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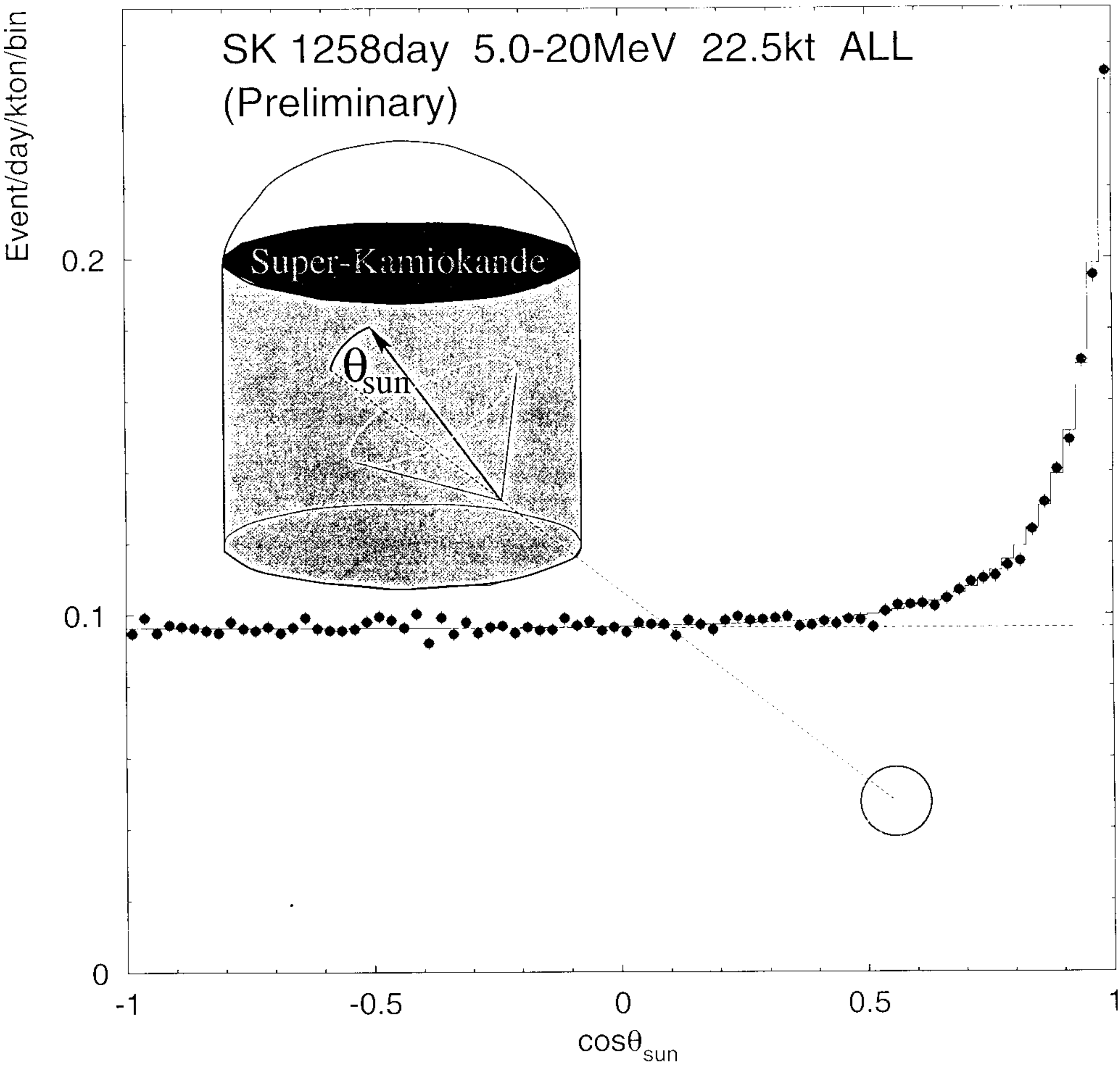
Solar Peak >5 MeV



SK reached its design threshold!

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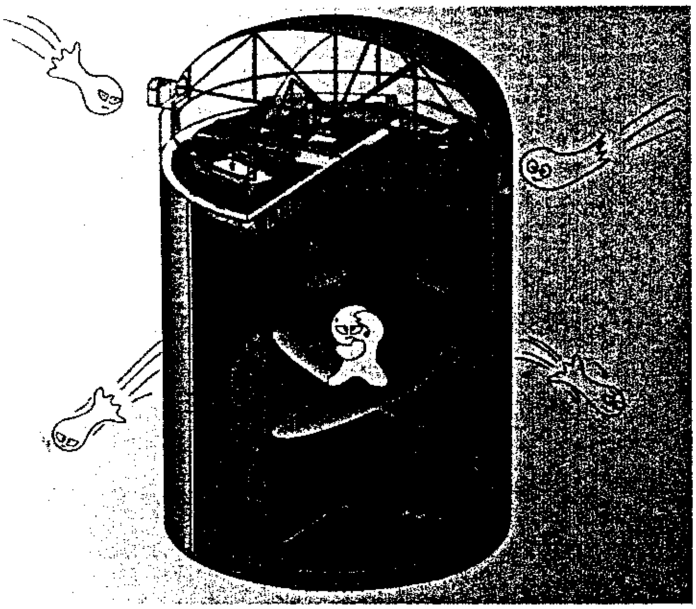
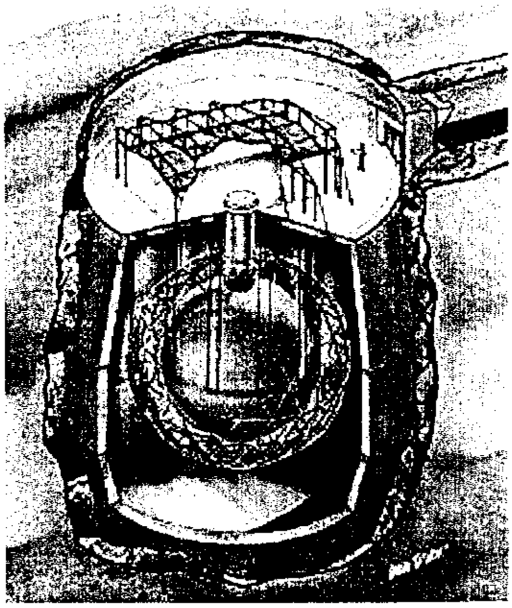
Super-Kamiokande Zenith-Spectrum & SNO CC Rate





International Workshop on Neutrino Oscillations in Venice, July 24, 2001

Michael B. Smy, UC Irvine

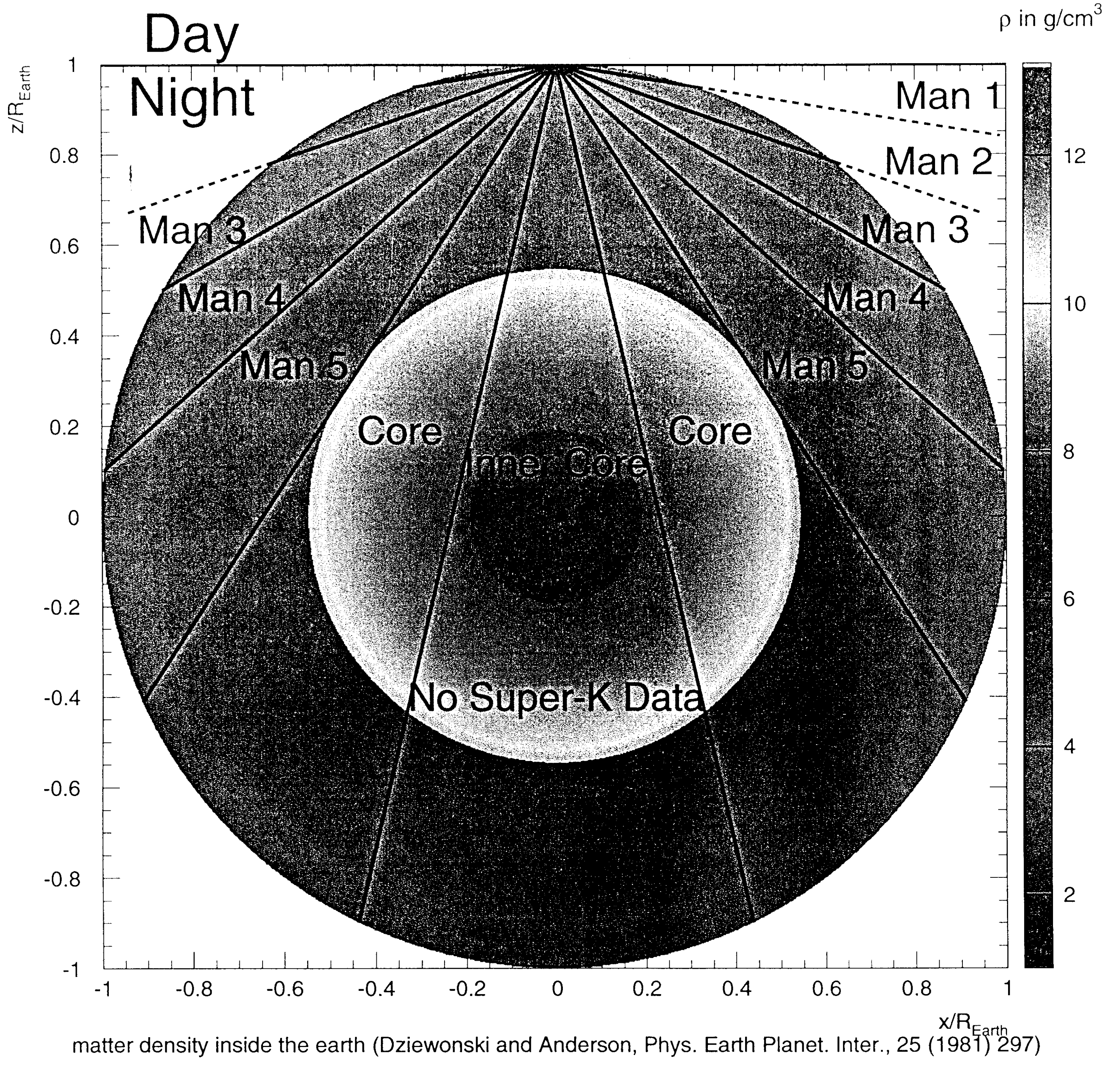
Flux Results

Total Flux:

- 18500 Events above 5 MeV
- $\phi = (2.32 \pm 0.03(\text{stat.})^{+0.08}_{-0.07}(\text{syst.})) \times \frac{10^6}{\text{cm}^2 \cdot \text{sec}}$
- $= (0.451 \pm 0.005(\text{stat.})^{+0.016}_{-0.014}(\text{syst.})) \times \phi_{\text{SSM}}$
- 1.3 ± 2.0 events (18-21) MeV
  Hep$\leq$4.3SSM (90% C.L.)

