SoLid: Search for oscillations at short distance of the BR2 research reactor

N. Ryder, A. Vacheret* and A. Weber for the SoLid collaboration

Physics Motivations

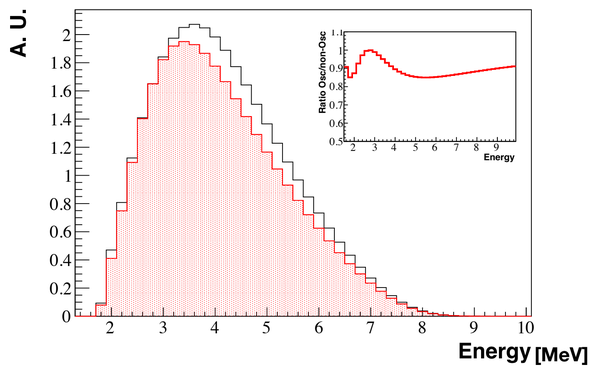
A few anomalies at a similar L/E have emerged in oscillation data :

- 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]

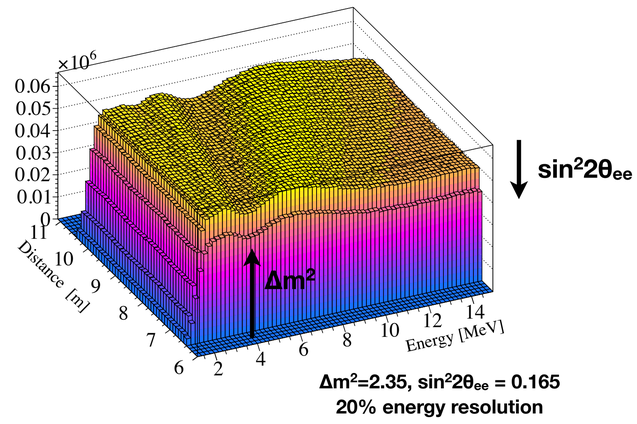
A possible explanation for this is a light neutral particle (called sterile neutrino) which only couples to other standard model neutrinos via oscillation at short distance (mass around ~1 eV). Recent Planck 2013 data [6] leaves some possiblity for an additional neutral candidate but with mass around ~ 0.2-0.4 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 and test sterile neutrino hypothesis



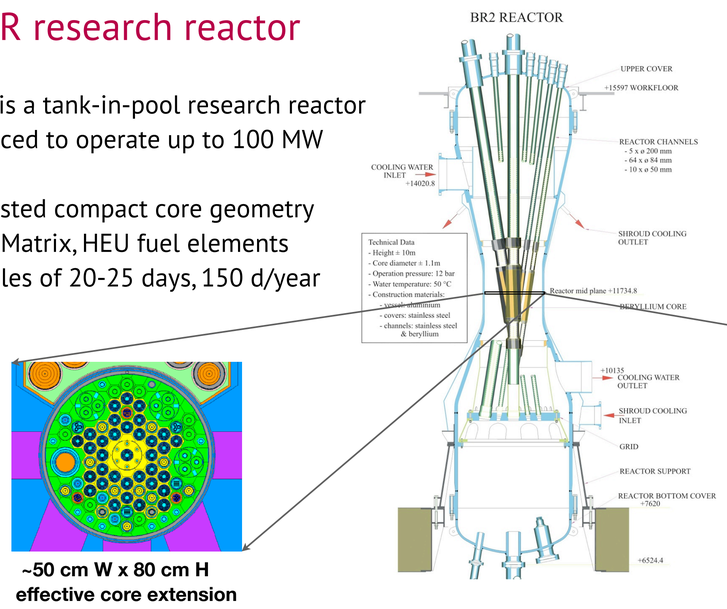
Sensitivity to small oscillations can be maximised by:
- use of a compact source (research reactor)
- use a highly segmented detector with good energy reconstruction



