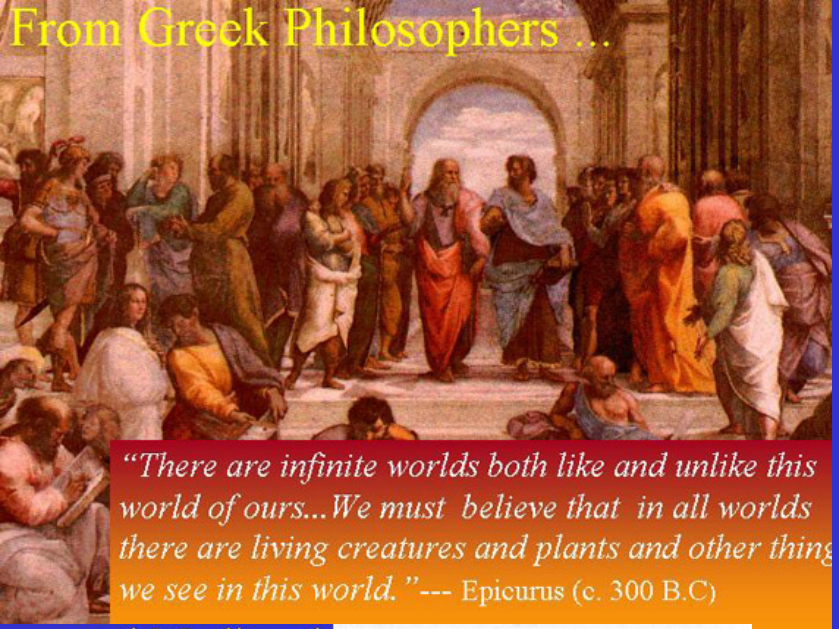
La Fisica Moderna e l'INFN (LNF)

Massimiliano Bazzi

Stages Invernali

16 Febbraio 2015

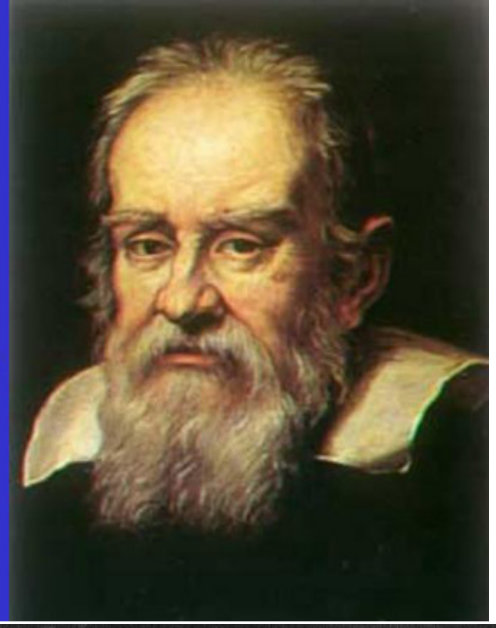
From Greek Philosophers ...



"There are infinite worlds both like and unlike this world of ours...We must believe that in all worlds there are living creatures and plants and other thing we see in this world."--- Epicurus (c. 300 B.C)

...to Medieval Scholars...

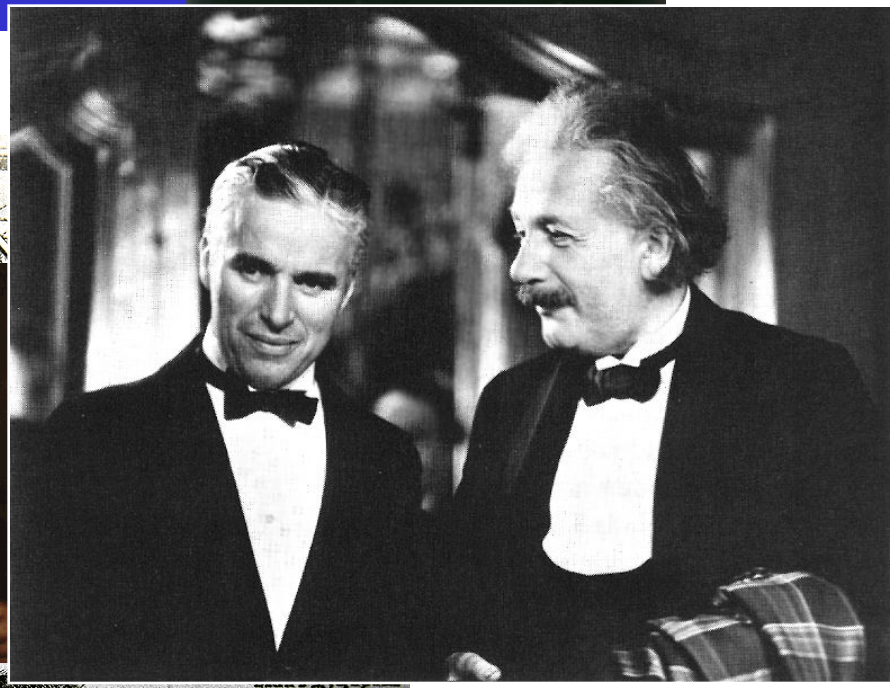
"I [regard]... as false and damnable the view of those who would put inhabitants on Jupiter, Venus, and Saturn, and the moon, meaning by 'inhabitants' animals like ours and men in particular."



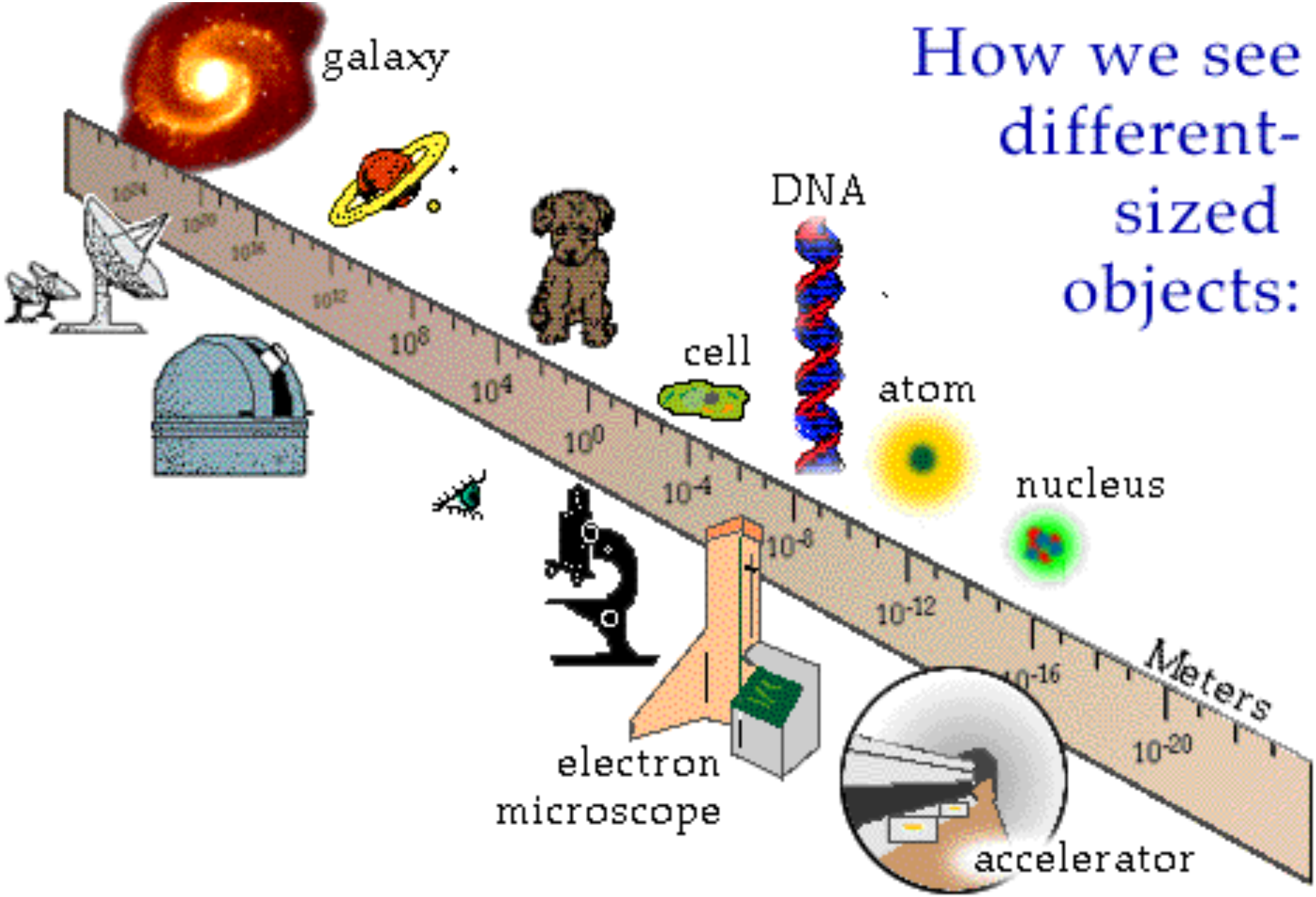
...and Medieval Martyrs...

"There are countless suns and countless earths all rotating around their suns same way as the se of our system. We suns because they largest bodies and but their planets r invisible to us bec smaller and non-h countless worlds i are no worse and inhabited than our

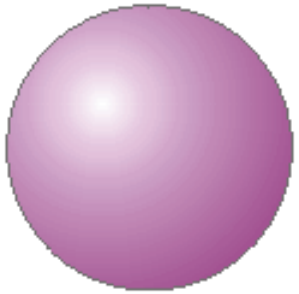
Giordano Bruno (1584) in De L'infinito Universo



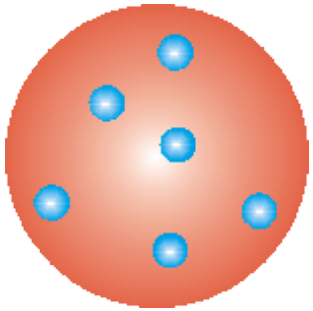
How we see different-sized objects:

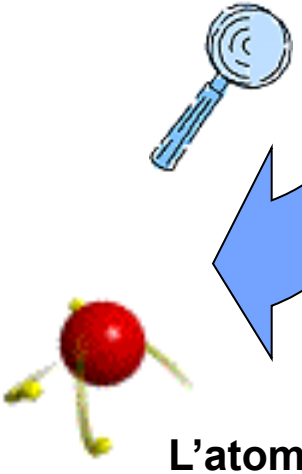


L'atomo all'inizio del '900



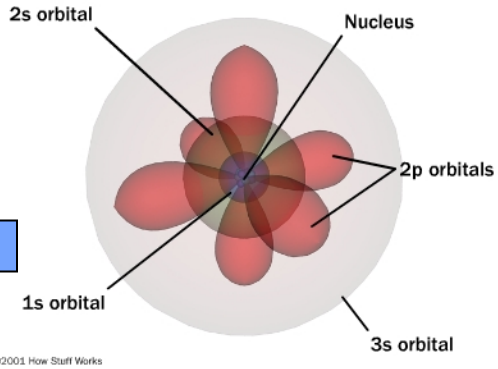
L'atomo di Thompson

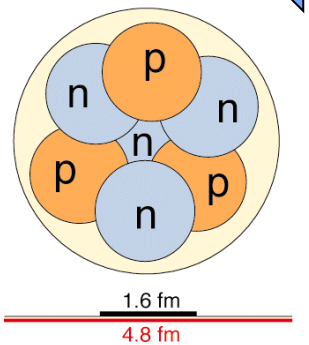




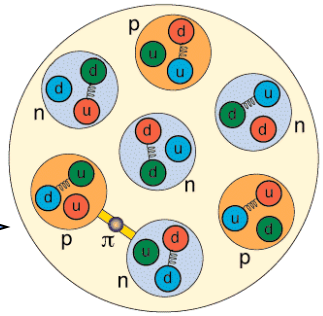
L'atomo di Rutherford e Bohr

L'atomo quantistico





La struttura del nucleo



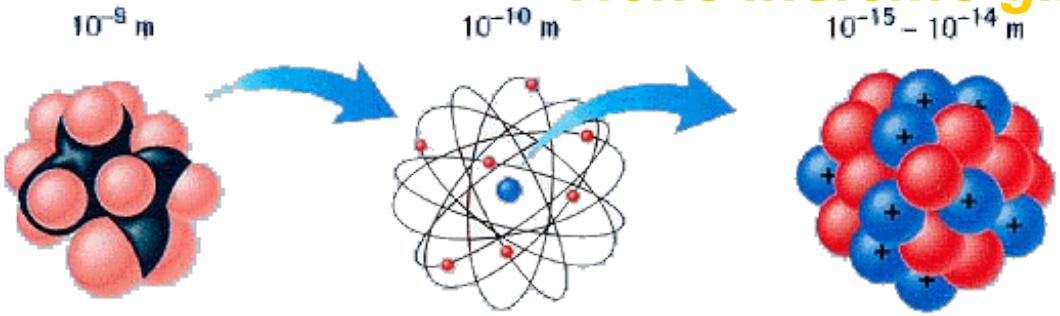
Il nucleo oggi

Le forze fondamentali

forza	*intensità*	*effetto*
Gravitazionale	1	***Vi tiene seduti***
Debole	10^{29}	***Decadimenti:*** $n \rightarrow p + e^- + \nu$
Elettromagnetica	10^{40}	***Tiene insieme gli atomi***
Forte	10^{43}	***Tiene insieme i nuclei***

W
bosone

Z
bosone



γ
fotone

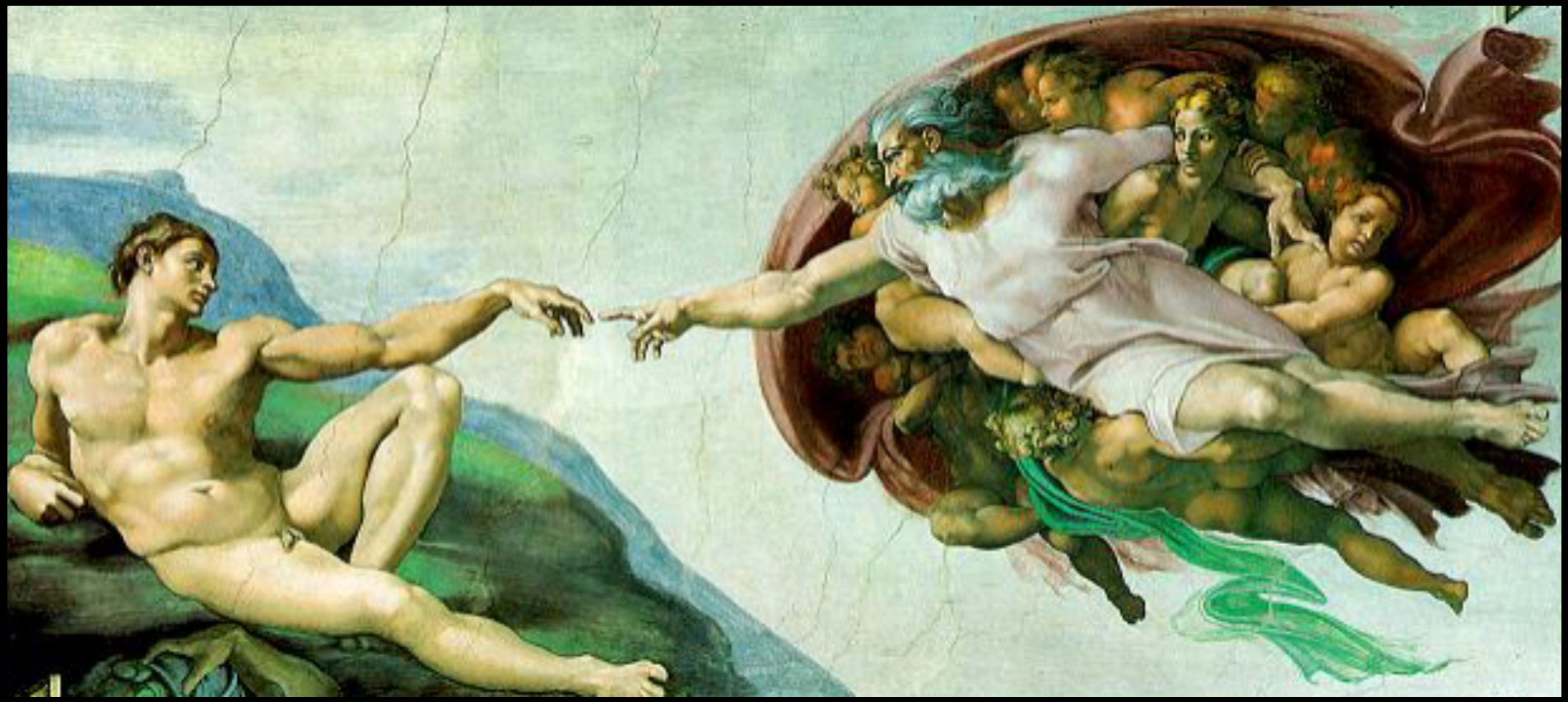
g
gluone

The Standard Model

	Fermions			Bosons	
Quarks	u up	c charm	t top	g gluone	Force carriers
Quarks	d down	s strange	b bottom	γ fotone	Force carriers
Leptons	ν_e e-neutrino	ν_μ μ-neutrino	ν_τ τ-neutrino	W bosone	Force carriers
Leptons	e elettrone	μ muone	τ tau	Z bosone	Force carriers
	I	II	III	Higgs Boson	
	Families of matter				

