Radioactive Neutrino Sources in Large Volume Detectors For Sterile Neutrino Search

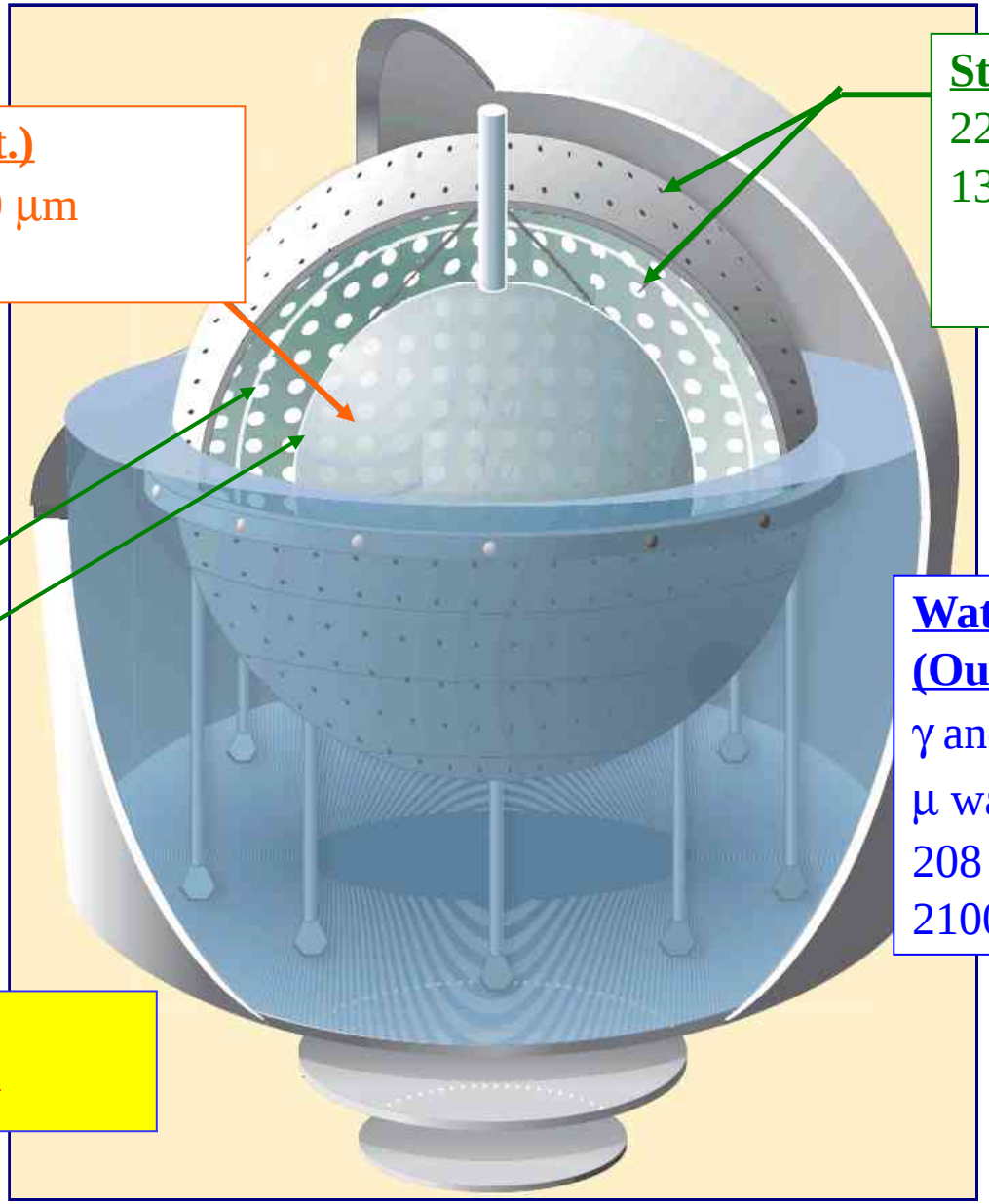
Werner Maneschg

SOX within Borexino

Scintillator (Inner Det.)
270 t PC+PPO in a 150 μm thick nylon vessel

Stainless Steel Sphere:
2212 photomultipliers
1350 m^3

Nylon vessels:
Inner: 4.25 m
Outer: 5.50 m

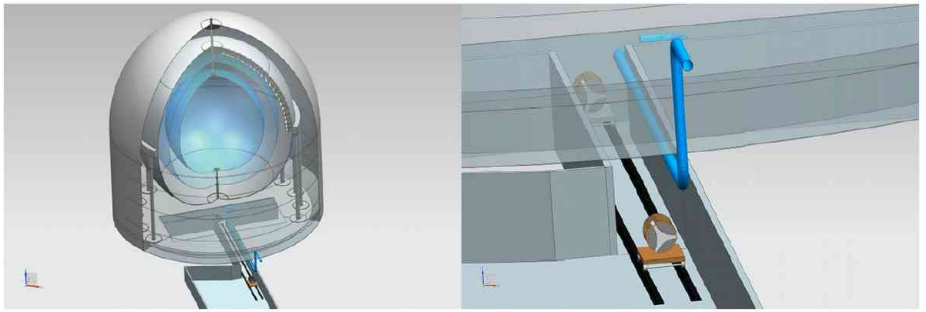


Water Tank (Outer Det.):
γ and n shield
μ water Cherenkov detector
208 PMTs in water
2100 m^3

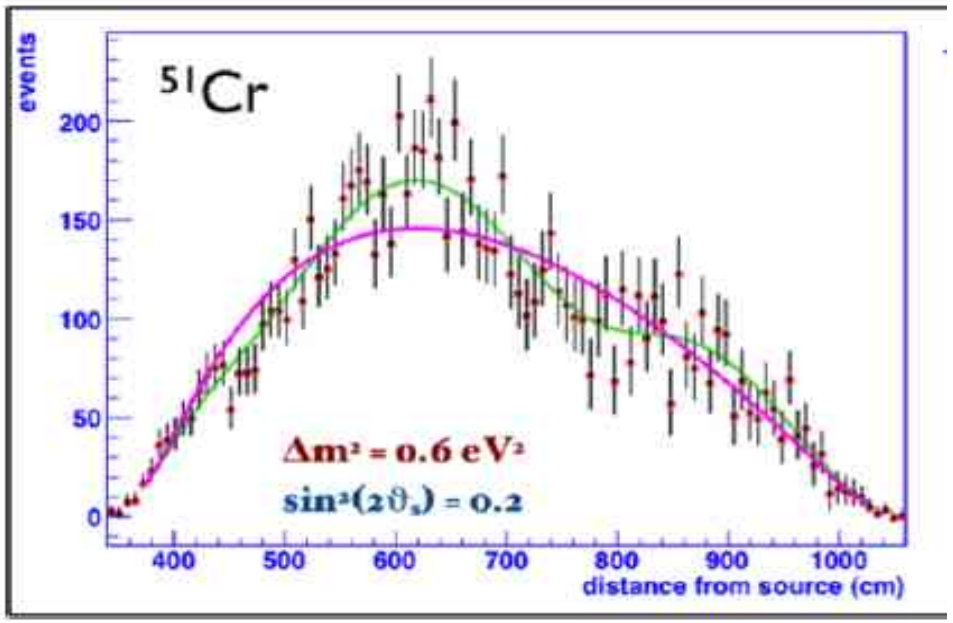
Excellent shielding of external background

