Supernova Neutrinos in LENA: SNoWGLoBES and νp Elastic Scattering

LENA Working Group Meeting

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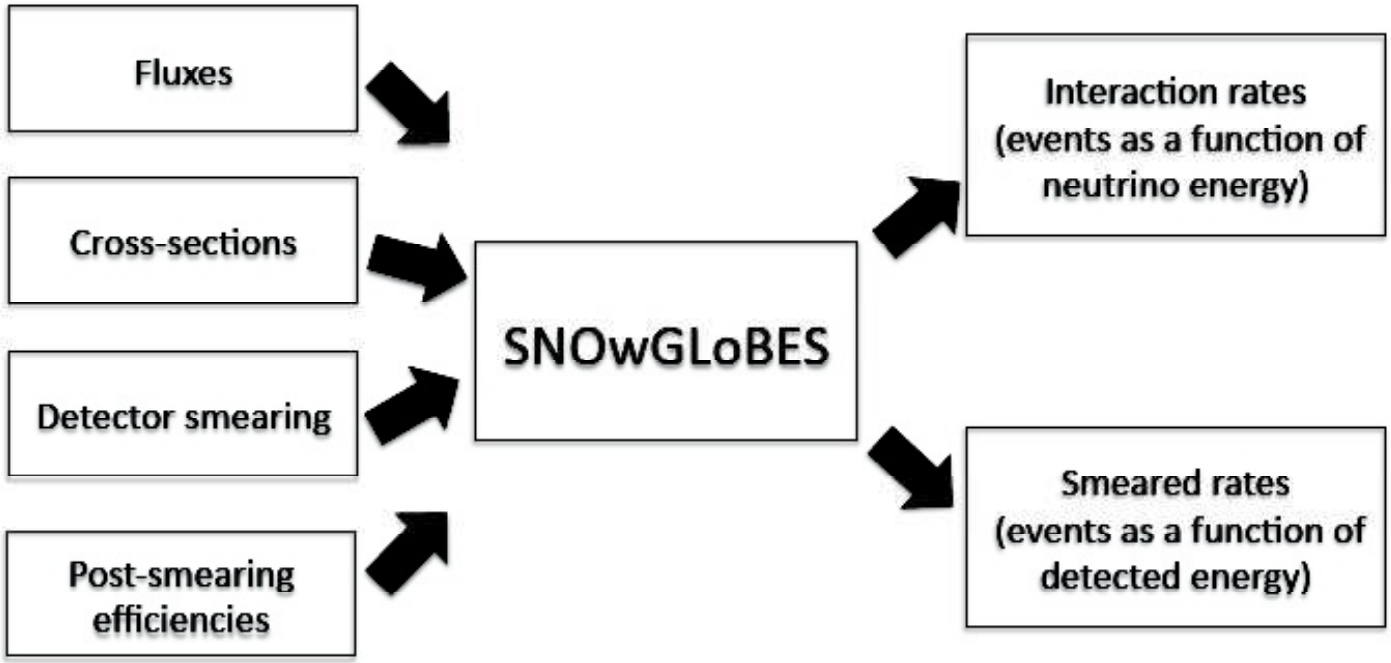
My Work

