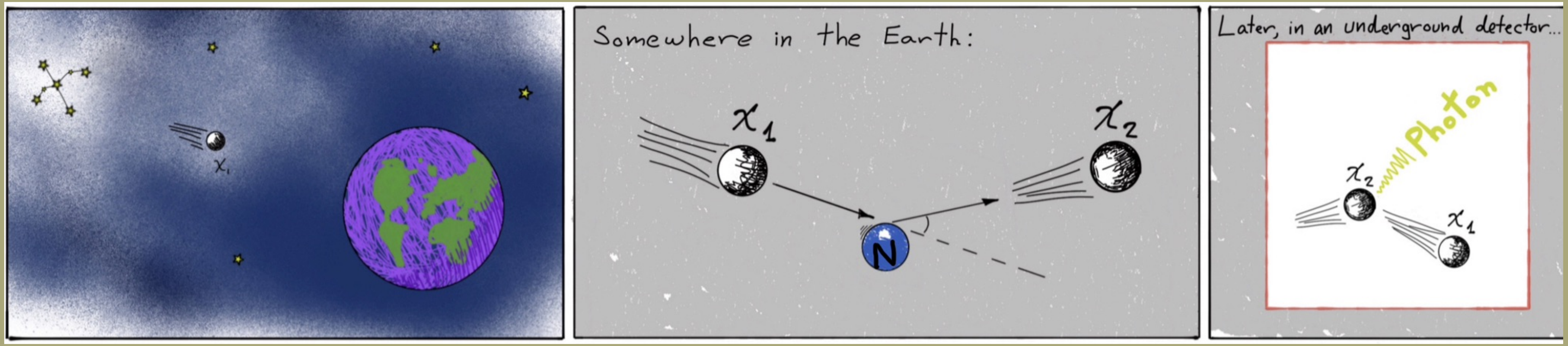
Earth-Catalyzing Detection of Magnetic Inelastic Dark Matter



