Updates for Light Dark Matter Search

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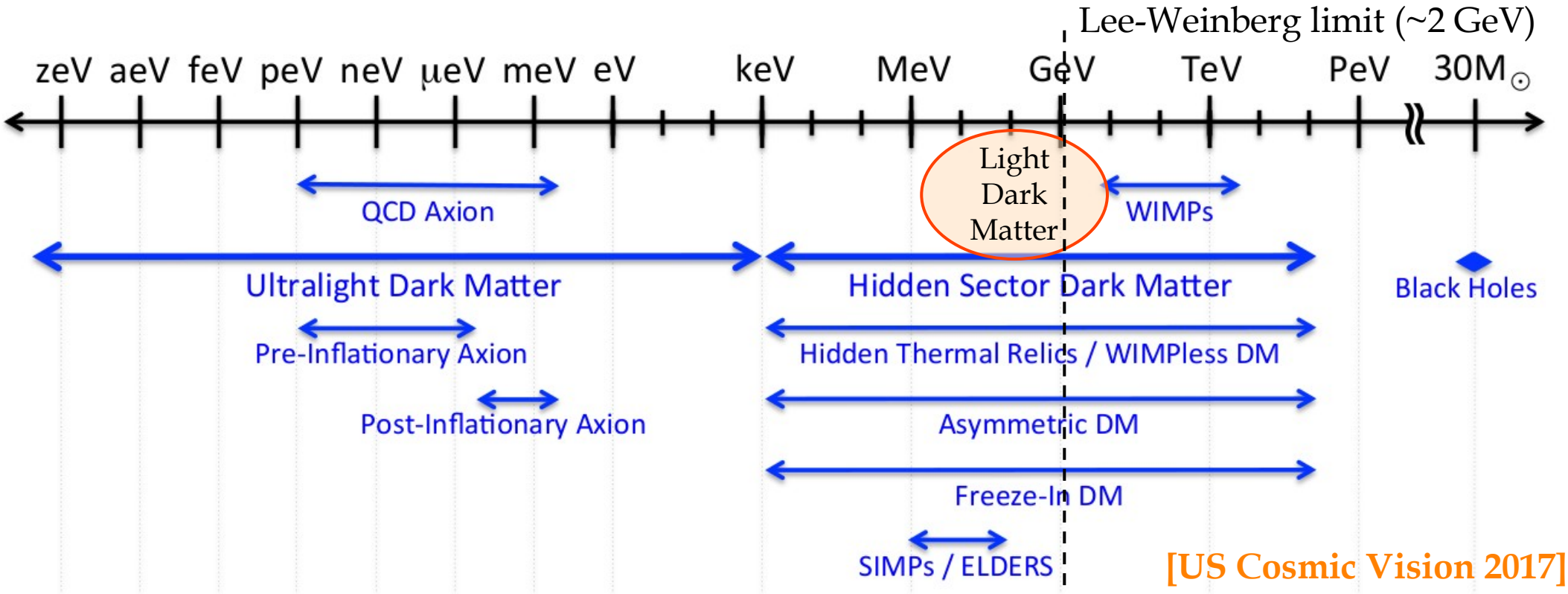
Physics Motivation of LDM Search at DUNE

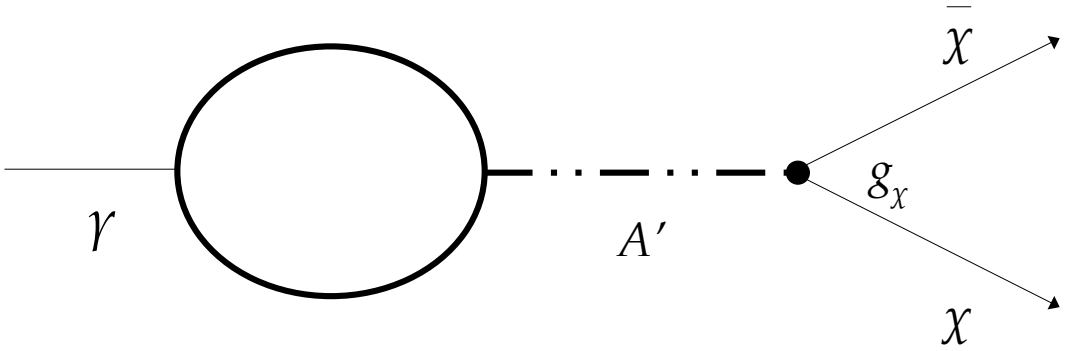


- Searching for dark matter in **sub-GeV mass range** using **high-intensity proton beam** is a well-motivated physics topic.
- Specifically, we're trying to search for dark matters produced by introducing a **new gauge boson** called **'dark photon'** and the **new interaction** mediated by the dark photon is called **'portal interaction'**.

