ASTRONOMIE V PODZEMÍ

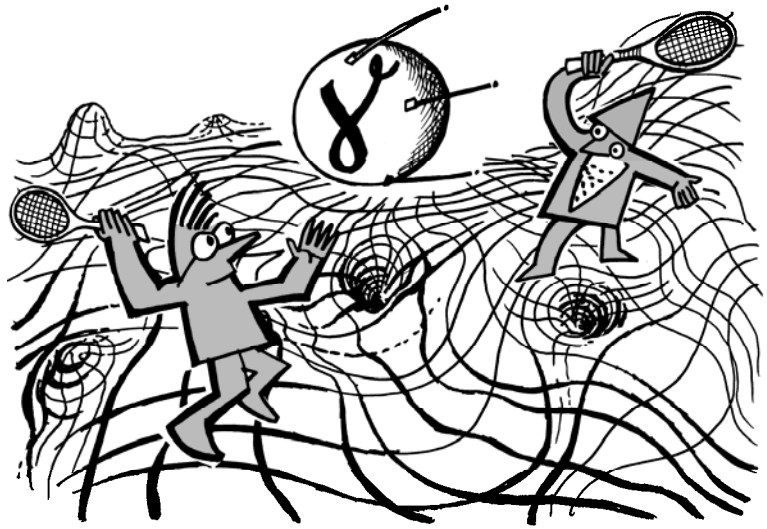
Ing. arch. Ivan Havlíček, hvězdárna Zlín 2011

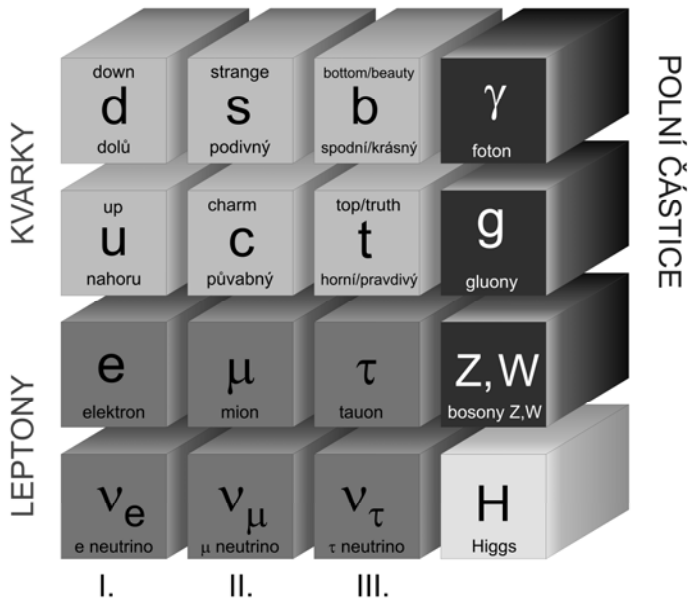

Gran Sasso

Three Generations of Matter (Fermions)

	I	II	III	
mass→	2.4 MeV	1.27 GeV	171.2 GeV	0
charge→	⅔	⅔	⅔	0
spin→	½	½	½	1
name→	u up	c charm	t top	γ photon
Quarks	4.8 MeV, -⅓, ½, d down	104 MeV, -⅓, ½, s strange	4.2 GeV, -⅓, ½, b bottom	0, 0, 1, g gluon
Leptons	<2.2 eV, 0, ½, ν_e electron neutrino	<0.17 MeV, 0, ½, ν_μ muon neutrino	<15.5 MeV, 0, ½, ν_τ tau neutrino	91.2 GeV, 0, 1, Z^0 weak force
	0.511 MeV, -1, ½, e electron	105.7 MeV, -1, ½, μ muon	1.777 GeV, -1, ½, τ tau	80.4 GeV, ±1, 1, $W^\pm$ weak force

Bosons (Forces)



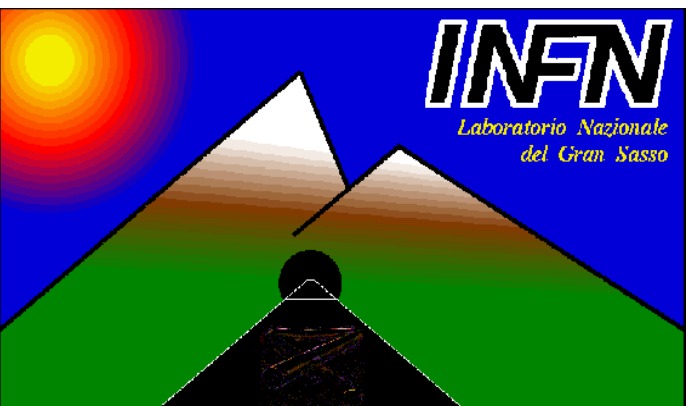


National Laboratory Gran Sasso

- Otevření: 1987
- 1400 m pod povrchem
- Mionový tok: 3×10^{-4} s^{-1} m^{-2}
- Experimenty: 3 haly, plocha 17 300 m^2, délka 100 m
- Přístup: z dálničního tunelu

Vědecké aktivity

- Neutrinová fyzika (OPERA, BOREXINO, ICARUS, LVD, GERDA...)
- Temná hmota (DAMA/LIBRA, WARP, XENON, CRESST)
- Jaderné reakce, astrofyzika (LUNA)
- Základní fyzika (VIP)
- Geofyzika (ERMES, GIGS)



Fyzika v LNGS

Výzkum Vesmíru a temné hmoty

DAMA/LIBRA
CRESST
WARP
XENON

LBL - CNGS
OPERA
Icarus T600

Vlastnosti neutrin a jejich úloha ve vývoji Vesmíru

2β0ν
CUORICINO
CUORE
GERDA
COBRA

Jak vypadají nitra Slunce a Země?

