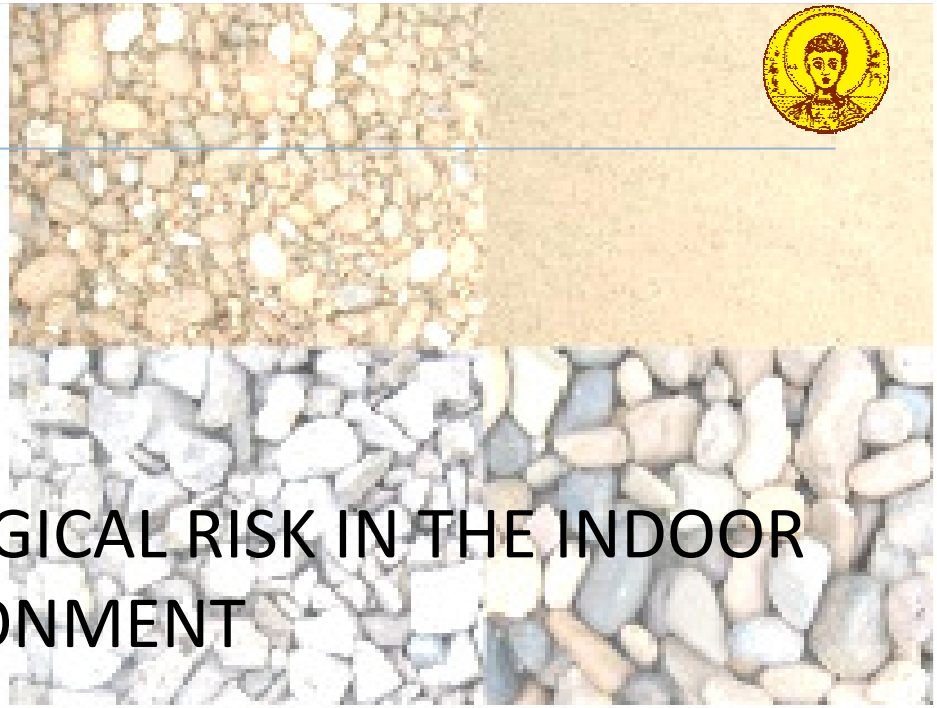
# CheRRIE



# CHEMICAL AND RADIOLOGICAL RISK IN THE INDOOR ENVIRONMENT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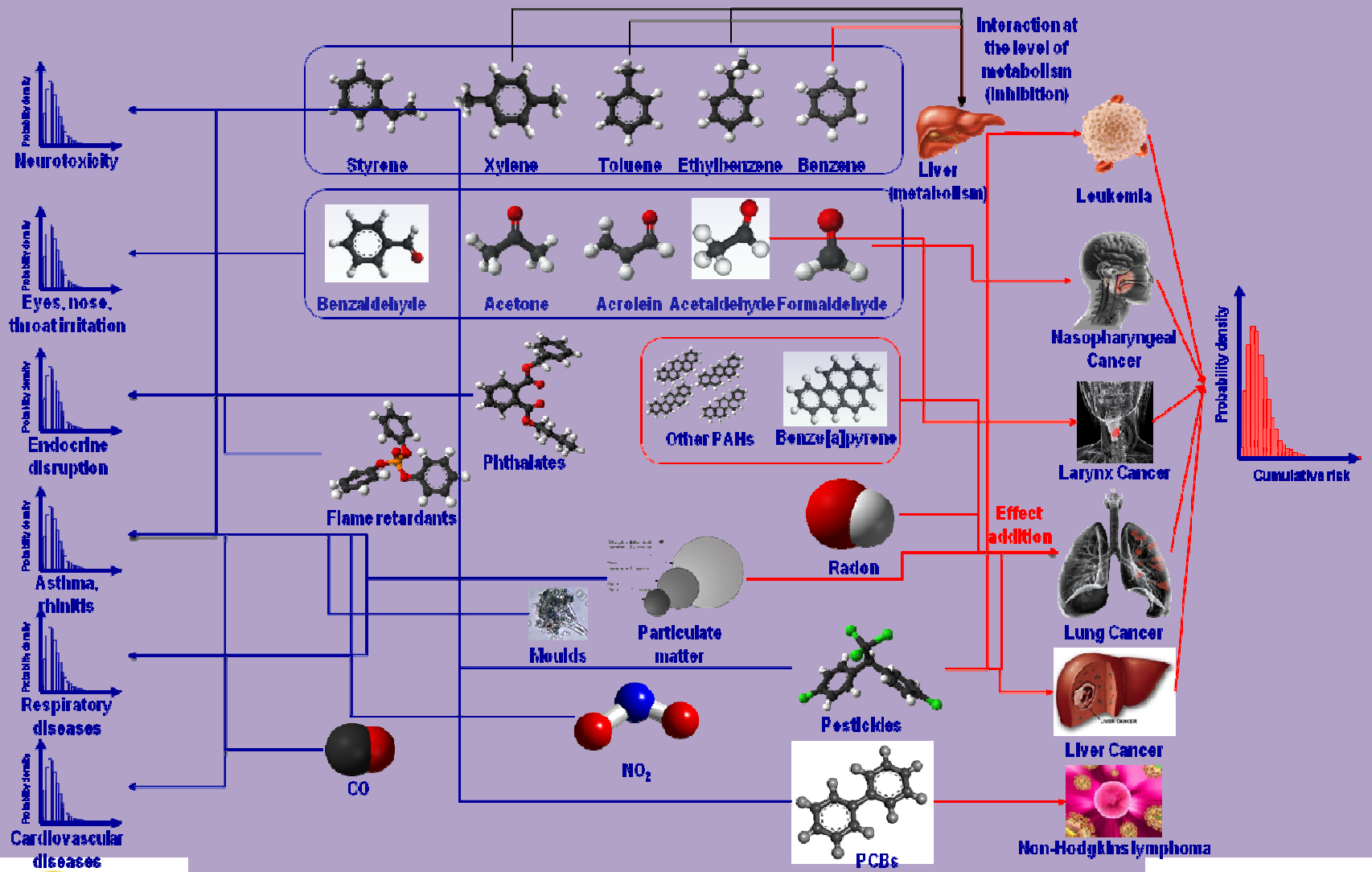
# CheRRIE main objectives – addressing building materials

- Recording of radioactivity and chemicals emissivity from **building materials** both traditional and modern used in typical Greek and Bulgarian constructions
- Calculation of time evolution of annual equivalent and internal dose due to exposure to radiological and chemicals resulting from exposure to the materials of the above structures.
- Assessment of the health burden on the population from exposure to ionizing radiation and toxic chemicals emitted from the building / construction materials

# Indoor risks – What and why





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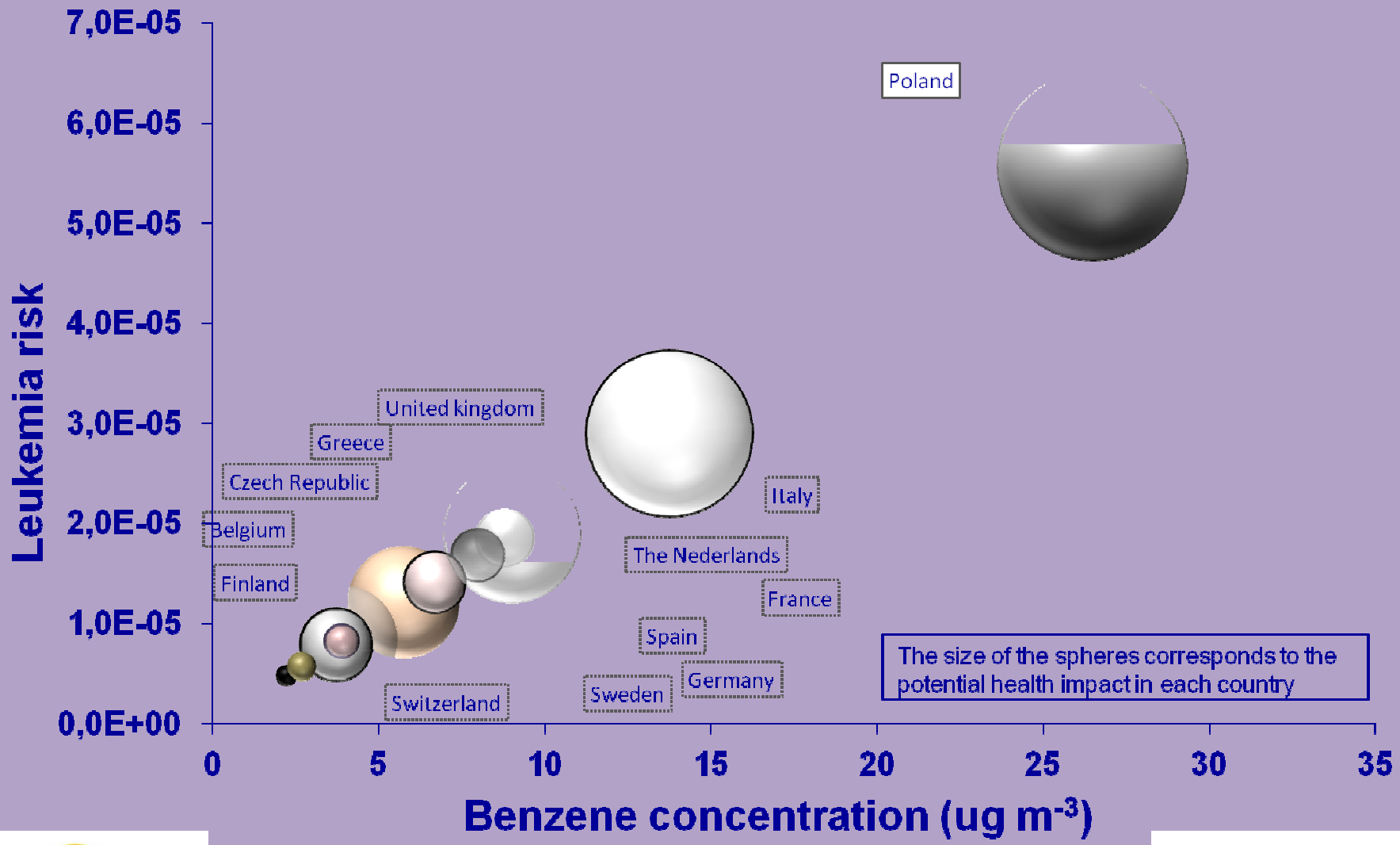
# Exposure to benzene





