The obscure tale of the PDFs

Progress

Jordan Seneca

February 1, 2018

- hierarchy n.
  A group of persons or things organized into successive ranks or grades with each level subordinate to the one above:[1]

[1] https://www.thefreedictionary.com/hierarchy

- hierarchy n.
- ordering n.
  A sequence or arrangement of successive things[2]

[2] https://www.thefreedictionary.com/ordering

- ~~hierarchy n.~~
- ordering

Motivation

Here are the parameters necessary to accurately predict the oscillation probability of a neutrino through matter.

- Oscillation parameters
- The number of electrons in the neutrino's path
- Energy of the neutrino
- Flavor of the neutrino
- Neutrino Mass Ordering (NMO)

$$P_{3\nu}m(\nu_\mu \rightarrow \nu_\mu) \simeq 1 - sin^2 2\theta_{23} cos^2 \theta_{13}^m sin^2 \Big(\frac{AL}{4} + \frac{\Delta m_{31}^2 + \Delta^m m^2) L}{8E_\nu} \Big) - some other terms \quad (1)$$

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Requires knowledge of the following:

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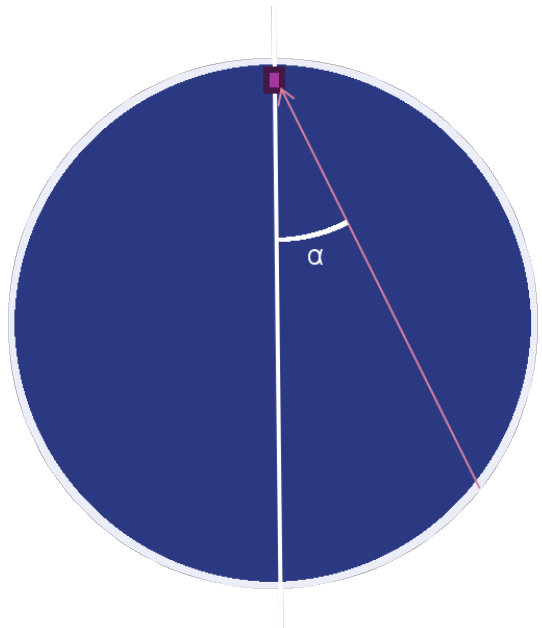
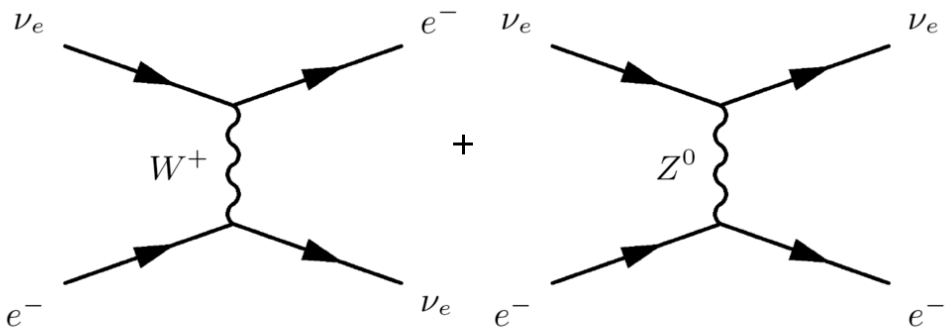
- The matter density of the Earth
- The distance travelled through the Earth
  - $\rightarrow$ known by neutrino direction

Figure: Parametrization of electrons in path using the Earth



Motivation: neutrino flavor

The flavor of a neutrino is defined by the interaction it induces.



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- Energies and directions of product particles

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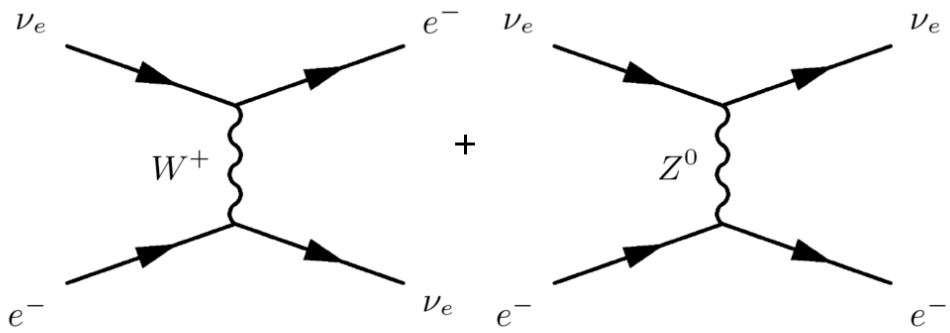


