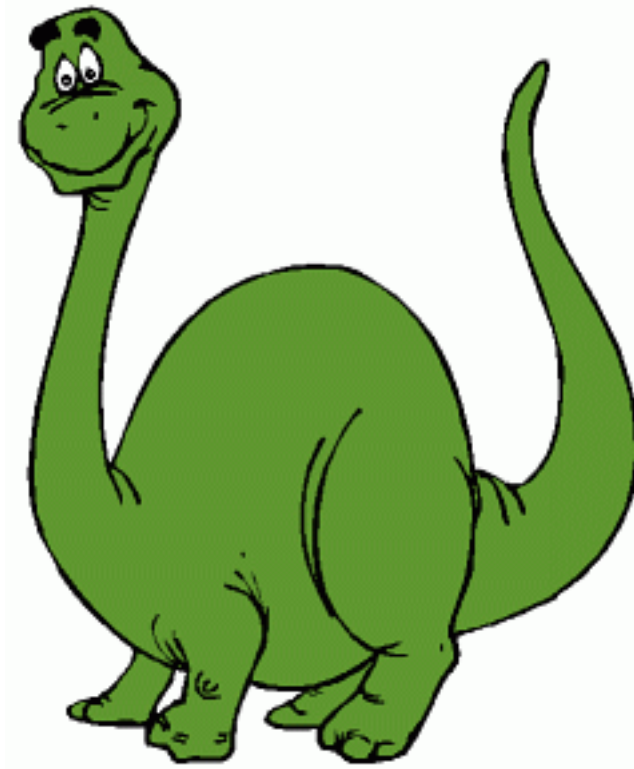


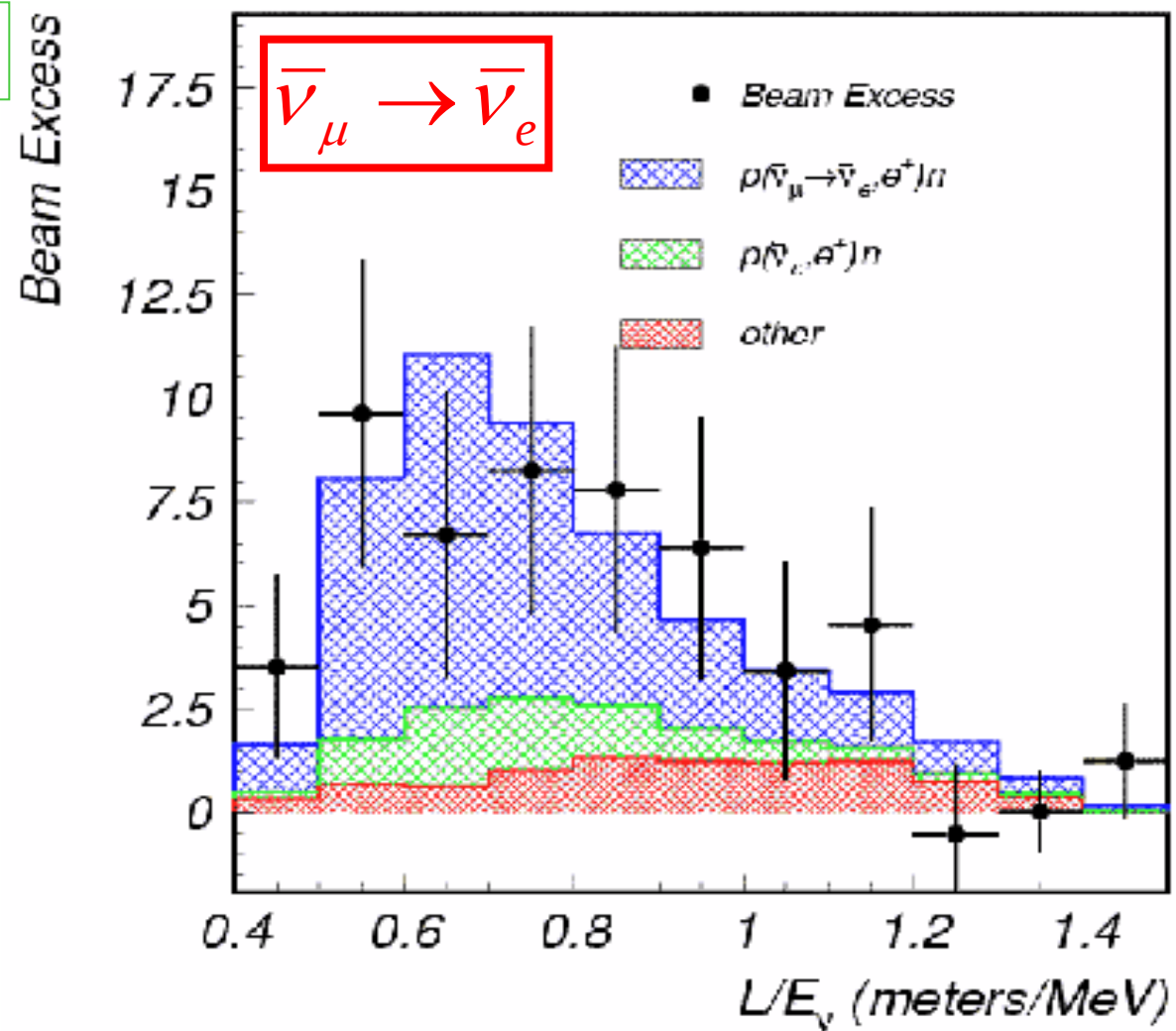
NESSIE



Neutrino Experiment with Spectrometers in Europe

P. Bernardini
Consiglio di Sezione
June 25, 2012

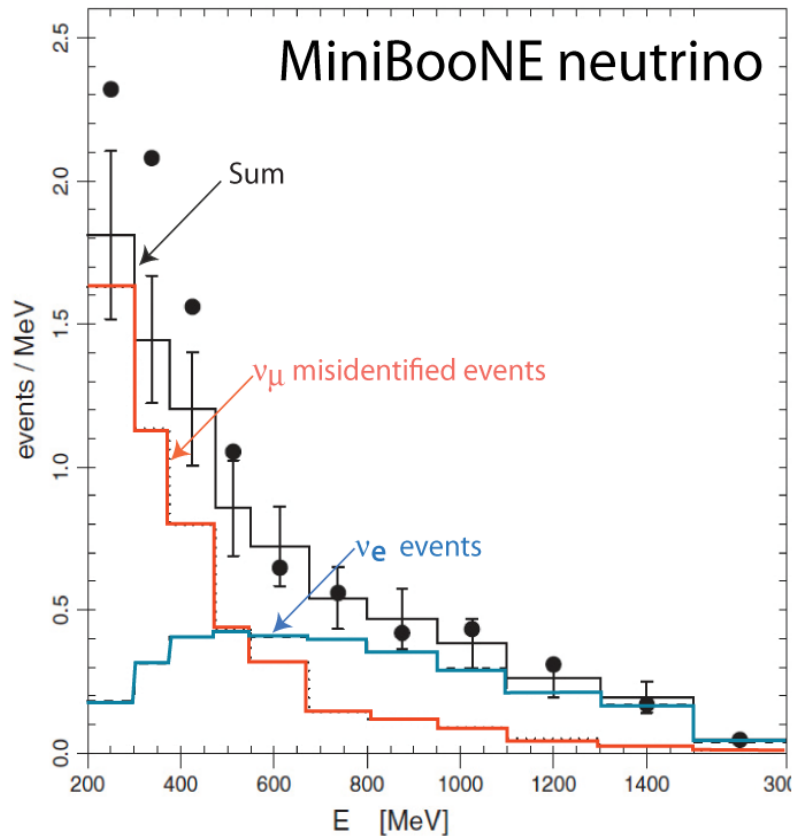
Physics case - LSND



Excess: $87.9 \pm 22.4 \pm 6.0$ events

