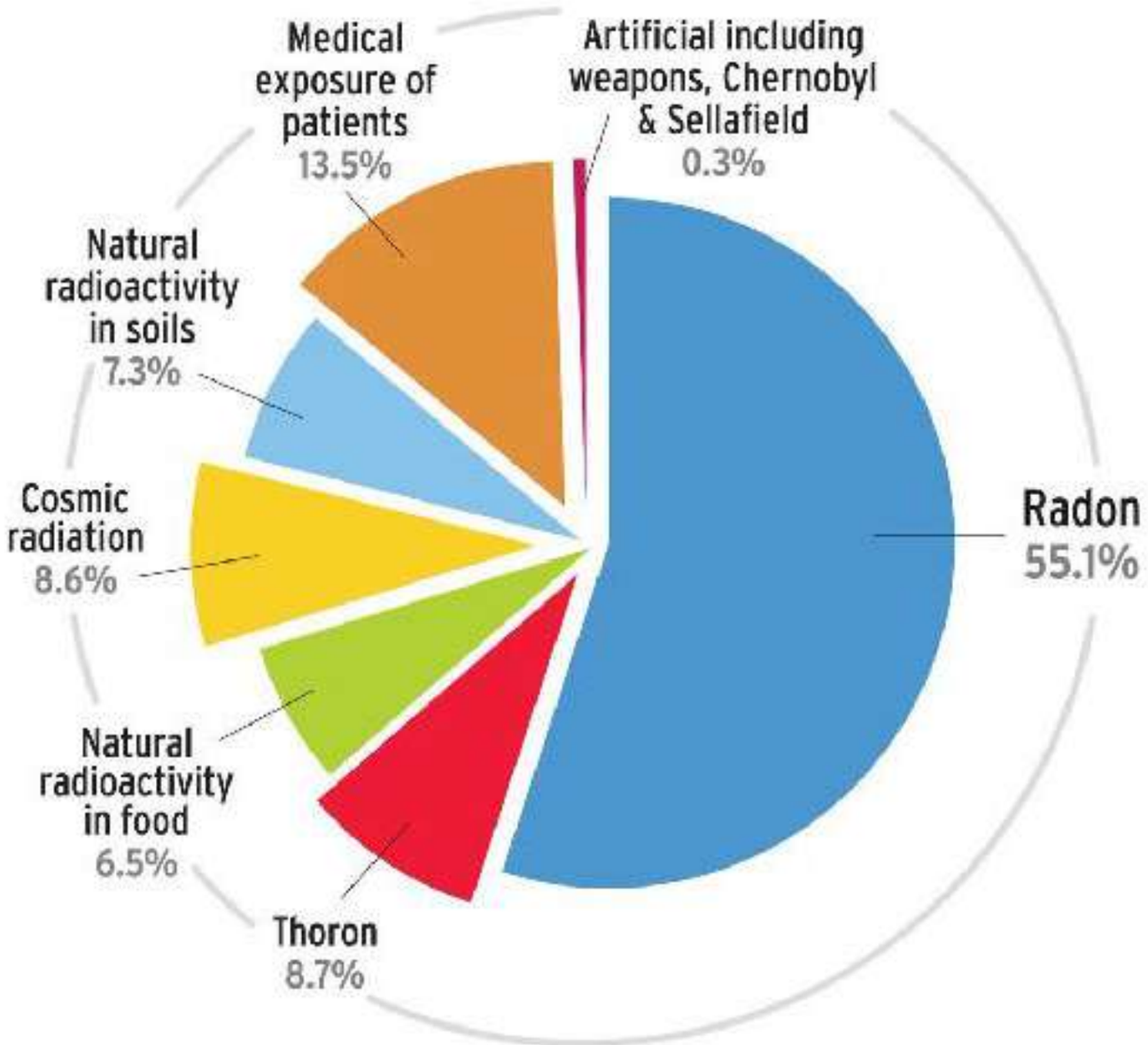
L'Atomo Inquieto

Breve introduzione alla radioattività e alle sue applicazioni

Claudio Tuniz

Radiazioni ionizzanti



Effects:

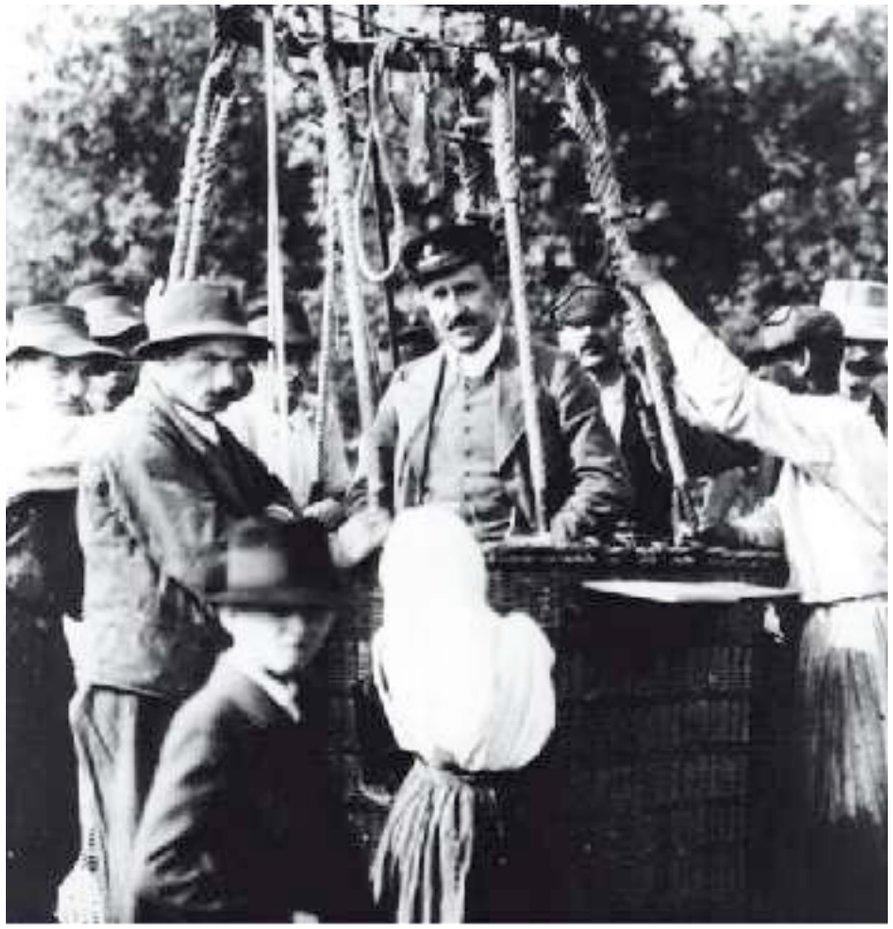
- Nuclear reactions
  - Radionuclides
- Ionisation energy loss
  - Nuclear tracks
  - Thermoluminescence
- Ion implantation

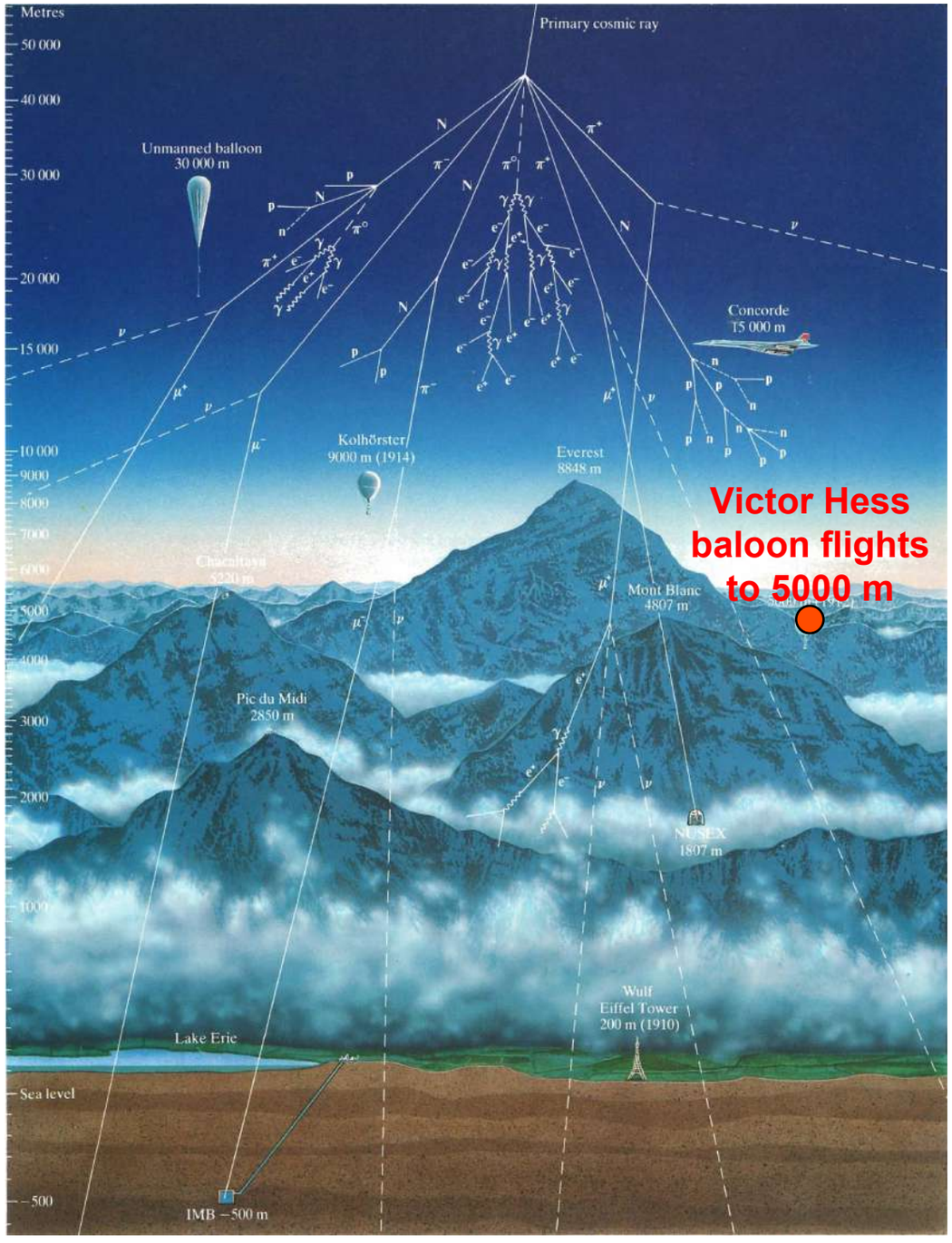
Domenico Pacini, 1911

“appare confermino le esperienze di cui è oggetto questa nota ... che esista nell’atmosfera una sensibile causa ionizzante, con radiazioni penetranti, indipendente dall’azione diretta delle sostanze radioattive del terreno.”

