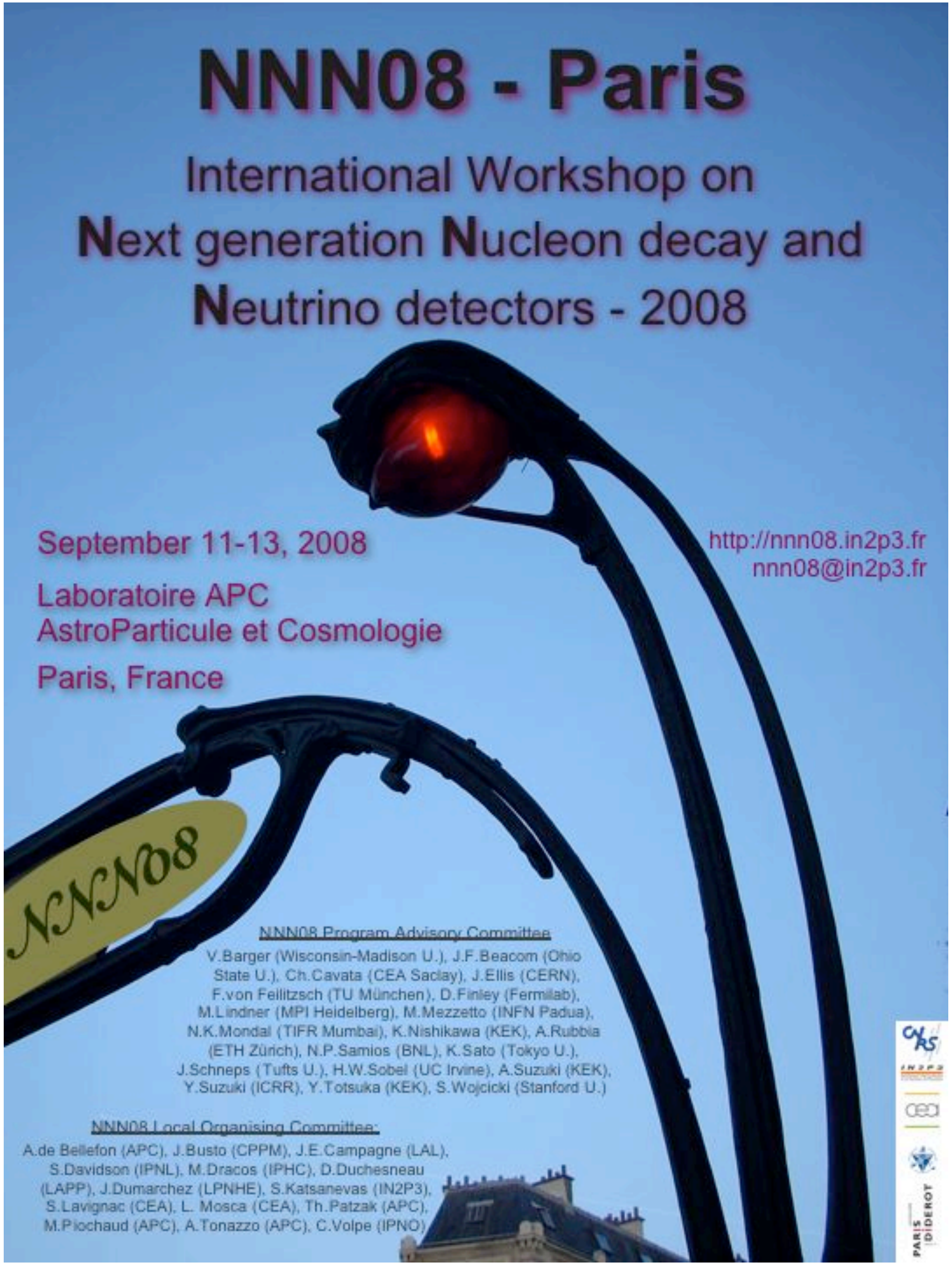


a summary (focused on Europe)

Alessandra Tonazzo
APC -
Université Paris 7

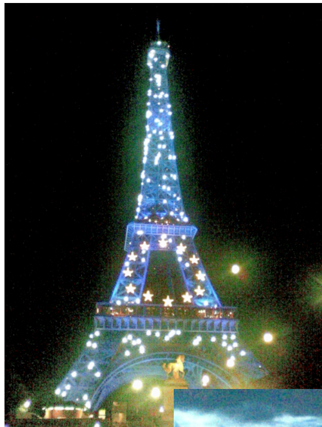
on behalf of the LOC

NNN08 - Paris

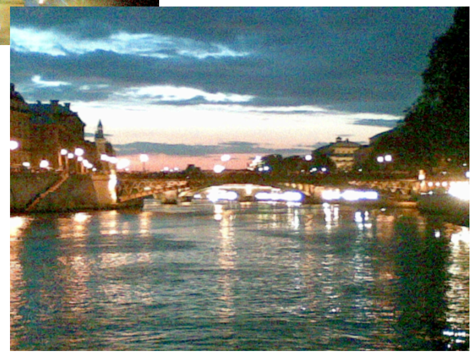
9th of a series of International Workshopn on Next generation
Nucleon decay and Neutrino detectors

NNN05 (SUNY), NNN00 (UCI/FNAL), NNN01 (LSU), NNN02 (CERN),
NNN05 (Aussois), NNN06 (Seattle), NNN07 (Hamamatsu)

~100 participants from 12 countries
Research institutes + Private firms



Seine river cruise - Conference dinner



Scientific Program

- Thursday, 11 September 2008

  09:10-10:30 **Proton Decay**

  11:00-13:10 **Supernova Neutrinos**

  14:30-19:10 **Current & Near Future Neutrino Experiments**

- Friday 12 September 2008

  09:00-12:45 **Towards next generation projects**

  14:00-18:25 **R&D towards Large Scale Detector**

- Saturday 13 September 2008

  09:00-10:00 **"Interdisciplivary" topics**

  10:00-11:00 **Engineering**

  Discussion

  - H.Murayama *"Neutrino and proton decay what can we learn FOR FUNDAMENTAL PHYSICS AND COSMOLOGY"*
  - Totsuka nemorial talk - H.Kajita

Apologies to the speakers I will not mention explicitly....

Recent results and near future

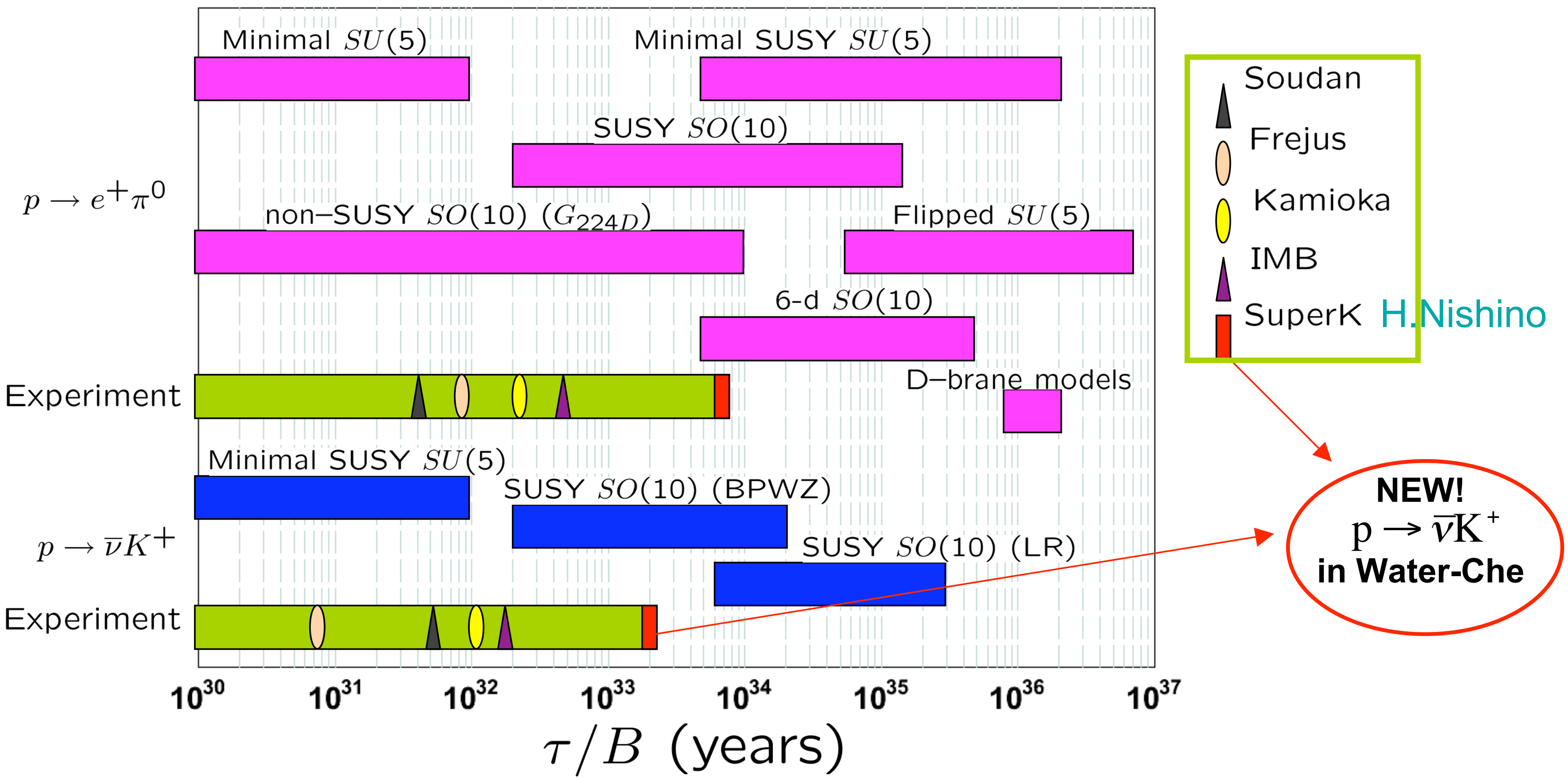
		Speaker
Borexino	>1yr data: $N_{nu}(^{7}Be)=49\pm3_{stat}\pm 4_{sys}/100t$; $\mu_{\nu}<5.4x10^{-11}\mu_{B}$	F.vonFeilitzsch
MINOS	CC $3.36x10^{20}$POT: $\Delta m^{2}=(2.43 \pm 0.13)x10^{-3}eV^{2}$, $\sin^{2}(2\theta)>0.9$; ν_{e} disappearance θ_{13} soon	A.Sousa
SuperK	after 2yrs of SK-III, SK-I+II+III>25000 ν_{atm}. $\theta_{23}=45\pm5^{o}$, $f_{s}<23\%$	M.Fechner
KamLAND	solar $\Delta m^{2} = 7.59 \pm 0.21\ 10^{5}(eV^{2})$, geo-$\nu$ 73 ± 27. New physics opportunities after purification	A.Kozlov

Speaker		
K.Morishima	**OPERA**	Taking data, 123d, $6x10^{18}$POT
S.Centro	**ICARUS T600**	Installed underground at LNGS, filling soon
T.Lachenmeier	**Double Chooz**	Building detector, data in 2009 with Far Det., in 2010 with both detectors, $\sin^{2}2\theta_{13}<0.03$ after 3y
K.Lau	**Daya Bay**	Civil construction ongoing, detector building start in 2009, data taking with full setup in Dec.2010. Goal $\sin^{2}2\theta_{13}<0.01$
L.Kormos	**T2K**	Apr.2009 first nu's, then install ND and start full run. Results in 2010. Address $\sin^{2}2\theta_{13}$, δ_{CP}, θ_{23}
P.Shanahan	**NOVA**	Back on track! FD construction 2011-13

Crucial impact on future neutrino beam strategy !

