

RES-NOVA

Archaeological Pb-based observatory for SN neutrino detection

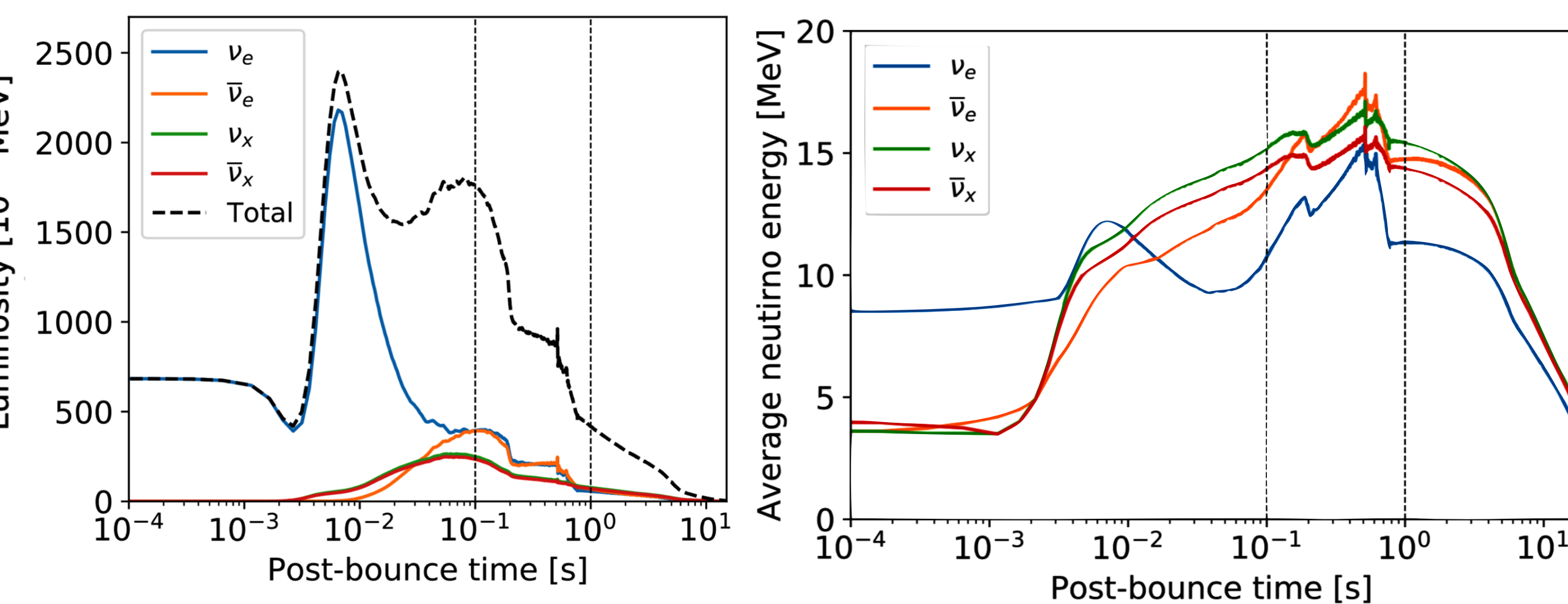


Work based on (see links):
RES NOVA physics potential
RES-NOVA background budget

Luca PATTAVINA
luca.pattavina@lngs.infn.it

SUPERNOVA neutrino signals

Massive stars ($>8M_{\odot}$) at the end of their lives become Supernovae (SNe). 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 ($x=\mu,\tau$) 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 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) Threshold-less

