PROGRESS UPDATE

Master's project

Bas Jongewaard

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KM3NeT
University of Amsterdam

PROJECT

PROJECT

Aim of project:

- For a new detector, find out which is better: larger dimensions, or increased angular resolution?

PROJECT

Ok, but how do we do that?

- Simulate universe of neutrino sources!

SIMULATION

Assumptions:

1. Neutrino signal comes from blazars
2. Distribution of sources follows the Star Formation Rate (SFR)
3. The neutrino luminosity L_ν is the same for every source

Main input parameters:

1. Source density at $z = 0$: the normalisation constant $\mathcal{H}_0$
2. Total observed neutrino flux Φ_{total}, taken from the IceCube experiment: $\Phi_{\mathrm{IceCube}} = 10^{-8}\ \mathrm{GeV}^{-1}\ \mathrm{s}^{-1}\ \mathrm{m}^{-2}$

Simulation:

- Universe is simulated in 'shells' of comoving volume.
- The amount of sources in a shell is given by:

$$N_{\mathrm{shell}} = 4\pi \, D_{\mathrm{H}} \int_{z_1}^{z_2} D_{\mathrm{C}}^2(z) \, \frac{\mathcal{H}_{\mathrm{SFR}}(z)}{E(z)} \, dz$$

$$\approx 4\pi \, D_{\mathrm{H}} \, D_{\mathrm{C}}^2(z_{\mathrm{centre}}) \, \frac{\mathcal{H}_{\mathrm{SFR}}(z_{\mathrm{centre}})}{E(z_{\mathrm{centre}})} \, dz$$

(Justified because dz is very small.)

For every source:

- Generate random comoving distance D_C in shell (flat distrib.)
- Compute corresponding redshift z
- Compute corresponding neutrino flux Φ_ν

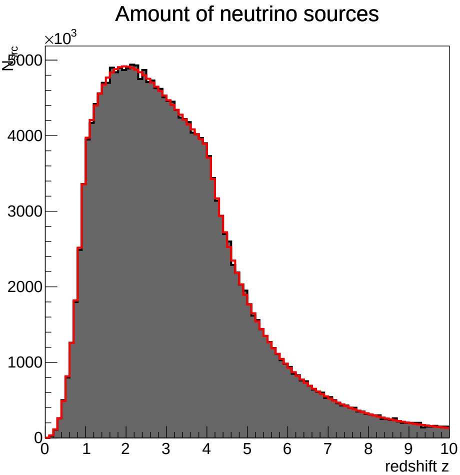
$$D_C(z) = D_H \int_0^z \frac{dz'}{E(z')}, \qquad \Phi_\nu = \frac{\Phi_{\text{total}}}{4\pi\,\xi\,\mathcal{H}_0\,D_H\,D_C^2\,(1+z)^2}$$

Also:

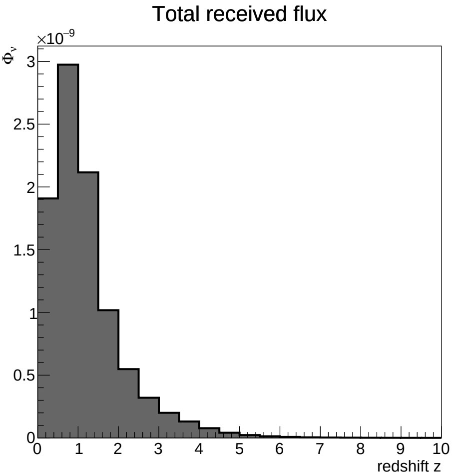
- Generate random angles ϕ and θ in an isotropic way
  (AKA right ascension and declination)

ANALYSIS

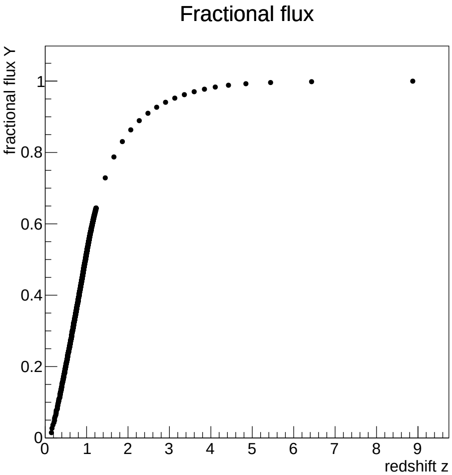
Expected amount of sources (red) & simulated amount of sources (black)
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



