

Rabi & My (Ad)Venture in Particle Physics (th.+exp.)

Xiangdong Ji, UMD

Rabi Fest, MCFP, UMD

Oct. 20, 2022

A nuclear theorist

- Quantum many-body physics
- Deep-inelastic scattering
- Nucleon structure
- Form factors
- Proton spin & mass
- QCD Factorization
- Lattice QCD
-

Collaboration with Rabi in 2005-2013

An SO(10) GUT model with lopsided mass matrix and neutrino mixing angle θ_{13}

Xiang-dong Ji (Maryland U.), Ying-chuan Li (Maryland U.), R.N. Mohapatra (Maryland U.) (Oct, 2005)

Published in: *Phys.Lett.B* 633 (2006) 755-760 • e-Print: [hep-ph/0510353](https://arxiv.org/abs/hep-ph/0510353) [hep-ph]



pdf



DOI



cite



claim



32 citations

DOE/ER/40762-352

An SO(10) GUT Model With Lopsided Mass Matrix and Neutrino Mixing Angle θ_{13}

Xiangdong Ji,¹ Yingchuan Li,¹ and R. N. Mohapatra¹

¹*Department of Physics, University of Maryland, College Park, Maryland 20742*

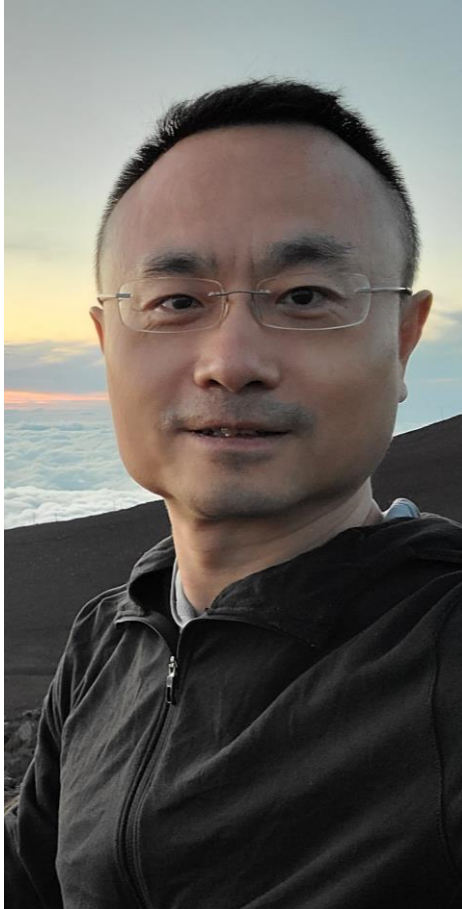
(Dated: October 15, 2018)

Abstract

An alternative supersymmetric SO(10) grand unification model with lopsided fermion mass matrices is introduced. It generates a large solar-neutrino-mixing angle through the neutrinos' Dirac mass matrix constrained by the SO(10) group structure, avoiding the fine-tuning required in the Majorana mass matrix of right-handed neutrinos. The model fits well the known data on masses and mixings of quarks and leptons, and predicts a sizable lepton mixing $\sin^2 2\theta_{13} \simeq 0.074$, which is significantly larger than that of the original lopsided model.

$$\sin^2(2\vartheta_{13}) = 0.093 \pm 0.008$$

Dr. Yingchuan Li, Amazon, AI Division



Hi Rabi, I felt very lucky to get the chance to work with you in the early days. What I have learned from you is not limited to physics, but also the way to approach problems without preset boundaries. Even though I have moved to another field, this learning has played the most crucial role in my everyday work.

