Get INSPYRED

Introduction to Modern Physics and to the LNF-INFN Activities

INSPYRE

INternational School on modern PhYsics and REsearch

"Challenges in Modern Physics and Quantum Technologies"

1-5 April 2019

Catalina Curceanu
LNF-INFN

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

INFN
Istituto Nazionale di Fisica Nucleare

About 90 students
of 15 nationalities
from 46 schools
all around the world!

INSPYRE 2019

INternational School on modern PhYsics and REsearch

"Challenges in Modern Physics and Quantum Technologies"

INFN Laboratori Nazionali di Frascati
Auditorium B. Touschek

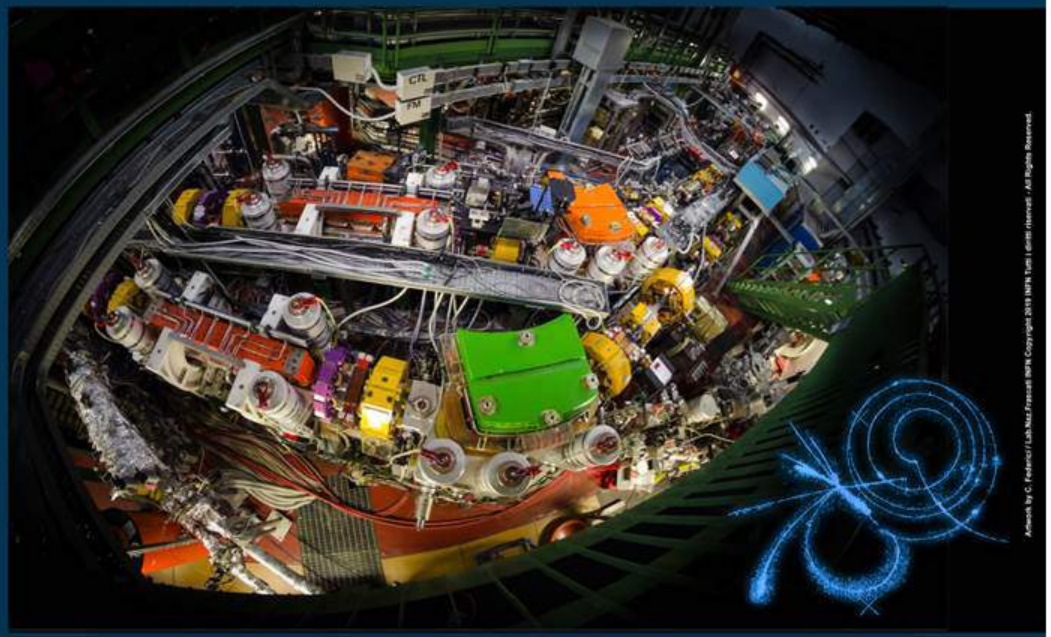
9th Edition, April 1st - 5th 2019

Directors
Catalina Curceanu, Rossana Centioni

http://edu.lnf.infn.it/inspyre-2019/

Organization
Camilla Paola Maglione, Debora Bifaretti

The INSPYRE 2019 School is dedicated to the hottest topics of Modern Physics and to the powerful Quantum Technologies. About 100 students in last years of high school, coming from all around the world, will take part to lectures given by experts, hands-on experiments and will visit the main experiments and accelerating facilities of LNF-INFN. INSPYRE 2019 will host a two-days dedicated event organized in the framework of the European COST Action CA15220 Quantum Technologies in Space.



cost

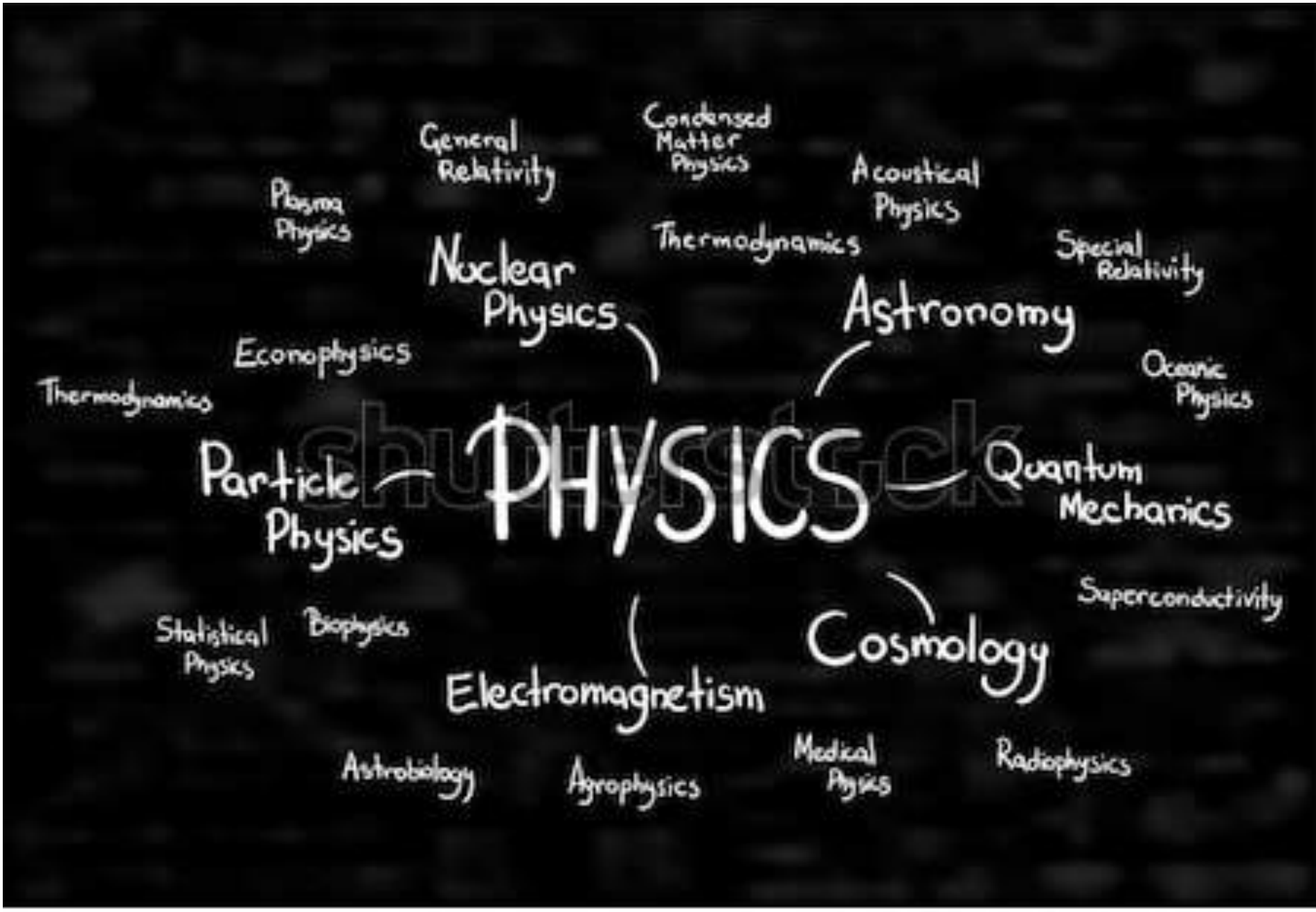
SIDS-Ufficio Educazione e Divulgazione Scientifica

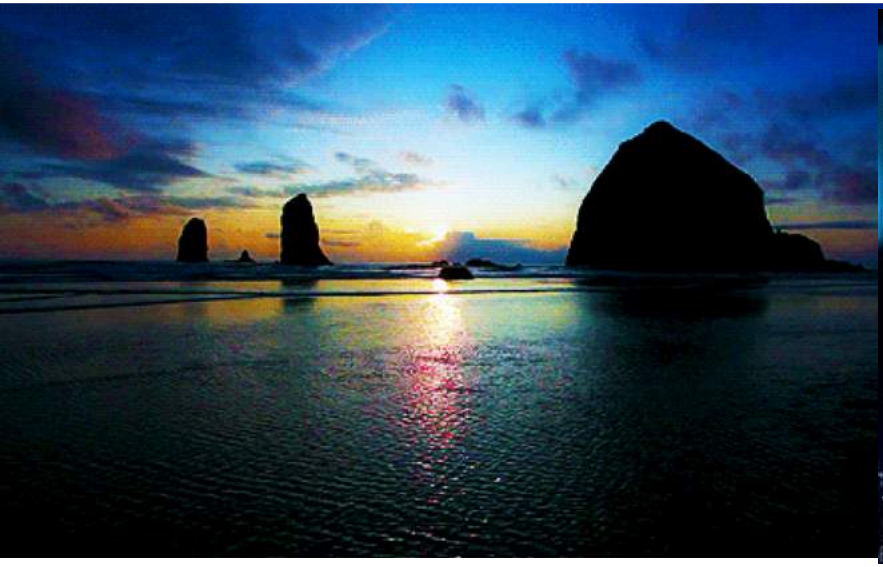
EVERYTHING HAPPENS FOR A REASON AND THAT REASON IS

EVERYTHING HAPPENS FOR A REASON AND THAT REASON IS USUALLY

PHYSICS


$a = mg(\sin\theta - \mu\cos\theta)$
$T = 2\pi\sqrt{\frac{l}{g}}$
$x = \frac{F_o \cos \omega t}{m(\omega_o^2 - \omega^2)}$
$F = \frac{Gm_{Jason}m_{Earth}}{r^2}$
www.foxtrot.com



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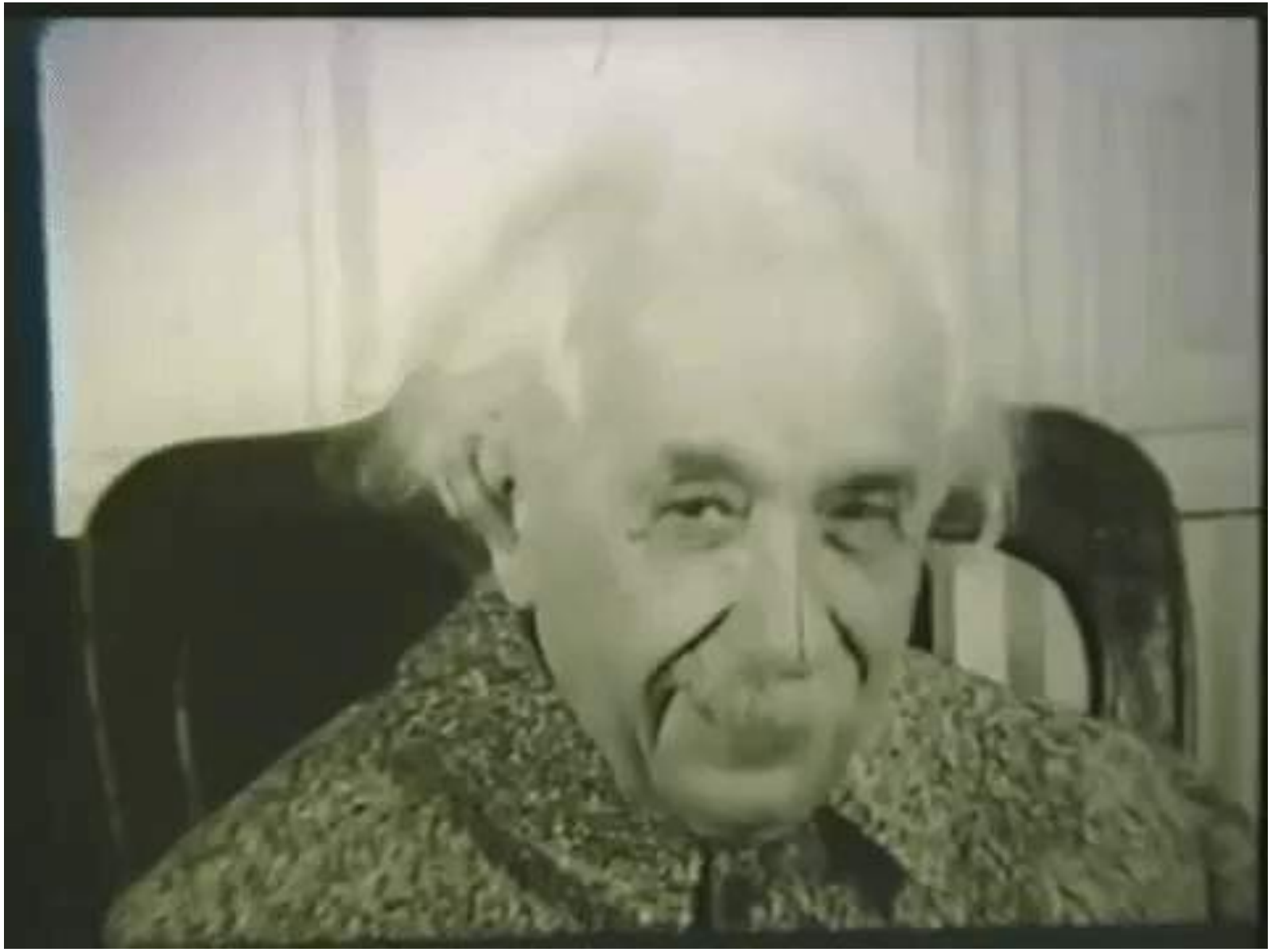


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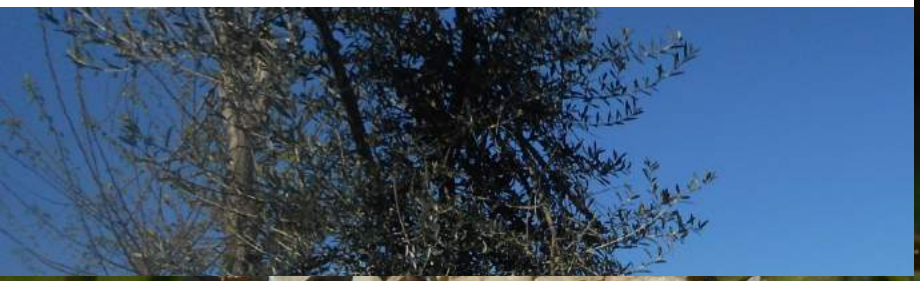
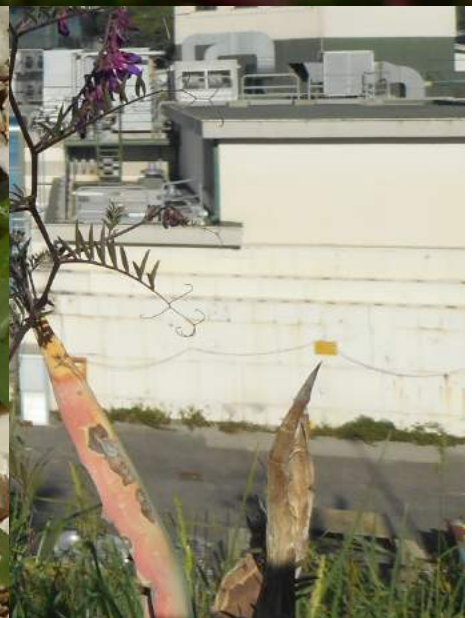
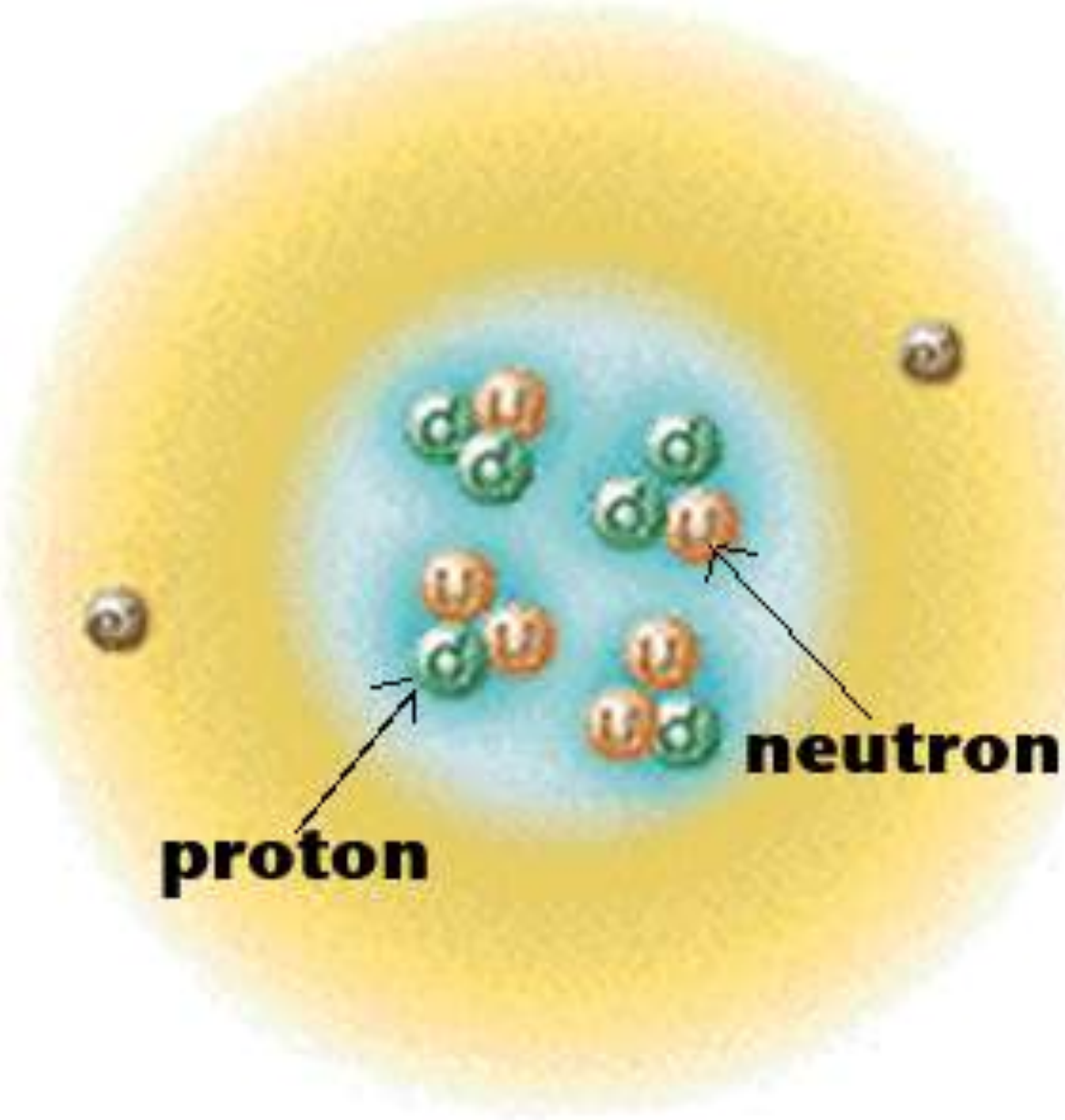
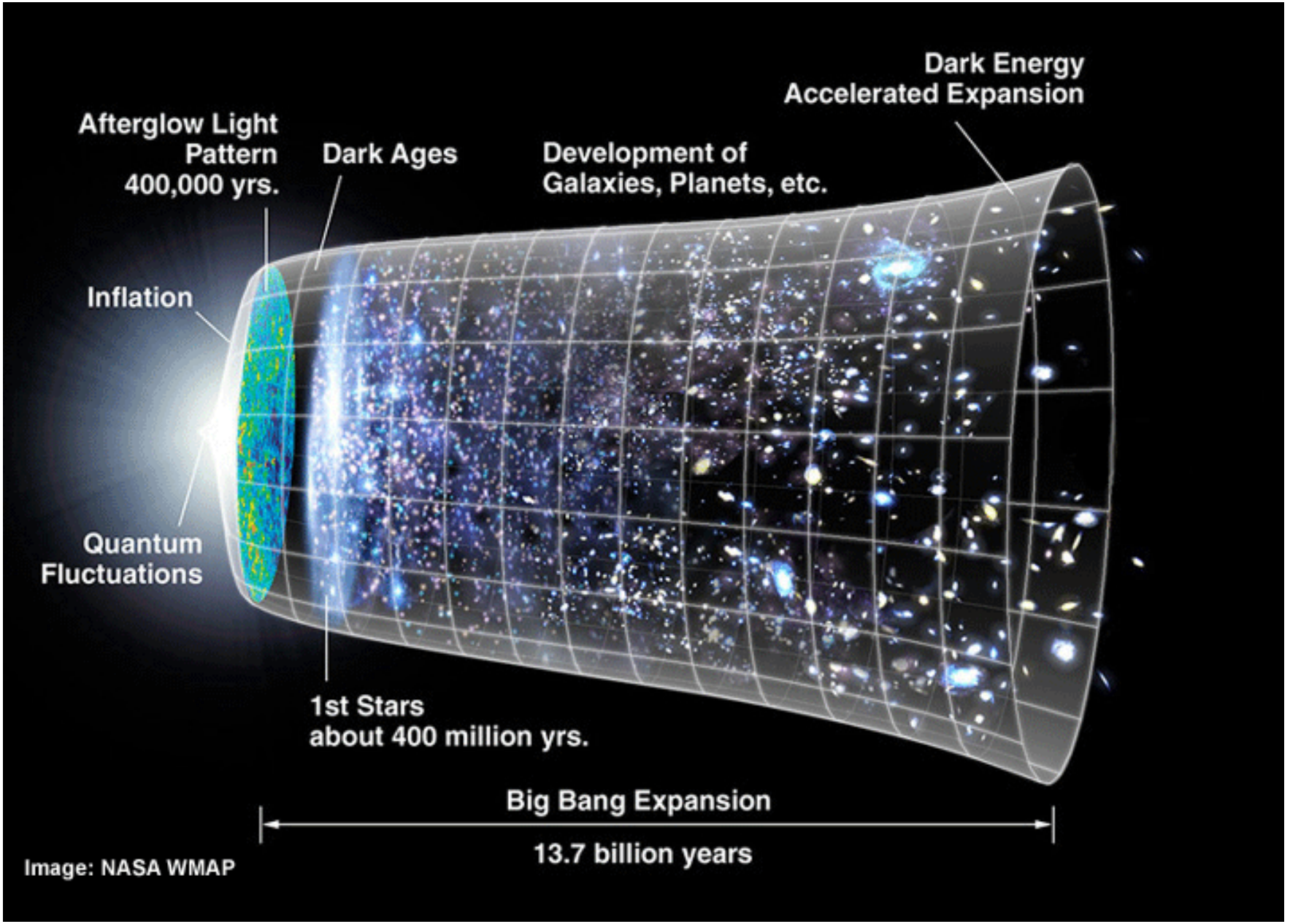
Inside LNF-INFN

