Group meeting
28/11/2019

KM3NeT simualtion

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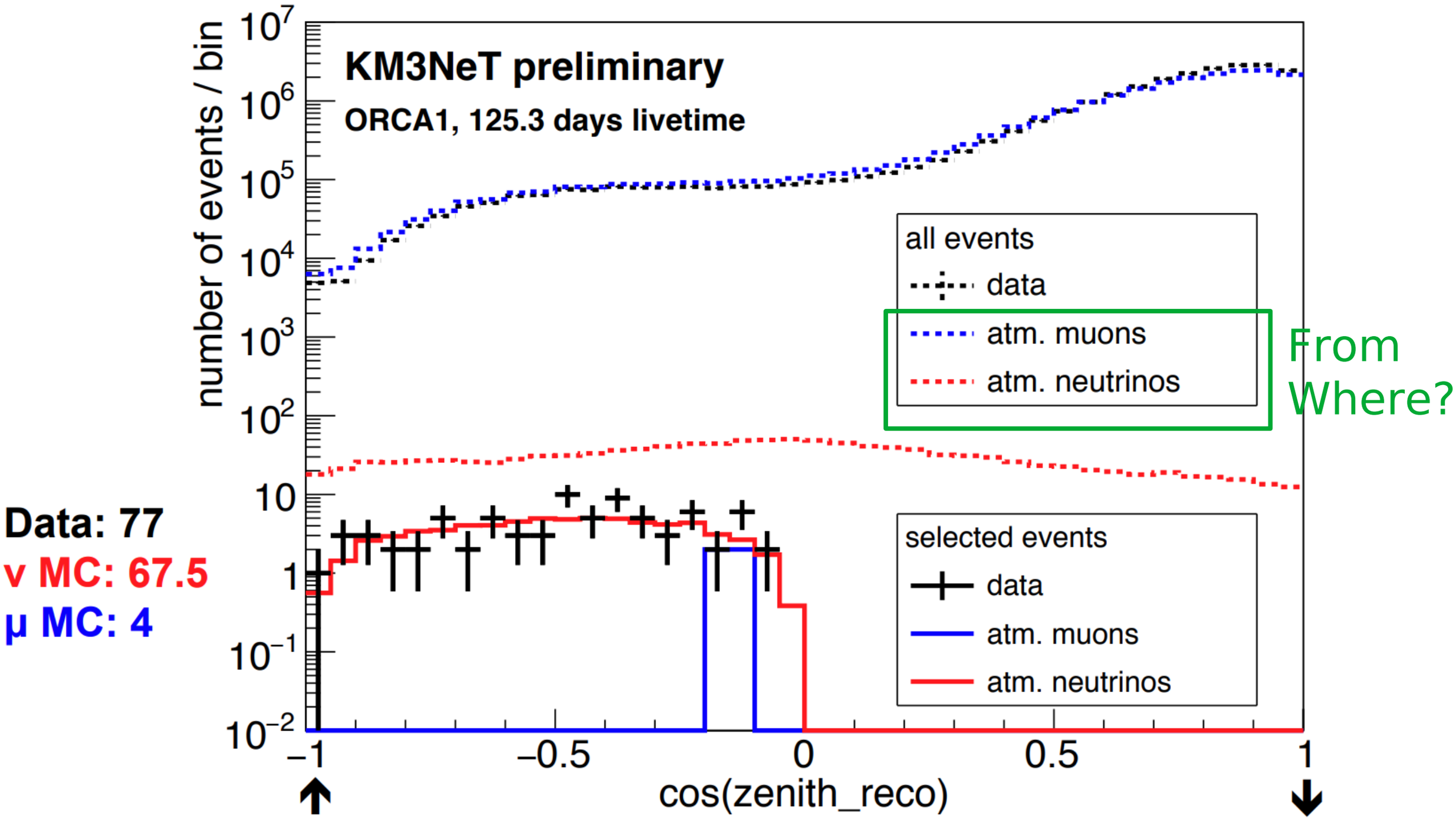
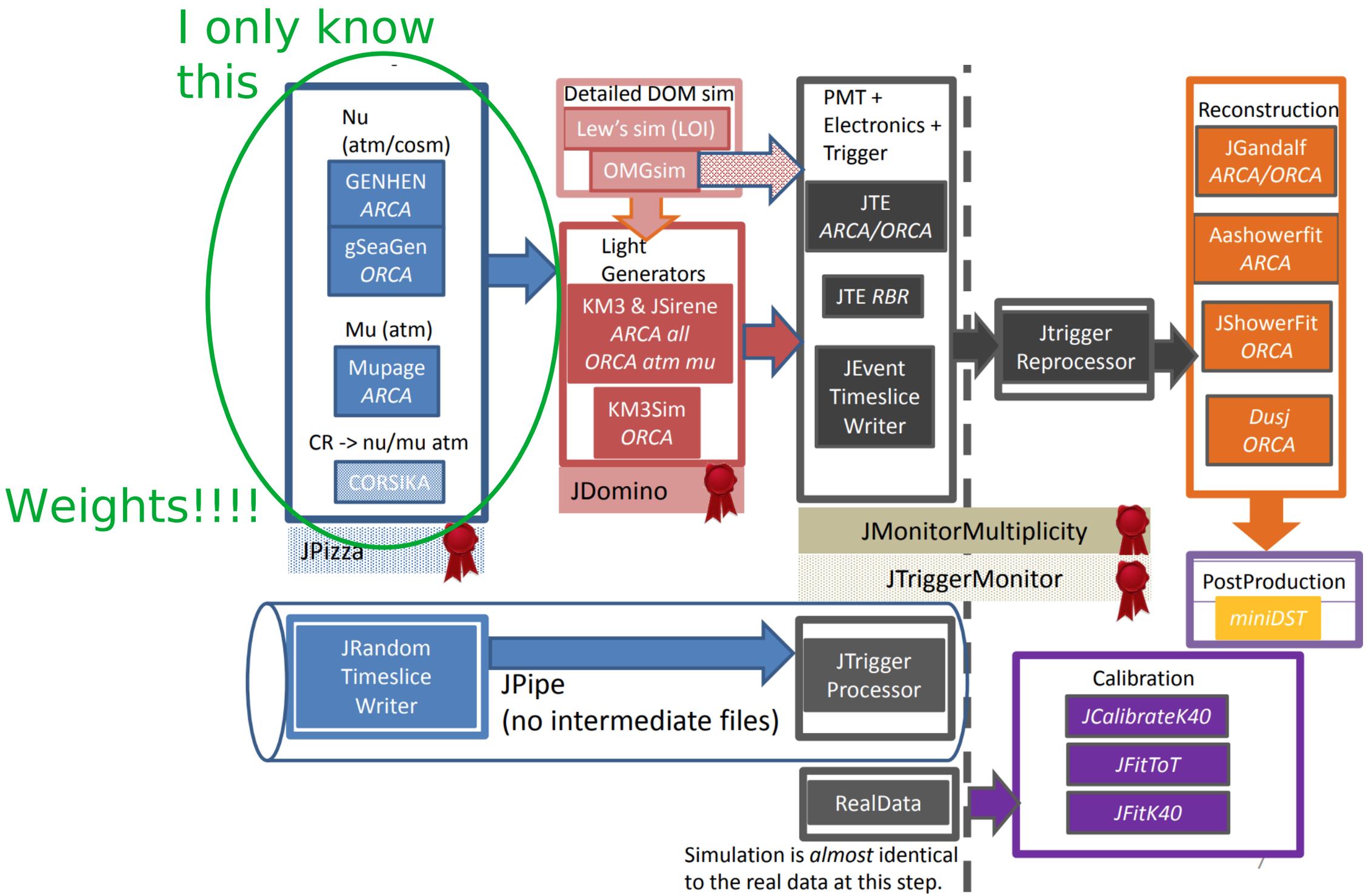
ICRC19

