Energy Reconstruction and Diffuse Neutrino Flux

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(on behalf of the ANTARES collaboration)

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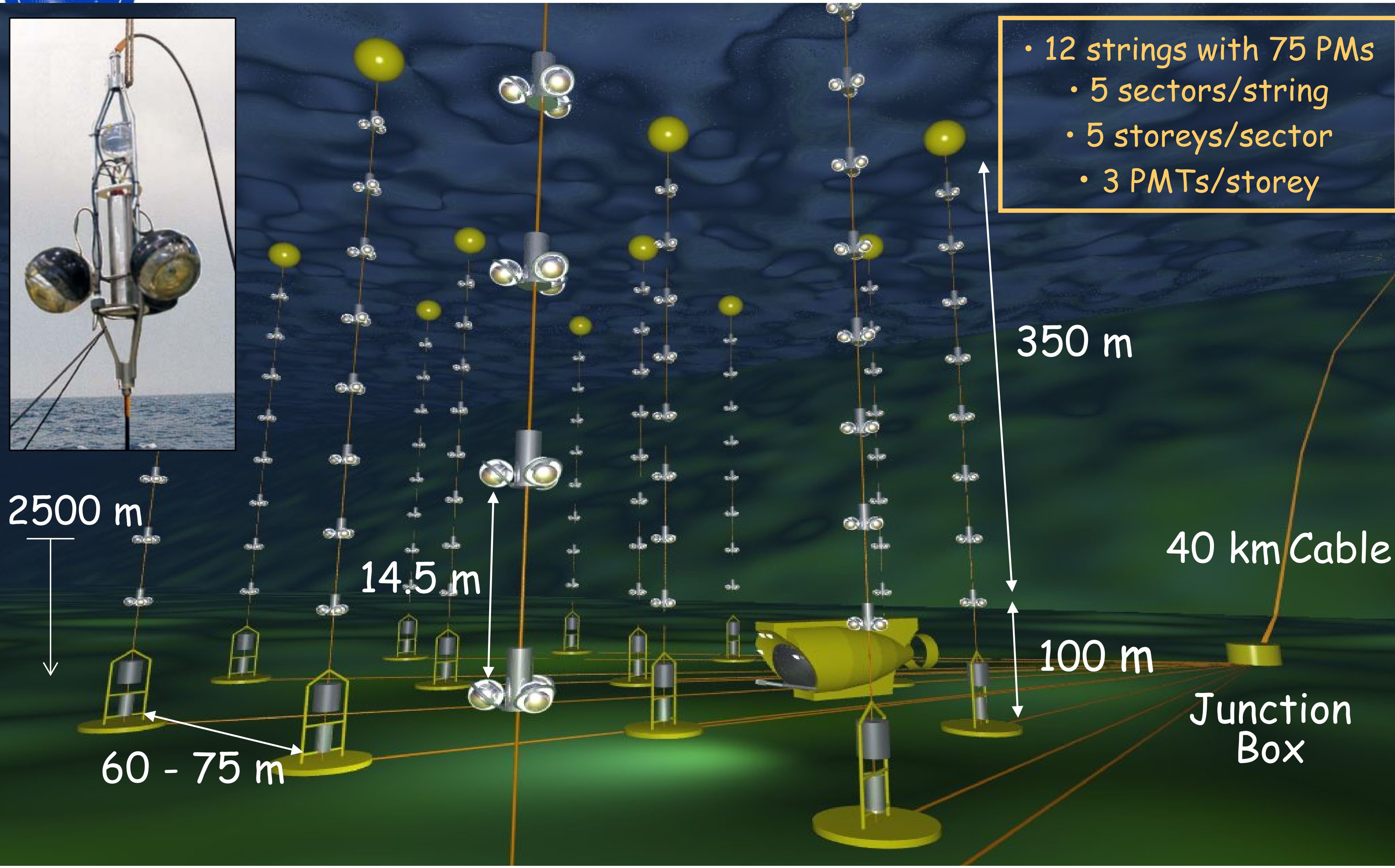
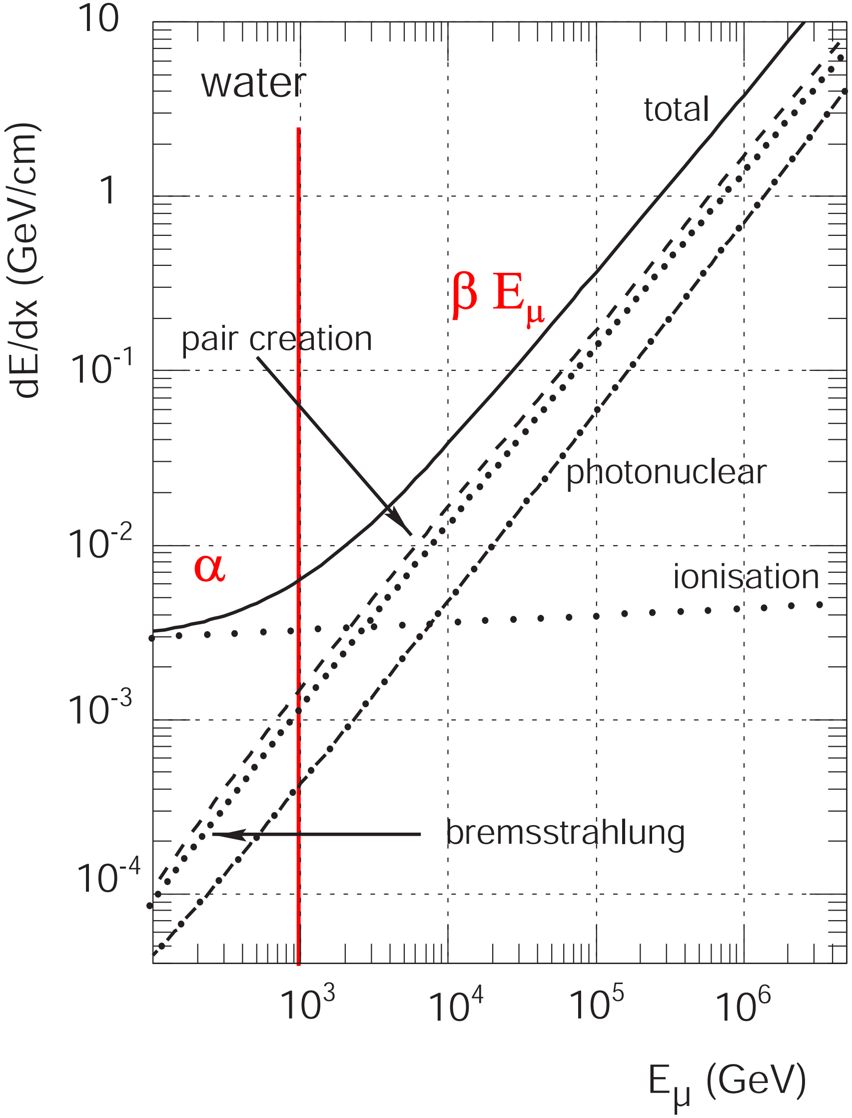
ANTARES experiment

