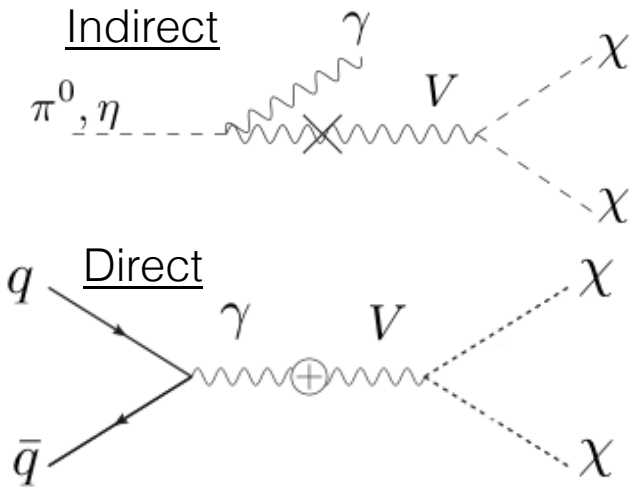
2016 SLAC Dark Matter Workshop
DMA WG: Summary of Invisible DM searches at FNAL

R. Van de Water (LANL)

Synergy with Intensity Frontier at Fermilab

Production:

- From proton-target interactions
- Requires intense beams ~2×10^{20} protons/yr and variable energies (8 GeV, 120 GeV, etc)



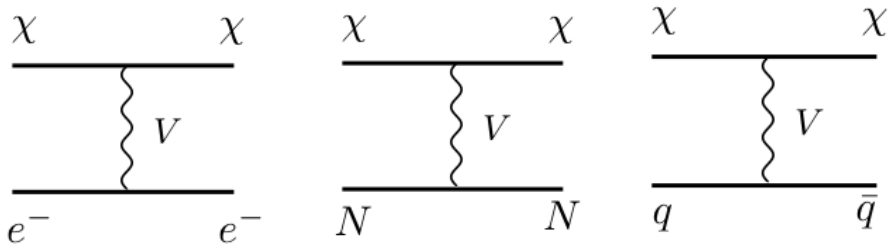
8 GeV

120 GeV for higher WIMP mass reach

Direct Detection:

- Highly boosted elastic scattering off nucleons, electrons, or DIS
  > 10 MeV final state energy
- Require detectors that are
  - near ~km
  - large ~100 tons
  - sensitive, well-understood
  - excellent external background rejection

Probes Models with $m_V > 2m_\chi$ (invisible decay)

