Neutrino Interaction Cross Section Using IceCube cascades Data

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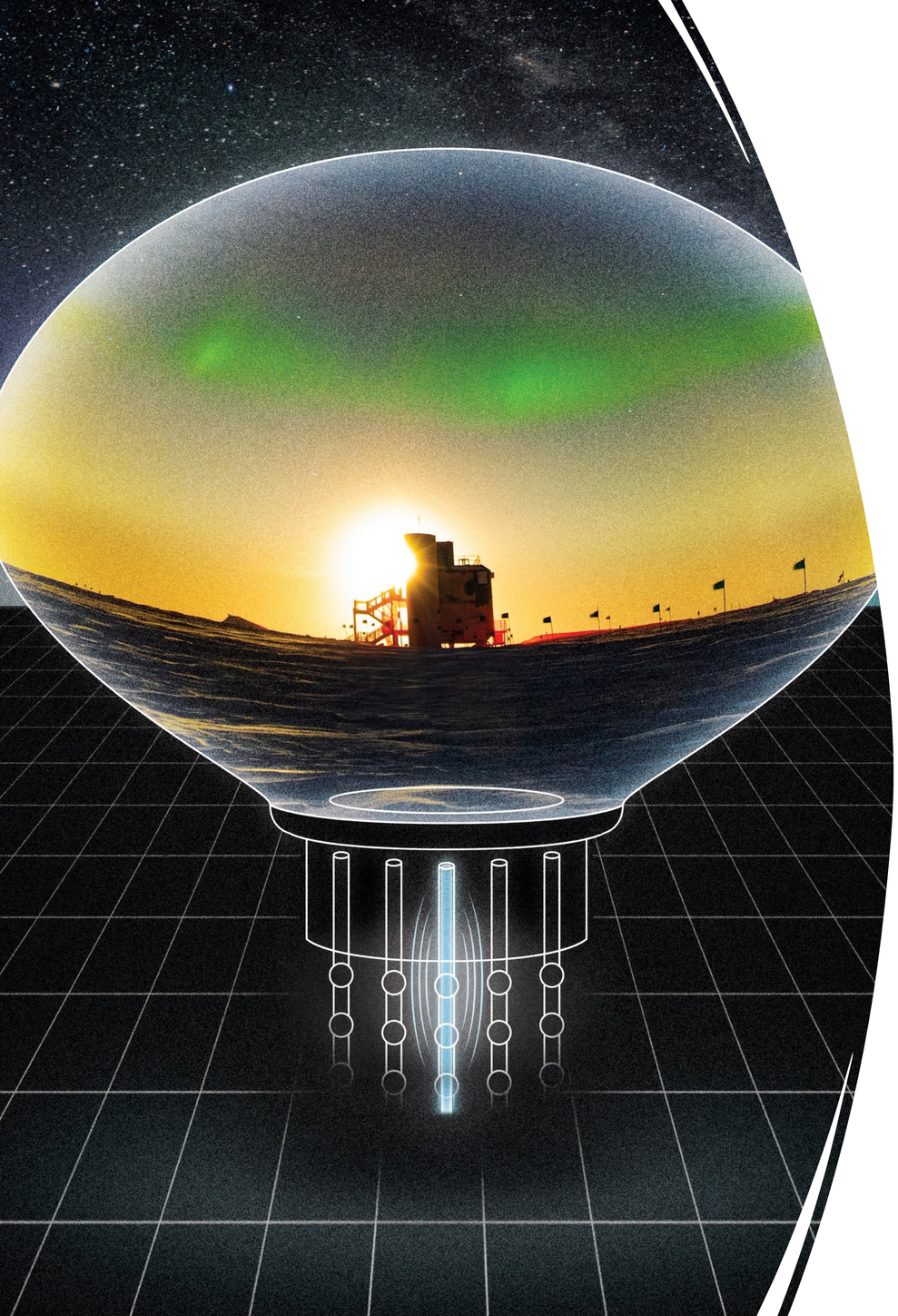


