Liquid scintillator detector development for the study of neutrino anomalies

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Overview

Neutrino anomalies
The STEREO experiment
Postdoc proposal
Conclusions

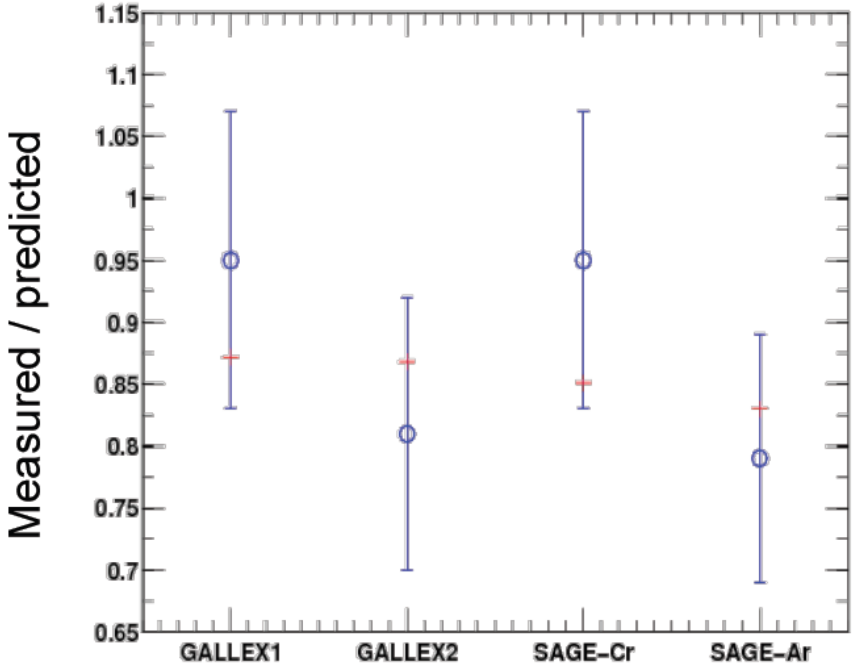
Open questions in oscillation physics

- Oscillations extremely successful description of neutrino flavour change during propagation, θ_{13} just measured !
- Still, some open questions:

Anomaly	Type	Significance
Gallium	ν_e disappearance	2.7σ
Reactor	$\bar{\nu}_e$ disappearance	3.0σ
LSND	$\bar{\nu}_\mu \rightarrow \bar{\nu}_e$	3.8σ
MiniBoone	$\bar{\nu}_\mu \rightarrow \bar{\nu}_e$	3.0σ

Gallium anomaly

- GALLEX and SAGE experiments looked for low energy solar neutrinos using Gallium-based detectors



