What Napoleon and Fukushima have in common?

Nothing but…a physicist!

1. New level instrumentation
2. Trace elements: who killed Napoleon? Nobody?
3. Chernobyl and Fukushima: what about us

RARE EVENTS

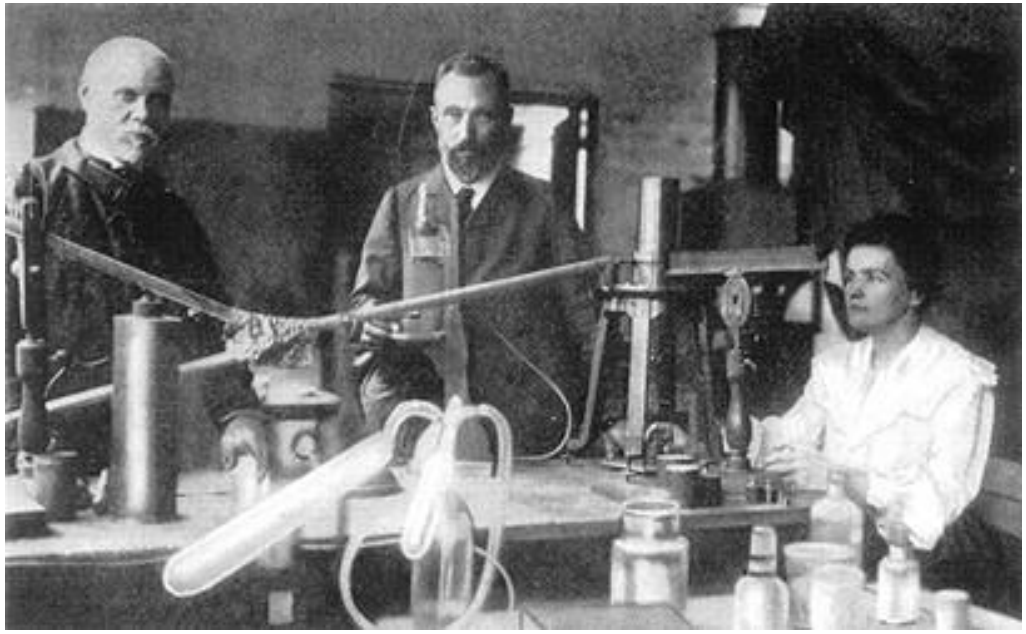
1. Neutrino interactions
2. Interaction by Dark Matter Particles
3 Rare nuclear process

COSMIC RAYS

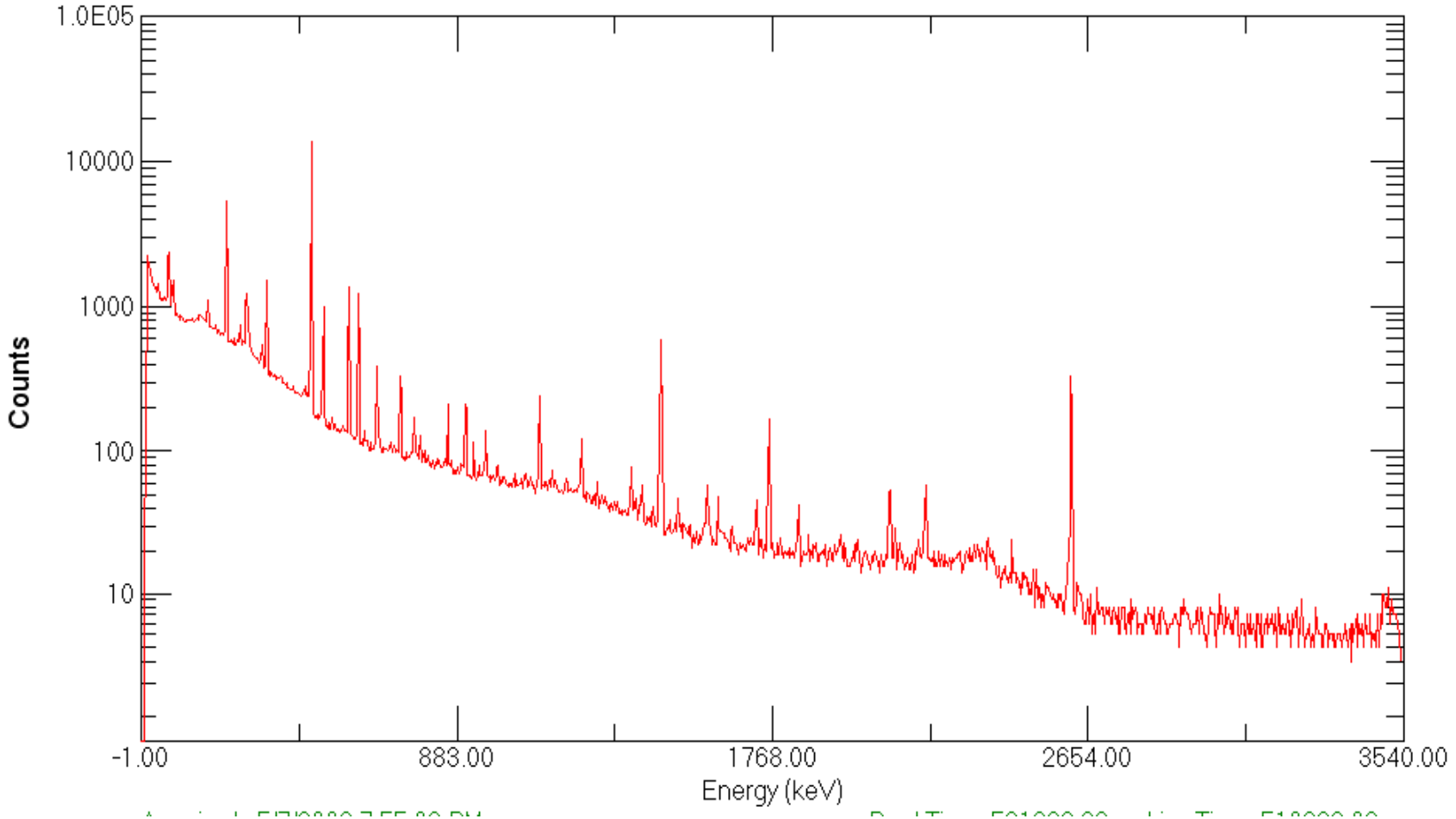
Go underground

RADIOACTIVITY

Natural and artificial



X and γ spectra in environment



X, α and γ spectroscopy

Laboratorio di Radioattività

Laboratorio -3

Rivelatori a basso fondo
per misure Low Activity

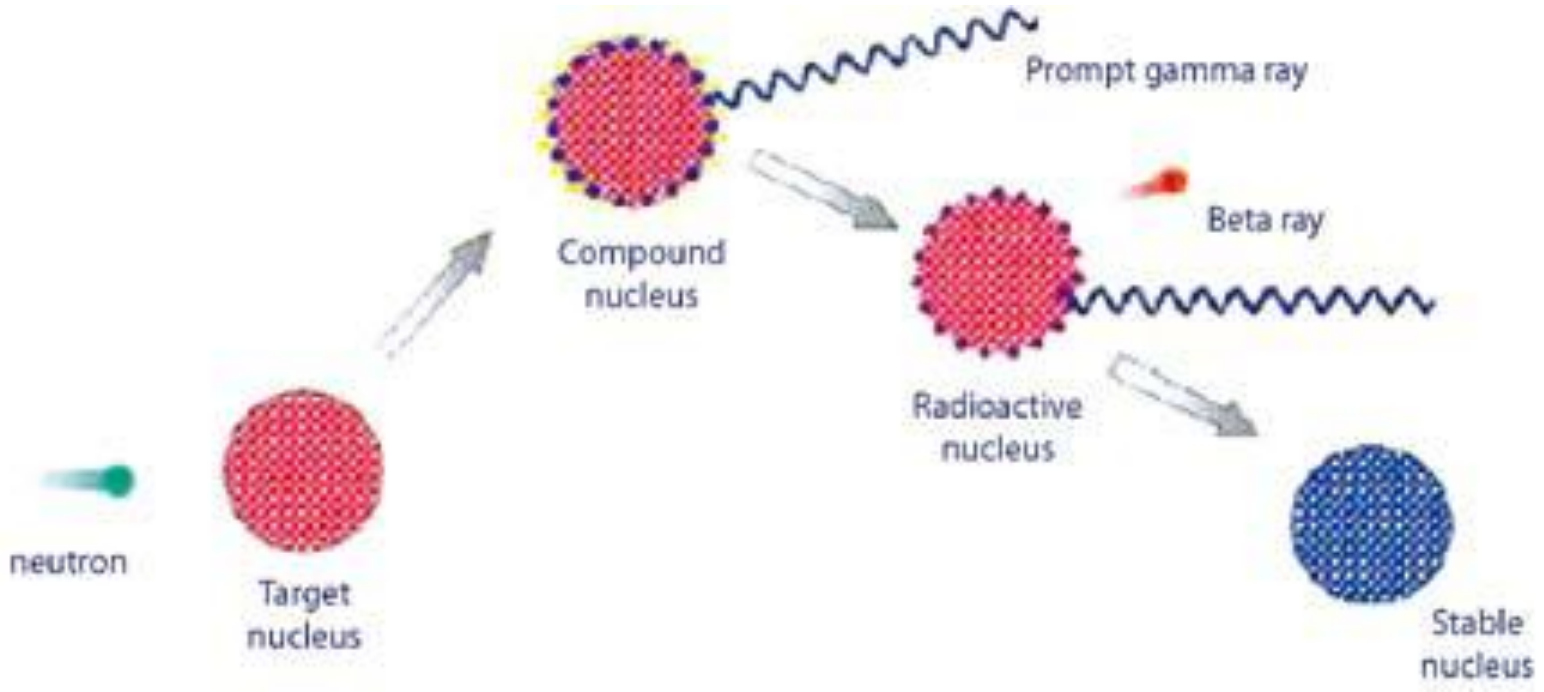
γ

2 Rivelatori HPGe planari con
finestra di Berillio
2 Rivelatori HPGe tipo n
100%eff rel

- ✓ ***TIMS*** *(Thermal Ionization Mass Spectrometry)*
- ✓ ***PSMS*** *(Plasma Source Mass Spectrometry)*
- ✓ *Inductively Couple d Plasma Mass Spectroscopy*

C

Neutron Activation Analysis



Particularly sensitive to search for As $\Rightarrow$ only stable isotope **75**As

Thermal neutrons => ^{76}As

Arsenic as other elements concentrates itself in nails, hairs etc. Very important in criminology

Il cinque maggio

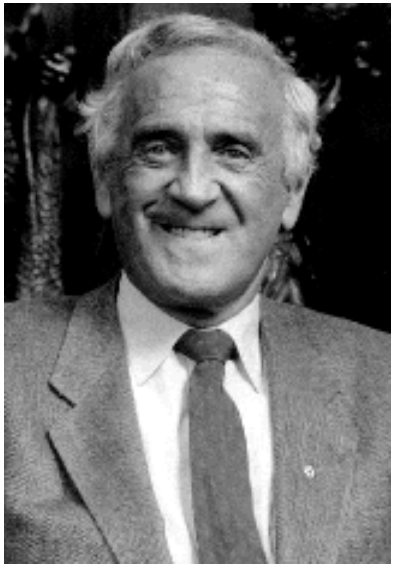
.....e i dì nell'ozio
chiuse in sì breve sponda,
segno d'immensa invidia
e di pietà profonda,
d'inestinguibil odio
e d'indomato amor.

The fifth of May

.....and his idle days
closed in such a short site,
target of immense envy
and of deep pity,
of unchanged hate
and of untamable love