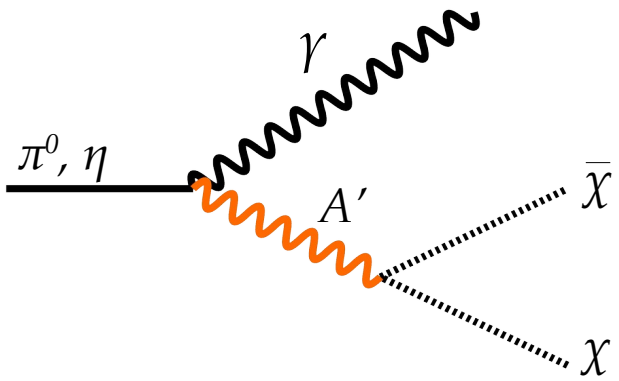
LDM Benchmark Model

- In this scenario, SM photon is **kinetically mixed with 'dark photon'**.

- Dark matter can be produced through the 'portal interaction'.

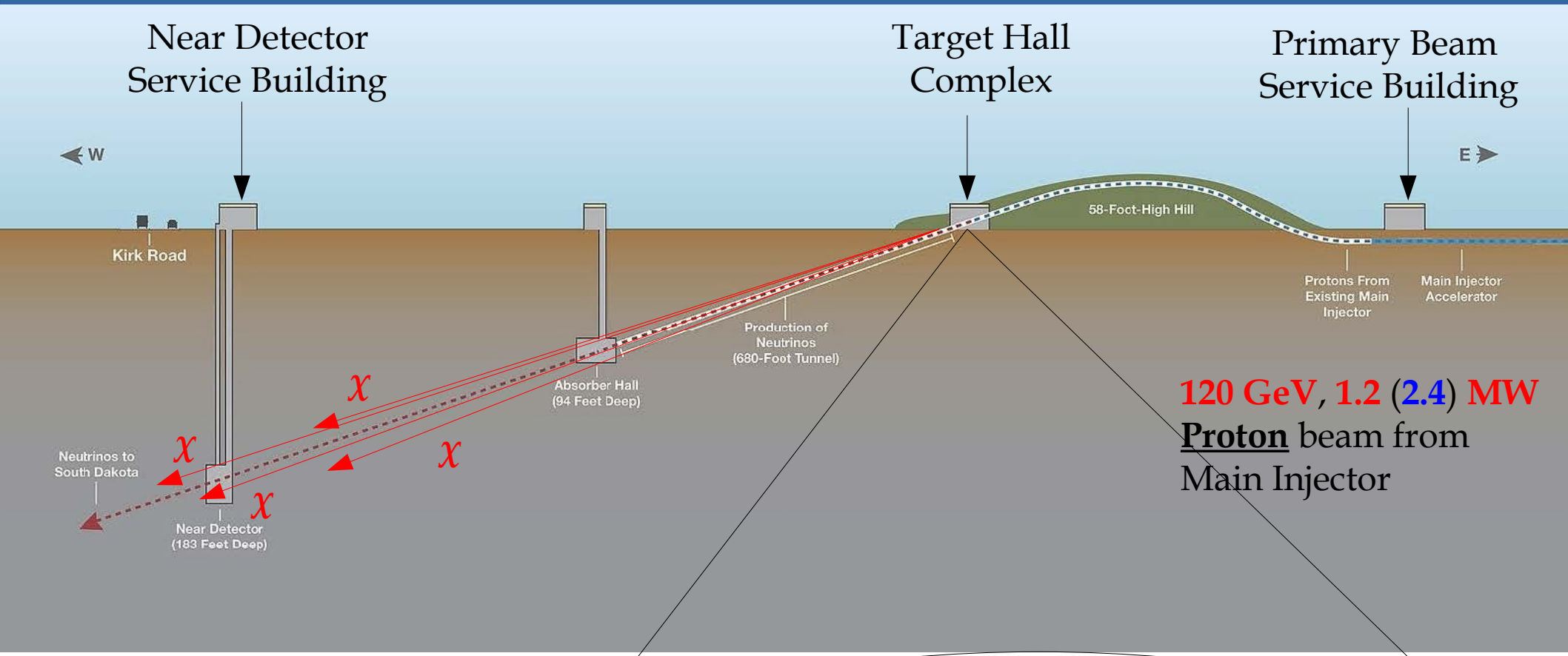