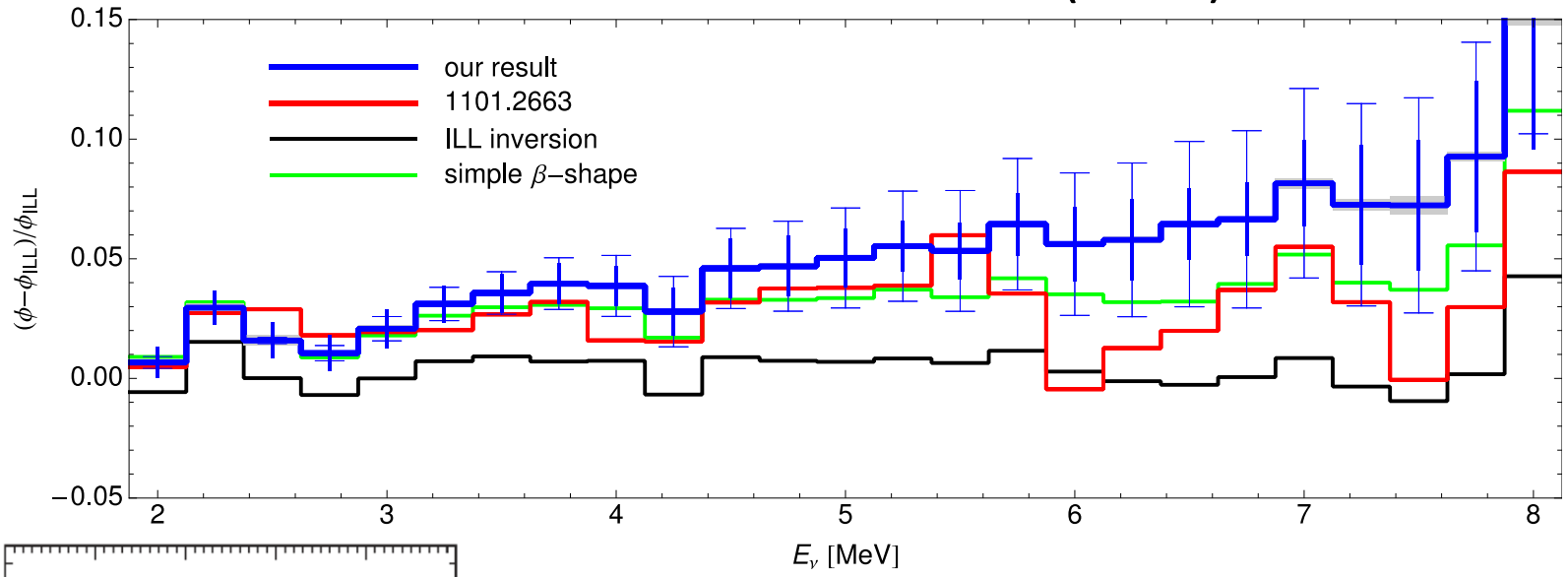
Detectors calibrated with ~MCi ν_e sources

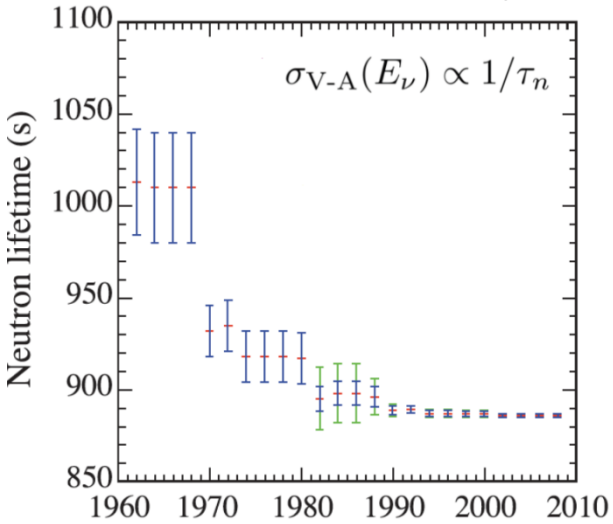
Deficit observed during calibration runs:

$R_{obs/pred}=0.86\pm0.05$ (Bahcall)