Sant ‘ Helene

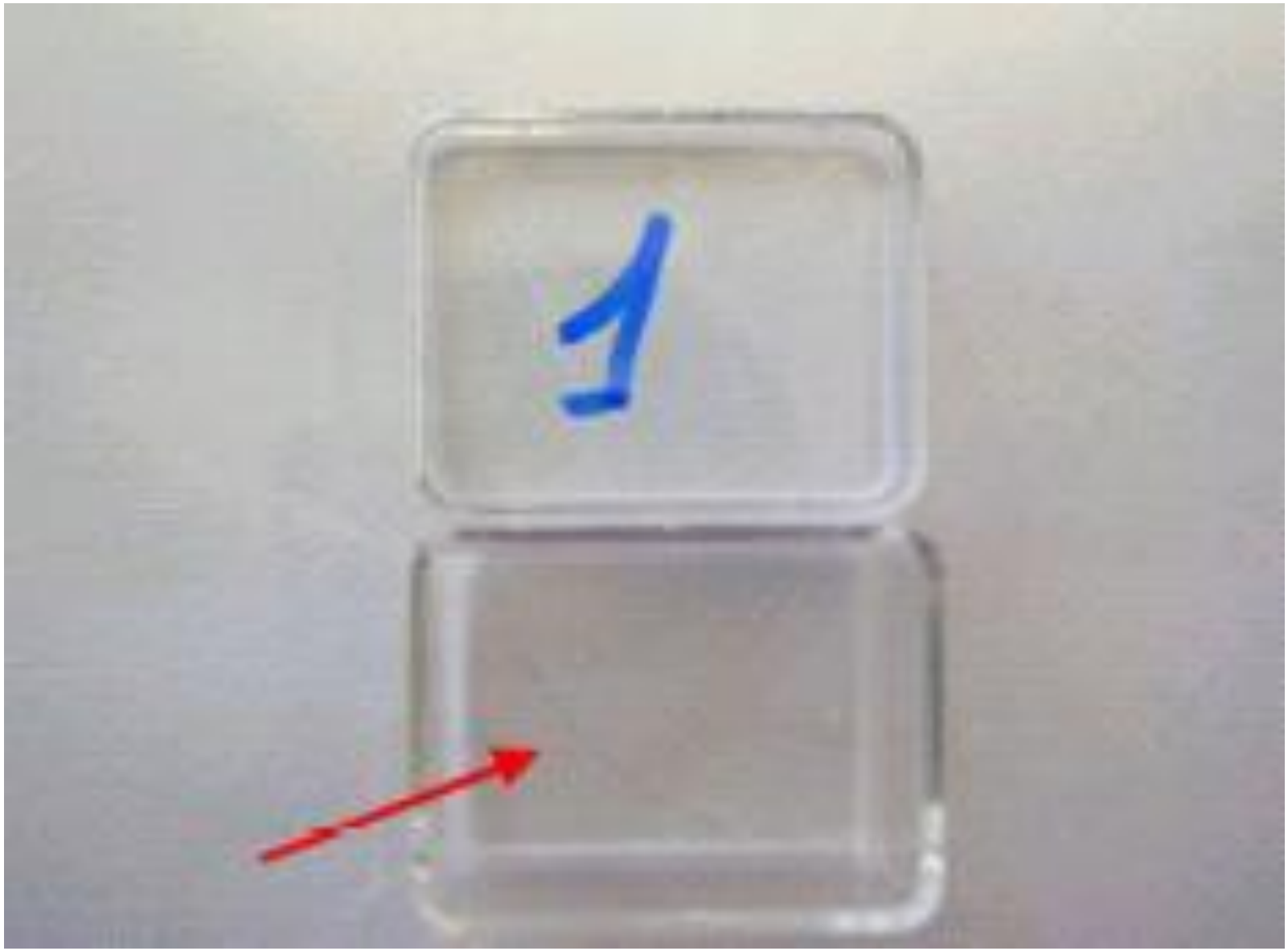
Please meet these people



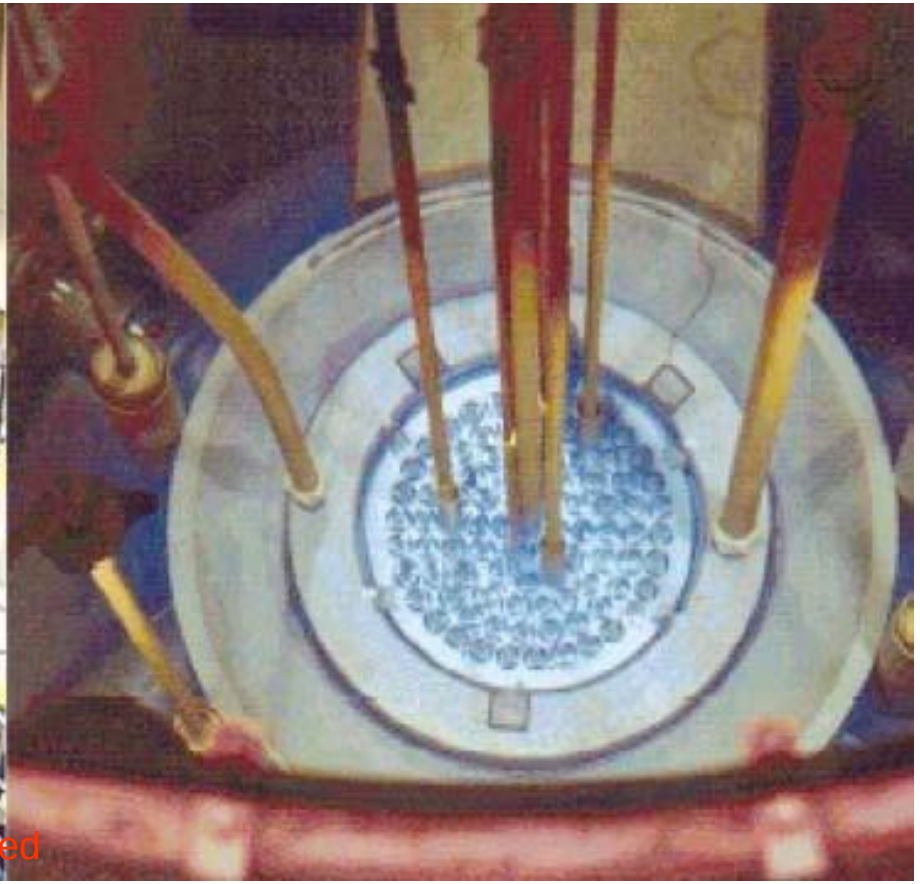
Positive and **negative** measurements

The Longhood tapissery

X ray fluorescence **=> 0.08 g cm^{-2}** a value presently **non acceptable**


1

The Pavia reactor



Certified calibrated standards have been used

Measurements on the As content in the hairs of a **living subject**, and comparison with the content in the hairs of **Aiglon** and of **Empress** Josephine

Contemporary hair
As(in 10-2 ppm)

Present 1	8,6 ±,9
Present 2	5,6 ± 1,8
Present 3	11,0 ± 3,5
Present 4	12,4 ± 3,9
Present 5	2,4 ± 1,1
Present 6	7,1 ± 2,8
Present 7	5,4 ± 1,7
Present 8	4,0 ± 1,4
Present 9	4,3 ± 3,1
Present 10	4,8 ± 2

Aignon and Josephine

As (in ppm)

Aiglon 1812 - 1	9,4 ± 1,0
Aiglon 1812 - 2	6,1 ± 0,6
Aiglon 1816 - 1	12,6 ± 1,3
Aiglon 1816 - 2	9,9 ± 1,0
Aiglon 1821 - 1	9,9 ± 1,1
Aiglon 1821 - 2	11,2 ± 1,3
Aiglon 1826 - 1	7,6 ± 0,8
Aiglon 1826 - 2	8,5 ± 0,9
Josephine - 1	0,8 ± 0,4
Josephine – 2	1,2 ± 0,5

Arsenic in the hairs of the Emperor

As (in ppm)

Corse 1770 – 1	8.3± 0,9
Corse 1770 - 2	6,3 ± 0,7
Elba 1814 – 1	4,4 ± 0,5
Elba 1814 - 2	3,5 ± 0,4
S. Elene 5 May 1821 - 1	13,1 ± 1,3
S. Elene 5 May 1821 - 2	16,7 ± 1,7
S. Elene 5 May 1821 - 3	14,2 ± 1,4
S. Elene 5 May 1821 - 4	17,0 ± 1,7
S. Elene 5 May 1821 - 5	15,4 ± 2,3
S. Elene 5 May 1821 - 6	18,9 ± 2,2
S. Elene 6 May 1821 - 1	15,2 ± 2,0
S. Elene 6 May 1821 – 2	9,7 ± 1,

Along the hair

Fragment	**Mass (mg)**	**As (ppm)**
2A	0,012	27,6 ± 3,0
2B	0,022	22,0 ± 2,5
2C	0,026	21,4 ± 2,5
2D	0,032	17,5 ± 2,0
2E	0,032	16,6 ± 1,9
2F	0,026	20,7 ± 2,4

Arsenic content in the water of the spring liked by the Emperor (near his first grave)


PYRAMIDES
FRIEDLAND

Sample	As (µg/L)
N.1	1,0000
N.2	1,5000
N.3	2,0000
N.4	1,2500
N.5	1,1000
N.6	0,8000
Average	1,28 ± .43

Presently legally accepted limit => 10

Arsenic intake from **medicines** and definirtely from paper on walls , but **not from water**

We believed it was the end , but it was not true

Pubblished by about 100 national and international journals

New York Times

The New York Times

Hair Analysis Deflates
Napoleon Poisoning Theories

Was Napoleon poisoned?

now, a team of scientists at Italy's **National Institute of Nuclear Physics** in Milan-Bicocca and Pavia has uncovered strong evidence to the contrary.

Contact with many pathologists:

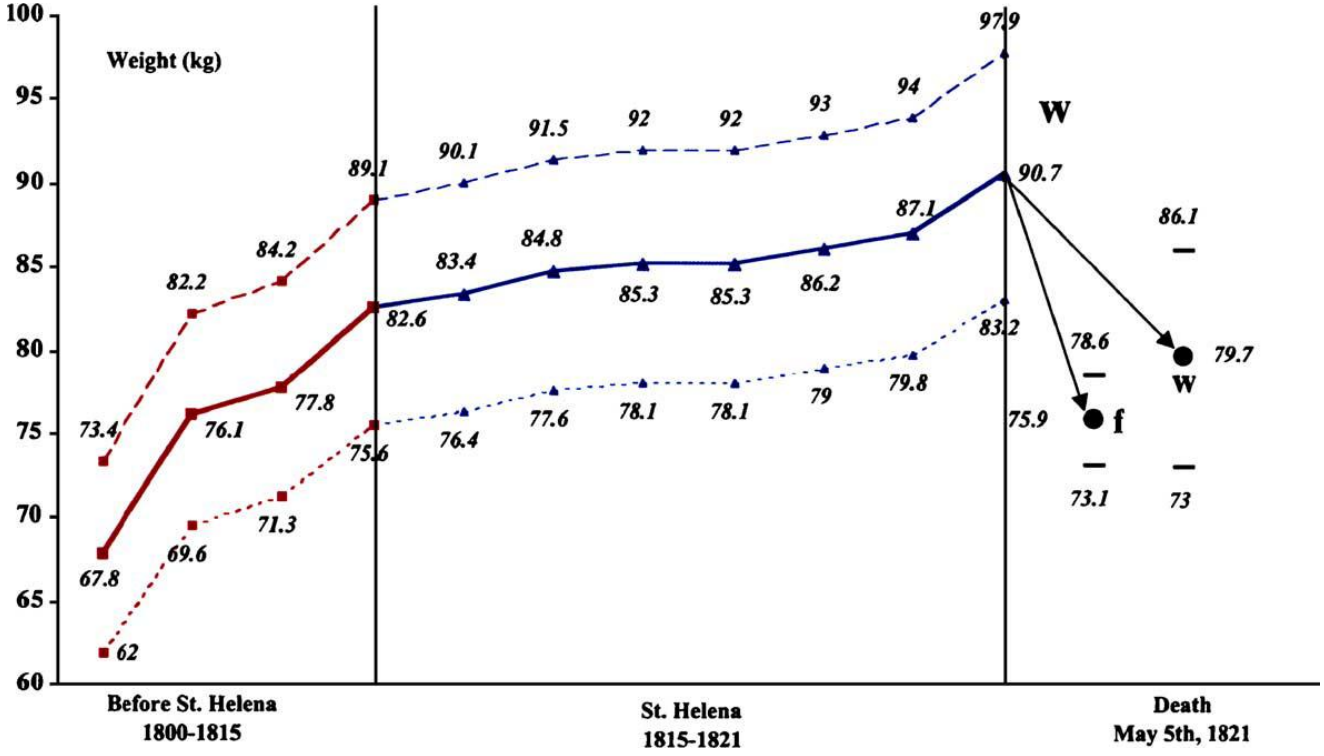
J.T.Hindmarsh Royal College of Phatologists of England and Canada and P.F.Corso Norwalk Hospitala (Connecticut)

A.Lugli Department of Pathology – Basel University

- **Very precise patologic analysis**
- Change with time of the body weight compared with twelve sampoles in various **museums** compared with voluntary people
- Comparison with the subcutaneous fats of **270** people
- Comparison with gastic and other characteristics of patients dead of **cancer** with the **very accurate authopsy** of **Francesco Antonmarchi** (pupil of the famous Giuseppe Maccagni of Siena university


A


B


Weight (kg)
100
95
90
85
80
75
70
65
60
97.9
W
90.7
86.1
79.7
W
78.6
f
75.9
73.1
73
83.2
79.8
79
78.1
78.1
77.6
76.4
75.6
71.3
69.6
62
89.1
90.1
91.5
92
92
93
94
84.2
82.2
73.4
82.6
83.4
84.8
85.3
85.3
86.2
87.1
77.8
76.1
67.8
Before St. Helena
1800-1815
St. Helena
1815-1821
Death
May 5th, 1821

Was Napoleon Really too Obese for the Diagnosis of "Gastric Cancer"?

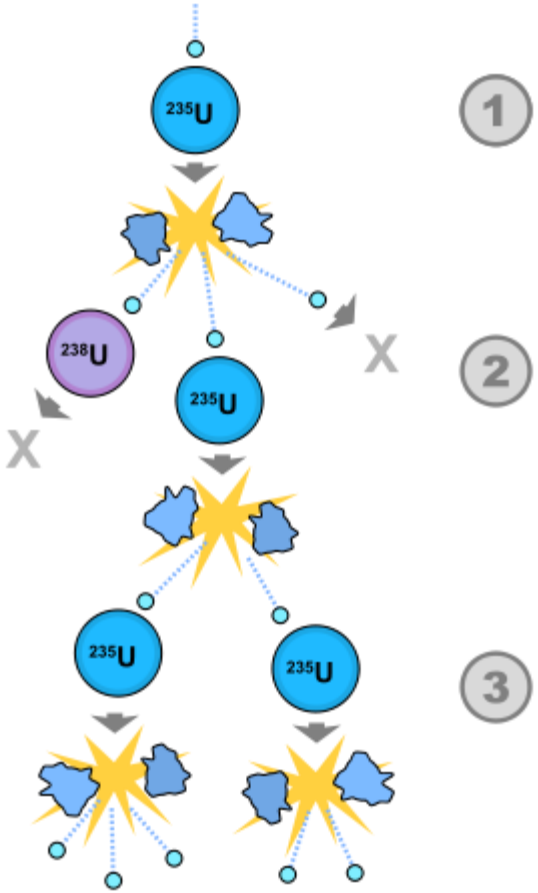
Lugli et al Adv Anat Pathol Volume 18, Number 2, March 2011

The Medical Mystery of Napoleon Bonaparte

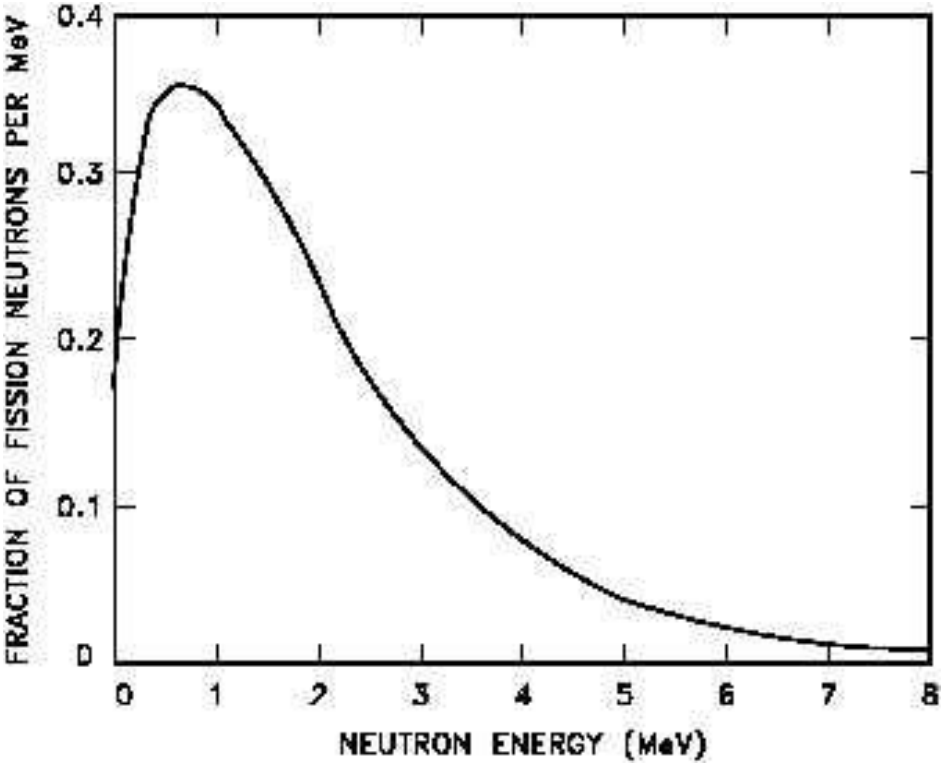
An Interdisciplinary Exposé

Alessandro Lugli, MD, Massimiliano Clemenza, PhD,† Philip E. Corso, MD,‡ Jacques di Costanzo, MD,§ Richard Dirnhofer, MD,‖ Ettore Fiorini, PhD,† Costanza Herborg, PhD,¶ John Thomas Hindmarsh, MD,#** Edoardo Orvini, PhD,¶ Adalberto Piazzoli, PhD,††† Ezio Previtali, PhD,† Angela Santagostino, PhD,‡‡ Amnon Sonnenberg, MD,§§‖‖ and Robert M. Genta, MD, FACG¶¶##*