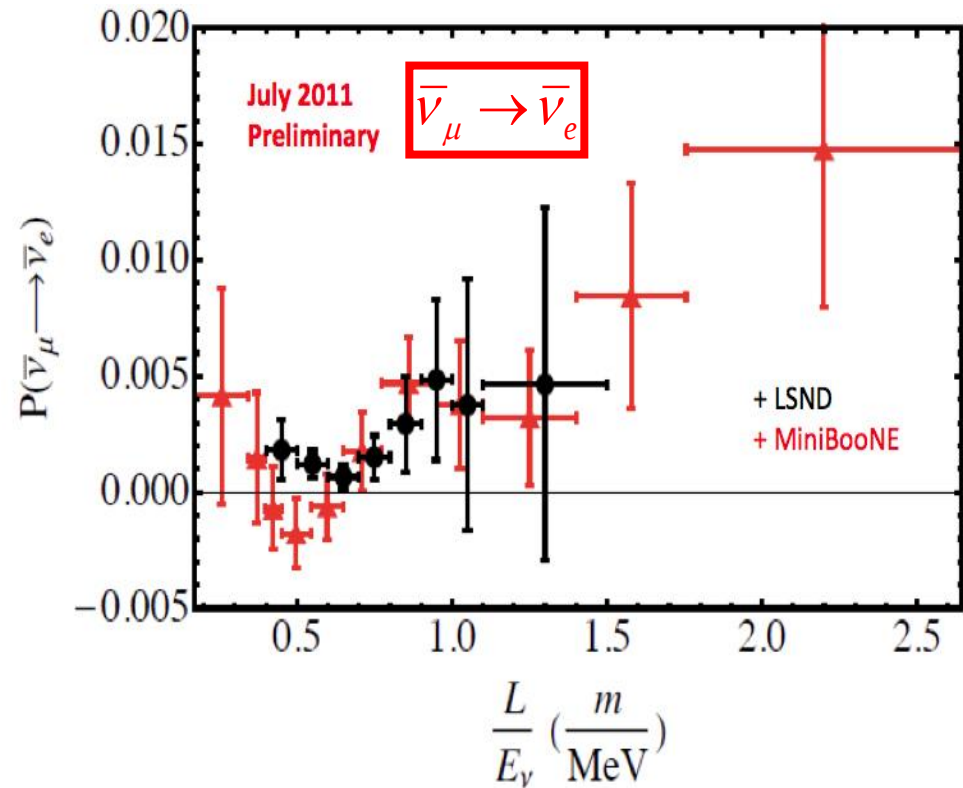
- | The experimental evidence is very strong : 3.8 s.d.
- | The experimental result has not been challenged

Physics case - MiniBooNE



Neutrino run

Slight low energy disagreement between data (*black dots*) and sum of predictions (*black line*)