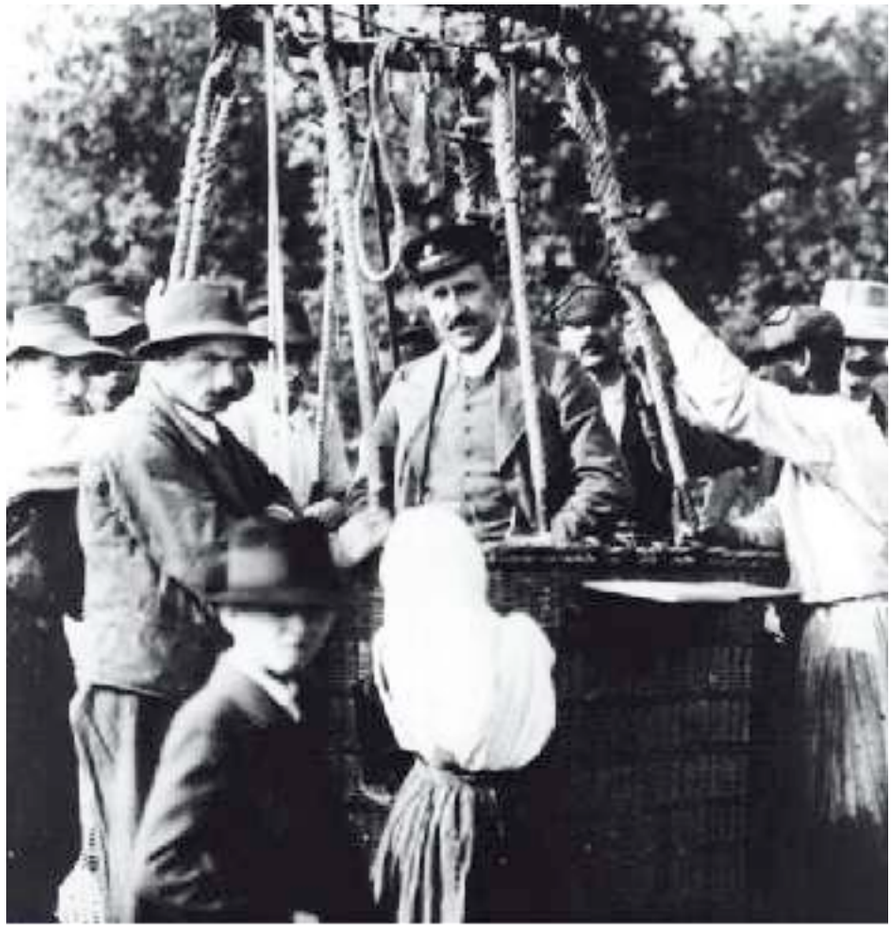
Nuovo Cimento, febbraio del 1912

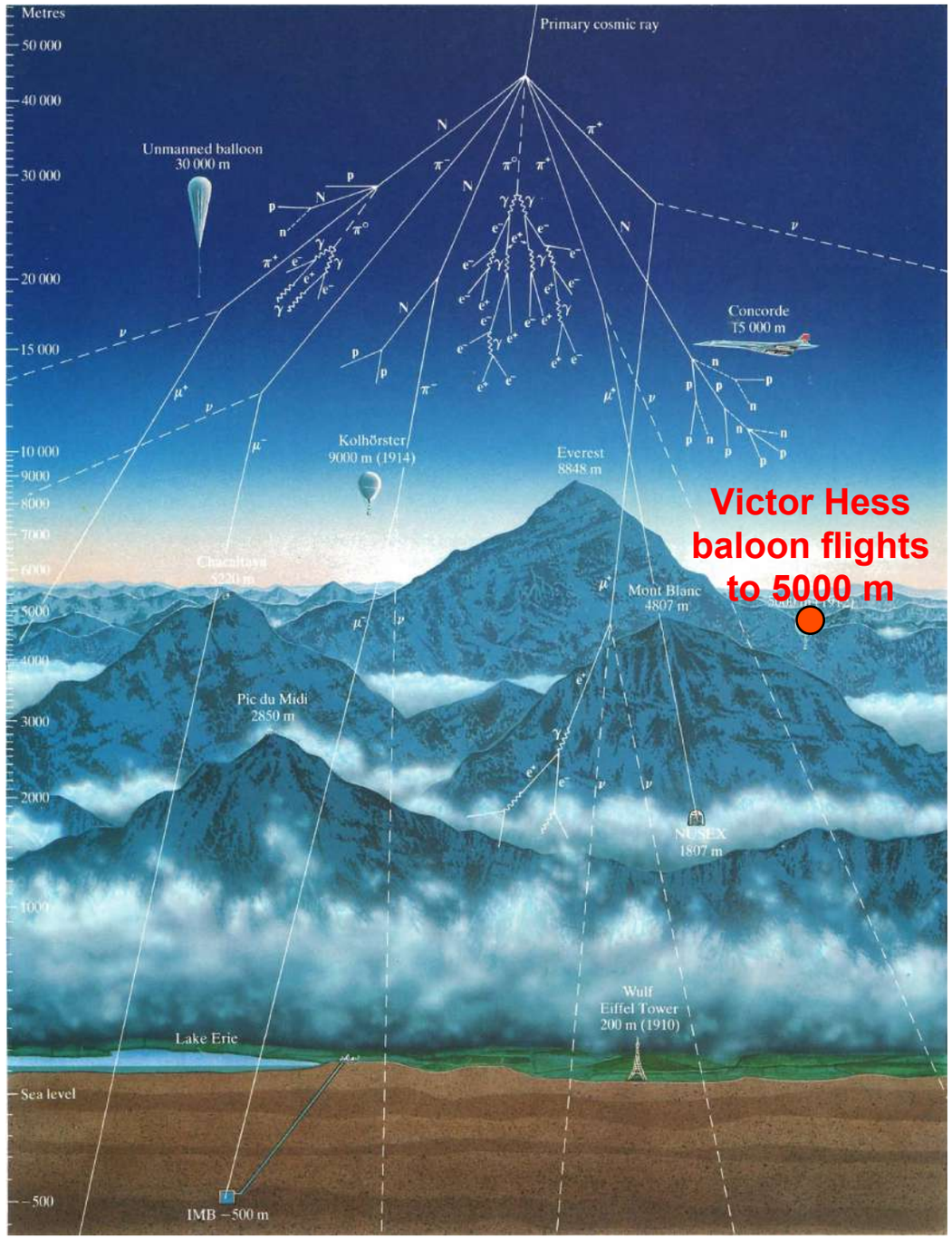
Victor Hess, 1911





Victor Hess, 1912





Energia e flusso

Table 5.1 Comparison of Solar Wind, SCR, and GCR Fluxes

	Solar Wind	SCR	GCR
Nucleon energies	0.3 – 3 keV	~1 – 100 MeV	~0.1 – >10 GeV
Electron energies	~1 – 100 eV	<0.1 – 1 MeV	~0.1 – >10 GeV
Proton fluxes (cm^{-2} sec^{-1})	$\sim 3 \times 10^8$	100	2 – 4
Penetration depth in solid matter	μm	cm	m

Source: Vaniman, D. et al., in *Lunar Sourcebook: A User's Guide to the Moon*, Heiken, D.H. et al., Eds., Cambridge University Press, London, 1991, 27. With permission.

Accelerator Mass Spectrometry
C. Tuniz et al., CRC Press, 1998

Bersagli extraterrestri

Production rate

$$P_X(R,d) = \int_E \{\Sigma_k \Sigma_j \phi_k(E,R,d) \sigma_{j,k}(E) N_j\}\, dE$$

Recent cosmic ray exposure history of ALHA81005,

C. Tuniz, D.K. Pal, R.K. Moniot, W. Savin, T.H. Kruse, G.F. Herzog,

Geophysical Research Letters, 10, 804 (1983)

Exposure history of the Torino meteorite,
R. Wieler, Th. Graf, P. Signer, S. Vogt, G.F. Herzog, C. Tuniz, D. Fink, L.K. Fifield, J. Klein, R. Middleton, A.J.T. Jull, P. Pellas, J. Masarik and G. Dreibus, **Meteoritics & Planetary Science** 31(1996) 265-272.

Be-10 in Australasian tektites,
D.K. Pal, C. Tuniz, R.K. Moniot, T.H. Kruse and G.F. Herzog, **Science**, 218, 787 (1982).

Bersagli terrestri

Table 7.1 Cosmogenic Radionuclides Produced in Terrestrial Matter

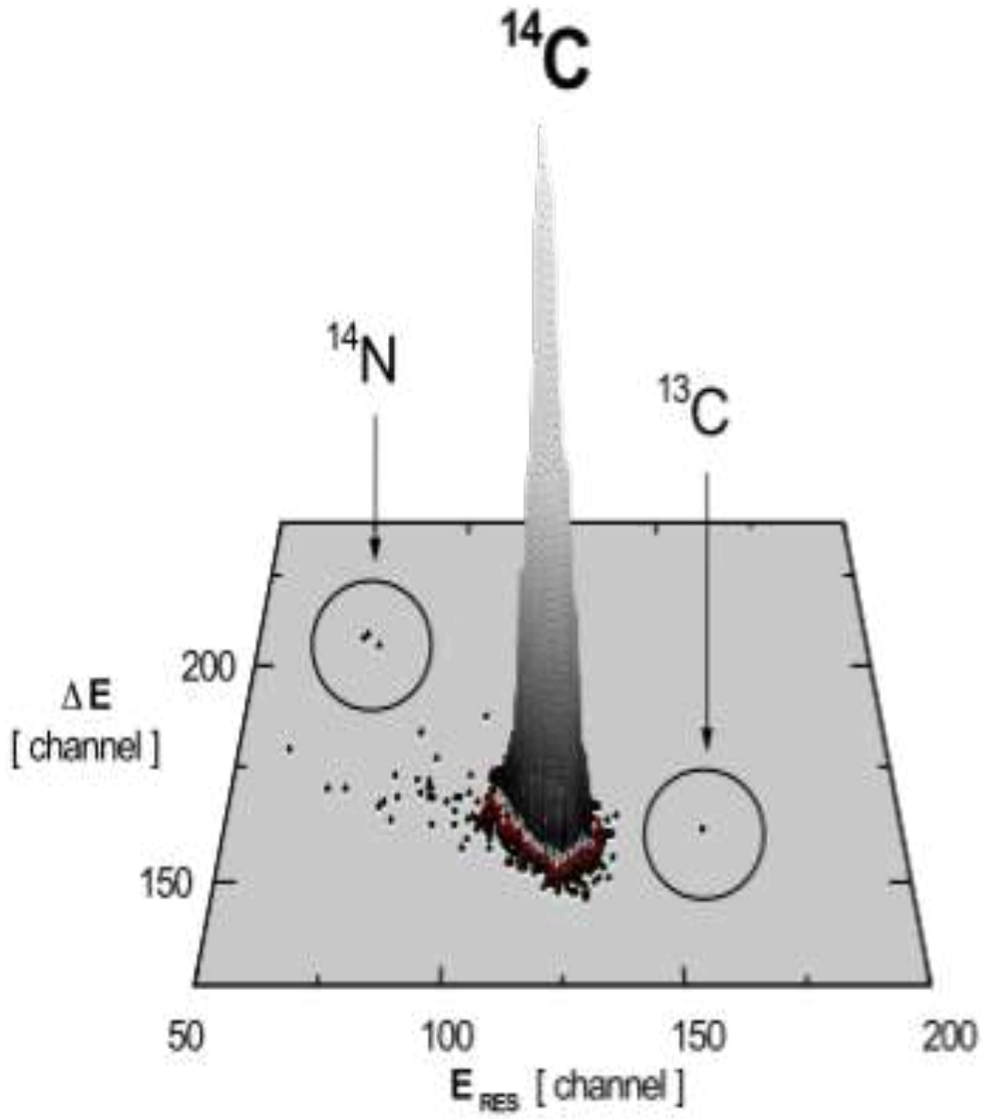
Radionuclide	Half-Life ($t_{1/2}$)	Main Terrestrial Target Elements	
		Atmosphere	Lithosphere
^{3}H	12.3 a	N, O	O, Mg, Si, Fe
^{7}Be	53.3 d	N, O	O, Mg, si, Fe
^{10}Be	1.51 Ma	N, O	O, Si, Mg, Fe
^{14}C	5730 a	N, O	O, Mg, Si, Fe
^{22}Na	2.61 a	Ar	Mg, Al, Si, Fe
^{26}Al	720 ka	Ar	Cl, K, Ca, Fe
^{32}Si	~140 a	Ar	Cl, K, Ca, Fe
^{36}Cl	301 ka	Ar	Cl, K, Ca, Fe
^{39}Ar	269 a	Ar	K, Ca, Fe
^{41}Ca	103 ka	Kr	Ca, Ti, Fe
^{81}Kr	210 ka	Kr	Rb, Sr, Zr
^{90}Sr	28.8 a	Fission	
^{129}I	15.7 Ma	Xe	Te, Ba, Ce, La

Note: The listed isotopes have been measured by AMS or have been proposed to be measured by AMS.