Nuclear fission: an incredible source of energy

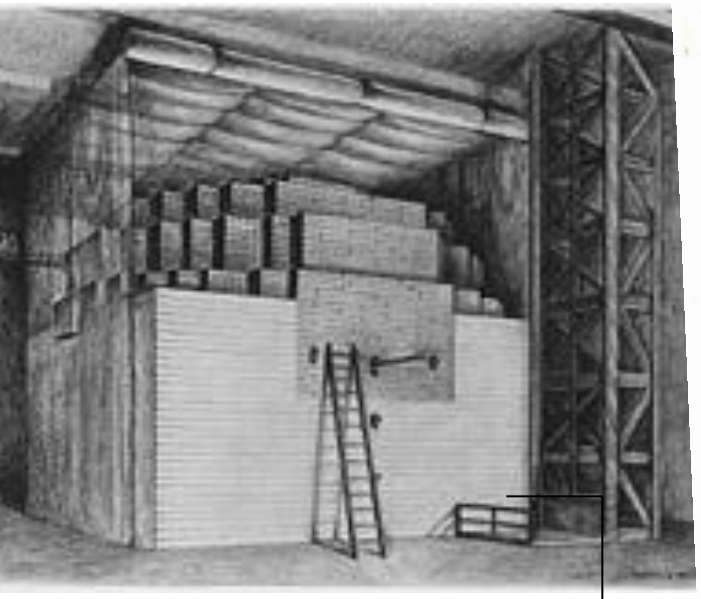


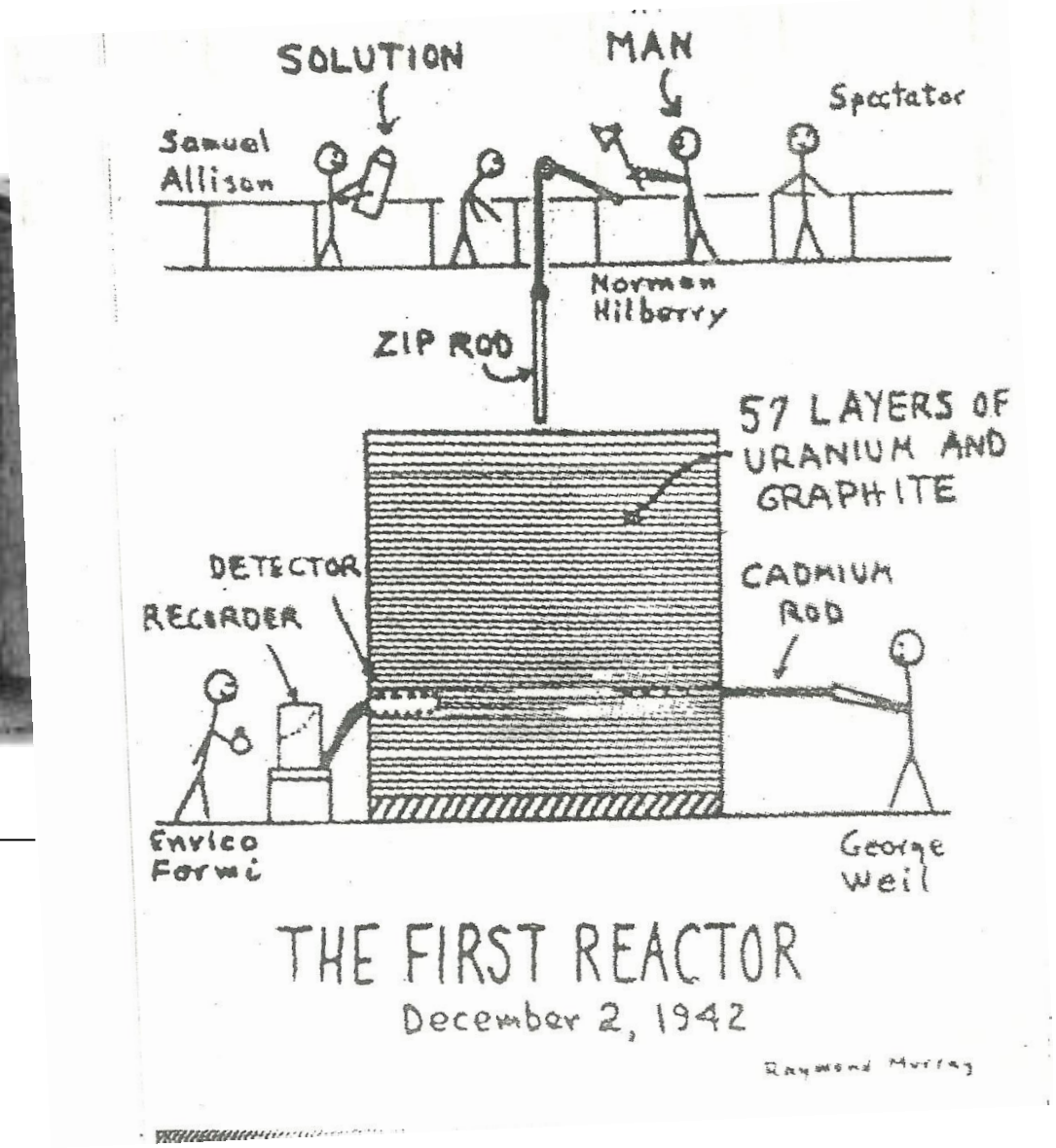
Chain reaction



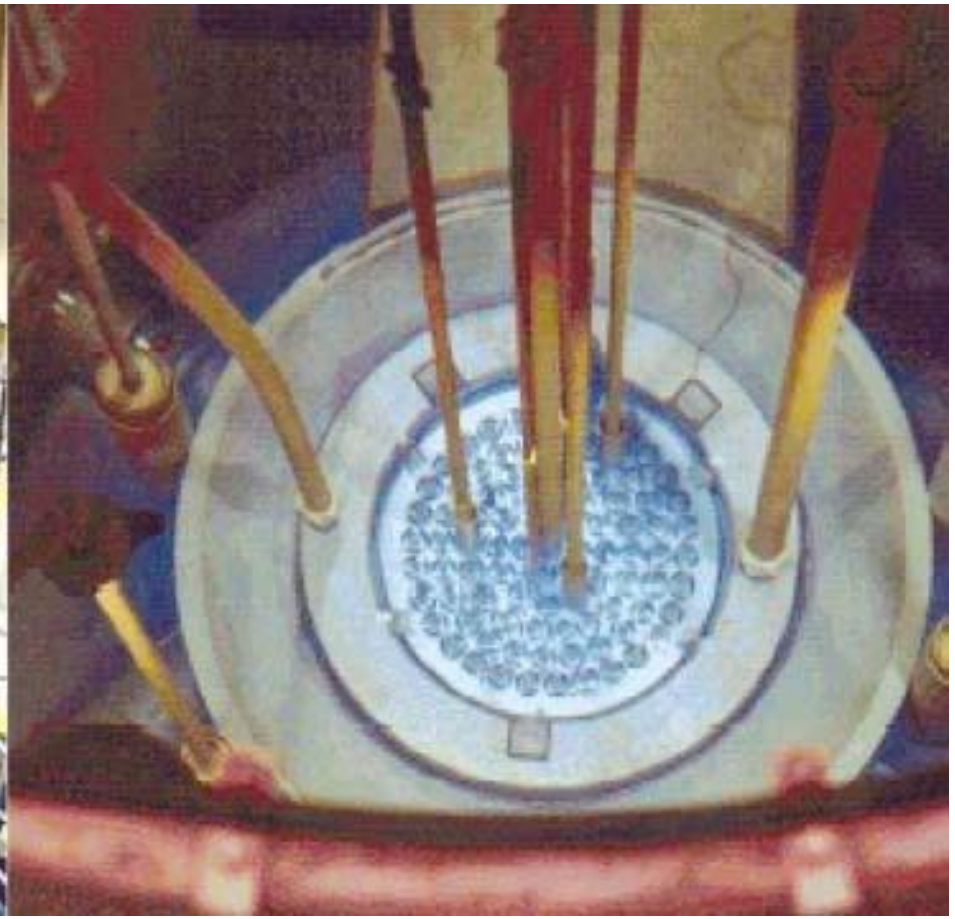
Neutron energy

The first reactor





LENA reactor in Pavia



Effects of radiation

Sievert (Sv) => joule/kgxQ

Medium exposure => a few mSv/year
Extra dose to people => < 1 mSv/anno professionals < 20 mSv/year
Death (50% in 30 days) => 2.5-4.5 Sv
Additional death per million=> 25 Sv/milion

Doses"often non considered"
Radiotherapy e radiodiagnostics (**1/5 , 1/3 , 1/20**)
^{210}**Pb e** ^{210}**Po** in smokers -> **~1/3 more**

Enrichment

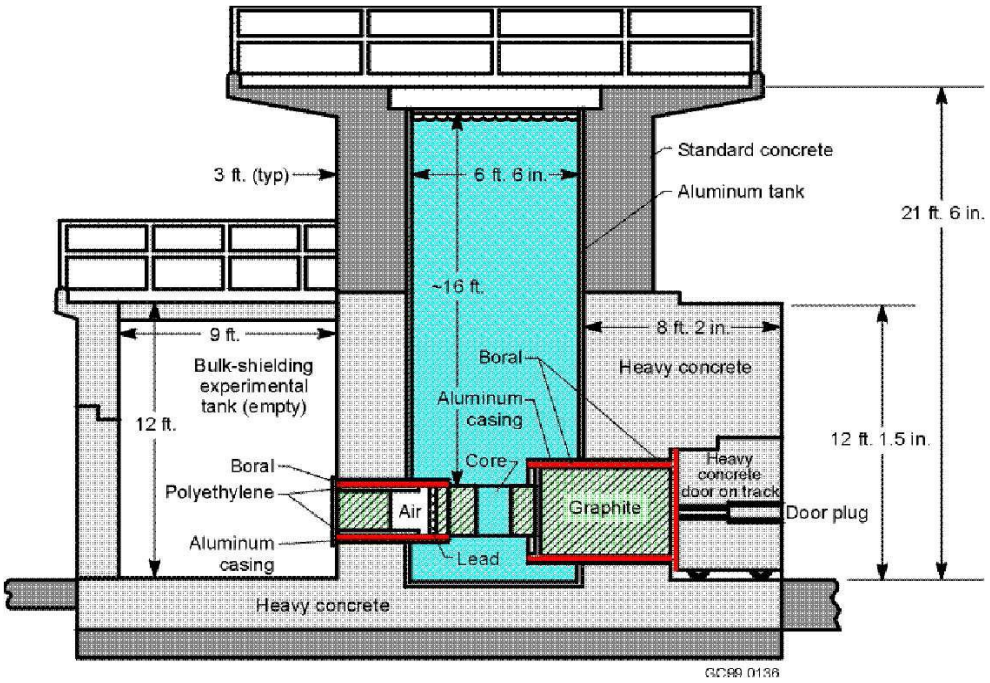
Percentegs of ^{235}U:
Natural Uranium => 0.7%
Uranium for power reactors =>3-5%
Small reactors => ~20 %
Bombs => ~90 %