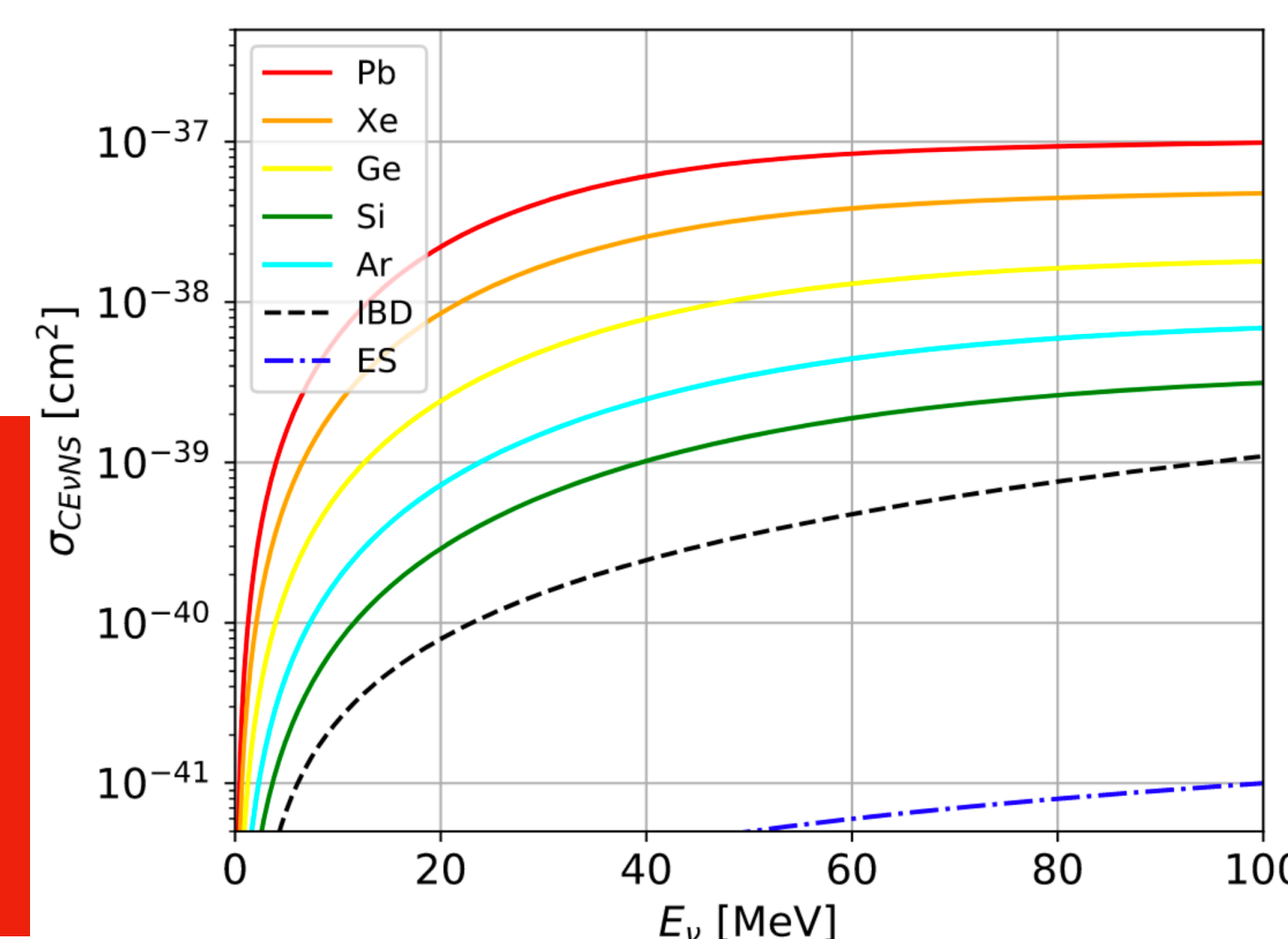
| | PROTONS | ELECTRONS | NUCLEI |
|-----------------|---|--|---|
| CHARGE CURRENT | Inverse beta decay $\bar{\nu}_e + p \rightarrow e^+ + n$ $\bar{\nu}_e \rightarrow e^+ + \gamma$ | Elastic scattering $\nu + e^- \rightarrow \nu + e^-$ $\bar{\nu}_e/\nu_e \rightarrow e^-/e^+$ | Inelastic scattering $\nu_e/\bar{\nu}_e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