SCK•CEN BR2 MTR research reactor

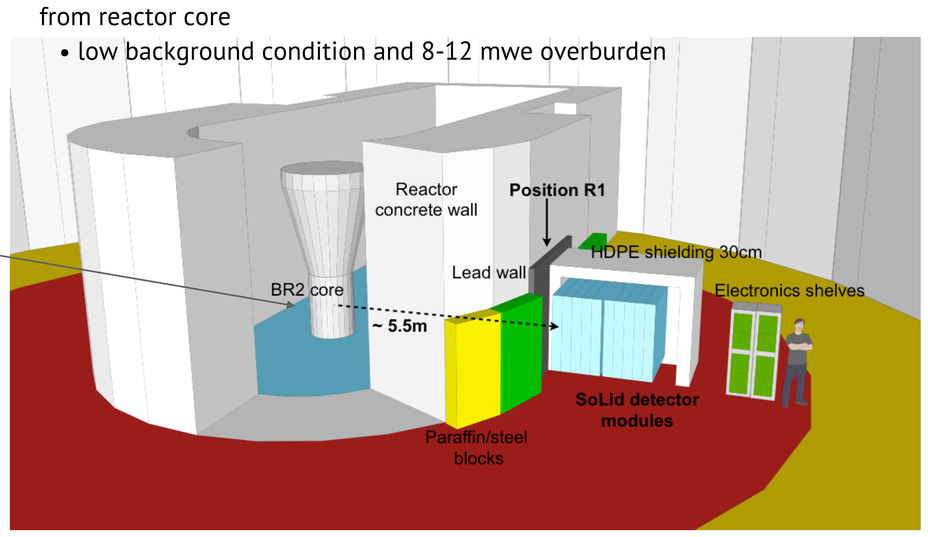
BR2 is a tank-in-pool research reactor licenced to operate up to 100 MW

- twisted compact core geometry
- Be Matrix, HEU fuel elements
- cycles of 20-25 days, 150 d/year



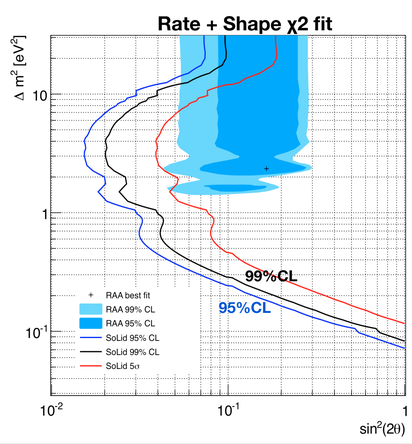
Experimental set up

2.88 tonne segmented solid scintillator detectors at 6.8m from reactor core
- low background condition and 8-12 mwe overburden



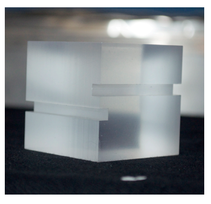
SoLid sensitivity to new oscillations

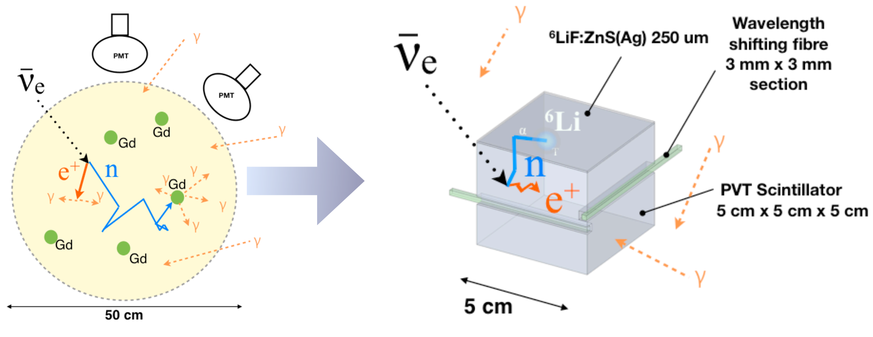
- 416 ν/day/ton
- target detector efficiency 41%
- Energy resolution ΔE/E ~ 22% at 1 MeV
- 300 days running (140 d/year) stars in 2016
- flux, power & efficiency systematics in contour



SoLid detector technology

Move away from traditional approach (LS+Gd):
- better neutron ID
- Localise more precisely antineutrino interaction

