GDR neutrino au LLR

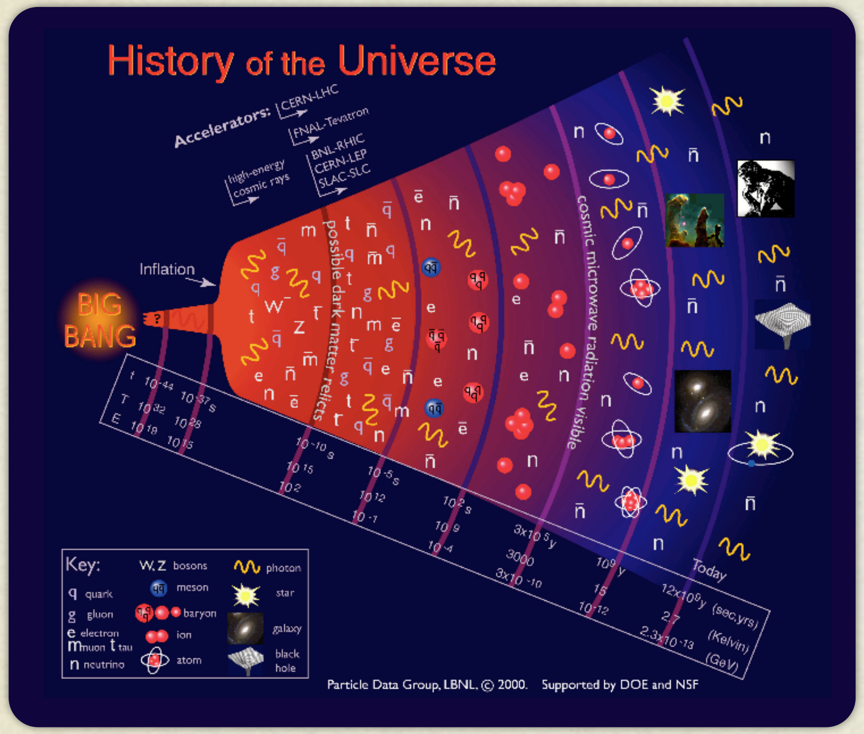
April, 29th-30th 2010

LAGUNA

Michela Marafini

- APC -Paris

FUNDAMENTAL QUESTIONS



The Big Bang origin of the Universe requires matter and antimatter to be equally abundant at the very hot beginning.

1 particle out of 10 billion pairs of particles and anti-particles left over…

$$\eta = \frac{n_b - n_{\bar{b}}}{n_\gamma} \sim 10^{-10}$$

Measured CP baryonic violation is not enough

=> need Lepton CP violation?

..may be..

Lepto-Bariogenesis

Interaction conserve B+L

M. Fukugita and T. Yanagida, Phys. Lett. B 174 (1986) 45

1

The **GUT** need a measure of **proton decay** to be proof

arXiv:hep-ph/0601023v3

ASPERA

"We recommend that a new **large European infrastructure** is put forward, as a future international **multi-purpose facility** on the 10^5-10^6 ton scale for improved studies of:

- proton decay and of
- low-energy neutrinos from astrophysical origin.

The three detection techniques being studied for such large detectors in Europe,
- Water-Čerenkov,
- Liquid Scintillator and
- Liquid Argon,

should be evaluated in the context of a **common design** study which should also address the **underground infrastructure** and the possibility of an eventual detection of **future accelerator neutrino beams**."

The Design Study program for the **LAGUNA** project has been **approved as a whole by the European Commission** (EC).

Support the part of the program which is more difficult to be funded on a national (regional) basis.

1.7 M€ to be mainly devoted to **the sites infrastructure studies**

LAGUNA

Large Apparatus for Grand Unification and Neutrino Astrophysics

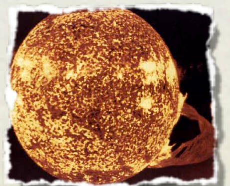
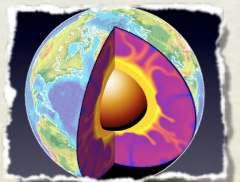
Proton Decay: $p \rightarrow e^+ + \pi^0$

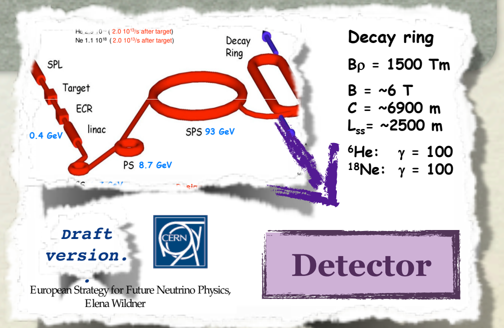
- limit up to 10^{35} y $p \rightarrow K^+ + \bar{\nu}$

Neutrino Physics:

- **supernovae neutrinos (SNB, DSN)**
- atmospheric neutrinos
- solar neutrinos
- **accelerator neutrinos** (SPL, βB, νFactory)
- **geo-neutrinos**

