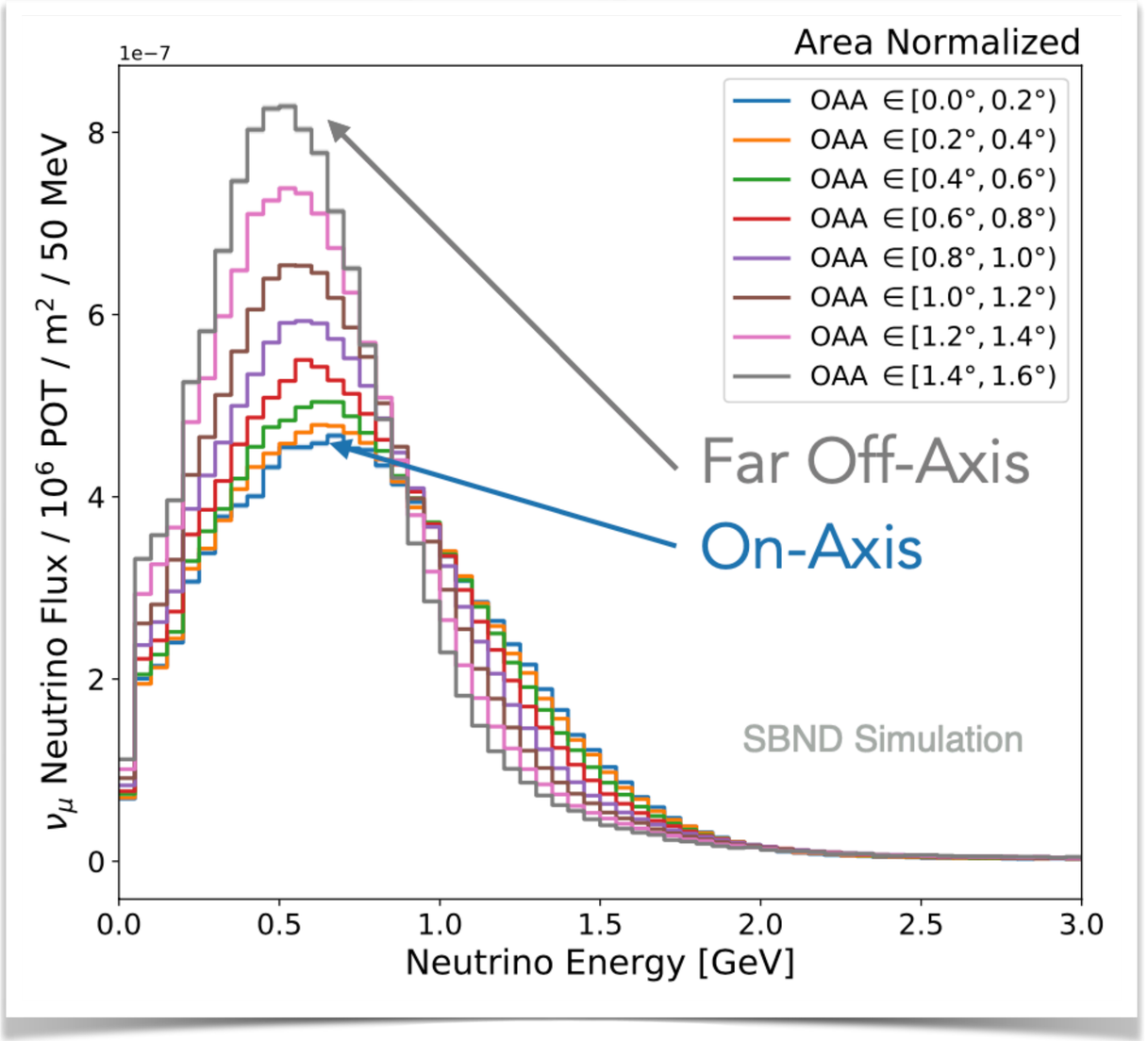
The potential BSM prospects of SBND-PRISM



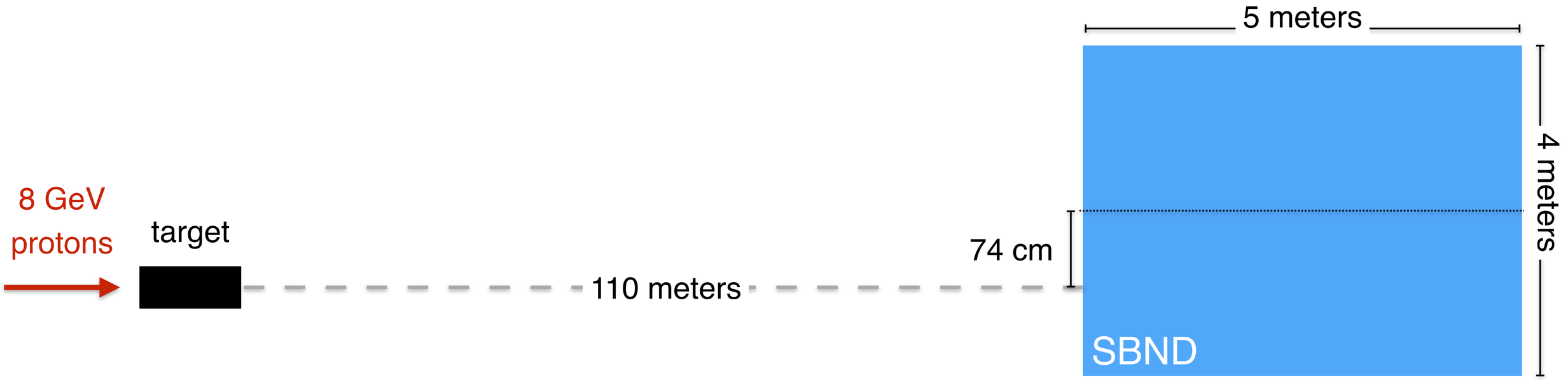
Pedro Machado

On behalf of the SBND collaboration

2nd Short-Baseline Experiment-Theory Workshop 2024

SBND-PRISM in a nutshell

SBND is sufficiently close to the beam target such that effects due to the beam angular spread are noticeable



*not to scale, not a real picture of SBND

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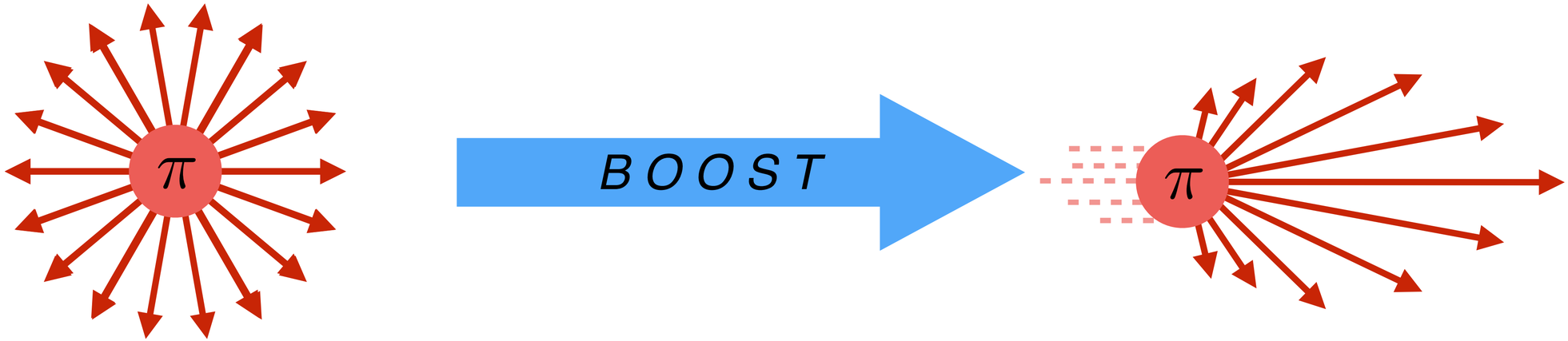
SBND-PRISM in a nutshell