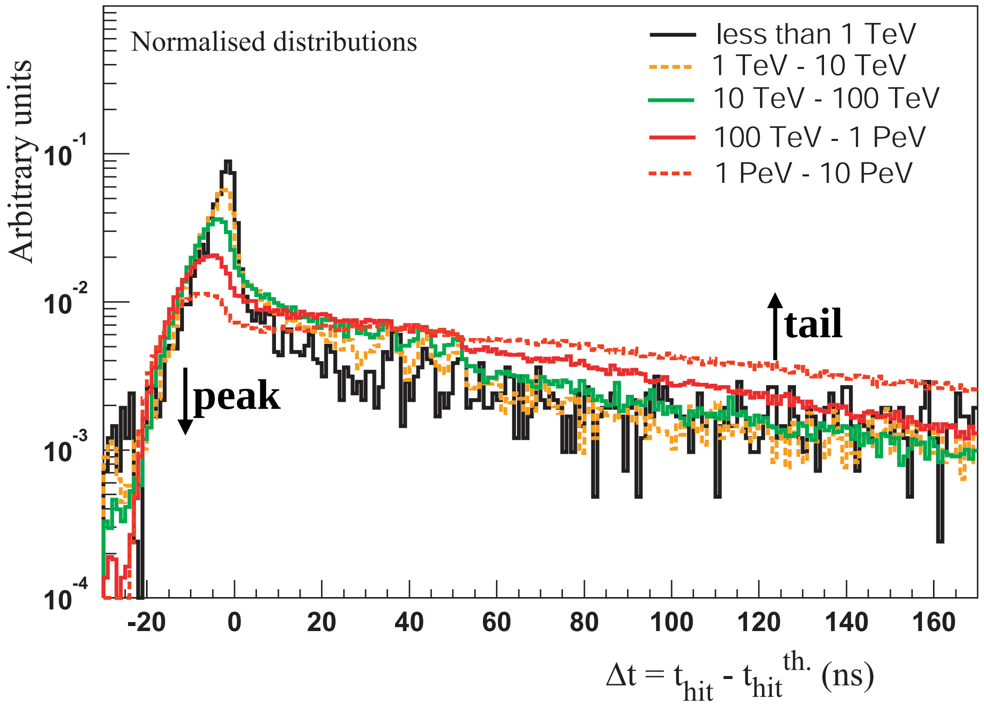


Muon energy loss evolution



$$\left|\frac{dE_\mu}{dx}\right| = \alpha + \beta\ E_\mu$$

$\Rightarrow$ Effects on the hit time residue distribution



Method 1: empirical method

2 ≠ hypothesis : Low Energy / High Energy

$\frac{A_i}{A_i^{MIM}}$ Small → $\Rightarrow x_S$

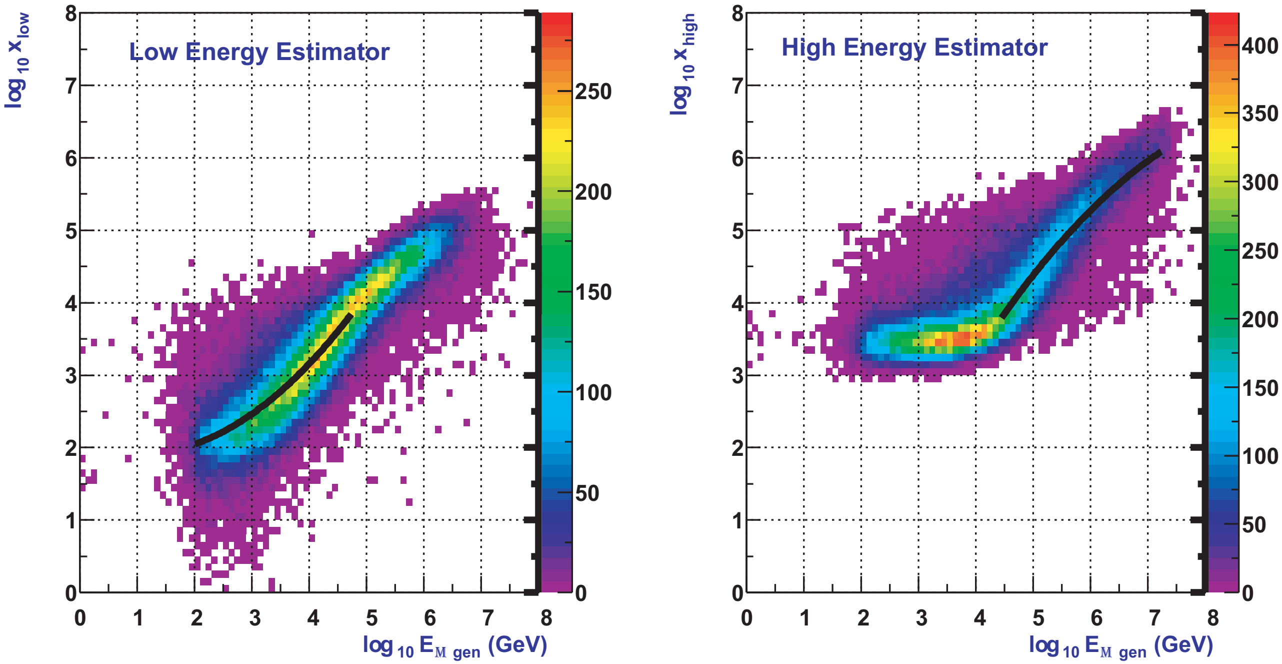
$\frac{A_i}{A_i^{MIM}}$ Large → $\Rightarrow x_L$

