ARPA Lombardia – Presentation

www.arpalombardia.it

ARPA Lombardia

- ARPA is a government Agency in charge of **preventing and monitoring environmental pollution**
- It is one of the 21 Italian Agencies operating in the framework of the Network of Italian Environmental Agencies (SNPA), coordinated by the National Environmental Agency (ISPRA) in Rome

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

ARPA Lombardia - Organization

- Lombardia region: 9 Million people, 15% of Italian population, highest concentration of productive activities
- ARPA Lombardia:
  - 13 offices in the main towns of the region
  - Around 1,000 people employed: chemists, biologists, physicists, engineers, etc.
  - Headquarters: Milano

ARPA Lombardia – Main fields of activity

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Agenzia Regionale per la Protezione dell'Ambiente

- Air
- Surface water
- Groundwater
- Biodiversity

Environmental Monitoring

- Industrial emissions (air, water, wastes)
- Environmental remediation
- Noise
- Non Ionizing Radiation

Controls

- Hydrographic service
- Geological Risk
- Meteorology
- Weather Climatology

Natural Risks

- Radioactivity
- Radon

Radiation Protection

- IPA, As, Ni, Cd, Pb Samples
- Annual and daily bulletins
- Monitoring campaigns

Air Quality

- Environmental impact assessments
- Strategic environmental assessments

Environmental Assessment

Radiation Protection Centre

- 12 staff members: physicists, chemists and engineers
- 2 measurement labs (Milano and Bergamo), 1 radiochemistry lab accredited under ISO 17025

- Equipment for alfa, beta and gamma measurement, both in field and in lab
- Tools for data evaluation and risk assessment

Radiation Protection Centre

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- Member of the National Network for Environmental Radioactivity Monitoring (RESORAD)
- Member of IAEA ALMERA Network
- Scientific advisors of National and Regional Health Authorities for problems due to radioactive materials

Regione Lombardia

- Since 2000 member of ISO Committees

ISO International Organization for Standardization

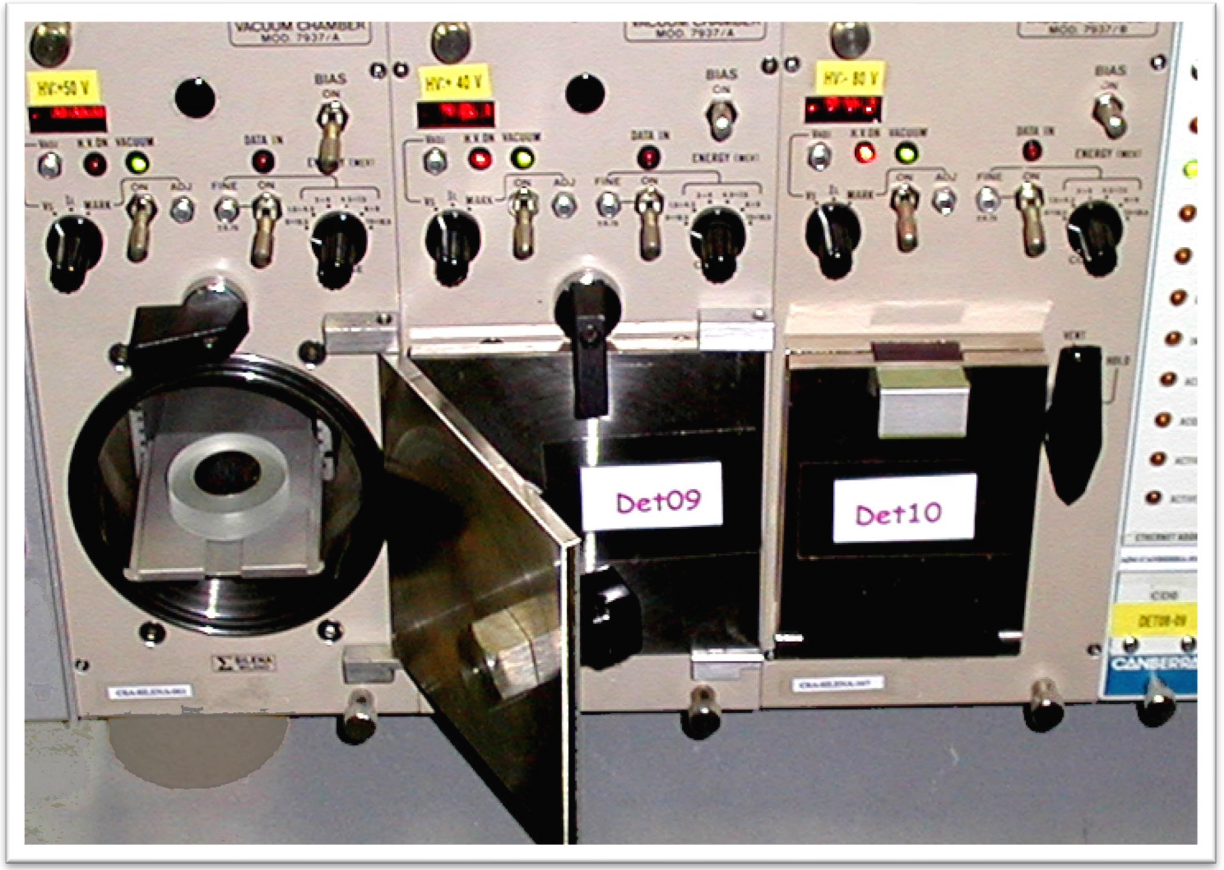
Equipments & Methods:

- 6 **HPGe** γ detectors
- 1 **HPGe** γ/X detector
- 1 portable **HPGe** γ detector (in-situ measurements)

X and γ emitters (5 keV<E<2 MeV)

Equipments & Methods:

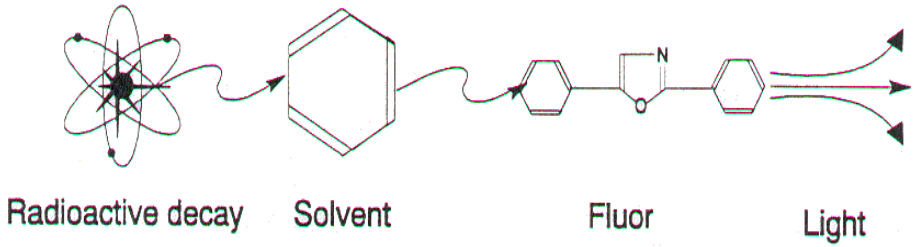
- 3 **Silicon surface barrier** detectors
- Electrodeposition device



- *Plutonium*
- *Uranium*
- *Thorium*
- ^{210}Po
- ^{241}Am

Equipments & Methods:

- 1 ultra low-level **liquid scintillation counter** (LSC)



Gross α and β

U isotopes

^{226}Ra

^{222}Rn

^{3}H

^{210}Pb

^{90}Sr

Equipments & Methods:

- 2 gross α counters (**ZnS**)
- 1 gross α/β counter (**gas flow proportional counter**)

Gross α and β, ^{90}Sr, ^{210}Pb

Equipments & Methods:

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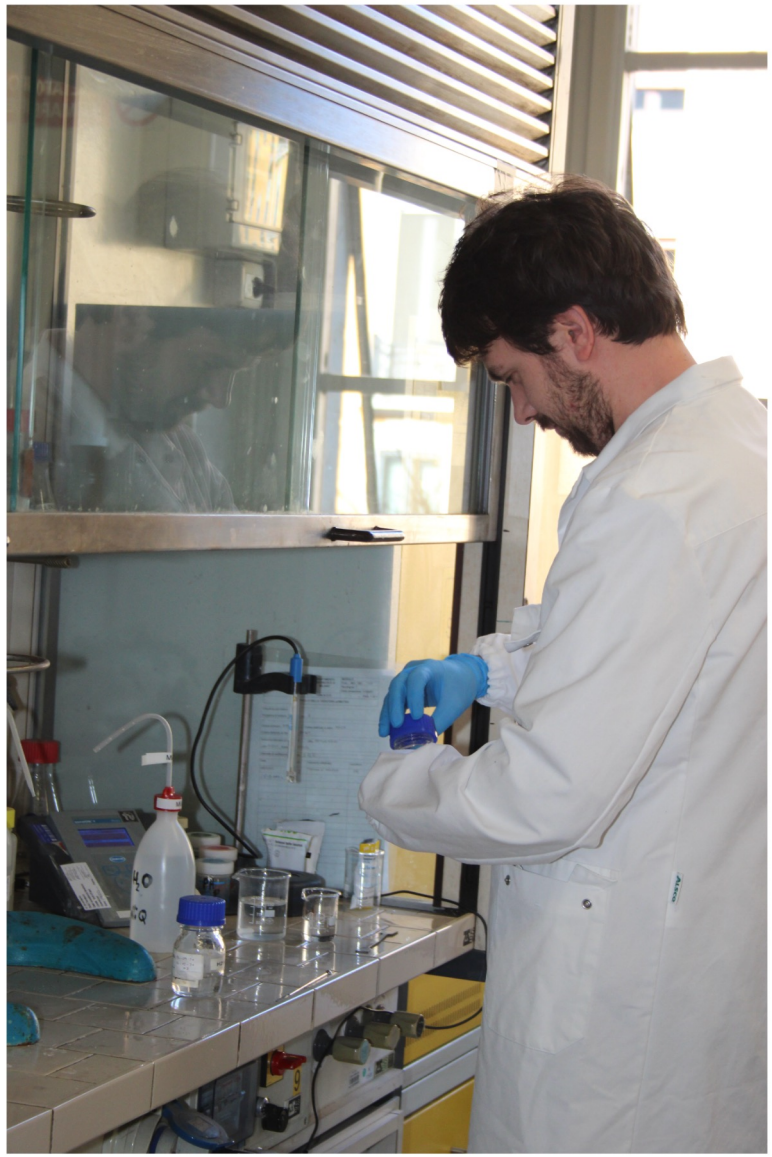
Pre-treatment of organic and inorganic matrices:

- Plastic fume-hood for HF treatment
- Mills and blenders
- Ovens and muffle furnaces

Chemical lab facilities:

- Ionic and extraction chromatography
- Atomic absorption spectrometer
- (ICP-MS: coming soon)
- Surveilled area for radioactive tracing

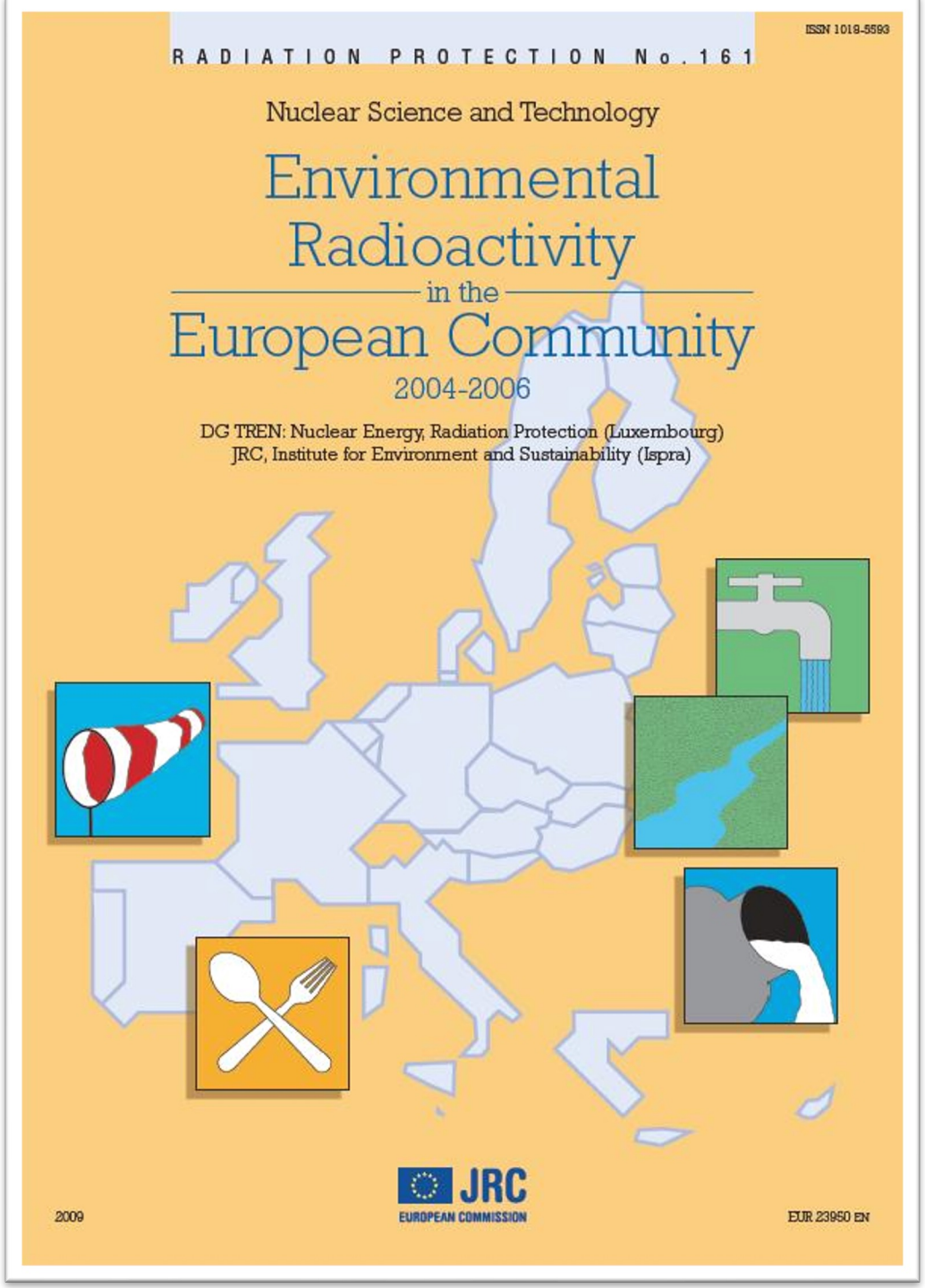


Equipments & Methods:

- **Nuclear track detectors** (CR39) and **electrets** for indoor ^{222}Rn measurement
- **Lucas cells** and **ionization chamber** (Alphaguard) for ^{222}Rn in air and water

Equipments & Methods:

- Portable survey probes (**NaI, HPGe, Geiger-Muller, solid and plastic scintillators, proportional counters**) for in-field measurement of α, β and γ contamination



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European and National Environmental Radioactivity Network

Monitoring Network

ARPA is part of the **National Environmental Radioactivity Network,** fulfilling requirements of European Union:

- European Commission Recommendation 2000/473
- European Council Directives (2013/51/EURATOM)

Environment Monitoring

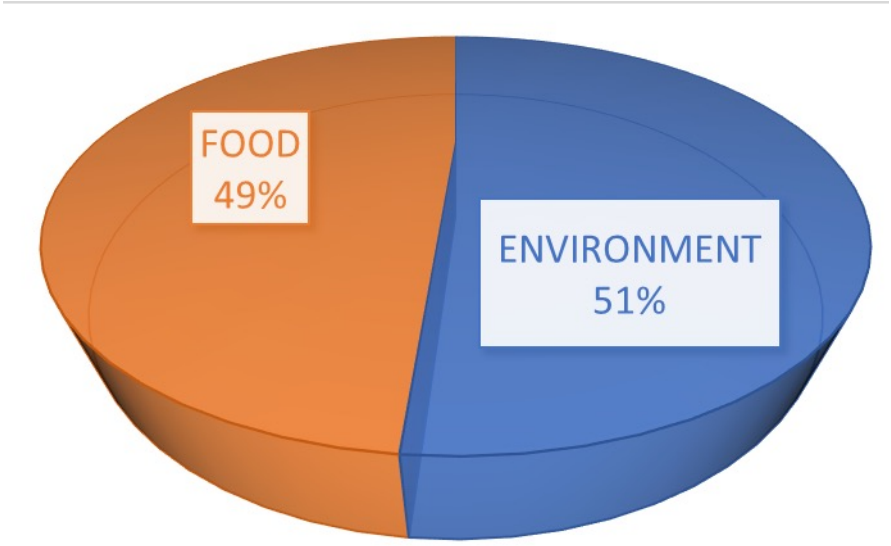
Source Related Monitoring

No. of samples analyzed

- Food and environmental samples, about 1000 samples per year

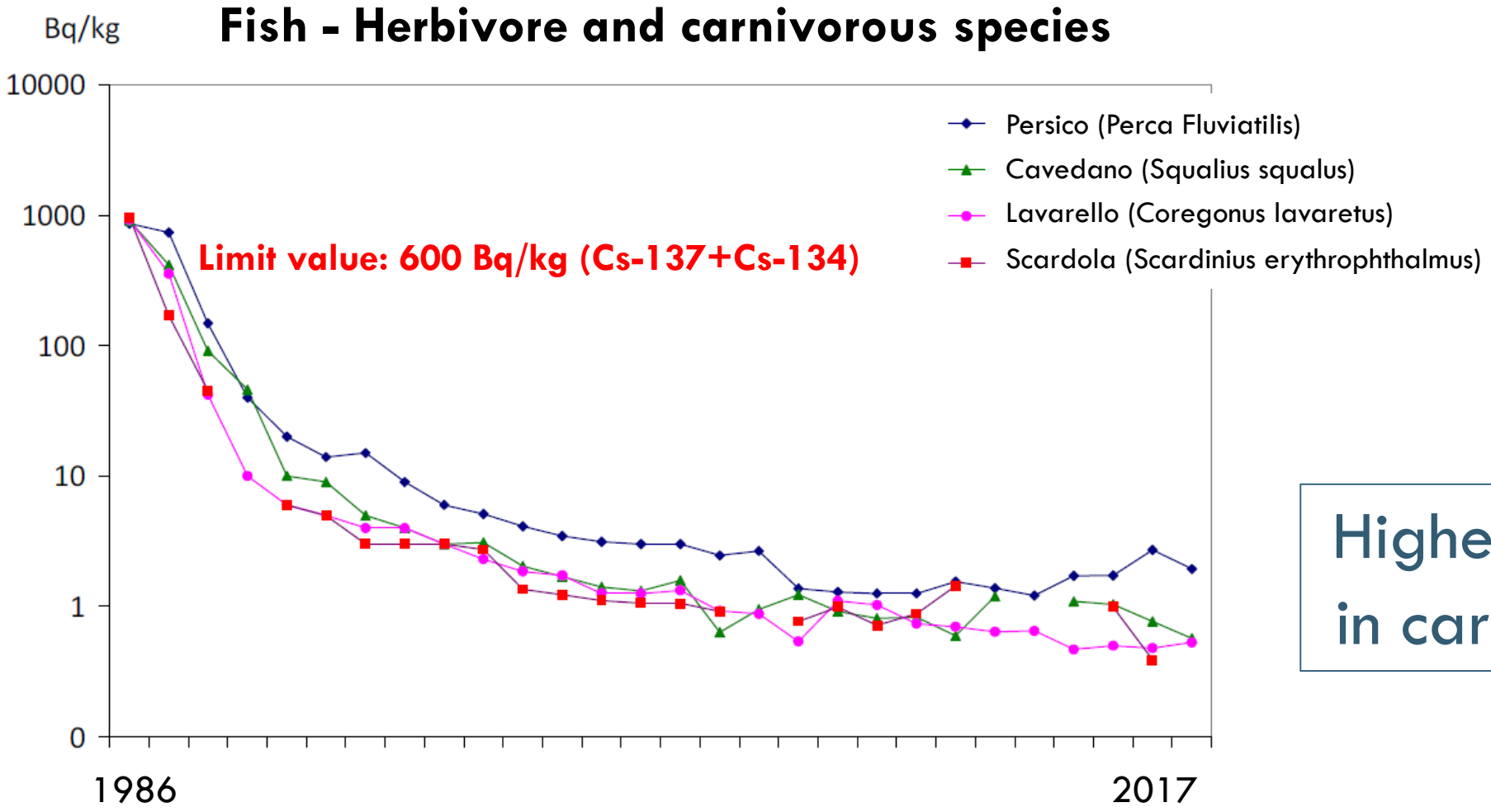
Sample	Radionuclide	Minimum Detectable Activity
AIR	GROSS BETA Cs-137	0,005 BQ/M^3 0,03 BQ/M^3
SURFACE WATER	GROSS BETA Cs-137	0,6 BQ/L 1 BQ/L
DRINKING WATER	H-3 Sr-90 Cs-137 NATURAL RADIONUCLIDES	100 BQ/L 0,06 BQ/L 0,1 BQ/L NOT SPECIFIED
MILK	Sr-90 Cs-137	0,2 BQ/L 0,5 BQ/L
MIX DIET	Sr-90 Cs-137	0,1 BQ/DAY PER PERSON 0,2 BQ/DAY PER PERSON

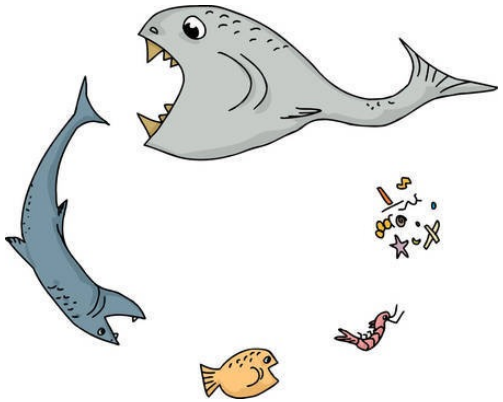
as required by European Commission Recommendation 2000/473



