Search for Extragalactic Contributions to the Atmospheric Neutrino Flux

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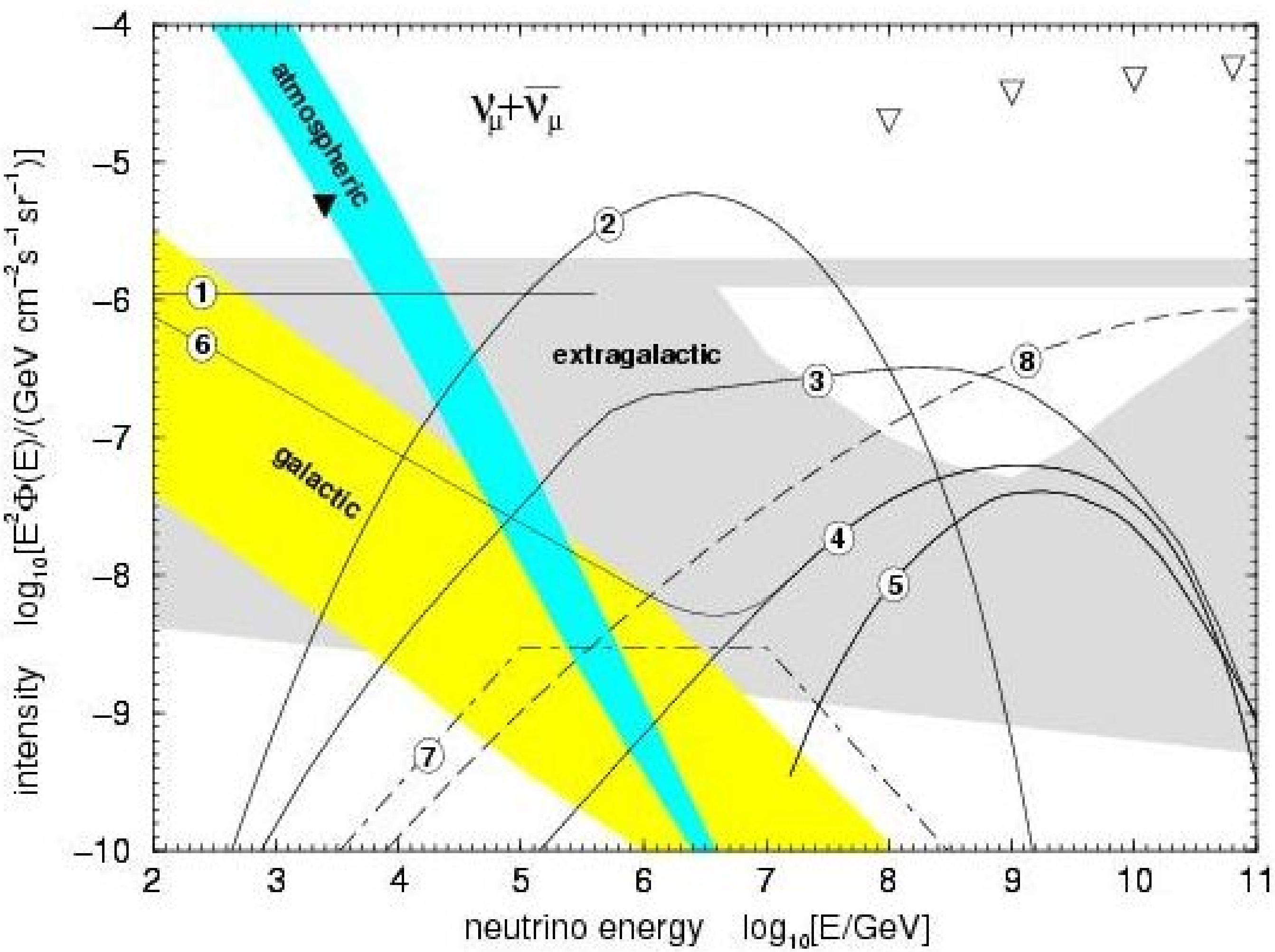
Overview



<u>Atmospheric neutrino flux:</u>

decreases with $E_\nu^{-3.7}$

Search for <u>extraterrestric contribution</u>

predicted energy spectrum E_ν^{-2}

AGN (1- 4, 6)

CMBR neutrinos (5)

