Introduction to Modern Physics and to the LNF-INFN Activities

INSPYRE 2016

INternational School on modern PhYsics and Research

QUANTUM LEGACY

15-19 February 2016

Catalina Curceanu
LNF-INFN

INFN
Istituto Nazionale di Fisica Nucleare

INSPYRE 2016

INternational School on modern PhYsics and REsearch

"THE QUANTUM LEGACY"

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

INFN - Laboratori Nazionali di Frascati
Auditorium B. Touschek

6th Edition, February 15 - 19 2016

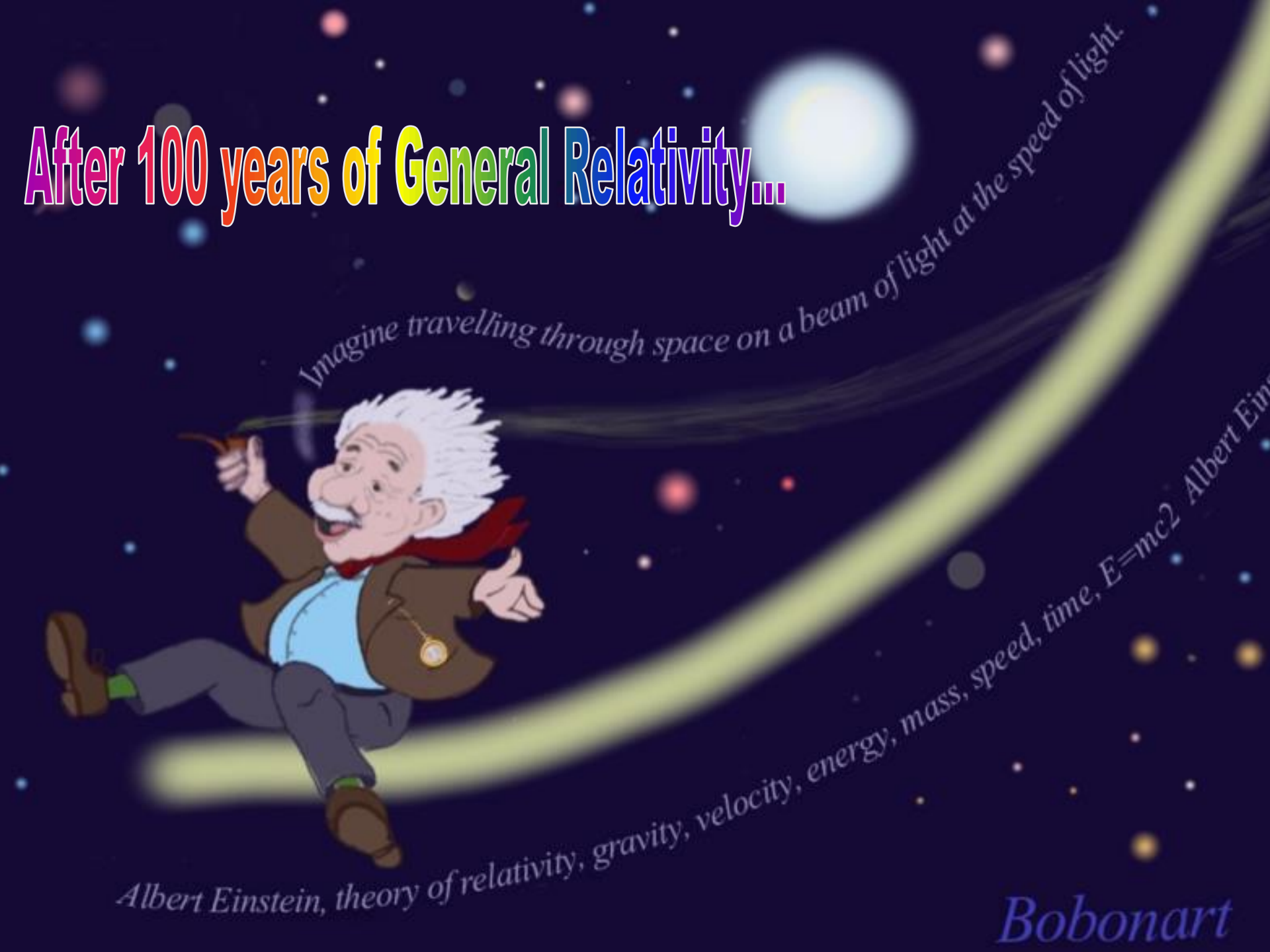
The School is open for students in their last year(s) of high school/college coming from all European countries.
Organized in lectures and experiments on Modern Physics and its applications in Society. The official language is going to be English.

Directors
Catalina Curceanu
Rossana Centioni

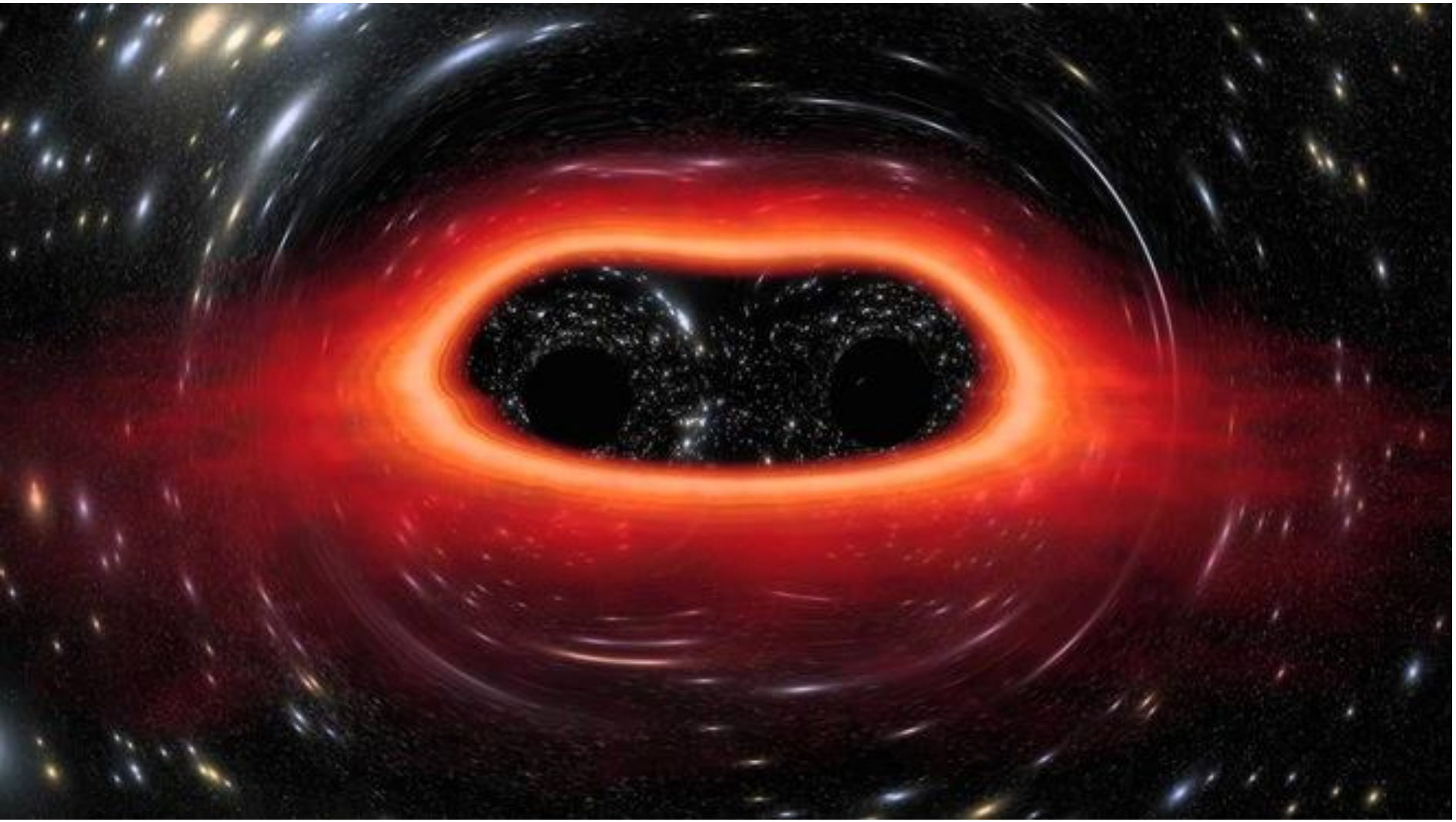
Secretariat
Marina Scudieri
Beatrice Zuaro

SIDS-Ufficio Comunicazione ed Educazione Scientifica
stages@lists.lnf.infn.it tel. 069403 - 2871 - 2753
HTTP://EDU.LNF.INFN.IT

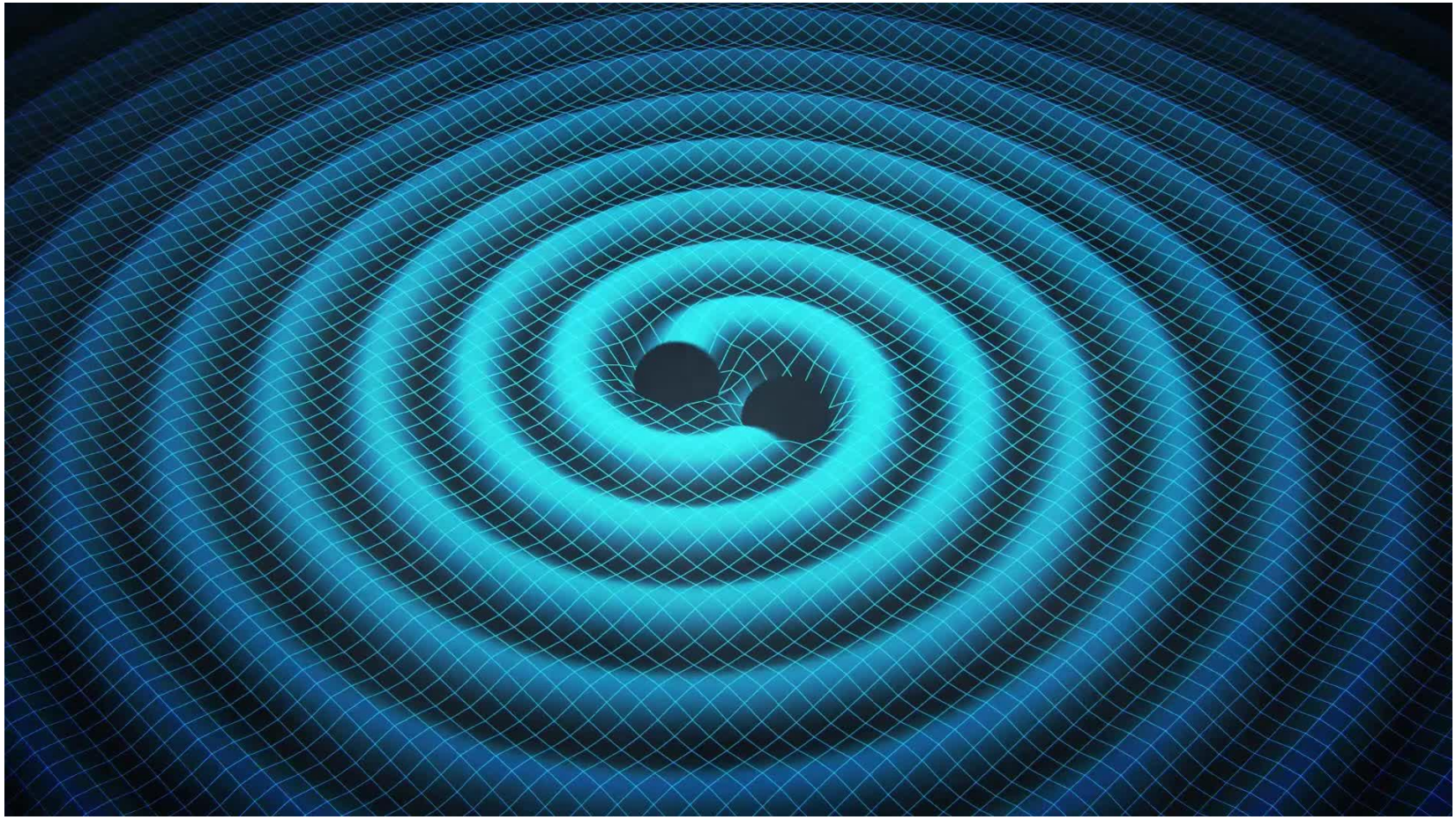
After 100 years of General Relativity...



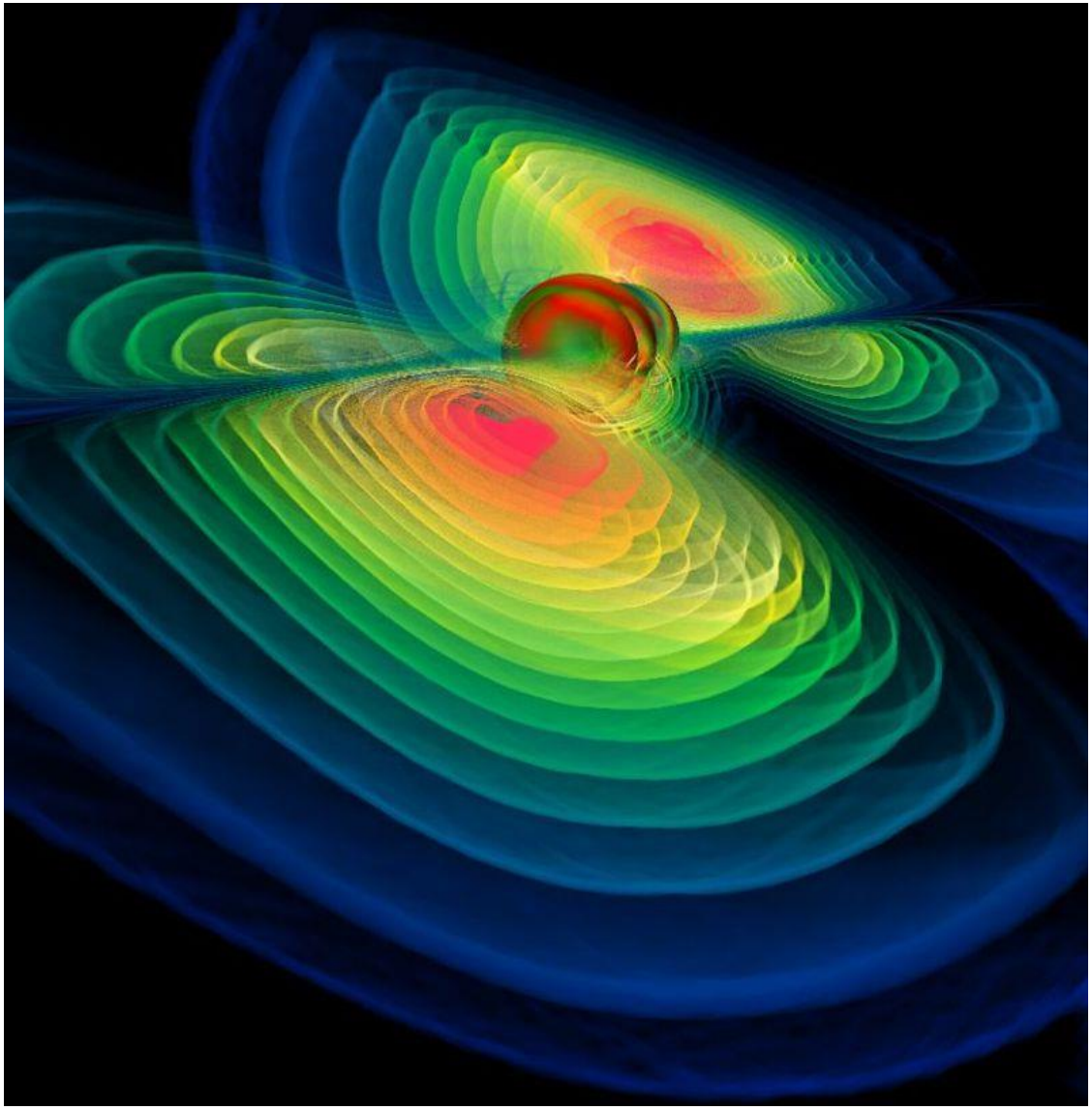
Discovery of the gravitational waves (14 Sept. 2015 -> 11 Feb 2016)



Discovery of the gravitational waves (14 Sept. 2015 -> 11 Feb 2016)

