Highlights of NuFact 09 oscillation session

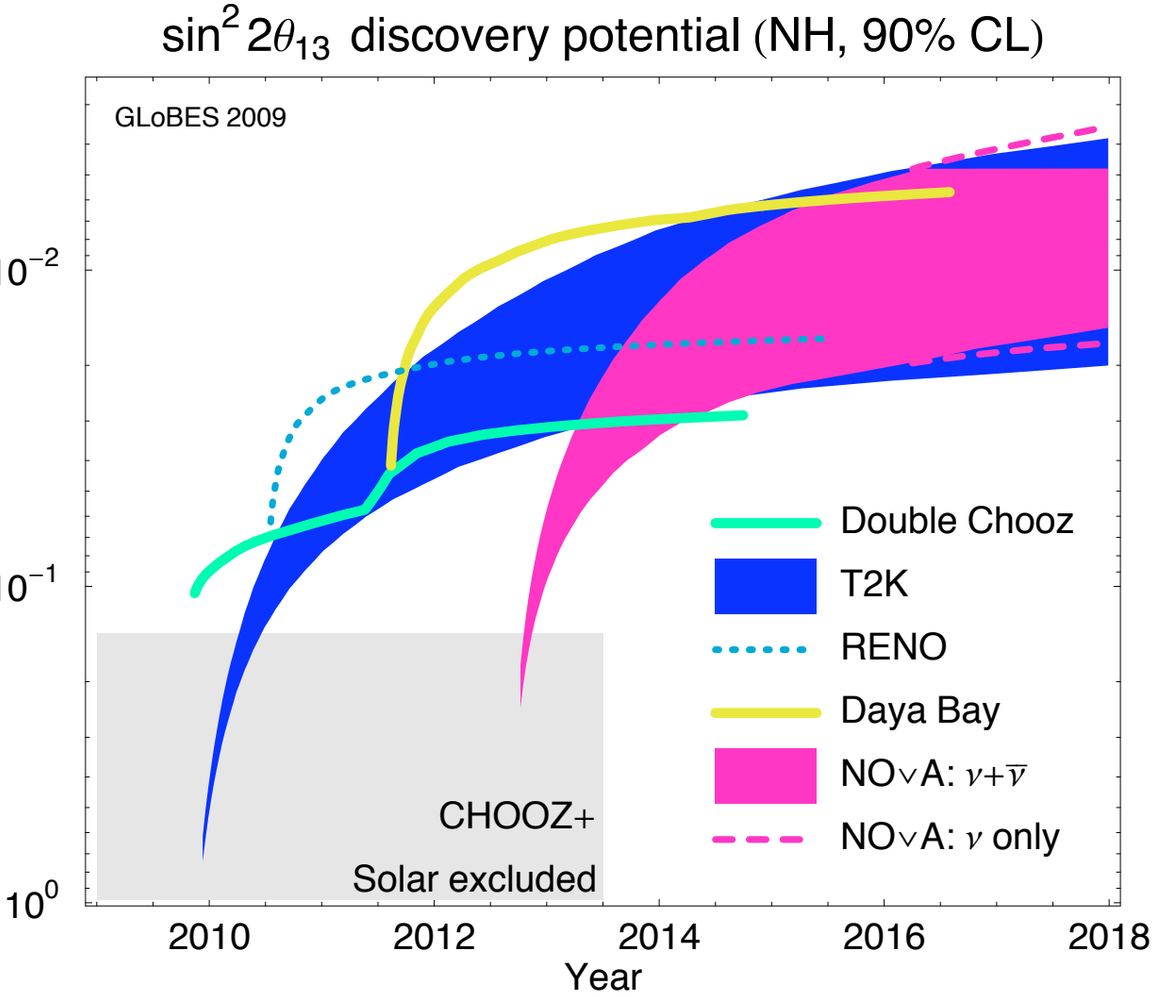
Fanny Dufour

September 7th 2009

Future synergies

Very nice overview

Patrick Huber



Summary

- If current hints for θ_{13} are true, we should expect exciting results in 1-2 years
- Very difficult to get CP or mass hierarchy without upgrades, even in the best case!
- With upgrades, good chances at 90% CL ($\sin^2 2\theta_{13} > 0.01$)
- With upgrades, 20-30% chance at $3\,\sigma$ ($\sin^2 2\theta_{13} > 0.02$), no $5\,\sigma$
- Final sensitivities governed by Daya Bay, T2K and NOνA
- Coodination between beams crucial for early physics!

Setup	t_ν [yr]	$t_{\bar{\nu}}$ [yr]	$P_{\rm Th}$ or $P_{\rm Target}$	L [km]	Detector	$m_{\rm Det}$
Double Chooz	-	3	8.6 GW	1.05	L. scint.	8.3 t
Daya Bay	-	3	17.4 GW	1.7	L. scint.	80 t
RENO	-	3	16.4 GW	1.4	L. scint.	15.4 t
T2K	5	-	0.75 MW	295	Water	22.5 kt
NOνA	3	3	0.7 MW	810	TASD	15 kt

Low energy atmospheric neutrinos

New to me!

