

Introduction to Modern Physics and to the LNF-INFN Activities

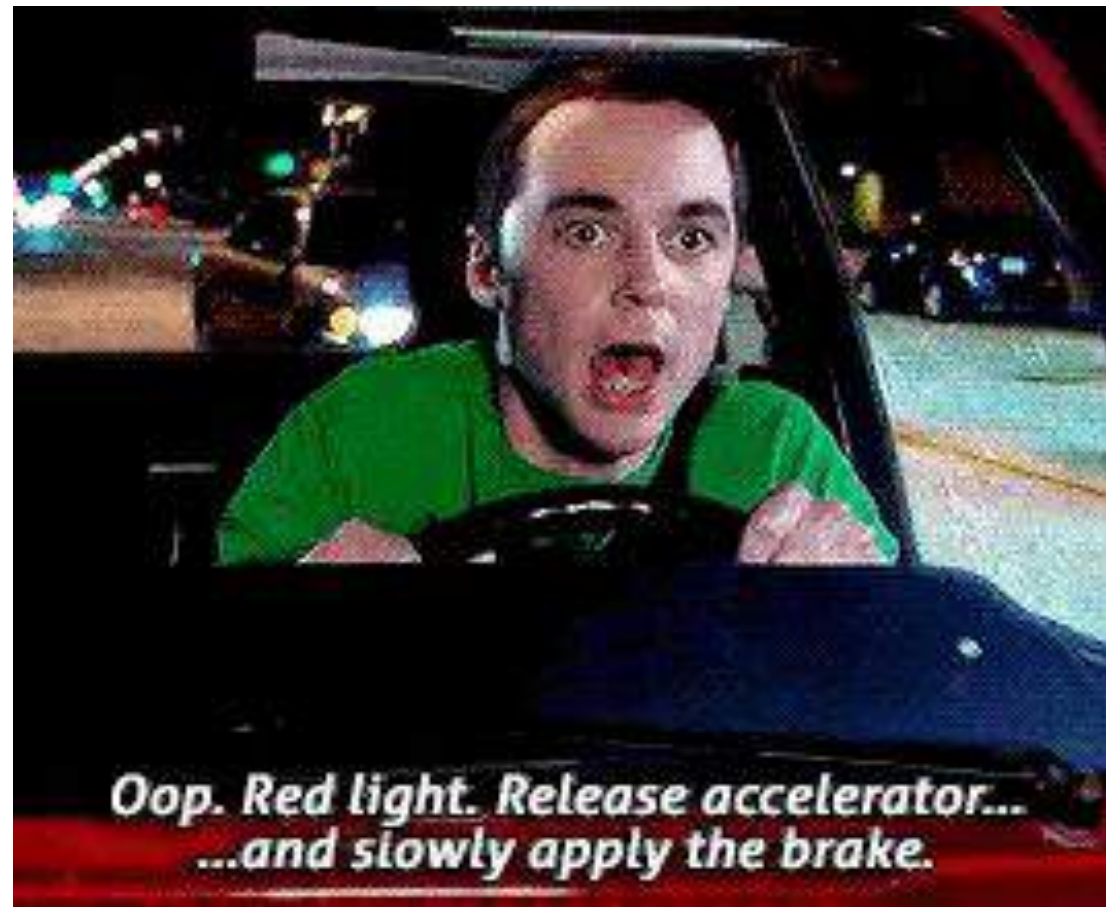


“The MagicLand Of Accelerators”
12-16 February 2018

Catalina Curceanu
LNF-INFN



<http://bit.ly/2nX9Bto>



*Oop. Red light. Release accelerator...
...and slowly apply the brake.*

“The MagicLand Of Accelerators”

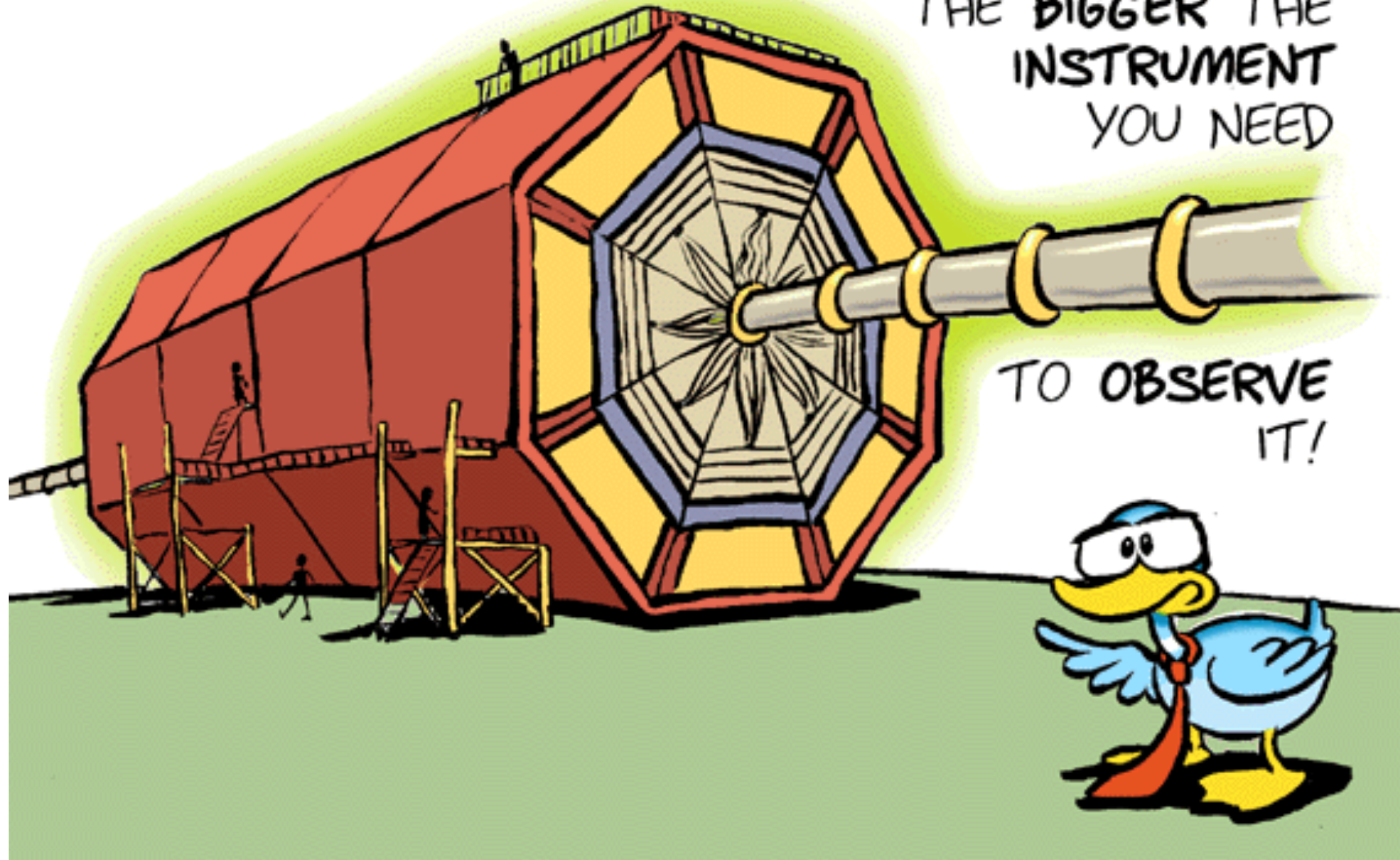




out the tower
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eo used in his

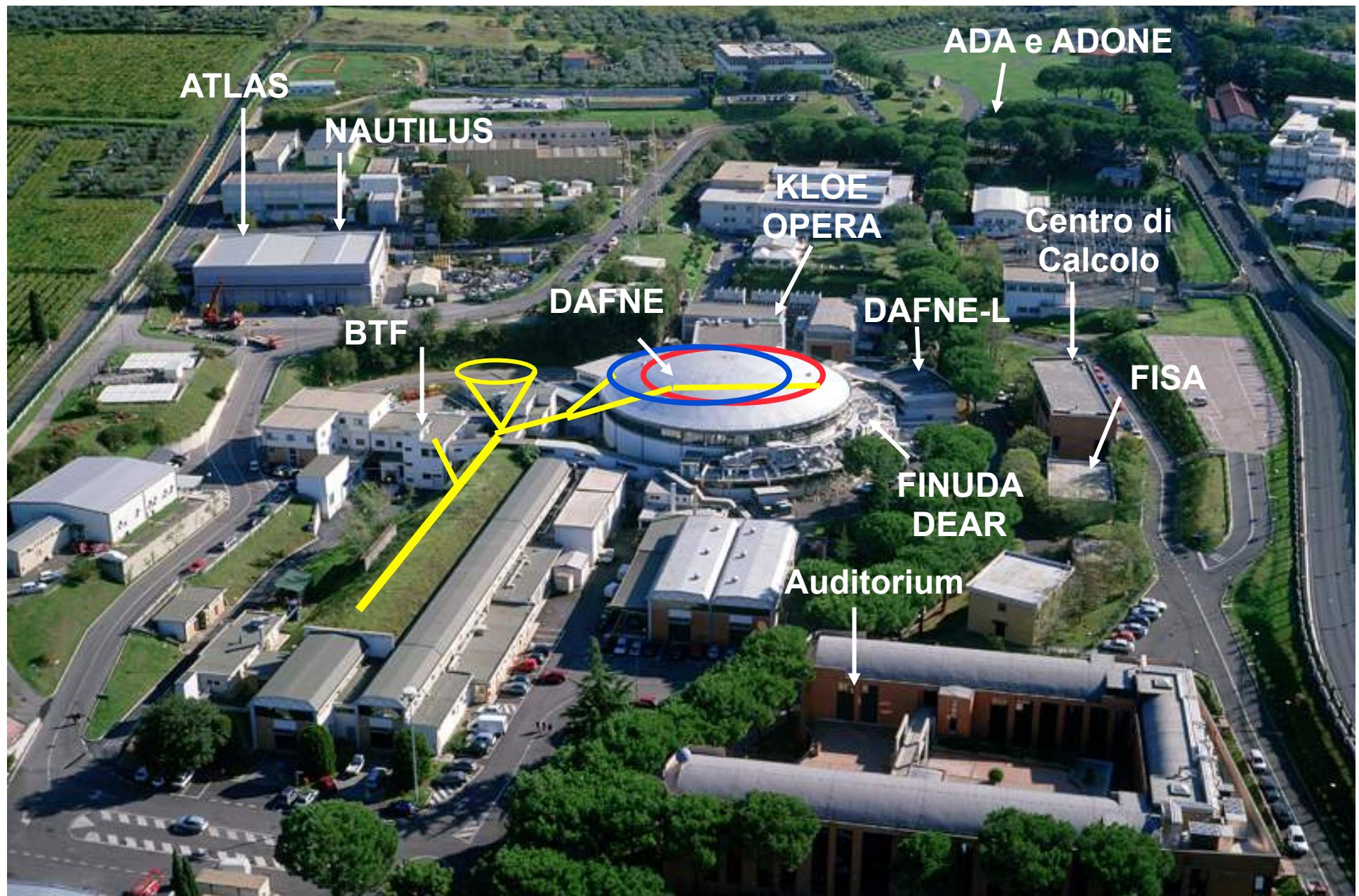
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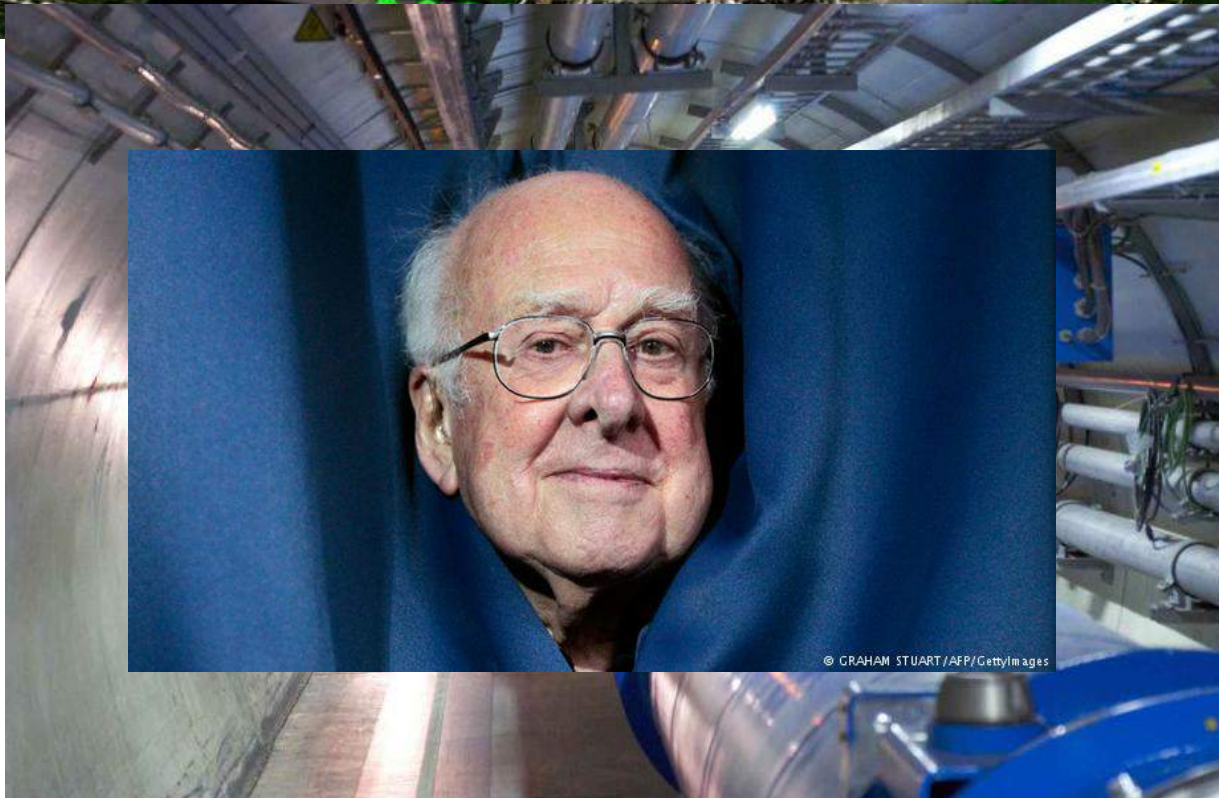
THE **SMALLER** THE THING YOU WANT TO OBSERVE,
THE **BIGGER** THE
INSTRUMENT
YOU NEED



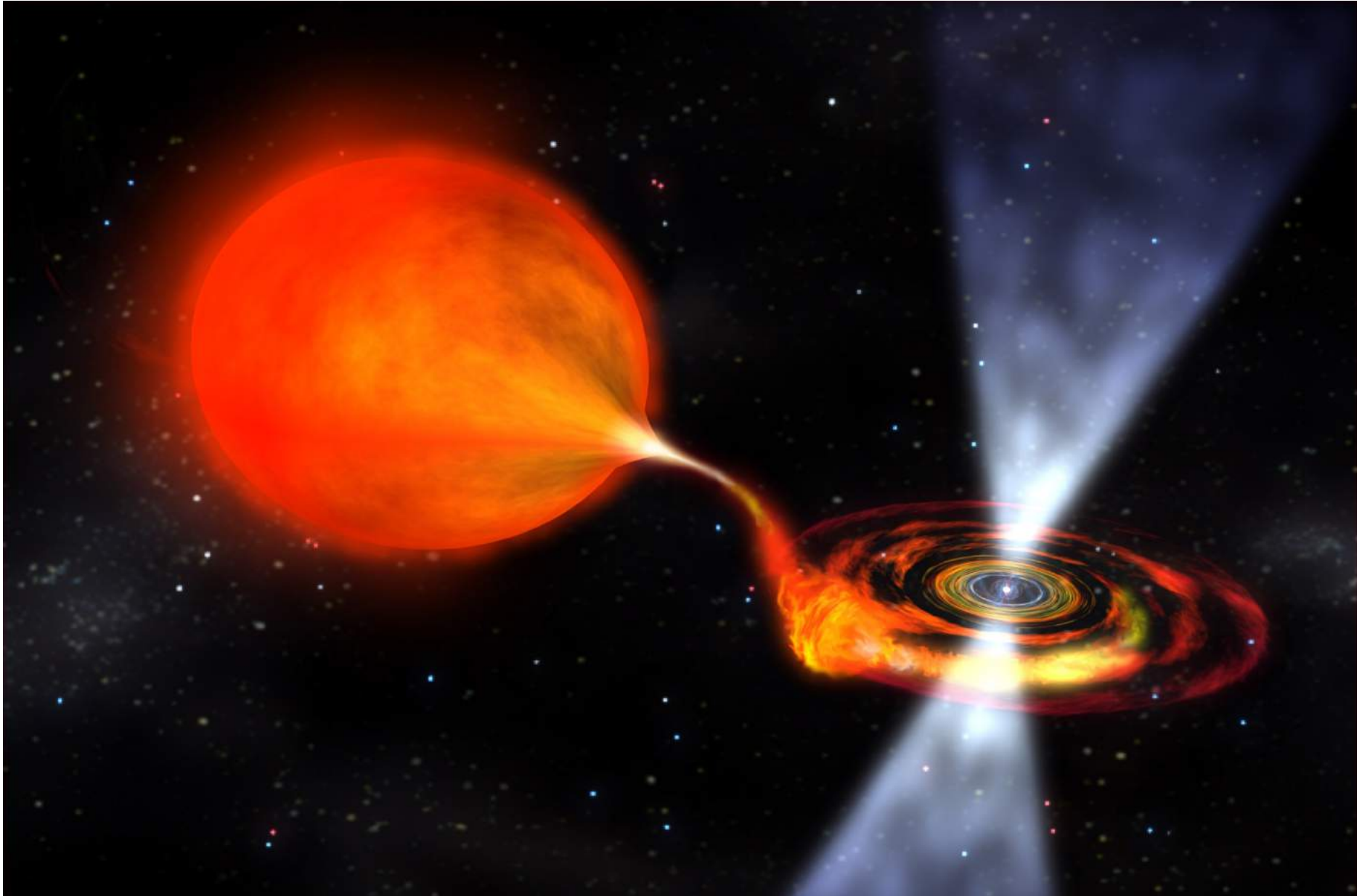
TO OBSERVE
IT!