The physics

In meson two-body decays,
there is a correlation among meson energy
and nu energy and direction



For a given pion energy, give me θ_ν and I give you E_ν

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SBND-PRISM in a nutshell

The physics

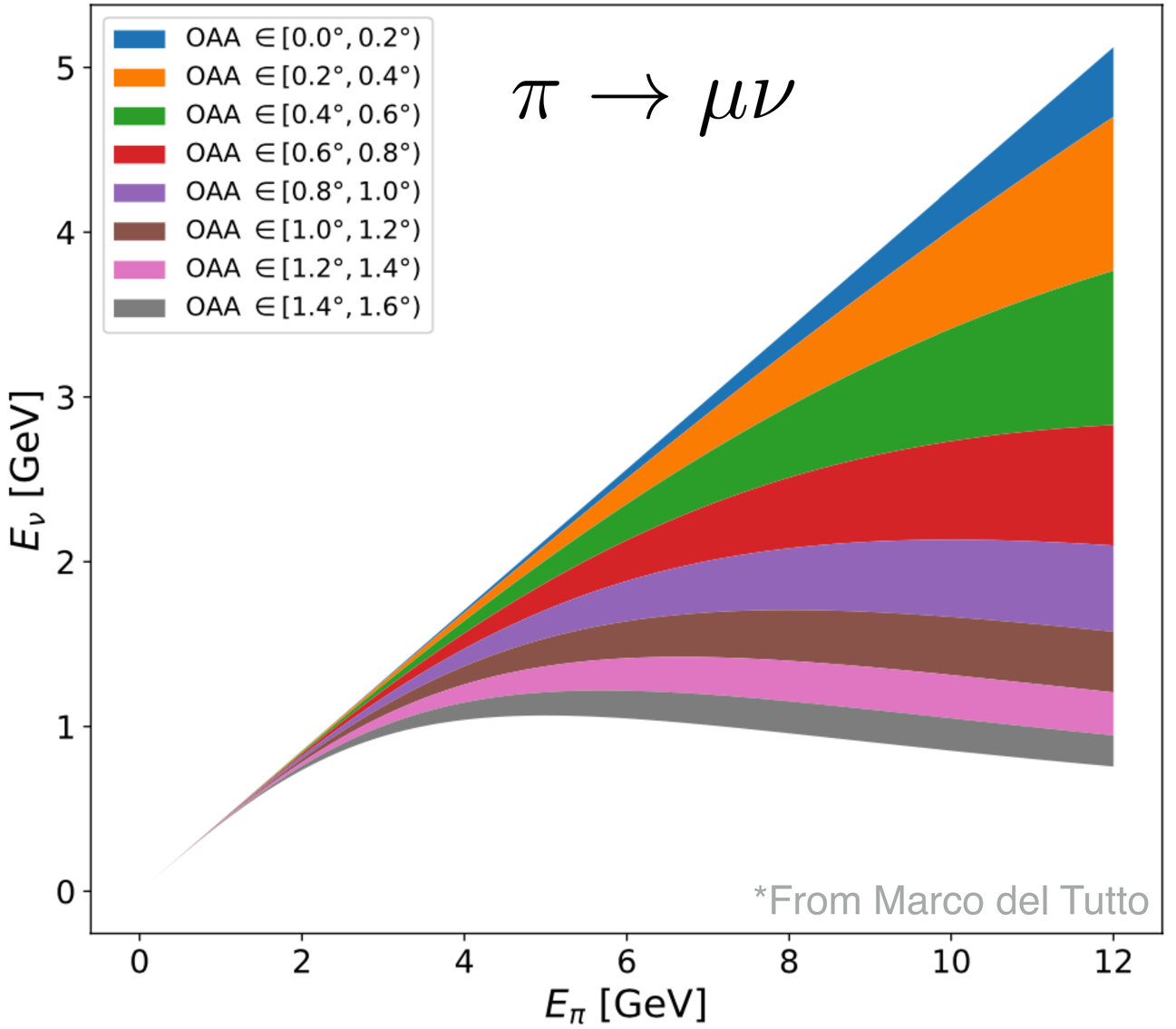
In meson two-body decays,
there is a correlation among meson energy
and nu energy and direction

The effect

By looking off the beam axis, we scan
different neutrino spectra

The beauty

This correlation is purely due to kinematics,
which mitigates flux systematics
Signal and background could have
different angular dependences
Only requires effort on analysis



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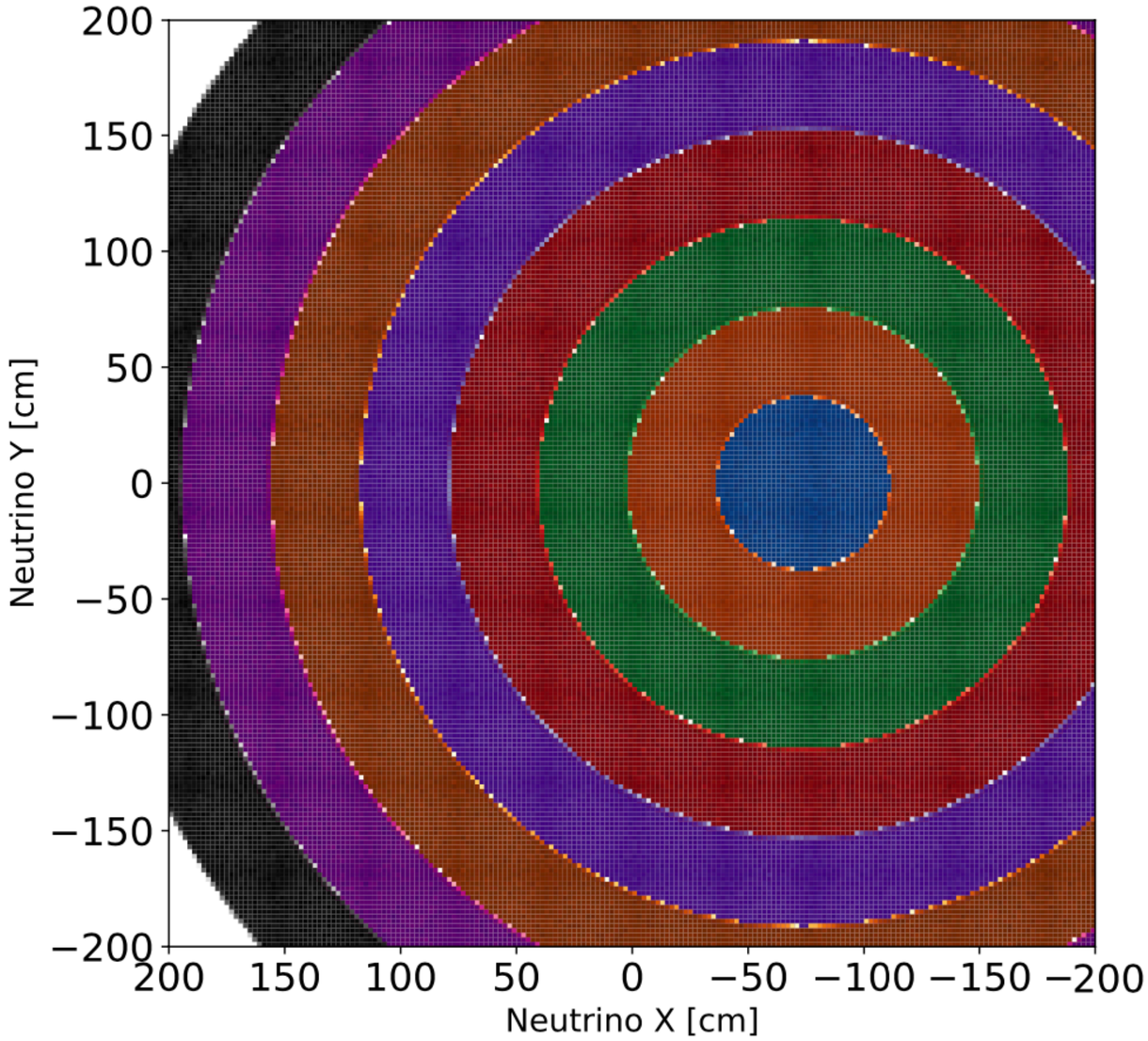
SBND-PRISM in a nutshell