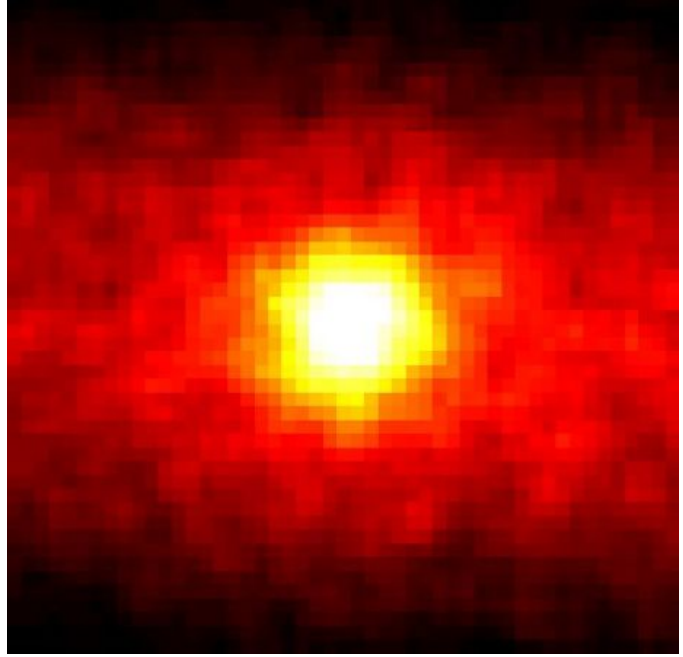
BOREXINO

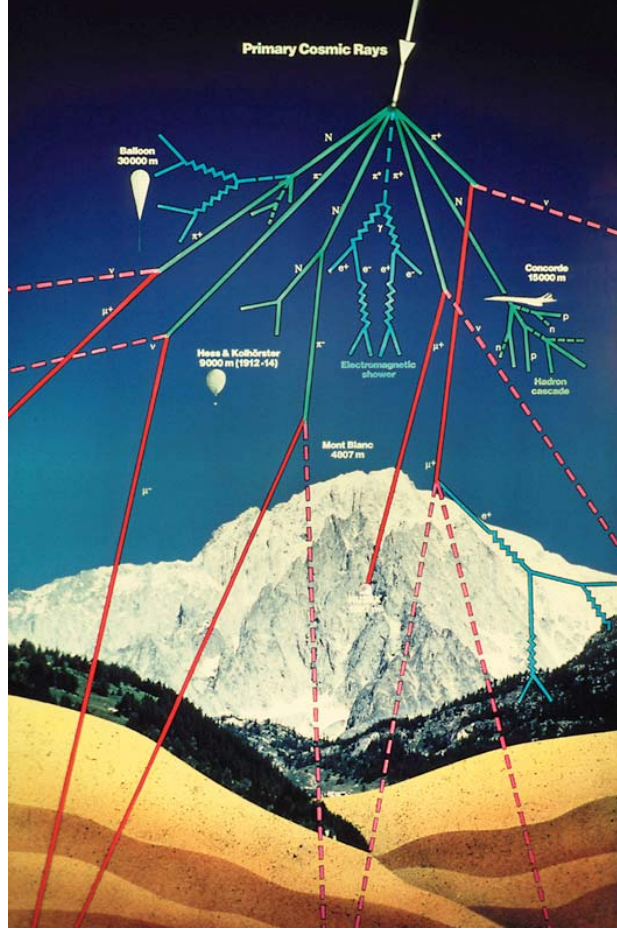
LVD

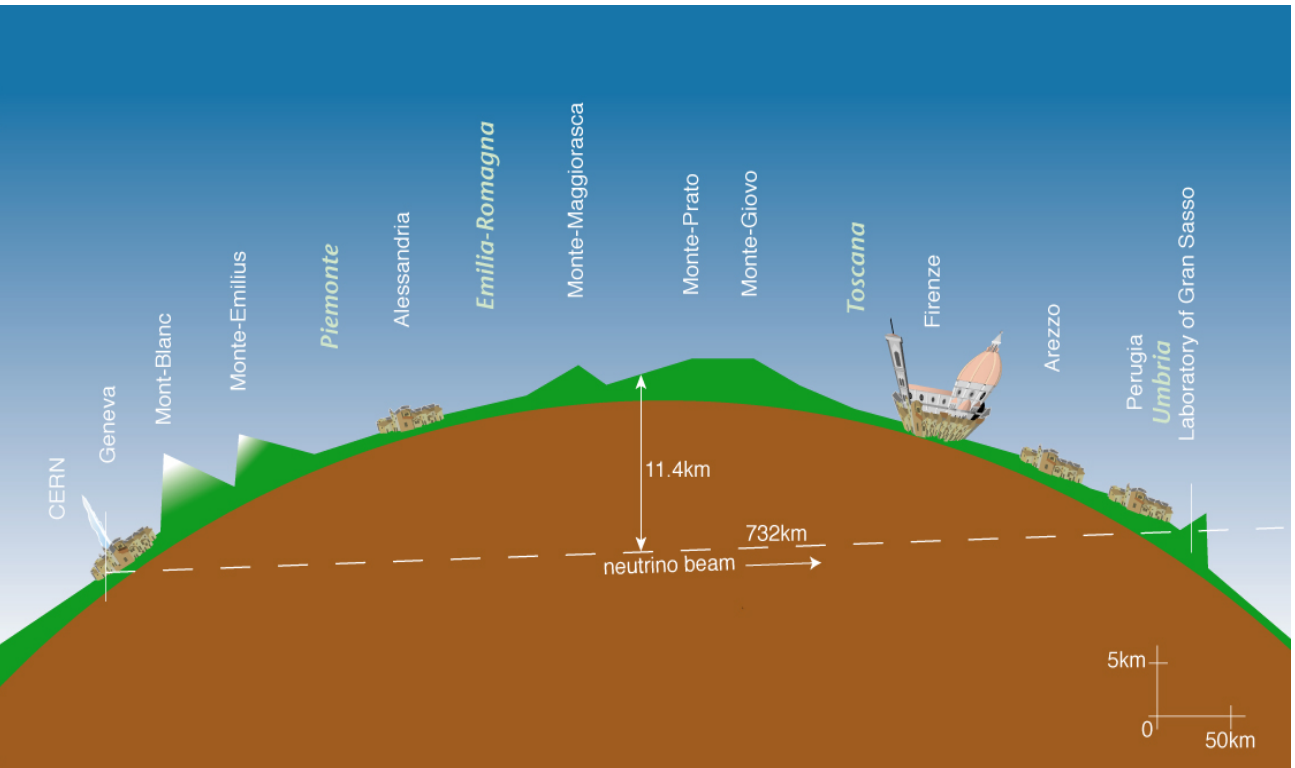
Exploze supernov

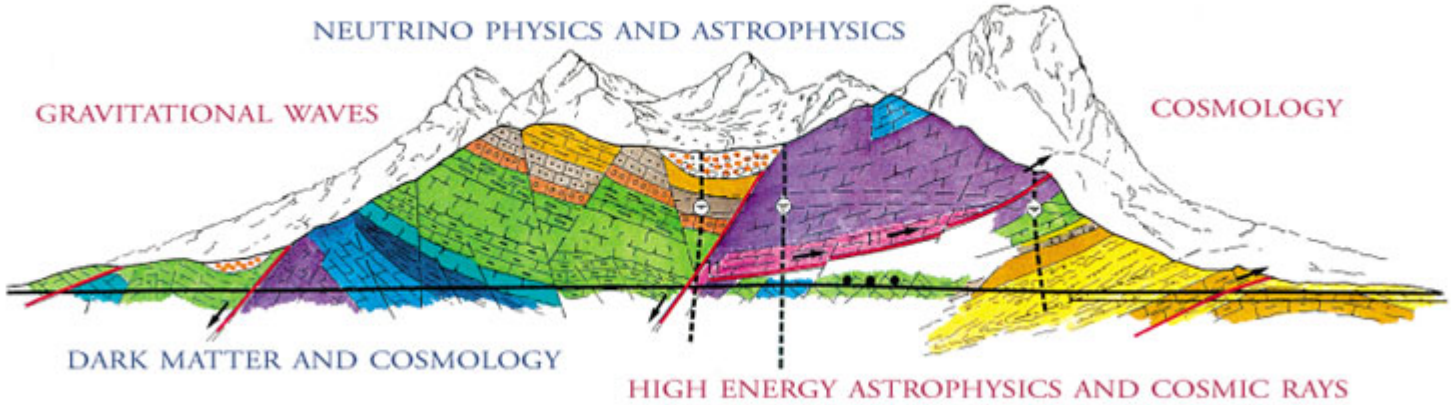
Zdroje neutrin

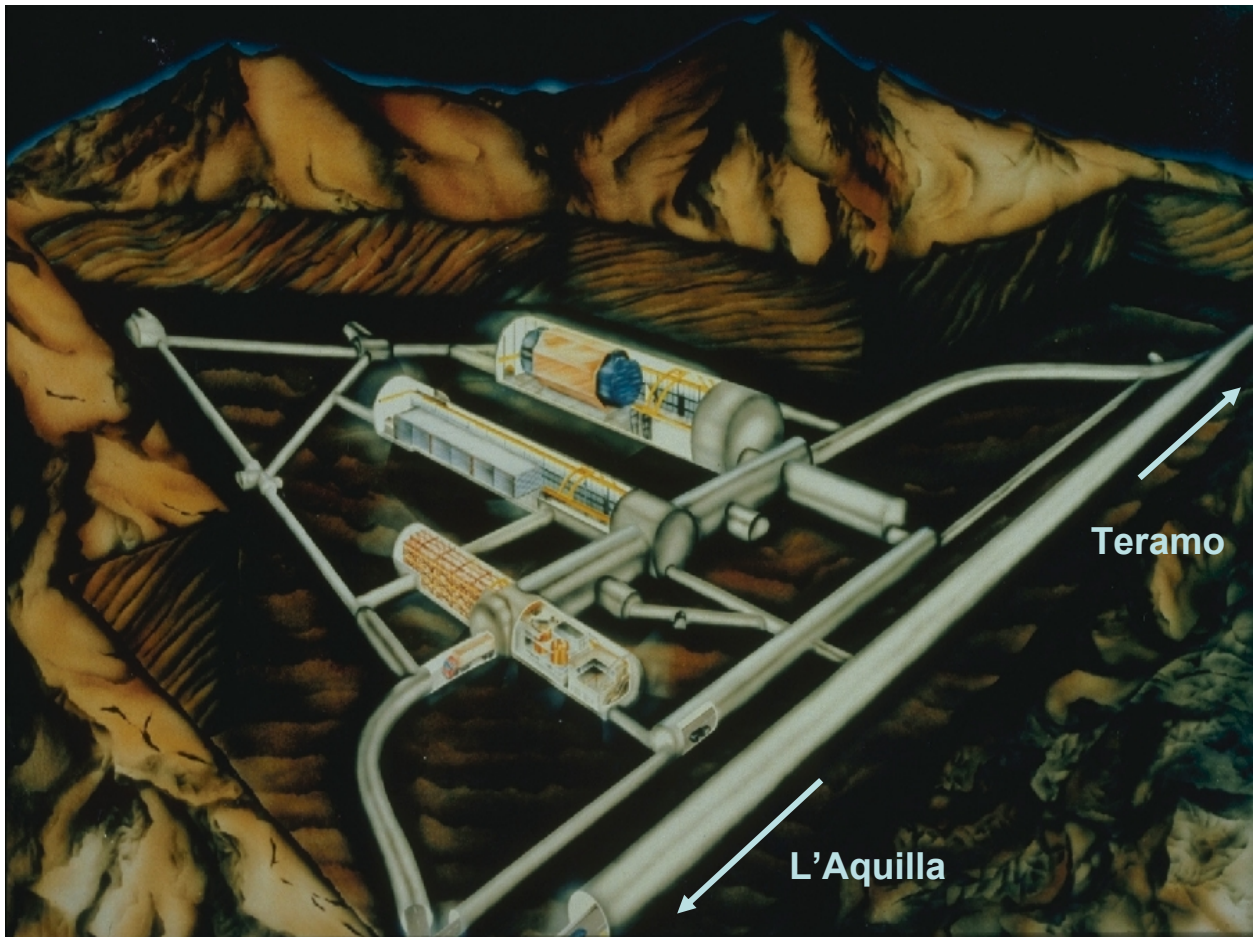
- reliktní neutrina
- Slunce
- horní atmosféra
- supernovy
- nitro Země
- jaderné reaktory
- urychlovače, CERN



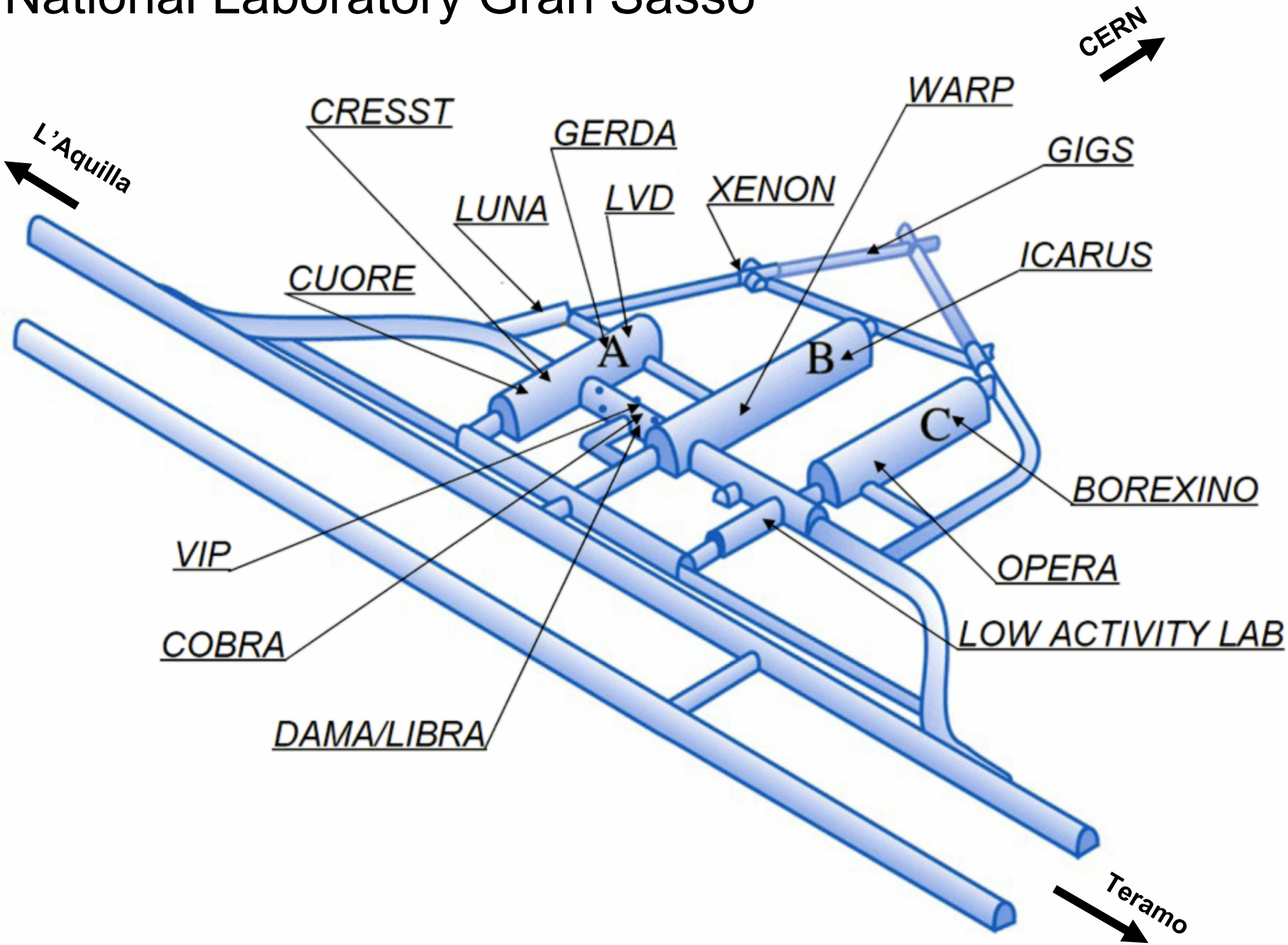


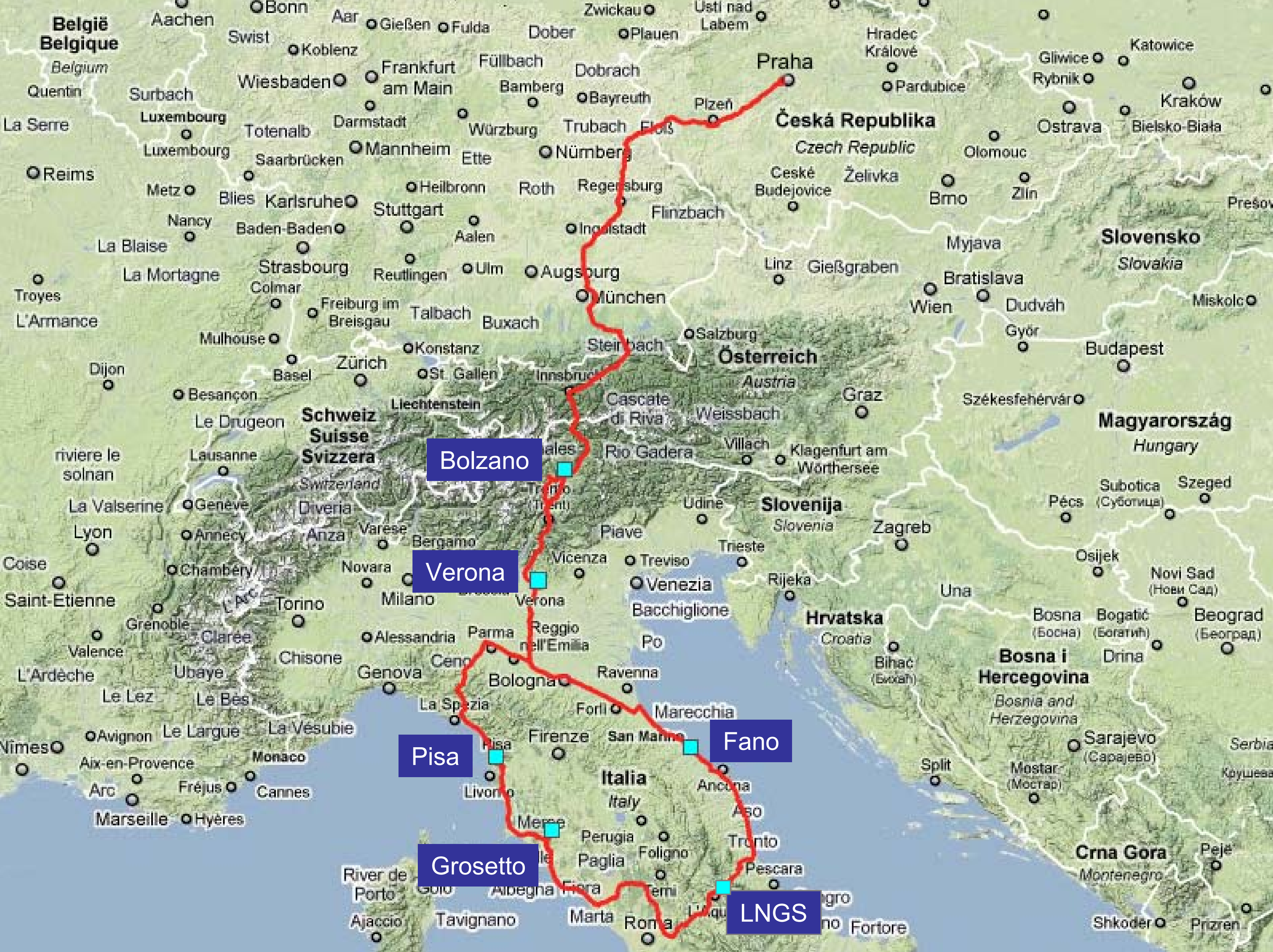



NEUTRINO PHYSICS AND ASTROPHYSICS
GRAVITATIONAL WAVES
COSMOLOGY
DARK MATTER AND COSMOLOGY
HIGH ENERGY ASTROPHYSICS AND COSMIC RAYS