The CHERNOBYL event

RBMK boiling water **initialy studied for military reasons**

Graphite as **moderator**

Thermal power => **3200 Mwatt** => electric **1000** Mwat



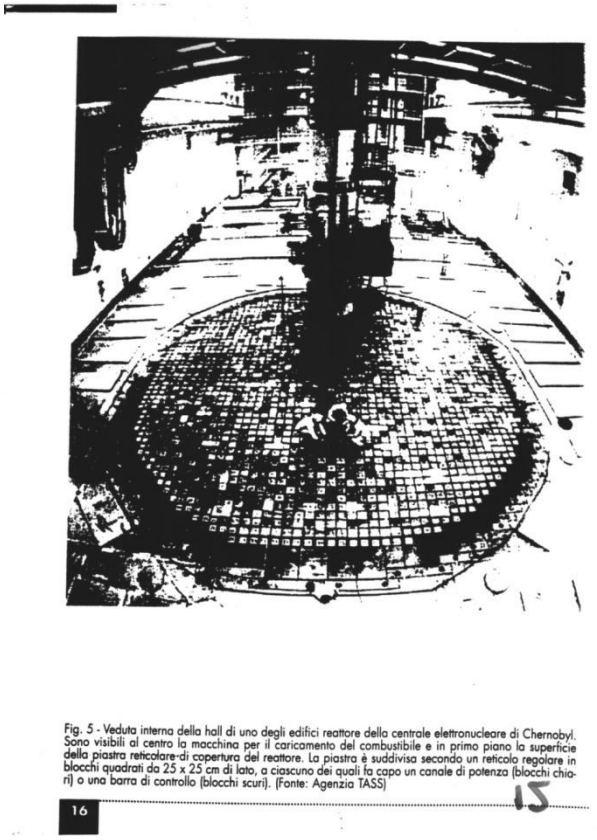
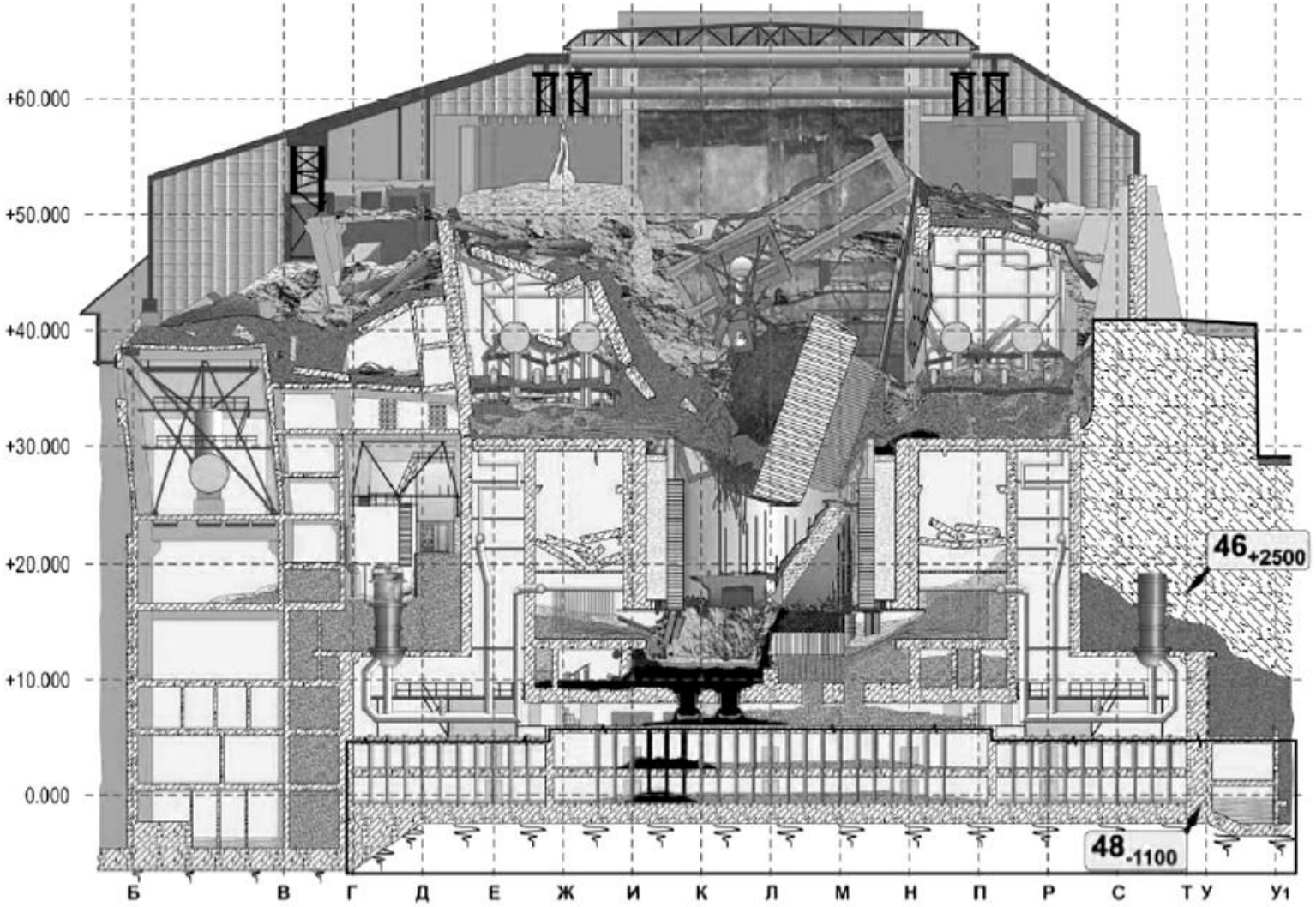


Fig. 5 - Veduta interna della hall di uno degli edifici reattore della centrale elettronucleare di Chernobyl. Sono visibili al centro la macchina per il caricamento del combustibile e in primo piano la superficie della piastra reticolare di copertura del reattore. La piastra è suddivisa secondo un reticolo regolare in blocchi quadrati da 25 x 25 cm di lato, a ciascuno dei quali fa capo un canale di potenza (blocchi chiari) o una barra di controllo (blocchi scuri). (Fonte: Agenzia TASS)

16

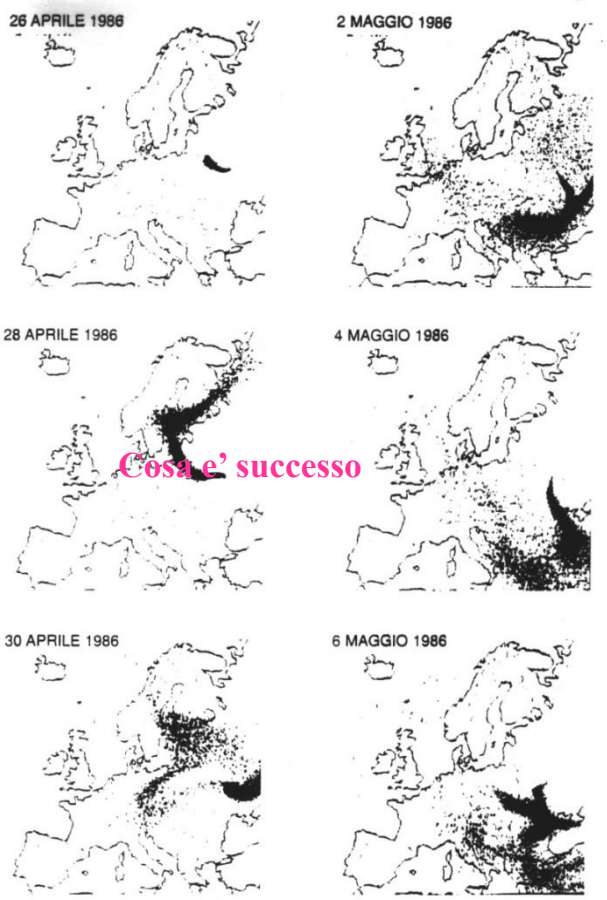
Sarcophagus



What happened

⇒**1.00 del 25.4.1986** The reactor power is reduced to bring it from **3200** to **700-800** Mwatt
⇒**13.05** power at **1600** Mwatt . Turboalternators are **disconnetted**
⇒**14.00** the emergency cooling sistem is isulated **violating security laws**
Energy is requested from Kiev **the experiment is delayed by 9**
⇒**23.00** Power is reduced
⇒**23.10** Expected power 700-1000 Mwatt **Reactor at 30 M**
⇒**1.00 of 26.4.86** Power is increased only to **200 Mwatt.** Only **6-8** bars
⇒ **1.03 two pomps** are added to the working six **: Eccessive flux**
⇒**1.10 all control bars bars are extracted**
⇒**1.23 ' 04 C** The vapor-turbine valve **is closed** to continue by inertiaper. . The security system would block the reactor. **It is disconnected**
.Reactor at **200** Mwatt without removal of heat **Increase of temperature and power**.
⇒**1.23 ' 40 ''** Operators pres **AZ-5 . Bars do not insert**
⇒**1.24 ' 00 '' Power diverges => two explosions** (vapor and hydrogen formed by water on zirconium **Reactor explodes , building is destryed, gas , powder is emitted.**
Graphite at 2000 burn
⇒ **Next days Fire stops under 5000 tons of dolomite, boron, carbide . sand , lead**

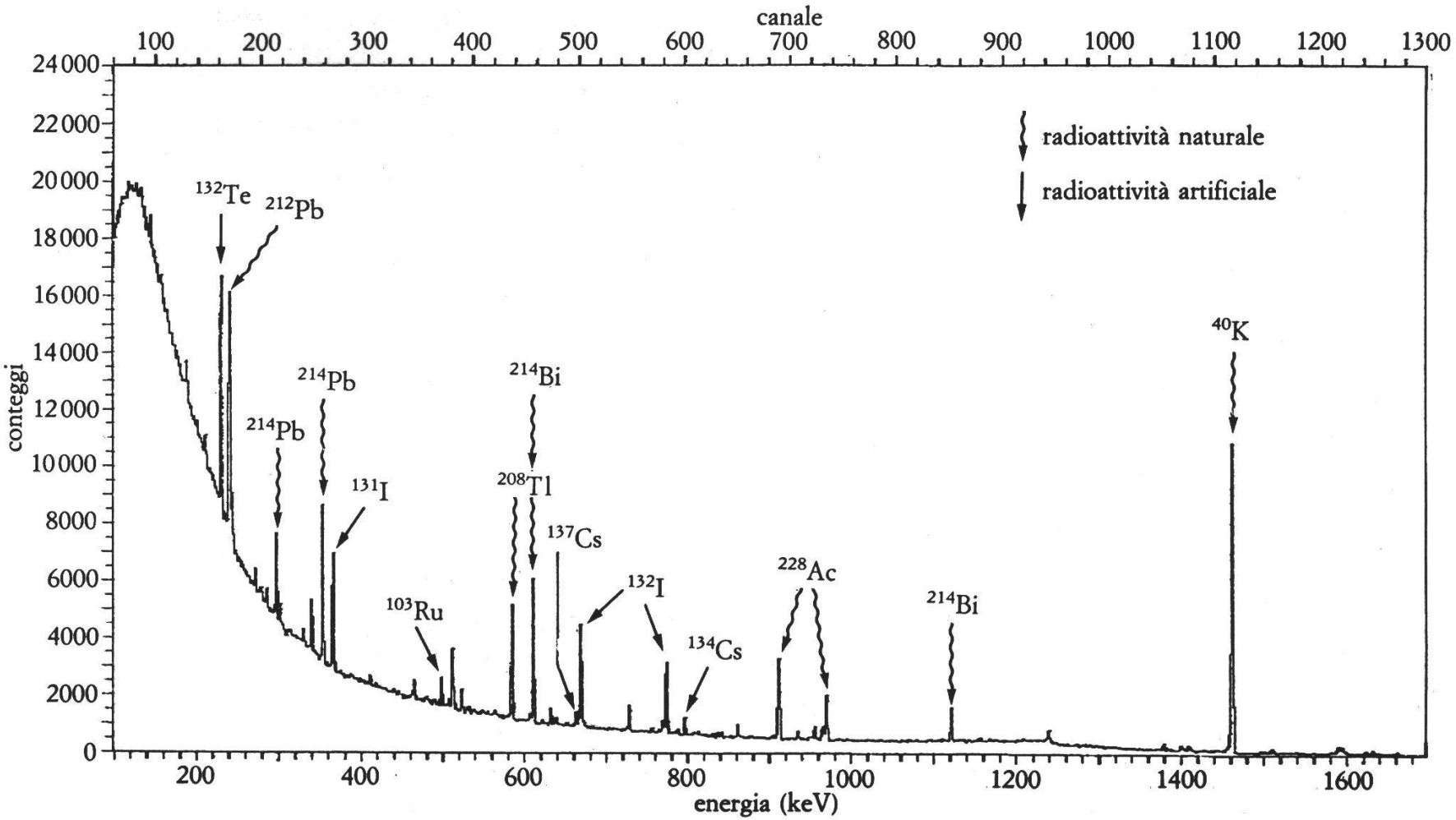
^{137}Cs fallout



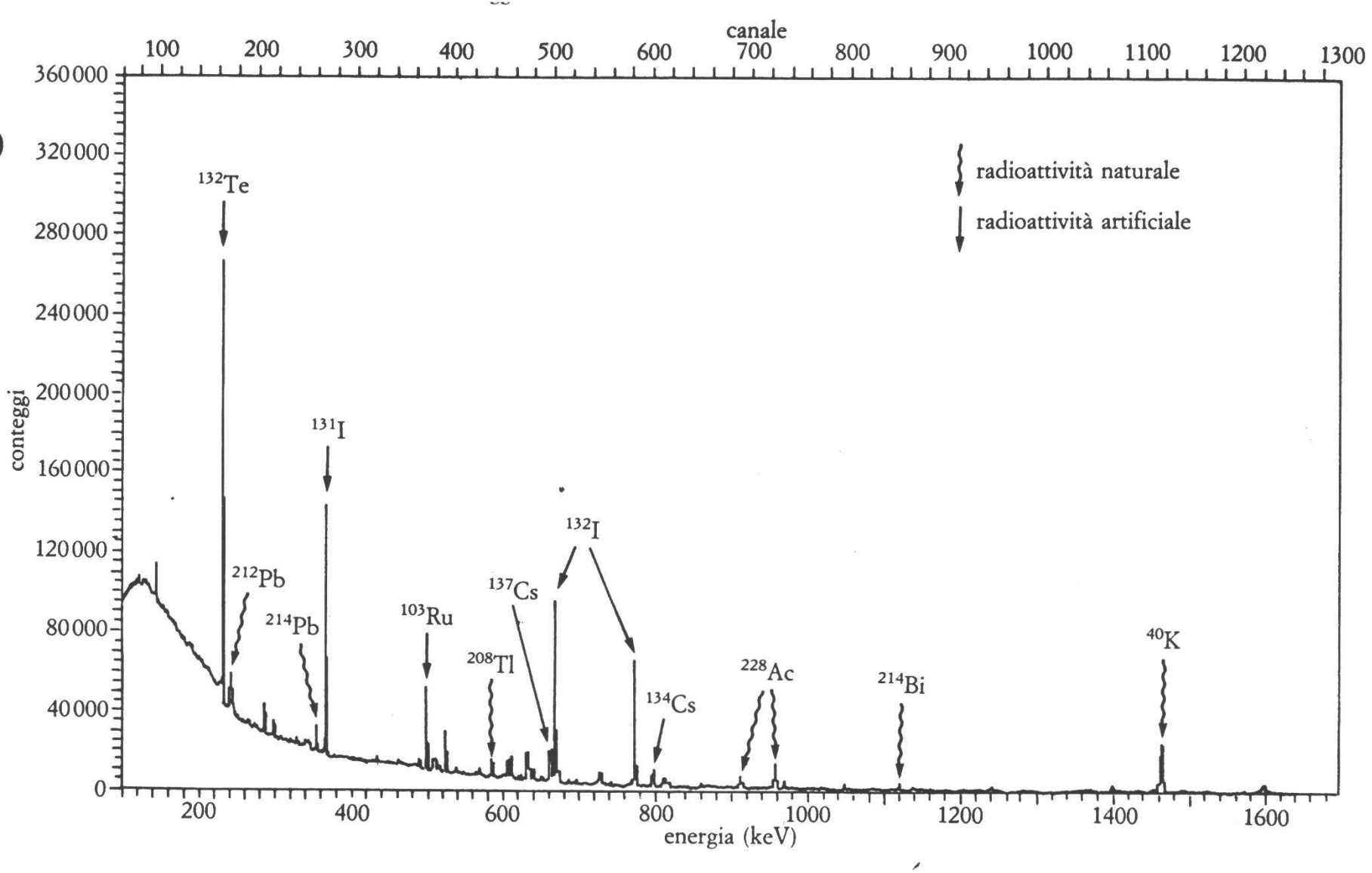
Cosa e' successo

Fig. 28 - Evoluzione del pennacchio di Chernobyl tra il 26 aprile e il 6 maggio 1986. Nei due giorni successivi all'incidente le correnti in quota allungano la nube che si sprigiona dal reattore distrutto in direzione ovest/nord-ovest sulla Polonia e sulla Svezia, interessando nei giorni seguenti la Scandinavia, l'Olanda, il Belgio e la Gran Bretagna. Fra il 30 aprile e il 2 maggio la direzione dei venti prevalenti ruota prima verso sud-est e poi verso sud-ovest, portando la nube a interessare gran parte dell'Europa centrale, i Balcani e il Mediterraneo settentrionale. (Fonte: NEA-OCSE)