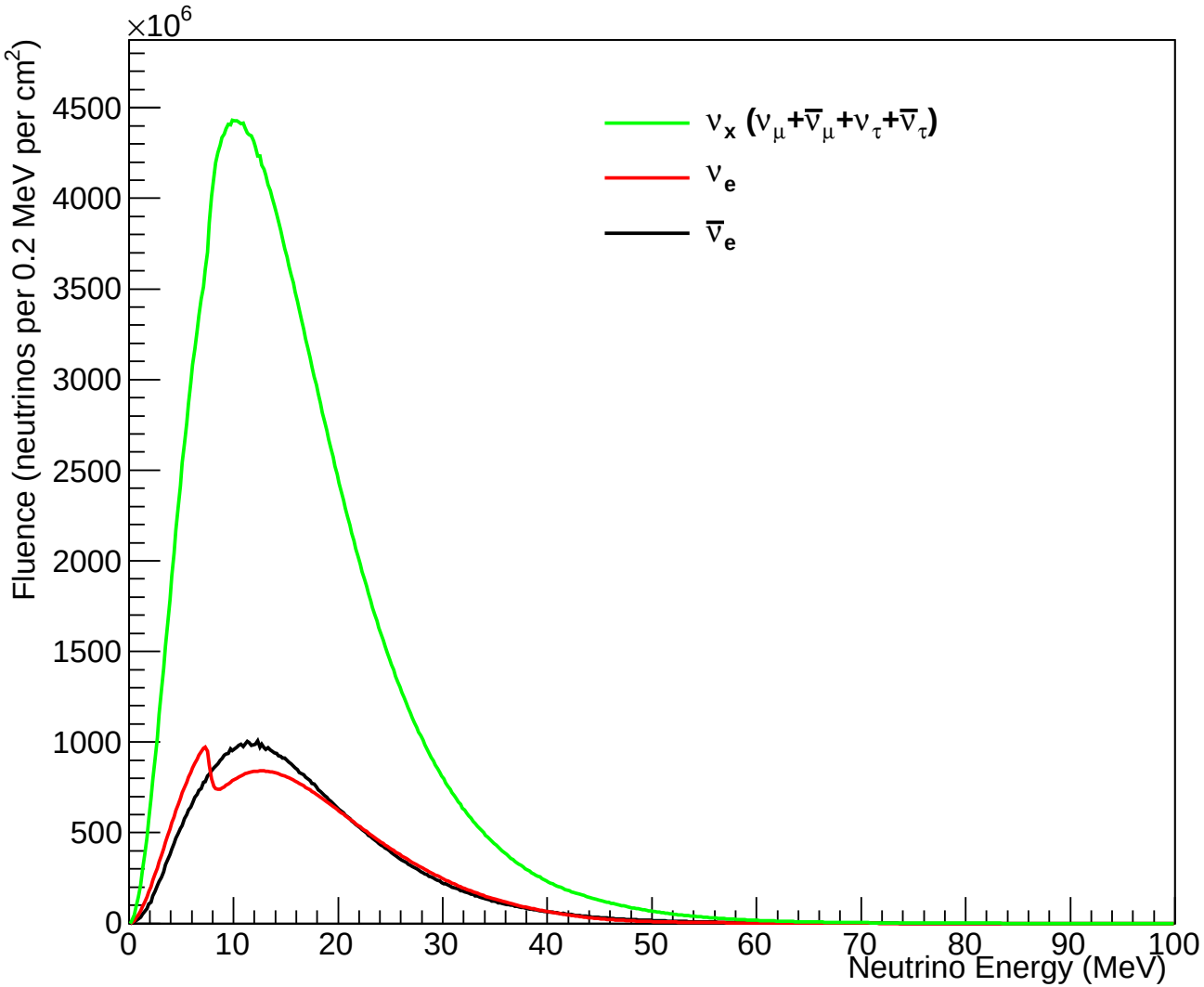
- **Thesis** for bachelor of science diploma
- **Main goal:** Time resolvend analysis of SN neutrino signal in LENA
  - Use and extend SNoWGLoBES
  - Include neutrino-proton elastic scattering channel
- **Motivation:**
  - How are νp spectra shaped in LENA?
