# Suppression of the radon background by a prototype PICASSO emulsion container

J. Bočan, V. Bočarov, P. Čermák, J. Koníček, S. Pospíšil, I. Štekl*

*Institute of Experimental and Applied Physics, Czech Technical University in Prague,*
*Horská 3a/22, 12800 Prague, Czech Republic*

C. Leroy

*University of Montreal, Montreal, Canada H3CJ7*

K. Jílek

*National Radiation Protection Institute,*
*Šrobárova 48, 110 00 Prague, Czech Republic*

July 29, 2004

A new PICASSO droplet detector is under development for its installation at SNO laboratory. The PICASSO detector will be devoted to the detection of cold dark matter. The concept of the PICASSO experiment is based on the use of large mass superheated droplet modular detectors (e.g. [1]) for the detection of nuclear recoils induced by neutralino nucleus interaction. Background suppression represents the crucial point for such a detection technique. The sources of background signal for the PICASSO detector are $\gamma$-rays, mips's, neutrons and $\alpha$-particles due to U/Th contamination of the detector and its environment. $\gamma$-rays and mips's contribute to the signal at temperatures much higher than the normal temperature of operation. Shielding against neutrons can be achieved by their moderation with paraffine or water bringing their energies below detection threshold. $\alpha$-background produced by $\alpha$-emitters in the salt used to equalize the densities of gel and droplets can be reduced by an iterative filtration process. Present in the detector environment, radon is another source of noise. Radon can diffuse into the detector and induce an $\alpha$-background. Radon $^{222}$Rn (from $^{238}$U-decay chain) is a radioactive gas originated by decay of $^{226}$Ra. It decays further with $T_{1/2}$ = 3.85 days and $E_\alpha$ = 5.49 MeV to isotopes of $^{218}$Po ($T_{1/2}$ = 3.05 min., $E_\alpha$ = 6.00 MeV), $^{214}$Pb ($T_{1/2}$ = 26.8 min., $\beta$ emitter), $^{214}$Bi ($T_{1/2}$ = 19.7 min., $\beta$ emitter) and $^{214}$Po ($T_{1/2}$ = 0.164 ms, $E_\alpha$ = 7.69 MeV).

The purpose of our measurement was to estimate the tightness and penetrability of a prototype PICASSO emulsion box against radon. The PICASSO box has been placed into a bigger plastic box. A Si detector has been installed in each box. One Si detector monitors the radon concentration in outer atmosphere (with respect to the box under investigation), while the second Si detector monitors radon inside the box under investigation. The saturated ratio of both values determines the penetrability. The source of radon (pitchblende) has been inserted into the outer plastic container to obtain a high level radon environment. Radon monitoring was based on an electrostatic collection of its progeny $^{218}$Po and $^{214}$Po on the Si detector entrance

---

*for PICASSO collaboration

window with spectroscopic counting of $\alpha$ particles by the Si detector (e.g. [2]). A spectrometer TAIP was used for $\alpha$ particles energy measurement. The spectrometer was developed at CTU Prague in 1993. The spectrometer contains all the spectrometric modules needed for energy measurement as well as the source of voltage for Si detector. It also includes digital memory to save spectra during measurement. Memory of the spectrometer allows the save from 224 up to 1792 spectra depending on the spectrum range. The spectrometer allows one to define automatic measuring sequence, e.g. time of measurement, number of measured spectra, spectrum range etc. It is possible to select a number of channels in spectrum in the range from 128 up to 1024 channels. Our measurements were accumulated in 256 channels spectra. It is possible to connect the spectrometer with a PC computer. The maximal input pulse amplitude is limited to 7 V, the highest counting rate is 50000.

During the years 2003 and 2004 our group has performed two long-time experiments (duration 2 months and 2.5 months, respectively) with a PICASSO emulsion container. The first measurement was done using one TAIP spectrometer which was switched between two Si detectors, one located inside the PICASSO box and the second one in the outer plastic box. A detailed description of the experimental procedure and results obtained from the measurement can be found in [3]. Our group has performed during the last months the second (improved) measurement of the radon tightness of the PICASSO box. The detector parts were the same, but two TAIP spectrometers were used. This second long-time test was, then, a measurement of parallel type, representing a clear advantage over the first measurement [3]. We used the same source of radon as in the first experiment (pitchblende) to obtain a high level radon environment.