- Type of product particles
- Energies and directions of product particles

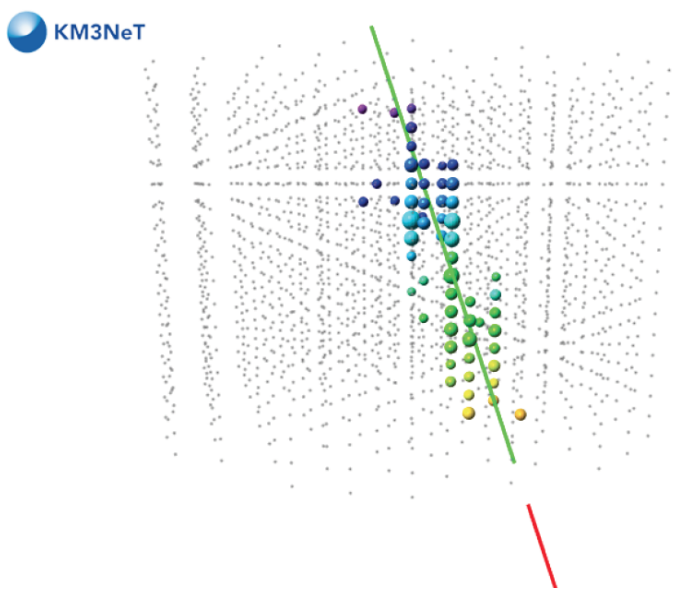
Motivation: neutrino energy

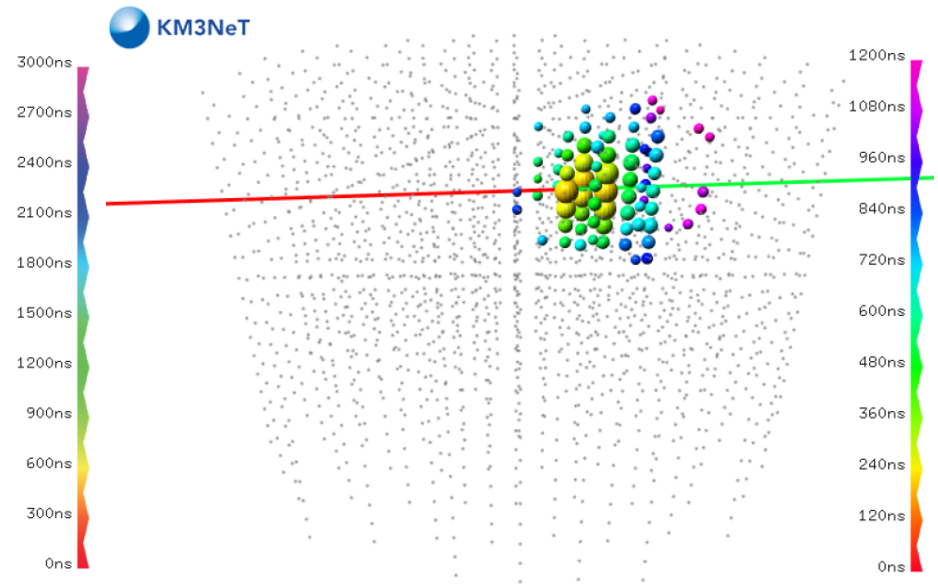
The neutrino energy affects the following outcomes:

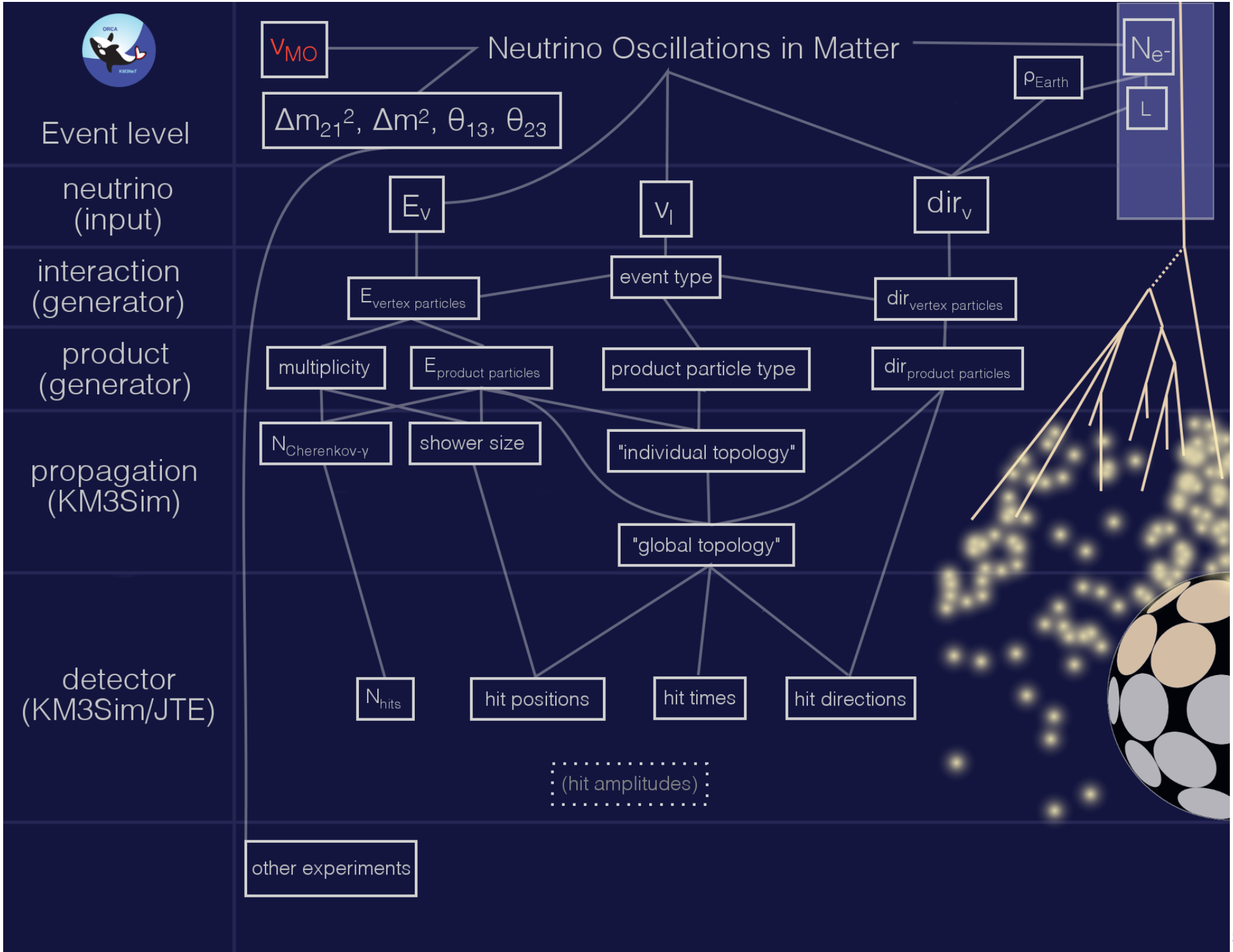
- The size of the event in the detector (PMT positions)
- The number of $\gamma_{cherenkov}$

