Light ν fluxes at NP04

From GEANT4 beam simulations

UPDATE 3

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GEANT4 simulations

REMINDER

"Correct" geometry of NP04

From Laura and Sylvain emails exchange

- Dimensions of NP04

  $h = 6.075$ m

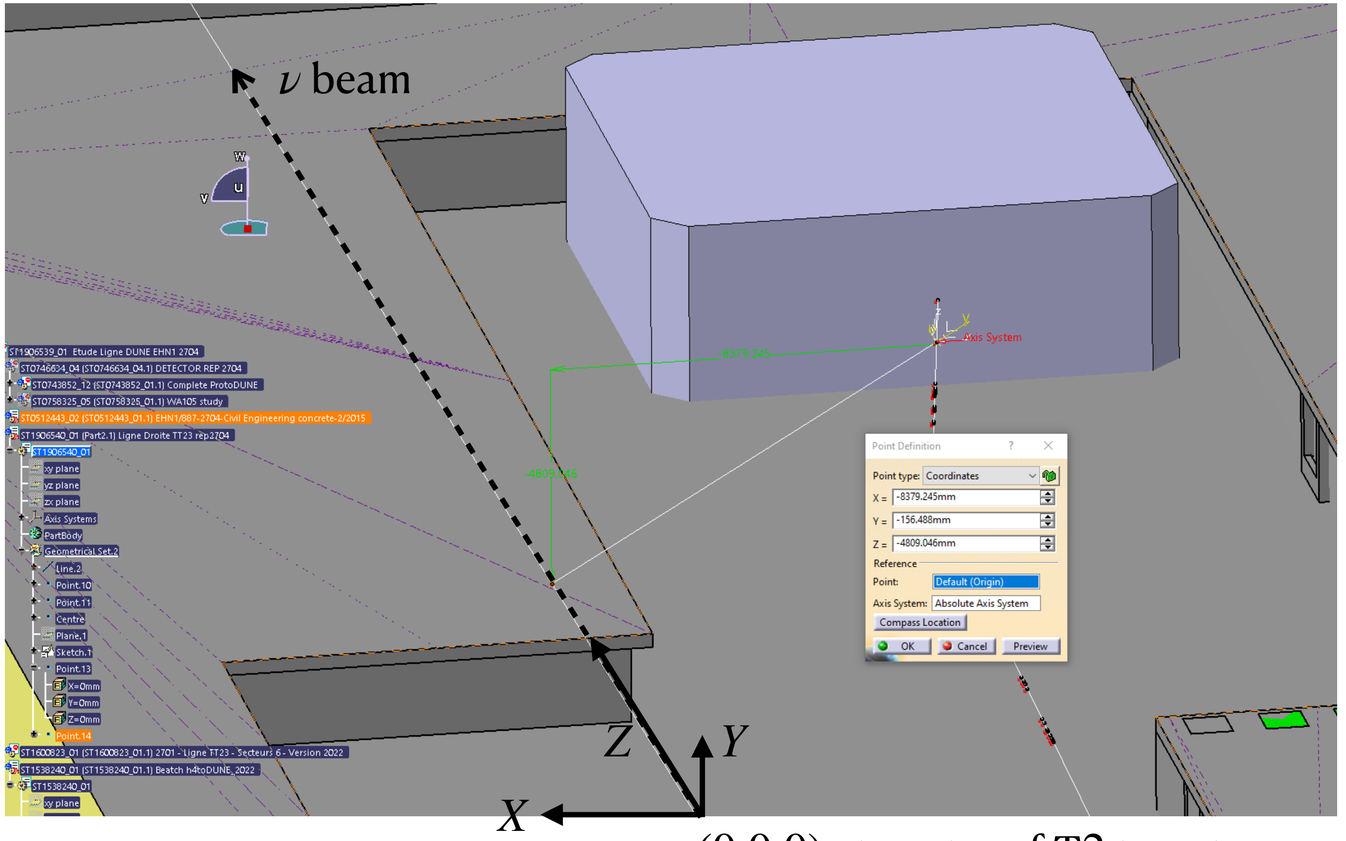
  $l = 2 \times 2.317$ m

  $w = 7.07$ m

- Mass of NP04

  278.64 tons

  ($\rho_{\mathrm{LAr}} = 1.4$ tons/m^3)



(0,0,0) at center of T2 target

- Distance T2-DUNE center

  $d_{\mathrm{OA}_x} = -8.38$ m

  $d_{\mathrm{OA}_y} = 4.811$ m

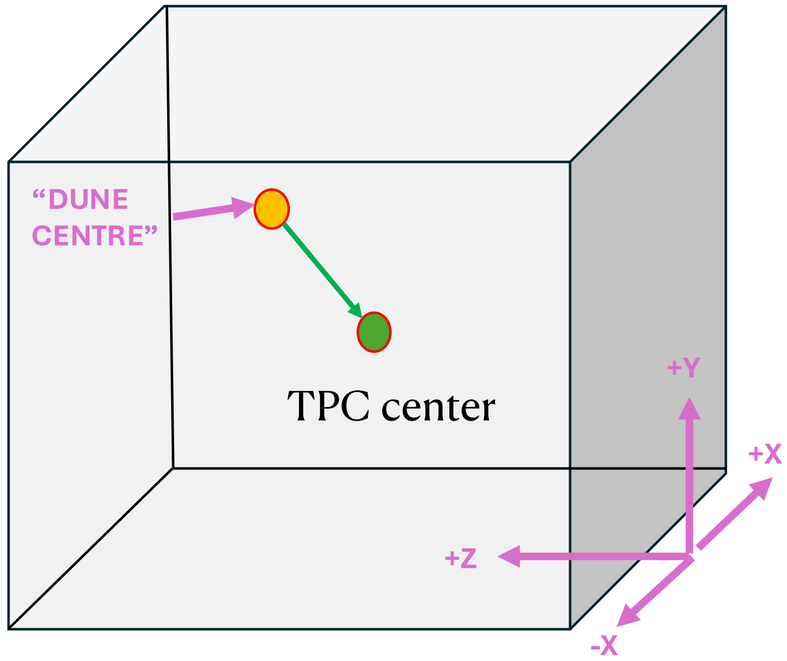
  $d_{\mathrm{det}_z} = 722.592$ m

GEANT4 simulations

“Correct” geometry of NP04

From recent discussion with Ciaran

DUNE center = center of the cryostat ≠ TPC center



GEANT4 simulations

"Correct" geometry of NP04

From recent discussion with Ciaran

DUNE center = center of the cryostat ≠ TPC center

In LArSoft coordinates:

$DC_C = (197.5911, 323.1968, 368.0451)$ cm

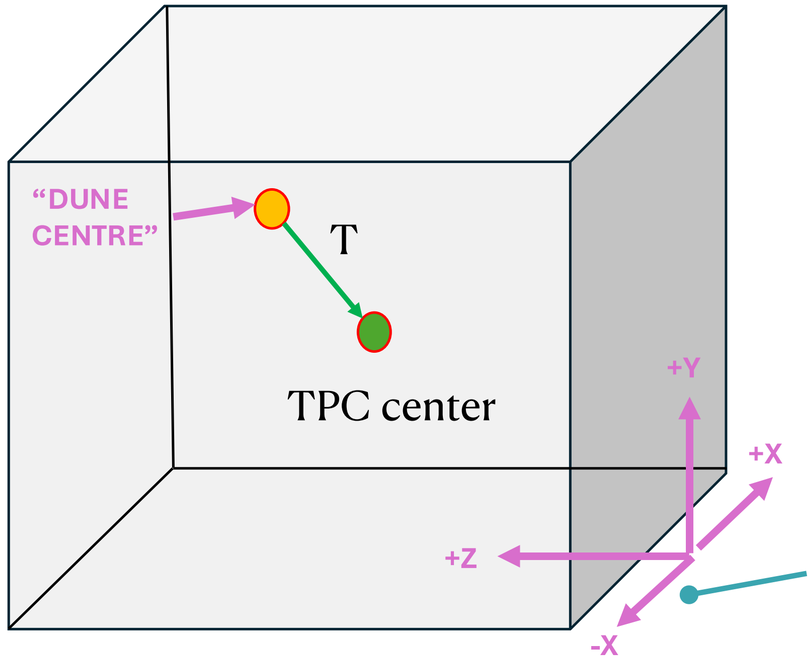
$TPC_C = (0, 303.75, 231.7)$ cm

Translation from TPC_C to DC_C:

$T = TPC_C - DC_C = (-197.5911, -19.4468, -136.3451)$ cm

Displacement between T2 and TPC_C:

$d = D + T = (-6.40, 4.62, 721.23)$ m (in T2 coordinates)



Notice change of X sign in LArSoft

GEANT4 simulations

REMINDER

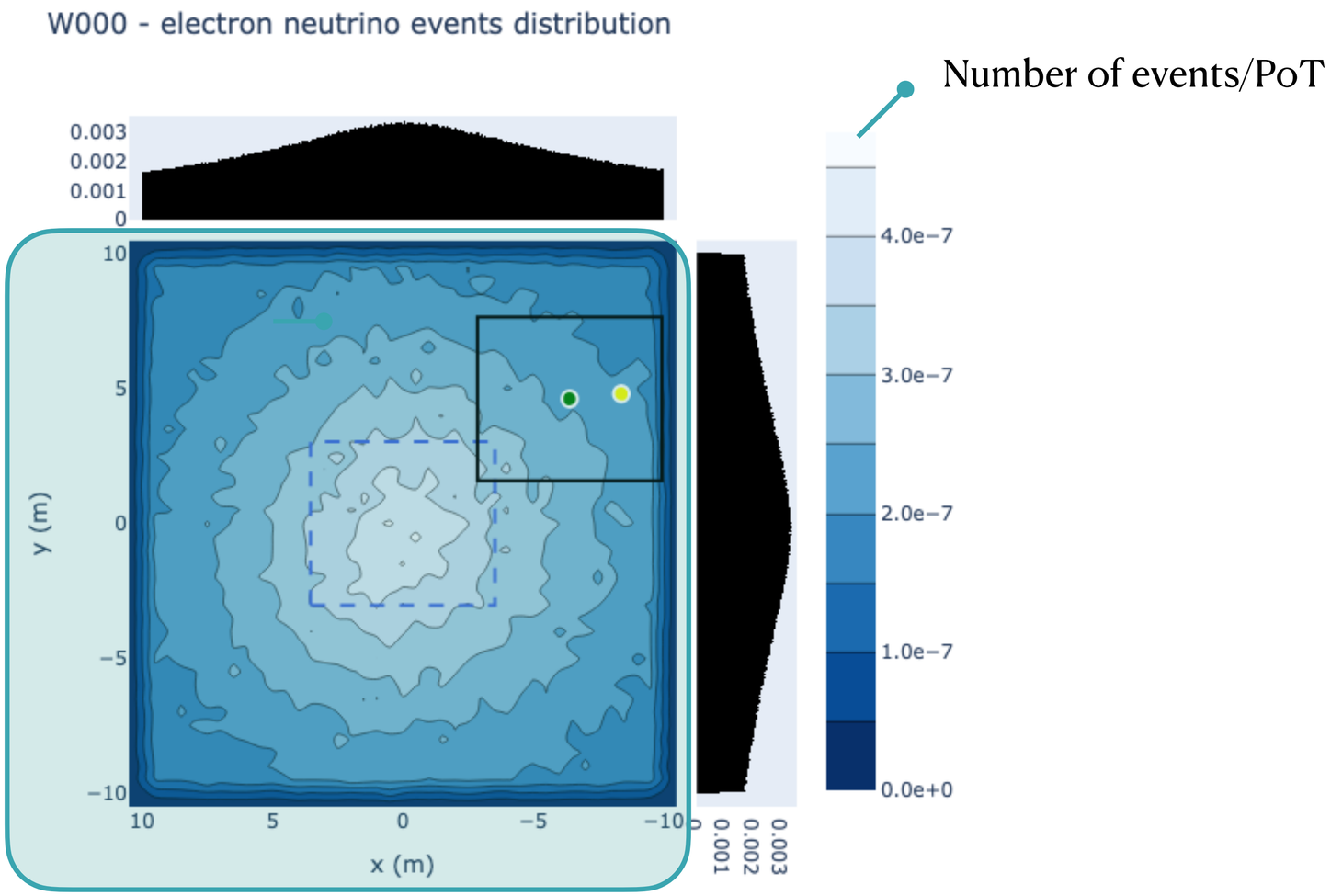
The wobbling configurations

Present GEANT4 Henri simulations (v3) contain light charged mesons, and neutral kaons produced from T2 to the soil with:

- w000 wobbling configuration with magnets switched off, beam to H4
- w133 wobbling configuration with magnets between T2 and TAX switched on
- wNP04 wobbling configuration to produce hadrons to H4 beam line (current data set)

