

RAGGI COSMICI

IL COSMO IN LABORATORIO

CHARLES AUGUSTIN DE COULOMB

PARIGI, 1785



*Home Made
Physics
Elettricità*



**Coulomb scopre che un elettroscopio
si scarica **spontaneamente****

WILHELM RÖNTGEN



HENRI BECQUEREL



MARIE CURIE

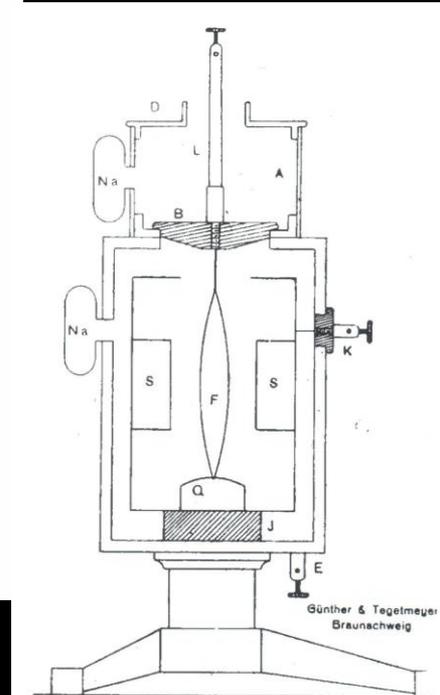


1895 – 1898
SCOPERTA DELLA
RADIOATTIVITÀ

Theodore Wulf

INVENZIONE DELL'ELETTROMETRO

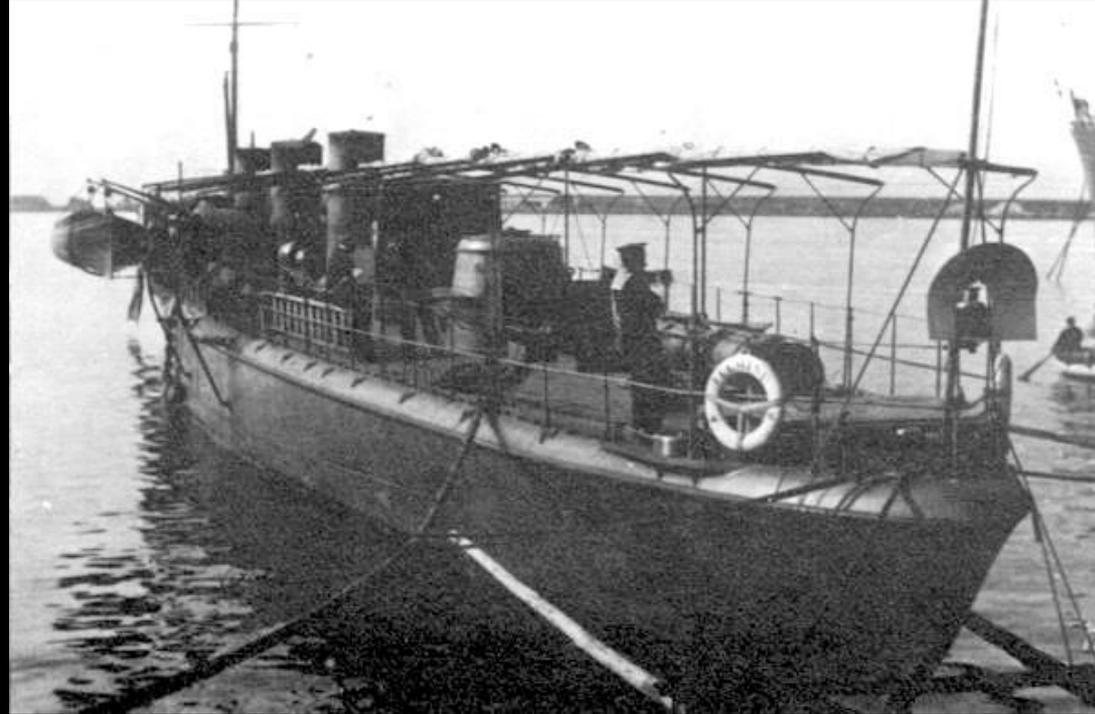
Olanda, 1909



Domenico Pacini

ESPERIMENTI SOTTOMARINI

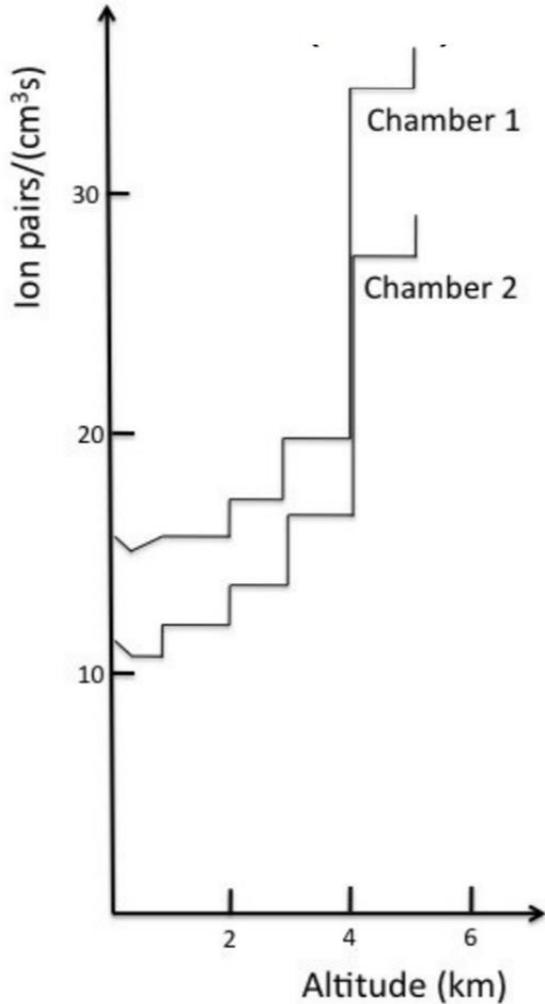
Lago di Bracciano e Livorno, dal 1907 al 1911



la radiazione **dimuisce** con la
profondità

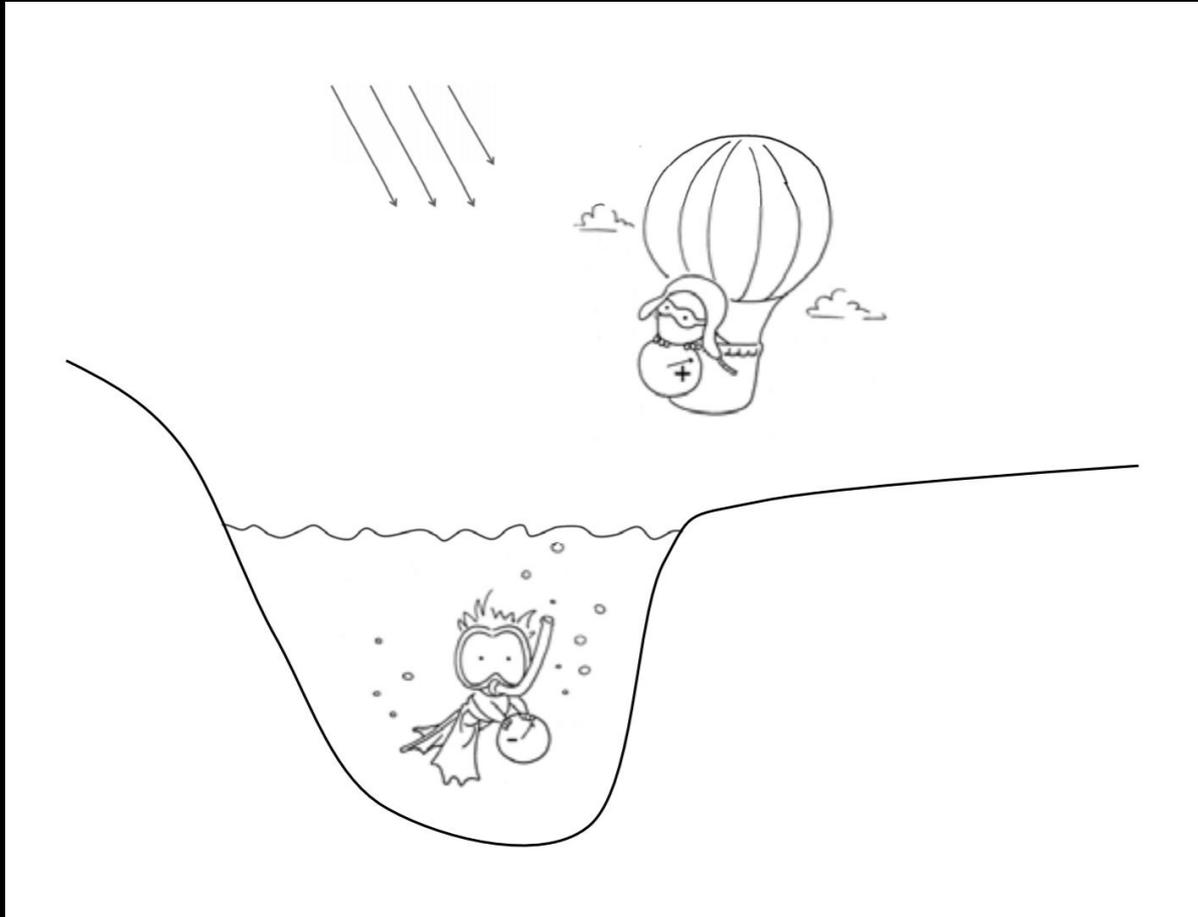
VICTOR Hess

VOLO IN MONGOLFIERA DALLA BOEMIA A BERLINO, 1912



la radiazione **aumenta** con
l'altitudine

la radiazione misteriosa deve avere
origine **extra-terrestre**



Pacini muore nel 1934
Hess vince il Premio Nobel nel 1936

ROBERT MILLIKAN

CHICAGO, 1920

inventa IL nome "Raggi Cosmici"