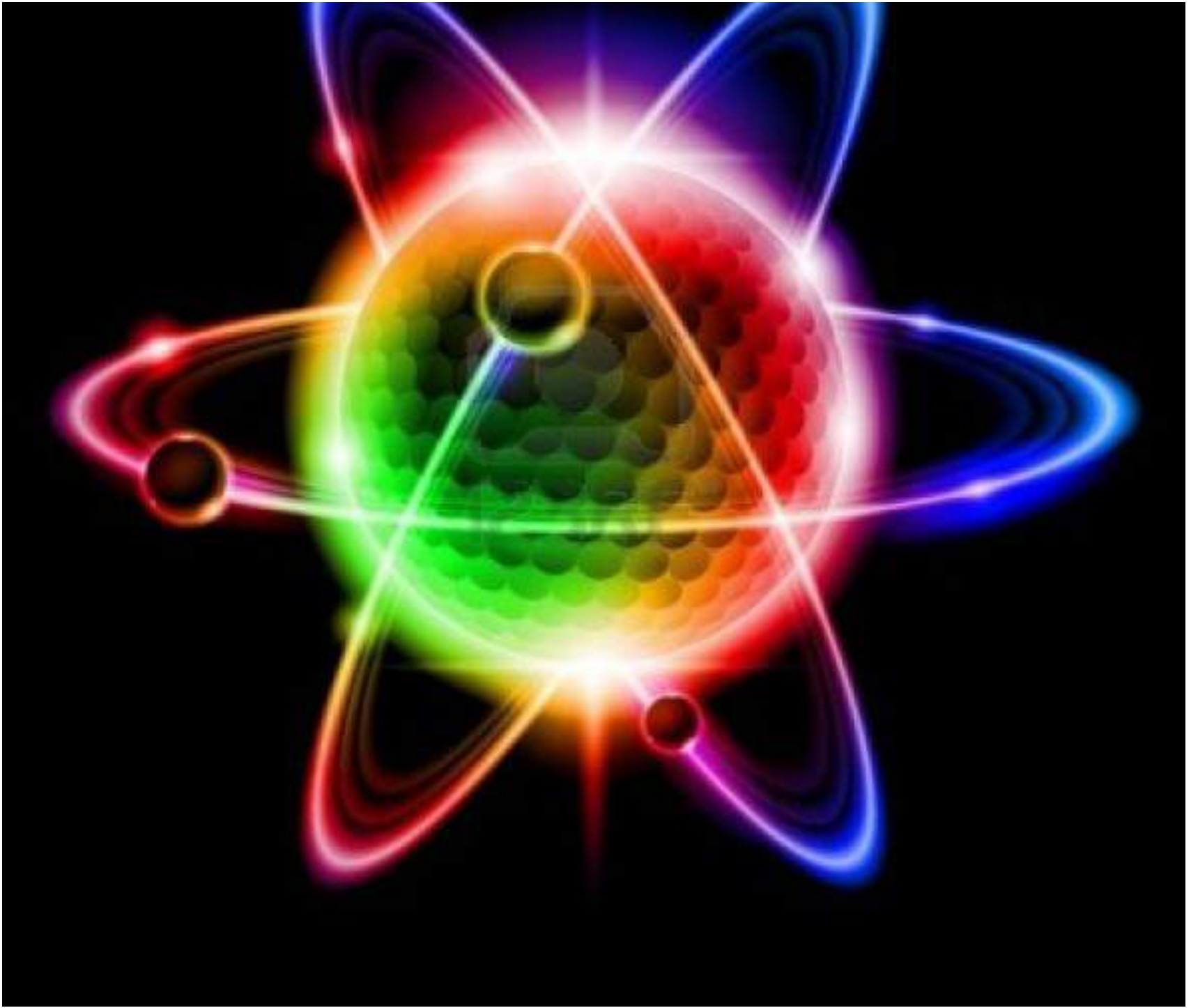
Laboratori Nazionali di Frascati



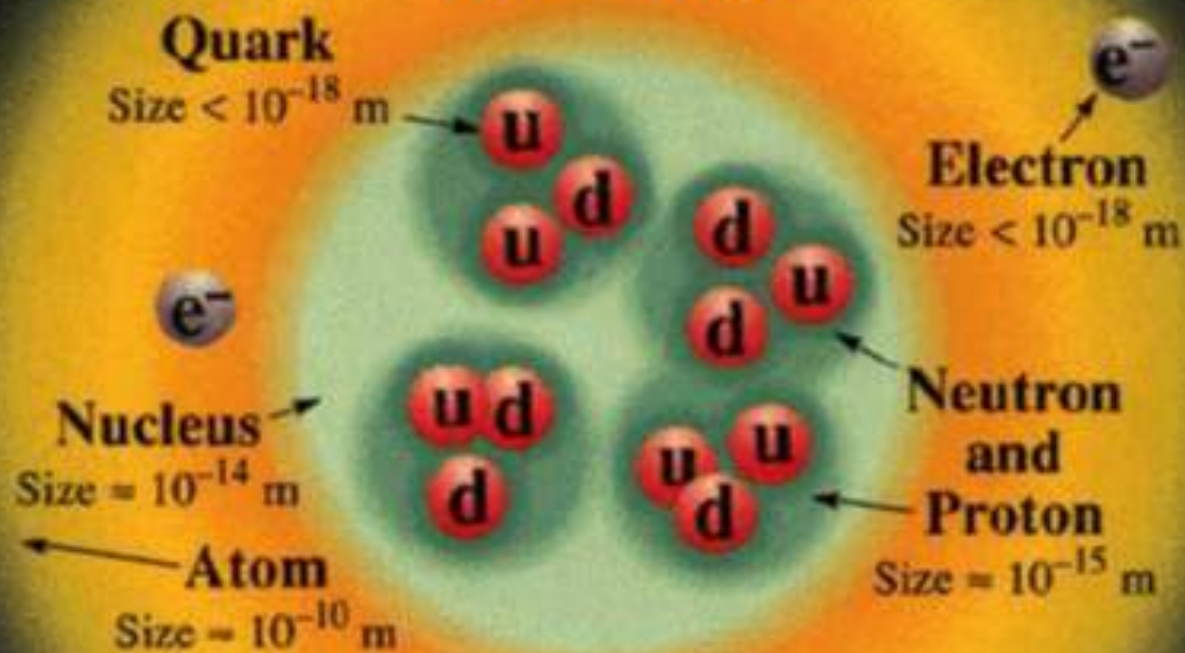


Universe as an accelerator



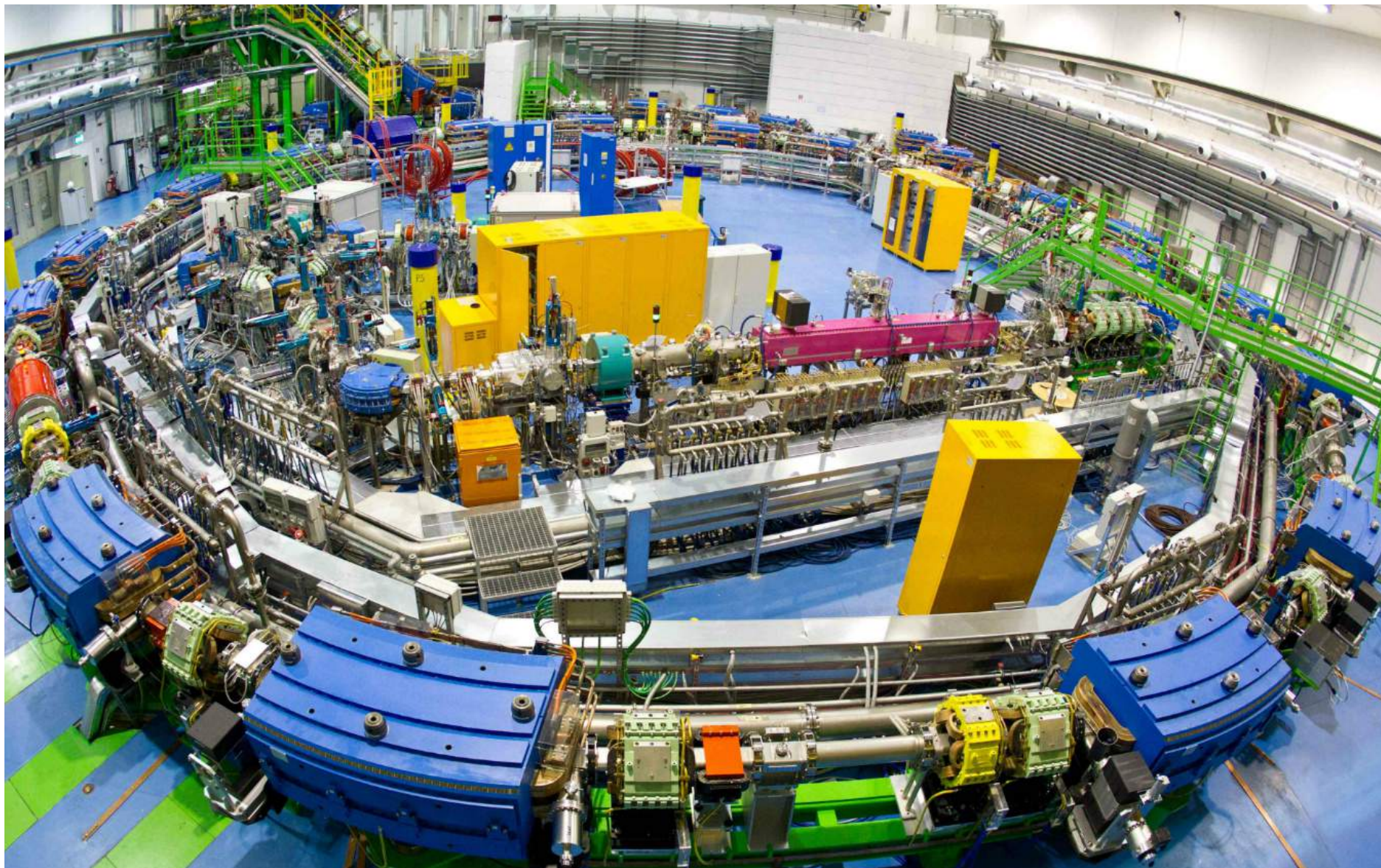


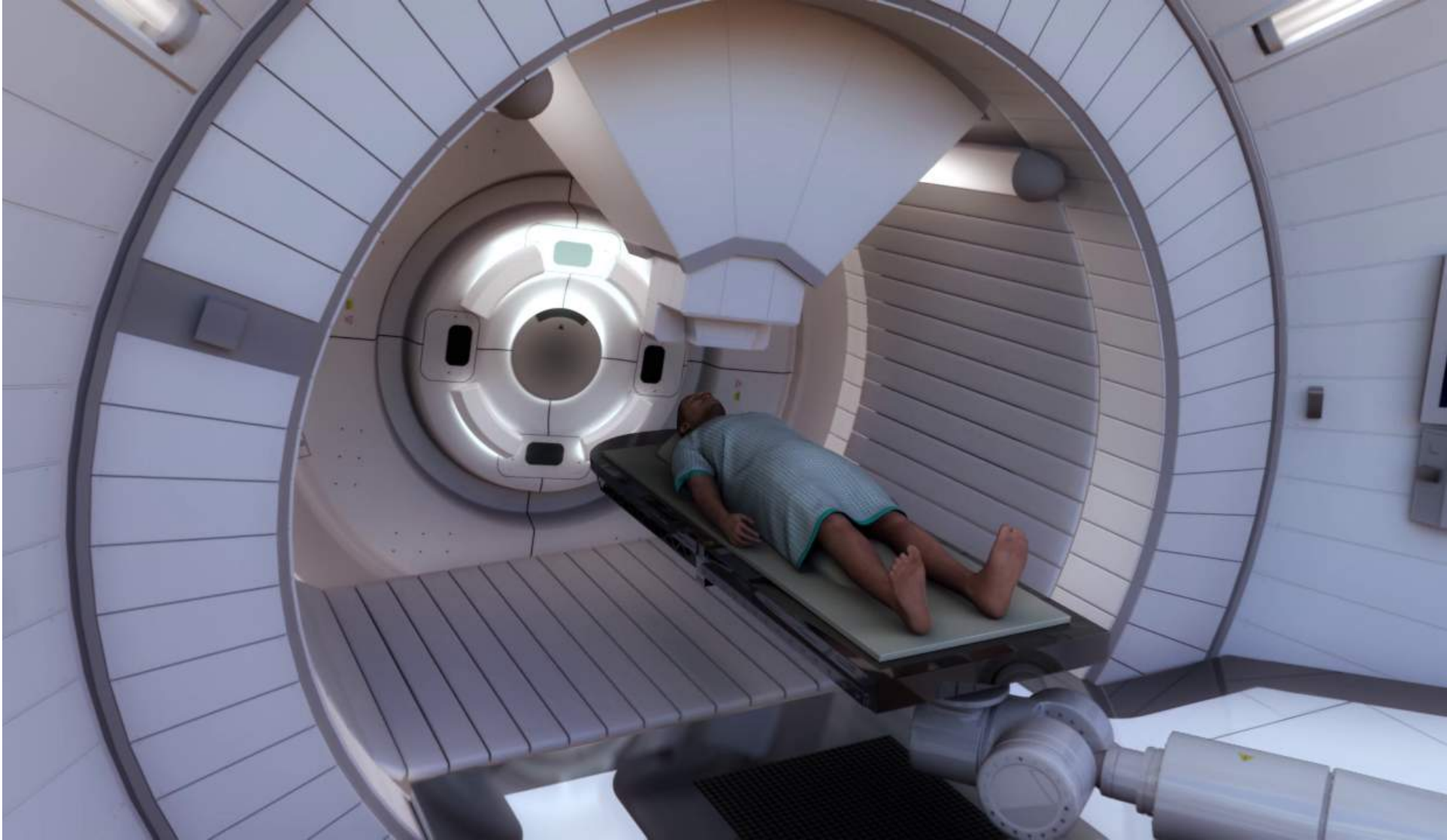
Structure within the Atom



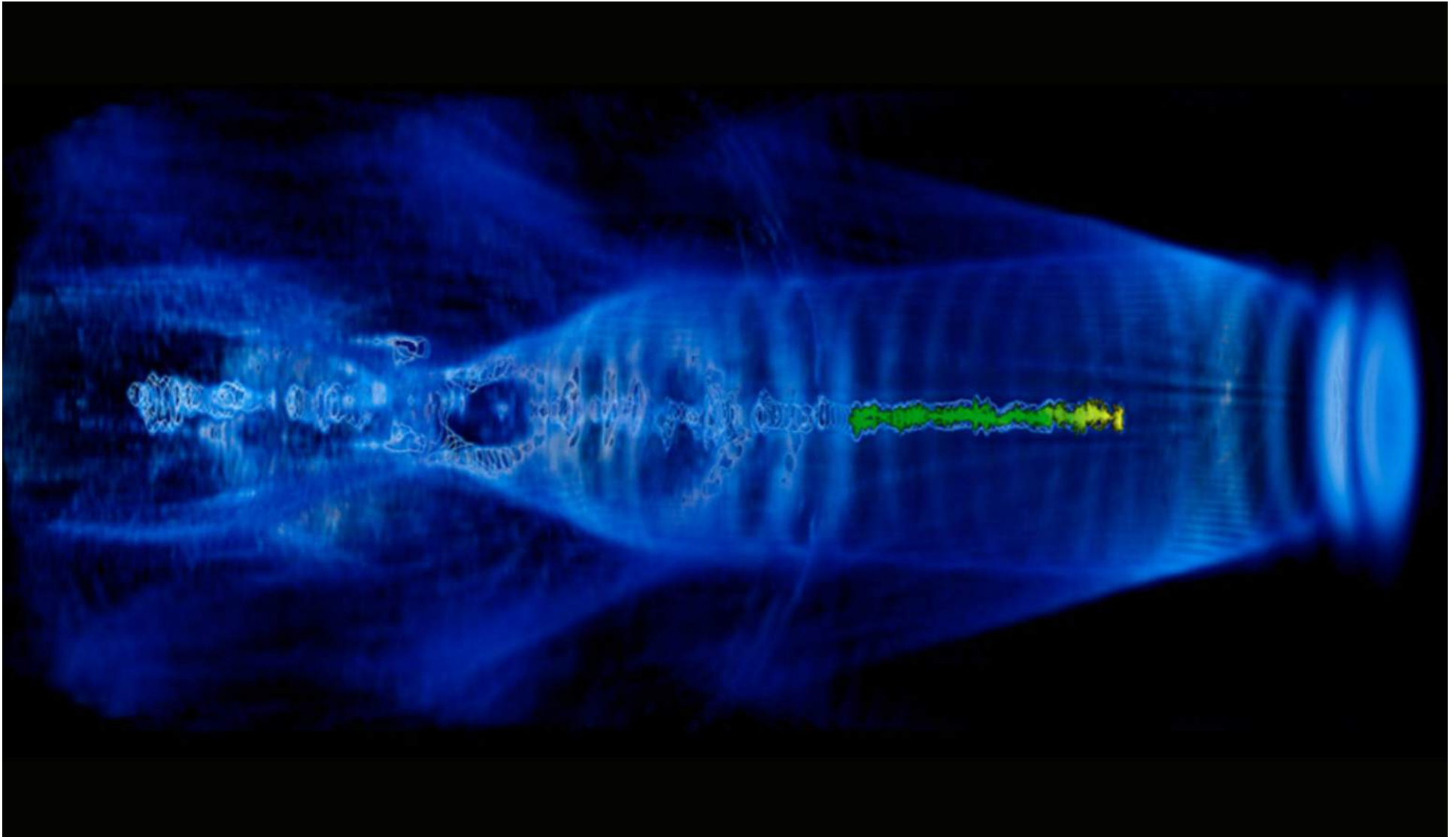
If this picture were drawn to the scale given by the protons and neutrons, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

CNAO

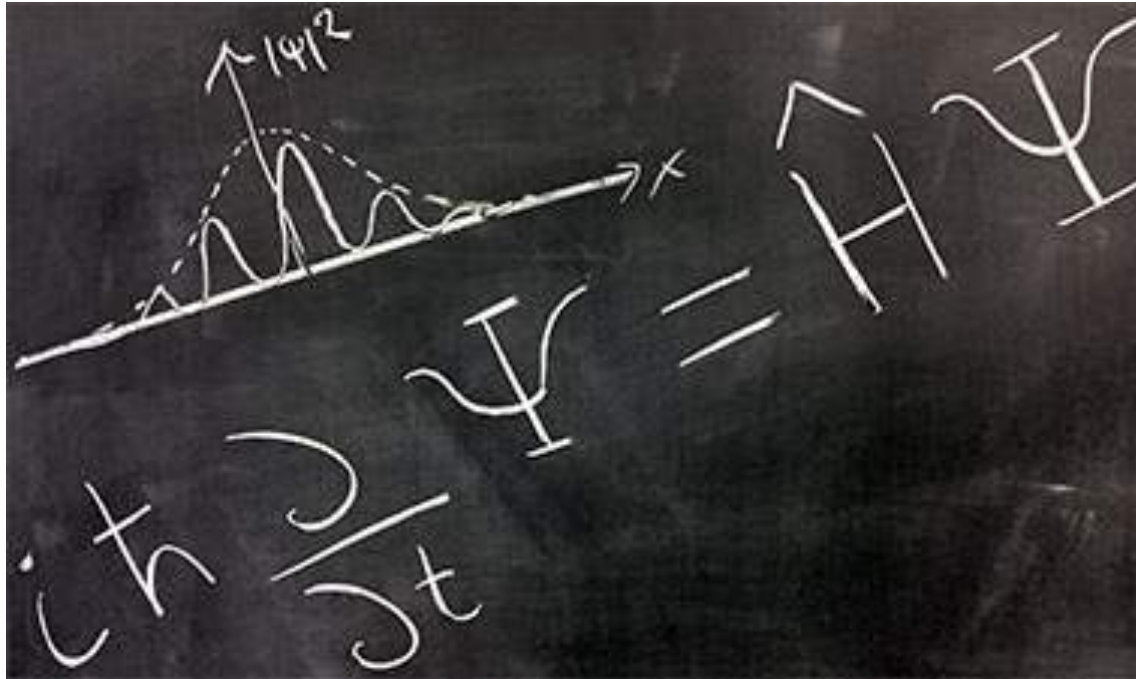




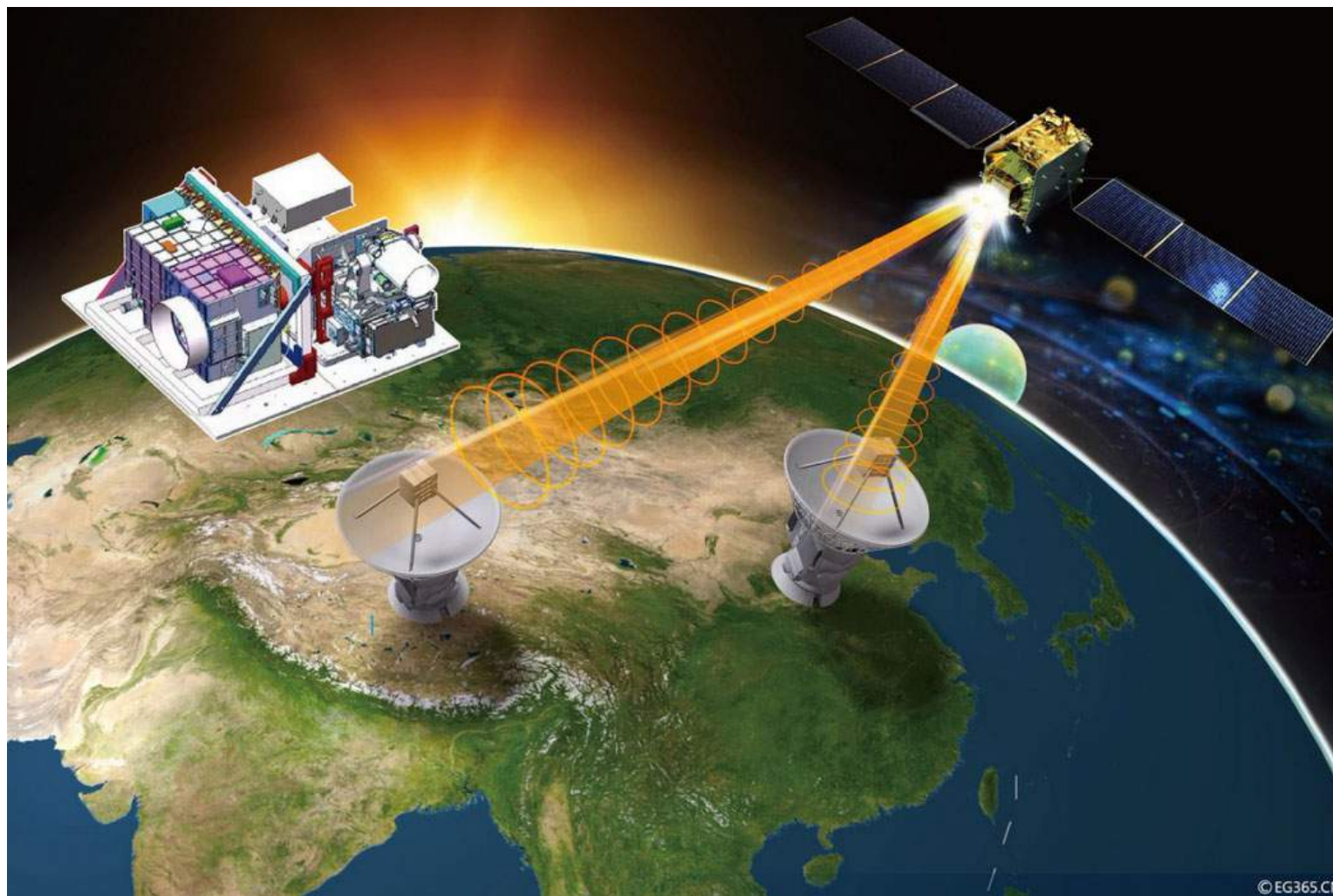
Plasma accelerators – new generation'



