L'esperimento ENVIRAD-SPLASH gruppo V

Collaborazione CA, CT, LNS, MI, NA, PV, SA, TO, TS

Gruppo di Torino:

Daniela Allasia, Daniela Maurizio, Giuseppina Rinaudo

sono inoltre coinvolti numerosi insegnanti di scuola secondaria e specializzandi della Scuola di Specializzazione per l'Insegnamento Secondario - SIS

Scopi:

- *diffusione della cultura scientifica nella scuola secondaria superiore, in particolare nel campo della* ***radioattività ambientale***
- *sviluppo di materiali didattici sulla radioattività adatti alla scuola secondaria*
- *sviluppo/sperimentazione di rivelatori utilizzabili in una scuola secondaria*

Le attività

- *interventi nelle scuole:* svolti da molti anni, inizialmente nell'ambito delle offerte didattiche del CeSeDi (Provincia di Torino) e ultimamente nell'ambito del Progetto Lauree Scientifiche con l'iniziativa "Un esperimento in prestito" (risultati presentati al congresso GIREP-EPEC di Opatija, ago. 07)
- *interventi nell'ambito dello stage di fisica nella CasAlpina di Mompellato (valle di Susa):* misure di livelli di radiazione e.m. e ionizzante in quota
- *attività varie in collaborazione con docenti di scuola secondaria:* con due nuovi rivelatori di radiazione acquistati in parte con fondi INFN del 2006 (su questa parte del progetto sono state svolte due tesi di laurea magistrale in fisica)
- *studio/sperimentazione di rivelatori adatti alla scuola secondaria*

Tutta la documentazione è disponibile nei siti
http://www.iapht.unito.it/uranio

http://www.iapht.unito.it//stagefisica/

GIREP EPEC Conference
Opatija – August 27-31, 2007

- Why do the words “nucleus” or “nuclear energy” generate fear?
- Is there anything we can do to change this irrational attitude?

Daniela Allasia, Giuseppina Rinaudo

Experimental Physics Dept. – University of Torino –

http://www.iapht.unito.it/uranio

Aims

Convince the teacher that

- basic concepts are accessible to secondary school students
- simple experiments are feasible with rather inexpensive, easy to handle and safe radiation detectors, which help to understand the basic physics and the "dosimetric" measurement units, that are fundamental in radiation phenomena
- richer experiments are possible with more sophisticated detectors (NaI scintillator and multichannel spectrometer)
- there is much physics and mathematics related to the experiments

Show the students that

- radiation is natural, there is a lot of radiation around us
- there are different types of radiation
- they can have fun in detecting radiation in the environment
- ionizing radiations are just a particular type of radiation
- it is important to know what makes ionizing radiations "different" from other types of radiation
- **ionizing radiations can be detected and measured**

The experiment
Part 1: recognize and detect different radiations

- *electromagnetic radiation* detected by a cellular telephone (in Italy it is familiar starting from kindergarden!)

- *visible light* from the sun or from a lamp

- *infrared radiation* detected by an infrared thermometer

- finally *ionizing radiation* detected by a *Geiger detector*

Common features of "radiations"

- we start from "familiar" radiations to discover their common characteristics
- for example, from electromagnetic radiation *produced* and *detected* by a cellular telephone, possibly using a telephone with a visible antenna
- and an inexpensive, but sufficiently accurate, "cell radiation" detector

The students recognize that

- the radiation comes from a "source";
- it travels in space (also in empty space)
- can be *produced* only by particular devices
- can be *detected* only by particular devices (we do not see it)
- it carries *energy* from the source to the detector

About "energy"

Important concepts about "energy" (in summary):

- "radiant energy" is energy that can travel also in empty space
- energy is needed to produce and detect the radiation
- the *source* is a device that can transform other forms of energy in "radiant energy"
- the *detector* is a device that can transform "radiant energy" into other forms of energy
- energy is carried by "quanta" (Planck relation: $E=hf$)
- different kinds of radiation carry different energy quanta: the energy of the quantum increases from cellular, to IR, to visible and, finally to ionizing radiation
- for cellular, IR and visible radiations a huge number of energy quanta are needed to make the detector work, so that their flux appears to be continuous
- on the contrary, the energy of ionizing radiation is tremendously large
- it is so large that a single "energy quantum" can be detected with a suitable detector such as a Geiger counter

