

LeptonInjector

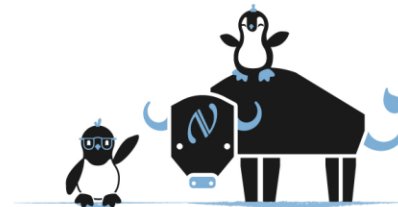
Ben Smithers

IceDUNE Workshop - 2021



IceDUNE

JUNE 16-18, 2021



What are LeptonInjector and LeptonWeighter?

- Event Generator and Weighter
- [LeptonInjector](#)
 - Generates Deep Inelastic Scattering, Glashow Resonance events
 - For generating atmospheric neutrino events
- [LeptonWeighter](#)
 - Weights events to any desired cross section, neutrino flux!

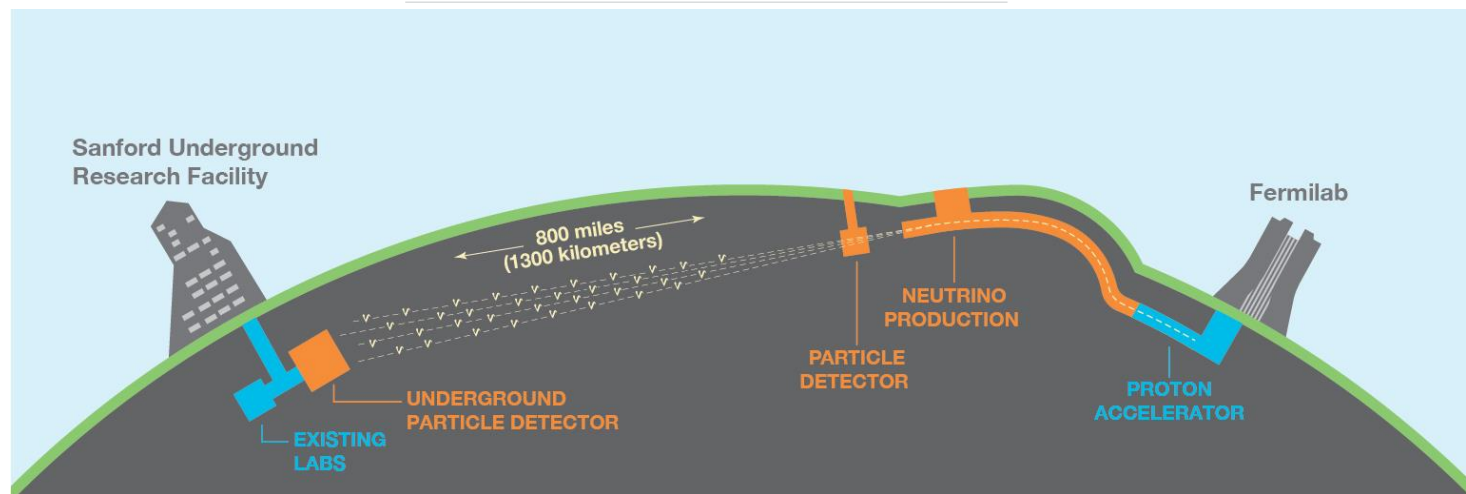
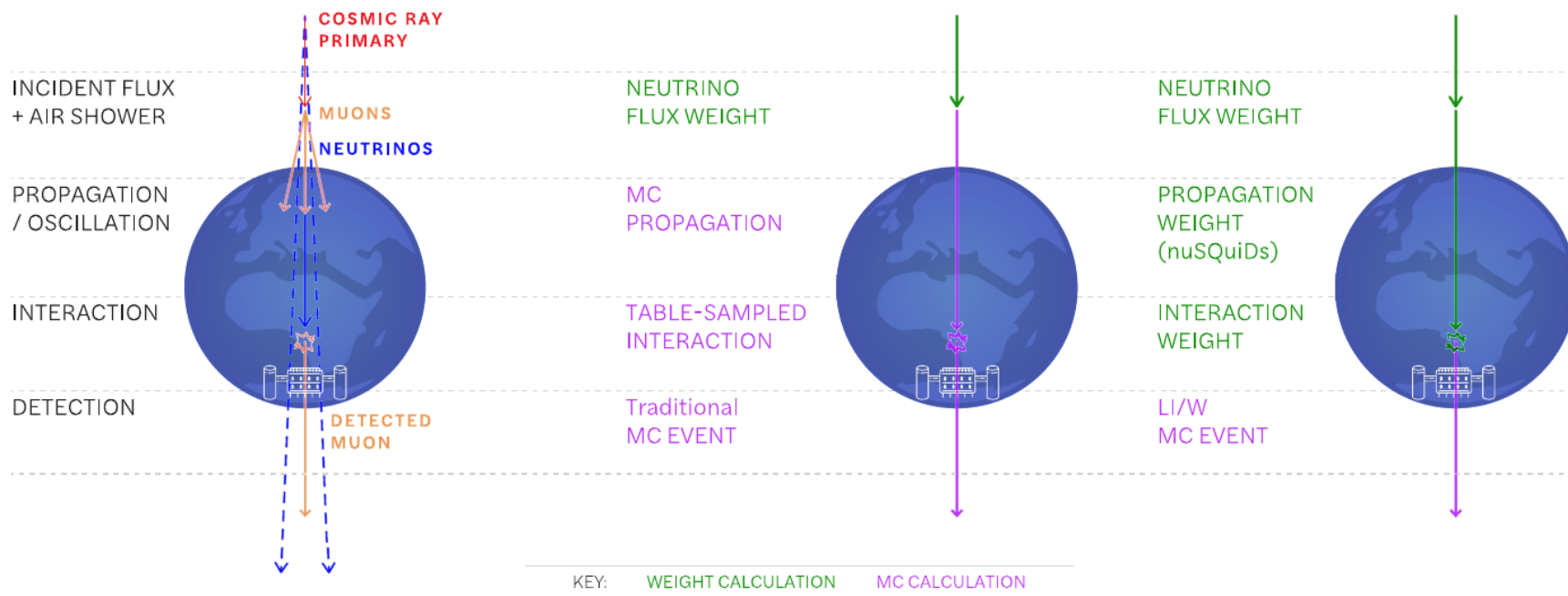
lepton
Injector