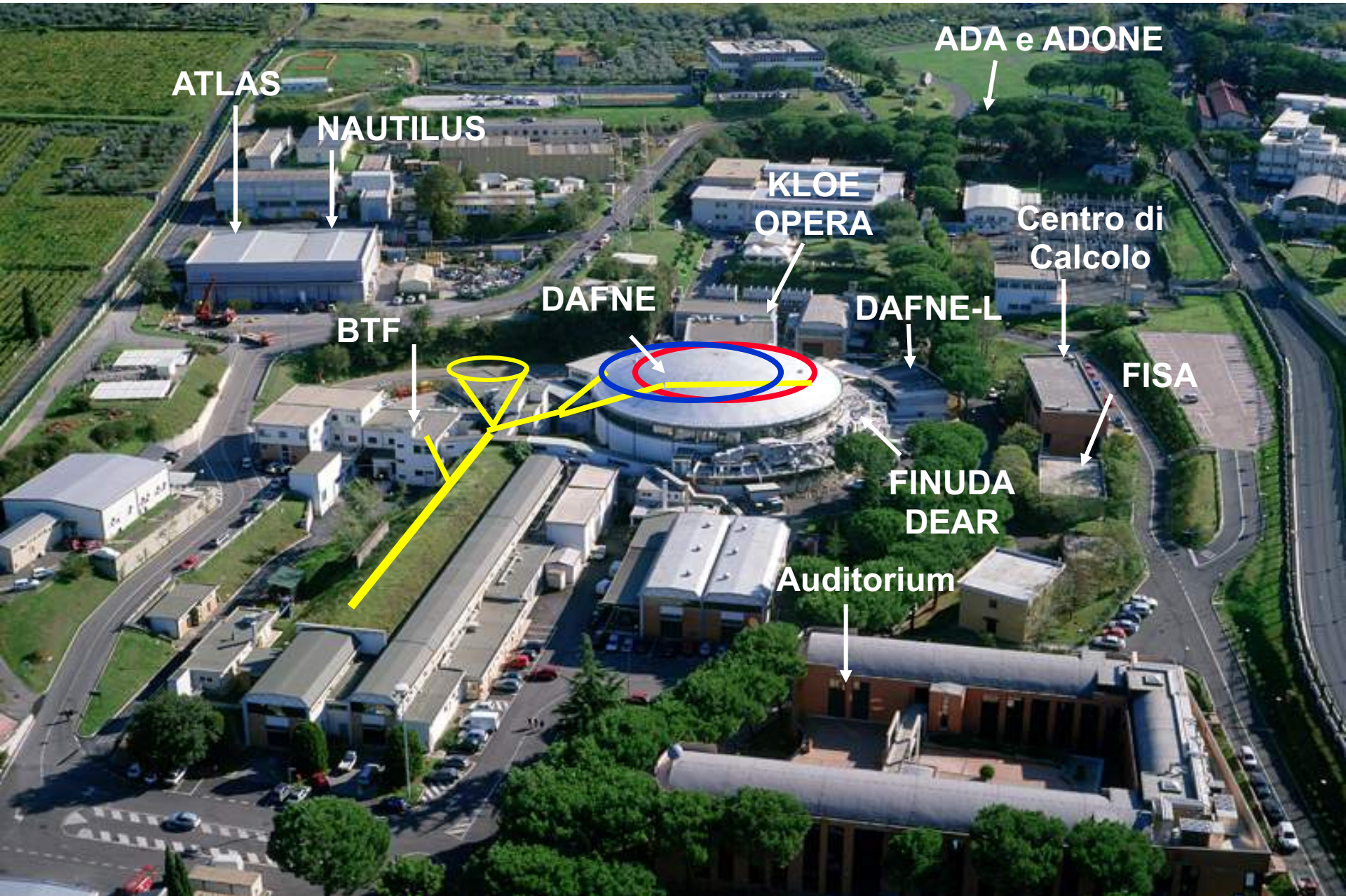


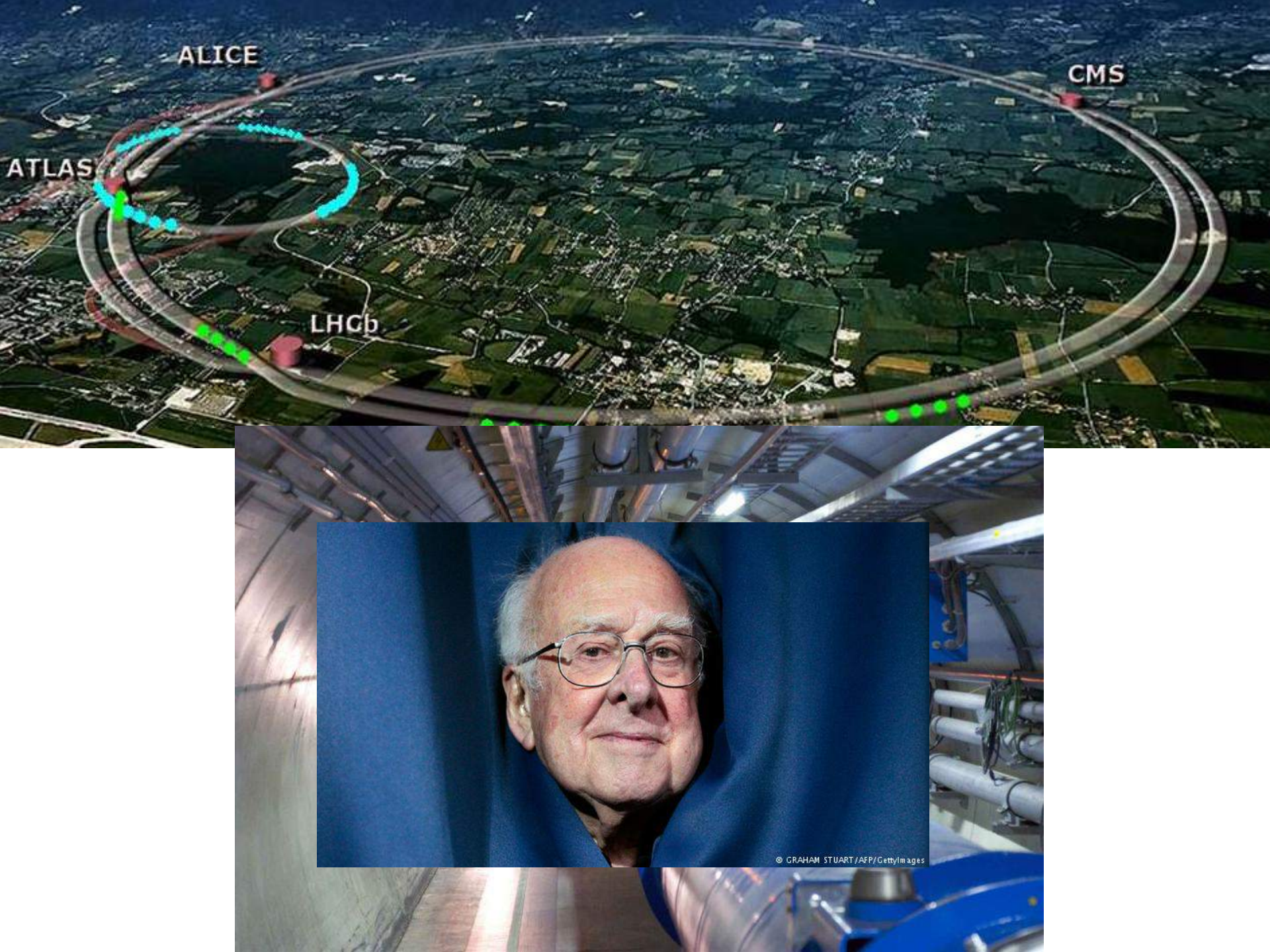



neutron
proton

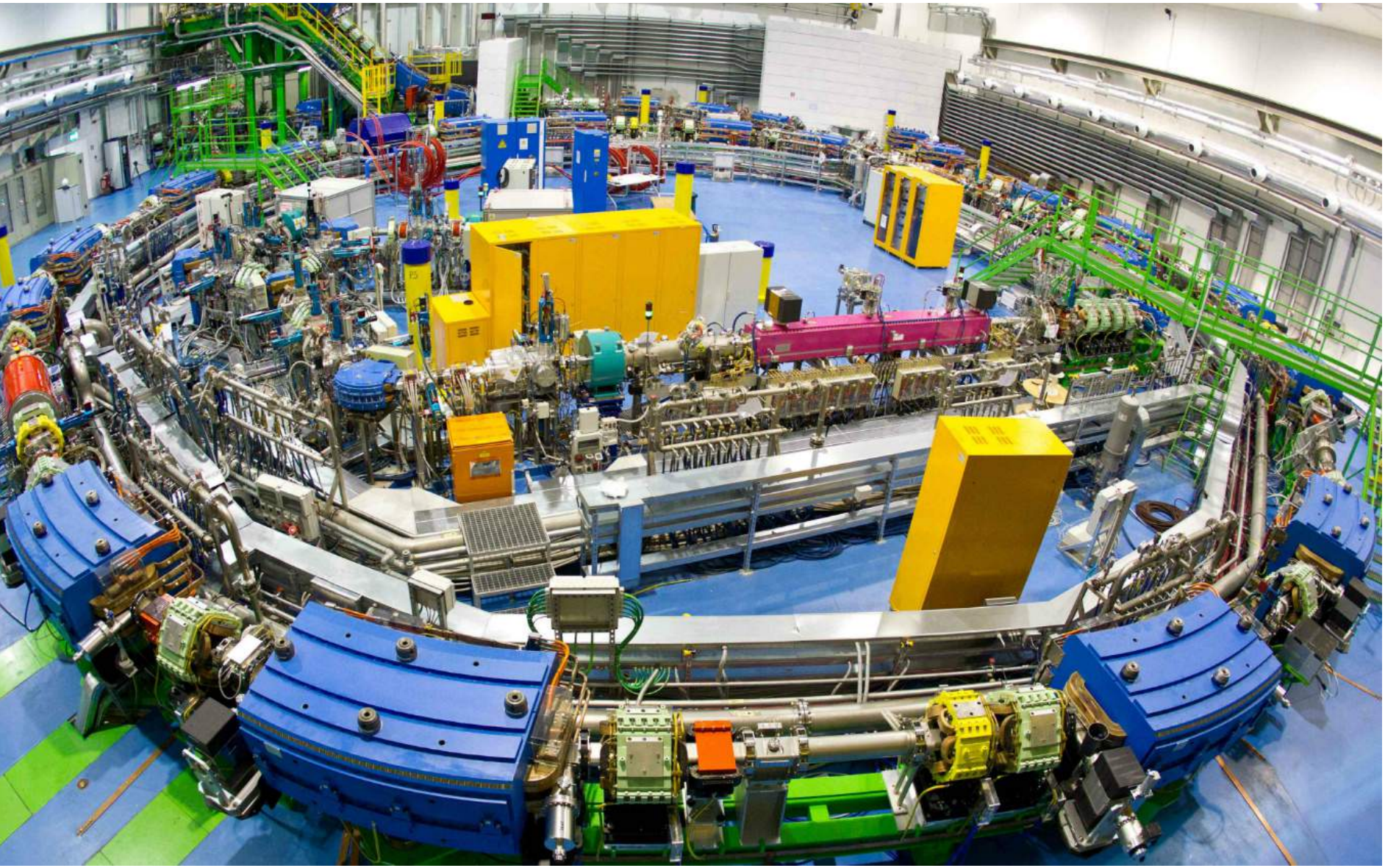

Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years
Image: NASA WMAP

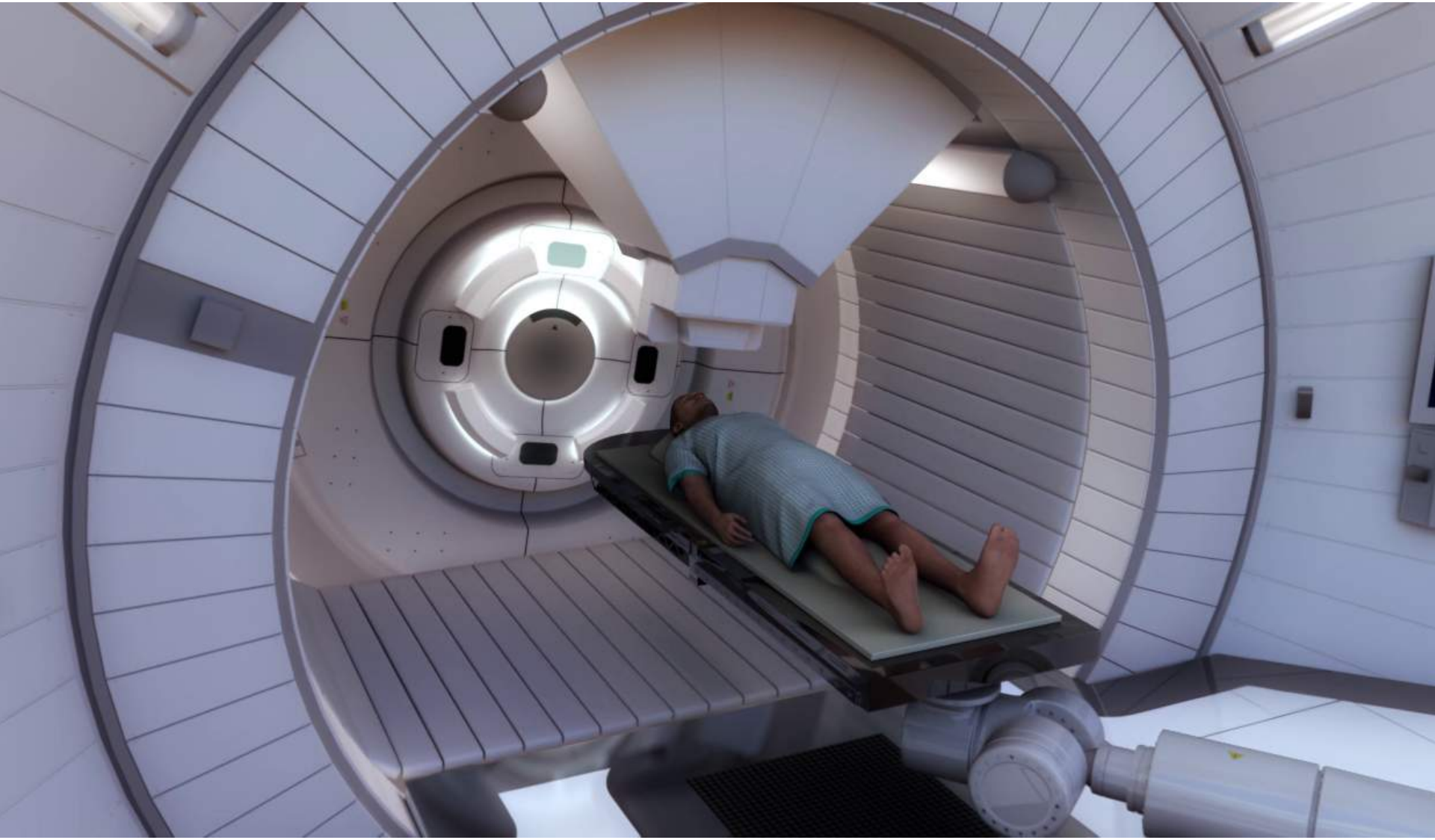
Laboratori Nazionali di Frascati




ALICE
CMS
ATLAS
LHCb
© GRAHAM STUART/AFP/GettyImages

CNAO





Monday 1 April – Auditorium B. Touschek

09:00 – 10:00	Registration
10:15 – 11:00	*Welcome (LNF-INFN Director: P. Campana)*
10:15 – 11:00	*Get INSPYRED – Introduction and Presentation of LNF-INFN activities* *(INSPYRE Directors: C. Curceanu, R. Centioni)*
11:00 – 11:30	*Coffee Break*
11:30 – 13:30	**Students' introduction – Speed date INSPYRE 2019**
13:30 – 14:30	Lunch
14:45 – 16:00	**The Standard Model of Particle Physics (Antonio Polosa, Univ. Sapienza Roma)**