Anti-neutrino run

LSND-like anomaly for $E > 430$ MeV

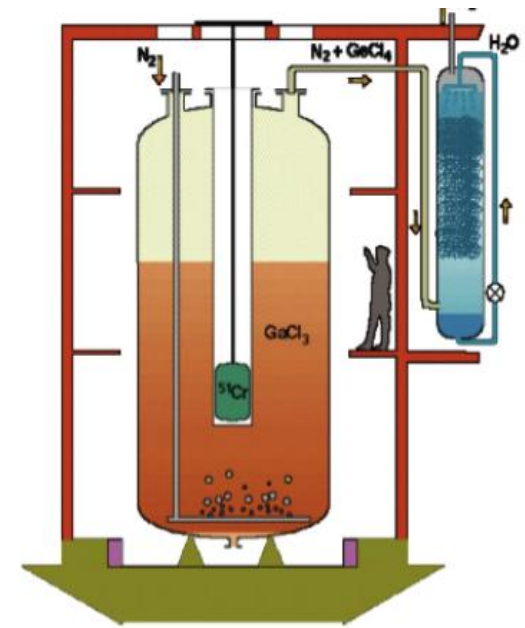
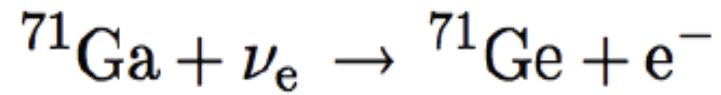
99.4% probability of anomalous ν_e production

Physics case - Gallium

Calibration of SAGE and GALLEX experiments by means of radioactive sources (^{51}Cr , ^{37}Ar)

Detection/prediction ratio:

$$R = 0.86 \pm 0.05 \quad (2.7 \sigma \text{ effect})$$



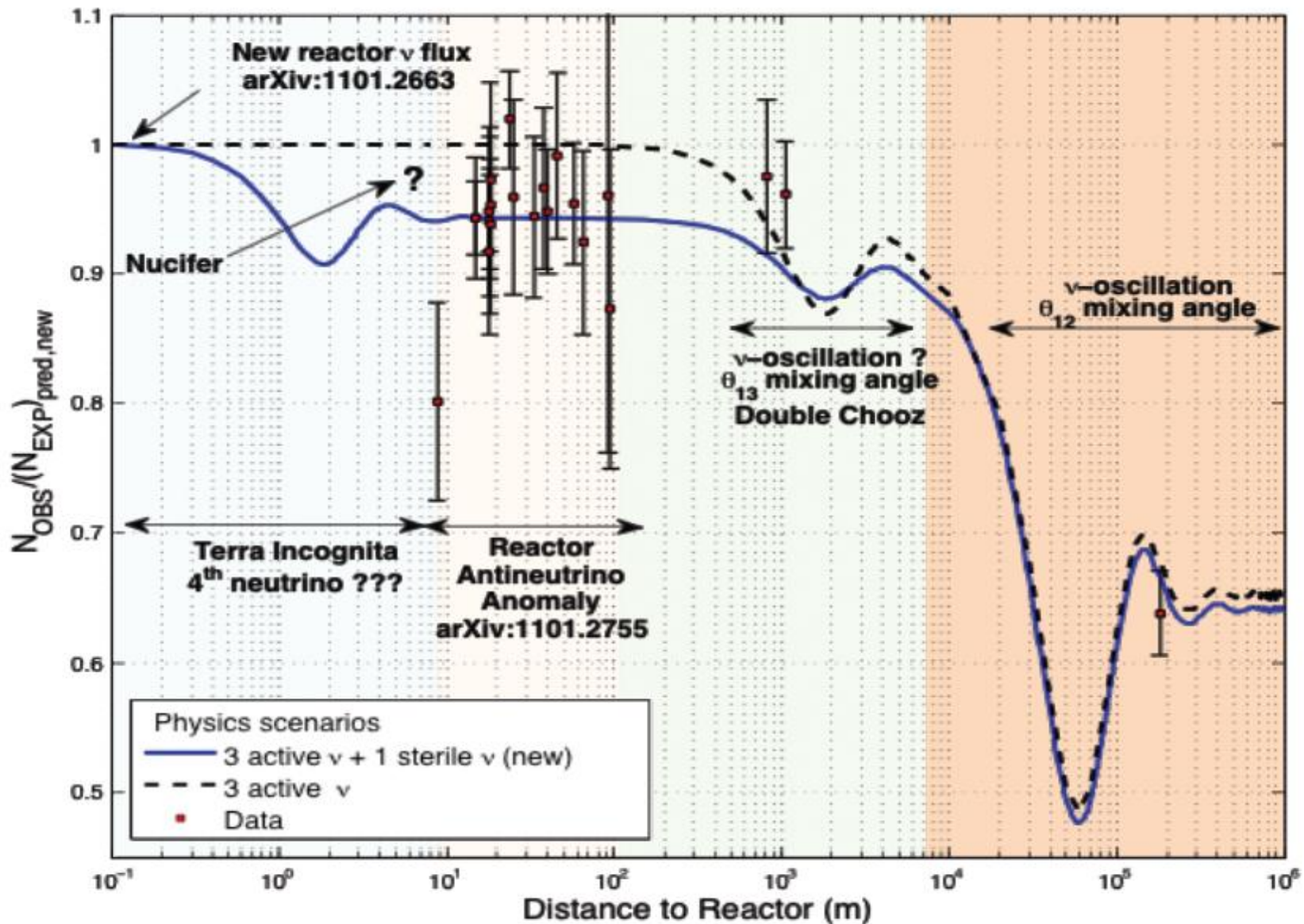
30.3 tons of Gallium
in an aqueous solution : $\text{GaCl}_3 + \text{HCl}$