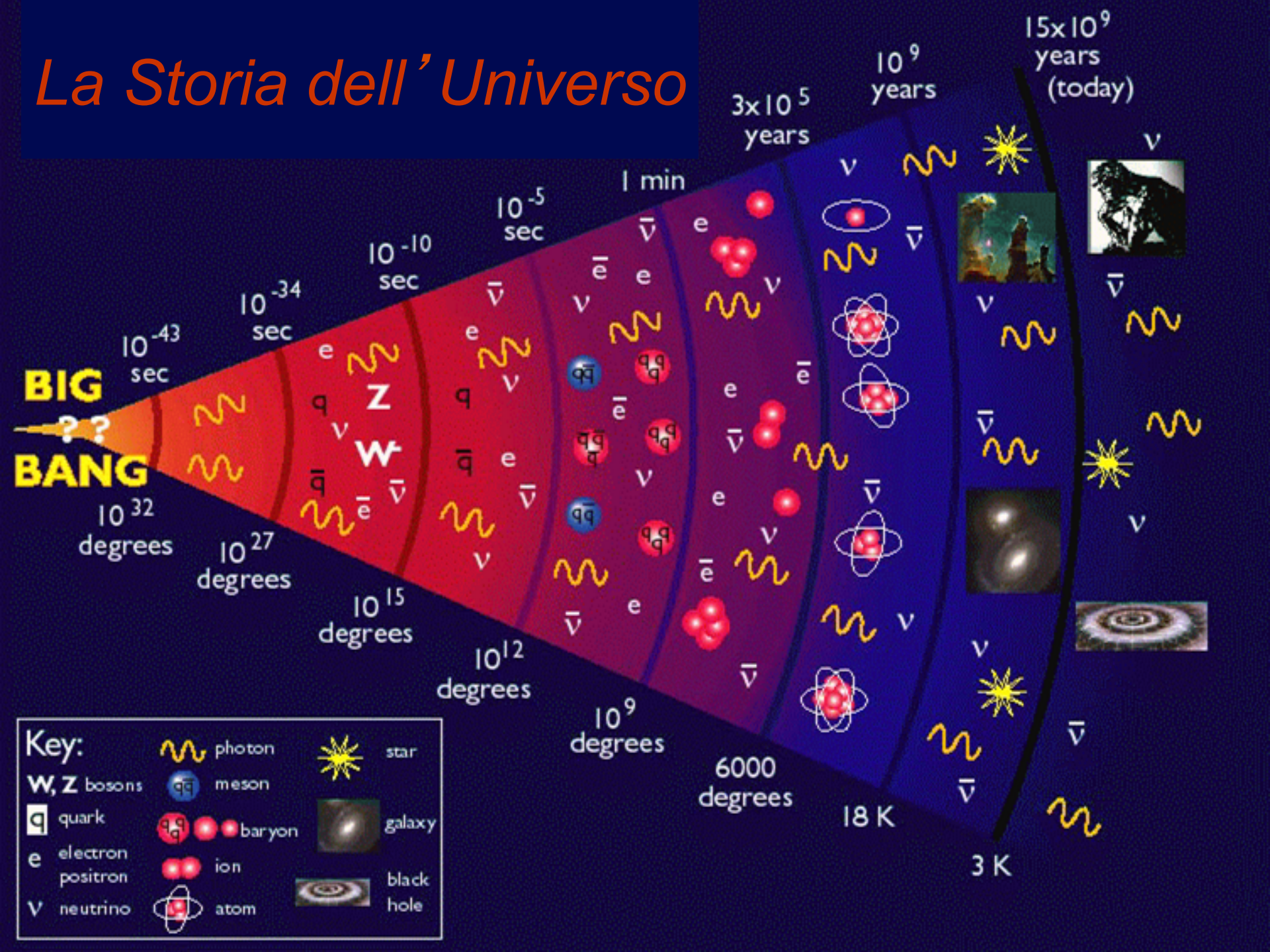
Gravity

The… "opera Ghost"



Creation (Michelangelo Buonarroti, 1475 - 1564)

La Storia dell'Universo



Istituto Nazionale di Fisica Nucleare

L'INFN

- promuove, coordina ed effettua la ricerca scientifica nel campo della fisica sub-nucleare, nucleare e astroparticellare,
- nonche' la ricerca e lo sviluppo tecnologico necessari alle attivita' in tali settori,
- in stretta connessione con l'Universita'
- e nel contesto della collaborazione e del confronto internazionale.

1951

4 Sezioni universitarie

Milano, Torino, Padova, e Roma

1957

Laboratori Nazionali di Frascati

Frascati

INFN
Istituto Nazionale di Fisica Nucleare

Legnaro

Gran Sasso

19 Sezioni

11 Gruppi collegati

4 Laboratori Nazionali

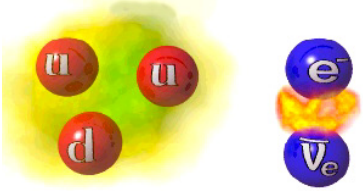
VIRGO-EGO

European Gravitational Observatory

Laboratori del Sud (Catania)

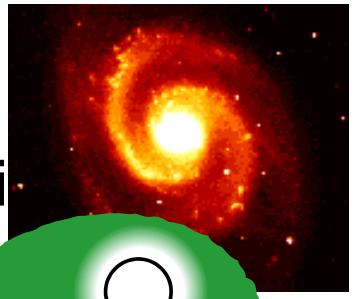
Che cosa si fa ai Laboratori Nazionali di Frascati?

Ricerca fondamentale

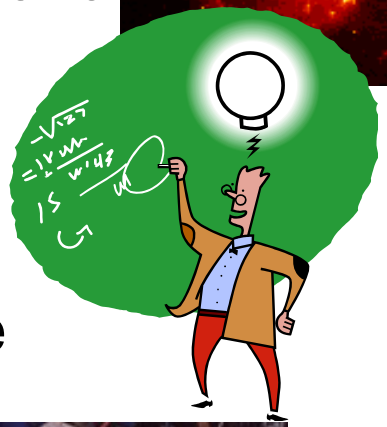


- Studi sulla struttura intima della materia

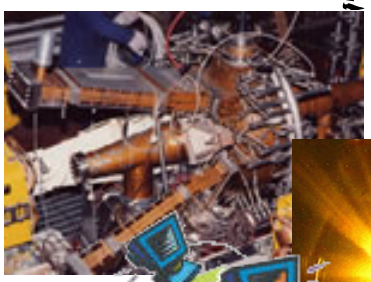
- Ricerca di onde gravitazionali



- Elaborazione di modelli teorici



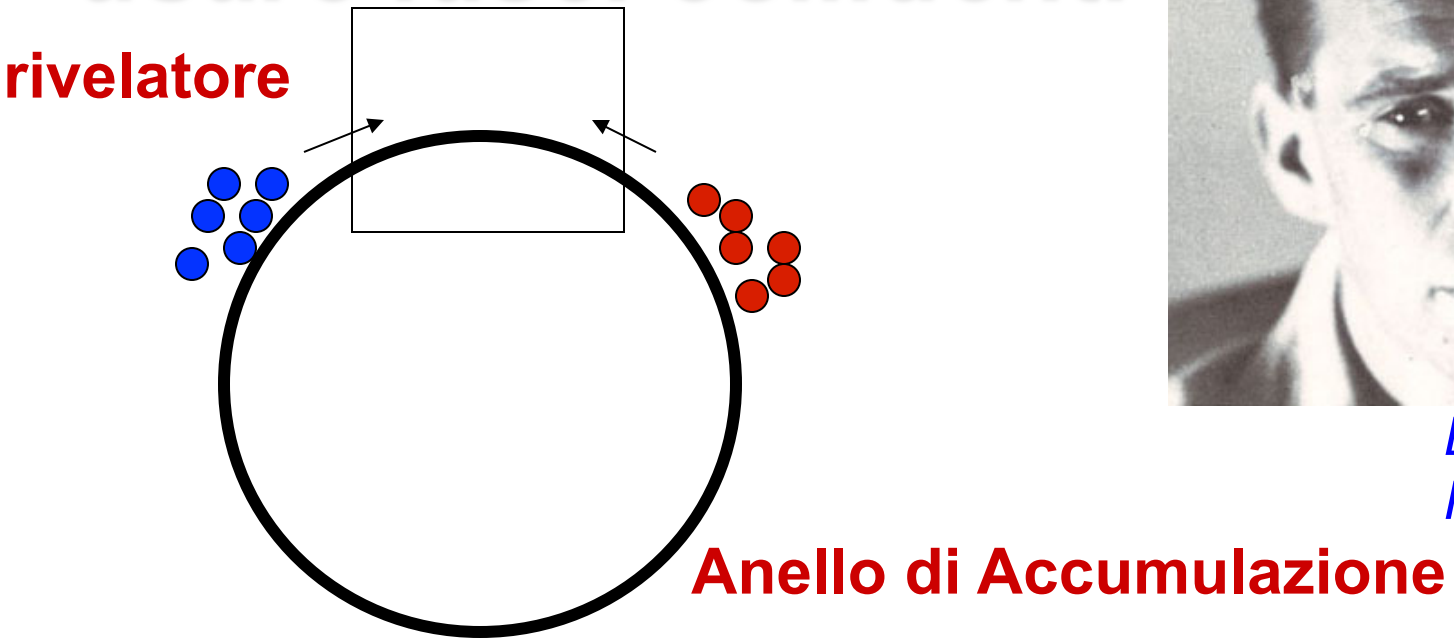
- Sviluppo e costruzione di rivelatori di particelle
- Studio e sviluppo di tecniche acceleratrici

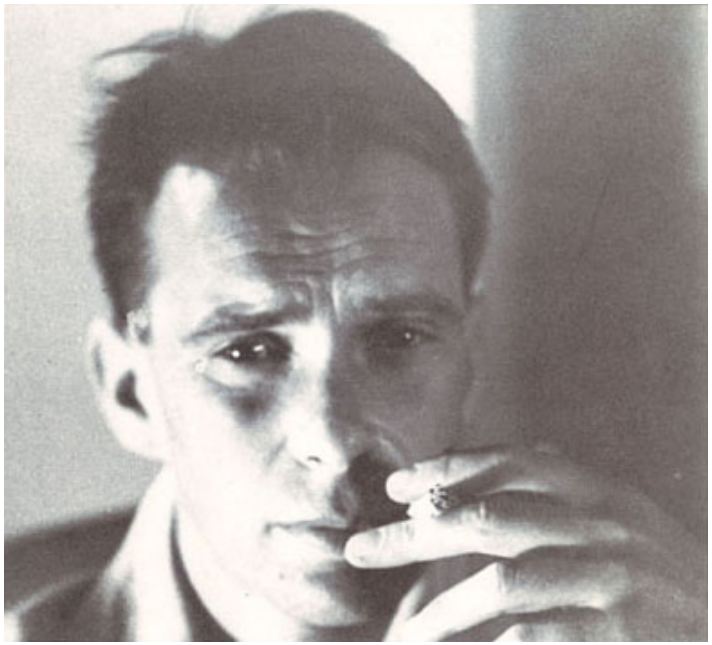


- Studi di materiali e ricerche bio-mediche con luce di sincrotrone

- Sviluppo e supporto di sistemi di calcolo e reti

Un nuovo approccio: usare fasci collidenti

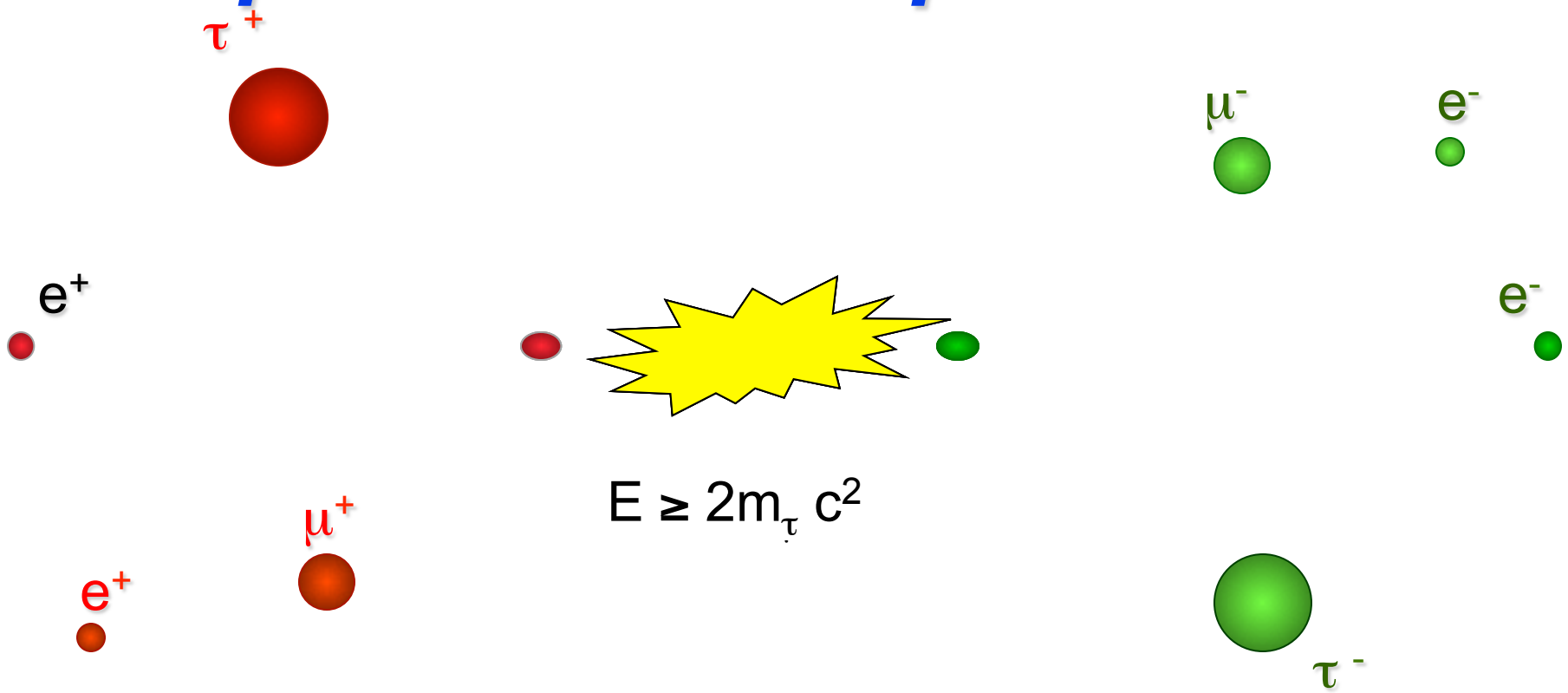




Bruno Touschek, Frascati, 1960

- Le particelle che non interagiscono, possono essere riutilizzate al giro successivo
- Collisione nel centro di massa
- Le particelle circolanti possono essere sia elementari che complesse (come nuclei o atomi).