The total time of measurement of the second long-time test was $\approx$ 1800 hours. We investigated, in the measured spectra, two $\alpha$ peaks from $^{218}$Po and $^{214}$Po decay with energies 6.00 MeV and 7.69 MeV, respectively. In figs. 1 and 2 are presented peak areas of $^{214}$Po and $^{218}$Po measured in the outer and inner boxes, as well as the time dependence of the suppression factor of the PICASSO container. The time of one measurement was one hour, but in figs. 1 and 2 peak areas were summed for 16 hours (to obtain higher statistics in the inner box). The results show that the PICASSO box is not absolutely non-penetrable against radon, as already observed after the first measurement [3]. The data presented in figs.1 and 2 allow two conclusions: i) the suppression factor is decreasing with time, ii) the average suppression factor of the PICASSO box after 2.5 months of measurement is $9\times10^4$.

During both long-time measurements all spectra were analyzed in term of peak area (number of pulses). The aim of the next step in our research and development was to transform a number of pulses in peaks into a source activity. Therefore, we performed calibration measurements with our experimental setup at the National Radiation Protection Institute using their knowledge of how to precisely measure radon source activity. Both our boxes with Si detectors (outer box was opened) were inserted into a stainless steel container. At the beginning of the measurement relatively high activity (1 MBq/m$^3$) of radon was injected into the stainless steel container. Both TAIP spectrometers measured 26 hours spectra in the inner and outer boxes. The spectra were saved every hour. The time dependence of the $^{218}$Po and $^{214}$Po peak areas during the activity calibration measurement are given in figs.3 and 4, respectively. The absolute radon activity in the stainless steel box was determined at the beginning and at the end of measurement. A calibration curve for peak areas (see fig. 5) was obtained using the corresponding peak areas of $^{218}$Po and $^{214}$Po and the absolute radon activities.

Our group is, in the framework of the PICASSO collaboration, responsible for issue of radon which is a problem of great importance in such low background underground experiments. This responsibility includes the measurement of radon activity in the underground site, as well as the suppression of background inside the PICASSO detector due to radon. In following months, the effort of our group will concentrate on the improvement of radon tightness of the PICASSO container to be possibly achieved by addition of a thin cover (not to increase the amount of possible sources of radioactivity close to the PICASSO detector) with high attenuation of radon. A new portable spectrometer for radon measurement is under development in our group. We expect to finish it in several months and install it in the underground laboratory for continuous measurement of radon activity.

