Search for a Higgs Portal scalar boson decaying to e^+e^- in MicroBooNE

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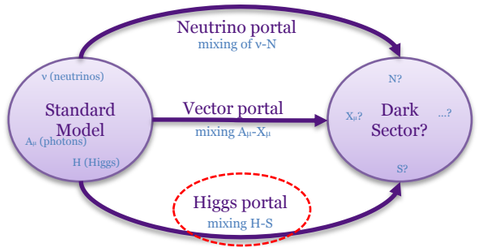
The Higgs Portal model

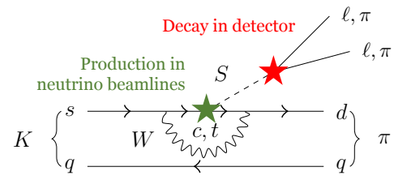
New dark sector scalar S mixes with the Higgs boson

S acquires coupling to the Standard Model fermions via the Higgs Yukawa coupling

Two model parameters: mixing angle θ, and scalar mass



Production and decay of scalars



Can be produced in kaon decays via penguin diagram

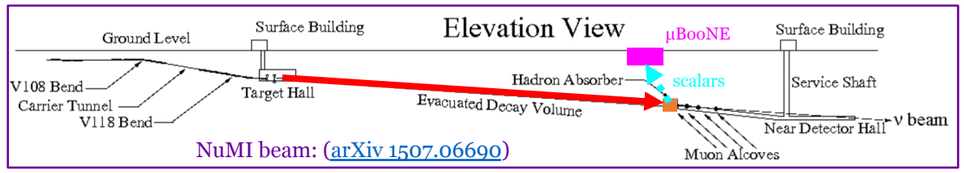
Scalars travel a macroscopic distance – hundreds of meters

Decay to electron-positron pairs (for masses below the di-muon threshold)

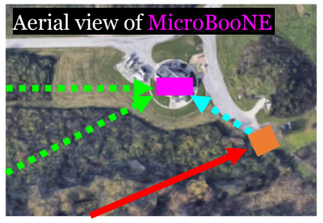
More info in Batell, Berger, Ismail, Phys Rev D 100, 115039 (2019)

Signature of Higgs Portal scalars in MicroBooNE

We utilize kaons decaying at rest in the NuMI hadron absorber (stops remnant protons & mesons in beamline)

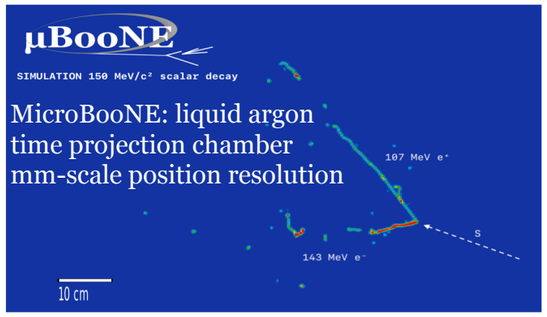


NuMI beam: (arXiv 1507.06690)



Scalars coming from direction of hadron absorber have an 'opposite' direction to typical neutrino interactions in MicroBooNE

Search for large-opening-angle events pointing towards the absorber



MicroBooNE: liquid argon time projection chamber mm-scale position resolution

Reconstruction and selection

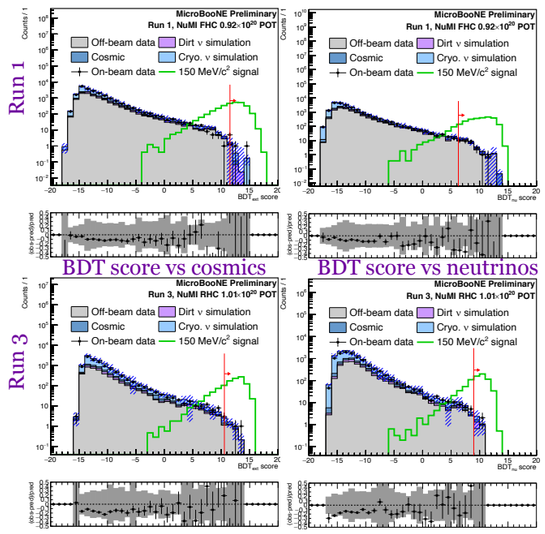
We are using only 8% of the available NuMI dataset for this first search

Using Pandora reconstruction, search for pairs of reconstructed objects

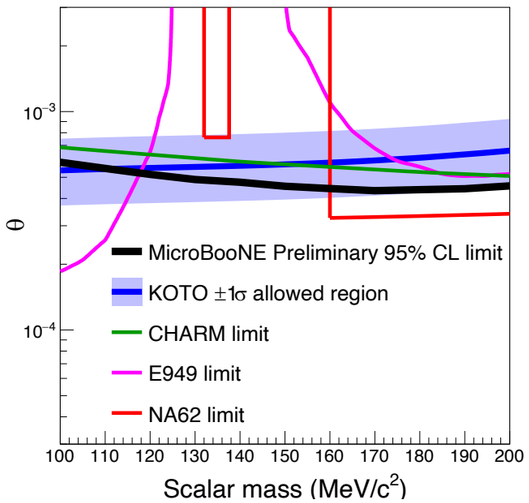
Geometrical based selection e.g. angles, lengths – no calorimetric or PID info used for this first analysis

Four Boosted Decision Trees trained to discriminate signal decays from background (cosmic or neutrino) across two run periods ('Run 1' and 'Run 3')

Two-dimensional BDT cuts are chosen to maximize sensitivity



Results



We observe 5 events in signal region after BDT cuts, consistent with background expectation of 2.0±0.8

- All 5 are visually consistent with backgrounds, e.g. stopping muons with decay electrons; three-prong neutrino interactions; photon+proton production

We set a competitive limit in the 120—160 MeV/c² scalar mass range

We can exclude at 95%CL the remaining central value model parameters required to explain the KOTO anomalous excess of $K_L \to \pi^0$+invisible decays

More info: **MICROBOONE-NOTE-1092-PUB**
See also the **ICHEP** talk: **YouTube link (@4h30m)**

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