- SBND can be logically divided in several slices
- At 110 m from the target, 1º ~ 2 m
- Divide the detector in 8 slices of 0.2º



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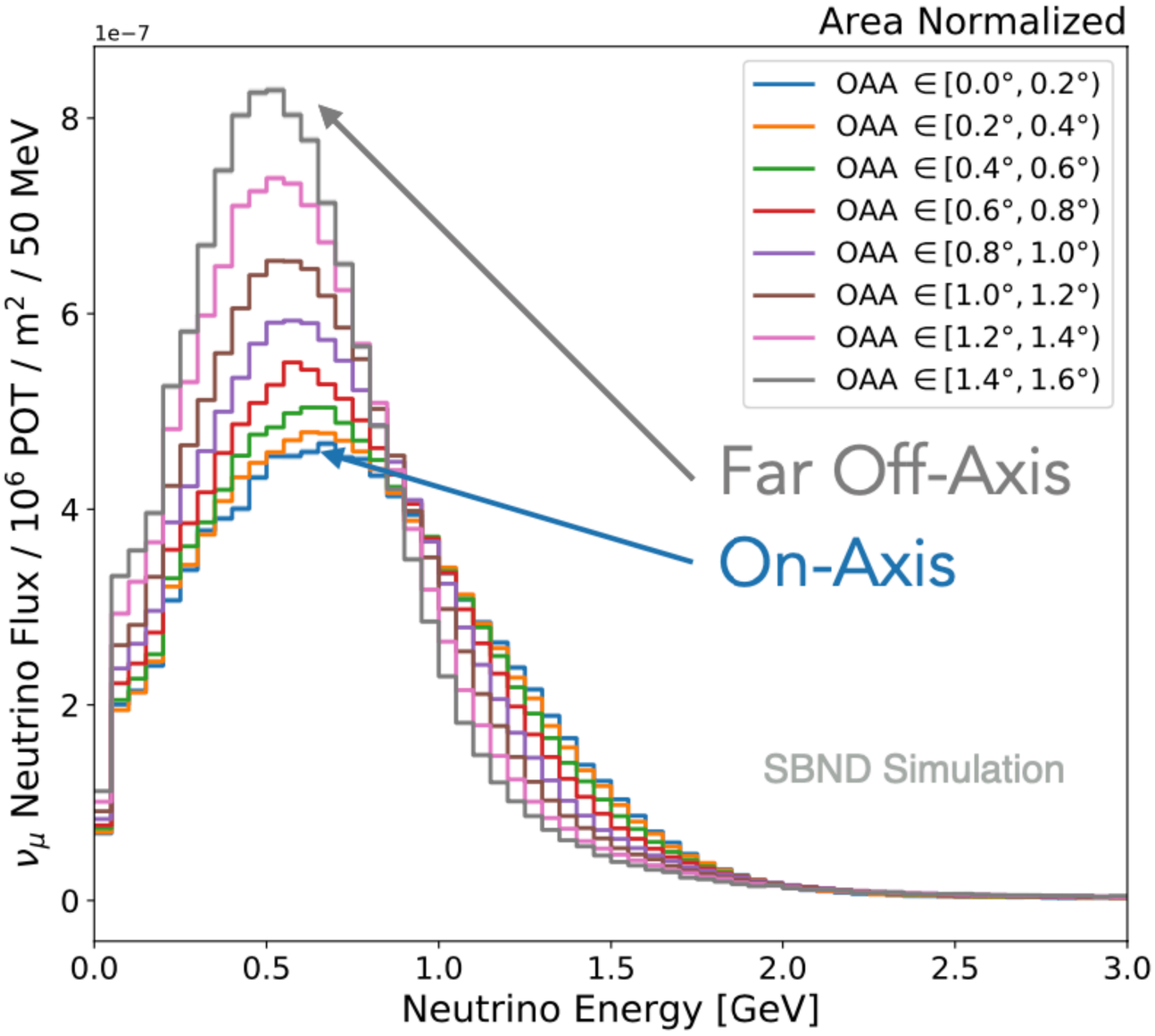
SBND-PRISM in a nutshell

Quantitatively, this is what happens to the muon neutrino flux as we go off-axis:

1. Shifts down in energy
2. Gets more peaked



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SBND-PRISM in a nutshell

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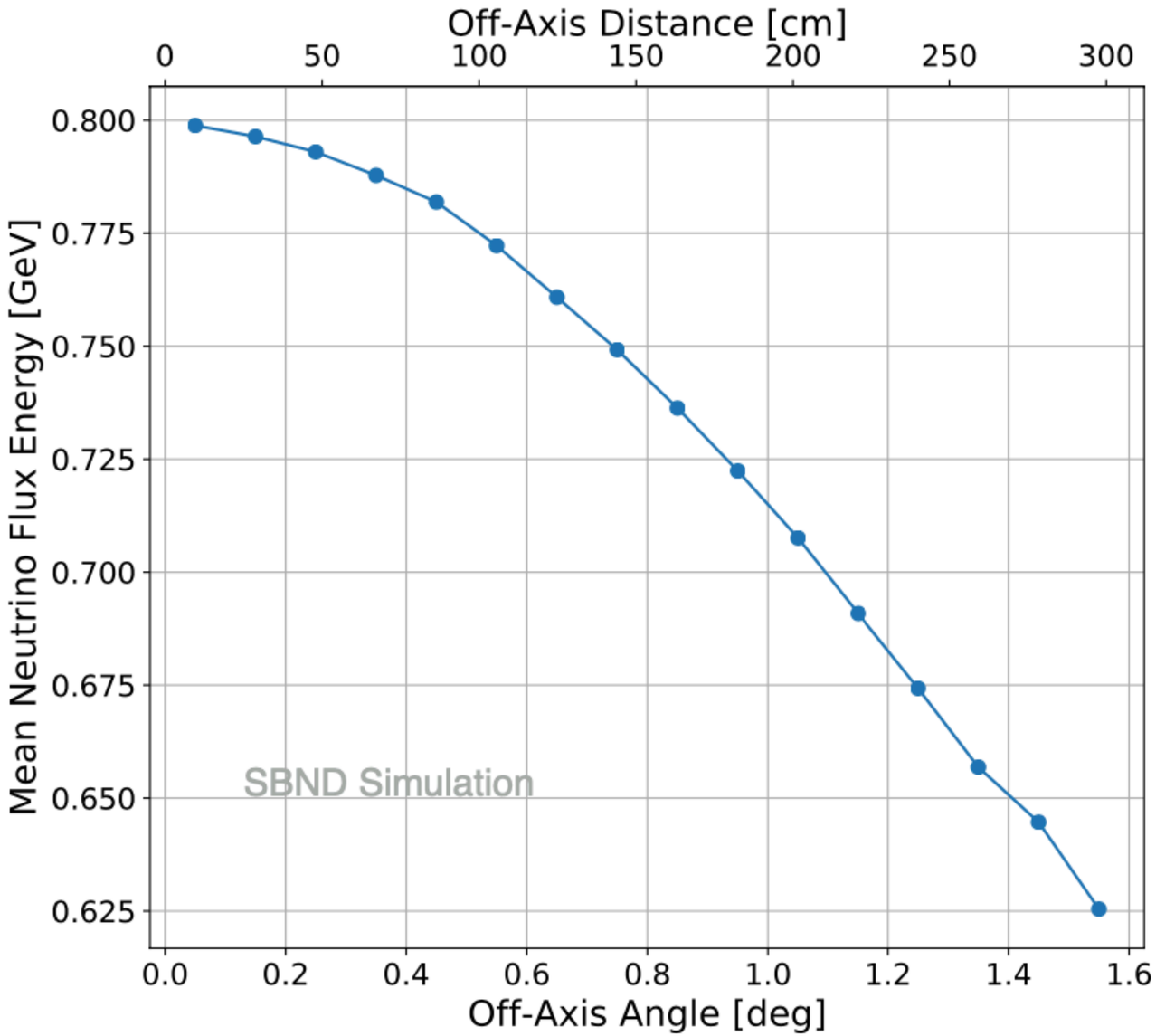
Mean ν_μ energy goes down by ~ 20%

What about ν_e ?



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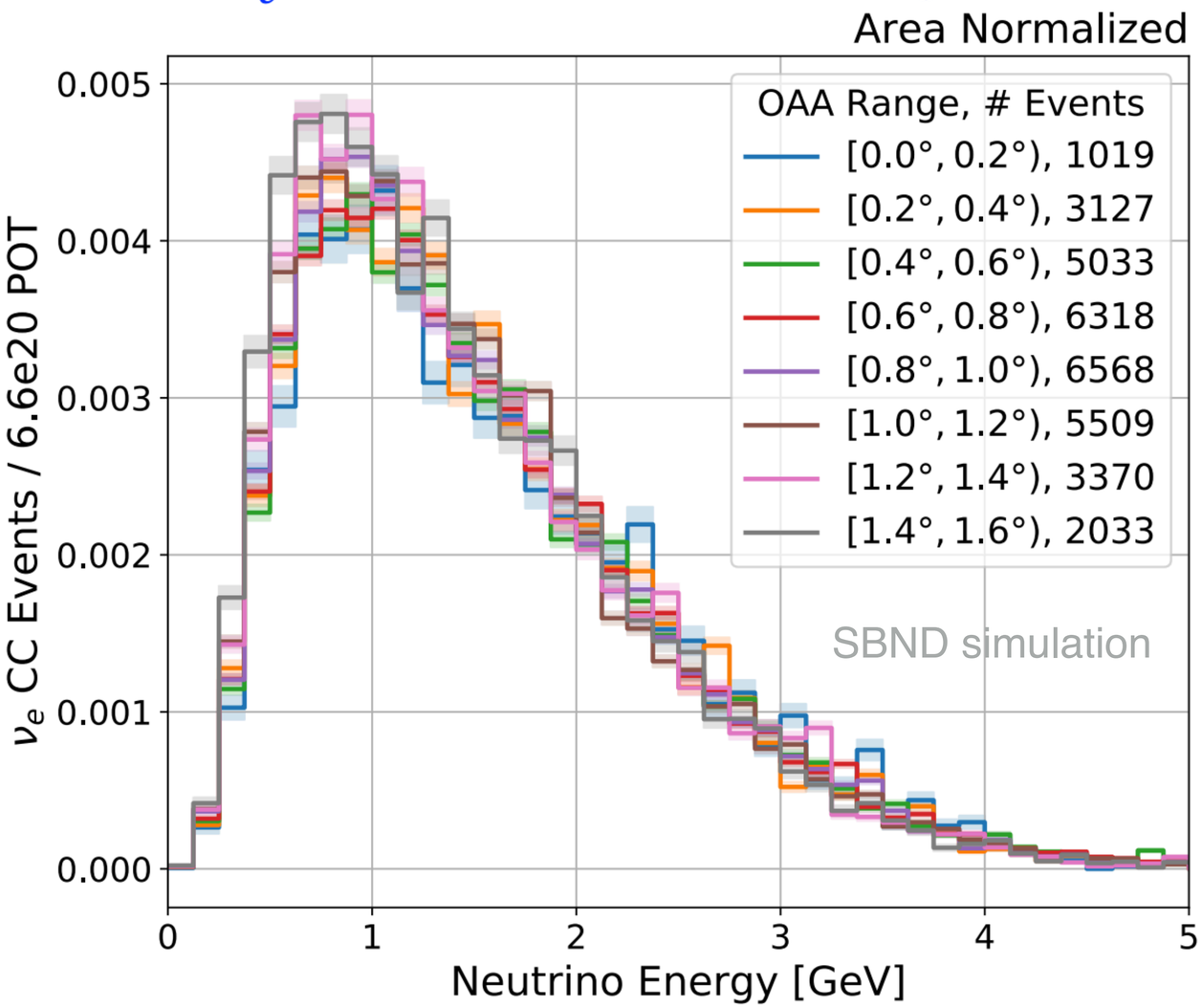