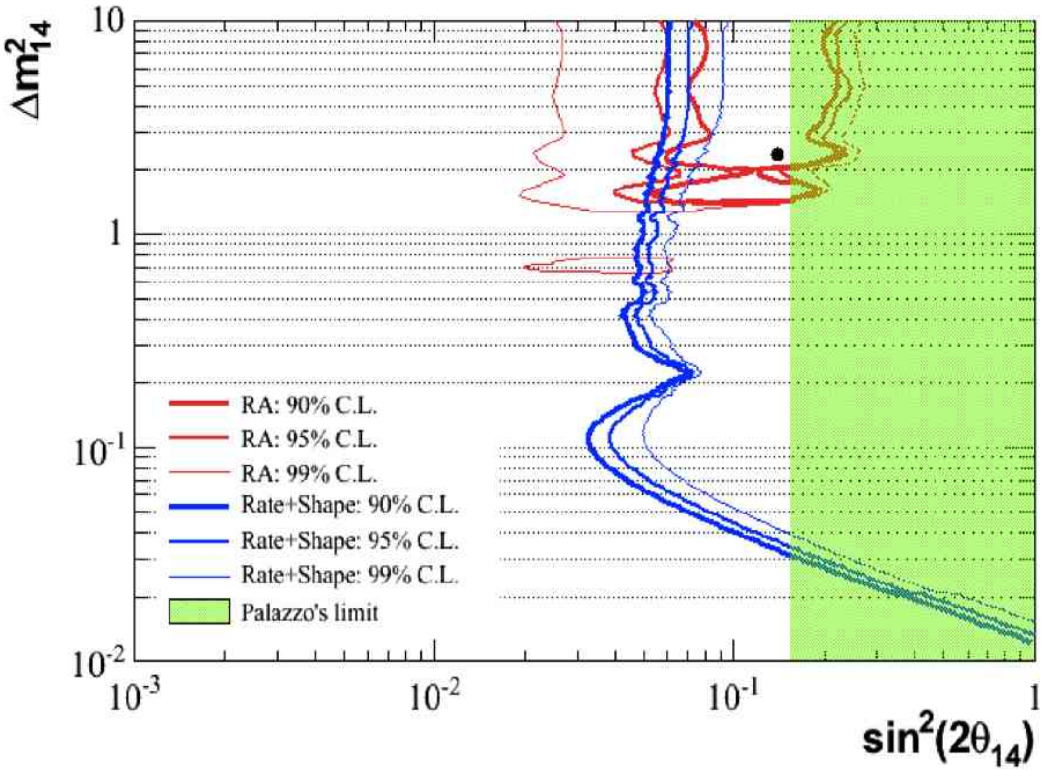
SOX within Borexino

51Cr source
(at bottom; event. In WT)



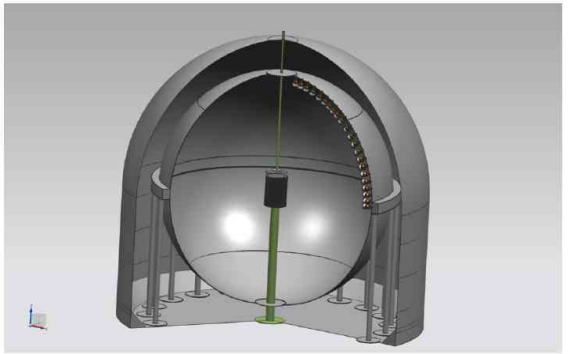
(a) (b)

