Visita ai Laboratori dell'INFN
10-11 Dicembre 2010
Laboratori Nazionali del Gran Sasso

Dipartimento di
Fisica
Universita' di TRIESTE

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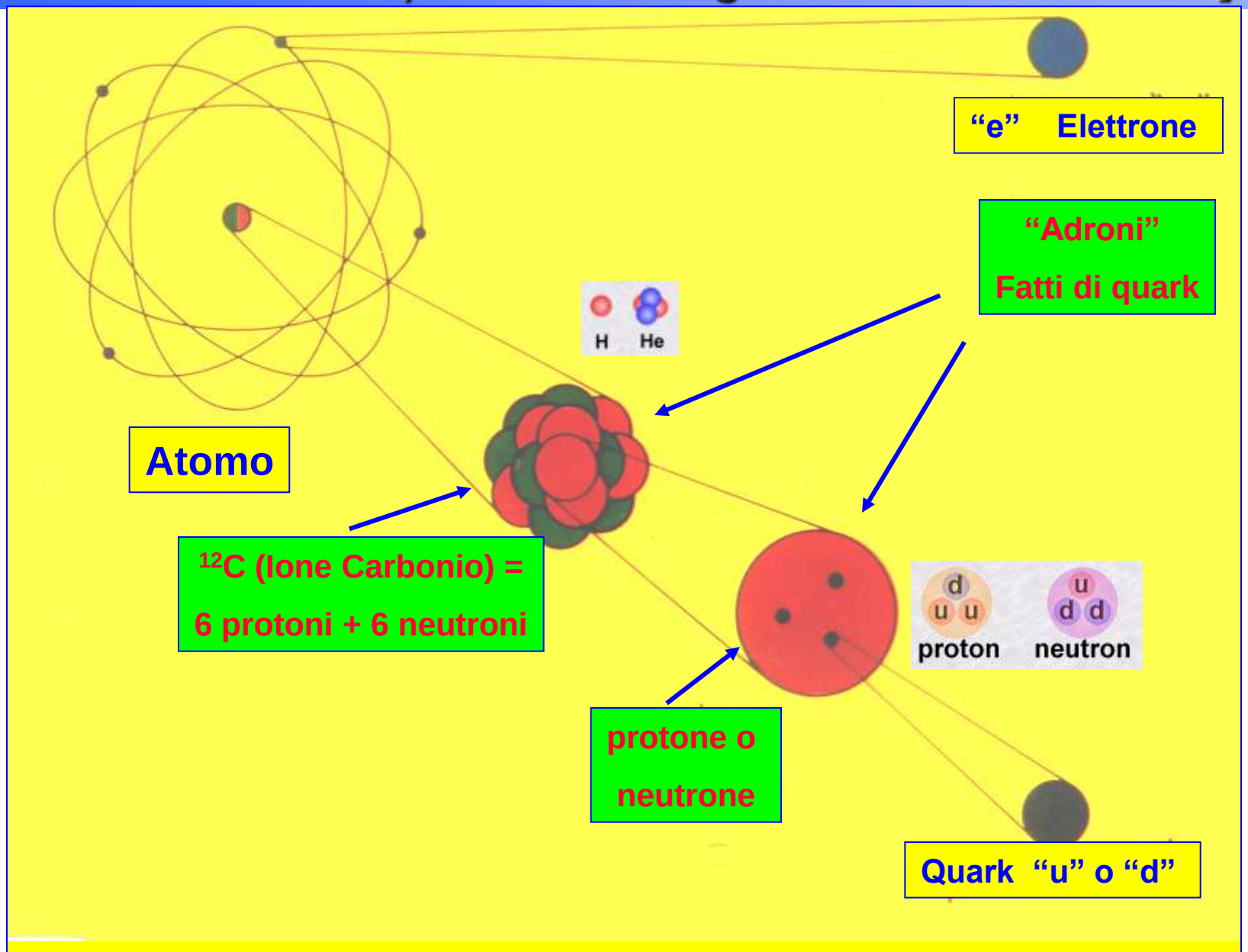
INFN
Istituto Nazionale di Fisica Nucleare

Atomo → Nucleo → Nucleoni: protoni e neutroni, ADRONI = Fatti di quark: con legame nucleare forte]



Modello Standard:

FERMIONI

Leptoni e quark

Costituenti Della Materia

e BOSONI

Fotoni/W,Z, gluoni

Portatori di Forza:

Elettromagnetica/
Nucleare Debole,
Nucleare Forte
(G) Gravitazionale?

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c^2	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	−1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	−1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	−1

Quarks spin = 1/2

Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.003	2/3
d down	0.006	−1/3
c charm	1.3	2/3
s strange	0.1	−1/3
t top	175	2/3
b bottom	4.3	−1/3

BOSONS

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

Unified Electroweak spin = 1

Name	Mass GeV/c^2	Electric charge
γ photon	0	0
W^-	80.4	−1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

Name	Mass GeV/c^2	Electric charge
g gluon	0	0

MODELLO STANDARD : Fermioni (Costituenti) e Bosoni (Mediatori)

$$\begin{pmatrix} u_i \\ d'_i \end{pmatrix}_L$$

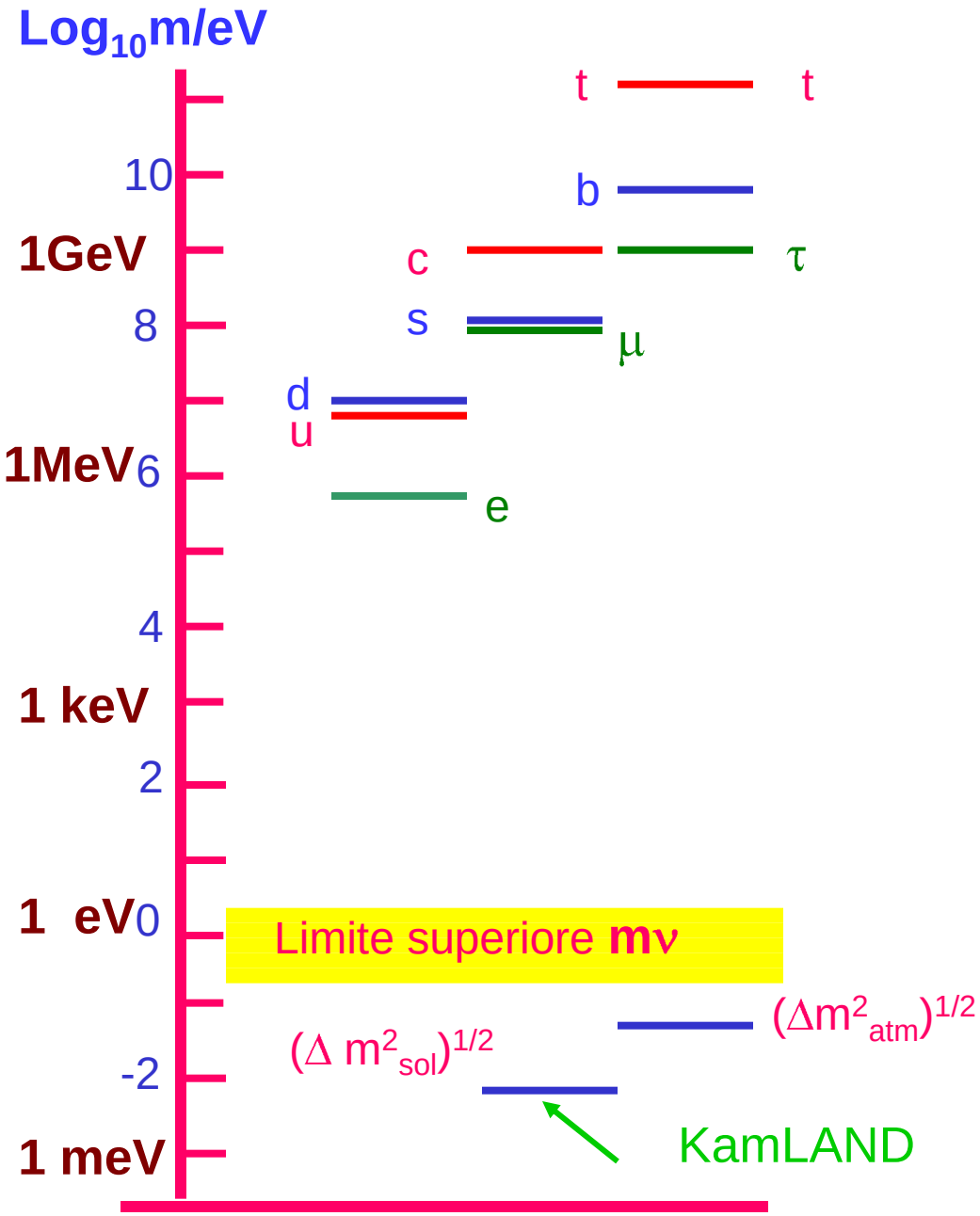
$$\begin{pmatrix} \nu_i \\ l_i \end{pmatrix}_L$$

	Famiglie di Fermioni I	II	III	Bosoni (mediatori delle interazioni)	
Quark	up +2/3, 3, u, 4	charm +2/3, 3, c, 1500	top +2/3, 3, t, 178000	Fotone 0, γ, 0	Interazione elettromagnetica
	down -1/3, 3, d, 80	strange -1/3, 3, s, 150	bottom -1/3, 3, b, 4700	Gluone 0, 8, g, 0	Interazione forte
Leptoni	Neutrino elettr. 0, ν_e, <0.000007	Neutrino muon. 0, ν_μ, <0.27	Neutrino tauon. 0, ν_τ, <31	Z zero 0, Z^0, 91187	Interazione debole
	Elettrone -1, e, 0.511	Muone -1, μ, 105.66	Tauone -1, τ, 1777.1	W positivo ±1, W^+, 80220	

Carica elettrica
Numero di colori di carica
Massa in MeV

l_{iR}, d_{iR}, u_{iR}

$$SU(3)_C \times SU(2)_L \times U(1)_Y$$



Massa dei fermioni: Quark e Leptoni

ν : Massa=0 ?

- no ν_R
- numero leptonico L <u>conservato</u>

ν: Massa >0 ?

- ν_R pesante
- numero leptonico L <u>non conservato</u>

Oscillazioni dei Neutrini

- Idea della massa dei neutrini suggerita per la prima volta da Bruno Pontecorvo

I Neutrini Interagiscono (Produzione o Rivelazione) come Autostati dell'Interazione Debole

$|\nu_e\rangle$, $|\nu_\mu\rangle$, $|\nu_\tau\rangle$ =Autostati dell'Interazione Debole

$|\nu_1\rangle$, $|\nu_2\rangle$, $|\nu_3\rangle$ =Autostati di Massa (H → Evoluzione t)

- I Neutrini si propagano (evolvono) come sovrapposizione di autostati di **massa: MESCOLAMENTO**

Mescolamento tra neutrini: p.es. due famiglie

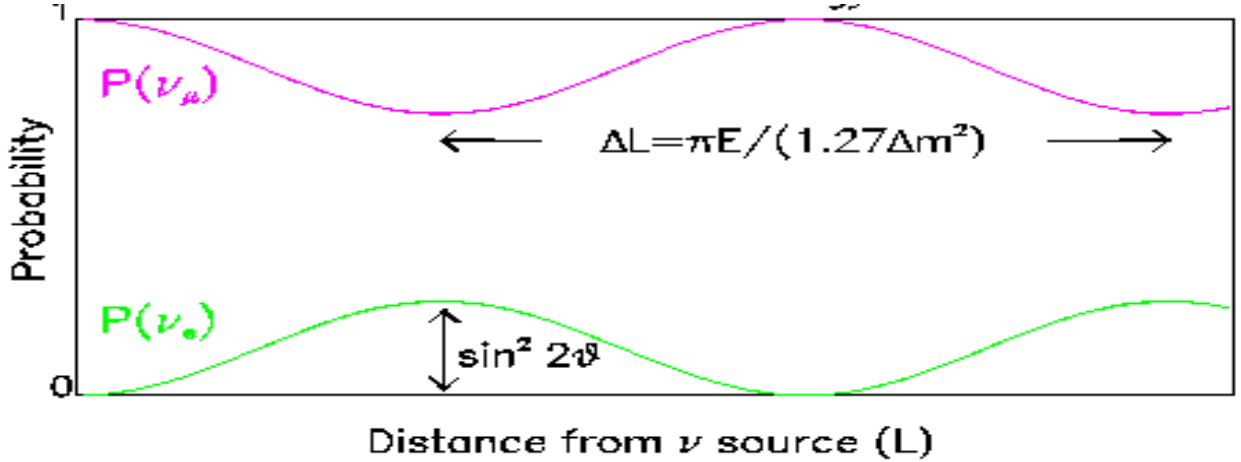
$$|\nu_e\rangle = \cos\theta\, |\nu_1\rangle + \sin\theta\, |\nu_2\rangle$$

$$|\nu_\mu\rangle = -\sin\theta\, |\nu_1\rangle + \cos\theta\, |\nu_2\rangle$$

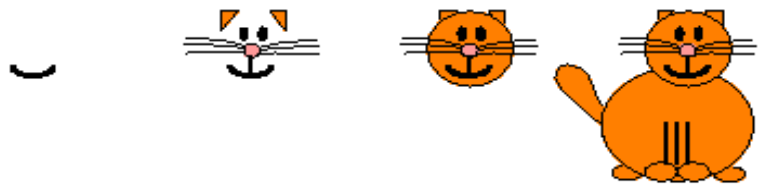
θ = mixing angle
Angolo di mescolamento

$$P_{\nu_\mu \nu_\mu} = 1 - \sin^2 2\theta \cdot \sin^2\left[1.27 \frac{\Delta m^2 \cdot L}{E_\nu}\right]$$

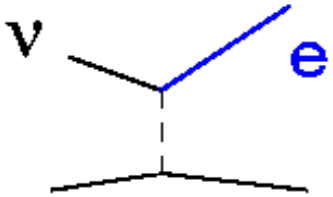
- Distanza percorsa **L=ct (Km)**
- Differenza di massa quadra **$\Delta m^2 = m_2^2 - m_1^2$ (eV^2)**
- Energia del neutrino **$E\nu$ (GeV)**



Comparsa/Appearance



"Appearance Experiments"
see the new neutrino type
in the detector



A *"Disappearance Experiment"* observes
fewer

than expected

Scomparsa/Desappearance

Esperimenti con Neutrini :

1) Sorgenti (Molto) Potenti
2)Apparati (Molto) Sensibili e (Molto) Massivi

Sorgenti naturali:

Sole, Supernovae, Raggi cosmici

Sorgenti Artificiali:

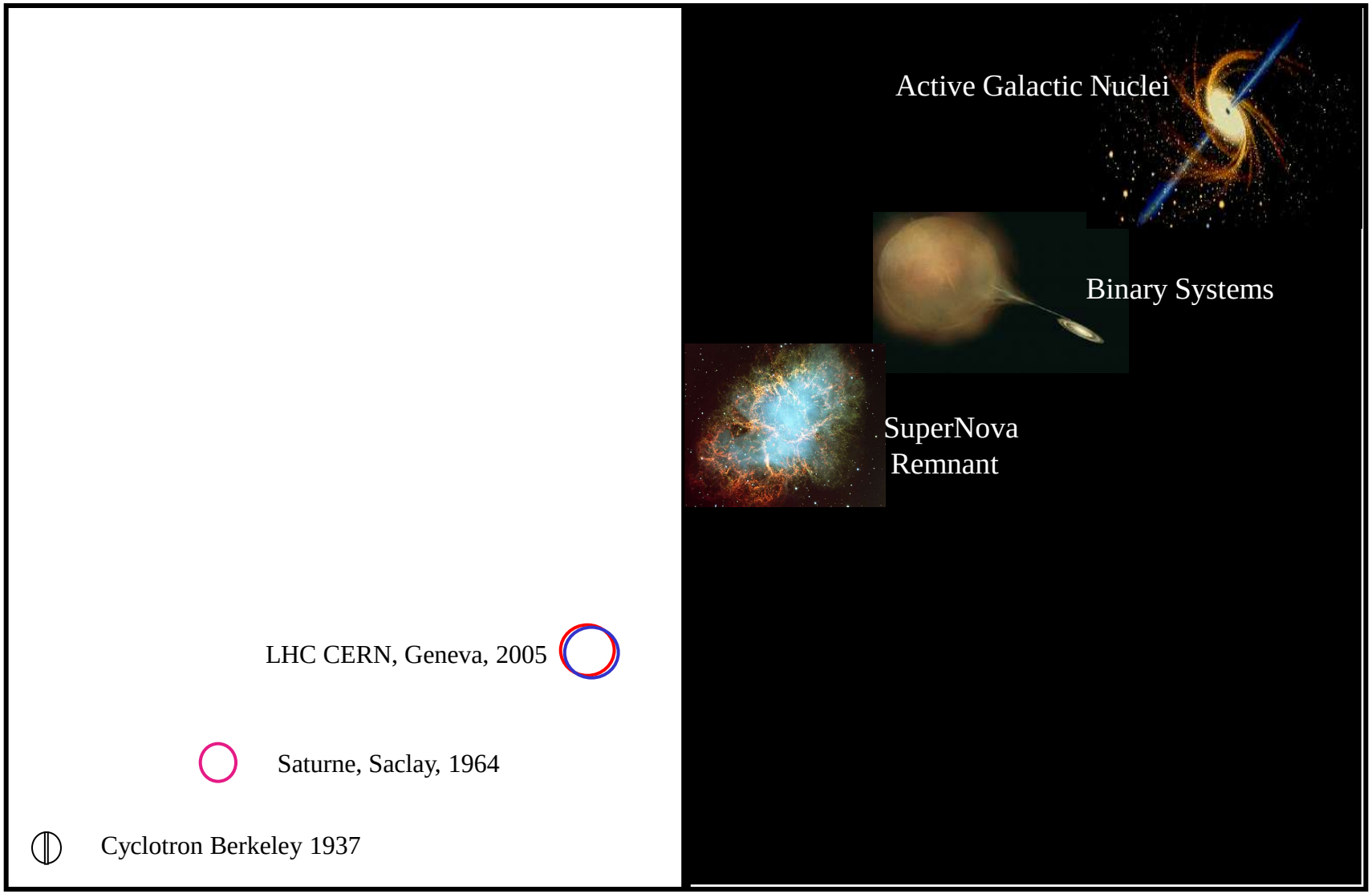
Acceleratori, Reattori Nucleari

Fisica Nucleare e Sunucleare ⇒ Astrofisica Nucleare e Sunucleare

Acceleratori Terrestri

Acceleratori Cosmici

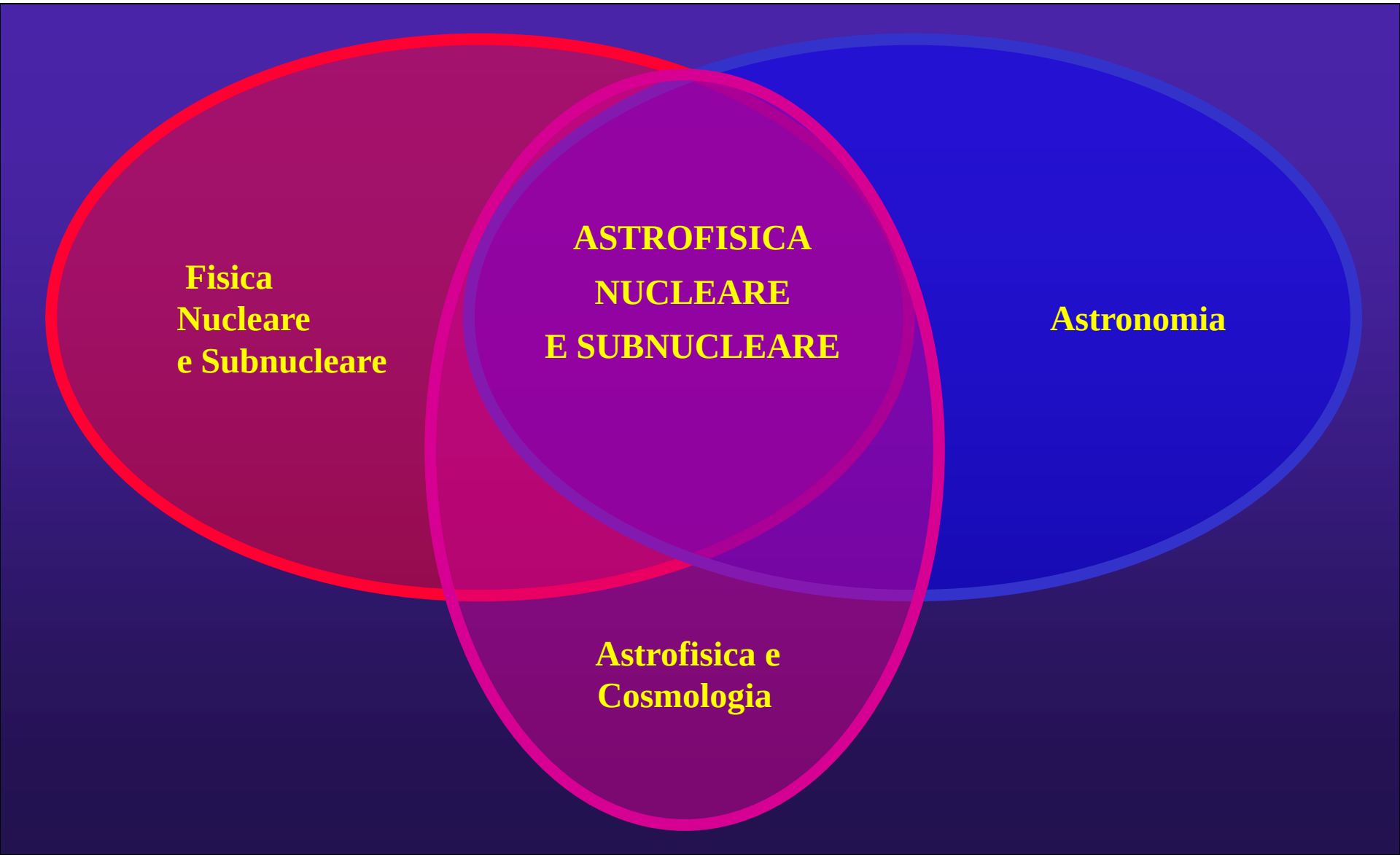
Diametro dell'acceleratore



Energia delle particelle accelerate

Astrofisica Nucleare e Subnucleare

(Fisica Astroparticellare/Astrofisica Particellare)



DISTANZE IN METRI (m)

		10^{26}	Raggio Universo
Yotta	Y	10^{24}	distanza tra galassie
Zetta	Z	10^{21}	raggio galassie
Exa	E	10^{18}	
			anno luce
Peta	P	10^{15}	
Tera	T	10^{12}	
			distanza Terra - Sole (UA)
Giga	G	10^{9}	distanza Terra - Luna
			diametro terrestre
Mega	M	10^{6}	orbita satellitare
			atmosfera
			montagna, profondita' oceanica
kilo	k	km 10^{3}	colle
			pista
			autobus
unita'		1 m 10^{0}	uomo
milli	m	cm mm 10^{-3}	
micro	μ	10^{-6}	cellule
nano	n	10^{-9}	molecole
			Angstrom, atomi
pico	p	10^{-12}	
femto	f	10^{-15}	fm (fermi) dimensione nuclei
			nucleone, particelle elem.
atto	a	10^{-18}	
zepto	z	10^{-21}	
yocto	y	10^{-24}	

ASTROPARTICELLE

COSMOLOGIA

ASTROFISICA

ASTRONOMIA

Fis. dello SPAZIO

TELESCOPI RADIOTELESCOPI

SATELLITI, SONDE

MICROONDE RADIO COMUNICAZIONI

GEOFISICA

INGEGNERIA MECCANICA

ELETTRICITA'

ELETTRONICA

BIOFISICA

CHIMICA FISICA

FISICA DELLA MATERIA

FISICA ATOMICA

MICROSCOPIO

MICROSCOPIO ELETTRONICO

ACCELERATORI DI PARTICELLE

FISICA NUCLEARE

FISICA SUBNUCLEARE

ASTROPARTICELLE


Trieste
Ancona
Gran Sasso
L'Aquila
Roma

Laboratori Nazionali del Gran Sasso

Location: Gran Sasso Tunnel (Abruzzi, Italy)

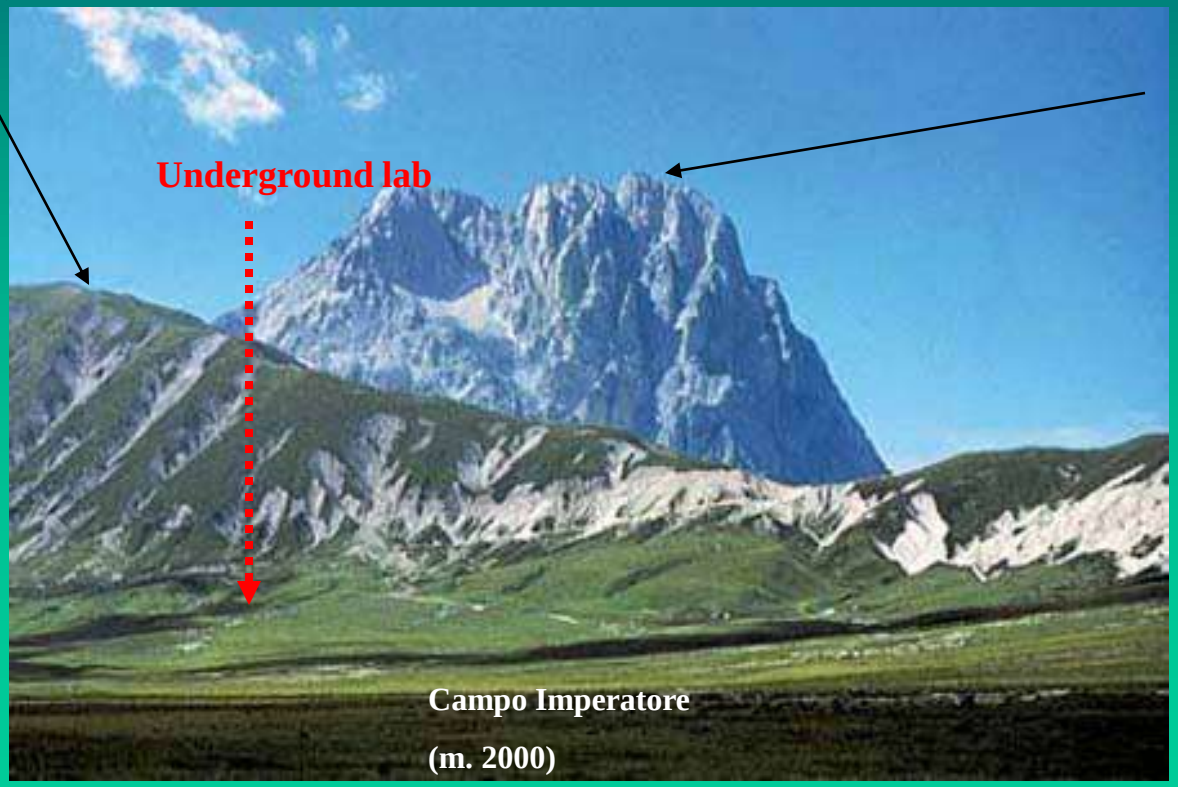
Depth: 1400 m (3800 mwe)

Operating Institution: Istituto Nazionale di Fisica Nucleare (INFN)

LNGS permanent staff: 60 (physicists, technicians, administration)

Scientists involved in LNGS experiments: 700 from 24 countries

Monte Aquila (m. 2600)

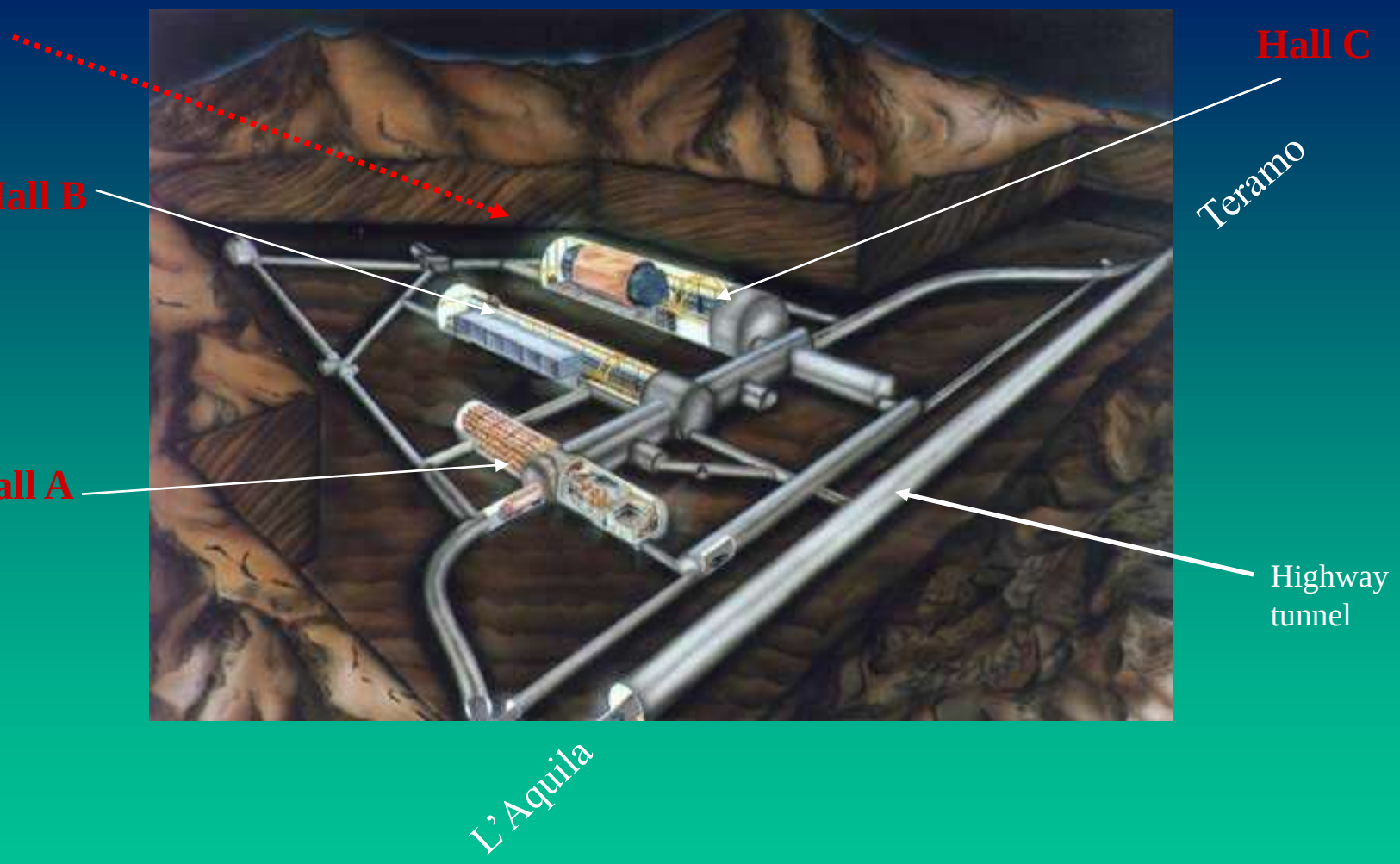


Corno Grande (m. 2910)

The area of Campo Imperatore above LNGS

LNGS

The LNGS Underground area



Underground area : 3 halls (100m x 20m x 15m) + service tunnels
Total volume : 180000 m^3

Surface: > 6000 m^2

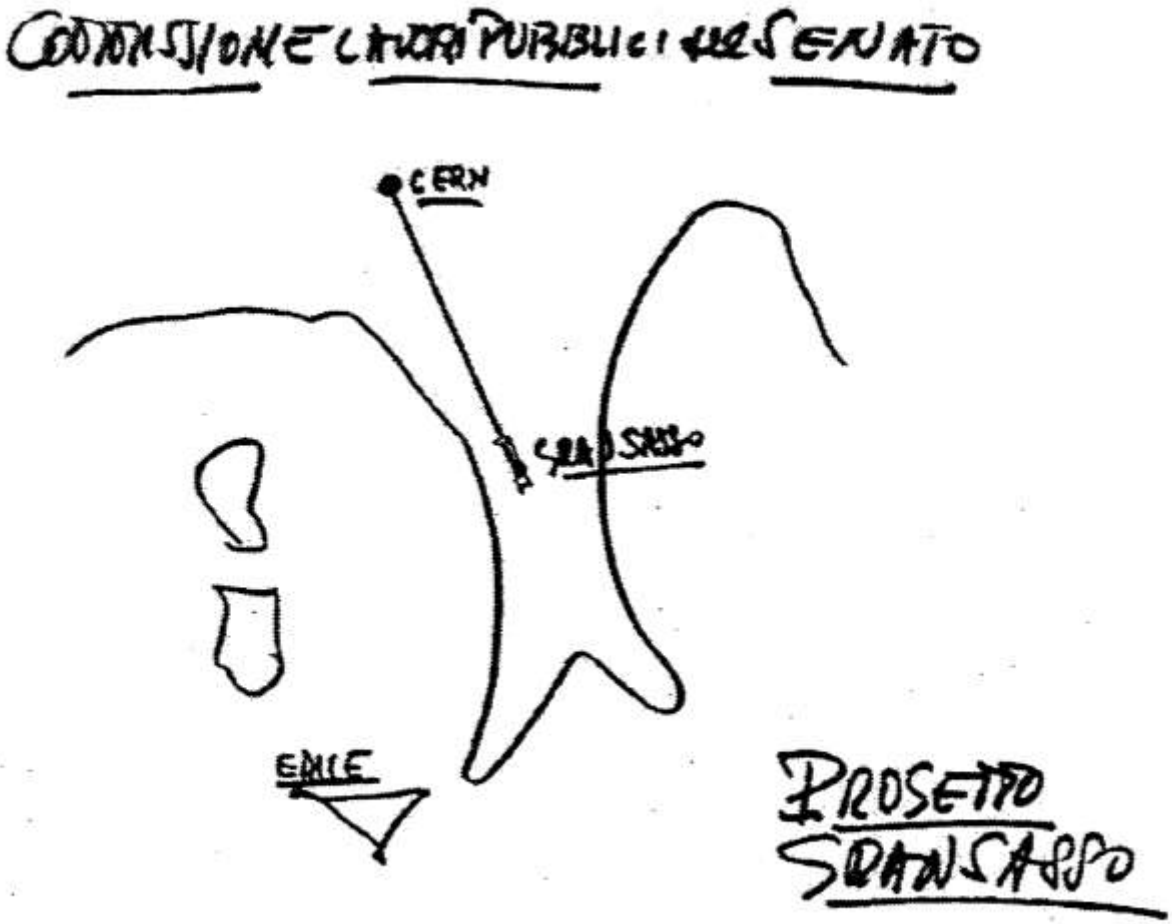


Figure 1.1.1: Sketch by A. Zichichi, 1979


CERN
(Losanna)
Lausanne
(Ginevra)
Genève
Grenoble
Torino
Novara
Milano
Monza
Bergamo
Brescia
Trento
Bolzano
Udine
(Lubiana)
Trieste
Vicenza
Verona
Padova
Venezia
Piacenza
Alessandria
Parma
Reggio nell'Emilia
Modena
Ferrara
Bologna
Ravenna
Forlì
Rimini
San Marino
Genova
La Spezia
Isola Palmaria
Neutrino's Beam
Prato
Firenze
Pisa
Livorno
Isola di Gorgona
Isola di Capraia
Isola d'Elba
Isola Pianosa
Isola del Giglio
Ancona
Perugia
Italia
Terni
LNGS
gran Sasso
Pescara
Image © 2006 GeoContent
© 2006 Europa Technologies
LNGS

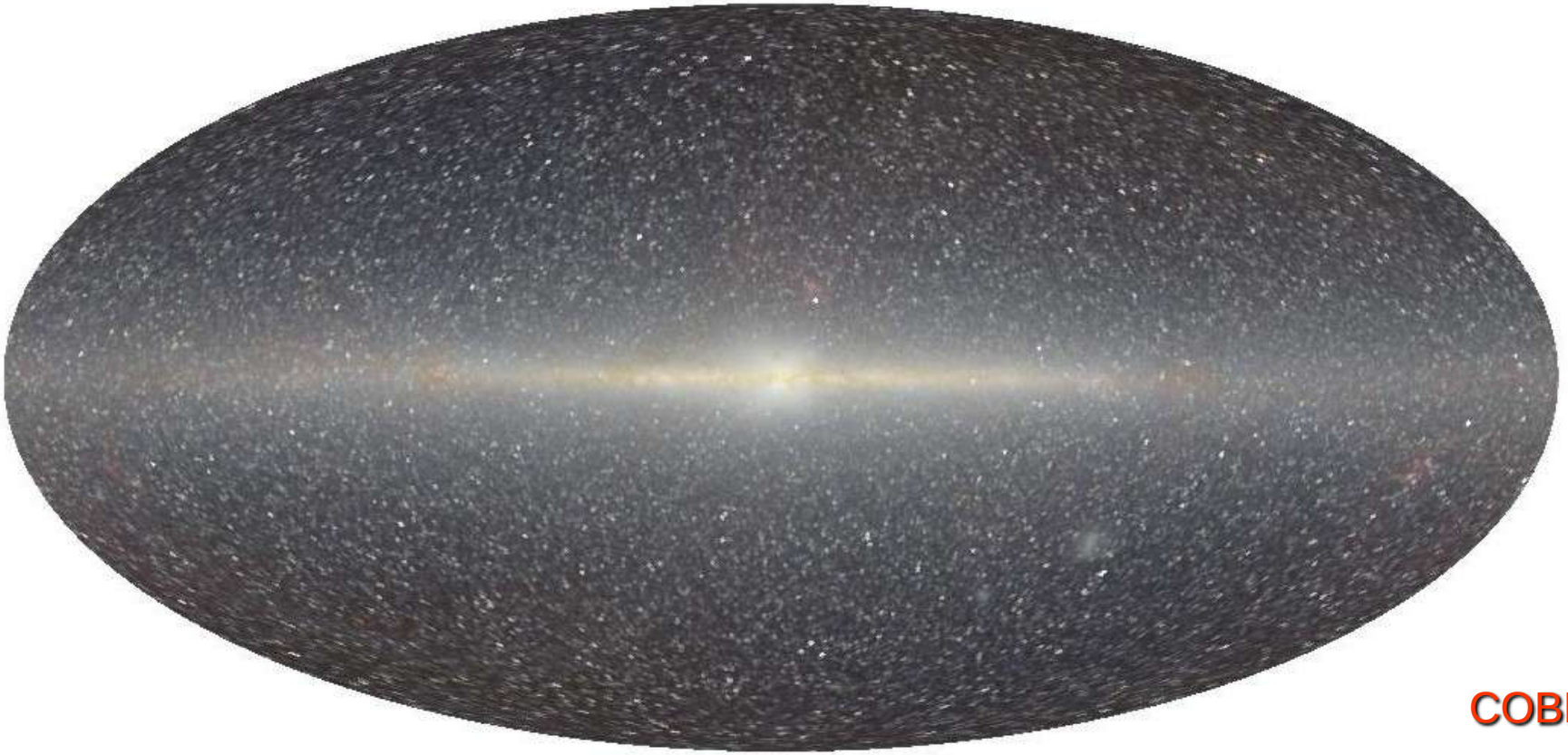
CERN
Geneva
Mont-Blanc
Monte-Emilius
Piemonte
Alessandria
Emilia-Romagna
Monte-Maggiorasca
Monte-Prato
Monte-Giovo
Toscana
Firenze
Arezzo
Perugia
Umbria
Laboratory of Gran Sasso
11.4km
732km
neutrino beam
5km
0
50km

