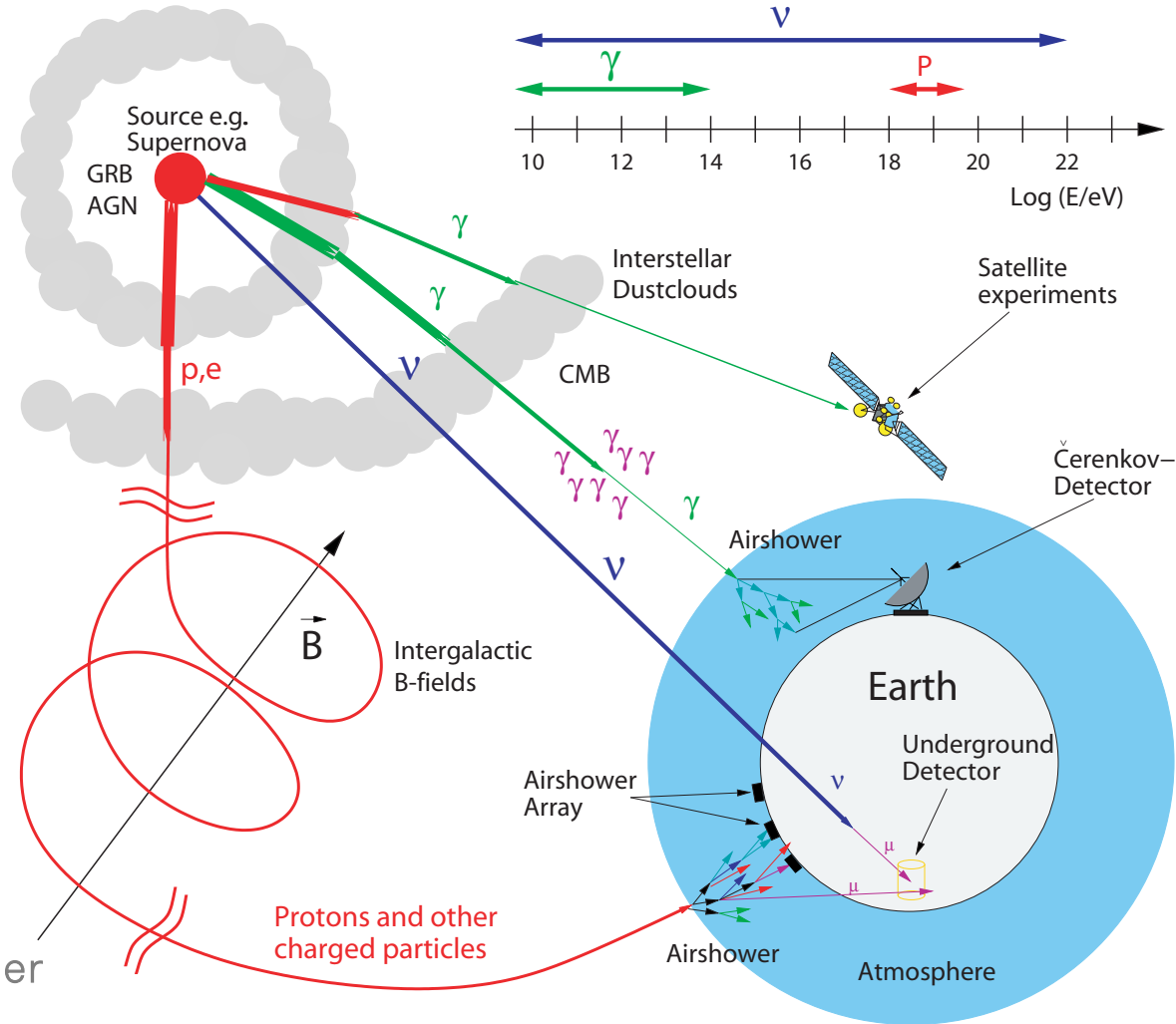

Synergies between the FPF and Neutrino Observatories

Tim Ruhe, TU Dortmund, tim.ruhe@tu-dortmund.de

