UNIVERSITÄT BERN

AEC
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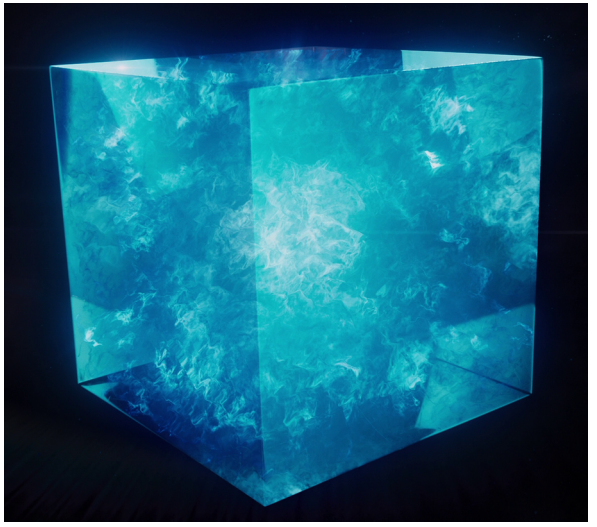
LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

ArgonCube

ProtoDUNE-ND: Containment Studies

Near Detector Workshop
Fermilab – Mai 25th, 2019

Patrick Koller (patrick.koller@lhep.unibe.ch)



marvelcinematicuniverse.fandom.com

Simulations for **ProtoDUNE-ND LAr** Component

ArgonCube 2x2 Demonstrator:

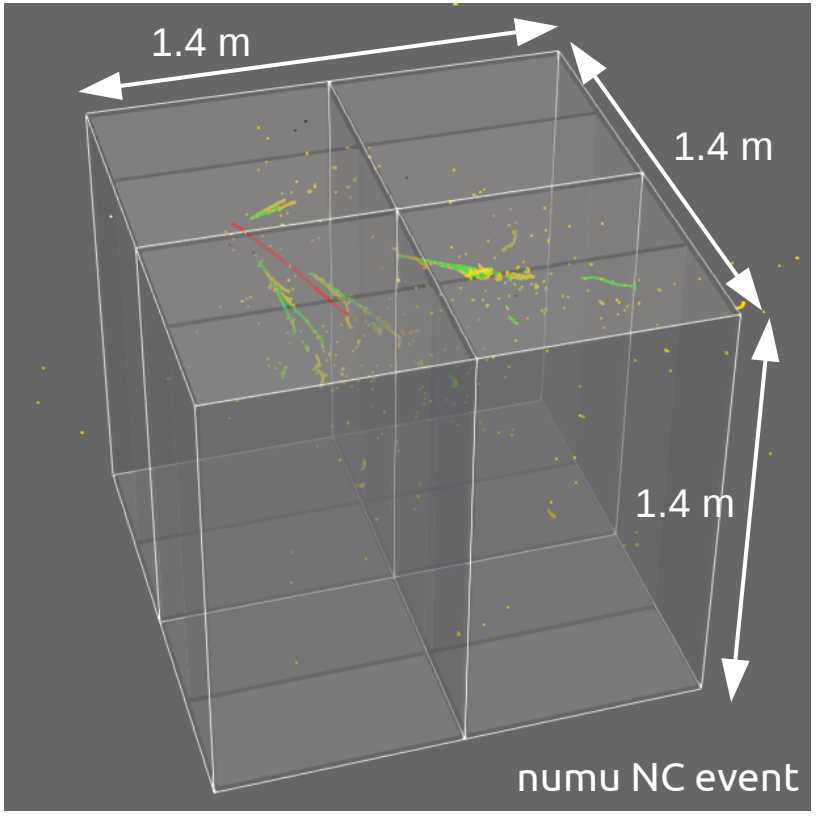
- **GEANT4 LAr simulation** based on ArgonBox*

  → basic understanding of event shape and containment in **2x2**

- cryostat geometry included (by **Chris/Rahul**)

- fiducial volume defined for event vertices
  - 30 cm from each side

    (~2x radiation length of LAr)



* https://github.com/dadwyer/argon_box

Simulations for **ProtoDUNE-ND LAr** Component

Downstream Tracker:

- **Repurpose existing detector components** in the **MINOS-ND hall**
- Example downstream tracker using a small portion of MINERvA:
  - **12 Tracker** modules: 24 x 2 cm **CH** planes
  - **10 ECal** modules: 20 x (2 mm **Pb** + 2 cm **CH**) planes
  - **20 HCal** modules: 20 x (2.54 cm **Fe** + 2 cm **CH**) planes
- Simple **GEANT** simulation (by **Chris/Rahul**):
  - **LAr** cylinder + **Fe** cylinder + **Al** cylinder + **Tracker** (1.4 x 1.4 m^2 sheets)

Simulations for **ProtoDUNE-ND LAr** Component

Neutrino Interactions:

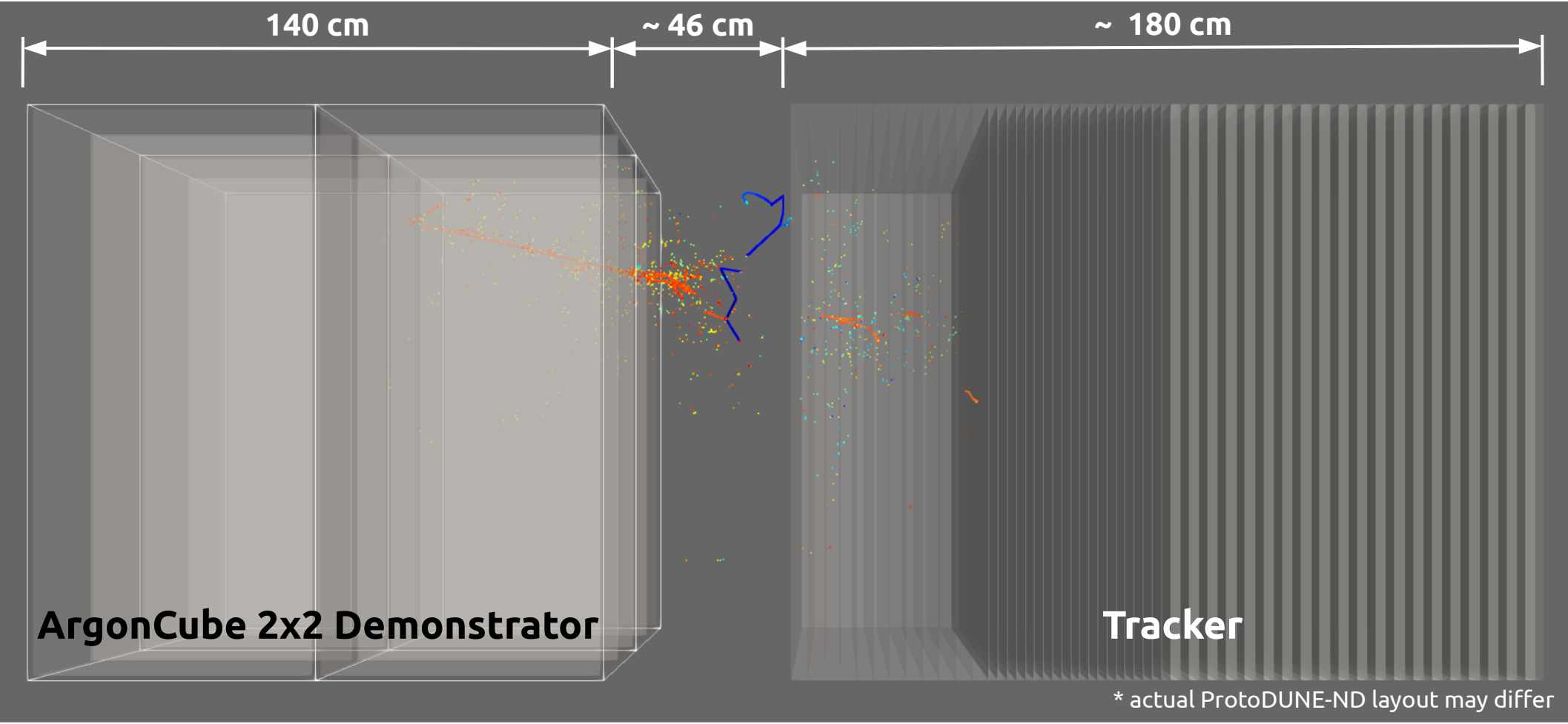
- high statistics **GENIE* Monte Carlo** sample
- only **numu** so far → **nue** under construction!