  - What impact have different flux models on the νp signal in LENA?
  - How is the SN neutrino signal changing in time (during burst)?
  - What is the maxiumum trigger rate for SN neutrinos?

SNOwGLoBES

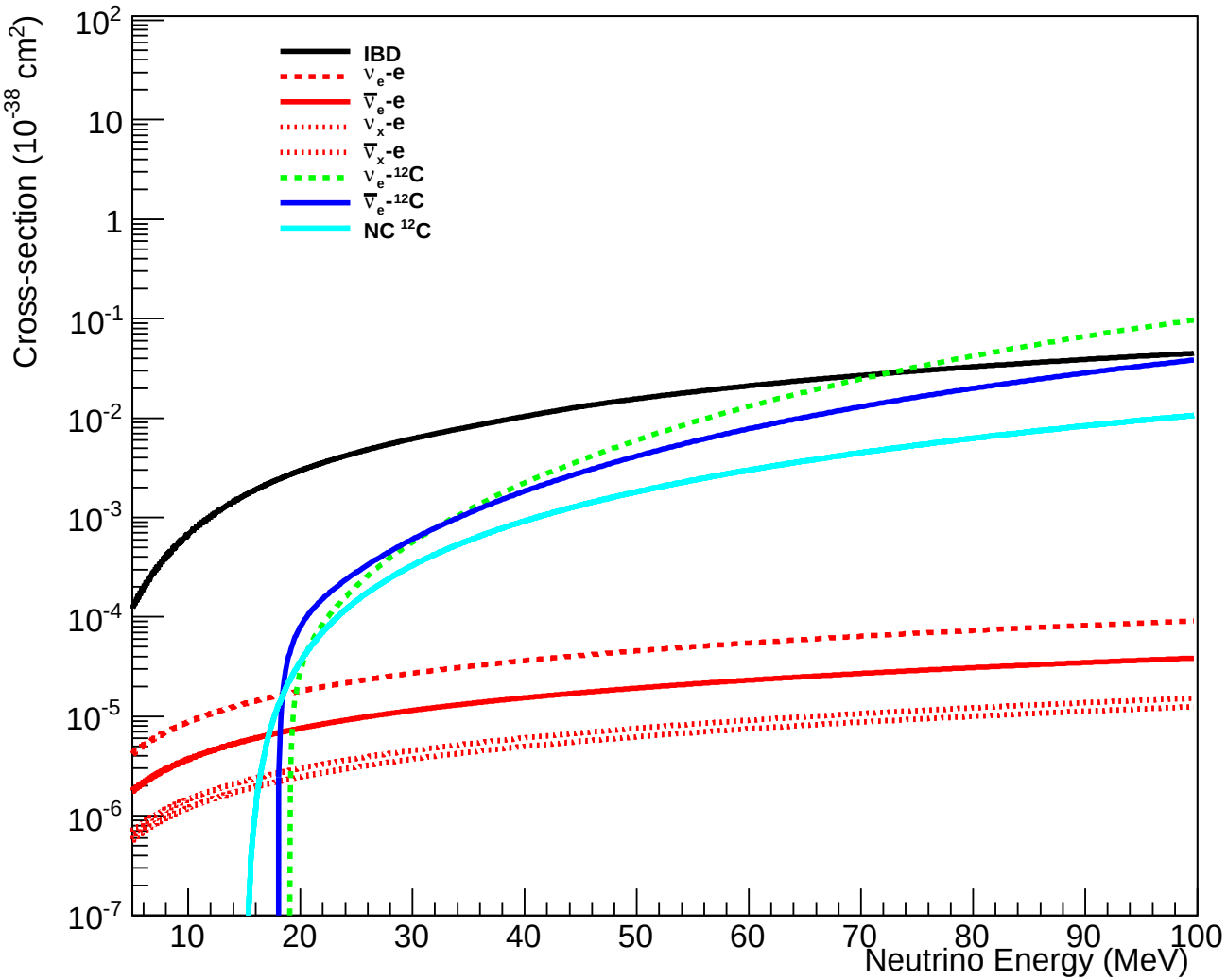
- Add-On for GLoBES
- Main Goal: Computing **interaction rates** and **visible energy spectra**