Measurements with a Geiger detector

Measurements:

- background radiation in different sites
- radiation emitted by weak natural sources
- dependence upon distance

Aims:

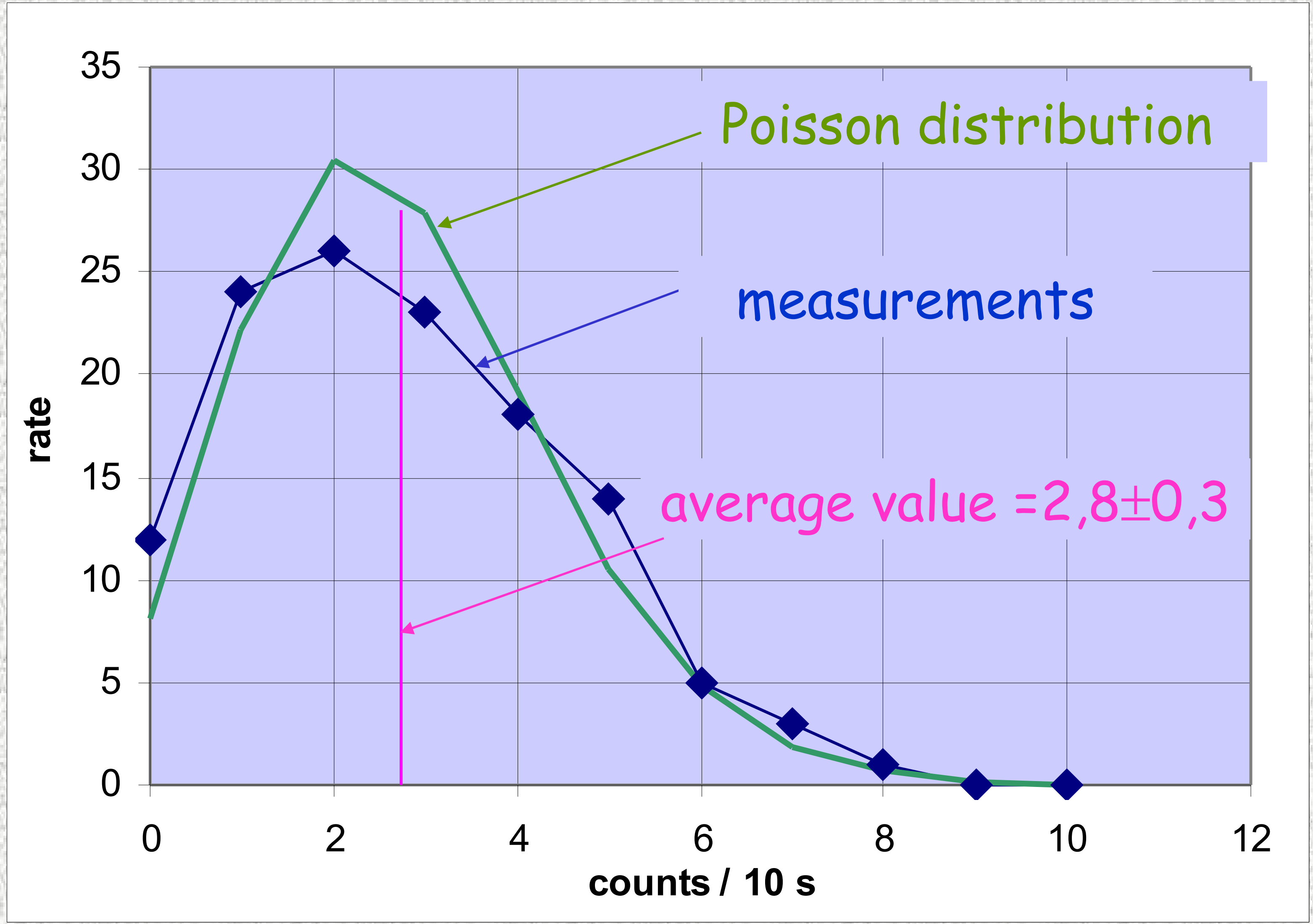
- "feel" that radiation is carried by single "energy quanta"
- observe that the time distribution of energy quanta is completely random

  → Poisson statistics
- map the background radiation on the territory

  → statistical error
- evaluate the "activity" of a source
- test dependence on inverse of distance squared
- learn about "dosimetric units"