Beamline:

- no **beam-profile** → random vtx distribution within **2x2**
- downstream tracker **aligned** with the **center of 2x2** (maximum acceptance)

* v2.12.10 with “ValenciaQEBergerSehgalCOHRES” configuration

ProtoDUNE-ND with **Tracker** Simulation*



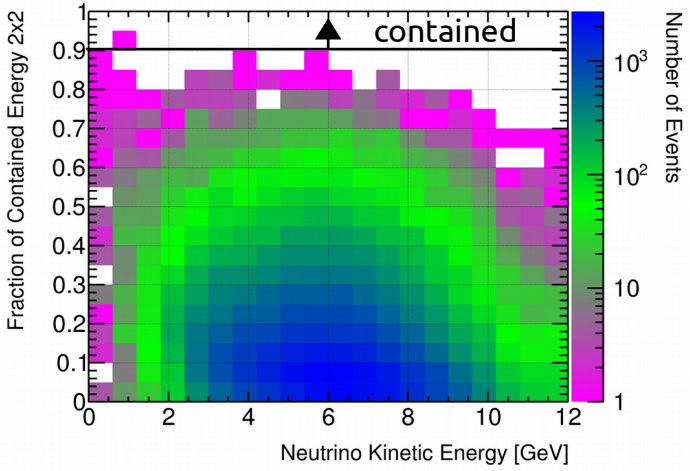
Containment Studies

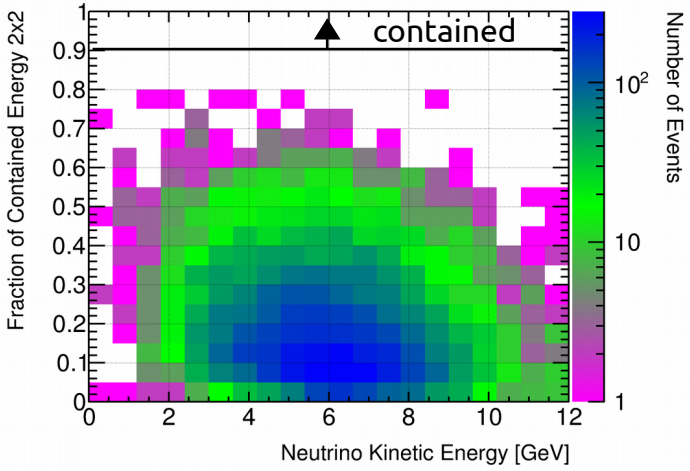
- Full event **w/ and w/o muon**
- Showers
  - **Pi0** → Roman Berner started working on a reconstruction algorithm*
  - **EM** (see backup slides)
  - **Proton-induced** (see backup slides)
- Other topologies
  - **Primary proton containment** in the absence of mesons
  - **Electron containment** for **nue** → in progess

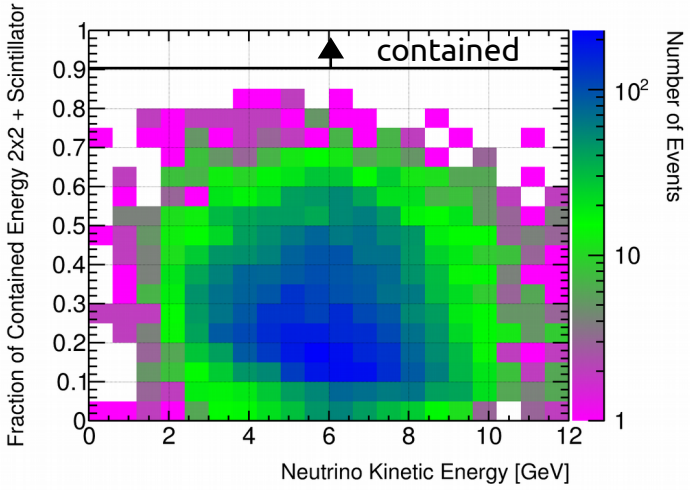
* continuing the work by **Damian Göldi**

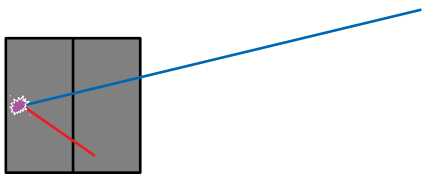
Event Containment

(~100k events)