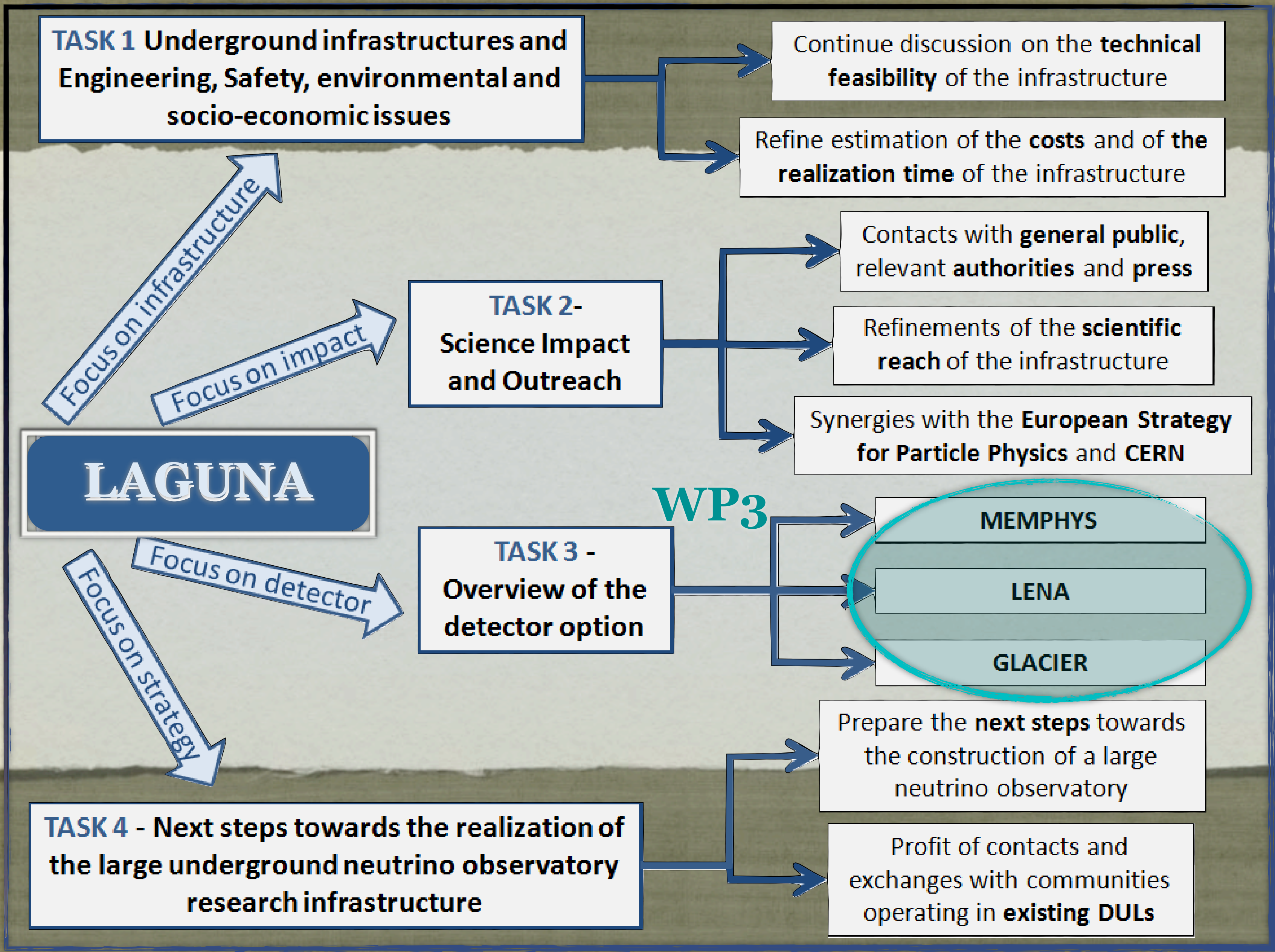




MANAGEMENT

http://laguna.ethz.ch



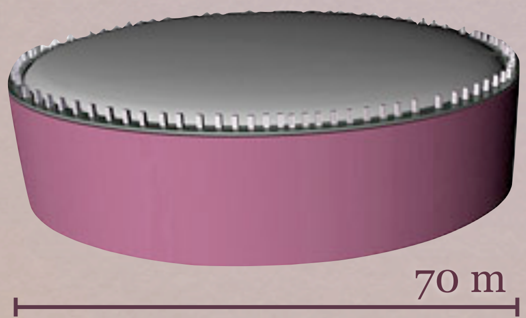
WP3: DETECTORS

Large Apparatus for Grand Unification and Neutrino Astrophysics

GLACIER

Liquid Argon

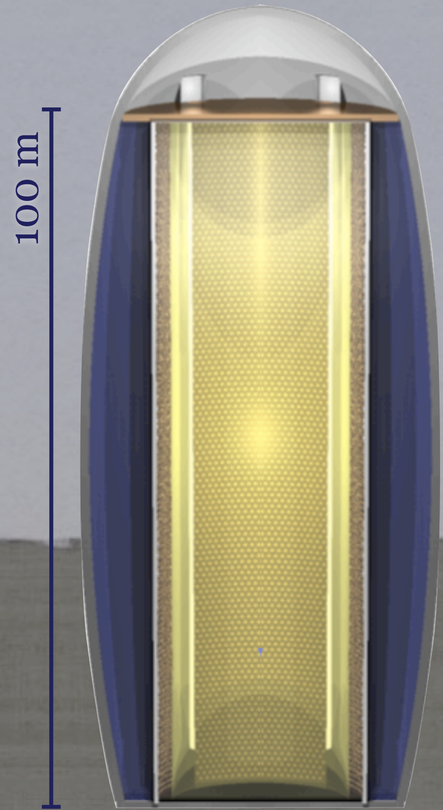
~ 100 ktons fiducial mass



LENA

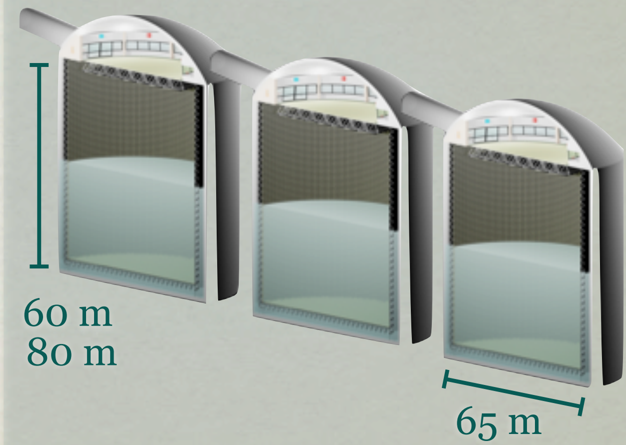
Liquid Scintillator

~ 50 ktons fiducial mass



MEMPHYS

~ 440 ktons fiducial mass
~ 570 ktons fiducial mass



Water Čerenkov

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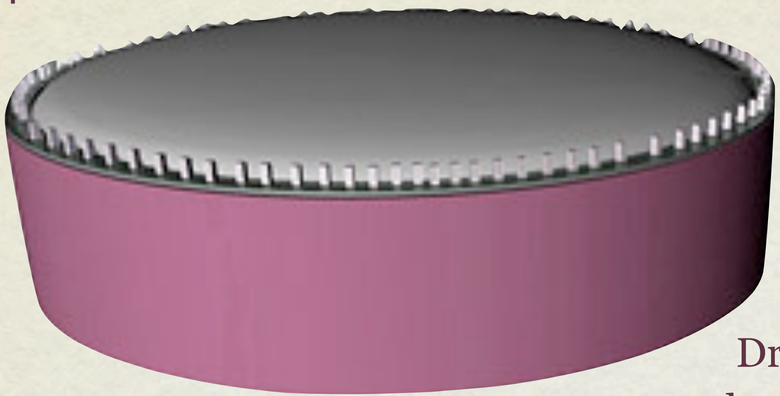
... *In a* 

GLACIER

Liquid Argon TPC

Up to ϕ=70 m

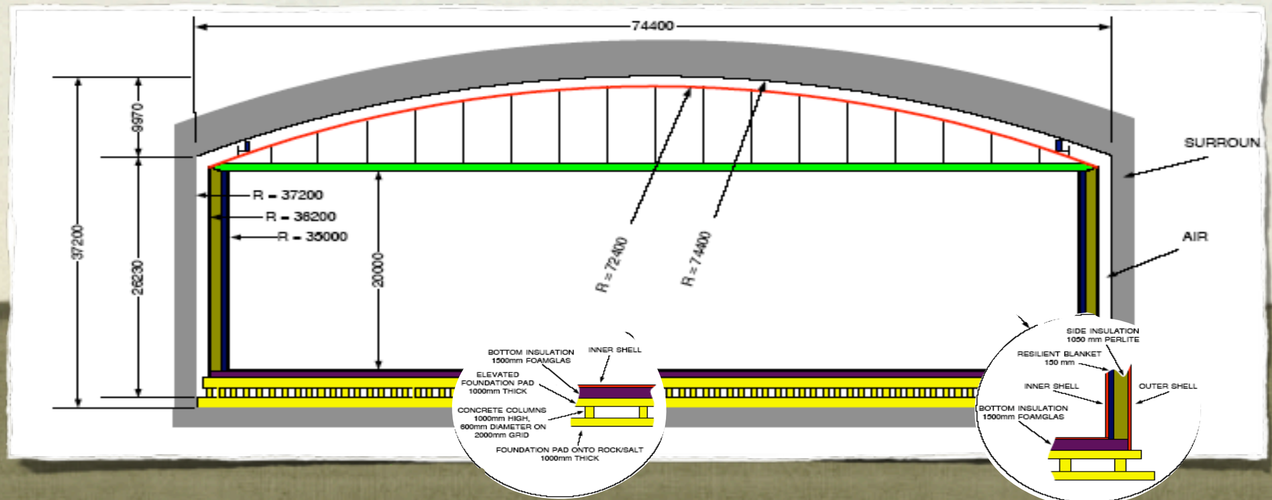


Drift length

h=20 m max

R&D items towards GLACIER

- LAr vessels (Technodyne study)
- Readout devices and electronics
- Argon purity
- High voltage systems
- Synergy with LAr Dark Matter experiments
- Studies for a large magnetized LAr volume



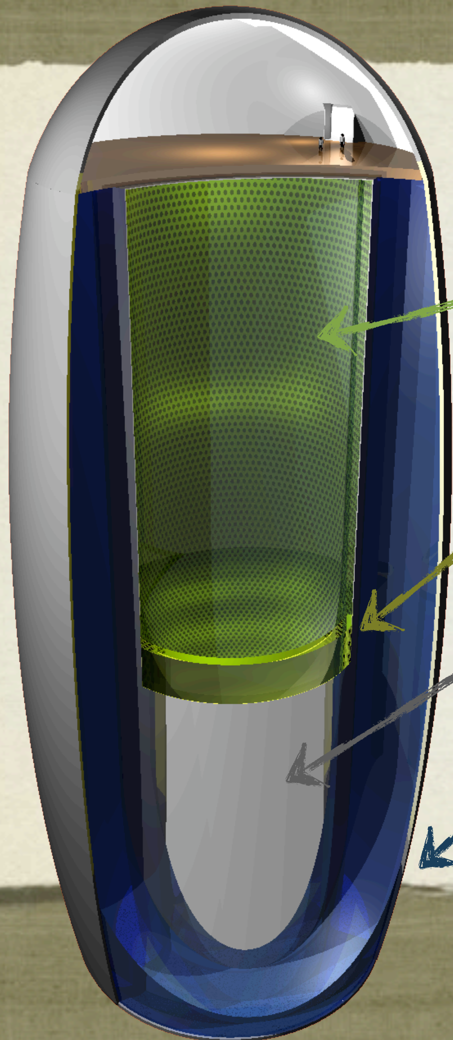
Long Drift performance

A. Rubbia hep-ph/0402110

... *In a* 

LENA

Liquid Scintillator

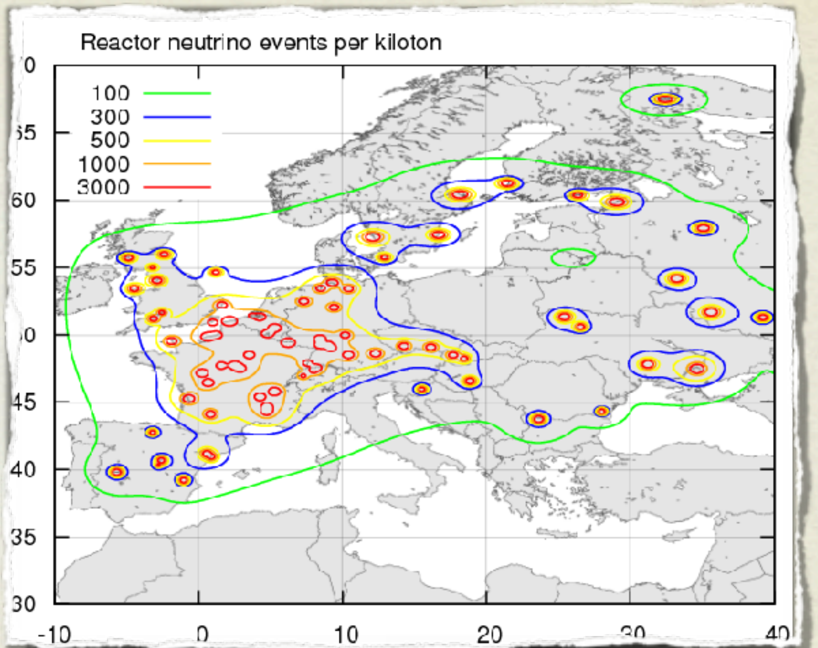


Liquid Scintillator
50 kt PXE / 43kt LAB
contained in an
Inner Nylon Vessel
R = 13m, 150mm thick

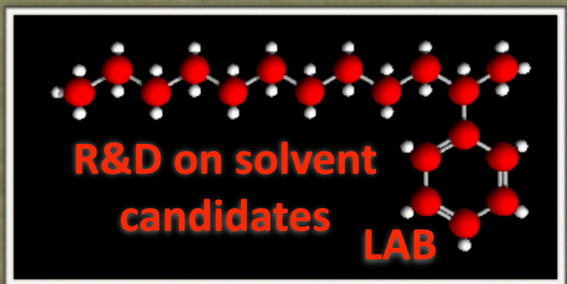
Buffer Region
without fluor, 2m thick

Steel Tank, 13500 PMs
R = 15m, h = 100m

Water Cherenkov Veto
1500 PMs, at least 2m



Low Energy Neutrino Astrophysics

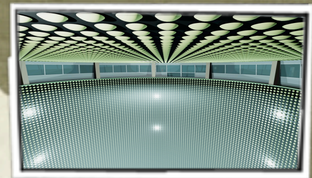


L.Oberauer, F.von Feilitzsch and W.Potzel
Nucl. Phys. Proc. Suppl. 138 (2005) 108

MEMPHYS

Water Čerenkov

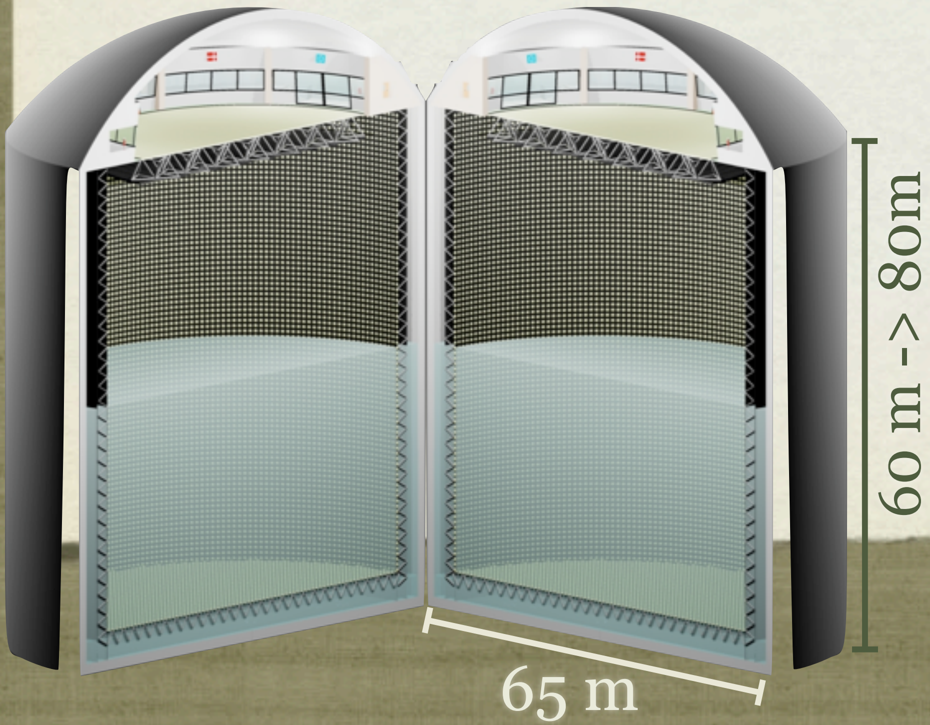
arXiv:hep-ex/0607026



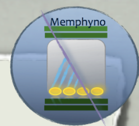
440 -> 570 kton fiducial mass

Np ~ 15 x 10^{34}

Water Čerenkov ("cheap and stable")
Baseline:
- 3 cylindric modules 60 x 65 m;
- Size limited by: attenuation length and pressure on the PMTs;
- Readout: 12"-10" PMTs, 30% geom. coverage