SNOwGLoBES: GVKM Model for Flux

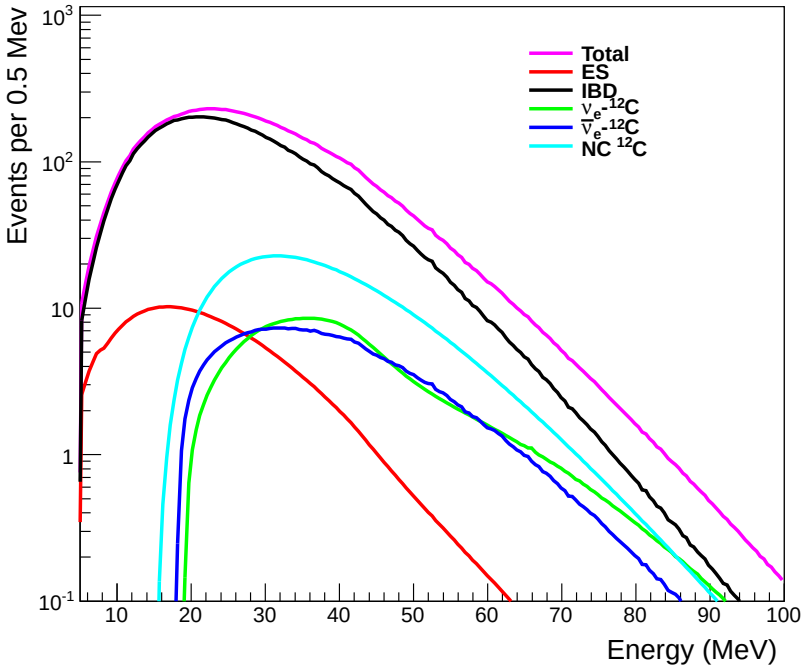


SNOwGLoBES: Cross-Sections in Scintillator

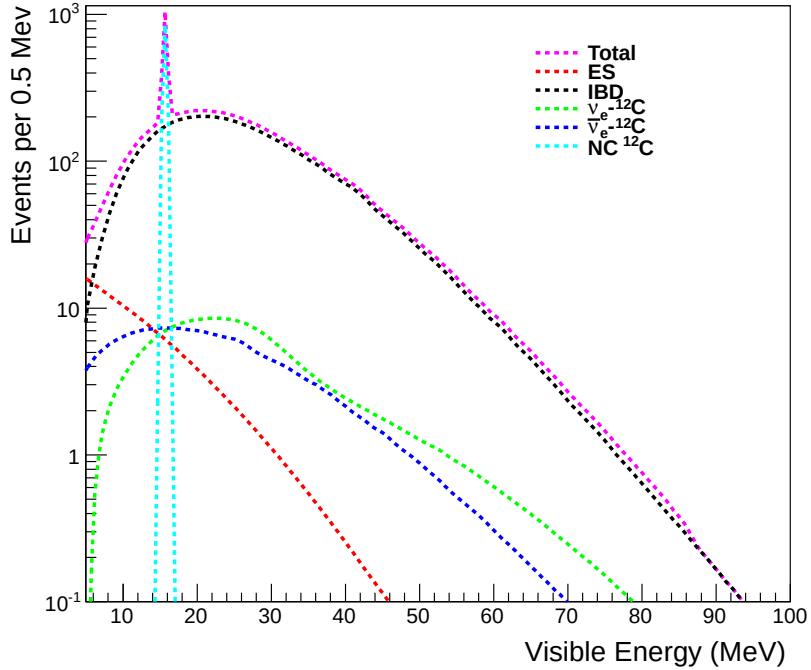


SNOwGLoBES: Event Rates in 50kton Scintillator

- Interaction rates as function of **neutrino energy**



- Interaction rates as function of **visible event energy**

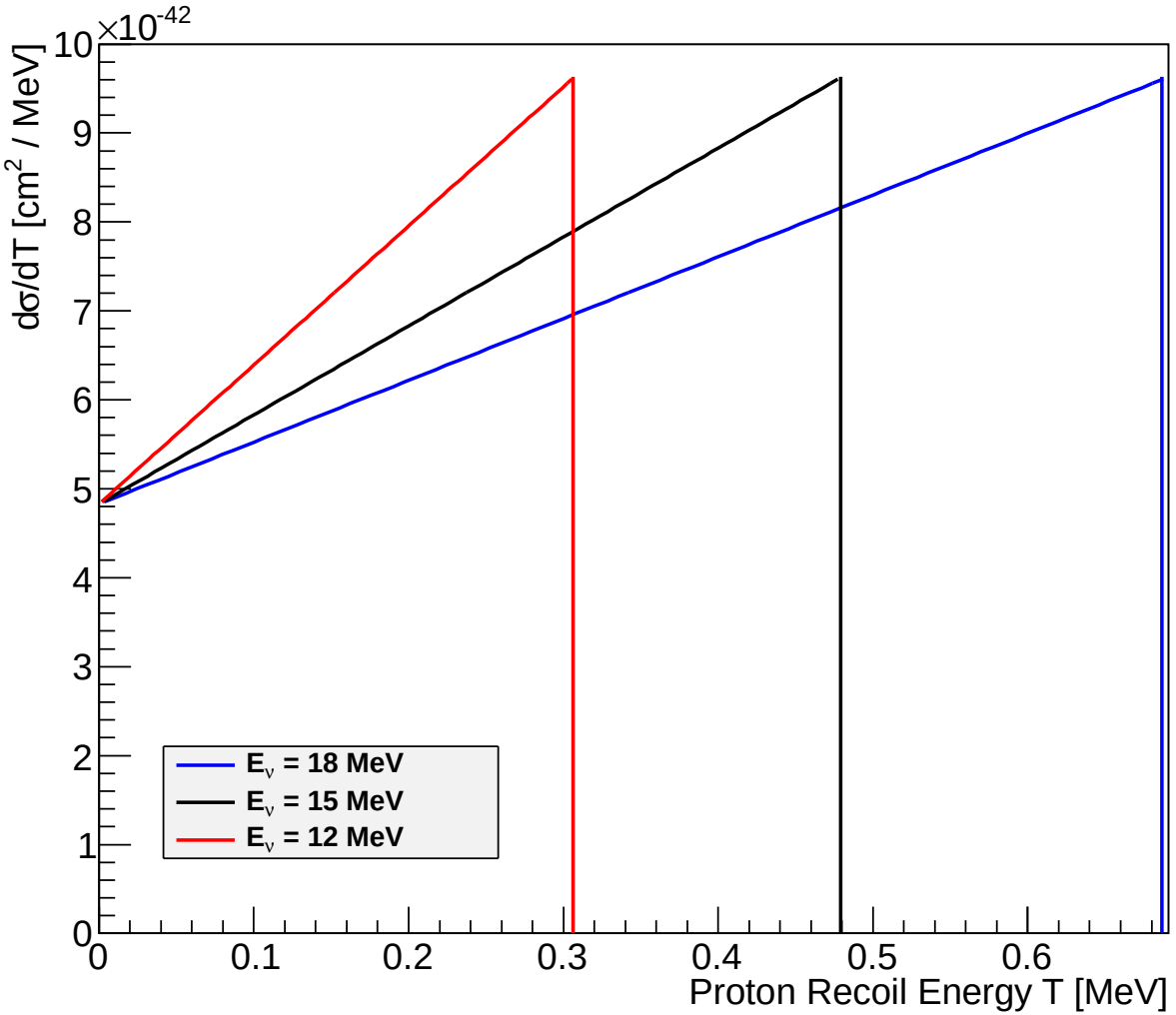


Elastic Proton-Neutrino Scattering

- Neutral current reaction
- Second highest statistics in LENA (after IBD with $\approx 10^4$ Events)
- Very sensitve to energy threshold due to small energy transfer + quenching:
  - Neutrino Energy $\mathbf{E}_\nu \rightarrow$ Proton Recoil Energy **T** $\rightarrow$ Visible Energy **T'**
- Mainly ν_μ, $\bar{\nu}_\mu$, ν_τ, $\bar{\nu}_\tau$ (ν_x) are contributing
  - Information on ν_x Flux
- LENA: Threshold determined by $^{14}\mathrm{C}$ Backgound $\approx$ 200keV

