The SoLid experiment

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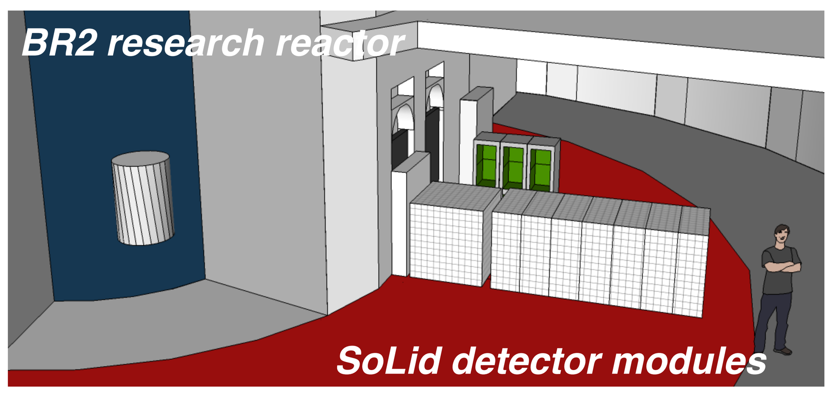
on behalf of the SoLid collaboration

SoLid

NEUTRINO 2016 SOUTH KENSINGTON, LONDON

Experimental layout

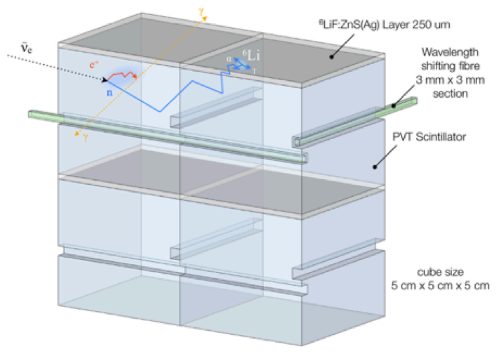
The SoLid experiment at the BR2 reactor



- Installed at the BR2 reactor in SCK•CEN (Mol, Belgium)
- Long detector covers a wide baseline range ~ 5.5 - 10 m
- SoLid experiment aims to resolve the Reactor Antineutrino Anomaly
- Precise measurement of the ^{235}U reactor flux

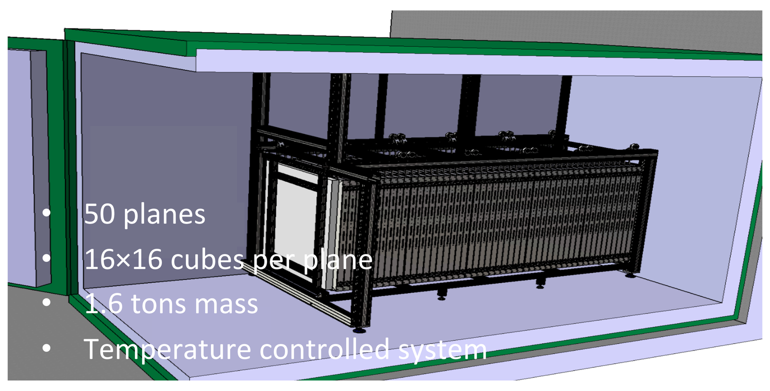
The SoLid detector concept

- Vertical planes of PVT cubes readout by optical fibers and SiPMs
- LiF:ZnS(Ag) screens for neutron detection
- Background suppression possible due to detector granularity and pulse shape discrimination in LiF:ZnS(Ag)



