Discussion of ν_τ recognition at ~1 TeV

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Update

- We continued energy containment study for both LAr and LKr
  - Liquid argon: radiation length is 14 cm, density is 1.4 g/cm^3
  - Liquid krypton: radiation length is 4.7 cm, density is 2.413 g/cm^3
- We started to working on the simulation of ν_τ neutrino, in order to look into the signatures of ν_τ neutrino events in the detector

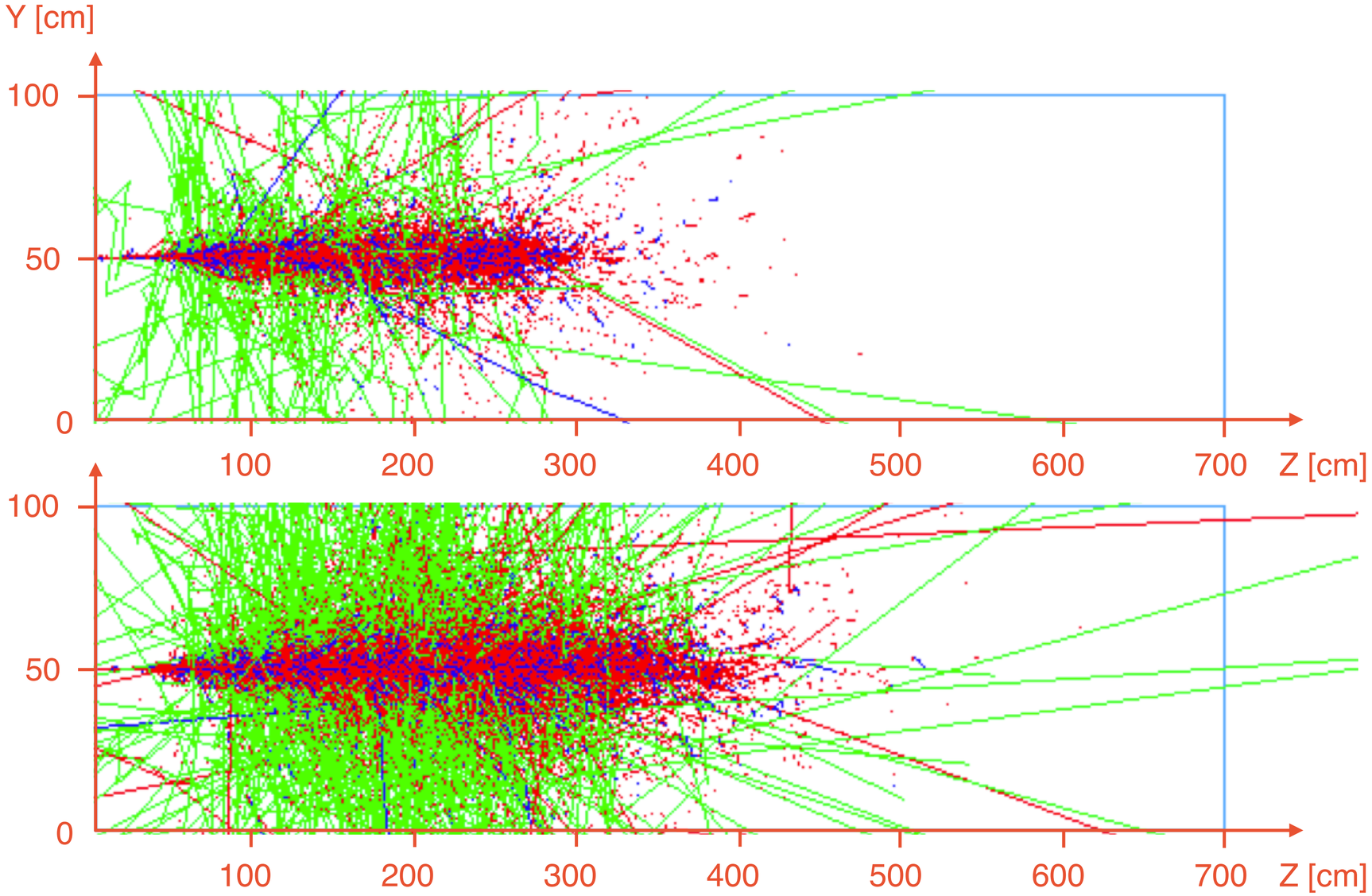
- *Use Geant4 to simulate leptons in a LAr/LKr detector*
  - ***Detector Size (cuboid)**: 1x1x7*
  - *Direction: (0, 0, 1). Currently no angle smearing.*
  - ***Vertex of electron is uniformly distributed along Z-axis** (0, 7000) mm*
  - *PhysicsList used in the simulation: FTFP_BERT*

