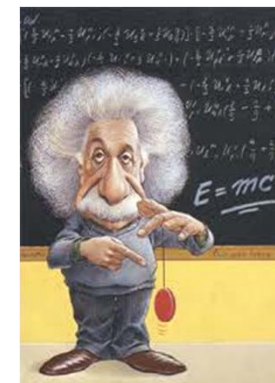




**Fisica:
un passaporto
per nuove frontiere**

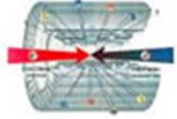


Alessandro Feliciello
I.N.F.N. - Sezione di Torino

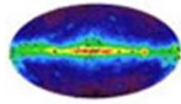
Sommario

- Introduzione
 - fisica delle **particelle**
 - fisica **nucleare**
- Come nasce un esperimento
 - l'esperimento **OBELIX**
 - l'esperimento **FINUDA**
- Un po' di attualità
 - primi risultati da **LHC**
 - il **neutrino** ~~superluminare~~
- Le ricadute tecnologiche
 - strumenti di calcolo
 - **web** e **GRID**
 - applicazioni **mediche**
 - studio e salvaguardia di **beni culturali**

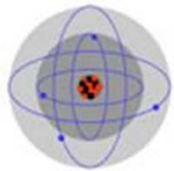
L'Istituto Nazionale di Fisica Nucleare



I. fisica delle particelle



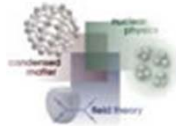
II. astrofisica particellare



III. fisica nucleare



V. ricerca tecnologica



IV. fisica teorica

<http://www.infn.it>

The map displays the following locations and acronyms:

- LNL** (Laboratori Nazionali di Legnaro) - Padova
- CNAF** (Centro Nazionale di Fisica Nucleare) - Bologna
- LNS** (Laboratori Nazionali Sudiciliani) - Catania
- LNF** (Laboratori Nazionali di Frascati) - Torvergata/Roma
- LNGS** (Laboratori Nazionali Gran Sasso) - L'Aquila

Other cities marked on the map include: Trento, Udine, Trieste, Milano Bicocca, Brescia, Ferrara, Pavia, Parma, Genova, Alessandria, Torino, Bologna, Firenze, Siena, Pisa, Perugia, Roma Sanita', Napoli, Salerno, Bari, Lecce, Cosenza, Messina, and Cagliari.

Le domande fondamentali

L'uomo da sempre si chiede:

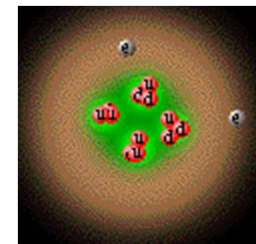
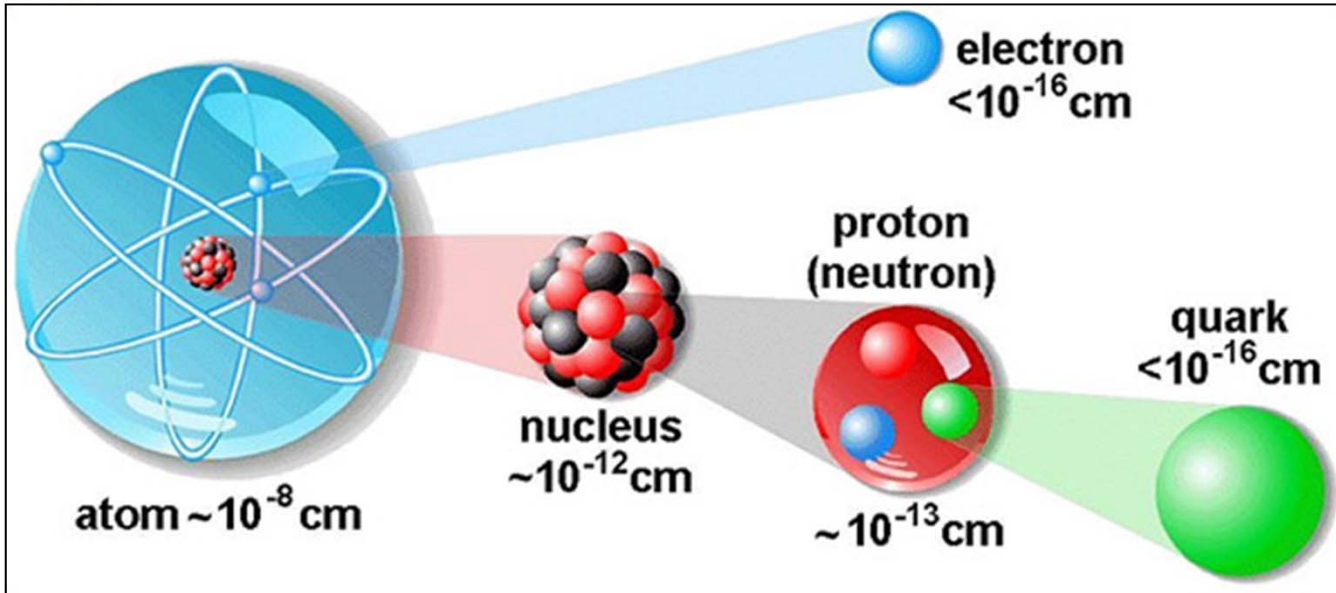
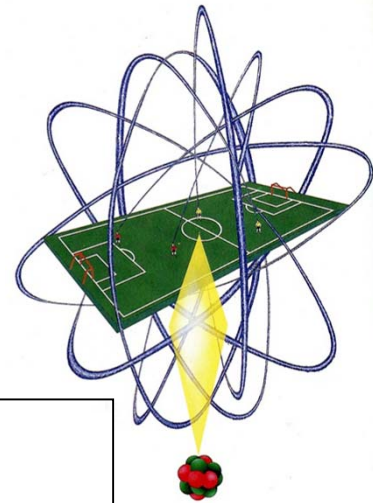
di che cosa è composta la materia?

cosa la tiene insieme?

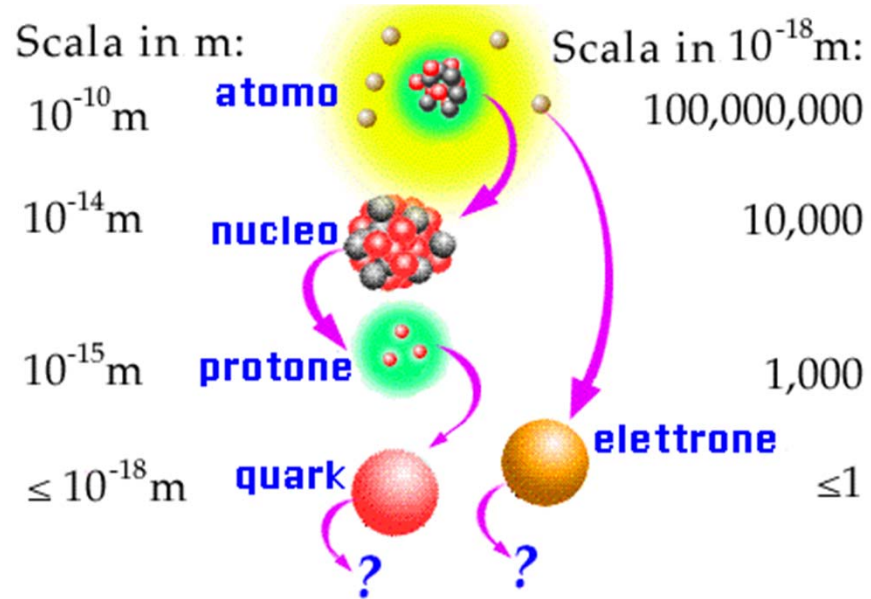
cosa genera la massa?



Di che cosa è costituita la materia?

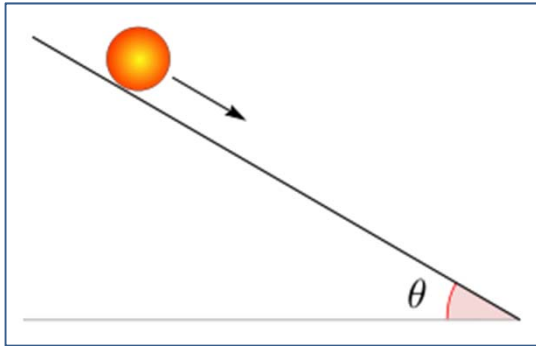


Le dimensioni del problema



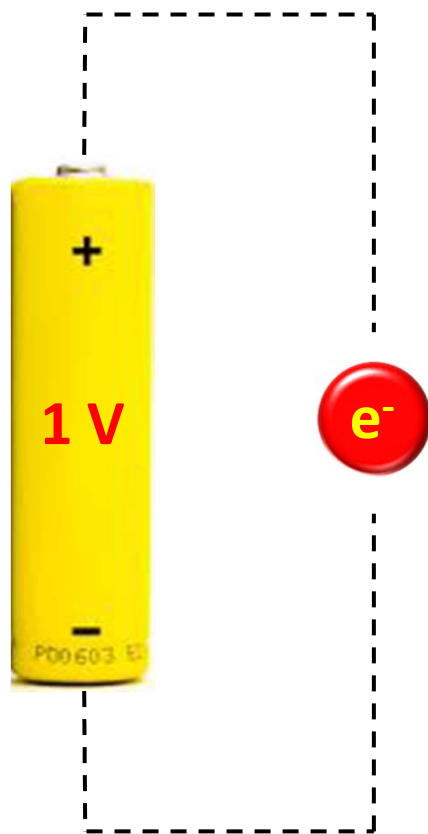
Valore	Potenza di 10	Prefisso	Simbolo
1.000.000.000.000.000.000	10^{18}	<u>Exa</u>	<u>E</u>
1.000.000.000.000.000	10^{15}	<u>Peta</u>	<u>P</u>
1.000.000.000.000	10^{12}	<u>Tera</u>	<u>T</u>
1.000.000.000	10^9	<u>Giga</u>	<u>G</u>
1.000.000	10^6	<u>Mega</u>	<u>M</u>
1.000	10^3	<u>Chilo</u>	<u>k</u>
100	10^2	<u>Etto</u>	<u>h</u>
10	10^1	<u>Deca</u>	<u>da</u>
0,1	10^{-1}	<u>Deci</u>	<u>d</u>
0,01	10^{-2}	<u>Centi</u>	<u>c</u>
0,001	10^{-3}	<u>Milli</u>	<u>m</u>
0,00001	10^{-6}	<u>Micro</u>	μ
0,00000001	10^{-9}	<u>Nano</u>	<u>n</u>
0,000000000001	10^{-12}	<u>Pico</u>	<u>p</u>
0,000000000000001	10^{-15}	<u>Femto</u>	<u>f</u>
0,000000000000000001	10^{-18}	<u>Atto</u>	<u>a</u>

Le energie in gioco



1 eV corrisponde all'aumento di energia di un elettrone sottoposto ad una differenza di potenziale di 1 V.




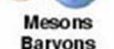
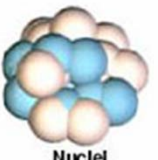

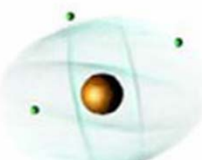



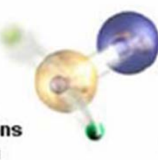
- 1 eV = $1,6 \times 10^{-19}$ Joule
- 1 MeV = 10^6 eV
- 1 GeV = 10^9 eV
- 1 TeV = 10^{12} eV



1 TeV è circa l'energia cinetica di una zanzara!

Che cosa tiene insieme la materia?

Forces

Strong	Electromagnetic
<p>Gluons (8)</p>  <p>Quarks</p>  <p>Mesons</p>  <p>Baryons</p>  <p>Nuclei</p> 	<p>Photon</p>  <p>Atoms</p>  <p>Light</p> <p>Chemistry</p> <p>Electronics</p>
Gravitational	Weak
<p>Graviton ?</p>  <p>Solar system</p>  <p>Galaxies</p> <p>Black holes</p>	<p>Bosons (W,Z)</p>  <p>Neutron decay</p> <p>Beta radioactivity</p> <p>Neutrino interactions</p> <p>Burning of the sun</p> 

The particle drawings are simple artistic representations

	intensità	raggio d'azione
• forte	10^{38}	$\approx 10^{-15}$ m
• elettromagnetica	10^{36}	∞
• debole	10^{25}	$\approx 10^{-18}$ m
• gravitazionale	1	∞

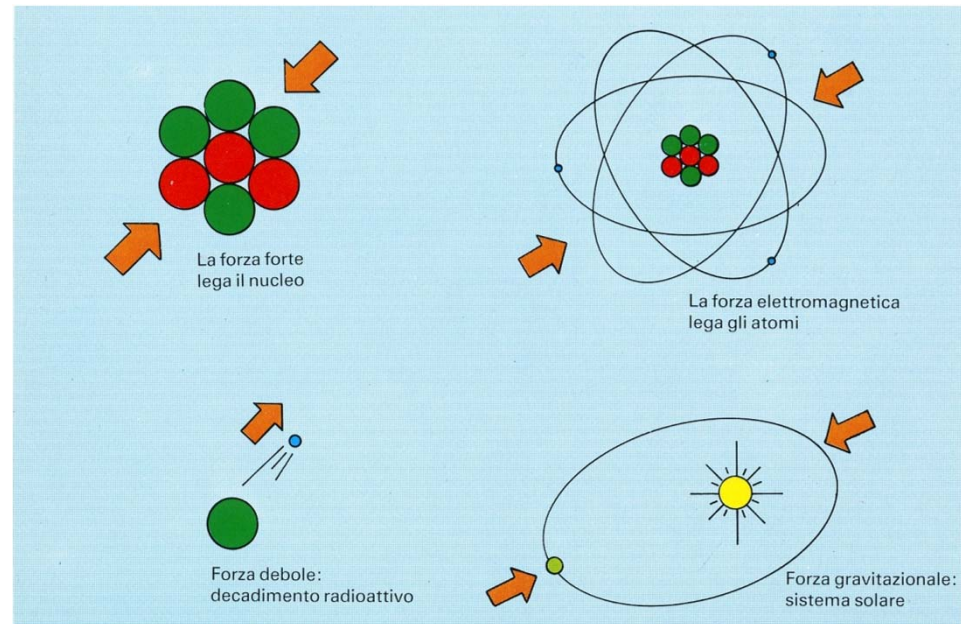


Tavola del modello standard

A. Felcicello / Liceo Collegio Sacra Famiglia, Torino, 8 e 19 marzo 2012

Standard Model of FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model summarizes the current knowledge in Particle Physics. It is the quantum theory that includes the theory of strong interactions (quantum chromodynamics or QCD) and the unified theory of weak and electromagnetic interactions (electroweak). Gravity is included on this chart because it is one of the fundamental interactions even though not part of the "Standard Model."

FERMIONS

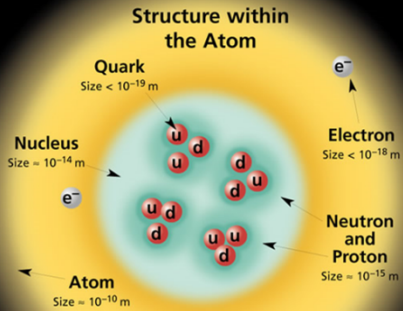
Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_e electron neutrino	$<1 \times 10^{-8}$	0	u up	0.003	2/3
e electron	0.000511	-1	d down	0.006	-1/3
ν_μ muon neutrino	<0.0002	0	c charm	1.3	2/3
μ muon	0.106	-1	s strange	0.1	-1/3
ν_τ tau neutrino	<0.02	0	t top	175	2/3
τ tau	1.7771	-1	b bottom	4.3	-1/3

Spin is the intrinsic angular momentum of particles. Spin is given in units of \hbar , which is the quantum unit of angular momentum, where $\hbar = h/2\pi = 6.58 \times 10^{-25}$ GeV s = 1.05×10^{-34} J s.

Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10^{-19} coulombs.

The **energy** unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. **Masses** are given in GeV/c² (remember $E = mc^2$), where $1 \text{ GeV} = 10^9 \text{ eV} = 1.60 \times 10^{-10}$ joule. The mass of the proton is $0.938 \text{ GeV}/c^2 = 1.67 \times 10^{-27}$ kg.

Structure within the Atom



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

BOSONS

Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W⁻	80.4	-1			
W⁺	80.4	+1			
Z⁰	91.187	0			

force carriers spin = 0, 1, 2, ...

Color Charge
Each quark carries one of three types of "strong charge," also called "color charge." These charges have nothing to do with the colors of visible light. There are eight possible types of color charge for gluons. Just as electrically-charged particles interact by exchanging photons, in strong interactions color-charged particles interact by exchanging gluons. Leptons, photons, and **W** and **Z** bosons have no strong interactions and hence no color charge.

Quarks Confined in Mesons and Baryons
One cannot isolate quarks and gluons; they are confined in color-neutral particles called **hadrons**. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs (see figure below). The quarks and antiquarks then combine into hadrons; these are the particles seen to emerge. Two types of hadrons have been observed in nature: **mesons** $q\bar{q}$ and **baryons** qqq .

Residual Strong Interaction
The strong binding of color-neutral protons and neutrons to form nuclei is due to residual strong interactions between their color-charged constituents. It is similar to the residual electrical interaction that binds electrically neutral atoms to form molecules. It can also be viewed as the exchange of mesons between the hadrons.

PROPERTIES OF THE INTERACTIONS

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$					
Baryons are fermionic hadrons. There are about 120 types of baryons.					
Symbol	Name	Quark content	Electric charge	Mass GeV/c ²	Spin
p	proton	uud	1	0.938	1/2
\bar{p}	anti-proton	$\bar{u}\bar{u}\bar{d}$	-1	0.938	1/2
n	neutron	udd	0	0.940	1/2
\bar{n}	anti-neutron	$\bar{u}\bar{d}\bar{d}$	0	0.940	1/2
Λ	lambda	uds	0	1.116	1/2
$\bar{\Lambda}$	anti-lambda	$\bar{u}\bar{d}\bar{s}$	0	1.116	1/2
Ω^-	omega	sss	-1	1.672	3/2

Property	Interaction	Weak (Electroweak)		Strong	
		Gravitational	Electromagnetic	Fundamental	Residual
Acts on:		Mass - Energy	Flavor	Electric Charge	Color Charge
Particles experiencing:		All	Quarks, Leptons	Electrically charged	Quarks, Gluons
Particles mediating:		Graviton (not yet observed)	W⁺ W⁻ Z⁰	γ	Gluons
Strength relative to electromag. for two u quarks at:	10^{-18} m 3×10^{-17} m	10^{-41} 10^{-41} 10^{-36}	0.8 10^{-4} 10^{-7}	1 1 1	25 60 Not applicable to hadrons
for two protons in nucleus					20

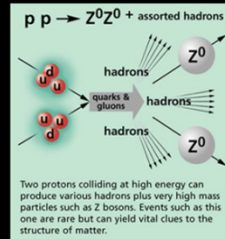
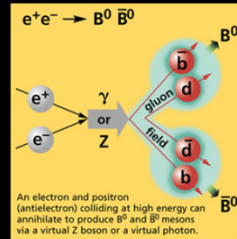
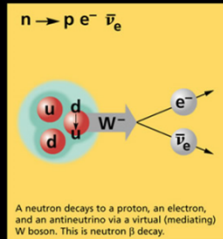
Mesons $q\bar{q}$					
Mesons are bosonic hadrons. There are about 140 types of mesons.					
Symbol	Name	Quark content	Electric charge	Mass GeV/c ²	Spin
π^+	pion	u\bar{d}	+1	0.140	0
π^-	anti-pion	$\bar{u}d$	-1	0.140	0
K⁻	kaon	s\bar{u}	-1	0.494	0
ρ^+	rho	u\bar{d}	+1	0.770	1
B⁰	B-zero	d\bar{b}	0	5.279	0
η_c	eta-c	c\bar{c}	0	2.980	0

Matter and Antimatter

For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or - charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z^0 , γ , and $\eta_c = c\bar{c}$, but not $K^0 = d\bar{s}$) are their own antiparticles.

Figures

These diagrams are an artist's conception of physical processes. They are not exact and have no meaningful scale. Green shaded areas represent the cloud of gluons or the gluon field, and red lines the quark paths.



The Particle Adventure

Visit the award-winning web feature *The Particle Adventure* at <http://ParticleAdventure.org>

This chart has been made possible by the generous support of:

- U.S. Department of Energy
- U.S. National Science Foundation
- Lawrence Berkeley National Laboratory
- Stanford Linear Accelerator Center
- American Physical Society, Division of Particles and Fields
- BURLE** INDUSTRIES, INC.

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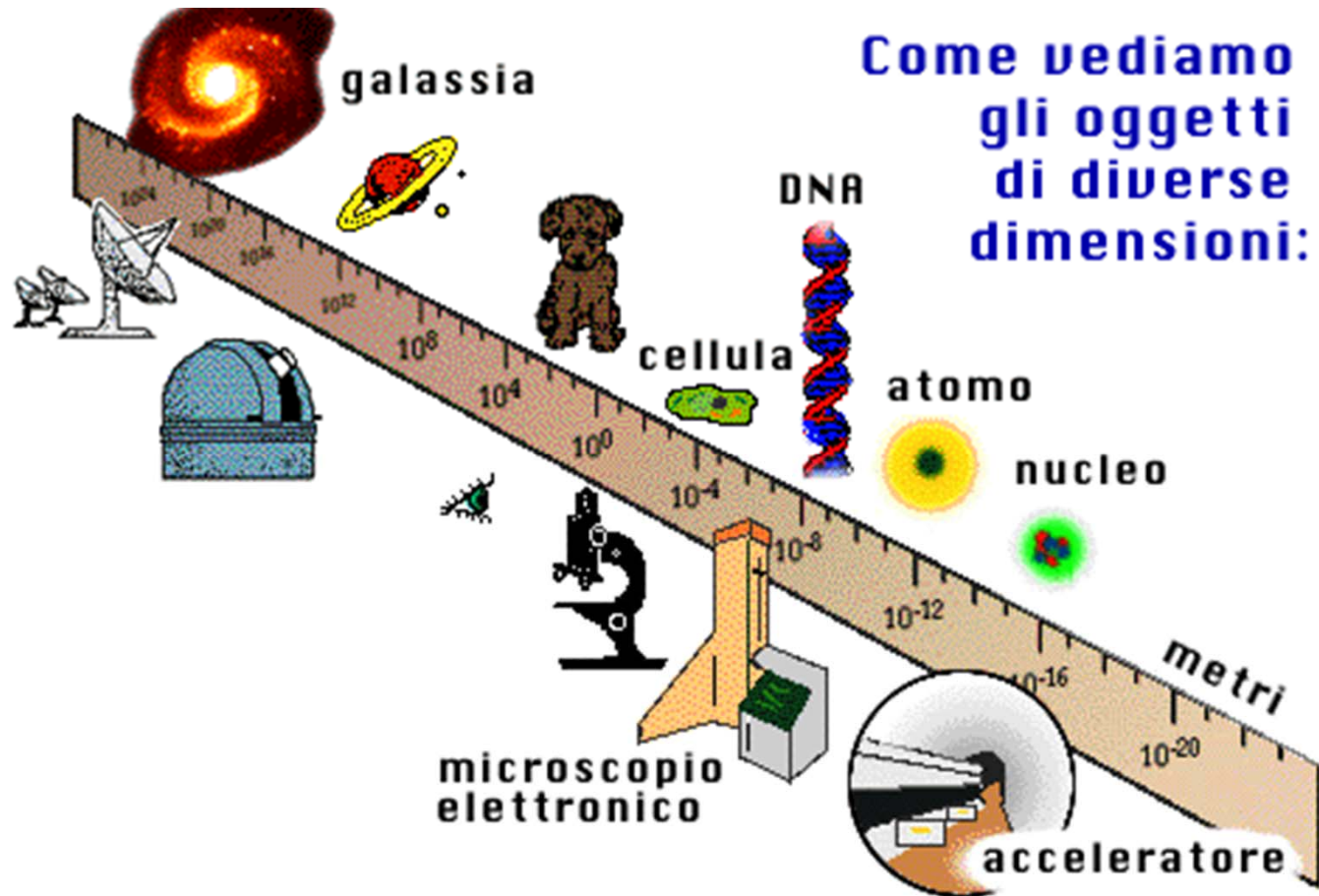
<http://CPEPweb.org>



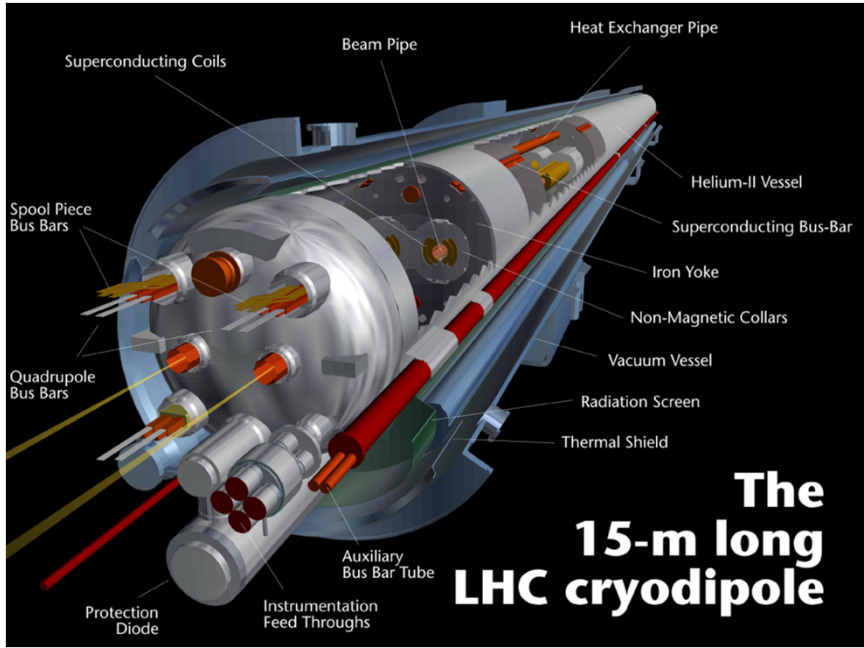
Un martello sempre più grande!