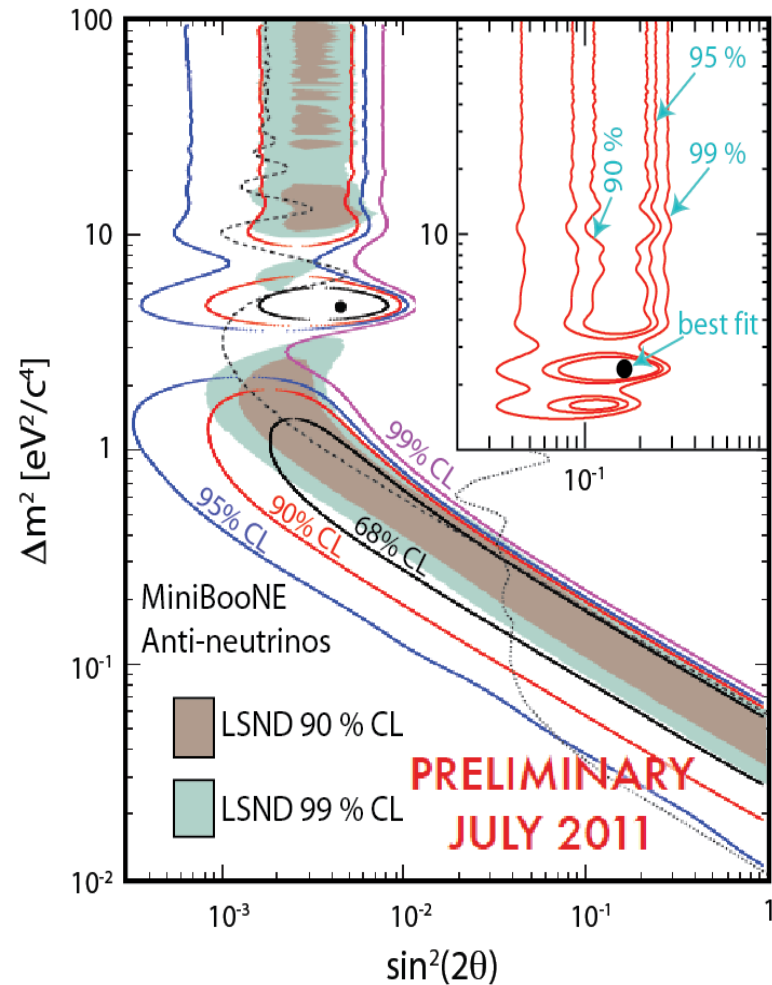
These results favour the existence of an undetected sterile neutrino in a broad range of values centred at $\Delta m_{\text{new}}^2 \approx 2 \text{ eV}^2$, $\sin^2(2\theta_{\text{new}}) \approx 0.3$

Physics case - Reactors

Detection/prediction ratio:

$$R = 0.937 \pm 0.027 \text{ (2.3 } \sigma \text{ effect)}$$

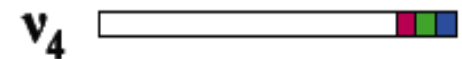




Allowed regions

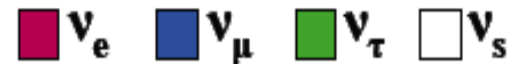
Right → ν_e disappearance
(reactors and Ga sources)

Left → anti- ν_e anomaly
(LSND / MiniBooNE)



Possible common origin of Δm^2_{new}

Four neutrino hypothesis to explain
different values of $\sin^2(2\theta_{\text{new}})$



Search for “anomalies” from neutrino and anti-neutrino oscillations at $\Delta m^2 \approx 1\text{eV}^2$ with muon spectrometers and large LAr-TPC imaging detectors.

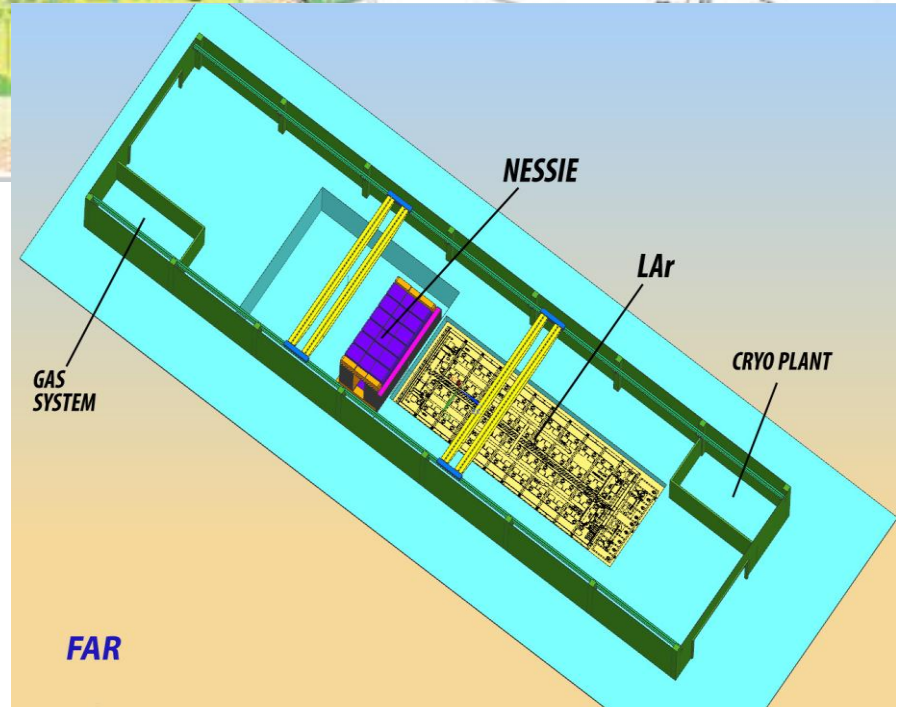


Table 1. Interaction rates in the LAr-TPC's at the Near (119 t) and Far locations (476 t) for 1 year of operation (4.5×10^{19} pot) with negative polarity beam. Oscillation events, in the electron-neutrino appearance mode, are also shown for some $\Delta m^2 - \sin^2(2\theta)$ parameters.

