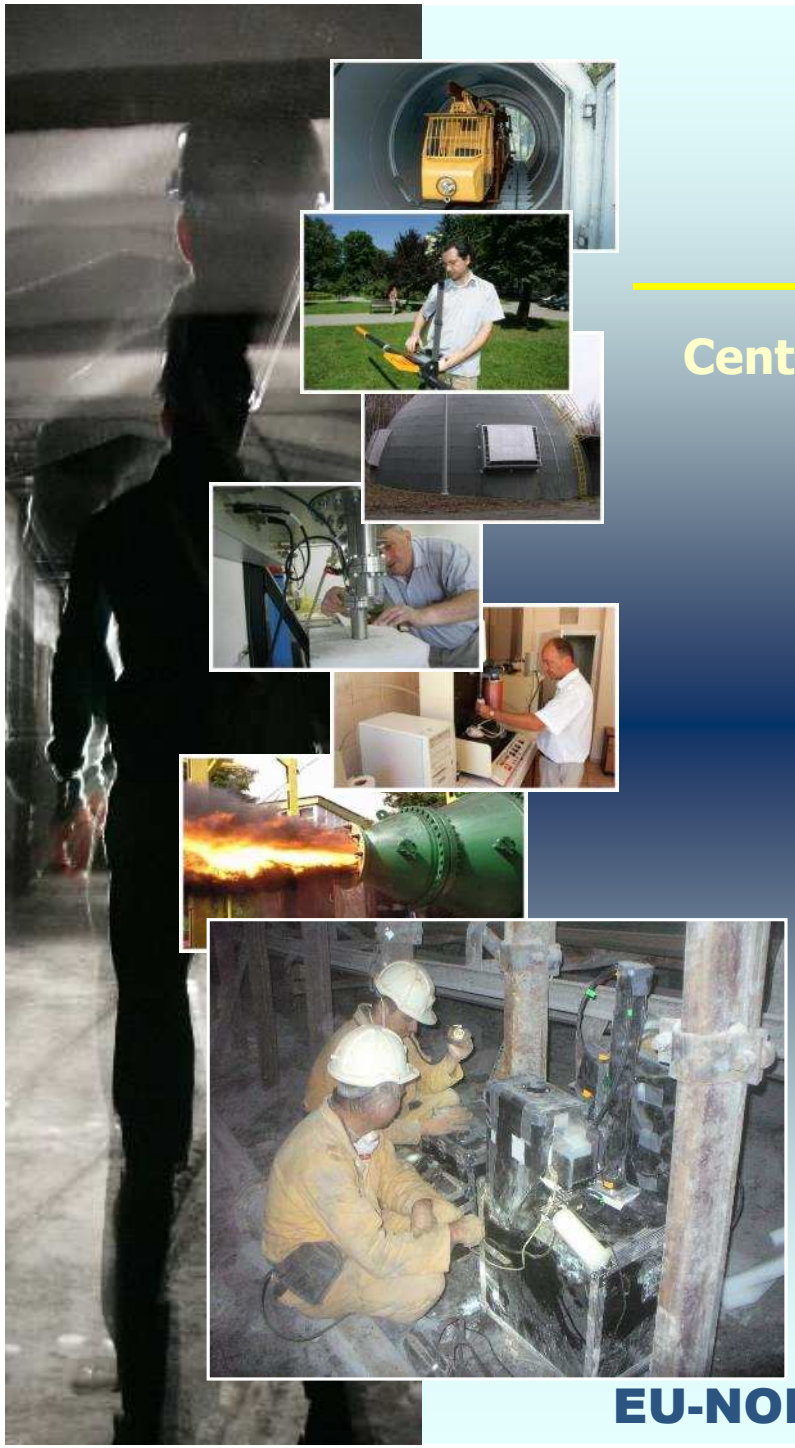

Central Mining Institute, Katowice, Poland

System of monitoring and control of the hazard caused by NORM in Polish coal mines

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General information

The radiation hazard is one of the natural hazards in underground mines like roof collapsion, mining-induced seismicity (earthquake-like events and tremors), fire, methane or coal dust explosion, gas and rock outburst, flood, bad climate (i.e. high temperature and humidity) …

The implemented system is based on the following assumptions:

- the primary goal is a preventive action;
- monitoring of radiation exposure should be carried out by existing mine services, preferably together with the monitoring of other hazards.

Sources and pathways of radiation risk in a coal mine

- **Radon and radon progeny** – the source of direct radiation risk to miners due to inhalation
- **Formation water with abnormal concentration of radium** – the carrier of pollution and the source of sediments with enhanced concentration of radium isotopes

OCCUPATIONAL RISK

Decree of Ministry of Economy from 28th June 2002

on work safety and hygiene, exploration technology and fire safety and security equipment in underground mines.