Teramo
L'Aquilla

National Laboratory Gran Sasso




Bolzano
Verona
Pisa
Fano
Grosetto
LNGS


POLIZIA


www.aldebaran.cz


PAGANICA
6 April 2009





Gran Sasso
10173 m


via Galilei
via Newton


Evolving physics


Evolving physics

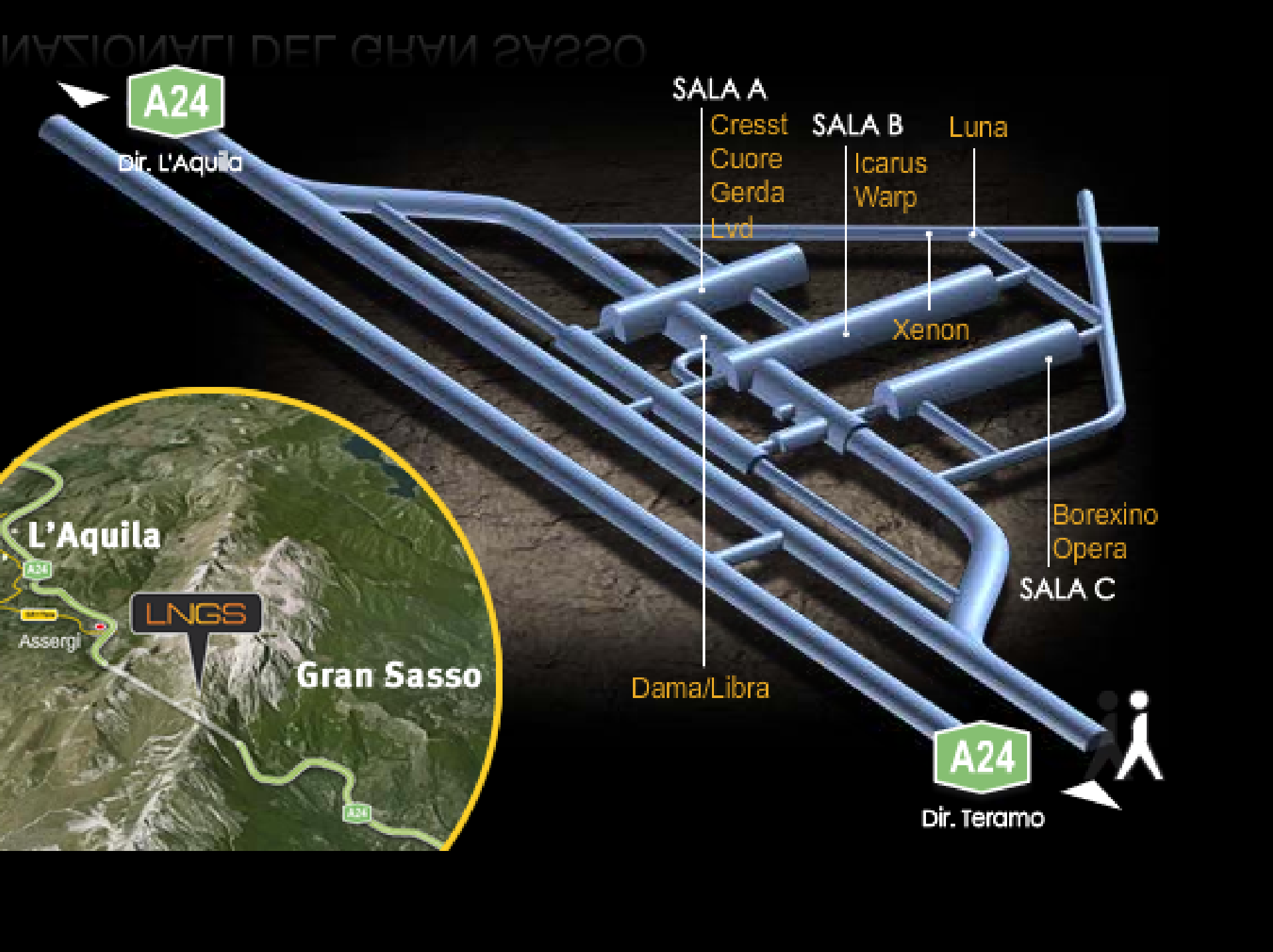

BOREXINO: a real time detector for solar neutrinos


6S1 3406


I.N.F.N.
PEUGEOT
307SW
CZ
8S1 3406


CZ


INFN-LABORATORI
NAZIONALI
DEL GRAN SASSO


A24
Dir. L'Aquila
SALA A
Cresst
Cuore
Gerda
Lvd
SALA B
Icarus
Warp
Luna
Xenon
Borexino
Opera
SALA C
Dama/Libra
A24
Dir. Teramo
L'Aquila
LNGS
Assergi
Gran Sasso


OPERA
Oscillation Project with Emulsion-tRacking Apparatus
Cíl: sledování oscilací $\nu\mu \rightarrow \nu\tau$ neutrin z CERNu
http://operaweb.lngs.infn.it/?lang=en
INFN-LABORATORI NAZIONALI DEL GRAN SASSO
USCITA EMERGENZA
EMERGENCY EXIT

CERN to Gran Sasso Neutrino Beam

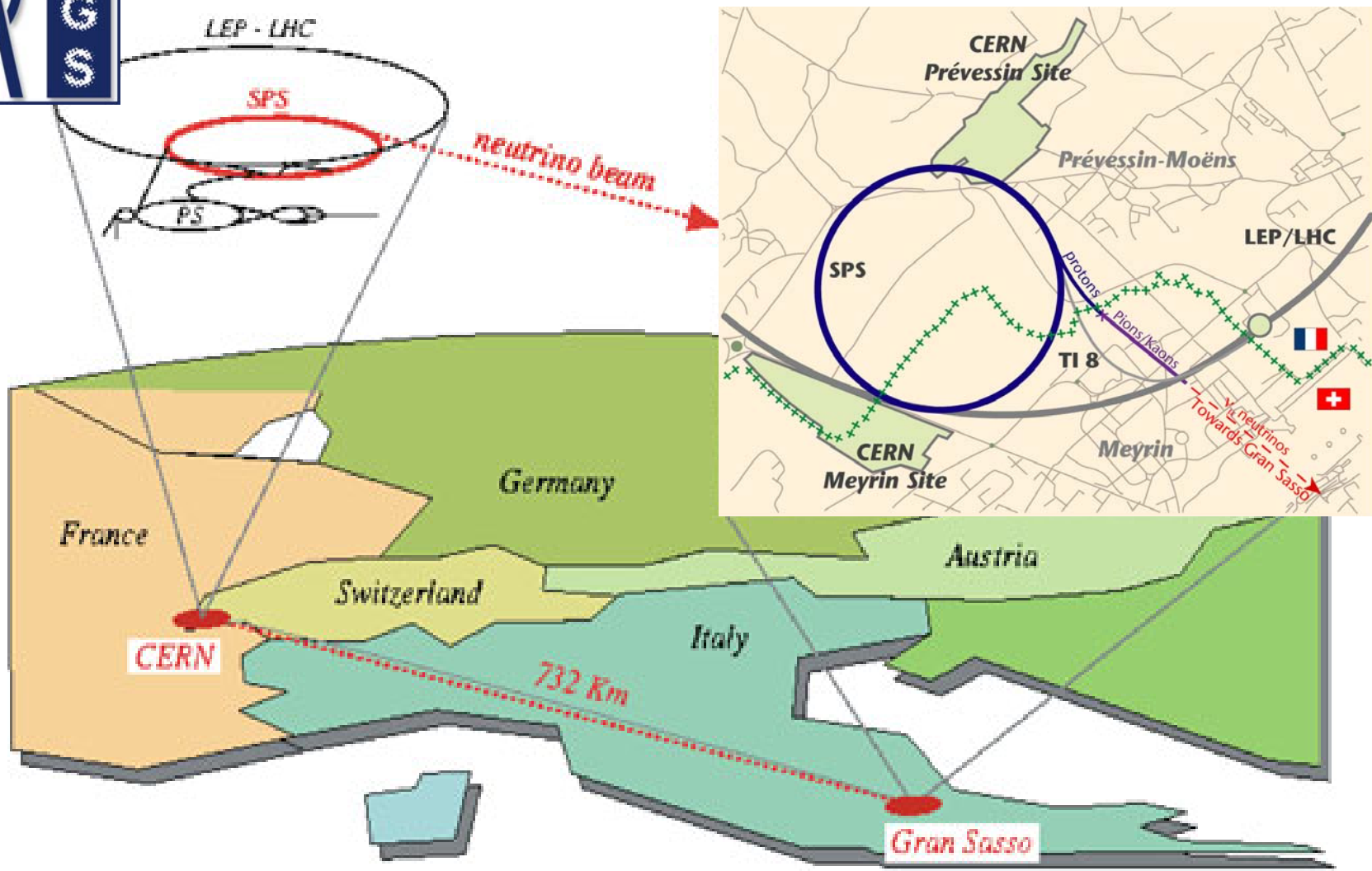
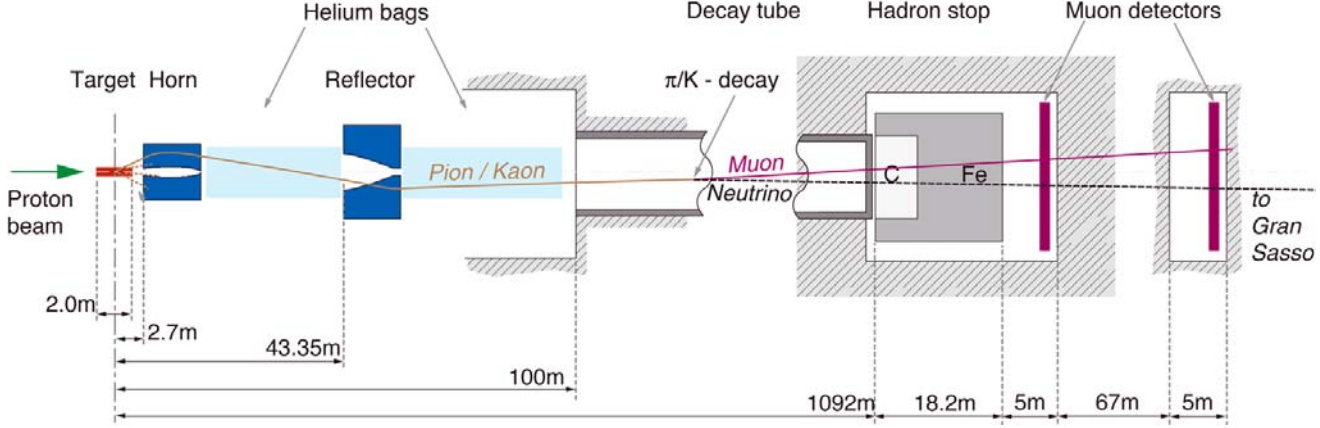
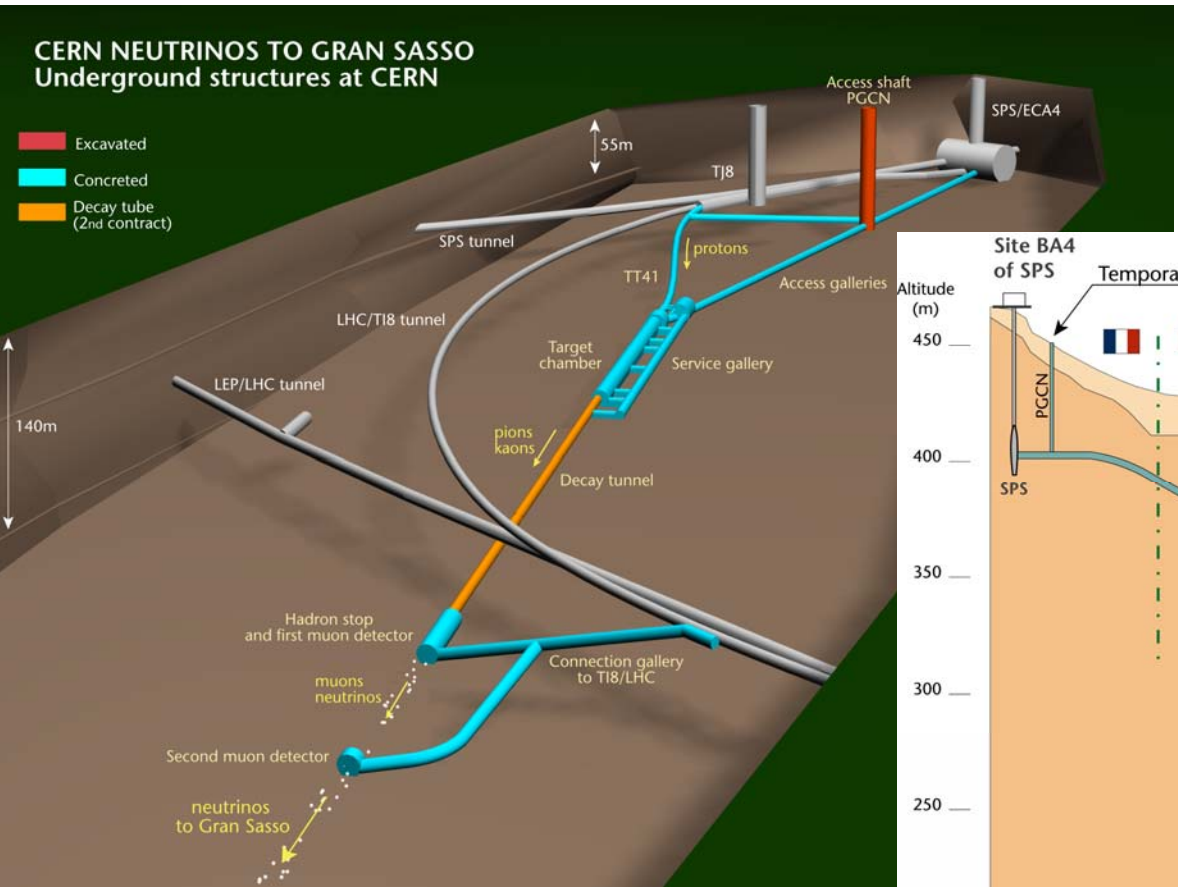
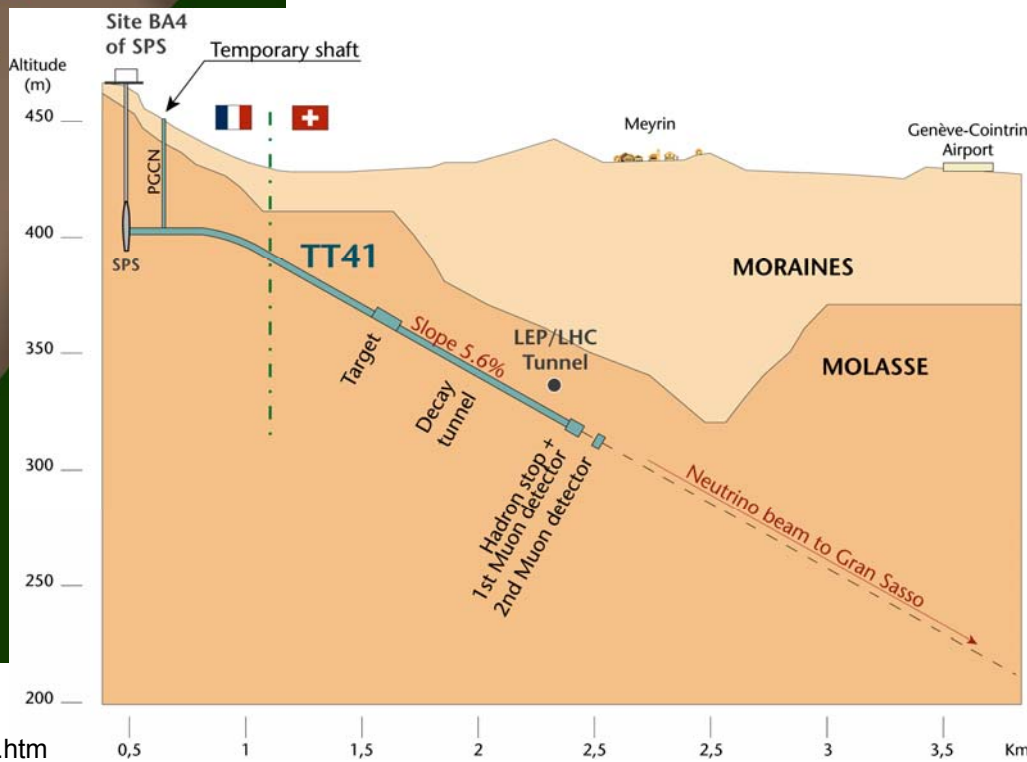


Fig. 2: Sketch of the 732 km distance from CERN in Geneva to Gran Sasso (near Rome).