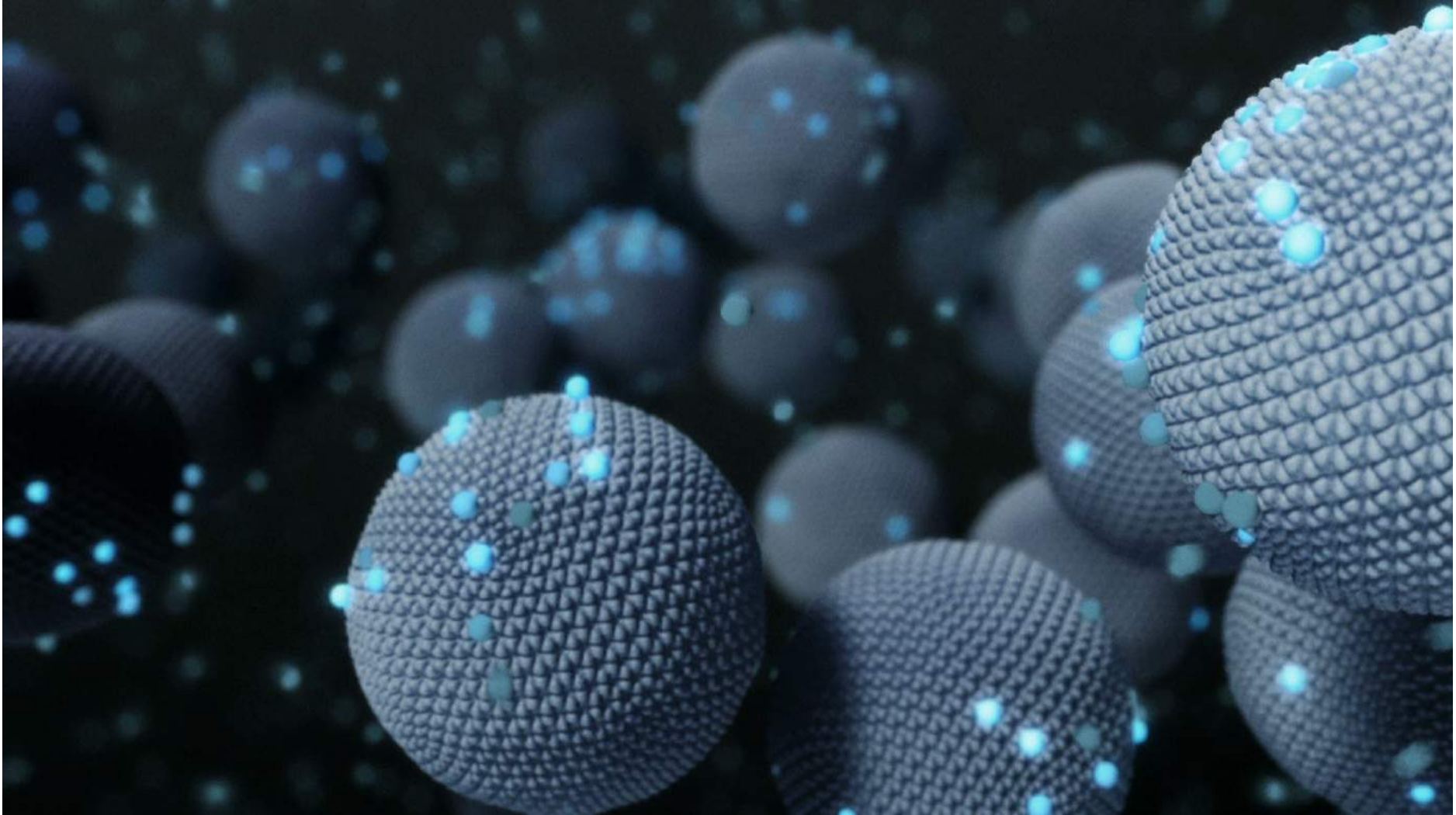
Quantum Mechanics



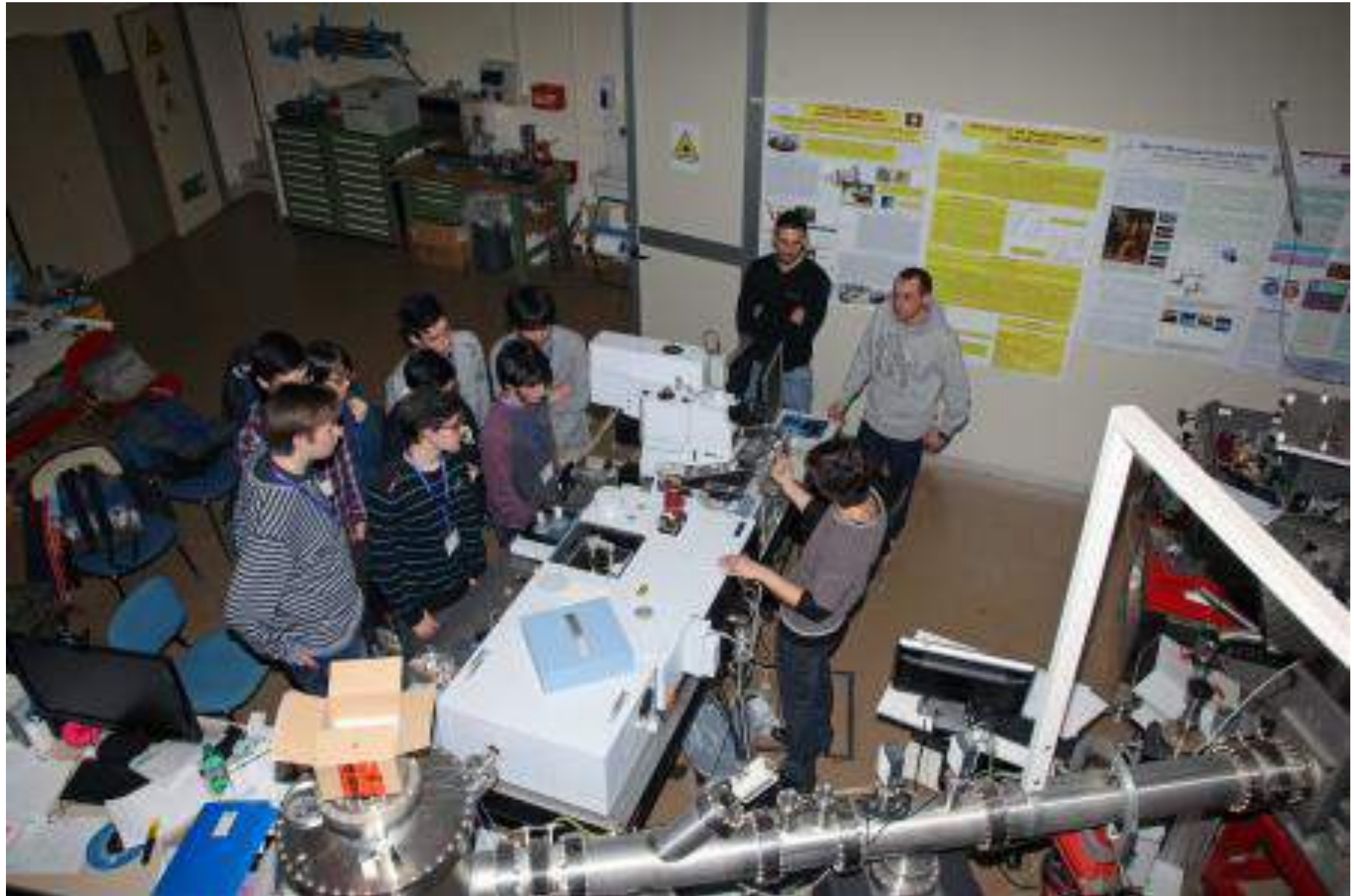
Quantum Technologies in Space COST Action CA15220 e TEQ



Nanotechnologies



Hands-on



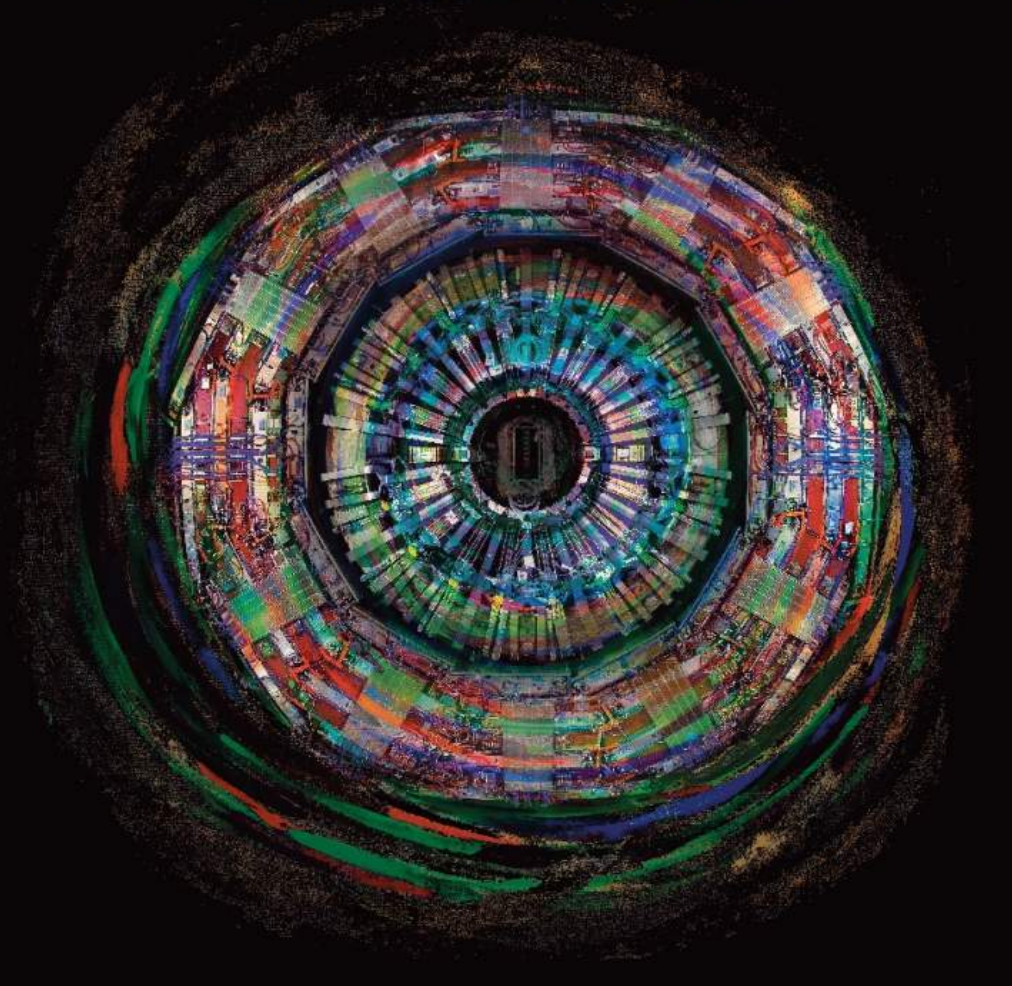


AMKA FILMS in coproduction with RSI - SRG SSR and AMEUROPA INTERNATIONAL with RAI CINEMA present

A FILM BY VALERIO JALONGO

THE SENSE OF BEAUTY

ART AND SCIENCE AT CERN



"WHAT IS ESSENTIAL IS INVISIBLE TO THE EYE"

AMKA FILMS - RSI - SRG SSR - AMEUROPA INTERNATIONAL - RAI CINEMA - VALERIO JALONGO - THE SENSE OF BEAUTY - ART AND SCIENCE AT CERN - 2017



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



Legnaro

Gran Sasso



19 Sections
11 Related Groups
4 National Laboratories



VIRGO-EGO
European Gravitational Observatory



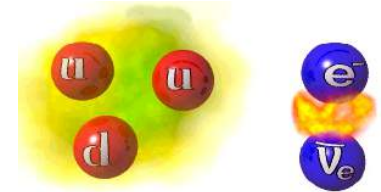
Laboratori del Sud (Catania)



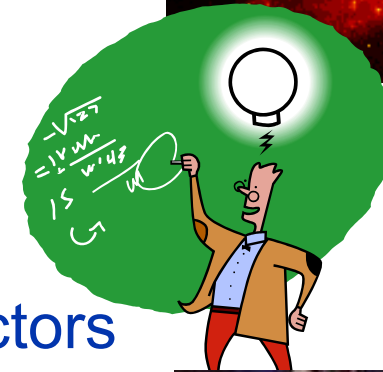
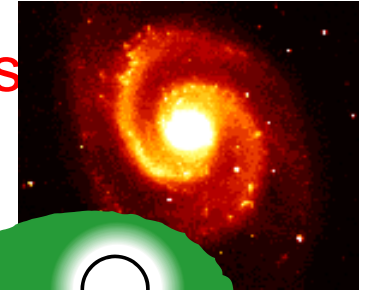
What are the activities performed at Laboratori Nazionali di Frascati?



Fundamental research



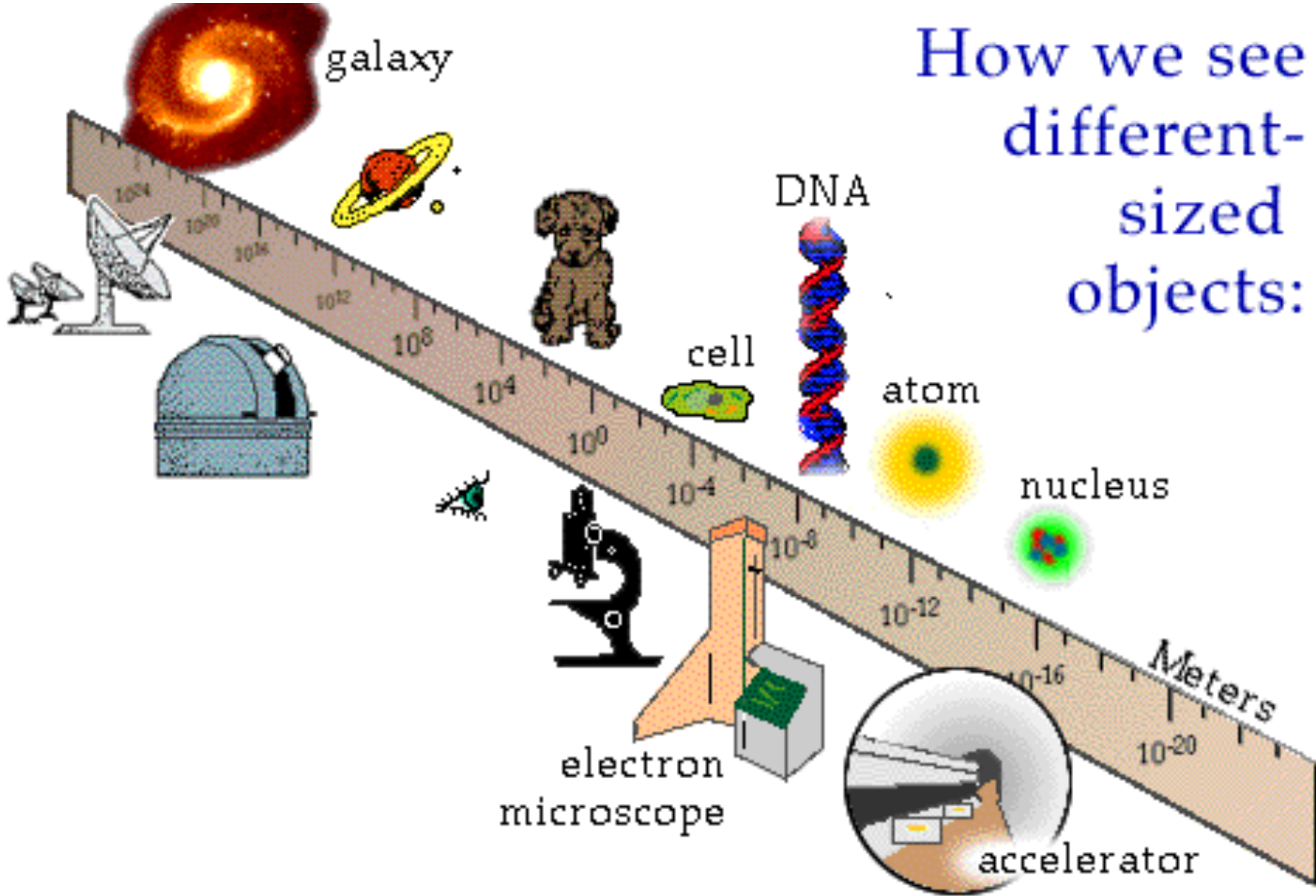
- Studies of the **ultimate matter structure**
- Search for **gravitational waves**
- Developments of **theoretical models**



- 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**



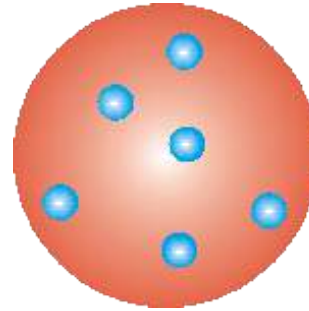
How we see different-sized objects:



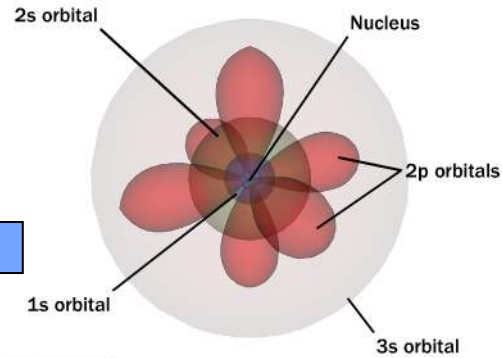
The atom in the beginning of '900



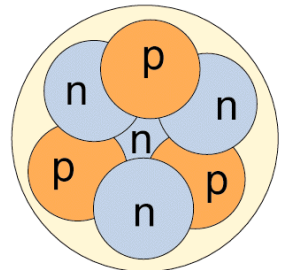
The Thompson's atom



Quantum mechanics - atom

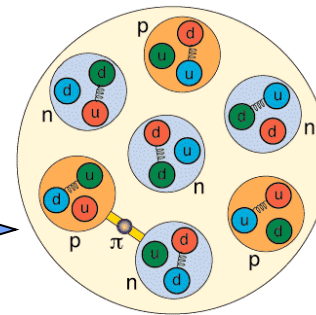


Rutherford e Bohr - atom



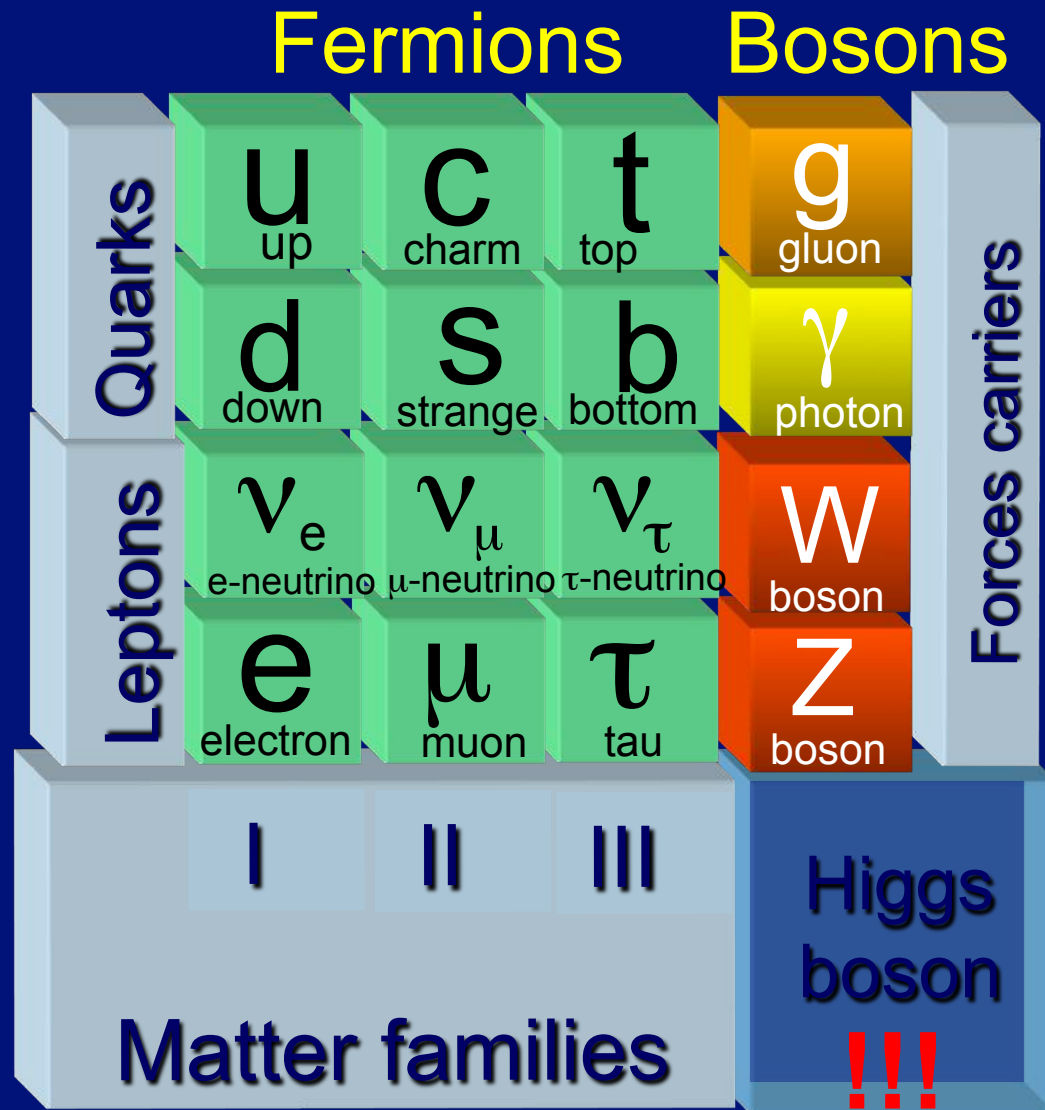
1.6 fm
4.8 fm

The nucleus structure




The nucleus today

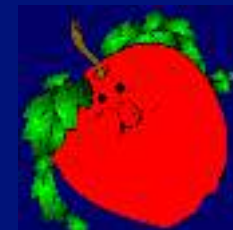
The Standard Model



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	<i>Italian</i> 346		<i>Foreign</i> 200	
Visitors 3960	Stages 310	Conference Workshops 17	Participants to Conf. / Work. 776	Master Courses 1 (27 positions)

LNF

DAFNE-light

LINAC

DAFNE

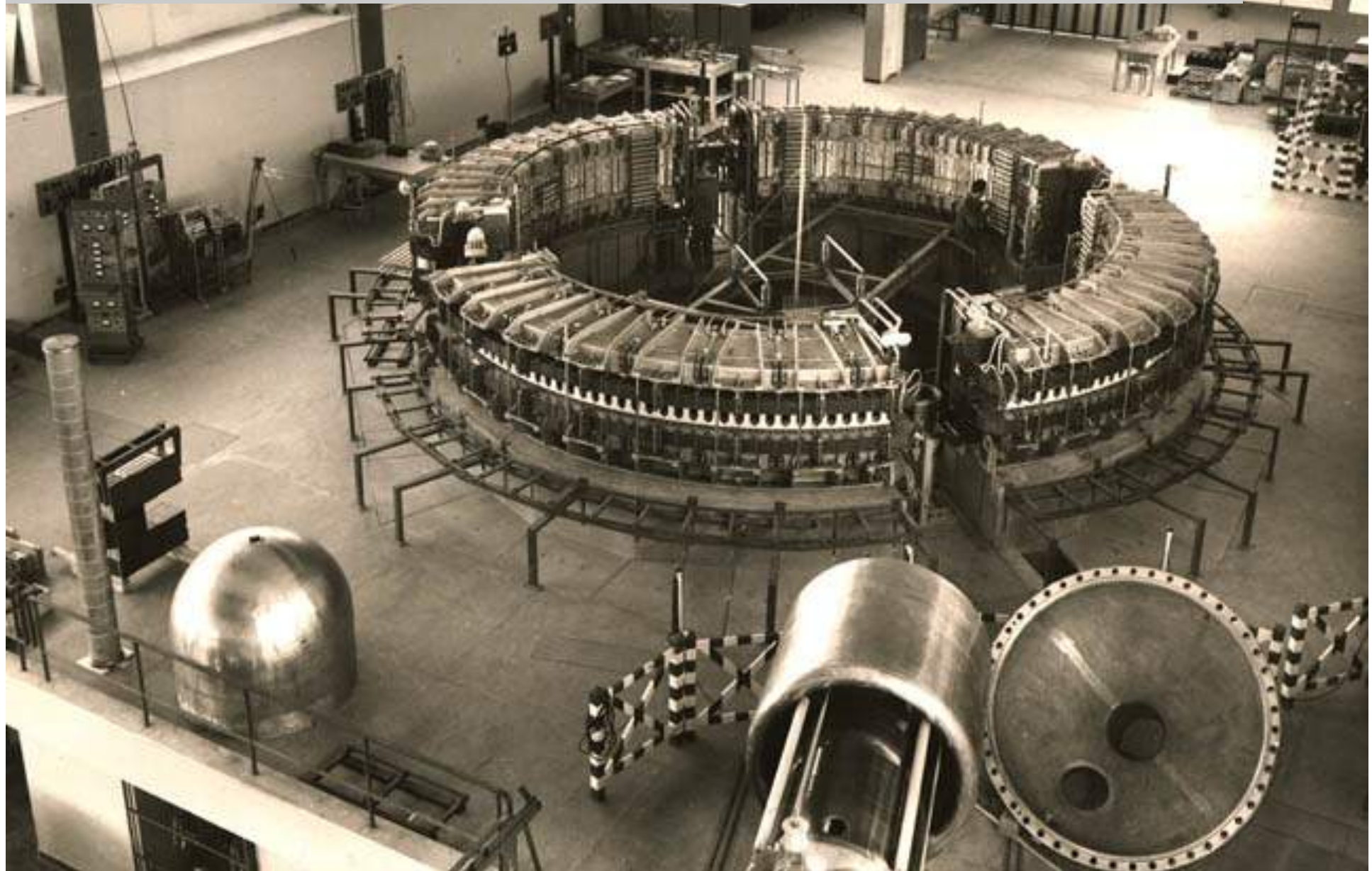
BTF

SPARC

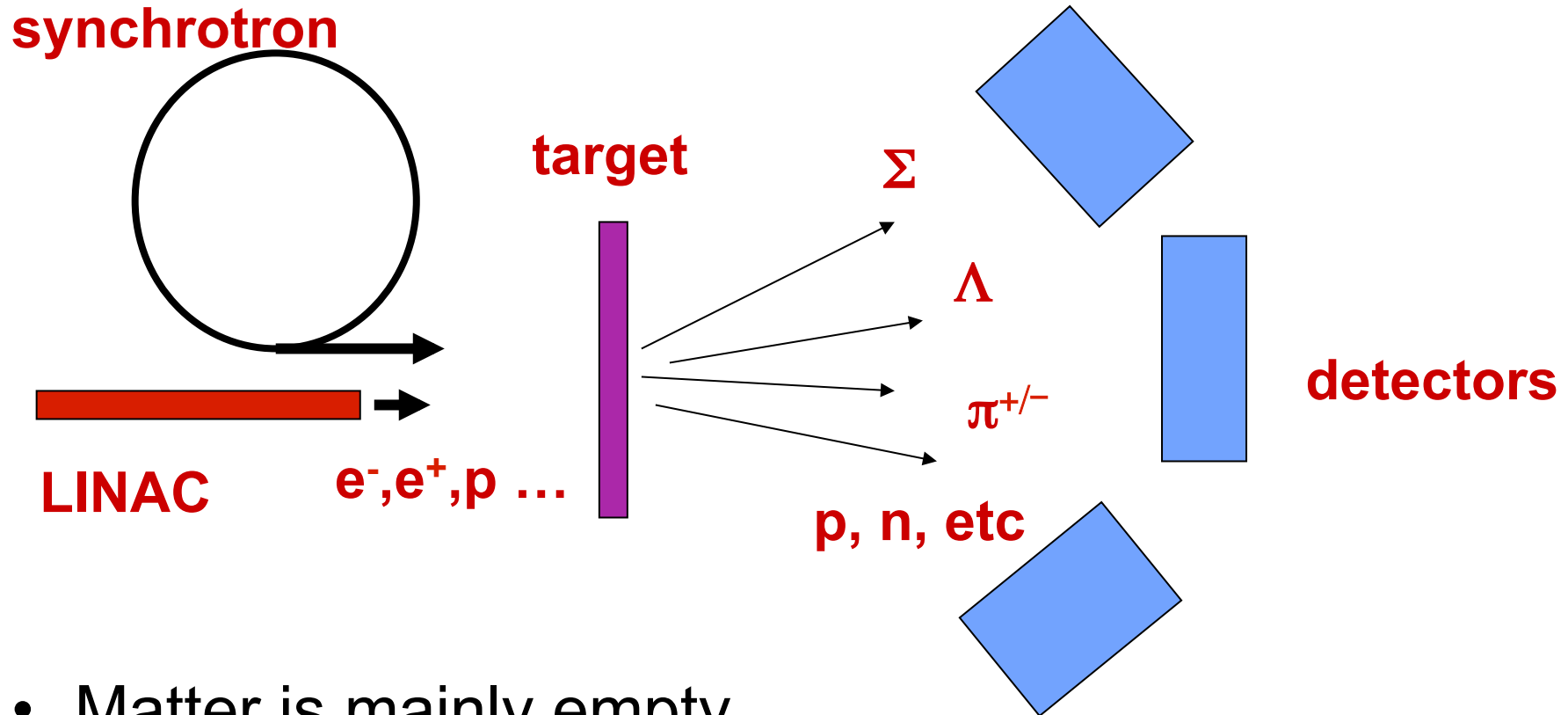
FLAME



Frascati electrosynchrotron 1959-1975

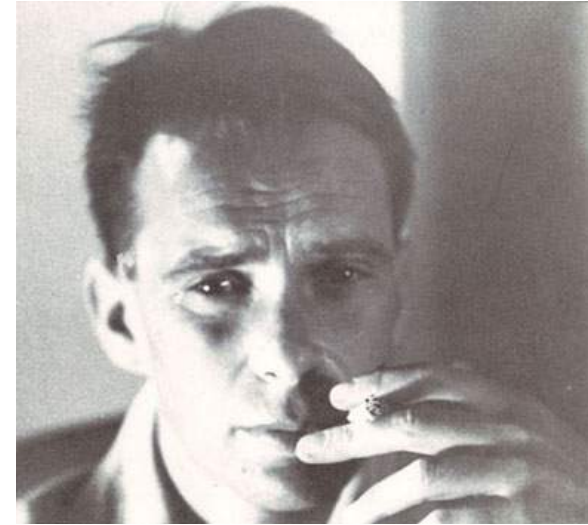
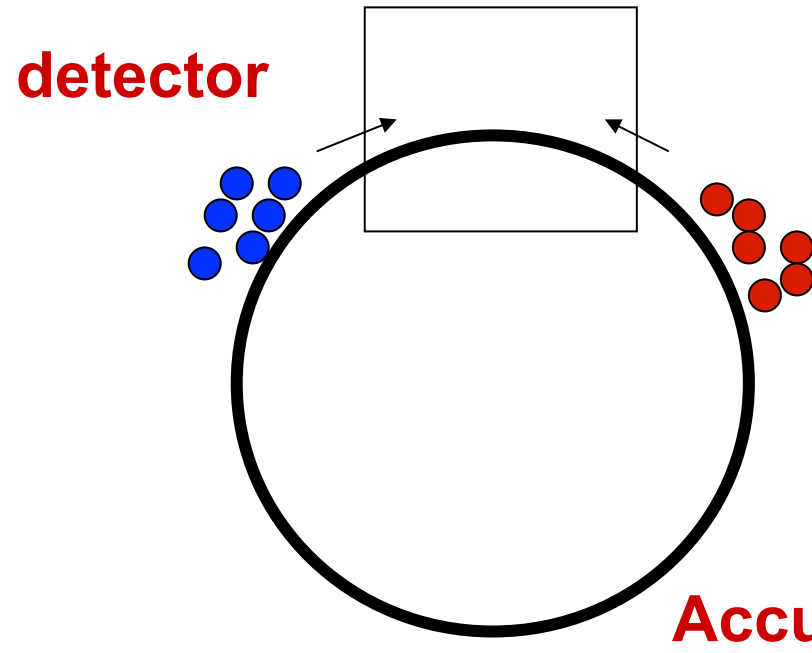


Observing on fixed target



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

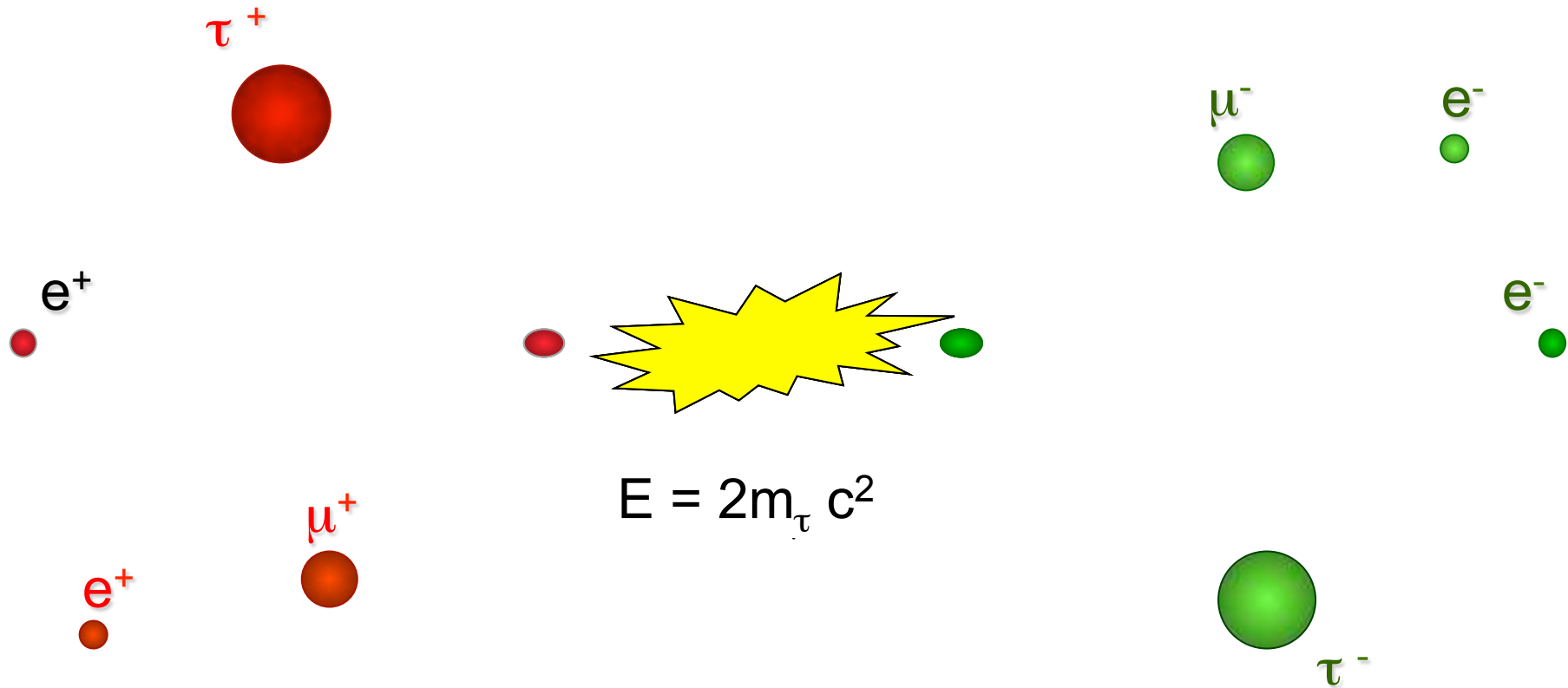
First Frascati's idea



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

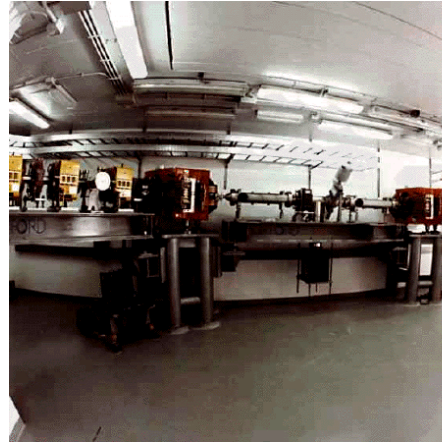
LEP al CERN di Ginevra 1988



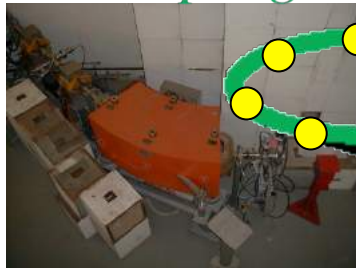
LHC at Cern (pp)