Reactor anomaly

- Reactor antineutrino flux re-evaluated (2011): +3.5%

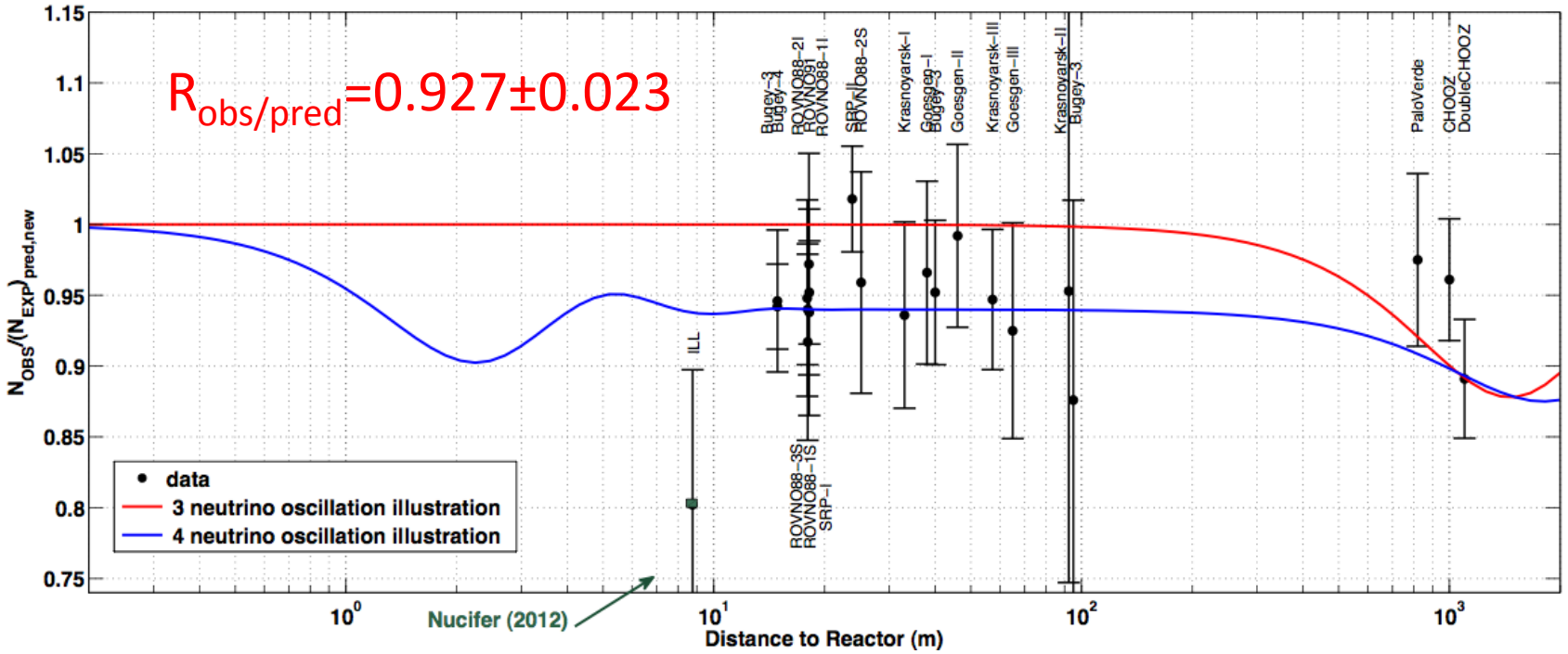




- Neutron lifetime decrease → σ_ν(Inverse Beta Decay) increase +1%
- Previously non-accounted long-lived isotopes in reactors +1%

