
Sterile neutrino search
with sources: SOX & CeLAND

a status report

IN2P3 Conseil Scientifique

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Why?

Detectors:

- Borexino and KamLAND
- **Large sizes**: larger or compatible w.r.t. oscillation lengths
- Already existing, running, and **well-known**

Sources:

- **Compact sizes**: equal to or smaller than the oscillation lengths
- Can be **calibrated** (even if @1% accuracy is a challenge)
- Already **produced** in the past (^{51}Cr) or in phase of production test (^{144}Ce)
- Can be removed: **background control**

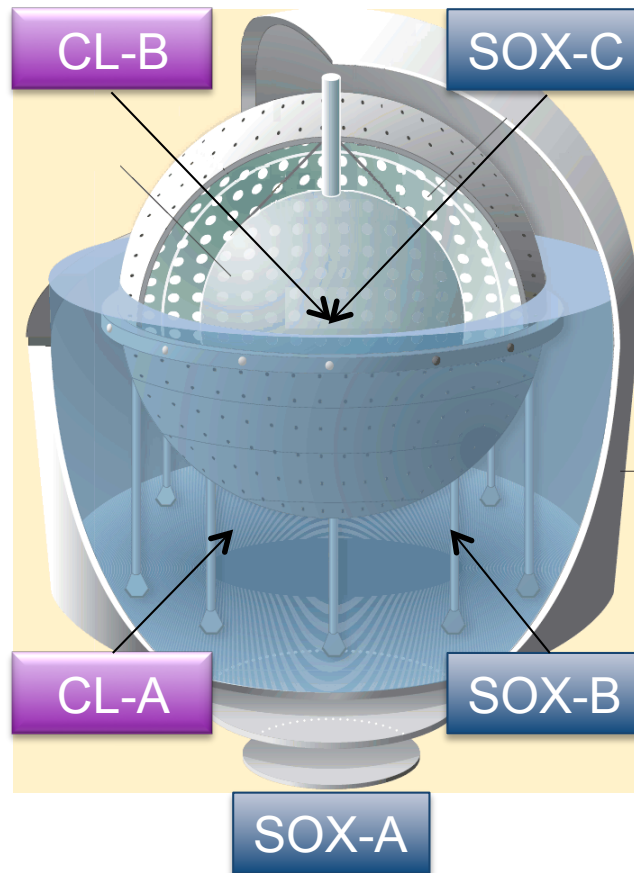
Funding:

- Clear message from **Europe**: 2 ERC grants ~ 5 ME
- Interest in the **US**: DOE funding ~ 0.75 M\$

Detector: **KamLAND**
(Borexino?)

CL-A (2015)
75 kCi ^{144}Ce in the WT
6 months of data taking

CL-B (2016/2017)
50 kCi ^{144}Ce source in
the center
1.5 y of data taking



Detector: **Borexino**

SOX-A (2015)
10MCi ^{51}Cr in Icarus pit
8.25 m from the center
3 months of data taking

SOX-B (end 2015)
75 kCi ^{144}Ce source in
W.T.. PPO everywhere
to enhance sensitivity

SOX-C (2016/2017)
50 kCi ^{144}Ce source in
the center. Only after
the end of solar
program

Source: anti- ν_e ^{144}Ce source: $Q \sim 3 \text{ MeV}$ and $t_{1/2} = 285 \text{ d}$