pensa siano
raggi gamma
di alta energia

ARTHUR COMPTON

St. Louis, 1925



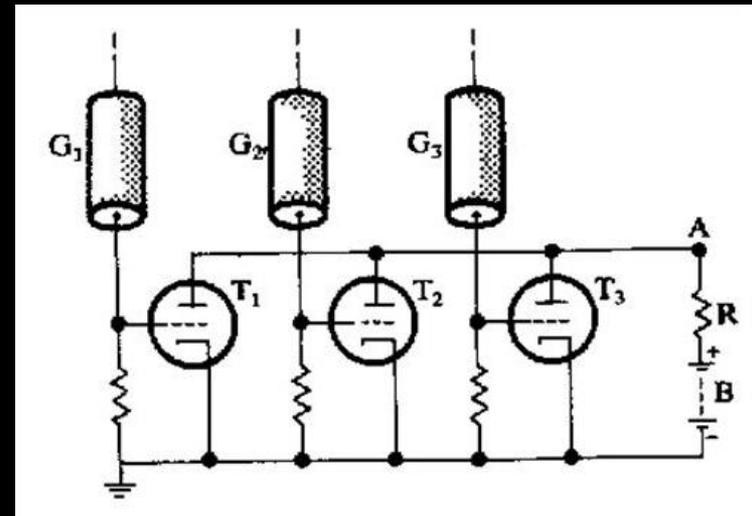
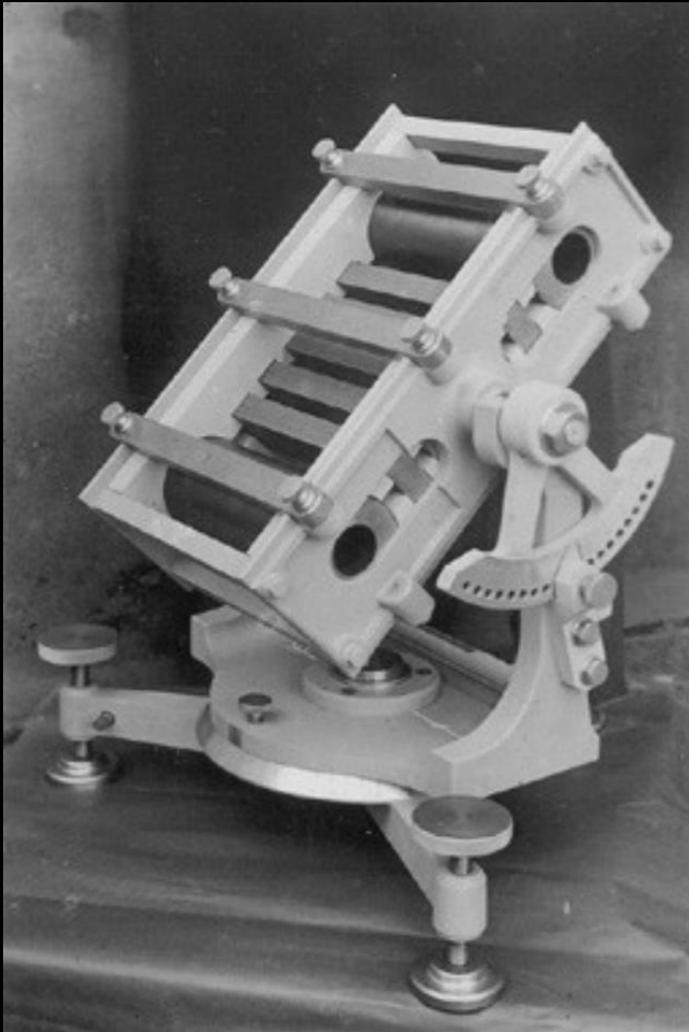
misura una variazione
con il **campo magnetico**
terrestre

sono **particelle cariche**

BRUNO ROSSI

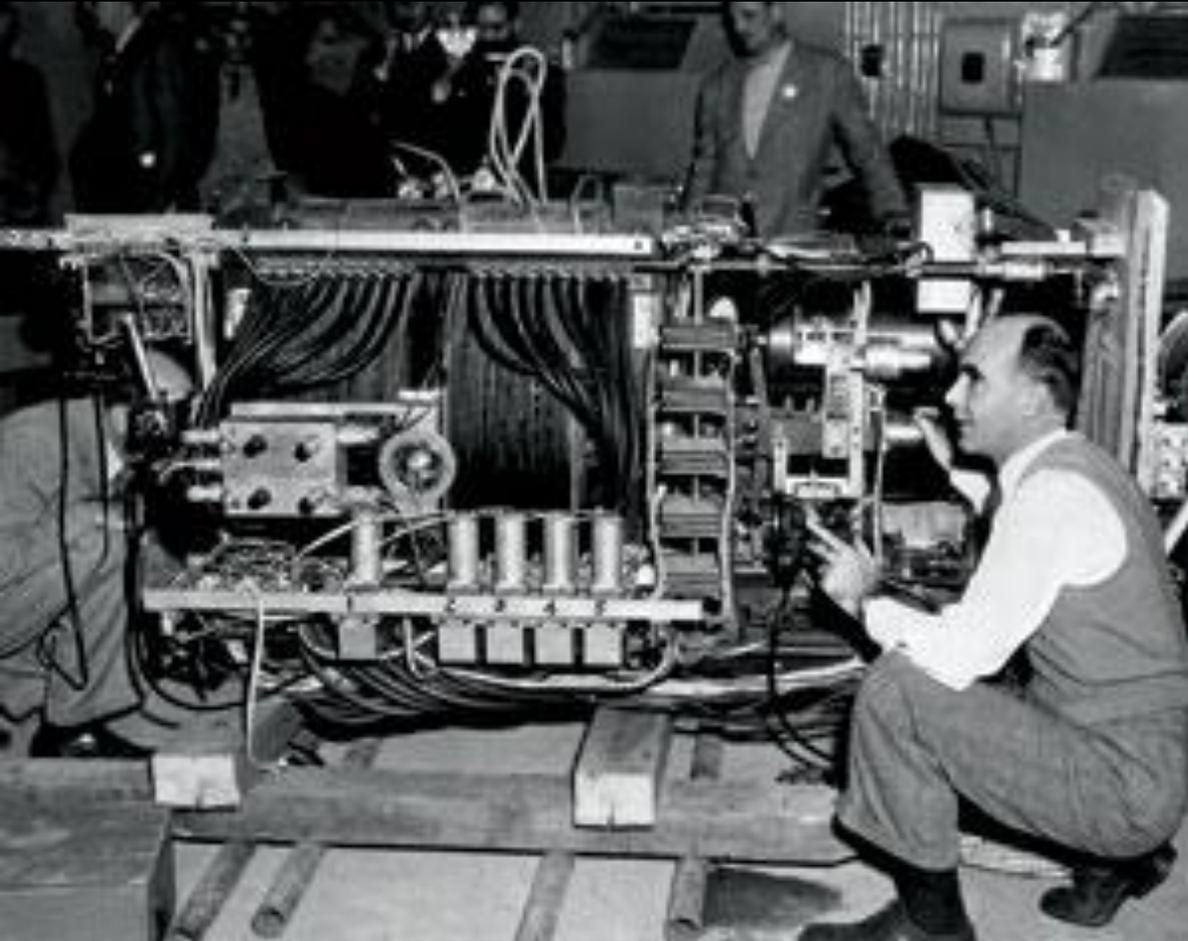
ARCETRI, 1930

primo
telescopio di
raggi cosmici
basato su
circuito a
coincidenze

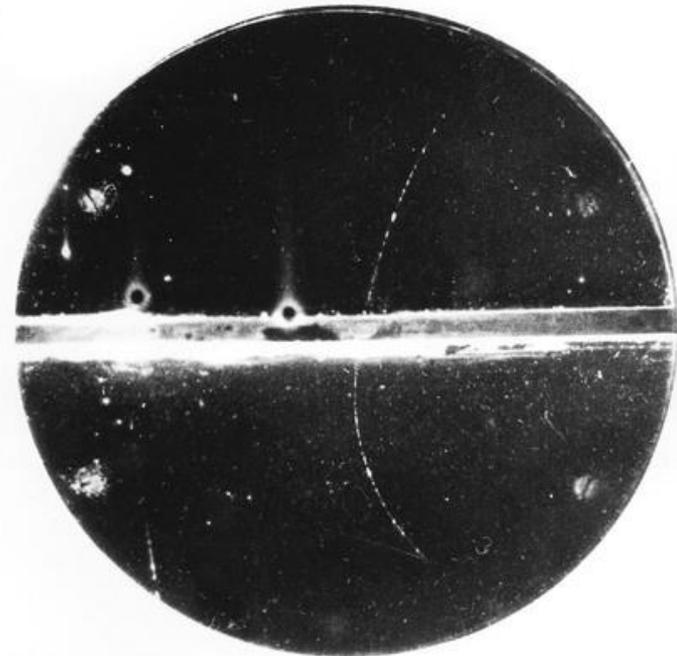


CARL ANDERSON

CALIFORNIA, 1932



nei raggi cosmici
scopre il **positrone**



CARL ANDERSON e SETH NEEDERMAYER

CALIFORNIA, 1936

appare il **mesotrone**



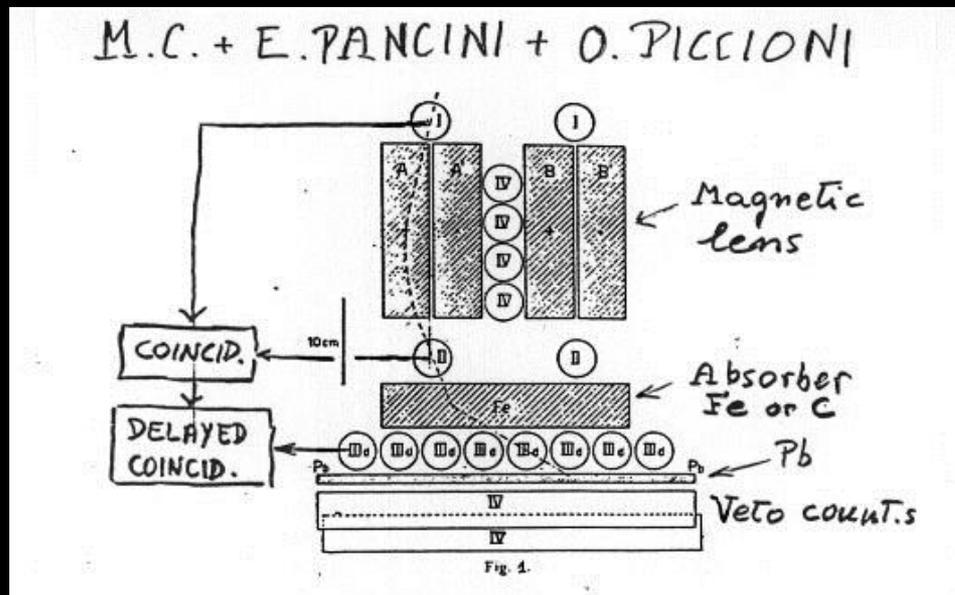
"The other double trace of the same type (figure 5) shows closely together the thin trace of an electron of 37 MeV, and a much more strongly ionizing positive particle with a much larger bending radius. The nature of this particle is unknown; for a proton it does not ionize enough and for a positive electron the ionization is too strong. The present double trace is probably a segment from a "shower" of particles as they have been observed by Blackett and Occhialini, i.e. the result of a nuclear explosion".