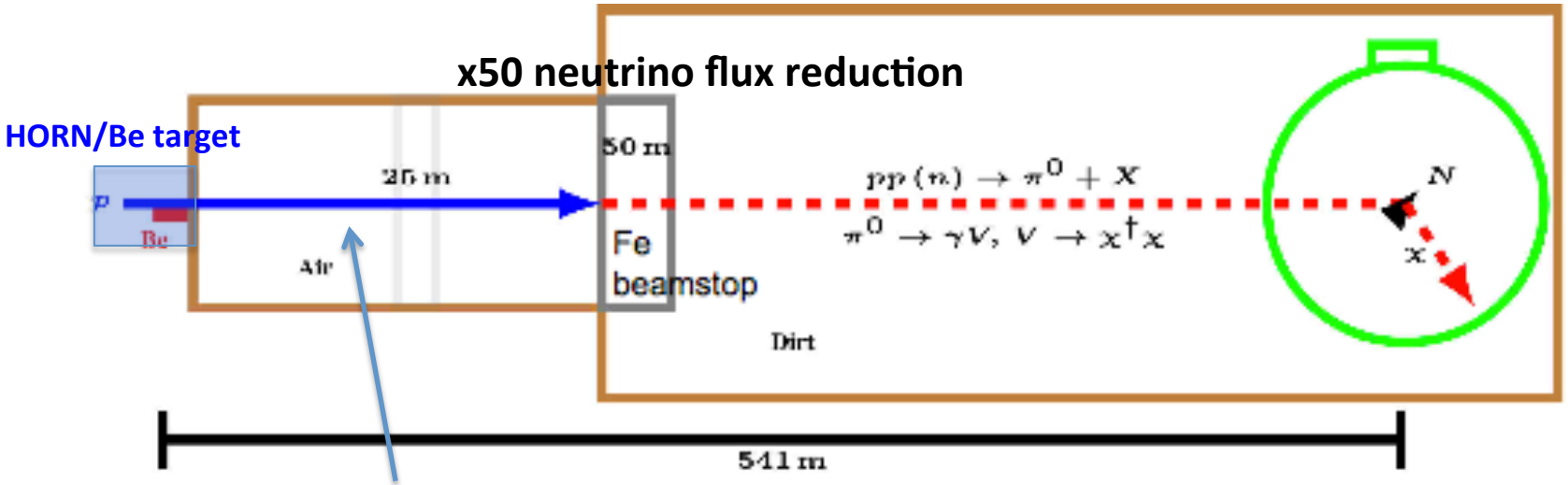


Neutrino sources and detectors are ideal for Dark Sector particle searches!

Downsides: 1) competes for protons with neutrino program.
2) neutrino backgrounds.

Current MiniBooNE Search (Rex Tayloe)

- Beam Dump run taken in 2014/15 - input from this community helped convince FNAL PAC to approve run, many thanks!
- Easy to configure, but **not ideal beam dump**:



Residual neutrino production in decay pipe air.
Ideal dump replaces HORN with beam stop, >500 neutrino flux reduction

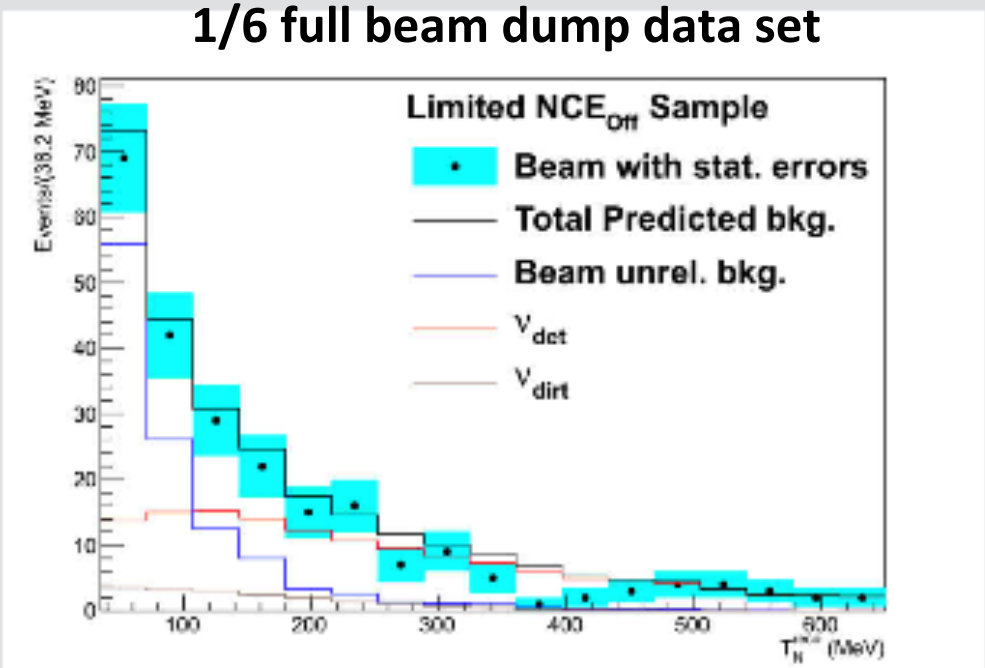
MiniBooNE: Despite limitation, significant sensitivity can be achieved

- Preliminary results presented (1/6 data set)
- Full unblinded results from MB soon!
- Many important lessons learned.

- Projected errors in full sample:
  - 3% statistical
  - 10% systematics

Impressive small error for experiment not designed to search for DM!!
- Leverages a decade of neutrino running!

