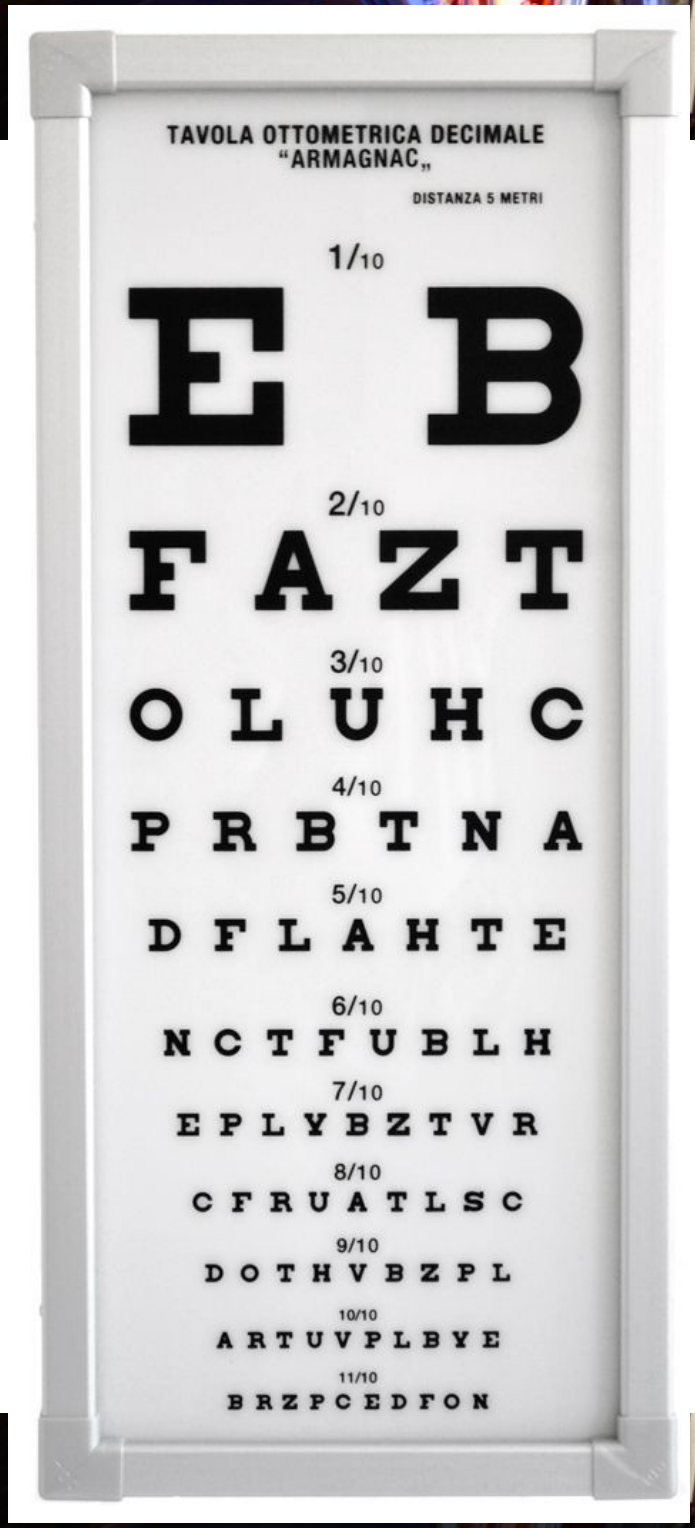
Antimateria

Simone Stracka
simone.stracka@cern.ch

INFN
PISA
Istituto Nazionale di Fisica Nucleare
Sezione di Pisa

- Prima di iniziare: riuscite a leggere la seconda riga?




Bas Armagnac
Marie Duffau
Hors d'Age
Product of France

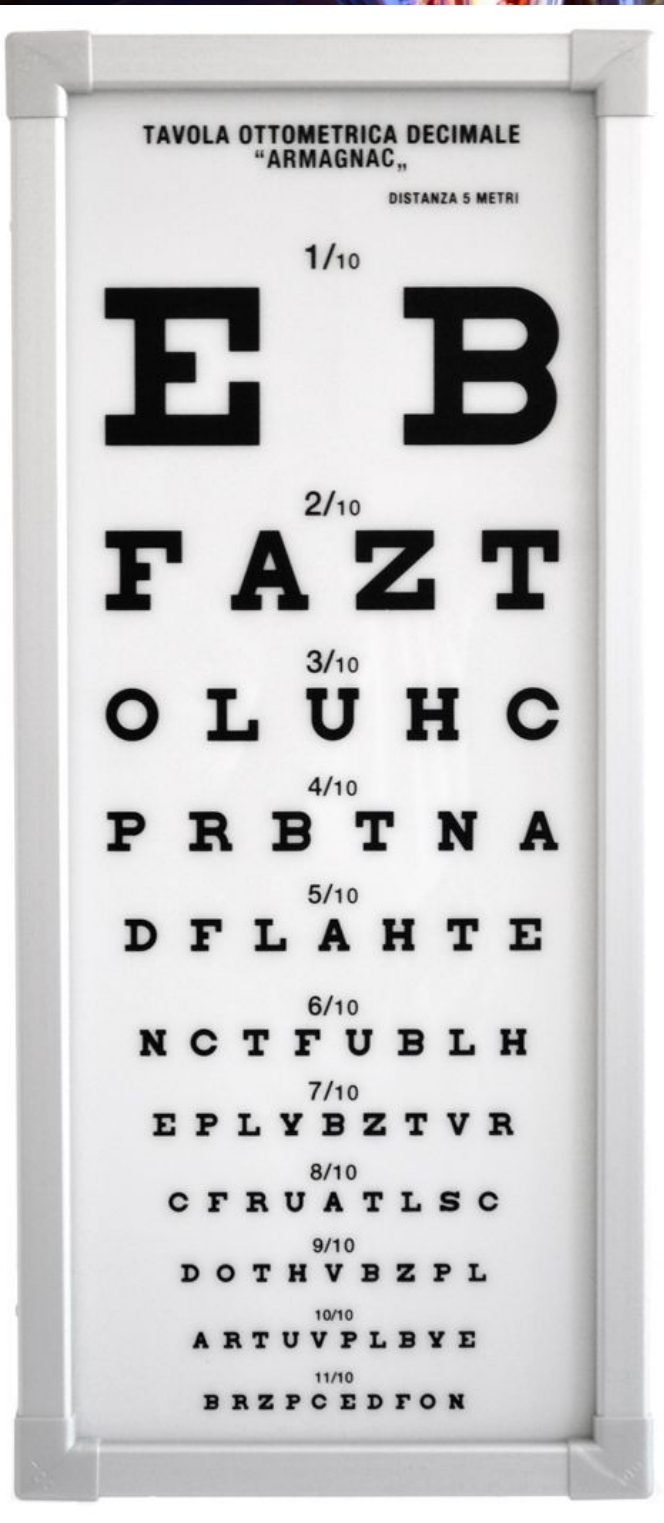
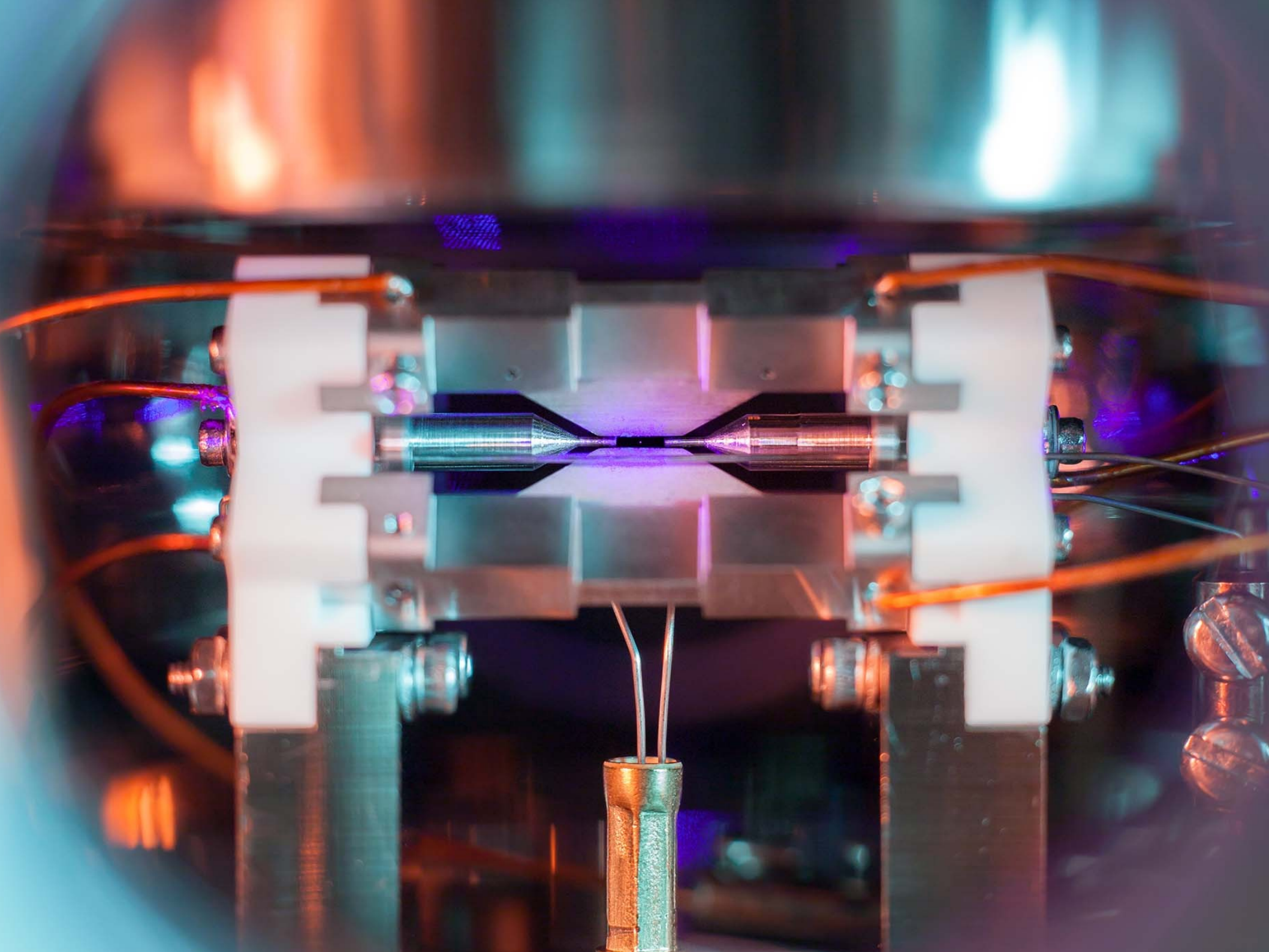
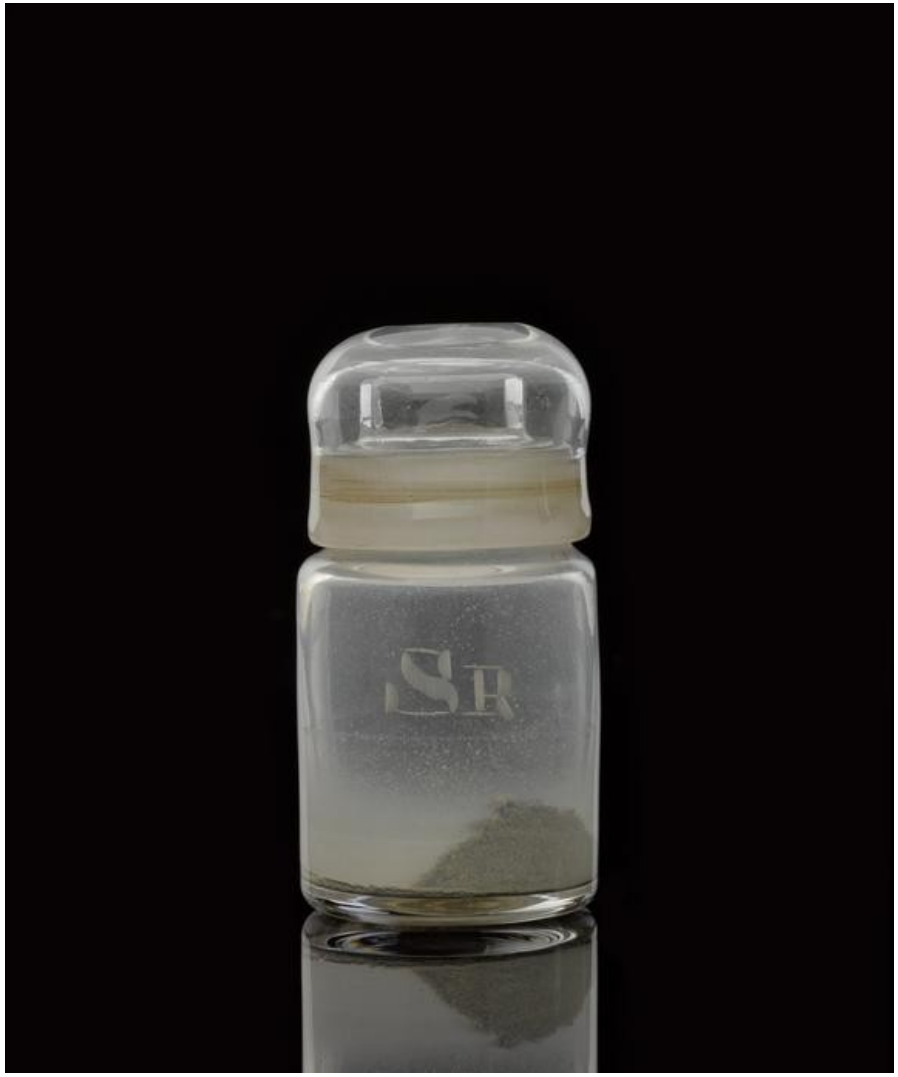