Physics at future underground detectors (1): Nucleon decay

K.Babu



Challenge for next generation detectors:

➡ Sensitivity 10^{34}-10^{36}y in $p \to e^+\pi^0$ and $p \to \overline{\nu}K^+$

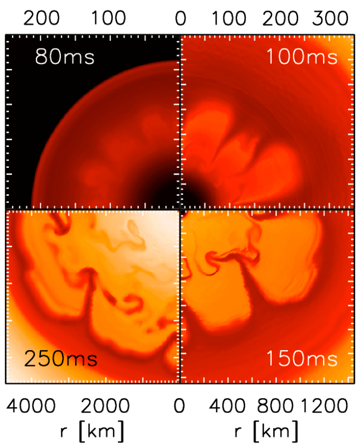
Physics at future underground detectors (2) : SuperNovae

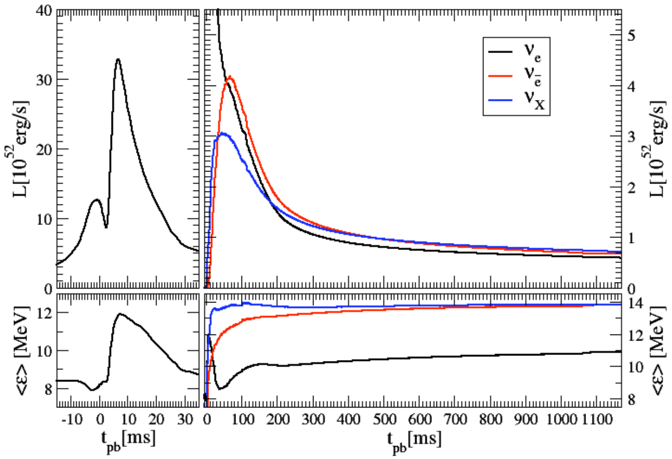
Th.Janka

Core Collapse

- Neutrino signals form CC SN are unique probes of the physics inside the SN core and nascent SN
- Measuring SN neutrinos (flux, E and t) could help us understand explosion dynamics/mechanism and properties of SN matter

new 2-D simulations





Challenge for future detectors:
➡Sensitivity even for distant SN
➡Spectral measurement in Energy and time

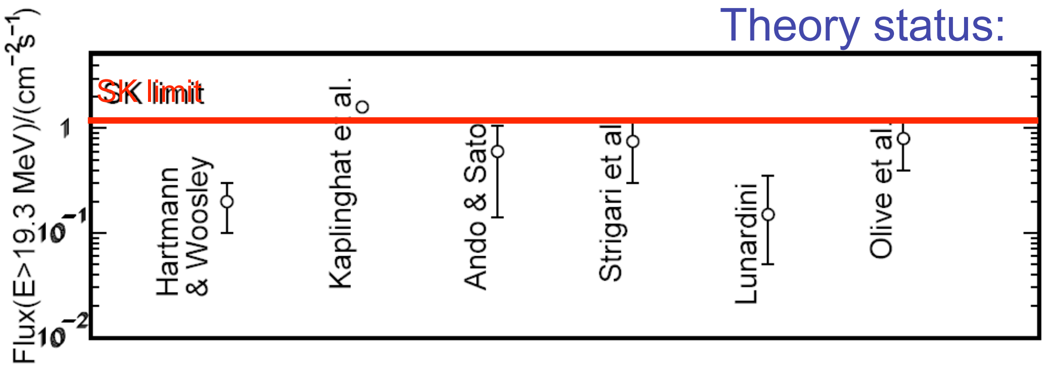
Physics at future underground detectors (2bis) : SuperNovae

C.Lunardini

Diffuse SN neutrinos

- The feeble signal of all past SN probes deep in stars' interior
- Alternative to a galactic SN. Continuous, no waiting time
- Might become standard "everyday" physics in the future

Theory status:



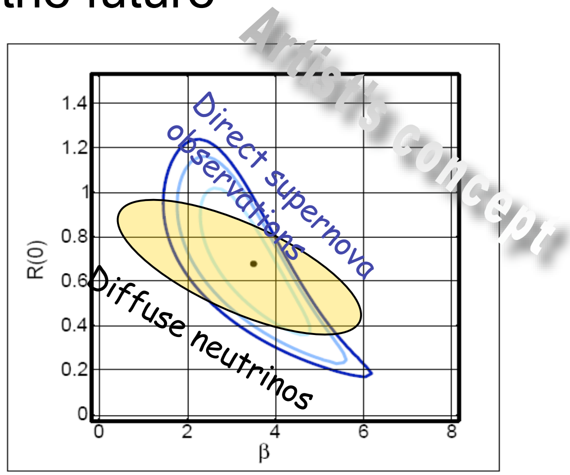


Fig. 5. Best fit point and isocontours of χ^2 in the space of the parameters describing the SNR function, $R_{SN}(z)$. These are the intercept, $R_{SN}(0)$ (in units of 10^{-4} yr^{-1} Mpc^{-3}) and the power, β. The contours refer to 68.3, 90, 95.4% C.L..

Challenge for next generation detectors:

➡ increase statistics (= size)

➡ reduce backgrounds, also to gain spectral sensitivity (e.g.:Gd in H_2O)

➡ improve detection of other than anti-ν_e: e.g. $\nu_e + {}^{40}Ar \rightarrow {}^{40}K + e^-$

Physics at future underground detectors (3) : Neutrino Beams

- Goals: "ultimate" measurement of neutrino oscillation parameter, in particular the unknown ones: **θ_{13}, sign(Δm_{13}), δ_{CP}**

3-family ν oscillations in matter => "magic" baseline $\frac{2\pi}{\sqrt{2}G_F n_e} \sim$ 7500 km

- up to 8 possible degeneracies => need different baselines and/or different types of beam to resolve them

➡ <u>SuperBeam</u>: very high intensity "traditional" Beam $\nu_\mu \rightarrow \nu_\mu$

➡ <u>Beta Beam</u>: pure ν_e or anti-ν_e from accelerated β-decaying ions $\nu_e \rightarrow \nu_\mu$

➡ <u>ν-Factory</u>: pure $\nu_\mu + \bar{\nu}_e$ or $\bar{\nu}_\mu + \nu_e$ from decay of accelerated $\mu^\pm$s

$\nu_e \rightarrow \nu_\mu$(wrong sign)

Challenge for next generation detectors:
➡ large size
➡ lepton flavour identification
➡ (charge measurement)

Future detectors

General requirements for next generation nucleon decay, neutrino astrophysics and beam neutrino detectors:

- Large mass (MegaTon...)
- Low Energy threshold
- Low background: shielding from cosmic rays (deep underground) or excellent cosmic bkg rejection capabilities
- Particle identification

Techniques:

- Water Cherenkov (+ Gd)
- Liquid Scintillator + Gd
- Liquid Argon
  - →all need large nb of PMTs
  - →all need large size underground excavations

What / Where ? @NNN08

	Beams	Detectors			PMTs	Excavation
		Water Cherenkov	Liquid Scint.	Liquid Argon		
Europe	P.Soler	A.Tonazzo: **MEMPHYS** G.Martin-Ch.: **PARISROC**	T.Marrodan **LENA** C.Buck: **R&D**	A.Marchionni: **GLACIER** F.Pietropaolo: **MODULAR**	B.Combettes **Photonis massive production**	G.Nuujten: **Phyasalmi** R.Margineau: **Slanic**
USA	M.Diwan **FNAL to Homestake**	K.Lande: **R&D** M.Vagins: **GADZOOKS**		K.Soderberg: **TPC R&D** D.Cline: **100kt LAr R&D**		K.Lande: **DUSEL**
Japan	T.Hasegawa **JPARC**	M.Shiozawa: **R&D**			H.Aihara: **HPD**	

(more projects ongoing but not presented at this conference)

Europe's plans

Following the request by the UDiG Workshop organizers,
I will concentrate on Europe

- Beam plans

- R&D for Liquid Scintillator [**LENA**]
- R&D for Water Cherenkov [**MEMPHYS**]
  - PMm^2 program
  - MEMPHYNO prototype
- R&D for Liquid Argon
  - [**GLACIER**]
  - [**MODULAr**]

- Underground site excavation studies
  - Phyasalmy (Finland), Unirea (Romania), [Fréjus (France)]

- EU-funded common Projects:
  - LAGUNA, EUROnu

European Beam Plans

P.Soler

- The International Scoping Study looked at physics, accelerator and detector prospects for suture ν-oscillation facilities

  [ArXiv 0712.4129 0802.4023 0712.4129]

  - for a ν-Factory: baseline 2 detectors, 4000 and 7500 km
    - for "golden channel" Magnetised Iron [cfr INO, I.Dharmavaram] or Magnetised Emulsion Cloud chambers
    - for other channels, Magentised Liquid Argon or Magnetised Totally Active Scint. Detector (TASD)
  - for Super-Beam or Beta-Beam, no magnetisation needed
    - Water Cherenkov (basselline 500kt), Liquid Argon or non-magn.TASD
  - Beams:
    - Super-Beam: CERN-LNGS (730km) or CERN-Fréjus (130km)
    - Beta-Beam: CERN(SPL)-Fréjus (130km)
    - ν-Factories: several R&D projects on accelerator concept (MERIT,MICE,EMMA,MuCool)