*From Vishvas Pandey @ MITP 2023

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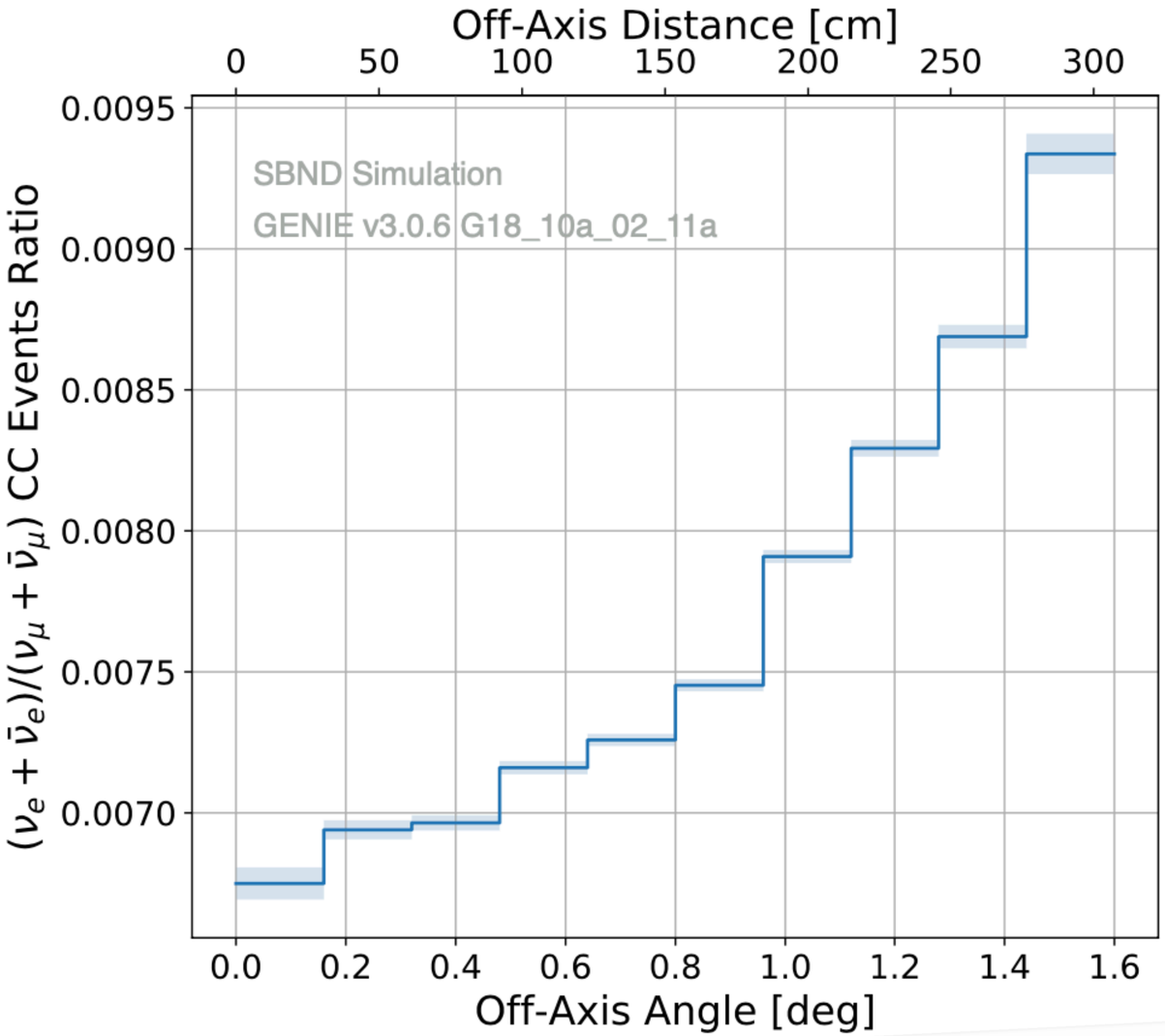
The relative ν_e contamination increases going off-axis



*For reference, for 6.6E20 POT, we get between 1k to 6.5k ν_e events in each slice

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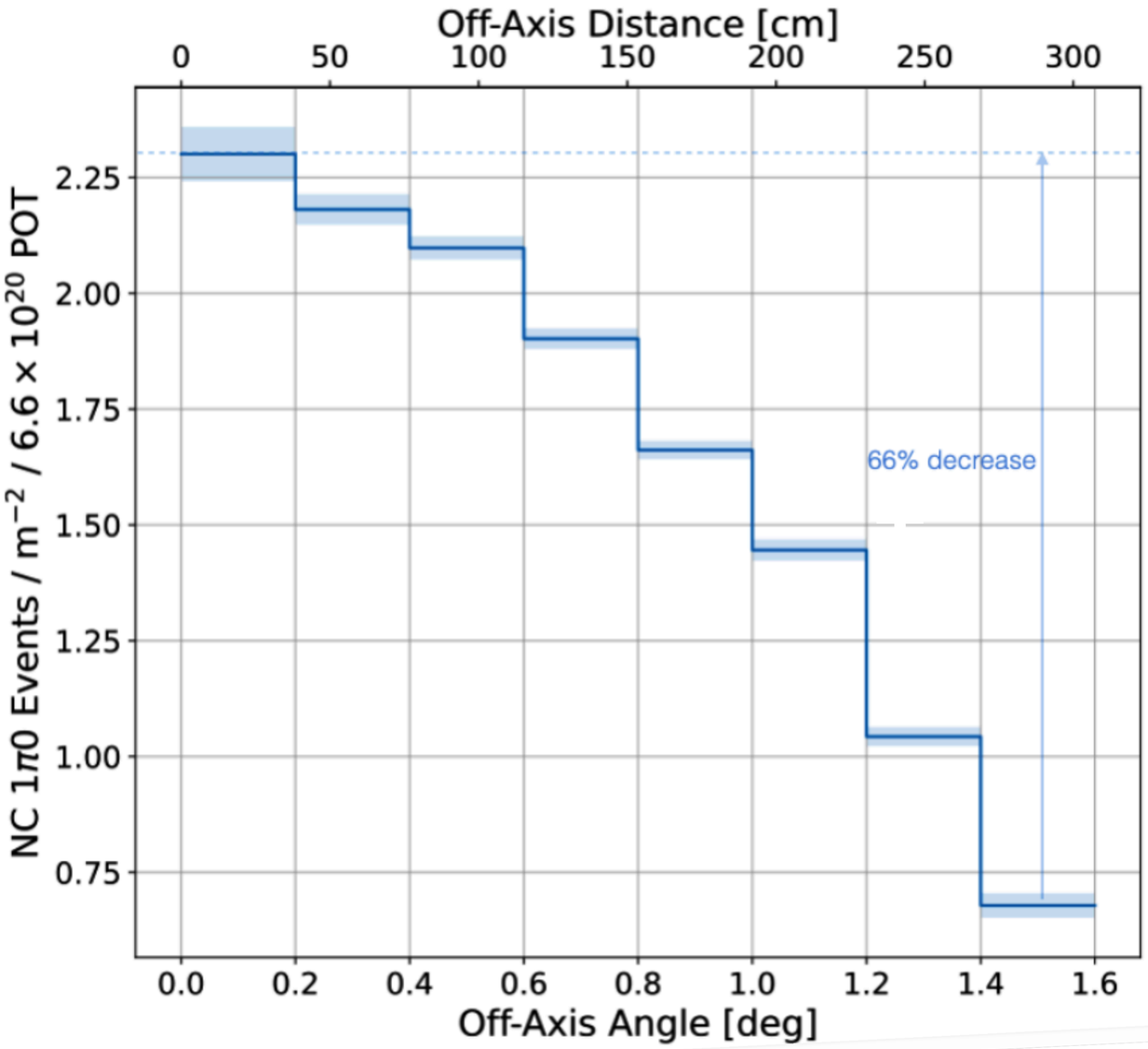

Other backgrounds can also decrease nontrivially

Why should we care?