Accelerator Mass Spectrometry
C. Tuniz et al., CRC Press, 1998

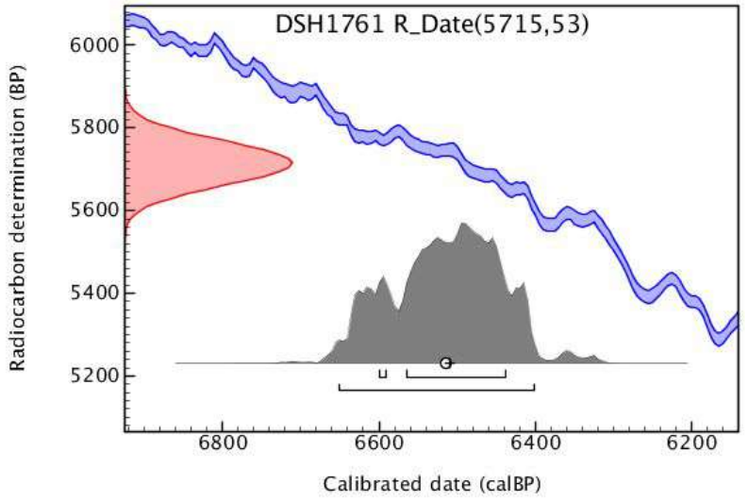
Datazione ^{14}C

ANSTO, Australia

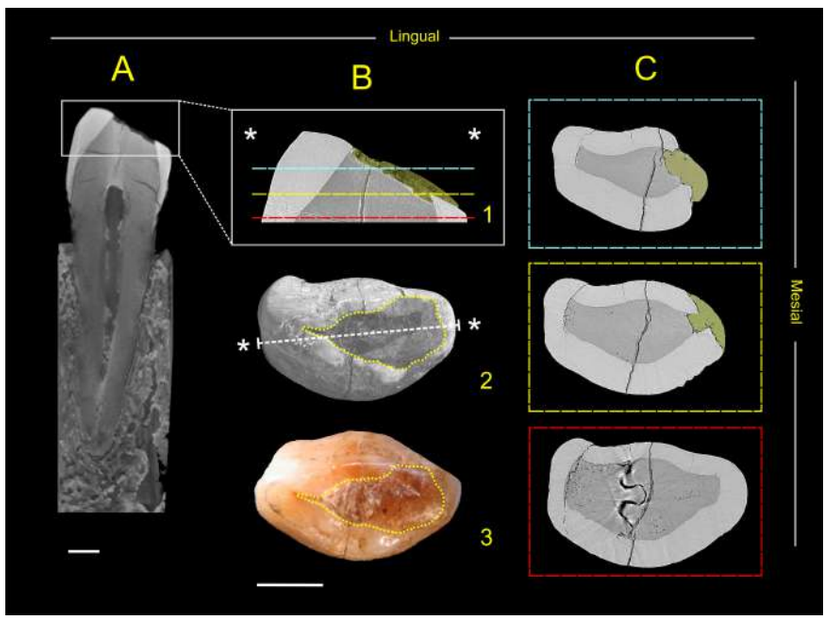


Accelerator Mass Spectrometry
C. Tuniz et al., CRC Press, 1998

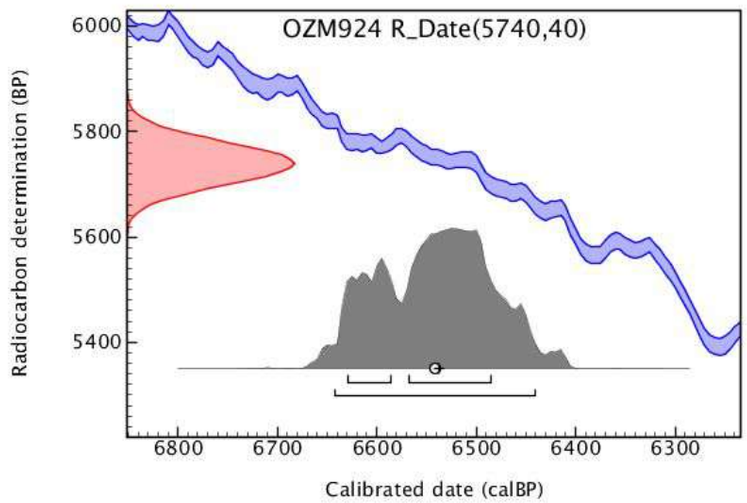
Cronometri e microscopi



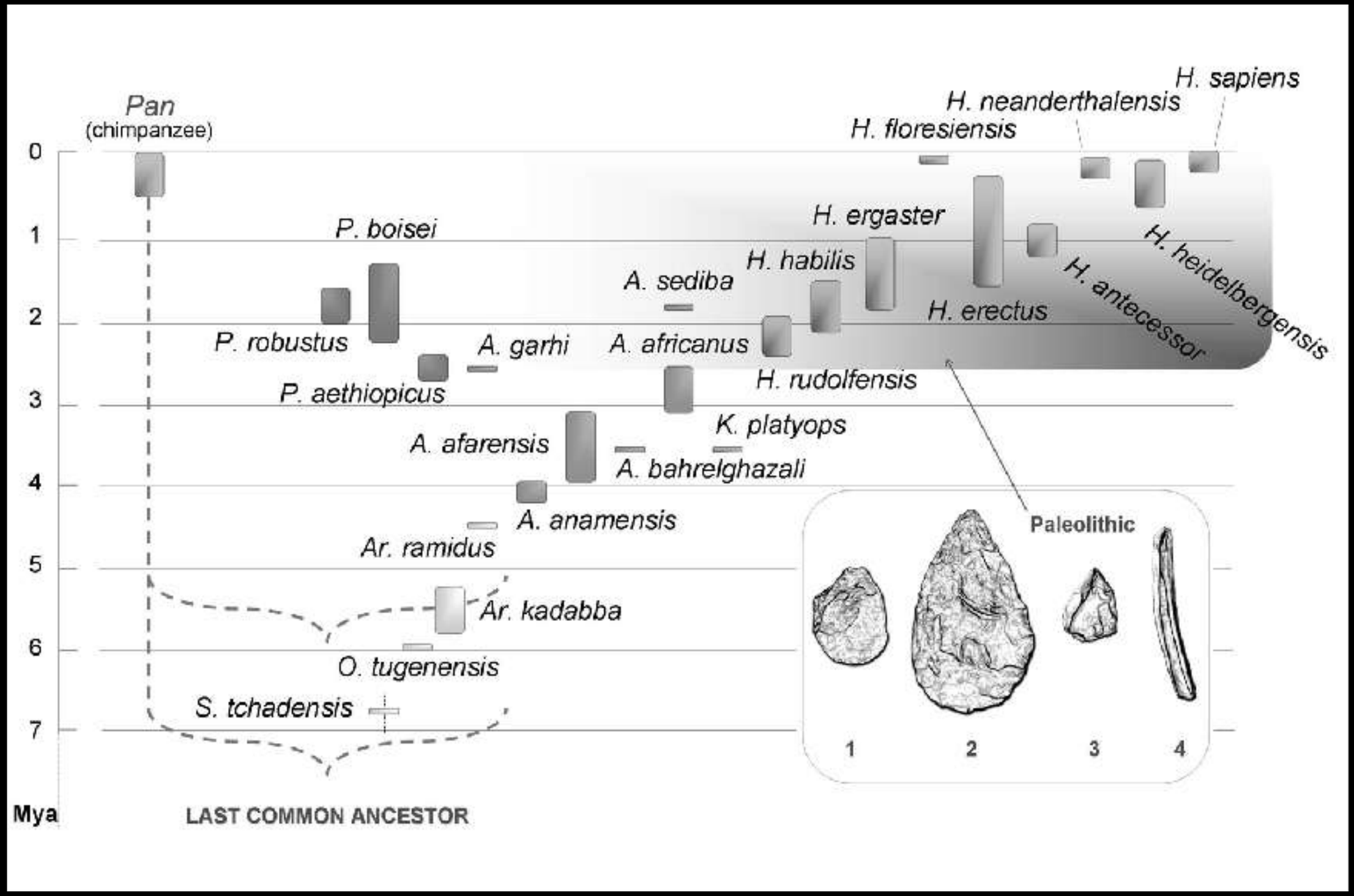
cera d'api
4695-4453 a.C.



mandibola
4668-4496 a.C.

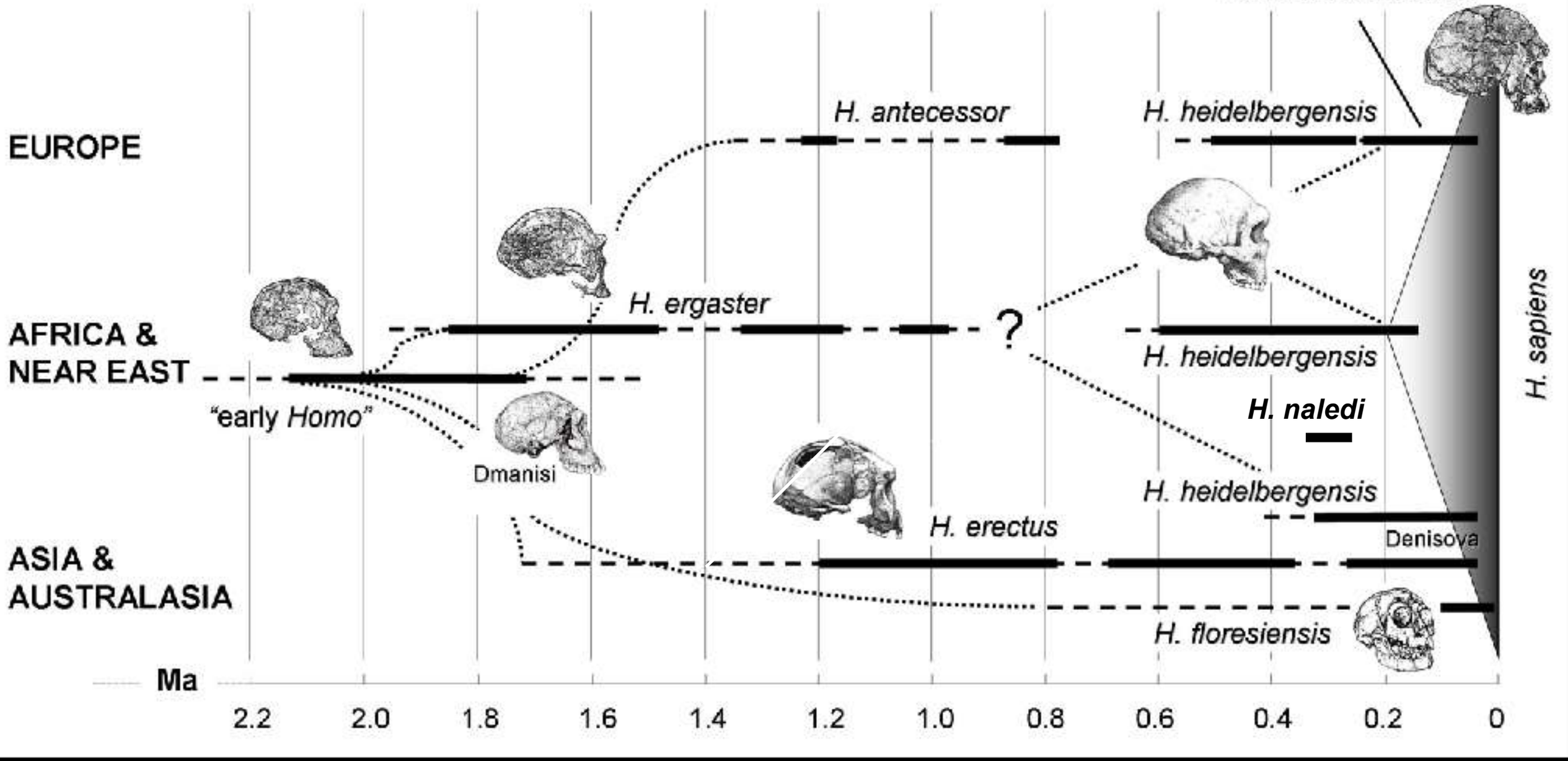


Federico Bernardini, ClaudioTuniz, et al. "*Beeswax as Dental Filling on a Neolithic Human Tooth*. PLoS ONE **7**(9)



40K-40Ar

10Be/26Al



OSL, 234U/230Th

14C

40K-40Ar

10Be/26Al

Radioattività

uranio 1789 **radioattività** 1898 **nucleo** 1911 **radioattività' artificiale** 1933

Henrich Klaproth

Antoine-Henri Becquerel
Marie Curie
Pierre Curie

Ernest Rutherford

Irène e Frédéric Curie

La paura

Pierre Curie

Lezione Nobel, 6 giugno, 1905

“ Si può perfino pensare che il **radio** possa diventare molto pericoloso in mani **criminali**, e qui si può sollevare la questione se l’umanità possa trarre beneficio dai segreti della Natura, se sia pronta a usarli a proprio vantaggio o se questa conoscenza non possa essere essere dannosa.”

Verso l'energia nucleare

Neutroni e uranio

Fermi, 1934

Fissione

Hahn, 1939

Reazione a catena

Leó *Szilárd*, 1940

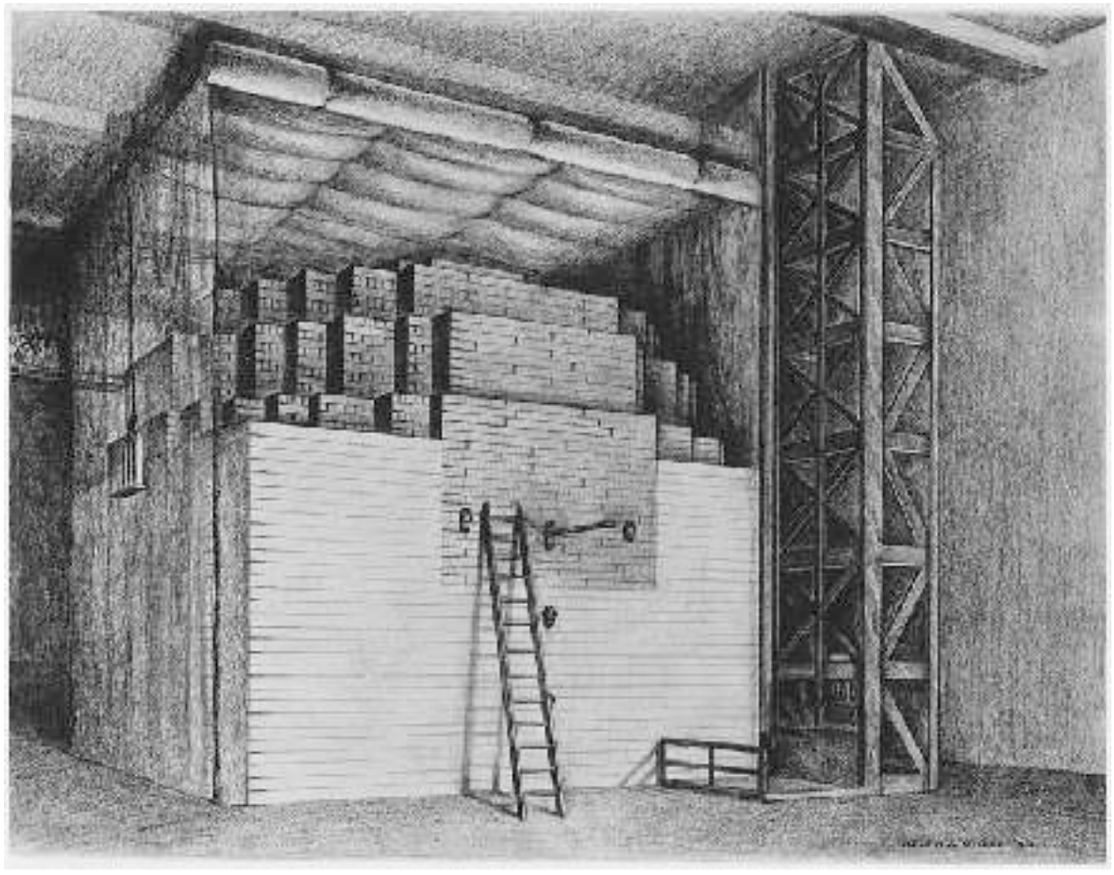
Reattore

Fermi, 1942

Verso la bomba

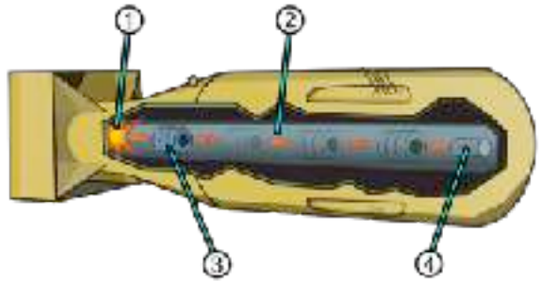
"Il navigatore italiano è entrato nel nuovo mondo"