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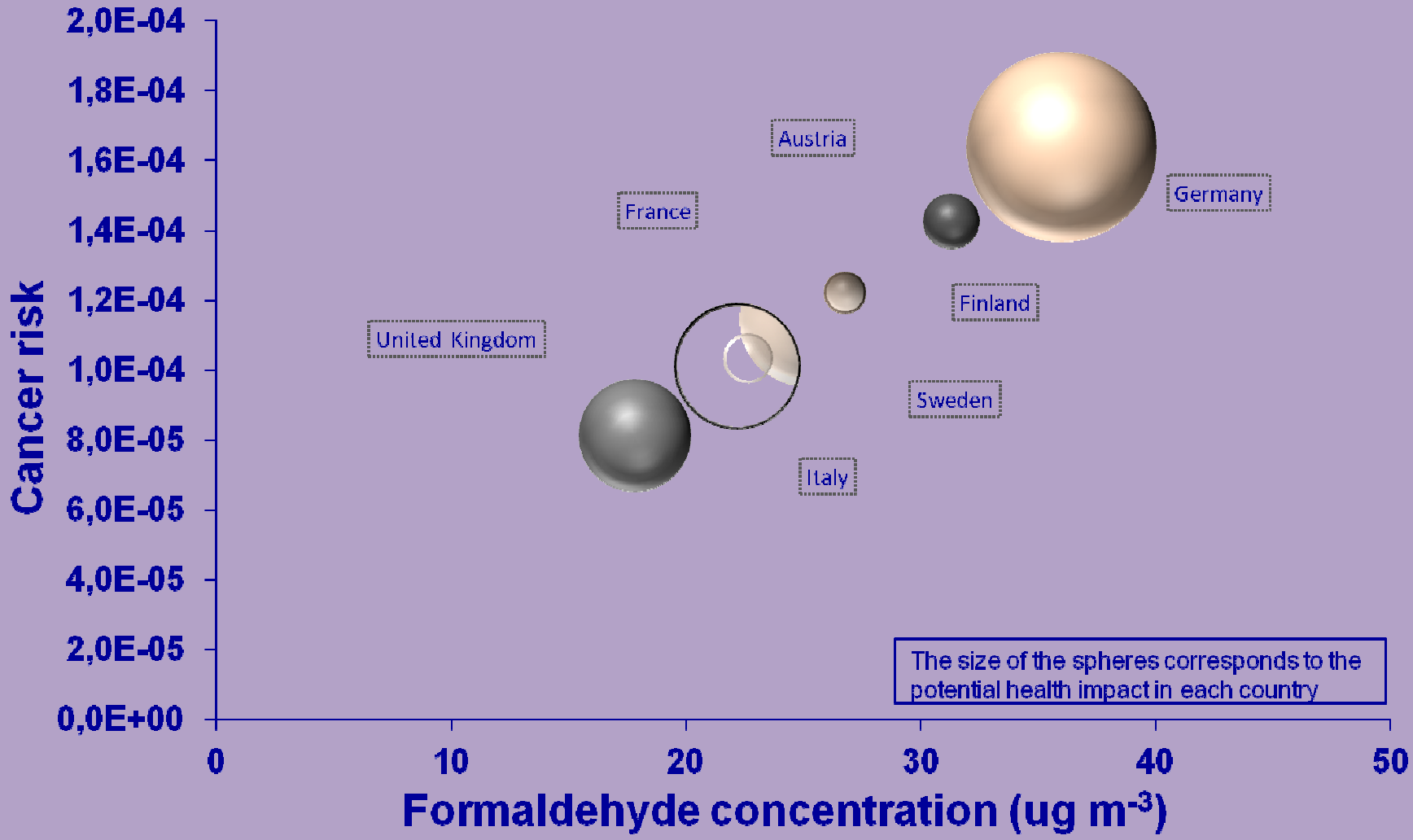
# Exposure to formaldehyde

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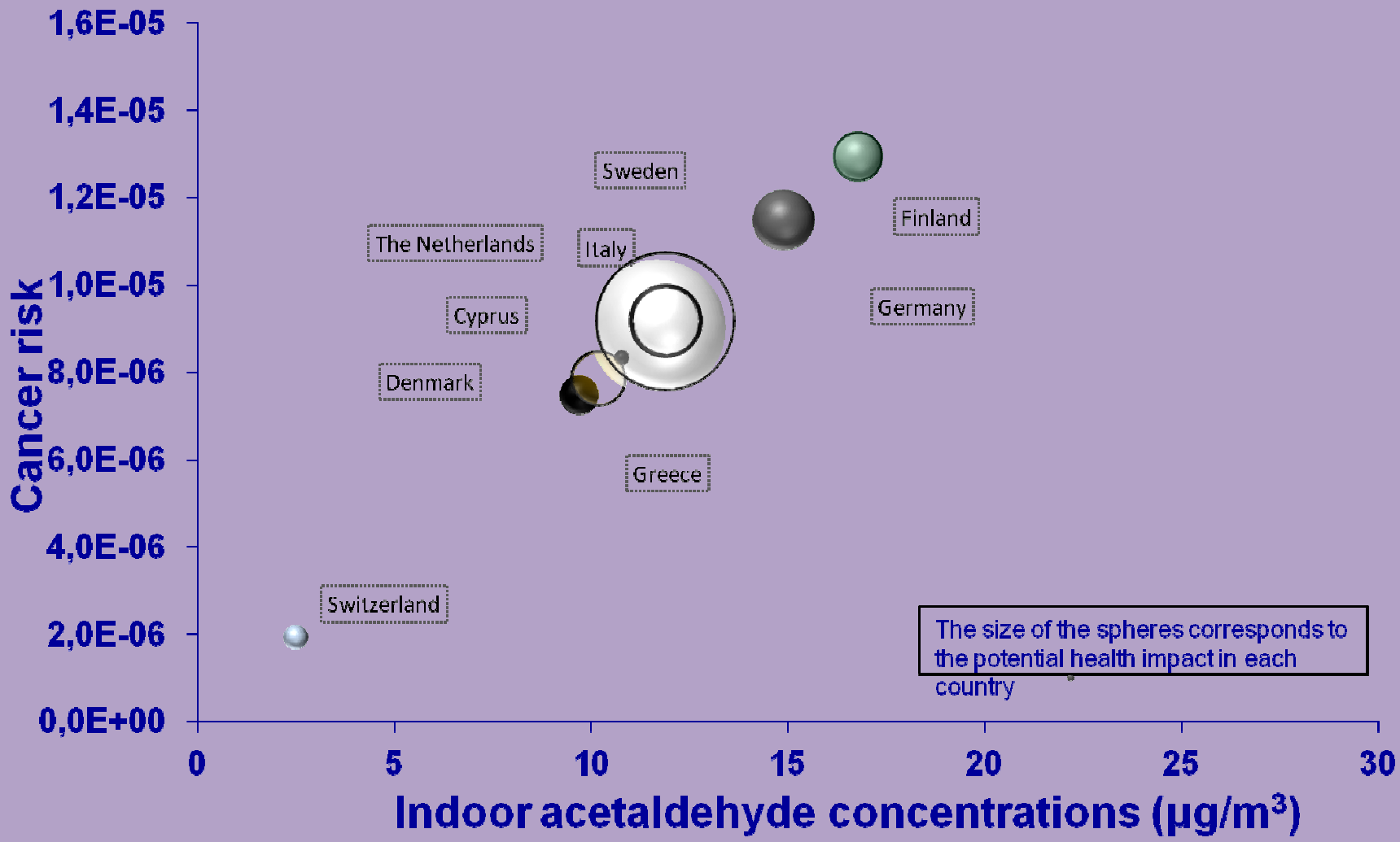
# Exposure to acetaldehyde





