Long-Lived Particle Searches with the Short-Baseline Neutrino Experiments

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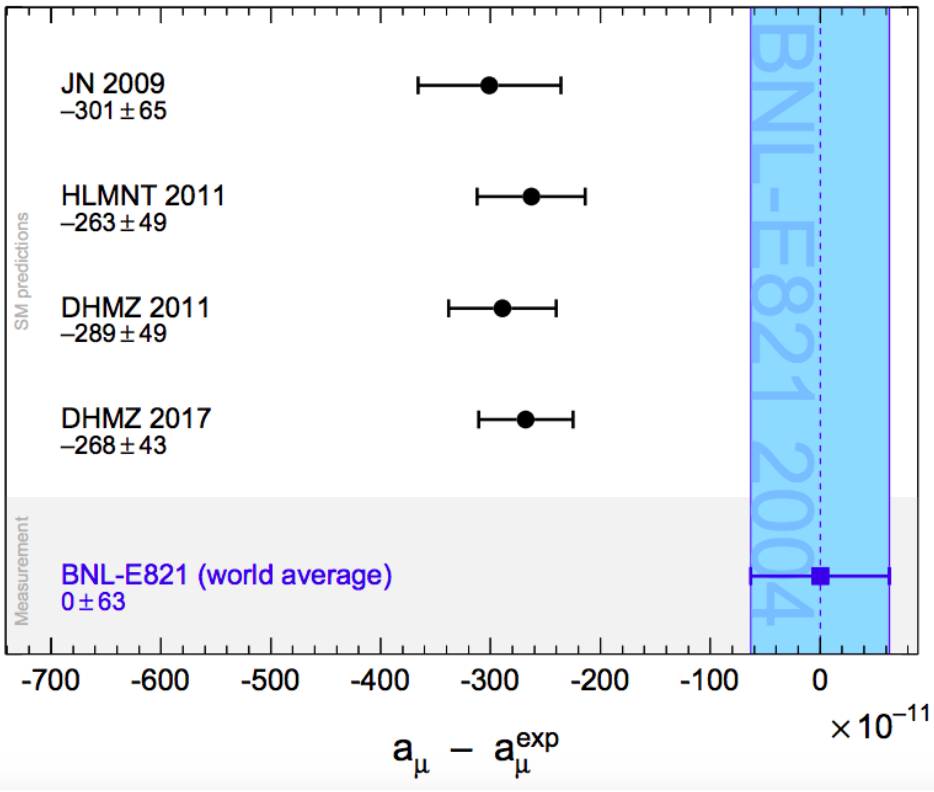
Light hidden sector portals

