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Radon Monitor RADIM 3A

Use:

The Radim3A instrument is used for monitoring indoor radon concentration, temperature, humidity and pressure.

Features:

- **high sensitivity:** (0.8 imp/h)/Bq/m^3, accuracy of radon measurement: (30±6), (300±19),(3000±60).. Bq/m^3
- **continuous battery operation:** 40 days
- **humidity, temperature and pressure measurement,**
- an optimal form of the chamber and high electric field **reduces** the **influence of humidity**, the results are corrected for humidity,
- **fast response** to a step change of radon concentration,
- **simple operation** by means of 3 buttons or by PC computer (remote control)
- **large memory:** 16096 measurements can be stored in the memory
- **sampling time**: adjusted from 10 minutes to 24 hours
- **Simple data reading:** results are presented as counts or Bq/m^3. The mean, maximum, minimum is calculated in an adjustable time interval (ROI). **PC program with graphics data presentation** works under Windows. Simple data export to Excel.

Instruction Manual

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1.0 - <u>Use of the Instrument</u>

The Radim3A instrument is   developed for monitoring indoor radon concentration, temperature, humidity and pressure.

2.0 - <u>Design of the Instrument</u>
The RadimA monitor is supplied as a complete unit consisting of the following components:
-    the RadimA instrument with an instruction manual,
-    the program for storing and processing data in PC,
-    the cable, the line adapter and the transport box.

3.0 - <u>Technical Parameters</u>

Measured quantity:	air radon concentration
Functioning principle:	the radon diffuses into the chamber, covered by felt. The felt absorbs the air-borne radon decay products. The radon activity is determined by measuring the α-activity of ^{218}Po (RaA), collected by the electric field on the surface of the semiconductor detector.
Instrument response:	$(0.8$ counts/h$)/($Bq/m$^3)$
Minimum concentration:	activity determined with a statistical error equal to $\pm$ 20%: 30 Bq/m3 for 1- hour measurement
Maximum concentration:	150 kBq/m^3 for 1-hour measurement
Sampling time:	adjustable from 10 minutes to 24 hours
Effect of humidity:	the change in the relative humidity from 50% to 90% decreases the sensitivity for –6.5%. The results are automatically corrected for the effect of humidity
Electronics:	low power, protection of data
Power:	battery powered- 6 NiMH batteries with capacity of 4.5 Ah
Current:	4mA during measurement, 57 μA during stand up
Operation time:	40 days from the battery, from main: limited by thememory capacity
Memory:	a maximum of 16096 measurements i.e. results of 670- days monitoring can be stored in memory when 1- hour sampling time is adjusted.
Thermometer:	precision of $\pm$0.5 C
Manometer:	range 750 až 1150 hPa, reading differentiation 0.1haP, precision $\pm$3hPa, temperature coefficient $\leq$ 0.1hPa/^{o}C
Hygrometer:	range 10 až 95%, precision $\pm$3%, the computer determines the absolute humidity (g/m^3)
Display:	LCD, 2x 16-characters,
Communication:	RS232 standard port
Control:	3 buttons: $\leftarrow$, Go, $\rightarrow$, remote control by PC
Dimensions and Weight:	230 x 170 x 90 mm, cca 2.5 kg
Climatic conditions:	temperature 5 to 40 C^o, relative humidity 10-95%
Calibration:	carried out by manufacturer and attested by The State Metrological Institute of the Czech Republic

4.0 - <u>Description of the Monitor</u>

The Radim3A was developed for monitoring the indoor radon concentration with very high sensitivity. The Radim3A is the last model of Radim- type monitors. The development of the monitors started in 1996 and now the monitor exhibits unique properties – more information can be found in the paper: Plch, Burian, Jílek, Vošahlík: "Unexpected properties of Radim- type monitors". Paper was presented in the conference " Protection against radon at home and at work", Prague , 28June – 3July, 2004.

Concept of the detection part:

The radon concentration is determined by measuring the α-activity of the radon decay product ^{218}Po (RaA), which is collected by the electric field on the surface of the semiconductor detector from the chamber of the detection system. Half of the spherical chamber is formed by a grid covered with the felt. The felt prevents the entrance of air-borne radon decay products (hereafter dpRn) and protects the detector against dust and light. Because most of the dpRn are positively charged, the vessel is connected to the positive pole of a high-voltage supply and the surface of the semiconductor electrode is connected to the negative pole. The positively charged dpRn are neutralized by water vapor and other admixtures. It is preferable to employ the highest possible voltage to decrease the effect of humidity. The instrument uses a stabilized voltage power supply of 2500 V which is controlled by the internal computer. High sensitivity of the instrument and a decrease in the dependence on the humidity can be achieved only when the detection vessel does not contain any areas with low electric field intensity and all the electric lines of force end on the surface of the semiconductor detector. The chamber was designed by computer modeling to optimize the chamber shape and a study was made of the electric field distribution in the vicinity of the detector. The mean distance between the detector and the chamber is about 6 cm and the chamber volume is 0.83 l. Experiments confirmed the theoretical assumptions that the instrument sensitivity is enormous even for such a small volume and that the effect of humidity is very low- see Chapter 5.0.

Description of the electronic design of the monitor:

A block diagram is given in the following figure:
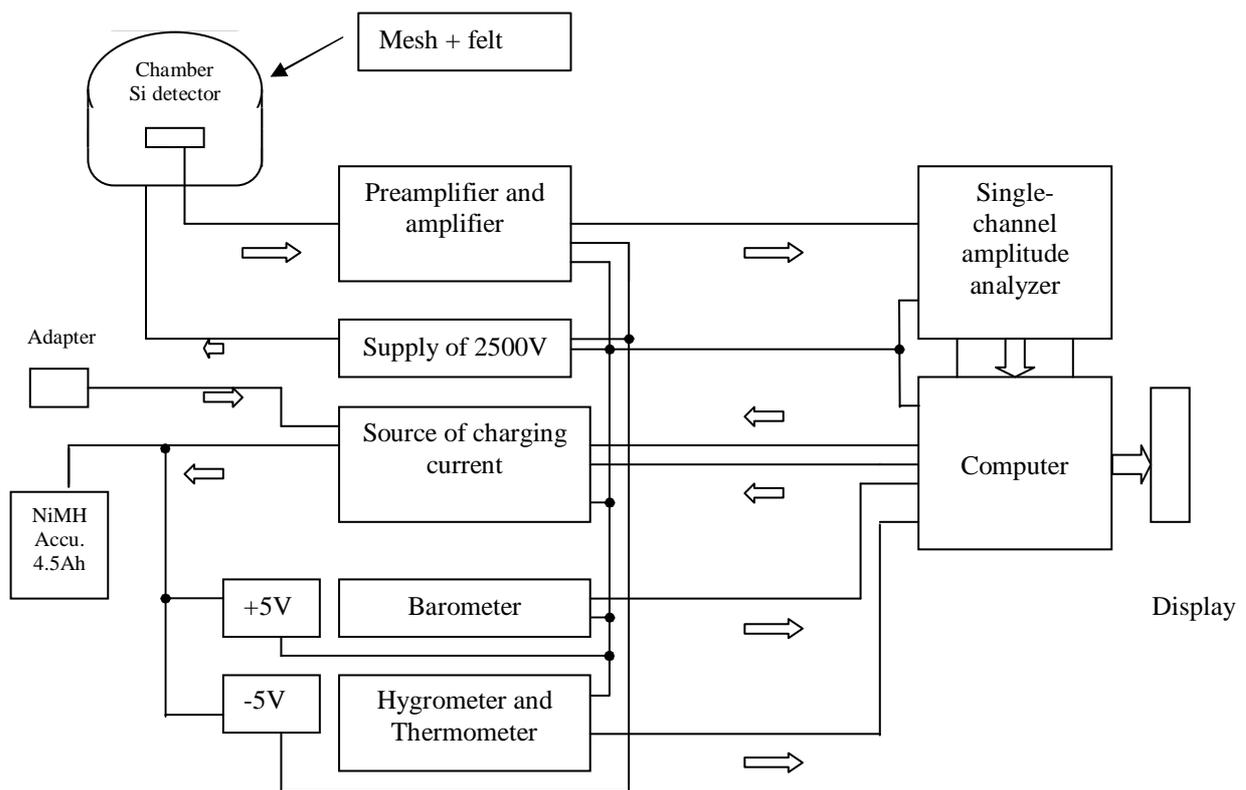
The signal from the semiconductor detector is treated by a charge-sensitive low-noise preamplifier and is amplified in a two-stage shaping amplifier. The output impulse is fed from the amplifier to a single-channel amplitude impulse analyzer, discriminating noise and selecting from the amplitude spectra those impulses that are formed by decay of RaA. The width and position of the window around the "RaA-peaks" was optimized to register practically all the α-particles formed in the decay of RaA (the particle energy is 6 MeV, the window around the RaA peak is adjusted from 3.2 MeV to 6.3 MeV) and so that the contribution of the α-particles from the "RaC'" peak (energy of 7.6 MeV) is minimal. This contribution is formed by spreading the RaC' peak out to the low-energy area, its contribution equals about 3% when RaA is in radioactive equilibrium with RaC'.

The design for the digital part and analogue part of the monitor was greatly affected by the requirement of maximum decrease of current consumption: the microprocessor works in a special regime, the supply of analogue part and HV source is off, when the monitor does not measure, LCD is usually blind and can be activated by pushing two buttons etc..

The NiMH - battery with capacity of 4.5Ah is used in the instrument. The battery can be charged by the internal charger and the external line- adapter. When the adapter is connected to the monitor the battery is charged continuously to compensate mean current consumption.

The analogue part of the electronics containing the preamplifier, amplifier, single-channel analyzer, 1.7kV supply, +5 and –5V source etc. and the accumulator charger is located on a board in the lower part of the instrument. The chamber of the detector is screwed to a tube that acts as a shielded preamplifier. A dish protecting the chamber is fixed to the upper part of the instrument box. Radon diffuses into the chamber through a space between the box and dish. A microcomputer with display and control elements is placed on a board which is under the front panel.

5.0-Tests of physical parameters of the instrument.

5.1 - Experiments related to the dependence of the sensitivity on the high voltage.

From the standpoint of the design for a low-power instrument, it was necessary to determine the minimal high voltage (hereinafter HV) applied to the chamber body, which is sufficient for collecting all free RaA species at a high relative humidity. Consequently, the following experiment was carried out: Two Radim3 instruments were placed in an aquarium together with a dish of water and a radon source- the realtive humidity was near 90%. The high voltage was stable for one Radim3, equal to 2000 V; the chamber of the other Radinm3 was connected to an external HV source, which was changed. As the radon concentration changed, the results of measurements using the two instruments were compared. The results are given in Fig. 2. It follows from the results that HV (working voltage of Radim3) equal to 1 700V is sufficient with a large reserve.

Fig.2 -Dependence of sensitivity on HV
(Deffierence between Radim3 with fixed HV= 2000V and   Radim3 with variable HV)
Relative humidity=89-93%
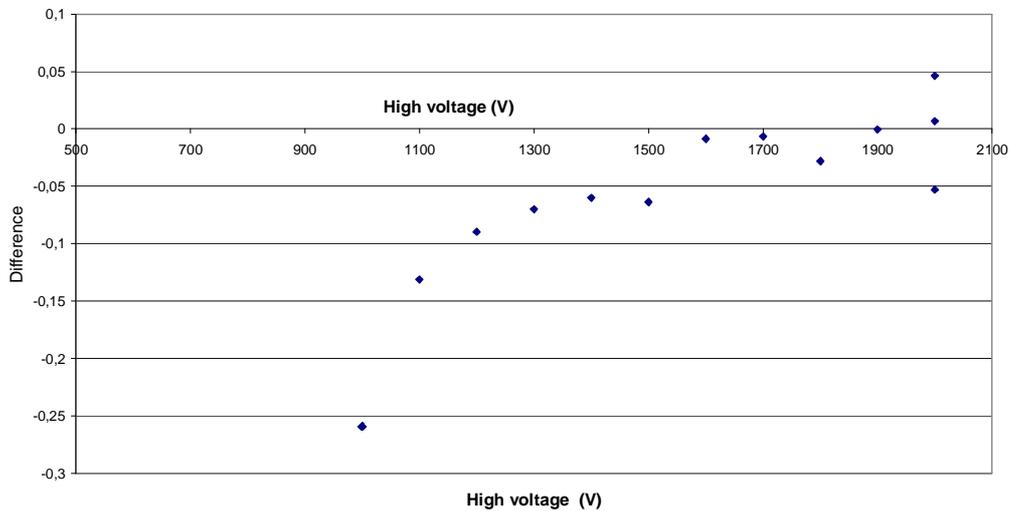
5.2 - Relationship between the number of impulses and the radon concentration

For correct interpretation of the results measured, it is useful to clarify the relationship between the measured counting rate of impulses **n** and the radon concentration **a**. This relationship will be derived for the hypothetical case where the activity of radon and its decay products in the detection system is equal to zero. At time t equal to 0, the high voltage is turned on and the instrument is brought into a space with radon concentration **a**. Radon diffuses into the detection chamber and decays to yield its decay products. As the monitor detects only α-particles and selects those impulses formed by decay of RaA, whewre the activity of RaA is of interest (the   half-time   of   decay   is equal to 3 minutes, RaA is practically in equilibrium with radon after about 6 half-times, i.e after about 20 minutes). Thus, the increase in the overall activity deposited on the   surface of the detector is dependent on the rate of diffusion of radon into the chamber and the rate of formation of RaA through decay of radon. Neglecting the diffusion (see below) the increase in the counting rate of impulses can N be described by the equation:

$$n = n_S \left(1 - \exp(-\lambda t)\right) dt \qquad (1)$$

where λ is equal to 0.23 min^{-1} (λ is equal to ln2/T$_{1/2}$, where T$_{1/2}$ is the half-time of RaA) and n$_S$ is equal to the saturated counting rate of impulses. Twenty minutes after the sudden increase in activity, term (1-exp(-λt)) is equal to 0.99. If the monitor is placed in a space with activity **a** at time 0 and the number of impulses N is measured over time T, then the number of impulses can be calculated as

$$N = n_S \int_0^T (1 - \exp(-\lambda t)) dt \qquad (2)$$

and, following integration,

$$N = n_S \left(T + \frac{1}{\lambda} (\exp(-\lambda T - 1)) \right) \qquad (3)$$

After attaining equilibrium, the exponential term in Eq.(3) can be neglected and the total number of impulses is then equal to

$$N = n_S \left(T - \frac{1}{\lambda} \right) \qquad (4)$$

where $1/\lambda$ is equal to 4.34 minutes - thus this initial "growth" period must be subtracted from the total measuring time. It should be added that this description is only approximate. Nonetheless, it is completely satisfactory for long- term measurements.