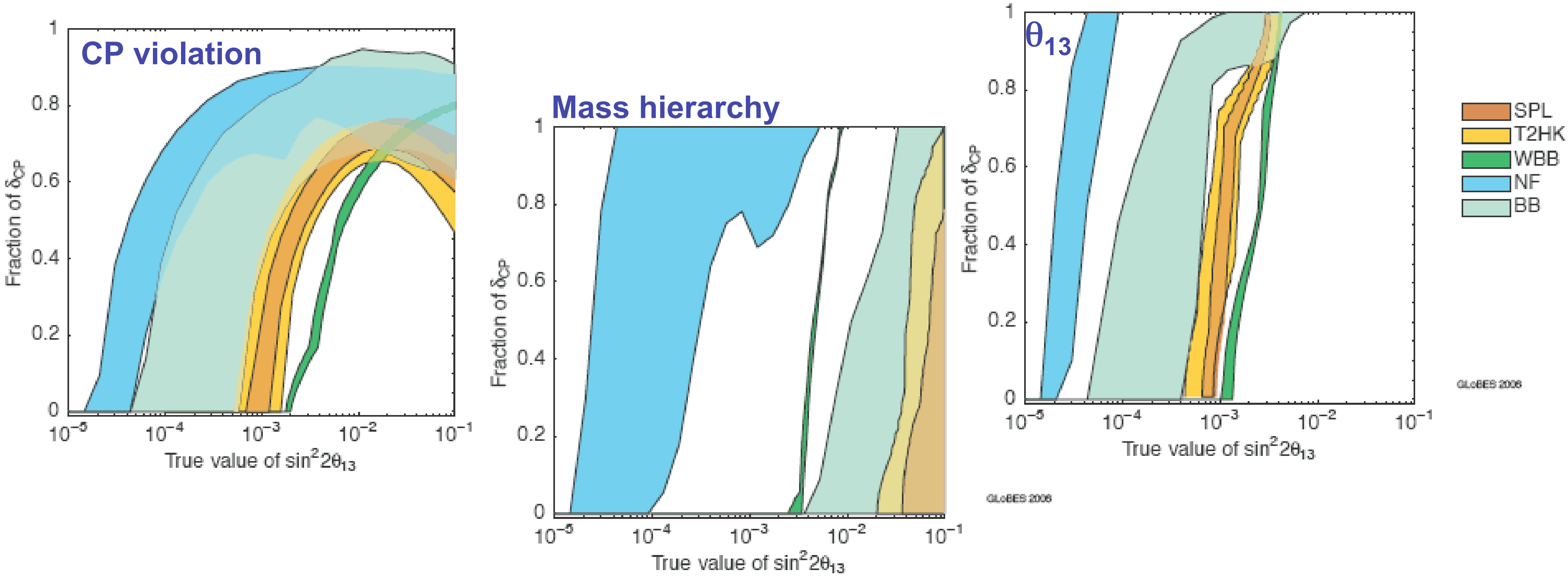
Note: Th.Schwetz: A low-E ν-Factory with non-magnetic detectors
[0805.2019] *"Making ν-Factory and b-beams talk to echother!"*

European Beam Plans

P.Soler

International Scoping Study conclusions

- Comparison of facilities from ISS:
  - If $\sin^2 2\theta_{13} > 10^{-2}$ super-beam and beta-beam facility compatible with neutrino factory to explore CP violation but accuracy might be issue
  - If $\sin^2 2\theta_{13} < 10^{-2}$, a neutrino factory with two detectors at ~7500 km and ~4000 km gives optimal CP violation coverage



Liquid scintillator : LENA

T.Marrodan

DETECTOR LAYOUT

Cavern
height: 115 m, diameter: 50 m
shielding from cosmic rays: ~4,000 m.w

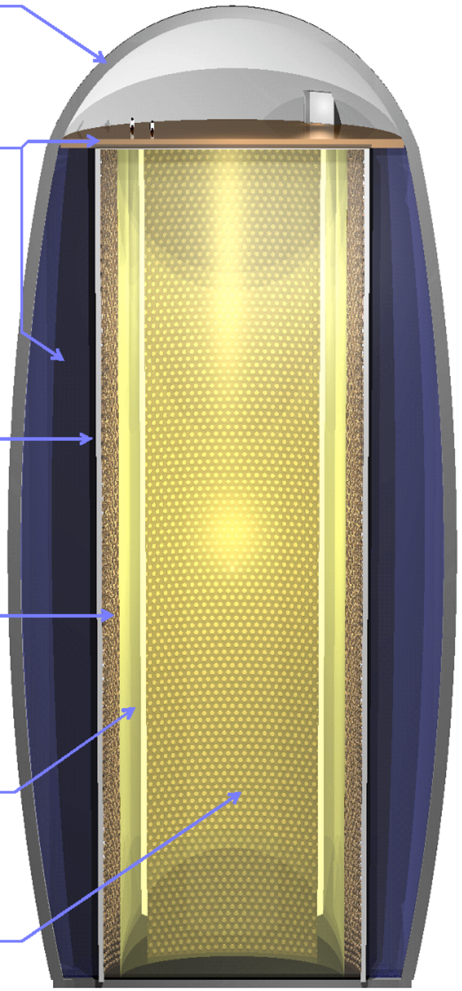
Muon Veto
plastic scintillator panels (on top)
Water Cherenkov Detector
1,500 phototubes
100 kt of water
reduction of fast
neutron background

Steel Cylinder
height: 100 m, diameter: 30 m
70 kt of organic liquid
13,500 phototubes

Buffer
thickness: 2 m
non-scintillating organic liquid
shielding external radioactivity

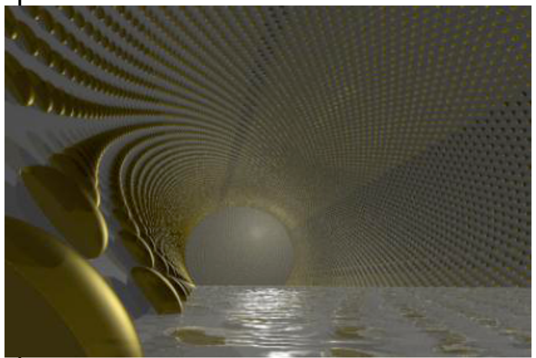
Nylon Vessel
parting buffer liquid
from liquid scintillator

Target Volume
height: 100 m, diameter: 26 m
50 kt of liquid scintillator

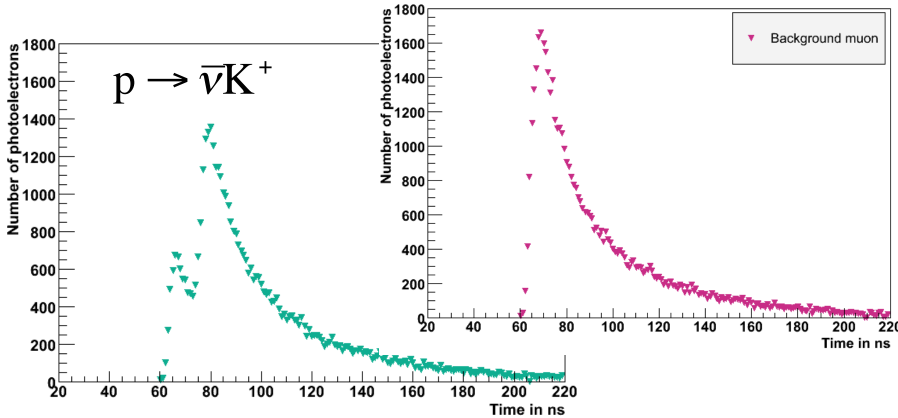


vertical design is favourable in terms of rock pressure and buoyancy forces

Favouite location:
Phyasalmyi (Finland)
other locations being studied



Pulse-shape discrimination:



Liquid scintillator R&D

C.Buck

Requirements for scintillator:

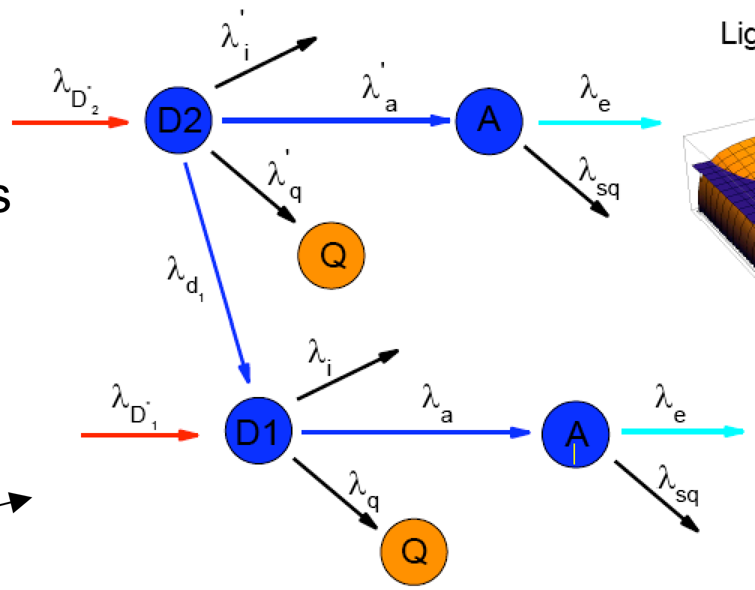
- High energy resolution
- Low energy detection threshold
- high purity (Borexino)
- fast signals (timing)
- moderate cost
- Improved stability of metal loaded scintillators

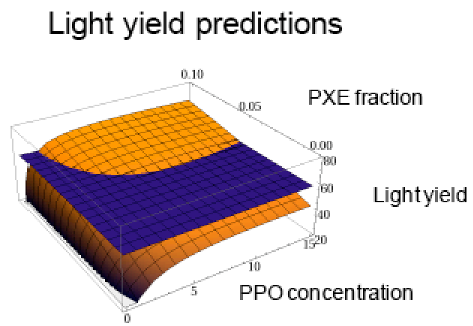
➡detailed study of many candidates for individual components