A couple of searches that could benefit from SBND-PRISM

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Sterile neutrinos

Take as an example

SBND-only sterile neutrino search

(ICARUS, μB, bear with me here for a second…)

Single detector search is always tricky

$$N \propto (\phi_S + \phi_B)\sigma \sim (\phi_\mu P_{\mu e} + \phi_e)\sigma$$

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We do the best we can (e.g. ν_μ to tune for ν_e)

but it's always good to have more handles

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But if we can leverage SBND-PRISM, the
cross section uncertainties could,
in principle, be mitigated

$$N_i \propto (\phi^i_S + \phi^i_B)\sigma \sim (\phi^i_\mu P_{\mu e} + \phi^i_e)\sigma$$

Cannot fit all slices at once!

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Cannot fit all slices at once!

Currently studying what we can gain

Interplay between SBND-PRISM and ICARUS could be very interesting

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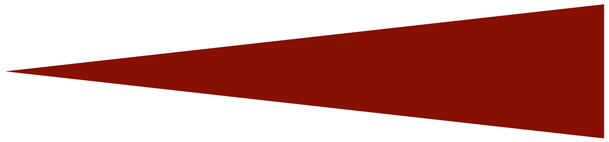
New physics from the beam

π^+ K^+



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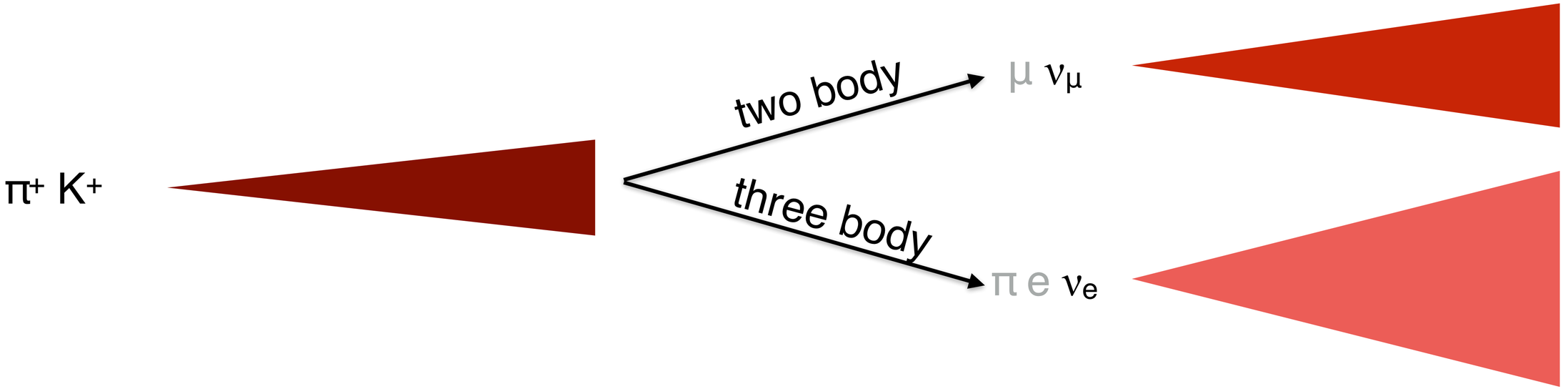

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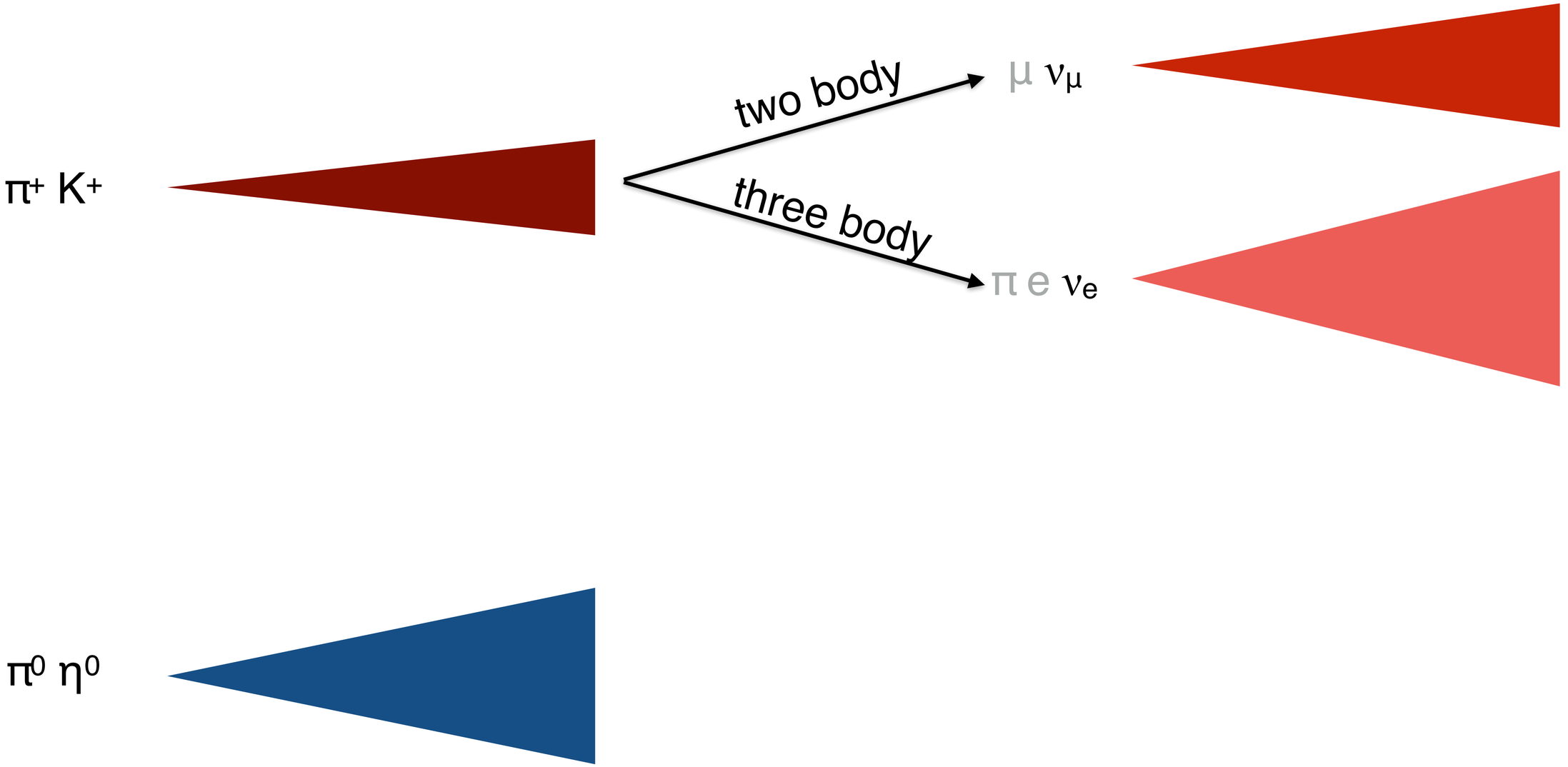

