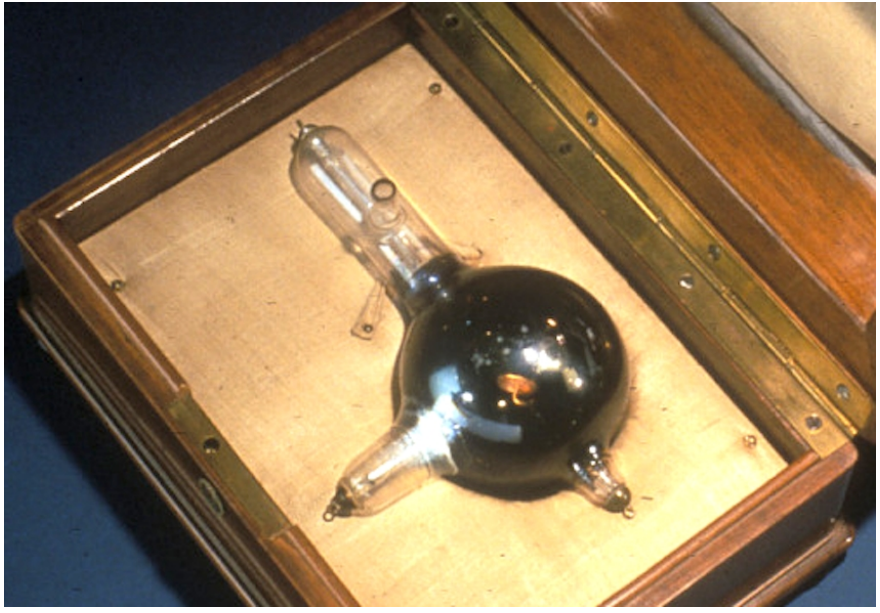
Breve storia degli acceleratori di particelle

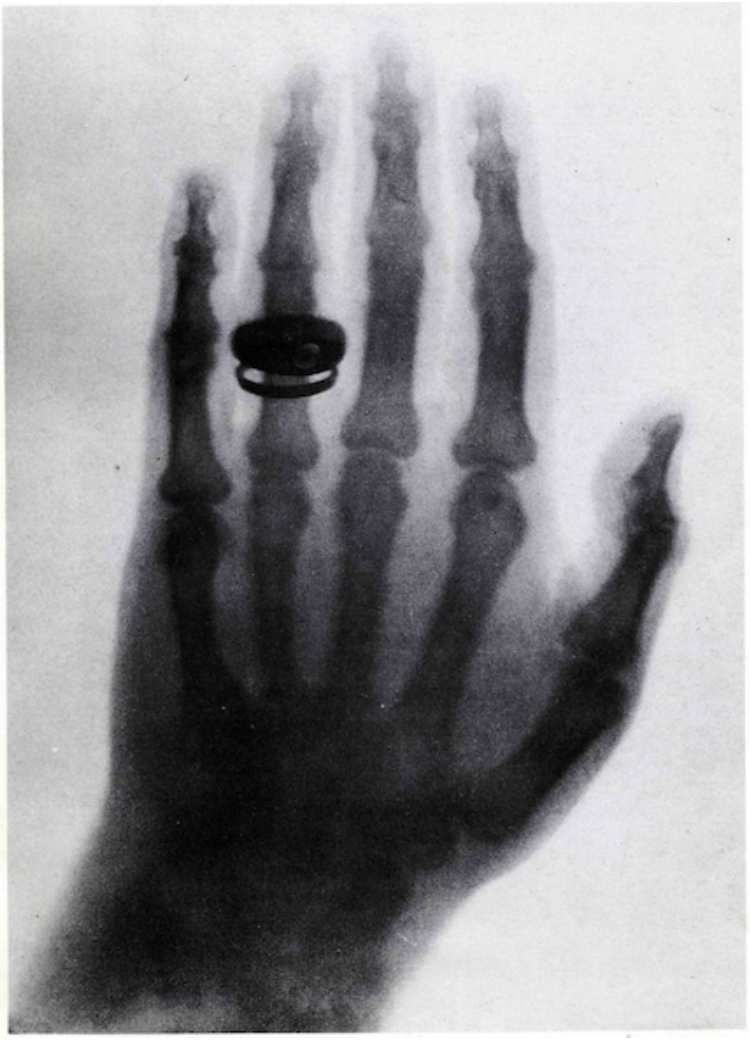
Elisabetta Pace – settembre 2022

Uno dei padri degli acceleratori:
Wilhelm Röntgen

Wilhelm Röntgen stava studiando a Wurtzburg il comportamento dei **tubi da vuoto**.

Accidentalmente, scoprì che uno schermo coperto di materiale florescente, a qualche metro di distanza, si “illuminava” anche quando il suo apparato era coperto da una scatola di cartone che non lasciava passare luce visibile. Chiamò questa radiazione elettromagnetica “**raggi X**”.





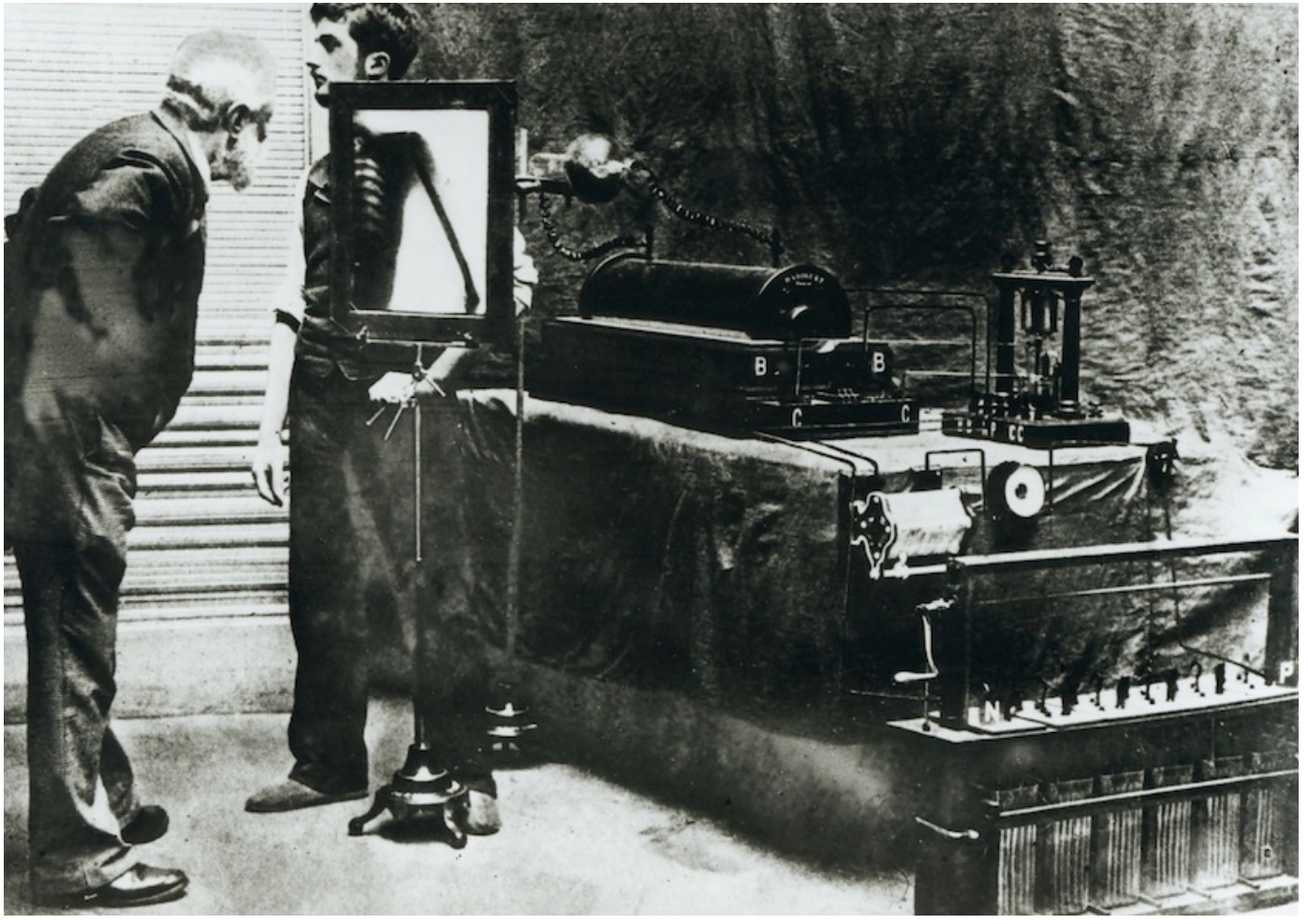
Usando una lastra fotografica, al posto dello schermo fluorescente, ottiene la prima radiografia: la mano della moglie Anna Berta Röntgen (1985)

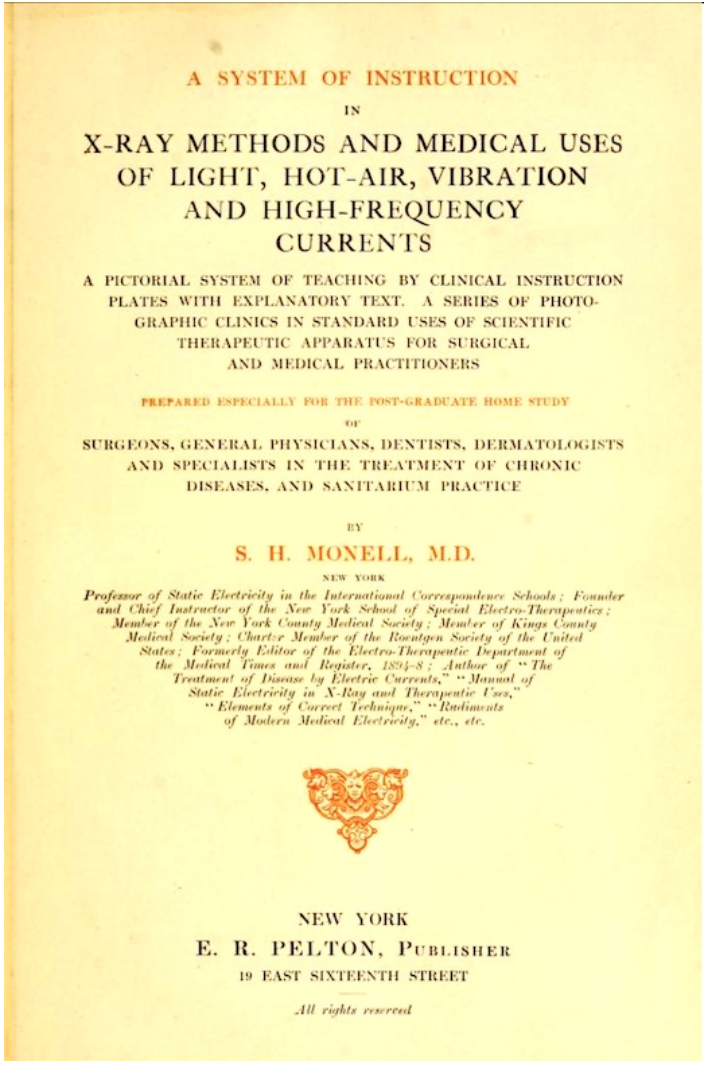
Nel giro di pochissime settimane, il nome di Röntgen è in quasi tutte le pubblicazioni scientifiche europee.

Nel 1901 gli verrà assegnato il primo Nobel per la fisica, il cui premio devolverà alla sua università.

Non brevetterà MAI le sue scoperte.

Già nel gennaio del 1896, riceve da Hascheck e Lindenthal, medici di Vienna, la foto a raggi X di una mano amputata. Essi avevano iniettato una miscela di sali di bismuto, piombo e bario nei vasi sanguigni della mano. Le vene risaltavano chiaramente nell'immagine: era la prima approssimazione di un angiogramma


B
B
C
C
P
N



A SYSTEM OF INSTRUCTION

IN

X-RAY METHODS AND MEDICAL USES OF LIGHT, HOT-AIR, VIBRATION AND HIGH-FREQUENCY CURRENTS

A PICTORIAL SYSTEM OF TEACHING BY CLINICAL INSTRUCTION PLATES WITH EXPLANATORY TEXT. A SERIES OF PHOTOGRAPHIC CLINICS IN STANDARD USES OF SCIENTIFIC THERAPEUTIC APPARATUS FOR SURGICAL AND MEDICAL PRACTITIONERS

PREPARED ESPECIALLY FOR THE POST-GRADUATE HOME STUDY

OF

SURGEONS, GENERAL PHYSICIANS, DENTISTS, DERMATOLOGISTS AND SPECIALISTS IN THE TREATMENT OF CHRONIC DISEASES, AND SANITARIUM PRACTICE

BY

S. H. MONELL, M.D.

NEW YORK

Professor of Static Electricity in the International Correspondence Schools; Founder and Chief Instructor of the New York School of Special Electro-Therapeutics; Member of the New York County Medical Society; Member of Kings County Medical Society; Charter Member of the Roentgen Society of the United States; Formerly Editor of the Electro-Therapeutic Department of the Medical Times and Register, 1894-8; Author of "The Treatment of Disease by Electric Currents," "Manual of Static Electricity in X-Ray and Therapeutic Uses," "Elements of Correct Technique," "Rudiments of Modern Medical Electricity," etc., etc.

NEW YORK

E. R. PELTON, PUBLISHER

19 EAST SIXTEENTH STREET

1902

https://archive.org/details/systemofinstruct00mone/page/n11/mode/2up?view=theater

TABLE OF CONTENTS

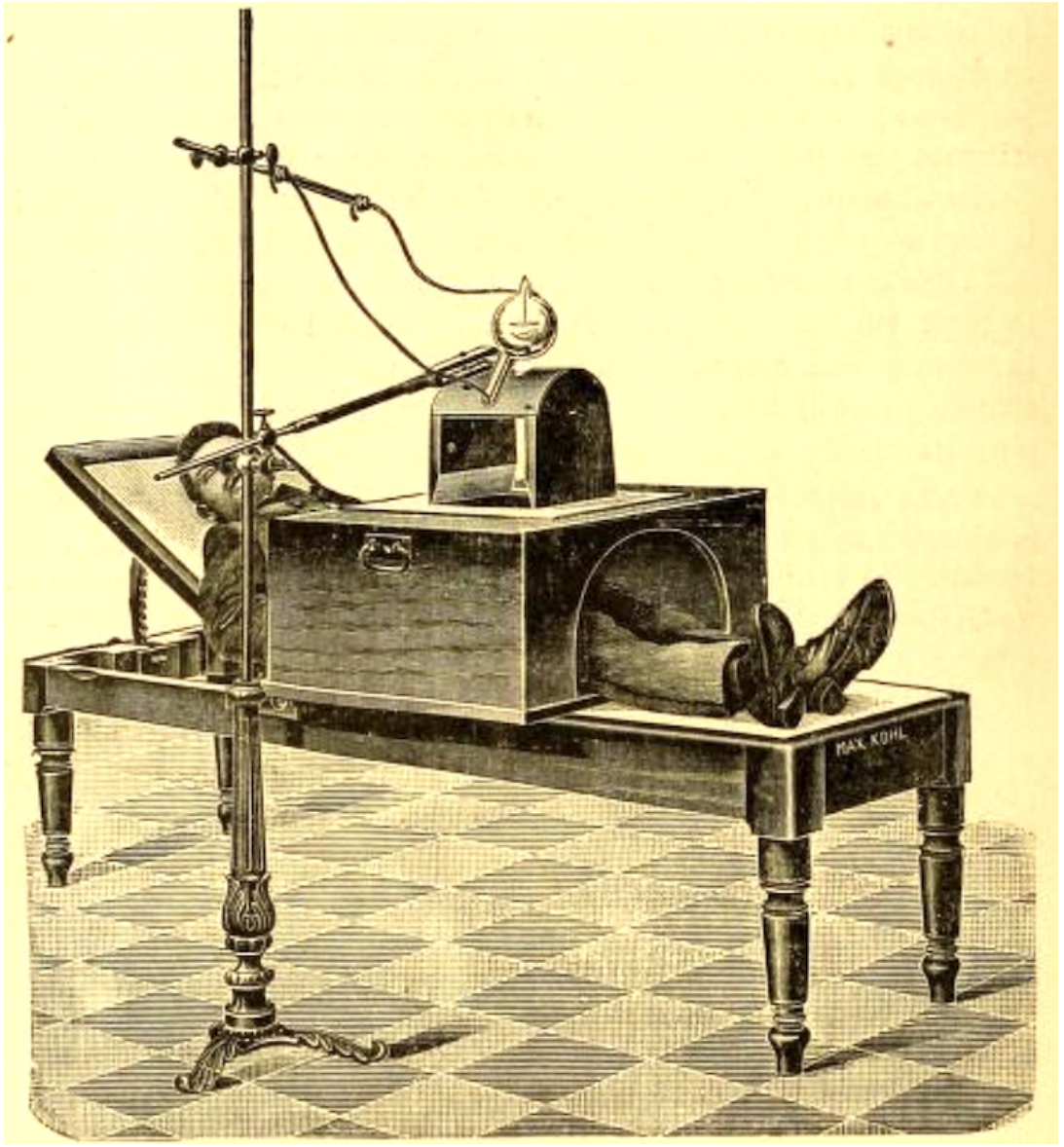
Directory of the Six Instruction Courses.

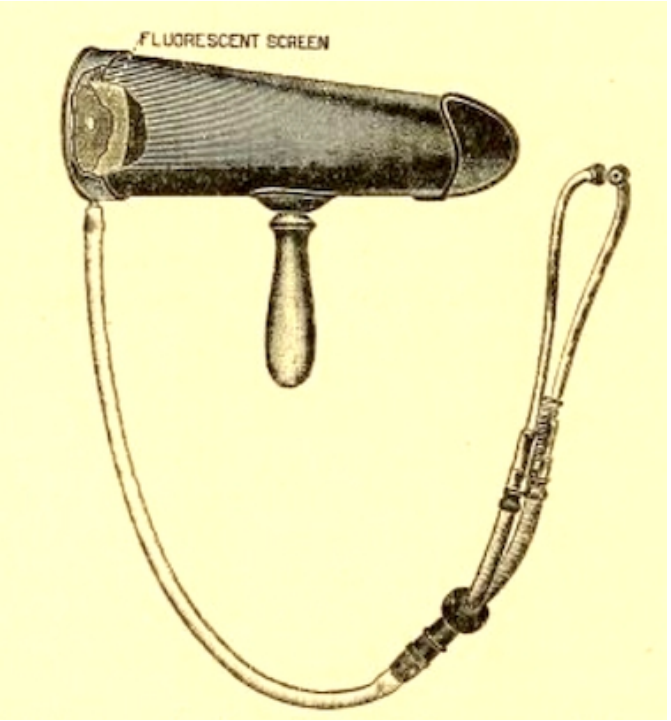
CHAPTER XVII.

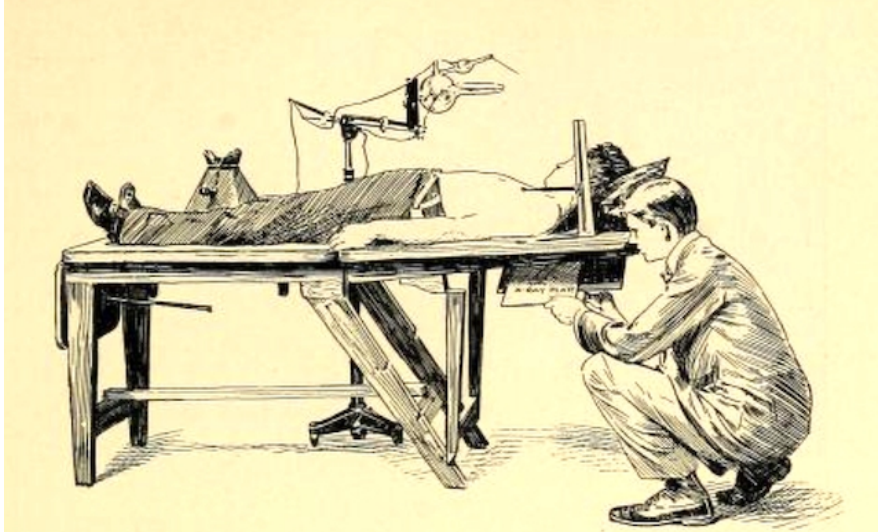
THE ART OF READING X-RAY SHADOWS.

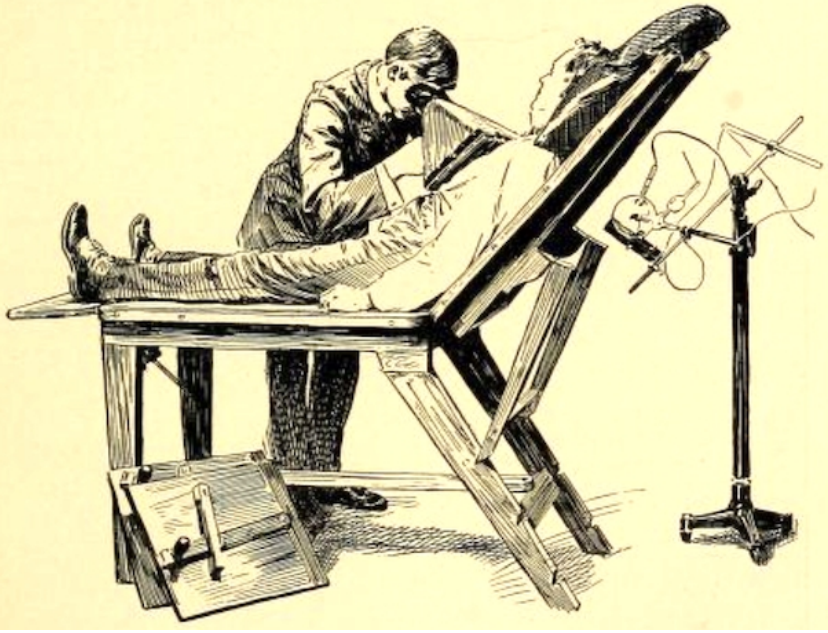
CHAPTER XXV.

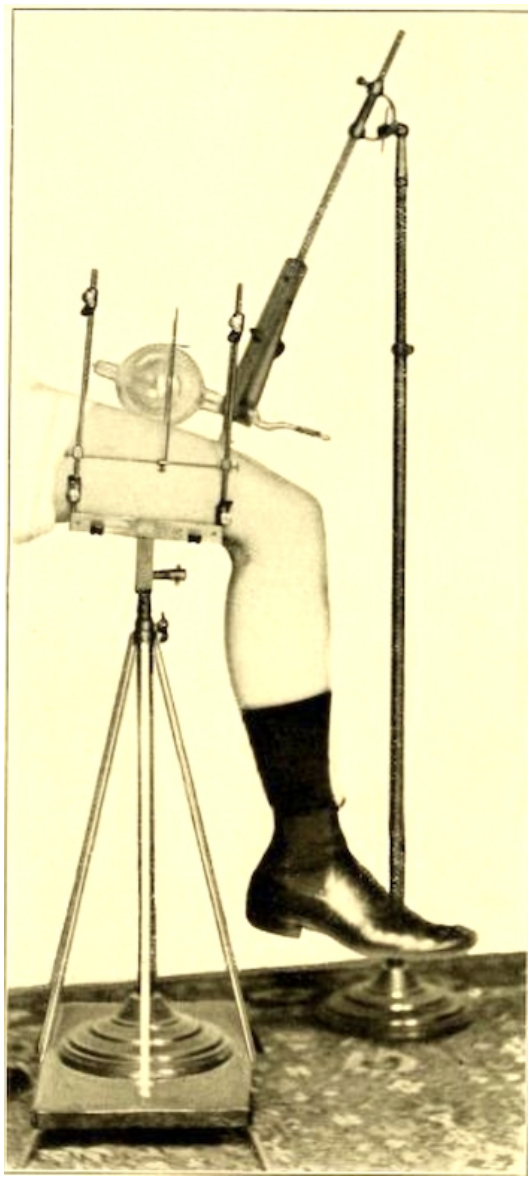
MEDICO-LEGAL RADIOGRAPHY.


MAX KOHL


FLUORESCENT SCREEN

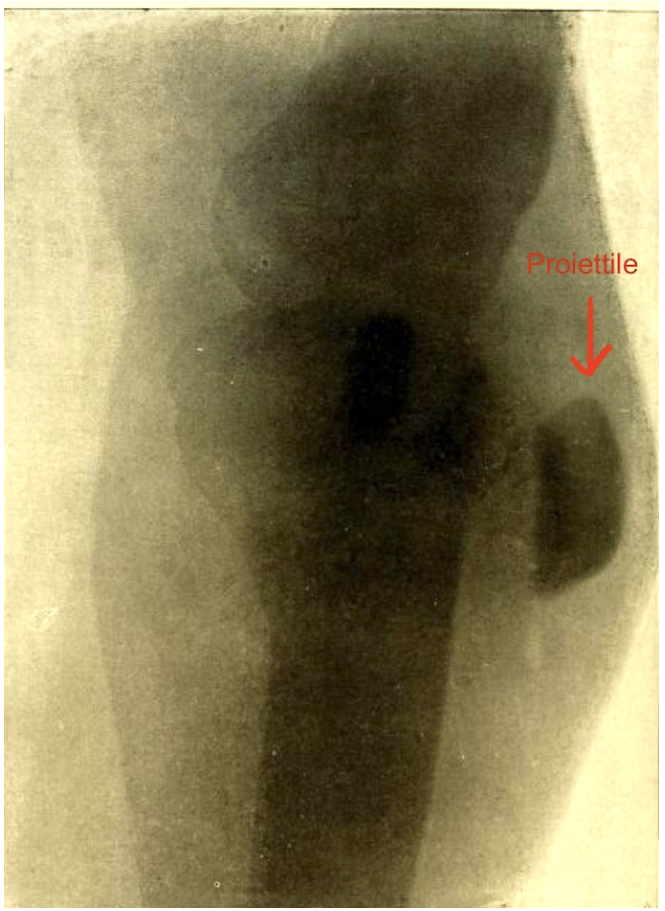


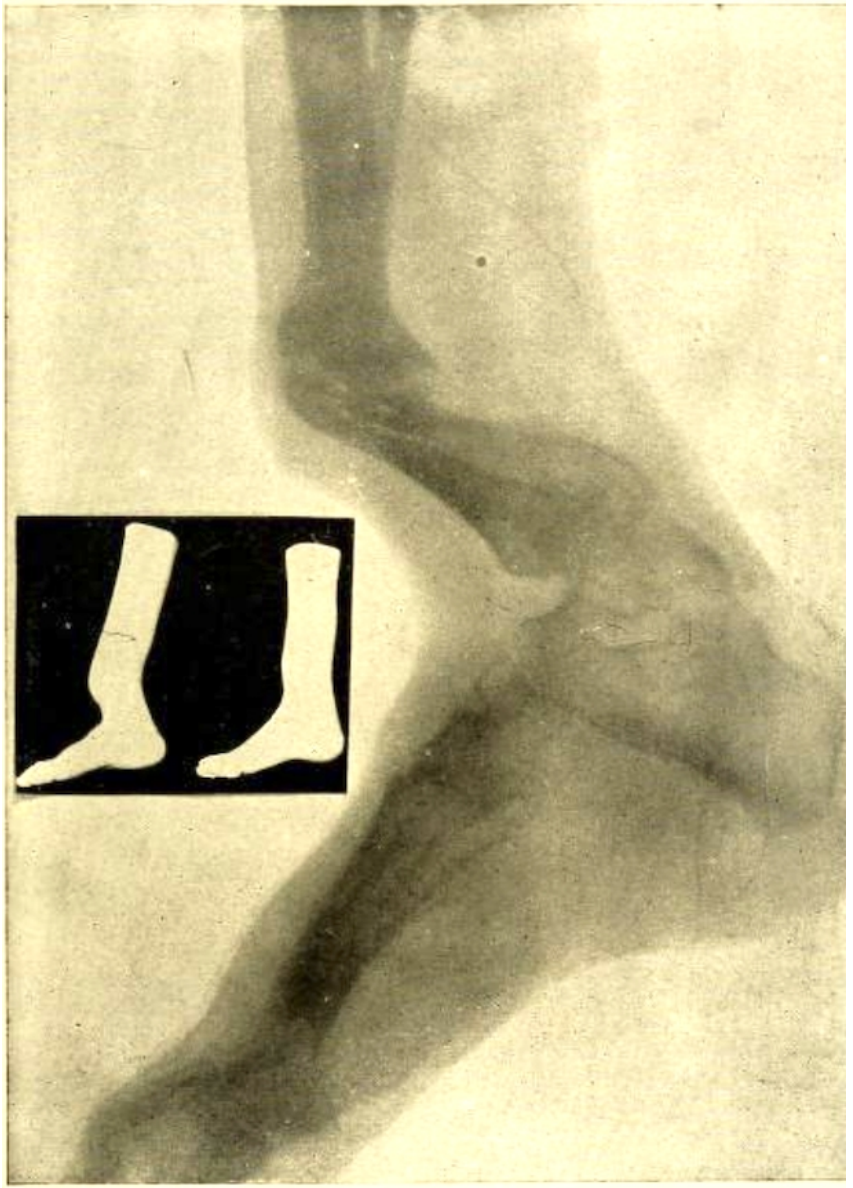




Chirurgia militare

PLATE 112.—This plate illustrates a gunshot shattering of the upper third of the right femur of an officer of the Imperial Light Horse at the battle of Elandslaagte, in the Boer war. Recovered and returned to duty without amputation. The picture was taken by Lieutenant Bruce. (Rebman, Ltd.)





Ortopedia

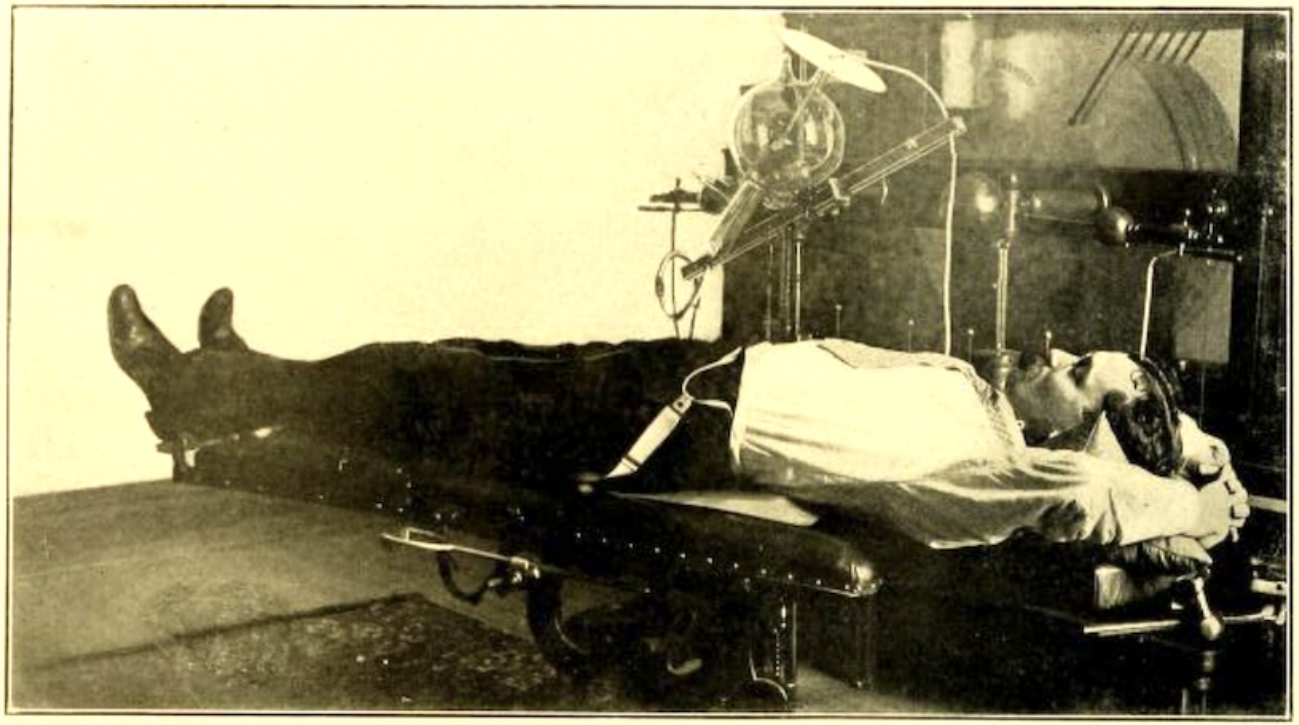
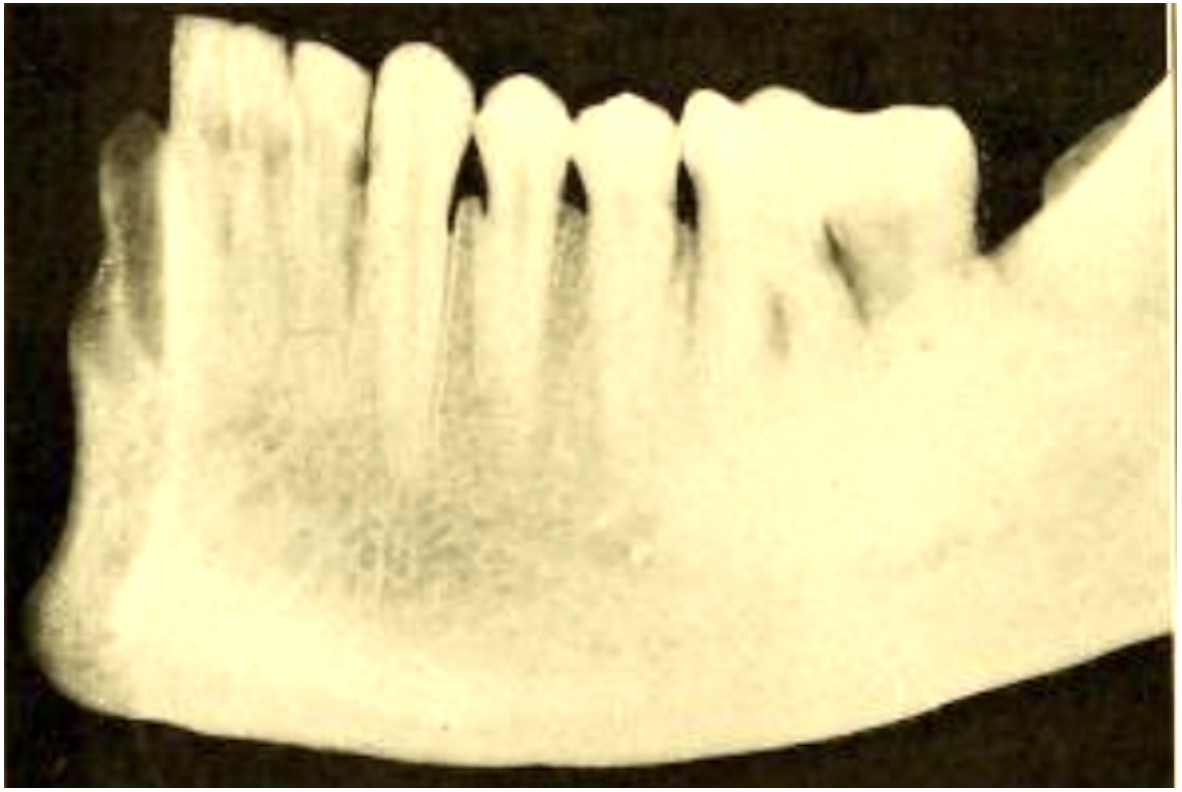


PLATE 120.—Method for Renal Calculus with dorsal position of patient. Photographed especially for this Instruction Course by Dr. Jicinsky during the actual exposure of a radiograph which resulted in detecting the calculus. The method is shown so plainly that others can easily duplicate it.