GRB (7)

topol.defects

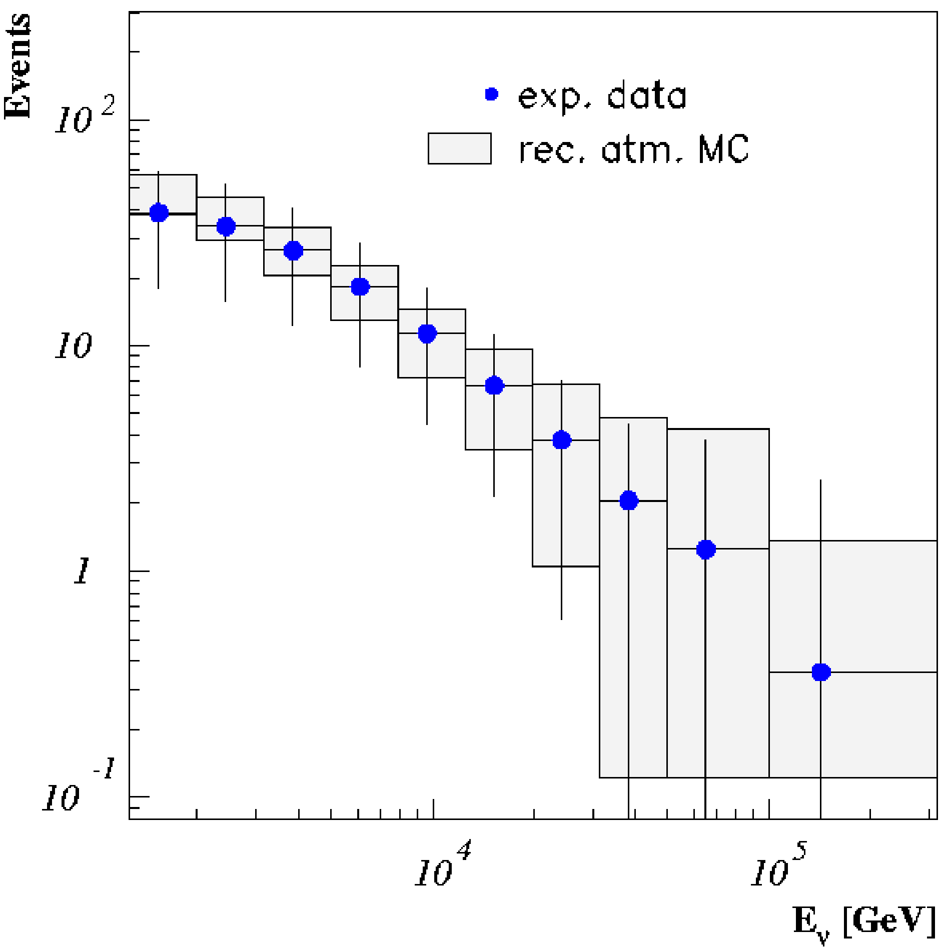
Overview

- Atmospheric neutrino flux decreases with $E_\nu^{-3.7}$
- Search for **extraterrestric contribution**
  - predicted energy spectrum E_ν^{-2}
- Diffuse neutrino flux measured with combination of **neural network** and **regularized unfolding**
- Setting an upper limit on extraterrestrial contribution
- Application of a confidence interval construction to the unfolding problem