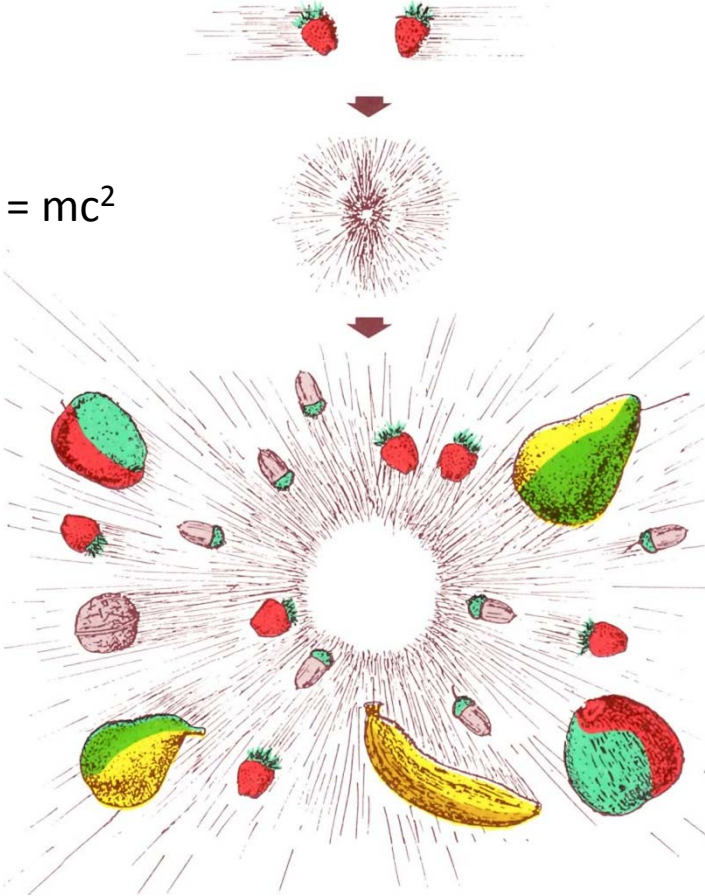
Lo strumento adatto



L'acceleratore LHC



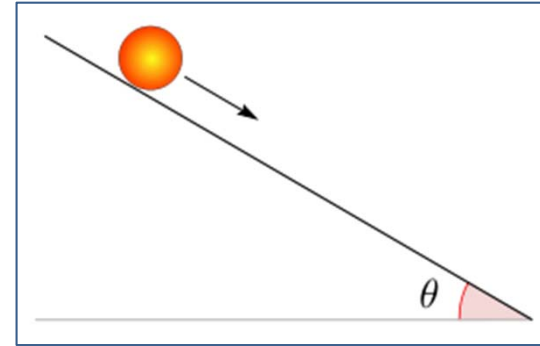
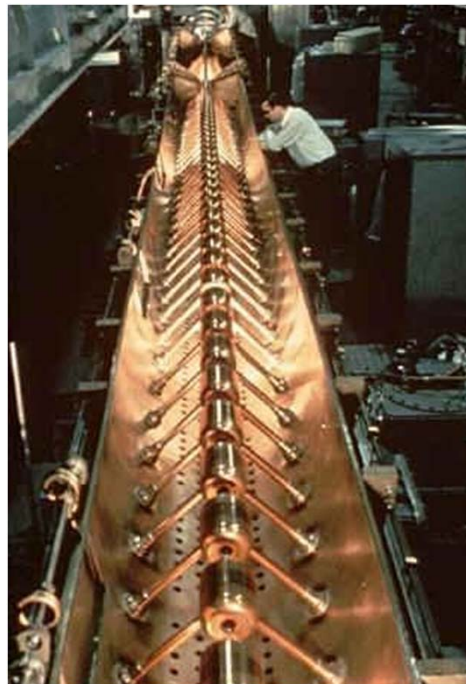
$$E = mc^2$$



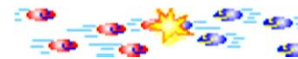
A. Felciello / Liceo Collegio Sacra Famiglia, Torino, 8 e 19 marzo 2012



Gli acceleratori lineari

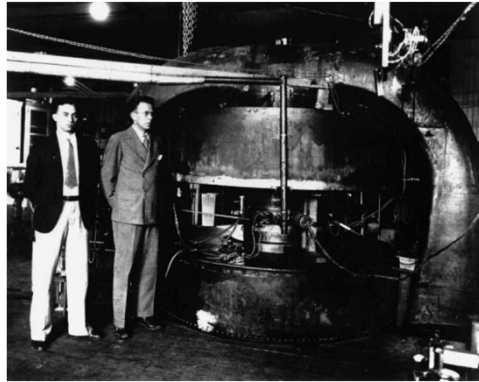
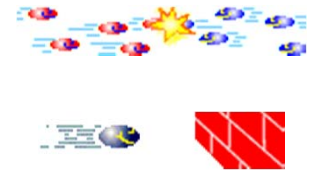


esperimenti a bersaglio fisso

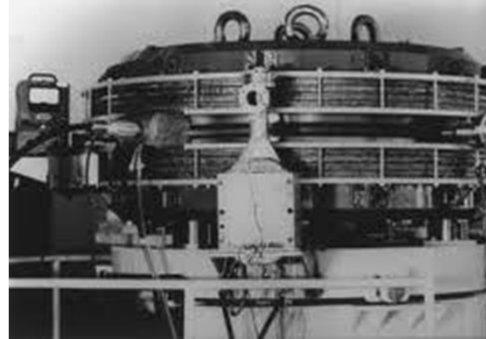


esperimenti con fasci collidenti

Gli acceleratori circolari



ciclotrone
(1929)



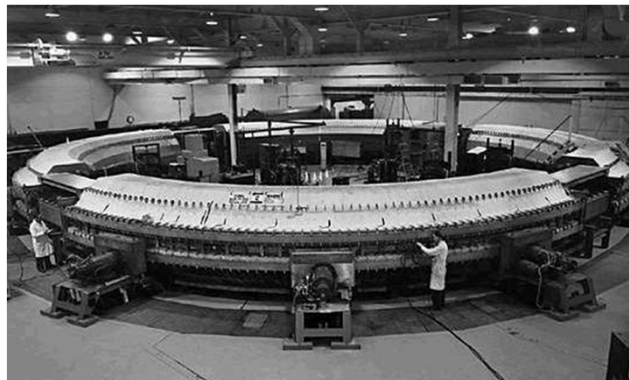
A.d.A.
(1961-1964)



betatrone
(6 MeV, 1942)



Adone
(1969-1993)

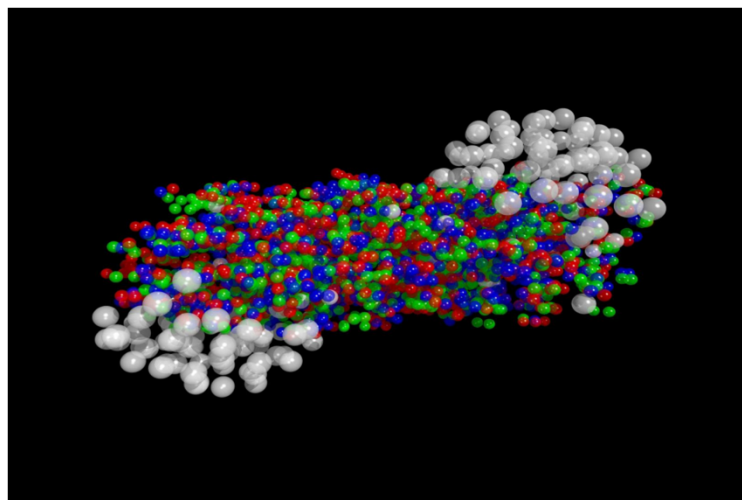
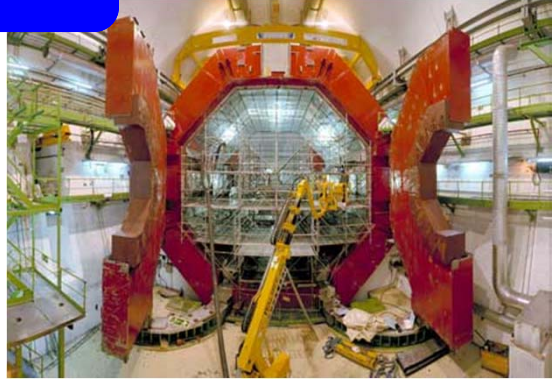
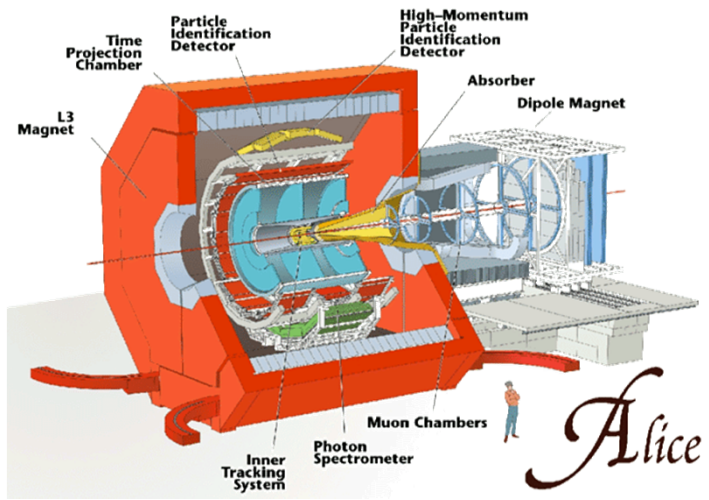


sincrotrone
(1952)

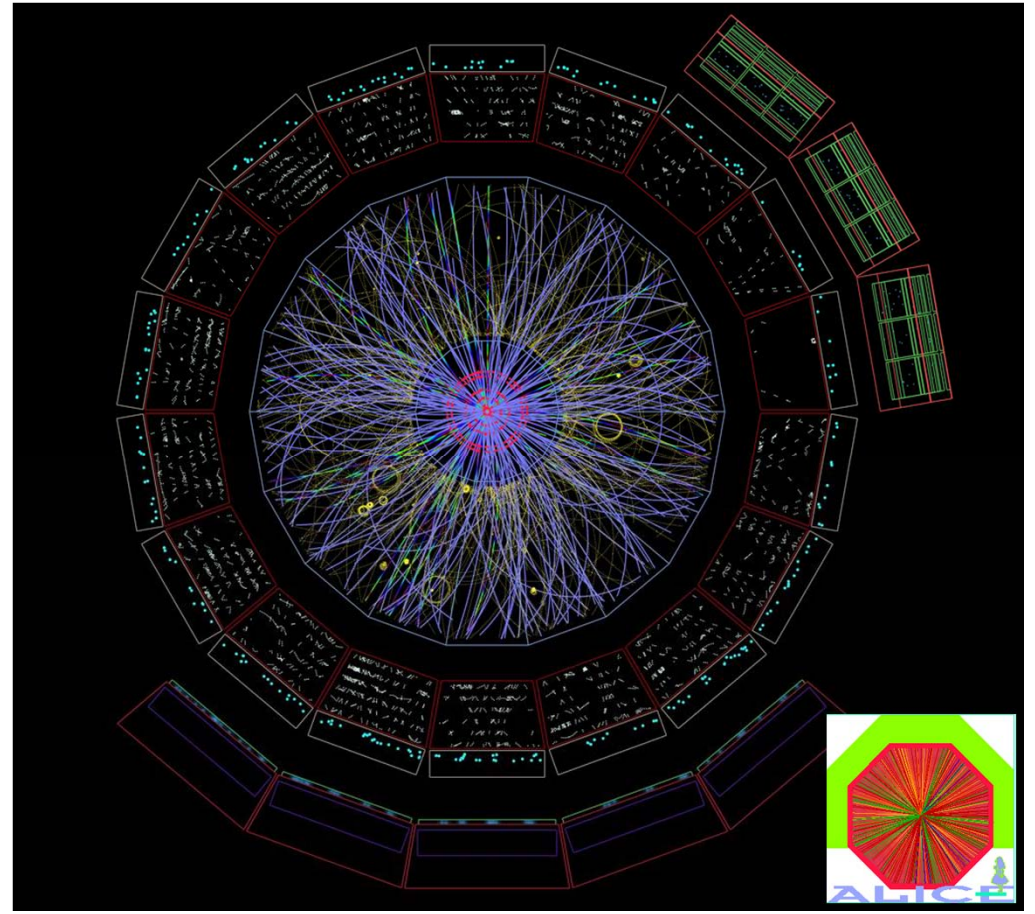


DA ΦNE
(2000- ...)

L'esperimento ALICE



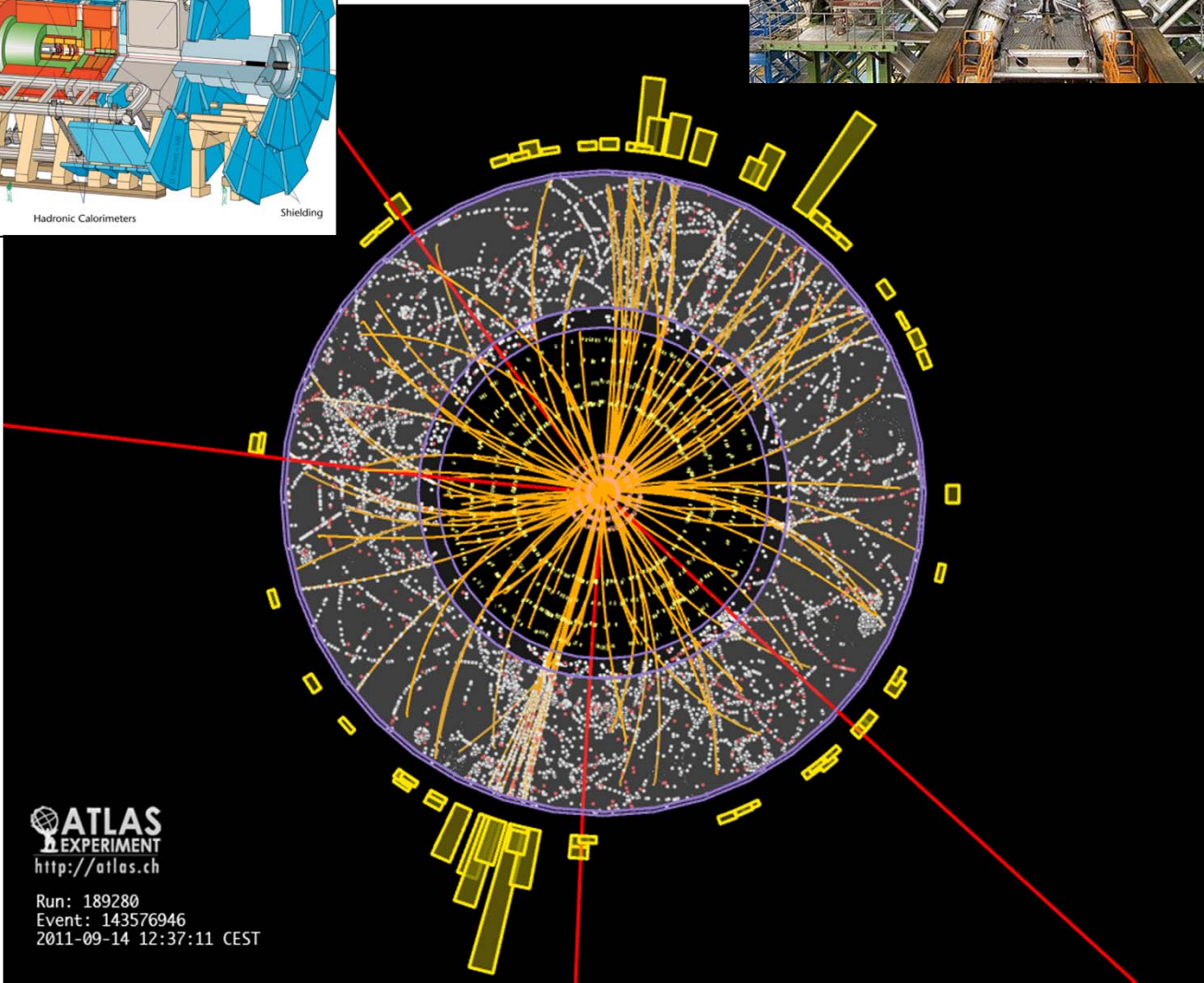
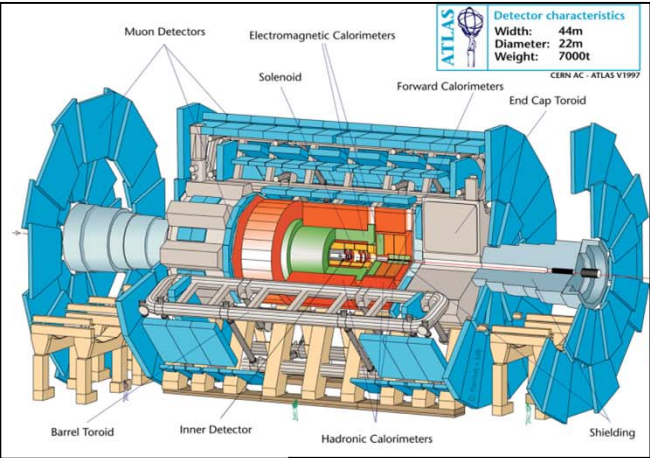
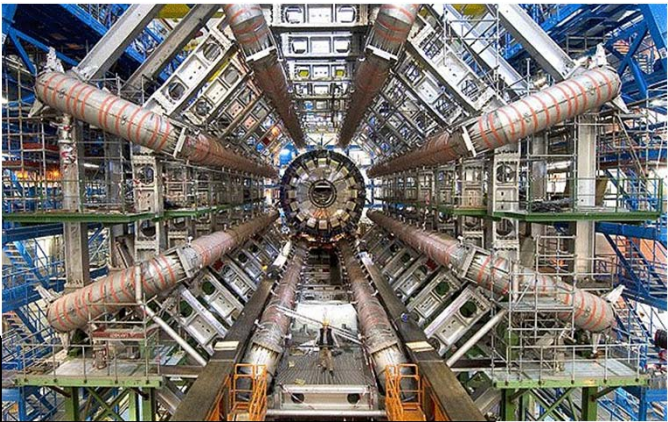
Pb + Pb @ 7 TeV



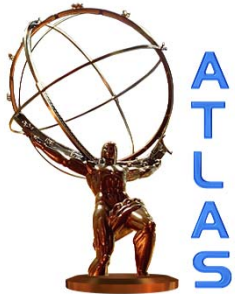
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L'esperimento ATLAS



A. Felciello / Liceo Collegio Sacra Famiglia, Torino, 8 e 19 marzo 2012

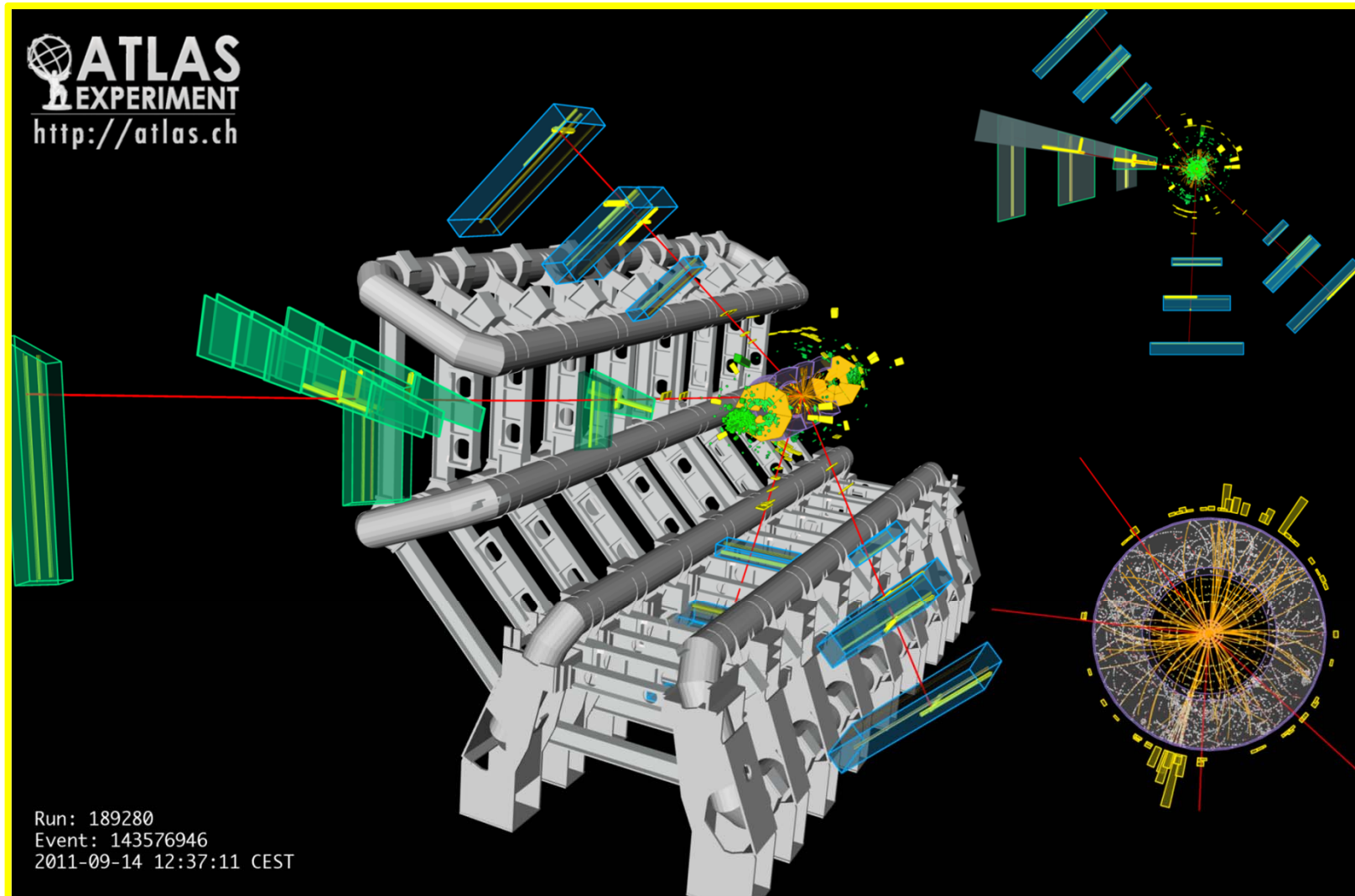


ATLAS
EXPERIMENT
<http://atlas.ch>

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Event: 143576946
2011-09-14 12:37:11 CEST