Tuesday 2 April – Auditorium B. Touschek

09:15 – 10:15

Accelerating the future (Massimo Ferrario, INFN-LNF)

10:30 – 11:30

The 7 mysteries of Modern Physics (Catalina Curceanu, INFN-LNF)

Tuesday 2 April – Auditorium B. Touschek

11:30 – 12:00 *Coffee Break*

09:15 – 10:15 Accelerating the future (Massimo Ferrario, INFN-LNF)

12:00 – 12:30 **My path into Particle physics. Hunting muons (Raffaella Donghia, INFN-LNF)**

10:30 – 11:30 The 7 mysteries of Modern Physics (Catalina Curceanu, INFN-LNF)

11:30 – 12:00 *Coffee Break*

12:30 – 13:00 **Characterization of the optical performance of laser retroreflectors for Satellite and Lunar Laser ranging techniques (Chiara Mondaini, INFN-LNF)**

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12:00 – 12:30 **A Physic Wars story: the VIP2 experiment and the rebel electron (Luca De Paolis, INFN-LNF)**

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13:30 – 14:30 *Lunch*

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14:45 – 16:00 **Vivere pericolosamente in the quantum world: taking shortcuts to adiabaticity and driving at the quantum speed limit (Sorin Paraoanu, Aalto University, Finland)**

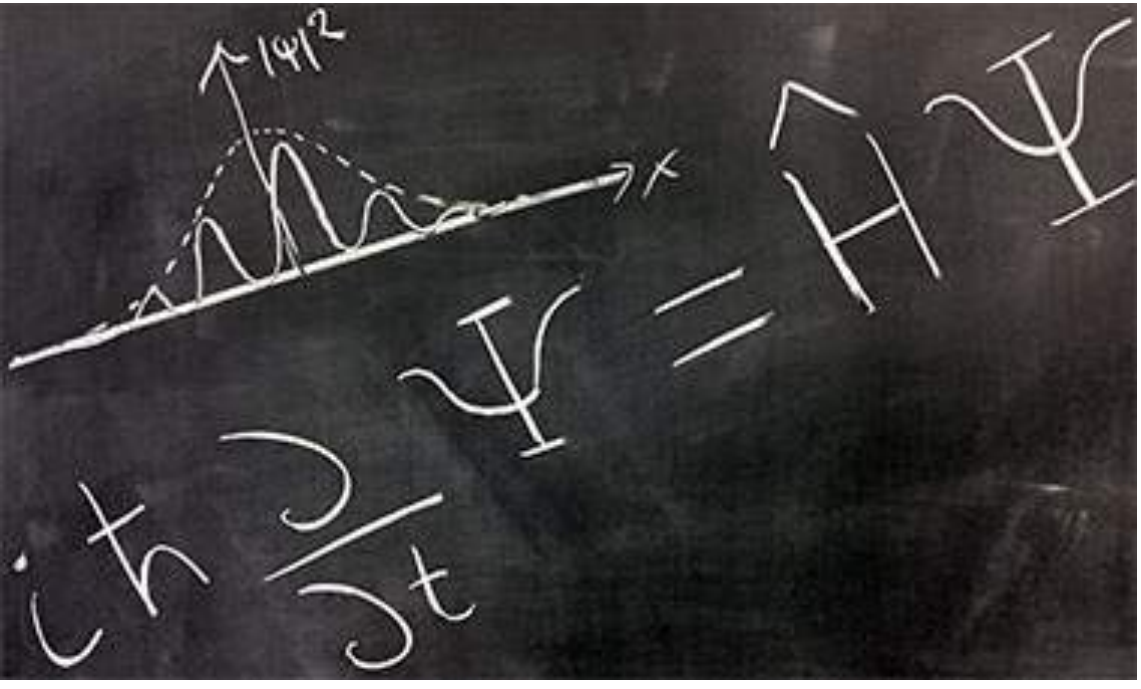
14:45 – 16:00 Vivere pericolosamente in the quantum world: taking shortcuts to adiabaticity and driving at the quantum speed limit (Sorin Paraoanu, Aalto University, Finland)

16:00 – 17:00 Visit to LNF and to Visitor Center

16:00 – 17:00 **Visit to LNF and to Visitor Center**

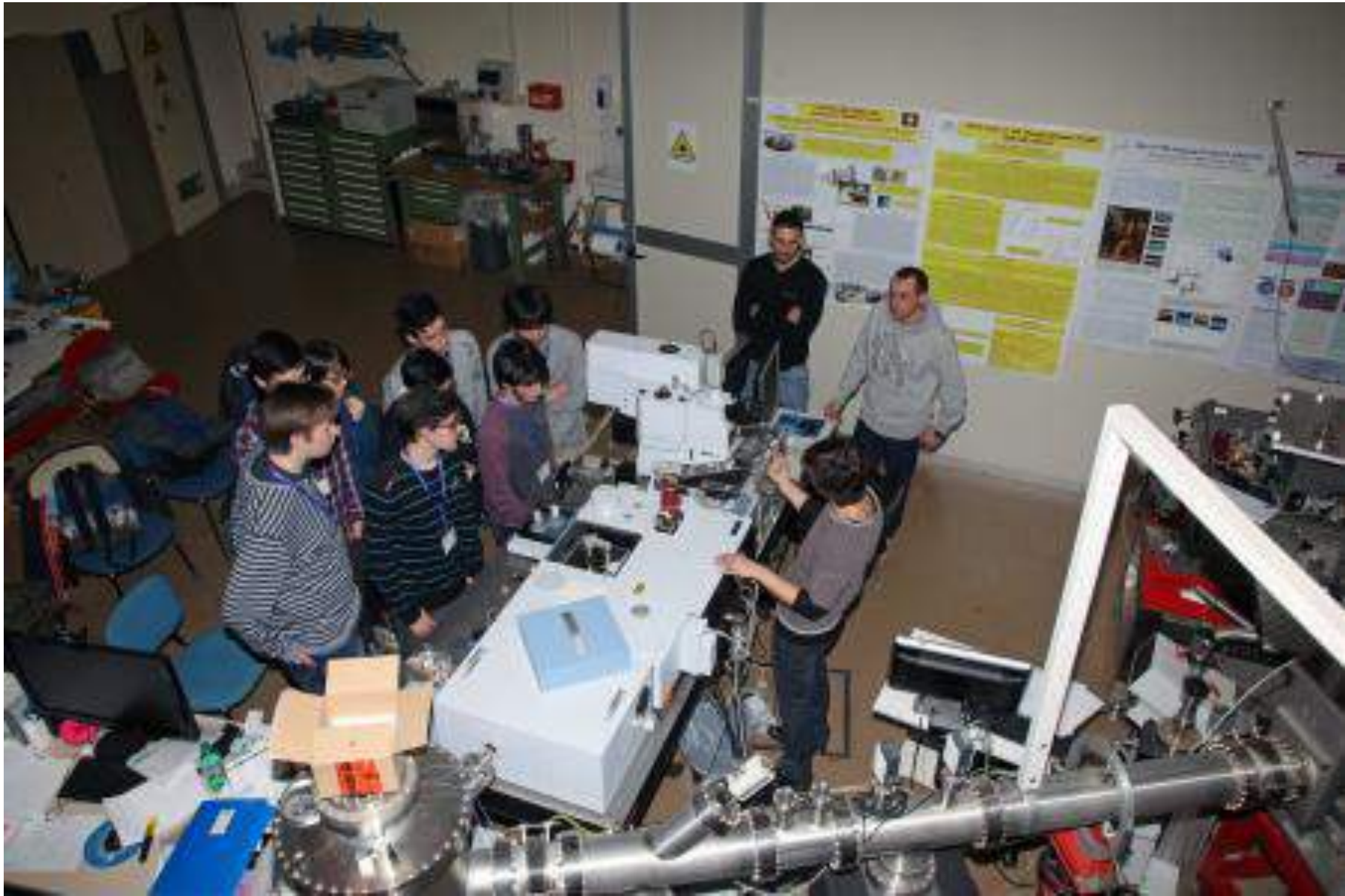
INSPYRE 2019 will host a two-days dedicated event organized in the framework of the European COST Action CA15220 – Quantum Technologies in Space, where recent progress in the quantum realm and main challenges for Quantum Technologies on Earth and in Space will be introduced.

Quantum Mechanics



Quantum Technologies in Space
COST Action CA15220 e TEQ

Hands-on



Wednesday 3 April – Auditorium B. Touschek

09:20 – 13:30	**Dedicated to experiments:** **•Quantum Mechanics experiments (S. Bertelli, E. Turri, INFN-LNF)** **•ArduSipm electronic (V. Bocci, F. Iacoangeli, INFN-Roma 1)** **•Atoms, X-rays and Synchrotron Radiation (A. Balerna, INFN-LNF)** **•Medicine & Physics (G. Gadda, INFN-Ferrara)** **•Channeling Technologies (S. Dabagov, D. Hampai, INFN-LNF)** **•Cosmic Ray (P. Ciambrone, G. Felici, C. Gatti, G. Papalino INFN-LNF)** **•Solar energy and photovoltaic systems (P. Bernardoni, INFN-Ferrara)** **•Discovering Enviromental Radioactivity (M. Alberi, E. Chiarelli INFN-Ferrara)** **•Gravitational lenses (P. Bergamini, Univ. di Ferrara)**
13:30 – 14:30	*Lunch*
14:45 – 16:00	**Einstein, E.T. and the cosmic gold factory (Viviana Fafone, Univ. Roma Tor Vergata)**
16:00 – 17:00	**Visit to LNF and to Visitor Center**
17:00 – 18:00	**Lectio Magistralis: Meet the qubit… and send it around! (Paolo Villoresi, Univ. of Padova) OPEN TO THE PUBLIC**
19:30	**Social Event**

Thursday 4 April– Auditorium B. Touschek

09:20 – 13:30

Dedicated to experiments:

- **Quantum Mechanics experiments (S. Bertelli, E. Turri, INFN-LNF)**
- **Bionanotechnologies (A. Cataldo, O. Calamai, S. Bellucci, INFN-LNF; A. Lustrissimi, Progetto Torno Subito Reg. Lazio)**
- **ArduSipm electronic (V. Bocci, F. Iacoangeli, INFN-Roma 1)**
- **Diagnostics and preservation of Cultural Heritage (M. Cestelli Guidi, M. Romani, INFN-LNF)**
- **Medicine & Physics (G. Gadda, INFN-Ferrara)**
- **Channeling Technologies (S. Dabagov, D. Hampai, INFN-LNF)**
- **Cosmic Ray (P. Ciambrone, G. Felici, C. Gatti, G. Papalino INFN-LNF)**
- **Solar energy and photovoltaic systems (P. Bernardoni, INFN-Ferrara)**
- **Discovering Enviromental Radioactivity (M. Alberi, E. Chiarelli, INFN-Ferrara)**
- **Simulation of events at LHC: from generation to reconstruction (G. Corcella, M. Testa)**
- **Gravitational lenses (P. Bergamini, Univ. di Ferrara)**

13:30 – 14:30

Lunch

14:45 – 16:00

Quantum nonlocality: science fiction becomes reality (Angelo Bassi, Univ. and INFN Trieste)

Friday 5 April – Auditorium B. Touschek

09:00 – 10:15	**Dark Matter searches, or else how to see something invisible (Elisabetta Baracchini, GSSI)**
10:15 – 11:15	**Physics at the LHC (Michelangelo Mangano, CERN)**
11:15 – 11:45	*Coffee Break*
11:45 – 12:45	**Schrödinger's cat in space (Rainer Kaltenbaek, Vienna University)**
12:45 – 13:30	**Discussions, participation certificates awarding and farewell**
13:30	*Lunch*

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

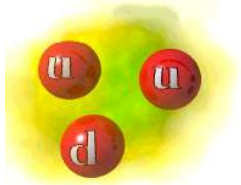
Laboratori del Sud (Catania)

19 Sections

11 Related Groups

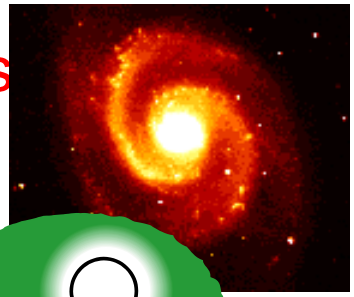
4 National Laboratories

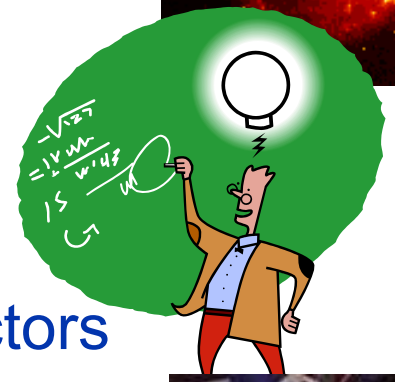
What are the activities performed at Laboratori Nazionali di Frascati?



Fundamental research

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





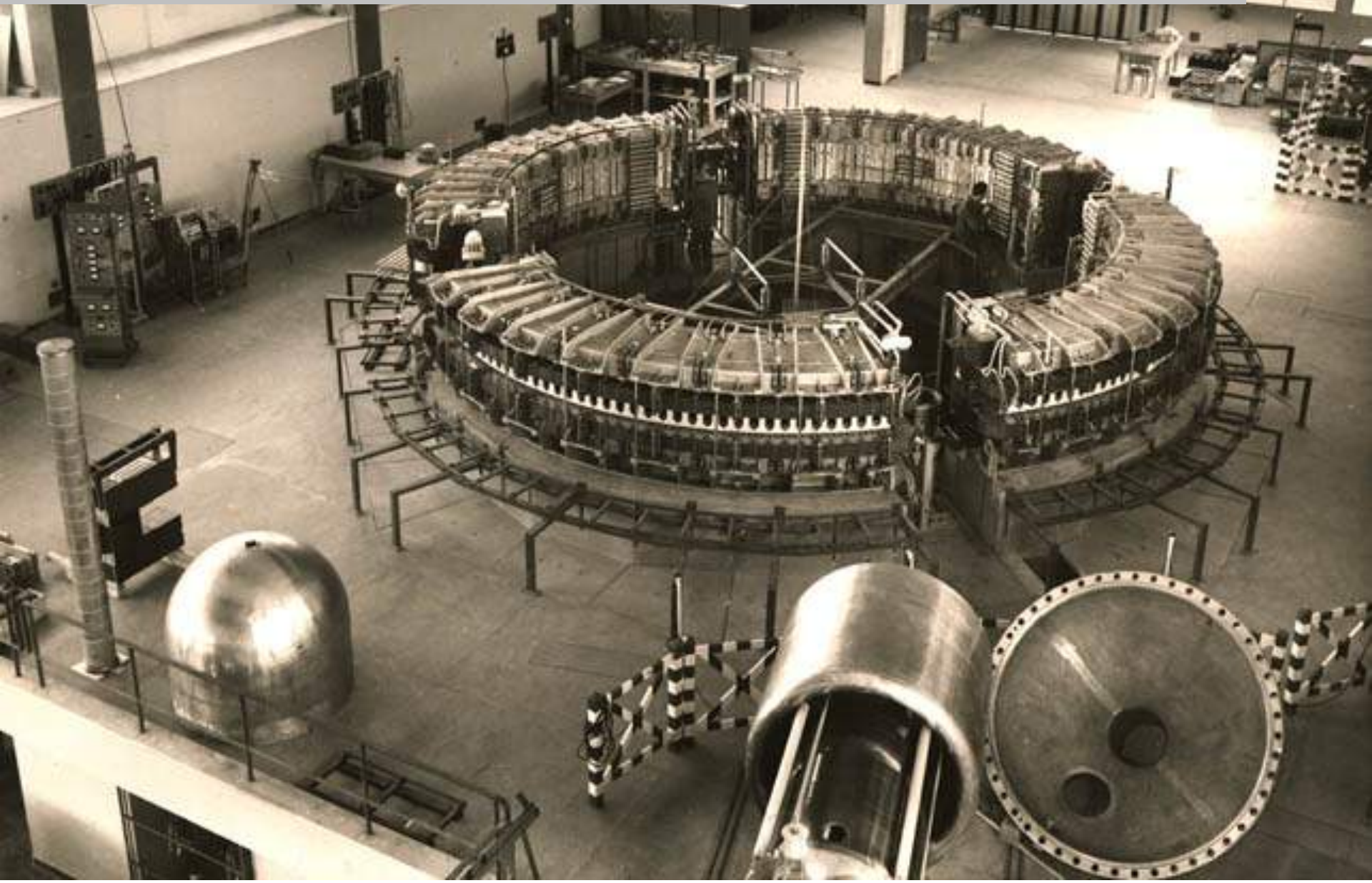
- Development and construction of particle detectors
- Studies and development of accelerating techniques
- Material studies and bio-medical research with the synchrotron light
- Development and support for computing systems and nets

Frascati National Labs (LNF)