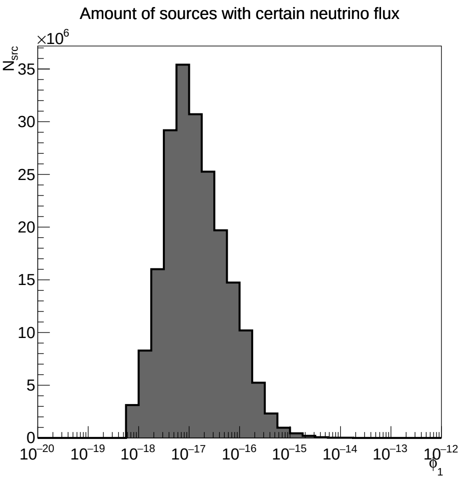
Simulated total flux vs redshift
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



Fractional flux Y
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})

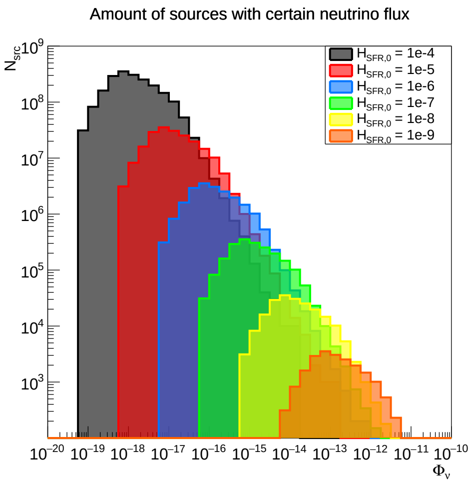


Amount of sources with a certain Φ_ν
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



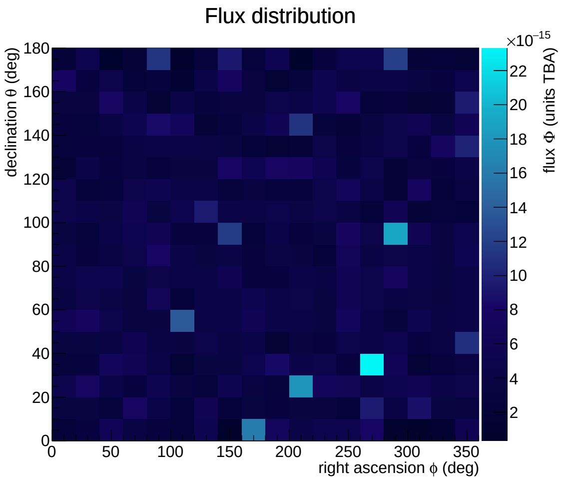
Amount of sources with a certain Φ_ν

(For $\mathcal{H}_0 = 10^{-5} \Leftrightarrow 10^{-9}$ Mpc^{-3}, logarithmic scale)



Every integral returns Φ_{total}, as required.

Flux distribution, corrected for θ
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



OUTLOOK

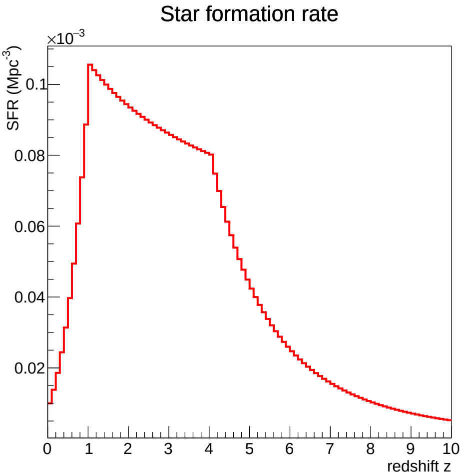
TO DO

Plans:

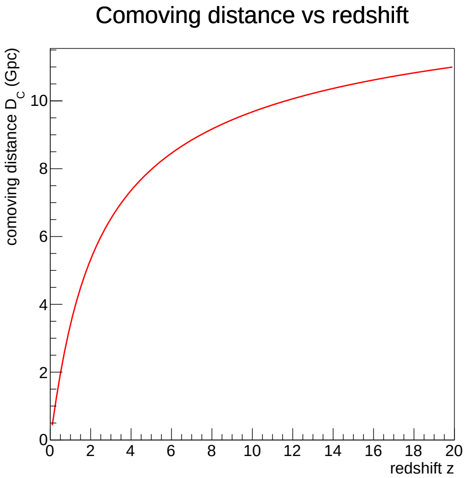
- Study catalogue
  - Analyse using same scripts
  - Compare to simulated universes
- Adjust N_{src} vs Φ_ν histogram
  - Reverse axis
  - Indicate fraction of total amount of sources
- Improve axis labels
  - Get rid of overlap between numbers and labels
  - Use e.g. 1×10^6 instead of 1000×10^3

