

New BSM Results from MicroBooNE

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for the MicroBooNE Collaboration

FIPs 2022
17- 21 October 2022, CERN

Short-baseline programme

ICARUS

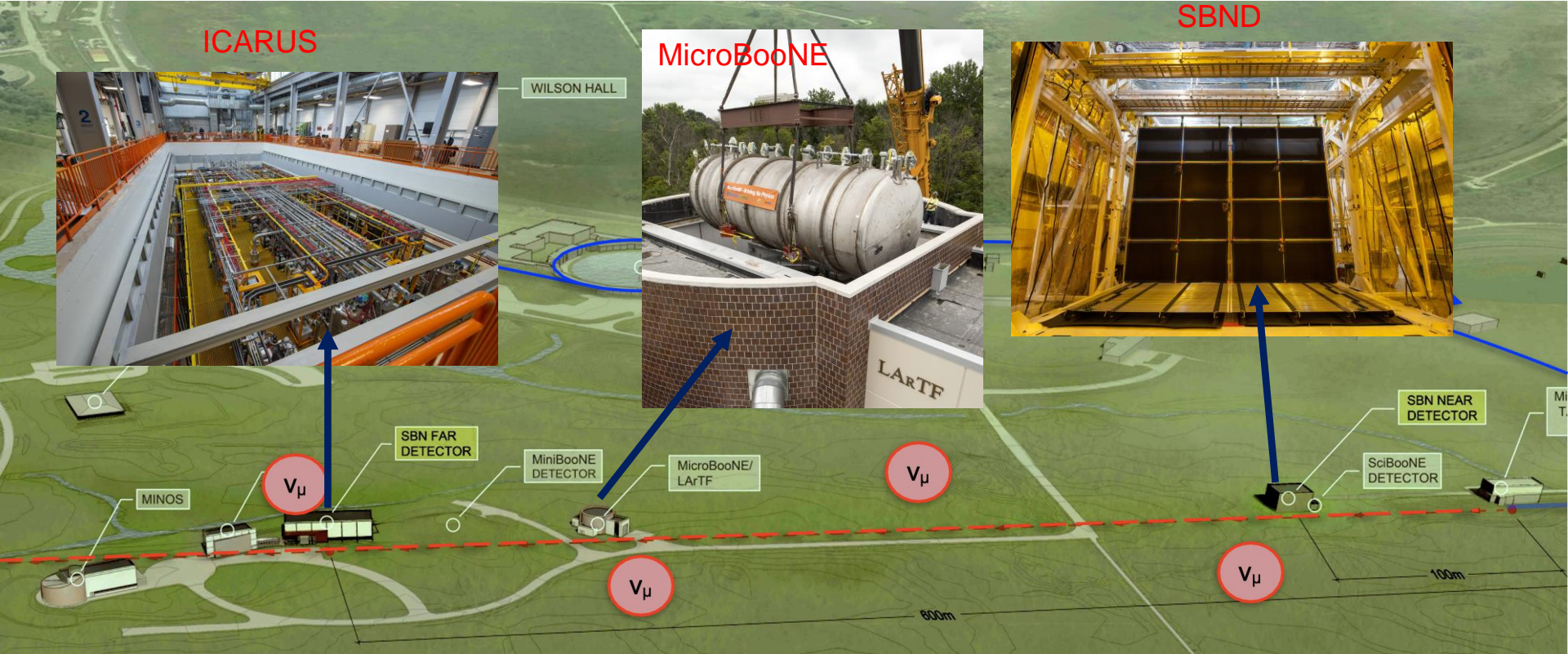


WILSON HALL

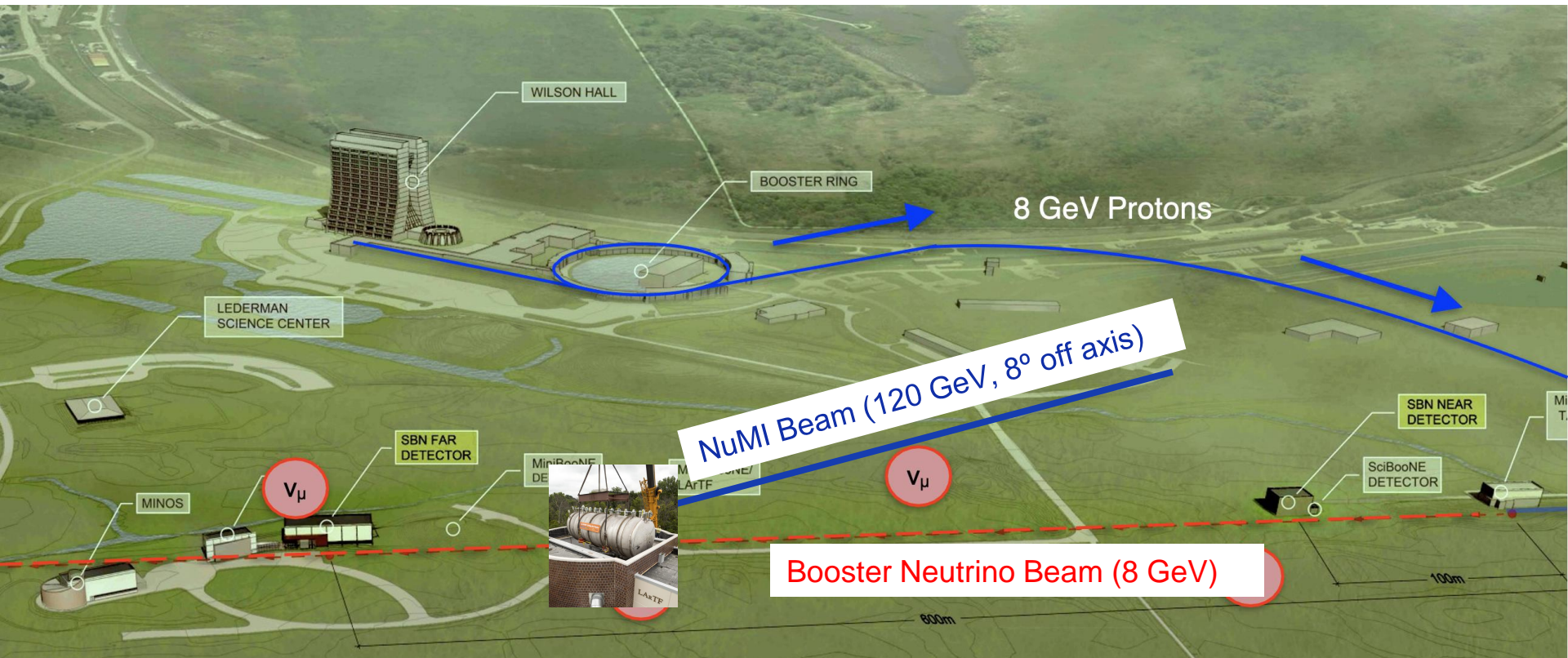
MicroBooNE



SBND