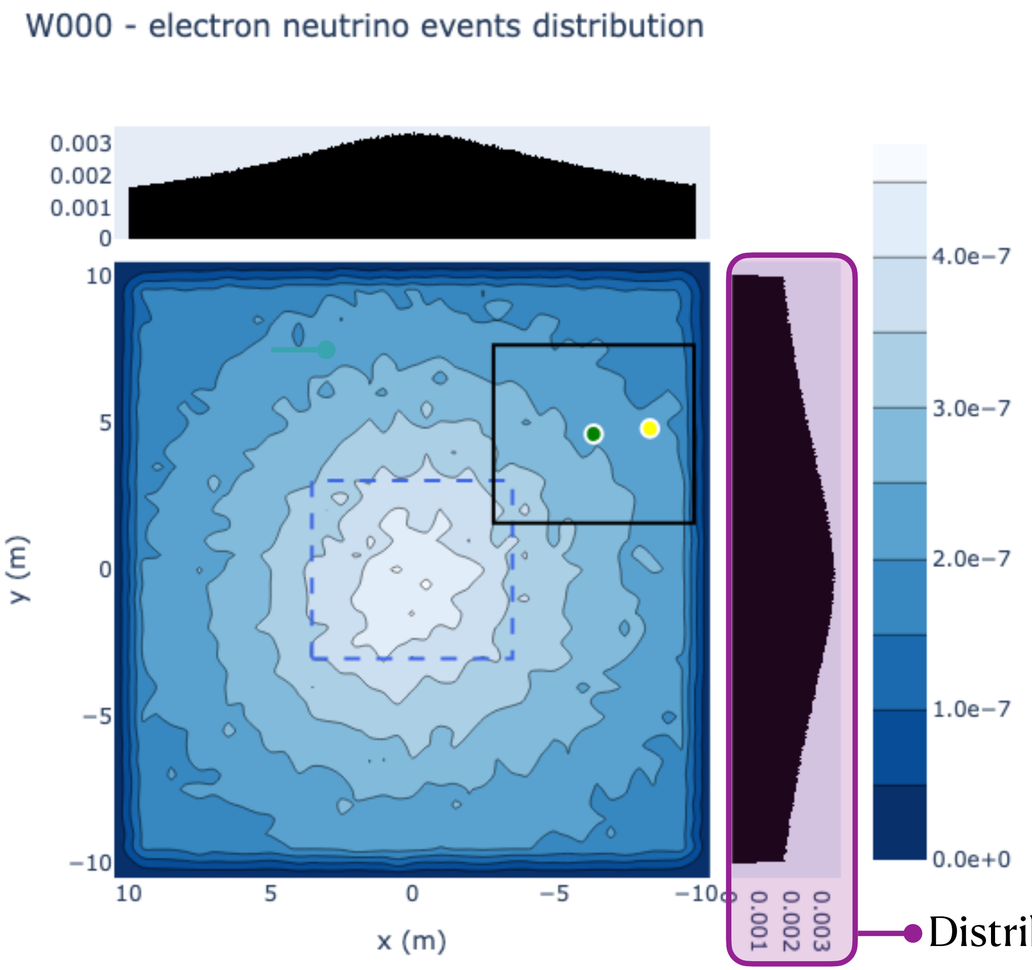
GEANT4 simulations

Distribution of ν_α events in the XY-plane



GEANT4 simulations

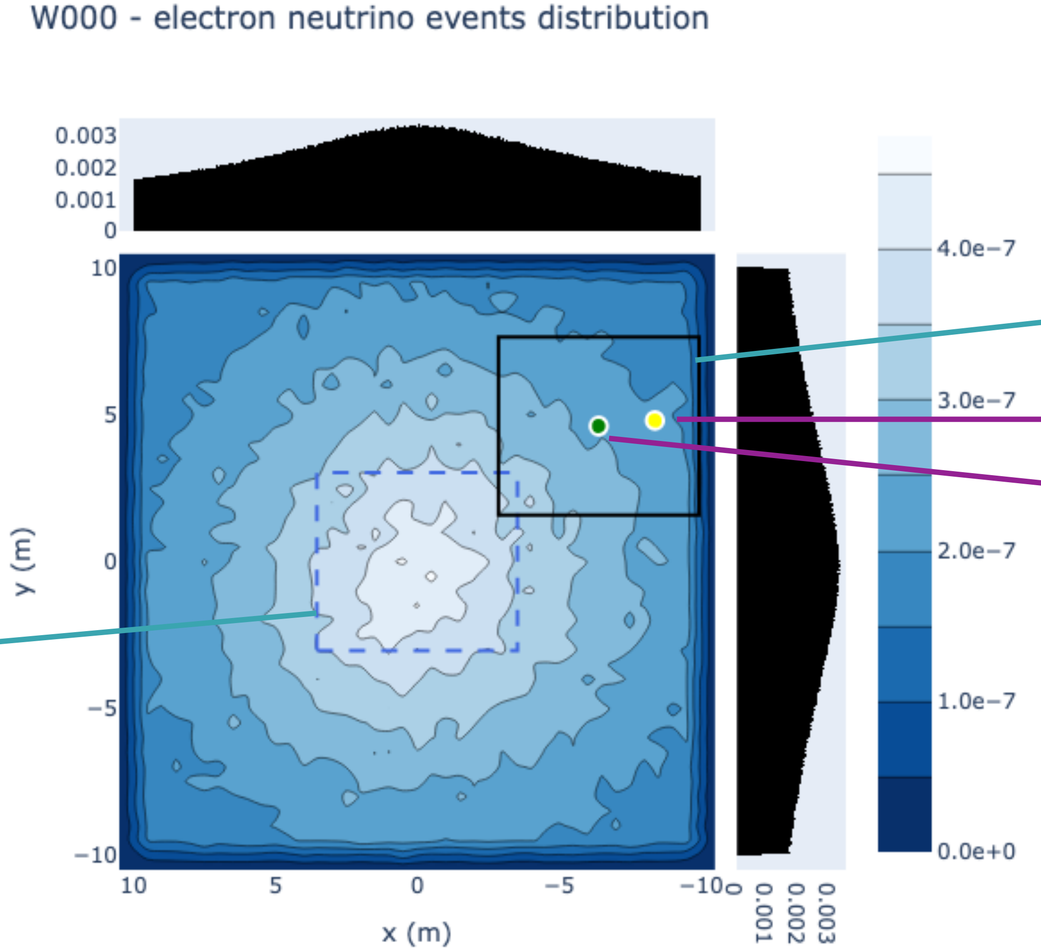
Distribution of ν_α events in the XY-plane