Reactor anomaly

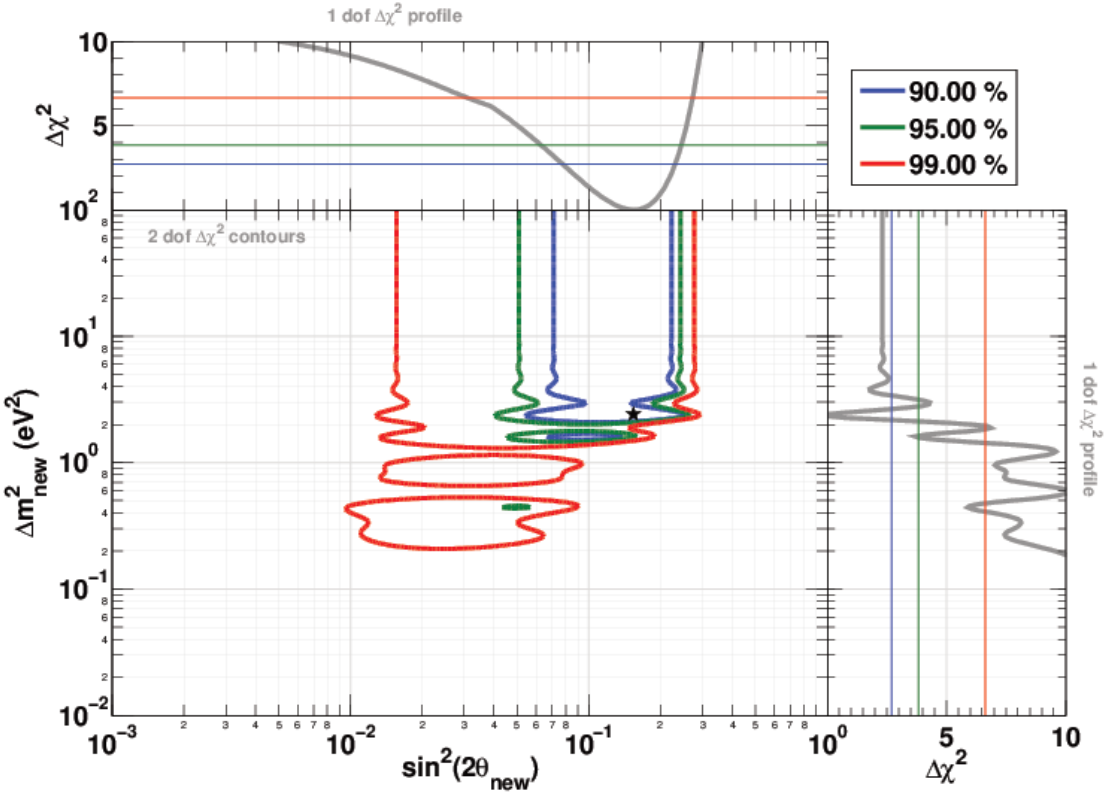
- → Re-analyse reactor neutrino experiments
- Result: 7% less events than expected! (3.0 σ)