Outline

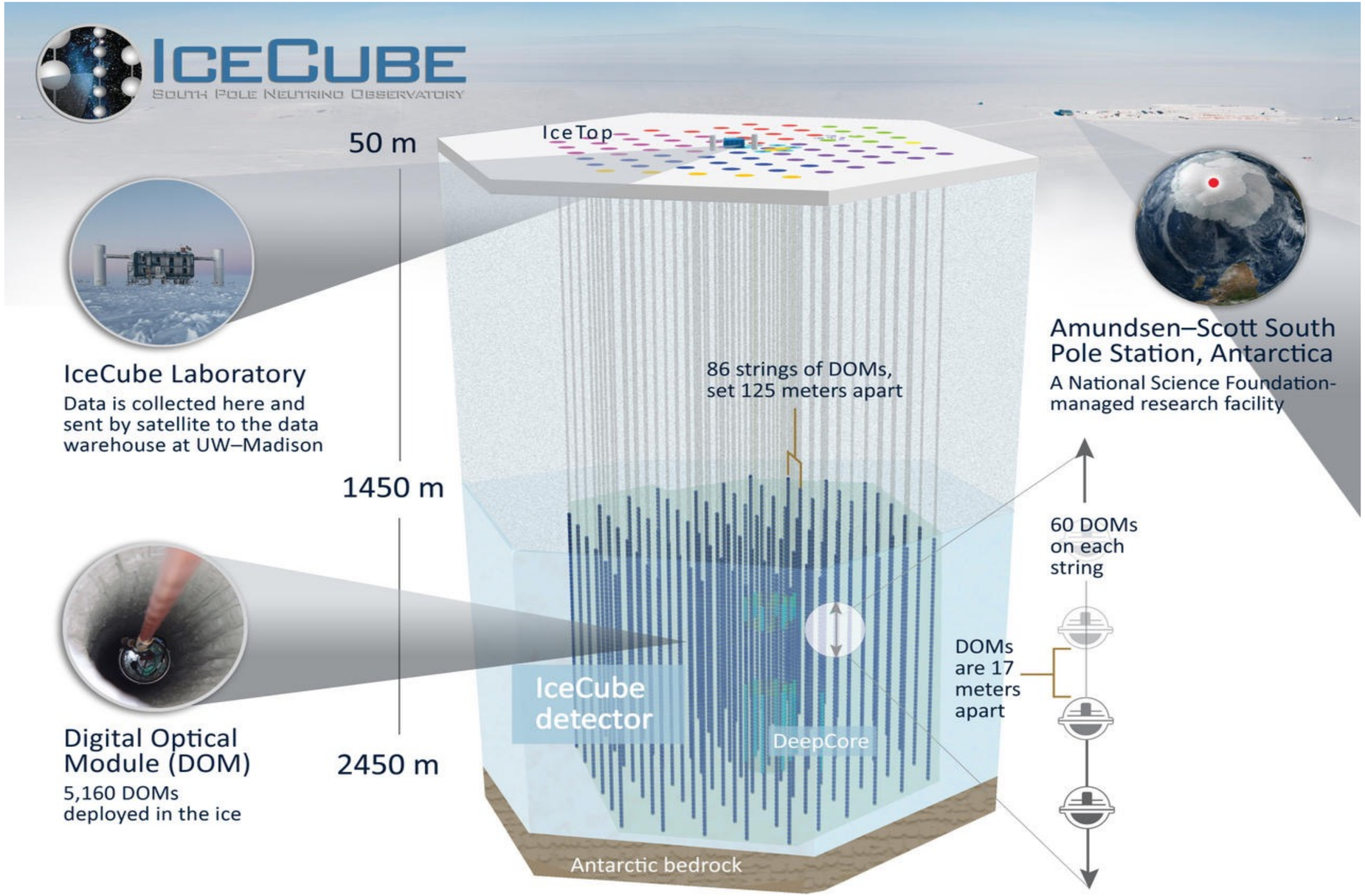
IceCube

Neutrino Interaction

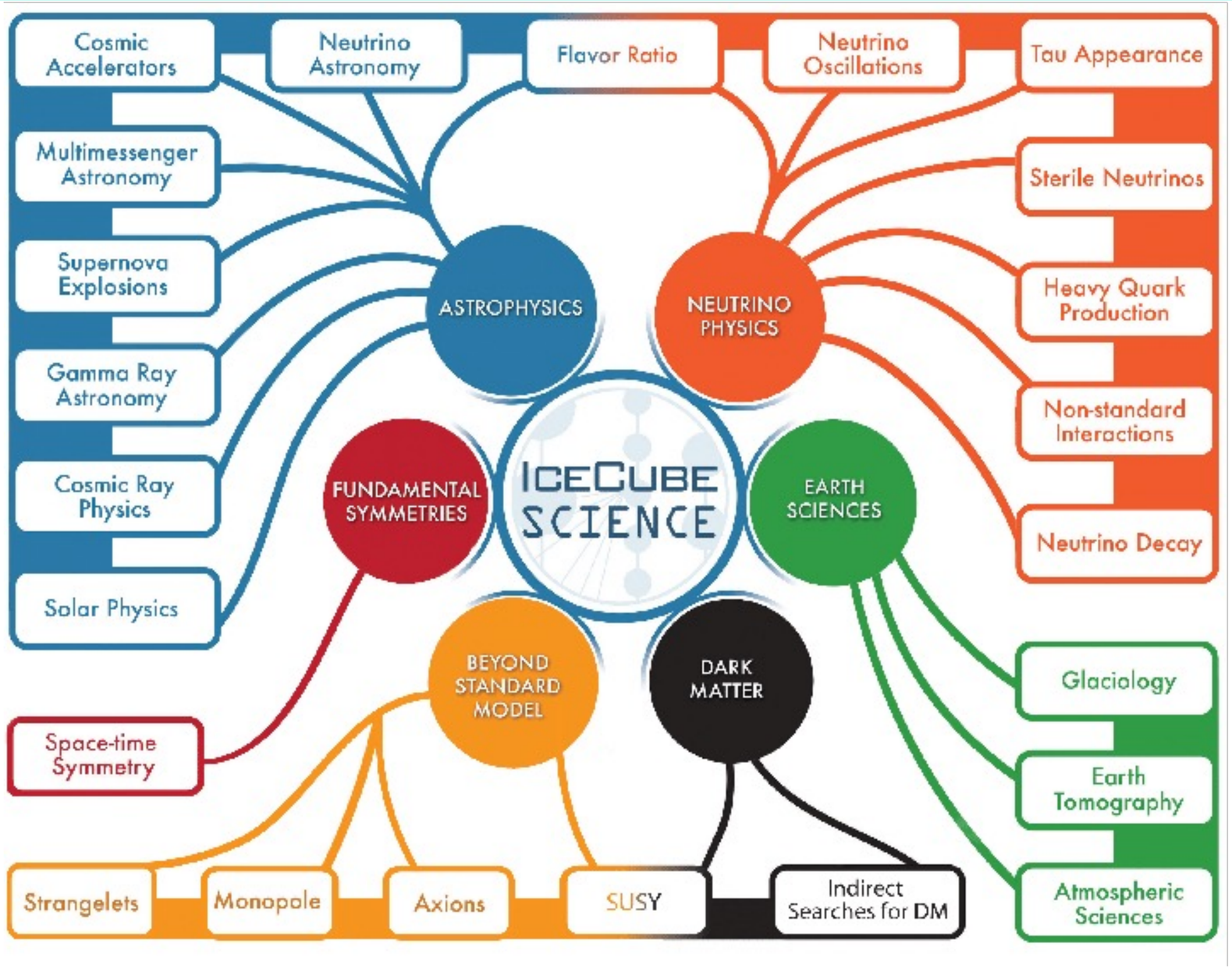
Analysis technique

MC Simulation (WIP)