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

Neutron number of target material Energy of incoming neutrino

Pb ideal target for CEvNS interactions

- Highest cross section
- Highest nuclear stability



Archaeological Pb for SN neutrino detection

Not all kind of Pb are suitable for the realization of a low-background neutrino detector

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

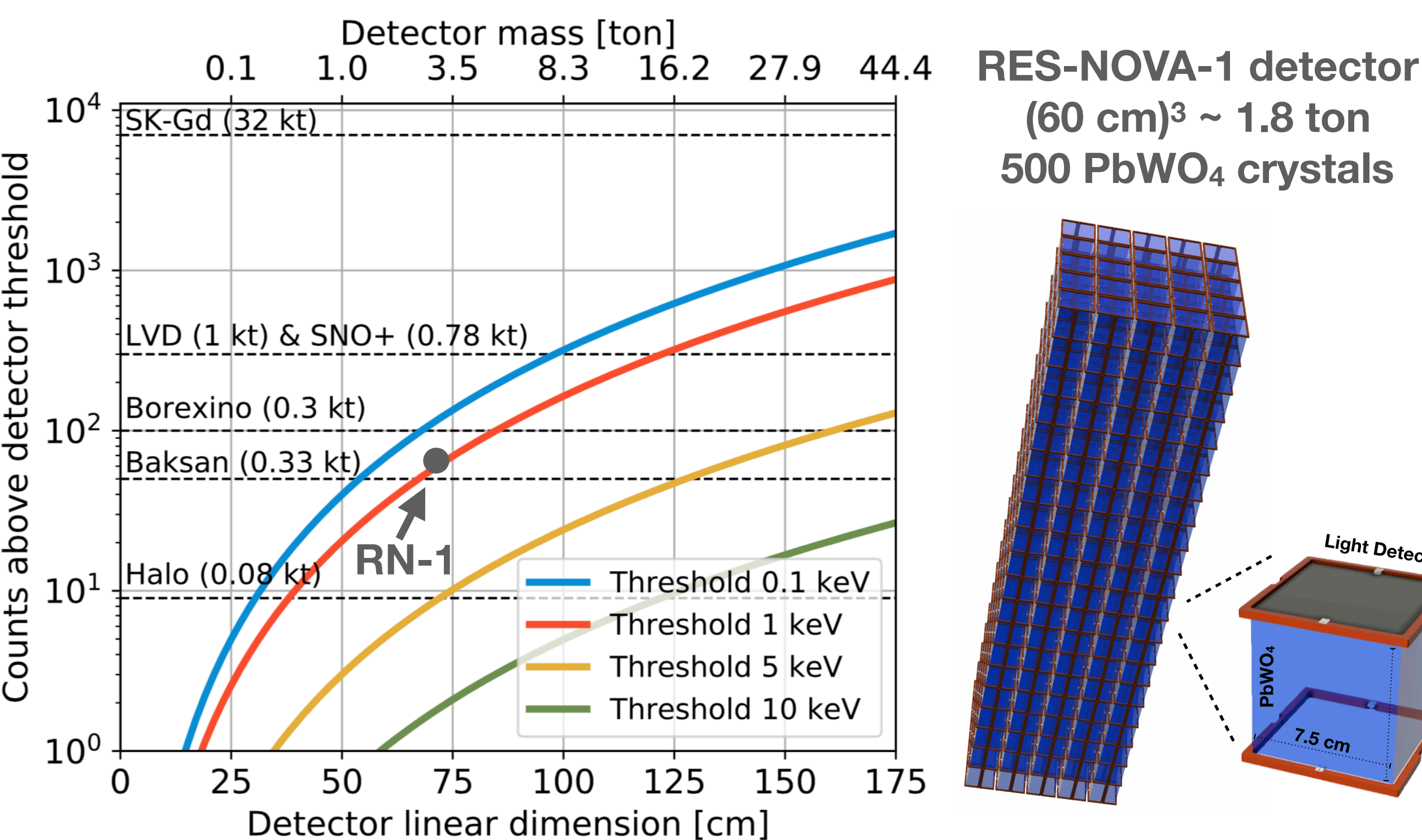
Archaeological Pb: negligible concentration of ^{210}Pb (2000 y old): **<1 mBq/kg**

