turbulence at its entrance, creating contamination potential and the possibility of collimator clogging.

ADVANTAGE OF THE NEW SYSTEM(*Figure 5*)

■ Low detection limit : better than 1 DAC.h (Radon compensation, if required gamma compensation is available)

■ Radial sampling structure does not create turbulence of sampled air at the collection site, assures that the detector is never contaminated and no dust is deposited on the detector..

■ Compact size of detector ,movable ,locatable close to operator workplace (sampling tube not required)

■ Version with sampling line is available for stack or ventilation duct monitor.

■ Gamma spectrometry is available for radioisotope identification and evaluation.

■ Low flow requirements: 90 CF/h (35 L/mn),provides very quiet operation.

■ Automatic filter advance (on time,on demand,local)

■ Standard hardware local processing unit (LPU) compatible with different type of sensor.

■ Display and loaddown the values in new international units system recommended by ICRP.

■ 30 days historic data of DACh and DAC per channel.

■ Possibility of controlling full installation, up to 250 measurement channels with PC or computer .

■ Low price system

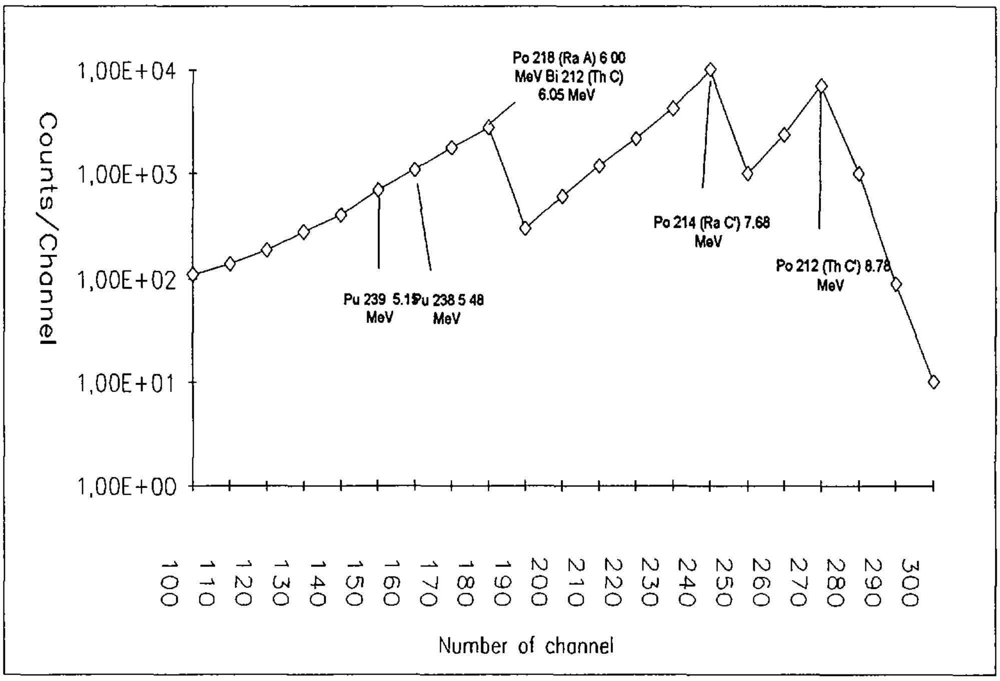


Figure 1 – Natural Background Alpha Spectrum of APM 100 Monitor Continious Data Acquisition during 17h 14mn Air Pumping

