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**

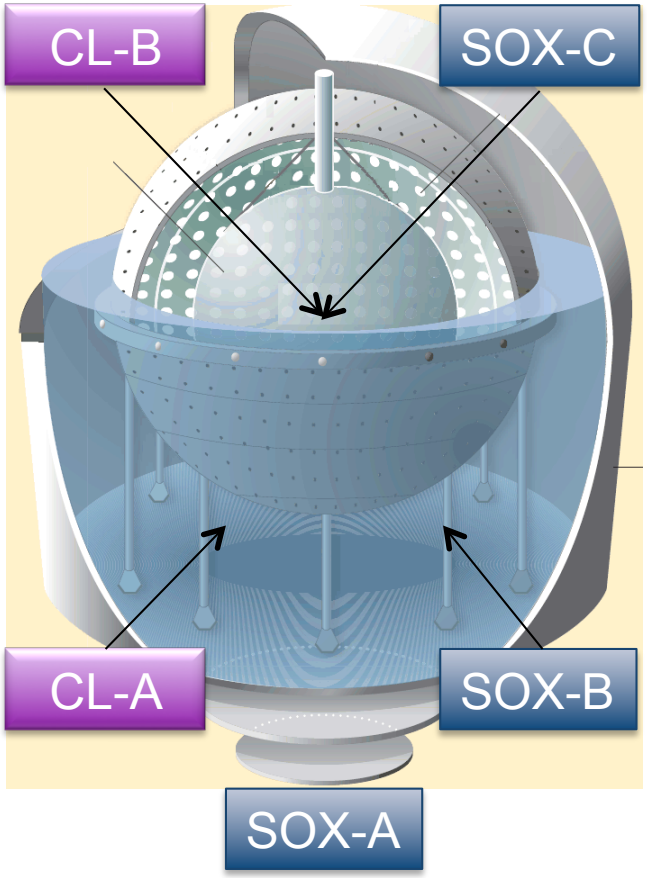
Funding:
- Clear message from **Europe**: 2 ERC grants ~ 5 ME
- Interest in the **US**: DOE funding ~ 0.75 M$

CeLAND SOX

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

CeLAND Phase A

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

Production: spent nuclear fuel reprocessing + REE extraction

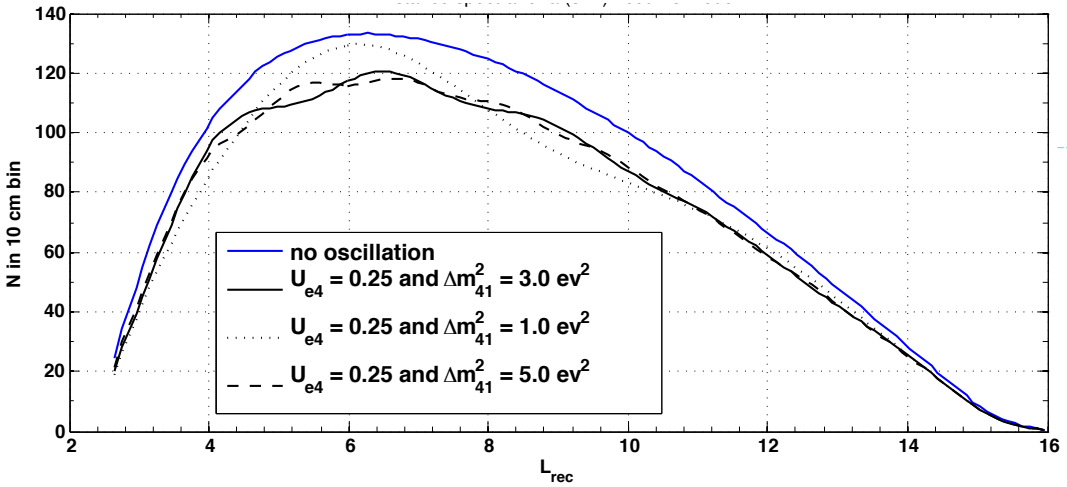
Detection: IBD - Eth = 1.8 MeV - (e+,n) coincidence