Calcoli



Odontoiatria

Malattie del torace, polmonari, dello stomaco e dell’addome

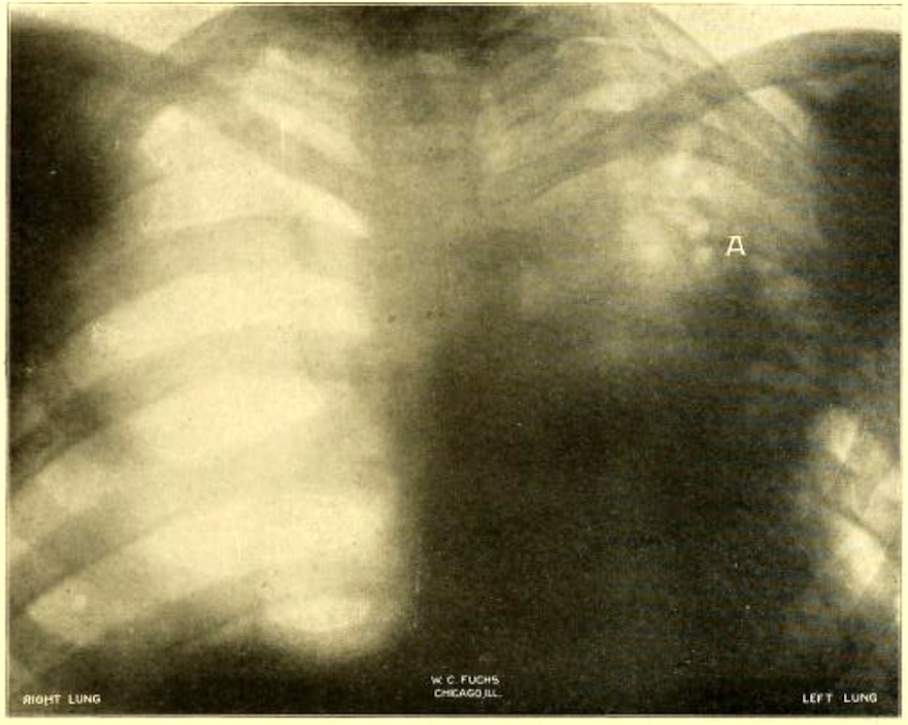


PLATE 148.—Tuberculosis of left lung showing darkened areas. Heart shadow undefined. Normal transparency of right lung shows it free from disease at time of radiographing the case. Examine this plate with mirror to reverse the picture.

Trattamenti terapeutici

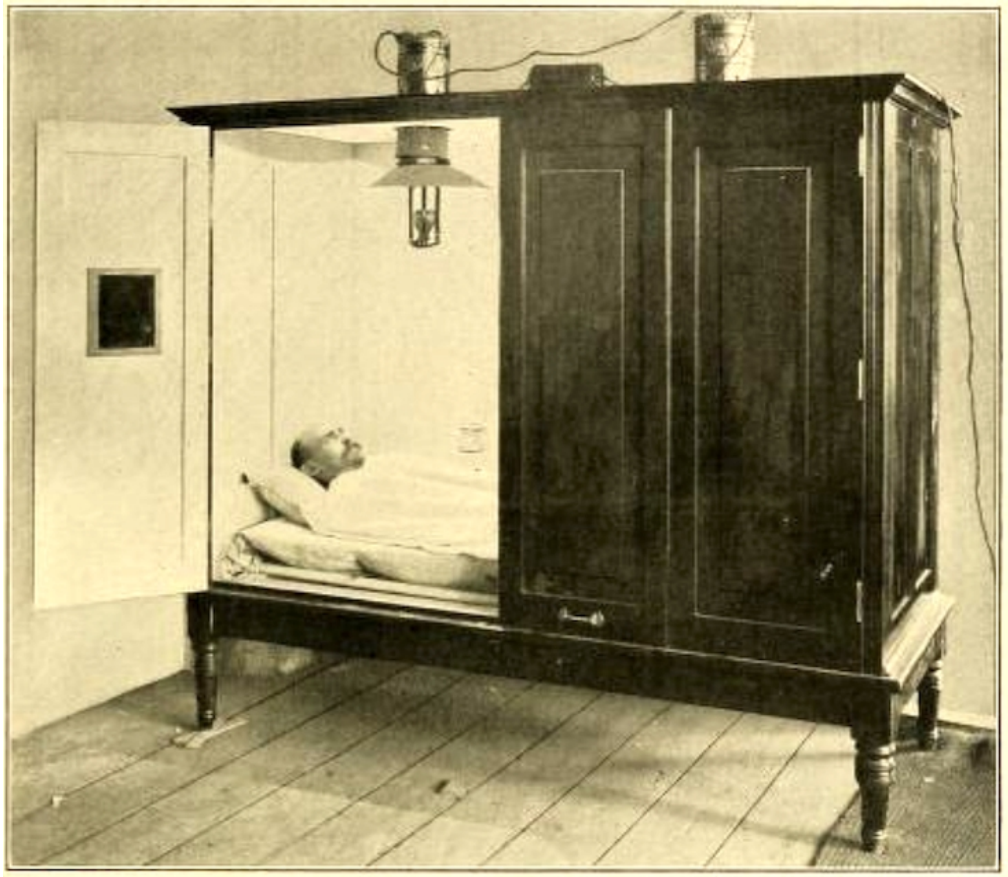


PLATE 215.—The five Instruction Plates immediately following illustrate a new Arc-Light Cabinet having two 15 Ampere lamps, with special reference to the general administration of the chief chemical rays with only a small amount of the heat rays. Especially designed to treat pulmonary tuberculosis and general skin diseases. Also for general tonic alterative effects. See text for full description and clinical information. This plate shows the patient on the asbestos couch covered with sheet, and last doors of cabinet ready to be closed. The blue glass observation-window seen in the open door gives the operator a view of patient during treatment. When the cabinet is closed direct patient to remove sheet to allow rays to reach entire body without hindrance. The cabinet only attains a comfortable warmth. It is not a "radiant heat" apparatus.

PLATE 165.—Raying Lupus of the Nose. Photographed especially for this work by Dr. L. E. Kelly, of Oakland, Cal., who writes: "Am treating sixteen cases of lupus, or tuberculosis of different parts. Two very bad cases affecting the rectum; one with the floor of the pelvis almost gone. Doing exceedingly well." Note the sheet-lead bent round the face with hole cut for affected nose. It is being tied behind with two pieces of tape to hold it in place, and the operator is adjusting the tube to position. When the lower pair of ribbons (seen hanging down) are also tied have the patient drop his hand to his lap, light up the tube and expose as taught.

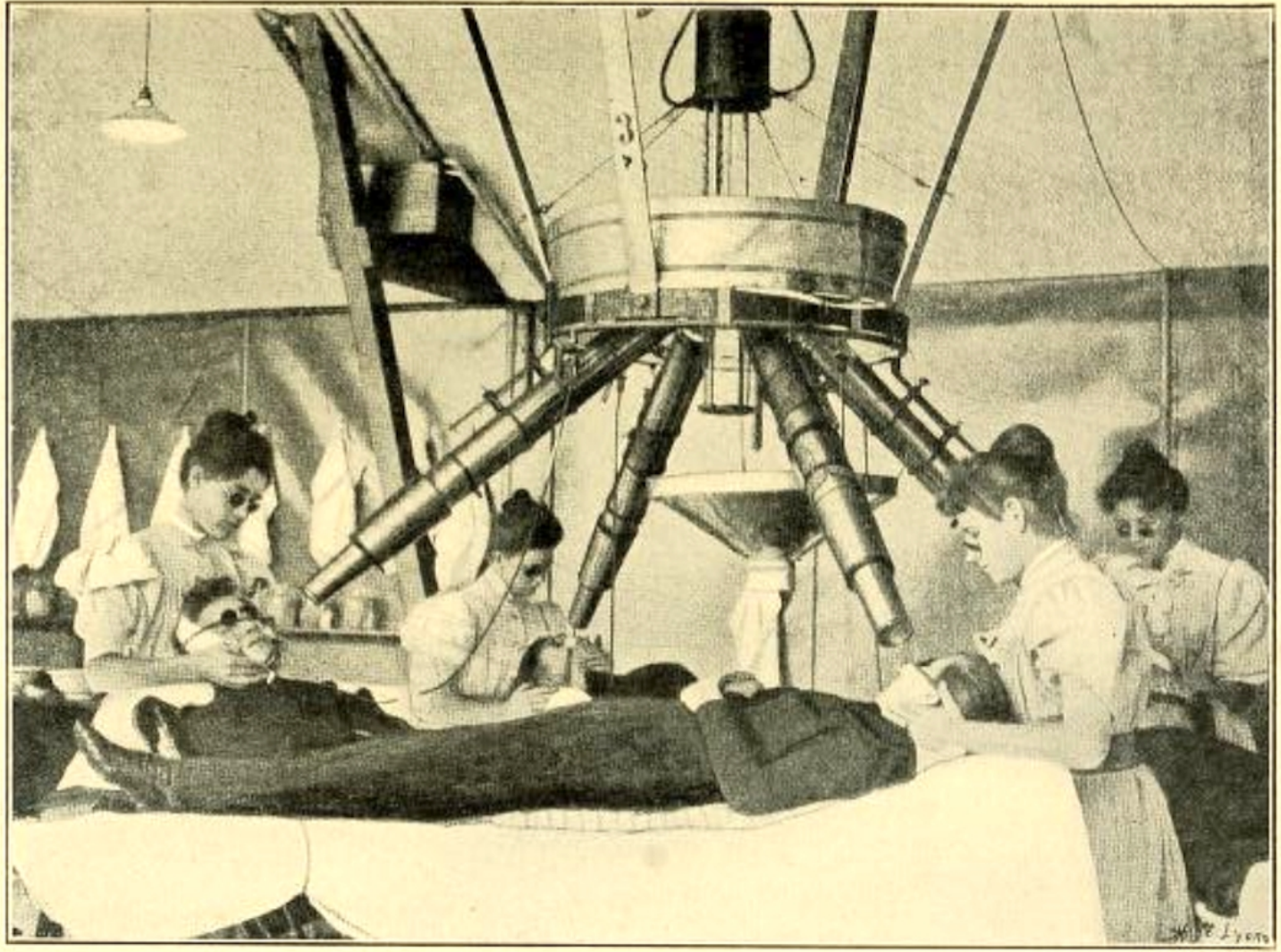


PLATE 189.—Finsen's pioneer arc-light "tube" apparatus treating four patients an hour. Its interest here is chiefly historical. These pictures were sent author by Dr. Finsen.

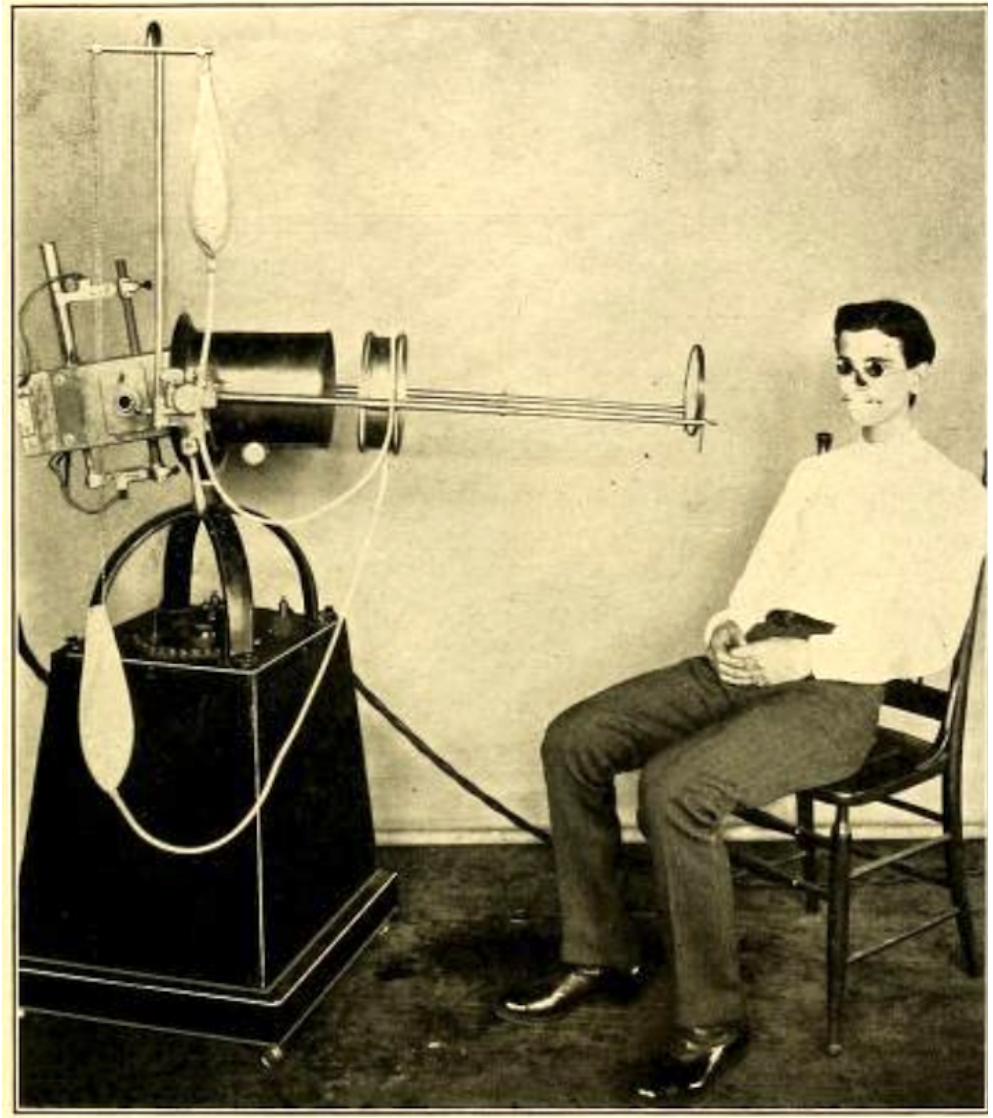


PLATE 211.—Showing rays focussed on end of nose and upper lip in lupus case. Pat

Ovviamente non si teneva ancora conto degli effetti collaterali dannosi delle radiazioni!!!!

Radium and Beauty

HERE are the first toilet preparations to embody Actual Radium, an astonishing new force for betterment, applied as an aid to Beauty. Learn how the amazing Energy of Radium has proved a boon to the human skin. Learn what Radium actually means to Beauty and how its power is employed in "Radior" Preparations. Study our $5,000 guarantee. Then turn to "Radior" Toilet Requisites. When you have used, enjoyed and tested them you will adopt them as your own first aid to Beauty.

PREHISTORIC woman first discovered her image in some quiet jungle pool. Ever since Beauty has engaged the world's attention.

Radium, though new to the world, is no less of absorbing interest. Its marvels have amazed and thrilled us all.

Who would have imagined that these two subjects would some day go hand in hand? Yet, in Radium, Science has discovered a revolutionary Beauty Secret.

Consult books on Radio-activity. Any number of them are in our public libraries. They will show you that Radium possesses an enormous power for human betterment.

The tiniest particle of Radium throws off a continuous stream of Energy Rays. An Energy never diminishing, never ceasing, day or night, year in, year out. A force a million times more powerful than any other known.

These Radium Rays are particularly valuable in effect upon the human skin. Dr. Louis Wickham and Dr. Degrais, specialists in the St. Lazare and the St. Louis Hospitals of Paris, have proved what Radium will do for even the most dreaded skin diseases.

Rays of Radium, in fact, energize and revivify any living matter with which they come in contact. They are "accepted by the human system as harmoniously as is sunlight by the plant."

This wonderful force for betterment has now been embodied in "Radior" Toilet Requisites, thus placing the power of Radium at the command of every woman who uses a face cream or powder, hair tonic or soap.

"Radior" Toilet Requisites are delightfully dainty and distinctive. They have an exquisite and exclusive fragrance all their own, a perfume not for sale in any market. They are the first and only preparations for the toilet to contain Actual Radium—Nature's greatest aid to Beauty.

Every "Radior" Preparation is guaranteed, under $5,000 penalty, to contain a definite amount of Actual Radium, and to retain its Radio-activity for at least twenty years. See Guarantee above.

In England, "Radior" Preparations are a success of several years' standing. They are used by noted women of title and fashion. They are the vogue in the leading shops.

We present them in the United States as the greatest beauty boon ever offered—to those who value perfection of complexion; rounded, youthful form; lustrous hair; a healthy skin and beautiful hair.

Each and every "Radior" Beauty Aid is the formula of a famous Parisian specialist, Entirely aside from Radium, you would choose "Radior" Preparations for themselves—for the silky smoothness of the creams—the impalpable purity of the powders and the lasting, haunting fragrances.

When to this perfection, as toilet preparations, is added the power of Actual Radium, the highest level of Beauty Culture is reached.

From toiletry "Radior" Face Powder to healthful "Radior" Skin Soap—from delightful "Radior" Face Powder to wonderful "Radior" Hair Tonic, "Radior" Toilet Requisites all contain actual Radium for Beauty's sake.

Space does not permit us to go into further details, but there are further facts concerning Radium and Beauty which every woman should know. They are contained in our booklet sent free on request.

"Radior" Toilet Requisites are necessarily higher by price. This must be expected in preparations containing the finest ingredients only, plus a definite quantity of Actual Radium. But the greater benefits obtained from "Radior" Preparations would justify an even higher price. The best is always the cheapest and goes further.

It is easy to prove the superiority of "Radior" Preparations. *Try them.* See how smoothly the Vanishing Cream rubs in.

Notice how your complexion improves with "Radior" Peau de Velour (night cream).

See how impeccably the face powder blends with the skin. How smoothly it adheres. Appreciate the soothing comfort of the Talc. Note the effects produced by the Hair Tonic.

Enjoy the strange, elusive fragrance.

They remember that each preparation has the power to work for betterment—the power of Actual Radium. It is easy to apply these tests.

Purchase "Radior" Toilet Requisites at any of the leading department and drug stores. If you are not delighted with them, communicate with us and we will see that your money is refunded.

Radior Articles	
[illegible]	$2
[illegible]	$1
[illegible]	$1
[illegible]	$2
[illegible]	$2
[illegible]	$10
[illegible]	$5
[illegible]	$2

Write Today for This Vitally Interesting Booklet

This is probably the most revolutionary booklet on the subject of Beauty ever published. You who have imagined that all had been done for Beauty which could be done should lose no time in availing yourself of this "new knowledge." Investigate the subject of "Radium and Beauty."

The booklet is revised from the book "Radium—Its Discovery and Power," by C. Arry, one hundred and twenty thousand copies of which have been distributed in England. It is yours with our compliments. To secure your copy before our first edition is exhausted, mail the coupon NOW.

RADIOR CO., LTD., of LONDON.
235 Fifth Ave., New York.

Gentlemen: Please mail me a copy of your booklet, "Radium and Beauty." I understand that this request places me under no obligation to you.

Name .....

Address .....

.....

RADIOR TOILET REQUISITES OBTAINABLE AT
Leading Department Stores of New York, Brooklyn and Newark
and
Liggett's Drug Stores

Radior
Toilet Requisites

Sole Manufacturers
Radior Co., Ltd., of London
235 Fifth Avenue, New York 187 Oxford St., London, W. 1.
If your Dealer cannot supply you communicate with us.

DRINK

SEE TESTIMONIALS

Over 100,000 people now drinking Radio-Active water from Revigators in Texas. Write or phone any of them—ask them about results they have obtained.

The REVIGATOR

—is the most Remarkable Invention of the Day. WHY?—Because of what it does for Humanity.

Radio-Active Water From the Revigator

Government tests show Revigator equally radio-active to the greatest Health Springs in the country

YOUR HEALTH IS YOUR WEALTH

HERE ARE JUST A FEW NAMES OF THE MANY THOUSANDS OF SATISFIED USERS

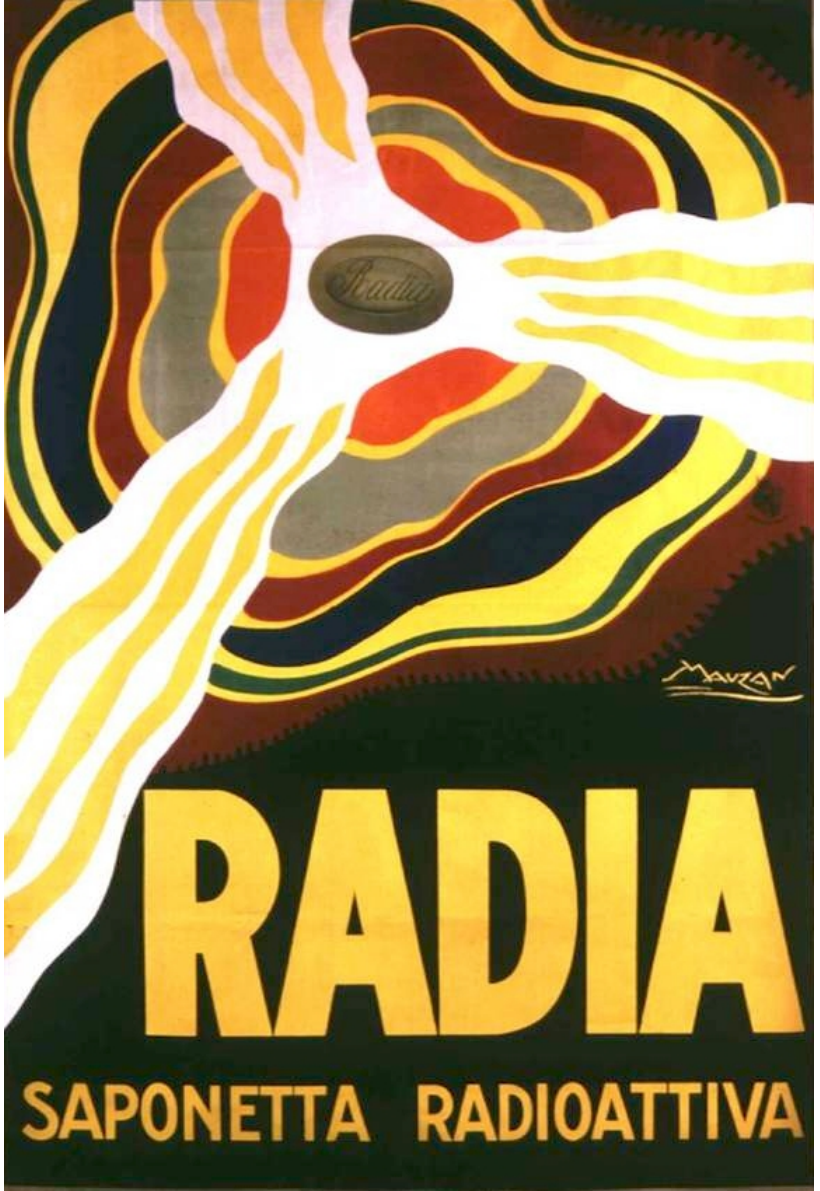
F. A. LOVELESS, 204 West Eighth Street, Fort Worth, Texas.
CLAY FRANCIS, Waco, Texas.
W. T. ELDRIDGE, Sugarland Industries, Sugarland, Texas.
JUDGE J. M. MATTHEWS, Harrisburg, Texas.
[illegible], Dallas, Texas.
JOHN M. MATHIS, SR., Attorney, 3508 Montrose Ave., Houston, Texas.
MRS. F. A. BUCKELEW, 5624 Willis Avenue, Dallas, Texas.
DR. H. W. STRAUSS, 1510 Main Street, Houston, Texas.
DR. GENEVIEVE LAUGHLIN, 2108 Live Oak Street, Dallas, Texas.
DR. J. F. KING, 1714 Hawthorn Street, Houston, Texas.
KENNETH W. MAYS, D. D. S., 3124 Main Street, Houston, Texas.
L. J. FLEMING, 318 Central Trust Building, San Antonio, Texas.
R. W. CROWDER, 2307 Ninth Street, Lubbock, Texas.
H. NEVELSON, 2230 C Street, Galveston, Texas.
J. W. SIMS, 310 Peach Street, Abilene, Texas.
MISS OPAL TEPE, Canadian, Texas.
MRS. W. F. HOLLAND, Miami, Texas.
SAM HINKLE, Dallas, Texas.
J. S. CAMERON, Pittsburg, Okla.
LEE MURPHY, Chanute, Okla.
J. L. McCARTY, Briggs, Texas.
J. J. LAMON, Baird, Texas.
J. H. McDONALD, Cisco, Texas.
G. T. SHATTUCK, 113 West Austin, Marshall, Texas.

A TRULY REMARKABLE INVENTION

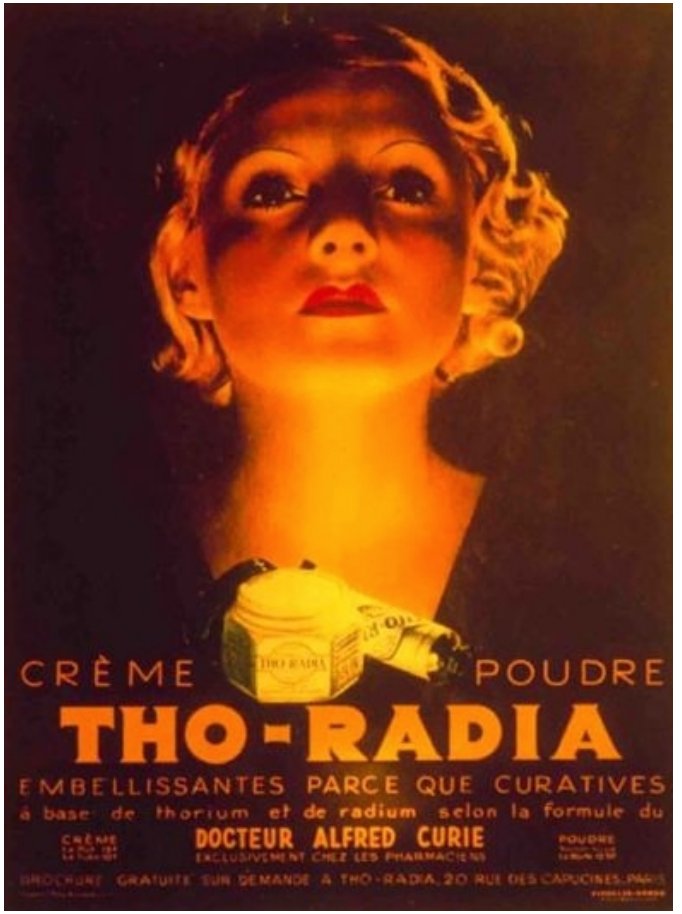
Just fill the Revigator at night. The water remains in contact with the radium ore walls 12 hours. By morning the water has returned to that healthful state found only in genuinely fresh water right at the springs. It is flavorless and odorless and is neither a medicine nor a drug. Just that restored element of freshness generated by the tiny explosions that occur when the radium rays strike the water. This water gives such health and vigor that science calls it "the vitamin element of water." You have never tasted water so soft and palatable except at genuine radio-active health springs.

PRONOUNCED RE-VIG-A-TOR

"Your Most Highly Prized Possession: Good Health"

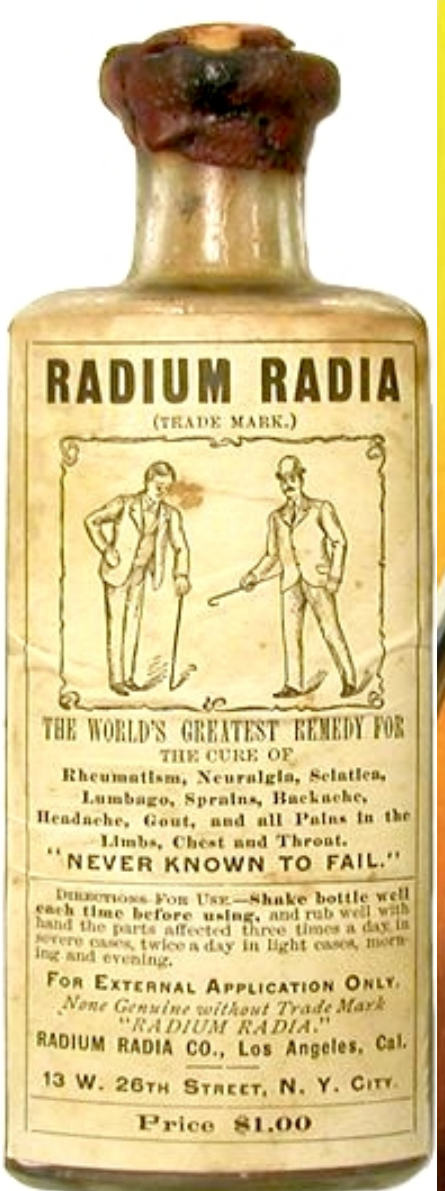

Radia
MAUZAN
RADIA
SAPONETTA RADIOATTIVA


RADIOCRÈMELINE


CRÈME
POUDRE
THO-RADIA
EMBELLISSANTES PARCE QUE CURATIVES
à base de thorium et de radium selon la formule du
DOCTEUR ALFRED CURIE
EXCLUSIVEMENT CHEZ LES PHARMACIENS
BROCHURE GRATUITE SUR DEMANDE A THO-RADIA, 20 RUE DES CAPUCINES, PARIS


Burkbraun
RADIUM
SCHOKOLADE
NACH Dr. SENFTNER
DEUTSCHES REICHSPATENT u. AUSLANDSPAT.
RADIUM


IRADIA
SOUS-VÊTEMENTS
RADIOACTIFS
DU DOCTEUR
BAURAY
IMP. DE LA MÉDITERRANÉE


RADIUM RADIA
(TRADE MARK.)
THE WORLD'S GREATEST REMEDY FOR
THE CURE OF
Rheumatism, Neuralgia, Sciatica,
Lumbago, Sprains, Backache,
Headache, Gout, and all Pains in the
Limbs, Chest and Throat.
"NEVER KNOWN TO FAIL."
DIRECTIONS FOR USE.—Shake bottle well each time before using, and rub well with hand the parts affected three times a day in severe cases, twice a day in light cases, morning and evening.
FOR EXTERNAL APPLICATION ONLY.
None Genuine without Trade Mark
"RADIUM RADIA."
RADIUM RADIA CO., Los Angeles, Cal.
13 W. 26TH STREET, N. Y. CITY.
Price $1.00


CONSEGNATA APPENA ESTRATTA: VIVA COME ALLE SORGENTI
LURISIA
L'ACQUA PIU' RADIOATTIVA DEL MONDO

TORCHON

RADIUM

plus d'odeurs

plus de blessures

se nettoie facilement

REMPLACE L'ÉPONGE MÉTALLIQUE

EAU MINERALE DES ABATILLES

ADMISE DANS LES HOPITAUX DE LA MARINE

SOURCE LA SANTÉ DES REINS STE ANNE

THERMALE JAILLISSANTE RADIOACTIVE

0,10 millimicrocurie

Captée à 465 m ce qui garantit sa pureté absolue, l'Eau des Abatilles Source Ste Anne élimine puissamment l'acide urique, les sables et les calculs.

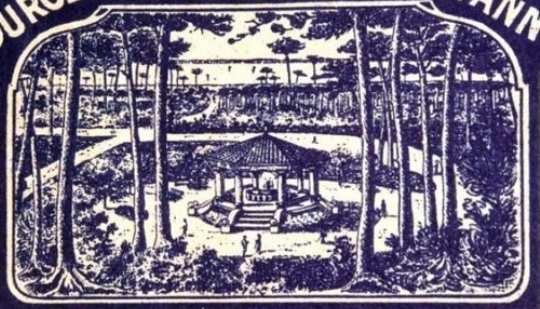
Eau unique par ses ions d'Iode et de Brome, elle combat les scléroses.

Par son magnésium, elle prévient la carence magnésienne génératrice de cancer et d'usure prématurée. Elle active les fonctions rénales et hépatiques.

Par sa pureté
Par sa légèreté
Par sa minéralisation

l'Eau des Abatilles est une Eau de table d'une valeur **incomparable.**

Eau idéale pour assurer la filtration et l'excrétion rénale.



PRÉVIENT L'URÉMIE

Autorisation ministérielle après avis de l'Académie de Médecine en date du 30 Juillet 1925

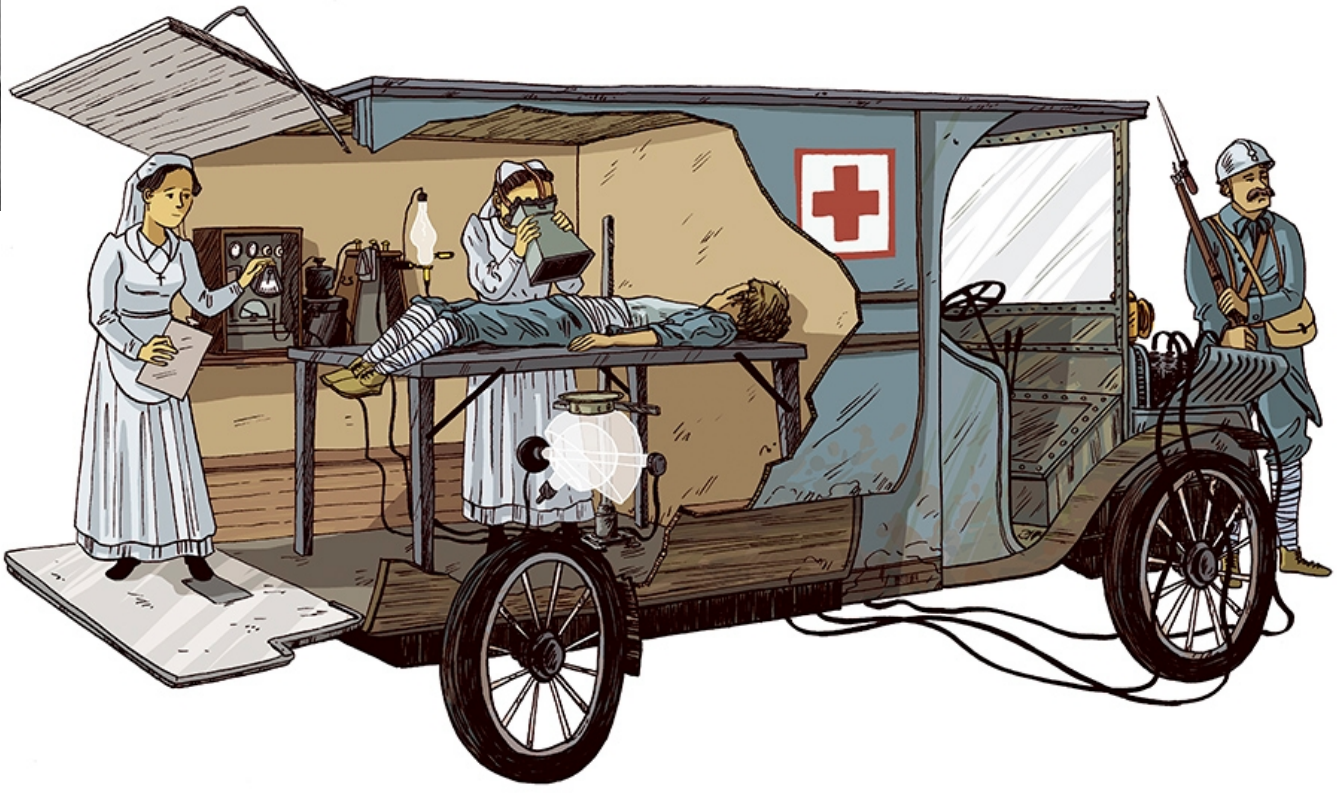
Propriété de la SOCIÉTÉ THERMALE DES ABATILLES
ARCACHON R.C. Bx 5160 B.
Société anonyme au capital de 10.363.500 Francs

ANALYSE
faite au Laboratoire de l'Académie de Médecine

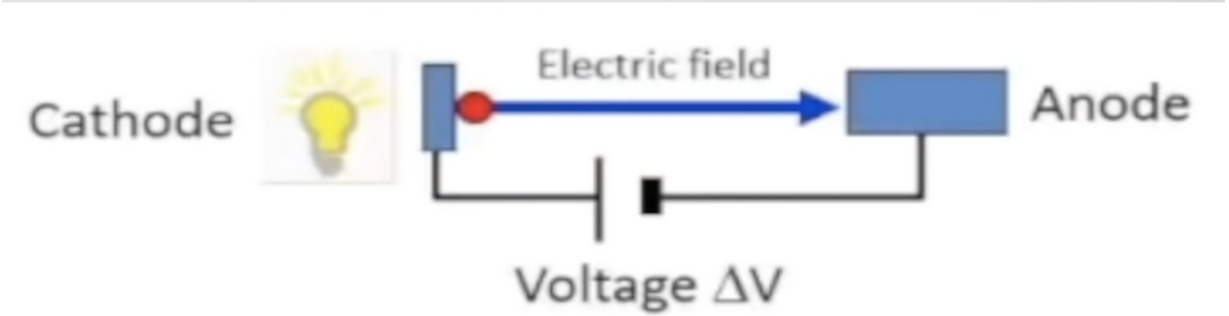
Acide carbonique.	0,0591
Chlore (Cl)	0,0809
Acide sulfurique	0,0099
Silice	0,0137
Sesquioxydes	*Traces*
Calcium (Ca)	0,0167
Sodium	0,0549
Magnésium (Mg)	0,0086
Brome	*Traces*
Iode	*Traces*
Total	0,2438

Néphrite — Pyélonéphrite
Colibacillurie
Albuminurie
Urémie — Mal de Bright
Crises nerveuses
Pyurie — Cystite
Prostatisme
Artériosclérose
Hypertension
Vertiges — Bourdonnements
Arthritisme — Goutte
Migraine — Asthme
Prurits — Eczéma
Infections urinaires
Intoxications — Grossesse
Pyrexies — Septicémie

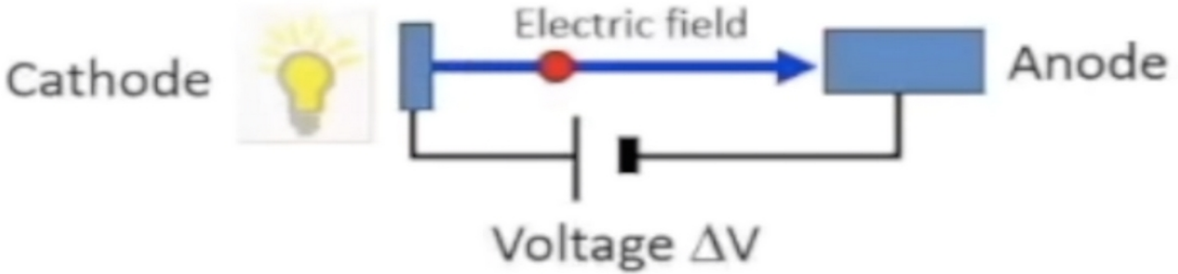
Le Petit Curie



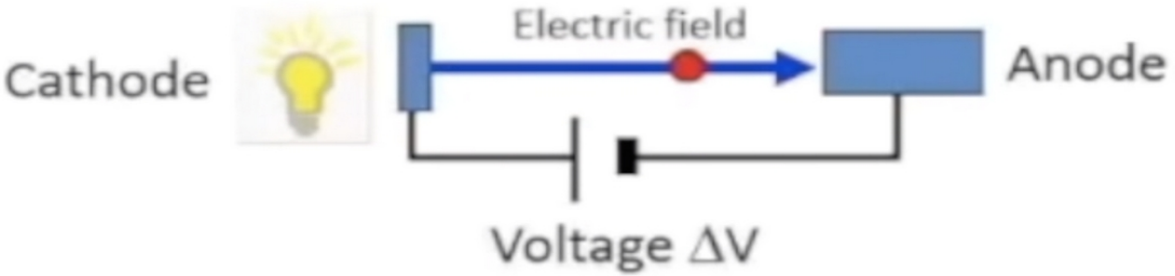
Ma come era fatto lo strumento di Röntgen?