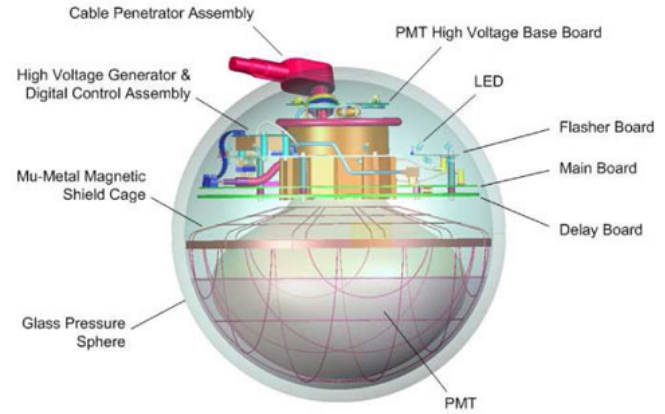
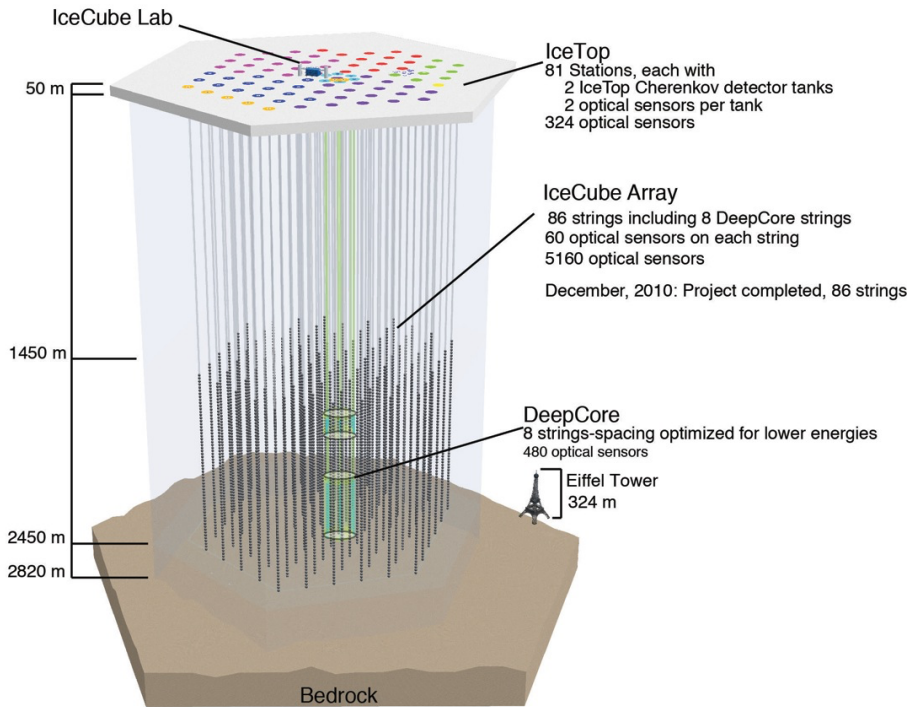
4th Forward Physics Facility Meeting

Why?