	Near		Far	
	Total	E<6 GeV	Total	E<6 GeV
ν_μ CC	2.49×10^6	7.26×10^5	3.44×10^5	9.66×10^4
anti- ν_μ CC	1.88×10^6	1.31×10^6	2.42×10^5	1.69×10^5
$\nu_e + \text{anti-}\nu_e$ CC	1.17×10^5	3.49×10^4	1.54×10^4	4.22×10^3
$\Delta m^2 = 0.4 \text{ eV}^2, \sin^2(2\theta) = 0.02$	3.41×10^2	3.32×10^2	8.17×10^2	7.84×10^2
$\Delta m^2 = 2.0 \text{ eV}^2, \sin^2(2\theta) = 0.002$	6.13×10^2	5.91×10^2	4.38×10^2	3.62×10^2
$\Delta m^2 = 0.064 \text{ eV}^2, \sin^2(2\theta) = 0.96$	4.32×10^2	4.21×10^2	1.46×10^3	1.42×10^3
$\Delta m^2 = 4.42 \text{ eV}^2, \sin^2(2\theta) = 0.0066$	6.01×10^3	5.67×10^3	1.89×10^3	9.89×10^2

ν_e appearance mode
negative polarity

Table 2. Rates of fully reconstructed events in the NESSiE spectrometers at the Near (241 t) and Far locations (661 t), for 1 year operation with negative polarity beam. The rows “NESSiE+LAr” correspond to events identified in both detectors. For some $\Delta m^2 - \sin^2(2\theta)$ «best fit» parameters the numbers of disappeared CC events are also shown (in parenthesis the percentage «oscillated / non-oscillated» is given).

	Near		Far	
	Total	E<6 GeV	Total	E<6 GeV
ν_μ CC (NESSiE+LAr)	1.19×10^6	2.29×10^5	1.42×10^5	2.09×10^4
ν_μ CC (NESSiE alone)	2.32×10^6	1.15×10^6	1.86×10^5	9.41×10^4
anti- ν_μ CC (NESSiE+LAr)	6.71×10^5	3.68×10^5	6.78×10^4	3.3×10^4
anti- ν_μ CC (NESSiE alone)	1.52×10^6	1.13×10^6	1.19×10^5	8.98×10^4
(3+1) $\Delta m^2 = 0.9 \text{ eV}^2$, $\sin^2(2\theta) = 0.083$	1.48×10^3 (0.1%)	1.45×10^3 (0.13%)	2.50×10^3 (2.1%)	2.43×10^3 (2.7%)
(3+1) $\Delta m^2 = 1.6 \text{ eV}^2$, $\sin^2(2\theta) = 0.034$	1.87×10^3 (0.12%)	1.84×10^3 (0.16%)	1.98×10^3 (1.7%)	1.70×10^3 (2.11%)
(3+2) $\Delta m_{41}^2 = 0.47 \text{ eV}^2$, $\Delta m_{51}^2 = 0.87 \text{ eV}^2$	1.96×10^3 (0.13%)	1.92×10^3 (0.17%)	3.50×10^3 (2.94%)	3.42×10^3 (3.8%)
(3+2) $\Delta m_{41}^2 = 1.00 \text{ eV}^2$, $\Delta m_{51}^2 = 1.60 \text{ eV}^2$	3.68×10^3 (0.24%)	3.6×10^3 (0.32%)	5.12×10^3 (4.3%)	4.96×10^3 (5.5%)

CC disappearance mode - negative polarity

Table 3. Interaction rates in the LAr-TPC's at the Near (300 m, 119 t) and Far locations (1600m, 476 t) for 1 year of operation ($4.5 \cdot 10^{19}$ pot) with positive polarity beam. Oscillation events, in the electron-neutrino appearance mode, are also shown for some $\Delta m^2 - \sin^2(2\theta)$ parameters.

