

**ThermoFisher**  
S C I E N T I F I C

*The world leader in serving science*

RadNose

**Personal Inhalation Dose Meter**  
**April 2008**

# Airborne Radiation Threats

- Threats from airborne radiation
  - Specifically material that can pose a threat
- Typical approaches
  - Standard air monitors
  - Monitoring versus samplers
- New approach to the problem
  - Smaller monitor
  - Less sensitive monitor
  - Different approach to reporting results

# Exposure Pathways

- Inhalation Dose Coefficient
  - Am-241 is  $4.2e-5 \text{ Sv Bq}^{-1}$
  - I-131 is  $7.4e-9 \text{ Sv Bq}^{-1}$
- External Dose Coefficient
  - Am-241 is  $6.74e-16 \text{ Sv s}^{-1} \text{ Bq}^{-1} \text{ m}^3$
  - I-131 is  $1.69e-14 \text{ Sv s}^{-1} \text{ Bq}^{-1} \text{ m}^3$
- Reference: Health Canada paper referencing ICRP (1996) Age-dependent doses to members of the public from intake of radionuclides: Part 5 Compilation of ingestion and inhalation dose coefficients. ICRP Publication 72. Ann. ICRP 26 (1), Pergamon Press, Oxford.
- Am-241  $0.074 \text{ Bq/m}^3$  (1 DAC) from Tom's handy reference.
- 10 CFR 835 states Am-241 DAC  $1e-1 \text{ Bq/m}^3$  (or  $5e-12 \text{ } \mu\text{Ci/ml}$ )

# Exposure to 1,000 DAC of Am-241 for 20 minutes

Internal Dose due to 1000 DAC	740	Bq/m <sup>3</sup>
Breathing Rate, Adult	2.00E+04	ml/min
Exposure Time	20	minutes
Activity in Lung	2.96E+01	Bq
Inhalation Dose Coefficient	4.20E-05	Sv/Bq
Dose in Sv	1.24E-03	Sv
Dose in mSv	1.24E+00	mSv
External Dose due to 1000 DAC	740	Bq/m <sup>3</sup>
External Dose Coefficient	6.74E-16	Sv s <sup>-1</sup> Bq <sup>-1</sup> m <sup>3</sup>
Exposure Time (seconds)	1200	seconds
Dose in Sv	5.99E-10	Sv
Dose in mSv	5.99E-07	mSv
Ratio:	2.08E+06	

# Math Issue? 10 CR 835 Federal Register January 2008

	<b>5E-12</b>	<b>μCi/ml</b>		<b>1E-01</b>	<b>Bq/m<sup>3</sup></b>
X	1.00E+06	μCi/Ci		1.00E-06	m <sup>3</sup> /ml
=	5.00E-18	Ci/ml		1.00E-07	Bq/ml
X	3.70E+10	Bq/Ci		2.70E-11	Ci/Bq
=	1.85E-07	Bq/ml		2.70E-18	Ci/m <sup>3</sup>
X	1.00E+06	ml/m <sup>3</sup>		1.00E+06	μCi/Ci
=	1.85E-01	Bq/m <sup>3</sup>		2.70E-12	μCi/ml
=	<b>2.E-01</b>	<b>Bq/m<sup>3</sup></b>		<b>3.00E-12</b>	<b>μCi/ml</b>

# Possible Scenarios?

- Availability of appropriate radioactive material
- Work at Sandia showed that explosions with small metal sources just moved them and created no appreciable airborne contamination.
- Troxler moisture gauge with 1.48 GBq (40 mCi) Am-Be source (compressed AmO<sub>2</sub> and Be powder)
- 20 Ci AmO<sub>2</sub> well-logging source (pressed ceramic powder)
- Standard instruments are available to resize powders making them more “deliverable”.
- Note: Beryllium is also very toxic! (and even harder to detect)
- Powders are much easier to suspend in a room than are metal sources...