Orlando Peres

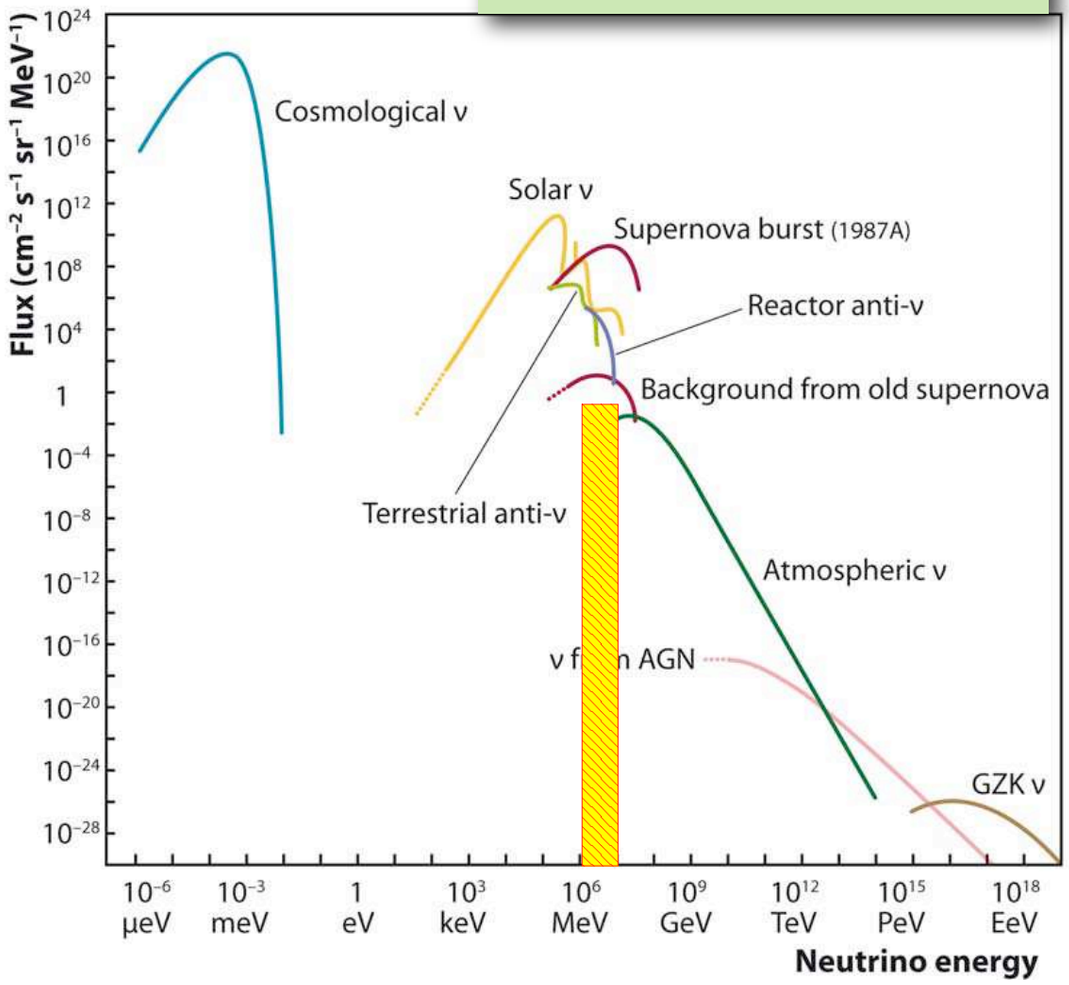
- Most of atmospheric neutrinos event sample are from pion/kaon decay in flight

$$p + p(p+n) \rightarrow X + \pi^+/K^+$$

$$\pi^+ \rightarrow \mu^+ \nu_\mu$$

$$\mu^+ \rightarrow e^+ \nu_e \bar{\nu}_\mu$$

But also we have contribution from π and μ decays at rest. For very low energies, below 0.1 GeV we can have neutrinos from both processes (decays in flight and at rest) . In this work we study to look for oscillation effects for these very low atmospheric neutrinos: sub-subGeV sample.



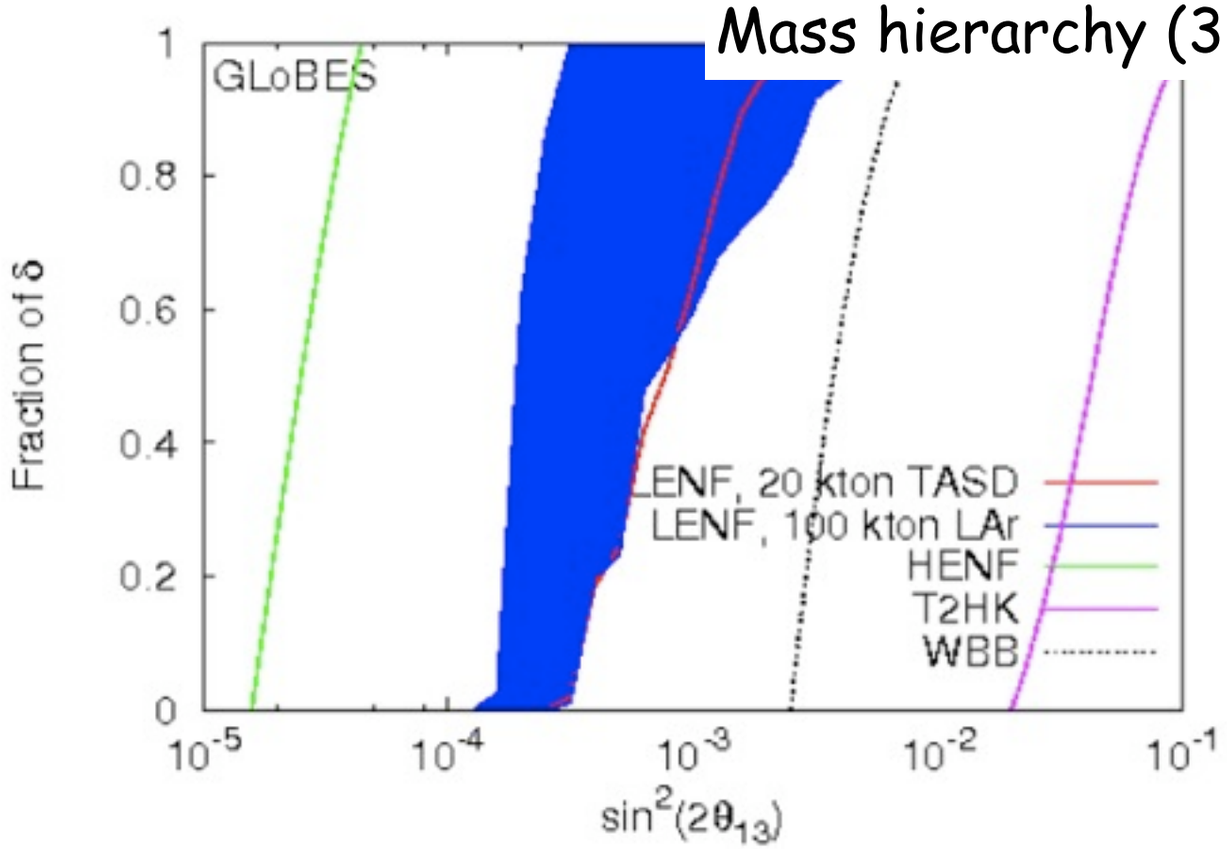
At low energy, the muons can be below Cherenkov threshold. In this "invisible muon" case, we will see only the Michel electrons.