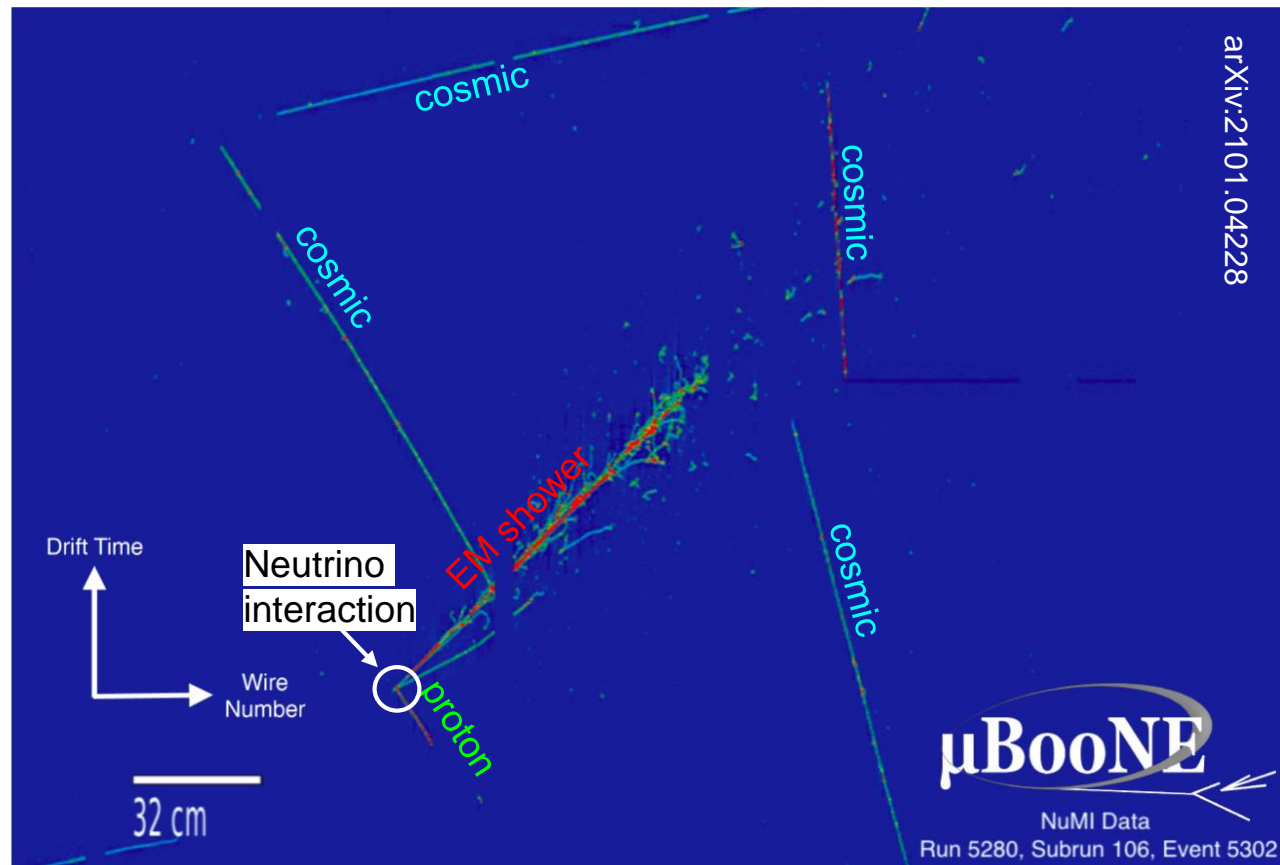


One experiment – two beams

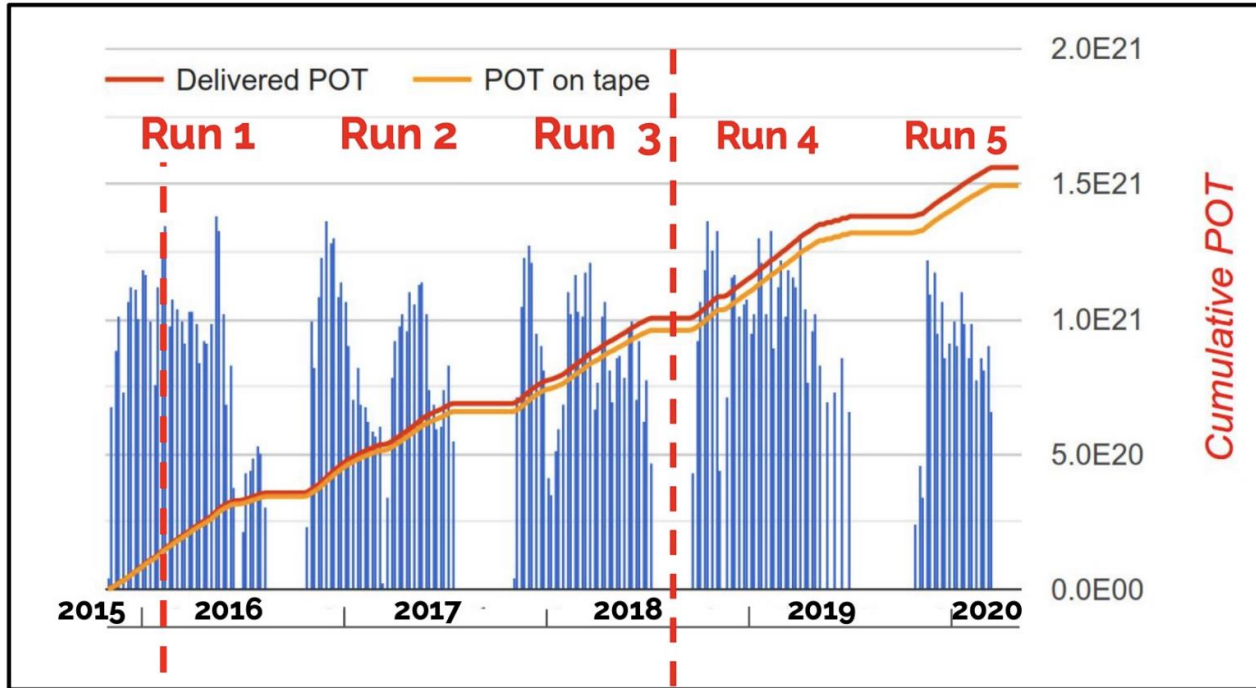


LArTPC – a powerful technique

- Few mm resolution.
- Excellent energy measurement.
- Excellent e- γ separation.
- Particle identification through dE/dx, range,...
- Timing through scintillation light.