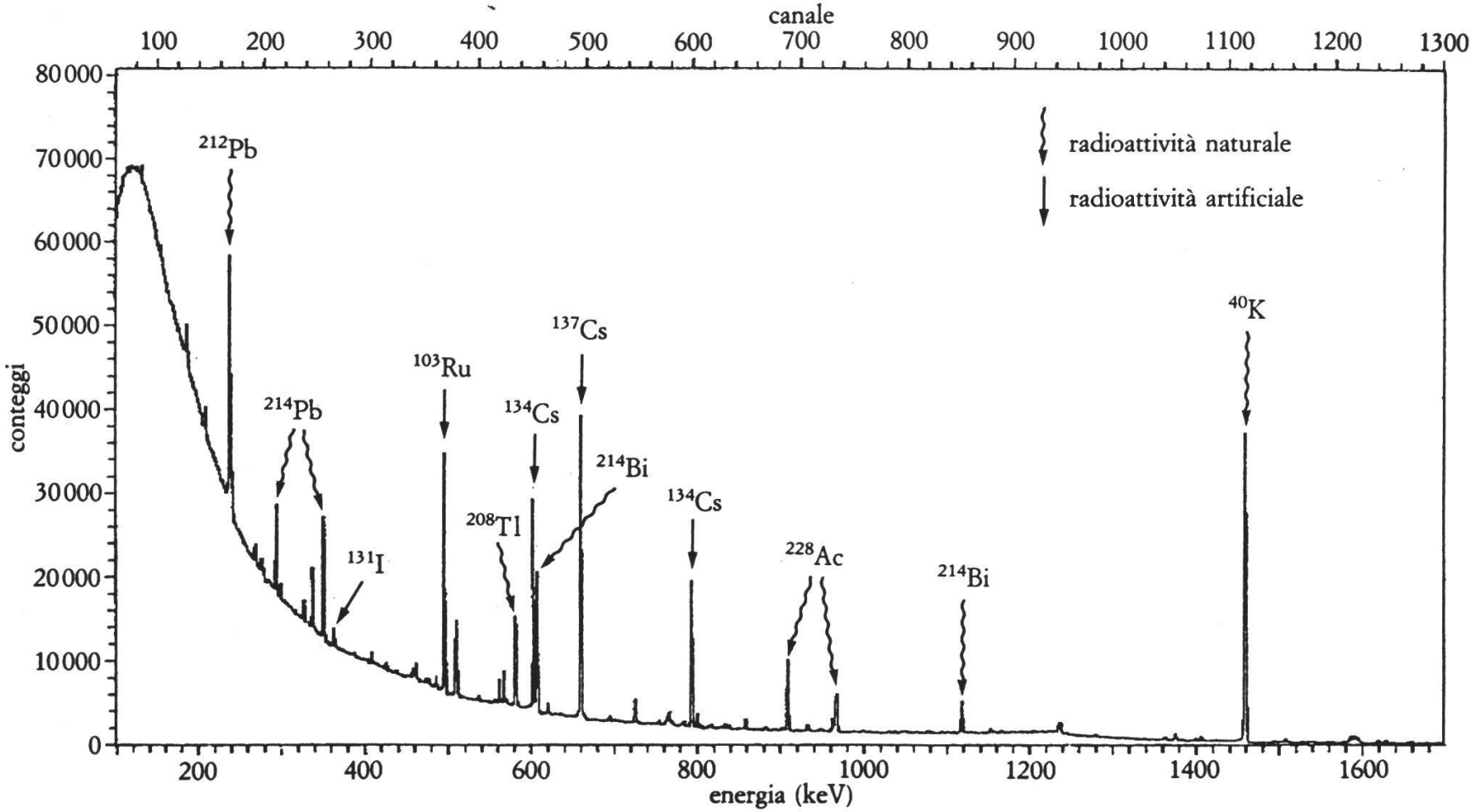
Afternoon of april 30 1986



May 2-3 1986


canale
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
360000
320000
280000
240000
200000
160000
120000
80000
40000
0
conteggi
radioattività naturale
radioattività artificiale
^{132}Te
^{131}I
^{212}Pb
^{214}Pb
^{103}Ru
^{208}Tl
^{137}Cs
^{132}I
^{134}Cs
^{228}Ac
^{214}Bi
^{40}K
200
400
600
800
1000
1200
1400
1600
energia (keV)

26.6.1986


canale
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
80000
70000
60000
50000
40000
30000
20000
10000
0
conteggi
radioattività naturale
radioattività artificiale
212Pb
214Pb
131I
103Ru
208Tl
134Cs
137Cs
214Bi
134Cs
228Ac
214Bi
40K
200
400
600
800
1000
1200
1400
1600
energia (keV)

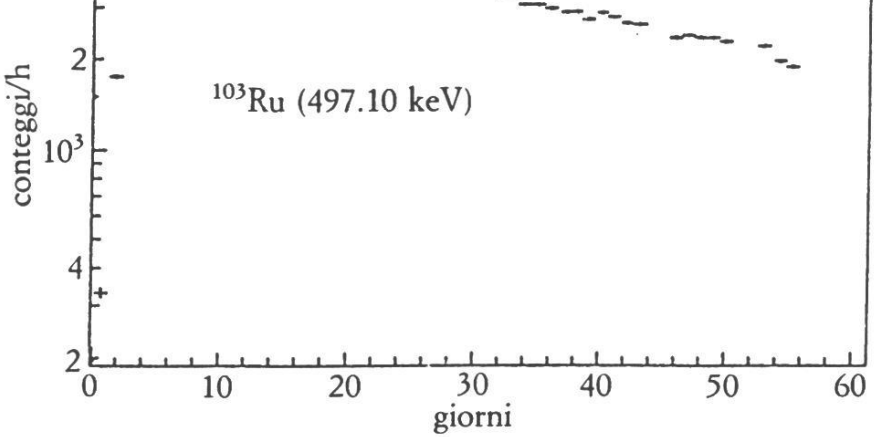


Fig. 4. - Andamento dei conteggi dovuti al ^{103}Ru.

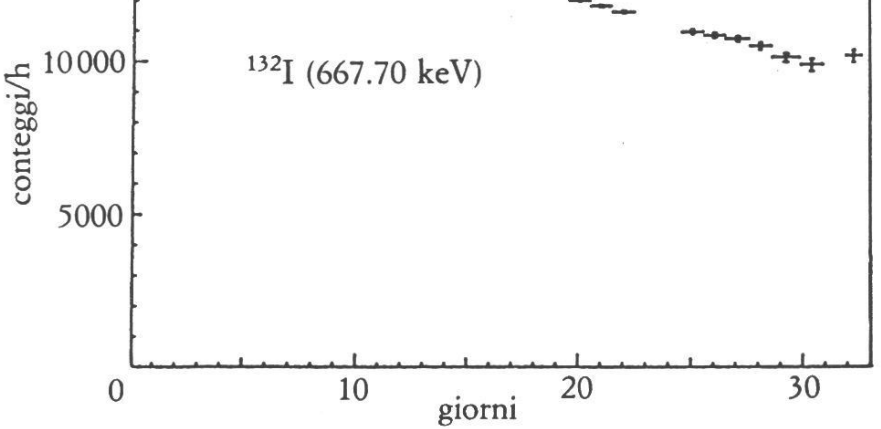


Fig. 6. - Andamento dei conteggi dovuti al ^{132}I (^{132}Te).

Fig. 5. - Andamento dei conteggi dovuti al ^{131}I.

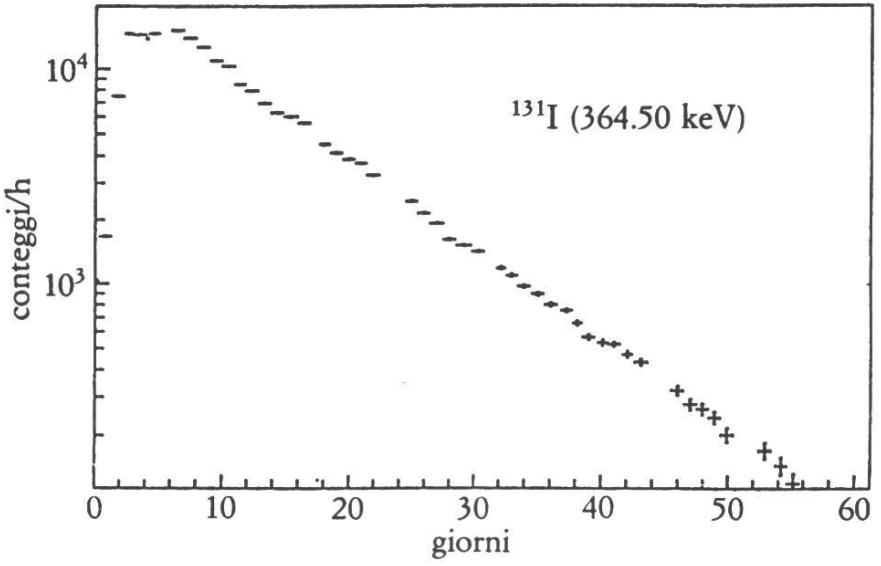
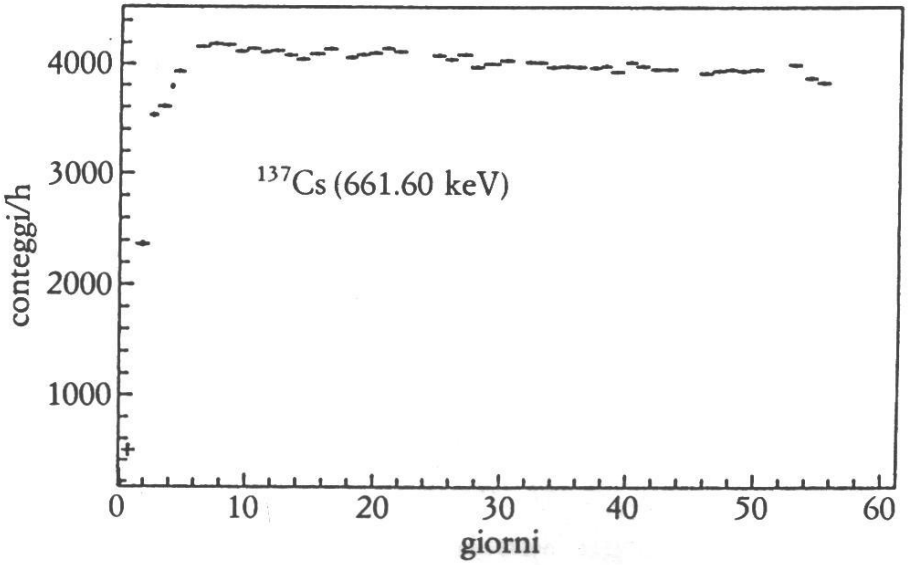
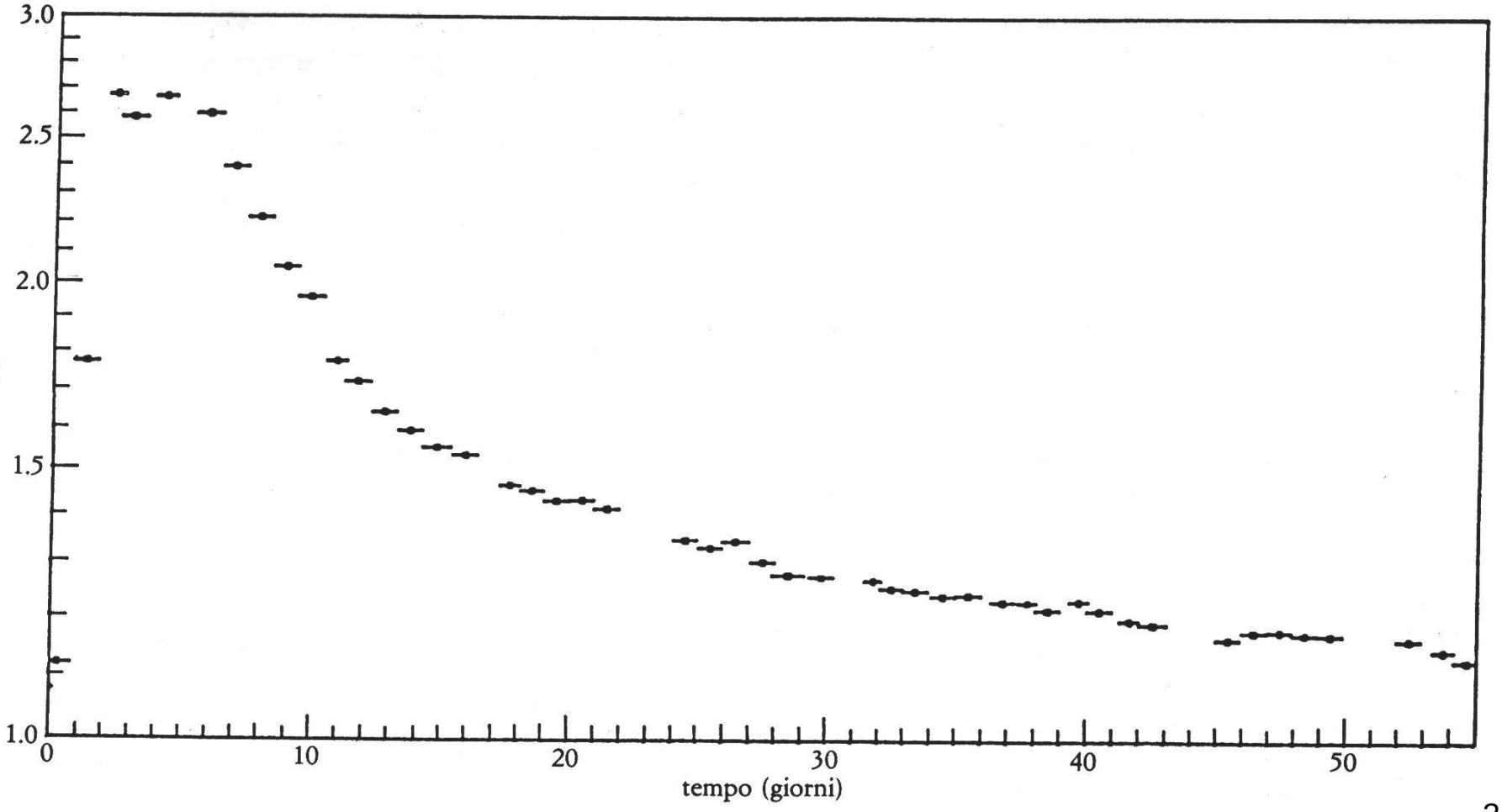


