

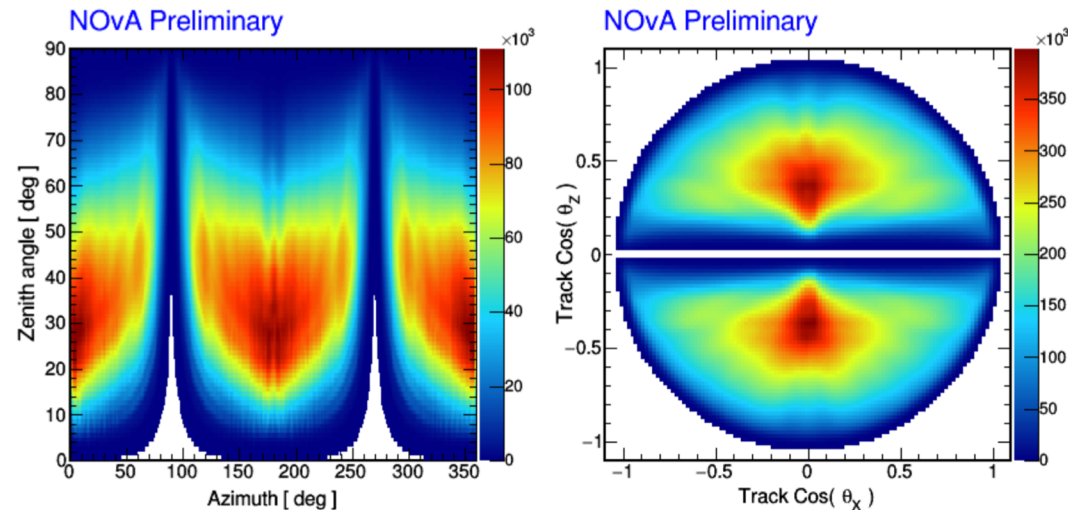
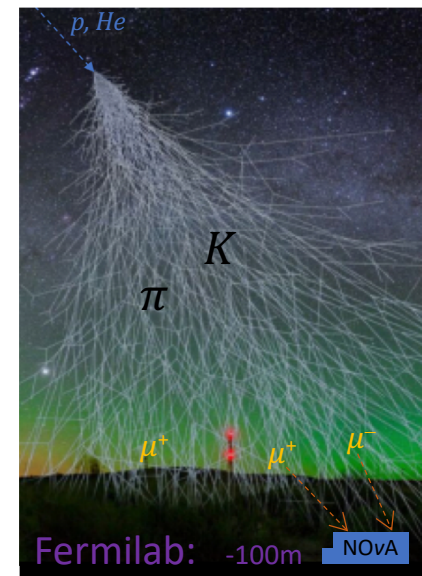
Muon Radiography with the NOvA Near Detector

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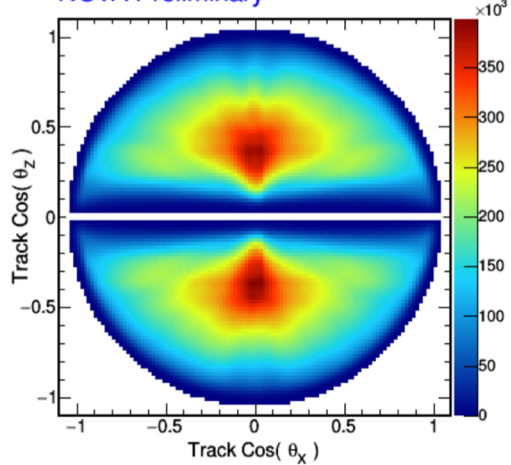
(for the NOvA Collaboration)

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Downstream-Upstream Subtraction of μ -FLUX

NOvA Preliminary



NOvA-ND acceptance is Forward-Backward (UpStream - DownStream) and Left-Right (L-R) symmetric: this allows one to subtract those corresponding μ -Flux angular regions, which have the same: Zenith angles (the same incoming *surface intensity* of the cosmic muons) and the same Attenuation \Rightarrow in the Flat-surface Approximation: e.g. $(D-U) / (D+U)$ ratio
The overburden variations (non-flatness, excavation, buildings) should be visible as Bumps.