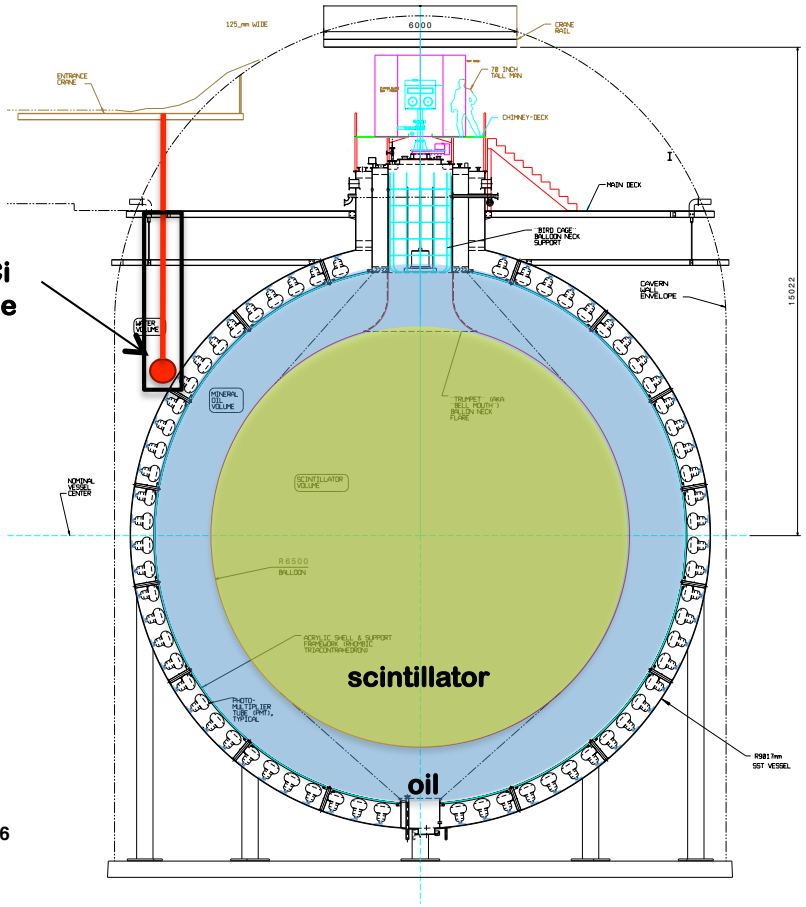
Resolutions: 7.0%/sqrt(E) - 15 cm

No bg expected!

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

Shielding tungsten alloy, 47 cm diameter,
16 cm thickness, ρ=18.5 g/cm^3





CeLAND Status

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

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

Logistic: No final solution secured for transportation

Activity Calibration: Calorimeter design ongoing, Ge

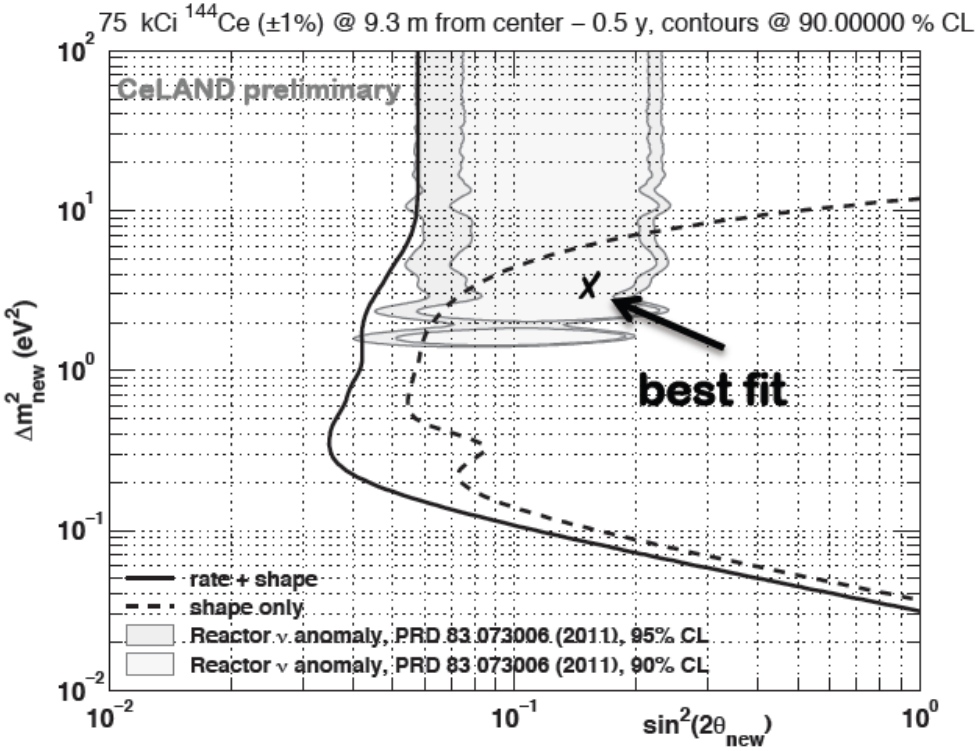
Host Detector Deployment: KamLAND: **OK**