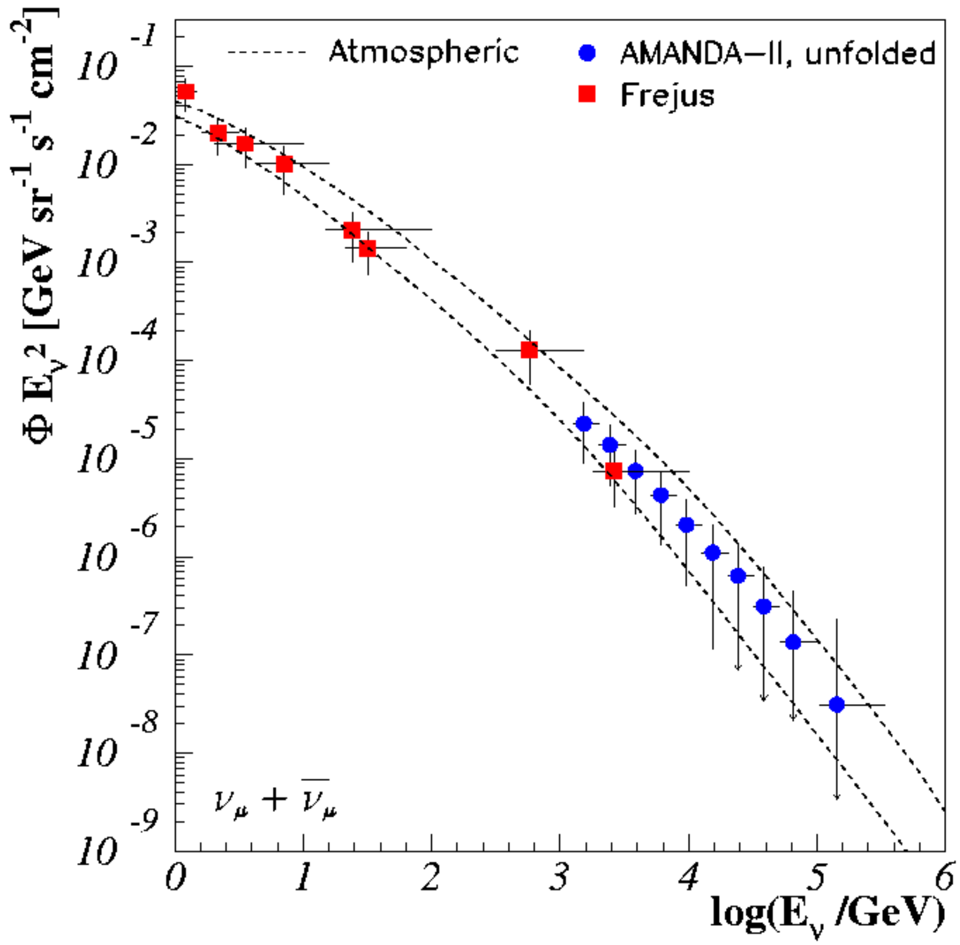
AMANDA year 2000 data

Reconstructed and unfolded

neutrino energy spektrum



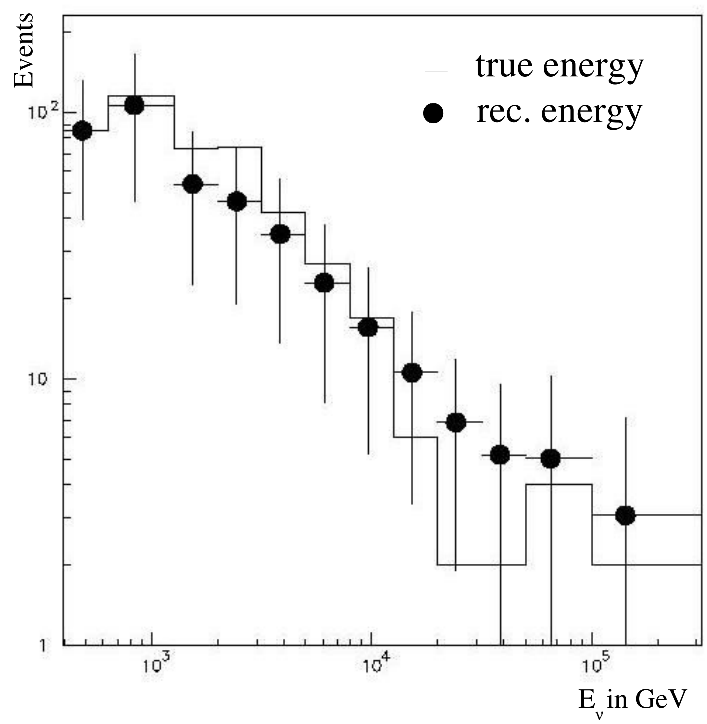
neutrino fluxes



Confidence Belt Construction

- 90% confidence belt construction (Feldman & Cousins) applied to an unfolding problem
- Generate individuell probability density funcions – pdf
- Monte Carlo for 21 different signal contributions **μ**
- **μ = flux Φ • E^2**
- Reconstruction and unfolding of the energy

10^{-7} E^2 GeV/cm^{2}s sr

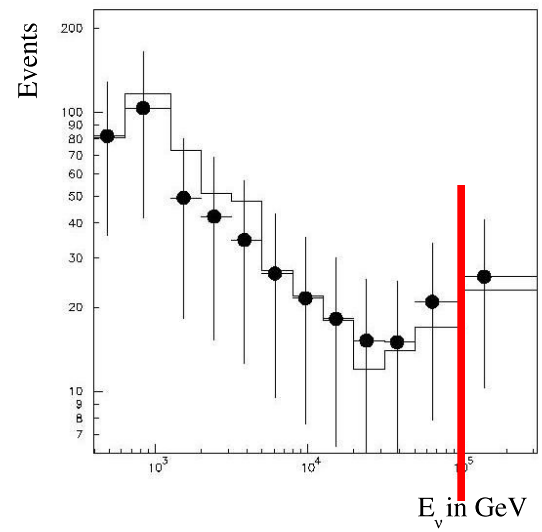


- **10^{-8}** GeV cm^{-2}s^{-1} sr^{-1} $\leq$ **μ** $\leq$ **10^{-6}** GeV cm^{-2}s^{-1} sr^{-1}

