# A new limit on diffuse supernova neutrino flux

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# Summary

- Introduction: diffuse supernova neutrino flux
- Present limits
- Improving the limit
- Conclusions

# Diffuse supernova neutrinos

- • There is a diffuse neutrino emitted by past supernovae (Diffuse Supernova Neutrinos Flux, DS$\nu$F)
- • The DS$\nu$ is correlated to various physics, such as supernova model, past supernova rate and neutrino oscillation.

By Constraining the DS$\nu$F, we can probe

$\nu$ oscillation, or the star formation in the universe

- • In this study we will reveal a new limit for DS$\nu$F for electron neutrino type.

# Past supernova rate

We need to compute

$$\frac{d\Phi}{dE} = \left(\frac{c}{H_0}\right) \int R_{SN}(z) \frac{dN_\alpha(E(1+z))}{dE'} \left|\frac{dt}{dz}\right| (1+z)dz$$

where E'=E(1+z).

$$\frac{dN_\alpha(E)}{dE} = \left(\frac{E}{E_w}\right)^{-\alpha_w} e^{-(E/E_w)(1+\alpha_w)}$$

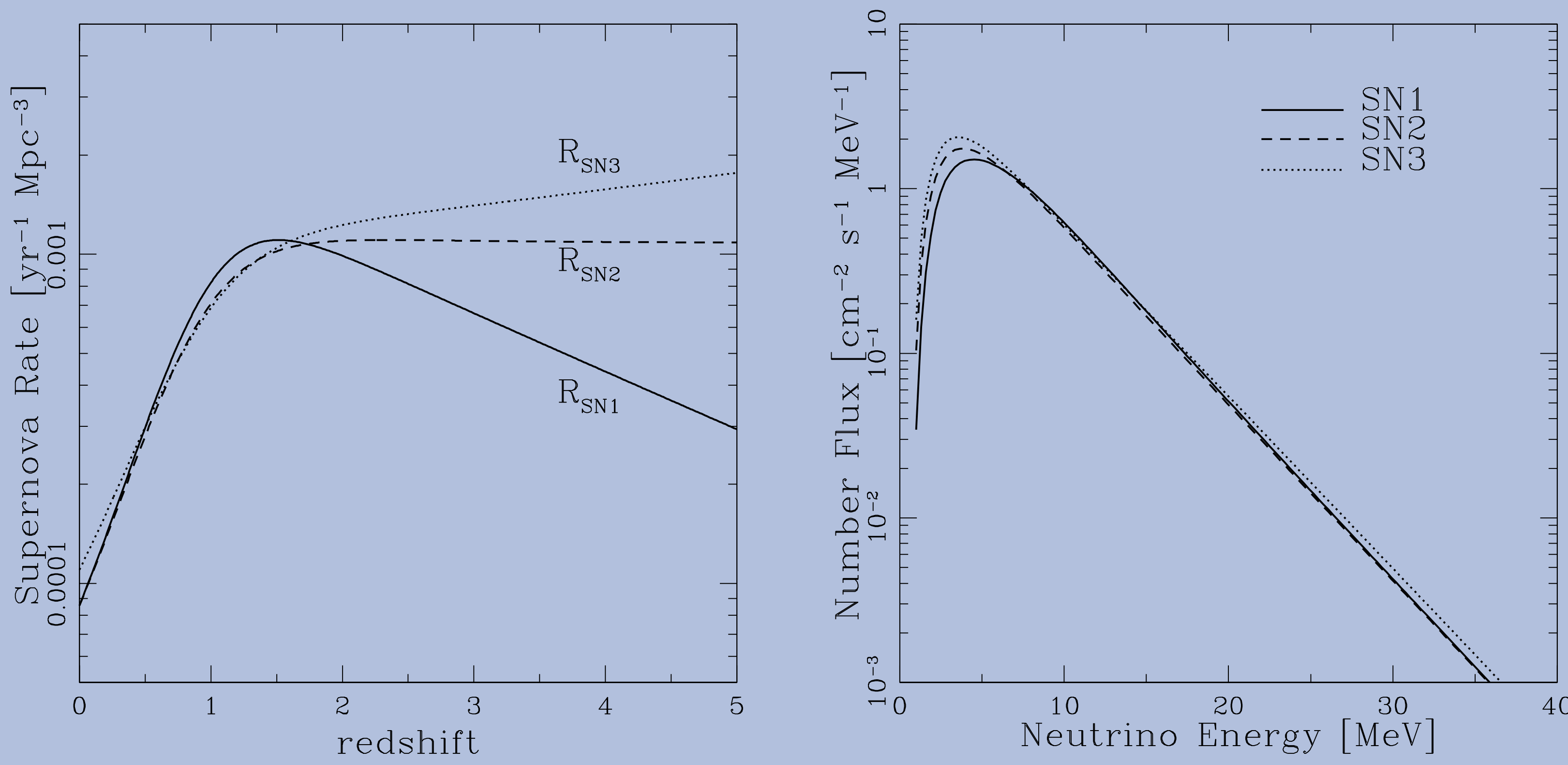
where $E_w$ are the temperature of different $\alpha$ types of neutrinos,