$\Rightarrow$ 2 estimators following a hit classification

$$x_{\substack{S\\L}} = N_{hit}\left[\left(\frac{\sum_i A_i}{\sum_i A_i^{MIM}}\right)_{\substack{S\\L}} - 1\right]$$

Compared A_i to what a MIP would have produced

$\log_{10} x \Leftrightarrow \log_{10} E_\mu$ relation
fitted by a parabola



Method 2: physical method

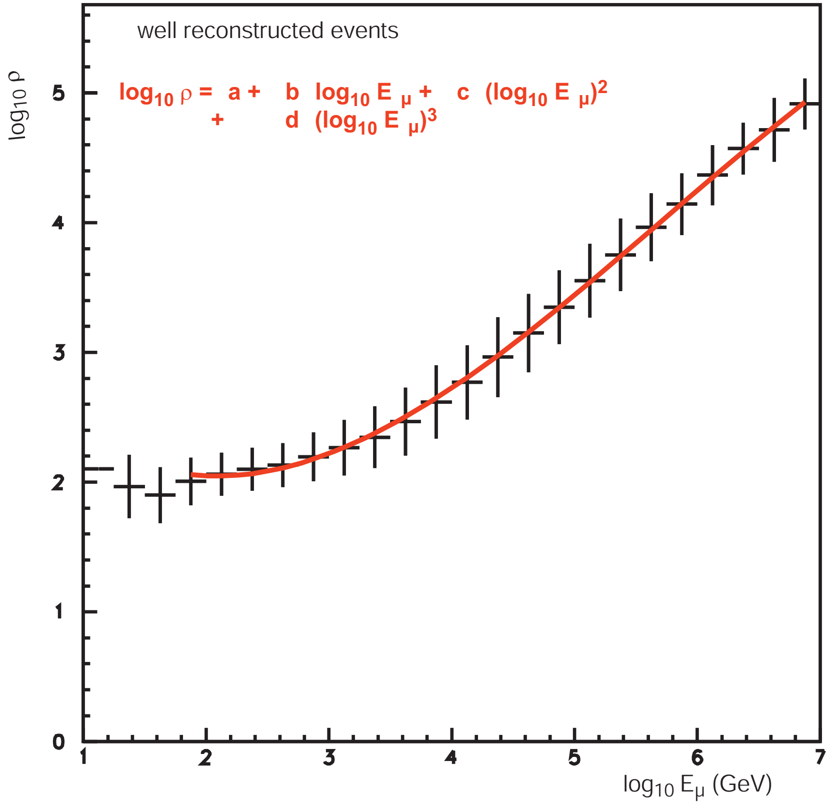
- dE/dx estimator ρ defined as:

$$\rho = \frac{1}{L_\mu} \frac{\Delta A}{R(\vec{r}, \theta, \varphi)}$$

$\Delta A = \Sigma i\ Ai$, **total hit amplitude of the event**

muon path length

detector response



$R(\vec{r}, \theta, \phi)$ fraction of μ light seen by PMT

Function of :

- water properties ($\lambda_{att} \sim 55$ m);
- PMT angular response ($\alpha_{\theta j}$).

