DEEP UNDERGROUND NEUTRINO EXPERIMENT

WARWICK

Spherical Array Target
ν Flux Simulations

John Back

University of Warwick

1st October 2015

Introduction

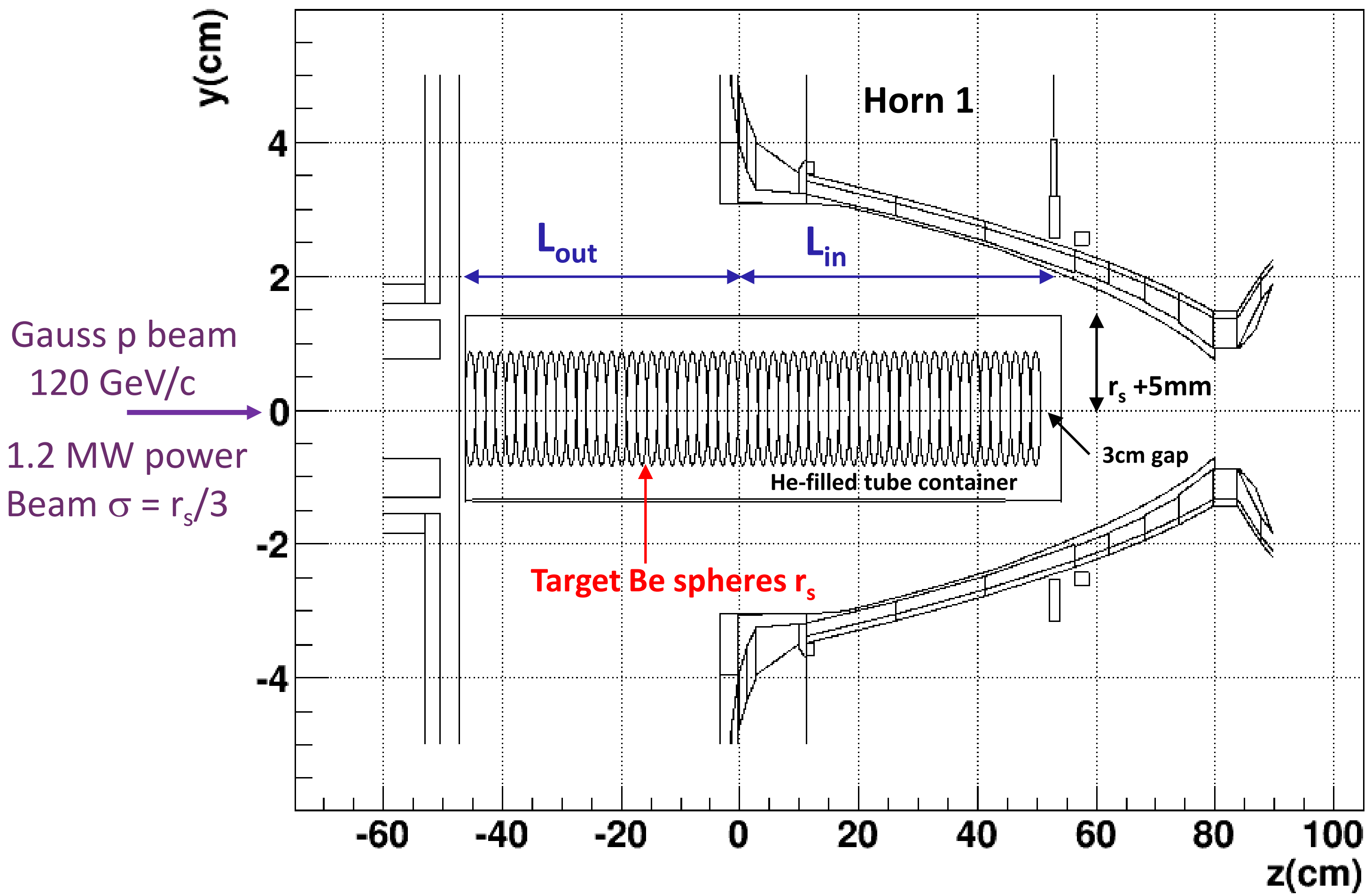
- Beryllium Spherical Array Target (SAT):
  - idea and design from C. Densham's RAL high power target group
  - alternative to the nominal T2K-like graphite cylindrical target
    - He cooling, larger surface area, lower stresses

- First simulations on SAT neutrino fluxes by Quynh Nguyen
  - See DocDB number 9547 for details

- This work: extending simulations for optimising
  - Sphere radius (4.5 to 10.5 mm) = 3 x beam width
  - Total target length, equivalent to 1.5, 2, 2.5 and 3 effective λ
  - Target position relative to start of Horn 1 (assumed to be z=0)
  - Also compare with graphite SAT

- Using G4LBNE v3r3p8
  - Reference geometry, only replacing nominal target with SAT set-up
  - 120 GeV/c protons, 1.2 MW beam power, Gaussian beam