The relationship between the equilibrium counting - rate of impulses n$_s$ and the radon concentration a can be expressed as follows:

$$n_S = aV\varepsilon_d \eta_S \varepsilon_s \qquad (5)$$

where **a** is the radon concentration (Bq/m^3),
  V is the volume of the chamber (m^3),
  ε_d is the detection efficiency (counts/s/Bq),
  η is the probability of formation of positively charged dpRn,
  ε_S is the efficiency of the collection of dpRn on the detector

It follows from the principle that the detection efficiency is practically equal to 50% and it is stated in the literature that about 87% of dpRn is positively charged. The volume V is equal to 0.83 l for our instrument. The efficiency of collection of dpRn is an unknown quantity. From the results of the measured response, we can estimate the efficiency of collection to be 0.7.

Experiments related to radon transport into the detection chamber

When relatively thick felt was used (thickness approx. 2 mm) to cover the chamber, the diffusion of the radon through the cover can be quite prolonged. Consequently, the following experiment was carried out: reference Radim3 No. 93 (felt cover, sampling time 30 minutes) and Radim3 No. 94 (sampling time 5 minutes and felt cover) were placed in the barrel. The

measurement was started synchronously in both instruments at low radon concentrations. Radon was injected into the barrel exactly 30 minutes after starting the measurement and the growth curve was measured. The accuracy of the measurement was checked on the basis of the ratio of the equilibrium radon concentration values measured using the Radim3 No.93 and No.94 instruments. For Radim3 No.94 (five-minute sampling), the ratio of the number of impulses to the average value of the saturated number of impulses was calculated. The results are depicted in Fig. 3 together with the theoretical values. The theoretical values were calculated as follows: Equation (2) is integrated from time T1 to time T2 (T1 and T2 are the times from filling the barrel - i.e. sudden concentration changes), yielding the relationship for the measured number of impulses:

$$N = n_s\{ (T2-T1) + 1/\lambda (\exp (-\lambda T2) – \exp(-\lambda T1)) \}$$

The saturated number of impulses is equal to $n_s (T2- T1)$ and then the ratio can be calculated from this equation.

Result: as follows from Fig. 3, the experimental curve is really "delayed" and the diffusion delay equals approx. 2 minutes.

Fig.3- The growth curve and the estimation of diffusin time
Radim3 No.93 with felt cover
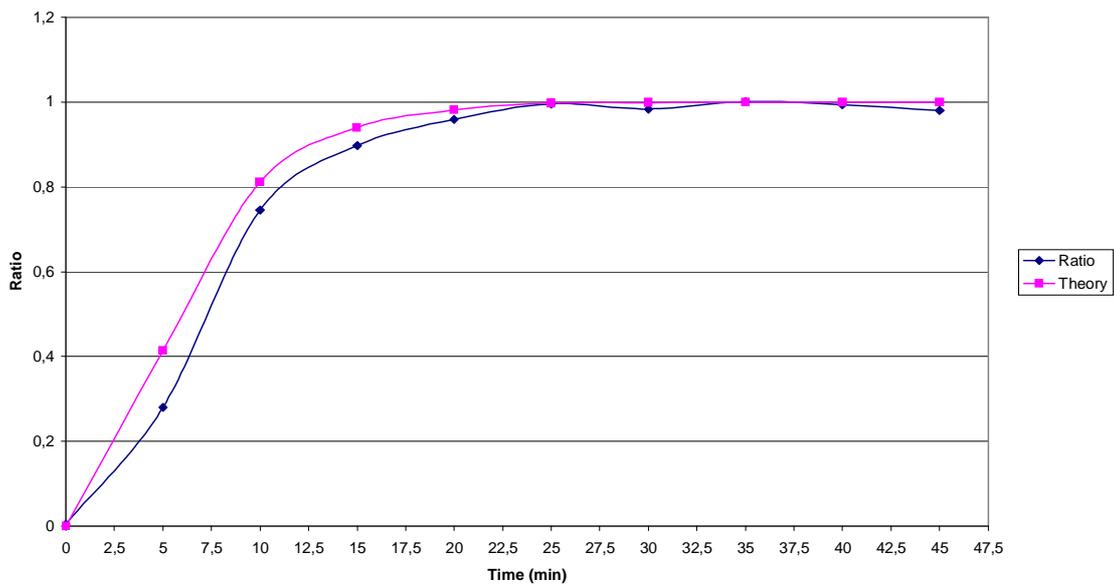
5.3 - The humidity dependence of the response of Radim2 and Radim3 monitor

Compared to competitive instruments, the Radim2 and Radim3 instruments exhibit very low humidity dependence, which is linear in a broad range of relative humidities (hereinafter RH). The humidity dependence was determined repeatedly by the manufacturer, several times at The Authorised Metrological Center of Czech Republic (AMC), at National Radiation Protection Institute - Prague (hereinafter NRPI) and in the laboratory of the University in Gent. It was found that humidity dependence is low and linear when the chamber is filled by diffusion and the cover if the chamber is an optimal one (quit different dependence was found when the chamber is filled by the pump).

The measurement of the humidity dependence for repeated several times in 2003 with Radim3 (the monitor has an optimal covering of the detection chamber). Fig.4 depicts the typical result of one measurement. Thus the average value of the slope of the dependence on RH for Radim3 instruments **- 0.0017 ± 0.0007** and the average value of the slope of the dependence on AH for instrument R3 No. 93 is: **- 0.0061 ± 0.002. When the relative humidity changes from 50% to 90% the response decreases for - 6.5%** (the results of Radim3 measurement are automatically corrected for humidity)

Fig.4 -The dependence of the response on relative humidity
(experiment in 2003, the response determined by AlphaGuard)

Response ((counts/hour)/(Bq/m3)) = -0,0015 RH + 0,9858
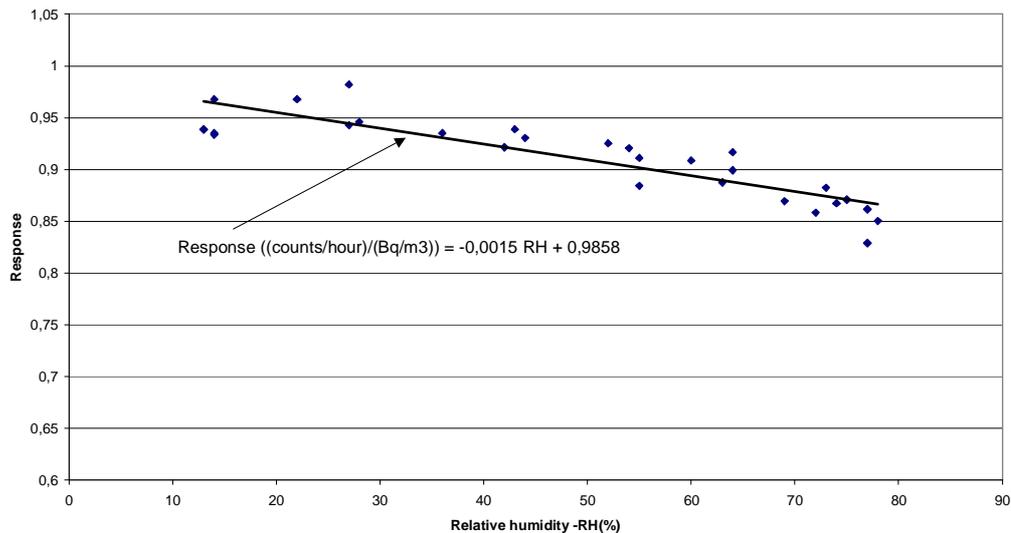
5.4 - Decrease in sensitivity caused by VOC.

Posterdörfer [2] and other authors state that increased neutralisation of $^{218}Po^+$ ions occurs through the effect of admixtures that have a lower ionisation potential than PoO_2 equal to 10.44 eV (Chu and Hopke[5]) -Po does not exist in the free form, but forms an oxide with atmospheric oxygen. The work of Busigin [4] gives the curve of the dependence of the collection efficiency on the concentrations of various admixtures. The "worst" admixtures seem to be ethylene and NO_2 (ionisation potential 9.74 eV). Hopke [1] pointed out that an increase in the concentrations of NO_2 and VOC above 100 ppb can cause a significant decrease in the efficiency of equipment based on collection of Po ions.

Consequently, we have **carried out experiments in 2003** to determine the effect of VOC. The Radim2P-REF, Radim3 No.93, No.94 and No.95 (No.95 has closed chamber, filled by a pump) instruments were employed in the experiments. Tab. 1 summarizes the results of the relative decrease in the measured radon concentration in the individual experiments with injection of VOC. A similar procedure was employed for injection of benzene, which has a very low ionisation potential of 9.24 eV.

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Tab. 1 - The effect of VOC

Experiment	Injected	Instrument	Decrease (%)	Note
ACETONE1	**0.5 g liquid**	R3 No.93	-(**49** ±1.2)	Enormous concentration
		R3 No. 94	-(**59** ±2.2)	
ACETONE2	100ppm –gas	R3 No.93	-(5.5 ±2.6)	
		R3 No. 94	-(5.7 ±2.2)	
ACETONE3	100ppm –gas	R2PF-REF	-(0.3 ±2.6)	
		R3No.95 **(closed chamber)**	-(0.6 ±3.1)	
ACETONE4	500ppm –gas	R3 No.93	-(4.7 ±2.1)	
		R3No.95(closed)	-(**19.1** ±3.5)	
ACETONE5	500ppm –gas	R2PF-REF	-(2.6 ±1.4)	
		R3 No. 94	-(1.5 ±3.1)	
Acetic Acid1	50ppm- gas	R3 No.93	- 3.0	Temporary change
		R3No.95(closed)	0	Temporary change
Acetic Acid1	500ppm- gas	R3 No.93	-(2.8 ±2.1)	
		R3No.95(closed)	-(1.7 ±4.4)	
Benzene1	100 ppm- gas	R3 No.93	-(5.4 ±1.3)	
		R3No.95(closed)	-(**19** ± 4)	
Benzene 2	100 ppm- gas	R2PF-REF	0 ± 1.5	
		R3 No. 94	0 ± 1.8	

In the experiments denoted as "**smoke**", smoke from about 1/2 cigarette was injected into the closed 100 l barrel, where the instruments were inserted - i.e. there was a very high concentration in the barrel (according to the author - a smoker, the smoke from two cigarettes creates a aerosol concentration in a room with a volume of approx. 75 m^3 that increases factor F (EER/RC) from 0.2 to 0.6 - i.e. the aerosol concentration in the room must be about 200 000 particles/cm^3). The concentration in the barrel must thus be 200 to 500 times higher. The results of the "smoke experiment are given in Tab.2

Tab.2- Effect of smoke

Experiment	Injected	Instrument	Decrease (%)
SMOKE 1	Smoke from half of cigarette	R3 No.93	-(17 ±6.7)
		R3No.95(closed)	+(**18** ±3)
SMOKE 2	Smoke from half of cigarette	R2PF-REF	-(12.7 ±4.0)
SMOKE 3	Smoke from half of cigarette	R3 No.93	-(24.3 ±10)
		R3 No.94	-(7.8 ±5.7)
		R3No.95(closed)	+(**19.9 ±5.8**)
SMOKE 4	Smoke from half of cigarette	R3 No.93 (felt)	-(9.8 ±3.2)
		R3 No.94(cloth)	+(3.9 ±2.4)
		R3No.95(closed)	**-(5.2 ±2.2)**

5.5 - Dependence of the response on F (aerosol concentration)

The high voltage (further HV) connected to the detection chamber was adjusted to 1.7 kV in order to work Radim3 on counting plateau. The dependency of counting rate on HV was measured when equilibrium factor F was near 0.4. Additionally was found that when F-factor is low- low concentration of aerosols the response of monitor is lower and dependency on relative humidity (further RH) is higher. Physical reason of this changes was not explained.

The HV was increased from 1.7 kV to 2.5 kV. The function of Radim3A was checked in the radon chamber of National Radiation Protection Institute (SÚRO, Prague). The radon chamber is very well equipped and F- factor can be changed from less then 0.1 to 0.99 and RH from 10 to 95%. As the reference instrument is used AlphaGuard (further AG) which is linked to PTB, Germany and NRPB, Emgland. The F- factor and f was determined by the monitor Fritra4, which measures radon concentration, concentration of all components of radon daughters.

Results:

a. Conditions: F= **0.4** ± 0.14, RH = near 30%. **Result: ratio of Radim3/AG= 0.92 ± 0.05.**

b. Conditions: F= **0.2** ± 0.03, RH = from 30 to 75%.
   Result: ratio of Radim3/AG= 0.92 ± 0.05.

c. Conditions: F= **0.7** ± 0.06, RH = from 30% to 85%.
   Result: ratio of Radim3/AG= 0.92 ± 0.05.

d. Conditions: F= **0.24** ± 0.03, RH = near 53%.
   Result: ratio of Radim3/AG= 0.92 ± 0.05.

Conclusion:

- **increase of HV from 1.7 to 2.5 kV solved the problem of influence of F- factor to Radim3A response,**
- the correction for RH works satisfactory.