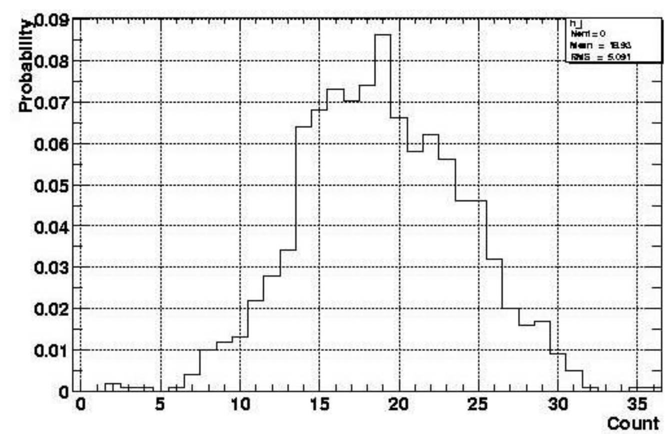
Constructing the pdf

- For each **fixed** signal contribution μ_i
- Plot the **energy distribution** for each of the 1000 one-year MC experiments
- Place an **energy cut** (100 TeV < E < 300 TeV) and count the event rate
- **Histogram** the **event rate**
- **Normalize** the histogram

e.g. $\mu = 2*10^{-7}$ GeV cm^{-2}s^{-1} sr^{-1}

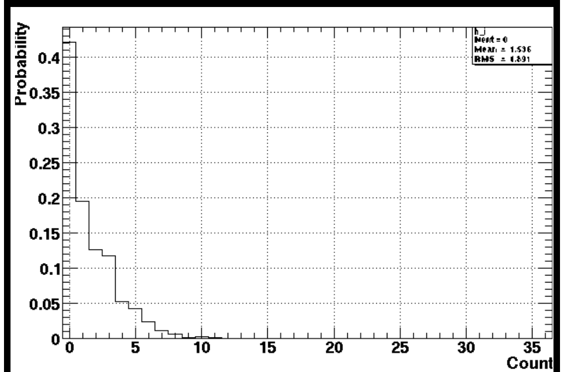


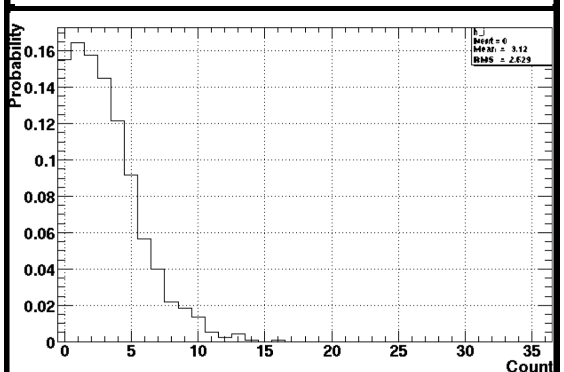
1000 times

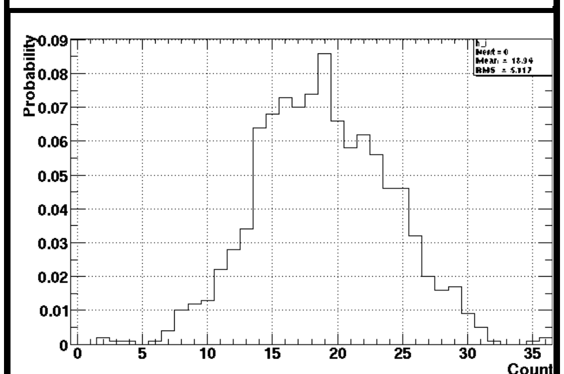


Constructing the probability table

PDF







	$n_1=0$	$n_2=1$	$n_3=2$	...
$\Rightarrow$ $P(n\|\mu_1=10^{-8})$	0.42	0.19	0.13	...
$\Rightarrow$ $P(n\|\mu_2=2\cdot 10^{-7})$	0.15	0.16	0.15	...
$\Rightarrow$ $P(n\|\mu_3=10^{-6})$	0.00	0.002	0.001	...

Find $P_{\mu\text{-max}}(n)$

probability table:

	n_1	n_2	...
μ_1	$P(n_1 \mid \mu_1)$	$P(n_2 \mid \mu_1)$	...
μ_2	$P(n_1 \mid \mu_2)$	$P(n_2 \mid \mu_2)$	...
...	...	...	...