Radioactivity in the environment - Fish

- Fish monitoring provides direct data of food contamination

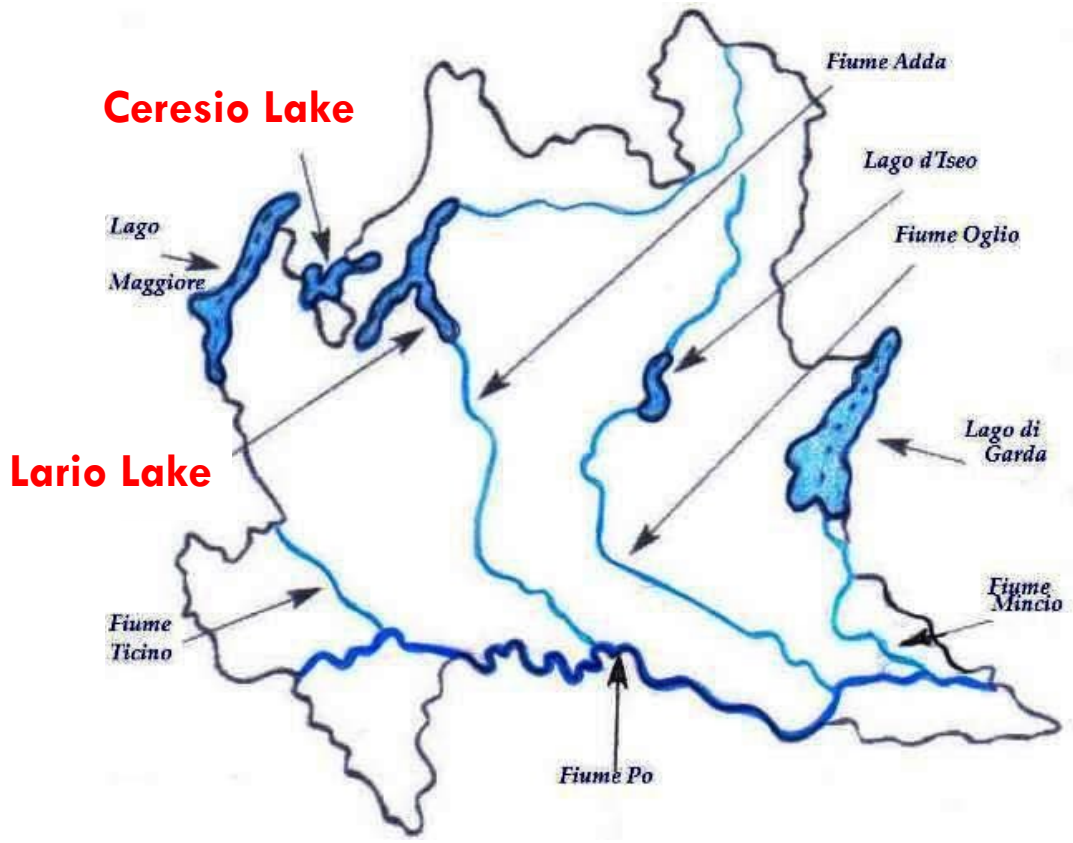


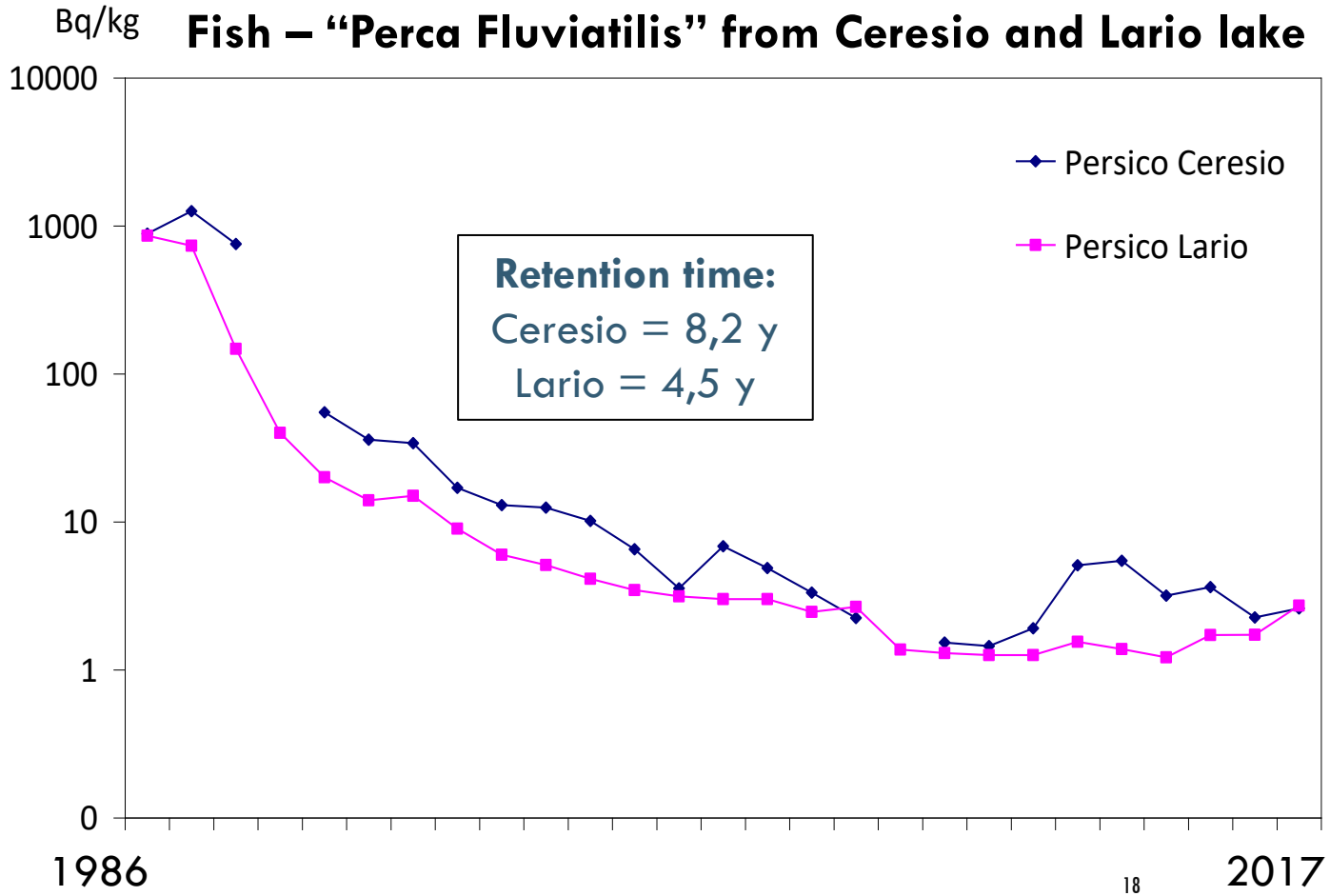


Higher Cs-137 values in carnivorous species

Radioactivity in the environment - Fish

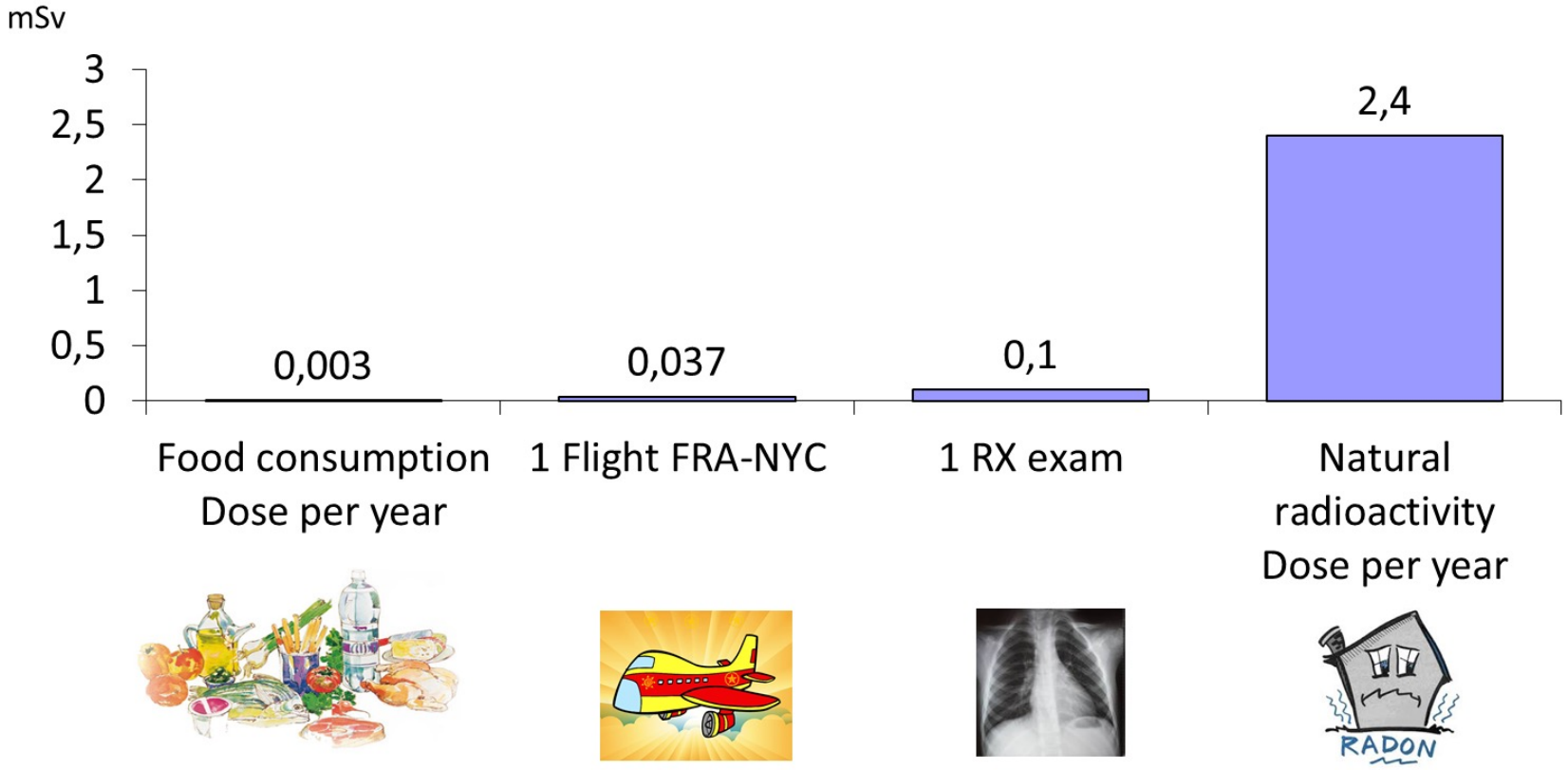
- Source of information about environmental dynamics of different water basins





Radioactivity in the environment

DOSE



Emergency Quick Alert

Air monitoring – Gas and particulate

- TSP monitoring: running since 1988
- Gas monitoring: running since 1997

Sampling point and frequency

- Milano city centre
- Particulate: Daily (continuous from 9 a.m. to 9 a.m.)
- Gas: Weekly

Measurement frequency

- Particulate: Daily, Weekly, Monthly
- Gas: Weekly

Monitoring conditions optimized for quick alert of "relevant" air contamination

Air monitoring – Sampling unit

- **Housing:** Commercial

(Air Sampler GMWL-2000 H - General Metal Work Inc. US)

- **Flow counter:** Commercial (Schlumberger; resolution 0,01 m^3)

Uncertainty in flow rate measurement: 5%

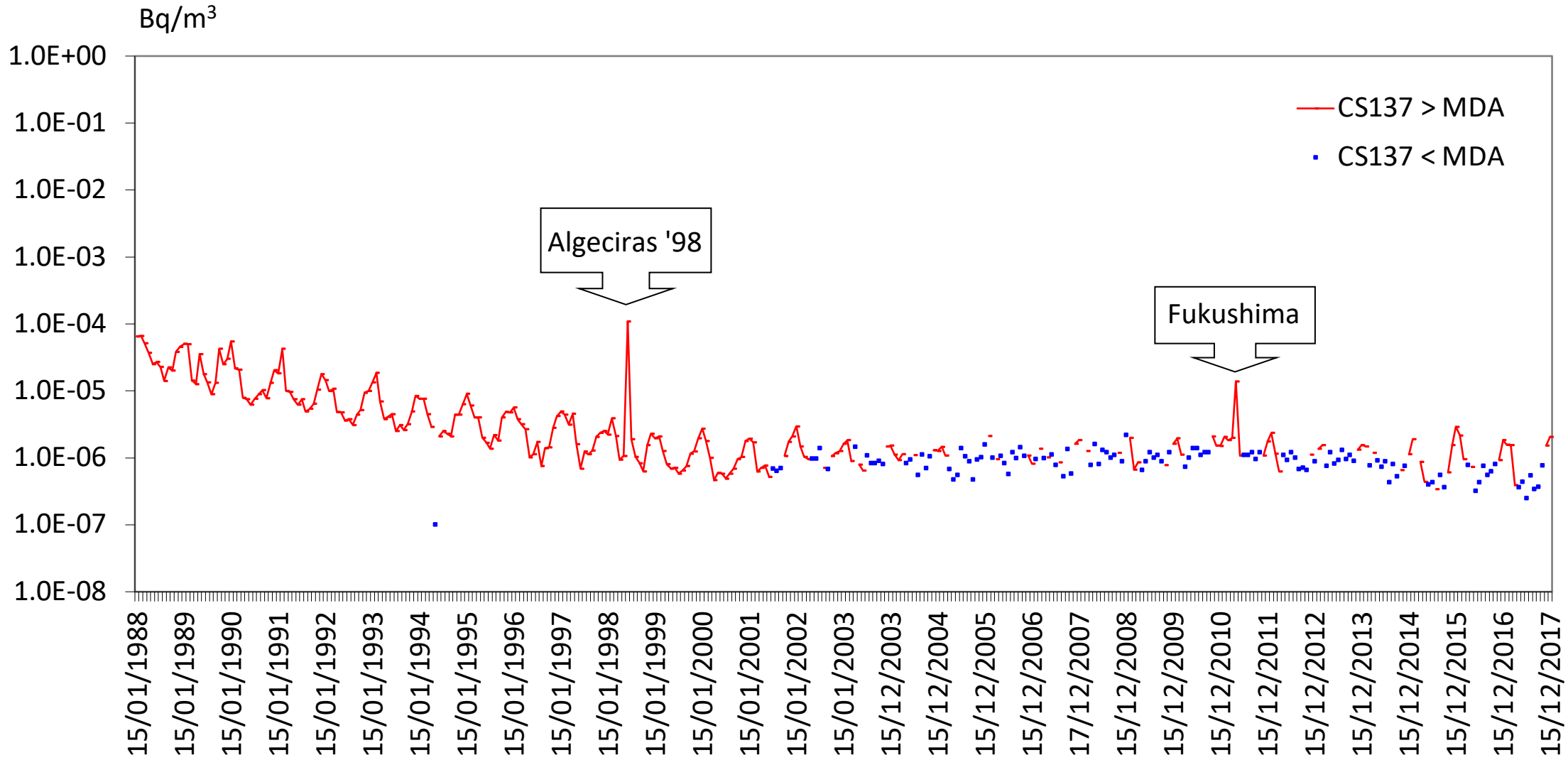
- **Pumping system:**

Flow: ≈ 100 m^3/h (≈ 2400 m^3/d)