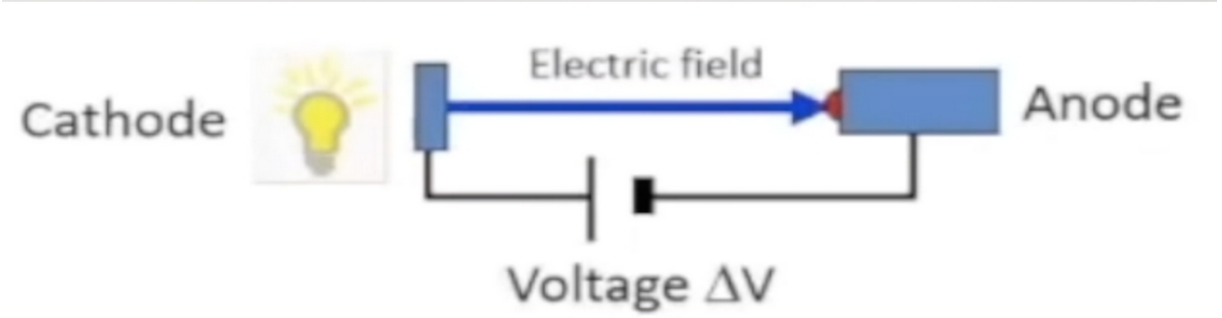
Ma come era fatto lo strumento di Röntgen?



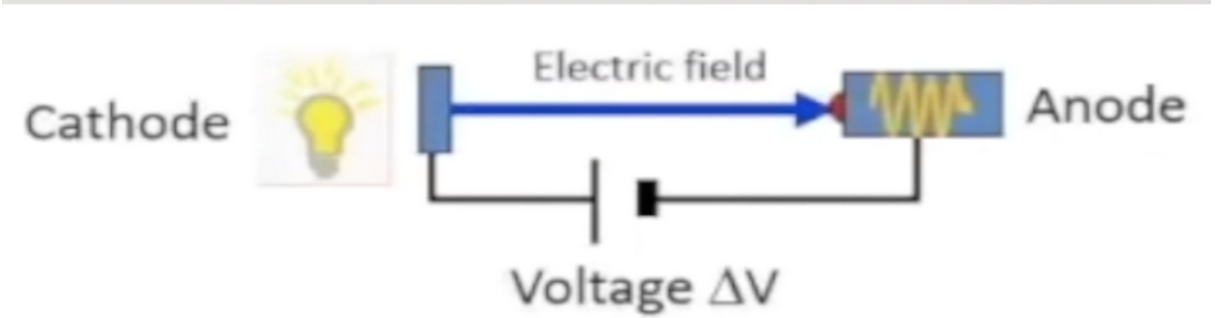
Ma come era fatto lo strumento di Röntgen?



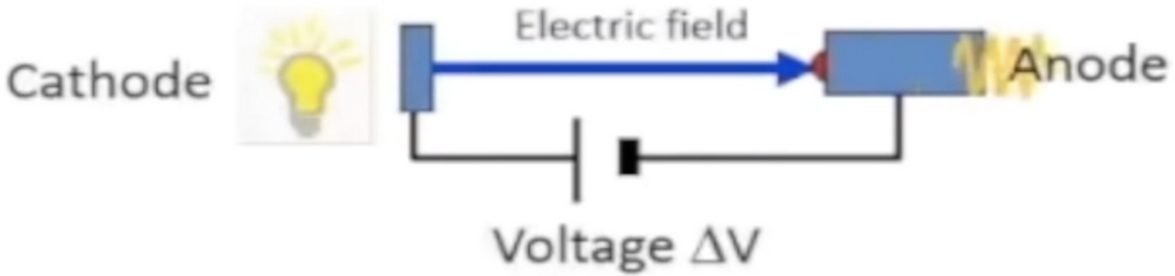
Ma come era fatto lo strumento di Röntgen?



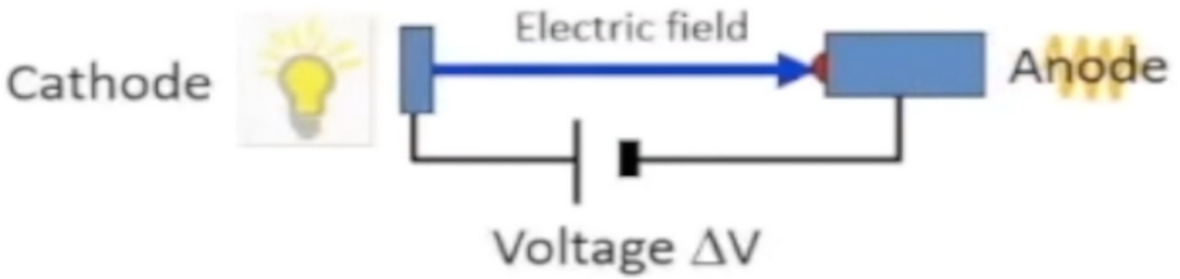
Ma come era fatto lo strumento di Röntgen?



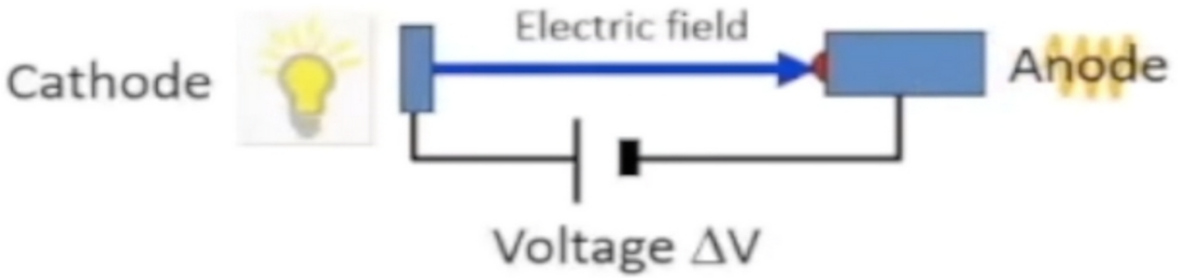
Ma come era fatto lo strumento di Röntgen?

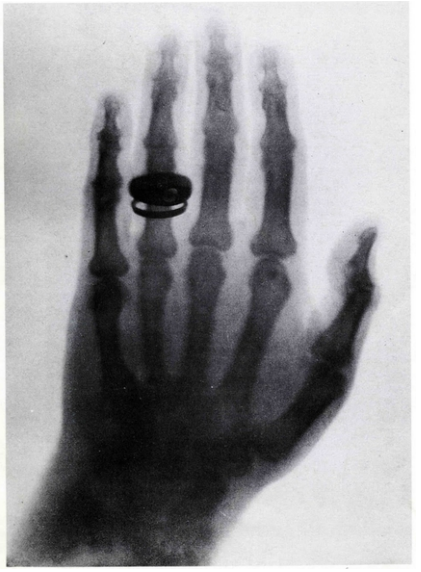


Ma come era fatto lo strumento di Röntgen?



Ma come era fatto lo strumento di Röntgen?





Ernest Rutherford

Il padre della fisica nucleare: Ernest Rutherford usa particelle alpha (atomi di elio) da elementi radioattivi per studiare reazioni nucleari, riuscendo ad osservare la trasmutazione di azoto in un isotopo dell’ossigeno

Ernest Walton Ernest Rutherford John Cockcroft

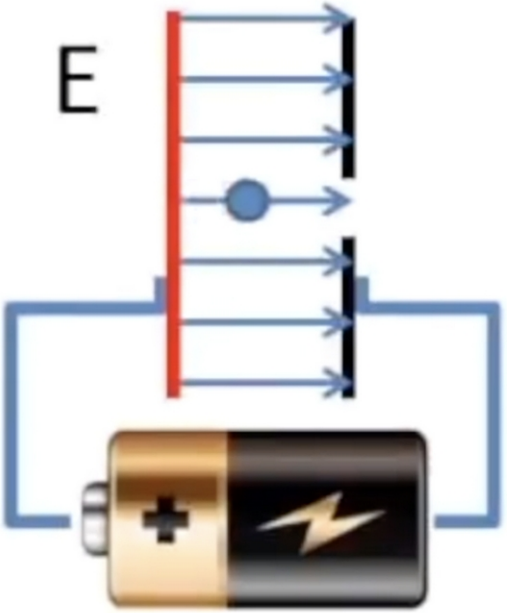
Nel 1932, al Cavendish Laboratory di Cambridge, **Cockcroft** e **Walton**, realizzarono un moltiplicatore di tensione di nuova concezione.
Accelerando protoni a 700 keV e facendoli impattare su un bersaglio di litio, fu possibile la prima disintegrazione nucleare artificiale della storia

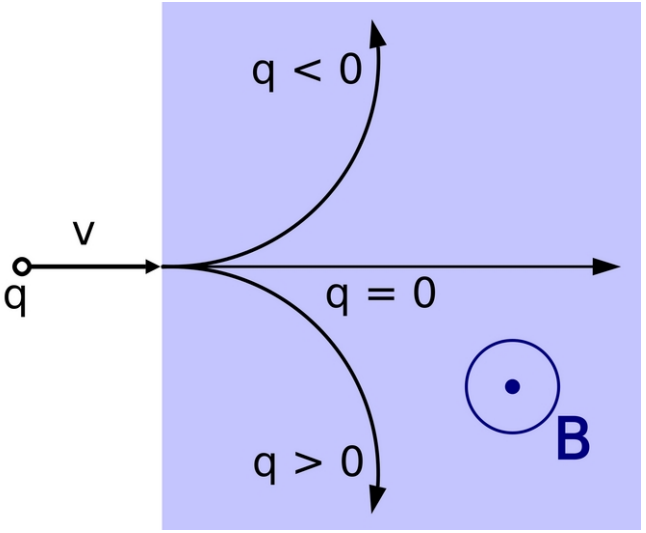
P + Li -> He + He

Nel 1951 vinsero loro il Premio Nobel per la Fisica per la "trasmutazione di nuclei atomici da particelle atomiche accelerate artificialmente".

Elementi base
di un acceleratore di particelle

Accelerare





Deflettere

Focheggiare

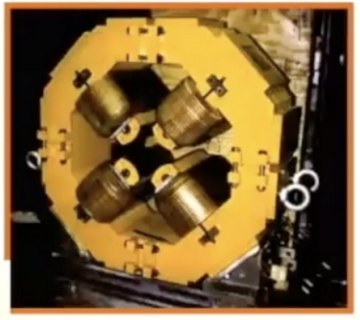
Quadrupoli magnetici

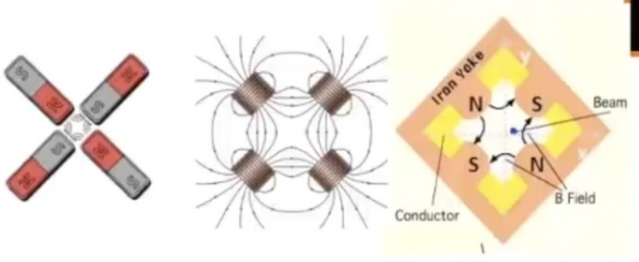
QUADRUPOLO: FOCHEGGIAMENTO

E' un magnete con **4 poli che focheggia le traiettorie delle singole particelle** così come fa una lente con la luce.

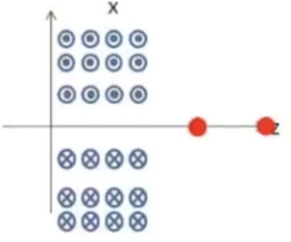
Caratteristiche di B

- B=0 al centro
- L'intensità di **B cresce linearmente** ed in maniera proporzionale allo spostamento rispetto all'asse di riferimento





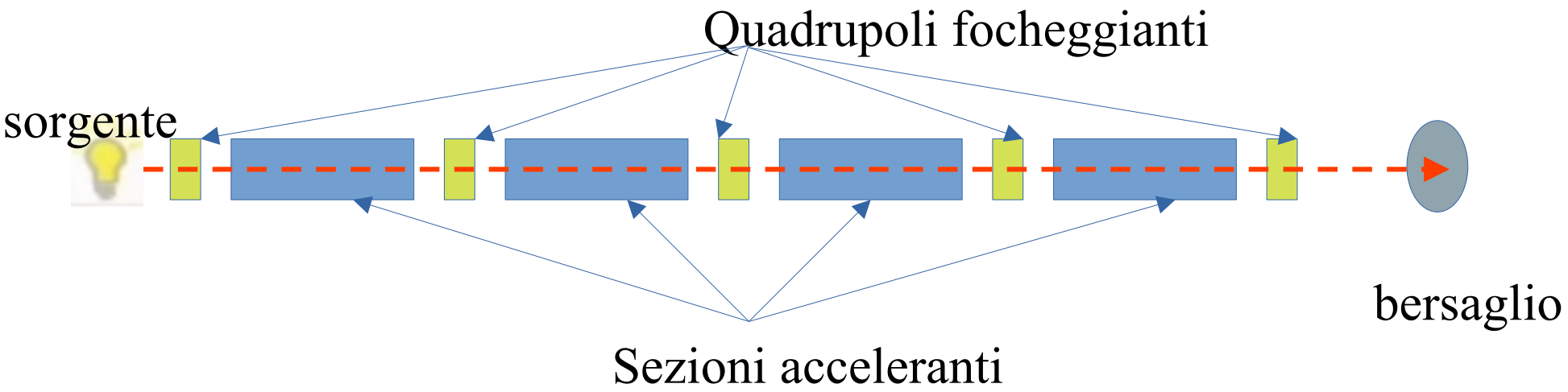
$$B_x = g \cdot y$$
$$B_y = g \cdot x \qquad g = \left[\frac{T}{m}\right]$$



01 - Alesini 5 - quadrupoli focheggianti.mp4

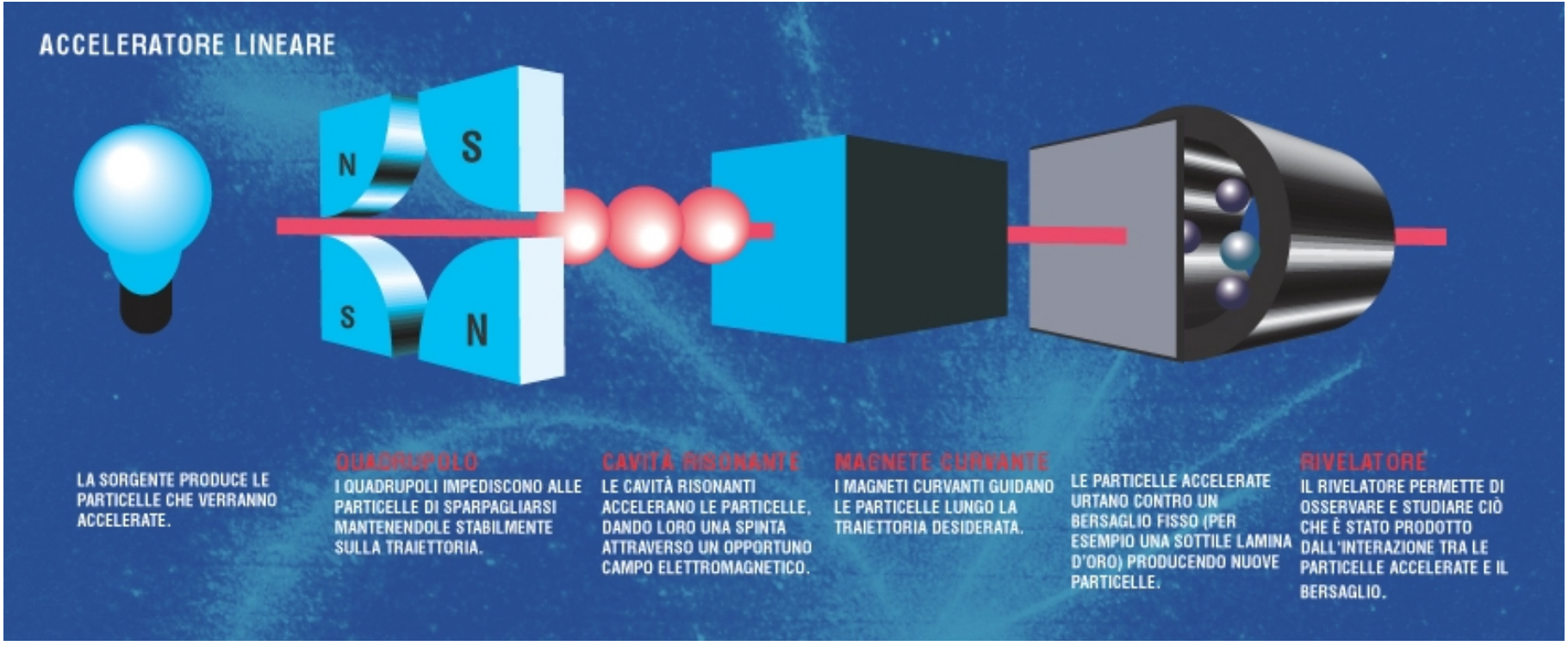
Alesini - Gli acceleratori di particelle - da microscopi subatomici a strumenti per la medicina
https://www.youtube.com/watch?v=cAx10c_xrtU
https://www.youtube.com/watch?v=kigQa-ZFcSw

Acceleratori lineari

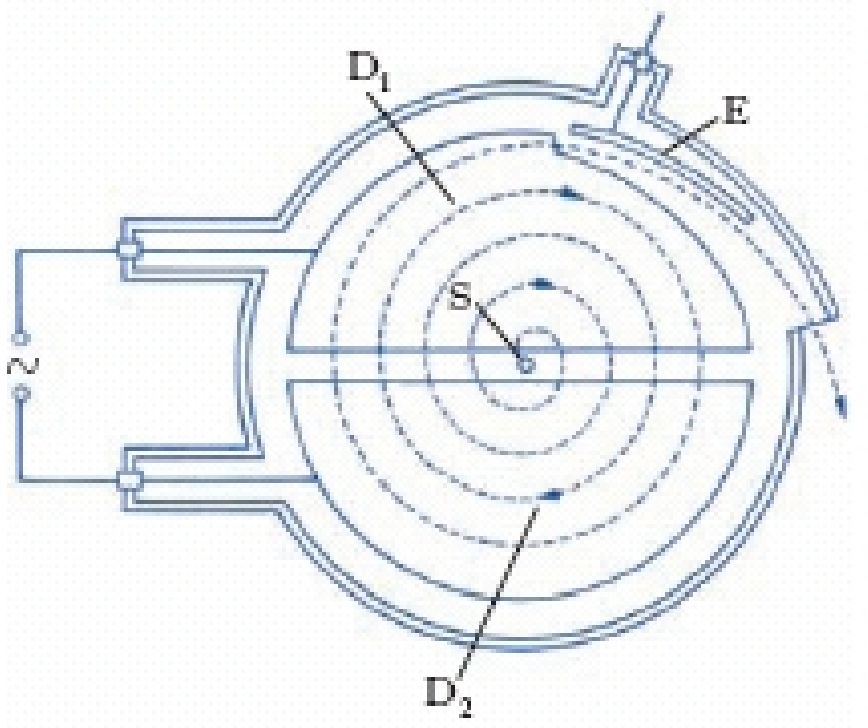


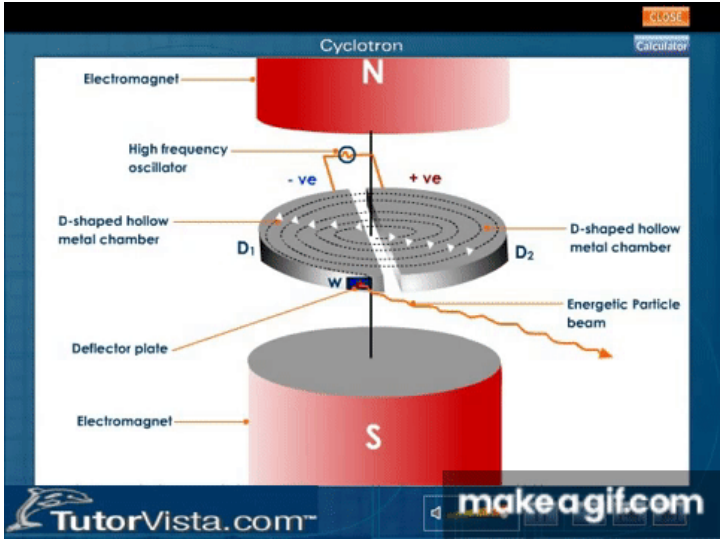
Diagnostica
Controlli
Vuoto

Lineari


ACCELERATORE LINEARE
N
S
S
N
LA SORGENTE PRODUCE LE PARTICELLE CHE VERRANNO ACCELERATE.
QUADRUPOLO
I QUADRUPOLI IMPEDISCONO ALLE PARTICELLE DI SPARPAGLIARSI MANTENENDOLE STABILMENTE SULLA TRAIETTORIA.
CAVITÀ RISONANTE
LE CAVITÀ RISONANTI ACCELERANO LE PARTICELLE, DANDO LORO UNA SPINTA ATTRAVERSO UN OPPORTUNO CAMPO ELETTROMAGNETICO.
MAGNETE CURVANTE
I MAGNETI CURVANTI GUIDANO LE PARTICELLE LUNGO LA TRAIETTORIA DESIDERATA.
LE PARTICELLE ACCELERATE URTANO CONTRO UN BERSAGLIO FISSO (PER ESEMPIO UNA SOTTILE LAMINA D'ORO) PRODUCENDO NUOVE PARTICELLE.
RIVELATORE
IL RIVELATORE PERMETTE DI OSSERVARE E STUDIARE CIÒ CHE È STATO PRODOTTO DALL'INTERAZIONE TRA LE PARTICELLE ACCELERATE E IL BERSAGLIO.

Ciclotroni



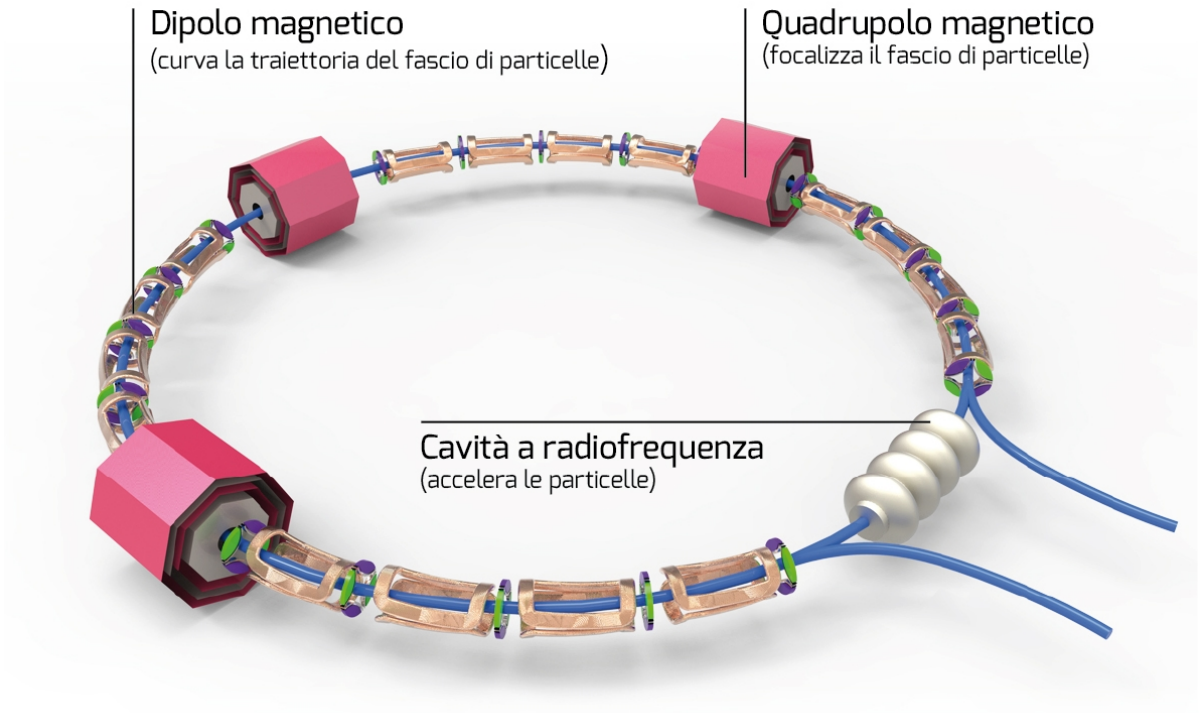


campo magnetico fisso

02 - ciclotrone.html

I ciclotroni si usano ancora oggi, per esempio per la produzione di radioisotopi per la radioterapia

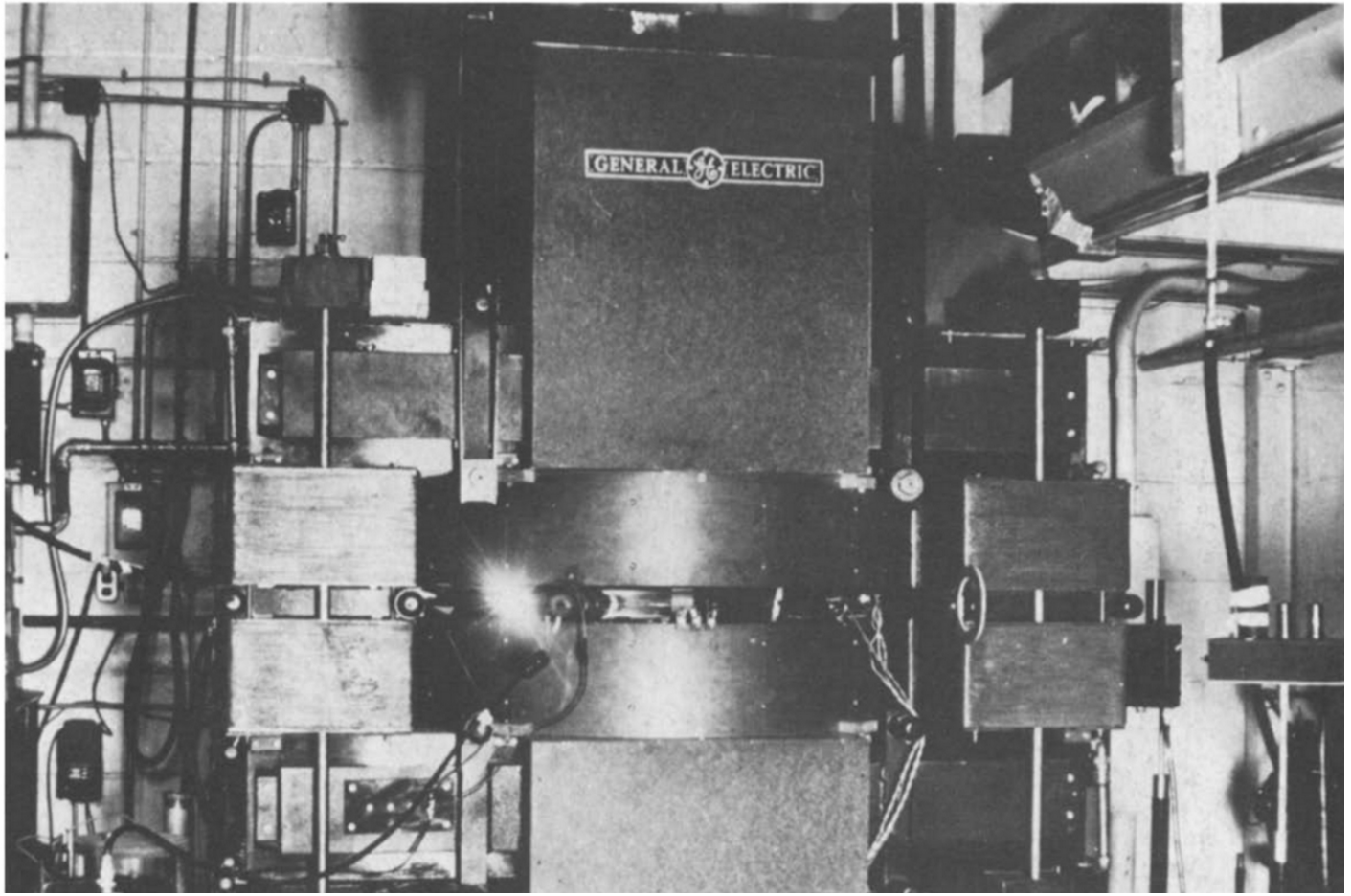
Sincrotroni



Campi magnetici variabili

La luce di sincrotrone

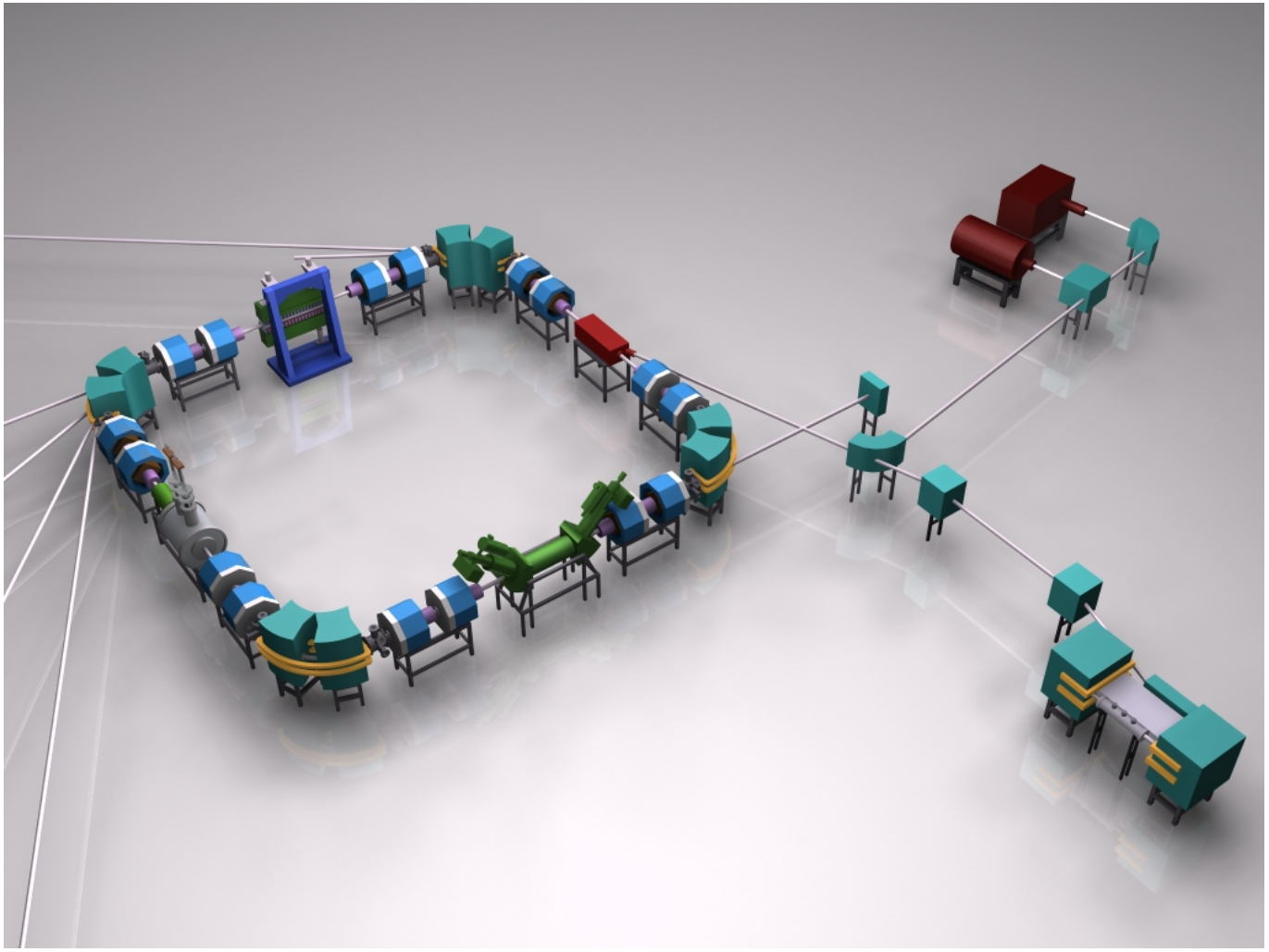
Già dalla meccanica classica si sapeva che particelle cariche accelerate emettono luce.