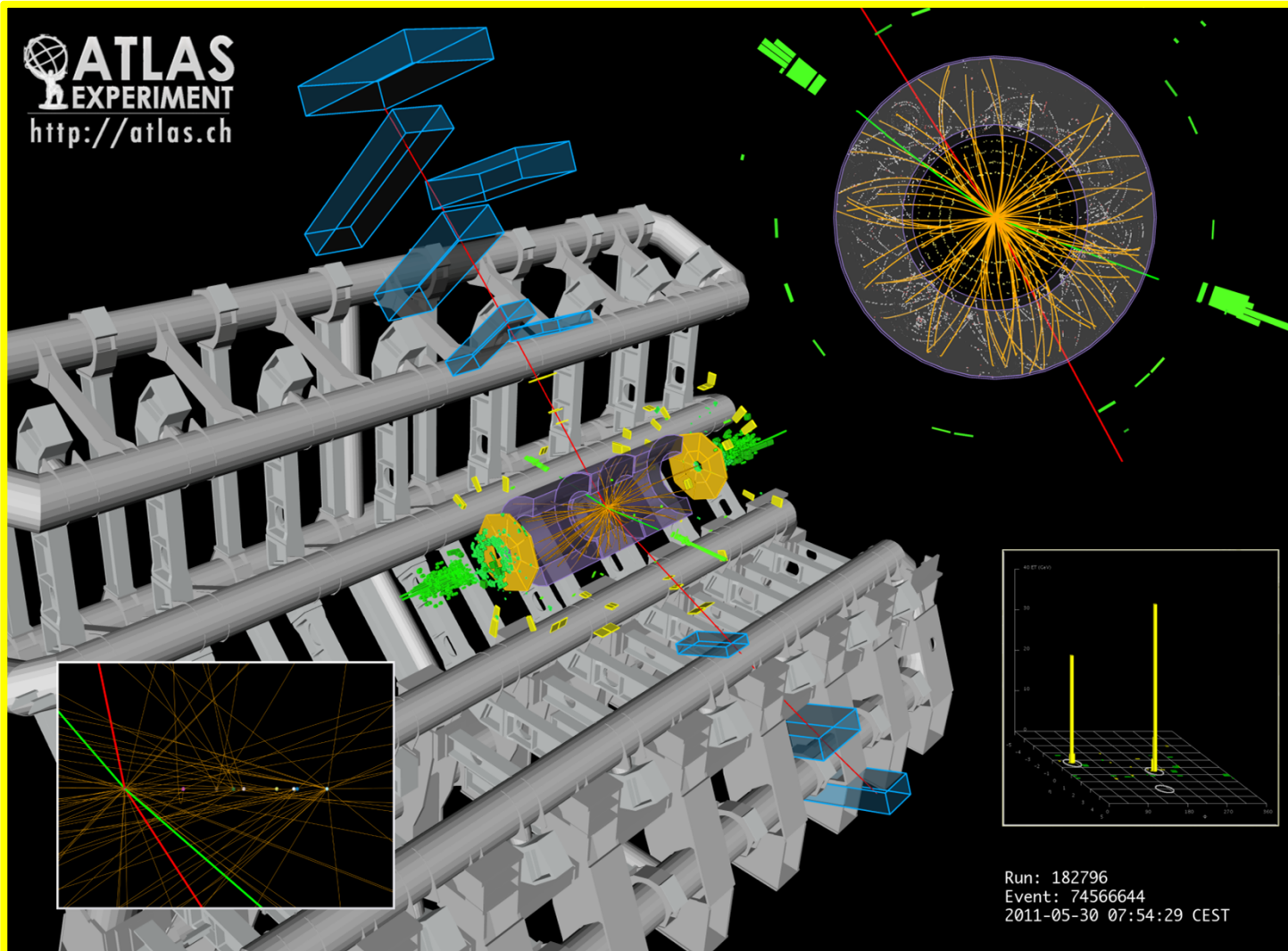
Il (famigerato) bosone di Higgs



4μ candidate with $m_{4\mu} = 124.6$ GeV

$p_T(\mu^-, \mu^+, \mu^+, \mu^-) = 61.2, 33.1, 17.8, 11.6$ GeV

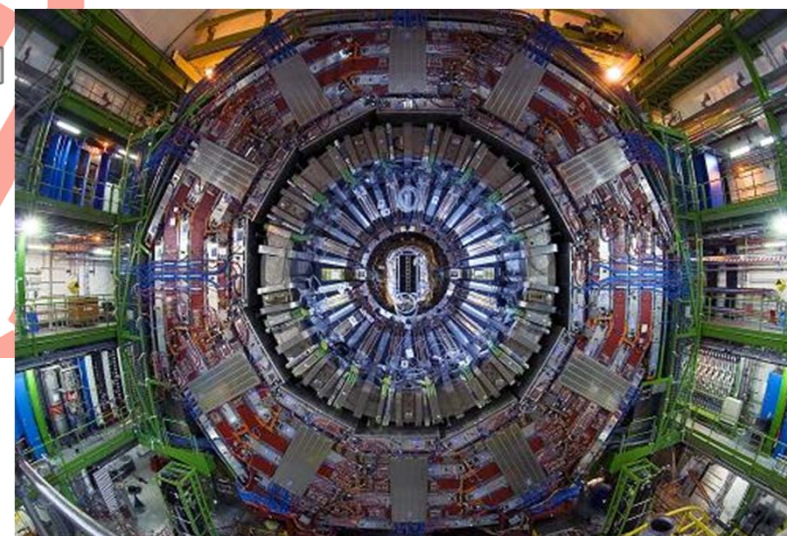
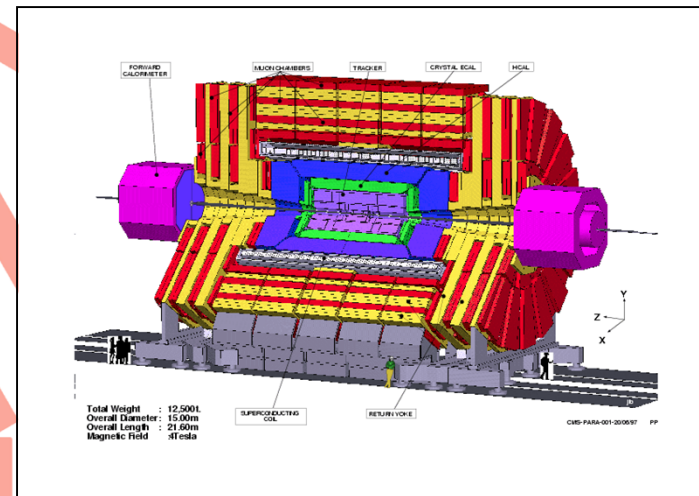
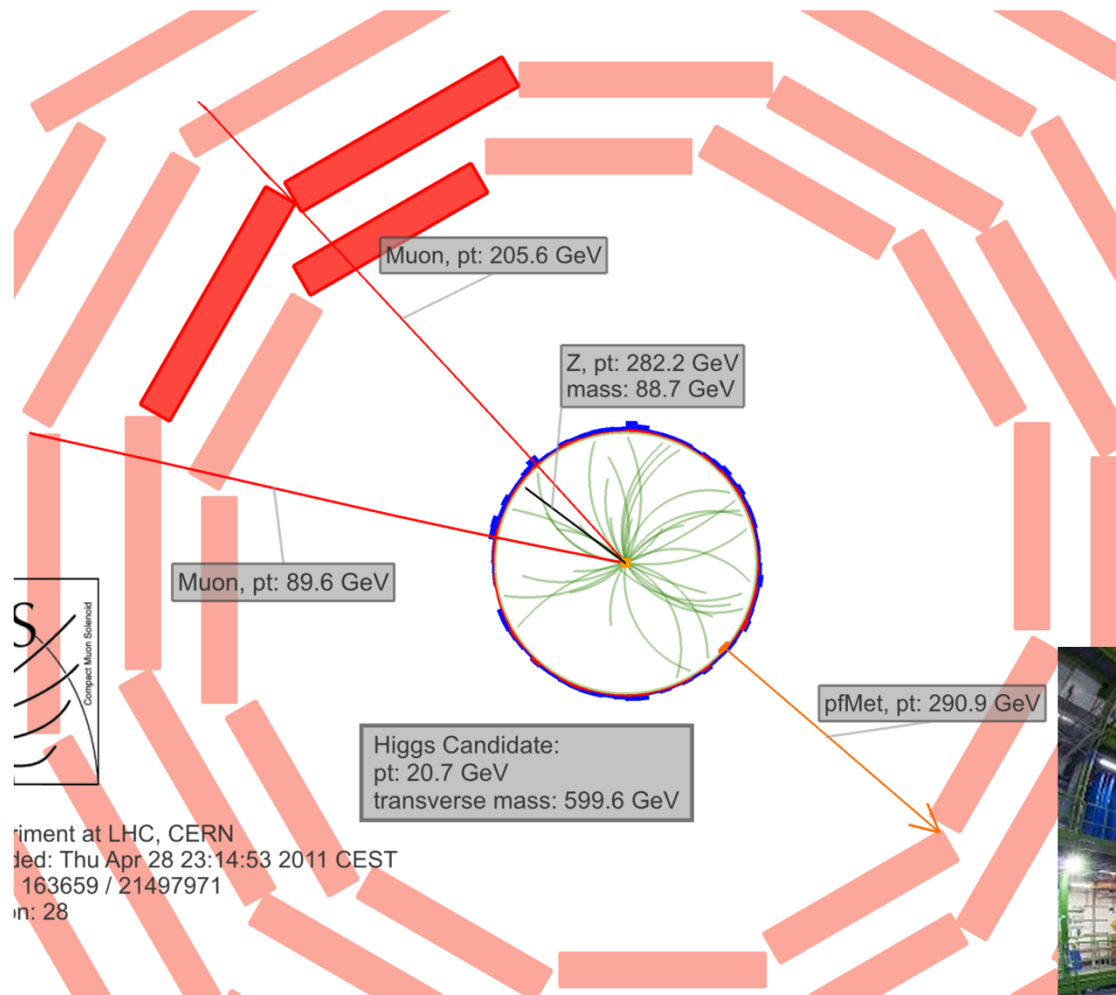
Il (famigerato) bosone di Higgs



$2e2\mu$ candidate with $m_{2e2\mu} = 124.3$ GeV

$p_T(e^+, e^-, \mu^-, \mu^+) = 41.5, 26.5, 24.7, 18.3$ GeV

L'esperimento CMS



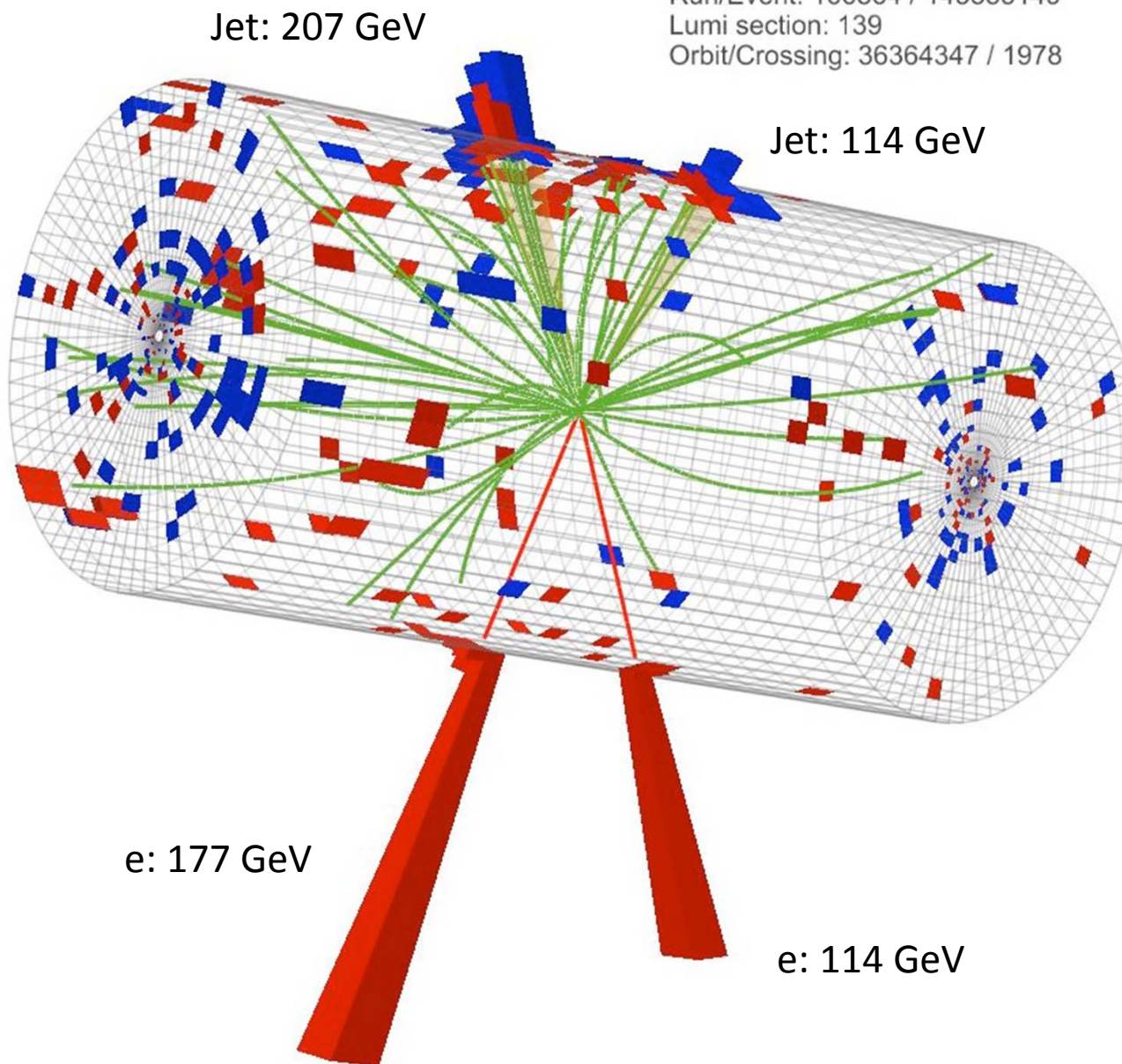
A. Felciello / Liceo Collegio Sacra Famiglia, Torino, 8 e 19 marzo 2012

Experiment at LHC, CERN
 Date: Thu Apr 28 23:14:53 2011 CEST
 ID: 163659 / 21497971
 Page: 28

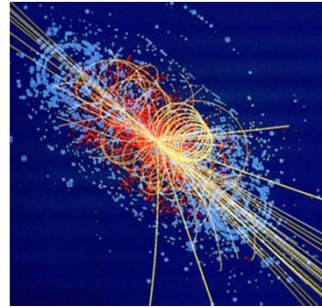
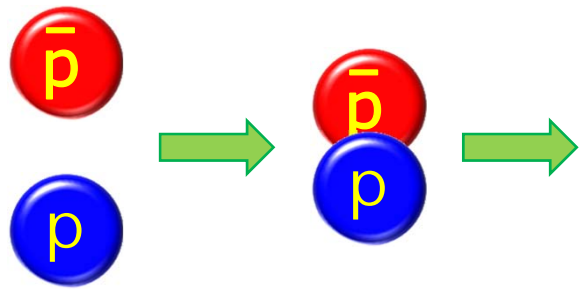
Il (famigerato) bosone di Higgs



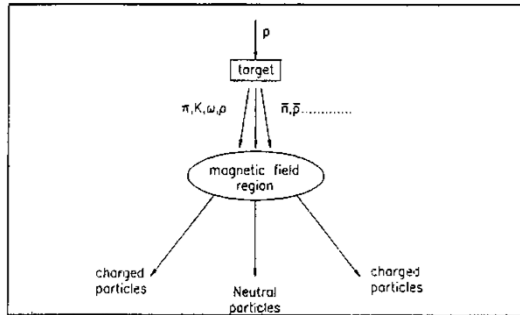
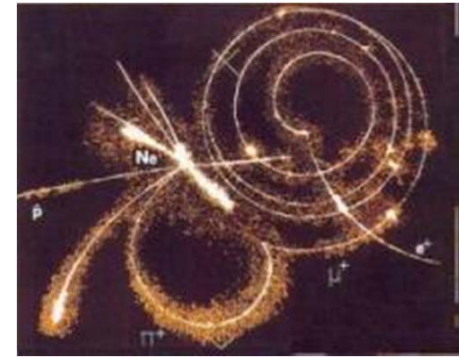
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Lumi section: 139
Orbit/Crossing: 36364347 / 1978



Sperimentare con l'antimateria



$$E = mc^2$$

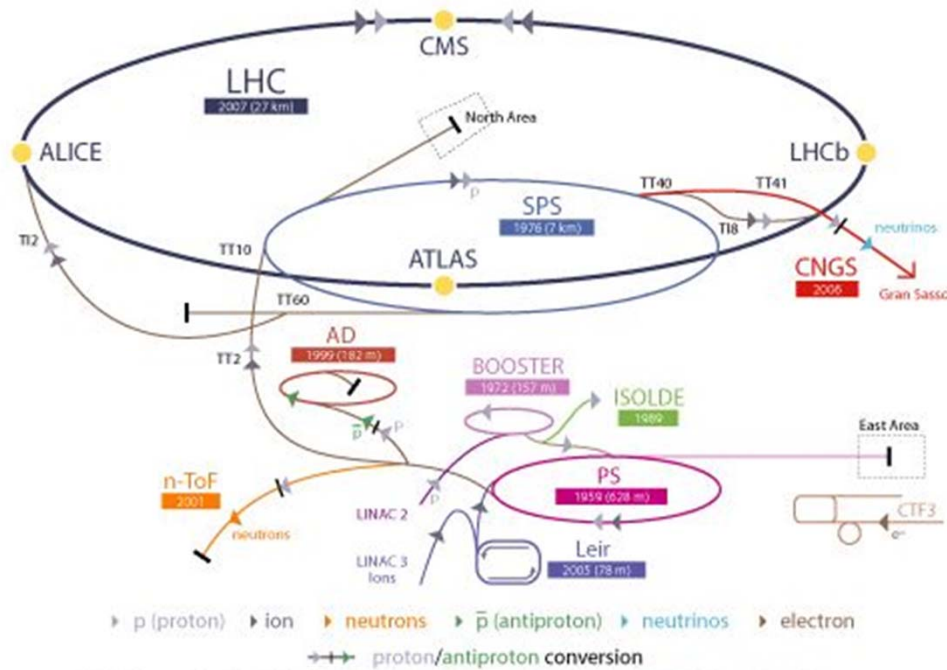


LEAR 1983 - 1996

Il laboratorio CERN



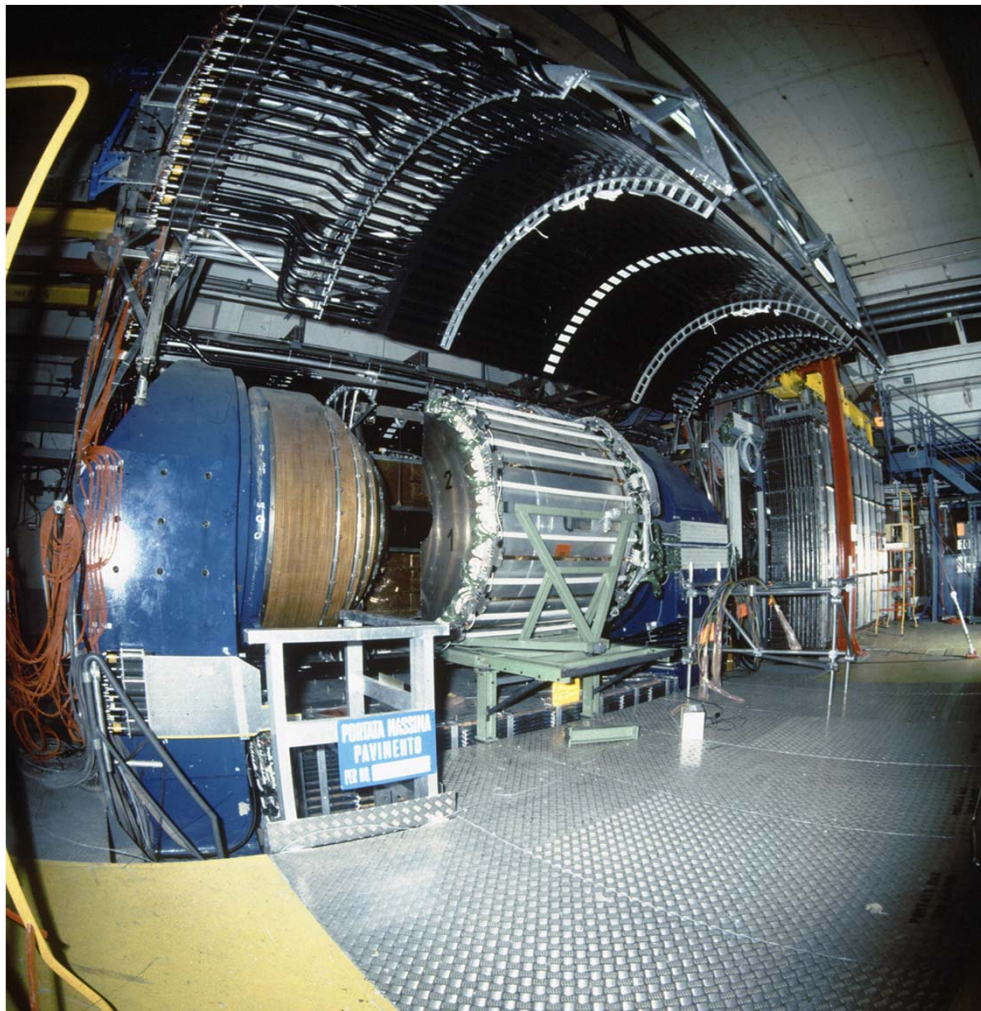
CERN Accelerator Complex



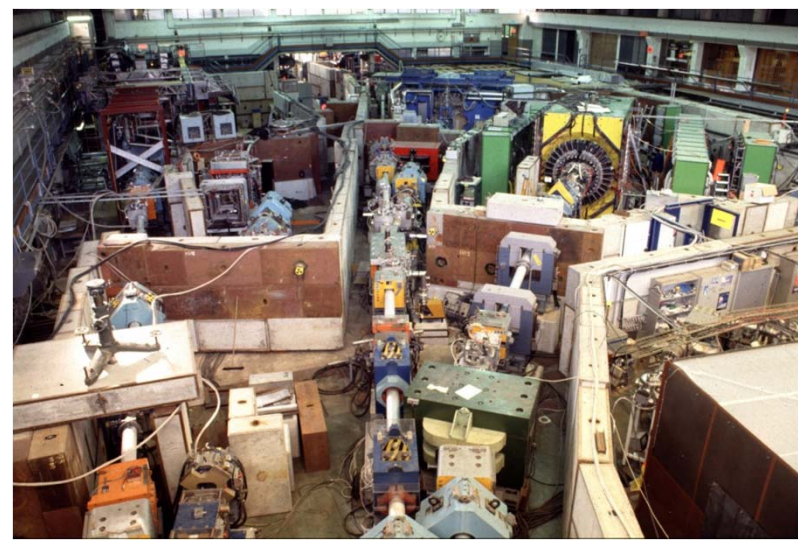
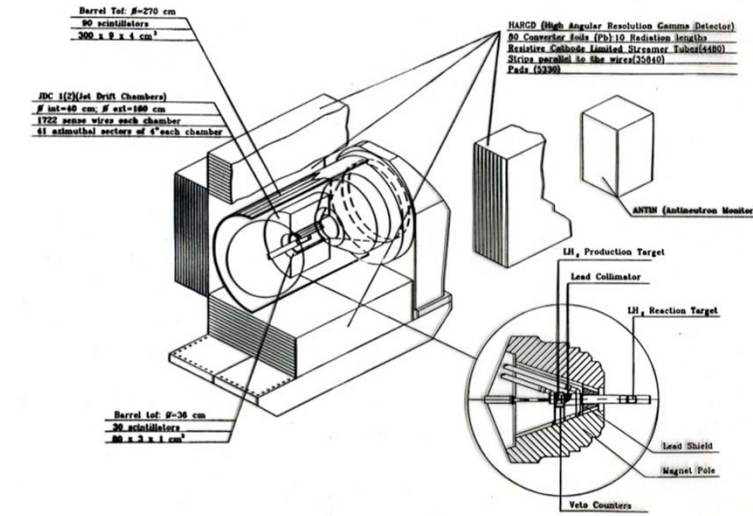
LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron
 AD Antiproton Decelerator CTF3 Clic Test Facility
 CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice
 LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight



L'esperimento OBELIX



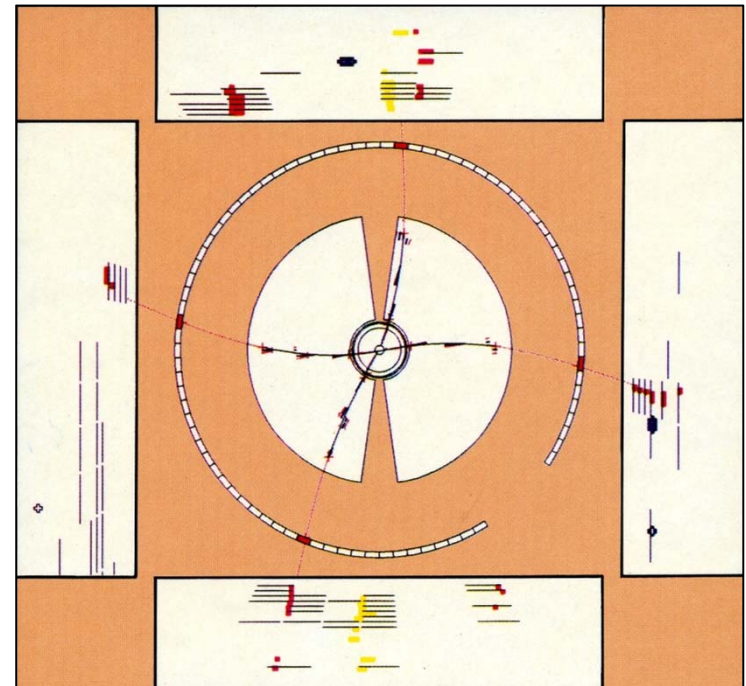
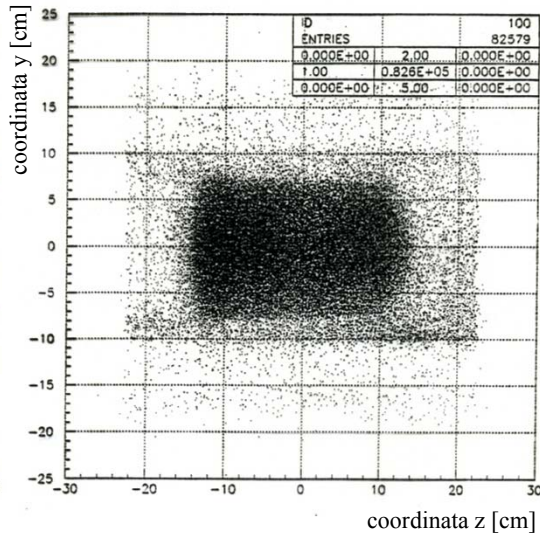
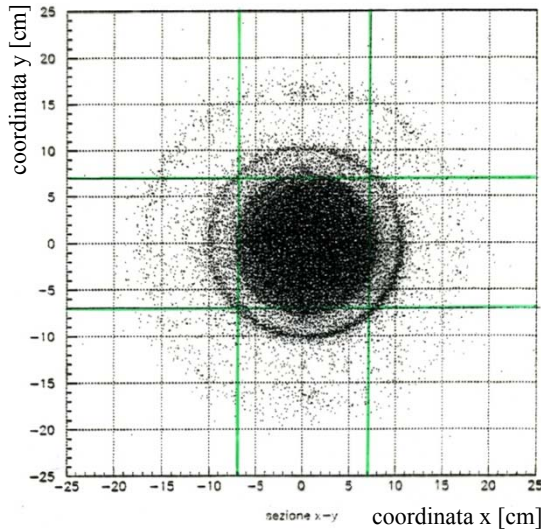
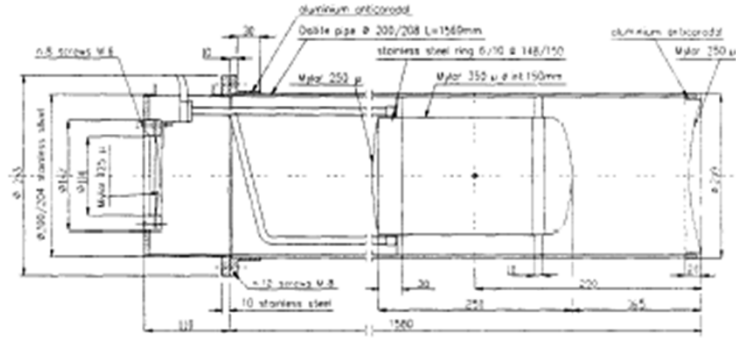
1990 - 1996



A. Felcicello / Liceo Collegio Sacra Famiglia, Torino, 8 e 19 marzo 2012



Una costosa radiografia!



Il ruolo dell'informatica



Cosa è un iper-nucleo?

Un **iper-nucleo** è il risultato di una **manipolazione genetica** effettuata su un nucleo

Particles

Leptons

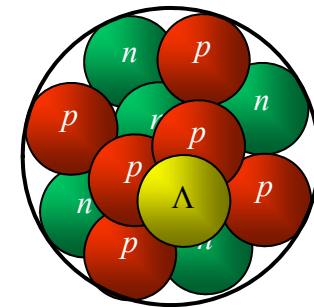
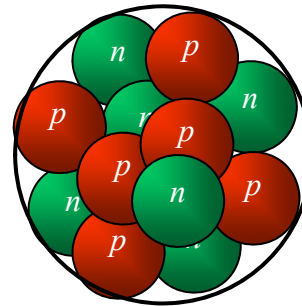
	Electric Charge		Electric Charge
Tau	-1	Tau Neutrino	0
Muon	-1	Muon Neutrino	0
Electron	-1	Electron Neutrino	0

Quarks

	Electric Charge		Electric Charge
Bottom	-1/3	Top	2/3
Strange	-1/3	Charm	2/3
Down	-1/3	Up	2/3

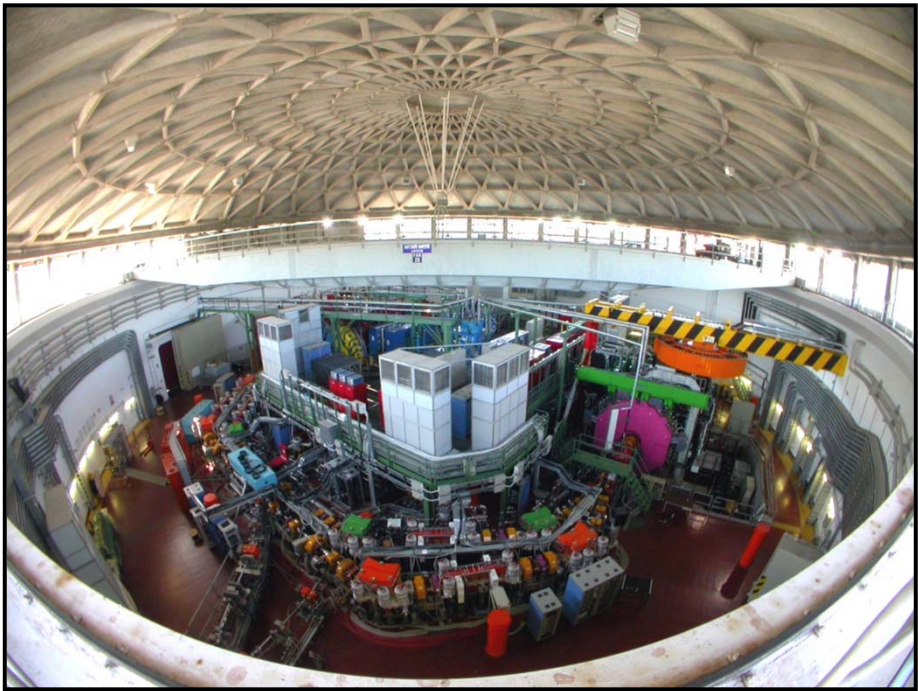
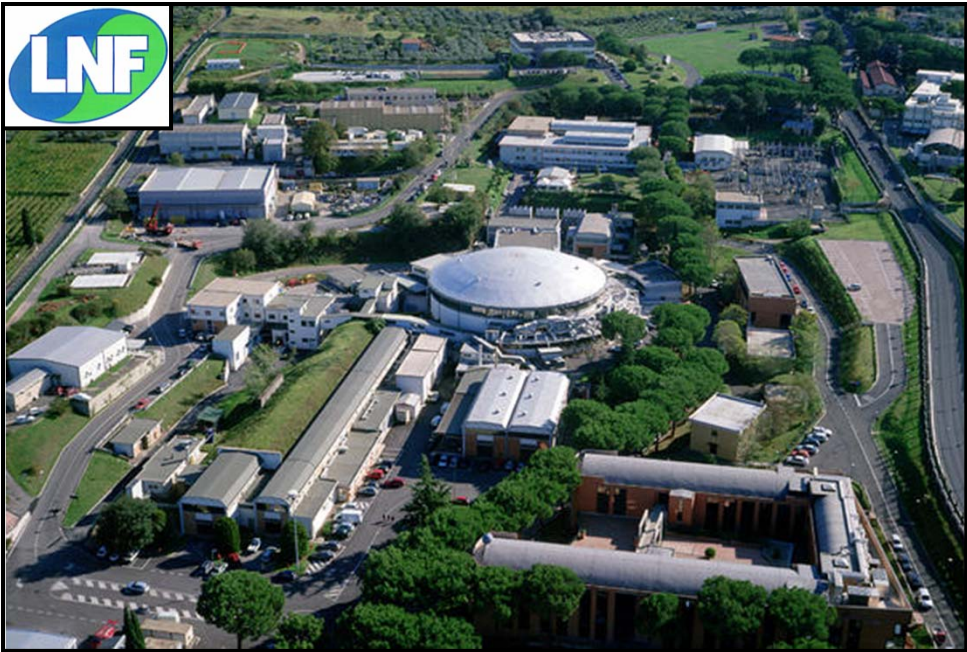
each quark: ●R, ●B, ●G 3 colors

^{12}C

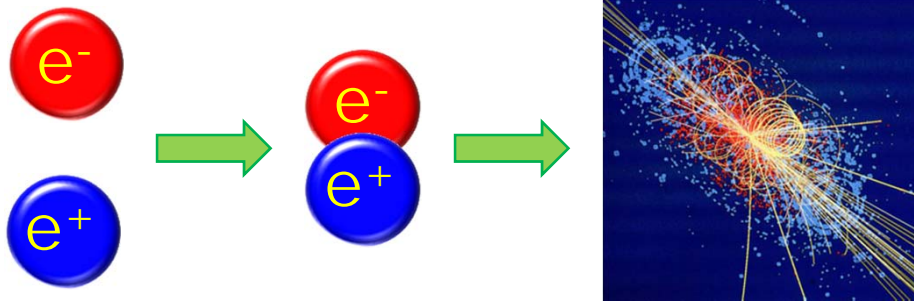


$^{12}_{\Lambda}\text{C}$

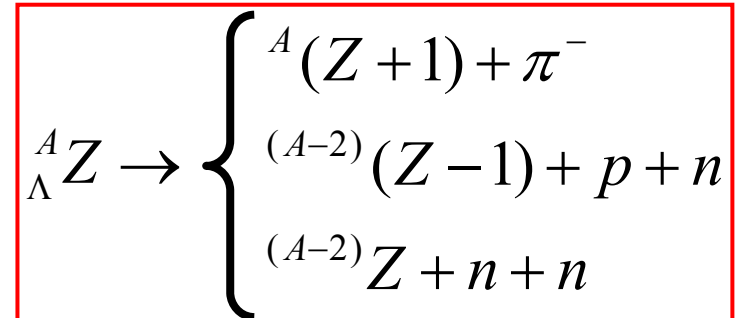
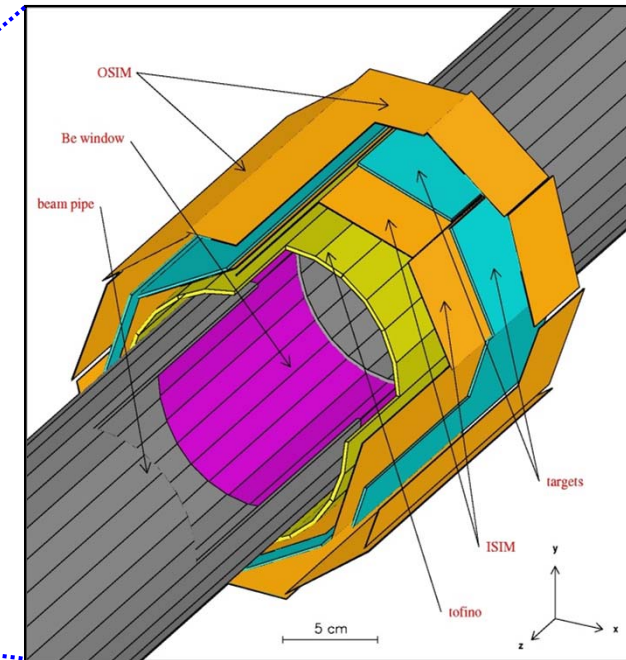
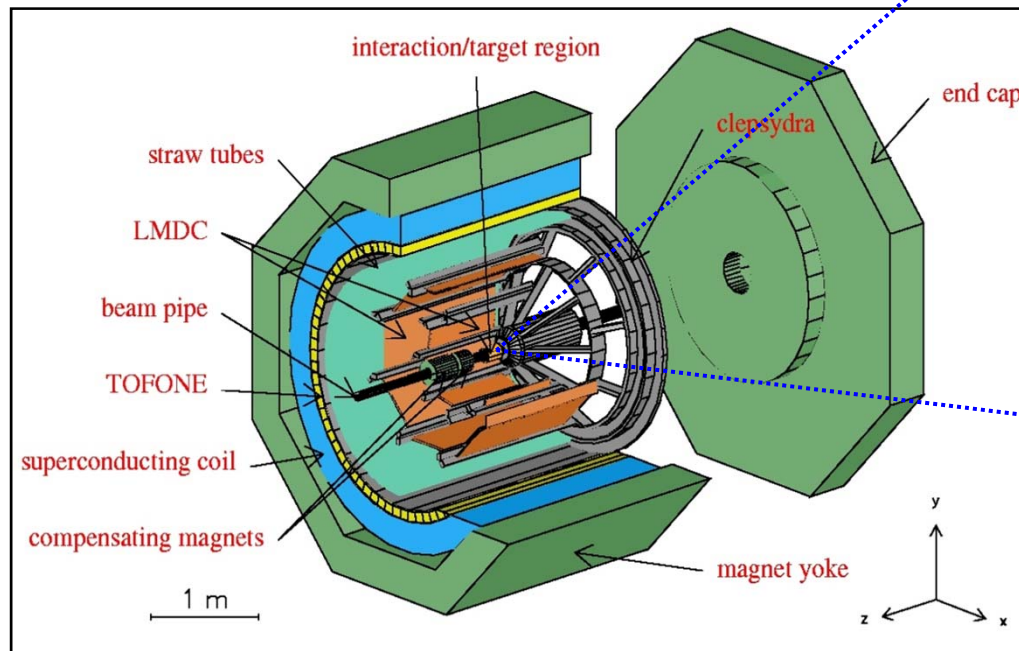
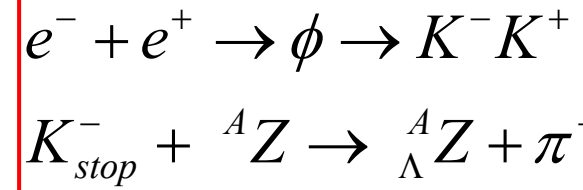
Il laboratorio LNF



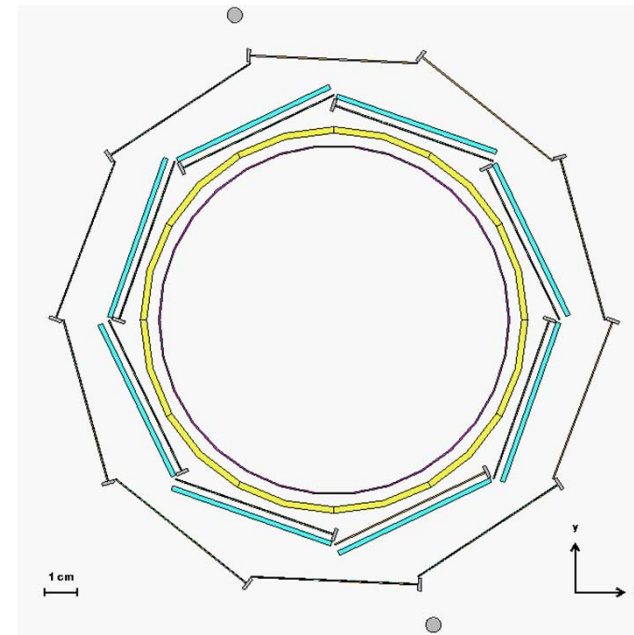
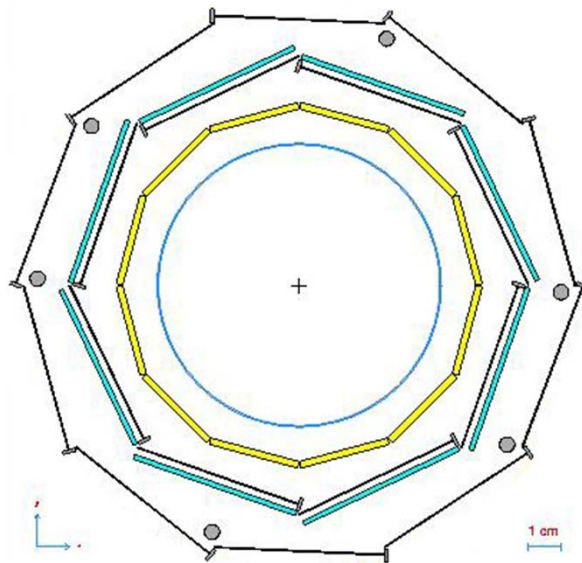
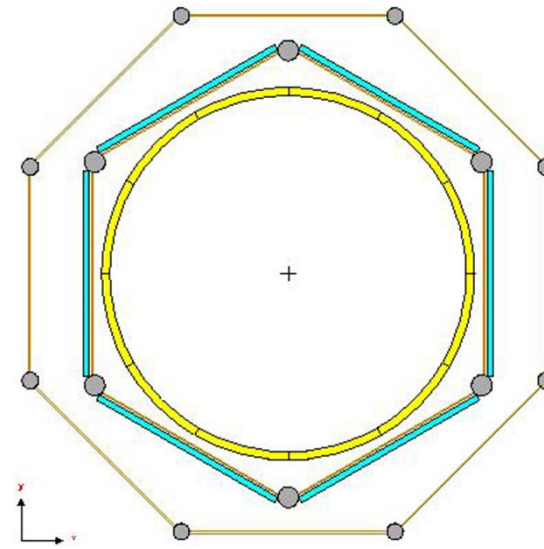
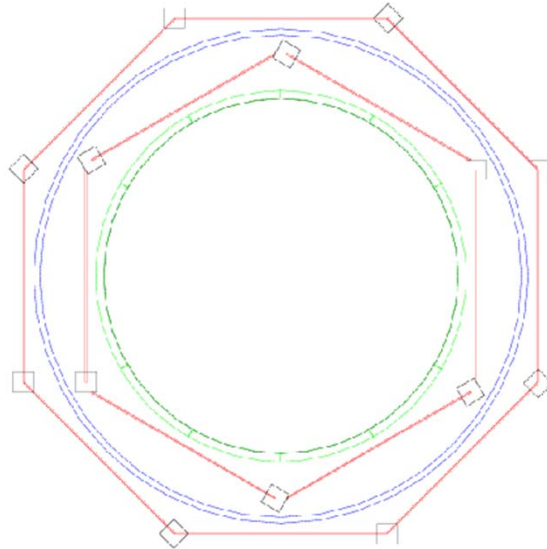
L'esperimento FINUDA