TAVOLA OTTOMETRICA DECIMALE
"ARMAGNAC„
DISTANZA 5 METRI
1/10
E B
2/10
F A Z T
3/10
O L U H C
4/10
P R B T N A
5/10
D F L A H T E
6/10
N C T F U B L H
7/10
E P L Y B Z T V R
8/10
C F R U A T L S C
9/10
D O T H V B Z P L
10/10
A R T U V P L B Y E
11/10
B R Z P C E D F O N



Stronzio

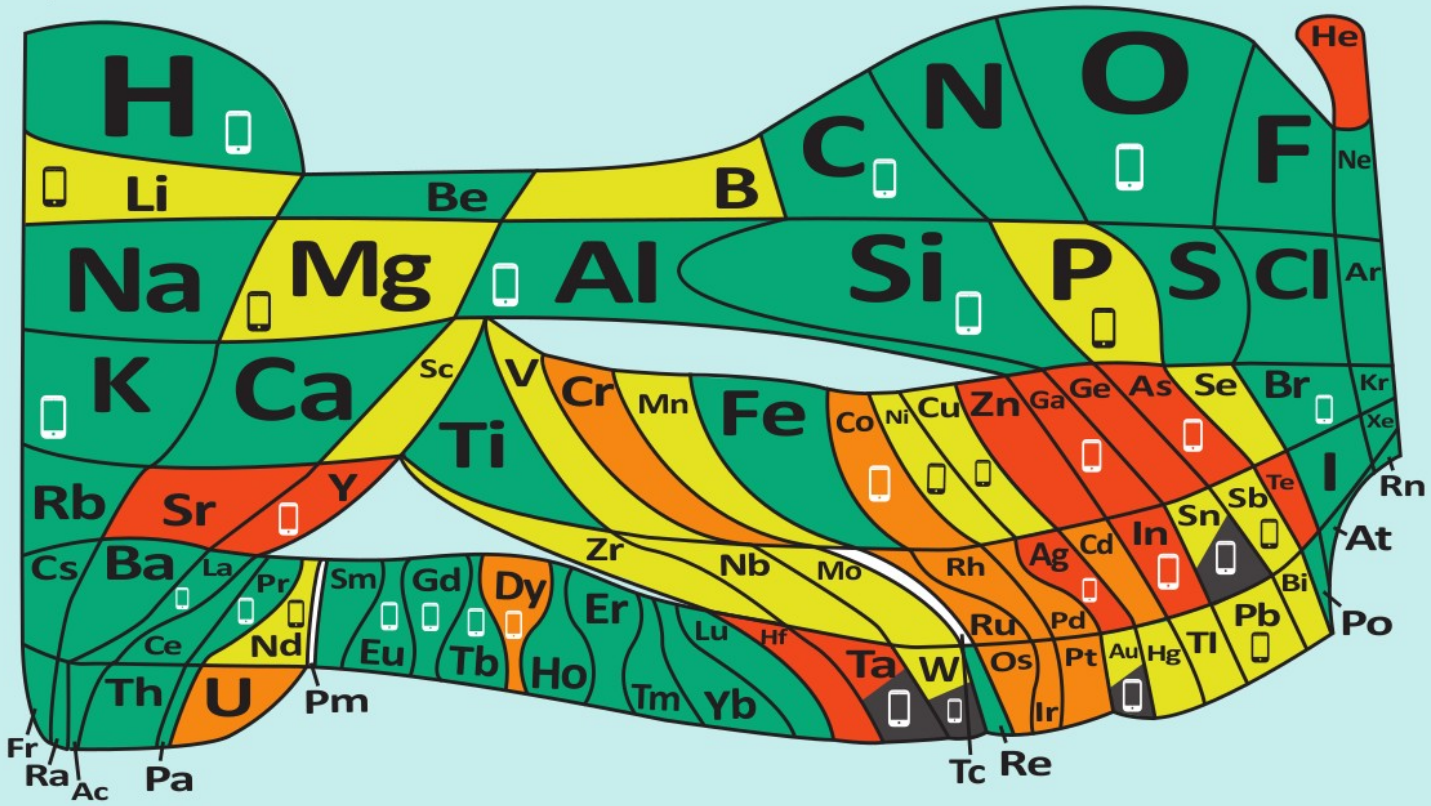


United Nations Educational, Scientific and Cultural Organization

2019 IYPT International Year of the Periodic Table of Chemical Elements

90 elementi chimici e la loro disponibilità relativa sulla Terra

Ci basteranno?



A grave rischio entro 100 anni

Sempre più a rischio per il crescente utilizzo

Disponibilità limitata, a rischio in futuro

Piena disponibilità

Di sintesi

Provenienti da minerali in zone di conflitto

Presenti negli smartphone

Scopri di più e divertiti con il videogioco su **http://bit.ly/euchems-pt**

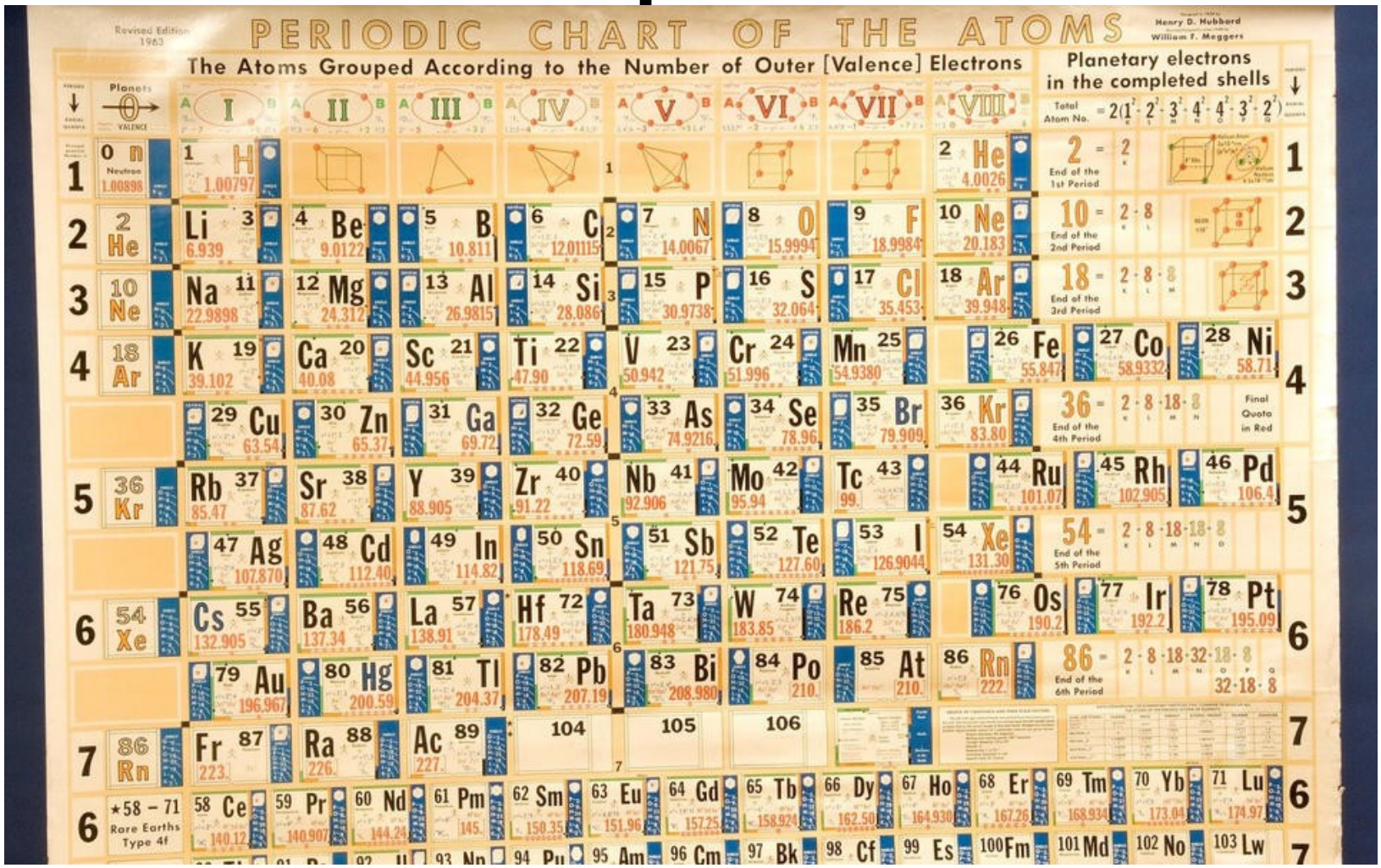
EuChemS European Chemical Society

Ispirato a WF Sheehan's 'A Periodic Table with Emphasis', pubblicato in Chemistry, 1976, 49, 17-18

но въ ней, мнѣ кажется, уже ясно выражается примѣнимость выставляемаго мною начала ко всей совокупности элементовъ, пай которыхъ извѣстенъ съ достовѣрностію. На этотъ разъ я и желалъ преимущественно найдти общую систему элементовъ. Вотъ этотъ опытъ:

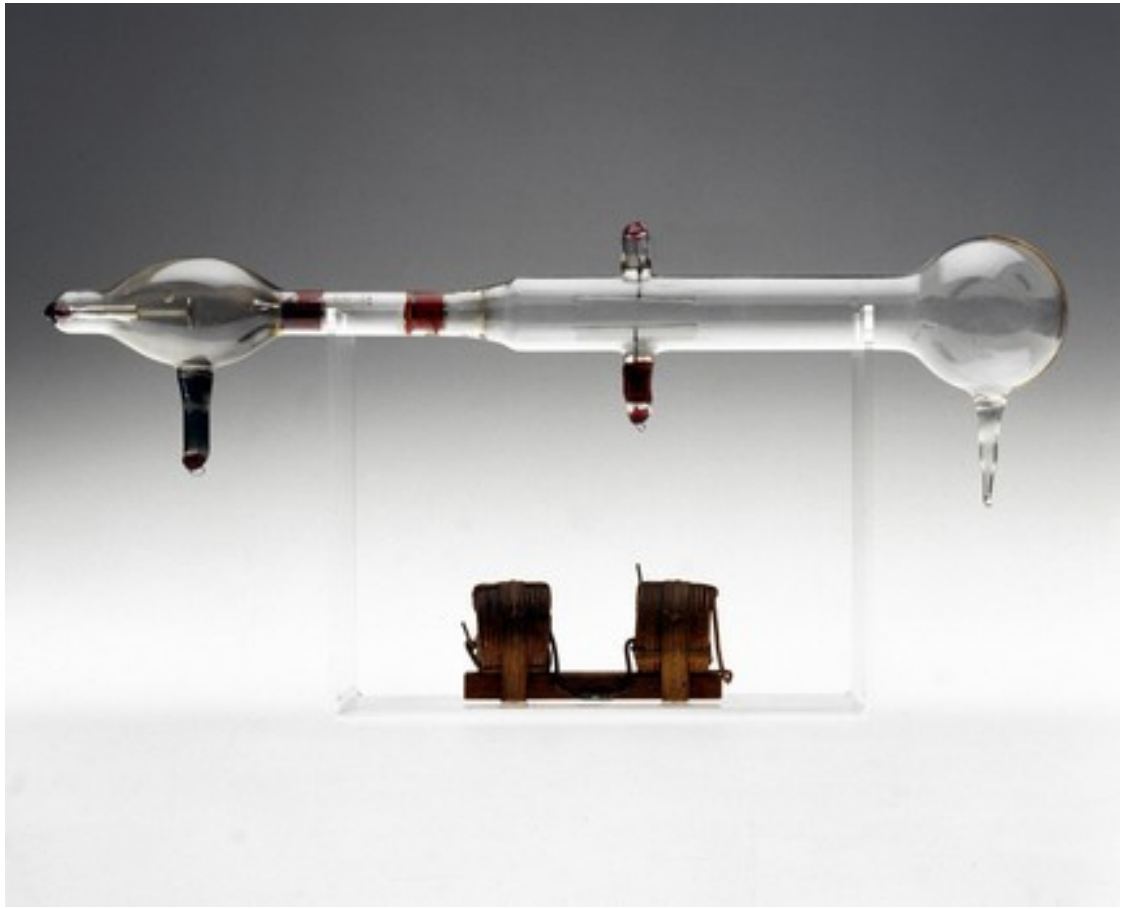
		Ti=50	Zr=90	?=180.
		V=51	Nb=94	Ta=182.
		Cr=52	Mo=96	W=186.
		Mn=55	Rh=104,4	Pt=197,4
		Fe=56	Ru=104,4	Ir=198.
		Ni=Co=59	Pl=106,6	Os=199.
H=1		Cu=63,4	Ag=108	Hg=200.
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

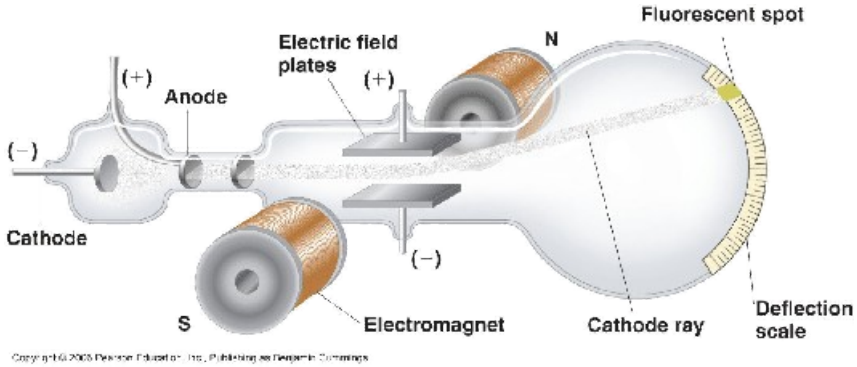
Tavola periodica



https://www.einaudi.it/catalogo-libri/narrativa-italiana/narrativa-italiana-del-novecento/il-sistema-periodico-primo-levi-9788806219505/

La scoperta dell'elettrone





J. J. Thomson, 1897

https://www.tsfx.edu.au/resources/47039.pdf

https://history.aip.org/history/exhibits/electron/

https://www.pbs.org/transistor/science/events/electron.html

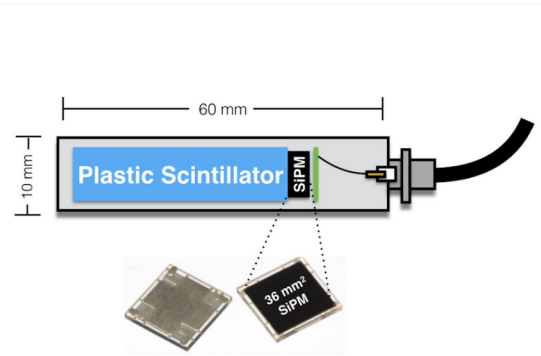
"To the electron -- may it never be of any use to anybody"

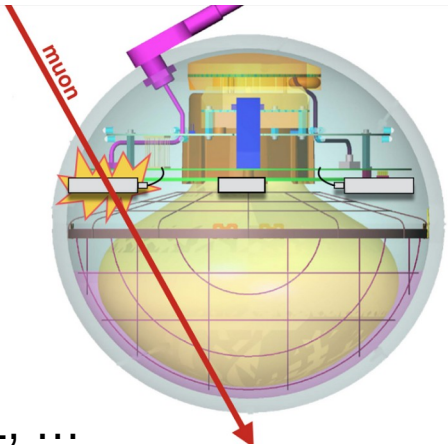
Rivelatori

“Excuse me... how can you discover a particle so small that nobody has ever seen one?”

ArduSiPM

Low cost Cosmic ray and Nuclear Radiation Detector



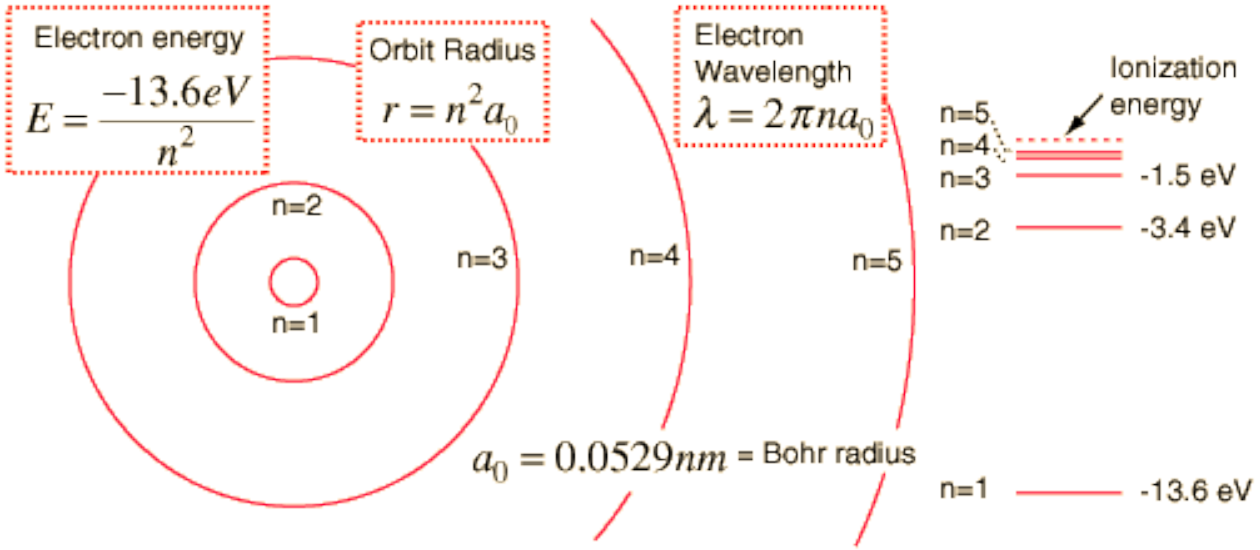


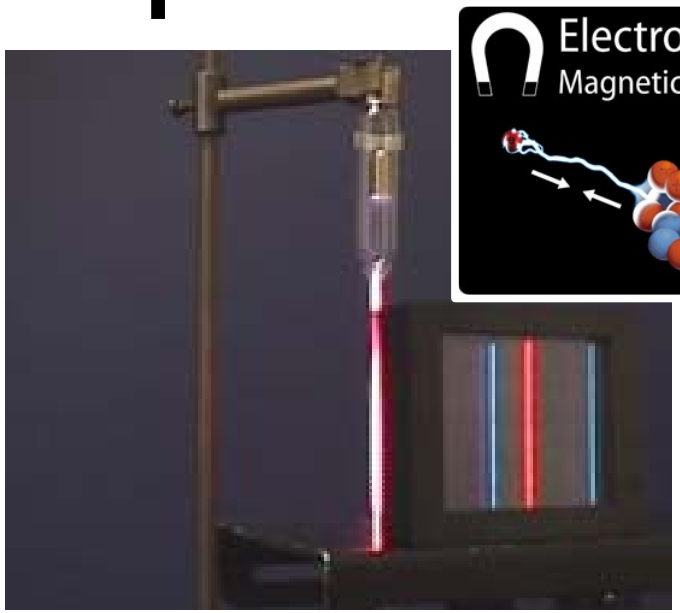
Sensori: AdvanSiD, SensL, …
Scintillatori: Bicron, Eljen, ...