- Enjoy retirement, a new adventure begins! :)
- Wish you the best, Yingchuan

Collaboration with Rabi in 2005-2013

Leptogenesis in Realistic SO(10) Models

Xiang-dong Ji (Maryland U. and Peking U.), Ying-chuan Li (Maryland U.), R.N. Mohapatra (Maryland U.), S. Nasri (Maryland U.), Yue Zhang (Peking U.) (May, 2006)

Published in: *Phys.Lett.B* 651 (2007) 195-207 • e-Print: [hep-ph/0605088](https://arxiv.org/abs/hep-ph/0605088) [hep-ph]

 pdf  DOI  cite  claim

 23 citations

Right-handed quark mixings in minimal left-right symmetric model with general CP violation

Yue Zhang (Peking U. and Maryland U.), Haipeng An (Maryland U.), Xiangdong Ji (Maryland U.), R.N. Mohapatra (Maryland U.) (Apr, 2007)

Published in: *Phys.Rev.D* 76 (2007) 091301 • e-Print: [0704.1662](https://arxiv.org/abs/0704.1662) [hep-ph]

 pdf  DOI  cite  claim

 76 citations

General CP Violation in Minimal Left-Right Symmetric Model and Constraints on the Right-Handed Scale

[Yue Zhang](#) (Peking U. and Maryland U.), [Haipeng An](#) (Maryland U.), [Xiangdong Ji](#) (Maryland U. and Peking U.), [Rabindra N. Mohapatra](#) (Maryland U.) (Dec, 2007)

Published in: *Nucl.Phys.B* 802 (2008) 247-279 • e-Print: [0712.4218](#) [hep-ph]


 pdf  DOI  cite  claim

 224 citations

Light Higgs Mass Bound in SUSY Left-Right Models

[Yue Zhang](#) (Peking U. and Maryland U.), [Haipeng An](#) (Maryland U.), [Xiang-dong Ji](#) (Maryland U. and Peking U.), [Rabindra N. Mohapatra](#) (Maryland U.) (Apr, 2008)

Published in: *Phys.Rev.D* 78 (2008) 011302 • e-Print: [0804.0268](#) [hep-ph]


 pdf  DOI  cite  claim

 47 citations

A Model With Dynamical R-parity Breaking and Unstable Gravitino Dark Matter

[Xiangdong Ji](#) (Maryland U. and Peking U.), [Rabindra N. Mohapatra](#) (Maryland U.), [Shmuel Nussinov](#) (Tel Aviv U.), [Yue Zhang](#) (Peking U. and Maryland U.) (Aug, 2008)

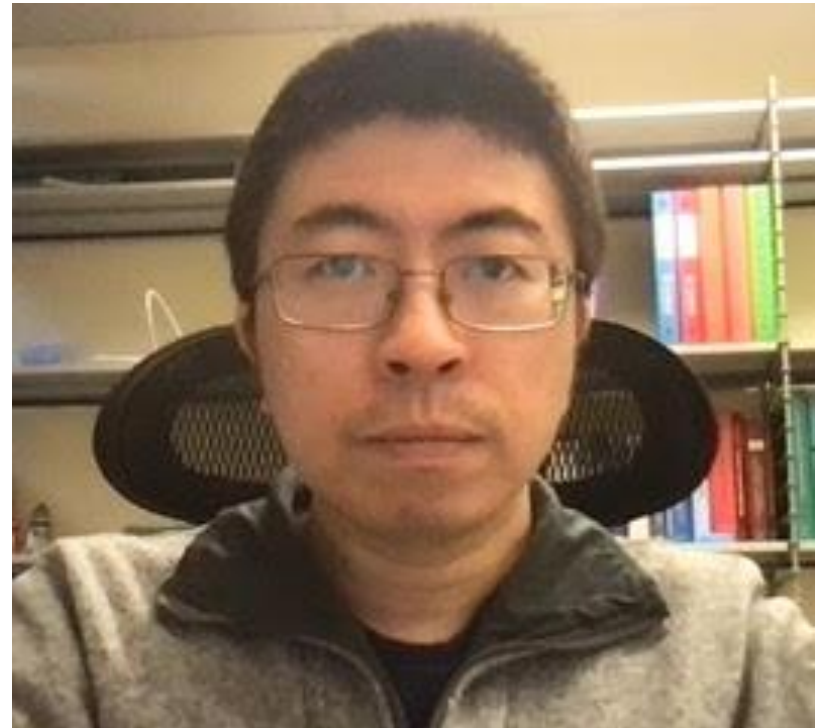
Published in: *Phys.Rev.D* 78 (2008) 075032 • e-Print: [0808.1904](#) [hep-ph]

 pdf  DOI  cite  claim

 20 citations

Yue Zhang, Assistant Prof. Carleton University, Canada

- Rabi: Congratulations to your great achievements in physics. They always inspire me to stay curious and explore the unknown. Working with you in Maryland belongs to the most exciting part of my journey. Enjoy retirement!



