RES-NOVA

Archaeological Pb-based observatory for SN neutrino detection

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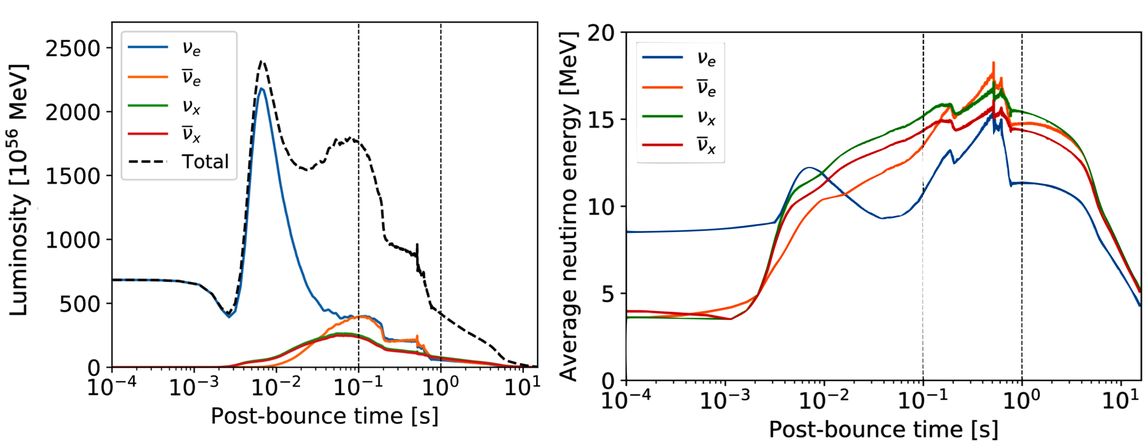
SUPERNOVA neutrino signals

Massive stars at the end of their lives become Supernovae.
Almost the entire gravitational energy of the star is released as anti-ν/ν of all flavors, in a time frame of few seconds.



anti-ν_x/ν_x (x=μ,τ) are the **most intense** and **energetic component** of the neutrino emission

Currently running neutrino observatories are mostly sensitive to anti-ν_e/ν_e

Need for a flavor independent (neutral current) highly sensitive neutrino detection channel

Detection of SN neutrinos via CEvNS

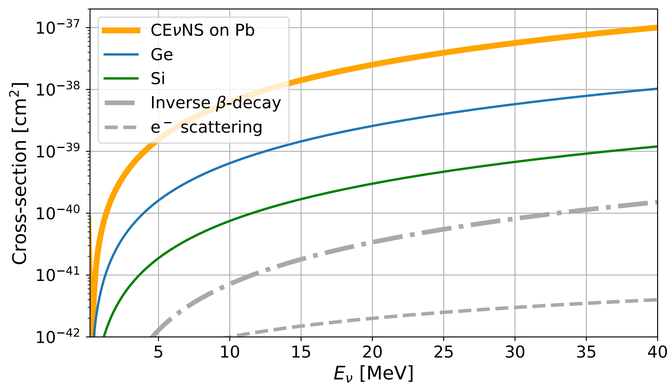
Coherent elastic neutrino-nucleus scattering (CEvNS) is an ideal channel:
i) Neutral current – ii) High cross-section – iii) No Threshold

	PROTONS	ELECTRONS	NUCLEI
CHARGE CURRENT	Inverse beta decay $\overline{\nu}_e + p \rightarrow e^+ + n$	Elastic scattering $\nu + e^- \rightarrow \nu + e^-$	Inelastic scattering $\nu_e/\overline{\nu}_e + (N,Z) \rightarrow e^{-/+} + (N \mp 1, Z \pm 1)$
NEUTRAL CURRENT	Elastic scattering $\overline{\nu}_x/\nu_x + p \rightarrow \overline{\nu}_x/\nu_x + p$		Coherent Elastic neutrino-nucleus scattering (CEvNS) $\overline{\nu}_x/\nu_x + A \rightarrow \overline{\nu}_x/\nu_x + A$

$$\sigma_{CE\nu NS} \sim N^2 \cdot E_\nu^2$$

Neutron number of target material — Energy of incoming neutrino

Pb ideal target for CEvNS interactions
- **Highest cross section**
- **Highest nuclear stability**



High-purity Archaeological Pb

Low-background Pb: high ^{210}Pb concentration (Q_{β^-}=63 keV $t_{1/2}$=22.3 y): **100 Bq/kg**

Archaeological Pb: negligible concentration of ^{210}Pb (2000 y old): **<715 μBq/kg**