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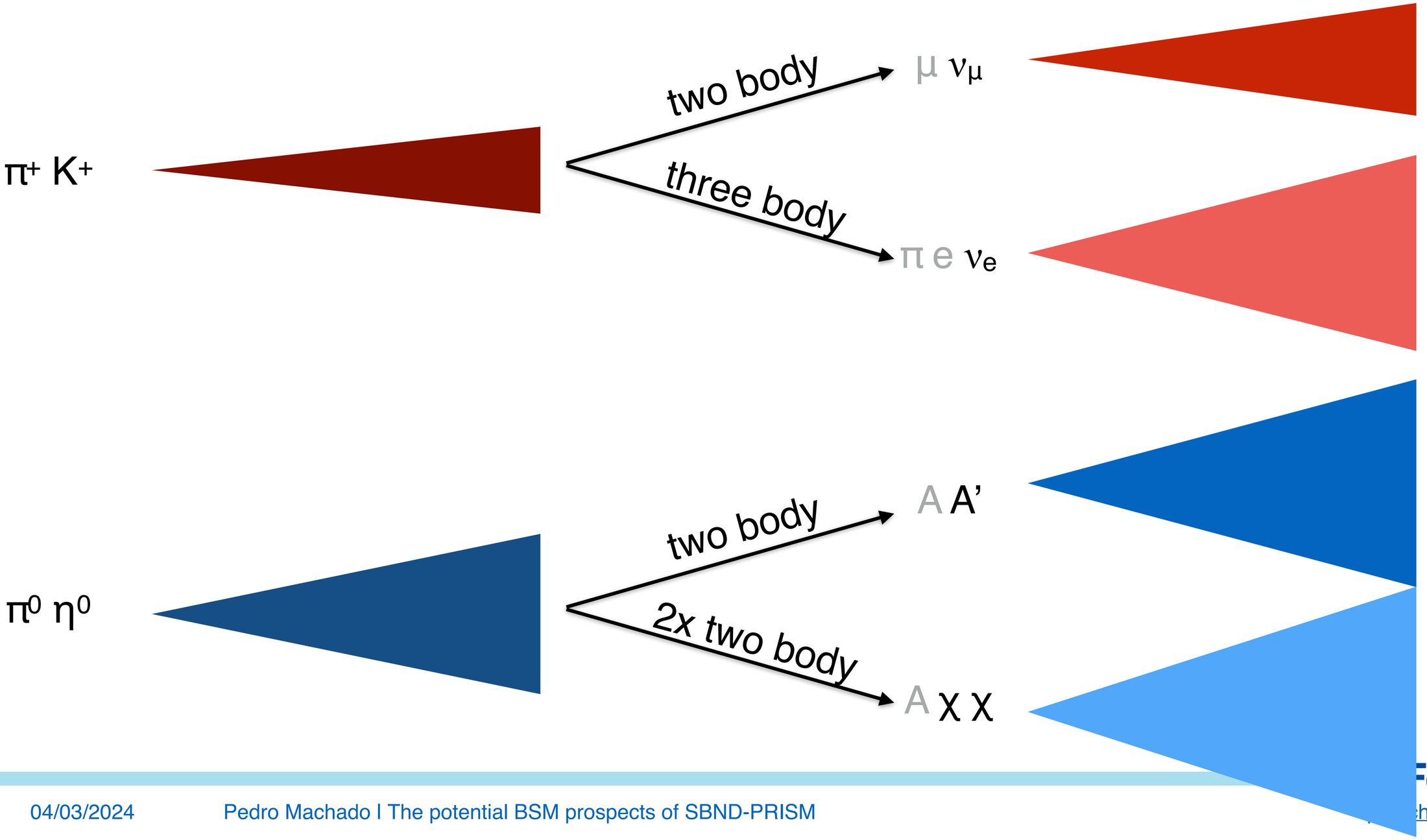

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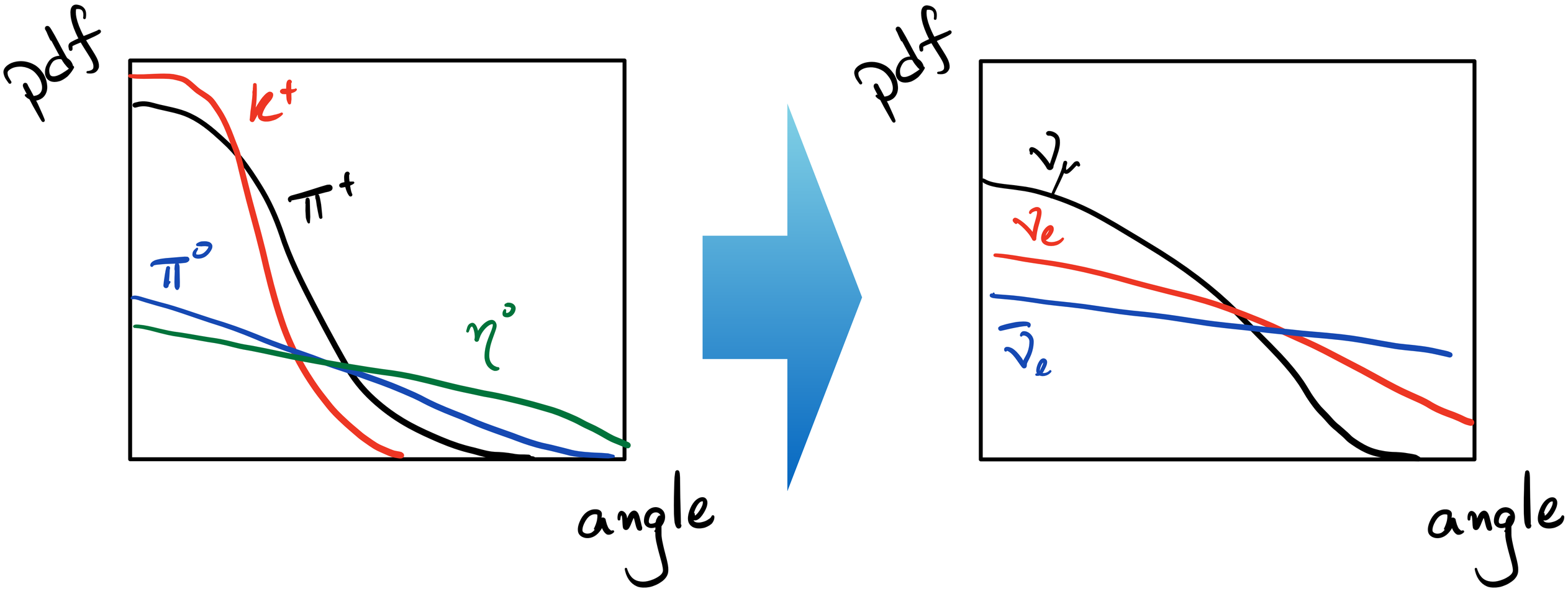
SBND-PRISM in a nutshell