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

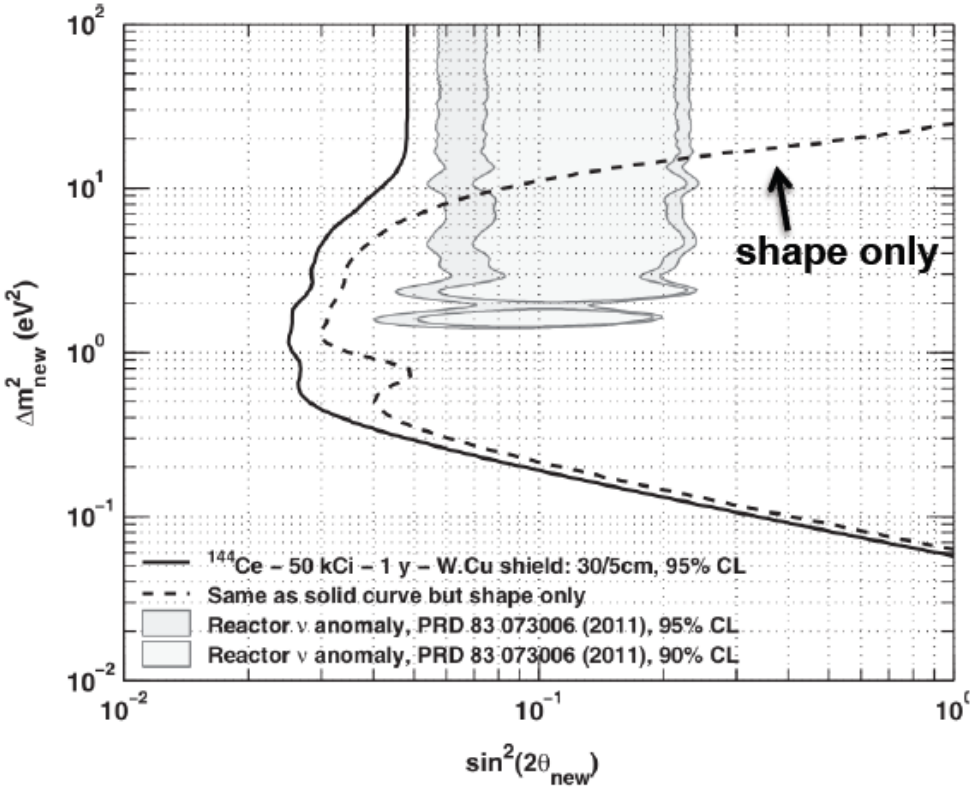
Goal: **Start Data Taking Middle 2015**

CeLAND Sensitivities

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)