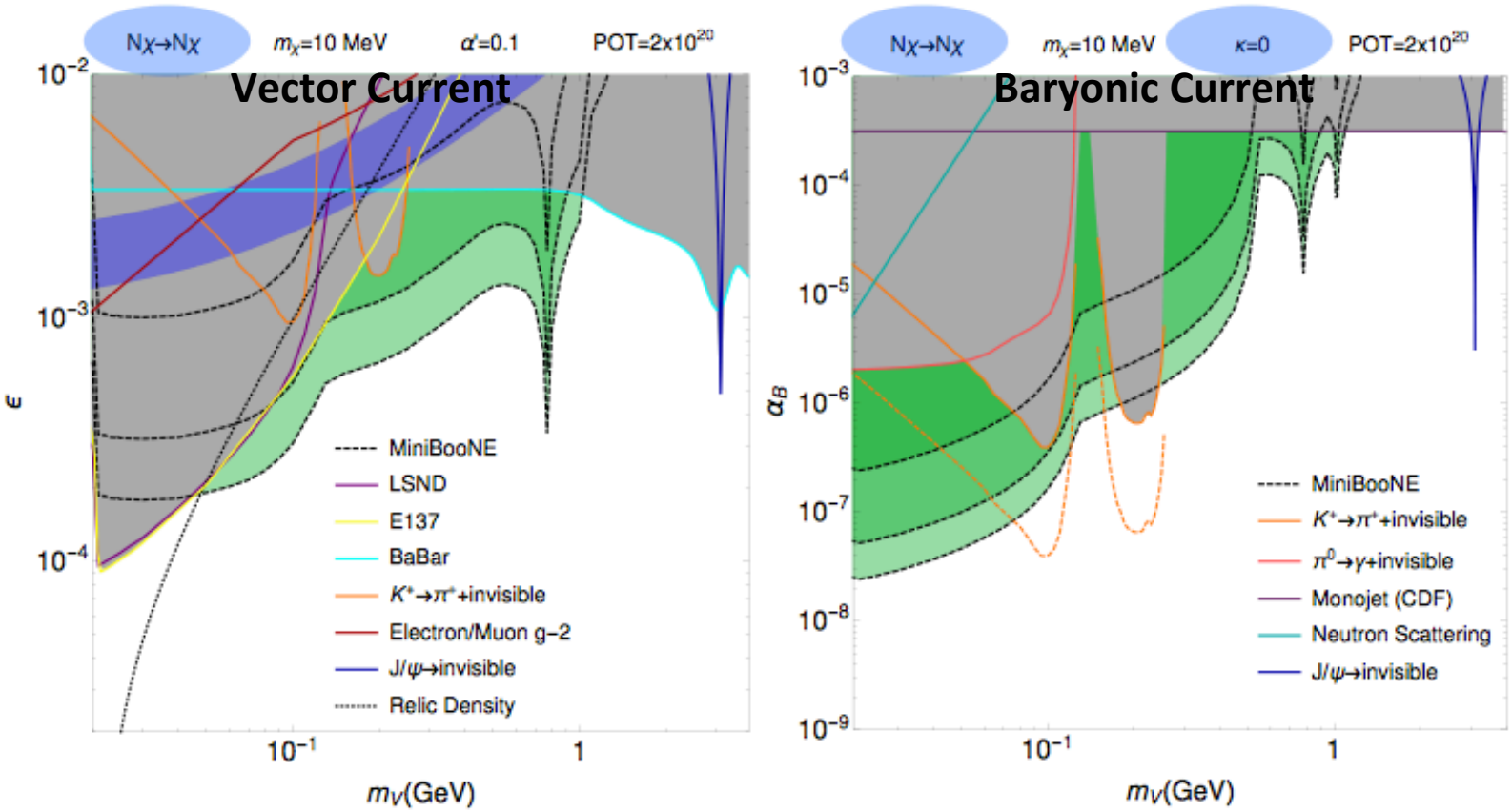
1/6 full beam dump data set



Sample event rates - MiniBooNE

Adam Ritz

[Batell et al '14, deNiverville et al, to appear]



Significant unexplored region in DM parameter space covered by MiniBooNE

Complex Scalar scenario has p-wave annihilation in early Universe, so is wide open...