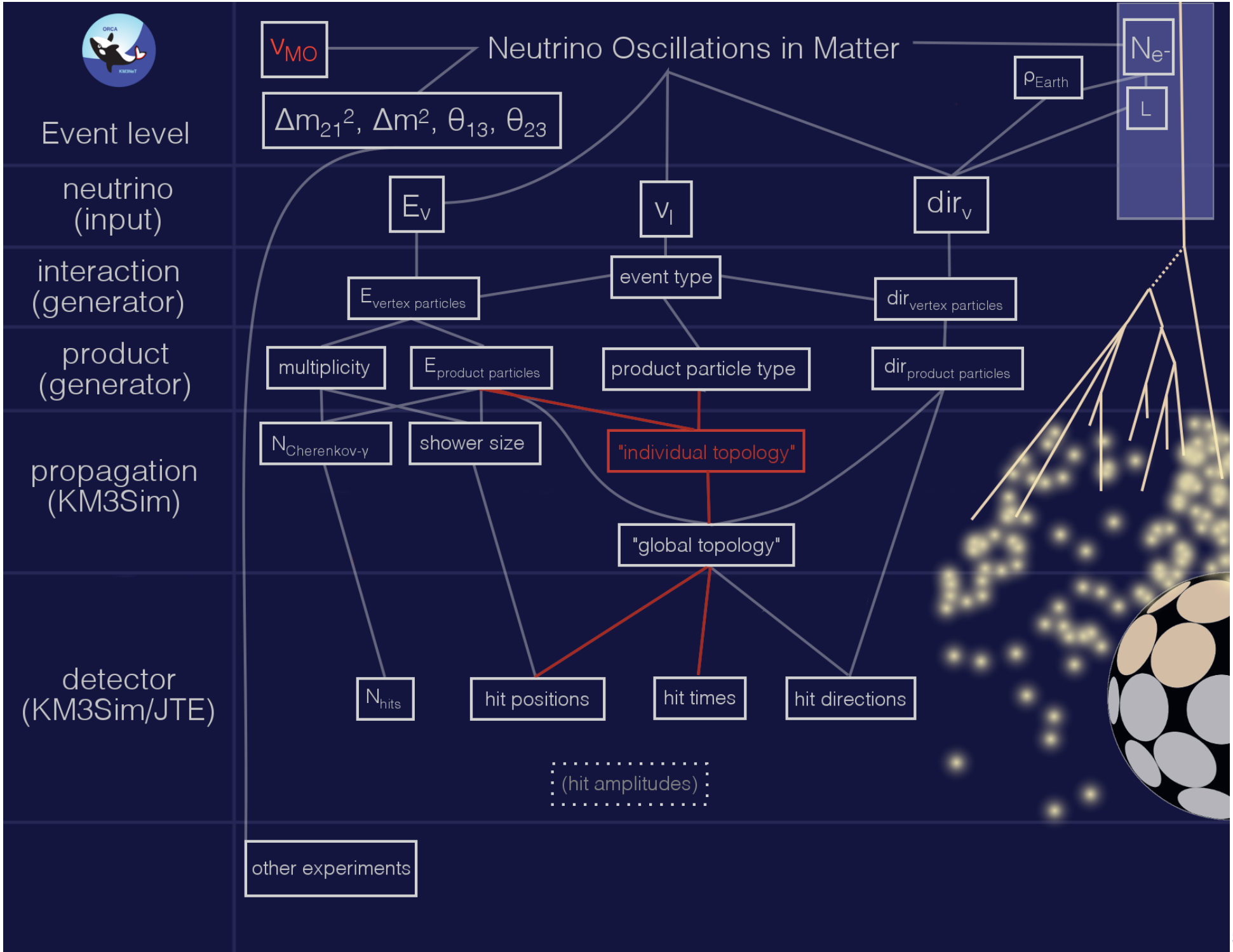
Motivation

Neutrino interaction events are currently categorized "track-like" and "shower-like". This categorization helps us distinguish between events producing muons, and other neutrino events.