- **Filtering unit:**

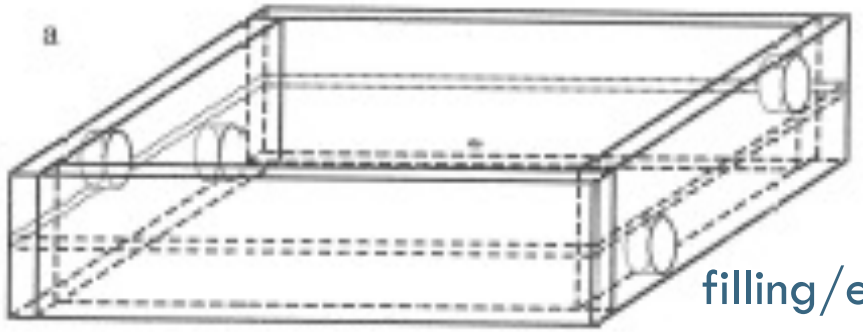
Glass microfiber filter (Whatman GF/A CAT No. 1820-866, 203x254 mm) + **iodine trap**

Air monitoring – Particulate



Air monitoring – Iodine trap

Methylmetacrylate box



2 beds, each one:

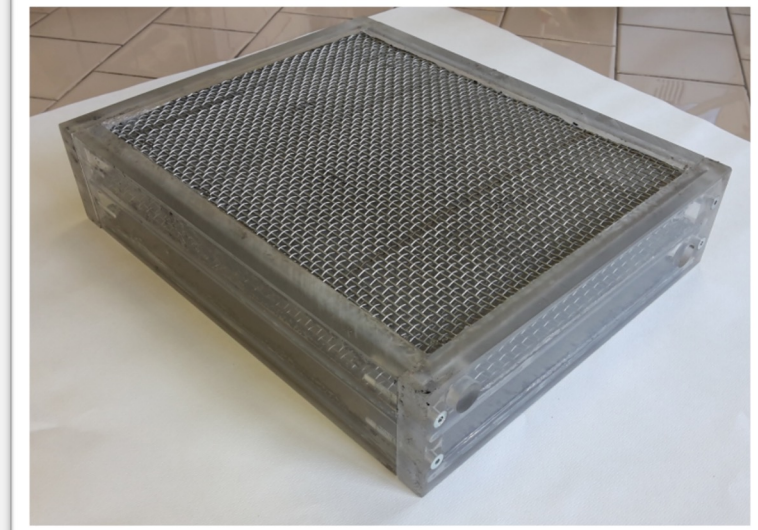
19 x 24 x **2,4** cm

≈ 500 g RKJ (≈ 1 L) (Marinelli)

filling/empting holes

Beds separated by double metal grids

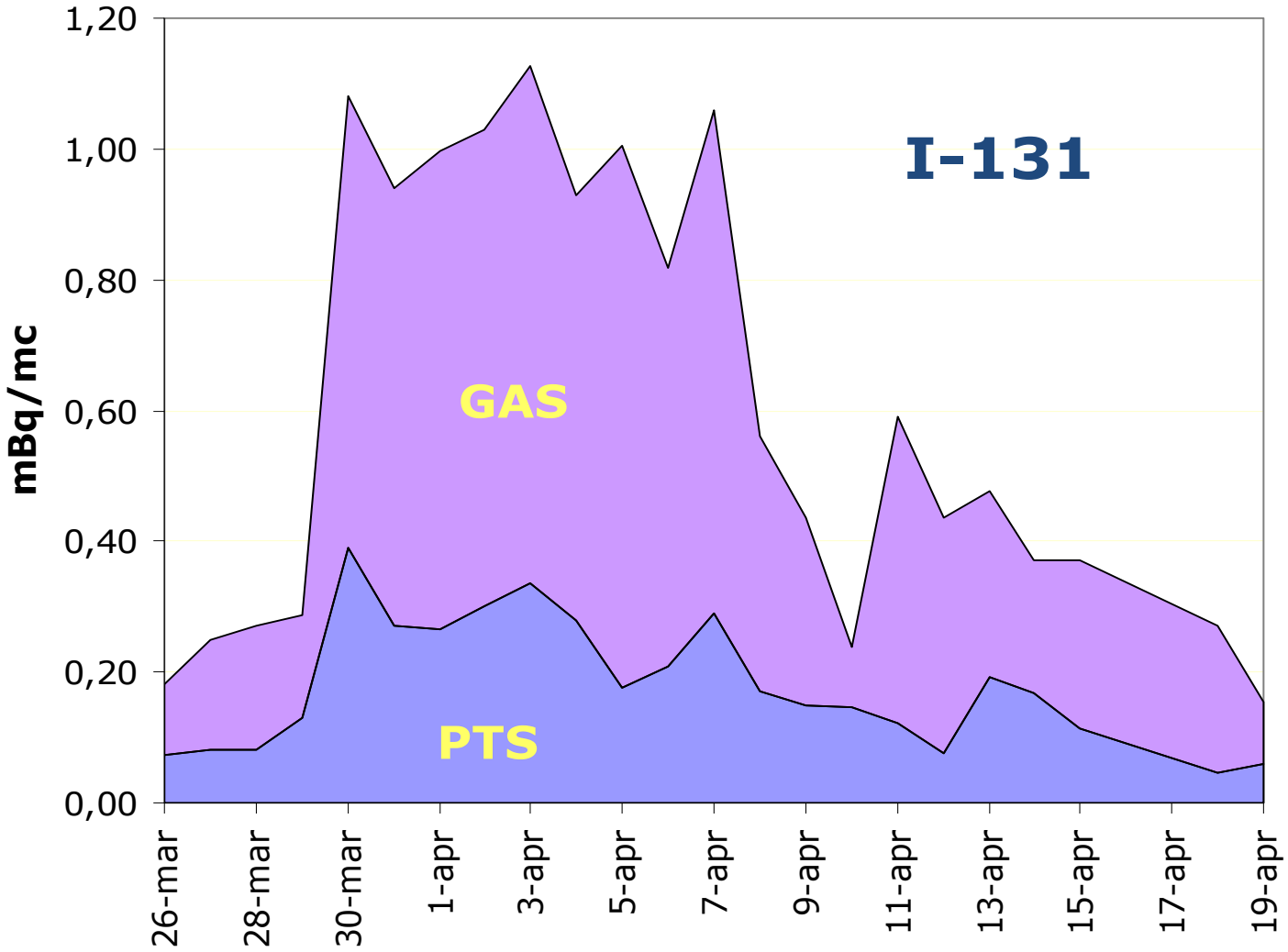
(2 different meshes), silicon sealed



NORIT RKJ

* Granular activated carbon
* Elemental, ionic and organic I retention
* Pellet diameter: 1.3 – 1.5 mm
* BET surface area: 900 – 1000 m2/g

Air monitoring – Iodine 131



FUKUSHIMA 2011

Radioactivity in Air (particulate)

Avg $I_{gas}/I_{particulate}$ = 80 %

Results comparable to those obtained by other EU laboratories (Masson et al, 2011)

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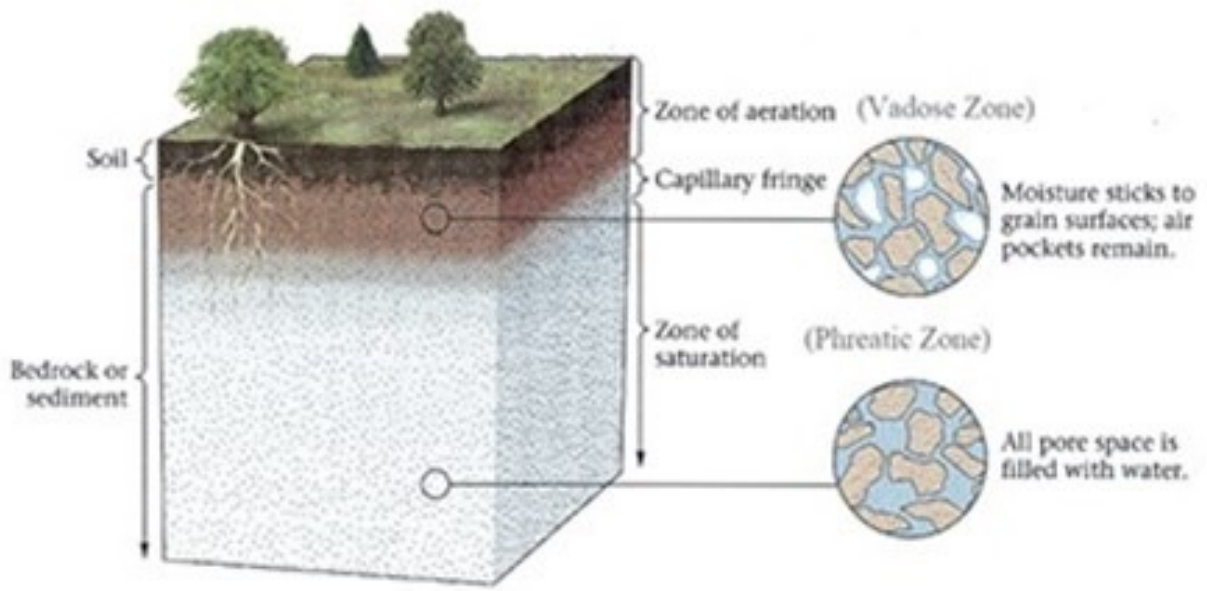
Drinking Water

Drinking water

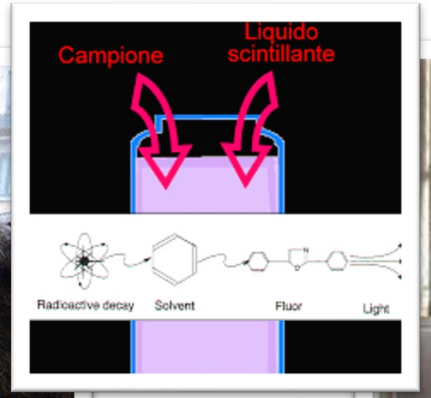
- According to European Council Directive 2013/51:
  - monitoring of major ground or surface water supplies and water distribution networks



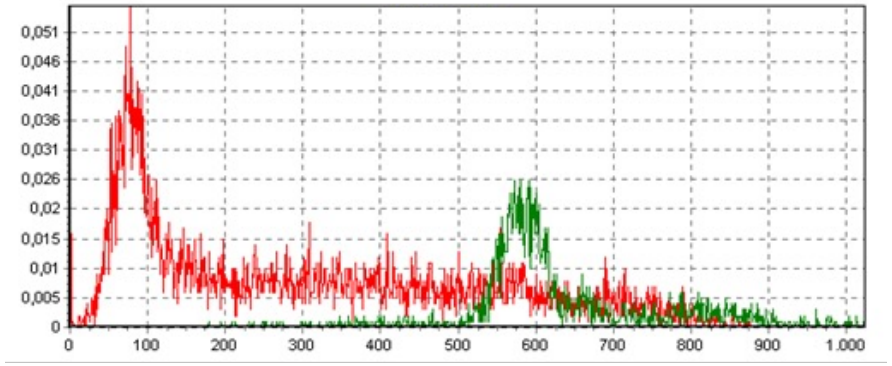
Parameter	Parameter value	Derived concentration	Limit of detection required by UE Directive
RADON	100 Bq/L		10 Bq/L
TRITIUM	100 Bq/L		10 Bq/L
INDICATIVE DOSE	0,1 mSv/y		
Gross Alpha		0,1 Bq/L	0,04 Bq/L
Gross Beta		1 Bq/L	0,4 Bq/L
U-238		3 Bq/L	0,02 Bq/L
Ra-226		0,5 Bq/L	0,04 Bq/L
Cs-137		11 Bq/L	0,5 Bq/L