Why?
- light dark matter
- muon g – 2
- neutrino masses



Hidden sectors: uncharged under the SM

Couple to SM through *mediator*

$S^2 H^2$ dark Higgs

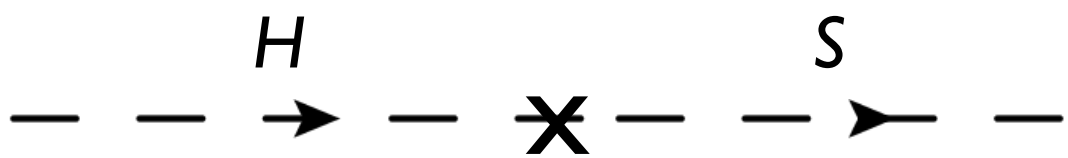
$F^{\mu\nu} F'_{\mu\nu}$ dark photon

LHN sterile neutrino

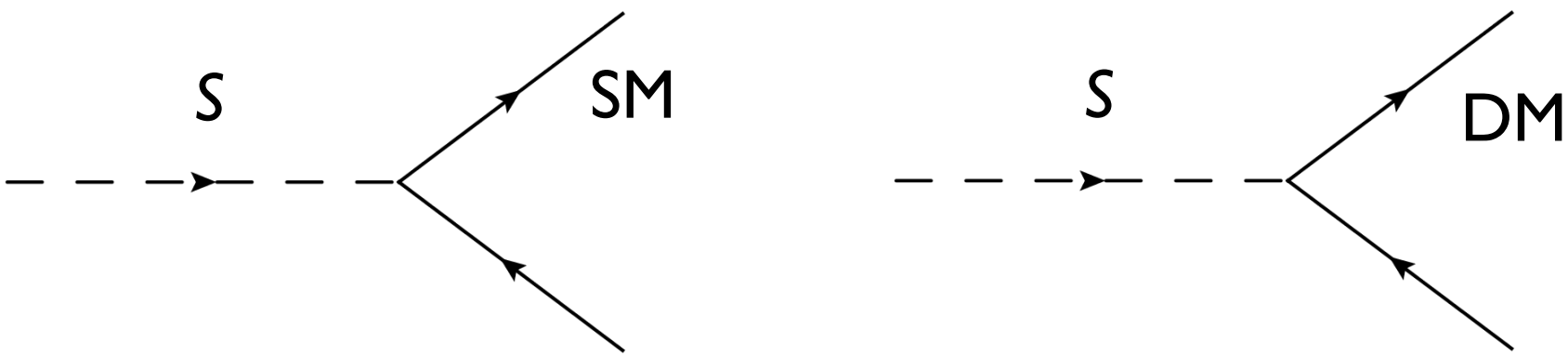
Hidden sectors at terrestrial experiments