Pb from shielding to active detector component



RES-NOVA dimensions

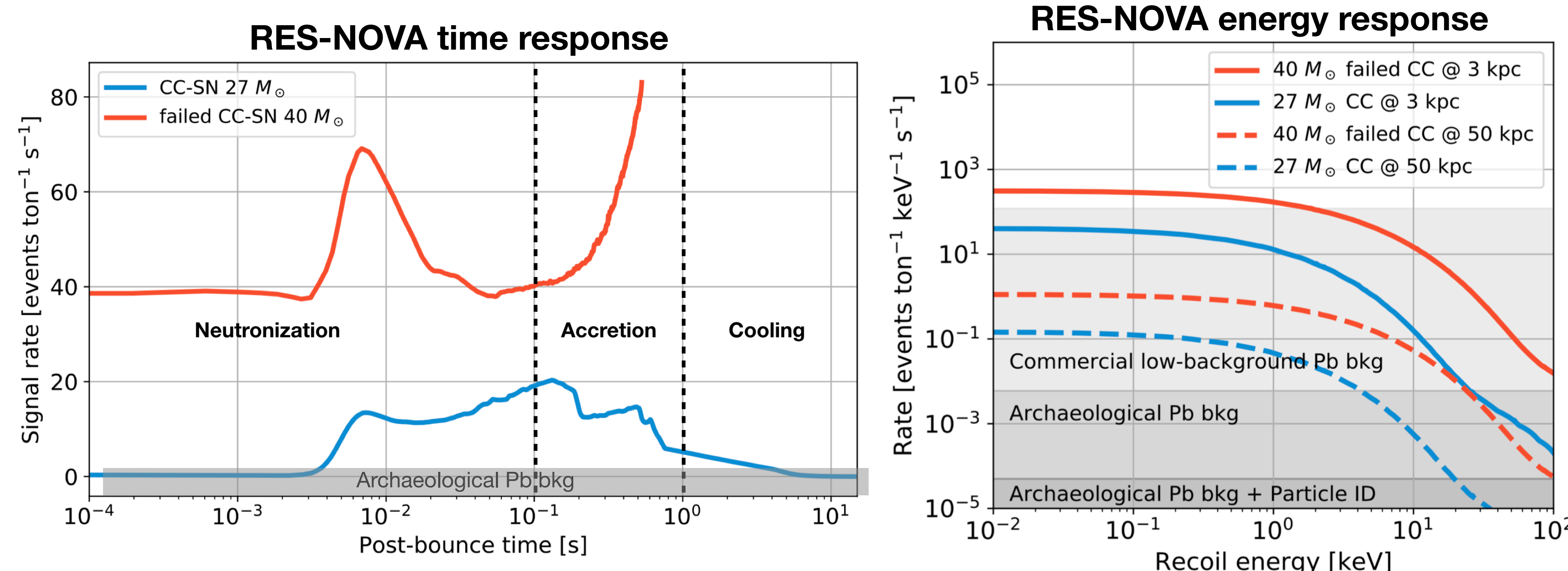
RES-NOVA will be an array of PbWO_4 crystals produced from archaeological Pb and operated as scintillating cryogenic detectors.



RES-NOVA while being a cm-scale detector can be as sensitive as super-size detectors (Borexino, SNO+, ...)