- To study oscillation effects discussed in this paper one needs much larger statistics which can be achieved with the Megaton-scale detector. The sub-sub GeV sample can be used to measure deviation of 2-3 mixing from maximal, the 1-3 mixing and the phase δ. We urge to have a full understanding of fluxes of these neutrinos that can have implication for detection of diffuse neutrinos from relic supernova.

Low energy neutrinos factory

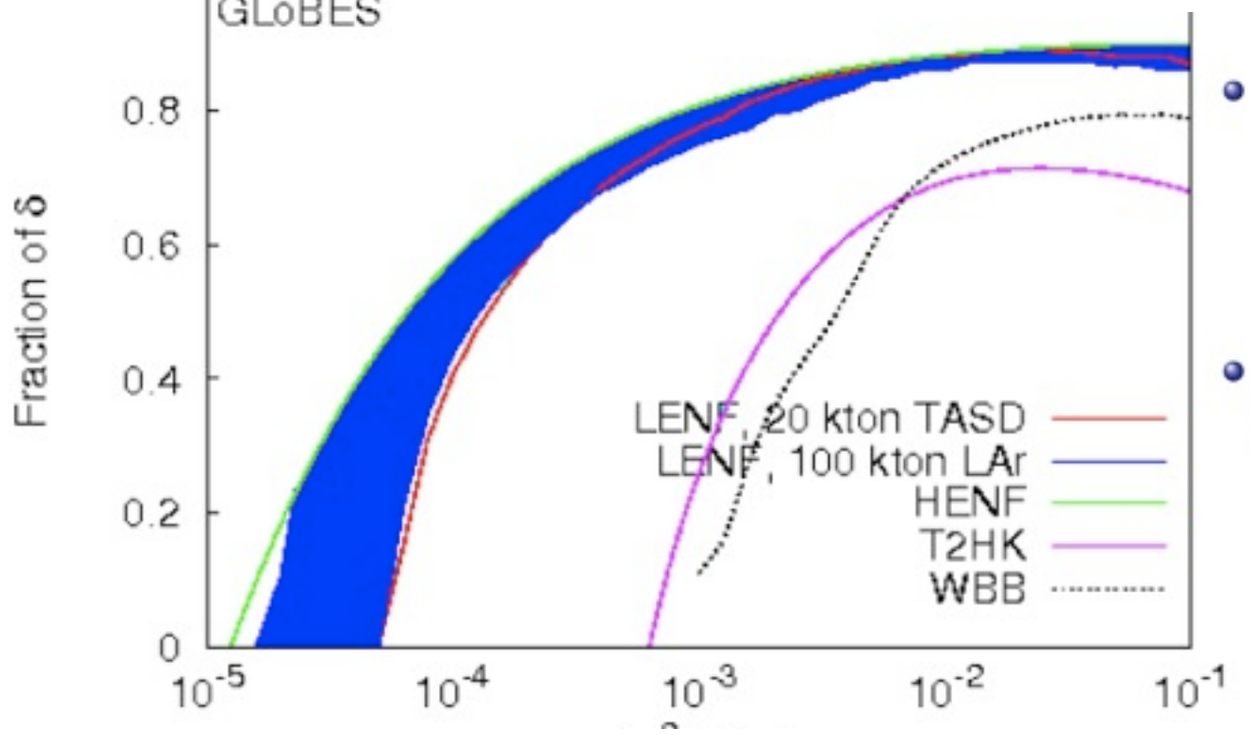
Tracey Li

Mass hierarchy (3 sigma)



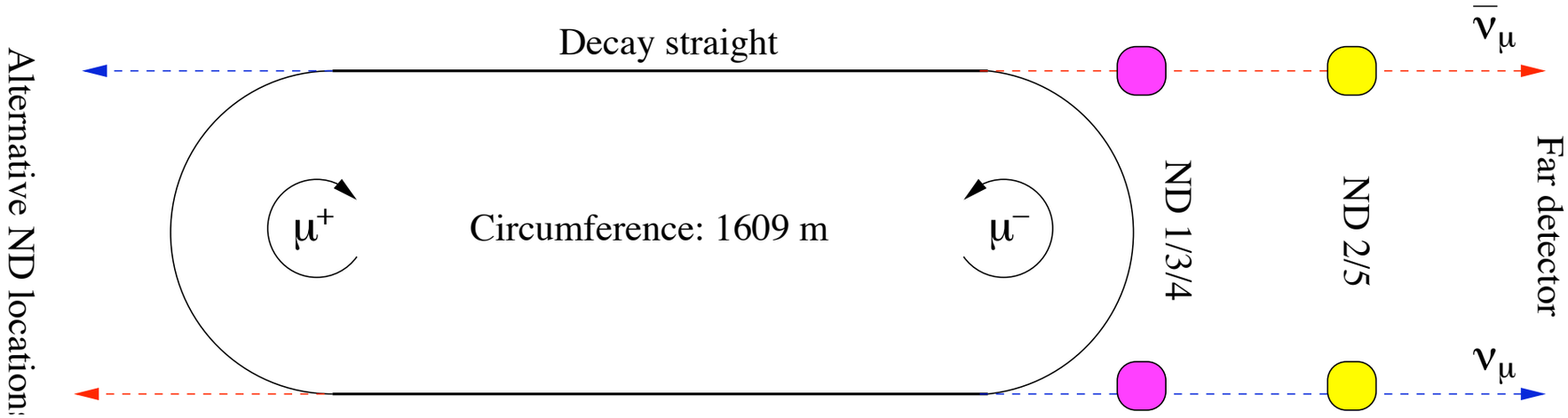
Results seems to be slightly worse than high energy neutrino factory but it is interesting to study every options possible.