- Can be explained with a sterile neutrino with L_{osc} ~ 2-10m

Reactor+Ga anomalies fit

- Both reactor and Ga anomalies can be explained by 1 sterile ν



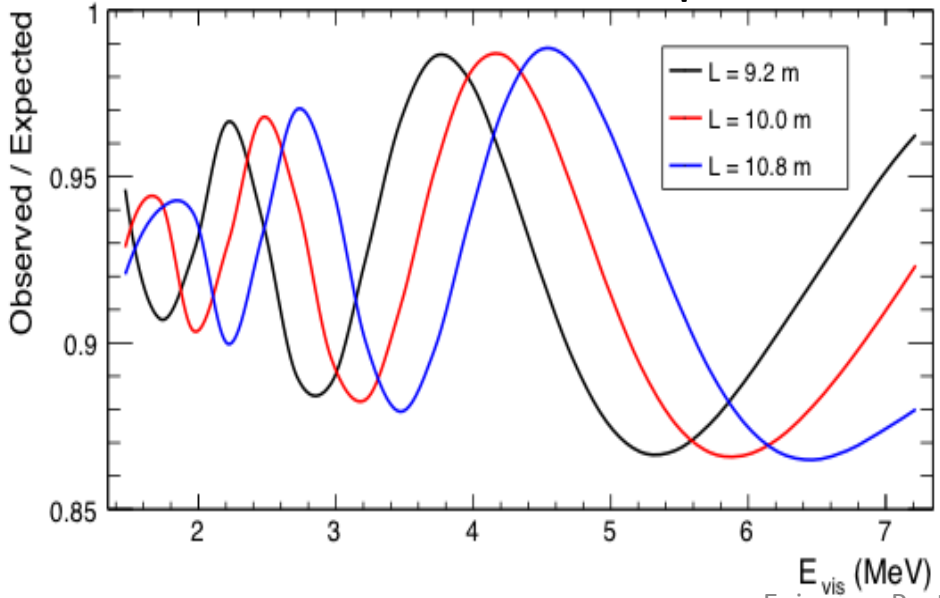
$\Delta m^2 \sim 2\ eV^2$

$\sin^2(2\theta_{ee}) \sim 0.2$

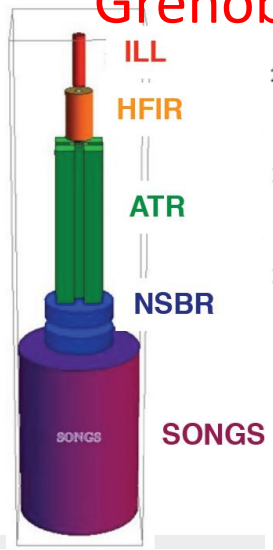
$L_{osc} \sim 7m$

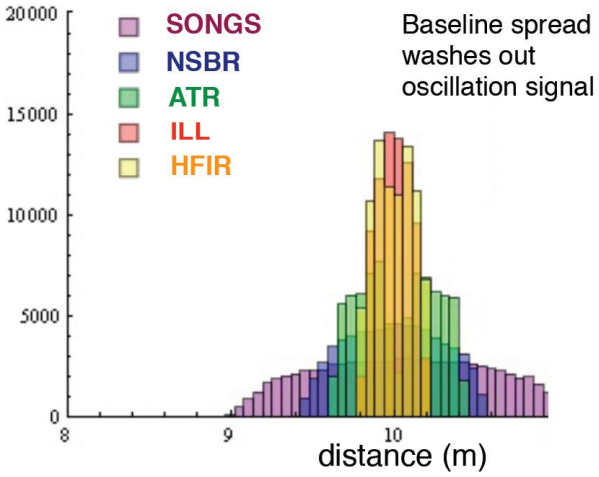
Future experiments