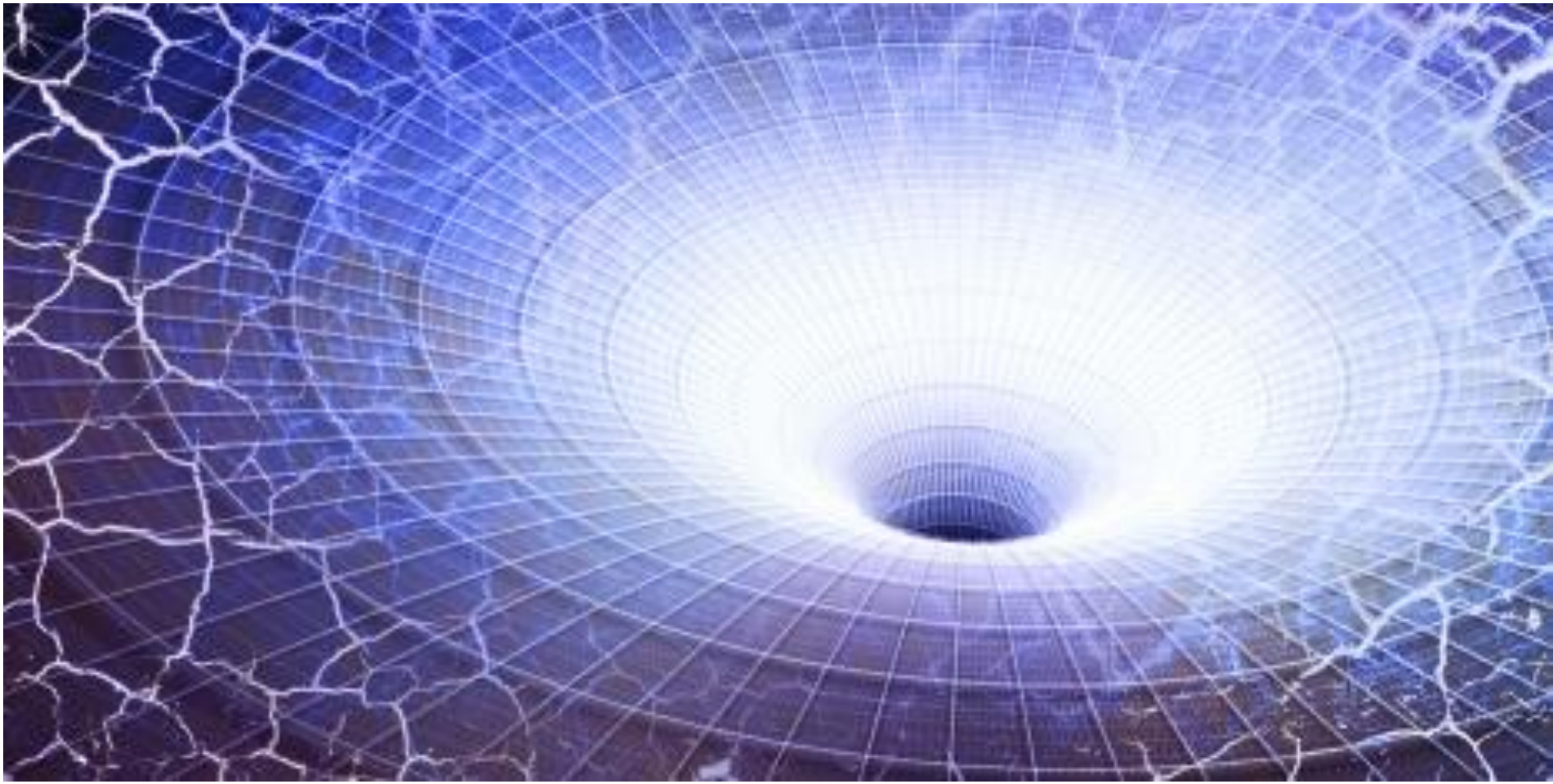


Discovery of the gravitational waves (14 Sept. 2015 -> 11 Feb 2016) – talk Viviana Fafone (19th feb)

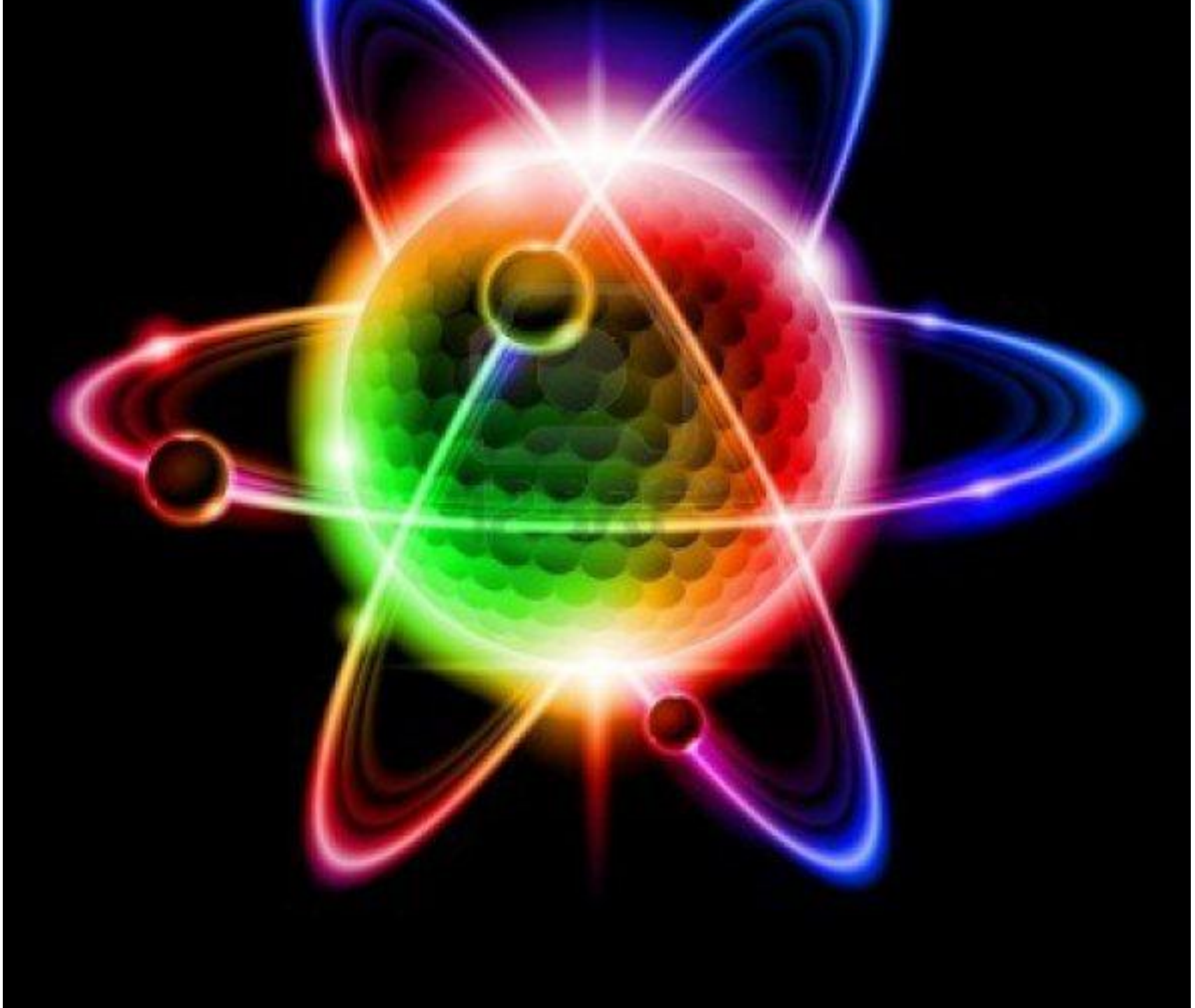


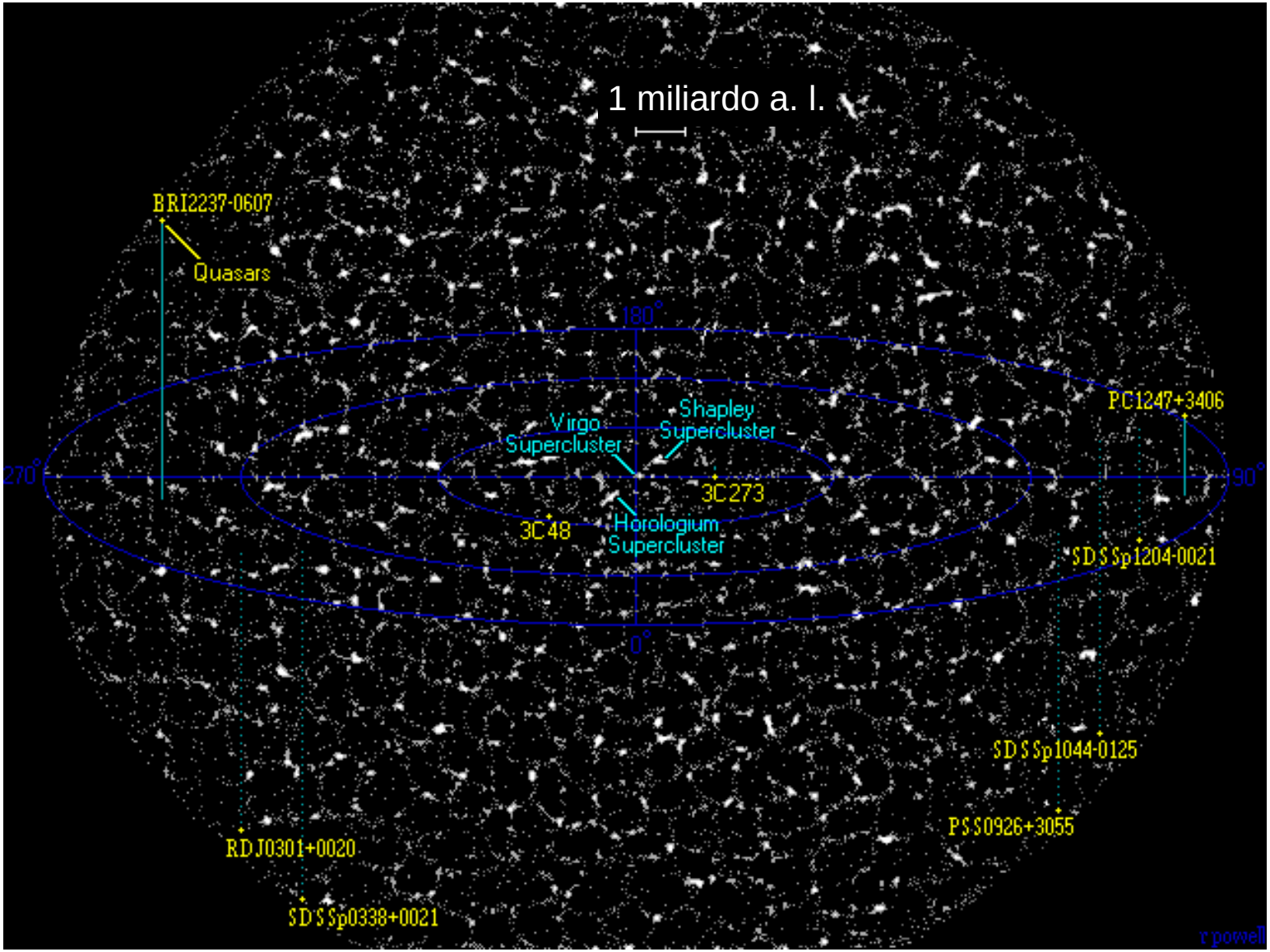
NAUTILUS at LNF-INFN

Towards quantum gravity?



....to interstellar travels?




1 miliardo a. l.
BRI2237-0607
Quasars
180°
270°
90°
0°
Virgo
Supercluster
Shapley
Supercluster
3C273
3C48
Horologium
Supercluster
PC1247+3406
SDSSp1204-0021
SDSSp1044-0125
PSS0926+3055
RDJ0301+0020
SDSSp0338+0021
r powell

Zoom In x15

Istituto Nazionale di Fisica Nucleare

The INFN promotes, coordinates and performs scientific research in the sub-nuclear, nuclear and astroparticle physics, as well as the research and technological development necessaries to the activities in these sectors, in strong connection with the University and in the framework of international cooperation and confrontation

1951

4 University Sections

Milano, Torino, Padova, e Roma

1957

Laboratori Nazionali di Frascati

Frascati

INFN
Istituto Nazionale di Fisica Nucleare

Legnaro

Gran Sasso

VIRGO-EGO

European

Gravitational

Observatory

Laboratori del Sud (Catania)

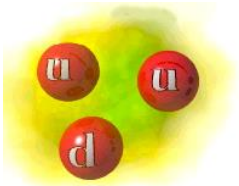
19 Sections

11 Related Groups

4 National Laboratories

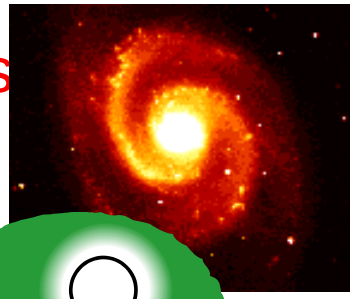
What are the activities performed at Laboratori Nazionali di Frascati?

Fundamental research

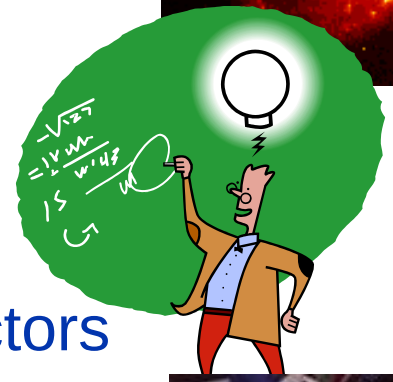


- Studies of the ultimate matter structure

- Search for gravitational waves



- Developments of theoretical models

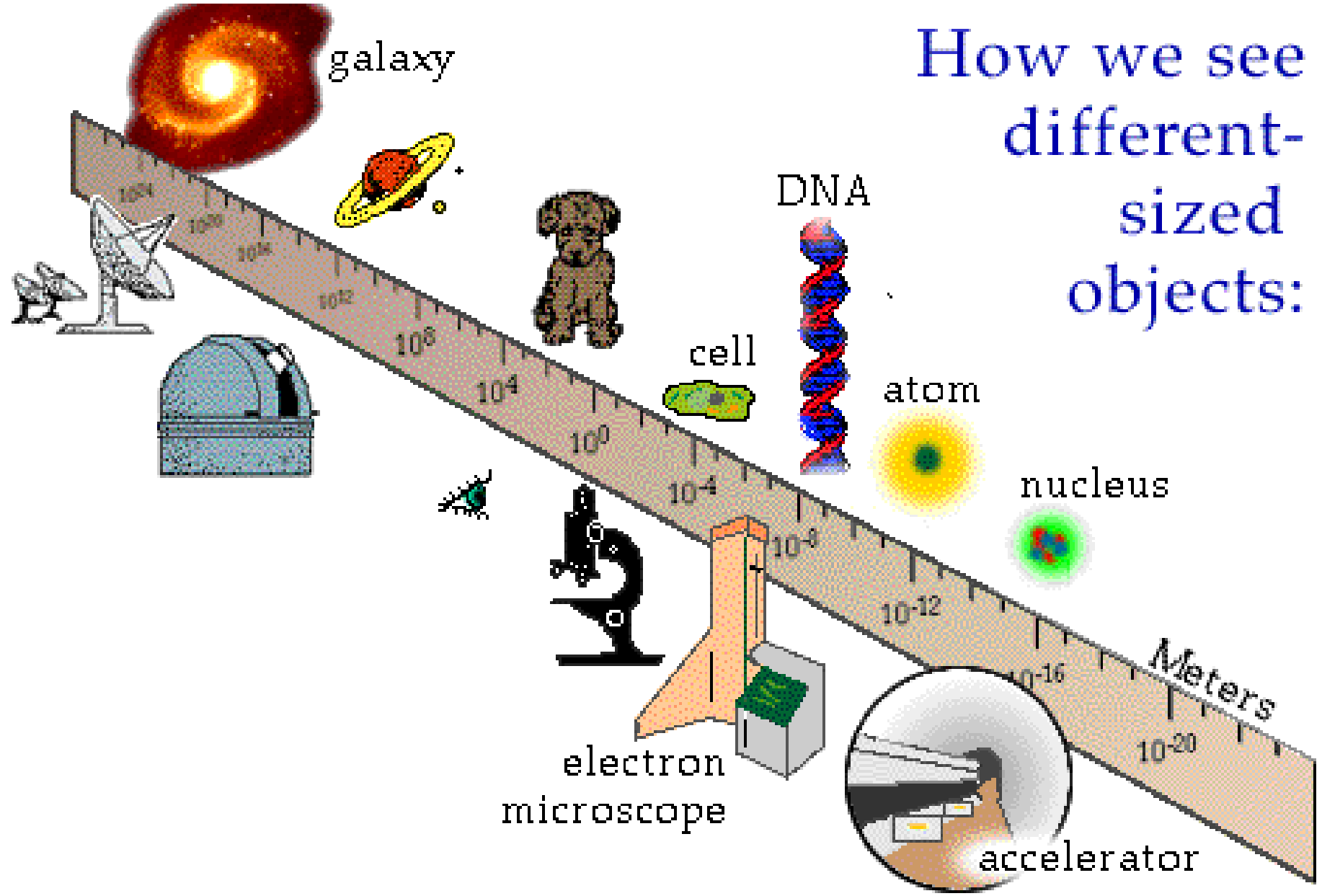


- Development and construction of particle detectors

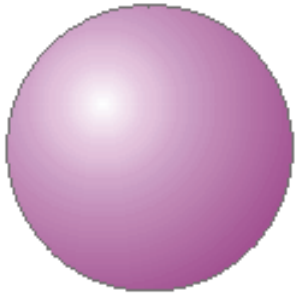
- Studies and development of accelerating techniques
- Material studies and bio-medical research with the synchrotron light

- Development and support for computing systems and nets

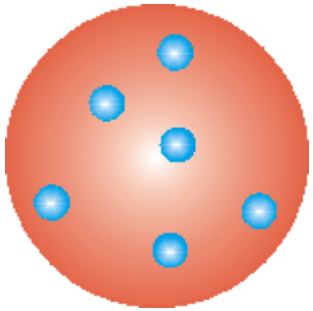
How we see different-sized objects:

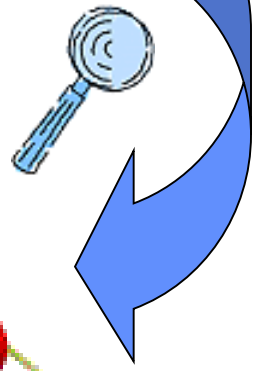


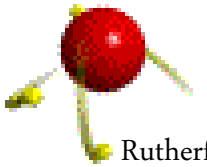
The atom in the beginning of ‘900



The Thompson’s atom

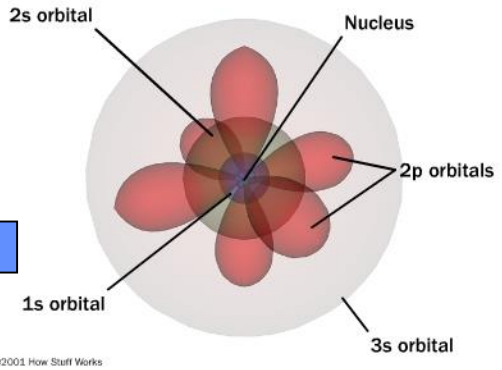


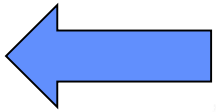


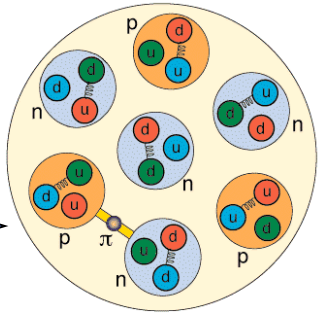


Rutherford e Bohr - atom

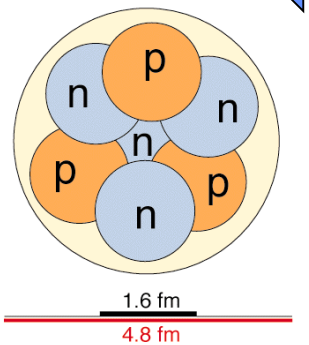
Quantum mechanics - atom





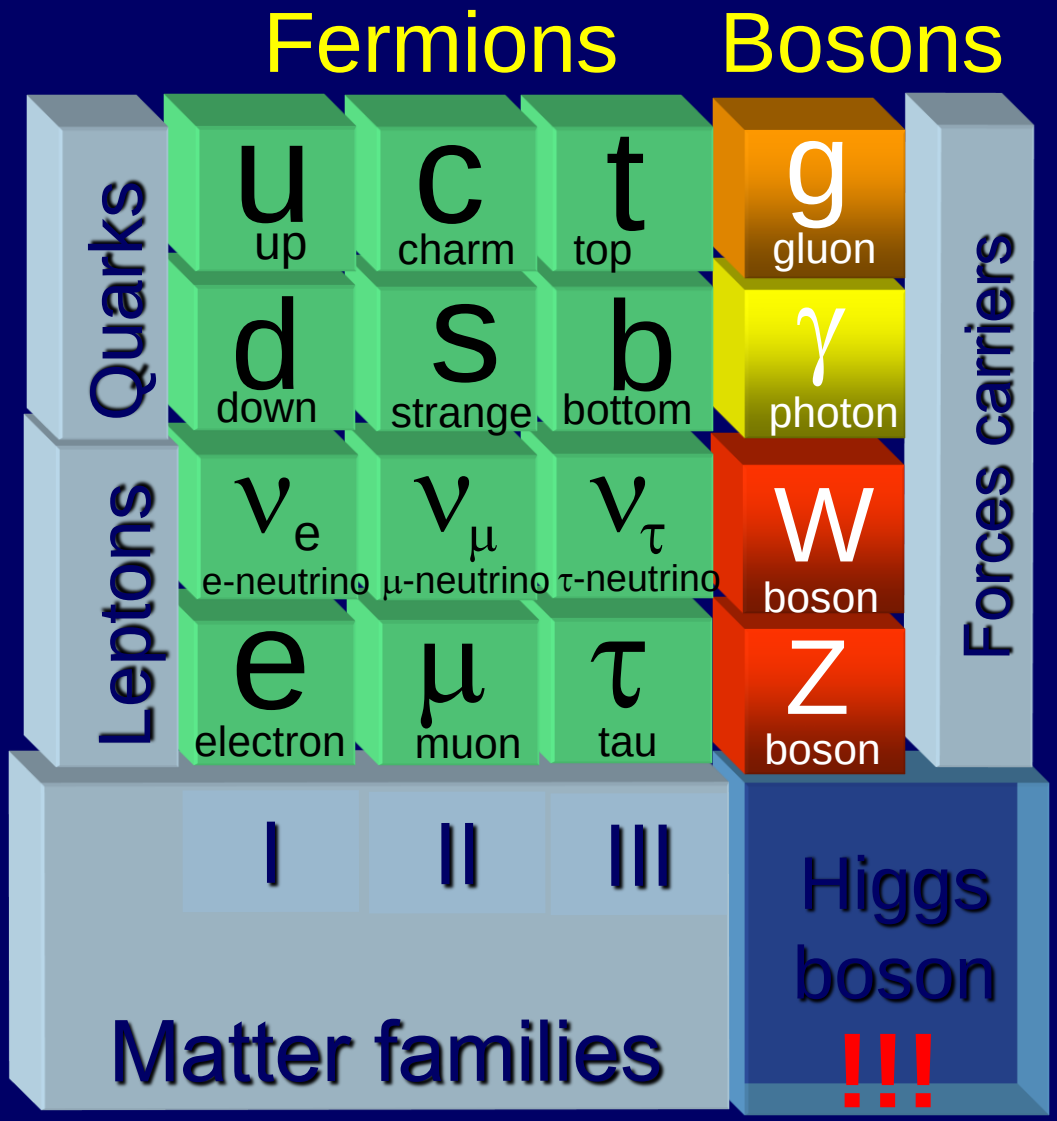


The nucleus today



The nucleus structure

The Standard Model



Gravitation

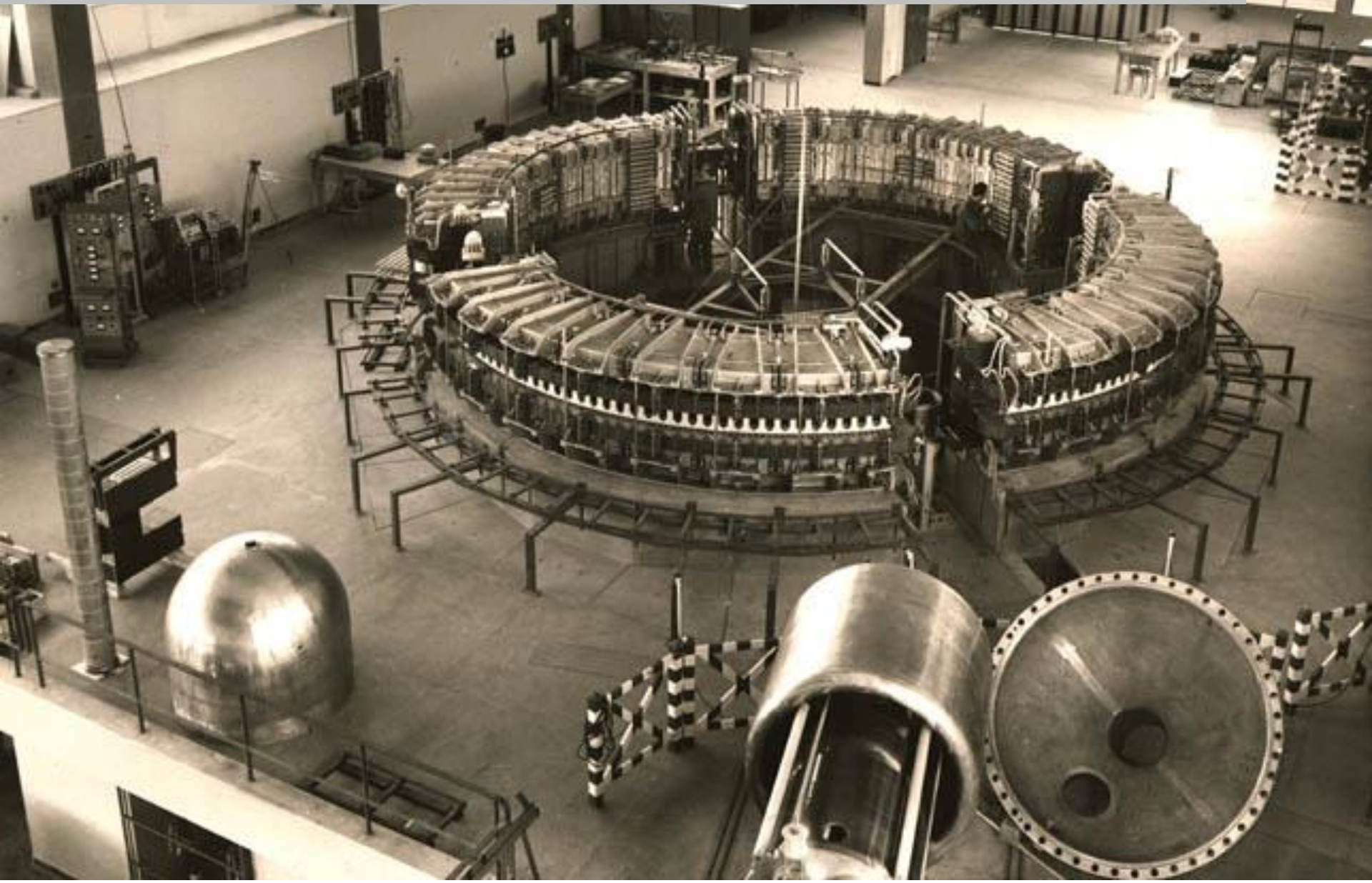
The “Opera ghost”

Frascati National Labs (LNF)

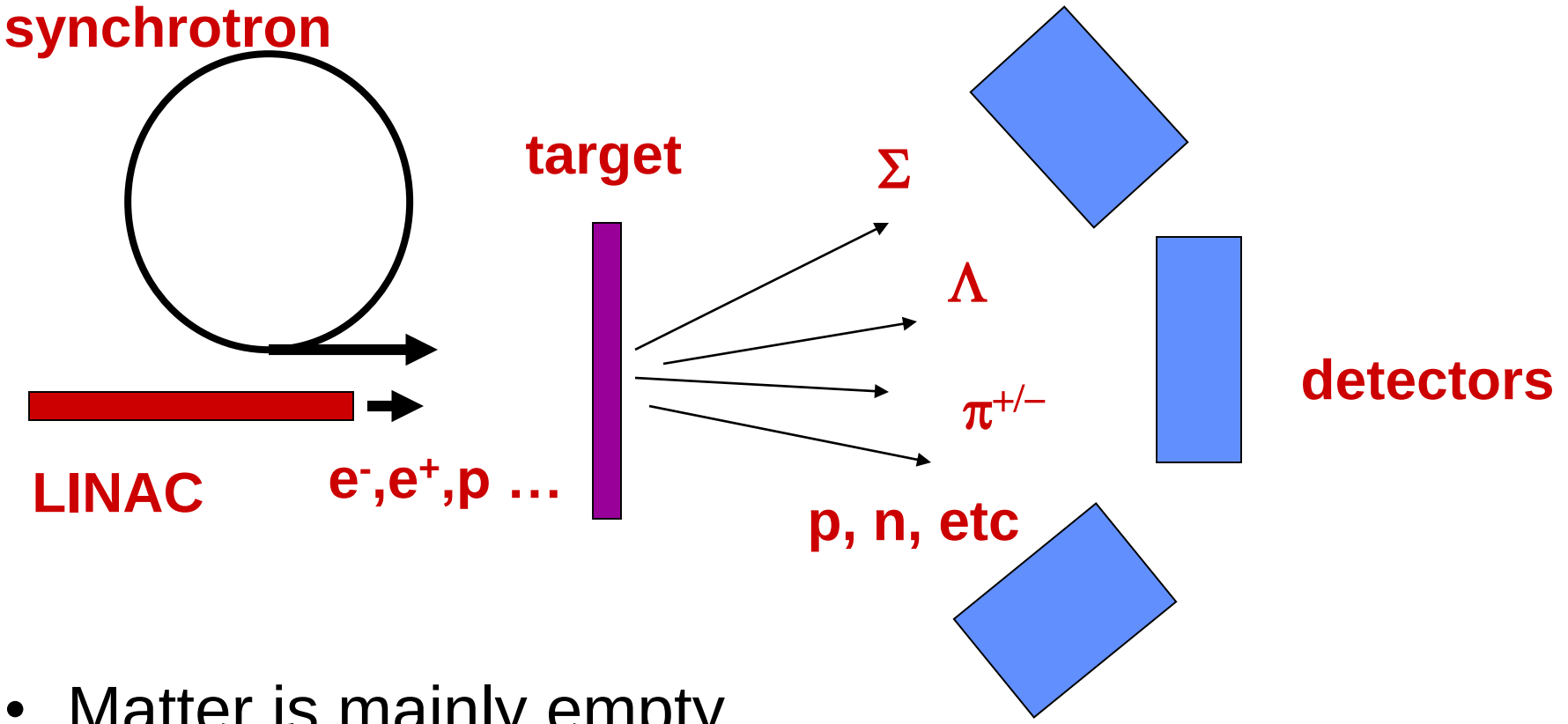
Total Staff **of which:** **364**	**Researchers** **98**	**Technologist/ Engineers** **57**	**Technicians** **170**	**Administration/ Services** **39**
External Users **546**	***Italian*** **346**		***Foreign*** **200**	
Visitors **3960**	**Stages** **310**	**Conference Workshops** **17**	**Participants to Conf. / Work.** **776**	**Master Courses** **1 (27 positions)**


LNF
DAFNE-light
LINAC
DAFNE
BTF
SPARC
FLAME

Frascati electrosynchrotron 1959-1975

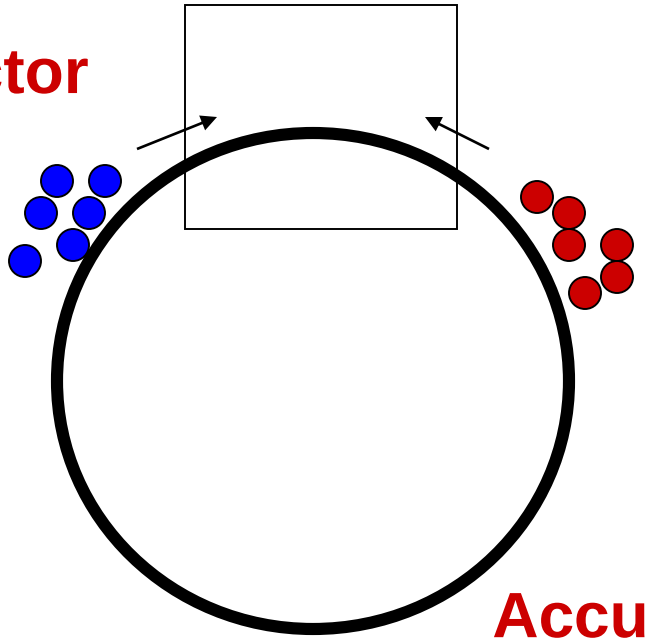


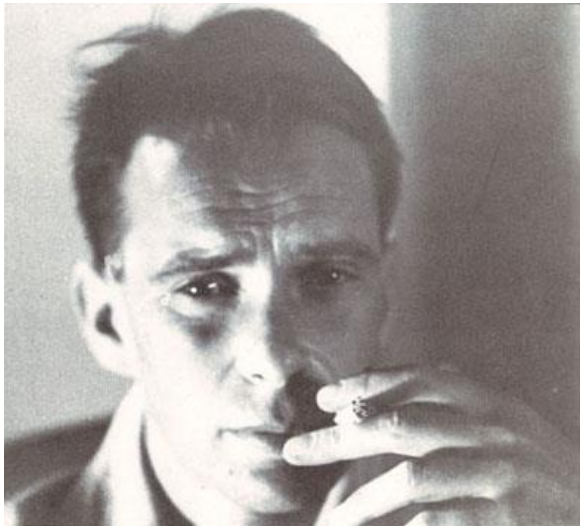
Observing on fixed target



- Matter is mainly empty
- All those particles which did not interact get lost
- Energy loss by moving the center of mass
- Target is complex