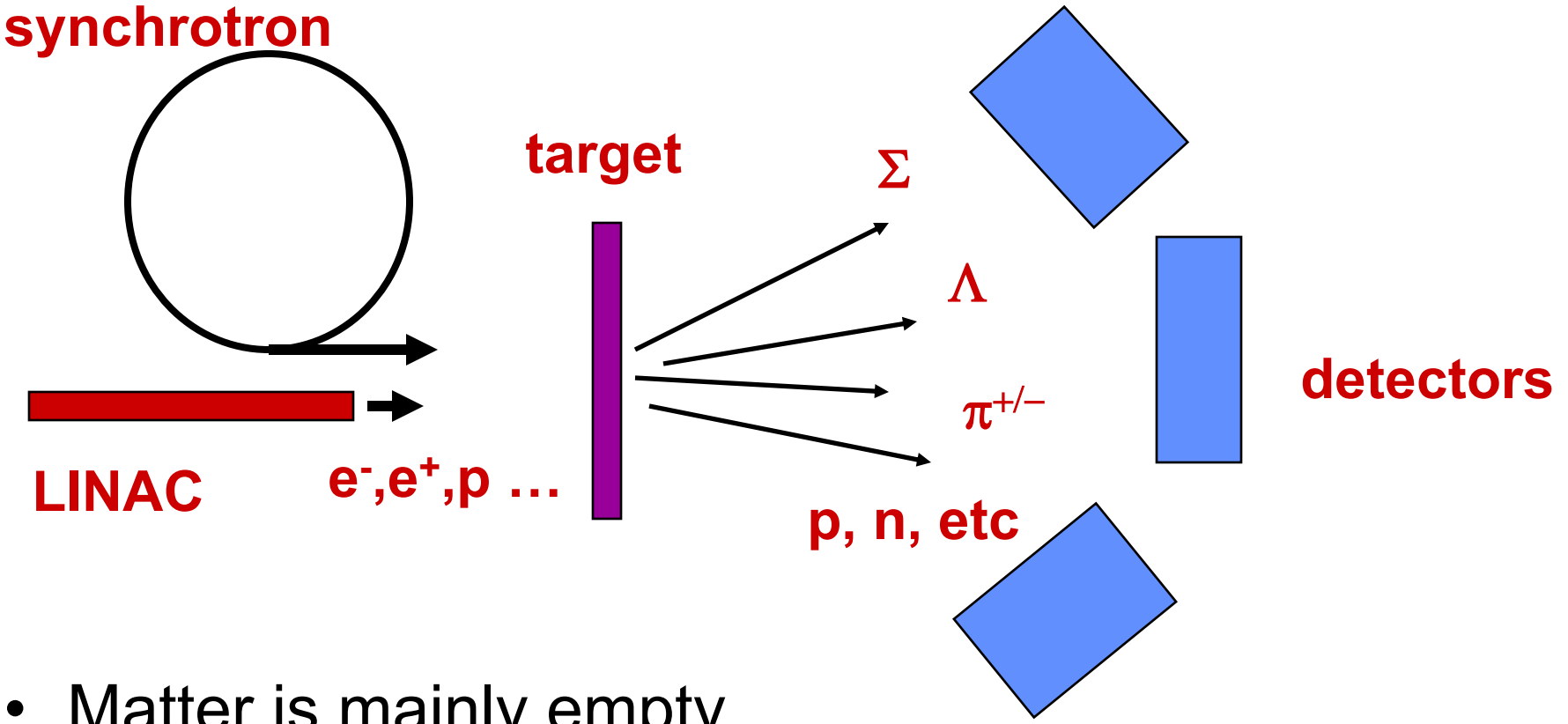
Total Staff of which: **364**	**Researchers** **98**	**Technologist/ Engineers** **57**	**Technicians** **170**	**Administration/ Services** **39**
External Users **546**	***Italian*** **346**		***Foreign*** **200**	
Visitors **3960**	**Stages** **310**	**Conference Workshops** **17**	**Participants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


LNF
DAFNE-light
LINAC
DAFNE
BTF
SPARC
FLAME

Frascati electrosynchrotron 1959-1975

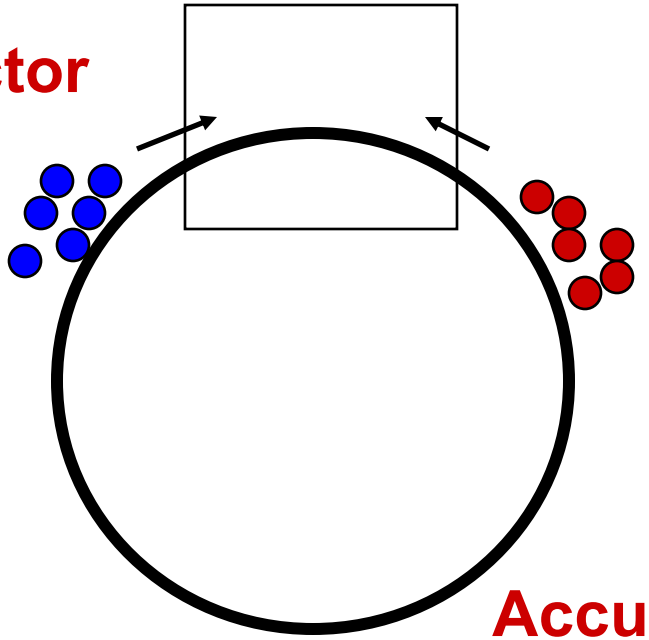


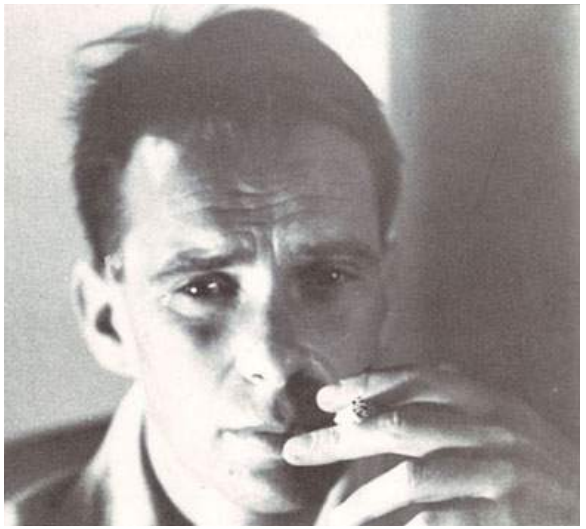
Observing on fixed target



- 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

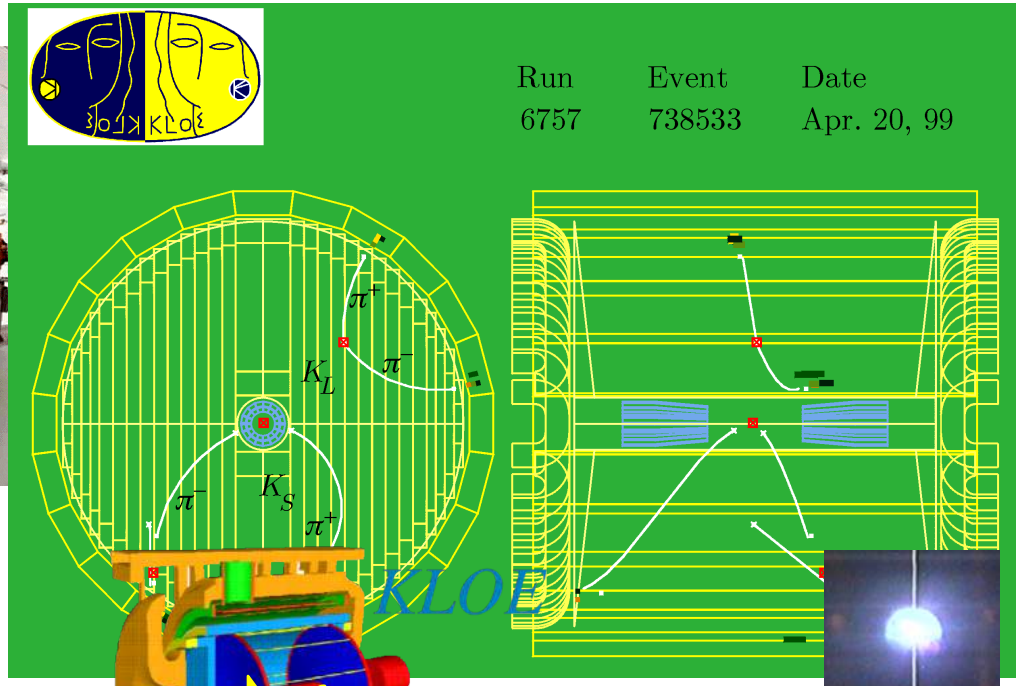
E = m c²

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

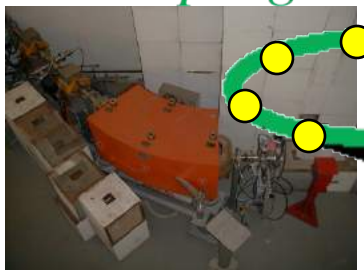
Matter-antimatter colliders

LHC at Cern (pp)

DAΦNE



Damping ring



Test beam

Main rings

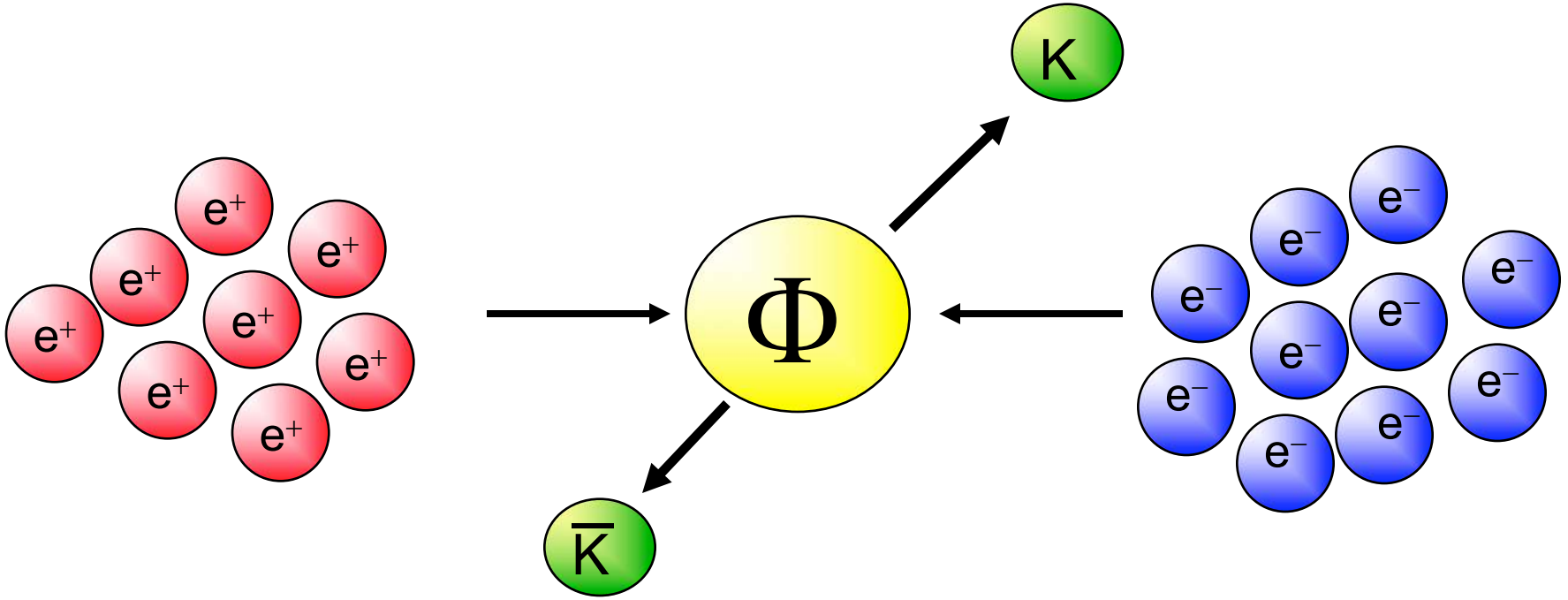
DAFNE-Light

Linac

DEAR
FINUDA

Physics at DAΦNE

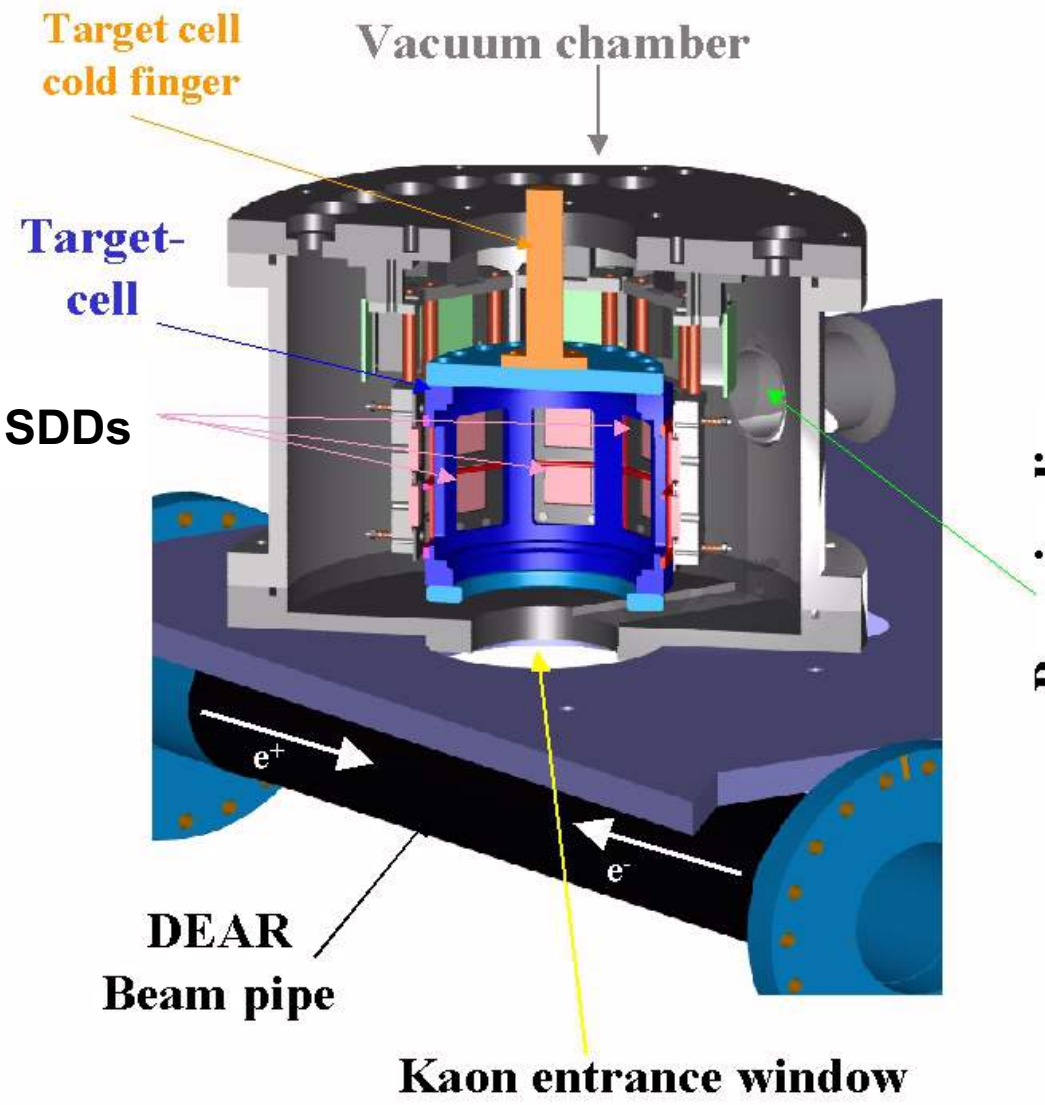
Out of the electron – positron collisions the Φ meson can be produced; it decays immediately in other two particles, the *K*-mesons (kaons). The kaons can be both neutrals or charged.



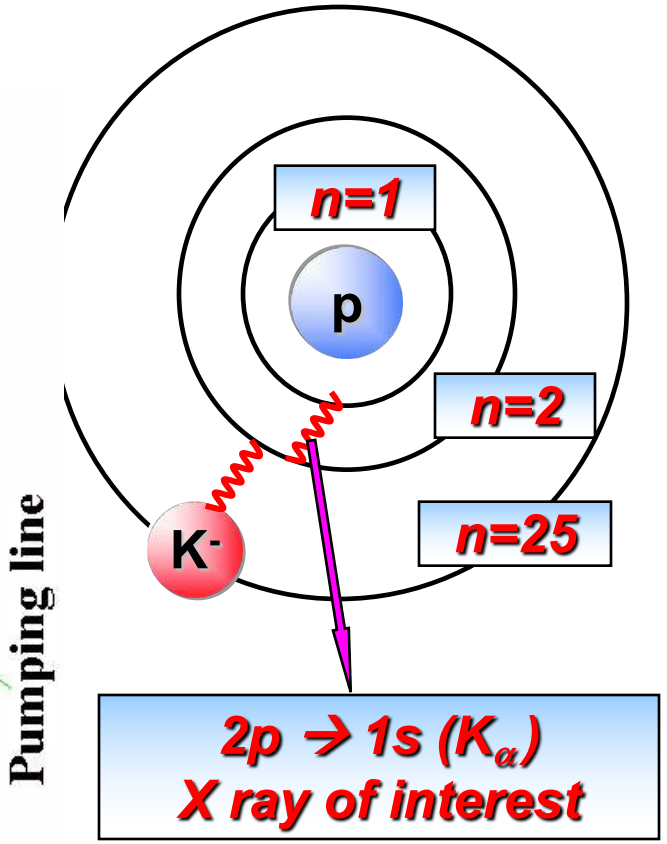
The *K* are the particles used by the three experiments, DEAR, FINUDA and KLOE, to reach their scientific goals. The DAΦNE luminosity allows to produce about 10000 *K* in a second

SIDDHARTA

(DAΦNE Exotic Atom Research)