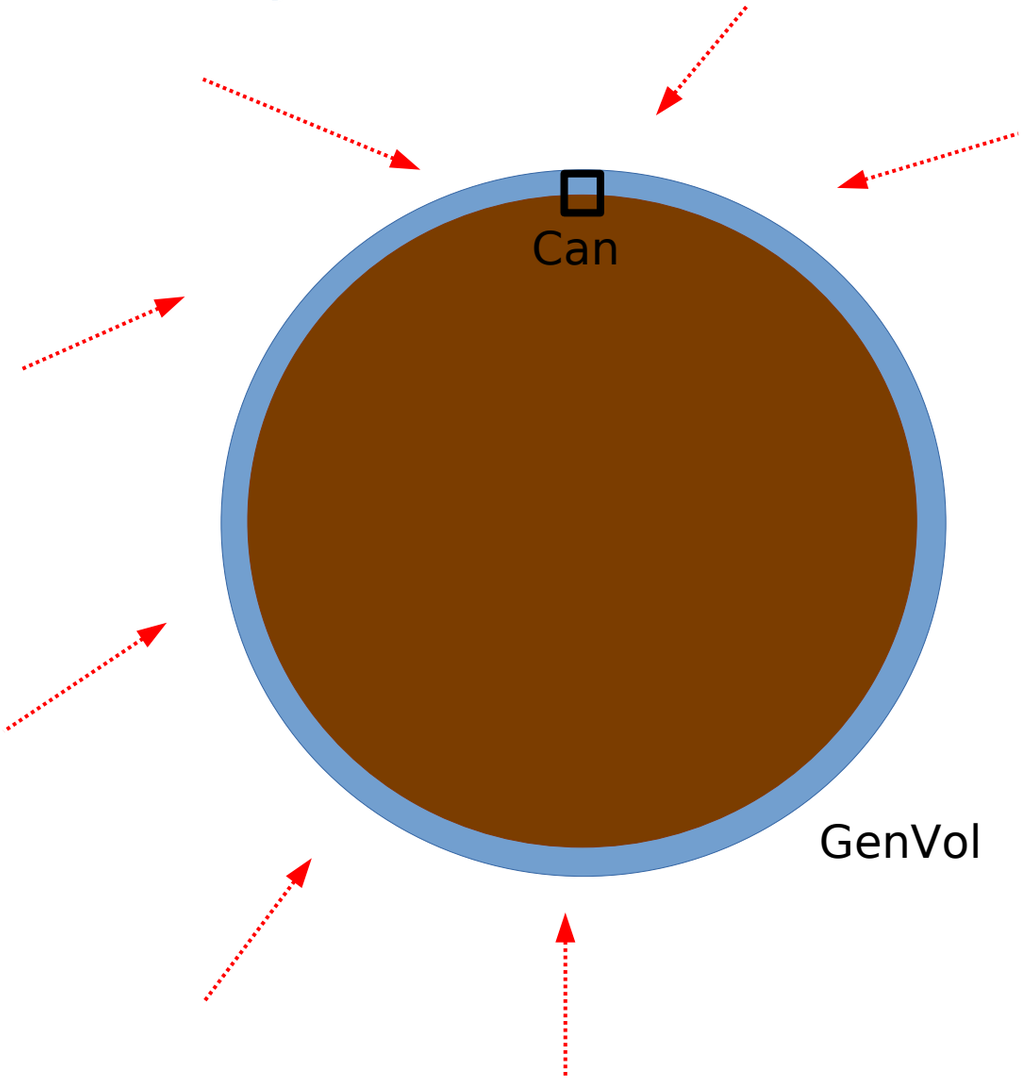

KM3NeT preliminary
ORCA1, 125.3 days livetime
number of events / bin
all events
data
atm. muons
atm. neutrinos
selected events
data
atm. muons
atm. neutrinos
cos(zenith_reco)
Data: 77
ν MC: 67.5
μ MC: 4
From Where?

Simulation chain

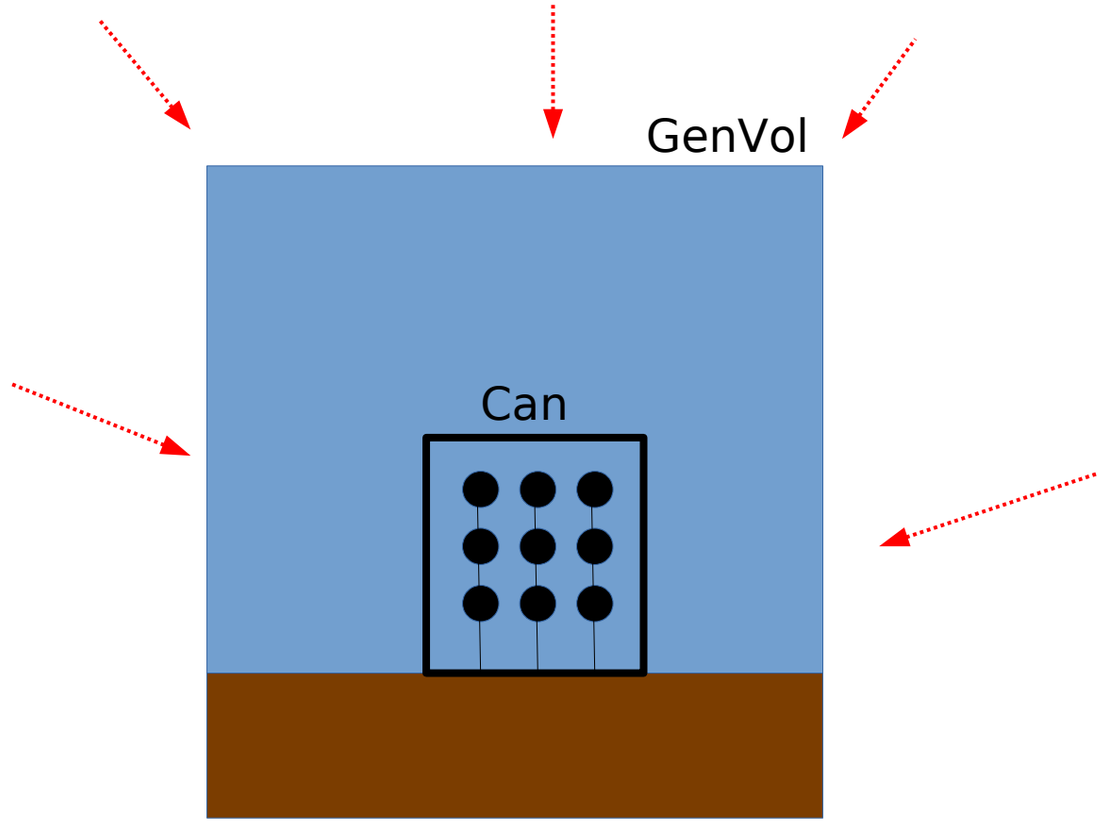


Nu&Mu in our detector

- Two ways:



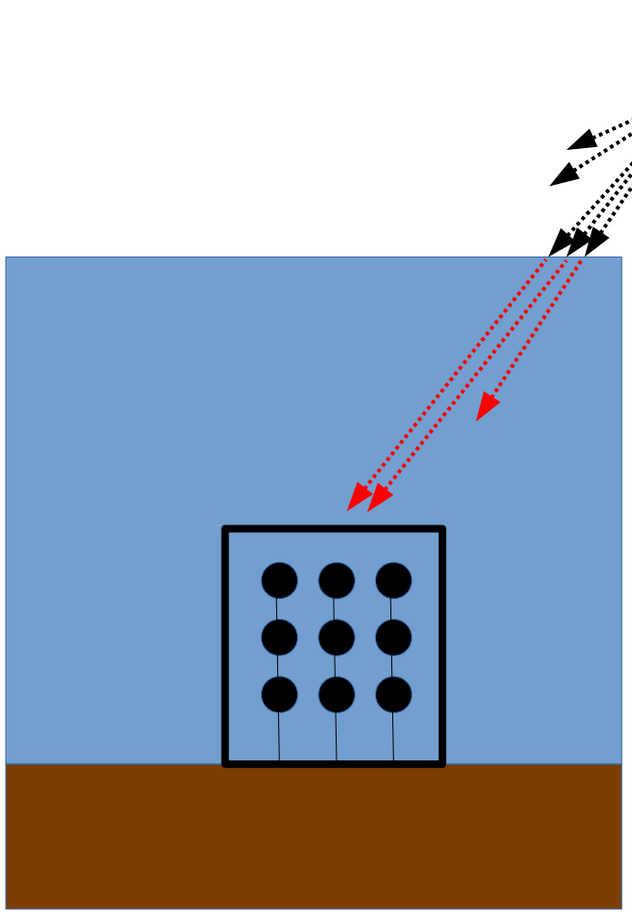
- Physic of propagation is included
- Computationally expensive



- Physic of propagation not included → Weights!!!
- High statistic

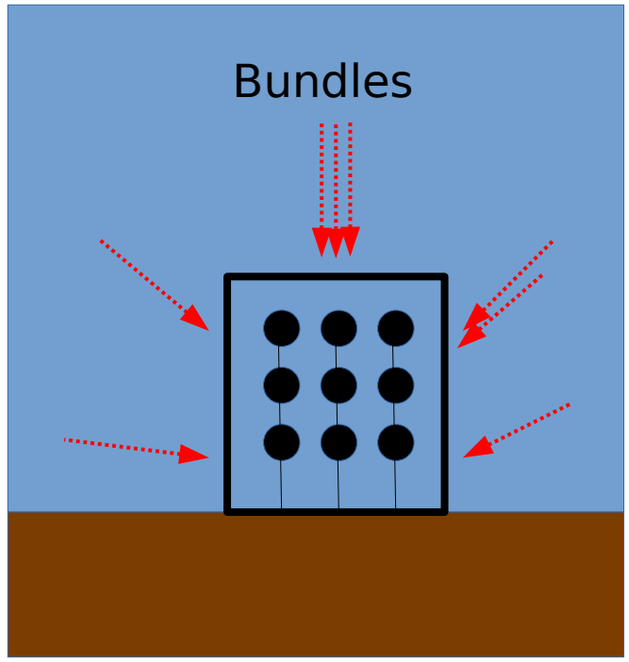
Atmospheric muons

- We only simulate downgoing muons (upgoing should be absorbed).



CORSIKA

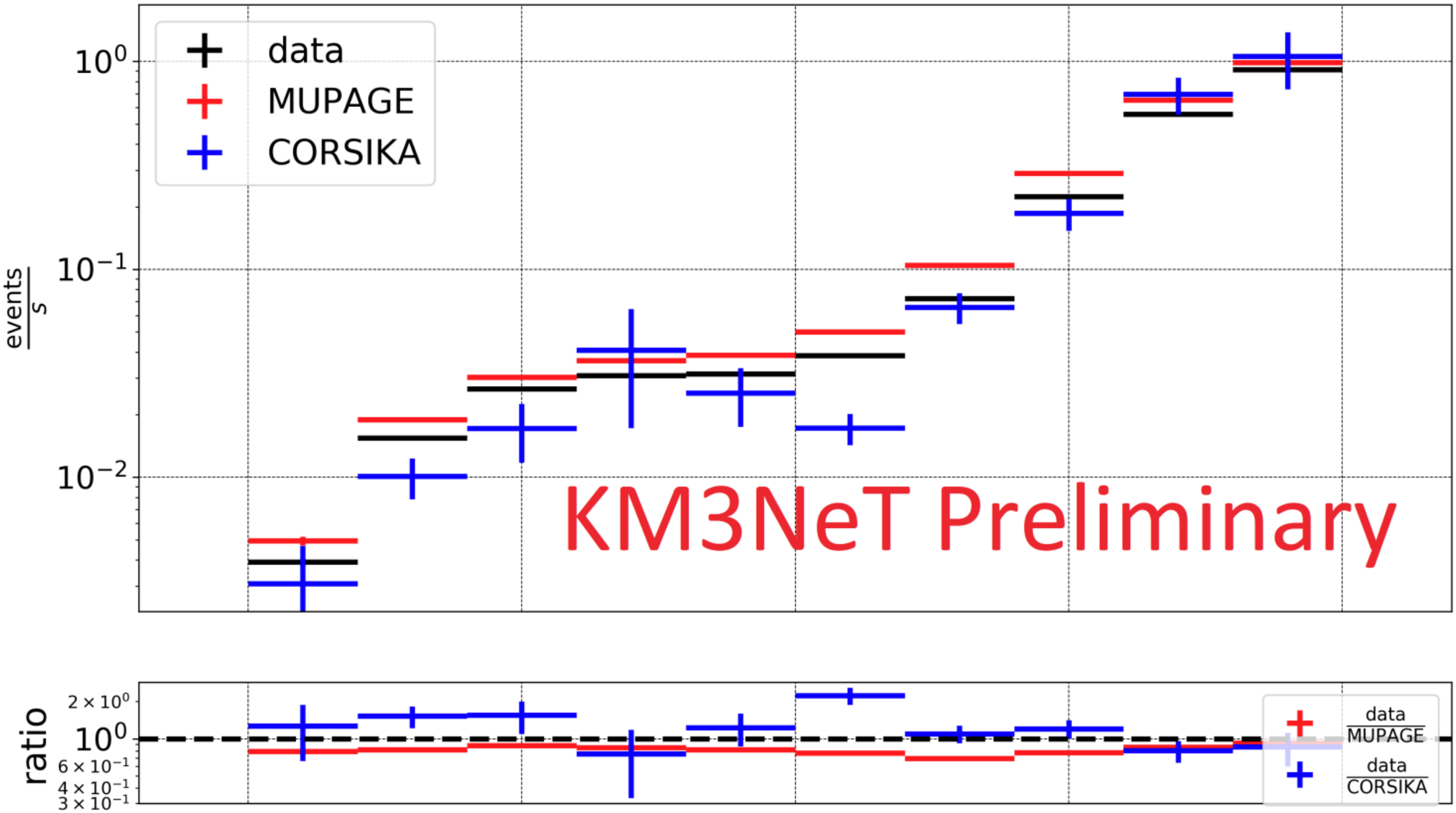
- Full cosmic ray simulation
- Propagation in water using MUSIC/PropaMuon/etc
- Weights!!!!



MUPAGE

- Parametrization of muons at can
- No weights!!!!

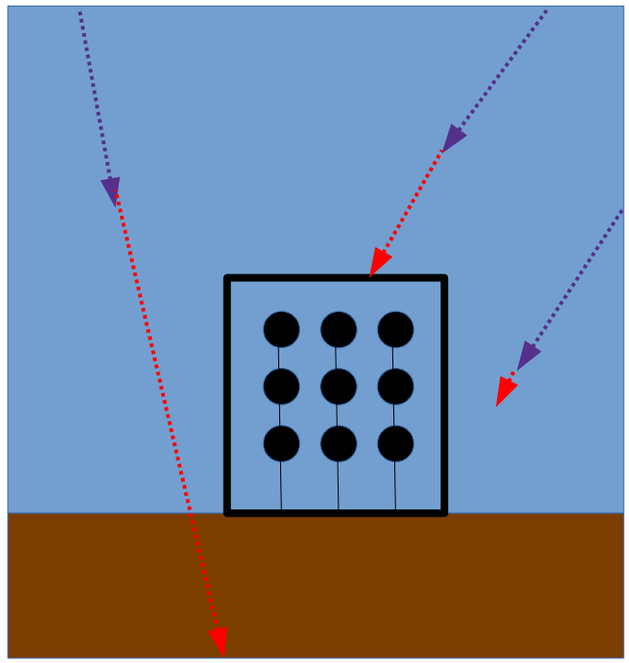
Atmospheric muons



Neutrinos

- Two sources (atmosphere and cosmic) but same simulation.
- Two main codes: gseagen (c++), genhen (fortran).