With amendment from 9th June 2006.

Establishes, for radiation risk caused by natural radioactivty:

- Monitoring methods
- Monitored places
- Monitoring frequency
- QA and QC
- Qualification of personnel involved

OCCUPATIONAL RISK

Source of risk	Measured quantity	Working limits	Frequency of measurement
Radon E_α	C_α - potential alpha energy concentration (PAEC) $\mu J \times m^{-3}$	$C_\alpha \leq 0.5$	Once per 3 months
		$C_\alpha > 0.5$	Monthly
External gamma radiation E_γ	**K** – air kerma rate, $Gy \times h^{-1}$	**K≤ 0.5**	Once per year
		K > 0.5	Once per 3 months
Committed dose based on:	E_{Ra} – effective committed dose caused by inhalation and accidental ingestion of water and sediments $mSv \times y^{-1}$		
Formation water	C_{RaW} – radium activity concentration $^{226}Ra + ^{228}Ra$	>1 kBq/m^3	Once per year
Sediment	C_{RaO} – radium activity concentration $^{226}Ra + ^{228}Ra$		Once per year

$$E = E_\alpha + E_\gamma + E_{Ra}$$

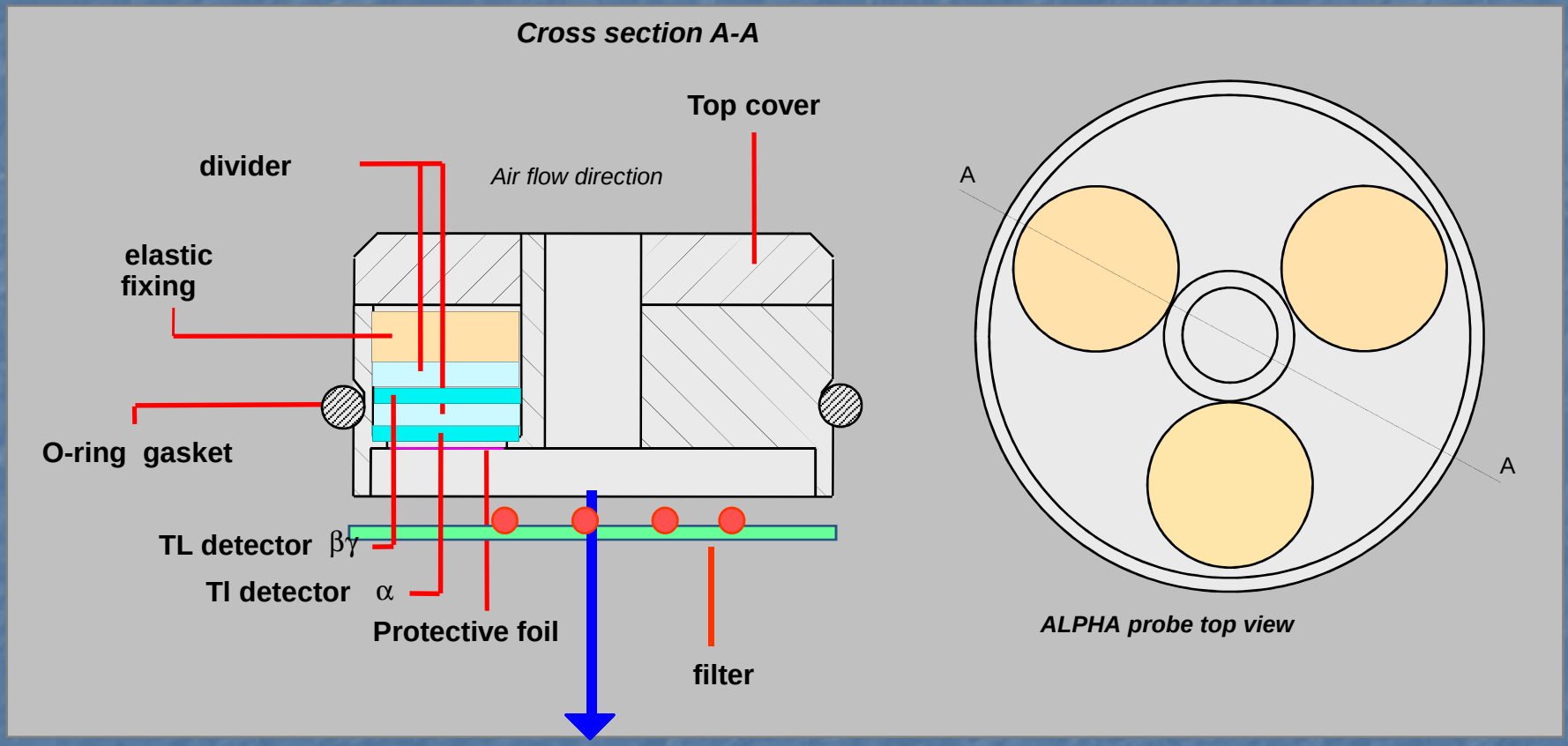
Methods and equipment

Effective dose corresponding to PAEC

$$E_{\alpha} = 0{,}0014 \times (C_{\alpha} + \Delta C_{\alpha} - C_{\alpha \mathrm{Tlo}}) \times t$$