- Plenty of reactor (short term) & accelerator (mid-term) experiments under consideration
- Probe Reactor+Ga anomalies and sterile ν at the same time:
  - Measure rate of reactor
  - Look at L/E dependence close to reactor ($L \sim L_{osc} \sim 10$ m)
- Reactor core size important – large cores wash out oscillation



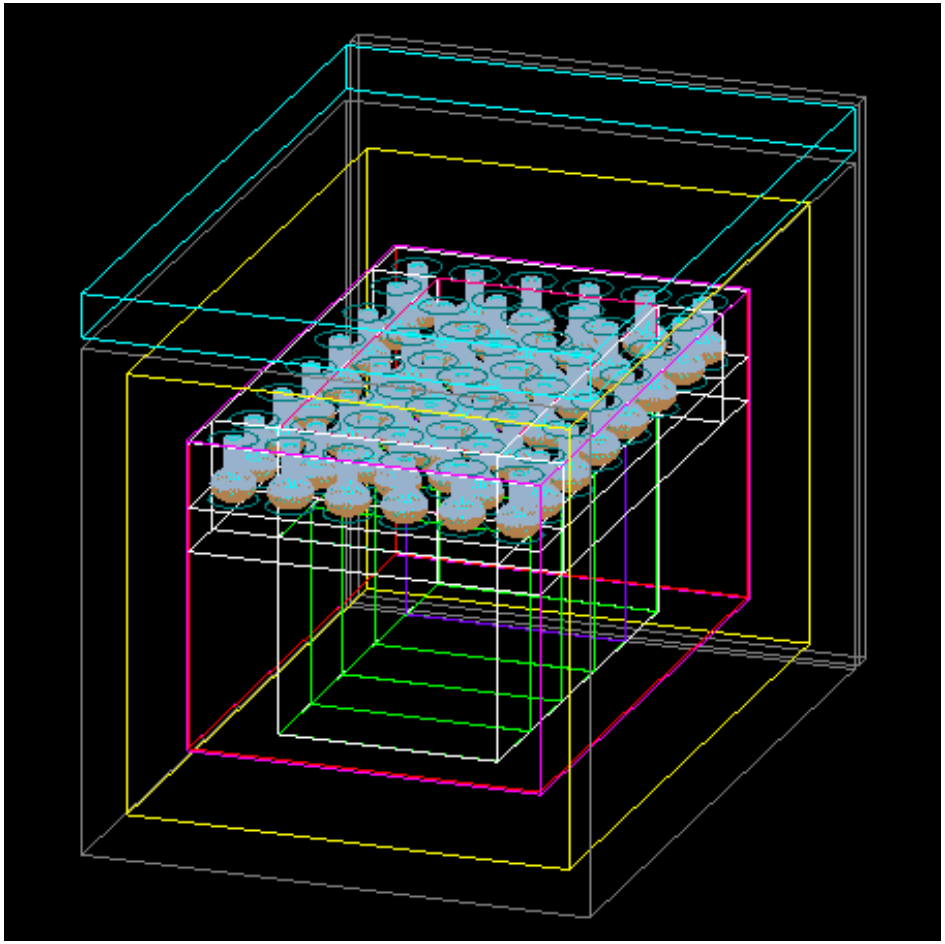
Grenoble's ILL most compact!