IceCube Detector

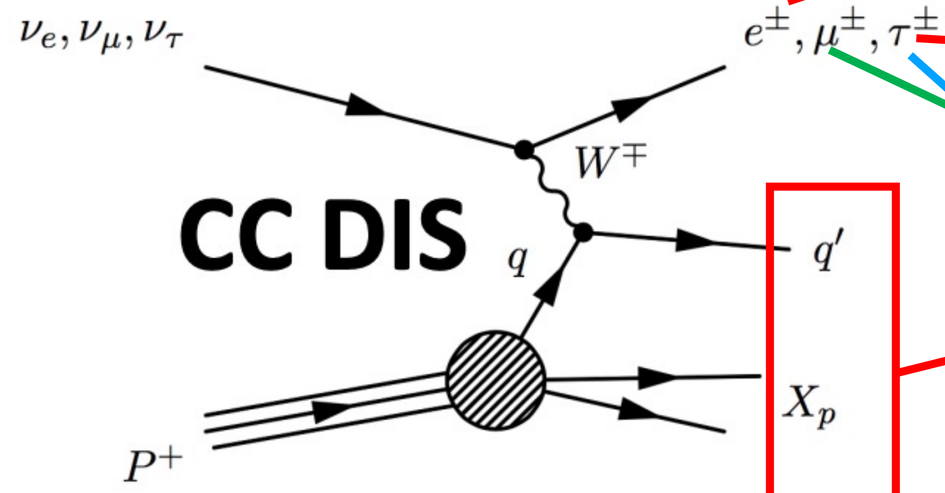


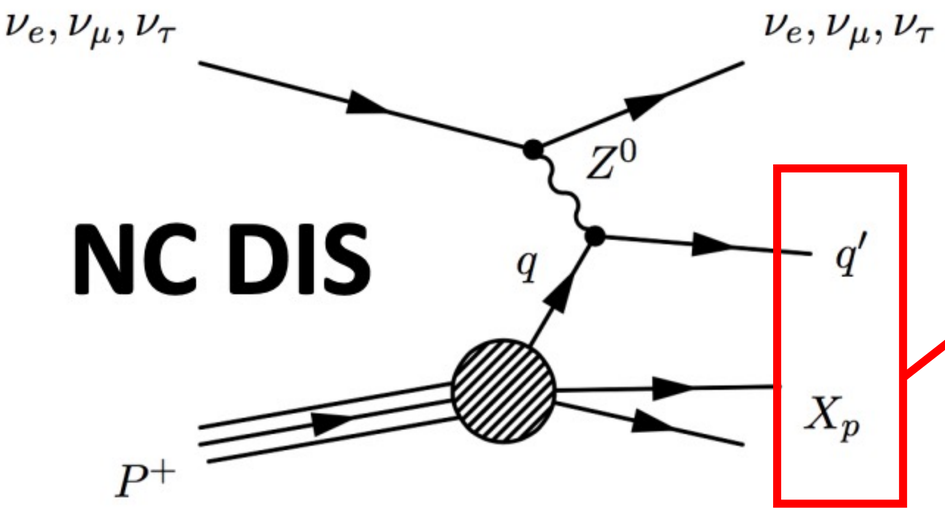
IceCube Science



Neutrino Interaction

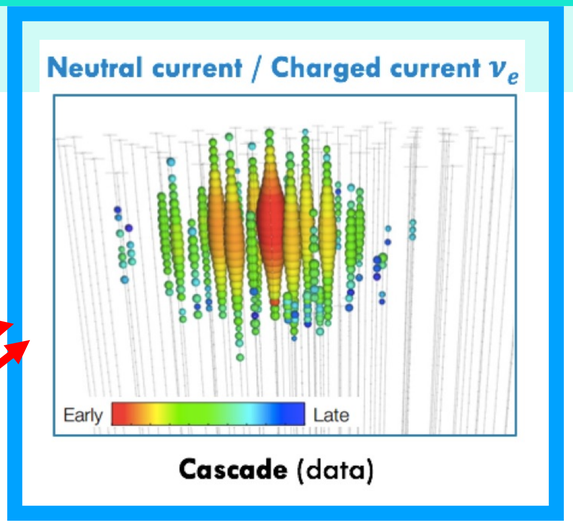
Neutrinos -> DIS -> charged secondaries -> Cherenkov Light (photons)



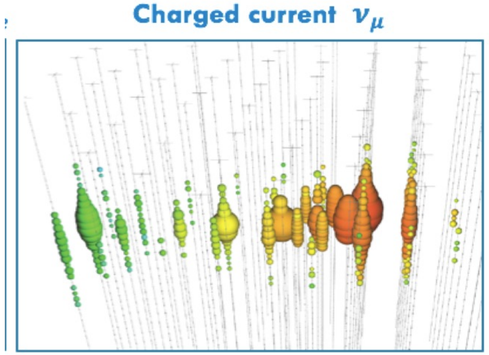


E<1PeV

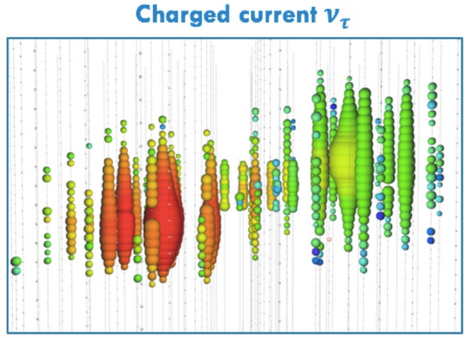
E>1PeV



Cascade (data)

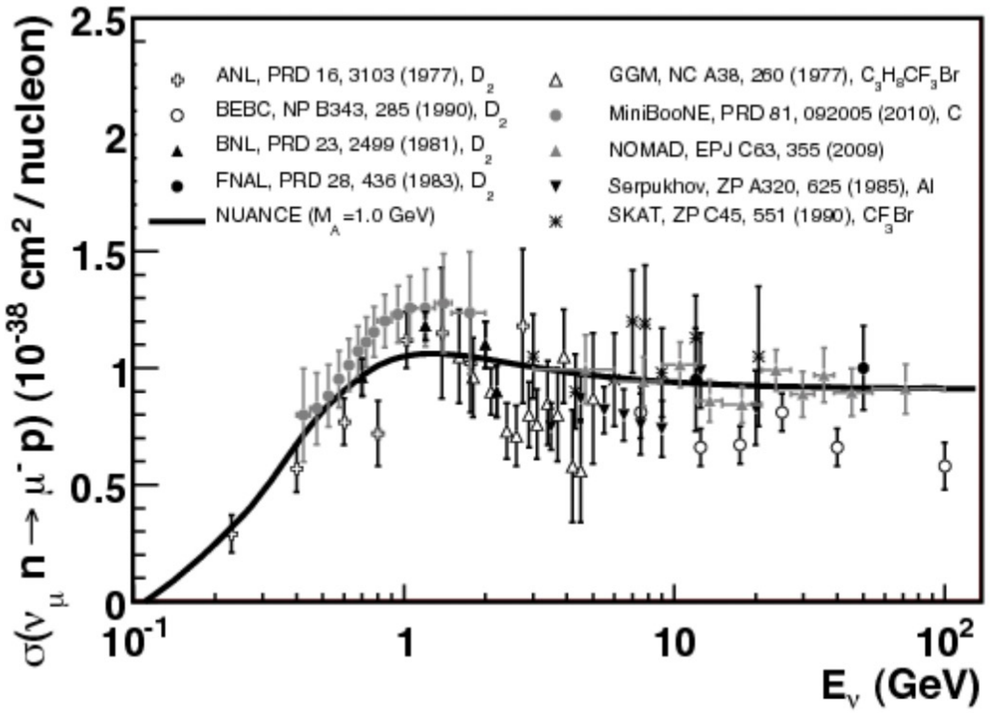


Track (data)



"Double-Bang" (simulation)