➡comparison of purification methods

➡timing measurements

➡detailed light-yield model for simulations





C.Buck, F.X. Hartmann, D.Motta. S.Schönert, CPL, 435 (2007) 252 - 256

C.Aberle, diploma thesis, MPIK Heidelberg (2008)

Liquid scintillator R&D

C.Buck

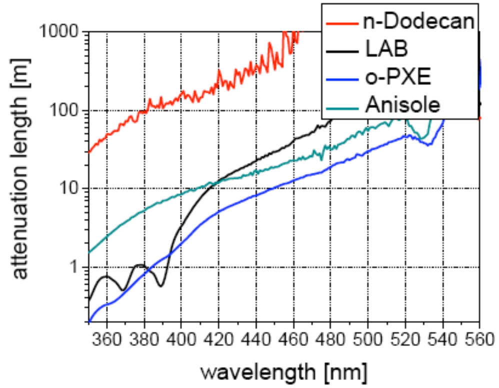
Comparison solvents

Scintillation yield

solvent	Yield
PC	1.00
Anisole	0.81
PXE	0.88
LAB	0.74
n-Dodecan	0.40
Oil	0.33

MPIK measurements (6 g/l PPO)

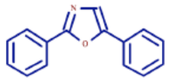
Attenuation length



- UV/Vis (MPIK): (absorbance + scattering)
- Single contributions determined at TU Munich

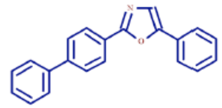
Comparison fluors

PPO



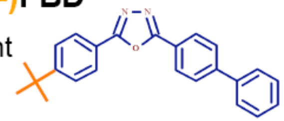
- transparent
- well established
- high quantum yield

BPO



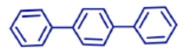
- high(est) light yield
- emission around 400 nm
- absorption properties
- limited availibility

(Butyl-)PBD



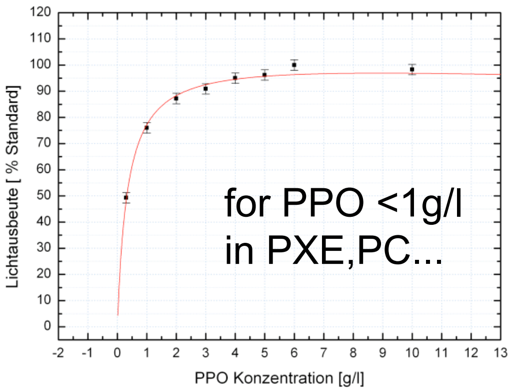
- high light yield
- poor quantum yield
- costs

pTP



- fast
- overlap with bis-MSB
- low solubility
- poor quantum yield

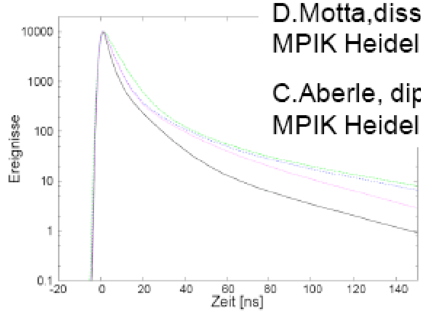
Critical concentration



for PPO <1g/l in PXE,PC...

for PPO ~3g/l in dodecane

Timing properties



D.Motta, dissertation, MPIK Heidelberg (2004)

C.Aberle, diploma thesis, MPIK Heidelberg (2008)

Liquid scintillator R&D

C.Buck

Metal loaded scintillators

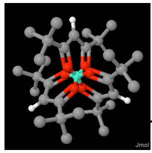
- Solar neutrinos (LENS, SIREN)
  - Yb, In, Gd
  - challenge: high loading

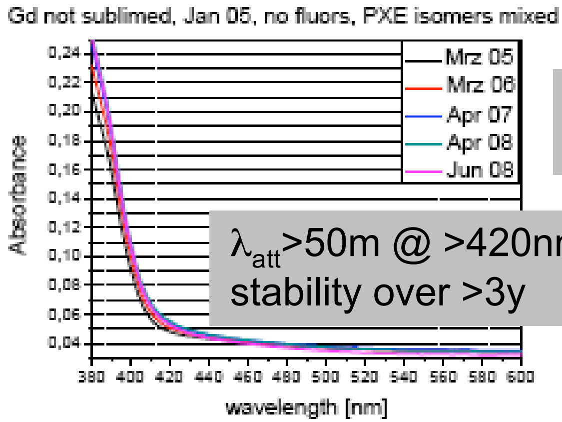
Indium-loaded scintillators at LLBF > 1 year
- MPIK: $In(acac)_3$ (F.X.Hartmann et al.)
- INR/LNGS: Carboxylic acid version

} > 50 g/l Indium

- Reactor (Double Chooz (LENA))
  - Gadolinium
  - Challenge: stability

carboxylates (LNGS)
beta-dikitonates (MPIK)





λ_{att}>50m @ >420nm
stability over >3y

100 kg produced
(for both DC detectors)

- bb decay (SNO+)
  - Neodymium
  - Challenge: transparency, purity

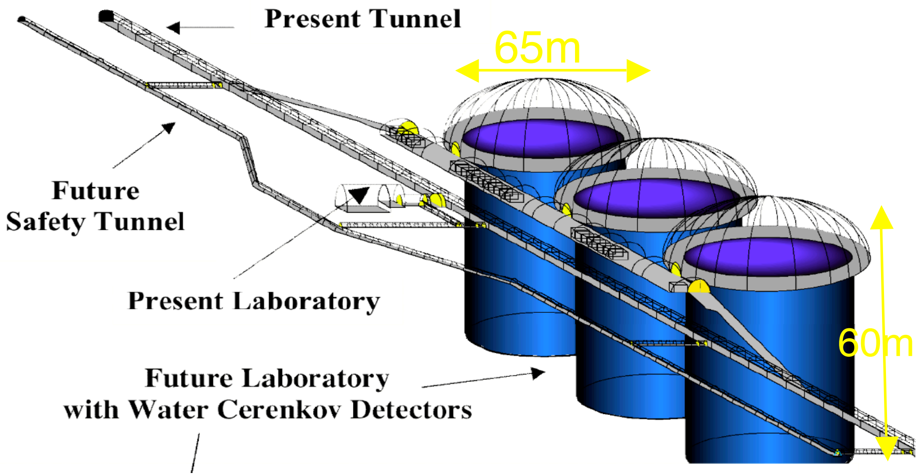
tests done on BDK and carvboxylates @ MPIK / LNGS

Water Cherenkov: MEMPHYS

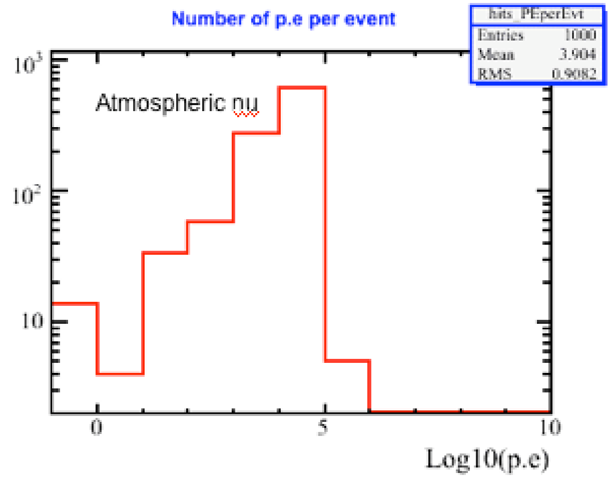
Megaton Mass PHYSics @Fréjus

- Water Cherenkov (“cheap and stable”)
- Total fiducial mass: 440 kt
- Baseline:

  3 Cylindrical modules 65x65 m
  - Size limited by light attenuation length (λ~80m) and pressure on PMTs
  - Readout: 12” PMTs, 30% geom. cover (#PEs =40%cov. with 20” PMTs)
- Installation in extension of LSM in the Fréjus tunnel, b/w France and Italy
  - 4800 m.w.e overburden
  - 130 km from CERN



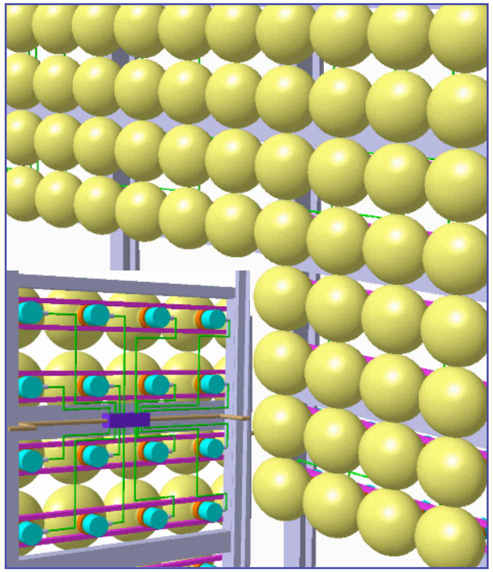
Simulation: Nuance + Geant4 + OpenScientist + AIDA/root



http://www.apc.univ-paris7.fr/APC_CS/Experiences/MEMPHYS/
arXiv: hep-ex/0607026

(Water Cherenkov) PMm^2 R&D

G.Martin-Chassard



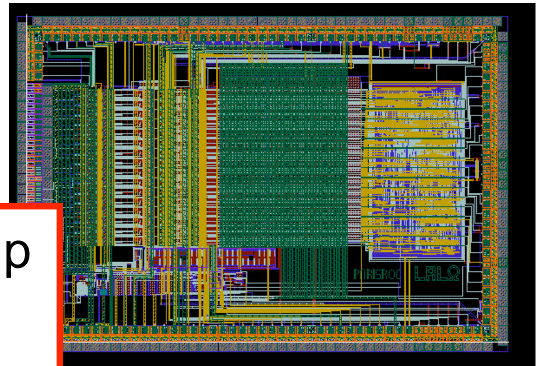
"Innovative electronics for array of photodetectors used in High Energy Physics and Astroparticles".

R&D program funded by French national agency for research (LAL, IPNO, LAPP and Photonis) (2007-2010)

<u>Basic concept</u>: very large photodetection surface → macropixels of PMTs connected to an autonomous front-end electronics.