Pile N. 1



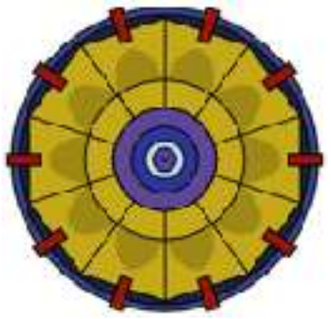
Chicago, 2 dicembre 1942

Little Boy



64 kg U arr, 13 kton

Fat man



6 kg Pu, 20 kton

Hiroshima e Nagasaki 1945

I pentimenti

con Hans Bethe, Niels Bohr, Richard Feynman, Enrico Fermi,
John von Neumann, Edward Teller, Stanislaw Ulam, Harold Urey,
…

Dopo il test Trinity di Alamogordo, 16 luglio 1945:

‘sono diventato Morte il distruttore di mondi’

Dopo Hiroshima e Nagasaki, agosto 1945:

‘i fisici avevano conosciuto il peccato, una conoscenza che non avrebbero più potuto perdere’

Spartire la conoscenza

ICTP Scientific council, 1964

corsa alle armi nucleari

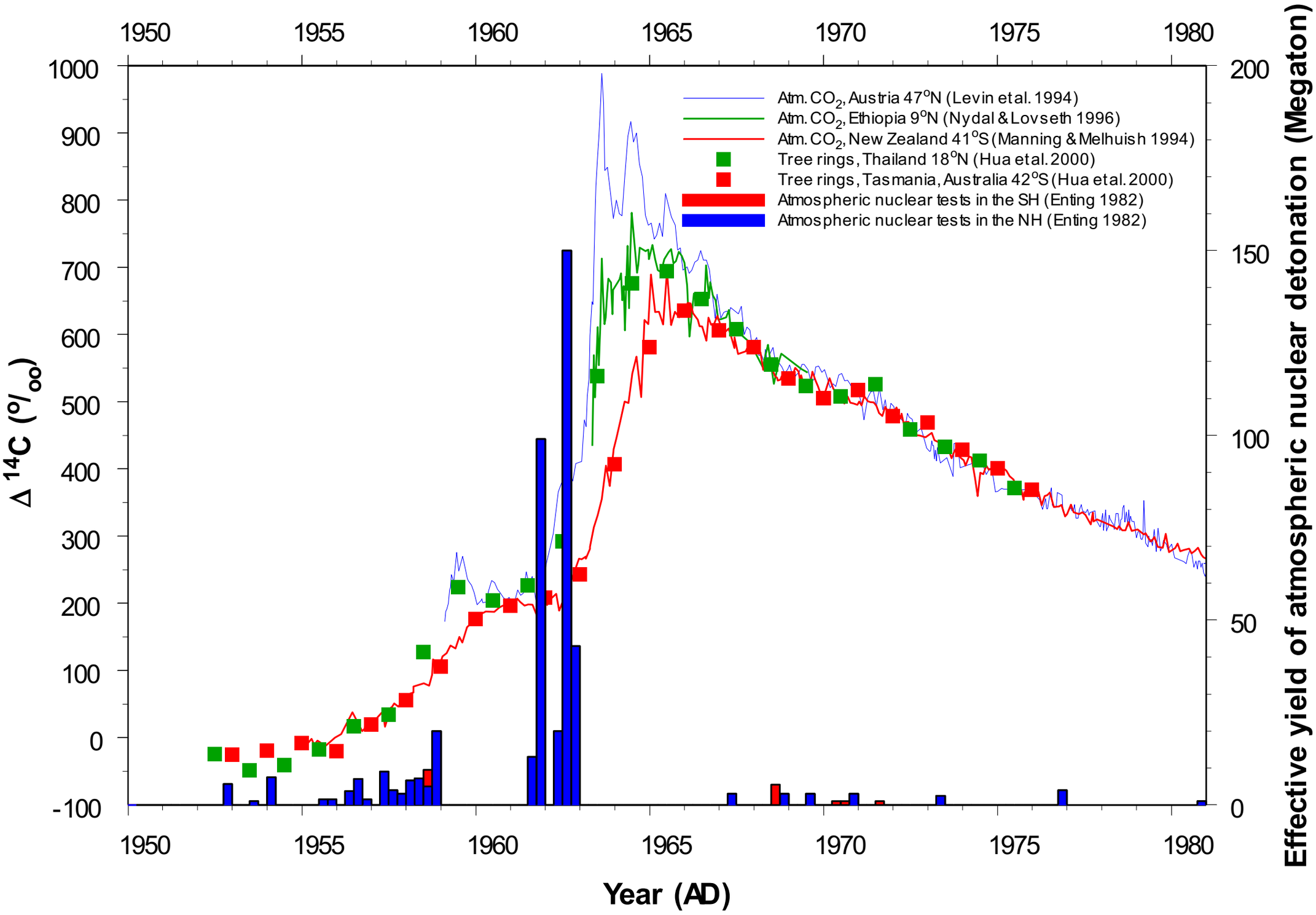
- 1949 USSR
- 1952 US bomba H (sud Pacifico)
- 1952 UK (Australia)
- 1953 USSR bomba H
- 1960 Francia (Algeria)
- 1963 PTBT
- 1964 Cina
- 1970 NPT
- 1974 India
- 1979 South Africa, Israele (sud Atlantico)
- 1996 Francia (Mururoa)
- 1996 CTBT
- 1998 Pakistan
- 2009 DPRK

Gli accordi

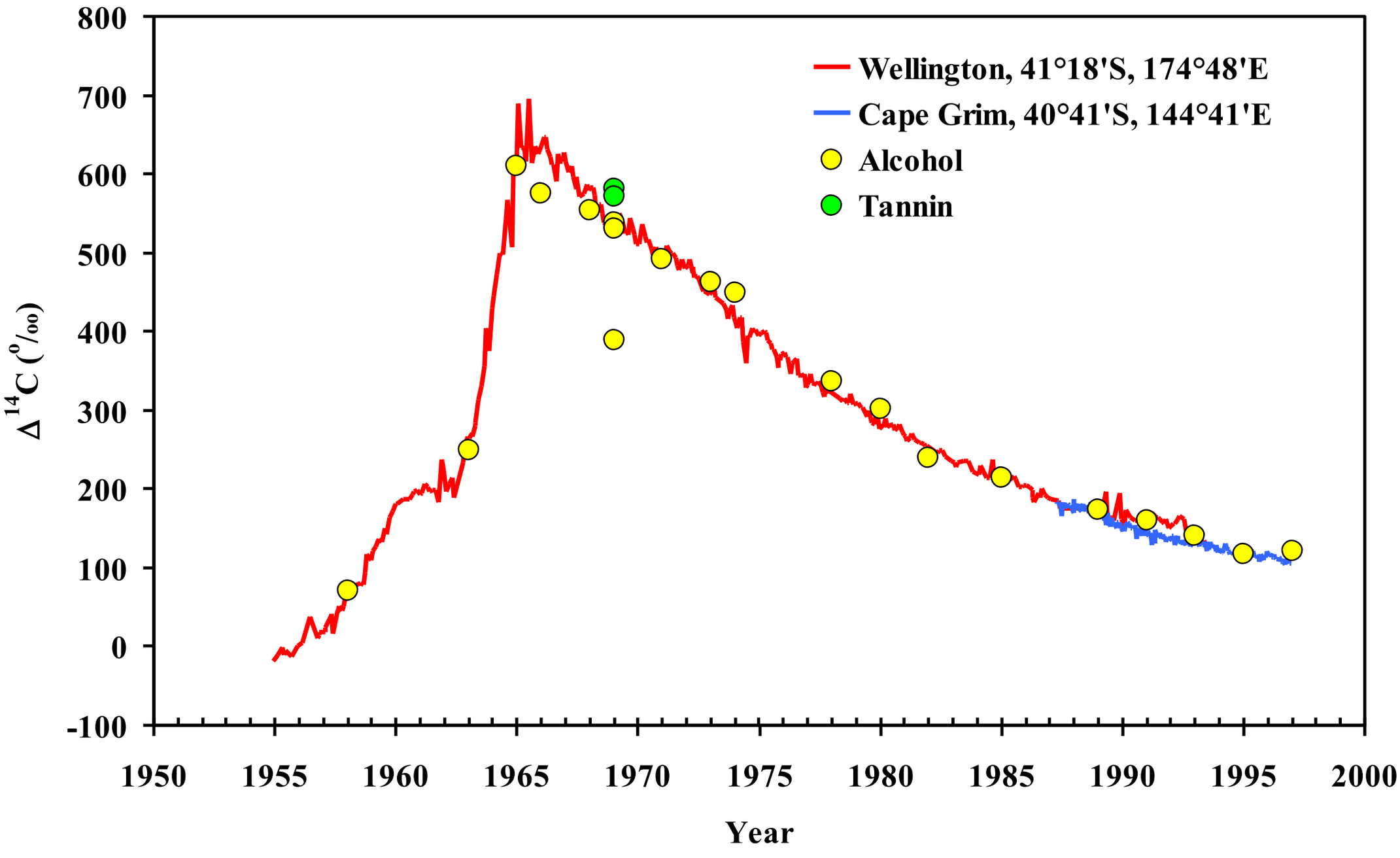
Kennedy firma il trattato sulla messa
al bando parziale dei test nucleari

