Physics potential of detecting ^{8}B solar neutrinos at JUNO

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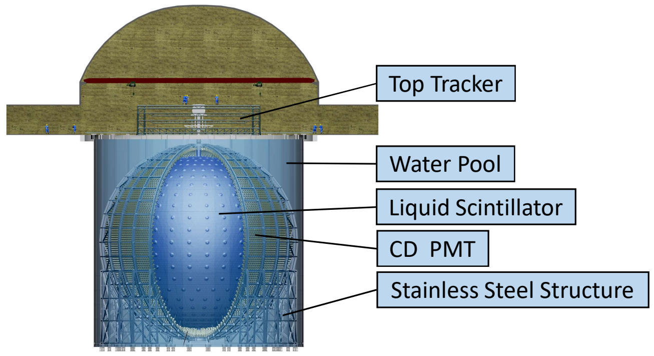
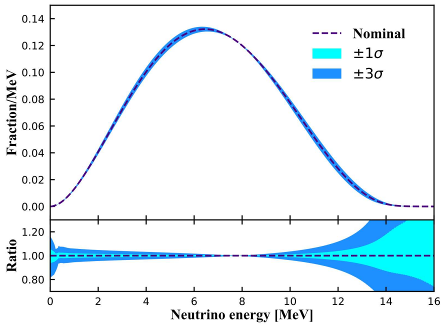
JUNO detector



- The central detector includes a 20 kton liquid scintillator target.
- 17,612 20-inch PMTs and 25,600 3-inch PMTs detect the light emitted by the LS.
- The main physics goal of JUNO is to determine neutrino mass ordering and make a precise determination of the oscillation parameters.
- In solar neutrino physics, JUNO can resolve the solar metallicity problem and the measurement of Δm^2_{21}.

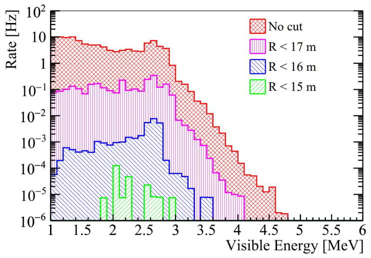
^{8}B-ν spectrum



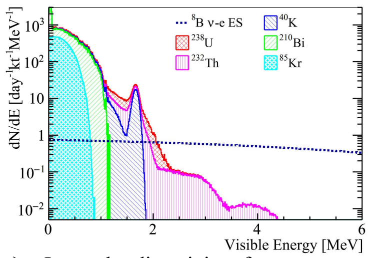
- ^{8}B ν_e spectrum together with the shape uncertainties.
- The primary detection channel is the neutrino electron elastic scattering (ES, 4cpd/kt).
- In addition, there are other channels known as charged current (CC) and neutral current (NC).

No.		Channels	Threshold [MeV]	Signal	Event numbers (10 years)
1	CC	$\nu_e + ^{12}C \rightarrow e^- + ^{12}N\,(1^+;\text{gnd})$ [32]	16.827	$e^- + ^{12}N$ decay (β^+, Q=17.338 MeV)	0.43
1		$\nu_e + ^{13}C \rightarrow e^- + ^{13}N\,(\frac{1}{2}^-;\text{gnd})$ [33]	2.2	$e^- + ^{13}N$ decay (β^+, Q=2.22 MeV)	3929
2		$\nu_e + ^{13}C \rightarrow e^- + ^{13}N\,(\frac{3}{2}^-;3.5\,\text{MeV})$ [33]	5.7	$e^- + p$	2464
4	NC	$\nu_x + ^{12}C \rightarrow \nu_x + ^{12}C\,(1^+;15.11\,\text{MeV})$ [32]	15.1	γ	4.8
3		$\nu_x + ^{13}C \rightarrow \nu_x + n + ^{12}C\,(2^+;4.44\,\text{MeV})$ [34]	6.864	$\gamma + n$ capture	65
4		$\nu_x + ^{13}C \rightarrow \nu_x + ^{13}C\,(\frac{1}{2}^+;3.089\,\text{MeV})$ [33]	3.089	γ	14
5		$\nu_x + ^{13}C \rightarrow \nu_x + ^{13}C\,(\frac{3}{2}^-;3.685\,\text{MeV})$ [33]	3.685	γ	3032
6		$\nu_x + ^{13}C \rightarrow \nu_x + ^{13}C\,(\frac{5}{2}^+;3.854\,\text{MeV})$ [33]	3.854	γ	2.8
7	ES	$\nu_x + e \rightarrow \nu_x + e$	0	e^-	3.0×10^5

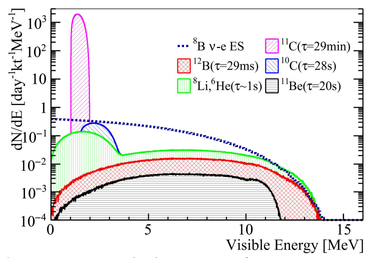
Background budget



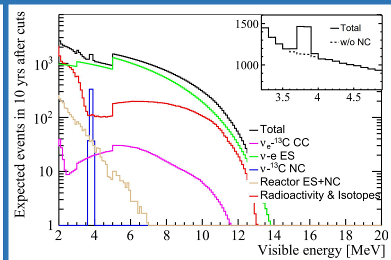
- External radioactivity after cut.
- Strategy: energy-dependent FV cuts.