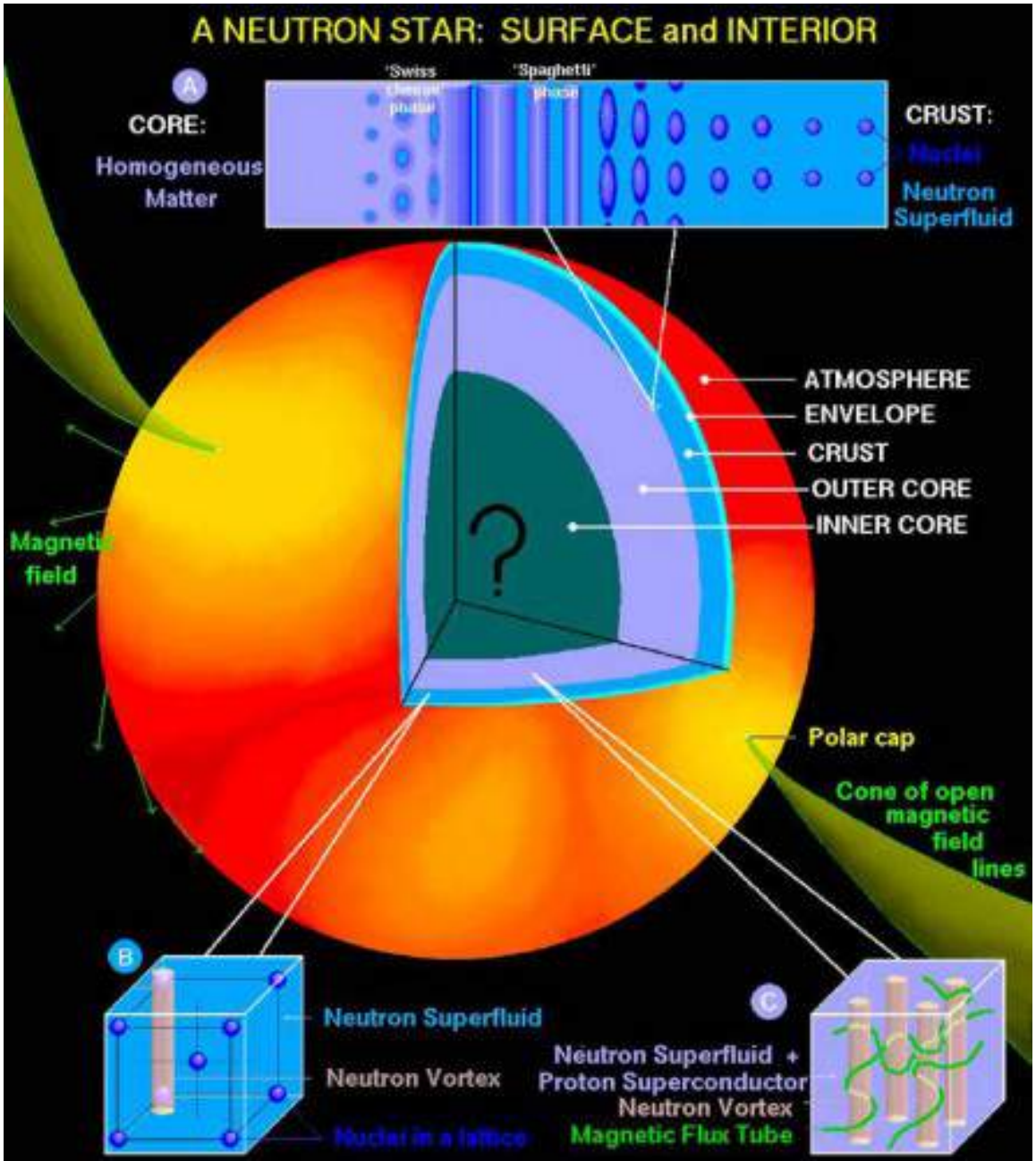


Kaonic hydrogen



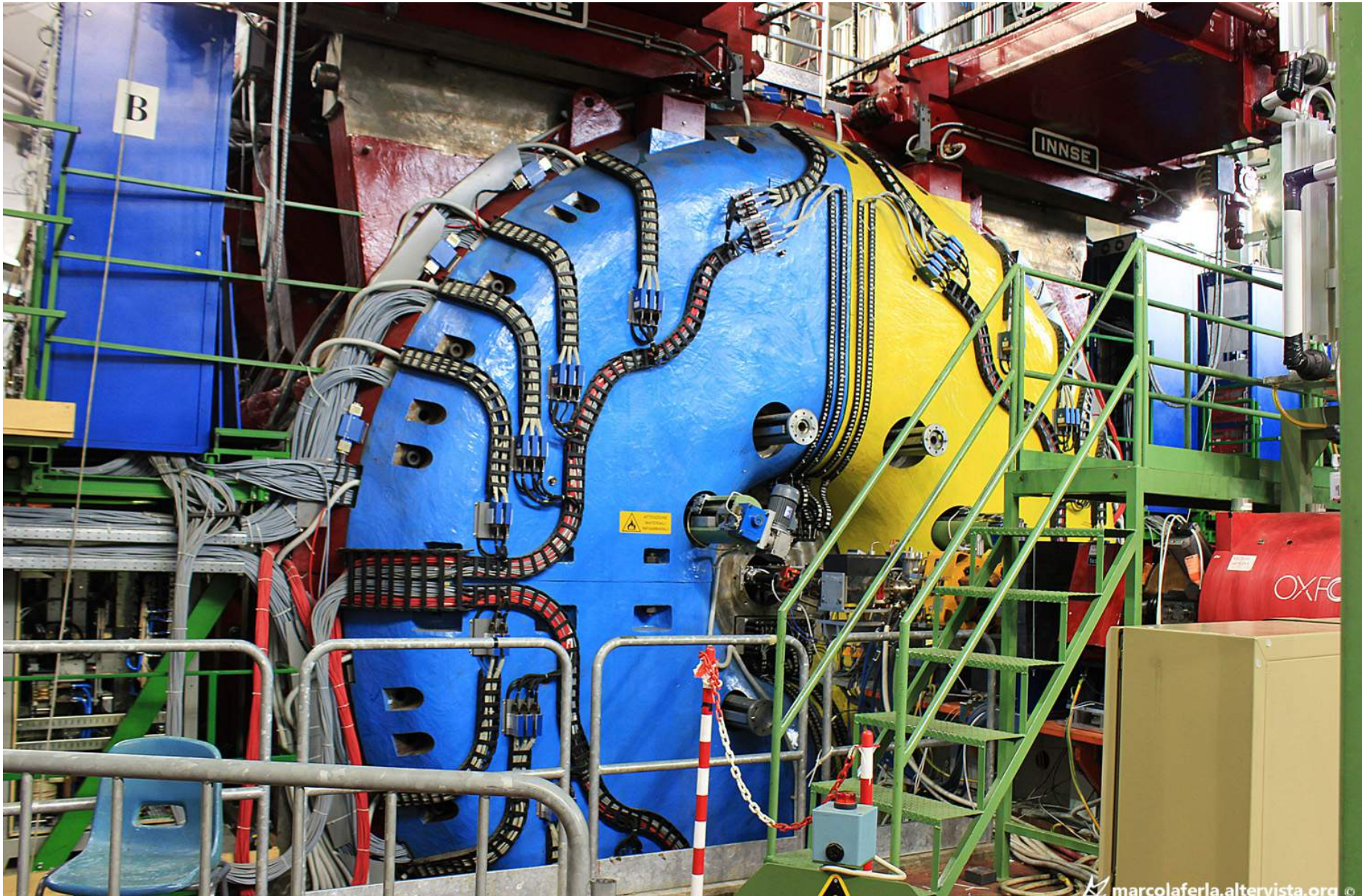
The DEAR experiment investigates the *strong force* by studying the *kaonic atoms* (in which a K^- is substituting an atomic electron).

Could strangeness play a role in neutron stars?

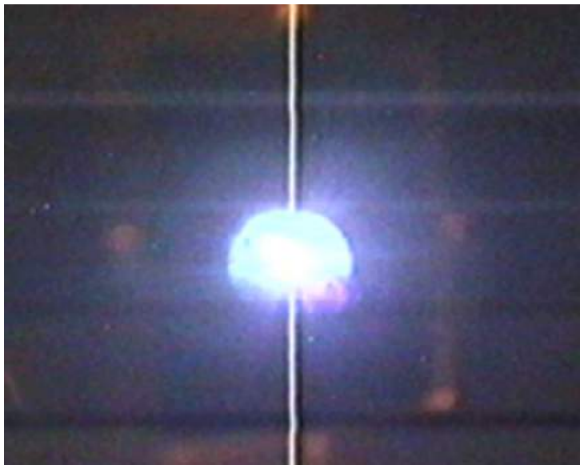


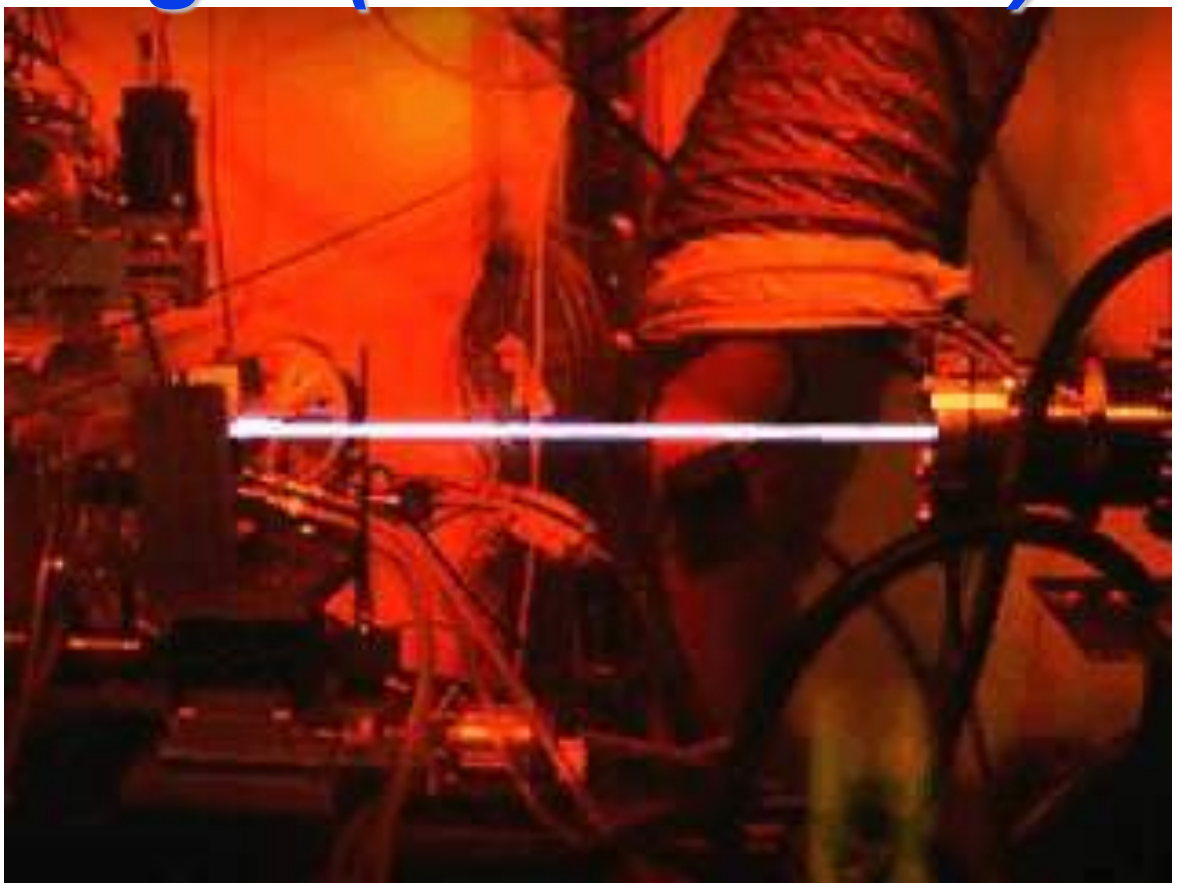
KLOE2

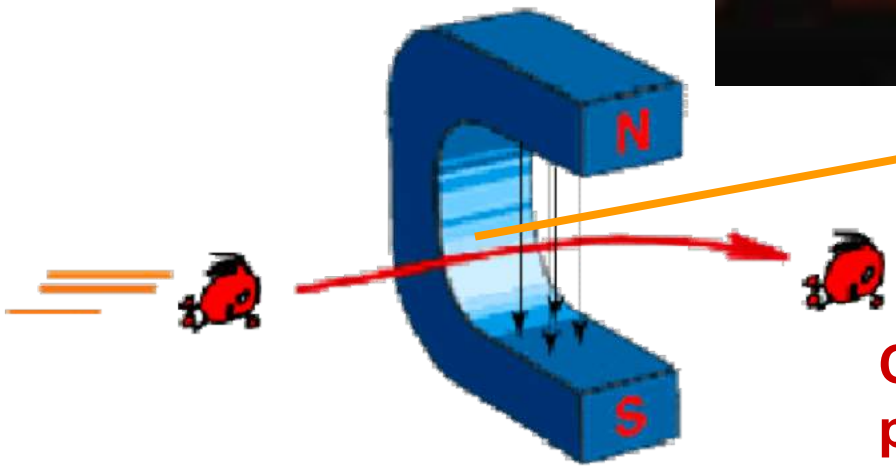
(K LOng Experiment)



Synchrotron light (DAΦNE-luce)







Light (photons)

European Synchrotron Radiation Facility

Charged particle

FLAME:Frascati Laser for Acceleration and Multidisciplinary Experiments

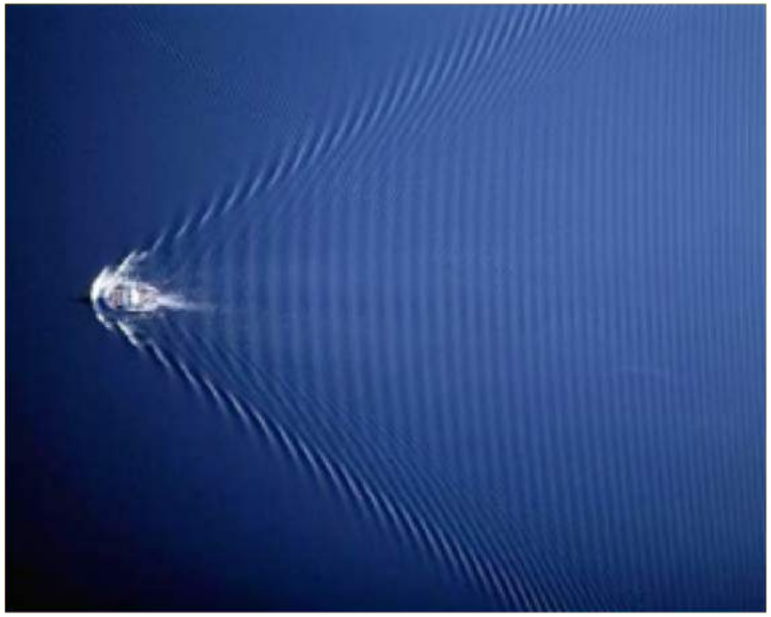
Laser of high power (> 100 TW), able to produce pulses of 6 J in 20 fs at 10 Hz

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

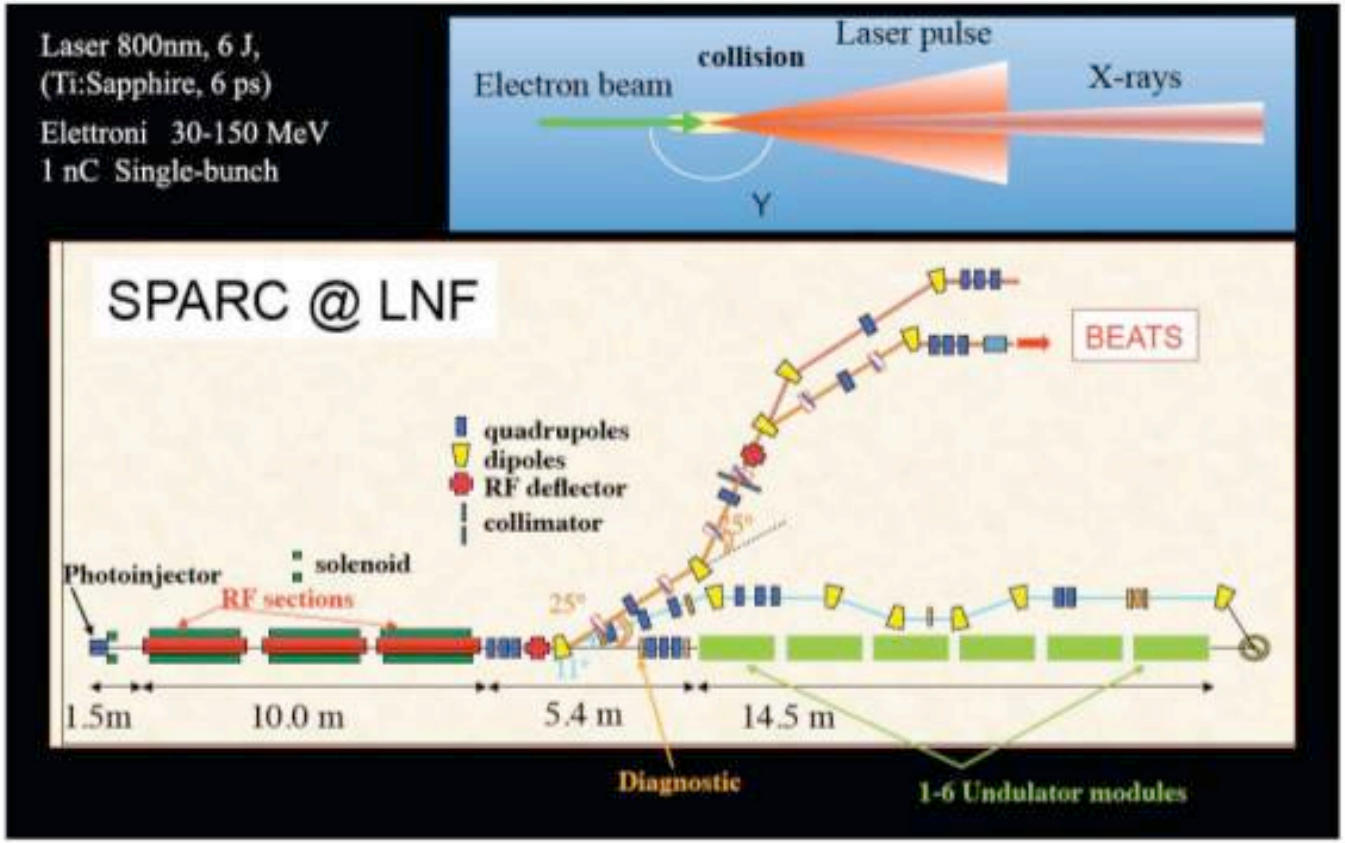


Fig. 1 – Sorgente Thomson ai LNF

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

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Medical diagnosis and material science