Experimental results

example of background radiation counts detected in 10 s



Map of the measurements done in the schools

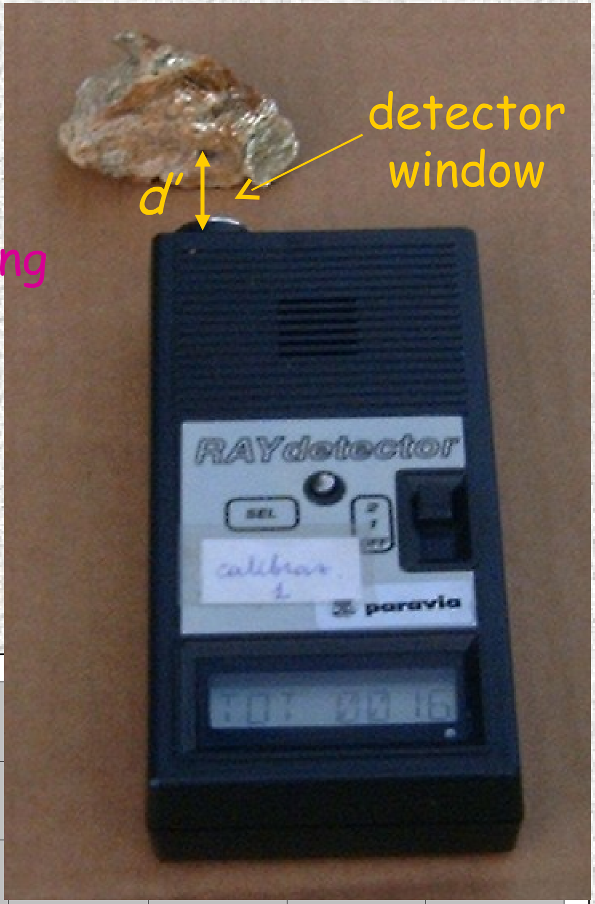
map #	school	Counts/s
1	ITIS Pinin Farina	0,46±0,04
2	Liceo cl. Balbo	0,43±0,04
3	Liceo sc. Copernico	0,35±0,03
4	Liceo sc. G. Ferraris	0,44±0,04
5	Liceo sc. Curie	0,40±0,04
6	Liceo cl. D'Azeglio	0,39±0,04
7	Liceo sc. Cattaneo	0,36±0,03
8	Liceo sc. Volta	0,42±0,04
9	Liceo sc. Gobetti	0,47±0,04
10	Liceo sc. Segré	0,43±0,04
11	Liceo sc. Einstein	0,42±0,04
12	Liceo sc. G. Bruno	0,40±0,04
13	Liceo sc. Gobetti (V.)	0,47±0,04
14	Liceo Europeo (Chivasso)	0,36±0,04
15	Liceo sc. Newton (Chiv.)	0,43±0,04
16	ITI Ferrari (Susa)	0,39±0,04
17	Liceo sc. Gramsci (Ivrea)	0,37±0,04
18	Lic.sc. Des Ambrois (Ulzio)	0,52±0,03