Physical System

Traditional approach

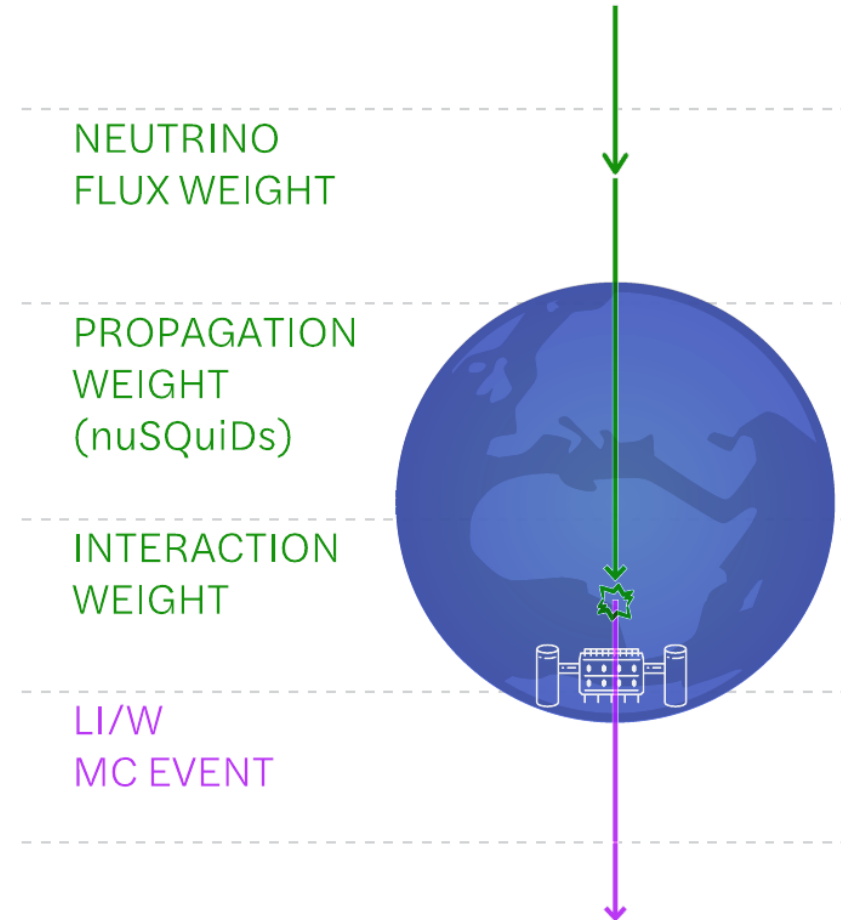
LI/W approach



Lepton Family Improvements

- Efficient algorithms solving neutrino transport now available
 - [NuSQuIDS](#), [Github](#)
- Separate, discrete problems
 - Flux Calculation
 - Event Generation
 - Event Weighting
- Weighting can be done after full event simulation