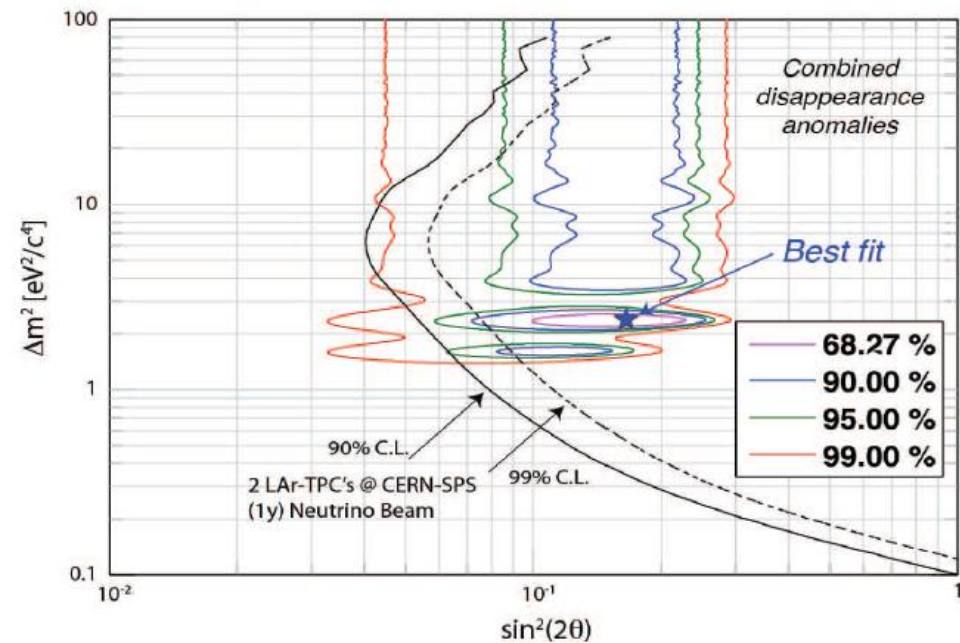
	NEAR		FAR	
	Total	E<6 GeV	Total	E<6 GeV
ν_μ CC	7.92×10^6	5.05×10^6	1.01×10^6	6.44×10^5
anti- ν_μ CC	5.29×10^5	1.98×10^5	7.34×10^4	2.63×10^4
ν_e + anti- ν_e CC	1.60×10^5	5.45×10^4	2.07×10^4	6.44×10^3
$\Delta m^2 = 0.4 \text{ eV}^2, \sin^2(2\theta)=0.02$	1.09×10^3	1.08×10^3	2.47×10^3	2.42×10^3
$\Delta m^2 = 2.0 \text{ eV}^2, \sin^2(2\theta)=0.002$	1.93×10^3	1.90×10^3	1.02×10^3	9.14×10^2
$\Delta m^2 = 0.064 \text{ eV}^2, \sin^2(2\theta)=0.96$	1.37×10^3	1.36×10^3	4.47×10^3	4.42×10^3
$\Delta m^2 = 4.42 \text{ eV}^2, \sin^2(2\theta)=0.0066$	1.75×10^4	1.70×10^4	3.59×10^3	2.40×10^3

ν_e appearance mode
positive polarity

Table 4. Rates of fully reconstructed events in the NESSiE spectrometers at the Near (241 t) and Far locations (661 t), for 1 year operation with positive polarity beam. The rows “NESSiE+LAr” correspond to events identified in both detectors. For some $\Delta m^2 - \sin^2(2\theta)$ «best fit» parameters the numbers of disappeared CC events are also shown (in parenthesis the percentage «oscillated / non-oscillated» is given).

	NEAR		FAR	
	Total	E<6 GeV	Total	E<6 GeV
ν_μ CC (NESSiE+LAr)	2.78×10^6	1.22×10^6	2.86×10^5	1.06×10^5
ν_μ CC (NESSiE alone)	5.35×10^6	3.59×10^6	4.15×10^5	2.84×10^5
anti- ν_μ CC (NESSiE+LAr)	1.89×10^5	5.62×10^4	3.15×10^4	6.9×10^3
anti- ν_μ CC (NESSiE alone)	3.99×10^5	2.98×10^5	4.33×10^4	2.25×10^4
(3+1) $\Delta m^2 = 0.9 \text{ eV}^2$, $\sin^2(2\theta) = 0.083$	3.76×10^3 (0.07%)	3.18×10^3 (0.1%)	6.44×10^3 (1.55%)	6.25×10^3 (2.2%)
(3+1) $\Delta m^2 = 1.6 \text{ eV}^2$, $\sin^2(2\theta) = 0.034$	4.76×10^3 (0.13%)	4.69×10^3 (0.16%)	5.26×10^3 (1.27%)	5.03×10^3 (1.77%)
(3+2) $\Delta m_{41}^2 = 0.47 \text{ eV}^2$, $\Delta m_{51}^2 = 0.87 \text{ eV}^2$	4.99×10^3 (0.1%)	4.92×10^3 (0.14%)	9.03×10^3 (2.17%)	8.77×10^3 (3.08%)
(3+2) $\Delta m_{41}^2 = 1.00 \text{ eV}^2$, $\Delta m_{51}^2 = 1.60 \text{ eV}^2$	9.37×10^3 (0.17%)	9.18×10^3 (0.25%)	1.33×10^4 (3.21%)	1.29×10^4 (4.53%)