Generically long-lived mediators for small portal couplings

Production from SM, e.g. $K \to \pi\, S$, $K \to \mu\, N$

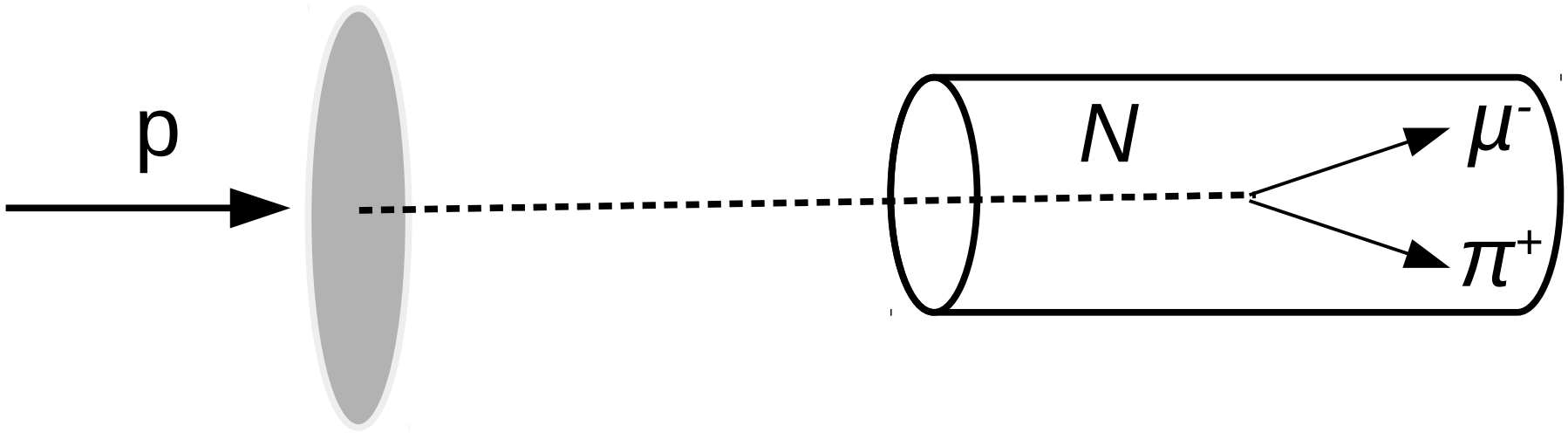


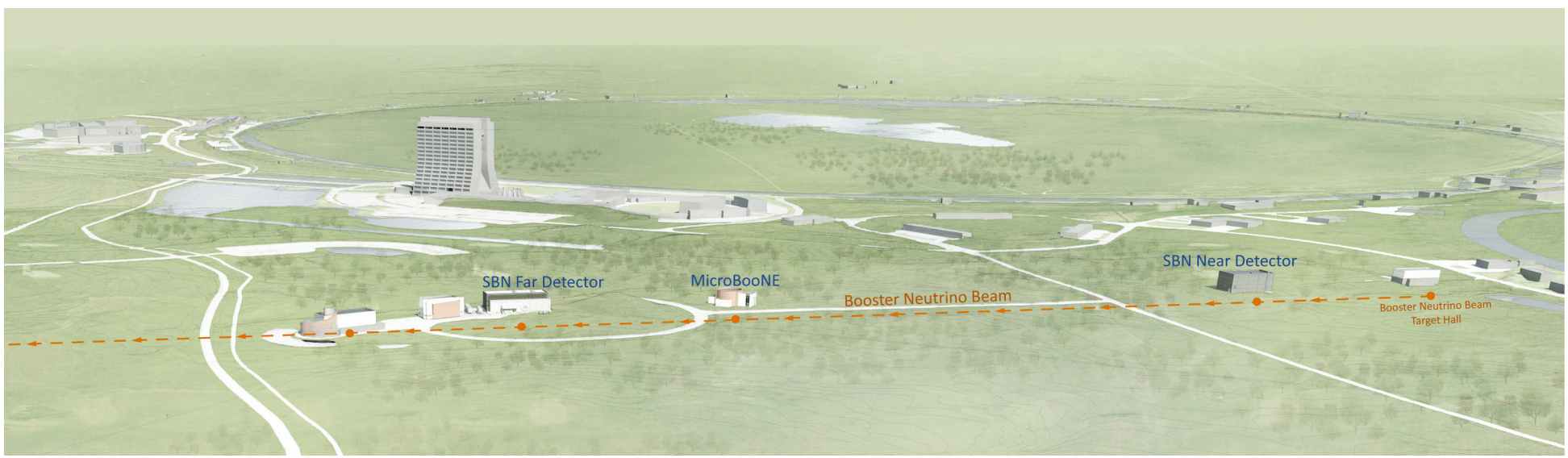
Decay of mediator depends on available modes