Replace large PMTs (20") by groups of 16 smaller ones (12") with central ASIC :

- **Independent channels**
- **charge and time measurement**
- **water-tight, common High Voltage**
- **Only one wire out (DATA + VCC)**



I. studies on 12" PMTs design
- parameter correlation
- potting
- pressure resistance

(collaboration with BNL since NNN07)

II. PArISROC readout chip
- complete front-end chip with 16 channels
- testboard now in layout, soon available

Water Cherenkov: MEMPHYNO

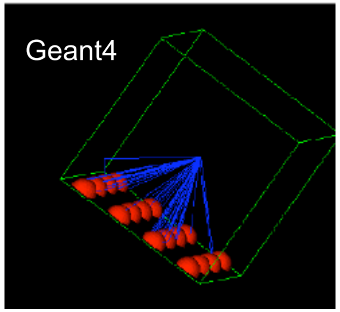
Goals:

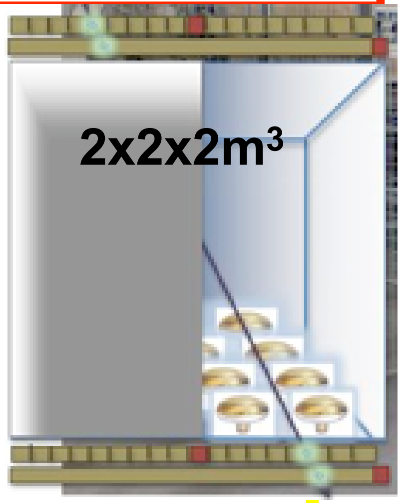
1. full test of electronics and acquisition chain with actual physics events
2. trigger threshold studies
3. self-trigger mode
4. Track reconstruction performances
5. Gd doping: feasibility and performance (if studies still needed...)

Test bench for photodetection solutions for large detectors

Plan:

1. Install at APC lab ("hall de montage") => cosmic muon data
   - direction selected with hodoscope
   - test timing, track reconstruction
2. Transport to Fréjus LSM lab
   - Measure backgrounds at underground site
   - Test trigger and thresholds
3. Expose to CERN beam [with DevDet European program]
   - Check electron vertex reconstruction and e/pi separation
4. Back to APC
   - Test Gd-doping





- for DSN detection in MEMPHYS
- for non-proliferation studies :

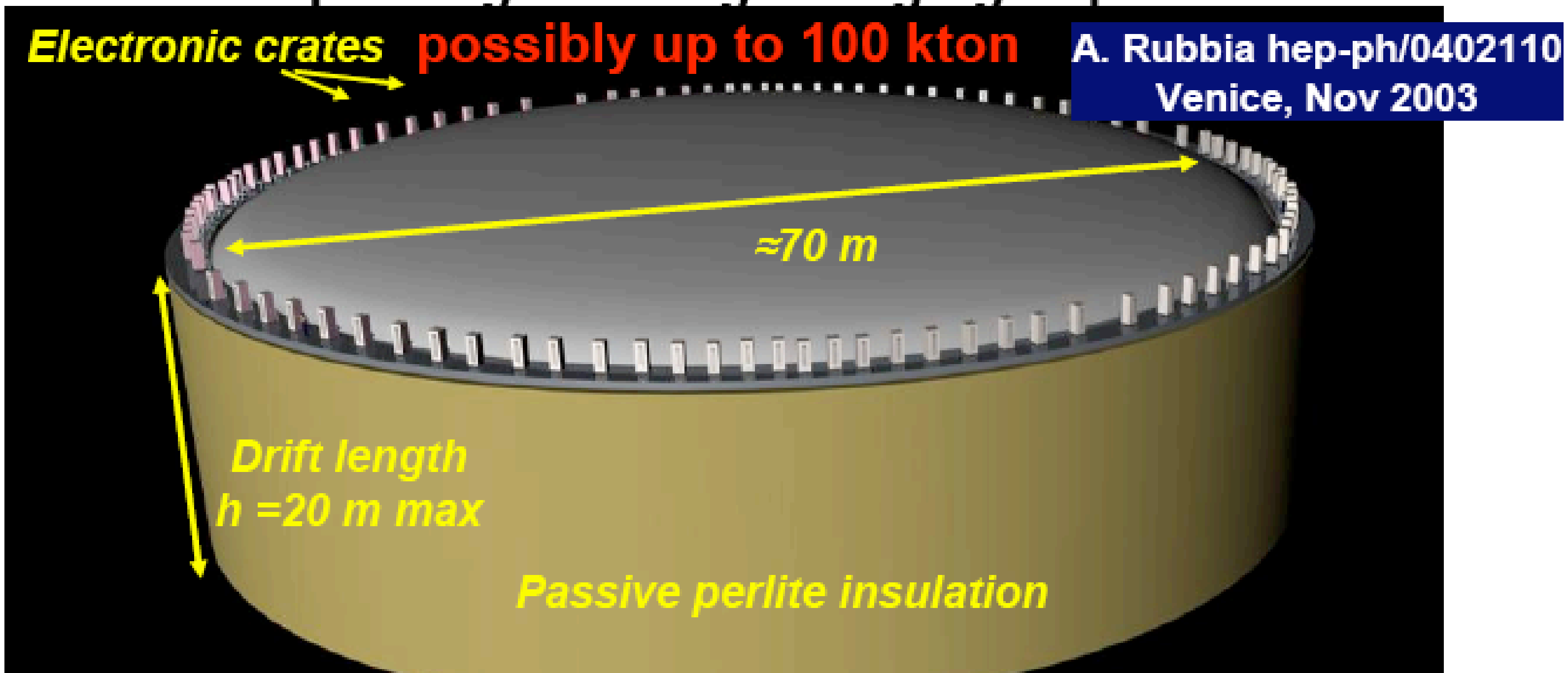
  MEMPHYNO is a "small-scale", "portable" detector, easy to install near reactor power plants

Liquid Argon: GLACIER

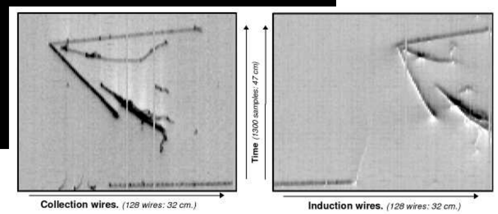
A.Marchionni

A scalable detector with a non-evacuable dewar and ionization charge detection with amplification

Giant Liquid Argon Charge Imaging ExpeRiment



Single module cryo-tank based on industrial LNG technology



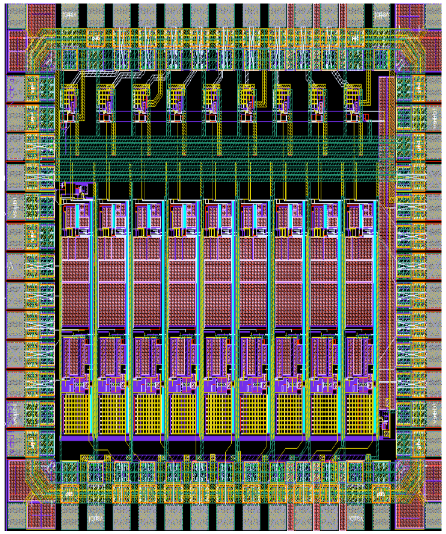
LAr-TPC @ CERN-WANF
Phys. Rev. D 74, 112001 (2006)

Liquid Argon: GLACIER

A.Marchionni

Critical issues for construction ➜ R&D items:

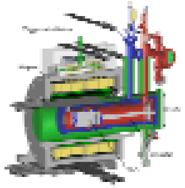
- Drift over long distances in Ar: Ok if high purity ➜ purification system
- Dewar ➜ (non evacuable?) R&D with Technodyne in LAGUNA
- HV system
- ReadOut system ➜ Novel techniques, other than wires, possibly with charge multiplications (double-phase with Large Electron Multiplier)
- Electronics ➜ Aggressive R&D on warm/cold solutions (IPNL+ETHZ)
  - analog ASIC amplifier working at cryo temperature
  - Gygabit Ethernet readout chain + network time distribution PTP
- Detector engineering



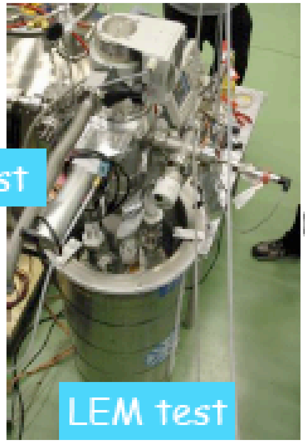
GLACIER R&D - Prototyping

A.Marchionni

Small prototypes ➠ ton-scale detectors ➠ 1 kton ➠ ?



B-field test



LEM test

proof of principle double-phase LAr LEM-TPC on 0.1x0.1 m² scale

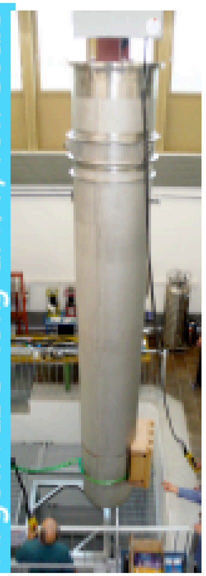
➠ **LEM readout on 1x1 m² scale**
UHV, cryogenic system at ton scale, cryogenic pump for recirculation, PMT operation in cold, light reflector and collection, very high-voltage systems, feed-throughs, industrial readout electronics, safety (in Collab. with CERN)

ArDM ton-scale

we are here

➠ **direct proof of long drift path up to 5 m**

ArgonTube: long drift, ton-scale

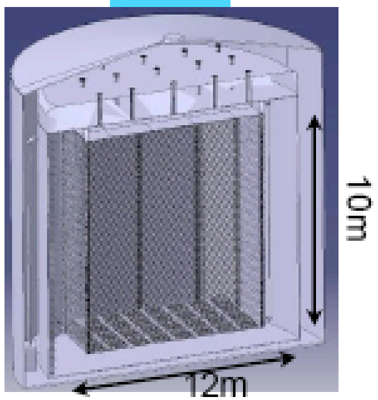


➠ **Application of LAr LEM TPC to neutrino physics**: particle identification (200-1000 MeV electrons), optimization of readout and electronics, cold ASIC electronics, possibility of neutrino beam exposure

Test beam
1 to 10 ton-scale

➠ **full engineering demonstrator for larger detectors**, acting as near detector for neutrino fluxes and cross-sections measurements, ...

