

SoLid : Search for oscillations with ^6Li detector at BR2

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Physics Motivations

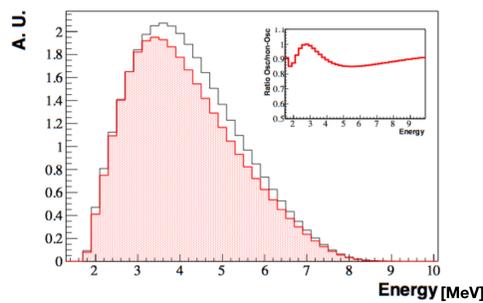
A few anomalies at a similar L/E have emerged in oscillation data at $2-3\sigma$ level:

- The LSND and MiniBooNE appearance results [1-2]
- The so-called *reactor anomaly* [3] after a recent re-evaluation of anti-neutrino spectra [4]
- the Gallium anomaly from re-analysis of SAGE and Gallex calibration runs [5]

A possible explanation for this is a light neutral particle (called sterile neutrino) which only couples to other standard model neutrinos via oscillation at short distance (mass around ~ 1 eV).

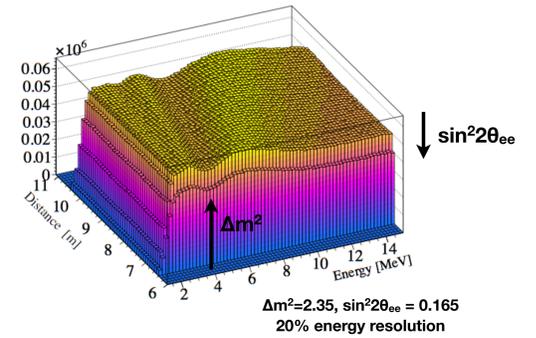
➔ need new and more precise data to clear the anomalies

Search for a new oscillation phenomenon at short baseline (5-10 m) of a research reactor to cross-check previous short baseline results [6] and test sterile neutrino hypothesis



Sensitivity to small oscillations can be maximized by:

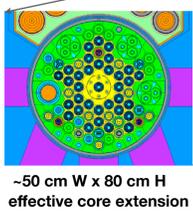
- use of a compact source (research reactor)
- use a highly segmented detector with good energy reconstruction



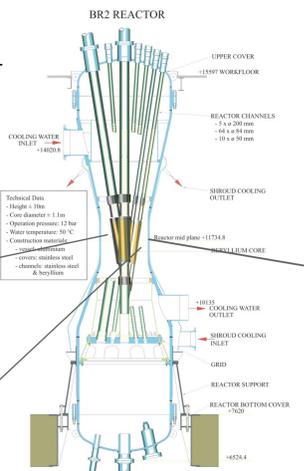
SCK-CEN BR2 (Mol, Belgium) MTR research reactor

BR2 is a tank-in-pool research reactor licenced to operate up to 100 MW

- twisted compact core geometry
- Be Matrix, HEU fuel elements
- cycles of 20-25 days, 150 d/year
- Simulation with MCNP/MURE [7]: prediction of antineutrino emission



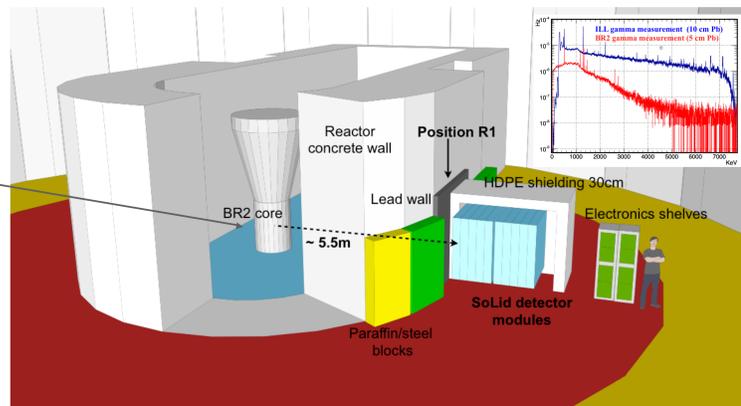
-50 cm W x 80 cm H effective core extension