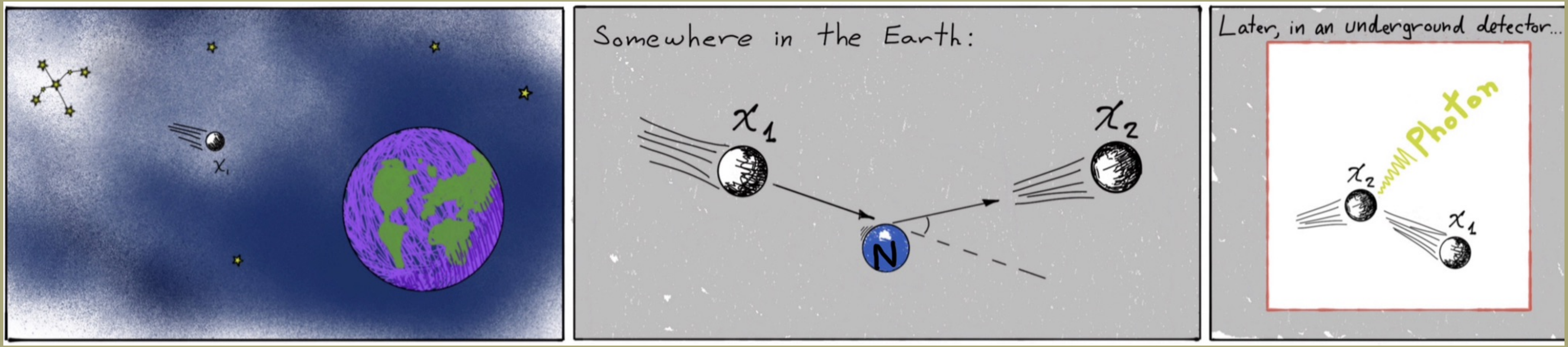
Graham Kribs
University of Oregon

1904.09994 (JHEP) and work in preparation

with
Josh Eby
Patrick Fox
Roni Harnik

Key Idea

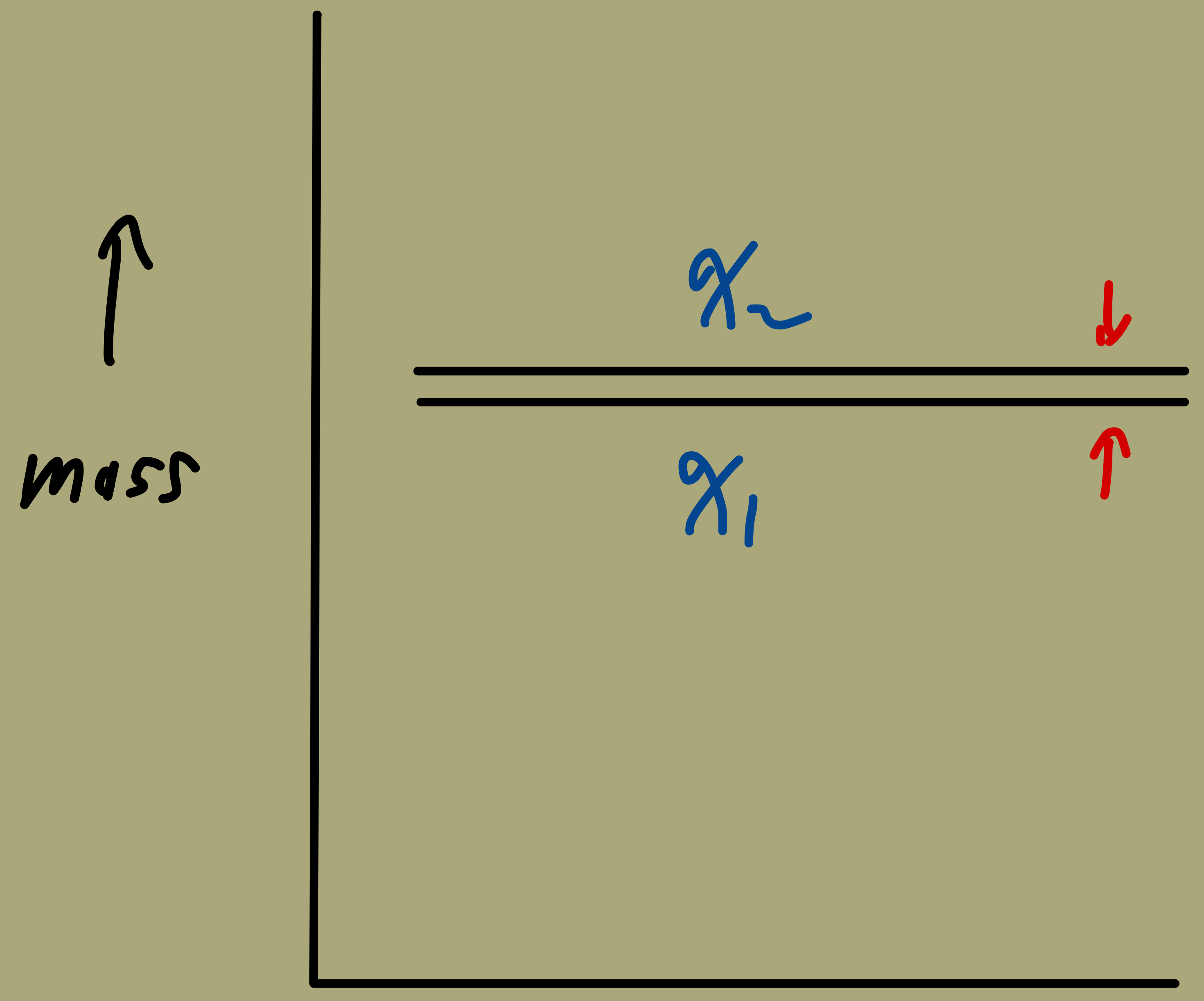
Use the entire Earth as an upscatter target for "magnetic inelastic dark matter".



Inelastic Dark Matter

[Han, Hempling; Hall, Moroi, Murayama; Tucker-Smith, Weiner ...]