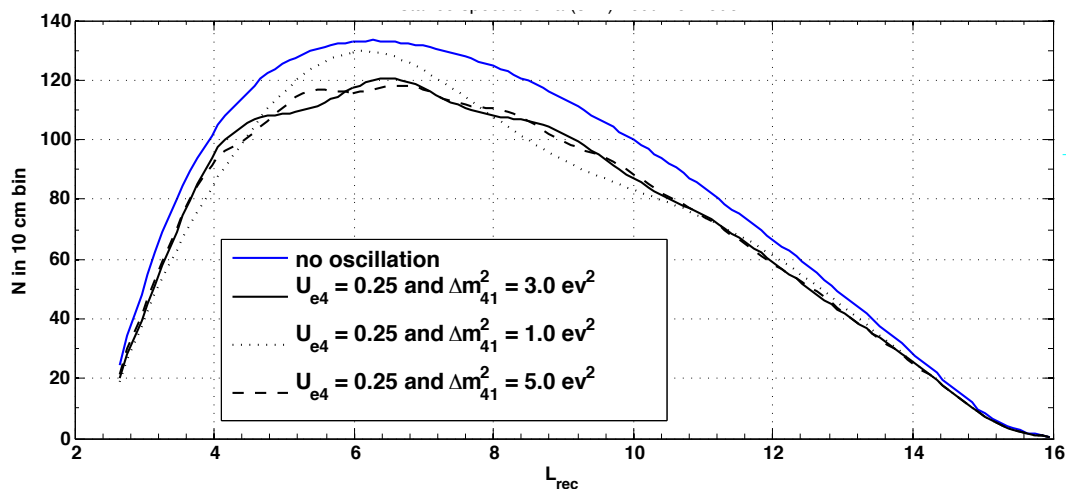
Production: spent nuclear fuel reprocessing + REE extraction

Detection: IBD - $E_{th} = 1.8 \text{ MeV}$ - (e+,n) coincidence

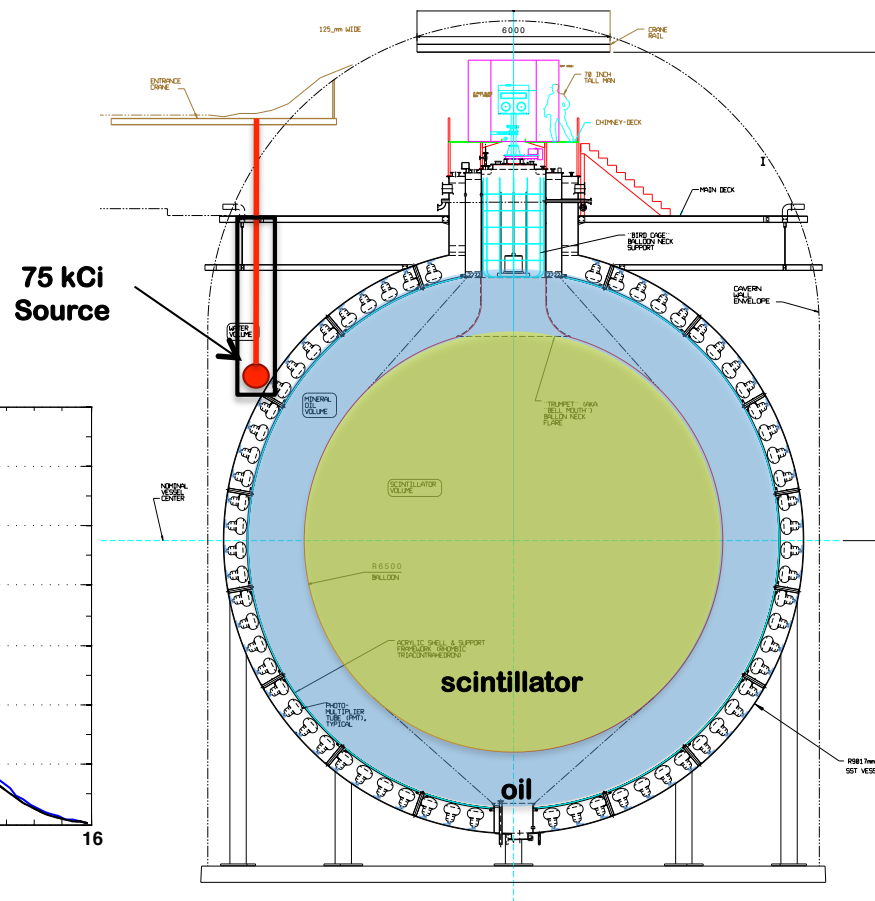
Resolutions: $7.0\%/\sqrt{E}$ - 15 cm

Source @2.5 m away from LS
75 kCi & 6-18 months of data taking

Shielding tungsten alloy, 47 cm diameter,
16 cm thickness, $\rho=18.5 \text{ g/cm}^3$



No bg expected!