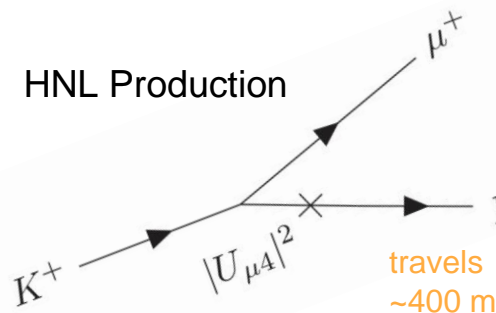
MicroBooNE data set



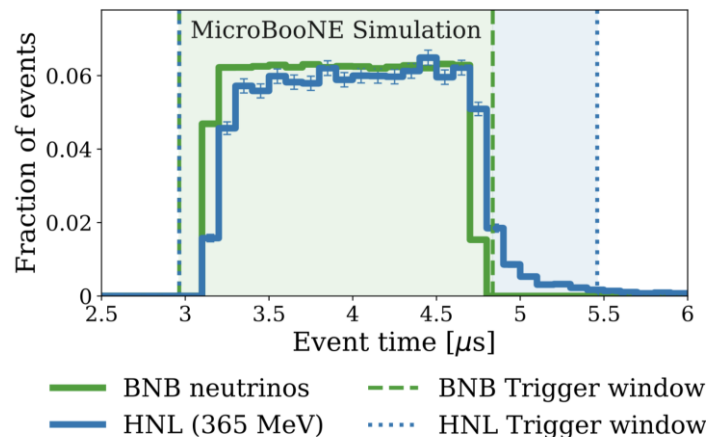
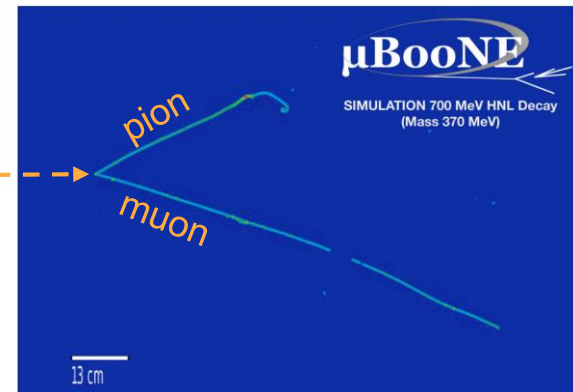
Results in this talk (~50 % of total)

Heavy Neutral Leptons

- Introduced in several talks.
- We are sensitive to HNLs with masses < 500 MeV.
- Final states: electrons, muons, pions.
- First analysis based on dedicated “late trigger” window.
- Excludes neutrino background from beam.



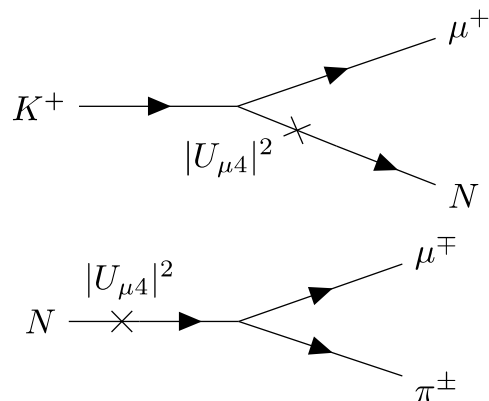
[Phys. Rev. D 101, 052001](#)



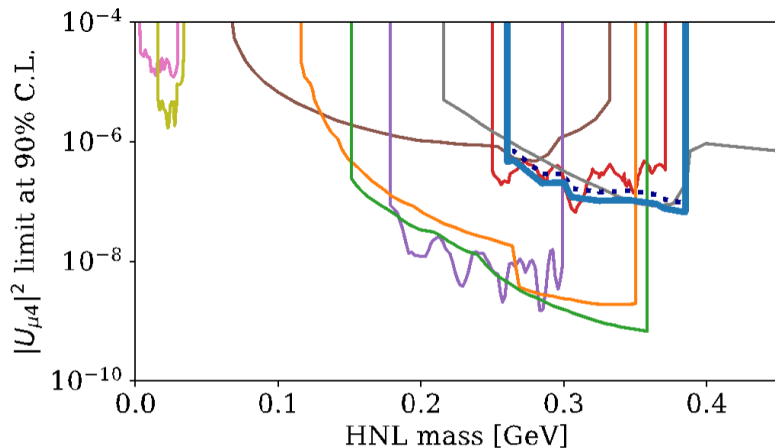
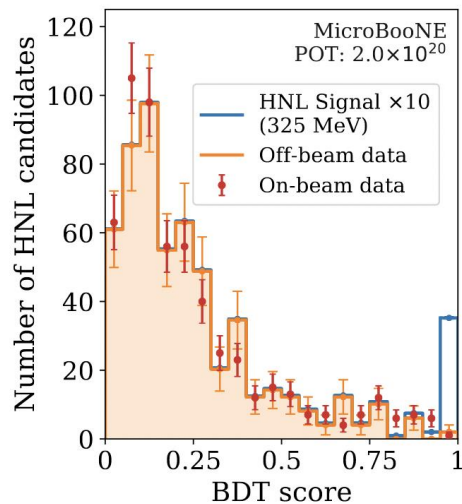
Heavy Neutral Leptons

Phys. Rev. D **101**, 052001

Focused on these production and decay channels:



BDT to search in mass range 260 – 385 MeV

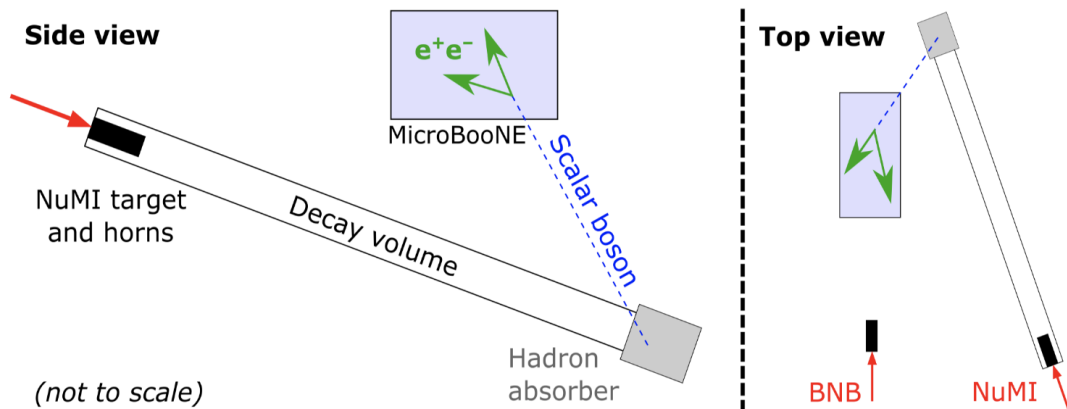
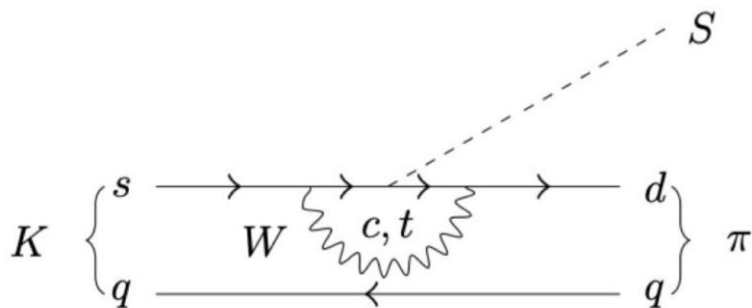


- | | | |
|---------|---------|-----------------------|
| — SIN | — NA62 | — NuTeV |
| — PIENU | — PS191 | ••• MicroBooNE [Dir.] |
| — KEK | — T2K | — MicroBooNE [Maj.] |
| — E949 | | |

Higgs Portal Scalars

[Phys. Rev. Lett. 127, 151803](#)

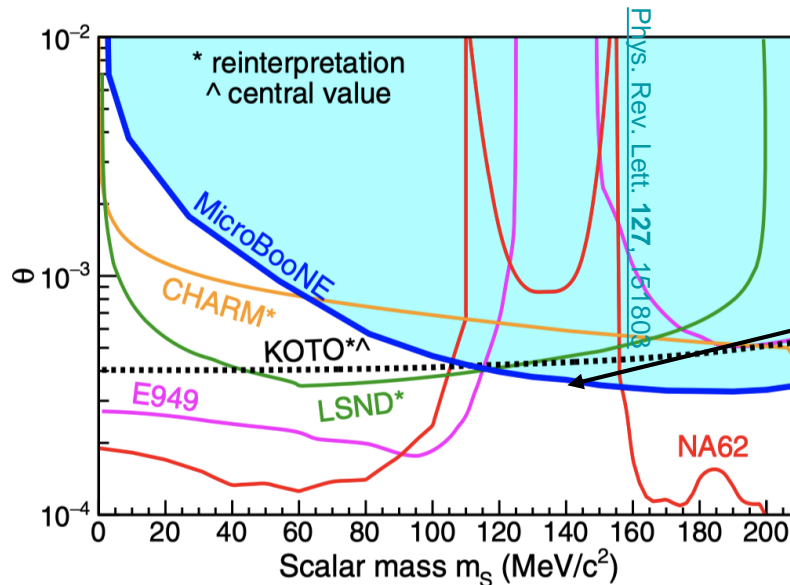
- Dark scalar that mixes with the Higgs boson
- Decays into l^+l^- or $\pi^+\pi^-$
- Using kaons decaying at rest in the NuMI beam dump



Higgs Portal Scalars

- We use a BDT to search for the $S \rightarrow e^+e^-$ decay
- One event passes all cuts, consistent with background
- Background expectation: 1.9 ± 0.8 events
- Rules out HPS contribution to initial KOTO measurement