Mamography

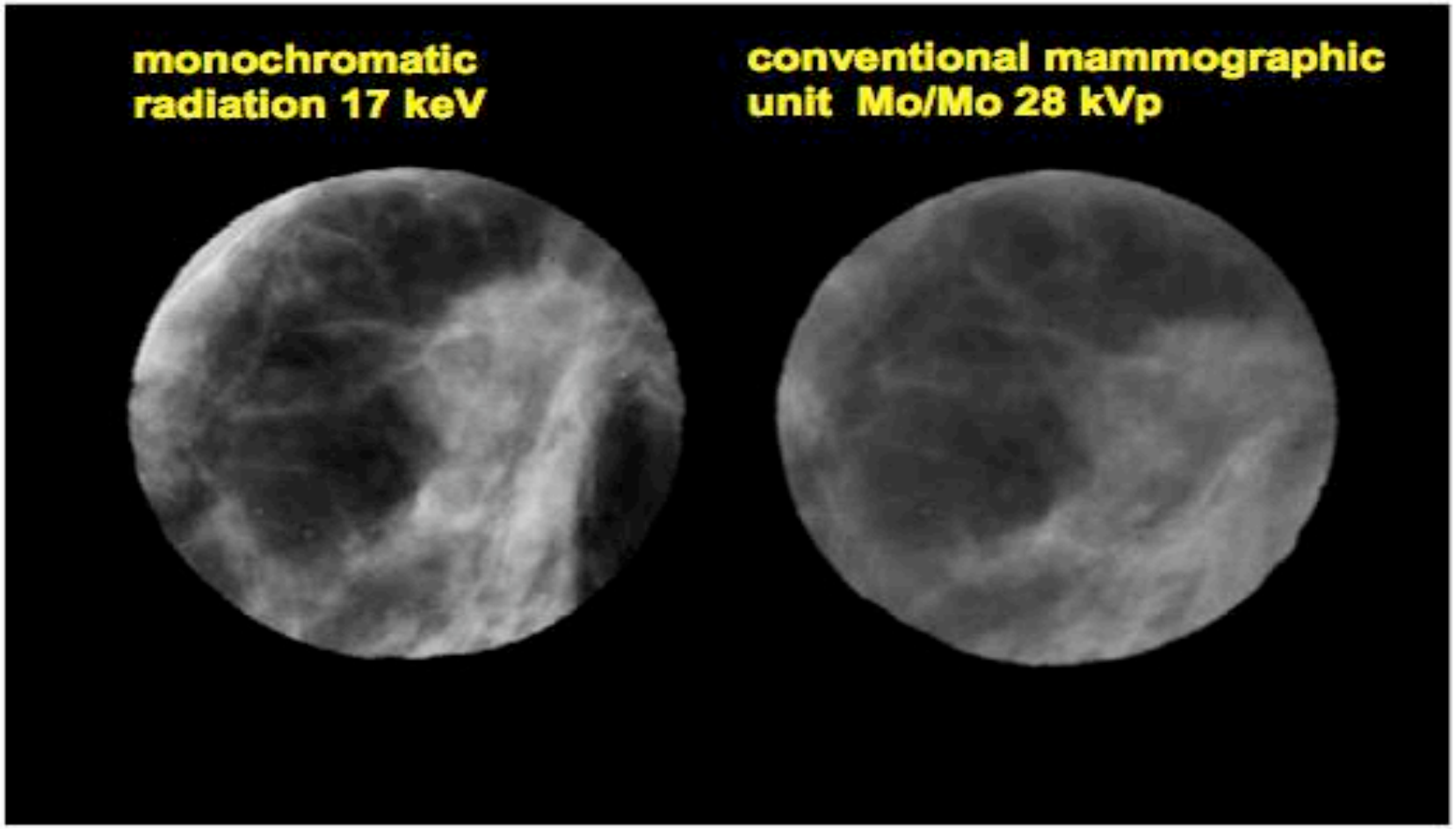
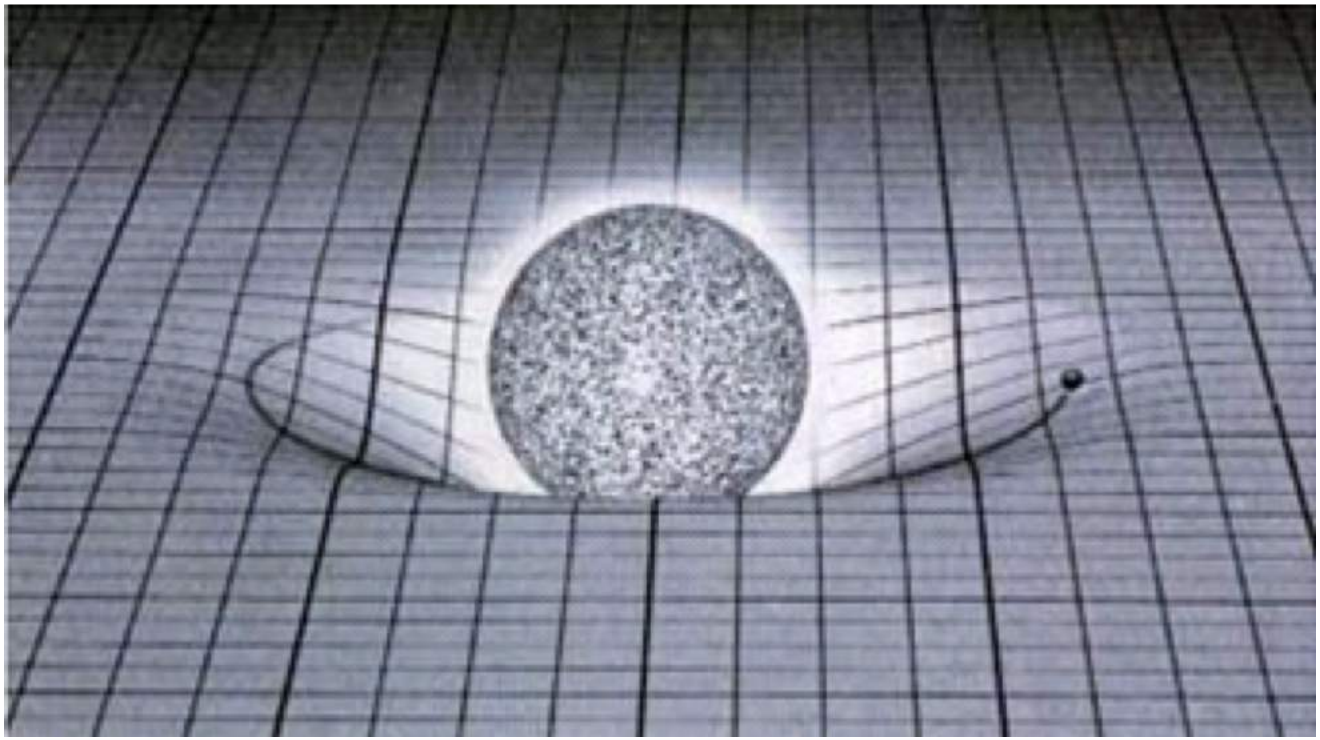
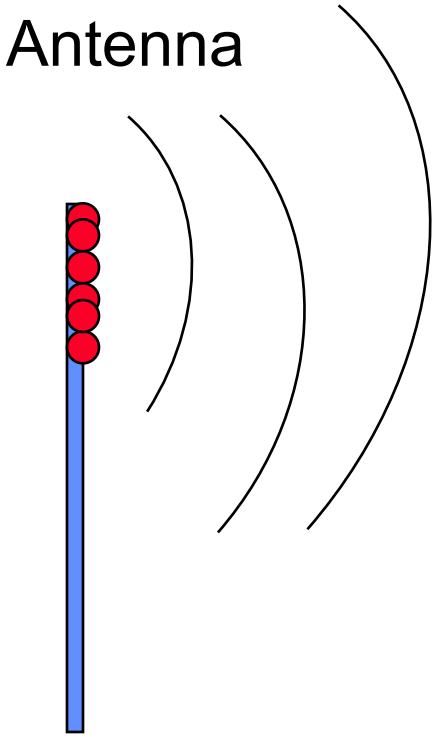


Fig. 3 – Confronto fra una mammografia monocromatica (sinistra) con una tradizionale (destra).

Gravity force`

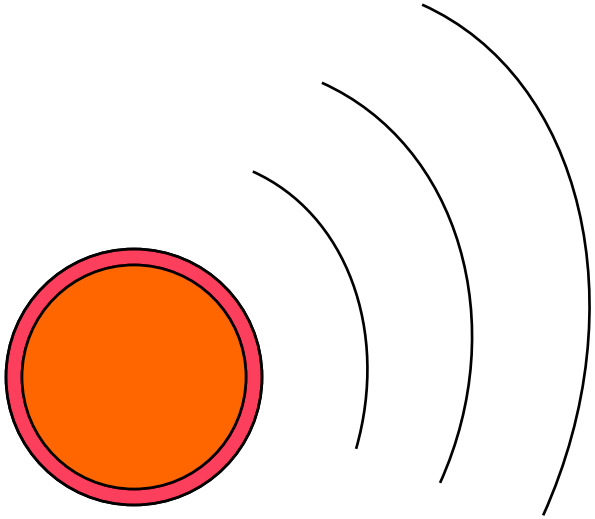


Distortion of space-time

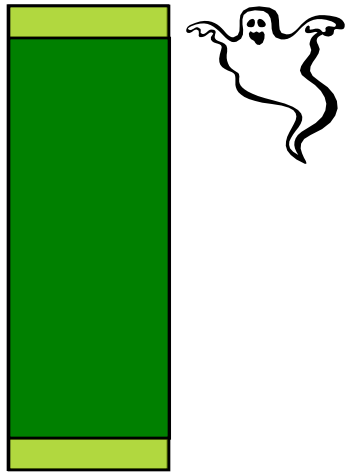


The electromagnetic waves are produced by an electric charge in movement

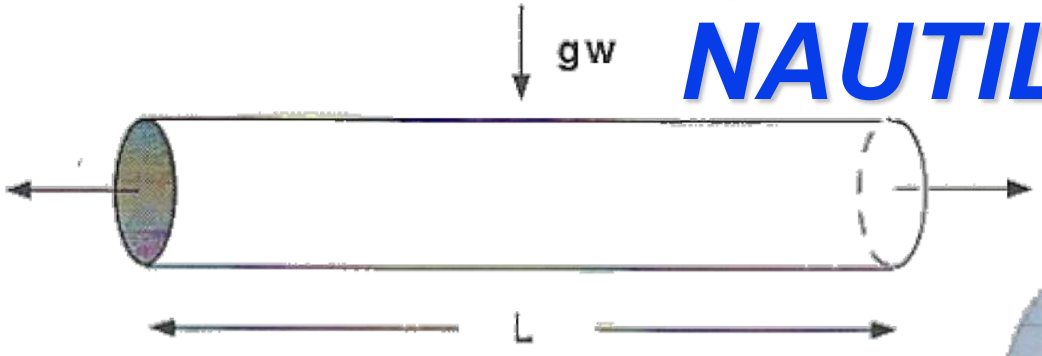
Gravitational waves: an analogy



Gravitational waves are produced by masses in movement….



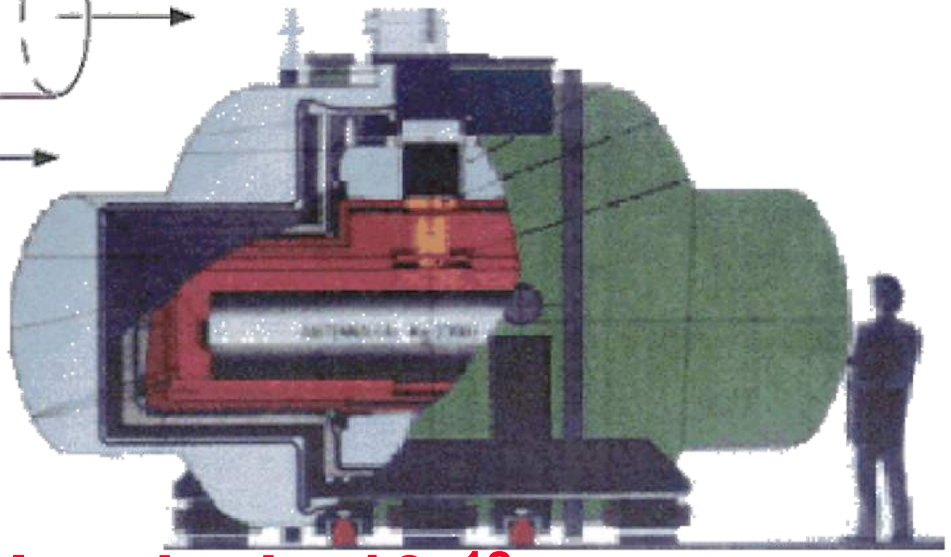
Search for gravitational waves: NAUTILUS



vibrations in the bar

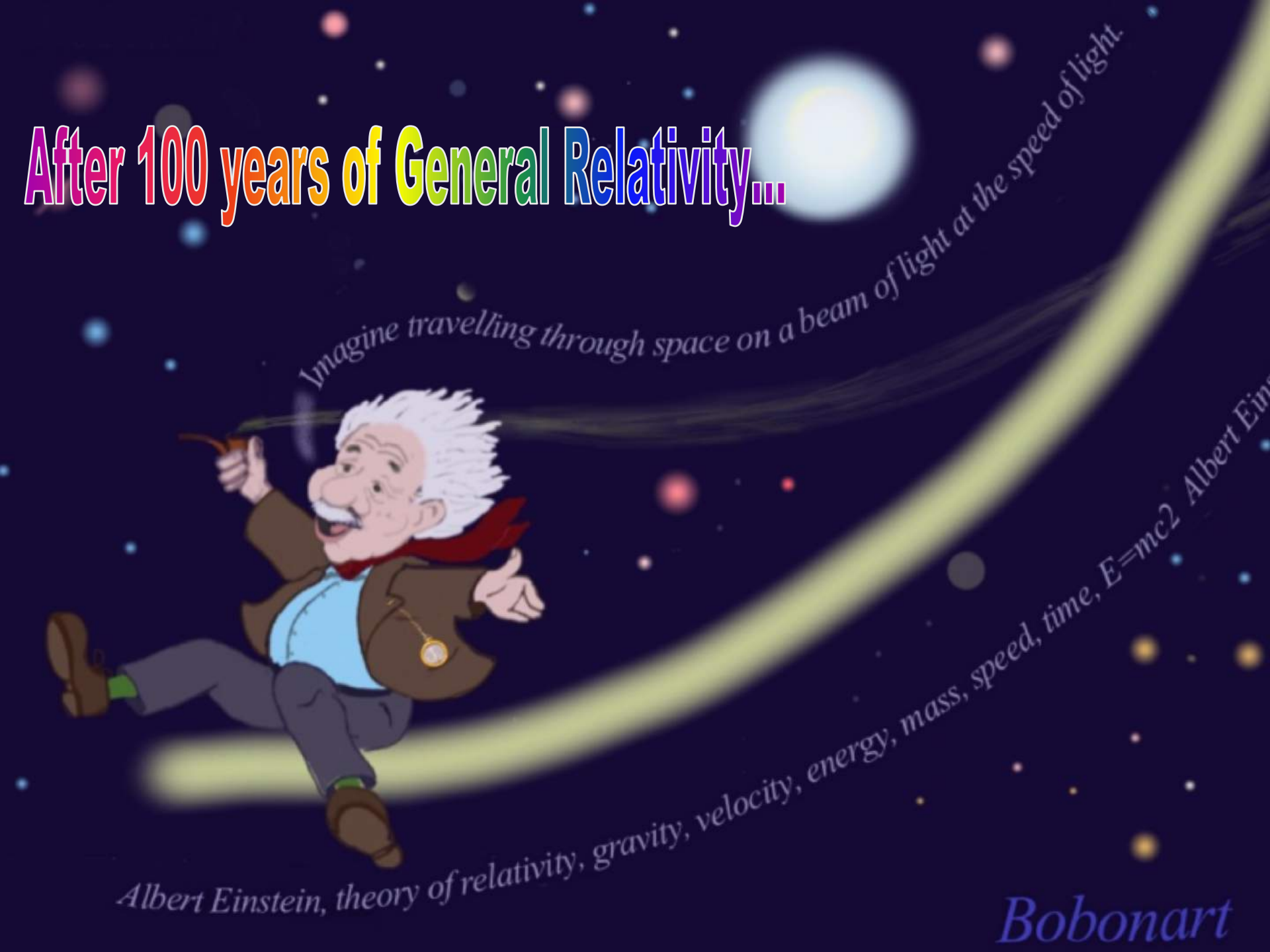
(for Al, L=3 m, f=915 Hz)

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

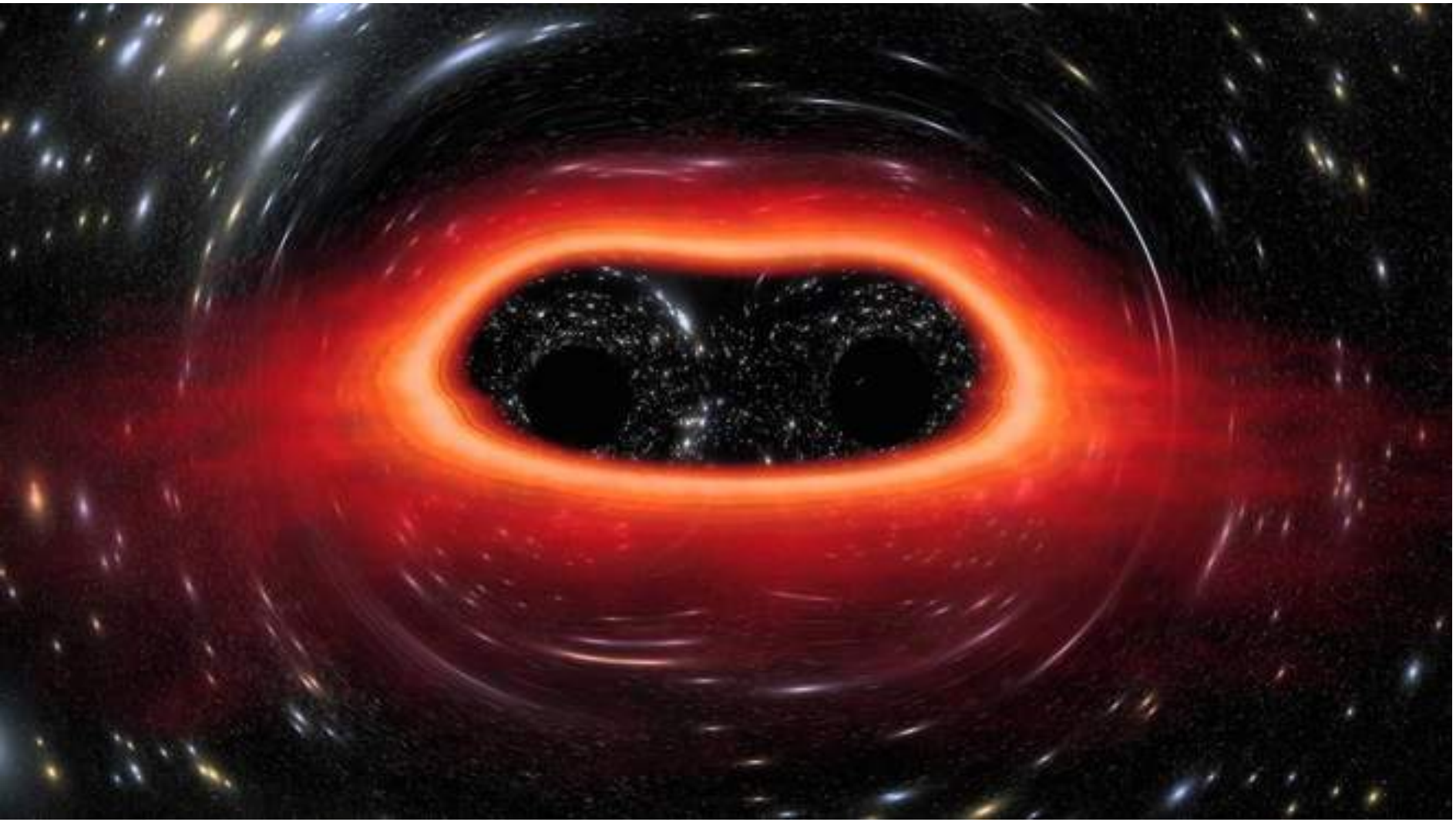


- **Supernova in our Galassia $h=10^{-18}$**
- **Supernova in Virgo $h=10^{-21}$**
- **Thermal noise @ T=300 K, $\Delta L=10^{-16}$ m**
- **Thermal noise @ T=3 K, $\Delta L=10^{-17}$ m**
- **Thermal noise @ T=300 mK → $\Delta L=10^{-18}$ m**