1 kton

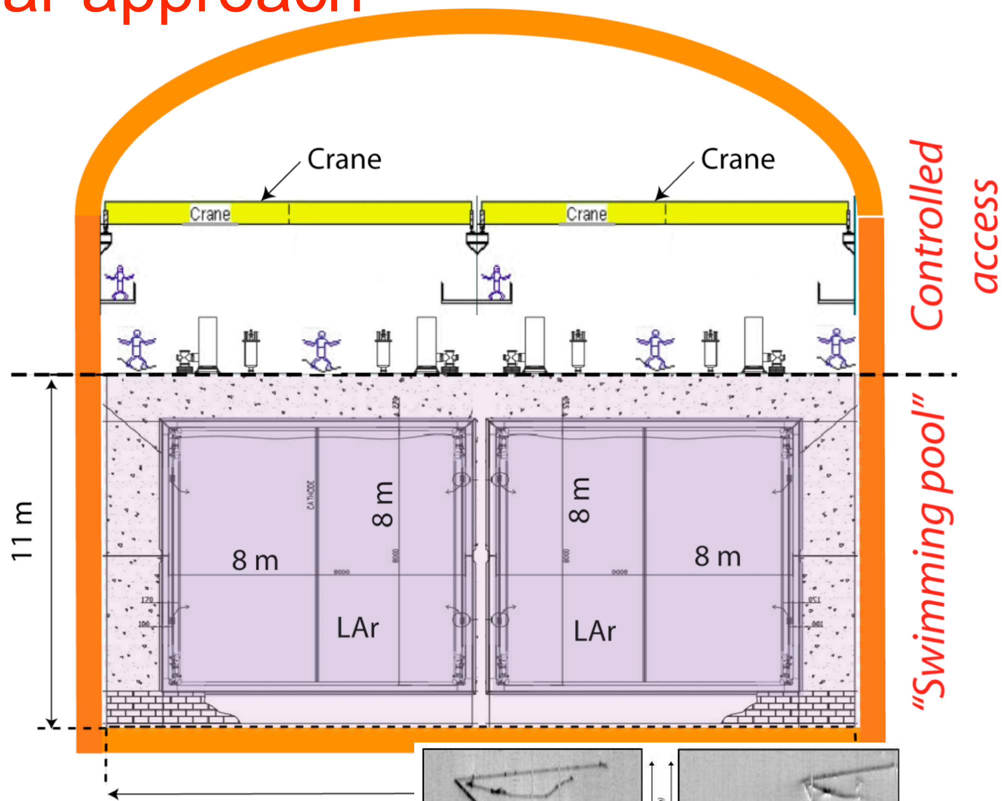


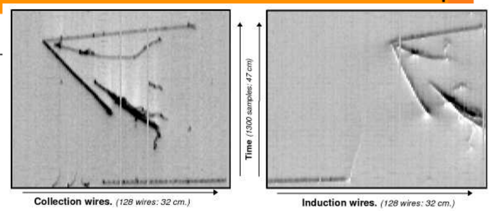
Liquid Argon: MODULAr

F.Pietropaolo

From ICARUS-T600 to a multi-kton LAr-TPC with a modular approach

- MODULAr will be initially composed by four identical module located in the new shallow-depth cavern
- Each module is a scaled-up version of the T600 (x 2.66^3):
  - 8 x 8 m^2 cross section and about 60 m length
  - LAr active mass: 5370 ton
  - 4 m electron drift
  - 3-D imaging similar to T600 but 6 mm pitch (three wire planes, ~50000 channels)





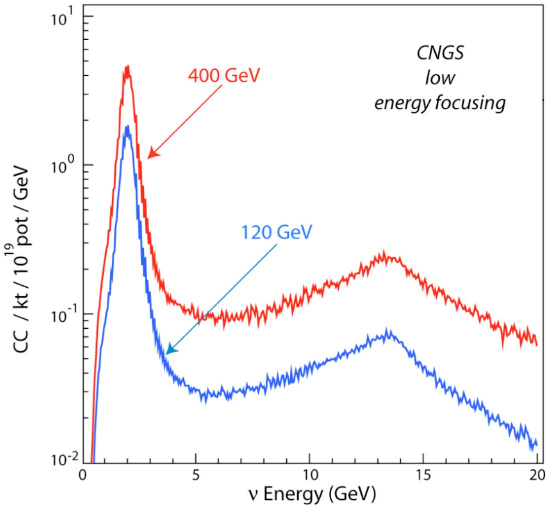
LAr-TPC @ CERN-WANF
Phys. Rev. D 74, 112001 (2006)

Proposal: Astroparticle Physics 29 (2008) 174–187

MODULAr at LNGS off-axis

F.Pietropaolo

732km CERN-LNGS, 10km off-axis

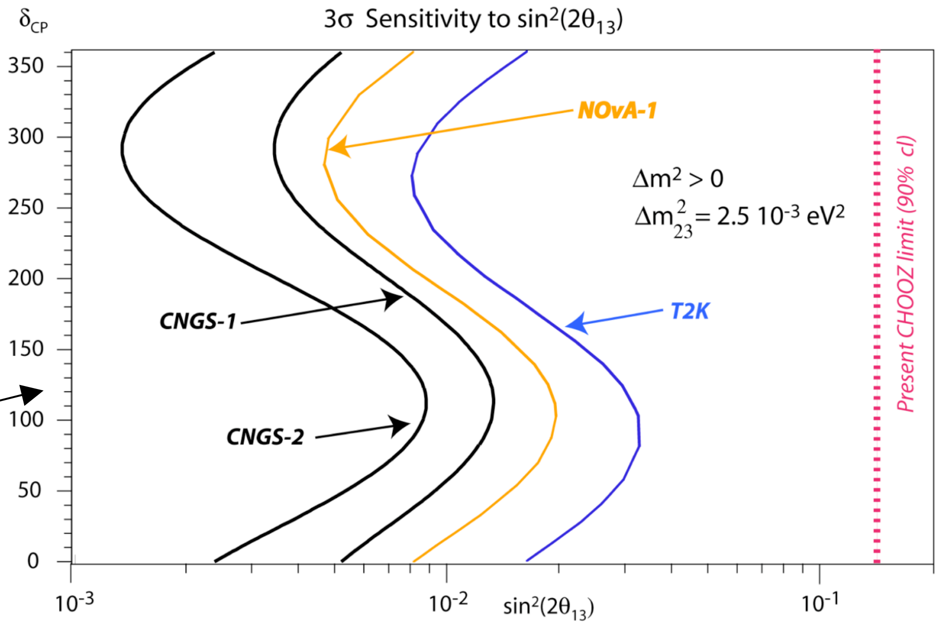


There is no near detector @CERN, but ICARUS-T600 will be operational on-axis (on → off axis normalisation is straightforward)

Thanks to LAr properties:
MODULAr (20 kt) + CNGS (1.2 10^{20} pot/y) ~ NOvA + NUMI (6.5$10^{20}$ pot/y)

Sensitivity to θ_{13} and δ_{CP}

CNGS-1(-2): 1.2 (4.3) 10^{20} pot/y
Exposure: 20 kt x 5 years
GLoBES: 5% beam syst., $\Delta E/E$ = 15%



MODULAr R&D

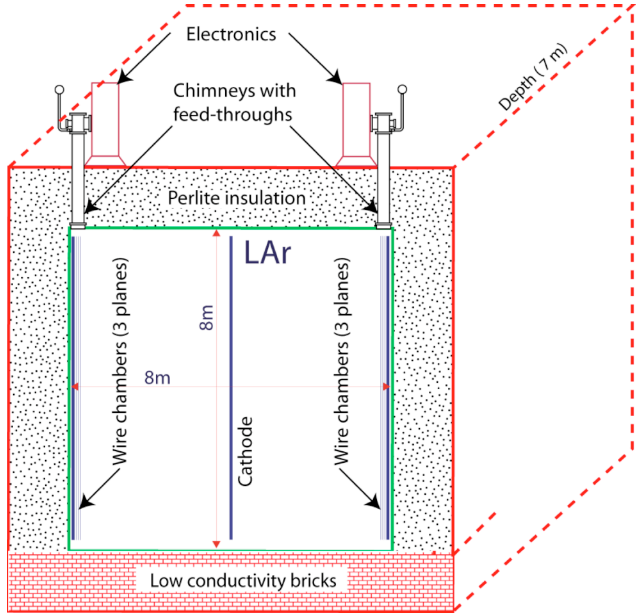
F.Pietropaolo

Scaling by only 1 order of magnitude w.r.t. ICARUS600 requires only some "not very substantial" R&D items:

- the filling process starting from air to pure LAr, taking into account the motion of the gas, optimizing the inlet and outlet geometries and minimizing the number of cycles;
- the thermal convection of the LAr, in order to optimize the temperature gradients and to ensure circulation in all regions of the dewar, both in the cool down and stationary phases;
- the out-gassing rate and the re-circulation processes necessary to achieve the required electron lifetime;
- the geometry of the compact re-circulators both in the liquid and in the gaseous phases.
- finally, also the electronics and DAQ may require some specific developments to improve the layout of the analogue front-end and the DAQ architecture.