07 ottobre1963

Antropocene

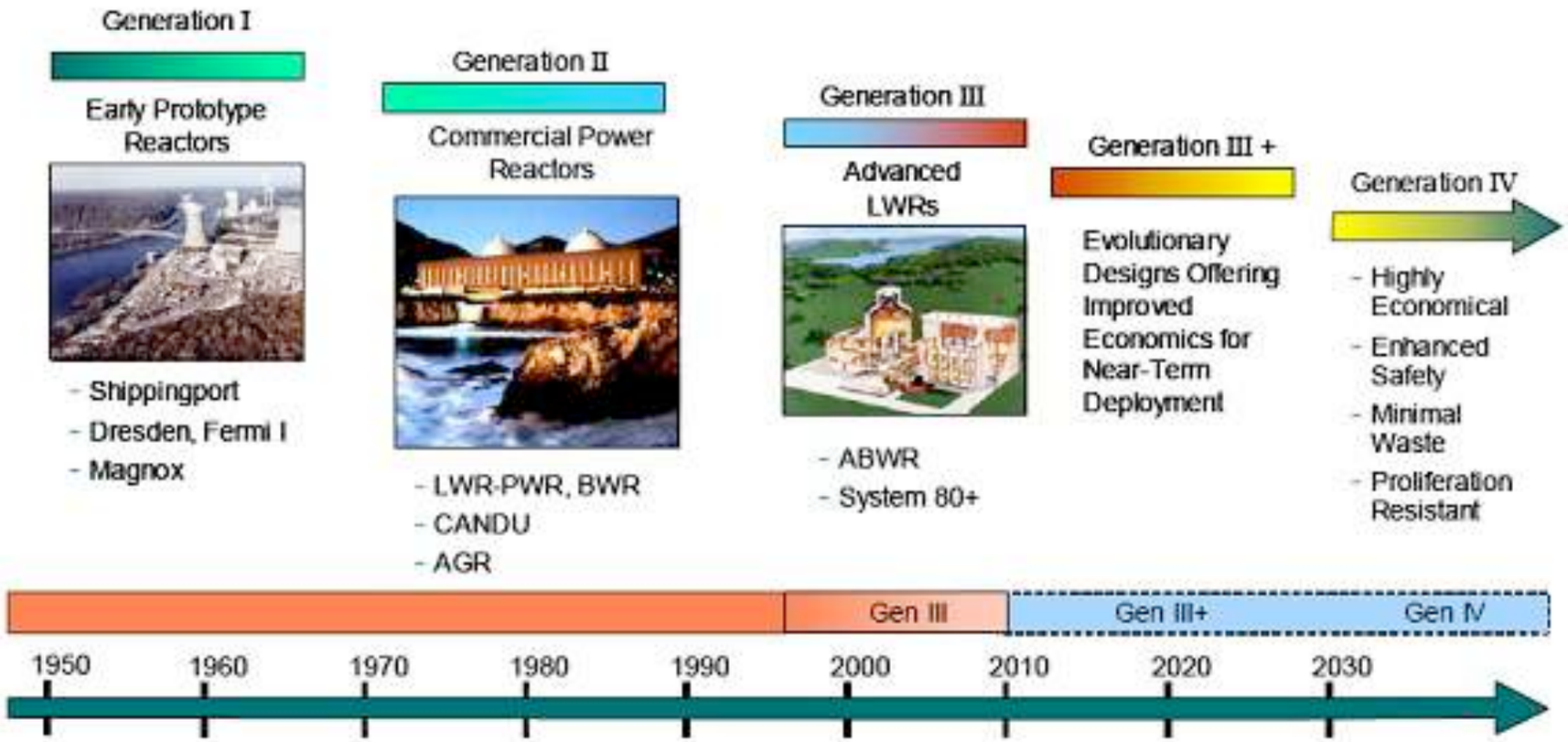


Bombe e vino



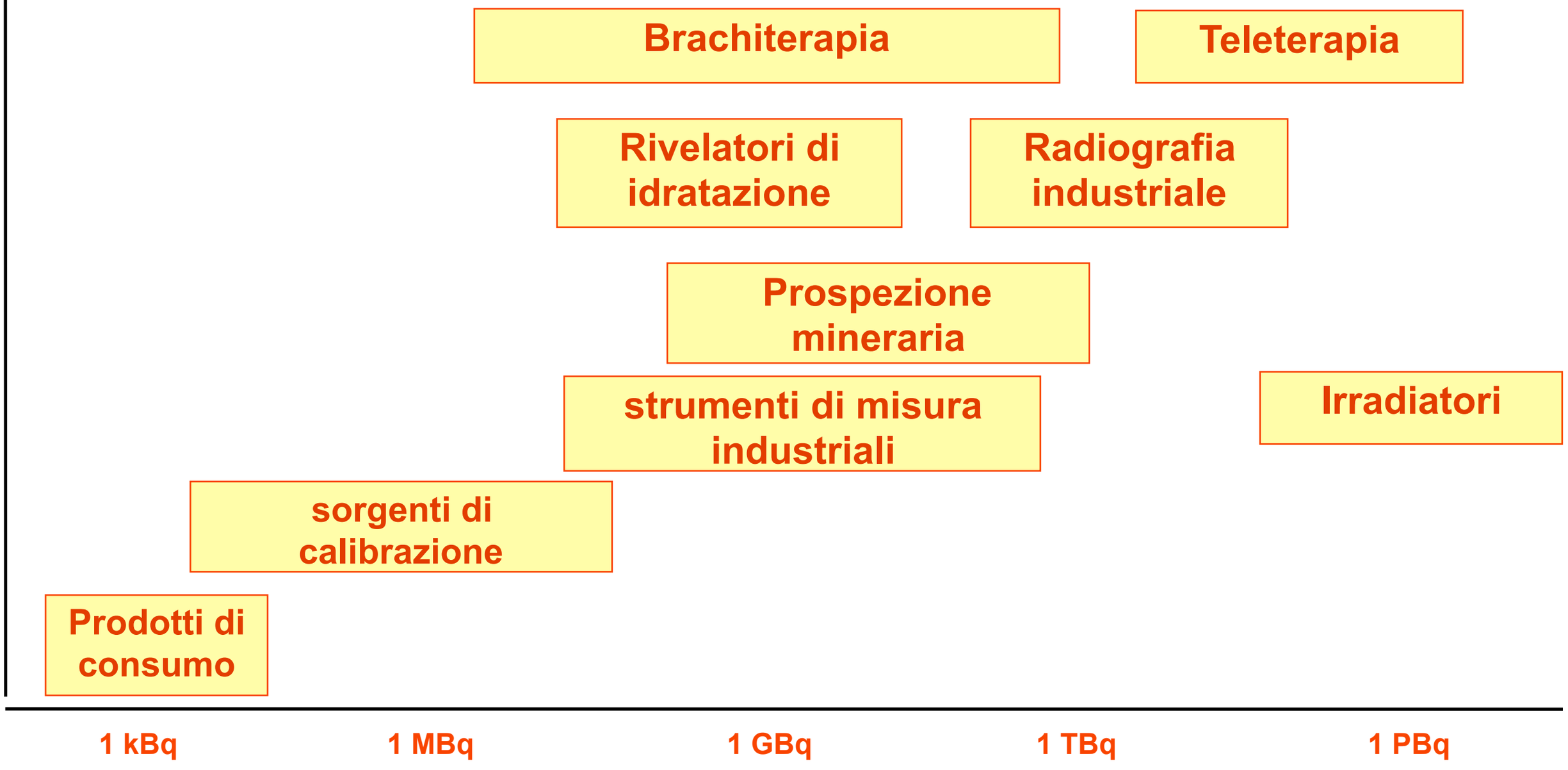
Forensic applications of 14C bomb-pulse dating
U Zoppi, … C Tuniz, … Nucl Instr. Meth. 2004

Energia nucleare



A Technology Roadmap for Generation IV Nuclear Energy Systems

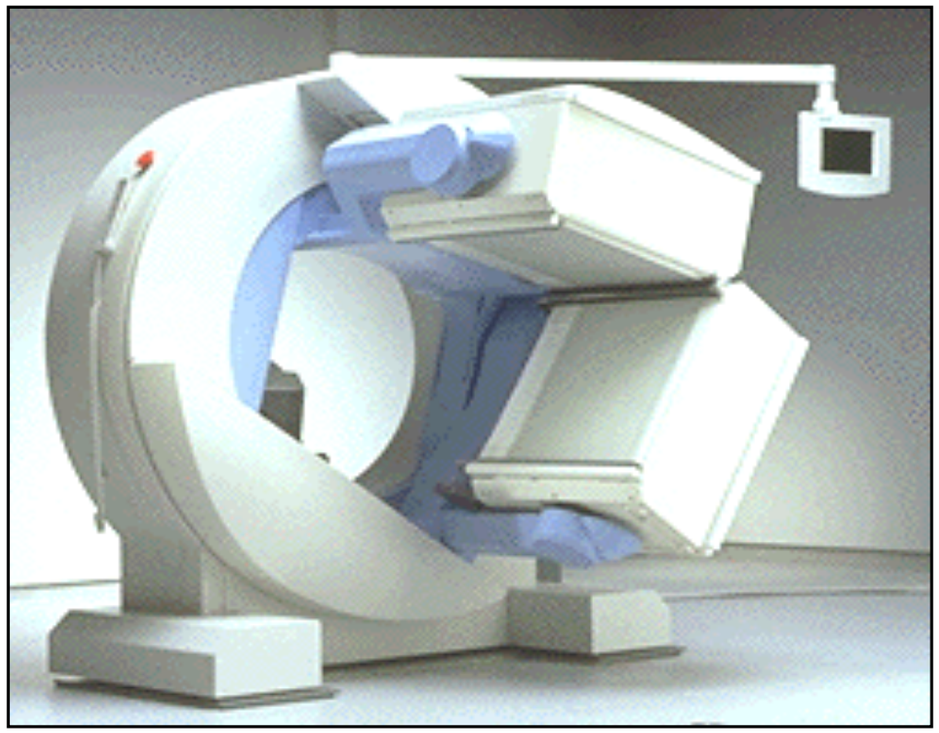
Radioattività per mille usi

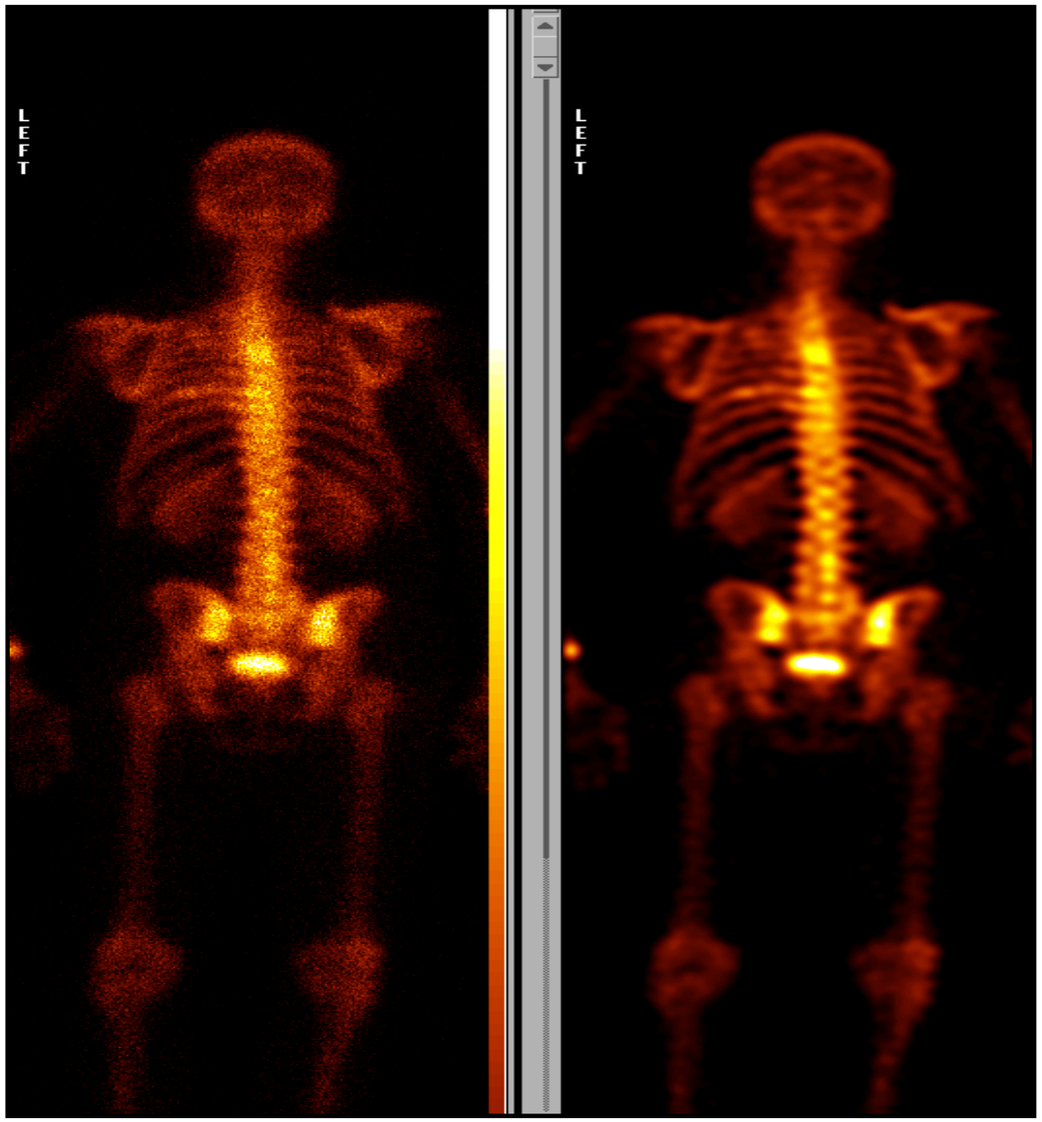


Medicina: terapia

Medicina: diagnostica

Gamma Camera





Biomedicina

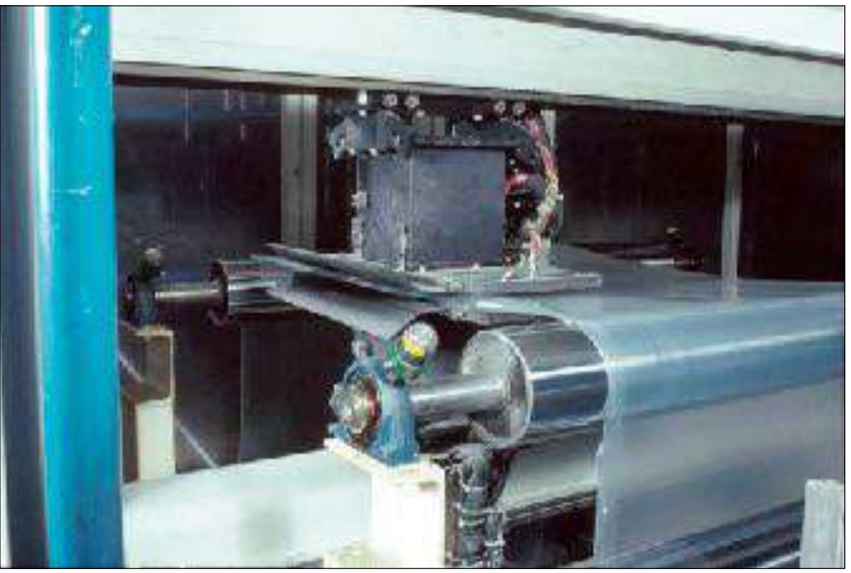
Somministrazione ai ratti, tramite sonda gastrica, di acqua con 100 nanogrammi 26Al (700 kyr). L'analisi dell'AMS dei campioni di cervello mostra che con una singola esposizione sono entrate tracce di 26Al direttamente nel tessuto cerebrale, con frazioni da 30 a 300 ppb della dose di input