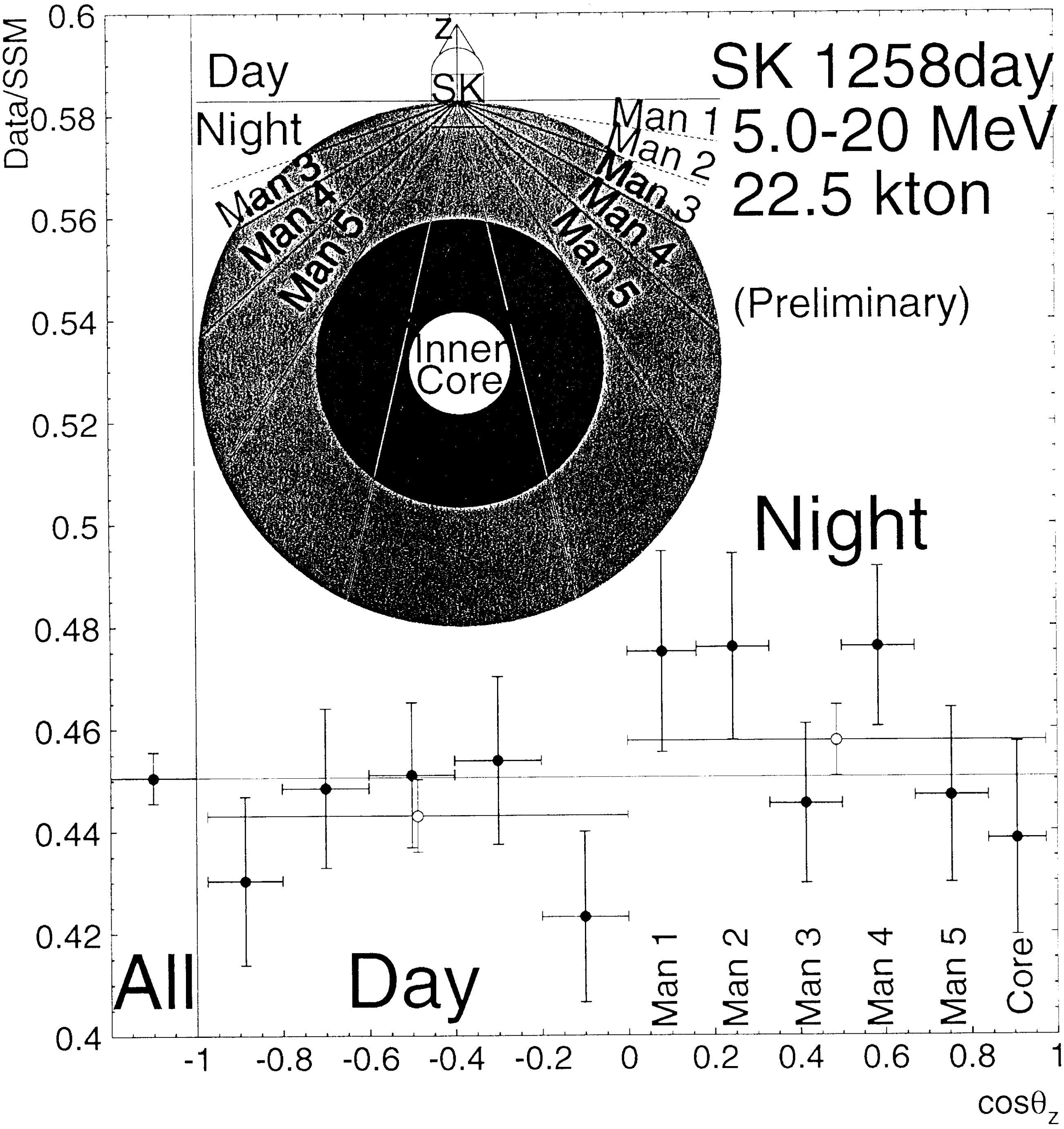
Day/Night:

- $\phi_D = (2.28 \pm 0.04(\text{stat.})^{+0.08}_{-0.07}(\text{syst.})) \times \frac{10^6}{\text{cm}^2 \cdot \text{sec}}$
- $\phi_N = (2.36 \pm 0.04(\text{stat.})^{+0.08}_{-0.07}(\text{syst.})) \times \frac{10^6}{\text{cm}^2 \cdot \text{sec}}$
- $\frac{\phi_D - \phi_N}{0.5(\phi_D + \phi_N)} = -0.033 \pm 0.022(\text{sta})^{+0.013}_{-0.012}(\text{sys})$
- Only 1.5σ away from 0!



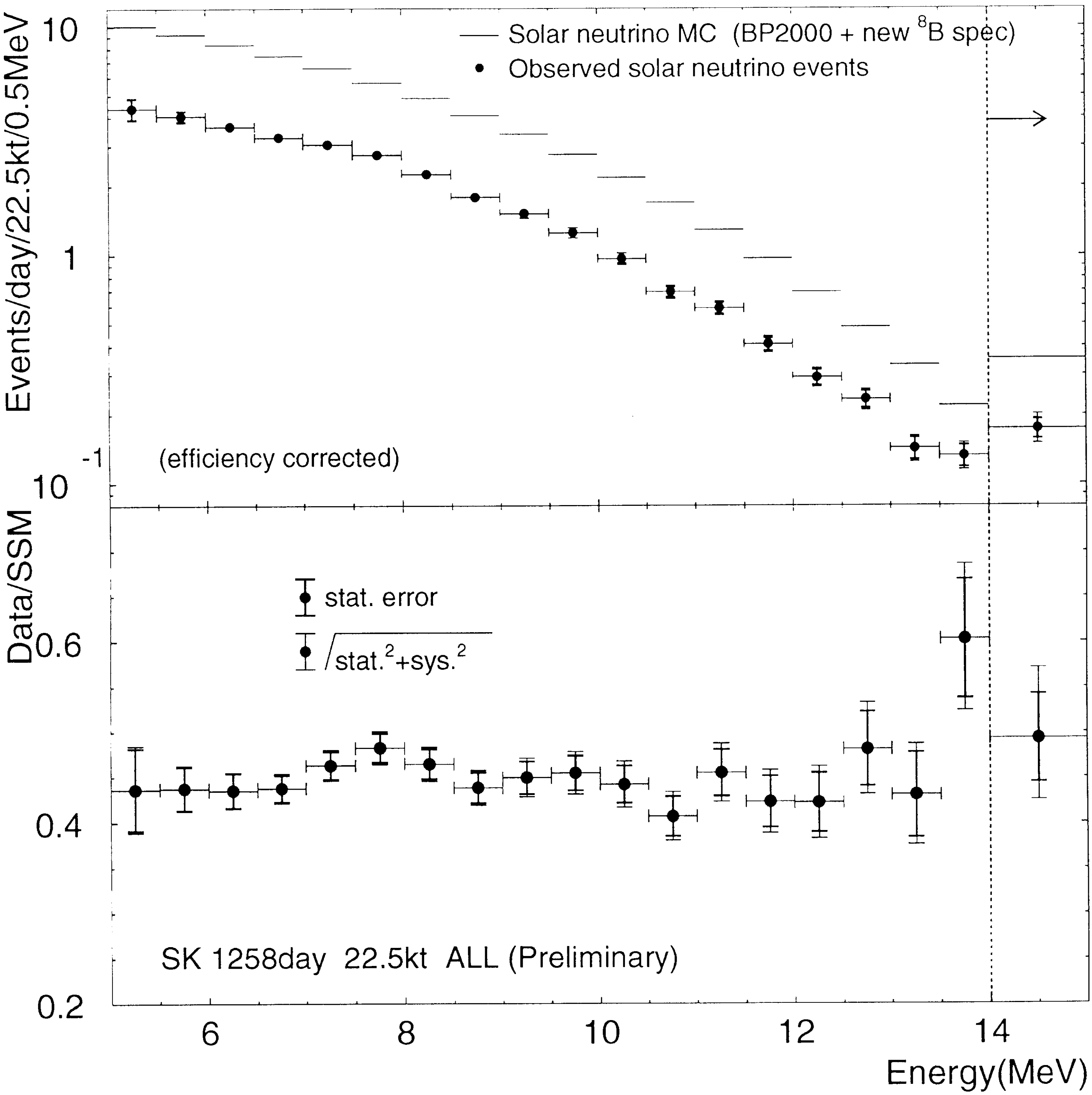
matter density inside the earth (Dziewonski and Anderson, Phys. Earth Planet. Inter., 25 (1981) 297)