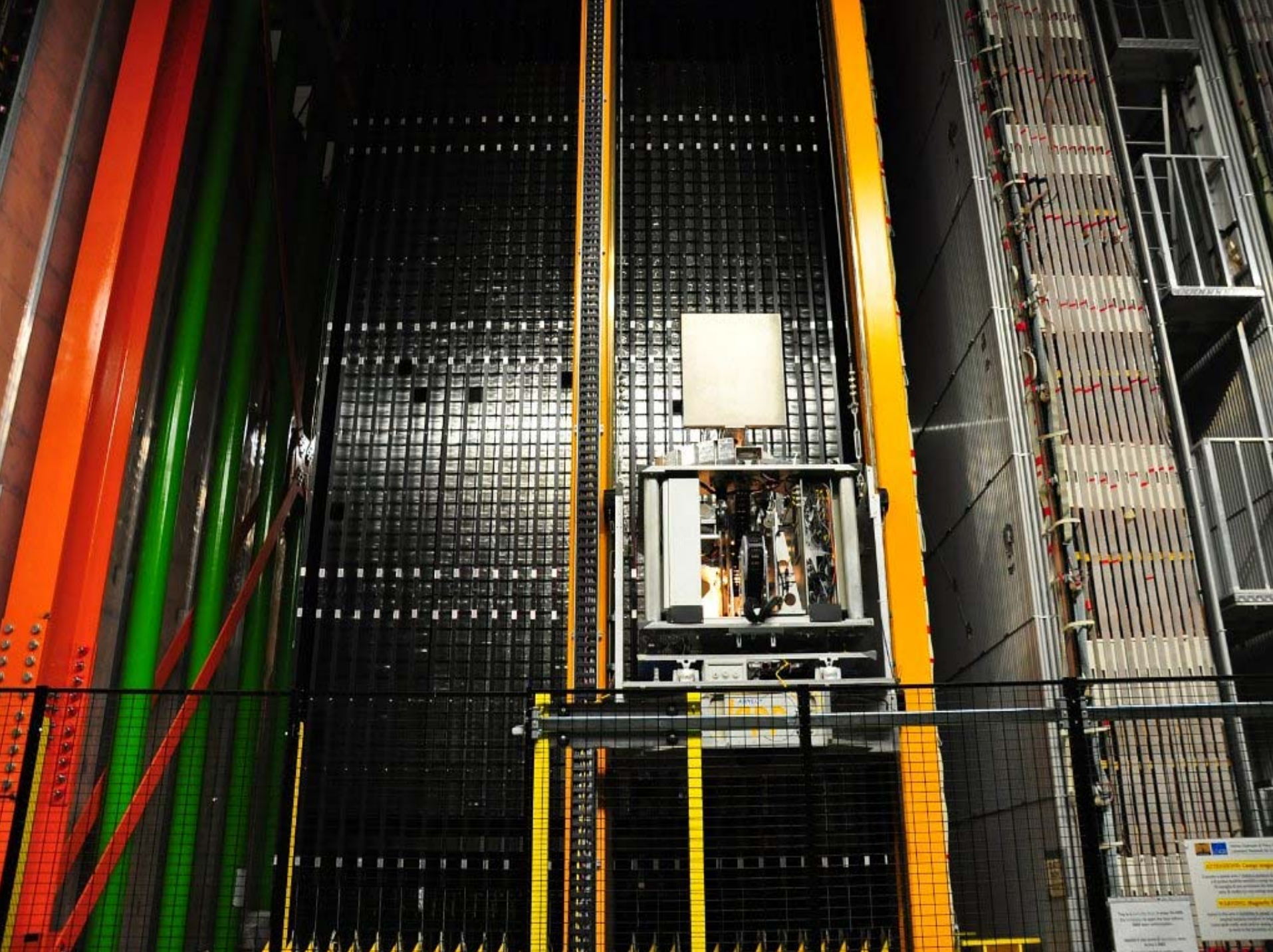
The CNGS (CERN Neutrinos to Gran Sasso) project aims at investigating the 'oscillation' of neutrinos. The project is motivated by the results obtained at the Superkamiokande detector in Japan and supported by other experiments, observing neutrinos produced by cosmic rays in the atmosphere. These experiments measure a significant deficit in the flux of deteced muon-type neutrinos.



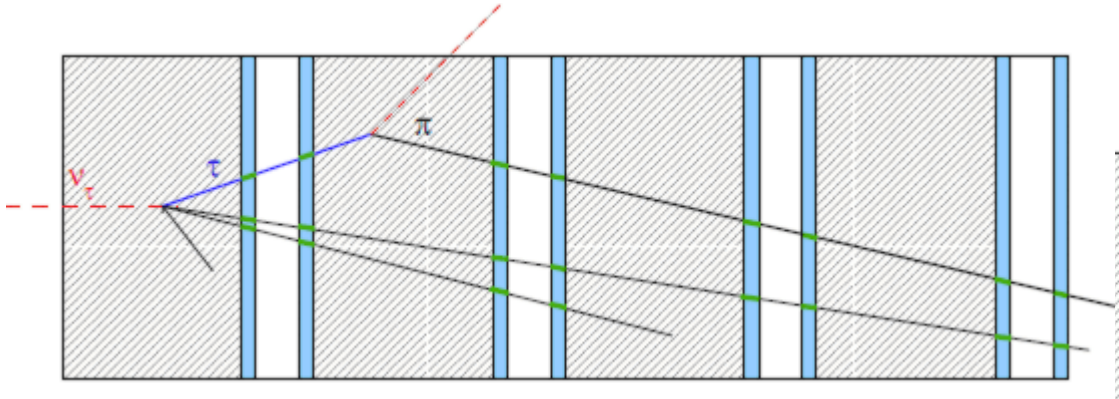


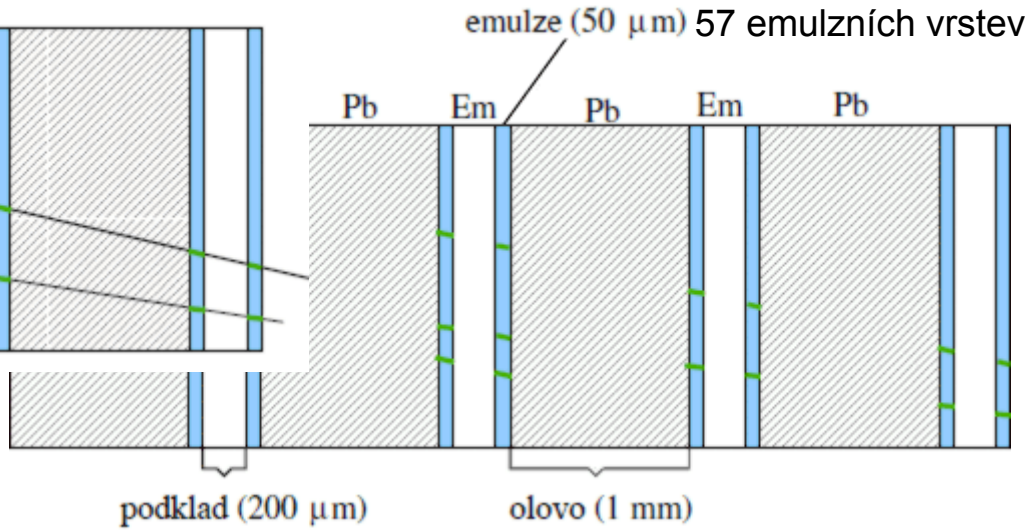


http://proj-cngs.web.cern.ch/proj-cngs/ProjetOverview/projetoverview2002.htm

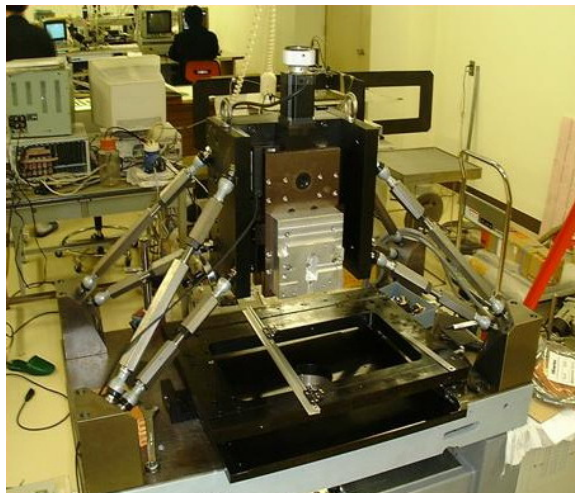


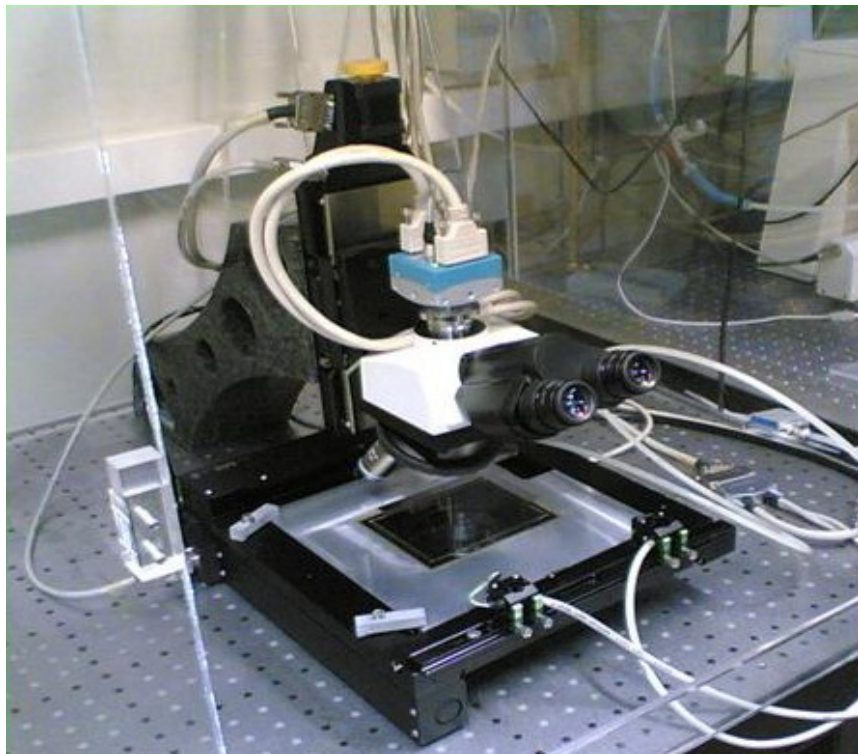

NACANCO





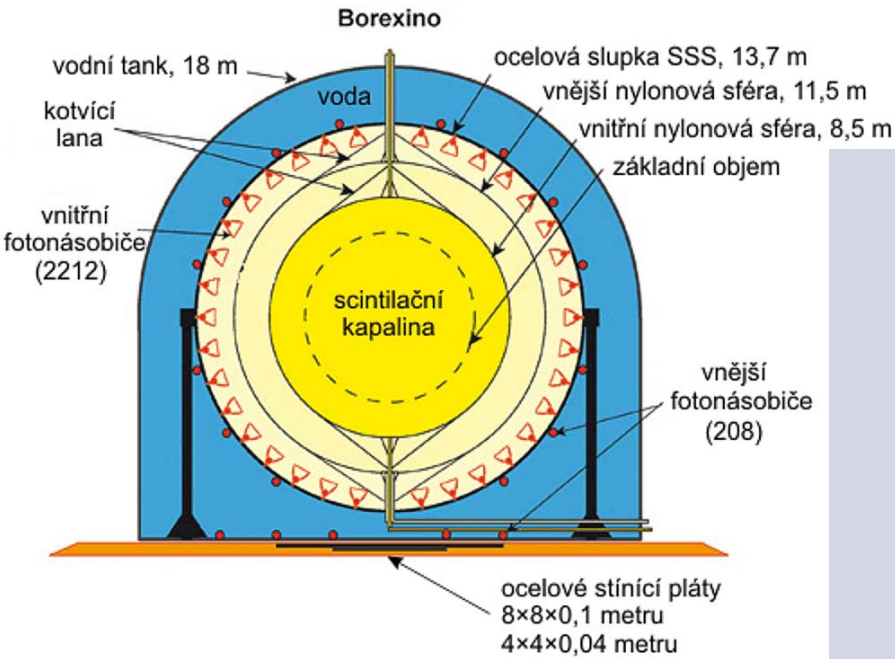
150 000 cihliček!
1 300 tun!
2006: testy
2007: testy
2008: 1698 interakcí
2009: 3500 interakcí
31. 5. 2010: oznámení o prvním detekovaném tau neutrinu. historicky první tau neutrino detekované jako produkt oscilace.
celkem by v posbírané kolekci dat mohla být tři