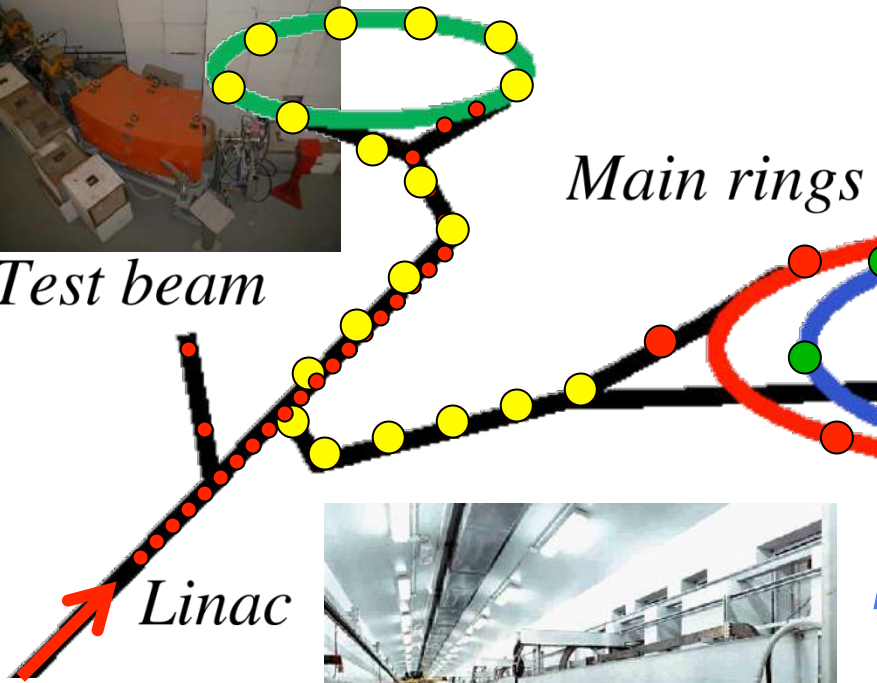
DAΦNE



Damping ring



Test beam



DEAR
FINUDA

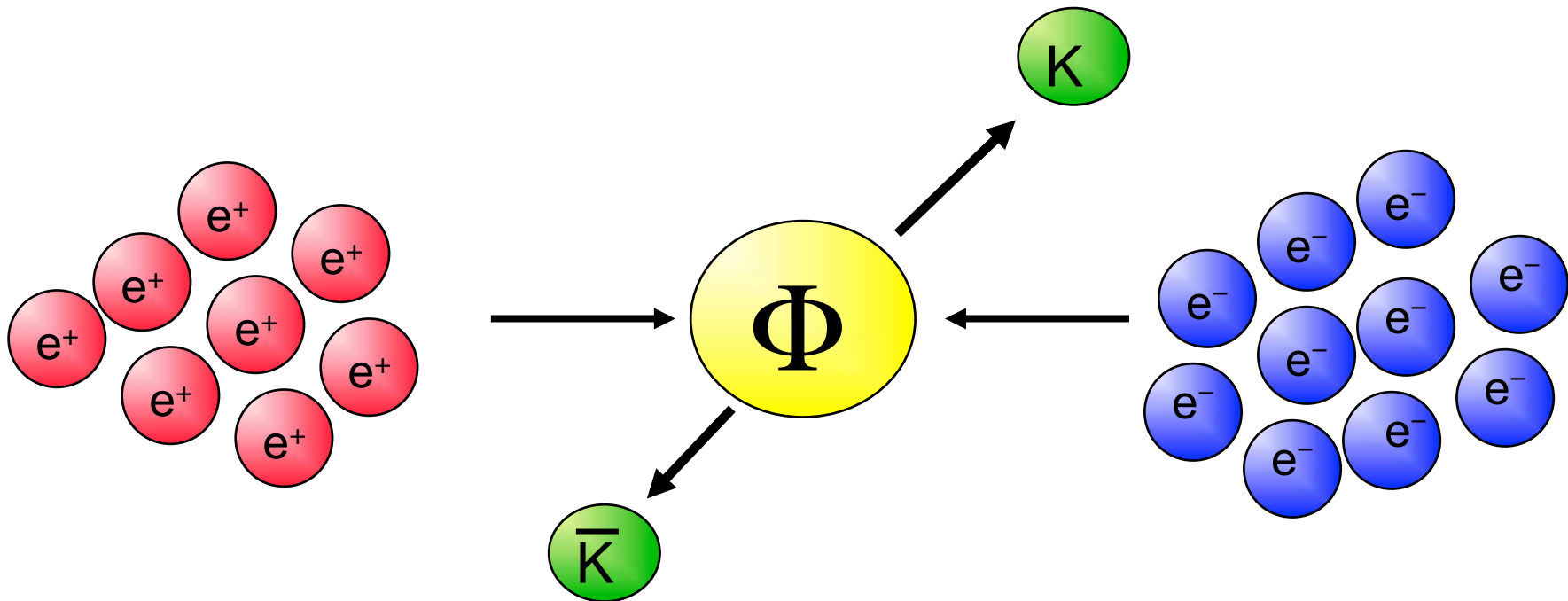
Run	Event	Date
6757	738533	Apr. 20, 99

DAFNE-Light



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.



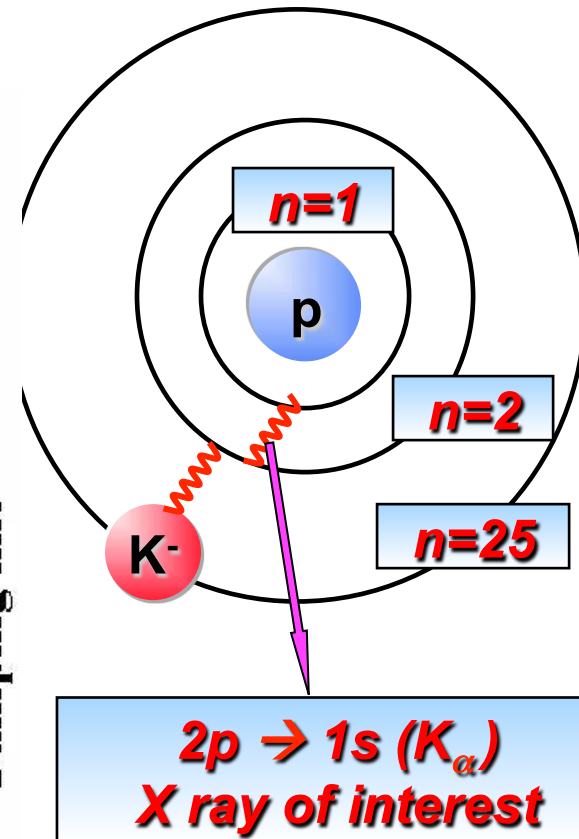
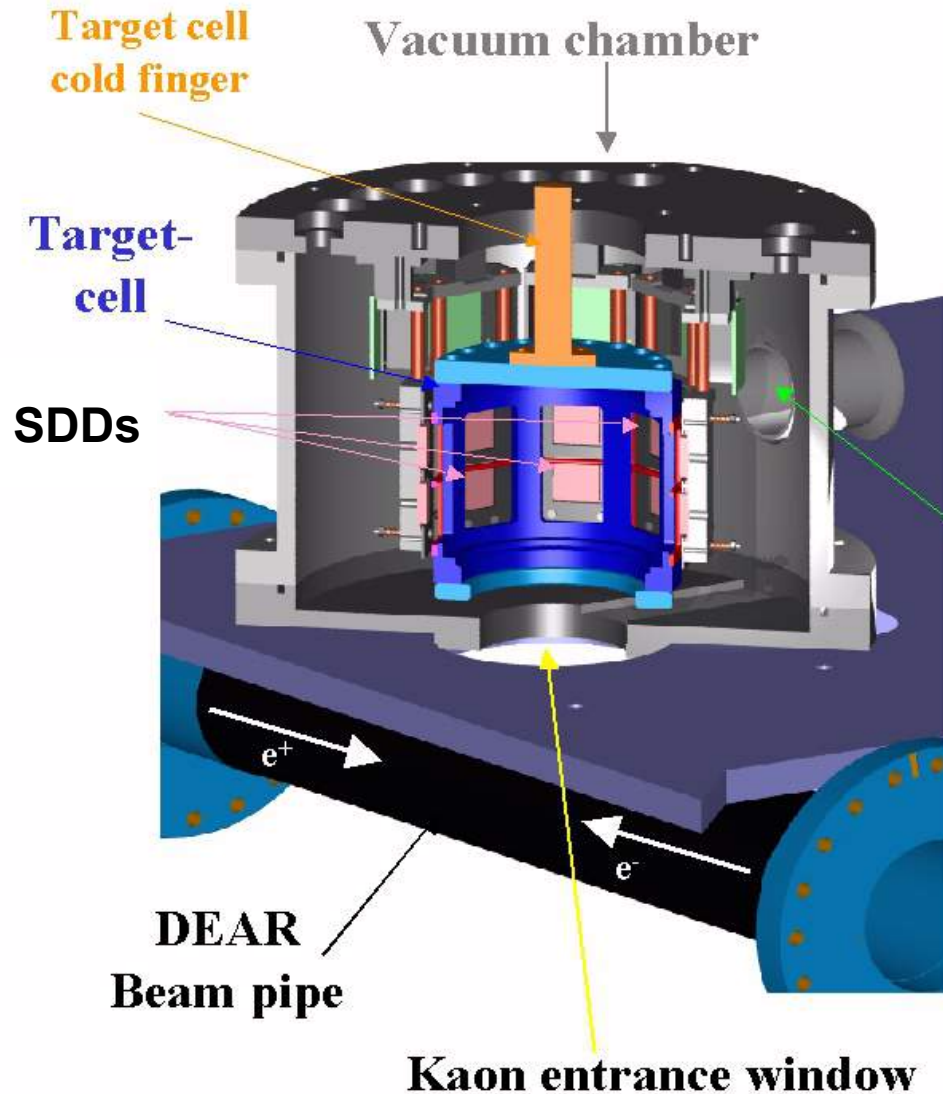
The K are the particles used by the three experiments, DEAR, FINUDA and KLOE, to reach their scientific goals.

The DAΦNE luminosity allows to produce about 10000 K in a second

SIDDHARTA

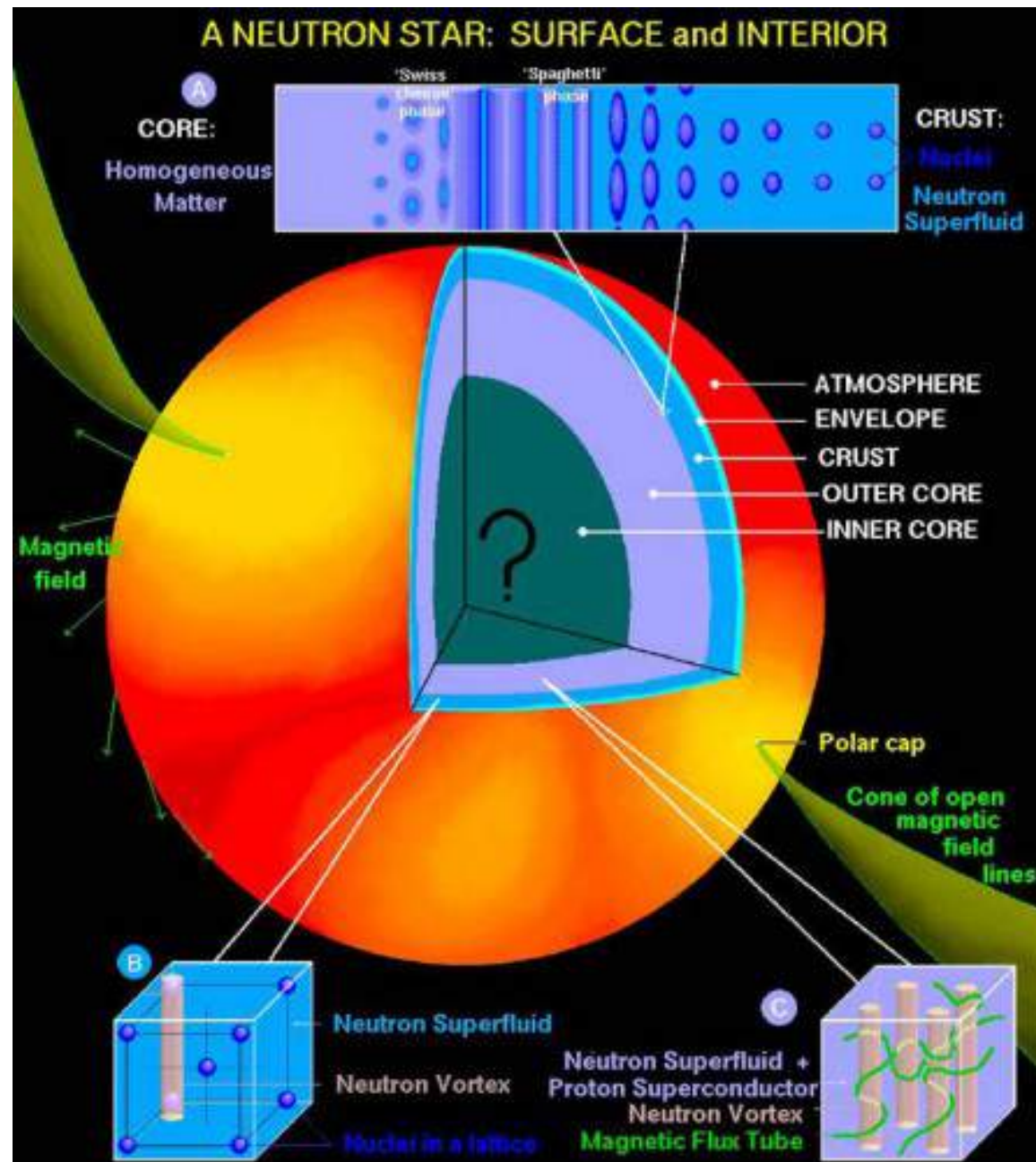
(DAΦNE Exotic Atom Research)

Kaonic hydrogen



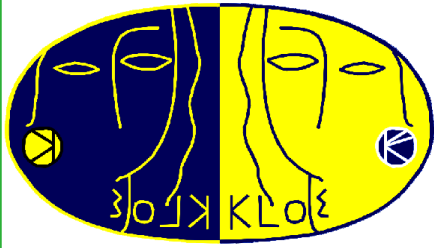
The DEAR experiment investigates the strong force by studying the kaonic atoms (in which a K^- is substituting an atomic electron).

Could strangeness play a role in neutron stars?

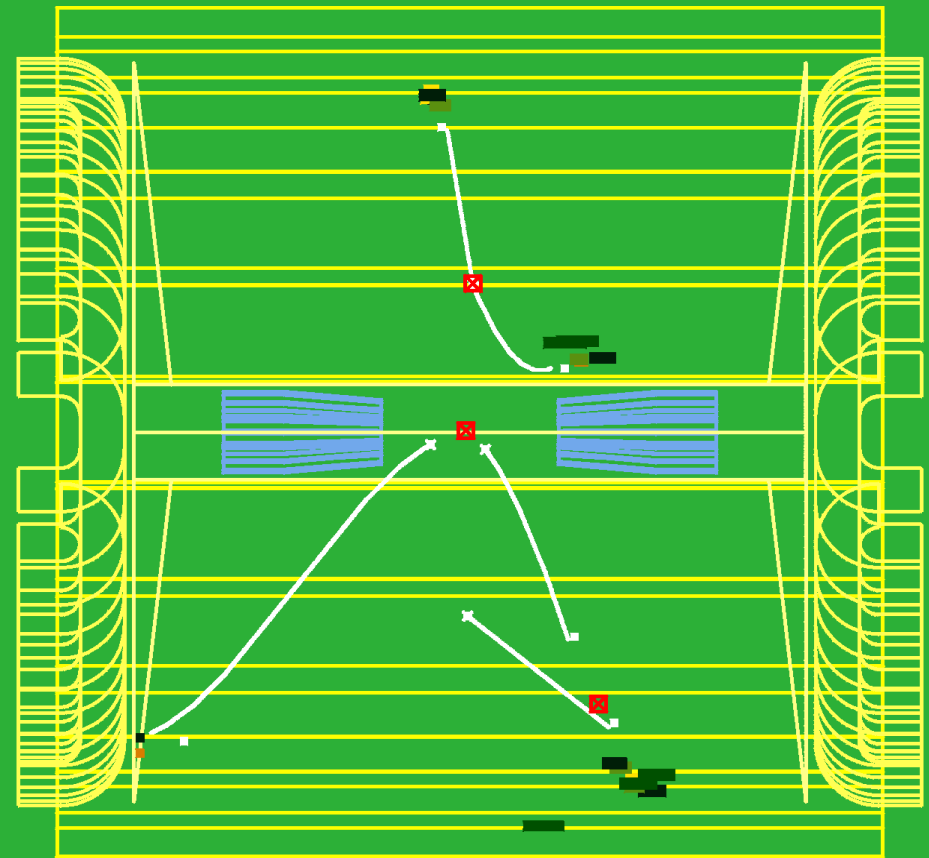
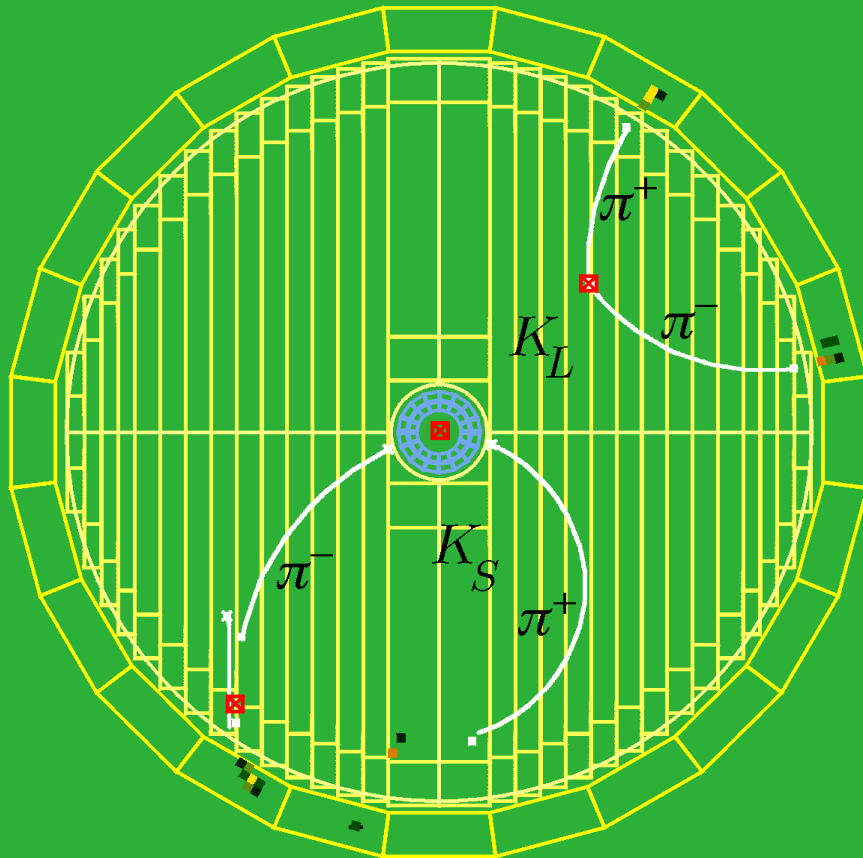


KLOE

(K LOng Experiment)