Day/Night Asymmetry

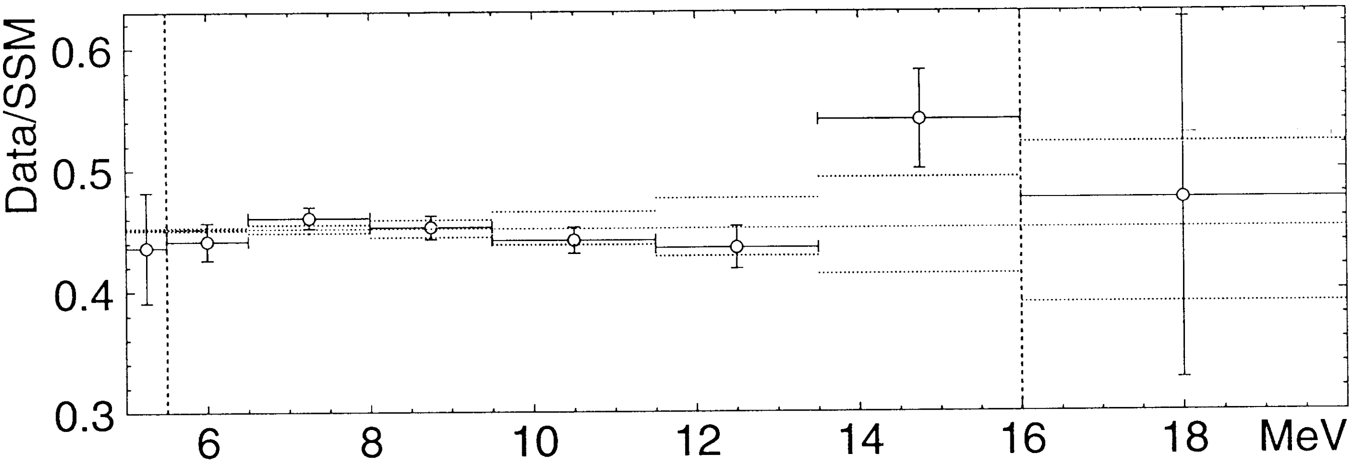


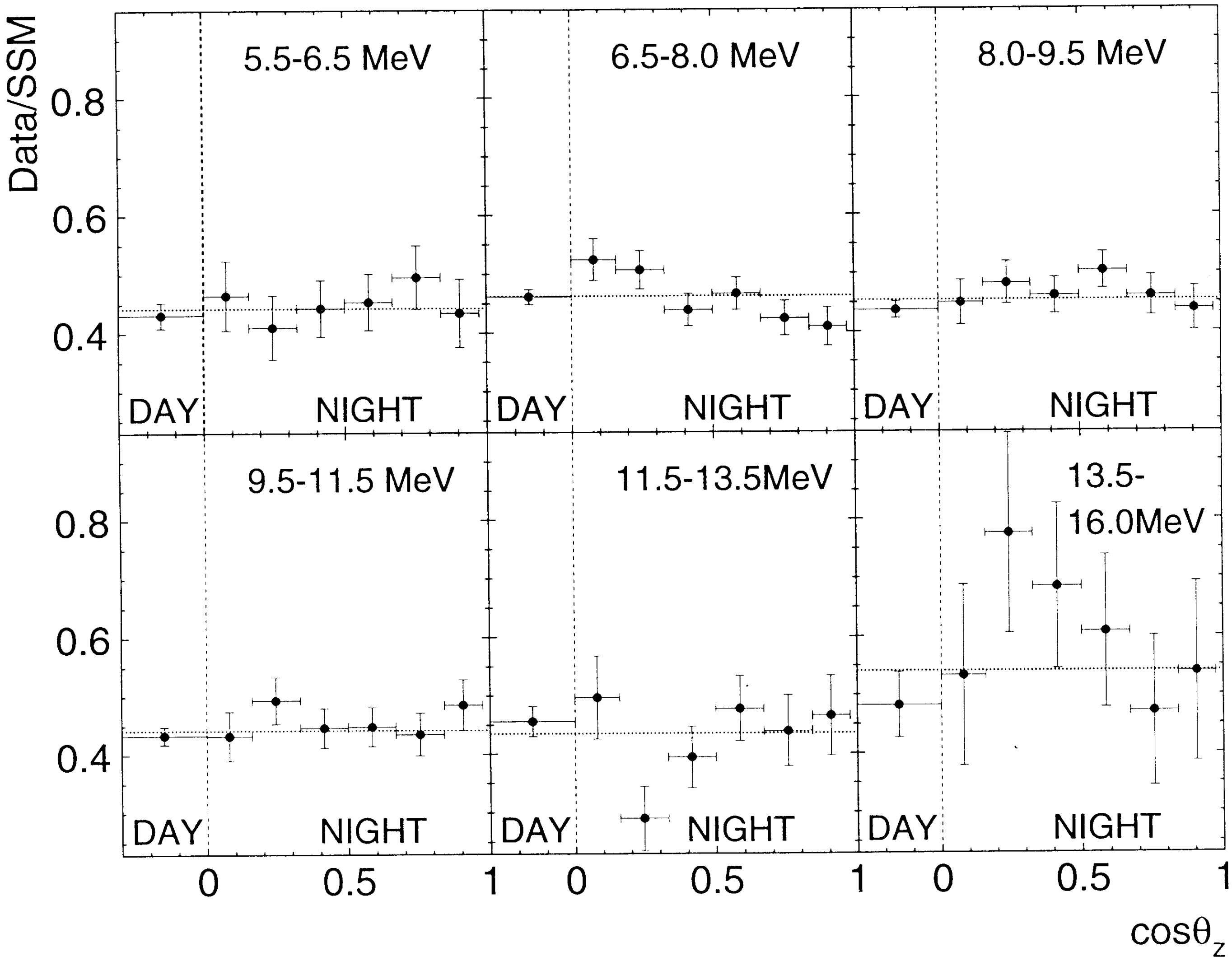
$$\frac{D-N}{\frac{1}{2}(D+N)} = -0.033 \pm 0.022(\text{stat.})^{+0.013}_{-0.012}\ (\text{syst.})$$

The Recoil Spectrum



Zenith-Spectrum





χ^2 Definition

Variation Matrix (in zenith angle)

Deviation Vector (in zenith angle)

$$\chi^2 = \sum_{i=1}^{8} \vec{\Delta}_i^T \cdot V_i^{-1} \cdot \vec{\Delta}_i + \left(\frac{\delta_{\rm corr}}{\sigma_{\rm corr}}\right)^2 + \left(\frac{\Delta_{\rm SNO}}{\sigma_{\rm SNO+SK}}\right)^2$$

Energy bin

Correlated Uncertainty Deviation

SK measured Flux

Oscillated SSM Flux

$$\left(\vec{\Delta}_i\right)_z = \frac{\phi_{i,z}^{\rm meas}}{\phi_i^{\rm SSM}} - \frac{\phi_{i,z}^{\rm osc}({\rm Hep})}{\phi_i^{\rm SSM}} \times f\left(E_i, \delta_{\rm corr}\right) \times \alpha$$

Energy–correlated Uncertainty shape

Flux Normalization

$$\Delta_{\rm SNO} = \frac{\phi_{\rm SNO}^{\rm meas}}{\phi_{\rm SNO}^{\rm SSM}} - \frac{\phi_{\rm SNO}^{\rm osc}({\rm Hep})}{\phi_{\rm SNO}^{\rm SSM}} \times \alpha$$