\Leftarrow DownStream \Leftarrow Forward

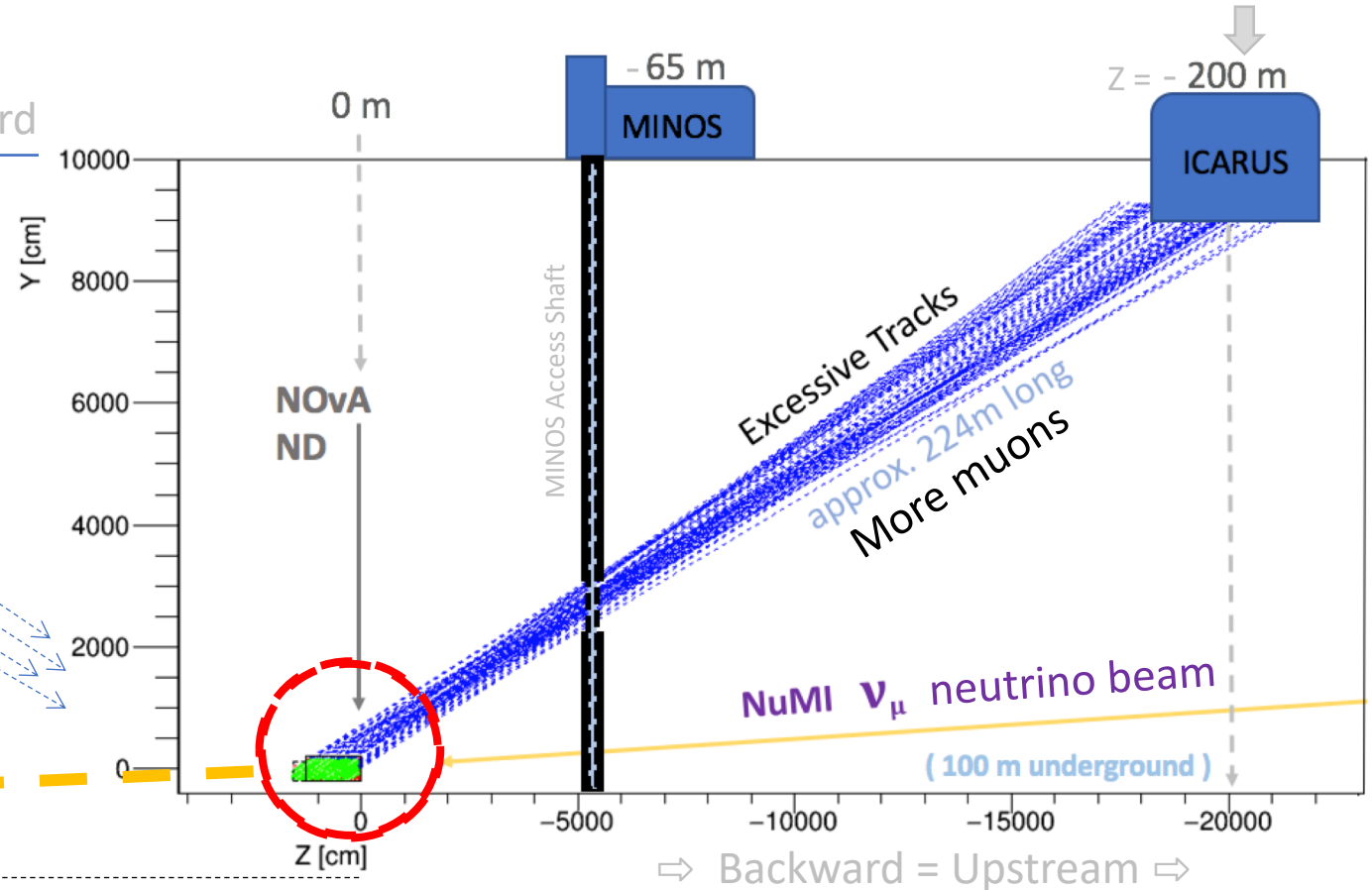
flat surface here

muons

attenuation

Y = -100 m NuMI beam $\nu_\mu \nu_\mu$