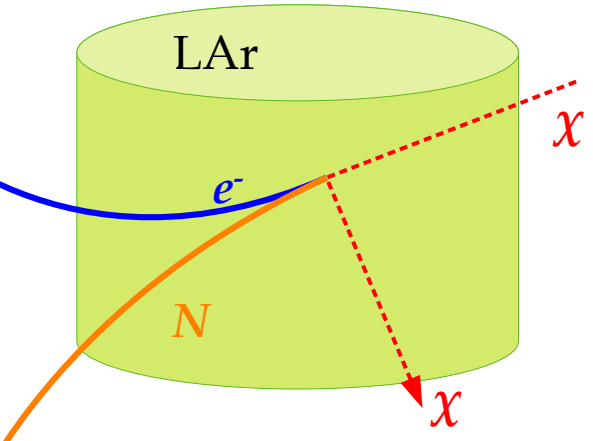
- Therefore, in principle, dark matter can be made **whenever there is a photon.**

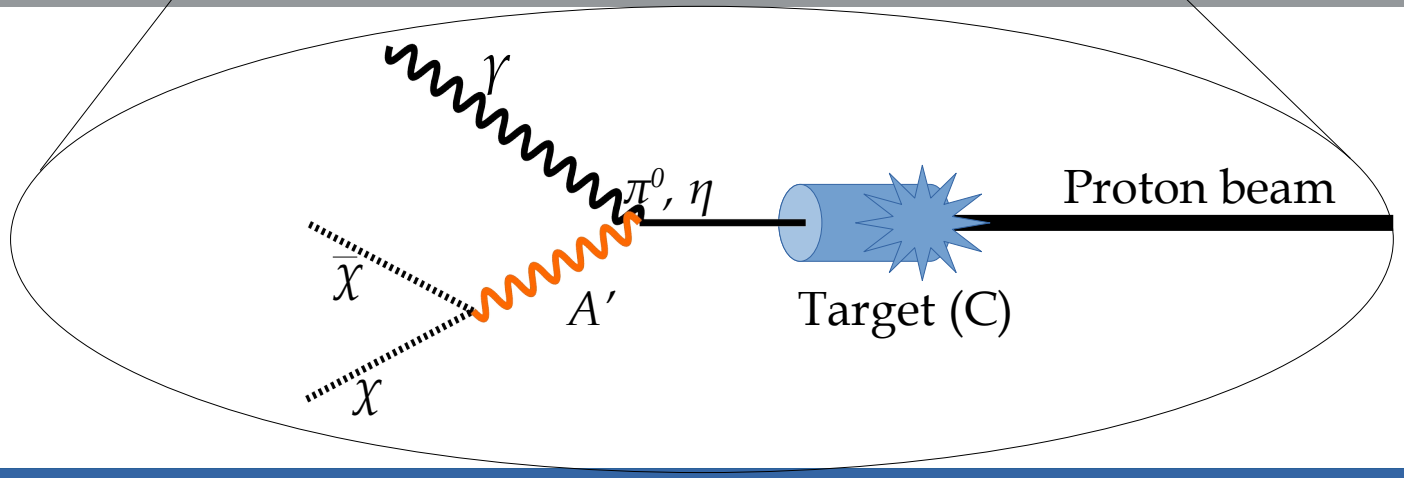


DUNE provides very suitable environment in that sense.