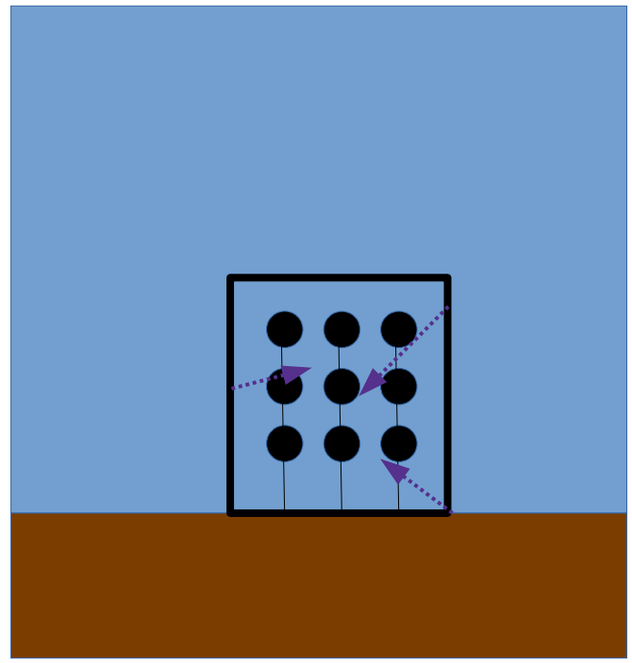
Track



(A)NuMu CC

- Generate neutrino interactions in a volume surrounding the can.
- Propagation muon in water using MUSIC/PropaMuo/etc

Shower



(A)NuE CC, (A)Numu NC, (A)NuE NC

- Generate neutrino interactions in can

Neutrinos weigths!!!

$$W_{evt} = W_{gen} \cdot \phi(E_\nu, \theta_\nu).$$

Choose:
-atmospheric (Honda) * OSCPROB
-cosmic (Diffuse E-2)

From generator (genhen,gseagen)

$$W_{gen} = \frac{W_{genc} \cdot E_\nu^X \cdot P_{scale} \cdot P_{Earth}(E_\nu, \theta_\nu)}{N_{Tot}},$$

Phase space

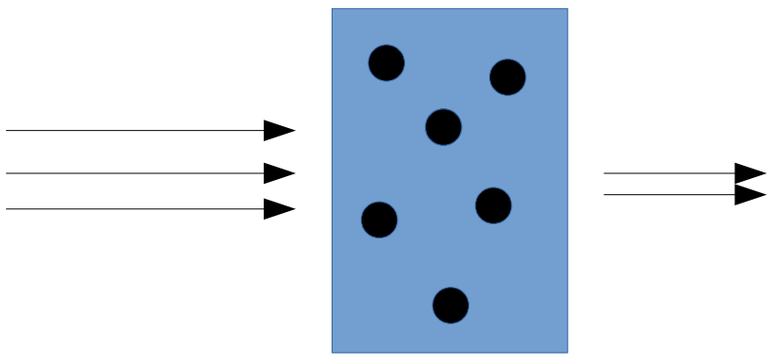
$$W_{genc} = I_E \cdot I_\theta \cdot T_{gen} \cdot A_{gen} \cdot N_\nu$$

Ntot = Number of neutrinos we shoot
E^X = energy factor to correct for energy spectrum use to shoot neutrinos (NOT REAL FLUX)
T_{gen} = generation time (to get number of events in T_{gen} seconds)

Neutrinos weigths!!!

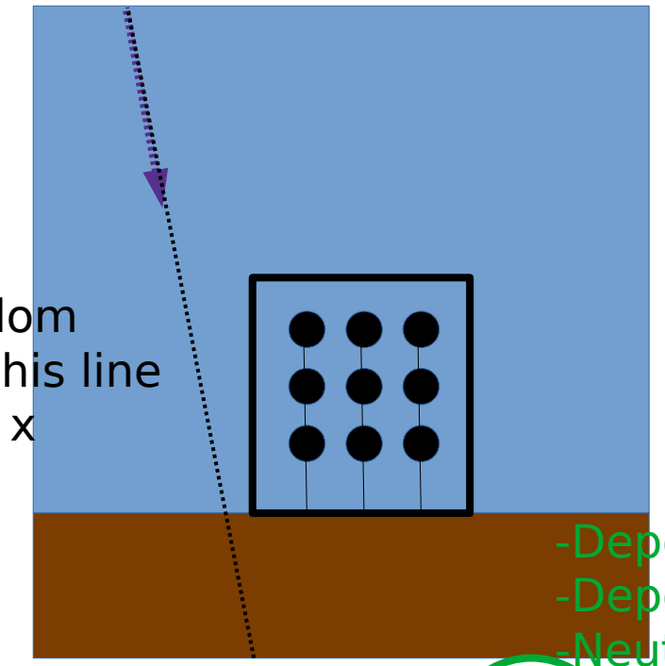
- In real life, if you buy a neutrino gun an you shoot 10^6 neutrinos of 100 GeV to our detector, none of them will interact (P_int~0).
- Thus, we play to be god → force the interaction of the neutrino!!!!!
- Being god has a price → weights!!!!

$$\frac{\mathrm{d}\Phi}{\mathrm{d}z} = -n\sigma\Phi,$$



$$\Phi = \Phi_0 e^{-n\sigma z},$$

P_{int} = exp[-n*sigma*z]