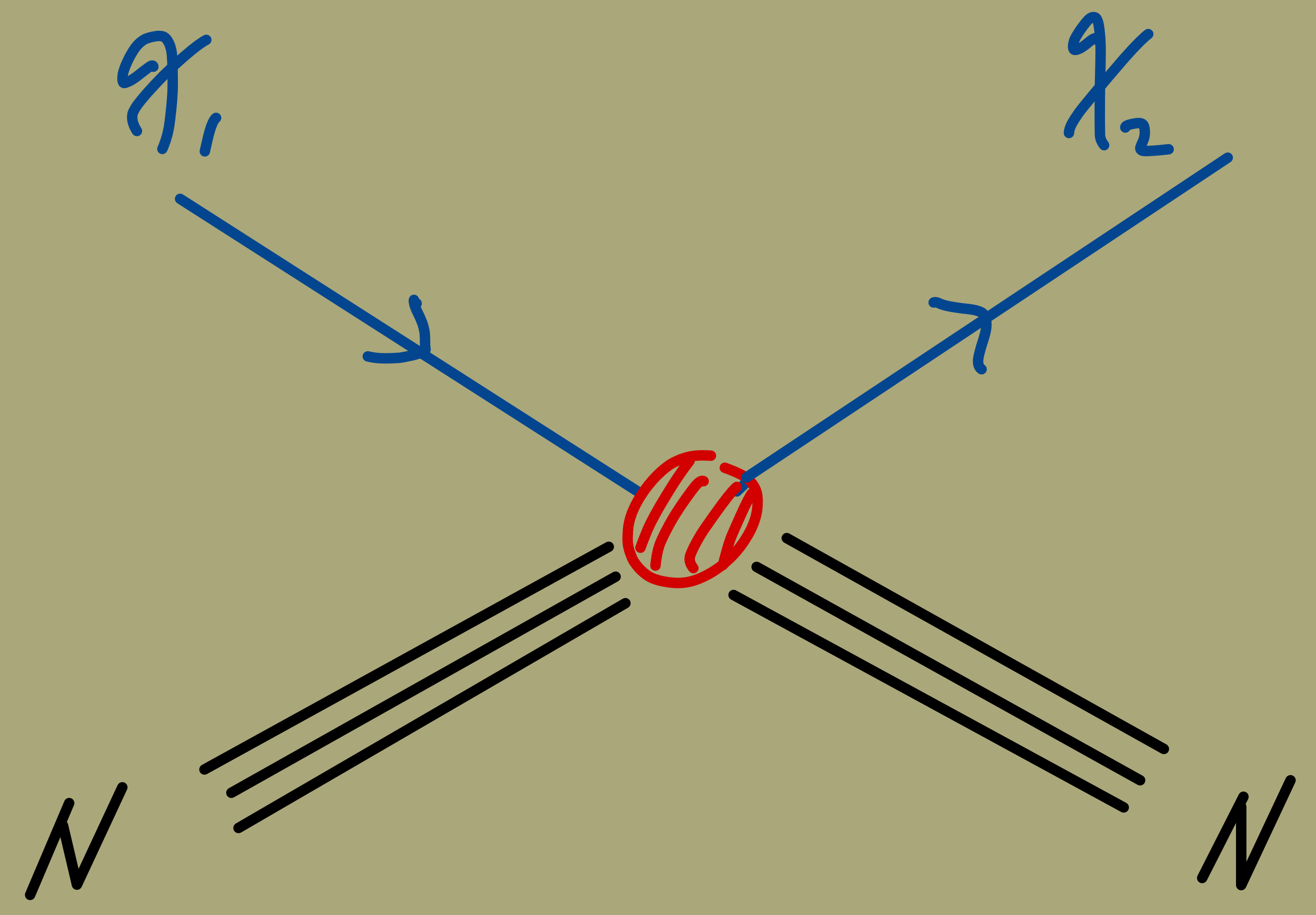
Model with dark matter (χ_1) and excited state (χ_2):



$\delta = m_2 - m_1$

$\sim \mathcal{O}(10\text{s}-100\text{s keV})$

Scattering proceeds dominantly through inelastic upscatter:

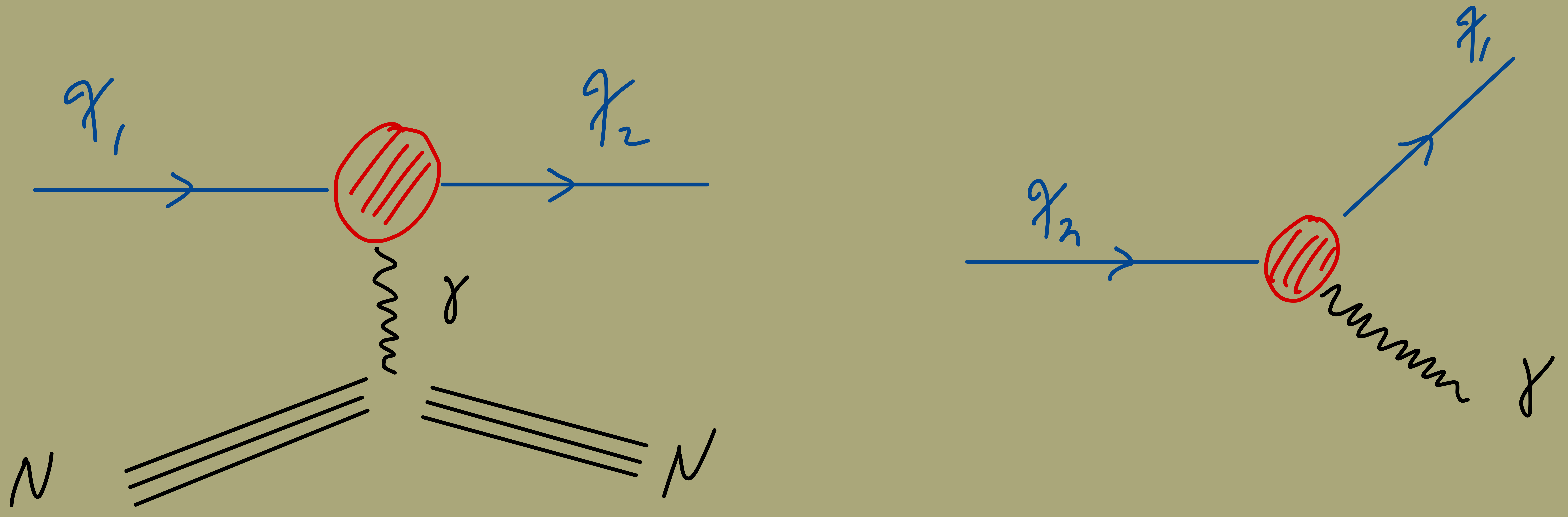


Magnetic Inelastic Dark Matter

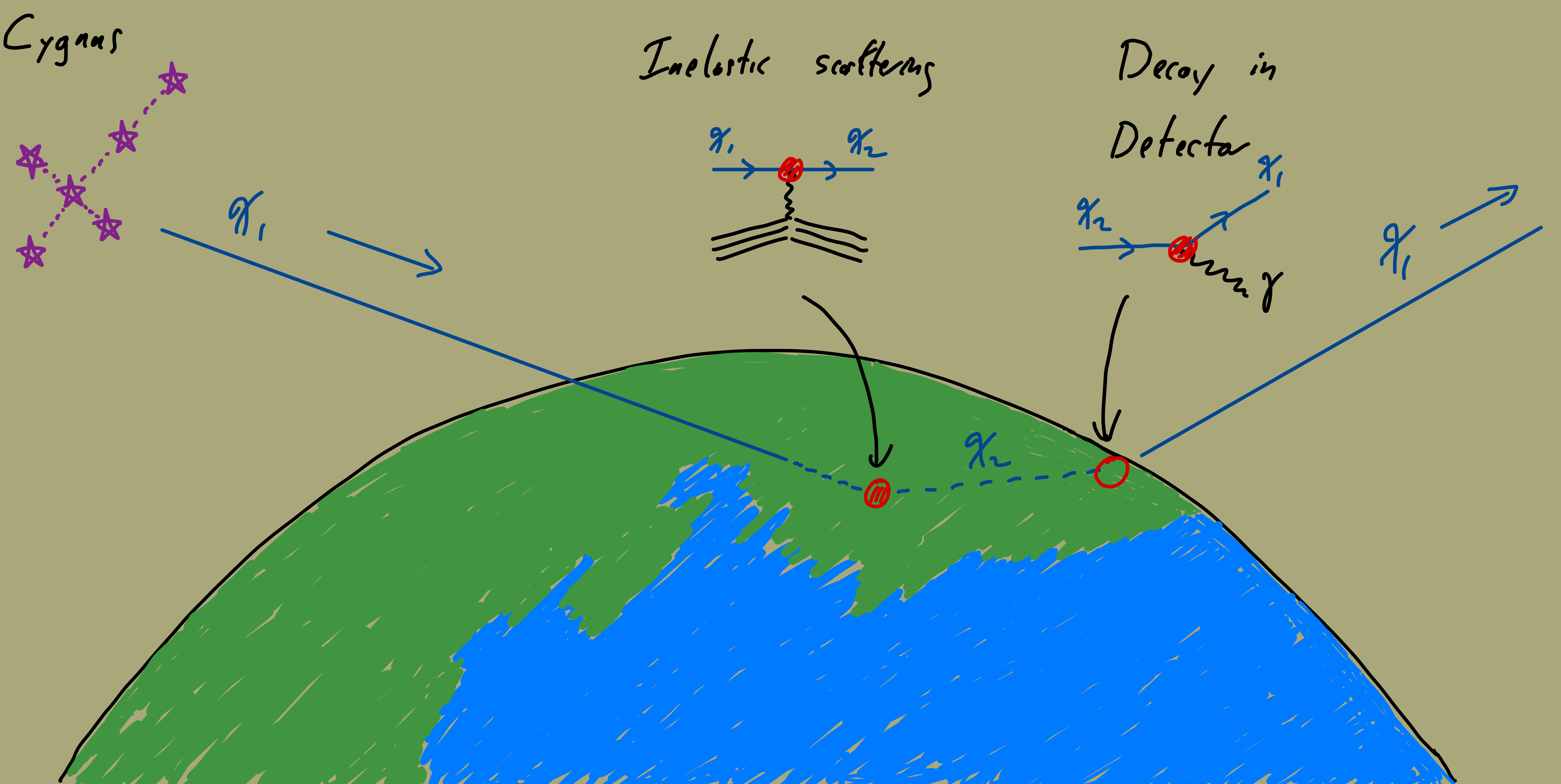
[Chang, Weiner, Yavin]

$$\Delta \mathcal{L} = g_M \frac{e}{8 m_\chi} \bar{\chi}_2 \sigma_{\mu\nu} \chi_1 F^{\mu\nu}$$