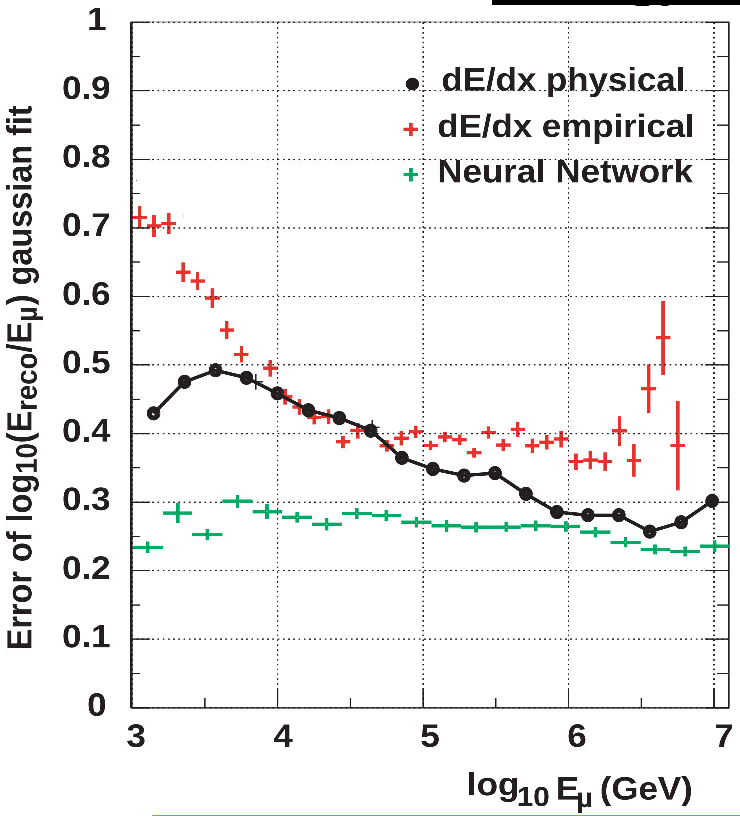
Method 3: neural network approach

- Input (11 param.):
  - hit amplitude, time and residue distribution;
  - muon track parameters.

- Output: E_μ

NN only trained with HE simulated events (E_μ > 1 TeV)