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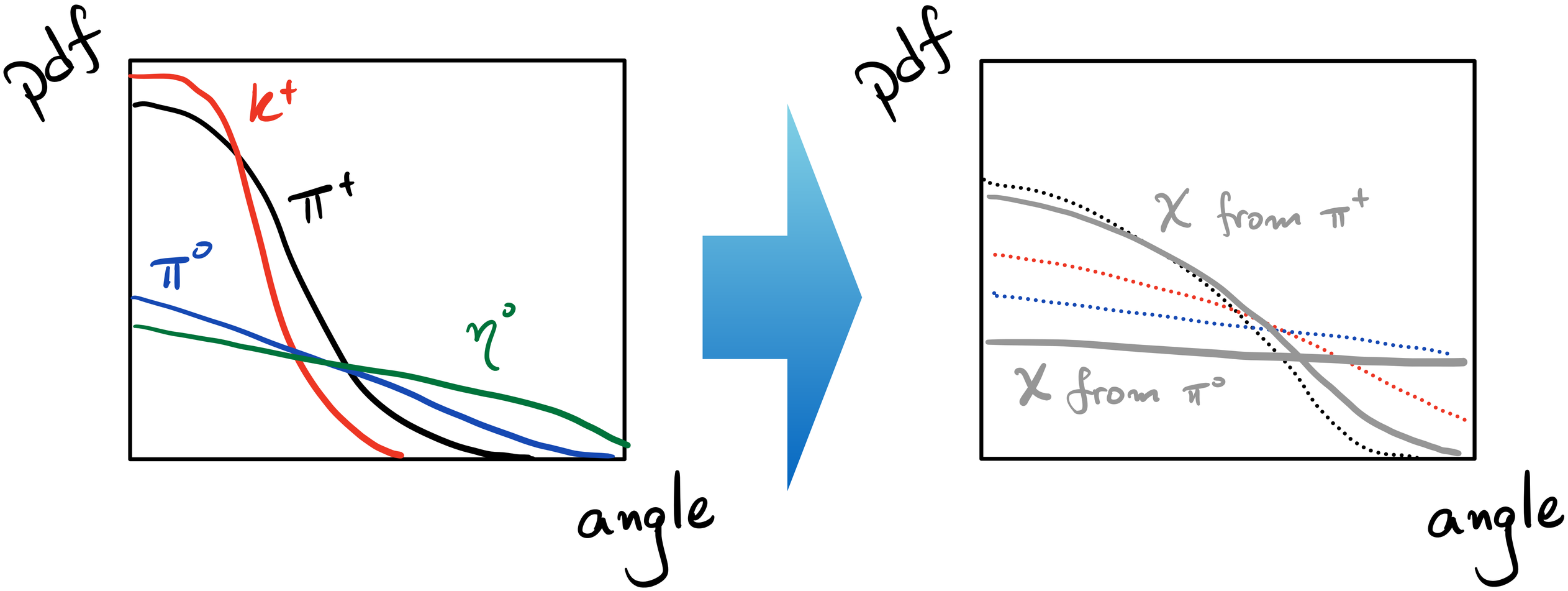
SBND-PRISM in a nutshell



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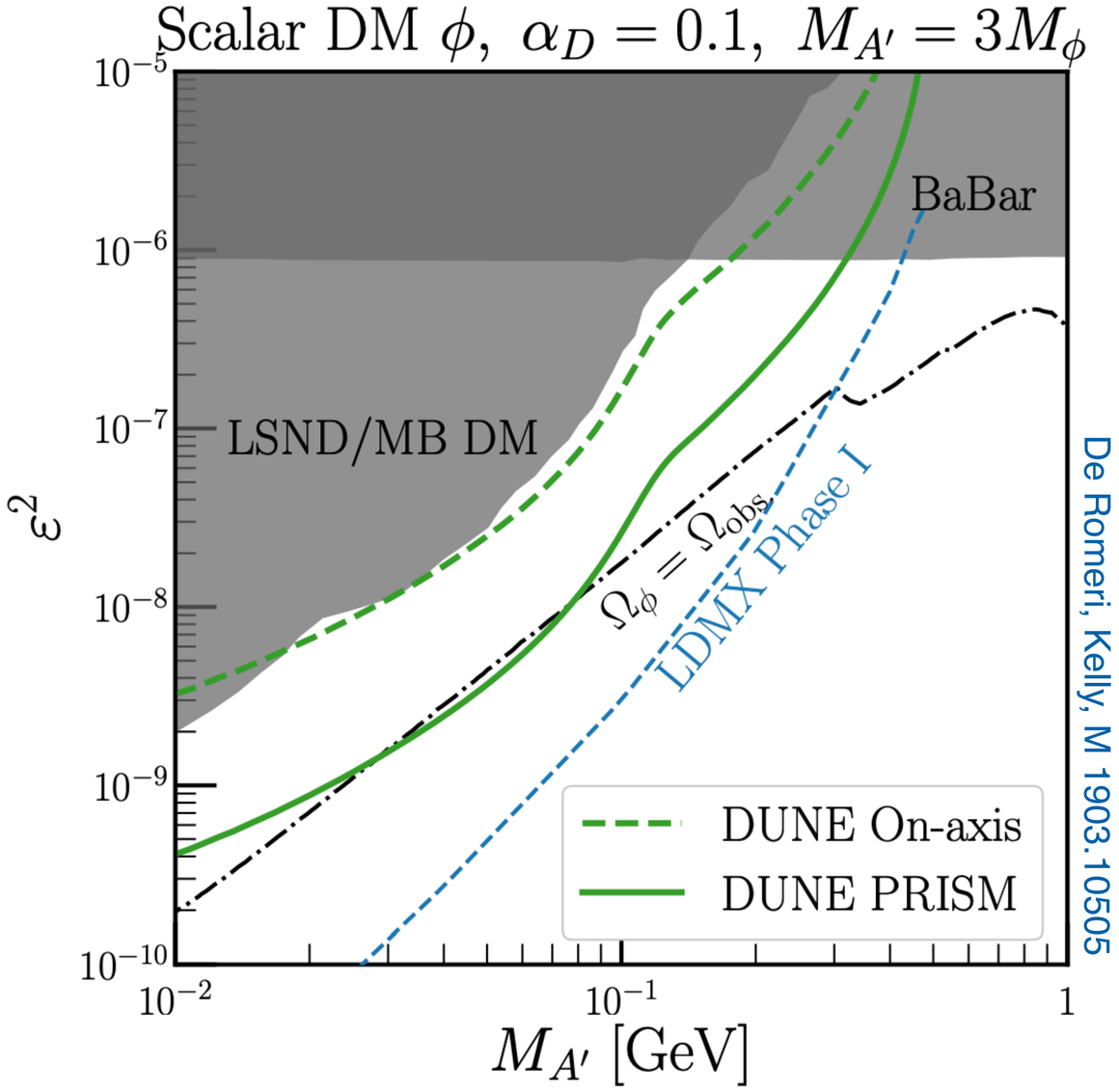
SBND-PRISM in a nutshell

Concept works well in enhancing BSM sensitivity at DUNE

More studies are needed for SBND and for different BSM scenarios: axions, DM, dark photons, light scalars, …



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Conclusions

Neutrino angular spread in BNB have noticeable impact on SBND

The correlation among pion energy, and neutrino energy and direction allows for "scanning" the neutrino spectrum by looking at off-axis events in SBND

That correlation is due to kinematics, which could mitigate impact of flux systematics on experimental searches

Several BSM scenarios could benefit from SBND-PRISM: sterile neutrinos (and all variations), dark matter, dark photons, axions, light scalars, …

How can we further leverage SBND-PRISM?

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