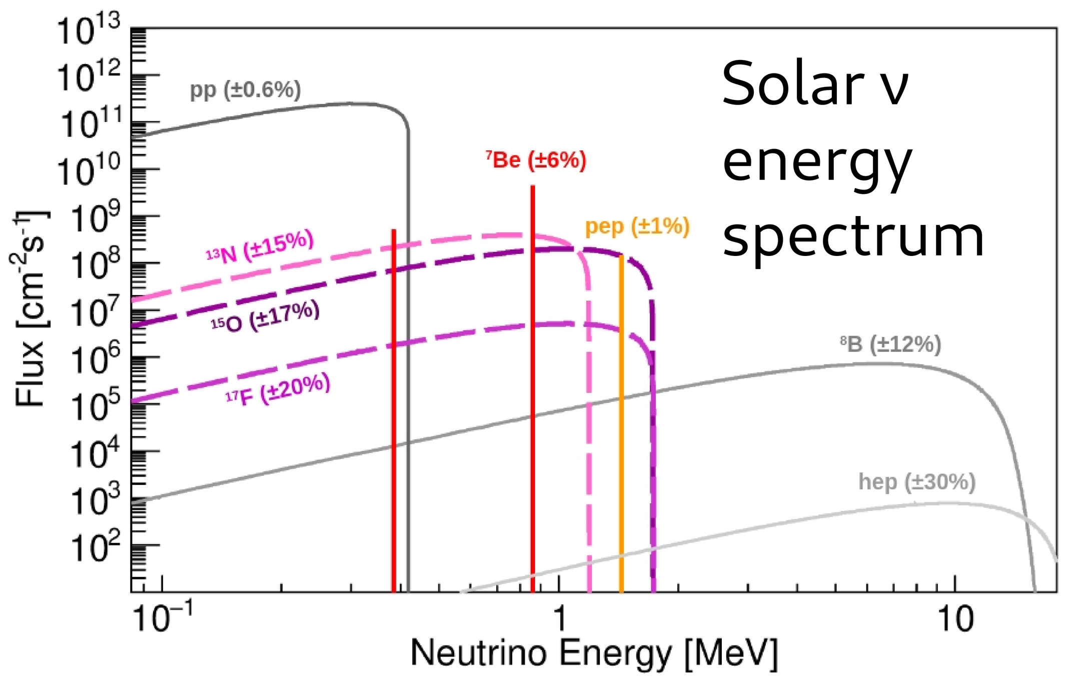
JUNO sensitivity to ^{7}Be, *pep*, and CNO solar neutrinos

JUNO will be competitive to improve the ^{7}Be, *pep*, CNO solar ν fluxes measurements in most of the radiopurity scenarios, and to explore details of solar ν oscillations.

Davide Basilico (INFN)
on behalf of the JUNO Collaboration

Why solar ν are interesting?