**MARCELLO
CONVERSI**

**ETTORE
PANCINI**

**ORESTE
PICCIONI**

**Roma,
LUGLIO 1943**



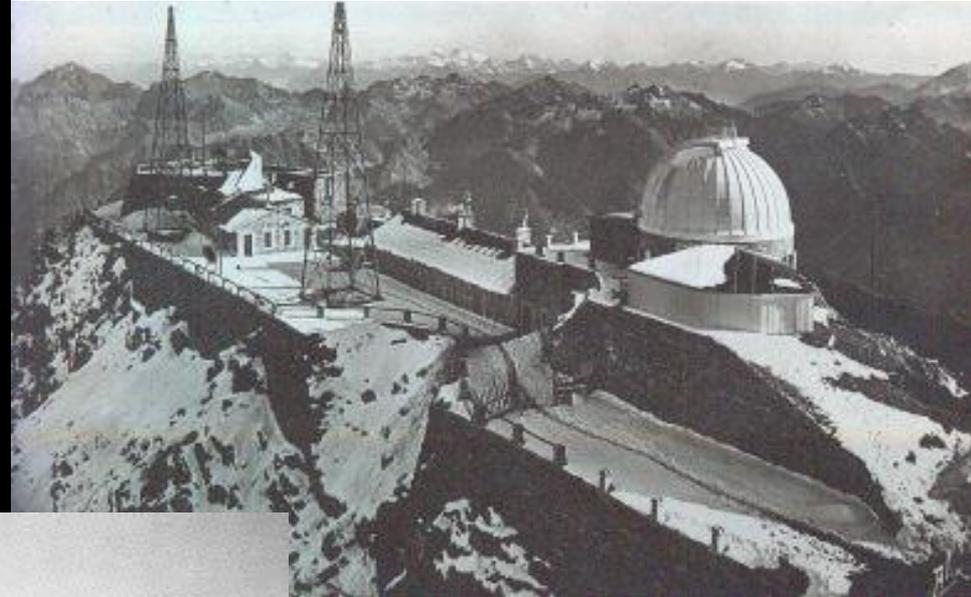
**scoperta del
muone**

LABORATORI ad ALTA QUOTA

LABORATORIO Testa GRIGIA
Plateau Rosa



OBSERVATOIRE MIDI-PYRÉNÉES
PIC DU MIDI



EDOARDO AmALDI
GILBERTO BERNARDINI
ETTORE PancINI



**Cecil
Powell**

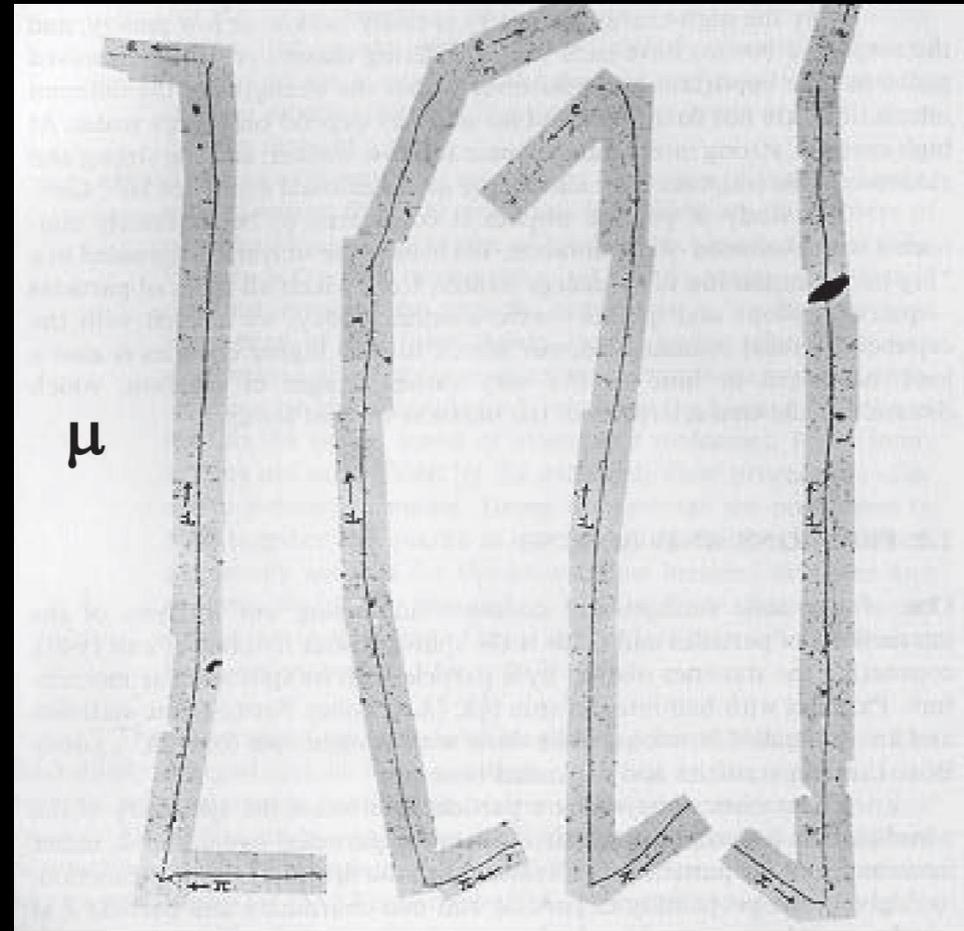
**Giuseppe
Occhialini**

Pic du Midi, 1947

scoperta del **pione**
con le emulsioni
fotografiche

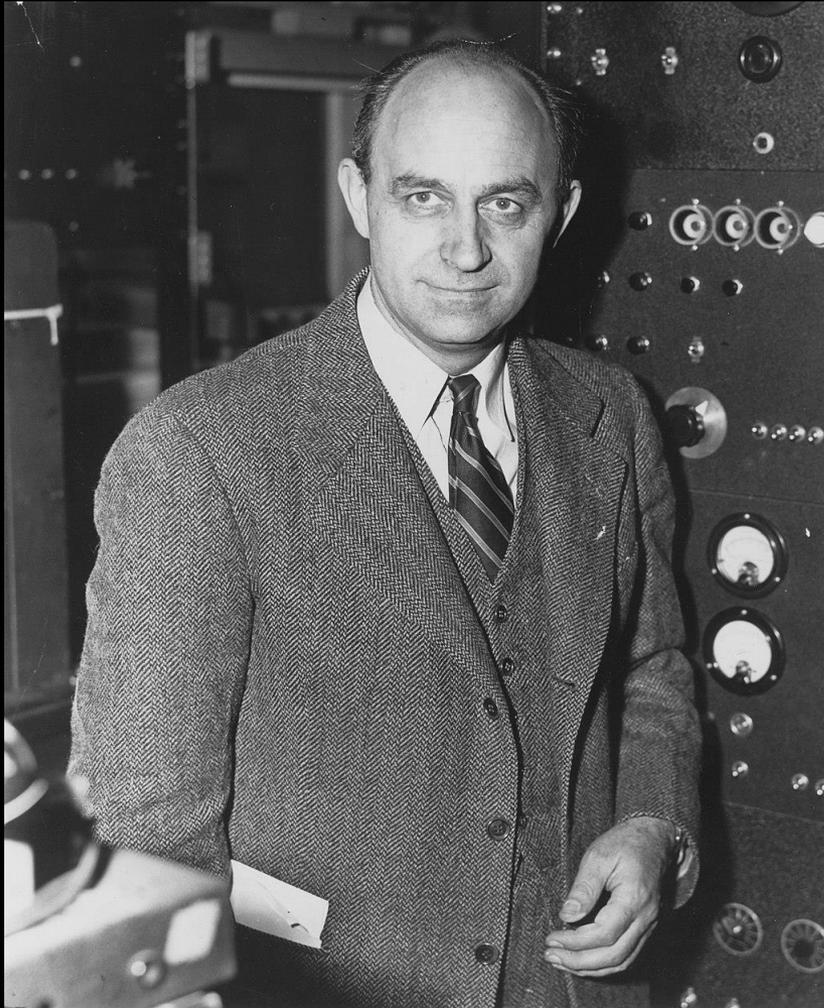


$$\pi \rightarrow \mu\nu$$
$$\mu \rightarrow e\nu\nu$$

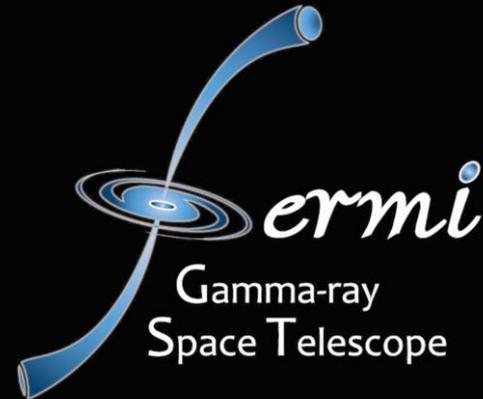
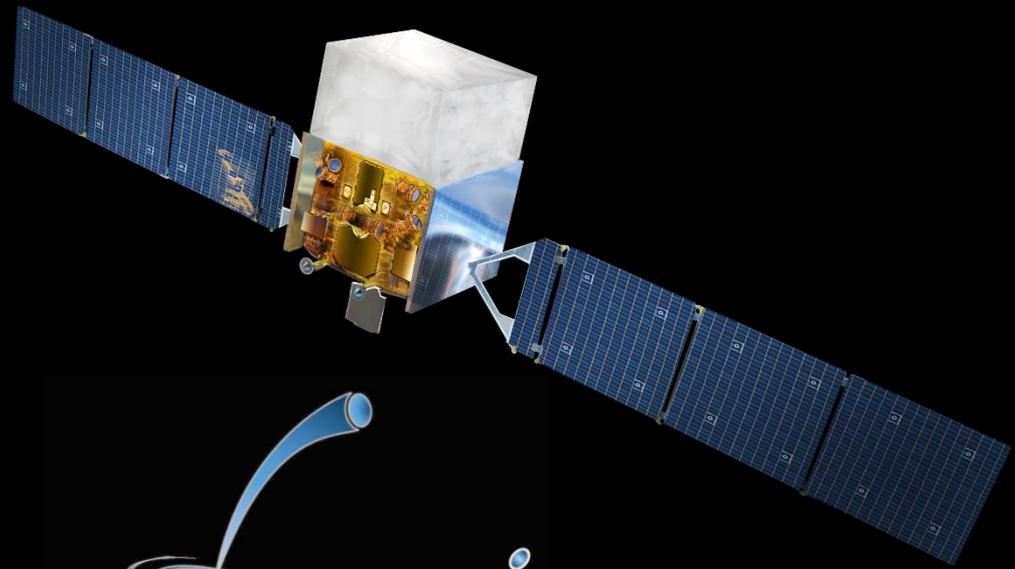


