Solar Neutrino Detection Sensitivity in DARWIN via Electron Scattering

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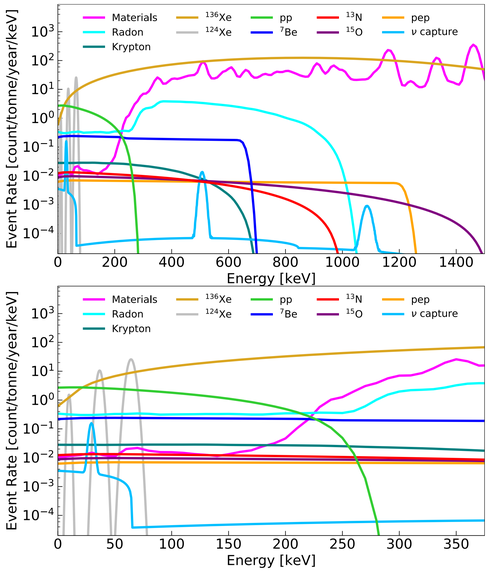
Abstract: We detail the sensitivity of the liquid xenon (LXe) DARWIN observatory to solar neutrinos via elastic electron scattering. We find that DARWIN will have the potential to measure the fluxes of five solar neutrino components: pp, ^{7}Be, ^{13}N, ^{15}O and pep. The precision of the ^{13}N, ^{15}O and pep components is hindered by the double-beta decay of ^{136}Xe and, thus, would benefit from a depleted target. A high-statistics observation of pp neutrinos would allow us to infer the values of the weak mixing angle, $\sin^2\theta_w$, and the electron-type neutrino survival probability, P_e, in the electron recoil energy region from a few keV up to 200 keV for the first time, with relative precision of 5% and 4%, respectively, at an exposure of 300 ty. An observation of pp and ^{7}Be neutrinos would constrain the neutrino-inferred solar luminosity down to 0.2%. A combination of all flux measurements would distinguish between the high (GS98) and low metallicity (AGS09) solar models with 2.1-2.5σ significance, independent of external measurements from other experiments or a measurement of ^{8}B neutrinos through coherent elastic neutrino-nucleus scattering in DARWIN. Finally, we demonstrate that with a depleted target DARWIN may be sensitive to the neutrino capture process of ^{131}Xe.



proton-proton chain

$p + p \rightarrow d + e^+ + \nu_e$

$^{7}Be + e^- \rightarrow {}^{7}Li + \nu_e$

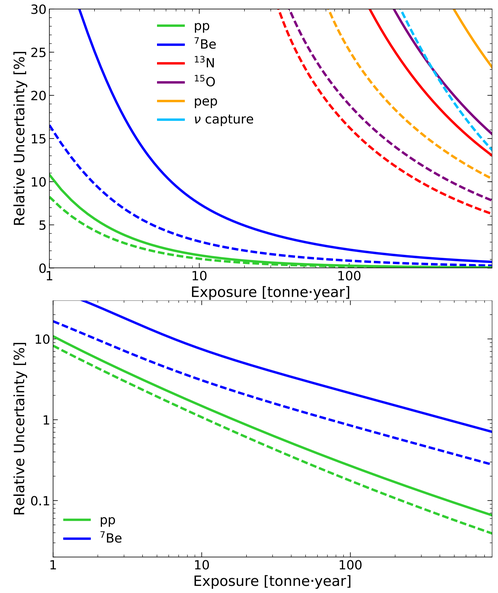
$p + e^- + p \rightarrow {}^{2}H + \nu_e$