Distribution of events in Y-axis norm to 1

GEANT4 simulations

Distribution of ν_α events in the XY-plane



Projection of NP04

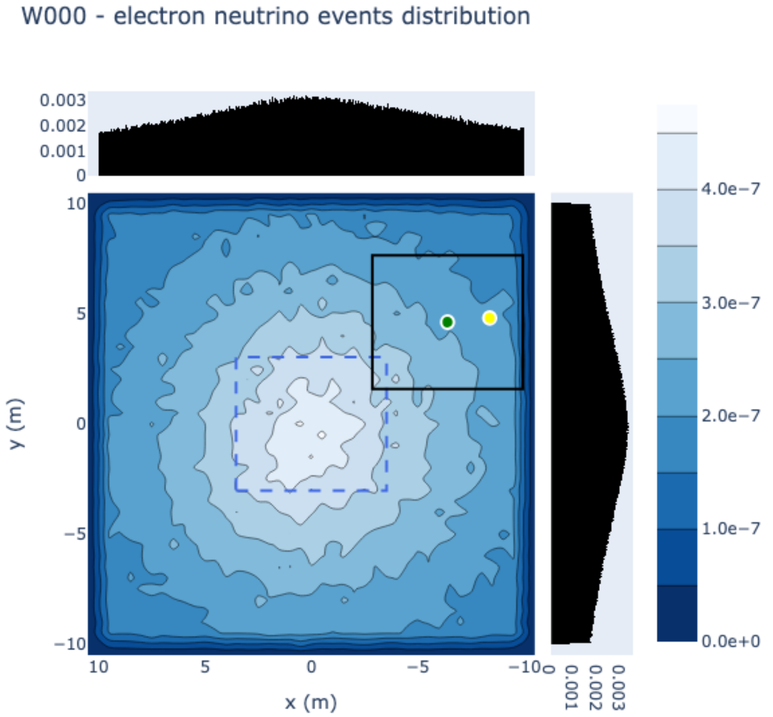
DUNE centre

TPC centre

Projection of NP04-like placed on beam axis

GEANT4 simulations

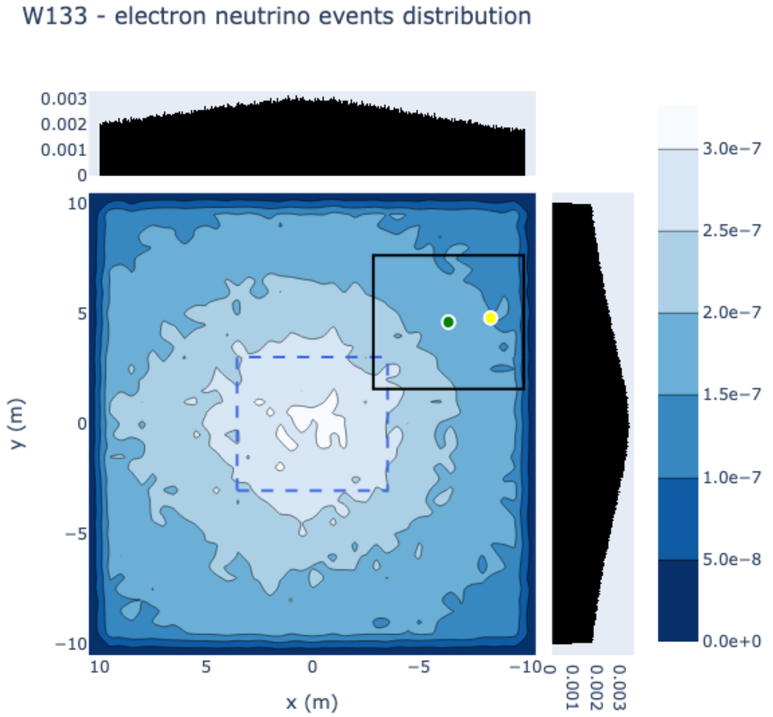
Distribution of ν_e events in the XY-plane



--- $6.6 \cdot 10^{-5}$ events/PoT

— $4.1 \cdot 10^{-5}$ events/PoT

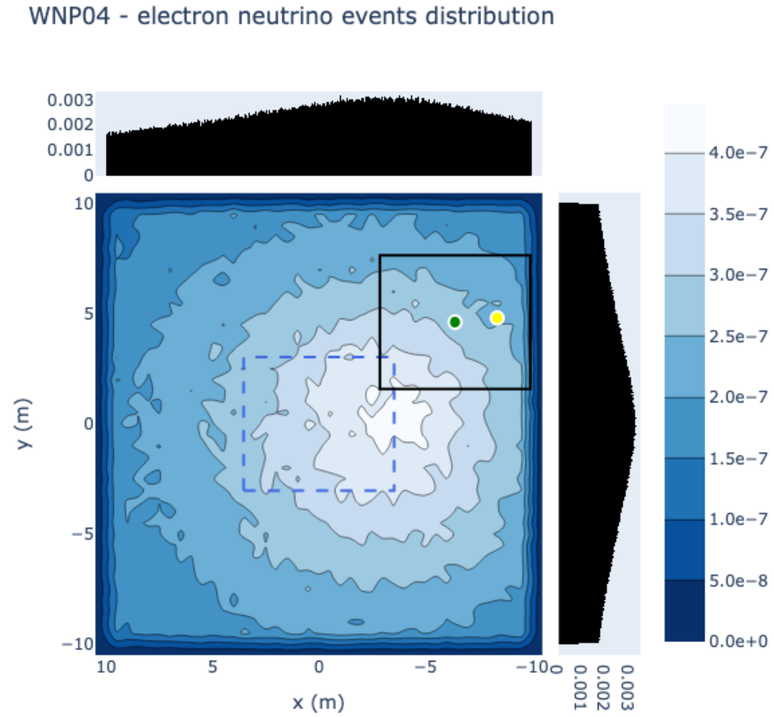
37.5 % reduction



--- $4.8 \cdot 10^{-5}$ events/PoT

— $3.0 \cdot 10^{-5}$ events/PoT

36.5 % reduction



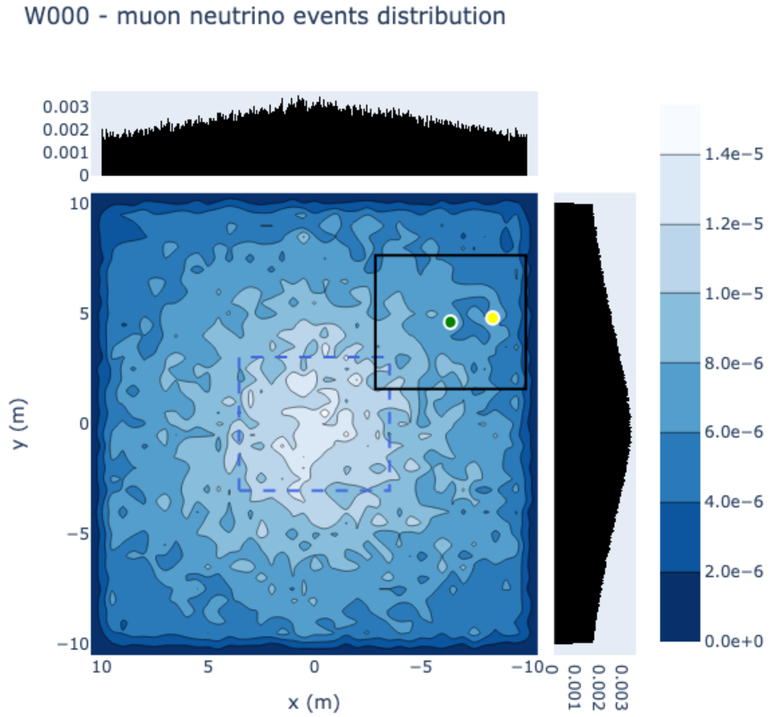
--- $5.9 \cdot 10^{-5}$ events/PoT

— $4.8 \cdot 10^{-5}$ events/PoT

19.5 % reduction

GEANT4 simulations

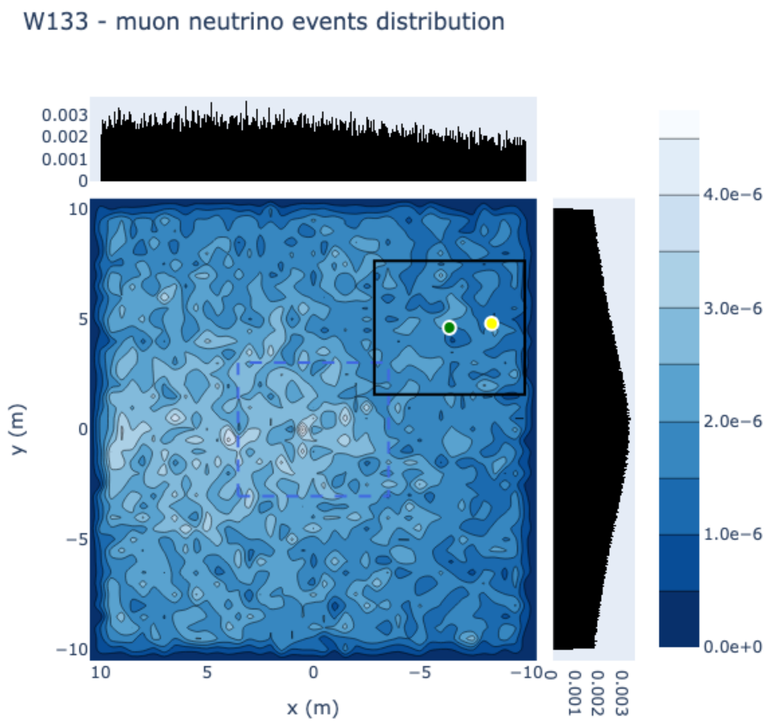
Distribution of ν_μ events in the XY-plane