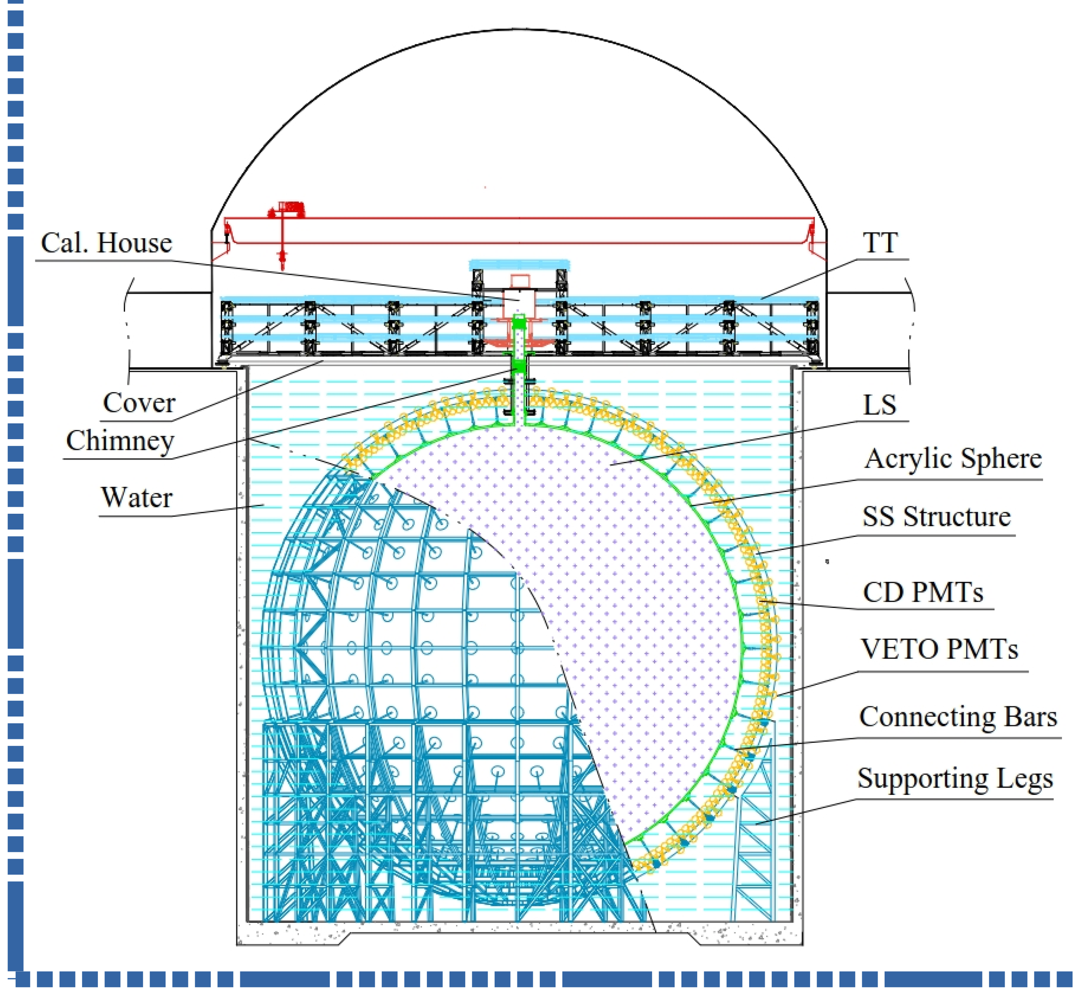
1) **Solar metallicity puzzle.** Solar fluxes depend on metallicity: CNO and ^{7}Be can help to disentangle between Low Metallicity and High Metallicity (28% and 9% flux difference).

2) **Periodical modulations**: day-night (flavor regeneration in Earth), or induced by temperature changes by helioseismic waves

3) Search for neutrino **Non Standard Interactions**.

JUNO

A huge, radiopure, multi-purpose liquid-scintillator detector located in Southern China.



- Data taking starting in 2025.
- 20kt of ultrapure liquid scintillator.
- Low background levels: internal radiopurity + passive shielding (1900 m.w.e.).
- Excellent energy resolution: scintillator light yield (~10^4 phot/MeV) + 43600 PMTs coverage (~75%) with quantum Efficiency ~35%.