-Depends on E
-Depends on CC/NC
-Neutrino Generator

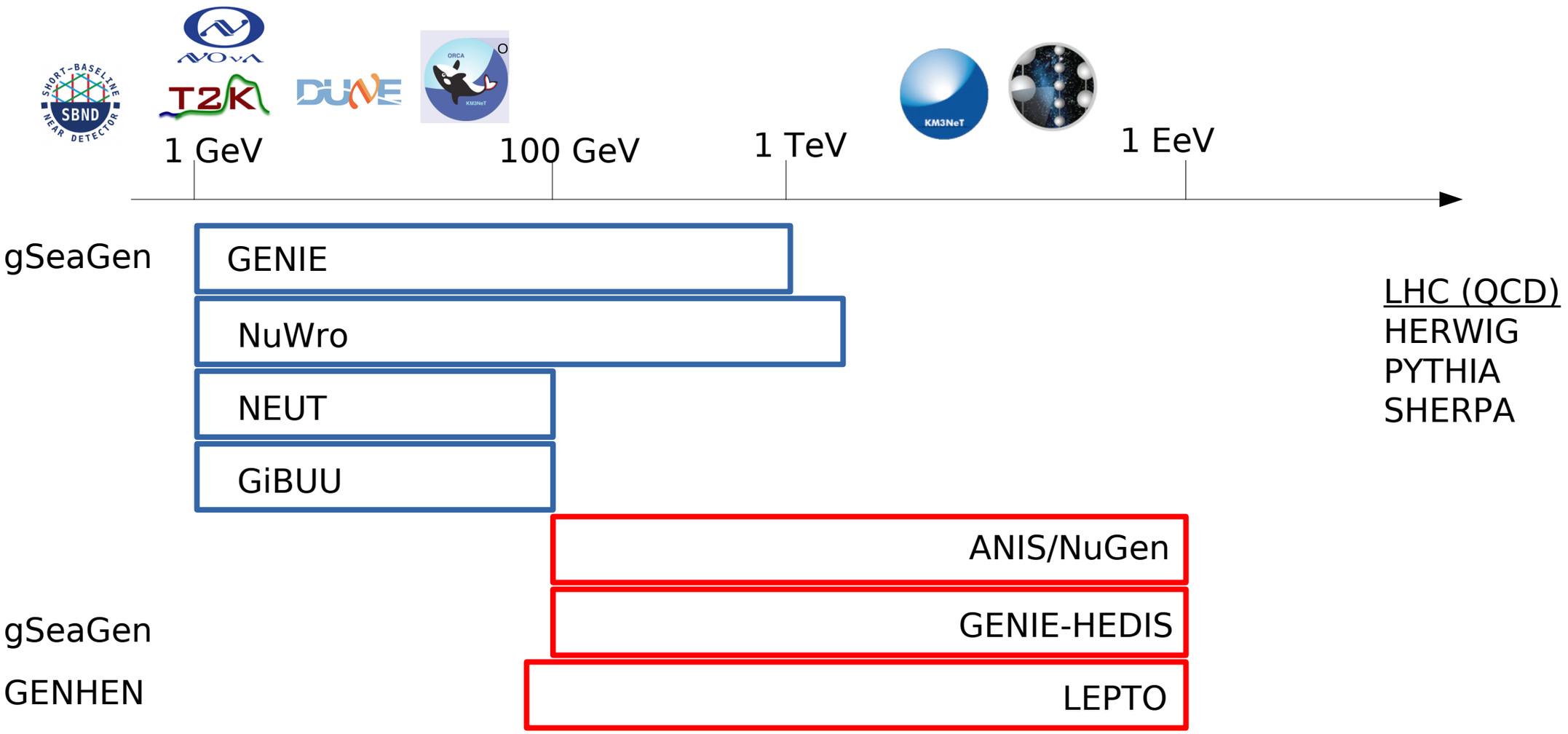
P_{int} = exp[-N_A*sigma*L_{rho}]

w ~ $P_{int}P_{earth}$= exp[-N_A*sigma*L_{rho}] * exp[-N_A*$sigma_{CC+NC}$*L_{earth}]

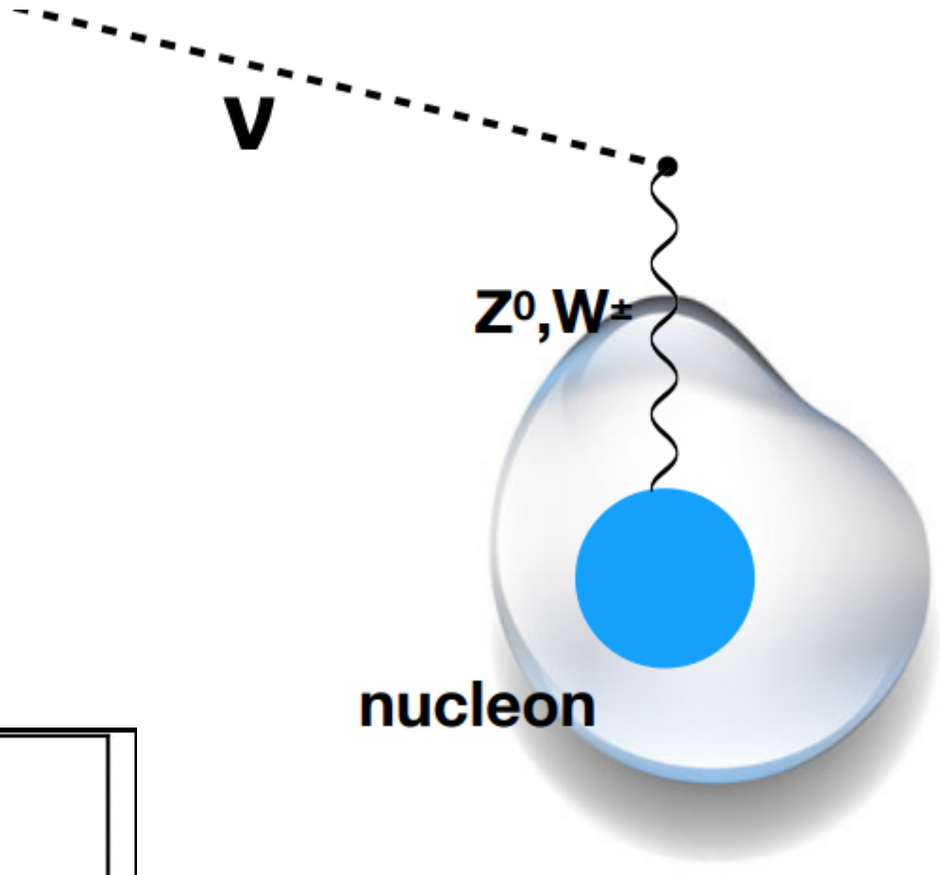
How to compute cross sections:

- Cross sections are important for two main reasons
  - Total cross section → P_{int}
  - Differential cross section → Final state particles

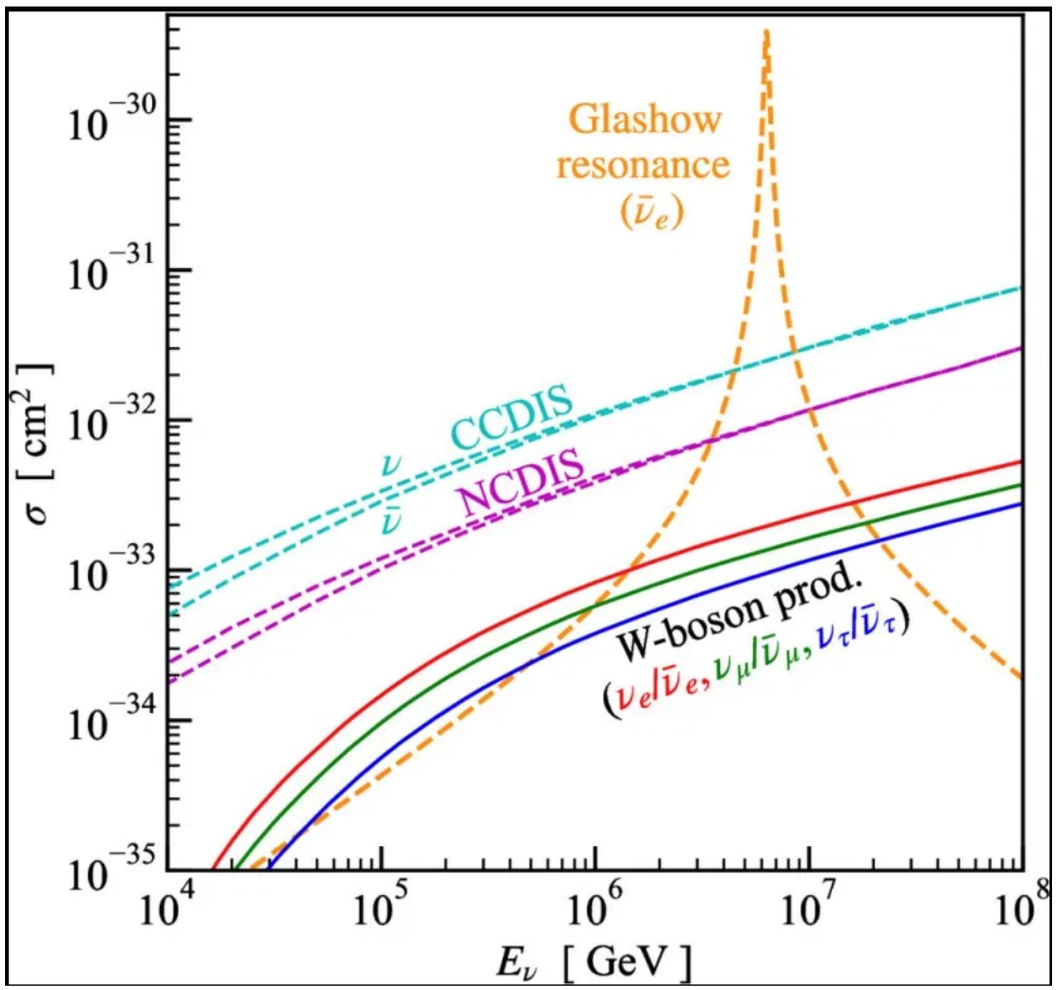
- Several implementations depending on the energy regime.