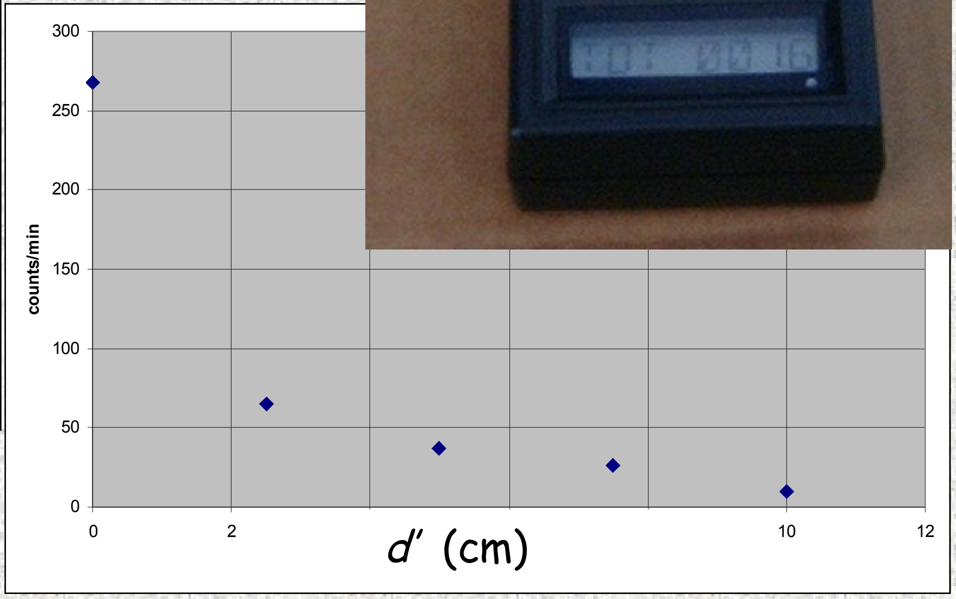
average: 0,41 spread: 0,05

Measurements on a “radioactive” rock

Aim: to learn about
- background level subtraction
- statistical significance of the radiation level
- reduction of the radiation level by distance and screening

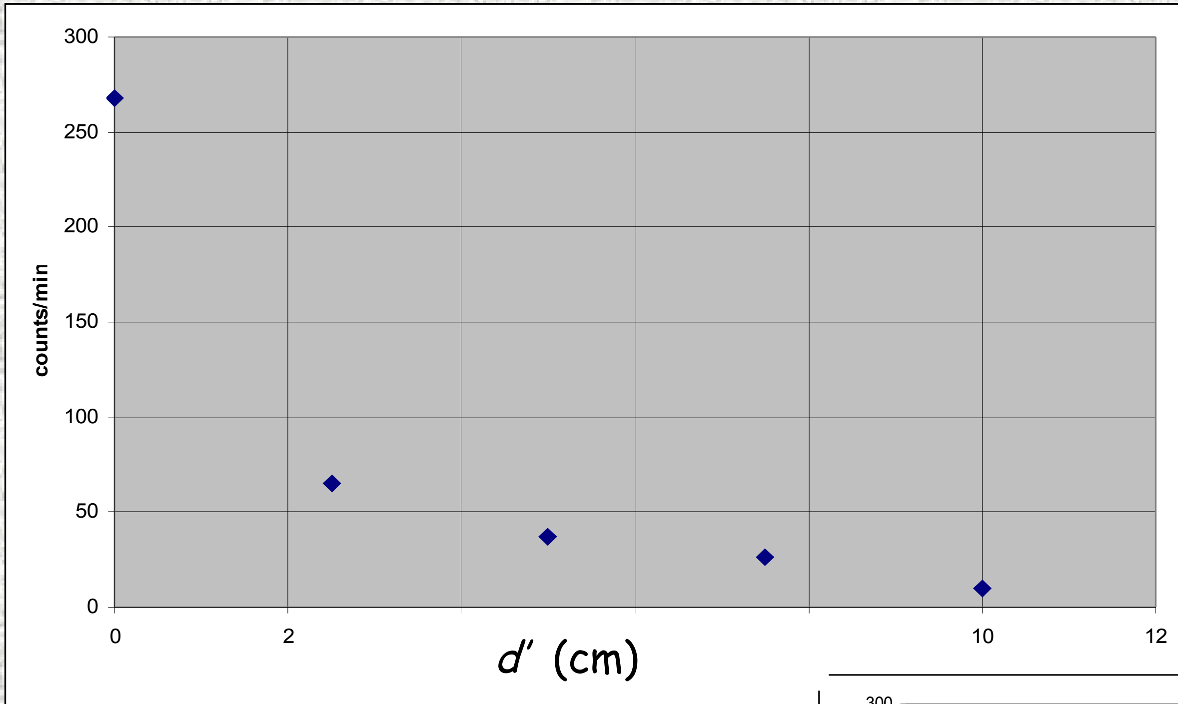
Minimum distance *d′* from detector window	Counts/min	Counts/min after background subtraction
0 cm	246±7	268±7
2,5 cm	87±3	65±4
5 cm	49±2	37±3
7,5 cm	39±2	27±3
10 cm	32±2	10±3
background	22±2	