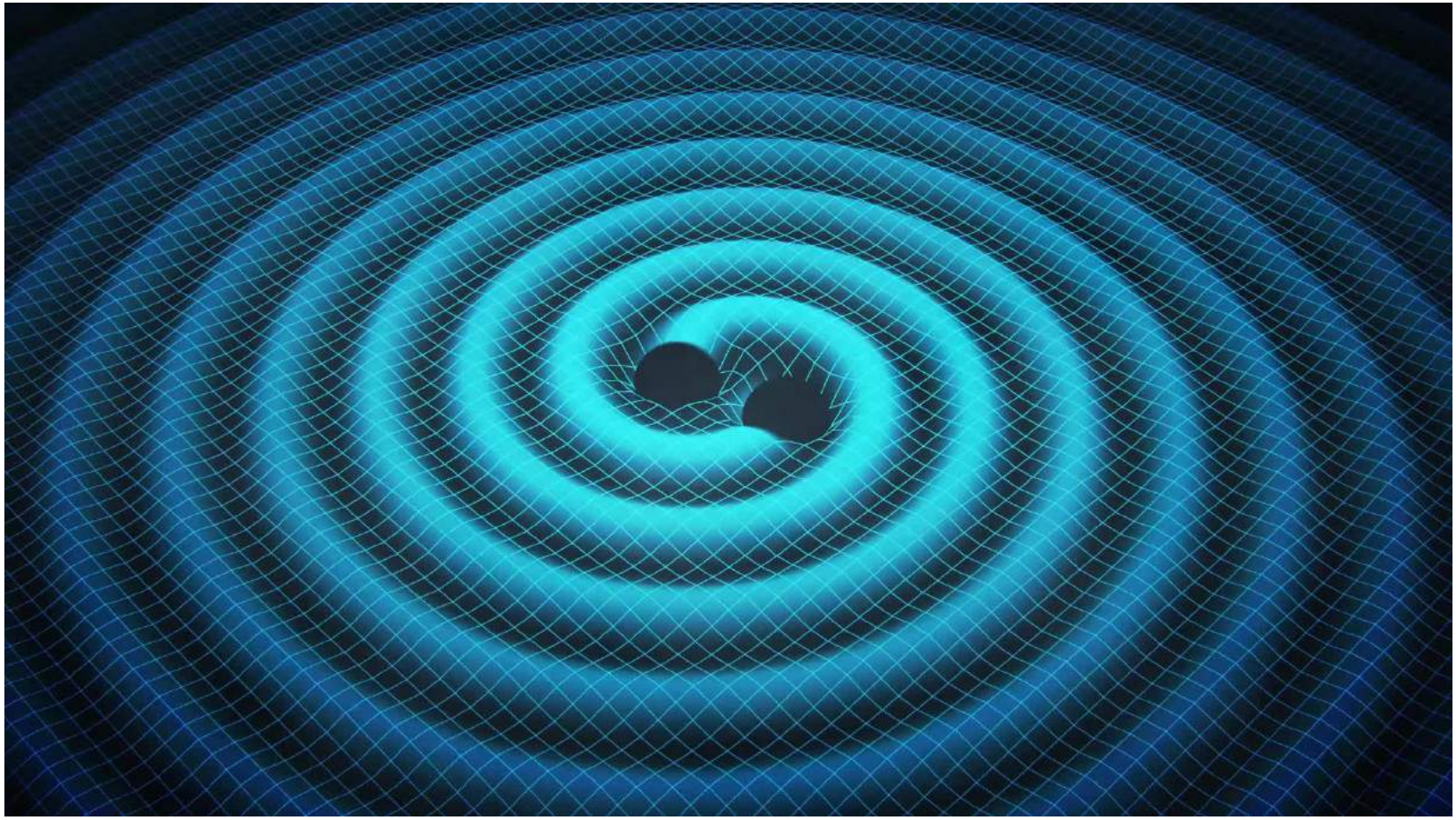
After 100 years of General Relativity...



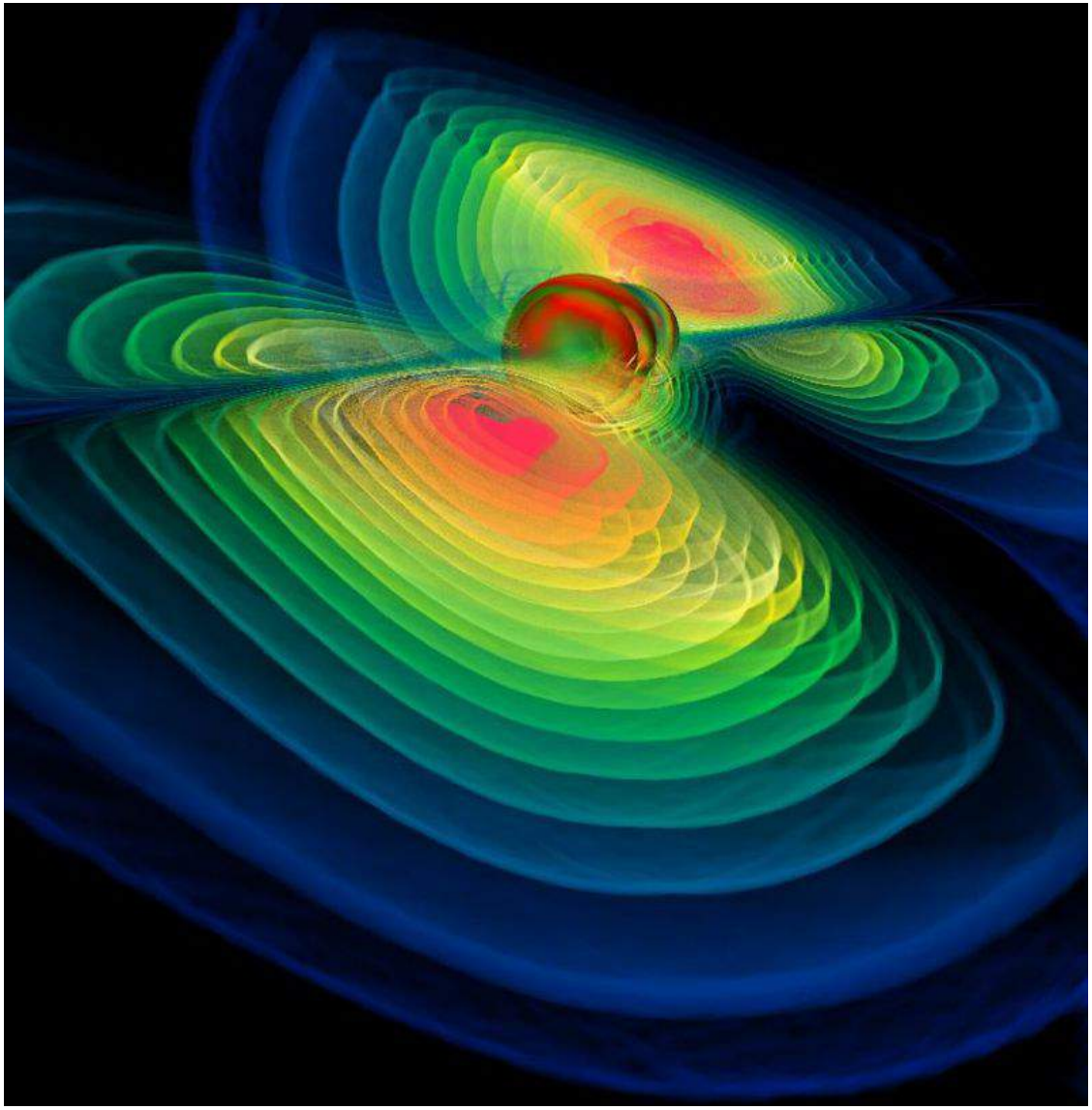
Discovery of the gravitational waves (14 Sept. 2015 -> 11 Feb 2016)



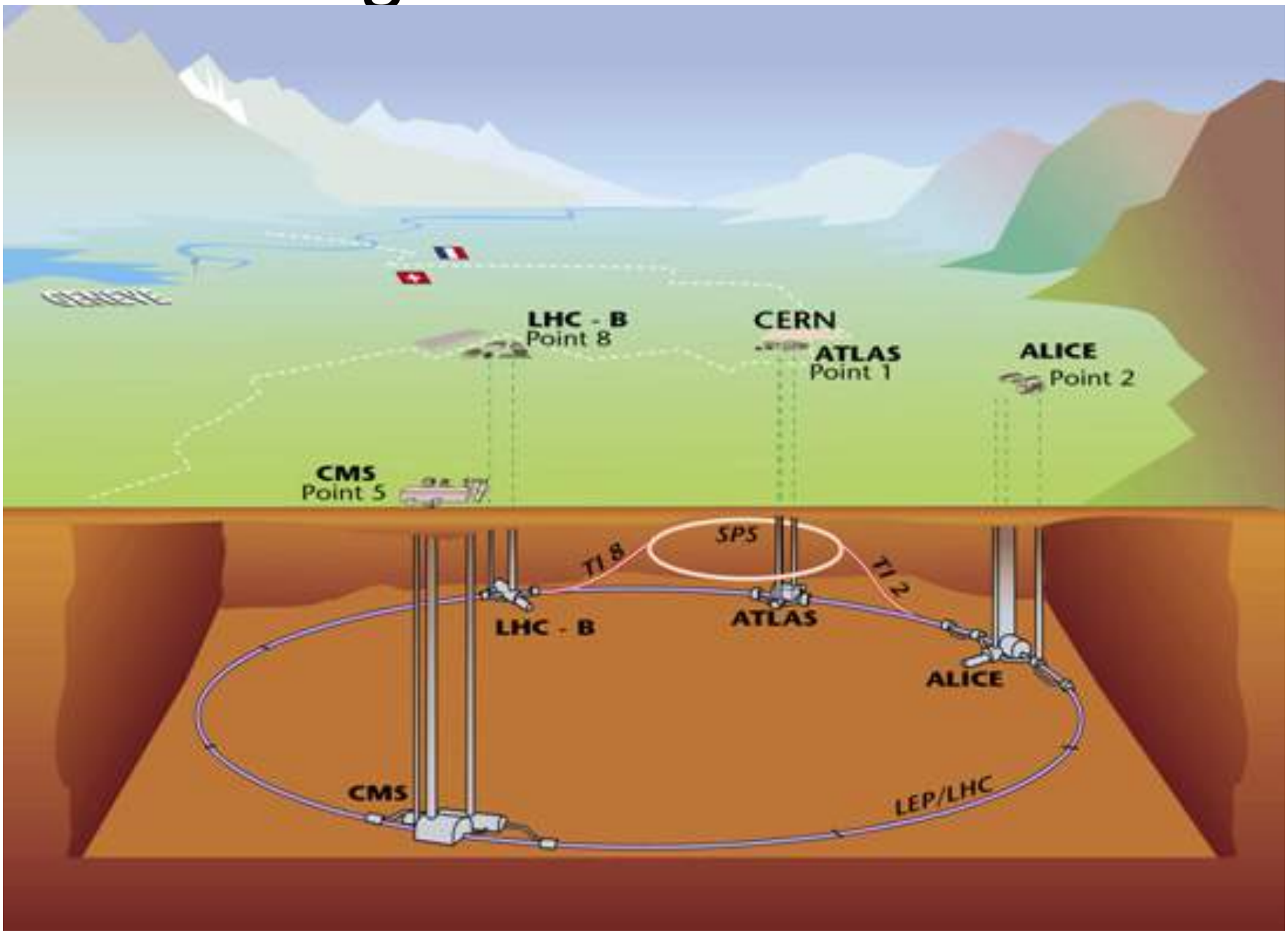
Discovery of the gravitational waves (14 Sept. 2015 -> 11 Feb 2016)



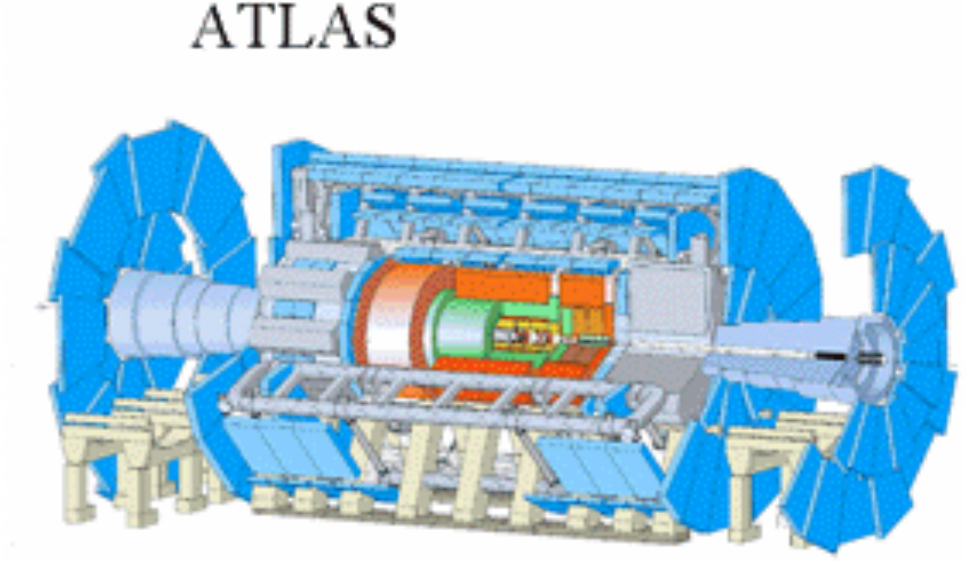
Discovery of the gravitational waves (14 Sept. 2015 - > 11 Feb 2016) – talk Viviana Fafone