1947 – Sincrotrone di 70Mev presso i laboratori di ricerca
della General Electric a Schenectady
Una finestra di vetro ha permesso di “vedere” per la prima volta la luce di sincrotrone

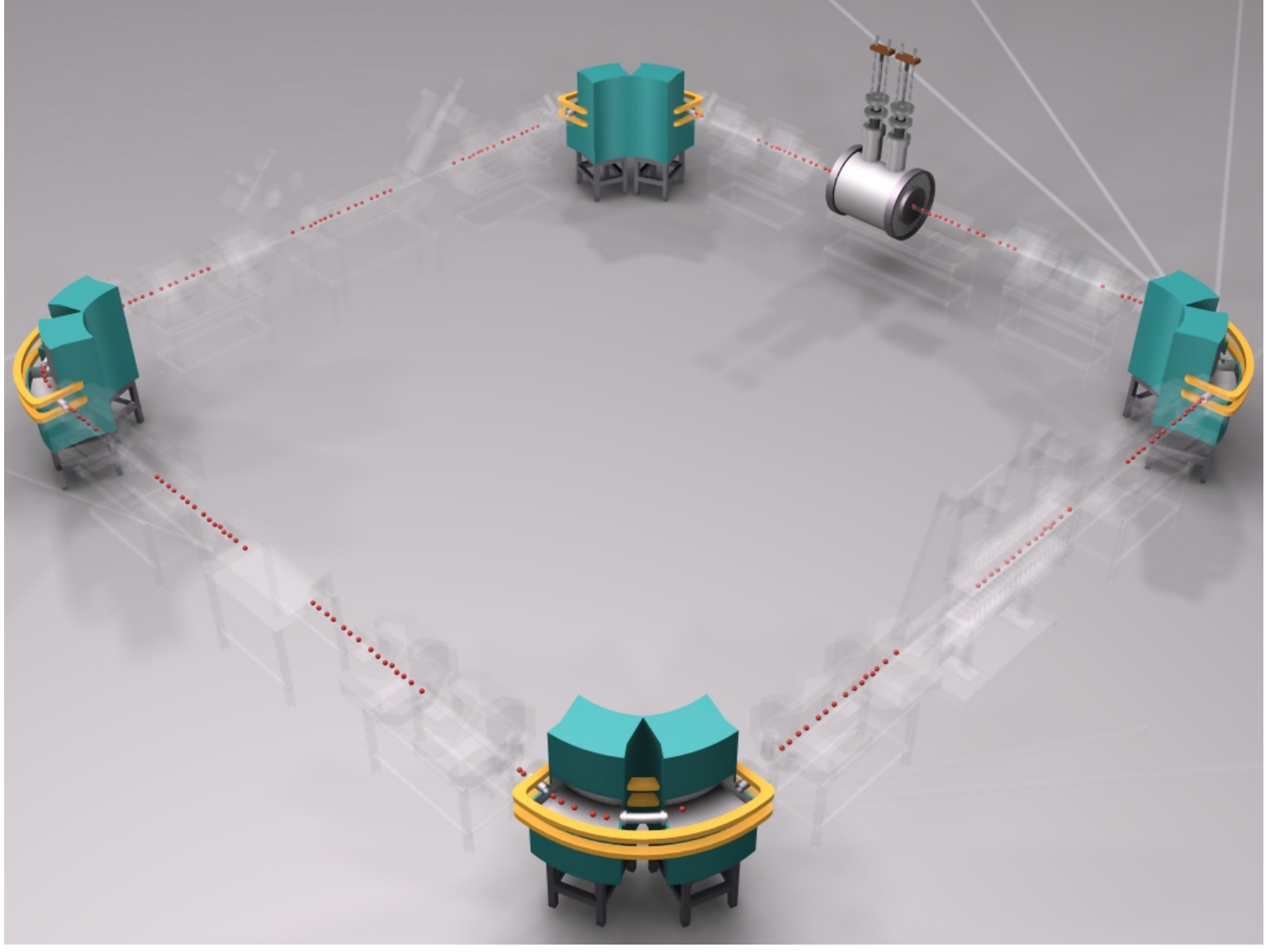
Bob Langmuir, Frank Elder, Toly Gurewitsch, Ernest Charlton and Herb Pollock

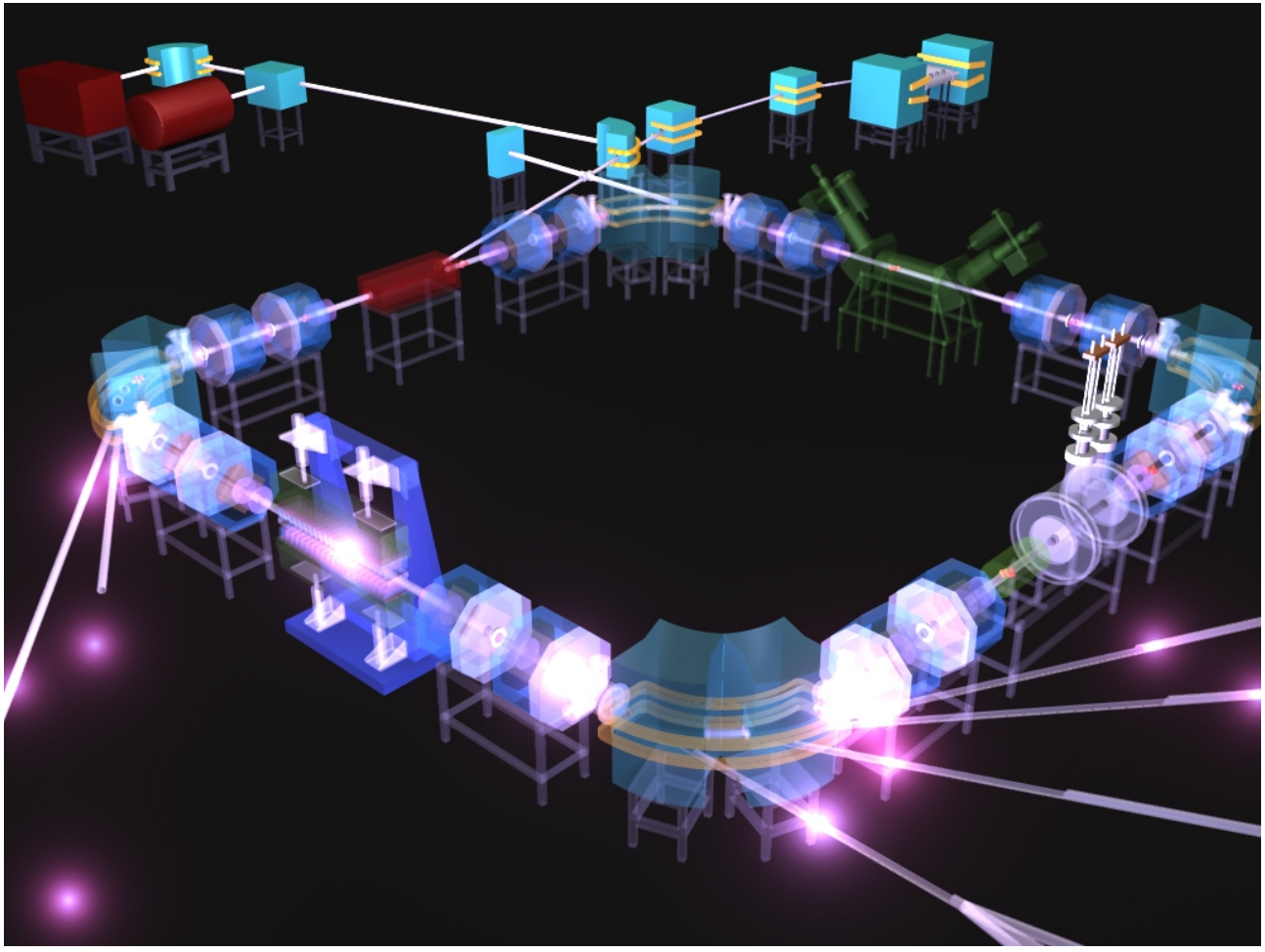
03 - luce 1947.mp4



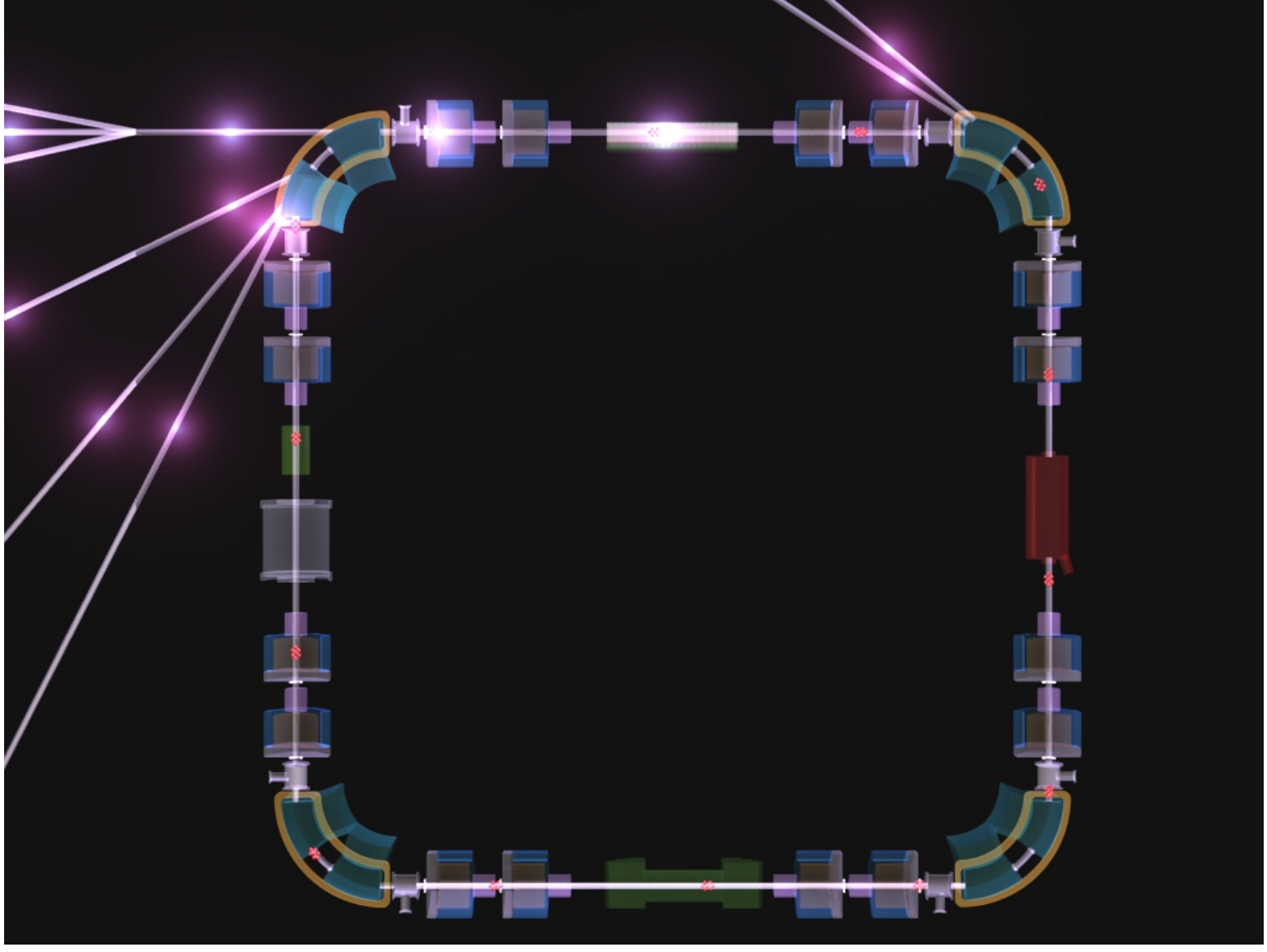
Luce di sincrotrone

https://www.isa.au.dk/animations/animations.asp





04 - sincrotrone2.mp4



Inizialmente la produzione di luce di sincrotrone è stata considerata solo una fastidioso fenomeno.
A Frascati, Stanford, Medison sorgono le prime attività dedicate all'uso della luce di sincrotrone a partire dagli anni '80.
Ora esistono laboratori in cui questa produzione è privilegiata

Nel 1978 parte a Frascati un progetto denominato PULS (Progetto Utilizzo Luce di Sincrotrone) che aveva il compito di studiare l'uso sistematico della radiazione emessa da ADONE per esperimenti nel campo della struttura della materia, in particolare vengono fatte le prime ricerche sulla spettroscopia di assorbimento di raggi X da stati profondi.

La luce, o meglio la radiazione elettromagnetica, è il principale mezzo di indagine nel campo scientifico

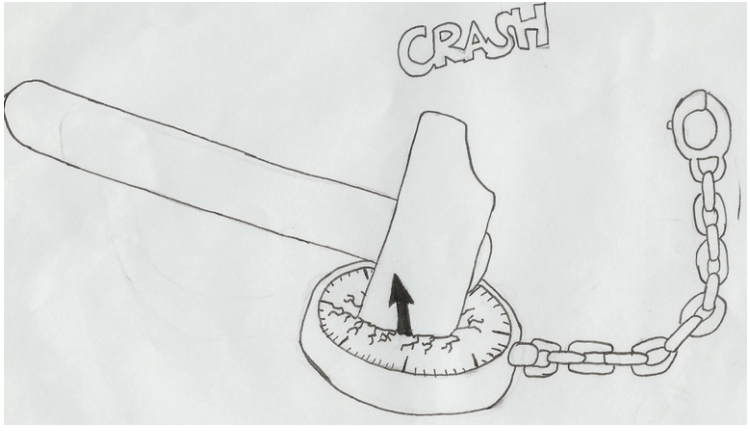
perché

la radiazione elettromagnetica si accoppia debolmente con la materia

↓

il sistema in esame e' debolmente perturbato

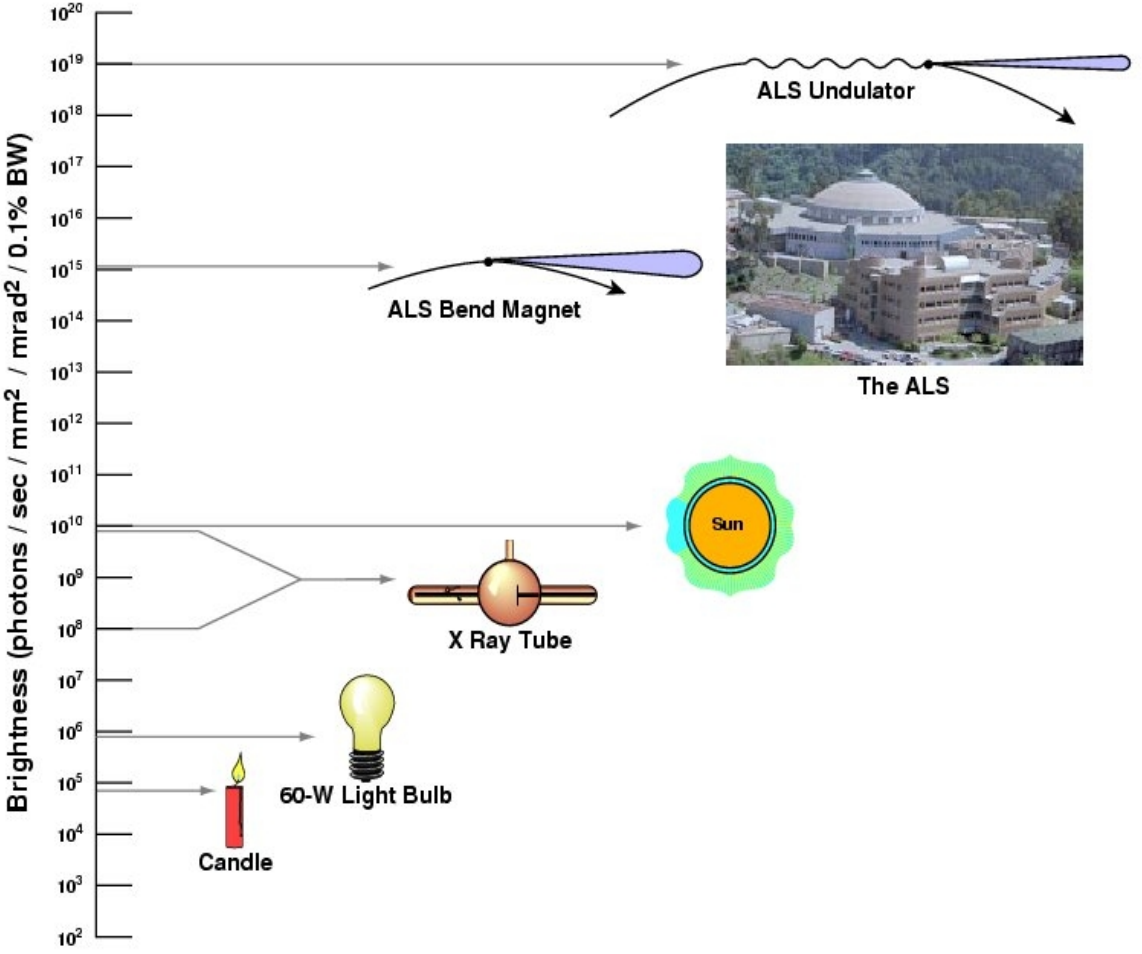
in altre parole si ha un mezzo di indagine non distruttiva della materia

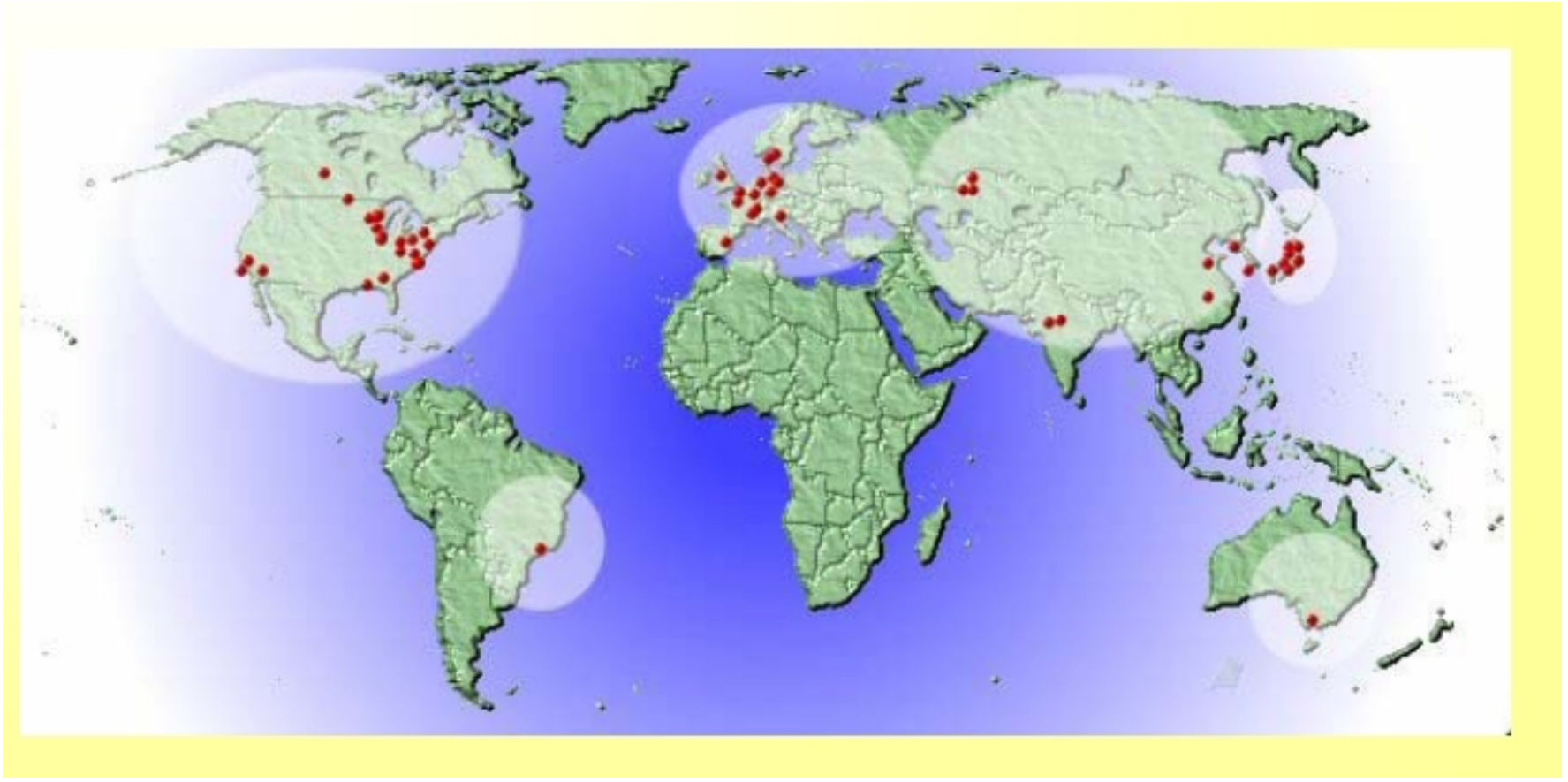


Inoltre la radiazione elettromagnetica si manipola facilmente (specchi, lenti, cristalli,…)

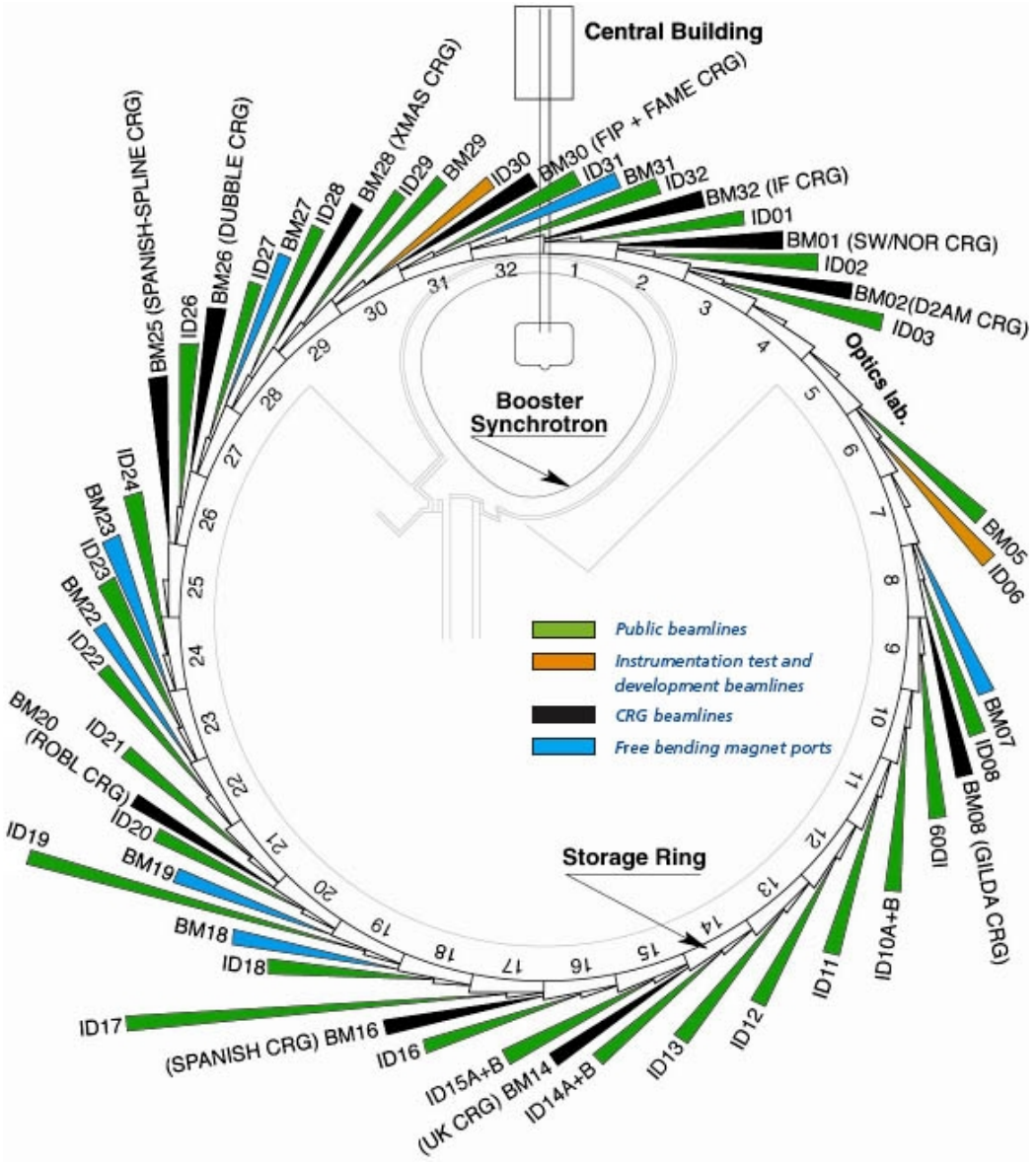
How Bright Is the Advanced Light Source?

ALS





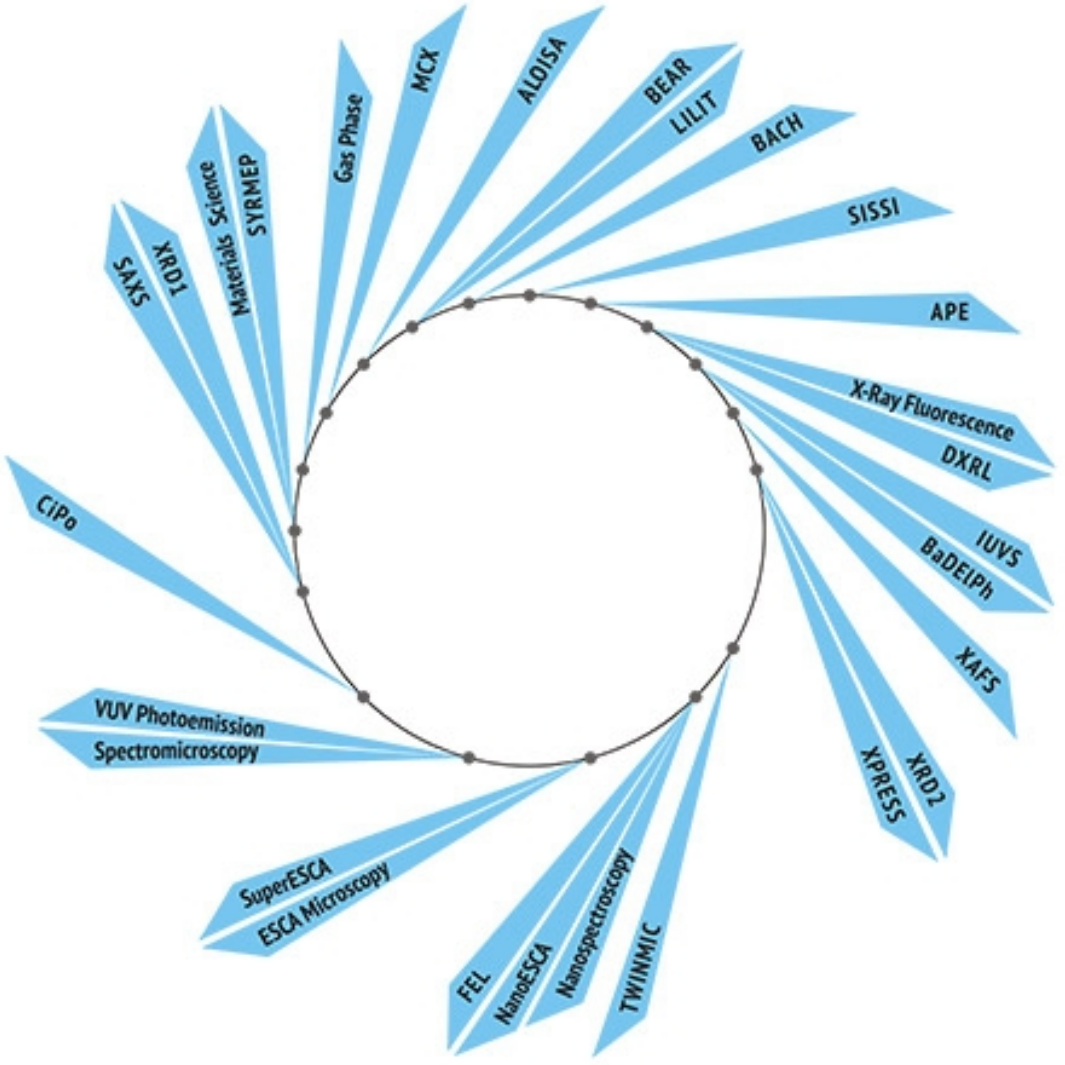
Le macchine dedicate nel mondo per la produzione di luce di sincrotrone – circa 40 funzionanti ed altre in costruzione



ESRF (Grenoble) 44 beam lines

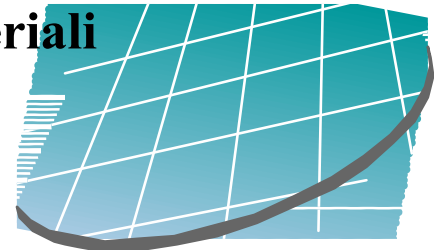
ELETTRA a Trieste

28 linee



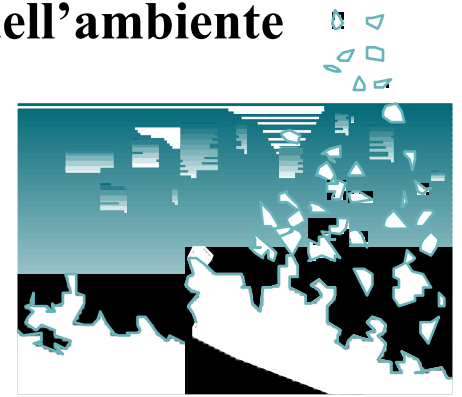
Dove si utilizza

- Scienze dei materiali



- biologia

- Scienze dell'ambiente

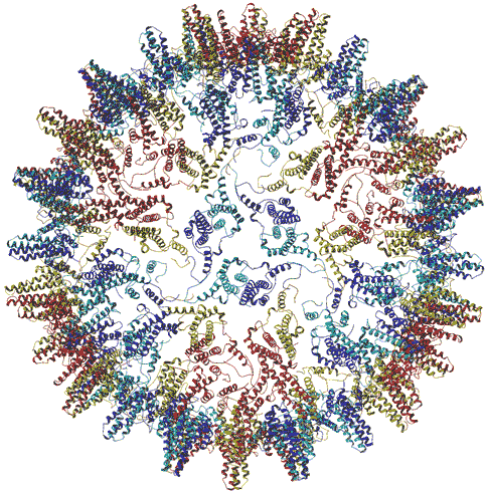


- medicina

- fisica

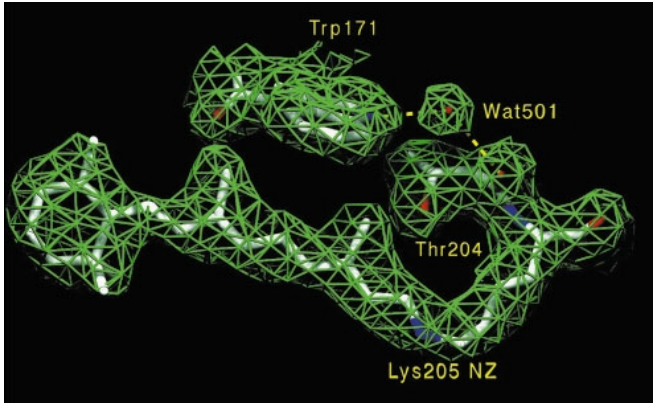
- chimica

Nei moderni sincrotroni la diffrazione viene principalmente usata per lo studio di strutture proteiche



Struttura del capside del virus dell'epatite B

Struttura della rodpsina, proteina specializzata nella trasformazione della luce solare in segnale riconoscibile e trasportabile al cervello.



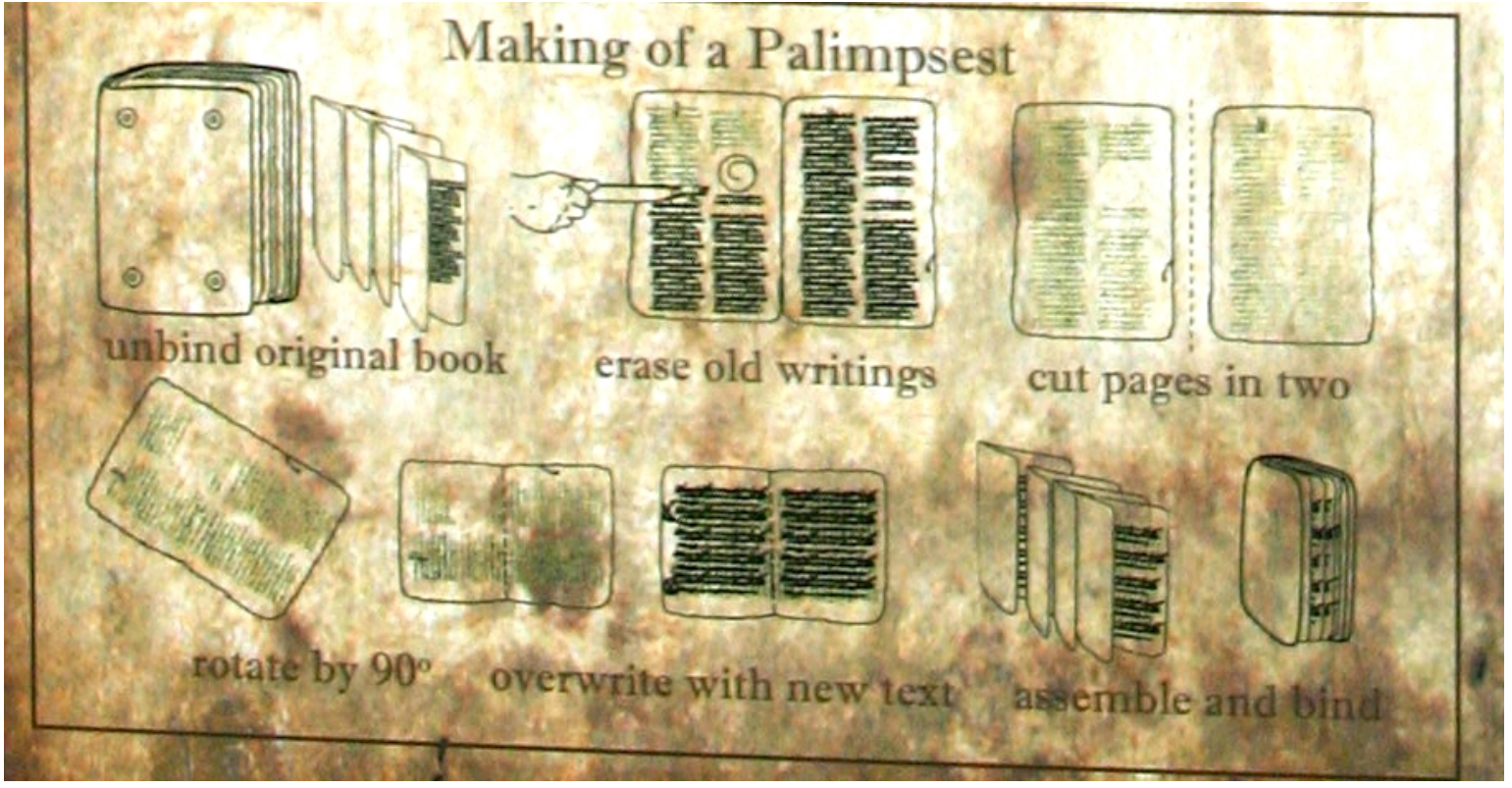
Lo stato chimico del mercurio nei pesci: a seconda dello stato chimico il mercurio puo’ essere piu’ o meno tossico

Villa dei Papiri (Ercolano)

Il caso del Palinsesto di Archimede

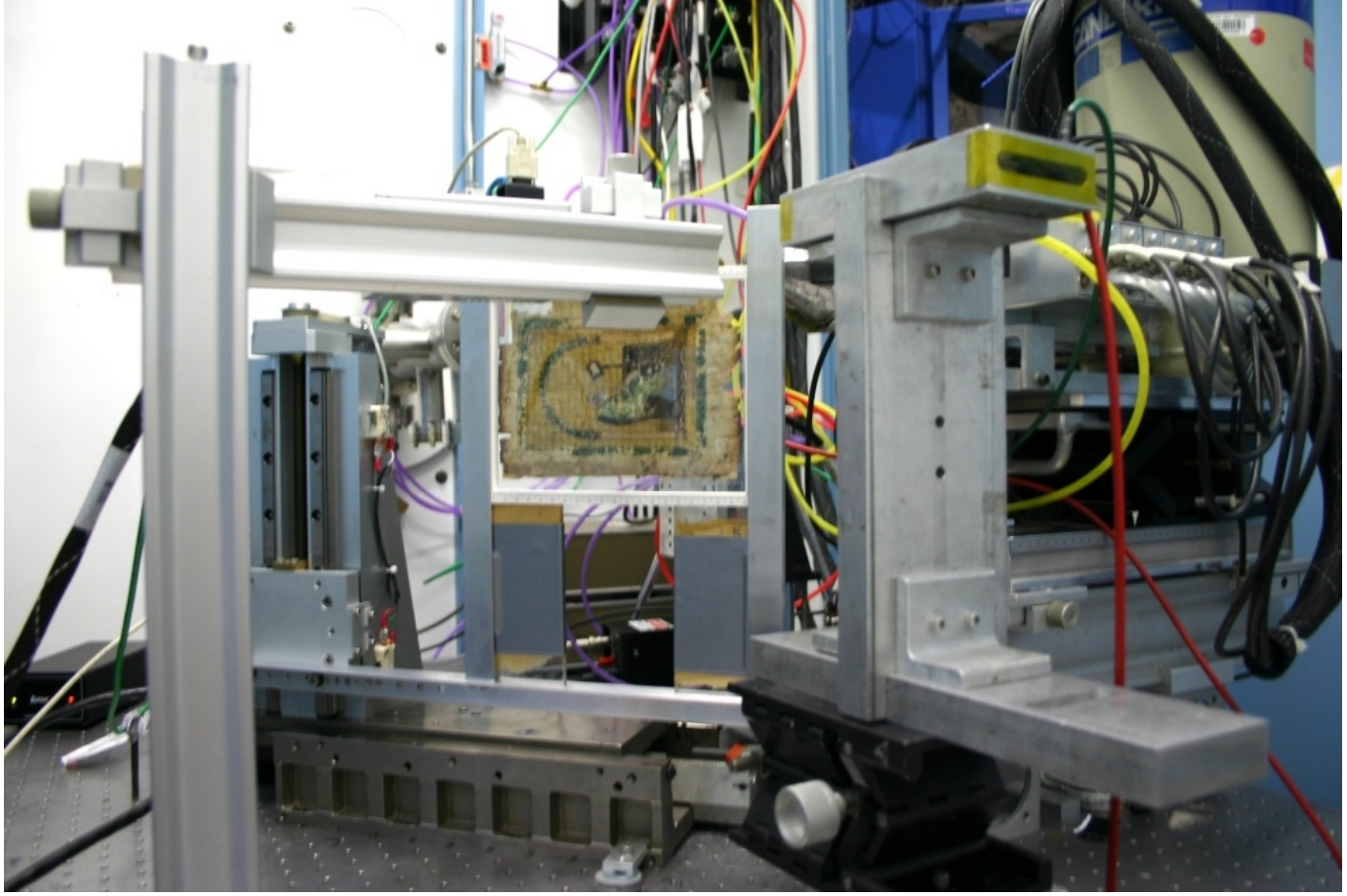
Nel 1906 il filologo J.L Heiberg scopre un libro di preghiere del 13° secolo di origine bizantina. Sotto lo scritto, in alcune parti, si osservava uno scritto in greco databile nel 10° secolo e che riportava copie di trattati scritti da Archimede e che erano andati perduti.

come si costruisce un palinsesto

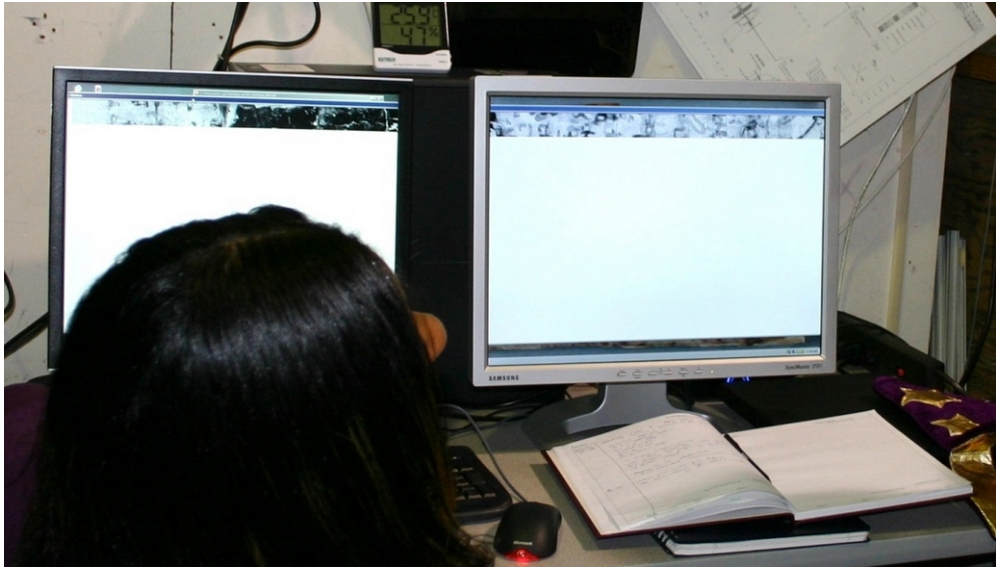


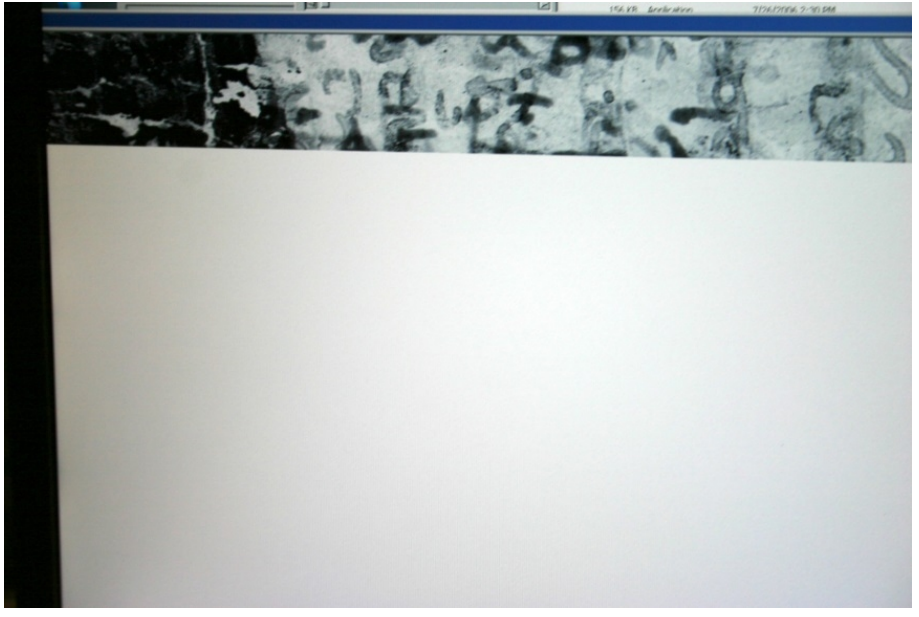
Vogliamo recuperare il primo scritto nascosto dal secondo intervento senza rovinare il libro come è ora.