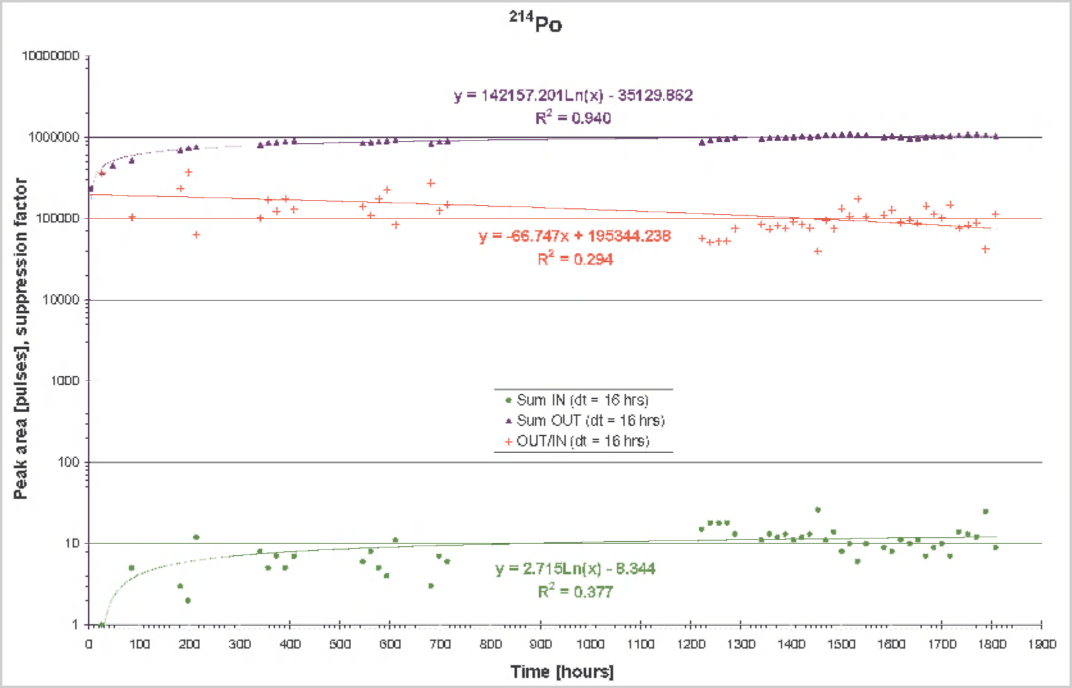

Figure 1: Time dependence of the suppression factor (middle curve) of the PICASSO box calculated from the $^{214}$Po data. Upper and lower curves give the time dependence of $^{214}$Po peak area measured in the outer plastic box and in the PICASSO box, respectively. Peak areas were summed for 16 hours. Suppression factors were calculated as ratio of corresponding peak areas in the outer plastic box and in the PICASSO box.

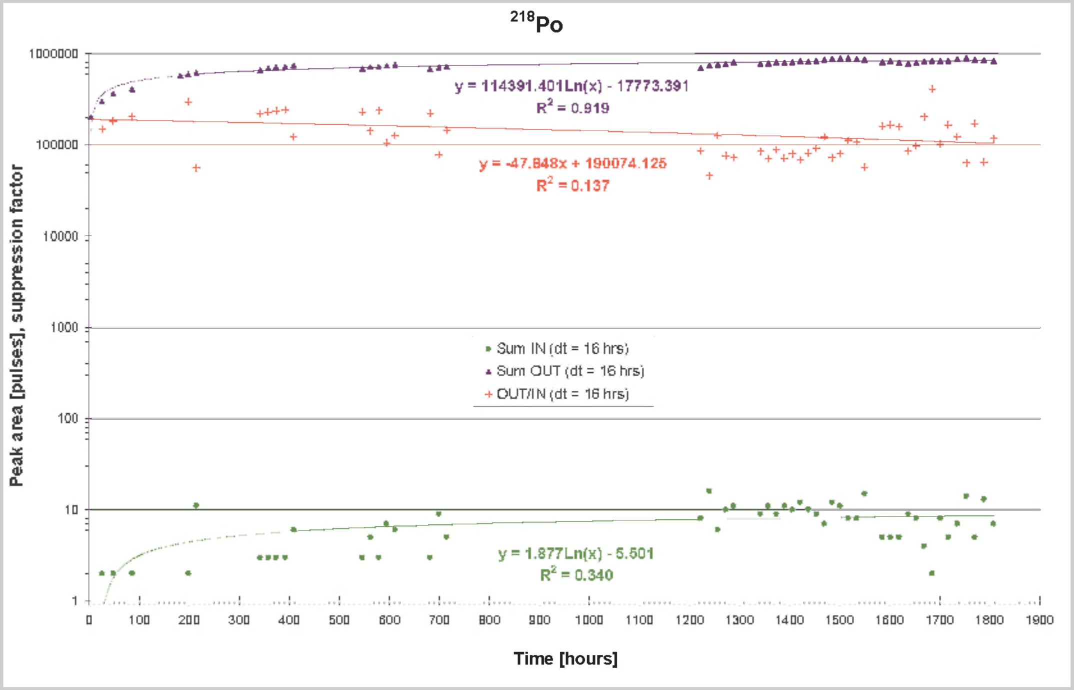

Figure 2: Time dependence of the suppression factor (middle curve) of the PICASSO box calculated from the $^{218}$Po data. Upper and lower curves give the time dependence of $^{218}$Po peak area measured in the outer plastic box and in the PICASSO box, respectively. Peak areas were summed for 16 hours. Suppression factors were calculated as ratio of corresponding peak areas in the outer plastic box and in the PICASSO box.