5×5×5 cm^3 cubes

Phase I upgrade



BR2 reactor at SCK•CEN

Research reactor
- Highly enriched in ^{235}U
- Compact reactor core

High thermal power
- Typical values between 40 and 80 MW

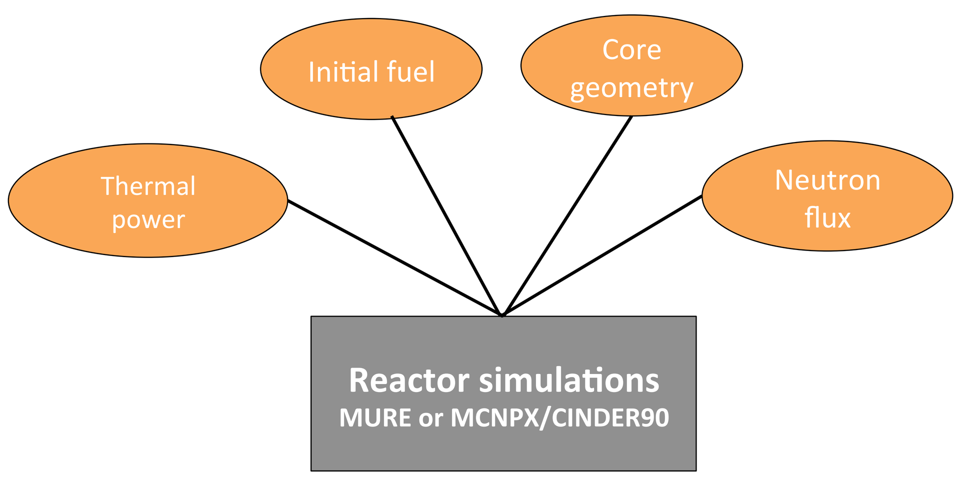
150 days per year duty cycle
- Reactor off data for background subtraction

Low level of reactor correlated background

Excellent collaboration with SCK•CEN

Antineutrino flux from BR2

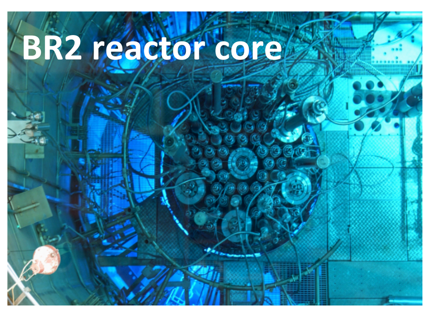
Reactor flux prediction method

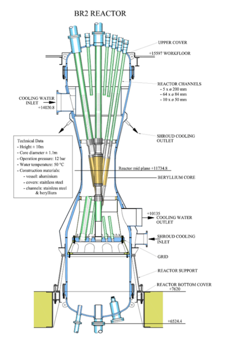


f_i , fission fractions for ^{235}U, ^{238}U, ^{239}Pu and ^{241}Pu

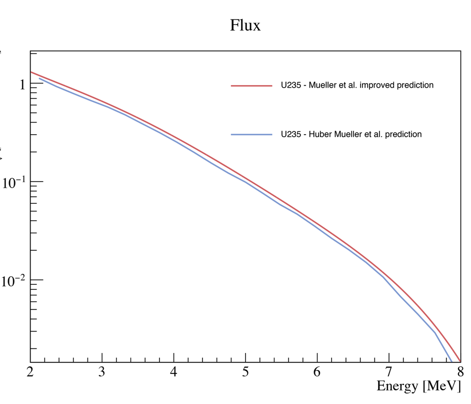
Energy spectrum (S_i) through improved ILL conversion method