- Internal radioactivity after cut.
- Strategy: time, space and energy correlation cuts.

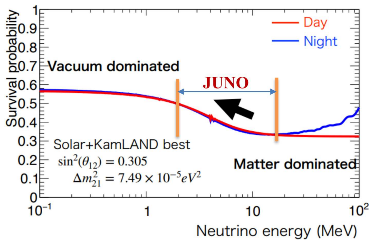


- Cosmogenic isotopes after cut.
- Strategy:
  a) Whole detector veto for non-track μ;
  b) The cylindrical volume veto around μ track;
  c) Three-Fold Coincidence cut (TFC) among the muon, spallation neutron capture, isotope decay.

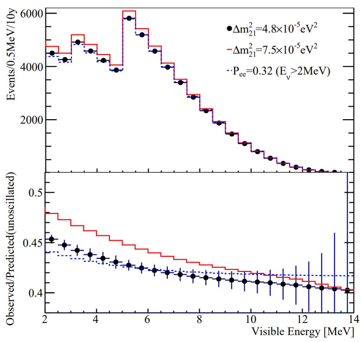


- Summary of signal and background spectra in 10 years of data taking.
- The discontinuities are caused by different FV cuts.

Survival probability

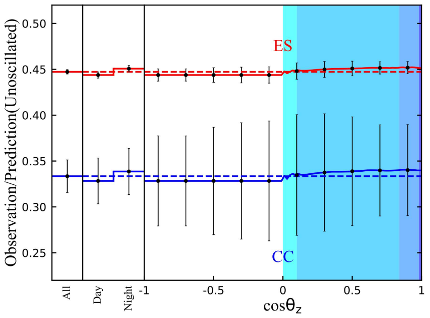


- The standard scenario of three neutrino mixing predicts a smooth upturn in the ν_e survival probability (P_{ee}) in the neutrino energy region between the high and low ranges.
- JUNO can observe the spectral upturn.



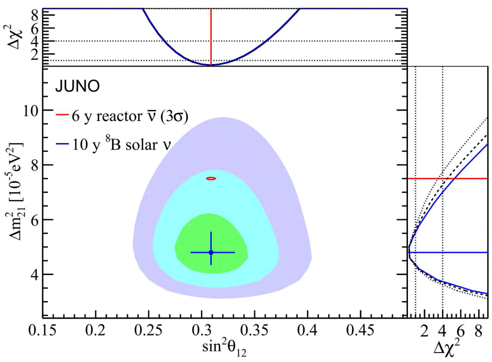
- The expected ^{8}B ν_e signal spectra produced in the standard LMA-MSW framework for different cases.
- The P_{ee} is assumed as a flat value for energy lager than 2 MeV.
- The comparison with the no flavor conversion cases, which shows the significant upturn.
- The upturn of blue line comes from the appearance of $\nu_{\mu,\tau}$.

Day-Night asymmetry



- Observation: the ^{8}B neutrino signals produced in the standard LMA-MSW framework.
- Prediction: the signals produced by the no-oscillation prediction.
- θ_z: the solar zenith angles.
- The ratio shows the day-night asymmetry for the signal rate.
- No day-night asymmetry exists in the NC channel detection.

Oscillation parameters



- The expected sensitivity of $\sin^2\theta_{12}$ and Δm^2_{21} with 10 years of data taking.
- For comparison, the red region shows the result from 6 years reactor $\bar{\nu}_e$ with 3σ uncertainty.
- The one-dimensional $\Delta\chi^2$ for $\sin^2\theta_{12}$ and Δm^2_{21} are shown in the top and right panels, respectively.
- By ^{8}B solar neutrinos, JUNO can measure Δm^2_{21} to a precision of 20%, and $\sin^2\theta_{12}$ to a precision of 8%.
- It will provide a unique possibility to compare Δm^2_{21} from reactor and solar channels using the same detector.

References

[1] JUNO, A. Abusleme et al., Feasibility and physics potential of detecting ^{8}B solar neutrinos at JUNO, Chin. Phys. C 45, 023004 (2021).
[2] JUNO, Jie Zhao et al., Model Independent Approach of the JUNO ^{8}B Solar Neutrino Program, arXiv:2210.08437 (2022).