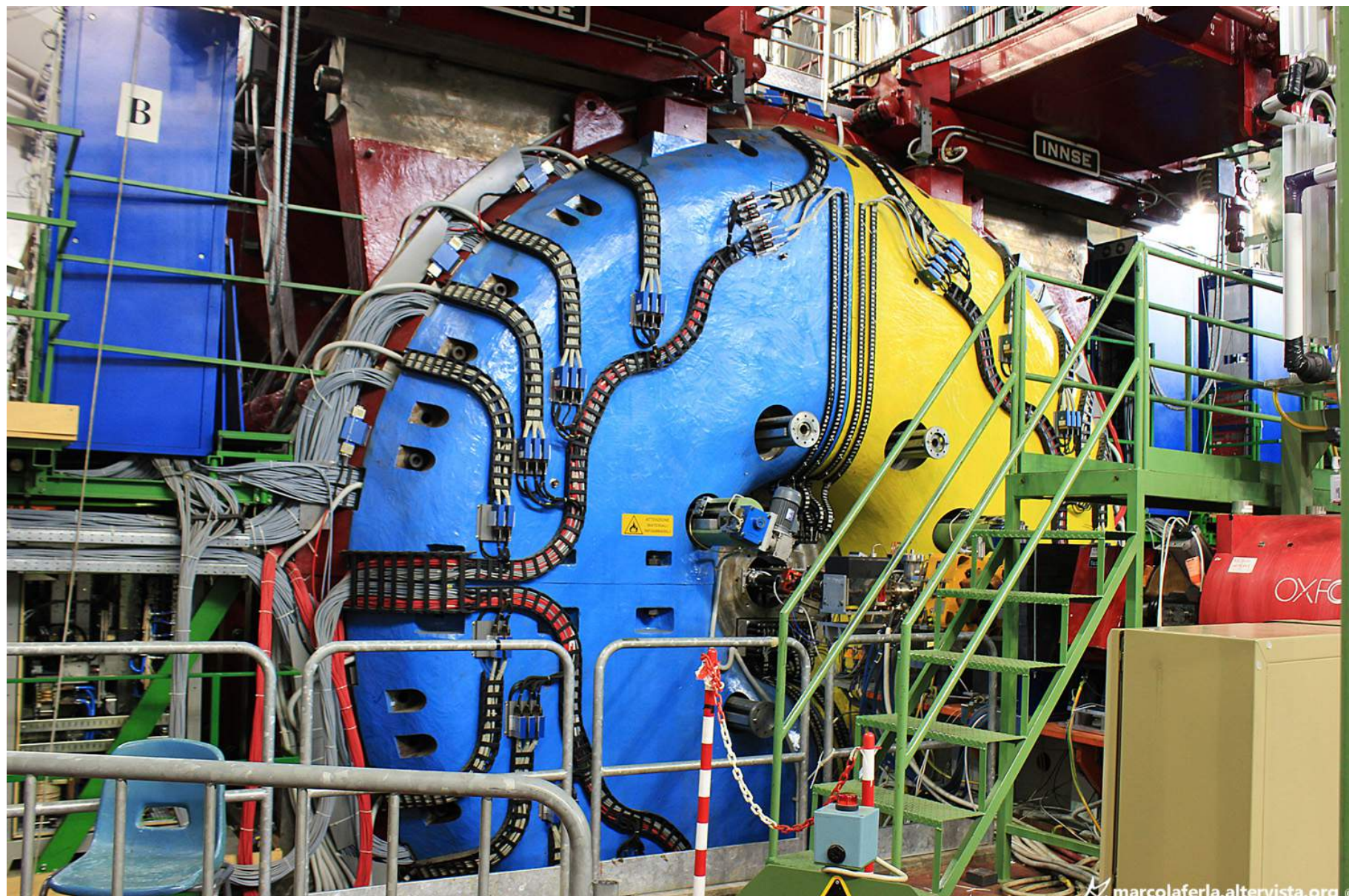


Run	Event	Date
6757	738533	Apr. 20, 99

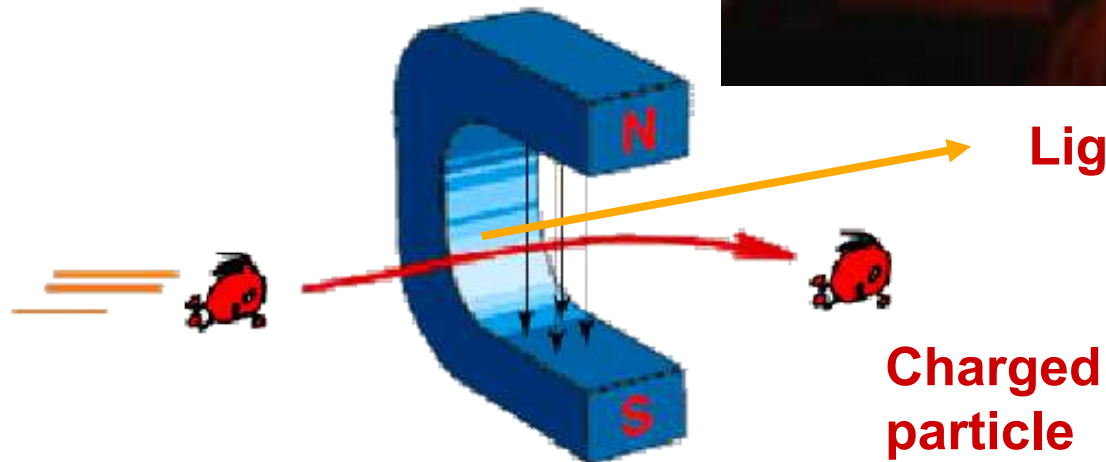
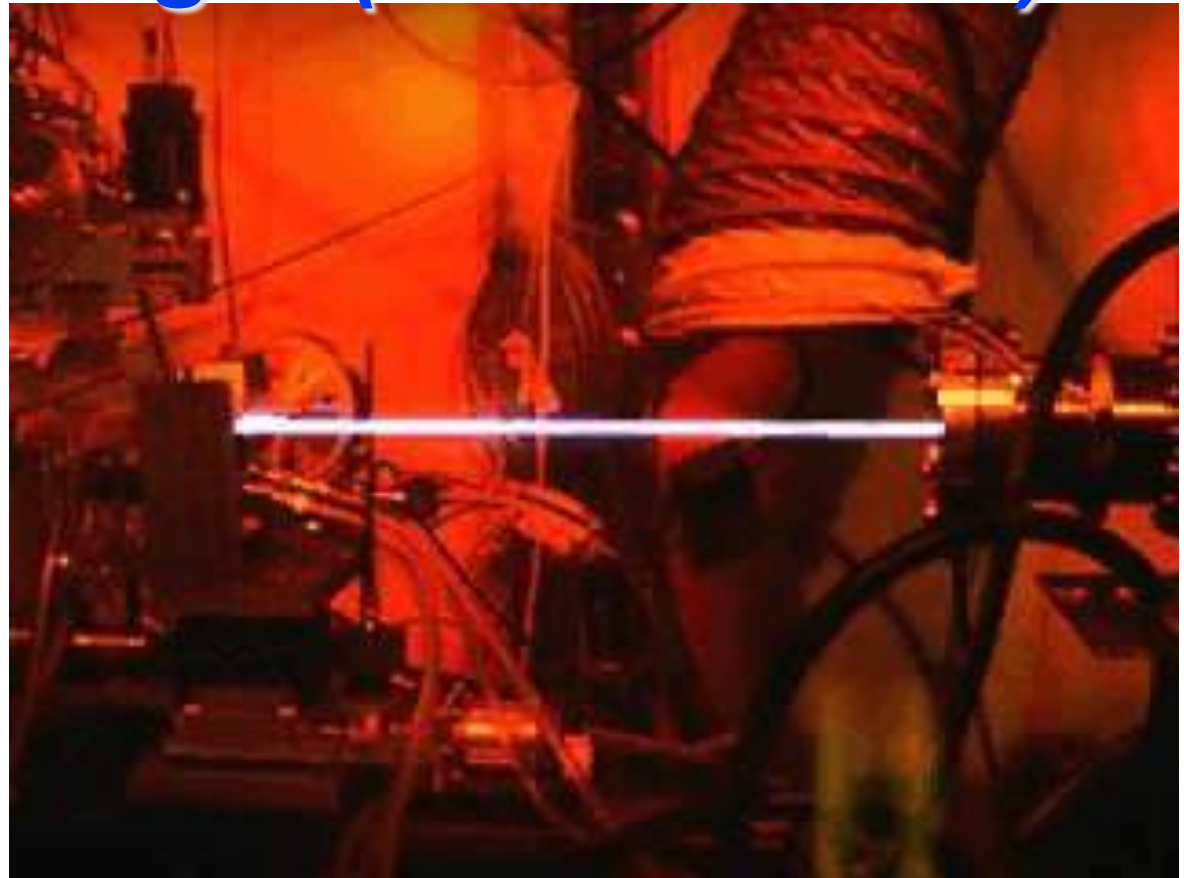


KLOE2

(K LOng Experiment)



Synchrotron light (DAΦNE-luce)



European Synchrotron
Radiation Facility

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

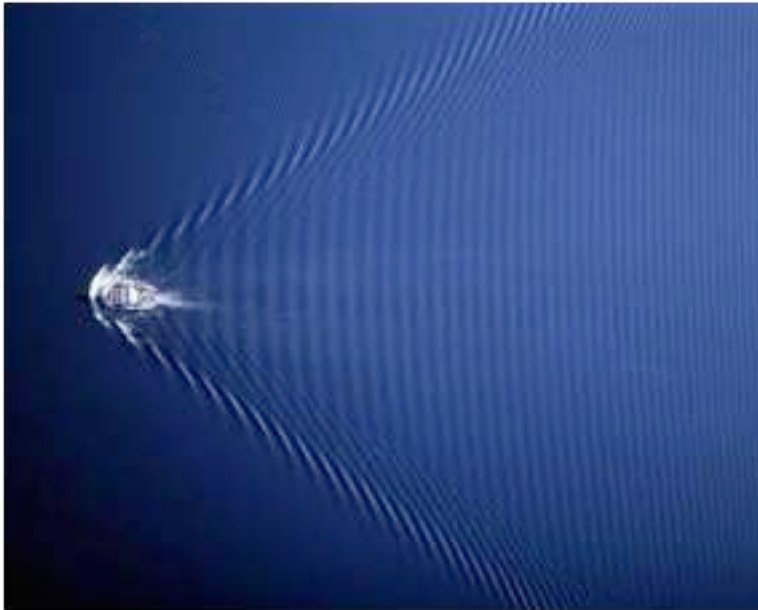


1) If FLAME beam is injected into a gas the electrons inside get highly accelerated (new acceleration technique)

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

Laser pulse creates a wave



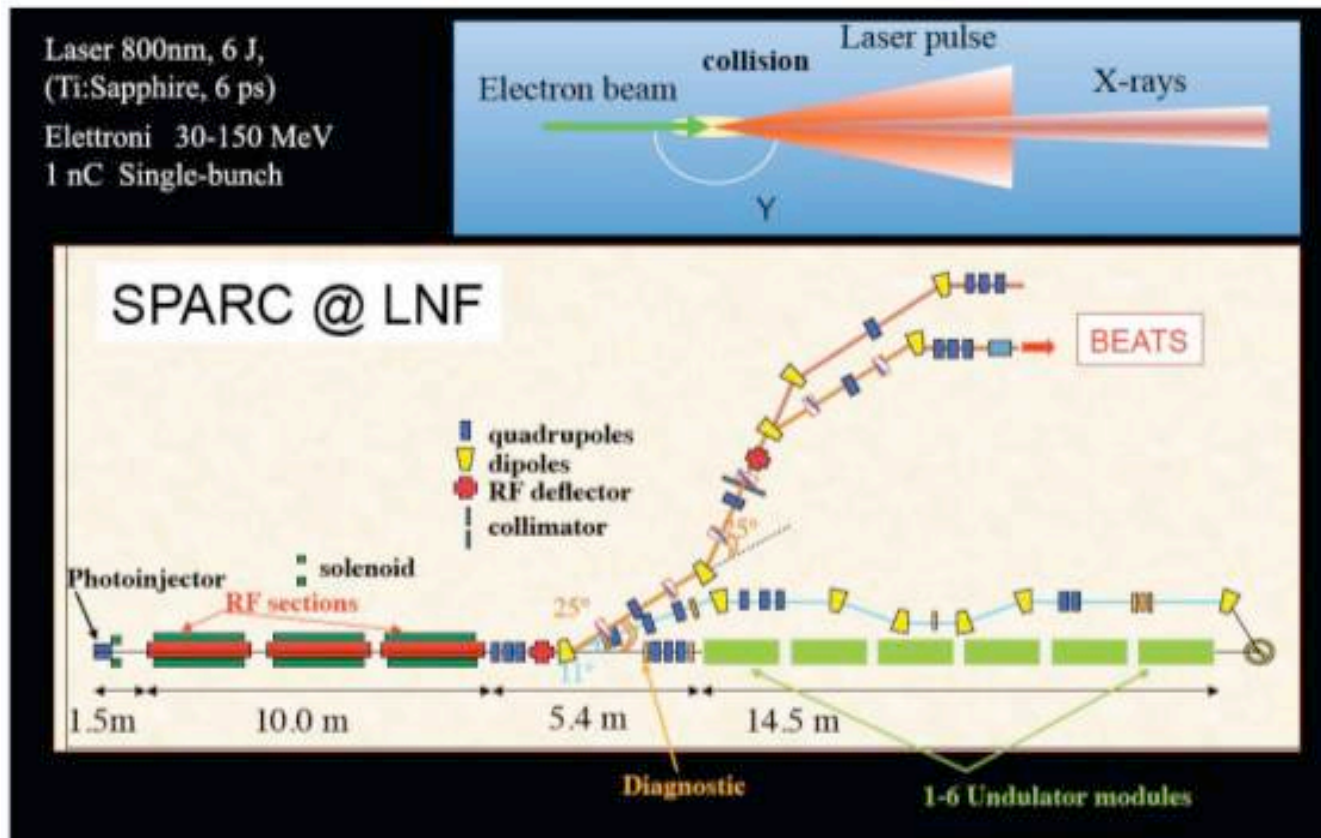
Particles get accelerated



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



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

Fig. 1 – Sorgente Thomson ai LNF

Medical diagnosis and material science

Medical diagnosis

Mamography

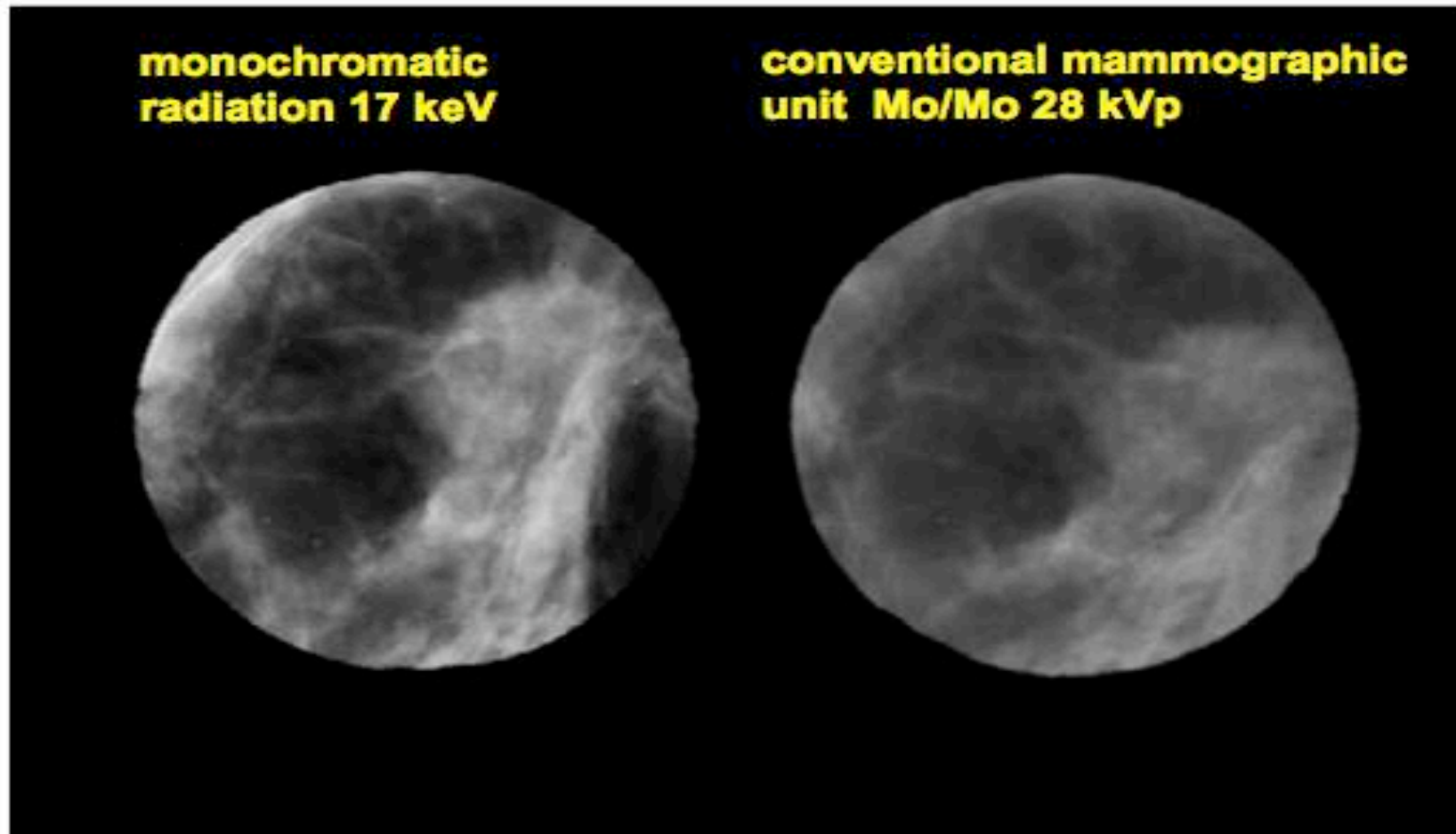
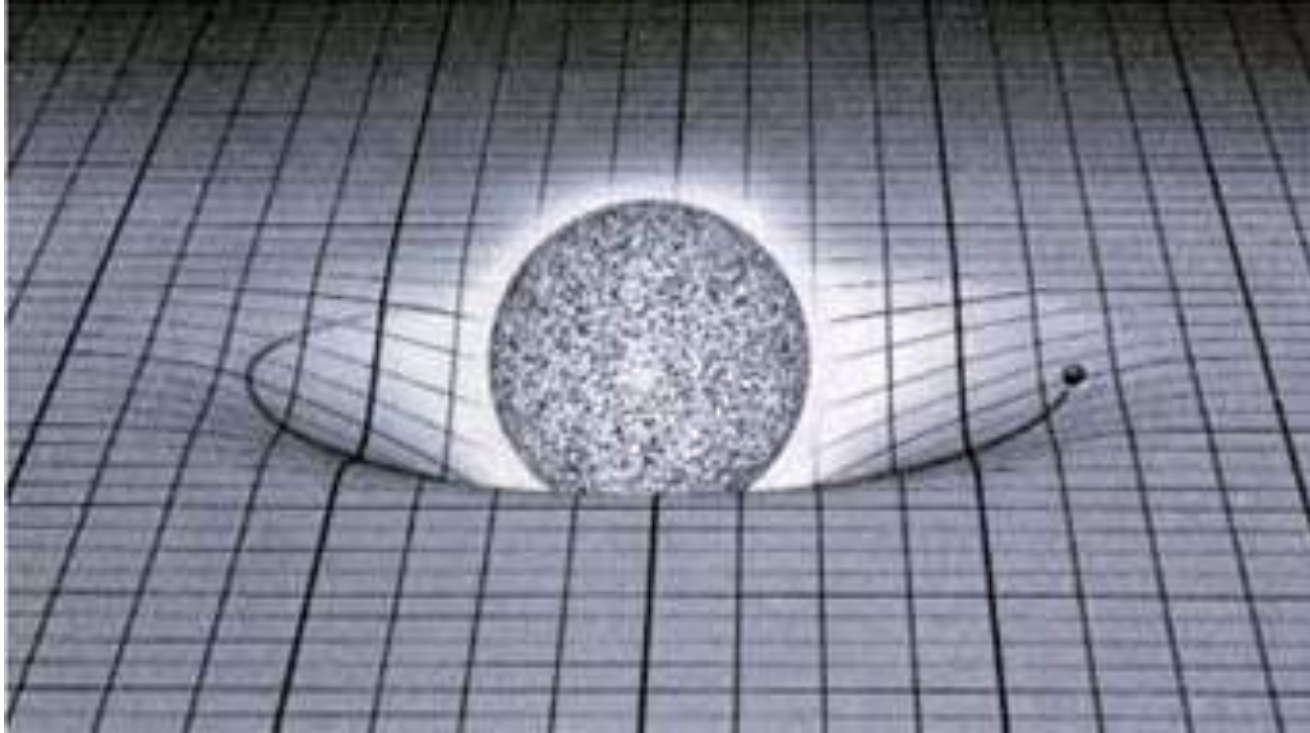


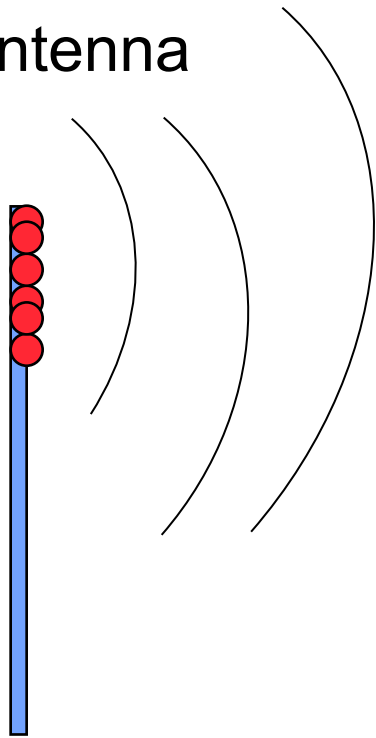
Fig. 3 – Confronto fra una mammografia monocromatica (sinistra) con una tradizionale (destra).