Note: visible decay independent of DM

Neutrino experiments as probes of hidden sectors





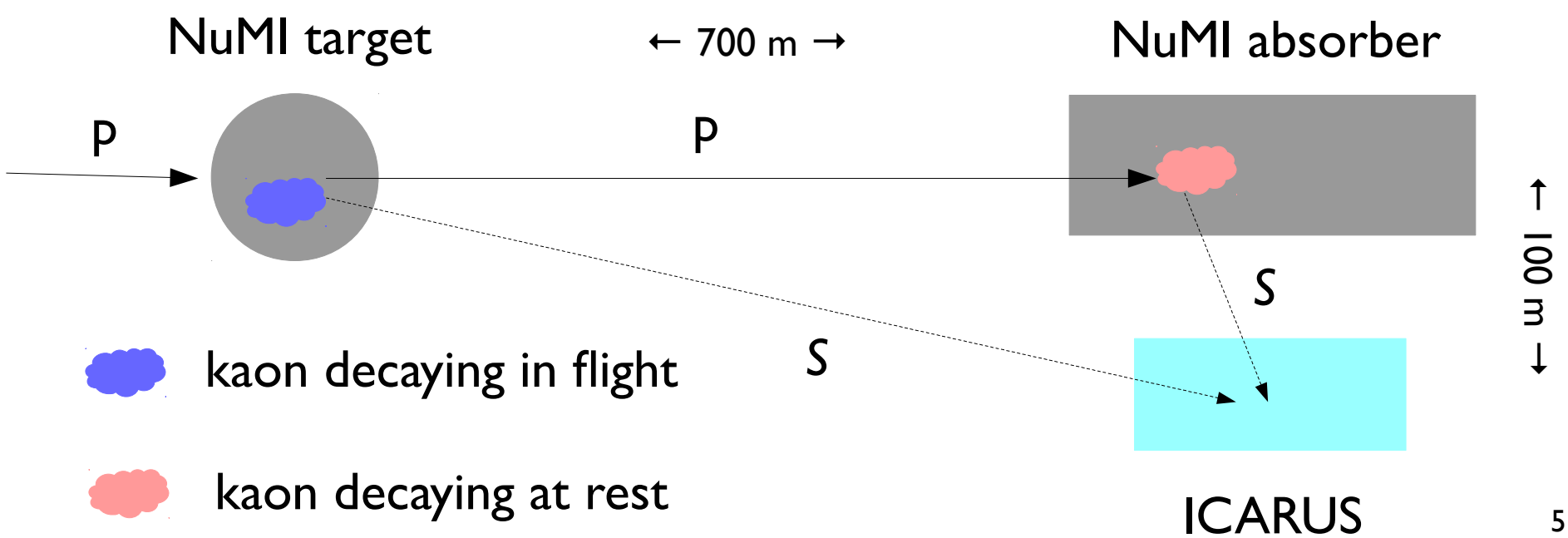
Off-axis production

ICARUS and μBooNE (on Booster beam axis) are ~7 degrees off NuMI beam line

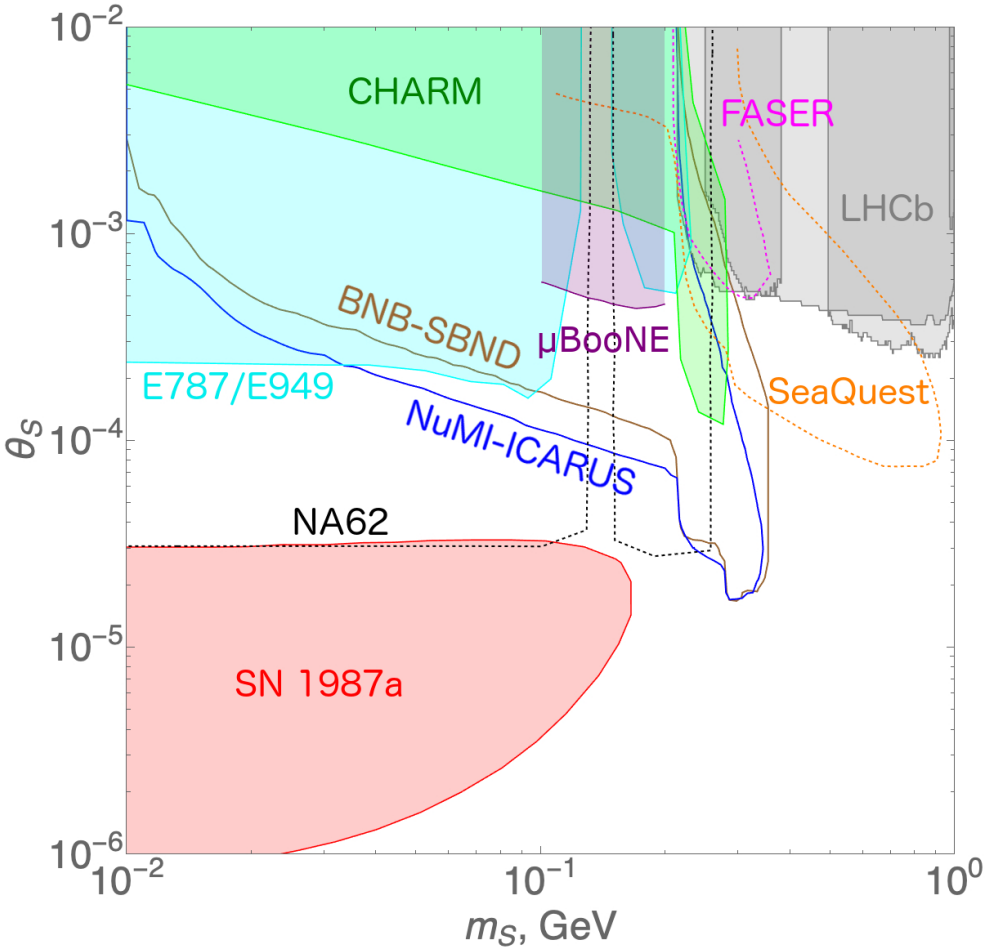
NuMI absorber stops beam → kaons decaying at rest