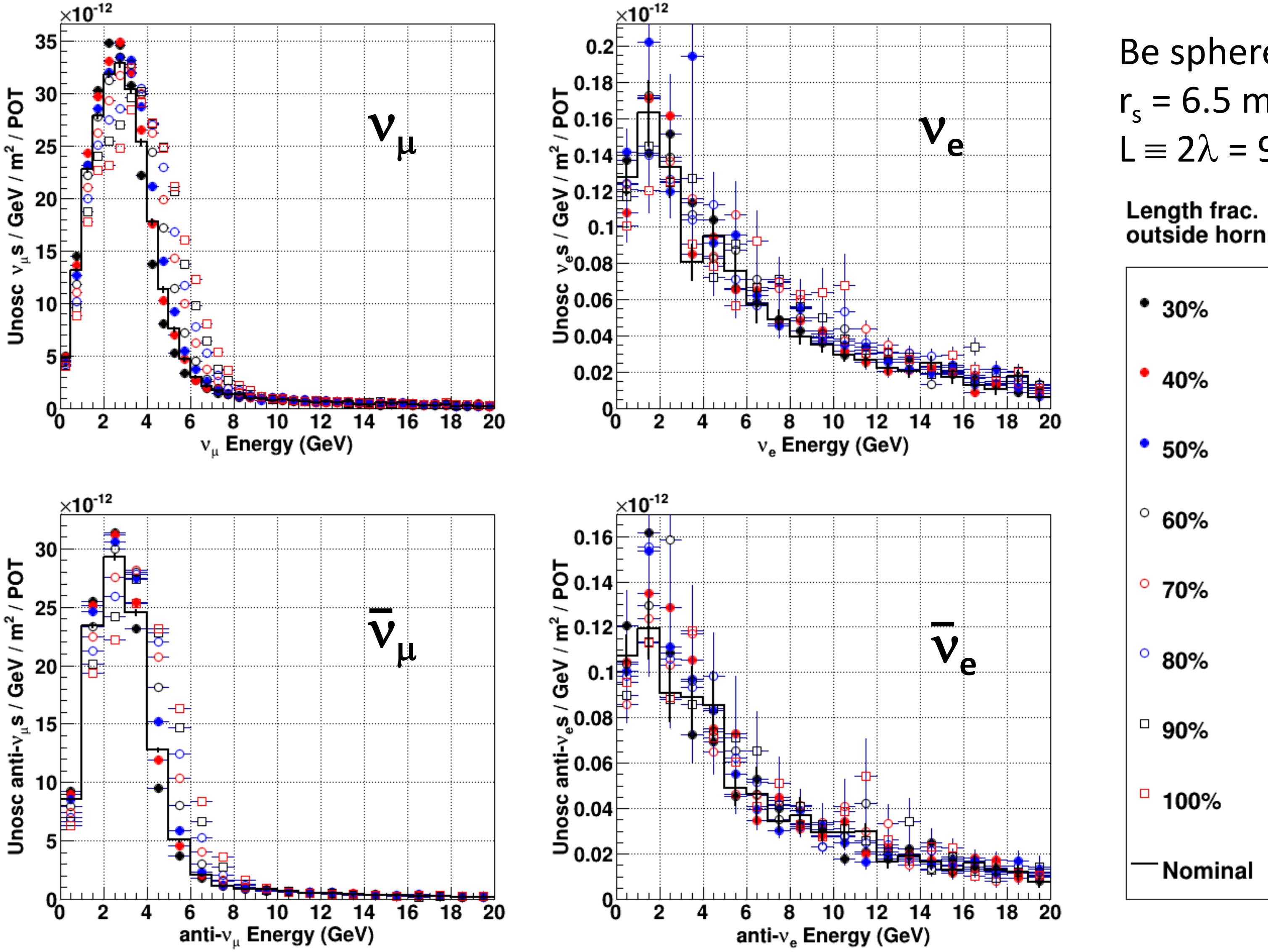
Geant4 (G4LBNE) SAT Reference Geometry



Engineering considerations: minimum feasible Be sphere radius $r_s \approx 6.5$ mm