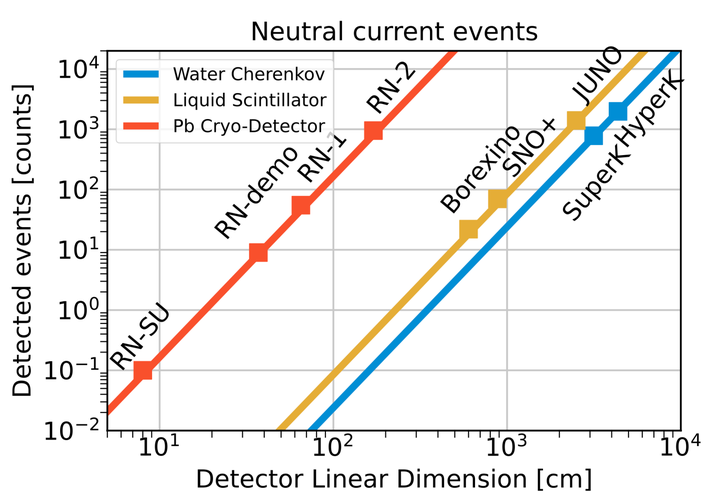
Nuclide	Low background Pb (Boliden®) [1]	Archaeological Pb [2, 3]
^{232}Th	<46 μBq/kg	<45 μBq/kg
^{238}U	<31 μBq/kg	<46 μBq/kg
^{210}Pb	(2.3±0.4) · 10^7 μBq/kg	<715 μBq/kg

Archaeological Pb-based detectors

[1] G. Heusser, Ann. Rev. Nucl. Part. Sci. 45 (1995) 543-590.
[2] L. Pattavina et al., Eur. Phys. J. A (2019) 55: 127.
[3] CUORE Coll., Eur. Phys. J. C (2017) 77: 543.

The RES-NOVA detector

RES-NOVA will be an array of $PbWO_4$ crystals produced from archaeological Pb and operated as scintillating cryogenic detectors.



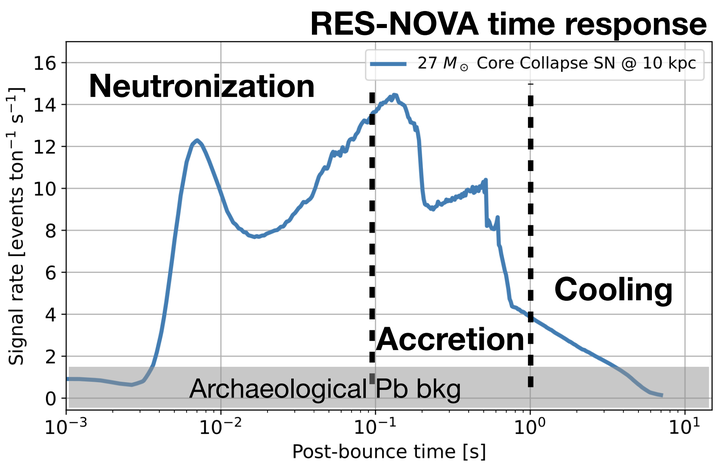
RES-NOVA-demonstrator
Detector volume: (30 cm)³
Detector energy threshold: 1 keV
Background @ ROI: 10⁻³ c/keV/ton/s

RES-NOVA is a cm-scale neutrino detector sensitive as kton-scale detectors (Borexino, SNO+, ...)

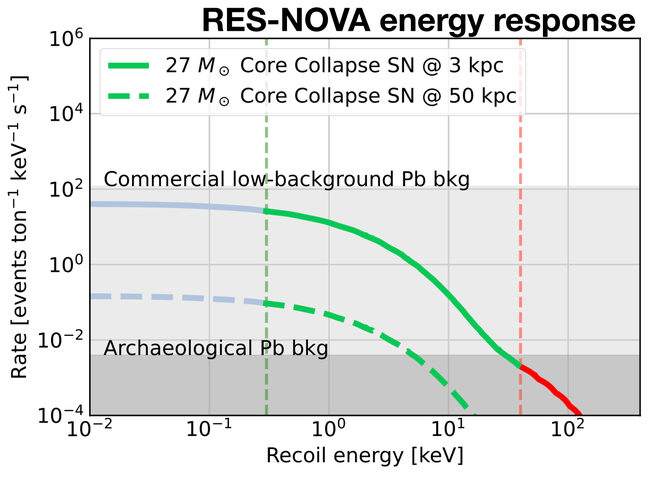
RES-NOVA detector response

RES-NOVA can be sensitive to SN neutrinos only when archaeological Pb is used as target material.

