Definition of interaction cross section

Shoot N_p point-like projectiles on

N_T targets of geometric cross-section σ each, spread over the area A:

What is probability for a projectile to hit a target ?

probability $= N_T \, \sigma / A = \sigma \, n_T$ ($n_T = N_T/A$ targets per unit area)

How many hits will happen in total ?

$N_{hits} = N_p \; \sigma \, n_T$ or: $\sigma = N_{hits} \, / \, (n_t \, N_p)$

(only strictly valid for no overlap of individual targets)

or: $N_{hits} = \sigma \; n_T \; N_p$

(1/s) (cm²) (1/cm) (1/s)

σ : interaction cross section

Estimate interaction of cross section of solar neutrinos in Chlorine experiment.

$C_2 Cl_4$ = 24 + 148 = 172 nucleons ≈ 172 u = 2.87×10^{-25} kg

610 t of liquid = 2.13×10^{30} molecules

On average, only 1/4 Cl atoms is a ^{37}Cl in natural occurring Cl

20 neutrons in this ^{37}Cl atom.

20 neutrons from Cl in a C_2Cl_4 molecule.

Only these 20 can make the reaction

$20 \times 2.13 \times 10^{30}$ nucleons = 4.25×10^{31} nucleons

$^{37}_{17}Cl$ 17 Protons, 20 neutrons

$^{35}_{17}Cl$ 17 Protons, 18 neutrons

$^{37}_{18}Ar$ 18 Protons, 19 neutrons

reaction in detector:

$n + \nu_e \longrightarrow p + e^-$

in ^{37}Cl

Davis Experiment: 4.25×10^{31} neutrons in the ^{37}Cl atoms

detection rate: 15 neutrino interactions / month = $15 / 2.6 \times 10^{6}$ s = 5.8×10^{-6} /s

but ≈30% have already decayed in 30 days (when the Ar is flushed out), as τ_{Ar} = 35 days

True rate: 5.8×10^{-6} / s / 0.7 = 8.27×10^{-6} / s

Neutrino flux: 6×10^{10} ν_e / (cm^2 s) from all channels

only 15% goes into Be branch :

only 0.5 (1 of 2) of neutrinos in the Be branch is above threshold

only 0.33 (1 of 3) of neutrinos do not oscillate away.

remaining eligible neutrinos: $N_p = 0.15 \times 10^{10}$ /(cm s)

$$N_{hits} = \sigma \, n_T \, N_p \qquad \sigma = \frac{8.27 \times 10^{-6} \text{ /s}}{4.25 \times 10^{31} \text{ nucleons} \times 0.15 \times 10^{10} \text{ / (cm}^2\text{ s)}}$$

$$\sigma = 1.3 \times 10^{-46} \text{ cm}^2$$

Caveat: Neutrinos come at different energies and are thus interacting with different probability. The higher the energy, the more likely the interaction. Thus, most of the neutrinos detected by the Cl are ^{8}B neutrinos.
Although small, the neutrinos from CNO cycle are detected as well in the Cl detector.

Read this account of John Bahcall, who did the calculations.
http://www.sns.ias.edu/~jnb/Papers/Popular/Scientificamerican69/scientificamerican69.html