810 km \leftarrow (to Ash River, Minnesota) $\nu_\mu \nu_e \nu_\mu$



\Rightarrow Backward = Upstream \Rightarrow

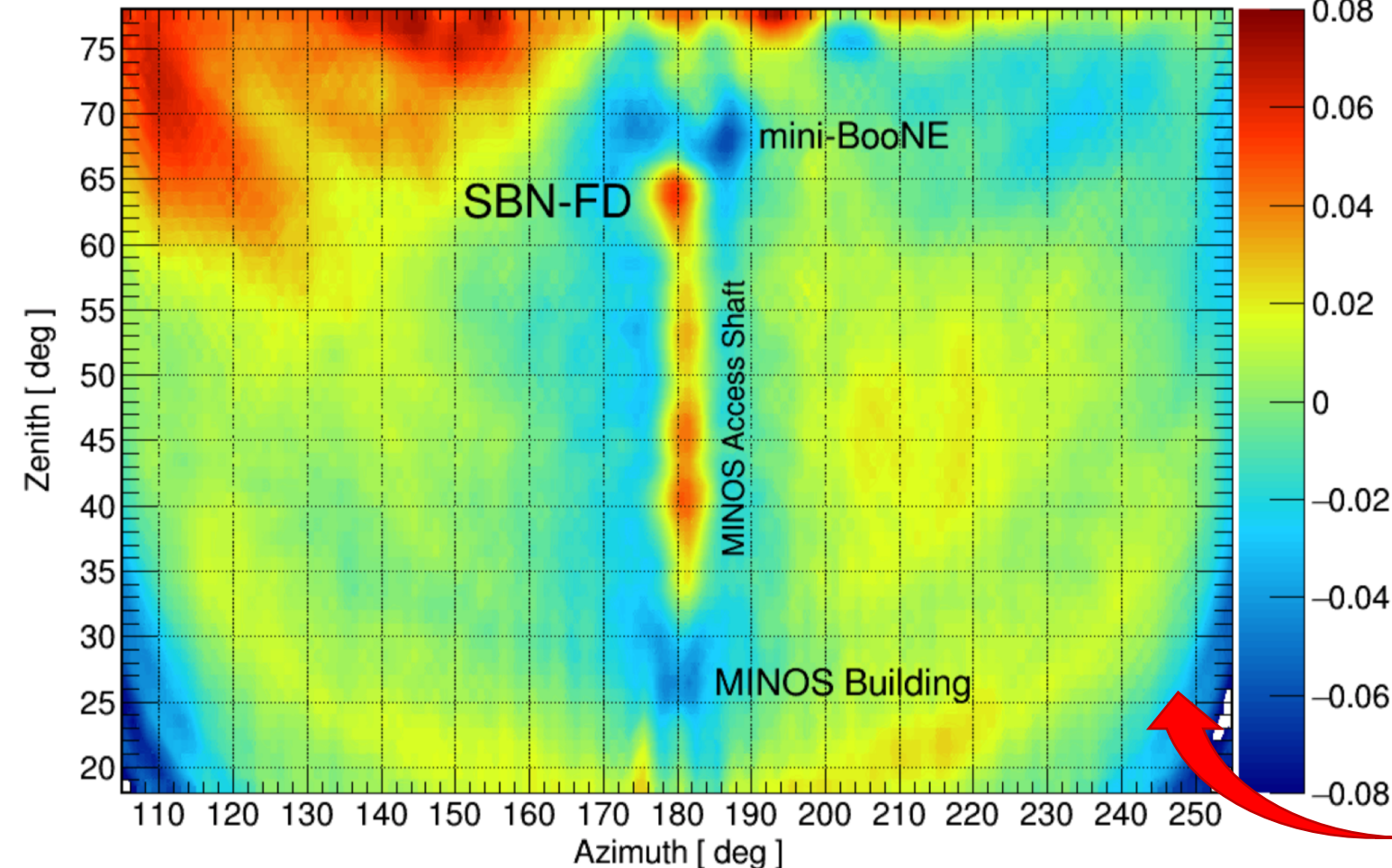
μ -Flux Differential Radiography (UpStream-DownStream)