5.6 - Dependence of the response on radon concentration

Porstendörfer [2] determined the rate of neutralisation of positively charged ^{218}Po ions in the room on the ionisation rate, caused mainly by radon and its decay products and stated that the occurrence of charged ions decreases rapidly with increasing ionisation rate - the concentration of positively charged ions decreases to 18% when radon concentration is 3000 Bq/m^3. It should be **emphasised that these results are related to the occurrence of ^{218}Po ions in the room; these ions are not collected by an electric field**. Nonetheless, the following should be pointed out:

The Radim monitors are usually calibrated by the manufacturer at radon concentration of approx. 10 kBq/m^3 and are then tested at concentration from 50 to 500 Bq/m^3. At AMC, monitors are routinely monitored at radon concentration between 1000 and 3000 Bq/m^3; however, in type tests, monitors have also been tested at concentration of about 50 kBq/m^3. Testing of Radim3 at BFS-Berlin was carried out at the levels: 1354, 9357 and 4217 Bq/m^3. The Radim3/BFS ratio was (0.90 ± 0.07), 0.95 ± 0.08), (0.90 ± 0.08).

Conclusion:

 no dependence of the monitor response on radon concentration was never observed.

References to the Chapter 5:

(1) Hopke, Philip K., *Use of electrostatic collection of ^{218}Po for measuring of Rn*, Health Physics 57:39-42 (1989)

(2) Porstendörfer J., Dankelmann V., Pagelkopf P., *Neutralisation processes and the fraction of the ^{218}Po- ions in air*, Third Eurosymposium on Protection against Radon, Liege 2001, 65-68 (2001)

(3) Howard A.J., Johnson B.K. , Strange W.P. *A high- sensitivity detection system for radon in air*. Nuclear Instruments and Methods in Physics Research A293,589-595 (1990)

(4) Busign A. Antoon W.,Voore, Babcock C. Philips C.R., *The nature of unattached RaA (218Po) Particles,* Health Physics,40, 333-343 (1981)

(5) Chu, K.D., Hopke P.K. *Neutralisation kinetics for polonium-218.* Environ. Science and Technology 22, 711-717 (1988)

6.0- Calibration and humidity dependence of the instrument response:

The purpose of calibration is to find a relationship between the saturated counting rate of impulses and the radon concentration. The calibration is carried out by the manufacturer using his own means (usually by relation to a reference Radium 2P instrument, which were attested in AMC many times) and the accuracy of the calibration is then verified in the AMC of the Czech Republic. Verification is carried out by comparing the results of measurement of radon concentrations provided by the Radim instrument and a reference instrument - using a secondary ATMOS standard or by some other means and then the value of the calibration factor CAL is adjusted so that the tested instrument yields the same results as ATMOS. The radon concentration **a** is calculated from the measured number of impulses N using the relationships:

$$a = \frac{N - B}{T * k} CAL \qquad \text{(Bq/m}^3\text{)} \qquad (7)$$

where   N is the number of impulses,

B is the number of impulses of the background, recalculated to time T,

T is the length of the measurement

CAL is calibration factor

The following expression is used to calculate factor k:

$$k = 1 - (a*AH + b*AH^2) \qquad (8)$$

Where AH is the absolute humidity and coefficients a and b describe the dependence of the response on the absolute humidity. The absolute humidity, given in g/m^3. The absolute humidity is determined from the relative humidity as follows:

$$AH = RH/100 * F(t) \qquad (9)$$

Where the relative humidity is given in % and the saturated vapour concentration is given in g/m^3. The concentration is dependent on the temperature t and is described by the relationship:

$$F(t) = 5.355 + 0.1489 * t + 0.0227 * t^2 \qquad (10)$$

7.0- Operation of the Instrument.

7.1- General Principles of Operation, Measurement and Depiction on Display.
The instrument is controlled by an efficient micro-computer. The software was designed so that the program offers a number of variants from which the operator makes a choice- i.e. the operator need not remember a set of commands or hunt through the manual. It is only necessary to have a rough idea of the types of operations carried out by the selected service-item of the Menu. The operator must also learn the manner in which measuring results are stored and displayed.
Measurement:
To start or stop measurement the sub- service **Strt** or **Stop** in main service **Meas** should be selected- no advanced programming of experiment is needed.
The memory and manner of storing the results:
The instrument has the memory where **16096** results – recordings - can be stored. The names of the items in the Menu, the sub-services and their description are written in English. The program offers statistical processing of the results, i.e. calculation of the mean and the standard deviation of the set of results. The set of results is stored in a **block**, whose number the program finds automatically when the measurement starts. The block is defined by the time of start and stop. The time of start, temperature, humidity and pressure is stored in the memory for each recording (record thereinafter). In the memory can be stored **128 blocks-experiments.** Data can statistically processed either from all the block or from selected time interval- ROI.
Concept of Operation and Depiction on the Display:
The conception of the software was based on the fact that an intelligent alpha- numerical LCD display was used with 2 lines of 16 characters each and the instrument is controlled by 3 buttons. The buttons are labelled as:

$$\boxed{} \qquad \boxed{} \qquad \boxed{}$$

$$\leftarrow \qquad \text{Go} \qquad \rightarrow$$
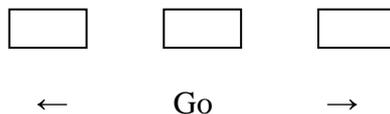
In choice of items offered in the **bottom line of the display**, the operator moves to the **left** using button " ←" and to the **right** using button " →", the selected action is confirmed using the Go button.
Text on the display:
The upper line of the display depicts the required information, a maximum 16 characters. The lower line is for choice, where the selected item is denoted on the display by enclosing between two arrows (in this description this will be denoted as > < and will be termed the cursor). The button Go switches the regime, denoted in the upper line.
Movement Regime:
Using the buttons ← and → the position of the cursor is moved. After pushing GO the movement regime changes to the action regime.
Action Regime:
Action depends on the symbol denoted by the cursor:
If the cursor selects the symbol "**!**" (the first symbol in the bottom line) the text changes to Yes > < No and the button Go finishes the settings,
If the cursor selects the symbol "?" the text changes to MAX > < MIN and the buttons ← and → shows maximal and minimal value,
If the cursor selects the number the text changes to INC > < DEC and the buttons ← and → Increments/ decrements the number.

Switching ON/OFF the instrument:

The instrument has no mechanical switch ON/OFF- only electronic one. The instrument is switched **ON by synchronous pushing the buttons ← and → .** The instrument is switched **OFF automatically** if radon is not measured, the regime of display is adjusted to automatic switch Off (see later) and no adapter and no PC cable is connected.

Switching OFF the display:

In order to reduce the power and to **protect the monitor against children a non- qualified person "playing"** the display can be adjusted to automatic switching off - see Chap.7.2. The display is activated again after synchronous pushing the buttons ← and →.

After turning the instrument on, the main **Menu** appears on the display - see picture below. The frame on the picture represents the display and the displayed text, the text which is outside the frame denotes the hidden items, which can be displayed when the cursor is moved to the right or to the left (the items can be read in a cyclic manner).

The items on the main Menu:

```
Menu:    System
X Del >Sys<  Env          Par Rdn Res
```

Action label
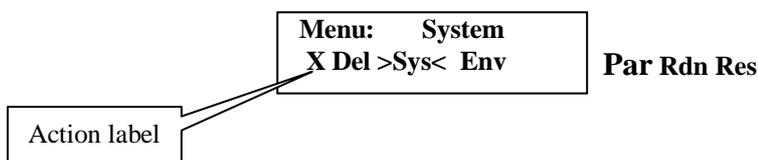
Main Menu:

As the description of the services can not be described as complete text on the LCD display with 16 characters, the main Menu consists of 6 items, where abbreviations denote items of Menu, indicated in the following figure, where the first steps of the services are also depicted.

Del Sys Env Par Rdn Res

| Dsp Tst LCD Clk Clr Ide Ret | Ret Bcg Sti Bat | Fre Run Inf Ret | ROI Blk Sta Vue BqI |

Ret Prs Tmp RHu AHu
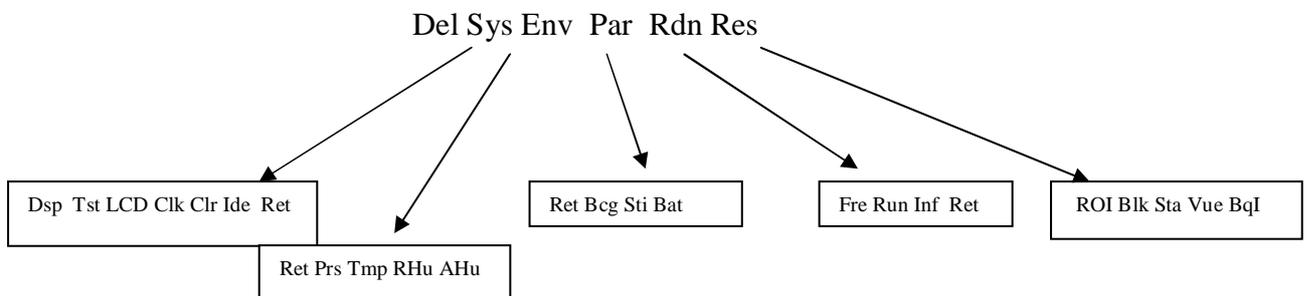
When items of the Menu are selected, the text on the upper line of the display also changes, indicating the function of the item - services.

List of services:

Abbreviation	Explanatory text	Function:
Sys	**System**	Adjusting the contrast of the LCD display, clock, memory clearing, choice of the display control, production number
Env	**Environment**	Reading of temperature, humidity, pressure
Par	**Parameters**	Background setting, adjustment of sampling interval, battery capacity
Rdn	**Radon Meas.**	Automatic measurement of radon, calculation of radon concentration, storing the result in the memory
Res	**ResultsRead**	results reading
Del	**LastMeasDel**	deleting of the last block

7.2-SubMenu Sys- Display On/Off, Test, LCD contrast, clock and memory clearing.

Selecting Sys- service on the bottom line of the display and pressing GO button, the following text appears on the display:

```
        LCD Contrast Set
        Dsp  > LCD< Tst          Clk  Clr  Ide  Ret
```

| Display On/Off | Contrast of LCD display | Test | Clock settings | Memory clear | Production number |
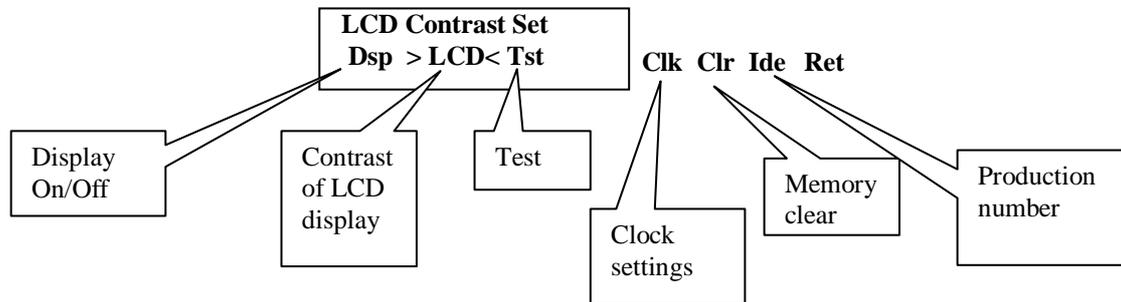
7.2.1- Display On/Off- service Dsp
After selection of Dsp in the service Sys display depicts:

```
        Display: Fixed On
         Ret  > Dsp< LCD
```

And the display is On constantly. In order to reduce the power and **protect the monitor against children a non- qualified person "playing"** push the **Go again** and the display changes to:

```
        Display: Auto off
         Ret  > Dsp< LCD
```

and if no button is pushed within 1 minute the display switches Off automatically. The display can be activated again by synchronous pushing the buttons ← and →.

7.2.2- Test of the monitor by internal generator- service Tst.
After beginning this operation, impulses with an exact frequency and amplitude are brought to the input of the preamplifier to test the correctness of the position of the analyzer window around the RaA peak and the functioning of the analog and digital parts of the electronics. The impulses are counted and the result is compared with the value stored in the computer memory. This operation can be begun when the background or radon are not being measured. If it is begun during these measurements, the display announces an error. Selecting the Tst- service the display depicts:

```
        Start of Test
        T  Inf  >Run< Res         Ret
```

| Action label | Measurement Information | Test start | Reading of the test result | Return into main Menu |
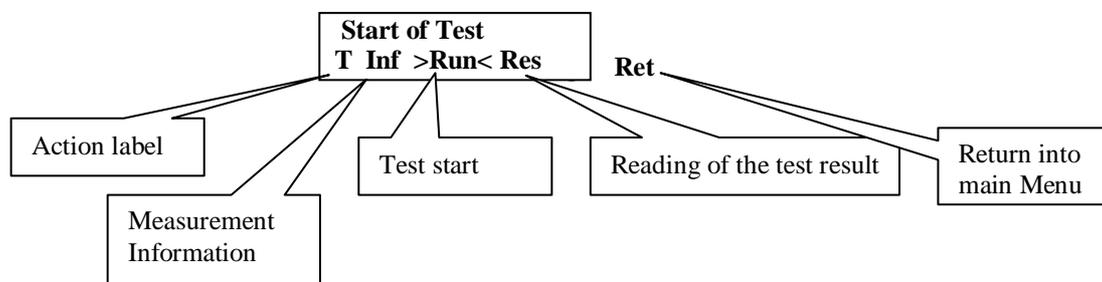
Measurement and evaluation of the test:
The Run- item must be selected in the Test- service and the procedure starts after pressing the Go button. The "Action symbol" changes to T. When "T" appears on the display the impulses are counted and it is not suitable to select any another service- only service Info.