First Frascati's idea

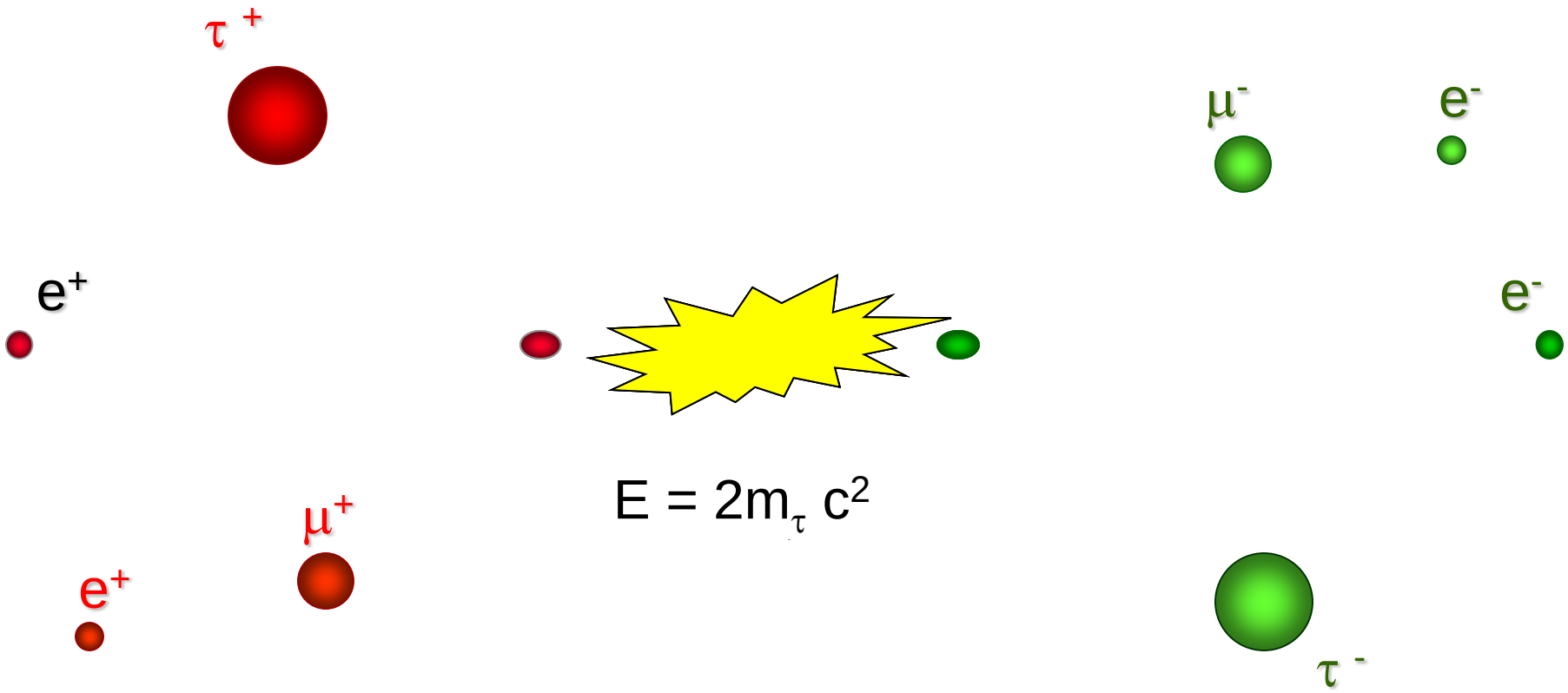




Bruno Touschek

- The non-interacting particles can be re-used in the successive rounds
- Collisions are performed in the center of mass frame
- The circulating particles can be either elementary or complex (nuclei or atoms)

Second Frascati's idea



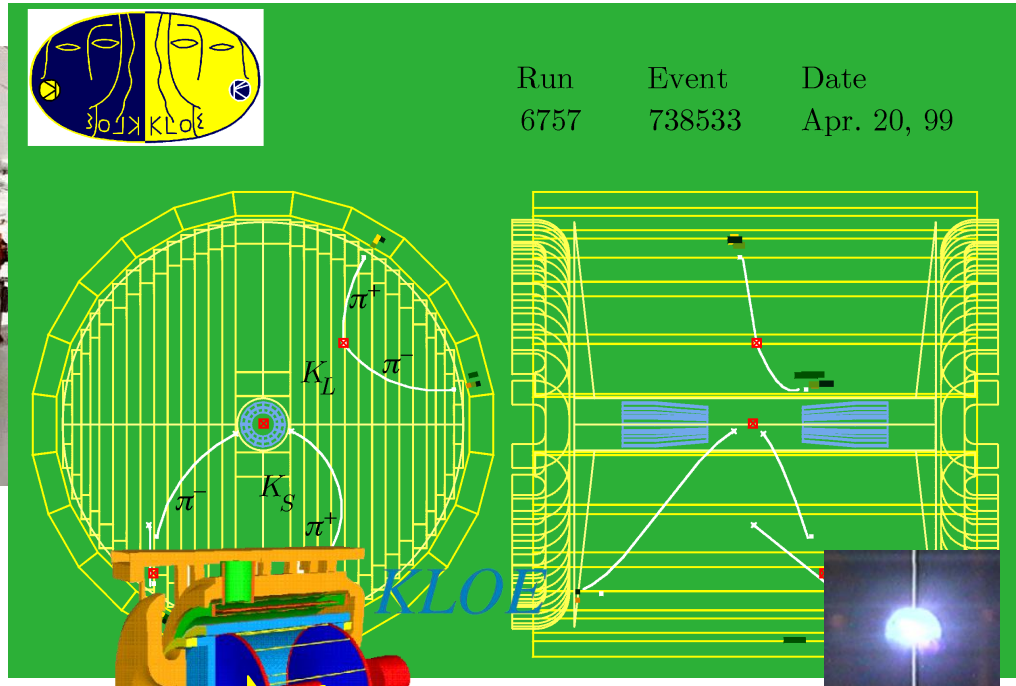
E = m c^2

Bigger the energy is, more and more particles can be studied

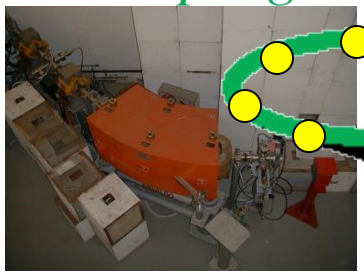
Matter-antimatter colliders

LHC at Cern (pp)

DAΦNE



Damping ring



Test beam

Main rings

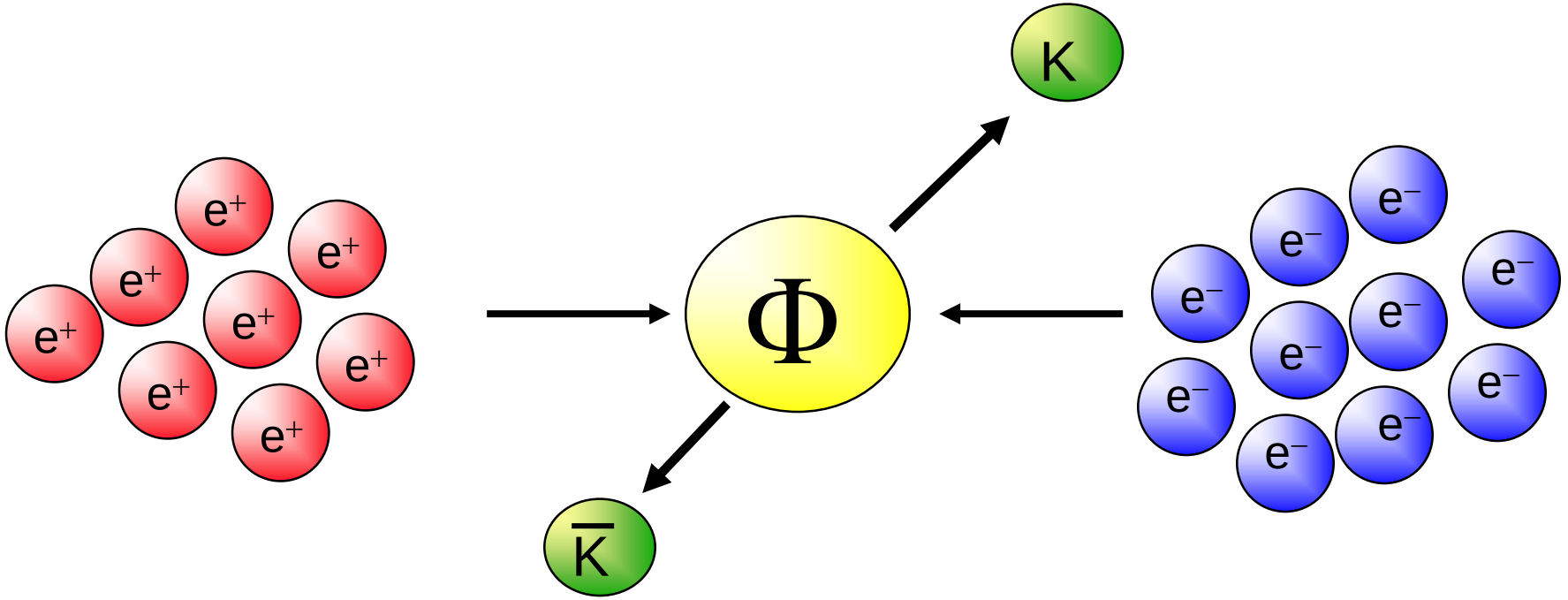
DAFNE-Light

Linac

DEAR
FINUDA

Physics at DAΦNE

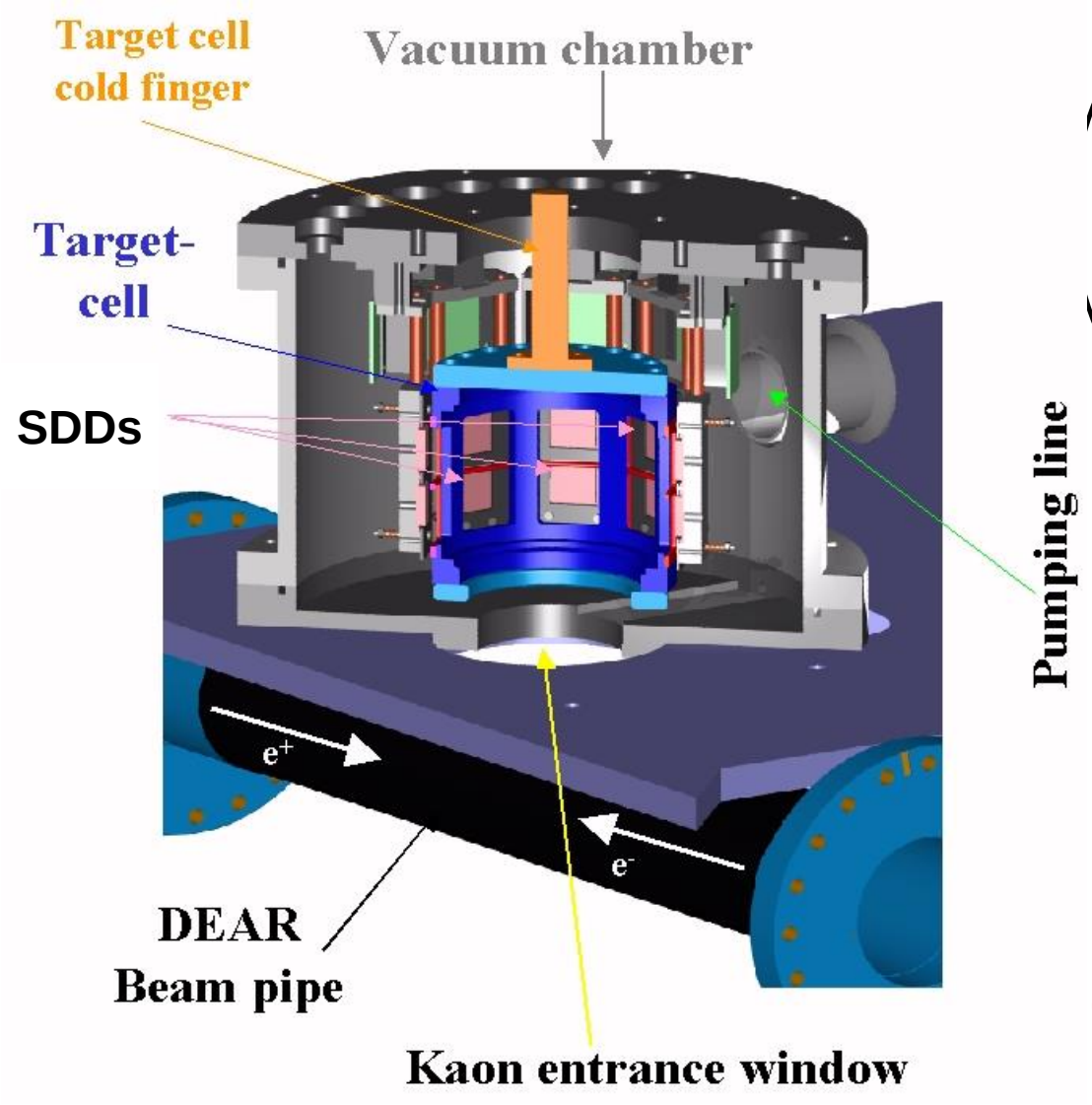
Out of the electron – positron collisions the Φ meson can be produced; it decays immediately in other two particles, the *K*-mesons (kaons). The kaons can be both neutrals or charged.



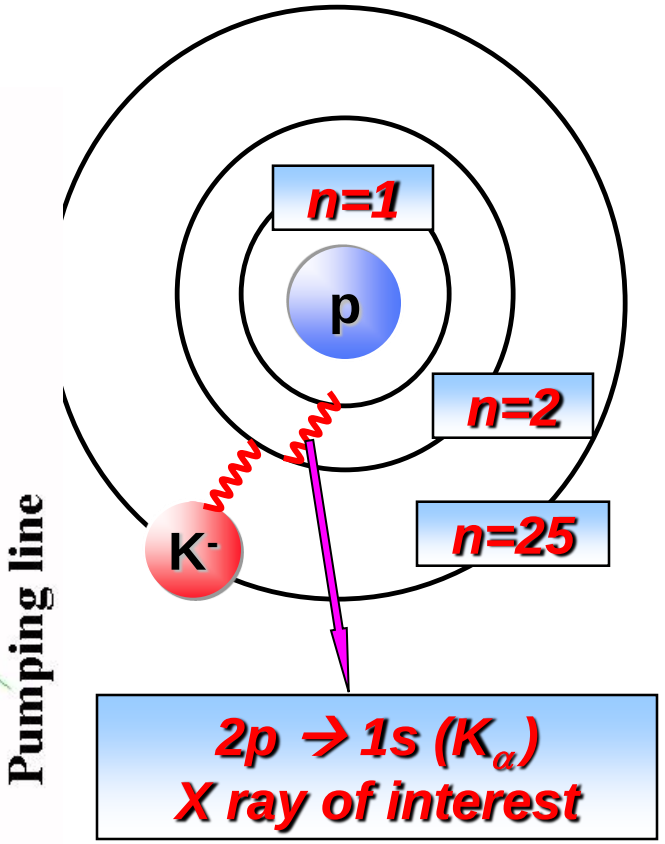
The *K* are the particles used by the three experiments, DEAR, FINUDA and KLOE, to reach their scientific goals. The DAΦNE luminosity allows to produce about 10000 *K* in a second

SIDDHARTA

(DAΦNE Exotic Atom Research)

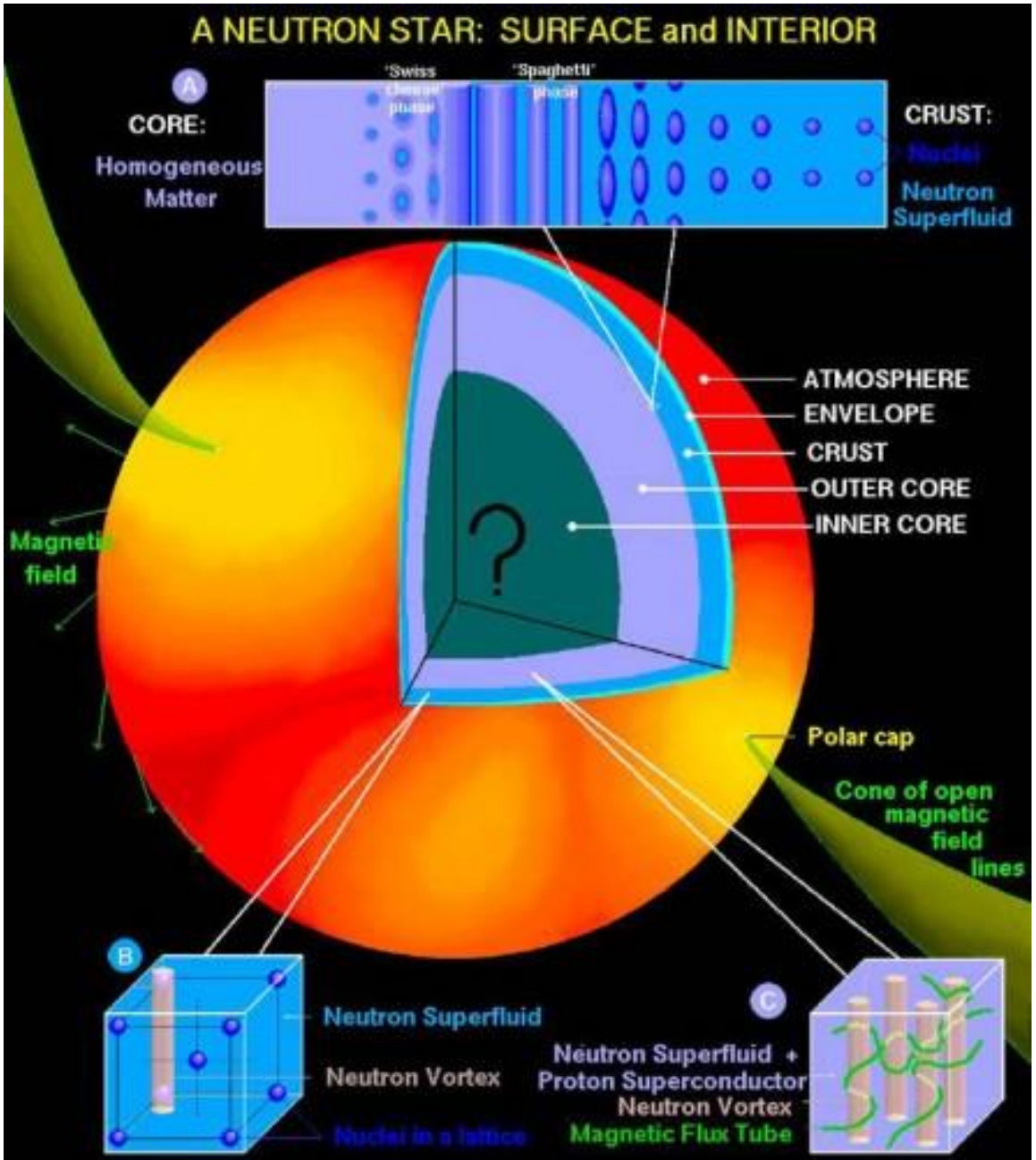


Kaonic hydrogen



The DEAR experiment investigates the *strong force* by studying the *kaonic atoms* (in which a K^- is substituting an atomic electron).