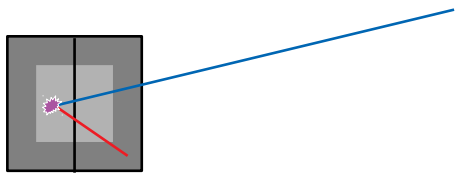




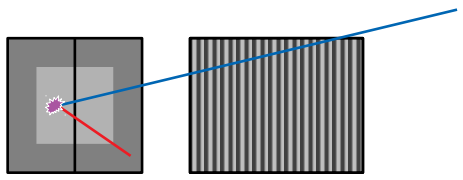




2x2 stand-alone



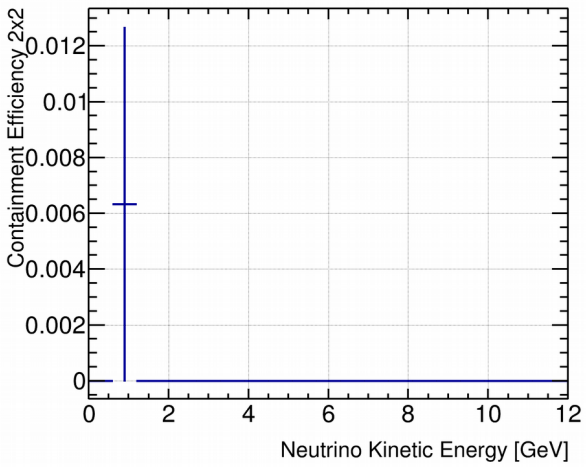
2x2 stand-alone
vtx in fiducial volume

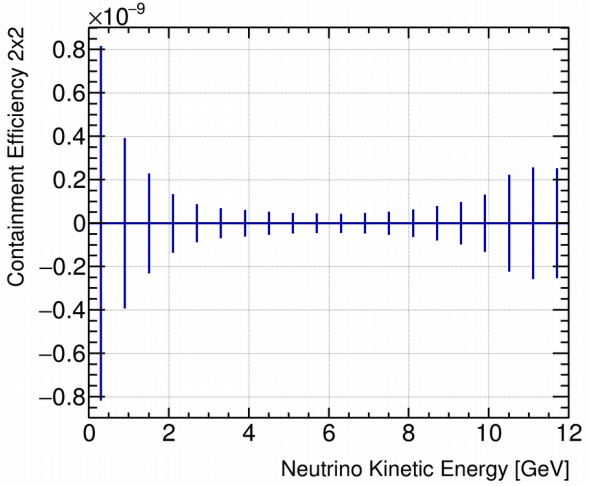


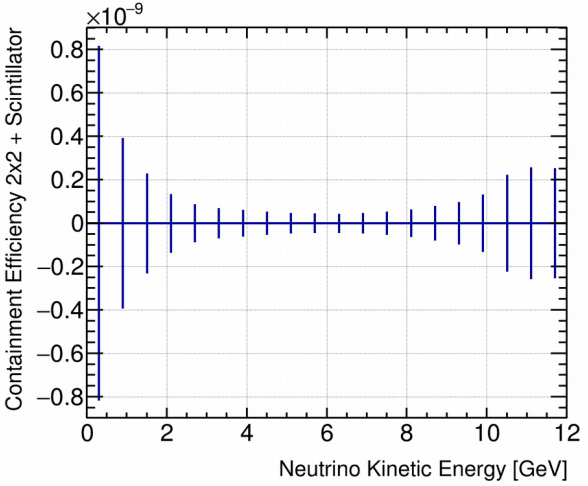
2x2 + Tracker
vtx in fiducial volume

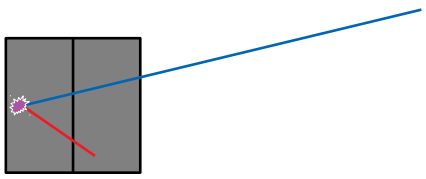
Event Containment Efficiency

(~100k events)









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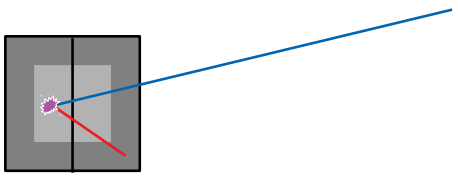
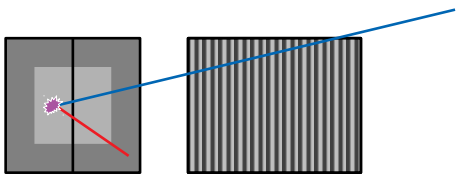
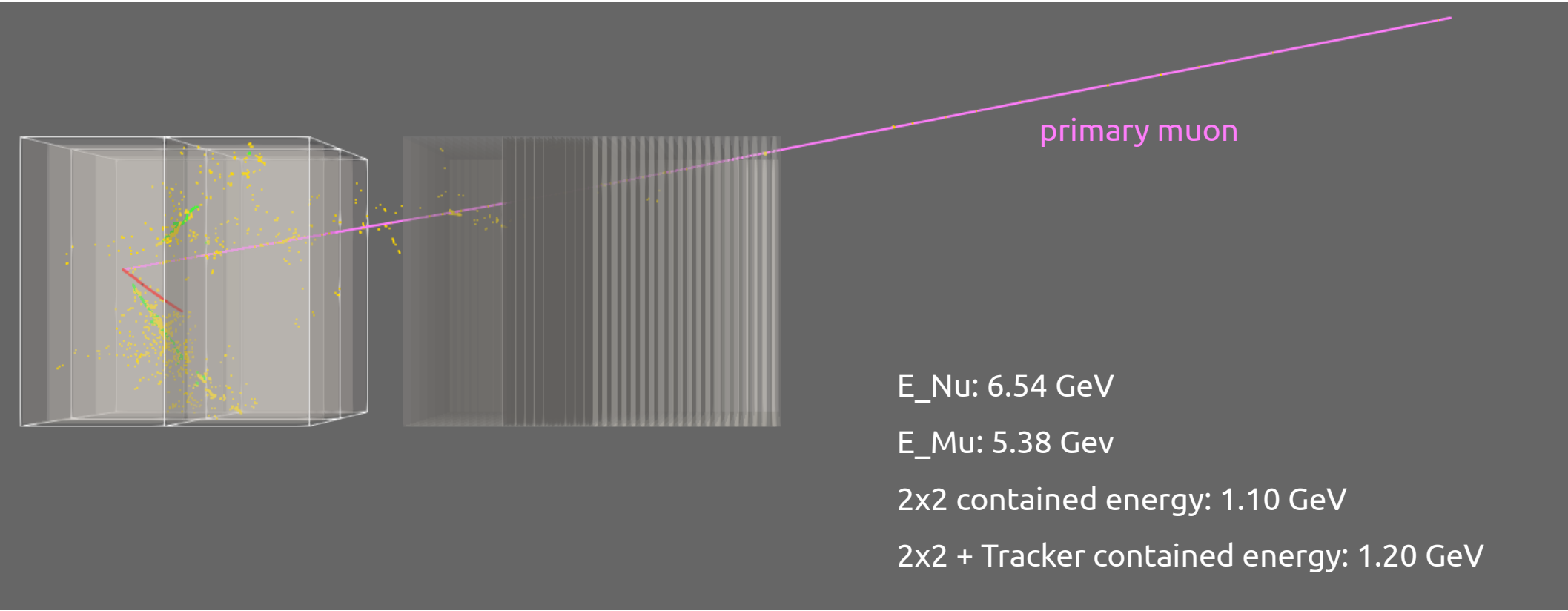


2x2 stand-alone
vtx in fiducial volume

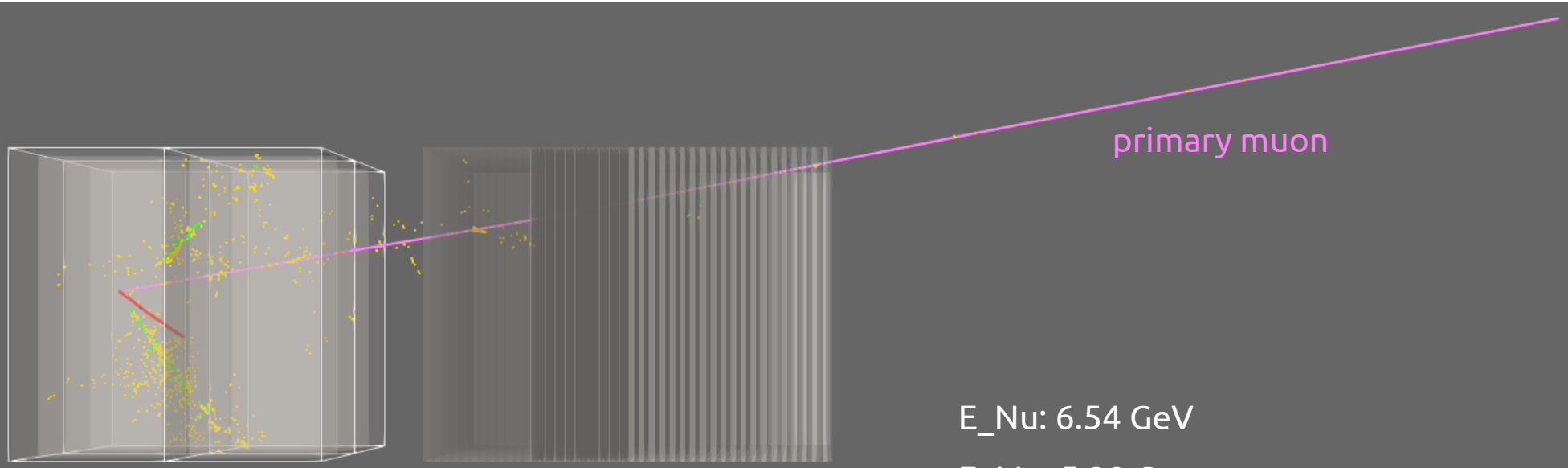


2x2 + Tracker
vtx in fiducial volume

Example of an Uncontained Event



Example of an Uncontained Event



E_Nu: 6.54 GeV

E_Mu: 5.38 Gev

2x2 contained energy: 1.10 GeV

2x2 + Tracker contained energy: 1.20 GeV

→ It's worth having a muon-range finder!