PC
D3

sluneční neutrina (pp, CNO, Be7)
detekce v reálném čase, tok 65×10^9 s^{-1} cm^2
možná detekce i zemských antineutrin
http://www.e15.physik.tu-muenchen.de/research_and_projects/borexino/



provoz: 2007

scintilátor: C^{14}

$\nu'_e + p \rightarrow e^+ + n$

$e^+ + e^- \rightarrow$ foton (511 keV)

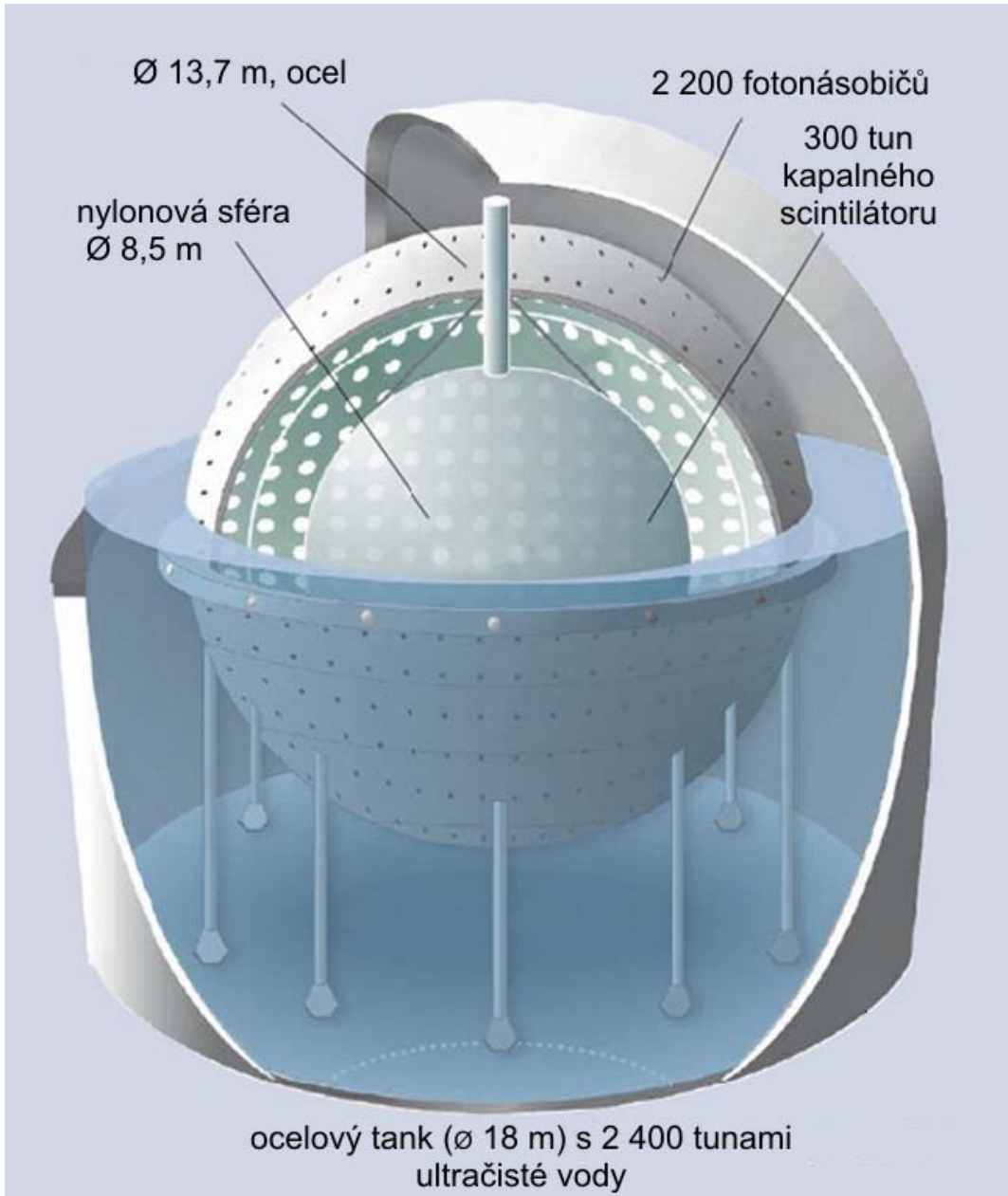
$n + p \rightarrow$ foton (2,2 MeV)

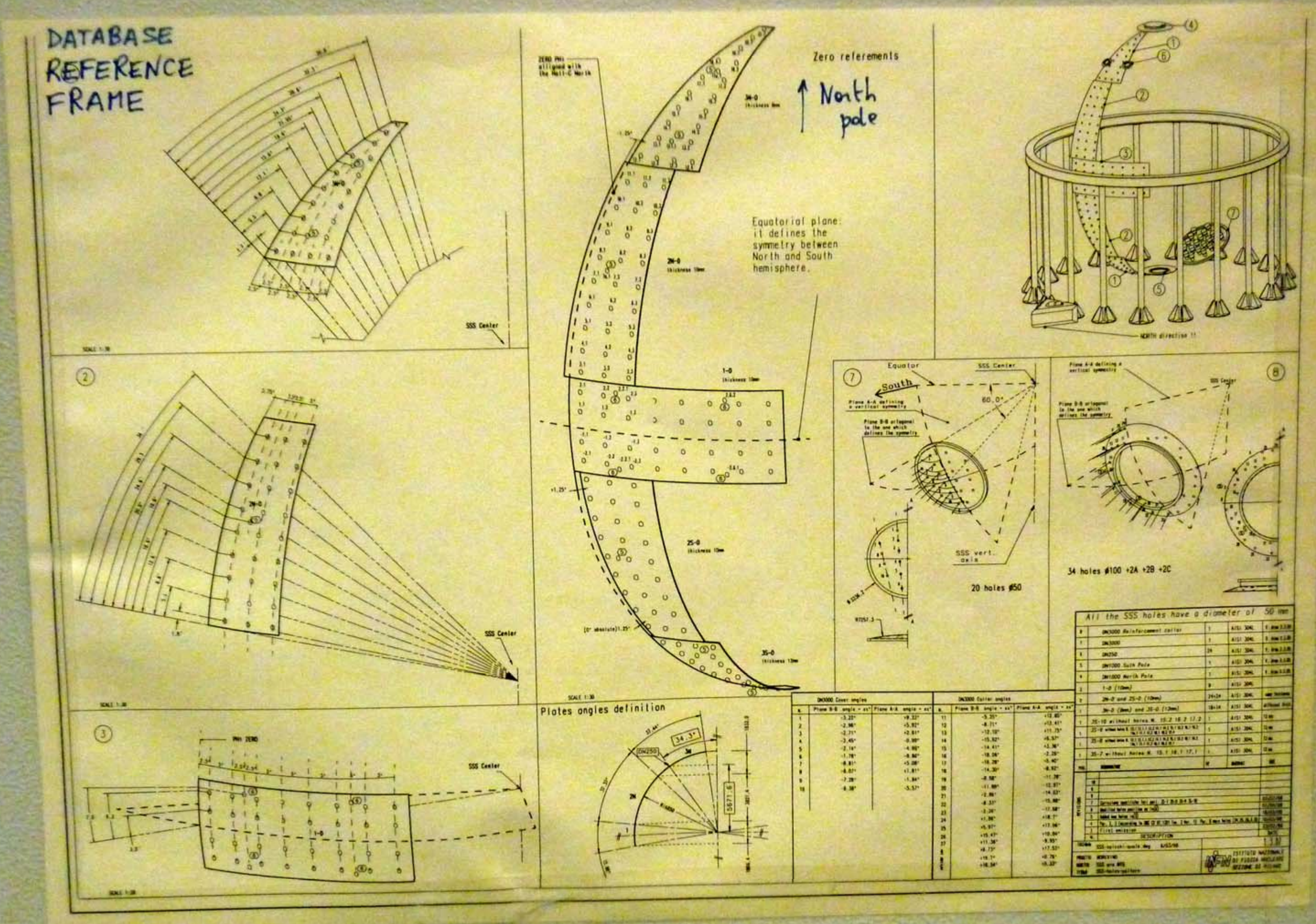
Δt = 256 μs

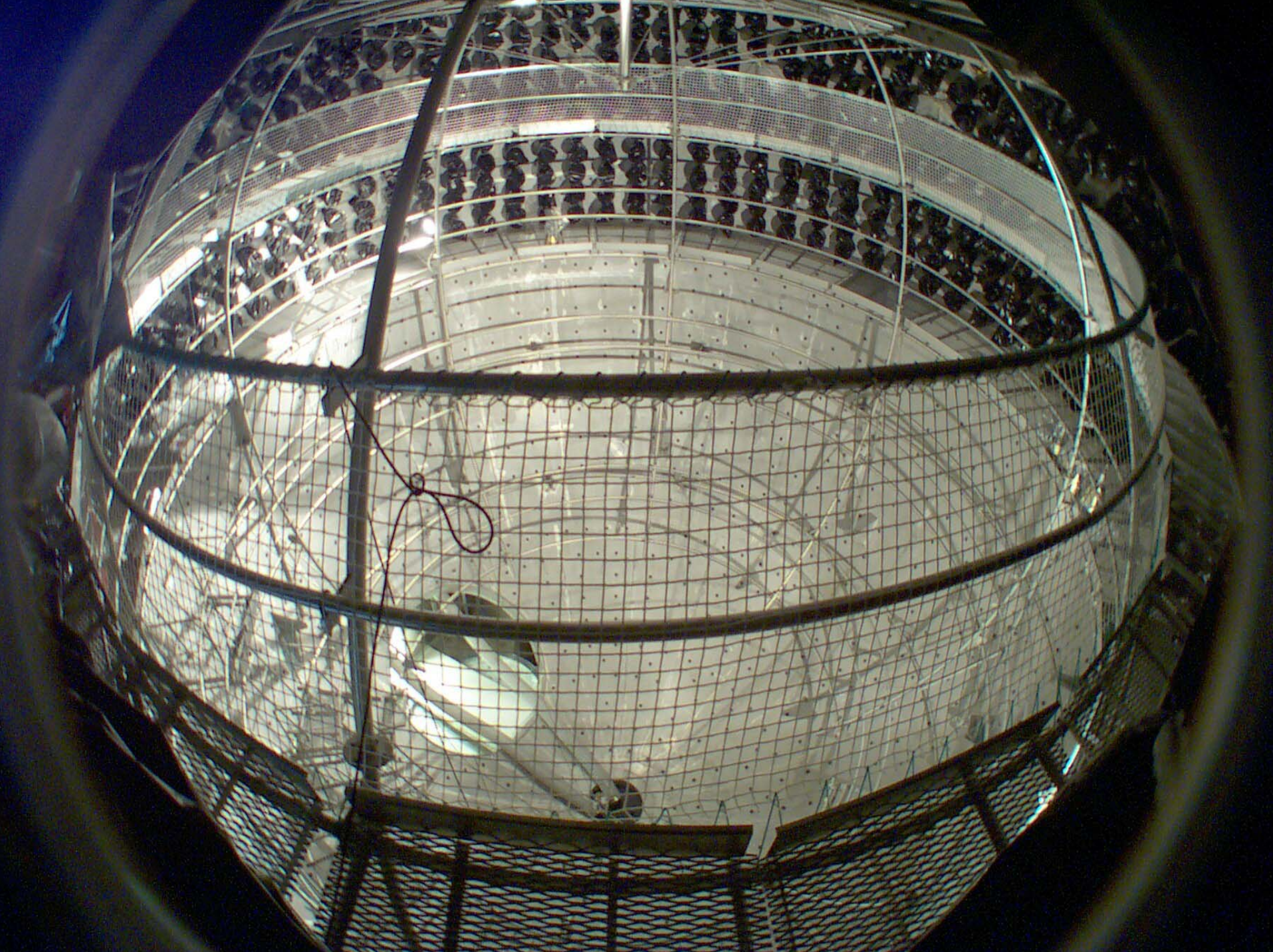
Čerenkovovo záření

miony

208 vnějších fotonásobičů




DATABASE
REFERENCE
FRAME
Zero referements
North pole
Equatorial plane:
it defines the
symmetry between
North and South
hemisphere.
SSS Center
Equator
South
SSS vert. axis
20 holes ø50
34 holes ø100 +2A +2B +2C
All the SSS holes have a diameter of 50 mm
Plates angles definition
NORTH direction !!