Reminder: Nominal target is the T2K-style graphite $L = 2\lambda$ cylinder

Example unoscillated flux spectra at far detector



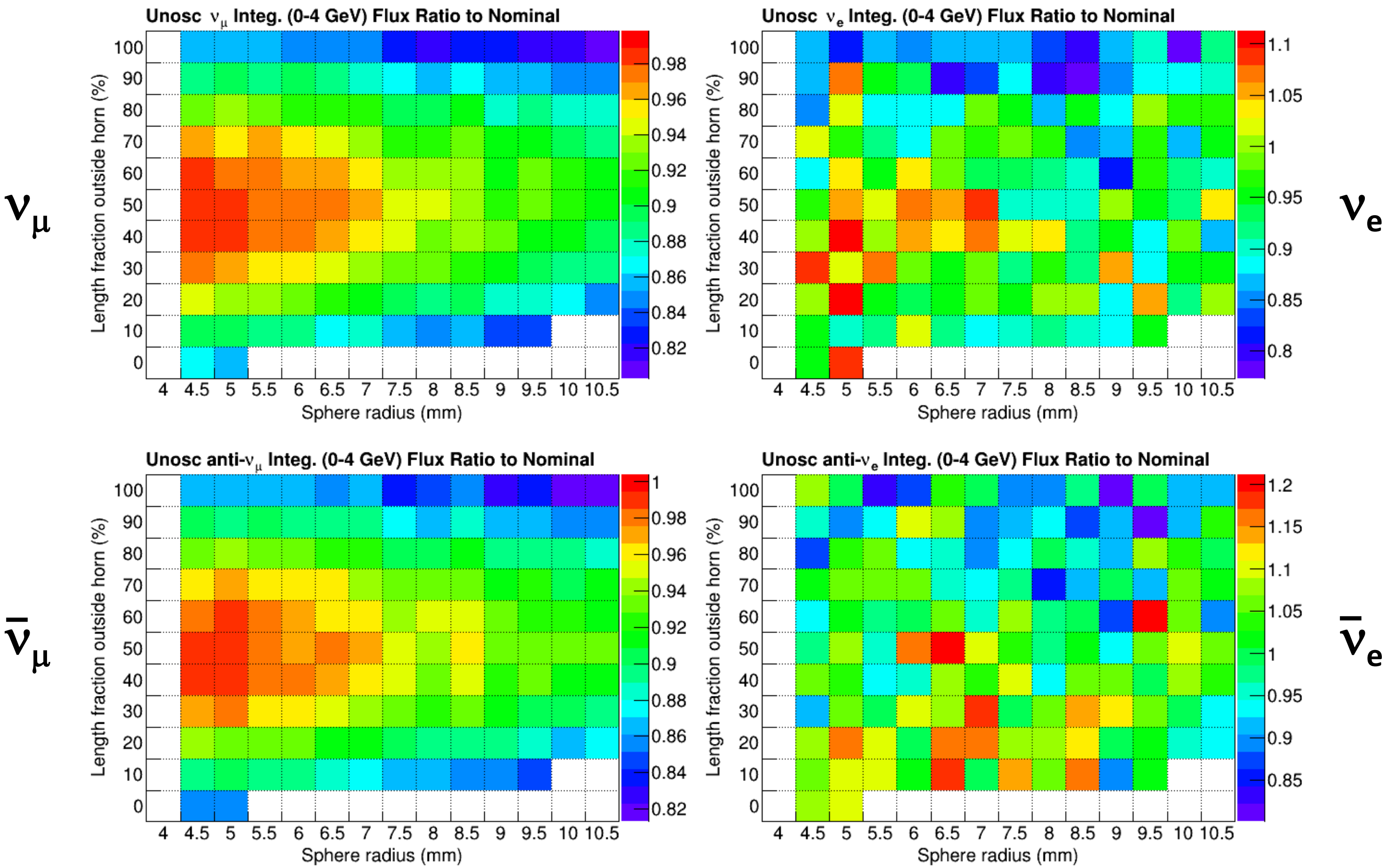
Be sphere

r_s = 6.5 mm

L ≡ 2λ = 97.5 cm

Need to maximise (integrated) flux for low energy (0-4 GeV) neutrinos

Integrated flux ratios for Be sphere: $L \equiv 1.5\lambda \approx 73$ cm

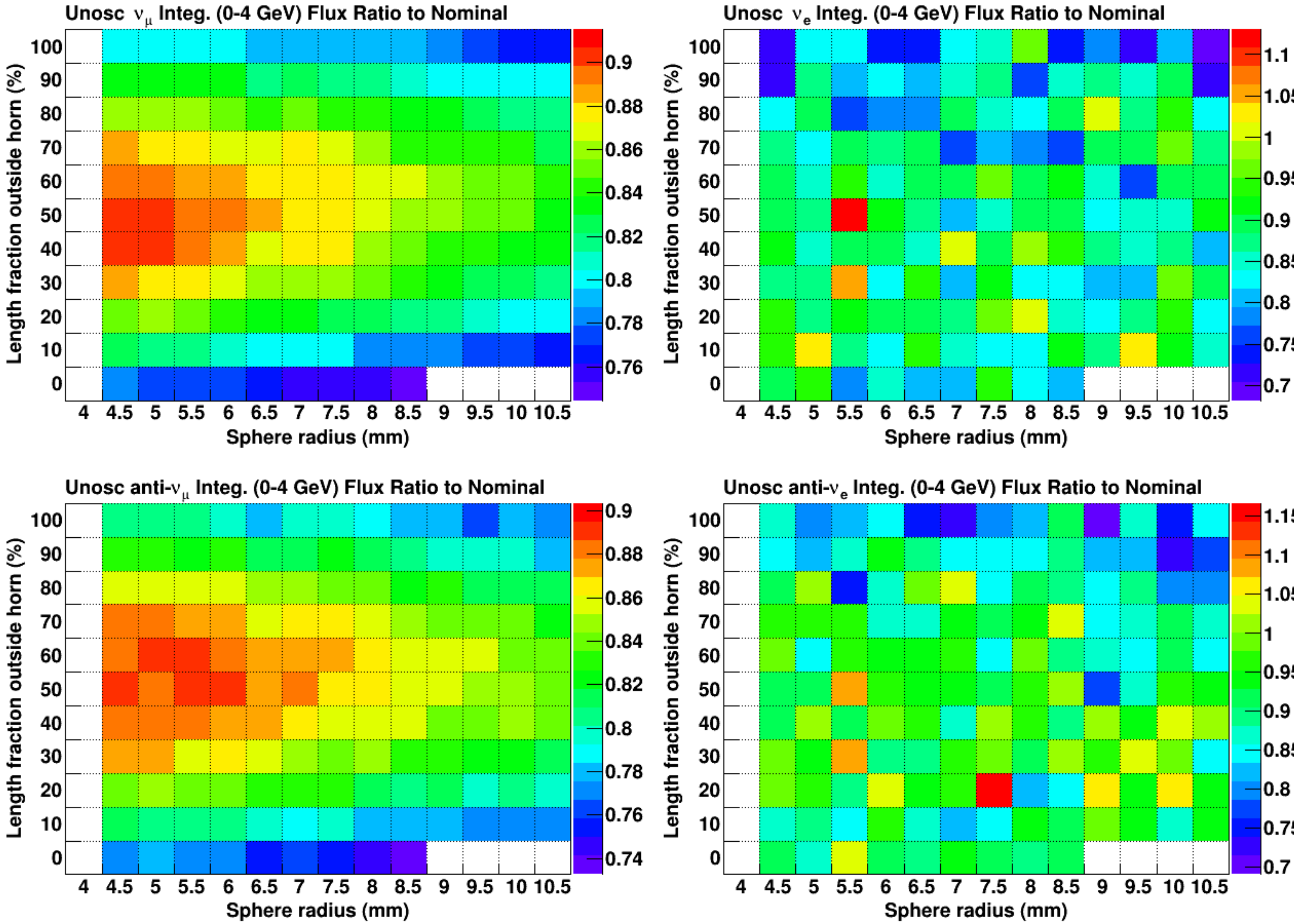


Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Integrated flux ratios for C sphere: $L \equiv 1.5\lambda \approx 67$ cm