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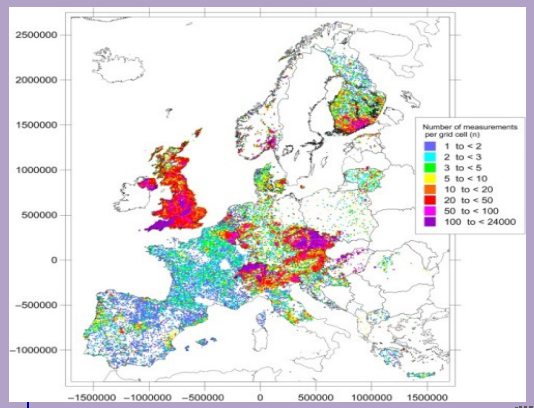
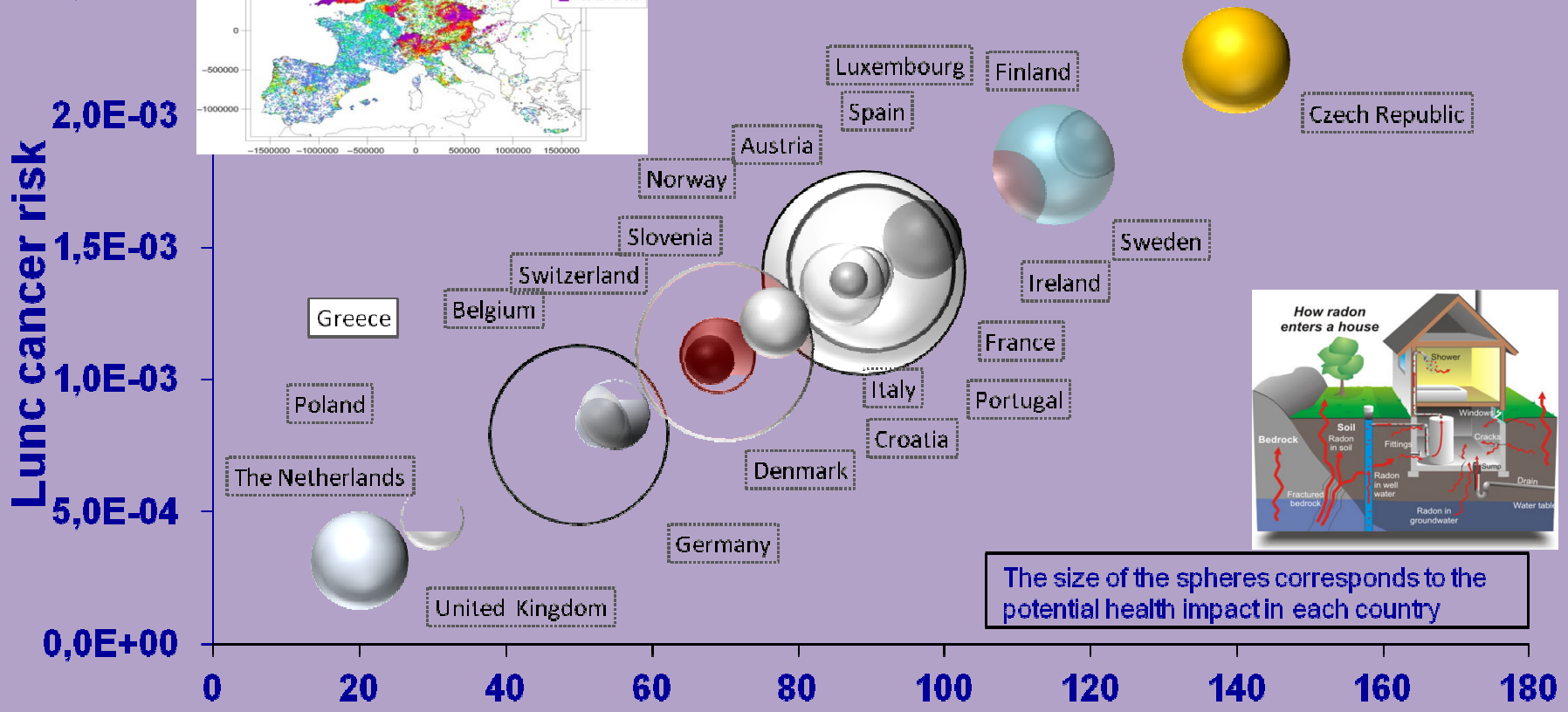
# Exposure to radon





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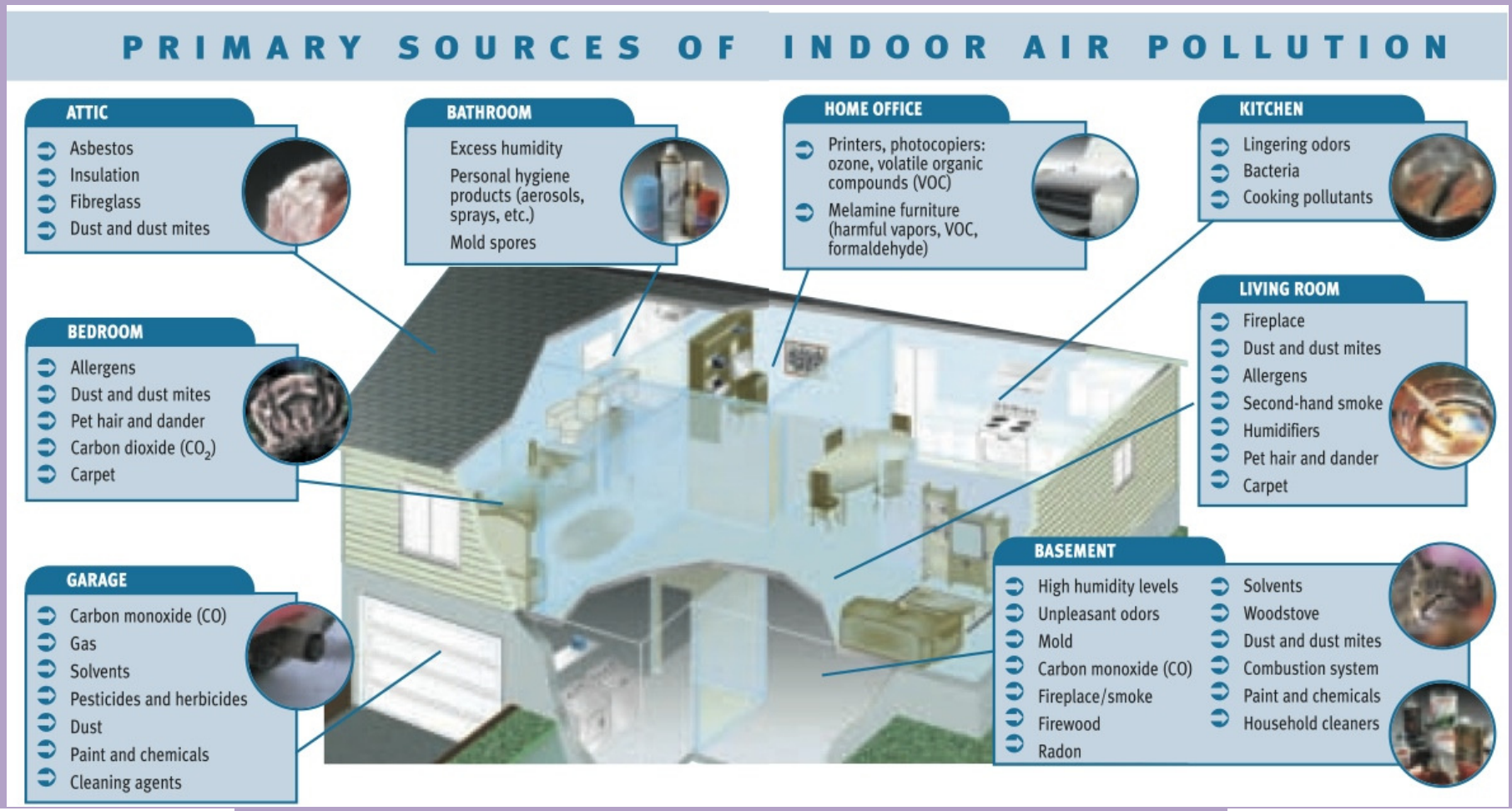
# Where they come from?

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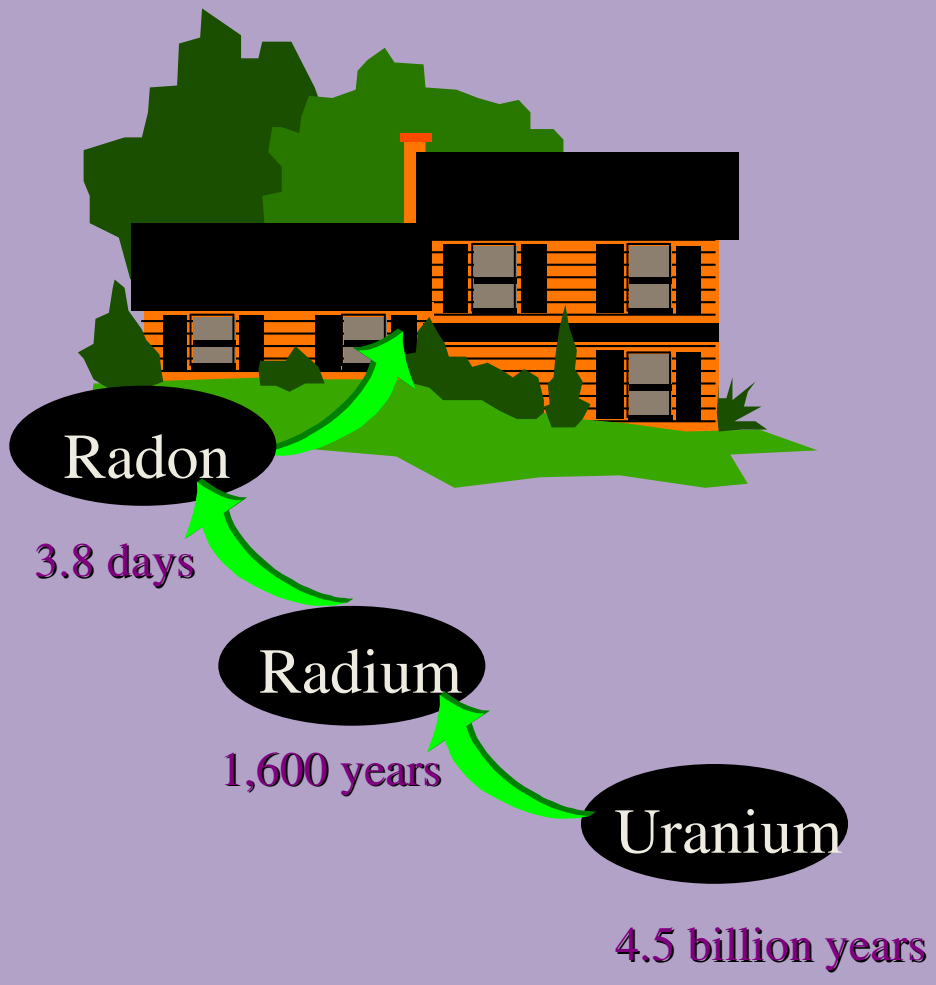
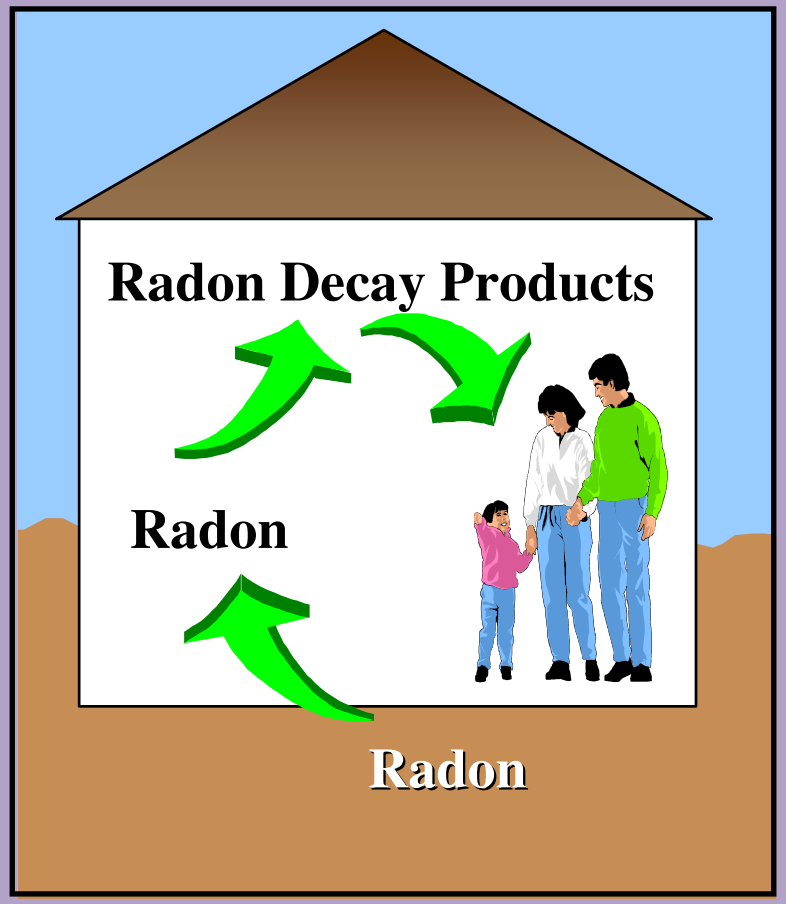
# What Is Radon –222 (radon)?