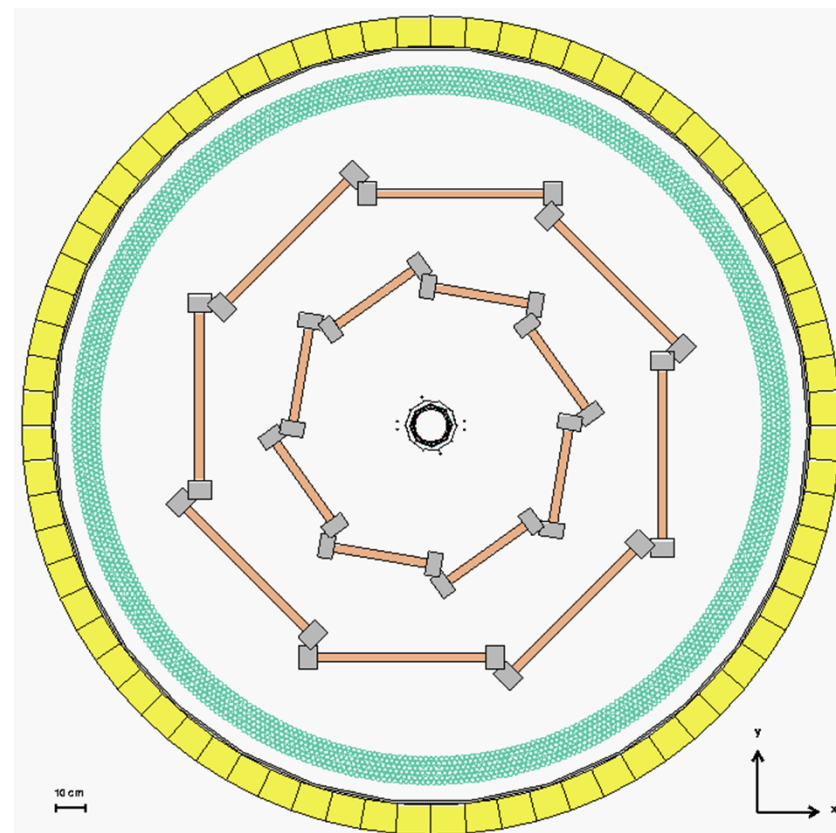
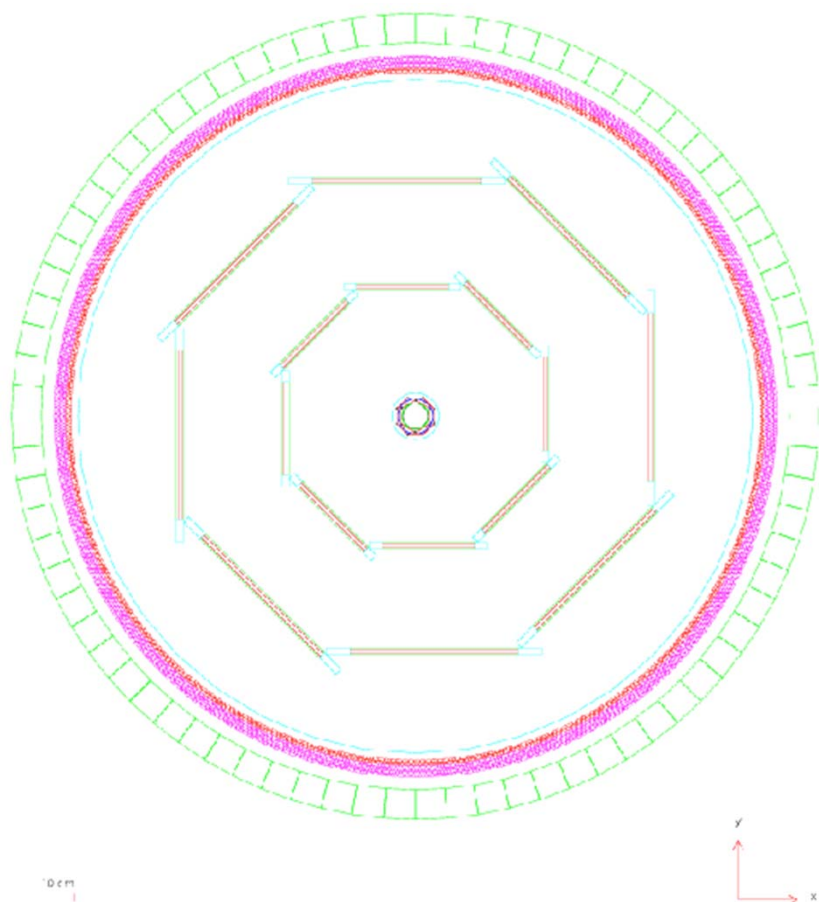
$$E = mc^2$$



L'evoluzione del rivelatore



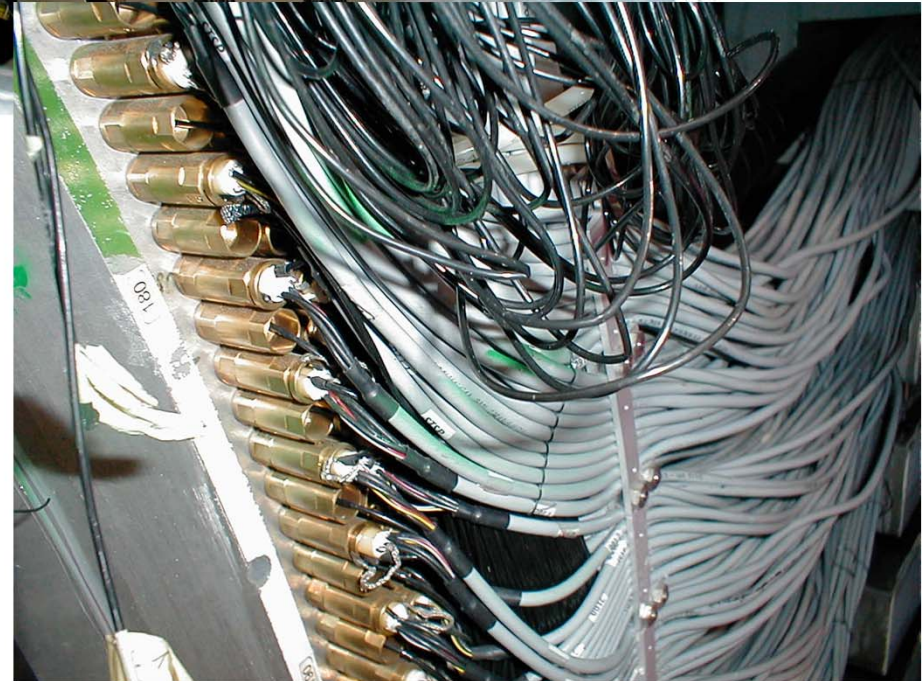
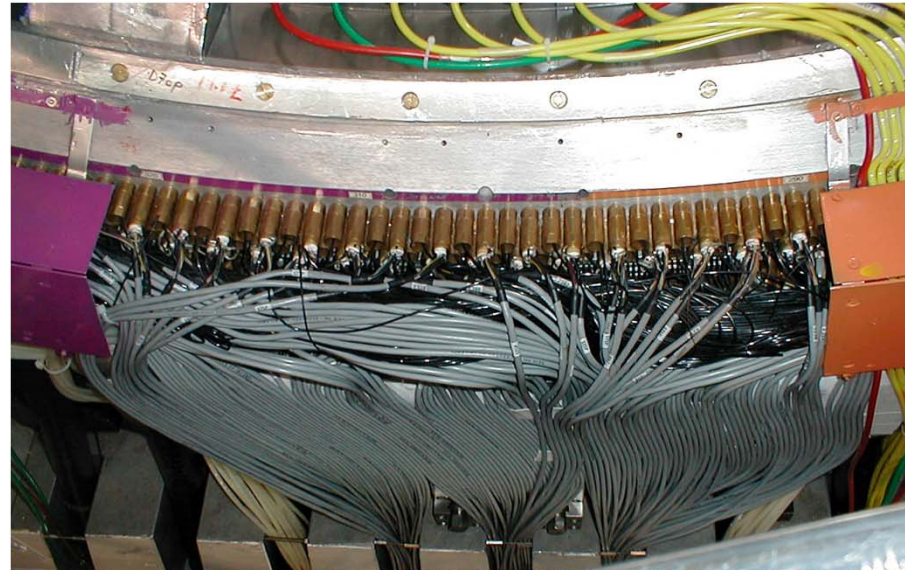
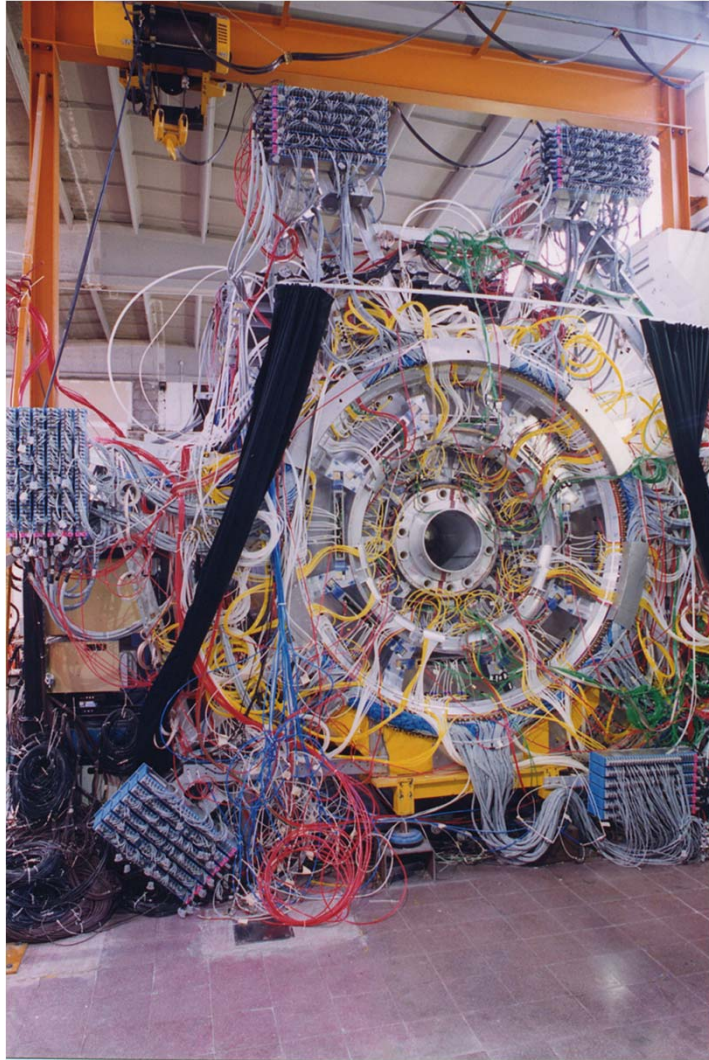
L'evoluzione del rivelatore



La fase realizzativa



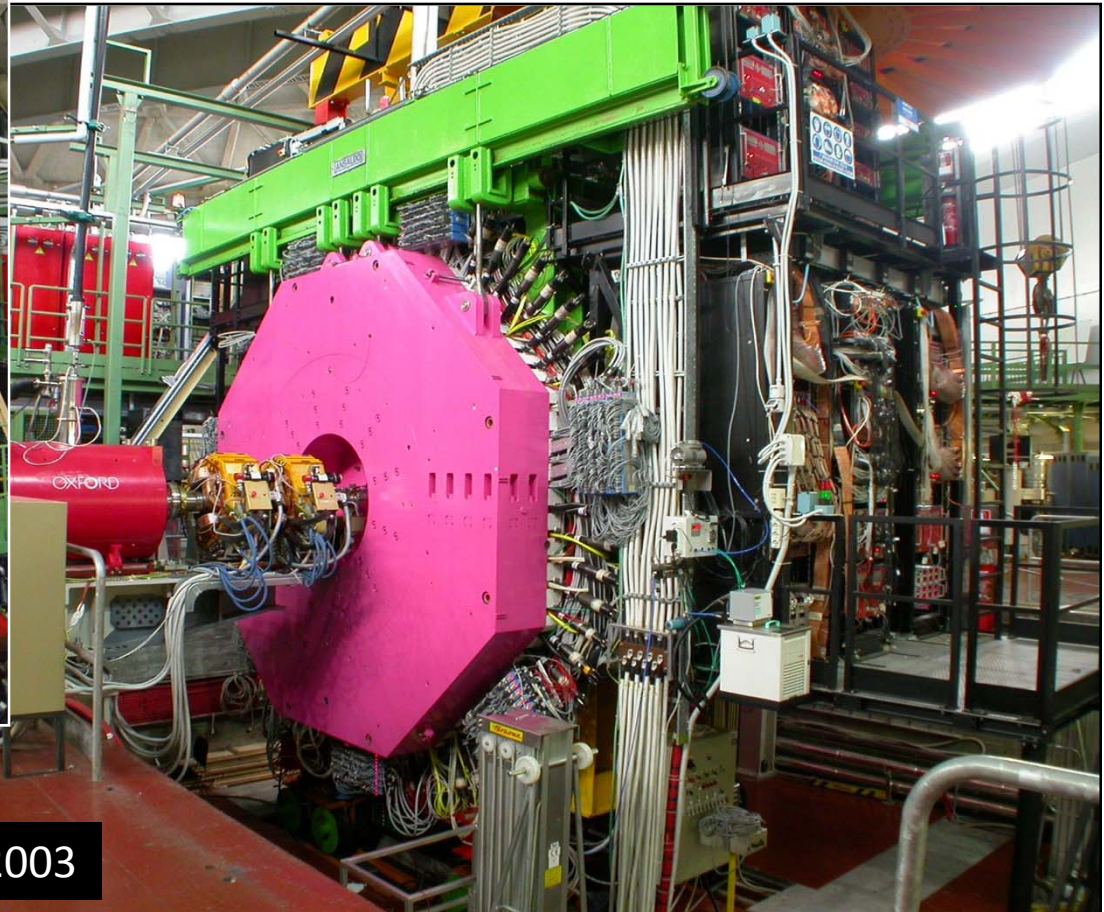
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L'apparato FINUDA

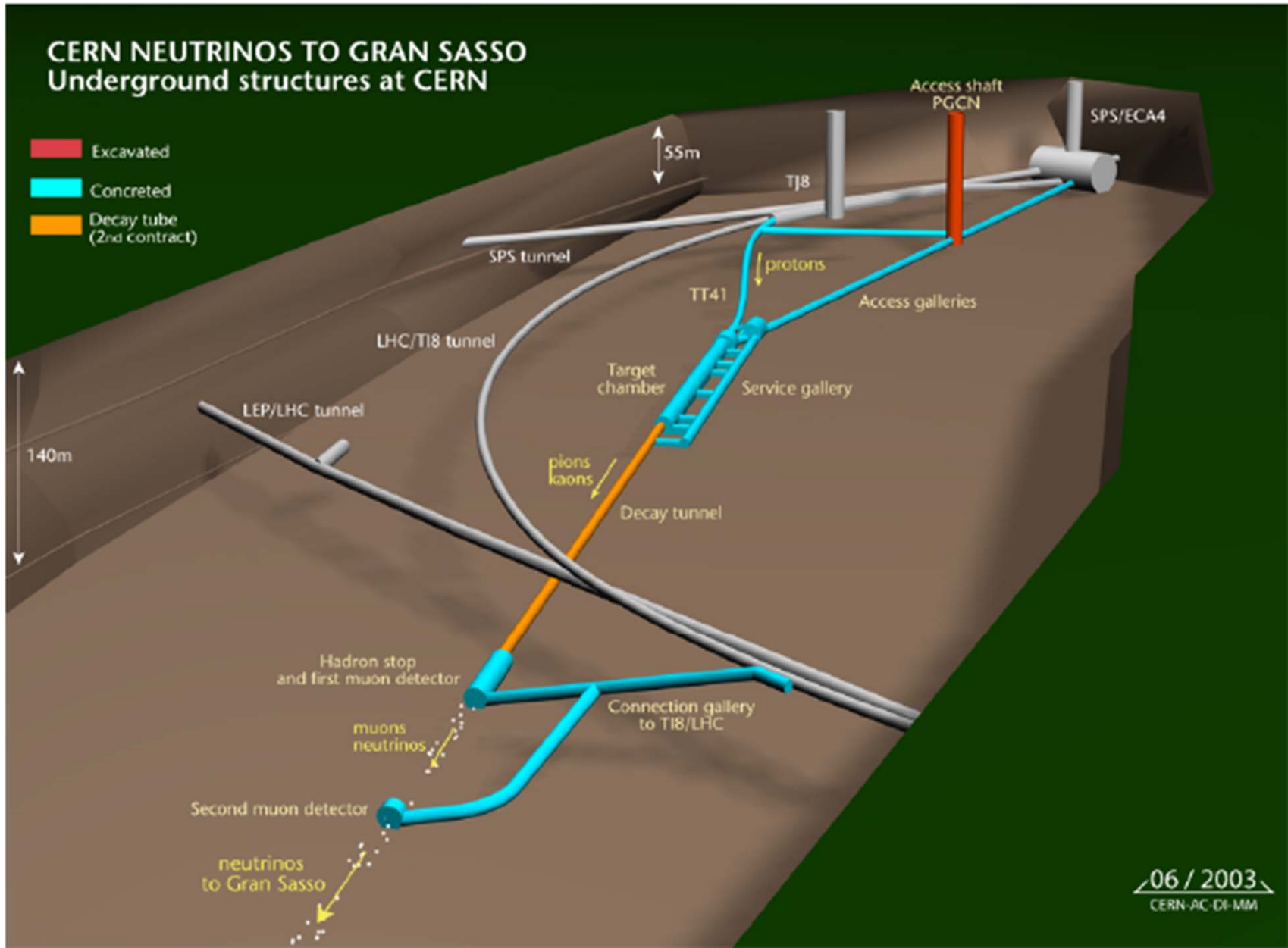


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maggio 2003

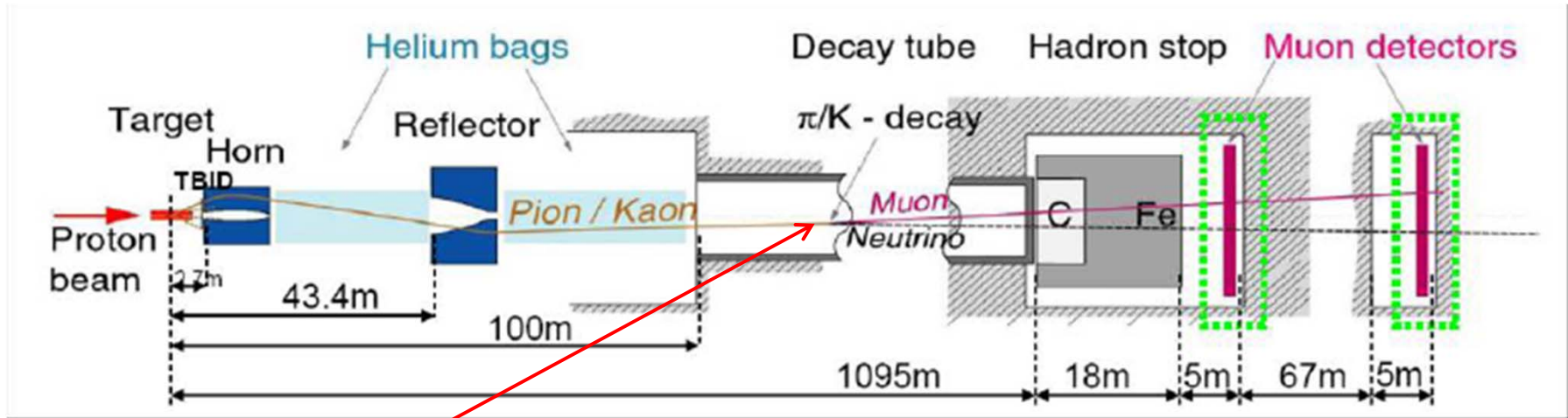
L'esperimento CNGS



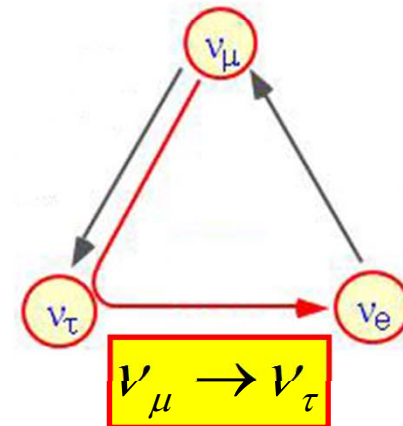
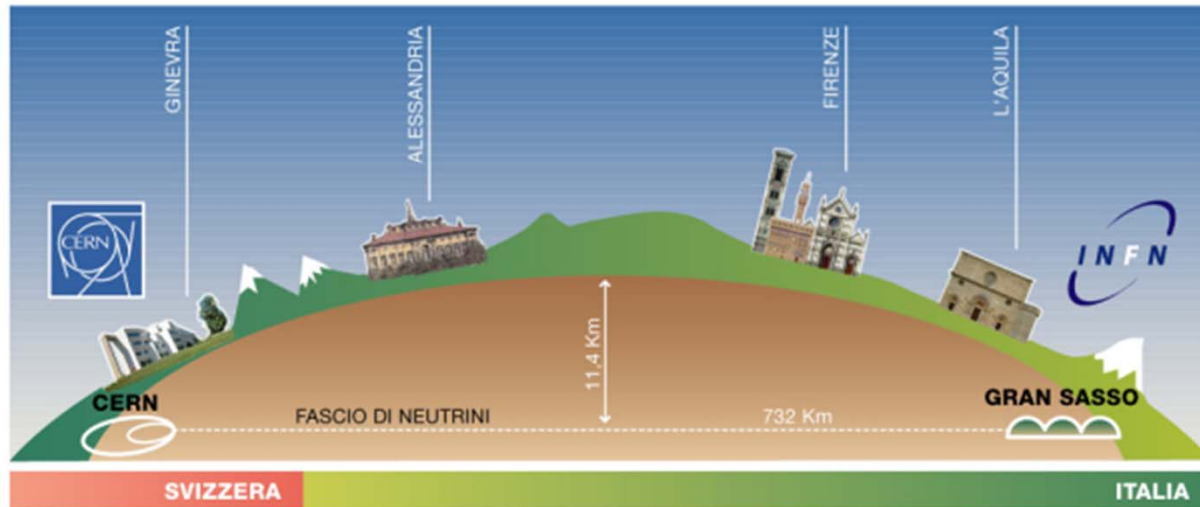
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L'esperimento CNGS



- ν_e e neutrino
- e^- electron
- ν_{μ} μ neutrino
- μ^- muon
- ν_{τ} τ neutrino
- τ^- tau