CP violation 3 sigma



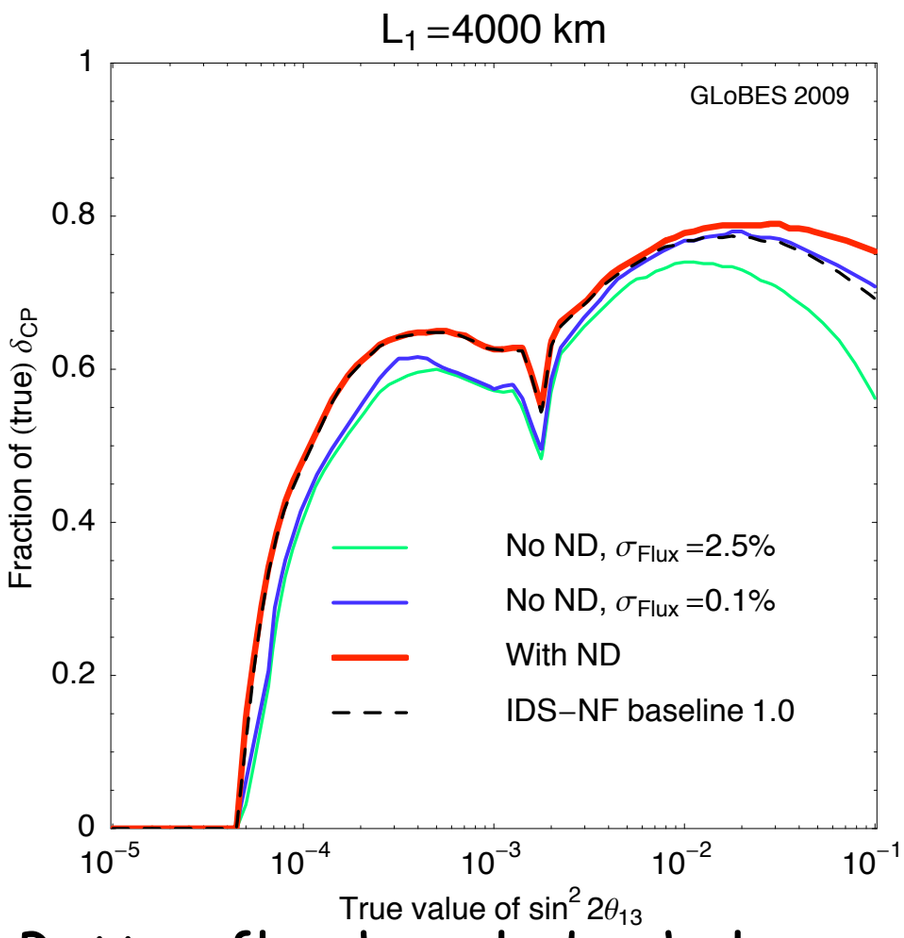
- We have simulated the following LENF set-up, optimized for measuring θ_{13}, δ and the mass hierarchy:
  L = 1300 km, $E_\mu = 4.5$ GeV, 1.4×10^{21} $\mu^\pm$ decays per year for 10 years.
- Using either a 20 kton TASD or 100 kton LAr detector, the LENF has excellent sensitivity to θ_{13} down to $\sin^2(2\theta_{13}) \simeq 10^{-4}$, to CP violation for $\sin^2(2\theta_{13}) \gtrsim 10^{-4}$, and to the mass hierarchy for $\sin^2(2\theta_{13}) \gtrsim 10^{-3}$.

Effect of near detectors for NF studies

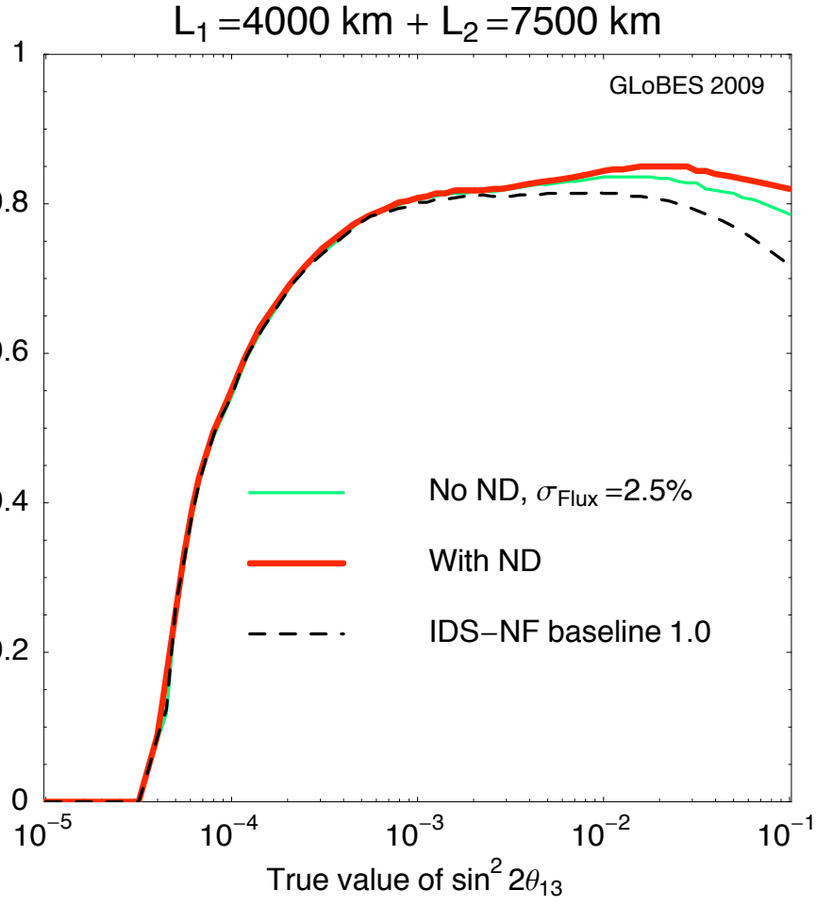


Jian Tang

Crucial to know more about



Better flux knowledge helps especially at high value of theta 13



When there are 2 far detectors, near detector doesn't help as much

Monte Carlo tools

Summary

Patrick Huber

GLoBES

- is the only open source software of its kind
- has withstood the test of time (next month, 5 years!)
- is at the core of most strategy documents
- completely in C
- flexibility to deal with complex many detector setups and non-standard physics

GLoBES is now a very well established tool.