$E_{\nu_e} \sim 9 - 16$ MeV

$E_{\bar{\nu}_e} \sim 12 - 18$ MeV

$E_{\nu_\mu \nu_\tau} \sim 15 - 22$ MeV

# Past supernova rate




Anto,Sato and Totani, Astr. Part. 18, 307(2003).

# Fluxes from past supernovae

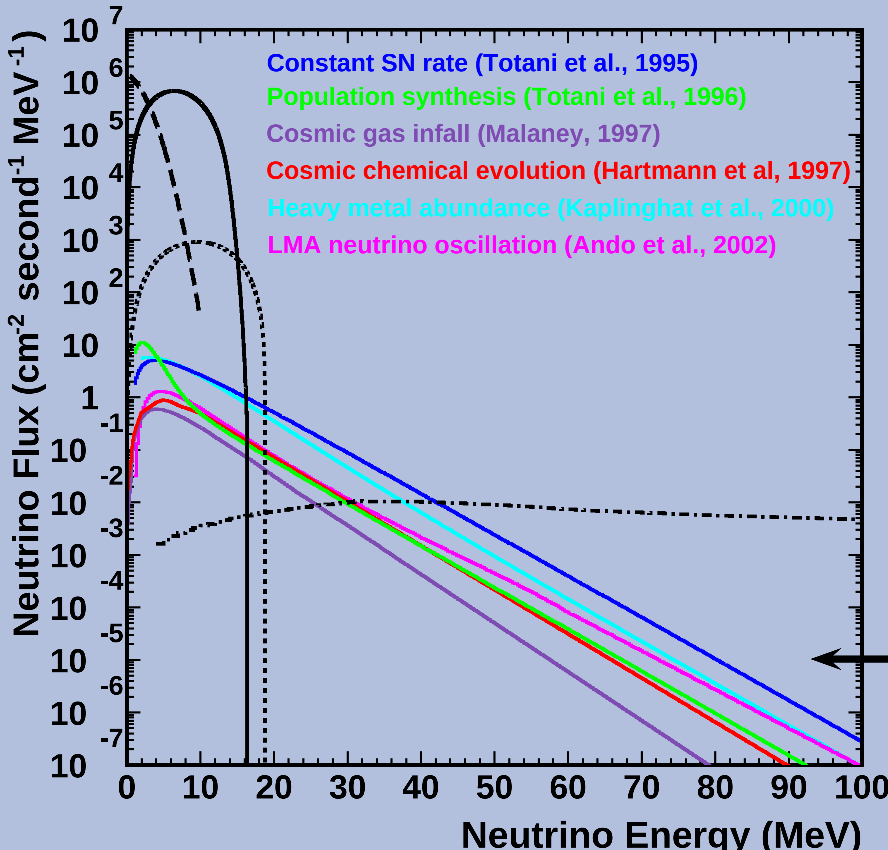
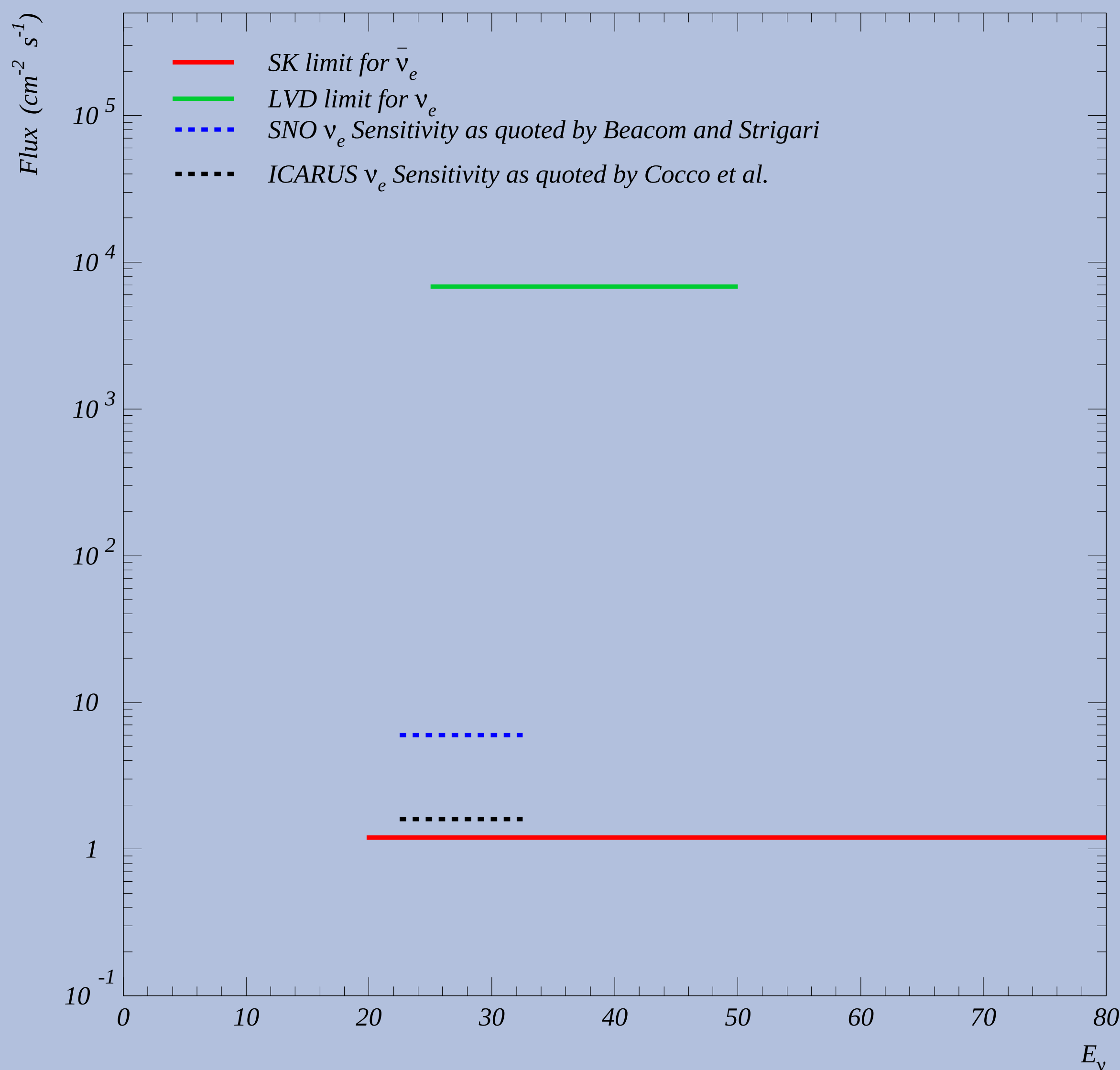