# Emergency Response Air Monitoring

## ■ Real-Time Monitors

- Typically large, often not very portable, but can be vehicle mounted
- Not too convenient, not “immediate”
- May be more sensitive than required for accidents or “events”
- Configuration may not be straightforward or intuitive
- AC powered

## ■ Air Samplers

- Delayed and averaged measurements of activity
- Requires handling of air filters for retrospective analysis

## ■ Monitor Placement

- How many monitors do you need?
- Where do you place them for the best coverage?
- How do you respond to alarms?
- How do you maintain them for full coverage during the required time intervals?

# A “New Approach”

## ■ RadNose

- Portable, personal, small, convenient, battery operated
- Low flow rate with low maintenance requirements
- Measures both alpha and beta activity in air
- Spectroscopy used for Radon progeny suppression
- Low level measurement after the exposure without handling the filter
- Reports results in count rate and integrated dose
- Ideal supplement to gamma pagers for early detection and personal protection



# Personal Alpha and Beta in Air Monitor

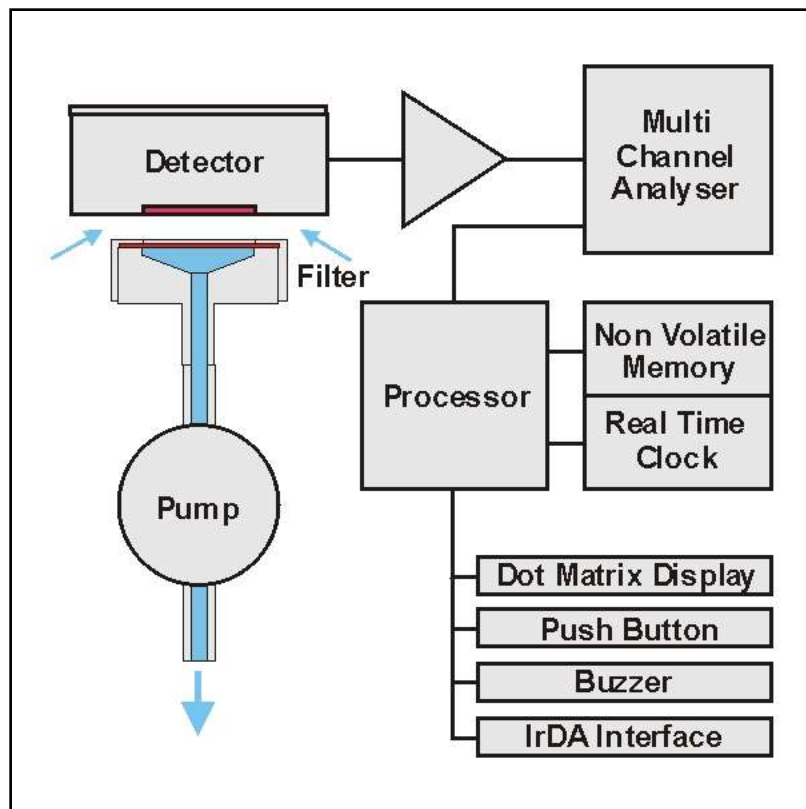


Spectroscopic Detector

- 1) Time, Alpha, Beta (cpm)
- 2) Alpha Dose (Rn compensated)
- 3) Beta Dose

Rechargeable battery for  
24 h operation

# MyRIAM - THEORY OF OPERATION



**Aerosol collection at the surface of a filter**

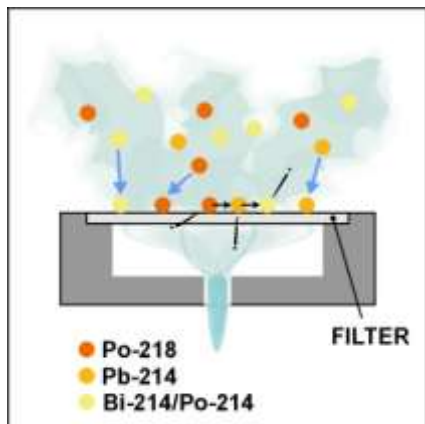
**Detection of Alpha & Beta particles using a semiconductor detector**

