BSM in neutrino experiments (cosmogenic and accelerator)

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Cosmogenic Dark Matter and Exotic Particle Searches in Neutrino Experiments

NF03 Contributed White Paper to Snowmass 2021

J. Berger[7], D. Brailsford[8], K. Choi[1], J. I. Crespo-Anadón[5], Y. Cui[3], A. Das[12], J.A. Dror[4], Alec Habig[10], Y. Itow[11], E. Kearns[2], D. Kim[*13], J.-C. Park[6], G. Petrillo[12], C. Rott[15,17], M. Sen[9], V. Takhistov[14], Y.-T. Tsai[†12], and J. Yu[16]

from SLAC: Yun-Tse Tsai *(lead editor)*, Anirban Das, Gianluca Petrillo

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Dark Sector Studies with Neutrino Beams

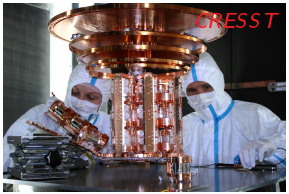
NF03 Contributed White Paper to Snowmass 2021

Brian Batell[*1], Joshua Berger[2], Vedran Brdar[3,4], Alan D. Bross[3], Janet M. Conrad[5], Patrick deNiverville[6], Valentina De Romeri[7], Bhaskar Dutta[8], Saeid Foroughi-Abari[9], Matheus Hostert[10,11,12], Joshua Isaacson[3], Ahmed Ismail[13], Sudip Jana[14], Wooyoung Jang[15], Kevin J. Kelly[16], Doojin Kim[8], Mathieu Lamoureux[17], Jong-Chul Park[18], Gianluca Petrillo[19], Adam Ritz[9], Seodong Shin[20], Tyler B. Smith[21], Yu-Dai Tsai[21], Yun-Tse Tsai[19], Richard Van de Water[6], Jason Wyenberg[22], and Jaehoon Yu[* 15]

from SLAC: Yun-Tse Tsai, Gianluca Petrillo

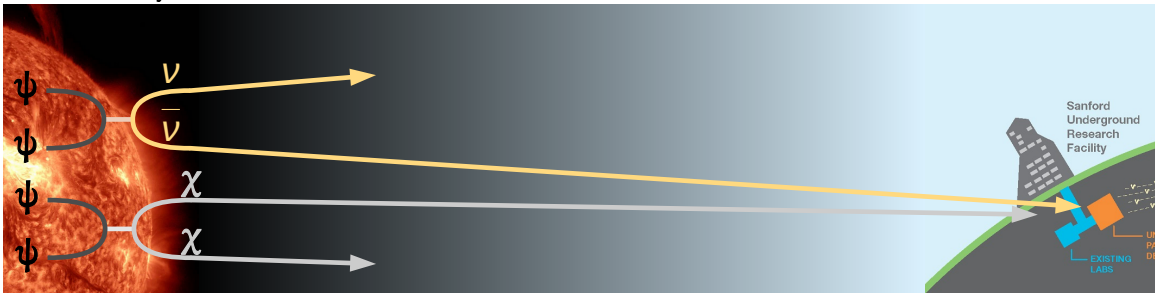
Dark Matter, Dark Sector, Dark Light...

- dark matter is here!
- probed by dedicated experiments with small size, zero-noise detectors
- the two papers are all about how do go further:
  1. focus the detection where there might be a large flux
  2. have large sensitive volumes



Look at the sky!