Un passo in piu`: Collisione di particelle e antiparticelle

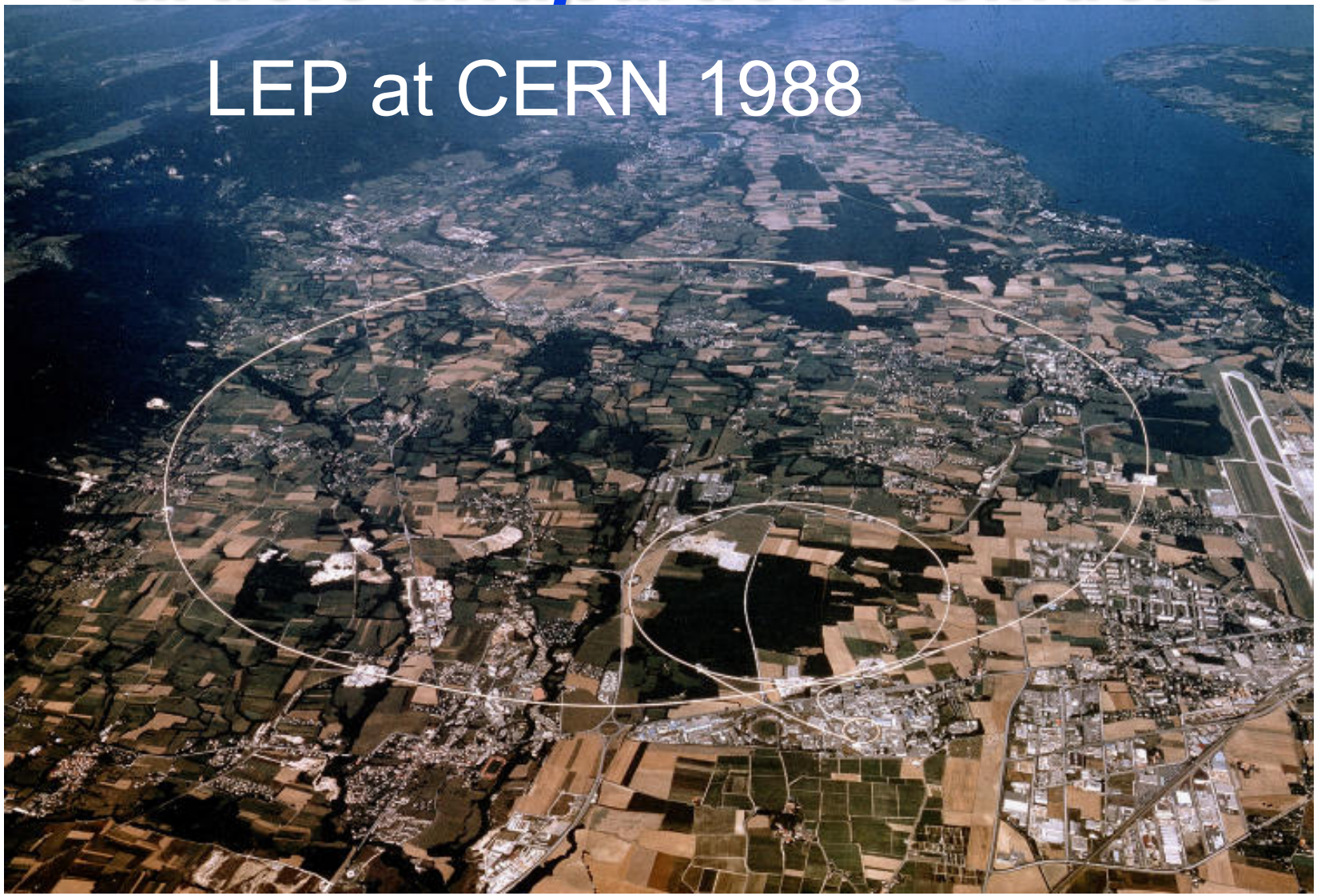


$E = m\,c^2$

Maggiore e' l'energia,

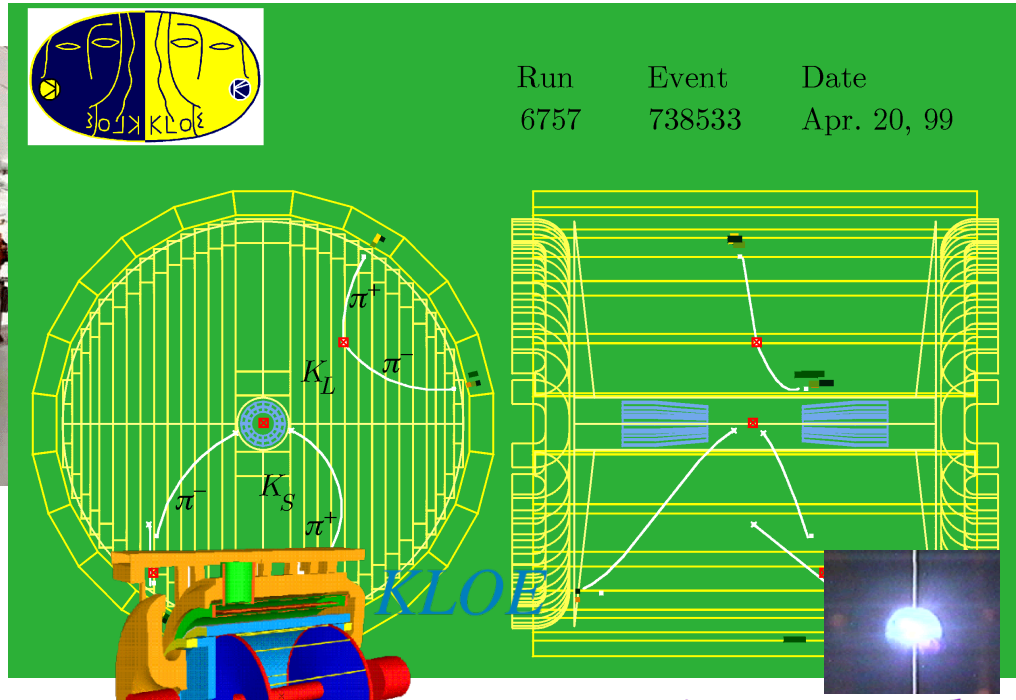
piu' e piu' particelle si possono studiare…

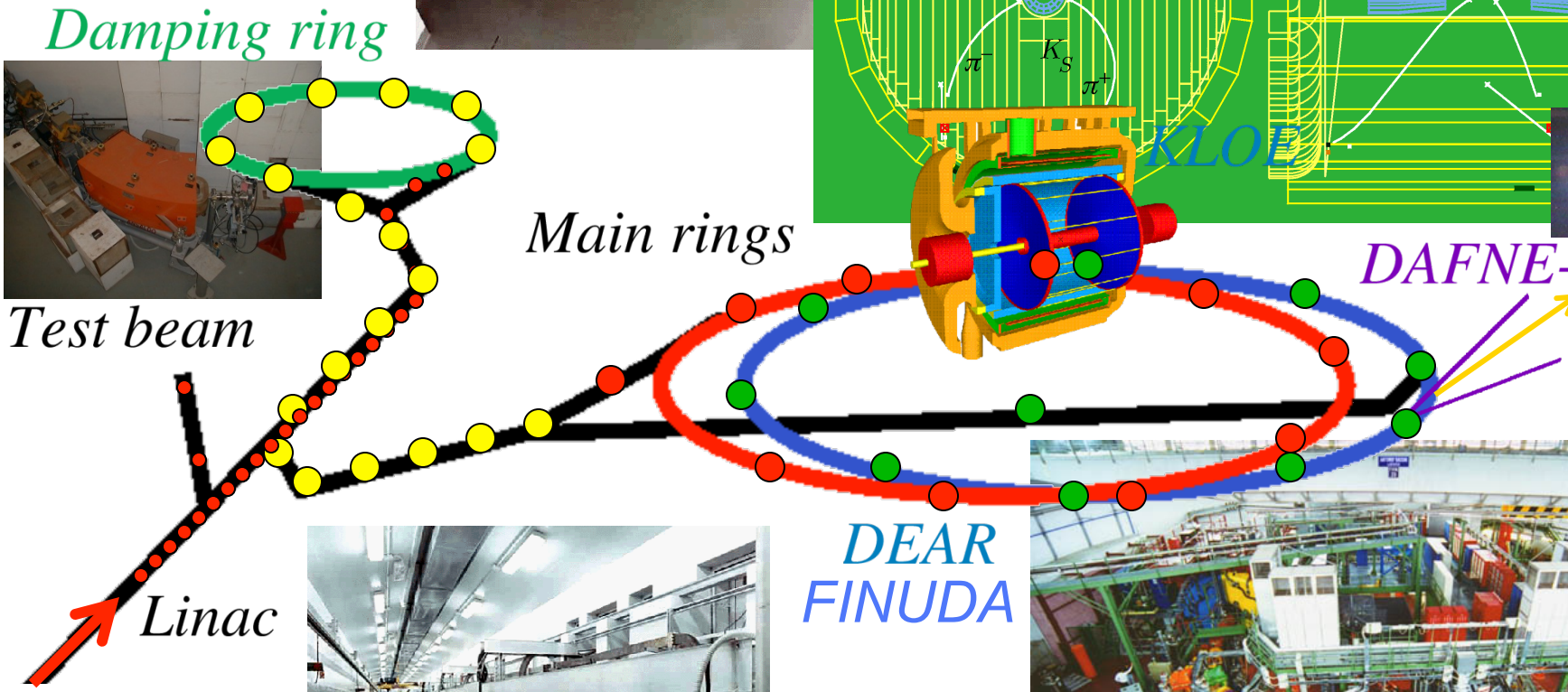
Particle-antiparticle colliders

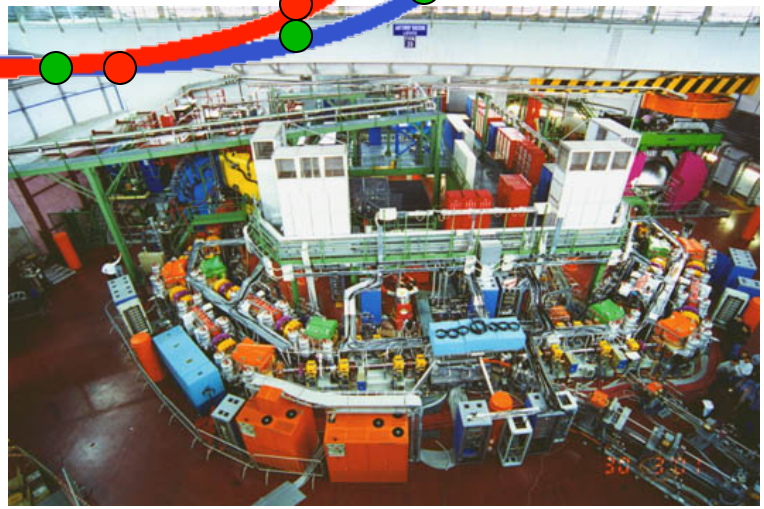


LHC at Cern (Geneve) 2008

DAΦNE

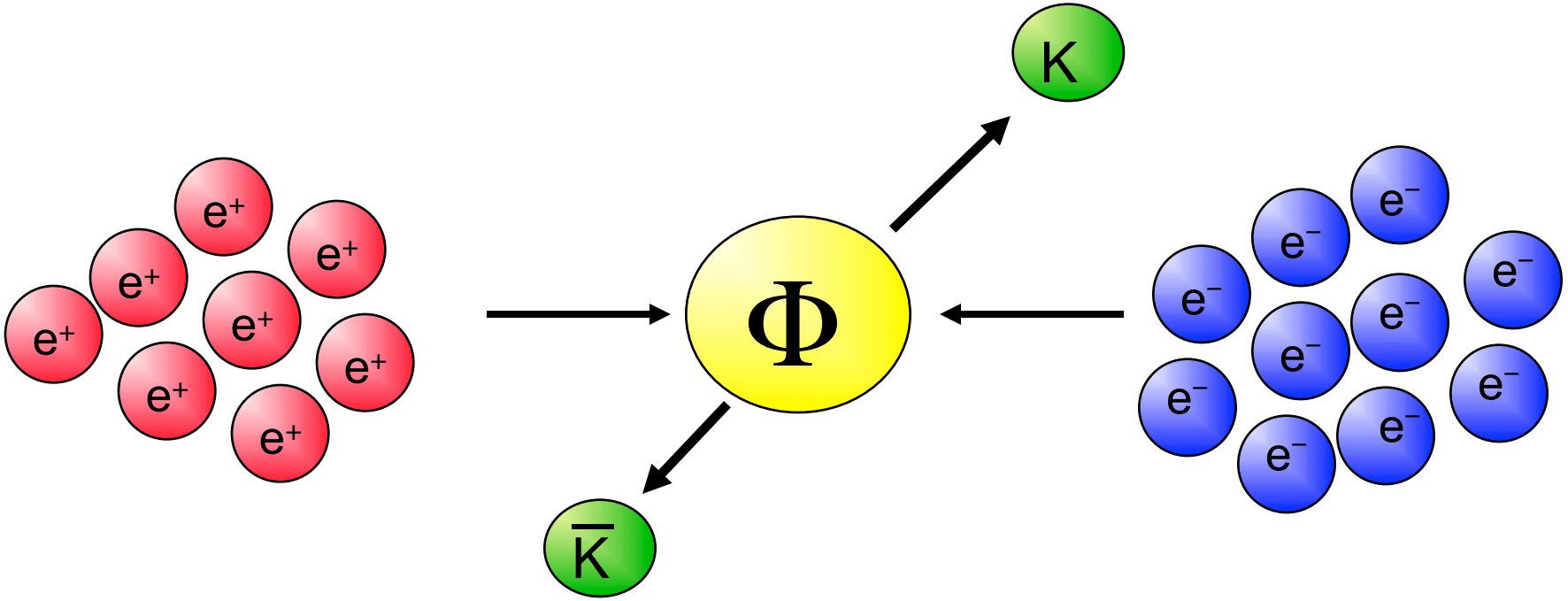

Run
Event
Date
6757
738533
Apr. 20, 99
K_L
K_S
π^+
π^-
π^-
π^+
KLOE


Damping ring
Test beam
Main rings
DAFNE-Light
Linac
DEAR
FINUDA



La fisica a DAΦNE

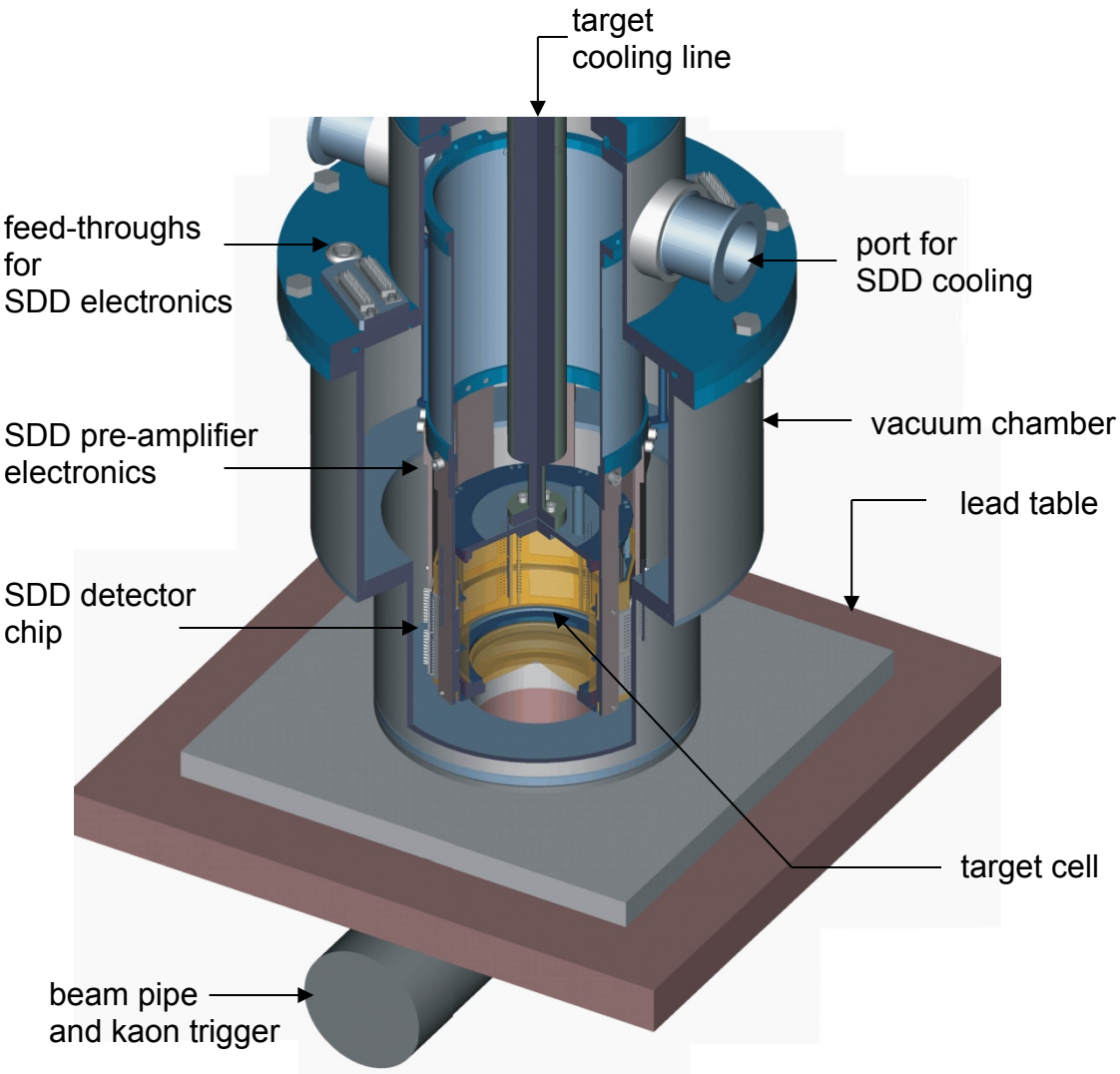
Dalle collisioni tra elettroni e positroni puo' essere prodotto il mesone Φ, che decade immediatamente in altre due particelle, i Kaoni *K*. I due *K* possono essere entrambi carichi o neutri.