SLICE prototype

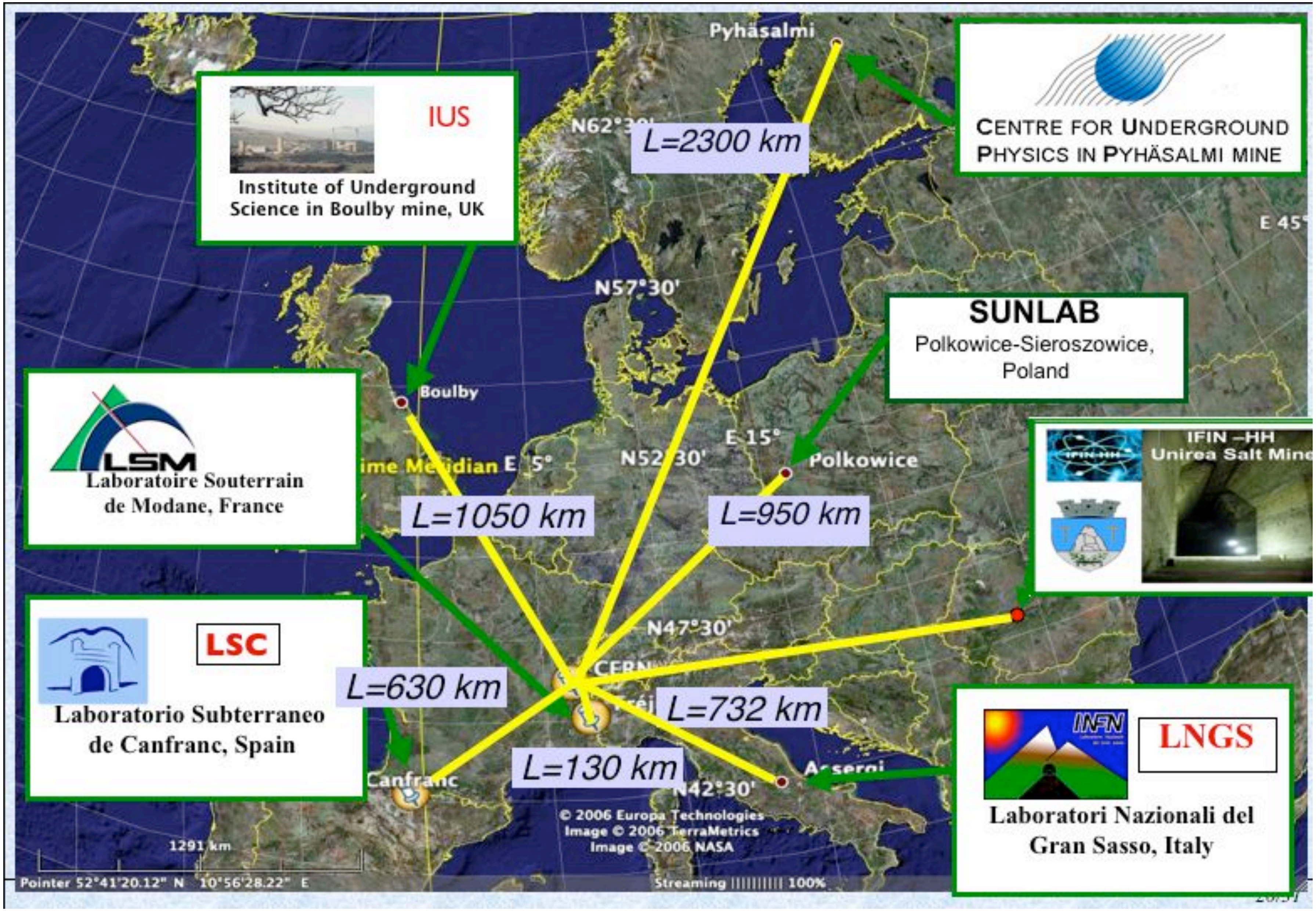
sensitive area 8x8m2, depth 4m



Physics scope

	Water Cerenkov	Liquid Argon TPC	Liquid Scintillator
Total mass	500 kton	100 kton	50 kton
$p \to e\,\pi^0$ in 10 years	1.2×10^{35} years ε = 17%, ≈ 1 BG event	0.5×10^{35} years ε = 45%, <1 BG event	~10^{32} years in 1year ε = 12%, BG under study
$p \to \nu\,K$ in 10 years	0.15×10^{35} years ε = 8.6%, ≈ 30 BG events	1.1×10^{35} years ε = 97%, <1 BG event	0.4×10^{35} years ε = 65%, <1 BG event
SN cool off @ 10 kpc	194000 (mostly $\nu_e p \to e^+ n$)	38500 (all flavors) (64000 if NH-L mixing)	20000 (all flavors)
SN in Andromeda	40 events	7 (12 if NH-L mixing)	4 events
SN burst @ 10 kpc	≈250 ν-e elastic scattering	380 ν_e CC (flavor sensitive)	≈30 events
SN relic	250(2500 when Gd-loaded)	50	20-40
Atmospheric neutrinos	56000 events/year	≈11000 events/year	5600/year
Solar neutrinos	91250000/year	324000 events/year	?
Geoneutrinos	0	0	≈3000 events/year

Underground sites



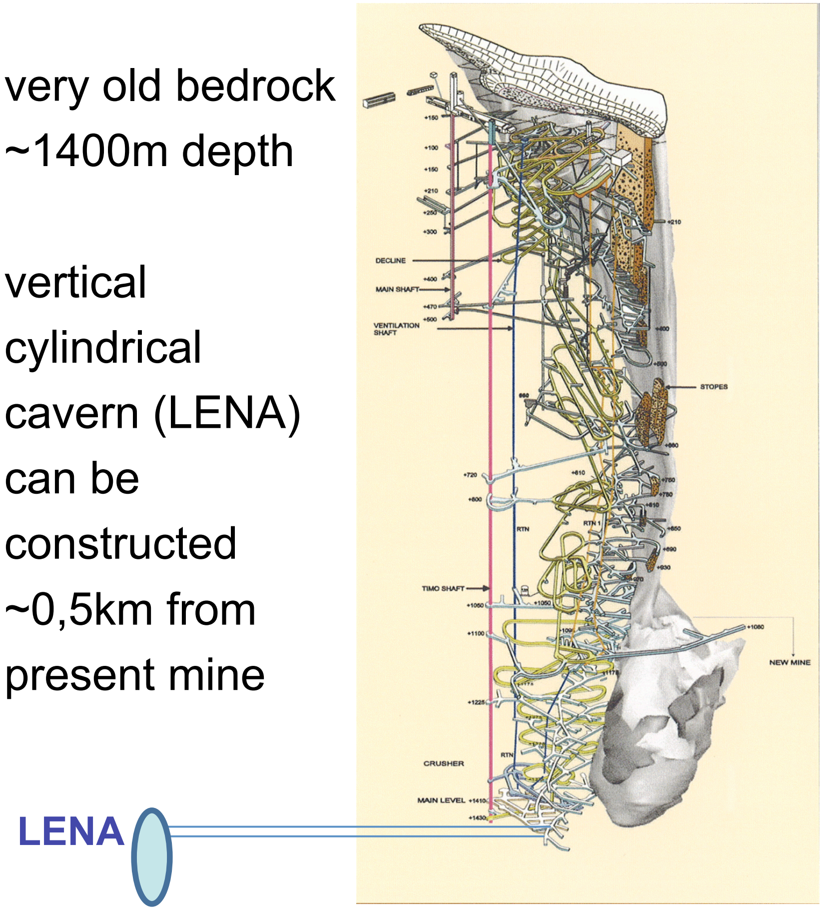
Pre-feasibility studies

G.Nujiten

Phyasalmi rock mine (Finland)

very old bedrock
~1400m depth

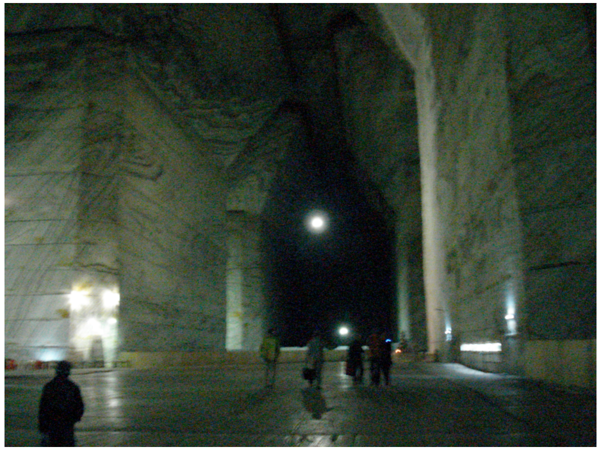
vertical cylindrical cavern (LENA) can be constructed ~0,5km from present mine

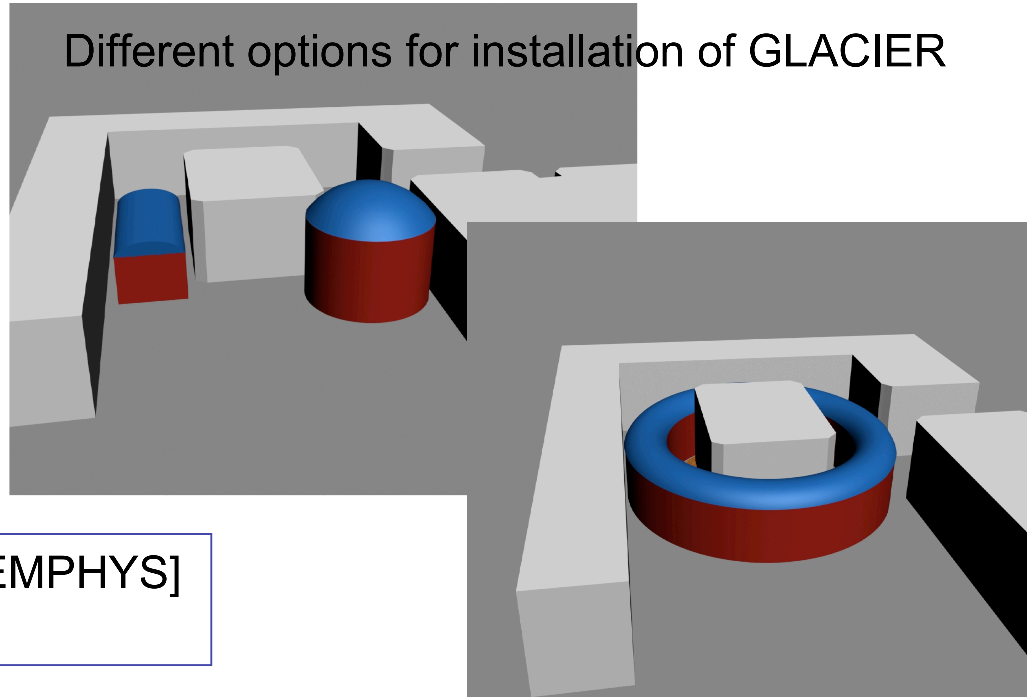


R.Margineau

Unirea salt mine (Romania)

under
~150m hill





+ **Fréjus** (France) [MEMPHYS]
cfr L.Mosca @NNN07

Europe FP7 funded projects

ASPERA (from ApPEC) is a network of national government agencies responsible for coordinating and funding national research efforts in Astroparticle Physics

recommendation in the roadmap:

"***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-Cherenkov, 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.

This design study should take into account worldwide efforts and converge, on a time scale of 2010, to a common proposal."