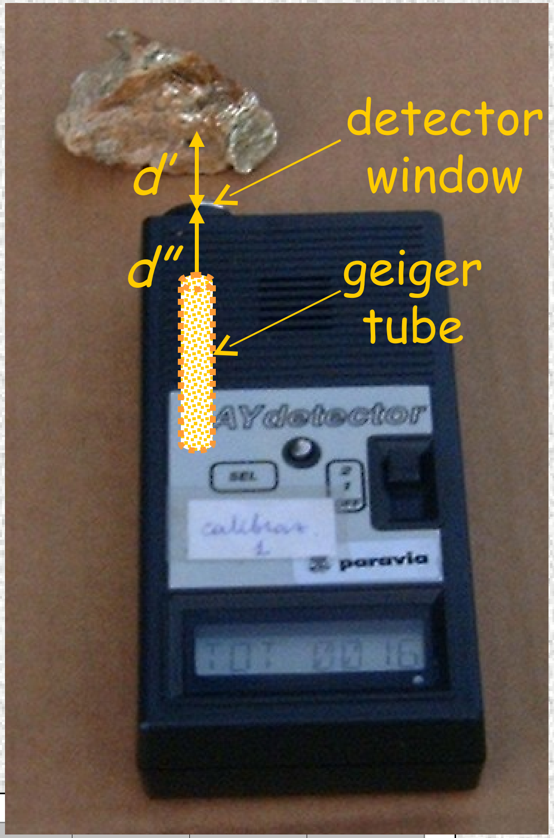




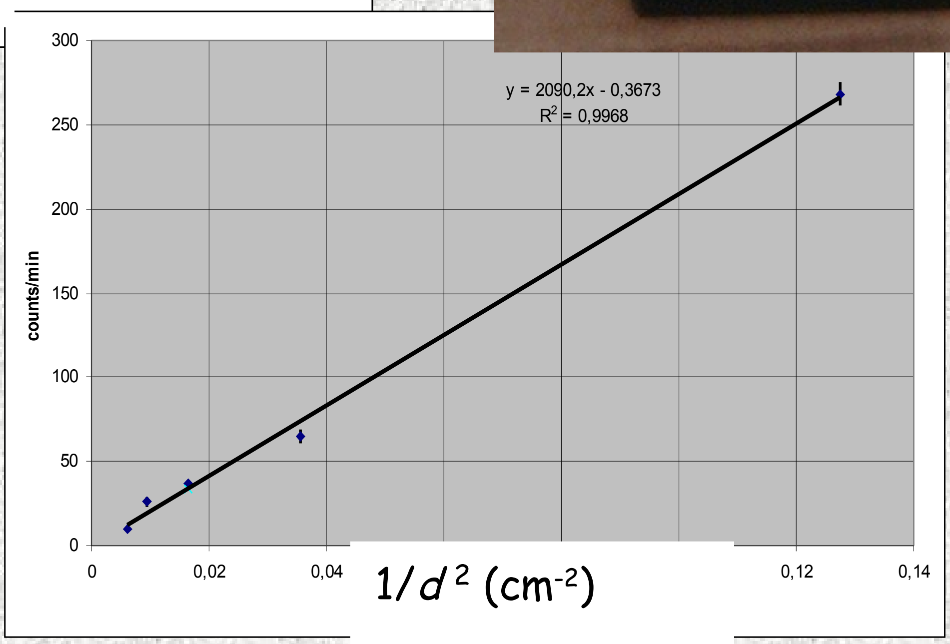
at 10 cm, the counts are only slightly larger than the background level

Fit to $1/d^2$ law





- absorption neglected
- fit the $1/d^2$ law, with effective distance $d = d' + d''$, where d'' is the unknown effective distance between the window edge and the Geiger tube (best fit: d'' = 2,8 cm)