How-To

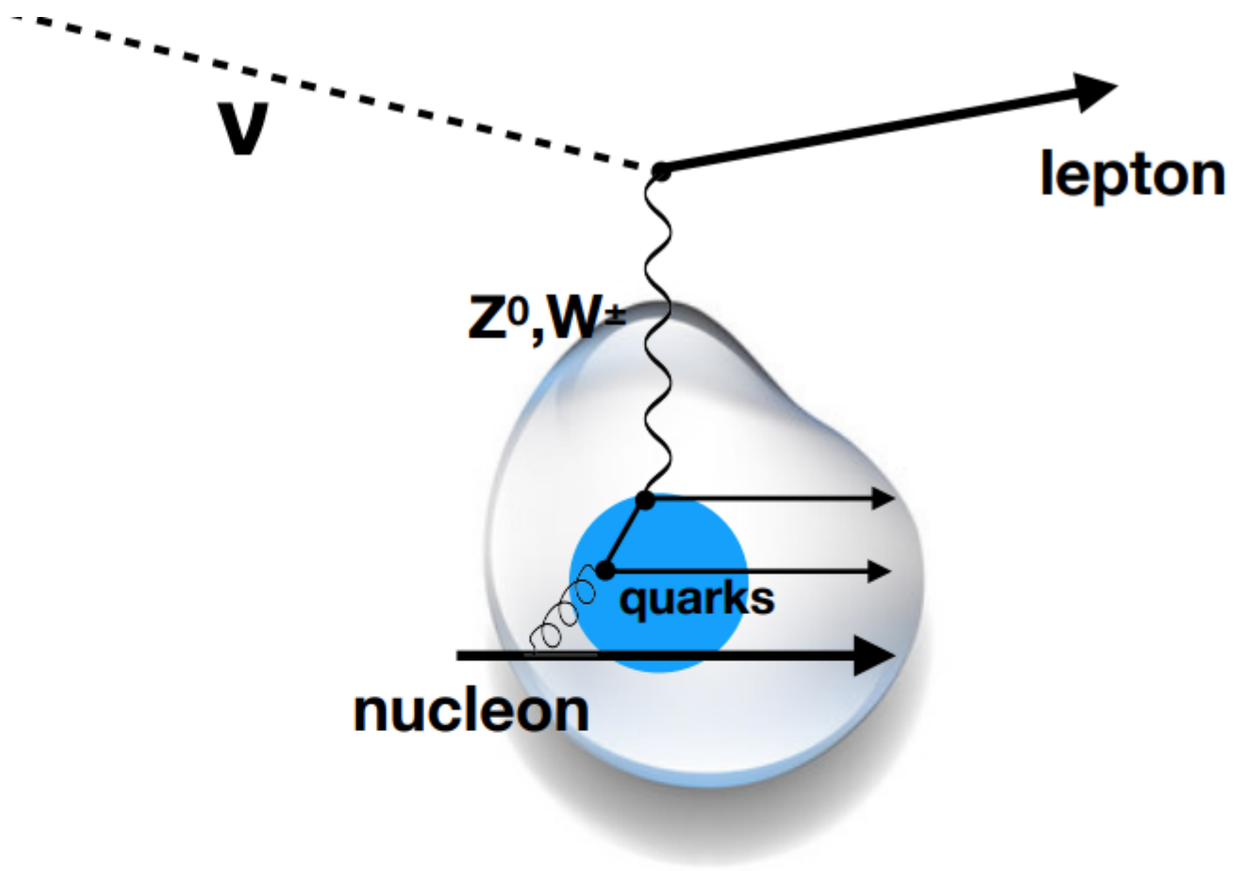


- Simulation neutrino interactions:
  - Probability of interaction -> $\sigma(E_\nu)$



How-To

- Simulation neutrino interactions:
  - Probability of interaction.
  - Kinematics of outgoing particles.



$$\frac{\mathrm{d}^2\sigma^{CC}_{\nu-n}}{\mathrm{d}x\mathrm{d}y} = \frac{G_F^2}{\pi} M_N E_\nu \frac{M_W^4}{(Q^2+M_W^2)^2}\left[y^2\frac{x}{2}\mathbf{F_1(x,Q^2)} + (1-y)\mathbf{F_2(x,Q^2)} + y\left(1-\frac{y^2}{2}\right)\mathbf{F_3(x,Q^2)}\right]$$