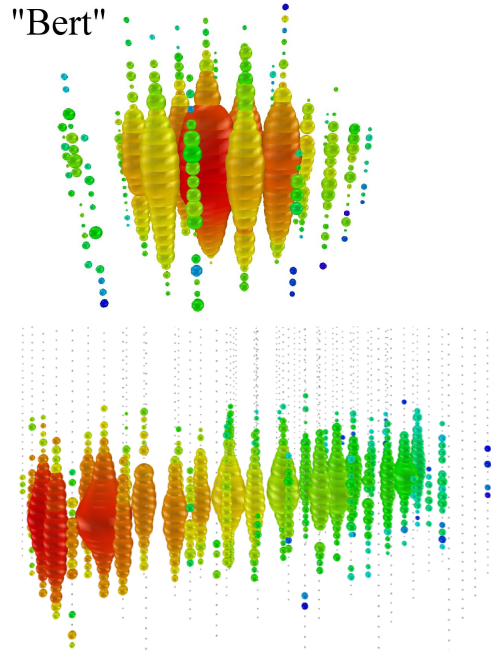


Credit: Wolfgang Wagner

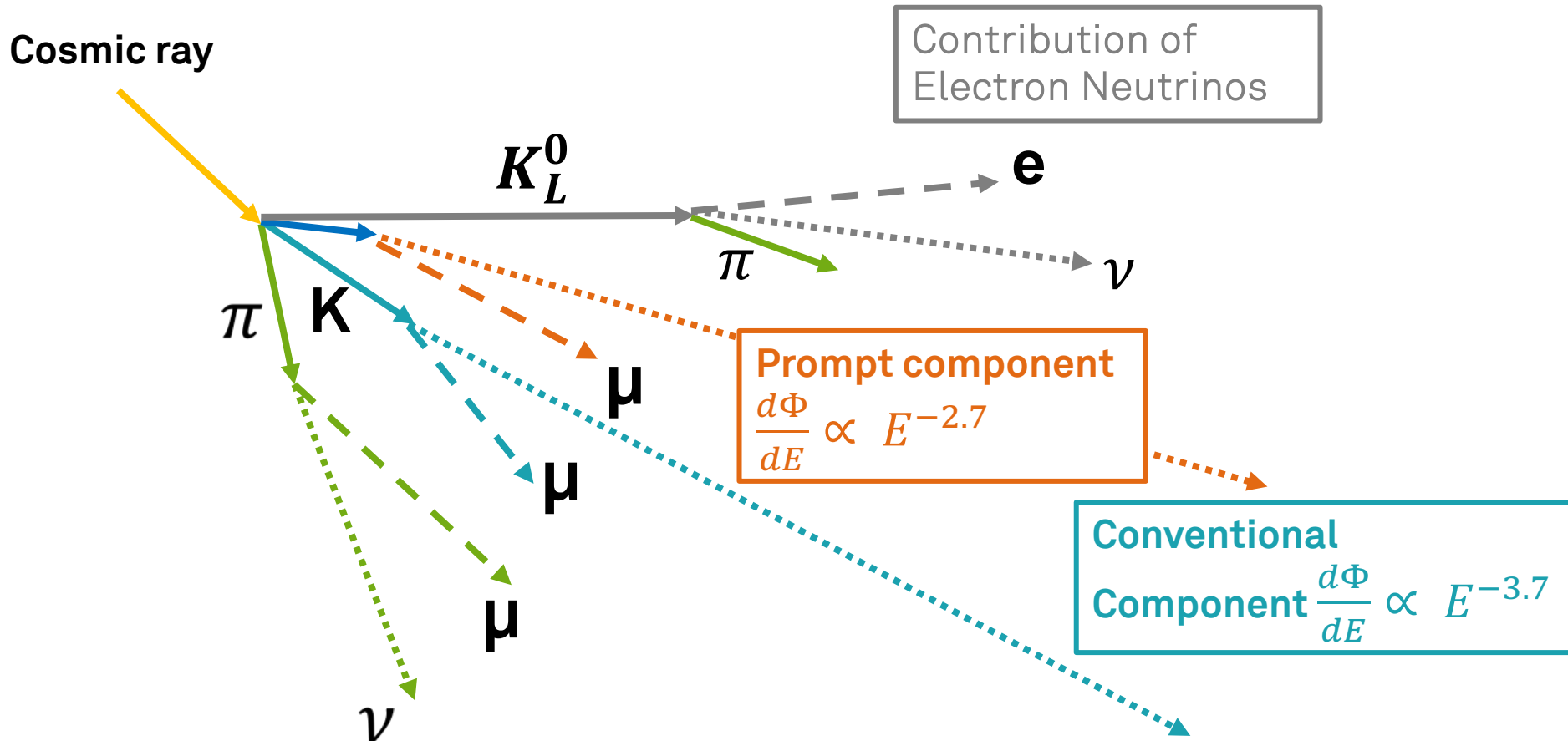
Neutrino Observatories



"Bert"