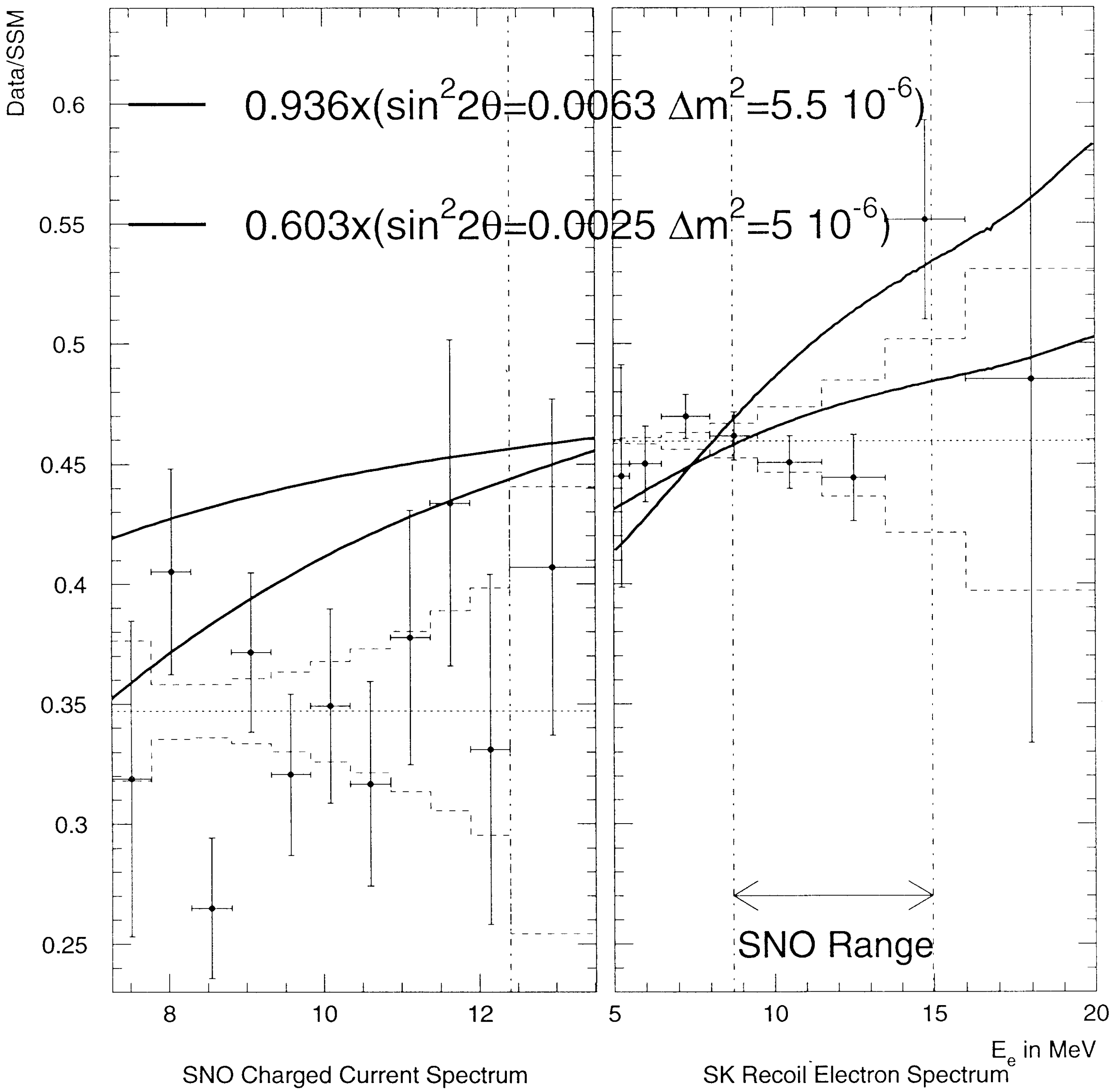
Standard Solar Model Flux

$$V_i = V_i({\rm stat.}) + V_i({\rm E\text{-}uncorr.})$$

full correlation in zenith angle
zero correlation in energy

last term for SK-SNO fit only!

SMA Solution



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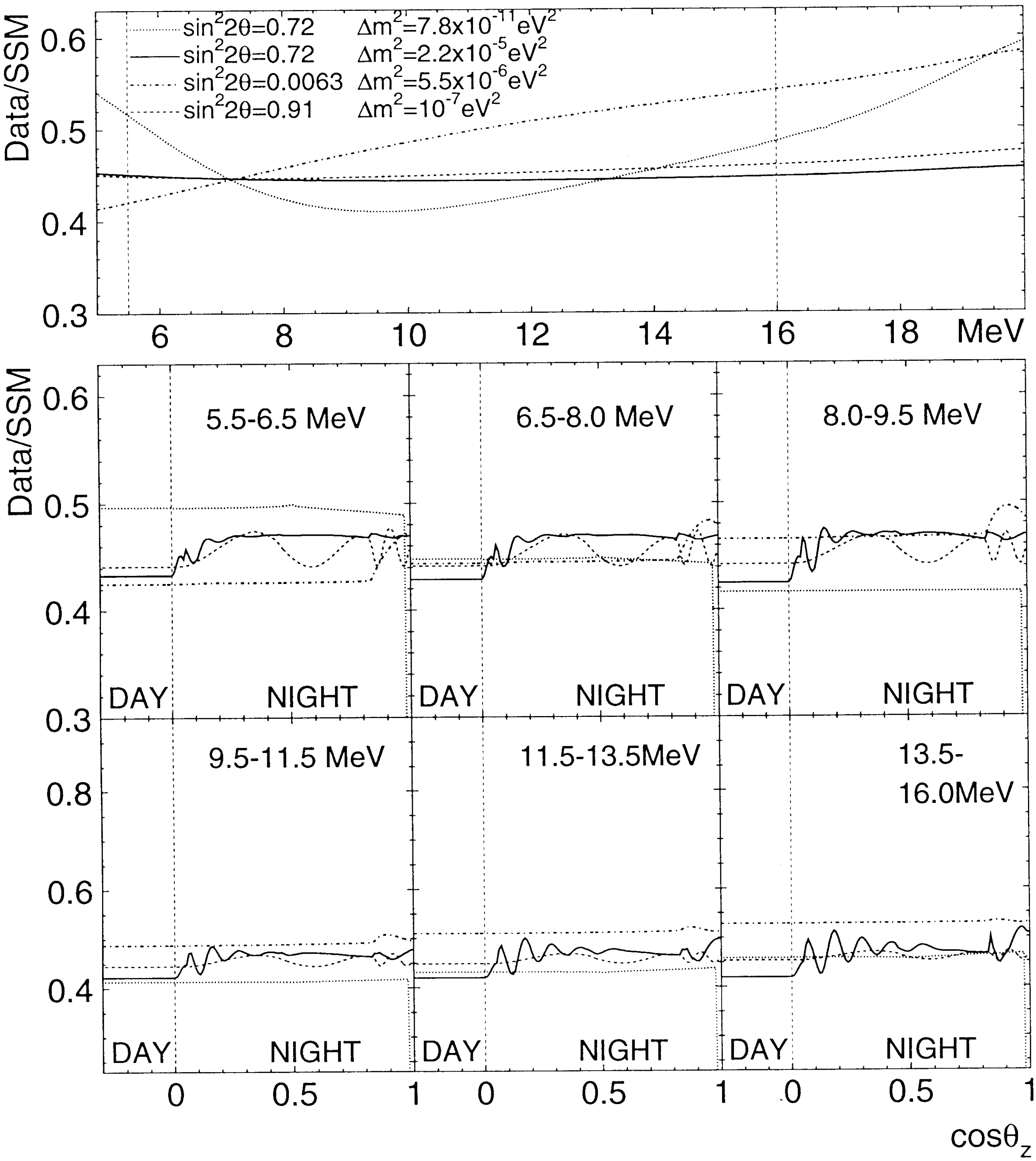
4 Solutions (Rate)



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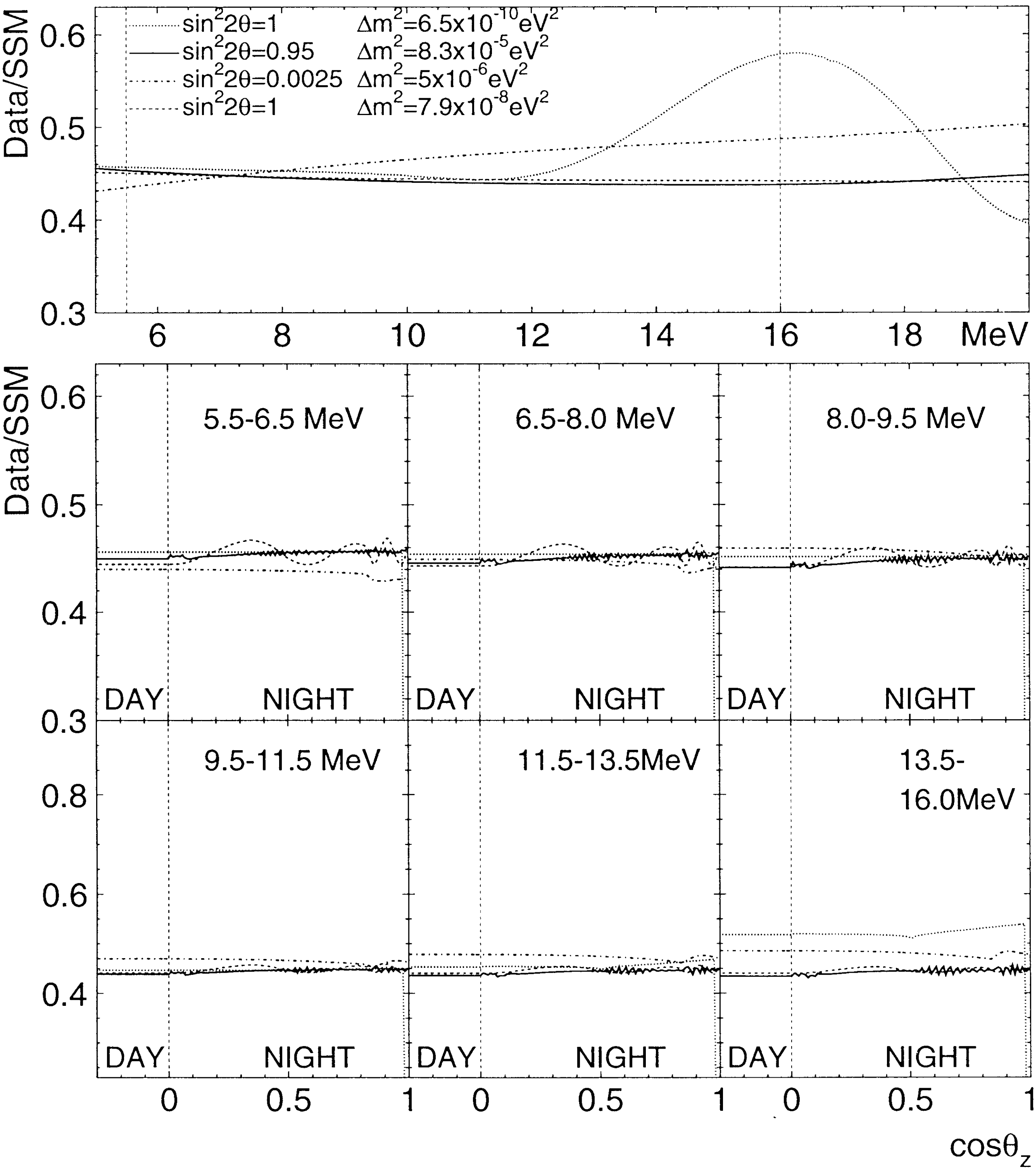
4 Solutions (Best Fits)