External facilities

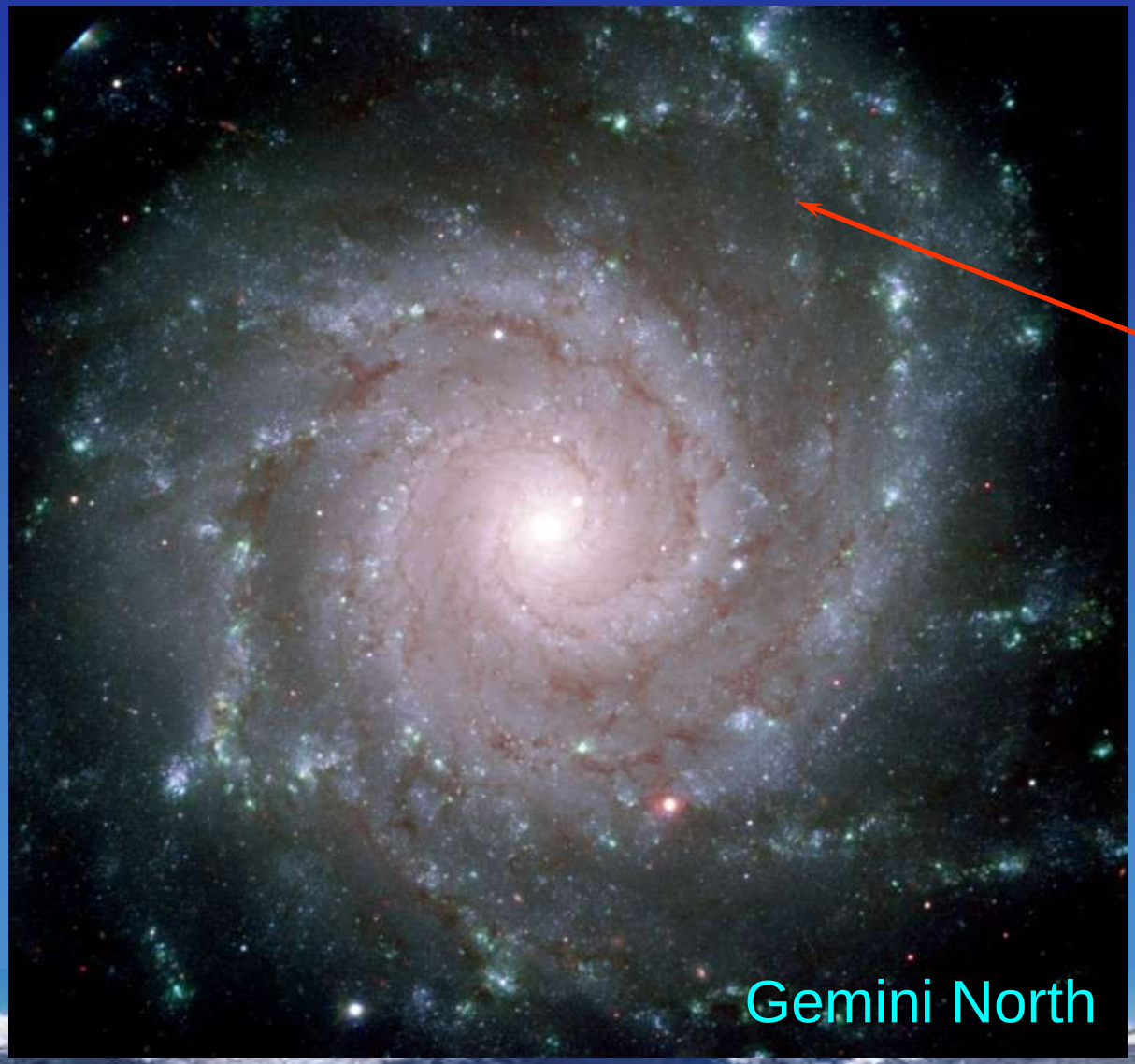
- Administration
- Public relationships support
- Secretariats (visa, work permissions)
- Outreach
- Environmental issues
- Prevention, safety, security
- General, safety, electrical plants
- Civil works
- Chemistry
- Cryogenics
- Mechanical shop
- Electronics
- Computing and networks
- Offices
- Assembly halls
- Lab & storage spaces
- Library
- Conference rooms
- Canteen

Astronomia

VIA LATTEA: La nostra Galassia



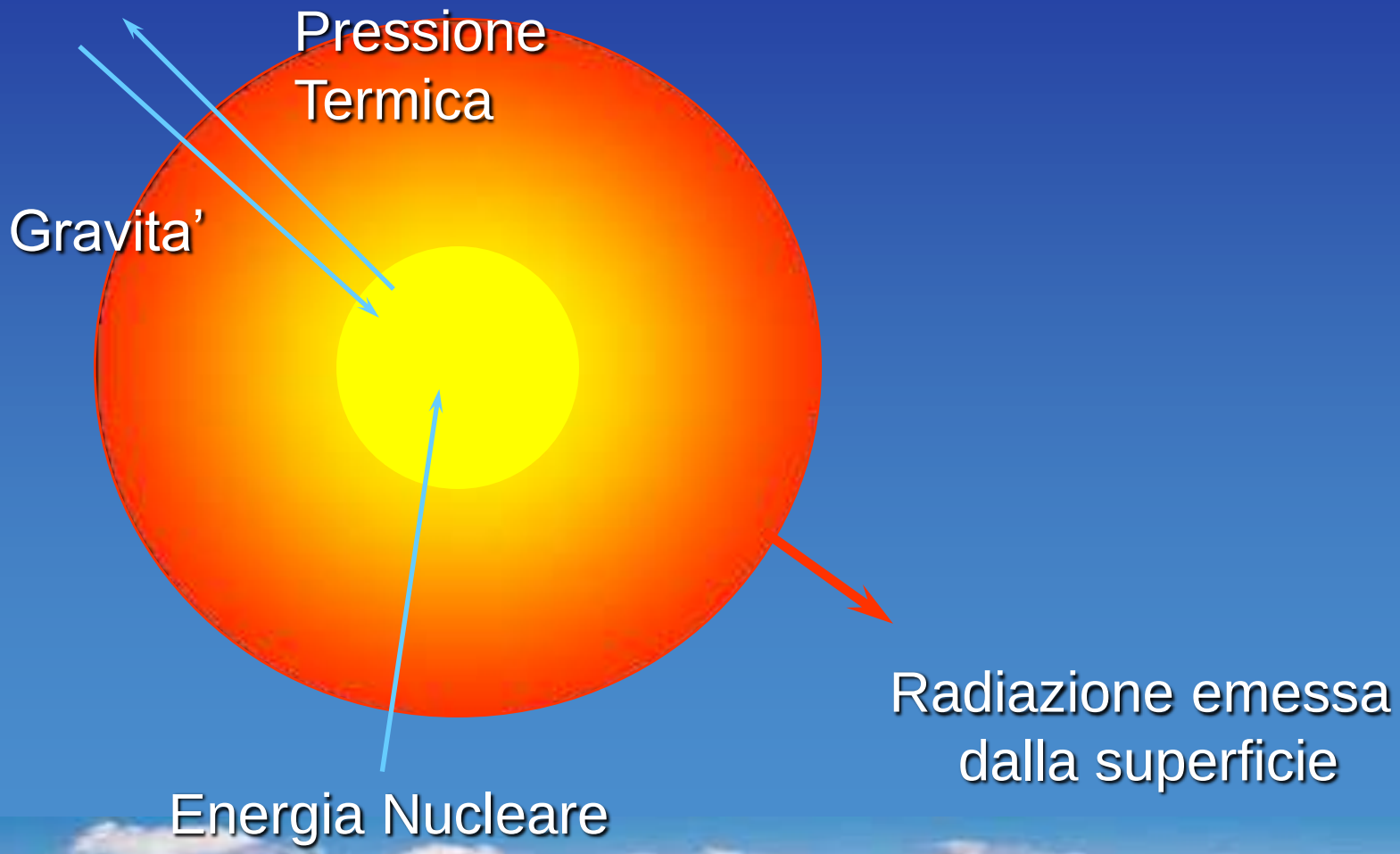
Galassia simile alla Via Lattea



Galassia
Spirale
NGC 628

Il sole sarebbe circa qui

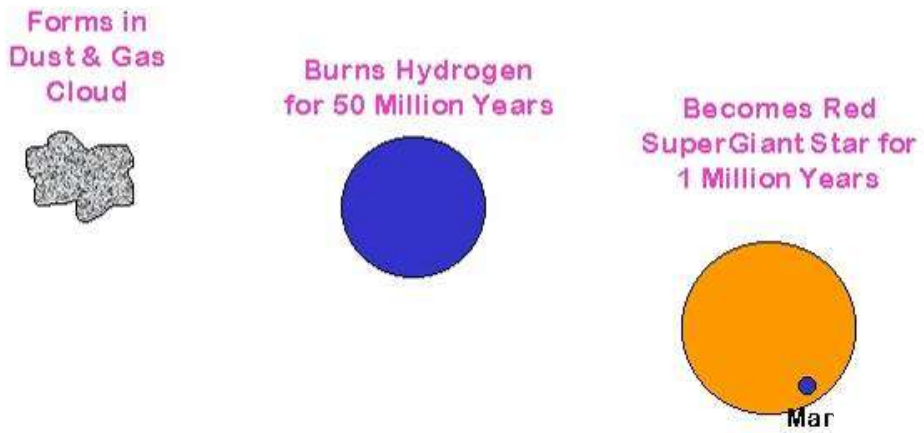
Struttura Stellare

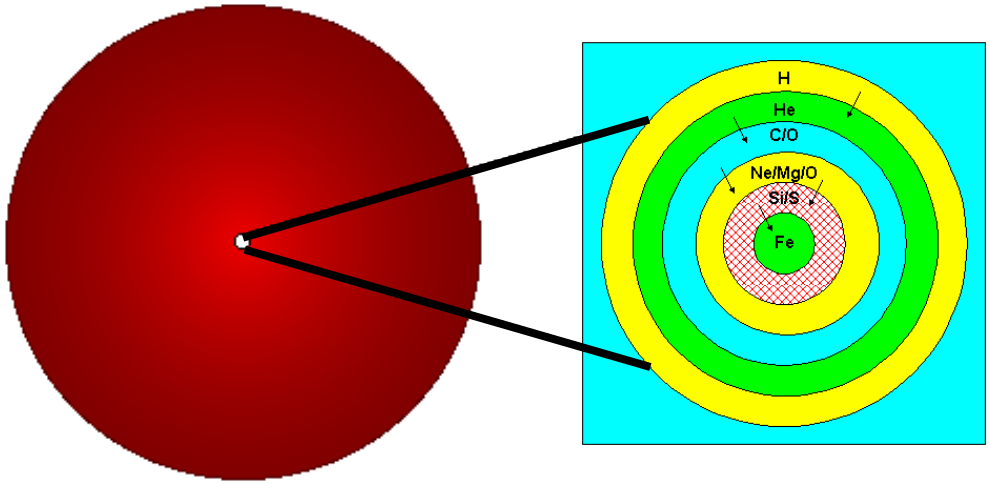


Nascita delle stelle

Evoluzione Stellare

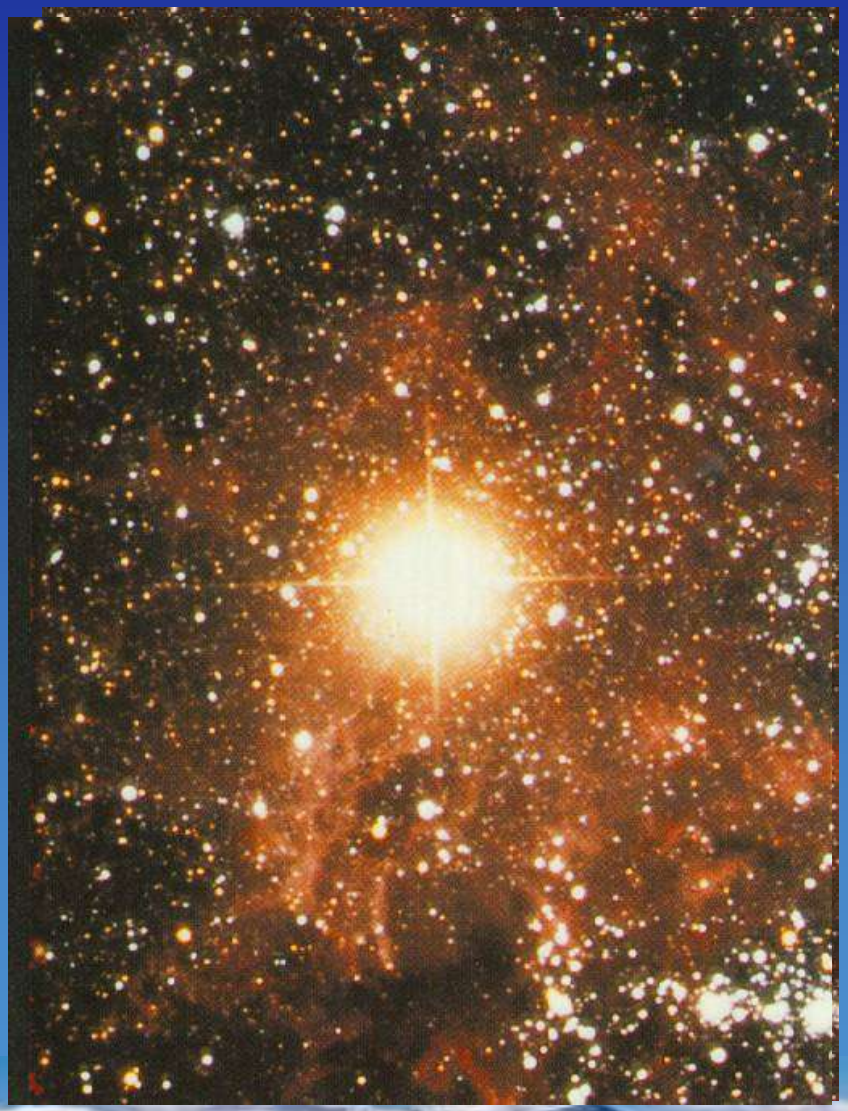
Vita di una stella grande (> 1,4 $M_\odot$)





Esplosione di Supernova (tipo II, Ib e Ic

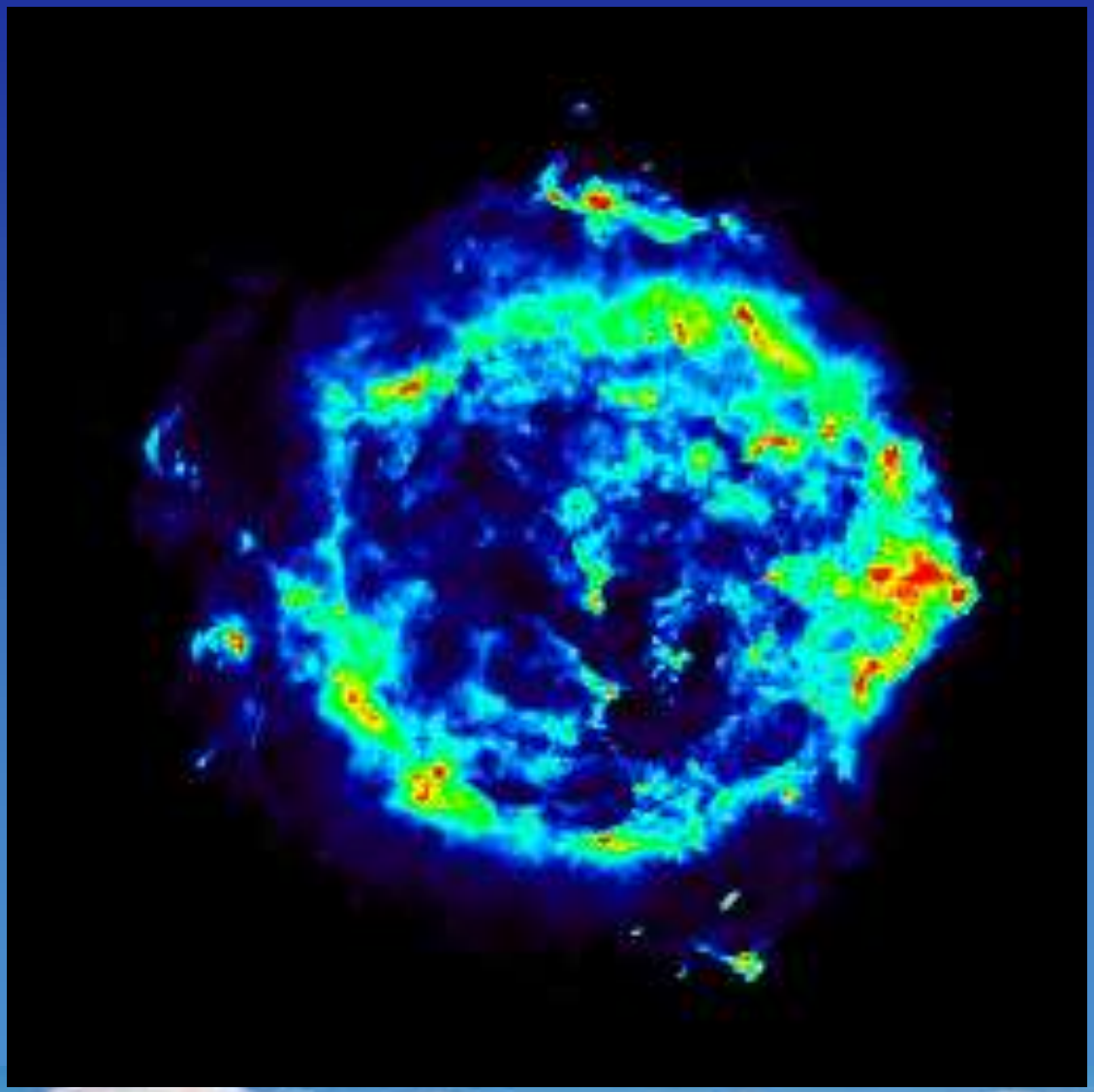
Supernova



Campo della supernova SN1987A
Dopo del 23 Feb.1987.

Grande Nube di Magellano

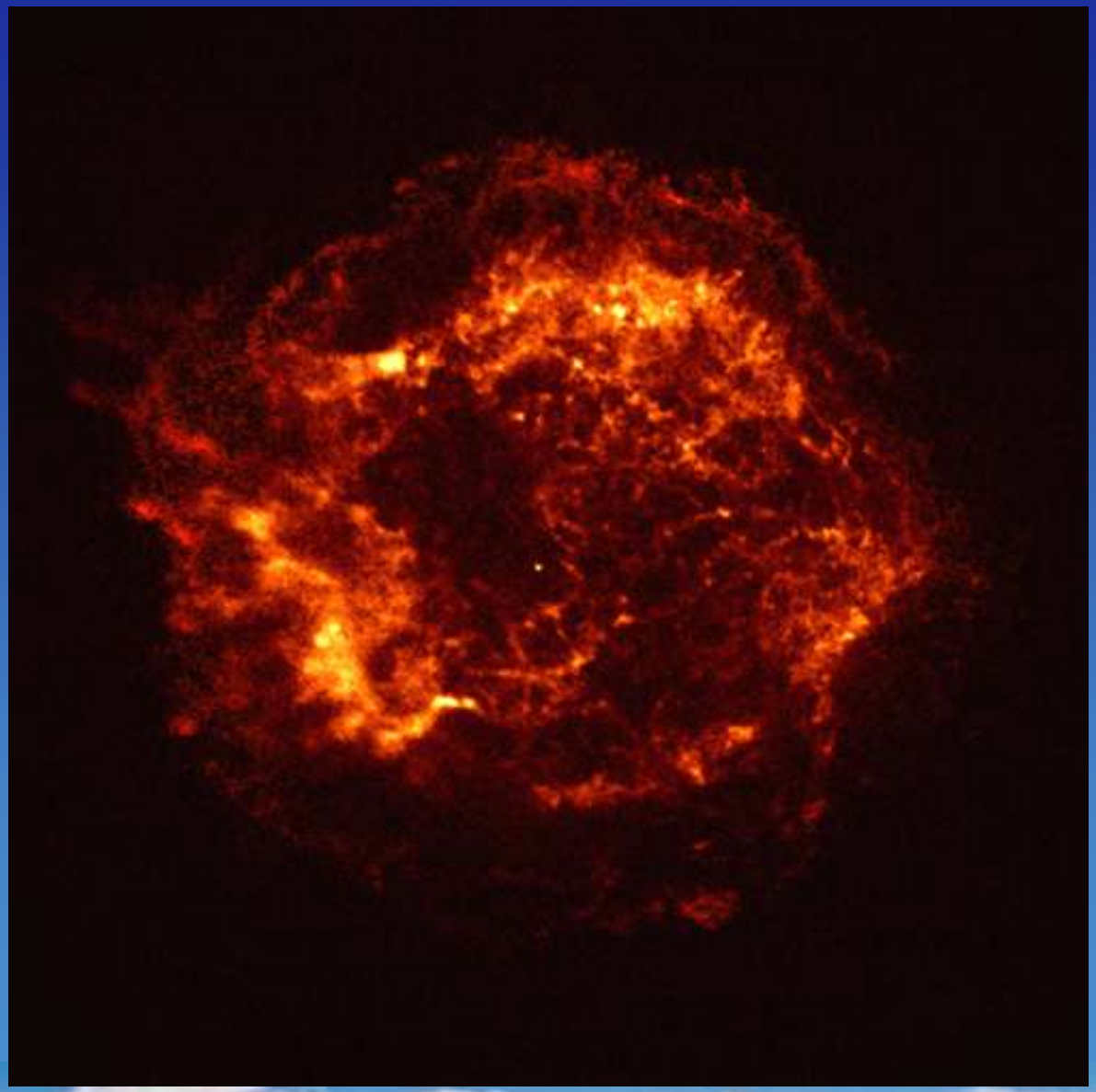
Anglo-Australian Telescope



Cassiopeia A

Supernova esplosa circa 250 anni fa.
Immagine Radio .

NRAO Very Large Array

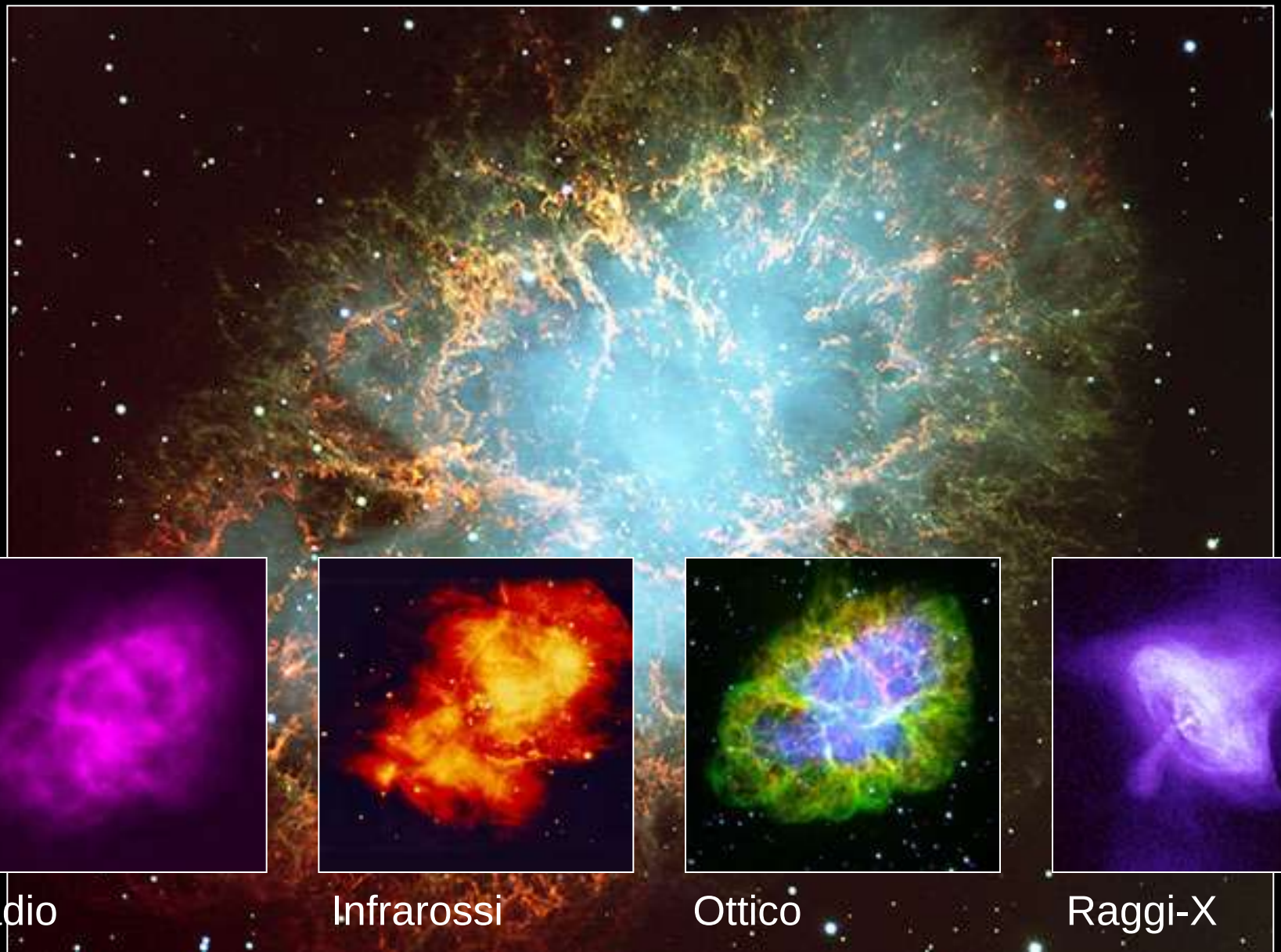


Cassiopeia A

Supernova esplosa circa 250 anni fa.
Immagine a Raggi-X

Chandra X-ray Observatory of NASA

La nebulosa del Granchio (Crab Nebula)
Supernova osservata dalla Cina nel 1054



Radio

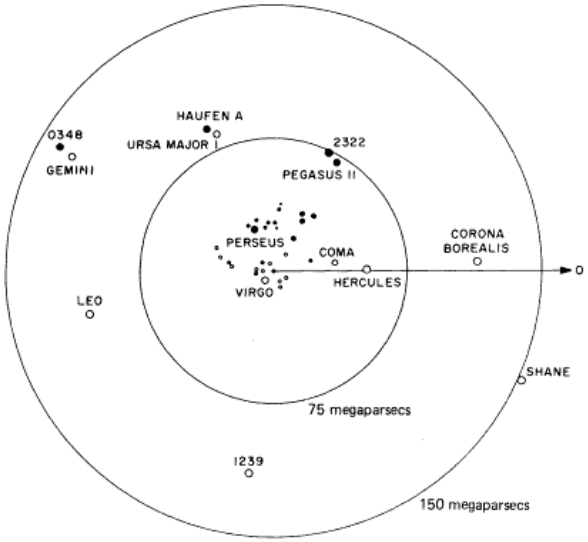
Infrarossi

Ottico

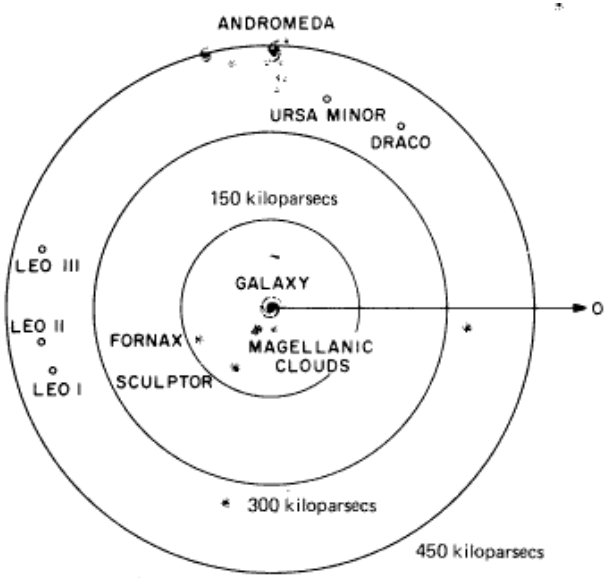
Raggi-X

Scale Astronomiche

Gruppi di Galassie

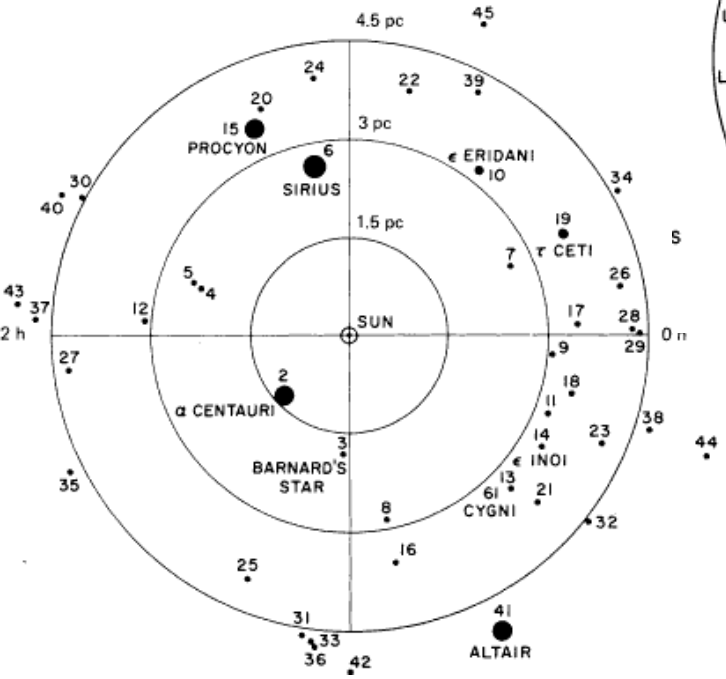


Galassie



150 Mpc

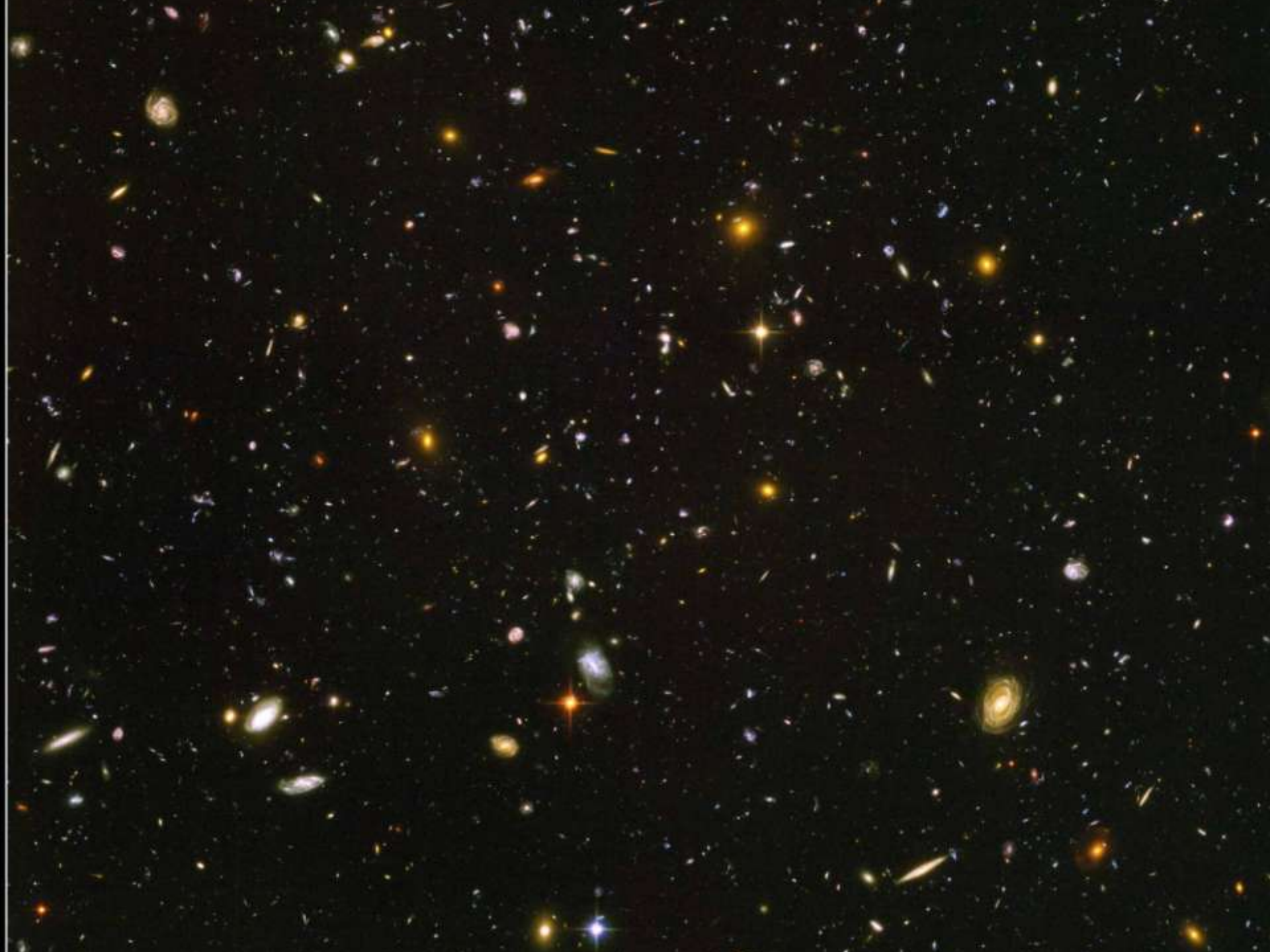
Stelle



450 kpc

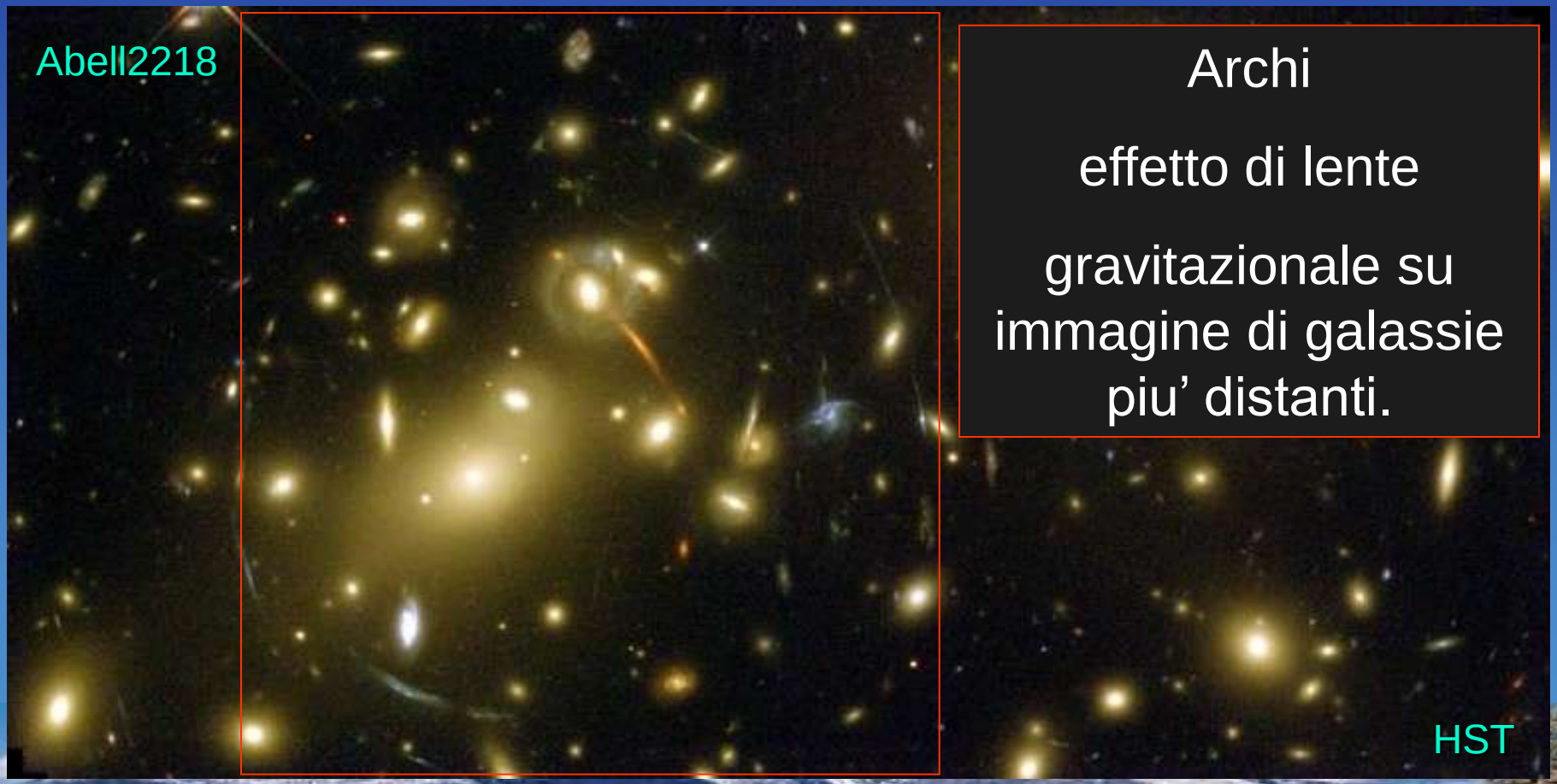
4.5 pc

1 pc (1 parsec) = 3 anni luce



Gruppi (Cluster) di galassie

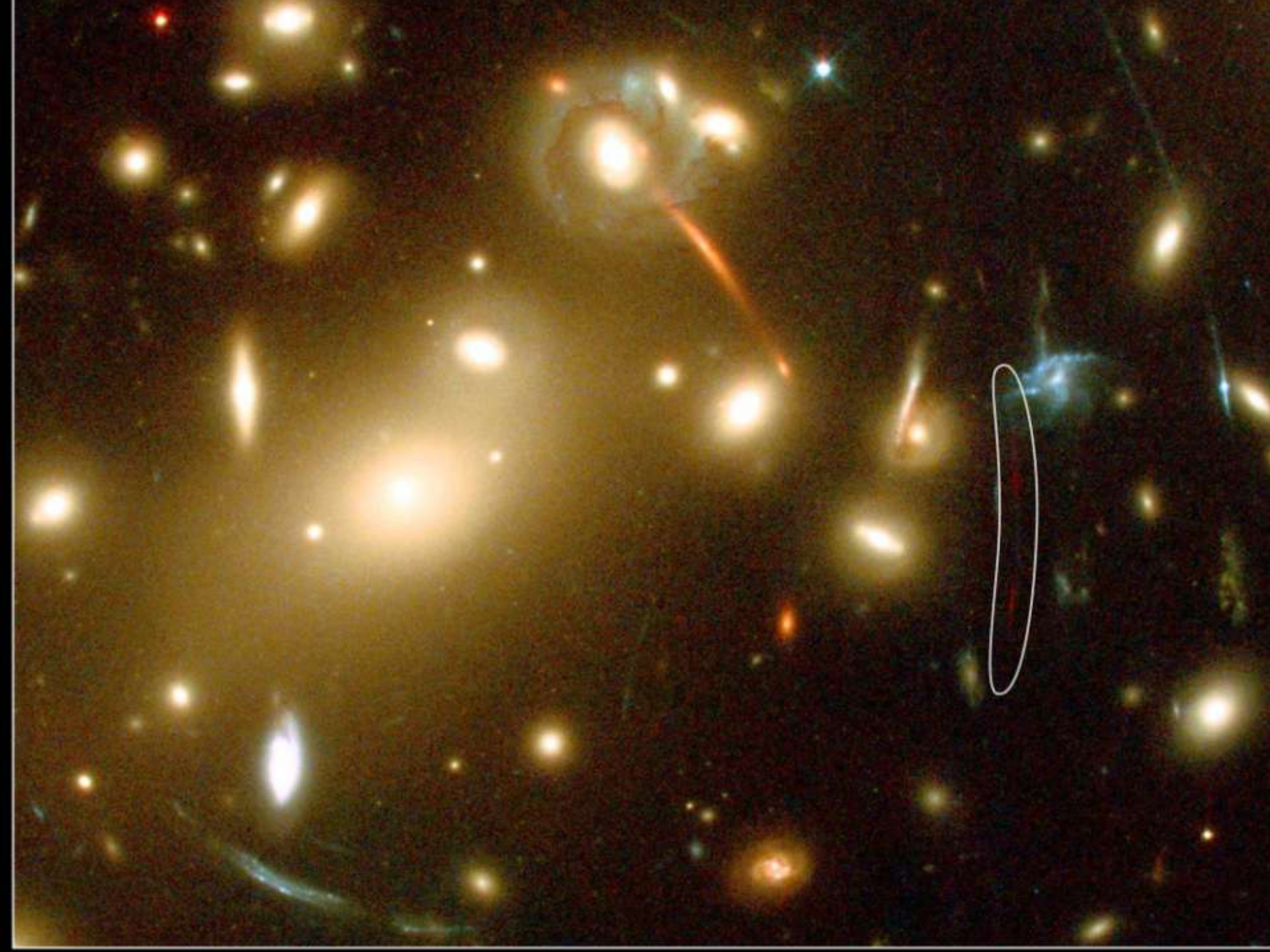
circa 50 volte le dimensioni della Via Lattea.