Figure 1.5: The expected SRN flux, calculated from six theoretical models, is presented. The SRN flux predictions are compared to the fluxes from the reactor $\bar{\nu}_e$ (dashed line), the $^8$B solar $\nu_e$ (solid line), the *hep* solar $\nu_e$ (dotted line), and the atmospheric $\bar{\nu}_e$ (dot-dashed line).

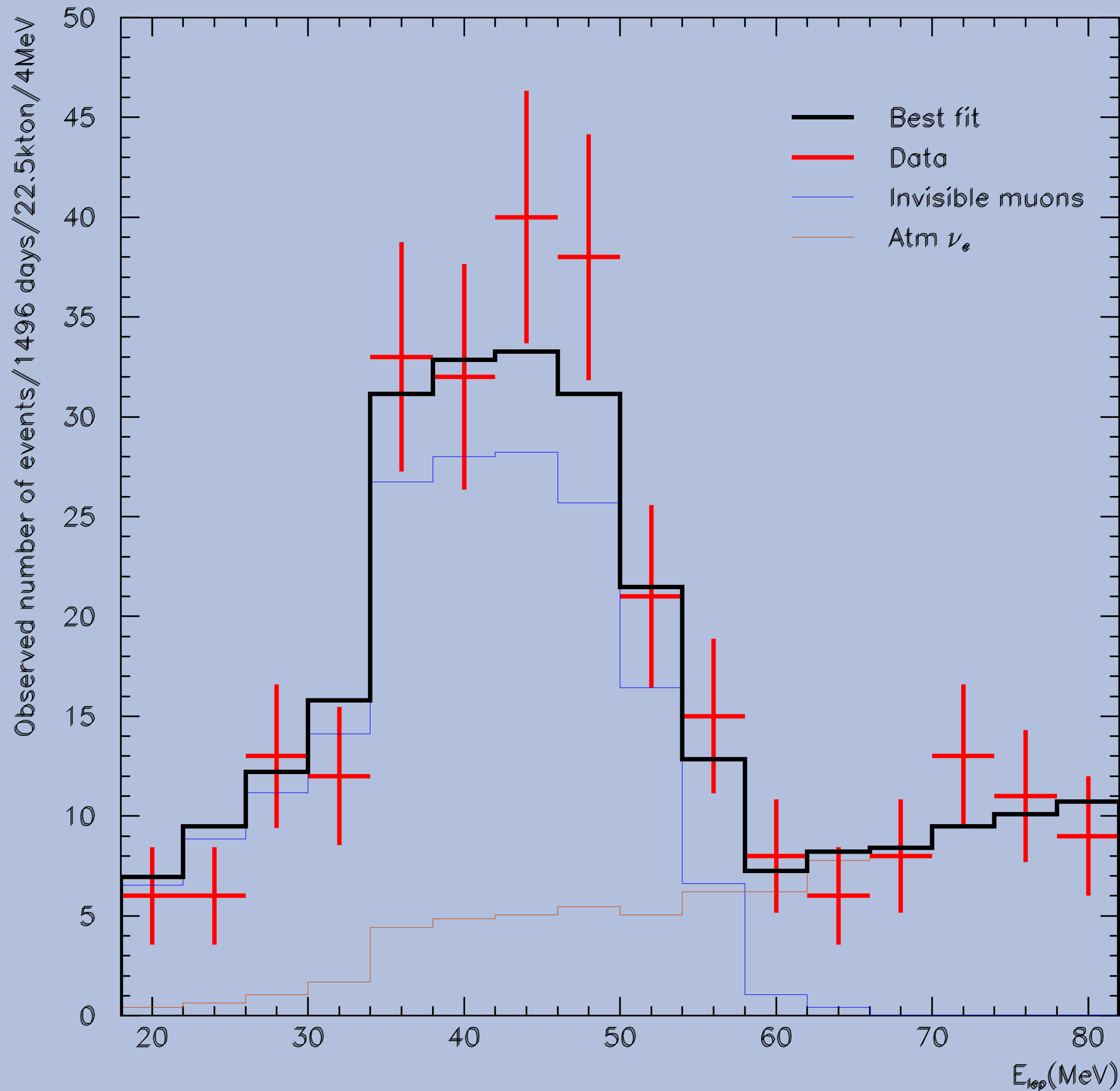
Exponential decay

Fluxes used by Super-Kamiokande experiment.