- - - $1.9 \cdot 10^{-3}$ events/PoT

— $1.2 \cdot 10^{-3}$ events/PoT

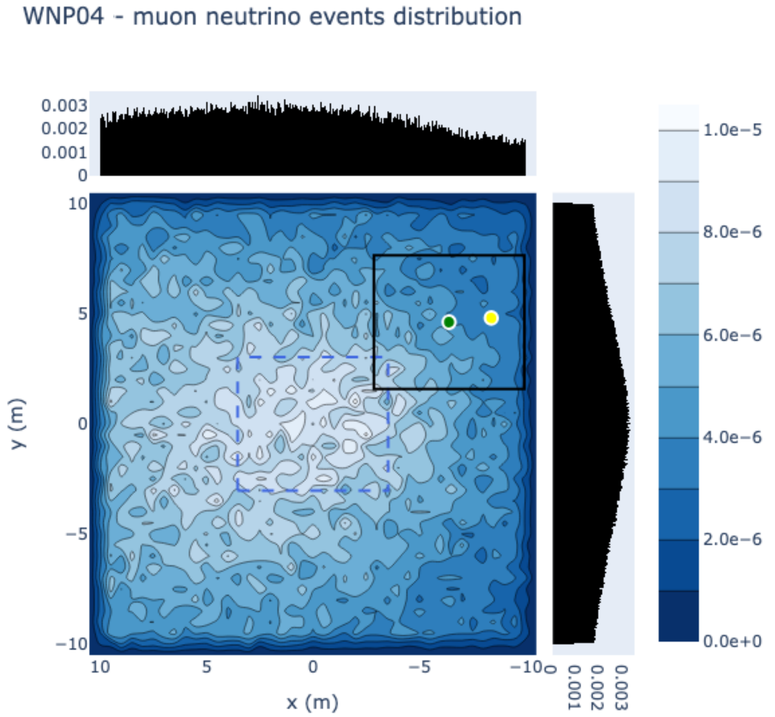
39.2 % reduction



- - - $4.3 \cdot 10^{-4}$ events/PoT

— $2.9 \cdot 10^{-4}$ events/PoT

32.3 % reduction



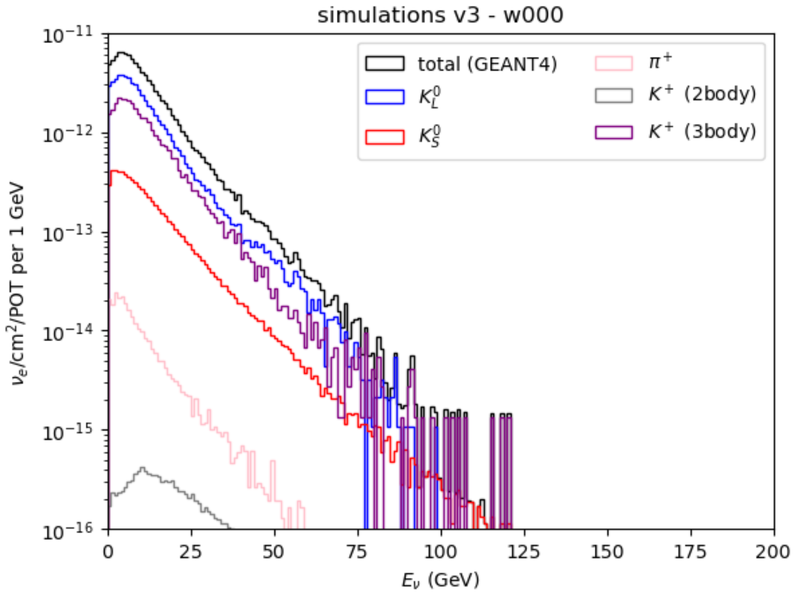
- - - $1.4 \cdot 10^{-3}$ events/PoT

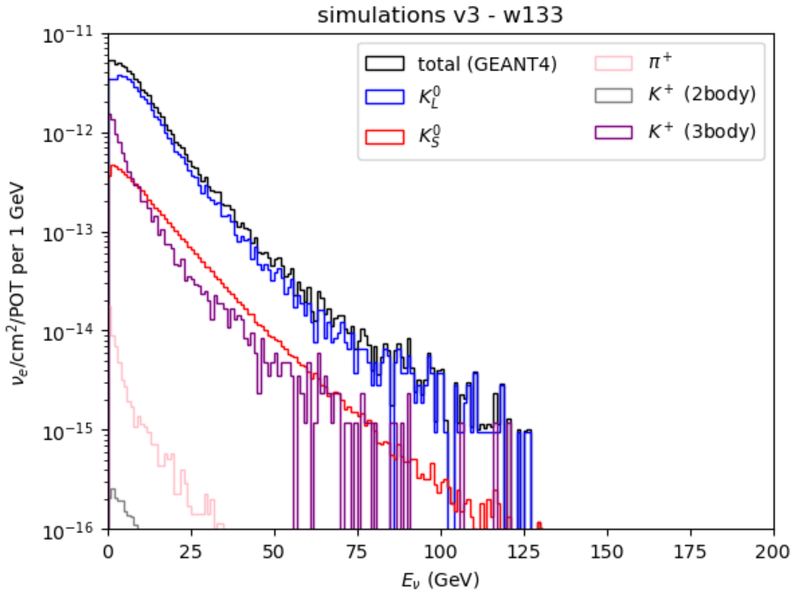
— $7.6 \cdot 10^{-4}$ events/PoT

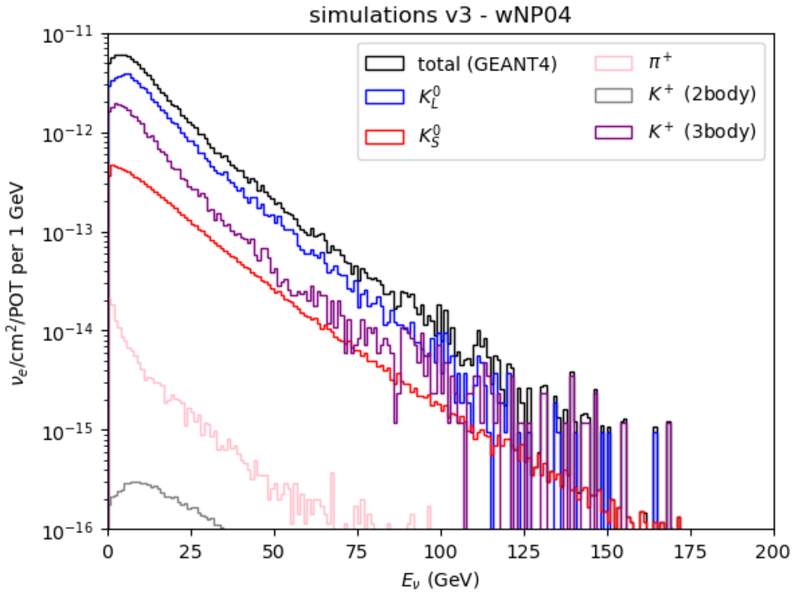
45.1 % reduction

GEANT4 simulations

ν_e fluxes crossing NP04



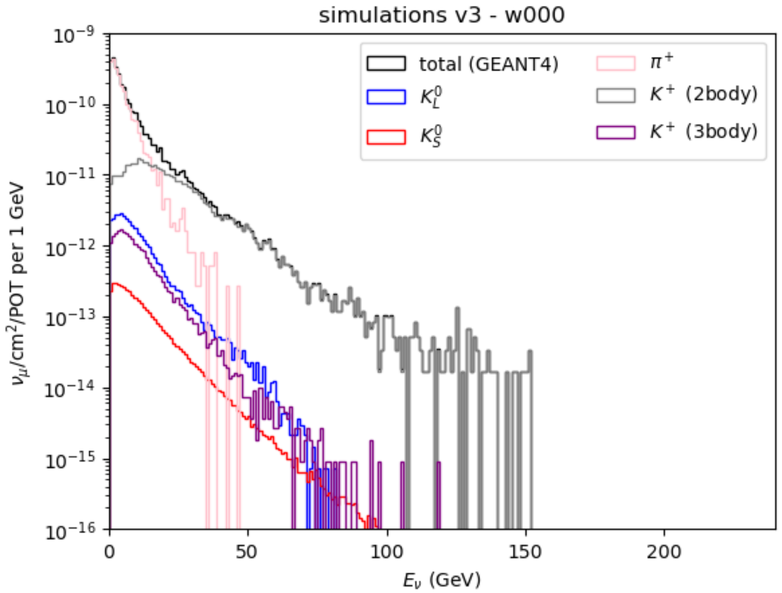


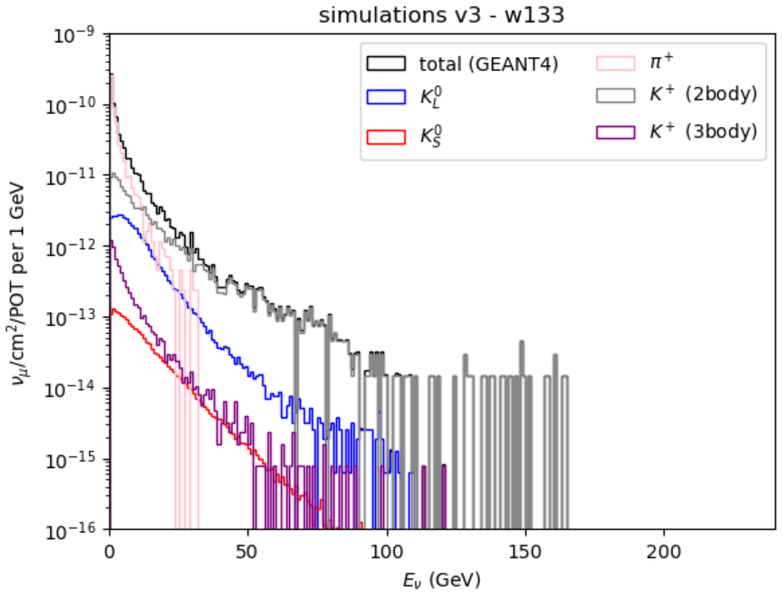


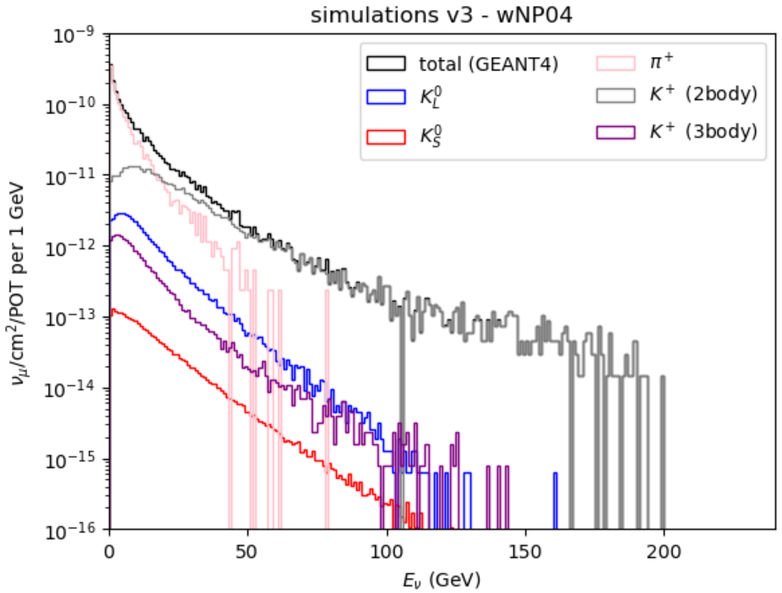
Preliminary

GEANT4 simulations

ν_μ fluxes crossing NP04



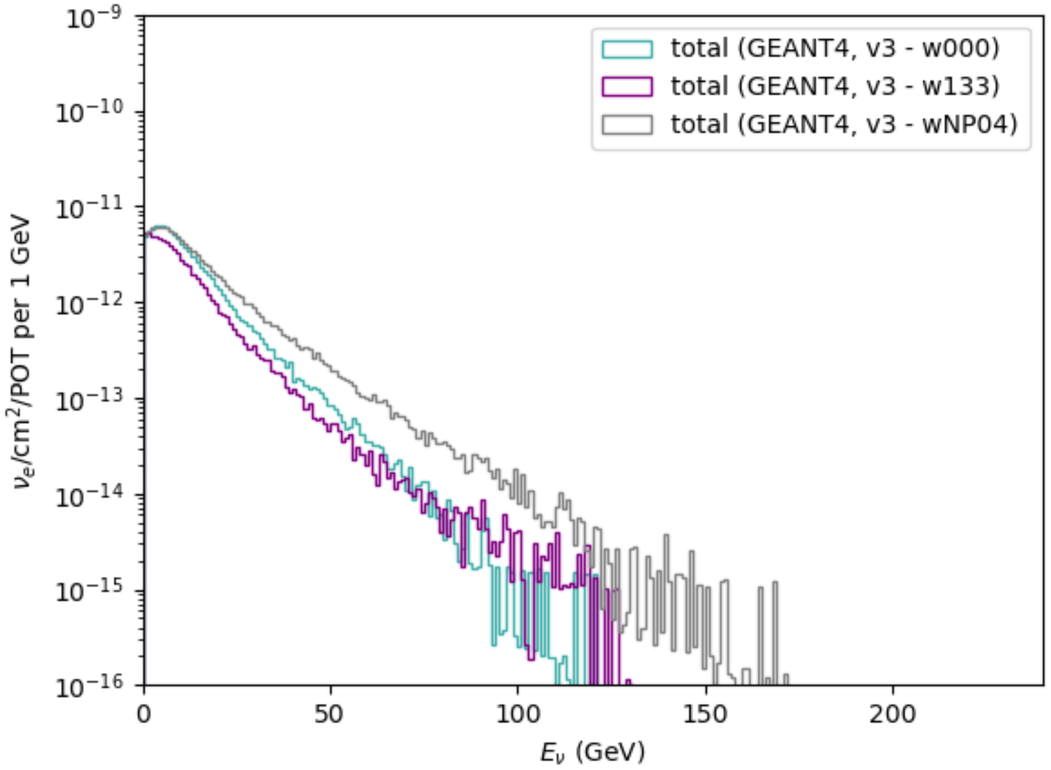


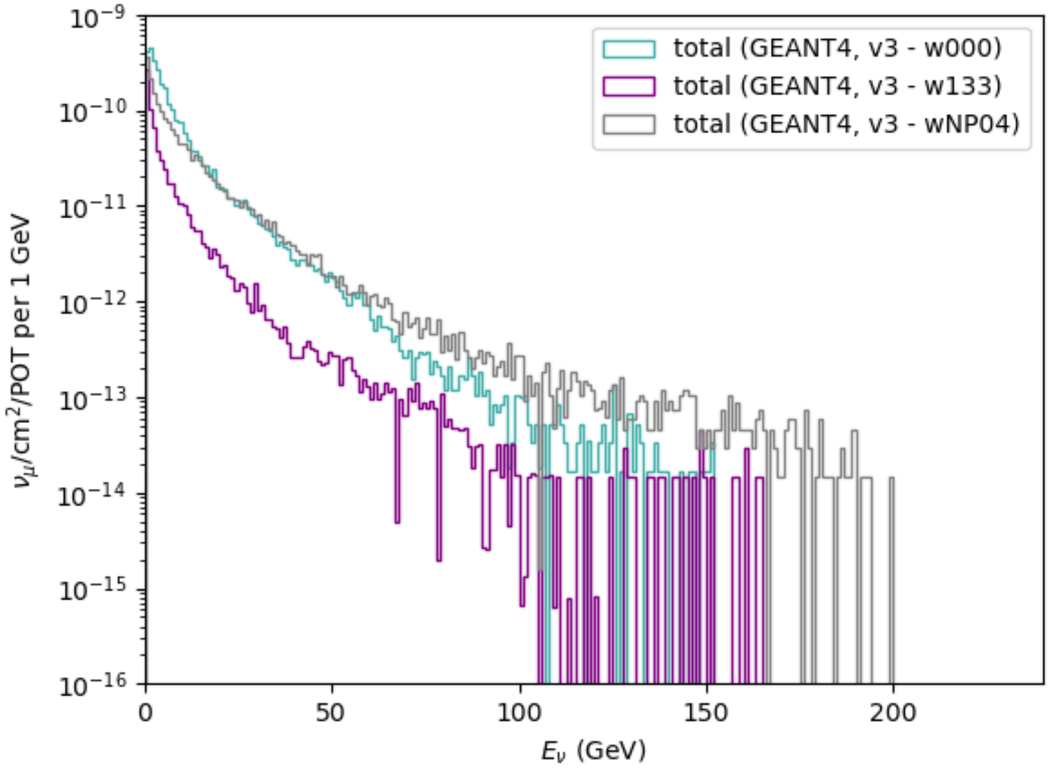


Preliminary

GEANT4 simulations

ν_e vs ν_μ flux comparison

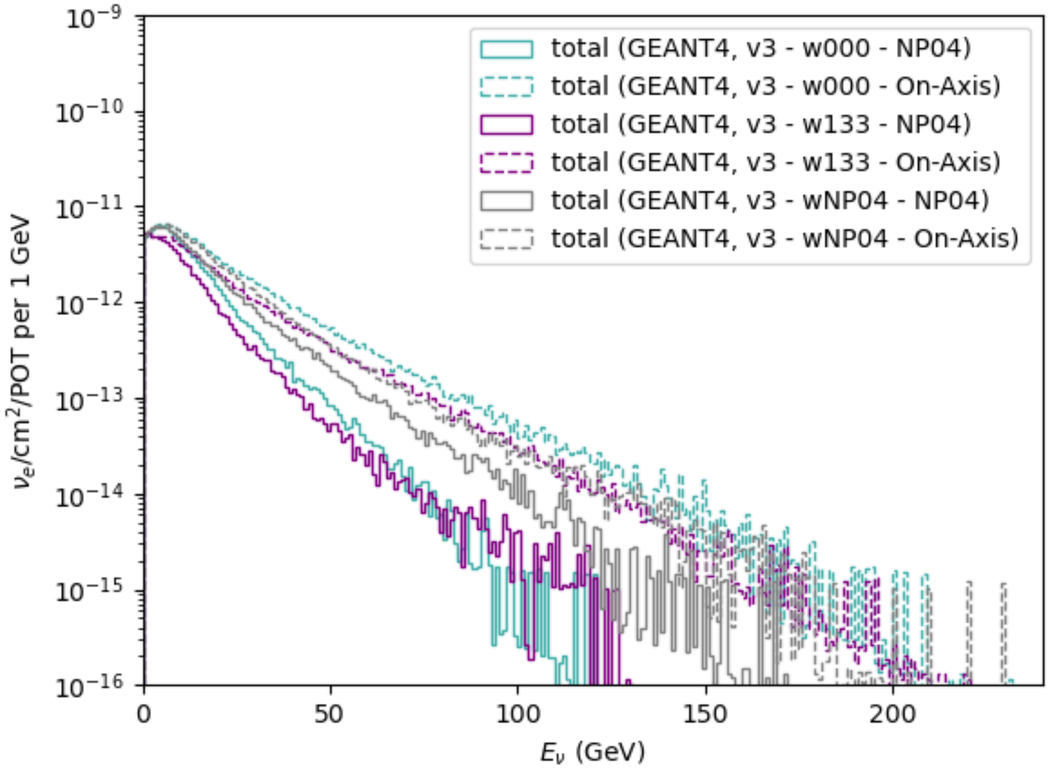


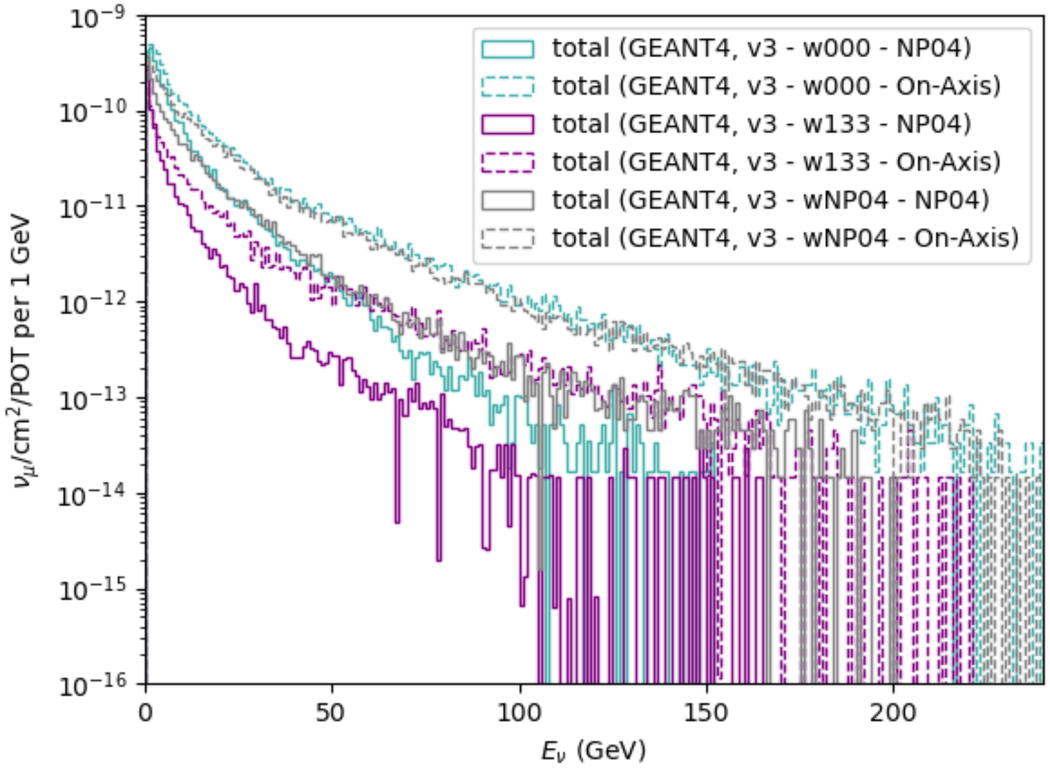


Preliminary