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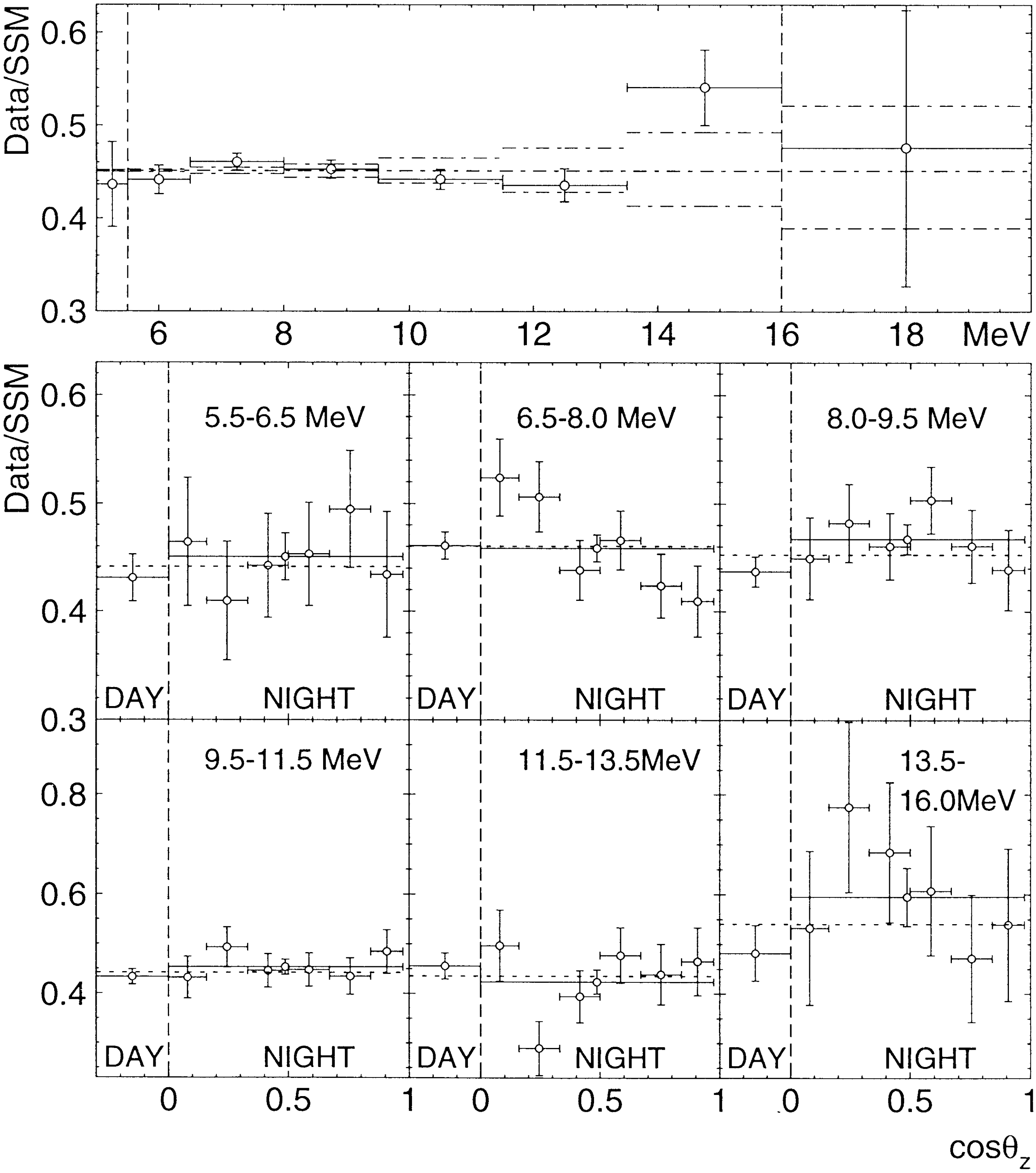
4 Solutions (Data)



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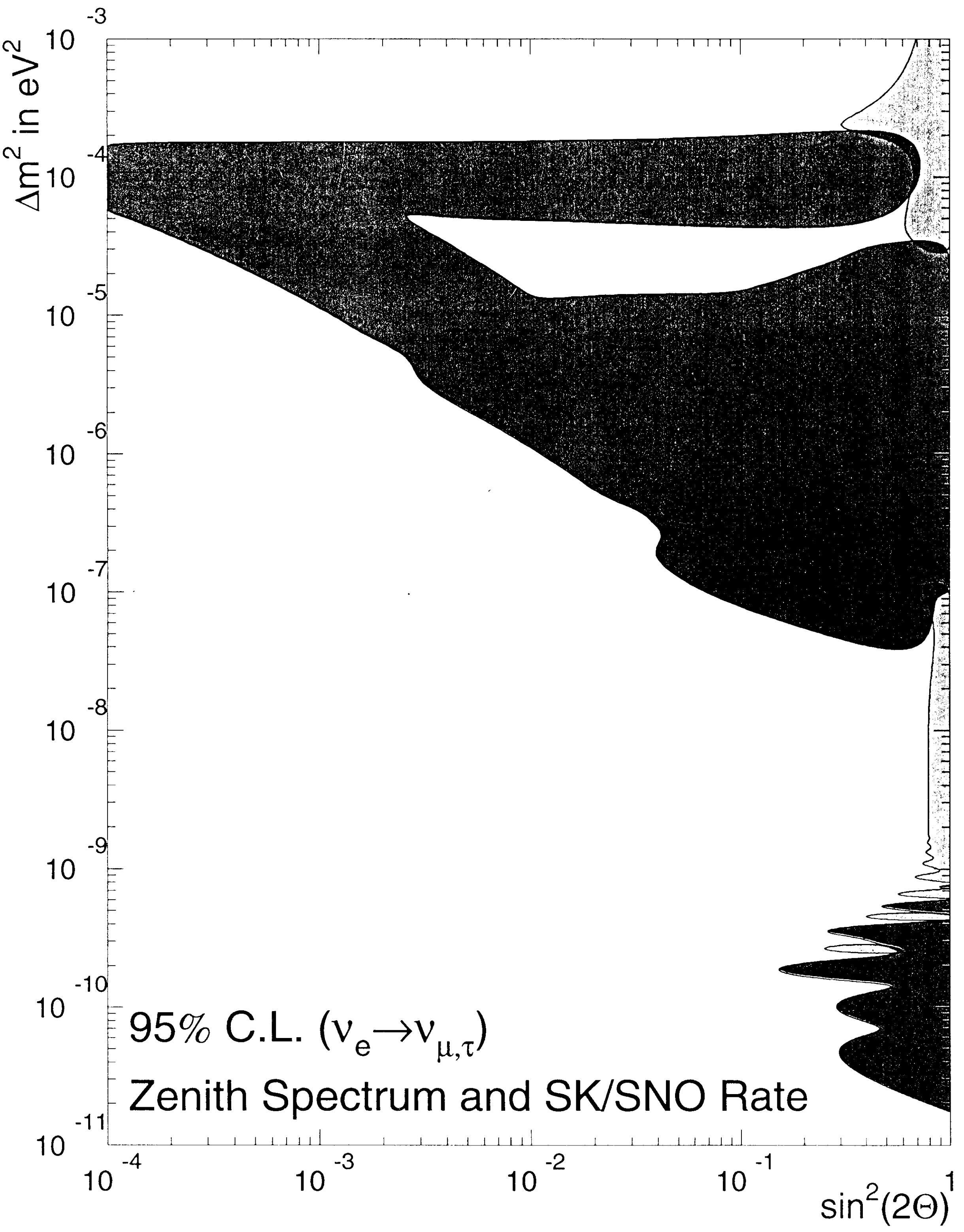
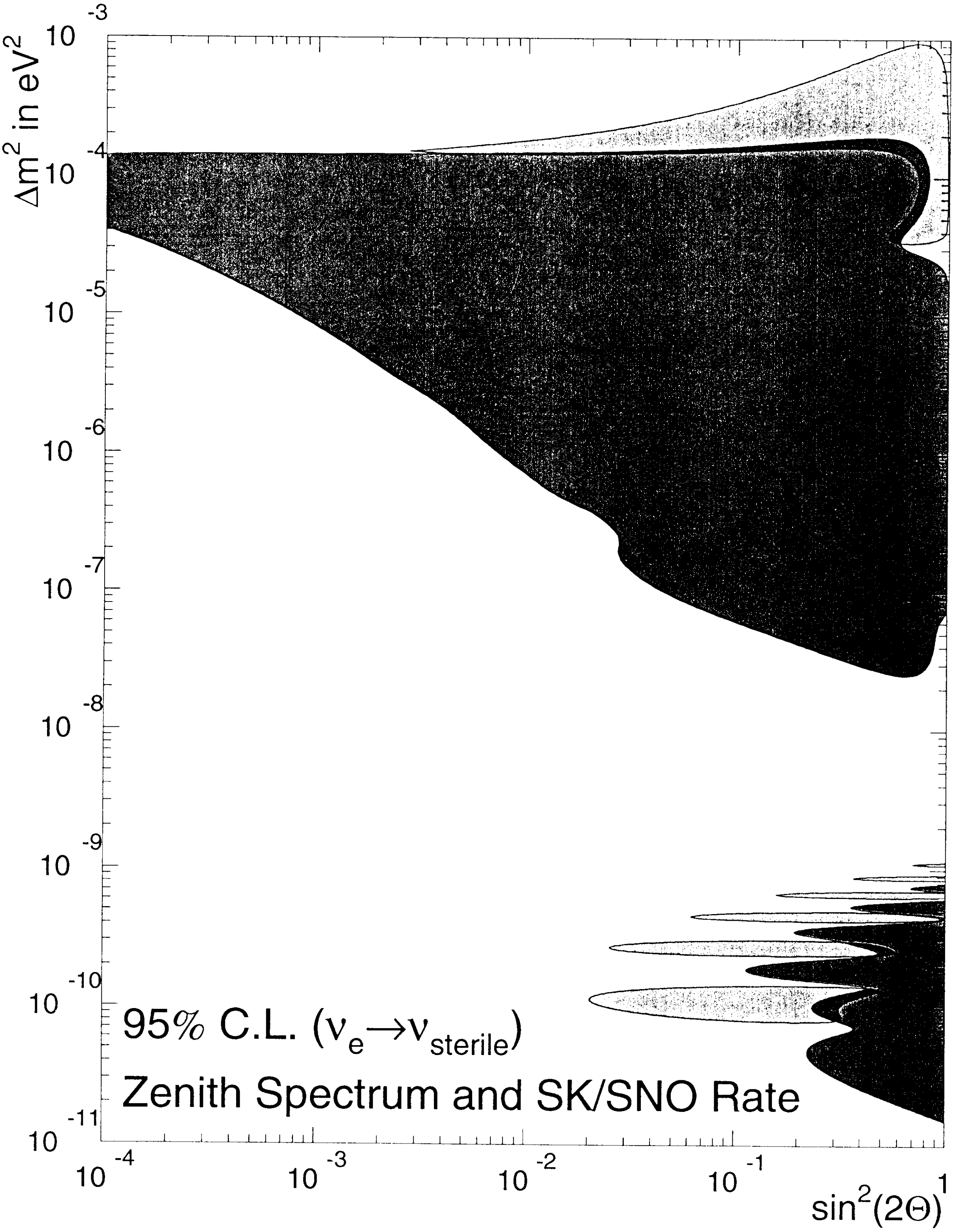
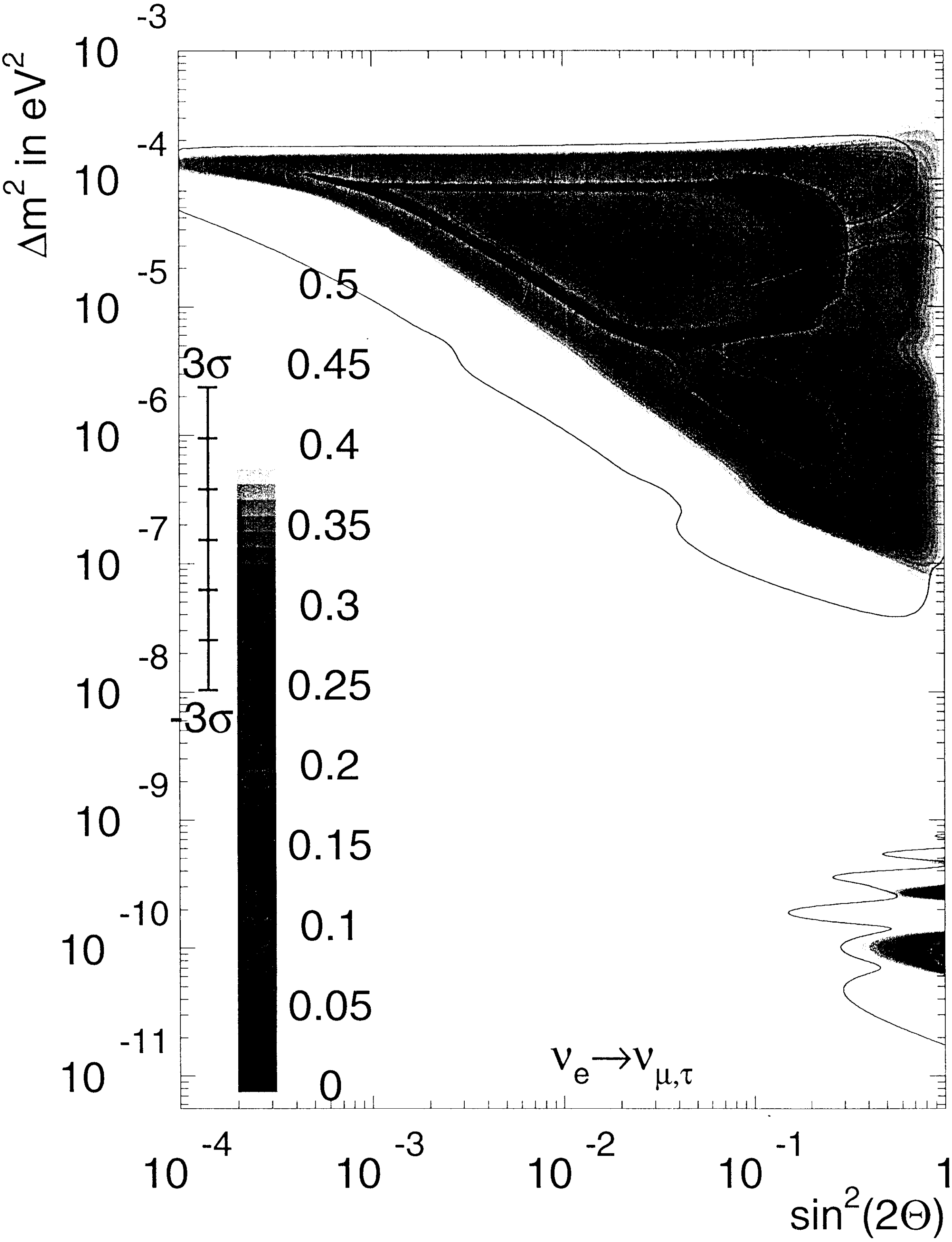
Fully Active 2ν Osc.