Dark Matter Beam Production

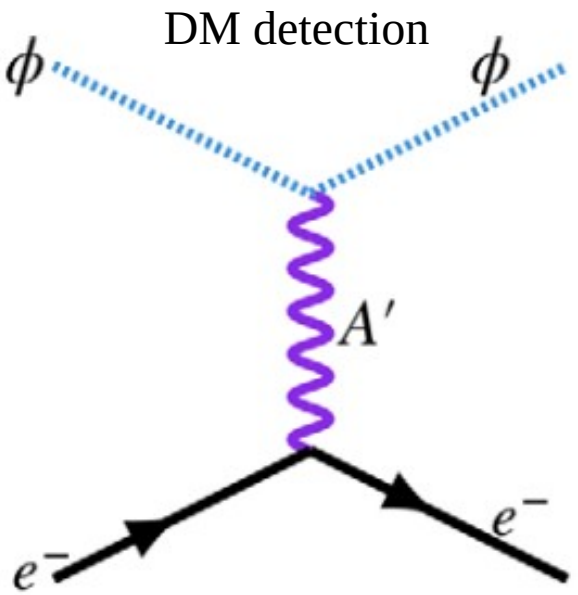




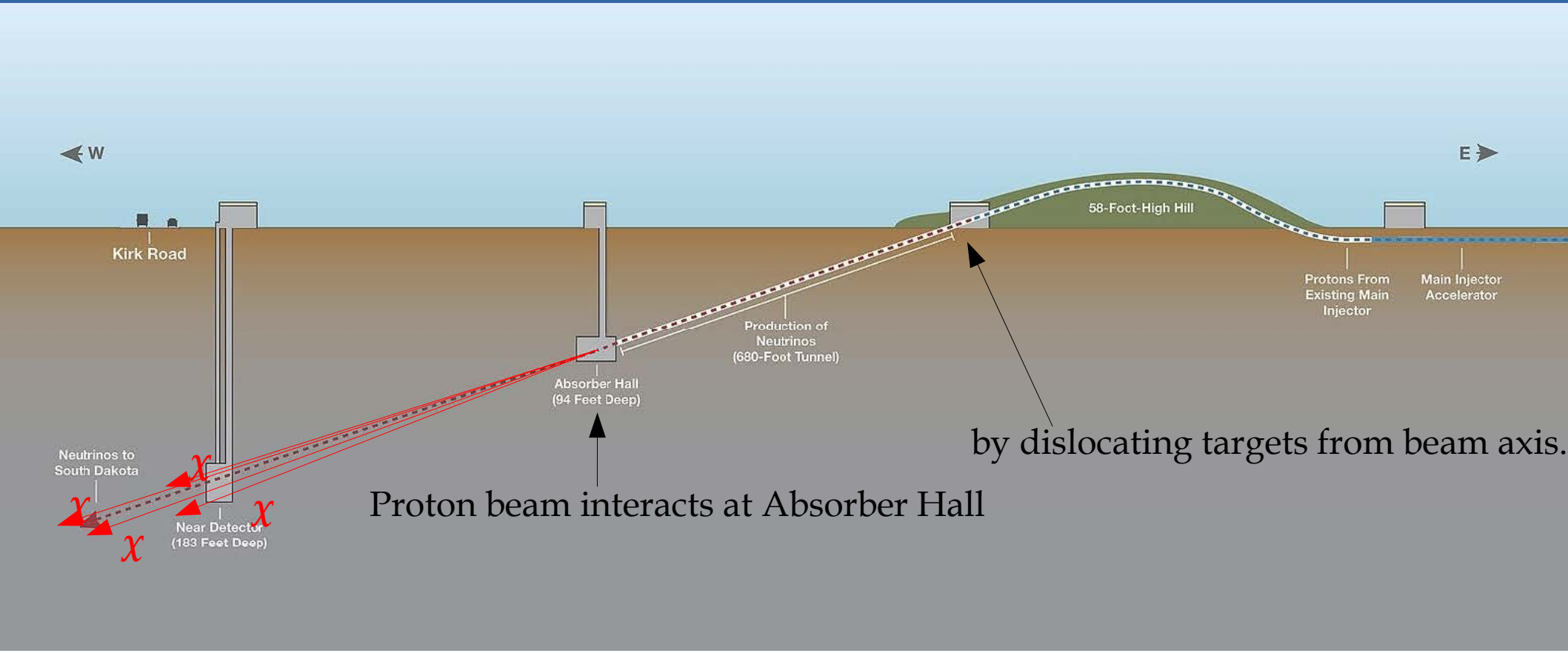


Signal and Background

- Major signal events are expected to be produced from
  - Neutral meson (π^0, η) decay and,
  - Cascade photon production
- Signal process:
  - DM-e^- scattering ($\varphi + e^- \rightarrow \varphi + e^-$)
  - DM-nuclei scattering (φ+Ar $\rightarrow$ φ+Ar or φ+p+X)
- Background:
  - υ-e^- scattering ($\upsilon + e^- \rightarrow \upsilon + e^-$)
  - υ_e+Ar$\rightarrow e$- + X
  - υ+Ar$\rightarrow$ υ+Ar+π^0