Gravity force`



Distortion of space-time

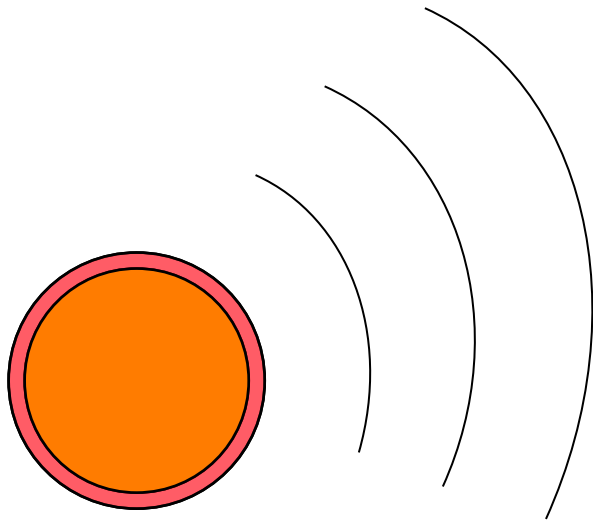
Antenna



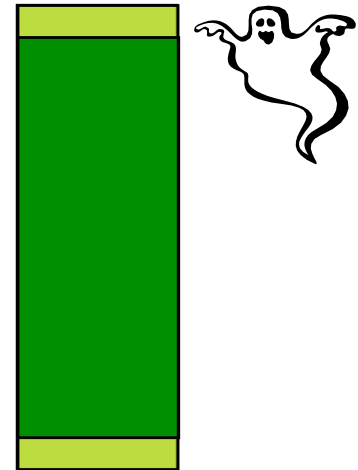
The electromagnetic waves are produced by an electric charge in movement



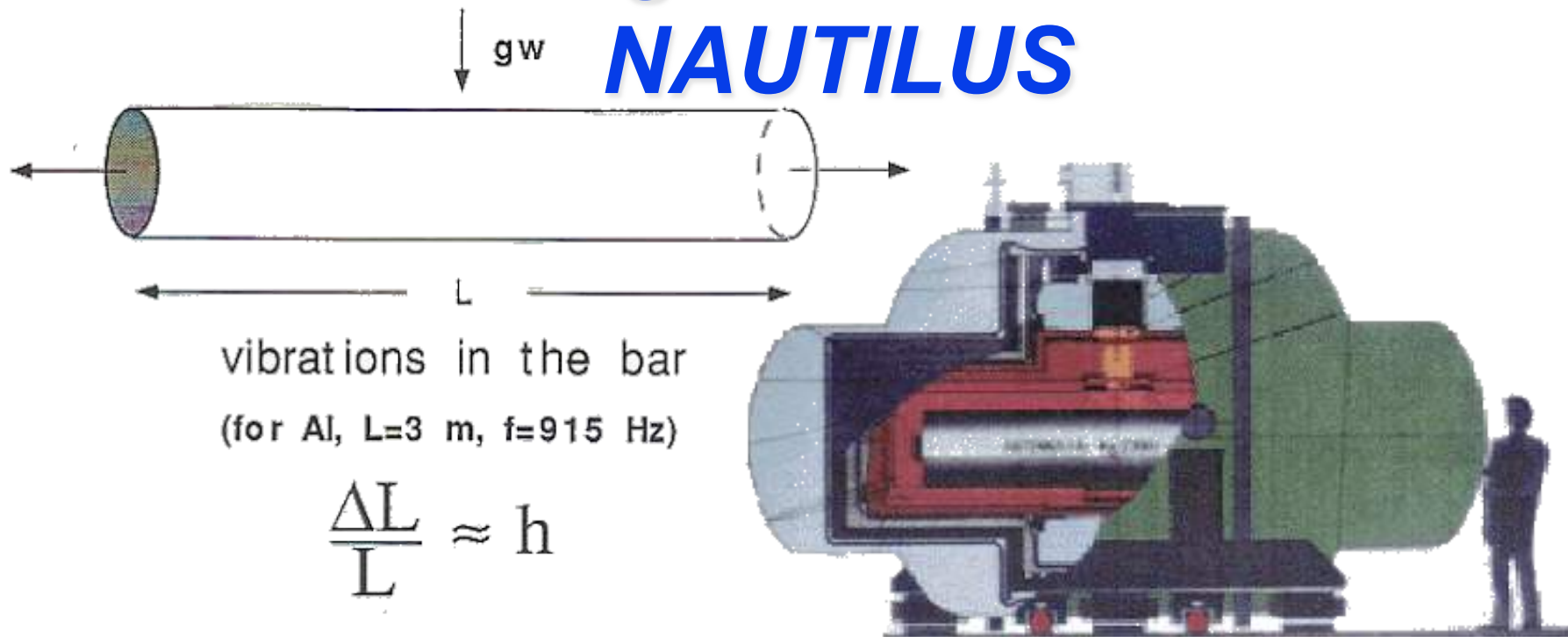
Gravitational waves: an analogy



Gravitational waves are produced by masses in movement....



Search for gravitational waves: **NAUTILUS**



- **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 $\rightarrow \Delta L=10^{-18}$ m**

After 100 years of General Relativity...

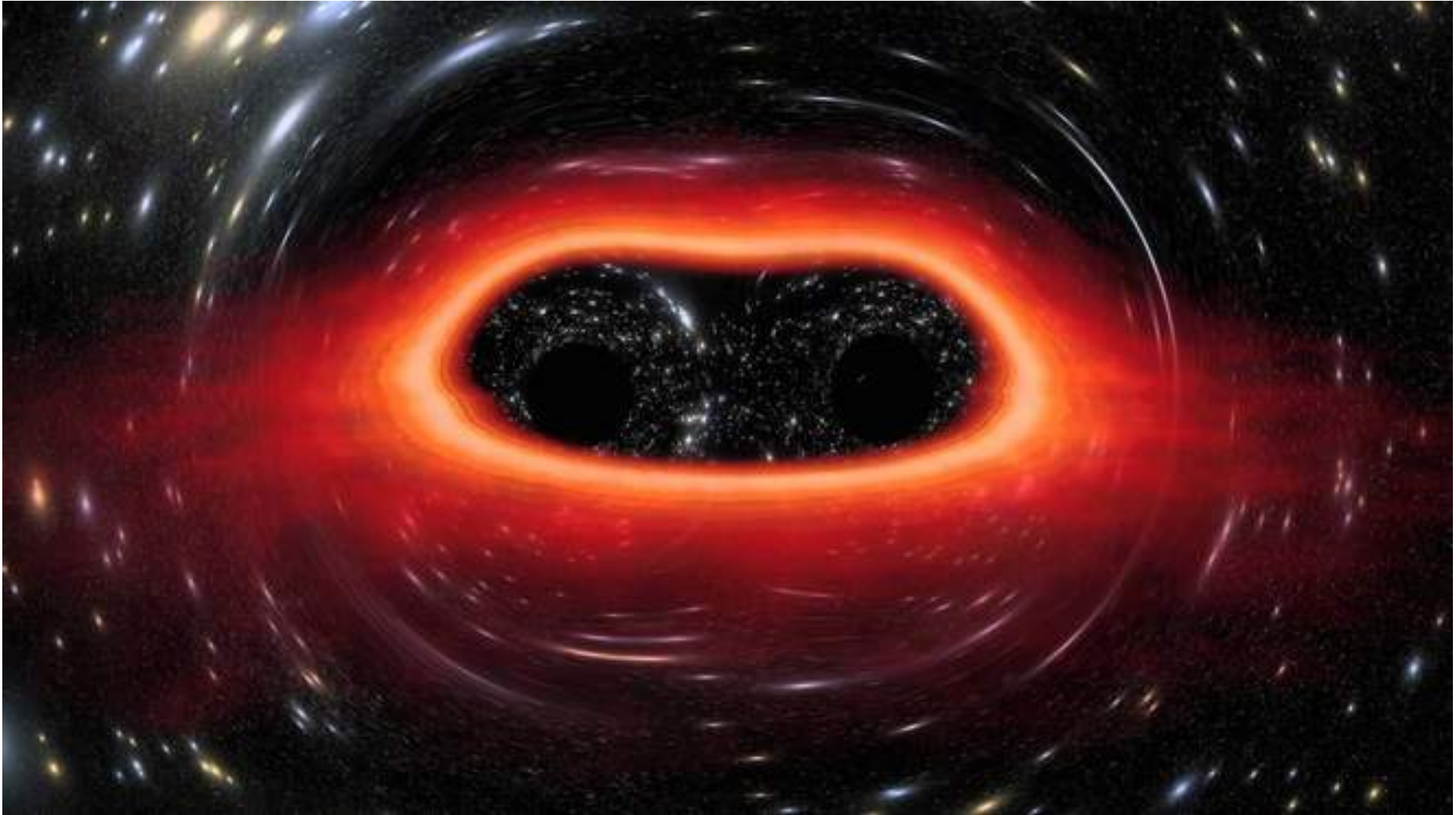
Imagine travelling through space on a beam of light at the speed of light.



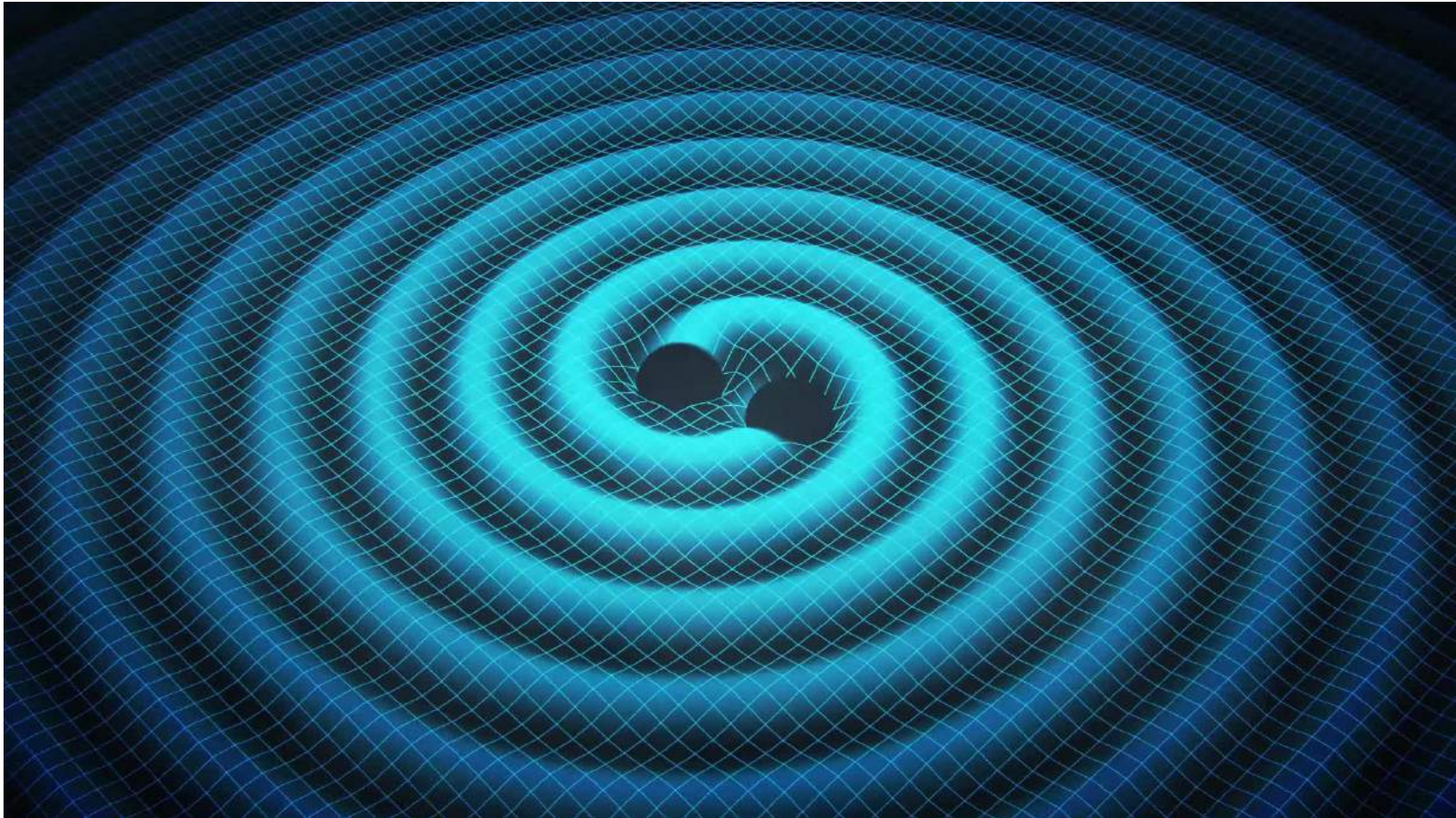
Albert Einstein, theory of relativity, gravity, velocity, energy, mass, speed, time, $E=mc^2$ Albert Ein

Bobonart

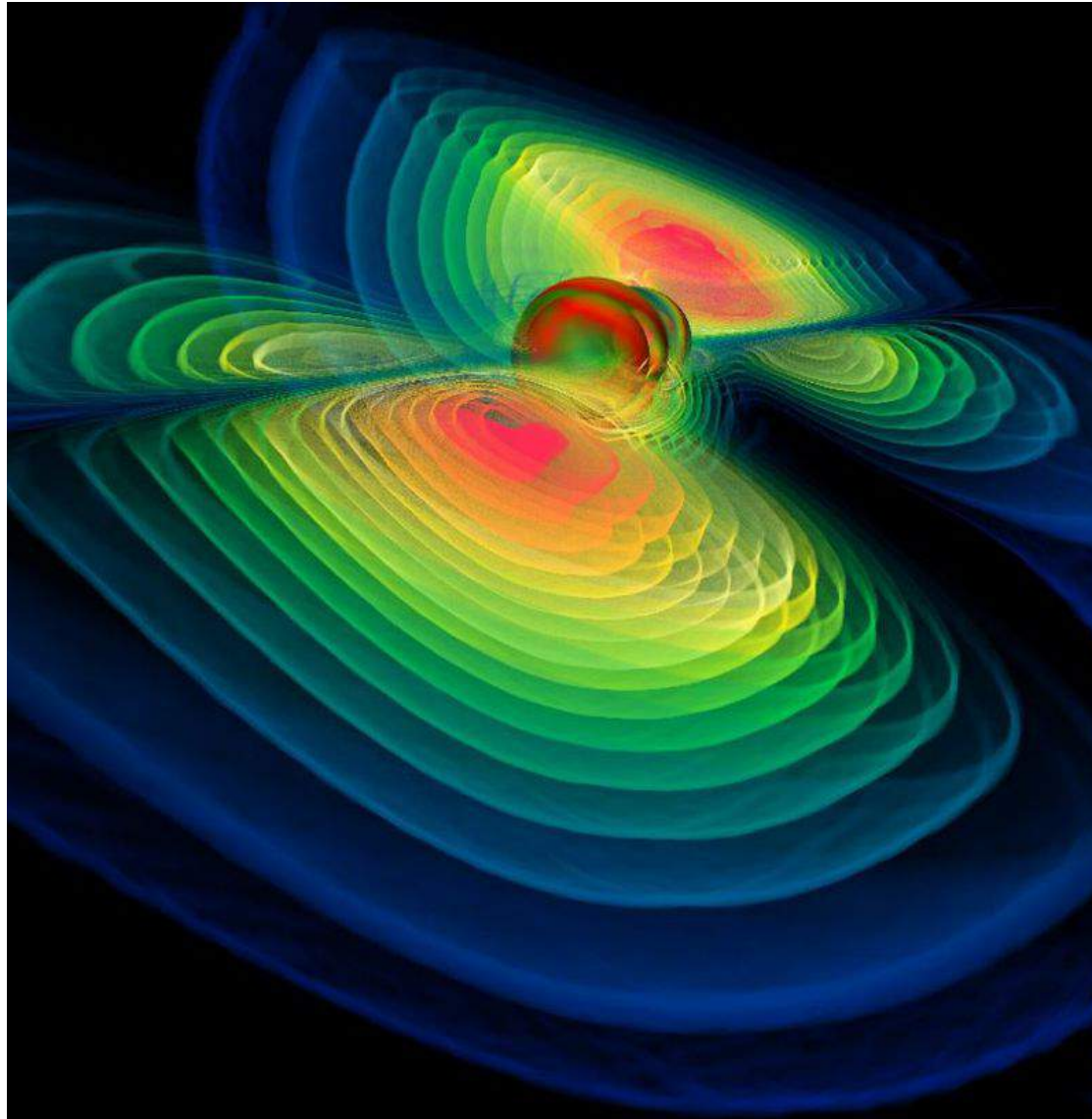
***Discovery of the gravitational waves (14 Sept.
2015 -> 11 Feb 2016)***