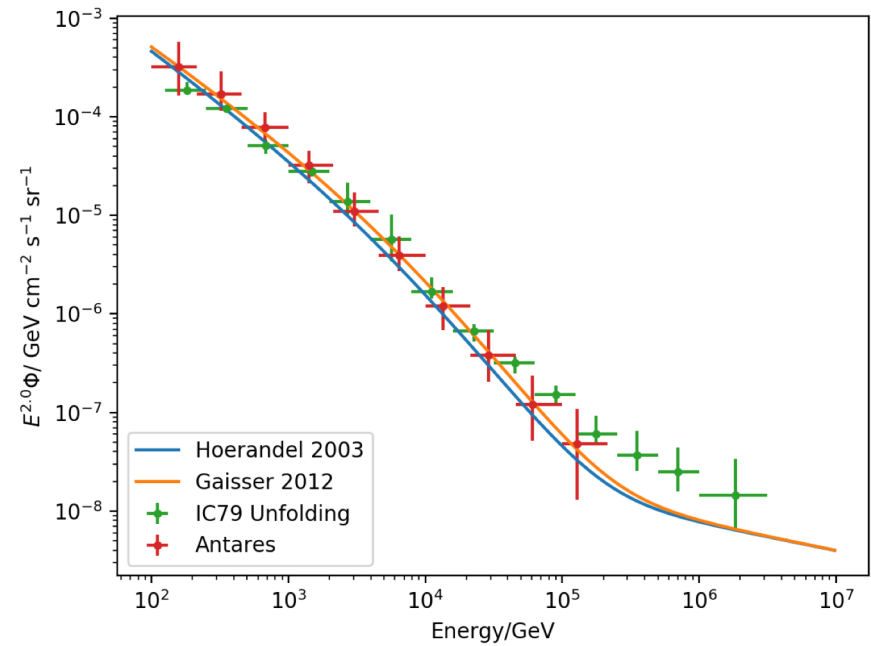
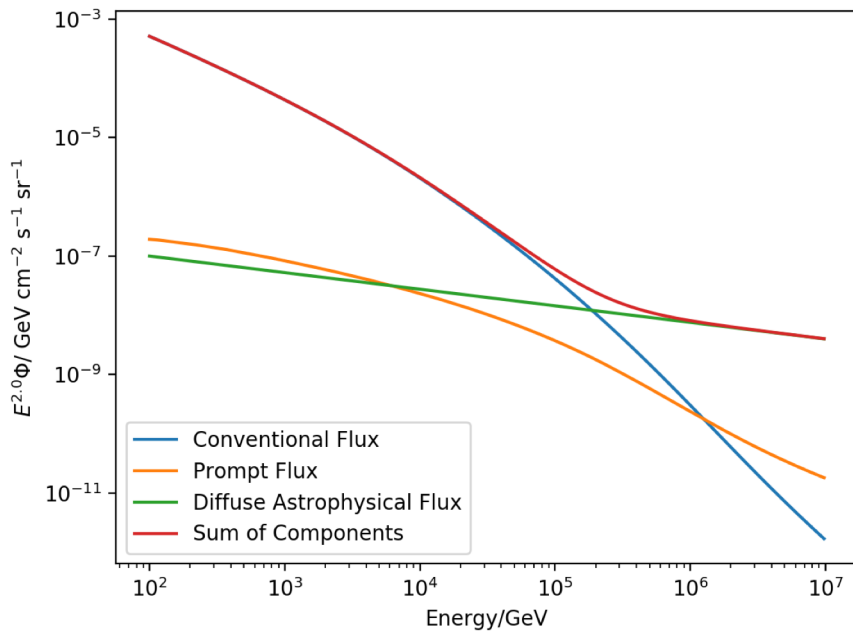


Atmospheric Neutrinos

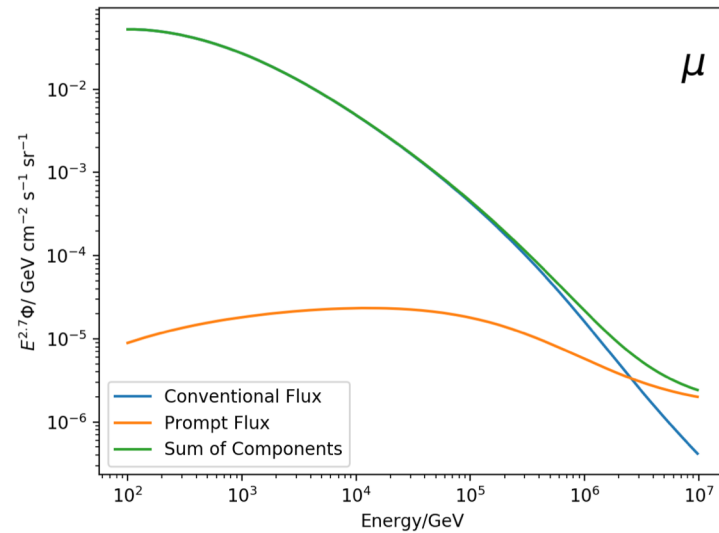
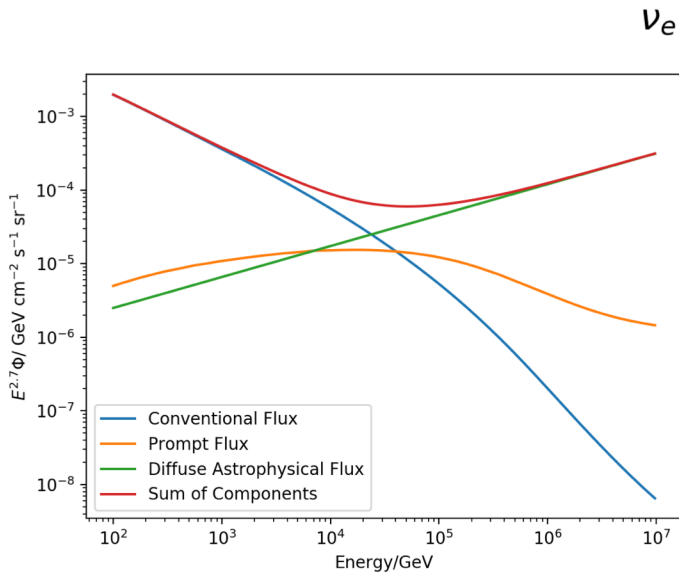