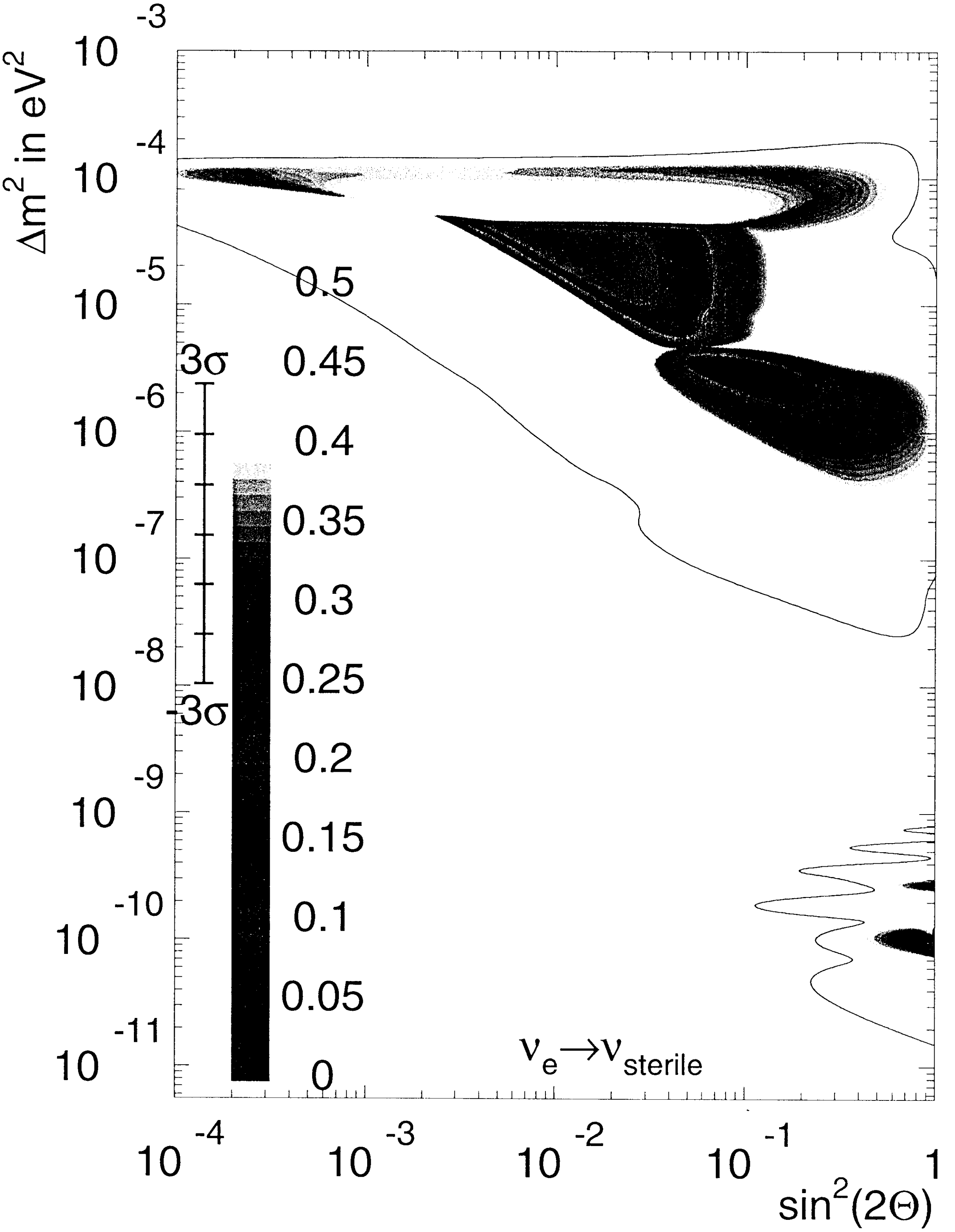
Fully Sterile 2ν Osc.