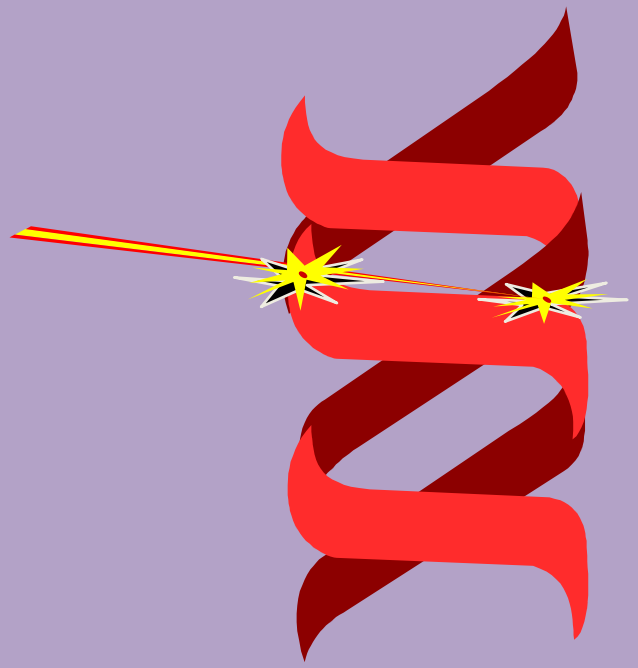

- *Radon is a gas*
- *It is naturally occurring*
- *You can not see or smell it*
- *It enters buildings from the soil beneath them*

# Why Is Radon A Concern?




- Radon decays into radioactive particles known as radon decay products.
- These particles are *easily inhaled and deposited in the lungs* where they can damage sensitive lung tissue.

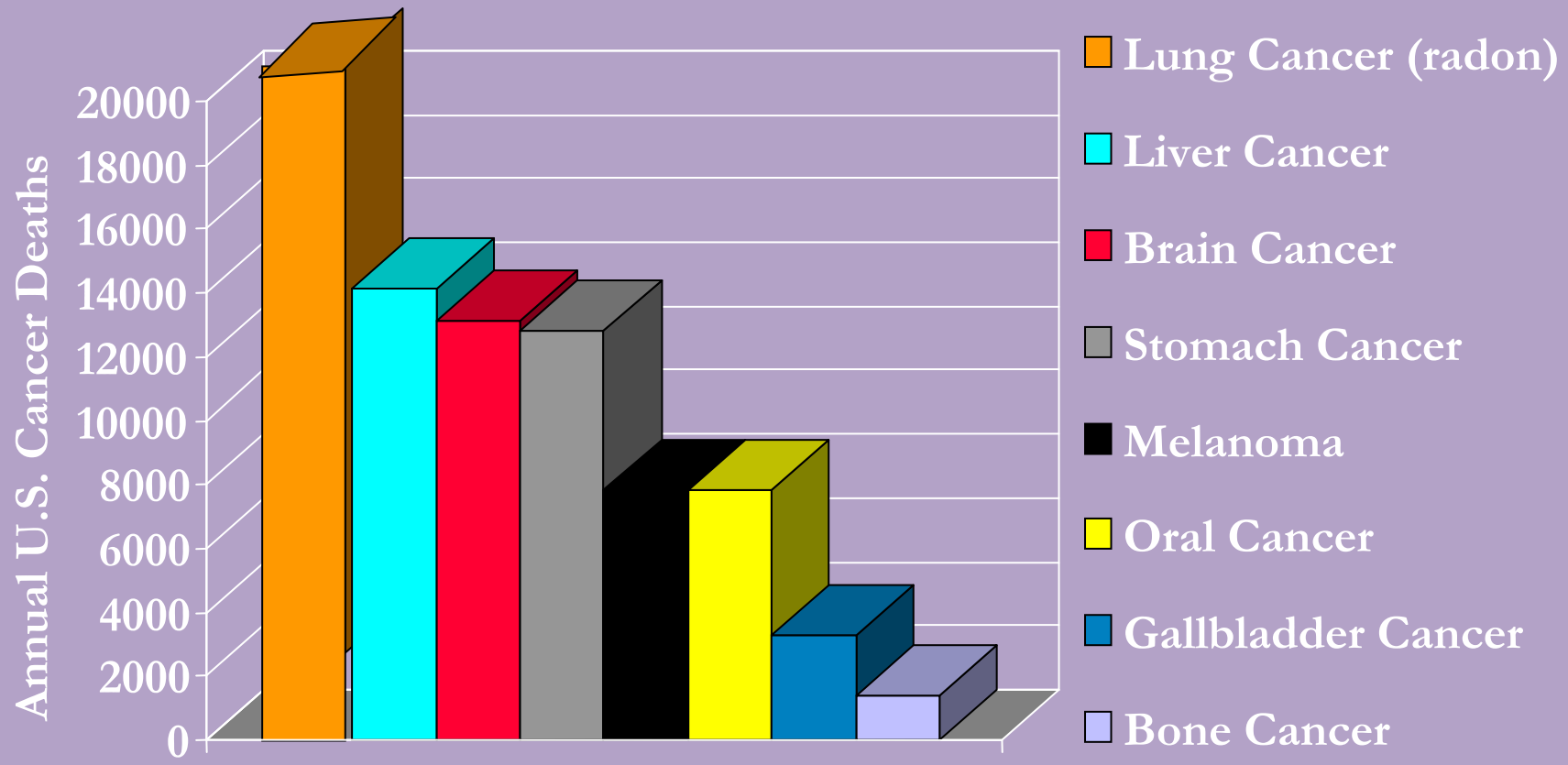
# What Happens When Radon Decay Products Are Inhaled?