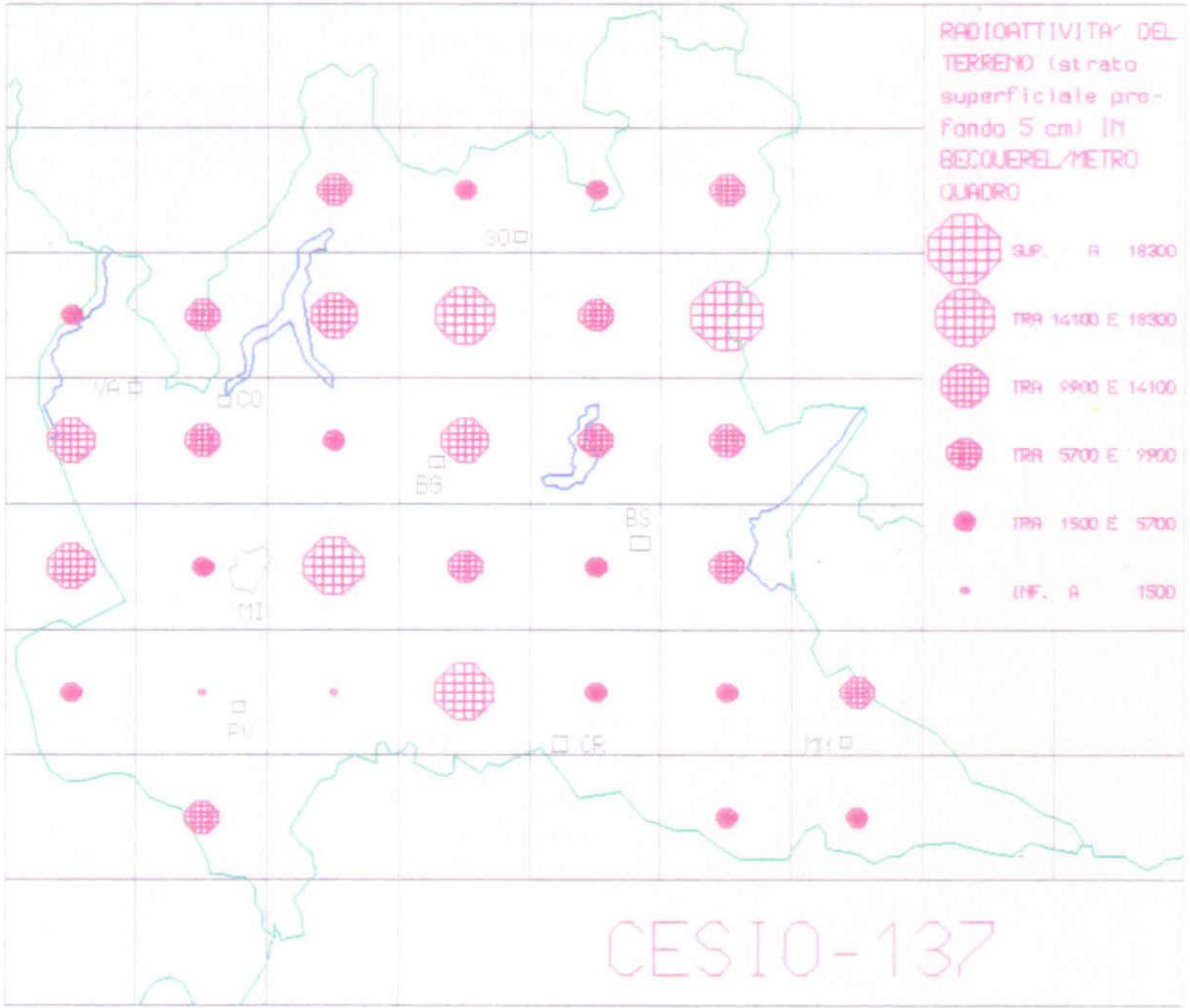
Fig. 7. - Andamento dei conteggi dovuti al ^{137}Cs.



Global activity

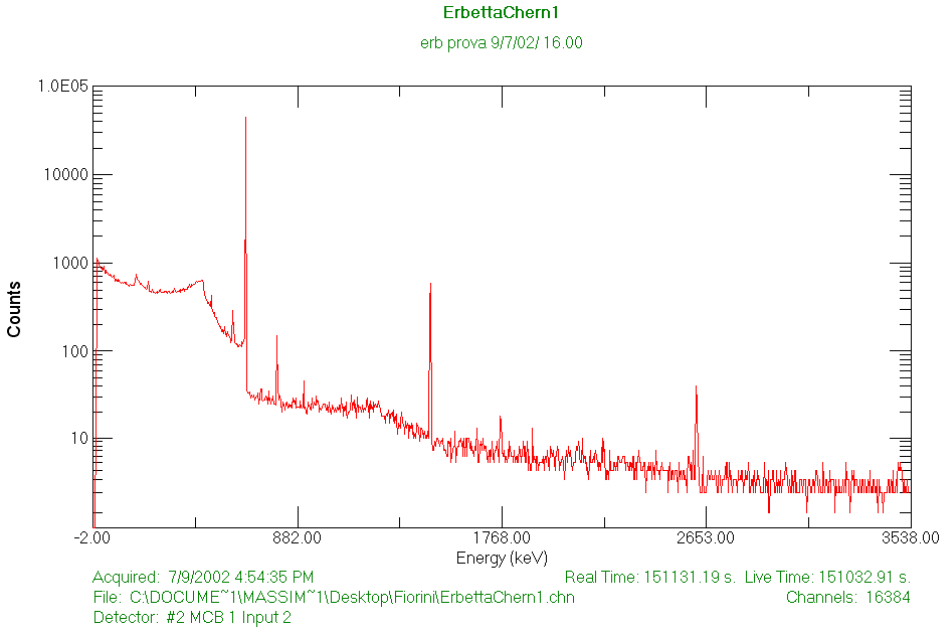


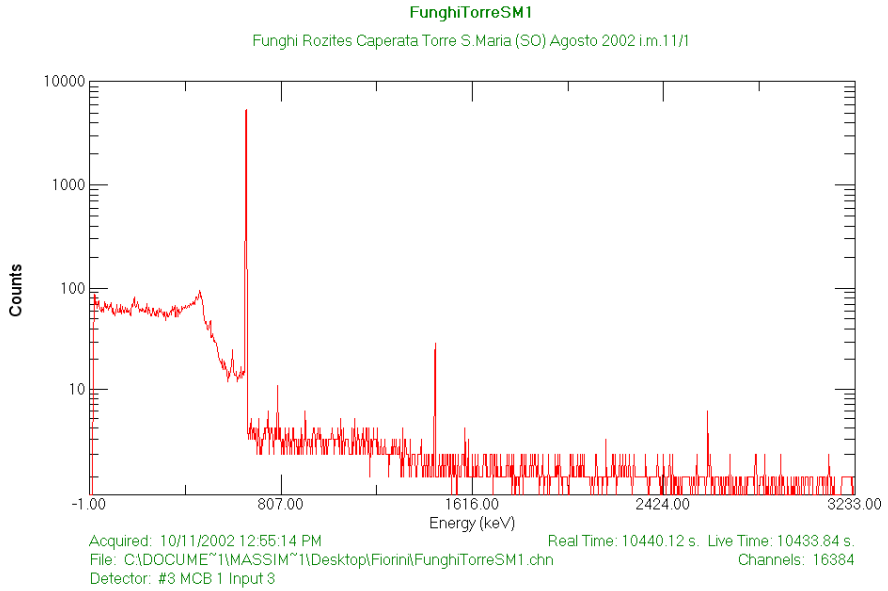
^{137}Cs in Lombardy



Measurement on the top of Gran Sasso

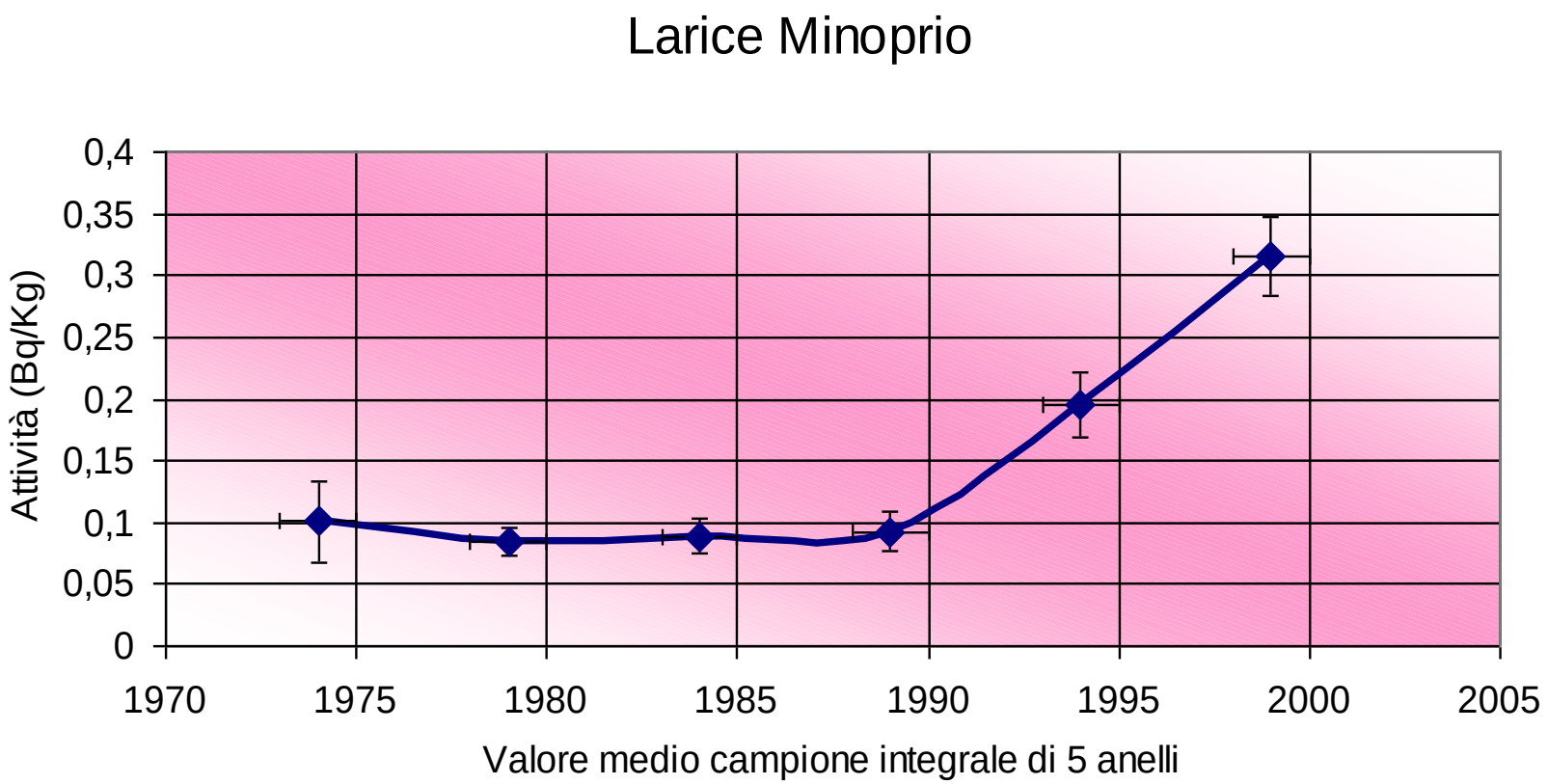
Measurements today





A (Larix) in the Minoprio park

The corresponding ^{137}Cs activity as a function of the year

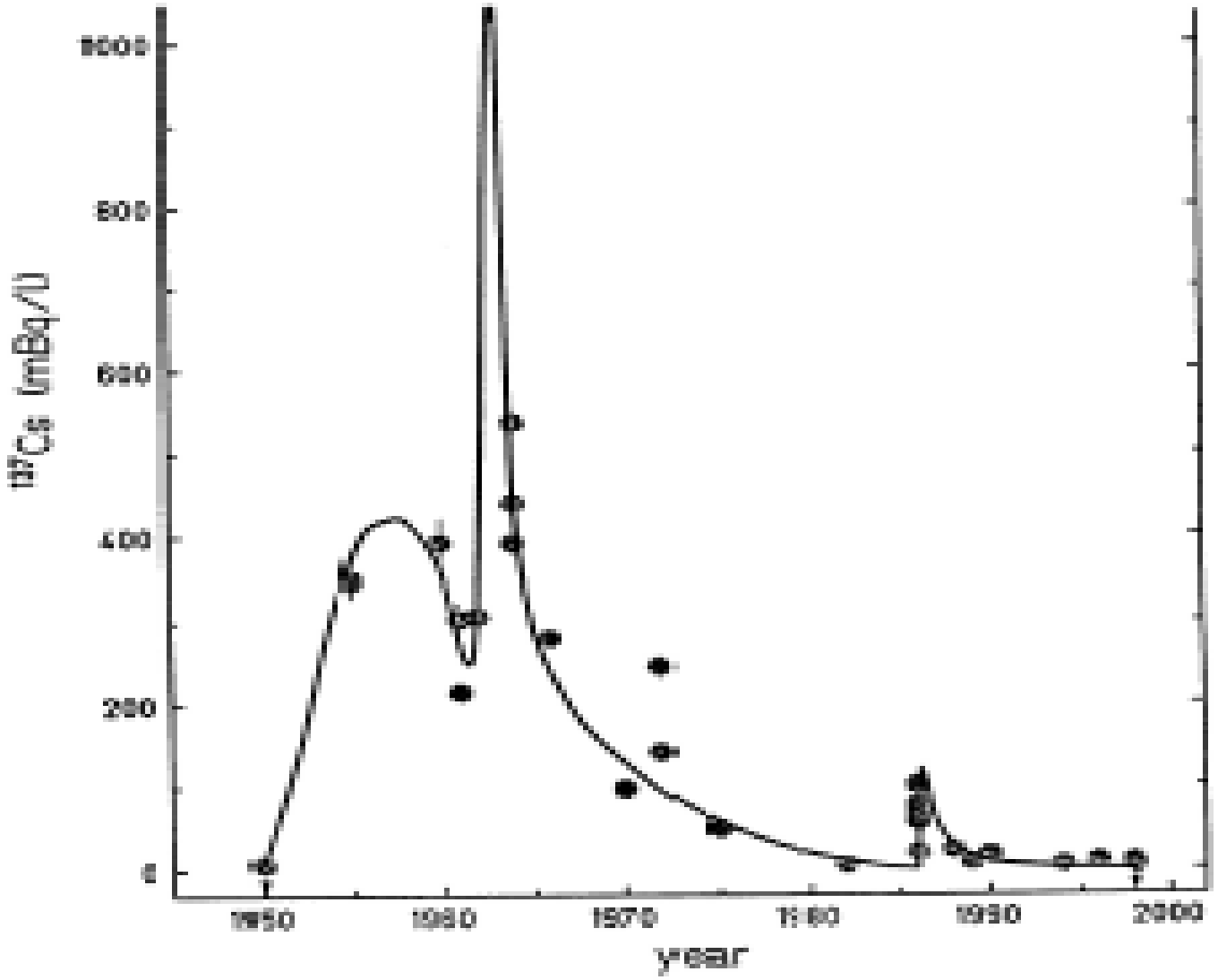


Rozites Caperata

^{137}Cs in mushrooms

CAMPIONI	^{137}Cs (Bq/Kg)	^{134}Cs (Bq/Kg)	^{40}K (Bq/Kg)	TF
Cantharellus cibarius	36,6	0,08	85,59	0,08
Boletus edulis	484,22	1,19	784,36	1,09
Trichloma terreum	448,55	1,24	294,91	1,01
Rozites Caperata	**13133,11**	**33,62**	**1098,78**	**29,69**