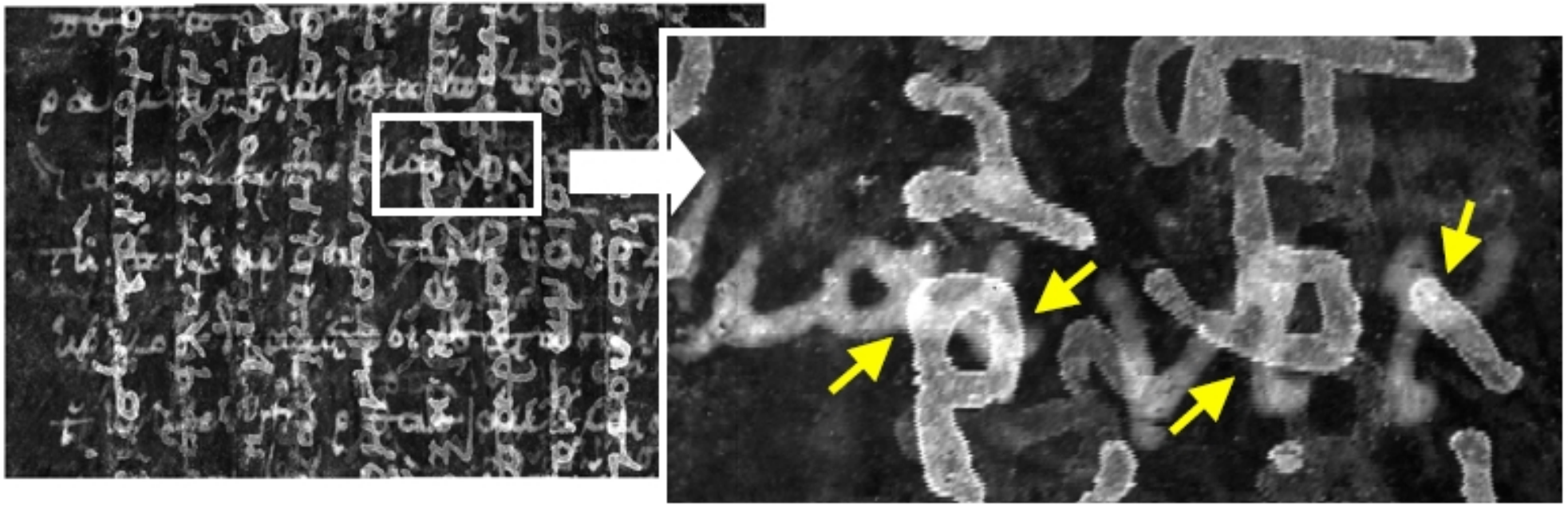
U. Bergmann
SSRL – Stanford, California

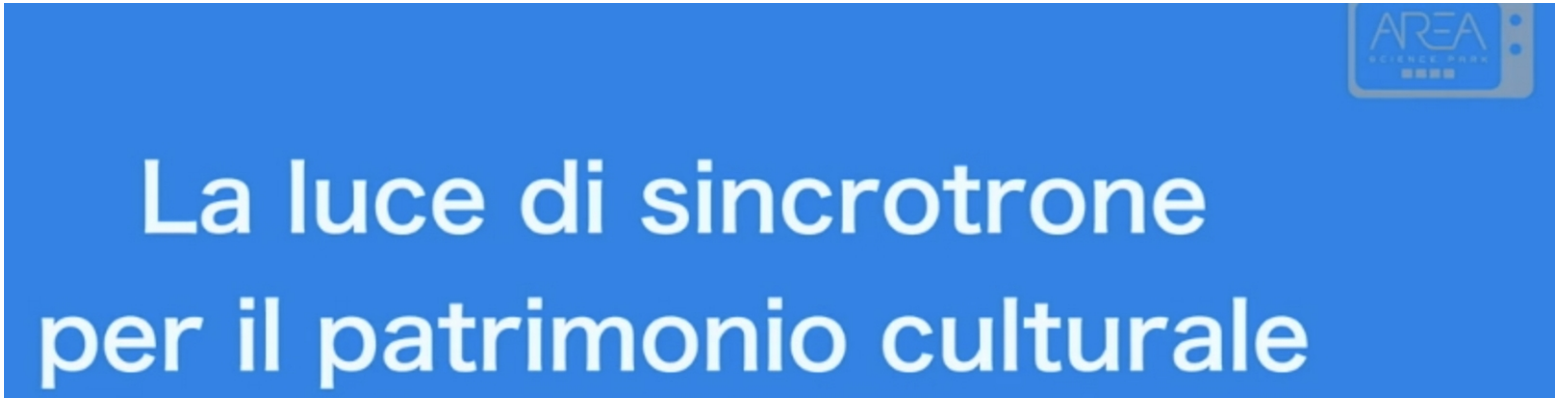


Con i raggi X si eccita il Fe, costituente principale dell'inchiostro usato nel 10° secolo: si rivela la fluorescenza emessa dalle parole sottostanti che sono scritte con questo tipo di inchiostro.


SAMSUNG







a Elettra, Trieste

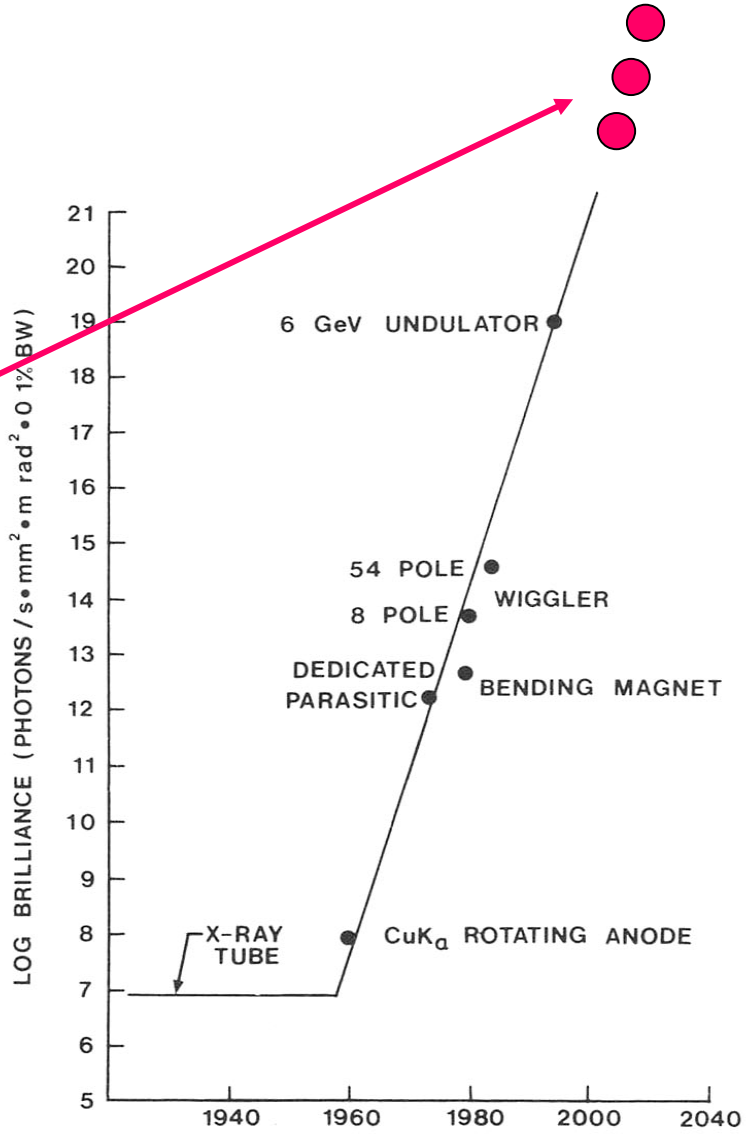
05 - dente della collana dell uomo di Neanderthal.mp4

La luce di sincrotrone per il patrimonio culturale ad Elettra (Trieste)

- Stradivari
- Monete antiche
- Un artiglio d’aquila rivela le capacità immaginative dei Neanderthal
- ….

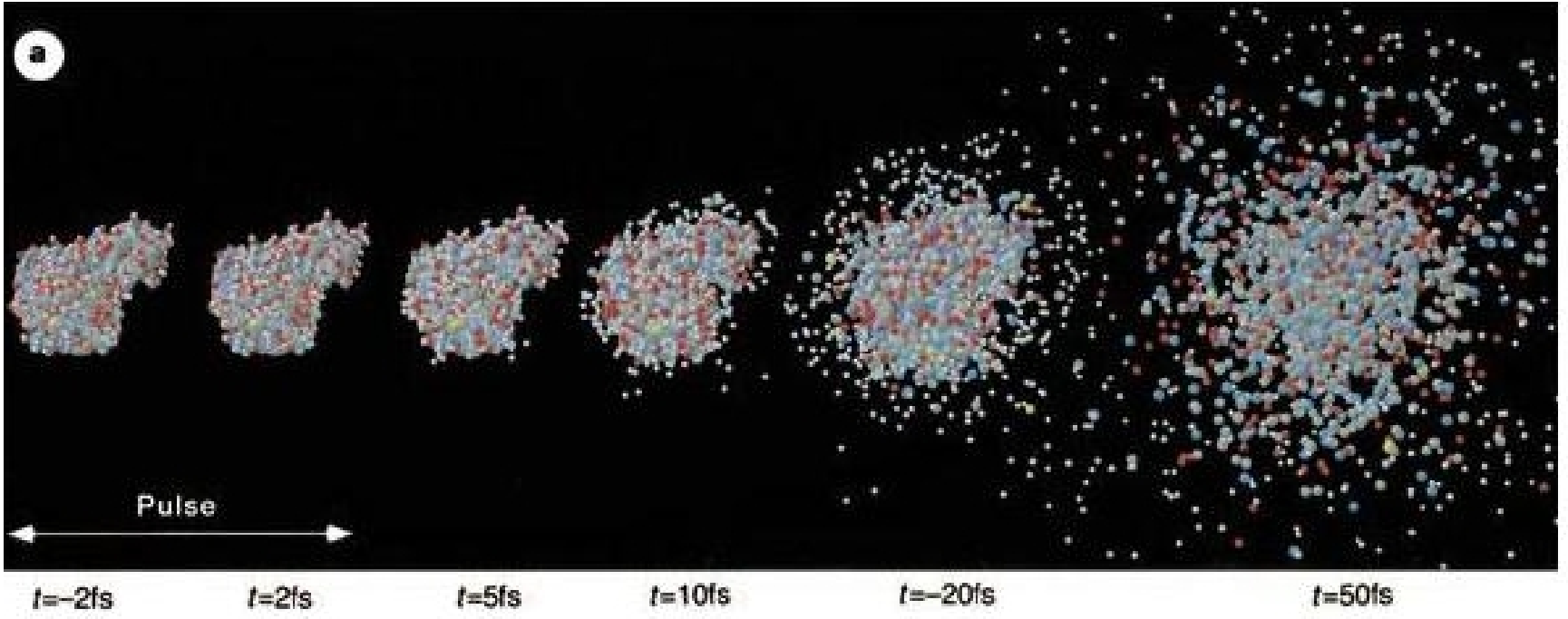
Sorgenti di 4th generazione: FEL (free electron laser)

Si cerca di aumentare la brillanza - le macchine in progetto hanno una brillanza media circa 1000 volte piu' alta di quelle attuali!

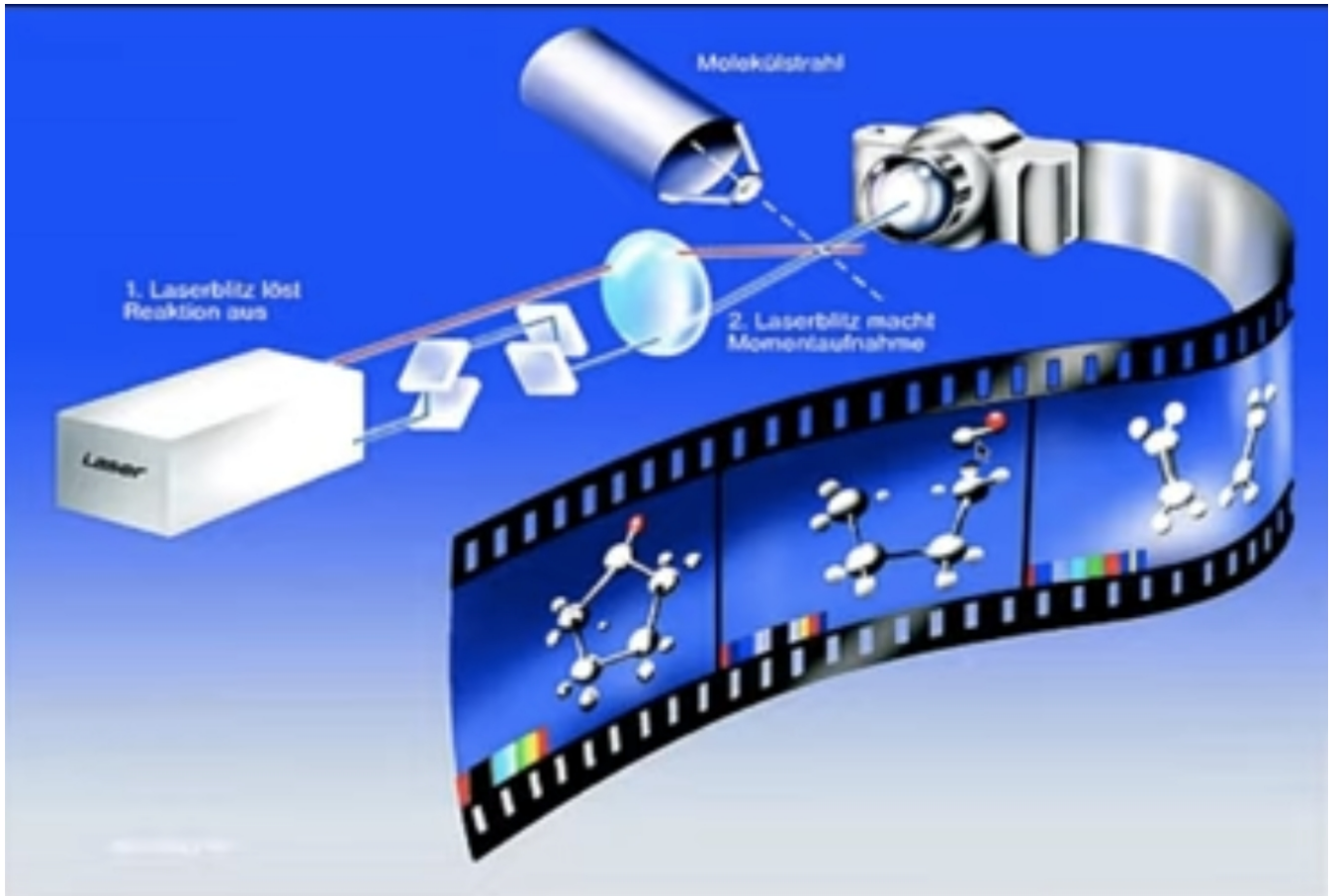


Diffrazione senza cristallo

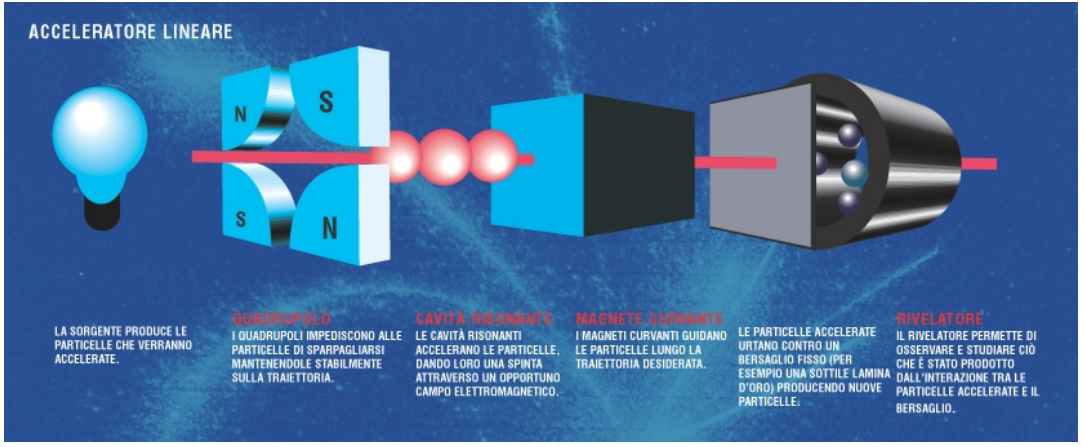
Problema: il campione si decompone in 20-30 fs

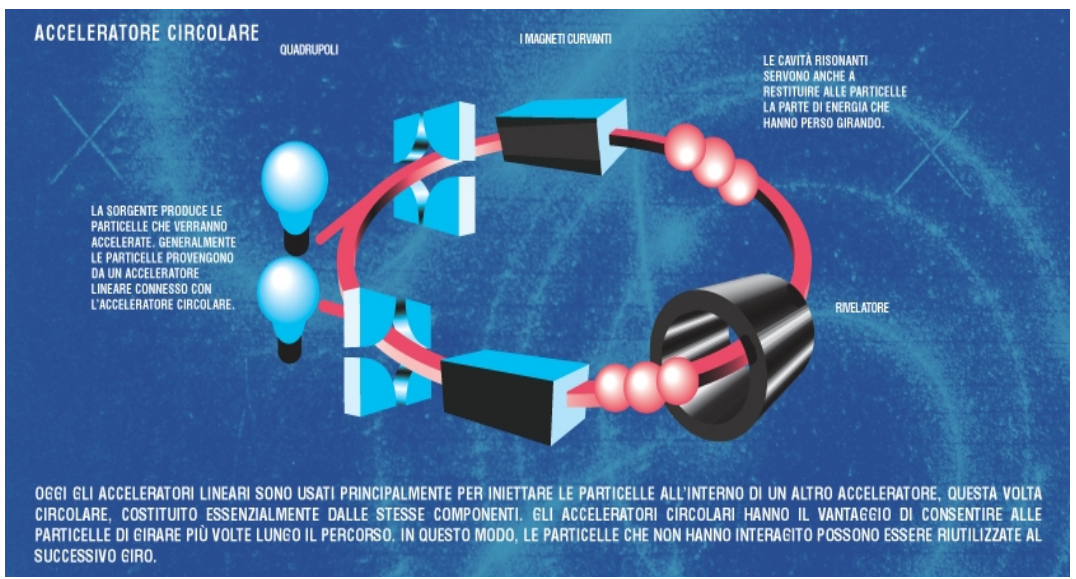


Andamento reazione chimica

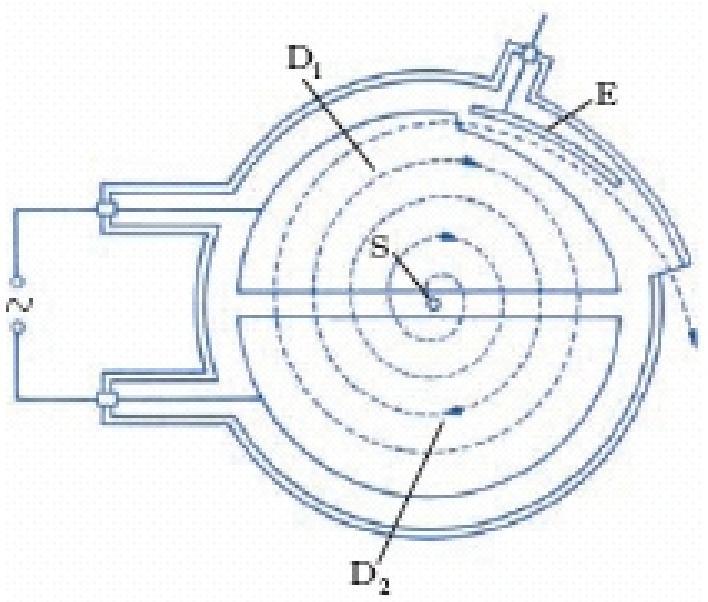


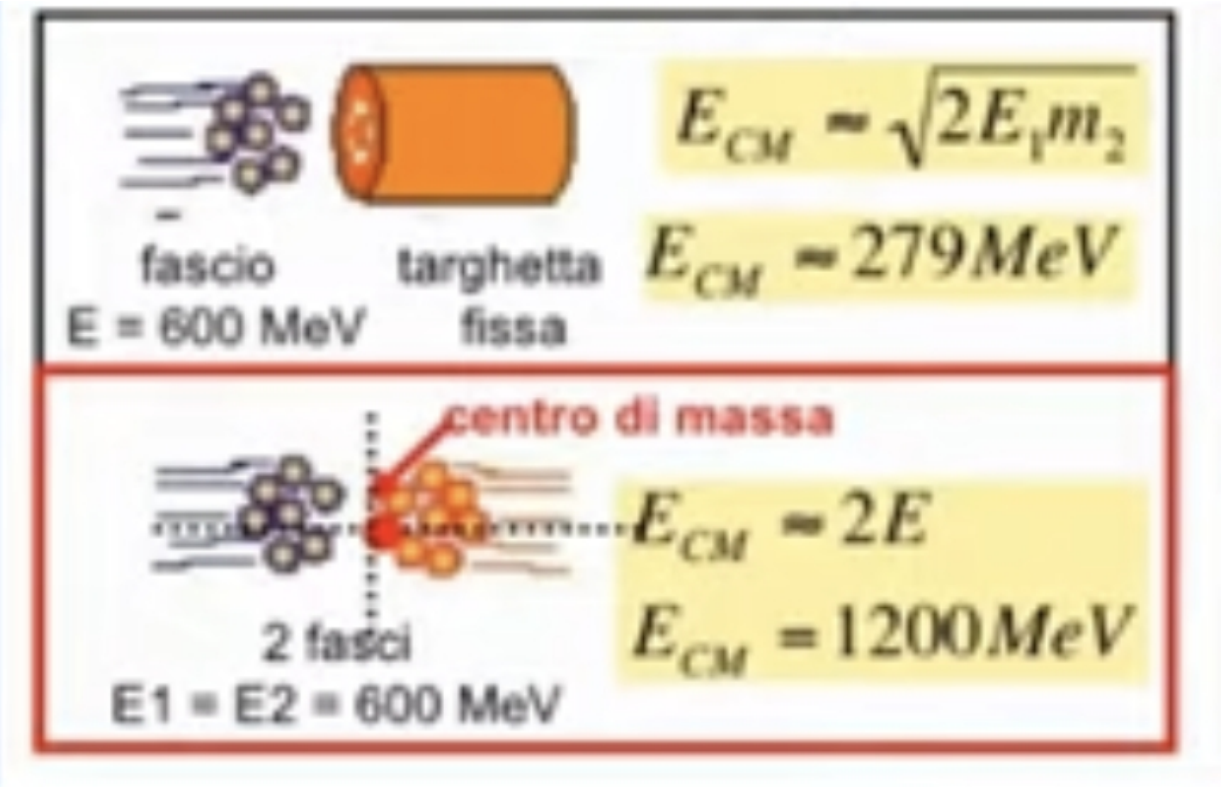
ADA: la madre di tutti gli acceleratori attuali (Bruno Touscheck, il padre)





Sono tutti sistemi in cui un fascio di particelle cariche viene accelerato e sparato su un bersaglio fermo.





Credits: Andrea Ghigo

XIX Edizione

INFN Laboratori Nazionali di Frascati
Istituto Nazionale di Fisica Nucleare
9 - 11 ottobre 2019

incontri di fisica

Corso di aggiornamento in Fisica Moderna
per docenti delle scuole secondarie di secondo grado

Andrea Ghigo

Gli acceleratori di particelle
nei
Laboratori Nazionali
di
Frascati

MULTIMEDIAEVENTI

AdA (Anello di Accumulazione) 1960-1965

AdA e costituito da un magnete a focheggiamento debole in grado di far circolare particelle (e+/e-) con una energia di *250 MeV.*

IL NUOVO CIMENTO

The Frascati Storage Ring.

C. Bernardini, G. F. Corazza, G. Ghigo
Laboratori Nazionali del CNEN - Frascati

B. Touschek
Istituto di Fisica dell'Università - Roma
Istituto Nazionale di Fisica Nucleare - Sezione di Roma

(ricevuto il 7 Novembre 1960)

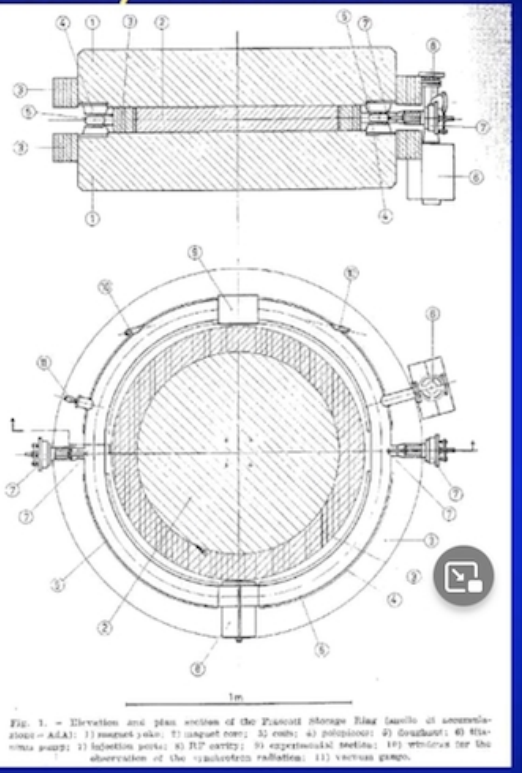
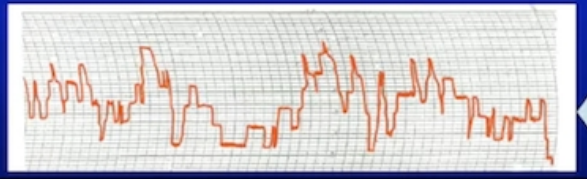


Fig. 1. – Elevation and plan section of the Frascati storage ring (anello di accumulazione – AdA): 1) magnet yoke; 2) magnet core; 3) coils; 4) polepieces; 5) conductors; 6) vacuum pump; 7) injection ports; 8) RF cavity; 9) experimental section; 10) windows for the observation of the synchrotron radiation; 11) vacuum gauge.



Registrazione dei primi elettroni accumulati in AdA. La vita media era 21 sec, il numero medio 2.3.