Neutrino Oscillations in Matter
ν_{MO}
Δm_{21}^2, Δm^2, θ_{13}, θ_{23}
ρ_{Earth}
N_{e^-}
L
Event level
neutrino (input)
interaction (generator)
product (generator)
propagation (KM3Sim)
detector (KM3Sim/JTE)
E_ν
ν_l
dir_ν
$E_{vertex\ particles}$
event type
$dir_{vertex\ particles}$
multiplicity
$E_{product\ particles}$
product particle type
$dir_{product\ particles}$
$N_{Cherenkov\text{-}\gamma}$
shower size
"individual topology"
"global topology"
N_{hits}
hit positions
hit times
hit directions
(hit amplitudes)
other experiments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shower size
"individual topology"
"global topology"
N_{hits}
hit positions
hit times
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(hit amplitudes)
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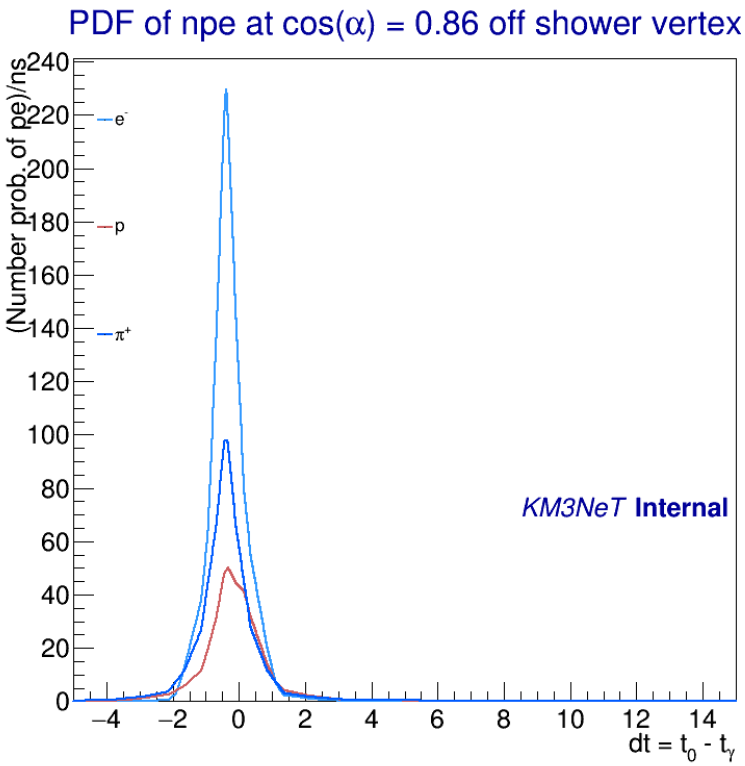
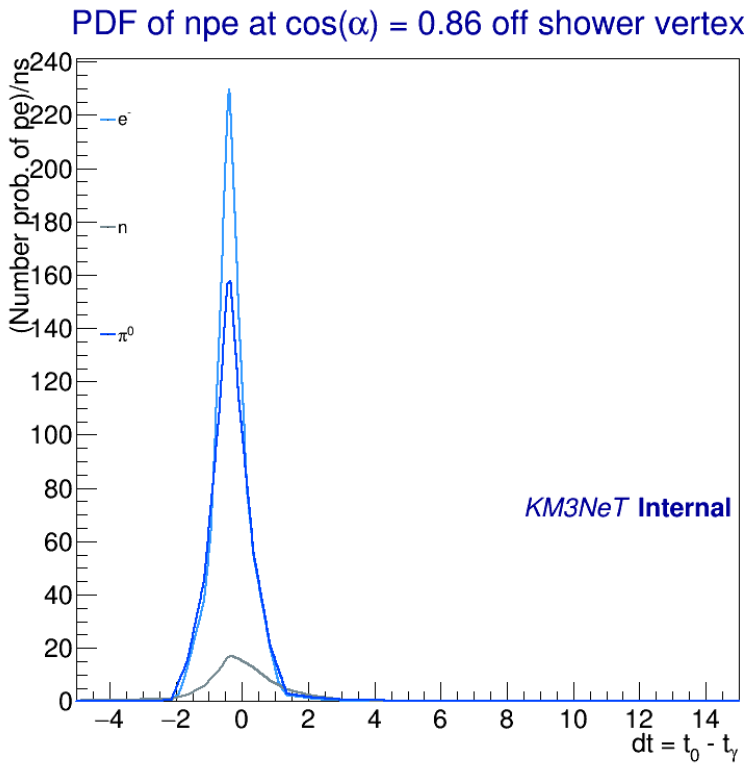
So what?

Features

Arrival time PDFs





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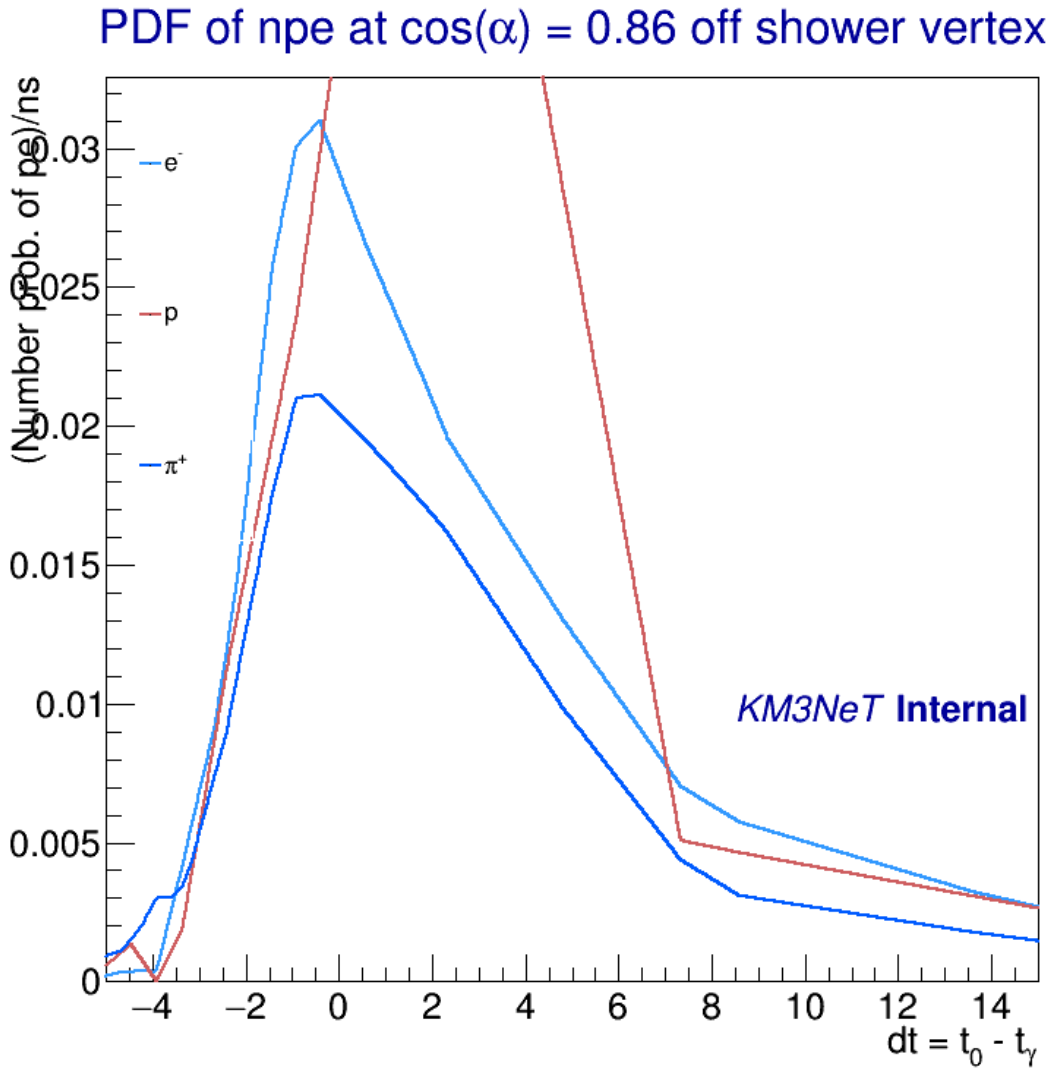