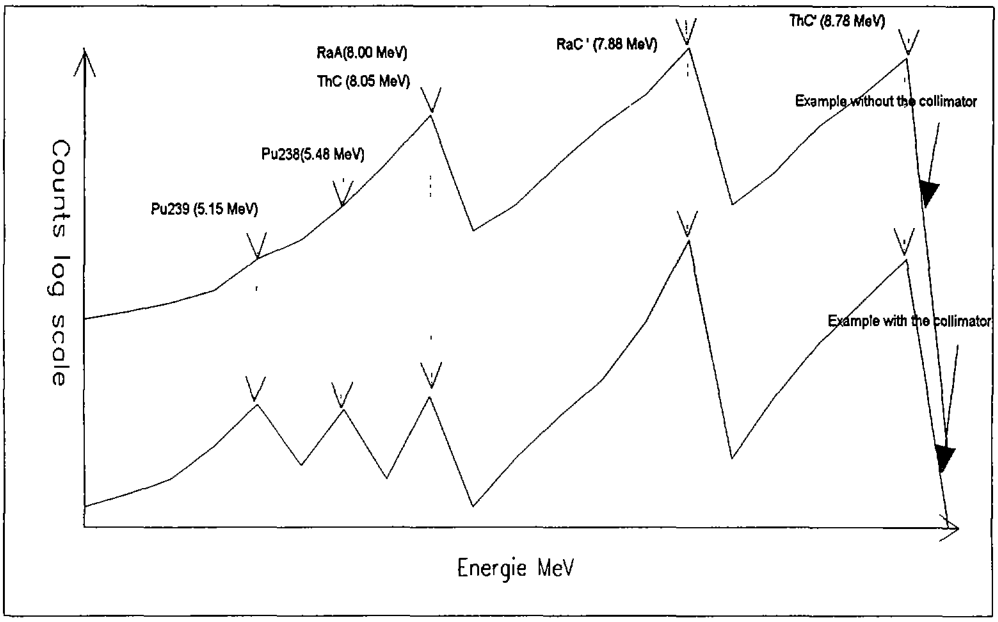


Figure 4 – Examples of Spectrum with and without collimator

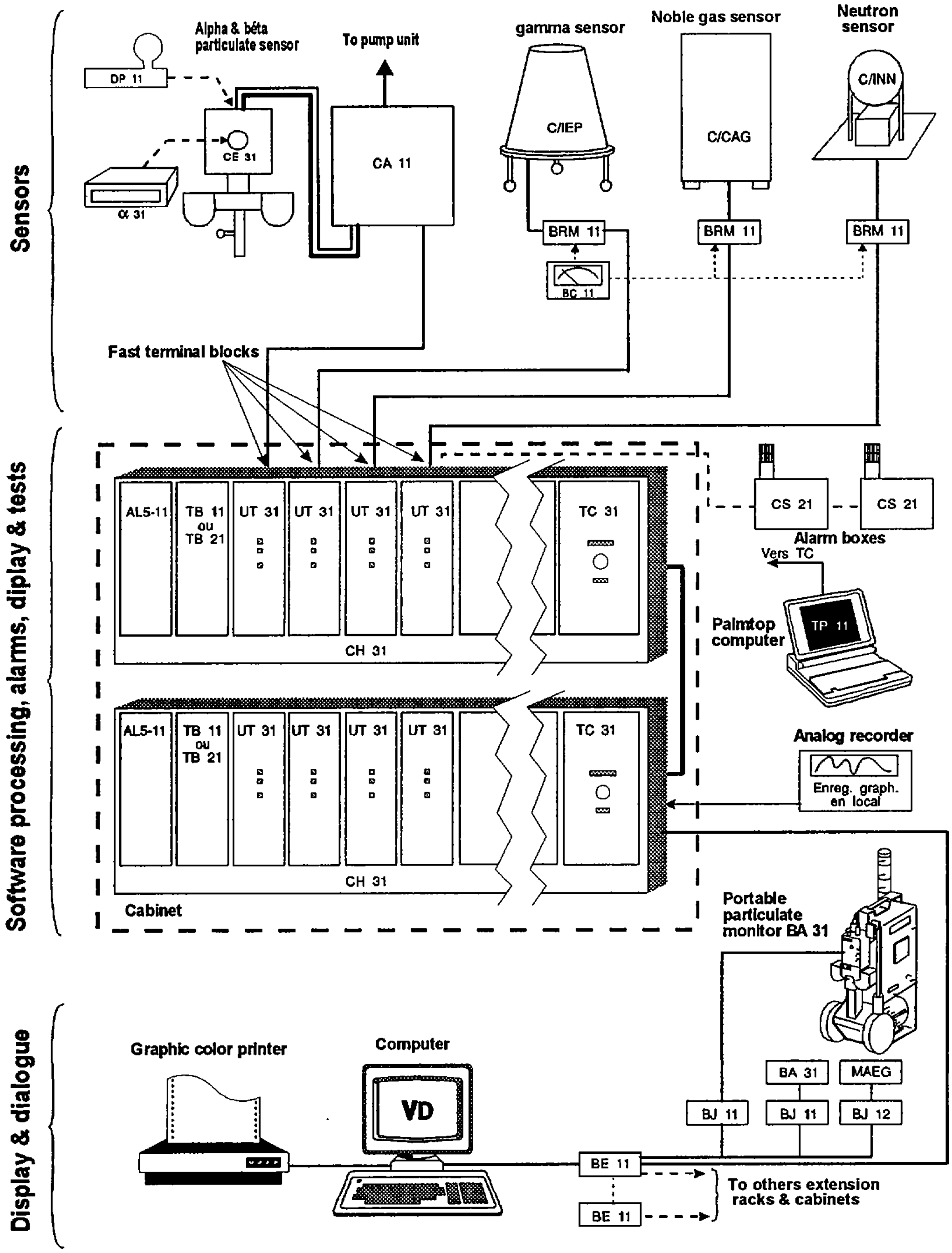


Figure 5 - Principle Diagram of EDGAR Radiation Monitoring System