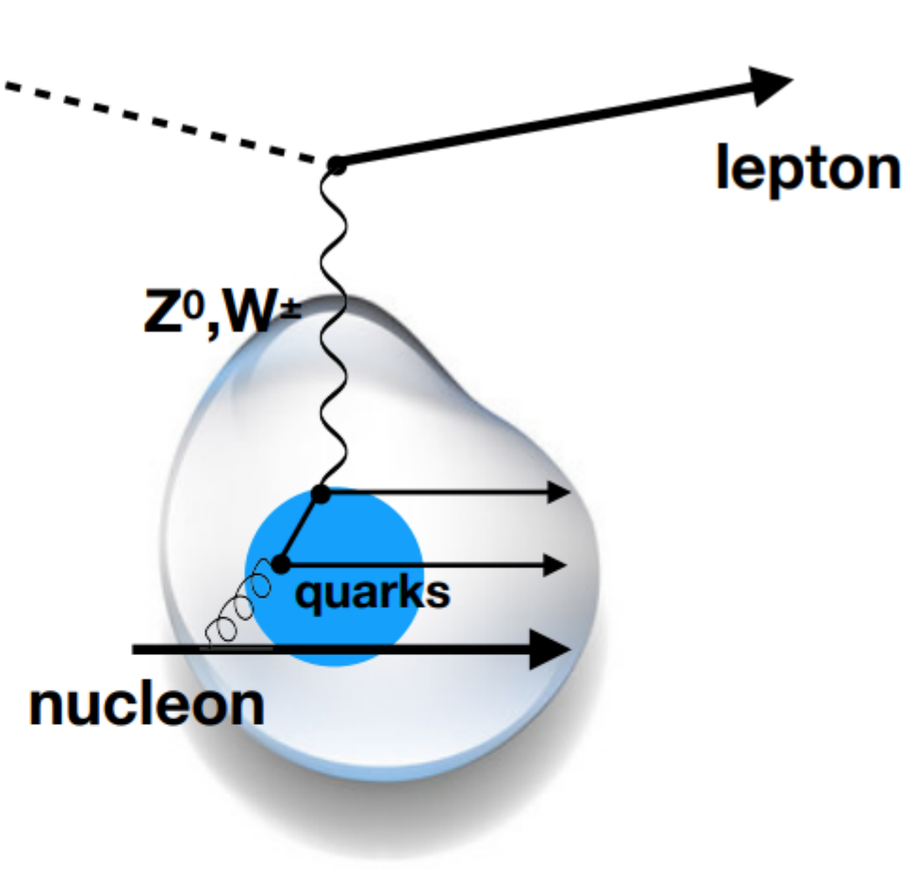
Structure Functions

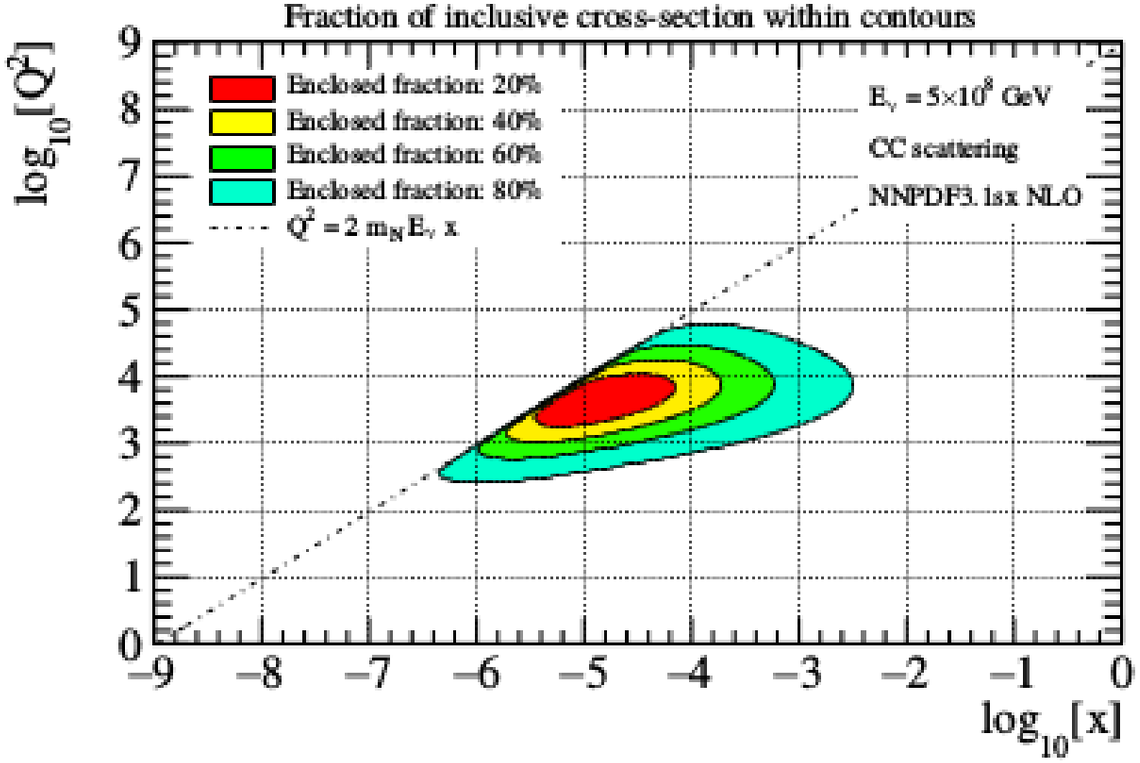
II

Nucleon QCD dynamics

How-To

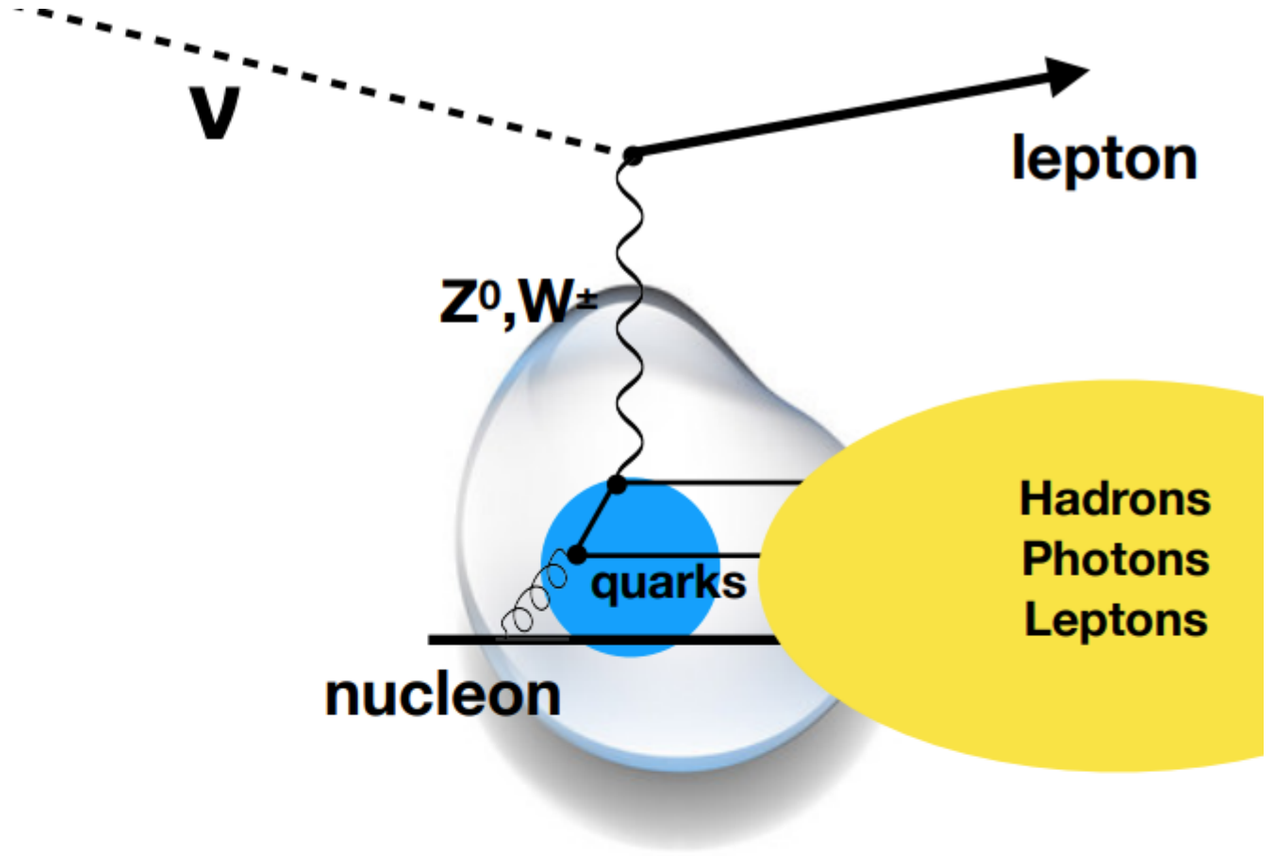
- Simulation neutrino interactions:
  - Probability of interaction.
  - Kinematics of outgoing particles -> $\frac{\mathrm{d}^2\sigma}{\mathrm{d}x\mathrm{d}y}$