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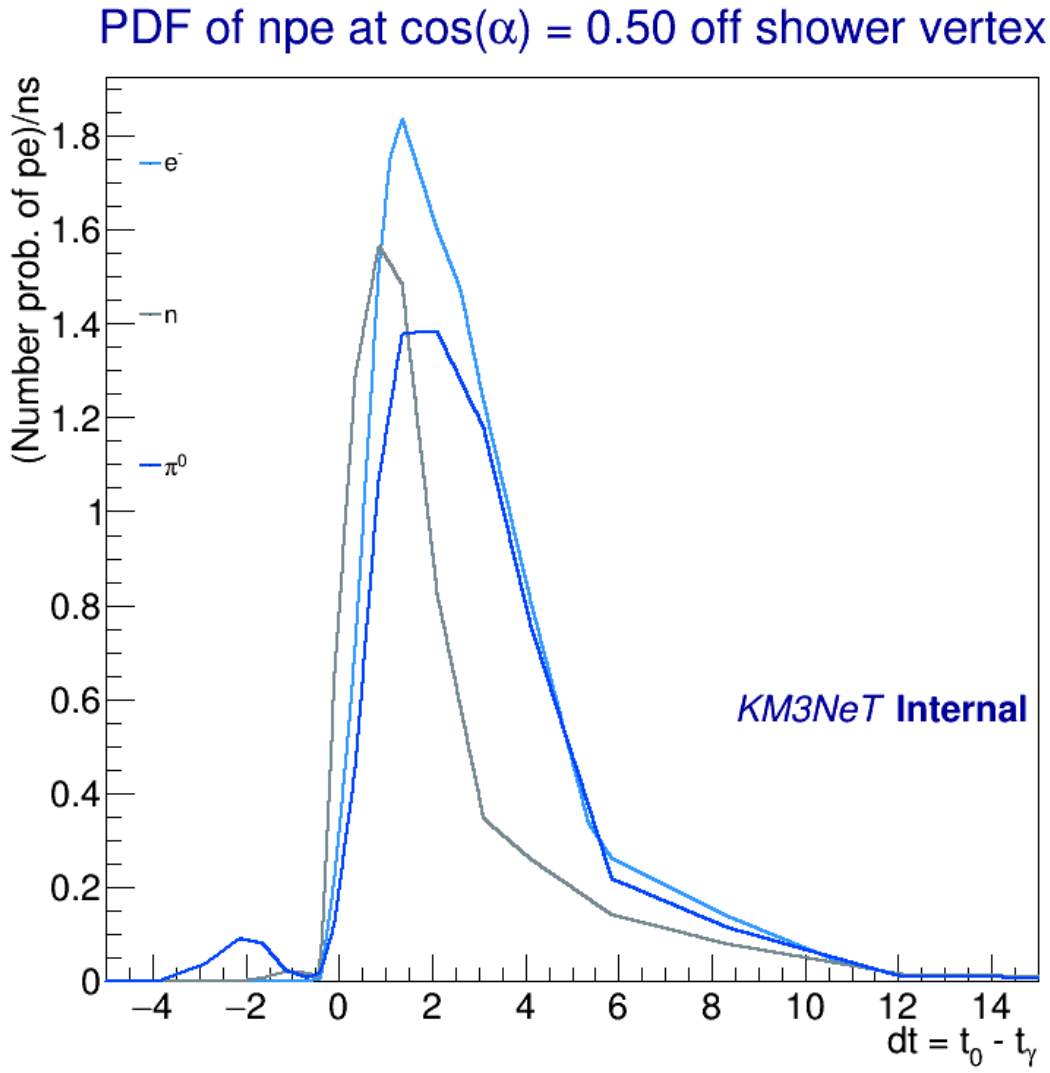