Experimental set up

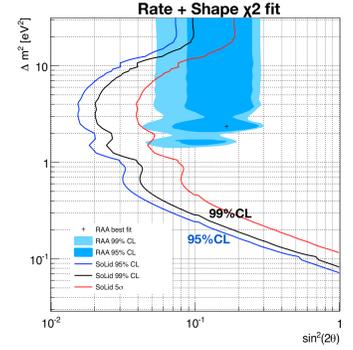
2.88 tons segmented solid scintillator detectors at 6.8m from reactor core

- low background condition and 8-12 mwe overburden



SoLid sensitivity to new oscillations

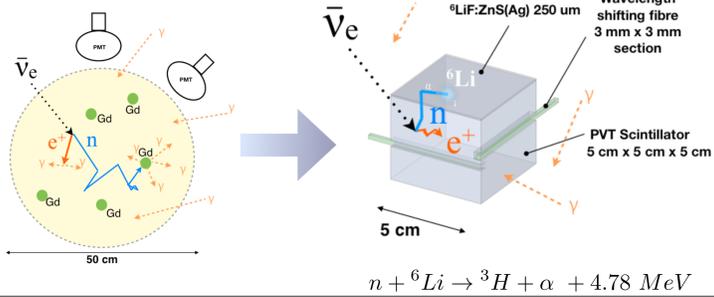
- 416 v/day/ton
- target detector efficiency 41%
- Energy resolution $\Delta E/E \sim 22\%$ / 16.6% at 1 MeV
- 300 days running (140 d/year) starts in 2016
- flux, power & efficiency systematics in contour



Novel SoLid detector technology

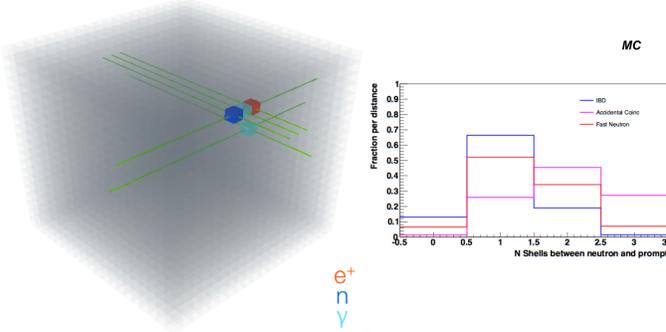
Move away from traditional approach (LS+Gd):

- Novel type of composite solid scintillator detector (PVT + 6LiF:ZnS)
- Inverse Beta Decay Detection
- Localise more precisely antinu interaction
- better neutron ID

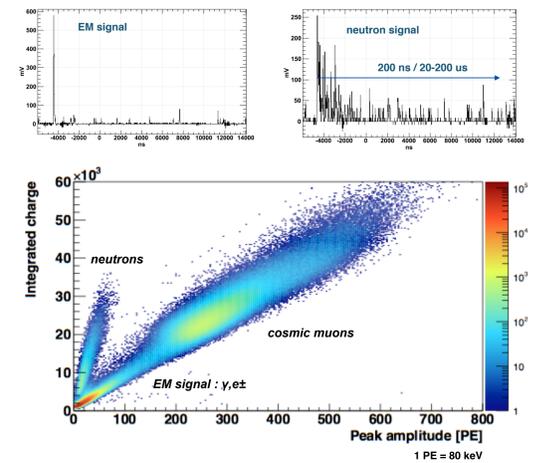


Voxelisation of target volume

- Topology well defined in space: tight spatial cut, multiplicity cut
- potential for direction reconstruction
- unique strategy to unfold unknown backgrounds