ENRICO FERMI

CHICAGO, 1949



meccanismo di Fermi di
accelerazione nelle
supernovae

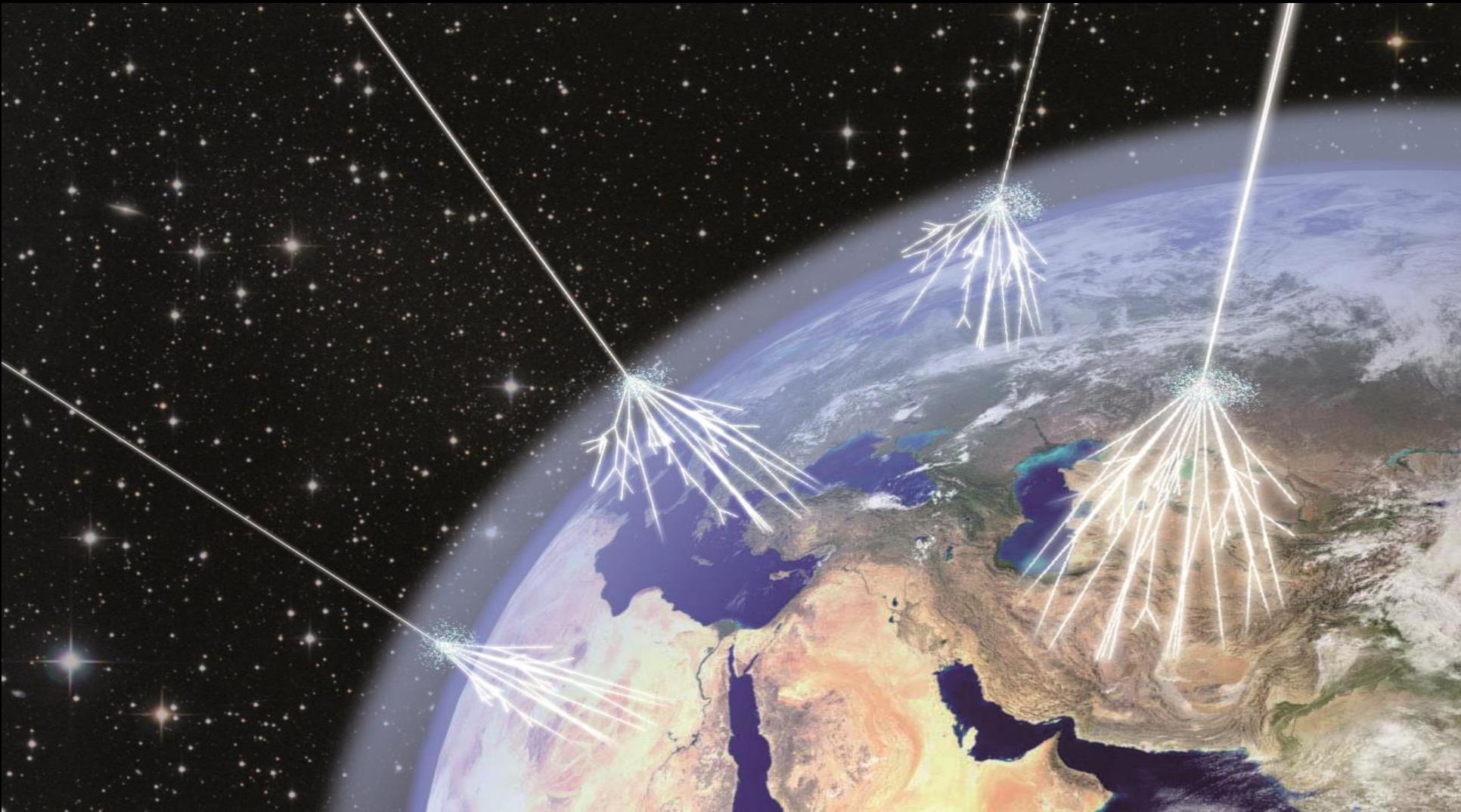


Raggi Cosmici PRIMARI

DIRETTAMENTE DA
SORGENTI COSMICHE

Raggi Cosmici SECONDARI

PARTICELLE DA COLLISIONE
CON ATMOSFERA

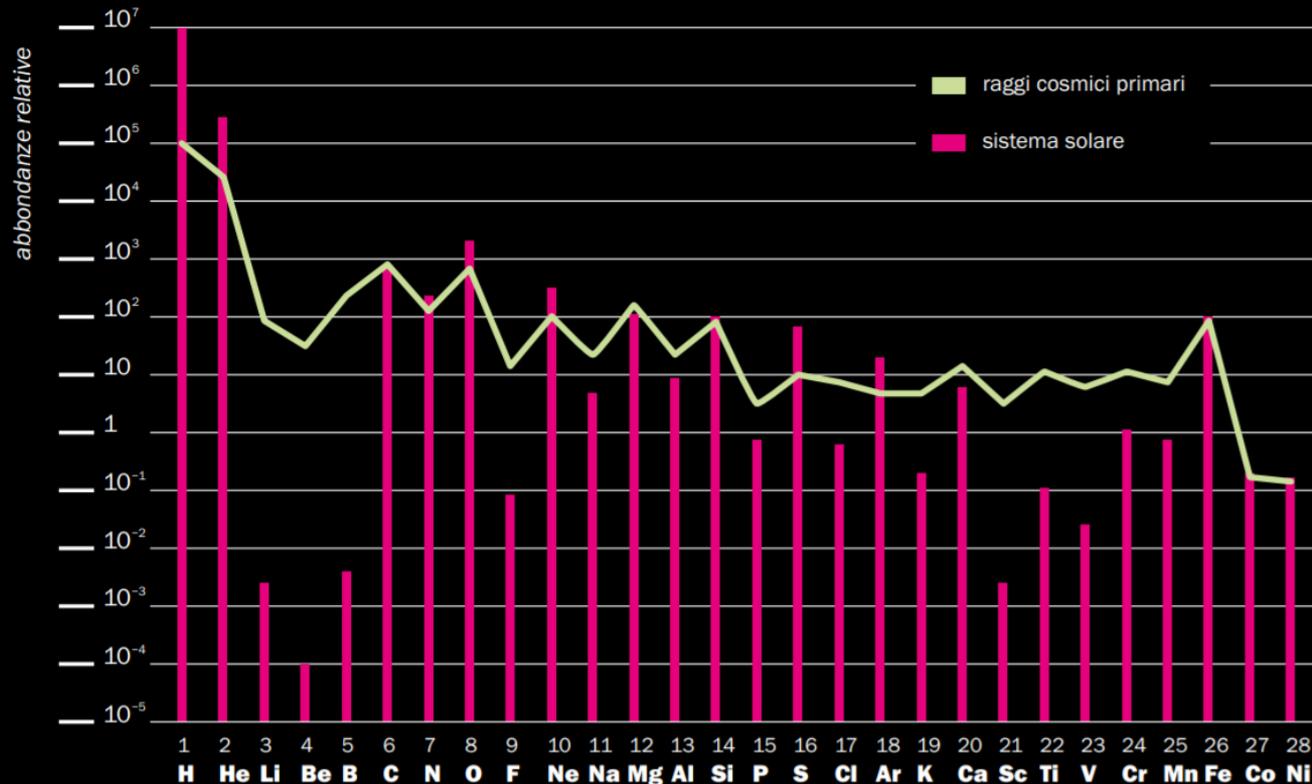


Raggi Cosmici Primari

95% PROTONI

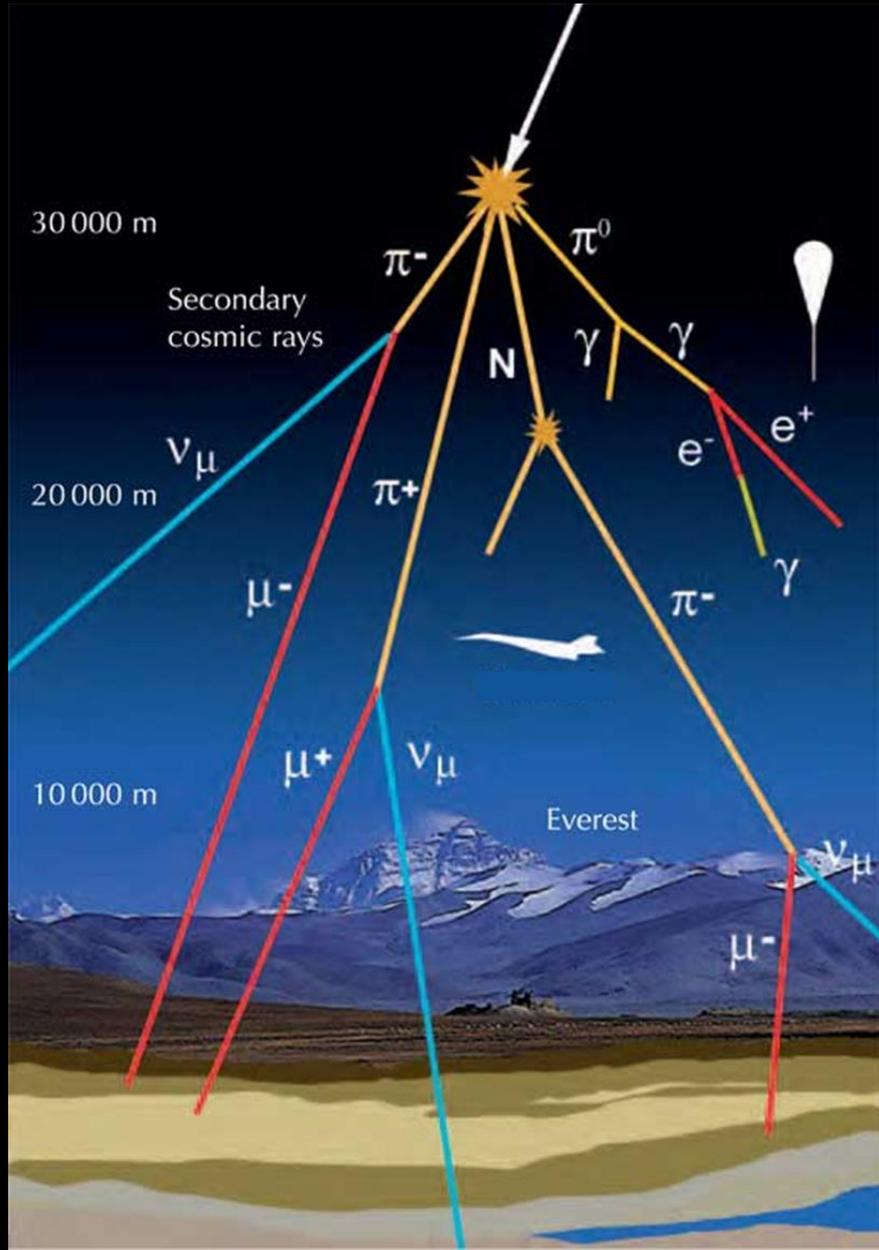
4.5% NUCLEI ELIO

0.5% ALTRI ELEMENTI



non c'è antimateria

RAGGI COSMICI SECONDARI



30% componente MOLLA
pioni, kaoni, neutroni,
fotoni, elettroni, positroni