**Separation of long living Alpha Nuclides from Radon daughters by alpha-spectroscopy**

**Beta gross counting and natural background subtraction**

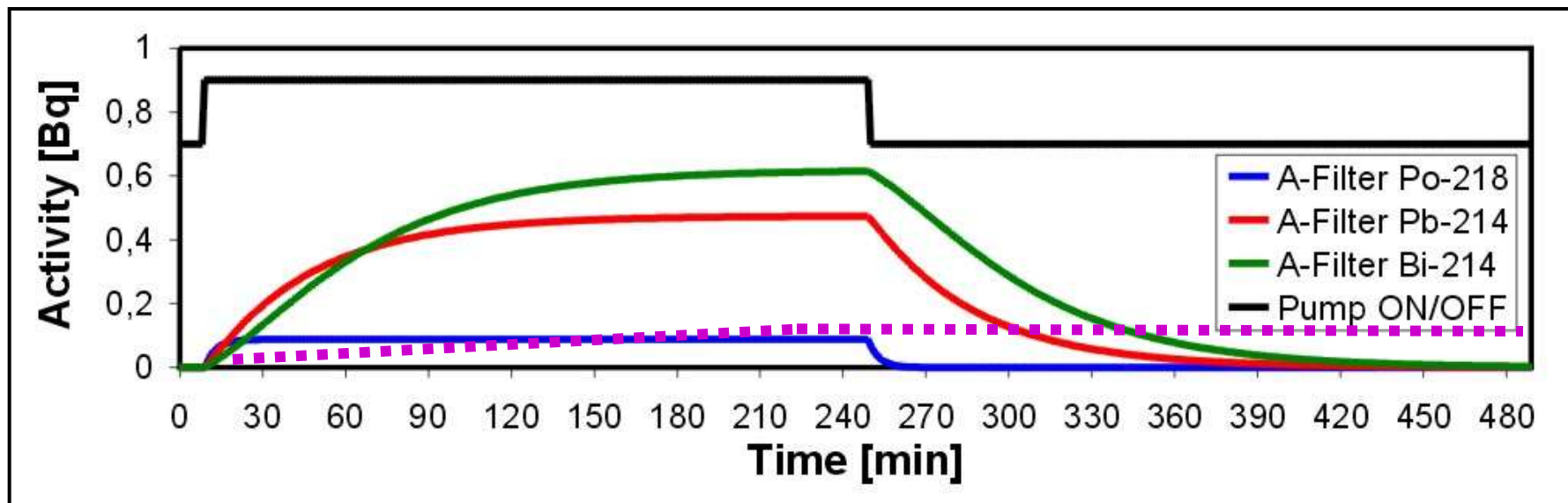
**Online calculation of non natural Alpha & Beta exposure**

# Theory of operation



Collection of Radon progeny on a filter  
Equilibrium between collection and decay  
after about 3 hours