Monoenergetic mediators traveling short distance to ICARUS

Different incoming direction than neutrino background



New MicroBooNE limits and beyond

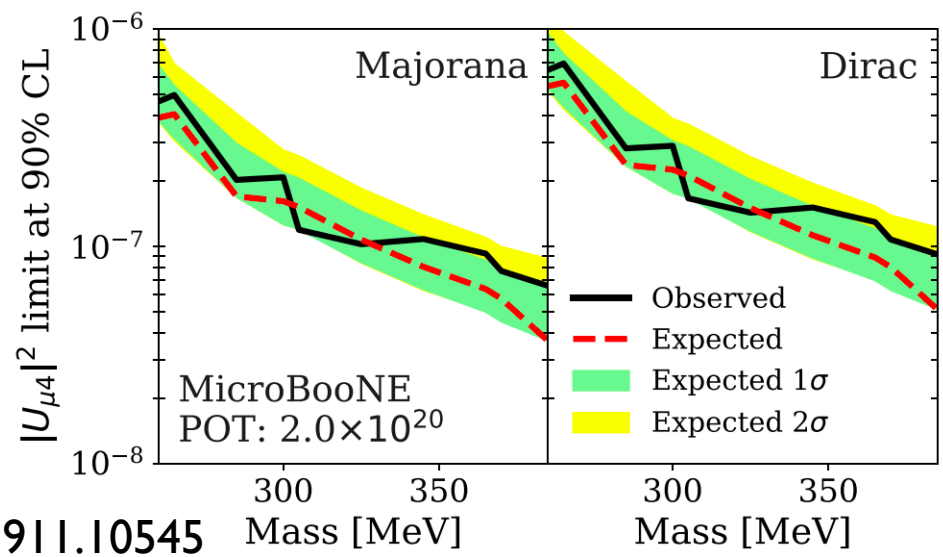


Excludes scalars with mass close to pion, from kaons decaying at rest in NuMI absorber (July 2020)

MICROBOONE-NOTE-1092-PUB

SBND and ICARUS can improve on these!

Batell, Berger, Al 1909.11670



1911.10545

Heavy neutral lepton search
Uses delayed travel of BSM particles relative to neutrinos
Can be applied to other models

Outlook

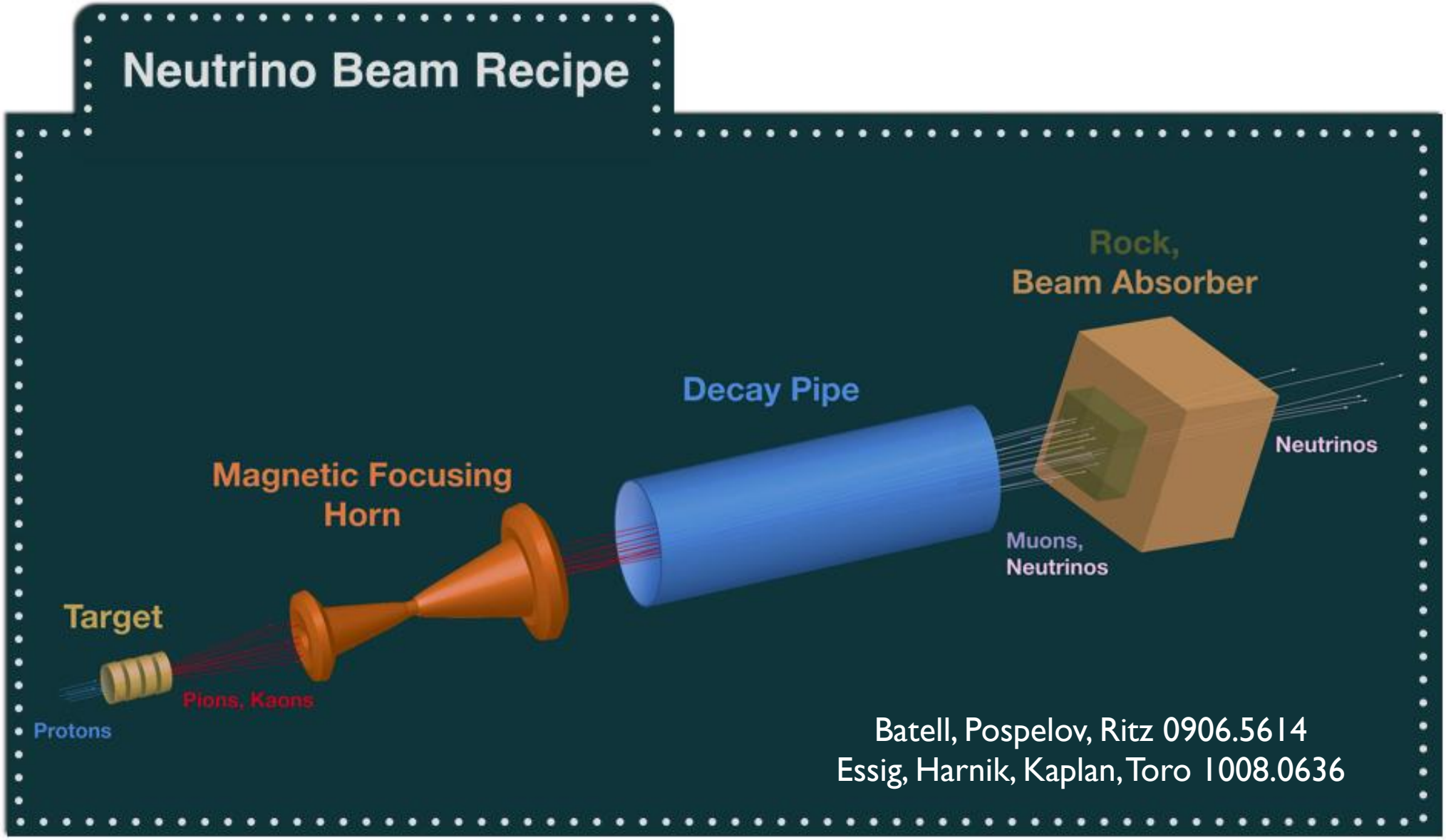
Neutrino oscillation experiments = proton beam dumps → probe light hidden sectors