If you want follow the running measurement select **Info**- service and the display depicts:

```
Running                    Number of
time:                      counted              Stop of
dd:hh:mm                   impulses             measureme
                                                nt

                  ┌──────────────────────┐
                  │ XX:XX:XX I: YYYYY     │   End Stp
                  │ T  Rem  >Ela< Beg     │
                  └──────────────────────┘

   Action label                      Time of the start      Time of the
                                                            end
              Elapsed
   Remaining  time
   time
```
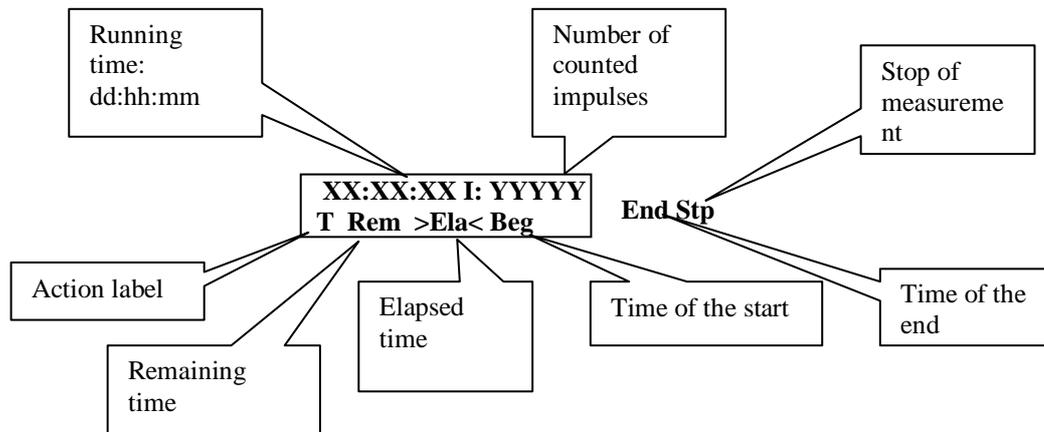
The service **Info has the identical form when radon or background is measured**. The measurement can be stopped using **Stp-** service.
Note:
 when the operation Test (measurement of radon or background) starts the "Running time" and counter does not changes for 20s. This delay is needed as analog part of Radim3A is supplied by voltage when measurement is going only- during another operations this part is switched off and so the needed power is reduced. It takes about 15s to adjust the stable condition in the amplifier.
Depiction of the result of the test:
The result of the POSITIVE test is depicted after selection of **Res**- service as:

```
┌──────────────────────┐
│ Dev. Test  OK:100%    │
│  Run  >Res< Ret       │
└──────────────────────┘
```

and the ratio of counted impulses to nominal number, given in %, is depicted in the upper line of the display.
If the counted number of impulse **differs** from the nominal number by **more than 5%** the notice " **Dev. Test Failed**" appears on the upper row of the display. In this case it is strongly recommended that the producer be contacted and that **the instrument not be used**.

7.2.3-Contrast adjustment of LCD- service LCD:
When the cursor is set to the item LCD and Go- button is pushed the display depicts:

```
┌──────────────────────┐
│ Contrast   setting    │
│  Ret   >Inc< Dec      │
└──────────────────────┘
```

when the cursor is set to Inc-item it is possible to increase the LCD contrast by pressing GO. The Dec- item decreases the contrast.

7.2.4-Clock settings- service Clk

When the cursor is set to the item Clk and Go- button is pushed the display depicts (fiction date and time is shown in this text):

```
Date:
ddmmrr                              Time:
                                    hh:mm:ss


            210304        10:02:38
            Ret   >Set< Ret
```
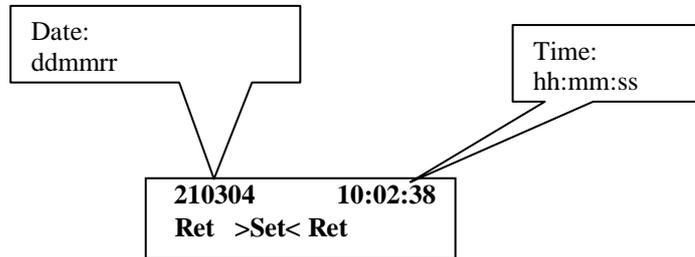
When the item Set is selected the display changes to:

```
            210304        10:02:38
               ←   >GO<   →
```
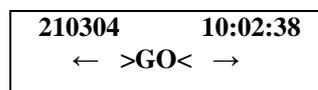
Using the button ← or   → the desired number, which should be changed, can be chosen (here is blinking line below the selected number). The program offers the possibility to change number by Inc or Dec and pushing of Go button. The program checks if the adjusted date and time is „sensible". All procedure of clock setting is finished when cursor is placed on the Action symbol: „!" and by confirmation by Yes.

7.2.5-Memory clearing- service Clr:

When the cursor is set to the item Clr and Go- button is pushed the display depicts

```
            Are You sure ?
             No   >No< Yes
```
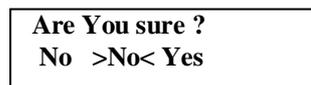
7.2.6- Reading of the production number- service Ide:

The production number of the each instrument is stored in the memory by the manufacturer (the storing procedure is available for the producer only) and the user of the instrument can read the number using Ide- service.

7.3-SubMenu Par- Background, sampling time and battery capacity.

By selecting Par- service on the bottom line of the display and pressing GO button, the following text appears on the display:

```
                 Background
            Ret  > Bcg<  Sti        Bat
```

Return into the main Menu

Background

Adjustment of the sampling time

Reading of the residual capacity of the battery
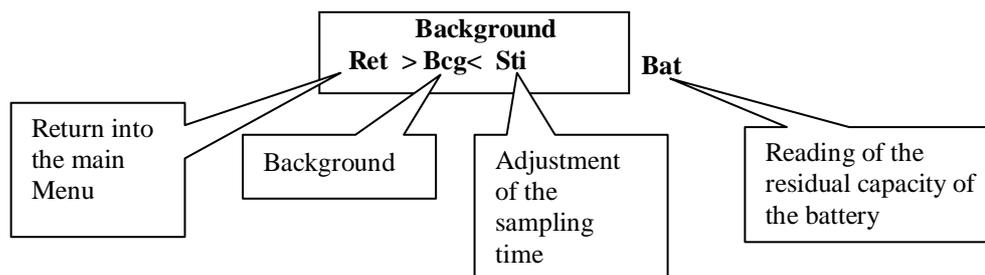
7.3.1- Background determination- service Bcg:

All types of radon monitors are contaminated after long- time measurement of high radon concentration- see Chapter 8.1. The service Bcg makes possible to measure background. When background is measured the HV is Off and the activity, which was deposited on the surface of semiconductor detector is determined.

By selecting Bcg- service on the bottom line of the display and pressing GO button, the following text appears on the display:

```
┌─────────────────────┐
│ The last used value │
│ of background       │
└─────────────────────┘
        ┌─────────────────────────┐
        │ Backgr/30 min:  XXX     │
        │ B  Run   >Set< Ret      │
        └─────────────────────────┘
   ┌──────────────┐  ┌──────────────┐  ┌──────────────┐
   │ Action label │  │ Measurement  │  │ Background   │
   │              │  │              │  │ setting      │
   └──────────────┘  └──────────────┘  └──────────────┘
```
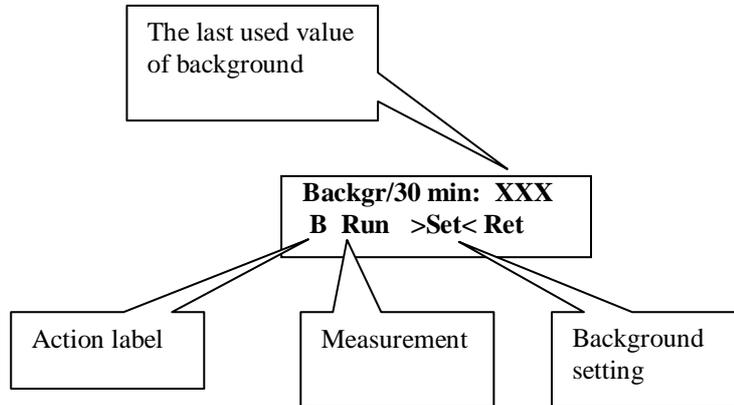
Background measurement:

Using the service Par, the   3 hours or longer sampling time should be adjusted. As the monitor is slightly sensitive to radon, it is recommended to place monitor into a space with very low radon concentration i.e. outside of house and to start background measurement at least 5 hours after last radon monitoring (one must wait for complete decay of RaC´). The measurement starts after selection of the item **Run** and confirmation by Go. After start the Action label changes to " B ". If you want follow the running measurement select Info-service, see Chapter 7.2.2

Background setting:

If the results of multiple measurements of the background is known or we know a trend of background changing it is possible to set the value of the background manually. The number of background counts /30 minute can be written by the **procedure for entering of numbers.** The procedure is very similar to the clock settings – only difference is that the procedure shows the last entered number (for instant 5):
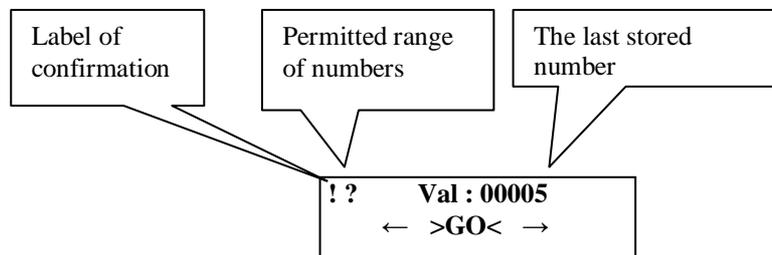
```
┌──────────────┐  ┌──────────────┐  ┌──────────────┐
│ Label of     │  │ Permitted    │  │ The last     │
│ confirmation │  │ range        │  │ stored       │
│              │  │ of numbers   │  │ number       │
└──────────────┘  └──────────────┘  └──────────────┘
          ┌─────────────────────────┐
          │ ! ?       Val : 00005   │
          │    ←   >GO<   →          │
          └─────────────────────────┘
```

Using the button ← or   → the desired number, which should be changed, can be chosen (there is blinking line below the selected number). The program offers the possibility to change number by Inc or Dec and pushing of Go-button The program checks if the adjusted number is within the given limits. All procedure of setting is finished when cursor is placed on the Action symbol: „!" and confirmation by Yes.

7.3.2 – Determination of Length of the Sampling Interval- service Sti

Choice of the length of the measuring interval:
The length of the measuring interval is selected with respect to the expected level of radon concentration and required statistical error of the measurement. The following table gives the relative measuring error, expressed in percent:

Tab.4- The statistical errors, given in %, for different radon concentration and sampling time T

OAR (Bq/m^3)	20	50	100	500	1000	2000	5000	10000	50000
T=0.5h	50	33	20	10	7	5	3.2	2.2	1.6
T=1.0h	35	20	16	7	5	3.2	2.2	1.6	1.1
T= 2.0 h	25	16	7	5	3.2	2.2	1.6	1.1	0.8

From this table follows that the length of 0.5 hour seems to be optimal, with acceptable statistical error even for very low concentrations- only for concentration below 100 Bq/m^3 the sampling time should be prolonged.
The length of the sampling time can be adjusted from 10 minutes to 24 hours.
Note: when sampling time is shorter than 30 minutes the seen radon concentration may be not correct, as the counting rate is not in an equilibrium with radon concentration. Therefore the shorter sampling time should be used when a fast process is studied and relative values are important.

Sampling time setting:
When the item Sti is selected the display changes to:

```
! ?        STime : 00:30:00
      ←   >GO<   →
```

Using the button ← or → the desired number, which should be changed, can be chosen (there is blinking line below the selected number). The program offers the possibility to change number by Inc or Dec and pushing of Go-button. The program checks if the adjusted number is within the given limits. All procedure of setting is finished when cursor is placed on the Action symbol: „!" and confirmation by Yes.

7.3.3- Reading of residual capacity of the battery- service Bat
The NiMH battery of 4.5Ah are used in the instrument. It is useful to know residual capacity of battery to estimate corresponding operational time. The capacity is estimated from voltage and discharging curve of the battery . The service **Bat** shows the residual capacity in % and so we are able to estimate operational time, knowing that operational time when the battery is totally charged .
Selecting Bat- service and pushing Go the display depicts for instant:

```
Bat: 7.327V = 20%
- Sti    >Bat<  Ret
```

Long term measurement:
If the planned experiment is longer than estimated operational time the adapter must be connected to the instrument and then the battery will be charged- see below.

Charging: connect the adapter to the instrument- the battery will be charged automatically to reach 100% capacity and then switches to the trickle- charging process, which compensates the mean power take-off. The totally discharged battery will be charged in about 12 hours (the internal charger gives 0.45A). The instrument controls the charging process - there is no need to "watch" charging.
 When internal charger is On the LED, placed in rear panel, is lighting.

7.4 - SubMenu Rdn- Automatic radon measurement and storage of the results.

By selecting Rdn- service on the bottom line of the display and pressing GO button, the following text appears on the display:
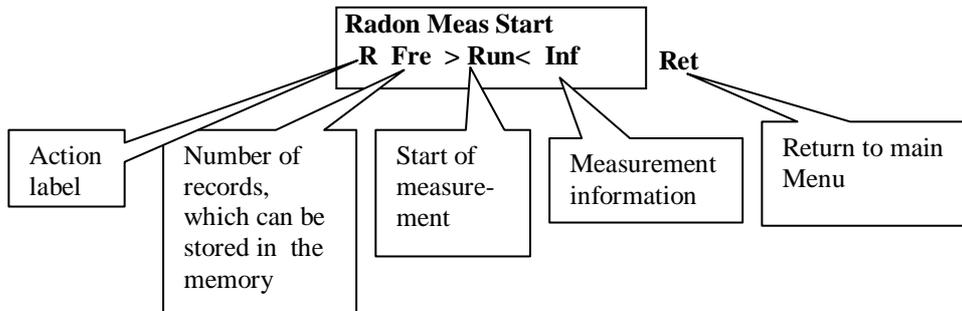
Before starting the measurement, the manufacturer recommend that the following be controlled:
- battery capacity (see Par- service),
- the length of sampling time (see Par- service),
- the background value (see Par- service),
- check the number of records, which can be stored in the memory – service Fre in Meas.