Motivation

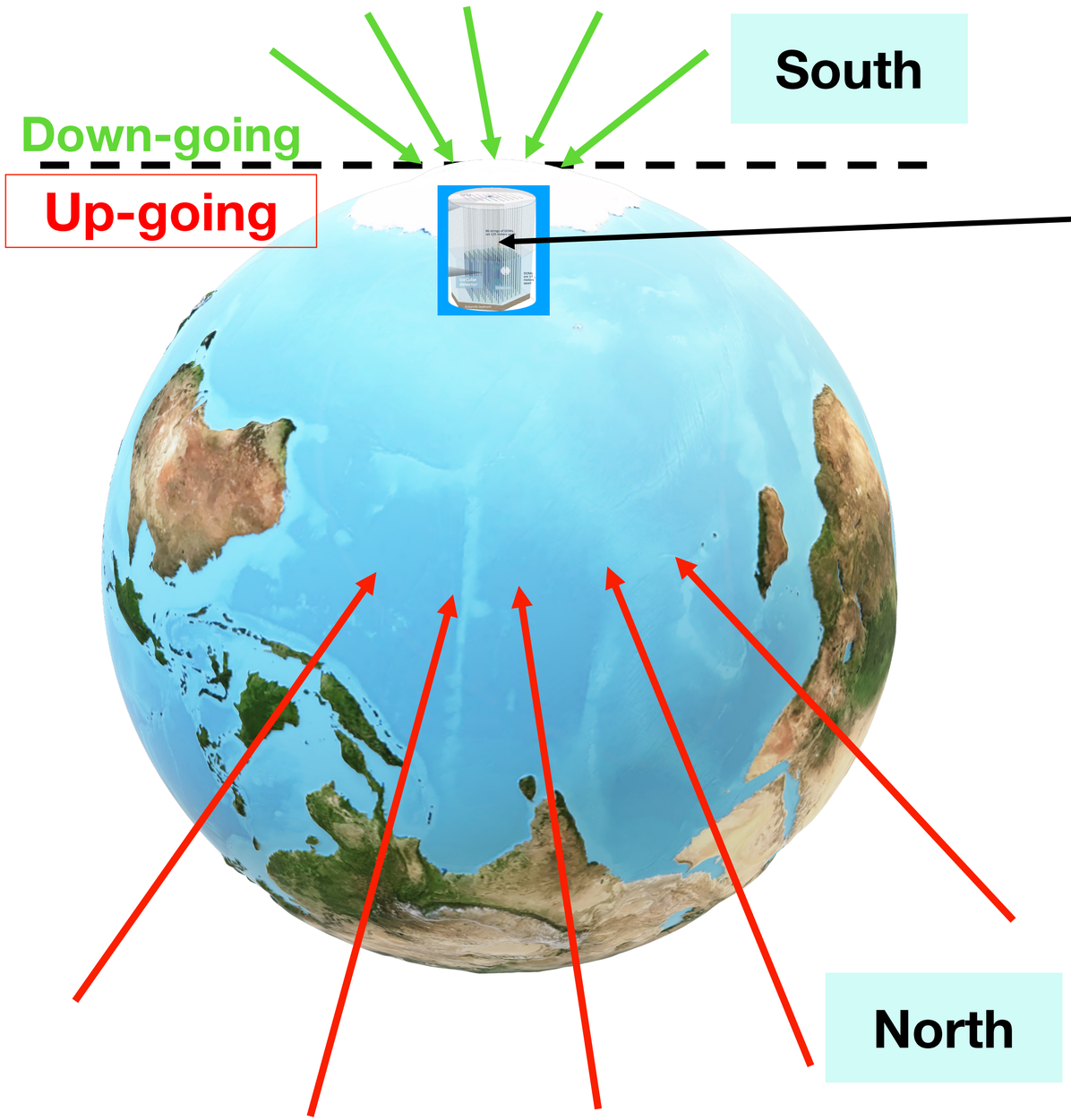


J.A. Formaggio, G.P. Zeller, Rev.Mod.Phys.84, 1307

Measurement of high energy

Analysis technique

Principle



With the increase of neutrino energy, the cross section increases. The up-going events get absorbed by the Earth.

Down-going : not affected by the Earth

Up-going : Earth absorption scales with cross section.

Analysis technique

Ratio

$$R(E_\nu) = \frac{N_{dw}(E_\nu)}{N_{up}(E_\nu)} = \frac{\int_{dw} \sum_i \Phi_\nu^i(E_\nu, \cos\theta_\nu) n_{ice} \sigma_{\mathrm{det}}^i(E_\nu) \mathrm{dcos}\,\theta_\nu}{\int_{up} \sum_i \Phi_\nu^i(E_\nu, \cos\theta_\nu) P_E^i\left(\sigma_E^i(E_\nu), \cos\theta_\nu\right) n_{ice} \sigma_{\mathrm{det}}^i(E_\nu) \mathrm{dcos}\,\theta_\nu}$$

Flux

E_ν **: Energy**

θ_ν **: Zenith Angle**

Cross section

Passing Fraction

Density of the target (Earth)

$$R(E_\nu) = \frac{N_{dw}^{final}(E_\nu)}{N_{up}^{final}(E_\nu)} \times CF(E_\nu)$$

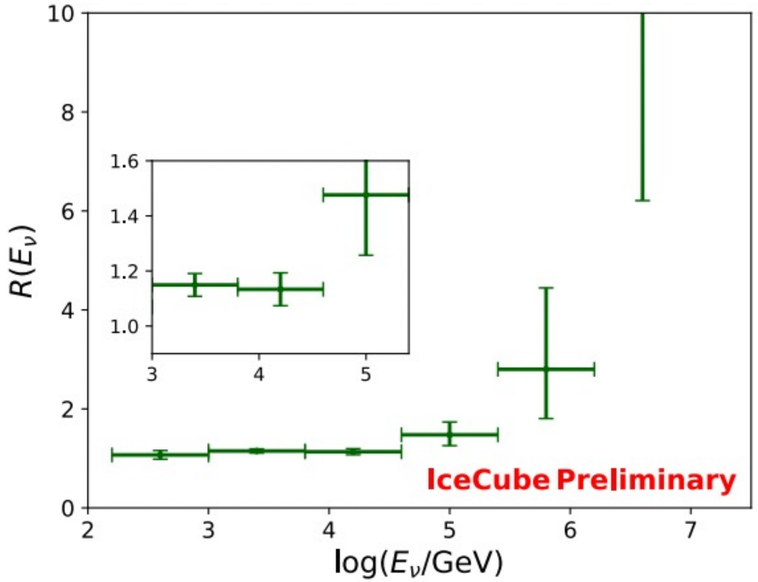
$$CF(E_\nu) = \frac{A_{up}(E_\nu)}{A_{dw}(E_\nu)}$$

Acceptance

Analysis Technique

From ratio to XS

- Take the ratio in each neutrino energy bin.
- Find the corresponding cross section for that ratio in ratio vs cross section curve.
- The cross section measured for each neutrino energy bins is the total cross section (CC+NC), average over neutrino and an.-neutrino with the ratio 1:1.