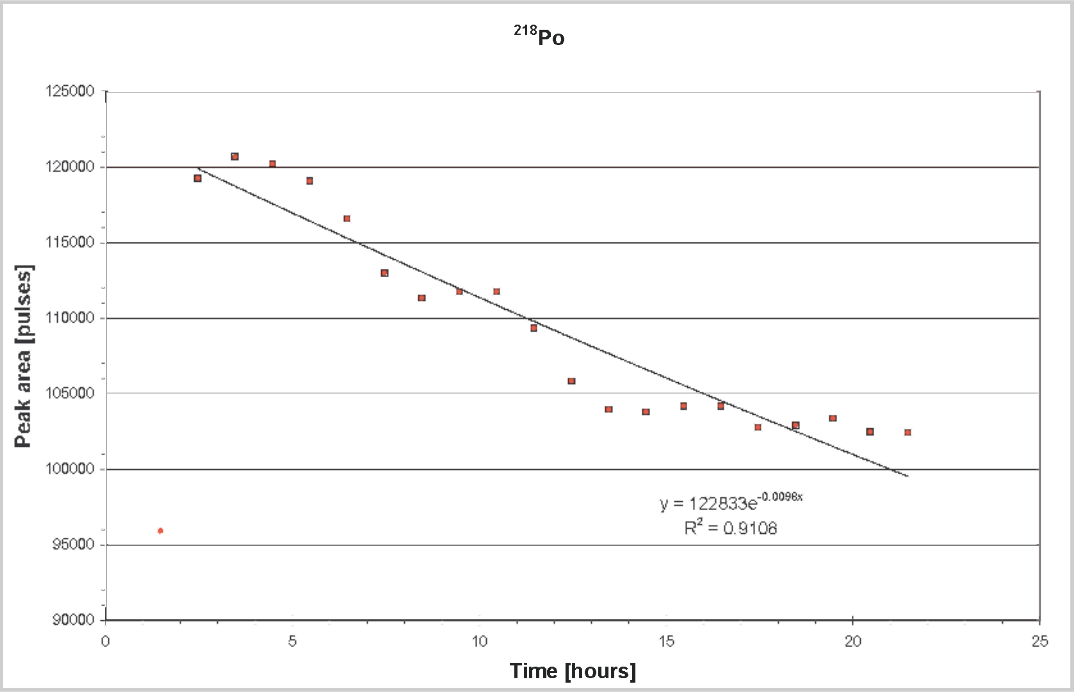

Figure 3: Time dependence of the $^{218}$Po peak area during the activity calibration measurement.

# References

[1] L.A.Hamel et al., *A superheated droplet detector for dark matter search*, Nucl. Instr. Meth. A 388 (1997) 91-99.

[2] Z.Janout et al., *Determination of radon in air using alpha particle detector*, Collect. Czech. Chem. Commun. 62 (1997).

[3] I.Štekl, S.Pospíšil, P.Čermák, J.Bočan, J.Koníček, V.Bočarov, C.Leroy, Measurement of radon penetrability of the PICASSO emulsion container. Picasso note, PSTR_03_009, 2003.