The measurement starts after selection of the **Run** service and confirmation by Go. After start the Action label changes to "R". If you want to follow the running measurement select Info-service, which depicts:

Info- service:

Running time: dd:hh:mm

Number of counted impulses

Stop of measurement

XX:XX:XX I: YYYYY
T Rem >Ela< Beg

End Stp

Action label

Elapsed time

Time of the start

Time of the end

Remaining time
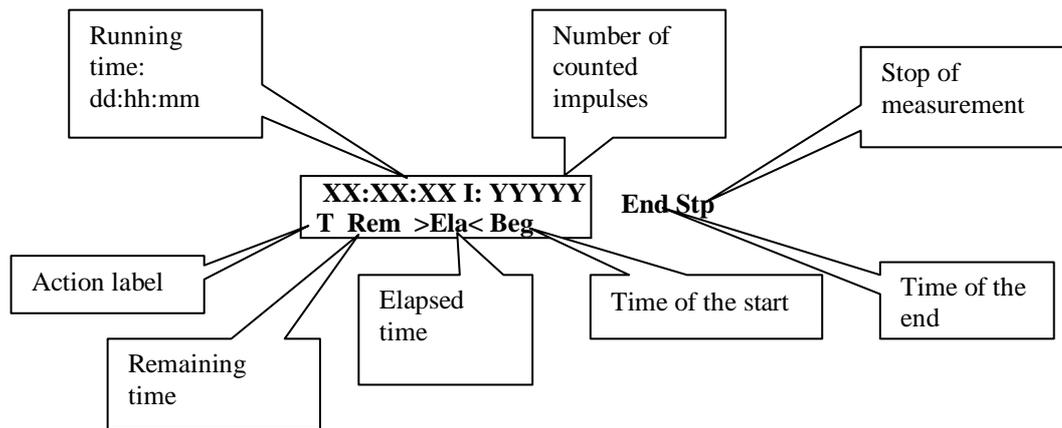
7.5 - SubMenu Res- <u>Reading of results</u>
Generally:
As it was noted above the results are stored in internal block as it is shown in the following figure:

BLOCK 1   BLOCK 2   BLOCK 3

Start   Stop Start   Stop Start   Stop

Date 1   Date 2 Date3   Date 4 Date 5   Date 6
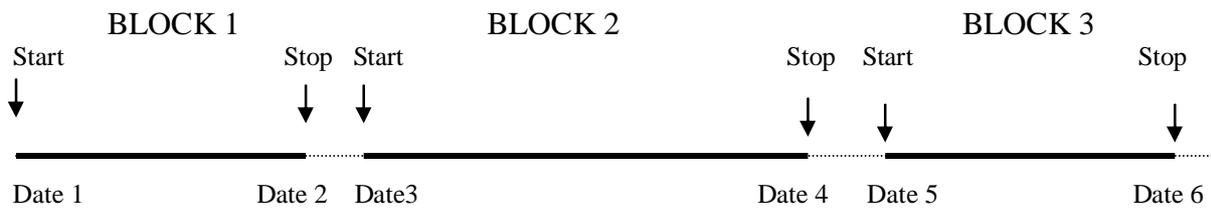
The block No.1 is defined by the start at Date 1 and by the stop at Date 2.
There is possibility to read the results of the whole block or to "cut out" a time interval in the block- ROI (Region of interest) , which is processed by the same way as the whole block.
By selecting Res- service on the bottom line of the display and pressing GO button, the following text appears on the display:

Reading of individual records

RegionOfInterest
- Ret > ROI< Bpr

Sta Vue

Action label

Return to the main Menu

ROI

Information about the block

Statistical treating of the block, ROI
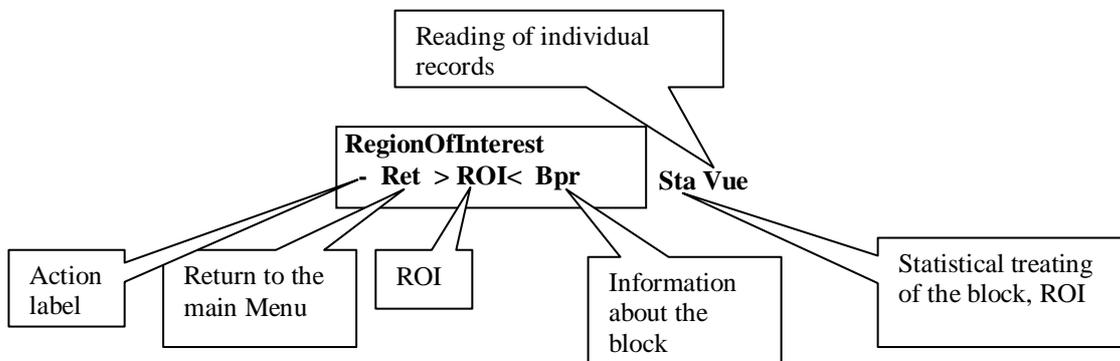
The 1st step of reading-selection of the block or ROI:
When the item **ROI** is selected the program offers:

Date	Time

DDMMRR hh:mm:ss
-- Blk > Beg< End   **Sel Ret**

Action label	Block selection	Start-time of the block	Stop- time of the block	Information about the block or ROI
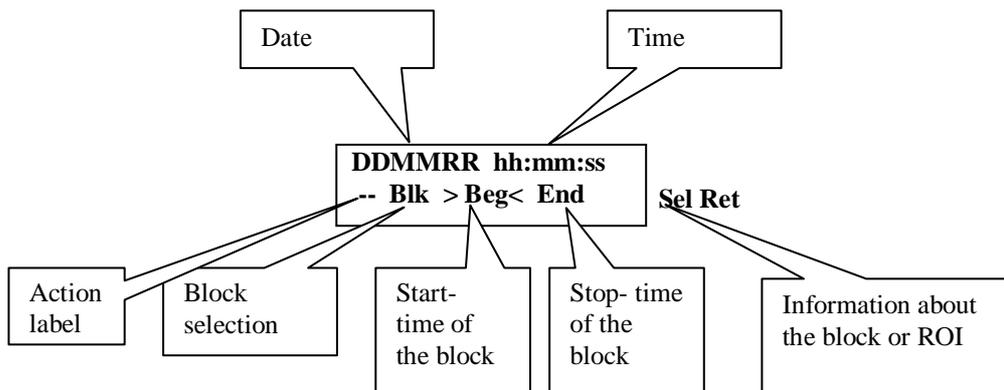
Block selection:
When the item **Blk** is selected the program offers:

Date	Time	Setting of start-time of the block

DDMMRR hh:mm:ss
-- 1st > Dec< Inc   **Last Set**

Action label	The 1st block	The preceding block	The next block	The last block
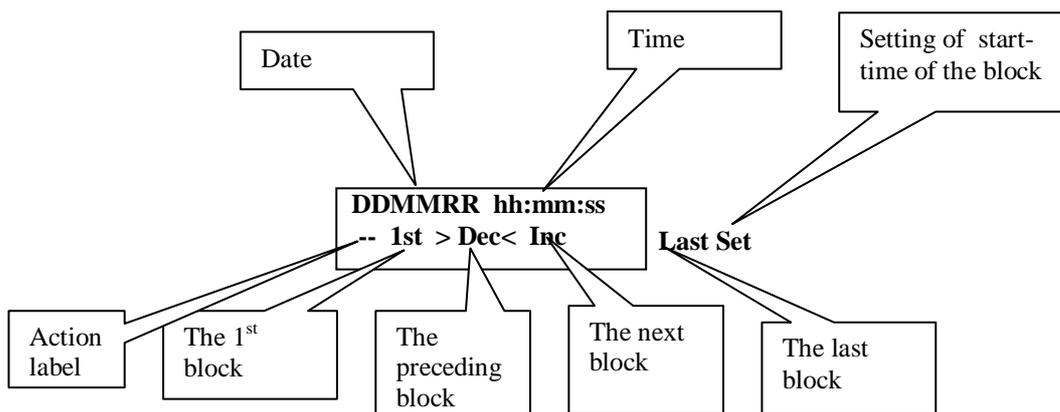
and using the service „1st", Dec, Inc, Last or Set we can select the block- the block is defined by the time of the start.

Information about the block:
After selection of the block we return to the service **Blk** and then we choose the service **Sel**- the program offers (for illustration the block No.5 with 165 records was used in the text):

Block number	Number of records in selected block

B: 5 SelR: 165
-- End > Sel< Ret
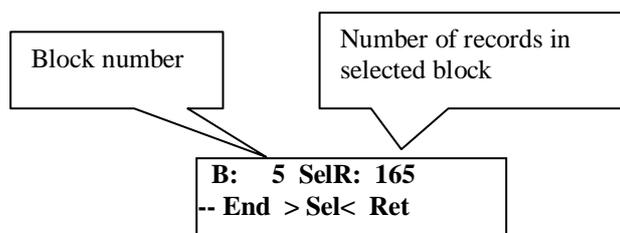
Selection of the time interval- ROI:

It is possible to cut-out a time interval from the selected block by the following procedure of the ROI definition: the item **Beg** should be chosen from the offer of the service ROI. The beginning of the ROI can be shifted from the start of the block using **Inc-** service**.** In the next step we find the item **End** and the end of the ROI can be shifted from the end of the block using **Dec-** service**.**

The 2nd step of reading **– the reading of the results**

We return to the beginning of the service **Res** and the **head** of the block/ROI can be found using the item **Bpr**:

Date and time of the start of the block/ROI	The length of the block- the number of records	The length of the ROI- the number of records

230304 11:28:31
-- Ret > Tim< STi   **Bcg Cmt Cal Len ROI**

Sampling time	Background	Comment	Calibration constant
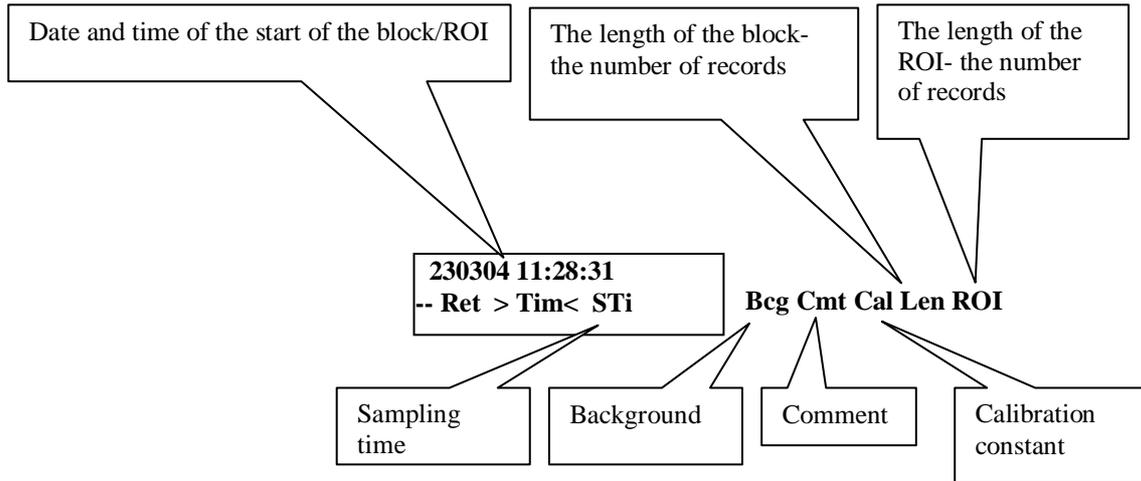
The service Cmt: there it is possible to write **numerical** comment.

Statistical treating of the results:

We return to the beginning of the service **Res** and after selection of the item **Sta** we can read mean value, standard deviation and maximal/minimal value in given data set.

OAR   Stat
-- Ret > RC< Imp   **Prs Tmp Rhu**

Statistics of the radon concentration in the block/ROI	Statistics of the number of counts in the block/ROI	Statistics of pressure in the block/ROI
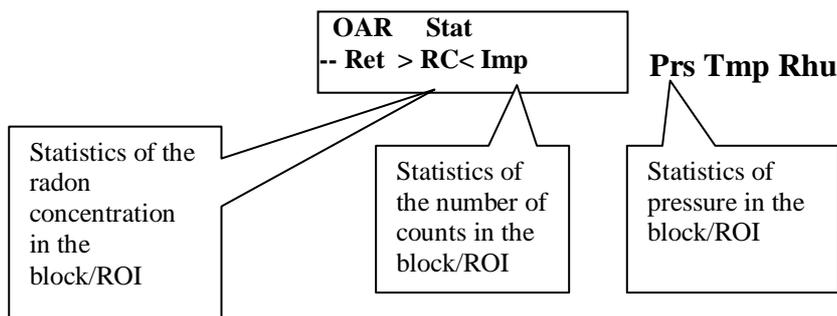
When we select the item **Vue** we can read individual results- records:

Record: 1
-- Ret > Set< Tim   **RC Imp Prs Rhu Tmp**

Setting of the number of record	Time of start of the record	Reading of radon concentration	Reading of counts

23
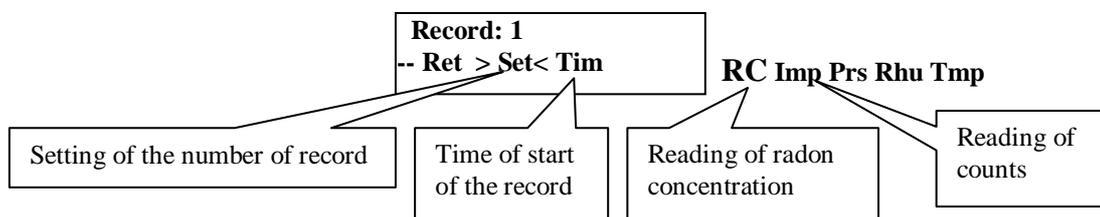
The program starts reading from the beginning of the selected block/ROI or from the entered number of the record. Subsequent pushing of the button Go increments the number of the record and to read another result- it is no need to return to the service Set to change the number of the record.