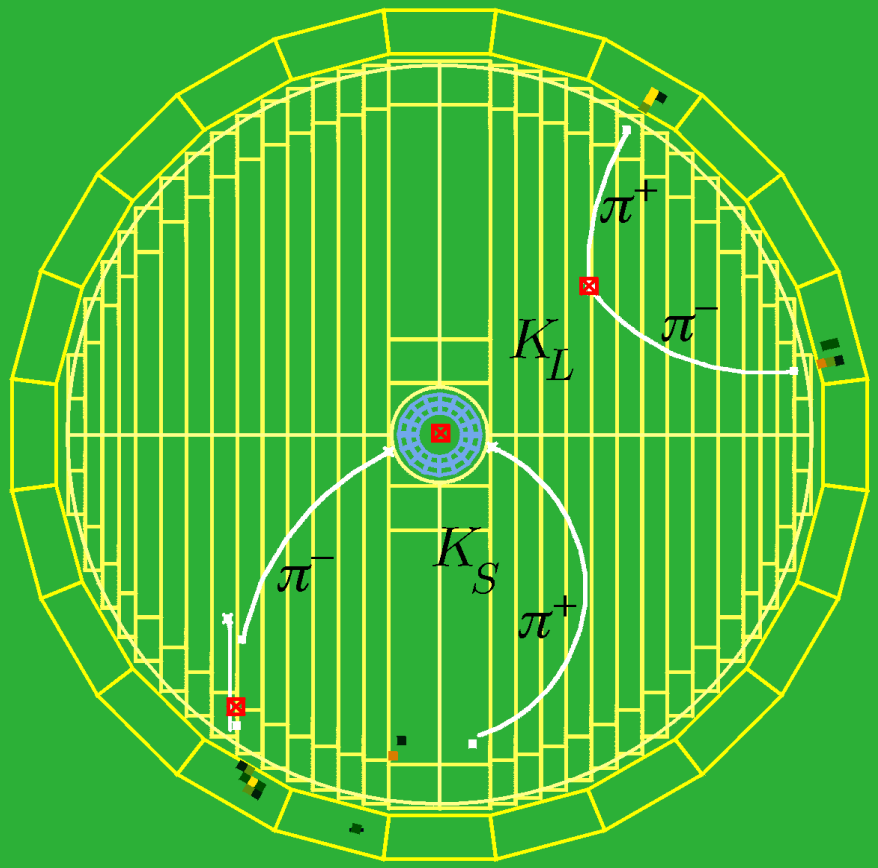
Could strangeness play a role in neutron stars?

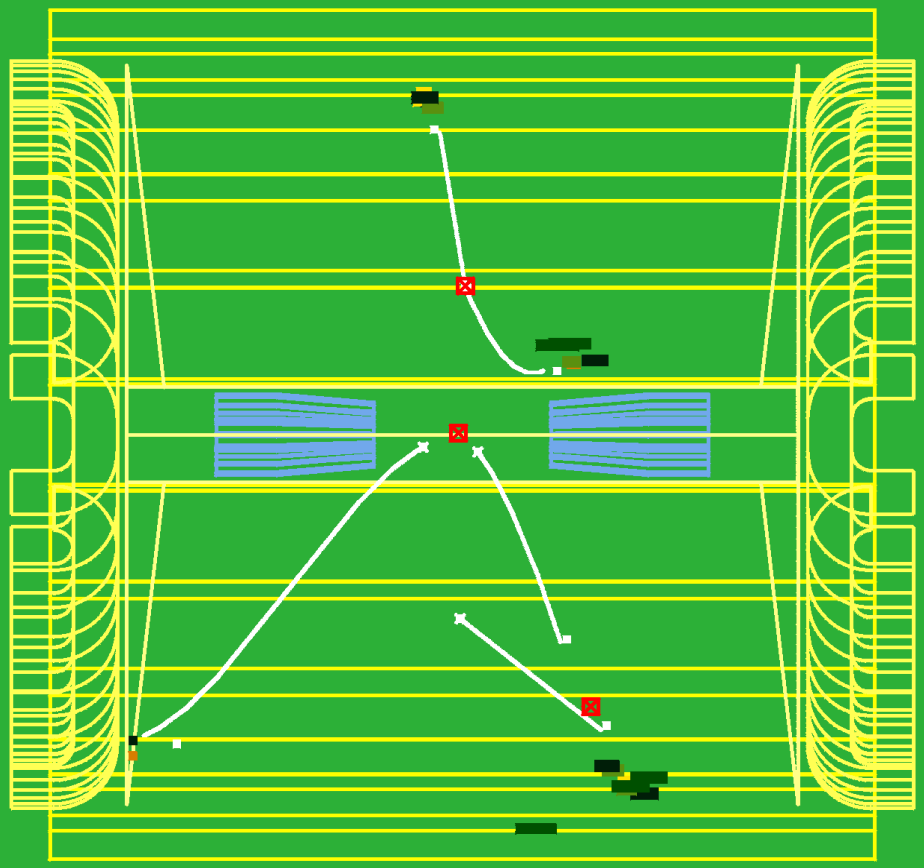


KLOE

(K LOng Experiment)

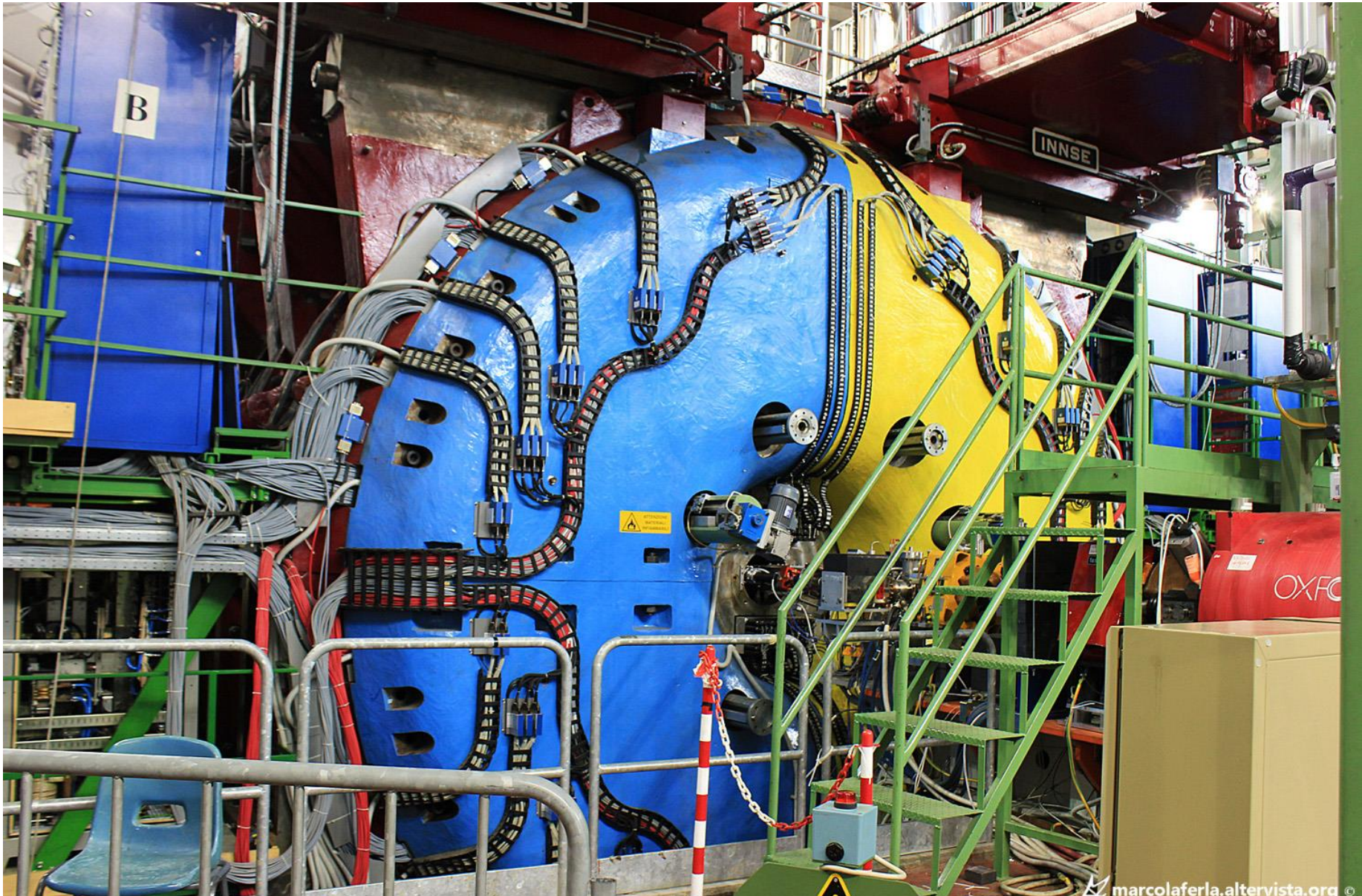
Run	Event	Date
6757	738533	Apr. 20, 99



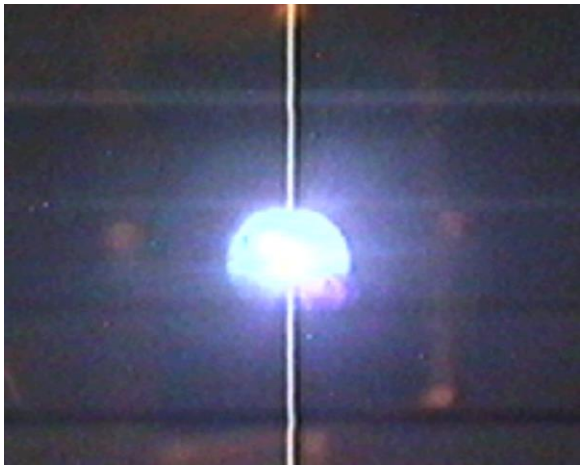


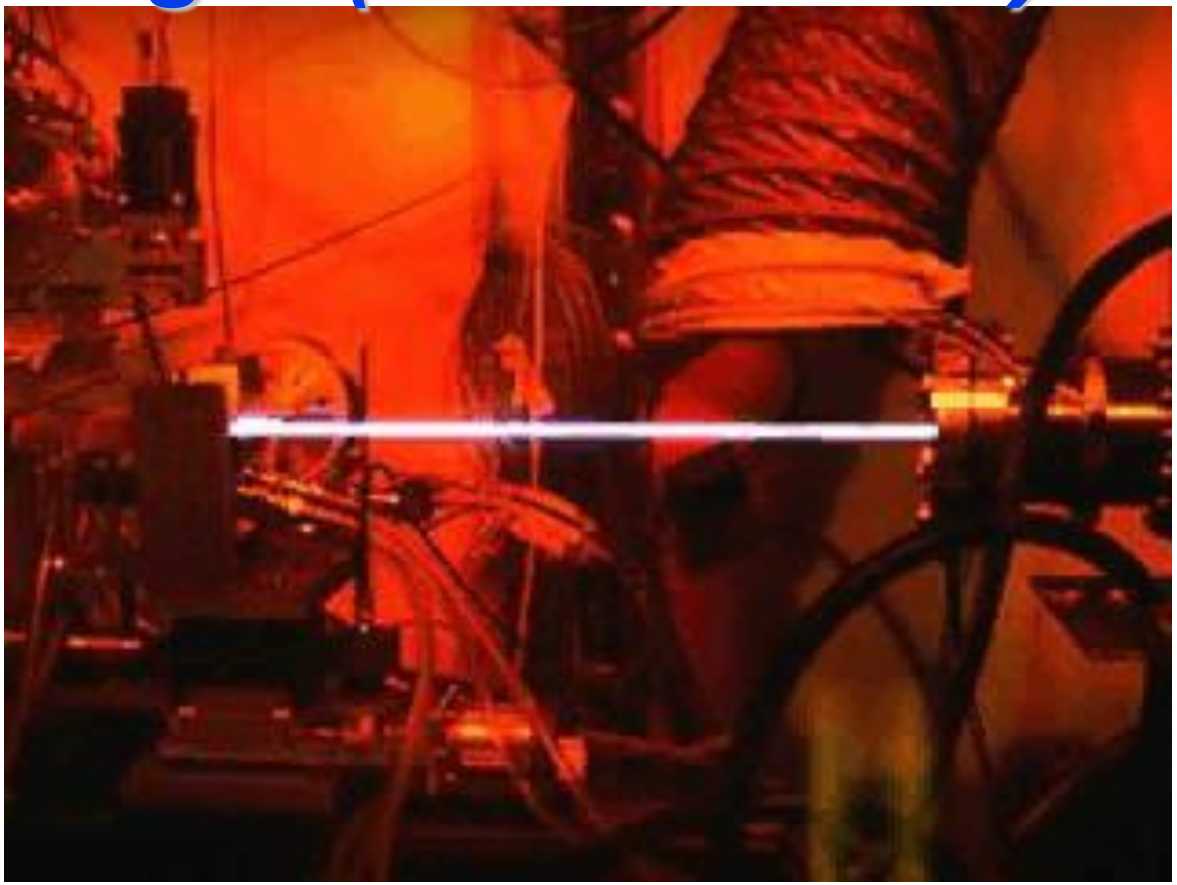
KLOE2

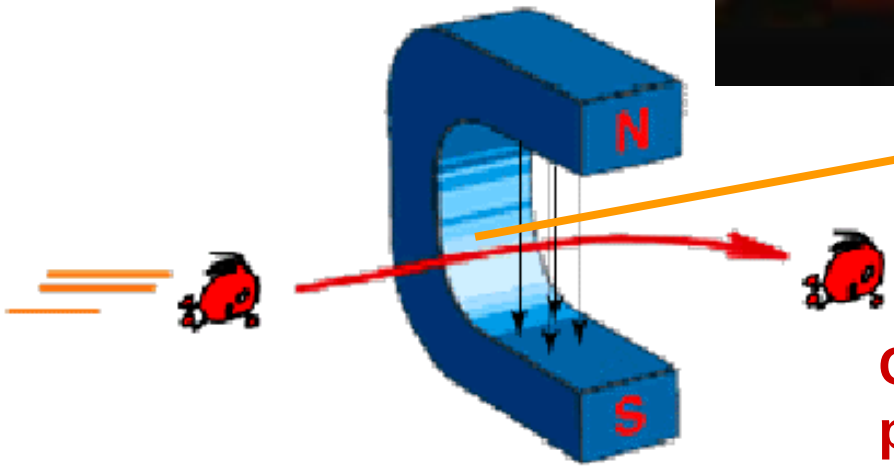
(K LOng Experiment)



Synchrotron light (DAΦNE-luce)







Light (photons)