LI/W approach



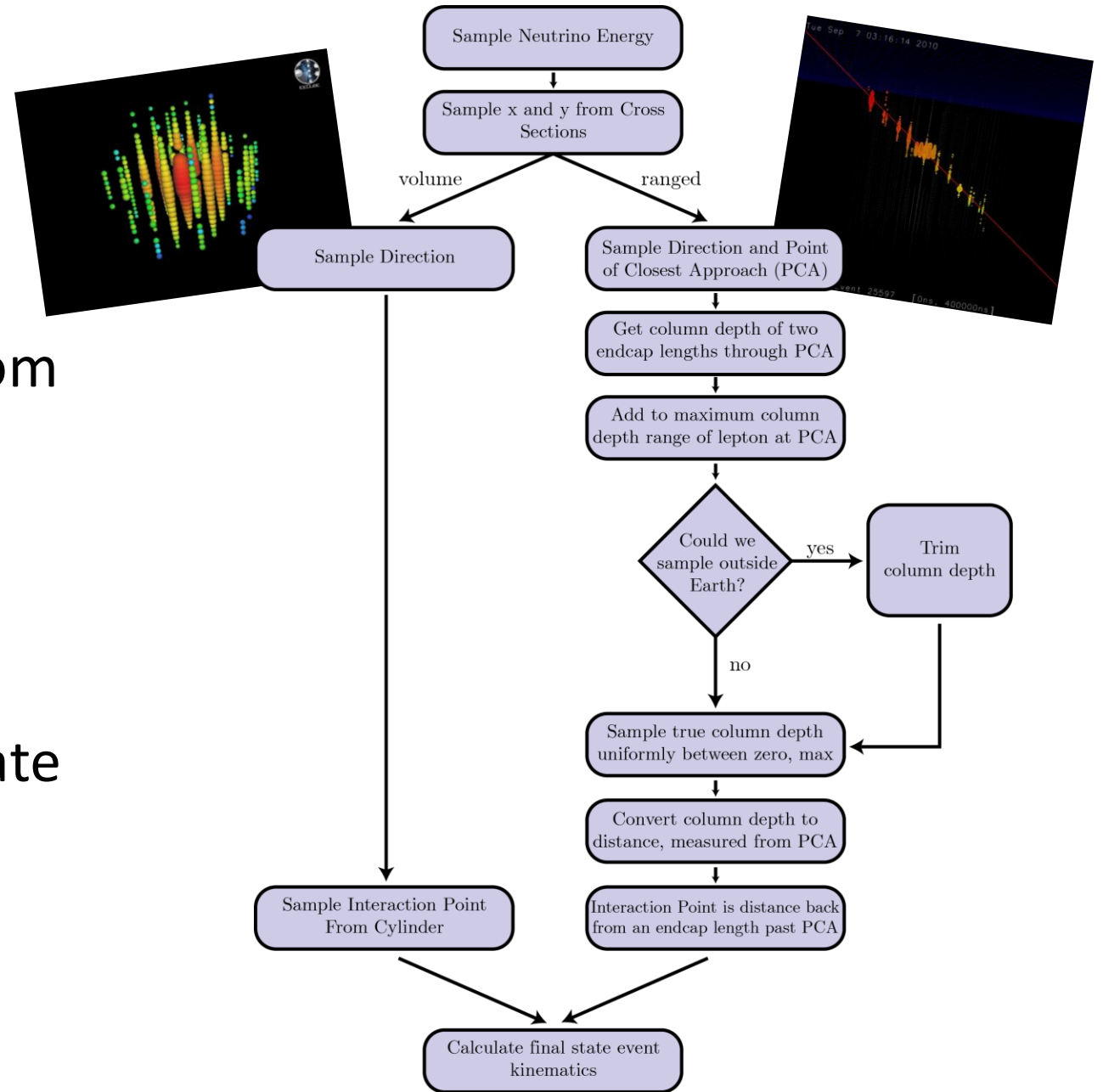
Configuring Lepton Injector

- Choose allowed azimuth, zenith, energies
- Power Law energy spectrum
- Cross Sections
- Final state particles
 - Lepton + hadrons
 - W^- decay products
- Configure Earth Models
 - Master branch is Icy PREM



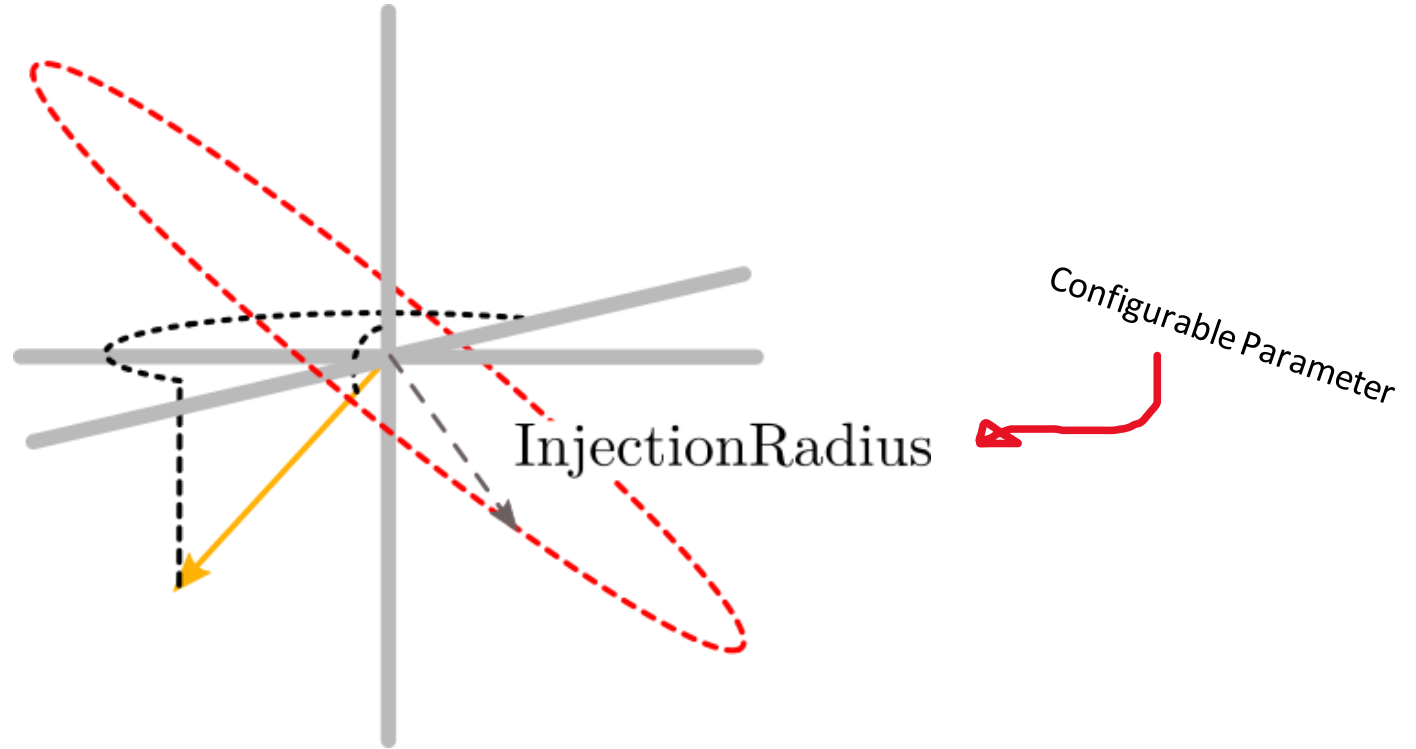
Event Generation

1. Sample some kinematics from cross sections
2. Choose interaction vertex
3. Calculate remaining final state event kinematics