*(**Neurotoxicology,** Walton, Tuniz, Fink, Jacobsen, Wilcox, 1995)*

Industria

Paper, plastic and glass thickness	**Pm-147, Sr-90, Tl-204 (beta)**
Metallic layer thickness	**Am-241, Cs-137, Co-60**
Liquid density	**Cs-137**
Liquid level	**Cs-137, Co-60**
Soil density	**Cs-137**
Soil moisture	**^{241}Am-Be, Cf-252 (neutrons)**
Ash coal concentration (on-line)	**^{137}Cs + ^{241}Am**
Prompt Gamma Neutron Activation Analysis	**Cf-252 (neutrons)**
Borehole logging	**Cs-137, Cf-252, ^{241}Am-Be**
Gamma tomography	**Cs-136, Am-241, Cd-109**
NDT	**Ir-192, Co-60, Cs-137**
X-ray fluorescence	**Fe-55, Cd-109, Am-241**

Transmission gauging



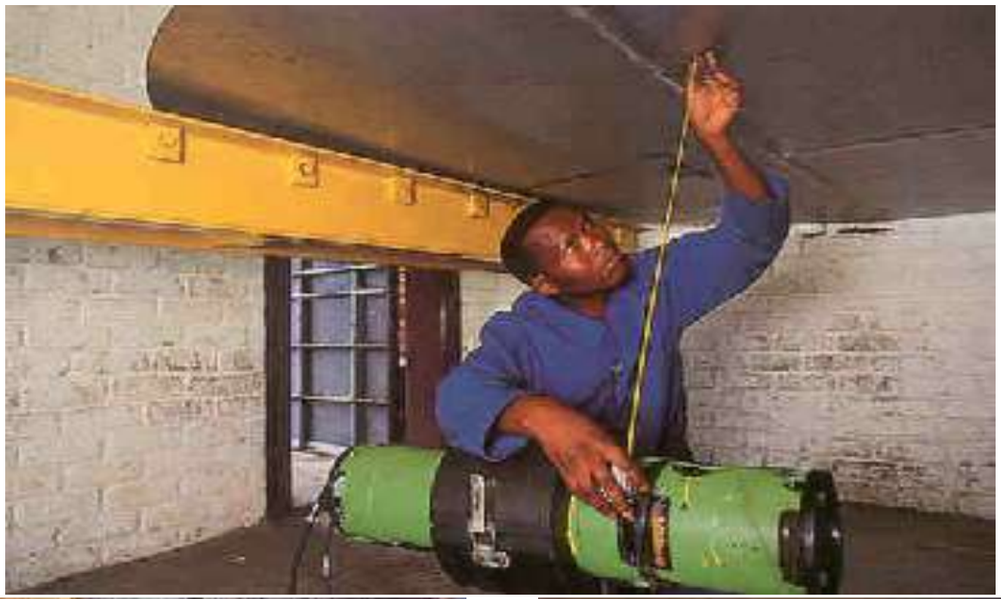
Thallium-204, $T_{1/2}$=3.77 years,
Beta particles– 763 keV.

Level Gauges in Use

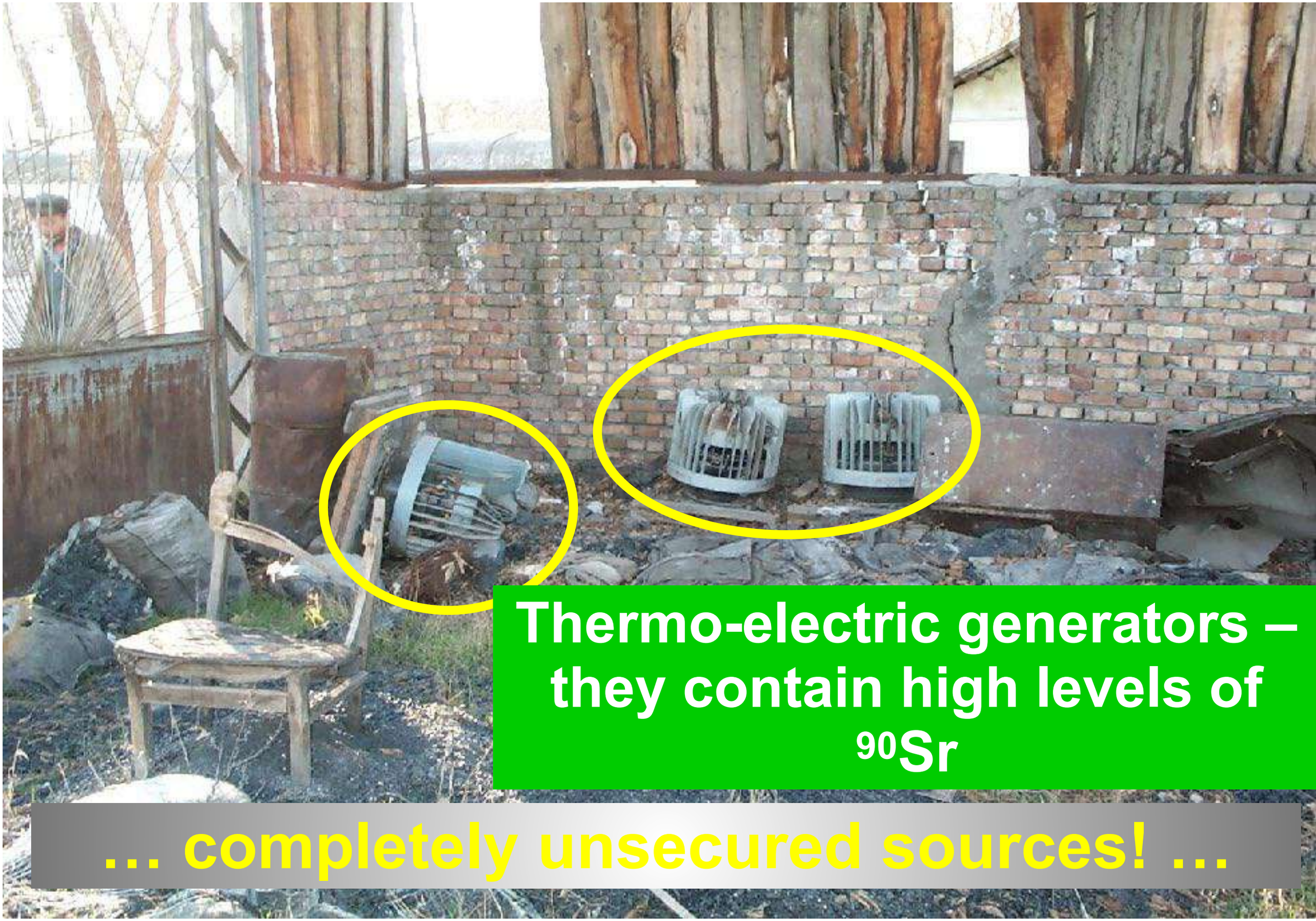
Non-Destructive Testing (NDT)

Inspection of metal and concrete structures

Iridium-192 sealed source



Mobile caesium irradiators in the former Soviet Union containing caesium-137


Thermo-electric generators – they contain high levels of ^{90}Sr
... completely unsecured sources! ...

The Abdus Salam
International Centre
for Theoretical Physics

Joint ICTP-IAEA 2019 International School on Nuclear Security

25 March - 5 April 2019, Miramare - Trieste, Italy

Terrorismo nucleare

- **Furto di un'arma nucleare**
- **Furto di materiale nucleare per la costruzione di un ordigno nucleare improvvisato**

- **Furto di altro material radioattivo per la costruzione di 'bombe sporche'**

- **sabotaggio di materiale e infrastruttura nucleare**

bersagli del terrorismo nucleare

> 25.000 armi nucleari

> 3.000 tonnnellate di uranio altamente arricchito (HEU) e plutonio

> 480 reattori per la ricerca (>100 with HEU)

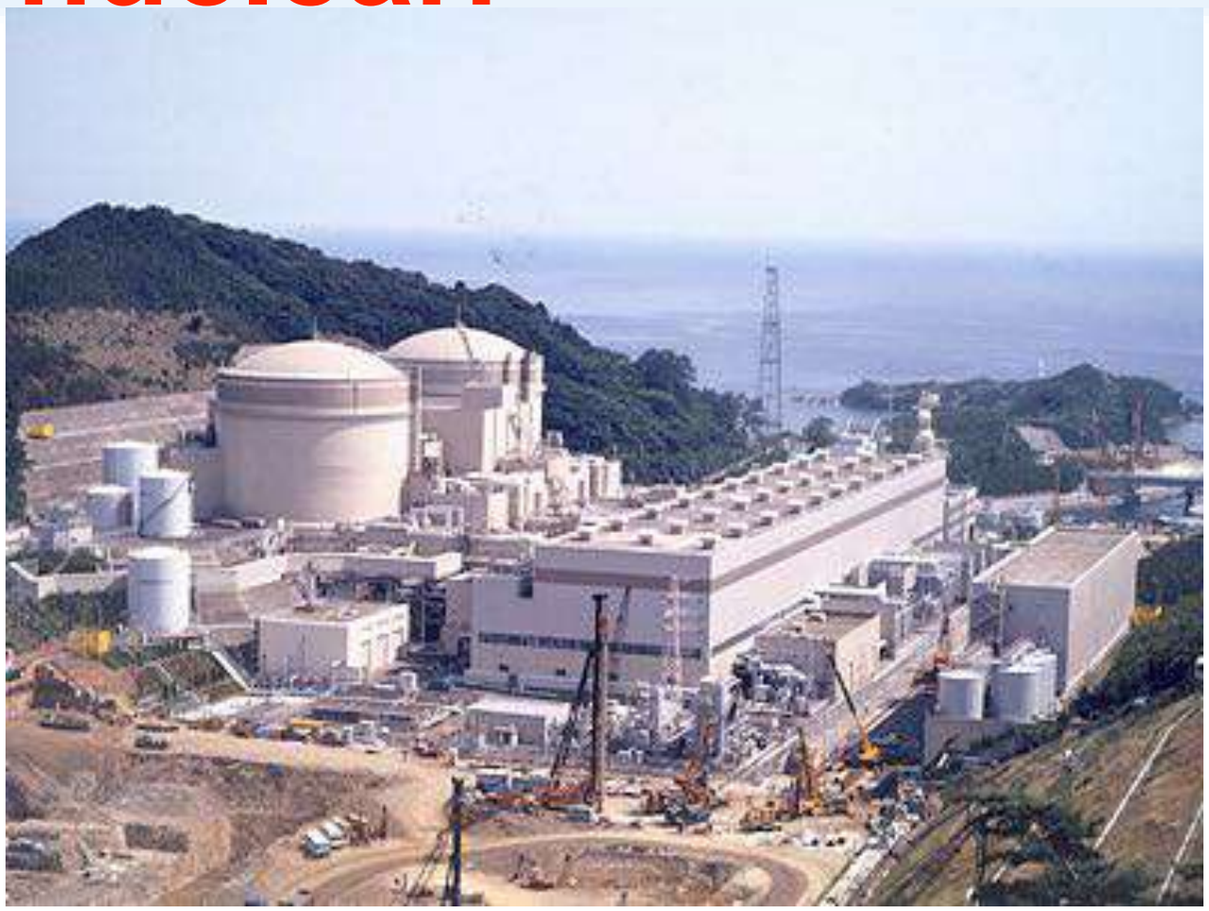
> 100 centri trattamento combustibile nucleare