Very useful to reproduce results and avoiding "personal code" bugs

Mattias Belnnow

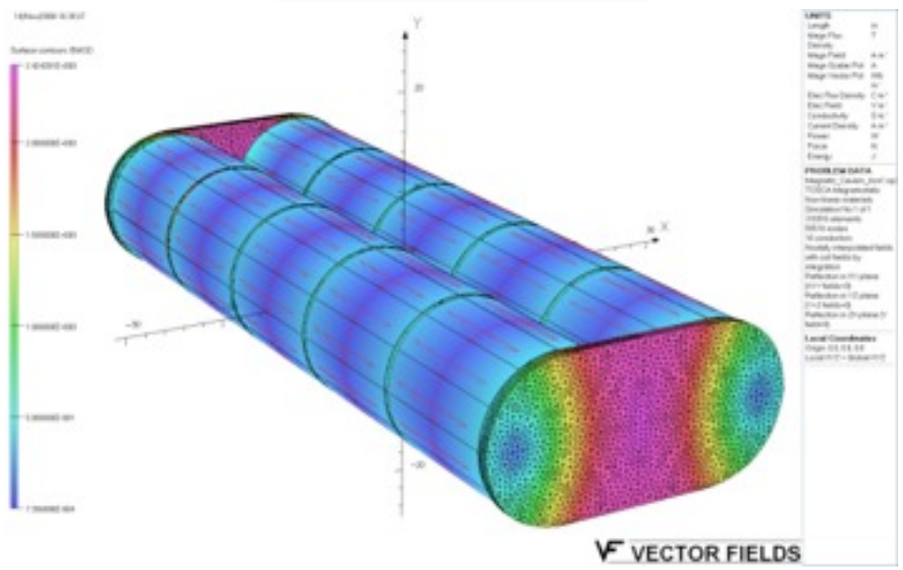
- It is a *plug-in* for GLoBES.
- Fully customizable MCMC codes.
- Uses a Matlab GUI for visualizing and interpreting the results.
- Effective also for a large number of parameters.
- Finding degenerate solutions.
- Fully compatible with standard GLoBES experimental definitions (AEDL files).

Monte Cubes is a new tool especially useful for large parameters space.

Three kinds of detectors for NF

TASD

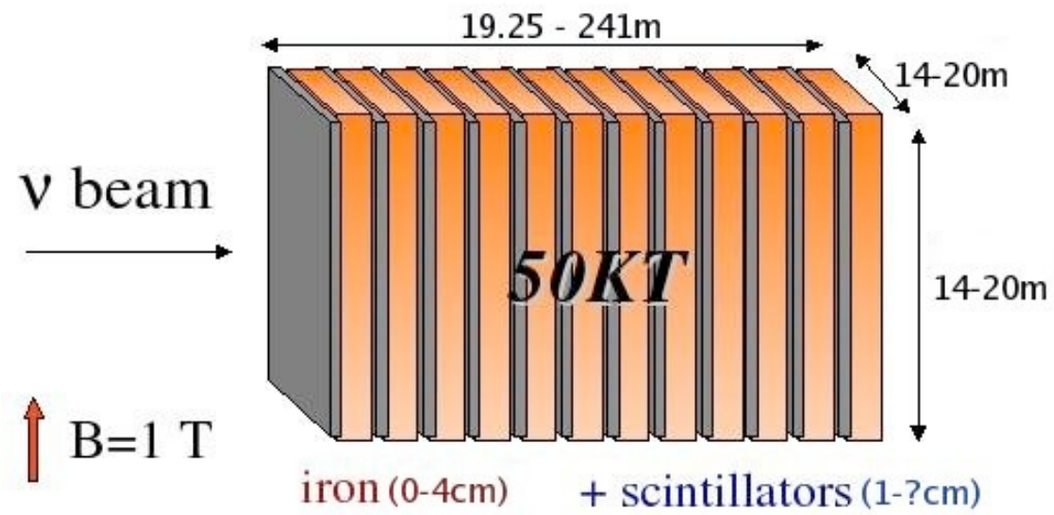
Malcom Ellis



Currently eye-scanning events, will automatize soon.