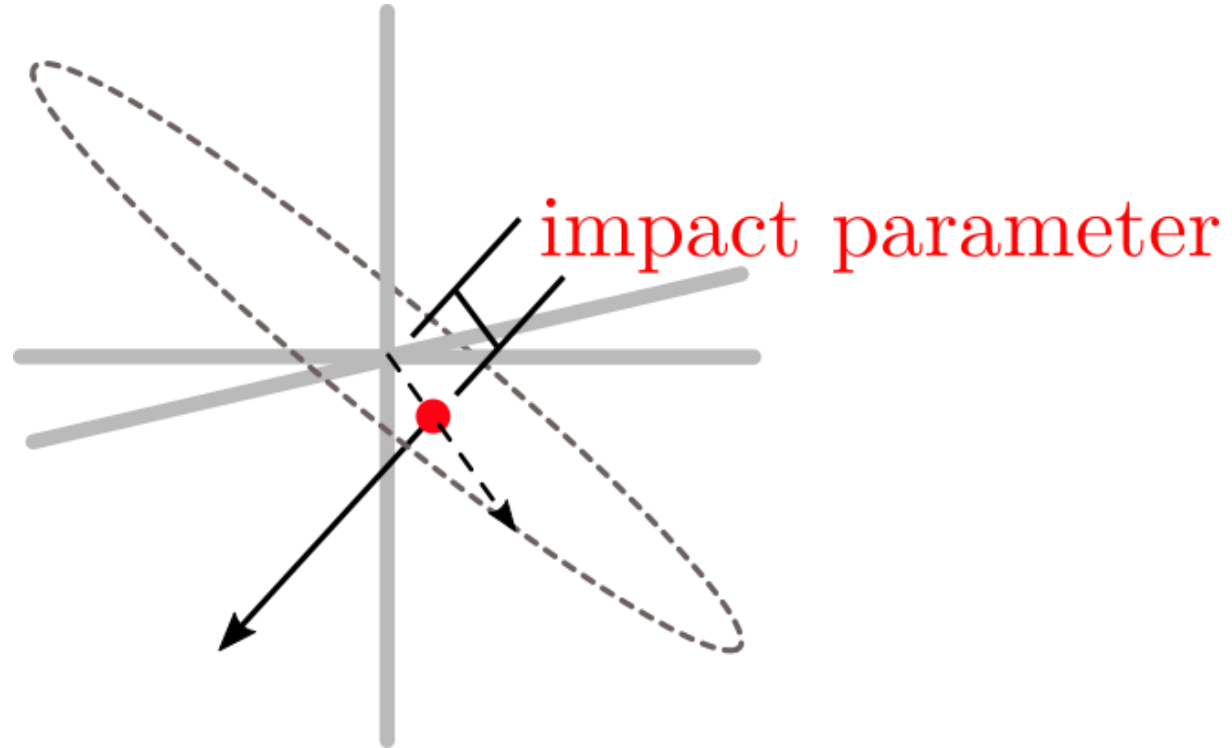
Ranged Injection

Choose direction, build disc
of configurable radius



Ranged Injection

Choose point on disc,
sample uniformly

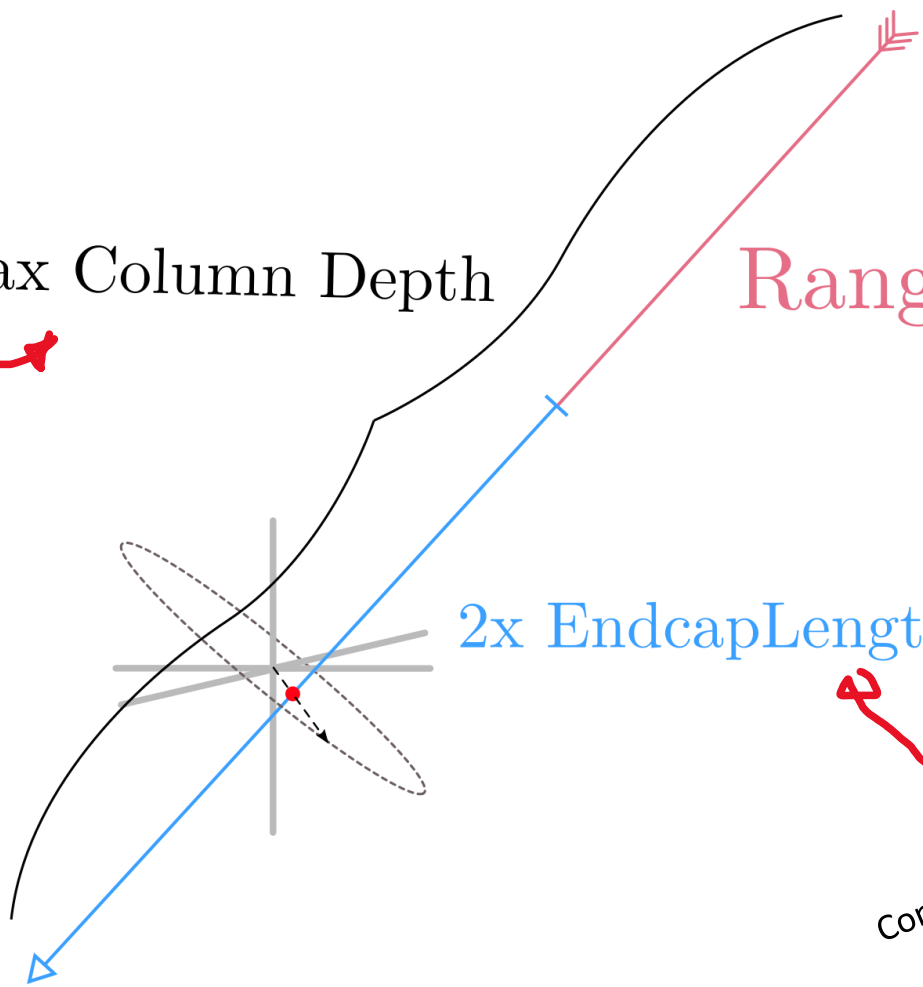


Ranged Injection

Done according to some Earth model

Max Column Depth

Range



2x EndcapLength

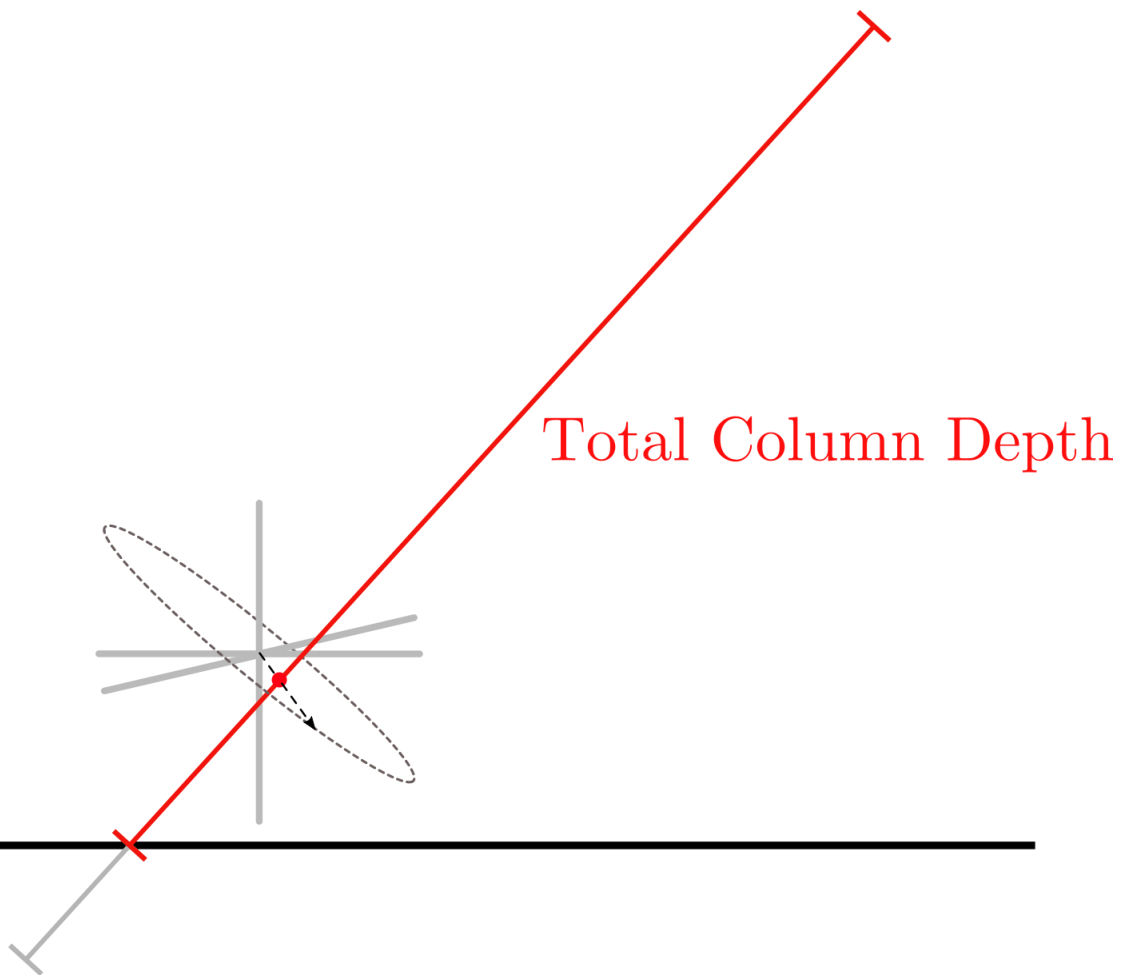
Configurable Parameter

Consider all injection locations to cover all possible event topologies

Ranged Injection