# Present limits for DS$\nu$F



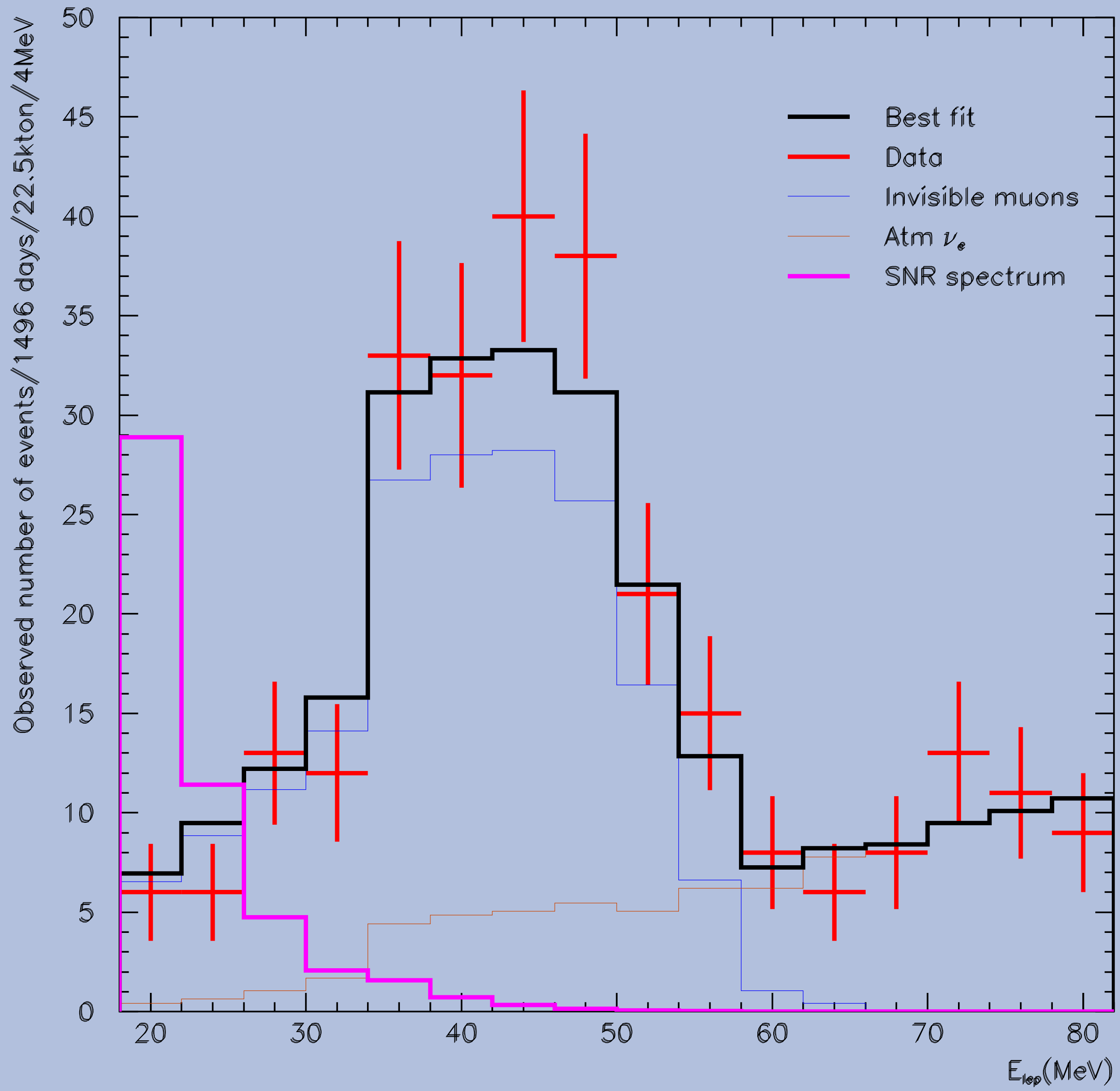
# SK limit for $\bar{\nu}_e$




$\bar{\nu}_e$: $\sigma(\bar{\nu}_e p \to e^+ n)$

no charge ID

# SK limit for $\bar{\nu}_e$



# Analysis of SK data

We need to compute

$$\chi^2 = \Sigma_{l=1}^{16} \frac{\left(-N_l^{data} + \alpha A_l + \beta B_l + \gamma C_l\right)^2}{(\sigma_l^{data})^2 + \sigma_{sys}^2}$$

As show before for high energy, ($E_\nu > 19.8$ MeV) we can parametrize the supernova spectrum by

$$\Phi(E_\nu) = \Phi_0 e^{-E_\nu/E_o},$$

where $E_0$ is the slope.