BACKUP

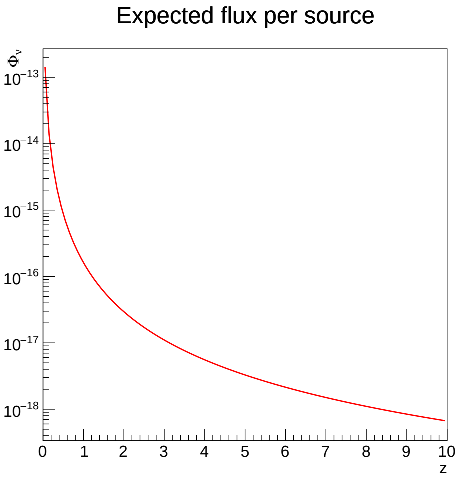
Star formation rate $\mathcal{H}_{\mathrm{SFR}}$
(For $\mathcal{H}_0 = 10^{-5}\ \mathrm{Mpc}^{-3}$)



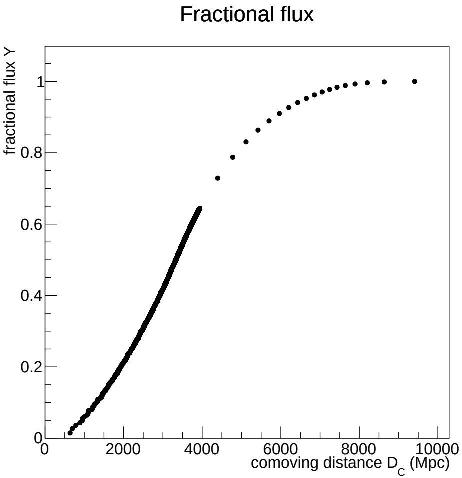
Comoving distance D_C vs redshift z
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



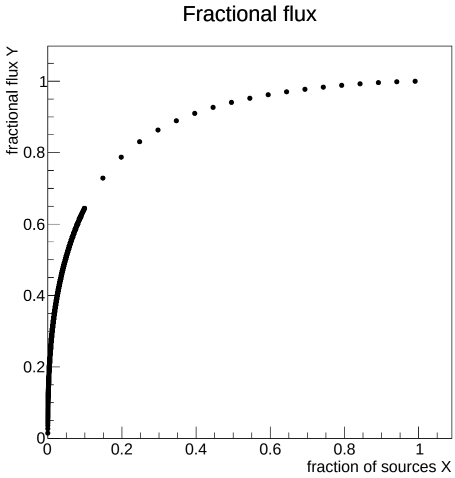
Relation between flux Φ_ν and redshift z
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



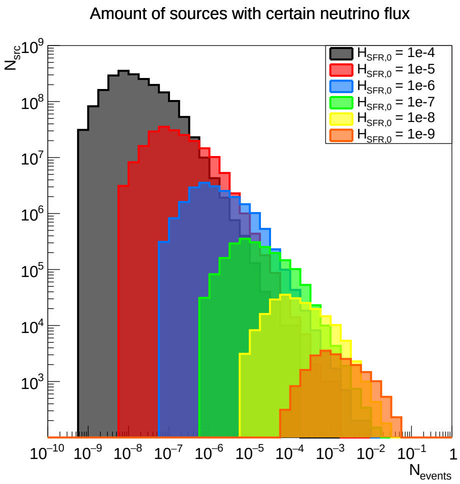
Fractional flux Y vs comoving distance D_C
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



Fractional flux Y vs fraction of sources X
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3})



Amount of sources with a certain amount of events
(For $\mathcal{H}_0 = 10^{-5} \Leftrightarrow 10^{-9}$ Mpc^{-3}, logarithmic scale)



3D representation of a generated universe
(For $\mathcal{H}_0 = 10^{-5}$ Mpc^{-3}, scaled down by a factor $\mathcal{S} = 10^4$)