Ignoring the Primary Muon Energy

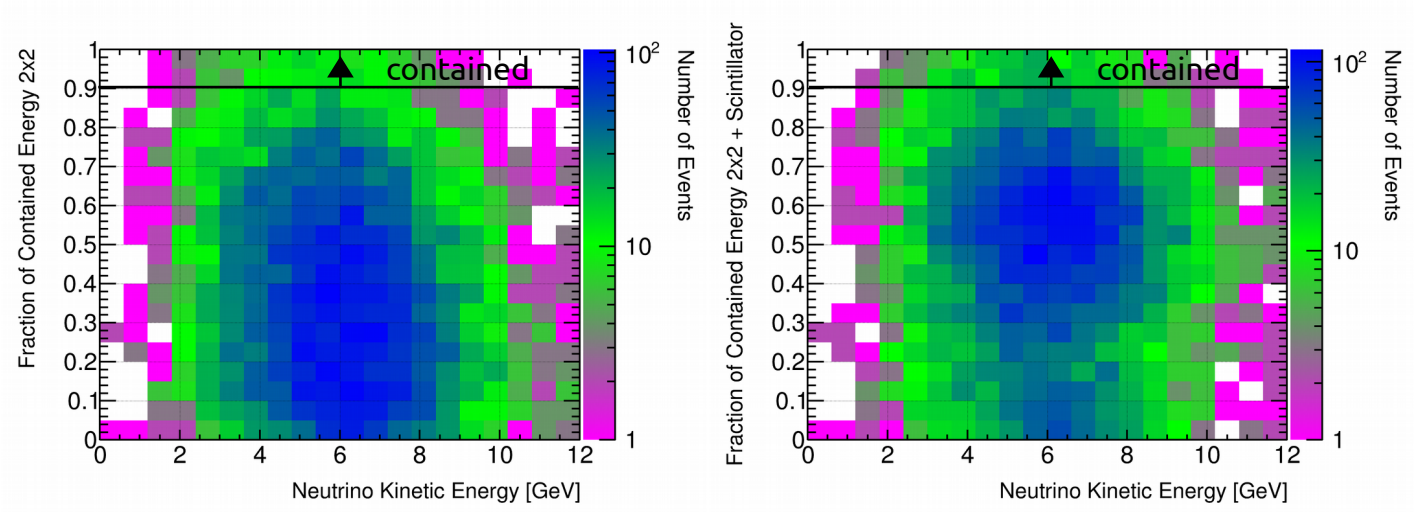
So far: contained if $\frac{E_{contained}}{E_{nu}} > 0.9$

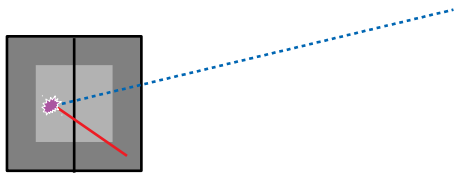
Now: contained if $\frac{E^{1}_{contained}}{E_{nu} - E_{mu}} > 0.9$

[1] Energy deposits by primary muon ignored

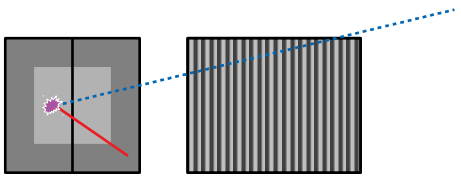
Event Containment w/o Muon

(~100k events)





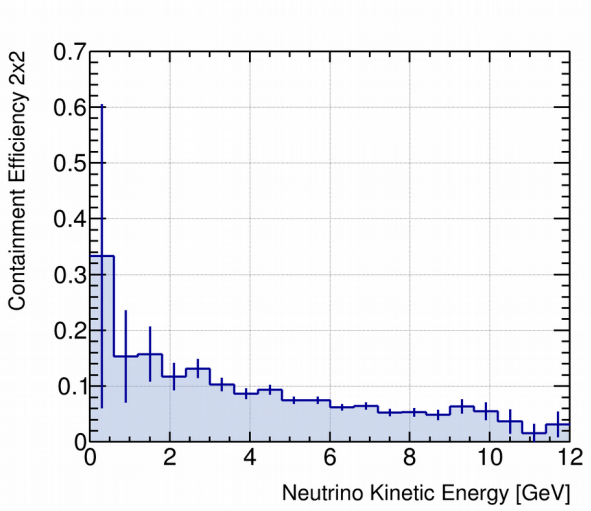
2x2 stand-alone
vtx in fiducial volume

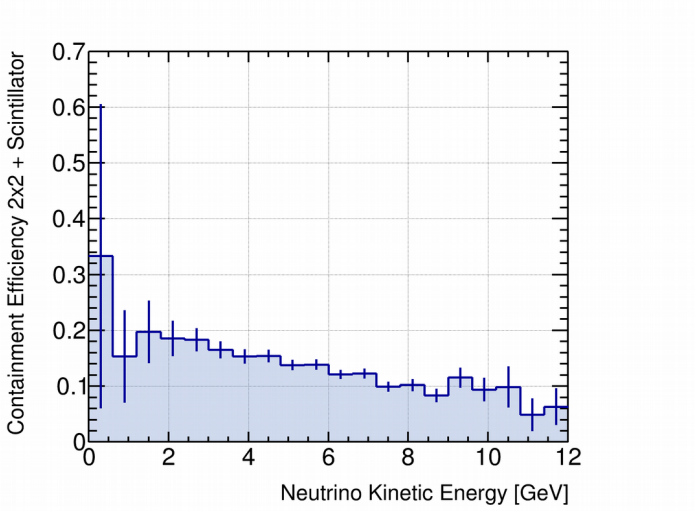


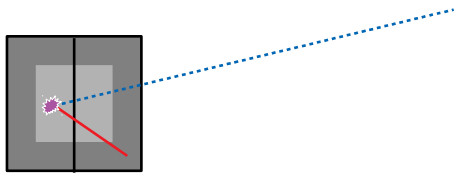
2x2 + Tracker
vtx in fiducial volume

Event Containment Efficiency **w/o Muon**

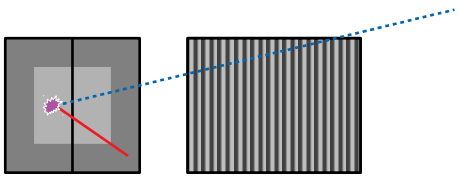
(~100k events)