Ensure injection outside physical space not allowed

Earth
Space

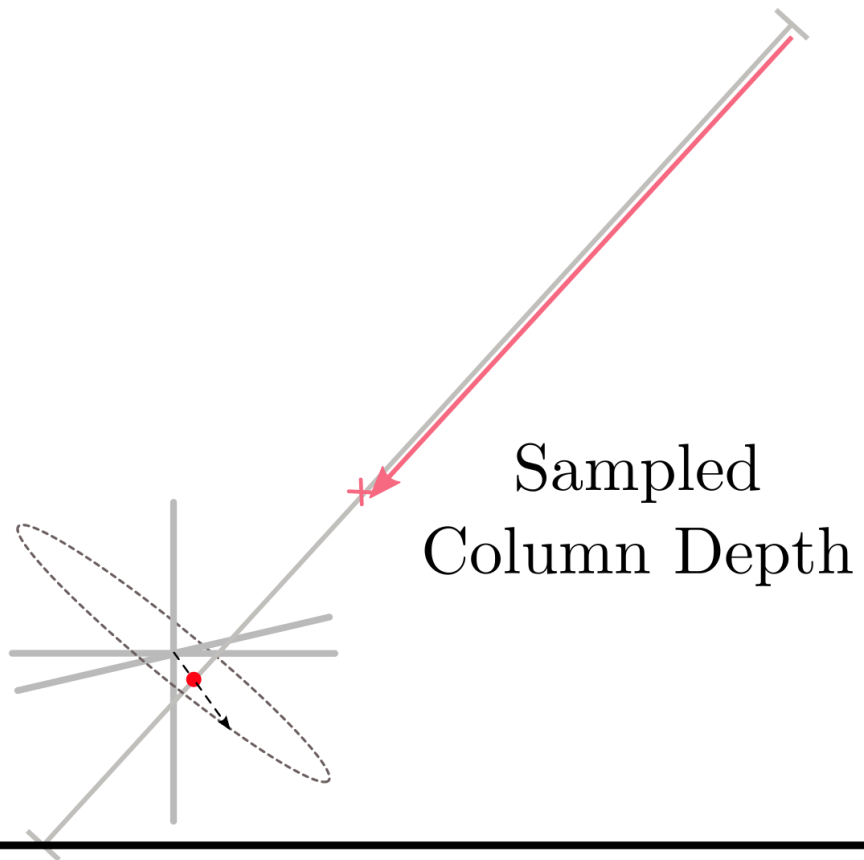


Ranged Injection

Sample injection
location, uniformly by column
depth, from max distance away

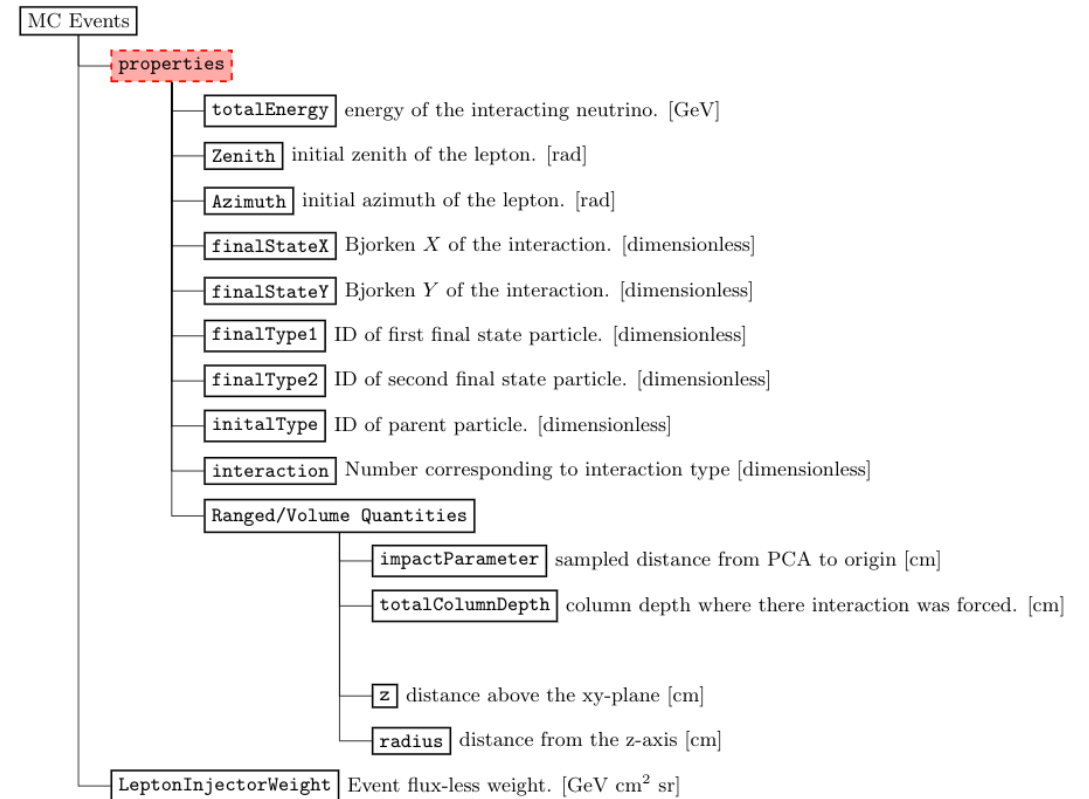
Earth

Space



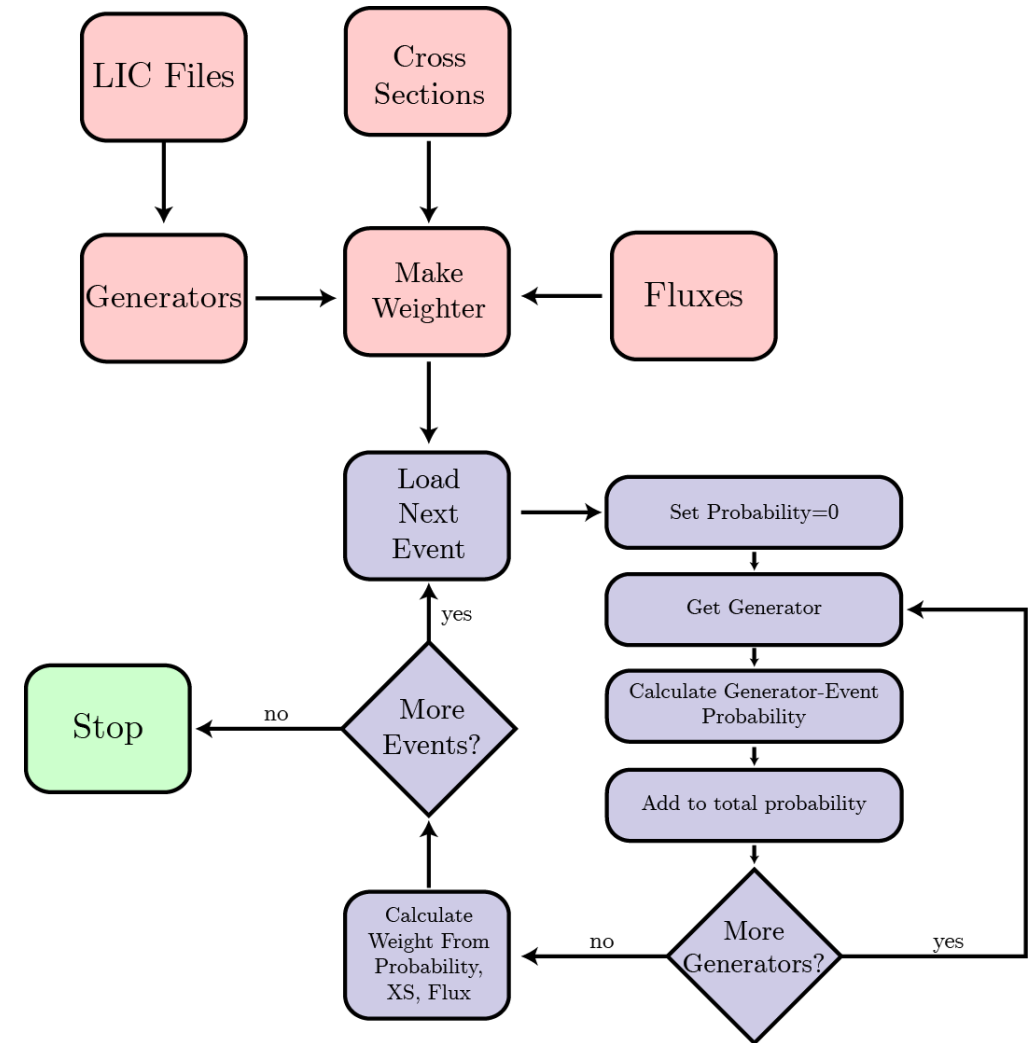
Lepton Injector Configuration (LIC) Files

- Serialized generation parameters for reweighting
- Contain
 - Copies of cross sections
 - All generation parameters



LeptonWeighter

- Uses LIC Files
- LW Reweights LI events
 - To any flux
 - To any cross section
- Can interface with [nuflux](#), [nuSQuIDS](#)



Event Reweighting

Calculate generation bias for each event from each subsample



$$p_{MC} \equiv N_{MC} \frac{\overset{\text{Number Made}}{1}}{\Omega_{gen} A_{tot}} \frac{\overset{\text{Generation Topology}}{1}}{\sigma_{tot}} \frac{\partial^2 \sigma}{\partial x \partial y} \frac{\overset{\text{Energy Spectrum}}{\phi(E)}}{\int_{E_{min}}^{E_{max}} \phi(E) dE}$$

Remove generation bias

$$w_{gen} \equiv [\Sigma p_{MC}]^{-1}$$

Reweight!

$$w_{event} = X_{col} \times N_A \times \underset{\text{Desired cross section}}{\partial_{xy} \sigma} \times \underset{\text{Desired Flux}}{\phi_{target}} \times w_{gen}$$

What to Remember

- LeptonInjector
 - Event generator
 - Ranged/volume modes
 - Work underway to incorporate more Earth geometries
- LeptonWeighter
 - Event weighter for LI
 - Weight events to any xs, flux
- Reweight to test new physics!
- See the example scripts!