Am-241 builds up during Pump ON  
..... remains when Pump OFF



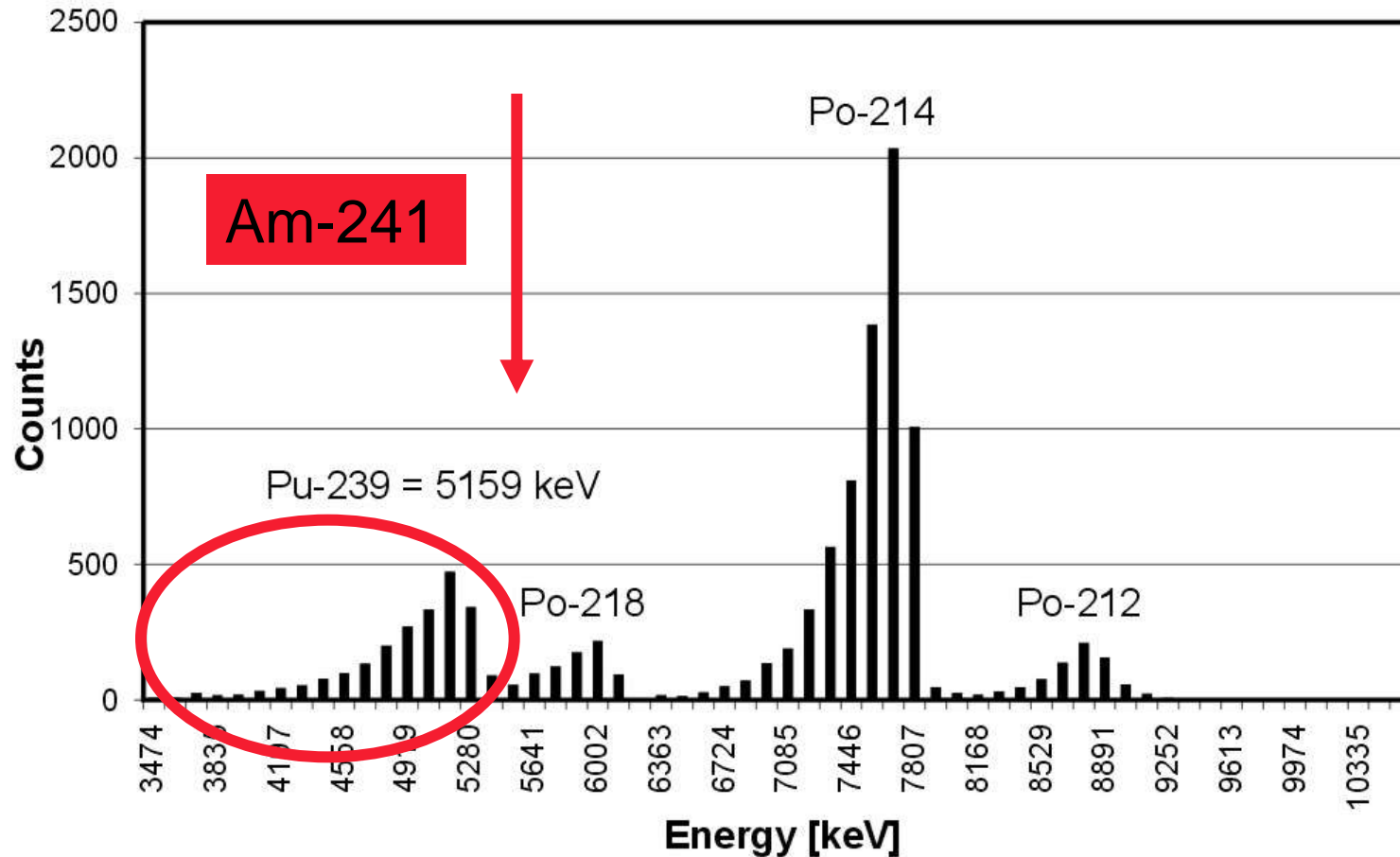
# TECHNICAL DATA

<b>Dimensions</b>	138 x 57 x 32 mm
<b>Weight</b>	300 g
<b>Battery operation</b>	over 40 hours
<b>Recharge time</b>	2 hours
<b>Basic sample interval</b>	1 min
<b>Data logging interval</b>	1...255 min (adjustable)
<b>Memory</b>	300 sequential ROI Data Records, Alpha Spectrum
<b>Pump rate</b>	0.25 LPM continuous sampling
<b>Filter operation time</b>	several weeks (normal ambient conditions)
<b>Alarm level</b>	adjustable

## Additional Features

One Button Control, Alarm Buzzer, Real Time Clock, Alphanumerical Display, Infrared Data Link, Non volatile Memory, Rugged Aluminium Cover, Windows™ Software, User Identification System

# Spectrum with LLRD and Rn-progeny



→ Spectral compensation of Po-218 spill-over required

# Airborne Radioactive Contamination

Sensitivity is suitable for emergency response and detection:

## Detection of Am-241:

Hazardous Levels > **200 DAC-h**  
(1/10<sup>th</sup> of annual limit for workers) in 1 min

Significant Levels > **10 DAC-h** in 60 min

## **Detection of Sr-90:**

Small levels > **5 DAC-h** within 1 min

**Low level detection (after mission, pump off)**

Very small levels > **1 DAC-h** within 1 min

# RadNose PC-Software

Parameter Setting:	History Interval (typically 10 min) Dose Alarm ( $\mu\text{Sv}$ ) Dose Coefficient Breathing Rate
Alpha Spectrum:	Accumulated, 60 channels
History:	Alpha Dose Beta Dose Alpha counts Beta counts Alpha Exposure Beta Exposure Alpha Average Concentration Alpha Average Concentration