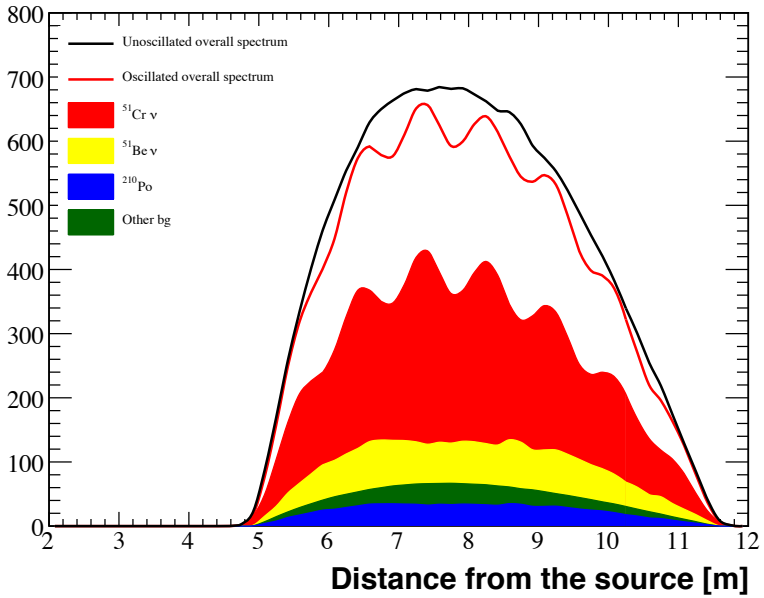
Production: neutron irradiation of ^{50}Cr in reactor (Oak Ridge/Ludmila)

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

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

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

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



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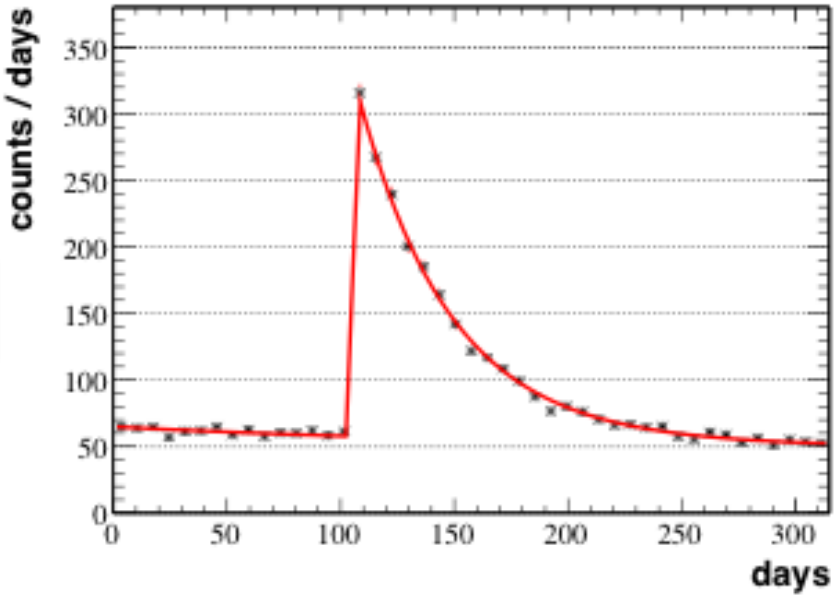