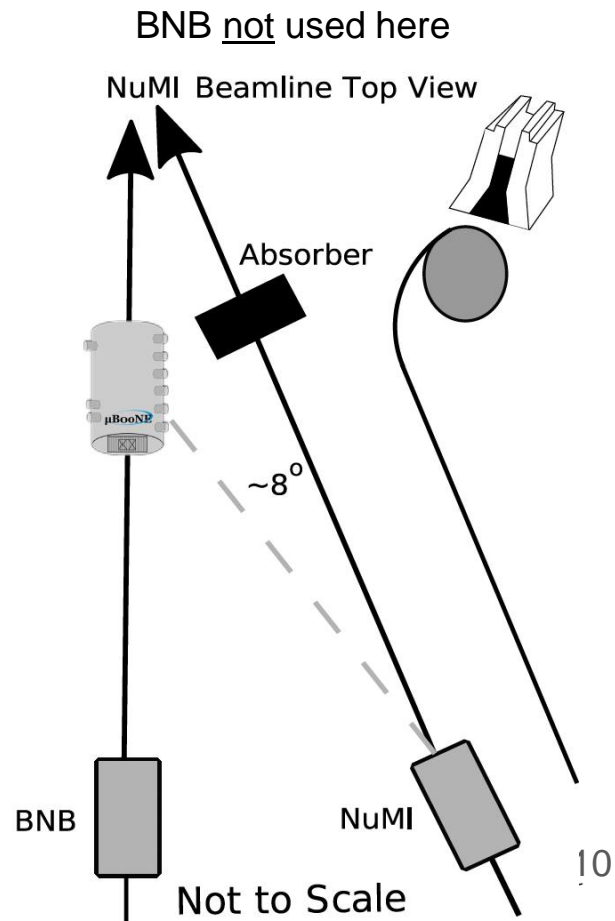
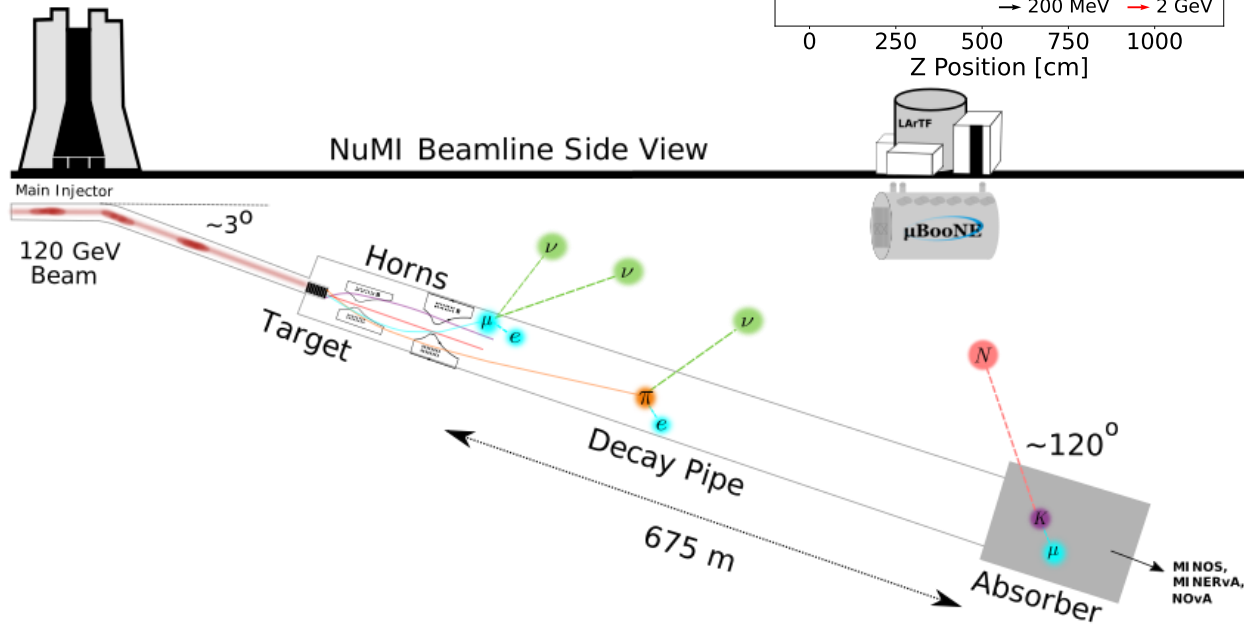
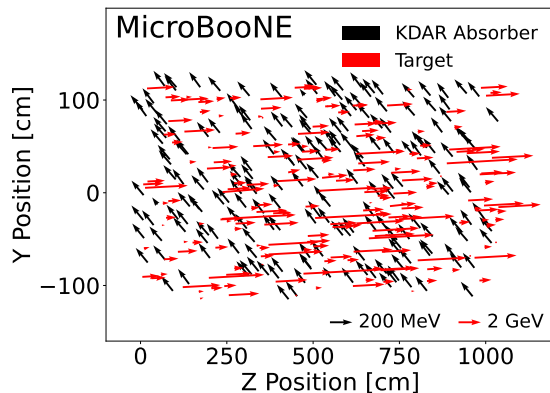
[Phys. Rev. Lett. 127, 151803](#)



World leading limit in this region!

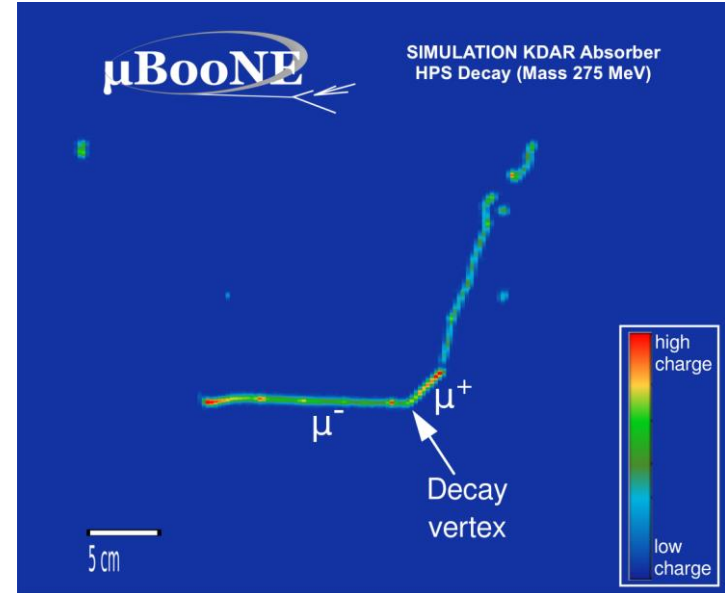
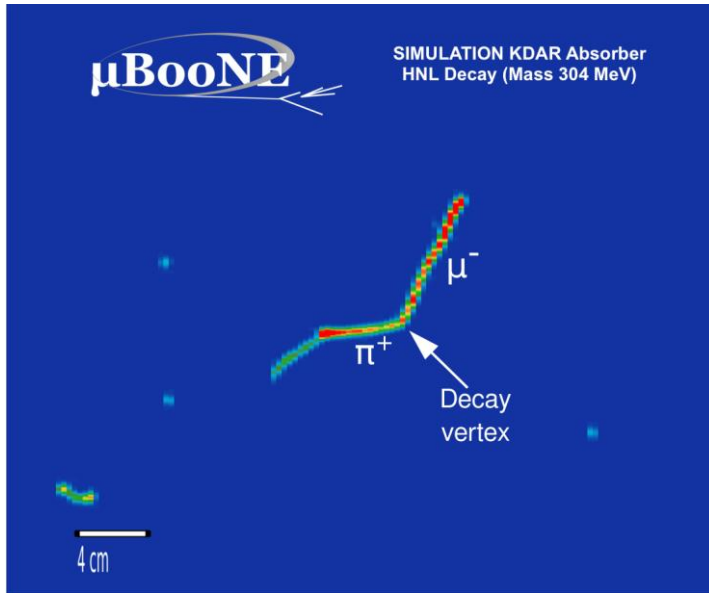
HNLs from the NuMI Absorber

- HNLs (or HPS) enter the detector from the absorber.
- Angular information helps to discriminate signal from neutrino beam background.