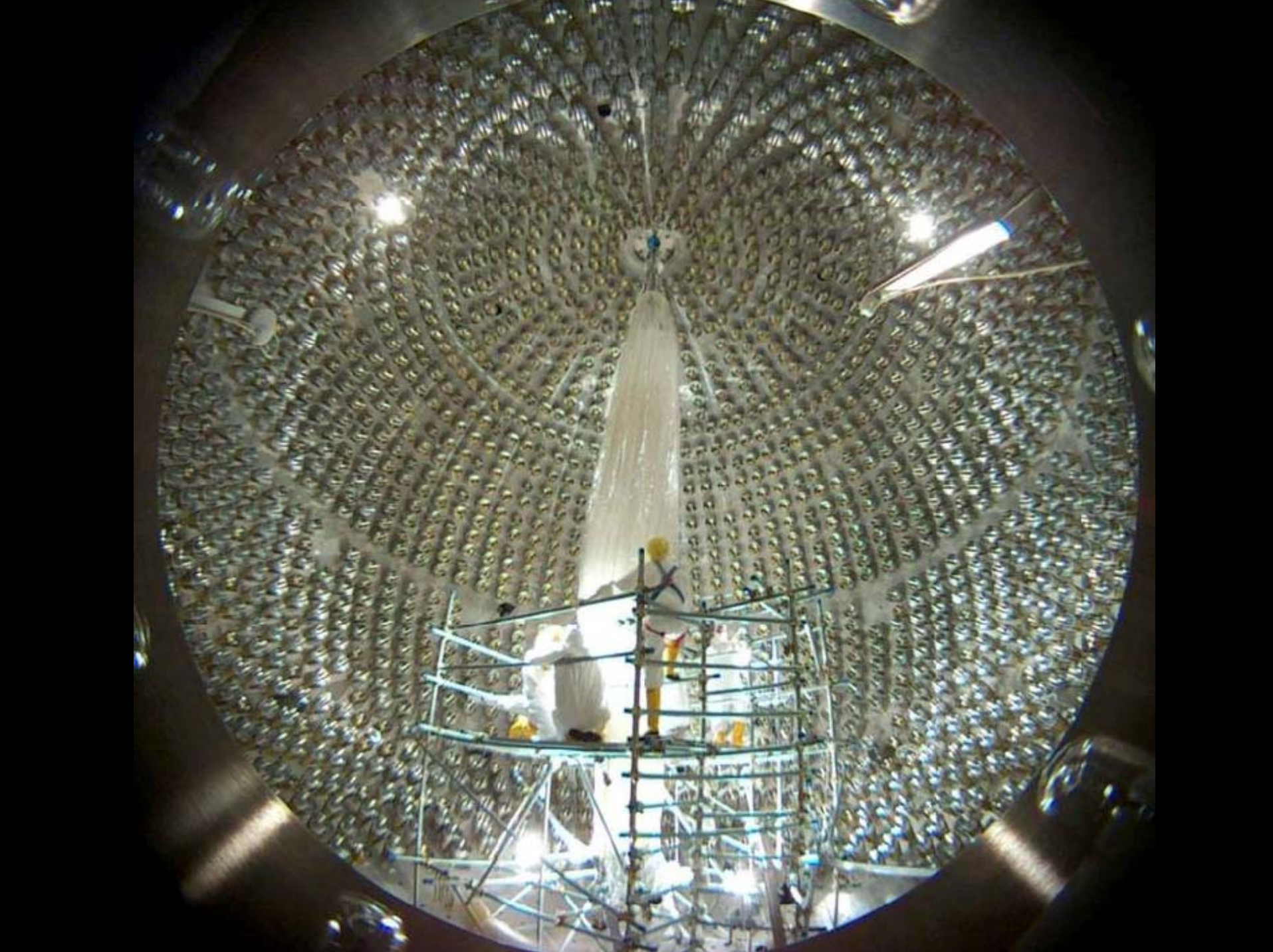
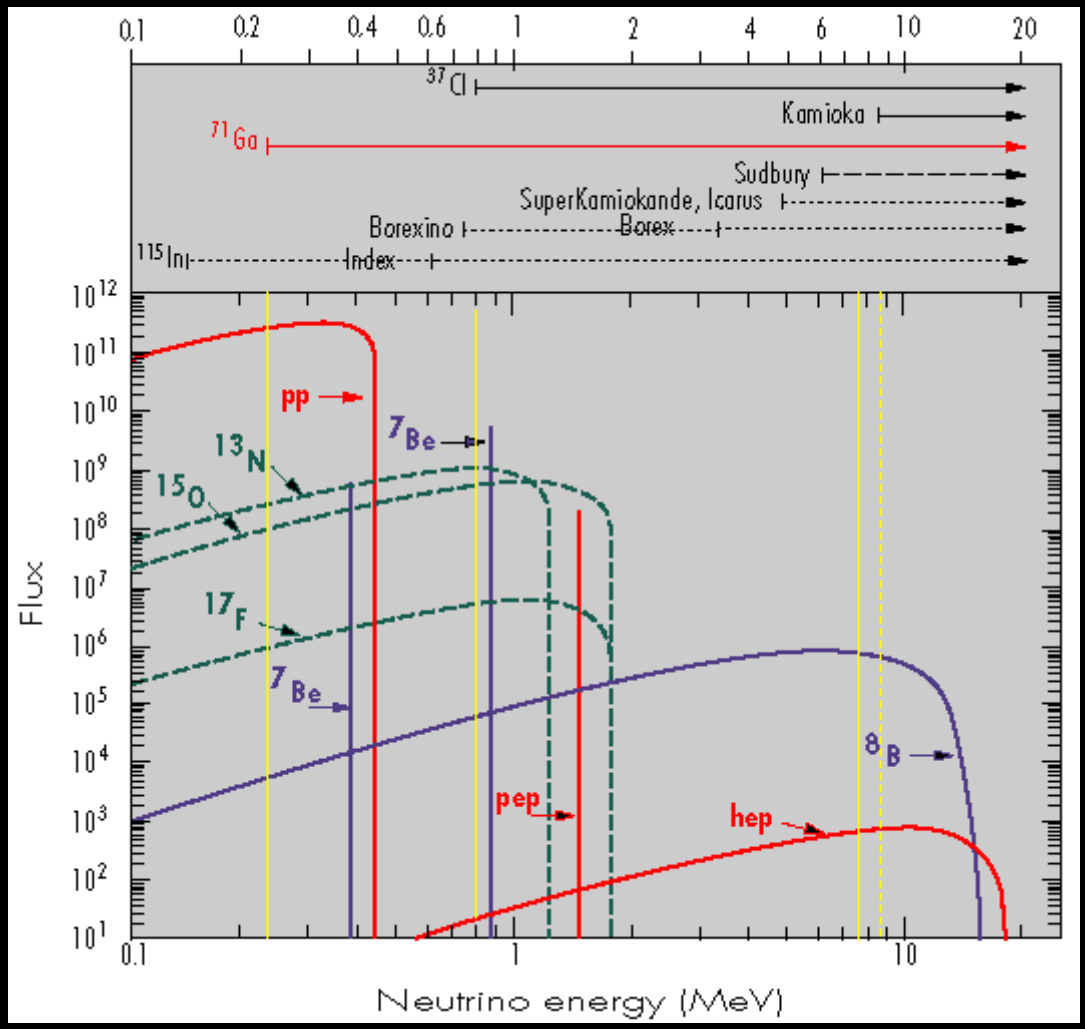
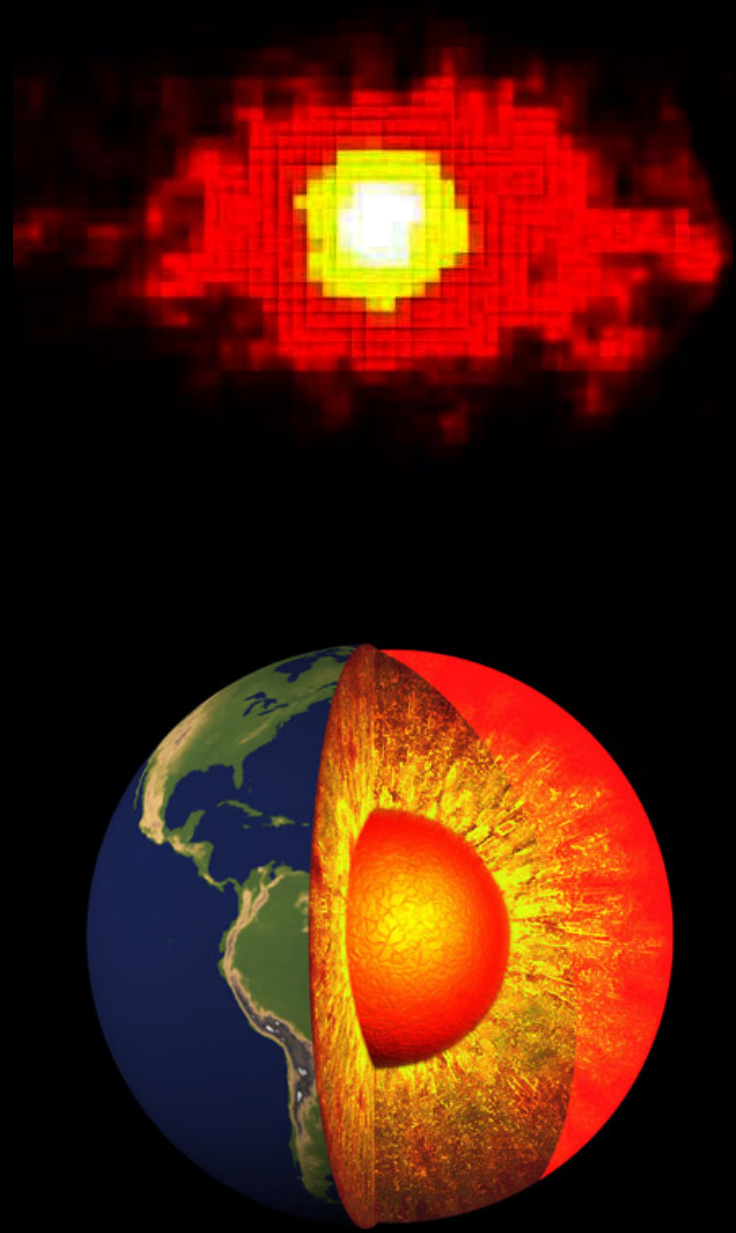