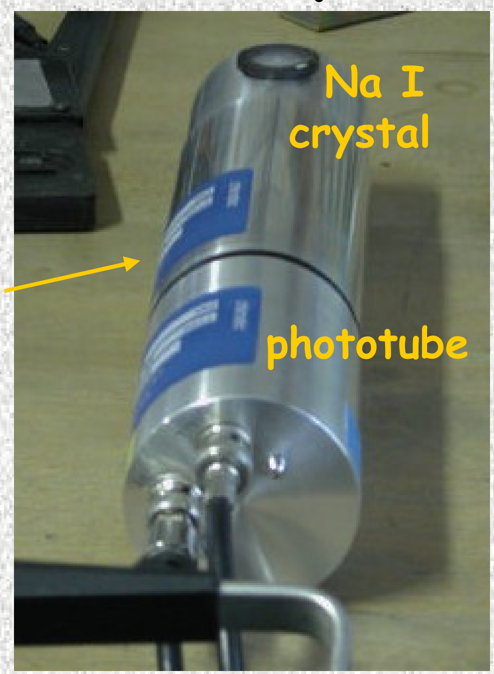


Experiment part 2:
examine the radiation to determine its composition

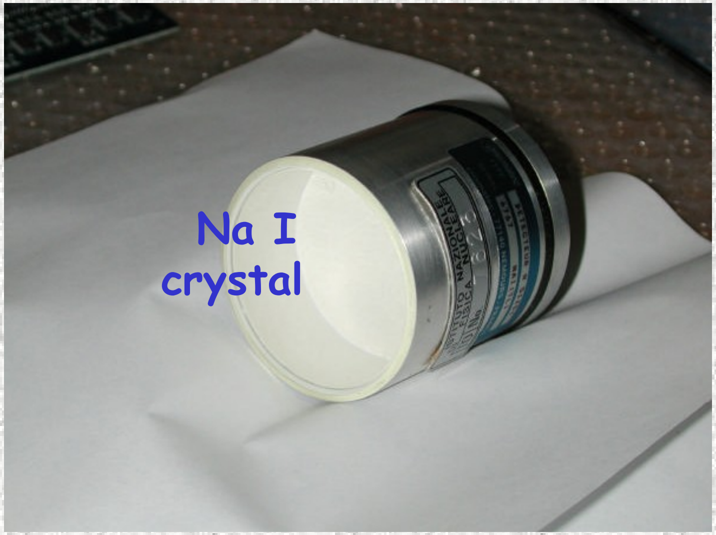
measurements with a scintillation counter:

- the entire spectrum is detected and analyzed
- calibration with a Cs_{137} source is performed (634 keV γ ray)
- radionuclides are identified using the peak energy value
- the activity is measured by integrating the area below the peak

detector



- the experiment is rather complex, for a secondary school student, but it is very rich
- it is used for presentations to particularly interested secondary school classes and in university lab



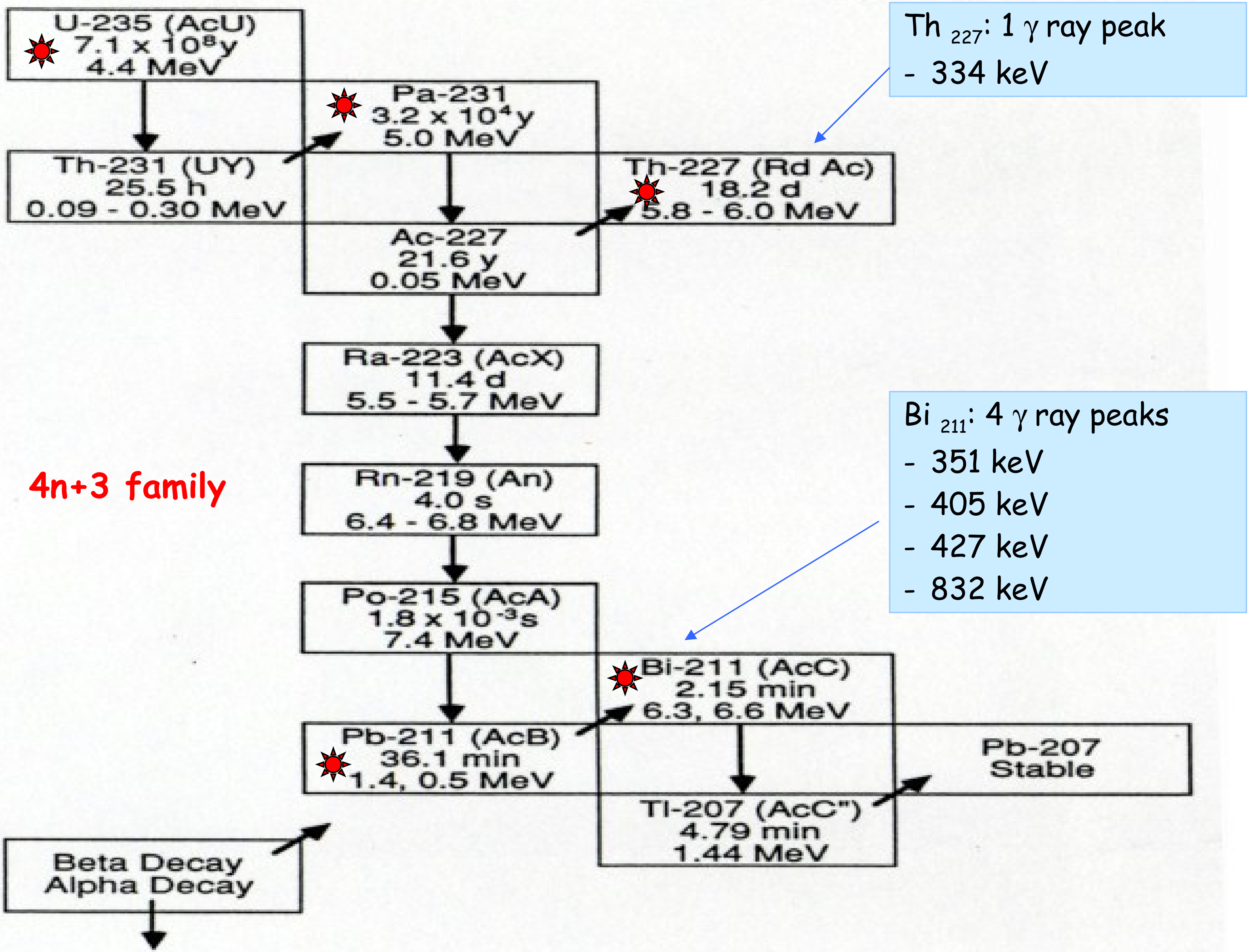
Example of data obtained in the analysis of a rock collected during an excursion in a cave of Saint Priest Laprune (France) by a secondary school class of a town close to the Susa Valley