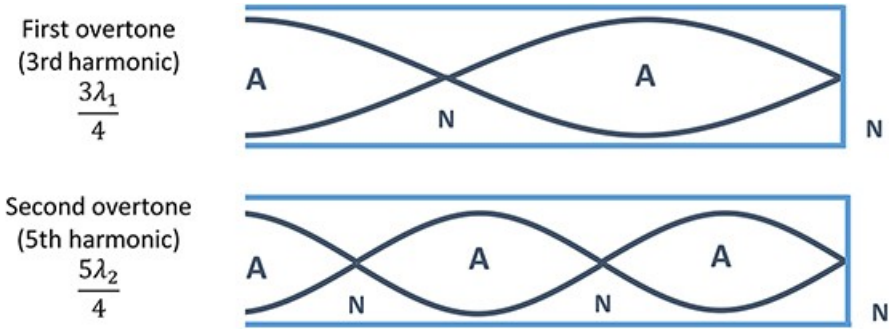
http://www.cosmicwatch.lns.mit.edu/detector

http://edu.lnf.infn.it/wp-content/uploads/2018/02/2018_02_14-ArduSiPM-INSPYRE-2018.compressed.pdf
https://arxiv.org/pdf/1506.01915.pdf

Varie scoperte dopo ...







https://doi.org/10.1088/978-1-6817-4469-8

Orologi, calcolatori

NIST
National Institute of Standards and Technology
Physical Meas. Laboratory

Basic Atomic Spectroscopic

Strontium (Sr)

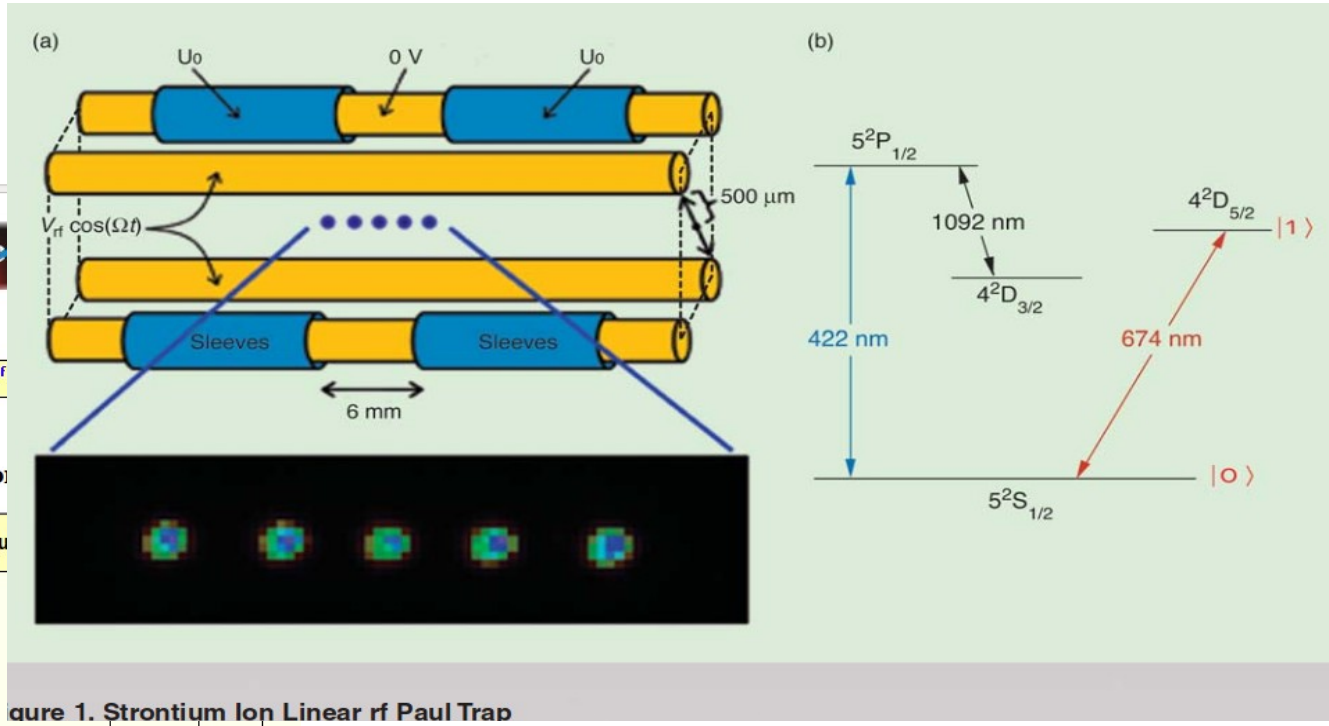
Other Elements | Neutral Atom | Singly Ionized

Main Page | Finding List | Element Name | Atomic Number | Periodic Table | Atomic Data | Strong Lines | Persistent Lines | Energy Levels | Persistent Lines | Energy Levels | Ref

Switch to ASCII Version

Persistent Lines of Singly Ionized Stro

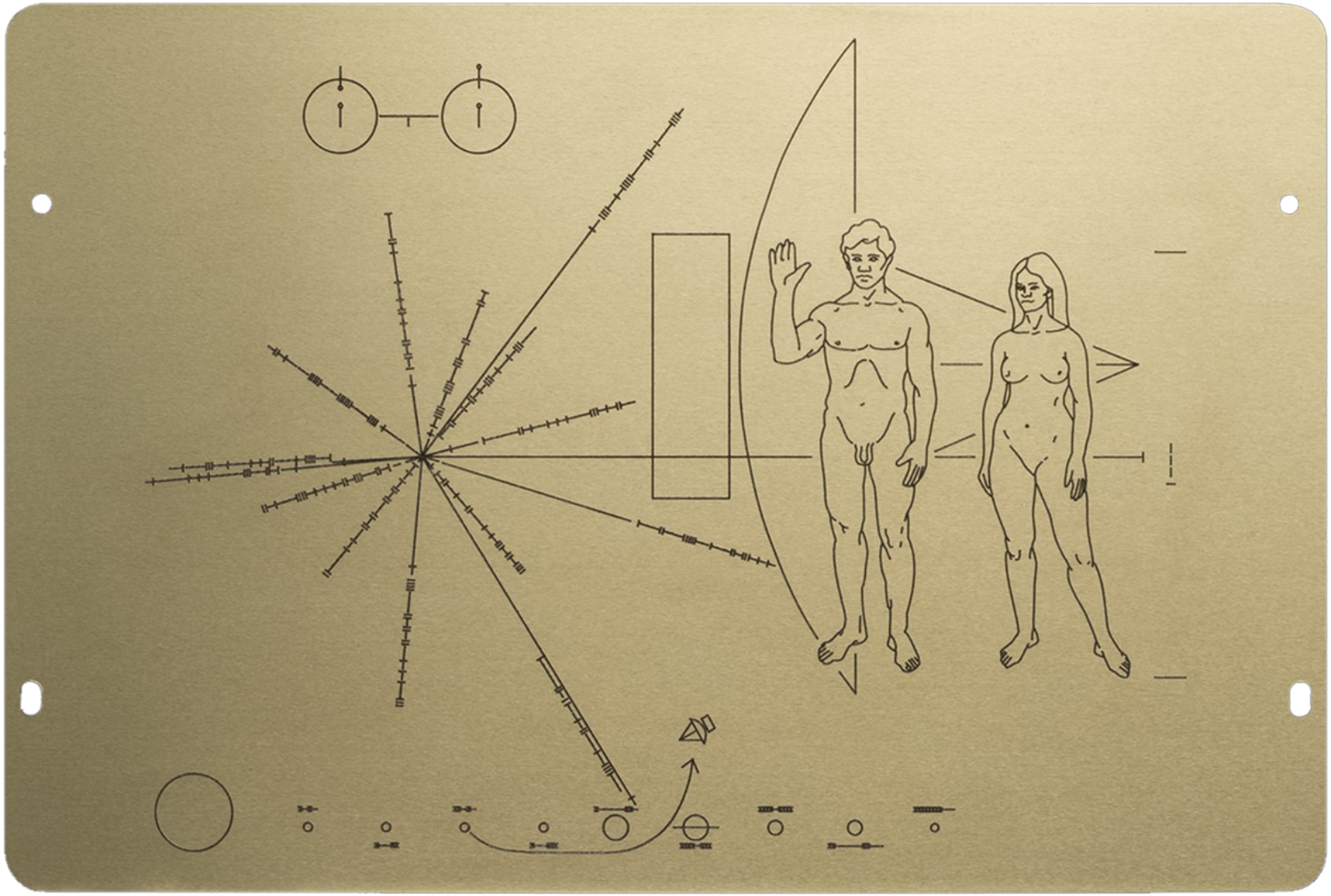
Intensity	Wavelength (Å)	A_{ki} ($10^8 s^{-1}$)	Energy Levels (cm^{-1})	Configu			
30	2152.84		14555.90	4*d*	$^2P°$	1/2	MC
			60991.7	4*f*	^2D	3/2	
30	2165.96		14836.24	4*d*	$^2P°$	3/2	MC
			60991.7	4*f*	^2D	5/2	
14	3380.71		23715.19	5*p*	$^2P°$	1/2	MC
			53286.31	5*d*	^2D	3/2	
20	3464.46	3.1	24516.65	5*p*	$^2P°$	3/2	MC
			53372.97	5*d*	^2D	5/2	
1000	4077.71	1.42	0.00	5*s*	^2S	1/2	MC
			24516.65	5*p*	$^2P°$	3/2	
700	4215.52	1.27	0.00	5*s*	^2S	1/2	MC
			23715.19	5*p*	$^2P°$	1/2	
7	4305.45	1.4	24516.65	5*p*	$^2P°$	3/2	MC
			47736.53	6*s*	^2S	1/2	
20	10327.31		14836.24	4*d*	^2D	5/2	S3
			24516.65	5*p*	$^2P°$	3/2	



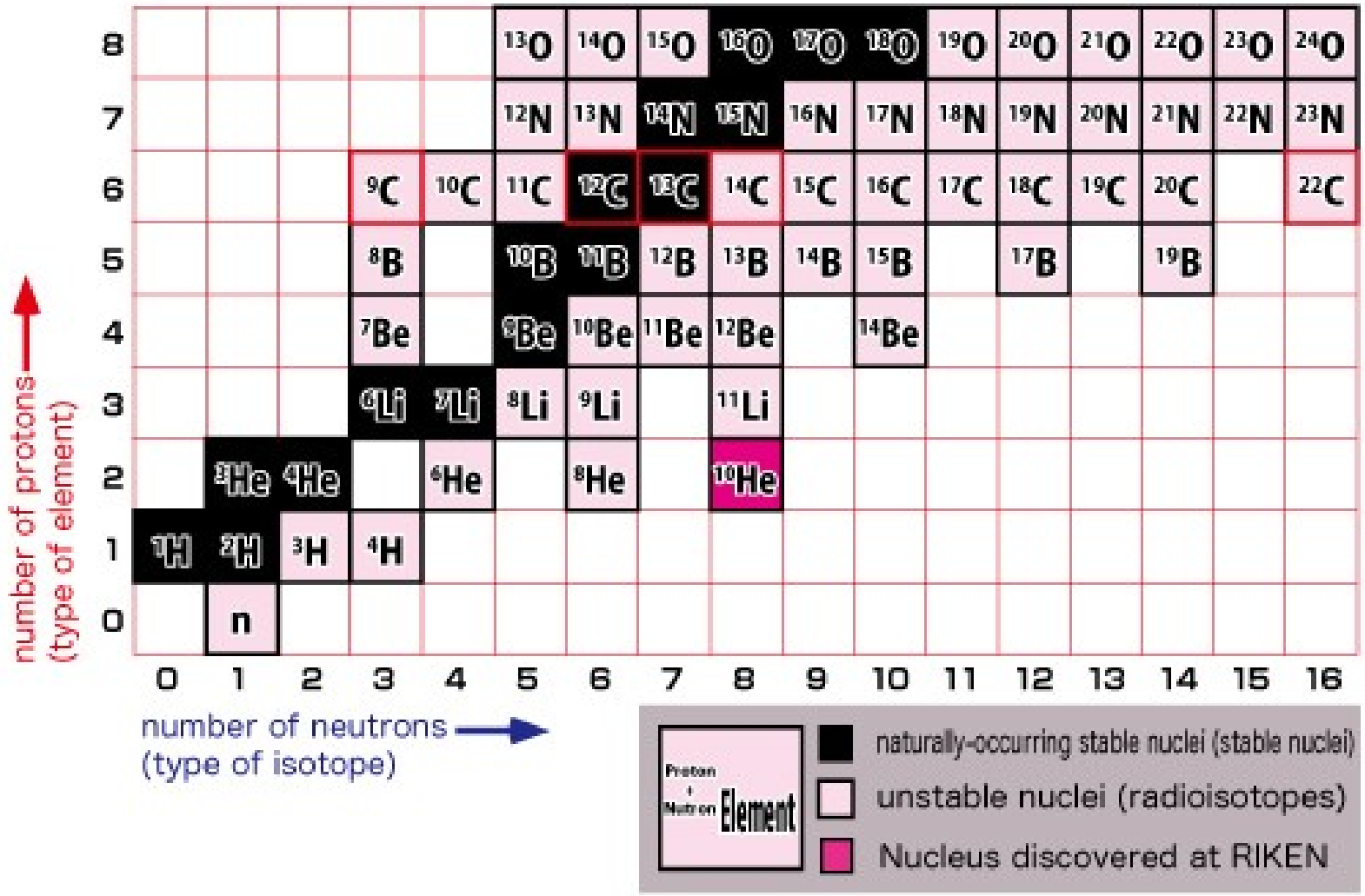
gure 1. Strontium Ion Linear rf Paul Trap