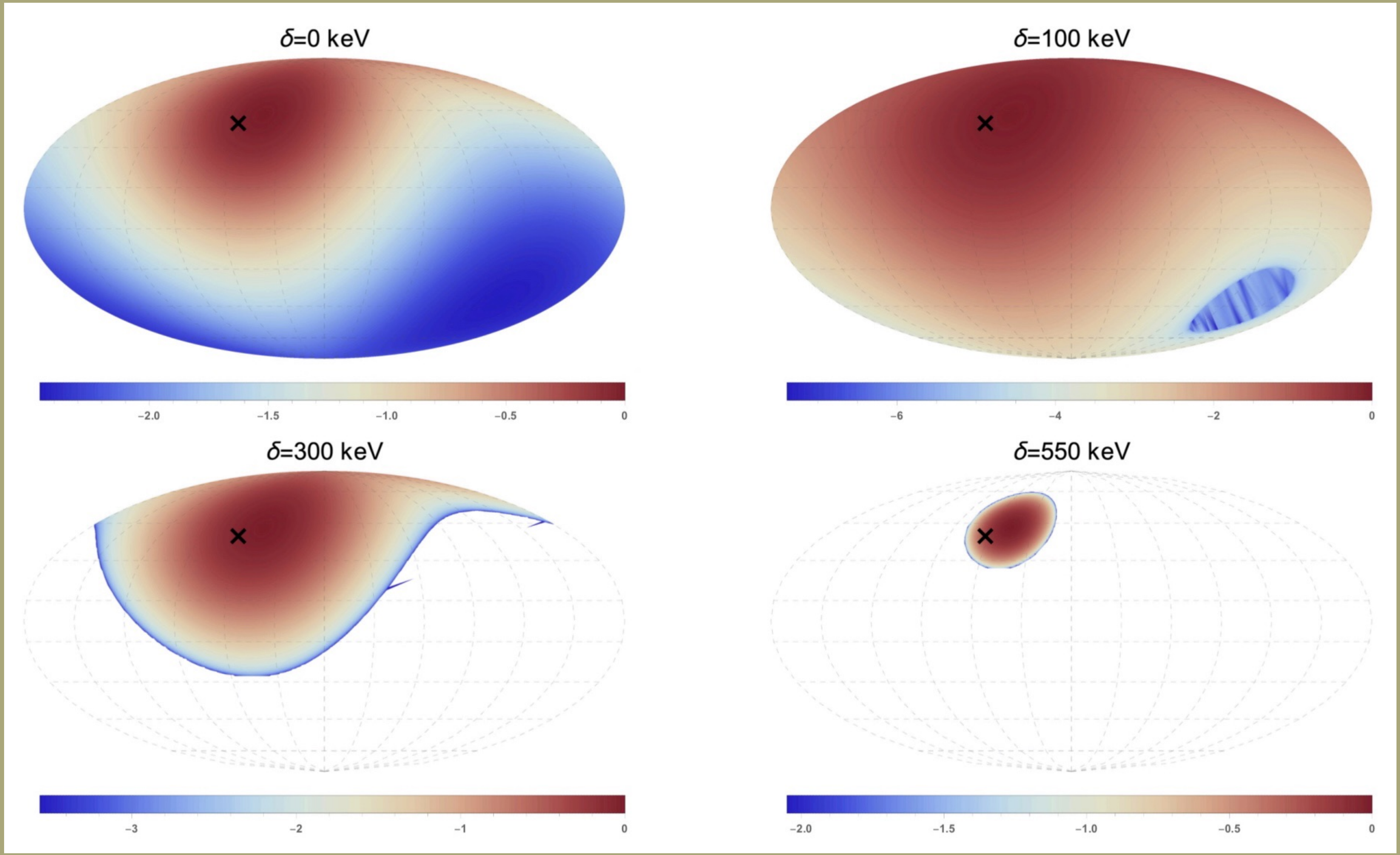
Upscatter and χ_2 decay through the same interaction:



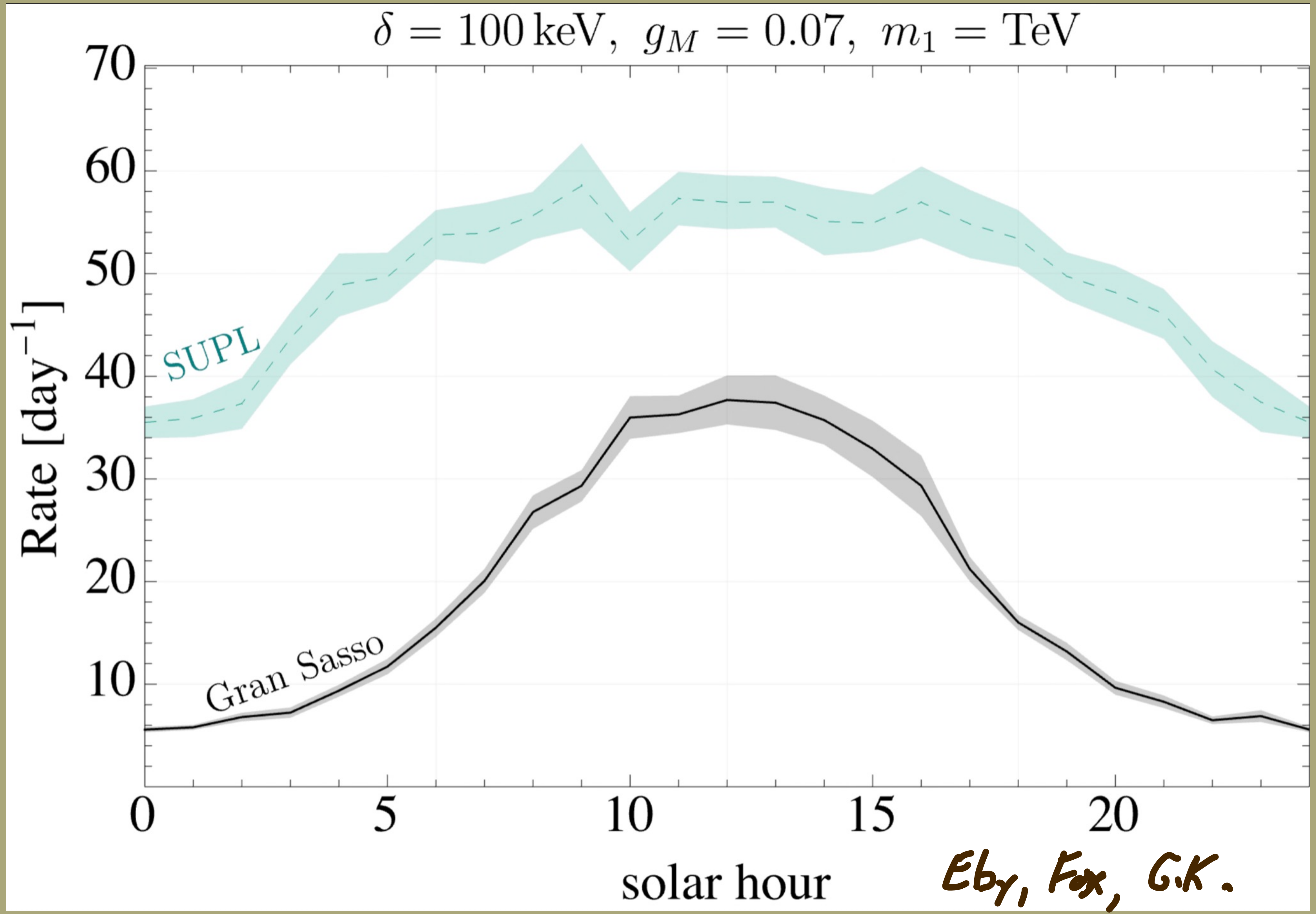
Monoenergetic Photon Signal



Directionality of (Inelastic) Dark Matter



Sidereal Daily Modulation



Outstanding method to separate signal from backgrounds.

Detection

Large volume (not mass) gaseous detector is ideal:

CYGNUS: Feasibility of a nuclear recoil observatory with directional sensitivity to dark matter and neutrinos

S. E. Vahsen,[1] C. A. J. O'Hare,[2] W. A. Lynch,[3] N. J. C. Spooner,[3] E. Baracchini,[4,5,6] P. Barbeau,[7] J. B. R. Battat,[8] B. Crow,[1] C. Deaconu,[9] C. Eldridge,[3] A. C. Ezeribe,[3] M. Ghrear,[1] D. Loomba,[10] K. J. Mack,[11] K. Miuchi,[12] F. M. Mouton,[3] N. S. Phan,[13] K. Scholberg,[7] and T. N. Thorpe[1,6]