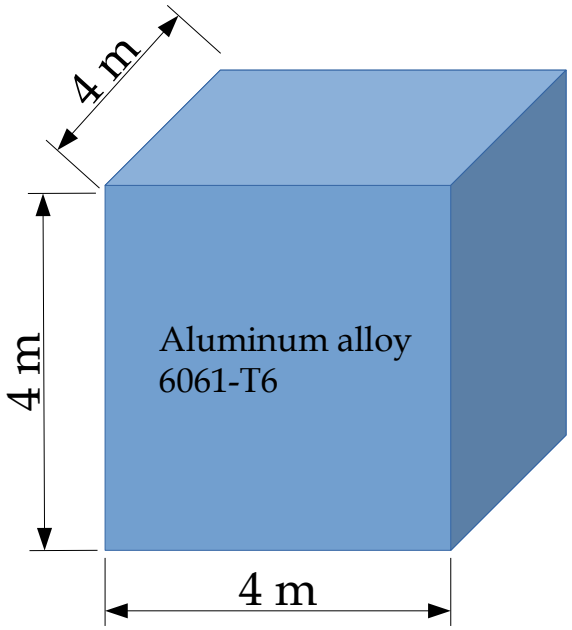
DUNE Dump Mode(or Off-Target) Simulation



- 'DUNE Beam Dump Mode' is an operation mode of DUNE proposed earlier this year.
- This is expected to **enhance** the **signal** flux.
  - reduced distance from interaction point to detector (574 m → ~300 m)
- This is expected to **reduce** the **background** flux.
  - The dump **absorbs** most of charged mesons, so it prevents neutrino production.

Hadron Absorber Geometry

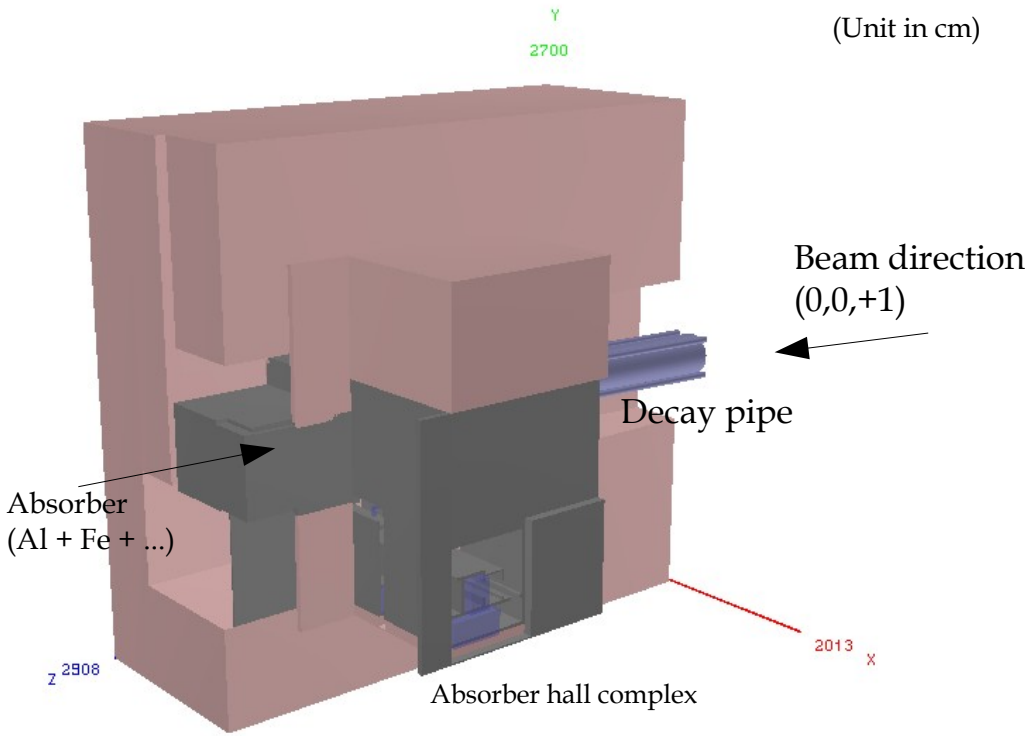
Simplified version of the dump:



Material Composition:

Element	Percentage (%)
Al	98.0
Mg	1.0
Si	0.6
Fe	0.4

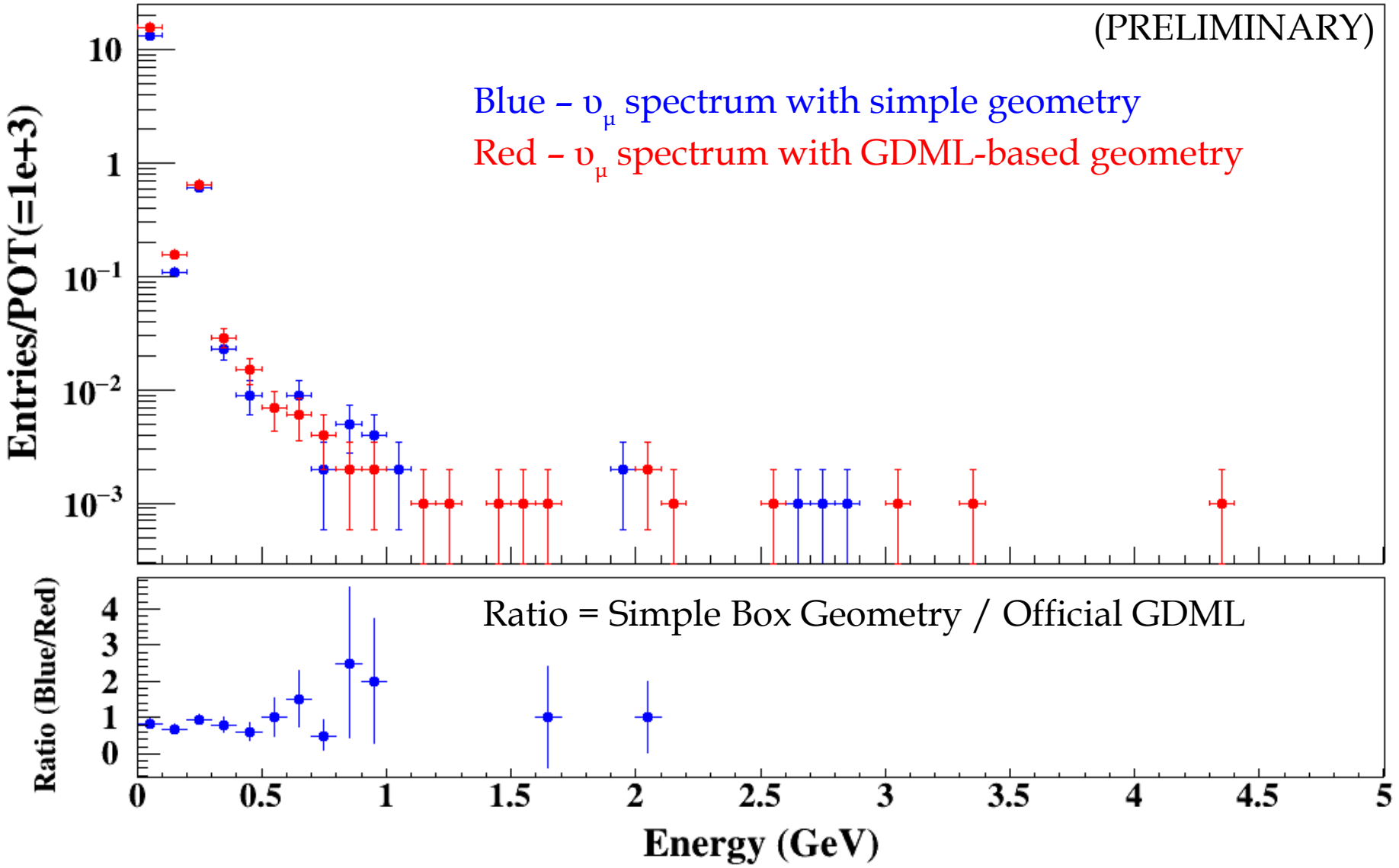
Realistic dump model:



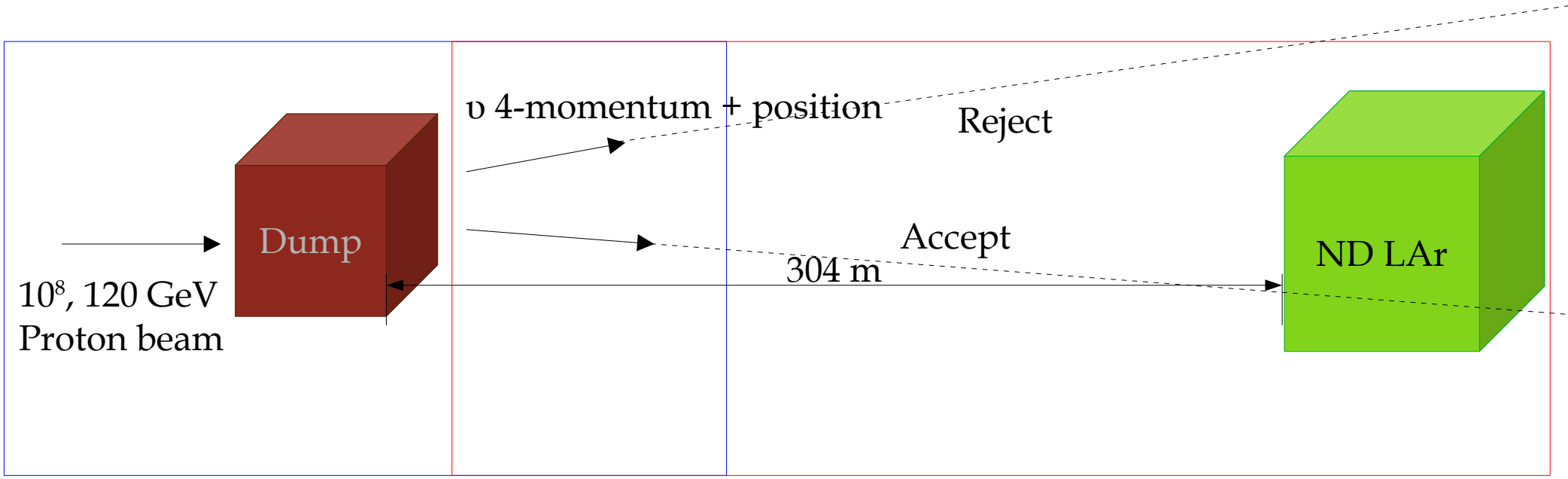
GDML file from G4LBNE software.

Dump GDML – Test Run

- Test simulations with 1,000 protons on target was performed.