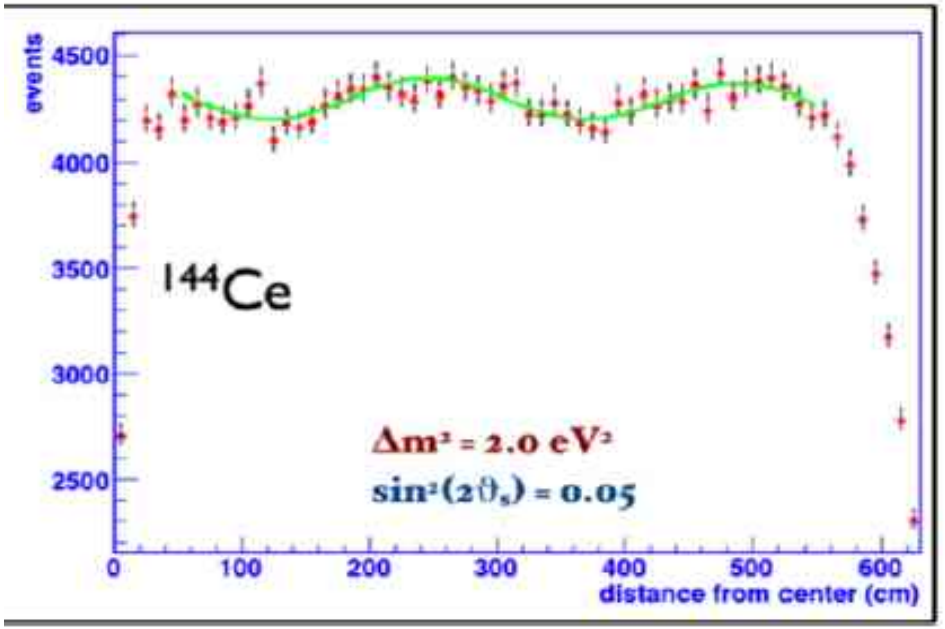


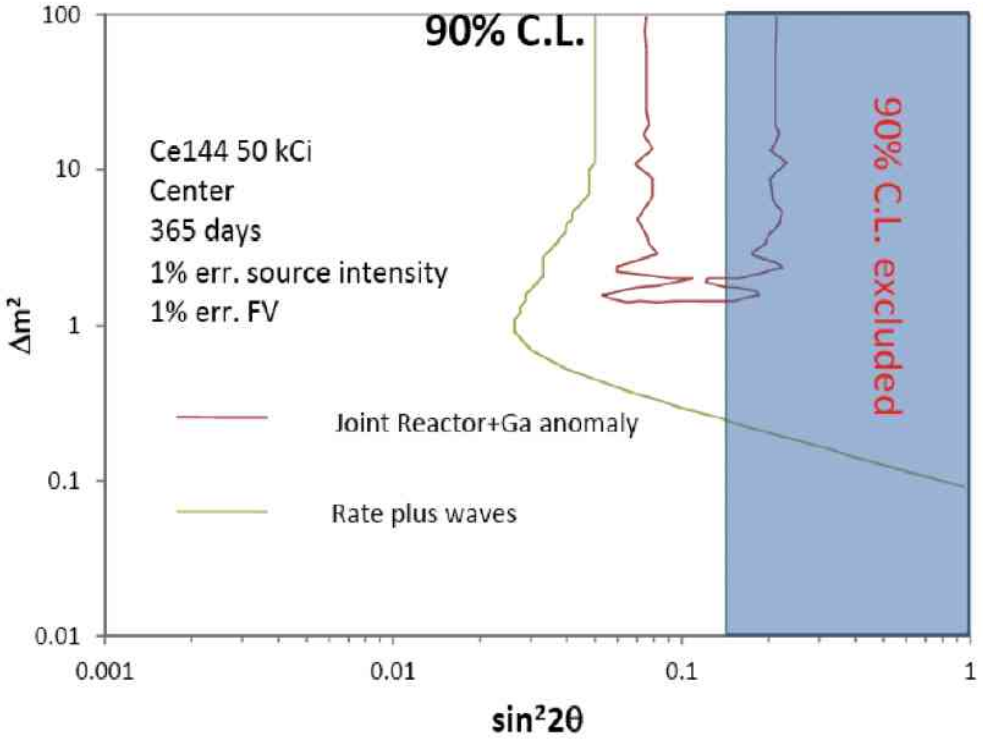


SOX within Borexino

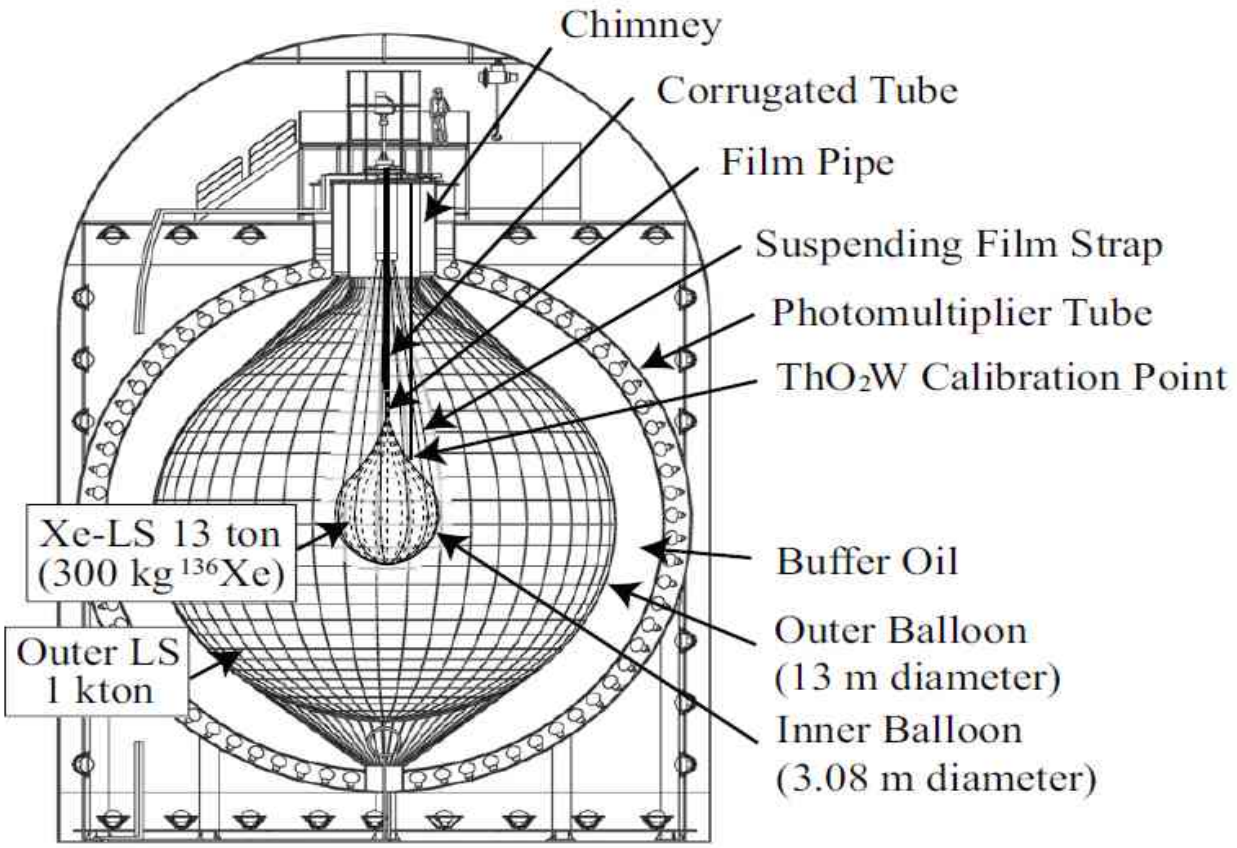
144Ce source
(at center)