[1] *Department of Physics and Astronomy, University of Hawaii, Honolulu, Hawaii 96822, USA*
[2] *The University of Sydney, School of Physics, NSW 2006, Australia*
[3] *Department of Physics and Astronomy, University of Sheffield, S3 7RH, Sheffield, United Kingdom*
[4] *Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, I-00040, Italy*
[5] *Istituto Nazionale di Fisica Nucleare, Sezione di Roma, I-00185, Italy*
[6] *Department of Astroparticle Physics, Gran Sasso Science Institute, L'Aquila, I-67100, Italy*
[7] *Department of Physics, Duke University, Durham, NC 27708 USA*
[8] *Department of Physics, Wellesley College, Wellesley, Massachusetts 02481, USA*
[9] *Department of Physics, Enrico Fermi Inst., Kavli Inst. for Cosmological Physics, Univ. of Chicago , Chicago, IL 60637, USA*
[10] *Department of Physics and Astronomy, University of New Mexico, NM 87131, USA*
[11] *Department of Physics, North Carolina State University, Raleigh, NC 27695, USA*
[12] *Department of Physics, Kobe University, Rokkodaicho, Nada-ku, Hyogo 657-8501, Japan*
[13] *Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM 87545, USA*

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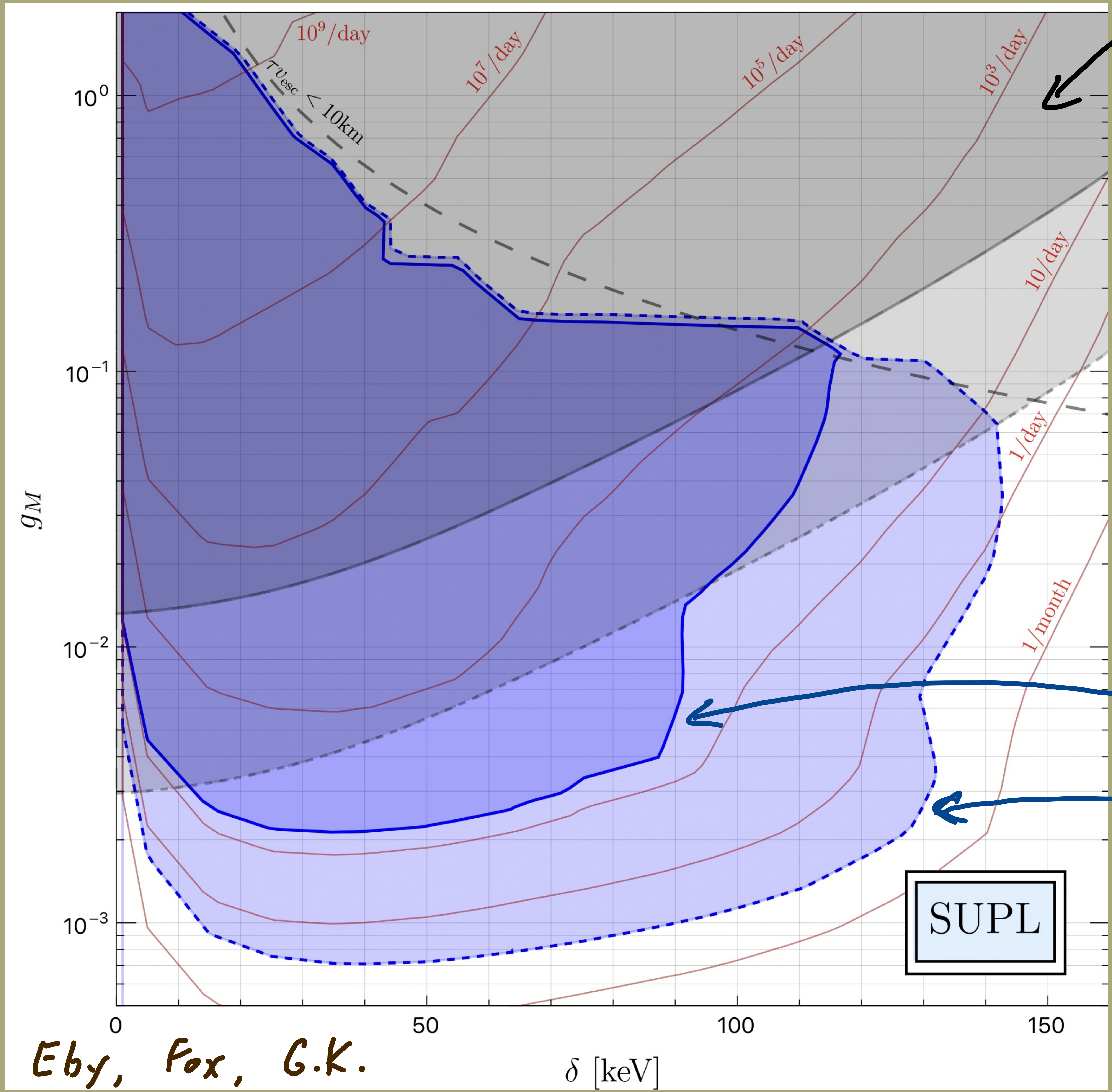
Now that conventional weakly interacting massive particle (WIMP) dark matter searches are approaching the neutrino floor, there has been a resurgence of interest in detectors with sensitivity to nuclear recoil directions. A large-scale directional detector is attractive in that it would have sensitivity below the neutrino floor, be capable of unambiguously establishing the galactic origin of a purported dark matter signal, and could serve a dual purpose as a neutrino observatory. We present the first detailed analysis of a 1000 m^3-scale detector capable of measuring a directional nuclear recoil signal at low energies. We propose a modular and multi-site observatory consisting of time projection chambers (TPCs) filled with helium and SF_6 at atmospheric pressure. By comparing