Atmospheric Neutrino Spectra

ν_μ



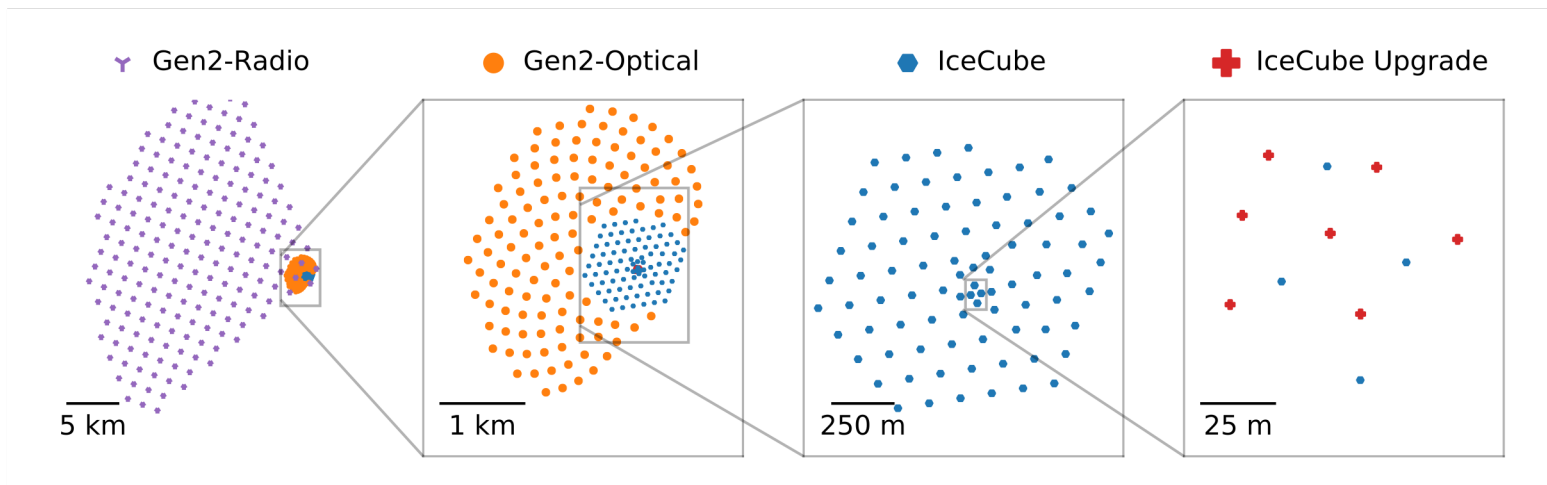
Muons and Nue



Future Neutrino Observatories

- One order of magnitude increase in cosmic neutrinos
- Improved angular resolution
- Detectable sources are 5 times fainter
- 156 day flare of TXS-0506+056 visible with 13 sigma without coincident detection of gammas

Will enable detailed studies of source classes or even individual sources.