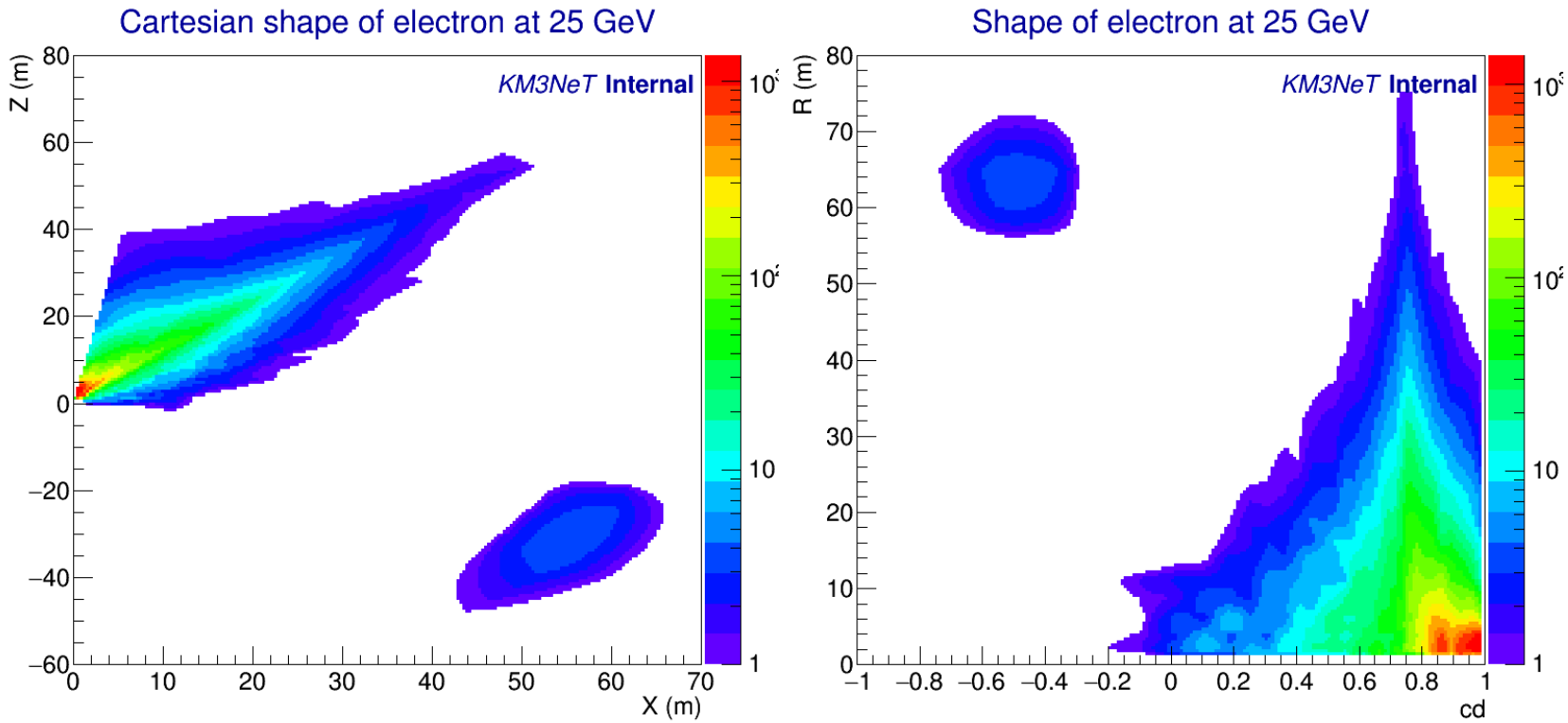
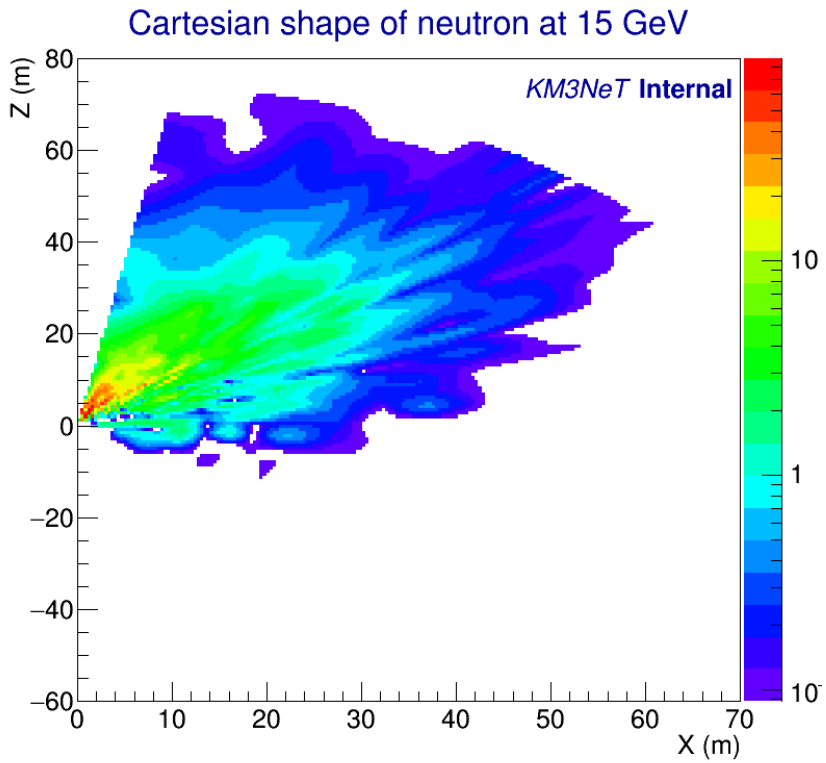
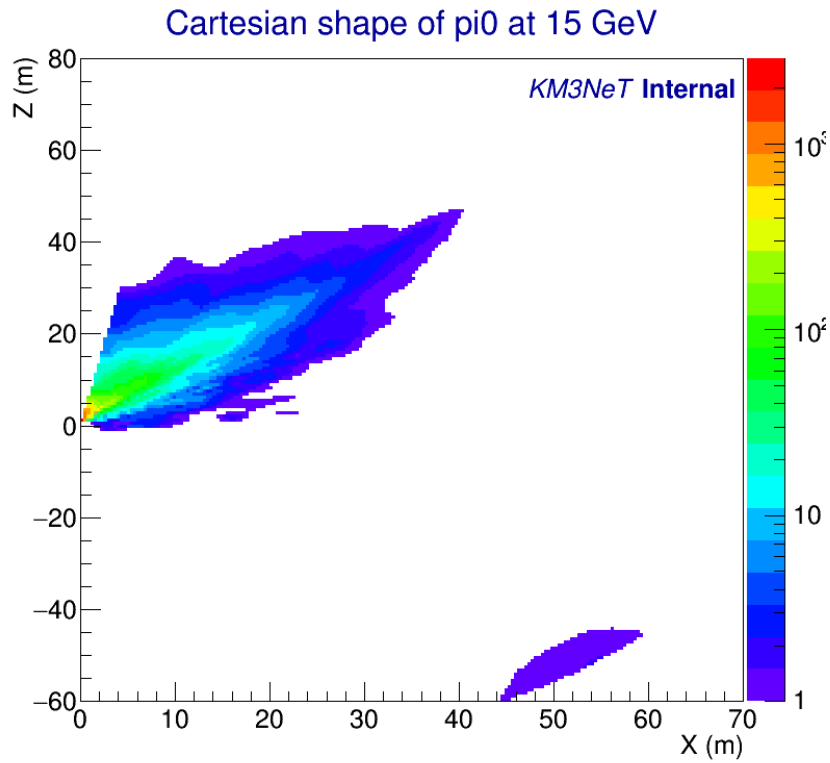