The **European Union** gives funding for collaborative infrastructure studies, provided institutions contribute with proper funds (personnel)

Two EU-FP7 funded programs are related to NNN08 subjects:

- LAGUNA and EUROnu

LAGUNA

Th.Patzak

Large **A**pparatus for **G**rand **U**nification and **N**eutrino **A**strophysics

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

21 beneficiaries in 9 countries: 9 higher education entities, 8 research institutes, 4 private companies (+4 additional universities)

For the 7 sites, evaluate:
- rock quality → feasibility
- access, geogr.location, environment
- distance from accelerators and reactors

→ WP2, WP3

Synergies of MEMPHYS, LENA, GLACIER

→ WP4

WP Nb.	**WorkPackage Title**
WP1	Management
WP2	Underground infrastructures and Engineering
WP3	Safety, environmental and socio-economic issues
WP4	Science Impact and Outreach

EUROnu

P.Soler

"A High Intensity Neutrino Oscillation Facility in Europe"
4.5MEuros, 15 beneficiaries in 9 countries

- WP1: Management
- WP2: Super-Beam: design of a 4 MW proton beam (SPL), target and collection system for a conventional neutrino beam
- WP3: Neutrino factory: define design for muon front-end, acceleration scheme, spent proton beam handling and component integration in an end-to-end neutrino factory simulation
- WP4: Beta beam: following from EURISOL, study production, collection and decay ring of beta beam for high Q isotopes (^{8}Li, ^{8}B)
- WP5: Neutrino detectors: study Magnetised Neutrino Iron Detector (MIND) performance for golden measurement at neutrino factory, water Cherenkov detector for beta and super beams and near detectors for all facilities
- WP6: Physics: comparison of physics performance, systematic errors and optimisation for all facilities

Summary and outlook

- NNN08 was a very dynamic workshop
- We had an exhaustive review of the physics scope for next generation detectors for proton decay, supernovae neutrinos and neutrino oscillations
- We got a vast overview of the plans of Europe, US and Japan on Beams, Detectors, R&D and Infrastructures
- Reminder on Europe:
  - ISS on future accelerators
  - Detectors: LENA, MEMPHYS, GLACIER and MODULAR
  - 7 possible underground labs
  - ASPERA priority: Large underground detectors for prootn decay, Particle Astrophysics and neutrino oscillations
  - 2 EU-funded projects: LAGUNA and EUROnu

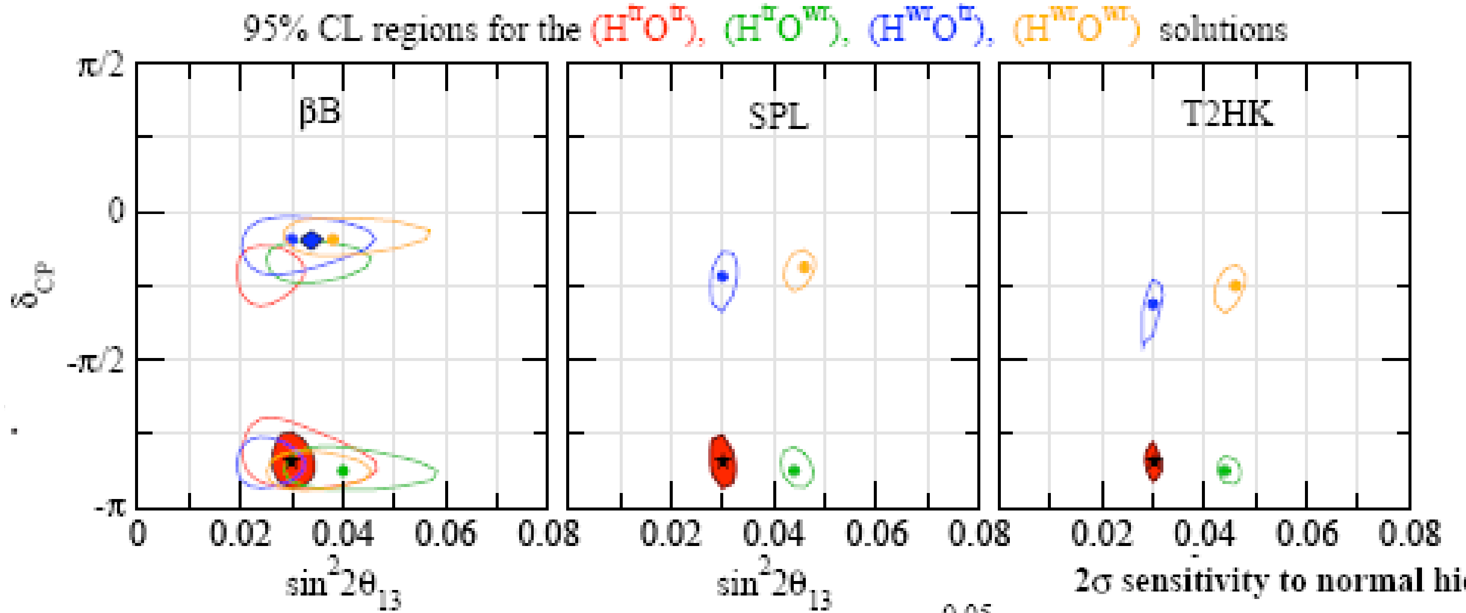
optimal strategy depends on θ_{13} :
current / near-future experiments are crucial

- New international collaborations are being started - looking forward to strengthening them at this UDiG workshop

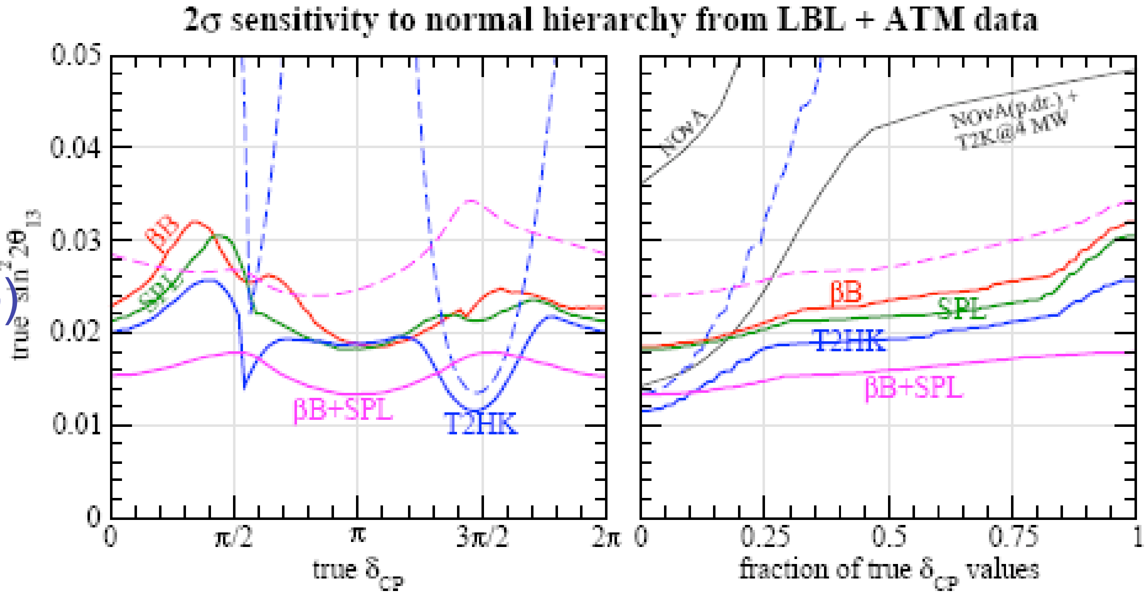
BACKUP

Resolving degeneracies

- Physics reach of Memphys+SPL; Betabeam+SPL and T2HK: Campagne, Mezzetto, Maltoni, Schwetz JHEP 04 (2007) 003.



– Resolve degeneracies by combining with atmospherics
– βB: cannot solve degeneracies (no ν_μ and insufficient spectral info)
– βB+SPL, SPL+ATM & T2HK can resolve degeneracies



PArISROC description (I)

- Complete front-end chip with 16 channels

  Sent in fabrication in **June 2008**

  Technology : **AMS SiGe 0.35 μm**

- Characteristics :
  - 16 inputs preamplifier
    - **Variable gain :1 → 8 (4bits) (common on 16 channels)**
    - **PMTs gain adjustment by a factor 4 (8 bits) (channel by channel)**
    - **Input dynamic range : 0 → 300 pe (0 → 50pC)**
    - **Good linearity (1%)**
  - 16 trigger outputs:
    - **Fast shaper (τ=15ns)**
    - **Low offset discriminator**
    - **Threshold provided by common 10bit DAC +4bit DAC/ch. (1/3 pe)**
    - **"OR" of 16 triggers output**
  - 1 digitized and multiplexed charge output :
    - **Dynamic range : 0 → 300 pe**
    - **Slow shaper with variable shaping time (τ=50ns,100ns,200ns)**
    - **SCA with depth 2**

PArISROC description (II)

- Coarse time measurement (timestamp) :
  - 24-bit counter @ 10MHz
  - Step : 100ns

- 12-bit ADC for charge and fine time measurement :
  - Wilkinson type ADC
  - T&H on slow shaper for charge measurement
  - T&H on TDC ramp (100ns) for fine time measurement
  - 2 discriminators with 12 bit ramp (100μs) as threshold

- Serialization of digital output information :

  Channel number - time stamp – charge - fine time

  4bits 24bits 12bits 12bits

CONCLUSIONS (1/2)

- The hard and very old bedrock (> 2 * 10^9 yr) of Finland provides by far one of the best locations in Europe to locate the LENA laboratory deep under the ground.
- Within Finland the Pyhäsalmi Mine offers the best location for this purpose, as it is the deepest present location in Finland 1400m below surface.
- The depth of the laboratory is at -1400m (top) to -1500m (bottom level).
- The location of the cavern is about 0,5km west from the present mine.
- Construction of the access tunnels can be started directly at -1400m due to good infrastructure at that level.

CONCLUSIONS (2/2)

- The shape of the cavern is vertical and ellipse to cope best with in-situ stresses
- The scintillator tank is also constructed vertically
- The infrastructure needed for LENA is already present on the surface as well as at -1400 m.
- The mine has one access tunnel, one main transport and one ventilation shaft. (probably one extra shaft has to be built)
- The mine can take over all excavated rock (~half a million m^3) until the year 2015.
- The layout of the underground tunnels is based on a double exit strategy that in case of accident there are two directions to flee from any location.

- Otanmäki and Vihanti are other possible locations