Deconvolution in a Nutshell

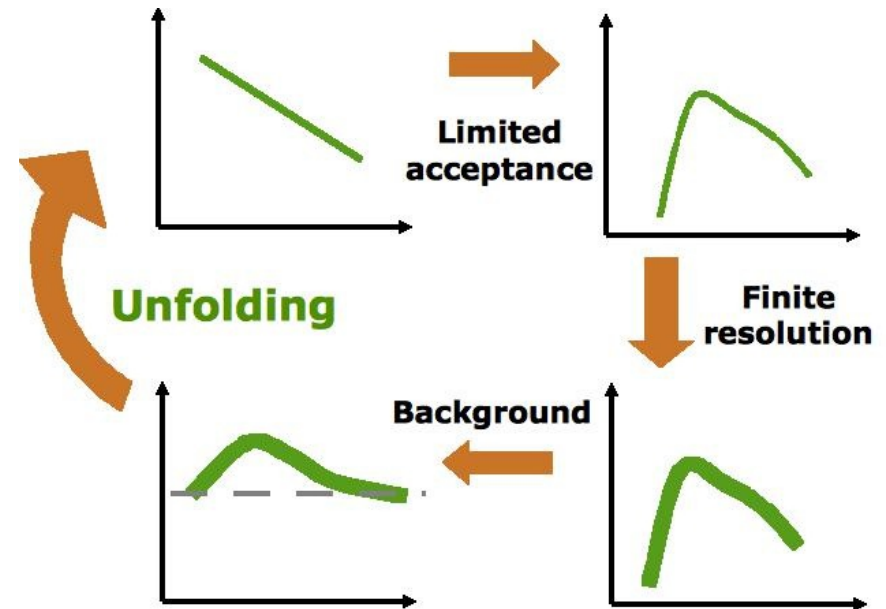
$$\underbrace{\frac{dN_\mu}{dE_\mu}}_{\text{Muon energy spectrum}} = \int_{E_\mu}^{\infty} \underbrace{\left(\frac{dN_\nu}{dE_\nu}\right)}_{\text{Neutrino energy spectrum}} \underbrace{\left(\frac{dP(E_\nu)}{dE_\mu}\right)}_{\text{Physics of neutrino interaction}} dE_\nu$$

Muon energy spectrum

Neutrino energy spectrum

Physics of neutrino interaction

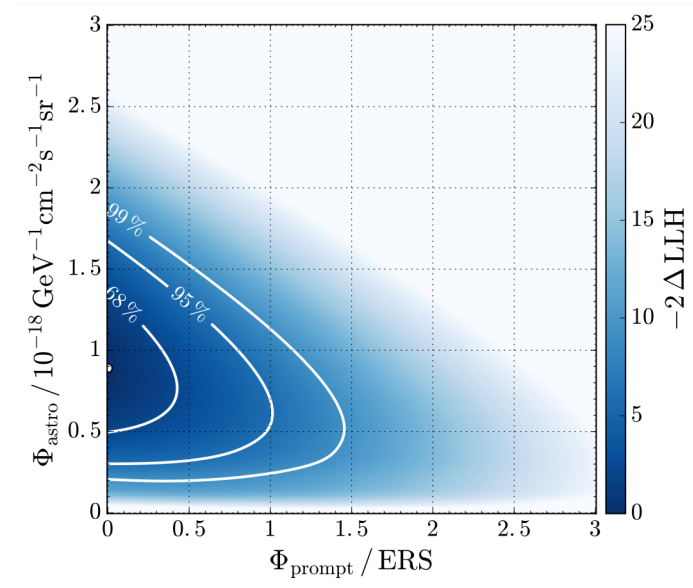
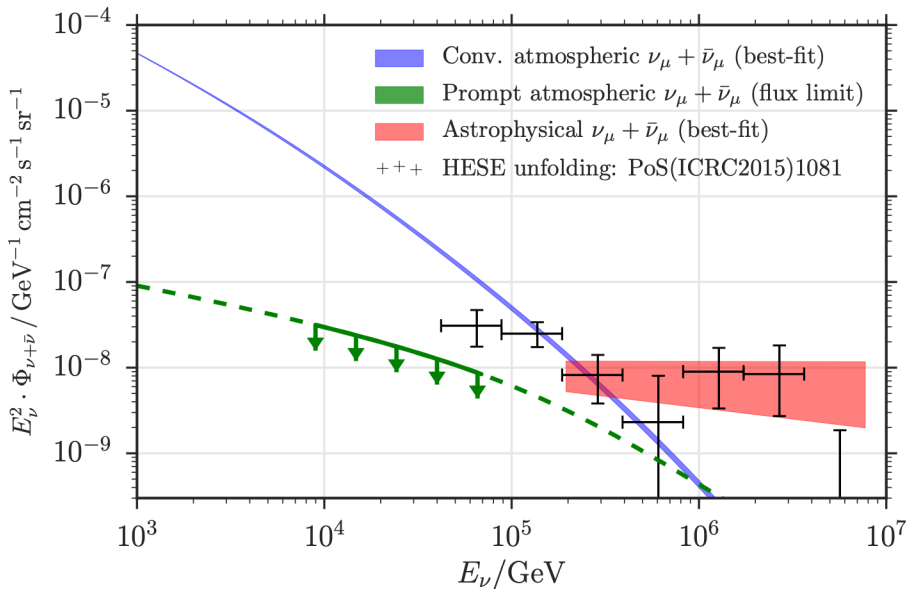
- Production of charged lepton in neutrino interaction is governed by stochastic processes
- Additional smearing, due to several detector effects