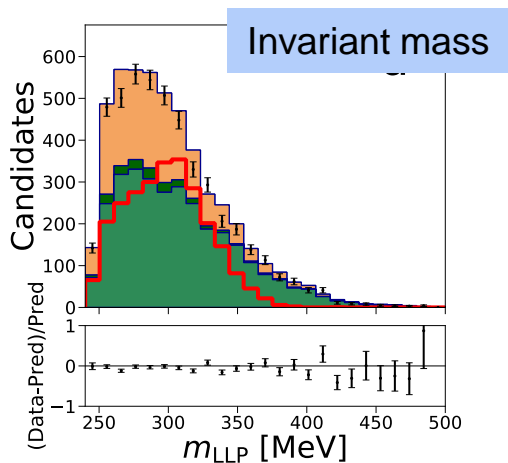
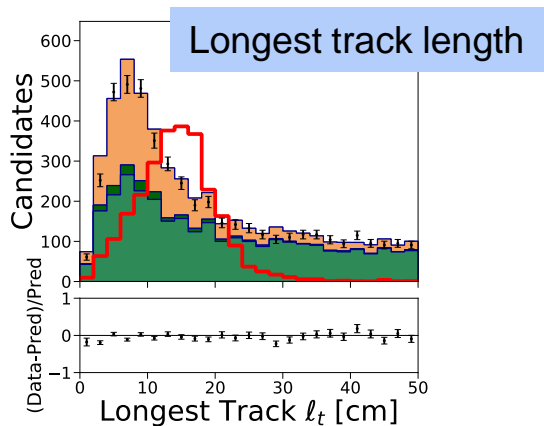
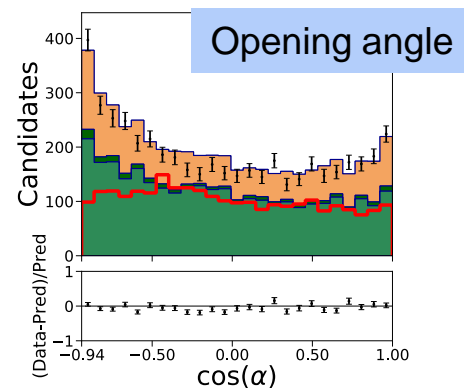
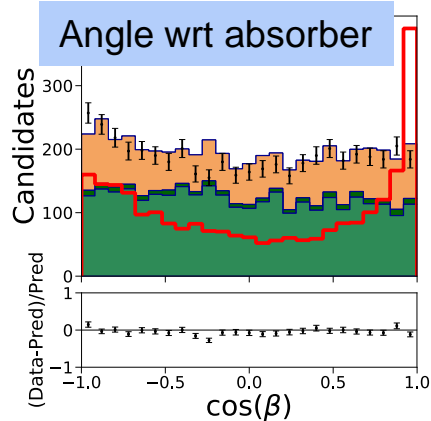
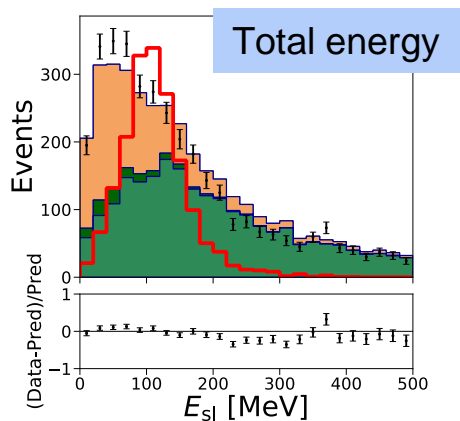


New HNL and HPS search

- As kaon decays at rest, HNL is mono-energetic for given mass.
- HNL and HPS decays produce similar two-track topology – one search strategy.
- Full simulation of beam, HNL/HPS production and decay kinematics, detector.



Signal and background kinematics

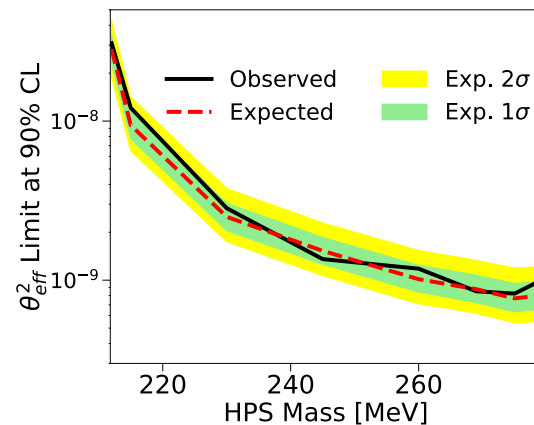
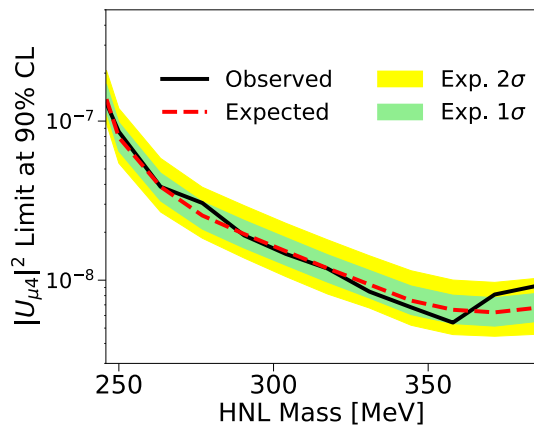
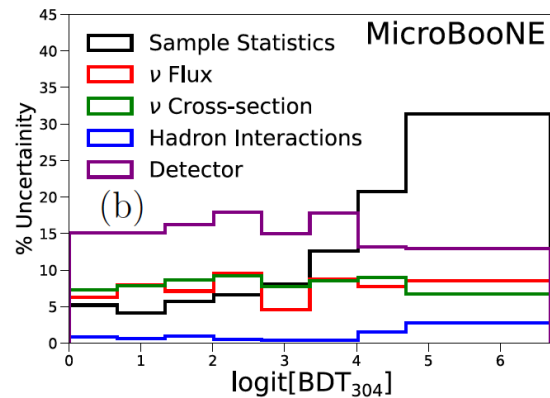
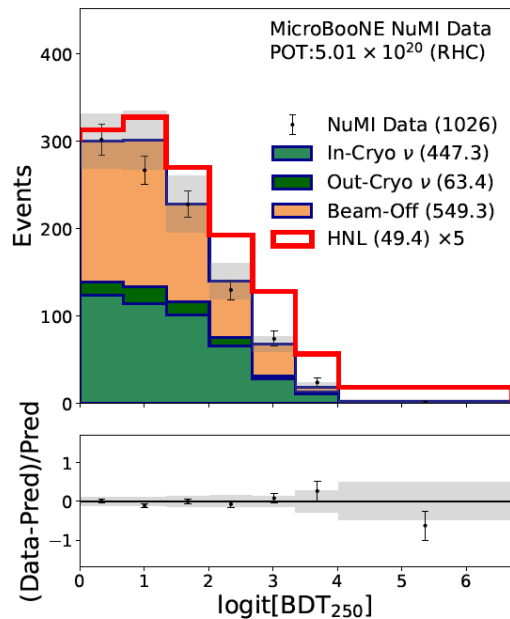