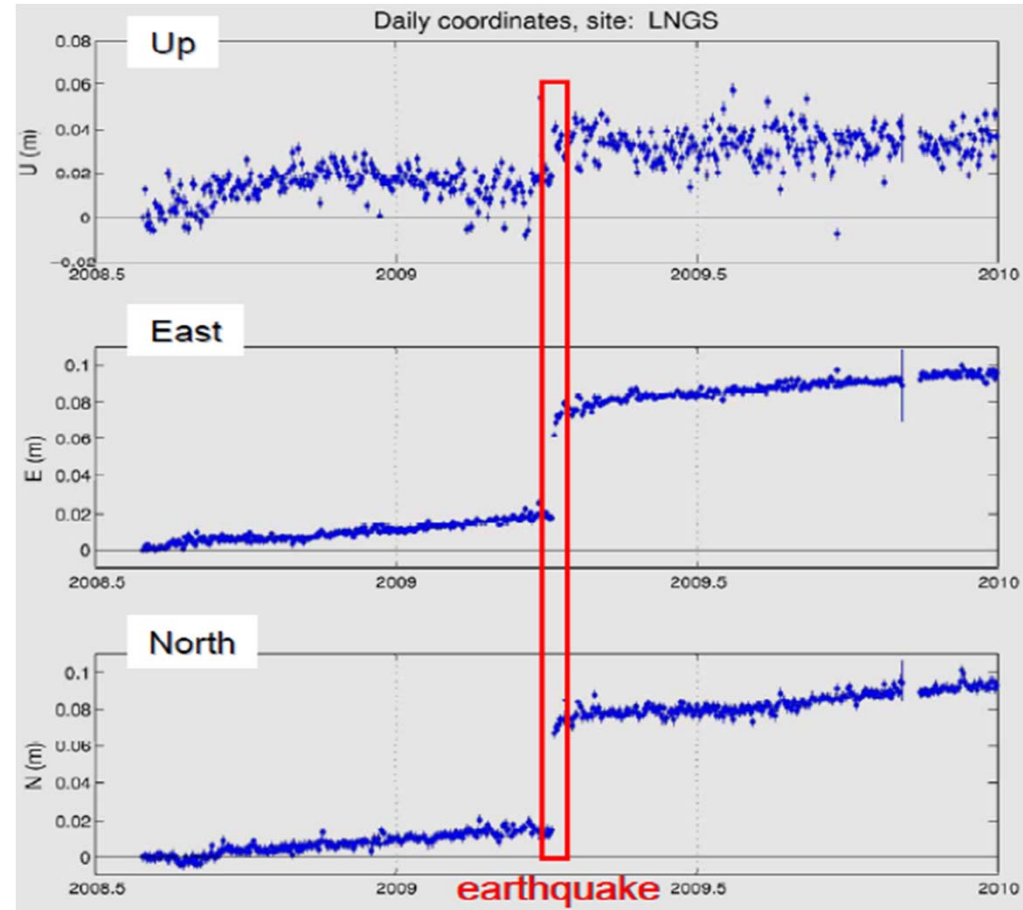


L'esperimento CNGS

la misura
della distanza
fra CERN e LNGS

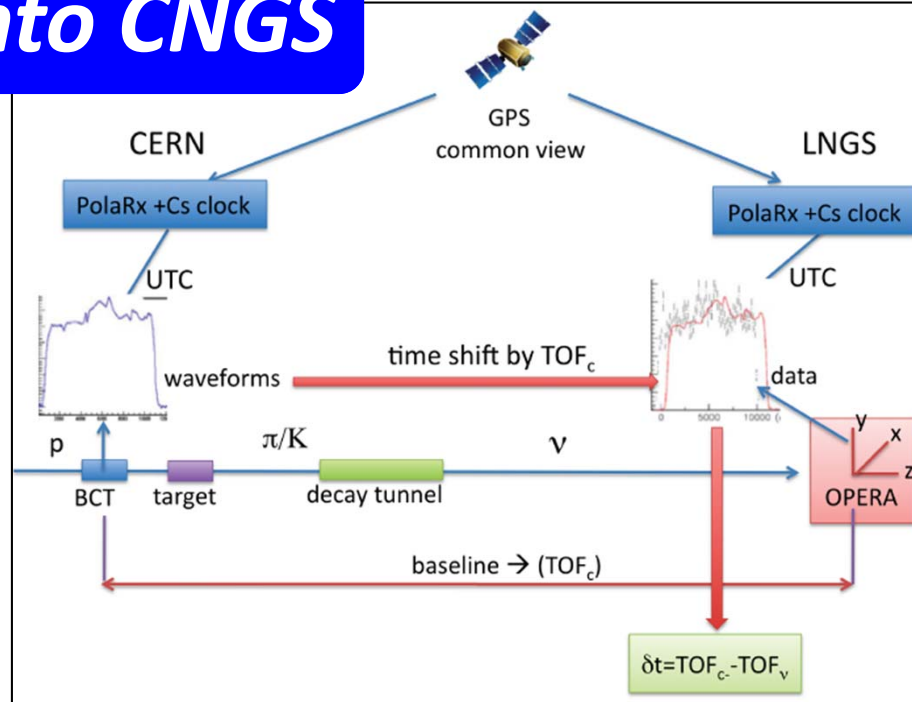
731278,0 m \pm 0,2 m

731 km \pm 20 cm

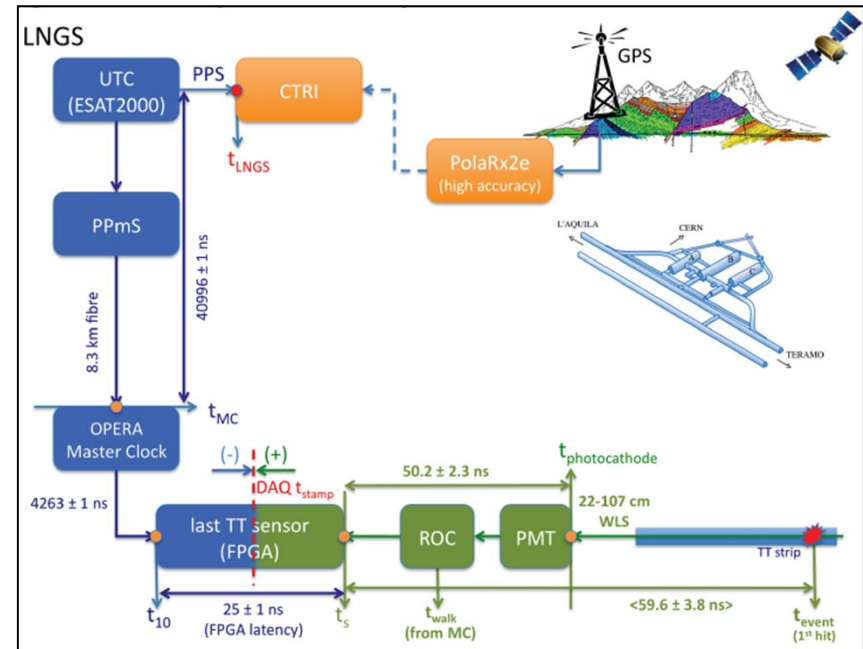
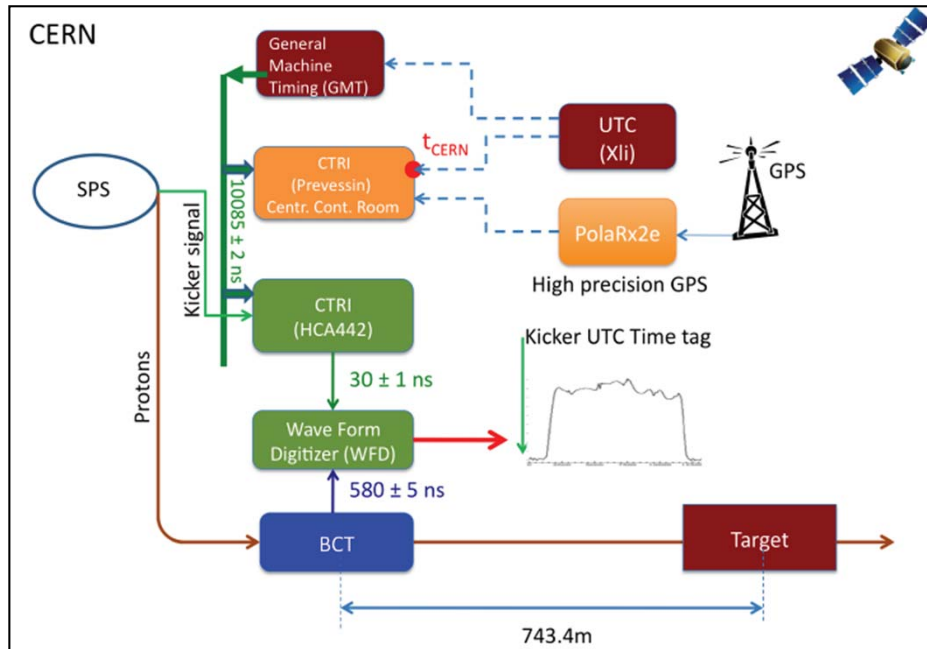


L'esperimento CNGS

la misura dell'intervallo di tempo



$= (57,8 \pm 7.8) \text{ ns}$



Il laboratorio LNGS



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LABORATORI NAZIONALI DEL GRAN SASSO

LNGS I NUMERI

- circa 750 SCENZIATI da 22 diversi Paesi
- circa 15 ESPERIMENTI in diverse fasi di realizzazione

GRAN SASSO schemato da 1.400 m di roccia

Tunnel autostrada A24 10.000m

LABORATORI NAZIONALI DEL GRAN SASSO

TORNA A INIZIO VISITA

SALA A: Cresti, Cuore, GEMMA, LUNA
SALA B: ICARUS, WARP, ALPHON
SALA C: BOREXINO, OPERA
Dama/Libra
A24 di L'Aquila
A24 di Teramo

INIZIA VISITA GUIDATA



Il rivelatore OPERA



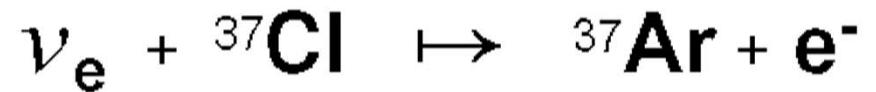
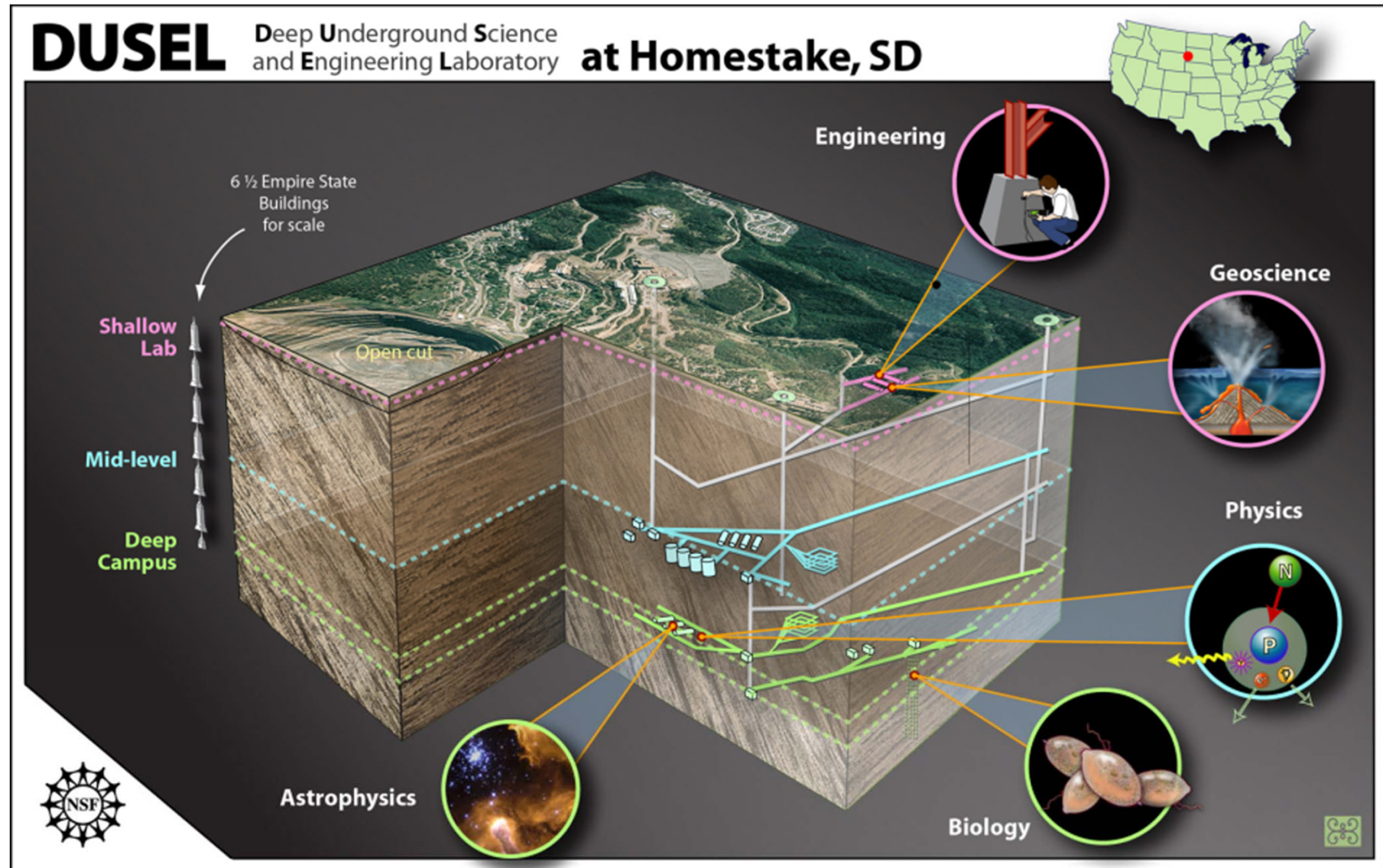
51



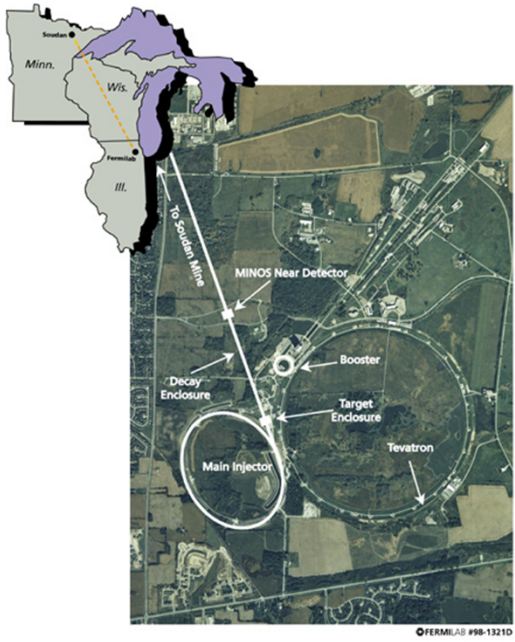
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L'esperimento di Davis

DUSEL Deep Underground Science and Engineering Laboratory at Homestake, SD

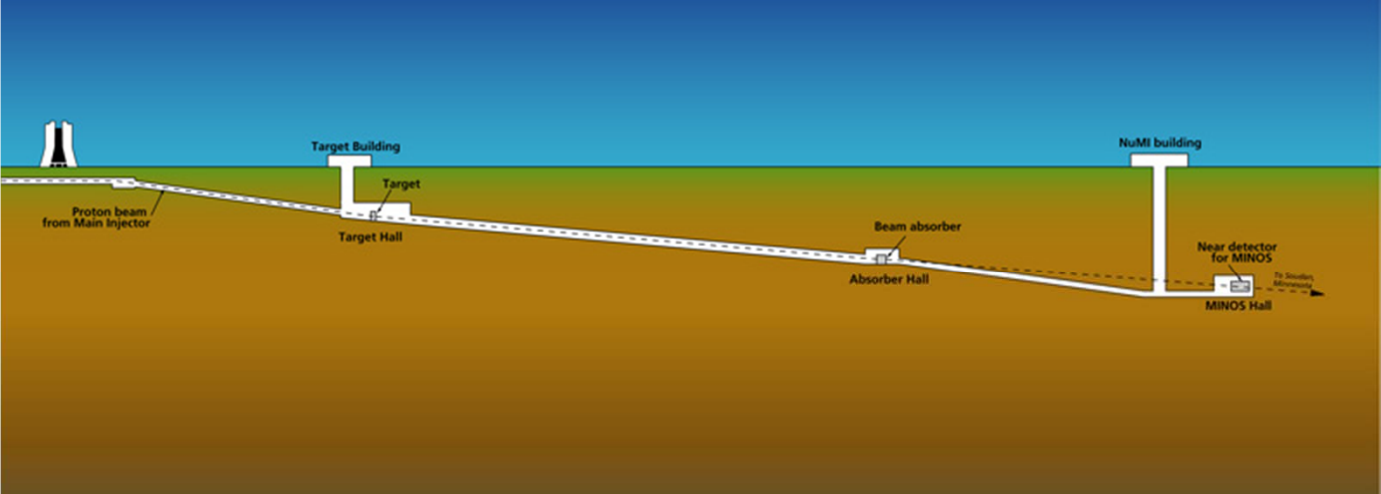


L'esperimento MINOS



NuMI Tunnel Project

Neutrinos at the Main Injector

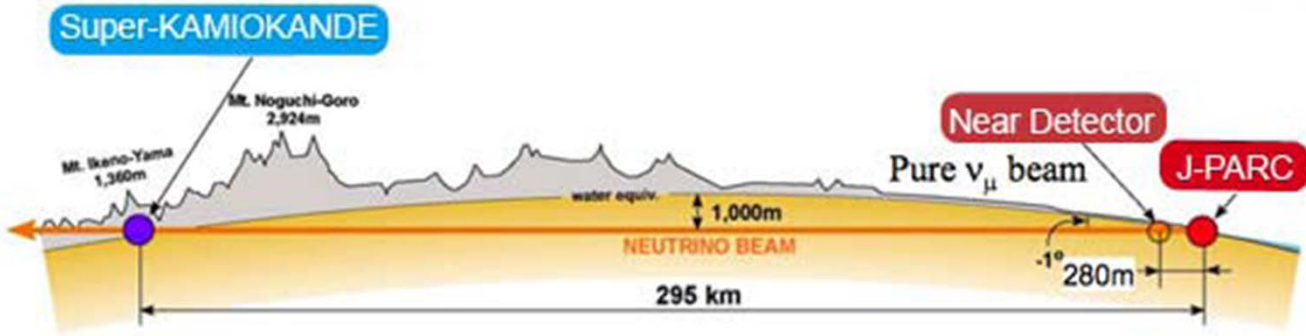
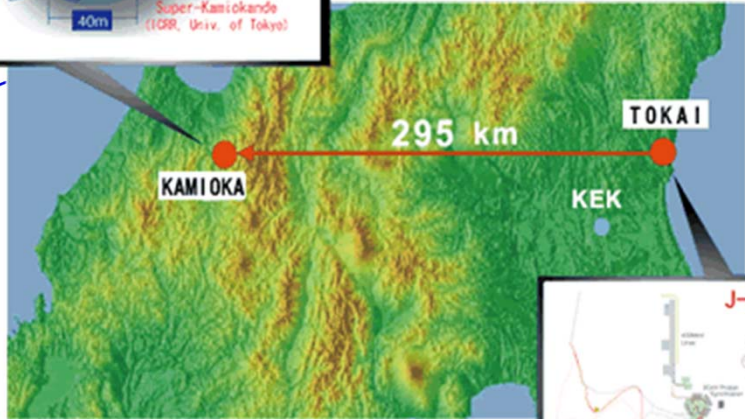
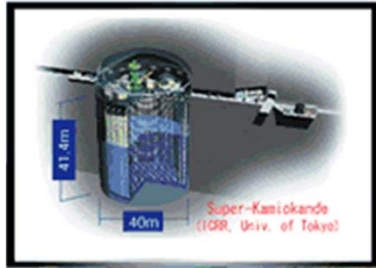
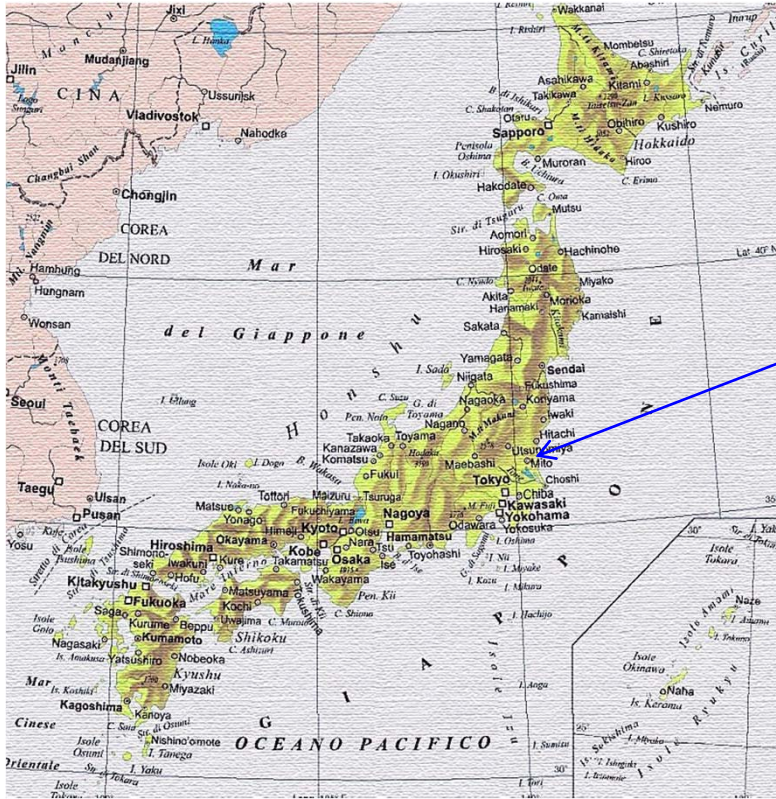


Main Injector Neutrino Oscillation Search

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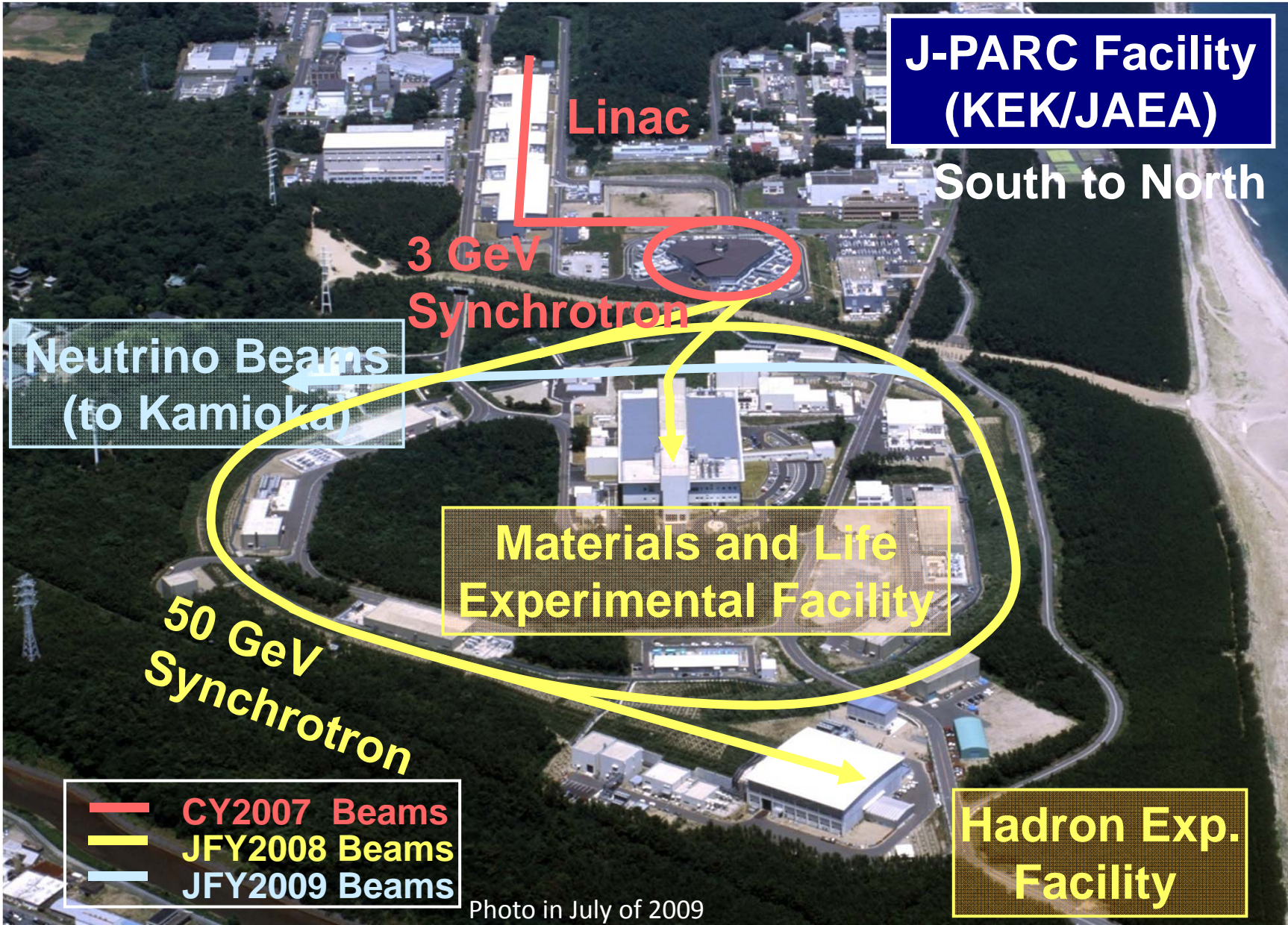
L'esperimento T2K