Sensitivity to solar ν fluxes

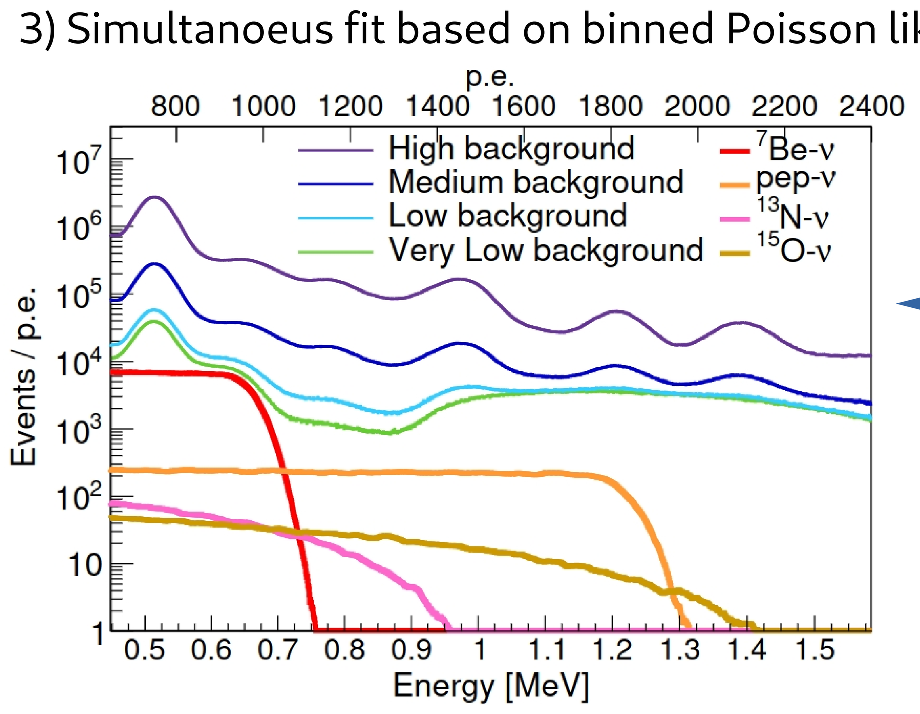
Signal and backgrounds

Neutrino detection: ν - e$^-$ elastic scattering
Internal backgrounds: intrinsic radioactive decays from 238U and 232Th chains and 85Kr.
Cosmogenic backgrounds: isotopes produced by cosmic muons.
External backgrounds: γ from materials surrounding the liquid scintillator, as PMT glass → suppressed via Fiducial Volume cut.

Background scenarios:
High: min. requirement for NMO measurement
Medium: 10x Borexino Phase-I levels
Low: Borexino Phase-I levels
Very Low: Borexino Phase-III levels

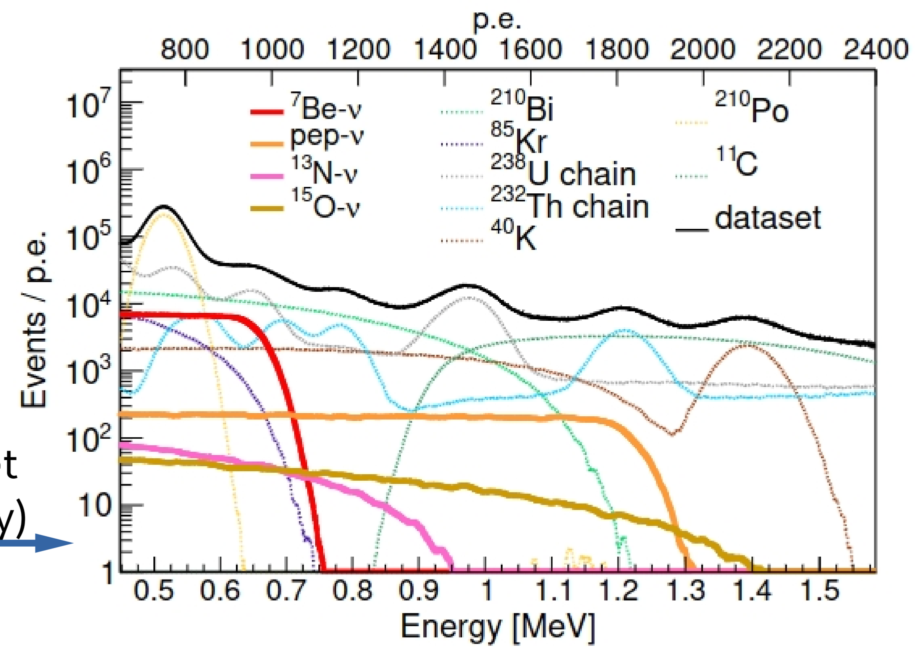
Analysis methods

Backgrounds are indistinguishable from neutrino signal on an event-by-event basis.
1) Generate Monte Carlo PDFs and build thousands toy-datasets.
2) Apply Three-Fold Coincidence performances → split each datasets in two: C11-enriched and C11-depleted.
3) Simultaneous fit based on binned Poisson likelihood.