- **Core geometry provided by SCK•CEN**
  - Implemented in simulation models

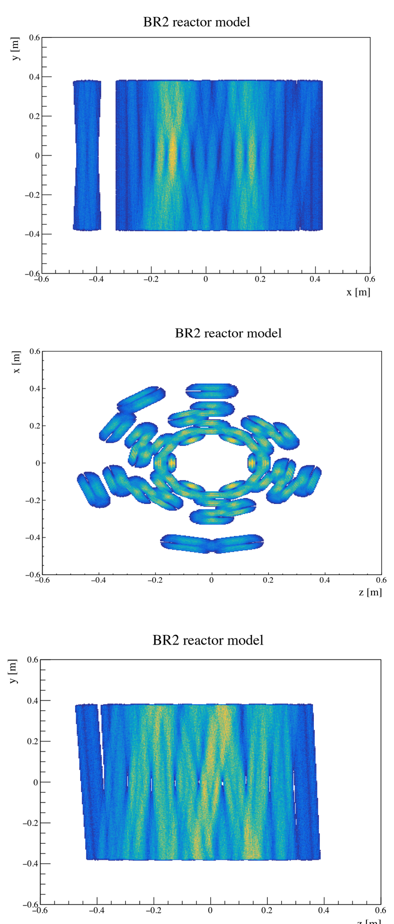




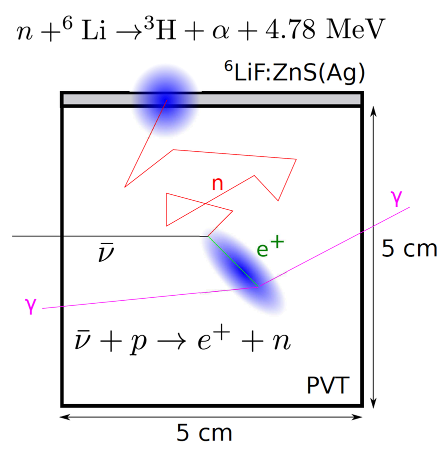
- **Initial fuel content is known by BR2**
- **Thermal power regularly monitored**
  - Accuracy of a few %



Spatial distribution of fissions in BR2



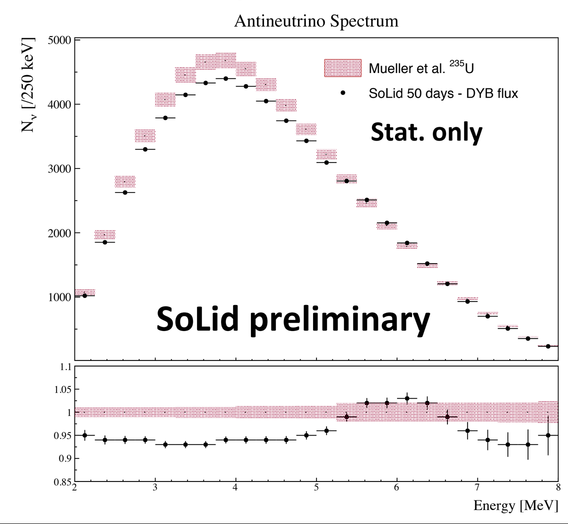
Interaction channel



Inverse beta decay in PVT
- High cross-section
- Threshold at 1.8 MeV

Prompt-delay coincidence
- Selection cuts using time and space correlation
- Neutron tagging using pulse shape discrimination

Expected antineutrino spectrum



- Precise spectrum and flux measurement in 150 days
- Probe the 5 MeV bump seen in power reactors
- Demonstrate reactor monitoring on surface

Sensitivity to sterile neutrinos

Gaussian χ^2 with pull terms for the systematic uncertainties

$$\chi^2=\sum_{i,j}\frac{(S_{ij}-(1+\alpha+a_E^i+a_L^j)T_{ij}-(1+\alpha_b)B_{ij})^2}{S_{ij}+(\sigma_{b2b}T_{ij})^2+(\sigma_{b2b}B_{ij})^2}+\frac{\alpha^2}{\sigma^2}+\frac{\alpha_b^2}{\sigma_b^2}+\sum_i\left(\frac{a_E^i}{\sigma_E^i}\right)^2+\sum_i\left(\frac{a_L^j}{\sigma_L^j}\right)^2$$

- Index i : bin in energy; 16 bins between 1.0 - 7.4 MeV
- Index j : bins in length; 25 bins between 5.5 - 8.0 m
- S_{ij} : Data expectation (no oscillation)
- T_{ij} : Theoretical antineutrino prediction (oscillations folded)
- B_{ij} : Background

Parameters	Values
Reactor power	60 MW
Target mass	1.6 tons
IBD efficiency	30 %
S:B	3:1
Energy resolution	$14\%/\sqrt{E_\nu}$