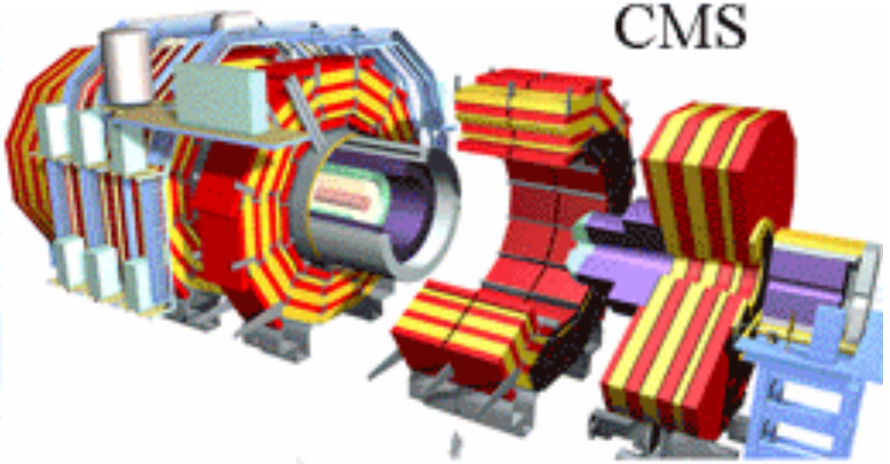


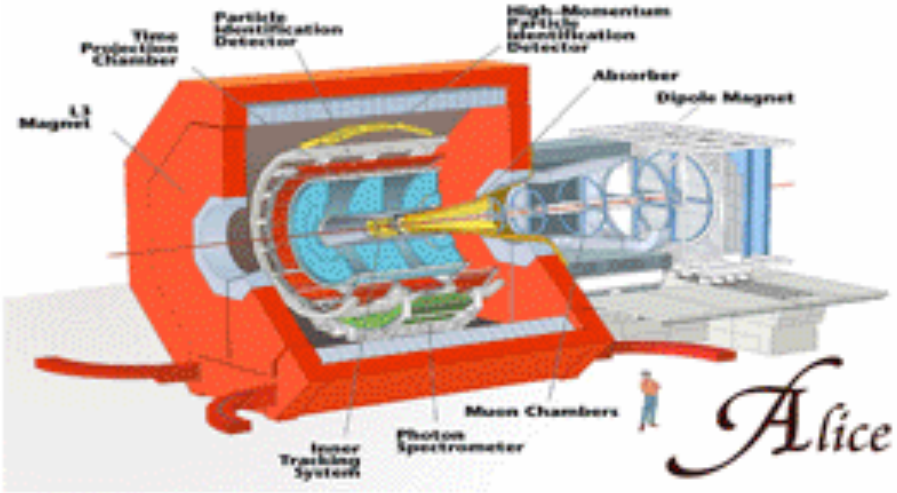
Large Hadron Collider

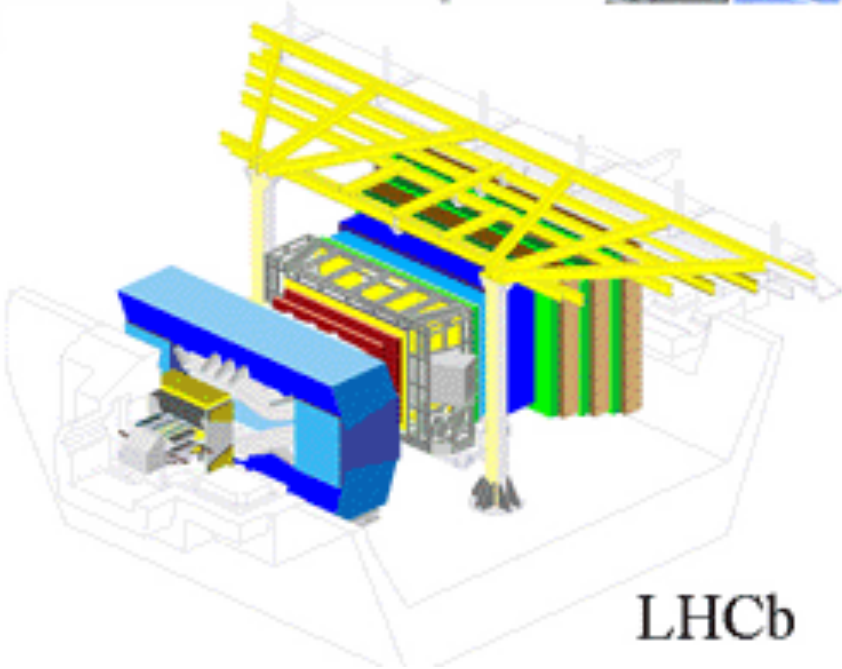


Large Hadron Collider

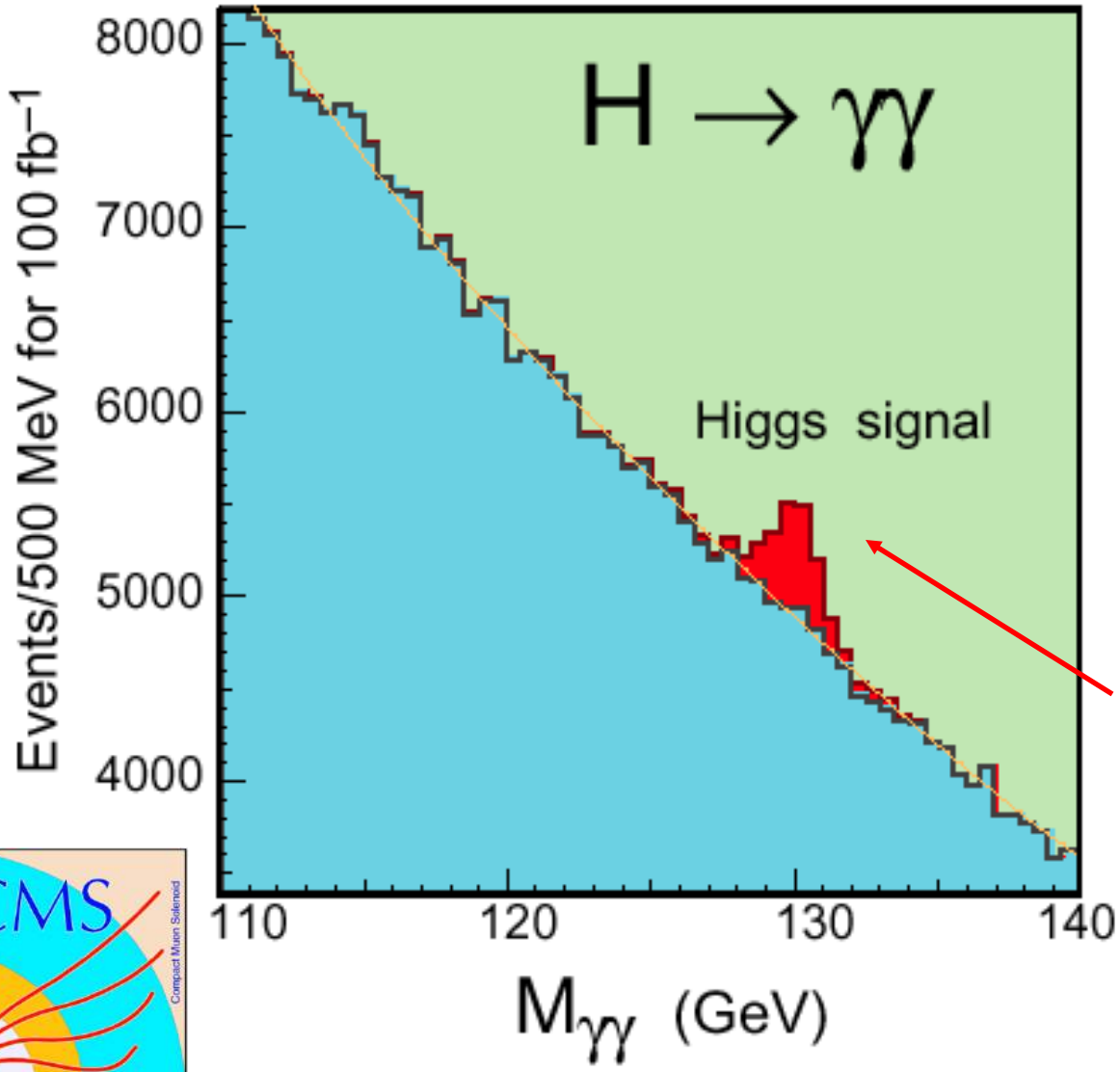




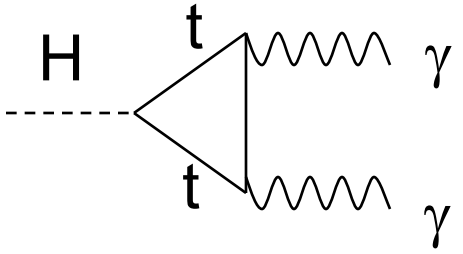




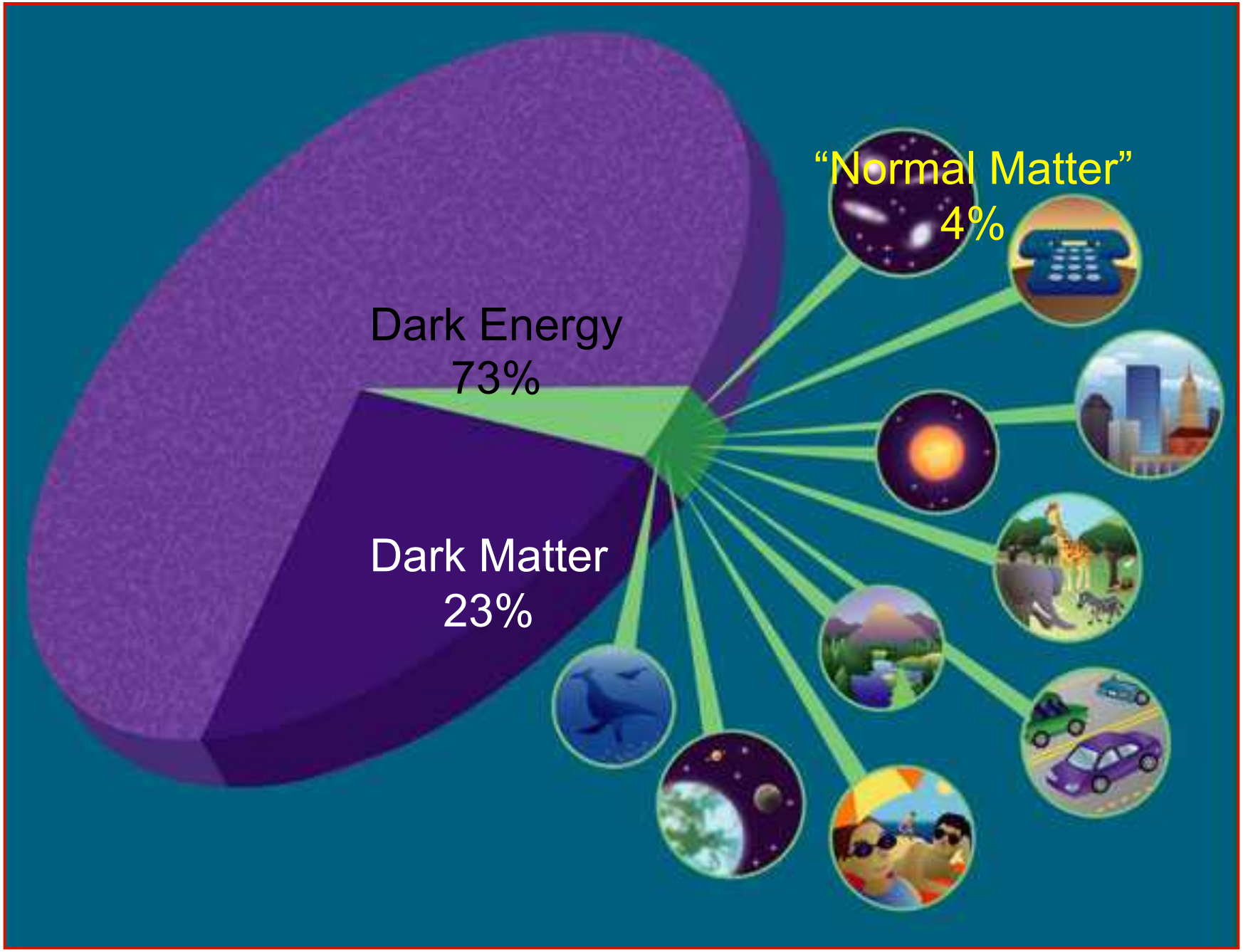
Higgs Decay to Photons

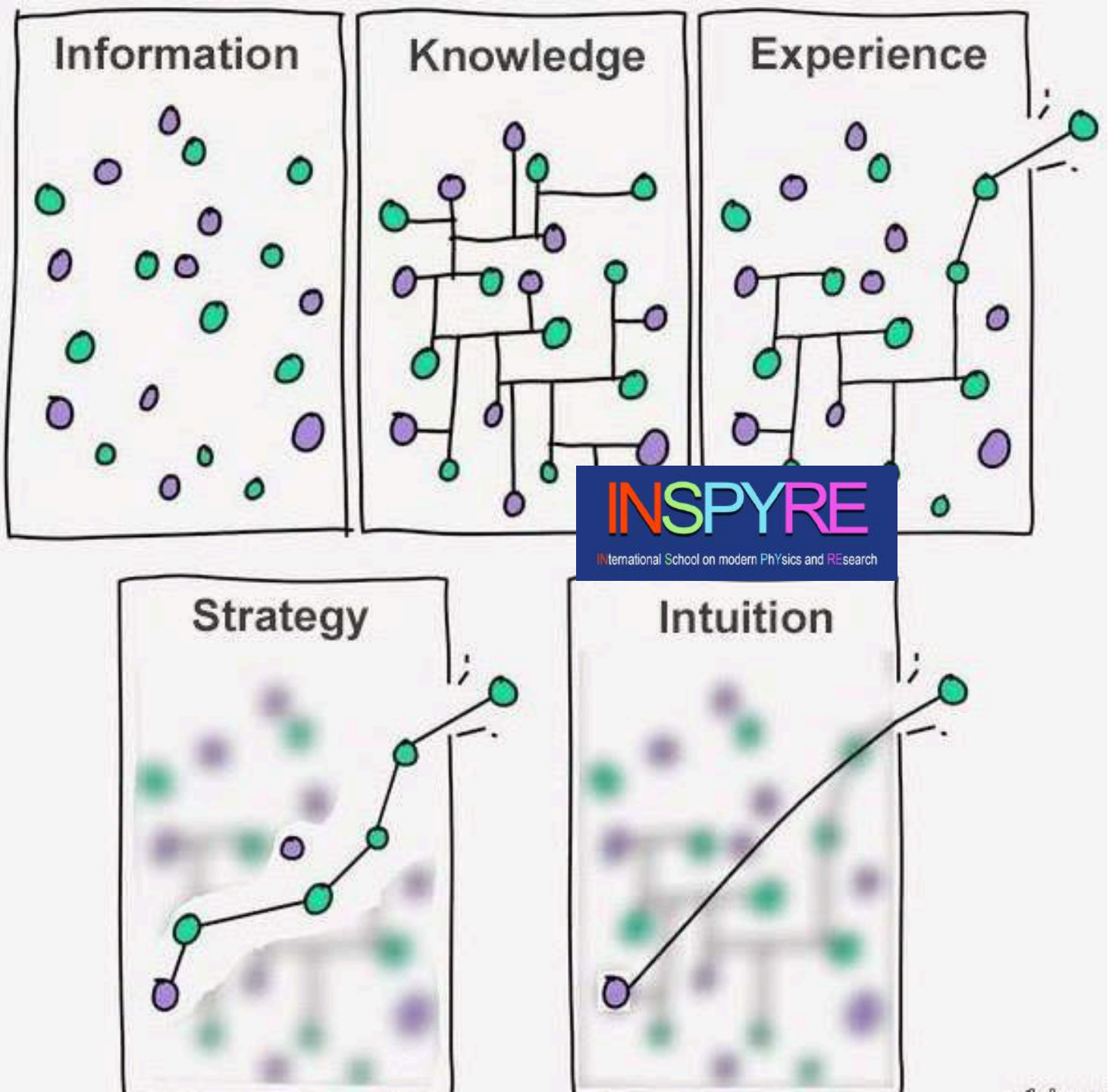


Rare decay in SM



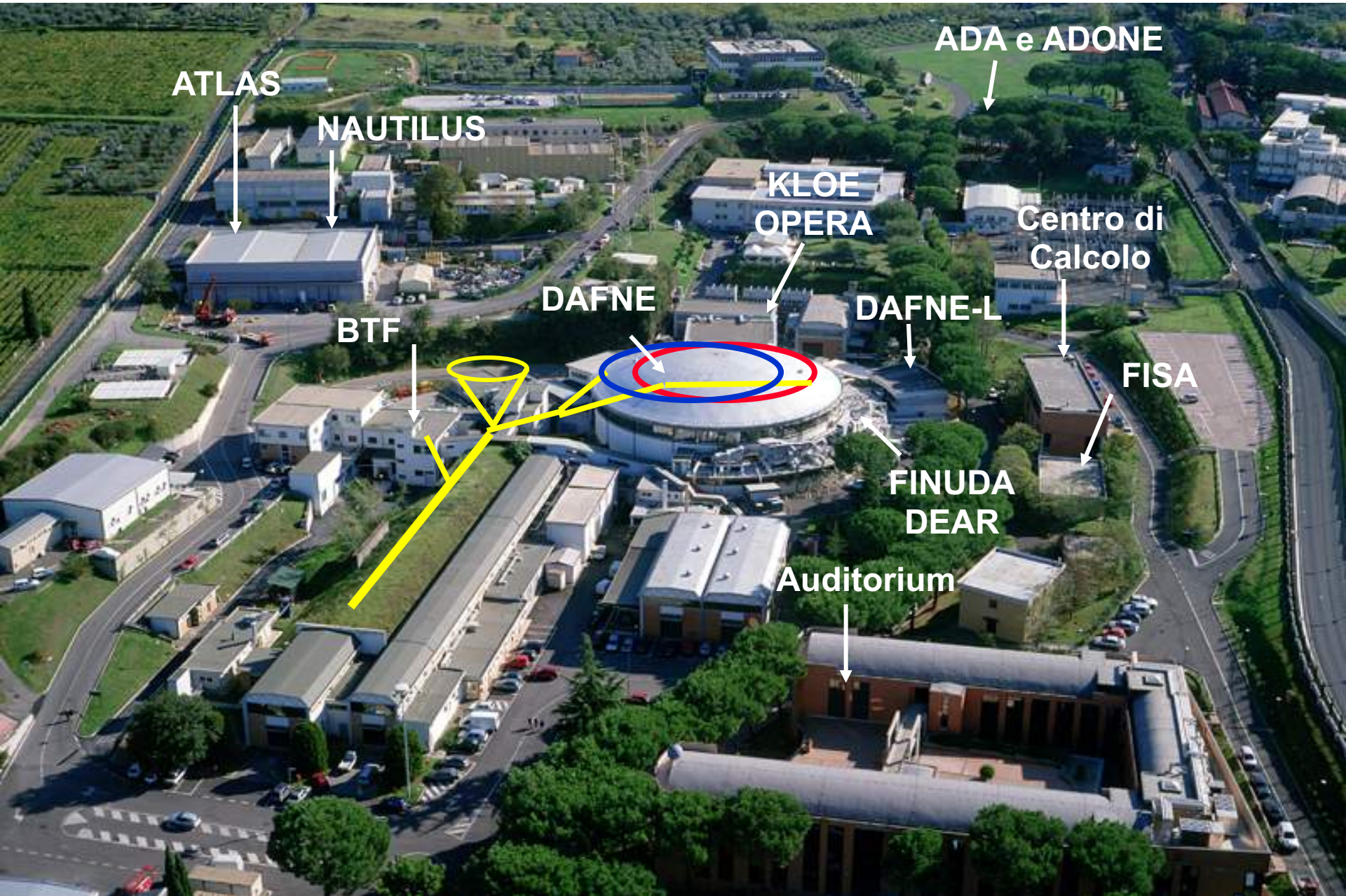
LHC detectors have been optimized to find this peak!


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


Information
Knowledge
Experience
INSPYRE
International School on modern PhYsics and REsearch
Strategy
Intuition

Frascati

Laboratori Nazionali di Frascati




April Fools'day

Discovering The Bigon

In 1996, Discover Magazine reported on the discovery of a new fundamental particle of matter. On any other day, this would be a momentous discovery, but this was April 1. The fundamental particle was called “the Bigon” and it’s the size of a bowling ball, although it only exists for just millionths of a second.

Just in case you were dubious about the discovery, the article dryly notes: "Is there any chance that the bigon is just a figment – or some kind of ridiculous April Fool’s joke, as virtually all other physicists are saying? People are so cynical, responds Zweistein. Science, he points out, routinely produces findings that seem too marvelous to be believed – and that yet turn out to be true."

CERN Finds Evidence For The Force

In 2015, CERN took a brief break from unraveling the fabric of the universe to lay out a grand April Fools' prank. They issued a press release announcing the "first unequivocal evidence for the Force."

Details of the Force were hazy, but it could reportedly be used for "long-distance communication, influencing minds, and lifting heavy things out of swamps." The breakthrough came from a seminal paper by Ben Kenobi of the prestigious University of Mos Eisley in Tatooine. A small green spokesperson for the laboratory also noted: "Very impressive, this result is."

Just in case their readers had been living under a *Star Wars*-proof rock since 1977, CERN revealed the next day that it was an April fools' joke.