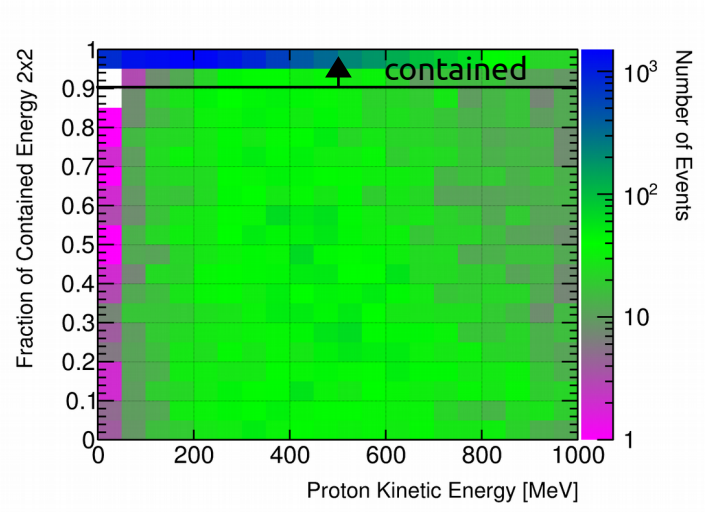
2x2 stand-alone
vtx in fiducial volume

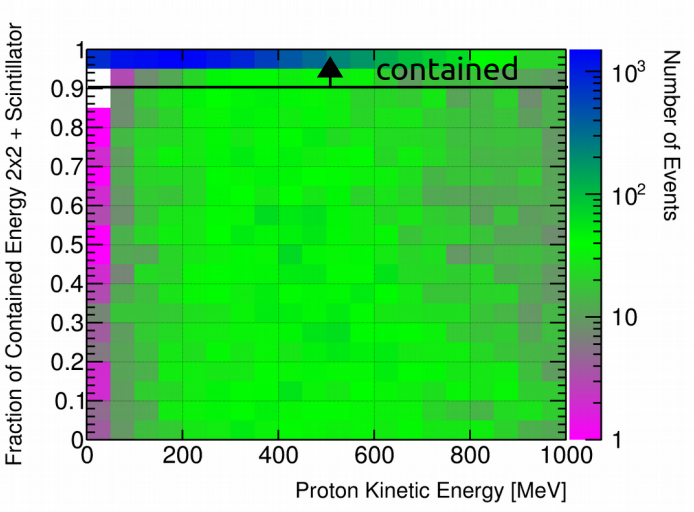


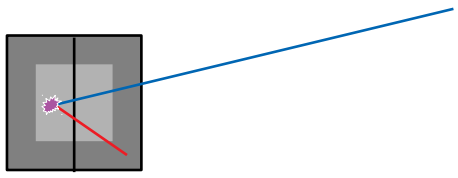
2x2 + Tracker
vtx in fiducial volume

Primary Proton Containment, no Mesons

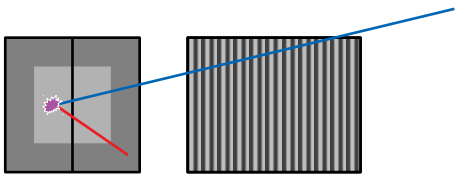
(~1M events)







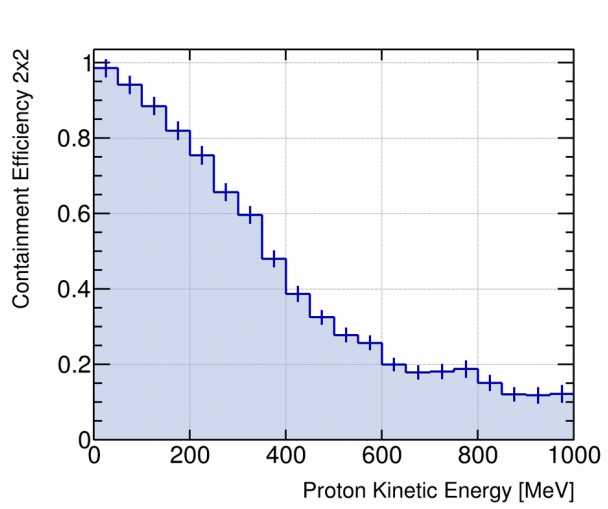
2x2 stand-alone
vtx in fiducial volume

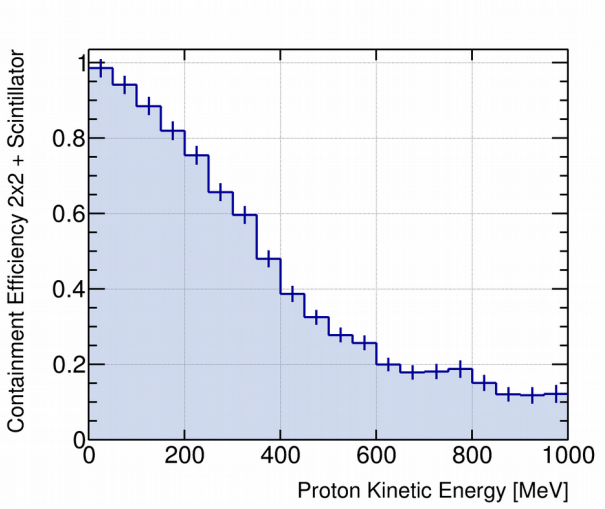


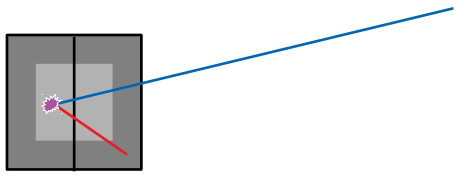
2x2 + Tracker
vtx in fiducial volume

Primary Proton Containment Efficiency, no Mesons

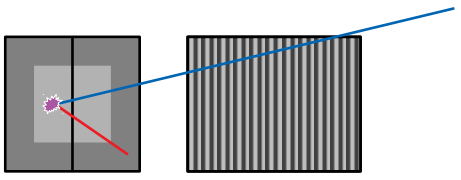
(~1M events)







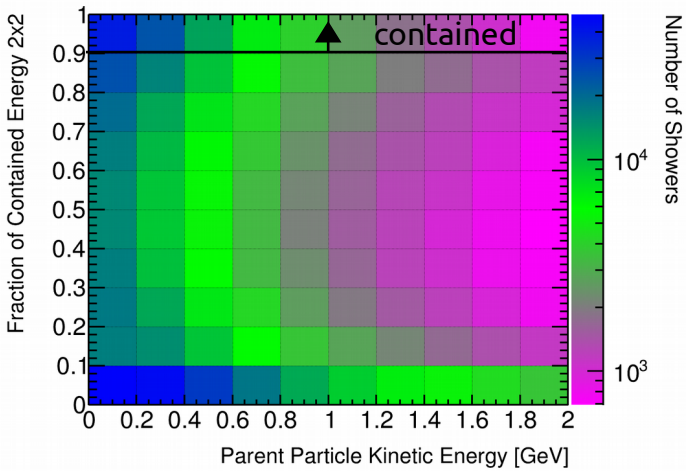
2x2 stand-alone
vtx in fiducial volume

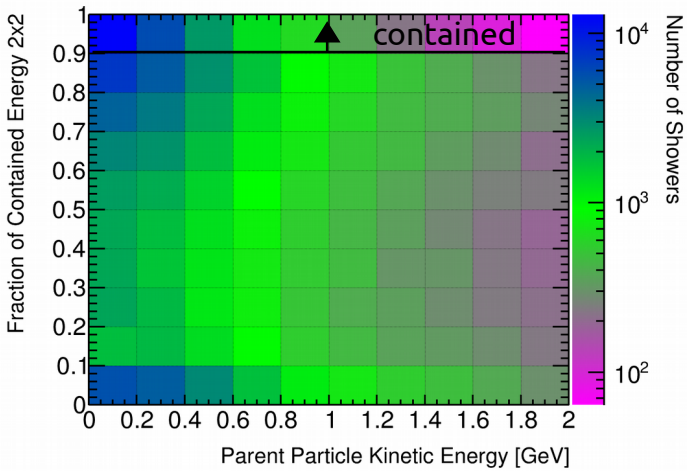


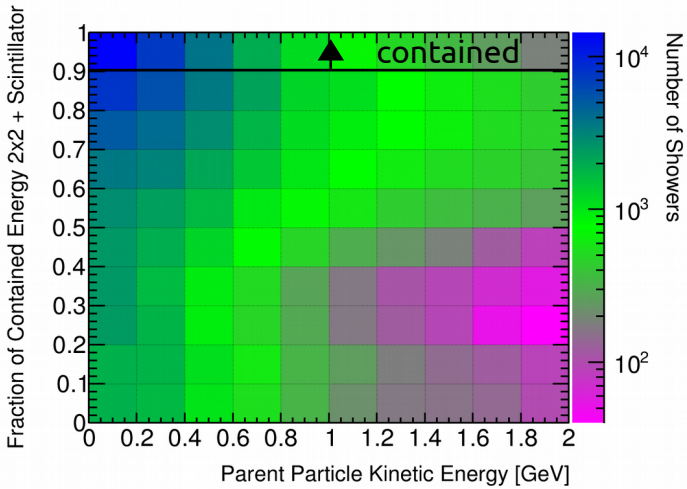
2x2 + Tracker
vtx in fiducial volume

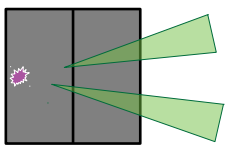
Pi0 Containment

(~100k events)