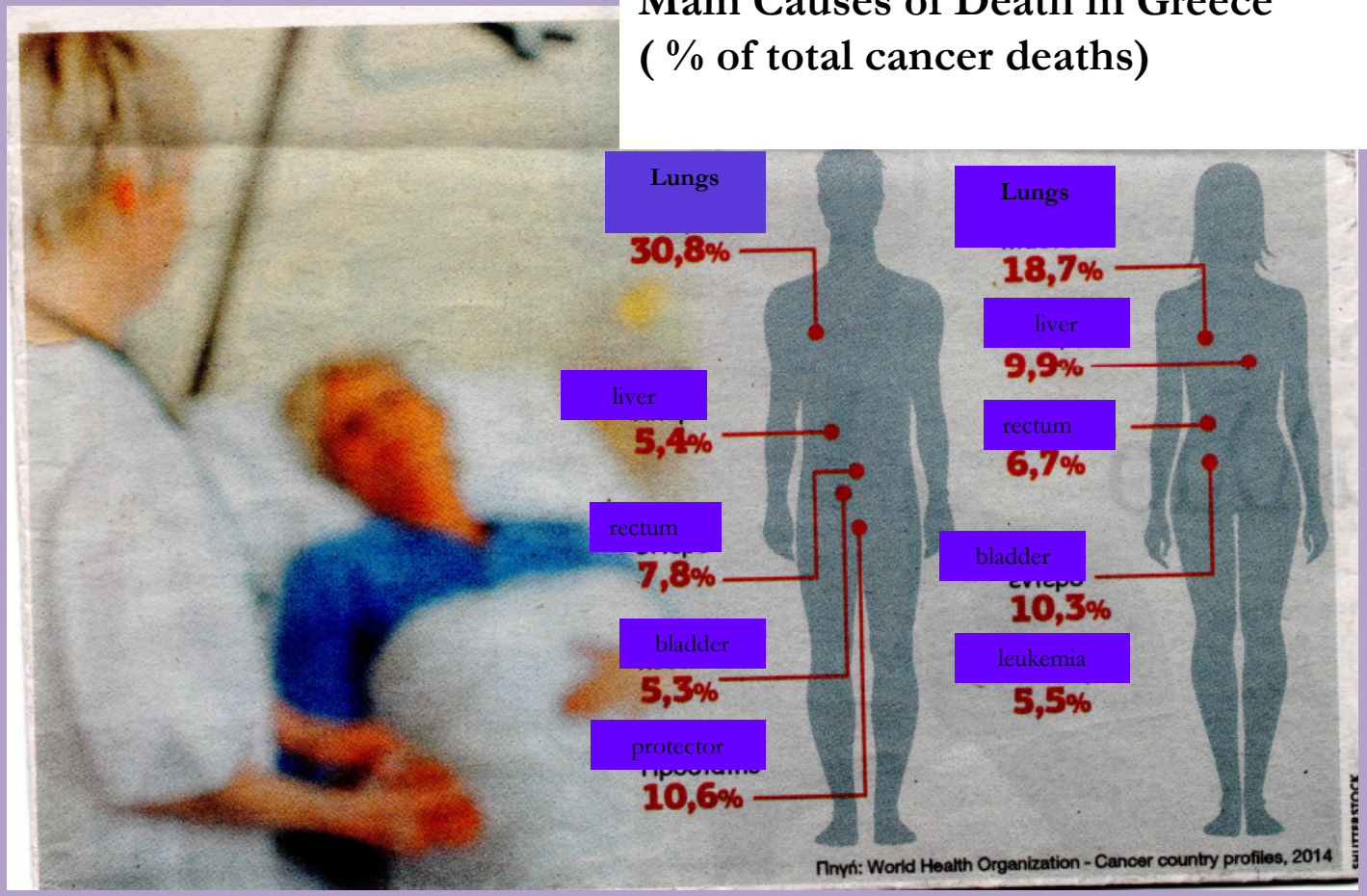
*Double Strand Breaks*

- Highly radioactive particles adhere to lung tissue, where they can irradiate sensitive cells.
- Radiation can alter the cells, increasing the potential for cancer.

# Comparing Radon Related Cancer to Other Cancer Types



# Main Causes of Death in Greece
# ( % of total cancer deaths)



# How to achieve the objectives

- Execution of field measurements in Greece and Bulgaria and lab analysis on building materials based on international reference standards and calibration tests.
- Development of a database of the radiological, physical and chemical characteristics of building materials used in Greece and Bulgaria.
- Use of INTERA platform for computation of population exposure to radiological and chemical hazards coupled to time-activity patterns and field and lab emission measurements.
- Setting up of an indoor environment and health advanced IT infrastructure based on grid computing to support effective scientific and stakeholder networking in order to better protect public health.

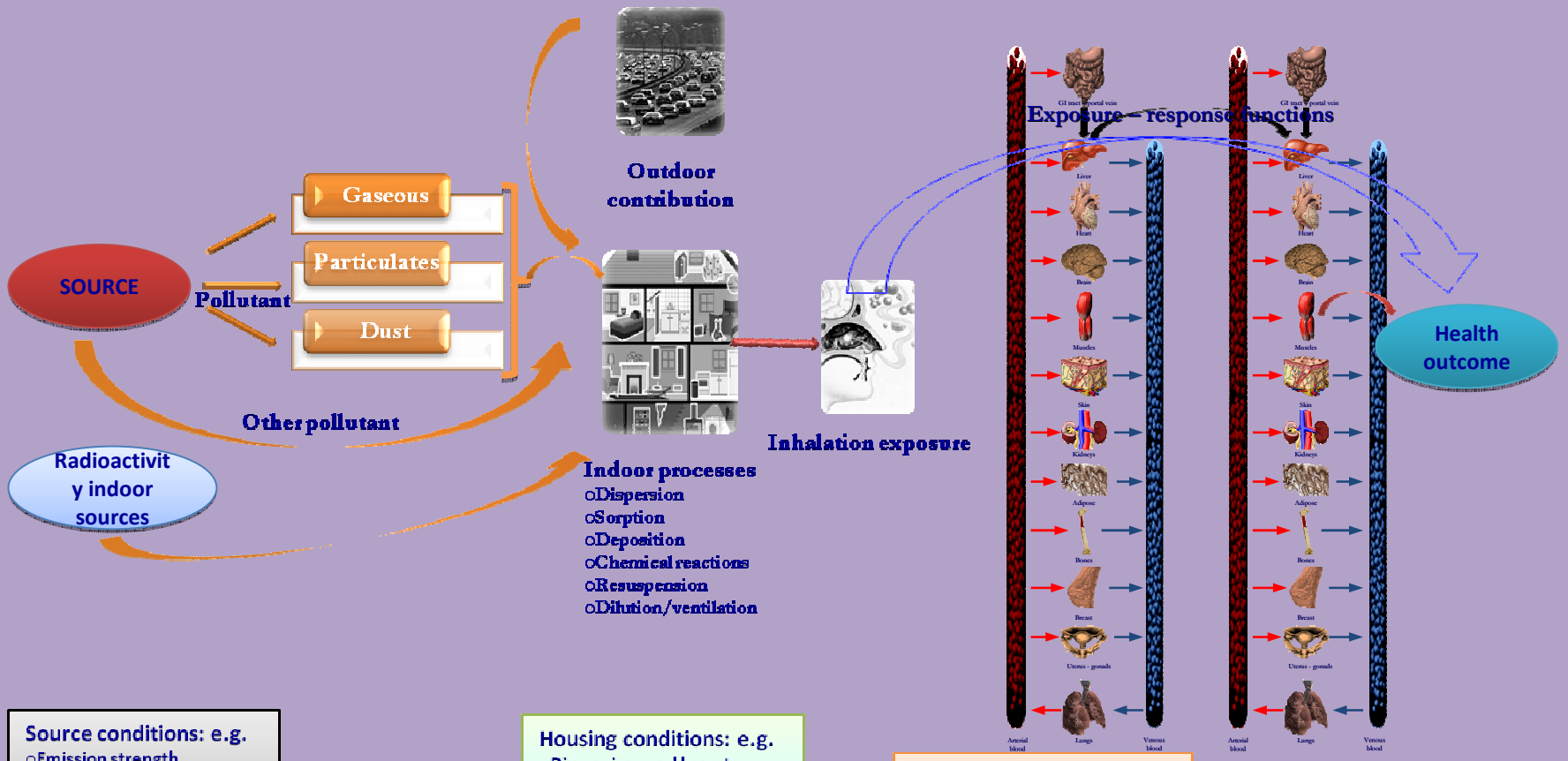
# Main expected impacts (1)

- Definition of a set of exposure indicators for combined exposure to radiological and chemical hazards in residential and public buildings in the Greece-Bulgaria trans-boundary regions.
- Development of a methodology to integrate the existing data towards assessing the effect of co-exposure to these hazards, focusing on susceptible population sub-groups, primarily on children of developing age, pregnant women and the elderly.
- Recommendations on radiological and chemical protection of the population.

# Main expected impacts (2)

- Improvement in the quality of the materials used in building construction and/or refurbishing in the trans-boundary regions allowing building constructors, raw material producers and recycling companies to base their purchasing decisions for raw materials on the findings of the project whilst protecting public health.
- Contribution to the European legislation concerning the use of structural/building materials for residential buildings.
- Enhancement of public awareness of potential health risks of building materials and enhancement of consumer choice in the building material market.

# Methodological concept of the CheRRIE approach




**Source conditions: e.g.**
- Emission strength
- Chemical/physical/radiological properties of pollutant

**Housing conditions: e.g.**
- Dimensions and layout
- Ventilation characteristics
- Sources location

**Individual conditions: e.g.**
- Time activity patterns in house
- Source use pattern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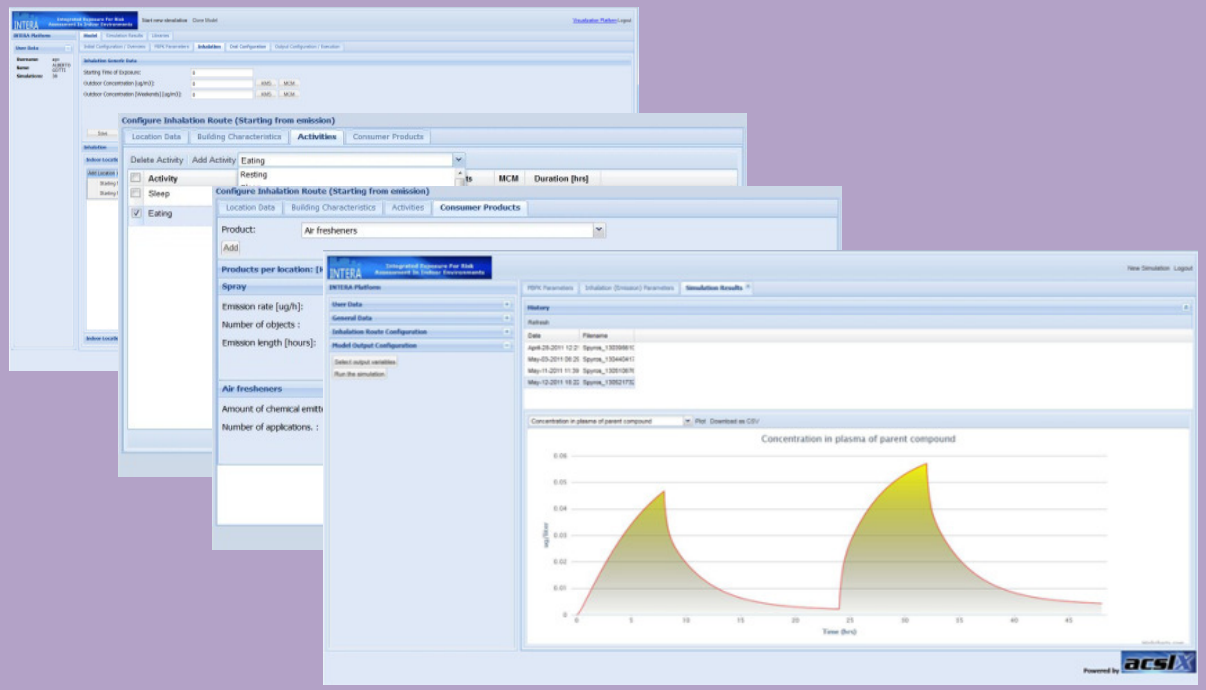
# The INTERA Platform