MEMPHYNO PROTOTYPE



- **Full test of NEW "electronic and acquisition" chain;**
- **Trigger threshold study**
- **Self-trigger mode**
- **Track reconstruction performances;**
- **Gd doping: flexibility and performance.**

TEST BENCH for photodetection and electronic solutions for LARGE detectors

LAGUNA

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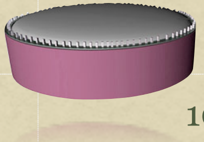
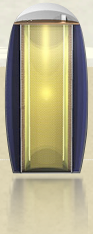
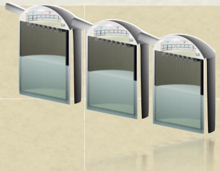
WP3: DETECTORS

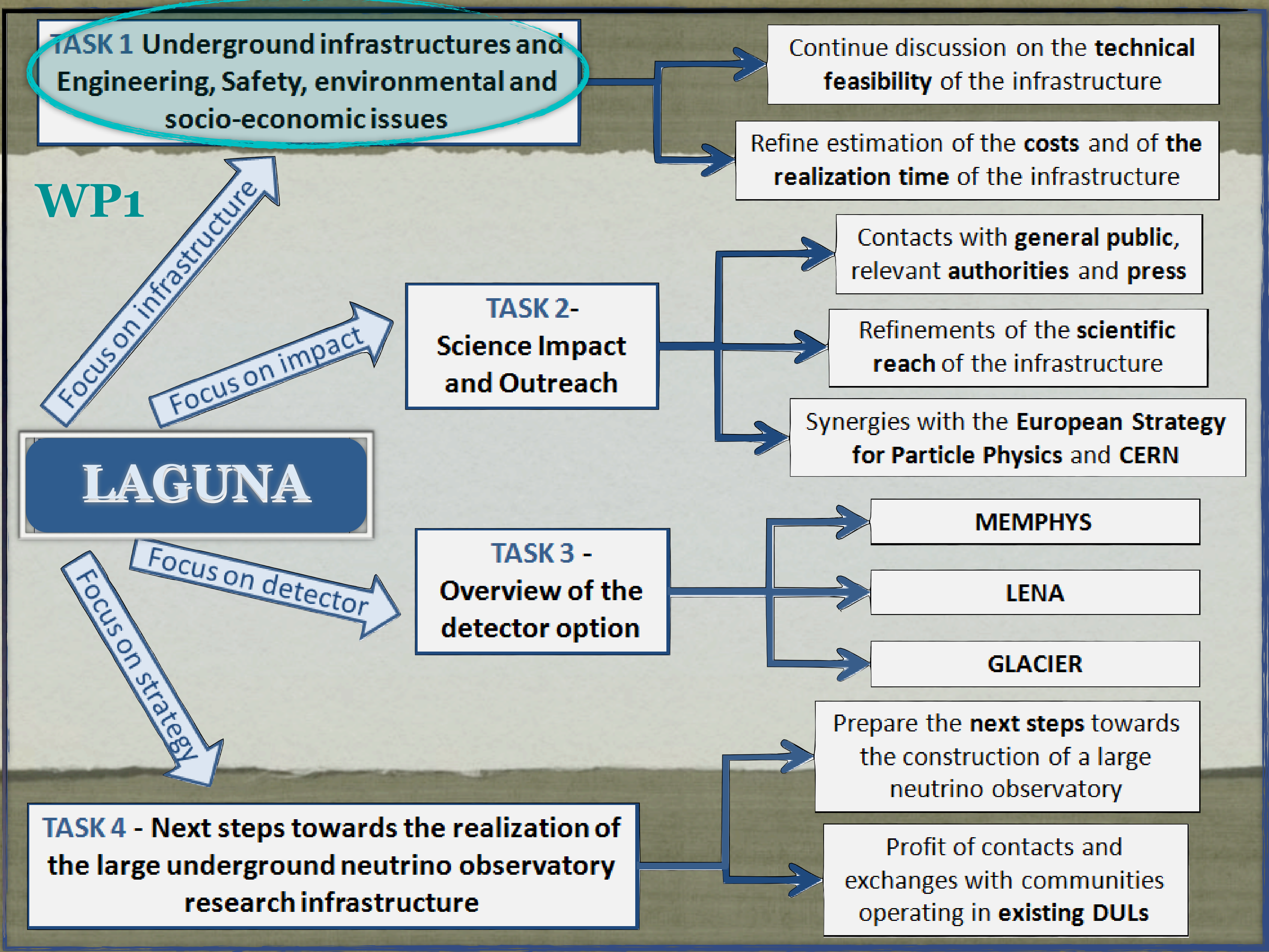
Complementarity between the techniques

Outstanding physics goals

	 GLACIER	 LENA	 MEMPHYS
Total mass	100 Kton	50 kton	500 Kton
p -> $e\pi^0$ in 10 y	0.5×10^{35} y ε = 45%, ~1 BG event	?	1.2×10^{35} y ε = 17%, ~1 BG event
p -> ν K in 10 y	1.1×10^{35} y ε = 97%, ~1 BG event	0.4×10^{35} y ε = 65%, <1 BG event	0.15×10^{35} y ε = 8.6%, ~30 BG events
SN cool off at 10 Kpc	38·500 (all flavors) (64·000 if NH-L mixing)	20·000 (all flavors)	194·000 (mostly $\nu_e p \to e^+ n$)
Sn in Andromeda	7 - (12 if NH-L mixing)	4 events	40 events
SN burst at 10 Kpc	380 ν_e CC (flavor sensitive)	~ 30 events	~ 250 ν-e elastic scattering
DSN	50	20-40	250 (2500 with Gd)
Atm. neutirnos	~1·100 events/y	5600 events/y	56·000 events/y
Solar neutrinos	324·000 events/y	?	91·250·000/y
Geo-neutirnos	0	~ 3·000 events/y	0

MANAGEMENT

http://laguna.ethz.ch



WP1: LOCATIONS

http://laguna.ethz.ch

7 proposed locations

FINLAND

Pyhäsalmi Mine is located in Pyhäjärvi (Holy Lake), 450 km north of Helsinki and 150 km south of Oulu, has expressed its interest to be chosen as one of the locations for the underground laboratory. It is the oldest operating metal mine in Finland and the deepest in Europe, and is currently owned by Inmet Mining Corporation (Canada). The hard and very old bedrock of Finland provides one of the best locations to dig very large and deep caverns for the LAGUNA detectors. A small cosmic ray experiment (EMMA) is already located in the mine.

FRANCE

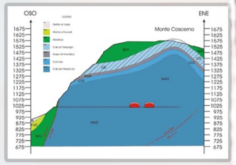
An underground laboratory LSM "Laboratoire Souterrain de Modane", is presently located along the Fréjus road tunnel between France and Italy. This laboratory, in operation since 1982, is hosting two particle physics experiments requiring an extremely low-background environment to study neutrino properties and looking for Dark Matter. The extension of the laboratory considers the construction of very large underground caverns to host the LAGUNA detectors.

GREAT BRITAIN

Boulby is a salt, potash and other minerals mine located in Cleveland North East England, on the coast, 20 km north of the town of Whitby. The mine is run by Cleveland Potash Ltd. Opened in 2003, the Parker underground laboratory, at 1100 m depth and with 1000 m² of space, has housed a series low background particle physics experiments aimed at searches for Dark Matter. The possibility for LAGUNA arises because of a new commitment by the mine to extend workings to deeper levels that will give access to strong, hard rock, notably dolomite and anhydrite, that have potential to sustain the envisioned large caverns.

ITALY

his site located in a mountain relief in the area of Valnerina (Nera River Valley) in Umbria, was chosen to allow in addition detection of the existing neutrino beam from CERN (Geneva) to LNGS (Gran Sasso National Laboratory. The laboratory will be dug under a mountain with a slope, which permit a large overburden with a horizontal access tunnel. The Umbria site was selected for absence of significant groundwater circulation in the rock mass and protecting wildlife and environmentally controlled area.

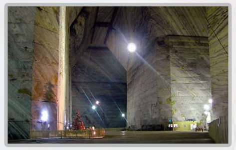


POLAND

The Polkowice-Sieroszowice mine is located in the south-western Poland, 90 km NW of Wroclaw. The mine belongs to KGHM Polska Miedź S.A. – the holding of copper ores mines and metallurgic plants. The mine is operating within tectonically stable and good quality hard rock consisting of dolomites and anhydrites, and locally of saltrock. Anhydrite layers provide excellent conditions for locating the LAGUNA laboratory.

ROMANIA

Slanic-Prahova is located in the outer Carpathians area (Prahova County), 40 km NE of Ploieşti in Romania. The Unirea salt mine, one of the Slanic mines, is administrated by SALROM SA. Very large caverns 30m wide and 35m high, dug in salt, are presently existing and a low background laboratory was successfully installed in one of the caverns. A new dedicated cavern dug in salt would be prepared for the LAGUNA project.



SPAIN

The Canfranc Underground Laboratory (LSC, "Laboratorio Subterráneo de Canfranc") is located in the Spanish side of the Pyrenees, under the mountain of "El Tobazo" and has an ongoing particle physics programme aimed at very low background experiments for the studies of neutrino properties and search for Dark Matter. The current laboratory can be accessed via the roadway or railway tunnels. The extension of the laboratory considers the excavation of very large underground caverns to host the LAGUNA detectors.

7 underground site candidates

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LAGUNA

http://laguna.ethz.ch

LAGUNA@BOULBY

BOULBY Potash - Salt Mine
Underground Laboratory

Great Britain

1050 Km form CERN
1400 m depth

- ☑ GLACIER
- ☑ LENA
- ☐ MEMPHYS

Laguna Meeting - December, 8th 2009

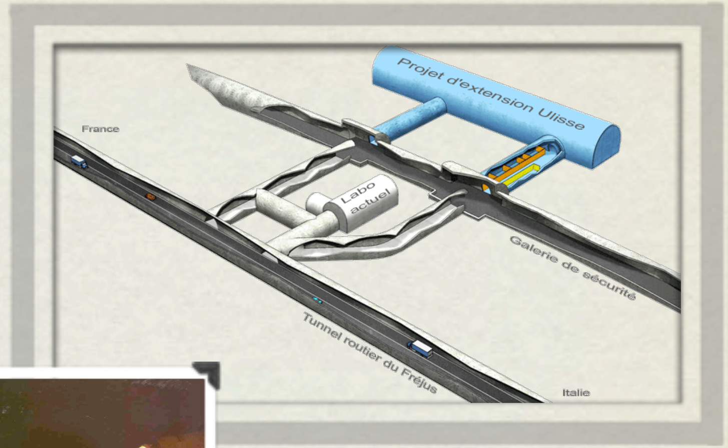
LAGUNA@LSM

Laboratoire Souterrain de Modane

France

130 Km form CERN
4800 w.m.e. depth

- ☑ GLACIER
- ☑ LENA
- ☑ MEMPHYS



ULISSE: extension program

M. Marafini - APC -Paris

LAGUNA@LSC

http://laguna.ethz.ch

Laboratorio Subterraneo
de Canfranc

Spain

630 Km from CERN
900 m depth

- ☑ GLACIER
- ☑ LENA
- ☑ MEMPHYS

Laguna Meeting: right now!!!!