<u>Energy resolution factor 2 -3</u>



Method 1: empirical method

Method 2: physical method

Method 3: neural network

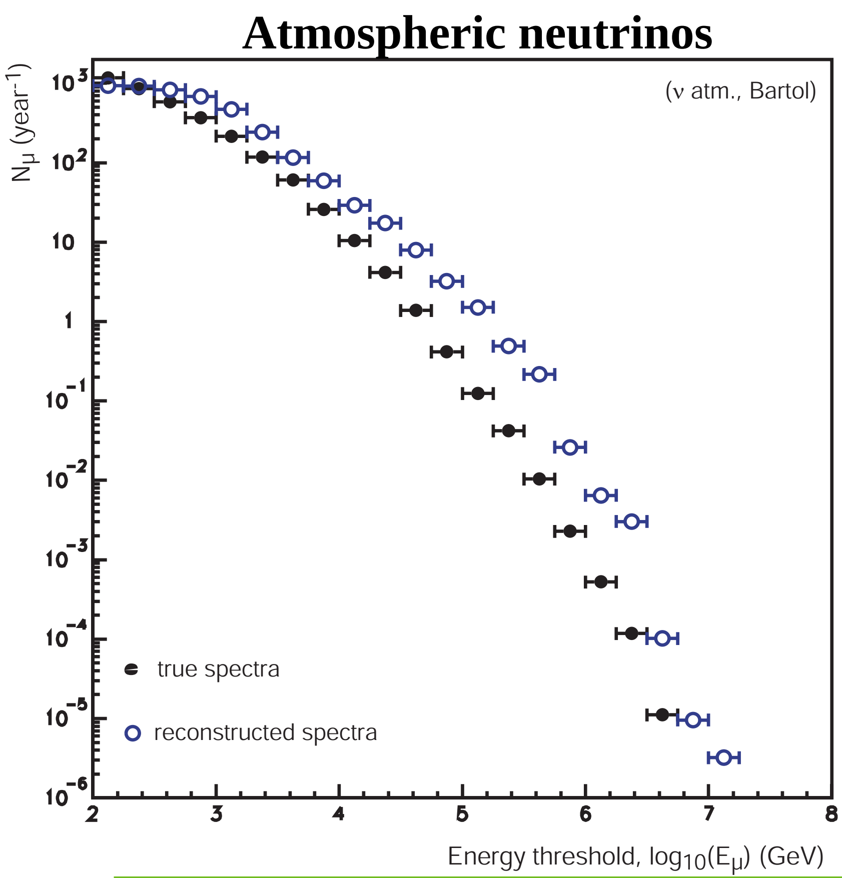
⇒ Energy resolution ~ 2 – 3 above 1 TeV

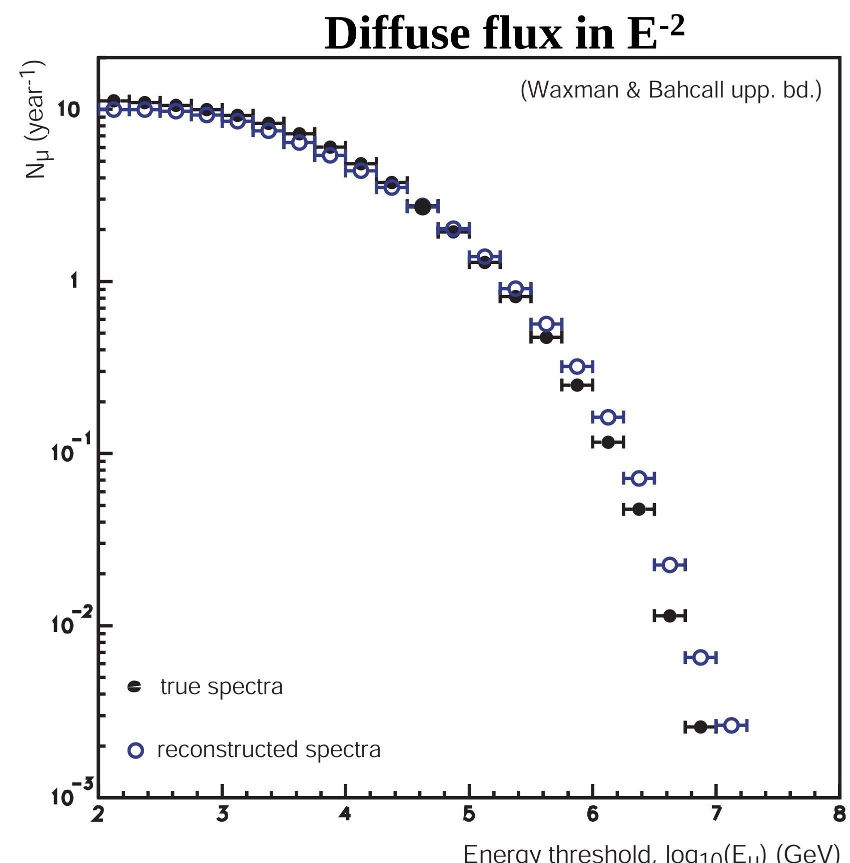
Application to diffuse ν flux