Cerium Source

- 75 kCi ^{144}Ce - ^{144}Pr production in 2014: **OK** – Negotiation ongoing
- Delivery of 75 kCi ^{144}Ce in Jan. 2015

Shielding: Design for phase 1 – cost/schedule: **OK**

Logistic: No final solution secured for transportation

Activity Calibration: Calorimeter design ongoing, Ge

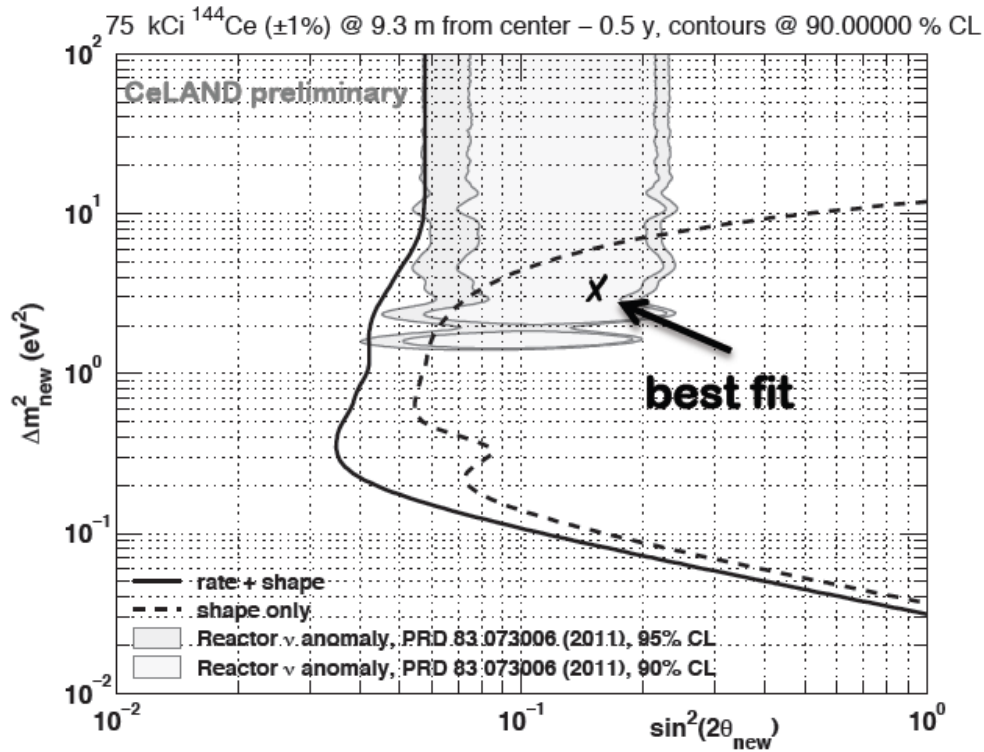
Host Detector Deployment: KamLAND: **OK**

CeLAND Collaboration:

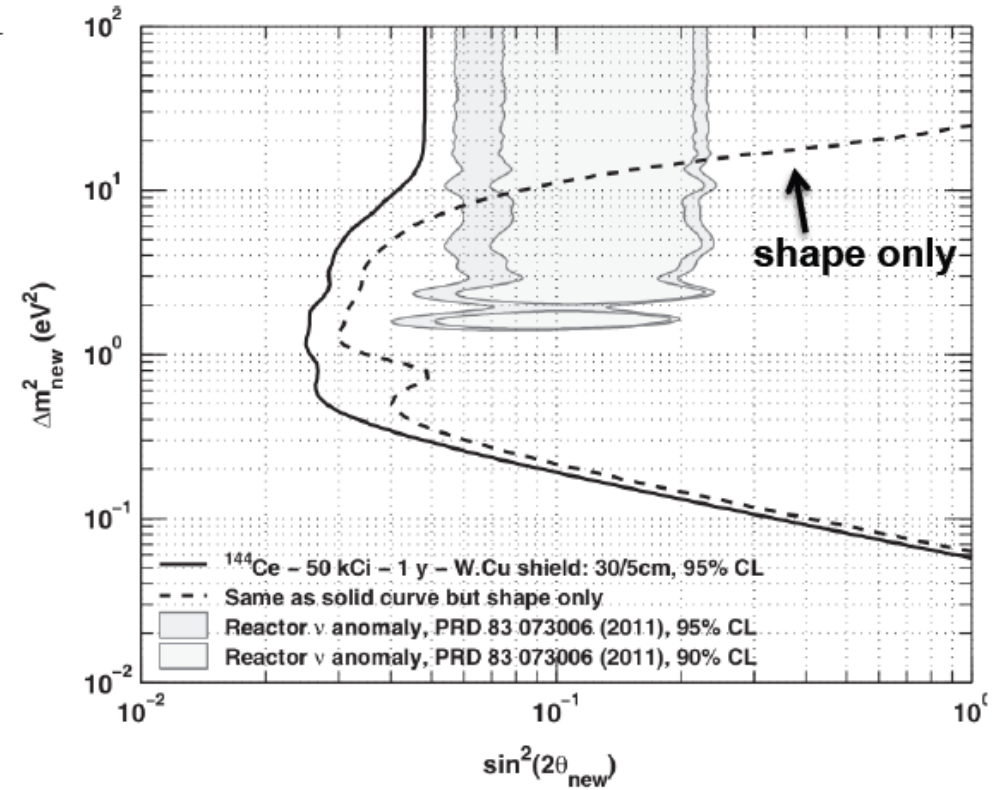
- CEA: DSM-Irfu / DEN / SPR / LNHB / DRI
- KamLAND Japanese Collaboration, Irfu (ERC), Hawaii U. (DOE funding), LBNL/UCB, Russia (Mephi)