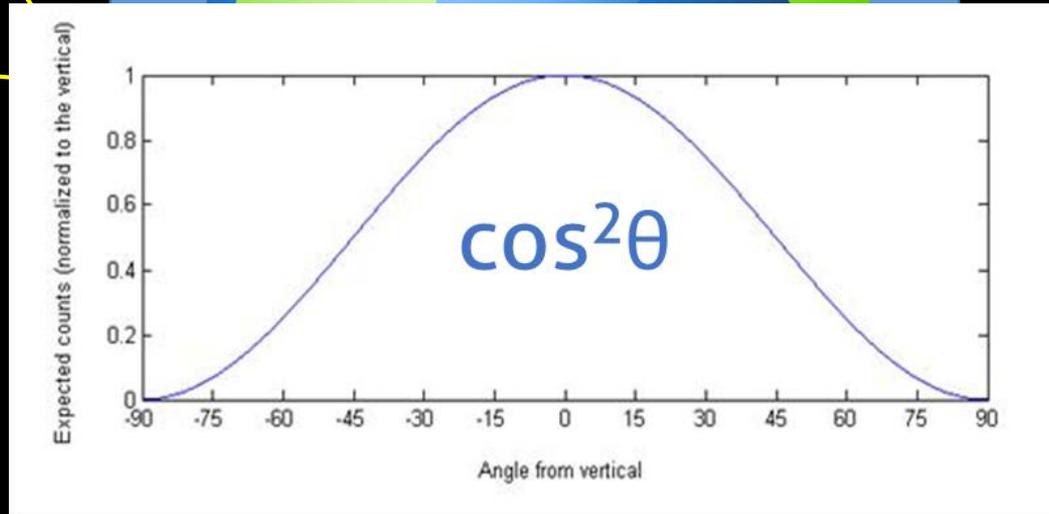
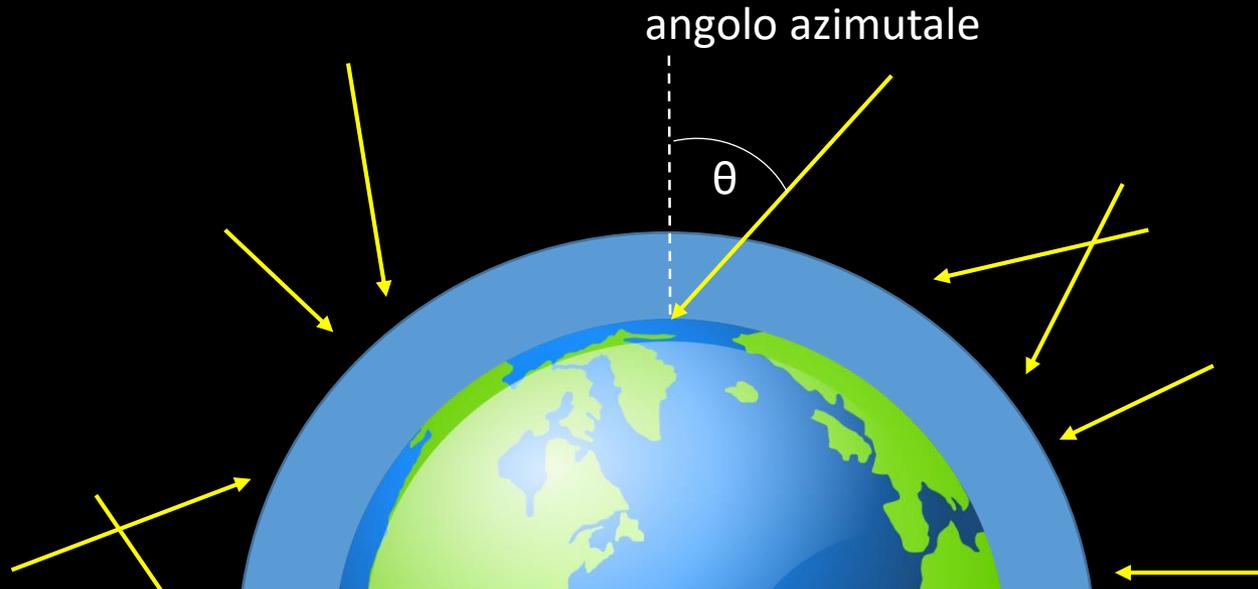
70% componente DURA
muoni

1 / cm² · s

100 / 🖐 · s

RAGGI COSMICI SECONDARI

DISTRIBUZIONE ANGOLARE



RAGGI COSMICI SECONDARI

CALCOLO DELLA DISTANZA PERCORSA

muone vita media $2 \mu\text{s}$ – energia 3 GeV

$$s = vt$$

$$= 3 \cdot 10^8 \frac{\text{m}}{\text{s}} \cdot 2 \cdot 10^{-6} \text{s}$$

$$= 600 \text{ m}$$

RAGGI COSMICI SECONDARI

CALCOLO DELLA DISTANZA PERCORSA

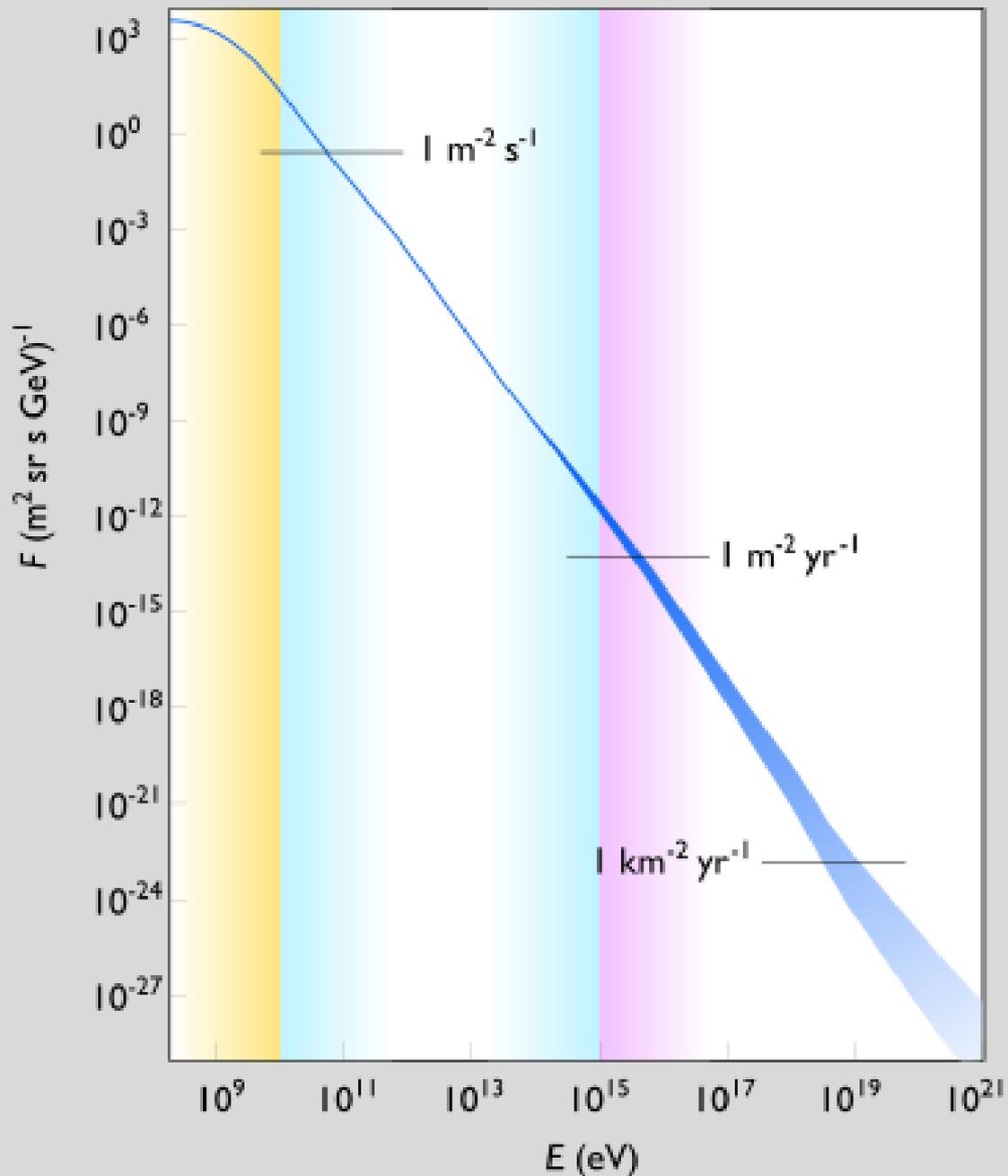
muone vita media $2 \mu\text{s}$ – energia 3 GeV