LAGUNA@PYHÄSALMI

http://laguna.ethz.ch

CENTRE FOR UNDERGROUND PHYSICS IN PYHÄSALMI MINE

Pyhäsalmi Mine
Center of Underground physics

Finland

2300 Km form CERN

- ☑ GLACIER: 2500 w.m.e.
- ☑ LENA: 4000 w.m.e.
- ☑ MEMPHYS: 3000 w.m.e.

Laguna Meeting - September, 2nd 2009

LAGUNA

LAGUNA@SUNLAB

http://laguna.ethz.ch

SUNLAB - Salt Mine

Poland

950 Km form CERN

- [x] GLACIER: 600-1100 m
- [x] LENA: 1370 m horiz.
- [ ] MEMPHYS

Laguna Meeting - March, 31st 2009

LAGUNA@UNIREA

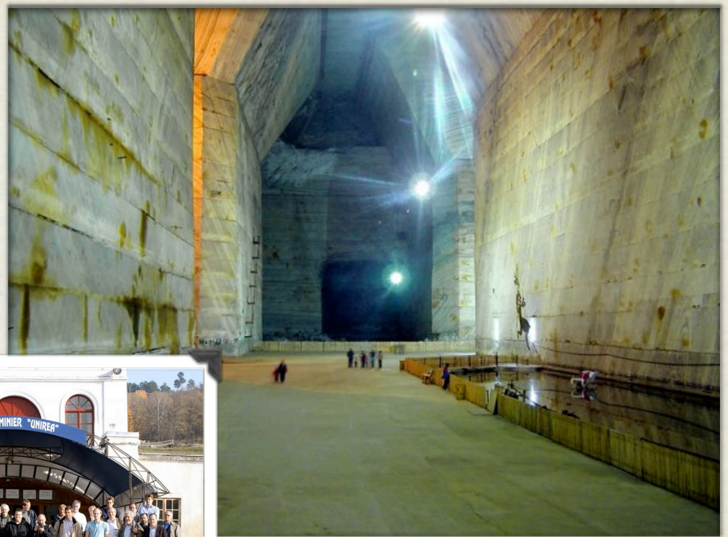
http://laguna.ethz.ch

UNIREA - Salt Mine

Romania

1456 Km form CERN
1600-750 w.m.e. depth

- ☑ GLACIER
- ☐ LENA
- ☐ MEMPHYS



Laguna Meeting - November 2008

LAGUNA@CASO

http://laguna.ethz.ch

CASO: Umbria
green field

Italy

659 Km form CERN
600 m

- ☑ GLACIER
- ☐ LENA
- ☐ MEMPHYS

WP1: LOCATIONS

http://laguna.ethz.ch

Site	Distance from CERN	Type of detector: Glacier	Lena	Memphys
Boulby (UK)	1050 Km	1400 m	? 1400 m	no
Canfranc (Spain)	630 Km	900 m	875 m	530 m
Fréjus (France/Italy)	130 Km	4800 mwe	4800 mwe	4800 mwe
Pyhäsalmi (Finland)	2300 Km	2500 mwe	4000 mwe	3000 mwe
Slanic (Romania)	1546 Km	600 -750 mwe	no	no
Sunlab (Poland)	950 Km	600-1100 m	? 1370 m	no
Umbria (Italy)	659 Km	600 m (?)	no	no

MANAGEMENT

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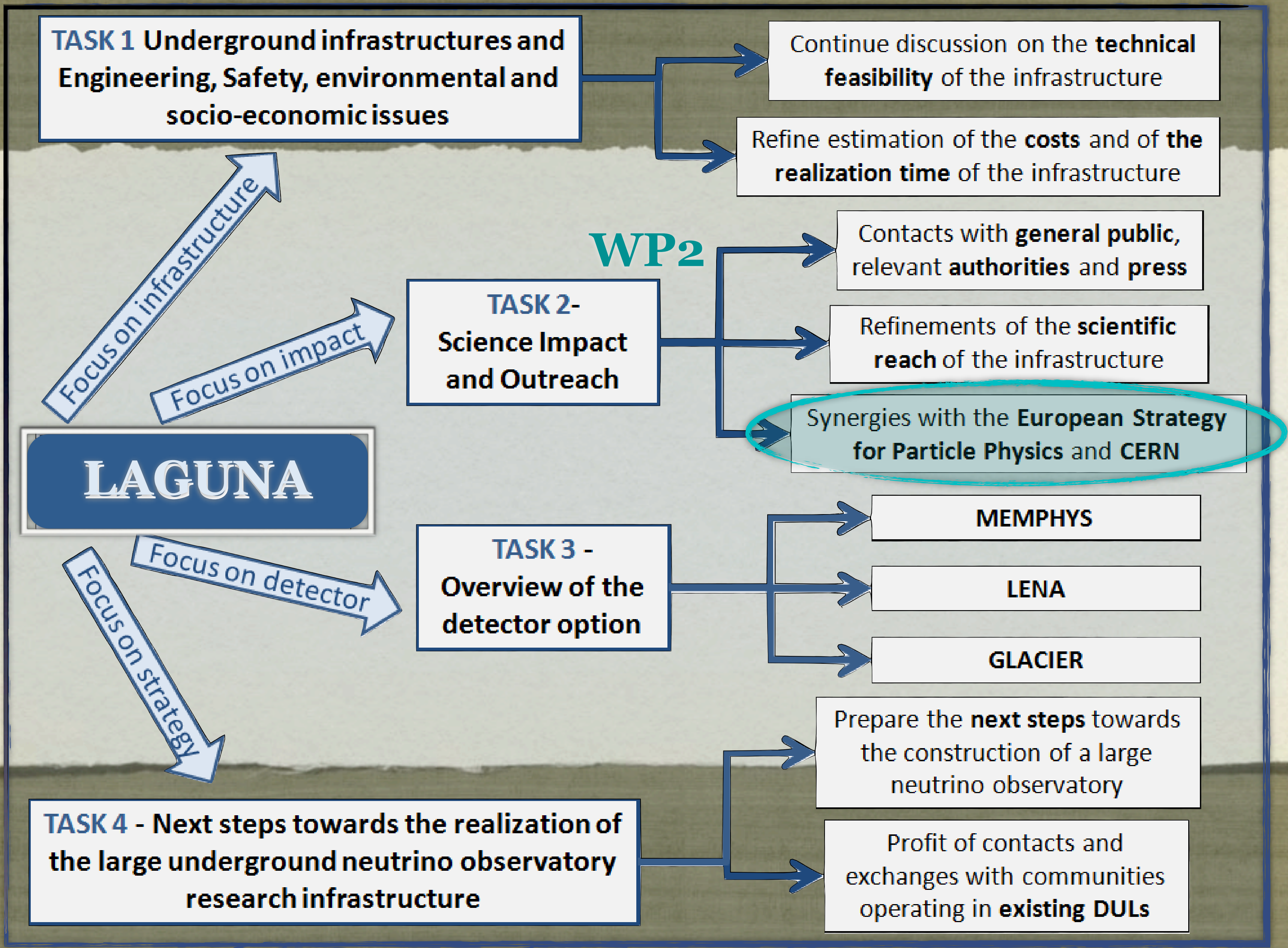
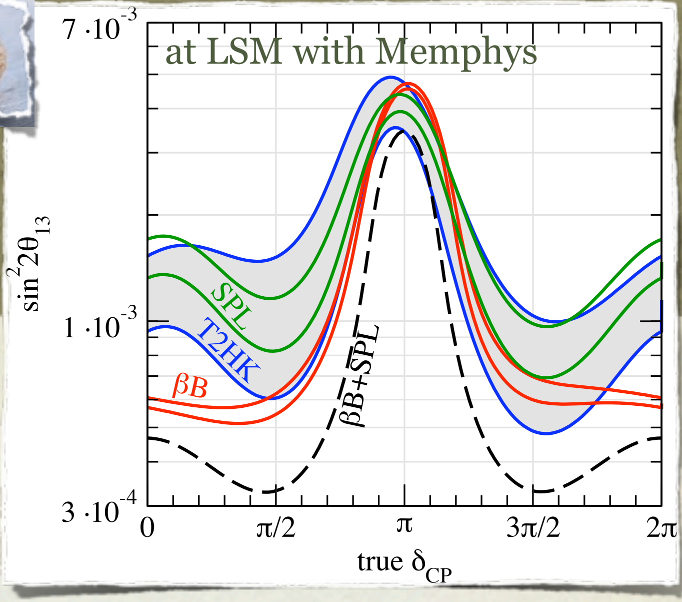


WP2: OUTREACH

... *In a* 

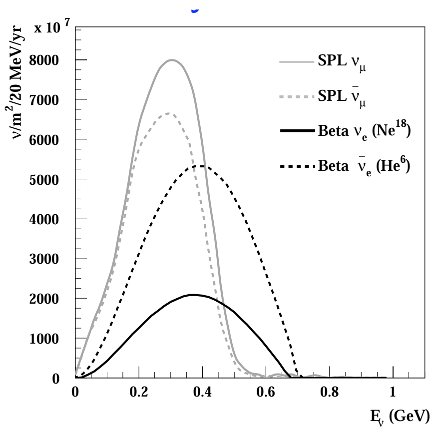


hep-ph/0603172

EUROnu

Possible realization of a neutrino beam in Europe at CERN. Study of performances at the different underground sites.

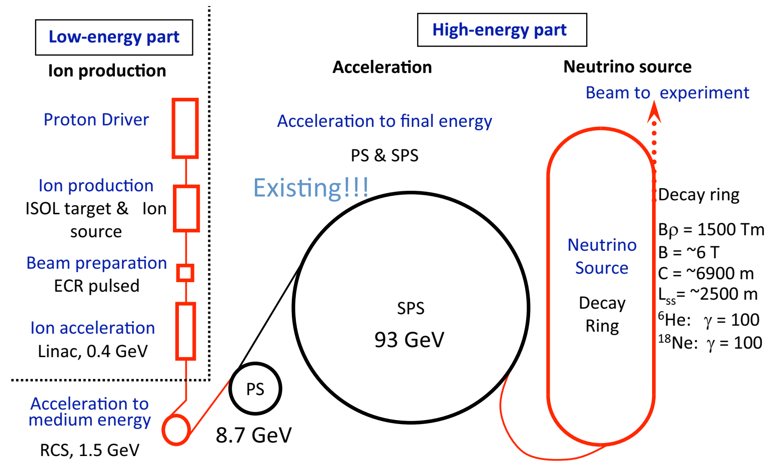
SuperBeams - SPL ν beam at CERN



- A 3.5 GeV, 4MW Linac: the SPL.
- A liquid mercury target station (or maybe Carbon, following A. Longhin recent studies) capable to manage the 4 MW proton beam. R&D required.
- A conventional neutrino beam optics capable to survive to the beam power, the radiation and the mercury. Already prototyped.
- A sophisticated close detector to measure signal and backgrounds.
- A megaton class detector under the Frejus, L=130 km: Memphys.