Energy Containment

- Electron shower in LAr

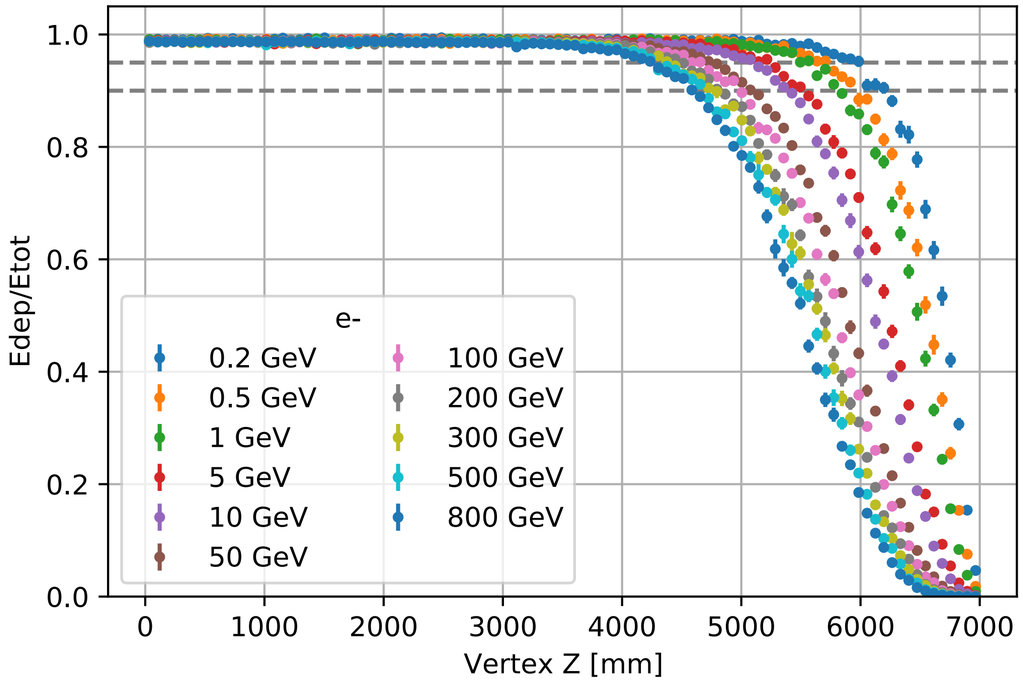
200 GeV e-

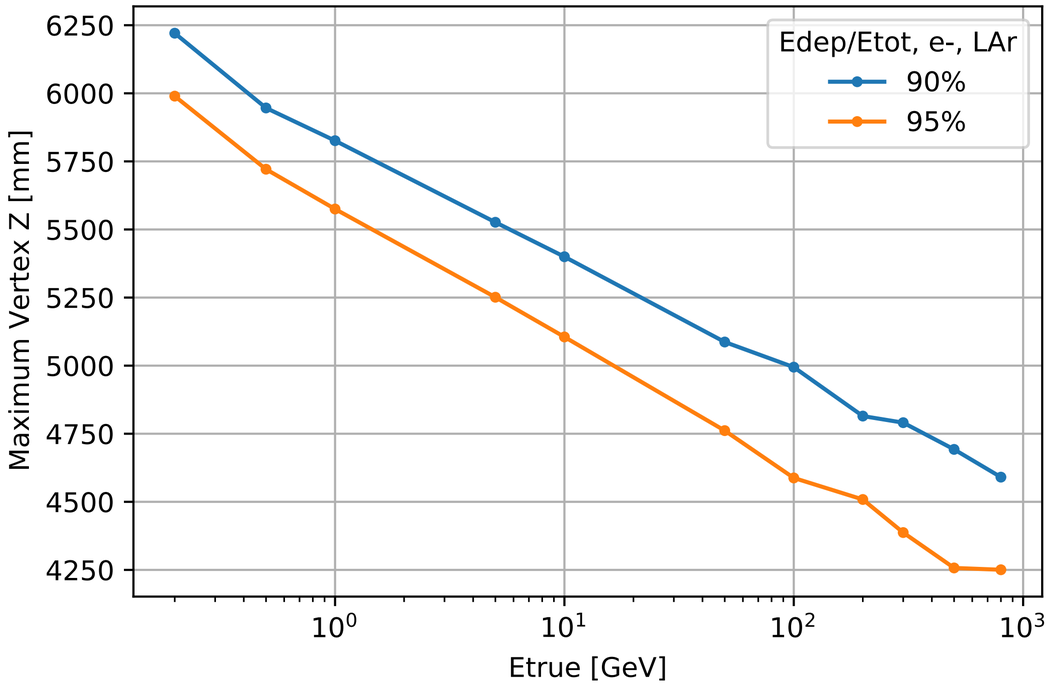
1 TeV e-



Energy Containment

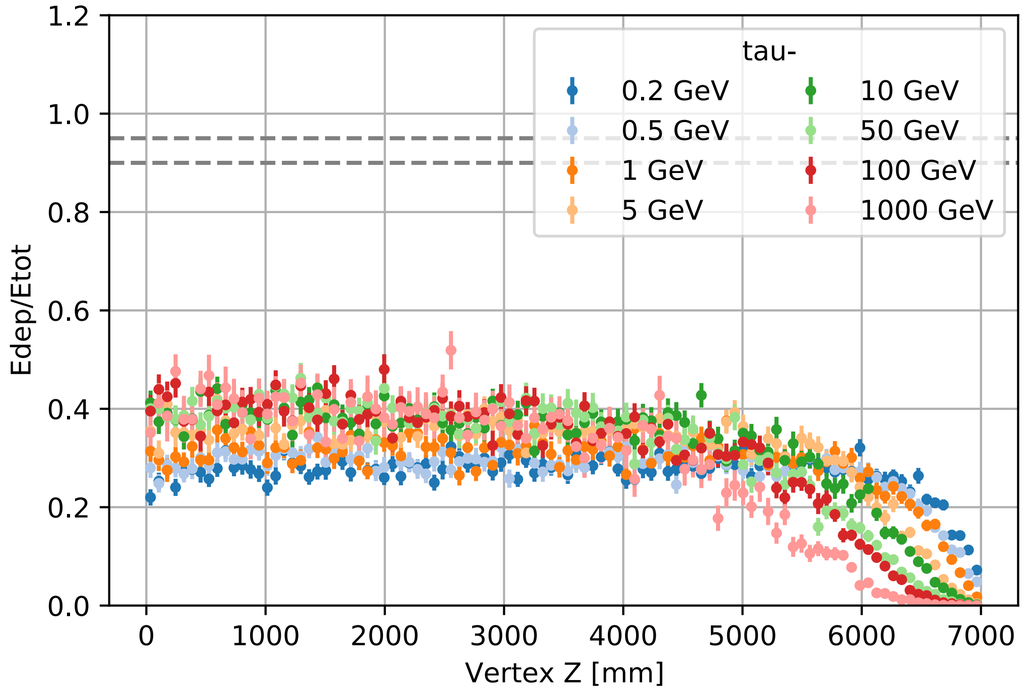
- Electron shower in LAr





Energy Containment

- τ^- in LAr: missing energy from τ^- decay



Decay mode	Branching ratio
Leptonic	35.2%
$e^-\bar{\nu}_e\nu_\tau$	17.8%
$\mu^-\bar{\nu}_\mu\nu_\tau$	17.4%
Hadronic	64.8%
$\pi^-\pi^0\nu_\tau$	25.5%
$\pi^-\nu_\tau$	10.8%
$\pi^-\pi^0\pi^0\nu_\tau$	9.3%
$\pi^-\pi^-\pi^+\nu_\tau$	9.0%
$\pi^-\pi^-\pi^+\pi^0\nu_\tau$	4.5%
other	5.7%