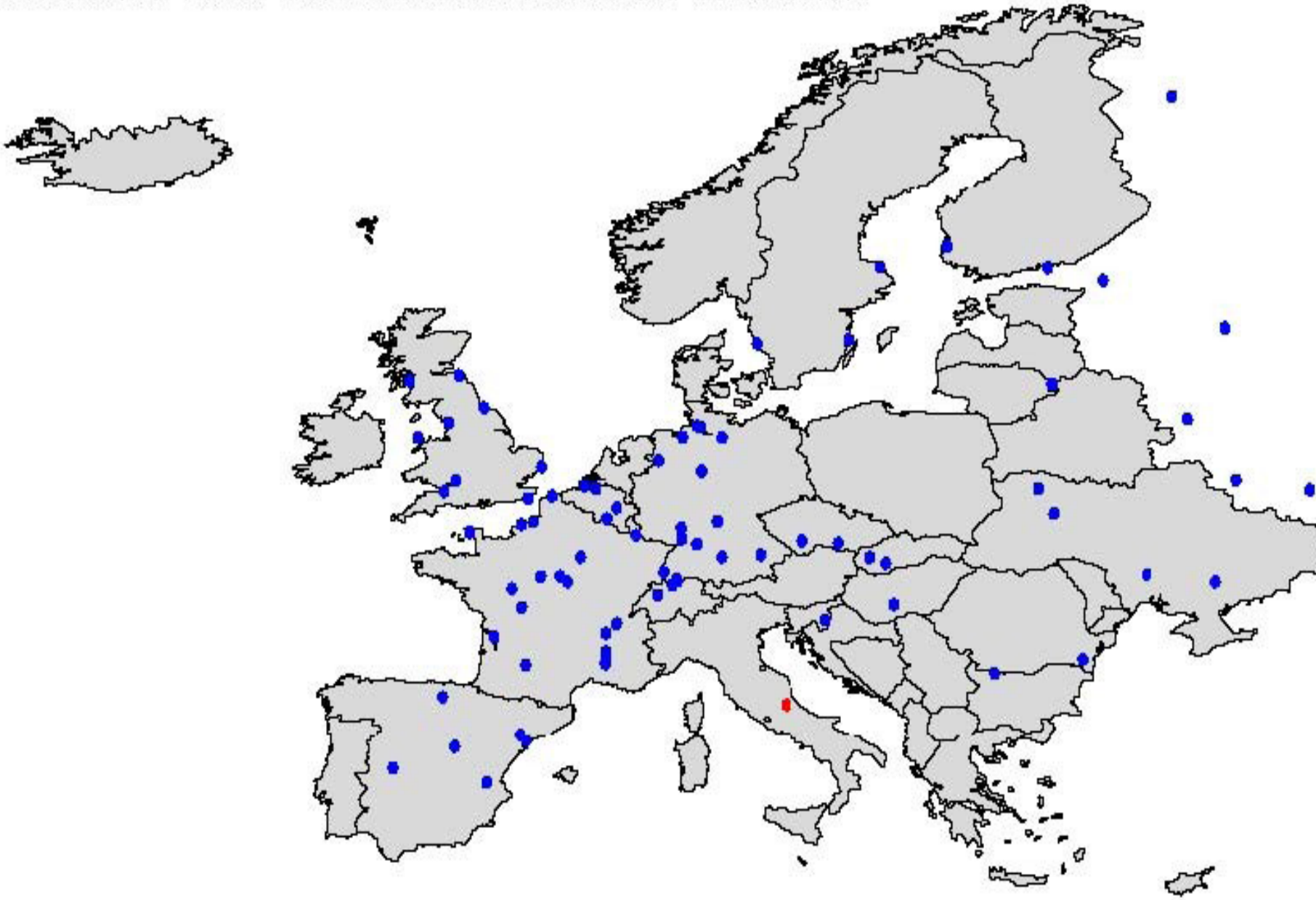

photo: BOREXINO calibration





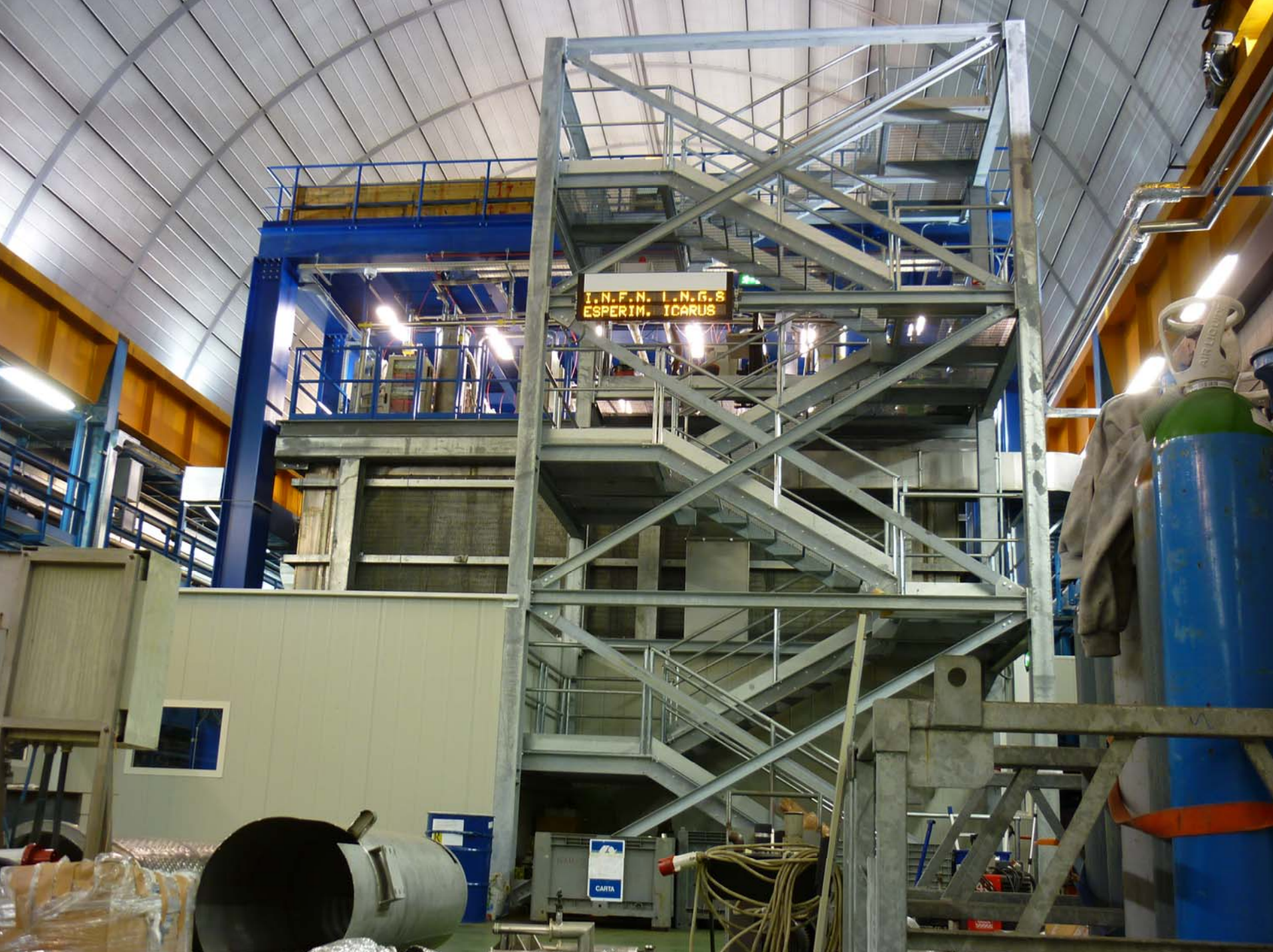
BOREXINO
výzkum procesů probíhajících uvnitř Slunce
výzkum oscilací neutrin
výzkum geoneutrin

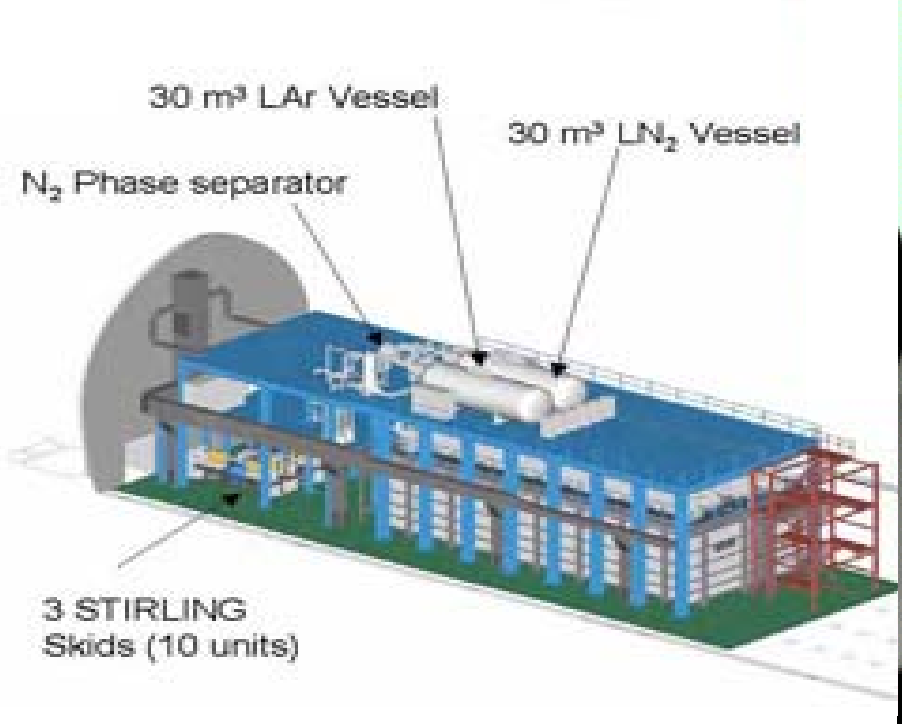
DISTRIBUTION OF EUROPEAN REACTORS CONSIDERED FOR BOREXINO

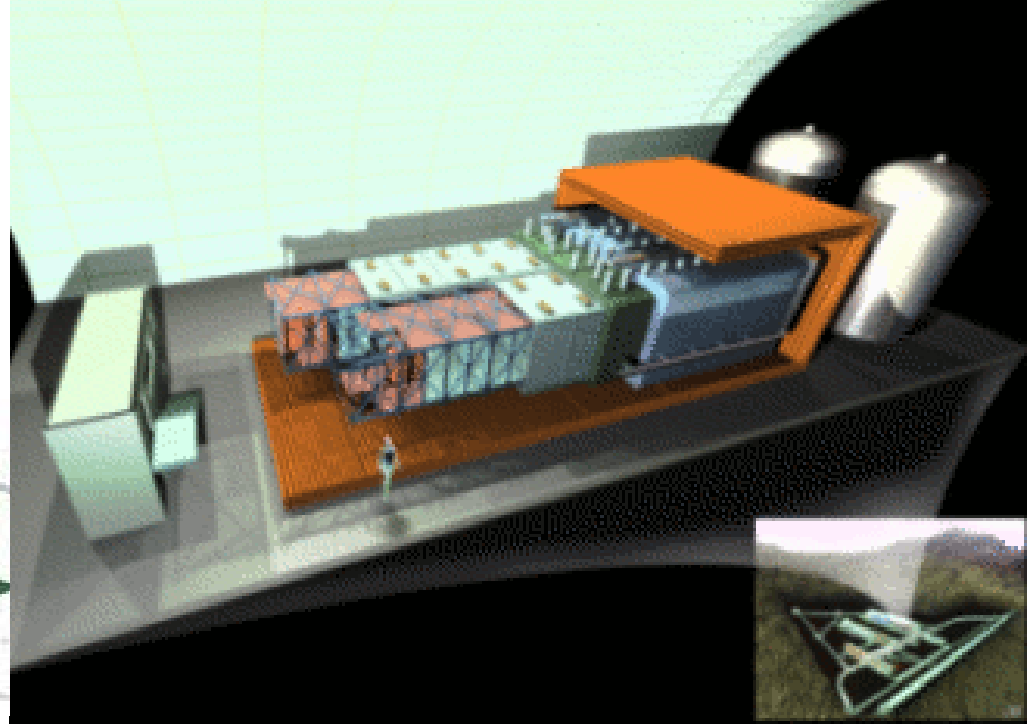


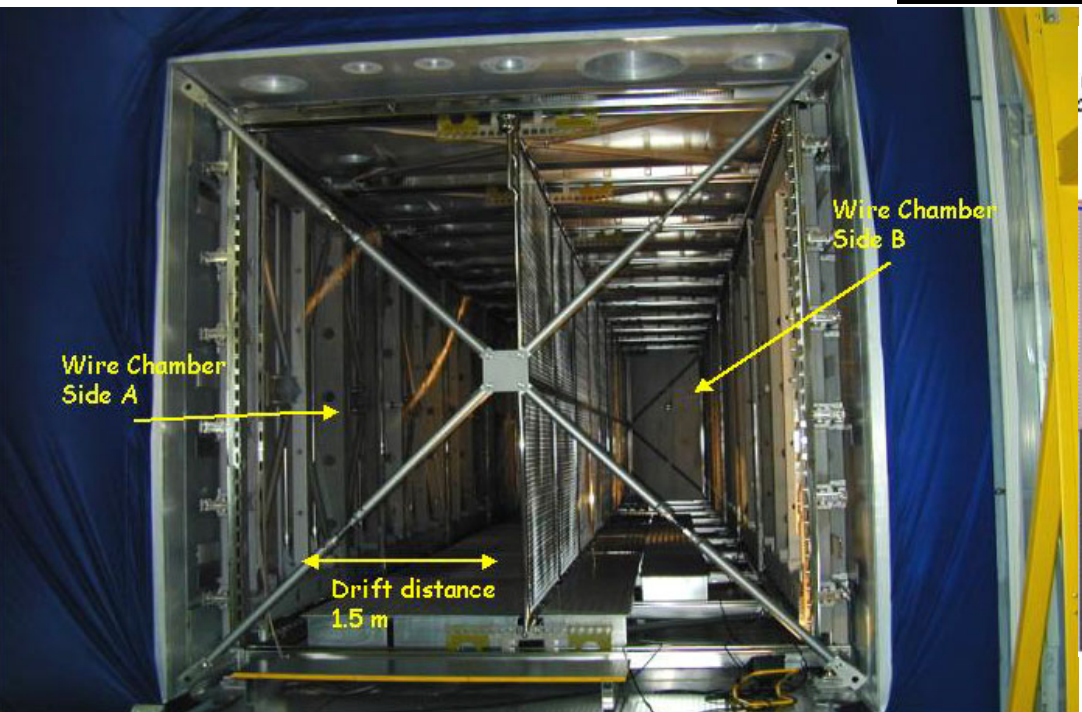
Imaging Cosmic And Rare Underground Signals

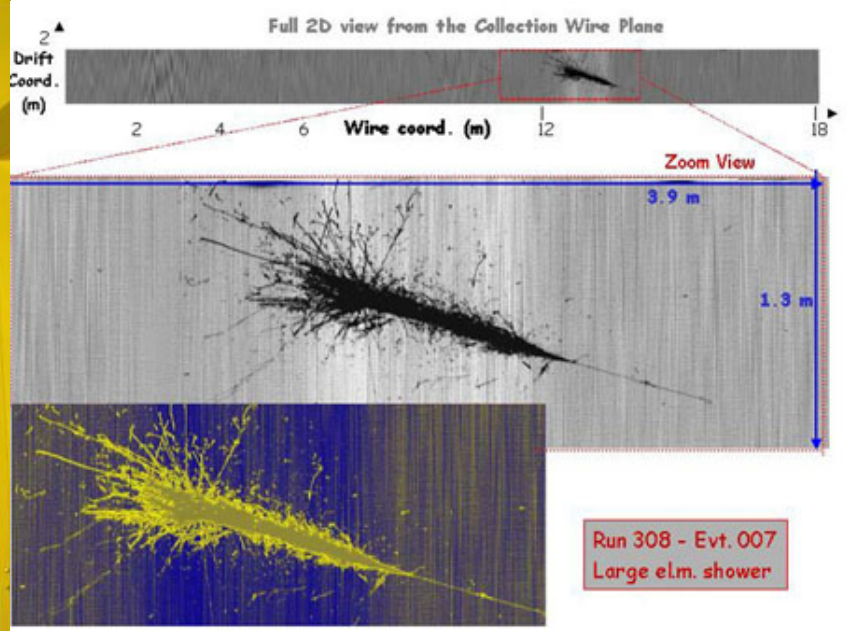
The **ICARUS** program concerns the usage of Liquid Argon (LAr) detector for studies of neutrinos from CNGS beam. The ICARUS detector filled with 600 tons of liquid argon, T600, has started data taking this year (2010).