Drinking water: Monitoring network

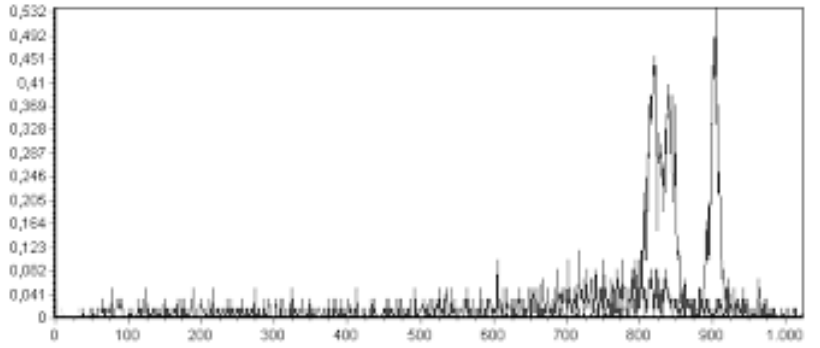
- Extensive monitoring of Gross Alpha and Beta:
  - Sampling about 0,5 L of water from tap
  - Measurement by Liquid Scintillation Counting



Gross Alpha Beta



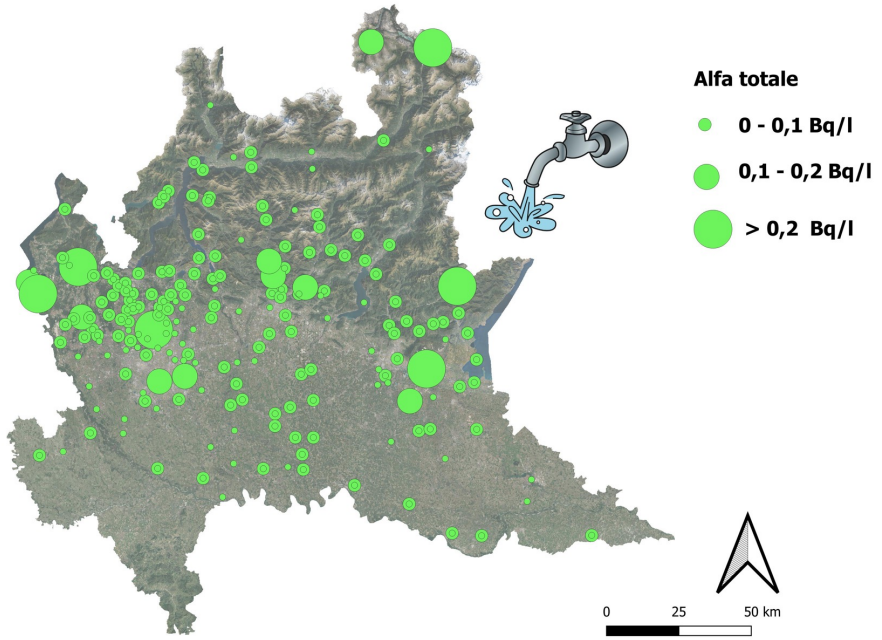
Radon 222

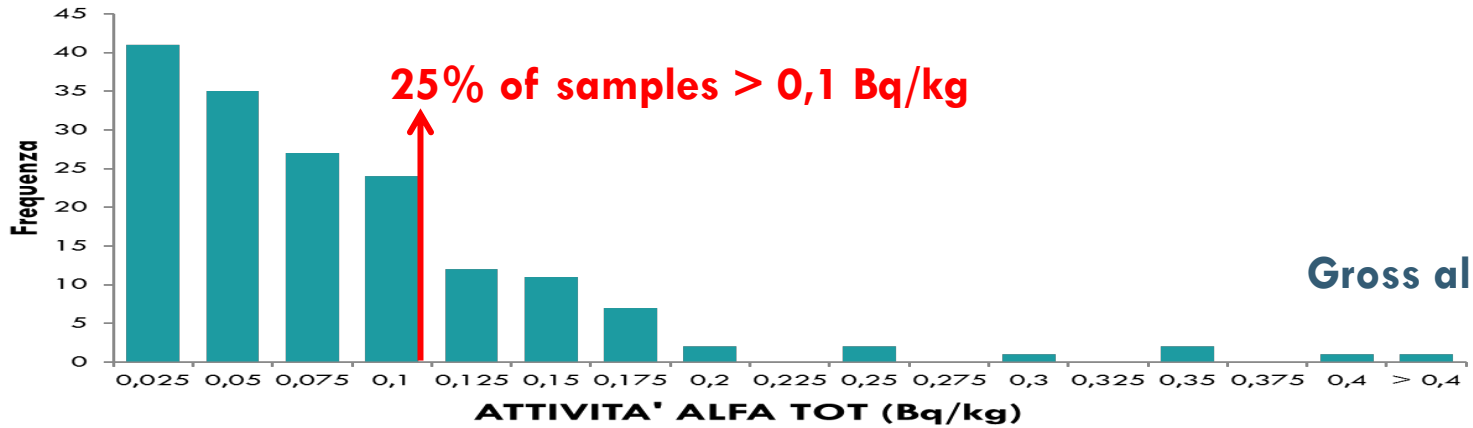


Drinking water: Monitoring network

Results at a glance:

- Gross Alpha:
  - 25% of samples > 0,1 Bq/L
  - Mainly due to Uranium isotopes (natural origin)
- Gross Beta:
  - < Limit of Detection (0,08 Bq/L)
- Artificial nuclides (Gamma Spec.) < L.D. (0,0005 Bq/L for Cs-137)

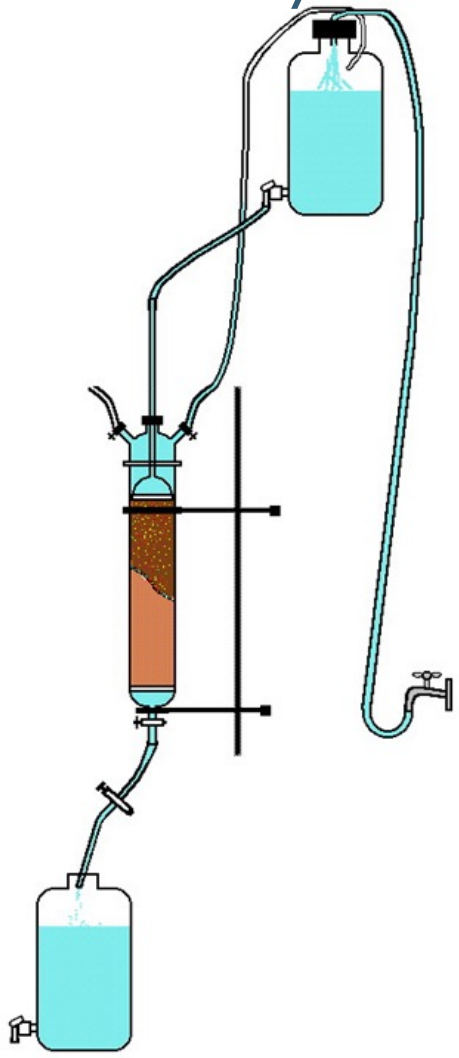




Gross alpha activity in underground waters

Drinking water: Monitoring network

- In selected points, continuous sampling for high sensitivity monitoring by Gamma Spectrometry



METHOD

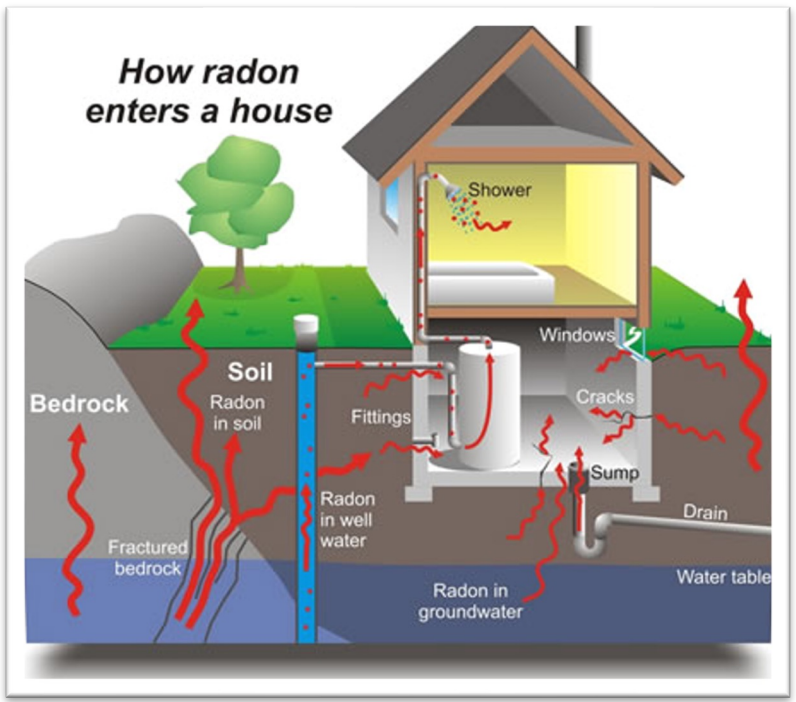
- Continuous elution, over 1 month, on a colum (1 kg) of ionic exchange resin
- Measurement by Gamma Spec. for 4000 minutes

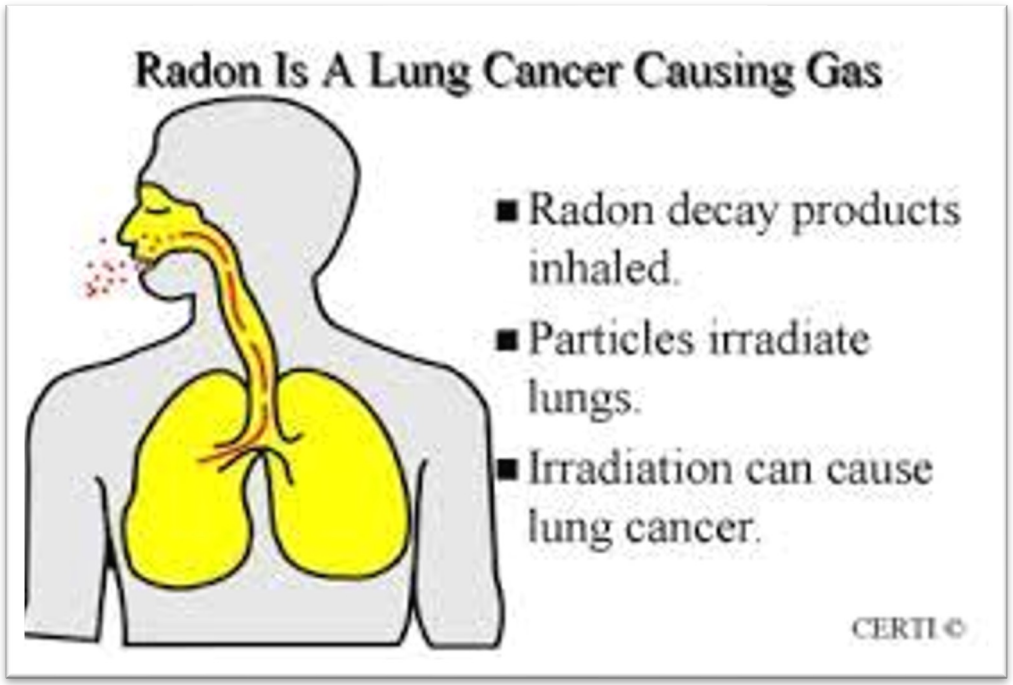
HPGe Detectors, 30% relative efficiency:

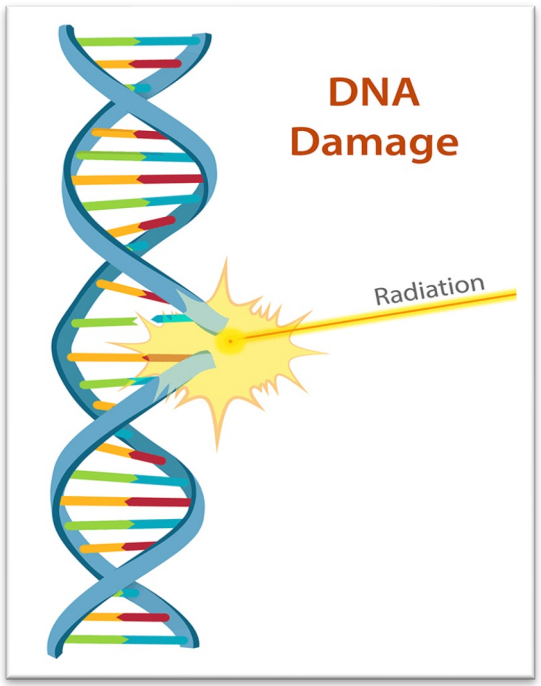
Parameter	Amount of sample	Counting Time	Limit of detection *
Cs-137	1 L	1000 min	0,1 Bq/L
	200 L	4000 min	0,0005 Bq/L