NPE yield

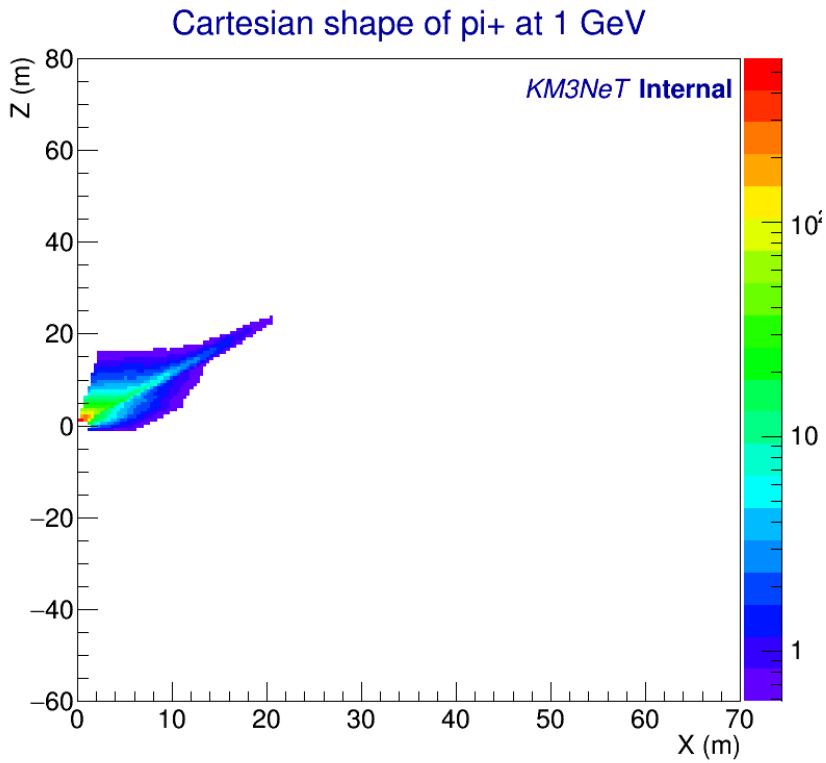

Cartesian shape of electron at 25 GeV
KM3NeT Internal
Z (m)
X (m)
Shape of electron at 25 GeV
KM3NeT Internal
R (m)
cd

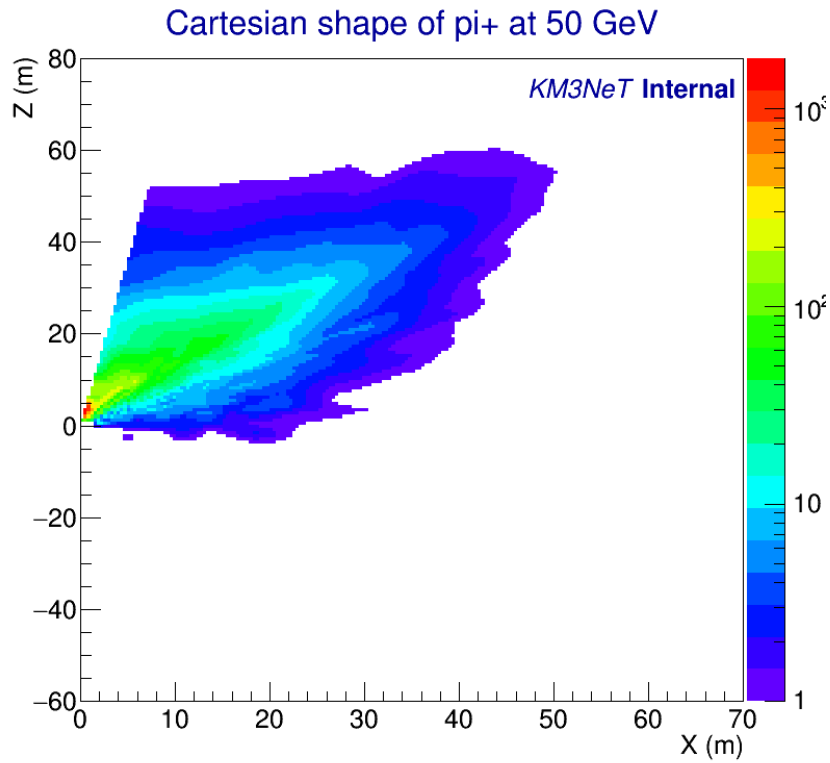
NPE yield


Cartesian shape of neutron at 15 GeV
KM3NeT Internal
Z (m)
X (m)