Look where dark matter is already: accumulated in massive objects (Galactic Centre, Sun...).
What we may see:

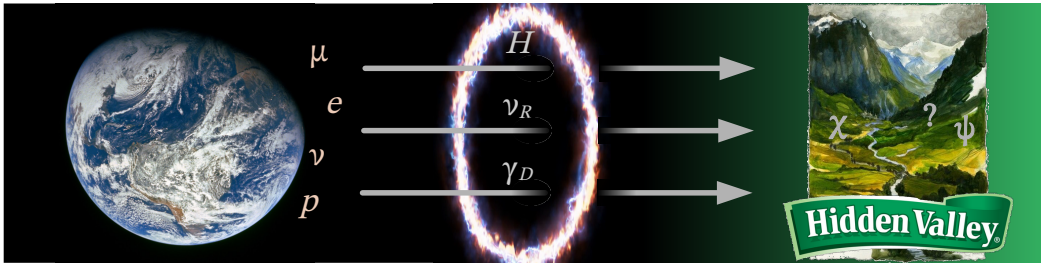


- (excess of) neutrinos from dark matter decay
- "Boosted" Dark Matter: from very weak interaction with SM, and requires hierarchy *(10 pages about that...)*

Behind you!

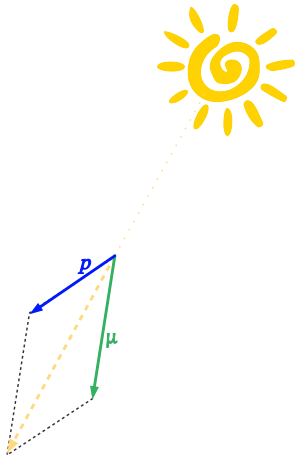
We can be producing Dark matter in the same facilities where we produce neutrinos (neutrino beam targets, atmosphere)

- "portal" concept
- an arbitrary Dark Matter world
- interacts with Standard Model via a single weak mediator
- may be Higgs-related, (dark) photon, (right-handed) neutrino (30 pages)



Major experimental features: cosmogenic sources

- 100% duty cycle: we don't know when DM interaction could happen
- point to source: reconstruction of incoming particle direction
  - low threshold: don't miss anything
  - can manage high multiplicity for large DM mass
- scintillator: fast, good energy resolution
- water: large, threshold hides heavies (protons)
- LArTPC: detailed view of high multiplicity interactions, secondary interaction vertex resolution
- environment air, water, ice: the largest, but sparse

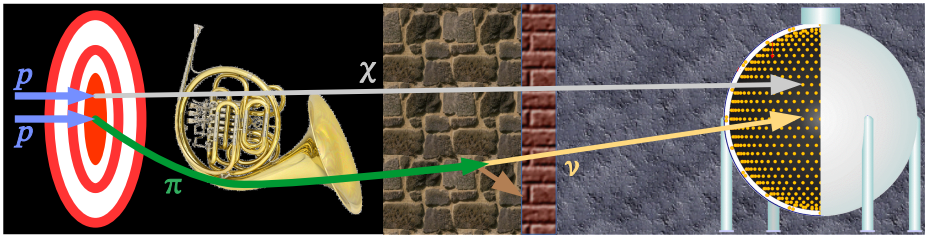


Reconstruction of incoming particle direction.

Major experimental features: neutrino beams

Fora a competitive search for Dark Matter in neutrino beams:

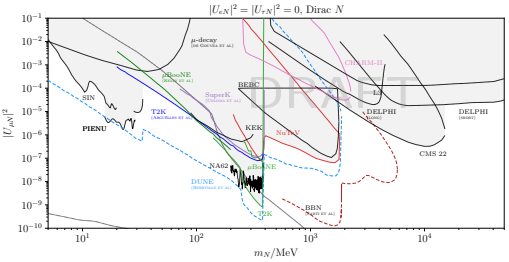
- high beam intensity is essential
- neutrinos are background: special runs with no neutrino "focussing" are better
- moving off-beam also reduces neutrino "contamination"
- pulsed beams help rejecting neutrino background



Neutrino background can be reduced by not focussing (or diverting) pions.

Summary

- we are interested in the use of neutrino detectors for dark matter
- Dark Matter detection signatures are often similar to neutrinos'
- there are cases where they are competitive because of size, thresholds or resolution
- the game is getting tough, with stringent limits (to which these detectors already contribute)



Constraints on mixing of heavy neutrino with mass m_N and μ.