* Limit of detection required by EU: 0,5 Bq/L

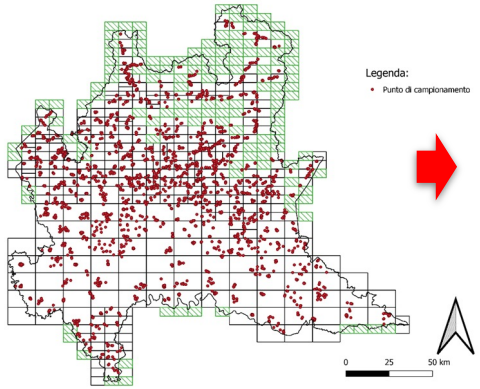
Radon indoor

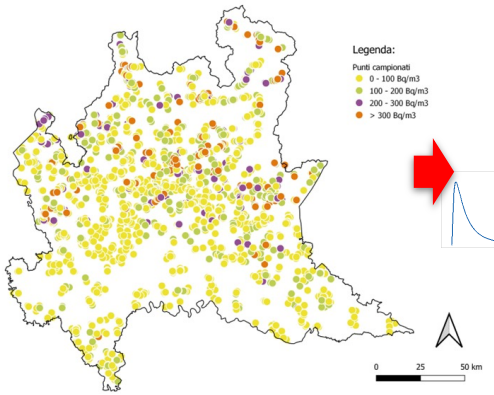


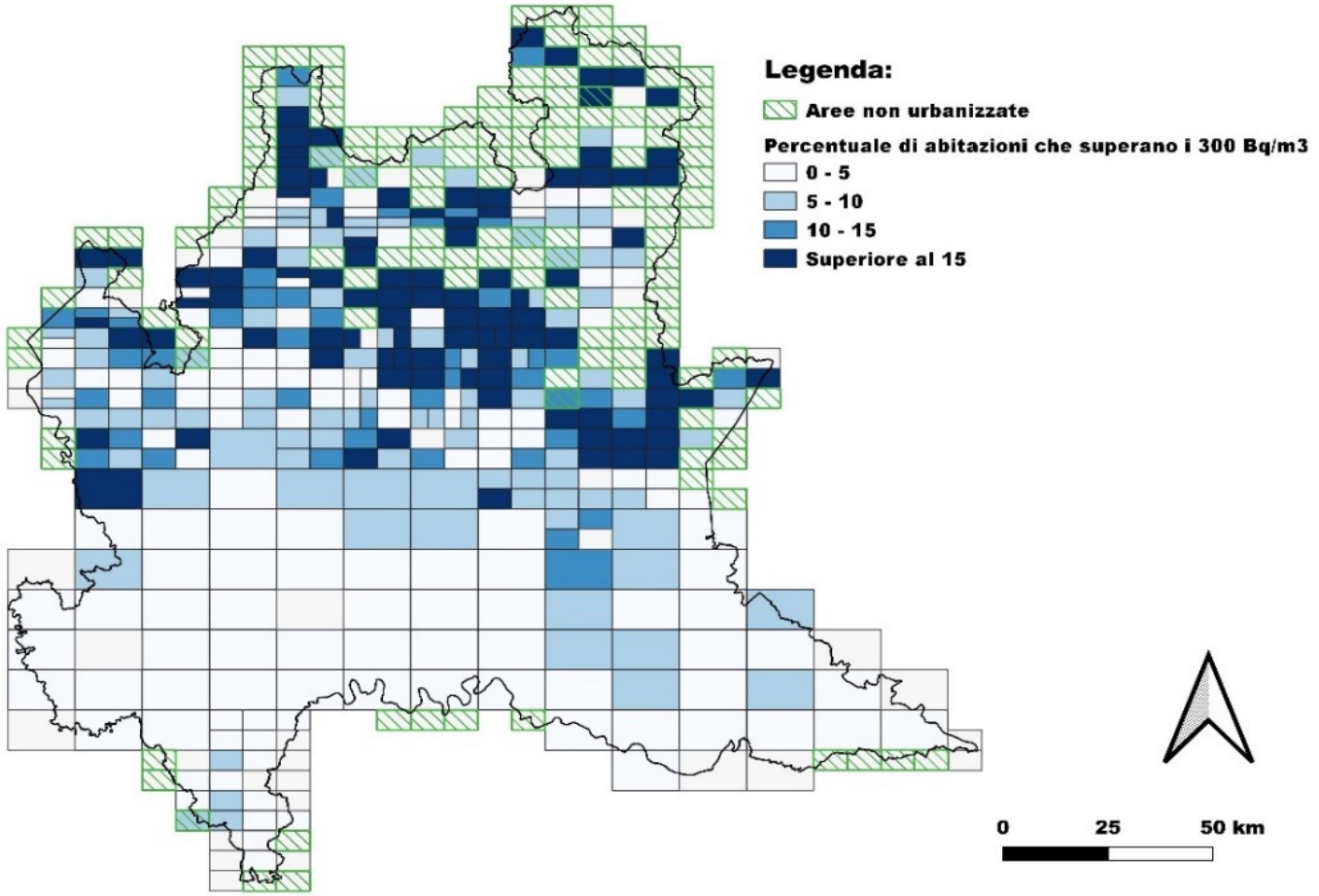




Radon indoor







In-field activities

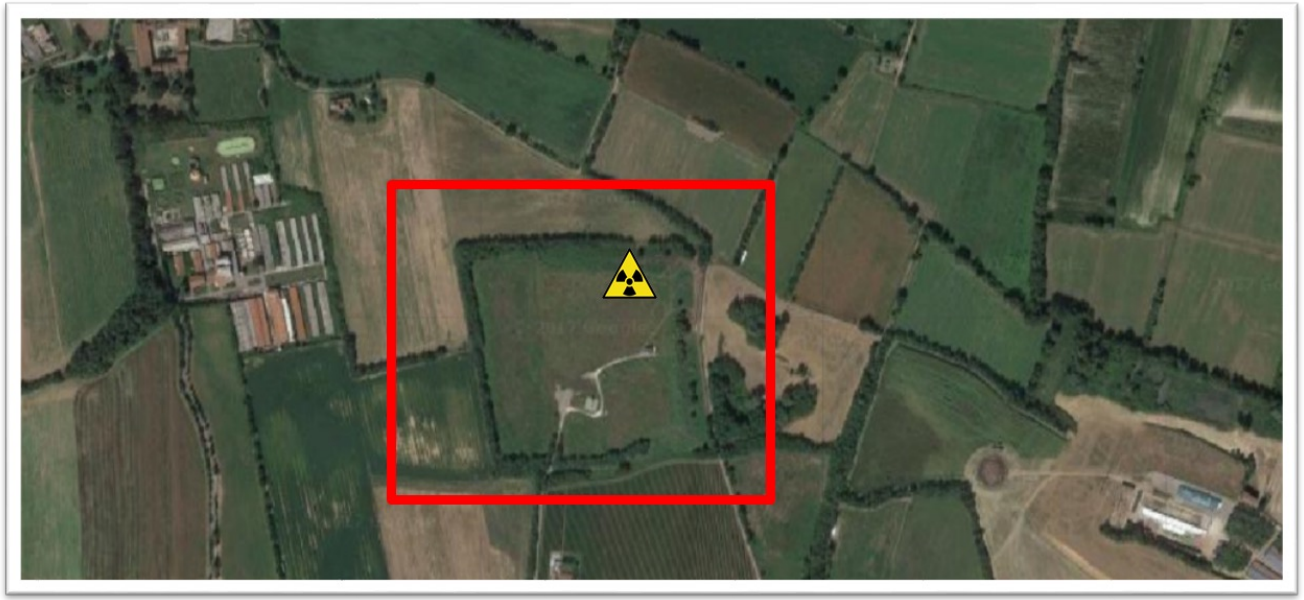
- Technical support to public authorities (health offices etc.) facing radioprotection problems
- Assistance to stakeholders in case of accidents involving radioactive sources

Retrieval of guinea pigs contaminated by ^{3}H in the decommissioning of a pharmaceutical factory

Melting of a ^{137}Cs and a ^{60}Co source in a steel factory

Exposure scenario: Waste waters from waste repository

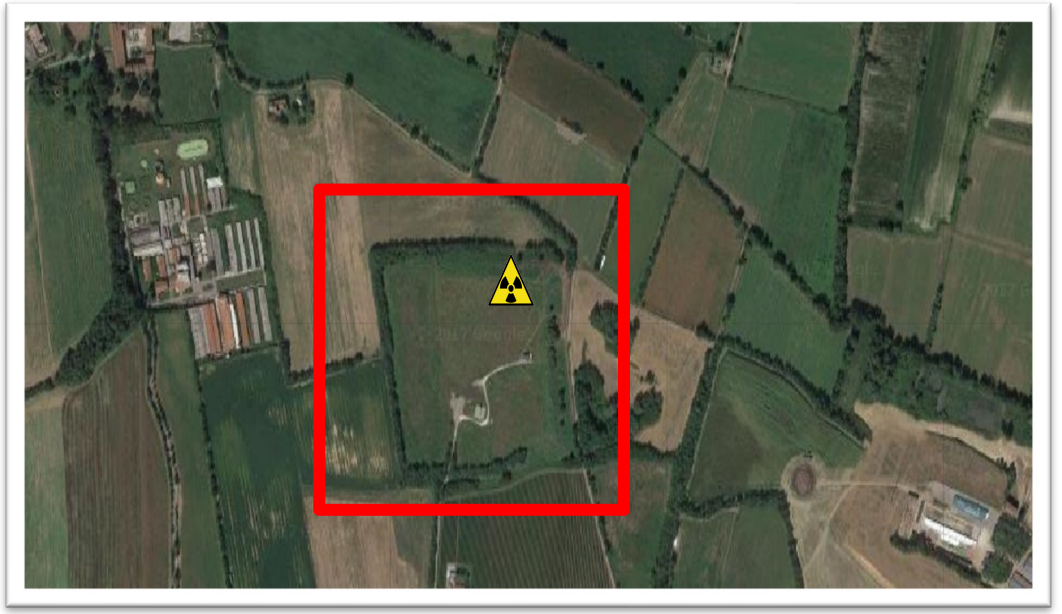
- Surveillance around contaminated sites
  - Foundry slag repositories contaminated by artificial nuclides: Cs-137, Am-241



Foundry slag repository contaminated by Cs-137

Exposure scenario: Waste waters from waste repository

Production of big amounts of waste water contaminated by Cs-137



Definition of exposure scenario:

- waste collected by tanks
- sent for waste processing to an ordinary sewage
- sludge (which concentrate Cs) used in agriculture

Exposure scenario: Waste waters from waste repository

Cs-137: 100 Bq/kg

Contaminated waste water
1000 ton/year

10^2 Bq/kg * 10^6 kg/y
= 10^8 Bq/y

10^8 Bq/y

«Clean» Waste water

Sewage treatment plant

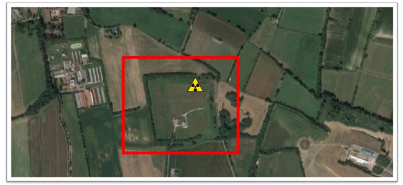
Clean water → River

Sludge → Agriculture

2000 ton/y

10^8 Bq/y / 2*10^6 kg/y
= 500 Bq/kg

Exposure scenario: Waste waters from waste repository



Sludge (500 Bq/kg Cs-137) in agriculture:

- Max amount per area: 0,75 kg/m^2 of agricultural land (National Regulation)
- Cs-137 (Bq/m^2) = 500 Bq/kg * 0,75 kg/m^2 = 375 Bq/m^2
- Sludge mixed with soil (10 cm depth -1500 kg/m^3) :

  375 Bq / (1m^2 * 0,1m * 1500kg/m^3) = 2,5 Bq/kg

10 cm of soil contaminated by Cs-137 – 2,5 Bq/kg

1 µSv/y, mainly due to external irradiation (97%)

RESRAD - Argonne National Laboratory - http://resrad.evs.anl.gov/

Exposure pathways: external irradiation, food ingestion, etc.