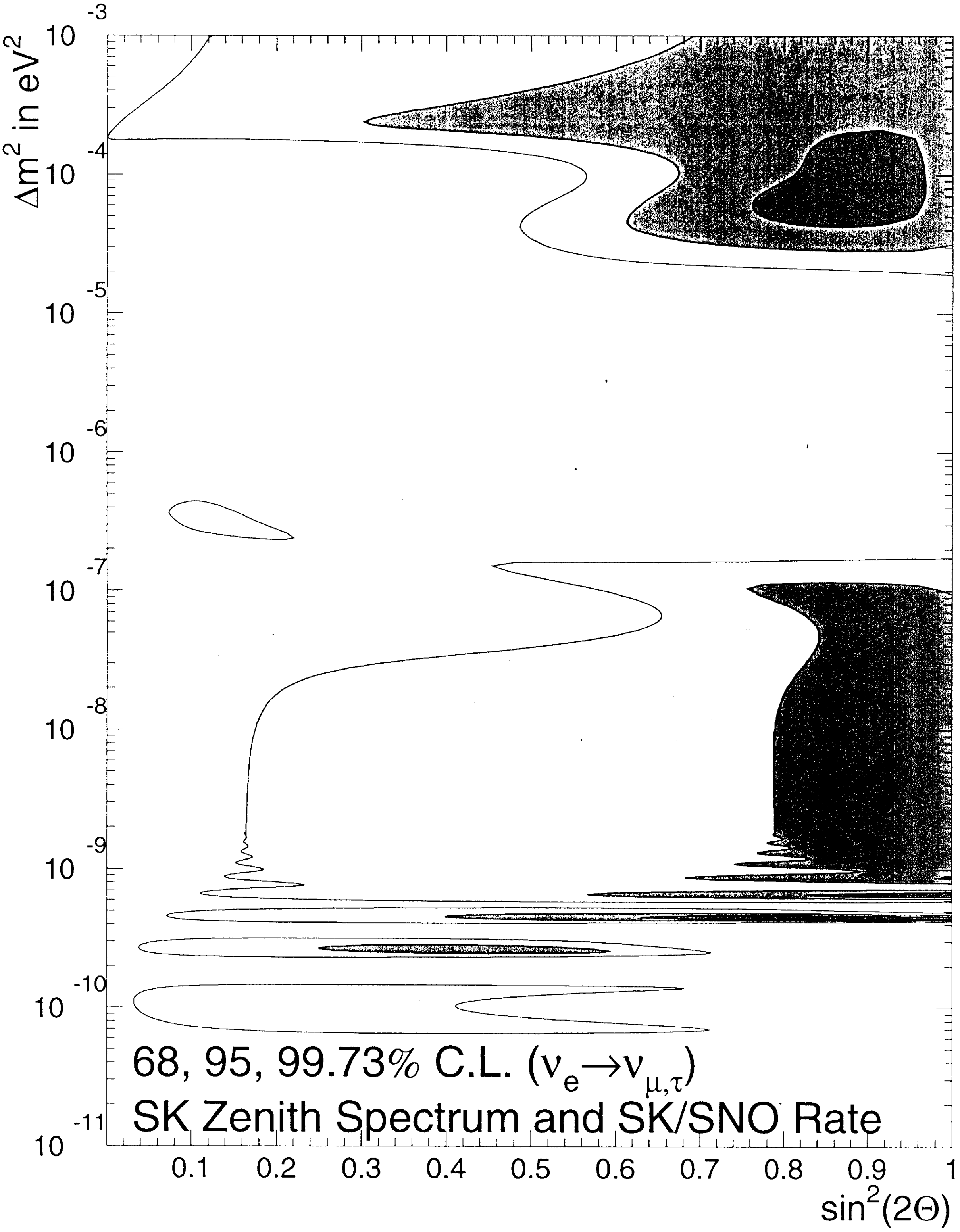
Fit for SNO CC



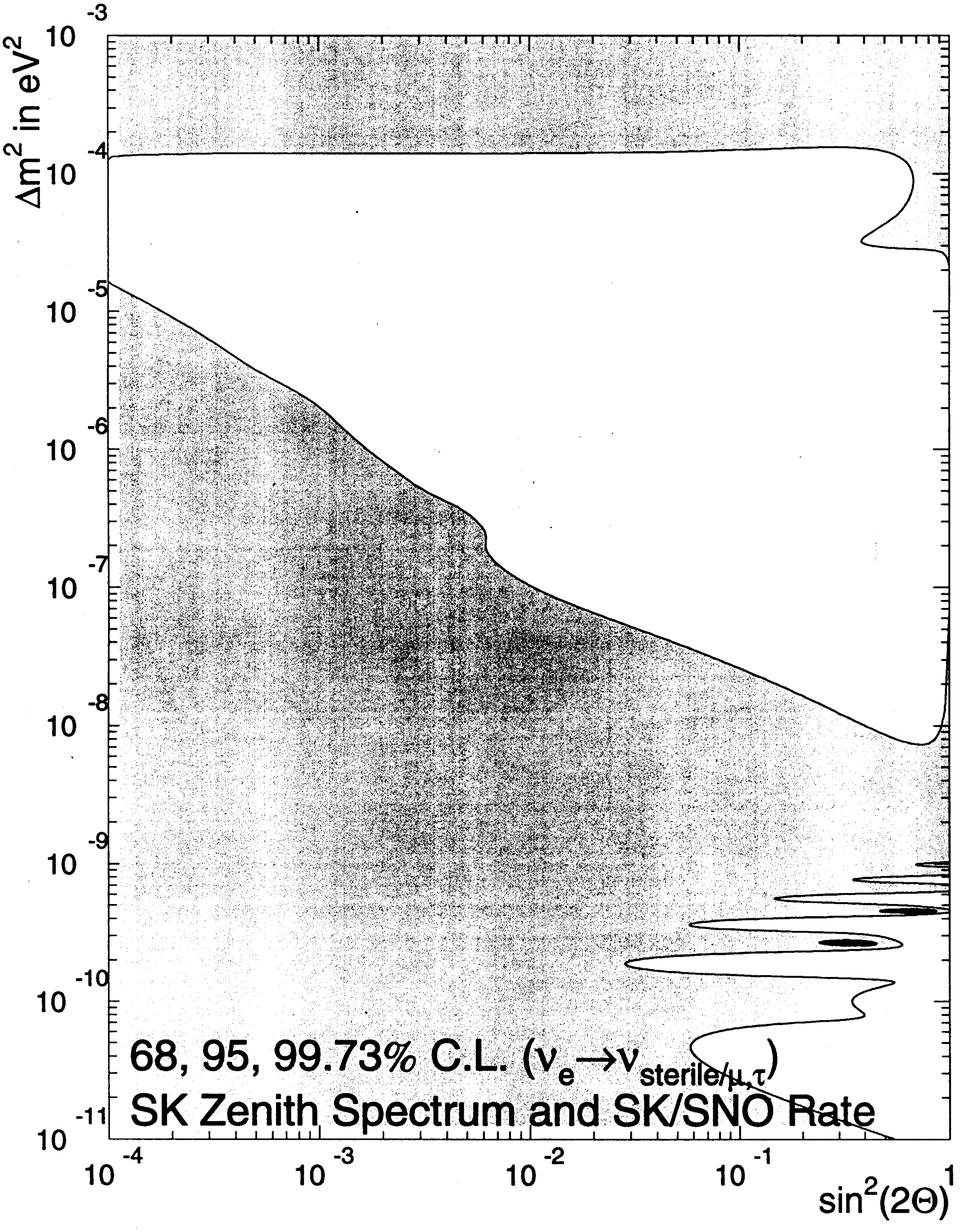
Fit for SNO CC



Combined χ^2 (2ν)



Combined χ^2 (3ν)



Fully Sterile Osc

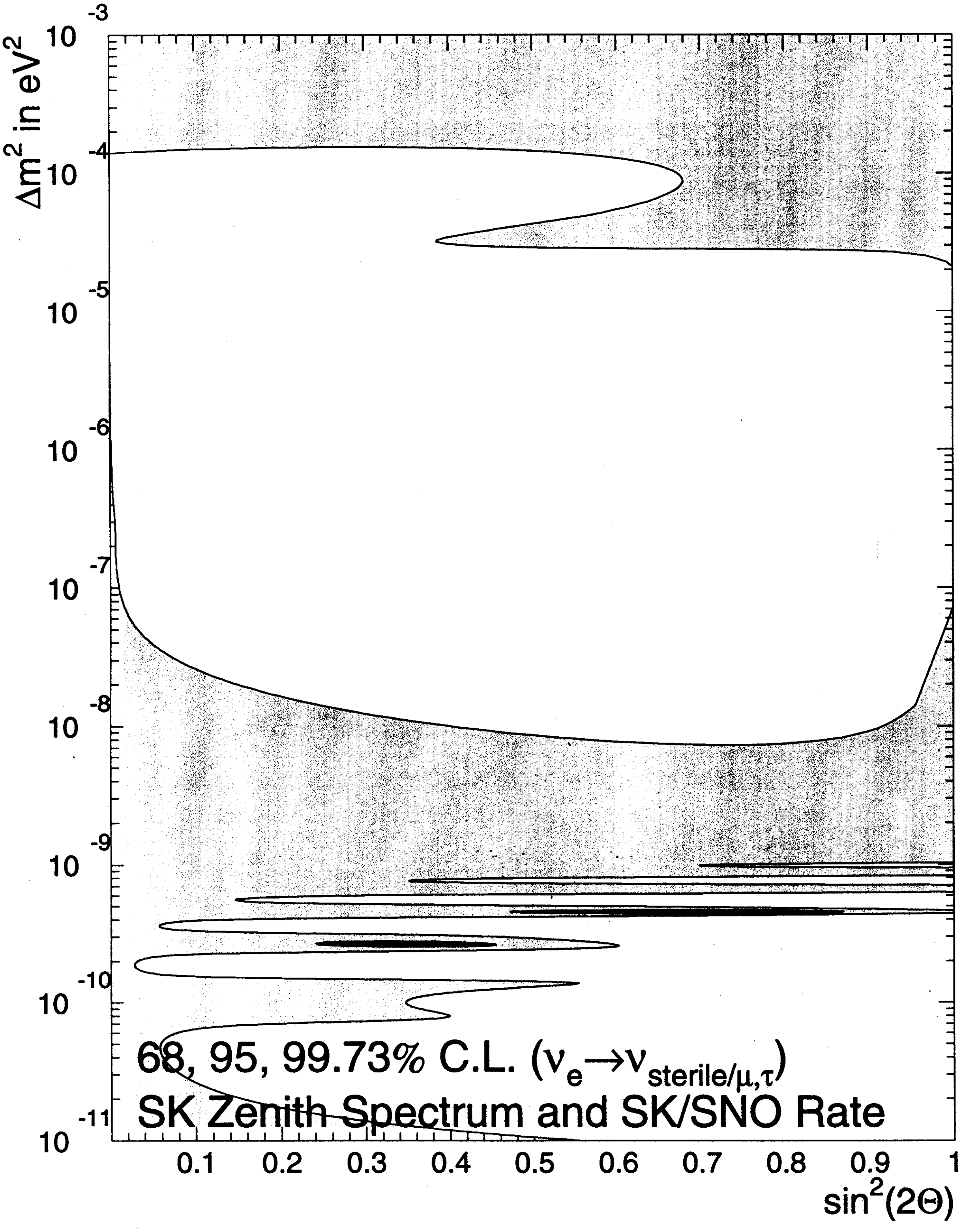
How much disfavored?