06 - Ghigo – Ada.mp4

Primi collider elettrone-positrone

- Frascati
- Stanford
- Novosibirsk

Colliders elettroni – positroni

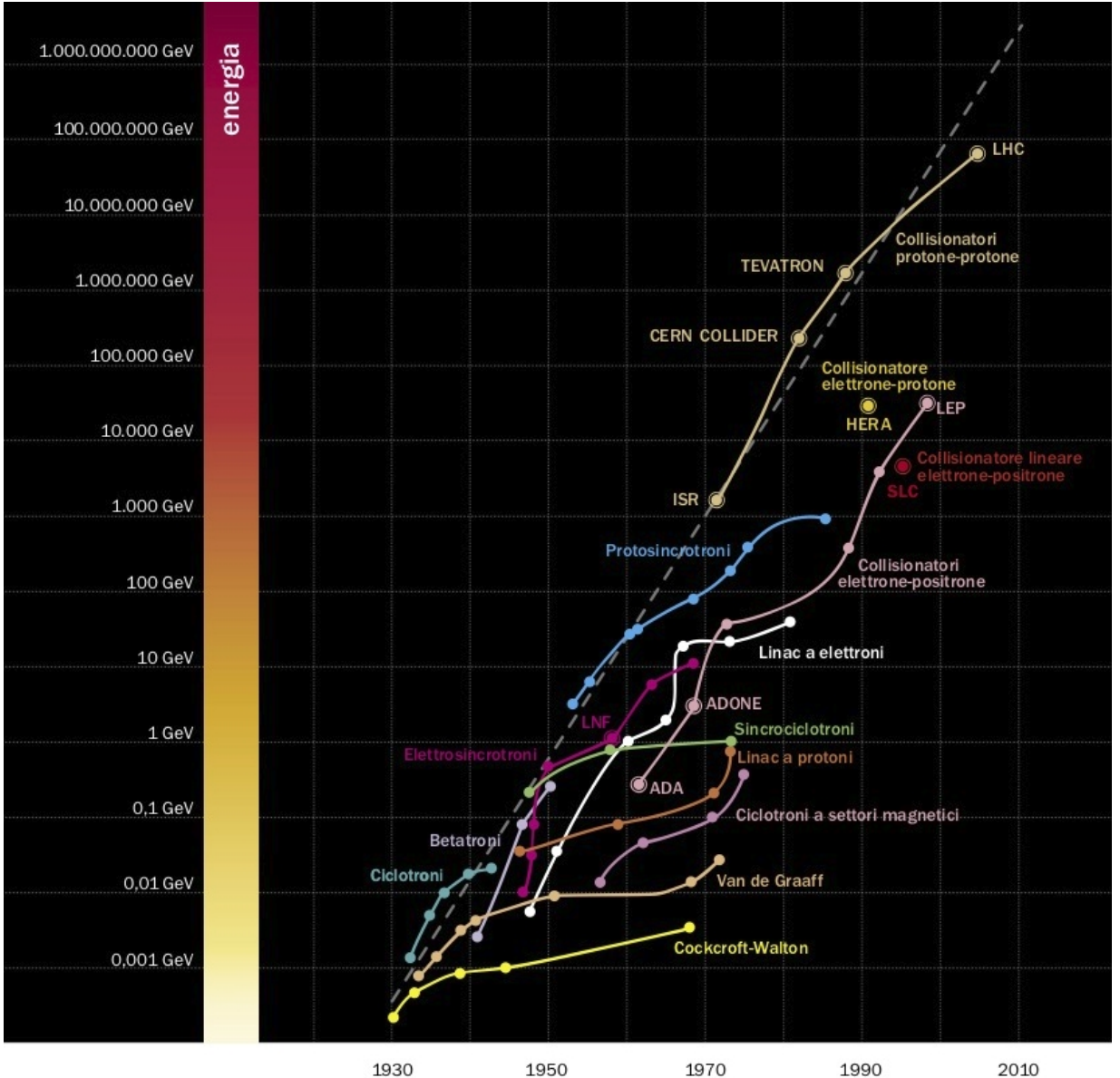
Acceleratore	Luogo	Anni di operazione	Energia elettroni	Energia positroni
AdA	Frascati, Orsay	1961–1964	**250 MeV**	250 MeV
Princeton-Stanford (e^-e^-)	Stanford	1962–1967	300 MeV	300 MeV
VEP-1 (e^-e^-)	Novosibirsk	1964–1968	130 MeV	130 MeV
VEPP-2	Novosibirsk	1965–1974	700 MeV	700 MeV
ACO	Orsay	1965–1975	550 MeV	550 MeV
SPEAR	Stanford	1972-1990(?)	3 GeV	3 GeV
VEPP-2M	Novosibirsk	1974–2000	700 MeV	700 MeV
DORIS	Hamburg	1974–1993	5 GeV	5 GeV
PETRA	Hamburg	1978–1986	20 GeV	20 GeV
CESR	Cornell	1979–2002	6 GeV	6 GeV
PEP	Stanford	1980-1990		
SLC	Stanford	1988-1998(?)	45 GeV	45 GeV
LEP	CERN	1989–2000	**104 GeV**	104 GeV
BEPC	Pechino	1989–2004	2.2 GeV	2.2 GeV
VEPP-4M	Novosibirsk	1994-	6.0 GeV	6.0 GeV
PEP-II	Stanfrod	1998–2008	9 GeV	3.1 GeV
KEKB	Tsukuba	1999–2009	8.0 GeV	3.5 GeV
DAΦNE	Frascati	1999-present	0.7 GeV	0.7 GeV
CESR-c	Cornell	2002–2008	6 GeV	6 GeV
VEPP-2000	Novosibirsk	2006-	1.0 GeV	1.0 GeV
BEPC II	Pechino	2008-	1.89 GeV	1.89 GeV
VEPP-5	Novosibirsk	2015-		
ADONE	Frascati	1969-1993	1.5 GeV	1.5 GeV
TRISTAN	Tsukuba	1987-1995	30 GeV	30 GeV
SuperKEKB	Tsukuba	2016-	7.0 GeV	4.0 GeV

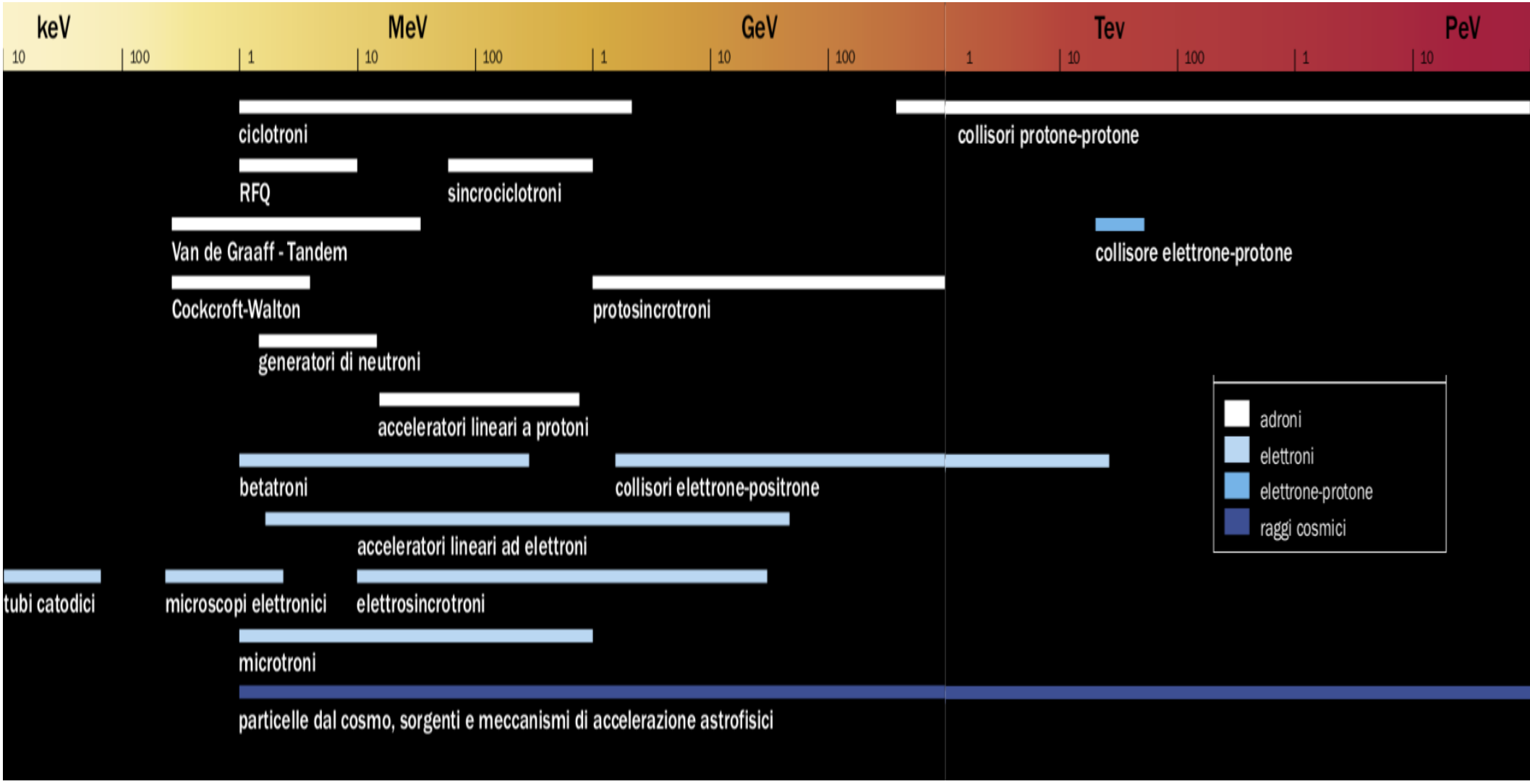
Collider adronici

Acceleratore	Luogo	Anni di operazione	Particelle	Energia del fascio
ISR	CERN	1971–1984	Proton/Proton	31.5 GeV
SppS	CERN	1981–1984	Proton/Antiproton	270-315 GeV
Tevatron I	Chicago	1992–1995	Proton/Antiproton	900 GeV
Tevatron II	Chicago	2001–2011	Proton/Antiproton	980 GeV
RHIC polarized proton mode	Brookhaven	2001–present	Polarized Proton/Proton	100-255 GeV
RHIC ion mode	Brookhaven	2000–present	d - Au Cu - Cu Cu - Au Au - Au U- U	3.85-100 GeV per nucleon
LHC proton mode	CERN	2008–present	Proton/Proton	6.5 TeV (design: 7 TeV)
LHC ion mode	CERN	2010–present	Pb - Pb Proton - Pb	2.76 TeV per nucleon

Collider elettroni/protoni

Acceleratore	Luogo	Anni di operazione	Energia elettroni	Energia protoni
HERA	Hamburg	1992–2007	27.5 GeV	920 GeV


energia
1.000.000.000 GeV
100.000.000 GeV
10.000.000 GeV
1.000.000 GeV
100.000 GeV
10.000 GeV
1.000 GeV
100 GeV
10 GeV
1 GeV
0,1 GeV
0,01 GeV
0,001 GeV
1930
1950
1970
1990
2010
LHC
Collisionatori protone-protone
TEVATRON
CERN COLLIDER
Collisionatore elettrone-protone
HERA
LEP
Collisionatore lineare elettrone-positrone
SLC
ISR
Protosincrotroni
Collisionatori elettrone-positrone
Linac a elettroni
ADONE
LNF
Sincrociclotroni
Elettrosincrotroni
Linac a protoni
ADA
Ciclotroni a settori magnetici
Betatroni
Ciclotroni
Van de Graaff
Cockcroft-Walton

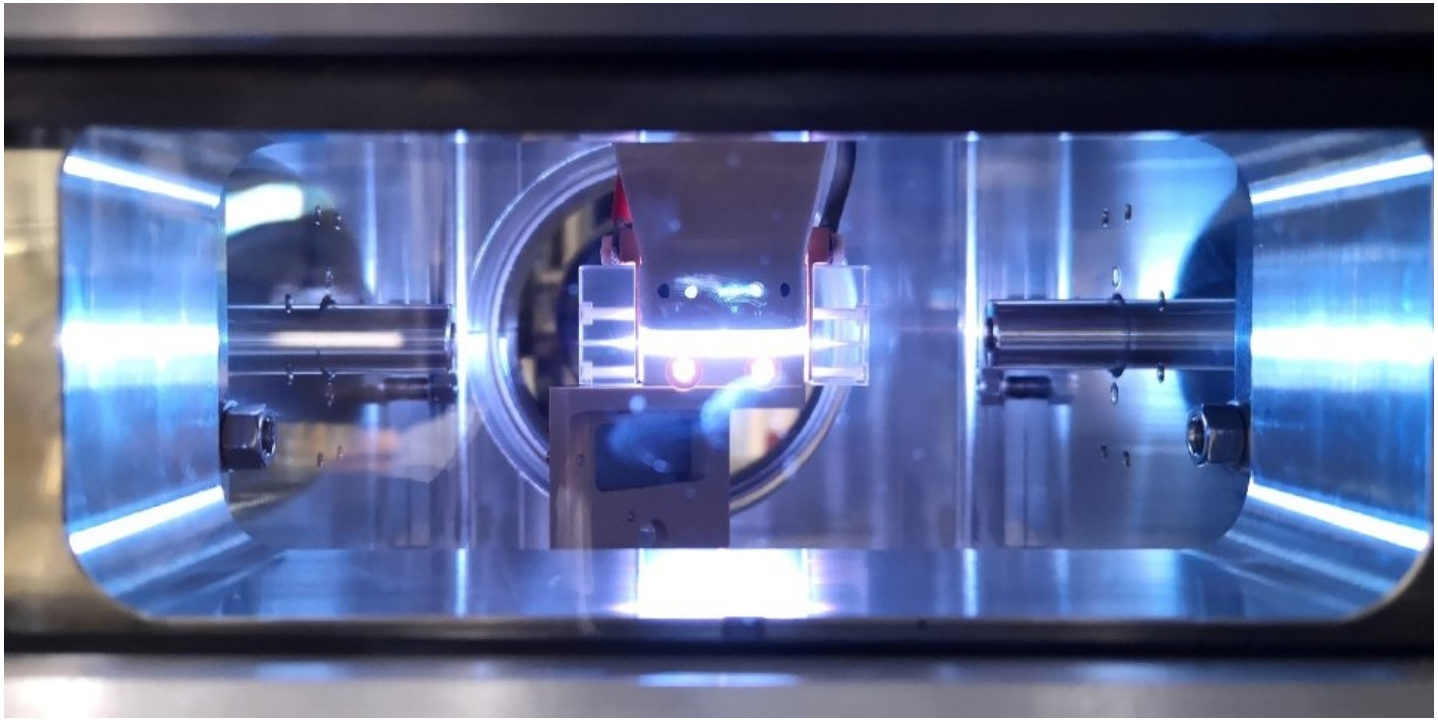

keV
MeV
GeV
Tev
PeV
10
100
1
10
100
1
10
100
1
10
100
1
10
ciclotroni
collisori protone-protone
RFQ
sincrociclotroni
Van de Graaff - Tandem
collisore elettrone-protone
Cockcroft-Walton
protosincrotroni
generatori di neutroni
acceleratori lineari a protoni
betatroni
collisori elettrone-positrone
acceleratori lineari ad elettroni
tubi catodici
microscopi elettronici
elettrosincrotroni
microtroni
particelle dal cosmo, sorgenti e meccanismi di accelerazione astrofisici
adroni
elettroni
elettrone-protone
raggi cosmici

	circonferenza
AdA	4 metri
LHC	27 chilomtri

Punti critici per i futuri acceleratori di particelle

- Aumentare l’energia
- Miniaturizzare
- Ridurre i costi
- Variabilità (facile) dei parametri del fascio

07 - Ferrario - accelerazione al plasma.mp4



Massimo Ferrario
https://www.youtube.com/watch?v=dQqC8xZlBnE

Rivelatori di particelle

- Rivelare
- Tracciare
- Identificare

caratteristiche dei rivelatori

Sensibilità
capacità di produrre un segnale per un certo tipo di radiazione e di energia

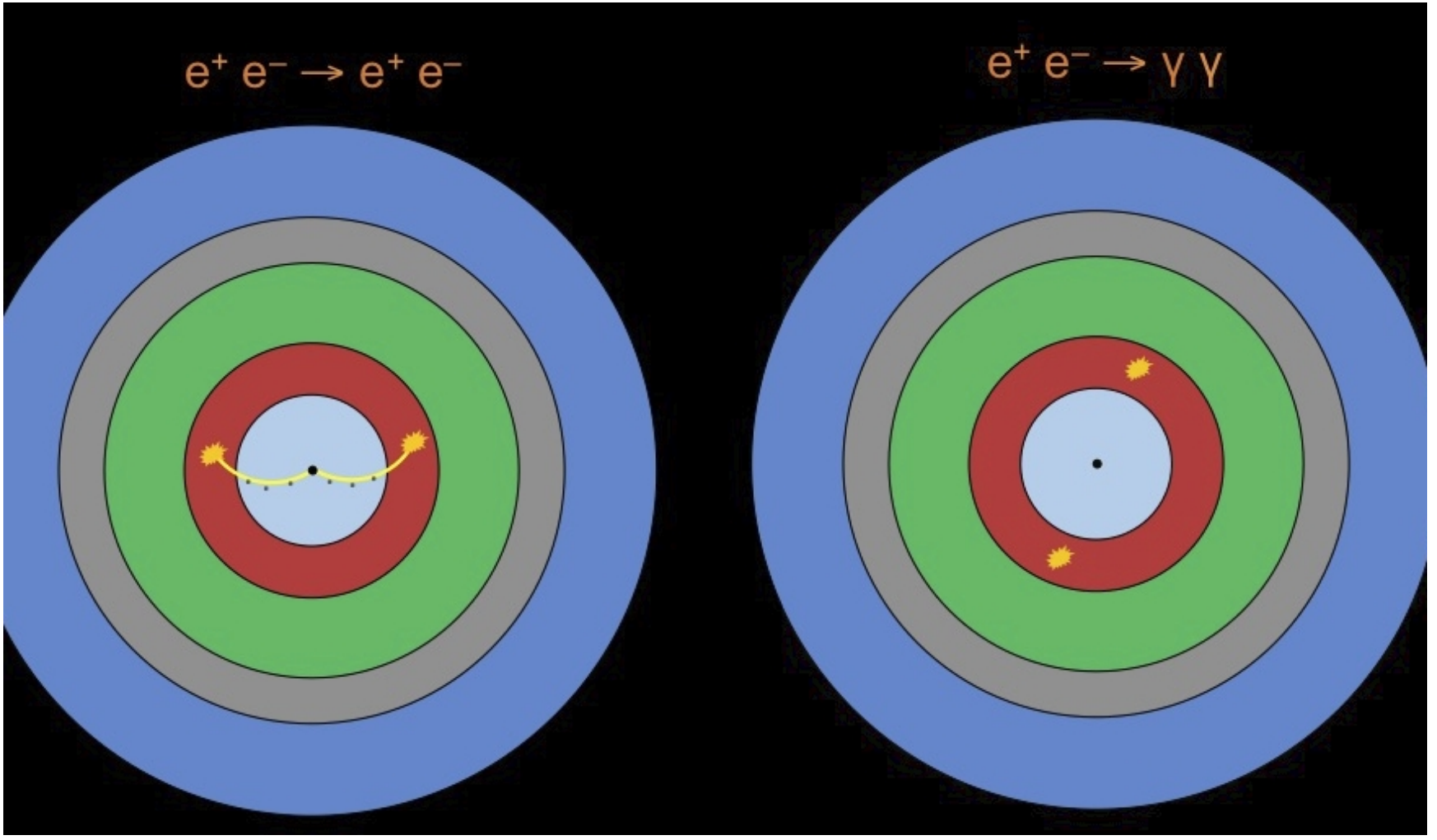
Risoluzione
capacità di distinguere tra due misure vicine di una grandezza fisica misurata (es. posizione o tempo)

Efficienza
frazione di particelle rivelate rispetto a quelle incidenti

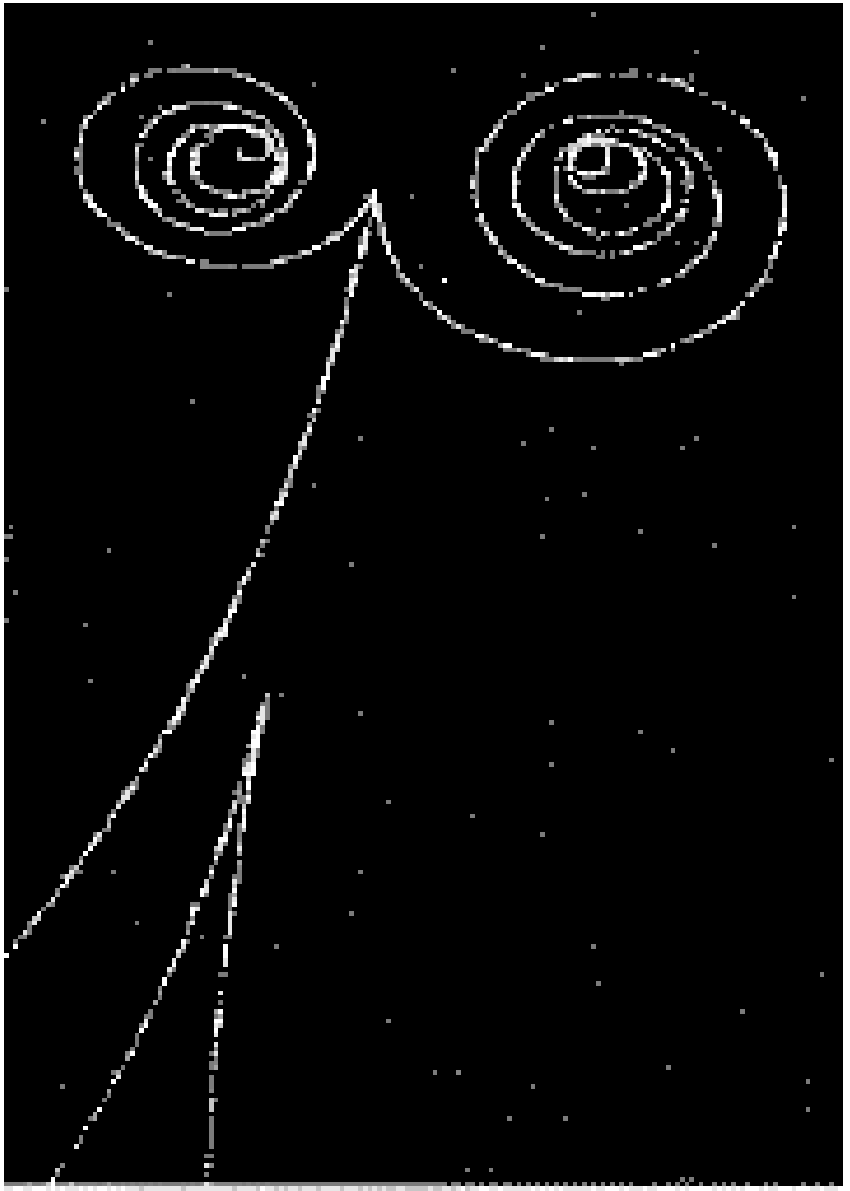
Tempo morto
tempo necessario per essere di nuovo attivo dopo la rivelazione di una particella

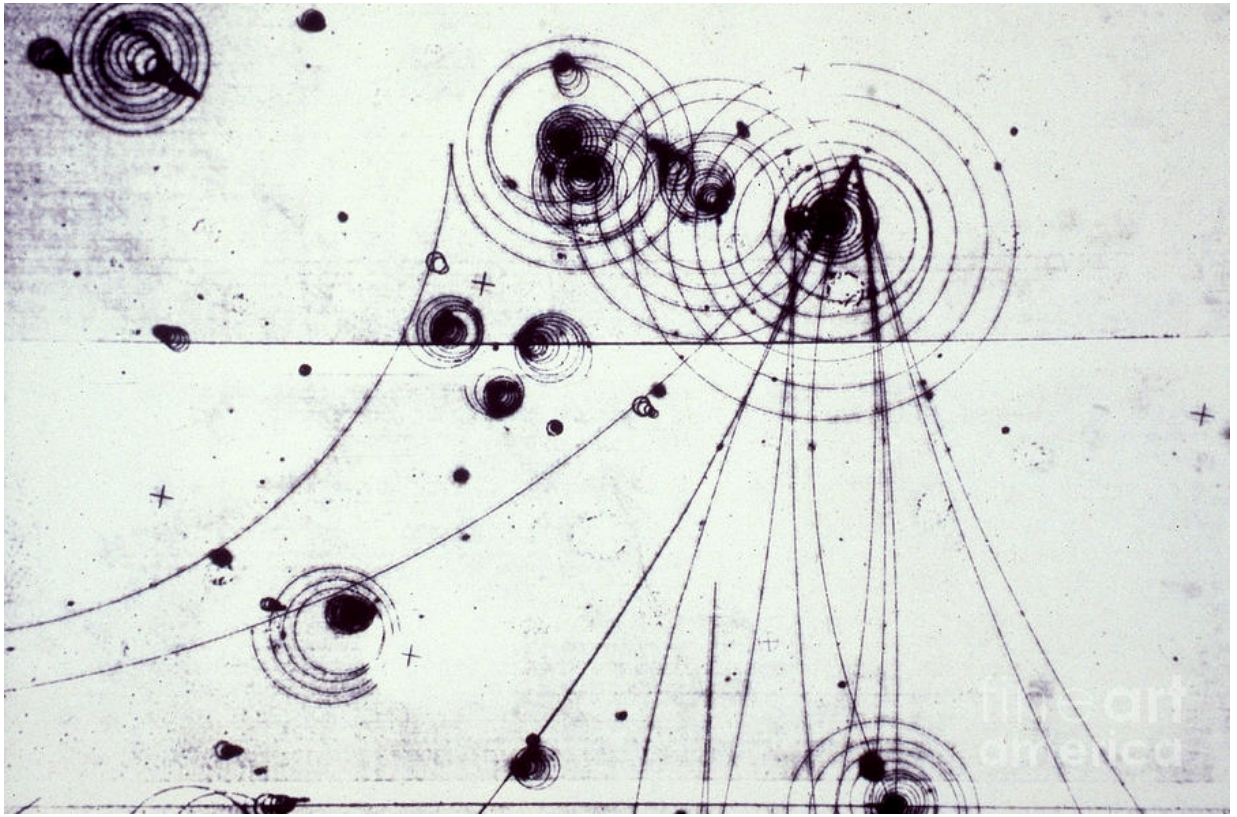
Credits: Danilo Dominici

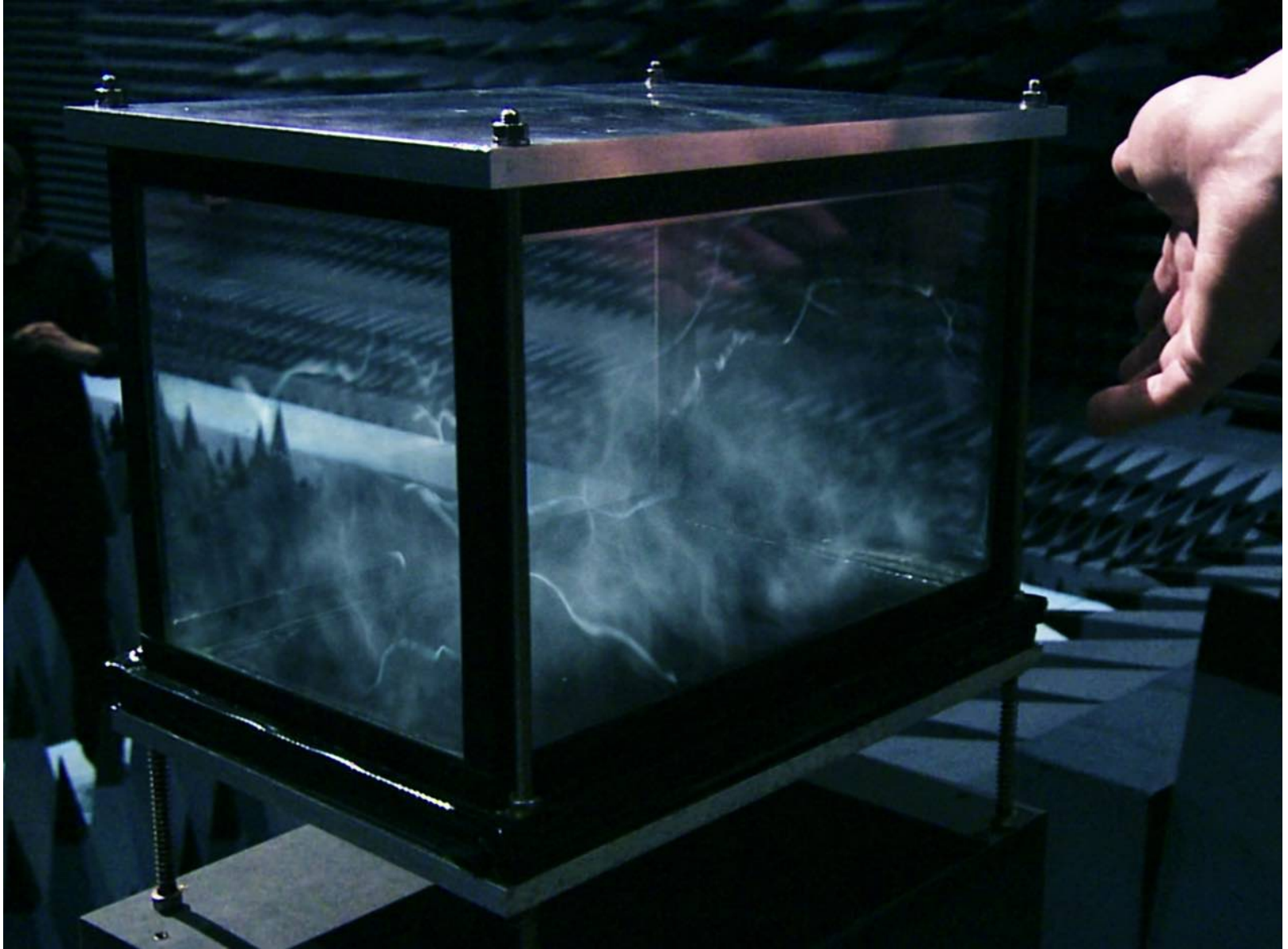
Credits: Danilo Dominici

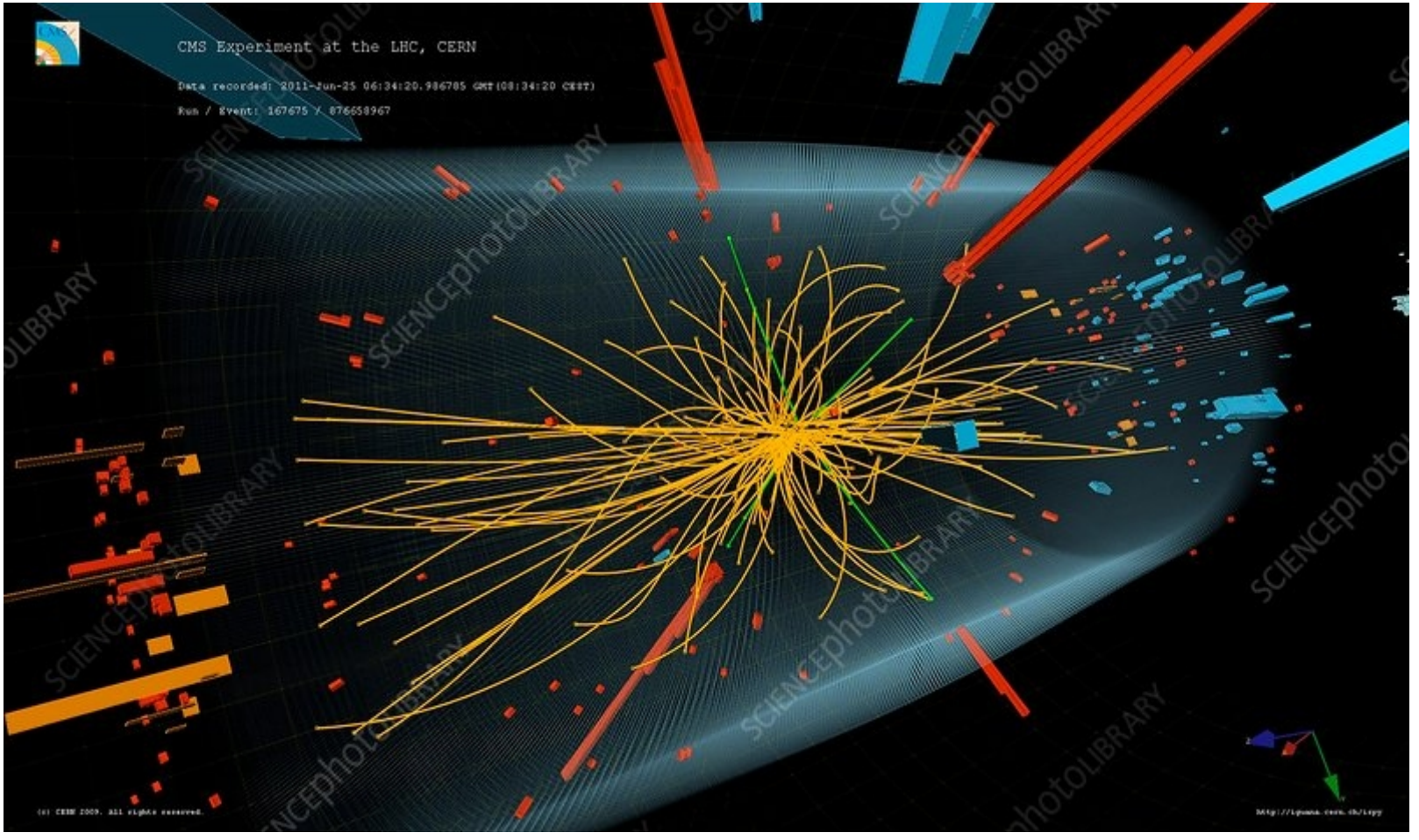


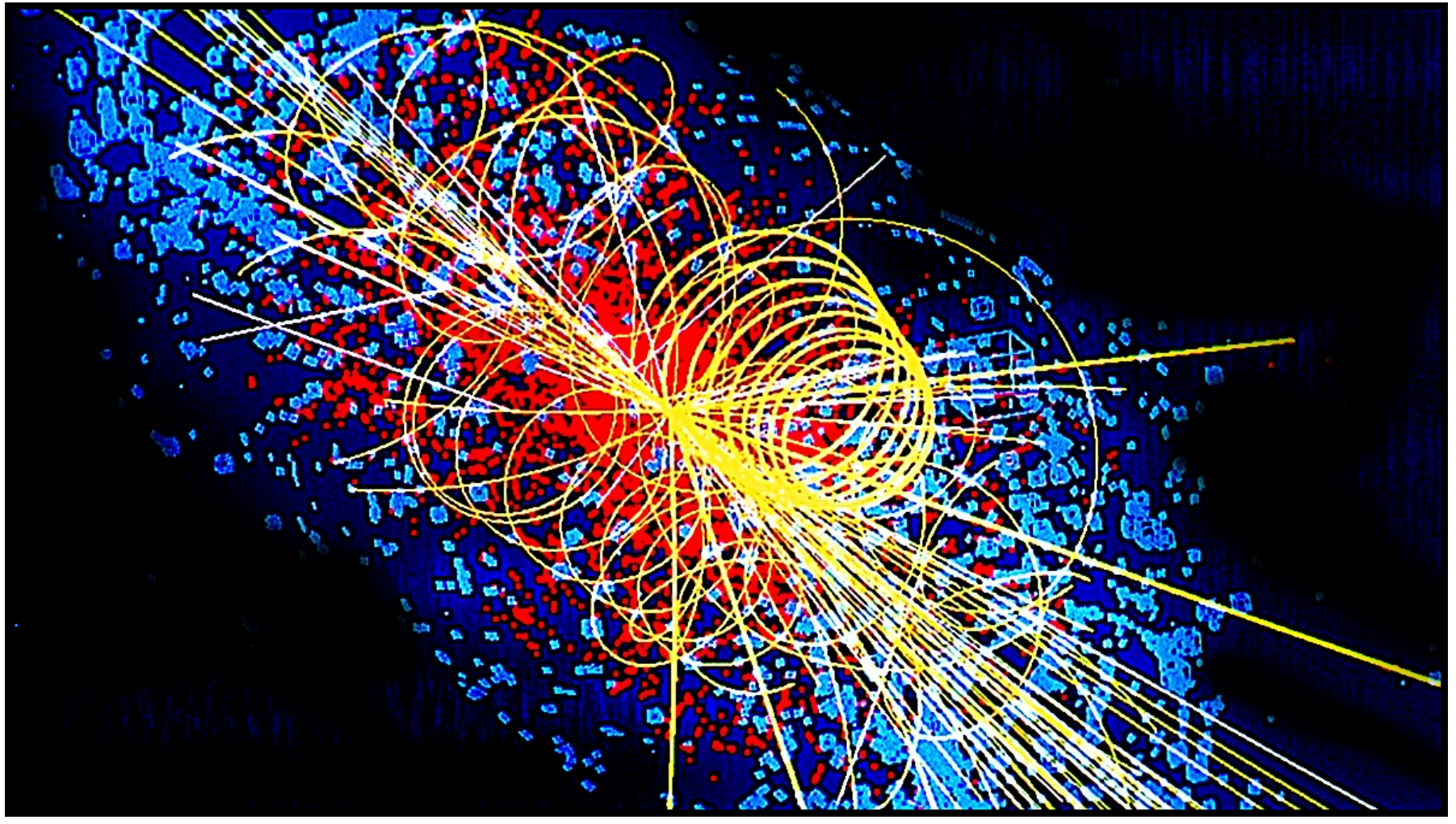
Credits: Danilo Dominici

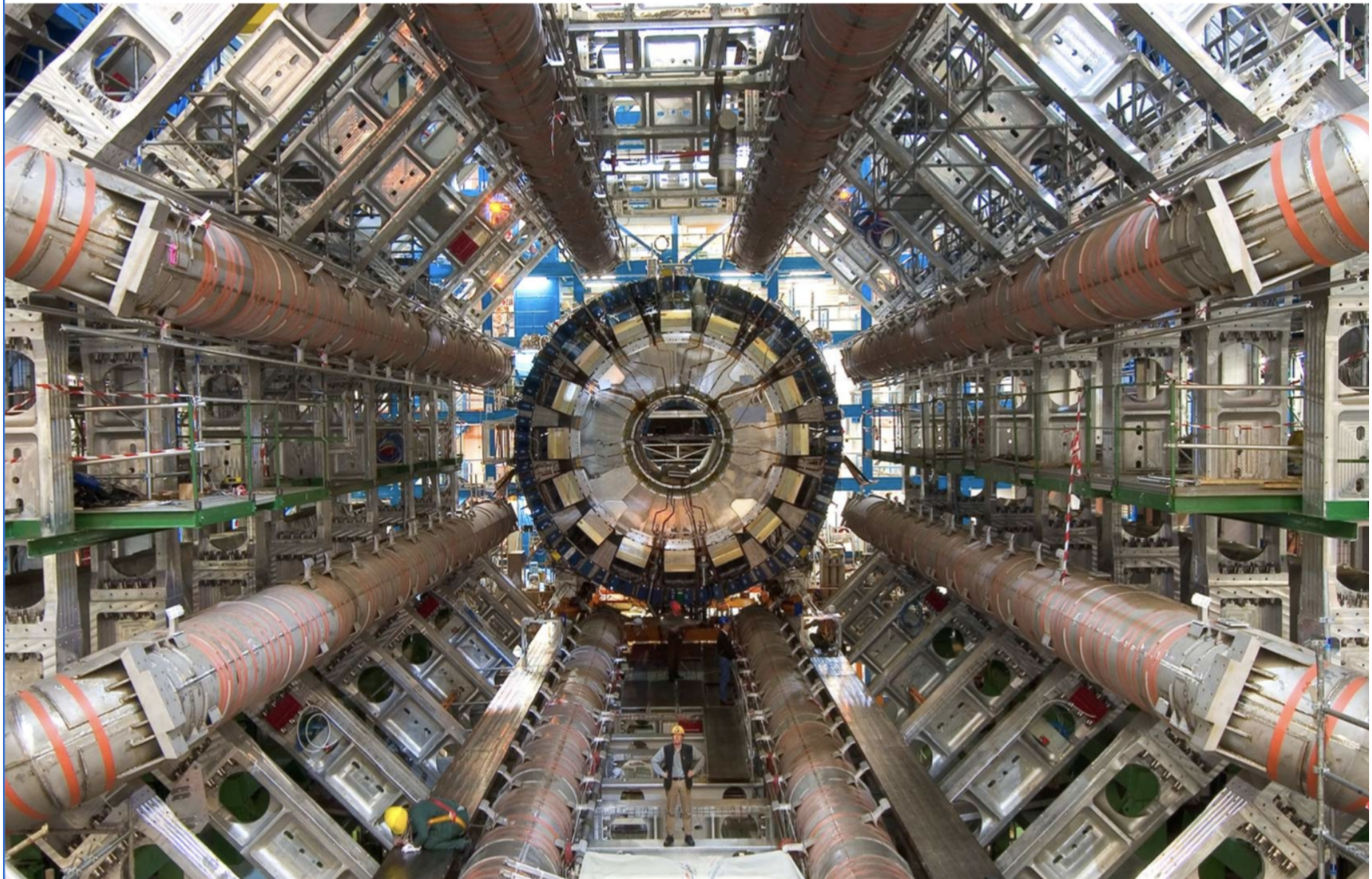


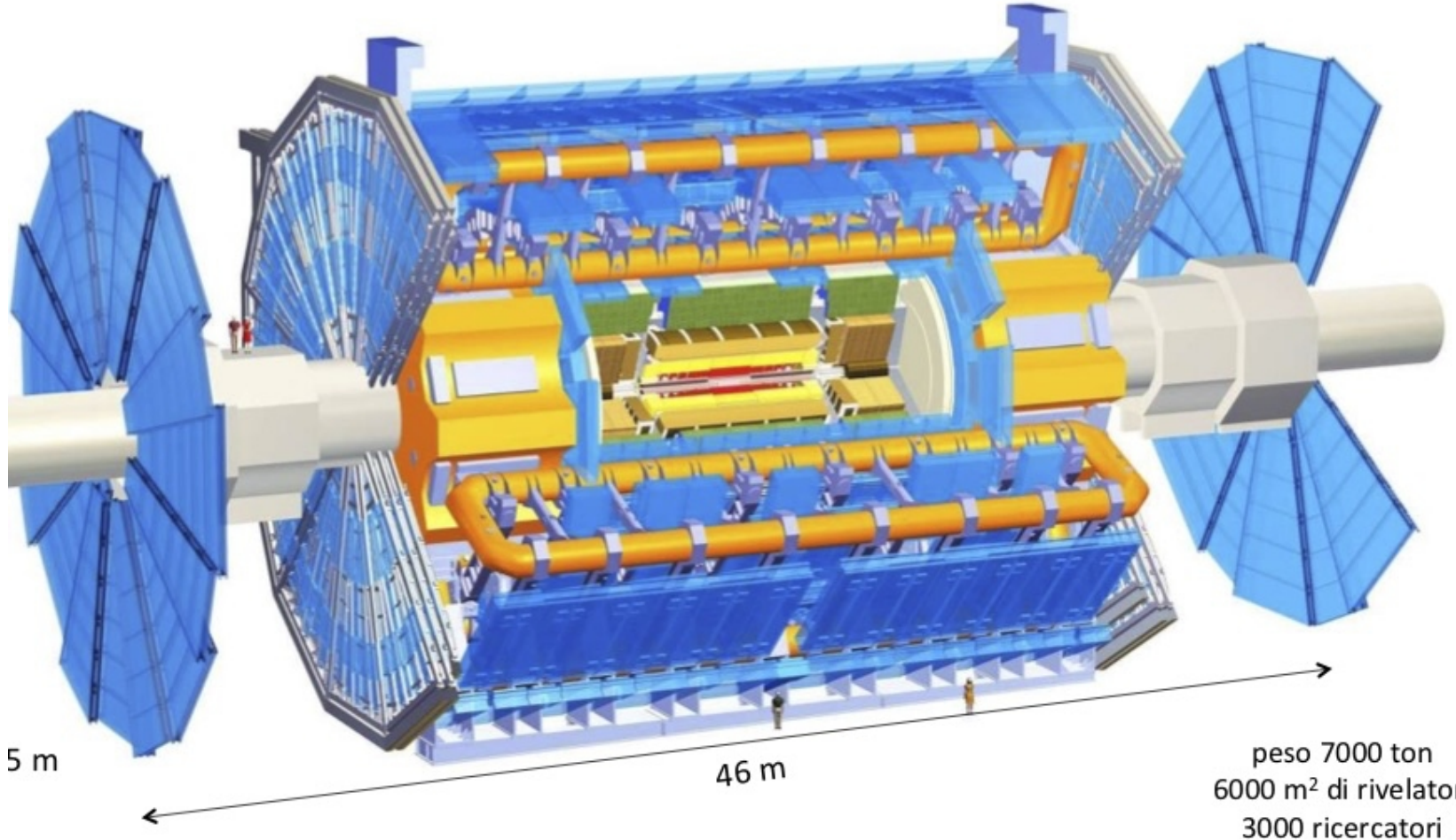





CMS Experiment at the LHC, CERN
Data recorded: 2011-Jun-25 06:34:20.986705 GMT(08:34:20 CEST)
Run / Event: 167675 / 876658967
(c) CERN 2009. All rights reserved.
http://iguana.cern.ch/iguy