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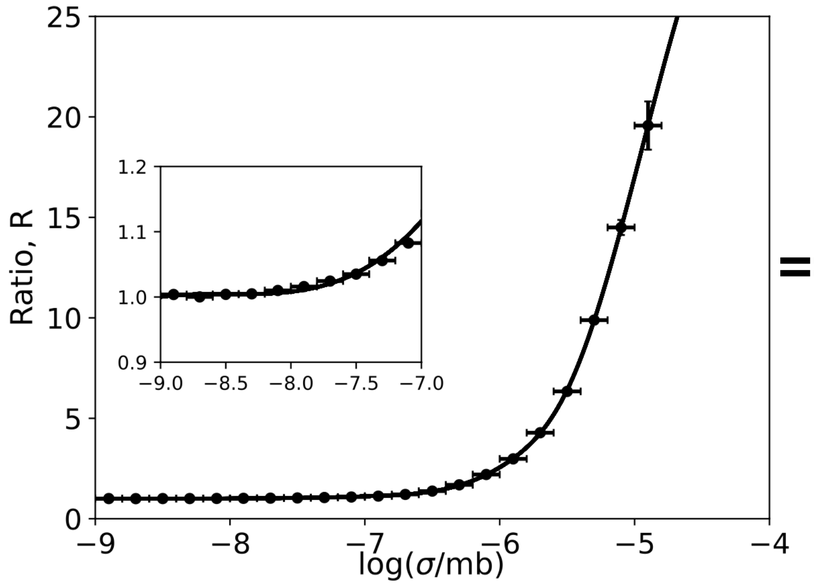

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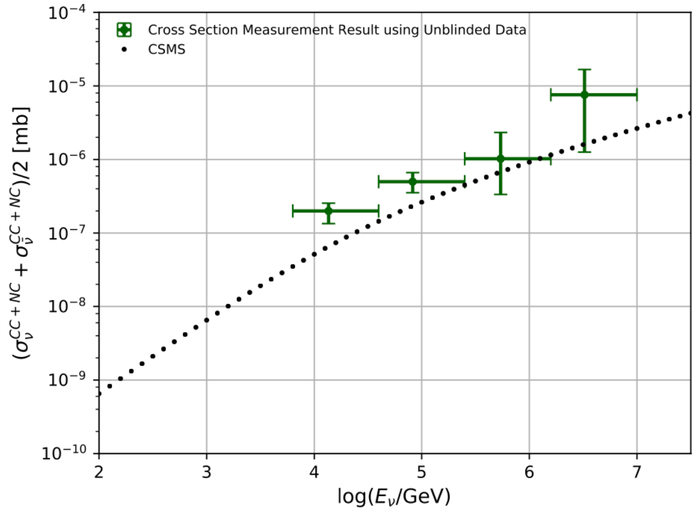
Results $\sigma(E_\nu)$



[Yiqian Xu PhD Thesis]

Data & MC samples

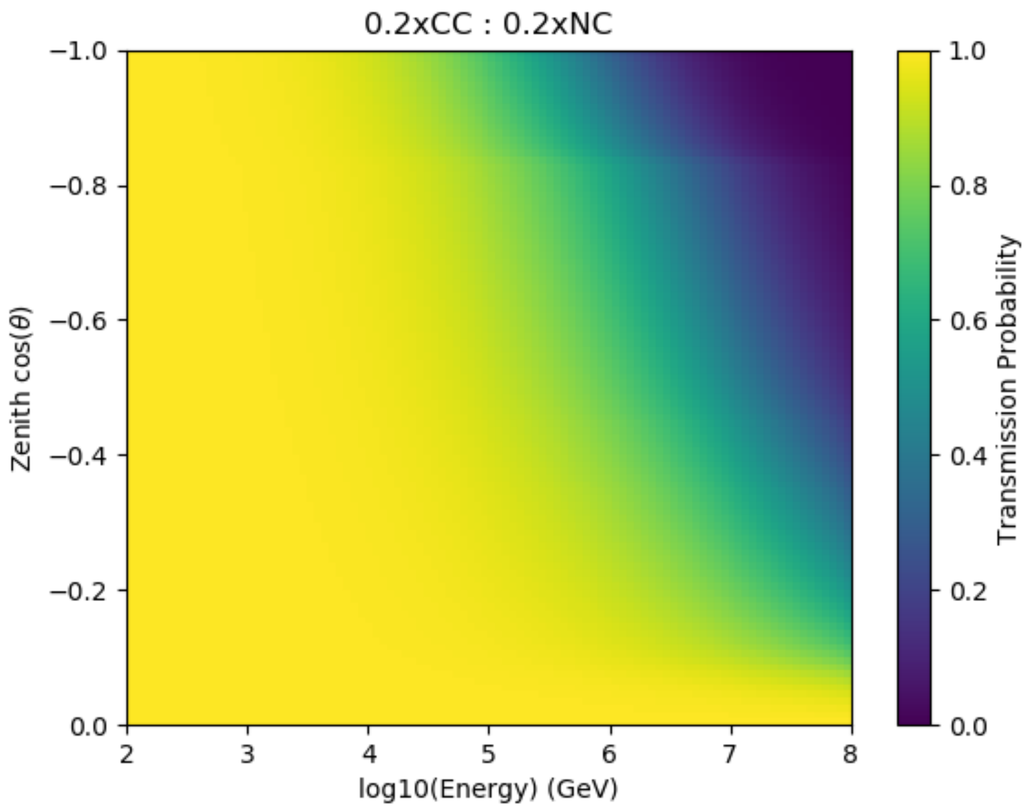
- nuSQuIDS for Passing Fraction (Transmission Probability) Estimation
- MC : NuGen : Neutrino Simulation 3 flavors
- MC : MuonGun : Atmospherics Muon Simulation
- Data : 11 years (2010-2020) cascades data from Zelong current Analysis (under unblinding request) improved reconstruction resolution and updated event selection (BDT and cut based)