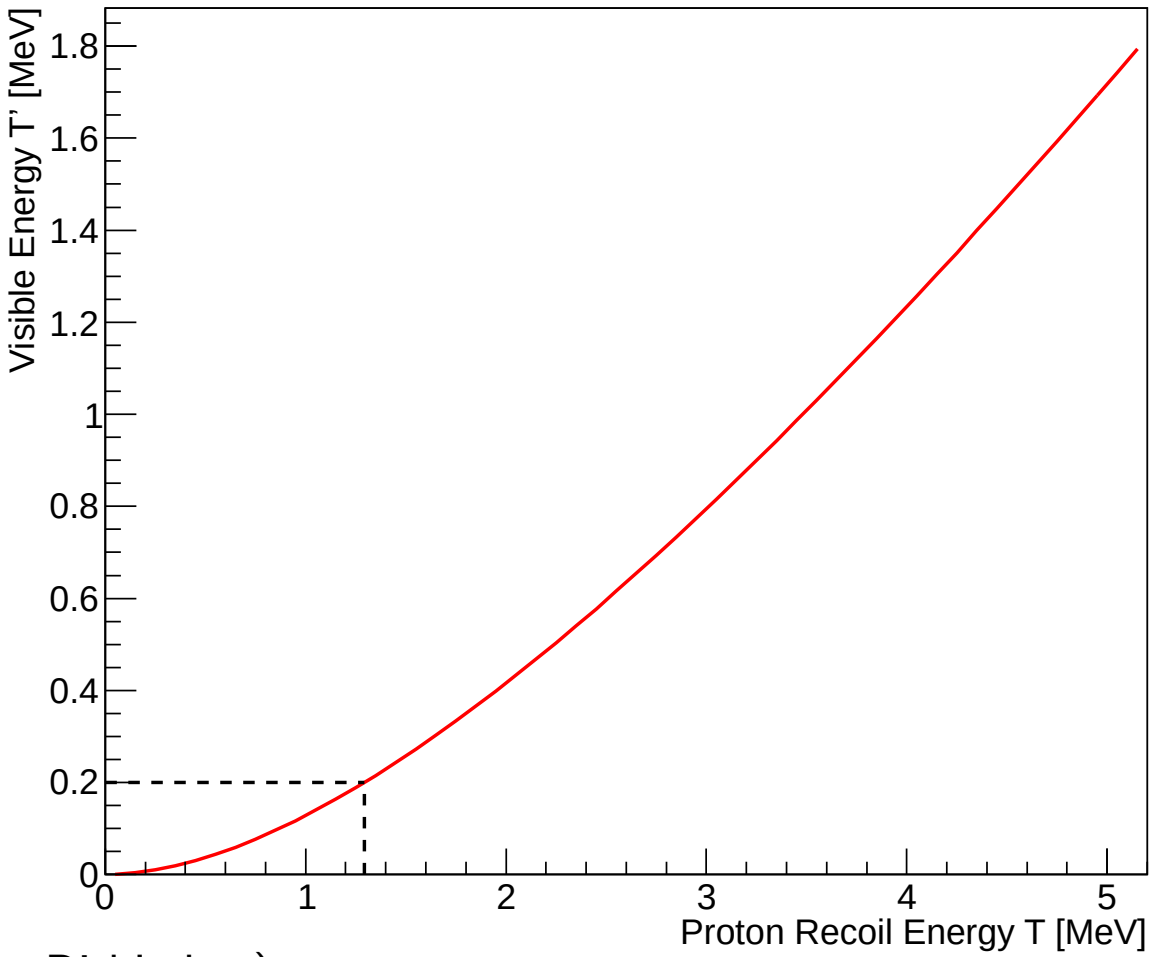
Proton Recoil Spectrum

Neutrino Energy $\mathbf{E}_\nu \rightarrow$ Proton Recoil Energy $\mathbf{T}$



Quenching