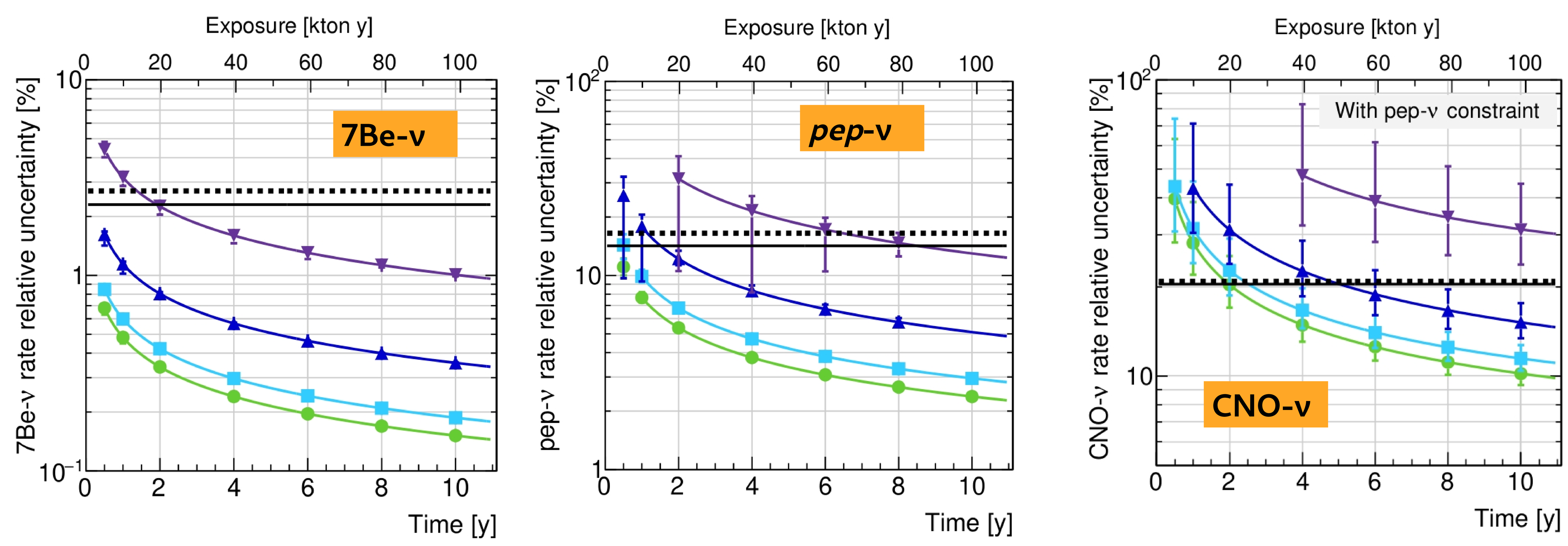


Generated C11-depleted datasets (6y)

Fitted C11-depleted dataset (medium bkg, 6y)