Earth Propagation

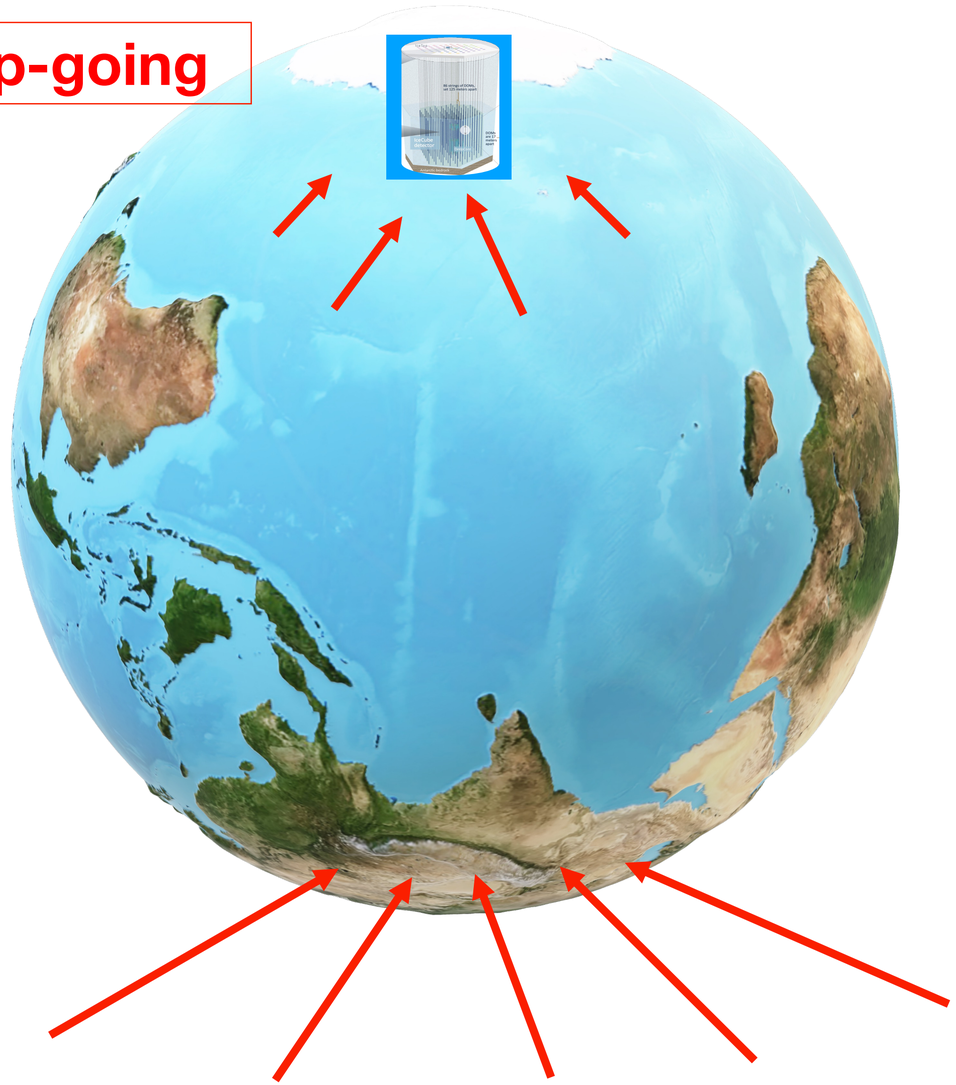
nuSQuIDS: A toolbox for neutrino propagation

arXiv:2112.13804 [hep-ph]