# RadNose PC-Software

RadNose V1.1.3 [SN55\_3\_26\_2008 18-42 ... 3\_27\_2008 11-32.myr] ✕


**CONTROL**

COM1 ▾

**START**


**STOP**


**READ**



**OFF**

**DATA**





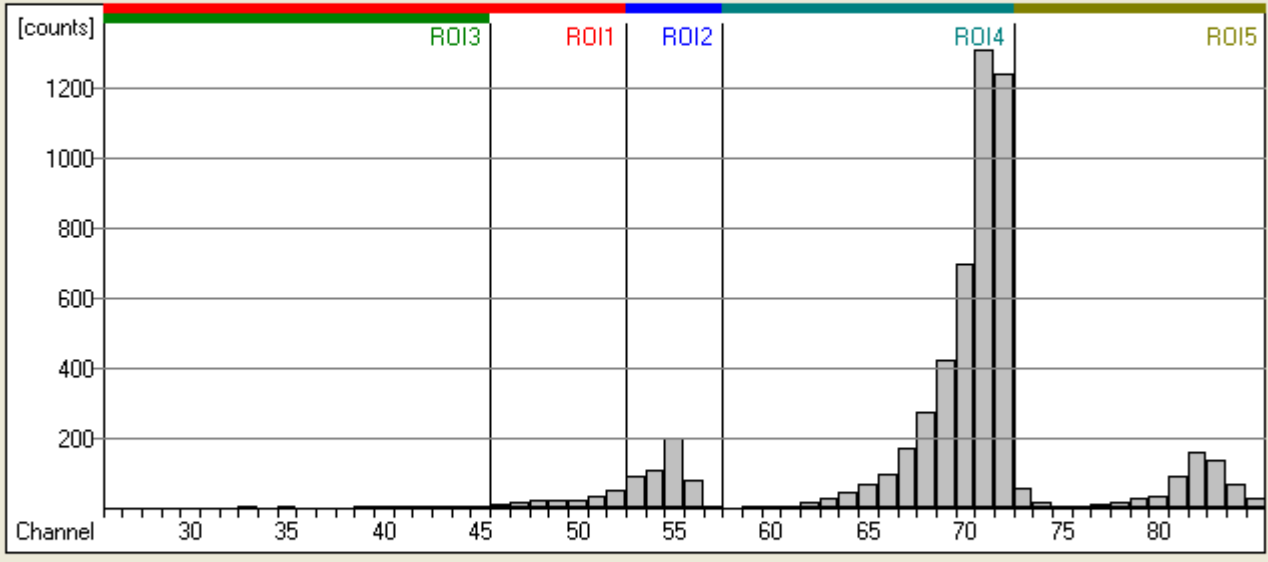
**TEXT**

SI -> US

**INFO**

S/N 55 FW:14    Sampling with Pump    User-ID 603    Label 1 0    Label 2 0    Label 3 0

26.03.2008 18:42 ... 27.03.2008 11:32    Interval 5 min    Messung im Büro




[counts]