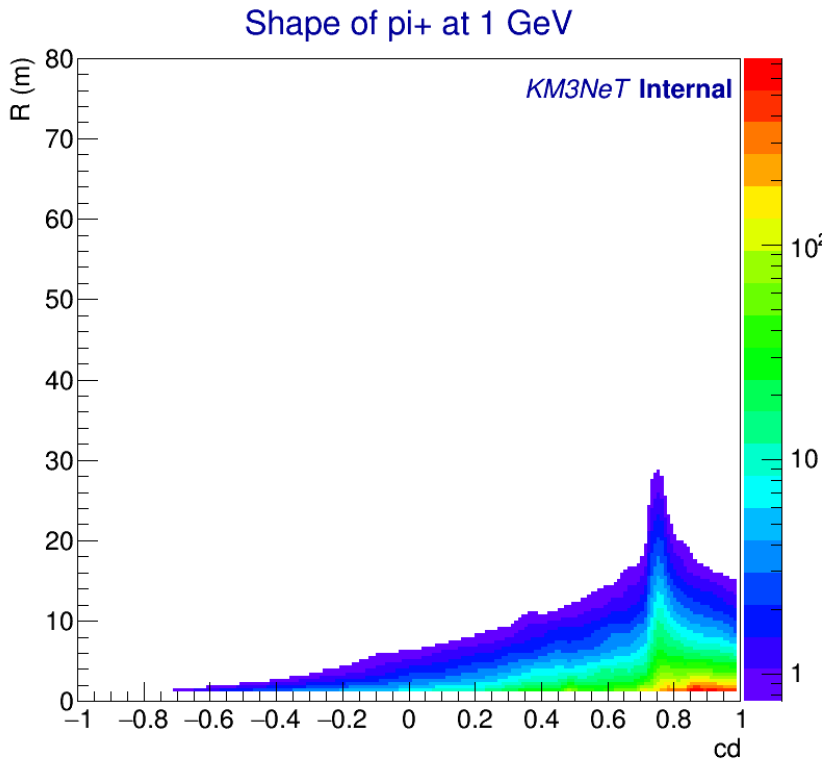

Cartesian shape of pi0 at 15 GeV
KM3NeT Internal
Z (m)
X (m)

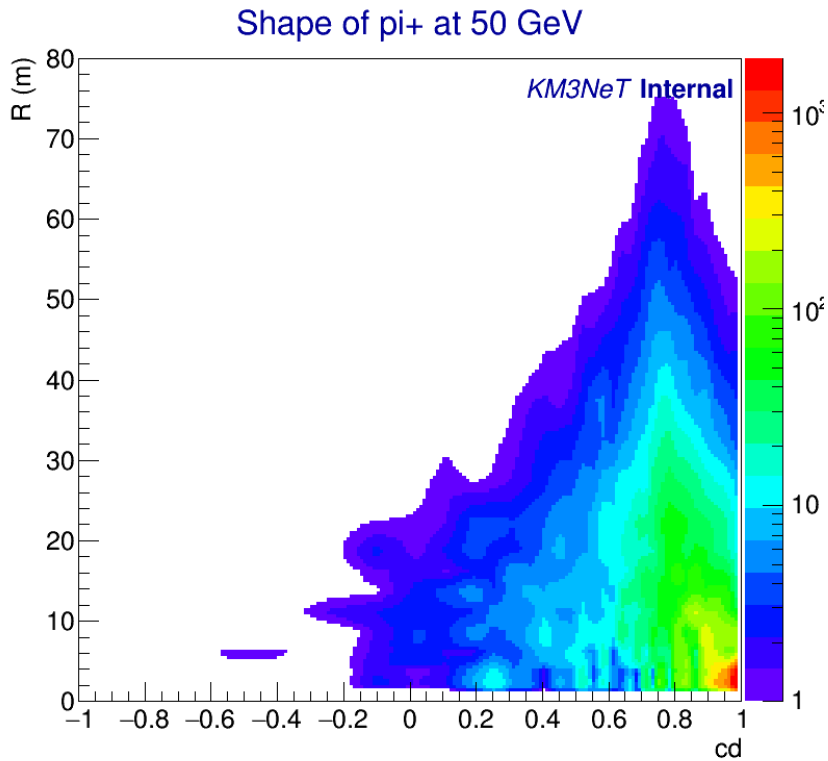
NPE yield


Cartesian shape of pi+ at 1 GeV
KM3NeT Internal
Z (m)
X (m)
80
60
40
20
0
−20
−40
−60
0
10
20
30
40
50
60
70
10
1


Cartesian shape of pi+ at 50 GeV
KM3NeT Internal
Z (m)
X (m)
80
60
40
20
0
−20
−40
−60
0
10
20
30
40
50
60
70
10
1

NPE yield


Shape of pi+ at 1 GeV
KM3NeT Internal
R (m)
cd


Shape of pi+ at 50 GeV
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R (m)
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