7.6 - SubMenu Del- <u>deleting the last block</u>

By selecting Del- service on the bottom line of the display and pressing GO button, the following text appears on the display and then it is possible to delete the last block:

```
Are you sure ?
-- No  > No< Yes
```

8.0 – Technical notes

8.1 - Contamination of the Radim3A monitor

It has been found that **the background increases** after prolonged use of the Radim 3 monitor. This increase is caused by accumulation of ^{210} Pb on the surface of the detector (other instruments are affected by this phenomenon). The ratio of the accumulated activity a_{Pb} to the radon activity a_{Rn} can be described approximately by the relationship:

$$a_{Pb} / a_{Rn} = \lambda_{Pb} \quad t = 0.032 / year \qquad (K1)$$

Under the assumption that the efficiency of the detection of α-particles emitted by RaA and ^{210}Po is the same (practically the same energy) the following values are obtained for the background after **measuring of radon a_{Rn}** for a period of **one month:**

a_{Rn} (kB/m^3)	5	10	50
a_B (imp/h)	13	27	133!!!!

This corresponds to a relatively high increase in the background. In order to assess the effect of the background on the overall precision of the measurement, it is useful to examine the statistics of the measurement in somewhat greater detail.

Effect of the background on the precision of the measurement:

During the measuring time, the number of impulses is measured, described by the symbol N_{B+S}, where index B indicates the background and index S is the index for the sample. The counting rate of the background is determined from the number of impulses N'_B, which is measured during an interval with length t_b:

$$N_S = N_{B+S} - N_B' t_S / t_B = N_B + N_S - N_B' t_S / t_B \qquad \text{(K2)}$$

and the dispersion σ of the thus-determined number of impulses is then described by the relationship:

$$\sigma^2 = N_S + N_B + N_B'\left(t_S / t_B\right)^2 \qquad \text{(K3)}$$

This relationship can be rearranged to the form:

$$\sigma^2 = N_S + N_B' t_S / t_B\left(1 + t_S / t_B\right) \qquad \text{(K4)}$$

and, after introducing the frequency of the background n_B, which is equal to N_B'/t_B, the final form is obtained:

$$\sigma^2 = N_S + n_B t_S\left(1 + t_S / t_B\right) \qquad \text{(K5)}$$

The statistical error is usually expressed as:

$$s = \frac{\sigma}{N} * 100\left(\%\right) \qquad \text{(K6)}$$

for which the following modifications:

$$\frac{\sigma^2}{N_S^2} = \frac{1}{N_S} + \frac{n_B t_S}{n_S^2 t_S^2}\left(1 + t_S / t_B\right) = \frac{1}{n_S t_S}\left\{1 + \frac{n_B}{n_S}\left(1 + t_S / t_B\right)\right\} \qquad \text{(K7)}$$

yield the relationship:

$$s = \frac{1}{N_S^{1/2}}\left\{1 + \frac{n_B}{n_S}\left(1 + \frac{t_S}{t_B}\right)\right\}^{1/2} \qquad \text{(K8)}$$

the counting rate of impulses n_S (imp/hour) is given by the relationship:
$$n_S = a_{Rn} k$$

where a_{Rn} is the concentration of radon (Bq/m^3), and
k is the response of the instrument equal to 0.8.
The selection standard deviation s (%) was calculated for various levels of concentration and background. The results are given in Tables K1 and K2.

Table K1 - The standard deviations for $t_B = 0.5$ h and $t_S = 0.5$ h.

a_{Rn} (Bq/m^3):	50	100	200	500	Background (imp/h)
s (%)	20	14.9	10.5	6.7	0
s(%)	21	15	10.6	6.7	0.5
s (%)	22	15.2	10.7	6.7	2
s (%)	25	16.5	11.1	6.8	10
s (%)	29	17.9	11.6	7	20
s (%)	49	26.8	15.3	8	100

Table K2 - The standard deviations for $t_B = 0.5$ h and $t_S = 1$ h.

a_{Rn} (Bq/m^3):	50	100	200	500	Background (imp/h)
s (%)	15	10.9	7.5	4.7	0
s (%)	15	10.6	7.5	4.7	0.5
s (%)	16	10.8	7.6	4.7	2
s (%)	19	12.1	8.0	4.8	10
s (%)	23	13.5	8.6	5	20
s (%)	41	21.8	12.1	6.1	100

Conclusions and Recommendations:
– in order to prevent contamination of the detector, it is necessary to **shorten the measuring time for high activities to a minimum,** i.e. at the beginning of the measurement it is useful to determine the activity level and, if this is greater than 20-30 kBq/m^3, the measurement should be shortened to several days.
– when measuring low activity levels, i.e. concentration of less than 100 Bq/m^3, it is essential to prolong the measuring time to at least 1 hour and to measure the background for several hours in an environment where the concentration of radon is known to be low. It is useful to measure the background at least 5 hours after the monitor was placed in the area with the high concentration of radon.
– when the background is higher than about 200 imp/hour, contact the manufacturer, who will replace the detector.

8. 2- Determination of the ventilation coefficient.
When the method of mitigation of a dwelling against radon risk should be proposed it is very useful to know the air exchange rate (thereinafter ventilation coefficient) and rate of radon entry into a room.
When the rate of radon entry can be expected stable (there are no day- variations of radon concentration and the difference between internal/external temperature is high) there is possible to realise the following experiment:
1. The radon concentration should be measured for several days to find if it is stable within about 20%.
2. The studied room must be ventilated substantially. During the ventilation the Radim3A should be placed into the room to measure for several hours (the sampling time should be 0.5 hour) " zero" radon concentration.
3. Then the room is closed and the growth curve is measured. It is very useful to reach equilibrium radon concentration (estimation of needed time is given below).

The rate if radon entry and ventilation coefficient can be determined from the measured growth curve.

Theory:

the change in the radon concentration **da** is given by the differential equation:

$$da = \frac{Rdt}{V} - ladt - \lambda adt \qquad (T1)$$

where   a is the radon concentration (Bq/m^3)

              R is the rate of radon entry into the room (Bq/hour)

              l is a constant characterizing the rate of air change – ventilation coefficient (h^{-1})

              V is the volume of the room ($m^{3)}$

              l is the decay constant of radon, equal to

              ln 2/T1/2 = 0.008 h-1.

Assuming that the rate R and ventilation do not change during the test period, the differential equation has a solution in the form:

$$a = \frac{R}{V(l + \lambda)}(1 - \exp(l + \lambda)t) \qquad (T2)$$

This equation contains two unknowns: rate **R** and the ventilation coefficient **l**. These quantities are determined from the radon concentrations activities a_i measured at times t by using the method of regression analysis to fit a curve to the measured values, where this curve has the form:

$$a_i = a_0(1 - \exp(-nt_i)) \qquad (T3)$$

and constants a_0 and n are determined, which can be used to determine the required rate R and ventilation coefficient l. The latter usually has a value between 0.1 and 0.5 h^{-1}. The following table gives times T at which the term 1 - exp(-nT) attains value P at various ventilation coefficients l:

Tab. 1: Time T (h) required to attain the required values of 1-exp(-nT))

(1-exp(-nT)):	0.1	0.63	0.9	0.95
l=0.1 h^{-1}	0.98	9.3	21	28
l=0.3 h^{-1}	0.3	3.2	7.5	9.7
l=0.5 h^{-1}	0.2	2	4.5	5.9

The success of the experiment depends on whether is possible to obtain a sufficient number of results with small statistical errors, from which both the equilibrium activity a and the initial increase can be determined. The numerical analysis can be greatly simplified if the value of a_0 can be determined in the first step. This requires the determination of several experimental values of a_i in an area where the activity no longer changes greatly. Except for very low ventilation coefficients around 0.1 h , it is sufficient to select an overall measuring time of about 12 hours to determine these points on the growth curve (see Tab. 1). It is then important in the estimation of the shape of the beginning of the growth curve that the period of the cycle be as short as possible. As mentioned above, this requirement is contradictory to the requirement of attainment of a sufficiently low statistical error. An interval of 30 minutes seems a reasonable compromise.

8.3- A new battery charger of Radim3A monitor.

The battery can be charged when the AC adapter is connected to "Charger-connector" placed in the rear panel and the instrument works in ON-regime (the ON- regime is switched by pushing both buttons "←" and "→"). The internal battery charger works in two regime:
- **main charging**: the battery is charged by 0.5 A and the LED on the rear panel is lighting red . The voltage of battery is measured in periodic intervals and displayed in "BAT" service with the notice "Charge". Charging automatically stops when voltage is not increasing (voltage about 8.9 V) and the notice changes into "Full"
- **trickle regime**: if the battery is charged and AC adapter is still connected to instrument the battery is charged by 25 mA and the LED on the rear panel is lighting green. This current compensates the consumption of instrument (4 mA) and self- discharging of NiMH battery. This version is recommended when instrument should work continuously longer then 40 days.

9.0- PC program for reading, evaluation of data and remote control of Radim3A

The program is intended for collection and storing of data from the Radim3A monitor. It works in the Windows 95/98/T environment.

The **minimum PC configuration** must comply with the following requirements:
- operating system for Windows 95 and higher
- 486 and higher processor
- 16 MB RAM
- VGA graphic card
- 1 x RS232
- 1 x LPT.

> **The operation of the system retains the rules of operation of the MS-Windows system. It can be controlled using the menu, mouse or functional keys.**
> The functions and a description are given in the following text.

9.1 Introduction

9.1.1. Installation
As this is an application for Windows 95 and higher, the applications should be installed in the standard manner used for these systems.
The program should be installed in the following manner:
The CD disc contains the SETUP.EXE program. After turning on the program, it is necessary to follow the installation program. After entering the place of installation, the program begins to install itself automatically and the program announces the end of installation.

9.1.2. Description of the program
The program works in two basic modes, OFF LINE and ON LINE. If the instrument is not connected to the PC, the text OFF LINE appears in the bottom line on the left of the Main Panel- see later. In the OFF-LINE mode, the operator can view stored data and store data in files. In the ON-LINE mode, in addition to the above functions, communication with

the instrument function can be set, the data is read from the memory and the monitor Radim3A can be controlled by PC.

When the PC program is started the small window with the Main Panel appears in your computer- see Fig.5. Before connection of Radim3A with PC use the service **Set** to set the number of communication port , i.e. COM1 or COM2.

After connection of the PC with the Radim3A the small icon, placed the lower corner of the main panel, denotes connection of the PC.

The following operation can be selected in the main panel:
- load data from the file,
- save data to the file,
- read data from Radim3A,
- show graph of the whole active block,
- show data table of the active block,
- show data overview (the list of the blocks)
- File- operation with the files,
- Remote- information about Radim3A parameters, data read from Radim3A, remote control,
- Set- selection of the number of the communication port and exported data format

Fig.5- The main control panel

View graph or data table, info = list of the blocks, Control of Radim3A parameters

Set number of COM, export data format

Table of the selected block

The list of the blocks

Selection of the number of the block

Remote control etc.

Root Directory, Data Export etc

Read data from the file

Save data in the file

Read data from Radim3A

Remote control

Radim3A parametrs

Graph of the selected block

9.1.3- Reading data from Radim3A:

Use the service Remote and then Data or to click to the icon "Radim3A" to read all memory. Starting this service and the small window is depicted:

and after selection " Read data" appears the window:
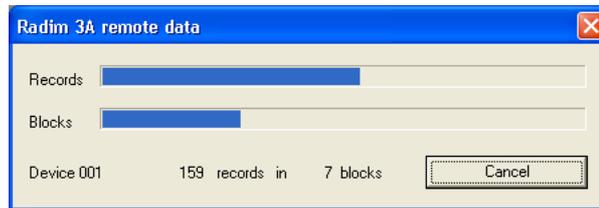
9.1.4-Information about the blocks:

When icon "i" is used the list of the blocks is depicted. The start and end of the block, number of records etc. can be found in the list.

9.1.5-Selection of the block:

The number of the block can be selected in the Main Panel (see above) or in the list of the blocks (icon "i") where it is possible to mark the needed block.

9.1.6-The graph of the selected block:

The graph can be depicted using the icon in the Main Panel or using service View- see Main panel. After selection of the service the following appears in the window:

Fig.6- The graph of selected block

The number of the block

The information about the block

Selection of concentration,counts, humidity etc.