$\mathbf{P_{\mu\text{-max}}(n_1)}$

1. Estimate $\mathbf{P_{\mu\text{-max}}(n)}$ for each counting rate n by using the probability table

Constructing the ranking table

probability table:

	n_1	n_2	...
μ_1	$P(n_1 \mid \mu_1)$	$P(n_2 \mid \mu_1)$	...
μ_2	$P(n_1 \mid \mu_2)$	$P(n_2 \mid \mu_2)$	...
...	...	...	...

1. Estimate $P_{\mu\text{-max}}(n)$ for each counting rate n by using the probability table

$$\mathbf{R(n|\mu) = P(n_1|\mu) / P_{\mu\text{-max}}(n_1)}$$

2. Calculate the ranking factor (likelihood-ratio)

$$\mathbf{R(n|\mu)} = P(n|\mu)/P_{\mu\text{-max}}(n)$$

Using the ranking table

probability table:

	n_1	n_2	...
μ_1	$P(n_1 \mid \mu_1)$	$P(n_2 \mid \mu_1)$	...
μ_2	$P(n_1 \mid \mu_2)$	$P(n_2 \mid \mu_2)$	...
...	...	...	...

1. Estimate **$P_{\mu\text{-max}}(n)$** for each counting rate n by using the probability table
2. Calculate the ranking factor (likelihood-ratio) **$R(n|\mu)$** $= P(n|\mu)/P_{\mu\text{-max}}(n)$

ranking table:

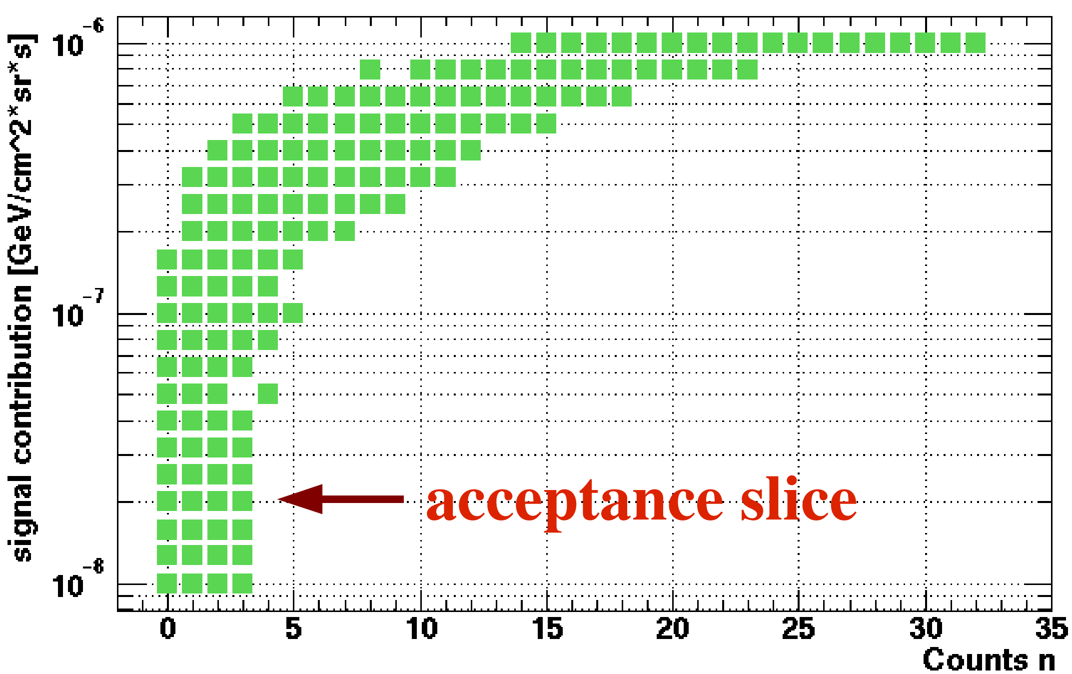
	n_1	n_2	...
μ_1	$R(n_1 \mid \mu_1)$	$R(n_2 \mid \mu_1)$	...
μ_2	$R(n_1 \mid \mu_2)$	$R(n_2 \mid \mu_2)$	...
...	...	...	...