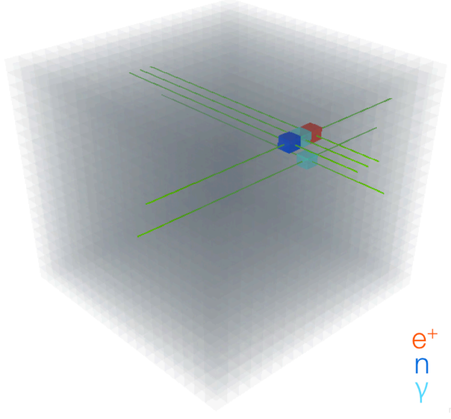


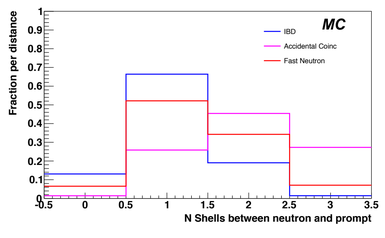


$$n + {}^{6}Li \rightarrow {}^{3}H + \alpha \ + 4.78\ MeV$$

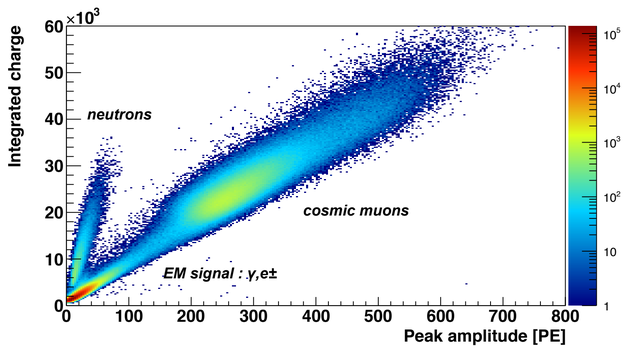
Voxelisation of target volume

- Add precise spatial information of
- potential for direction reconstruction
  - unique strategy to unfold unknown backgrounds



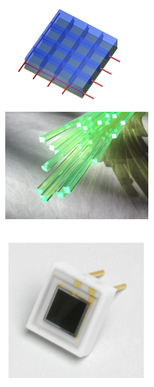


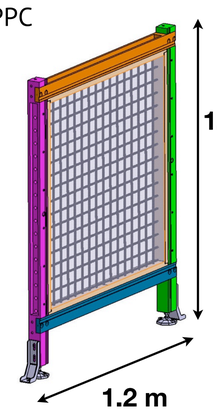
Detector response



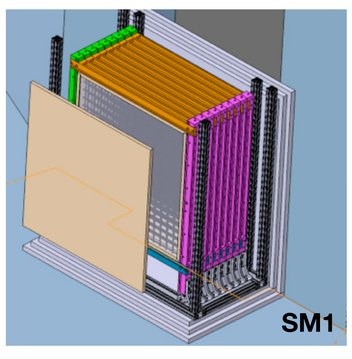
Detector design

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



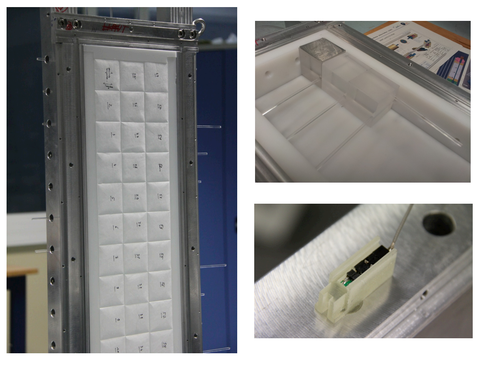


Detector divided in 40 detector planes (1.2m H x 1.2m W x 2m D)
- 2.88 tonne fiducial volume
- 12 000 cells
- 1970 channels



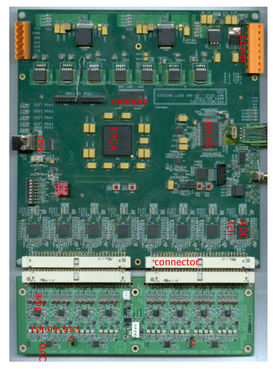
Staged R&D

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



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)

[1] *A. Aguilar-Areval 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. C83, 065504 (2011), arXiv:1006.3244*
[6] *P. A.R. Ade et al., Planck Collaboration, Planck 2013 Results, arXiv:1303.5062*