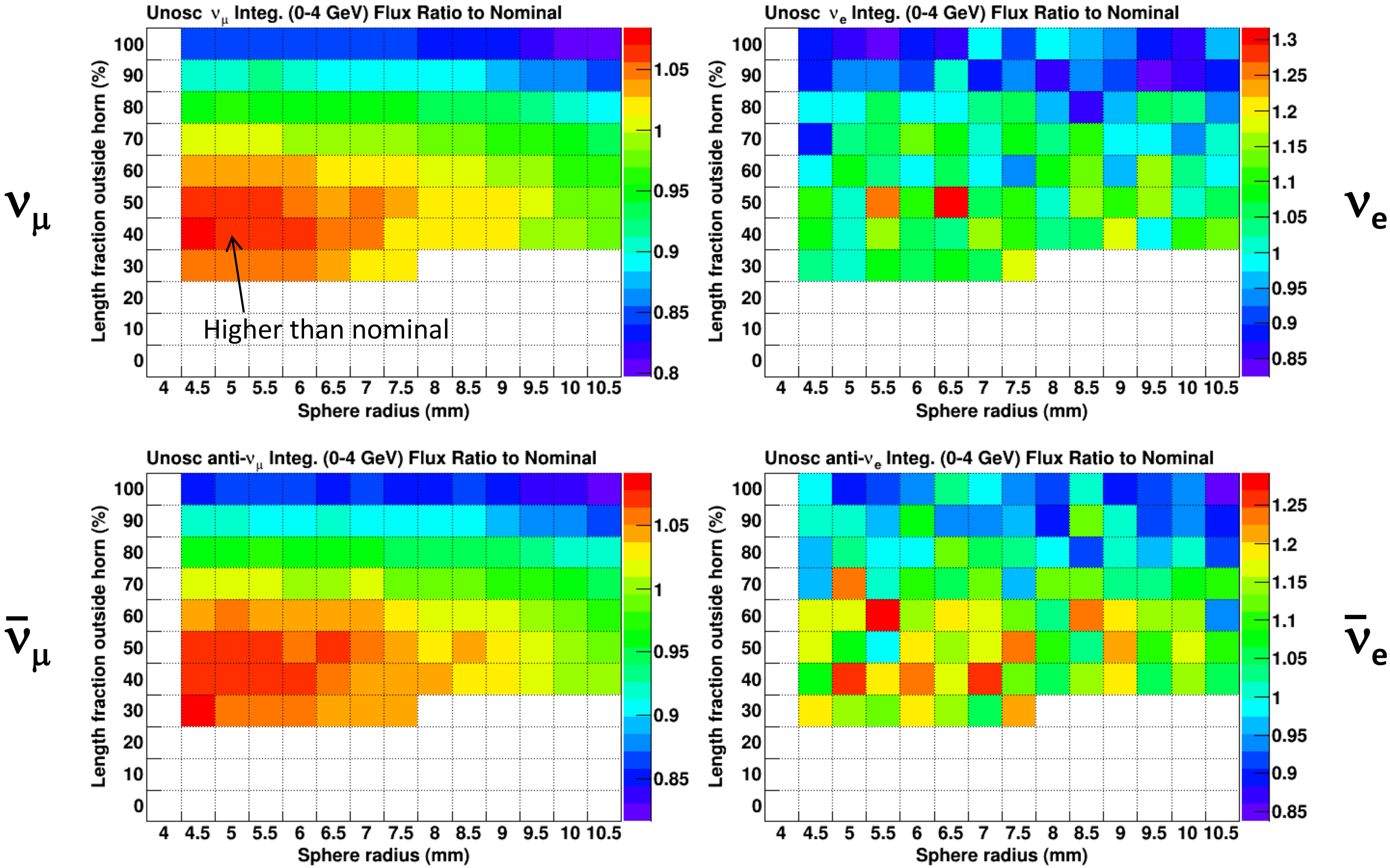
ν_μ ν_e

$\bar{\nu}_\mu$ $\bar{\nu}_e$



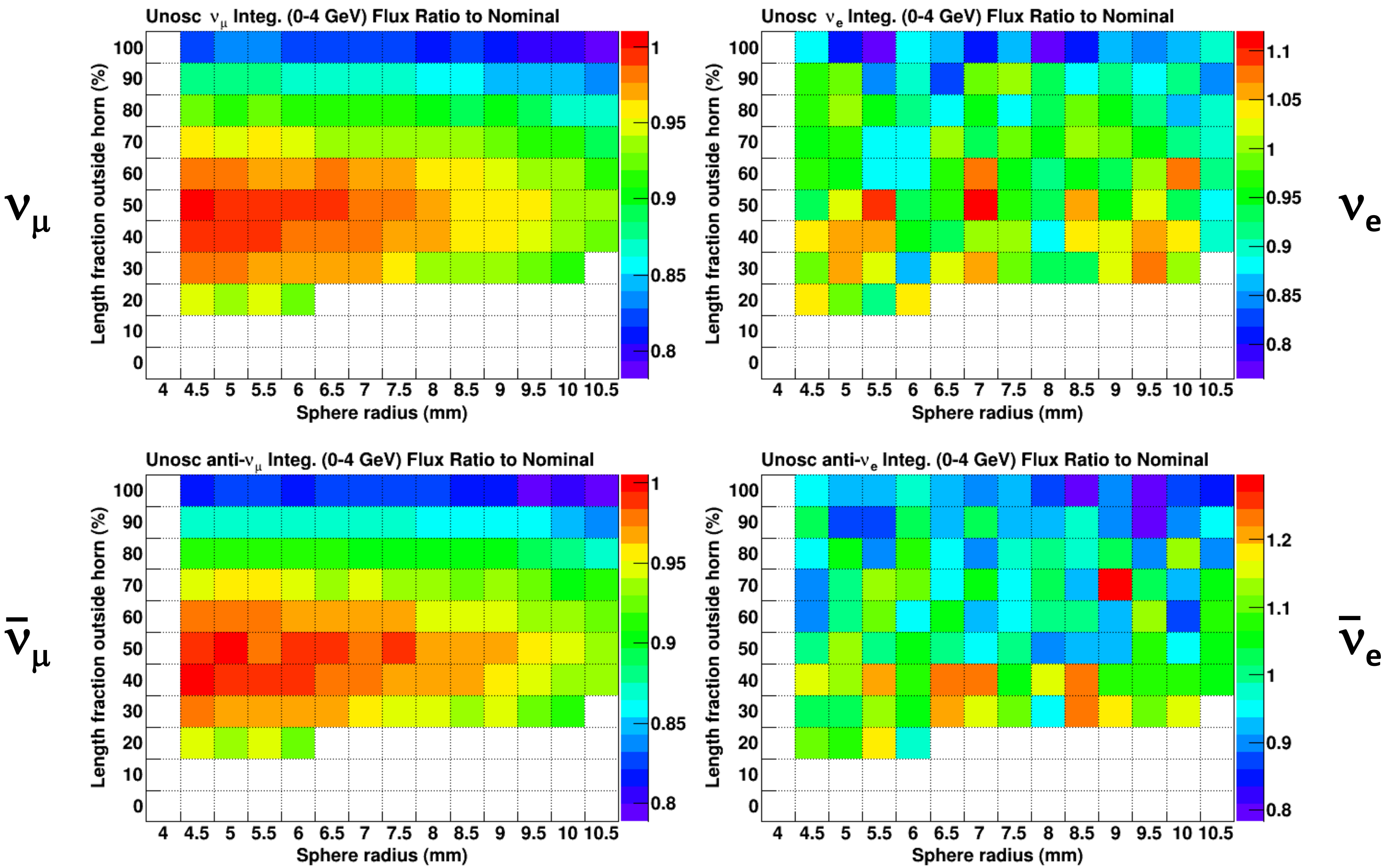
Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Integrated flux ratios for