4n+3 family (uranium/actinium)

4n+2 family (uranium/radium)

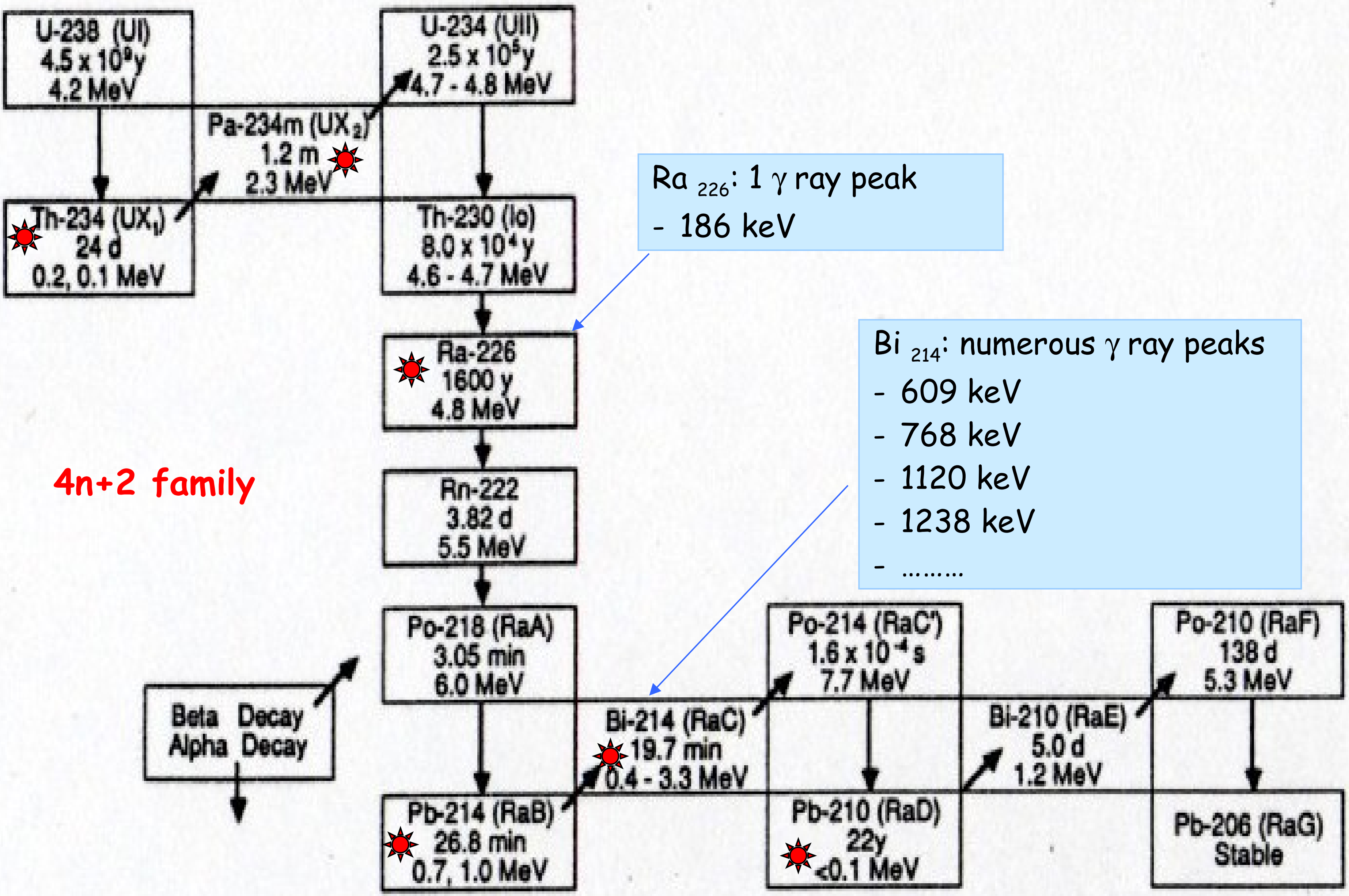
a real rock contains many radionuclides, reflecting the original distribution of the "radioactive families" at the time of its formation