European Synchrotron Radiation Facility

Charged particle

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

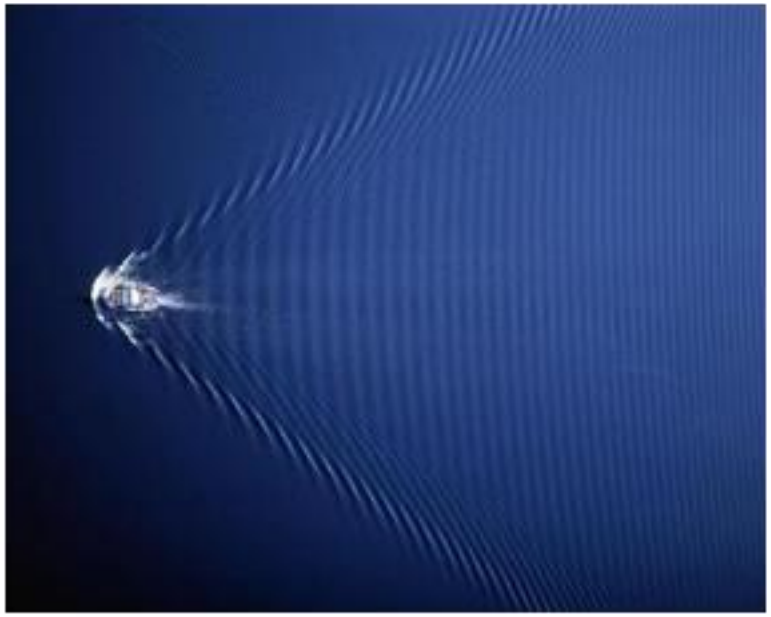
Started December 2010

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

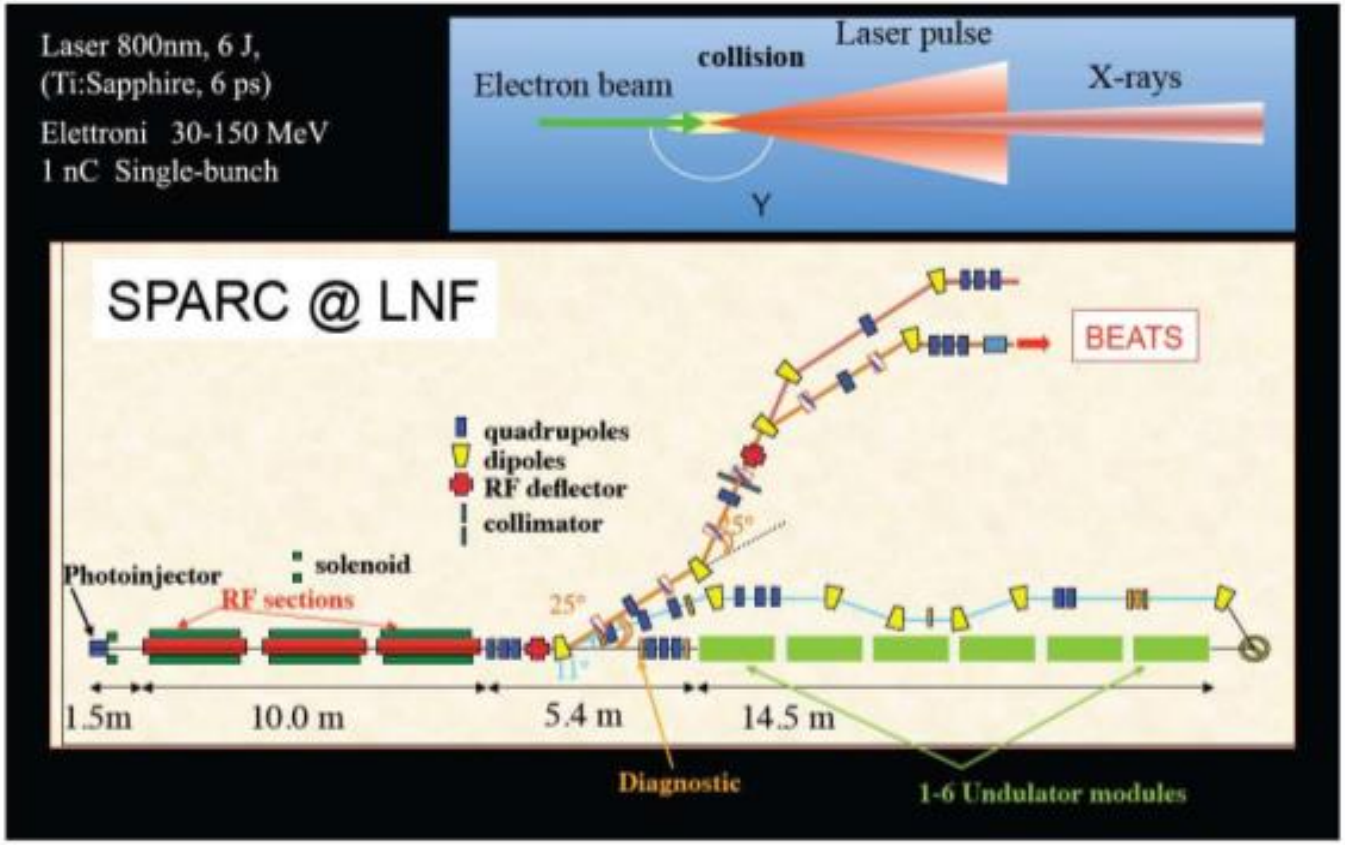


Fig. 1 – Sorgente Thomson ai LNF

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

.

Medical diagnosis and material science

Medical diagnosis

Mamography

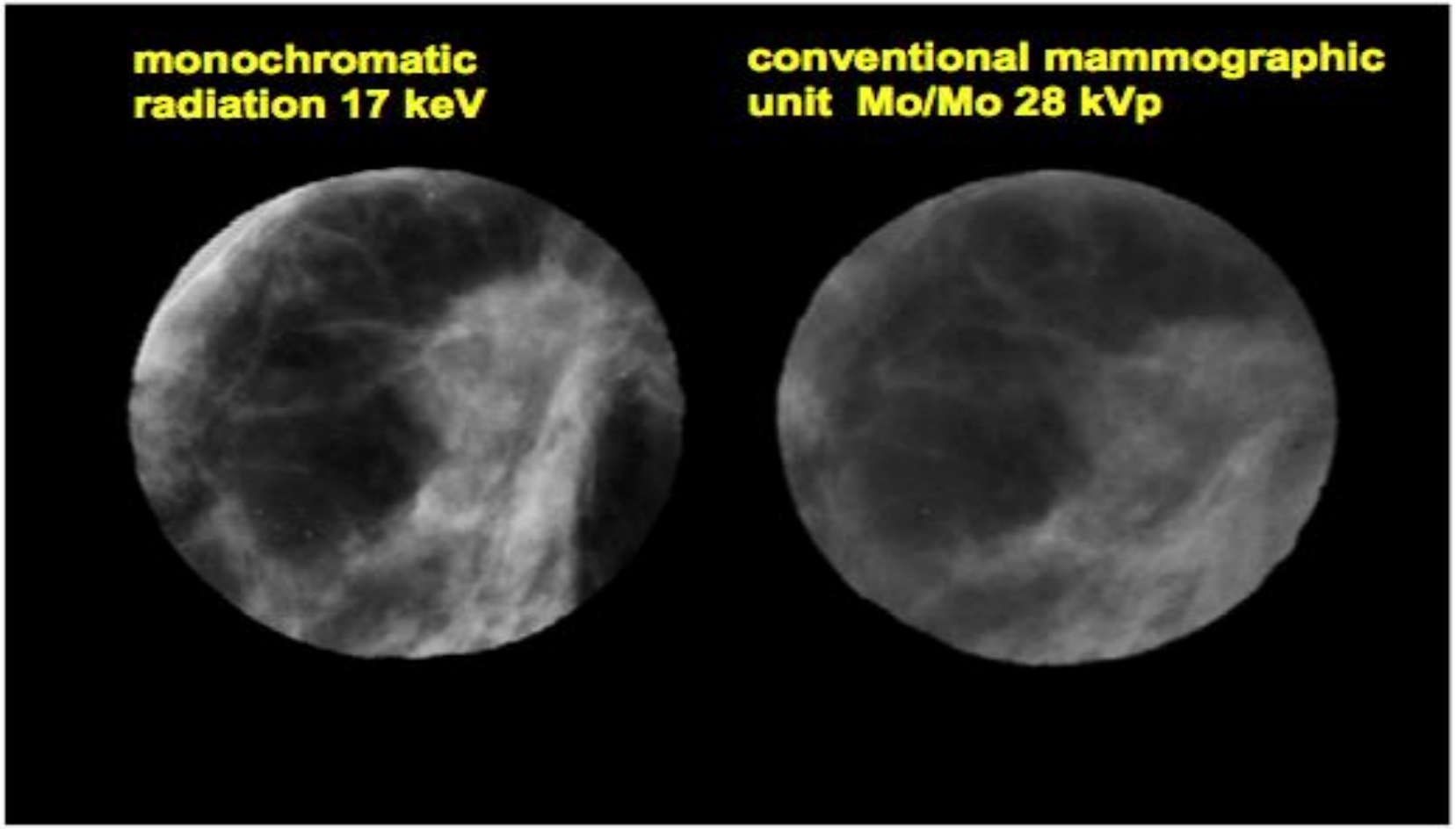
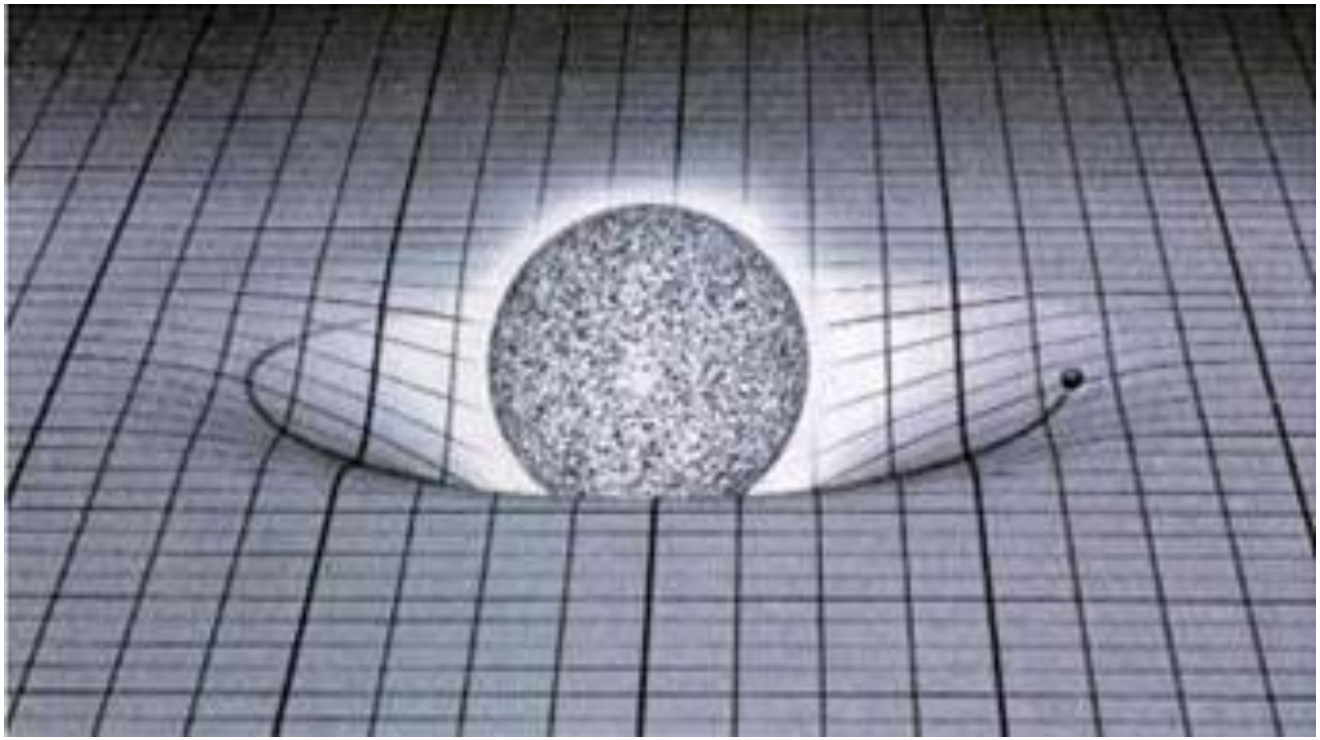


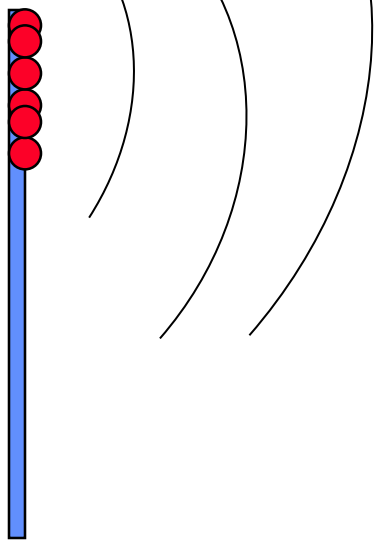
Fig. 3 – Confronto fra una mammografia monocromatica (sinistra) con una tradizionale (destra).

Gravity force`



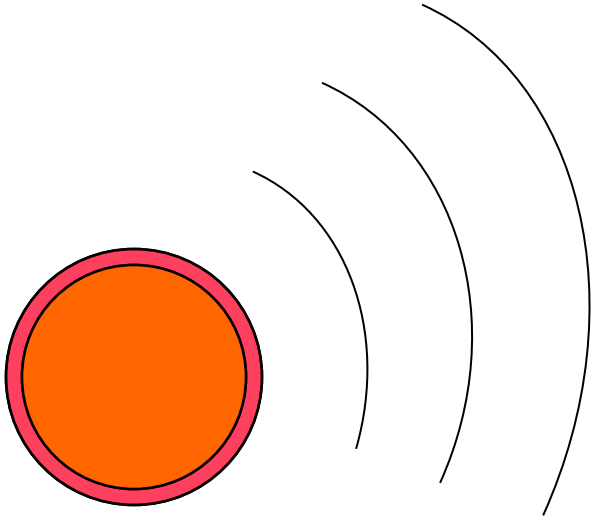
Distortion of space-time

Antenna

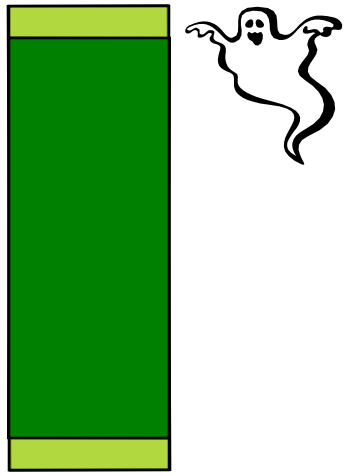


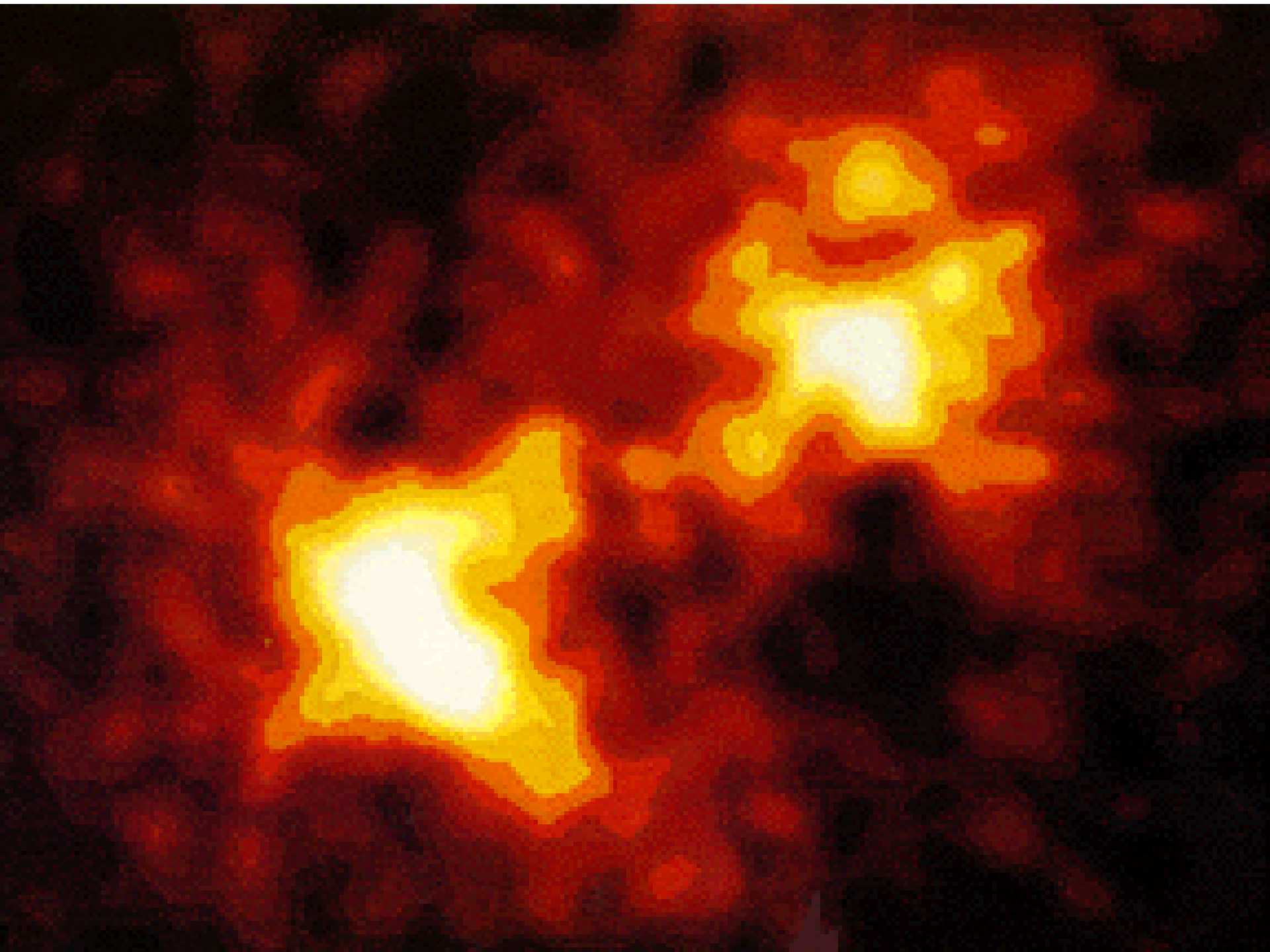
The electromagnetic waves are produced by an electric charge in movement

Gravitational waves: an analogy

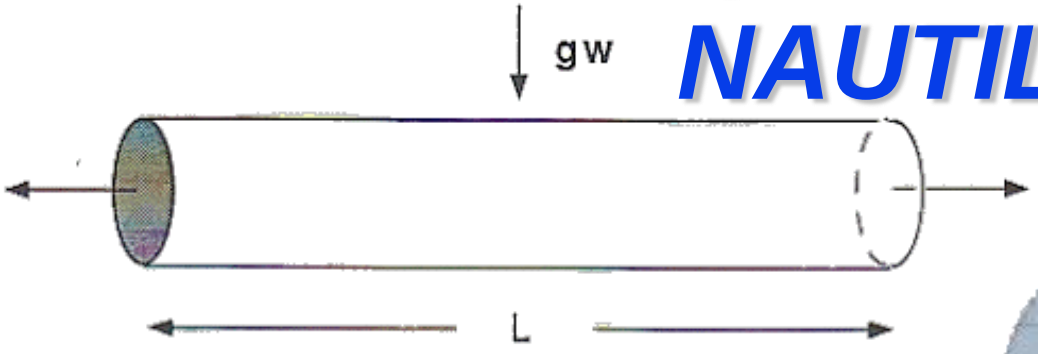


Gravitational waves are produced by masses in movement….