RES-NOVA detector response

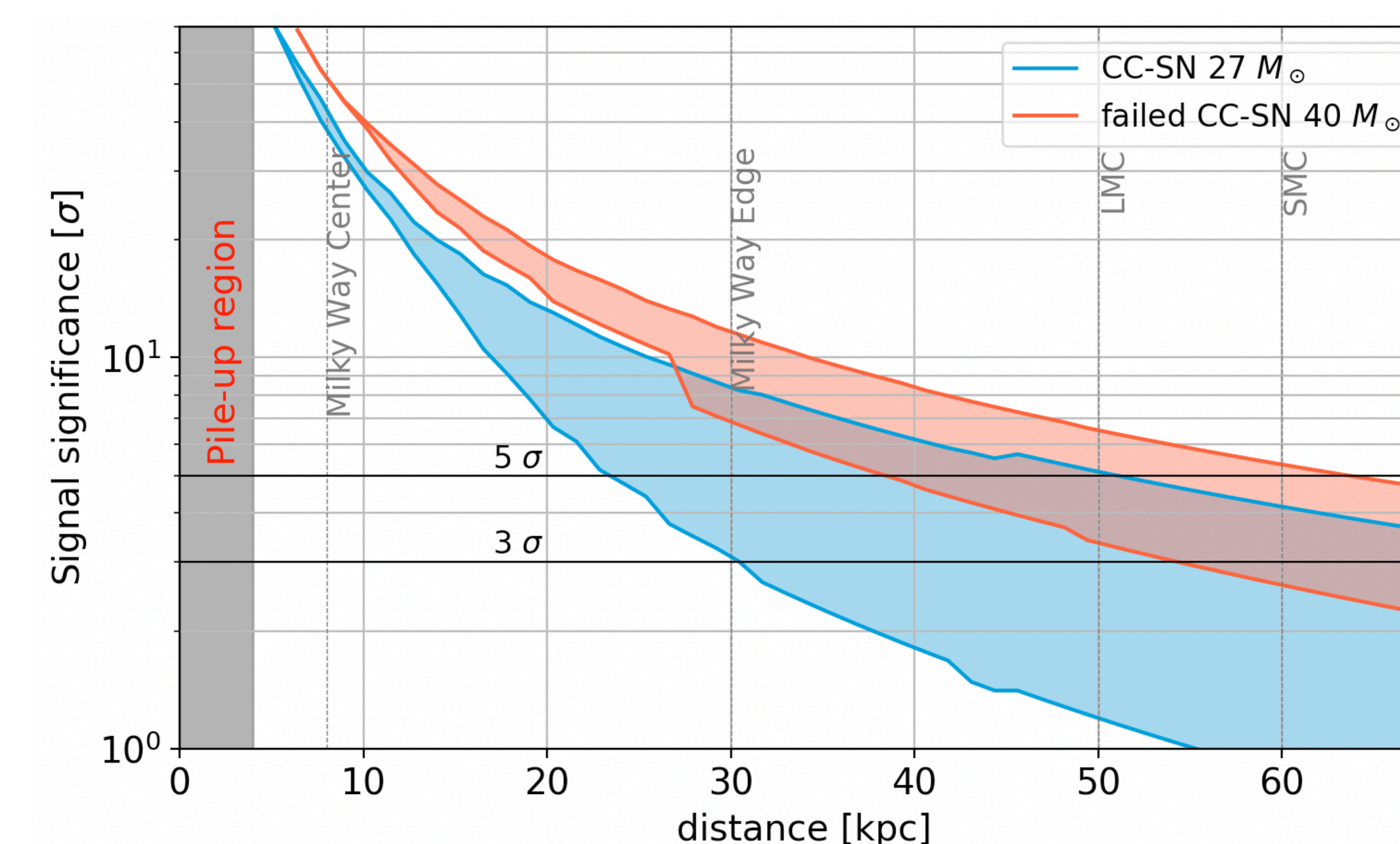
RES-NOVA can be sensitive to SN neutrinos only when archaeological Pb is used as target material.



Such a small scale detector can reach out to the Large Magellanic Cloud, and can clearly identify the SN type, everything while being sensitive to all neutrino flavors.

RES-NOVA sensitivity

RES-NOVA's sensitivity to SN neutrinos can be enhanced when the detector is operated as scintillating cryogenic detector (heat+light read-out)



RES-NOVA with only a total detector volume of $(60 \text{ cm})^3$ can probe the entire Milky Way Galaxy for SN neutrinos with 5σ sensitivity