Channel

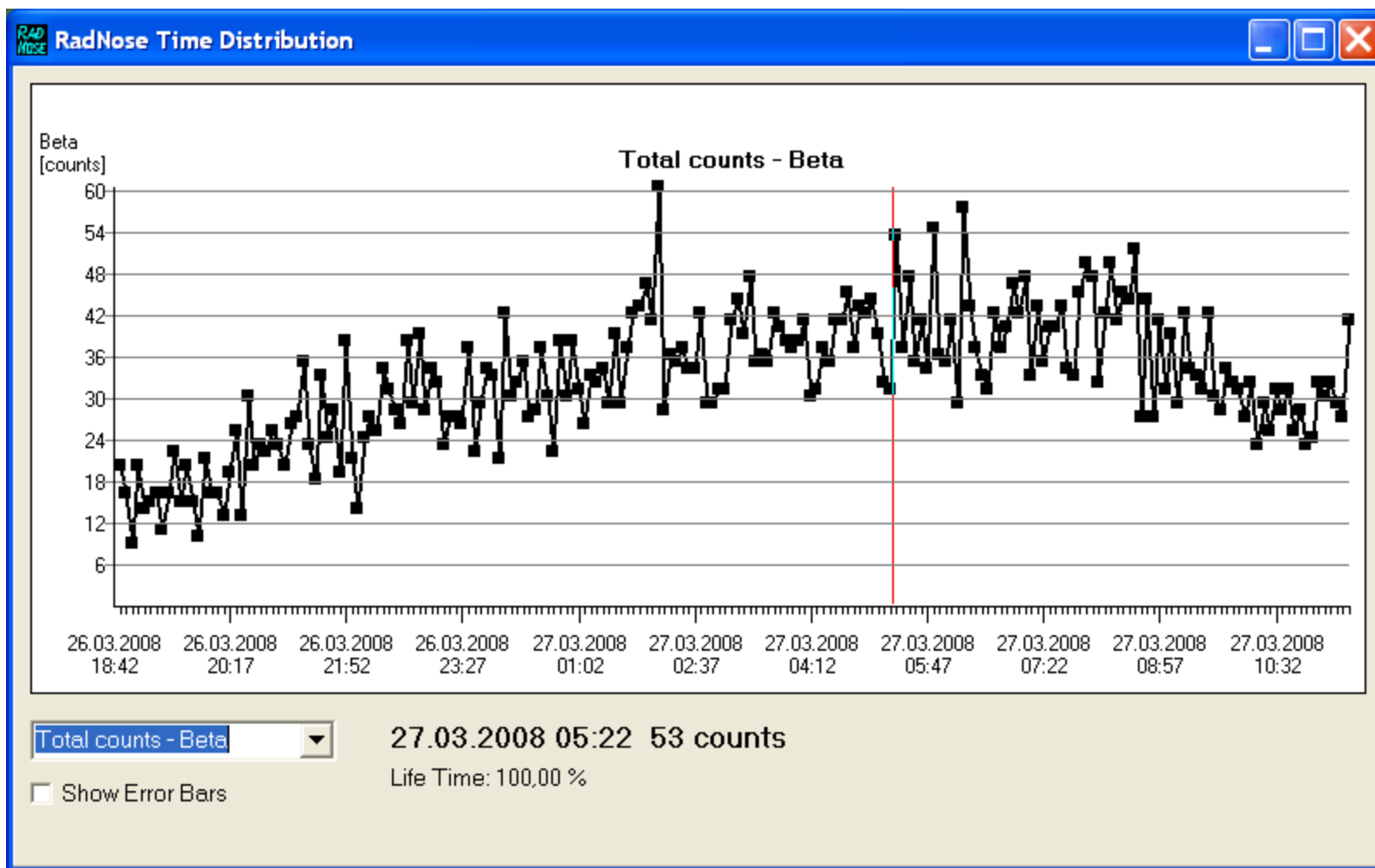
**RESULTS**    Recent

<b>Last Exposure Measurement</b>	<b>Dose Coeff. e(50)</b>	<b>Last Dose Measurement</b>
<b>ALPHA</b> < 18,89 Bqh/m <sup>3</sup>	4,70E-5 Sv/Bq	< 820,8 µSv
<b>BETA</b> < 58,55 Bqh/m <sup>3</sup>	1,50E-7 Sv/Bq	< 8,1 µSv