0.2 x CSMS



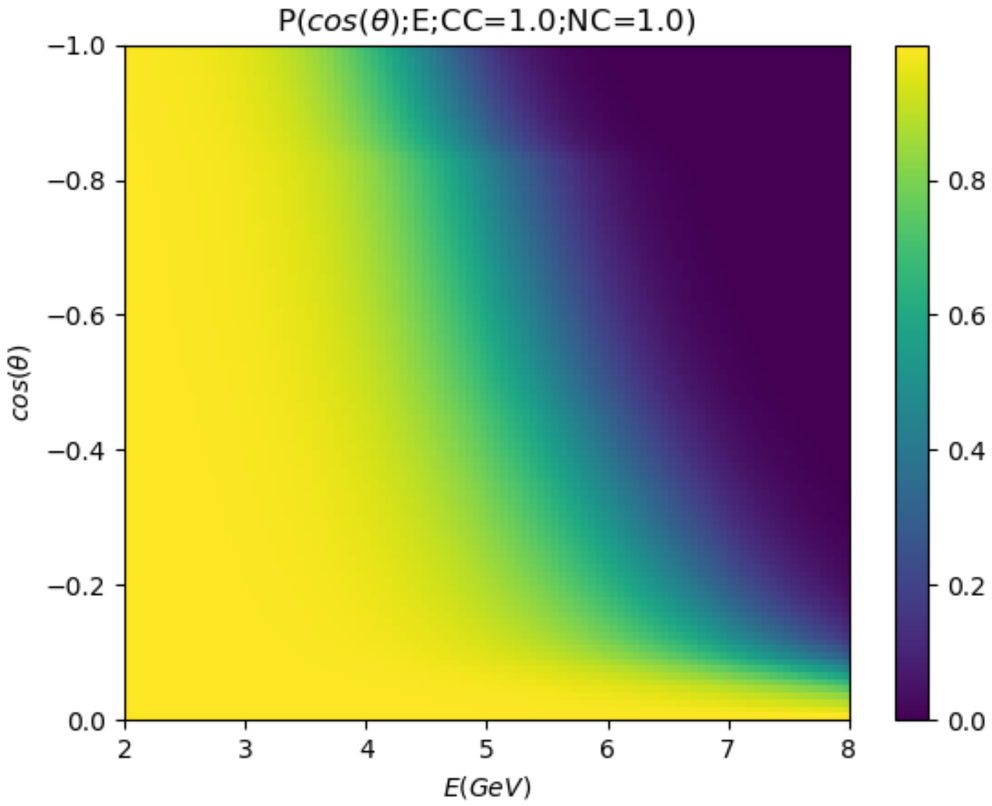
Up-going



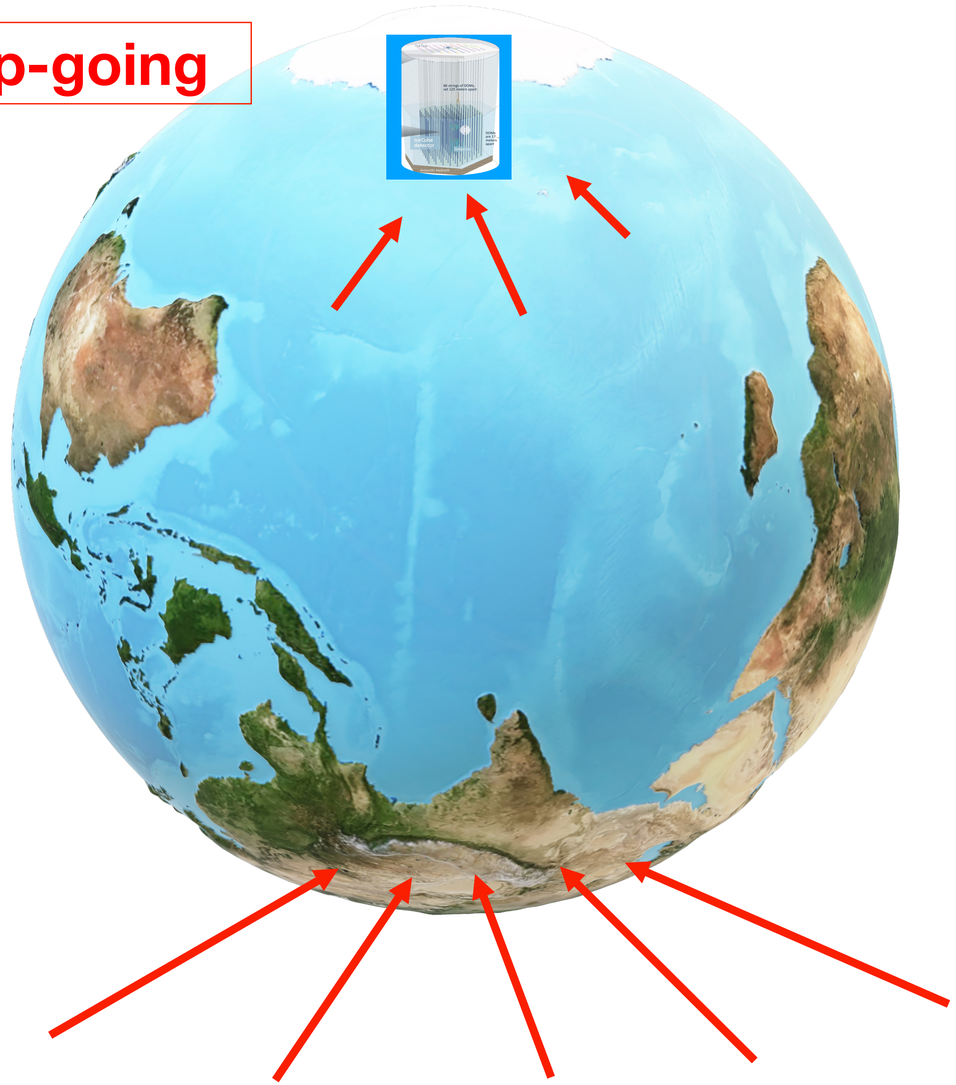
Earth Propagation

nuSQuIDS: A toolbox for neutrino propagation

1 x CSMS



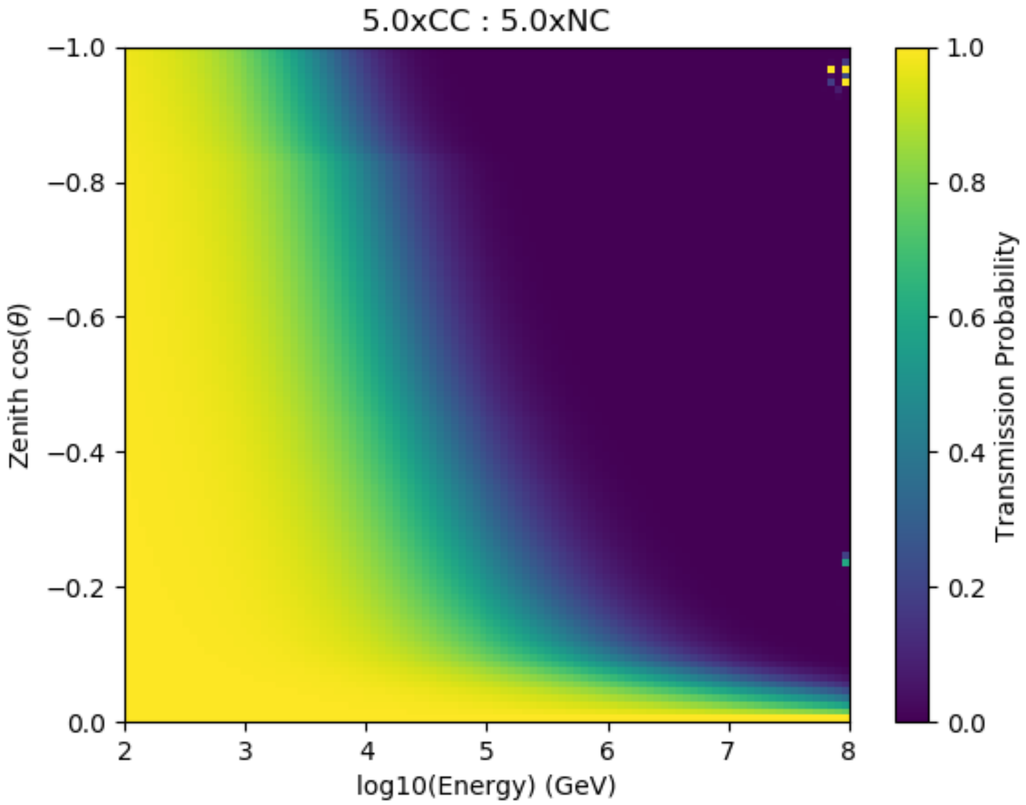
Up-going



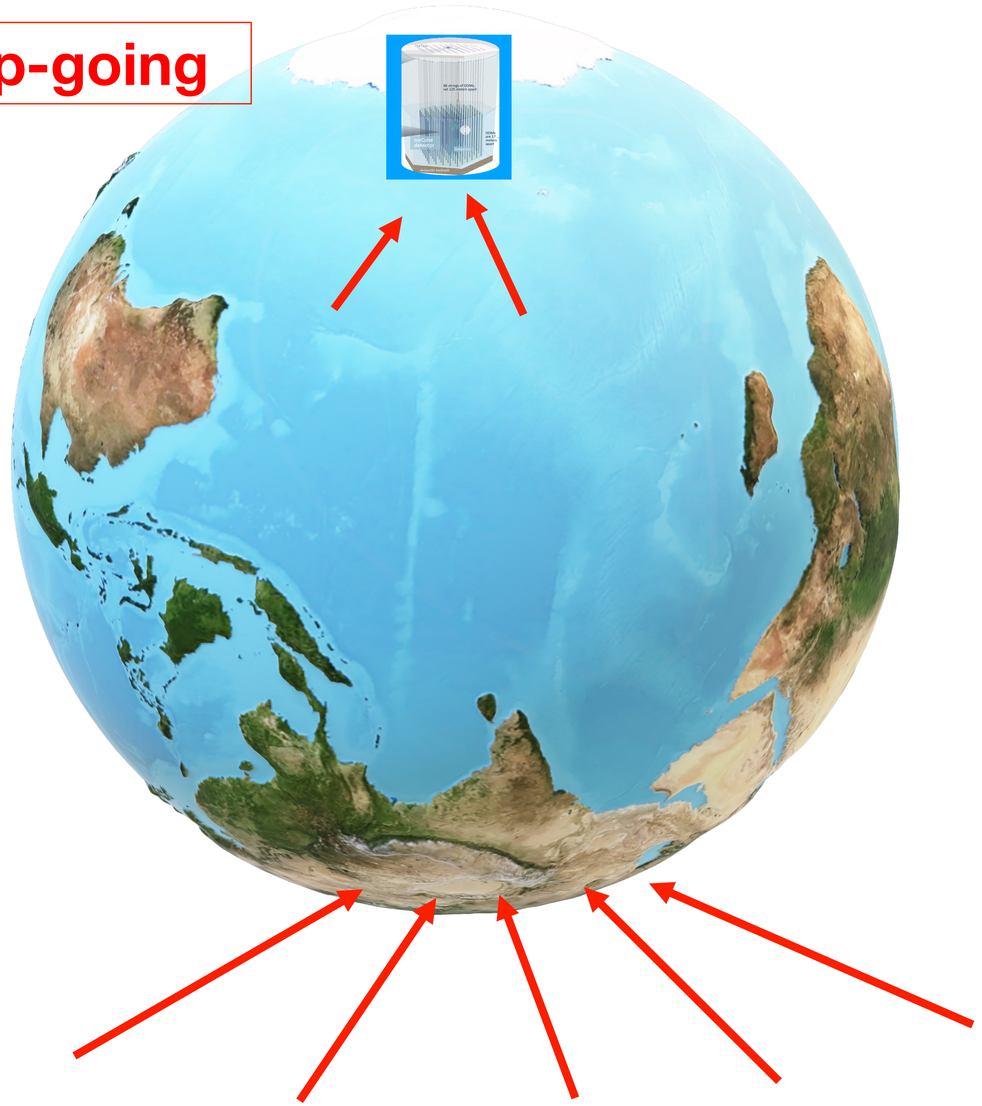
Earth Propagation

nuSQuIDS: A toolbox for neutrino propagation

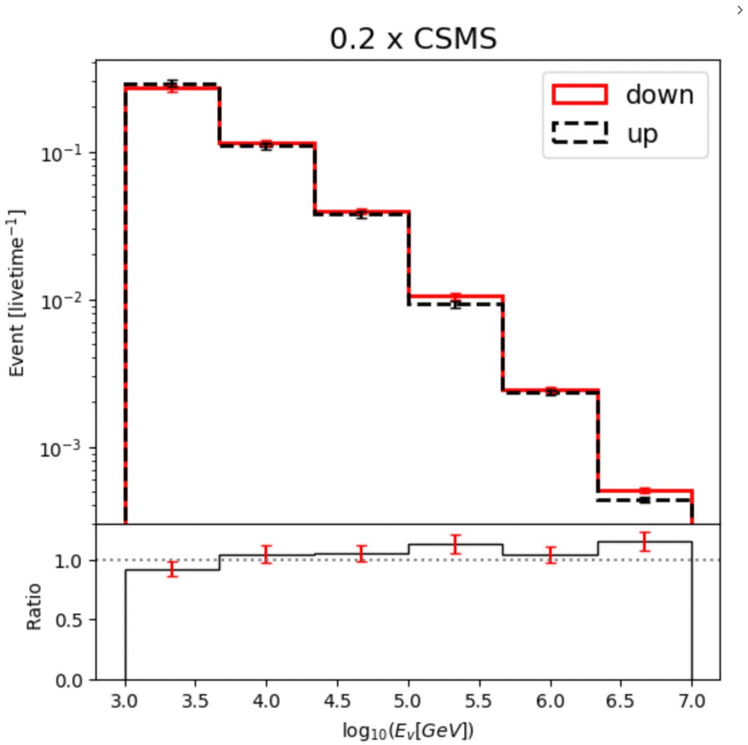
5 x CSMS

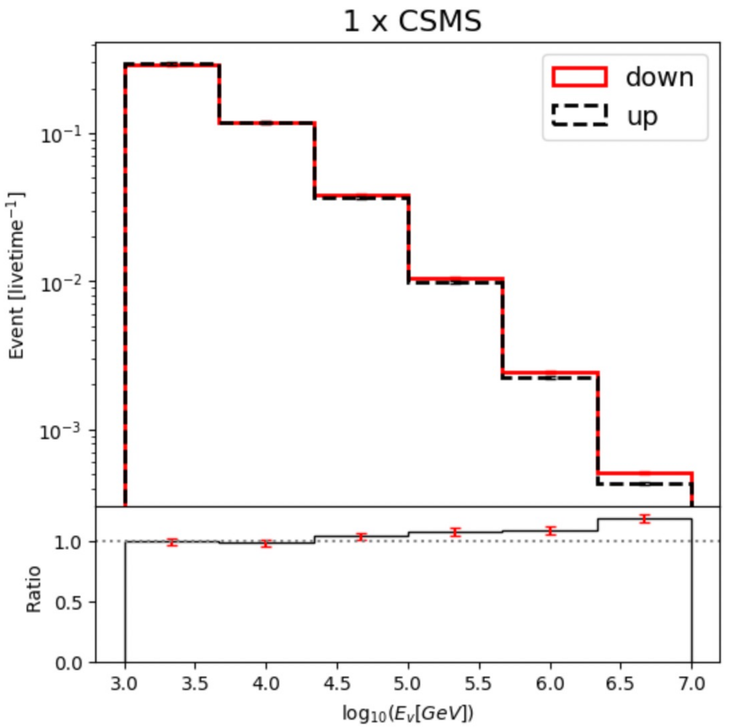