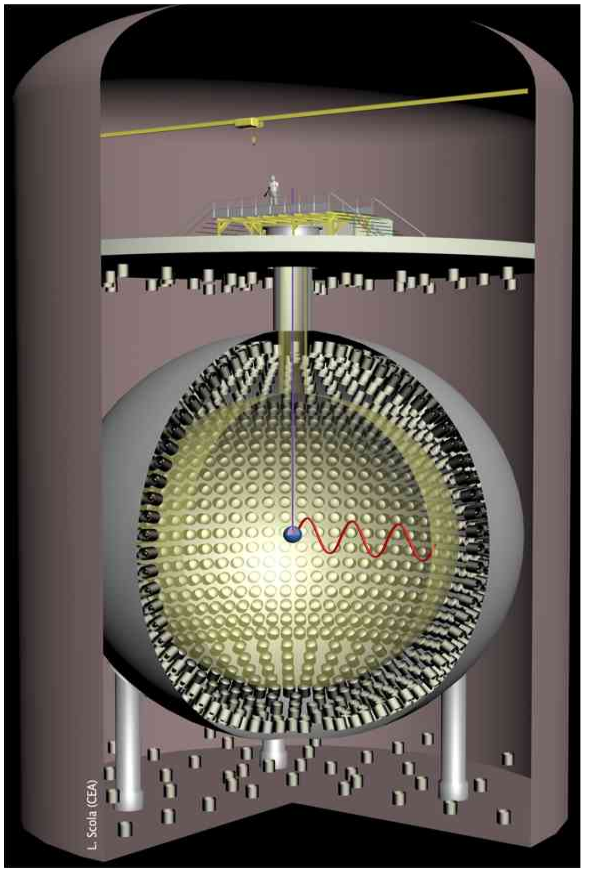






CeLAND within KamLAND





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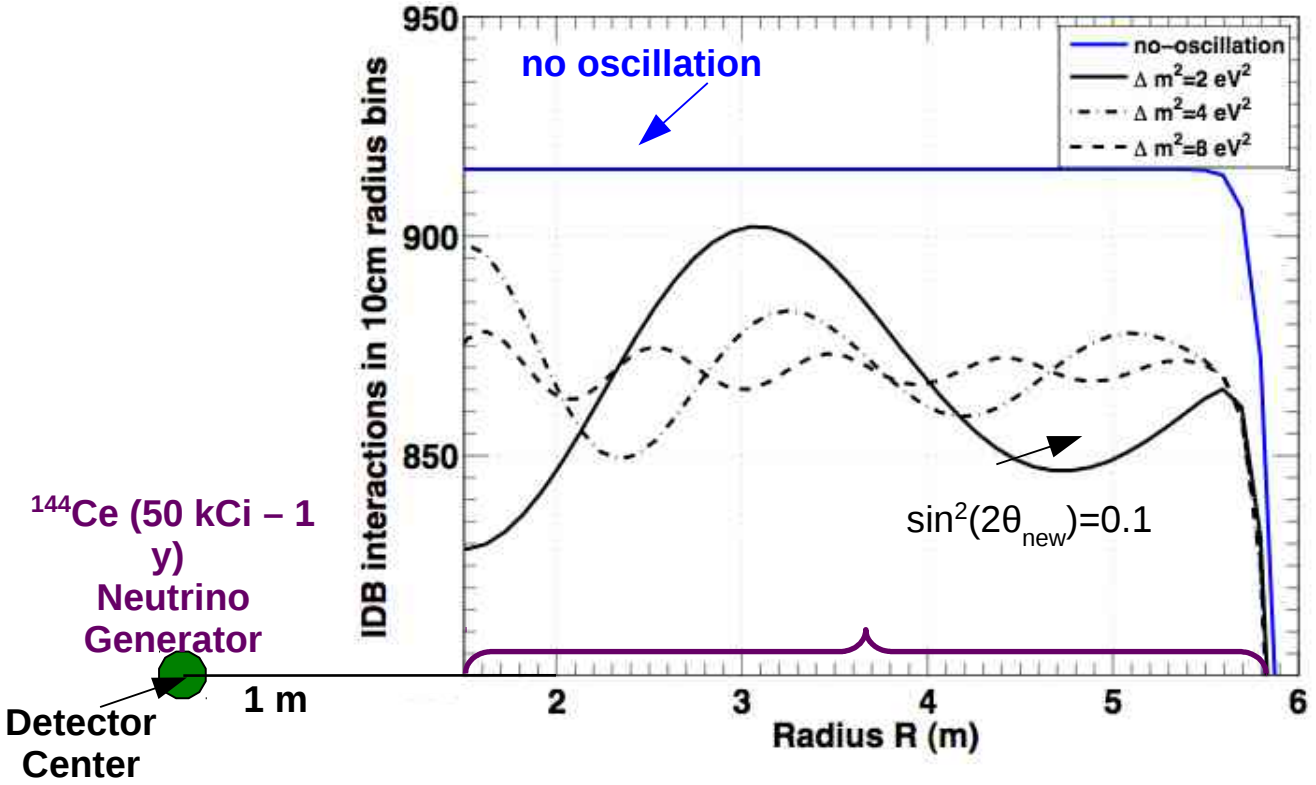
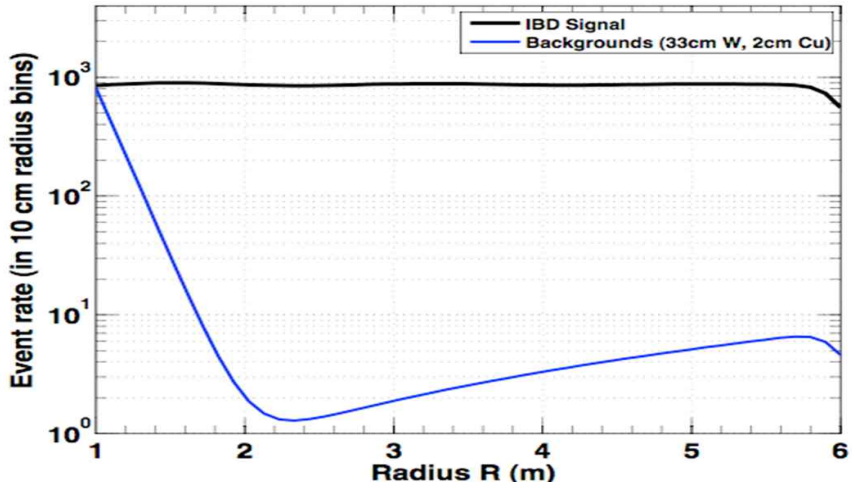
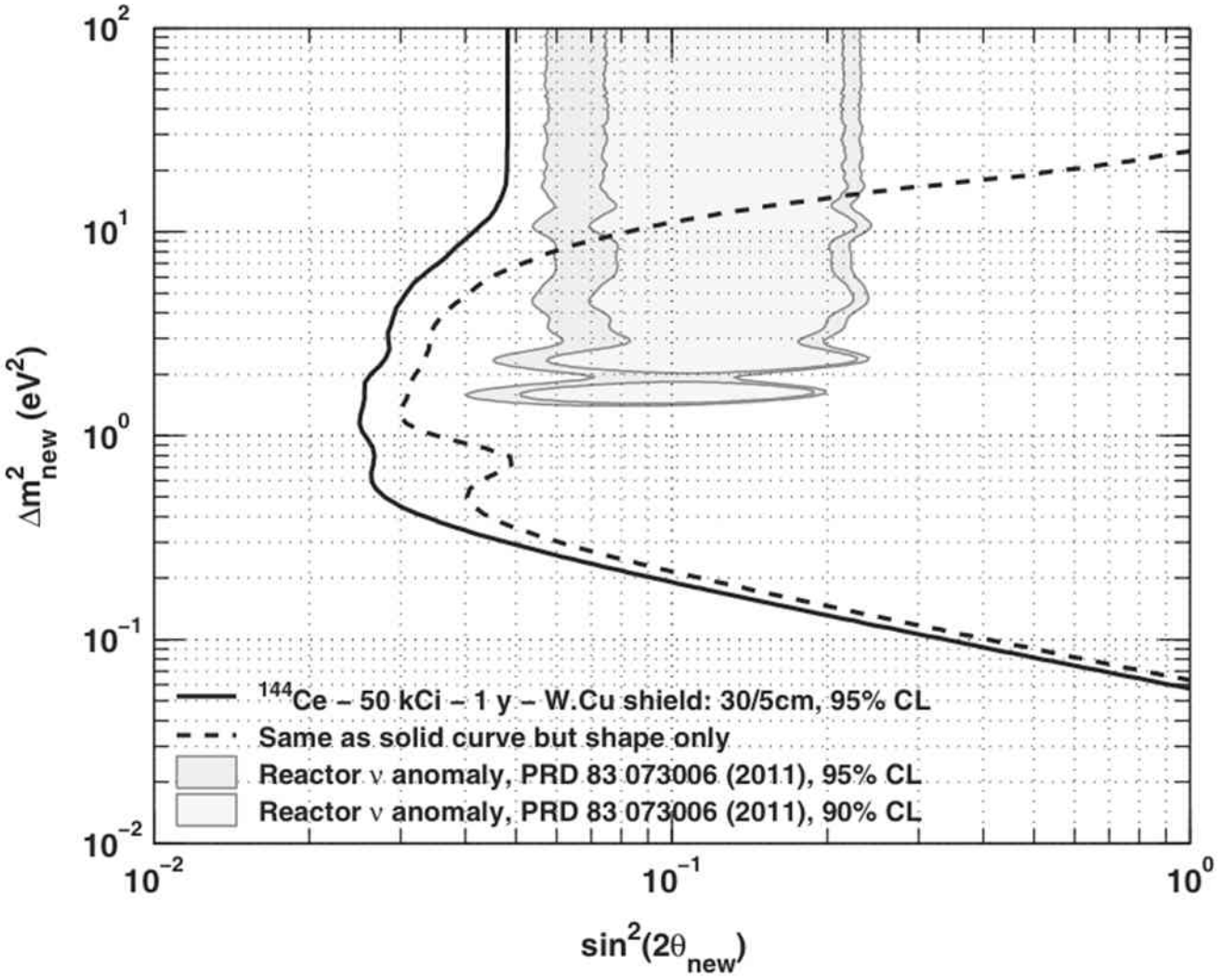
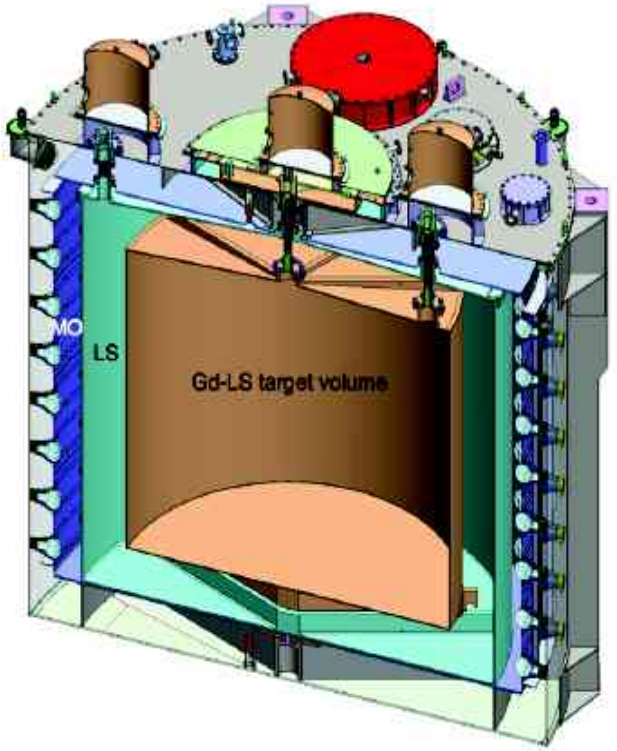