SOX Status

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

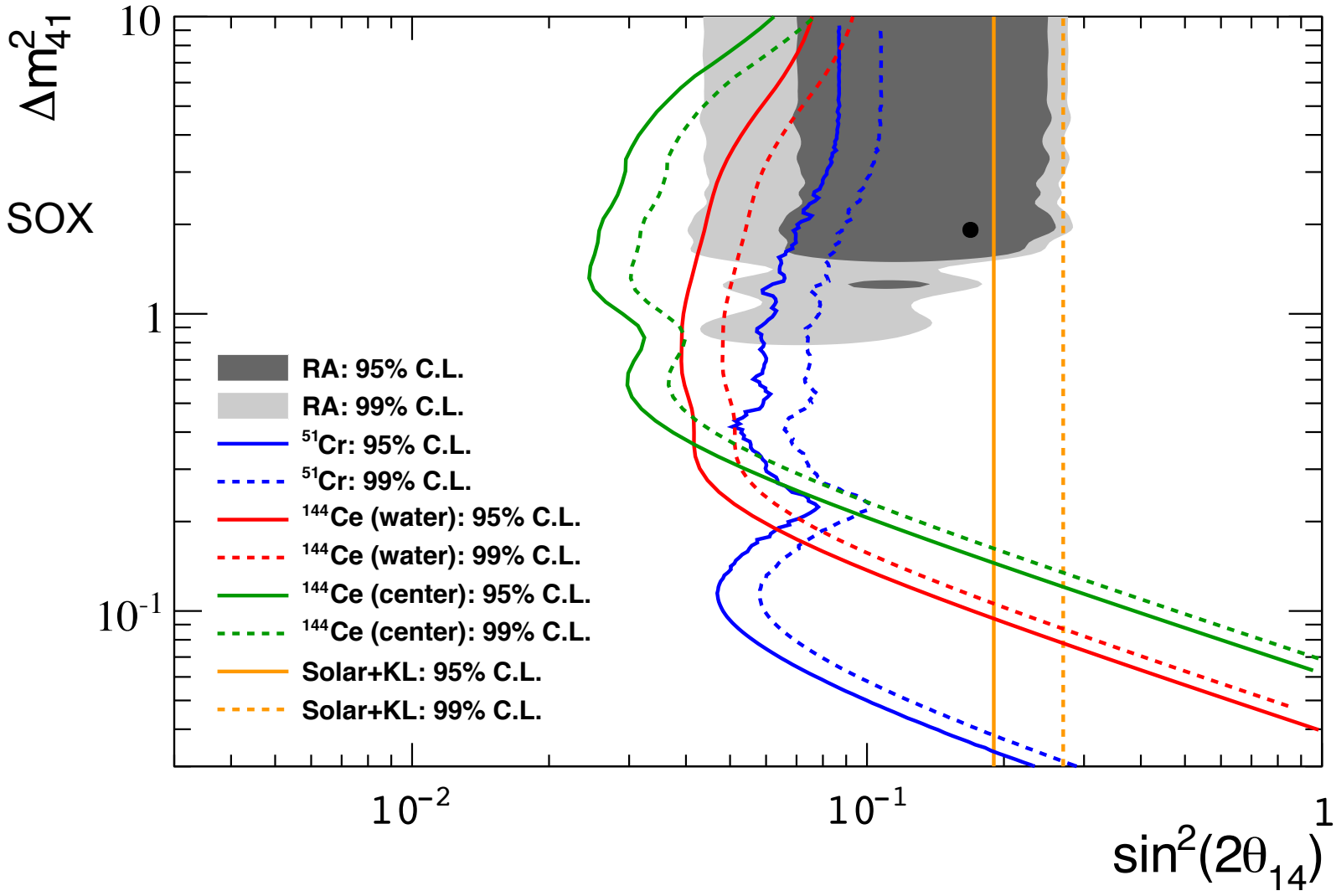
Source activity calibration: Calorimeter + Ge + Chemical (50V)

SOX collaboration: Borexino Collaboration + new members from Dresden and Virginia Tech

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

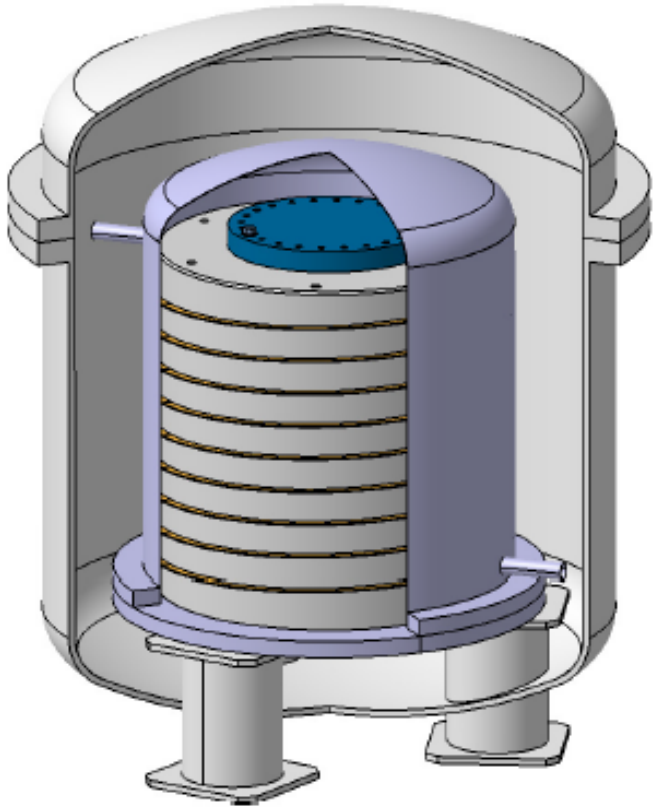
Several calibration approaches to reduce the systematic error on the source activity at 1% accuracy