Beta Beam (P. Zucchelli: Phys. Lett. B532:166, 2002)

M. Lindroos M. Mezzetto, "Beta Beams", Imperial College Press, 2009



- $\overline{\nu}_e$ generated by He^6, 100 μA, $\Rightarrow 2.9 \cdot 10^{18}$ ion decays/straight session/year.
- ν_e generated by Ne^{18}, 100 μA, $\Rightarrow 1.1 \cdot 10^{18}$ ion decays/straight session/year.

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LAGUNA

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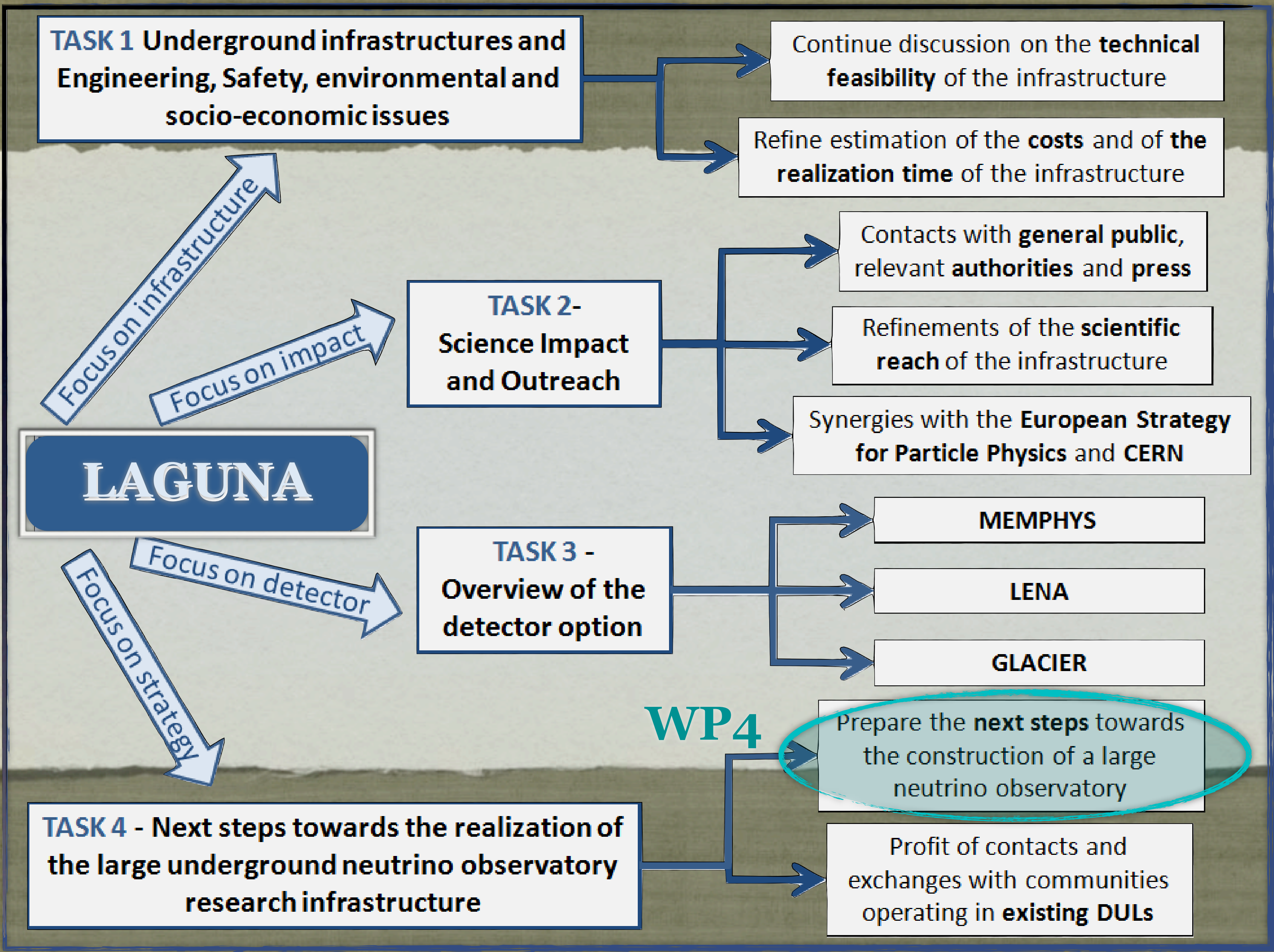
MANAGEMENT


TASK 1 Underground infrastructures and Engineering, Safety, environmental and socio-economic issues
Continue discussion on the technical feasibility of the infrastructure
Refine estimation of the costs and of the realization time of the infrastructure
Focus on infrastructure
Focus on impact
TASK 2- Science Impact and Outreach
Contacts with general public, relevant authorities and press
Refinements of the scientific reach of the infrastructure
Synergies with the European Strategy for Particle Physics and CERN
LAGUNA
Focus on detector
Focus on strategy
TASK 3 - Overview of the detector option
MEMPHYS
LENA
GLACIER
WP4
Prepare the next steps towards the construction of a large neutrino observatory
TASK 4 - Next steps towards the realization of the large underground neutrino observatory research infrastructure
Profit of contacts and exchanges with communities operating in existing DULs

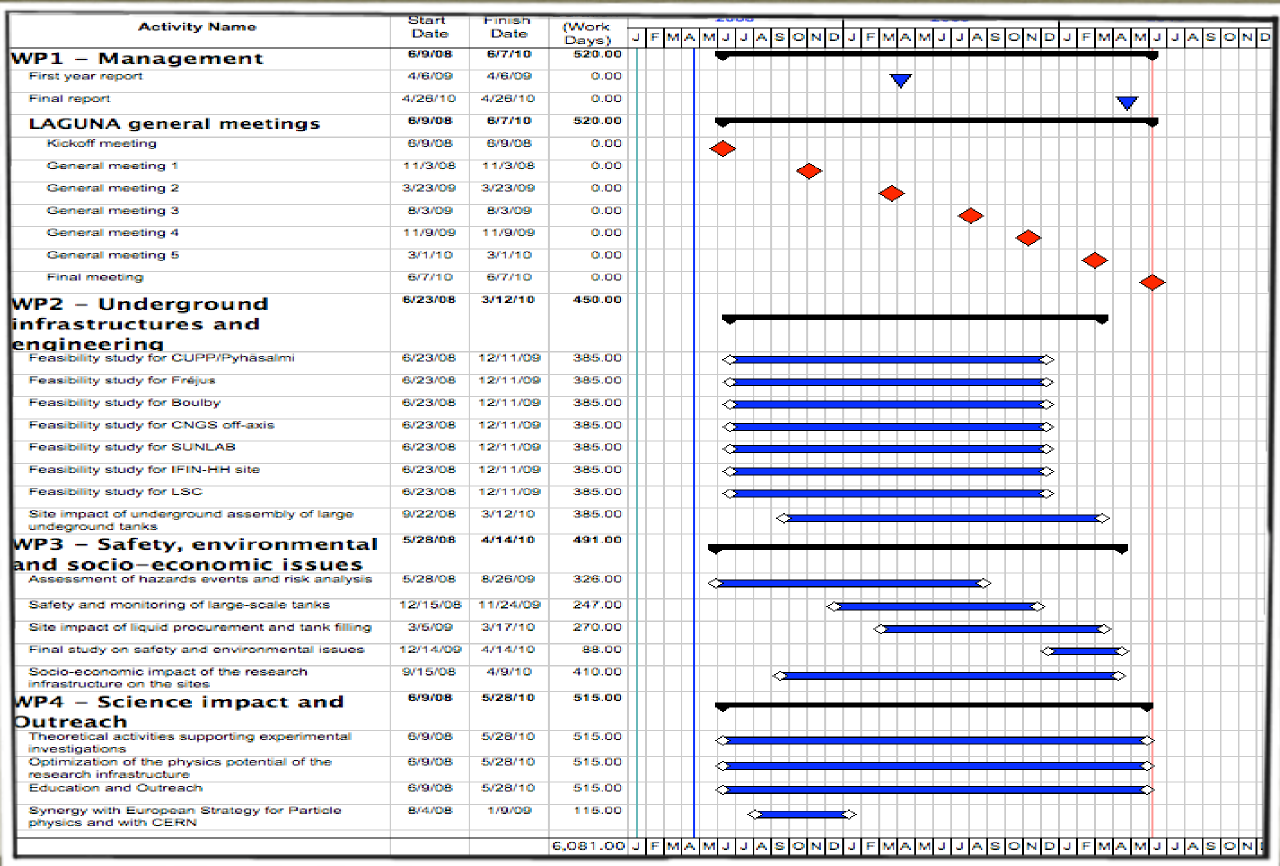
TIME SCALE

WP1 Management

WP2 Underground infrastructure and engineering

WP3 Safety, environmental and socio-economic issues

WP4 Science impact and Outreach



Activity Name	Start Date	Finish Date	(Work Days)
WP1 – Management	**6/9/08**	**6/7/10**	**520.00**
First year report	4/6/09	4/6/09	0.00
Final report	4/26/10	4/26/10	0.00
LAGUNA general meetings	**6/9/08**	**6/7/10**	**520.00**
Kickoff meeting	6/9/08	6/9/08	0.00
General meeting 1	11/3/08	11/3/08	0.00
General meeting 2	3/23/09	3/23/09	0.00
General meeting 3	8/3/09	8/3/09	0.00
General meeting 4	11/9/09	11/9/09	0.00
General meeting 5	3/1/10	3/1/10	0.00
Final meeting	6/7/10	6/7/10	0.00
WP2 – Underground infrastructures and engineering	**6/23/08**	**3/12/10**	**450.00**
Feasibility study for CUPP/Pyhäsalmi	6/23/08	12/11/09	385.00
Feasibility study for Fréjus	6/23/08	12/11/09	385.00
Feasibility study for Boulby	6/23/08	12/11/09	385.00
Feasibility study for CNGS off-axis	6/23/08	12/11/09	385.00
Feasibility study for SUNLAB	6/23/08	12/11/09	385.00
Feasibility study for IFIN-HH site	6/23/08	12/11/09	385.00
Feasibility study for LSC	6/23/08	12/11/09	385.00
Site impact of underground assembly of large undeground tanks	9/22/08	3/12/10	385.00
WP3 – Safety, environmental and socio–economic issues	**5/28/08**	**4/14/10**	**491.00**
Assessment of hazards events and risk analysis	5/28/08	8/26/09	326.00
Safety and monitoring of large-scale tanks	12/15/08	11/24/09	247.00
Site impact of liquid procurement and tank filling	3/5/09	3/17/10	270.00
Final study on safety and environmental issues	12/14/09	4/14/10	88.00
Socio-economic impact of the research infrastructure on the sites	9/15/08	4/9/10	410.00
WP4 – Science impact and Outreach	**6/9/08**	**5/28/10**	**515.00**
Theoretical activities supporting experimental investigations	6/9/08	5/28/10	515.00
Optimization of the physics potential of the research infrastructure	6/9/08	5/28/10	515.00
Education and Outreach	6/9/08	5/28/10	515.00
Synergy with European Strategy for Particle physics and with CERN	8/4/08	1/9/09	115.00
			6,081.00

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TIME SCALE

WP1 Management

WP2 Underground infrastructure and engineering

WP3 Safety, environmental and socio-economic issues

WP4 Science impact and Outreach

WP1: Criteria for site prioritization

Physics -> What advantage does the site procure for proton decay searches? for neutrinos astrophysics? for long baseline neutrinos?