Near Detector Cosmic Data: Apr. 2015 – Oct. 2016

NOvA Preliminary

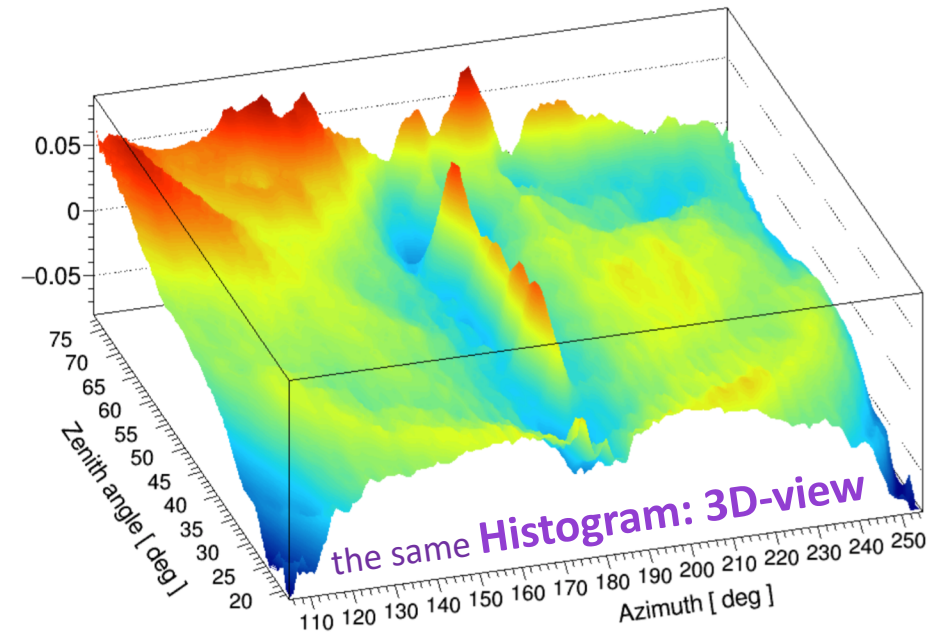
μ -Flux Asymmetry:

$$\frac{U - D}{U + D}$$



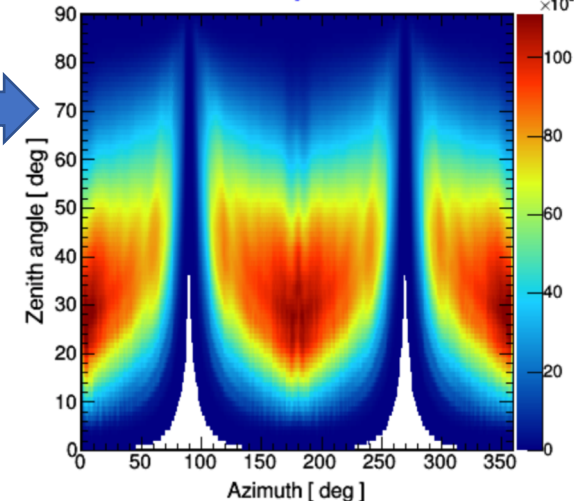
NOvA Preliminary

μ -Flux Asymmetry



Angular Muon
Flux used
to obtain the
RADIOGRAPHY
2D-Distribution

NOvA Preliminary



Left-Right μ -Flux difference:

Obtained from NOvA-ND Cosmic Data: Apr. 2015 – Oct. 2016

- without any Geant (e.g. flat Overburden) simulations
- without Surface-level (open-Sky) muon-Flux subtraction

Using SYMMETRIES of: ND Acceptance, μ -Flux(θ, ϕ), Attenuation(θ, ϕ)