CNO cycle

$^{13}N \rightarrow {}^{13}C + e^+ + \nu_e$

$^{15}O \rightarrow {}^{15}N + e^+ + \nu_e$

Backgrounds: ^{222}Rn, ^{136}Xe, ^{124}Xe, ^{85}Kr, materials



Flux Sensitivity

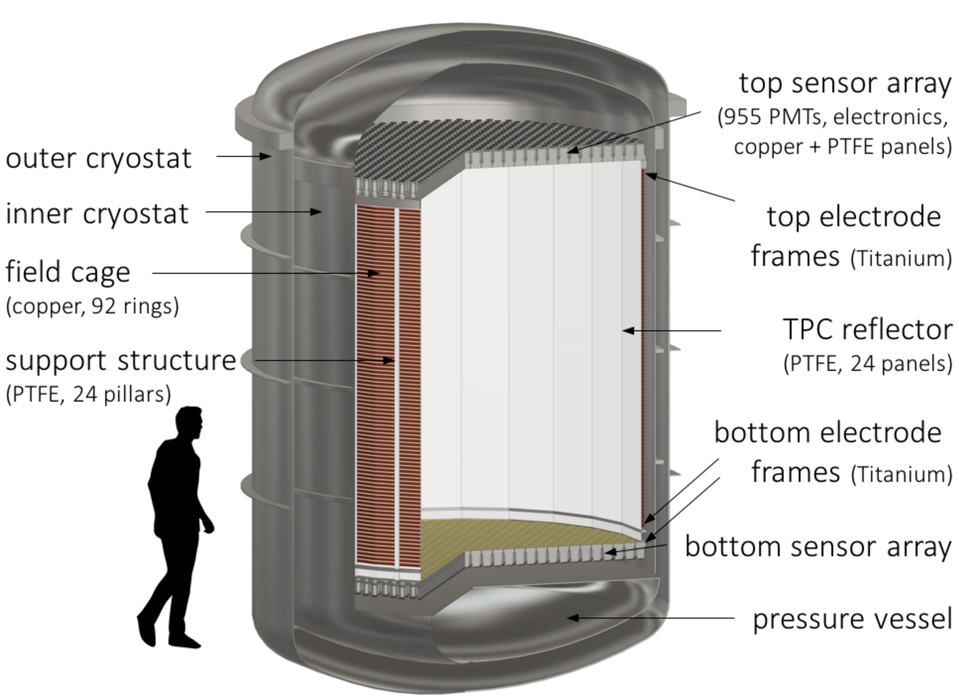
Natural target

pp ~ 0.15% **^{7}Be** ~ 1.2%
^{13}N ~ 20% **^{15}O** ~ 25%

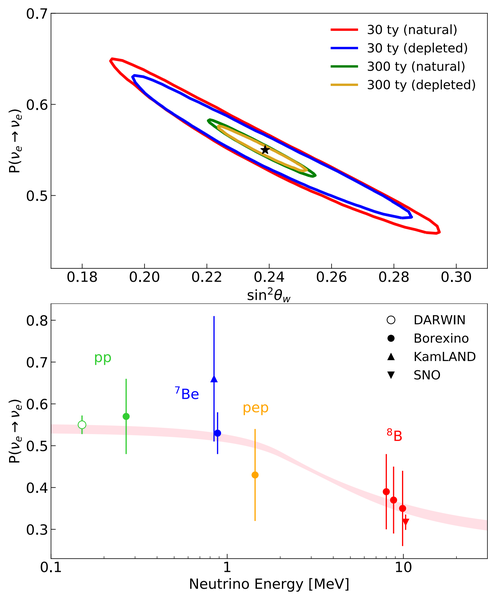
Depleted target

pp ~ 0.08% **^{7}Be** ~ 0.5%
^{13}N ~ 10% **^{15}O** ~ 12%
pep ~ 15.7%

ν capture (^{131}Xe)



The DARWIN Observatory



Electroweak Parameters

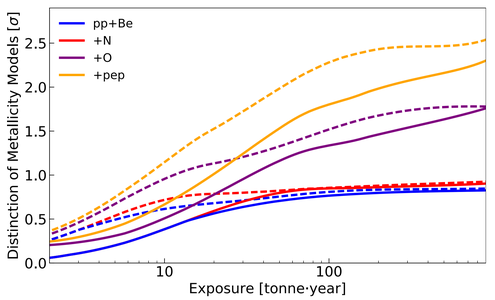
Weak Mixing Angle

4-5%

Electron-type Survival Probability

3-4%

Unprobed energy region
[1,200] keV



Solar Metallicity

High Z (GS98)
Low Z (AGS09)

Distinguished @ **2.1-2.5σ**

Reference: DARWIN collaboration, arXiv:2006.03114, submitted to EPJ C