Archi

effetto di lente

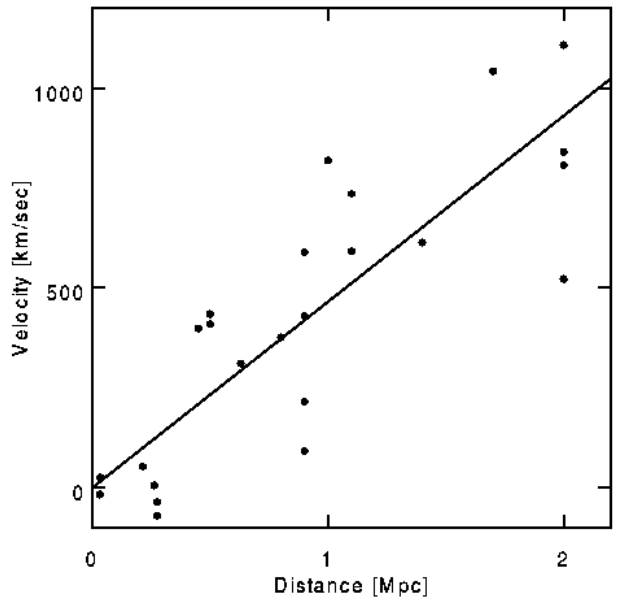
gravitazionale su immagine di galassie piu' distanti.

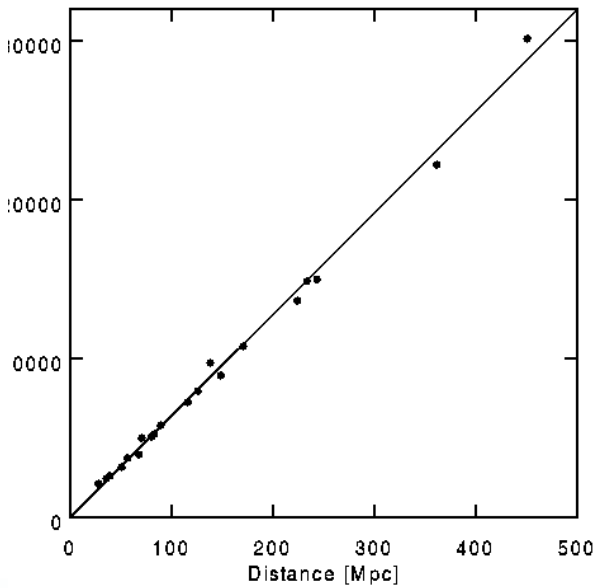


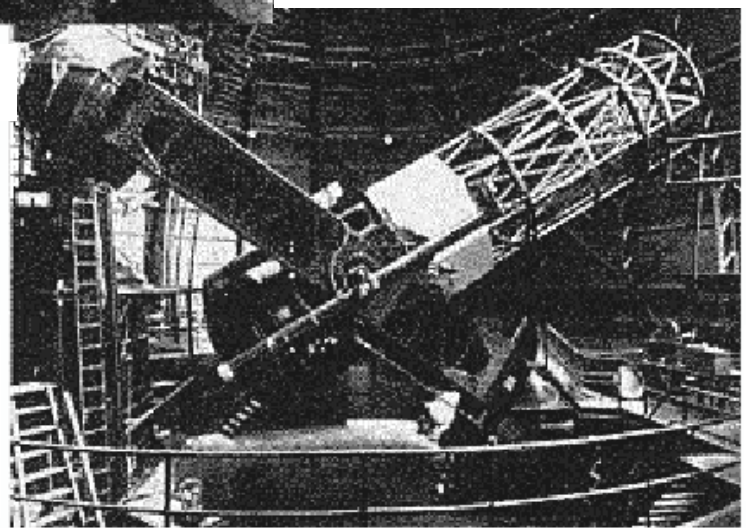
Cosmologia

Espansione dell'universo

Edwin Hubble





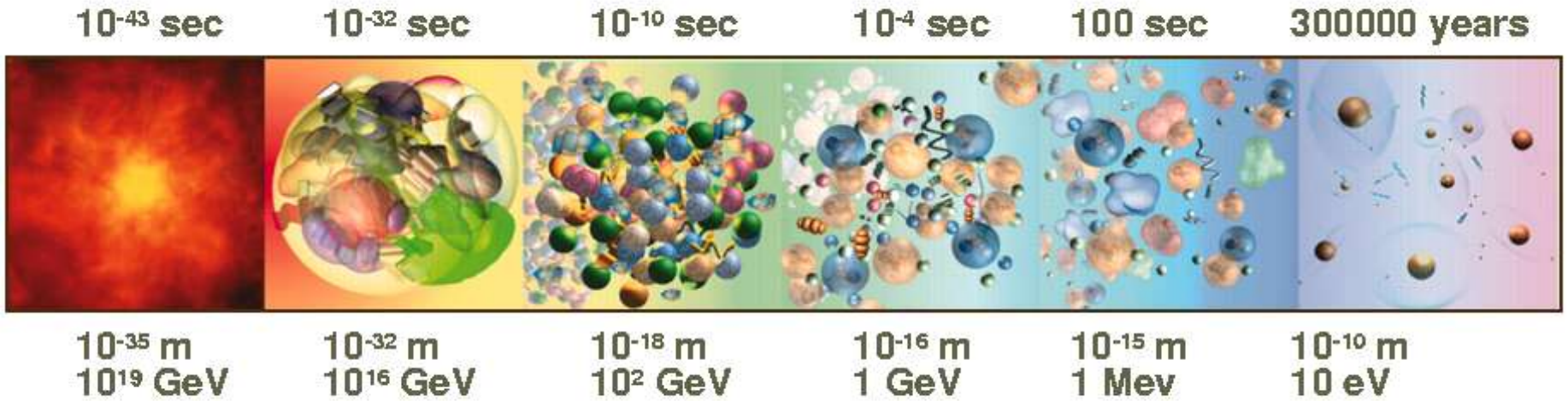


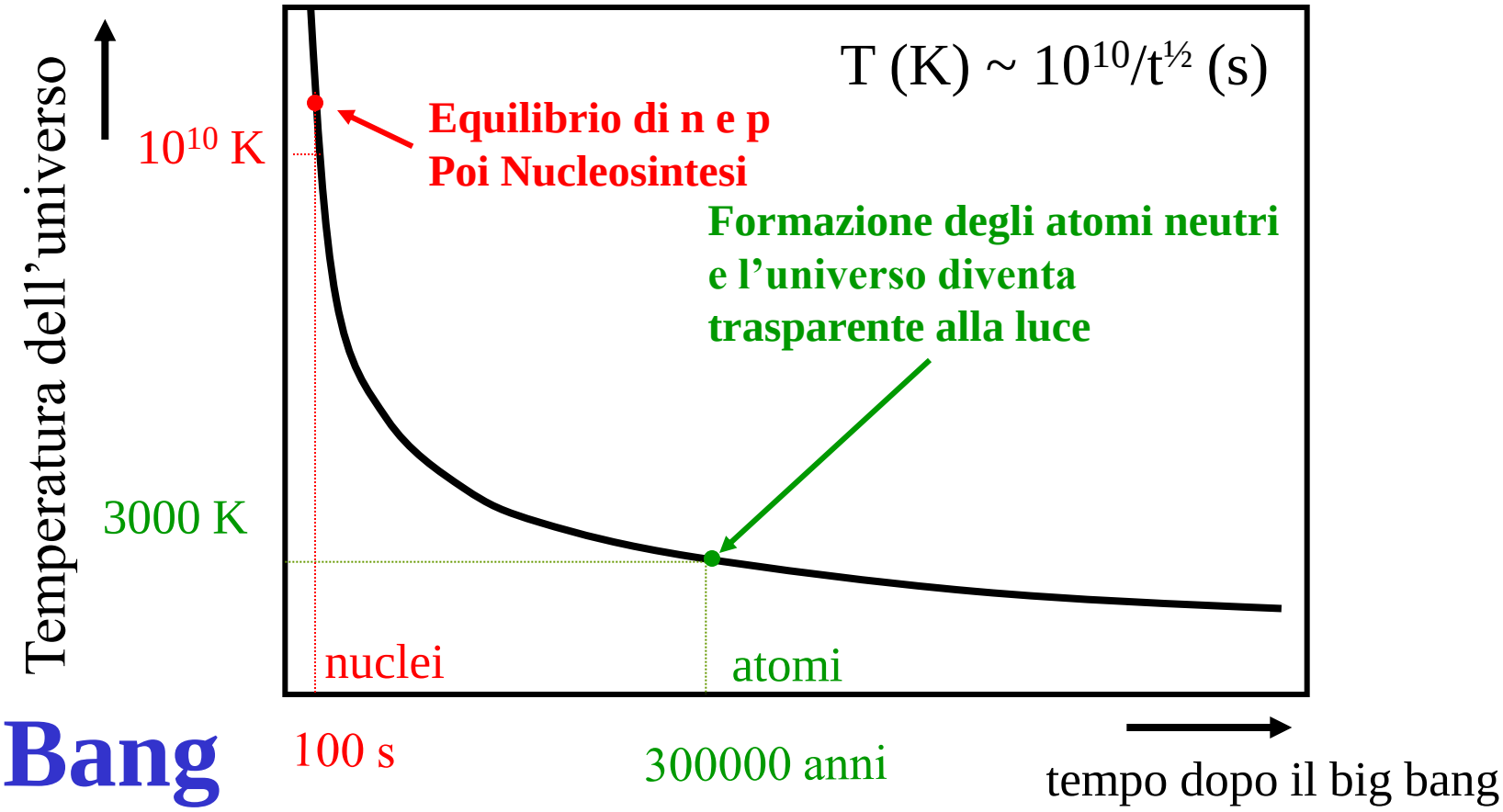
Mt. Wilson
100 Inch
Telescope

Velocita' delle galassie proporzionale alla distanza:

$v = H r$

$H \sim 70$ km/sec / Mpc

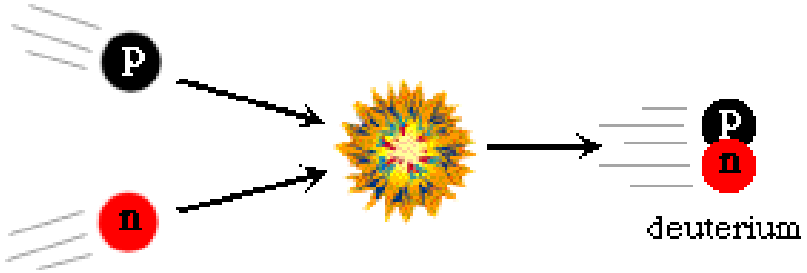

10^{-43} sec
10^{-32} sec
10^{-10} sec
10^{-4} sec
100 sec
300000 years
10^{-35} m
10^{19} GeV
10^{-32} m
10^{16} GeV
10^{-18} m
10^{2} GeV
10^{-16} m
1 GeV
10^{-15} m
1 Mev
10^{-10} m
10 eV


Temperatura dell'universo
$T\ (K) \sim 10^{10}/t^{1/2}\ (s)$
10^{10} K
Equilibrio di n e p
Poi Nucleosintesi
Formazione degli atomi neutri
e l'universo diventa
trasparente alla luce
3000 K
nuclei
atomi
100 s
300000 anni
tempo dopo il big bang

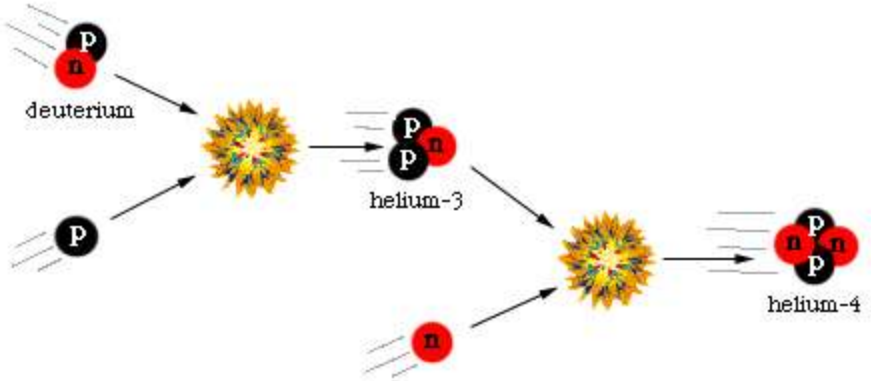
Big Bang

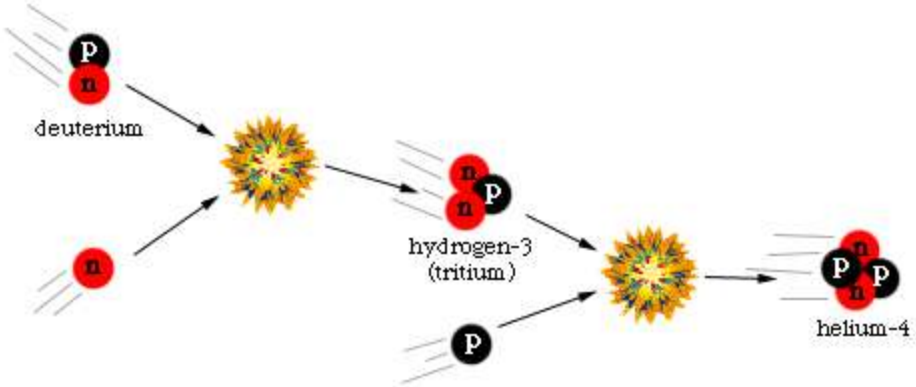
Nucleosintesi primordiale

Deuterio = il primo passo necessario per la nucleosintesi



Elio formato dal deuterio

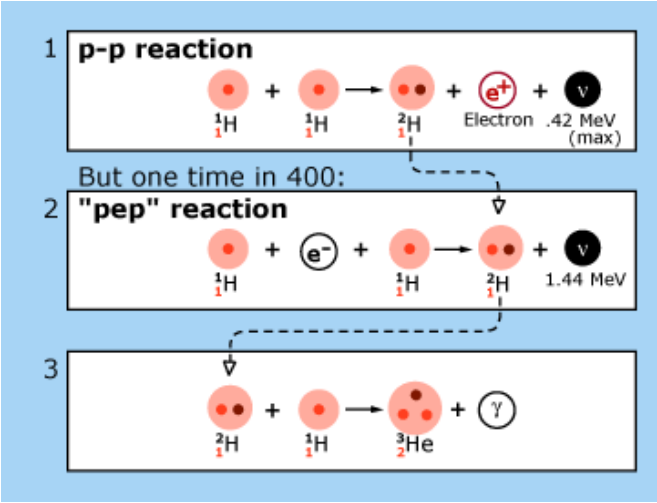




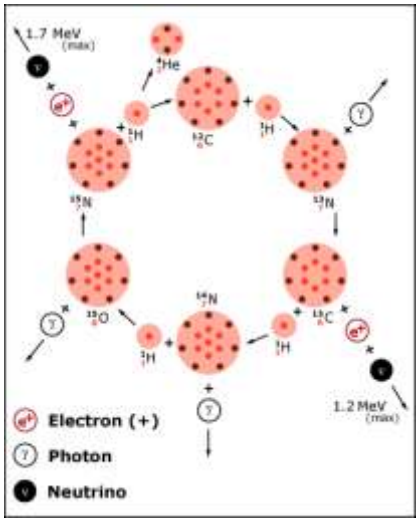
(Poi difficile per problemi con masse da 5 e 8 nucleoni)

Produzione di altri elementi nelle Stelle

Ciclo PP : stelle meno calde



Ciclo CNO : stelle piu' calde



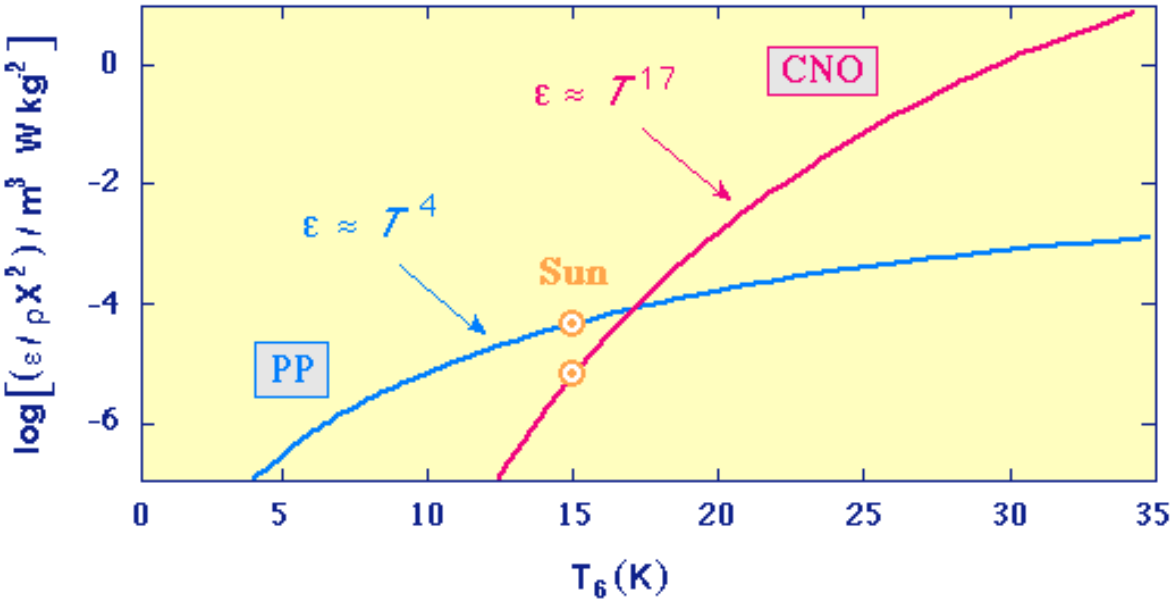
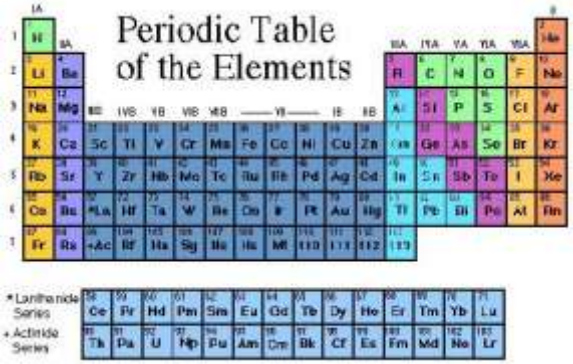
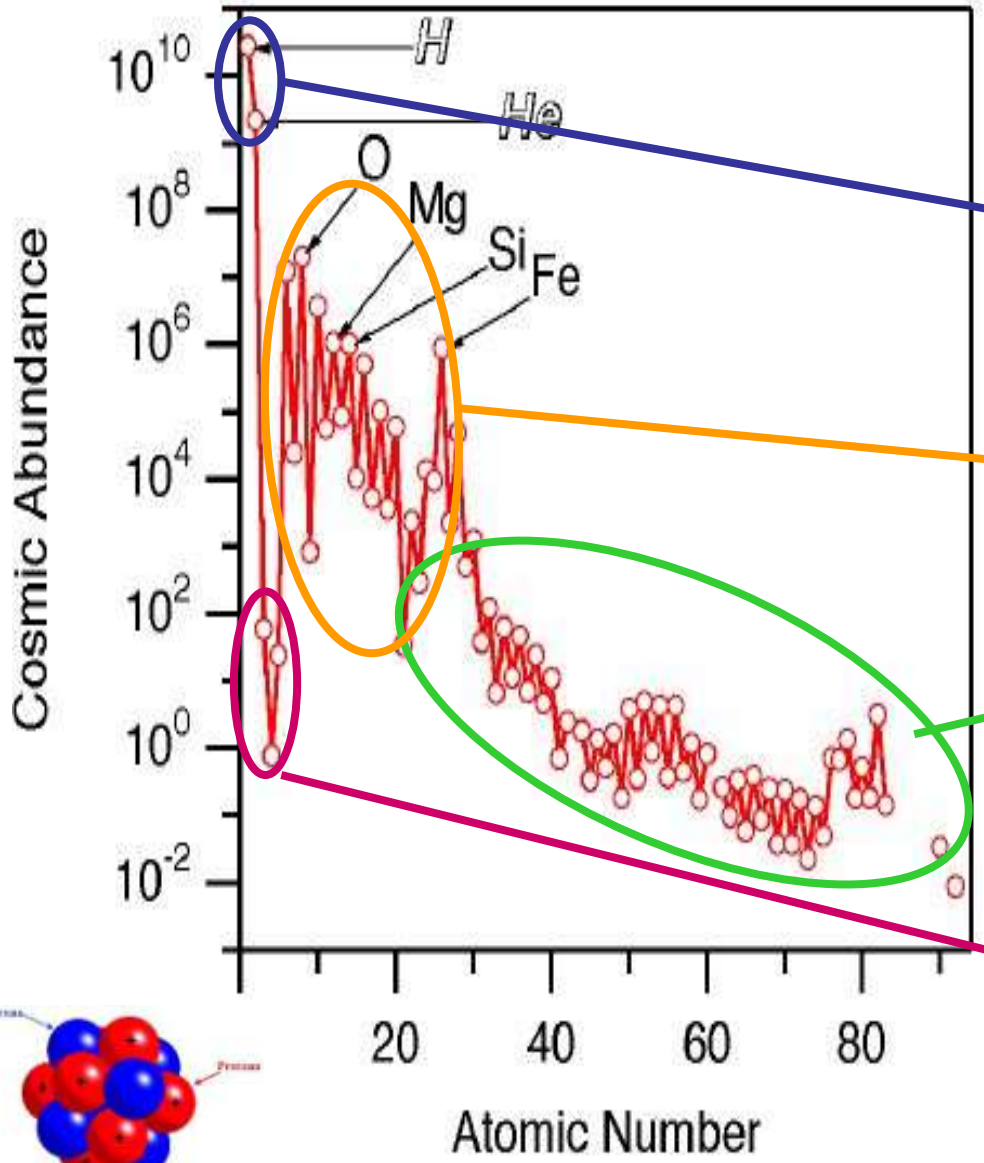


Tavola periodica degli elementi ========== >



Origine

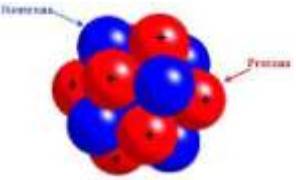


Big Bang Nucleosintesi

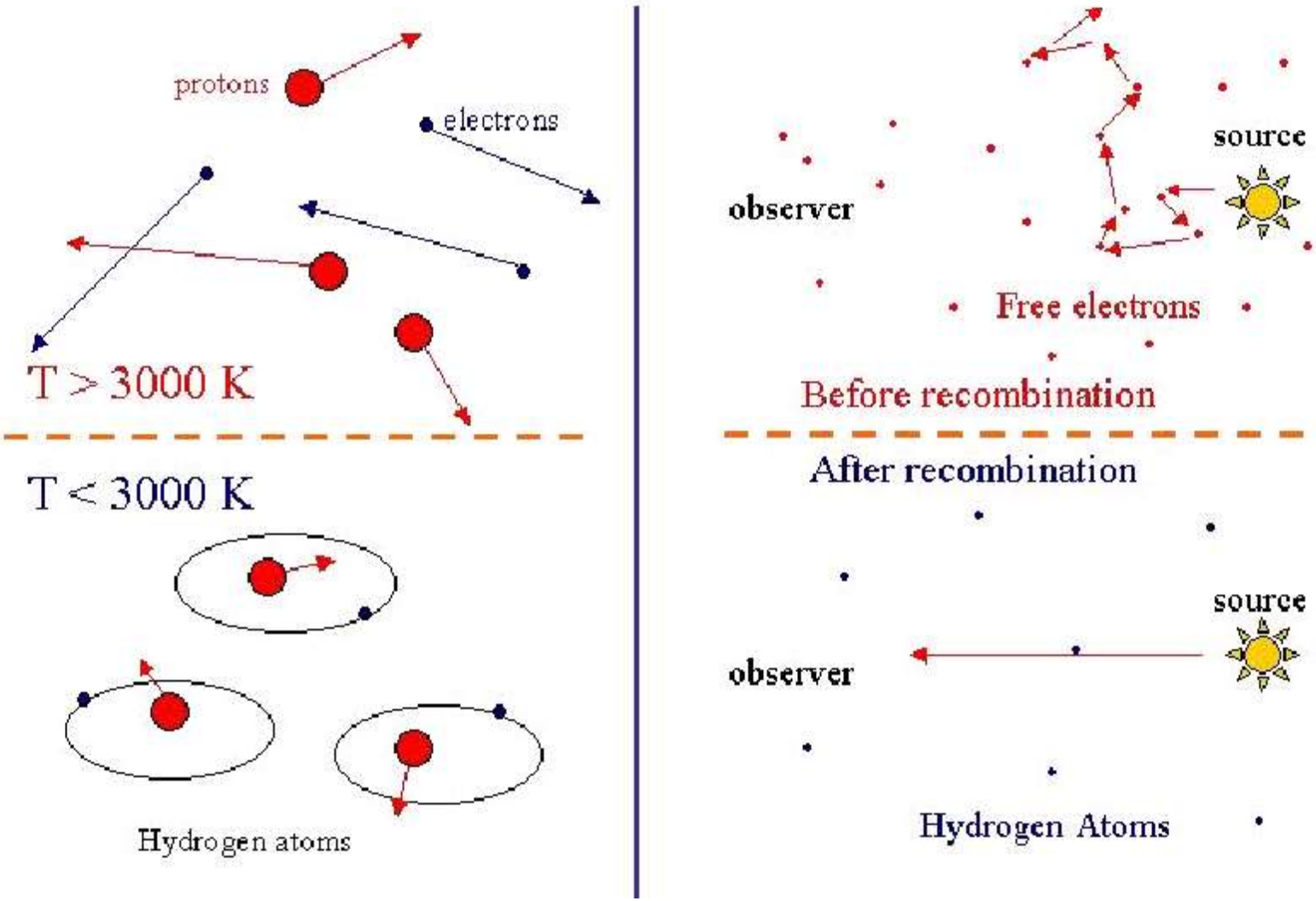
Stelle calde

Esplosioni di Supernova

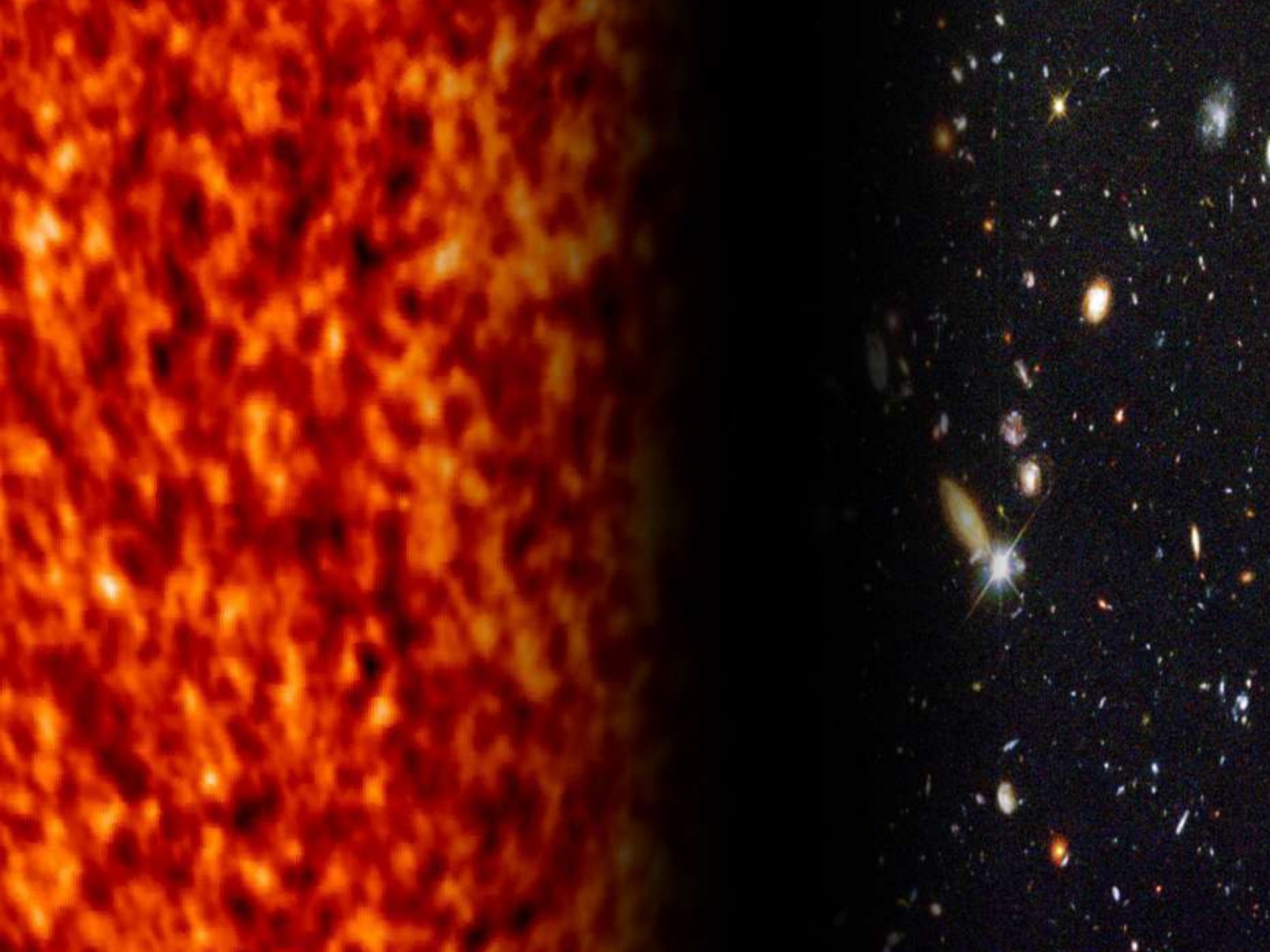
Interazioni con raggi cosmici



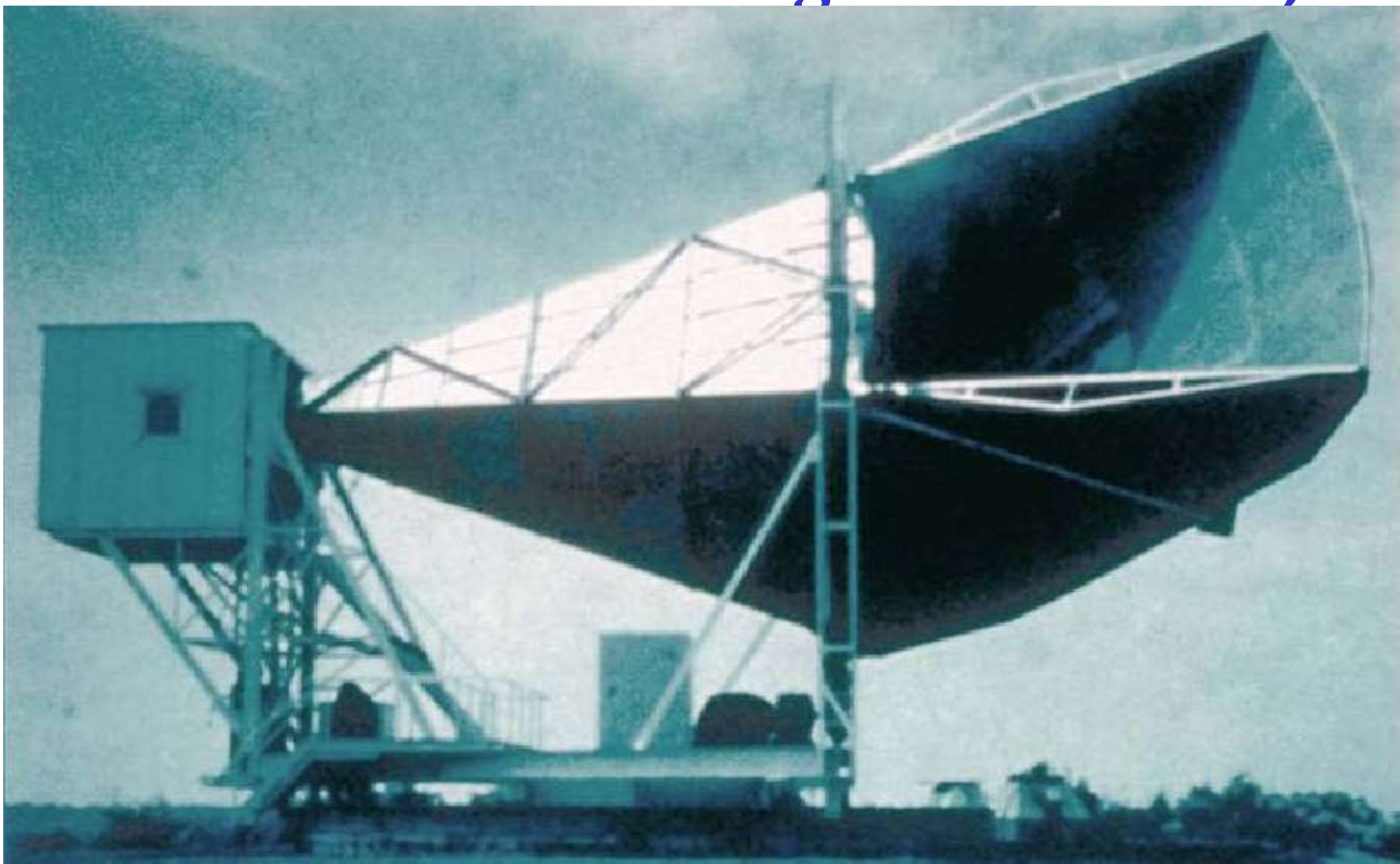
Prima: Universo Opaco



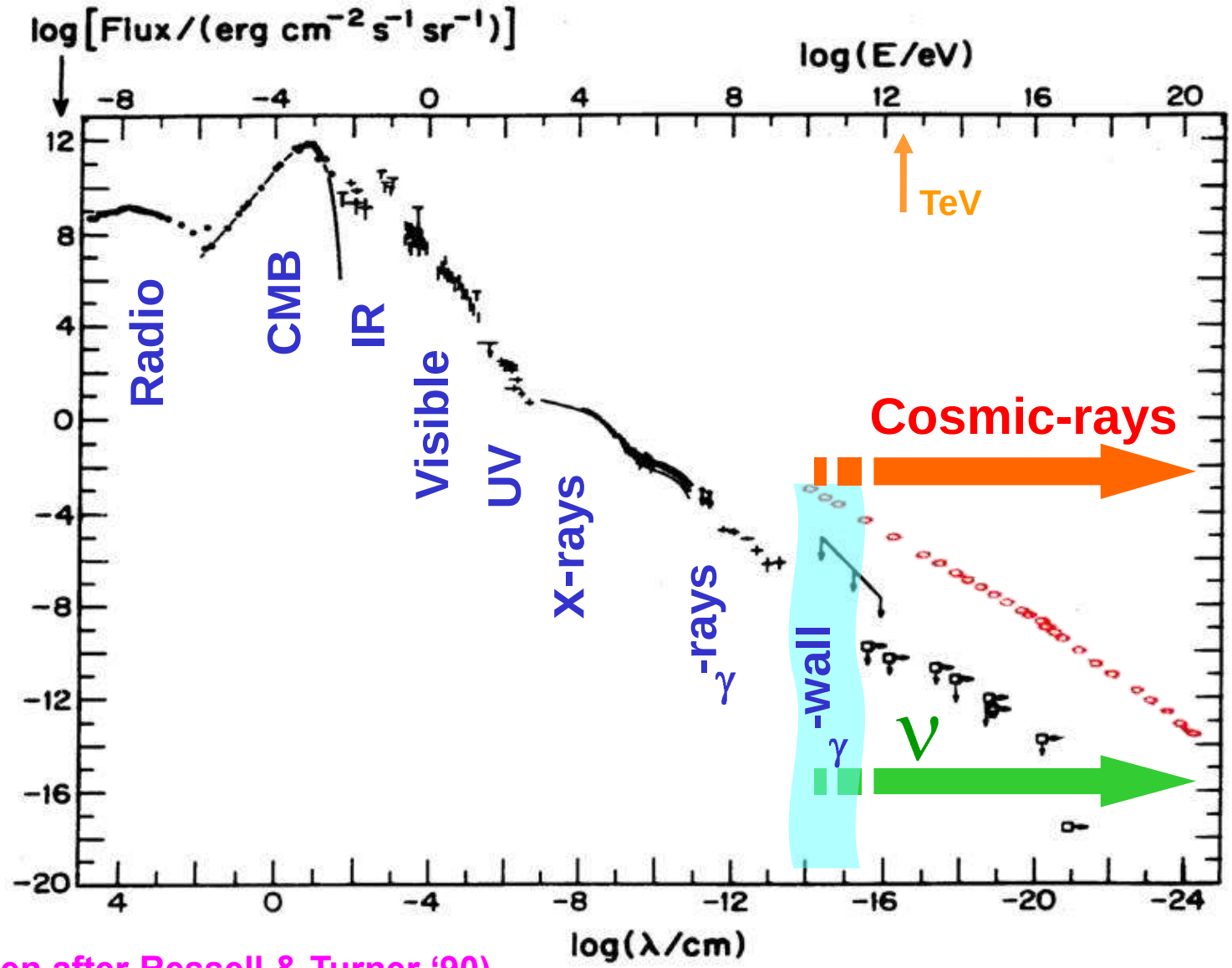
Dopo: Universo Trasparente



Penzias e Wilson : Scoperta del Fondo Cosmico a Microonde (Cosmic Microwave Background= CMB)