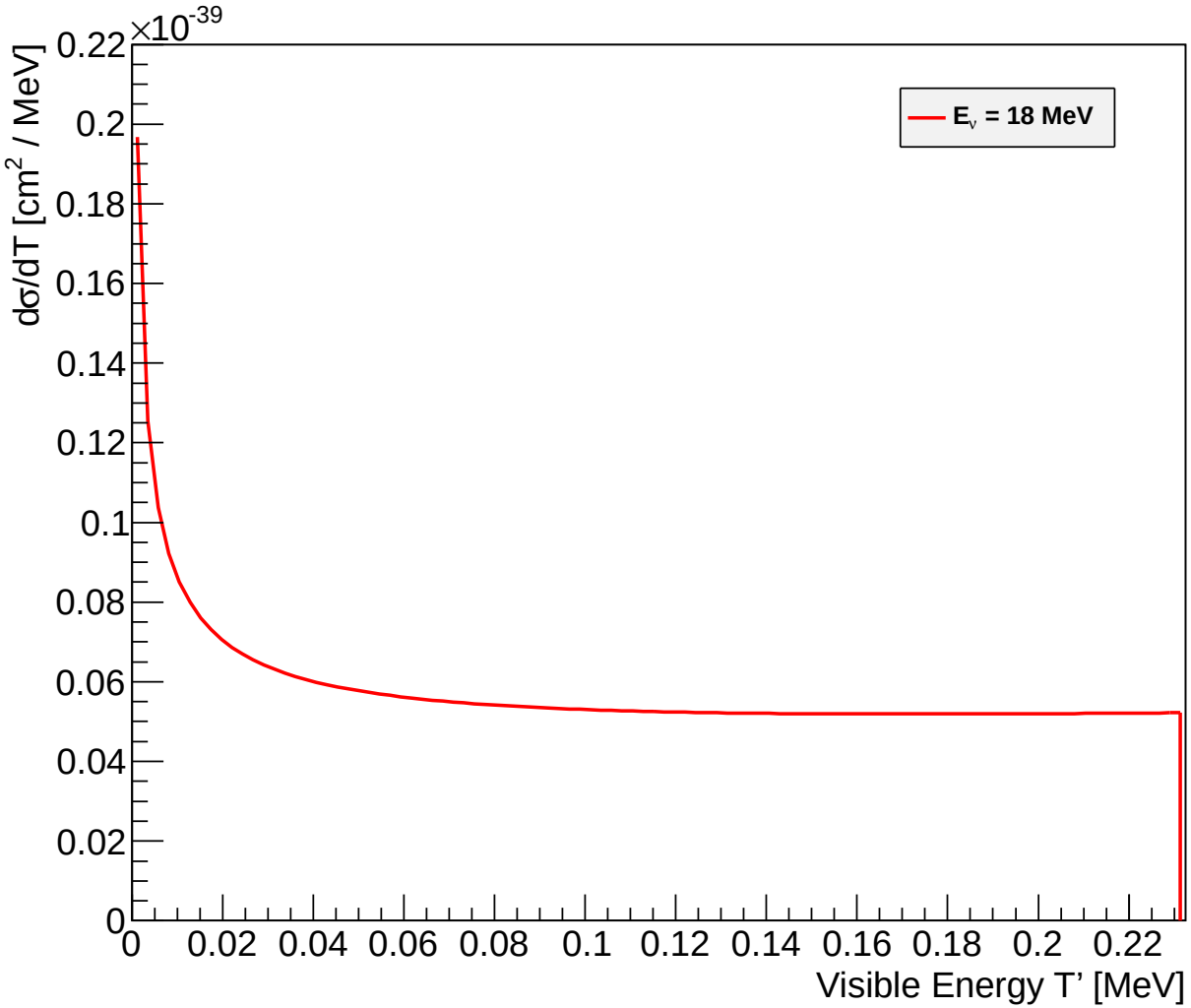
Proton Recoil Energy **T** $\rightarrow$ Visible Energy **T'**



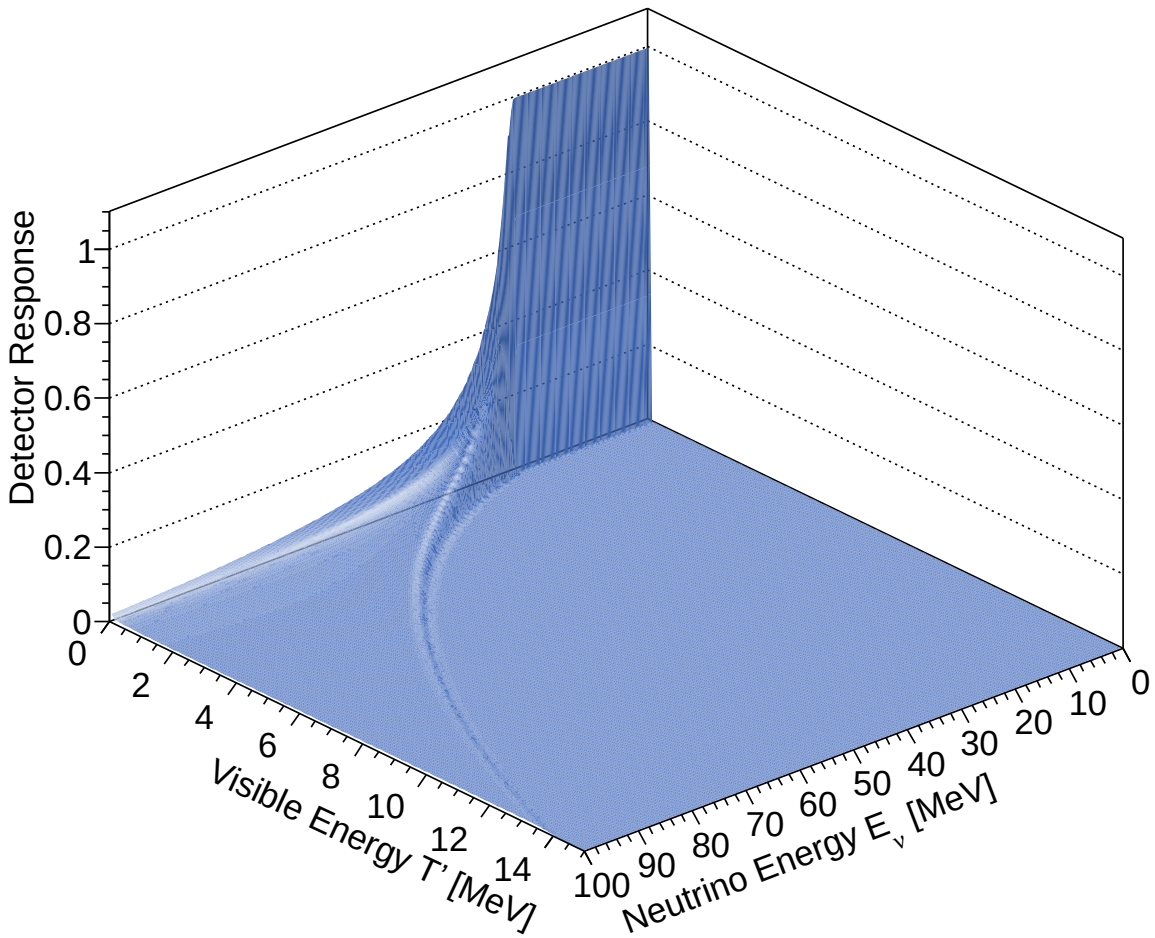
(according to Birk's law)