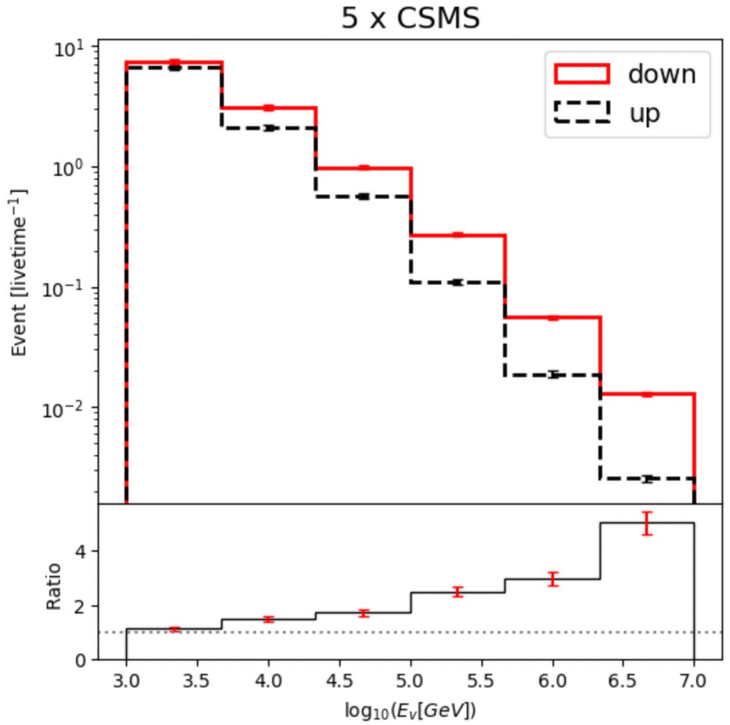
Up-going



MC NuGen Simulation : NuTau







Summary and outlook

- nuSQuIDS for Passing Fraction (Transmission Probability Estimation)
- **MC : NuGen : Increase statistics and simulate other falvors i.e NuE NuMu**
- **Exploring Likelihood Approach**
- MC : MuonGun : Atmospherics Muon Simulation
- Data : 11 years (2010-2020) cascades data from Zelong current Analysis(under unblinding request)