Rank (highest first)

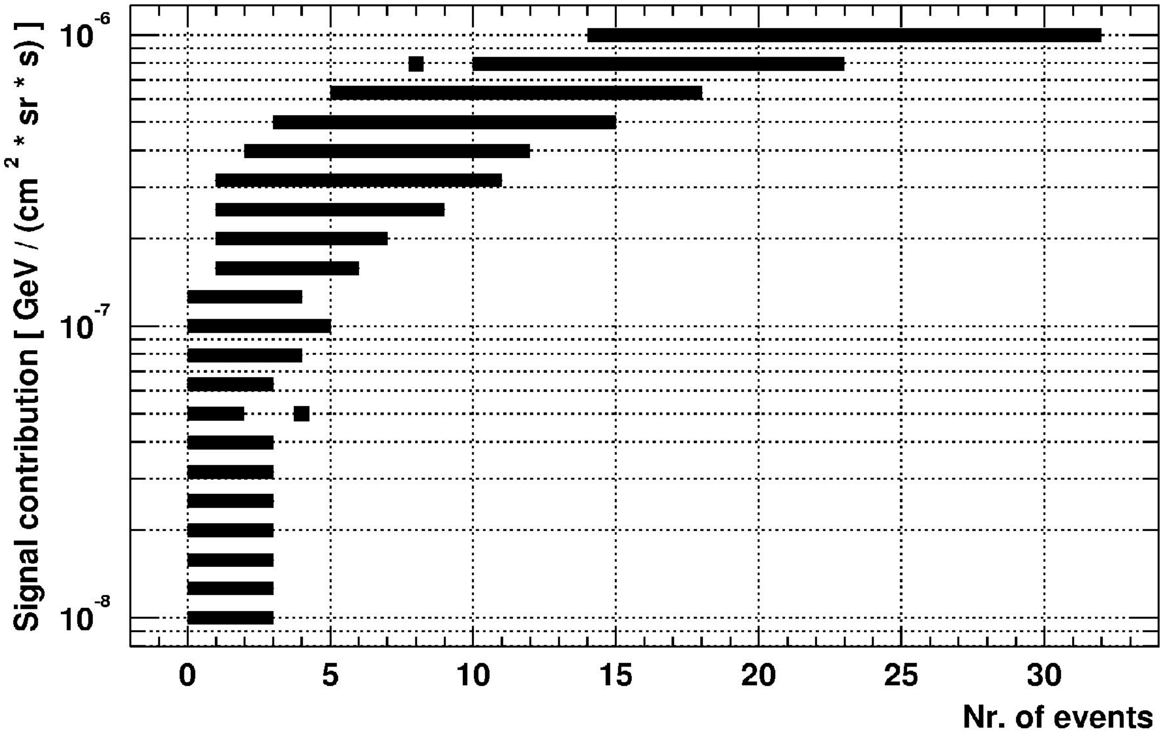
3. **Rank** the entries **n** for each signal contribution

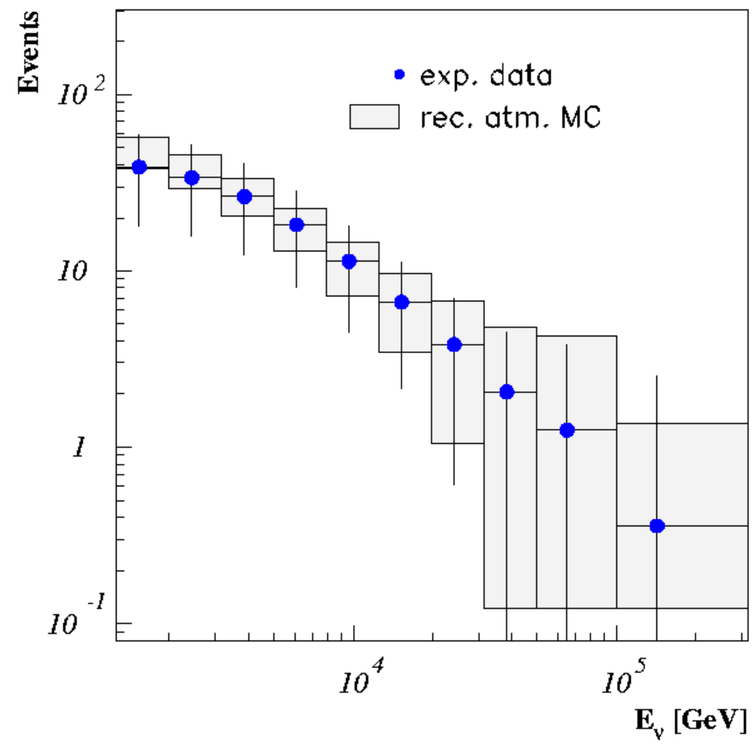
Constructing a confidence belt

4. **Include** for each fixed μ all counts **n** until the wanted degree of belief is reached
5. Plot the **acceptance slice** for the fixed μ