radionuclide	average activity (Bq)
Pb-210	$1,10 \cdot 10^5$
Bi-211	$1,64 \cdot 10^4$
X Pb-211	debole
# Bi-214	$2,04 \cdot 10^5$
# Pb-214	$1,94 \cdot 10^5$
Ra-226	$2,32 \cdot 10^5$
# Th-227	$1,34 \cdot 10^4$
Pa-231	$9,11 \cdot 10^3$
Pa-234m	$3,91 \cdot 10^5$
Th-234	$1,65 \cdot 10^5$
# U-235	$1,30 \cdot 10^4$
Am-241	$1,86 \cdot 10^3$



U-235 (AcU)
7.1×10^8y
4.4 MeV
Pa-231
3.2×10^4y
5.0 MeV
Th-231 (UY)
25.5 h
0.09 - 0.30 MeV
Th-227 (Rd Ac)
18.2 d
5.8 - 6.0 MeV
Ac-227
21.6 y
0.05 MeV
Ra-223 (AcX)
11.4 d
5.5 - 5.7 MeV
Rn-219 (An)
4.0 s
6.4 - 6.8 MeV
Po-215 (AcA)
1.8×10^{-3}s
7.4 MeV
Bi-211 (AcC)
2.15 min
6.3, 6.6 MeV
Pb-211 (AcB)
36.1 min
1.4, 0.5 MeV
Pb-207
Stable
Tl-207 (AcC")
4.79 min
1.44 MeV
Beta Decay
Alpha Decay
4n+3 family
Th $_{227}$: 1 γ ray peak
- 334 keV
Bi $_{211}$: 4 γ ray peaks
- 351 keV
- 405 keV
- 427 keV
- 832 keV

4n+2 family



Ra_{226}: 1 γ ray peak

- 186 keV

Bi_{214}: numerous γ ray peaks

- 609 keV
- 768 keV
- 1120 keV
- 1238 keV
- ………

What we learned from these activities

- different experiments on ionizing radiations are feasible,
- ranging from student driven measurements, which use rather inexpensive detectors, to teacher driven ones, done with rather complex equipment,
- that are effective to make the teacher and the students more familiar with this particular field of physics
- and to provide them some basis for a rational and scientific approach to the “nuclear problem”

Cose da fare e sviluppi futuri

- sviluppare materiali/documenti per l'utilizzo nella didattica di rivelatori già in dotazione (geiger collegati in linea per misure di lungo periodo, rivelatori a tracce tipo CR39)
- esaminare, provare nuovi rivelatori adatti anche all'utilizzo in una scuola secondaria
- promuovere "campagne" di misure estese della radiazione ambientale nelle scuole

Siamo aperte alla collaborazione con chiunque abbia buone idee!