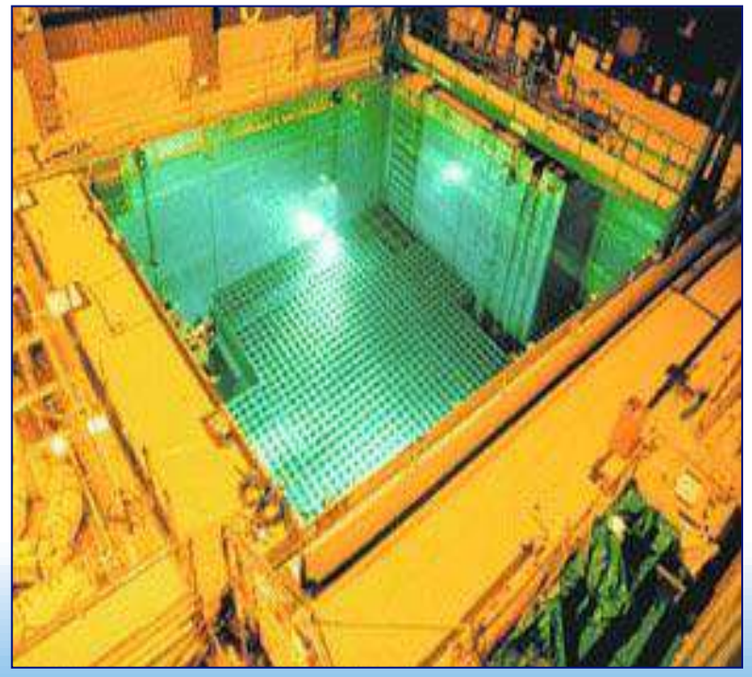
> 440 reattori nucleari di potenza

> 100.000 sorgenti radioattive di Categoria I e II

> 1.000.000 sorgenti radioattive di Categoria III

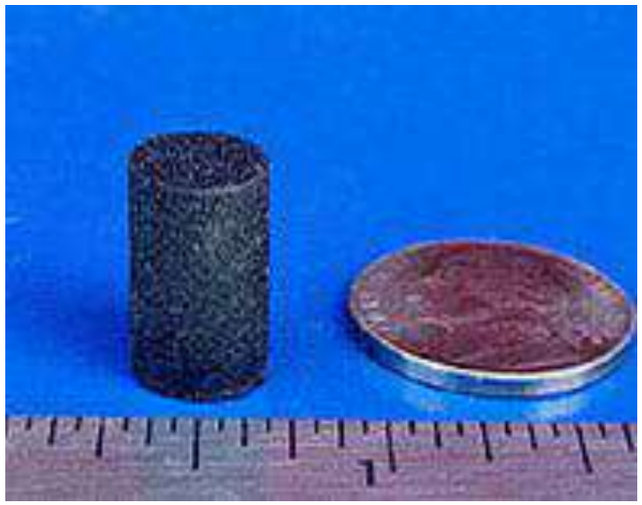
Centrali nucleari





ecco il materiale

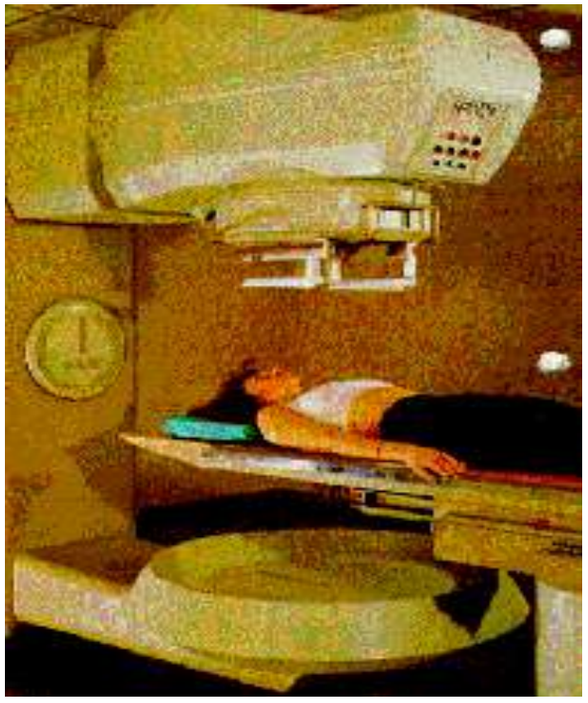
materiale nucleare (uranio, plutonio e torio) in diverse forme



sorgenti radioattive

materiali contaminati

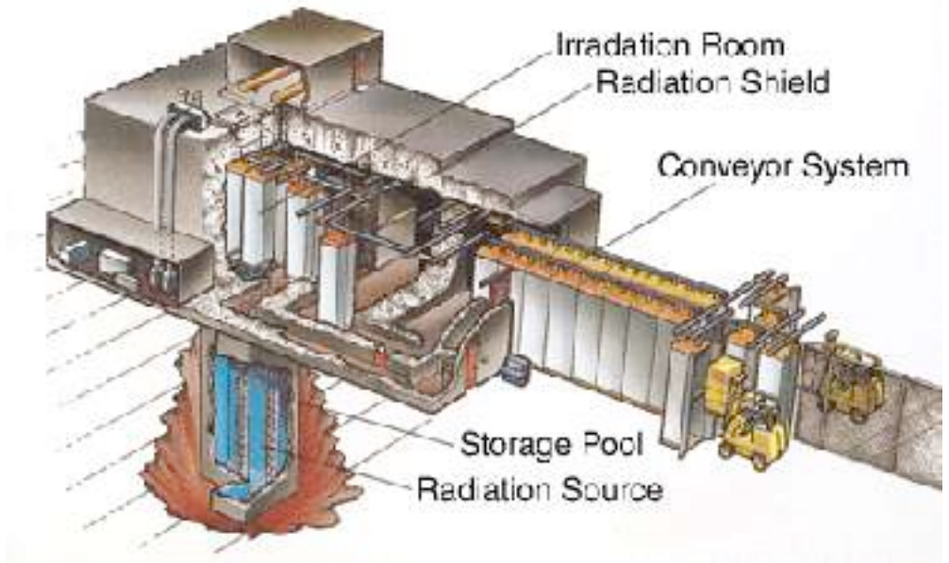
applicazioni della radioattività



Co-60 < 500 TBq Cs-137 < 50 TBq

Medicina

Industria



Co-60 < 500,000 TBq Cs-137 < 200,000 TBq

Agricoltura

Ricerca

Reattori di ricerca

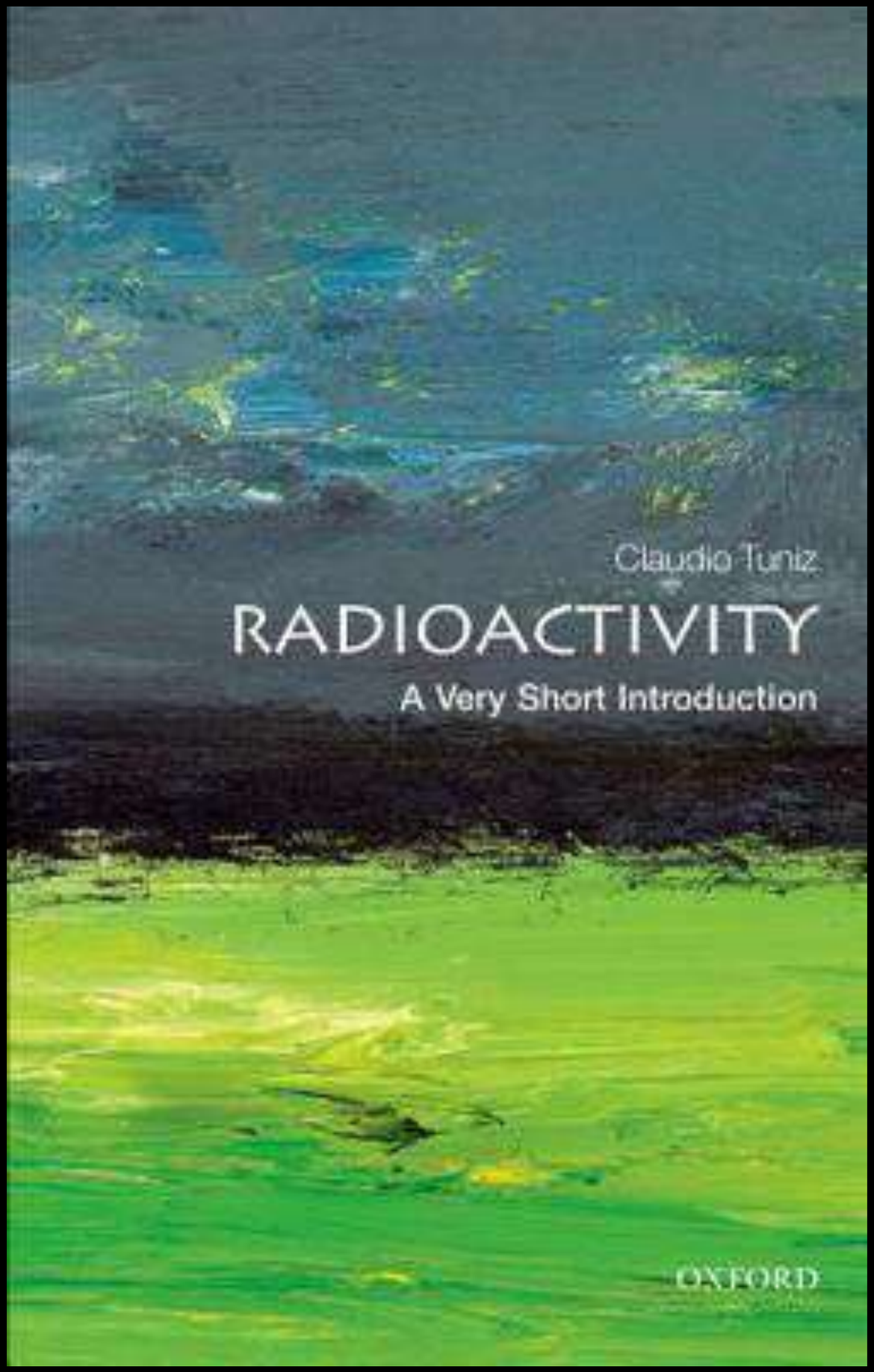
Varie

Ex-USSR 2002

Irradiatori
3500 Curies Cs-137

RTG
Fari URSS
400.000 Ci
Sr-90

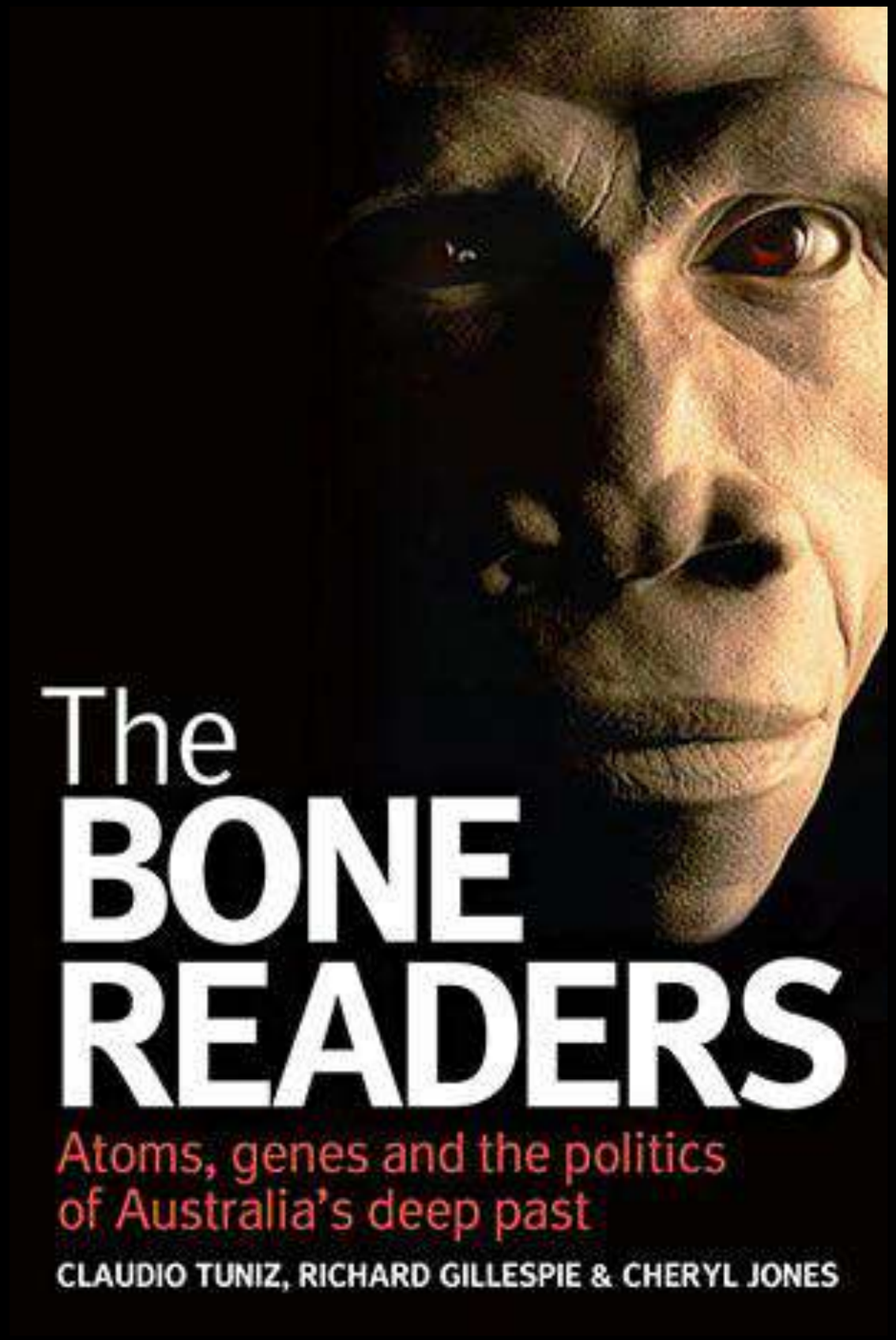

Carocci editore
Città della scienza
L'atomo inquieto
Breve storia della radioattività e delle sue applicazioni
Claudio Tuniz