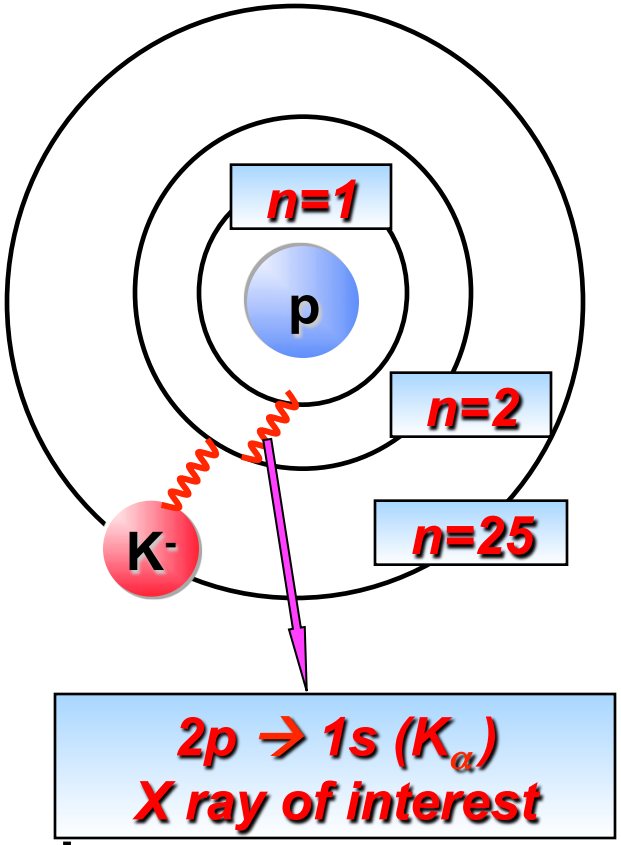
I *K* sono le particelle usate dai tre esperimenti DEAR, FINUDA e KLOE per i rispettivi obiettivi. La luminosità di DAΦNE, permette di produrre circa 10000 *K* al secondo.

SIDDHARTA

(Silicon Drift Detector for Hadronic Atom Research by Timing Application)



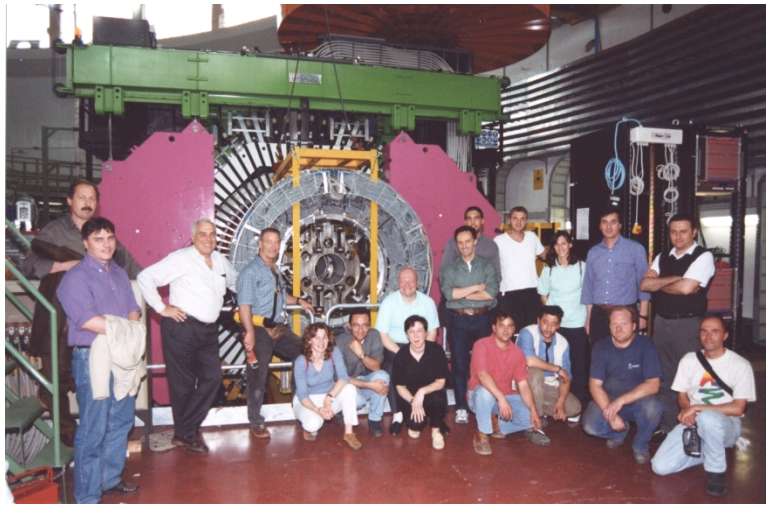
Idrogeno Kaonico



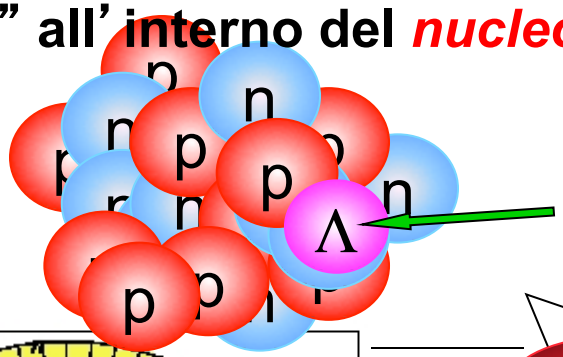
L' esperimento SIDDHARTA studia la *forza forte* attraverso lo studio degli *atomi kaonici* (in cui un K^- ha sostituito un elettrone atomico).

FINUDA

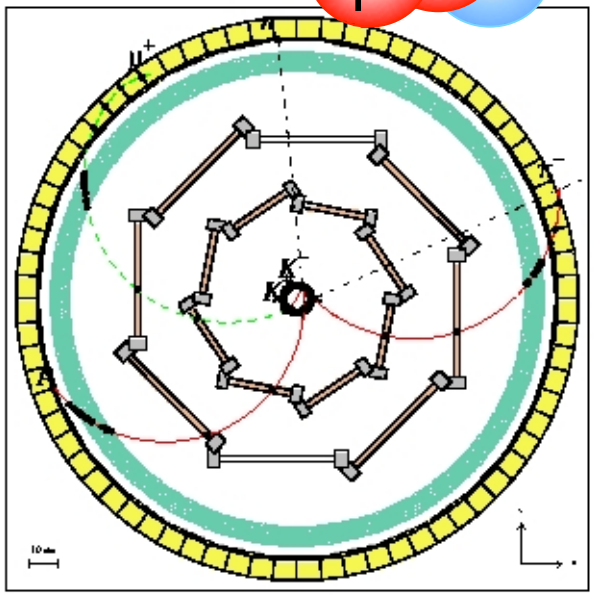
(Fisica Nucleare a DAΦNE)

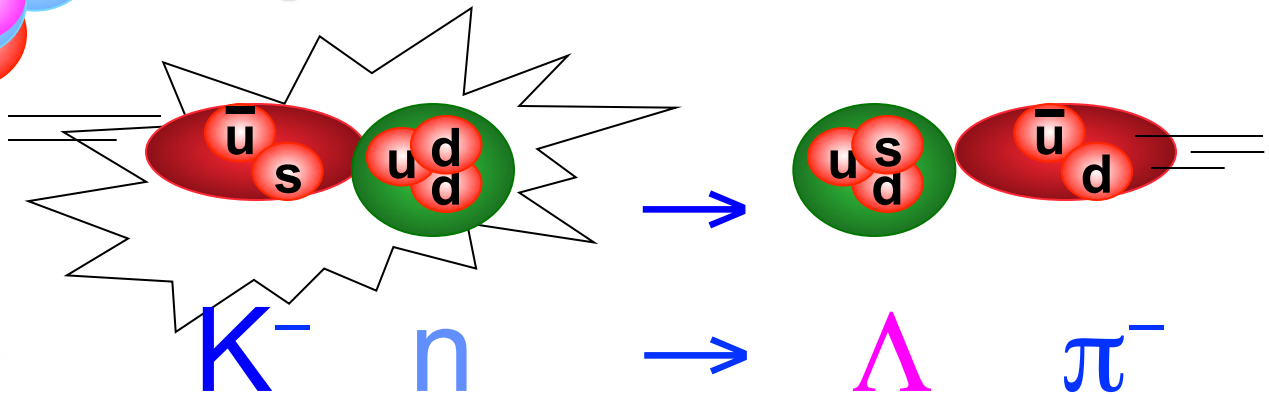


L' esperimento FINUDA studia la *forza forte* attraverso l' inserimento di un "corpo estraneo" all' interno del *nucleo*



Ipernucleo

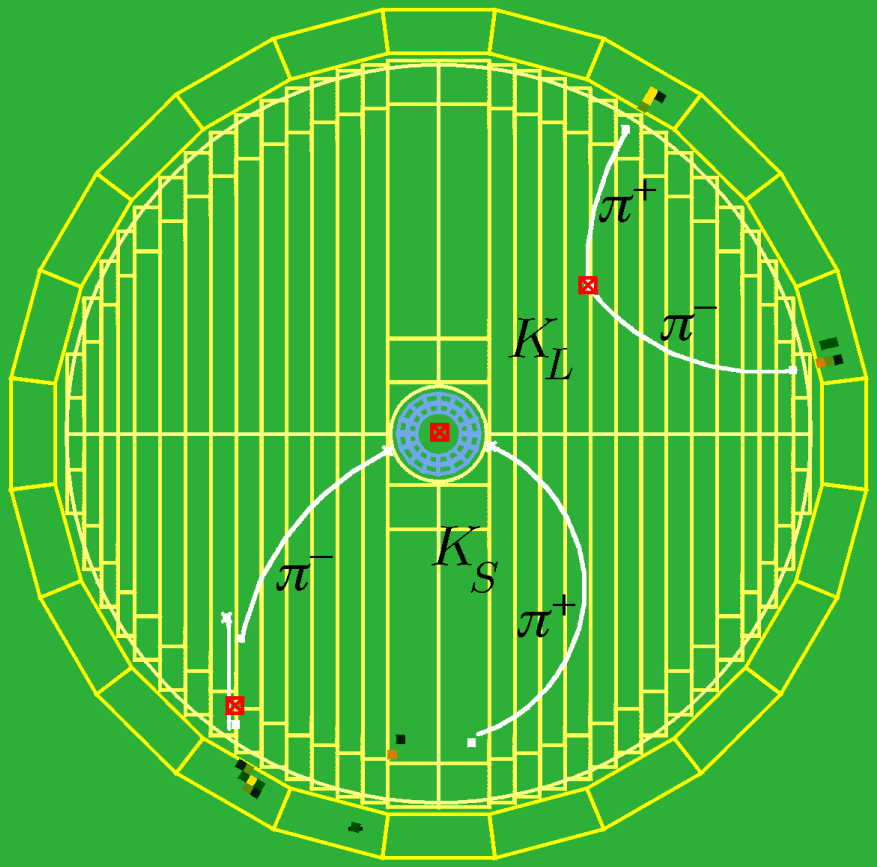


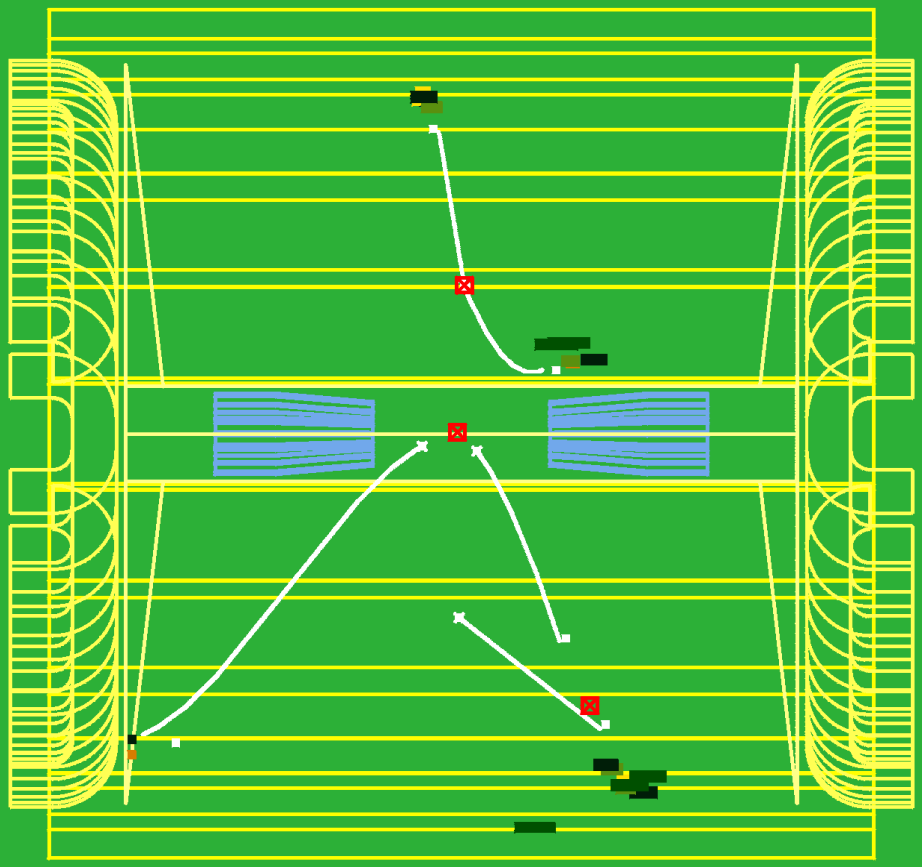


Ecco come appare un evento ipernucleare all' interno del rivelatore

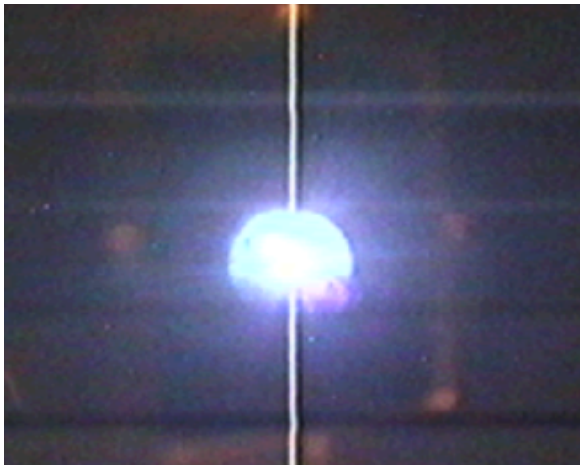
KLOE

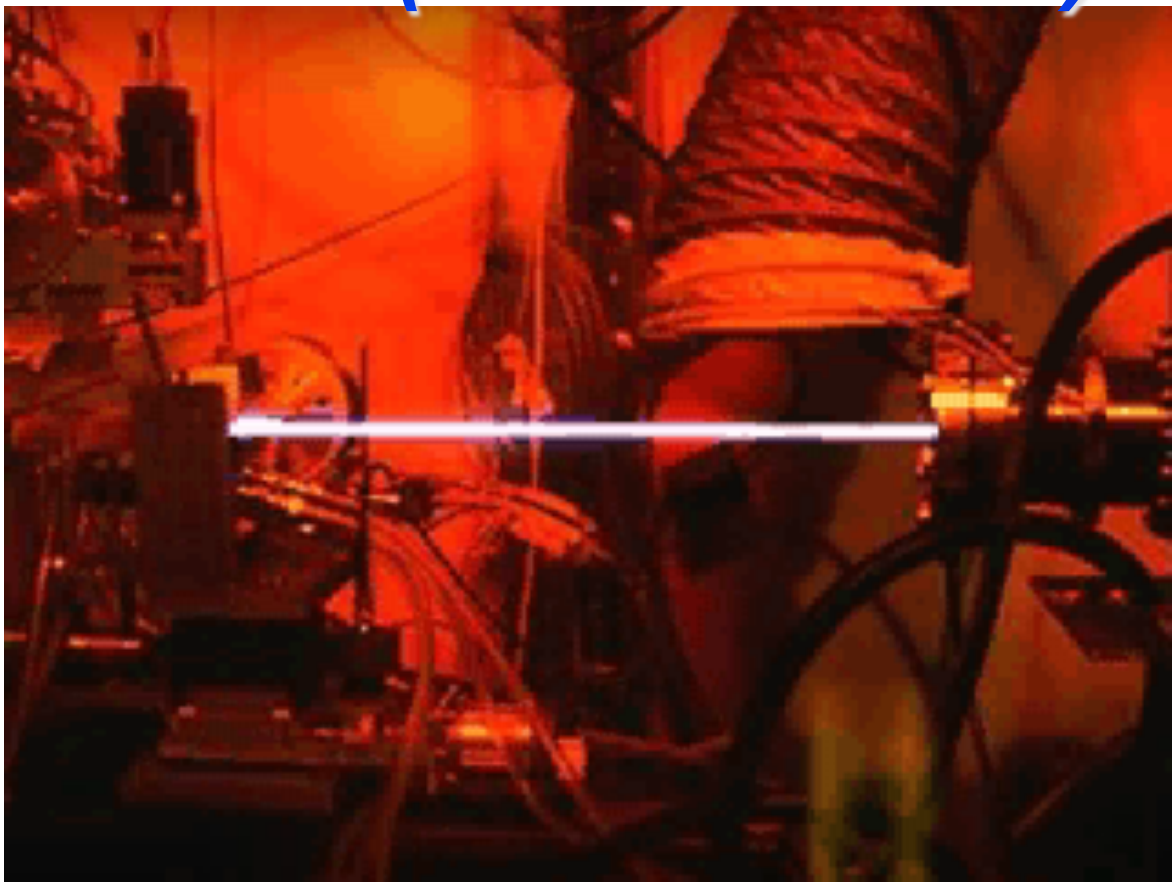
Run	Event	Date
6757	738533	Apr. 20, 99



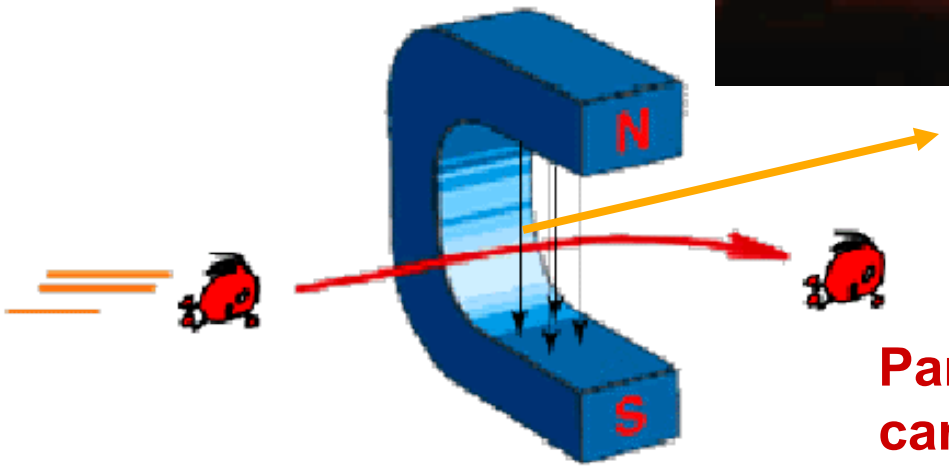


Luce di sincrotrone (DAΦNE-luce)