Sensitivity results

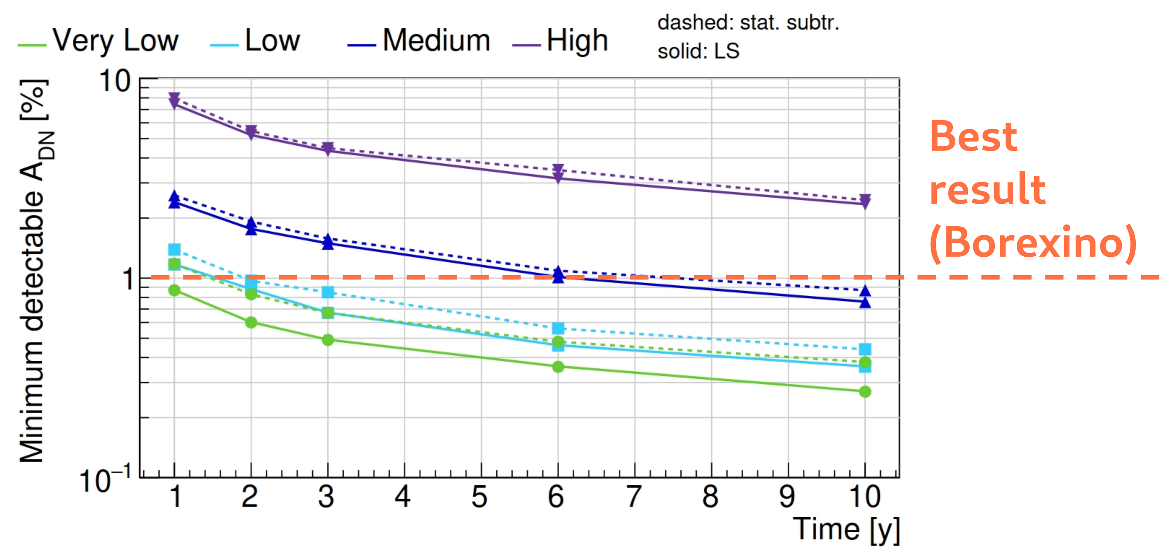


For most of the background scenarios considered (except for the worst one) JUNO will be able to reduce the Borexino uncertainty; for CNO-ν, this takes place if a constraint on the *pep* -ν rate is set.

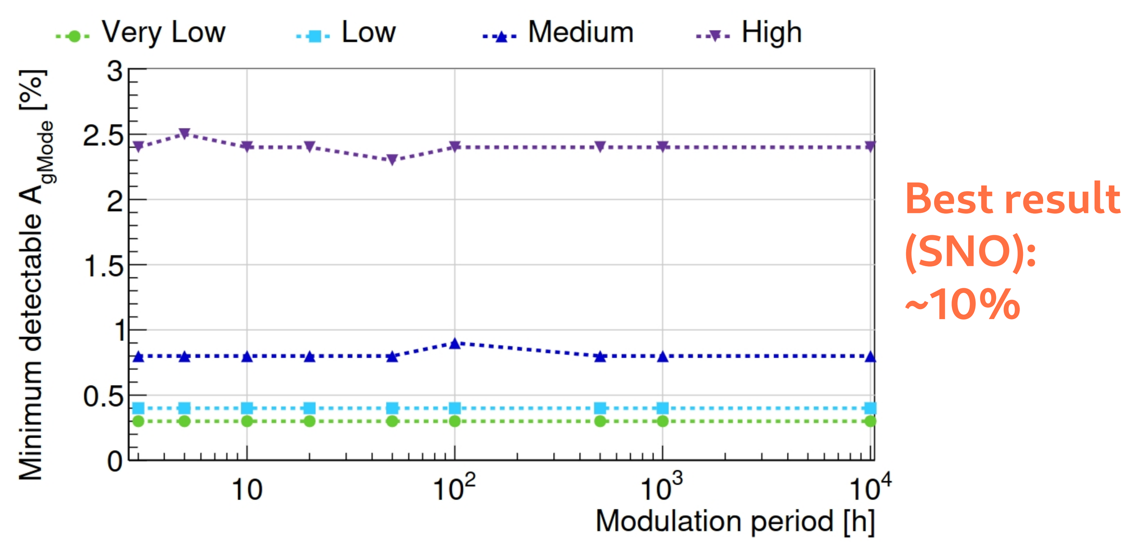
Periodical modulations

Day-night modulations: solar ν travelling at night cover distance inside Earth → coherent ν_e re-generation. Expected rate asymmetry A_{DN} ~ 0.1%, but Non-Standard Interactions theories predict larger A_{DN} .

Looking at ^{7}Be ν rate variations in time by applying:
- statistical subtraction of Day and Night datasets
- Lomb Scargle Method as Fourier transform extension



Gravity-driven helioseismic waves with unknown period may alter solar matter temperature T, on which solar ν fluxes strongly depend (Φ ~ T$^{\alpha}$, α = 11 for ^{7}Be ν)



- Sensitivity not depending on waves period.
- Temperature fluctuations could be detected up to $\Delta\mathcal{T}/\mathcal{T} \simeq A_{gMode}/\alpha \simeq 5\times10^{-4}$

Other JUNO solar-ν posters:

[320] "Feasibility study for 7Be and CNO solar neutrino directional measurement with JUNO", M. Malabarba

[286] "Feasibility of detecting B8 solar neutrinos at JUNO", J. Zhao

Poster based on

"JUNO sensitivity to ^{7}Be, *pep*, and CNO solar neutrinos" JCAP 10 (2023) 022

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