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

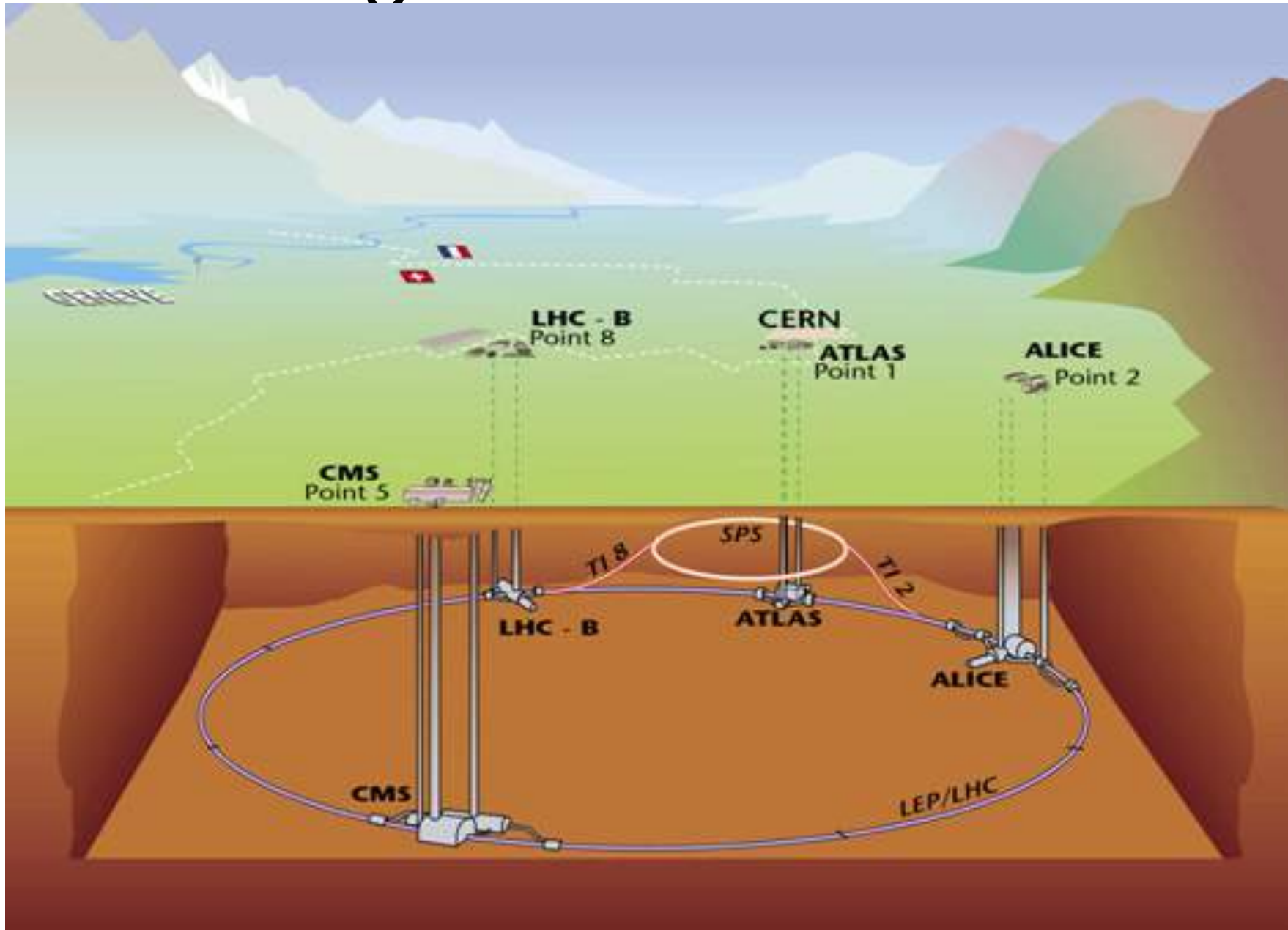


***Discovery of the gravitational waves (14 Sept. 2015 -
> 11 Feb 2016) – talk Viviana Fafone***



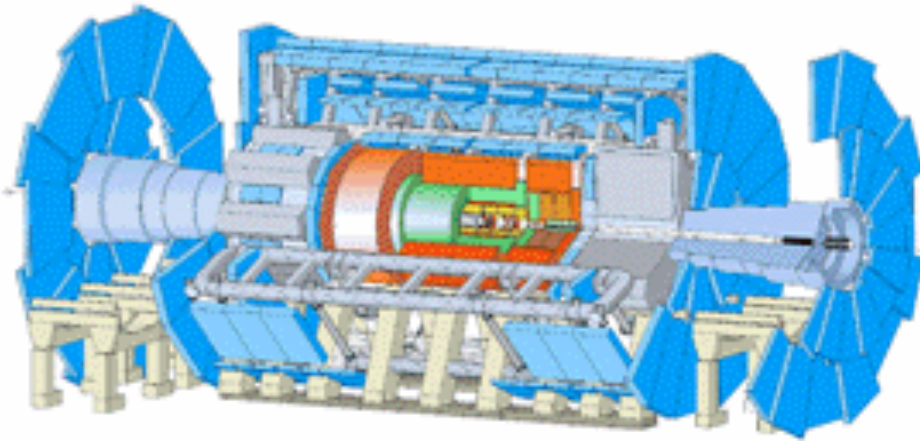


Large Hadron Collider

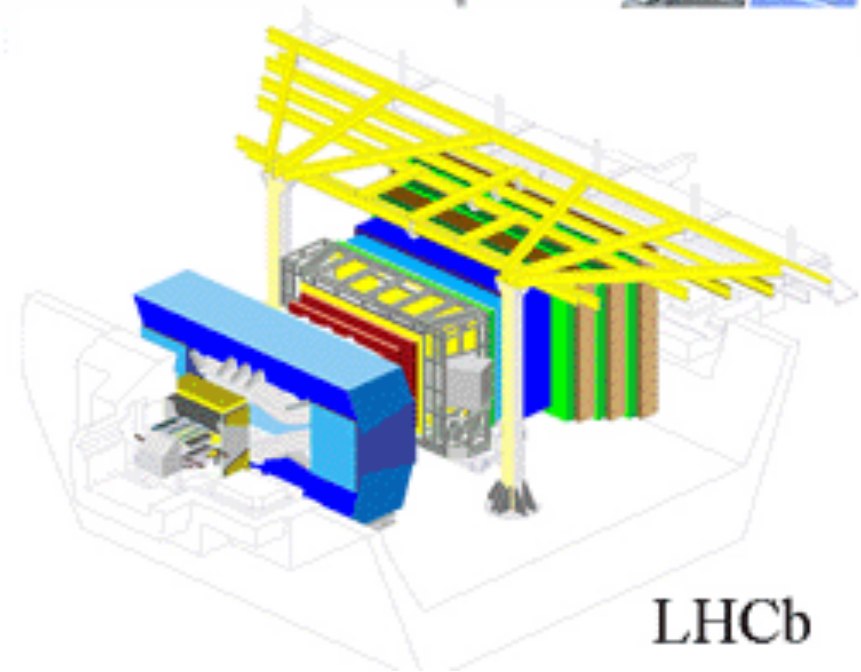
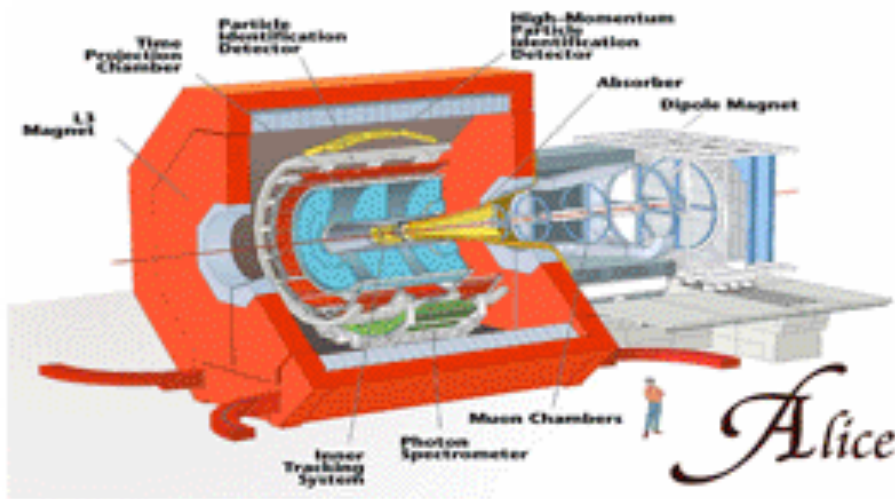
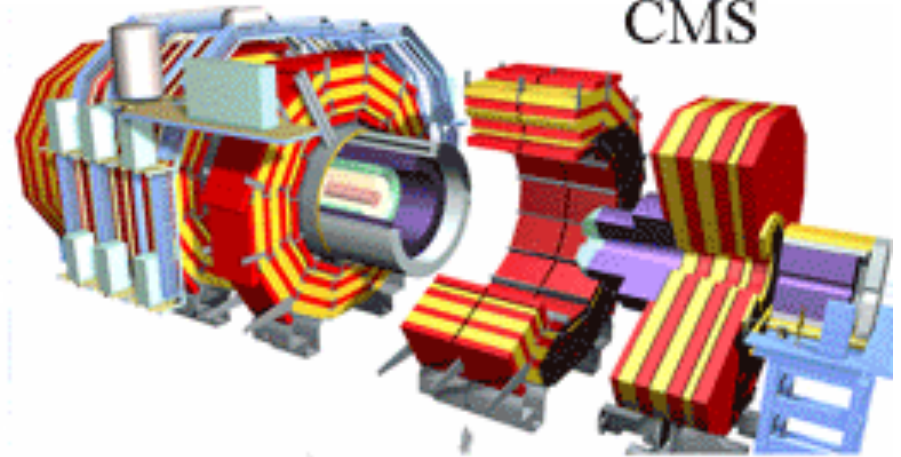


Large Hadron Collider

ATLAS

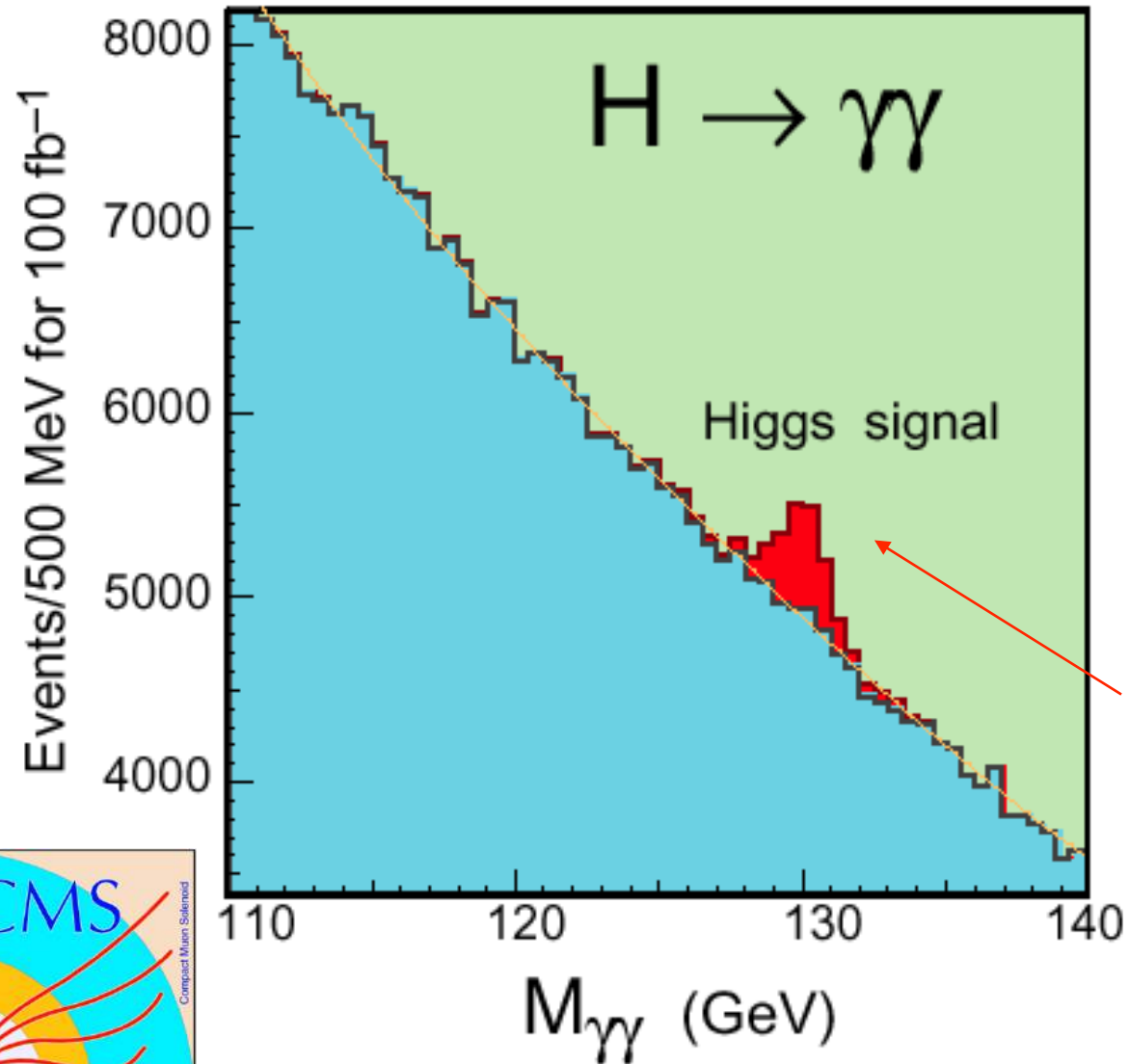


CMS

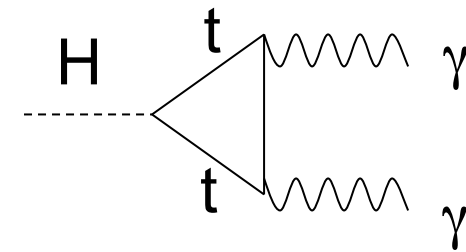


LHCb

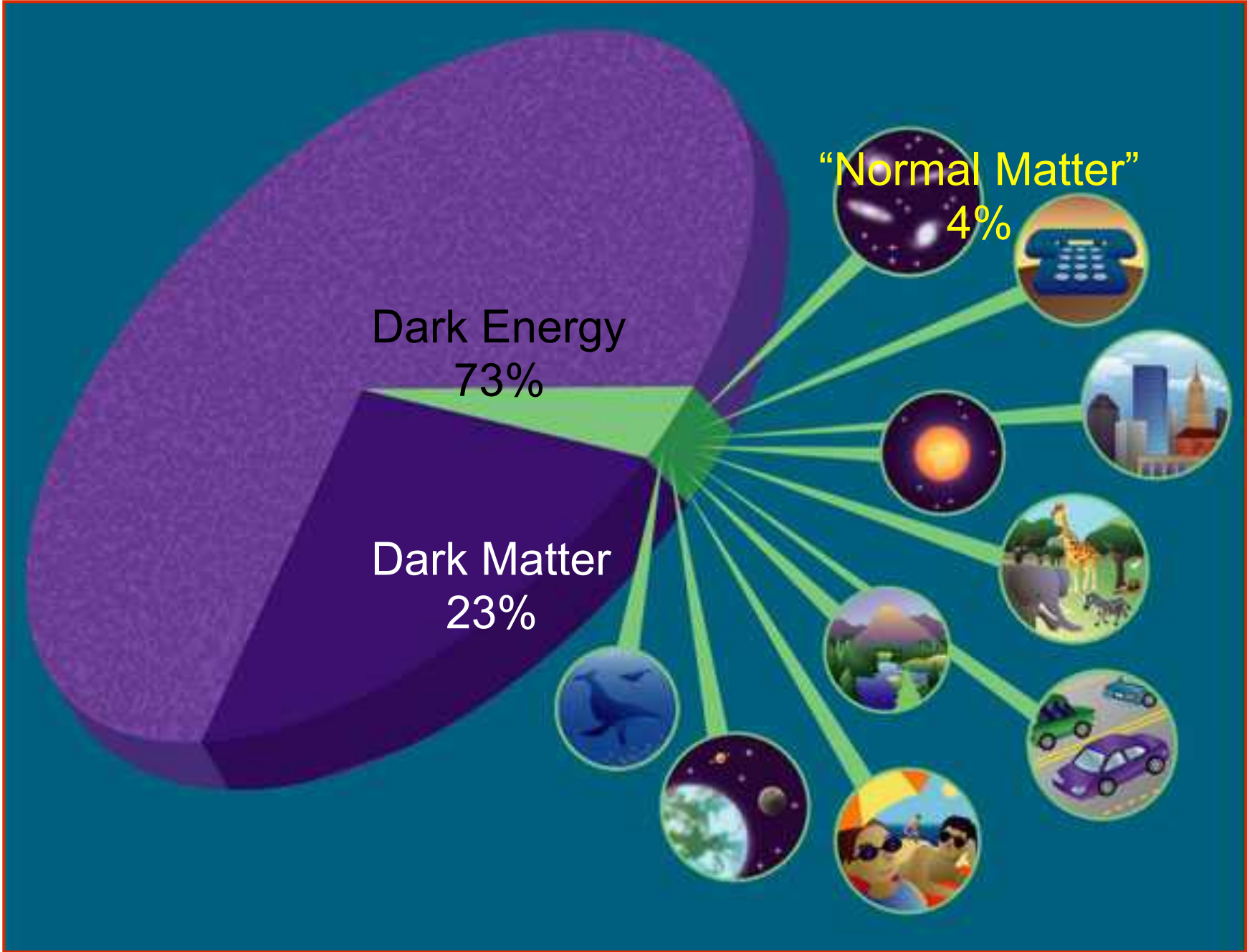
Higgs Decay to Photons



Rare decay in SM



LHC detectors have been optimized to find **this peak!**



Black holes



.....to interstellar travels?



CLASSICAL PHYSICS

ISAAC NEWTON
LAWS OF MOTION

CALCULUS
 $\int x^2 dx$ $\frac{d}{dx}$

CLASSICAL MECHANICS

FLUID MECHANICS
FLOW
LIFT
NEWTON'S CAR

CHAOS THEORY

LAW OF UNIVERSAL GRAVITATION
GRAVITY
ORBITS

OPTICS
REFRACTION
REFLECTION
DIFFRACTION
MICROSCOPE
TELESCOPE

ELECTROMAGNETISM
ELECTRIC FIELDS
MAGNETIC FIELDS
ELECTRICITY
LIGHT

THERMODYNAMICS
ENERGY
HEAT
TEMPERATURE
ENTROPY

RELATIVITY

ALBERT EINSTEIN
GENERAL THEORY OF RELATIVITY

CONSTANT SPEEDS OF LIGHT

SPECIAL THEORY OF RELATIVITY
 $E=mc^2$

TIME
SPACE

COSMOLOGY
ASTROPHYSICS
REFLECTION
REFRACTION
DIFFRACTION

WAVES
TRANSVERSE
LONGITUDINAL

JAMES CLERK MAXWELL

PHILOSOPHY

PHILOSOPHY OF SCIENCE
FREE WILL
HOW COME?
NATURE OF REALITY
JUST... WHY?

THE CHASM OF IGNORANCE

QUANTUM FIELD THEORY
QUANTUM ELECTRODYNAMICS

THE STANDARD MODEL

ATOMIC THEORY

CONDENSED MATTER PHYSICS
QUANTUM INFORMATION
COMPUTERS
LASERS

NUCLEAR PHYSICS
FISSION
FUSION

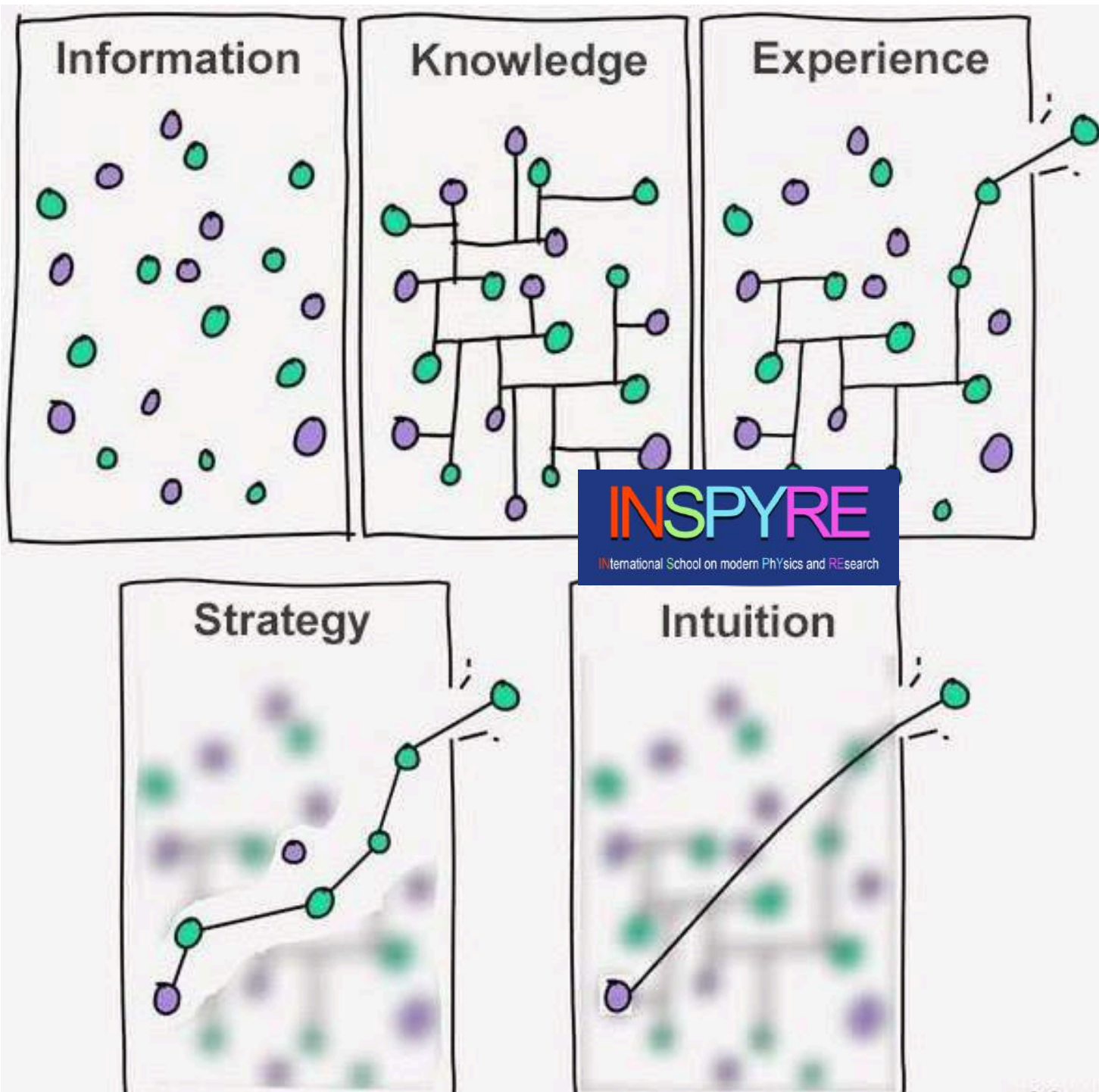
QUANTUM PHYSICS
YOUTUBE.COM/USER/DOMINICWALLSMAN @DOMINICWALLSMAN

PARTICLE PHYSICS

THE FUTURE
QUANTUM GRAVITY
STRING THEORY
SUPER STRATEGY
LOOP QUANTUM GRAVITY

DARK ENERGY

DARK MATTER
AND MANY MORE



Frascati



Carnevale Frascati – 13th February



Laboratori Nazionali di Frascati