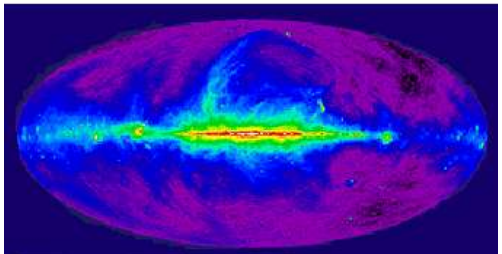
Cosmic Radiation



(by Halzen after Ressell & Turner '90)

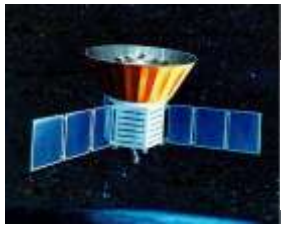
Multi-Wavelength Photons

Radio



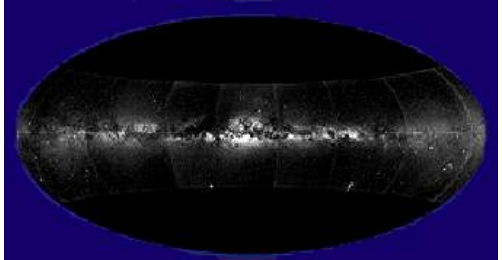
Radio télescope de Bonn

Infrared



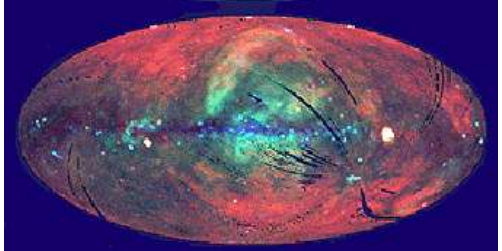
Satellite COBE

Visible light



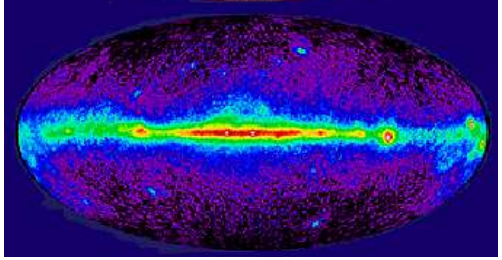
Télescope du Mont Palomar

X-ray



Satellite INTEGRAL

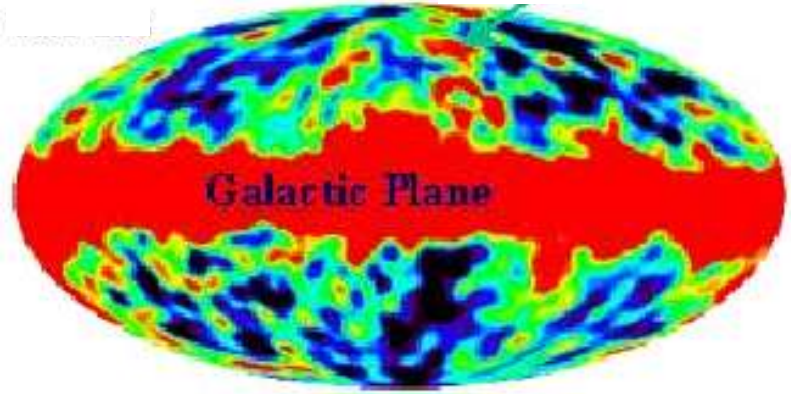
Gamma Ray



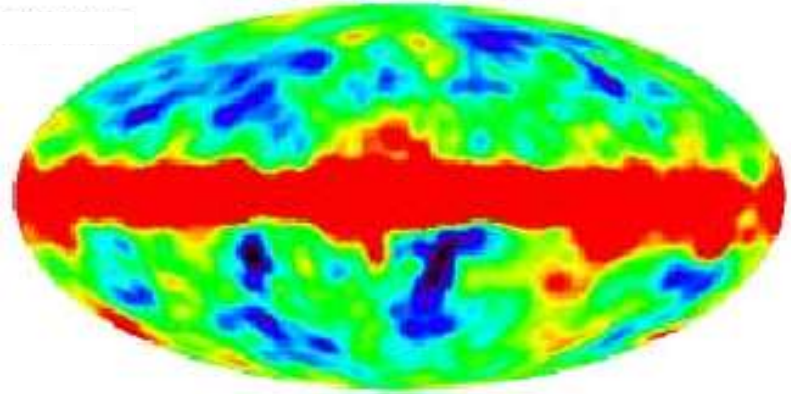
Satellite CGRO

Cosmic Microwave Background Radiation

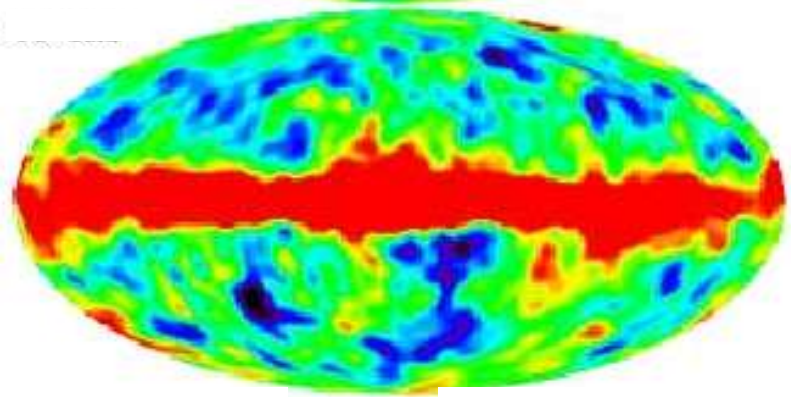
Microwaves: 31.5 GHz



53 GHz

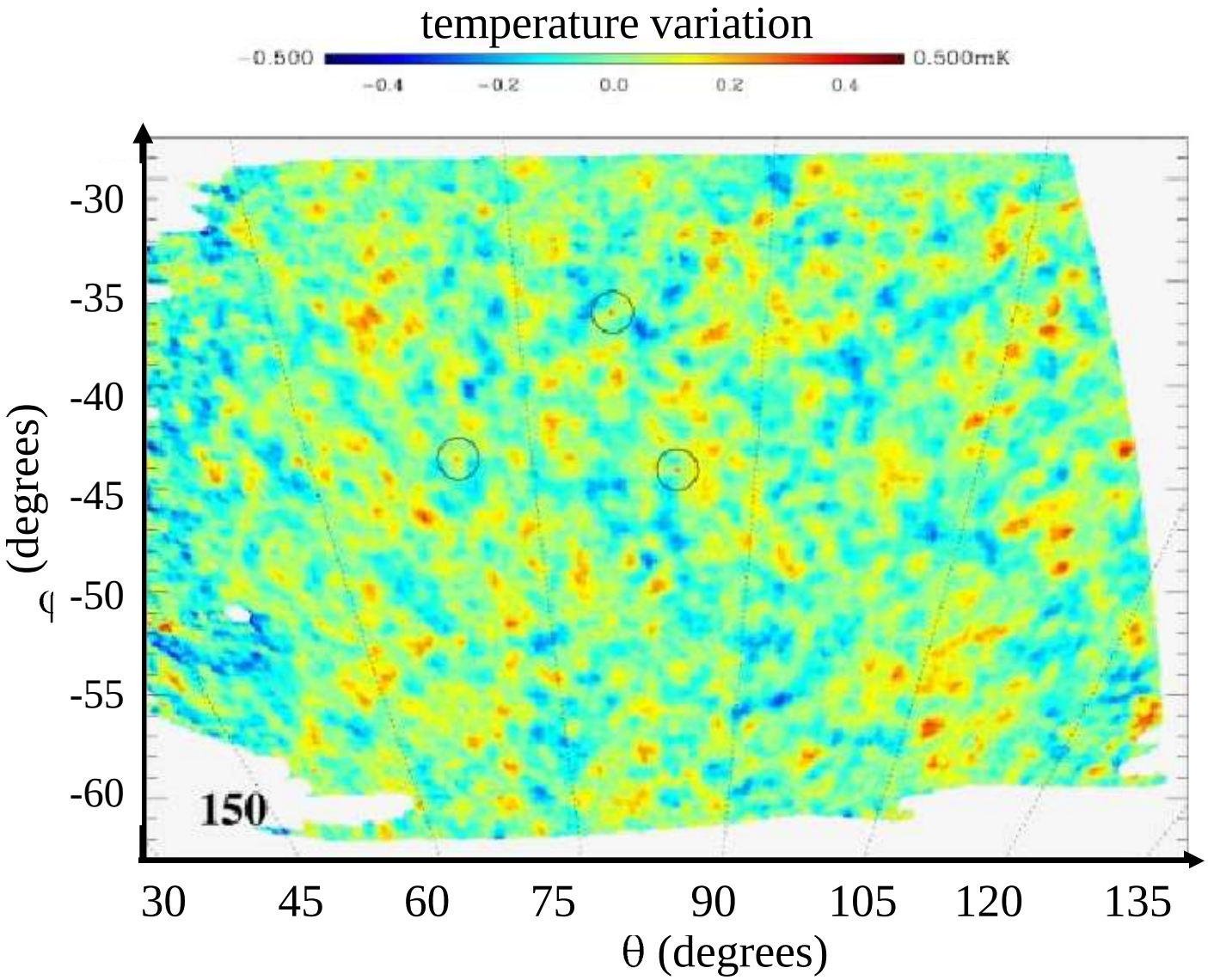


90 GHz



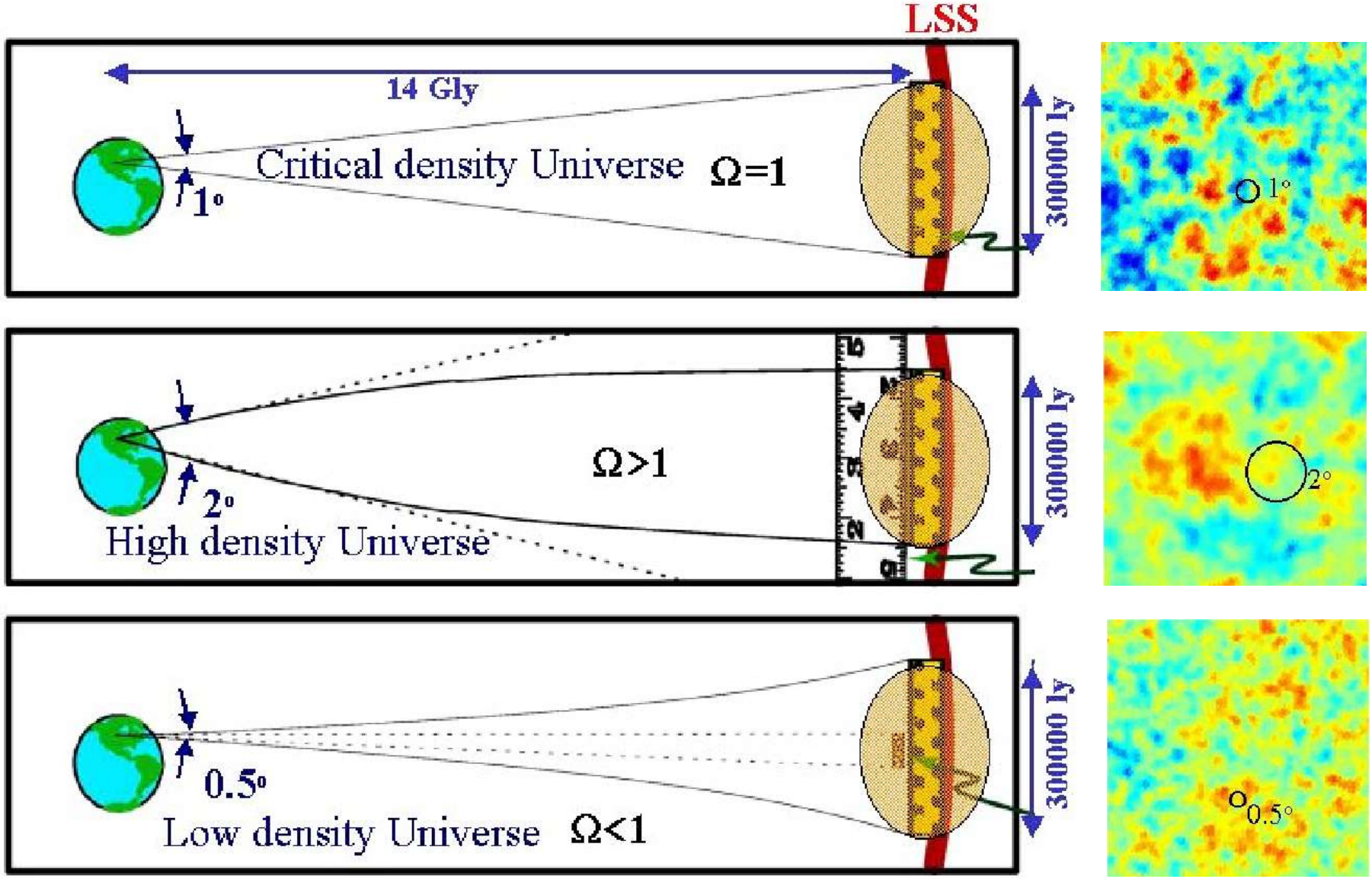
Temperature variations: – 100 μK  + 100 μK

Cosmic Microwave Background

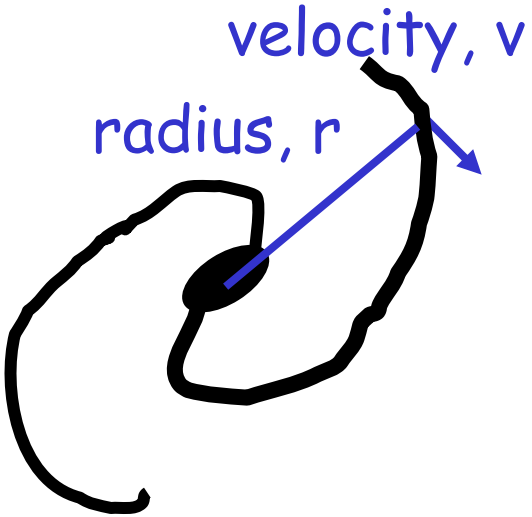


Analyse angular distribution to see typical variation scale

Fluttuazioni di CMB



Rotazione delle Galassie

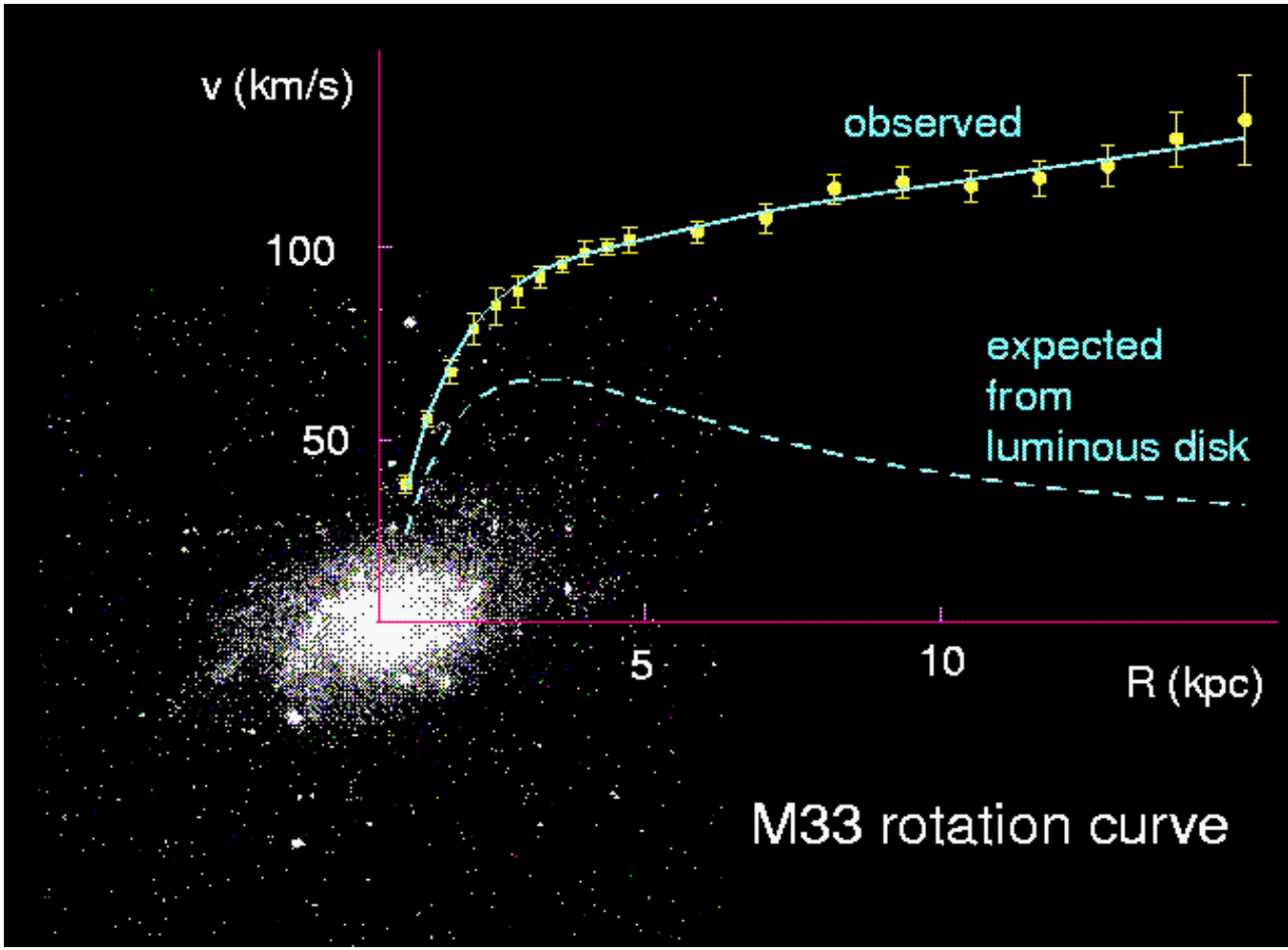


Gravity:

$G\,M(r) / r^2 = v^2 / r$

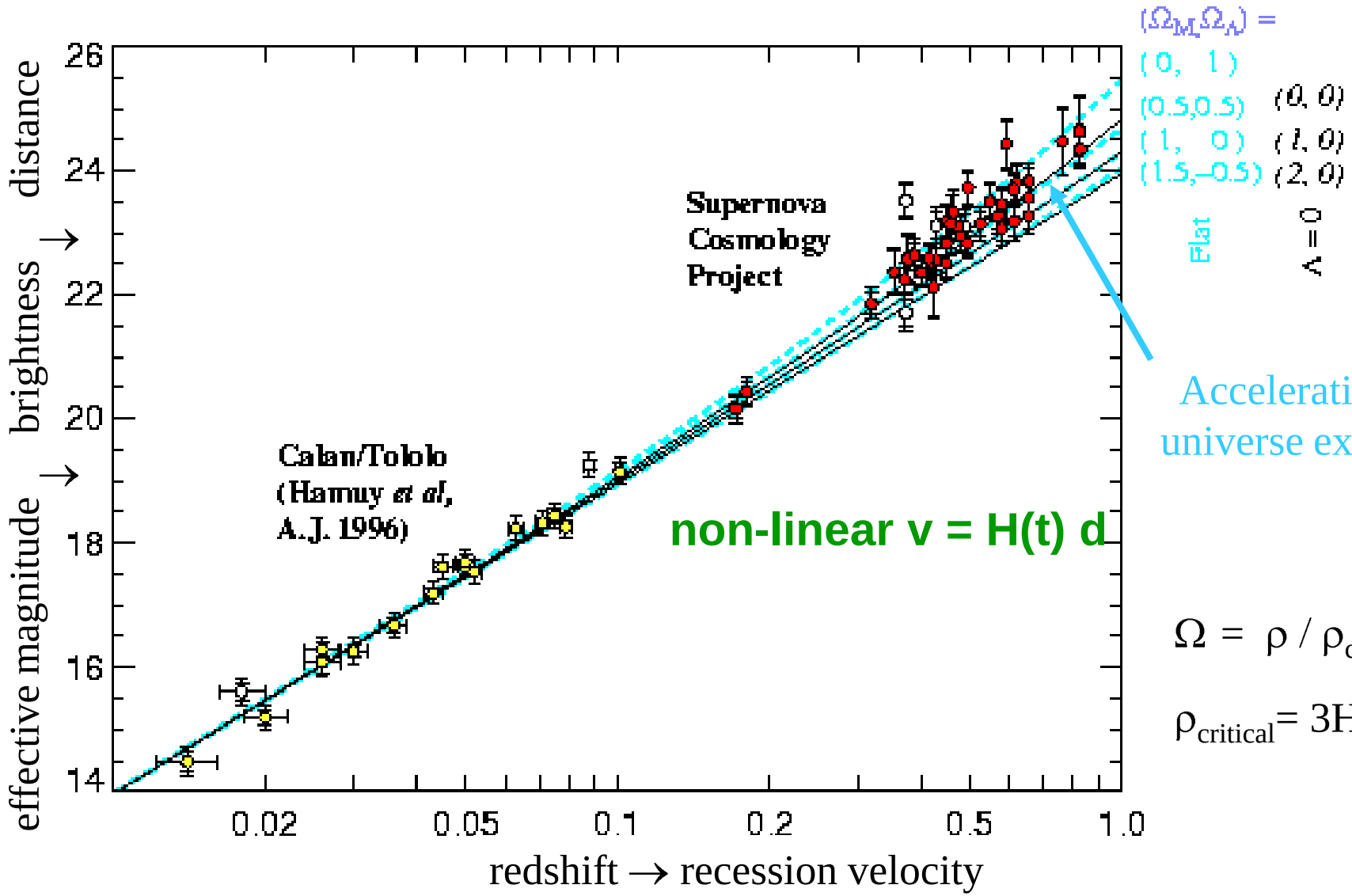
enclosed mass:

$M(r) = v^2\, r / G$



Luminous stars only small fraction of mass of galaxy

Espansione dalle Supernova Ia



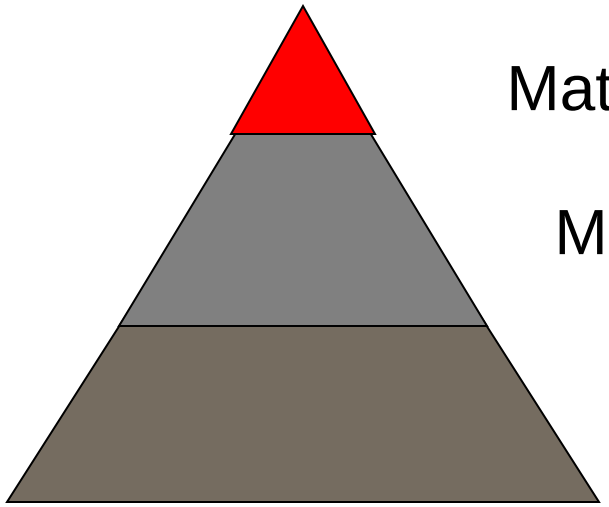
$\Omega = \rho / \rho_{critical}$

$\rho_{critical} = 3H^2/8\pi G_N$

Composizione dell'universo

Materia = 1/3

Energia Oscura = 2/3



Materia normale: 5%

Materia oscura: 30%

Energia oscura: 65%

RAI-TG1, 21 Agosto 2006- Osservata la Materia Oscura: La Piu' Diretta Misura della Materia Oscura Permette lo Studio della sua Natura

August 21, 2006 –

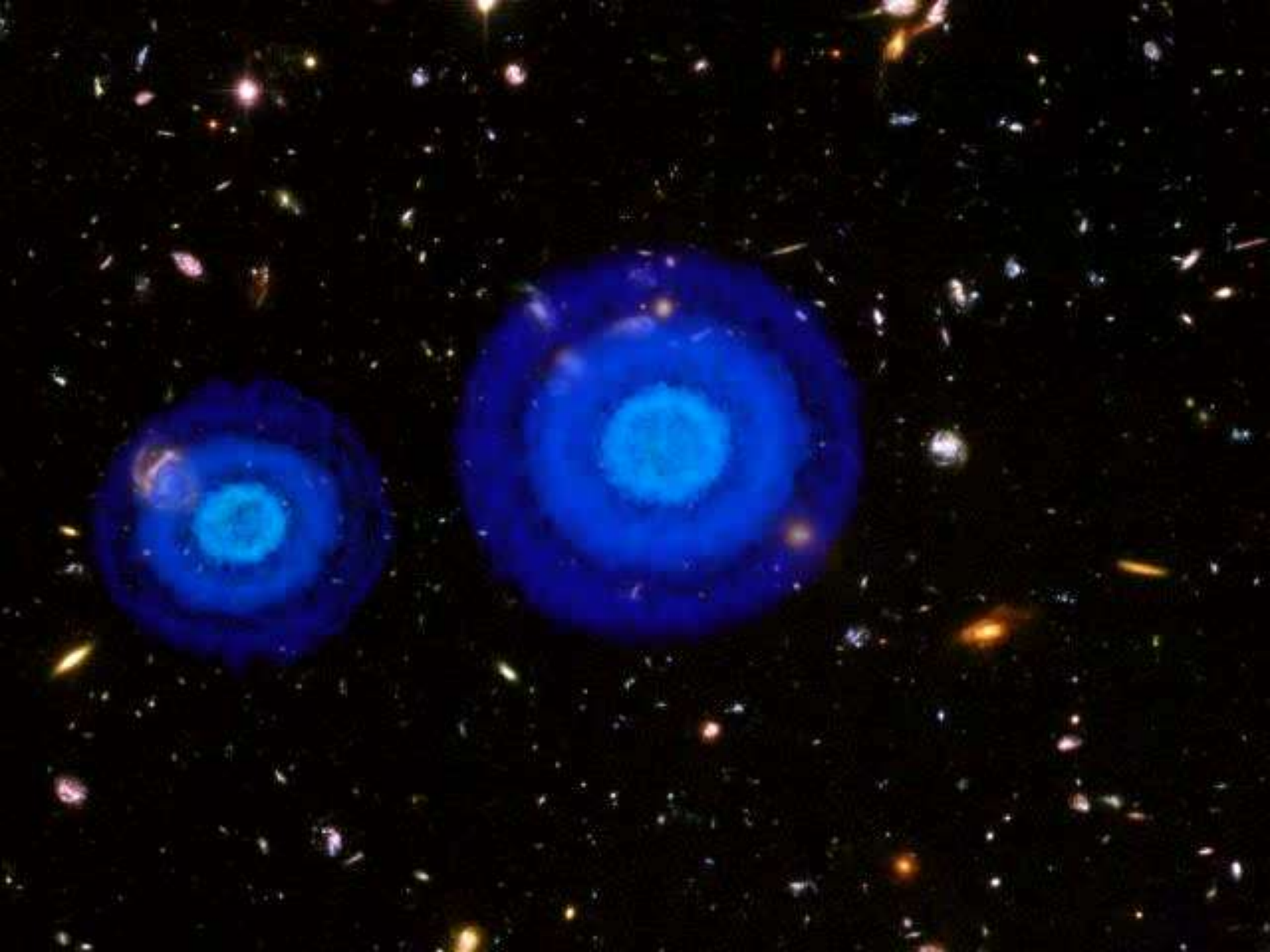
Dark Matter Observed:

Most Direct Measurement of

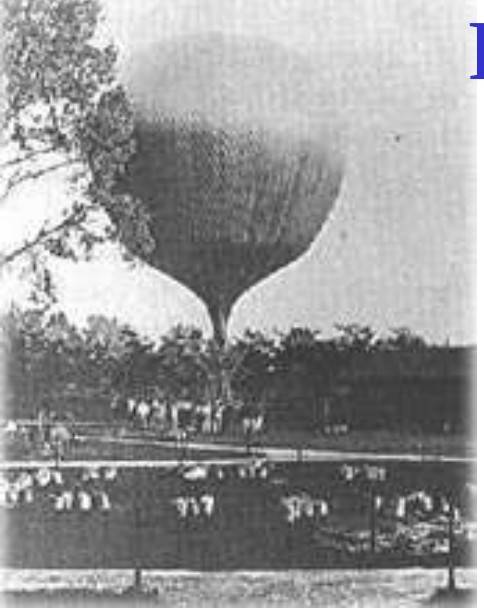
Dark Matter Allows Study of its Nature

-Press Release

- Neil Calder, Stanford Linear Accelerat
- neil.calder@slac.stanford.edu
- Stanford Linear Accelerator Center
- NASA Press Release
- Chandra Media Webstie
- View a visualization of the event (.mov / .avi)



Raggi Cosmici

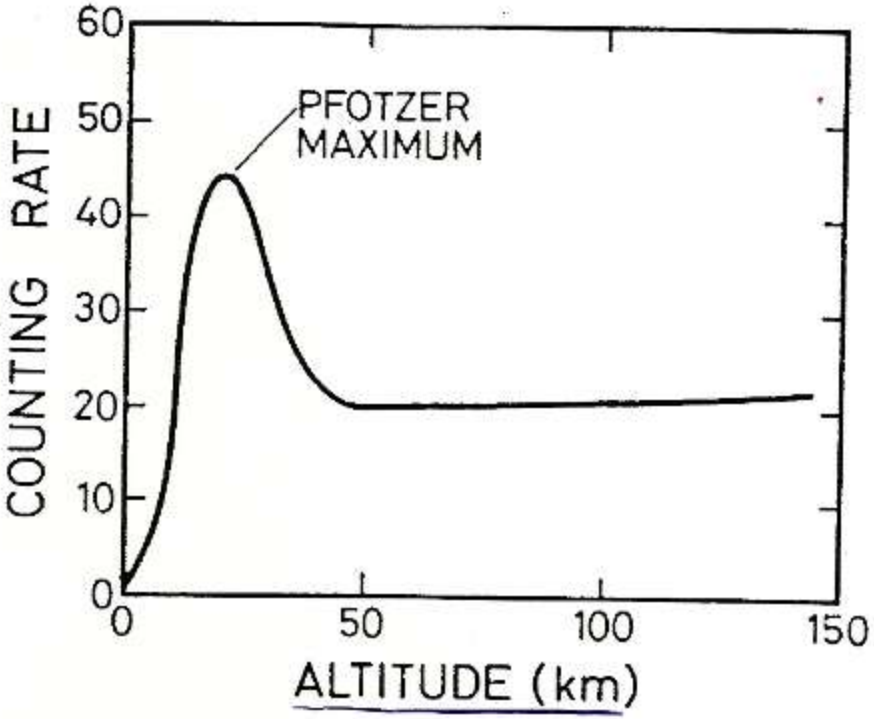


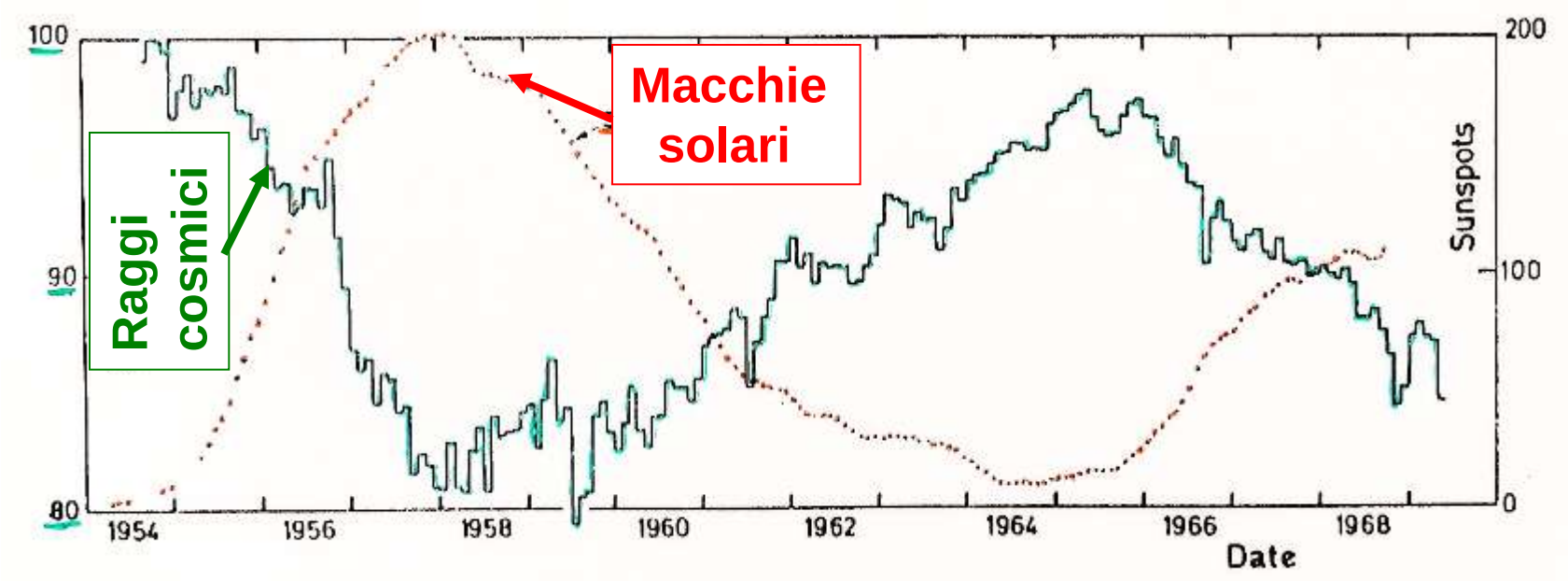
Colhoster 1914
@ 9km

Altitude (km)	Difference between observed ionisation and that at sea-level (ions cm^{-3}) s^{-1}
1	−1.5
2	+1.2
3	+4.2
4	+8.8
5	+16.9
6	+28.7
7	+44.2
8	+61.3
9	+80.4