Technical, geotechnical-> Rank of detector option in terms of geo technical feasibility? of excavation cost? construction cost? timescale? rank feasibility?

H&S -> Rank safety plan during excavation? during tank+detector construction? during operation? during decommissioning? what are the main risks?

Liquid -> Can the million ton of water be procured? 100 ktons LAr? 50 kton LScint?

Economic, political -> Level of local, regional and national support?

TIME SCALE

WP1 Management

WP2 Underground infrastructure and engineering

WP3 Safety, environmental and socio-economic issues

WP4 Science impact and Outreach

WP2

- freeze choice and location of detector in each site
- shift focus from feasibility for infrastructure, tank design, tank construction, costing, timescale..

WP3

- Time schedule presented for liquid procurement & socio-economic impact

CONCLUSIONS

ApPEC Road Map 2008: The priority project in this field is a new giant underground observatory which has to be global in nature and has to follow worldwide coordination and cost sharing. **A common FP7 design study, LAGUNA, is presently underway.** It evaluates three detection techniques: water Čerenkov detectors, liquid scintillator detectors and liquid argon imaging detectors. The study will also address the costs of underground infrastructures in several potential locations in Europe.

We recommend an additional coherent effort to complete the detector R&D programs that could not be fully supported within the FP7 Design Study. The design study should provide, on a time scale of 2010, the key elements of the discovery potential for the different options and sites and then converge to a common proposal.

CONCLUSIONS

http://laguna.ethz.ch

GLACIER: a long work of R&D in progress;

LENA: some new results with beam reconstruction and choice of the scintillator;

MEMPHYS: work of R&D in progress for the electronic and light sensor systems;

The studies carried on for the three experiment are made in contact-collaboration with the other groups in the world and are "interesting" in the context of an internationals collaboration.

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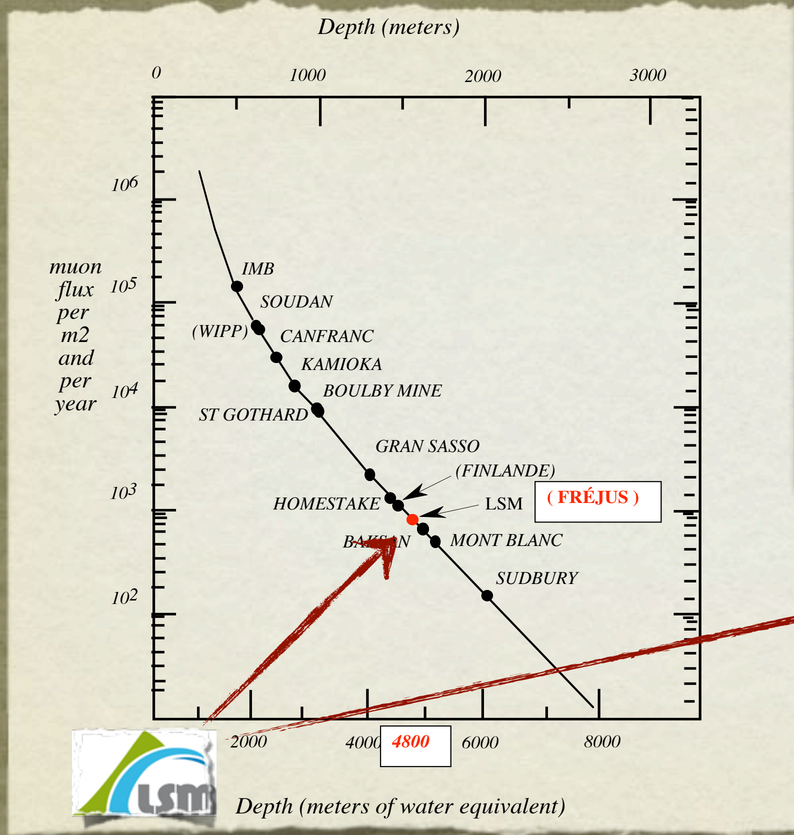
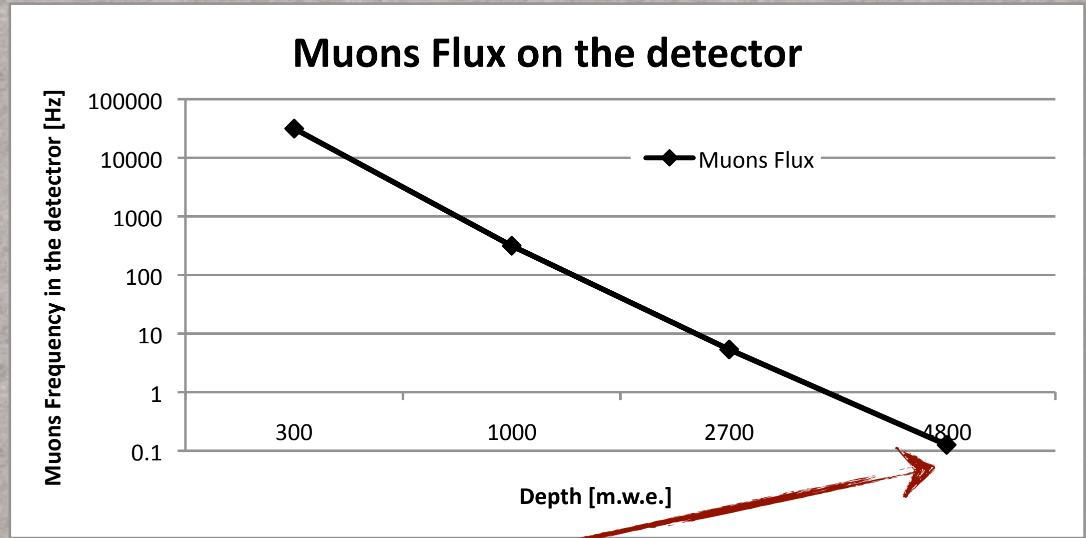
GRAZIE

WP1: LOCATIONS





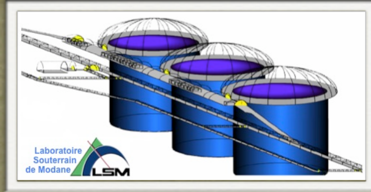
- Less background;
- Less dead time;
- Less muon spallation;

DEPTH m.w.e.	Muon rate s^{-1}
300	$1.56 \cdot 10^3$
1000	$5.9 \cdot 10^2$
2700	8.9
4800	0.2

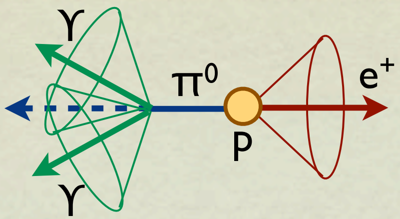
Work in progress for muon interactions in the rock, multiples backgrounds, **depth** and **latitude** studies for **reactor** and **atm** neutrinos bkg and **matter effect in the earth**.

PHYSICS WITHOUT ACCELERATOR

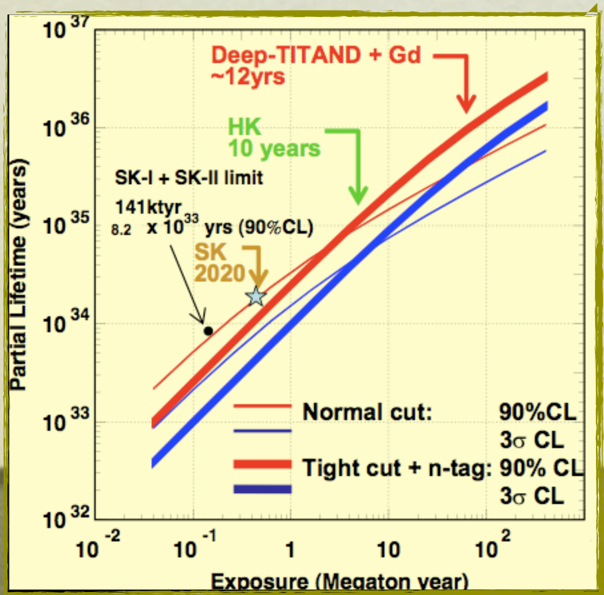
PROTON DECAY



$p \rightarrow e^{+} + \pi^{0}$ "Golden Channel"

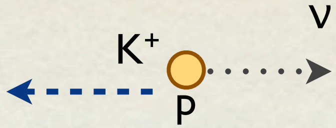


H₂O better then LAr, Scint.

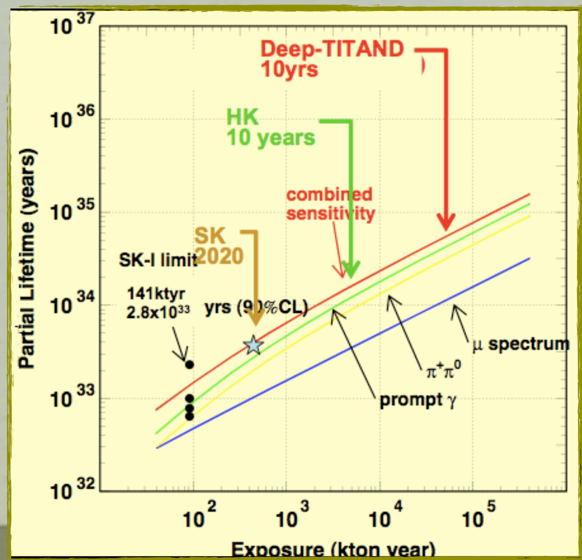


NNN09: Masato Shiozawa - "Nucleon decay searchesNucleon decay searches"

$p \rightarrow \bar{\nu} + K^{+}$



LAr, Scin. better then H₂O (K below Č. thr).