GEANT4 simulations

ν_e vs ν_μ flux on-axis vs off-axis comparison



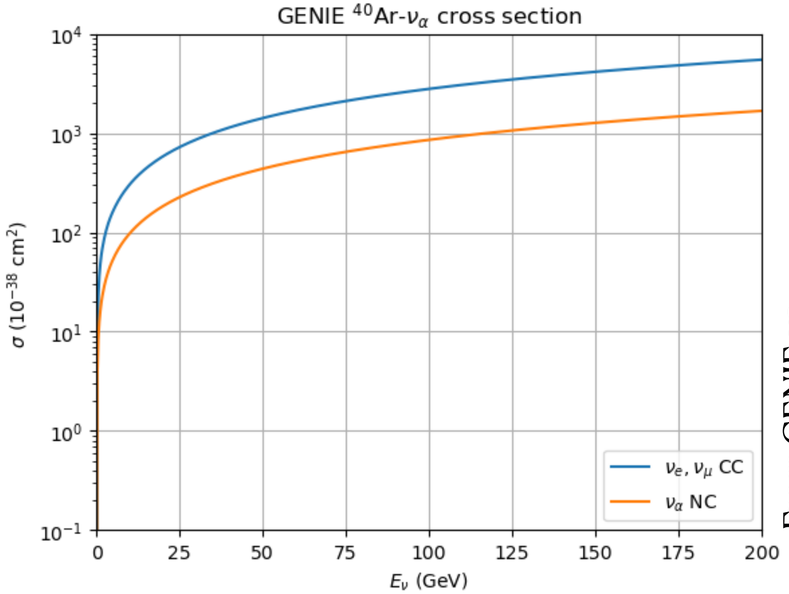


Preliminary

GEANT4 simulations

Neutrino interactions with Argon

Cross section of ν_α with ^{40}Ar



From GENIE v3

The number of interactions is given by

$$N = n\sigma\phi$$

with the number of targets

$$n = \frac{278.64 \cdot 10^6 \times 6.022 \cdot 10^{23}}{40}$$

GEANT4 simulations

Neutrino interactions with Argon in NP04

Total number of neutrino interactions in 5 years: $1.75 \cdot 10^{19}$ PoT

	Total number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	22483	15111	32932
ν_e-^{40}Ar – NC	7141	4847	10392
ν_μ-^{40}Ar – CC	391094	63456	362711
ν_μ-^{40}Ar – NC	125003	20407	114781

Preliminary

GEANT4 simulations

Neutrino interactions with Argon in NP04

Number of neutrino interactions per week: $1.5 \cdot 10^{17}$ PoT

	Weekly number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	193	130	282