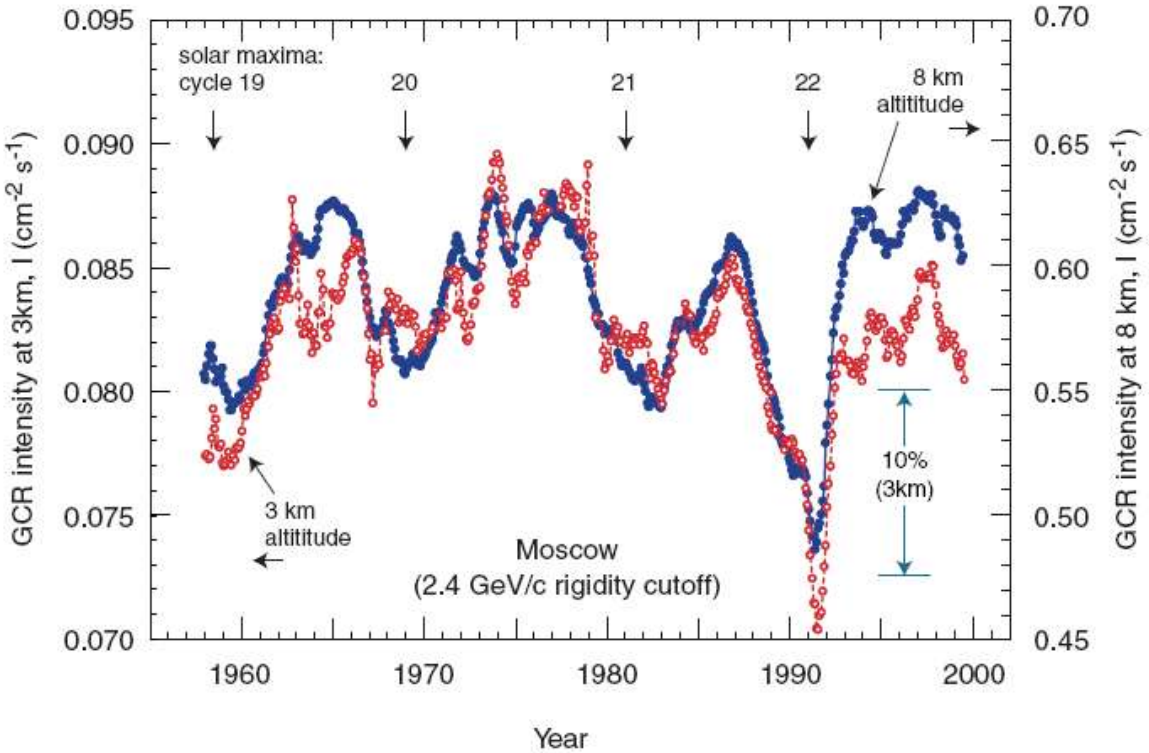
Millikan scettico sui "…Raggi … Cosmici" ys"

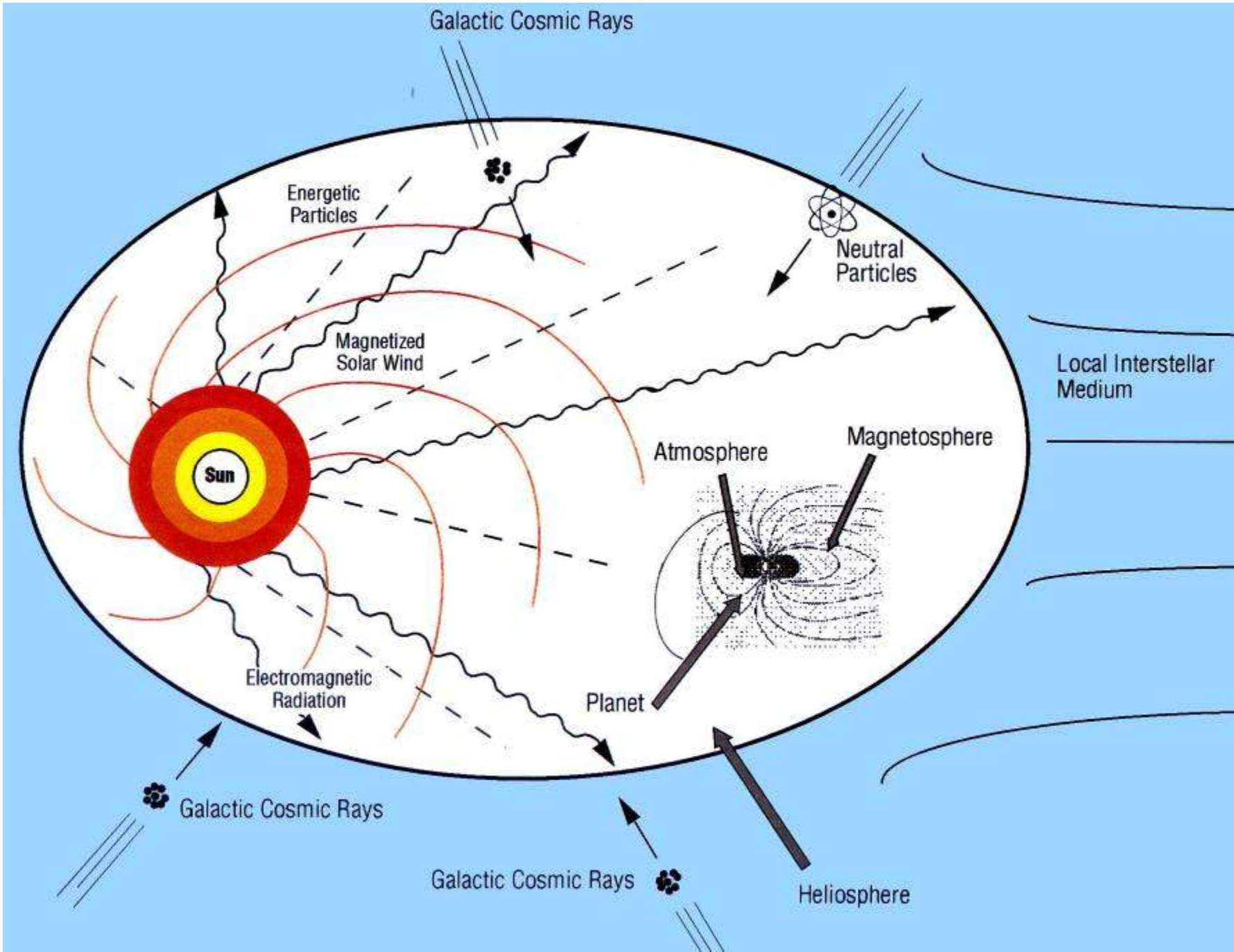
Ascese su Pallone:
Hess 1912 @ 5km





Anticorrelazione con i massimi del ciclo solare




Galactic Cosmic Rays
Energetic Particles
Neutral Particles
Magnetized Solar Wind
Local Interstellar Medium
Sun
Atmosphere
Magnetosphere
Electromagnetic Radiation
Planet
Galactic Cosmic Rays
Galactic Cosmic Rays
Heliosphere

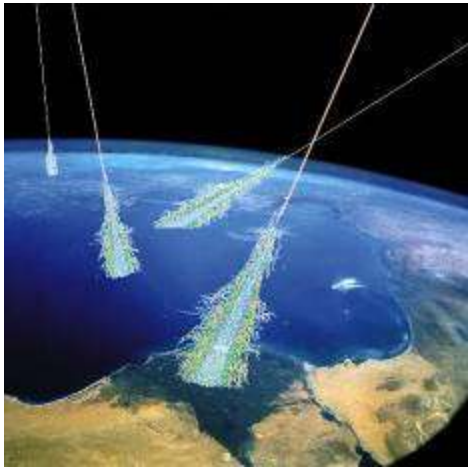
Composizione dei Raggi Cosmici

PRIMARI:

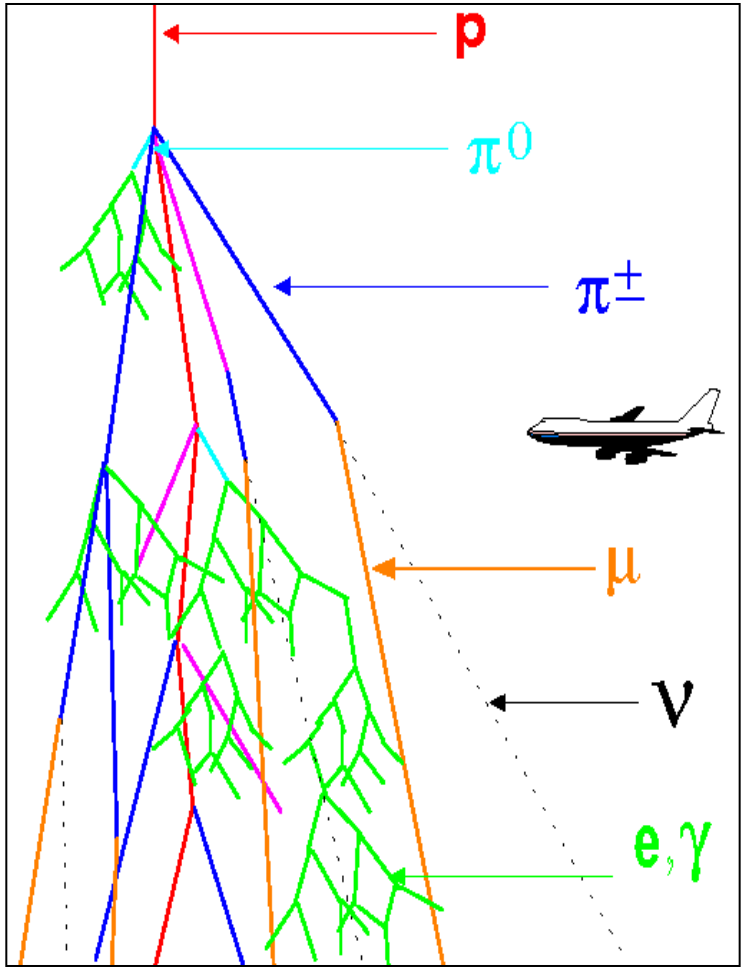
p ~ 87 %, α~10 %, N~1 %

e ~2 %

γ ~0.1 %, ν~0.1 % ?



Alta atmosfera :~ 1000/m²/s

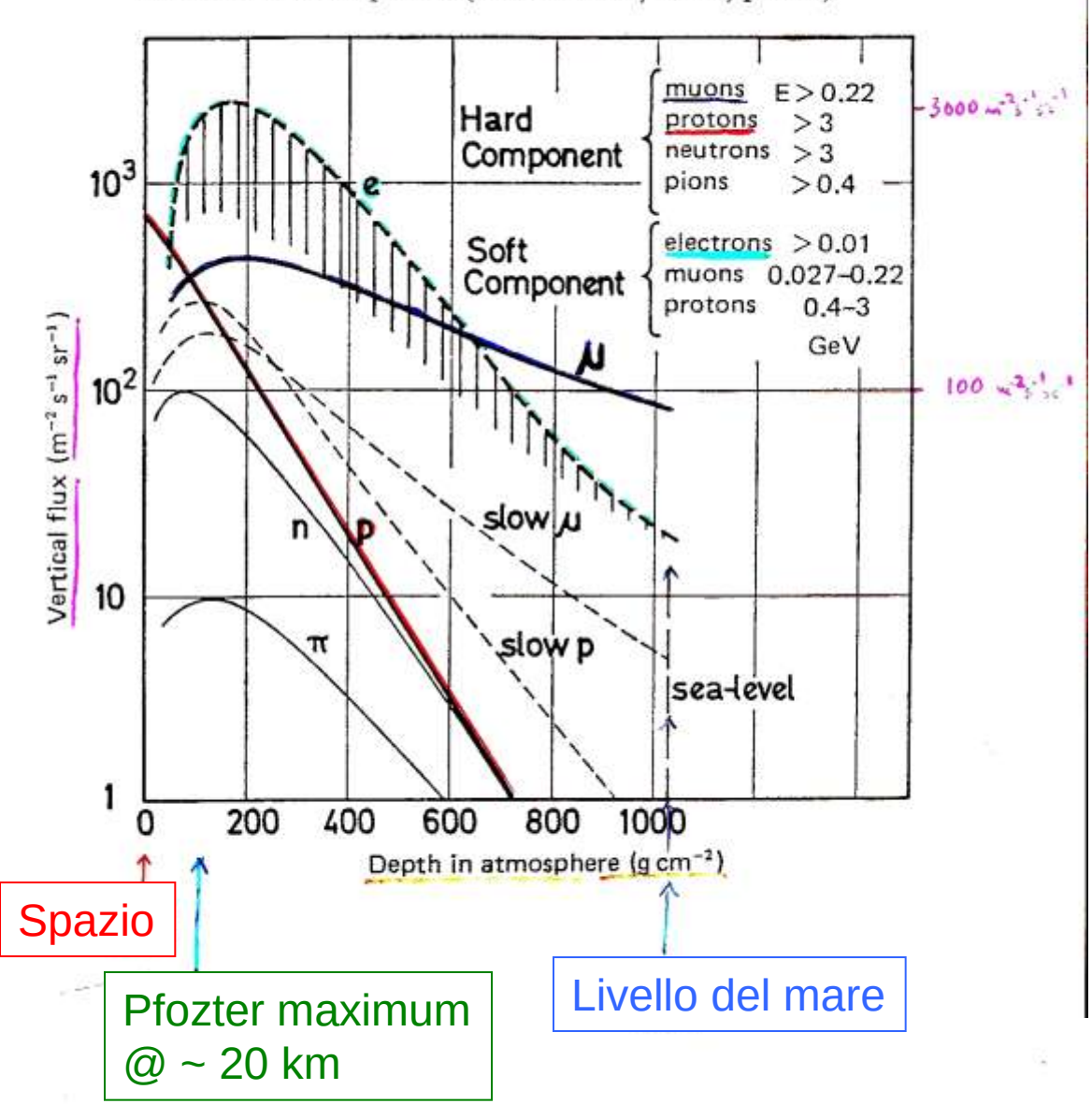


SECONDARI al livello del mare

μ ~ 30 %

p, n, ... ~ 2 %

ν ~ 68 %



Spazio

Pfozter maximum
@ ~ 20 km

Livello del mare

NOTE: $\tau_0(\mu) = 2.2\ \mu s$

$c\tau_0(\mu) = 2.2 \cdot 10^{-6} s \cdot 3 \cdot 10^{8} m s^{-1} = 660\ m$

$E = \gamma m_\mu c^2$

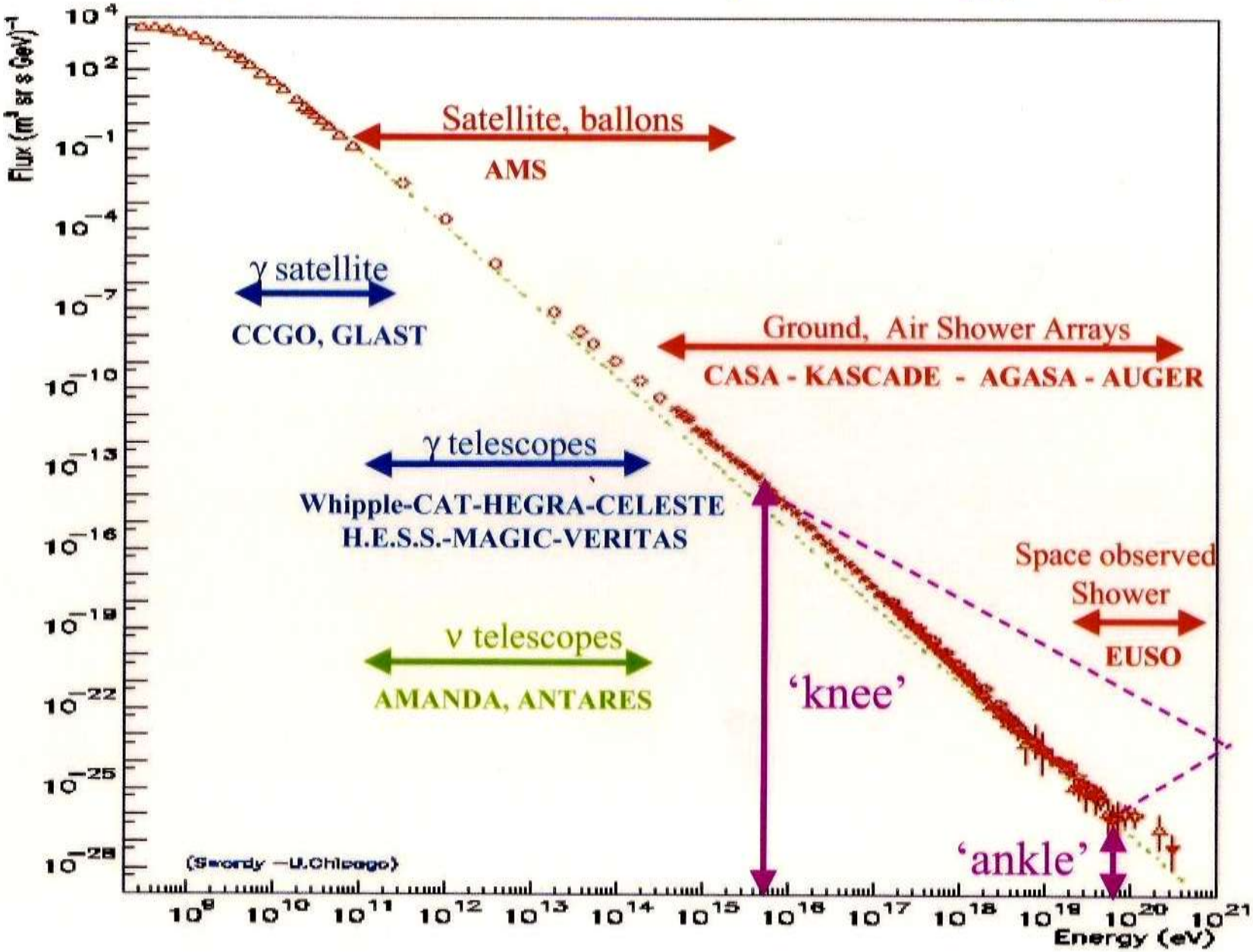
$\tau = \gamma \tau_0 \Rightarrow \gamma > 20$

RELATIVISTIC

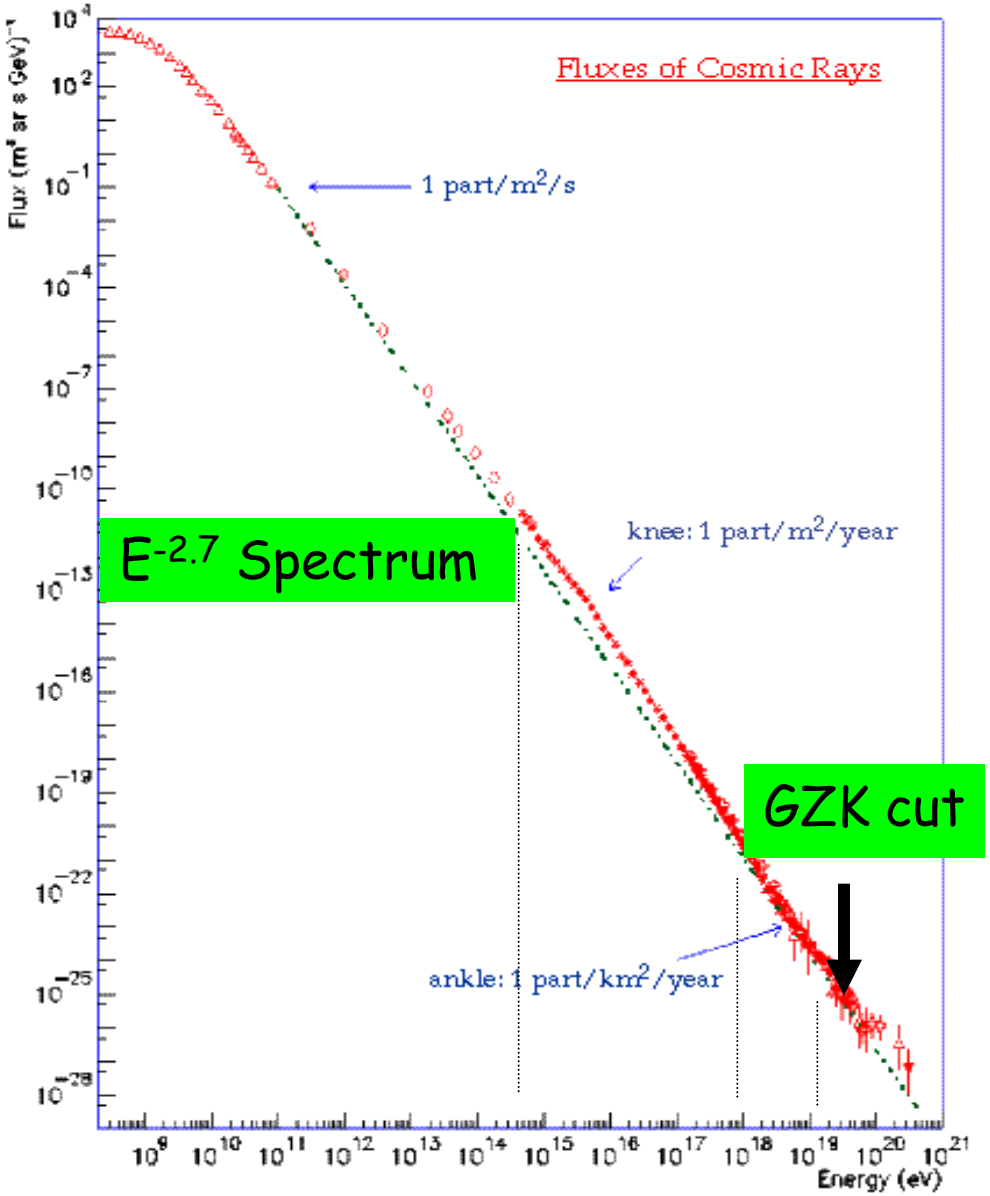
$m_\mu = 105\ MeV/c^2$

Flusso verticale di Raggi Cosmici vs. profondita' nell'atmosfera

Charged Cosmic Ray Energy Spectrum



The primary spectrum



Possible Origins

$E < 10^{15}$ eV
Galactic

$10^{15} < E < 10^{18}$ eV
Extra-galactic ?

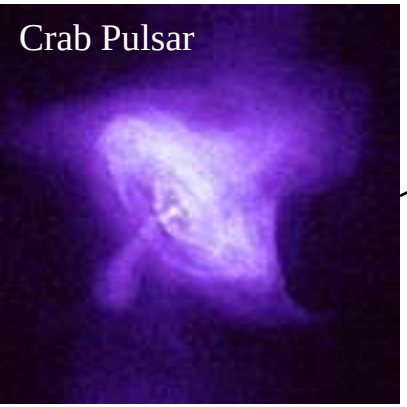
UHECR

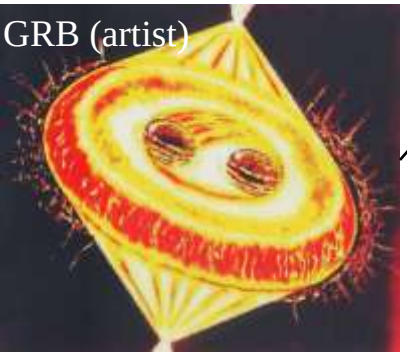
$10^{18} < E < 5.\ 10^{19}$ eV
Unknown

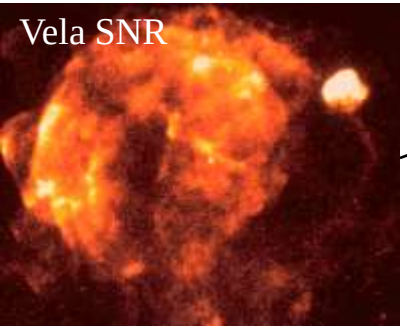
EECR

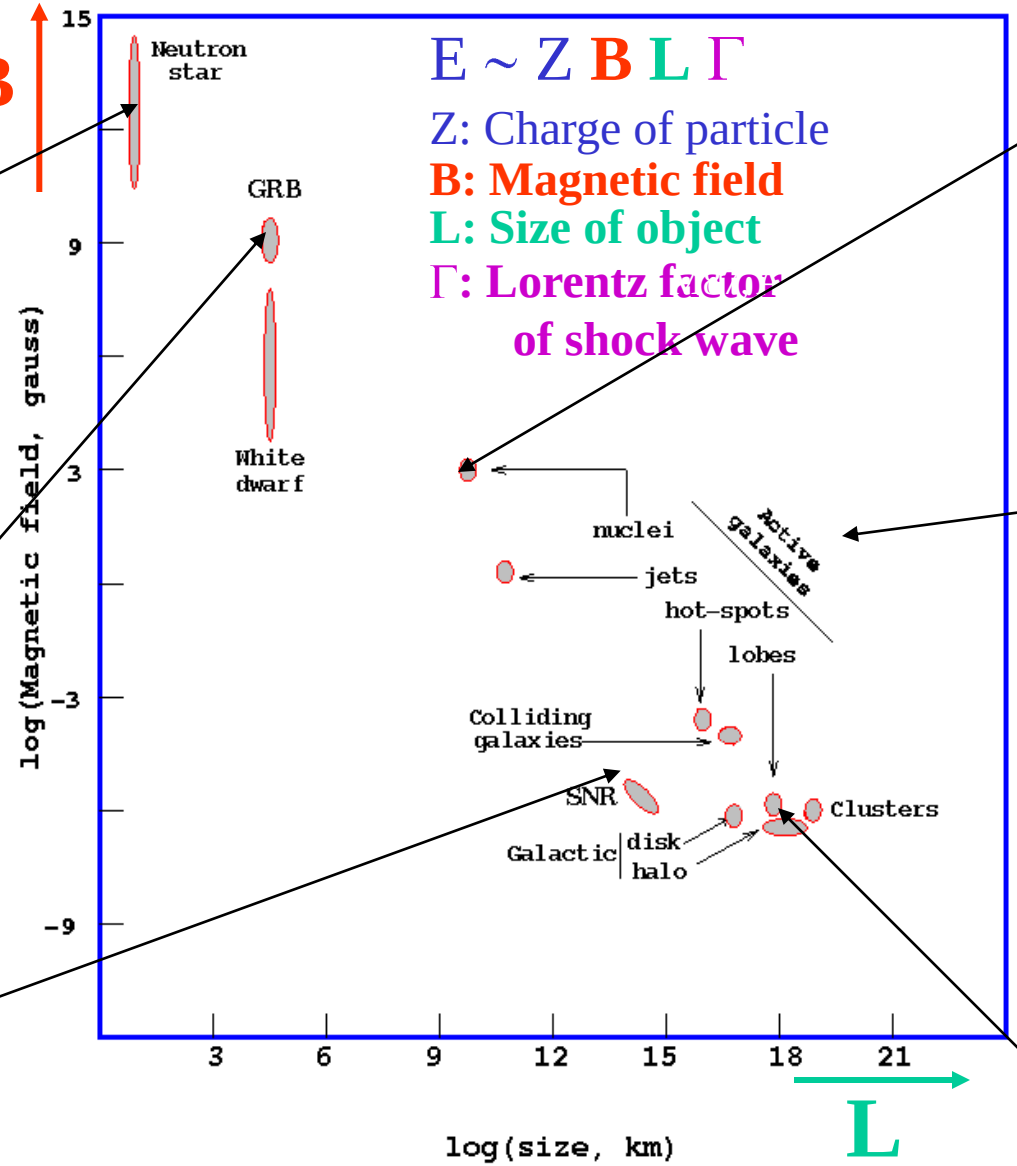
$5.\ 10^{19} < E < 3.\ 10^{20}$ eV
Unexpected

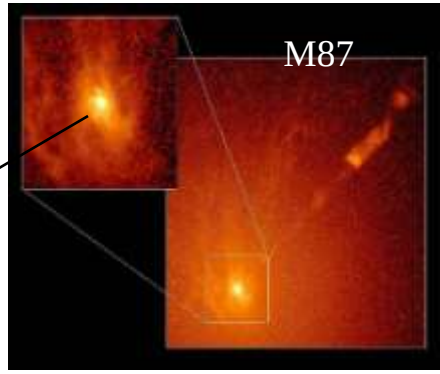
Acceleratori Cosmici: (Hillas Plot)

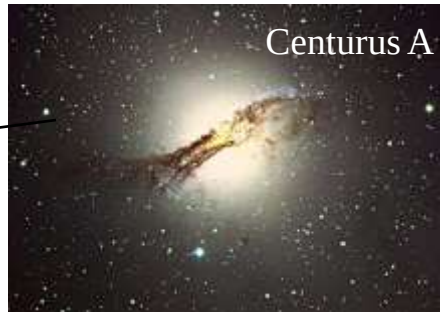


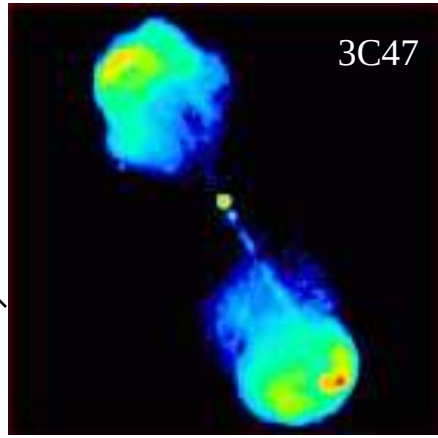




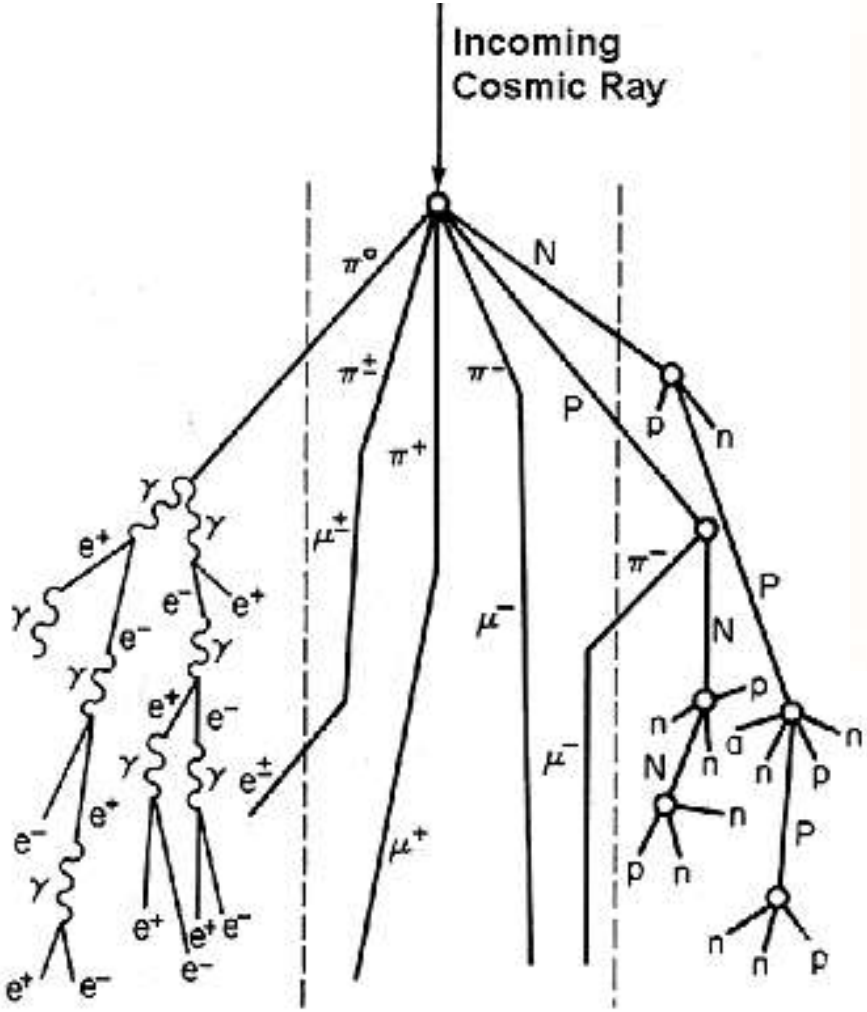


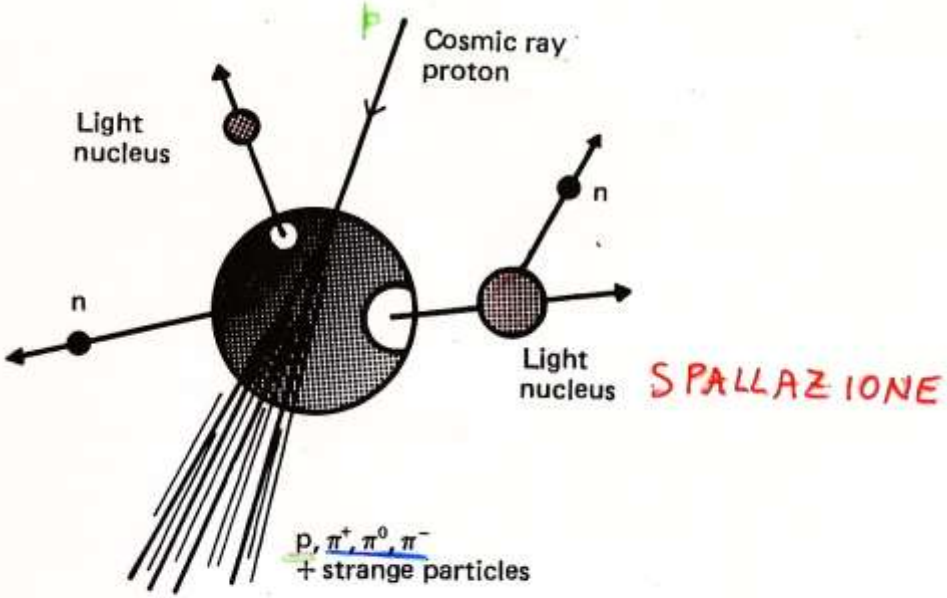


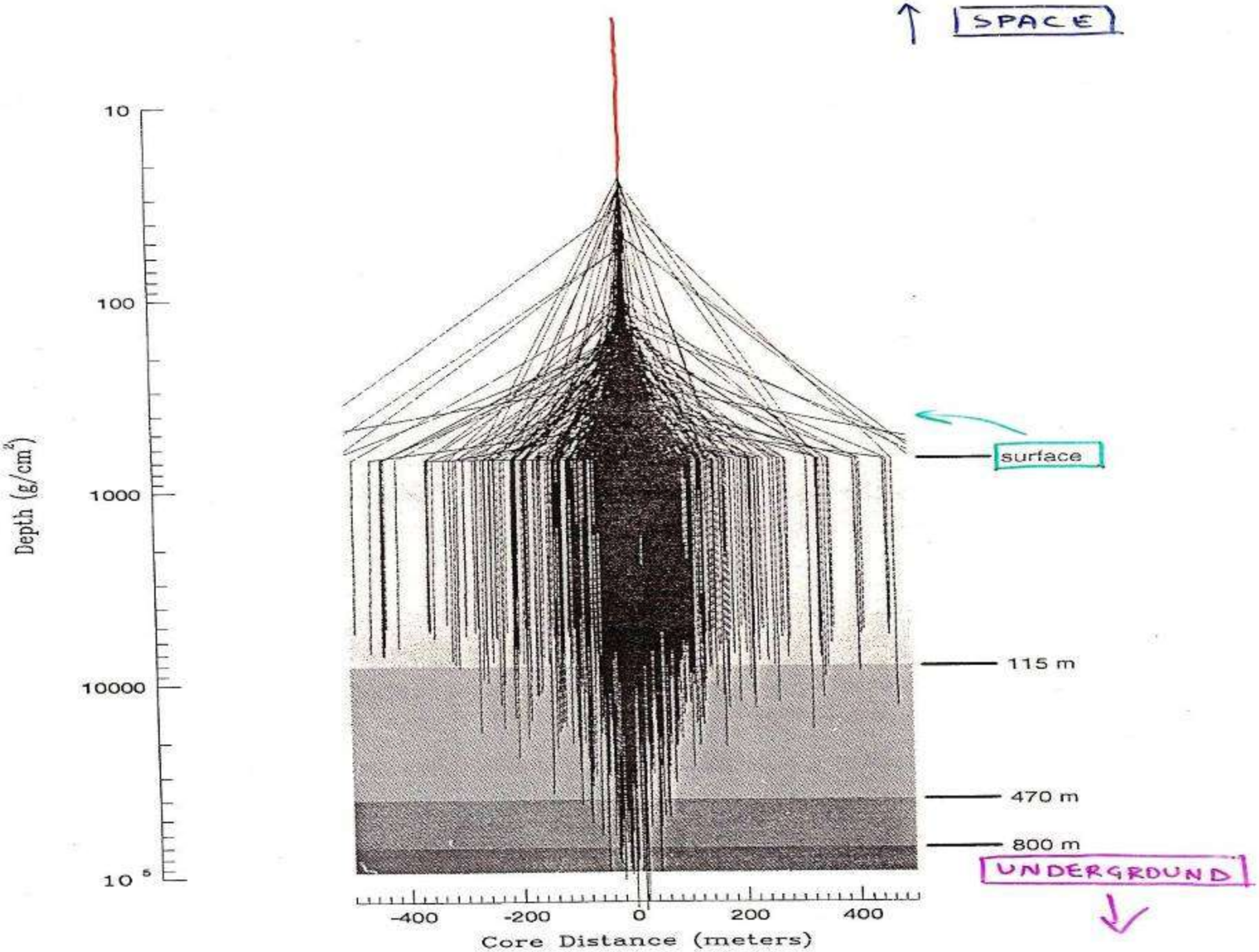




Interazione di Raggi Cosmici primari nell'atmosfera






SPACE
10
100
1000
10000
10 5
Depth (g/cm2)
surface
115 m
470 m
800 m
UNDERGROUND
-400
-200
0
200
400
Core Distance (meters)