https://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-02-4627

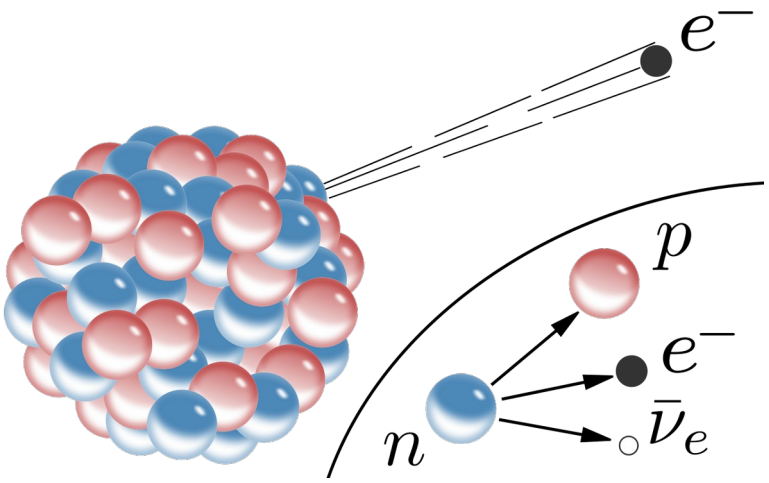
E mappe

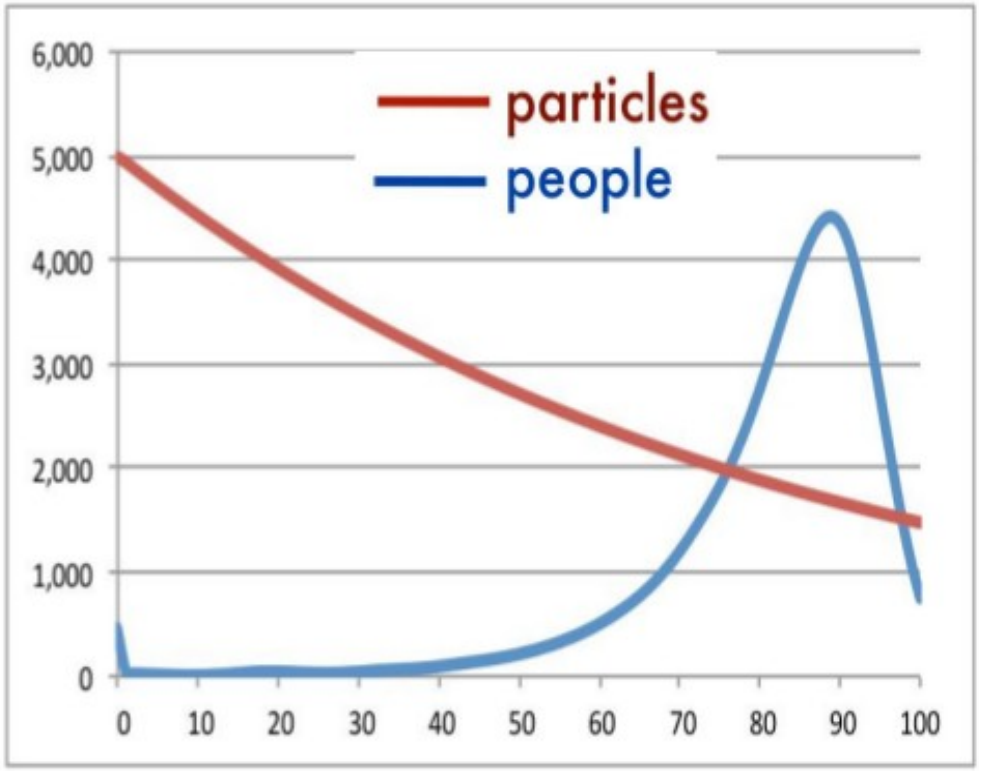


Isotopi

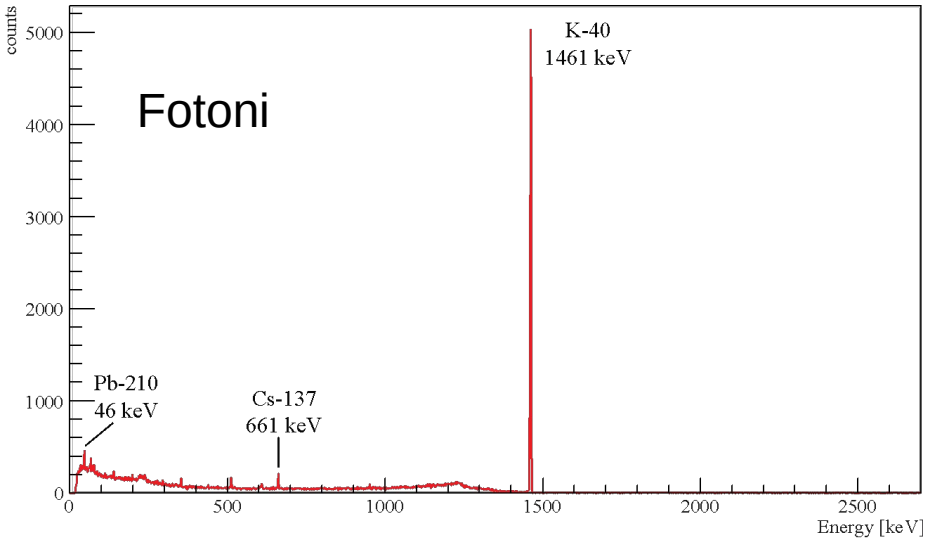

number of protons
(type of element)
number of neutrons
(type of isotope)
Proton + Neutron Element
naturally-occurring stable nuclei (stable nuclei)
unstable nuclei (radioisotopes)
Nucleus discovered at RIKEN