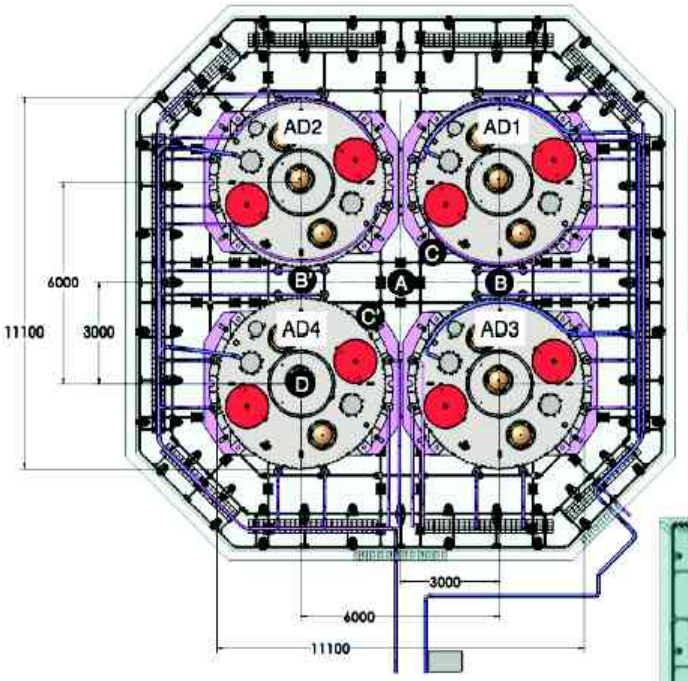


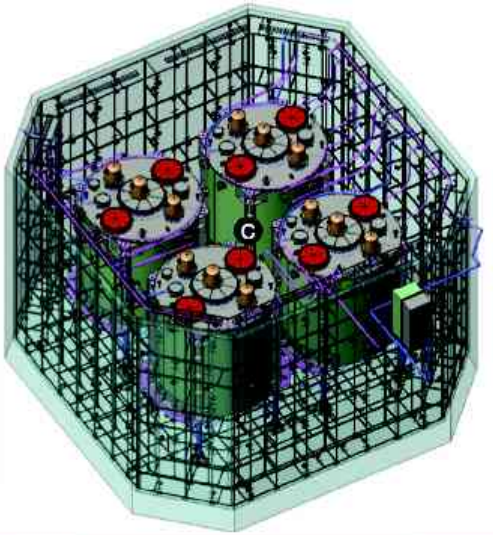
CeLAND within KamLAND

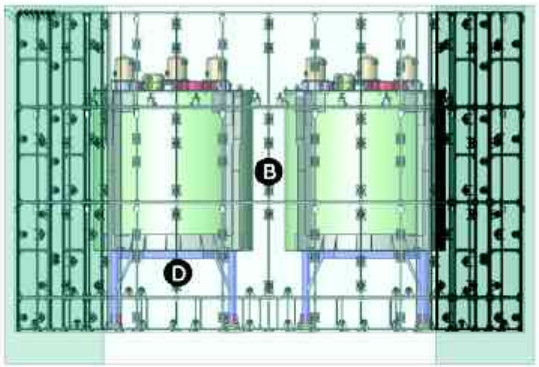


144Ce within Daya Bay

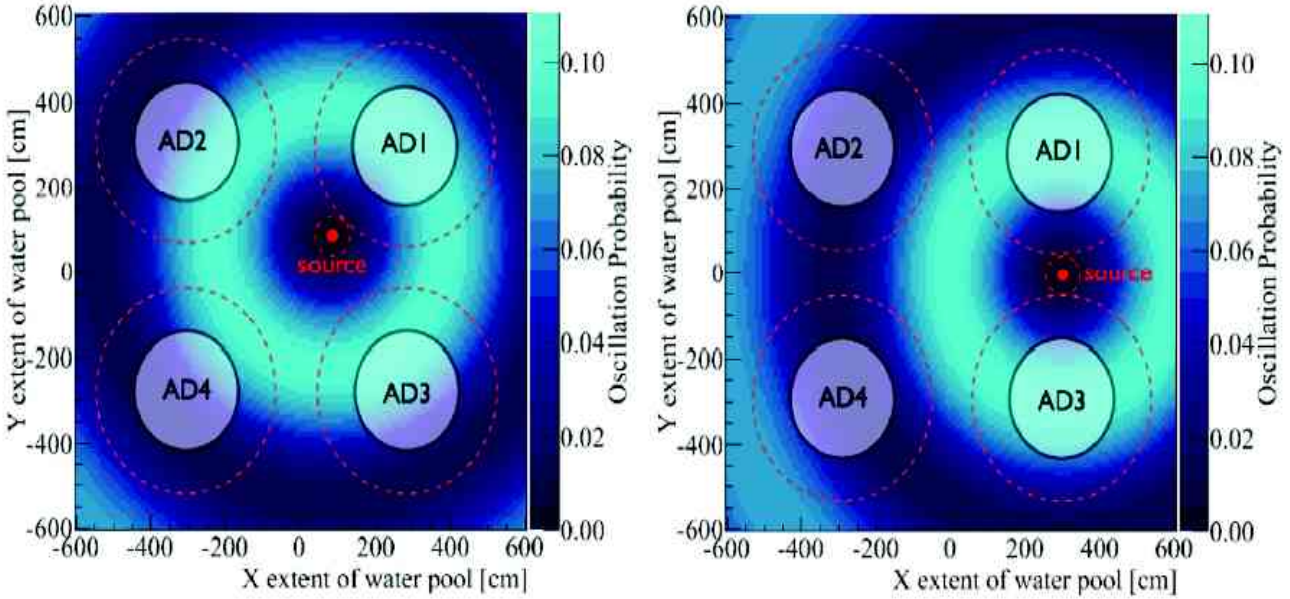


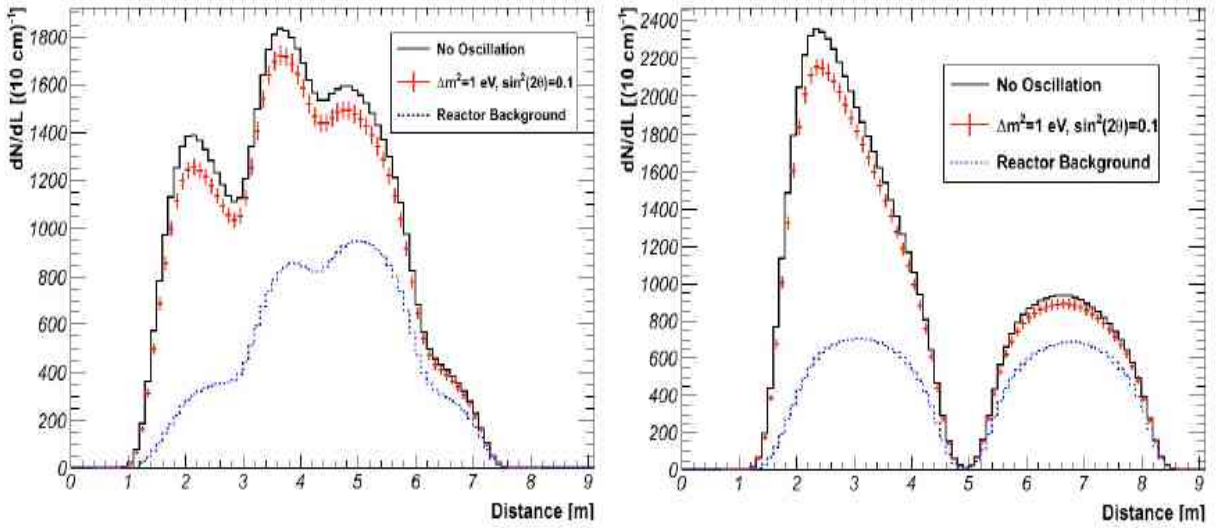