$$s = vt \gamma$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} = \frac{E}{m_{\mu}c^2} = \frac{3 \times 10^9 \text{ eV}}{10^8 \text{ eV}} = 30$$

$$s = 600 \text{ m} \cdot 30 = 18 \text{ km}$$

Flusso e Energia dei Raggi Cosmici

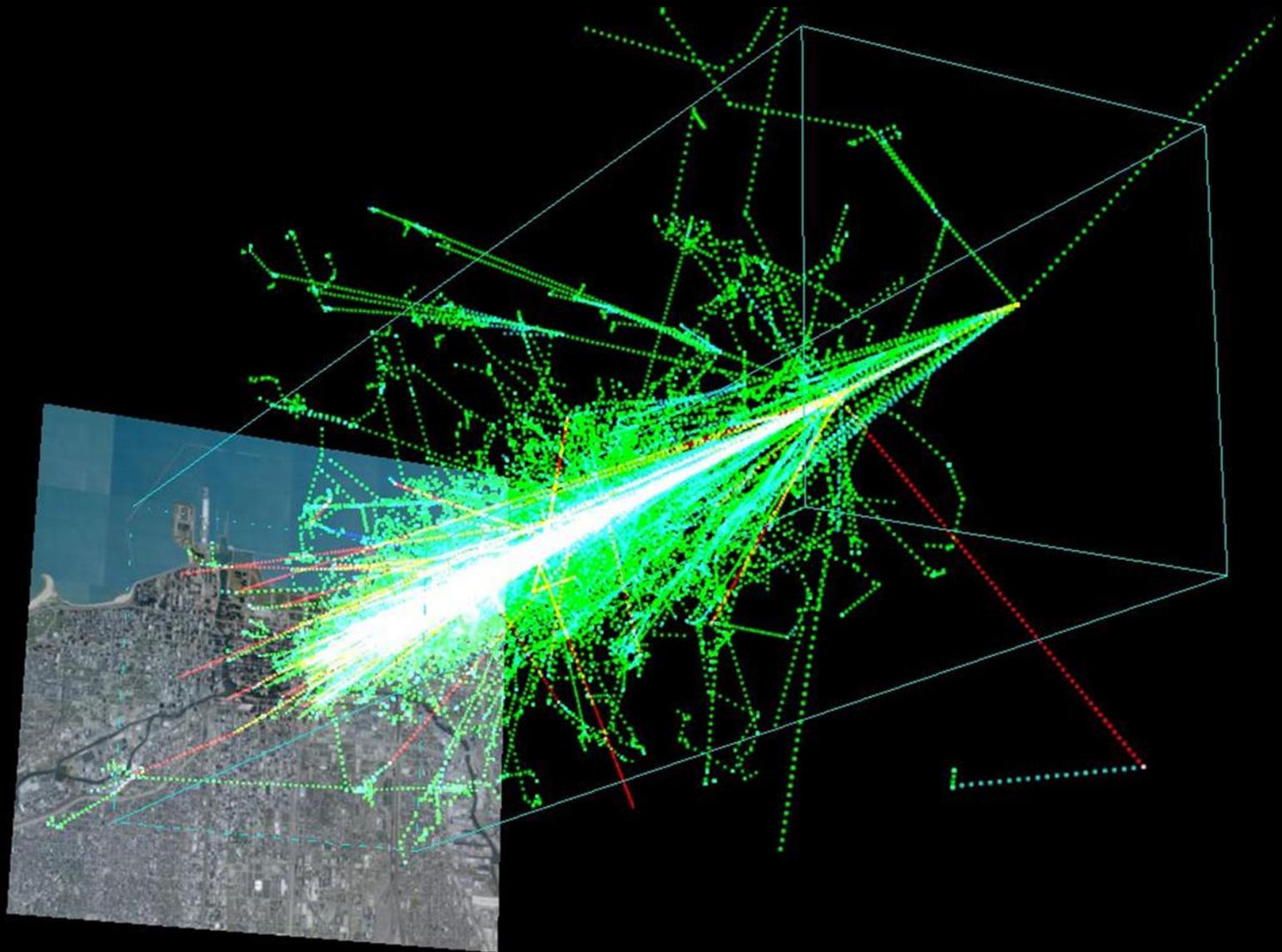


Osservatorio Pierre Auger



Osservatorio Pierre Auger

Sciame Cosmico in ARIA