**The INTERA computational platform is a web based software developed to assist the user in assessing aggregate and cumulative exposure to pollutants commonly found indoors following the "full-chain" from source to dose.**




http://www.intera.cperi.certh.gr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# INTERA platform: main components

The platform comprises four modules:

**1.Emissions-concentrations module**, linking emission sources to indoor air concentrations through IAQ modelling, taking into account indoor physical chemistry

**2.Exposure module** including several models for the dermal, inhalation and oral routes reflecting also differences in the loading mechanism and taking into account time activity patterns and variable inhalation rates based on activity, gender and body weight.

**3.Internal dosimetry module**, linking the temporal variation of exposure to internal dose dynamics through the development of a generic Physiology Based PharmacoKinetic/Dynamic model which accounts for different gender and age class.

**4.Uncertainty and variability** of exposure and risk determinants are assessed along the full chain through hierarchical modelling using Monte Carlo techniques.

# Gamma Spectrometry Laboratory Measurements

Laboratory Radiological measurements


## HPGe Detector

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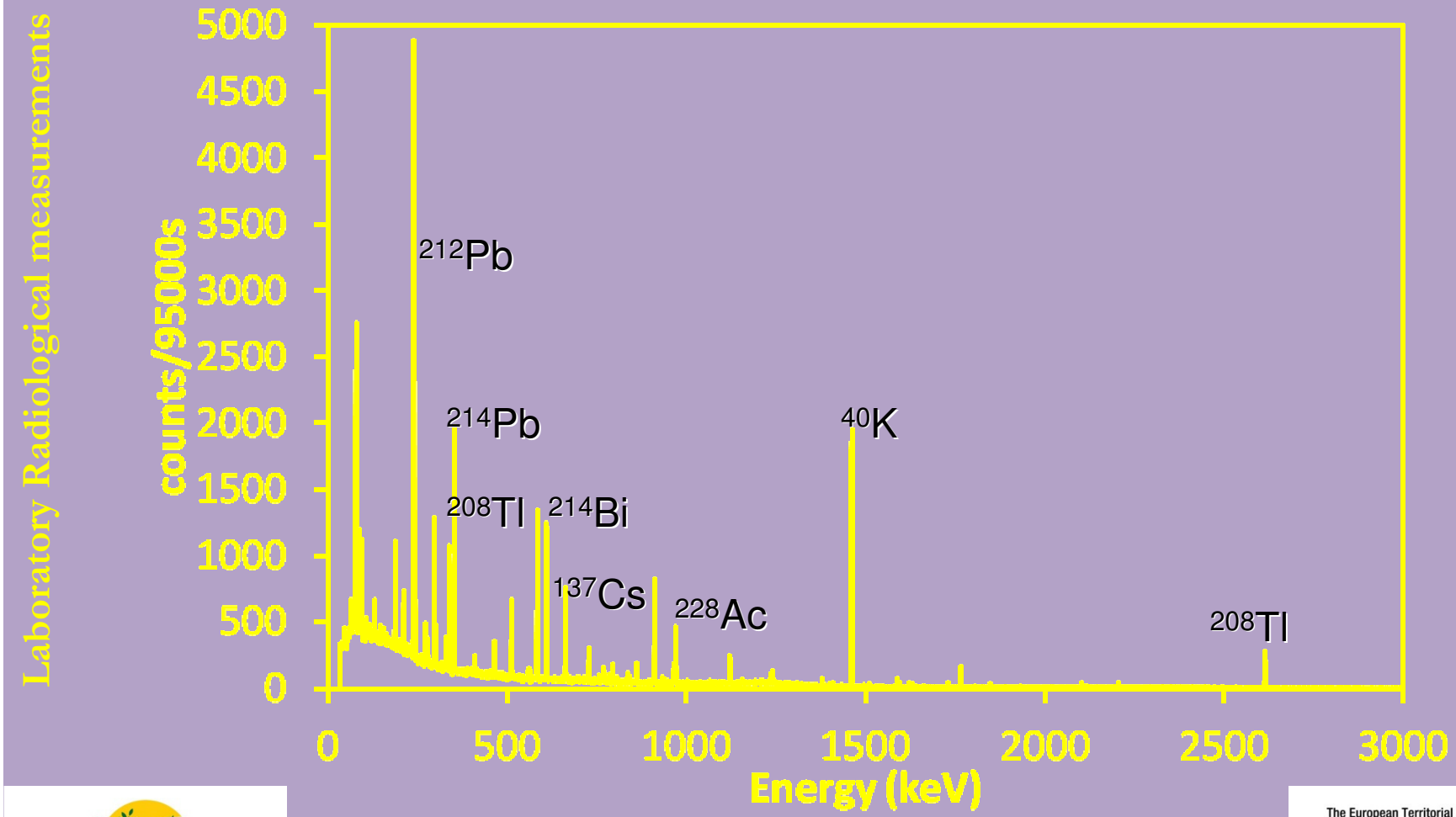
# Spectrum of an HPGe Detector





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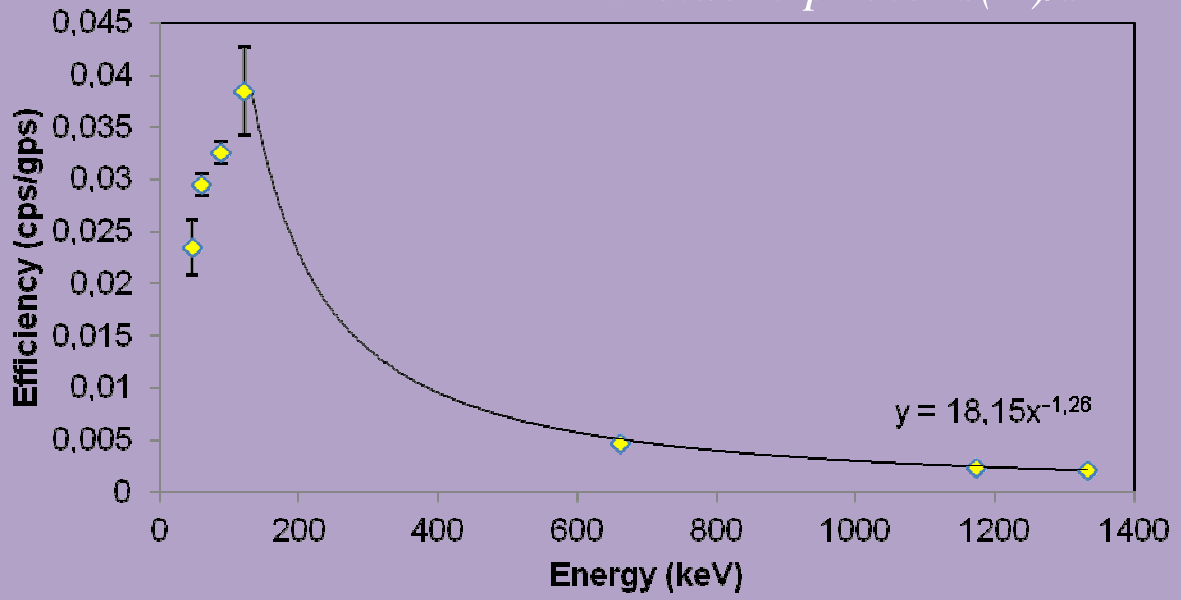
# Efficiency of the HPGe detector

Absolute efficiency: $$\varepsilon(E)=\frac{measured\ counts(E)/s}{emmited\ \ photons(E)/s}$$

Internal efficiency : $$\varepsilon(E)=\frac{measured\ counts(E)/s}{incident\ \ photons(E)/s}$$

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# Radioactivity Concentration

$$A = \frac{cps}{(\varepsilon \cdot FY \cdot M)}$$

**A: radioactivity concentration of the nuclide (Bq/kg).**
**cps: net counts per second detected only due to specific gamma energy radiation.**
**ε: The detector's absolute efficiency for the particular energy geometry and density.**
**FY: The probability of emitting gamma radiation per disintegration of the nucleus.**
**M: The sample mass (kg).**

# European Technical Guidance concerning the Natural Radioactivity of Building Materials

***Effective doses exceeding 1 mSv y$^{-1}$ should be taken into account from the radiation protection point of view.***

Dose criteria nationally in the range 0.3 - 1 mSv y$^{-1}$ of excess gamma dose to that received outdoors (50 nGy/h).