Claudio Tuniz
RADIOACTIVITY
A Very Short Introduction
OXFORD

Claudio Tuniz
John R. Bird
David Fink
Gregory F. Herzog

ACCELERATOR MASS SPECTROMETRY

Ultrasensitive Analysis for Global Science



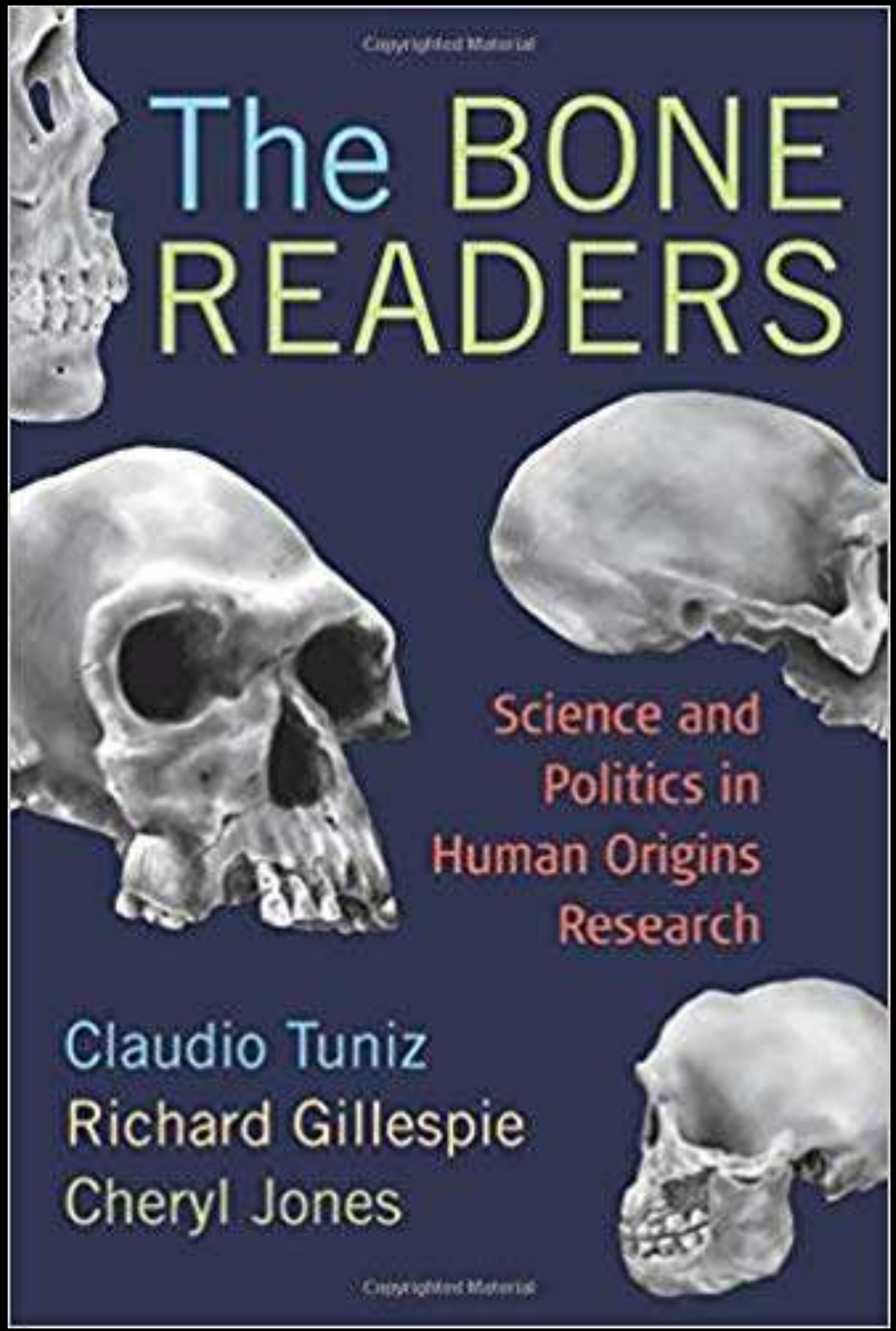
The BONE READERS

Atoms, genes and the politics of Australia's deep past

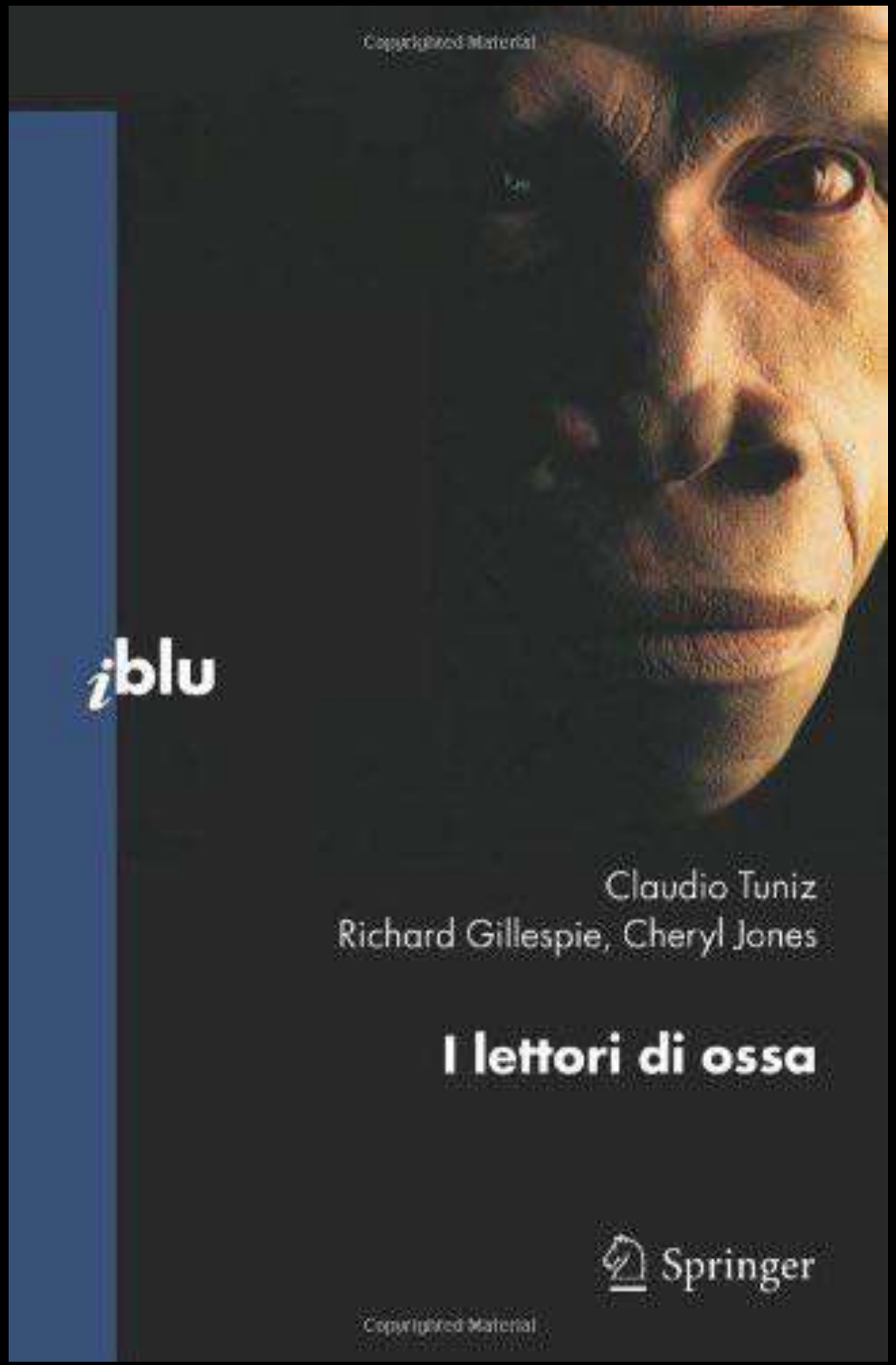
CLAUDIO TUNIZ, RICHARD GILLESPIE & CHERYL JONES

The BONE READERS

Science and Politics in Human Origins Research



Claudio Tuniz
Richard Gillespie
Cheryl Jones



iblu

Claudio Tuniz
Richard Gillespie, Cheryl Jones

I lettori di ossa

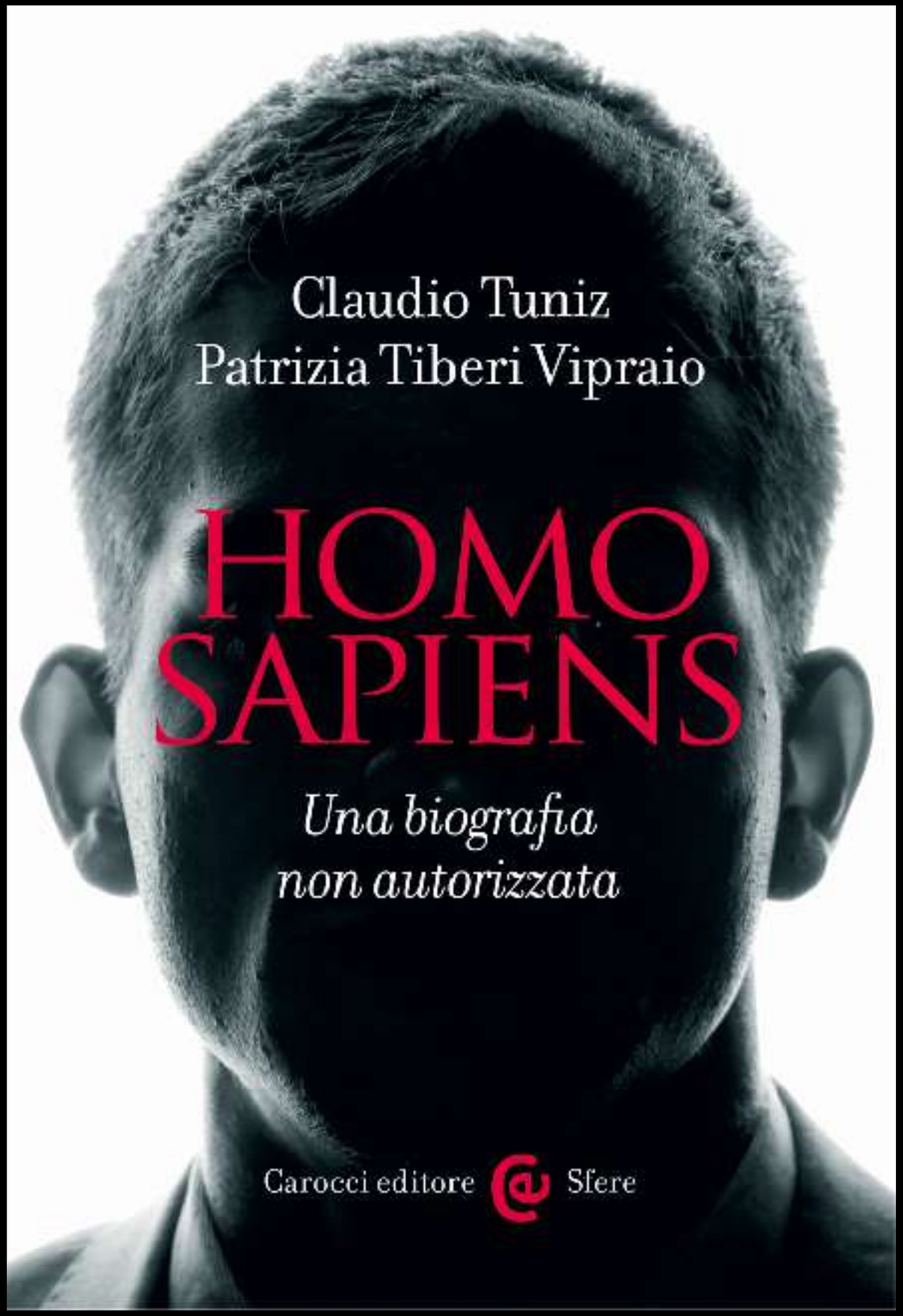
Springer

Claudio Tuniz
Patrizia Tiberi Vipraio

HUMANS

An Unauthorized Biography

Springer


Claudio Tuniz
Patrizia Tiberi Vipraio
HOMO SAPIENS
Una biografia non autorizzata
Carocci editore
Sfere

Claudio Tuniz | Patrizia Tiberi Vipraio

Dalle tribù di primati all'intelligenza artificiale

LA SCIMMIA VESTITA

Carocci editore Sfere