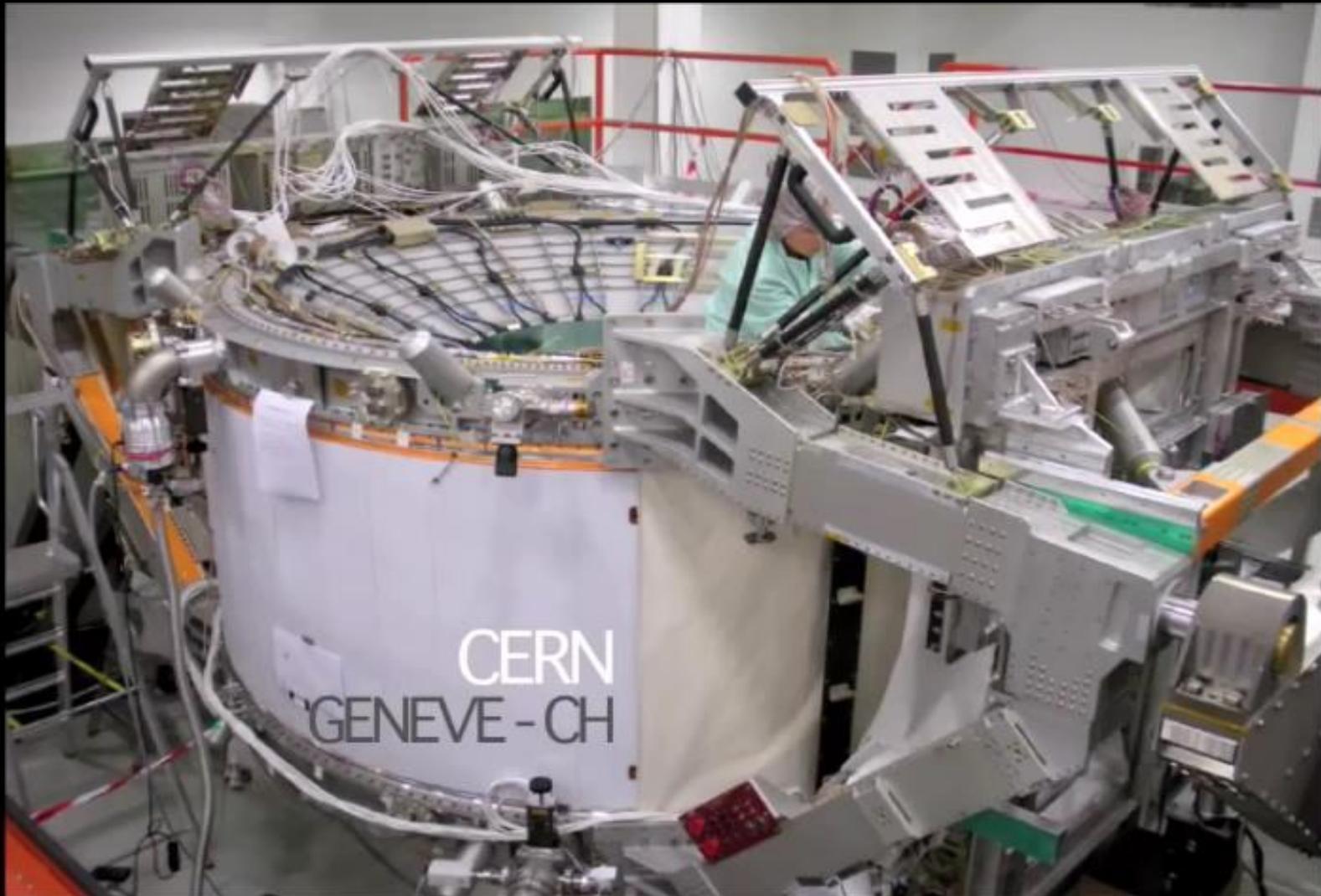
ALPHA MAGNETIC SPECTROMETER

AMS SULLA STAZIONE SPAZIALE INTERNAZIONALE

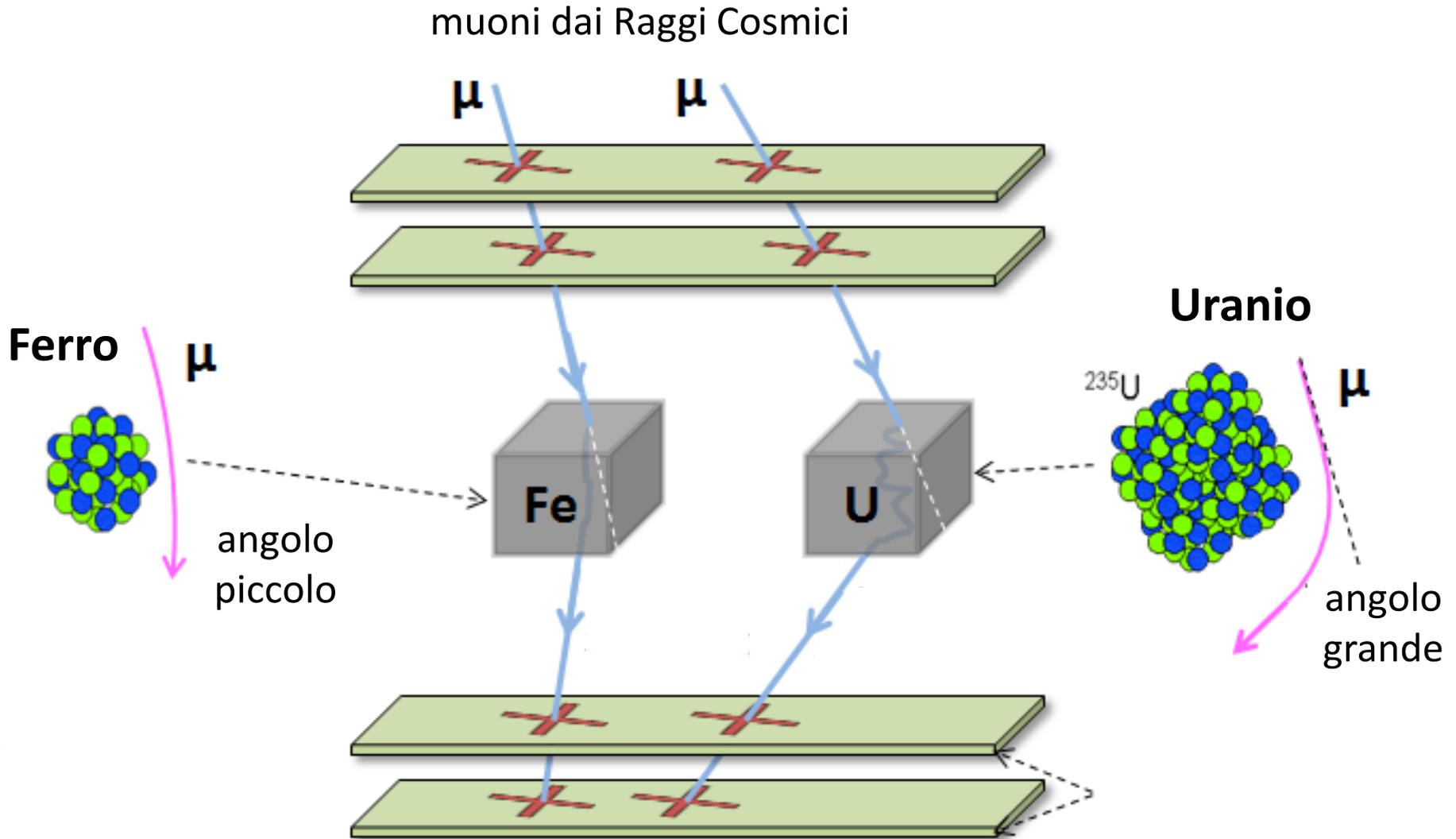


ALPHA MAGNETIC SPECTROMETER

AMS SULLA STAZIONE SPAZIALE INTERNAZIONALE

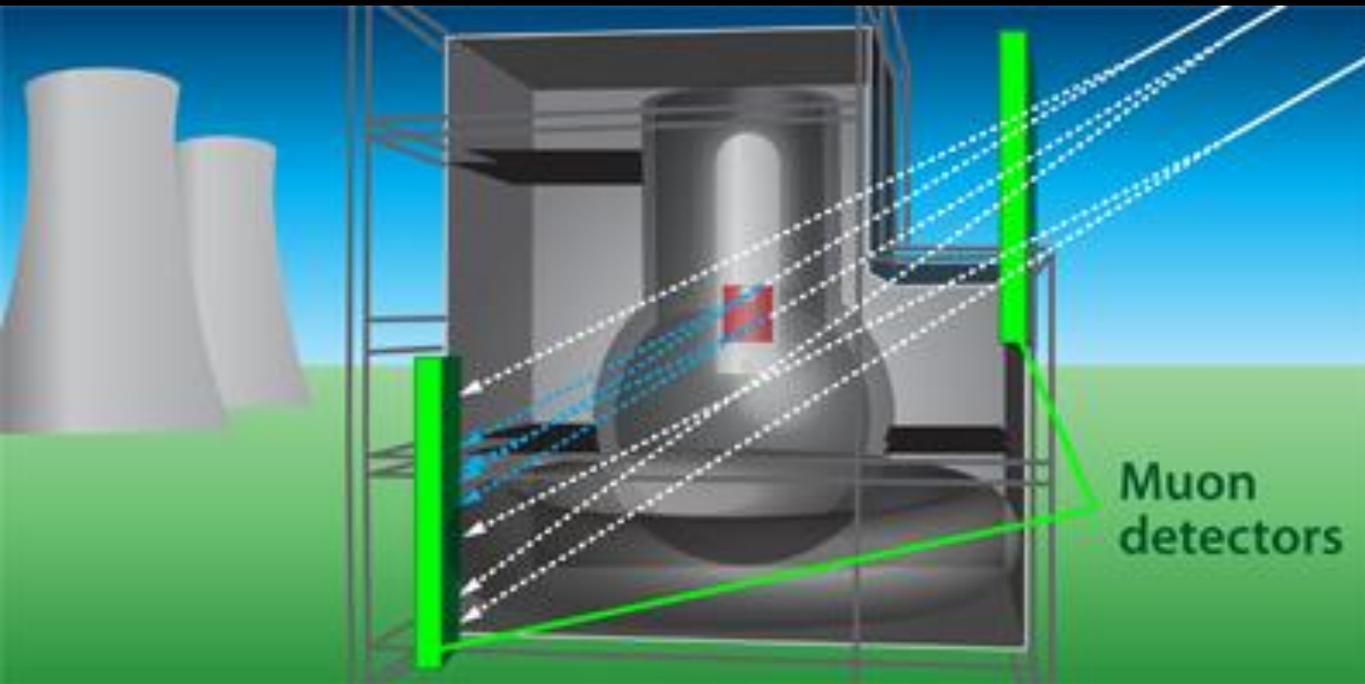


TOMOGRAFIA a MUONI



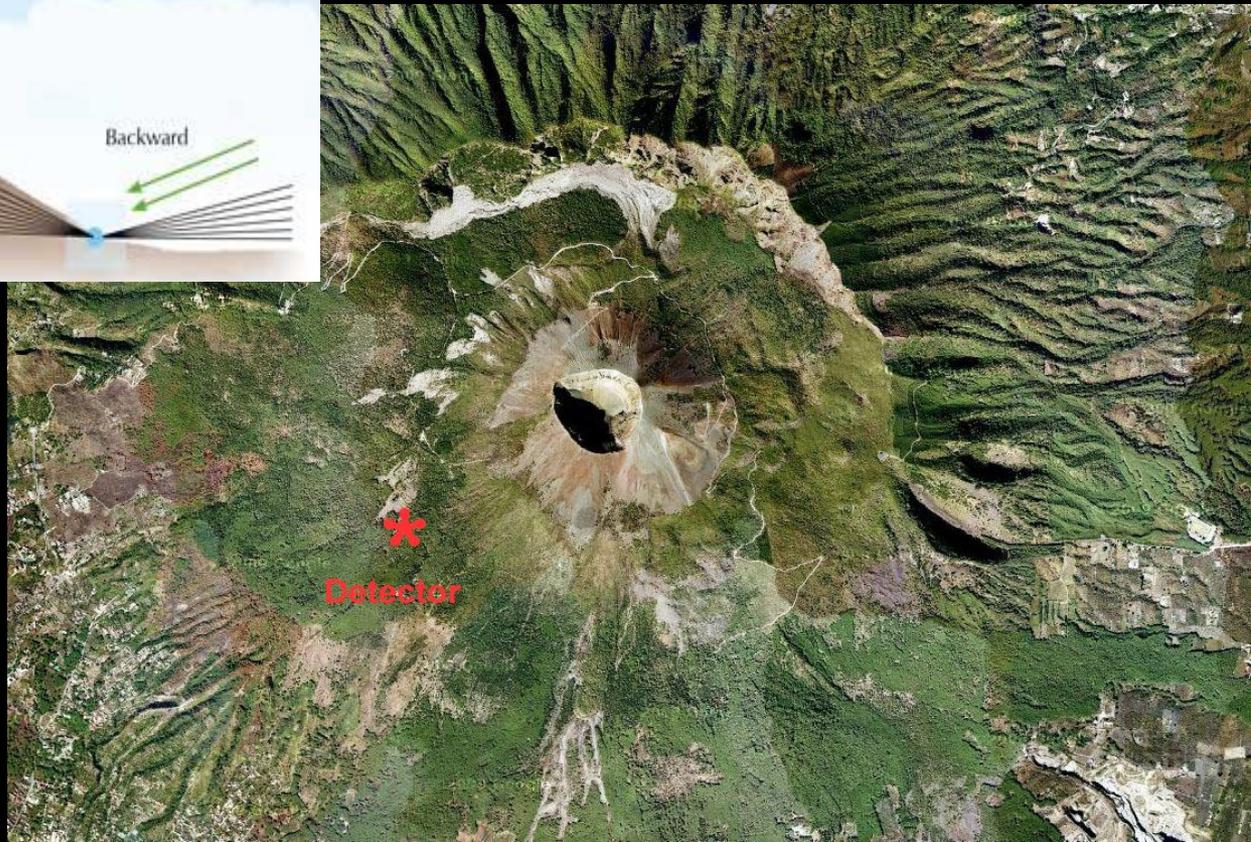
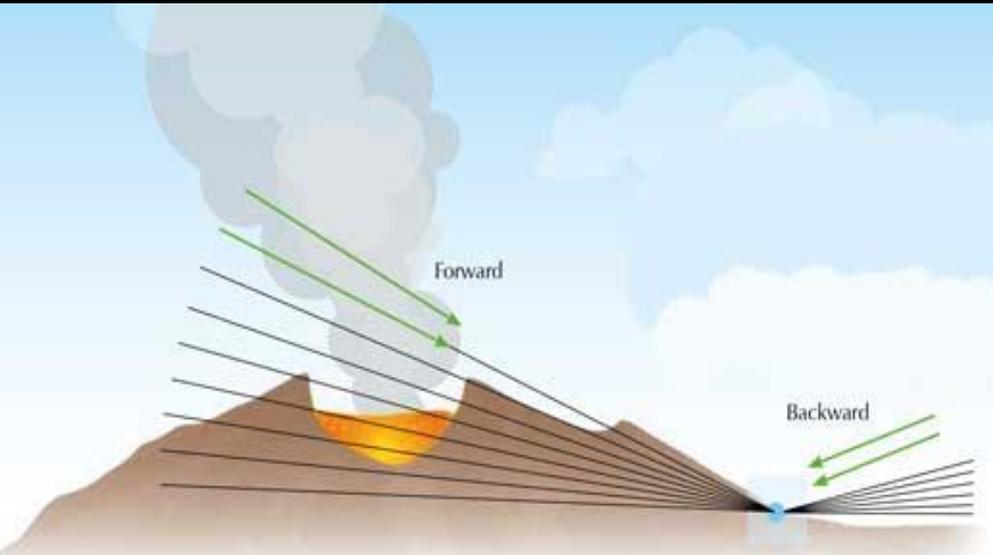
Tomografia a Muoni