CC disappearance mode - positive polarity

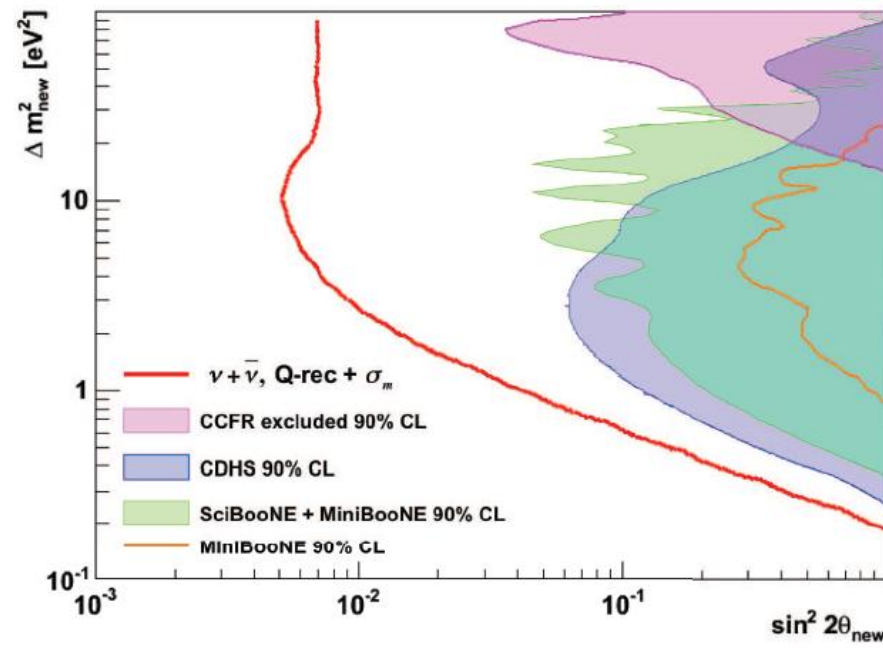


ν_e disappearance anomaly

Searching for disappearance rates depending on distance and energy

anti- ν_e appearance anomaly

Searching for ν_e excess (especially in antineutrino channel) depending on distance and energy



Pubblicazioni

- NESSiE Collaboration "Prospect for Charge Current Neutrino Interactions Measurements at the CERN-PS", [arXiv:1111.2242](#)
- ICARUS and NESSiE Collaboration "Search for "anomalies" from neutrino and anti-neutrino oscillations at $\Delta m^2 \sim 1 \text{ eV}^2$ with muon spectrometers and large LAr-TPC imaging detectors", [arXiv:1203.3432v2](#)
- K.N. Abazajian et al. "Light Sterile Neutrinos: A White Paper", [arXiv:1204.5379](#)

Tesi triennale

- F. Giglio "Studio su uno spettrometro per muoni di energia inferiore al GeV", aprile 2012

STATO del PROGETTO

- CSN II (presentazioni e referee)
- SPSC (risposta ai referee)
- Presidente (MoU)
- Sergio Bertolucci
- In attesa del pronunciamento del SPSC

Lecce

P. Bernardini, G. Mancarella, G. Marsella, A. Surdo ...
A. Del Prete, Calabrese

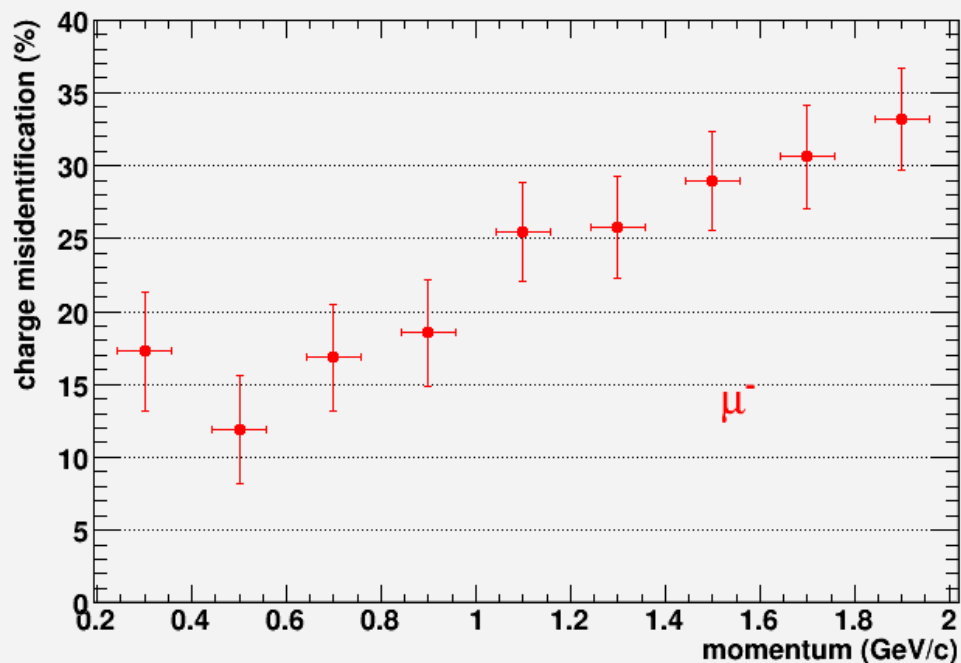
2012 Activity

Muon charge ID by the Air Core Magnet
Muon/electron separation
Simulation (detector, physical processes)
Software (event display)
Prototype design