Number of the graphs

The form of the grid

Reading the concentration, numberof of record etc. in the position of the cross
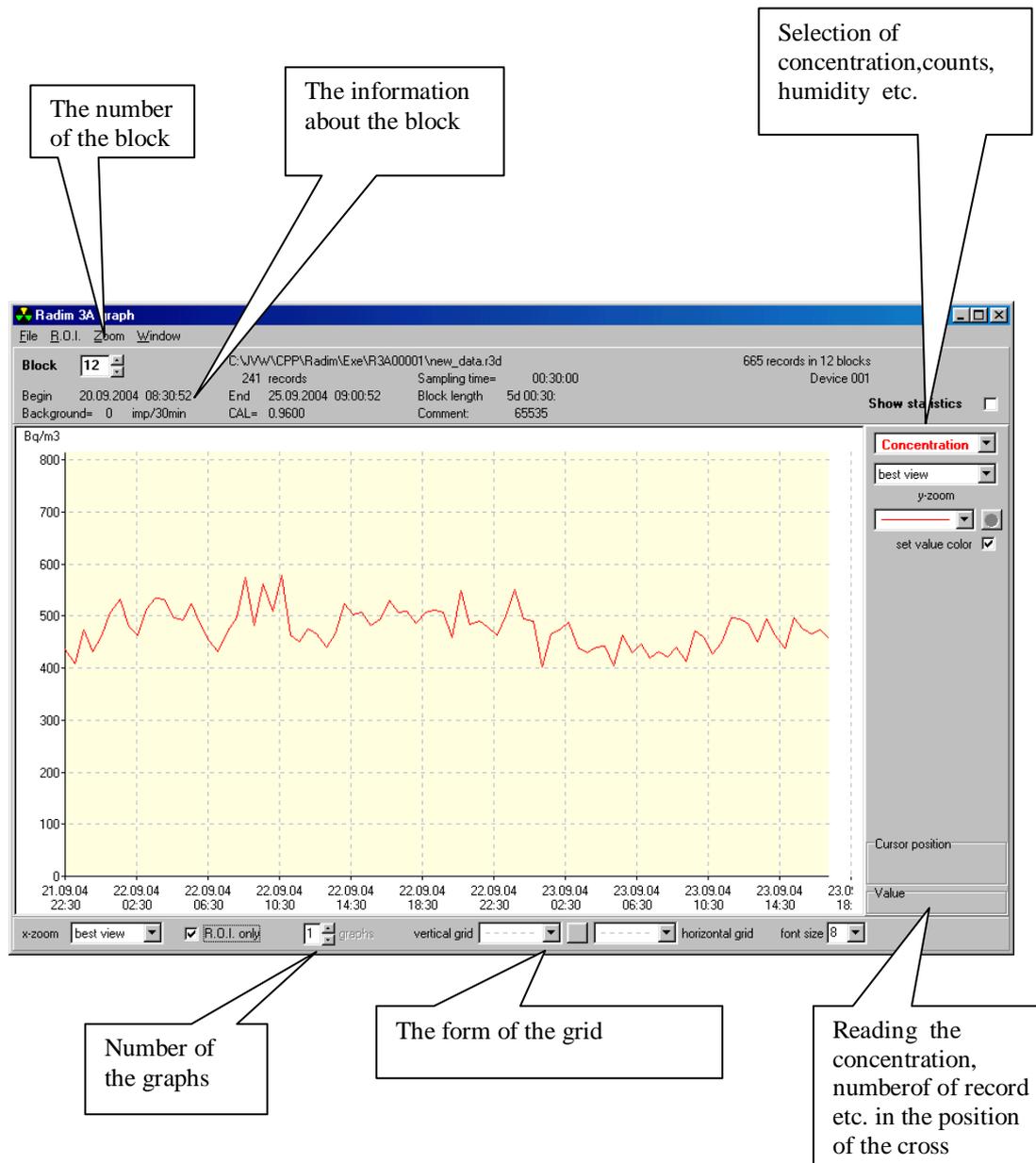
The value of concentration (counts etc), number of the record, date appears in this windows when the "cross" is moved in graph.

9.1.7-The data table of the selected block:
The data table can be depicted using the icon in the Main Panel or using service View- see Main panel. After selection of the service the following appears in the window:

Fig.7- The table of the selected block

Radim 3A data table

File R.O.I. Window

Block	8		C:\JVW\CPP\Radim\Exe\R3A00001\new_data.r3d			665 records in 12 blocks

Block 8

C:\JVW\CPP\Radim\Exe\R3A00001\new_data.r3d

47 records   Sample time= 00:30:00   665 records in 12 blocks   Device 001

Begin   16.08.2004 09:53:31   End   17.08.2004 09:23:31   Block length=   23:30:

Background= 0   cnt/30min   CAL= 0.9600   Comment: 65535

Record	Date & time	Block time	N [cnt]	Conc.[Bq/m3]	P [hPa]	T [°C]	Rh [%]	Ah [g/m3]
1	16.08.2004 09:53:31	00:00:	1158 ± 34	2377 ± 69	995.8	21.8	54.7	10.6
2	16.08.2004 10:23:31	00:30:	13250 ±115	27324 ± 236	995.7	21.8	58.3	11.3
3	16.08.2004 10:53:31	01:00:	9536 ± 98	19719 ± 201	994.7	21.9	60.1	11.7
4	16.08.2004 11:23:31	01:30:	3845 ± 62	7947 ± 127	994.7	22.0	59.4	11.7
5	16.08.2004 11:53:31	02:00:	1983 ± 45	4102 ± 91	994.4	21.9	60.3	11.8
6	16.08.2004 12:23:31	02:30:	1769 ± 42	3665 ± 86	994.0	21.7	62.3	12.0
7	16.08.2004 12:53:31	03:00:	1799 ± 42	3729 ± 87	993.3	21.6	63.1	12.1
8	16.08.2004 13:23:31	03:30:			92.9	21.6	64.0	12.3
9	16.08.2004 13:53:31	04:00:			92.6	21.5	64.9	12.4
10	16.08.2004 14:23:31	04:30:			92.5	21.5	65.6	12.5
11	16.08.2004 14:53:31	05:00:			92.5	21.4	66.2	12.5
12	16.08.2004 15:23:31	05:30:			92.1	21.4	66.7	12.6
13	16.08.2004 15:53:31	06:00:			91.9	21.4	67.5	12.8
14	16.08.2004 16:23:31	06:30:	1898 ± 44	3953 ± 90	991.4	21.4	67.6	12.8
15	16.08.2004 16:53:31	07:00:	1946 ± 44	4055 ± 91	991.4	21.4	68.1	12.9
16	16.08.2004 17:23:31	07:30:	1985 ± 45	4137 ± 92	991.3	21.3	68.6	12.9

Context menu:
Select all   Ctrl+A
Set as R.O.I.
Set as R.O.I. begin
Set as R.O.I. end
Deselect R.O.I.
Refresh last R.O.I.
Data Export   Ctrl+E

It is possible to mark time interval   using the left button of the mouse. Striking the right button of the mouse one can determine the R.O.I. (see later).

9.1.8- Determination of the R.O.I.:

Very often it is useful to evaluate the results from limited time interval, i.e. in Region Of Interest (R.O.I.- system). It can be done in the graph or in the data table.
Determination R.O.I. in the graph:
1. place the cross in the beginning of the needed time interval
2. pushing the left button of the mouse and keeping the button move to the end of the time interval
3. push the right button of the mouse and program offers the following possibilities:
- Set as R.O.I,
- Refresh last R.O.I.
- Select all , i.e. all data from the block.
The window changes to:

Fig.8- The graph of selected block with the R.O.I.
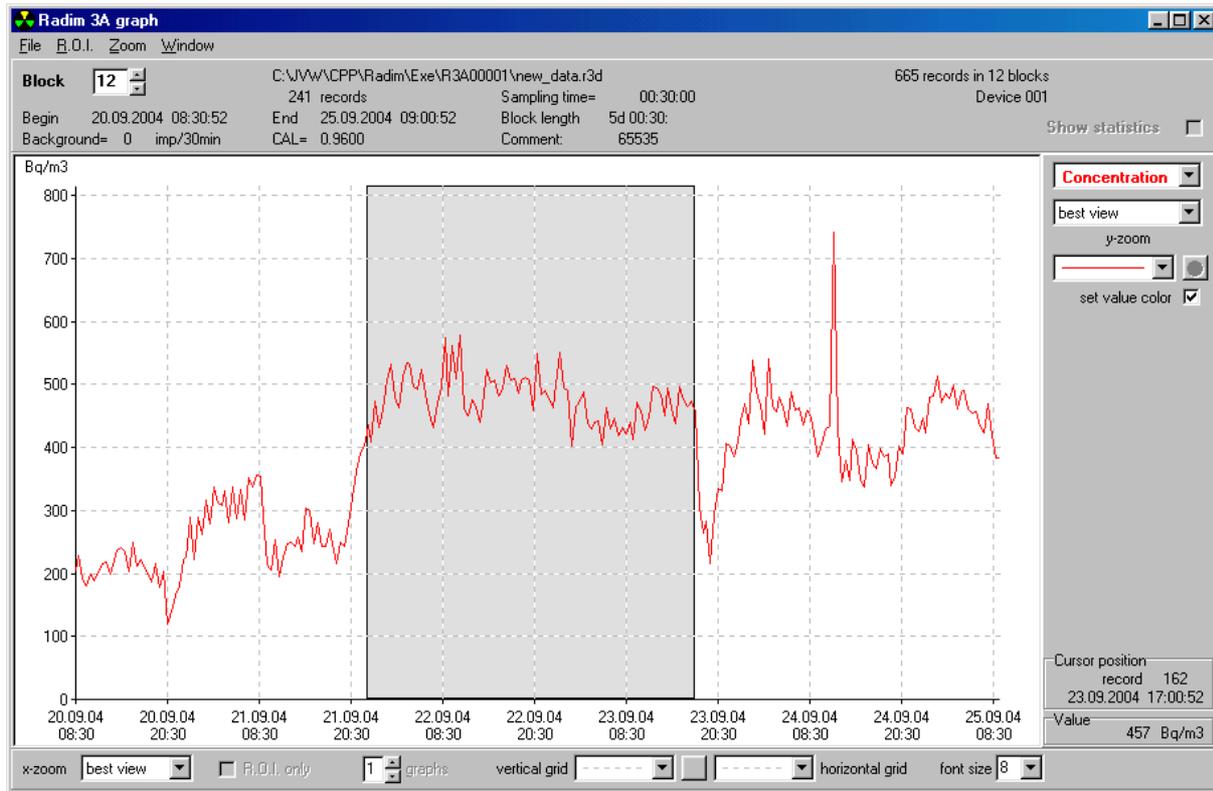
If the service "Set as R.O.I" is chosen it is possible to get **the statistical results of the R.O.I. clicking the icon "Show statistics"** (the upper right corner of the window) and selecting the version "R.O.I. only" (see the icon in the left side, lower line) Then the following window is depicted:

Fig.9- The graph of the R.O.I.
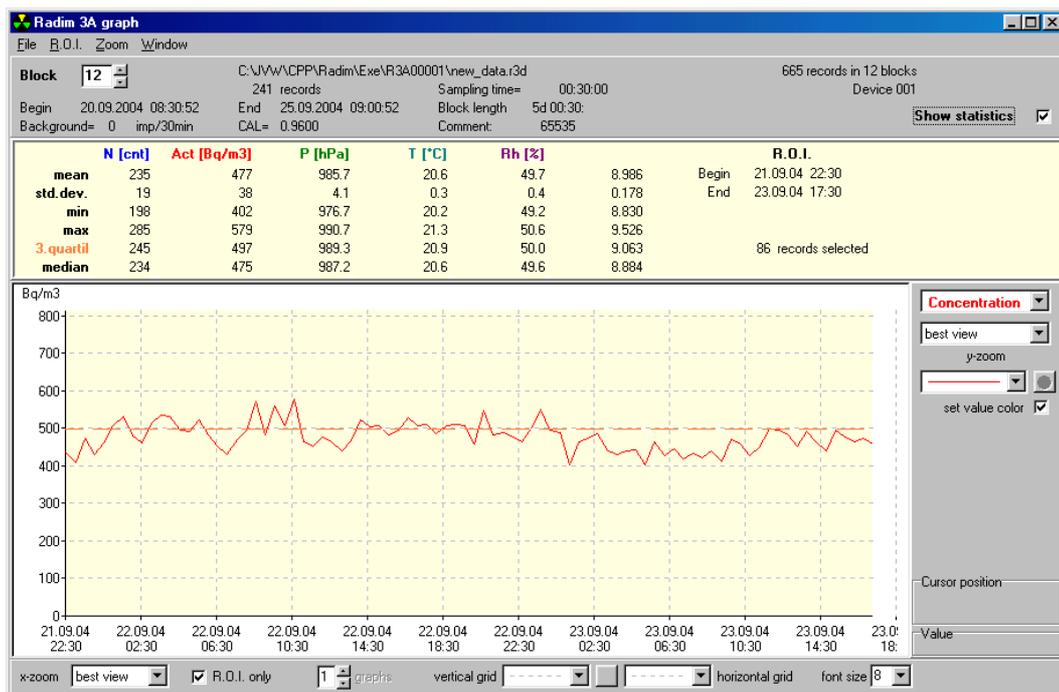
Determination of the R.O.I. in the data table of the selected block:
Click on the icon "data table of the block" placed in the Main panel, using the left button of the mouse, mark the time interval- records of the future R.O.I. and then push the right button of the mouse. When you choose "Set as R.O.I." the statistical treatment of the R.O.I. appears in the lower part of the window:

Fig.10- The data table with the R.O.I.

Radim 3A data table

File   R.O.I.   Window

Block 8   C:\JVW\CPP\Radim\Exe\R3A00001\new_data.r3d   665 records in 12 blocks
                 47 records   Sample time=   00:30:00   Device 001
Begin   16.08.2004 09:53:31   End   17.08.2004 09:23:31   Block length=   23:30:
Background=   0   cnt/30min   CAL=   0.9600   Comment: 65535

Record	Date & time	Block time	N [cnt]	Conc.[Bq/m3]	P [hPa]	T [°C]	Rh [%]	Ah [g/m3]
1	16.08.2004 09:53:31	00:00:	1158 ± 34	2377 ± 69	995.8	21.8	54.7	10.6
2	16.08.2004 10:23:31	00:30:	13250 ±115	27324 ± 236	995.7	21.8	58.3	11.3
3	16.08.2004 10:53:31	01:00:	9536 ± 98	19719 ± 201	994.7	21.9	60.1	11.7
4	16.08.2004 11:23:31	01:30:	3845 ± 62	7947 ± 127	994.7	22.0	59.4	11.7
5	16.08.2004 11:53:31	02:00:	1983 ± 45	4102 ± 91	994.4	21.9	60.3	11.8
6	16.08.2004 12:23:31	02:30:	1769 ± 42	3665 ± 86	994.0	21.7	62.3	12.0
7	16.08.2004 12:53:31	03:00:	1799 ± 42	3729 ± 87	993.3	21.6	63.1	12.1
8	16.08.2004 13:23:31	03:30:	1752 ± 42	3636 ± 86	992.9	21.6	64.0	12.3
9	16.08.2004 13:53:31	04:00:	1802 ± 42	3742 ± 87	992.6	21.5	64.9	12.4
10	16.08.2004 14:23:31	04:30:	1787 ± 42	3714 ± 87	992.5	21.5	65.6	12.5
11	16.08.2004 14:53:31	05:00:	1884 ± 43	3917 ± 89	992.5	21.4	66.2	12.5
12	16.08.2004 15:23:31	05:30:	1843 ± 43	3834 ± 88	992.1	21.4	66.7	12.6
13	16.08.2004 15:53:31	06:00:	1872 ± 43	3898 ± 89	991.9	21.4	67.5	12.8

R.O.I. statistics: 6 records selected   Begin 16.08.2004 12:53:31   End 16.08.2004 15:53:31   Length 03:00:

			N	Conc	P	T	Rh	Ah
mean			1811	3762	992.7	21.5	65.1	12.4
std.dev.			46	99	0.4	0.1	1.4	0.2
min			1752	3636	992.1	21.4	63.1	12.1
max			1884	3917	993.3	21.6	66.7	12.6
3.quartil			1802	3742	992.6	21.5	65.6	12.5
median			1799	3729	992.5	21.5	64.9	12.4

9.2.1- Saving the results in PC:
In the first step is useful to determine the directory, in which the data will be saved. Use the service " File" – see Main Panel and select "Data Root Directory"- the small window shows the path where data will be saved, for instant the path can be: C\Vlach\Data. In the following window you can see two sub-directory "R3A0001" and R3A0002". Explanation: each produced monitor has production number which is kept in the memory for instant R3A0001. Results of measurement of the used monitor are then automatically stored in the corresponding directory.