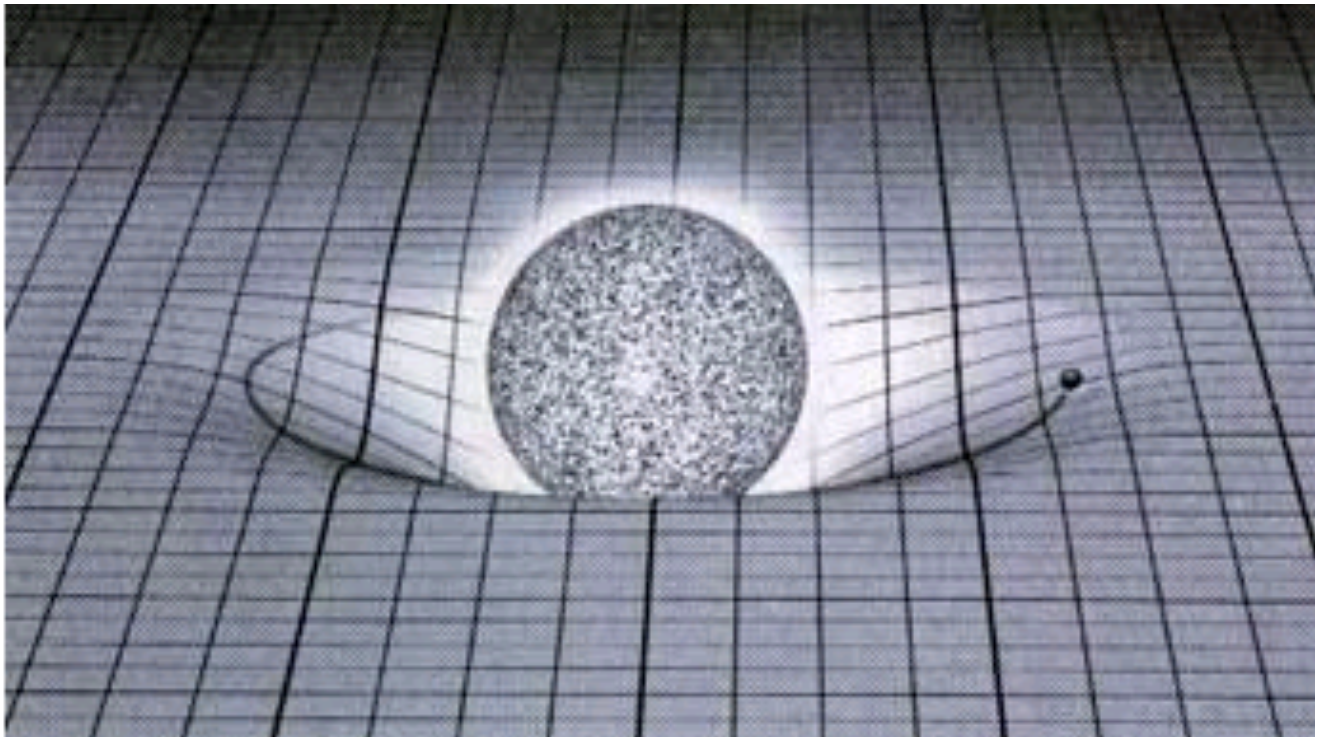




European Synchrotron Radiation Facility

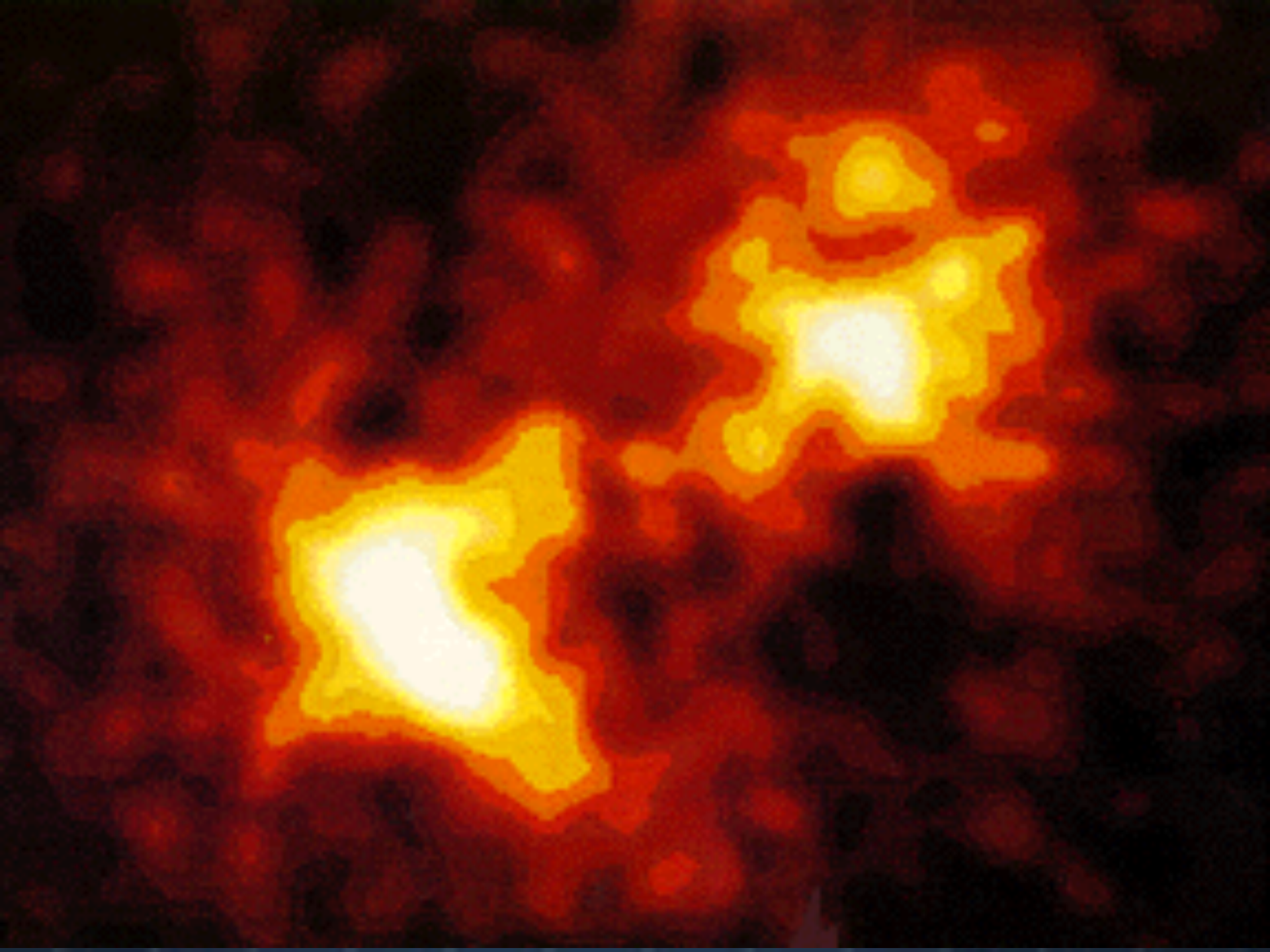


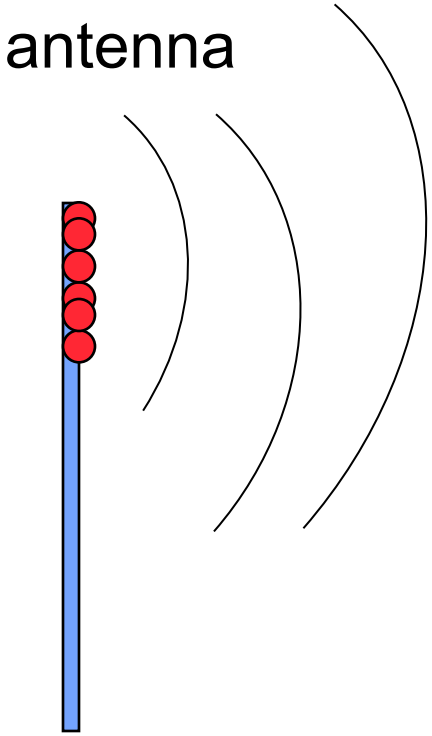
La forza di gravita`



Una distorsione nel tessuto dello spazio

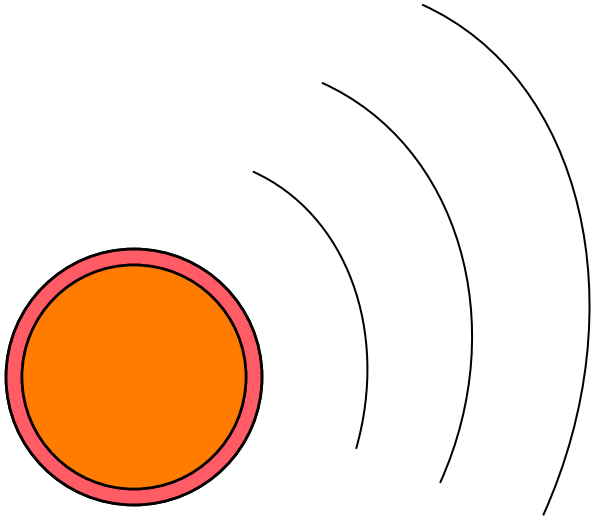
$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = -\frac{8\pi G}{c^4} T_{\mu\nu}$
A. EINSTEIN
L-10
Mary & Andrew



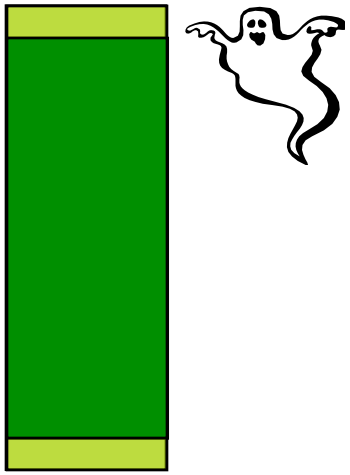


Le onde elettromagnetiche sono prodotte da cariche elettriche in movimento…

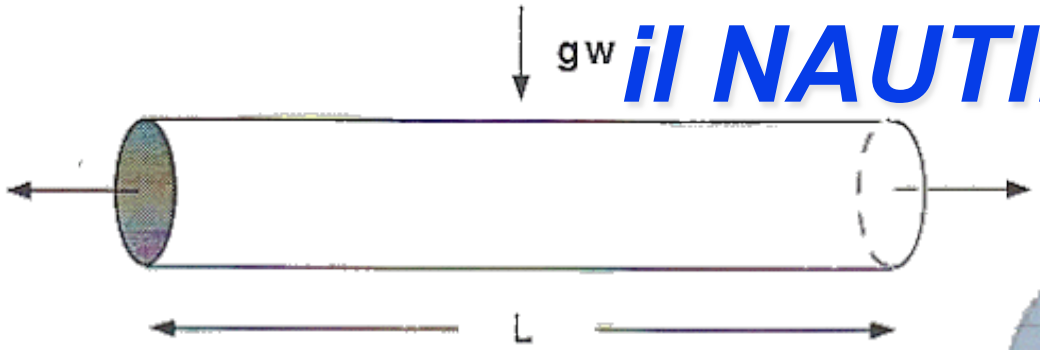
Onde Gravitazionali: un'analogia



Le onde gravitazionali sono prodotte da masse in movimento…



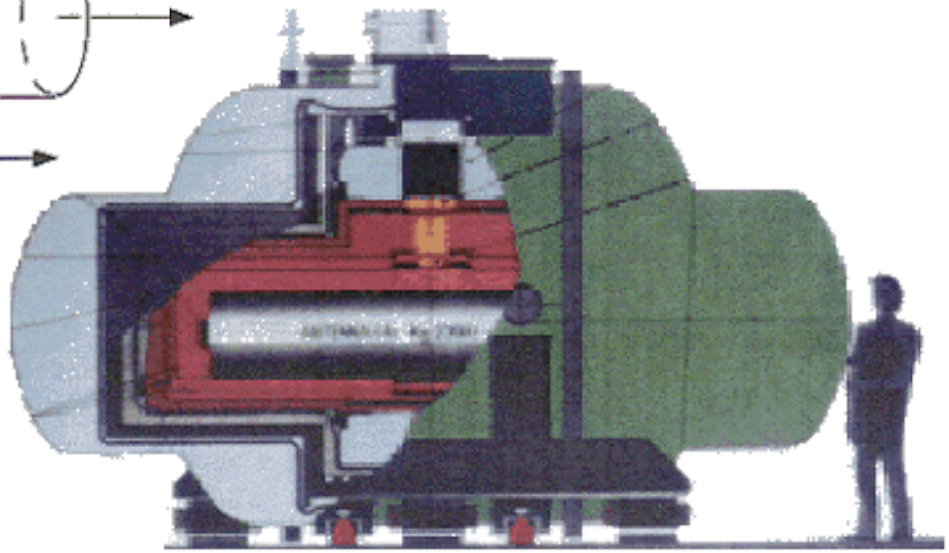
La ricerca di Onde gravitazionali: il NAUTILUS