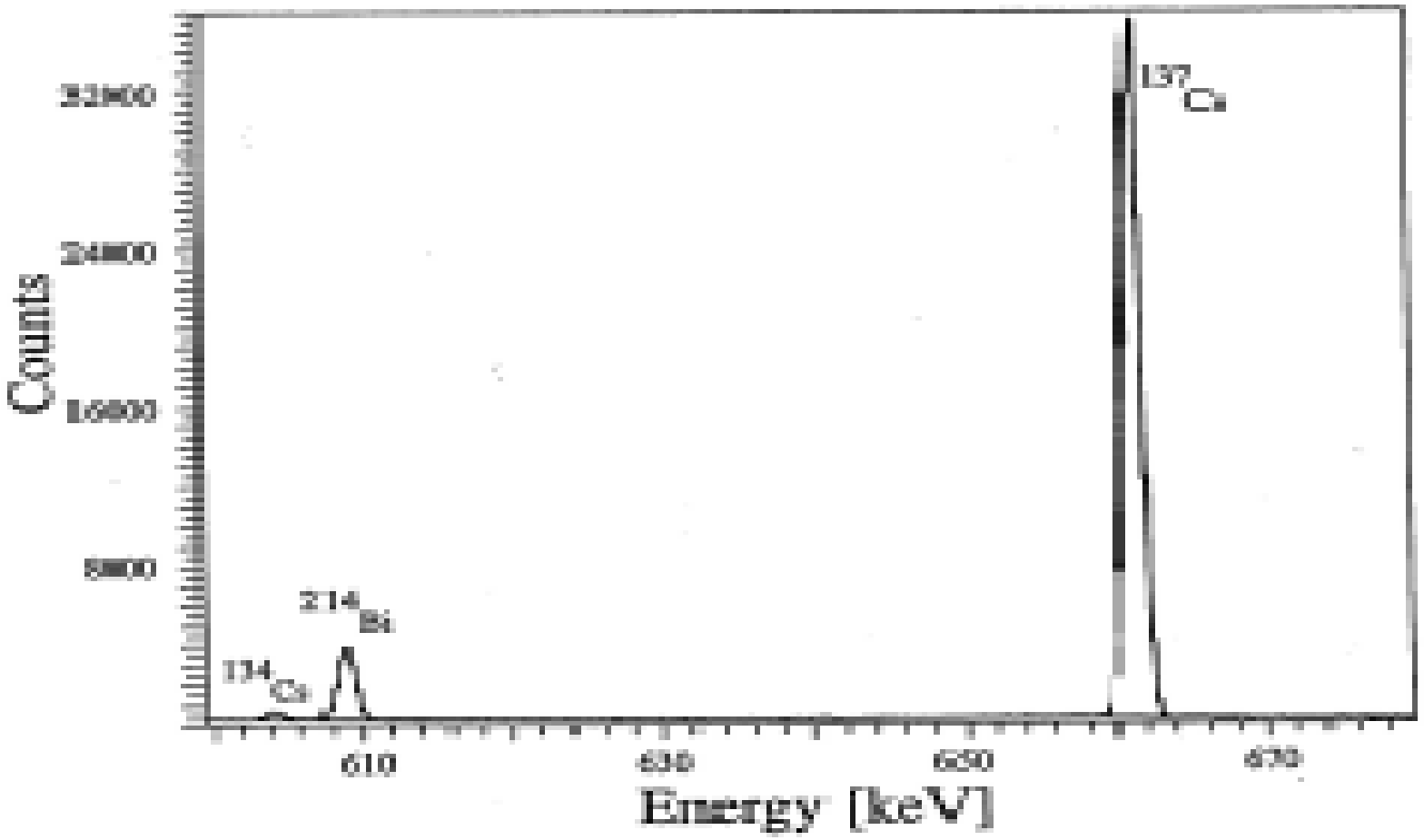
Activity of ^{137}Cs in Bordeaux wine



Wine measurements in France

Origine géographique	A(^{137}Cs) mBq/l	A(^{40}K) Bq/l	R(^{137}Cs/^{40}K)
Entre Deux-Mers	8,9 (22)	35,0 (5)	0,0043 (10)
Côtes de Bourg	< 4	32,1 (3)	< 0,0017
Madiran	< 4	29,5 (3)	< 0,0020
Côtes du Roussillon	< 5	39,9 (5)	< 0,0019
Jurançon	6,1 (2,5)	24,2 (4)	0,0042 (17)

Thhe Spagnish accindent in June 1998



Loss of ^{137}Cs from a Spagnish foundry (1998)

Starting date of measurement	m^3 per hour	Contamination (Bq/m^3)
15.5.98	504 ±5	30 ± 4
15.6.98	9 ±1	1.0 ± .2
4.7.98	11 ±1	1.3 ± .2
20.7.98	13 ±1.5	1.6 ± .3
3.8.98	11.4 ± 15	.6 ± .1
27.10.98	15 ± 2	.5 ± .1

Fukushima

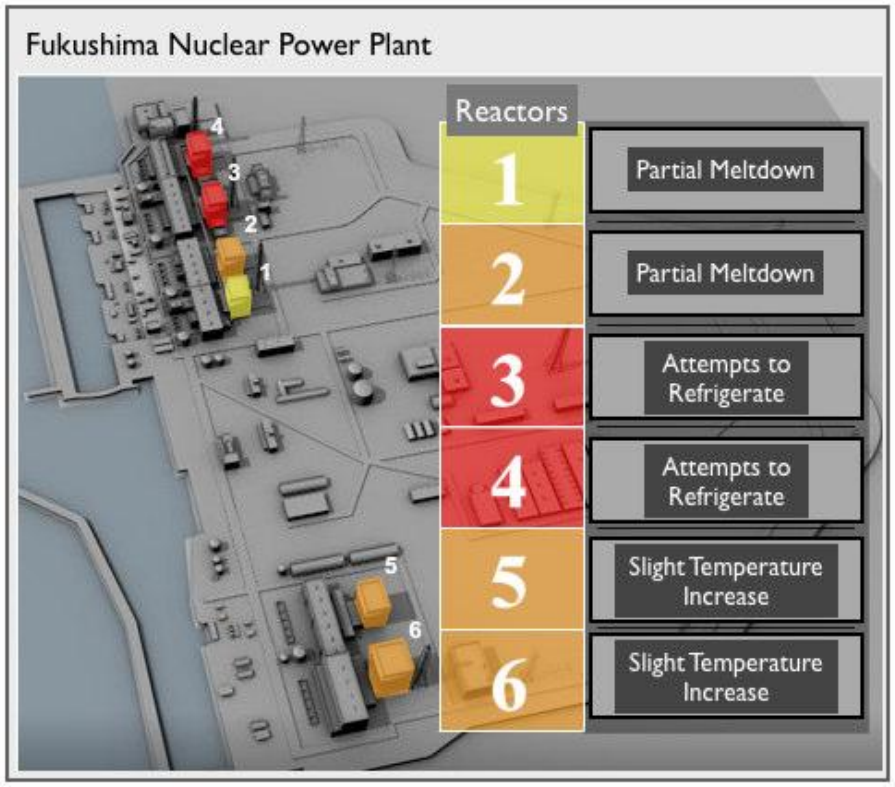
⇒ **At 14,46 => 6,46 italian hour on march 11 2011 Earthquake magnitude 8.9**

⇒ 55 reactors => involved 11

⇒ Fukushima reactors 1,2,3 si stop other 3 already stopped

⇒ Pressure increase => emission of radioactive gas

⇒ Evacuation from 30 km and measurement of ^{121}I



April 15 2011

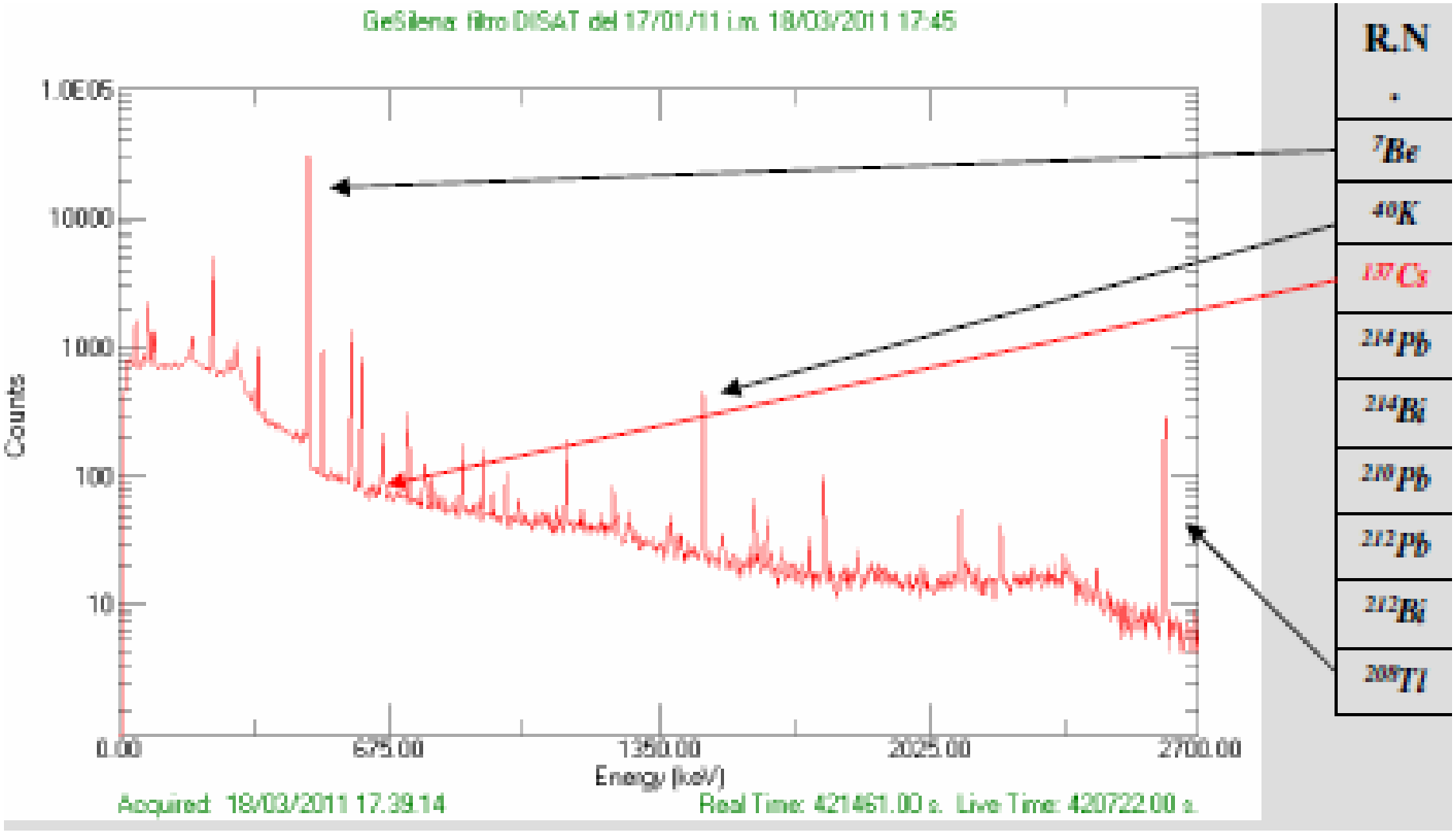
Unit	1	2	3	4	5	6
Power (MWe /MWth)	460/1380	784/2381	784/2381	784/2381	784/2381	1100/3293
Type of Reactor	BWR-3	BWR-4	BWR-4	BWR-4	BWR-4	BWR-5
Status at time of EQ	In service – auto shutdown	In service – auto shutdown	In service – auto shutdown	Outage	Outage	Outage
Core and fuel integrity	Damaged	Severe damage	Damaged	No fuel in the Reactor	**Cold Shutdown** Being maintained using off-site electrical power and existing plant equipment.	**Cold Shutdown** Being maintained using off-site electrical power and existing plant equipment.
RPV & RCS integrity	RPV temperature high but stable	RPV temperature stable	RPV temperature stable	Not applicable due to outage plant status		
Containment integrity	No information	Damage suspected	Damage suspected			
AC Power	AC power available - power to instrumentation – Lighting to Central Control Room	AC power available – power to instrumentation – Lighting to Central Control Room	AC power available – power to instrumentation – Lighting to Central Control Room	AC power available – power to instrumentation – Lighting to Central Control Room		
Building	Severe damage	Slight damage	Severe damage	Severe damage		
Water level of RPV	Around half of Fuel is uncovered	Around half of Fuel is uncovered	Around half of Fuel is uncovered	Not applicable due to outage plant status		
Pressure of RPV	Increasing	Stable	Stable			
CV Pressure Drywell	Increasing	Stable	Stable			
Water injection to RPV	Injection of freshwater – via mobile electric pump with off-site power	Injection of freshwater – via mobile electric pump with off-site power	Injection of freshwater – via mobile electric pump with off-site power			
Water injection to CV	No information	No information	No information			
Spent Fuel Pool Status	Fresh water injection by concrete pump truck	Freshwater injection to the Fuel Pool Cooling Line	Freshwater injection via Fuel Pool Cooling Line and Periodic spraying	Fresh water injection by concrete pump truck		