RESRAD ONSITE GRAPHICS

File Edit Options View

Plot Type
- Dose
- Concentration
- Dose/Source Ratio
- Soil Guidelines
- Risk

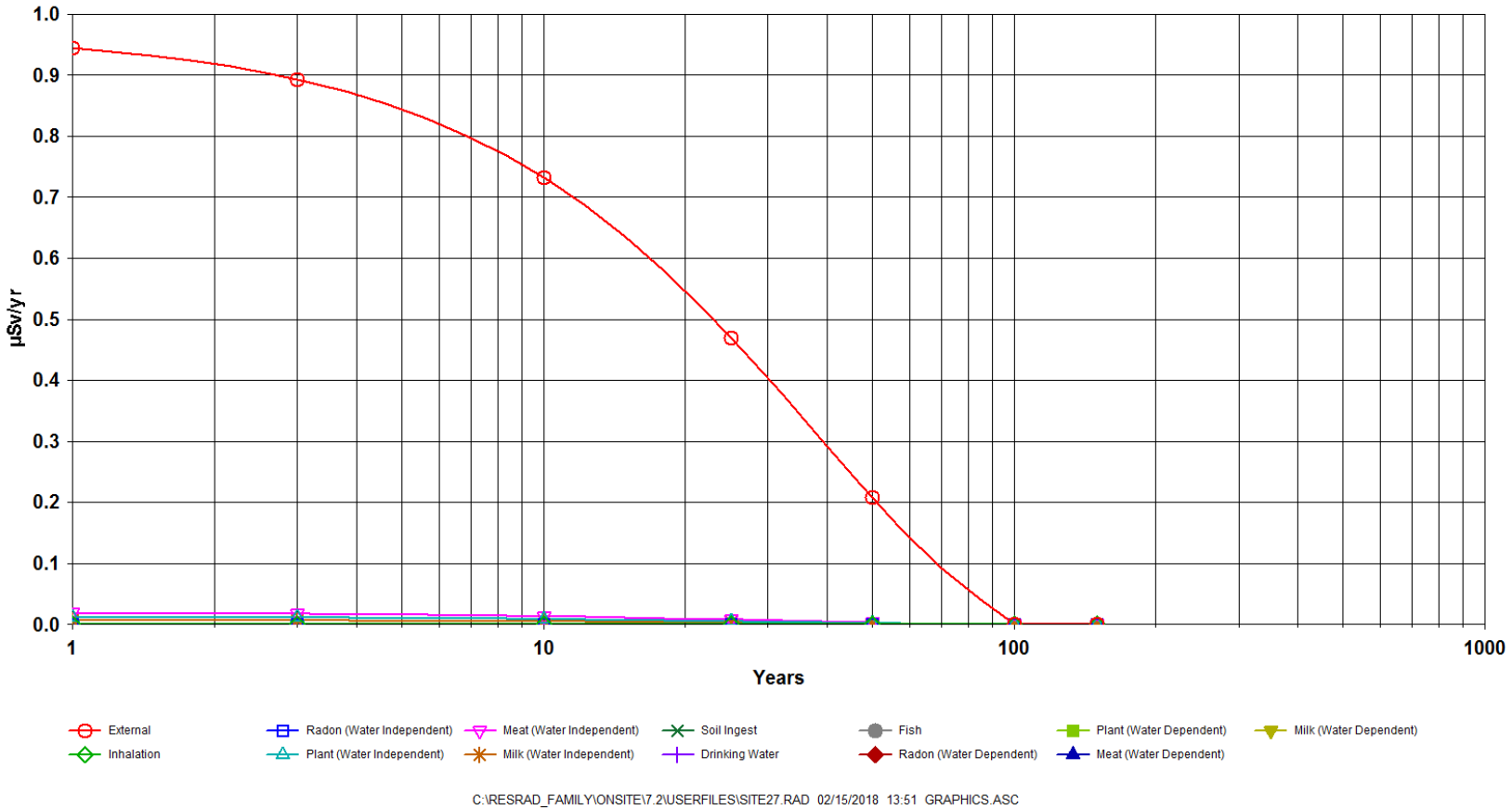
Radionuclide
- Summed
- Individual
- Individual and Progeny
- Individual and Threads

Cs-137

Pathways
- Summed
- Components
- Water Indep./Dependent
- Individual

External

DOSE: All Nuclides Summed, Component Pathways



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RESRAD - Argonne National Laboratory - http://resrad.evs.anl.gov/

Exposure scenario: Waste waters from waste repository

To resume:

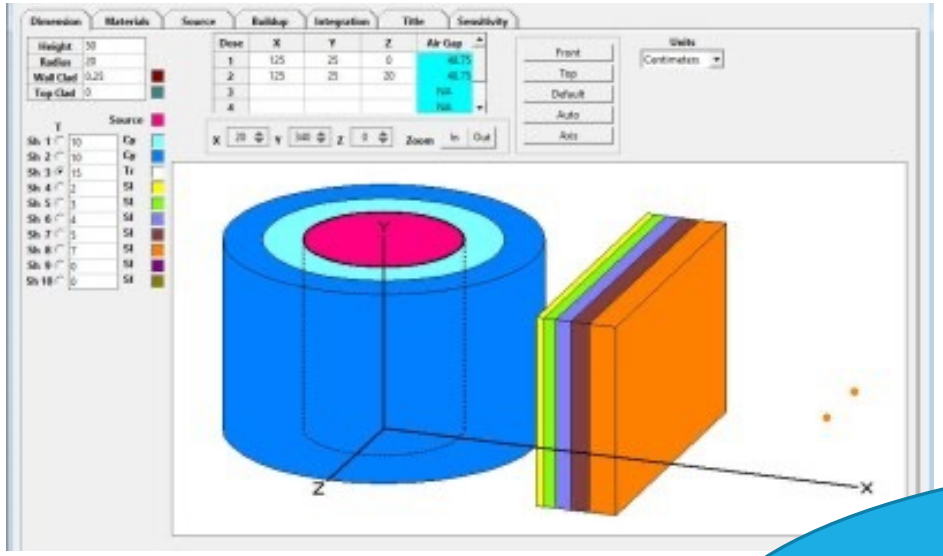
Exposure scenario: use in agriculture of slags contaminated by water contaminated by Cs-137

Waste water: 100 Bq/kg of Cs-137 ⇔ 1 µSv/y to the most exposed group

"Specific clearance level" for waste water corresponding to 10 µSv/y:

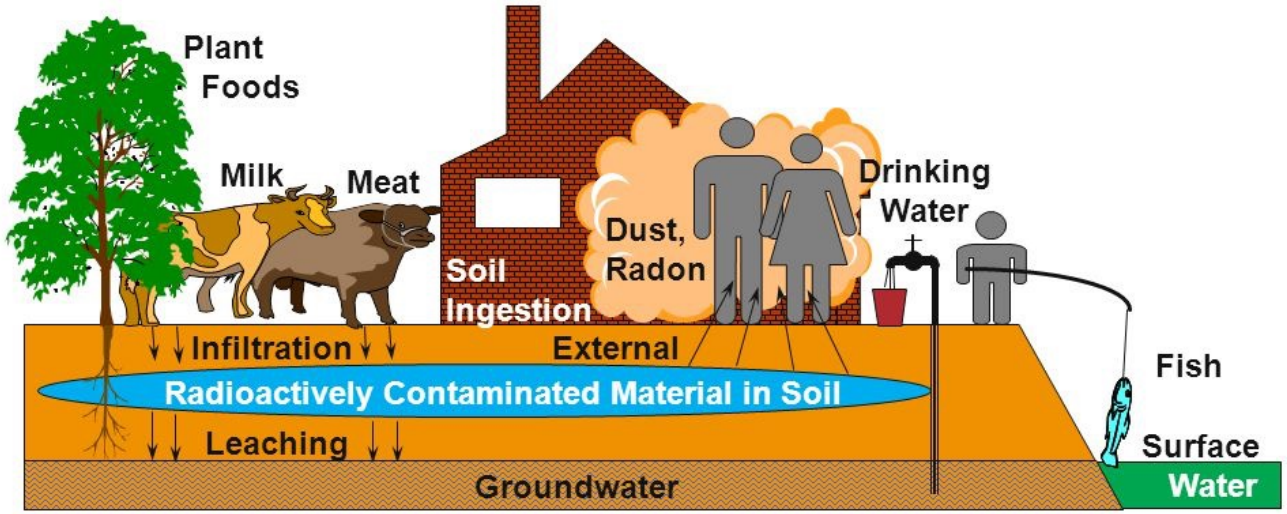
1000 Bq/kg of Cs-137

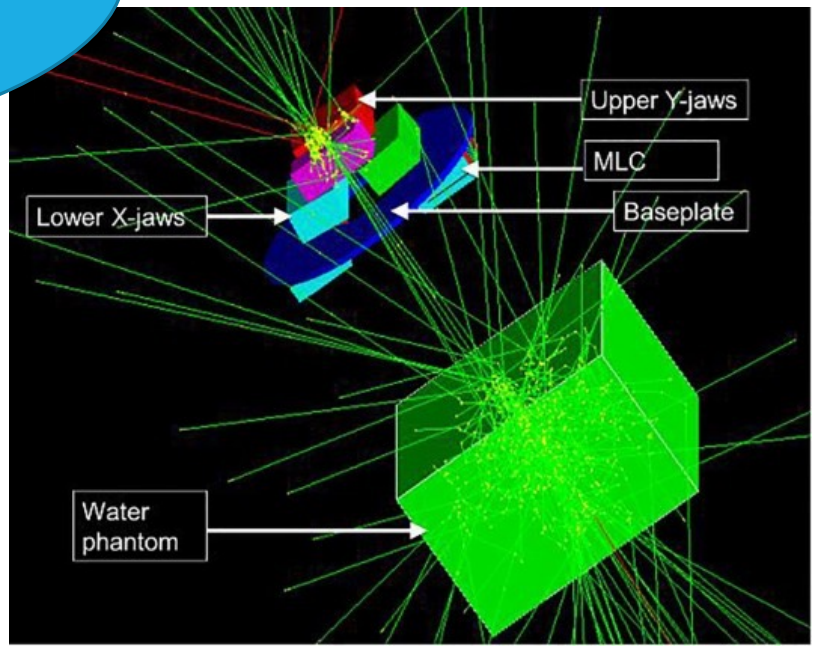
Required sensitivity: 1/10 of 1000 Bq/kg = 100 Bq/kg