vibrations in the bar

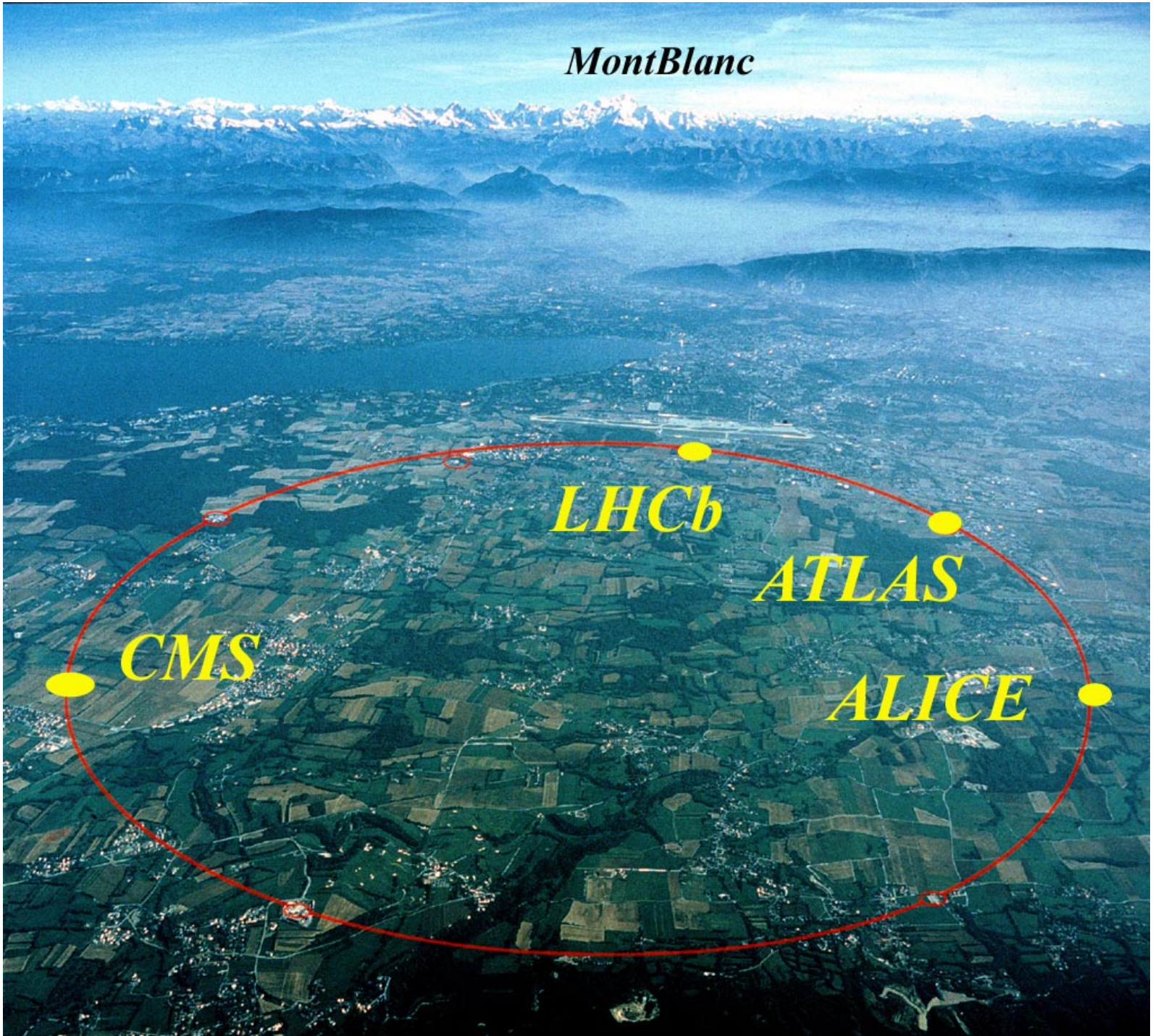
(for Al, L=3 m, f=915 Hz)

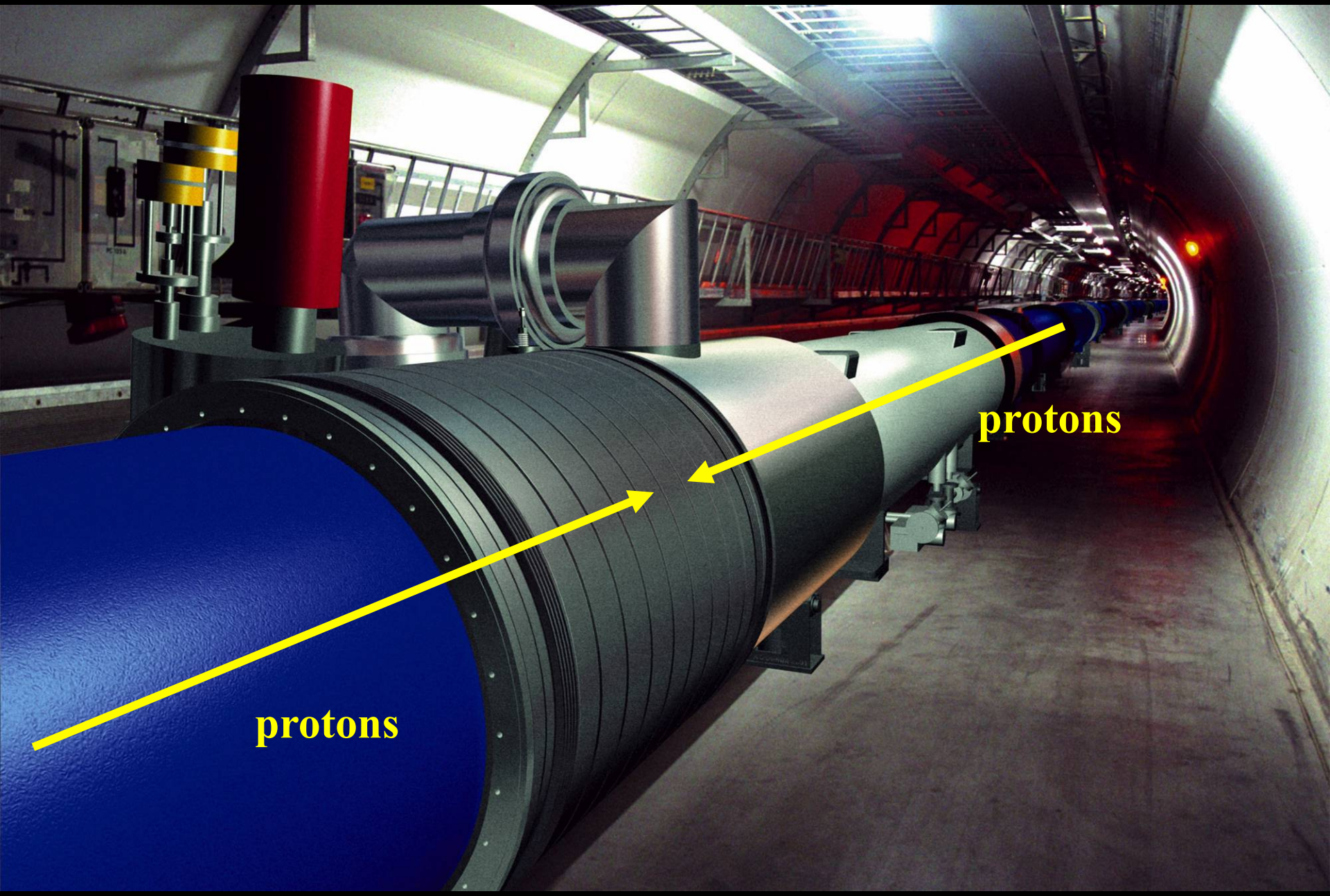
$$\frac{\Delta L}{L} \approx h$$

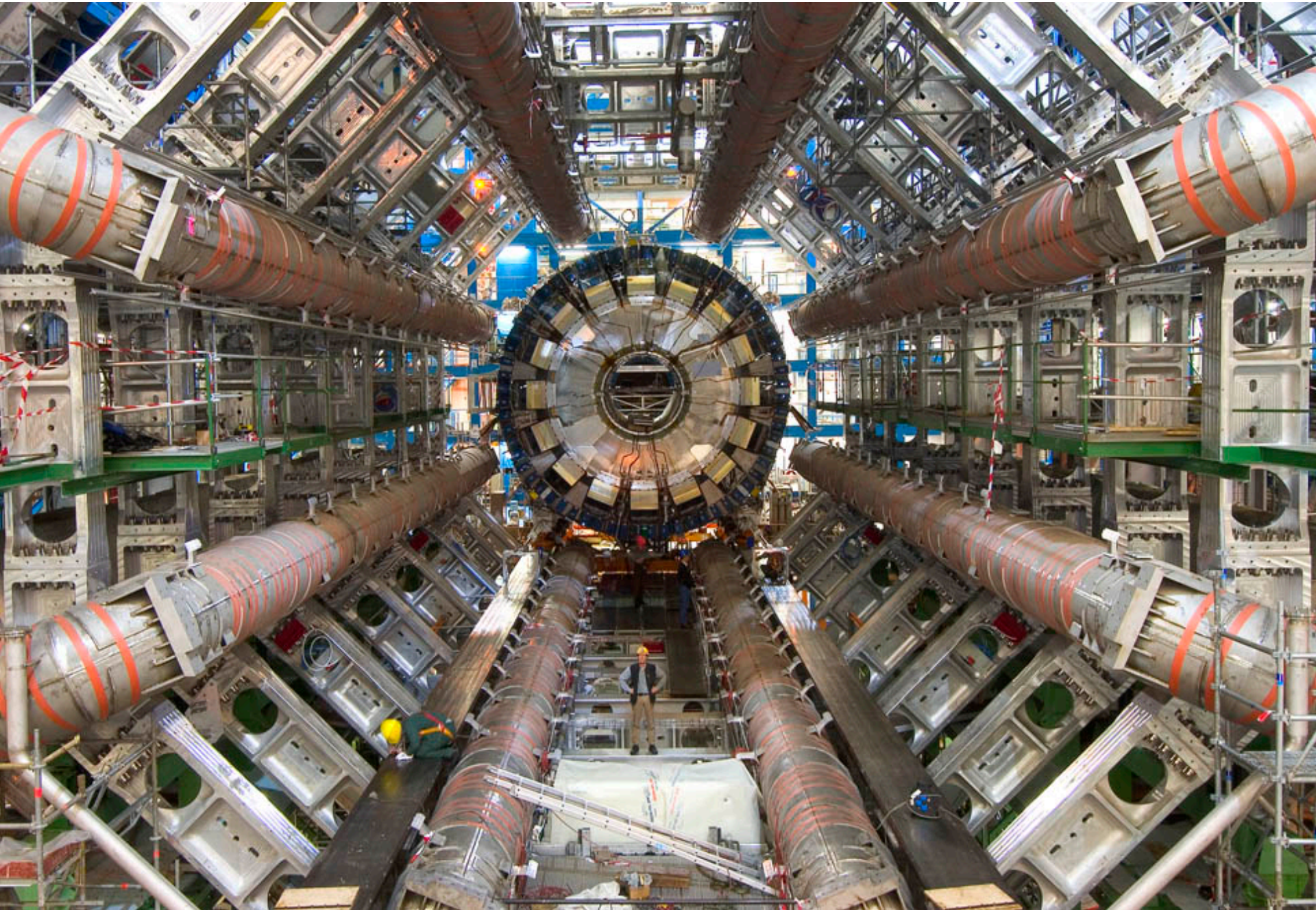


- Supernova nella nostra Galassia $h=10^{-18}$
- Supernova in Virgo $h=10^{-21}$
- Rumore termico @ T=300 K, $\Delta L=10^{-16}$ m
- Rumore termico @ T=3 K, $\Delta L=10^{-17}$ m
- Rumore termico @ T=300 mK → $\Delta L=10^{-18}$ m

LIGO
Hanford
GEO 600
Hannover
EXPLORER
Ginevra
LCGT
Kamioka
Tama 300
Tokio
ALLEGRO
Baton Rouge
LIGO
Livingston
AURIGA
Legnaro
NIOBE
Perth
VIRGO
Cascina (Pisa)
NAUTILUS
Frascati

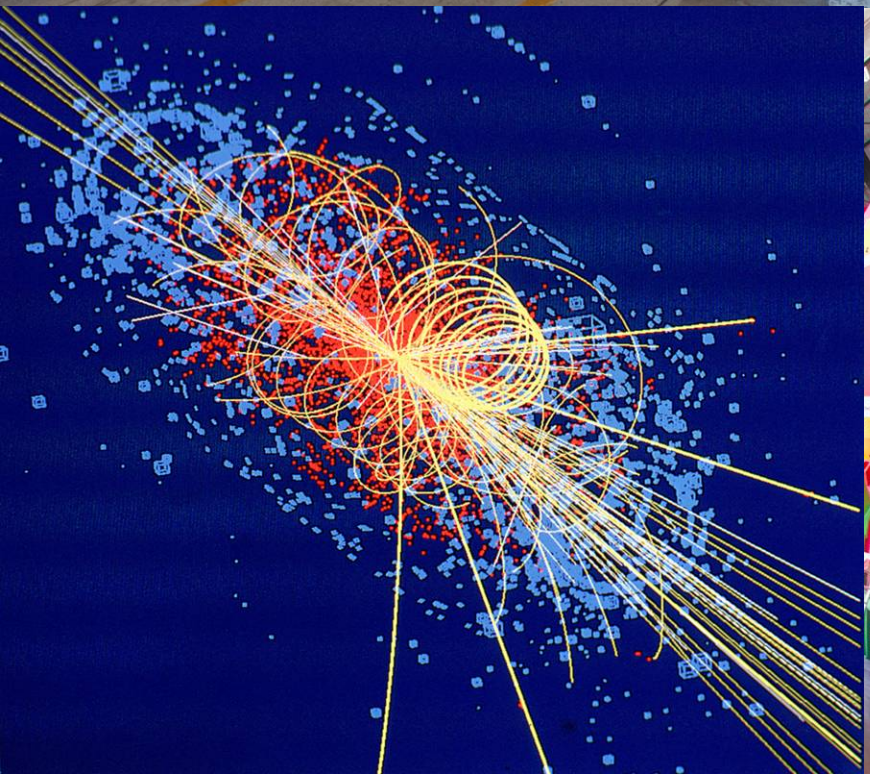

MontBlanc
LHCb
ATLAS
CMS
ALICE

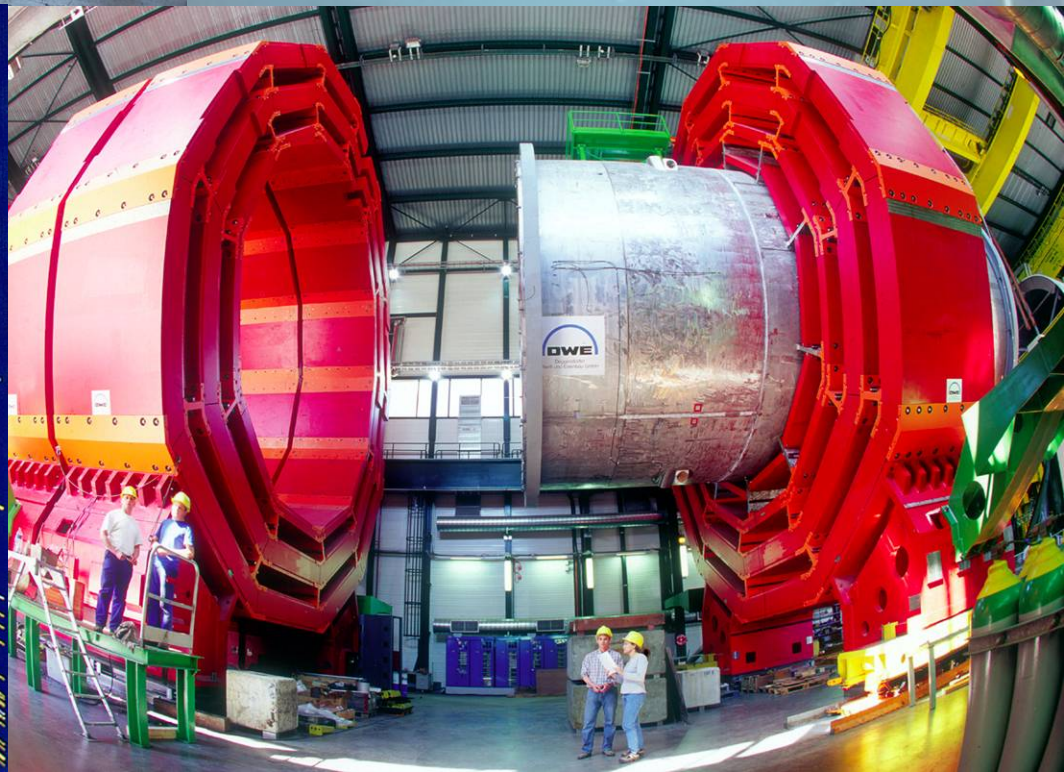

protons
protons



OWE

The particle accelerators and the huge detectors are demanding technological breakthrough effort as space research does





Evento simulato H → ZZ → 4μ

2010…esperimenti a LHC

A simulated event in ATLAS (CMS)

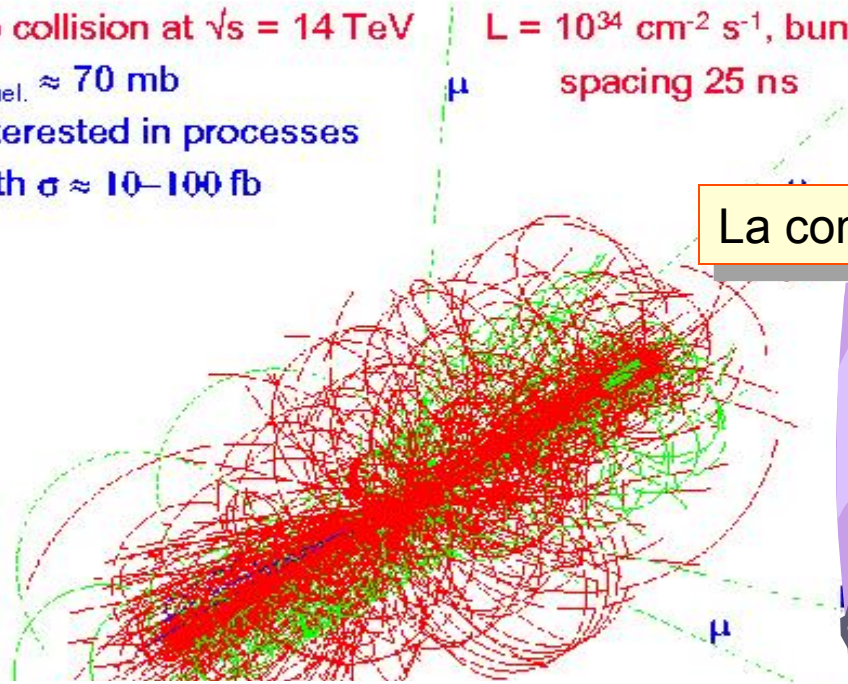
$H \rightarrow ZZ \rightarrow 4\mu$

pp collision at $\sqrt{s}$ = 14 TeV

$\sigma_{inel.} \approx 70$ mb

Interested in processes with $\sigma \approx 10$–100 fb

L = 10^{34} cm^{-2} s^{-1}, bunch spacing 25 ns



La complessita` degli eventi diventa enorme!