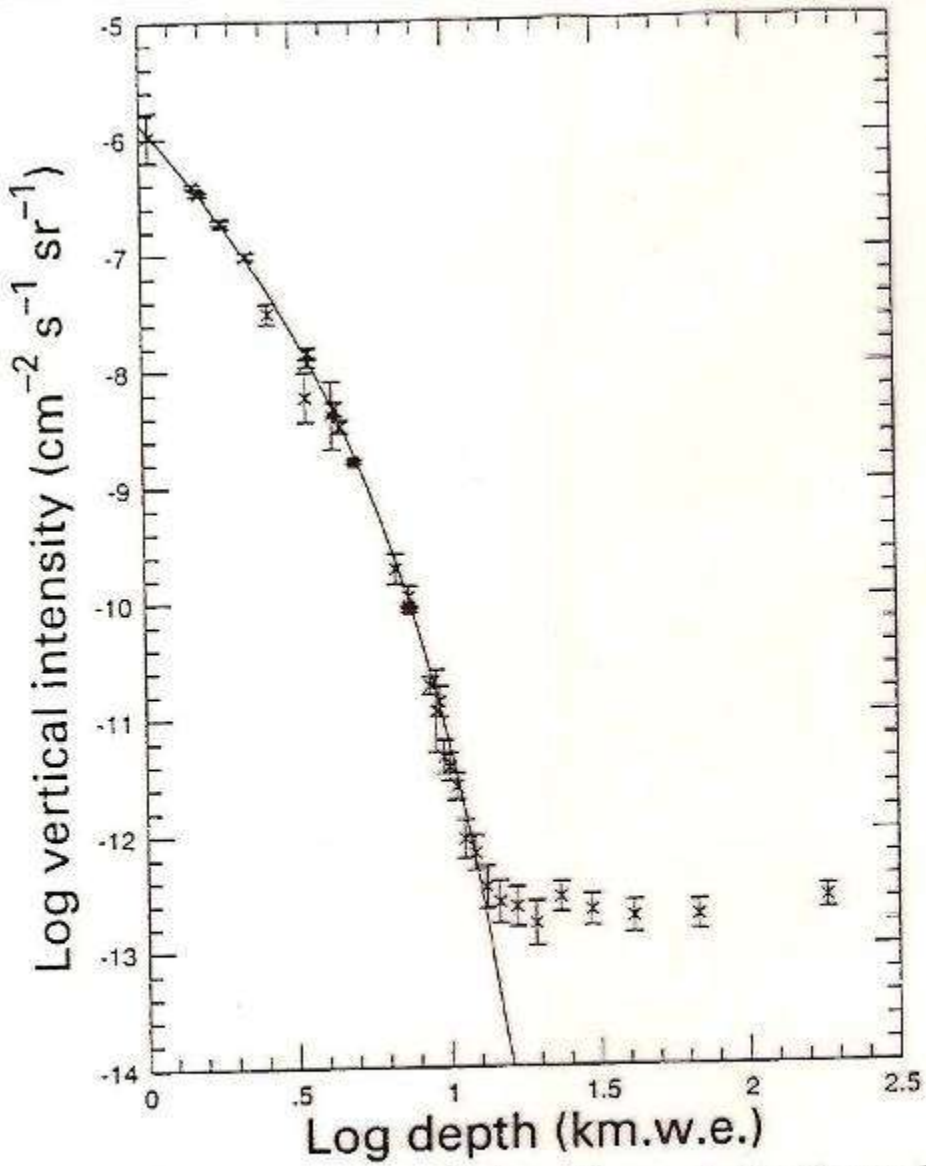
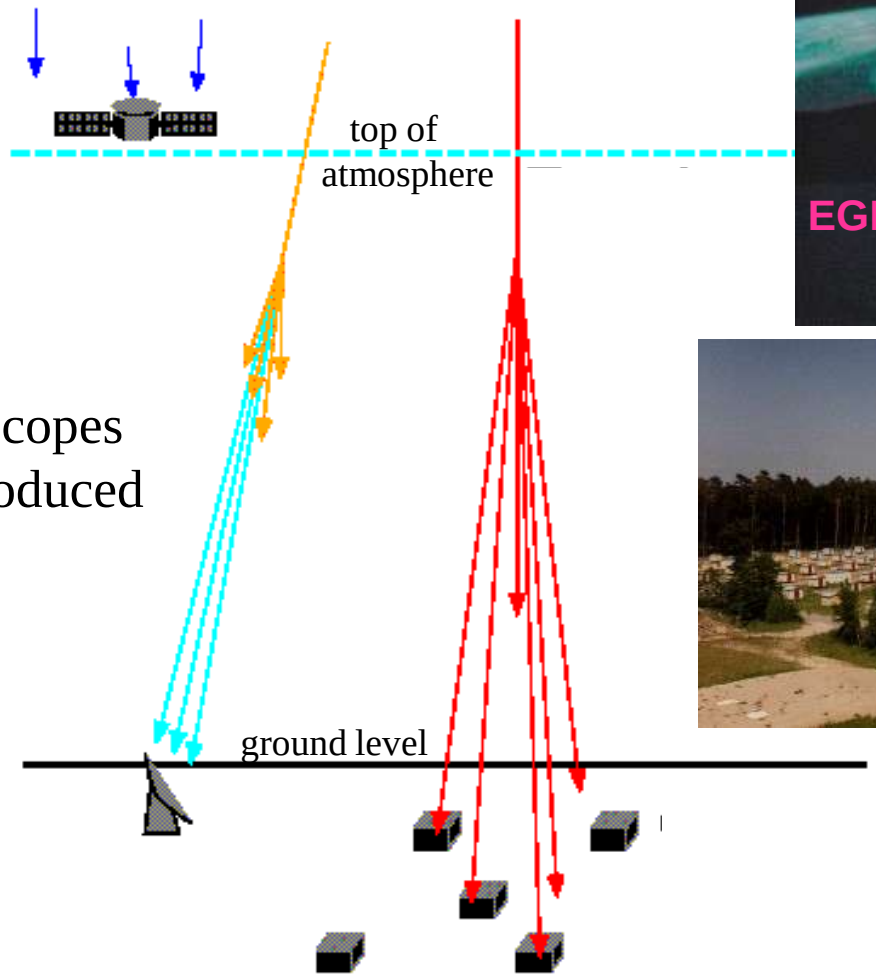


Figure 6.3: Relation between muon intensity and depth underground. The data are taken from a summary by Crouch (1987) with the addition of recent data from the Frejus experiment (Berger et al., 1989 – filled squares).

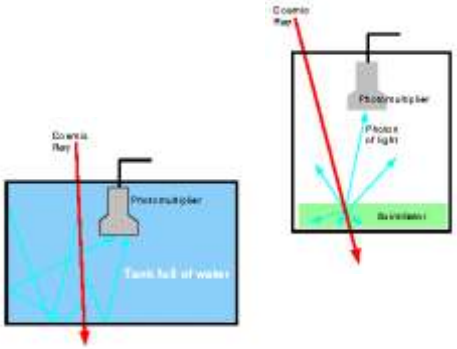
Rivelatori di raggi cosmici

Satellites

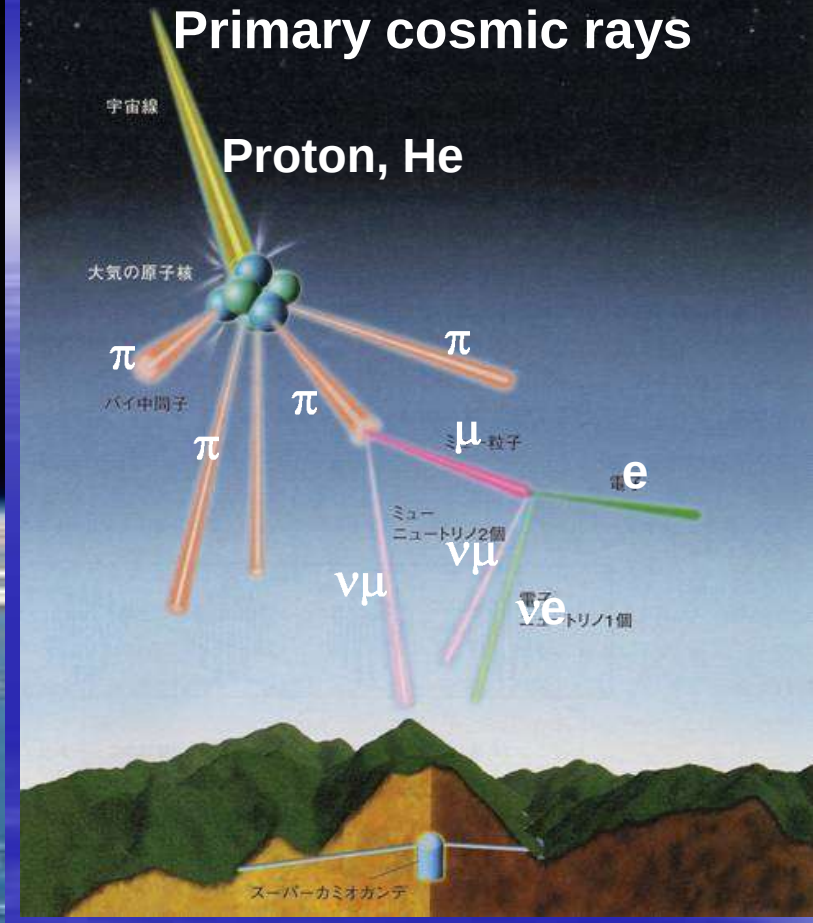


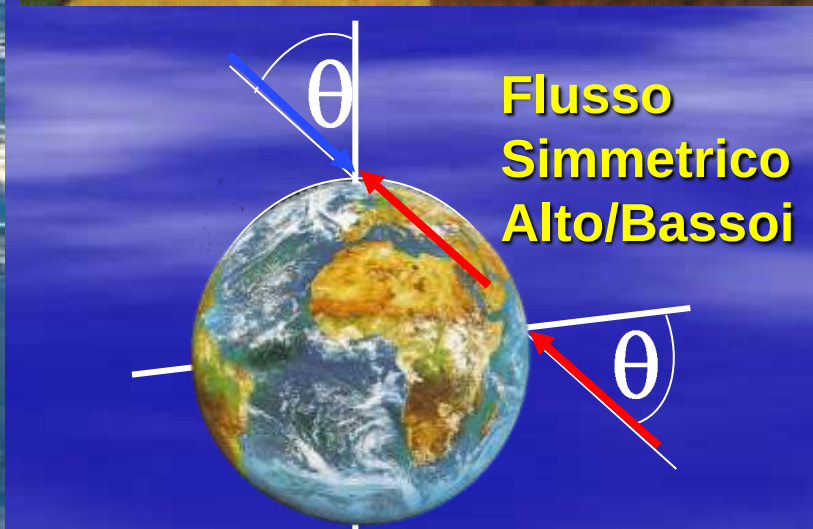
Ground based telescopes
looking at light produced
in atmosphere

Arrays of particle detectors

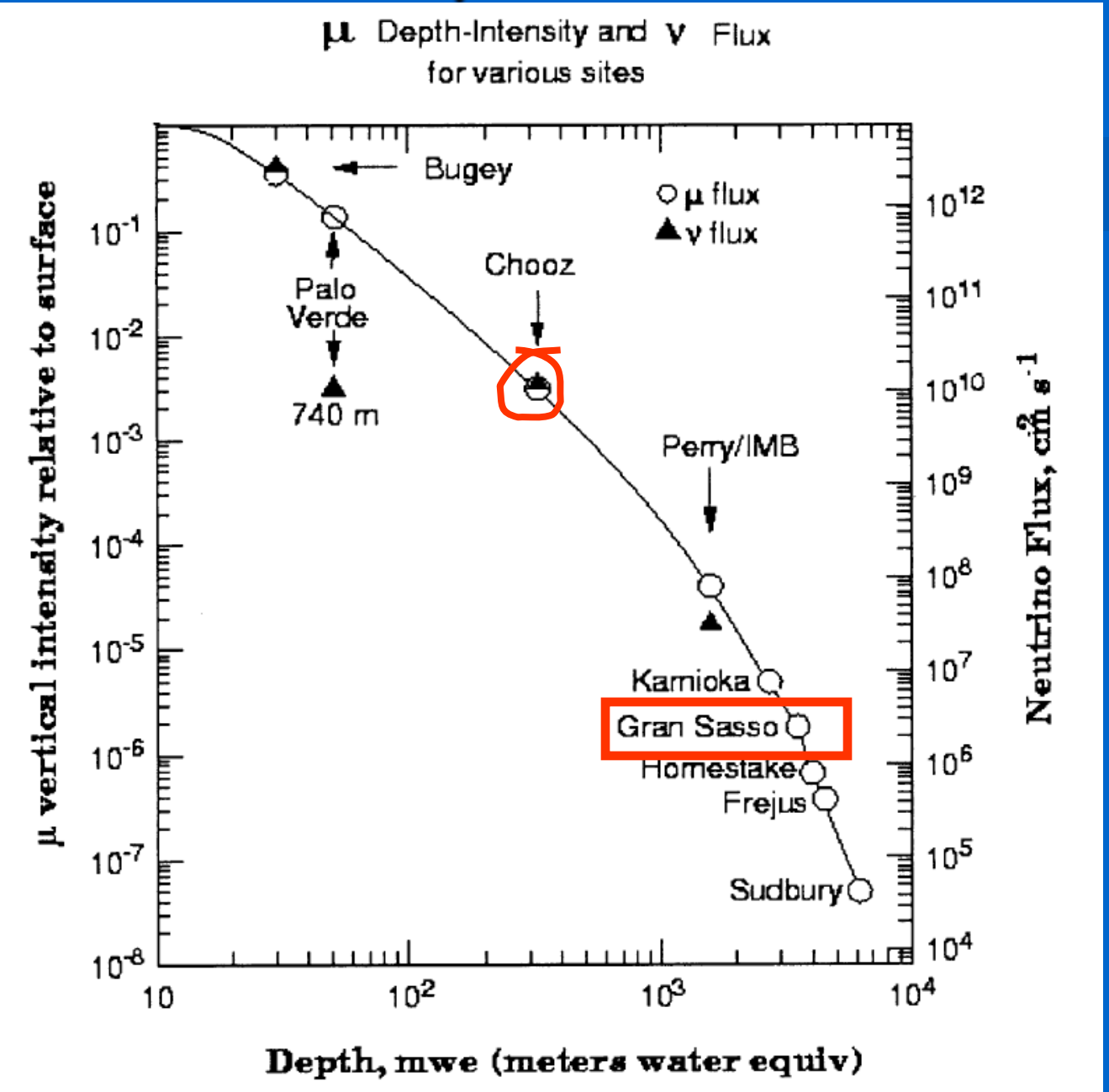


Sorgente Raggi Cosmici: ν Atmosferici

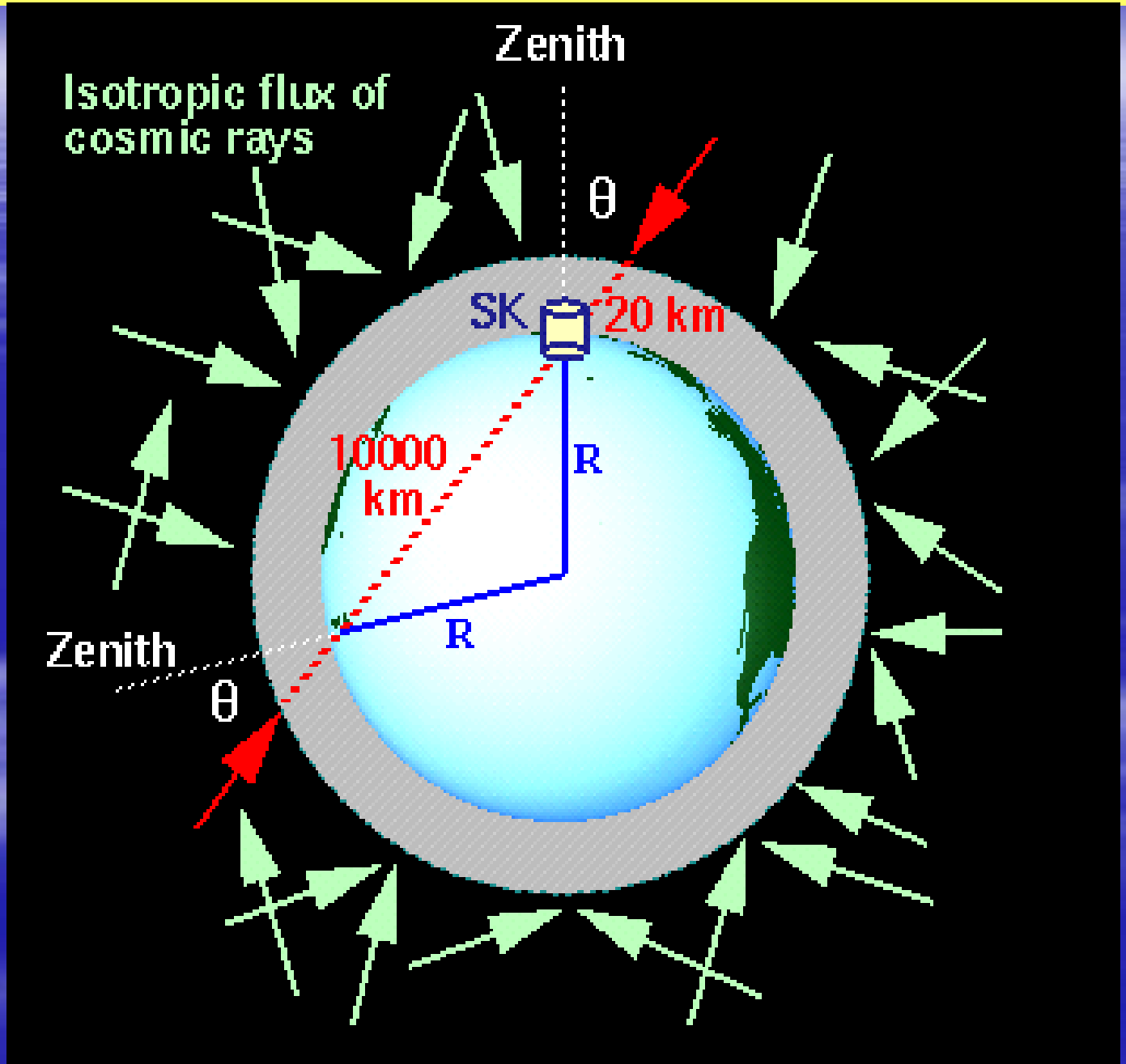




Flusso di μ


μ Depth-Intensity and ν Flux
for various sites
Bugey
μ flux
ν flux
Chooz
Palo
Verde
740 m
Perry/IMB
Kamioka
Gran Sasso
Homestake
Frejus
Sudbury
μ vertical intensity relative to surface
Neutrino Flux, cm^{-2} s^{-1}
Depth, mwe (meters water equiv)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10
10^{2}
10^{3}
10^{4}

Simmetria Alto/Basso

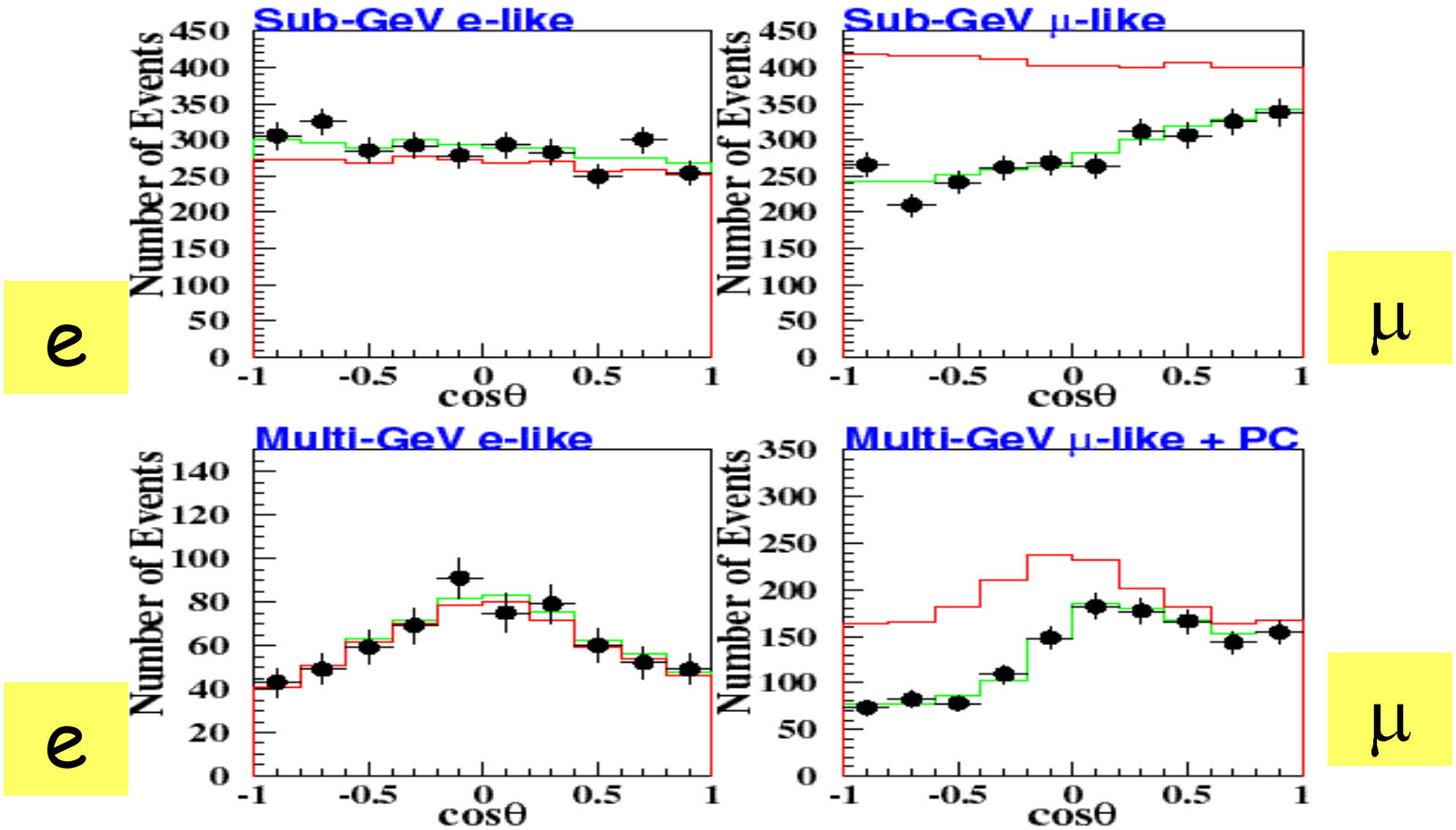


SK: Zenith angle distribution

SK:1289 days (79.3 kt y)

No oscillation

Best fit ($\Delta m^2=2.4\times10^{-3}eV^2$, $\sin^2 2\theta=1.00$)



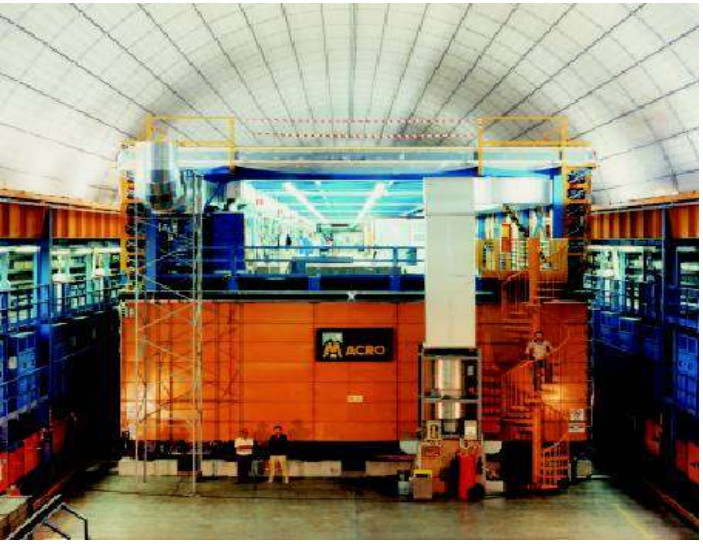
$$\frac{(\mu/e)_{Data}}{(\mu/e)_{MC}} = 0.638 \pm 0.017 \pm 0.050$$

The MACRO experiment

1984 : Proposal

1987 : Construction starts

1989 : First Supermodule ON

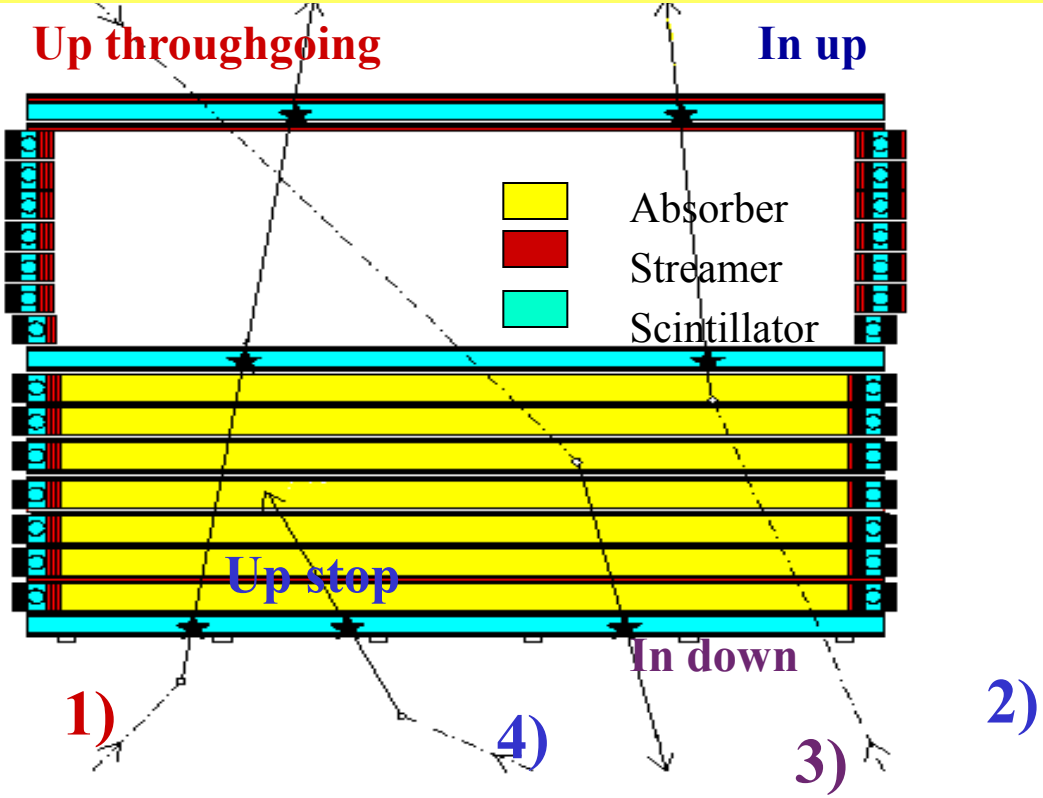


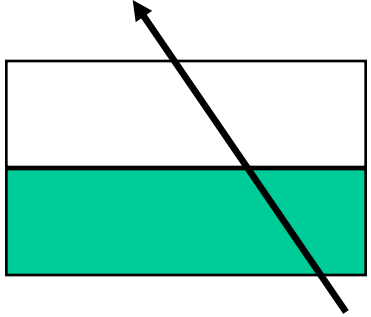
4/1994 : Full detector ON

12/2000 : Rest In Peace

Neutrino event topologies in MACRO

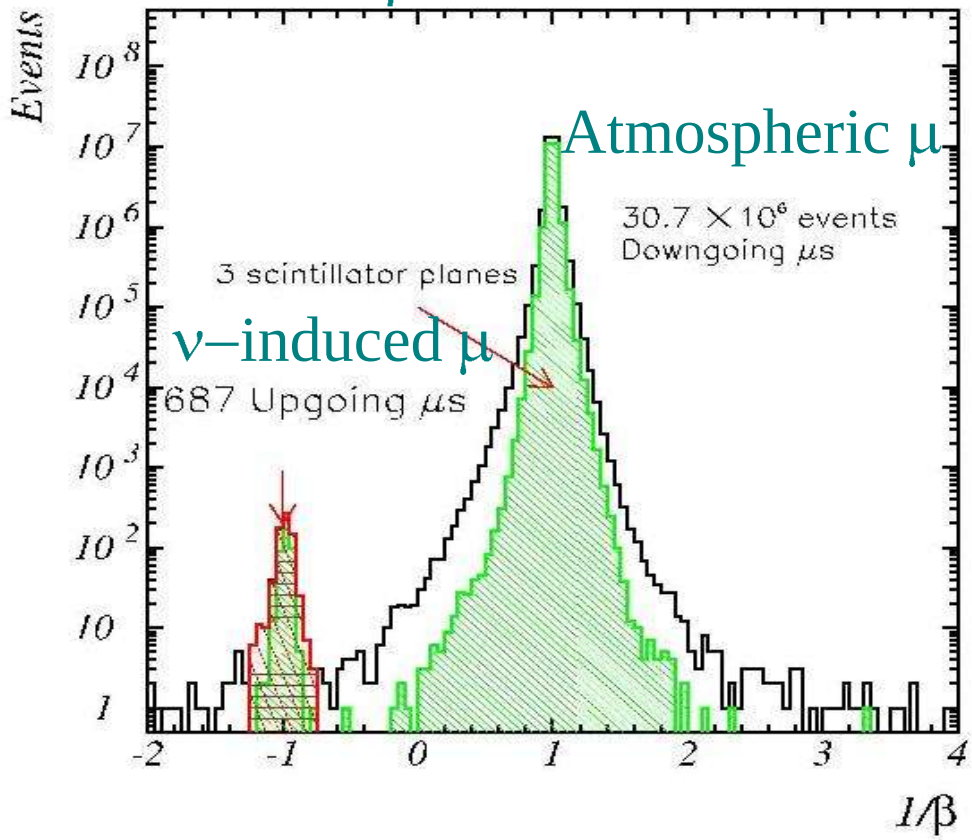
Detector mass ~ 5.3 kton

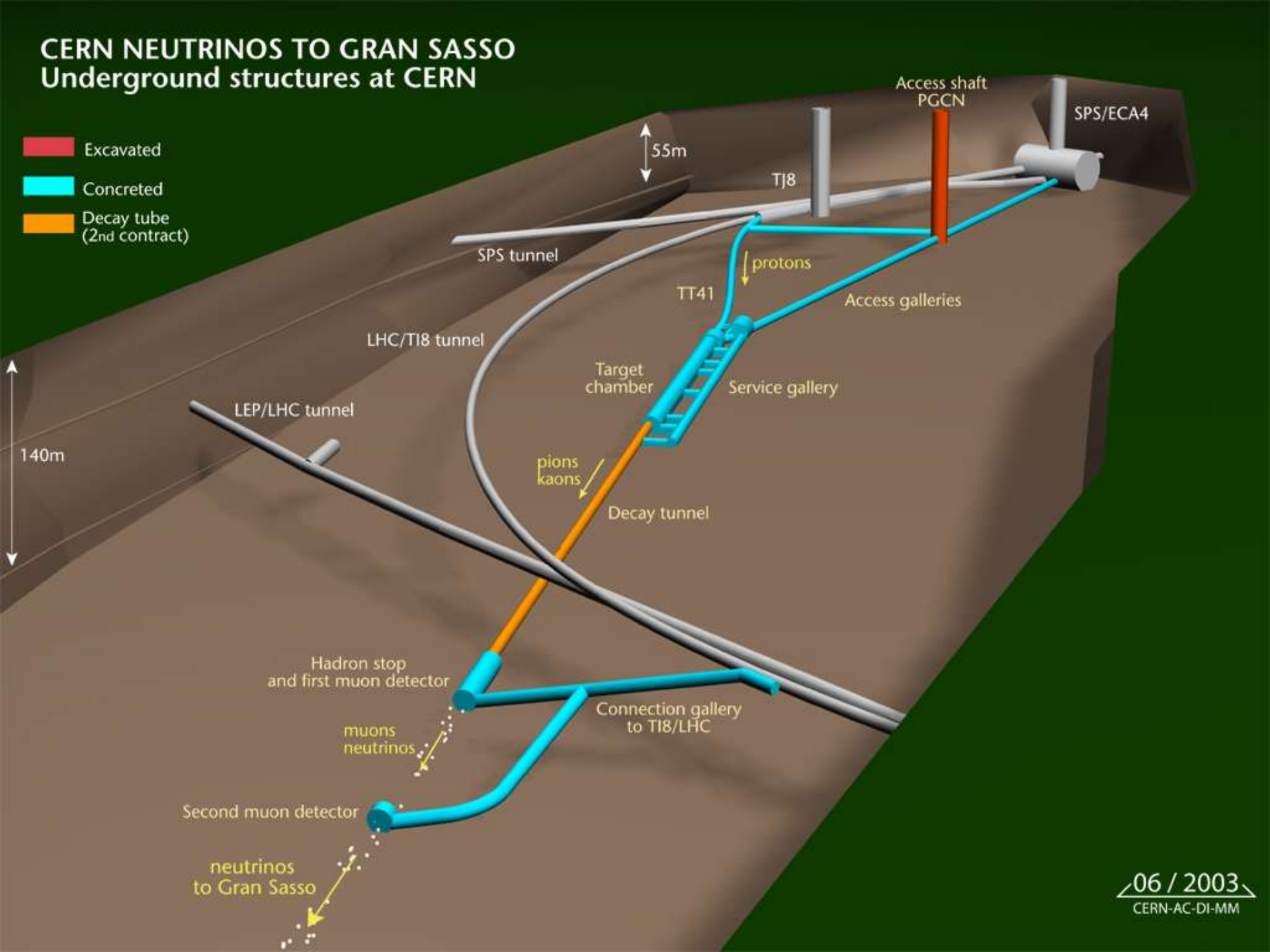




MACRO Upward throughgoing muons

1/β distribution:

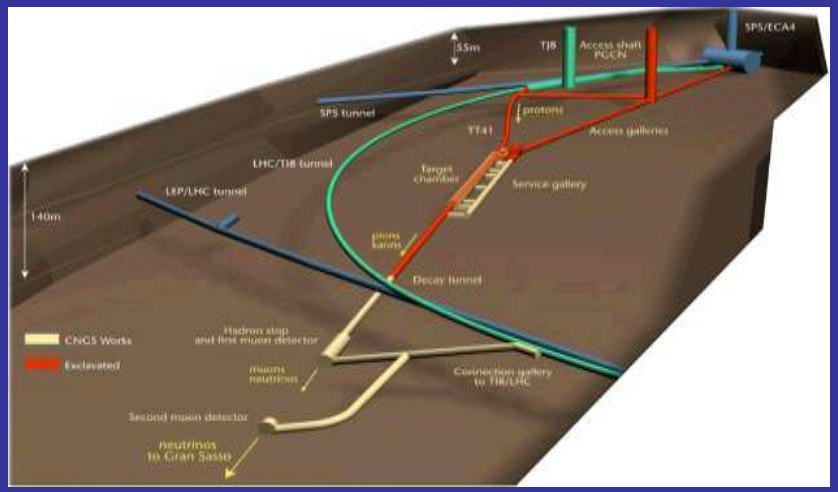



CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
Excavated
Concreted
Decay tube
(2nd contract)
Access shaft
PGCN
SPS/ECA4
55m
TJ8
SPS tunnel
protons
TT41
Access galleries
LHC/TI8 tunnel
Target
chamber
Service gallery
LEP/LHC tunnel
140m
pions
kaons
Decay tunnel
Hadron stop
and first muon detector
Connection gallery
to TI8/LHC
muons
neutrinos
Second muon detector
neutrinos
to Gran Sasso
06 / 2003
CERN-AC-DI-MM

ν beam from CERN:

OPERA

ICARUS



Fundamental physics

VIP

PRESENT EXPERIMENTS

$\beta\beta$ decay and rare events

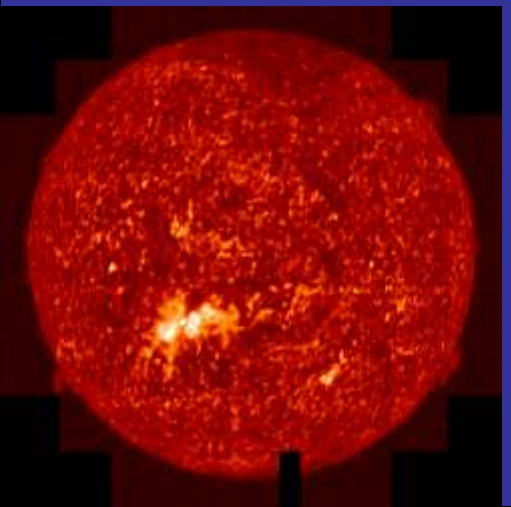
Cuoricino

CUORE; GERDA

Dark Matter

DAMA/LIBRA; CRESST

WARP; Xenon test



Solar ν

Luna

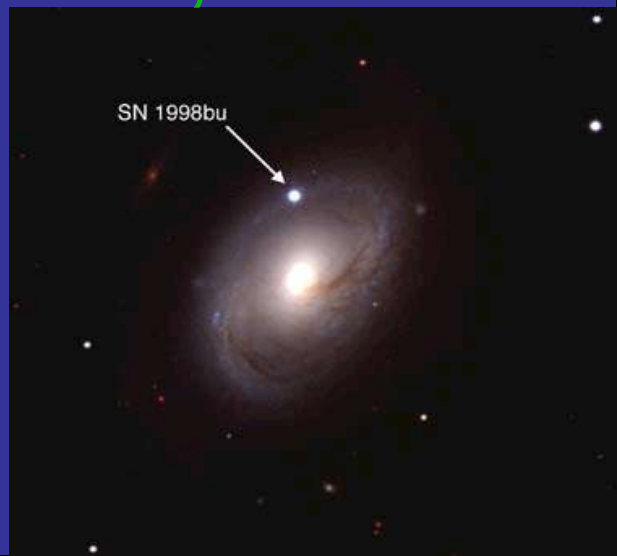
Borexino

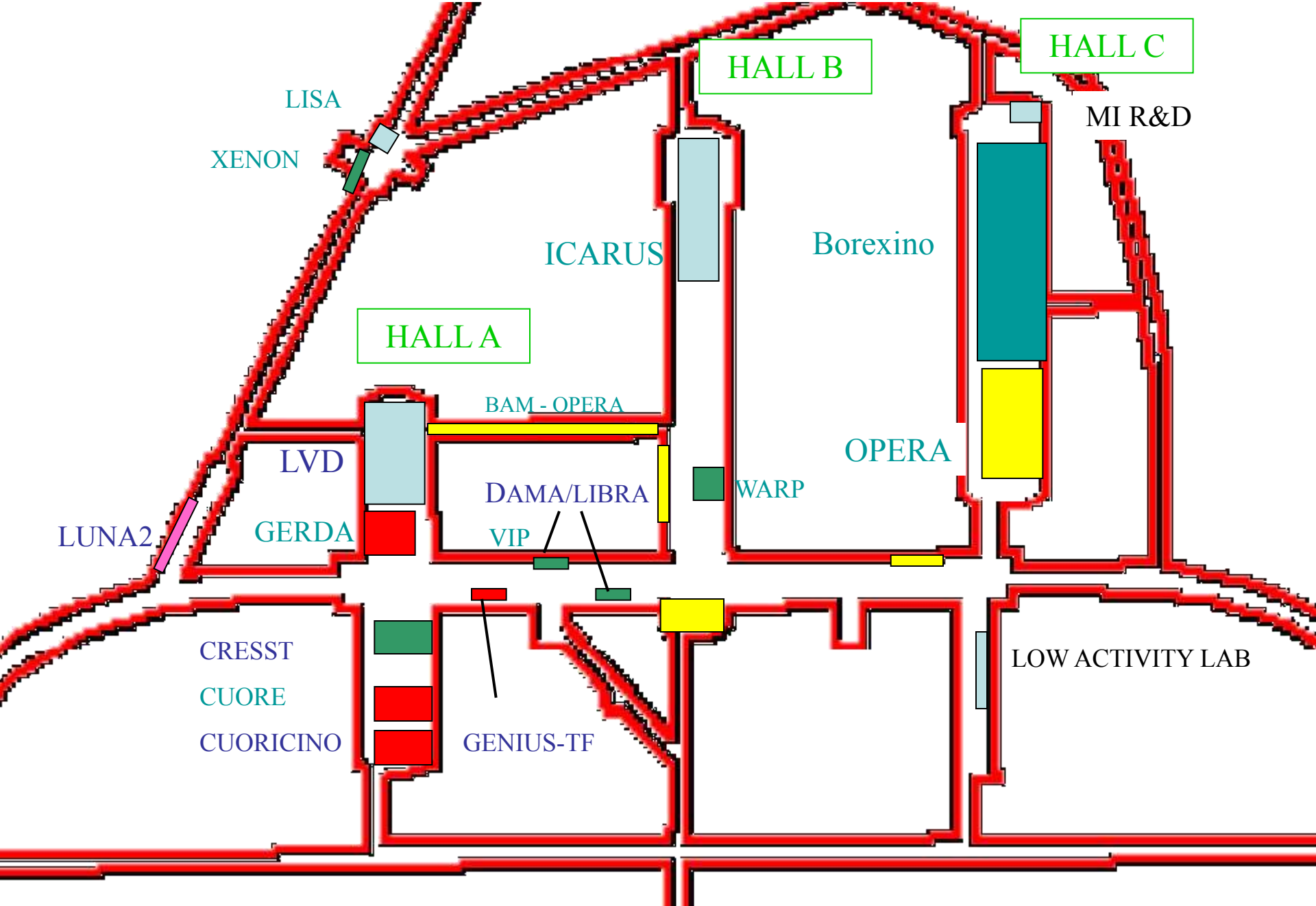
ν from Supernovae

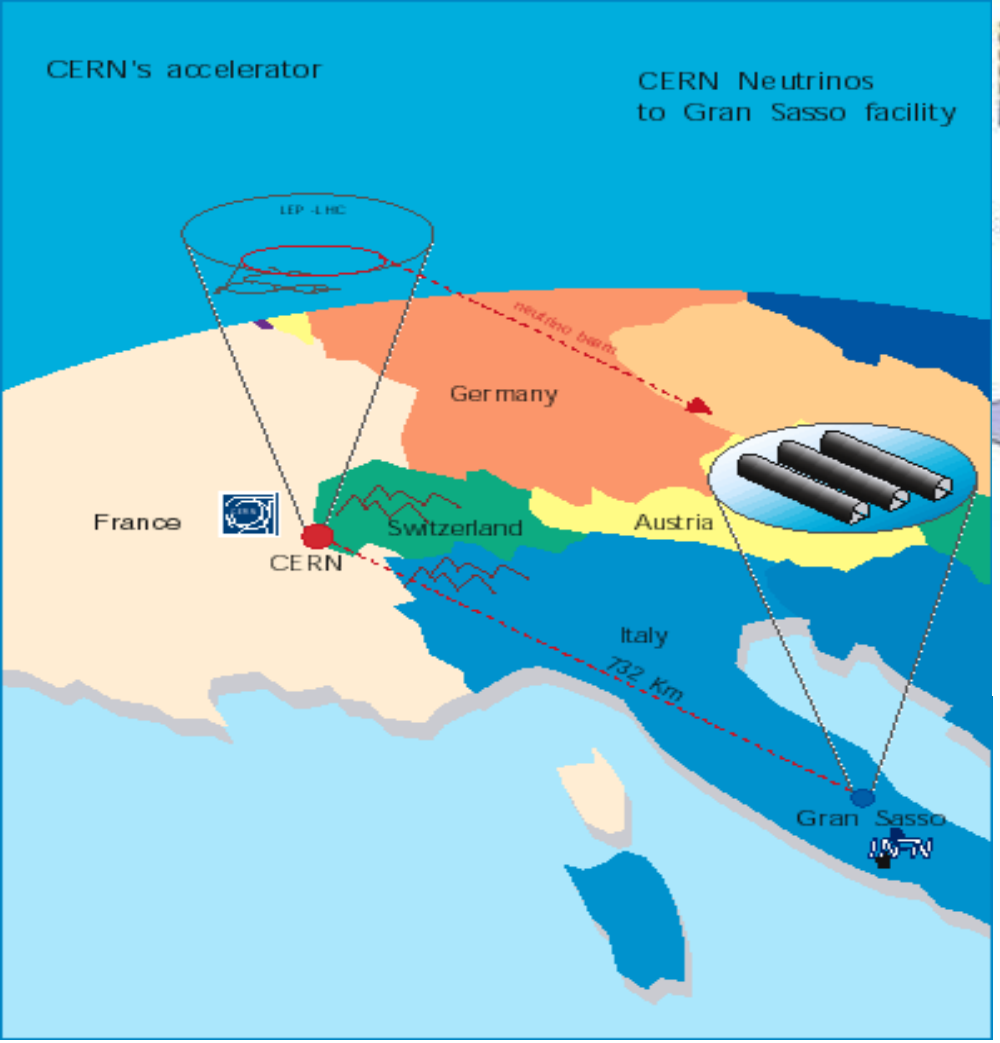
LVD

Borexino

ICARUS




HALL C
HALL B
LISA
XENON
MI R&D
ICARUS
Borexino
HALL A
BAM - OPERA
LVD
OPERA
DAMA/LIBRA
WARP
LUNA2
GERDA
VIP
CRESST
CUORE
CUORICINO
GENIUS-TF
LOW ACTIVITY LAB



OPERA

detector: 1.8 kton of Pb sheets and nuclear emulsions in the form of 230000 emulsion cloud chambers + 2 spectrometers (RPC and scintillating fibers)

goal: detection of ν_τ appearence from the ν_μ beam from CERN

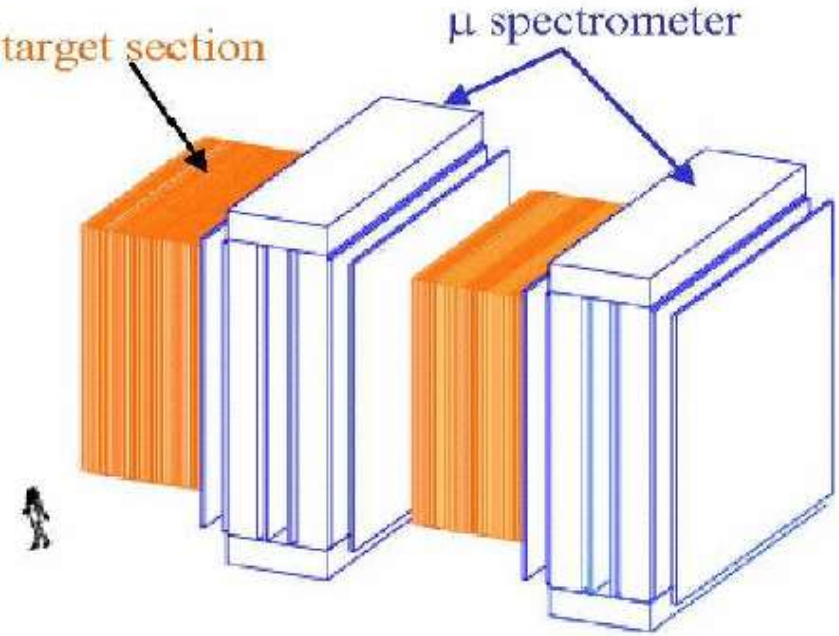
technique: identification of the tracks from decay of the τ emitted by the ν_τ interaction

status: under construction; spectrometers completed

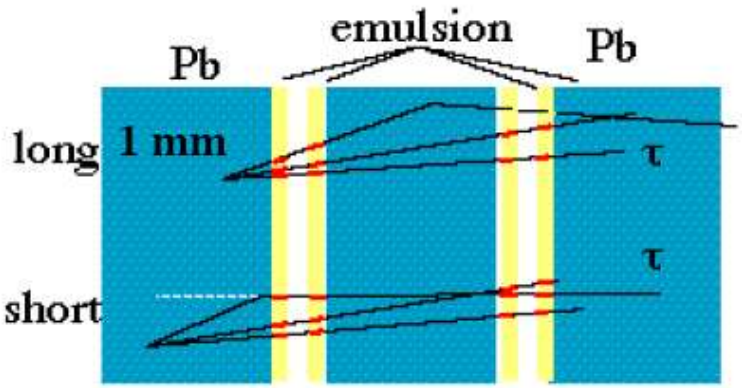
detector should be completed in 2006, ready for the ν beam from CERN

OPERA

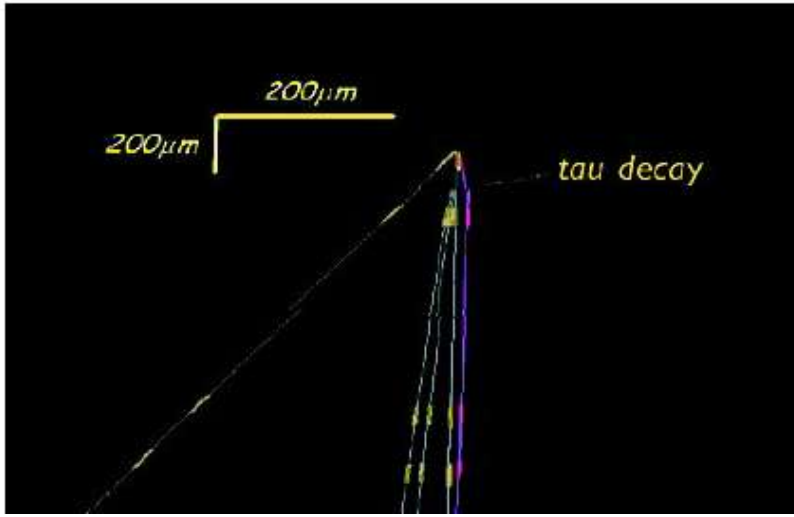
Collab.:
Italy, France, China, Germany, Belgium, Turkey, Switzerland, Russia, Japan, Israel, Croatia

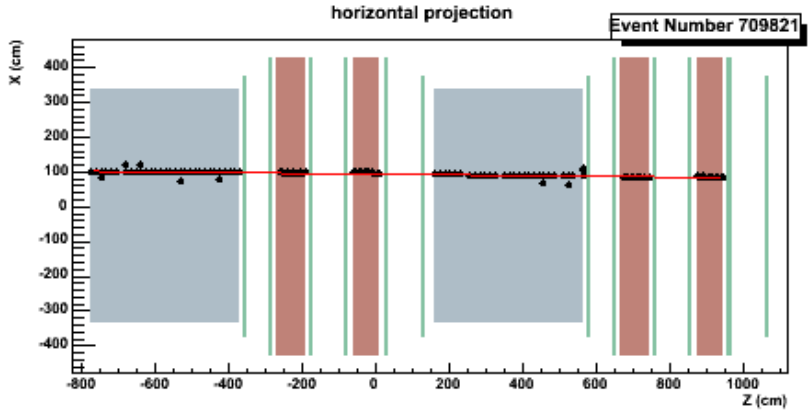


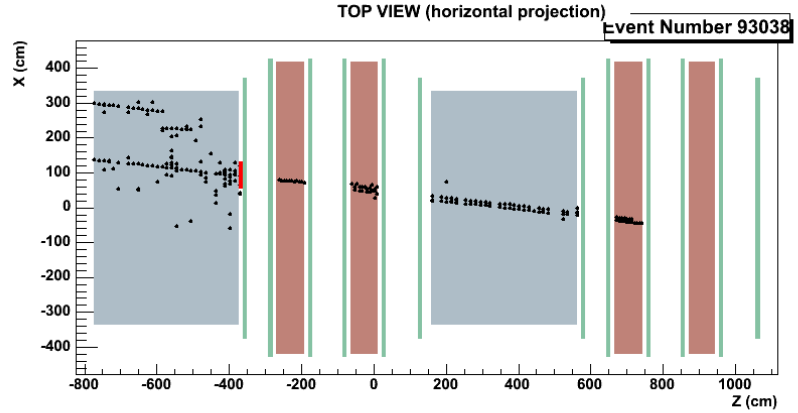
Layers of emulsions and Lead

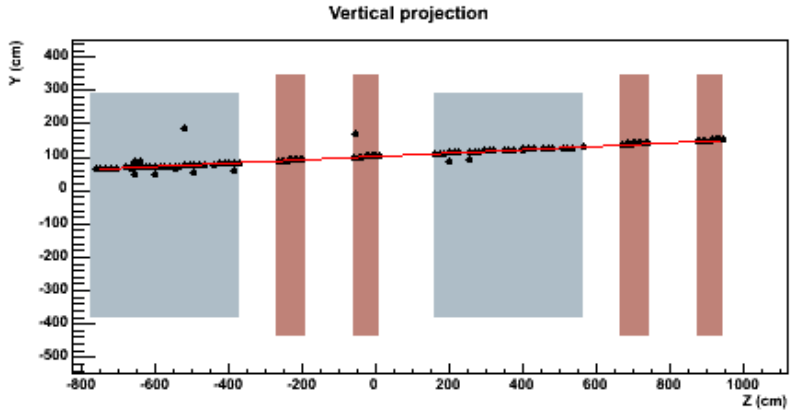


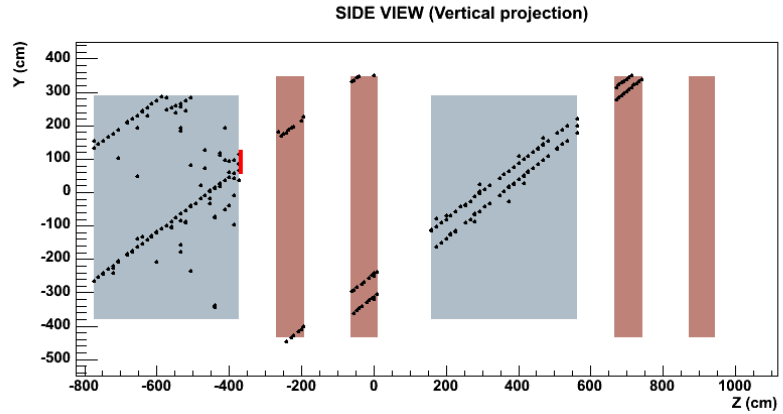
2 super-modules
1800 t sensitive mass
To detect τ is necessary a μm resolution because the τ decays in a really short time

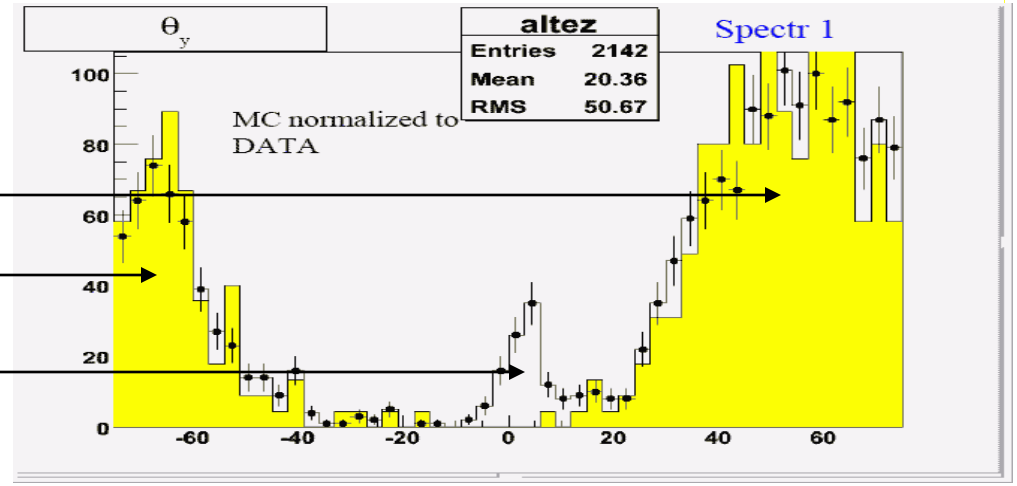










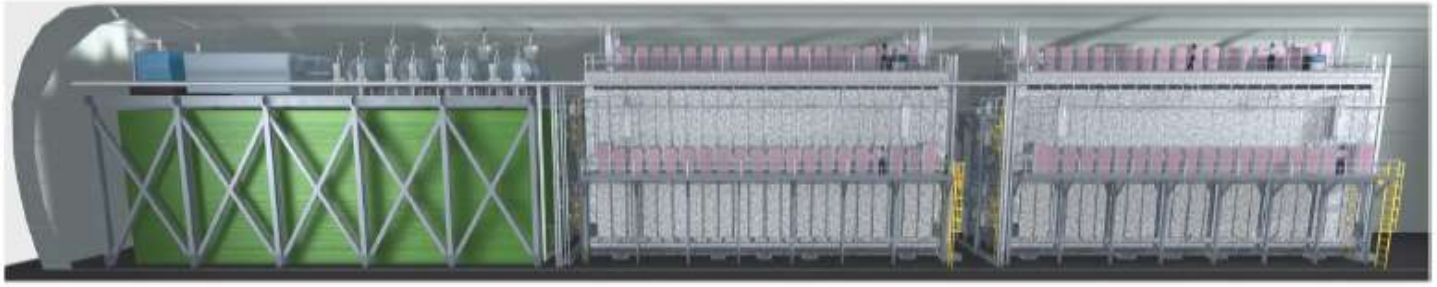


Cosmic rays induced events: Mostly down going

Beam events: ~horizontal tracks

ICARUS Imaging Cosmic and Rare Underground Signals

First Unit T600 | T1200 | T1200

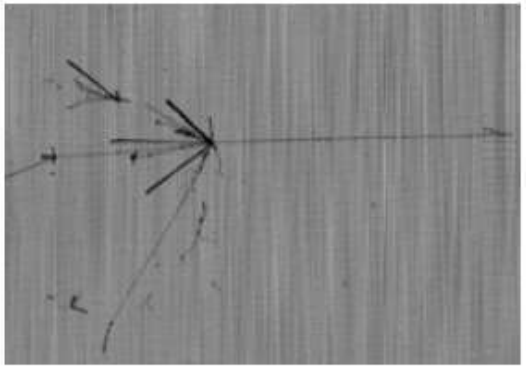


Collaboration:
Italy, Poland, China
Spain, Switzerland, USA

Liquid Argon (-176 °C)

First half of T600 module successfully operated in Pavia
Expect to install T600 in 2004
T3000 detector proposed as a series of five T600 modules

- Wide physics program
  - ν_τ and ν_e appearance on CNGS
  - atmospheric neutrinos
  - supernova neutrinos
  - solar neutrinos
  - proton decay



17 m

ICARUS

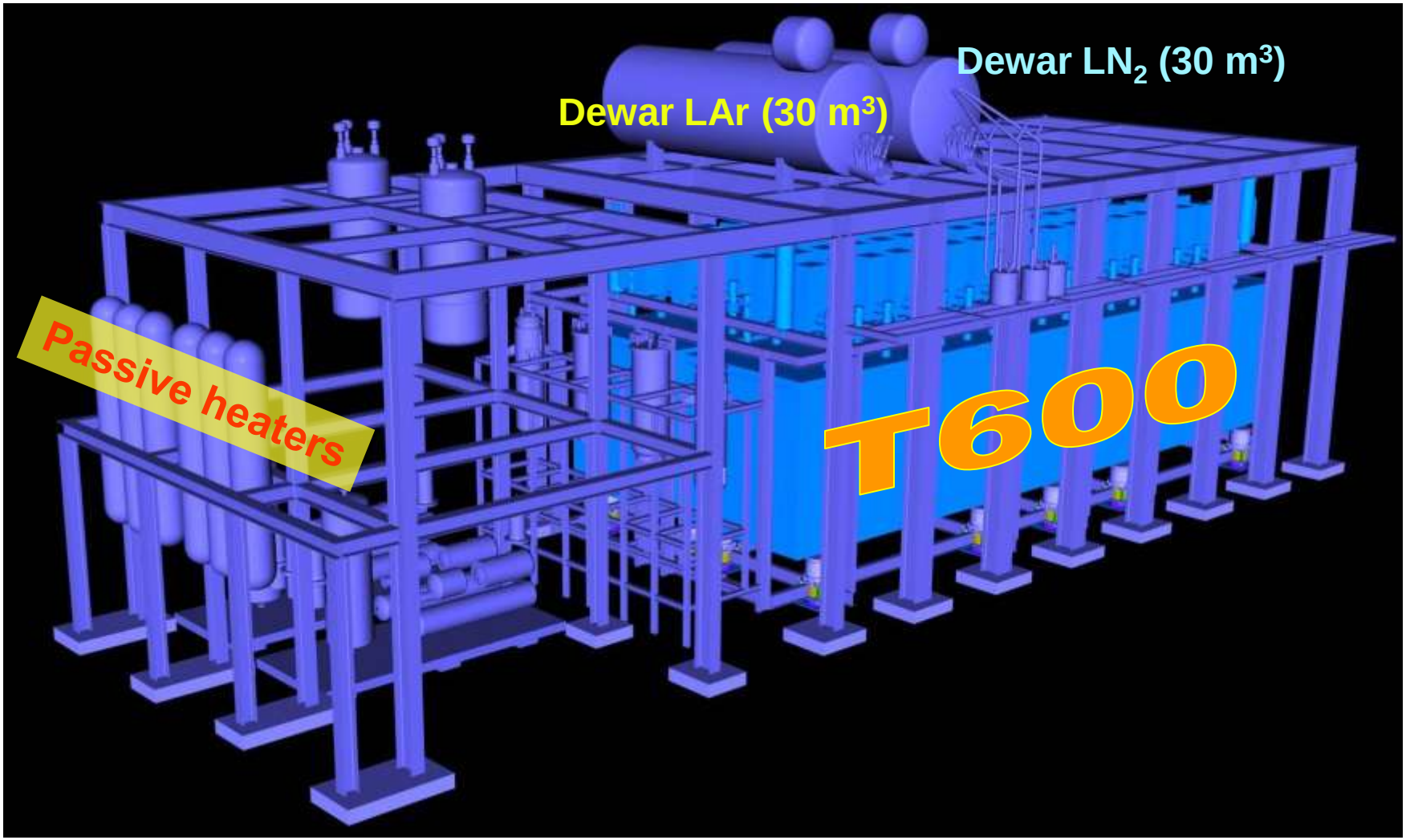
detector: 600 t and later 3000 tons of liquid Ar operated as a large time projection chamber

goal: detection of ν_τ appearence from the ν_μ beam from CERN
detection of solar neutrinos

technique: kinematic identification of the decay of the τ emitted by the ν_τ interaction

status: 600 t detector tested and ready to be installed at LNGS
Installation of 3000 t requires major works at the underground infrastructure

ICARUS T600 General layout



Installation in progress in Gran Sasso Hall B, commissioning after summer 2007

LUNA Laboratory for Underground Nuclear Astrophysics

udy of the cross section of nuclear reactions at stellar ergies

particular for pp chain

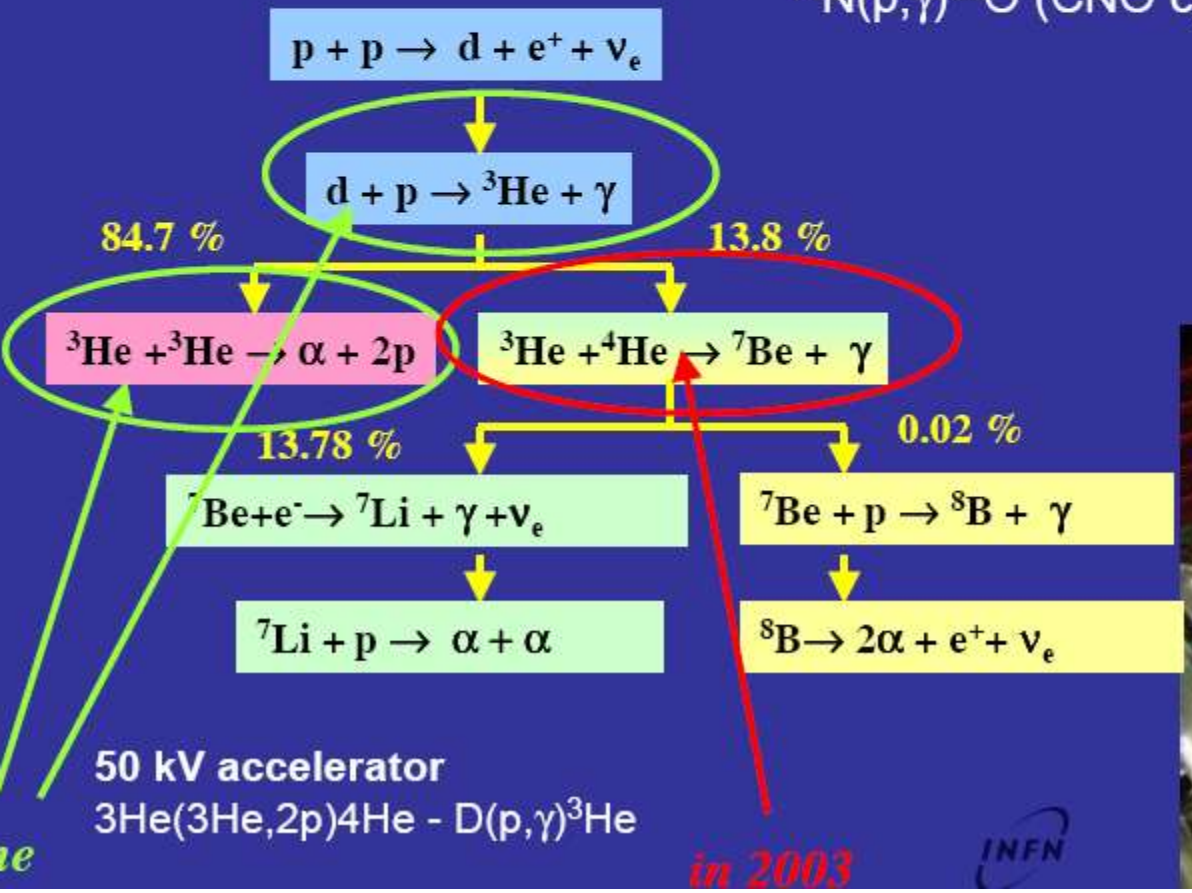
pp chain

2 accelerators: 50kV - 400kV

400 kV accelerator

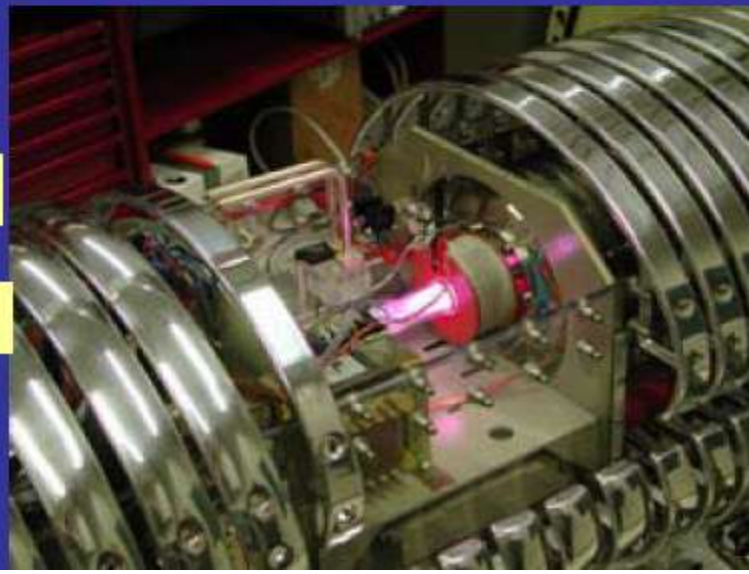
$^{14}N(p,\gamma)^{16}O$ (CNO cycle)

Collab.:
Italy, Germany, Hungary
USA, Portugal



50 kV accelerator
$^3He(^3He,2p)^4He$ - $D(p,\gamma)^3He$

in 2003



LVD Large Volume Detector

Collab.:
Italy, Brazil, Russia, USA, Japan

Running since 1992

1000 billions ν in 20s from the SN core

Measurement of neutrinos spectra and time evolution provides important information on ν physics and on SN evolution.

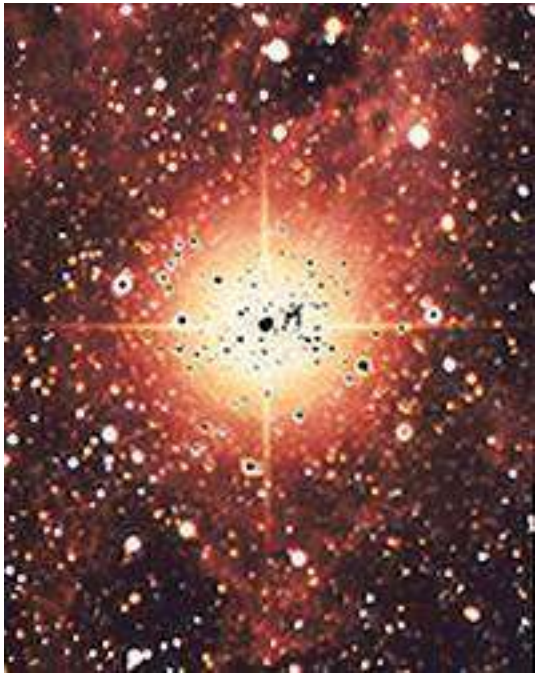
Neutrino signal detectable from SN in our Galaxy or Magellanic Clouds

2 - 5 SN/century expected in our Galaxy.

Plan for multidecennial observations

1000 tons liquid scintillator + layers of streamer tubes

300 ν from a SN in the center of Galaxy (8.5 kpc)



SN1987A

Early warning of neutrino burst important for astronomical observations with different messengers (photons, gravitational waves)

<u>SNEWS = Supernova Early Warning System</u>

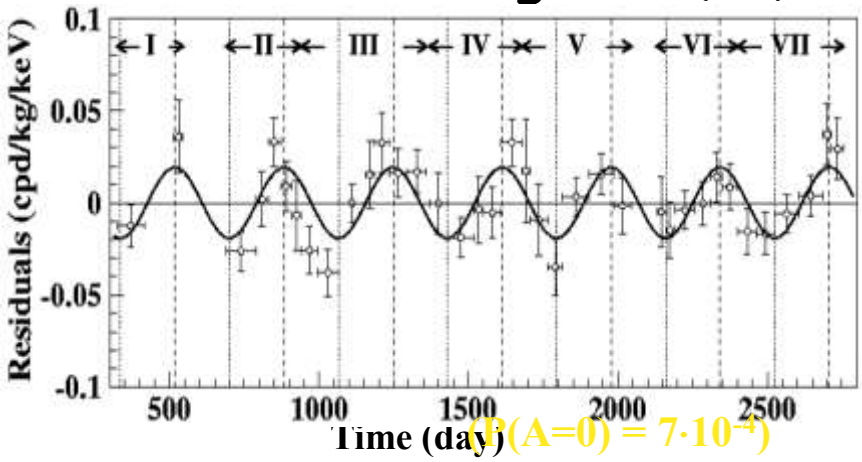
LVD, SNO, SuperK

in future: Kamland, BOREXINO

INFN

Dark matter search: DAMA

~100 kg NaI(Tl) high purity- ended 7/02



($P(A=0) = 7\cdot10^{-4}$)

Annual modulation==> evidence for WIMPS

Final analysis: total **107731 kg·d**

(Riv. N. Cim. 26 n. 1 (2003) 1-73)

fitted (all parameters free):
$A = (0.0200 \pm 0.0032)$ cpd/kg/keV ;
$t_0 = (140 \pm 22)$ d ; $T = (1.00 \pm 0.01)$ y

6σ

... ora DAMA/LIBRA

(Large sodium Iodide Bulk for RAre processes)

New apparatus - installed 2002 - 2003
~250 kg more radiopure NaI(Tl)

it will offer unique radiopurity, increased mass and deep control of the running parameters

NEW R&D for ultimate NaI(Tl) radiopurification started towards a possible 1 ton set-up DAMA proposed since 1996

DAMA

Dark Matter Search

Collab.:
Italy, China, Ukraine

Detection of WIMPs (Weakly Interacting Massive Particle) through the flash of light produced by a Iodine nucleus recoiling after having been hit by the WIMP.

DAMA looking for annual modulation with 100 kg NaI(Tl)

DAMA/NaI-1 to -7

107731 kg · d

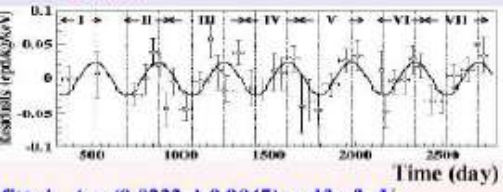
Annual modulation of the rate: the model independent result

Residuals of the rate vs time and energy

Riv. N. Cim. 26 n.1. (2003) 1-73

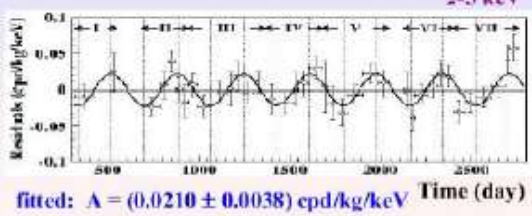
$A\cos[\omega(t-t_0)]$; continuous lines: t_0 = 152.5 d, T = 1.00 y

2-4 keV



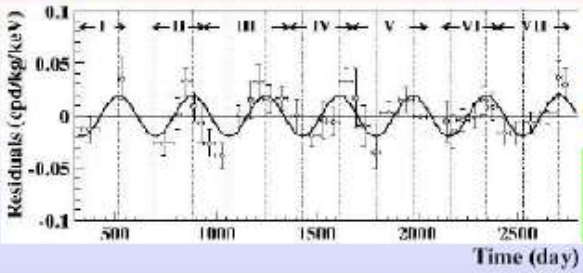
fitted: A = (0.0233 ± 0.0047) cpd/kg/keV

2-5 keV



fitted: A = (0.0210 ± 0.0038) cpd/kg/keV

2-6 keV



$P(A=0)=7\cdot10^{-4}$

$\chi^2/dof=71/37$

fitted: A = (0.0192 ± 0.0031) cpd/kg/keV

fitted (all parameters free):
A = (0.0200 ± 0.0032) cpd/kg/keV ;
t_0 = (140 ± 22) d ; T = (1.00 ± 0.01) y

The data favor the presence of a modulated behavior with proper features at 6.3σ C.L.