Be sphere: L ≡ 2.0λ ≈ 97 cm



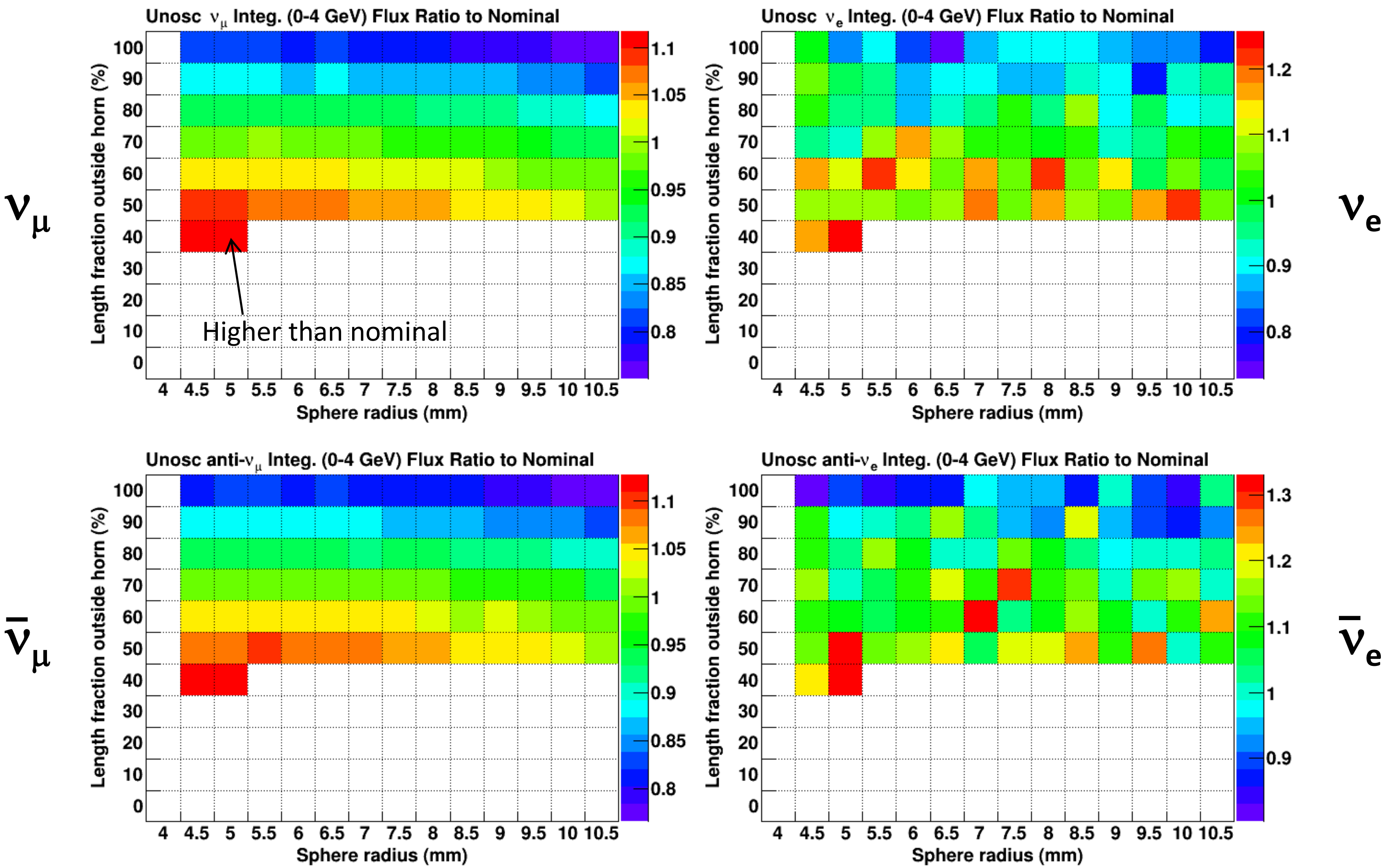
Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Integrated flux ratios for C sphere: $L \equiv 2.0\lambda \approx 90$ cm