MIND

Andrew Laing



Full Geant 3 simulation done, working on Geant 4 Analysis software

Liquid argon: see next slide

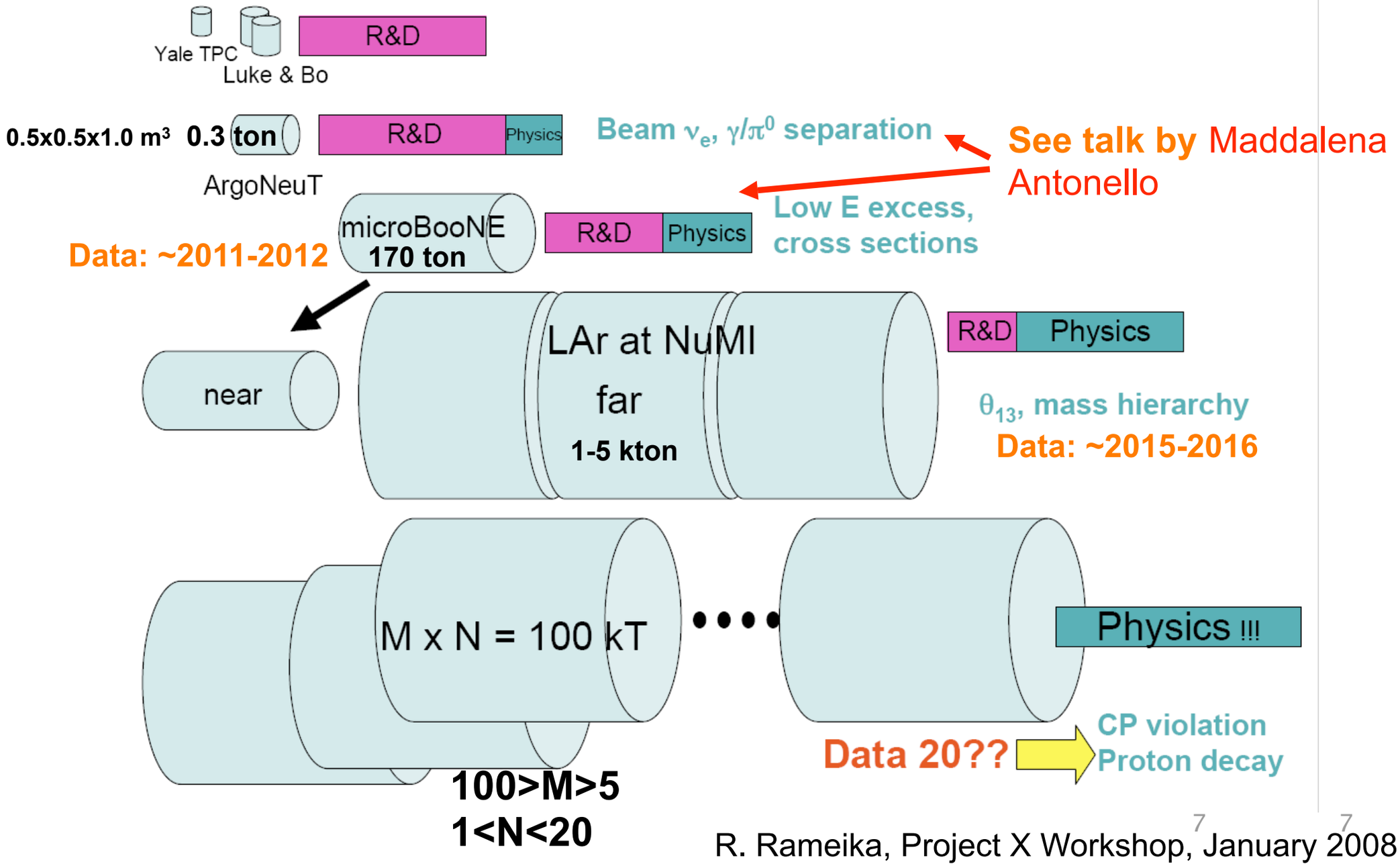
LAr at Fermilab

Takasumi Maruyama

Very strong LAr effort in the US

Proposed Strategy @ Fermilab

Evolution of the Liquid Argon Physics Program



R. Rameika, Project X Workshop, January 2008

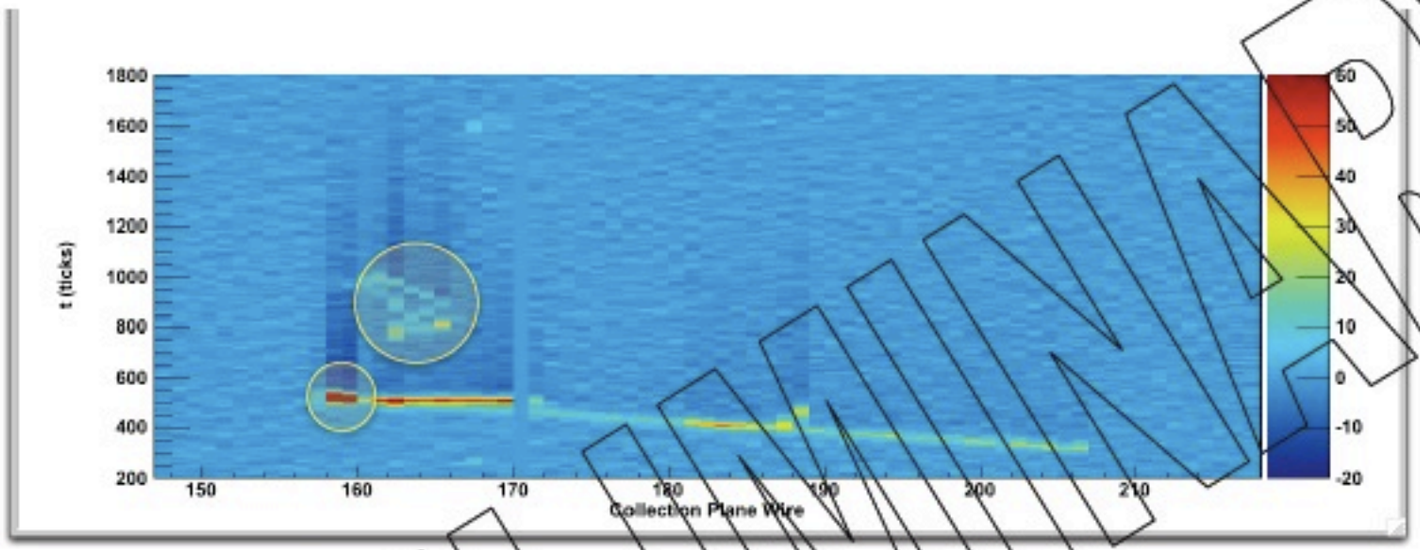
Some LAr real events

Ornella Palamara

Good to see real LAr events!

ArgoNeuT

A closer inspection of the event topology (thanks to the imaging capabilities of the LAr TPC) shows:



1) **large activity near the vertex**

$\mu^- + p + X$ (X = additional "short track" [2 wires] associated with high energy density deposition)

X compatible with a second 25 MeV p track

from nuclear evaporation (FSI in nucleus) or pion re-absorption

2) **an extra energy deposition** (37 MeV) possibly associated with the event (e^+e^- *pair*), induced by a neutral particle.