Present:

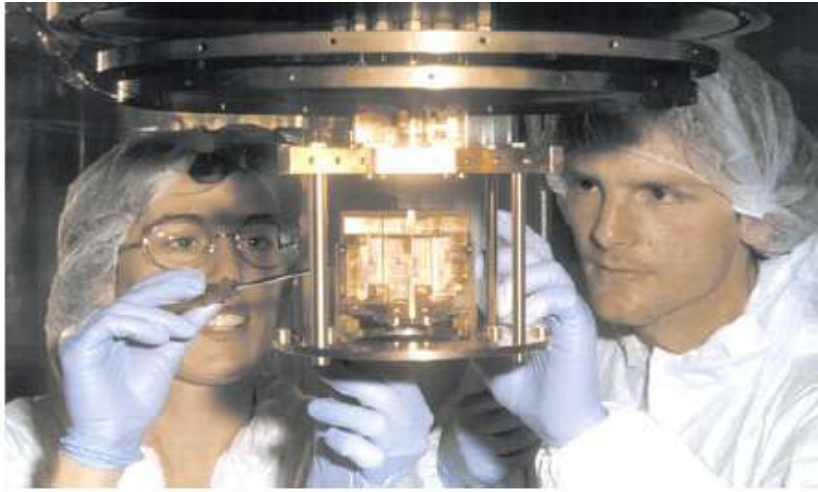
LIBRA

250 kg NaI(Tl)

Collab.:
Italy, Germany, UK

CRESST

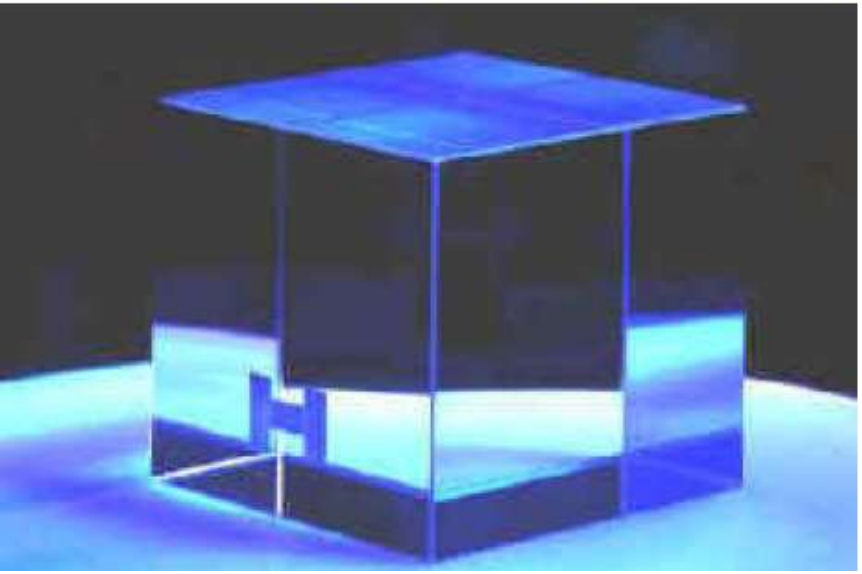
(Cryogenic Rare Events Search with Superconducting Thermometers)



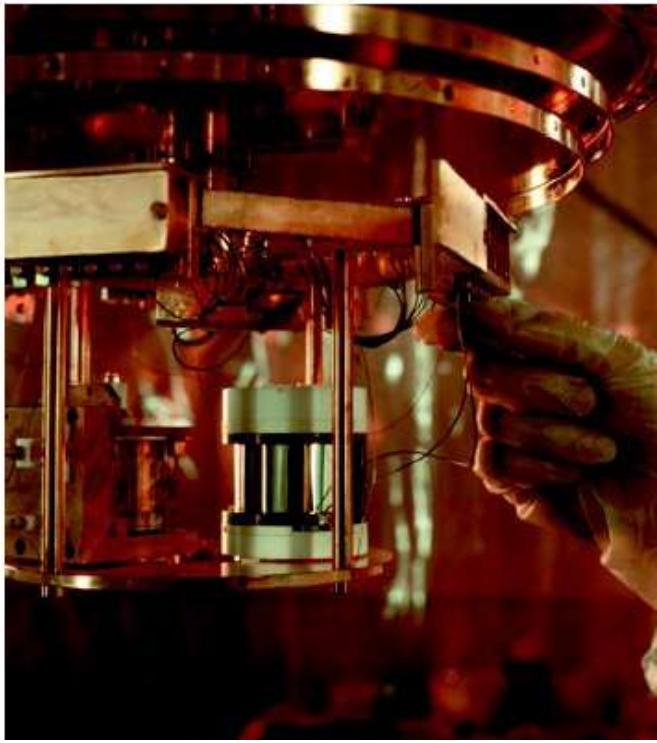
4 sapphire crystals= 1 kg

WIMPs search with cryogenic technique (running at 15 mK)

Looking for a very tiny temperature increase in the detector due to the energy deposited by nuclei hit by the WIMPs



Run until 2005



ββ decay neutrinoless experiments

β decay n --> p + e- + $\bar{\nu}$

2β0ν is a very rare decay: T(half life) ≥ 10^{-25} years)

$\nu = \bar{\nu}$

→Upper limit on the mass of ν_e 0,39 eV

Majorana neutrino

Heidelberg-Moscow
11 kg of enriched ^{76}Ge detect.
The most sensitive experiment in the world
$^{76}Ge \rightarrow {}^{76}Se + 2e^-$

Collab.:
Germany, Russia

GENIUS-TF
Test facility for GENIUS
40 kg HM Ge

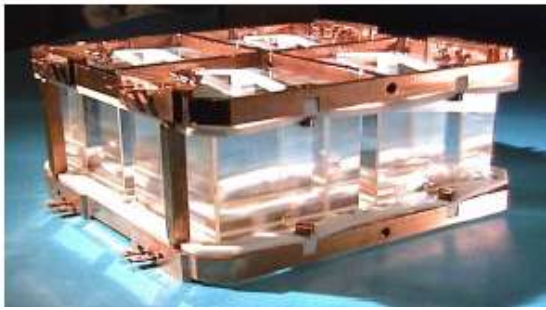
GENIUS (project)
Sensitive mass: 1 ton enriched Ge crystals in Liquid N_2
Status. Experimental tests requested (GENIUS-TF)

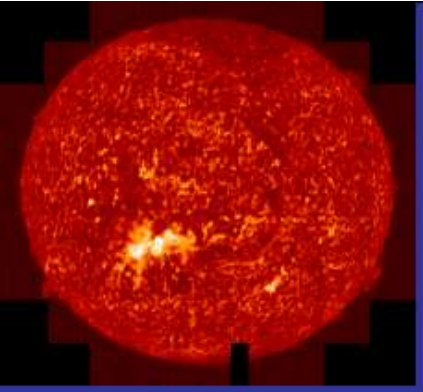
MIBETA (Milan)
20 detectors of natural TeO_2 crystals
^{130}Te mass = 2.3 kg

CUORICINO
Sensitive ^{130}Te mass = 40 kg
Status: running

CUORE
proposal presented in 2003
^{130}Te mass = 250 kg

Collab.:
Italy, Netherland, Spain, USA

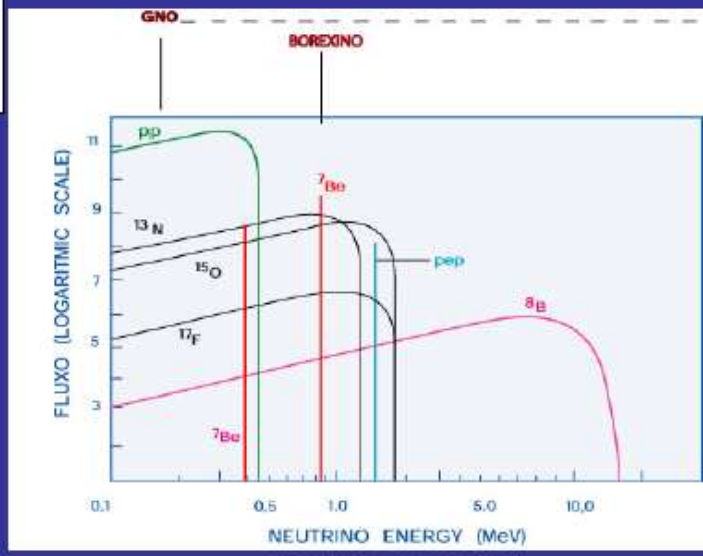




GNO

Collab.:
Italy, France, Germany

Goals: measurement of the interaction rate with an accuracy of 4-5% and monitoring the neutrino flux over a complete solar cycle.



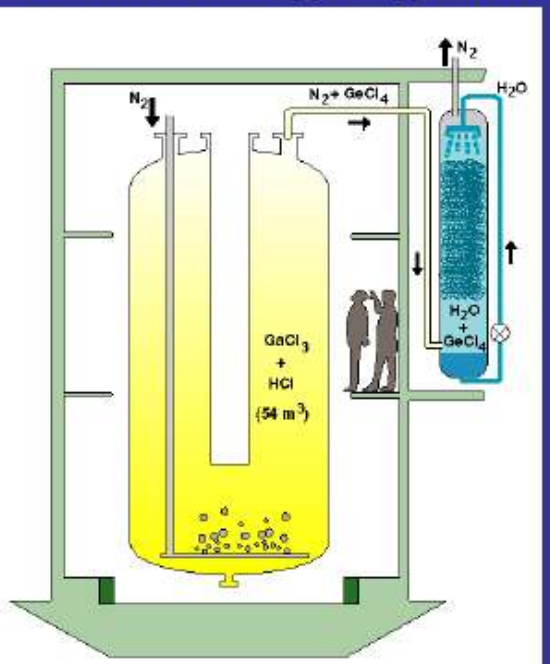
101 tons Gallium Cloride solution

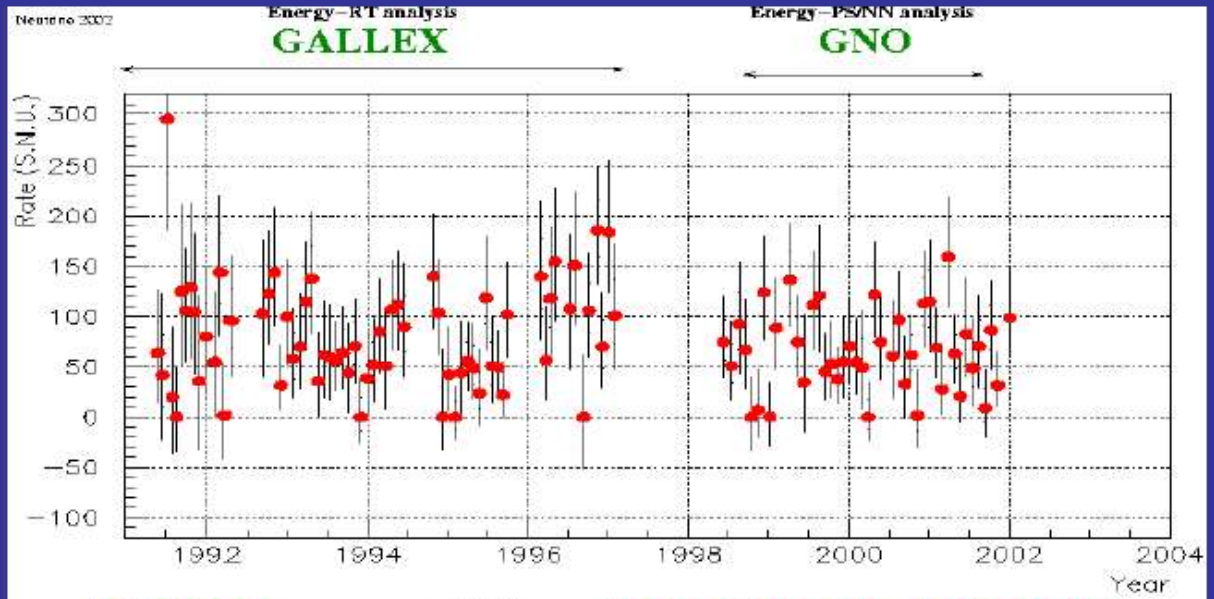
$^{71}Ge(\nu_e,e)^{71}Ge$

Energy threshold > 233 keV

Sensitive mainly to pp -neutrinos

SSM ⟹ 115 -135 SNU



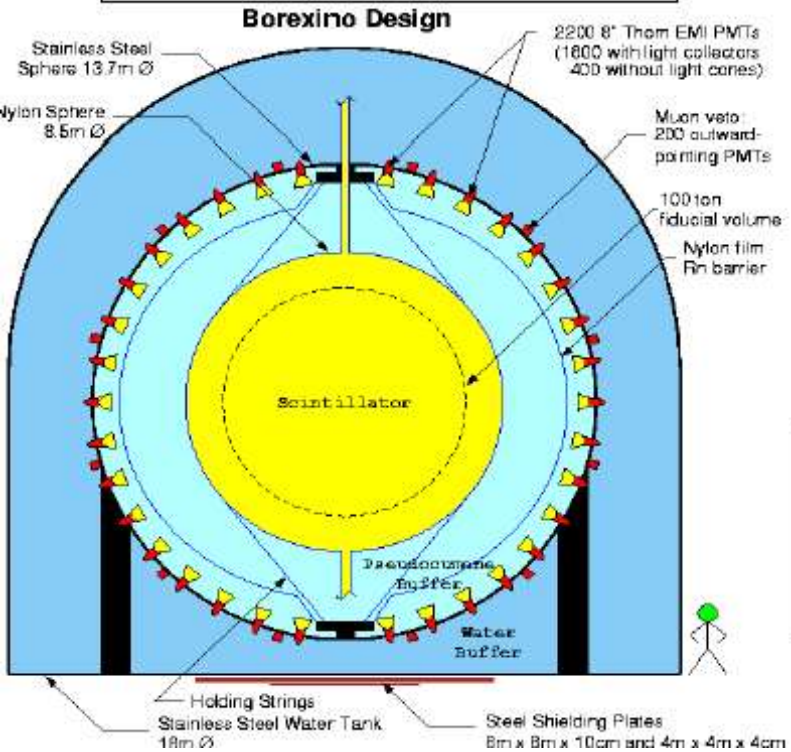


GALLEX	65 SR	77.5 +– 6.2 (stat) +– 4.5 (sys) SNU
GNO	43 SR	65.2 +– 6.4 (stat) +– 3.0 (sys) SNU
GNO+GALLEX	108 SR	70.8 +– 4.5 (stat) +– 3.8 (sys) SNU

BOREXINO

300 tons liquid scintillator in a nylon bag
2200 photomultipliers
2500 tons ultrapure water
Energy threshold 0.25 MeV
Real time neutrino (all flavours) detector
Measure mono-energetic (0.86 MeV) ^{7}**Be** neutrino flux through the detection of ν-e.
40 ev/d if SSM

18 m diam., 16.9 m height

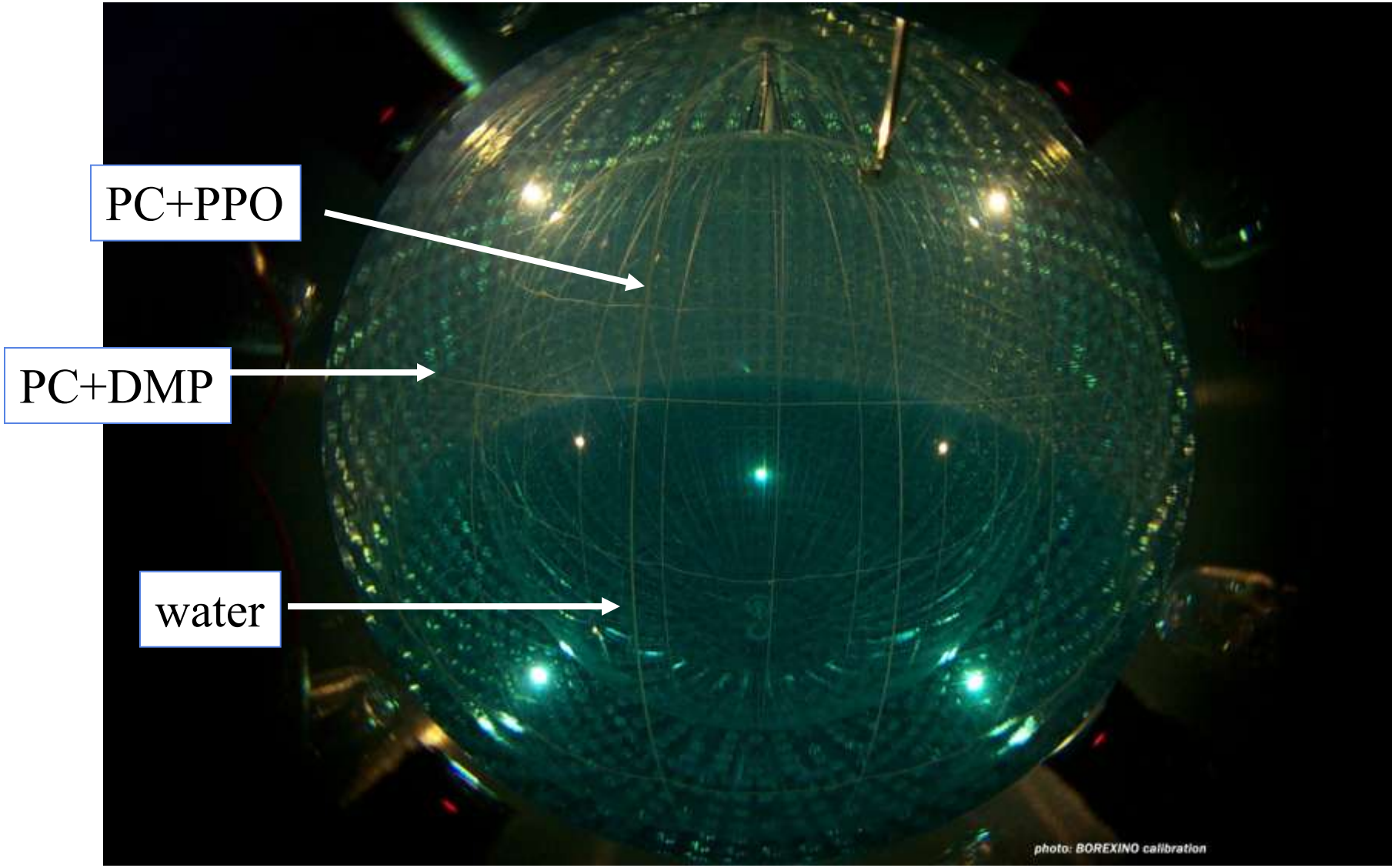


Sphere 13.7 m diam. Supports the P□Ms
optical concentrators
Space inside the sphere contains purifie
Purified water outside the sphere

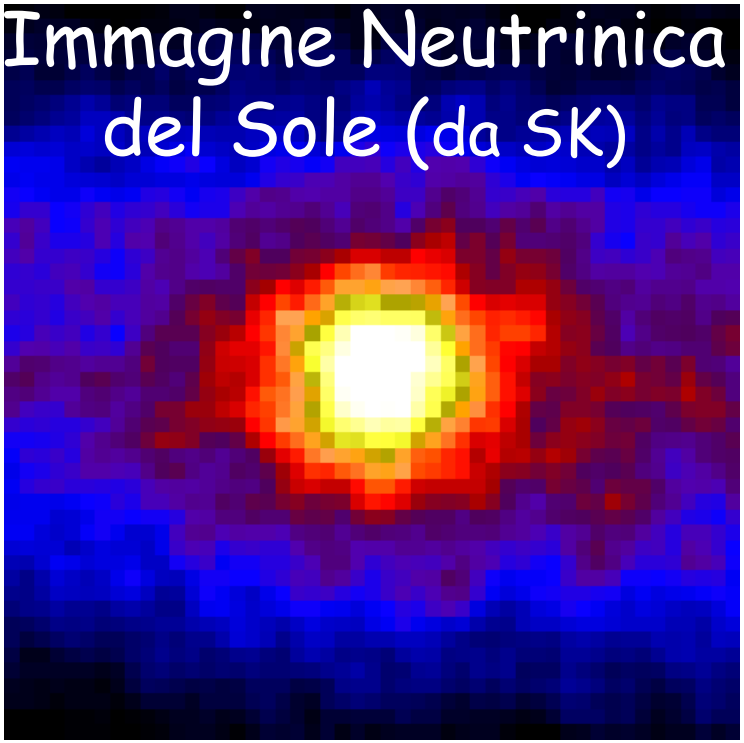
running in 2005

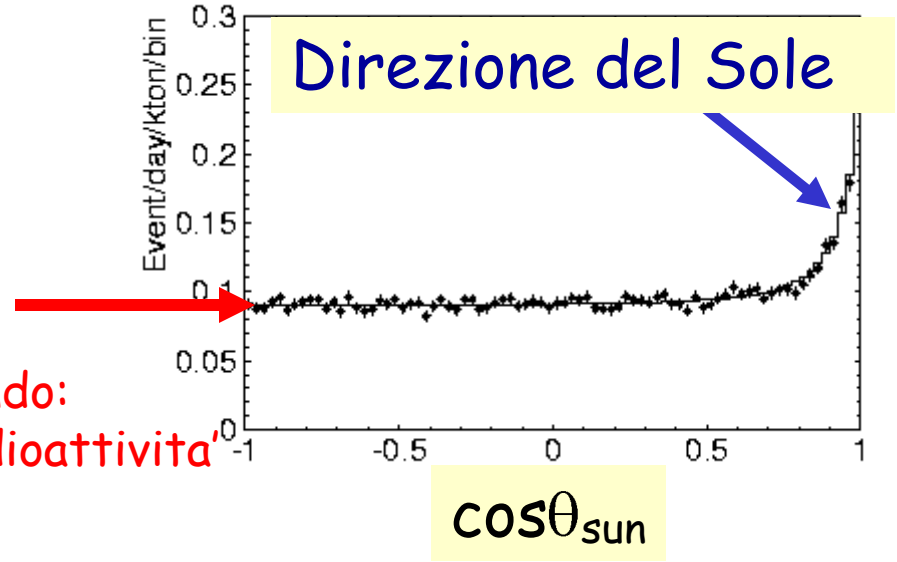
Collab.:
Italy, France, USA, Germany, Hungary, Russia, Belgium Poland, Canada

March 2, 2007 10:12: inside of the SSS



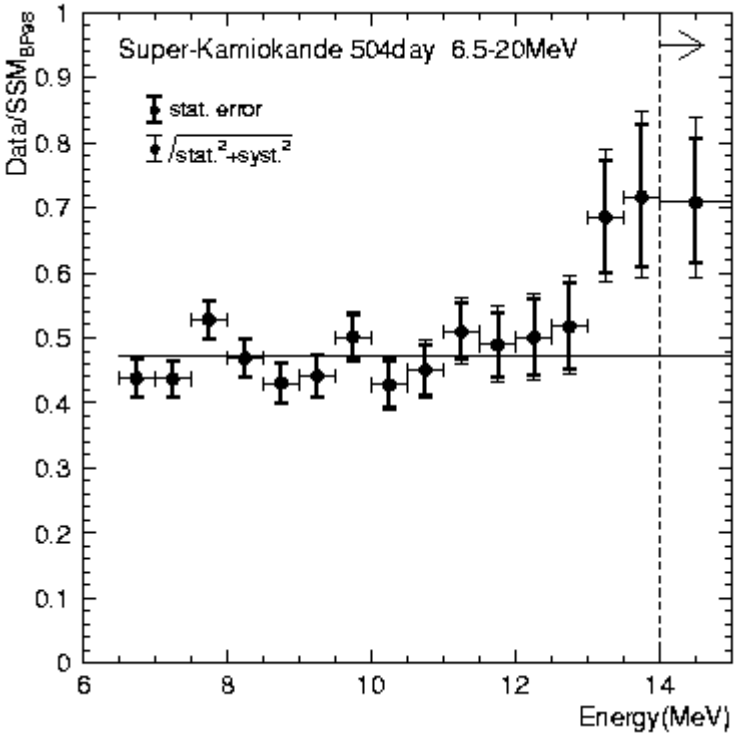
CUORE Site in Hall A at LNGS



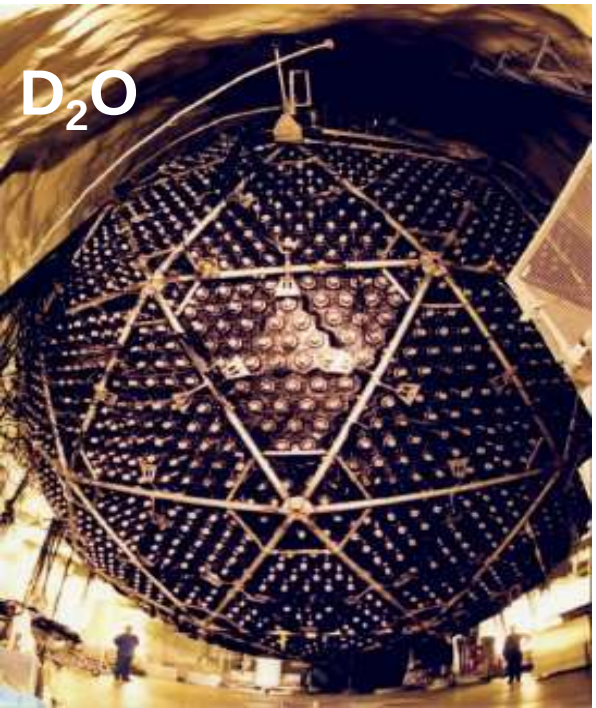


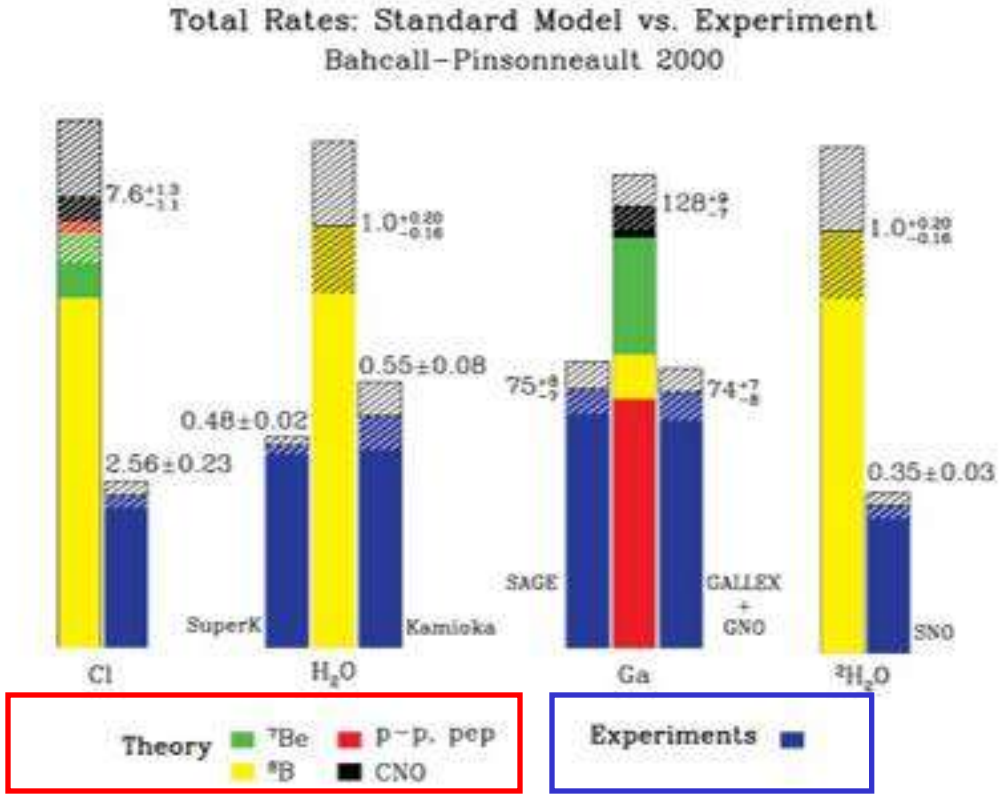
Rapporto:
osservati/attesi SSM

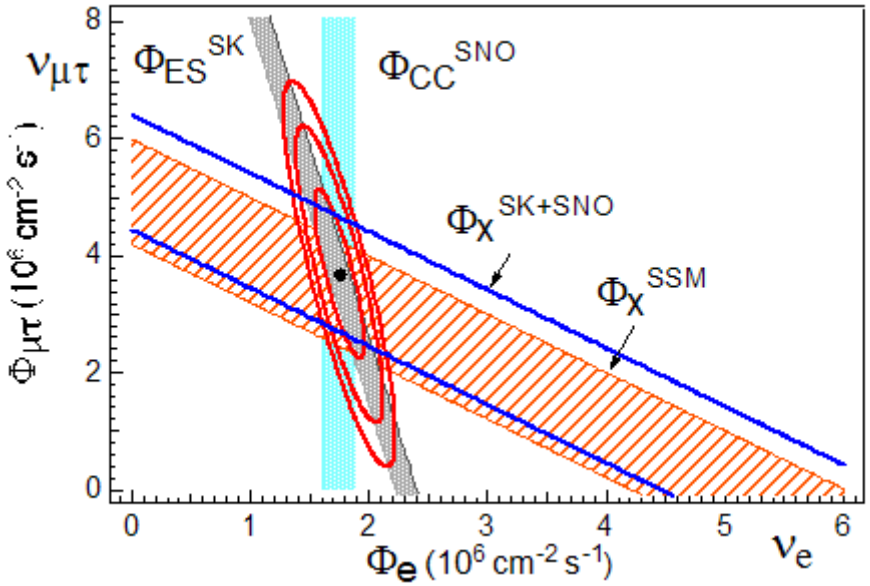
~ 0.5




Esperimento
SNO (Canada)


D_2O


Total Rates: Standard Model vs. Experiment
Bahcall–Pinsonneault 2000
$7.6^{+1.3}_{-1.1}$
2.56±0.23
0.48±0.02
$1.0^{+0.20}_{-0.16}$
0.55±0.08
75^{+9}_{-7}
128^{+9}_{-7}
74^{+7}_{-8}
$1.0^{+0.20}_{-0.16}$
0.35±0.03
SuperK
Kamioka
SAGE
GALLEX + GNO
SNO
Cl
H_2O
Ga
^2H_2O
Theory
^{7}Be
p−p, pep
^{8}B
CNO
Experiments


$\nu_{\mu\tau}$
Φ_{ES}^{SK}
Φ_{CC}^{SNO}
Φ_X^{SK+SNO}
Φ_X^{SSM}
$\Phi_{\mu\tau}$ (10^6 cm^{-2} s^{-1})
Φ_e (10^6 cm^{-2} s^{-1})
ν_e
0
1
2
3
4
5
6
8

Transnational Access to LNGS

GS has been recognized by EU as a European **Large Scale Facility**
ontract between EU and INFN funds **access** to the LNGS facilities for EU researchers
rt of the contract: December 2002; duration 28 months

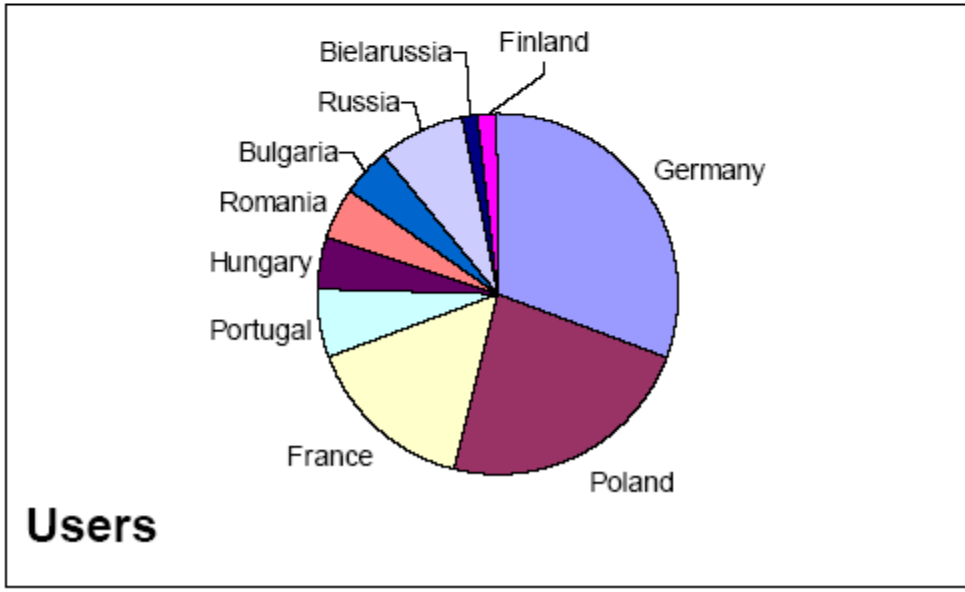
- **17 research Projects in the sectors**
  - Low background instrumentation
  - Accelerator facilities (LUNA)
  - Cryogenic facilities
  - Computing facilities
  - Geophysics and environmental physics
- **1020 Person-days delivered (July 2003)**

  880 person-days allocated

  900 person-days available

65 scientists from 10 different uintries are accessing LNGS through RI

ore than half of them are new users

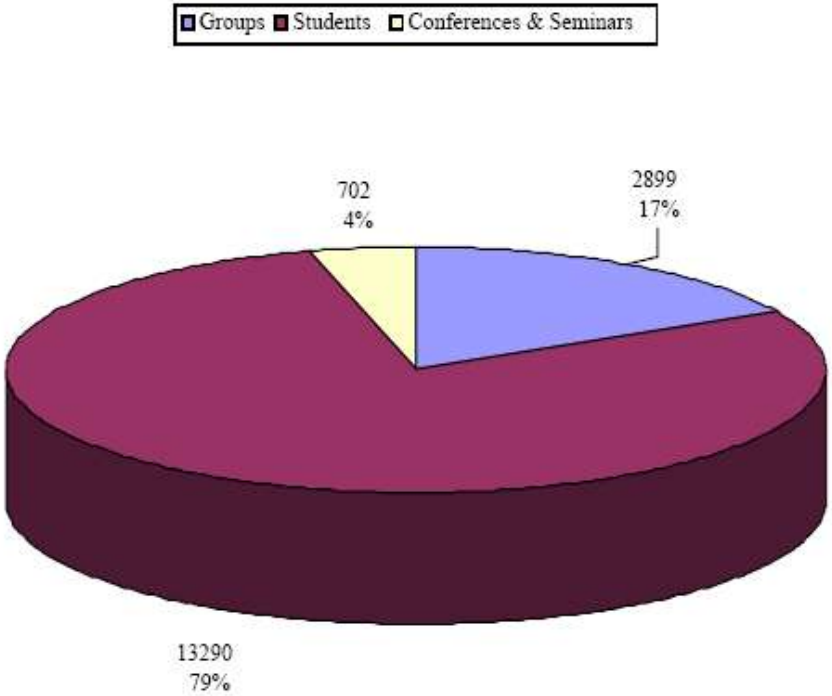


Visits at LNGS

Since 1990 it is possible to visit the Lab.

The number of visitors has increased during the years.

17,000 in 2003 **80% are students**



Anch'io Scienziato...

Anno scolastico 2002-2003

I Laboratori Nazionali del Gran Sasso dell'INFN in collaborazione con l'AIF - Associazione per l'insegnamento della Fisica - Sezione di L'Aquila bandiscono, per l'anno scolastico 2002-2003, il

CONCORSO: "ANCH'IO SCIENZIATO..."

riservato agli studenti delle Scuole Elementari, Medie e Superiori di Abruzzo e Molise.

Modalità di partecipazione

Al concorso possono partecipare classi, gruppi o singoli studenti con la presentazione di lavori scientifici a tema libero che potranno essere, per es., progetti, macchine, immagini, esperienze o risultati di esperimenti, e dovranno essere corredati di una relazione in formato dattiloscritto o multimediale o di una bibliografia.

Il giudizio della Commissione sui lavori presentati è definitivo e privilegia l'originalità, la forma espressiva e la riproducibilità di un eventuale esperimento scientifico.

Per facilitare il lavoro della Commissione esaminatrice i partecipanti devono inviare la scheda di adesione, debitamente compilata e scaricabile dal sito www.lngs.infn.it, entro il 28 febbraio al seguente indirizzo: Concorso "Anch'io Scienziato..." Laboratori Nazionali del Gran Sasso - SS 17 bis, km 18+910 - 67010 Assergi (AQ) oppure a mezzo Fax al numero: 0862 437521 o via email all'indirizzo: concorso2003@lngs.infn.it.

I progetti definitivi dovranno essere spediti allo stesso indirizzo entro il 10 maggio 2003 e quelli che risulteranno vincitori, saranno esposti per un arco presso la sala visitatori dei LNGS.

La proclamazione e la premiazione dei vincitori, prevedibilmente svolti, avverrà nella giornata dell'Open-Day dei Laboratori prevista per la fine del mese di maggio 2003.

I premi saranno assegnati alla Scuola di appartenenza degli studenti dichiarati vincitori dalla Commissione e gli studenti primi classificati riceveranno un attestato a testimonianza della loro partecipazione.

PREMI per le scuole

elementari
1. Kit di meccanica
2. Microscopio
3. Calcolatrice TI 15
4. Enciclopedia Zanichelli
5. Pubblicazioni scientifiche

medie
1. Kit di ottica
2. Kit di meccanica
3. Calcolatrice TI 83 PLUS
4. Enciclopedia Zanichelli
5. Pubblicazioni scientifiche

superiori
1. Calcolatrice TI 89 + CBL
2. Kit di elettromagnetismo
3. Kit di ottica
4. Calcolatrice TI 89
5. Enciclopedia Zanichelli

Per maggiori informazioni relative al concorso, alle modalità di partecipazione ed ai premi, consultare il sito:

www.lngs.infn.it

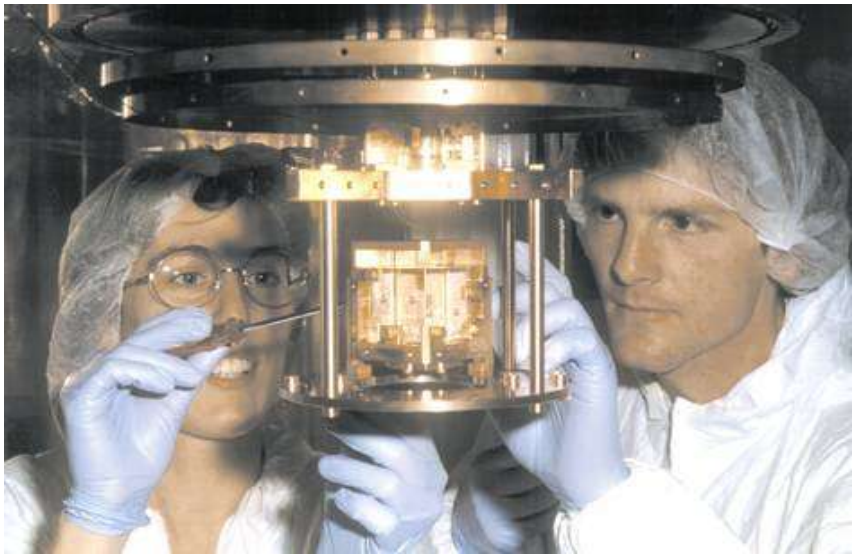
segreteria concorso: 0862 437365

Texas Instruments · Zanichelli · M.G. · Anglo American Book · AIF · INFN

INFN Istituto Nazionale di Fisica Nucleare

Laboratori Nazionali del Gran Sasso

Training



Outreach

Alta Formazione

Gran Sasso e Monti della Laga
Parco Nazionale

Il Parco Nazionale del Gran Sasso e Monti della Laga, istituito nel giugno del 1995, e' una delle aree protette più estese e preziose d'Europa.

Il Parco, con un'area di circa 150.000 ettari, si estende in tre regioni (Abruzzo, Marche e Lazio) e cinque province (L'Aquila, Teramo, Ascoli Piceno, Pescara e Rieti). Comprende 44 comuni.


TERAMO
A24
FONTECERRETO
A24 | ASSERGI
ASSERGI
CAMARDA
ROMA
A24
A24 | AQ EST
S17
L'AQUILA
PAGANICA
BAZZANO


MARCAFE
BAR RISTORANTE