I.N.F.N. L.N.G.S
ESPERIM. ICARUS
CARTA


30 m³ LAr Vessel
30 m³ LN2 Vessel
N2 Phase separator
3 STIRLING
Skids (10 units)



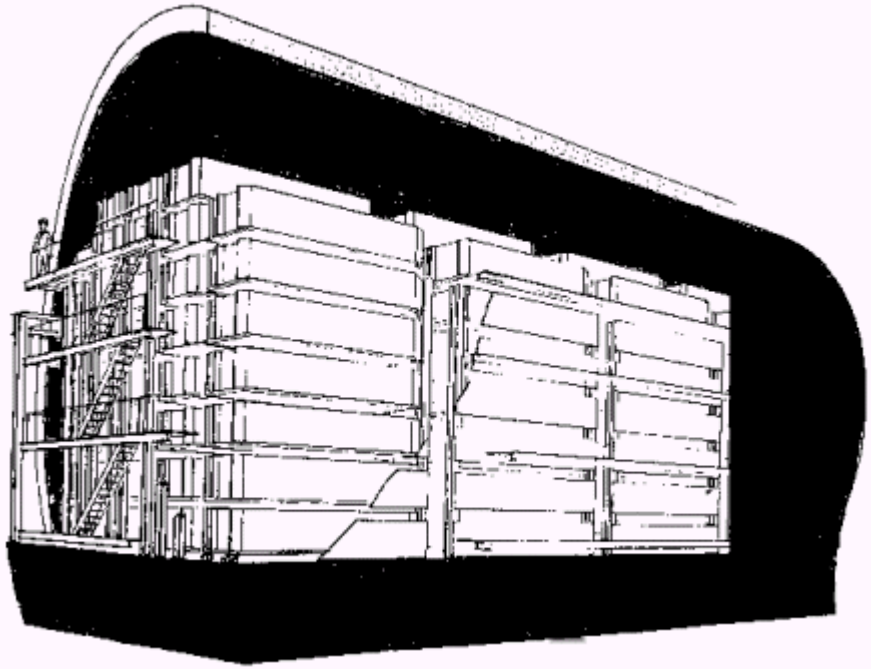

Wire Chamber
Side B
Wire Chamber
Side A
Drift distance
1.5 m


Full 2D view from the Collection Wire Plane
Drift
Coord.
(m)
2
4
6
Wire coord. (m)
12
18
Zoom View
3.9 m
1.3 m
Run 308 - Evt. 007
Large elm. shower

Large Volume Detector

LVD is an array of stainless steel tanks, 1.0x1.0x1.5 m^3, filled with liquid scintillator ($C_n H_{2n+2}$, <n> = 9.6, with r = 0.8 g/ cm^3), rise time 5 ns, attenuation lenght 15 m (l = 420 nm), with the activator POP (1g/l) and the wavelenght shifter POPOP (0.03 g/l). The tanks have their inner surfaces covered with mylar. In its final configuration, the experiment has 840 tanks, with an active mass of ~1.0 kton.
http://www.bo.infn.it/lvd/

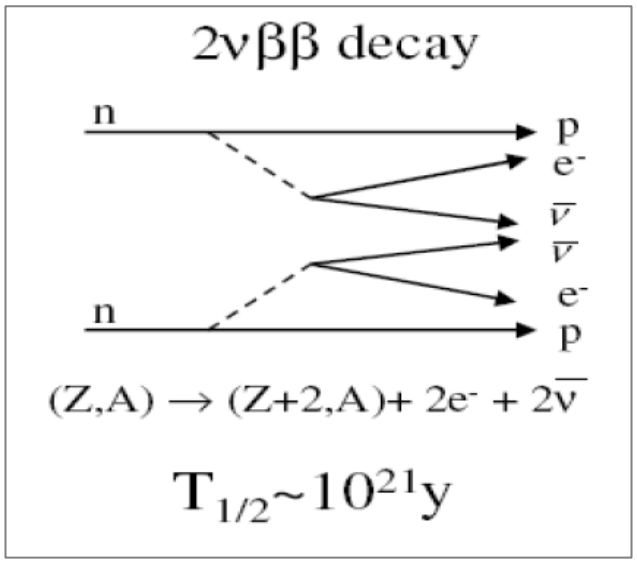

PROJETMANCOM
PORTATA t 40



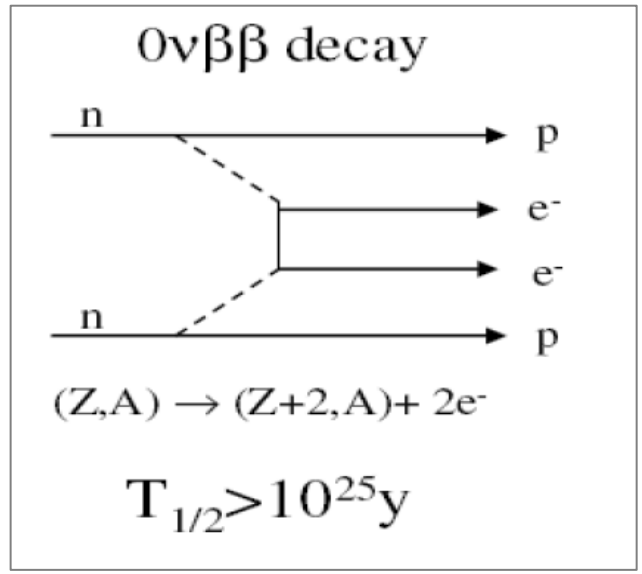
Je neutrino totožné se svou antičásticí?
(žádný takový fermion zatím není znám)
Jakou mají neutrina hmotnost?
$^{76}Ge \rightarrow {}^{76}Se$

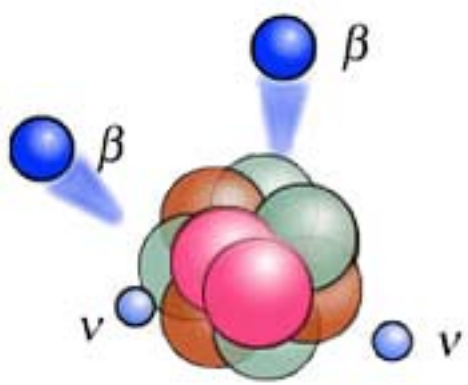
2010: spuštění detektoru
Ge detektory v kapalném argonu
(Ø 4 m) kolem vodní tank (Ø 10 m)

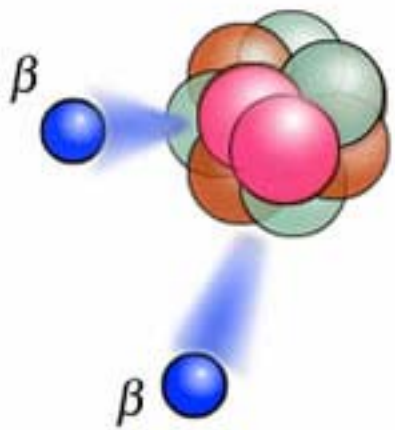
2β rozpad



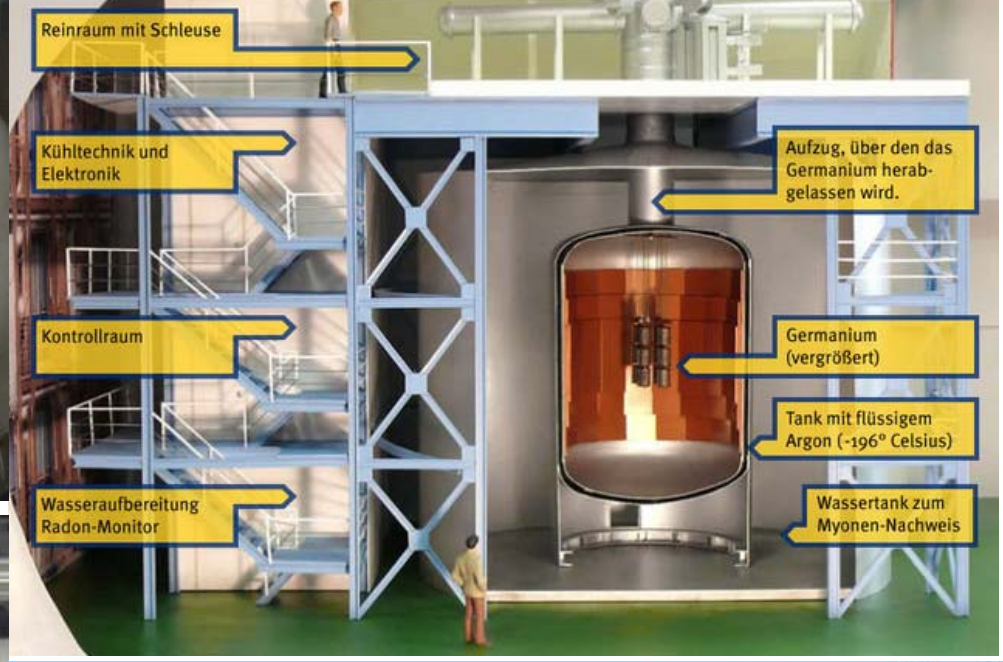
Candidate	Q(MeV)	Abund(%)
$^{48}Ca \rightarrow ^{48}Ti$	4.271	0.187
$^{76}Ge \rightarrow ^{76}Se$	2.040	7.8
$^{82}Se \rightarrow ^{82}Kr$	2.995	9.2
$^{96}Zr \rightarrow ^{96}Mo$	3.350	2.8
$^{100}Mo \rightarrow ^{100}Ru$	3.034	9.6
$^{110}Pd \rightarrow ^{110}Cd$	2.013	11.8
$^{116}Cd \rightarrow ^{116}Sn$	2.802	7.5
$^{124}Sn \rightarrow ^{124}Te$	2.228	5.64
$^{130}Te \rightarrow ^{130}Xe$	2.533	34.5
$^{136}Xe \rightarrow ^{136}Ba$	2.479	8.9
$^{150}Nd \rightarrow ^{150}Sm$	3.367	5.6

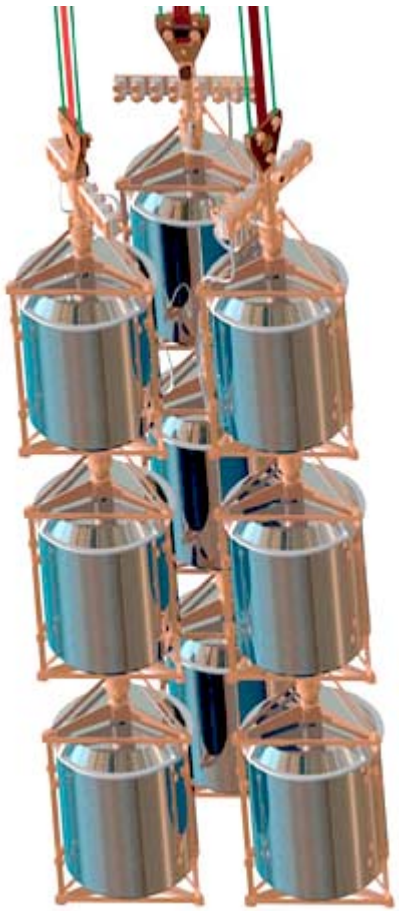


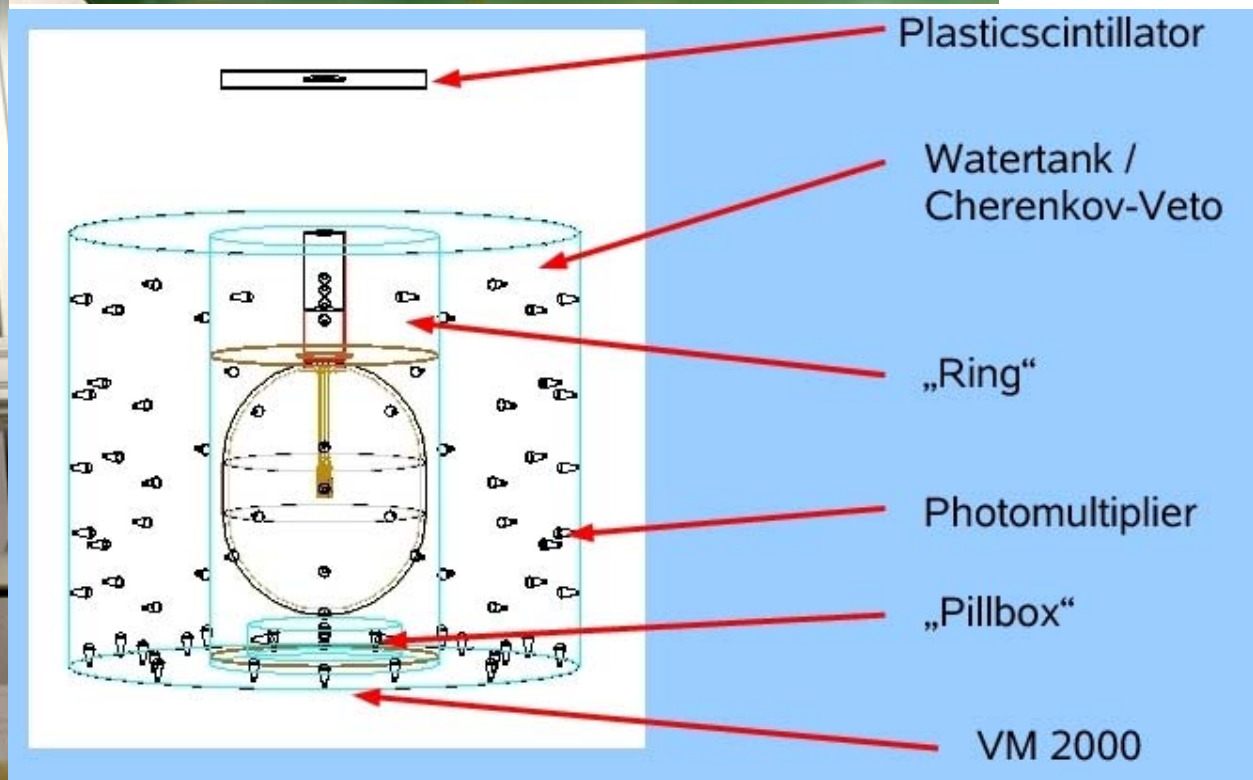





GERDA


Reinraum mit Schleuse
Kühltechnik und Elektronik
Aufzug, über den das Germanium herab-gelassen wird.
Kontrollraum
Germanium (vergrößert)
Tank mit flüssigem Argon (-196° Celsius)
Wasseraufbereitung Radon-Monitor
Wassertank zum Myonen-Nachweis




Plasticscintillator
Watertank / Cherenkov-Veto
„Ring“
Photomultiplier
„Pillbox“
VM 2000


CRESST
Cryostat
Dilution refrigerator
Cold finger
Cold box
Ingresso vietato
presa dati in corso
No entry
measurement running

VIRGO

https://wwwcascina.virgo.infn.it/

VIRGO


VIRGO
CERN