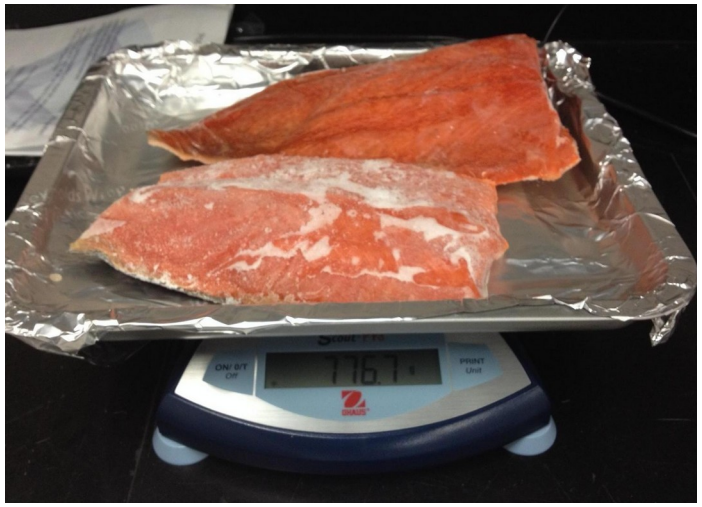
Decadimenti

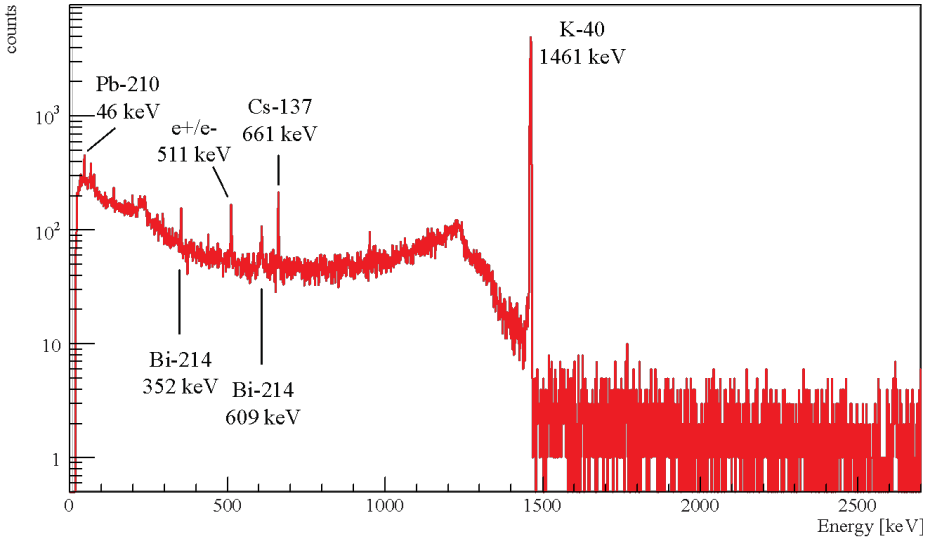


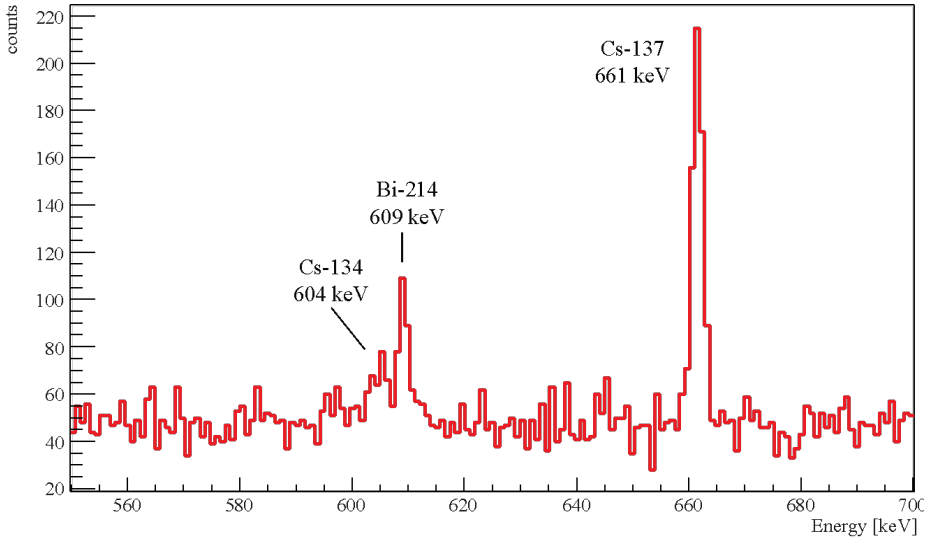


… nel piatto









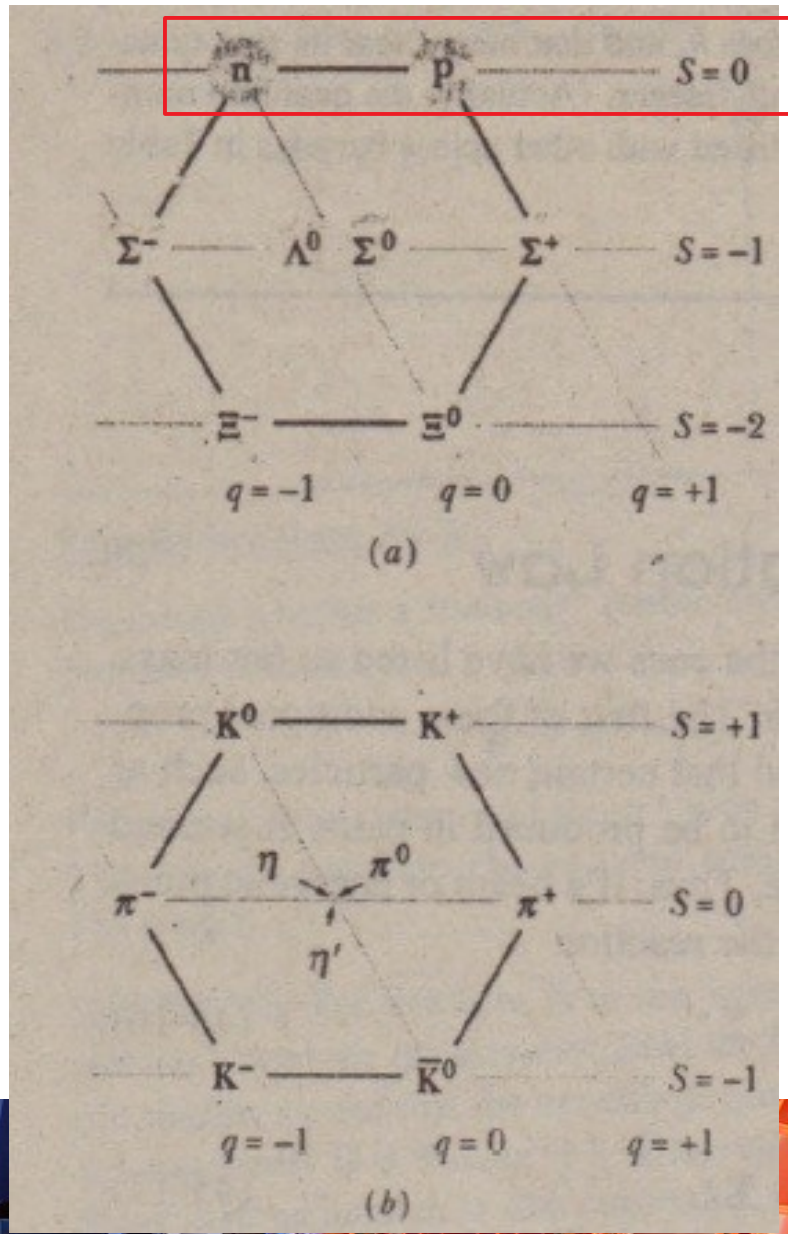
https://radwatch.berkeley.edu/salmon

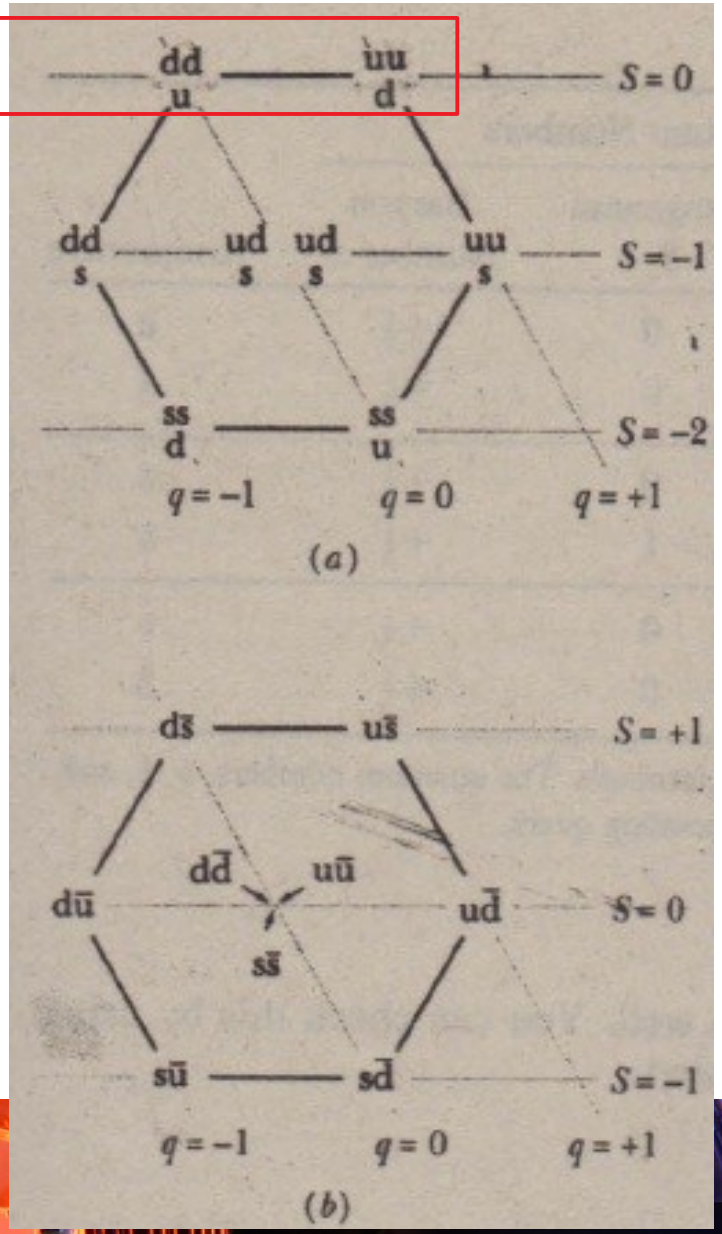
Il neutrone e l'idrogeno

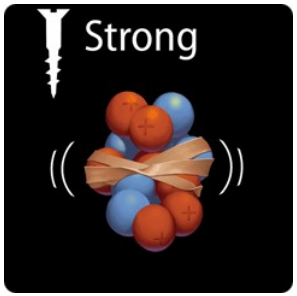
- Facciamo due conti!
  - m(p) = 1.00727647 u
  - m(e) = 0.00054858 u
  - m(n) = 1.00866492 u
  - m(H) = 1.00782503 u

- … e ricordiamo che la massa è una forma di energia
- A cosa è dovuta la differenza di energia?