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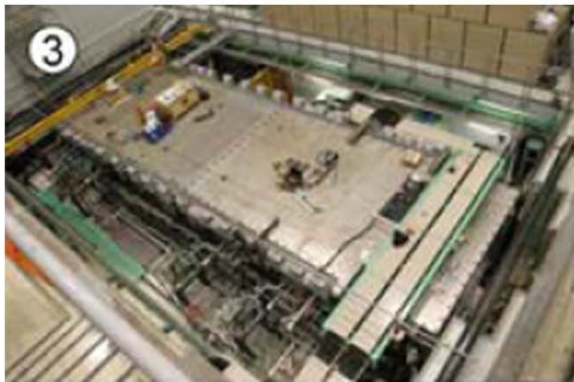
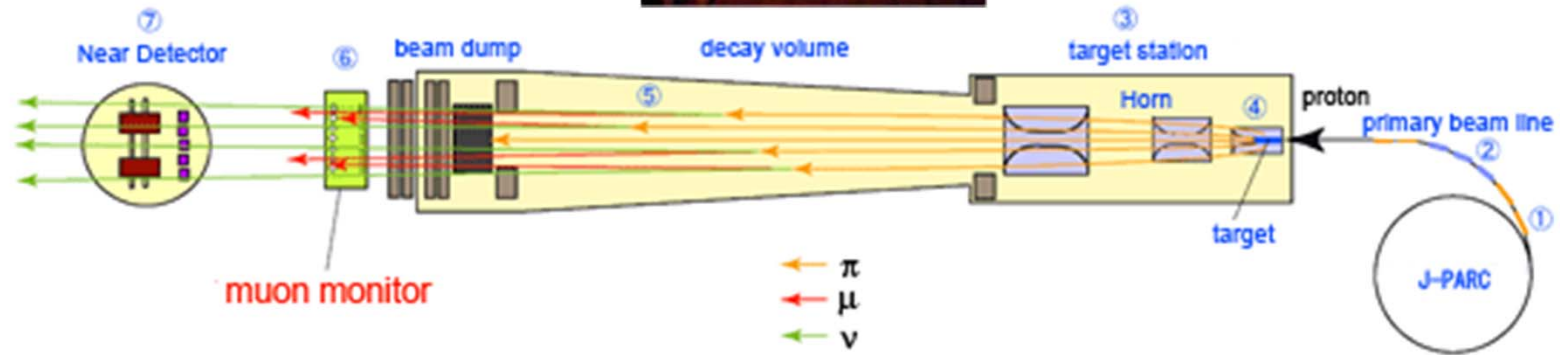
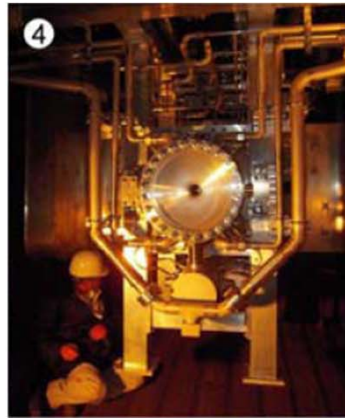
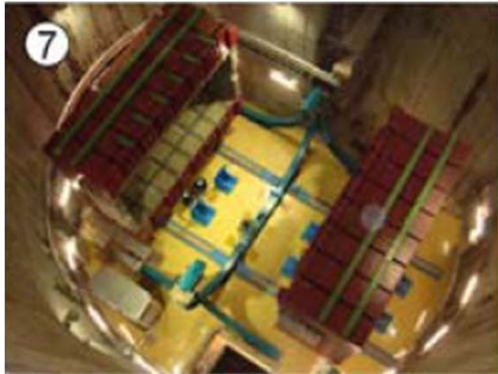
Il laboratorio J-PARC



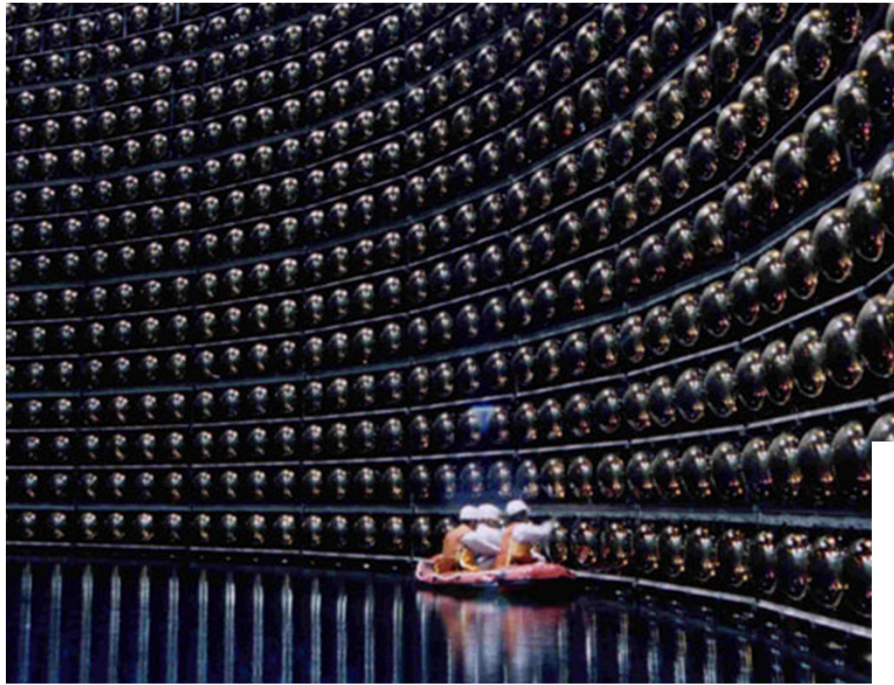
A. Felciello / Liceo Collegio Sacra Famiglia, Torino, 8 e 19 marzo 2012



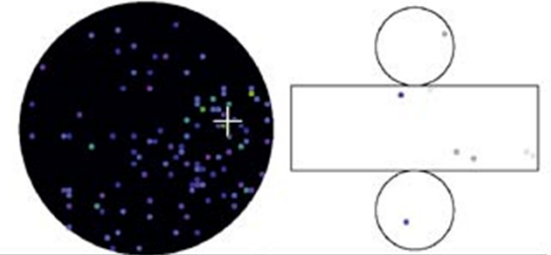
L'esperimento T2K



L'esperimento T2K

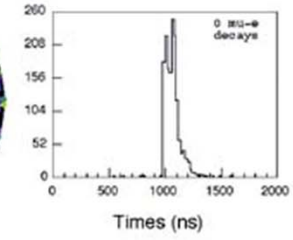
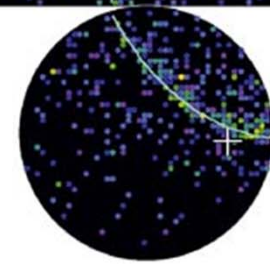
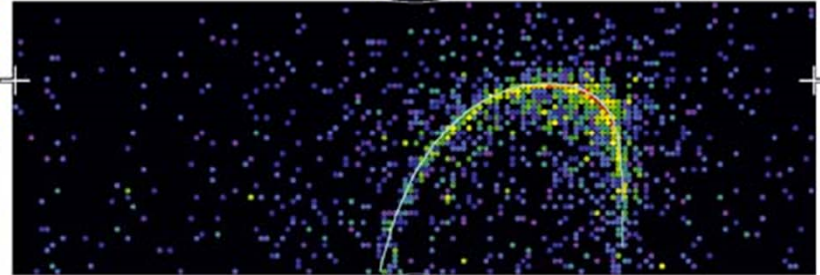


Super-Kamiokande IV
 T2K Beam Run 33 Spill 822275
 Run 66778 Sub 585 Event 134229437
 16-05-12:21:03:22
 T2K beam dt = 1902.2 ns
 Inner: 1601 hits, 3581 pe
 Outer: 2 hits, 2 pe
 Trigger: 0x80000007
 D_wall: 614.4 cm
 e-like, p = 381.8 MeV/c



Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.3-14.7
- 10.0-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2



Le ricadute tecnologiche

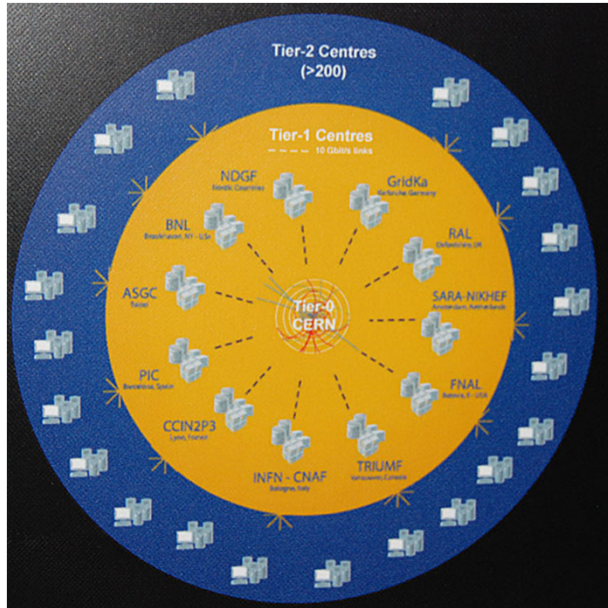
World Wide Web (WWW)



06 agosto 1991



GRID computing



MonALISA Repository for ALICE

[Catalogue browser](#)
[Repository Home](#)
[Administration Section](#)
[ALICE Reports](#)
[Events XML Feed](#)
[Firefox Toolbar](#)
[MonALISA](#)

● Running jobs
 ● Running jobs but no ML info
 ● Site service problem(s) prevents job execution
 ● No jobs match the site resources
 ● ML service down & no runn

Map options Show xroold transfers

Jump to: [Europe](#) [North America](#) [South America](#) [Asia](#) [World](#)
[Save position and options](#)

Repository Home - ALICE Web Page - ALICE Clusters - Contact - Links

Dynamic charts

close all

This page: bookmark, URL

Running jobs trend

9429 jobs

Running jobs trend

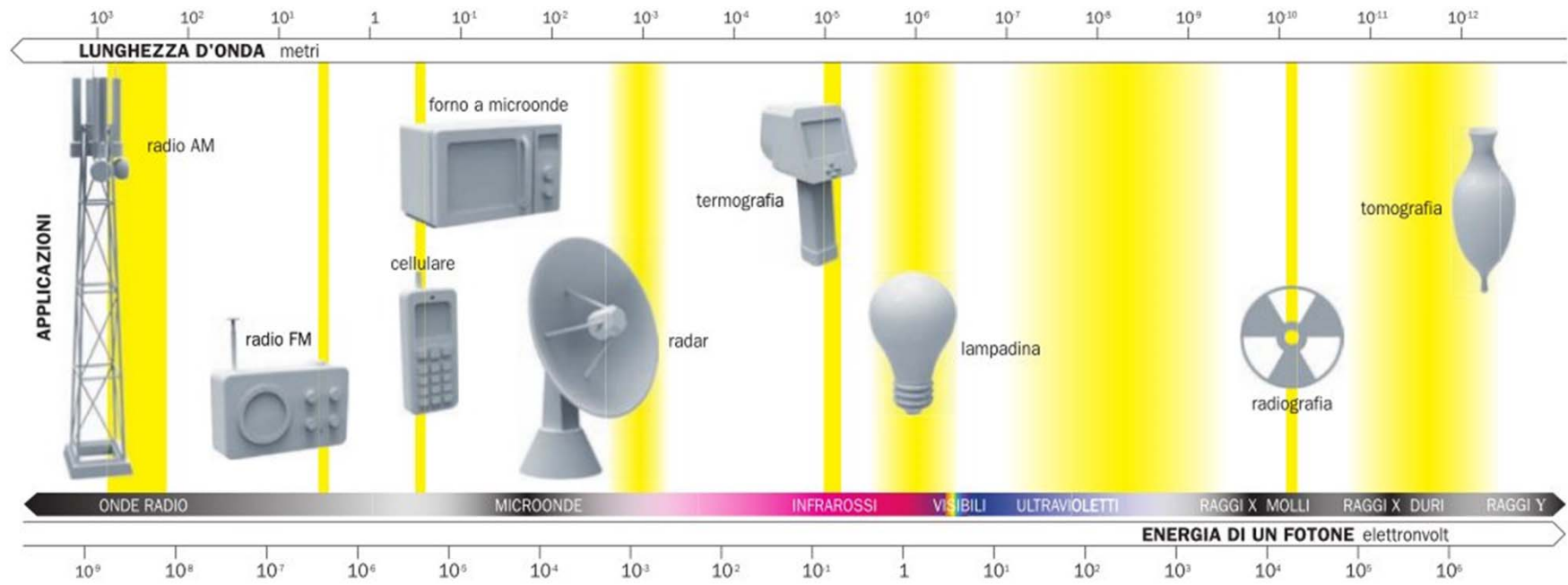
→ 24h
 → 12h
 → 6h
 → 1h

(click arrows for detailed view)

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La radiazione elettromagnetica

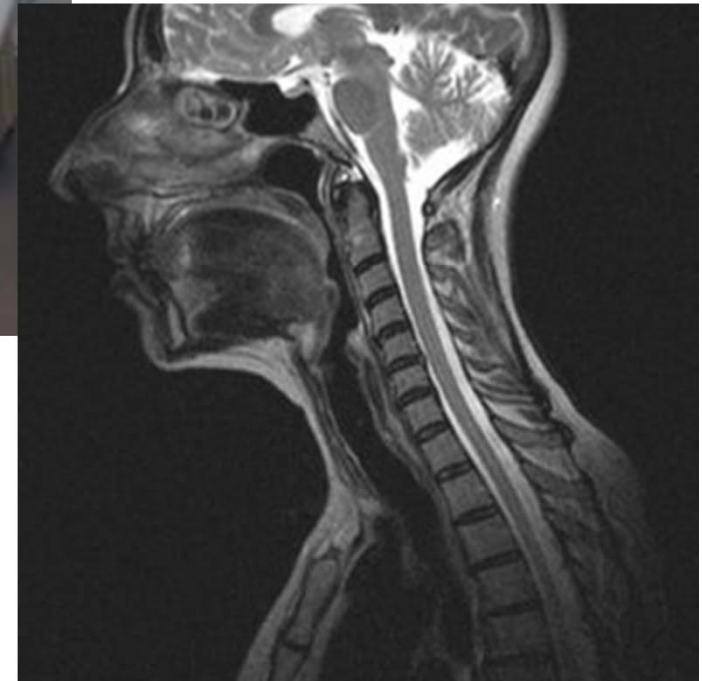


Contributi della fisica alla medicina

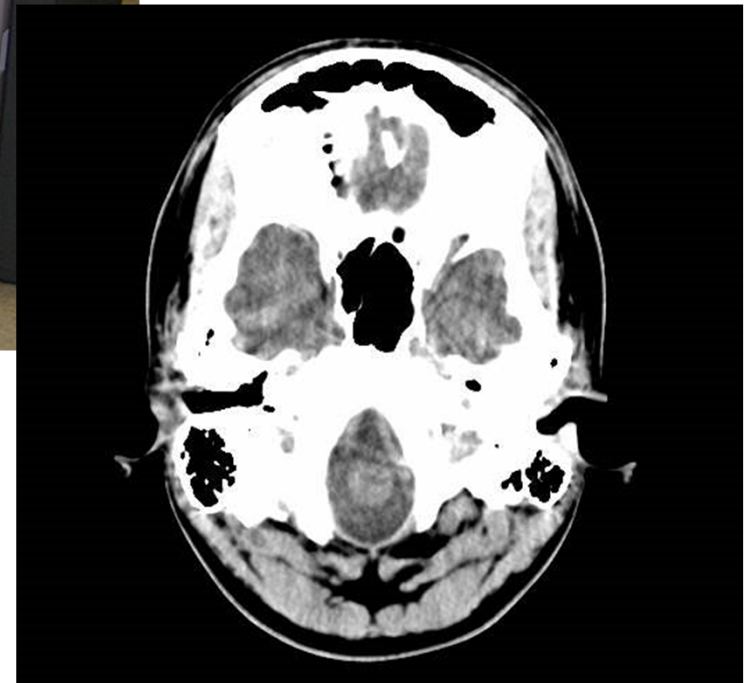
L'ecografia



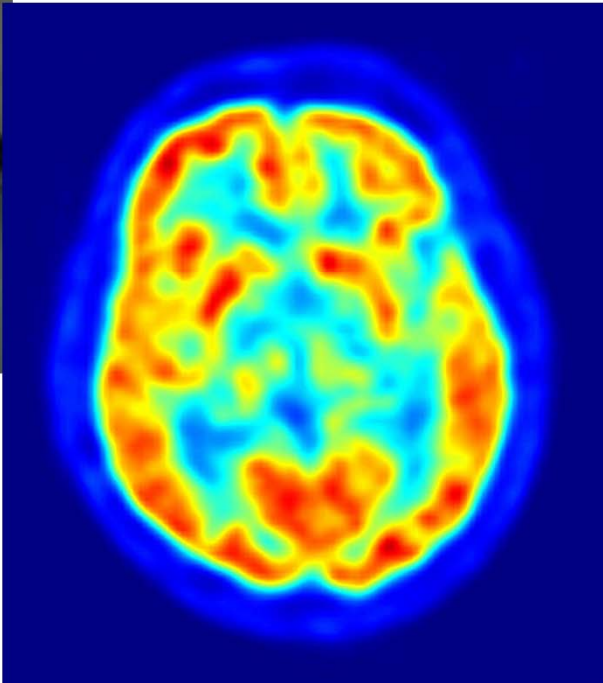
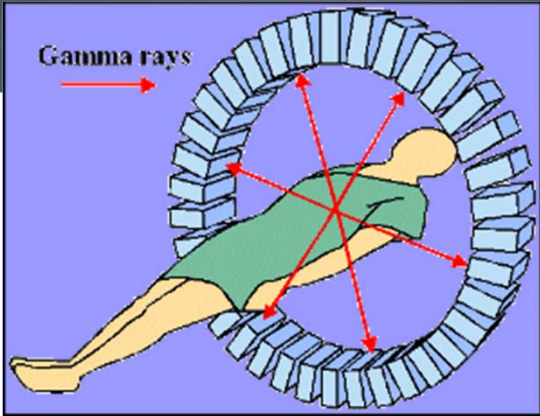
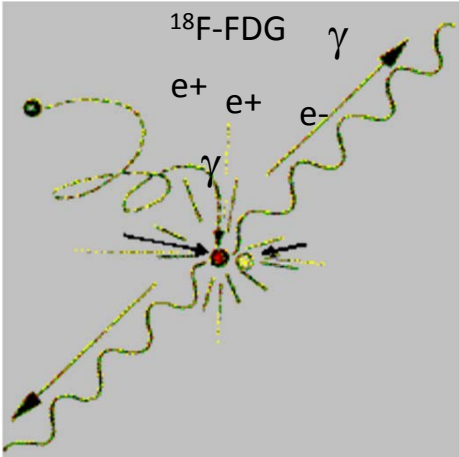
Risonanza Magnetica Nucleare (R.M.N.)



Tomografia computerizzata (T.C.)



Tomografia ad emissione di positroni (P.E.T.)



La P.E.T. nella diagnosi e nella cura dei tumori

96

**PET whole body
eseguita su un malato
oncologico prima e dopo
la chemioterapia**



**Prima della
chemioterapia**



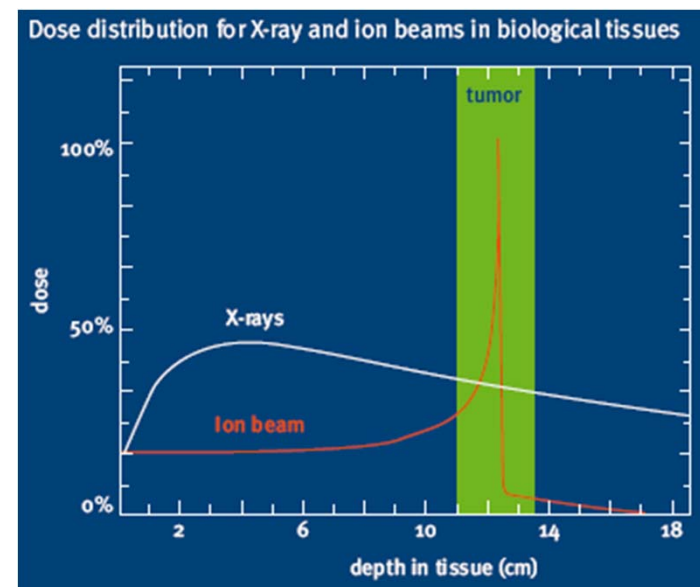
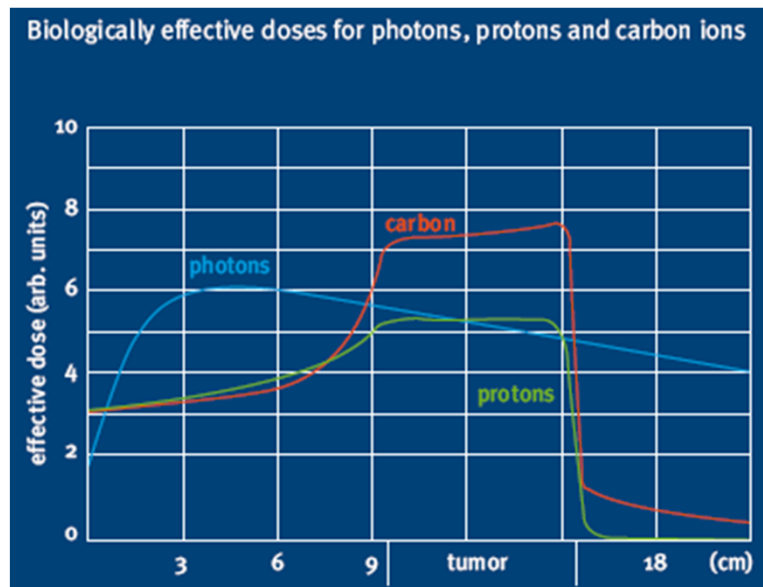
**2 mesi dopo la
chemioterapia**