Goal: Start Data Taking Middle 2015

Phase A



Phase B



SOX Phase A

Source: ν_e ^{51}Cr source: $E = 0.746$ MeV and $t_{1/2} = 40$ d (35 kg, 38% ^{50}Cr at Saclay)

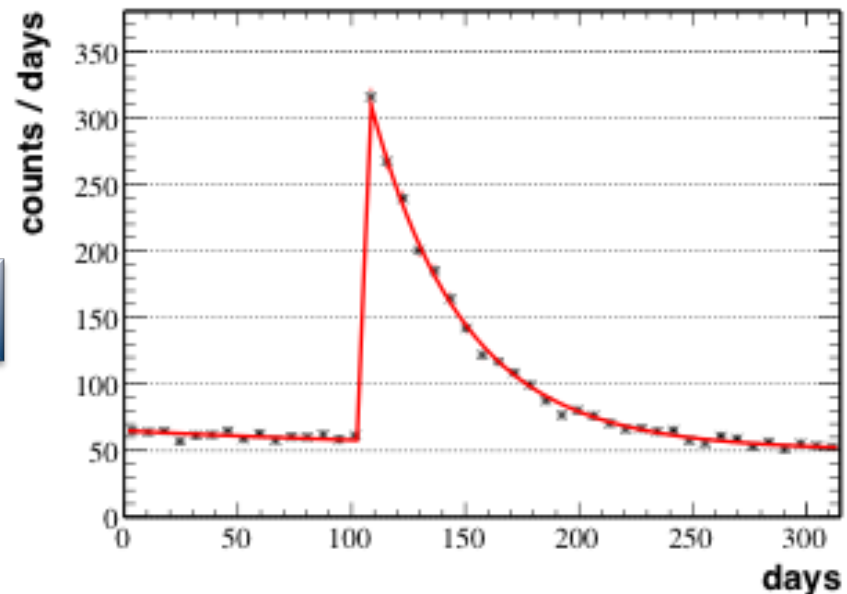
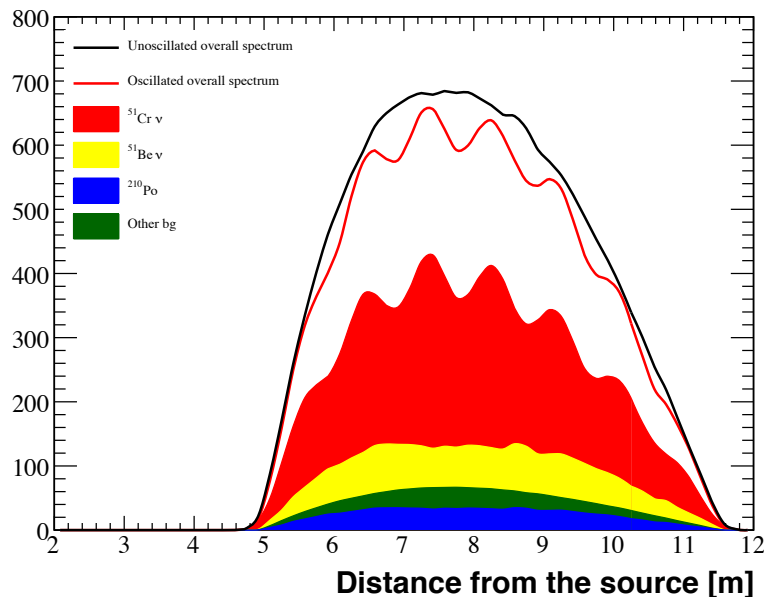
Production: neutron irradiation of ^{50}Cr in reactor (Oak Ridge/Ludmila)