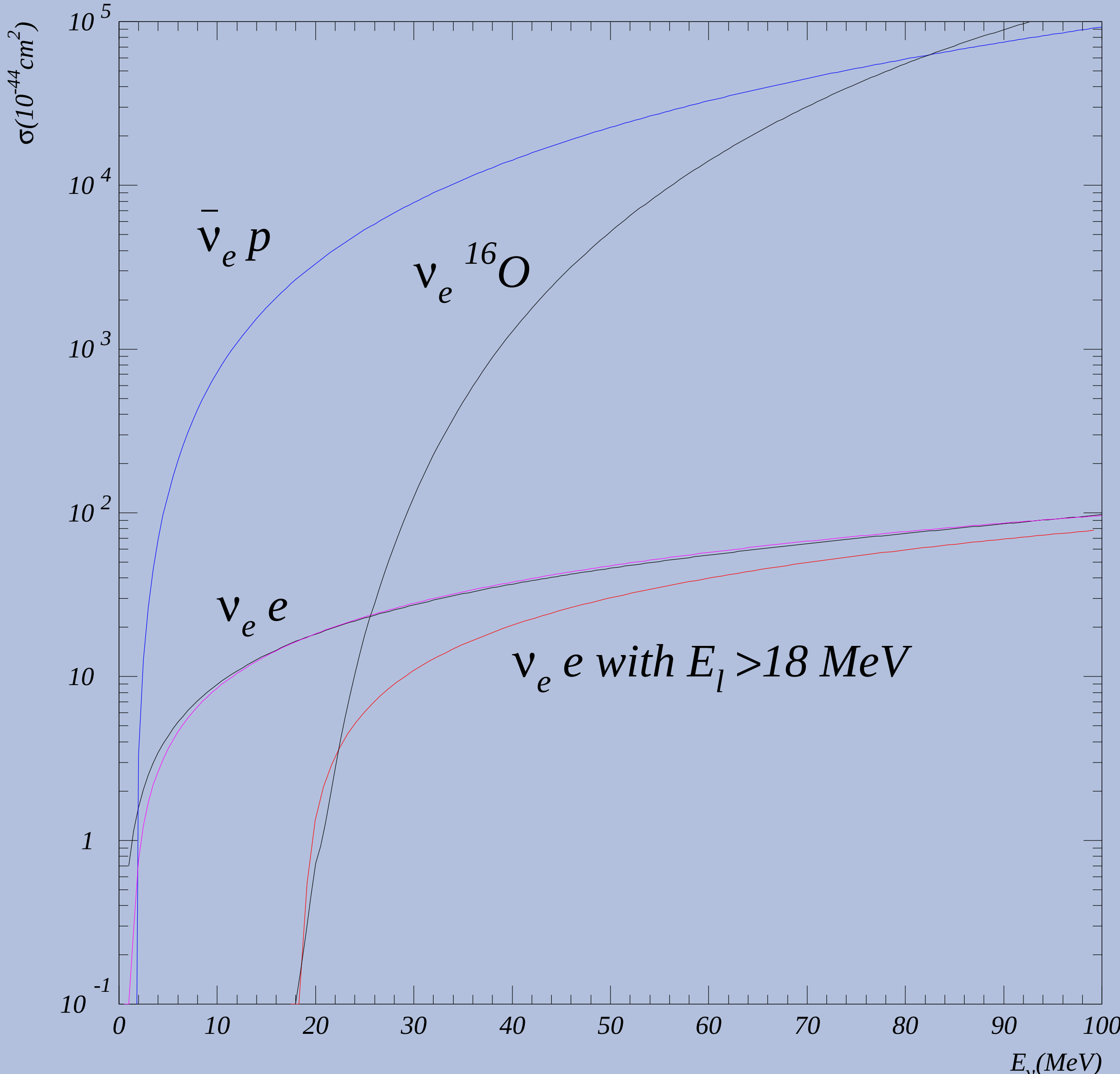
# Typical values for $E_0$

| *Model* | $E_0$ |
|---|---|
| LMA | $5.68$ |
| Pop. synthesis | $5.35$ |
| Cons. SN rate | $5.62$ |
| Lunardini | $4-7$ |
| Fukujita-Kawasaki | $3.76-5.81$ |
| Beacom-Strigari | $4.05-8.5$ |
| Ando et al | $3.88-5.19$ |

# SK limits for $\bar{\nu}_e$ DSNF

| $E_0$ | $\alpha_{max}$ | Flux limit$(s^{-2}s^{-1})$ |
|---|---|---|
| 3.5 | 4.95 | 1.17 |
| 5.35 | 7.00 | 1.20 |
| 5.5 | 7.31 | 1.31 |
| 7.5 | 11.40 | 1.55 |
| 8.5 | 14.16 | 1.70 |