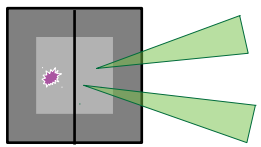




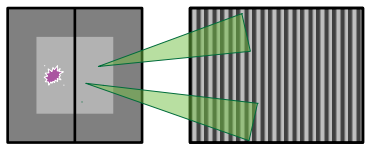




2x2 stand-alone



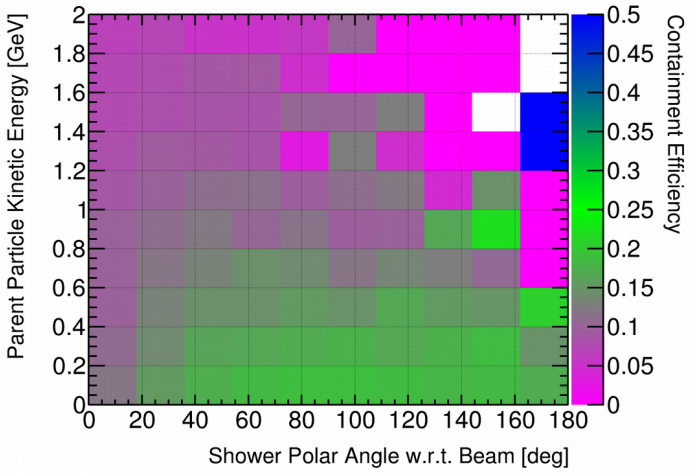
2x2 stand-alone
vtx in fiducial volume

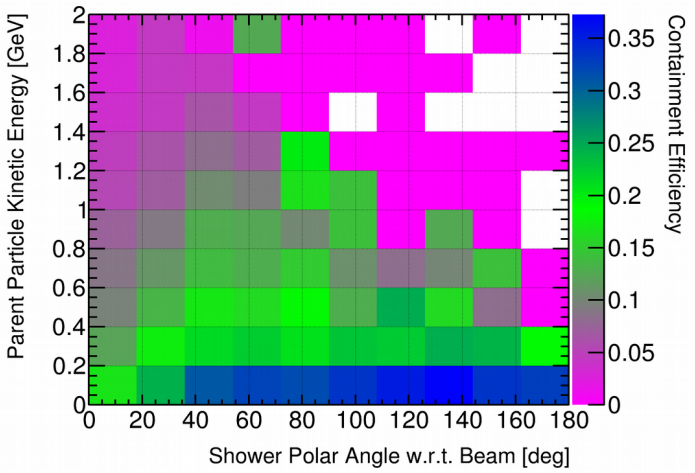


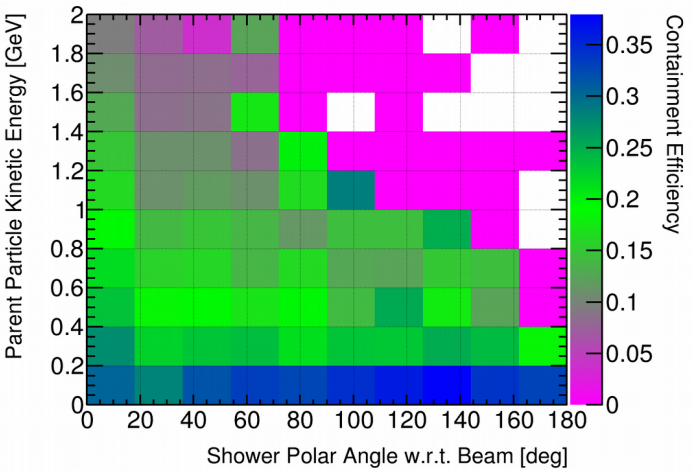
2x2 + Tracker
vtx in fiducial volume

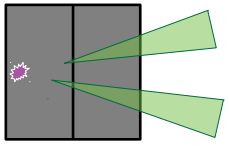
Pi0 Containment Efficiency

(~100k events)









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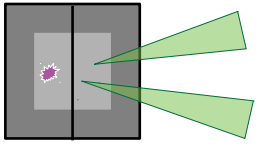
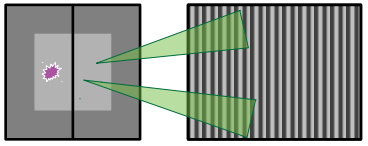


2x2 stand-alone
vtx in fiducial volume



2x2 + Tracker
vtx in fiducial volume

Time-line for **Fast*** **Neutron Tagging**

- Need a detaild **photon propagation simulation** for **2x2**

  → define light-readout requirements

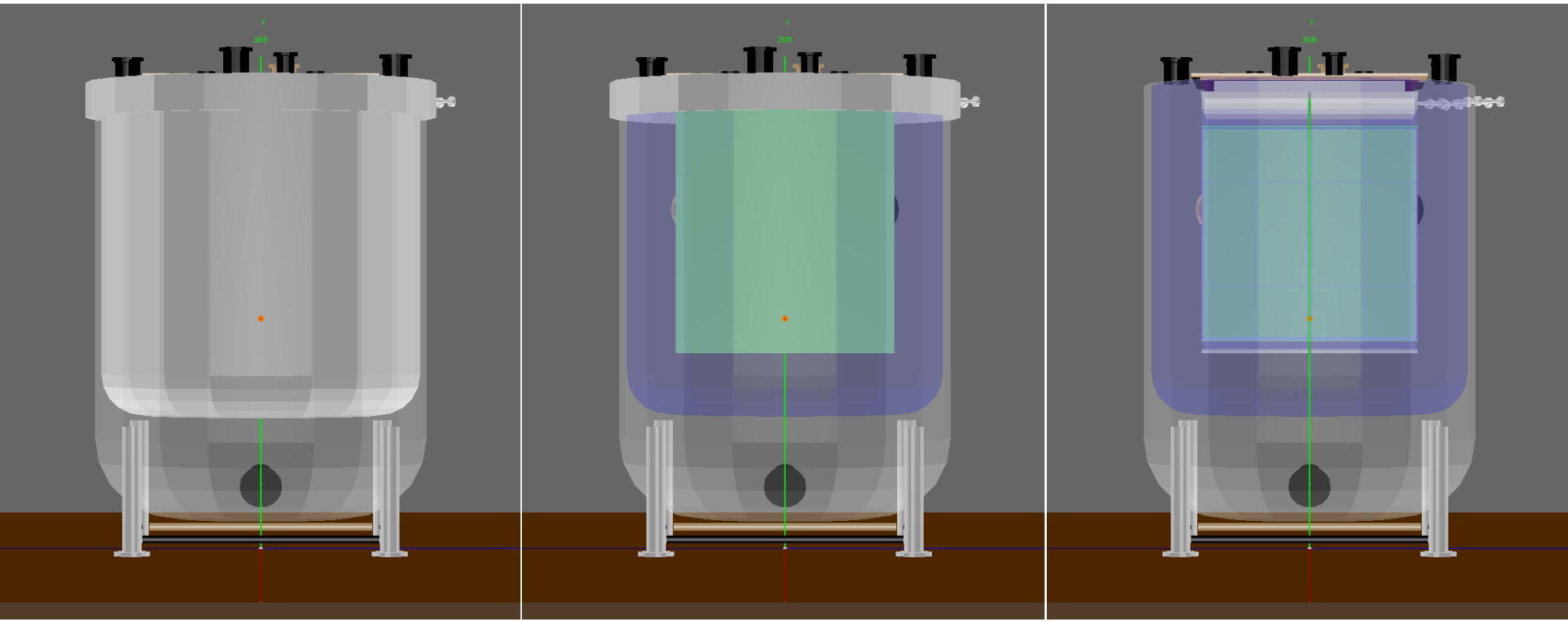
- **LArSoft** ready for integration of geometries **w/o** wire planes (**Kazu Terao**)