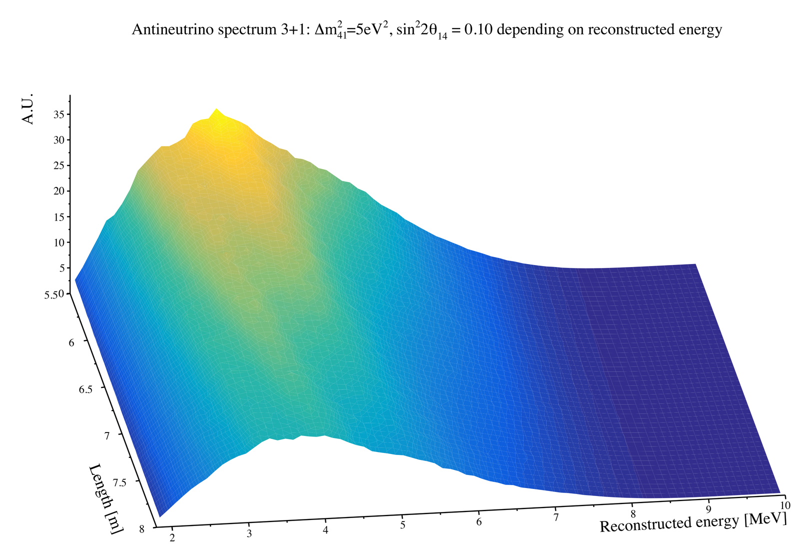
Error envelope

- σ : 100% signal normalization error
- σ_b : 10% error on the background normalization
- σ_{b2b} : 1% uncorrelated bin to bin errors
- σ^i_E : 10 % uncertainty on neutrino flux
- σ^j_L : 1 % uncertainty on position reconstruction

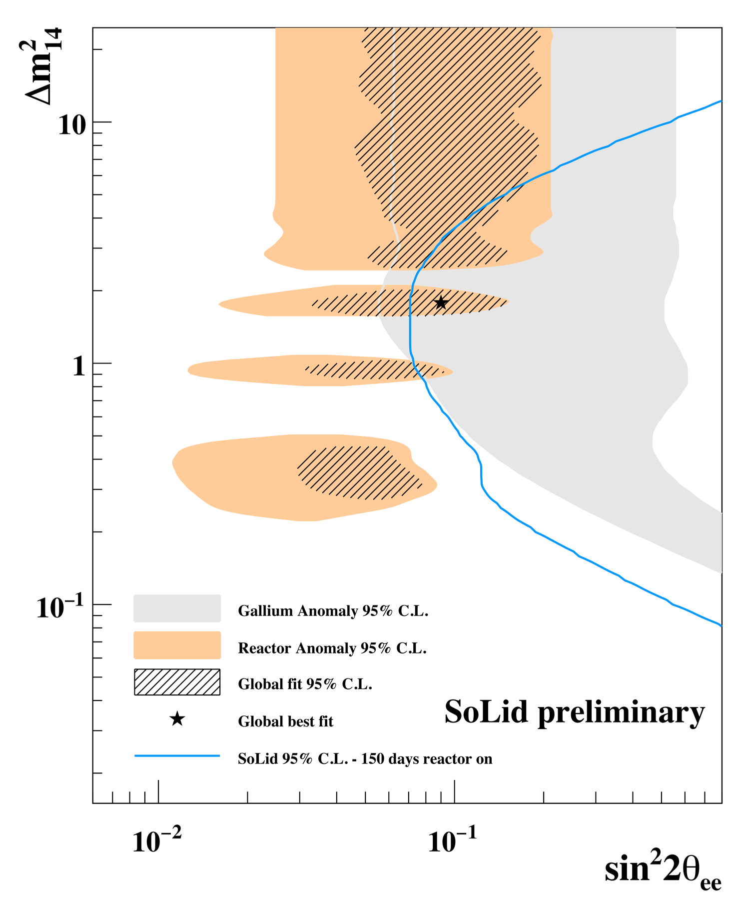
3+1 oscillation model

$$P_{\bar\nu_e\rightarrow\bar\nu_e}=1-\sin^2(2\theta_{ee})\sin^2(1.27\frac{\Delta m^2_{14}L}{E_\nu})$$

- Model with two free parameters
- χ^2 minimization over $\sin^2(2\theta_{ee})$, Δm^2_{14} and nuisance parameters



Phase I sensitivity



Allowed regions from Kopp et al., JHEP 1305 (2013) 050

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