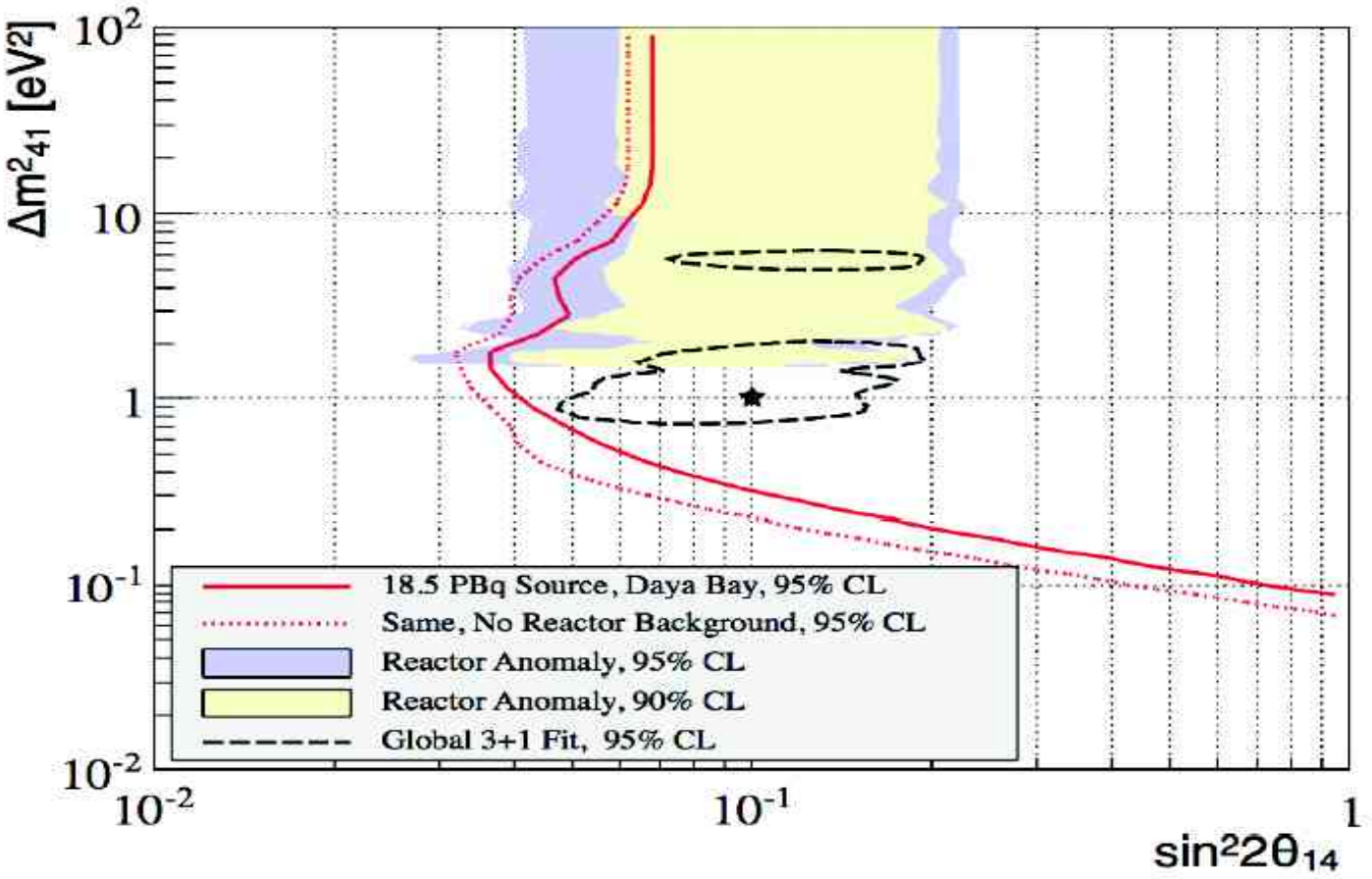


144Ce within Daya Bay

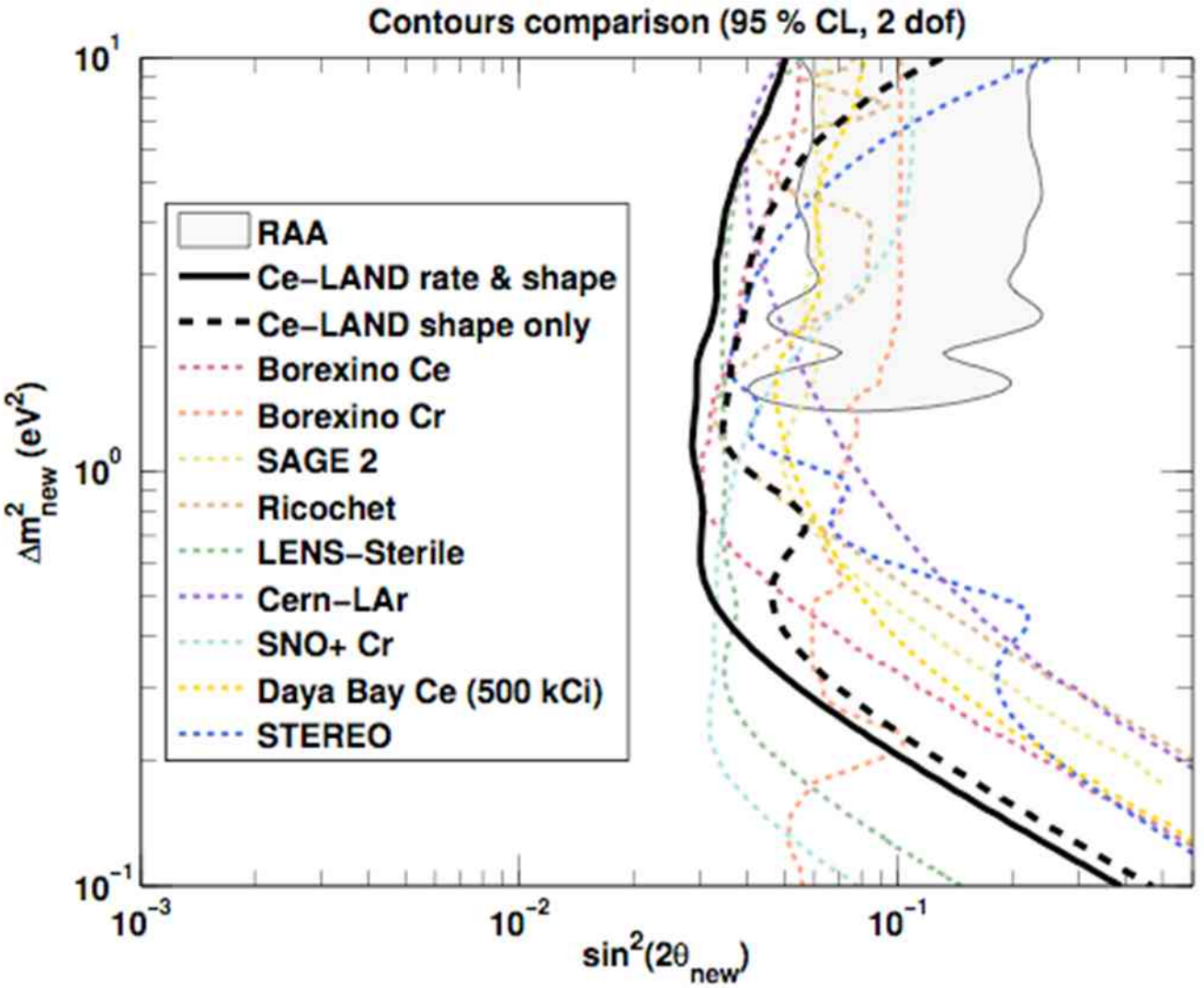




144Ce within Daya Bay



Summary I

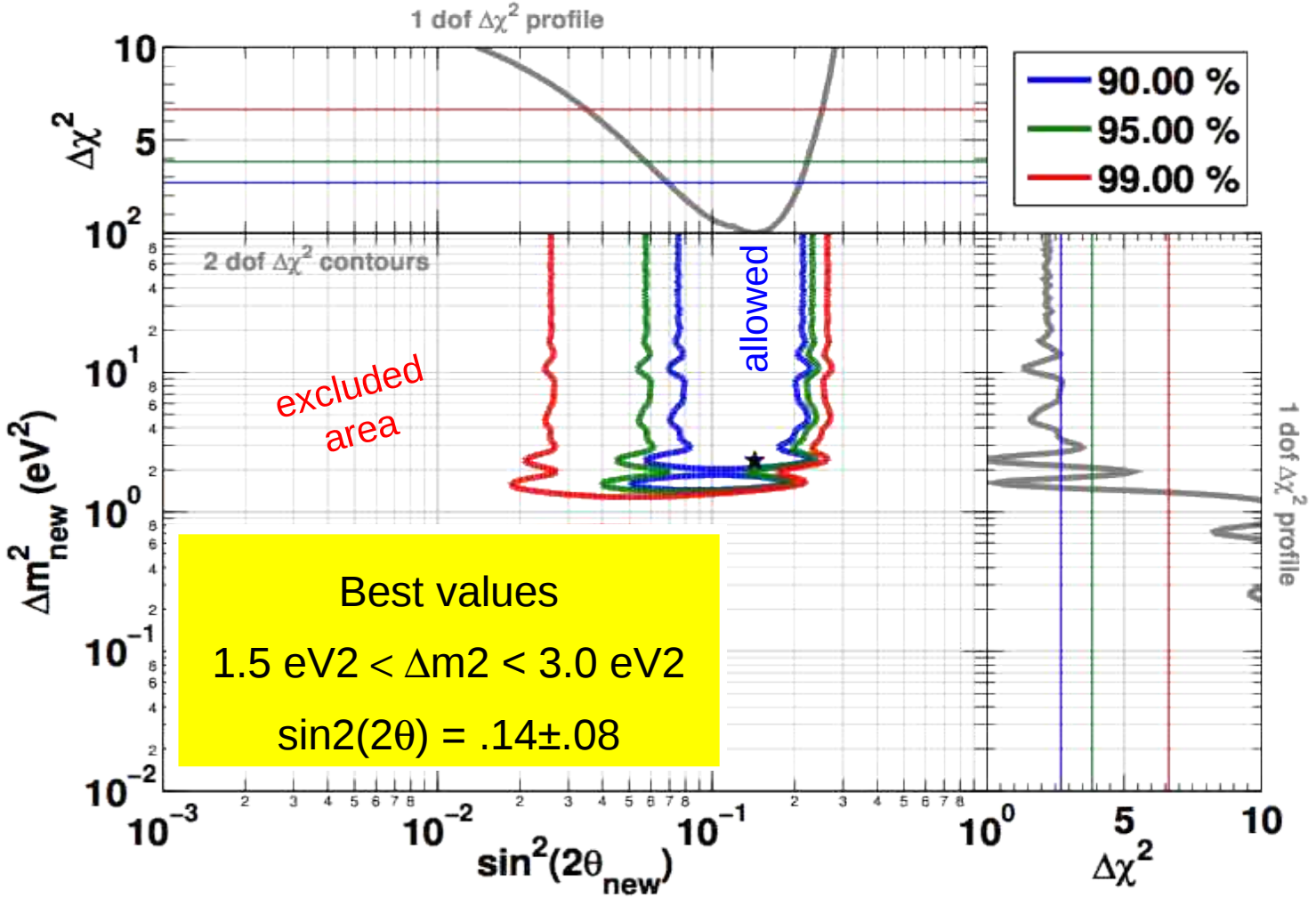

Contours comparison (95 % CL, 2 dof)
RAA
Ce–LAND rate & shape
Ce–LAND shape only
Borexino Ce
Borexino Cr
SAGE 2
Ricochet
LENS–Sterile
Cern–LAr
SNO+ Cr
Daya Bay Ce (500 kCi)
STEREO
10^{1}
10^{0}
10^{-1}
10^{-3}
10^{-2}
10^{-1}
Δm^2_{new} (eV^2)
$\sin^2(2\theta_{new})$