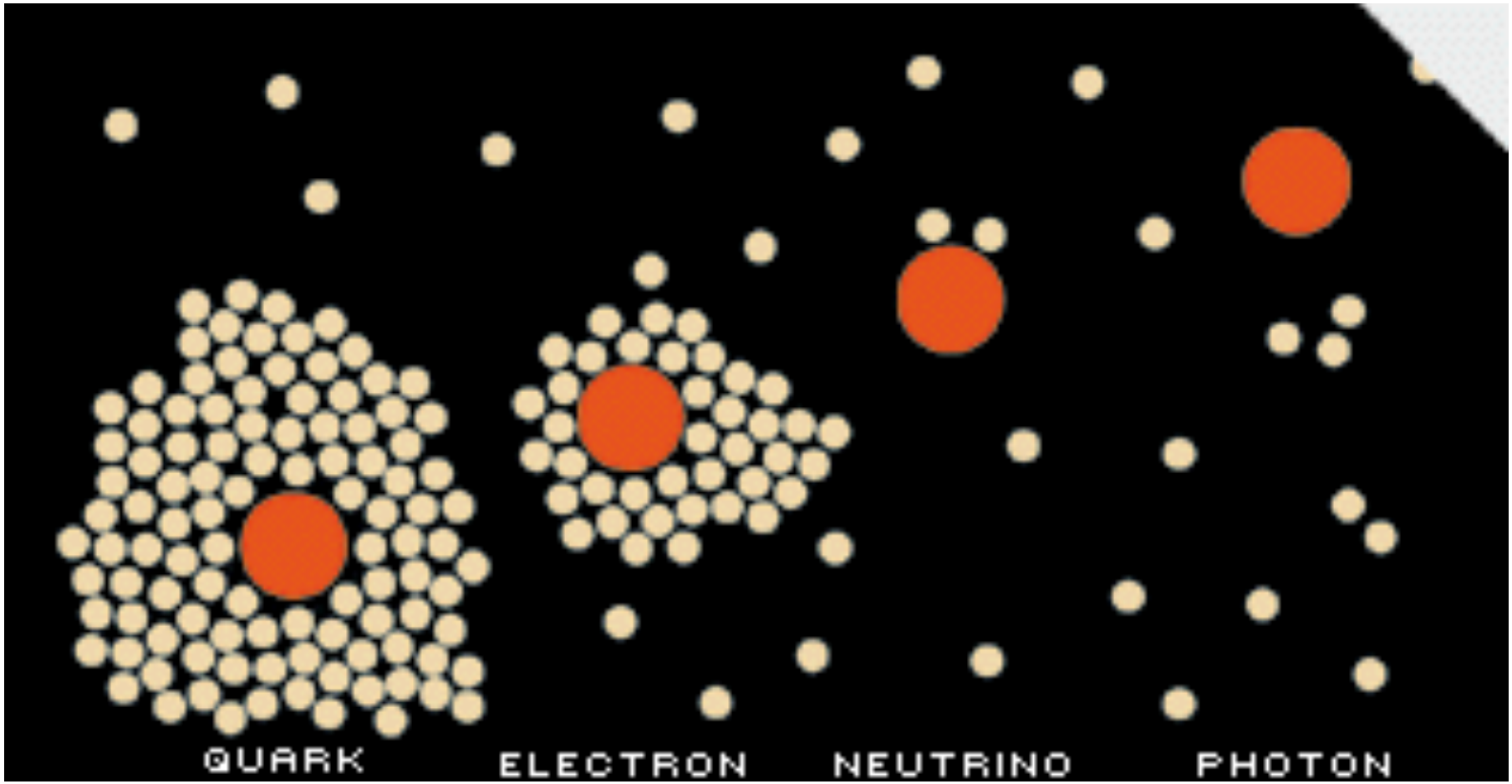
~ 23 eventi sovrapposti

~ 1900 particelle cariche + 1600 neutre da rivelare contemporaneaamente

≈ 23 overlapping minimum bias events / BC

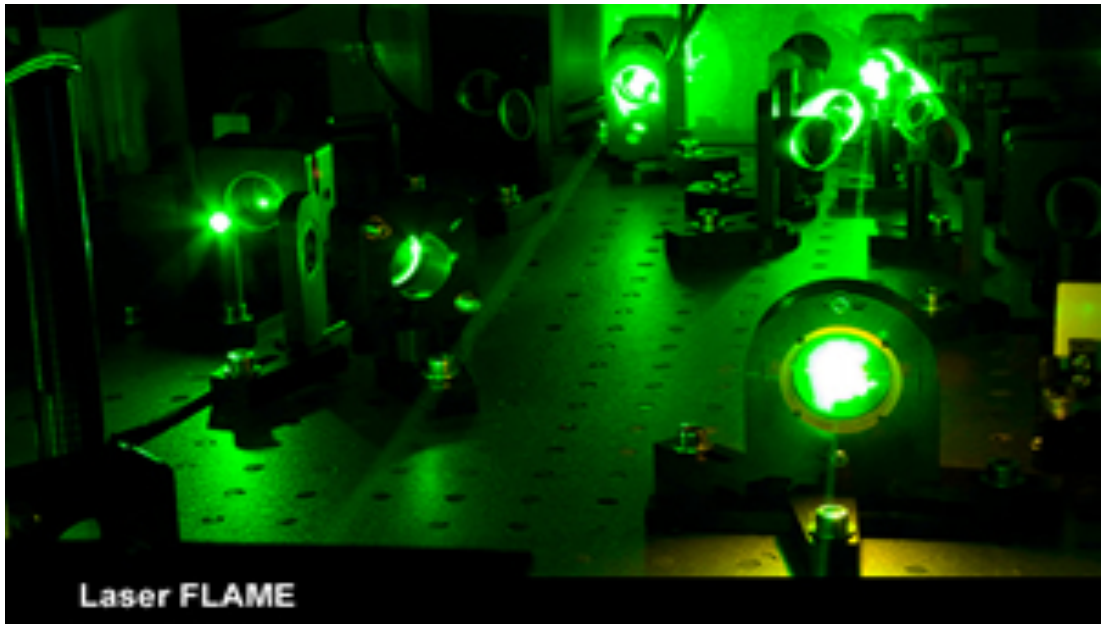
≈ 1900 charged + 1600 neutral particles / BC

All permeating Higgs field



FLAME:Frascati Laser for Acceleration and Multidisciplinary Experiments

Laser of high power (> 100 TW), able to produce pulses of 6 J in 20 fs at 10 Hz



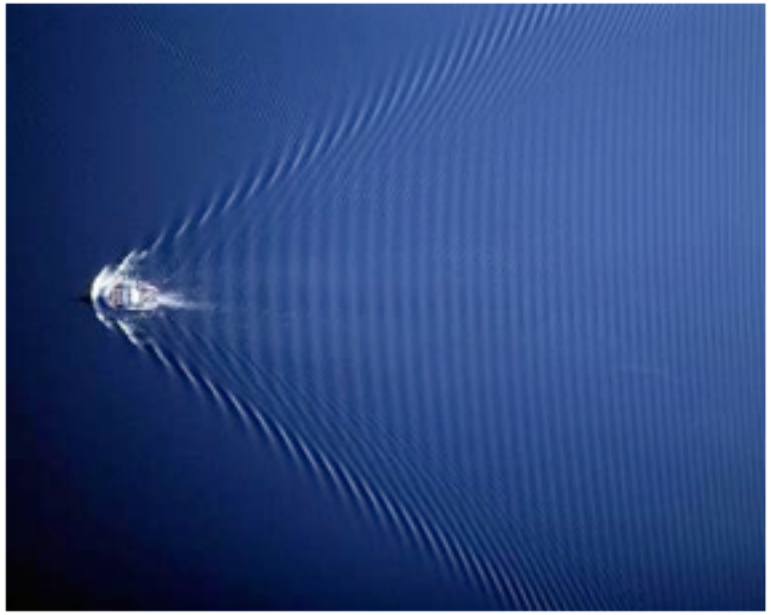
Started December 2010

1)If FLAME beam is injected into a gas the electrons inside get highly accelerated (new acceleration technique)

2)If FLAME beam is colliding head-on with an electron beam (SPARC) an intense source of X rays is produced

1) New acceleration technique

L'impulso laser produce nel plasma un'onda di scia simile a quella che lascia dietro di sè un'imbarcazione



Su quest' onda parte degli elettroni del plasma acquistano energia come un surfista che cavalca un' onda.

In few cm electrons get accelerations as in present accelerators of hundred meters

2) Intense X rays source

Electron beams from Linac (SPARC) with energies about 25-50 MeV collide with FLAME beam

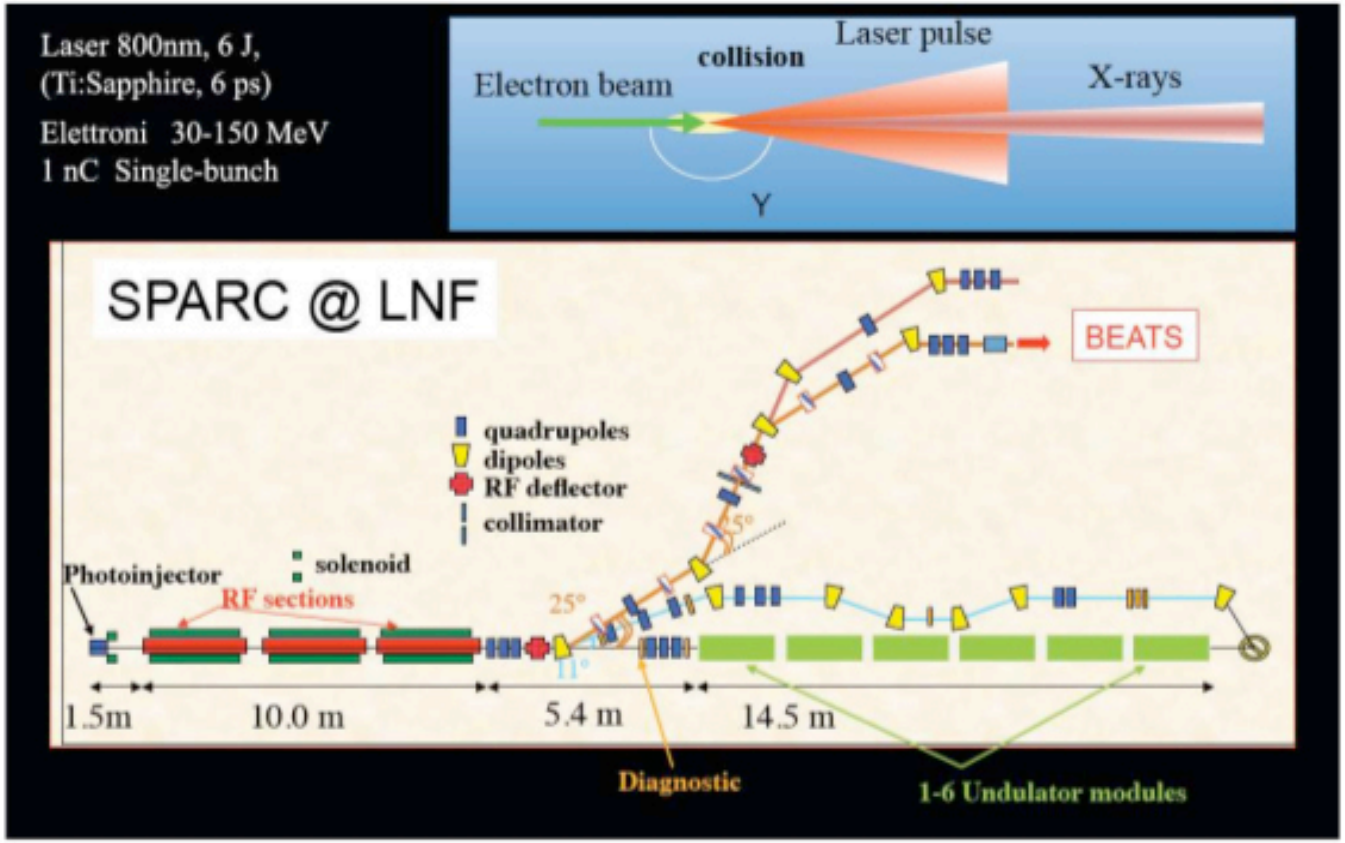


Fig. 1 – Sorgente Thomson ai LNF

Resulting in monochromatic X ray beams with energies between 20 and 800 keV

.