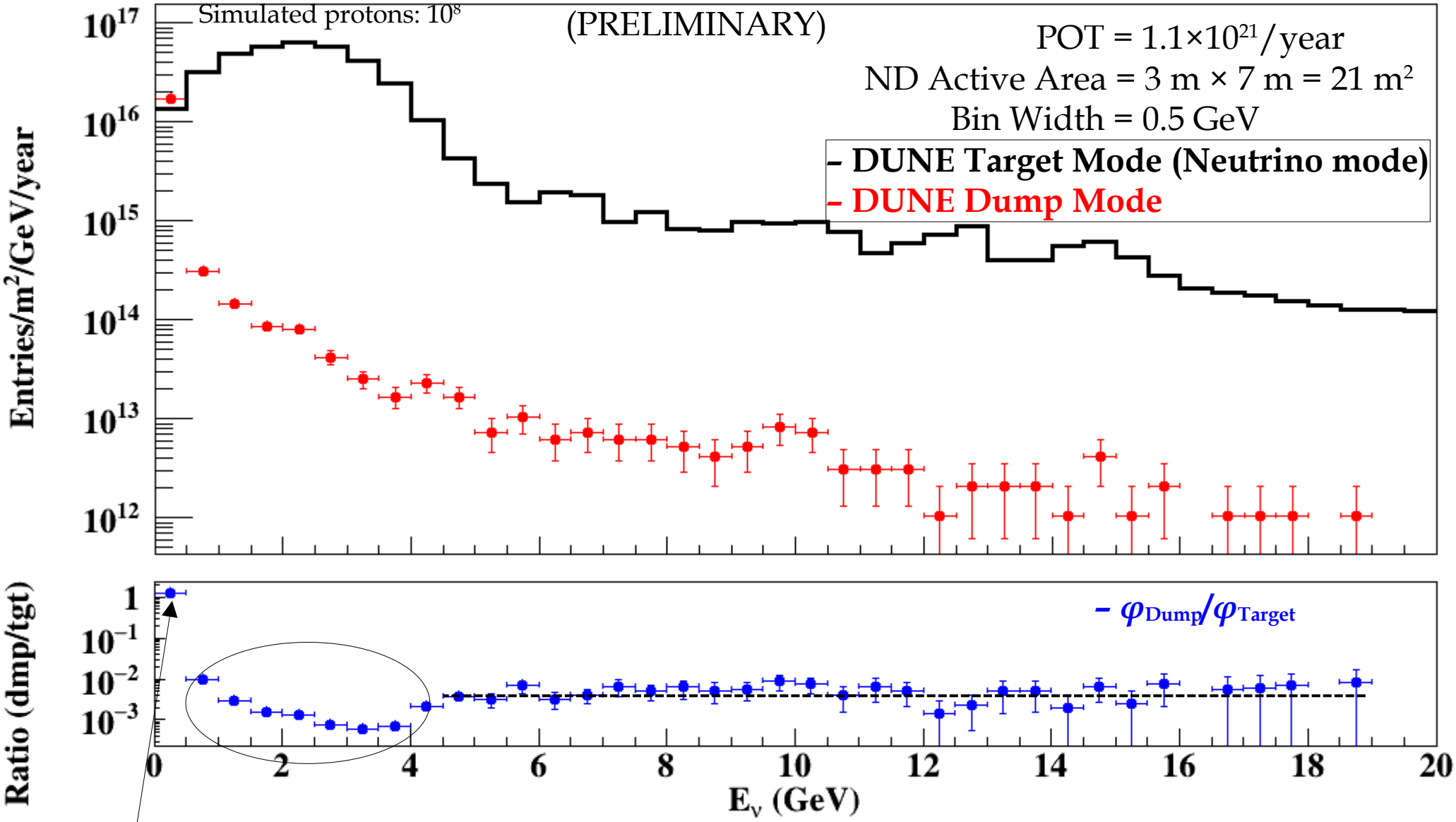
Simulation Work-flow



1: Record position where neutrinos were produced, and their 4-momentum.

2: Determine whether a neutrino is going to pass the ND-LAr (3 m x 7 m x 5 m) or not based on the recorded data at step 1.

Result



This dip is showing flux contribution of focusing horn.

Low energy neutrinos (decay-at-rest of pion or kaon)

Conclusion and Future Plan

- 10^8 Protons-on-target simulation has been done for a simplified DUNE dump geometry.
- The result indicates that the overall neutrino **background reduction** in 5 GeV – 20 GeV is **~10^{-3}**.
- I'll start new simulation runs using official DUNE hadron absorber GDML file soon.

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dump mode data production	→	→						
Signal / Background sample mass production			→	→	→			
Detector response / reconstruction study			→	→	→			
Sensitivity curve code development/test & sensitivity estimation	→	→	→	→	→	→	→	→