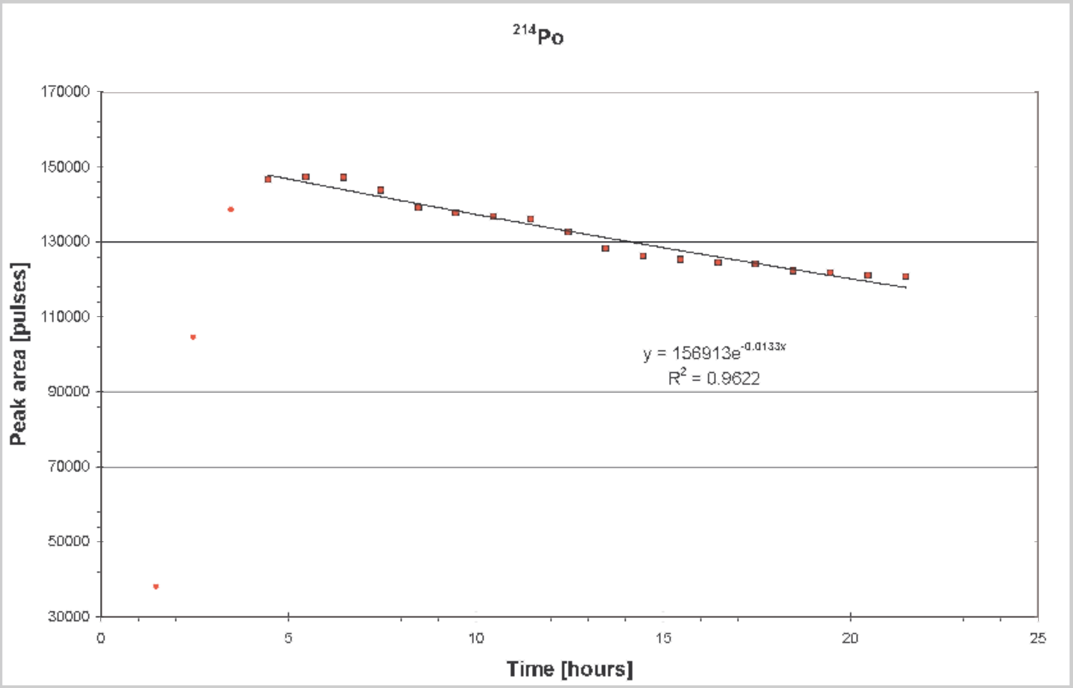

Figure 4: Time dependence of the $^{214}$Po peak area during the activity calibration measurement.

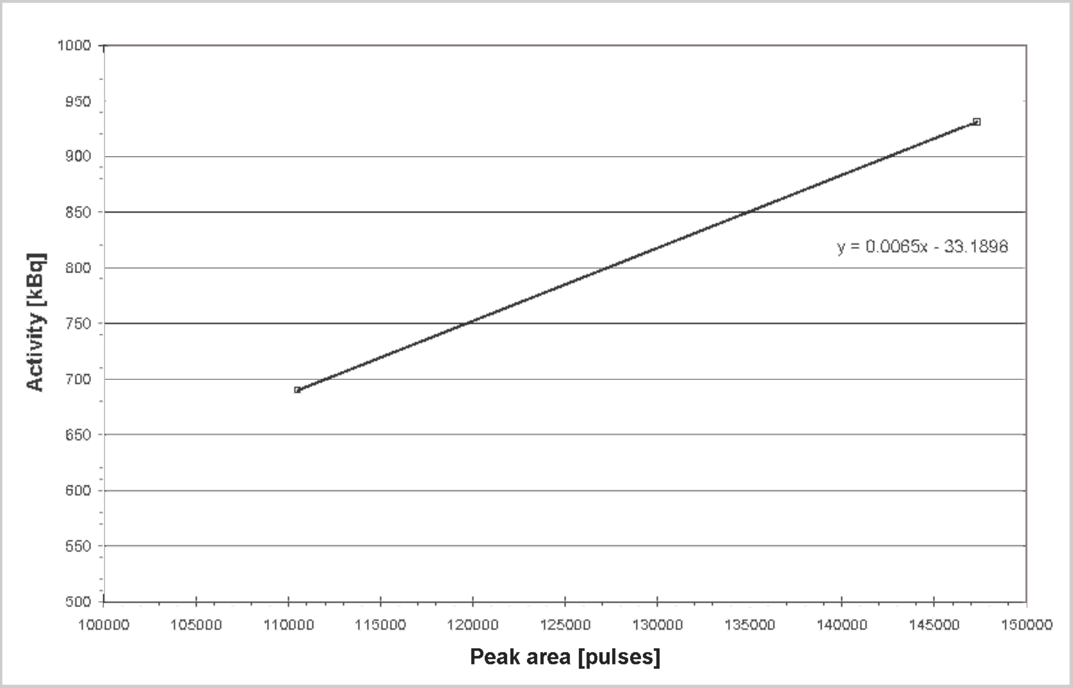

Figure 5: Calibration of the peak area to the radon source activity (using data from $^{214}$Po peak).