Detection: ES – Compton like edge energy spectrum + time decay component

Resolutions: $\sim 5\%$ at 1 MeV – spatial ~ 10 cm

Background: $^{85}\text{Kr} < 8.8$ cpd/100 t - $^{210}\text{Bi} = 18 \pm 4$ cpd/100 t – $^{238}\text{U} < 9.7 \cdot 10^{-19}$ g/g - $^{232}\text{Th} < 2.9 \cdot 10^{-18}$ g/g. Perfectly constrained after 3 years of data taking.

Detector: no modification needed! (ICARUS pit foreseen since beginning of Bx)



SOX Status

Chromium source and delivery

- 10 MCi production: negotiation ongoing with Oak Ridge and Ludmila
- The French agency (ASN) is about to sign the authorization to export the source from France to Italy.
- 5 x 2.4 MCi source to be delivered by plane to Italy
- Re-assembling of the source at Casaccia (not far from Rome and LNGS) by ENEA
- Truck transportation to LNGS (delivery time max 7 days)
- Preliminary contact with ISPRA (institute for environmental protection and research). Positive opinion on the feasibility.

Funding: Advanced ERC ~3.5 ME

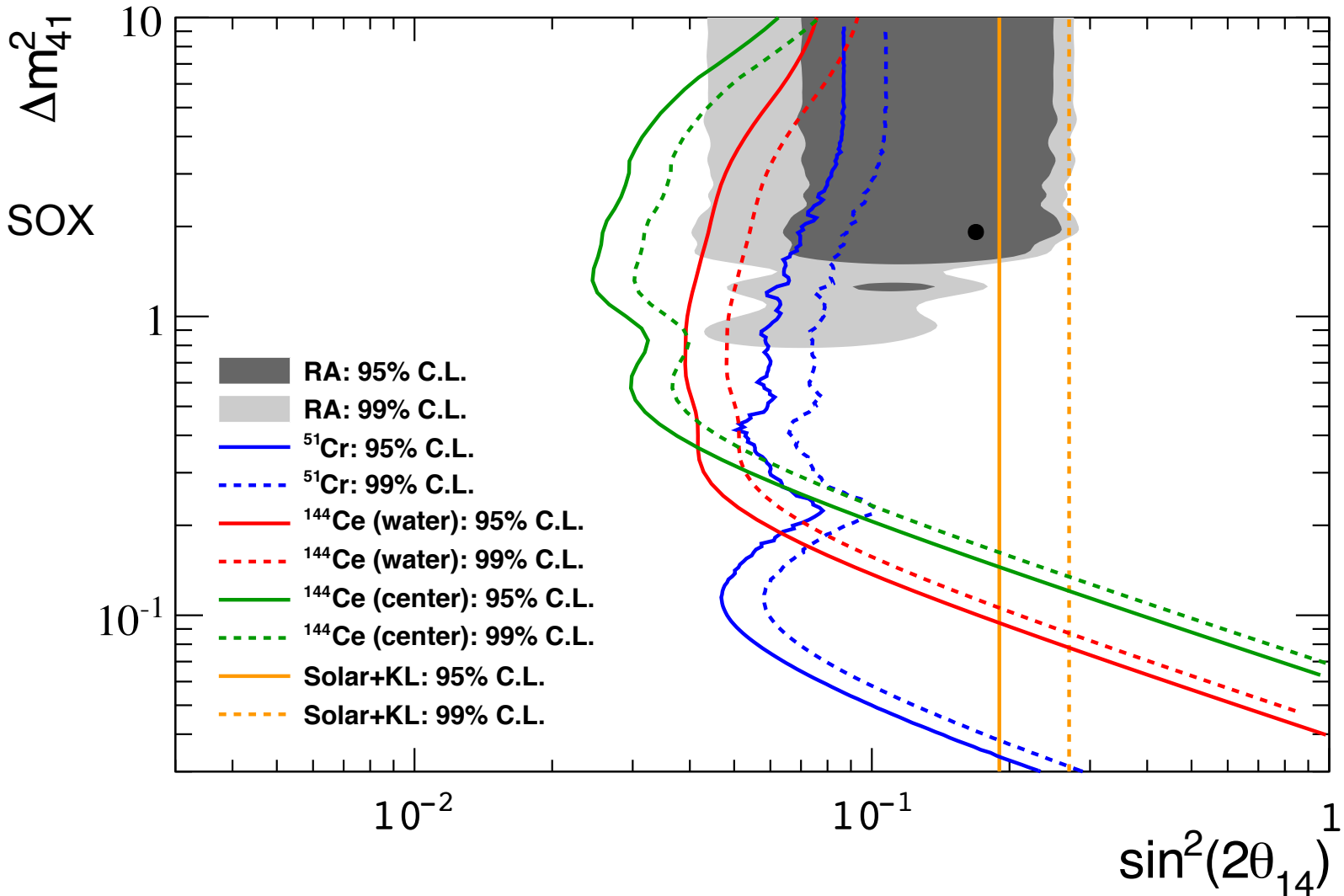
Source activity calibration: Calorimeter + Ge + Chemical (V50)