Medical diagnosis and material science

Medical diagnosis

Mamography

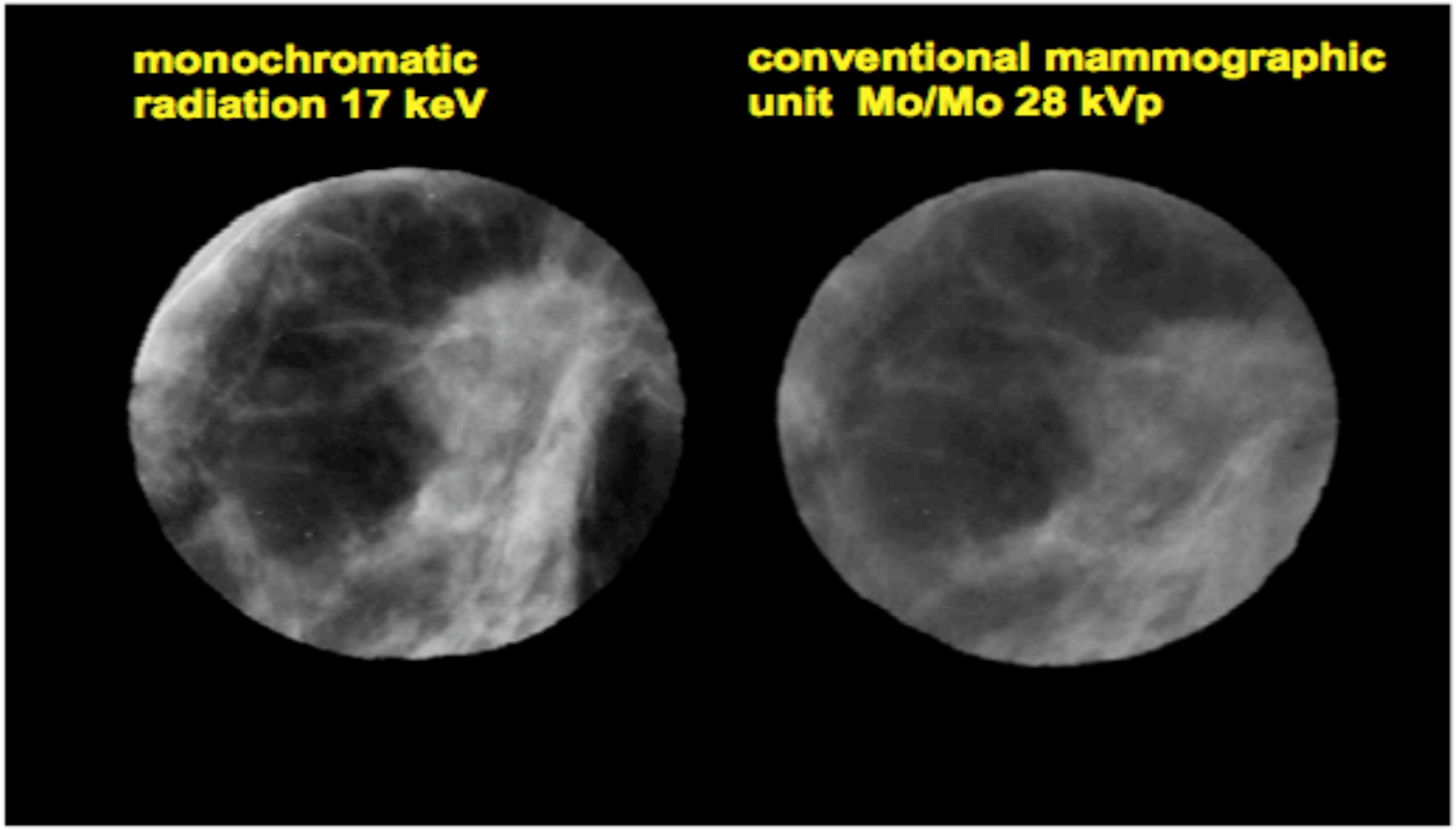
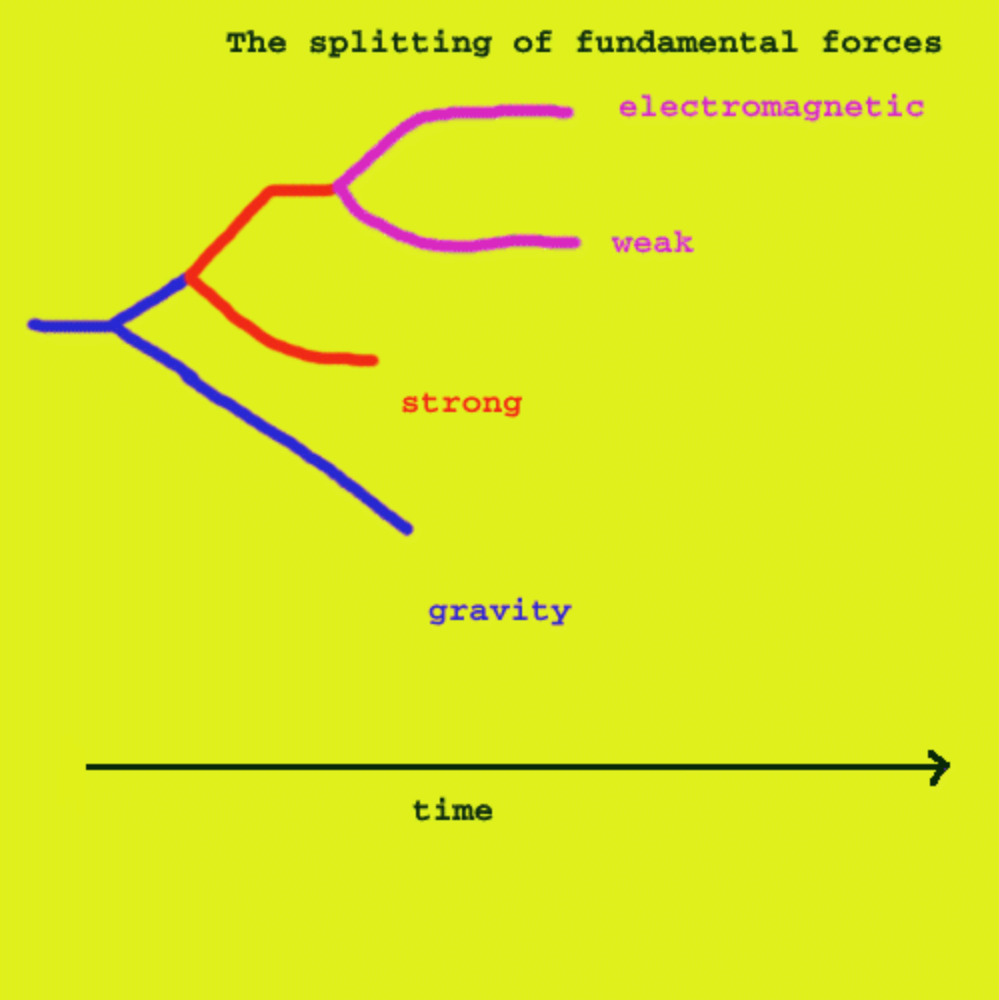


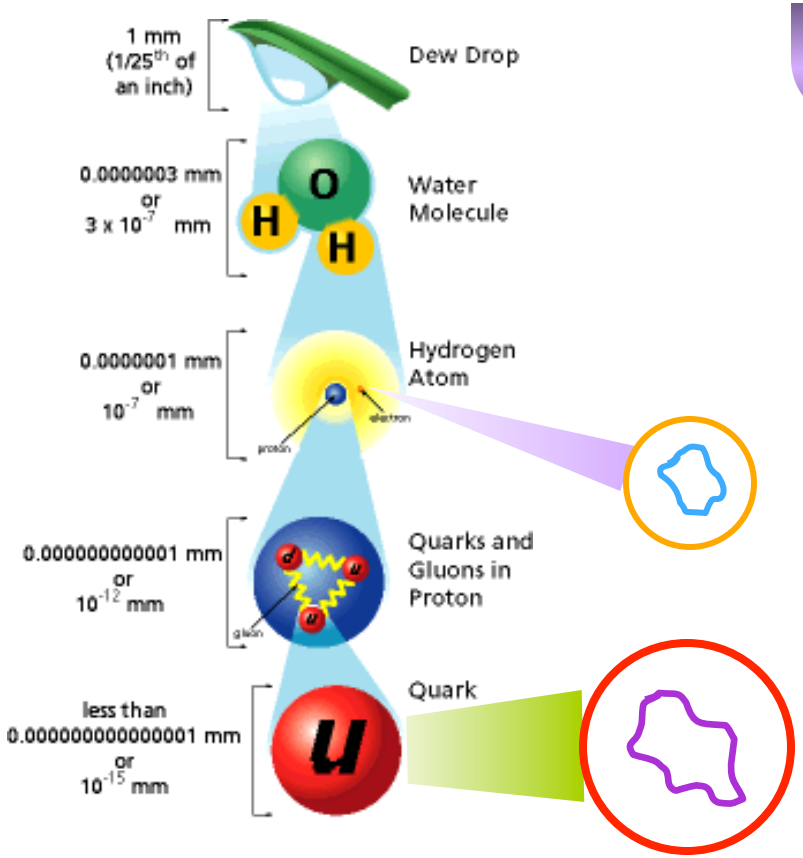
Fig. 3 – Confronto fra una mammografia monocromatica (sinistra) con una tradizionale (destra).

L'unificazione di tutte le forze?



Questioni Aperte

- Le particelle sono veramente puntiformi ?

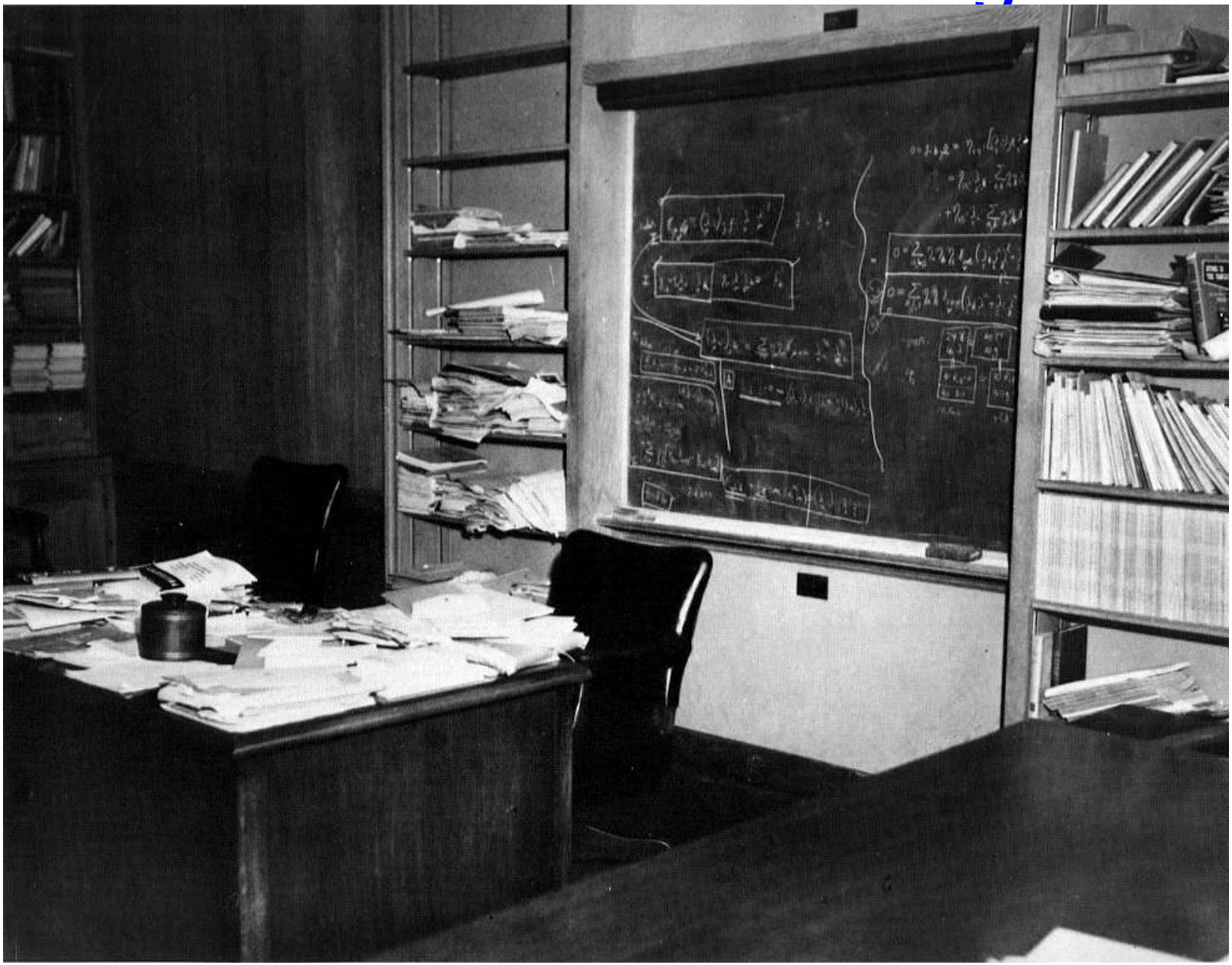


Teoria delle Stringhe

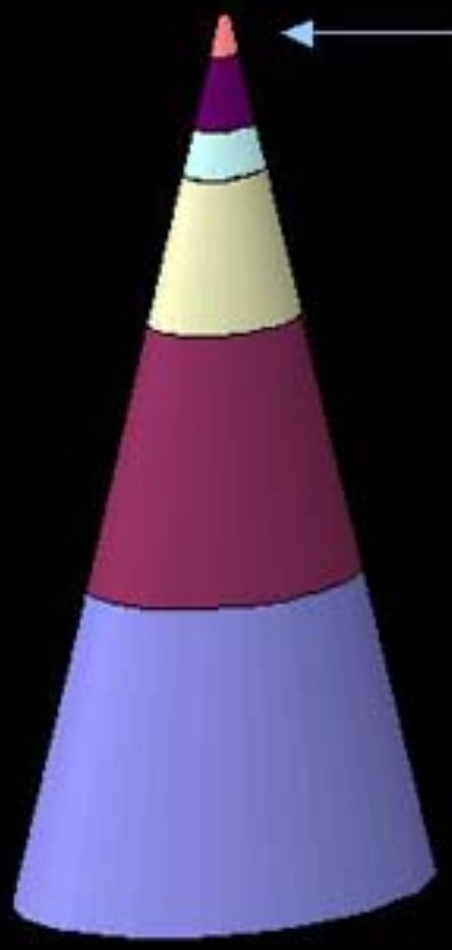
ulteriore livello microscopico: particelle non sono puntiformi, ma piccoli (10^{-33} cm) anelli oscillanti

diversi stati di oscillazione della stringa → particelle diverse

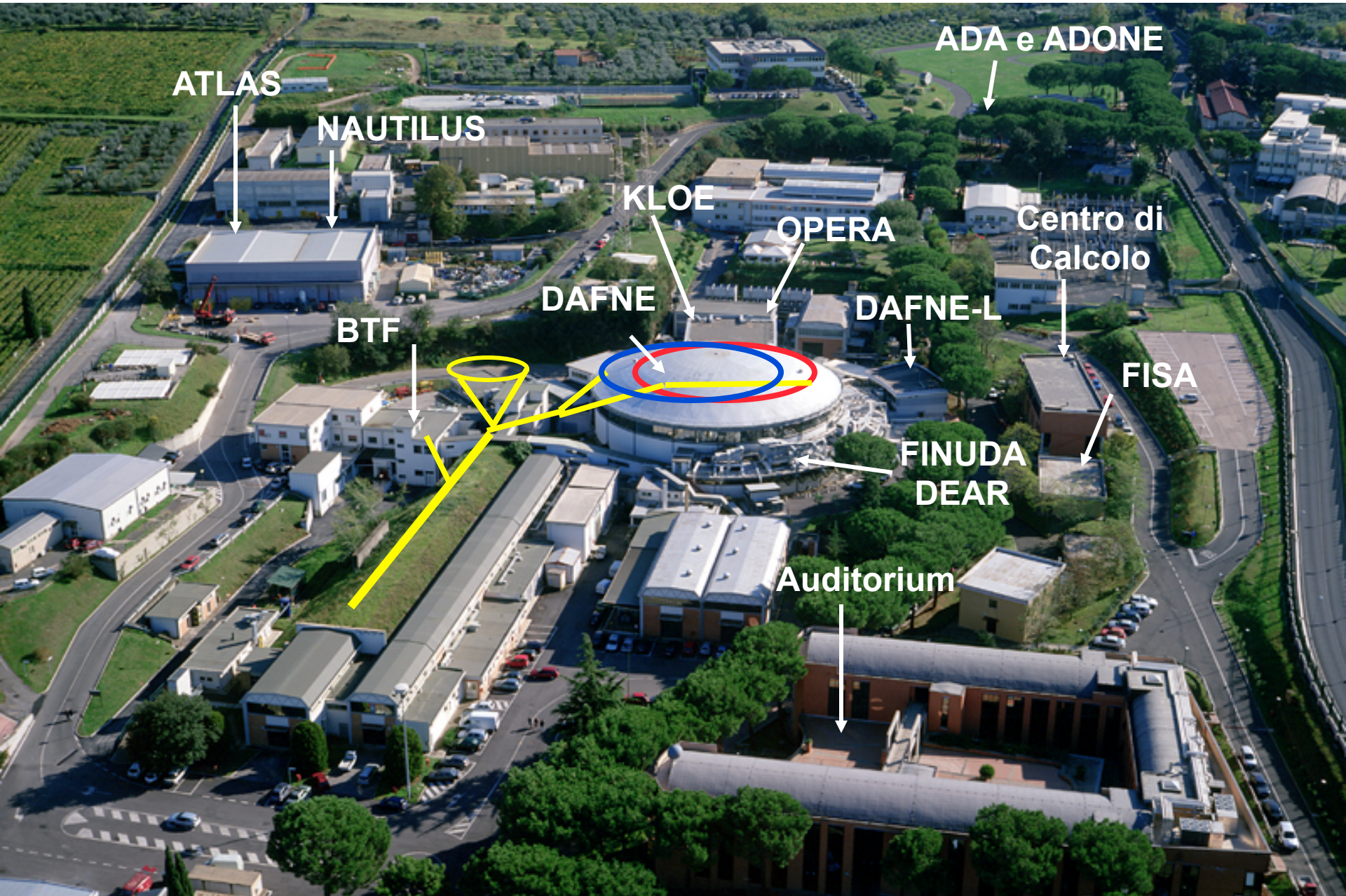
Einstein – l'ultima lavagna



Composizione dell'Universo



Other elements	0.03%
Neutrinos	0.3%
Stars	0.5%
Free H and He	4%
Dark matter	23%
Dark energy	72%

Non sappiamo di cos'e' fatto 95% dell'Universo

Laboratori Nazionali di Frascati, info: http://www.lnf.infn.it/sis/