90% F.C. Confidence Belt





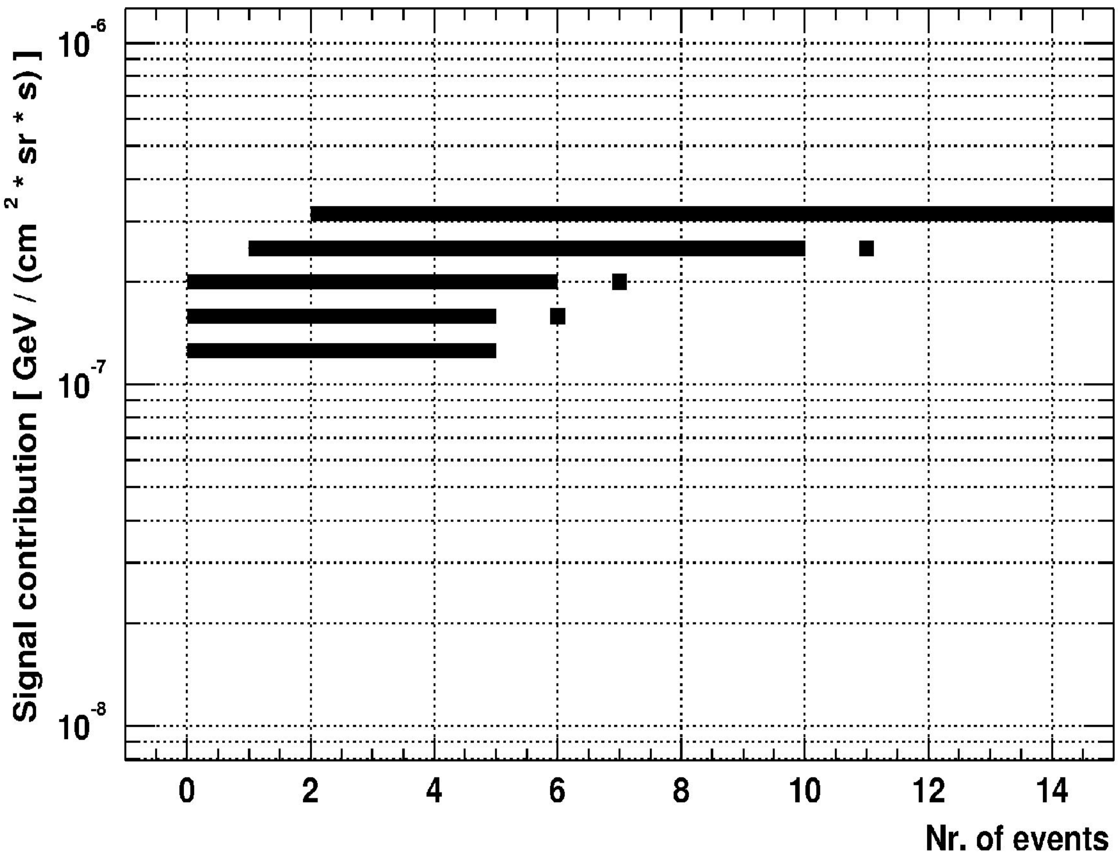
Year 2000 data:

- **0.36 events in the energy range of 100 TeV < E < 300 TeV**

Confidence belt was build by using integer events numbers

Enlarge the number of MC events by a factor of 10

90% F.C. Confidence Belt



Smaller binning

Confidence belt with higher statistics and more signal contributions in the event rate region of the data.

- $1.26*10^{-7}$ GeV $cm^{-2}s^{-1}$ sr^{-1} $\leq \mu \leq$ $3.16*10^{-7}$ GeV $cm^{-2}s^{-1}$ sr^{-1}
- $\Phi \bullet E^2 = 2.0*10^{-7}$ **GeV $cm^{-2}s^{-1}$ sr^{-1}**