Fig.11- Saving the results in a file
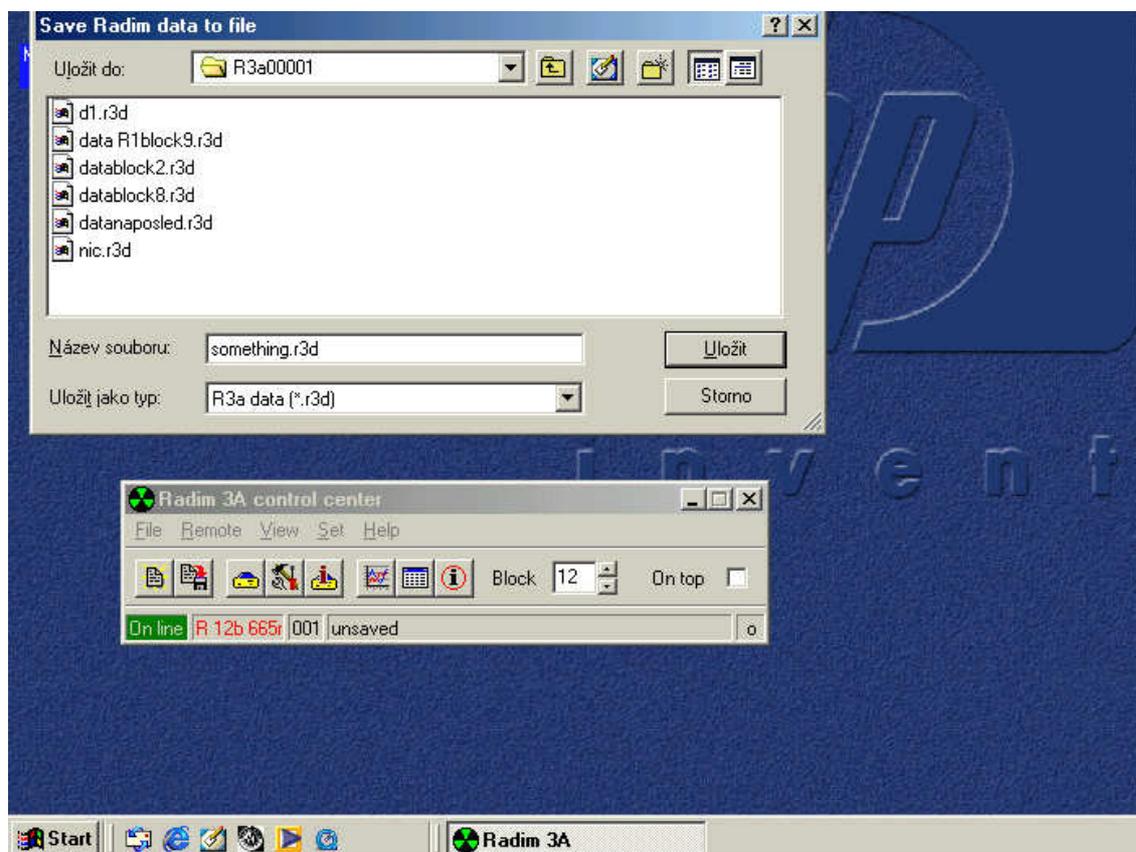
9.2.2- Export data to Excel (Word or similar)

The recommended procedure:
1. In the data table of the selected block mark the R.O.I.
2. Find the "Set" service in the Main Menu and then select service "Export format". The window is depicted in Fig.12.
3. Now it is possible to select what we want to export (concentration, counts, etc) and to adjust the format.
4. In the Main Menu the service "File" must be found and then the service "Data Export".
5. The similar window, as it is given in Fig.11, appears and then it is possible to write the name of the file but with extension ".csv".
6. To open the file in Excel or Word one must follow the proper path, for instant in our case: C\Vlach\ Data\R3A0001 and to find saved file with the name and extension csv in the sub-directory R3A0001 (or similar).

Fig.12- Set the export format
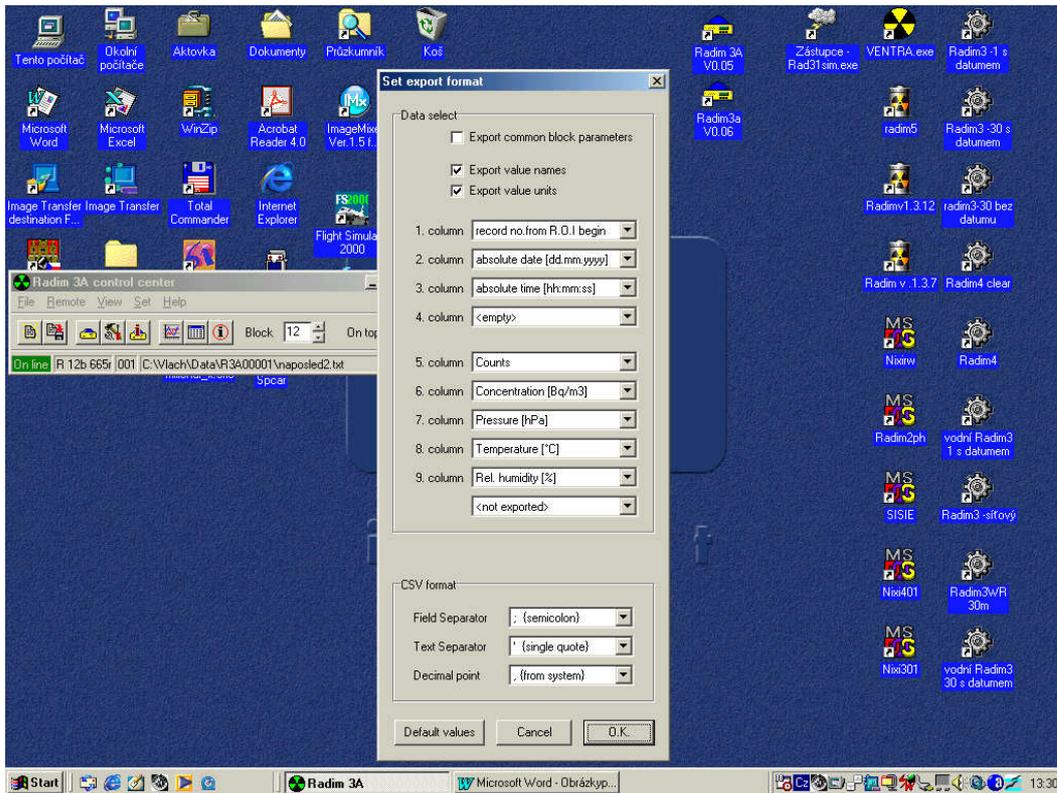
9.3.0- Information about the monitor parameters.

In the Main Panel select the icon of "Radim" with "i" and the following window is depicted:

Fig.13- The monitor parameters
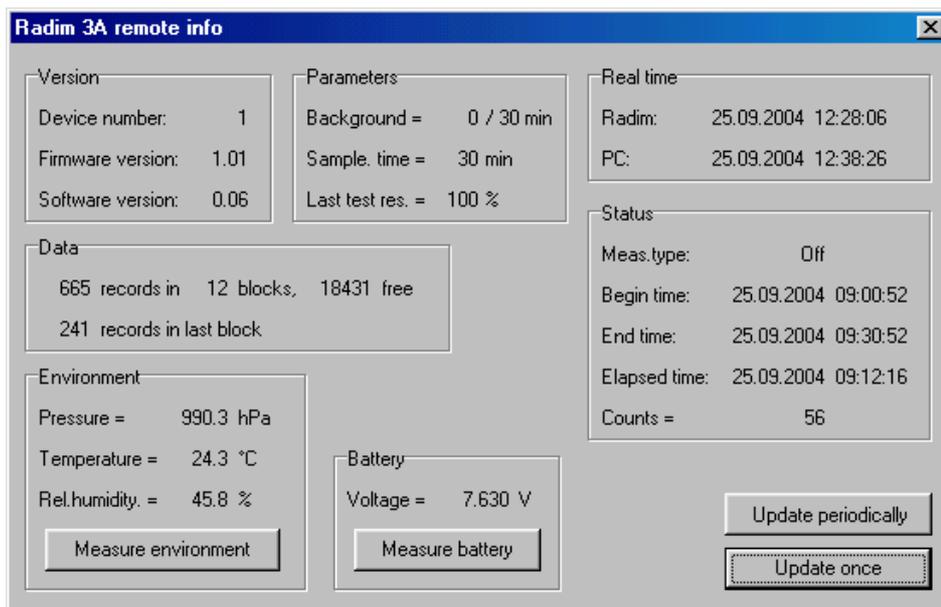
9.4.0- Remote control

In the Main Panel select the service Remote and Control and the following window is depicted:

Fog.13- Remote control of the Radim3A monitor
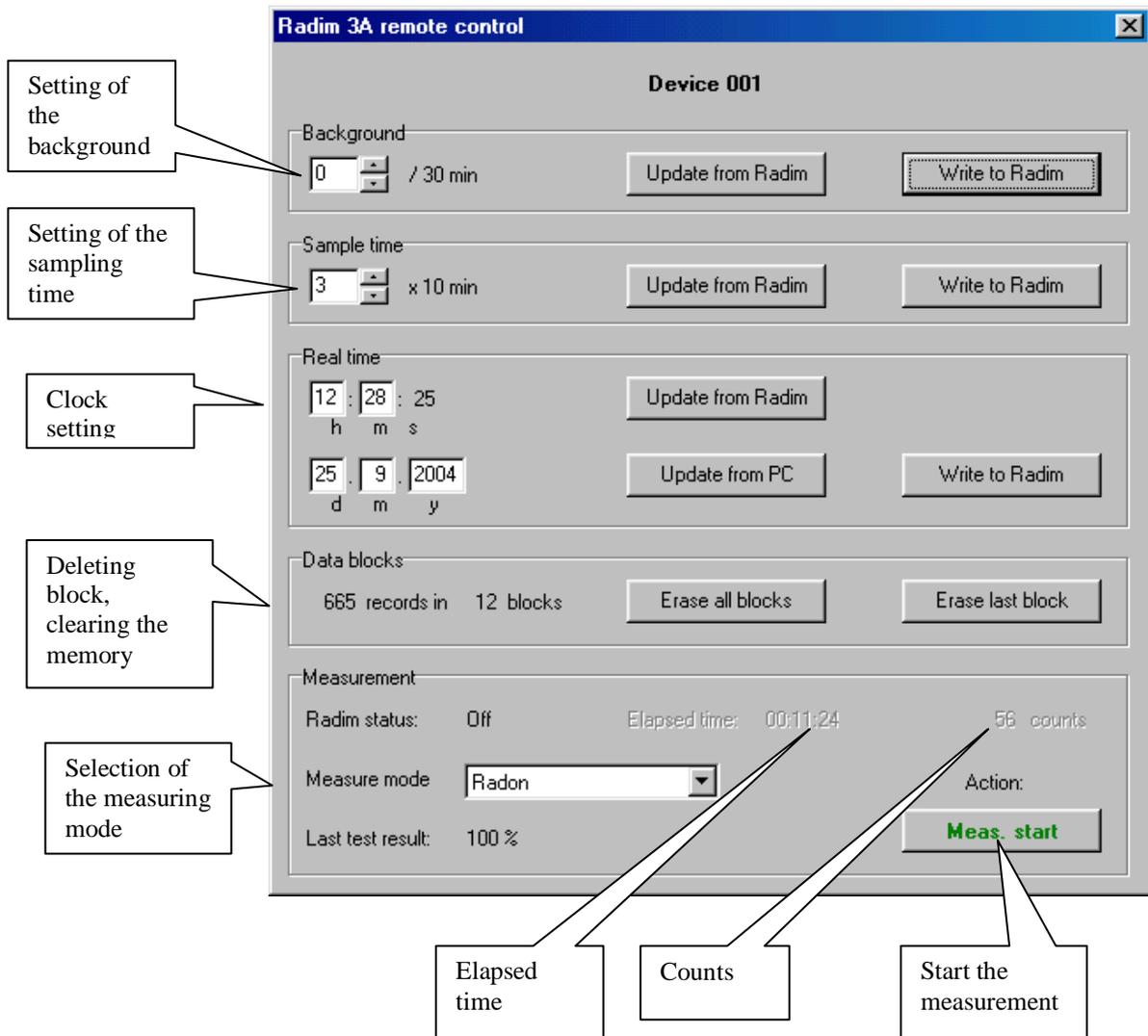
From the Fig. 13 it is clear what the service "Remote Control" offers. When we want to start "Test" , for instant, the mode Test must be selected and then clicking to small window "Meas. start" starts the measurement. The course of the measurement can be observed reading the elapsed time (time from the start of the measurement) and number of counts. Note: read the note in the Chapter 7.2.2- Test.