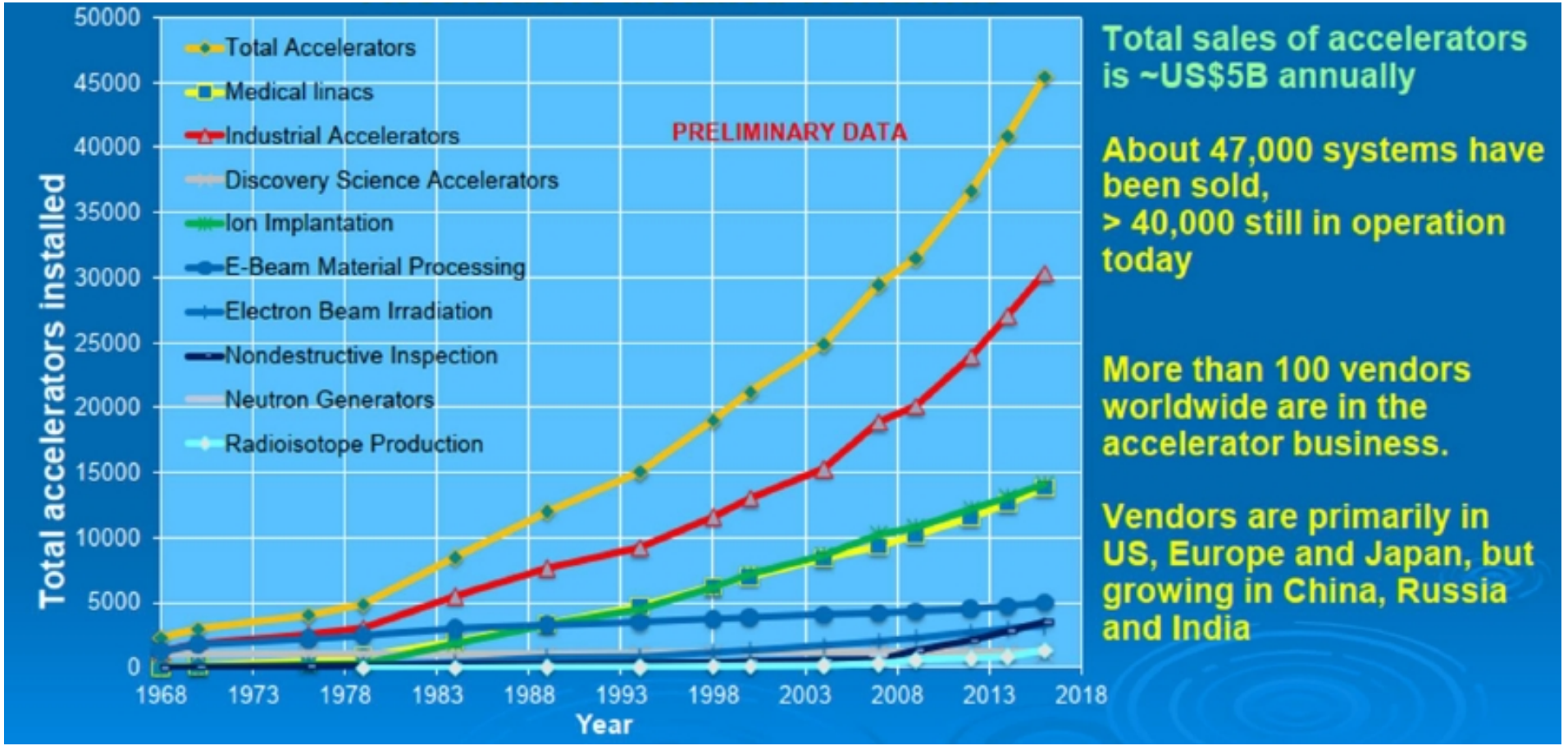






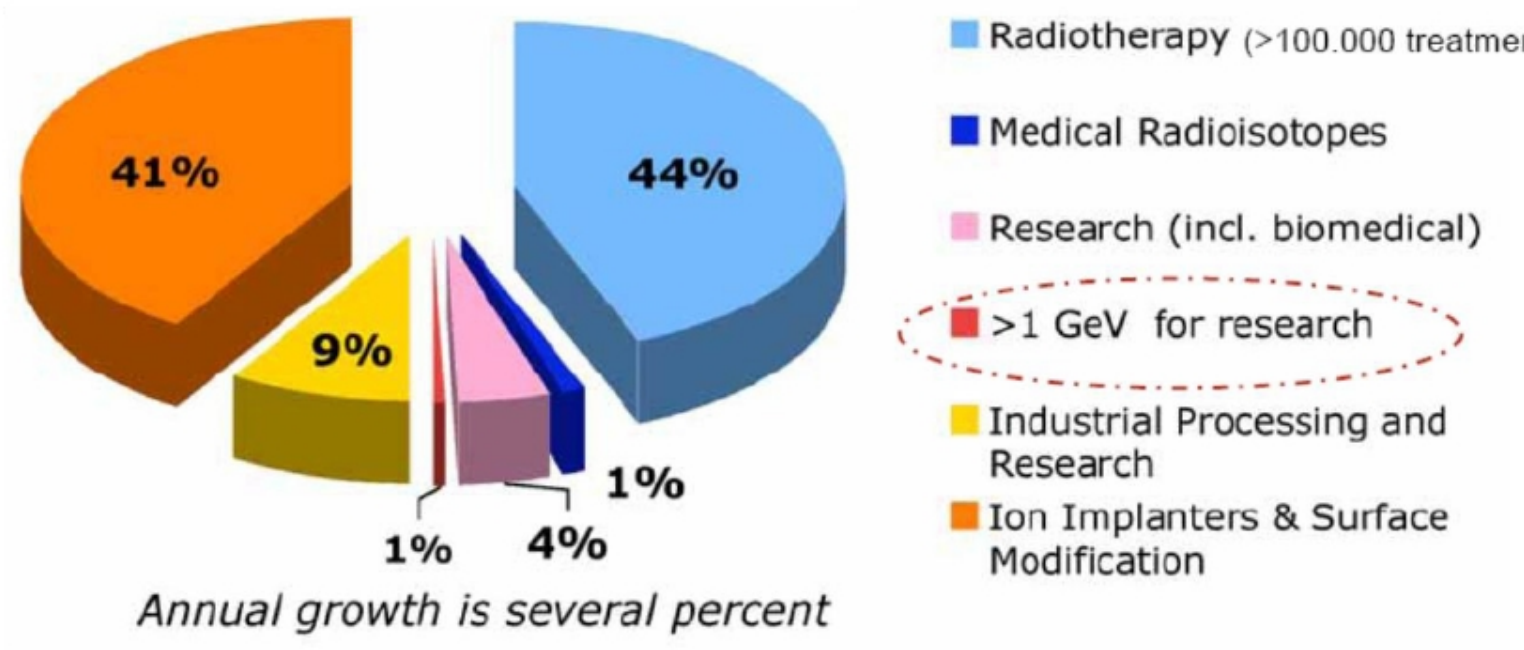
peso 7000 ton
6000 m^2 di rivelatori
3000 ricercatori
38 paesi del mondo

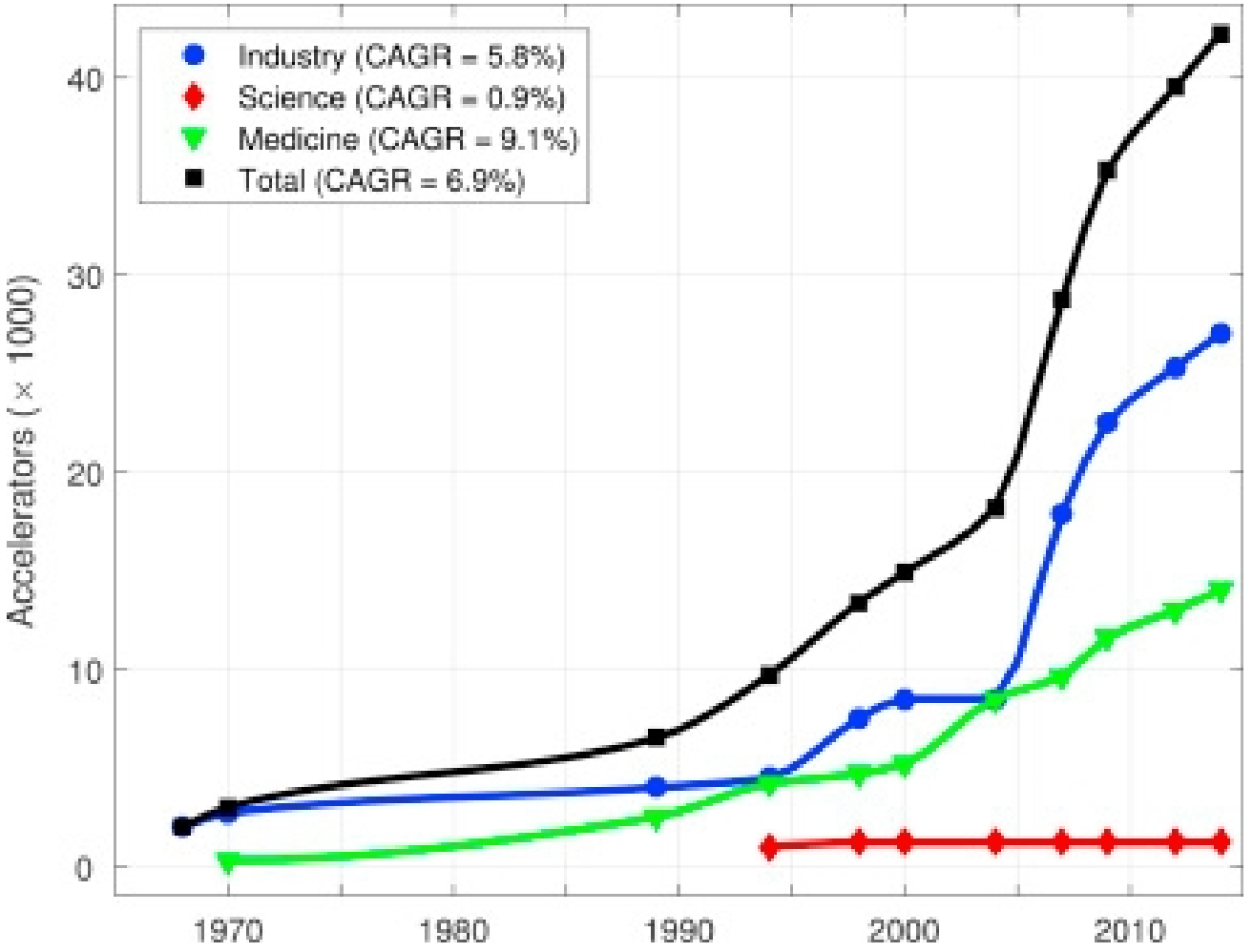
Accelerators installed worldwide



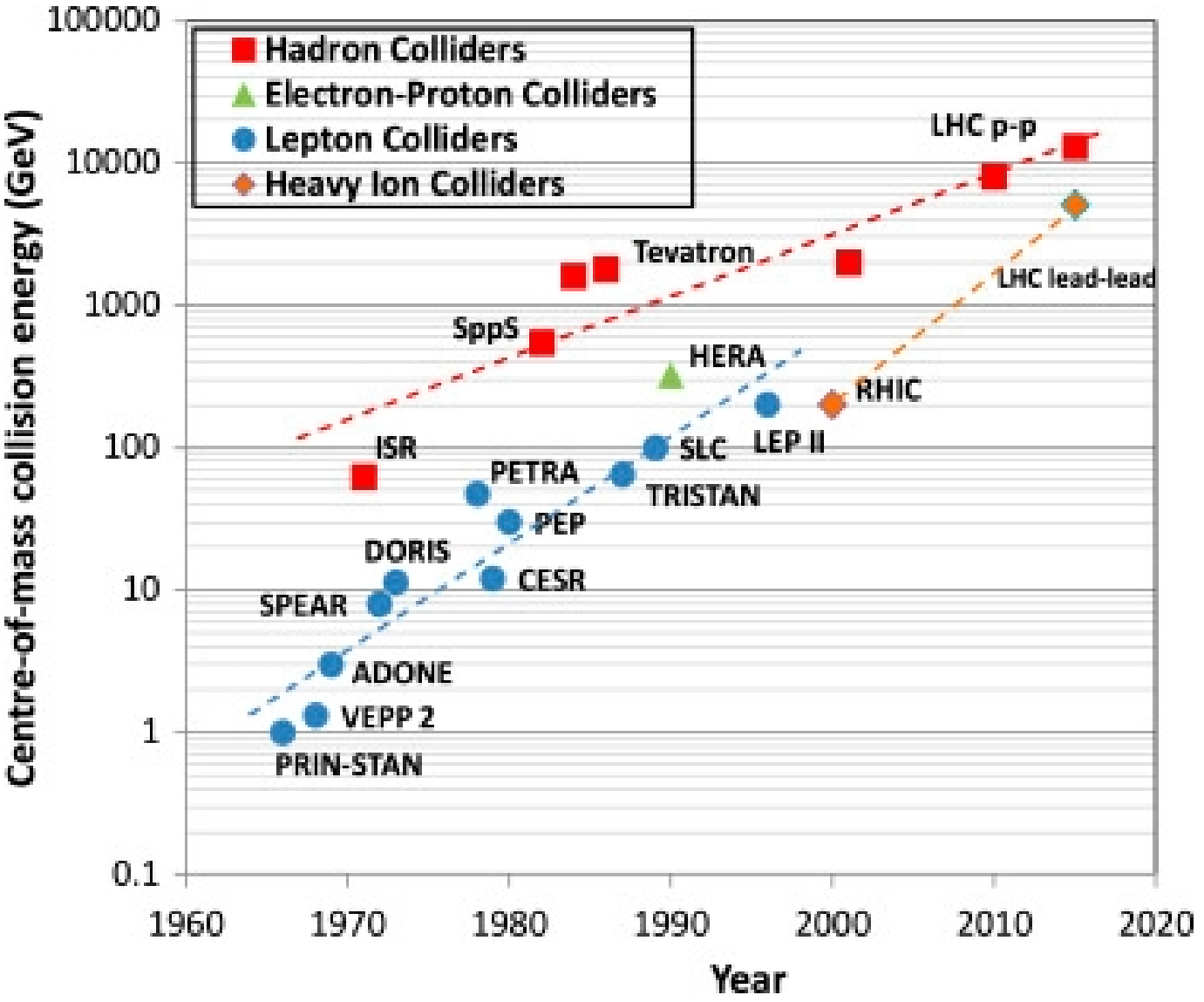
-Accelerators for Americas Future Report, pp. 4, DoE, USA, 2011

Credits:
Massimo Ferrario

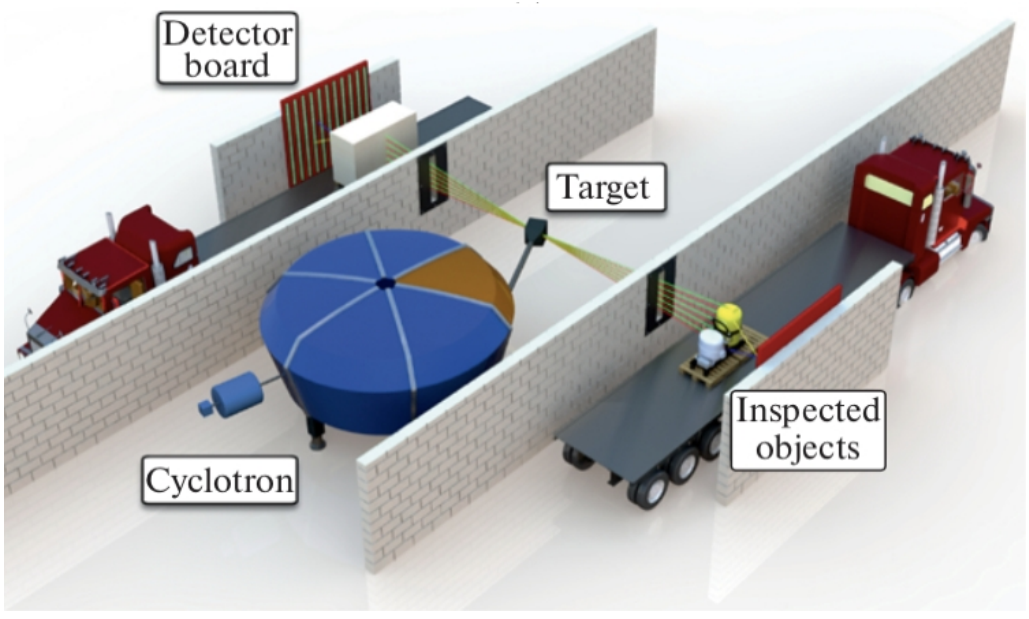

41%
44%
9%
1%
1%
4%
Annual growth is several percent
Radiotherapy (>100.000 treatments/yr)*
Medical Radioisotopes
Research (incl. biomedical)
>1 GeV for research
Industrial Processing and Research
Ion Implanters & Surface Modification



The socio-economic impact of a breakthrough in the particle accelerators' technology: A research agenda – Massimo Florio, Andrea Bastianin, Paolo Castelnovo


Hadron Colliders
Electron-Proton Colliders
Lepton Colliders
Heavy Ion Colliders
Centre-of-mass collision energy (GeV)
100000
10000
1000
100
10
1
0.1
1960
1970
1980
1990
2000
2010
2020
Year
LHC p-p
Tevatron
LHC lead-lead
SppS
HERA
RHIC
ISR
SLC
LEP II
PETRA
TRISTAN
PEP
DORIS
CESR
SPEAR
ADONE
VEPP 2
PRIN-STAN

Sistemi di ispezione
(containers e pacchi)



Sterilizzazione strumentazione medica: raggi gamma, elettroni e raggi X.

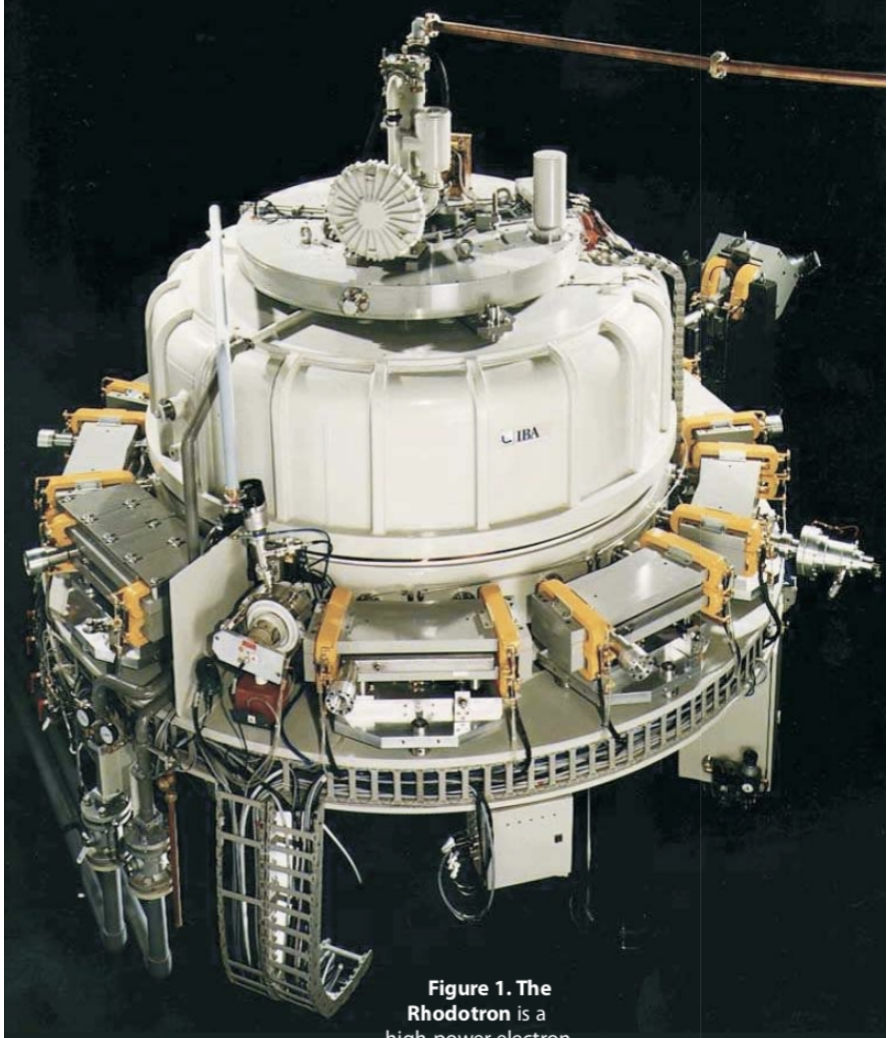
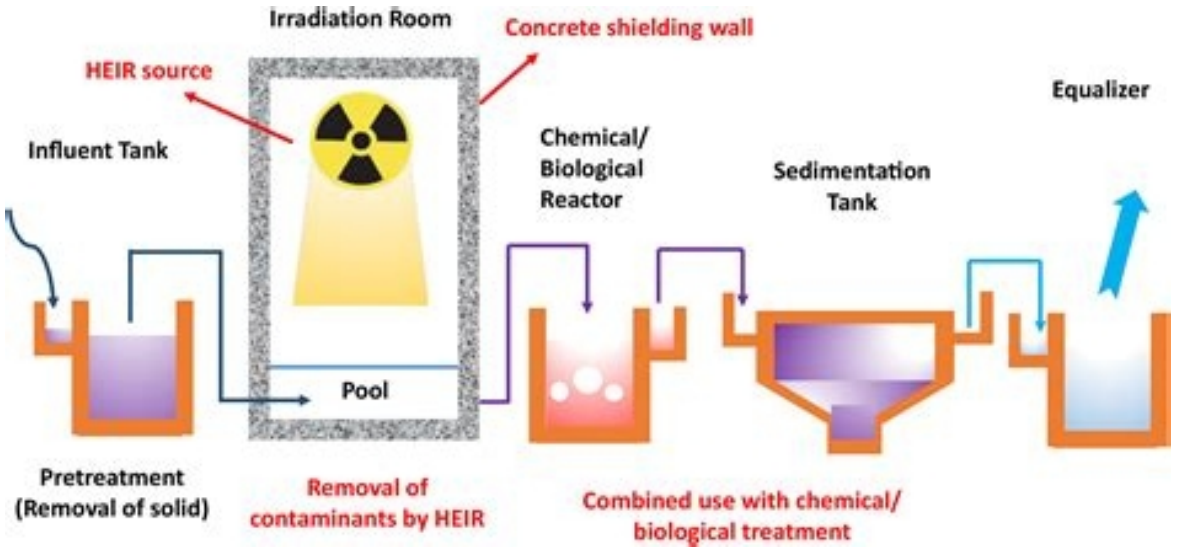
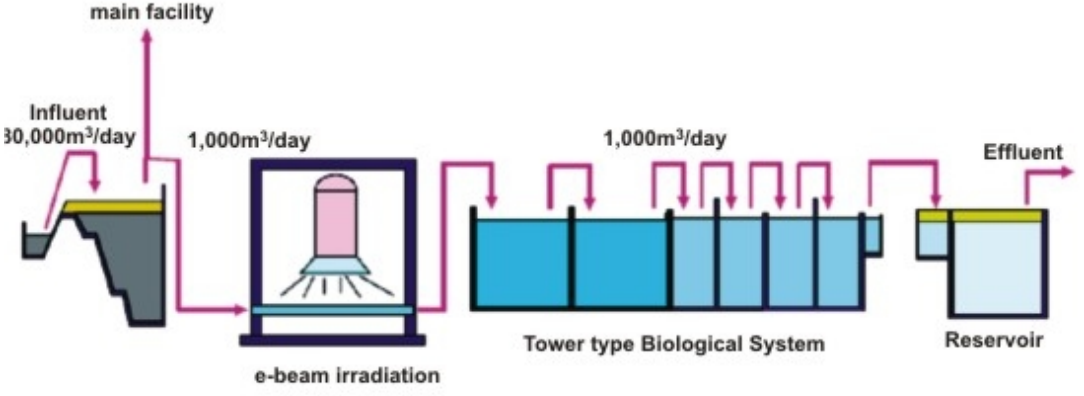


Figure 1. The Rhodotron is a high-power electron accelerator specifically developed for the sterilization of medical products in an industrial setting. These accelerators, about three meters wide, can produce up to 700 kW of beam power at electron energies of 7 MeV. (Photo courtesy of IBA, Louvain-la-Neuve, Belgium.)

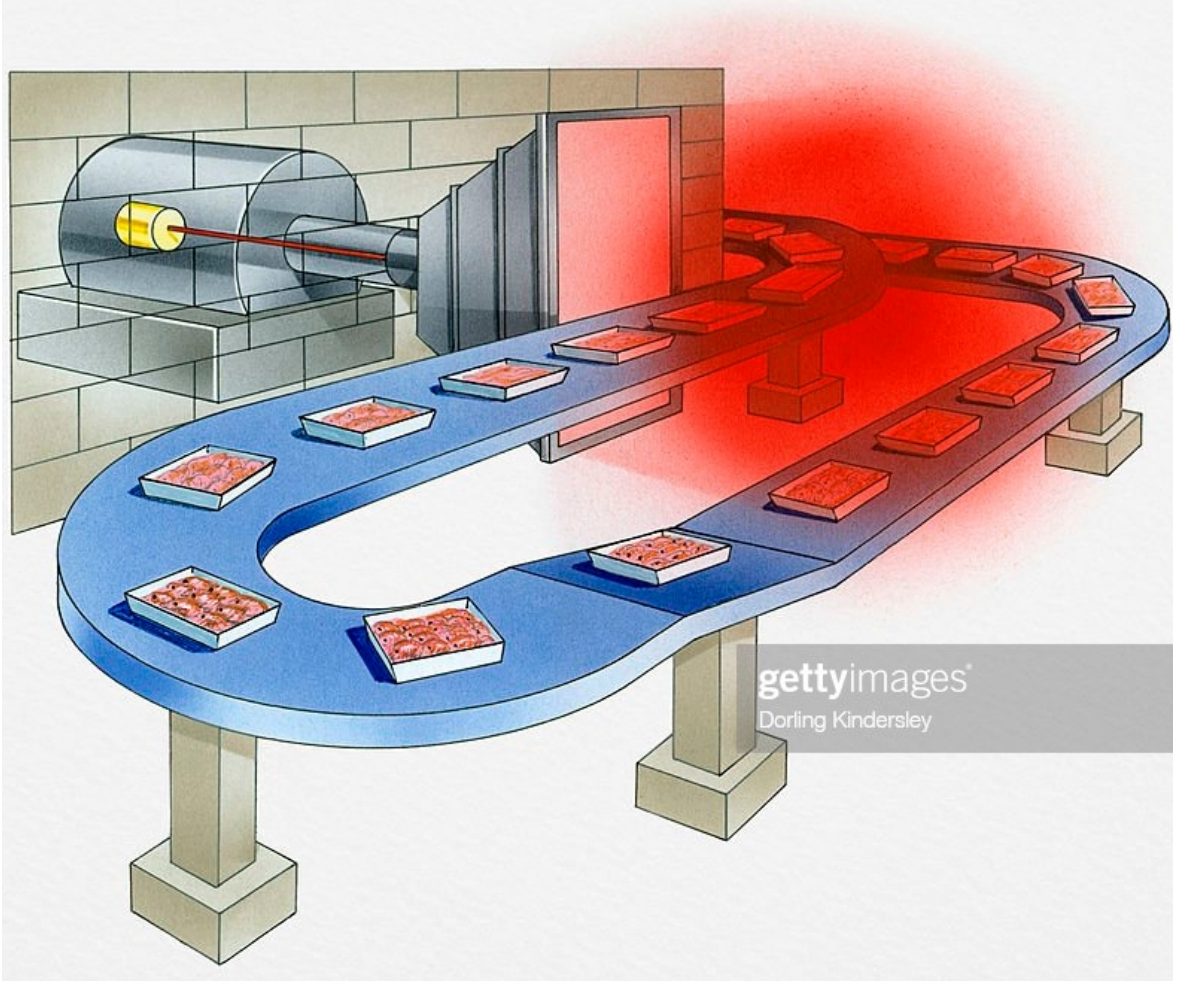


Disinfezioni acque reflue



Pastorizzazione fredda

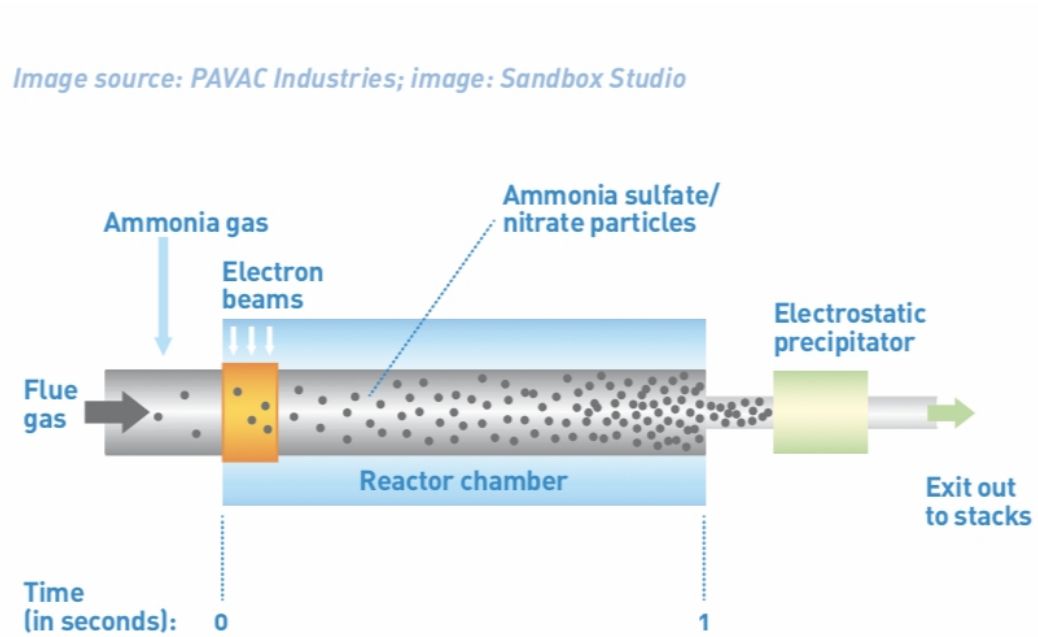
Le radiazioni ionizzanti sterilizzano l’alimento eliminando i batteri.

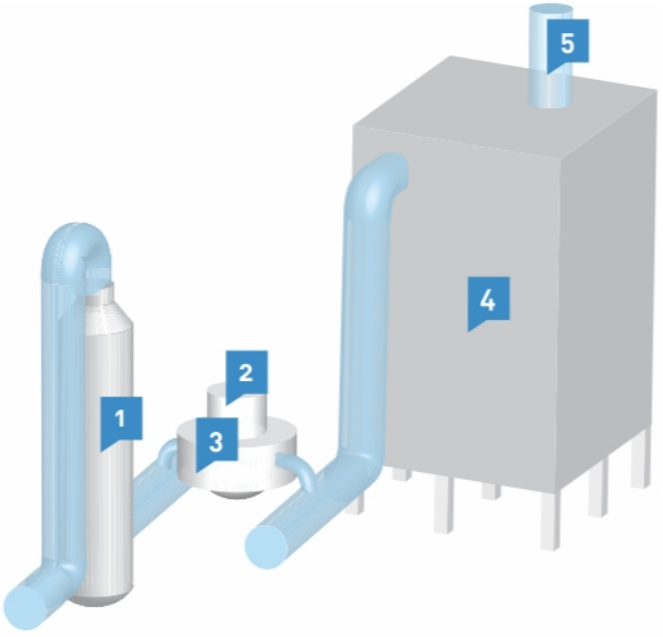


Gli alimenti più bombardati

Carne di maiale
Molluschi
Condimenti vegetali
Ortaggi e legumi
Enzimi
Frutta
Spezie ed erbe aromatiche
Pollame
Carne rossa
Guscio delle uova
Germogli

Inquinamento atmosferico dovuto ai fumi di fabbriche e centrali elettriche





Il trattamento inizia con una torre di condizionamento (1) che raffredda i fumi. Il gas raffreddato si sposta in un acceleratore (2), dove un fascio di elettroni innesca una reazione chimica (3) per **convertire anidride solforosa e gli ossidi di azoto** (inquinanti che si combinano con il vapore acqueo nell'atmosfera e reagiscono con la luce solare per creare piogge acide e smog) i**n solfato di ammonio e nitrato di ammonio**. Il precipitatore elettrostatico (4) rimuove i sottoprodotti solfati e nitrati e li raccoglie per essere venduti alle aziende di fertilizzanti. Il gas pulito esce dal camino (5)

Agricoltura

- Prevenzione della germinazione dei semi in caso di stoccaggio a lungo termine
- Stimolazione pre-semina
- Induzione di mutazioni per creare piante “migliorate”

Ingegneria energetica

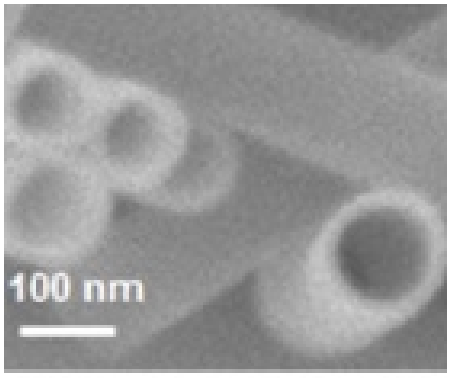
- irradiazione di biocarburanti allo scopo di migliorarne le proprietà
- liquefazione di prodotti gassosi nel sito produttivo al fine di aumentare la quota di gas naturale estratto
- irradiazione dei gas di scarico per rimuoverne gli ossidi di zolfo e di azoto

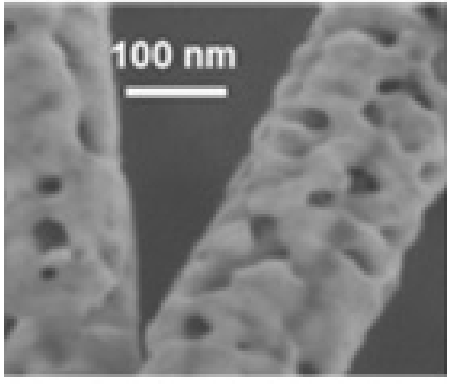
Vulcanizzazione di polimeri

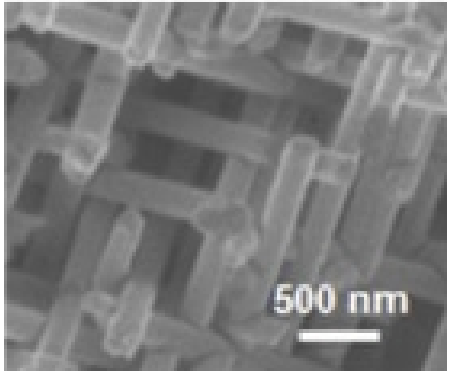
i polimeri dei materiali protettivi bituminosi possono essere vulcanizzati (o possono essere utilizzati al posto del bitume) su strade asfaltate per prolungarne la vita

Figure 2. A typical electron-beam processing facility, employing 10 large electron accelerators arrayed in a row of production stations. This facility produces shrink-wrap material. (Photo courtesy of Air Seal Corp, Duncan, SC.)