E_a	effective dose corresponding to PAEC, mSv
C_a, ΔC_a, C_{aTlo}	PAEC, PAEC total uncertainty and PAEC background respectively, μJ m^{-3}
t	exposure time , h

ALFA-2000 probe



TL detectors: $CaSO_4$: Dy detection of alpha particles

Integrating measurement devices

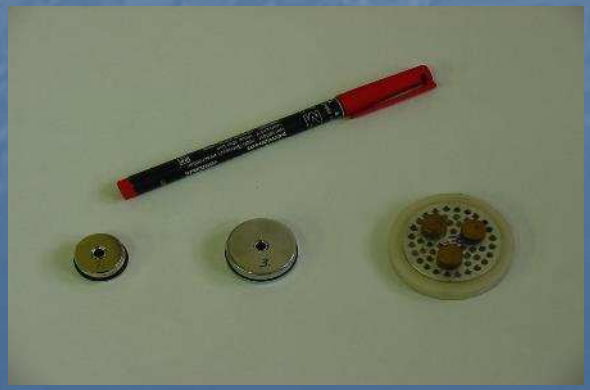
Aspirator AP-2000 EX

Aspirator SKC 224-PCEX8

Dust sampler Barbara 3a

The cyclone separates out the respirable fraction which is then collected on the filter.

Inside, in the cyclone, is placed the alpha probe with TL detectors that detect radiation emitted by aerosols collected on the filter.