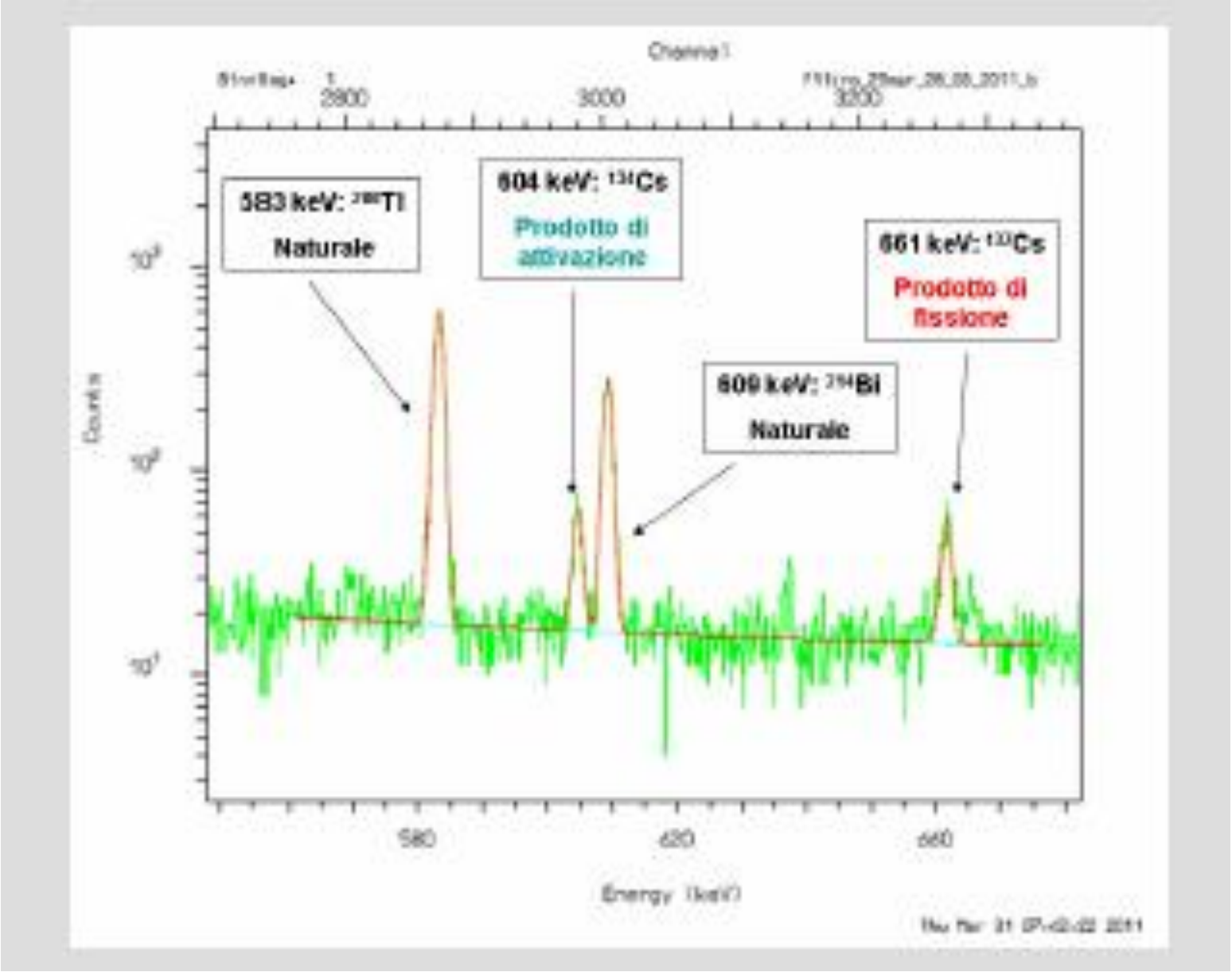
RPV: Reactor Pressure Vessel
RCS: Reactor Coolant System

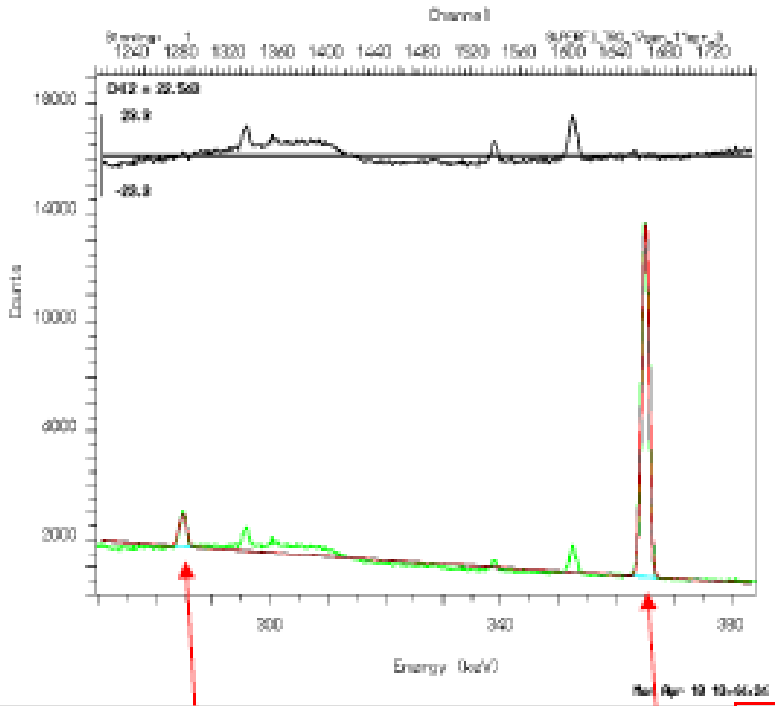
Measurements in Milano-Bicocca

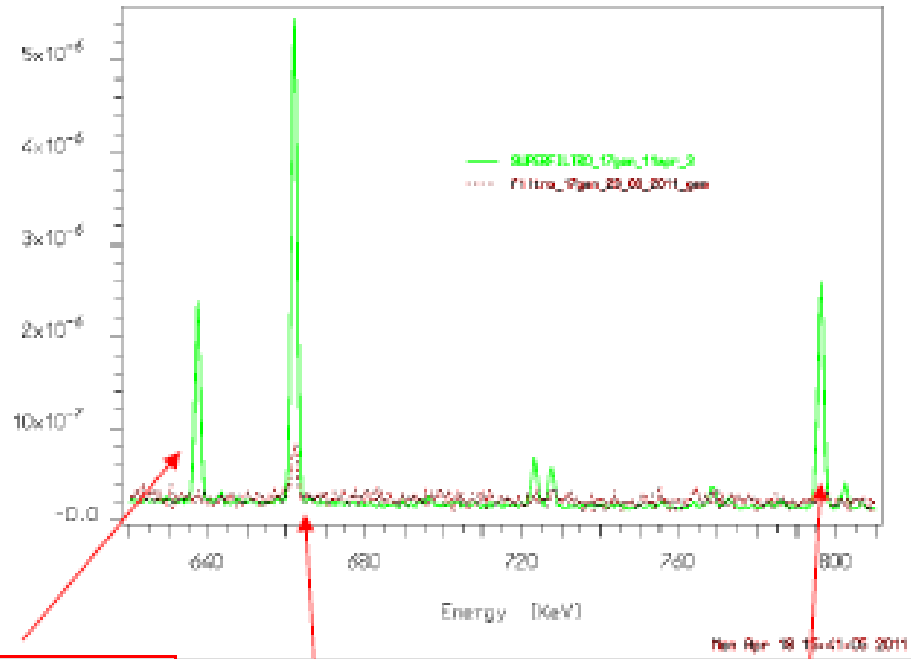
⇒ **May 15-18 No activity apart ^{137}Cs (.5 Bq/m3**

First measurement




583 keV: ^{208}Tl
Naturale
604 keV: ^{134}Cs
Prodotto di attivazione
609 keV: ^{214}Bi
Naturale
661 keV: ^{137}Cs
Prodotto di fissione
Counts
Energy (keV)





636 keV ^{131}I

284 keV ^{131}I

364 keV ^{131}I

661 keV ^{137}Cs

795 keV ^{134}Cs

KEK,Milano,Seattle

Nucleo	**KEK**		**Milano-Bicocca**		**Seatte**	
^{131}I	Data	μ Bq/m^3	Data	μ Bq/m^3	Data	μ Bq/m^3
	15-16.3	**32-20 x 10^6**	24.3	3	**17-18.3**	**32000**
	18.3	0.5x 10^6	**25.3**	**110**		
	20.3	**23x 10^6**	**26.3**	**150**		
	22.3	**9.6x 10^6**	**29.3**	**400**		
	23.3	1.9x 10^6	**30.3**	**140**		
	24-25.3	.7x 10^6	31.3	4		
	1.4	.1x 10^6	**1.4**	**33**		
			2.4	**23**		
			3.4	**19**		
			4.4	4		
			5.4	29		
			8.4	4		
			11.4	6		
			13.4			

Nucleo	**KEK**		**Milano-Bicocca**		**Seatte**	
^{134}Cs	Data	μ Bq/m^3	Data	μ Bq/m^3	Data	μ Bq/m^3
	15-16.3	**.67 x 10^6**	26.3	3		
	18.3	0.001x 10^6	**28.3**	**80**		
	20.3	**7.3x 10^6**	**31.3**	**2**		
	22.3	.12x 10^6	**1.4**	**12**		
	23.3	.1x 10^6	**2.4**	**11**		
	1.4	.2x 10^6	3.4	20		
		.	**5.4**	**2**		
			6.4	**11**		
			7.4	**8**		
			8.4	4		
			5.4	29		
			8.4	2		
			10.4	1		
			11.4	4		

Nucleo	**KEK**		**Milano-Bicocca**		**Seatte**	
^{137}Cs	Data	μ Bq/m^3	Data	μ Bq/m^3	Data	μ Bq/m^3
	15-16.3	**.7 x 10^6**	26.3	8		
	20.3	7x 10^6	**28.3**	**92**		
	22.3	**.1x 10^6**	**31.3**	**7**		
	28.3	.2x 10^6	**1.4**	**13**		
	30.3	.1x 10^6	**2.4**	**10**		
			3.4	38		
		.	**6.4**	**11**		
			7.4	**10**		
			11.4	**4**		
			12.4	3		
			13.4	4		
			8.4	2		

Physicists as detectives

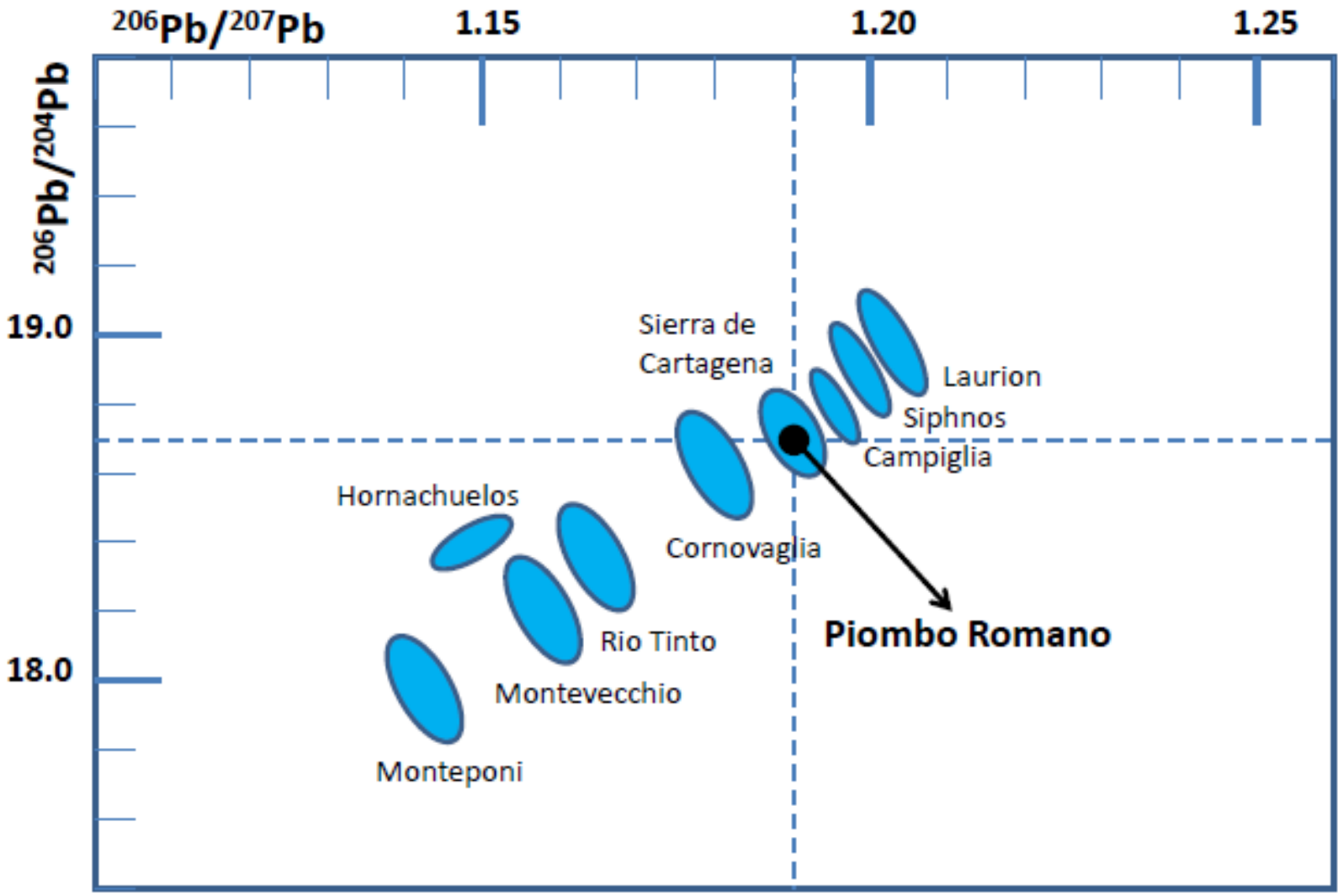
⇒An ancient **crime** . Killing of **Napoleon**

⇒Ancient living and crimes=> **archeometry**

⇒Recent **fakes** of archaeological objects and not only

⇒Difference between **environmental** and **natural** radioactivity. We are no more the same

⇒**Monitoring** and control of **radioactive** pollution and accidents


206Pb/207Pb
1.15
1.20
1.25
206Pb/204Pb
19.0
18.0
Sierra de
Cartagena
Laurion
Siphnos
Campiglia
Hornachuelos
Cornovaglia
Rio Tinto
Piombo Romano
Montevecchio
Monteponi