MicroBooNE NuMI Data
POT: 5.01×10^{20} (RHC)

- | NuMI Data
- In-Cryo ν
- Beam-Off
- Out-Cryo ν
- HNL ($m_{HNL} = 304$ MeV)

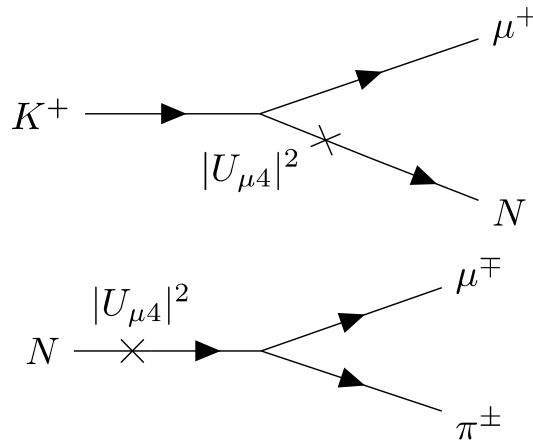
21 BDT Input variables

BDT output + Systematics \rightarrow Limit

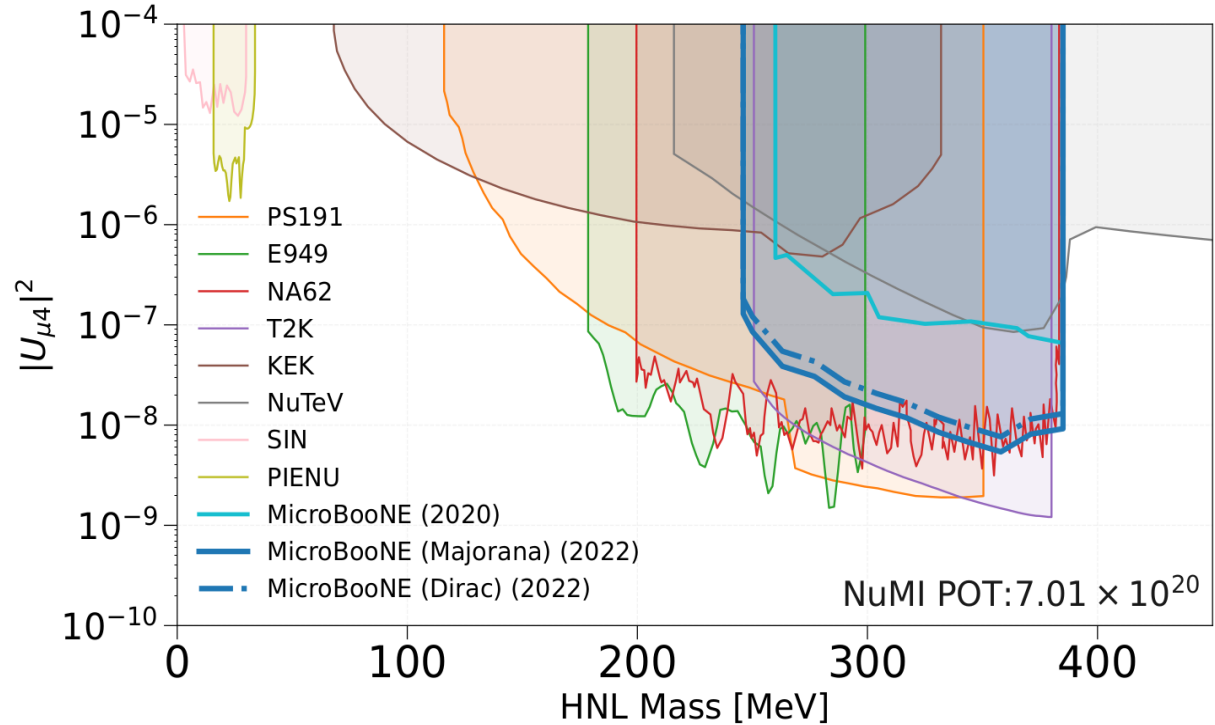


HNL result

Order of magnitude improvement on previous MicroBooNE HNL limit

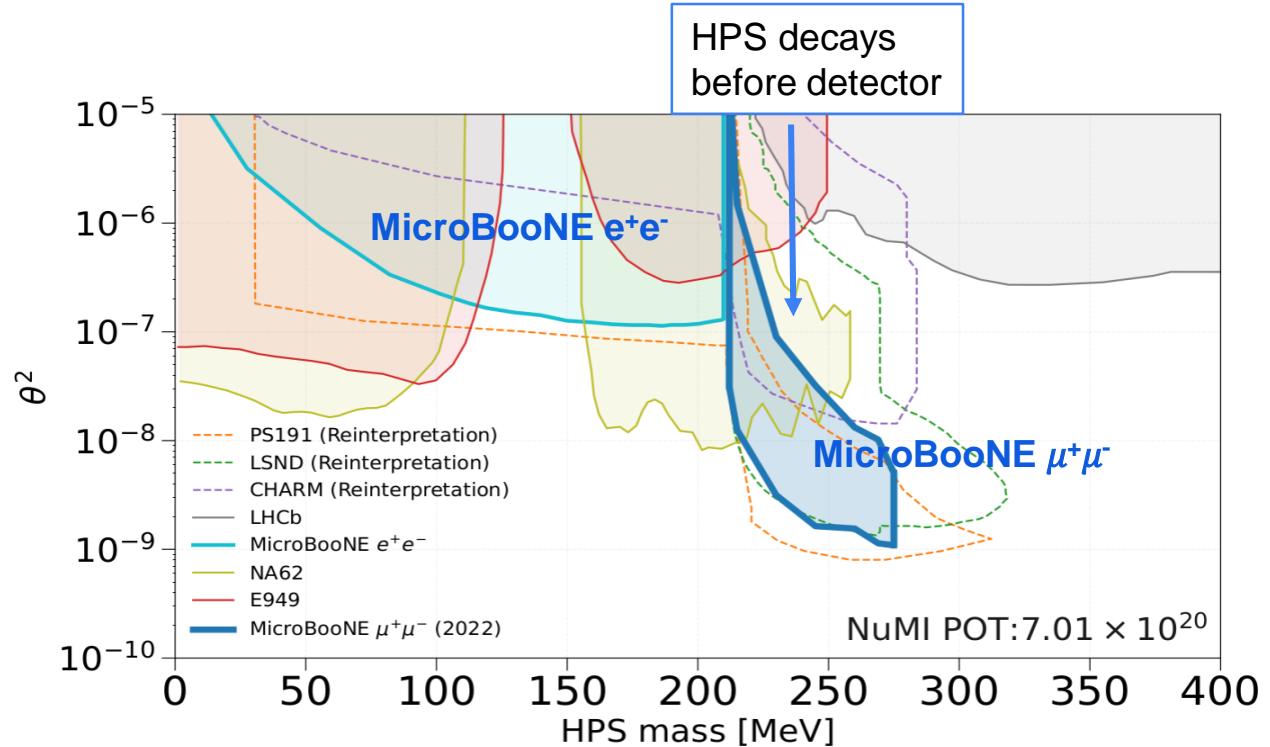
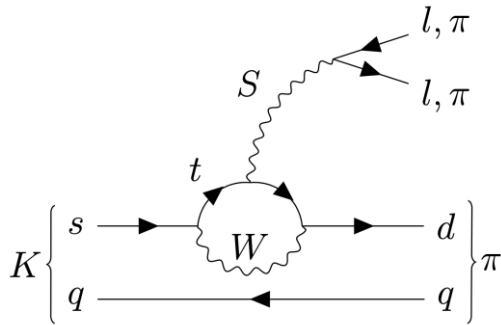


Majorana and Dirac HNLs



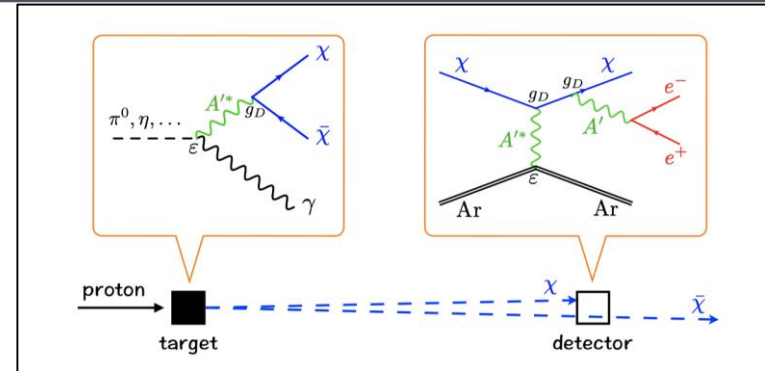
Higgs Portal Scalar Result

First constraints from a dedicated experimental search in this parameter range.

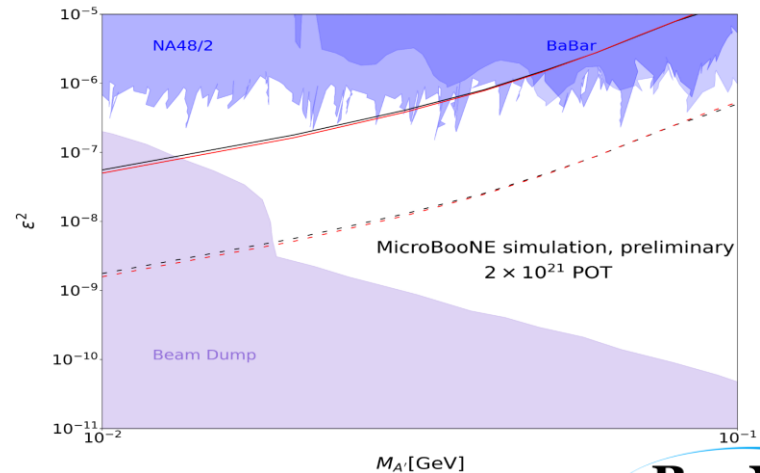


What else are we working on?

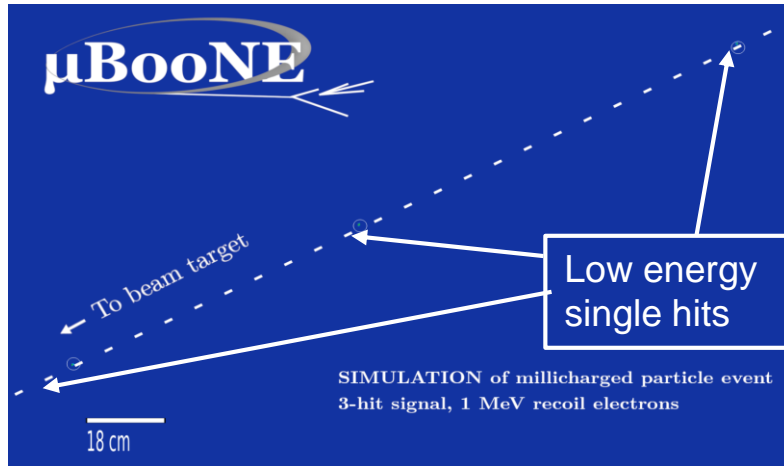
- Several HNL decay channels
- Models to explain low-energy excess (MiniBooNE)
- Neutron-antineutron oscillations
- Dark tridents
- Milli-charged particles



— MicroBooNE CNN $\alpha_D = 0.1$ - - - MicroBooNE CNN $\alpha_D = 1$
 — MicroBooNE BDT $\alpha_D = 0.1$ - - - MicroBooNE BDT $\alpha_D = 1$



JHEP 01 (2019) 001



Summary

- BSM searches are one of three pillars of MicroBooNE's physics programme (in addition to cross sections, low-energy excess).
- New 3+1 light sterile neutrino result this week on <https://arxiv.org/abs/2210.10216>
- New BSM results published on
 - Heavy neutral leptons
 - Higgs portal scalars
- More search results to be released soon.
- Important to perform full experimental analysis of data.
- Need support for BSM generators.