7/22/09 O. Palamara 23

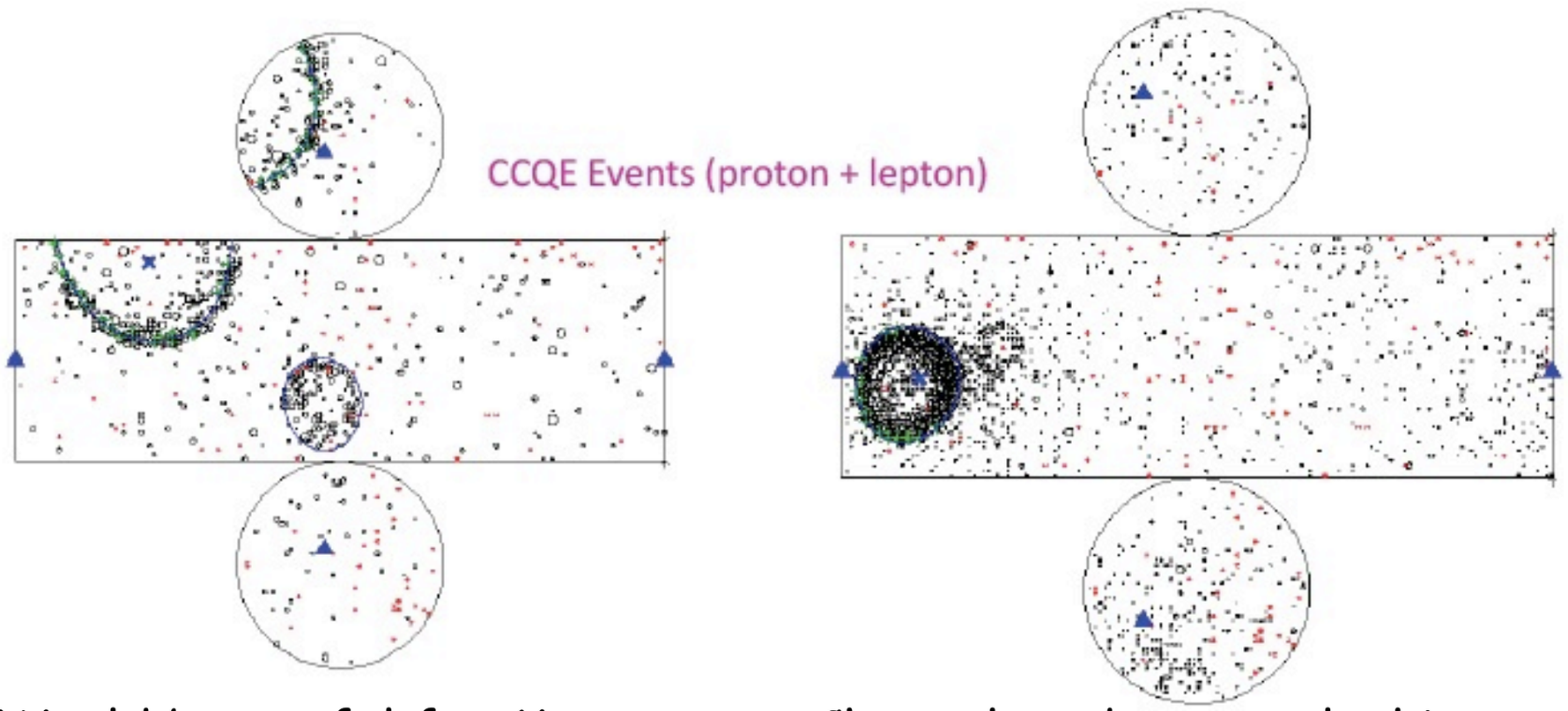
Many more interesting events in her talk!

Improving the old tools

Chris Walter

Worth keeping an eye on what can be done with atmospheric neutrinos!

What if we could identify all CCQE outgoing particle in a water Cherenkov detector ? (when proton is above Cherenkov threshold)



Would be useful for Mton water Cherenkov detector looking at atmospheric neutrinos.

Event class	Expected in 1 Mton yr (40% coverage)	Expected in 1 Mton yr (20% coverage)
Single proton	375	310
Tagged CCQE e-like	337 (53.0%)	295 (51.4%)
Tagged CCQE μ-like	500 (62.4%)	450 (61.3%)

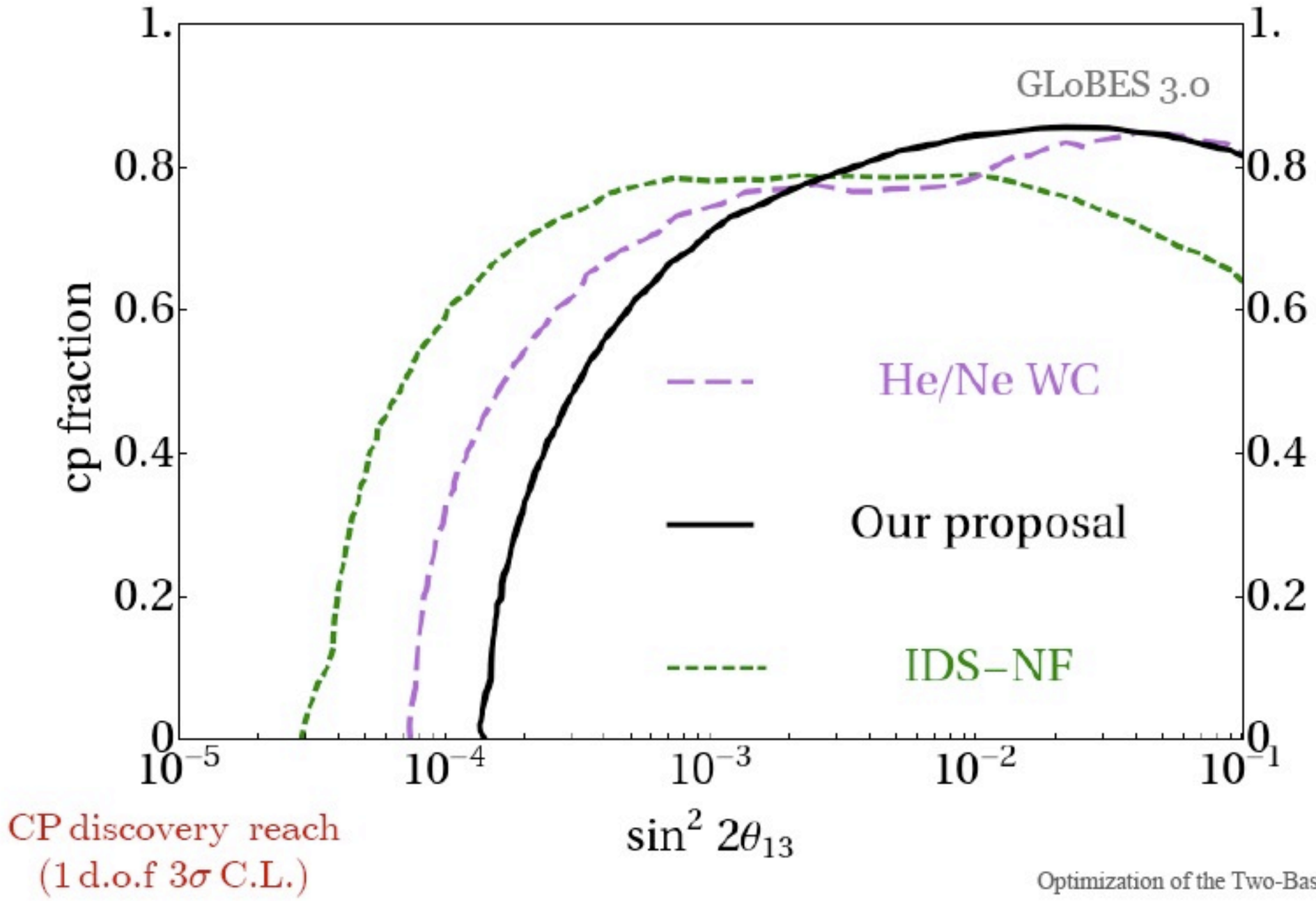
Would help constrain sterile admixture searches