Reattore A di Fukushima



Tomografia a Muoni

Camera Magmatica del Vesuvio

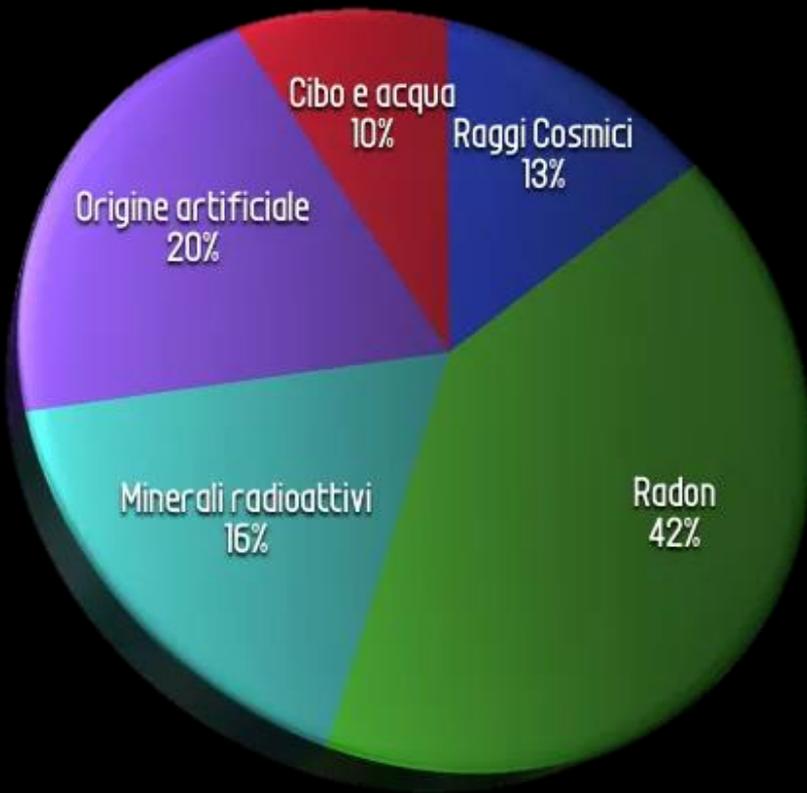


Tomografia a Muoni

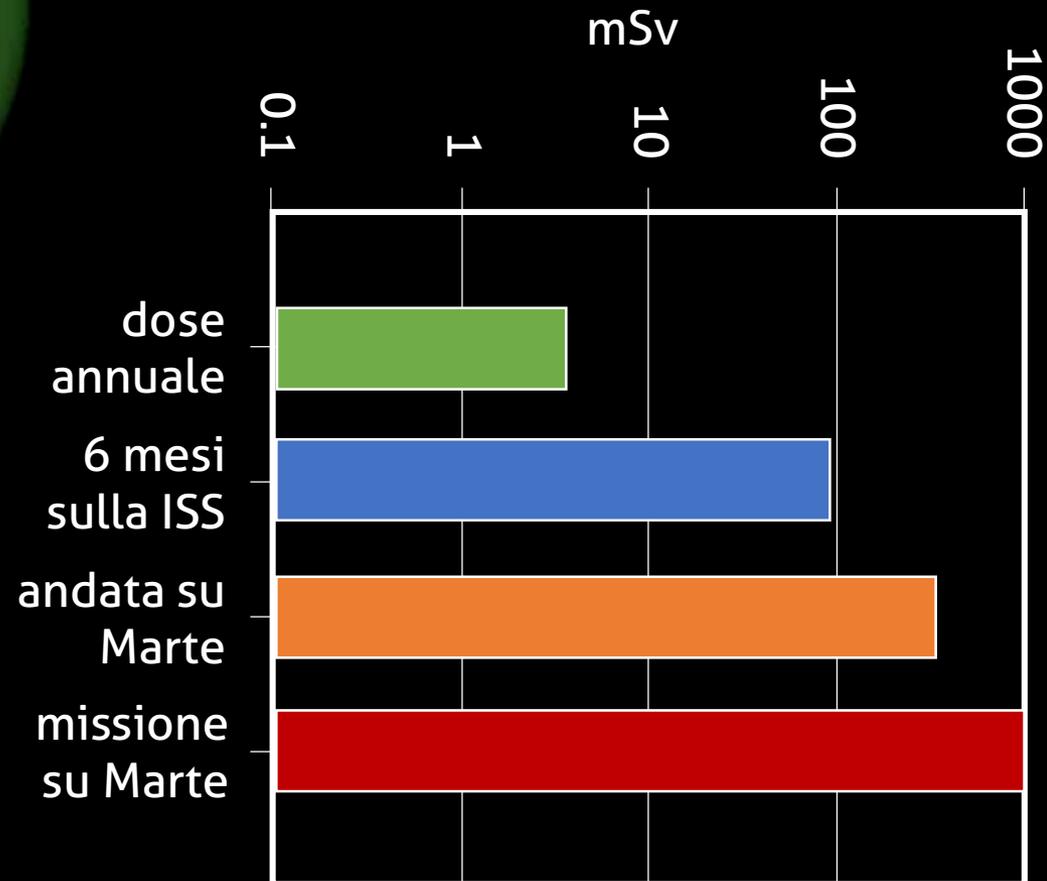
PIRAMIDE DI CHEFREN



Dosi di Radiazioni Medie Assorbite



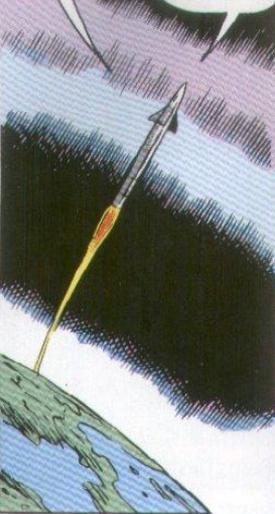
**Dose media assorbita
dall'uomo
4 mSv / anno**



HIGHER AND HIGHER, LIKE A SILVER BULLET, ROARS THE SLEEK SPACE CRAFT...

WE HAD TO DO IT!! WE HAD TO BE THE FIRST!

BUT WE'RE REACHING THE COSMIC STORM AREA... HANG ON!



RAK TAC TAC TAC TAC

HEAR THAT?? IT'S THE COSMIC RAYS!! I-I WARNED YOU ABOUT 'EM!!



THEY'RE PENETRATING THE SHIP!! OUR SHIELDING ISN'T STRONG ENOUGH!

BUT I DON'T FEEL ANYTHING!

NATURALLY! THEY'RE ONLY RAYS OF LIGHT! YOU CAN'T FEEL 'EM-- BUT THEY'LL AFFECT YOU JUST THE SAME!



MY HEAD!! IT--IT'S POUNDING AS THOUGH IT'S ABOUT TO BURST!!

BEN WAS RIGHT!! WE SHOULD HAVE WAITED... SHOULD HAVE GOTTEN HEAVIER SHIELDING!



JOHNNY! WHAT IS IT? WHAT'S HAPPENING TO YOU?

I DON'T KNOW, SIS! MY BODY FEELS HOT-- LIKE IT'S ON FIRE!! I-I FEEL LIKE I'M BURNING UP!!



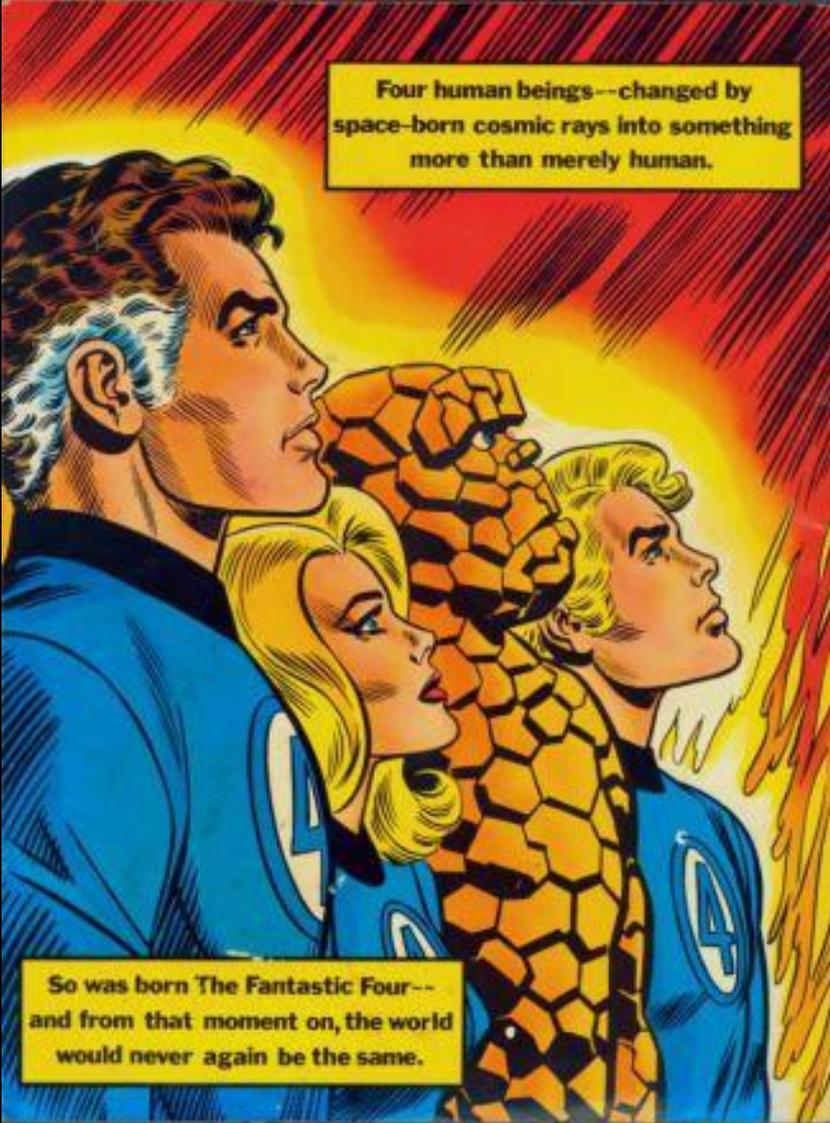
UGH!! LISTEN TO ME...

... SOMEBODY ELSE TAKE THE CONTROLS... I CAN'T HANDLE THE SHIP ANY MORE! MY-- MY ARMS ARE HEAVY-- TOO HEAVY-- CAN'T MOVE-- TOO HEAVY-- GOT TO LIE DOWN-- CAN'T MOVE!!

BEN!



Four human beings-- changed by space-born cosmic rays into something more than merely human.



So was born The Fantastic Four-- and from that moment on, the world would never again be the same.