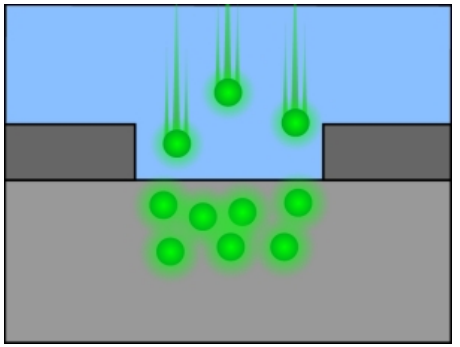
Swift heavy ions:
per la realizzazione di nano strutture in microsistemi

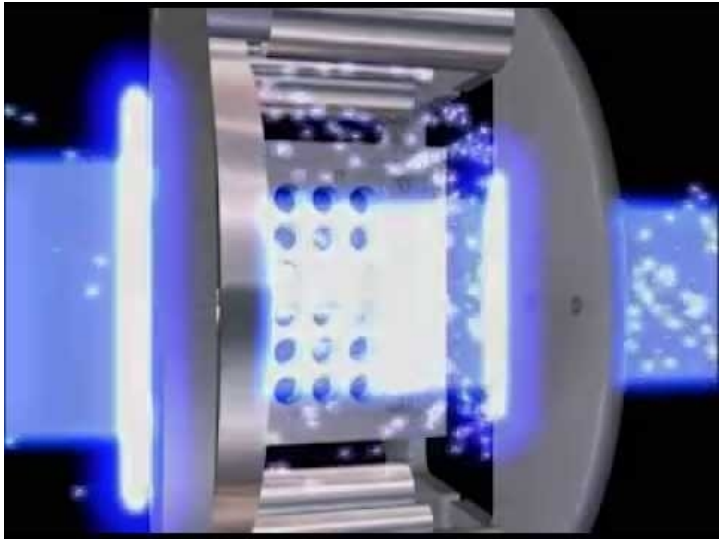






Impianto di ioni nella produzione di semiconduttori





Componentistica per computer quantistici

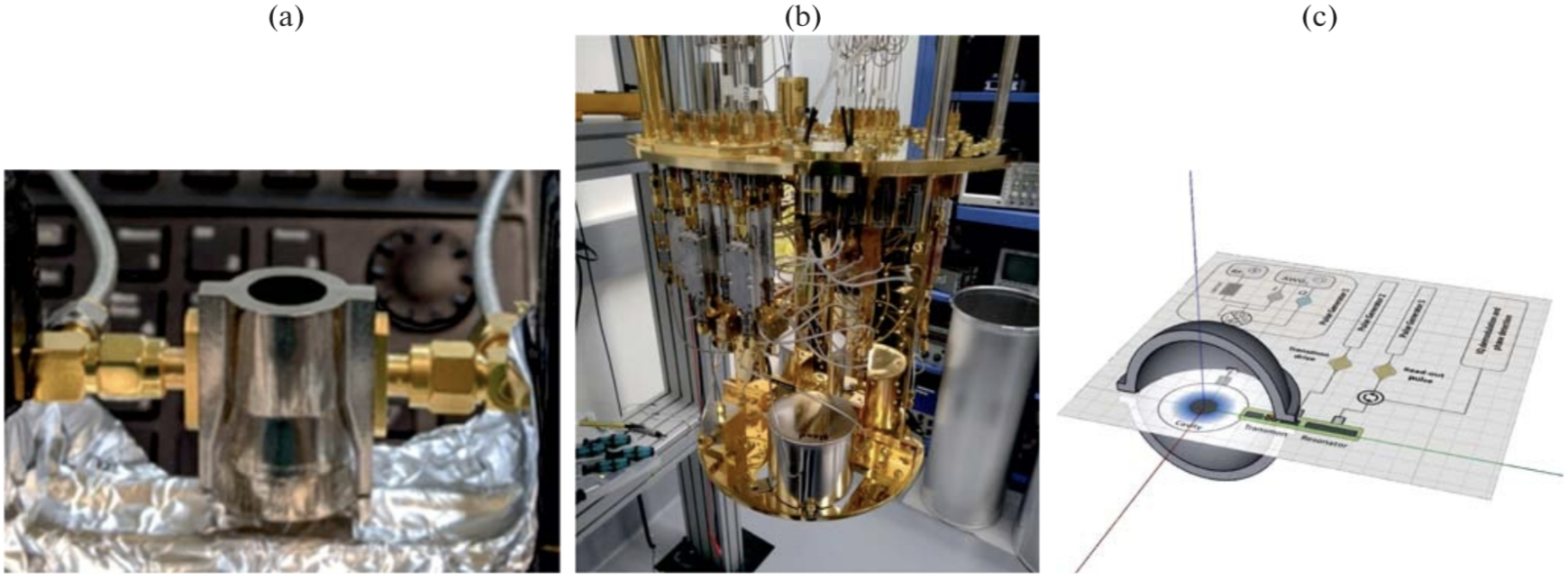
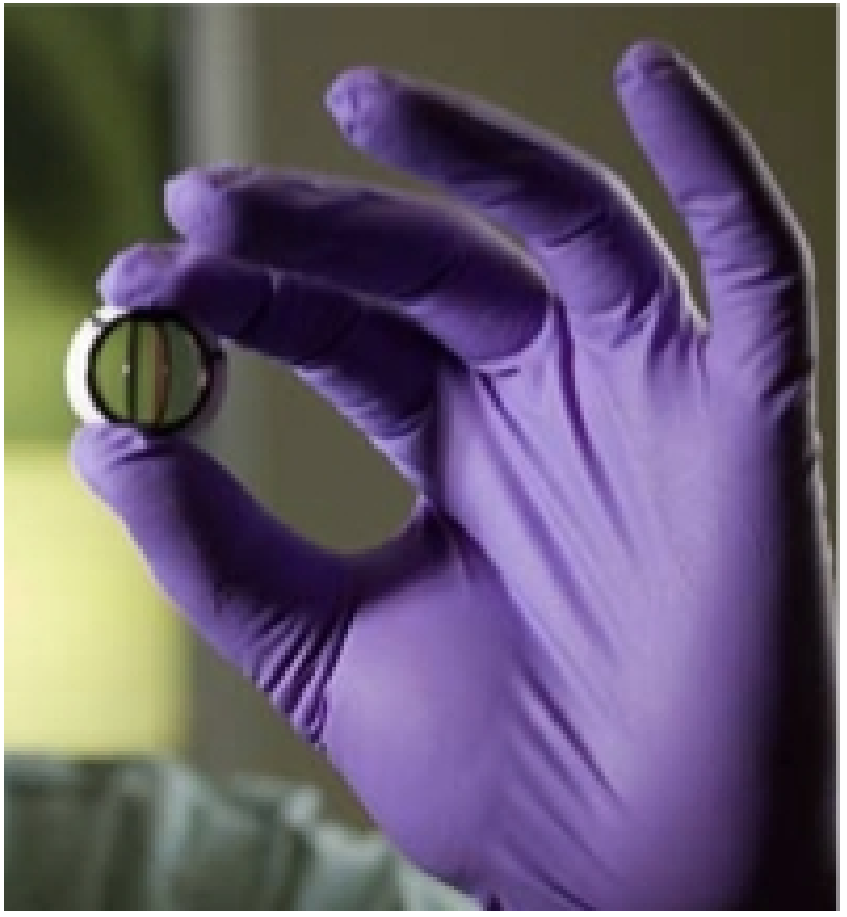


Fig. 19. (a) Superconducting quarter-wave resonator for quantum memory of a quantum computer, which is developed by RadiaBeam Technologies and made of Ti64 titanium alloy using 3D-printing technology. (b) Niobium resonators of this type were tested in a dilution refrigerator at the University of Chicago. Part (c) of the figure shows the schematics of the quantum bit based on a superconducting resonator.

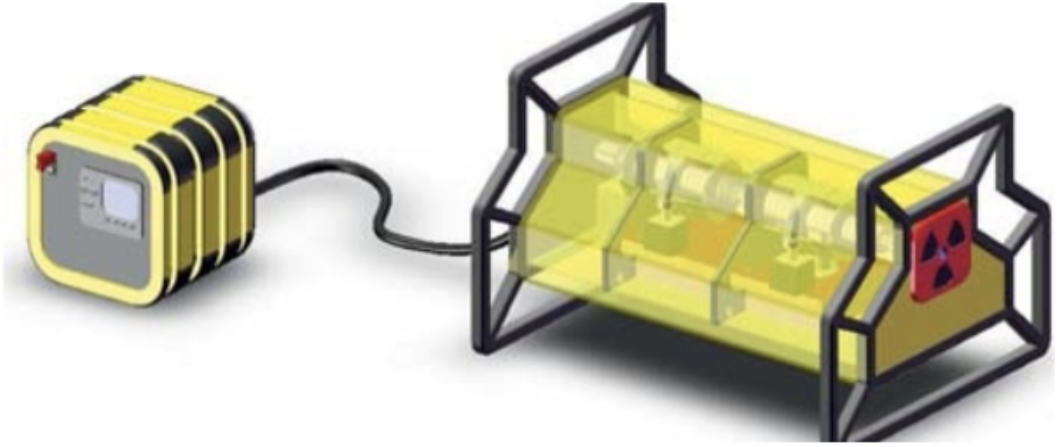
Valvole cardiache
realizzate in GPC (glassy polymeric carbon).
Per scongiurarne il rigettosono stati impiantati atomi di argento immediatamente sotto la superficie con una deposizione assistita da un fascio di ioni.
Operazione che sarebbe stata impossibile chimicamente.



(deposizione di vapori di argento con simultaneo bombardamento della superfici con atomi di argon a 700 eV)

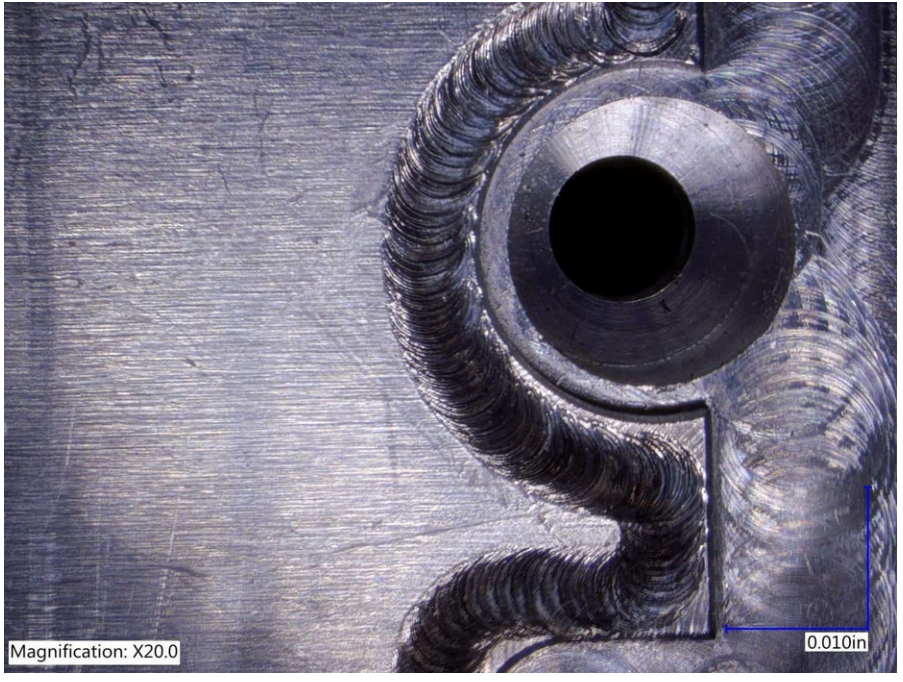
Gli **idrogel** sono prodotti sciogliendo alcuni polimeri in basse concentrazioni di acqua e quindi trattandoli con un fascio di elettroni. Questo intreccia la struttura interna dell'idrogel in una rete molecolare, permettendogli di trattenere l'umidità mantenendo la sua forma.

Sostituzione dei radioisotopi con acceleratori in modo di evitare il rischio di incidenti, perdite o uso dei radioisotopi per la produzione di armi



Concept of a portable accelerator for replacing radioactive isotopes

Saldatura a fascio di elettroni



Per ottenere giunti estremamente resistenti con una deformazione minima con autofusione

Simulazione dello spazio:

- Per la salute degli astronauti
- Per la salute dei materiali

Rubbia e il torio

INFN Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI FRASCATI

7 Science Matinées

Gli acceleratori di Particelle

Da microscopi subatomici a strumenti per la medicina

David Alesini
(INFN-LNF)

PRODUZIONE DI ENERGIA CON ACCELERATORI

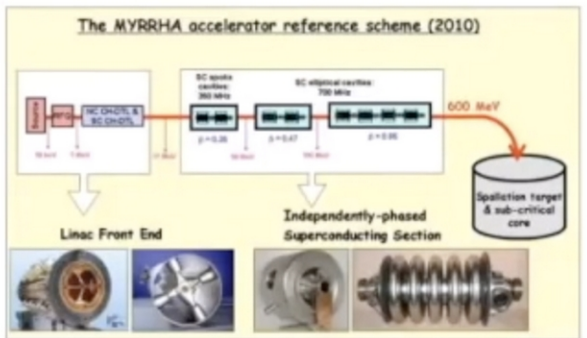
Un **ADS (Accelerator Driven System) è un reattore nucleare a fissione sottocritico** pilotato da un **acceleratore di protoni** ad alta energia (600 MeV- 1GeV). I **neutroni necessari** per sostenere il **processo di fissione** sono forniti dall'acceleratore di particelle

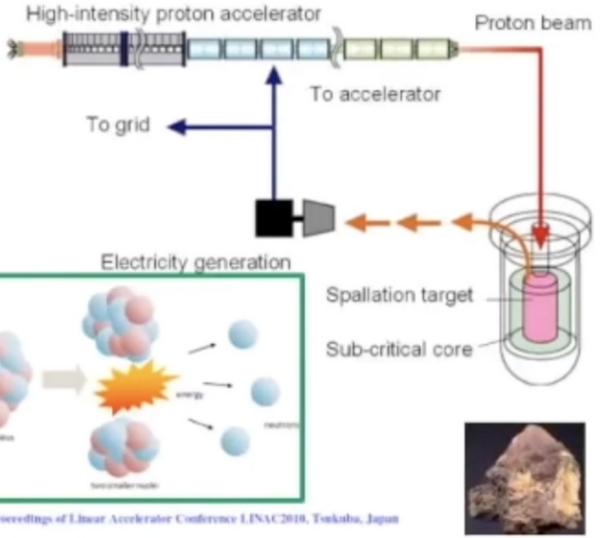
Vantaggi:

-Utilizza **torio come combustibile,** molto più abbondante dell'uranio e del plutonio

-**breve vita dei prodotti di scarto** (dell'ordine dei 100 anni contro le centinaia di migliaia di anni dei reattori attuali).

-**reattore intrinsecamente sicuro (fissione controllata)**





Proceedings of Linear Accelerator Conference LINAC2010, Tsukuba, Japan

PROTON LINAC FOR ADS APPLICATION IN CHINA

Shinian Fu, Shouxian Fang, Jiuqing Wang
IHEP, Institute of High Energy Physics, Beijing 100049, China
Xialing Guan
CIAE, China Institute of Atomic Energy, Beijing 102413, China

Alcuni esperimenti di laboratorio e molti studi teorici hanno dimostrato la possibilità teorica di tale impianto. **Carlo Rubbia**, è stato uno dei primi a concepire un progetto di un reattore subcritico, il cosiddetto "**amplificatore di energia**".
Nel 2012 gli scienziati e gli ingegneri del CERN hanno lanciato l'International Thorium Energy Committee (iThEC) un'organizzazione dedicata a perseguire questo obiettivo.

08 - Alesini 11 - produzione di energia con torio.mp4

Radioisotopi da ciclotrone

Si bombardano varie sostanze che diventano radioattive e vengono iniettate in un paziente, per:

- Radioterapia
- Diagnostica (PET)

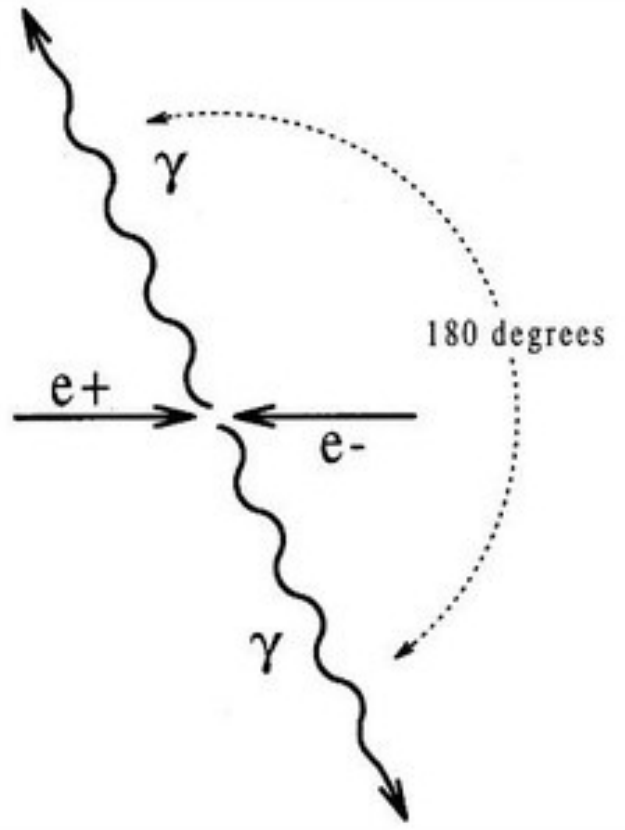
PET

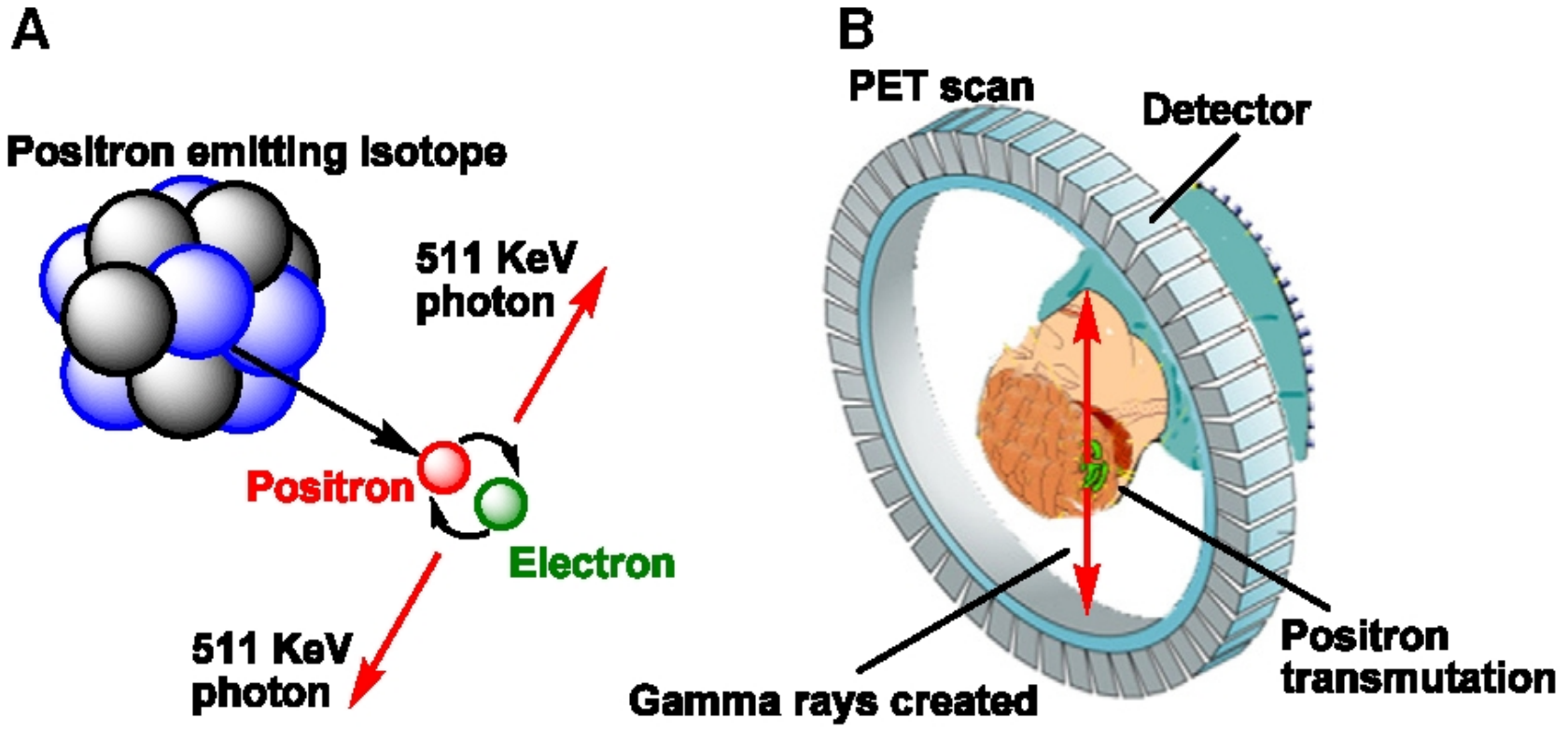
Si basa sull'emissione di positroni da parte di atomi instabili che vengono attaccati a un agente farmaceutico per essere trasportati nel sito desiderato.

Per esempio, glucosio radiomarcato, iniettato nel corpo del paziente, tende ad ammassarsi dove c'è un'attività metabolica più importante (cellule tumorali).

L'atomo instabile emette un positrone che si annichila immediatamente appena incontra un elettrone, dando luogo a due fotoni che viaggiano in direzioni opposte.

Se intorno al paziente metto un rivelatore di fotoni, riesco a capire il punto in cui sono stati emessi questi fotoni, quindi il punto in cui la sostanza è stata maggiormente assorbita.



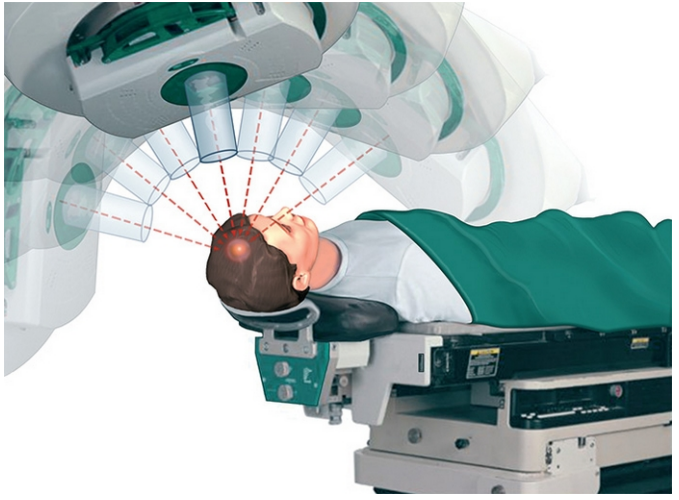

A
Positron emitting isotope
511 KeV
photon
Positron
Electron
511 KeV
photon
B
PET scan
Detector
Positron
transmutation
Gamma rays created

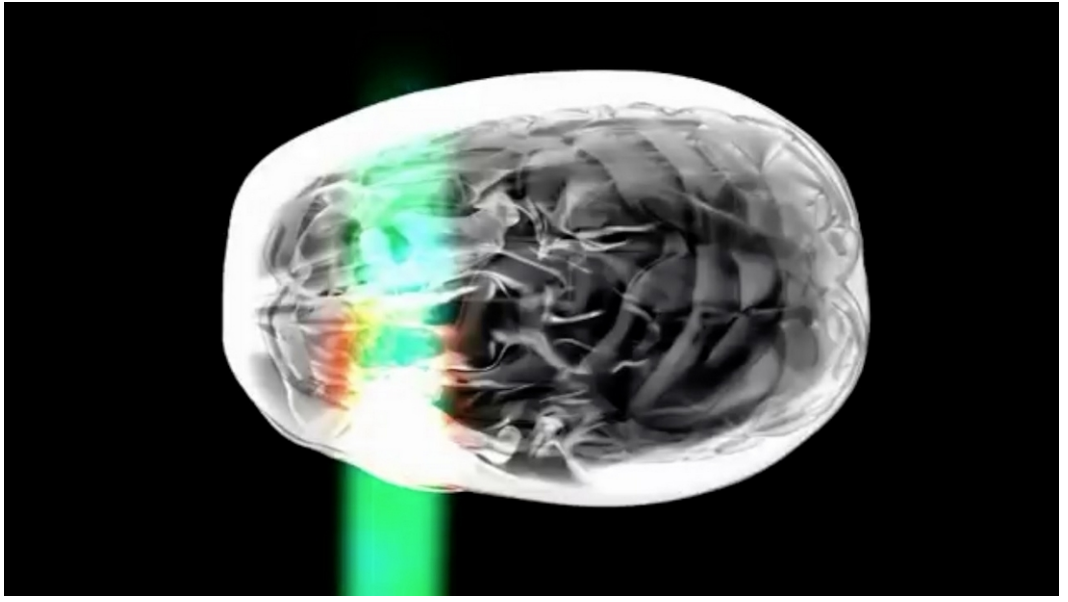
Typical radionuclides used for diagnostic imaging by PET.

Radionuclide	Half life (min)	Radiopharmaceutical	Target	Application
^{18}F	109.8	^{18}F-FDG	Glucose metabolism	Oncology, Neurology, Cardiology
		^{18}F-FLT	Amino acid metabolism	Oncology
		^{18}F-FES	Estrogen receptor	Breast cancer
		^{18}F-FP-CIT	Dopamin transporter	Parkinson's disease
		^{18}F-FET	Amino acid metabolism	Oncology,
		^{18}F-FMISO	Hypoxia	Oncology, Stroke
^{11}C	20.4	^{11}C-Methionine	Amino acid metabolism	Oncology
		^{11}C-Acetate	Fatty acid metabolism	Oncology, Cardiology
		^{11}C-Flumazenil	GABA receptor	Epilepsy
		^{11}C-PIB	β-Amyloid	Dementia
		^{11}C-DASB	Serotonin transporter	Depression
		^{11}C-Raclopride	Dopamin receptor	Parkinson's disease
^{13}N	9.96	^{13}N-Ammonia	Blood flow	Cardiology
^{15}O	2.07	^{15}O-Water	Blood flow	Neurology

Radioterapia

Irraggiamento di masse tumorali con raggi X





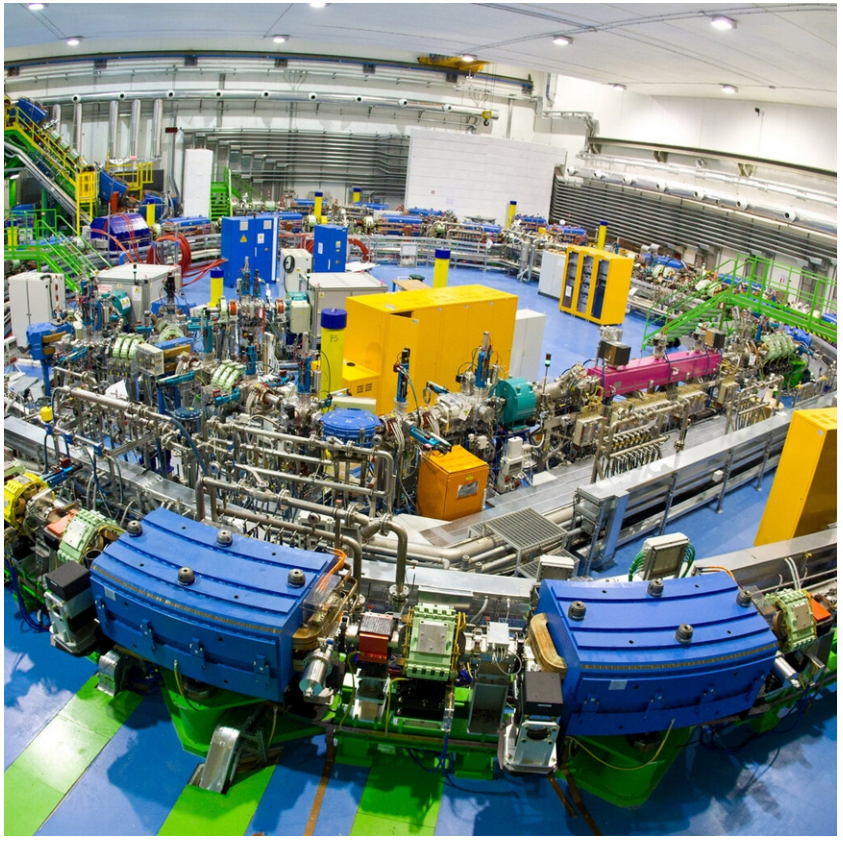
09 - radioterapia.mp4

Particle Accelerators for Tumour Therapy
https://www.youtube.com/watch?v=a8dtk95nYI8

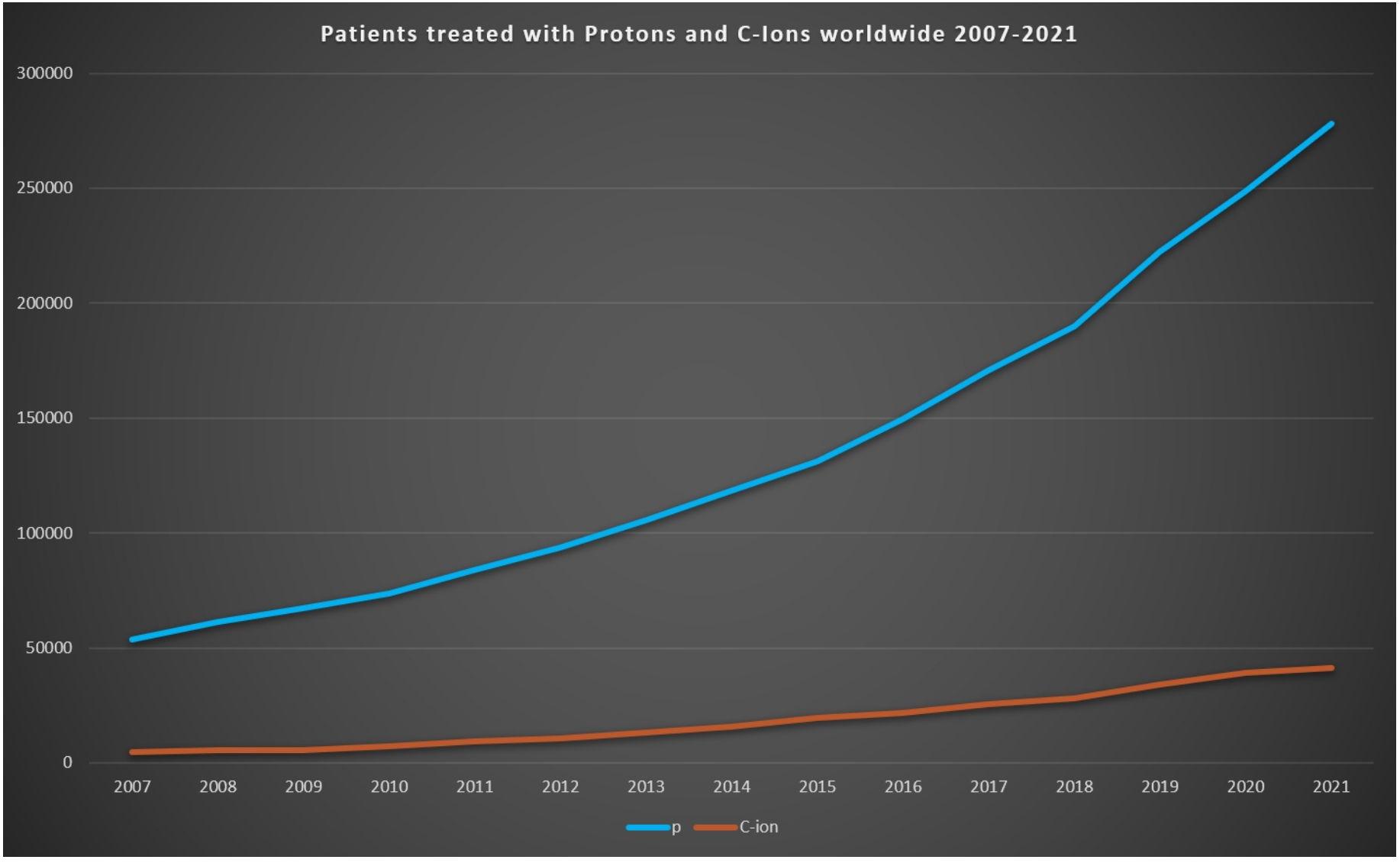
Adroterapia

Irraggiamento di masse tumorali con protoni o ioni pesanti (C)

10 - adroterapia.mp4



CNAO (Pavia)


Patients treated with Protons and C-Ions worldwide 2007-2021
300000
250000
200000
150000
100000
50000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
p
C-ion

protoni

nazione	operative	in costruzione	pianificate
Argentina		1	
Australia		1	
Austria	1		
Belgium	1		1
China	4	8	10
Czech Republic	1		
Denmark	1		
Egypt			1
Emirate of Abu Dhabi		1	
France			
Georgia			1
Germany	5		
India	1	2	1
Indonesia			1
Italy	3		3
Japan	19	2	
Norway		2	
Poland	1		
Russia	5	2	1
Saudi Arabia		1	
Singapore		2	1
Slovak Rep		1	
South Korea	2		
Spain	2		1
Sweden	1		
Switzerland	1		2
Tailand		1	
Taiwan	3	1	1
The Netherlands	3		
United Kingdom	6	1	
USA, CA.	43	7	8

Ioni C

Austria	1		
China	2	1	1
France		1	
Germany	2		
Italy	1		
Japan	7		
South Korea		2	
Taiwan		1	

Ioni He

South Korea		1	

Ioni di Elio sembrerebbero avere un alone minore

QUANTO COSTA UN ACCELERATORE?

F16	$15M
F117-A (stealth)	$100M
Dafne and KLOE	$150M
B-1B	$200M
INFN/year	$280M
B-2B (stealth)	$2B
Space shuttle:	$4B
Launching	$400M
Messina Bridge	$5B
NASA/year	$15B
ISS	$40B
US Defense/year	$400B

Credits:
David Alesini