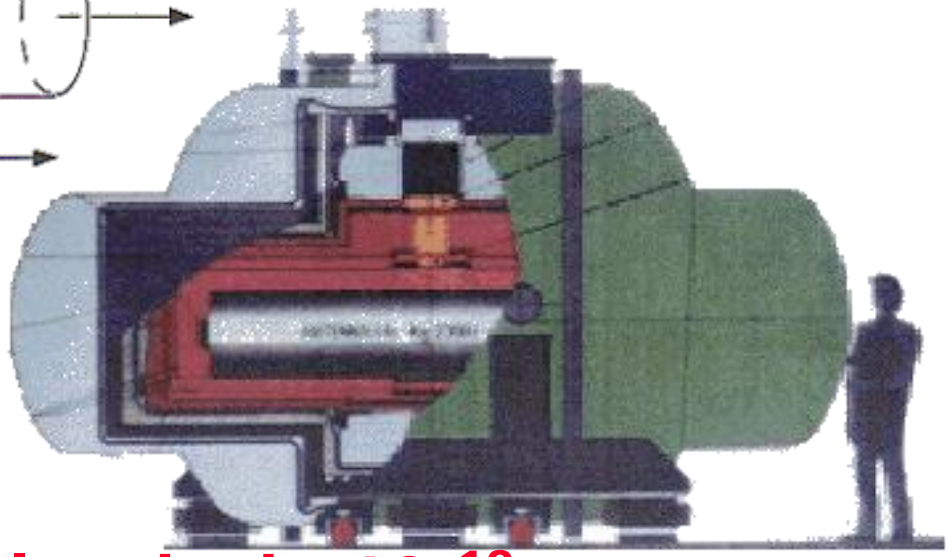
Search for gravitational waves: NAUTILUS



vibrations in the bar

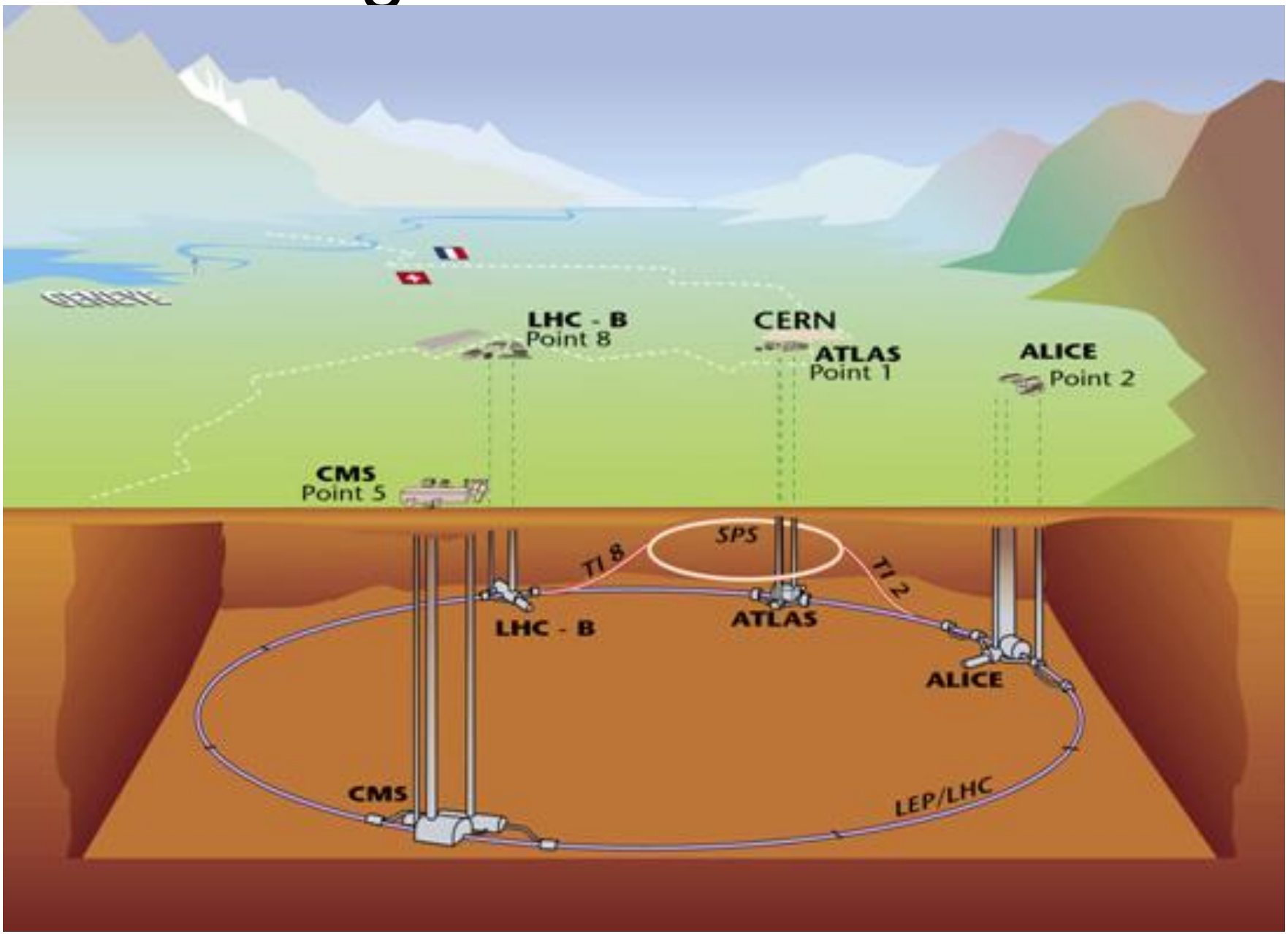
(for Al, L=3 m, f=915 Hz)

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



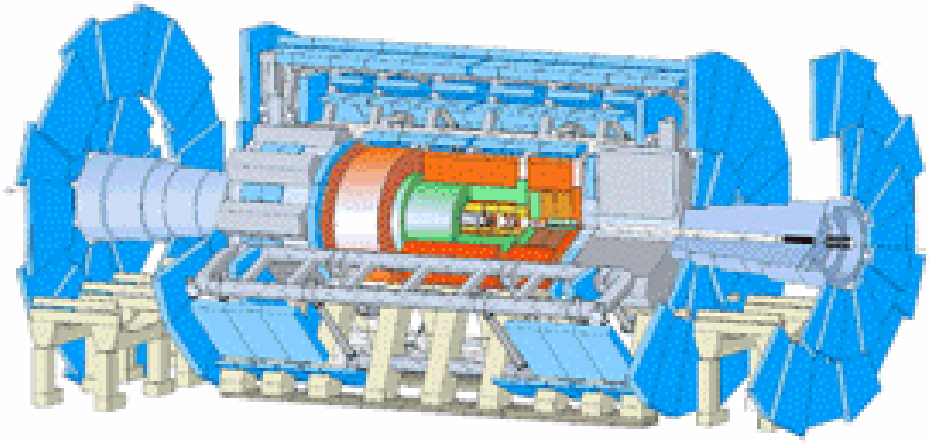
- **Supernova in our Galassia $h=10^{-18}$**
- **Supernova in Virgo $h=10^{-21}$**
- **Thermal noise @ T=300 K, $\Delta L=10^{-16}$ m**
- **Thermal noise @ T=3 K, $\Delta L=10^{-17}$ m**
- **Thermal noise @ T=300 mK → $\Delta L=10^{-18}$ m**