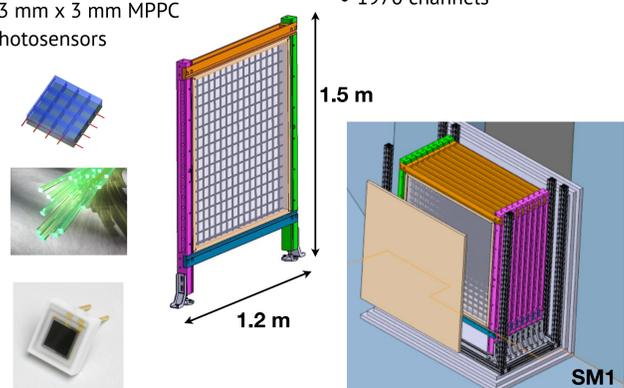


Detector response



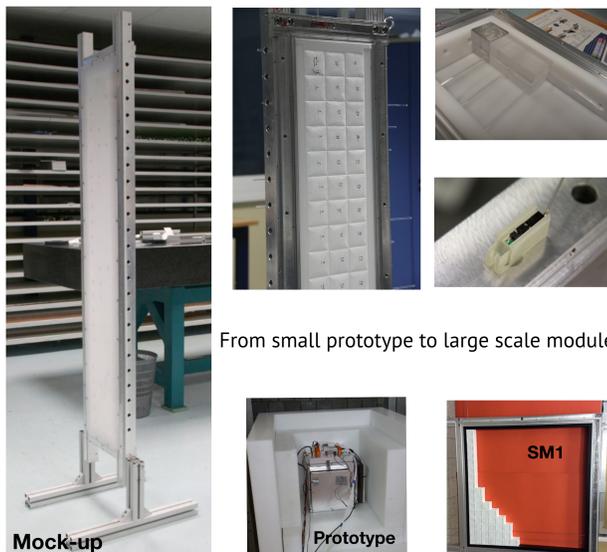
Detector design

- Detector cell 5cm x 5cm
- WLS fibre network for 3D localisation
- 3 mm x 3 mm MPPC photosensors



Detector divided in 40 detector planes (1.2m H x 1.2m W x 2m D)

- 2.88 tonne fiducial volume
- 12 000 cells
- 1970 channels



From small prototype to large scale module:

Staged R&D

1. **NEMENIX 8 kg prototype:** validation of detector response at BR2
2. **Detector plane Mock-up:** validation of detector design
3. **Large scale system SM1** to be built and tested in October 2014 at BR2

Electronics & Trigger

- Fast digitiser electronics
- MPPC signal amplification and stabilisation
 - 65 MS/s 12 bit ADC 64x ch.
 - FPGA pulse processing
 - charge injection
 - Trigger using n signature

Summary

The SoLid experiment will search for new oscillations at short distance from BR2 reactor:

- unique detector technology
- low background environment at BR2 for maximum sensitivity in 2 years running (2016-2017)
- Solid segmented det. for non proliferation purpose

[1] A. Aguilar-Arevalo et al. (LSND Collaboration), *Phys. Rev. D* 64, 112007 (2001). [2] A. Aguilar-Arevalo et al. (MiniBooNE Collaboration) *Phys. Rev. Lett.* 102, 101802 (2009). A. Aguilar-Arevalo et al. (MiniBooNE Collaboration) *Phys. Rev. Lett.* 105, 181801 (2010). [3] G. Mention et al., *The Reactor Antineutrino Anomaly*, *Phys. Rev. D* 83 (2011) & K. N. Abazajian et al., "Light Sterile neutrino: a white paper", arXiv:1204.5379, [4] T. A. Mueller et al. *Improved Prediction of Reactor Antineutrino Spectra*, *Phys. Rev. C* 83 (2011) & P. Huber, *On the determination of reactor Antineutrino Spectra from nuclear reactors*, *Phys. Rev. C* 84, [5] C. Giunti and M. Laveder, *statistical Significance of the Gallium Anomaly*, *Phys. Rev. C* 83, 065504 (2011), arXiv:1006.3244, [6] J. Kopp et al., *Sterile Neutrino Oscillations: The Global Picture*, *JHEP* 1305:050, 2013 [7] <http://www-subatech.in2p3.fr/en/component/content/article?id=253>