Fuori e dentro il nucleo

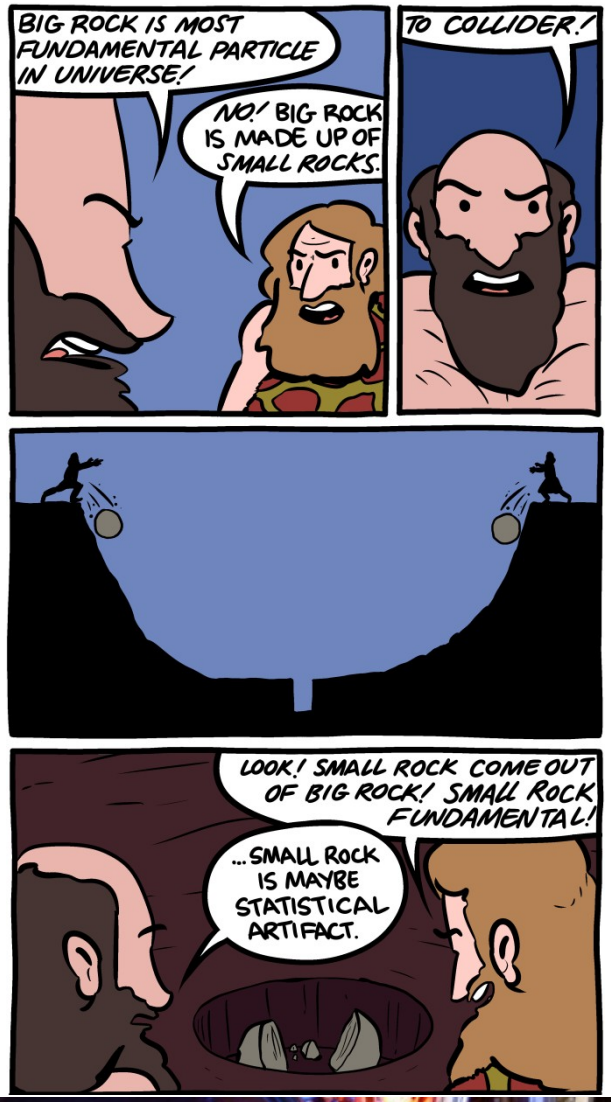


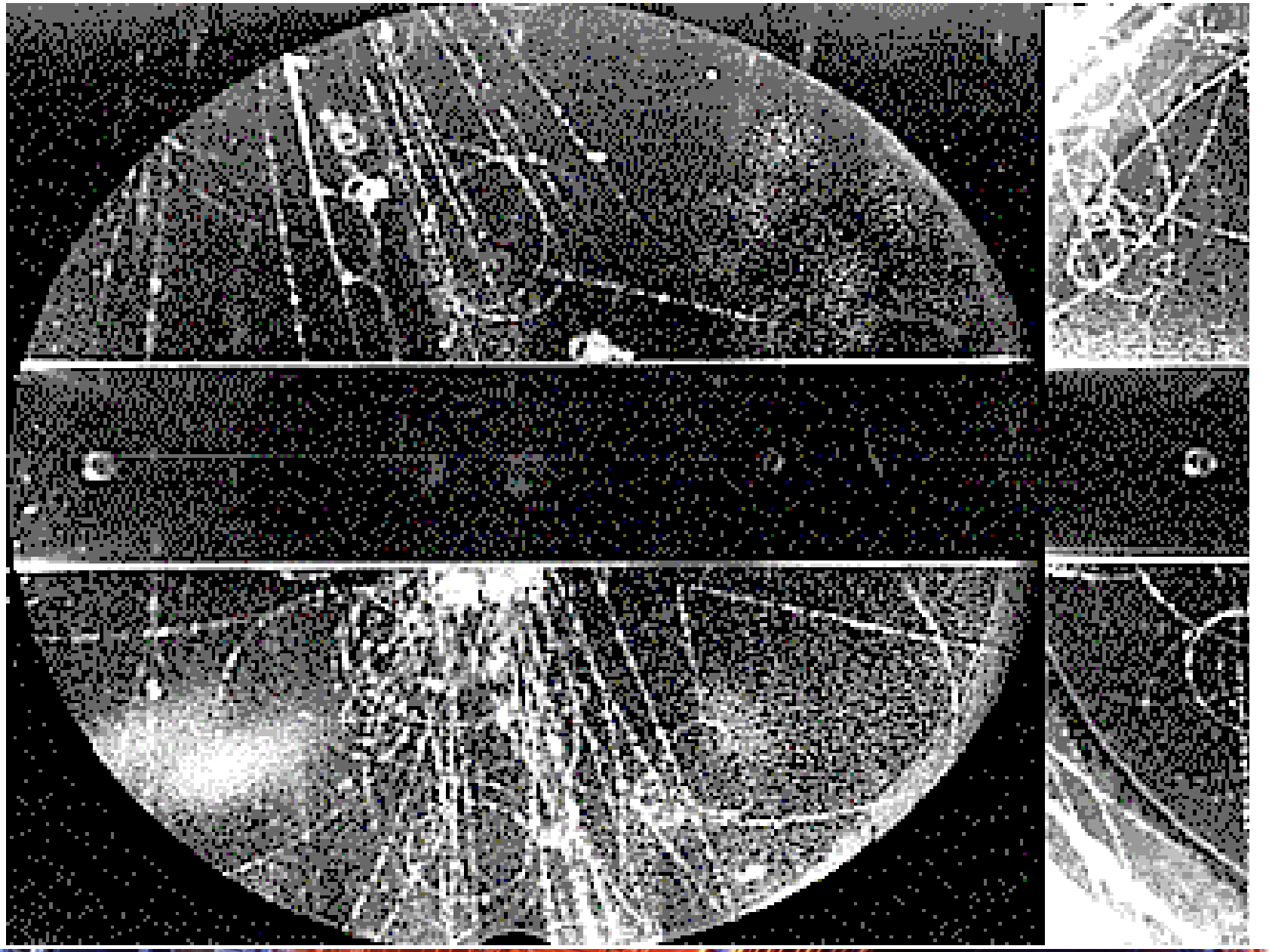




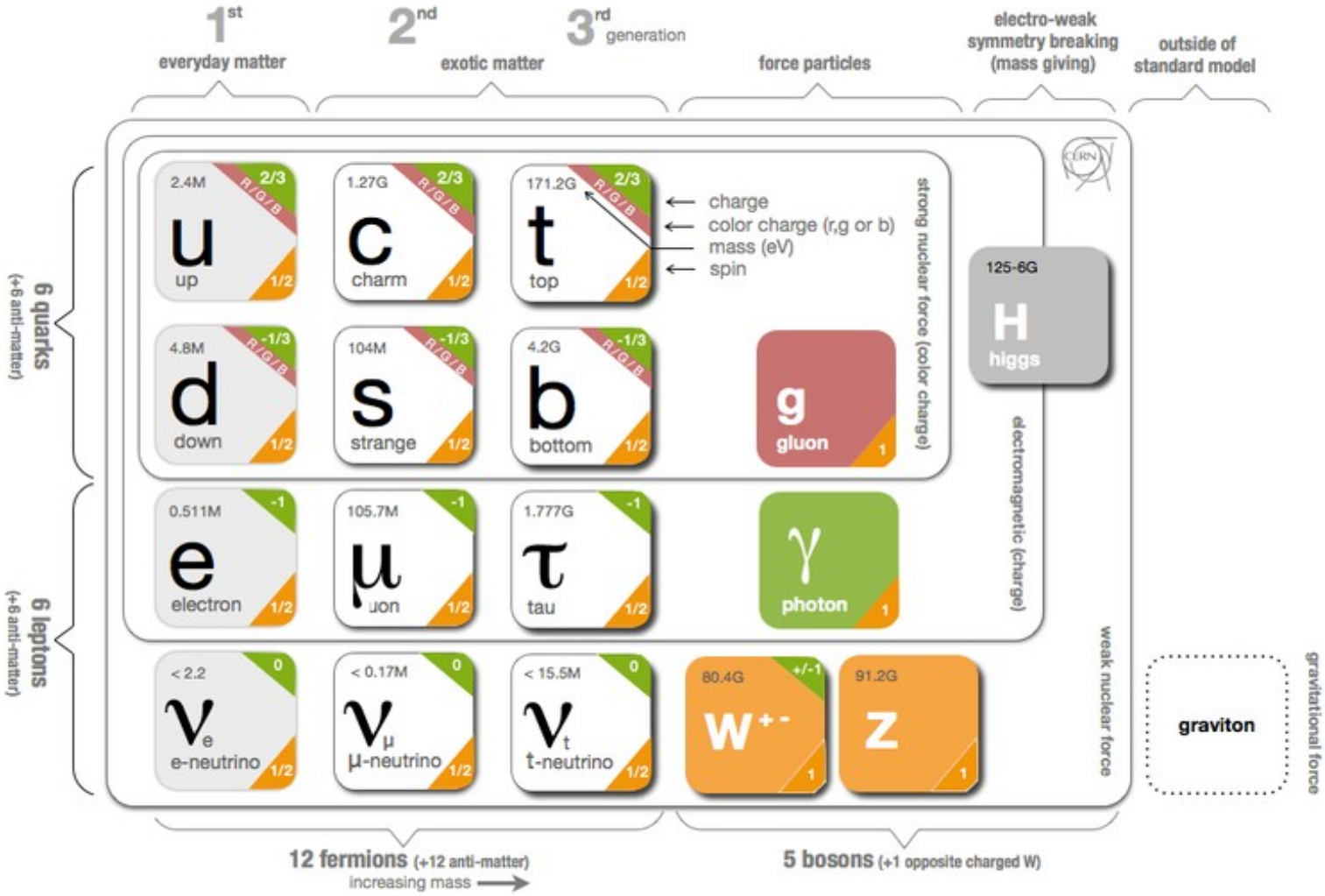
To collider!

- Gli esperimenti rivelano l'esistenza di particelle di cui nella vita di tutti i giorni non ci accorgiamo
- Per esempio, oggetti formati da un quark e un antiquark, tenuti insieme dalla forza forte: i mesoni
- Siamo in grado di creare molti di questi oggetti nei moderni acceleratori

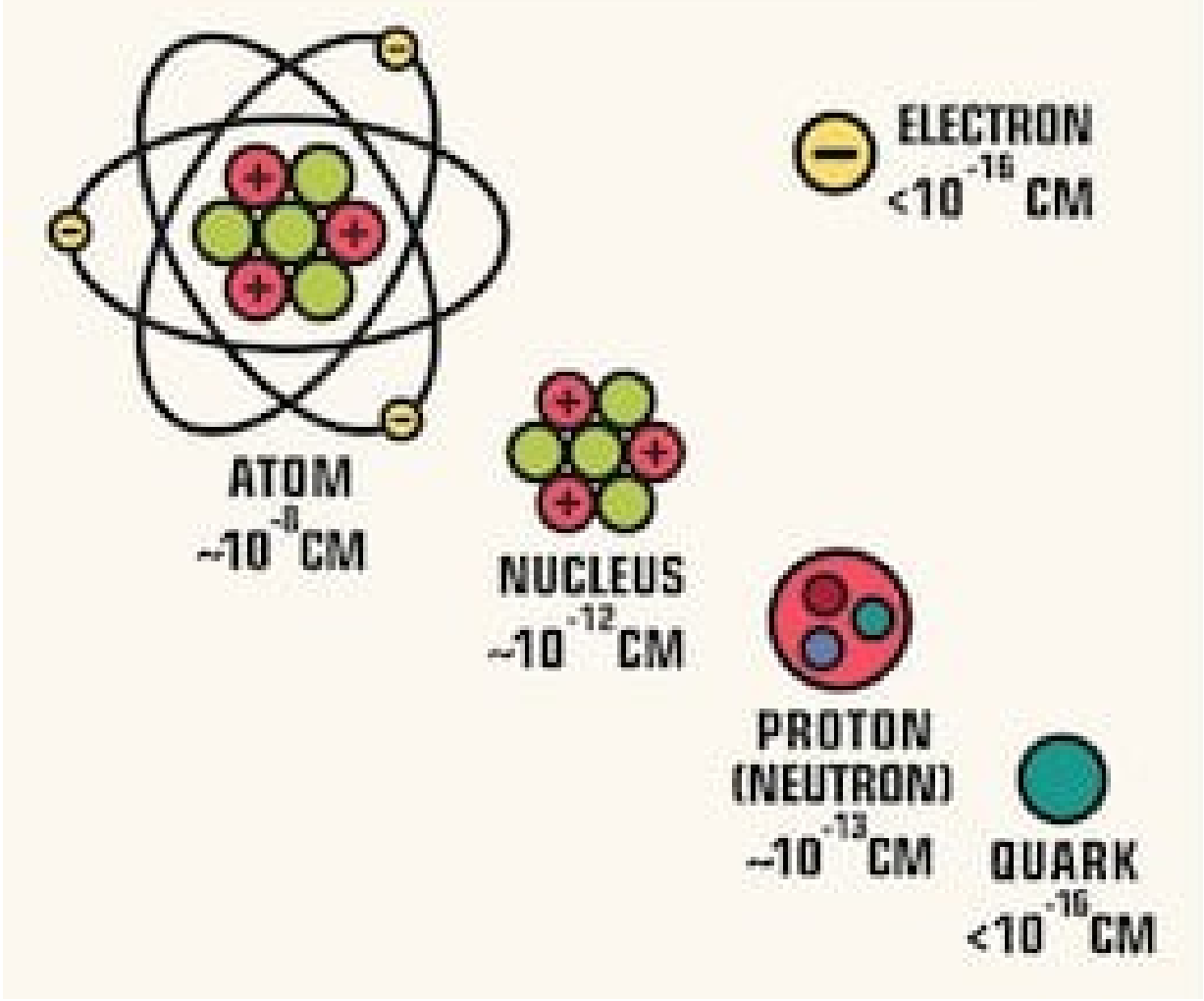




L’ultima tavola?



Particelle ...


ELECTRON
<10^-16 CM
ATOM
~10^-8 CM
NUCLEUS
~10^-12 CM
PROTON
(NEUTRON)
~10^-13 CM
QUARK
<10^-16 CM

… e un'antiparticella?

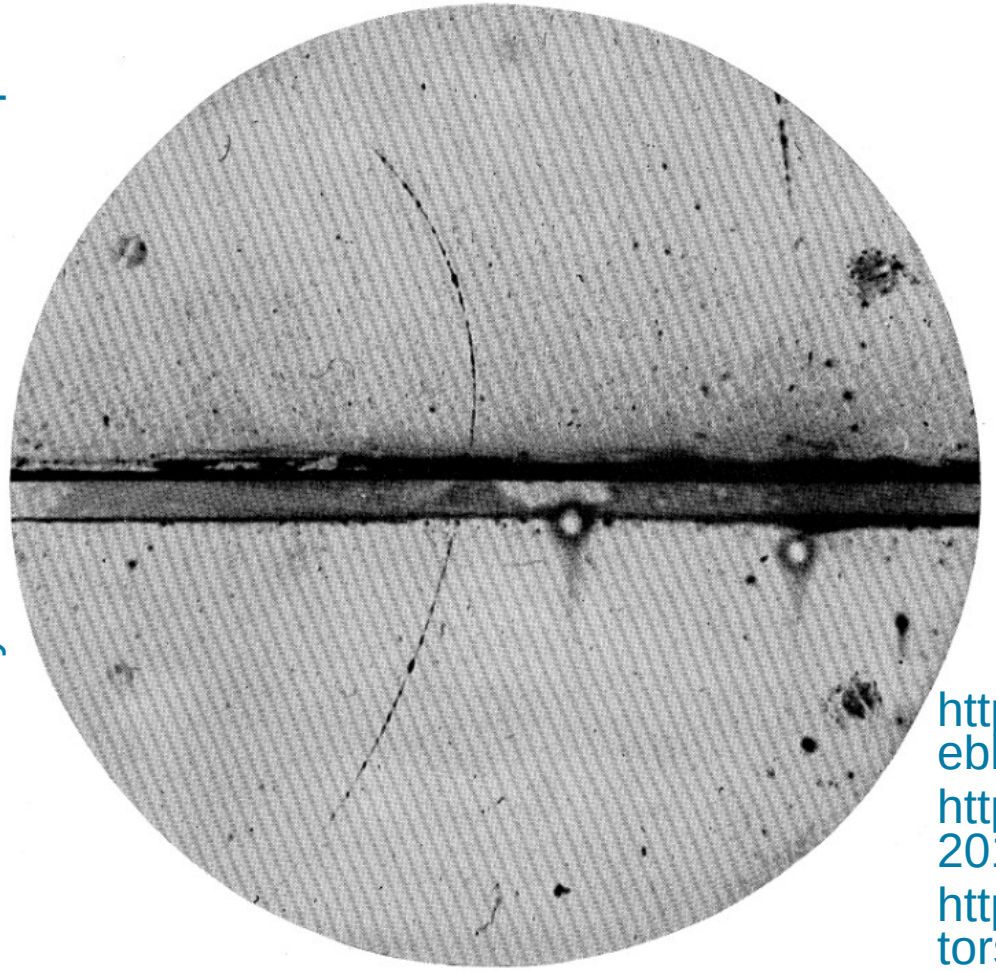


FIG. 1. A 63 million volt positron ($H\rho = 2.1 \times 10^5$ gauss-cm) passing through a 6 mm lead plate and emerging as a 23 million volt positron ($H\rho = 7.5 \times 10^4$ gauss-cm). The length of this latter path is at least ten times greater than the possible length of a proton path of this curvature.