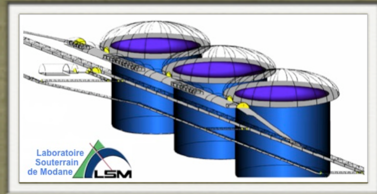


At NNN08 (and 09) SK showed improvement in this channel

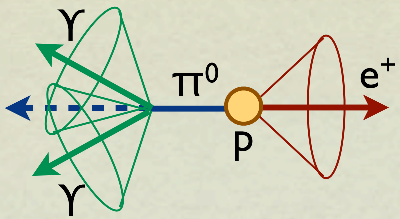
Haruki Nishino (*ICRR, University of Tokyo*)

PHYSICS WITHOUT ACCELERATOR

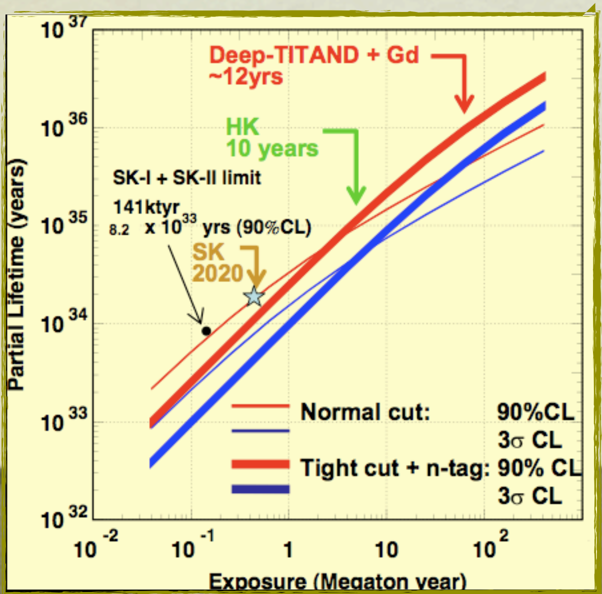
PROTON DECAY



$p \rightarrow e^+ + \pi^0$ "Golden Channel"



H_2O better then LAr, Scint.



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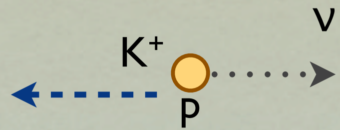


LAr, Scin. better then H_2O (K below Č. thr).

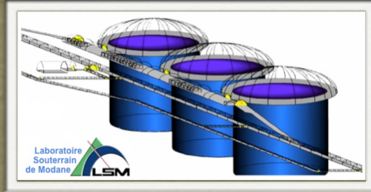
NEW SIZE STUDIES!

- 30% more fiducial volume
- => 572 ktons:
- 90% CLlimit for the life time
- => 1.4 10^{35} ys

PICS

PHYSICS WITHOUT ACCELERATOR

SUPERNOVA COLLAPSE υ

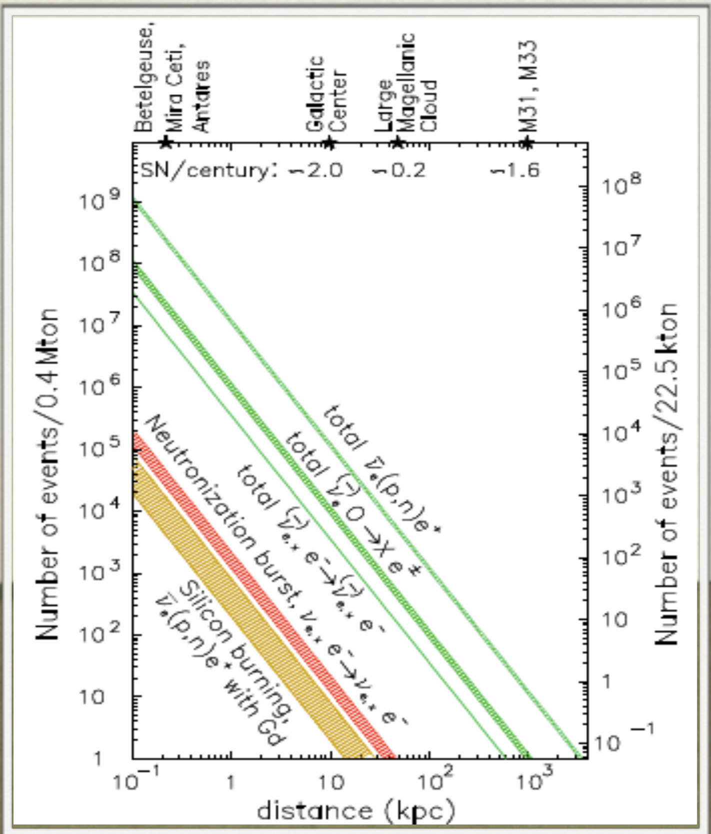


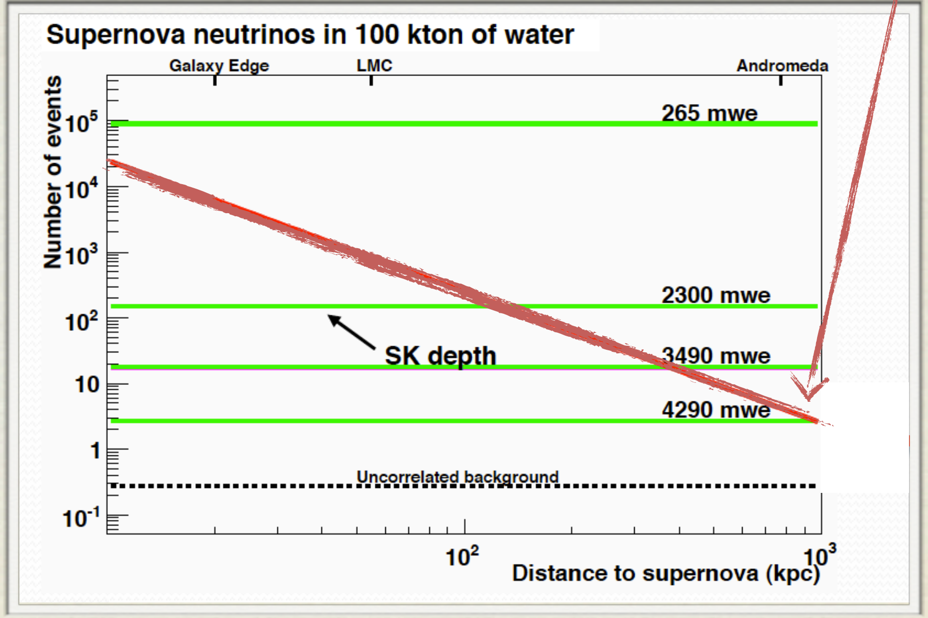
Galactic SN: Huge statistics => spectral analysis:

- in time
- in energy
- in flavor composition

Evidence up to ~ 1 Mpc

Fogli et al., hep-ph/0412046





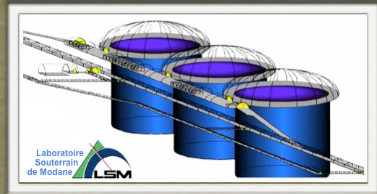
Access to =>

- SN explosion mechanism: shock waves, neutronization burst
- Neutrino production parameters: rate, spectra
- Neutrino properties

PICS

PHYSICS WITHOUT ACCELERATOR

SUPERNOVA COLLAPSE ν



- The probability of observe matter effect in the earth with explosion supernova neutrino depends on the latitude.

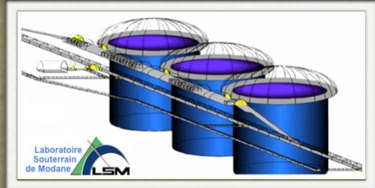
LOCATION	Latitude	Longitude	Sh.Prob. Earth
Pyhäsalmi, Finland	$63.66° N$	26.04°	0.581
Fréjus, France	$43.43° N$	6.73°	0.568
Boulby, England	$54.56° N$	-0.083°	0.577
Kamioka, Japan	$36.27° N$	137.3°	0.560
Canfranc, Spain	$42.7° N$	-0.52°	0.568
South Pole	$90° S$	0°	0.414

- **the best location is the norther;**
- **the effect is extremely light;**
- comparison measurements are possible if we take in account a not-showed detector in South Pole and one showed in Europe

LOCATION	*Pyhäs.*	*Fréjus*	*Boulby*	*Kamioka*	*Canfr.*	South P.
Pyhäsalmi	–	0.052	0.038	0.157	0.059	0.353
Fréjus	0.065	–	0.036	.220	0.013	0.307
Boulby	0.042	0.028	–	0.198	0.027	0.332
Kamioka	0.179	0.230	0.216	–	0.238	0.290
Canfranc	0.073	0.014	0.036	0.229	–	0.305
South Pole	0.519	0.461	0.495	0.435	0.458	–

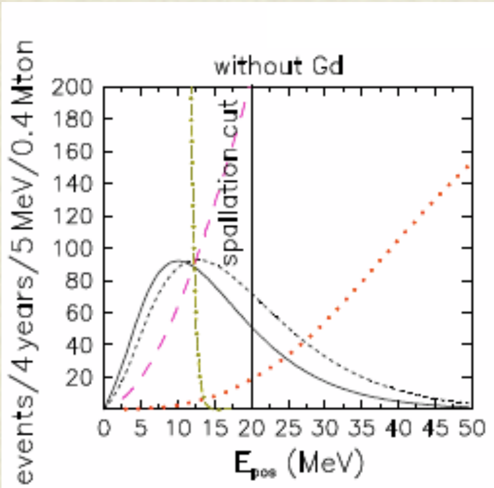
PHYSICS WITHOUT ACCELERATOR

SUPERNOVA DIFFUSE ν



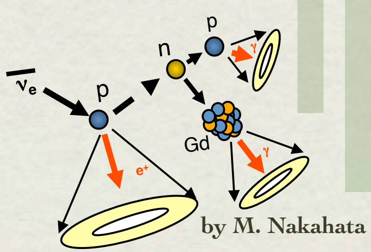
Small signal over very large bkg:

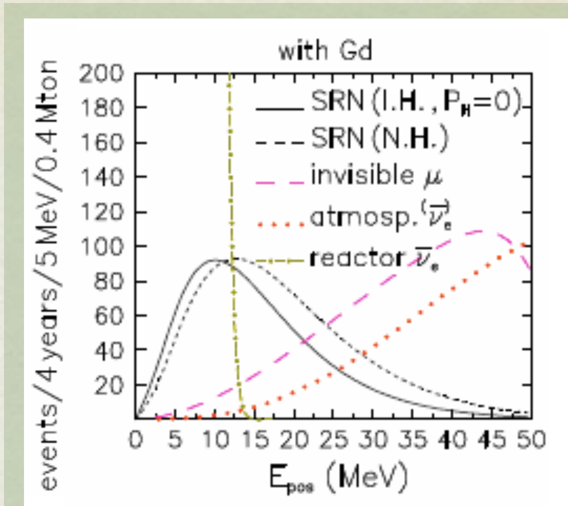
- Decay *e* from'' invisible μ''
- Atmospheric ν_e
- Reactor (E ≤ 10 MeV)



Fogli et al.
JCAP 0504:002,2005

Adding Gd *...
..to reject
the not





MEMPHYS could see the SRN in few years!