μBooNE has already set new limits on hidden sectors using existing data

More to be done, e.g. full use of timing information, new detectors, on-axis vs off-axis production

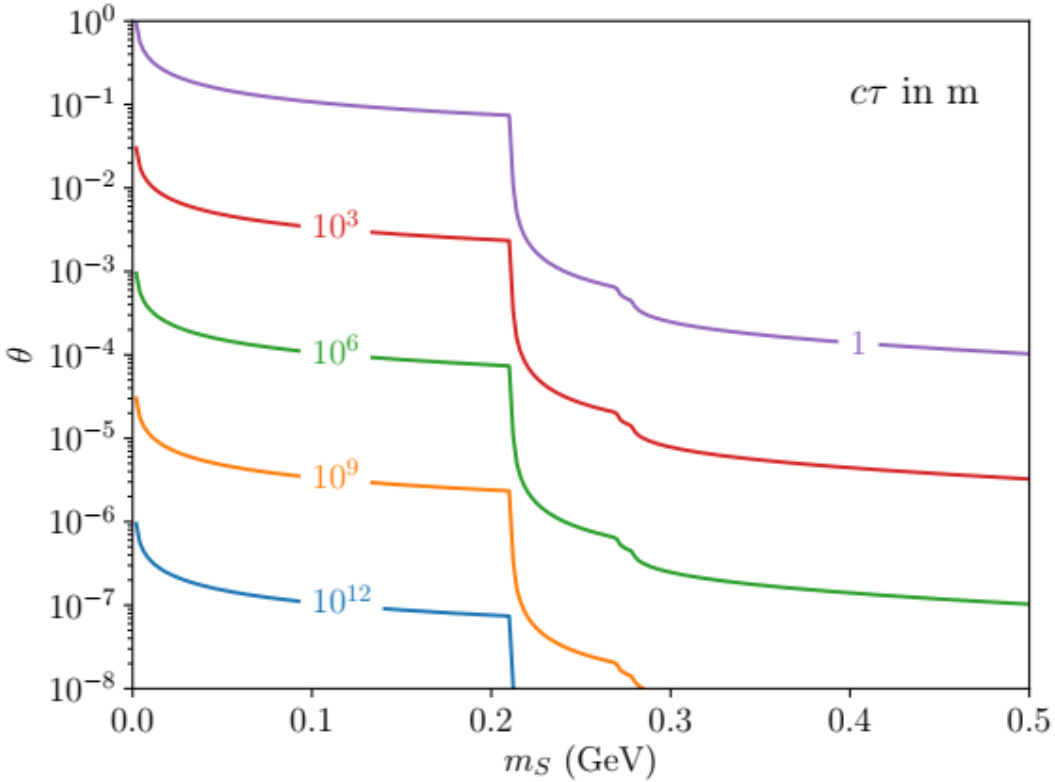
Backup slides

Neutrino beams as proton dumps



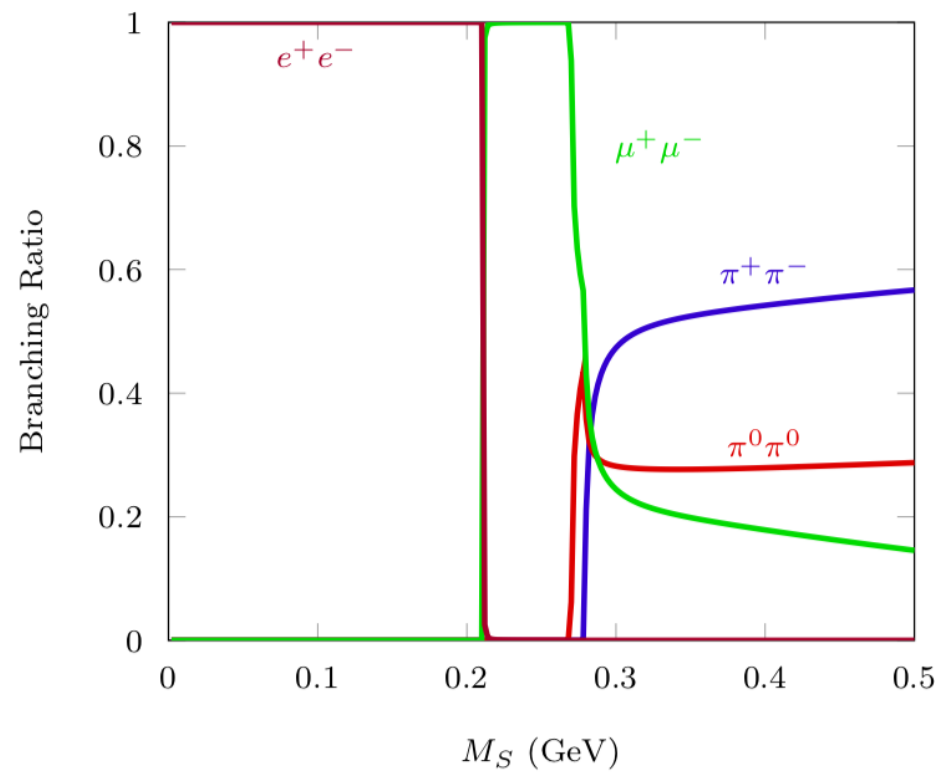
Batell, Pospelov, Ritz 0906.5614
Essig, Harnik, Kaplan, Toro 1008.0636

Scalar decays



Long-lived scalars for small mixing angles