- **Atmospheric μ background already rejected by dedicated cuts**

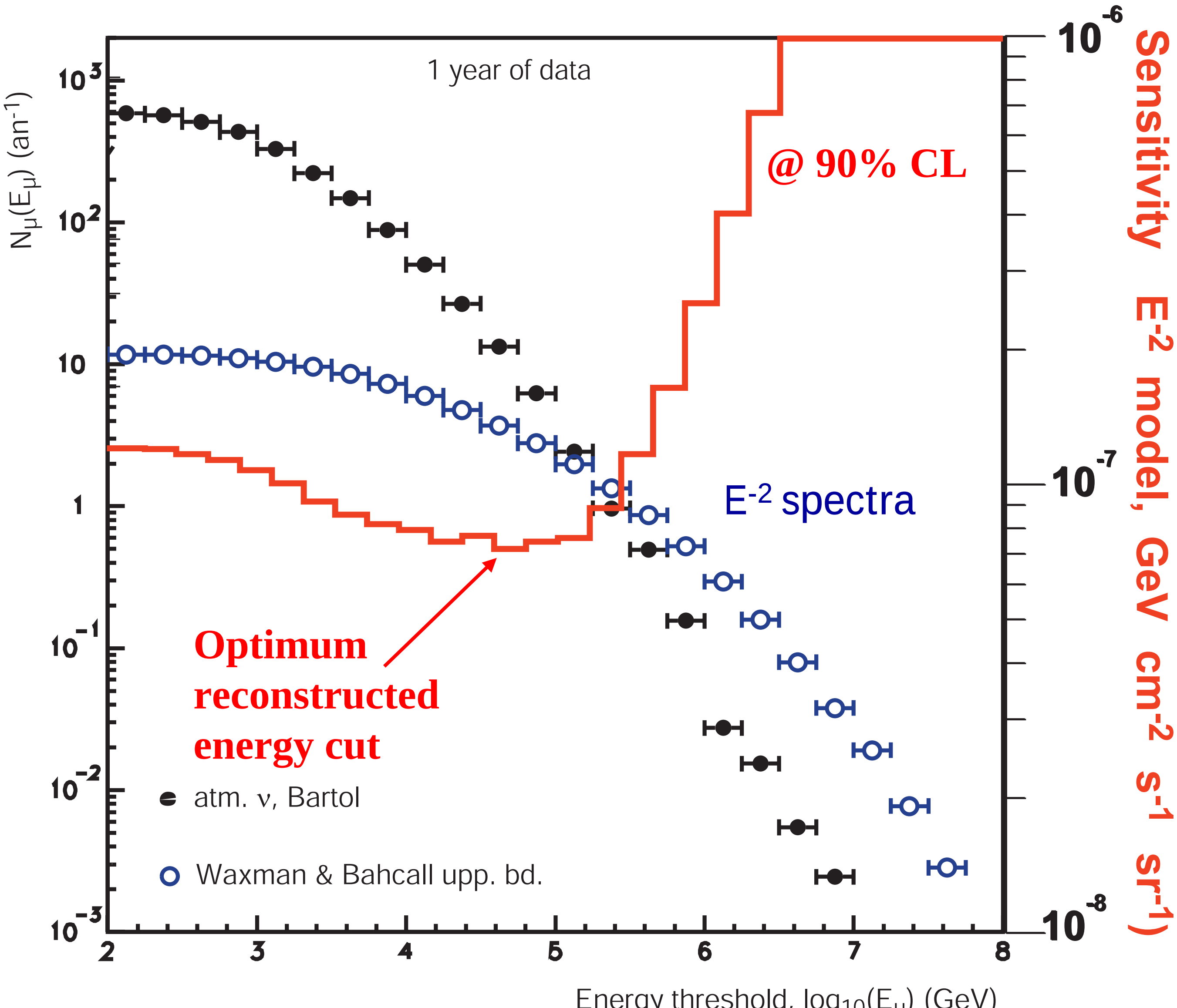
- Diffuse flux: addition of emission from astrophysical ν sources → typically in $\mathbf{E^{-2}}$
- Atmospheric ν background → typically in $\mathbf{E^{-3.6}}$