- for many d.o.f. need to use $\Delta\chi^2$ method
- minimize χ^2 w.r.t. oscillation parameters
- $\Delta\chi^2$=6.25
- disfavored by 2.5 σ

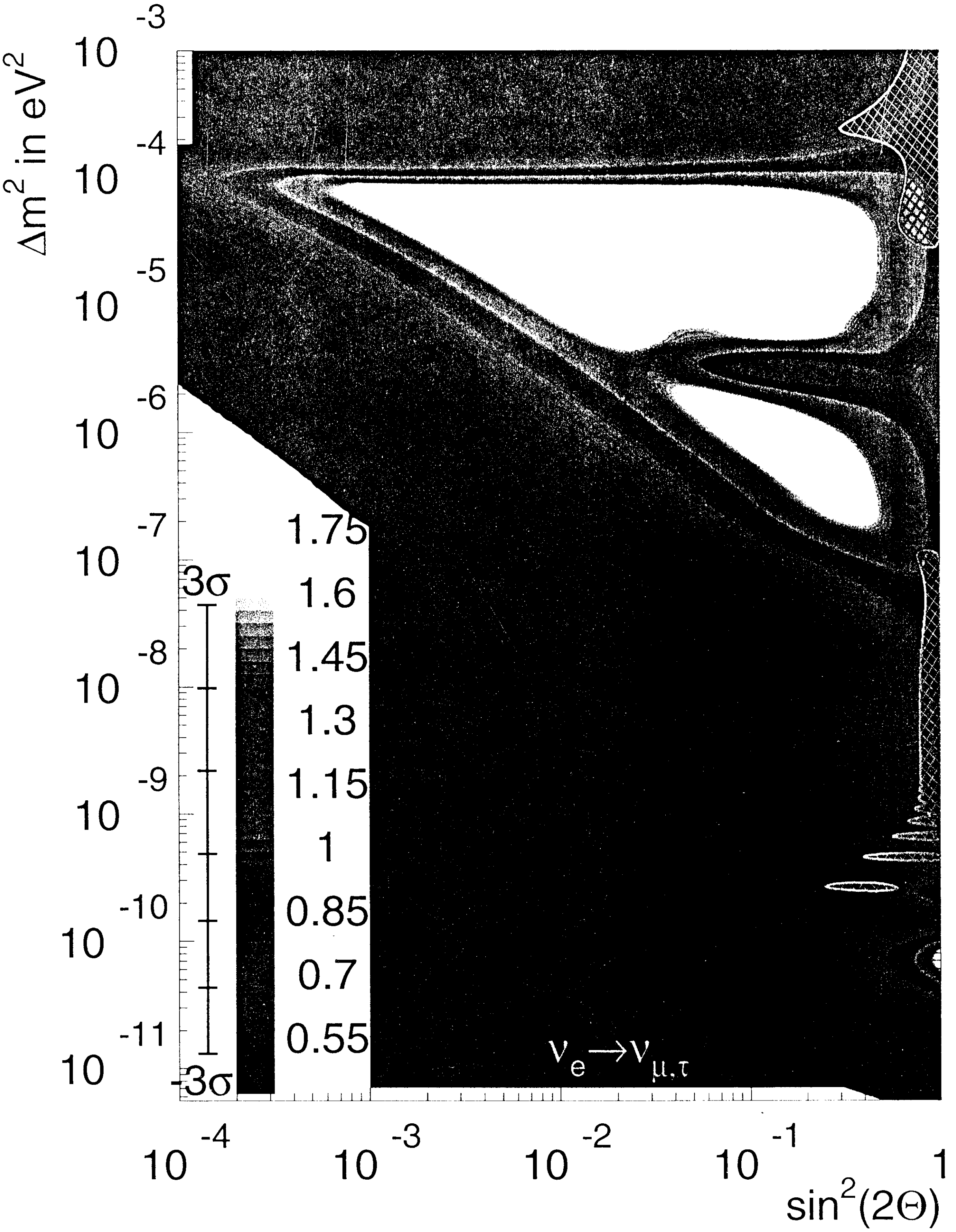
Estimate parameter:

- for many d.o.f. need to use $\Delta\chi^2$ method
- use χ^2 minimum from active case
  (no scan yet!!)
- assume 3 parameter

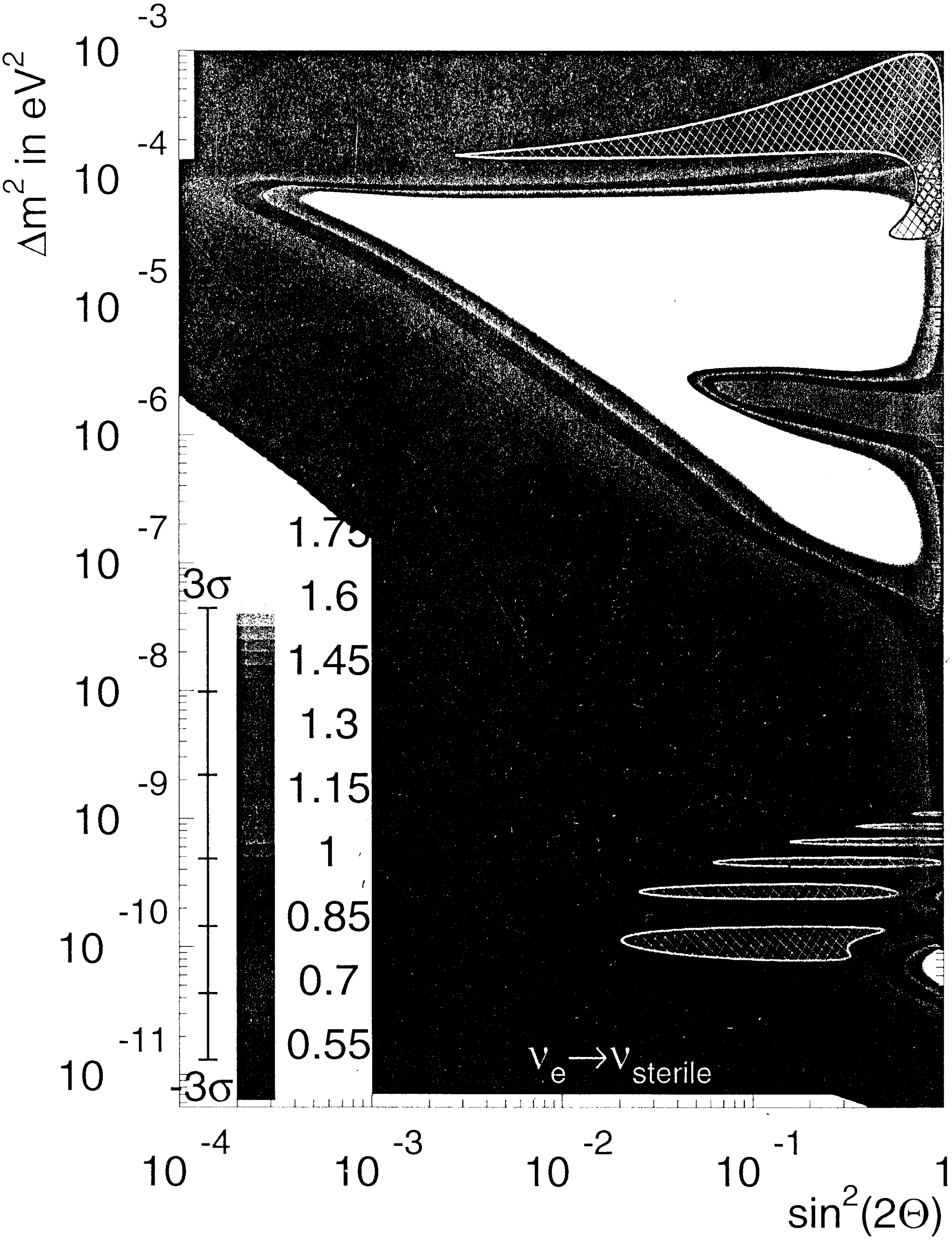
Combined χ^2 (3ν)



How Bright is ν Sun?



How Bright is ν Sun?



Conclusion

- SK Zenith Spectrum and SK-SNO Rate Comparison give 3σ oscillation signal
- SK Zenith Sp. constrains Spectral Distortion and Zenith Angle Variation
- LMA and High Δm^2 VAC fit best; LOW and Quasi VAC allowed at 90% C.L.
- SMA Disfavored by 3σ
- Fully Sterile Case Disfavored by 2.5σ