Mathematically: Fredholm integral equation of the first kind:

$$g(y) = \int_{E_{min}}^{E_{max}} A(E, y) f(E) dE + b(E)$$

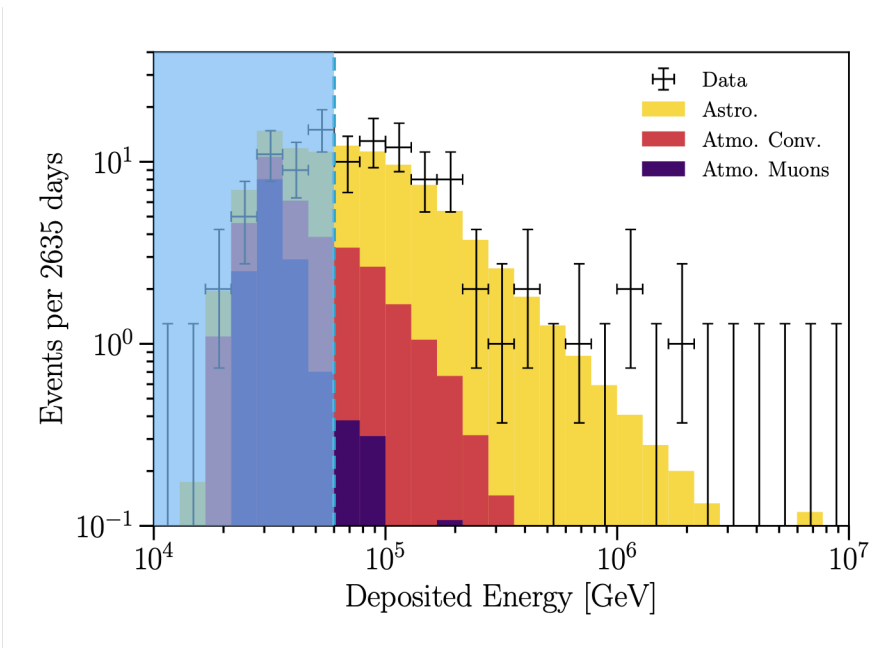
Experimental Results on the Prompt Component



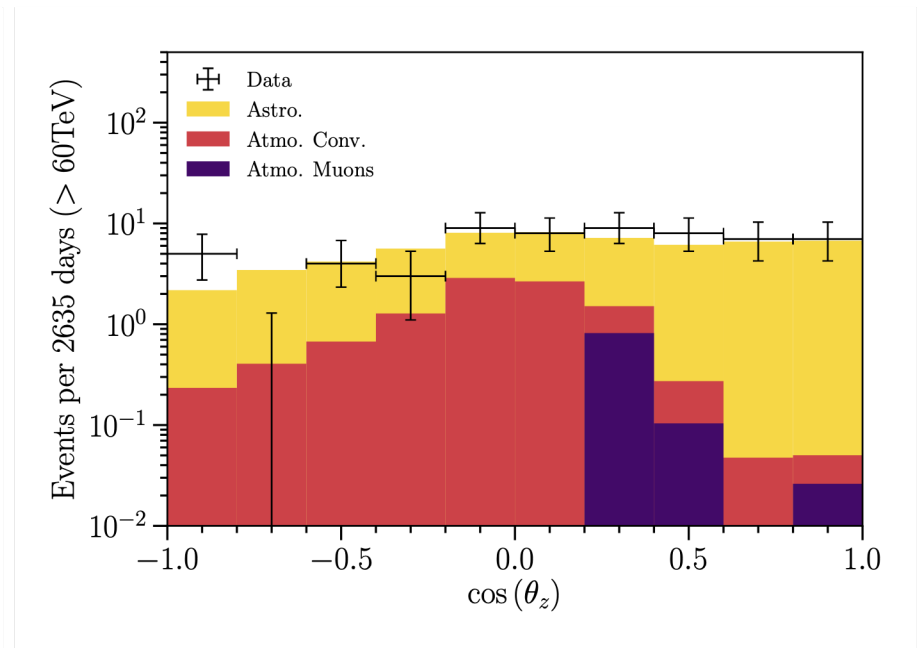
IceCube Collaboration: <https://arxiv.org/pdf/1607.08006.pdf>