Summary II

	Borexino	KamLAND	Daya Bay
Ongoing program	Solar neutrinos For 2-3 more years	0vbb with Xe136	Theta_13 at sub % precision
nu_e	Possible due to low background >0.2 MeV; → Cr51: best choice and possibly avail. until 2014 → data-taking in mid 2014 → After 3 month results ! → fastest choice → heat generation managable → no changes of detector necessary → No large interference with physics program	Not possible due to high background <1 MeV	Not possible due to high Background and high E-threshold
Anti_nu_e	→ Inverse beta decay → requires changes in detector setup → results after 1 year	→ Inverse beta decay → requires changes in detector setup → results after 1 year	→ Inverse beta decay → requires changes in detector setup → results after 1 year
Detectors	1	1	4
L	~ (1.5-4.5) m (source at center)	~ (1.5 – 6) m (source at center)	~(1.3 – 8) m

BACK UP

Reactors and Gallium



The no-oscillation hypothesis is disfavored at 99.8% CL

Many experimental projects

Sources	Reactors	Beams
CeLAND 144Ce 75 kCi@ KamLAND funded	Nucifer 7 m from Osiris reactor Data taking	IsoDAR Cycloton to produce 8Li arXiv:1205.4419
Borexino 51Cr > 5 MCi & 144Ce funded	Stereo 8m @ ILL	OscSNS New « Karmen type » exp. arXiv:0810.3175
Baksan 51Cr 3 MCi unlikely funded	Mars 8m @ ILL	MicroBoone
SNO+ / LENS 51Cr 10 MCi R & D	Scraam, Neutrino-4, DANNS, Poseidon	Icarus/Nessie 2 liq. Ar detec @ CERN
Katrin 3He in construction		

Borexino Detector performance I

fast coincidences

^{232}Th-chain: $^{212}Bi \xrightarrow[2.25\ keV]{\beta} {}^{212}Po \xrightarrow[\sim 800\ keV]{\alpha} {}^{208}Pb$ t=432.8ns

^{238}U-chain: $^{214}Bi \xrightarrow[3.2\ MeV]{\beta} {}^{214}Po \xrightarrow[\sim 700\ keV]{\alpha} {}^{210}Pb$ t=236ms

^{85}Kr:

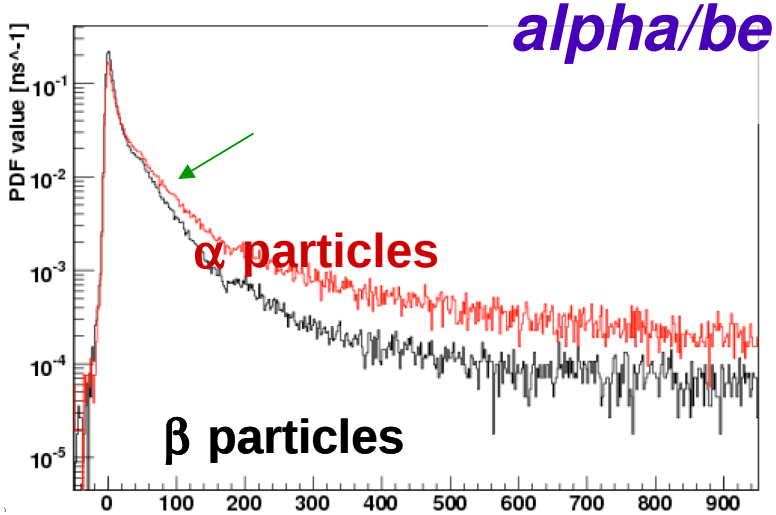
$^{85}Kr \xrightarrow[173\ keV]{\beta} {}^{85}Rb$ B.R. 99.56%, t=10.76y

$^{85}Kr \xrightarrow[173\ keV]{\beta} {}^{85m}Rb \xrightarrow[514\ keV]{\gamma} {}^{85}Rb$

B.R. 0.43%, t=1.46μs

Detector performance II

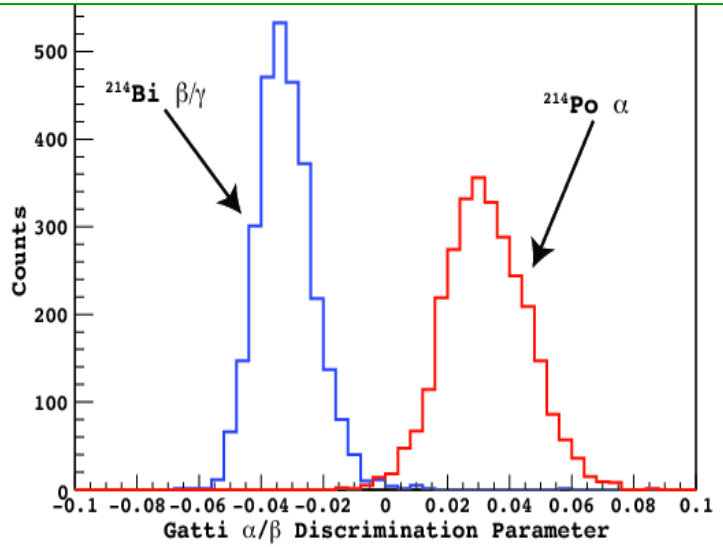
alpha/beta discrimination



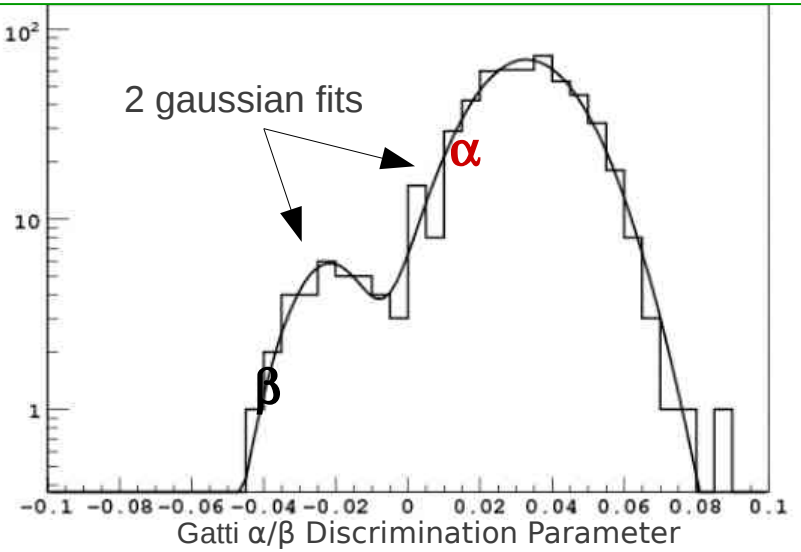
Scintillation pulse shapes:
the larger dE/dx of ionizing particle, the greater is the slow component of the de-excitating scintillator

Used Methods:
Optimum filter (Gatti`s method)

Full separation at high energy: ^{214}Bi-^{214}Po



Energy: @ 250-260 p.e.; near the ^{210}Po-peak



Detector performance III

Rejection of gamma-radiation

Position-reco. algorithms *via TOF (4 codes)*
Resolution*: 41+/-4 cm (@ ~100 keV) from ^{214}Bi-^{214}Po*
14+/-2 cm (@ ~800 keV) from ^{14}C

External background *from SSS and PMT`s:*
- mainly shielded by ~1.25m thick buffer
- outer part of Inner Vessel (at 4.25m (278 tons)) still affected
→ do a ***fiducial volume cut****: radius reconstr. only from data*

z vs R_c scatter plot