⇒ excess of high-energy events



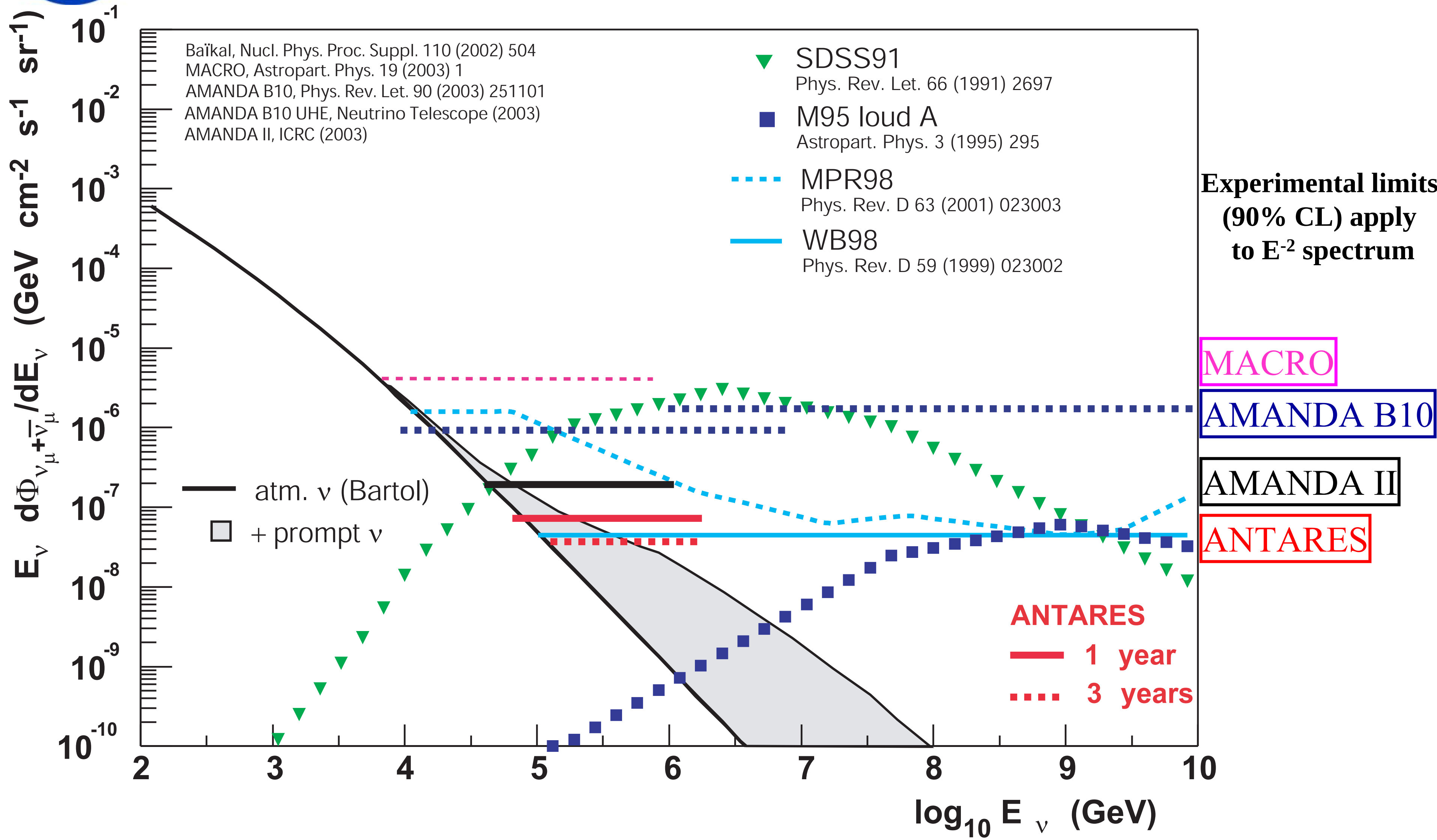


ANTARES diffuse flux sensitivity



dE/dx energy reconstruction method

Results for the 10 string ANTARES detector after cut opt.



Conclusion

- Energy resolution around a **factor of 2 - 3 on E_μ above 1 TeV** (constrained by the stochastic nature of the E loss processes)
  - $\Rightarrow$ 3 energy estimators with different methods
  - $\Rightarrow$ Based on the increase of emitted light due to muon catastrophic E losses

- ANTARES sensitivity @ 90% CL (in E^{-2} GeV^{-1} cm^{-2} s^{-1} sr^{-1}):

dE/dx method
10 string detector

$$E_\nu^2 \frac{d\Phi_\nu}{dE_\nu} \geq \begin{cases} 7.7\ 10^{-8} \\ 3.9\ 10^{-8} \end{cases} \text{GeV cm}^{-1}\ \text{s}^{-1}\ \text{sr}^{-1} \ \text{for} \begin{cases} E_\mu > 50\ \text{TeV} \\ E_\mu > 125\ \text{TeV} \end{cases} \text{after} \begin{cases} 1\ \text{year} \\ 3\ \text{years} \end{cases}$$

- – Effect of the prompt neutrino component
  Relatively small (~ 15%)

- – ANTARES sensitivity will be equivalent to AMANDA II