Estimation of the syst. error

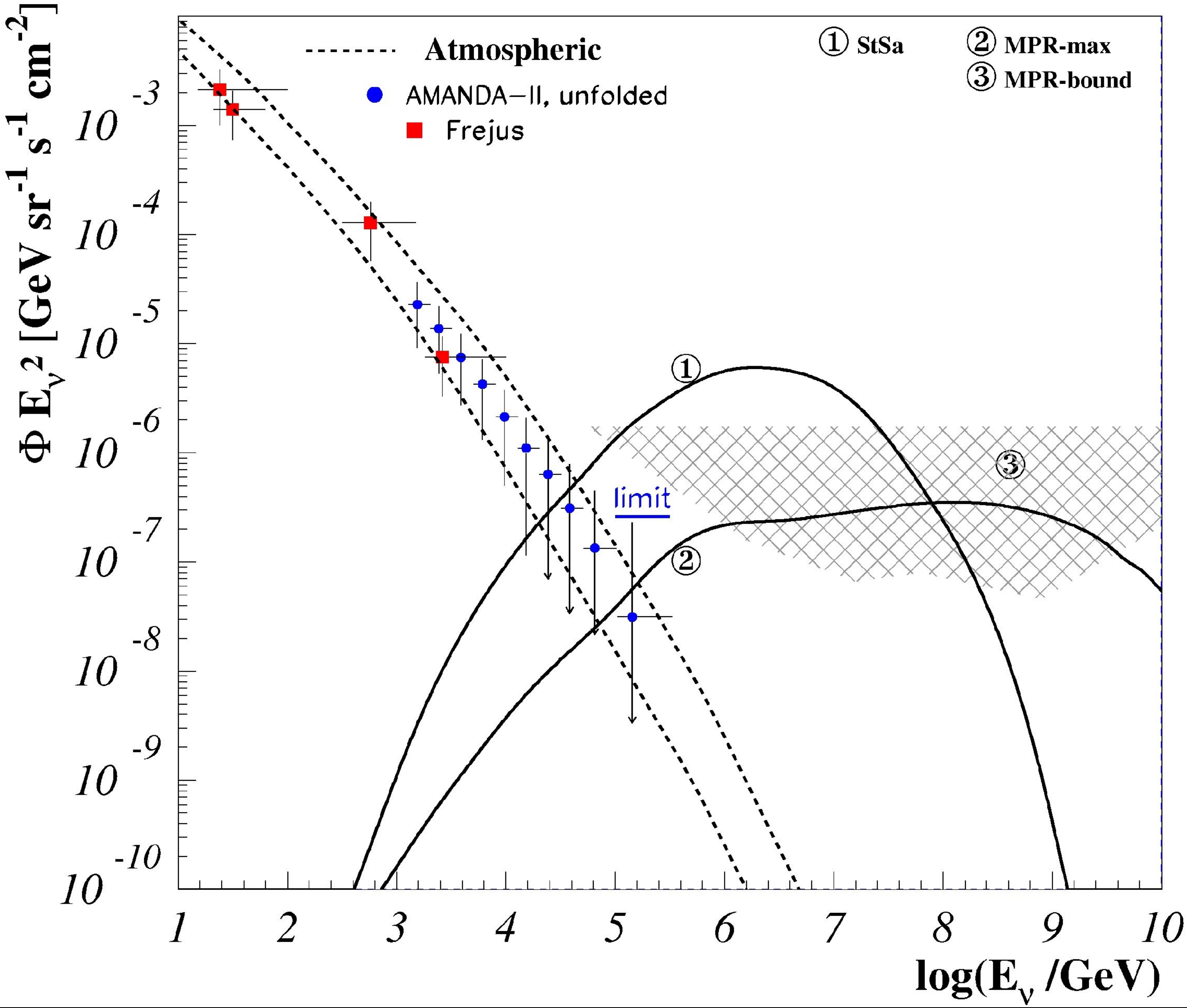
<u>Systematic error is the dominanting error source</u>

- disagreement of the depth intensity relation **< 10%**
  (product of energy loss * propagation * detection probability)
- uncertainty of the ν_μ to μ cross section **~ 10%**
- possible contamination of the data set
  - → flux might be too high up to **7%**
- uncertainty of the atmospheric neutrino flux: **25%**

➡ **<u>systematic error:</u> 30%**

$$\boxed{\Phi \bullet E^2 = 2.6*10^{-7}\ \mathrm{GeV\ cm^{-2} s^{-1}\ sr^{-1}}}$$

Extragalactic Contribution Limit



Summary

- Confidence interval construction applied to an unfolding problem
- Individuell pdf build from MC
- Energy cut for the 90% confidence belt construction: 100 TeV < E < 300 TeV
- Energy reconstruction and unfolding of the point source dataset (year 2000) leads to 0.36 counts after energy cut
- Systematic error of 30% estimated
- **Upper limit on extraterrestrial contribution:**

$$\Phi \bullet E^2 = 2.6 * 10^{-7} \text{ GeV cm}^{-2} \text{s}^{-1} \text{ sr}^{-1}$$

http://app.uni-dortmund.de/~muenich