* **PRL93, 2004**

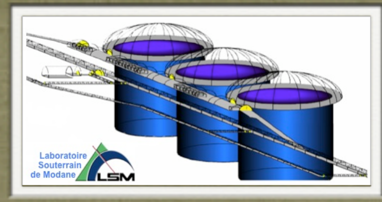
Direct measurement of emission parameters possible.

Yuksel et al., astro-ph/0509297

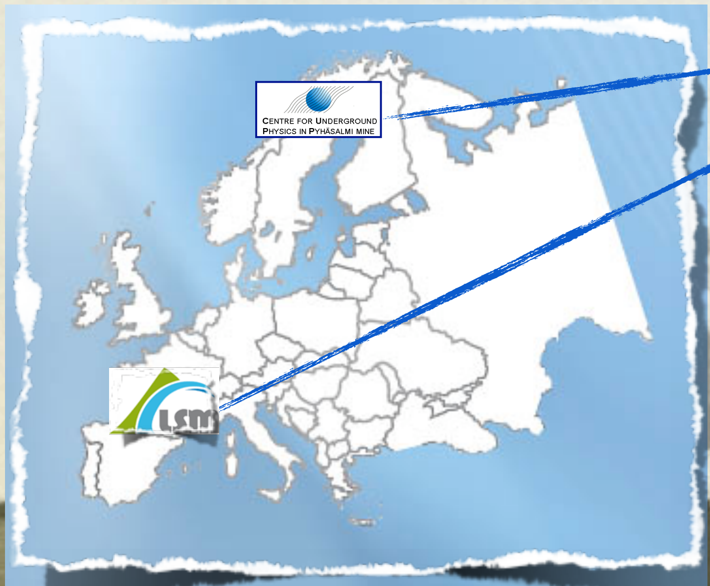
PICS

PHYSICS WITHOUT ACCELERATOR

SUPERNOVA DIFFUSE υ



- The Atmospheric neutrino flux depends from the latitude



Latitude study for diffuse Supernova neutrino background

Site	Latitude (N)	s_{atm}
Kamioka, Japan	36.27°	1
Pyhäsalmi, Finland	63.66°	2.0
Fréjus, France	43.43°	1.5

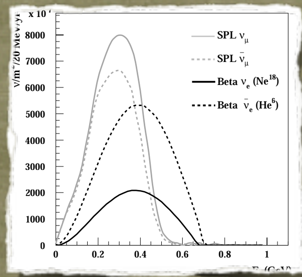
Dependence of the total atmospheric neutrino flux below 60 MeV on the detector location. The scaling factor s_{atm} compares the flux to the one at the Kamiloka site.

- **less invisible muons;**
- **less electronic anti-neutrinos;**

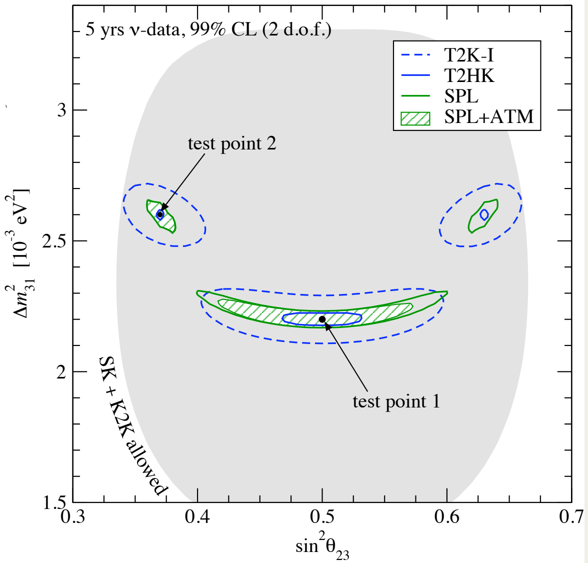
- **TO DO: Reactor neutrinos in a complete calculation (collaboration with Kai Loo..)**

PICS

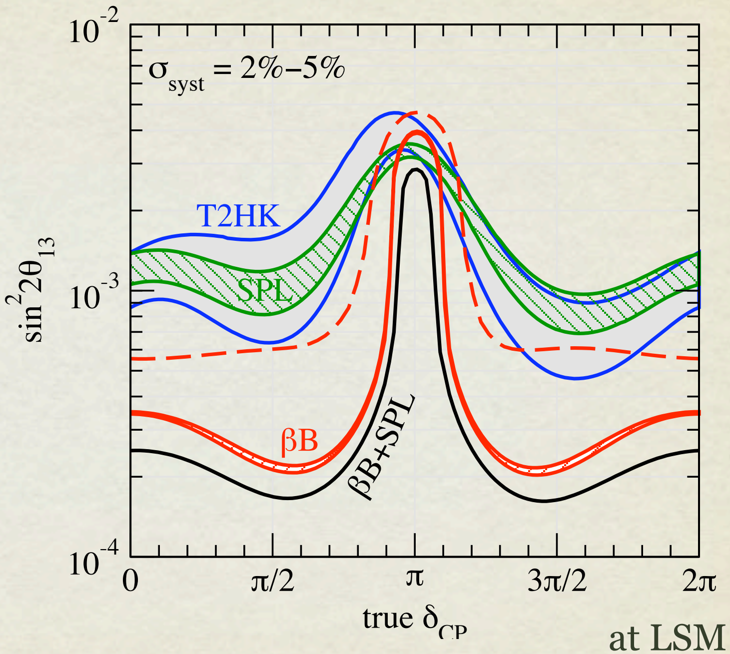
PHYSICS WITH SUPER BEAM



SuperBeams - SPL ν beam at CERN



- A 3.5 GeV, 4MW Linac: the SPL.
- A liquid mercury target station (or maybe Carbon, following A. Longhin recent studies) capable to manage the 4 MW proton beam. R&D required.
- A conventional neutrino beam optics capable to survive to the beam power, the radiation and the mercury. Already prototyped.
- A sophisticated close detector to measure signal and backgrounds.
- A megaton class detector under the Frejus, L=130 km: Memphys.



at LSM

A combination with atmospheric data resolve ϑ_{23} degeneracy

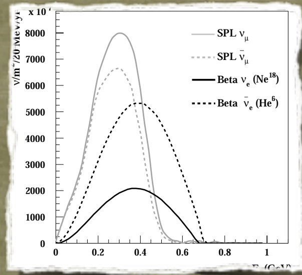
hep-ph/0603172

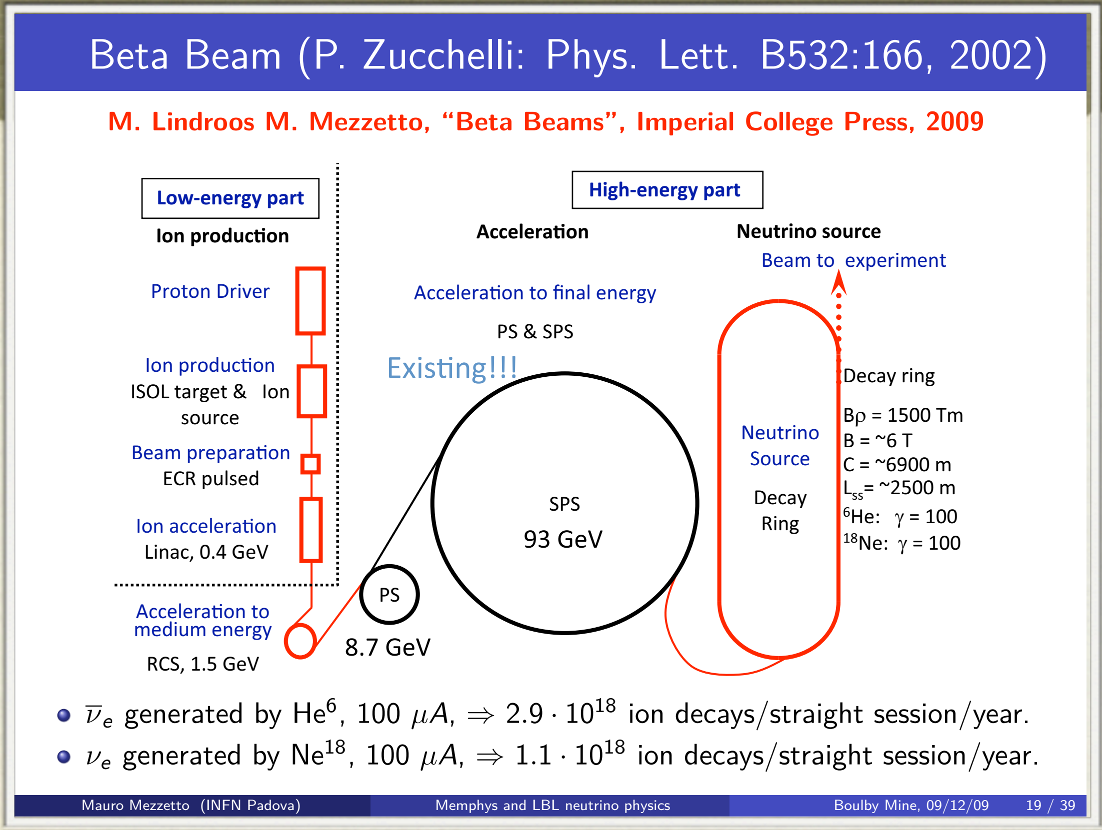
Possible realization of a neutrino beam in Europe at CERN

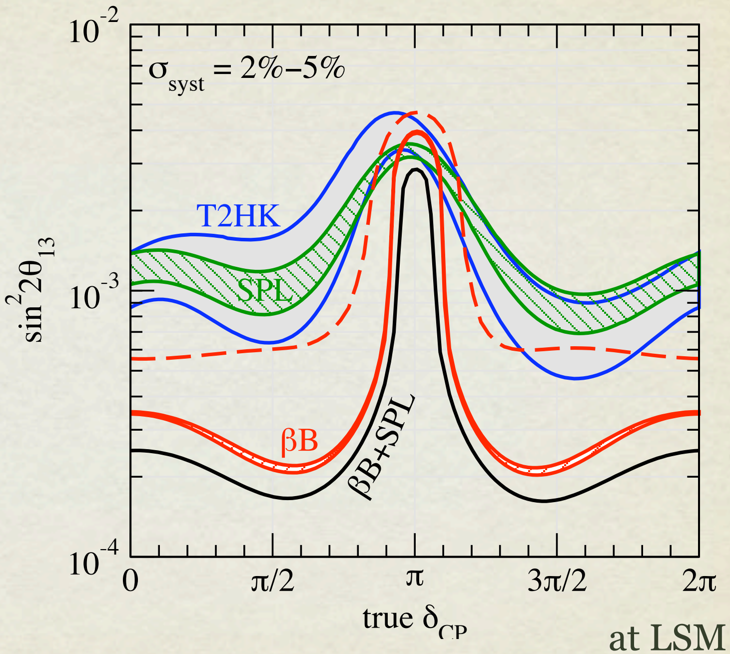
EUROnu

M. Marafini - APC -Paris

PHYSICS WITH BETA BEAM







at LSM

A combination of both super and beta beams is possible.

hep-ph/0603172

Possible realization of a neutrino beam in Europe at CERN

EUROnu

M. Marafini - APC -Paris