Assume SM decays only



Probability of decay in detector

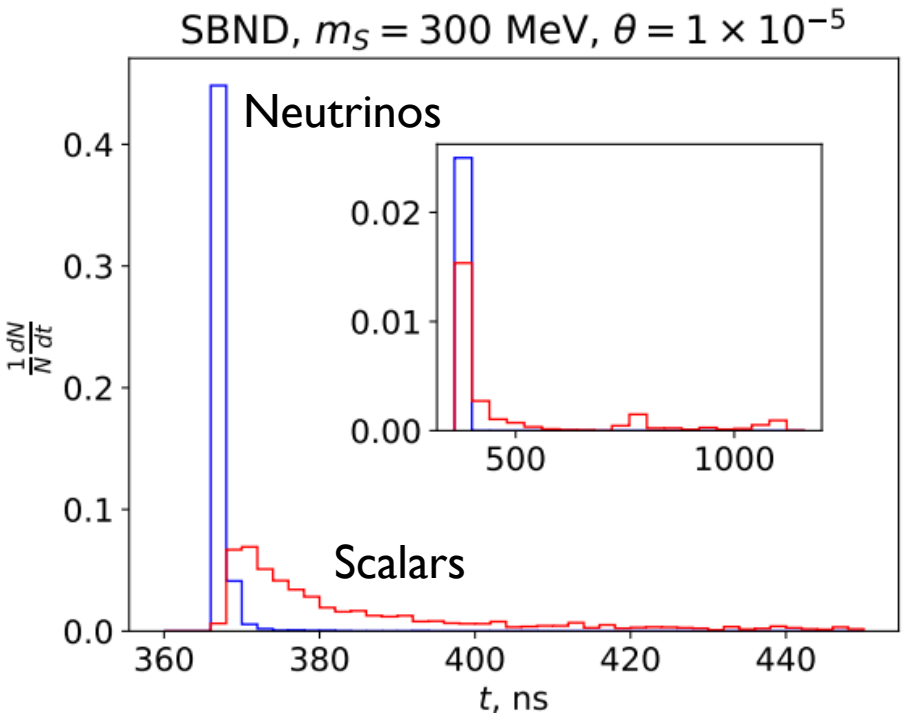
$$e^{-L_{\rm in}/\gamma\beta\tau} - e^{-L_{\rm out}/\gamma\beta\tau}$$

Using timing information

Significant delays possible for signal events

"Pileup" between bunches necessitates more detailed analysis

Even for neutrinos, not looking between bunches cuts cosmics



See also Ballett, Pascoli, Ross-Lonergan 1610.08512