Calibration with calorimeter for both the sources

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

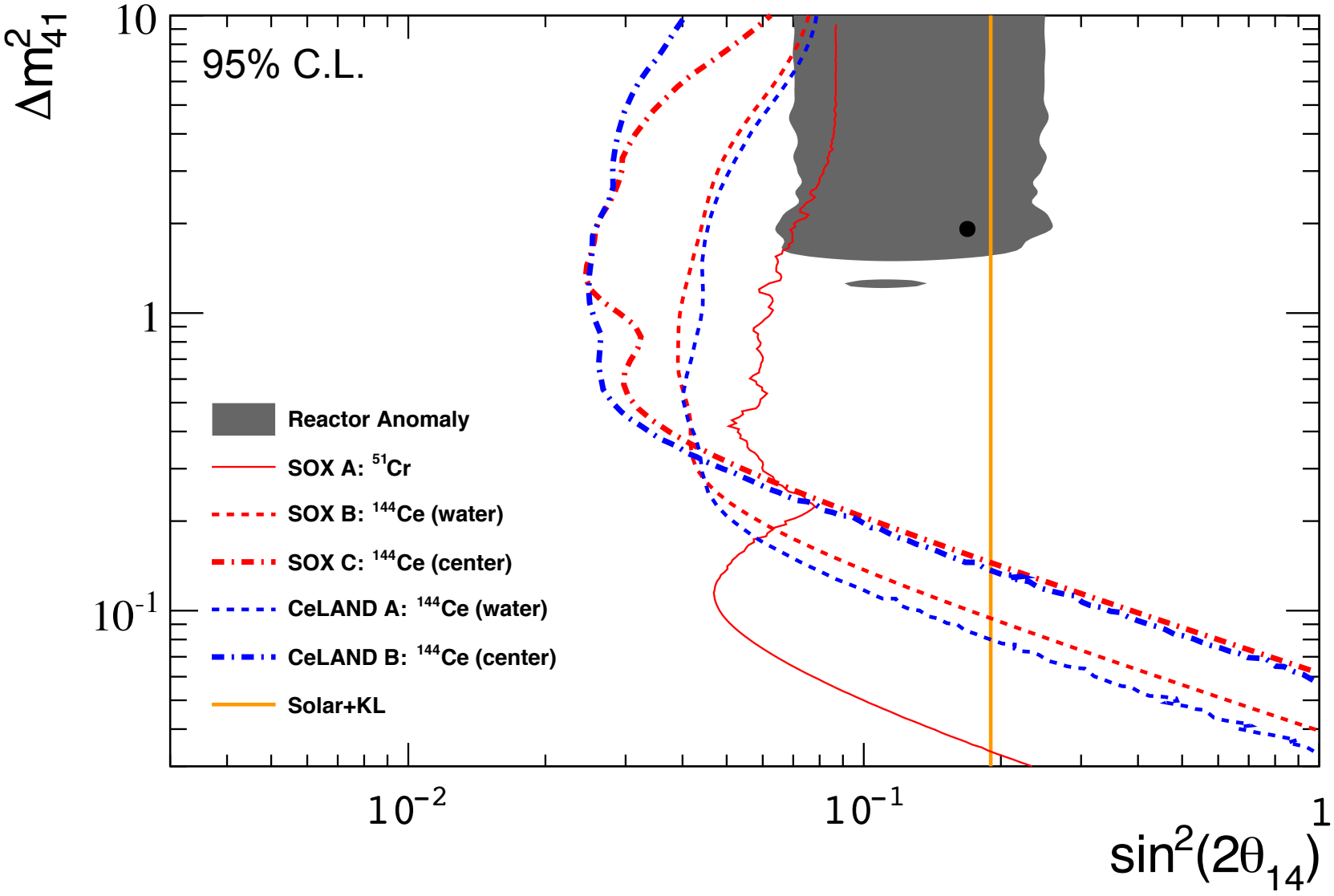
SOX-A: constant calibration along all the data taking: the calorimeter must fit the ICARUS pit

CeLAND-A calibrations before and after the data taking



75 kCi ^{144}Ce:
Thermal power ~ 0.6 kW
10 MCi ^{51}Cr:
Thermal power ~ 1.9 kW

CeLAND & SOX: All Phases



CeLAND & SOX + STEREO & SOLiD