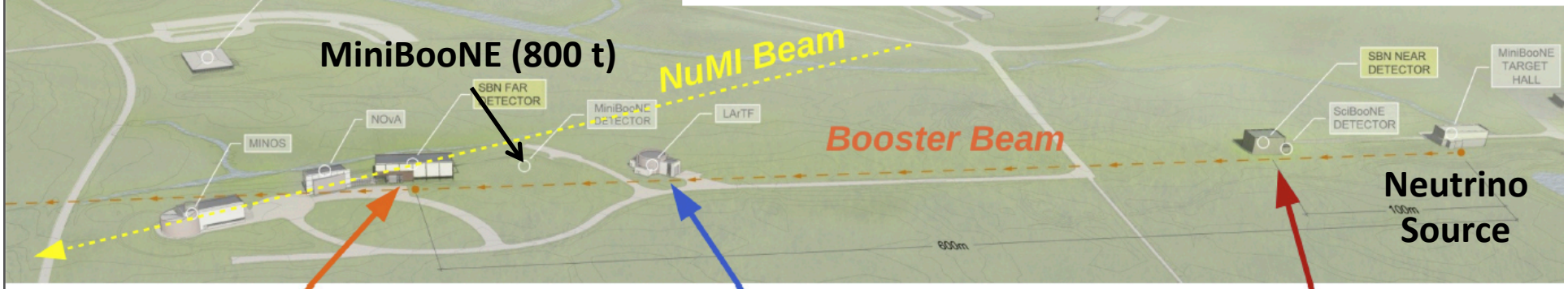
(~MeV range compatible with sterile neutrinos...etc)

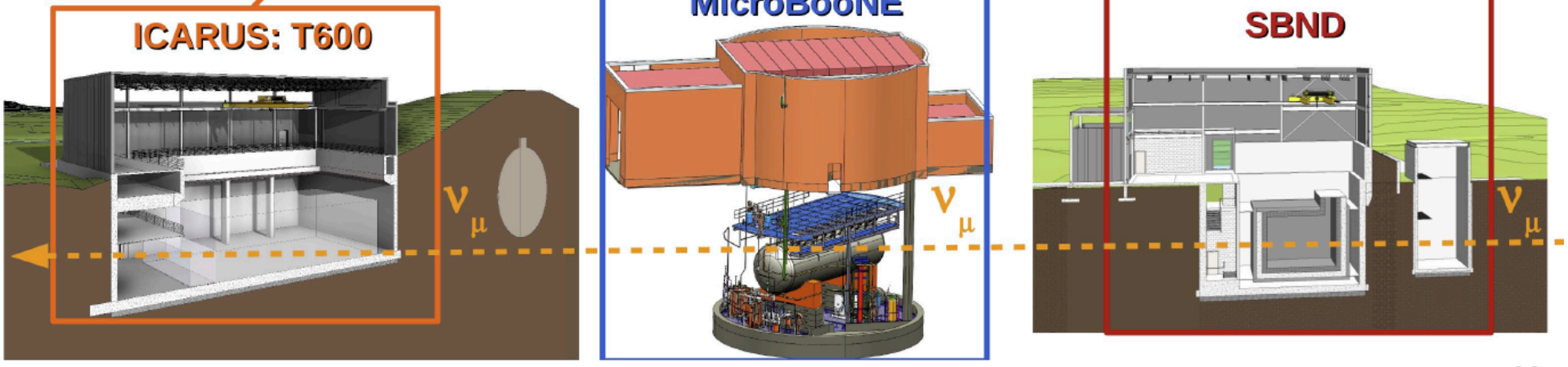
Philip Schuster

Improved Sterile Neutrino and DM Searches at the BNB with Multiple LAr TPC Detectors (Robert Cooper)

Proof of oscillations requires neutrino measurements at multiple distances.

Detector	Distance from BNB Target	LAr Total Mass	LAr Active Mass
SBND	110 m	220 t	112 t
MicroBooNE	470 m	170 t	89 t
ICARUS-T600	600 m	760 t	476 t





Far detector will have similar sensitivity as MB, but with unique event topology identification