Large Hadron Collider

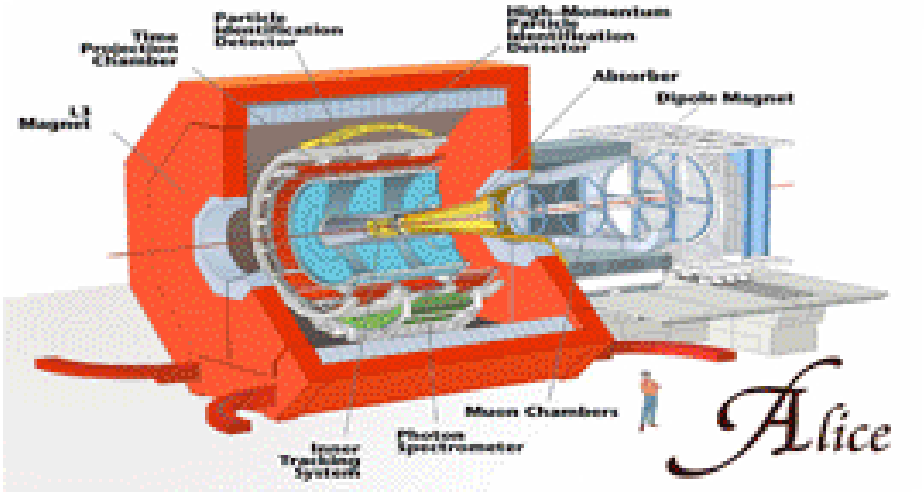


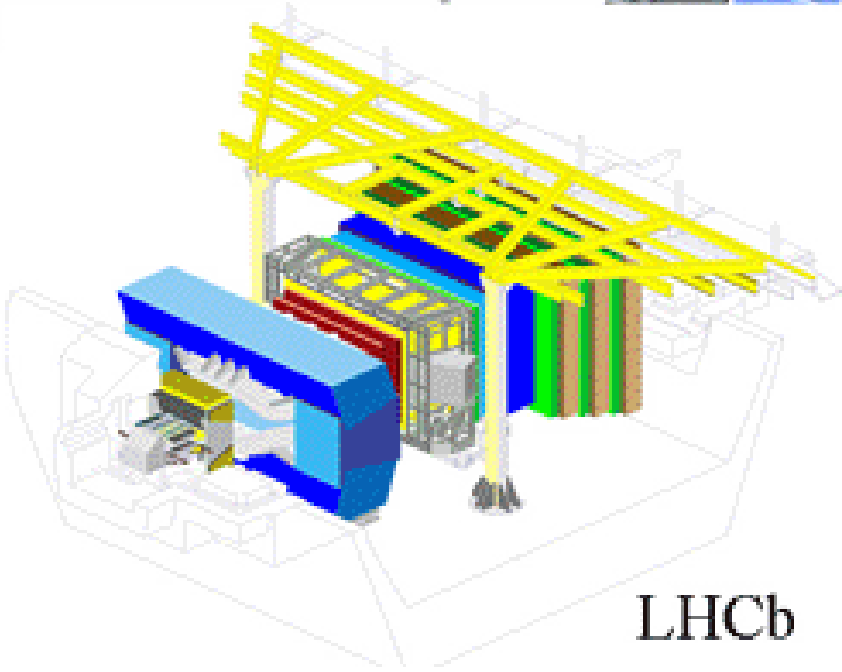
Large Hadron Collider

ATLAS



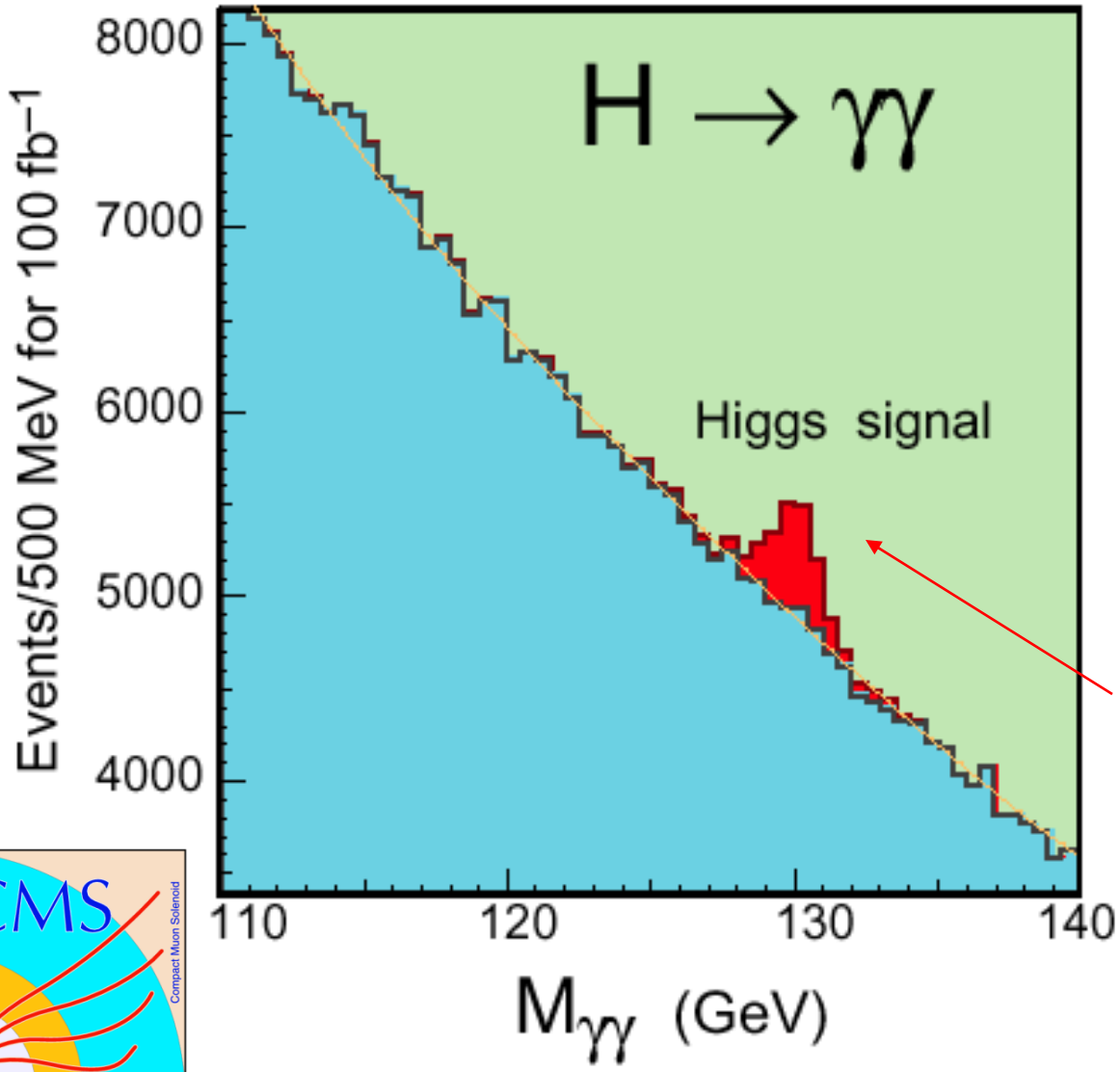
CMS



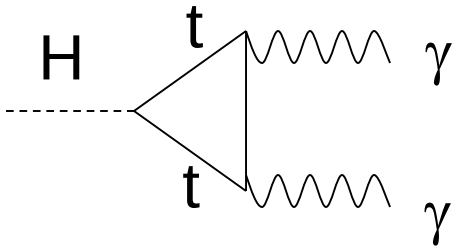


LHCb

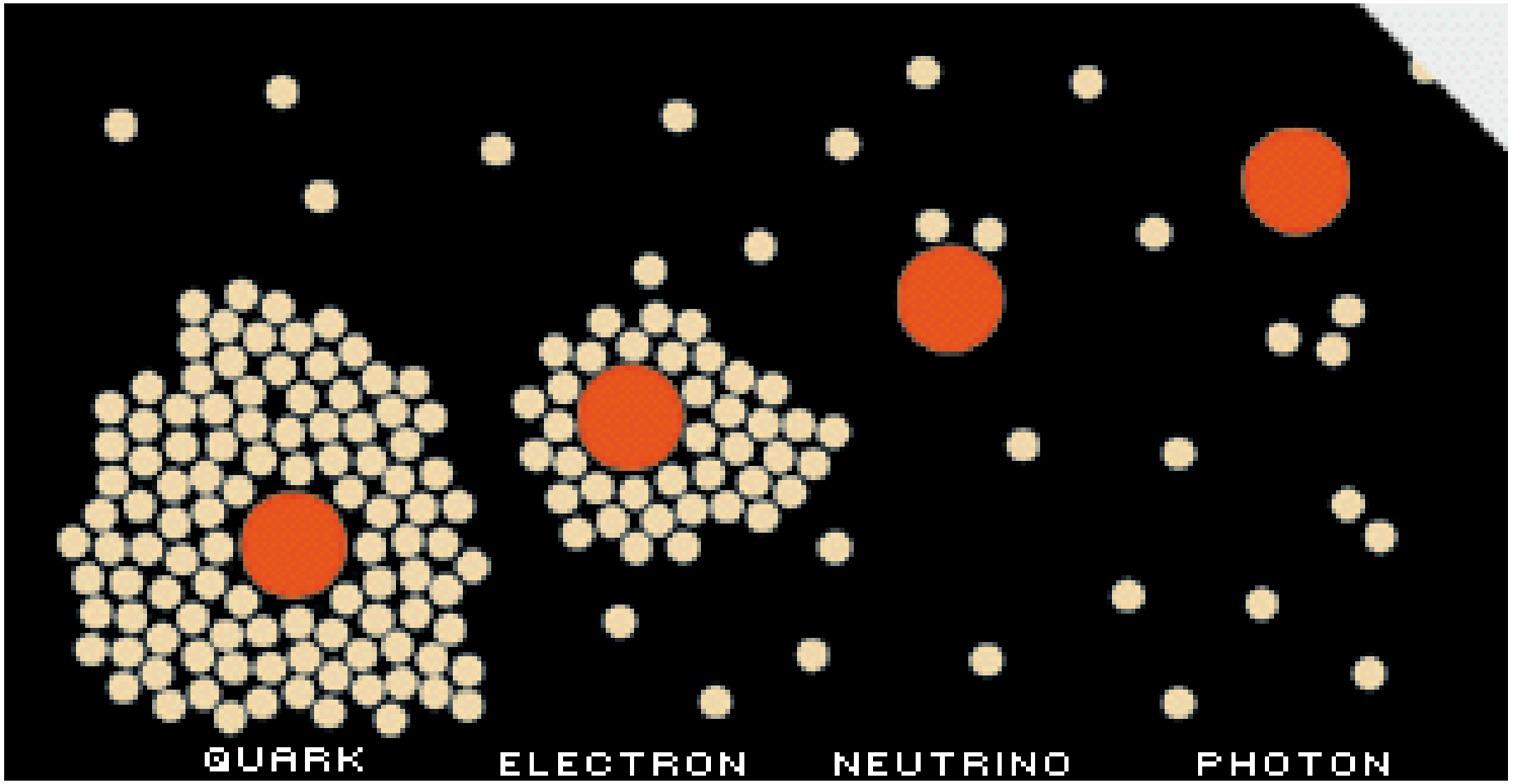
Higgs Decay to Photons



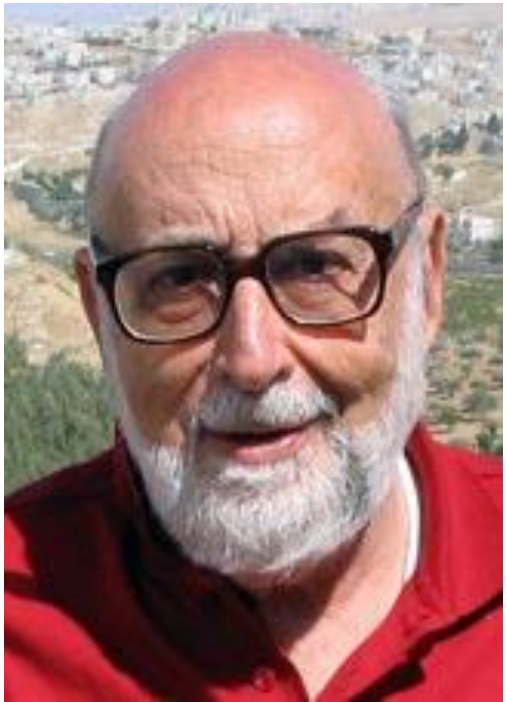
Rare decay in SM

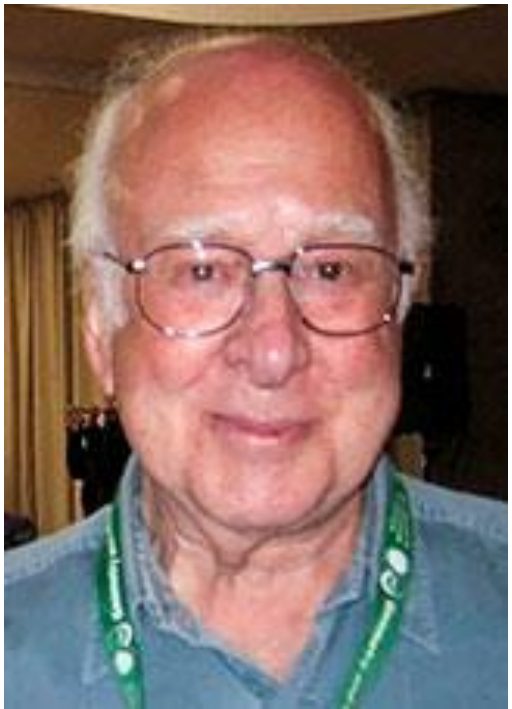


LHC detectors have been optimized to find this peak!

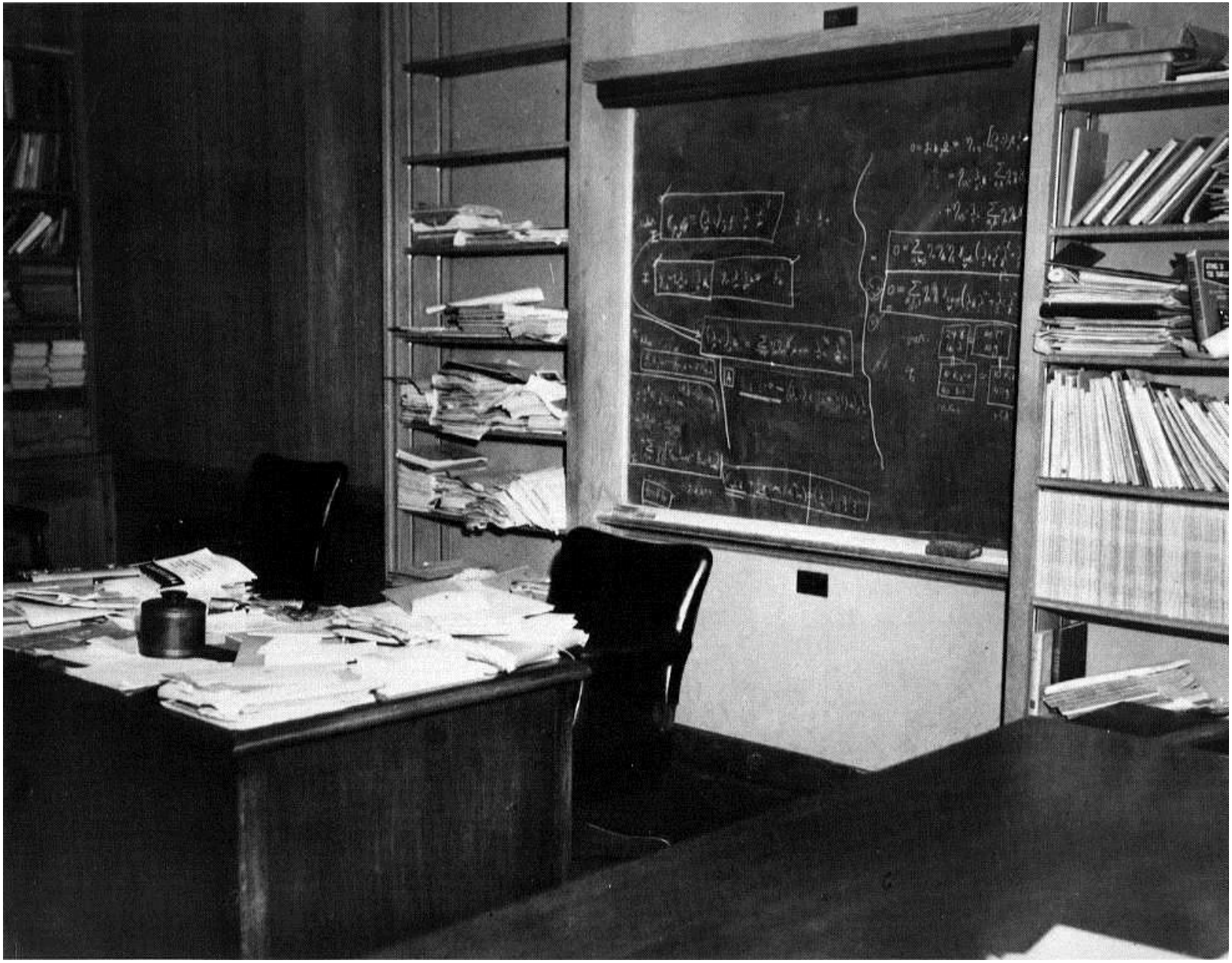

QUARK
ELECTRON
NEUTRINO
PHOTON

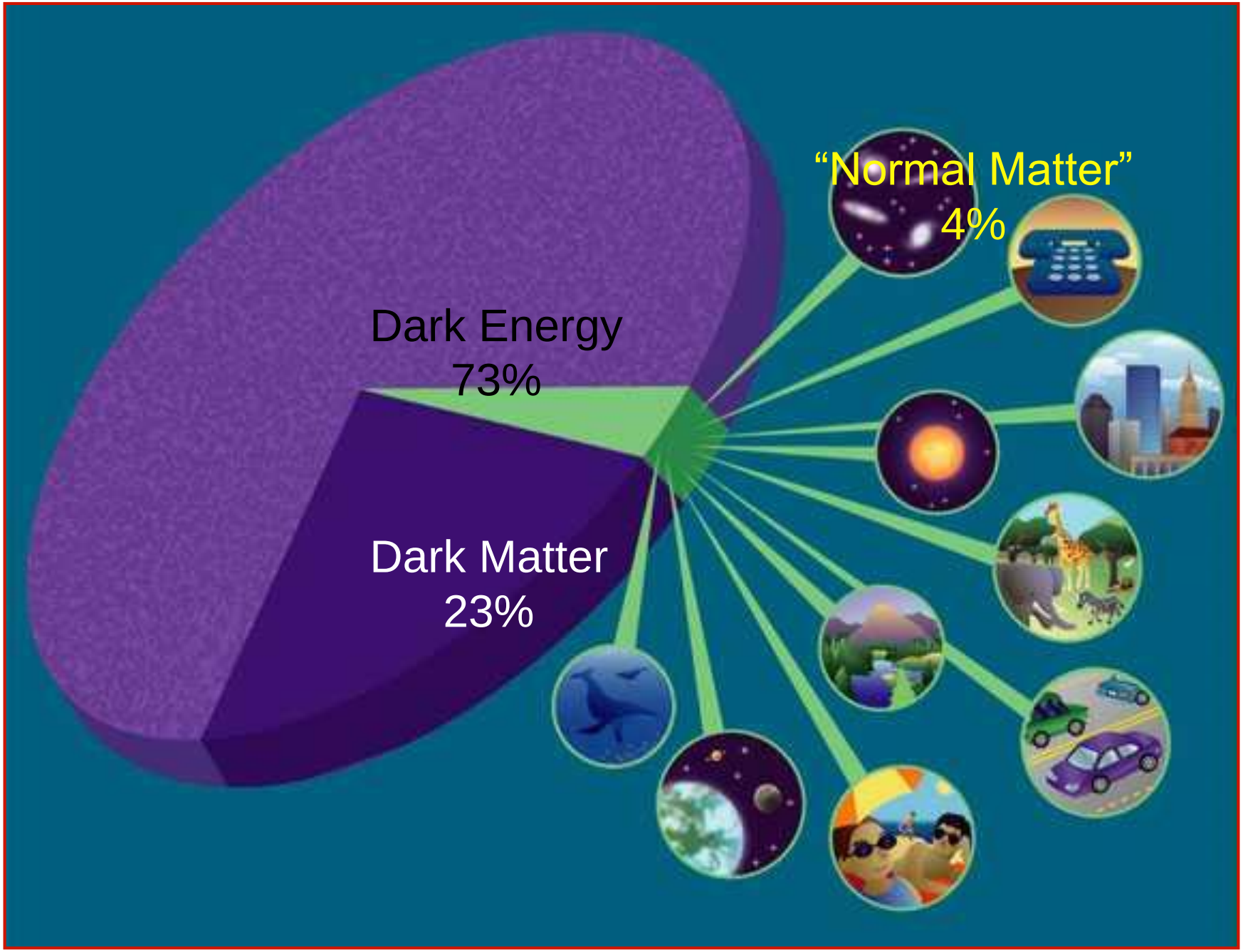
The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"* – *Francois Englert, Peter Higgs*





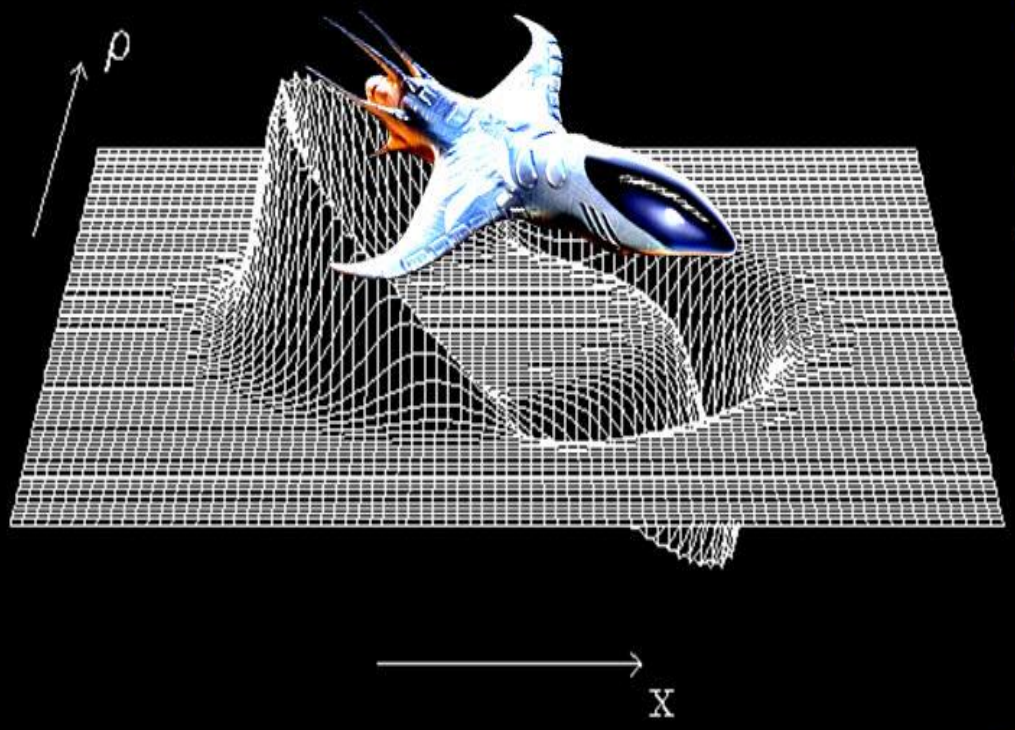
Einstein – last black-board




“Normal Matter”
4%
Dark Energy
73%
Dark Matter
23%

Alcubierre Warp Drive

$$\vartheta = -\alpha \ \mathrm{Tr}(\mathrm{K})$$

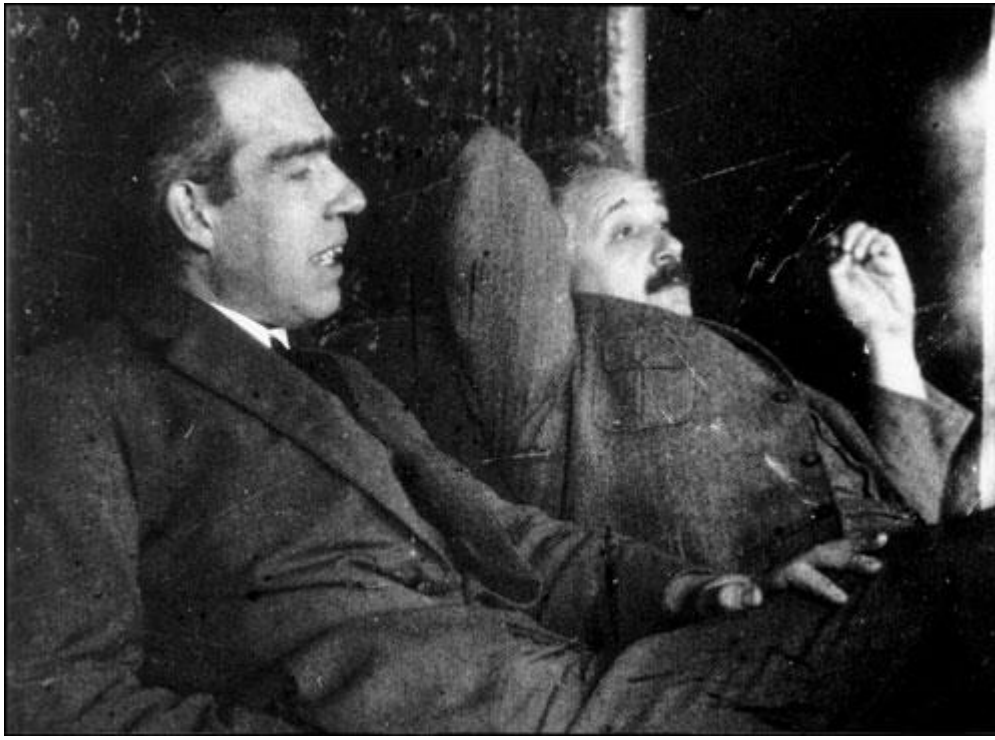


Alcubierre Warp Drive: stretches spacetime in a wave causing the fabric of space ahead of a spacecraft to contract and the space behind it to expand.

The ship can ride the wave to accelerate to high speeds and time travel.

Einstein quotes

There are two ways to live: you can live as if nothing is a miracle; you can live as if everything is a miracle.



TRY NOT TO BECOME A MAN OF SUCCESS, BUT RATHER TRY TO BECOME A MAN OF VALUE.

Laboratori Nazionali di Frascati