$$I = \frac{C_{Ra-226}}{300\,Bqkg^{-1}} + \frac{C_{Th-232}}{200\,Bqkg^{-1}} + \frac{C_{K-40}}{3000\,Bqkg^{-1}}$$

| Dose criterion (a) | 0.3 mSv y$^{-1}$ | 1 mSv y$^{-1}$ |
|---|---|---|
| Materials used in bulk amounts | $I \leq 0.5$ | $I \leq 1$ |
| Superficial and other materials with restricted use | $I \leq 2$ | $I \leq 6$ |

(a) effective dose rate excess to that received outdoors

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Laboratory Radiological measurements

## GAMMA SPECTROMETRY MEASUREMENTS

| No | Material | $^{40}K$ | $^{232}Th$ | $^{238}U$ | $^{226}Ra$ | $^{214}Pb/^{214}Bi$ | $^{137}Cs$ | / |
|---|---|---|---|---|---|---|---|---|
| | | (Bq kg$^{-1}$) | | | | | | |
| 1 | Granite salmon K - Chinese | 1177 | 80 | 50 | 66 | 54 | | **1,01** |
| 2 | Granite - Florina | 710 | 45 | 35 | 41 | 38 | | **0,60** |
| 3 | Granodiorite | 1043 | 125 | 70 | 139 | 99 | | **1,44** |
| 4 | Slate - Chalkidiki | 4 | 19 | 11 | 17 | 13 | | 0,15 |
| 5 | Marble - Kavala | 4 | 1 | 3 | 3 | 1 | | 0,02 |
| 6 | Marble - Thassos | 4 | 0,1 | 1 | 3 | 0,2 | | 0,01 |
| 7 | Marble - Drama | 4 | 0,1 | 1 | 3 | 0,2 | | 0,01 |
| 8 | Marble - Nevrokopi | 4 | 0,1 | 15 | 23 | 18 | | 0,08 |
| 9 | Sand | 526 | 27 | 19 | 22 | 19 | | 0,38 |
| 10 | Porcelain Tile Beige -Italy | 798 | 56 | 50 | 57 | 53 | | **0,74** |
| 11 | Porcelain Tile Gray -Italy | 529 | 49 | 47 | 49 | 46 | | **0,58** |
| 12 | Ceramic Tile Beige -Italy | 877 | 61 | 38 | 46 | 44 | | **0,75** |
| 13 | Ceramic Tile White - Greece | 491 | 72 | 60 | 77 | 73 | 0,5 | **0,78** |
| 14 | Rhyolite | 1880 | 171 | 98 | 80 | 59 | | **1,75** |
| 15 | Red Brick KEBE | 648 | 43 | 25 | 25 | 22 | | **0,51** |
| 16 | Red Brick Chalkidiki | 676 | 62 | 28 | 25 | 26 | 0,4 | **0,62** |
| 17 | Red Brick Chalkis | 643 | 37 | 25 | 25 | 22 | | 0,48 |
| 18 | Red Brick Chalastra | 661 | 48 | 25 | 37 | 33 | 1,4 | **0,58** |
| 19 | Concrete interbeton C16/20 | 16 | 2 | 14 | 38 | 22 | | 0,14 |
| 20 | Concrete interbeton C20/25 | 18 | 2 | 15 | 31 | 19 | | 0,12 |
| 21 | Cement Brick - Serres | 38 | 3 | 6 | 8 | 5 | 0,3 | 0,05 |
| 22 | YTONG | 183 | 12 | 14 | 14 | 10 | | 0,17 |
| 23 | Cement Brick - Kilkis | 5 | 2 | 17 | 34 | 27 | | 0,13 |
| 24 | Plaster | 451 | 21 | 19 | 16 | 17 | | 0,31 |
| 25 | Plasterboard | 4 | 0,1 | 5 | 0,8 | 0,2 | | 0,00 |

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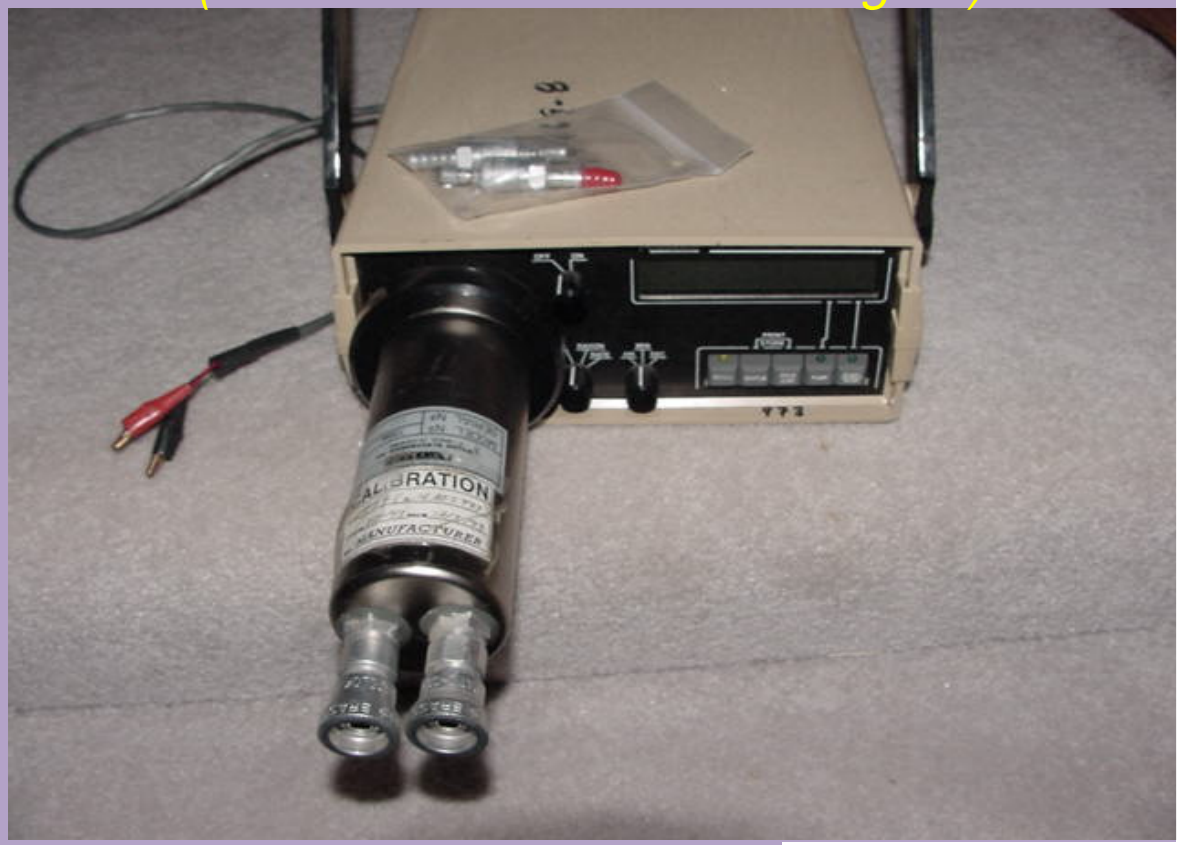
# IN-SITU Radon Measurements

In-Situ Radiological measurements

## E-perm
*(Long term measurements)*

## Pylon
*(20 min measurements - air grab)*



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# Long Term
# Radon Measurements in Drama (e-perm)

In-Situ Radiological measurements

| Radon concentration summer period (July-August 2014) Drama (Bq/m³) | |
|---|---|
| No of Measurements | 9 |
| Geometric mean (Bq/m³): | 129.1 |
| Arithmetic Mean (Bq/m³): | 135.7±45.5 |
| Max (Bq/m³): | 224.7 |
| Min (Bq/m³): | 67.5 |

| Radon concentration winter period (Nov-Dec 2014) Drama (Bq/m³) | |
|---|---|
| No of Measurements | 8 |
| Geometric mean (Bq/m³): | 158.0 |
| Arithmetic Mean (Bq/m³): | 172.4±66.8 |
| Max (Bq/m³): | 263.0 |
| Min (Bq/m³): | 57.9 |

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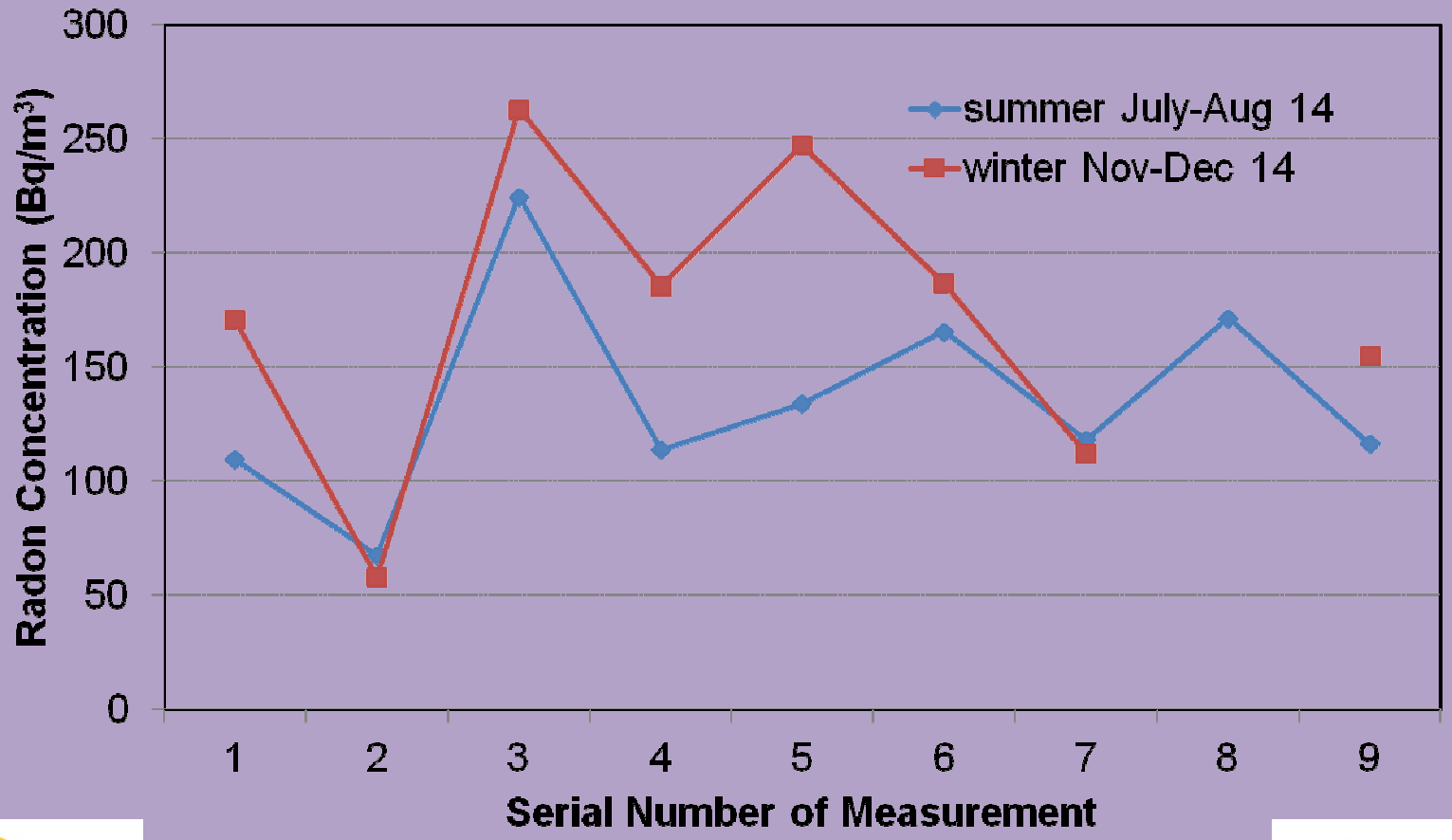
# Long Term
# Radon Measurements in Drama (e-perm)
# Seasonal correlation