PAEC grab sampling

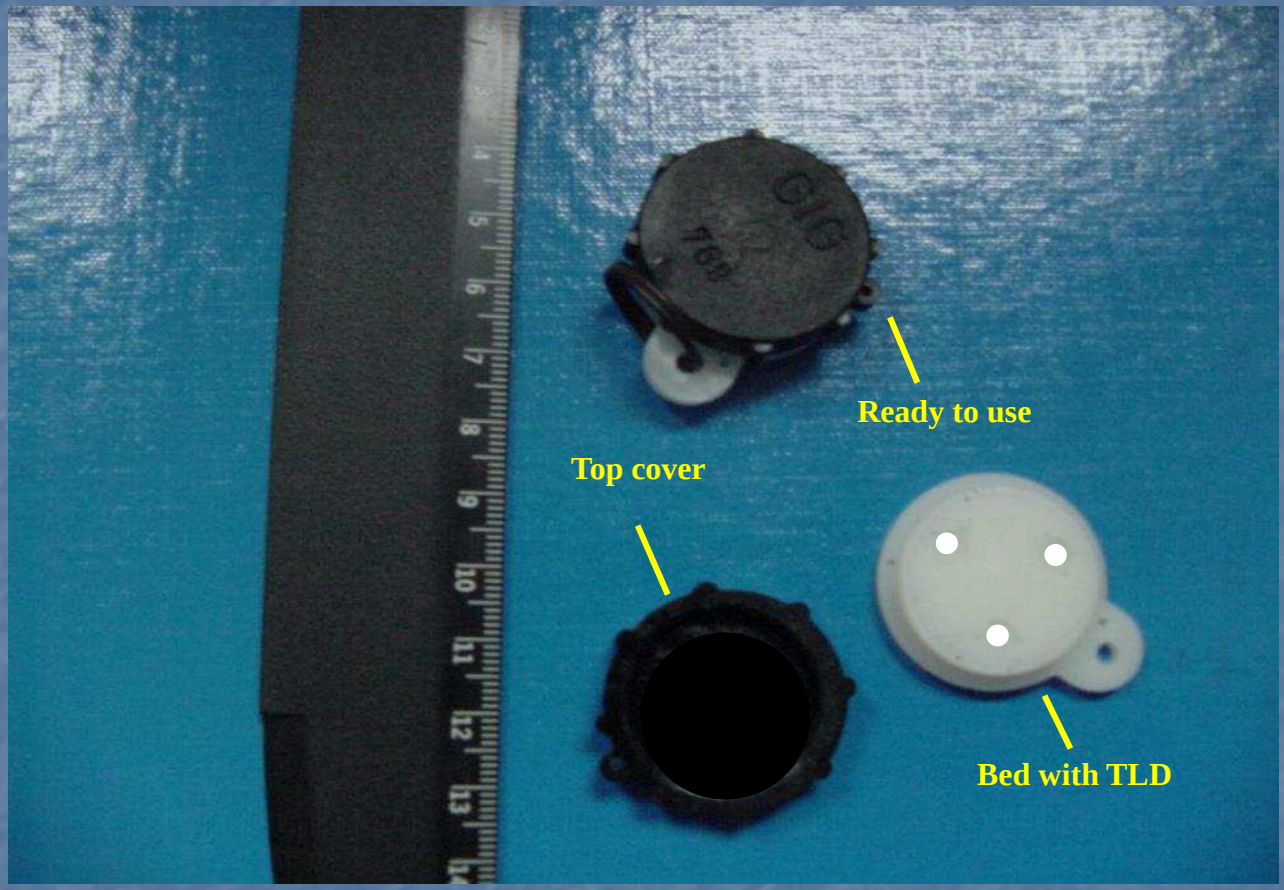
- RGR 40 – working in Markov cycle

Exposure to external gamma radiation

$$E_\gamma = 0{,}0014 \times (\dot{K} + \Delta\dot{K} - \dot{K}_{Tlo}) \times t$$

E_γ	effective dose derived from exposure to external radiation, mSv
K, ΔK, K_{Tlo}	kerma, kerma uncertainty and background, respectively, μGy/h
t	exposure time, h

Gamma-31 dosimeter



TL detectors LiF:Mg, Cu, P for gamma radiation

Effective committed dose caused by accidental intake of water and sediments

Evaluated on base of 5 typical risk scenarios,
taking in to account:

- Dust concentration in air,
- Air relative humidity,
- Breath rate,
- Application of respiratory tract protection means,
- Radium activity concentration in water and sediment .

Radium activity concentration in formation water

- Liquid scintilation spectrometry
- Measured radionuclides: ^{226}Ra & ^{228}Ra
- Units: $kBq \times m^{-3}$

Radium activity concentration in sediments

- High resolution gamma spectrometry
- Measured radionuclides: ^{226}Ra & ^{228}Ra
- Units: $Bq \times kg^{-1}$

Underground work places classification

Decree of Ministry of Internal Affairs from 20th September 2004

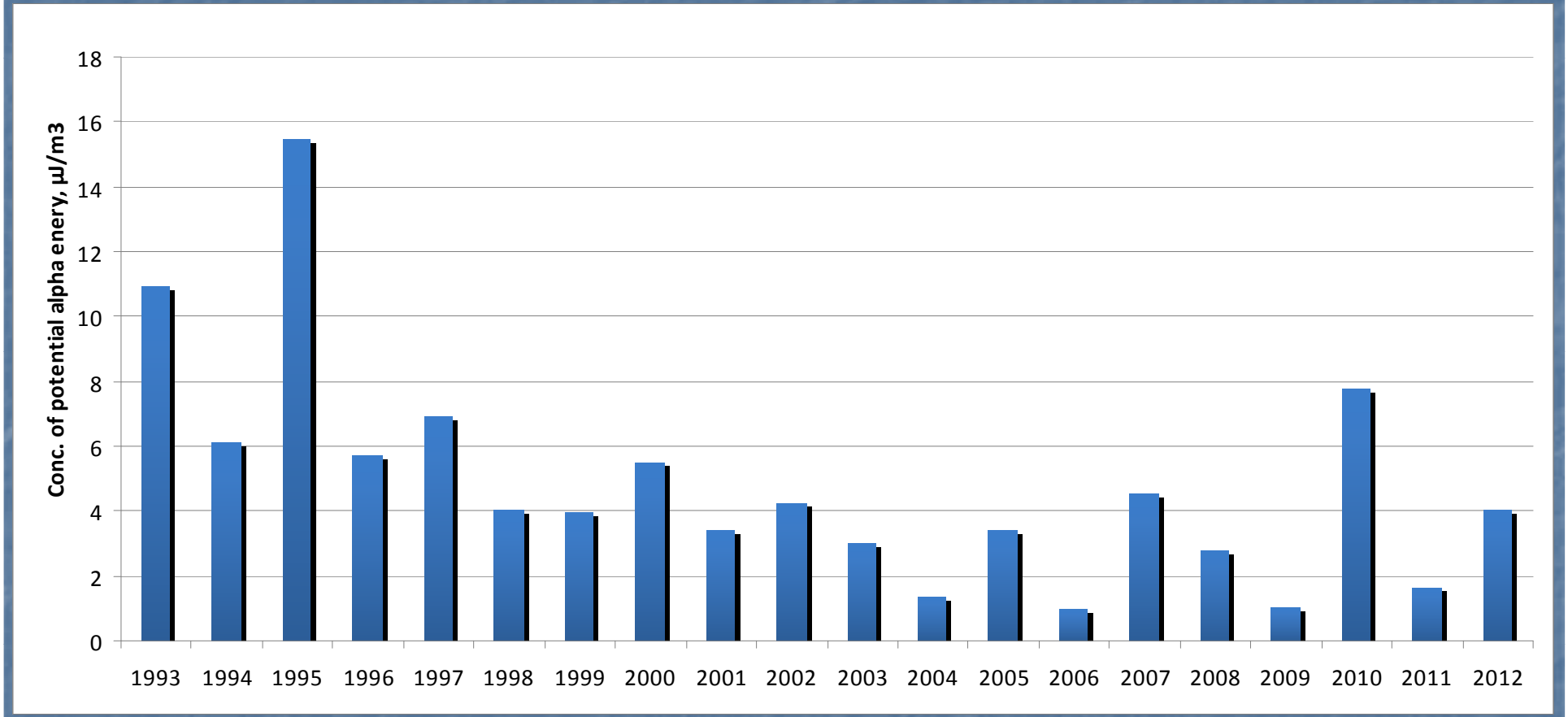
Category A – underground work places where miners are exposed to effective dose higher than 6 mSv per year