ν_e-^{40}Ar – NC	61	42	89
ν_μ-^{40}Ar – CC	3352	544	3109
ν_μ-^{40}Ar – NC	1071	175	984

Preliminary

GEANT4 simulations

Neutrino interactions with Argon in NP04

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ν_μ-^{40}Ar – CC	3352	544	3109
ν_μ-^{40}Ar – NC	1071	175	984

$\sim 170 - 370$ ν_e events/week

Preliminary

GEANT4 simulations

Neutrino interactions with Argon in NP04

Number of neutrino interactions per week: $1.5 \cdot 10^{17}$ PoT

	Weekly number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	193	130	282
ν_e-^{40}Ar – NC	61	42	89
ν_μ-^{40}Ar – CC	3352	544	3109
ν_μ-^{40}Ar – NC	1071	175	984

$\sim 4100 - 4400$ ν_μ events/week

~ 720 ν_μ events/week

deflection of π^+ by the magnets

Preliminary

GEANT4 simulations

Neutrino interactions with Argon. Off-axis effect

Total number of neutrino interactions in 5 years: $1.75 \cdot 10^{19}$ PoT

NP04-like on-axis	Total number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	60569	41260	47689
ν_e-^{40}Ar – NC	18978	12939	14988
ν_μ-^{40}Ar – CC	1142923	213656	933526
ν_μ-^{40}Ar – NC	360016	67267	293247

NP04	Total number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	22483	15111	32932
ν_e-^{40}Ar – NC	7141	4847	10392
ν_μ-^{40}Ar – CC	391094	63456	362711
ν_μ-^{40}Ar – NC	125003	20407	114781

Preliminary

GEANT4 simulations

Neutrino interactions with Argon. Off-axis effect

Number of neutrino interactions per week: $1.5 \cdot 10^{17}$ PoT

NP04-like on-axis	Weekly number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	519	354	409
ν_e-^{40}Ar – NC	163	111	128
ν_μ-^{40}Ar – CC	9796	1831	8002
ν_μ-^{40}Ar – NC	3086	577	2514

NP04	Weekly number of interactions		
	w000	w133	wNP04
ν_e-^{40}Ar – CC	193	130	282
ν_e-^{40}Ar – NC	61	42	89
ν_μ-^{40}Ar – CC	3352	544	3109
ν_μ-^{40}Ar – NC	1071	175	984

Preliminary