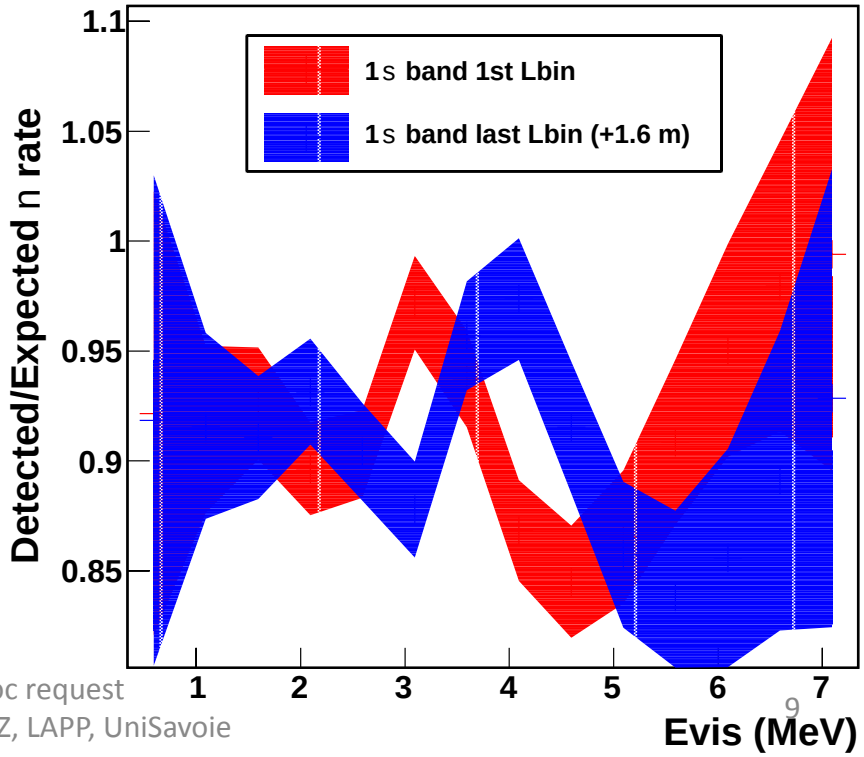


STEREO

- 2m^3 Gd-doped liquid scintillator detector 8m away of ILL reactor



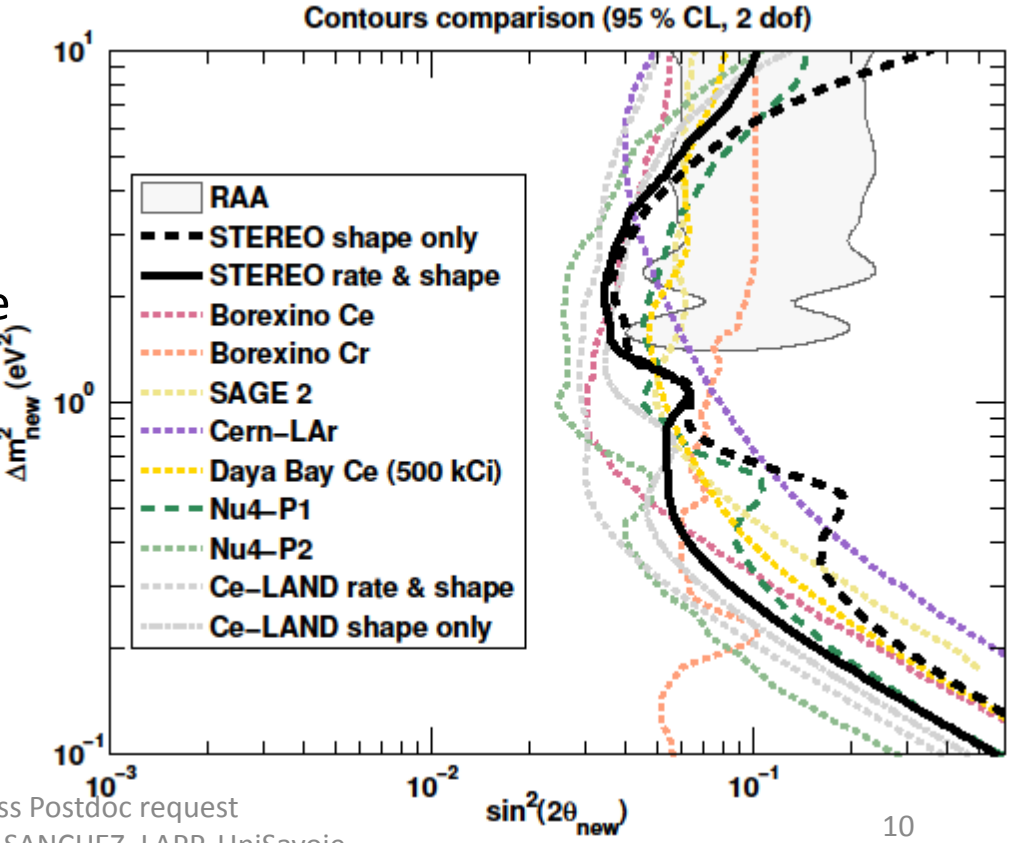
- Segmented target to see L/E dependence at different L's



STEREO

- STEREO should see sterile ν oscillation if it's there
- Good performance compared to competition (timing important!)
- Liquid scintillator technology well known (DoubleChooz, Nucifer)
- Quick, cheap experiment
- Potentially big impact
- Timeline:

11/2012 ILL Scientific Committee
04/2013 ANR funding decision
2013-2014 Design & construction
Late 2014 Lab tests
2015 Installation at ILL
2015-2016 Physics Run



Postdoc proposal

- Junior postdoc, 3 years (or 2+1), starting in 2013. Previous experience with liquid scintillators appreciated.
- Goals:
  - Design and implementation of calibration system with radioactive sources and light sources
  - Geometry and shielding optimization by means of GEANT4 simulations
  - Implication in other oscillation physics studies possible (e.g. LAGUNA)
  - Work with LAPTh theorists to understand consequences for cosmology
- Timeline:
  - Start of postdoc early 2013
  - STEREO installation 2015

Conclusions

- Neutrino anomalies are an exciting addition to the neutrino programme of the LABEx
- STEREO has the potential to address Reactor+Gallium anomalies in a short (~6yr) timescale; excellent bang for buck!
- Makes sense from a regional/geographical point of view: experiment at Grenoble's ILL reactor ; interested people in three Enigmass labos (LAPP, LPSC, LAPTh)
- Requested Postdoc to :
  - design and implement calibration system for liquid scintillator detector
  - optimize shielding and detector geometry with simulations
  - other oscillation physics studies possible (LAGUNA-LBNO)
  - explore implications for cosmology in collaboration with LAPTh

BACKUP

SLIDES