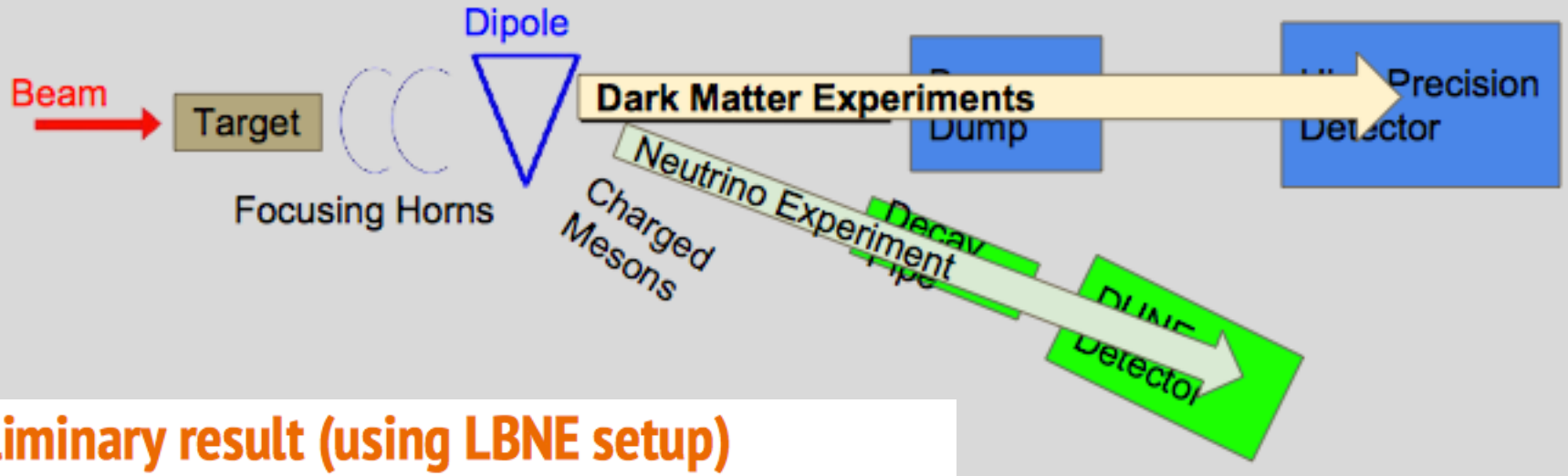
MB has demonstrated a DM search can be done!

Near detector x10 DM sensitivity compared to MiniBooNE

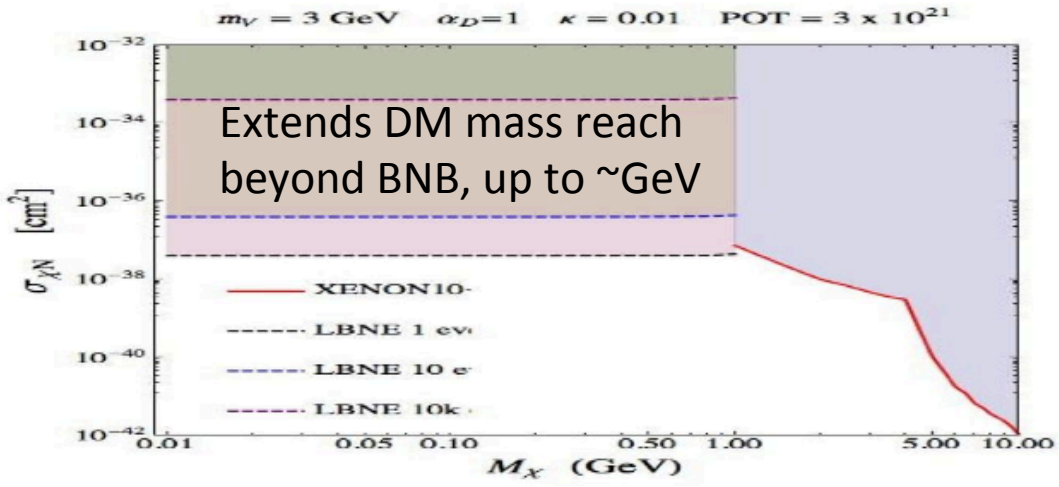
LBNF/DUNE (Animesh Chatterjee)

- Separate neutrino and antineutrino from DM.

Allows simultaneous neutrino and DM running!



Preliminary result (using LBNE setup)



LBNF/DUNE in design phase, good time to suggest changes that could enhance DM search and expand physics reach of experiment.

Challenge: Expanded DM search program at FNAL

- Intense competition for protons/resources at FNAL, requires help from the DM community…
- Propose a one year beam dump run at the BNB to increase DM search sensitivity >1-2 orders of magnitude in mixing
  - Low cost as it leverages large investment in multiple LAr TPC detectors.
  - Replace neutrino horn/target with beam dump at the end of the beam pipe (reduce nu background >1 order of magnitude).
- Propose specific design upgrades to LBNF/DUNE to improve ability to perform DM search.
- Help FNAL focus on DM searches leveraging intense proton beams, current/future neutrino experiments, and SeaQuest. **Develop a dedicated DM search program at FNAL!**