Introduction to Modern Physics and to the LNF-INFN Activities International Year of Light

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Catalina Curceanu LNF-INFN





United Nations

Educational, Scientific and Cultural Organization

"He whose face gives no *light*, shall never become a star."

Chi non ha luce in visto non diventera' mai una stella (William Blake)



- International
- Year of Light
- 2015





"It must be a strange world not being a scientist, going through life not knowing -- or maybe not caring about where the air came from, where the stars at night came from or how far they are from us. I want to know."

- Michio Kaku

# nagine travel/ing through space on a beam of the street of the space on a beam of the street of the space of From Relativity

meed, time, E.m.c2, Autor Einstein, the







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





### 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









## **The Standard Model**







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)



#### 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 $\tau$ + e e<sup>+</sup> e<sup>-</sup> $E = 2m_{\tau} c^{2}$ $\mu^+$ e<sup>+</sup> $E = m c^2$ Bigger the energy is, more and more particles can be studied

## Matter-antimatter colliders

## LEP al CERN di Ginevra 1988

### LHC at Cern (pp)



## **Physics at DAΦNE**

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



10000 K in a second



#### KLOE (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

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

#### Mamography



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





**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:

vibrations in the bar (for AI, L=3 m, f=915 Hz)

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



- Supernova in our Galassia h=10<sup>-18</sup>
- Supernova in Virgo h=10<sup>-21</sup>
- Thermal noise @ T=300 K, ∆L=10<sup>-16</sup> m
- Thermal noise @ T=3 K, ∆L=10<sup>-17</sup> m
- Thermal noise @ T=300 mK  $\rightarrow \Delta L=10^{-18}$  m

## Large Hadron Collider



## Large Hadron Collider







## Higgs Decay to Photons





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



## What is the Universe made of?



#### We are here

Other elements	0.03%
Neutrin 👁	0.3%
Stars	0.5%
Free H and He	4%
Dark matter	23%
Dark energy	72%
We do not know y up 95% of the uni	what make iverse.



#### **Alcubierre Warp Drive**



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.

A N D E R S O N I N S T I T U T E

Time Control Technologies and Methods

Innovation and Excellence in Time Technology

## 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