- Il positrone fu scoperto nel 1932 in immagini di raggi cosmici presi con una camera a nebbia, studiando la curvatura di una traccia nel campo magnetico e l'interazione della particella con il materiale circostante

http://www.asimmetrie.it/index.php/particelle-nella-nebbia

https://www.symmetrymagazine.org/article/january-2015/how-to-build-your-own-particle-detector

https://www.amnh.org/exhibitions/einstein/for-educators/building-a-cloud-chamber-cosmic-ray-detector

http://authors.library.caltech.edu/7189/1/ANDpr33b.pdf

Che bello! Dove lo trovo?

WE SELL THE SMALLEST THINGS IN THE UNIVERSE

The PARTICLE ZOO — Sewing the fabric of spacetime

Pick a currency: EUR

ZOO CART — 0 items in your cart

HOME | SHOP | ABOUT | INFO | GALLERY | PRESS | NEWS | GET THE APP

Search...

Home → Products → Antiparticle 14-pack

- SUBATOMIC PLUSH
- PARTICLE SETS
- STICKERS, MAGNETS, BUTTONS
- PRINT PRODUCTS
- ASTROPHYSICS
- OTHER STUFF
- Shop by tag

INTERACT

NEWSLETTER

Sign up for our newsletter for the latest news and products

type your email...

SUBATOMIC PARTICLE PLUSHIES
FROM THE STANDARD MODEL OF PHYSICS & beyond!
> MAKING PARTICLE PHYSICS FUN SINCE 2008!
> OVER 50,000 SOLD

ANTIPARTICLE 14-PACK

€135.44 EUR

Weight: Regular weight

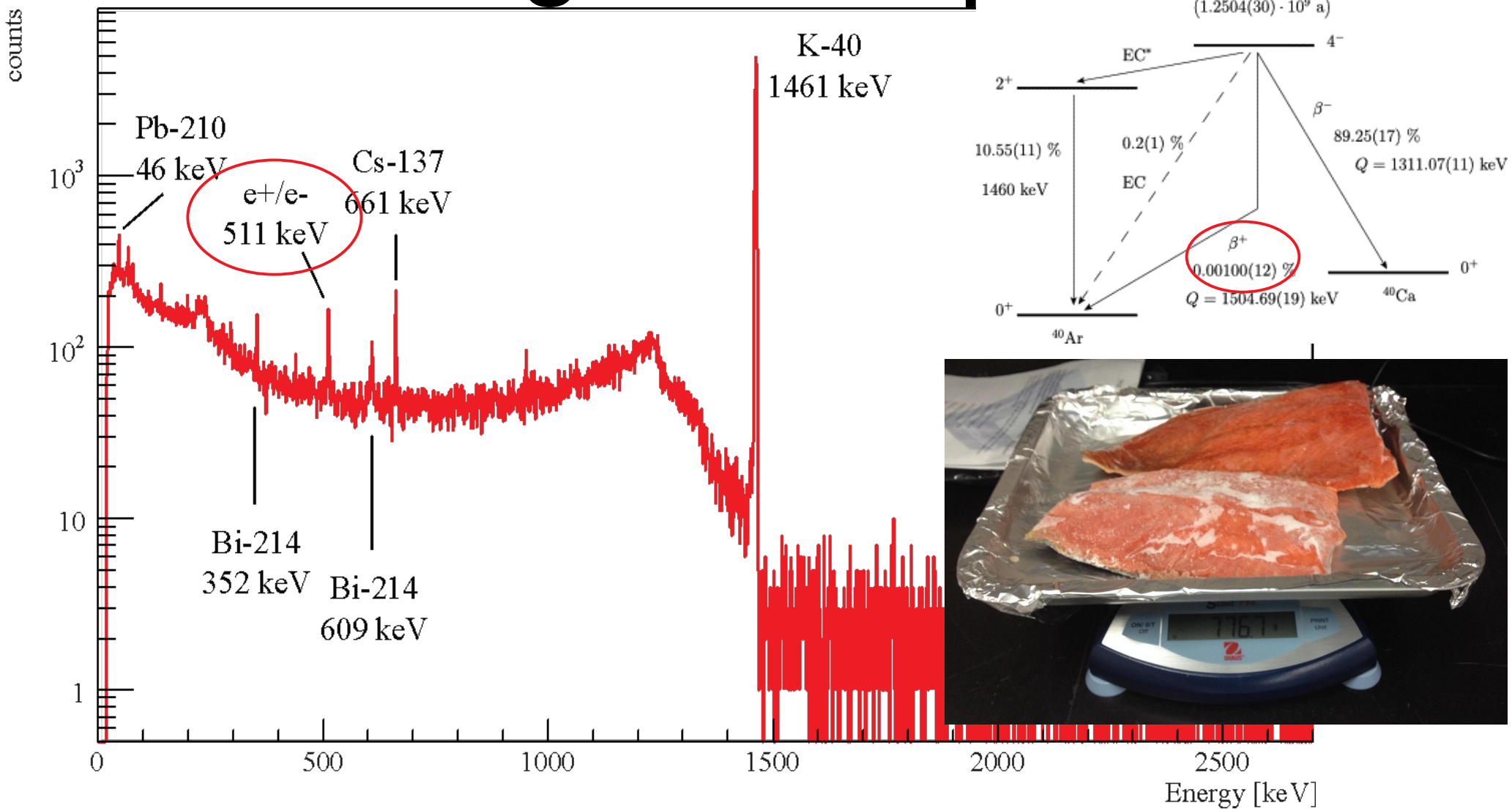
Qty: 1

ADD TO CART

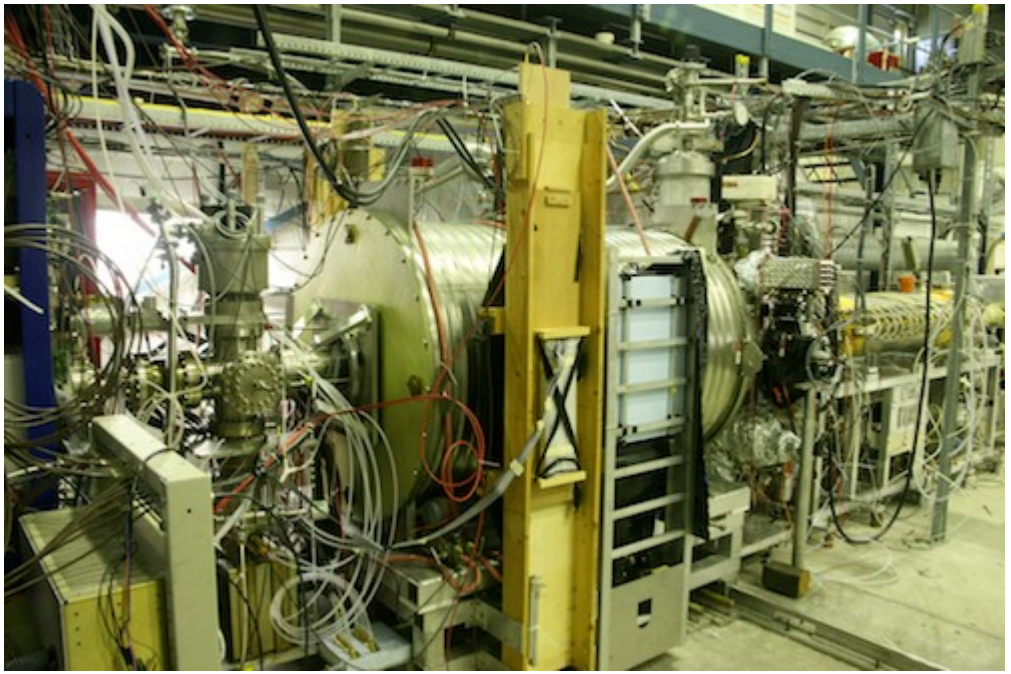
La banana e la PET

- “Una banana (ricca in potassio) produce in media un positrone ogni 75 minuti circa”
- Quando il positrone si ferma nel materiale, finisce per incontrare un elettrone e si annichila
- Il prodotto di questa reazione sono due onde elettromagnetiche di energia caratteristica, che viaggiano in direzioni opposte
- La somma delle due energie e` pari alla massa dei reagenti

Una sorgente di positroni



La fabbrica di antimateria



Un atomo alla volta

Ma dov’è finita?

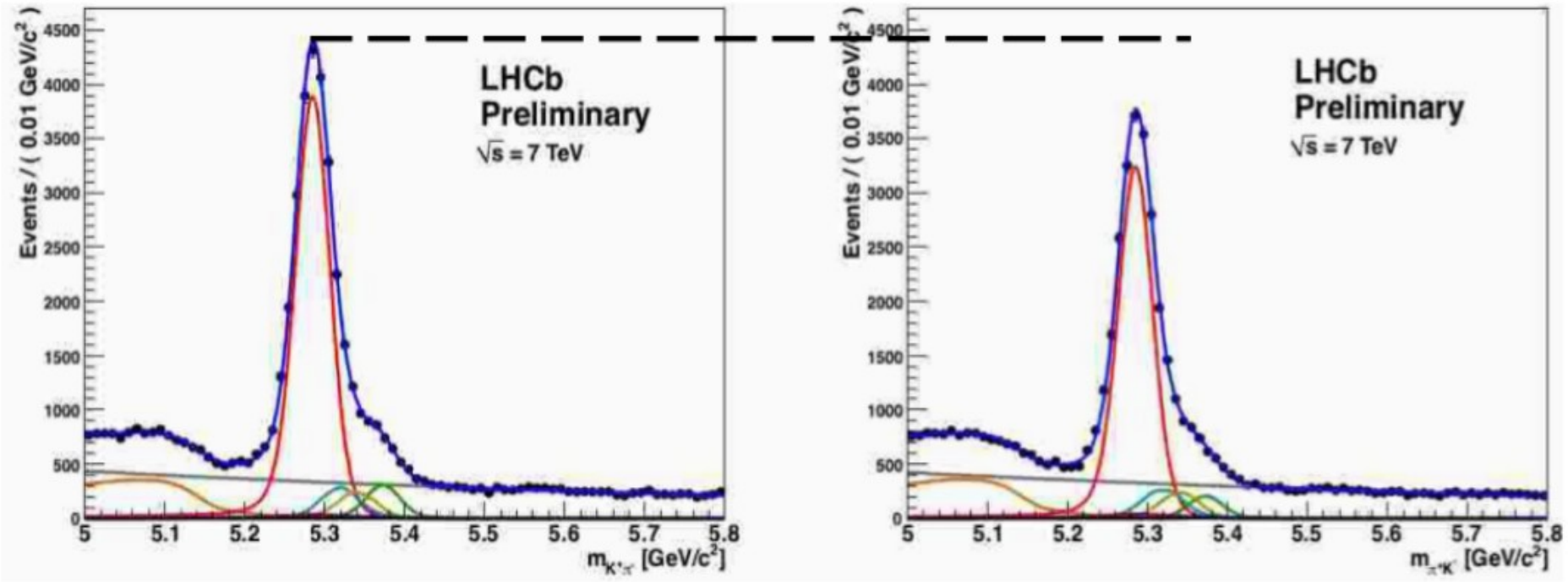
Materia e antimateria

Una storia d’amore


Chiquita

https://agenda.infn.it/event/12265/contributions/13250/attachments/9854/11094/KeyNoteEricCornell.pdf

Com’è successo?



$B^0 \to K^+\pi^-$ $\qquad$ $\overline{B}^0 \to K^-\pi^+$

Materia e antimateria si comportano “quasi” nello stesso modo… ma solo “quasi”