**Breathing Rate** 8100 m<sup>3</sup>/a 



# RadNose PC-Software

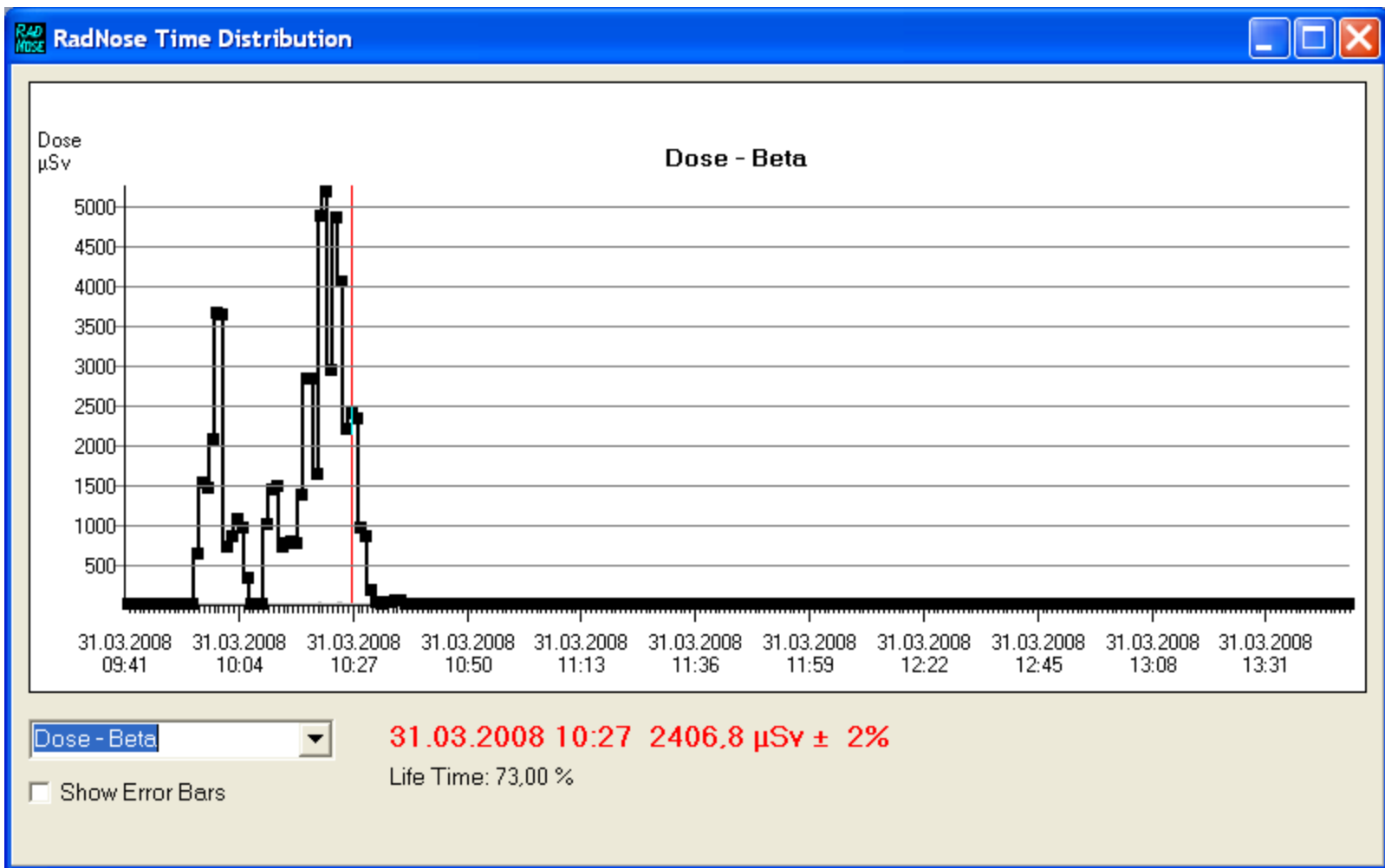


# Gamma Spill-Over into Beta Channel

## At 10 $\mu\text{Sv/h}$ (Cs-137):

- 150 cpm (“Beta” count rate-indication)
- approximately 0.2 mSv Beta Dose  
(calculated temporary inhalation dose, referring to Sr-90)
- beta dose display disappears when  
gamma exposure ends

# RadNose exposed to high Gamma Radiation



# RadNose Variants

## Security Applications:

- Alpha Detection and Dose Alarm (e.g. U, Pu, Am, Ra)
- Beta Detection and Dose Alarm (e.g. Sr/Y-90, Co-60, Cs-137)

## Uranium Industry:

- Alpha Detection and Dose Alarm (Uranium Dust )
- Radon Progeny Exposure and Dose Alarm

# Integrated Solutions

- ViewPoint and Matrix
- Provides Reach Back capability for RadNose as well as many other instruments
- Integrate different types of monitoring results (dose, spectrum) with time and location information
- Two way communications with the instruments
- Interface via cell phones, wireless networks, satellite communications
- Log data and view the same data in multiple locations

# Questions?

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