SOX collaboration: Borexino Collaboration + new members from Dresden (K. Zuber) and Virginia Tech (J. Link)

Secondary physics goals: neutrino magnetic moment, test of running EW

Goal: Start data taking (3 months) early 2015

SOX Sensitivities



A joint effort:

the calorimeter

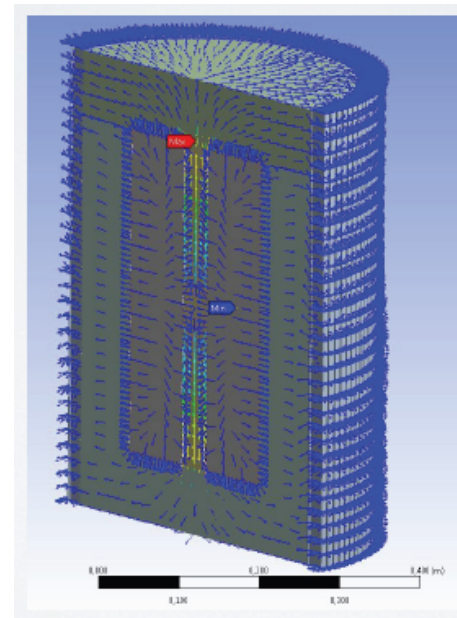
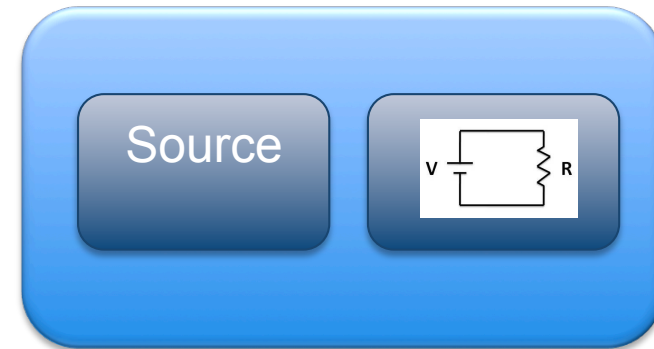
Several calibration approaches to reduce the systematic error on the source activity at 1% accuracy

Calibration with calorimeter for both the source

Common SOX/CeLAND development: two teams of engineers at CEA and in Genoa already working on it

SOX-A: constant calibration along all the data taking: the calorimeter must fit the ICARUS pit