Projected Sensitivity



Eby, Fox, G.K.

L2 ruled out now

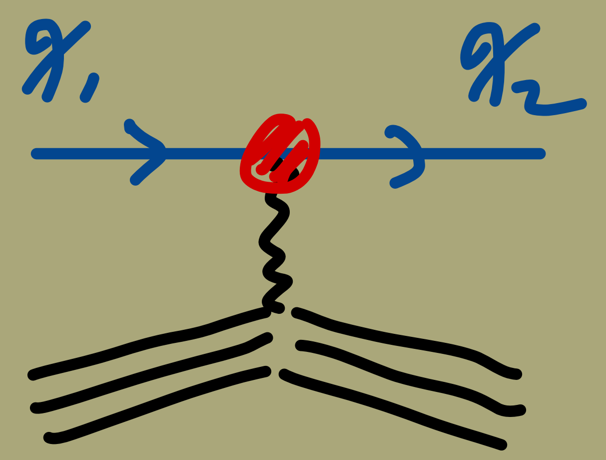
L2 maybe sensitive

CYGNUS daily modulation sensitivity 1000 m^3 + few years running:

a) as proposed

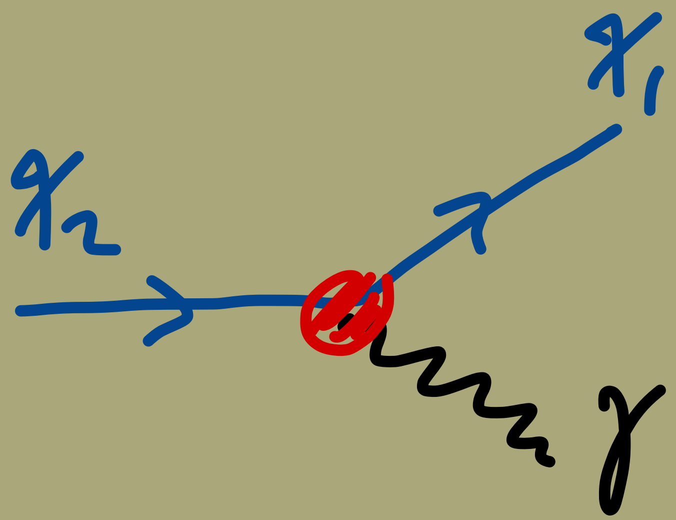
b) optimized for negligible backgrounds

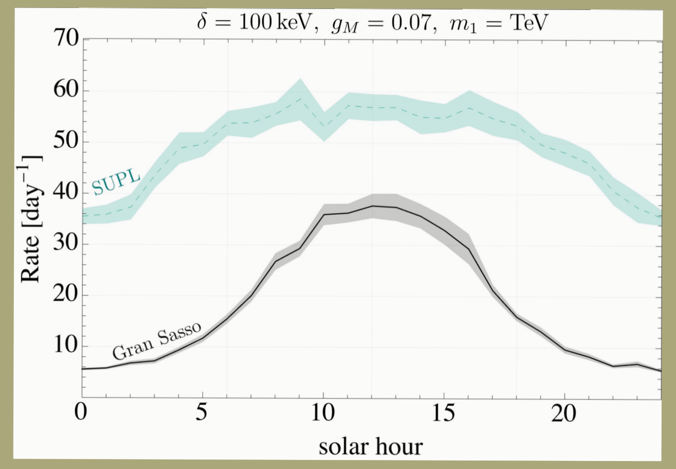
Conclusions

- 

leads to qualitatively new signals of DM

- Entire  can be utilized as an upscatter target

- Observe 

with sidereal daily modulation 

- CYGNUS - 1000 m^3 sensitivity exceeds LZ nuclear upscatter