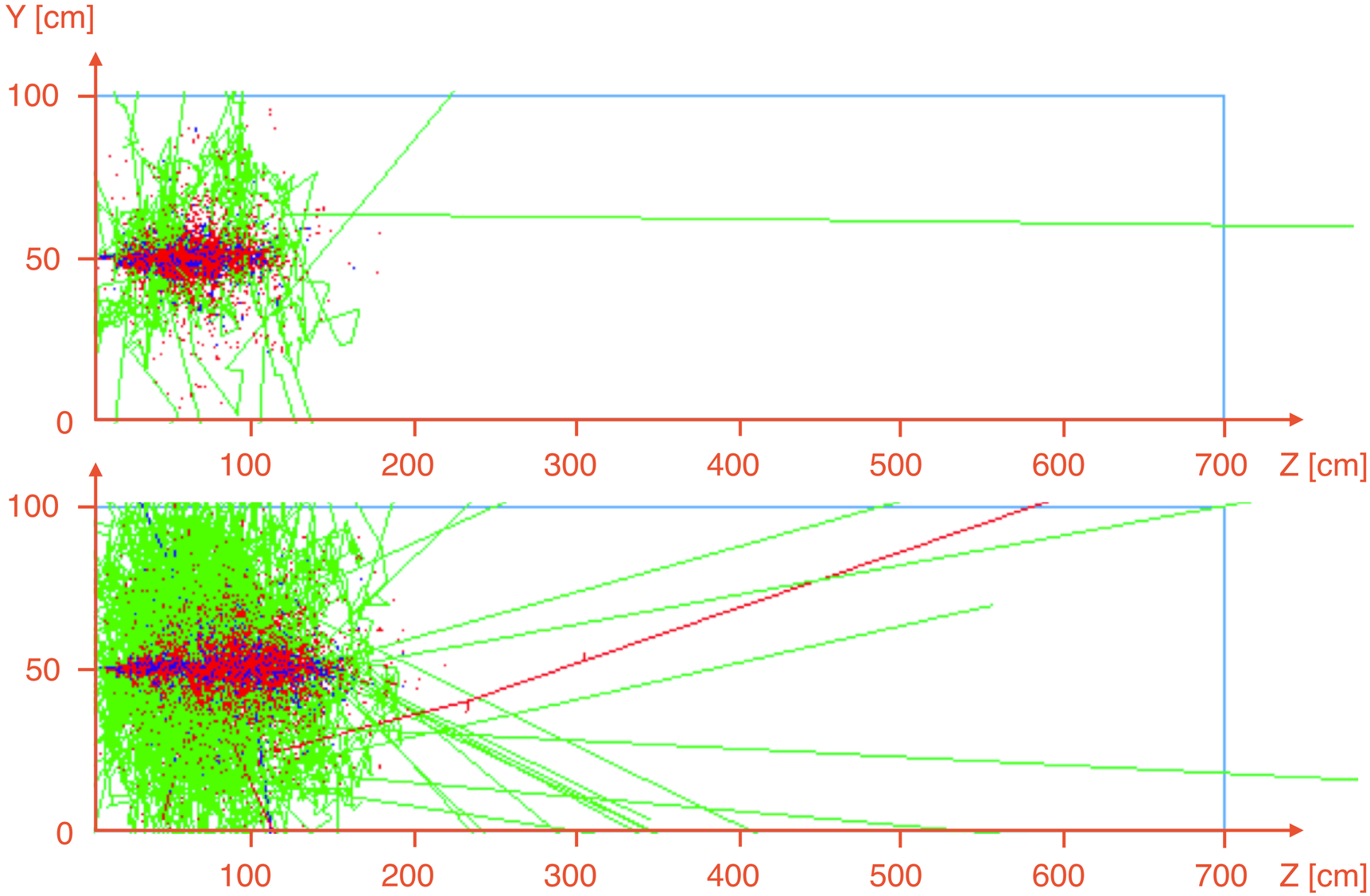
https://arxiv.org/pdf/2007.00015.pdf

Energy Containment

- Electron shower in LKr

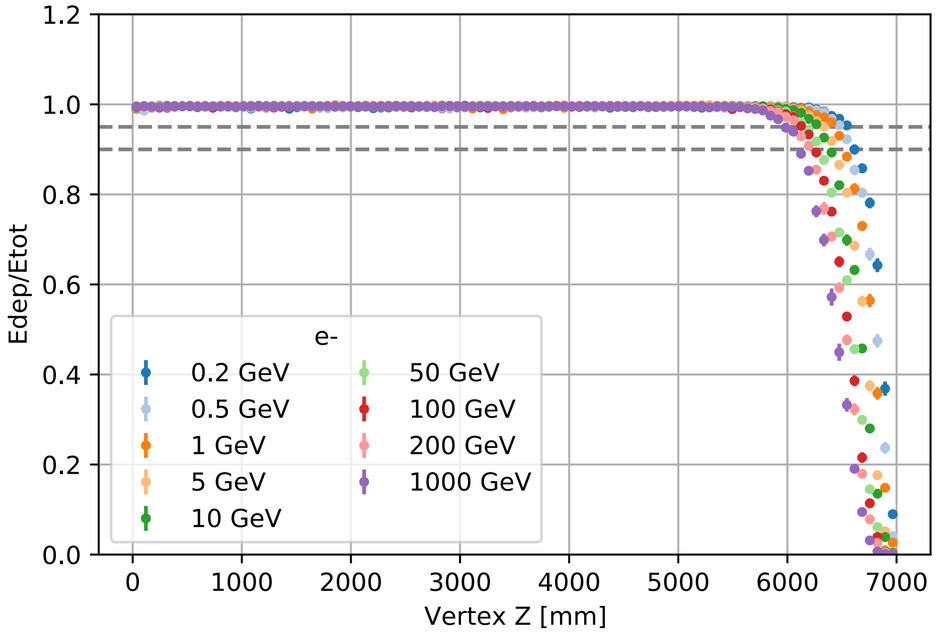
200 GeV e-

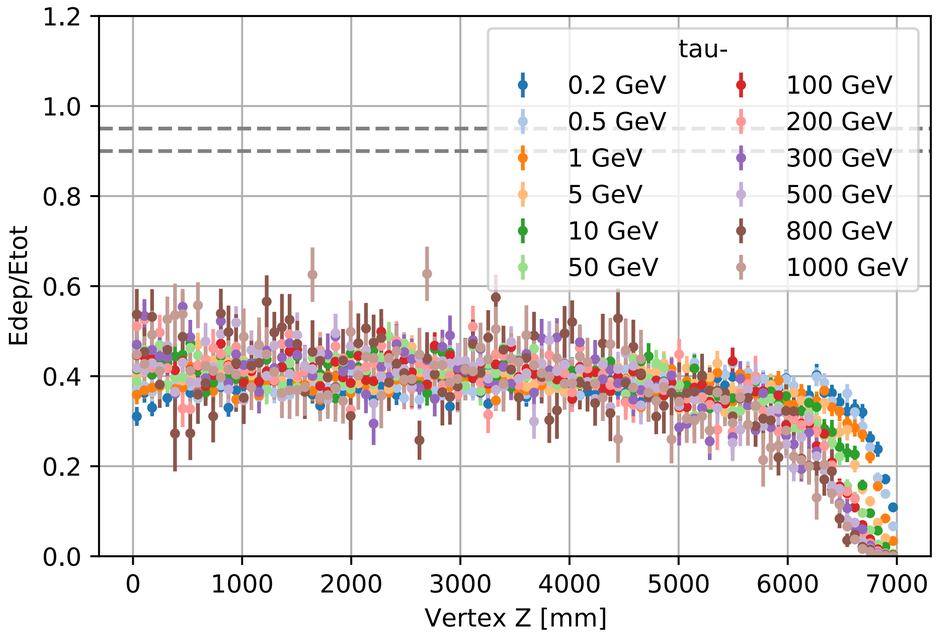
1 TeV e-

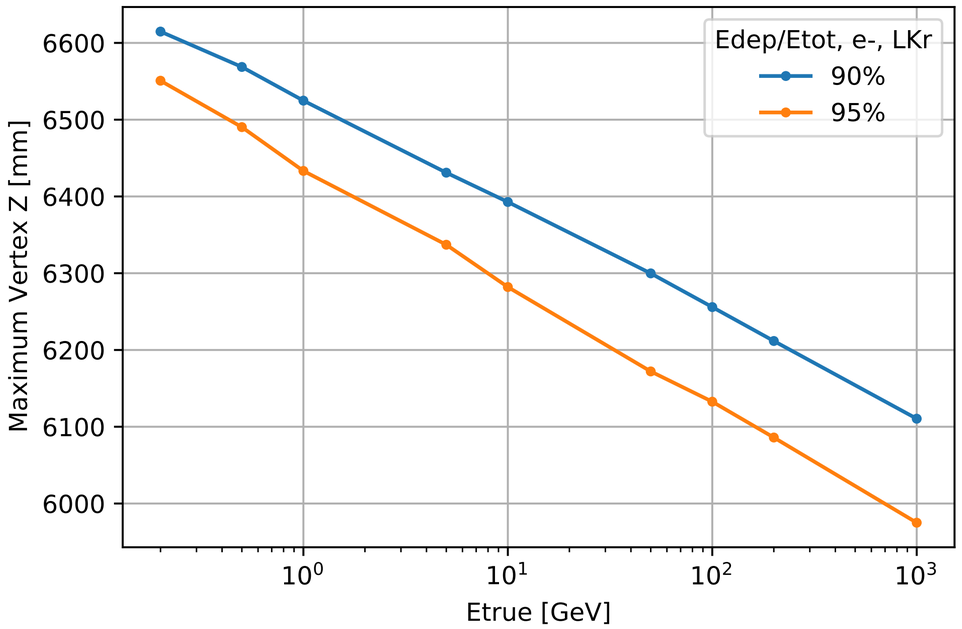


Energy Containment

- Krypton has better energy containment ability as expected