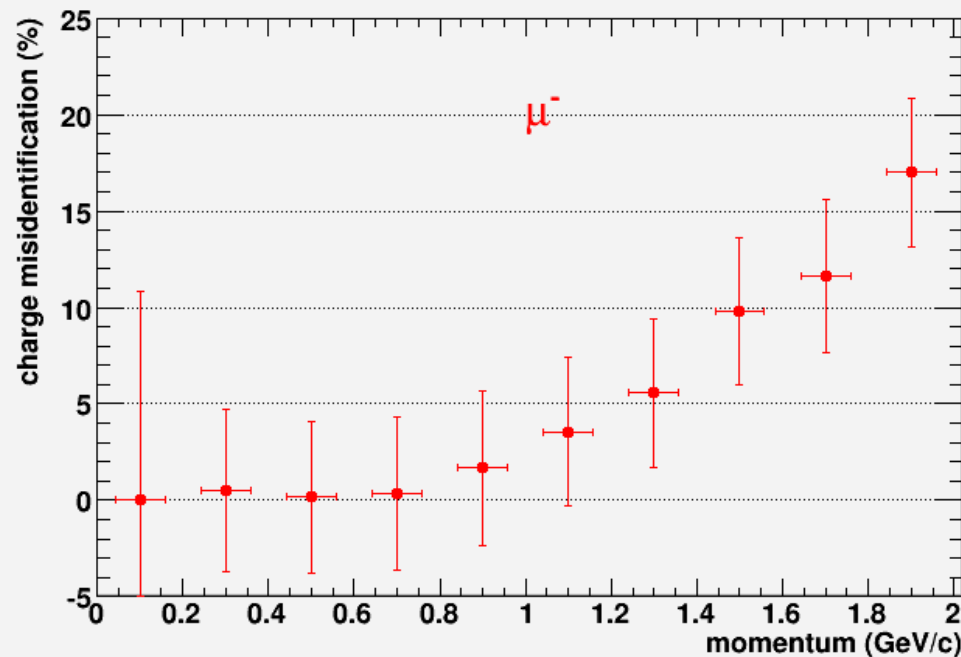
2013 Activity

Simulation + Algorithms + Analysis
Prototype (design, commissioning ...)

External Detectors and Multiple Scattering

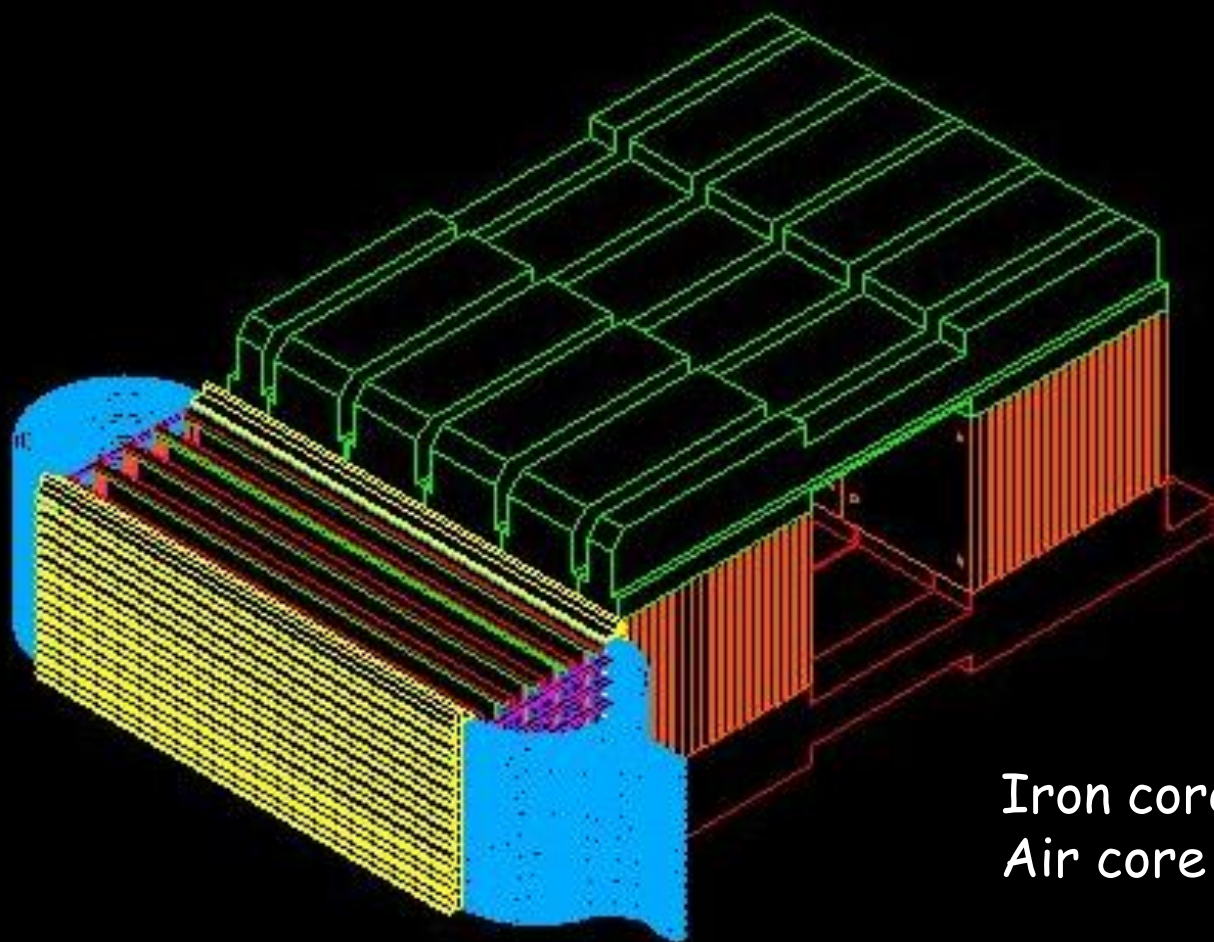


Internal Detectors and Sagitta Method



Prototype @ LNF

Power supply
Cooling
Magnetic field
Measurements
Detector test



Iron core magnet
Air core magnet

134.3 ton
3.3 ton

138 ton



Heavier pieces:

9 ton x 4

Necessità servizi di sezione nel 2013 e oltre

- | | | |
|---|-------------|--------|
| • Progettazione prototipo (6 mesi) : | 2 meccanici | al 50% |
| • Ordini e contatti con le ditte (3 mesi) : | 1 meccanico | al 50% |
| | 1 tecnico | al 50% |
| • Montaggio @ LNF (6 mesi) : | 3 meccanici | al 50% |
| | 1 tecnico | al 50% |
| • Running @ LNF (6 mesi) : | 1 tecnico | al 50% |