$\Phi_{\text{prompt}} = 0.0$ Best Fit, 0.00 – 0.19 (68% Confidence Limit)

High Energy Starting Events

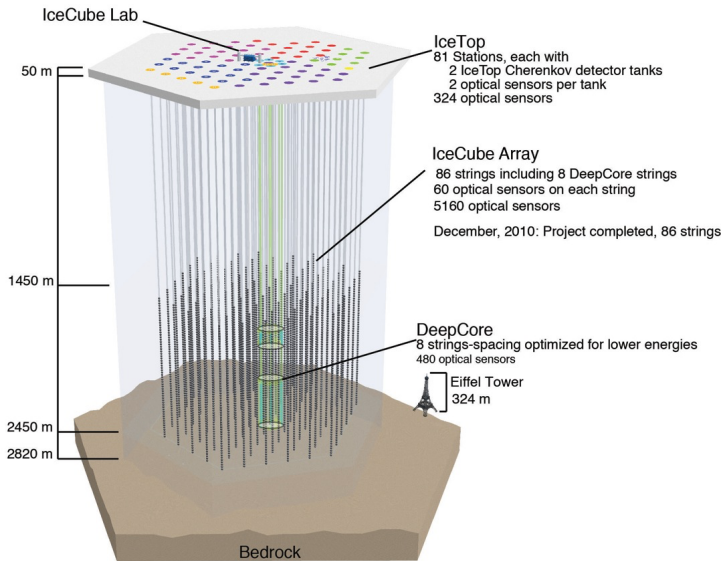


Source: <https://arxiv.org/pdf/2011.03545.pdf>



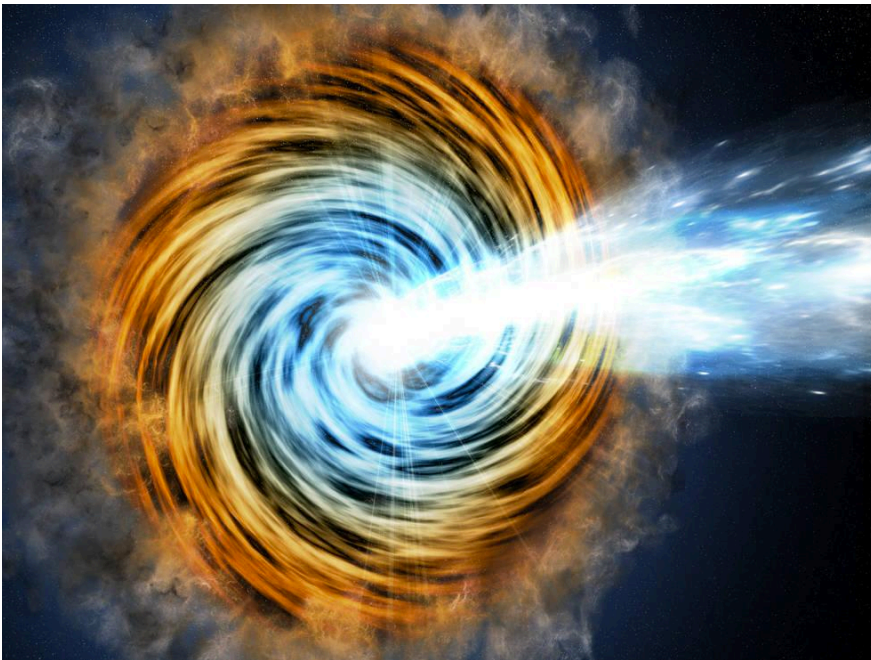
Well described by power law with index $\gamma = 2.87^{+0.20}_{-0.19}$

Searching for the Prompt Component



- High Energy Cascades ✓
- Diffuse Flux of Cosmic Neutrinos ✓
- Individual Neutrino Source ✓
- Prompt Atmospheric Neutrinos ✗

Studies of cosmic neutrino sources



- Future neutrino observatories will allow for more detailed studies of cosmic neutrino sources (e.g. acceleration mechanisms)
- Prompt component is a dominant background in these analyses
- Detailed modelling of the background is mandatory
- Models exist, but are still subject to rather large uncertainties
- Require input from experimental side
- FPF can contribute to a better understanding of prompt neutrinos