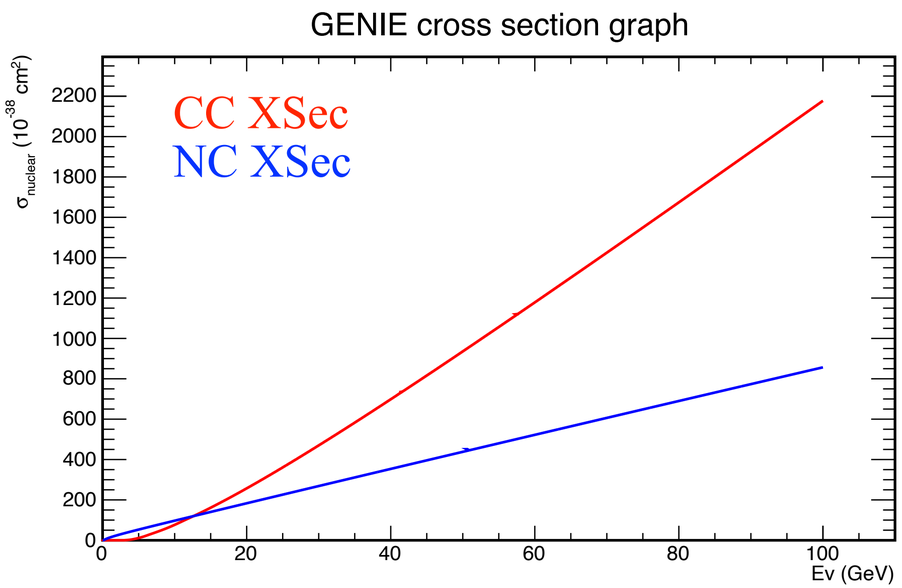


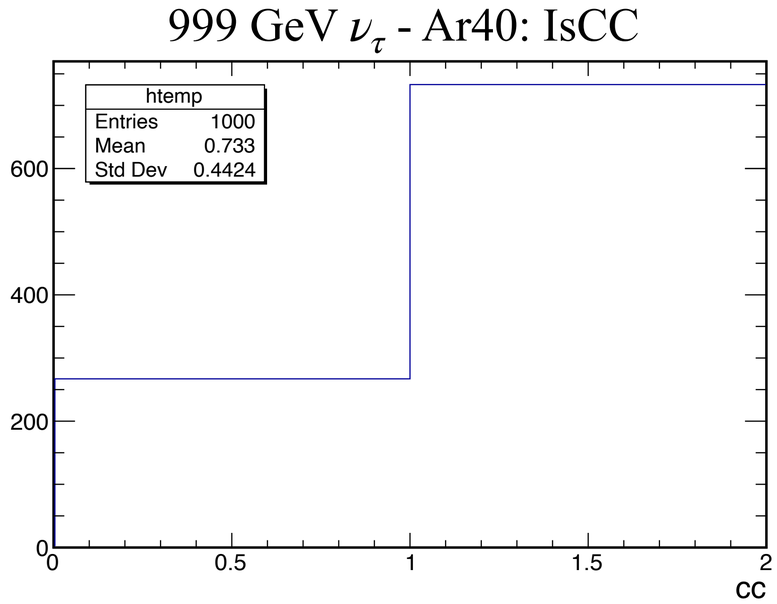




ν_τ-Ar interactions

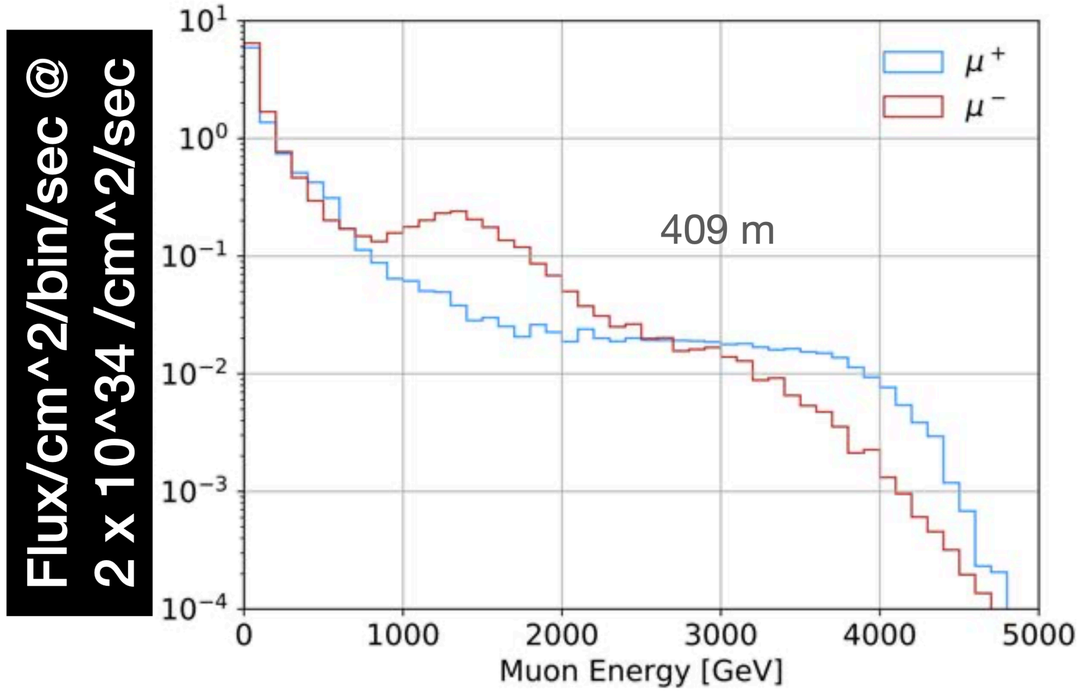
- The hadronic shower of the final state is also helpful for ν_τ recognition, but need more comprehensive simulations of neutrino interactions
  - The default GENIE doesn't have the cross section splines above 100 GeV. The cross section splines need to be calculated in advance. We'll need to consider ν_τ with energy up to several TeV
  - Need to read kinematics of final state particles from GENIE and simulate in Geant4, in order to study the event topology of ν_τ interactions





ν_τ recognition

- For ν_τ recognition, we need to consider the backgrounds
  - Muon flux from the interaction point
  - ν_μ/ν_e



calculation	From JB for Flare-10
generator	approx
Normalization mass*fb	1ton*fb
angular range	1 m / 620m
numu/anti-numu	43
nue/anue	10
nutau/ anutau	0.13

Numbers from Milind's slides