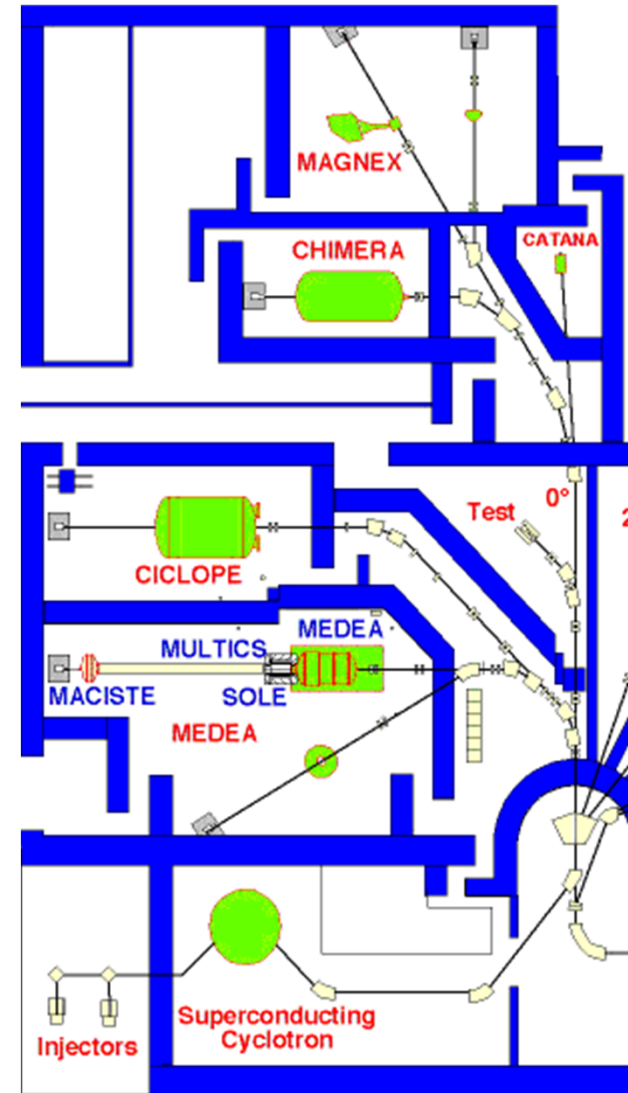
**4 mesi dopo la
chemioterapia**

Terapia con radiazioni

- radioterapia con **fotoni**: **cobaltoterapia**
 - acceleratore lineare
- radioterapia con **adroni**: **protoni** e **ioni**
 - Centro di AdroTerapia ed Applicazioni Avanzate (CATANA, Catania)
 - Centro Nazionale di Adroterapia Oncologica (C.N.A.O., Pavia)



Il laboratorio LNS



CATANA

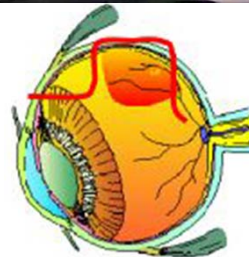
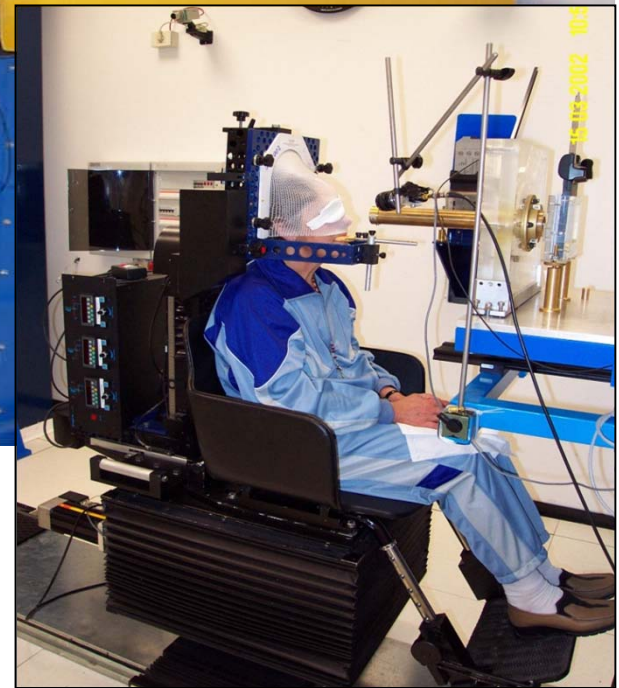
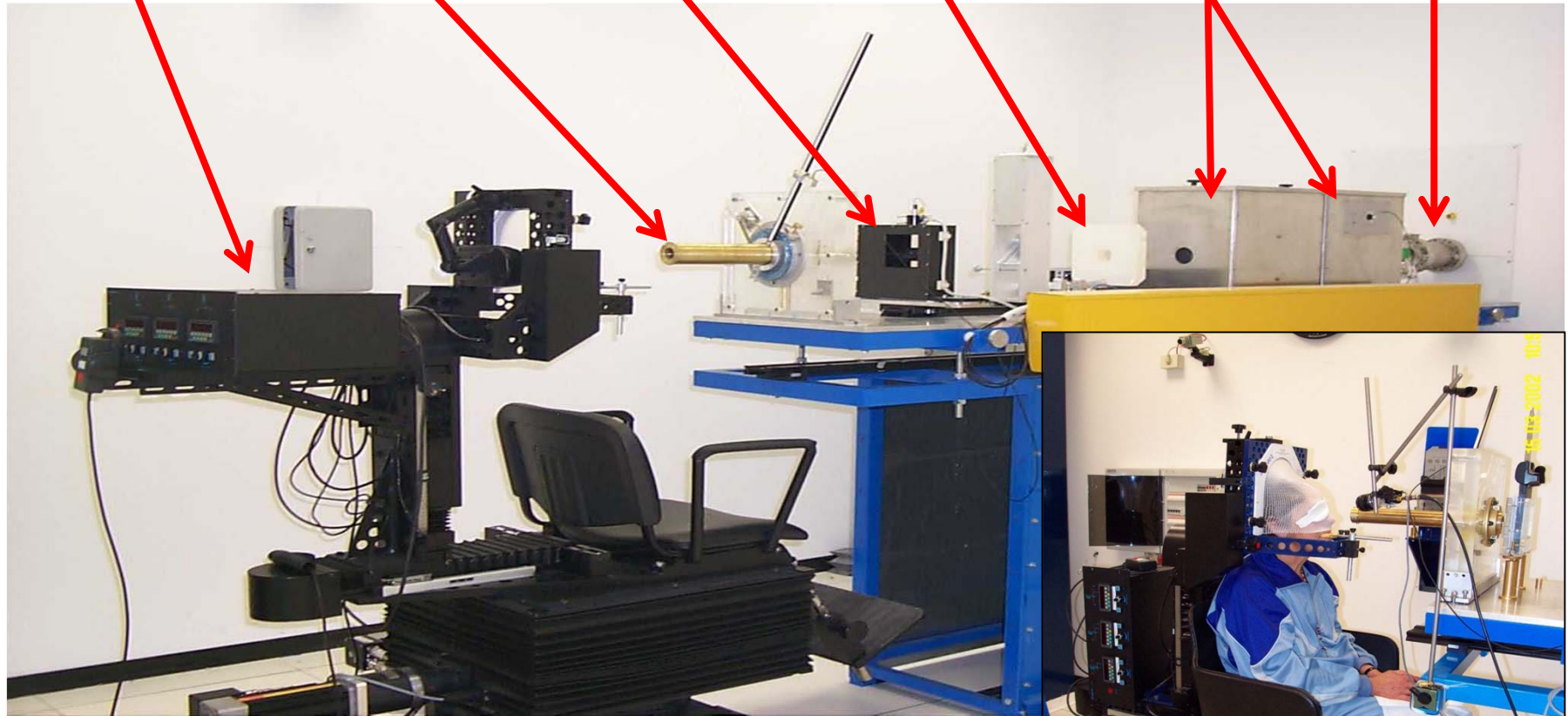
Motorized Chair
Final Collimator

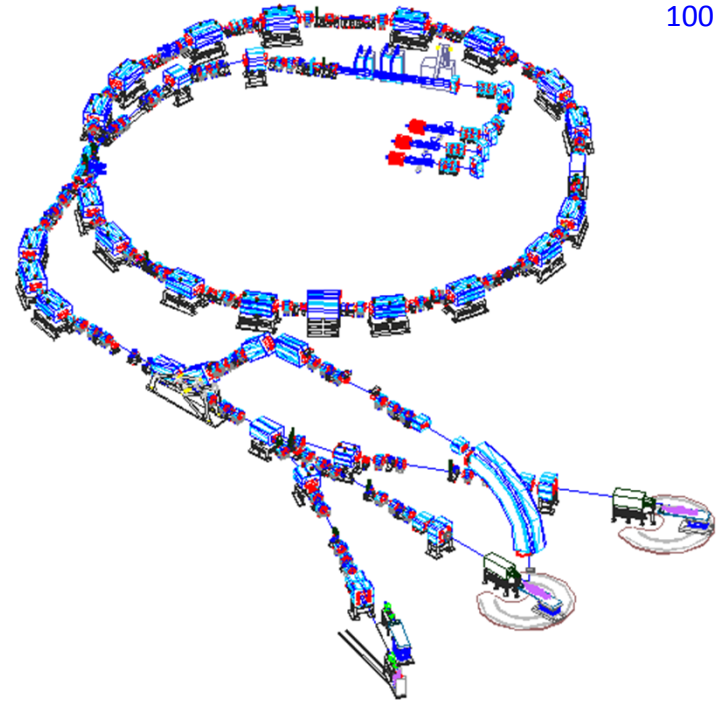
Centering Laser

Collimator

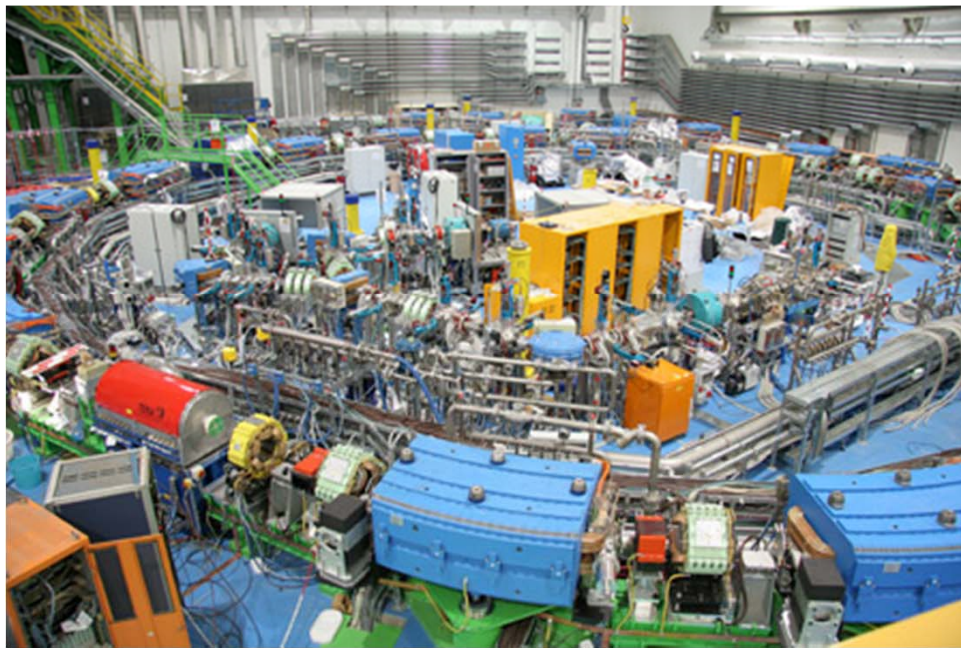
Range Shifter and Modulator

Exit Window

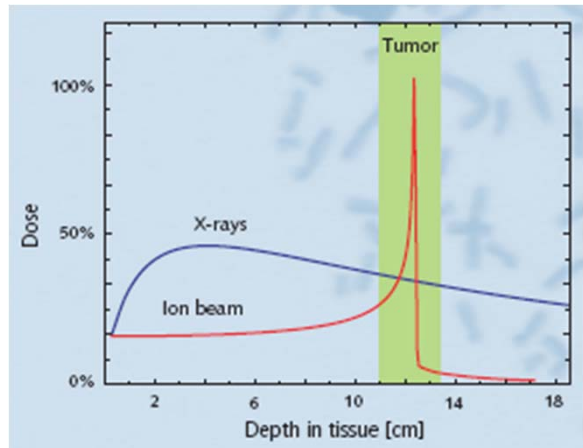
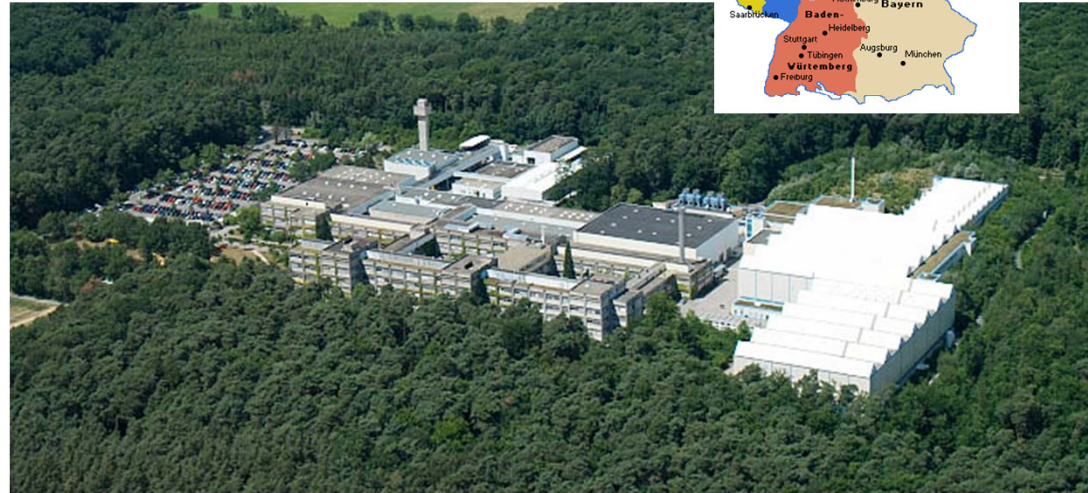
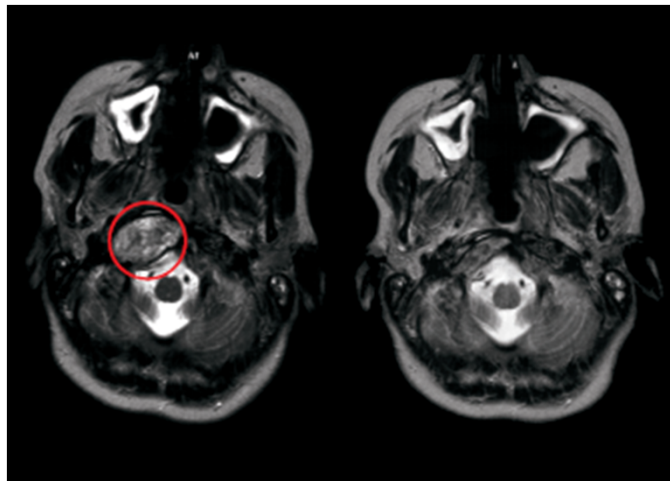
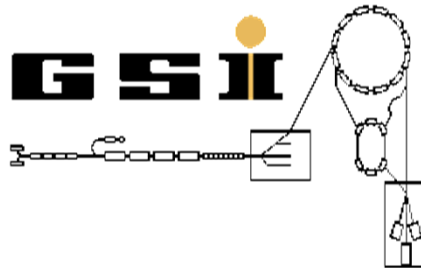




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Terapia con ioni



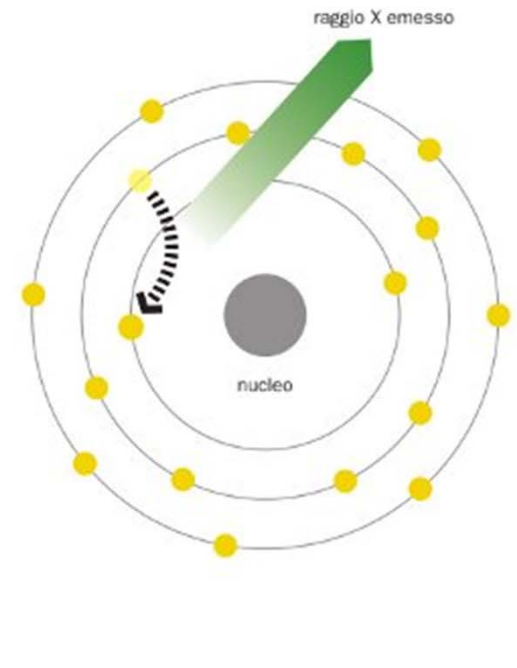
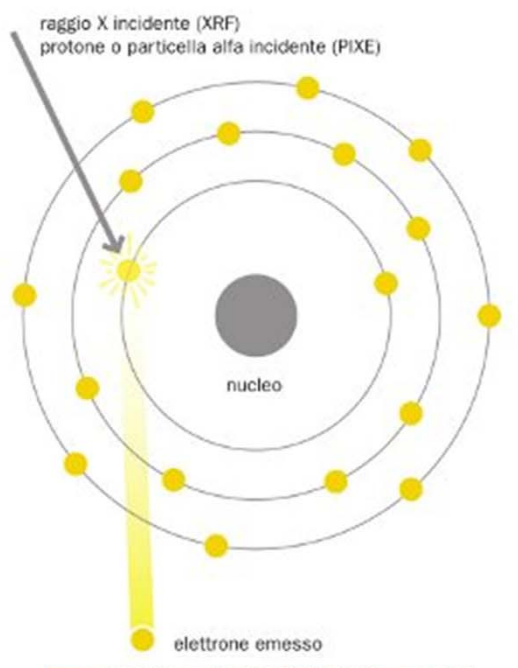
Terapia con ioni



Contributi della fisica all'arte

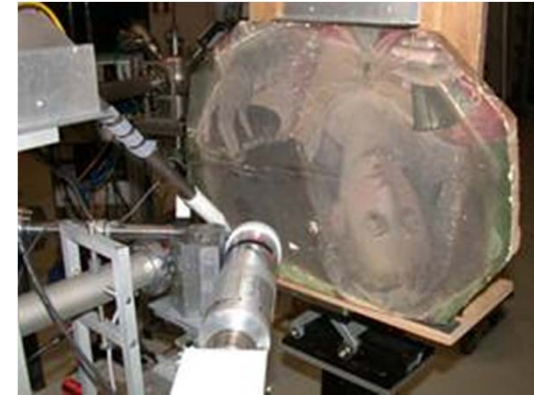
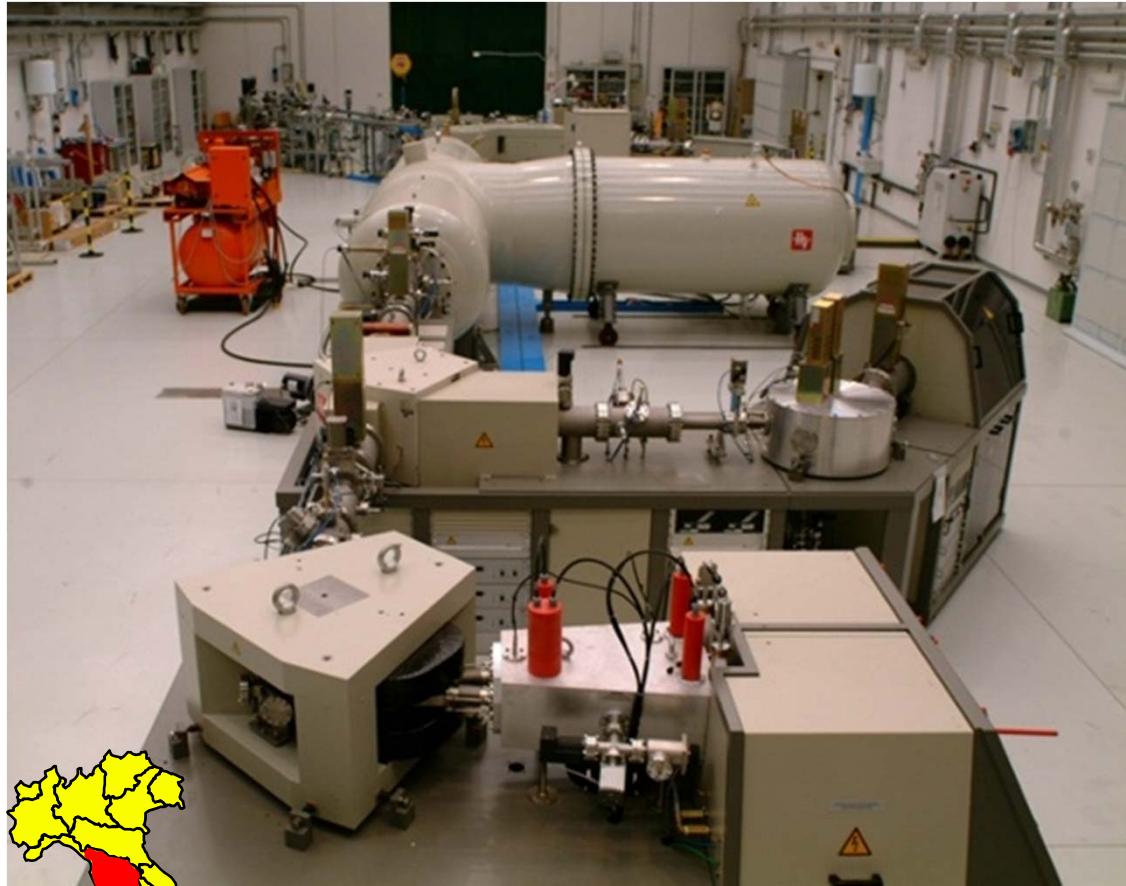
analizzare senza distruggere

La tecnica Xrf (X ray fluorescence)

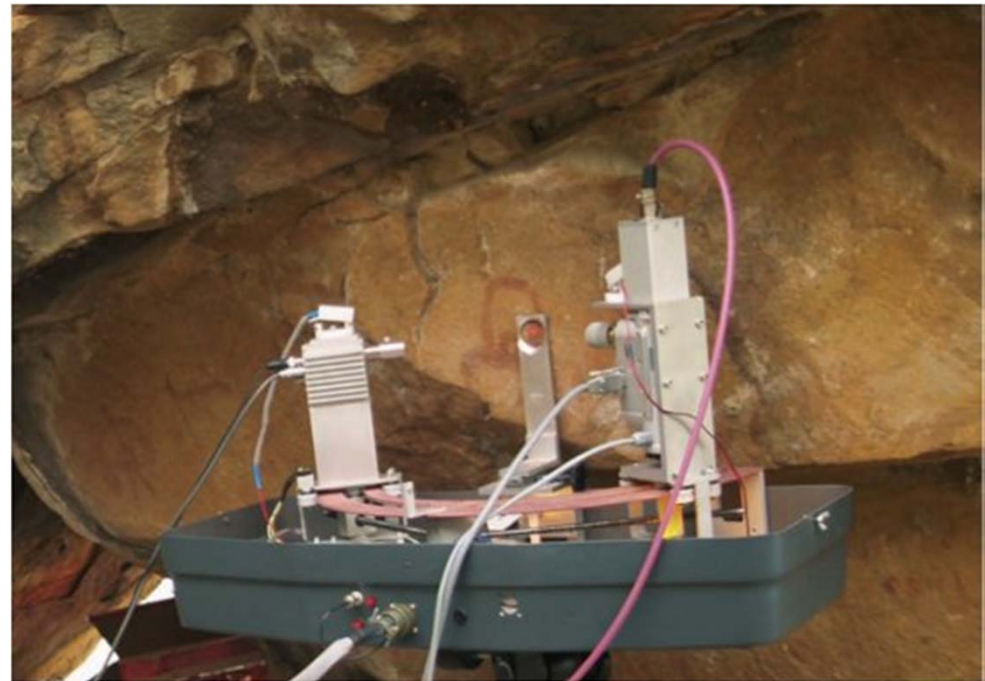


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Laboratorio di Tecniche Nucleari per i Beni Culturali (LABEC, Firenze)



Laboratorio di Analisi Non Distruttiva in Situ (LANDIS, LNS)



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