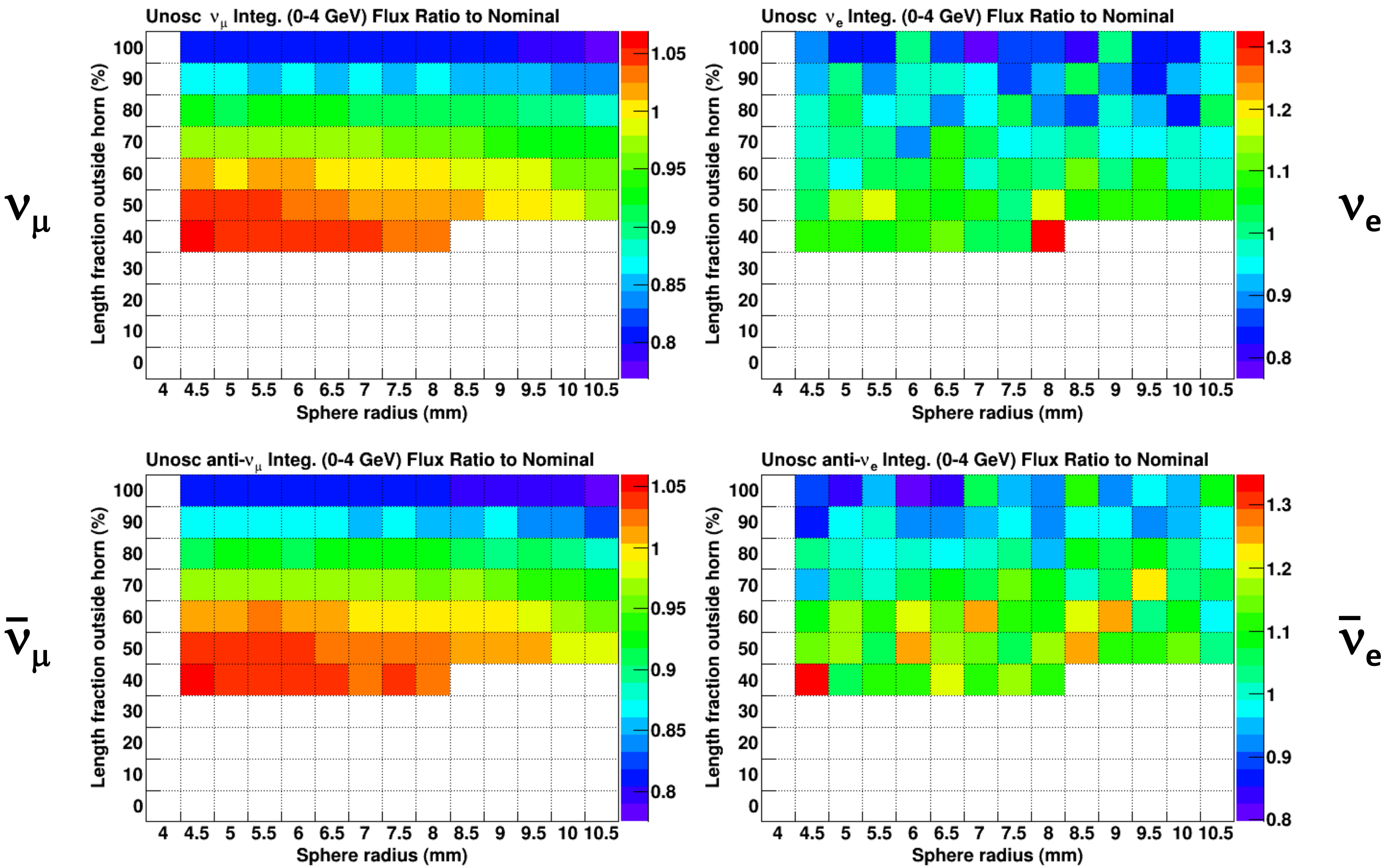
Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Integrated flux ratios for Be sphere: L $\equiv 2.5\lambda \approx 121$ cm



Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

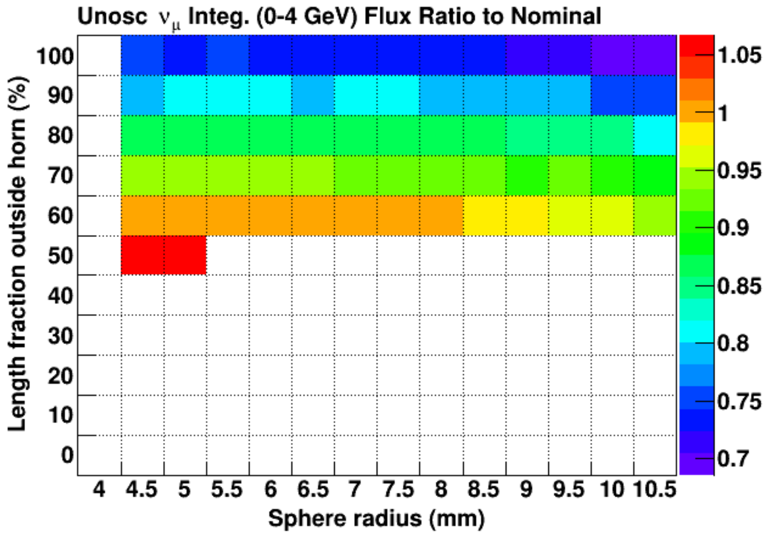
Integrated flux ratios for C sphere: $L \equiv 2.5\lambda \approx 112$ cm



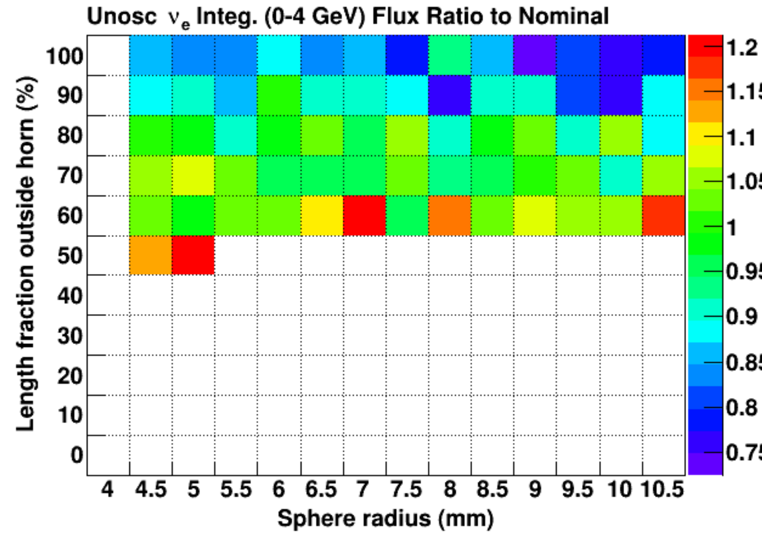
Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Integrated flux ratios for Be sphere: $L \equiv 3.0\lambda \approx 145$ cm