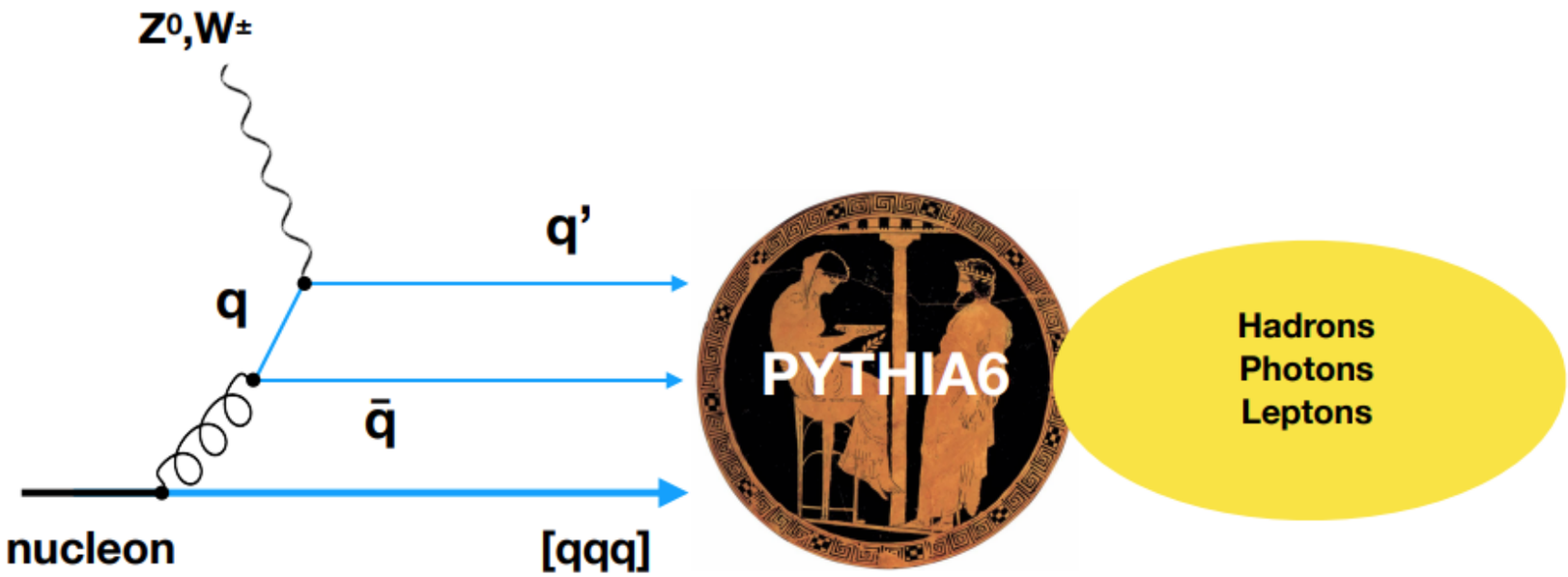




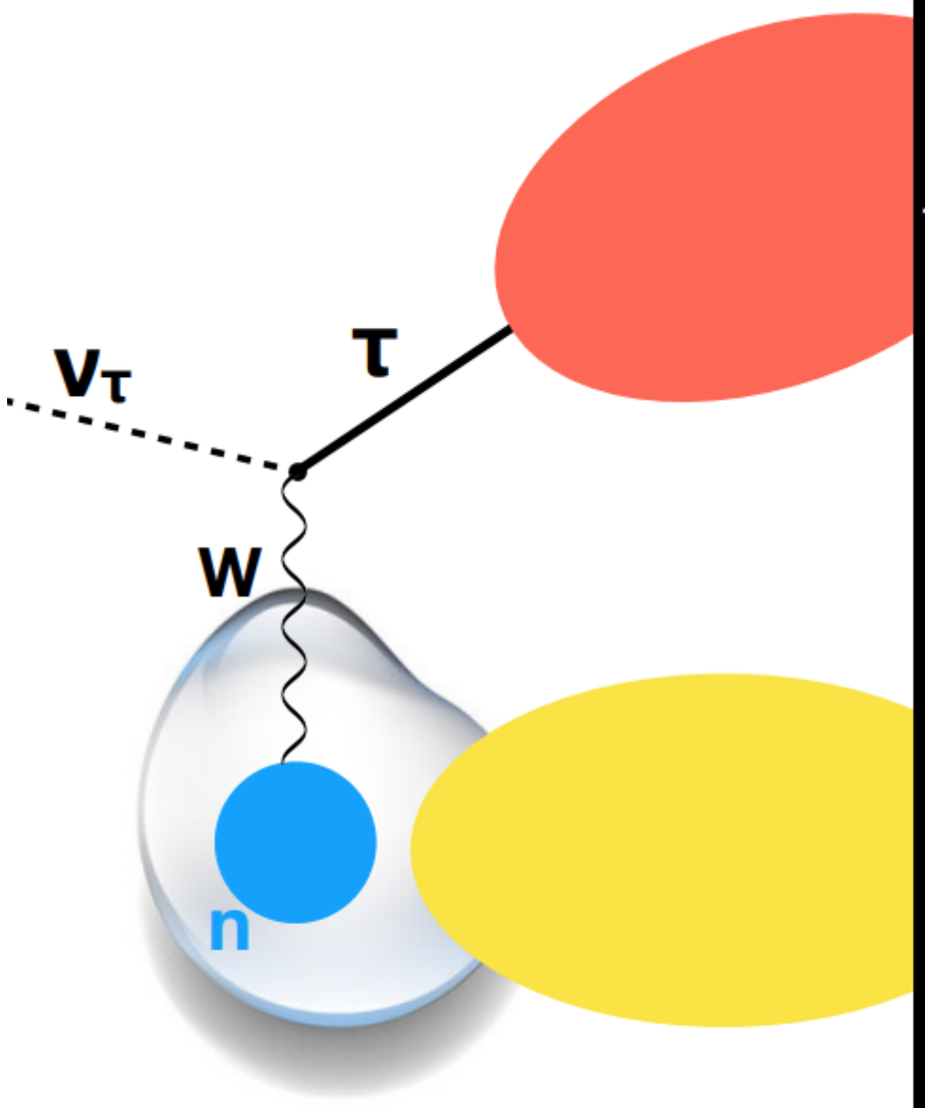
How-To

- Simulation neutrino interactions:
  - Probability of interaction.
  - Kinematics of outgoing particles.
  - Hadronization.





HEDIS




```
--> nu_tau (primary neutrino) E=8360.21 status/id=0/0
    `-tau- (leading_lepton) E=5554.04 status/id=3/4
          +-nu_tau E=3297.56 status/id=1/5
          `-rho- E=2256.48 status/id=3/6
              +-pi- E=1290.81 status/id=1/7
              `-pi0 E=965.675 status/id=3/8
                  +-gamma E=890.175 status/id=1/9
                  `-gamma E=75.4996 status/id=1/10
--> unnamed state (1000080160) E=14.8951 status/id=0/1
    +-neutron E=0.922834 status/id=11/2
    |    `-unnamed state (2000000001) E=2807.09 status/id=12/11
    |         +-u E=2806.31 status/id=12/12
    |         |    `-string E=2807.09 status/id=12/14
    |         |         +-eta E=2243.06 status/id=12/15
    |         |         |    +-gamma E=1083.88 status/id=1/21
    |         |         |    `-gamma E=1159.18 status/id=1/22
    |         |         +-rho+ E=542.988 status/id=12/16
    |         |         |    +-pi+ E=159.131 status/id=1/23
    |         |         |    `-pi0 E=383.856 status/id=12/24
    |         |         |         +-gamma E=243.584 status/id=1/31
    |         |         |         `-gamma E=140.273 status/id=1/32
    |         |         +-pi- E=9.73694 status/id=1/17
    |         |         +-pi0 E=5.21542 status/id=12/18
    |         |         |    +-gamma E=1.08007 status/id=1/25
    |         |         |    `-gamma E=4.13535 status/id=1/26
    |         |         +-omega E=3.59776 status/id=12/19
    |         |         |    +-gamma E=0.0816192 status/id=1/27
    |         |         |    `-pi0 E=3.51614 status/id=12/28
    |         |         |         +-gamma E=3.20452 status/id=1/33
    |         |         |         `-gamma E=0.311622 status/id=1/34
    |         |         `-Delta+ E=2.49298 status/id=12/20
    |         |              +-proton E=2.00807 status/id=1/29
    |         |              `-pi0 E=0.484947 status/id=12/30
    |         |                   +-gamma E=0.0471374 status/id=1/35
    |         |                   `-gamma E=0.437831 status/id=1/36
    |         `-ud_1 E=0.780469 status/id=12/13
    `-unnamed state (1000080150) E=13.9722 status/id=1/3
```

$$W_{evt} = W_{gen} \cdot \phi(E_\nu, \theta_\nu).$$

Draw("TMath::Log10(E)>>h(25,0,5)","Wevt*(cuts)")