*Corresponding to **restricted area** in the meaning of **Atomic Law***

Category B – underground work places where miners are exposed to effective dose higher than 1 mSv per year

*Corresponding to **supervised area** in the meaning of **Atomic Law***

Maximum values of measured PAEC years 1993-2012



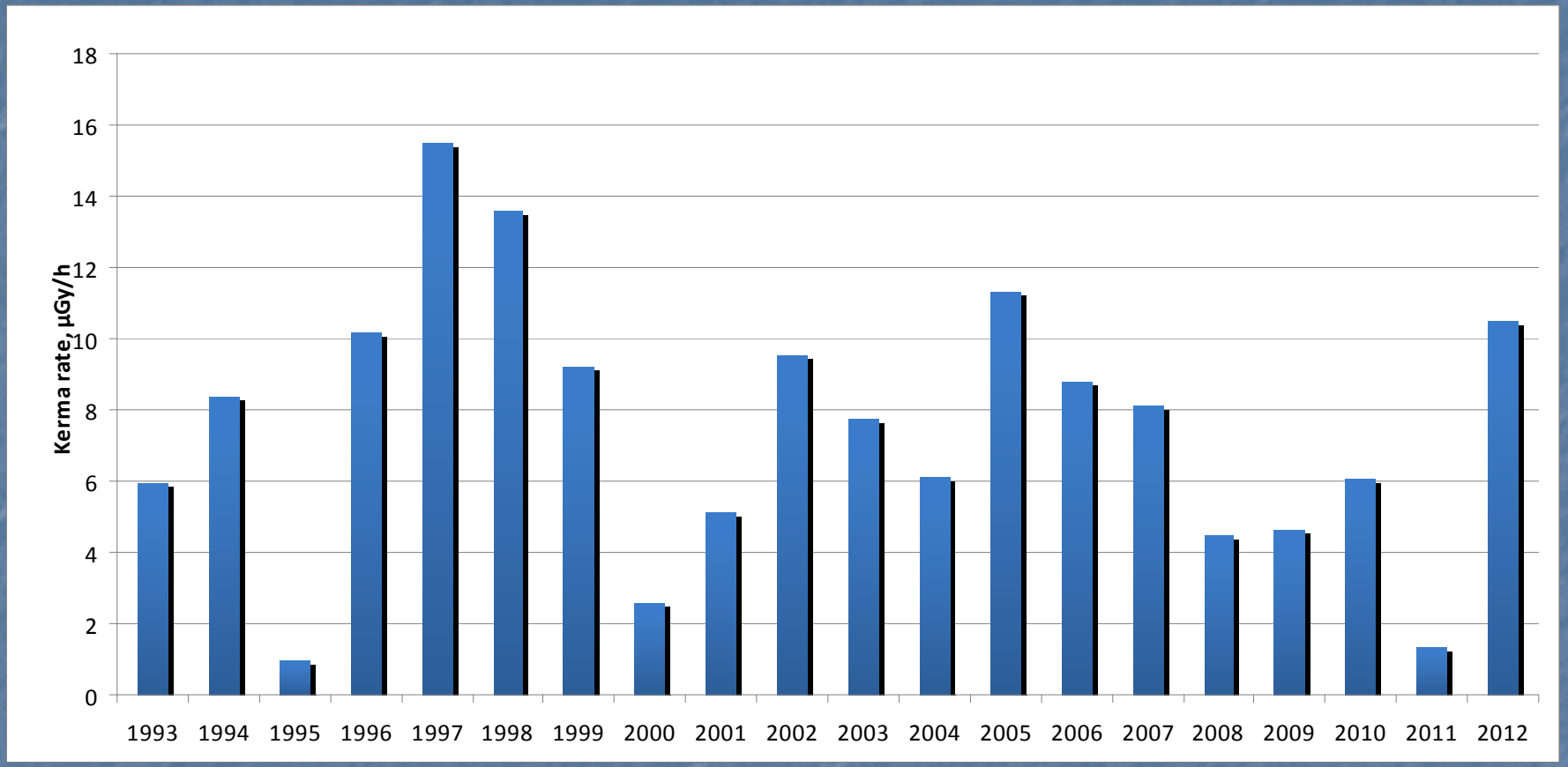
Assumption to effective dose, E, calculation:

PAEC background = 0,1 µJm^{-3},

total measurement uncertainty = 10%,

working time = 1800 h

Maximum values of measured air kerma rate years 1993-2012



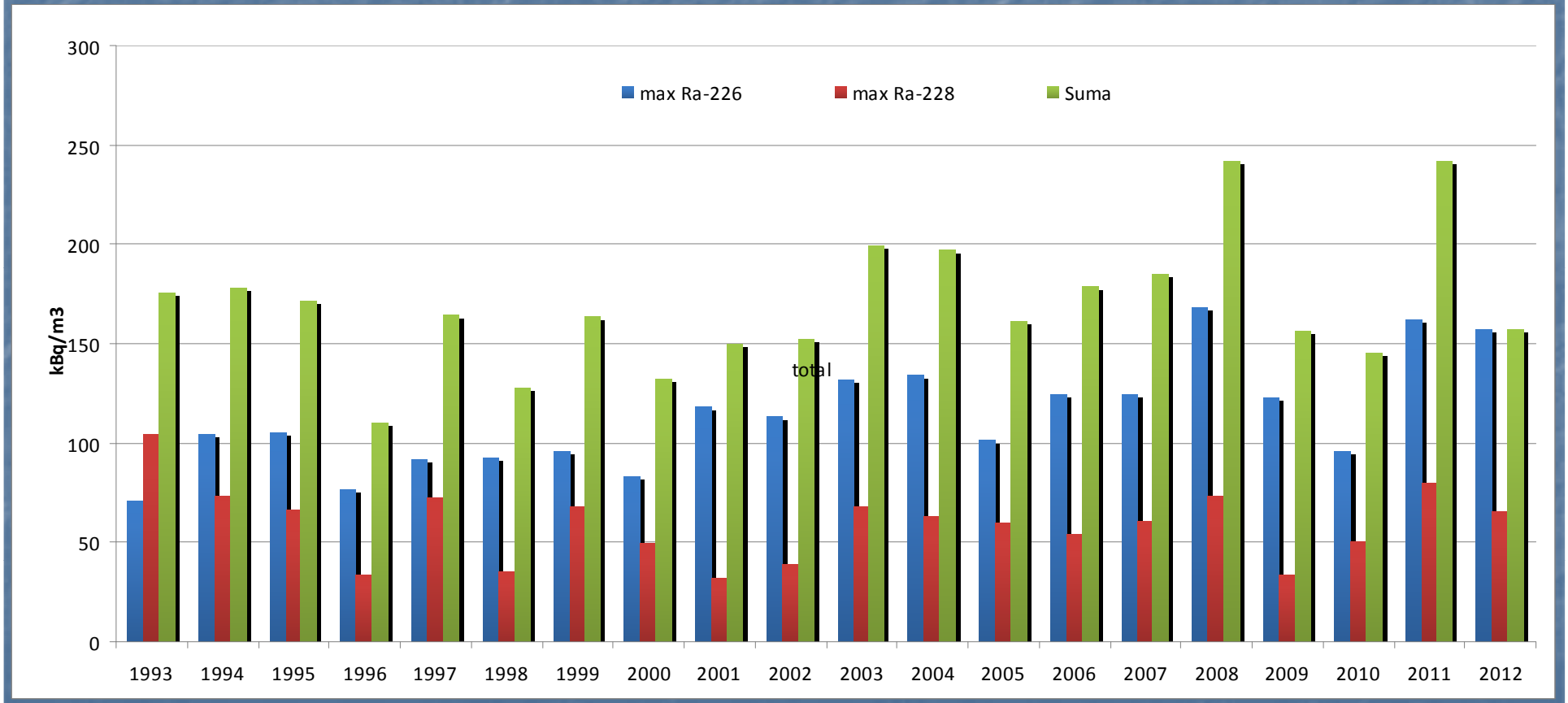
Assumption to effective dose, E, calculation:

background = 0.1 µGyh^{-1},

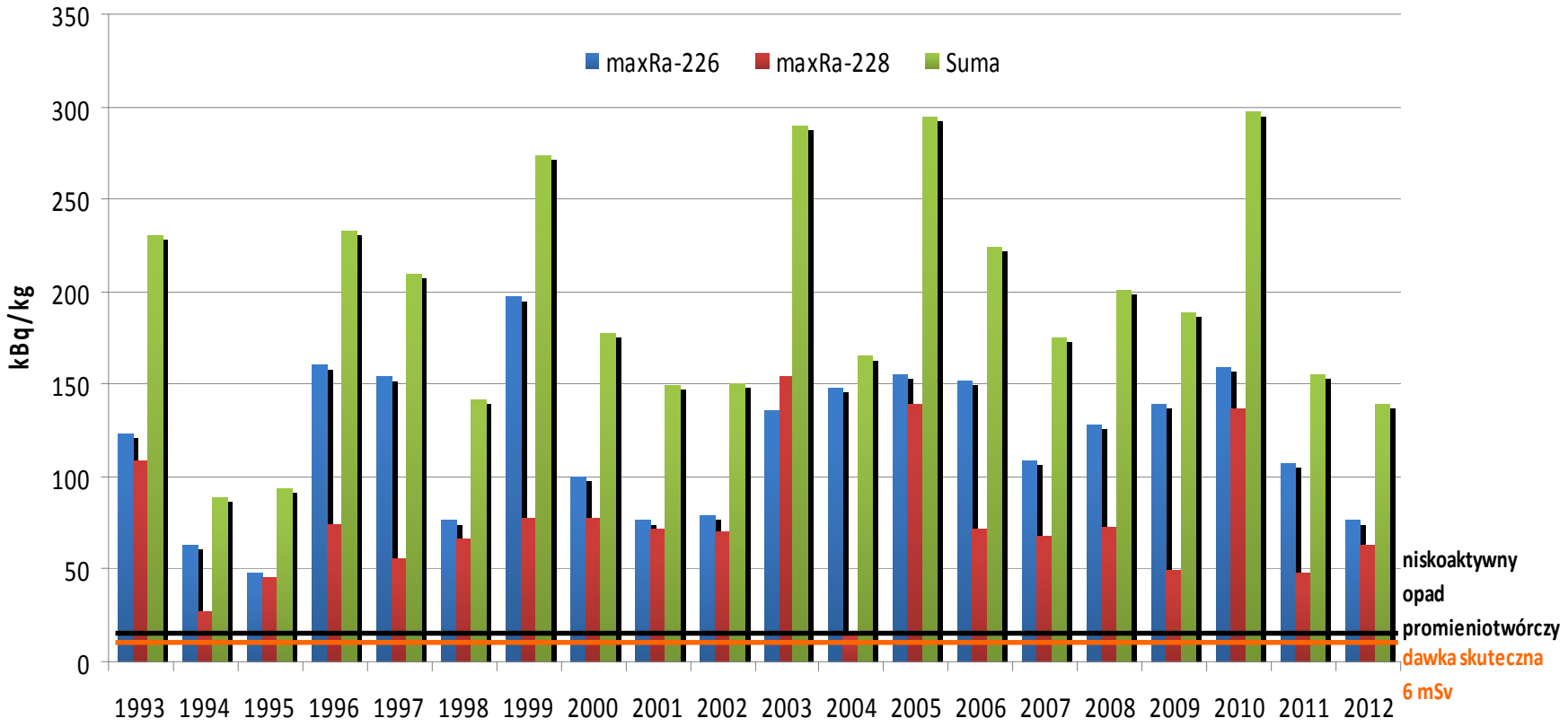
total measurement uncertainty = 10%,

working time = 1800 h

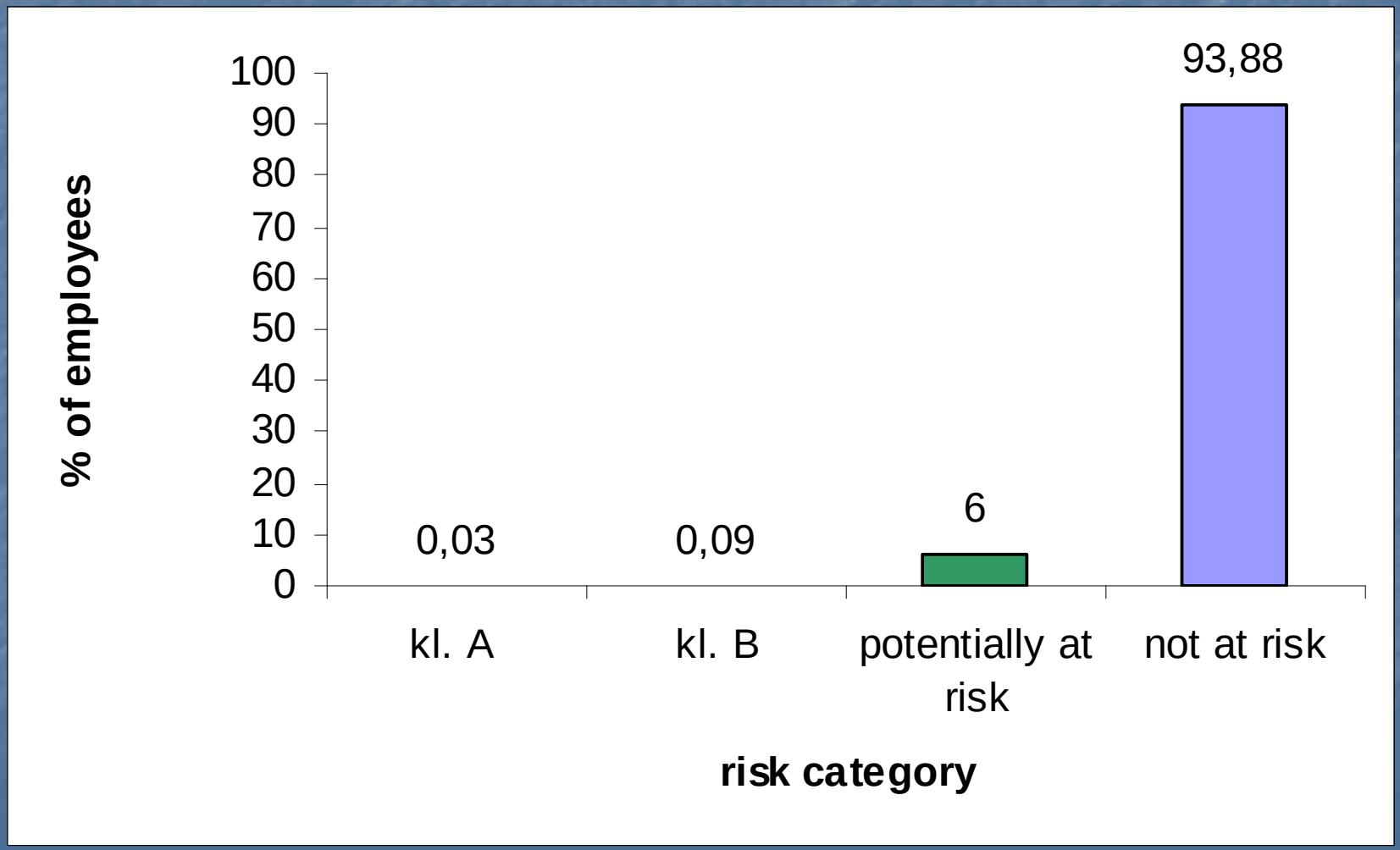
Maximum values of radium activity concentration in formation water , years 1993-2012



Maximum values of radium activity concentration in sediments, years 1993-2012



The proportions of the total number of miners working in particular work places, %

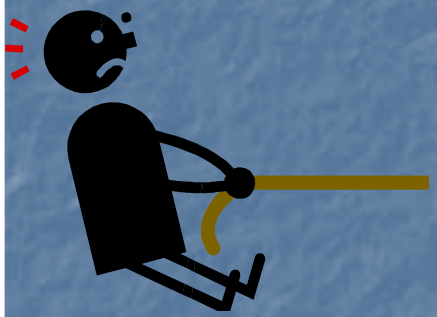


Conclusions

The system of the monitoring of radiation hazard in Polish mining industry is a unique, complete, first implemented in non-uranium industry. This system permits not only the assessment of miners exposure but due to the fact, that results can be obtained quickly, provides data necessary for preventive measures.

Important part of the system is the training of miners, managers, the staff of different services (ventilation specialists. hydrogeologists, geologists etc.). The training makes the co-operation easier and useful for all partners (i.e. mine services and laboratory providing measurements).

Radiation risk countermeasures



- Optimisation of ventilation network at the designing level
- Modification existing ventilation network
- Radon sources discrimination (sealing)
- Air filtration (individual or at work places)
- Water cleaning
- Controlled sediment precipitation
- Sediment removing
- Personnel training and principal rules of work hygiene emphasise

Environment:
mine water destination …

but it is an another story ……

The system of radiation risk monitoring in hard coal mining industry has been developed and is carried out by team of

Silesian Centre for Environmental Radioactivity

(former **Laboratory of Radiometry**), **GIG**:

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Thank you for the attention !