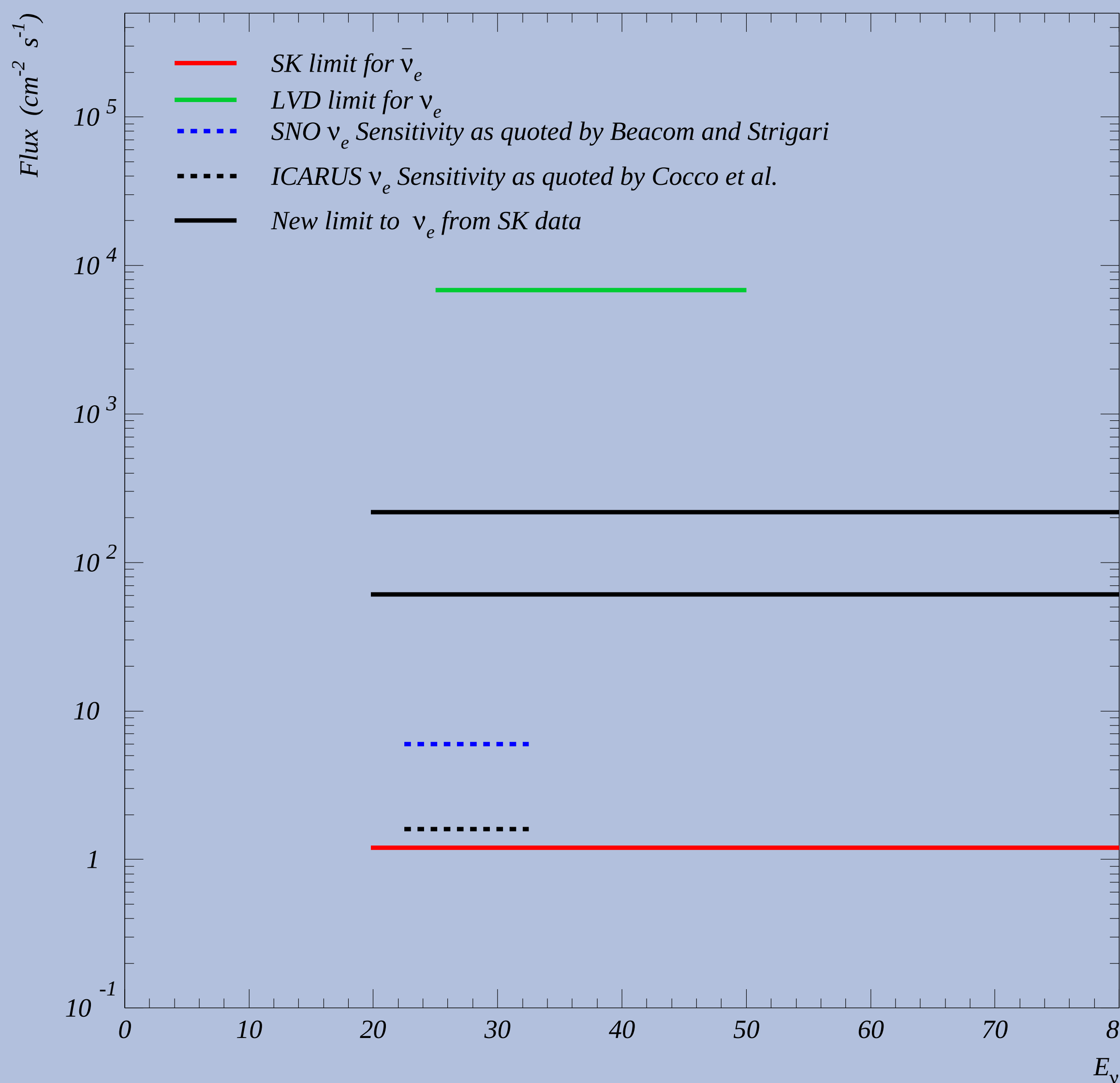
# X-section for supernova neutrino



# SK limits for $\nu_e$ DSNF

| $E_0$ | $\alpha_{max}$ | Flux limit$(s^{-2}s^{-1})$ |
|---|---|---|
| 3.5 | 4.65 | 217.80 |
| 3.8 | 4.90 | 190.25 |
| 5.5 | 8.05 | 102.07 |
| 7.5 | 17.60 | 71.56 |
| 8.5 | 23.60 | 60.75 |

# New limits for DS$\nu$F



# Conclusions

- Using the avaliable data from SK, we analyze the effect on changing the slope of the high energy part of supernova spectrum;
- We have found that the $\bar{\nu}_e$ flux limit, is from $\Phi^{\max}_{\bar{\nu}_e} < 1.2 - 1.68$ cm$^{-2}s^{-1}$.
- • We have found a new limit for the diffuse supernova electron neutrino flux, the limit is improved by a factor of 30-100: $\Phi^{\max}_{\nu_e} < 60 - 200$ cm$^{-2}s^{-1}$.