Quenched Recoil Spectrum

Neutrino Energy $\mathbf{E}_\nu \rightarrow$ Proton Recoil Energy $\mathbf{T} \rightarrow$ Visible Energy **T'**

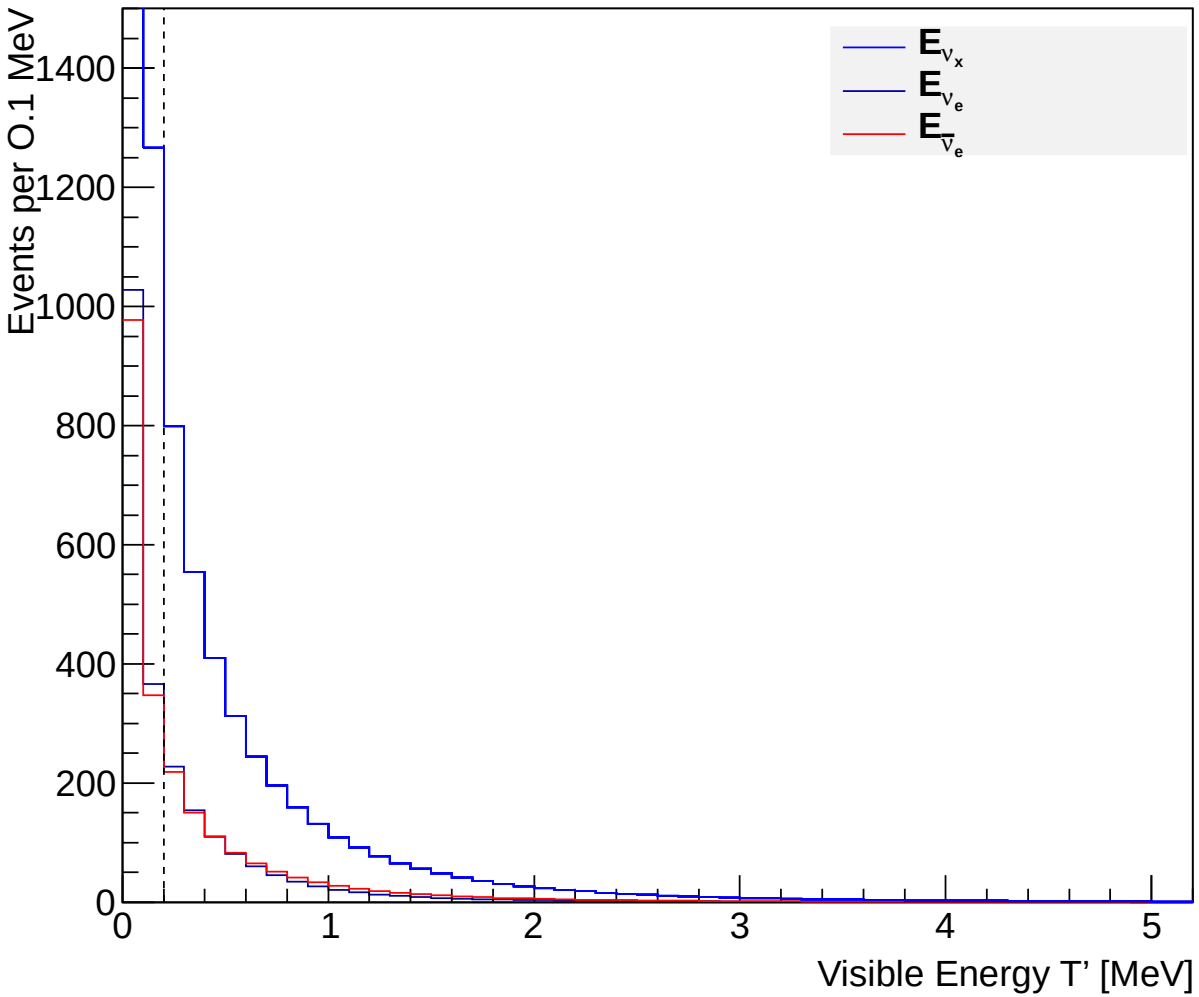


Detector Response



- Detector response = quenched recoil spectrum + energy resolution

Proton Recoil Spectrum – GVKM Supernova Model

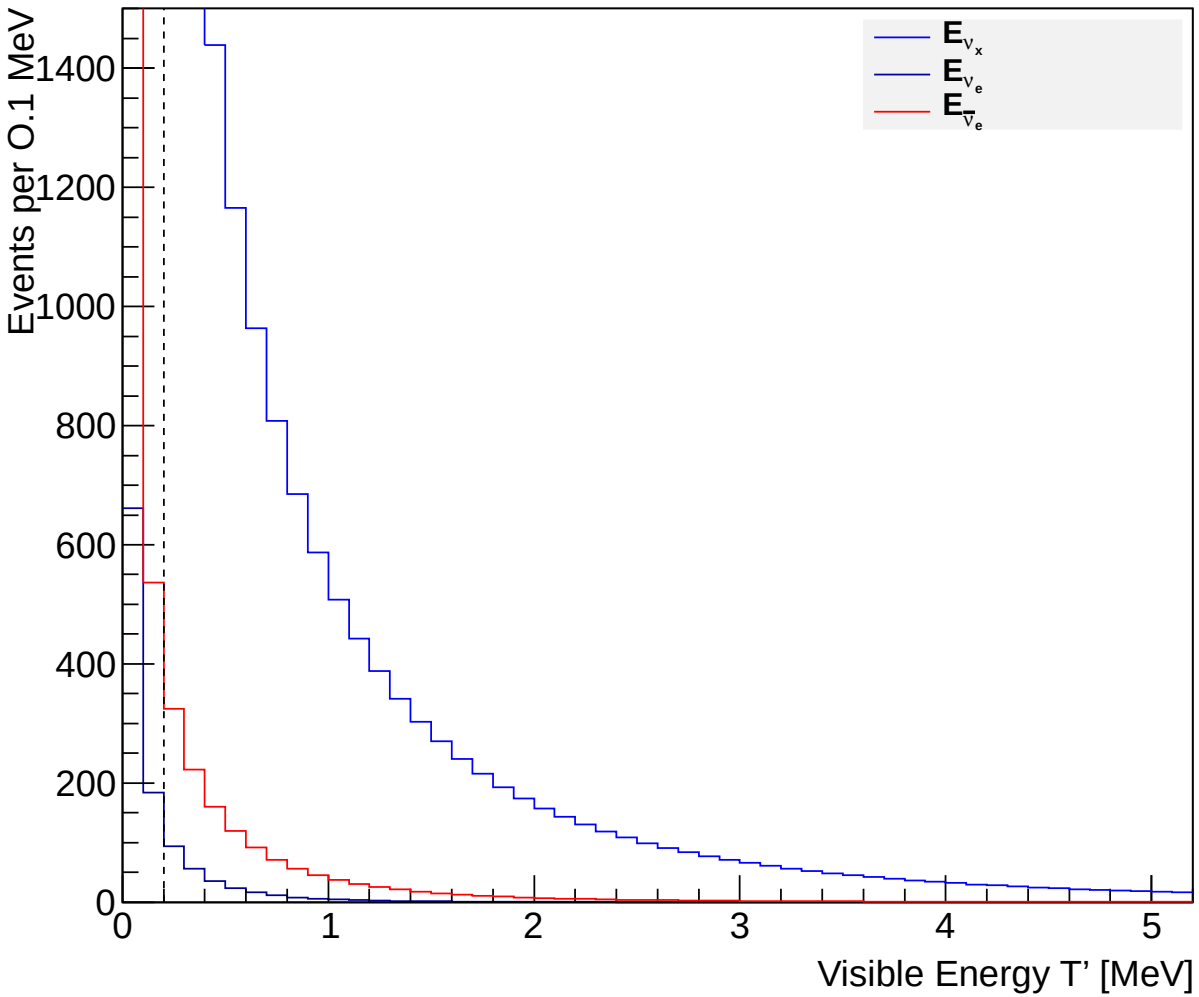


- $\langle E_{\nu_x} \rangle = 18\text{MeV}$
- $\langle E_{\bar{\nu}_e} \rangle = 15\text{MeV}$
- $\langle E_{\nu_e} \rangle = 12\text{MeV}$

Events:

- $N_{\nu_x} \approx 3610$
- $N_{\bar{\nu}_e} \approx 870$
- $N_{\nu_e} \approx 940$
- $N_{total} \approx 5420$

Proton Recoil Spectrum – Livermore Supernova Model



- $\langle E_{\nu_x} \rangle = 21.6\text{MeV}$
- $\langle E_{\bar{\nu}_e} \rangle = 15.4\text{MeV}$
- $\langle E_{\nu_e} \rangle = 12.0\text{MeV}$

Events:

- $N_{\nu_x} \approx 15100$
- $N_{\bar{\nu}_e} \approx 270$
- $N_{\nu_e} \approx 1340$
- $N_{total} \approx 16710$

Conclusion and Outlook

- Large sensitivity on mean neutrino energy
- νp-channel allows to measure ν_x Flux and Spectra
- Exact value of threshold is important for rate!

- **Outlook:**
  - Include νp-channel in SNoWGLoBES
  - Create time dependent rates and spectra in SNoWGLoBES

Thanks for your attention!