CeLAND-A calibrations before and after the data taking



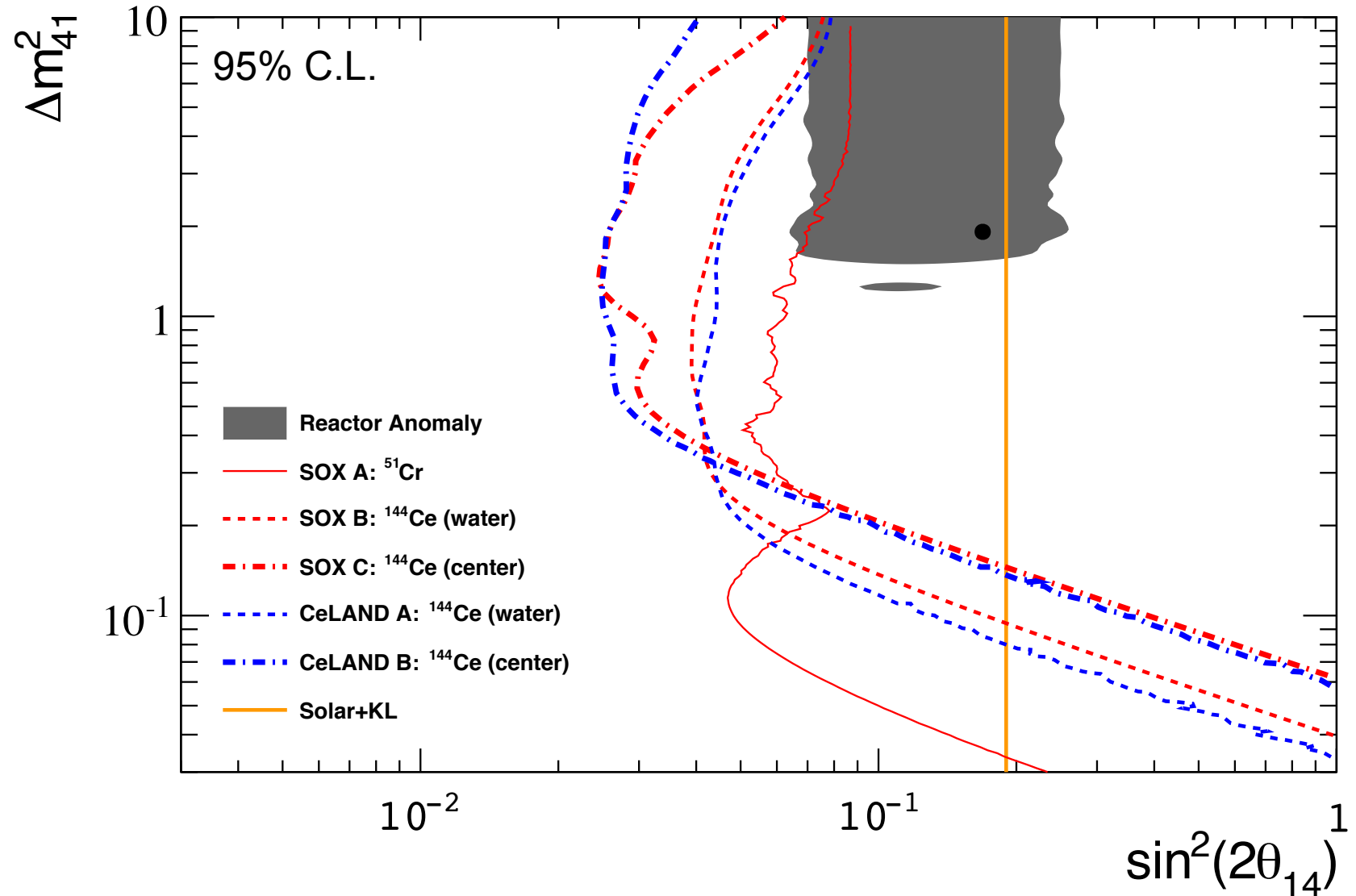
Preliminary study

10 MCi ^{51}Cr case:

Thermal power ~ 1.9 kW

With cooling: $T_{\text{ext}} 44$ deg

CeLAND & SOX: All Phases



CeLAND & SOX + STEREO & SOLiD