- First simple 2x2 geometry (**GDML**)** in co-op with **Hunter Sullivan**
  - implemented using **NDGGD** (despite lacking documentation)

* neutrons with energies > 1 MeV

** https://github.com/hcsullivan12/arc2x2ggd

ArgonCube 2x2 Geometry (GDML)



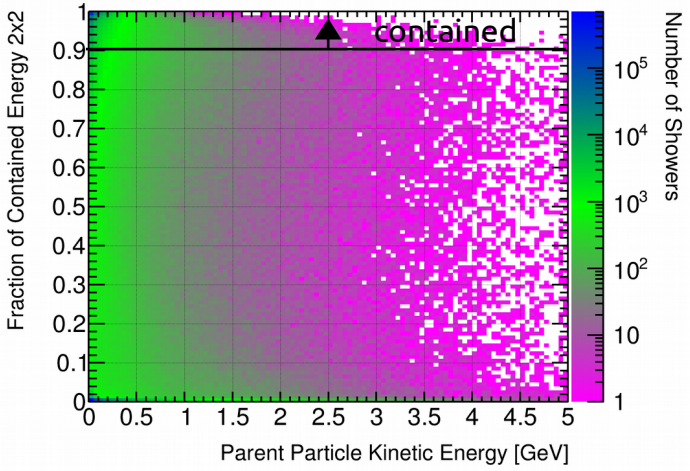
Outlook

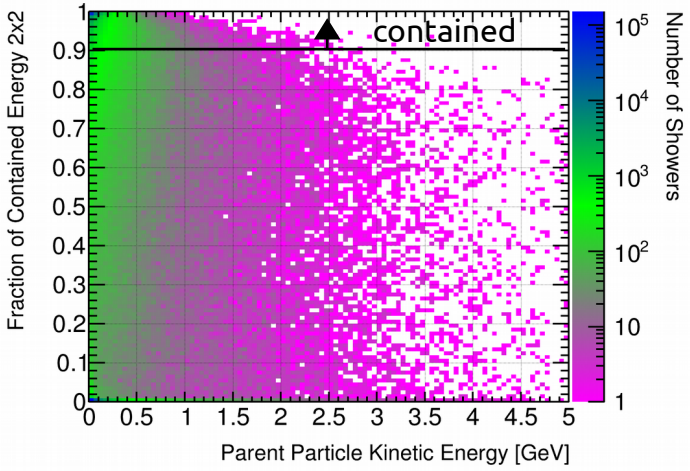
- The main goal is to **investigate** which **sub-sets** of events we will be able to easily **contain** in the **ProtoDUNE-ND LAr** component.
- Containment plots as a function of **hadronic energy**.
- Account for **dead material** (mainly tracker).
- More **sophisticated simulations** will be performed as soon as **new geometries** are available.
- **Photon propagation** simulation for **2x2**.

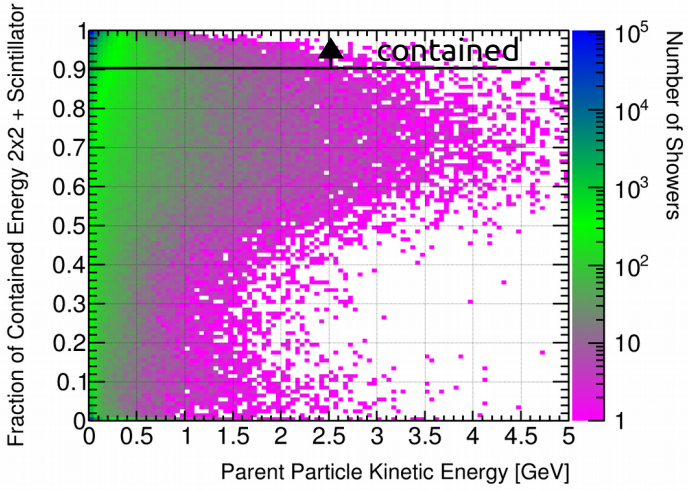
Backup

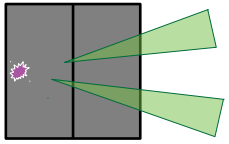
EM-Shower Containment

(~100k events)

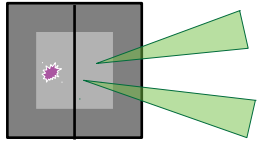




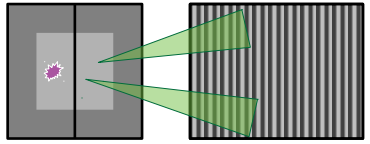




2x2 stand-alone



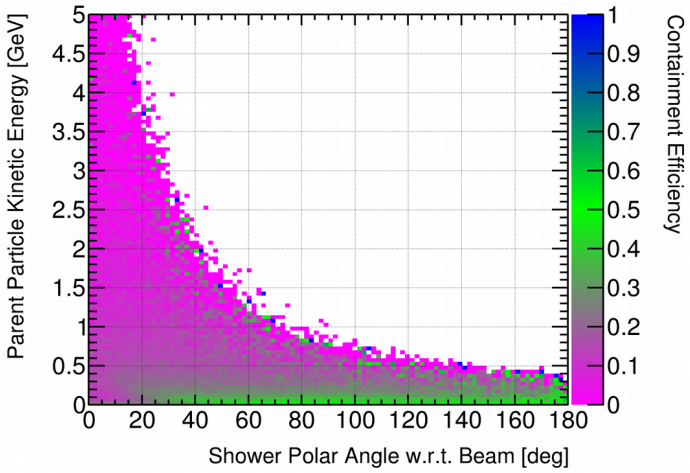
2x2 stand-alone
vtx in fiducial volume

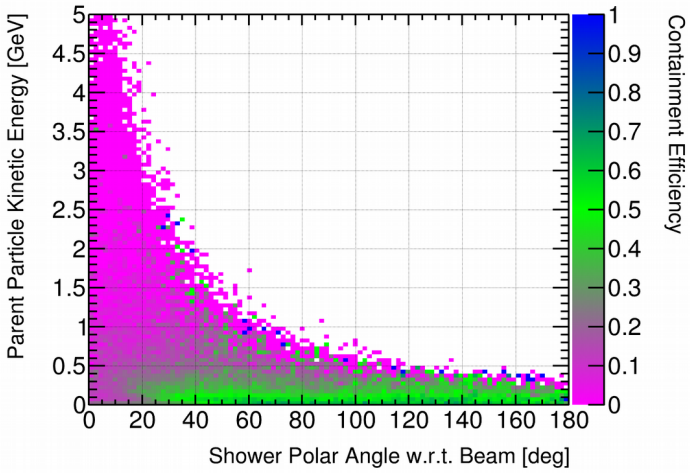


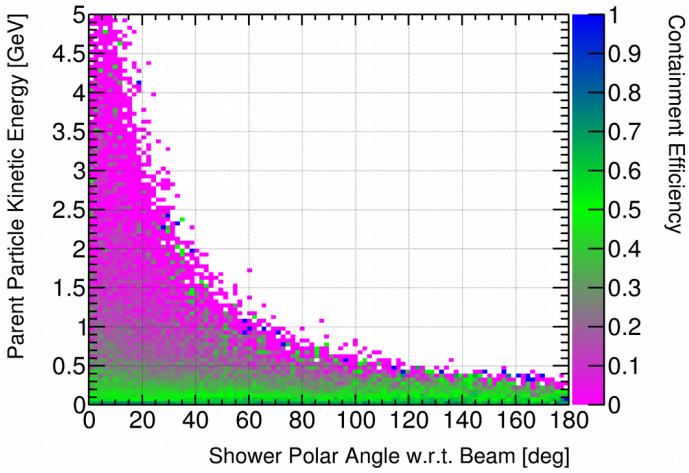
2x2 + Tracker
vtx in fiducial volume

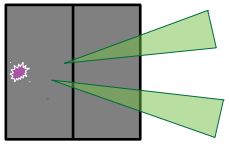
EM-Shower Containment Efficiency

(~100k events)