$$E_{ext} = \frac{A \cdot CF_6 \cdot T_e \cdot (0.5)^{\frac{d}{d_{1/2}}}}{X^2}$$

Modellistica





Caso 1: rete di monitoraggio

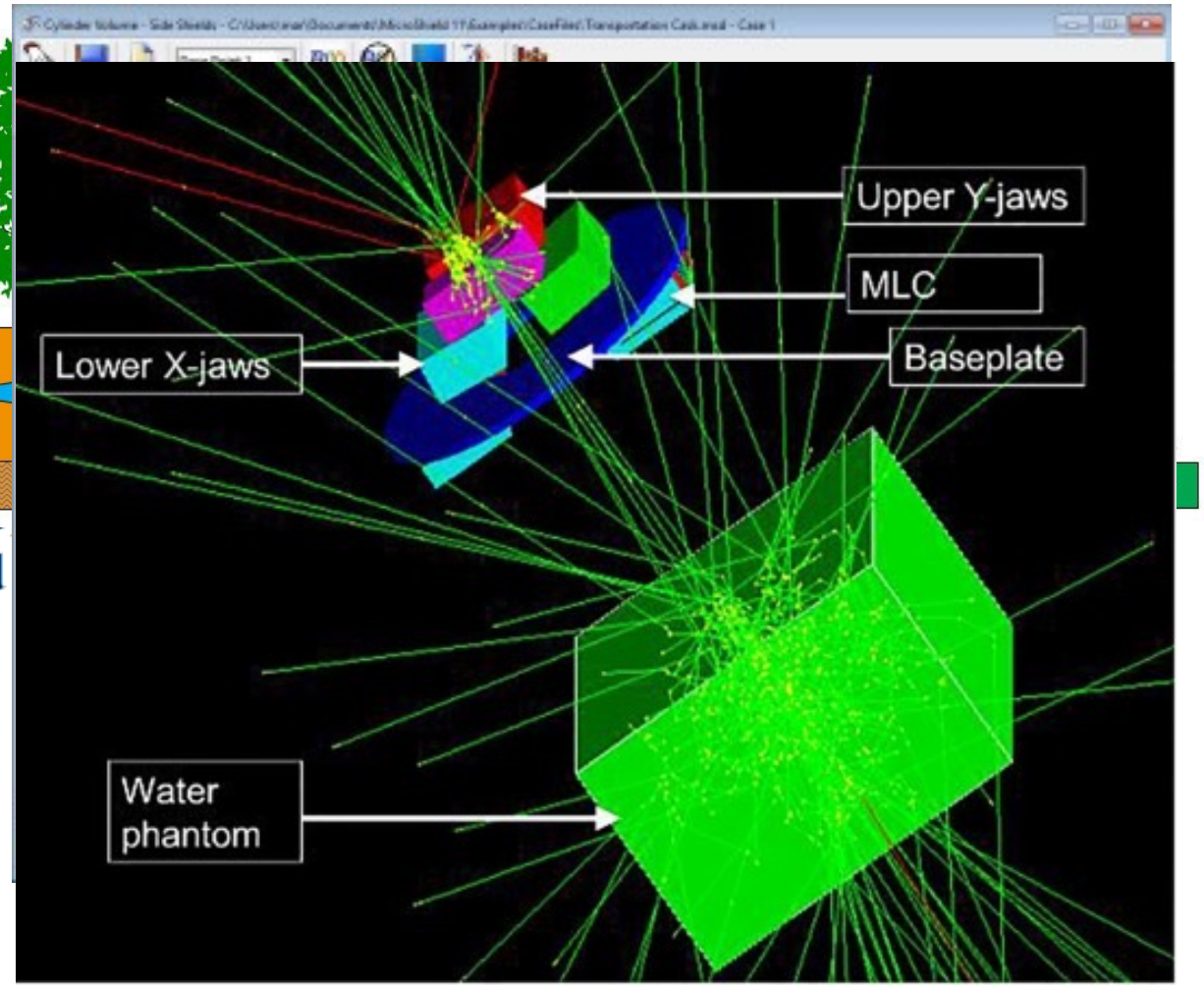
COSA MISURO	COSA MI INTERESSA
In <u>laboratorio</u>	
Contaminazione matrice (aria, acqua, alimenti, ecc.)	Rischio per gli individui esposti
Concentrazione di attività (Bq/kg)	Dose (µSv)

Modellistica

1. Modelli matematici
   (equazioni per stime di dose)

2. Software
   ResRad (dose alla popolazione)
   MicroShield (dose gamma in aria)

3. Codici Montecarlo
   es. GEANT4



Caso 2: attività in campo

COSA MISURO

In situ con strumenti portatili

Rischio per gli individui esposti

Rateo di dose (µSv/h)
(…ma non solo!)

COSA MI INTERESSA

Contaminazione matrici
al fine dell'allontanamento
(es. rifiuti, materiale contaminato)

Concentrazione di attività
(Bq/kg)

Perché misure in campo?

- ✓ Tempi ridotti
- ✓ Manipolazione non necessaria
- X Valutazione contributi ~~incertezza~~
- X Sensibilità peggiore

Sufficiente per
verificare limiti?
(es. livelli di
allontanamento)

Esempio: rifiuti solidi ospedalieri

Misura con portatile (es. dose gamma)

↓ Applico modello

Concentrazione media di attività (Bq/kg)

↓

Confronto con limiti di legge

↓

Posso smaltire il rifiuto come NON radioattivo?

Strumenti portatili – Misuratori di dose gamma

Rateo di dose gamma (µSv/h)

Es. **Identifinder**

Cristallo NaI

Identificazione radionuclidi tramite spettro

Strumenti portatili – Spettrometro gamma

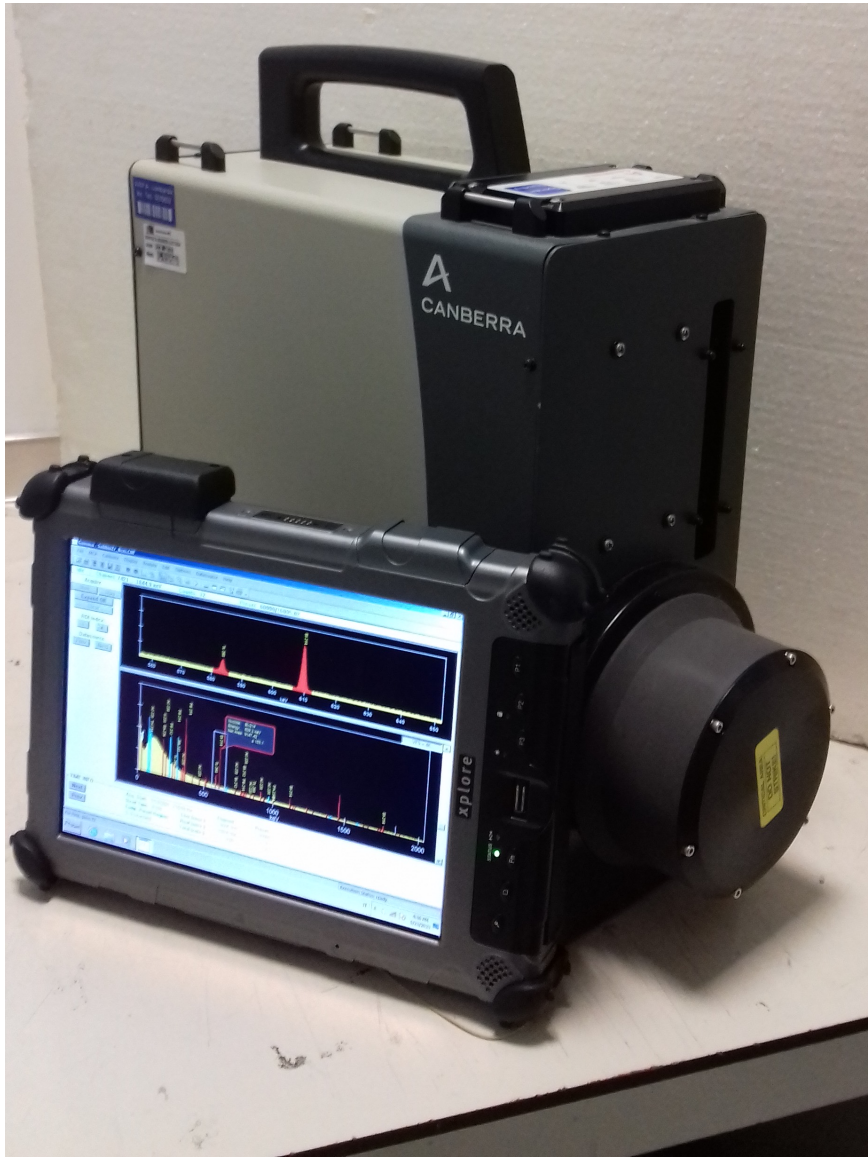
Acquisizione spettro gamma

Rateo di dose gamma (µSv/h)

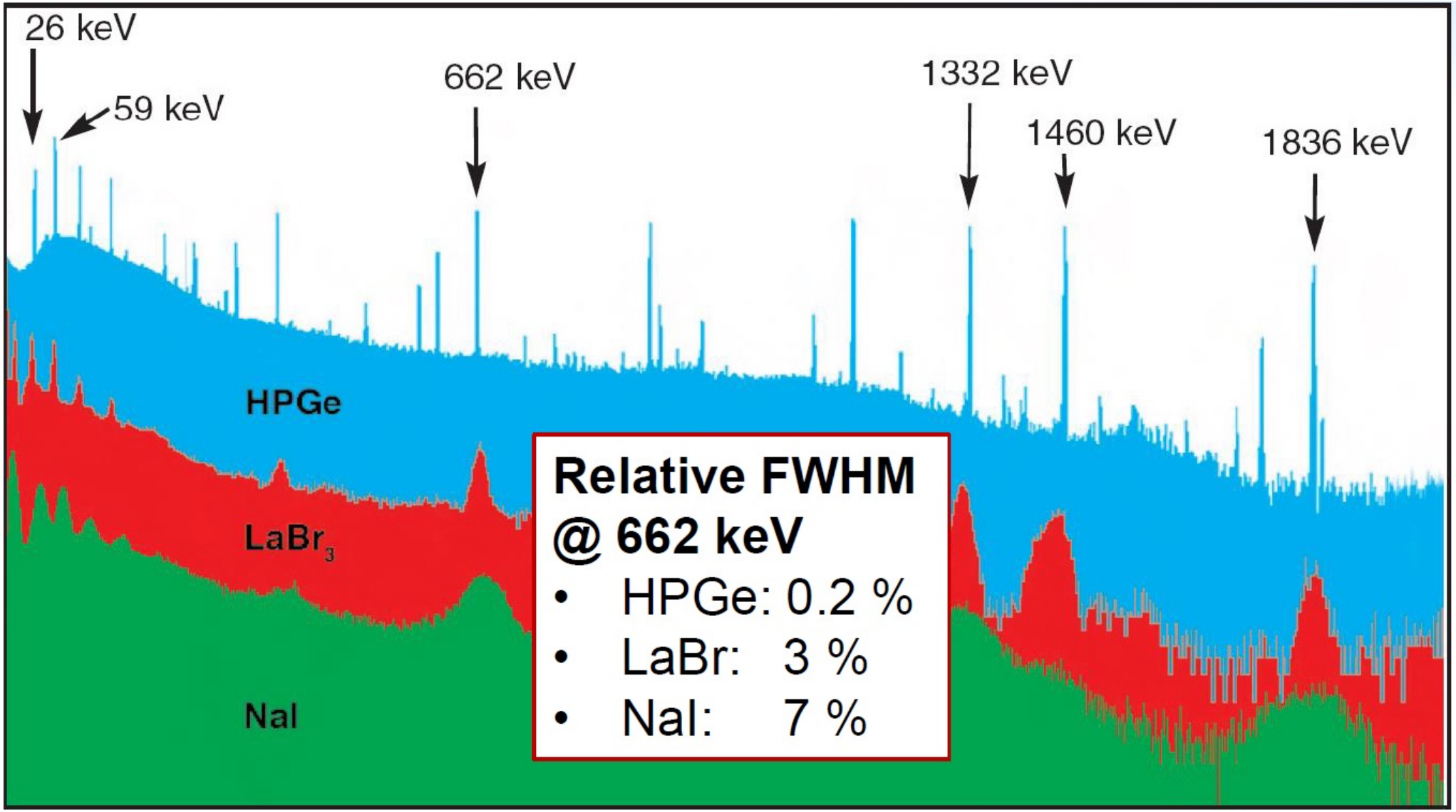
Es. **Falcon**

Rivelatore HPGe (Germanio)

Identificazione e quantificazione radionuclidi tramite spettro



Strumenti portatili



Strumenti portatili - Contaminametri

Conteggi al secondo (cps)
(in particolare alfa e beta)

Es. **Berthold LB 124**
ZnS + scintillatore plastico
Discriminazione alfa vs βγ

Modello

Quello che misuro (es. dose)

Grandezza derivata (es. concentrazione di attività)

Fattore di conversione

Dipende da:

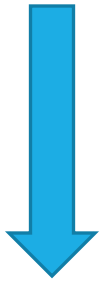
- Geometria
- Radionuclide
- Strumento

Quello che NON misuro (es. sensibilità strumento in dose)

Sensibilità analitica per grandezza derivata (es. concentrazione di attività)

Modellistica in breve

- ✓ Permette di ottenere risultati indirettamente (es. grandezze difficili da misurare)
- ✓ Ottimizzazione tempi e materiali (es. numero limitato di misure sperimentali)
- ✓ Simulazione scenari emergenza
- ? Approssimazione dello scenario reale
  - Non conosco perfettamente il campione
  - Presenza di disomogeneità



…il modello è sempre valido?

Necessità di una validazione sperimentale!

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