In-Situ Radiological measurements





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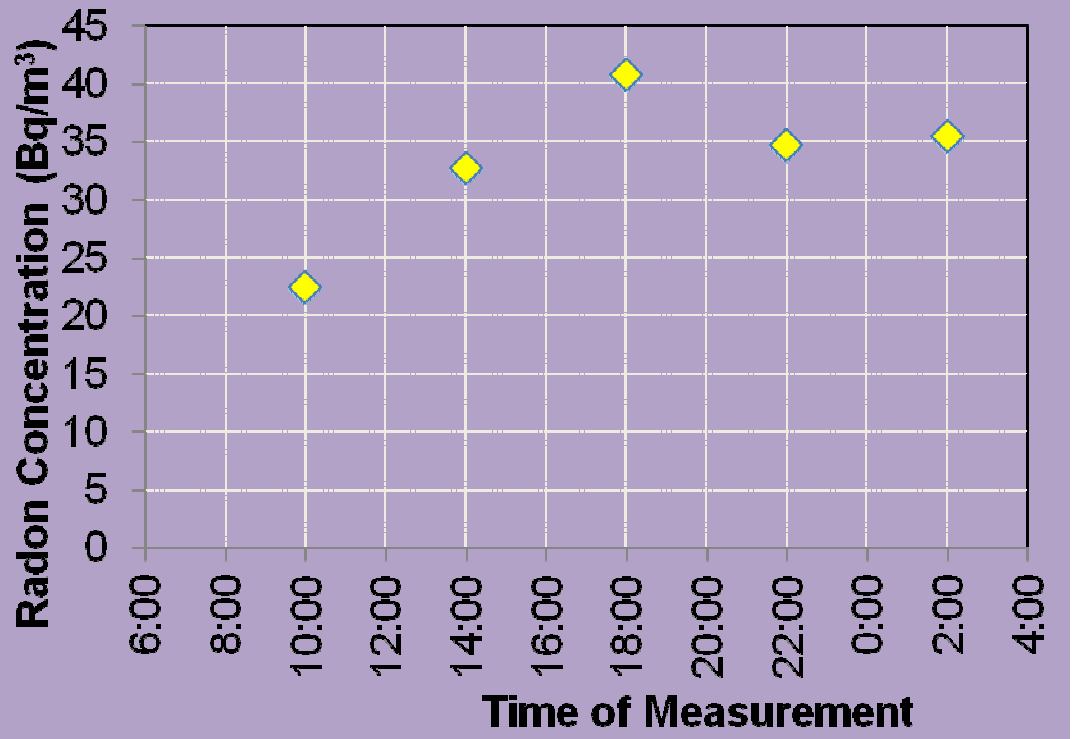
# Short Term
# Radon Measurements, Thessaloniki
# winter period (Oct.-Dec. 14)- Pylon instrument

In-Situ Radiological measurements

| | |
|---|---|
| No of Measurements | 15 |
| Geometric mean ($Bq/m^3$): | 20.1 |
| Arithmetic Mean ($Bq/m^3$): | 29.4±25.1 |
| Max ($Bq/m^3$): | 77 |
| Min ($Bq/m^3$): | 4 |

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# Conclusions (1)

- 250 different building and raw materials measured
- First comment : **marbles seem to have small concentration of radioactivity while granites have high concentration of radioactivity.**
- Complies with article 75 indoor dose rate in addition to outdoor external exposure, **shall not exceed 1 mSv per year** .
- Different radon measuring techniques were used:
- **a)** EIC (Electret Ion Chambers) **b)** Lucas cells (Pylon Instrument).

# Conclusions (2)

Radiological measurements

- Measurements in Drama using electret detectors:
- arithmetic mean **135.7±45.5 summer period, 172.4±66.8 winter period.**

- **Max values > 200 Bq/m$^3$**, but **< than 300 Bq/m$^3$**, **Do not exceed the limit of the 300 Bq/m$^3$ European Council Directive 2013/59/ EURATOM, Article 74** The reference levels for the annual average activity concentration **in air shall not be higher than 300 Bq m $^{-3}$**

- Correlation of results is being observed depending on seasonal variations of radon. **In winter period, radon concentrations are higher than in summer one.**

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BULGARIAN ACADEMY OF SCIENCES,

INSTITUTE OF MINEROLOGY AND CRYSTALLOGRAPHY

**PARTNER 2:**

ARISTOTLE UNIVERSITY OF THESSALONIKI

SPECIAL ACCOUNT OF RESEARCH FUNDS – DEPARTMENT OF CHEMICAL

**PARTNER 3:**

ALEXANDER TECHNOLOGIAL EDUCATION

INSTITUTE OF THESSALONIKI

**PARTNER 4:**

TECHNICAL CHAMBER OF GREECE

SECTION OF CENTRAL MACEDONIA

**PARTNER 5:**

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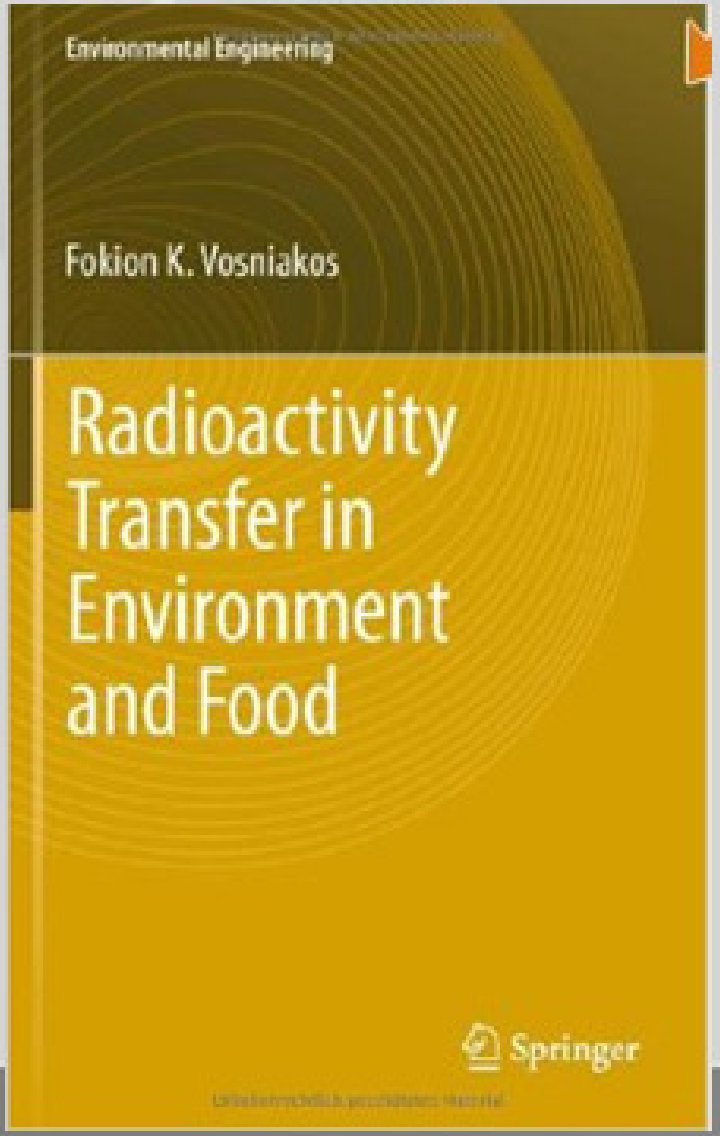
CHAMBER OF ARCHITECTS IN BULGARIA

BRANCH IN BLAGOEVGRAD

"The long fight to save environment represents democracy at its best. It requires citizens to practice the hardest of virtues: **self – restraint**"

***Edwin W. Teale (1953)***

# *Thank you for your kind attention*




- http://www.springer.com/environment/book/978-3-642-28740-4?otherVersion=978-3642-28741-1