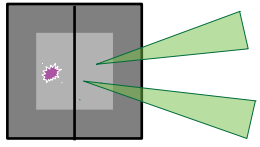




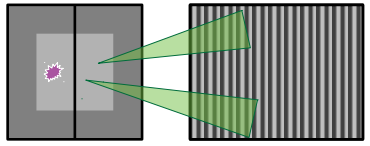




2x2 stand-alone



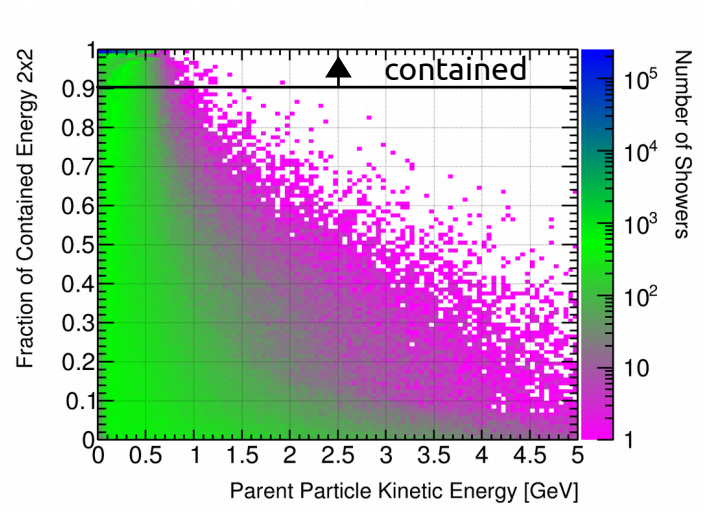
2x2 stand-alone
vtx in fiducial volume

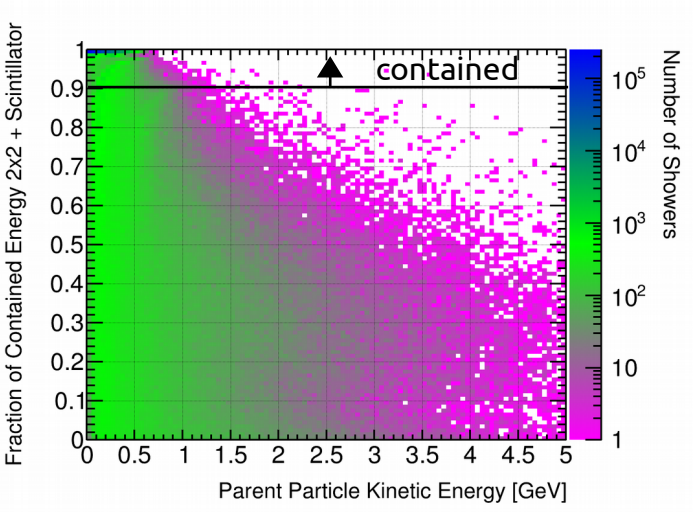


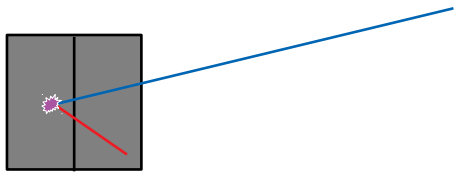
2x2 + Tracker
vtx in fiducial volume

Proton-induced Shower Containment

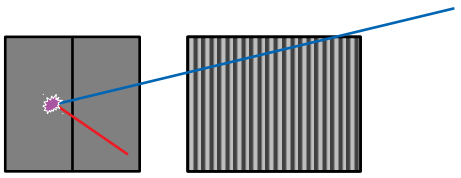
(~100k events)







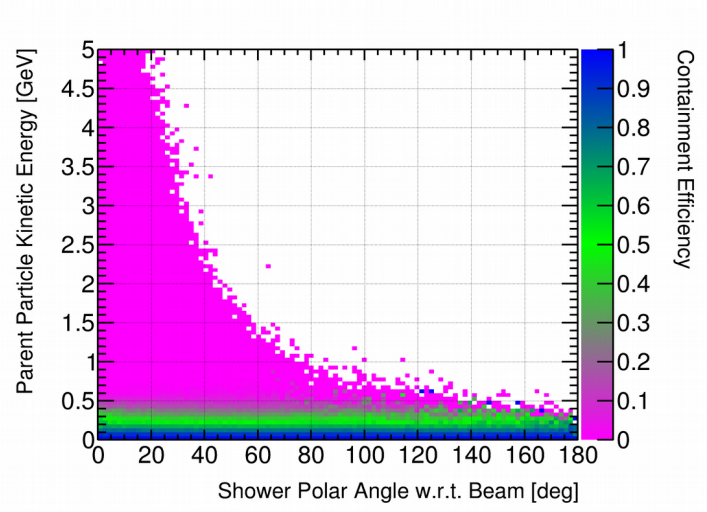
2x2 stand-alone

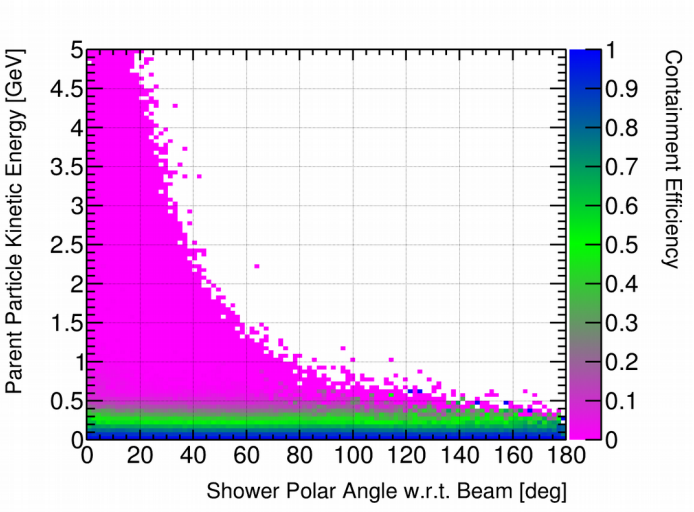


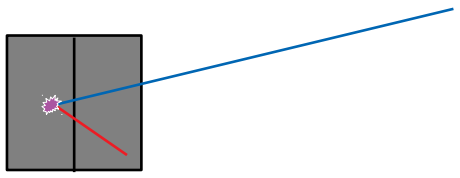
2x2 + Tracker

Proton-induced Shower Containment Efficiency

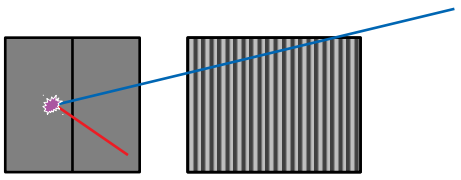
(~100k events)







2x2 stand-alone



2x2 + Tracker