Note:
Also useful if we use beta beams and superbeams

Beta-beam versus neutrino factory

Pilar Coloma

Comparison with the Neutrino Factory



CP discovery reach
(1 d.o.f 3σ C.L.)

A lot of info about Beta Beam and their performance compared to neutrino factories

And much more…

I was there.
I saw it !!!

Perfect pitching is awesome.

18th perfect pitching game of history and only one with a grand slam…

Non-standard interactions & sterile

Sorry I did not attend this session at all.

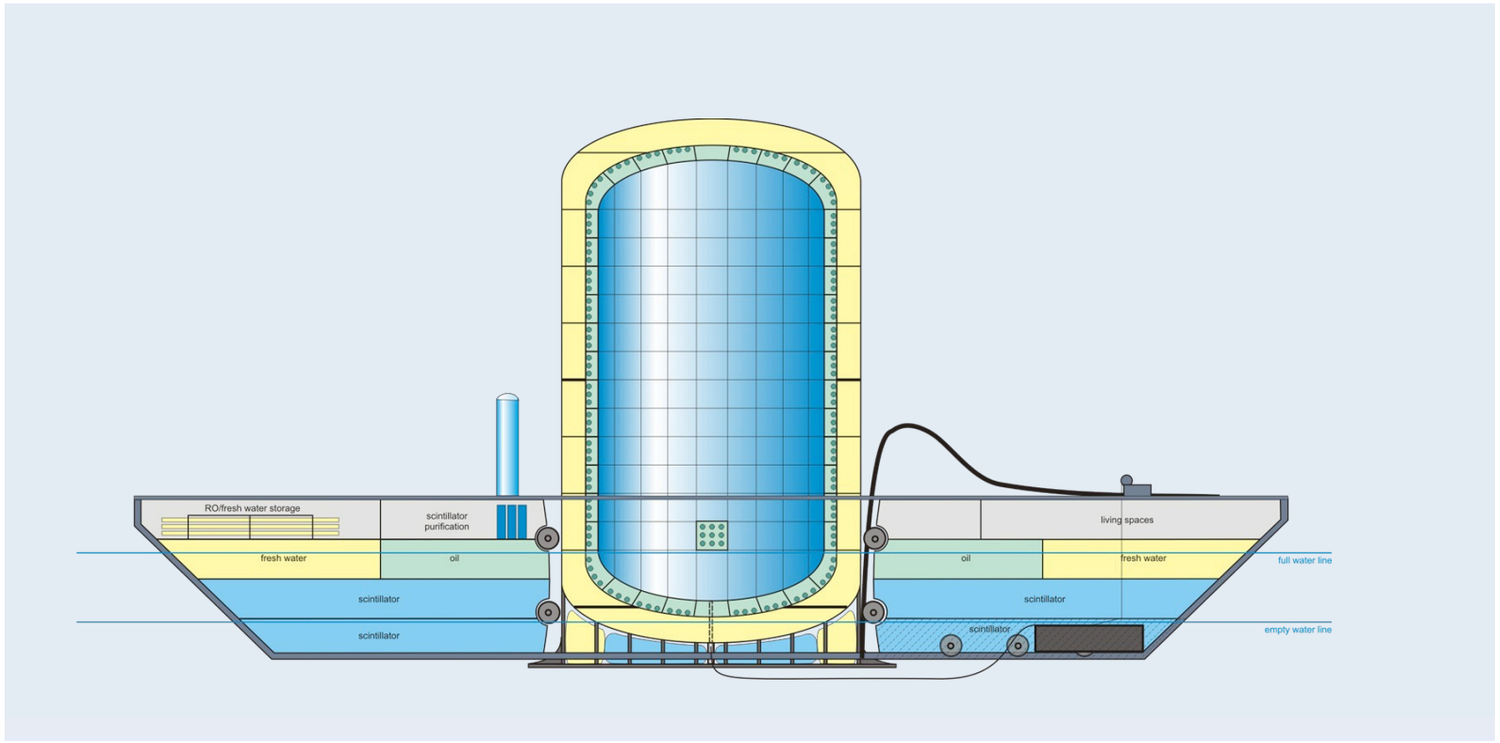
Physics with Beta-beam

Pilar Coloma

A lot of info about Beta Beam and their performance compared to neutrino factories

- We believe that the β-Beam we propose here represents an optimal setup:
  - It has the advantages of the high-γ He/Ne β-Beam, but solving the degeneracies that affected this setup for $\sin^2(2\theta_{13}) \sim 10^{-2}$
  - It uses the magic baseline to achieve good sensitivity to the mass hierarchy
- β-Beams still cannot compete with the NF for extremely small values of θ_{13}, but our proposal is better optimized for regions with $\sin^2(2\theta_{13}) > 10^{-3}$
  - The sensitivity is unaffected by the poor efficiencies for the lower energy bins
- However, we still are limited...
  - By the number of ions that can be produced: all the setups presented here are strongly limited by statistics
  - A study of the MIND detector performance when exposed to a β-Beam is lacking

and more


RO/fresh water storage
scintillator purification
living spaces
fresh water
oil
oil
fresh water
full water line
scintillator
scintillator
scintillator
scintillator
empty water line