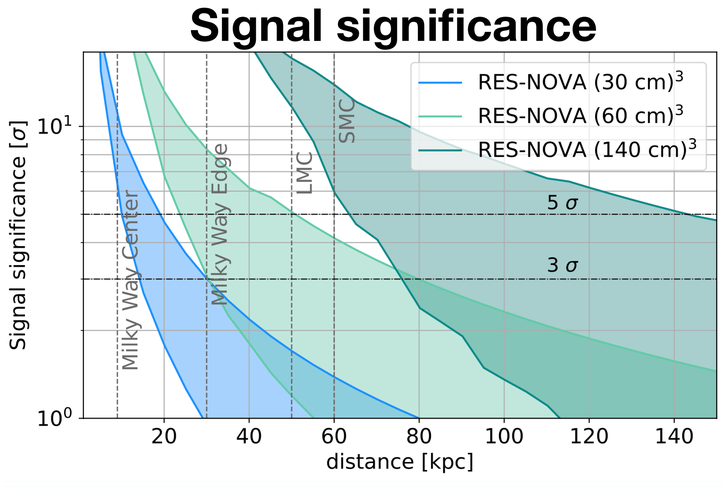
RES-NOVA time response



RES-NOVA energy response



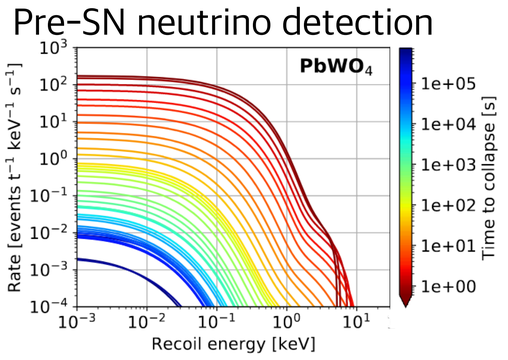
Signal significance



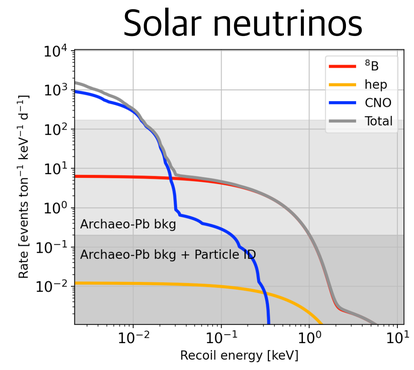
RES-NOVA can reach out to the Large Magellanic Cloud while being sensitive to all neutrino flavors.

Multi-disciplinarity

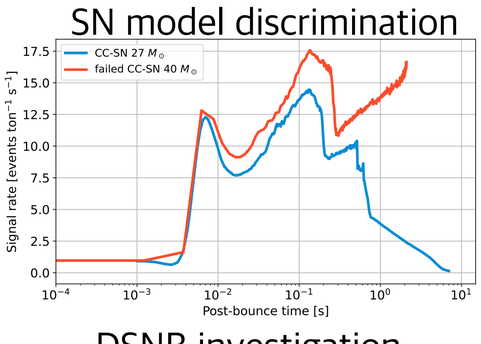
Pre-SN neutrino detection



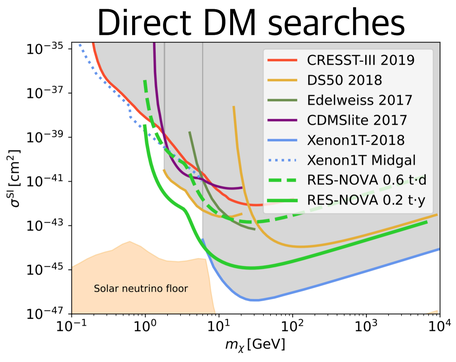
Solar neutrinos



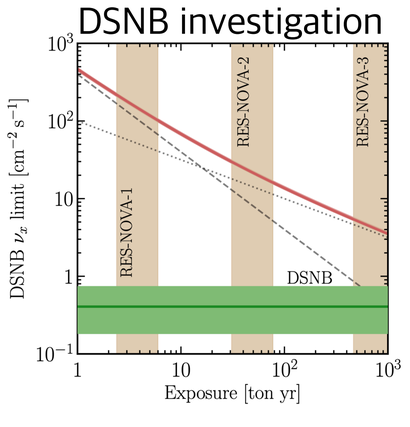
SN model discrimination



Direct DM searches



DSNB investigation



L. Pattavina et al., Eur. Phys. J. A 55, 127 (2019)
L. Pattavina et al., Phys. Rev. D 102, 063001 (2020)
L. Pattavina et al., JCAP 10 (2021) 064
RES-NOVA GoI, Eur. Phys. J. C 82, 692 (2022)
Suliga et al., Phys. Rev. D 105, 043008 (2022)
P. Eller, LP et al JCAP 10 (2022) 024

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