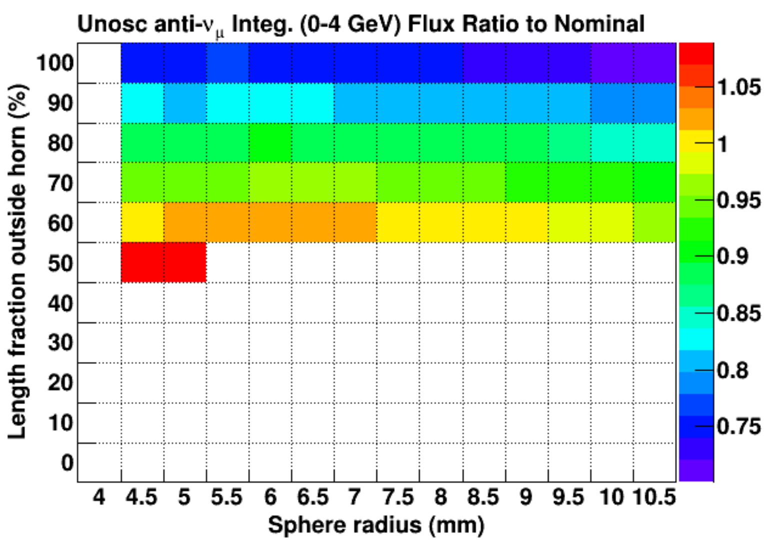
ν_μ



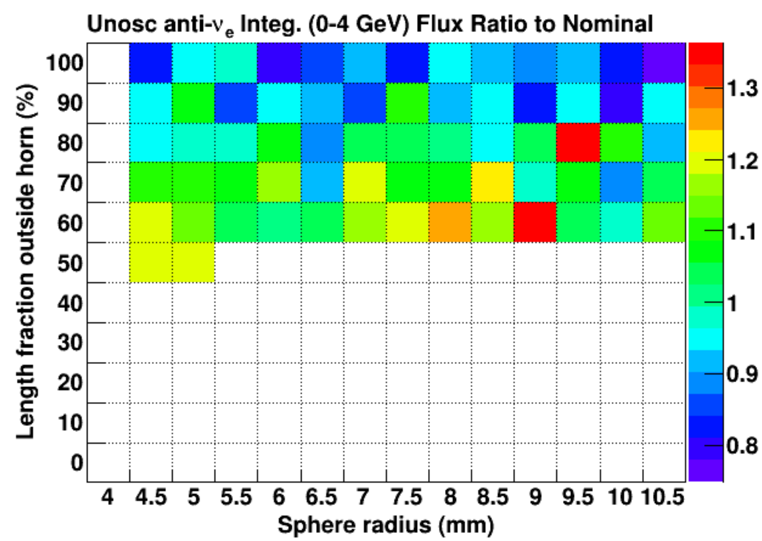
ν_e



$\bar{\nu}_\mu$

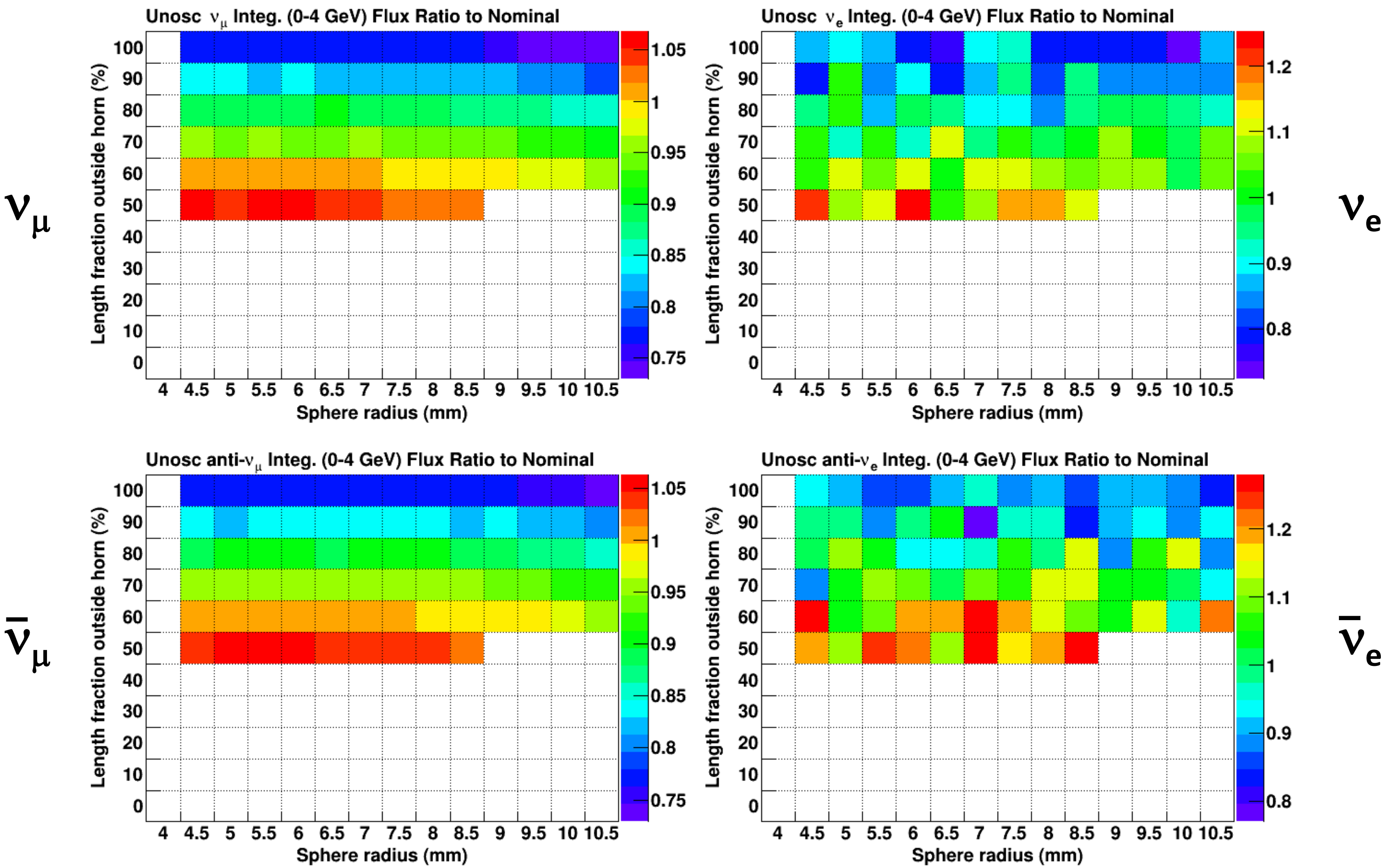


$\bar{\nu}_e$



Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Integrated flux ratios for C sphere: L ≡ 3.0λ ≈ 134 cm



Each square = integrated sphere flux/integrated nominal flux (E = 0-4 GeV)

Summary

- SAT fluxes comparable to reference target
  - 5 to 10% flux increase for certain configurations
  - Be better than graphite
  - Be spheres as small as possible ($r \approx 6.5$ mm)
  - Total length between 2 and 3 equivalent λ
  - Inserted about half-way into Horn 1

- Similar performance possible with new optimised Horn geometry?
  - Need geometry parameters put in a G4LBNE release