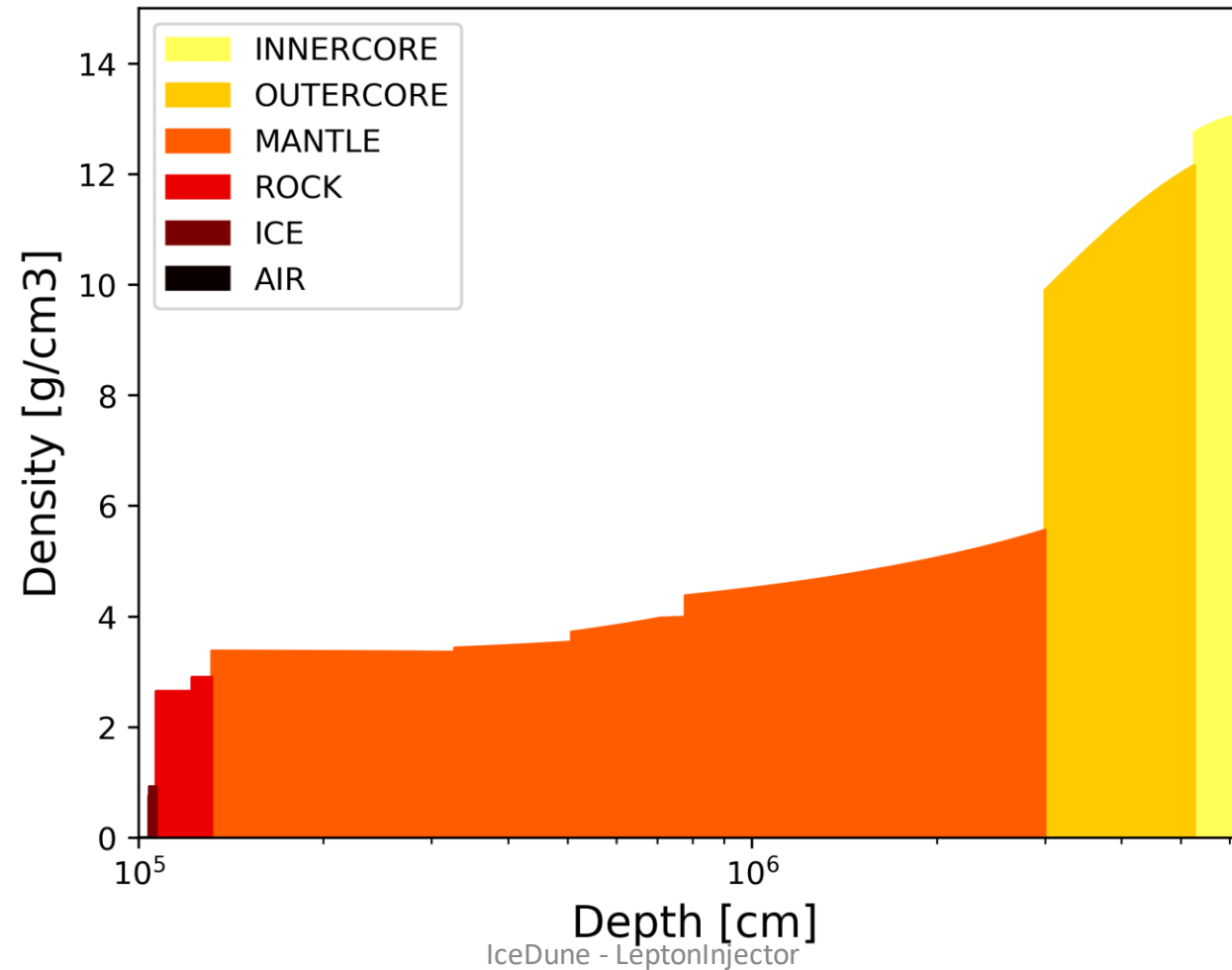


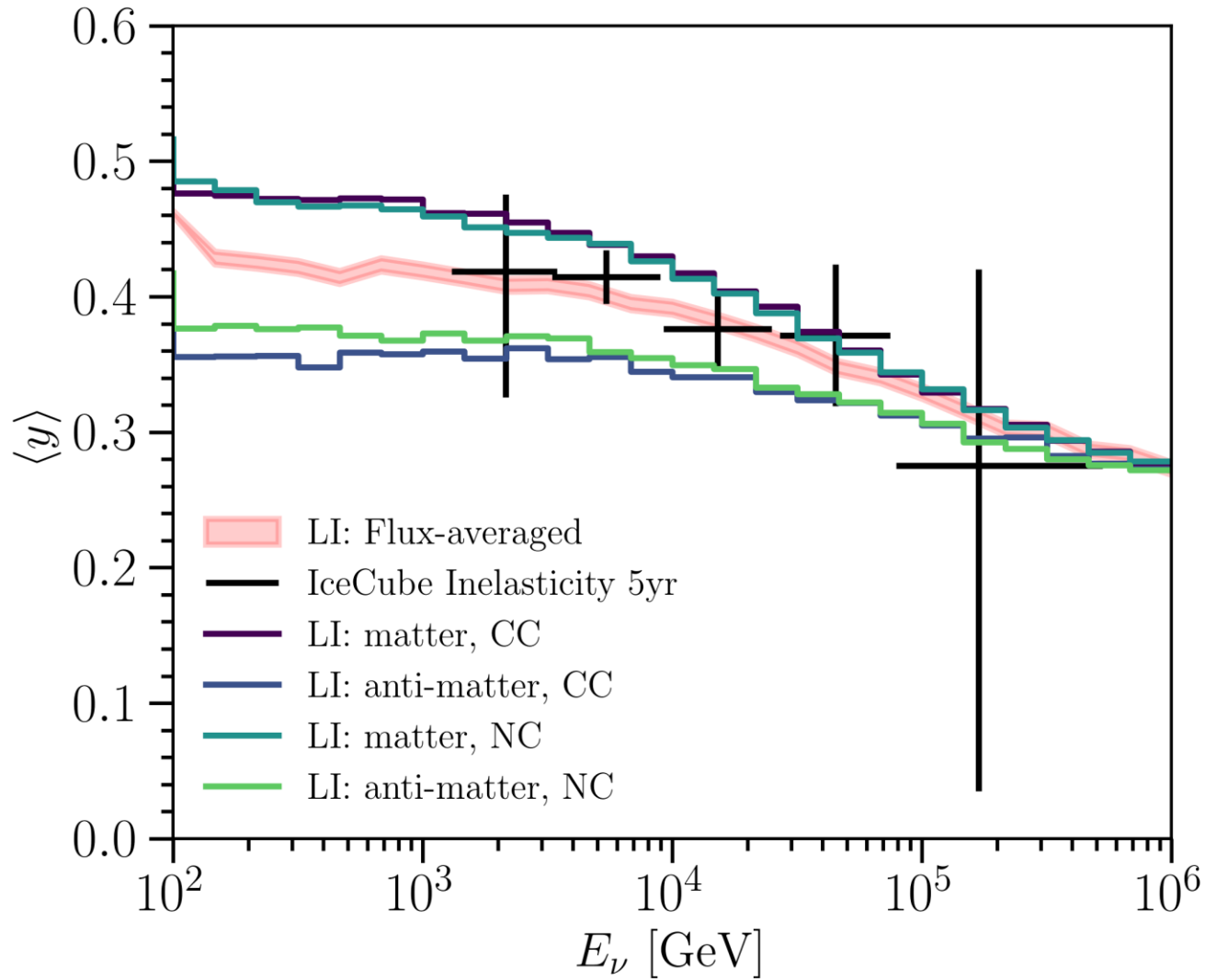
Thank you for your time!

Any questions?

Backup

Default Earth Model





Average inelasticity as a function of incident neutrino energy in LeptonInjector for [CSMS cross-sections](#), with [IceCube inelasticity results](#) overlain.