Haipeng An, Associate Prof., Tsinghua University

- “Hi Rabi, Congratulations on your fantastic achievements! I have learned a lot in collaborating with you and your class. Thank you!”

UMD-40762-471, UMD-PP-09-062, IC/2009/090

Leptogenesis as a Common Origin for Matter and Dark Matter

Haipeng An,¹ Shao-Long Chen,¹ Rabindra N. Mohapatra,¹ and Yue Zhang²

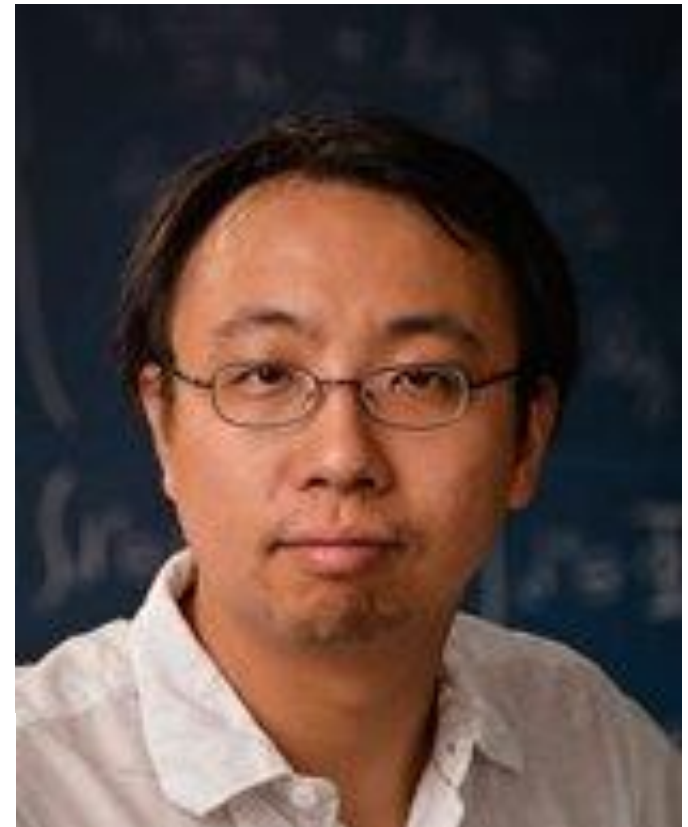
¹Maryland Center for Fundamental Physics and Department of Physics,
University of Maryland, College Park, Maryland 20742, USA

²The Abdus Salam International Centre for Theoretical Physics.

PRL **108**, 081806 (2012)

PHYSICAL REVIEW LETTERS

week ending
24 FEBRUARY 2012



Sneutrino Dark Matter in Gauged Inverse Seesaw Models for Neutrinos

Haipeng An,^{1,2} P. S. Bhupal Dev,¹ Yi Cai,³ and R. N. Mohapatra¹

¹Maryland Center for Fundamental Physics and Department of Physics, University of Maryland, College Park, Maryland 20742, USA

²Perimeter Institute, Waterloo, Ontario N2L 2Y5, Canada

³Department of Physics, Shanghai Jiao Tong University, Shanghai 200240, China

(Received 7 October 2011; revised manuscript received 17 November 2011; published 23 February 2012)

A Naturally Light Sterile neutrino in an Asymmetric Dark Matter Model

[Yongchao Zhang](#) (Maryland U. and Peking U., CHEP), [Xiangdong Ji](#) (Shanghai Jiaotong U. and Maryland U. and Peking U., CHEP), [Rabindra N. Mohapatra](#) (Maryland U.) (Jul 23, 2013)

Published in: *JHEP* 10 (2013) 104 • e-Print: [1307.6178](#) [hep-ph]

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 28 citations



YongChao Zhang
Professor @ Southeast
University, China)

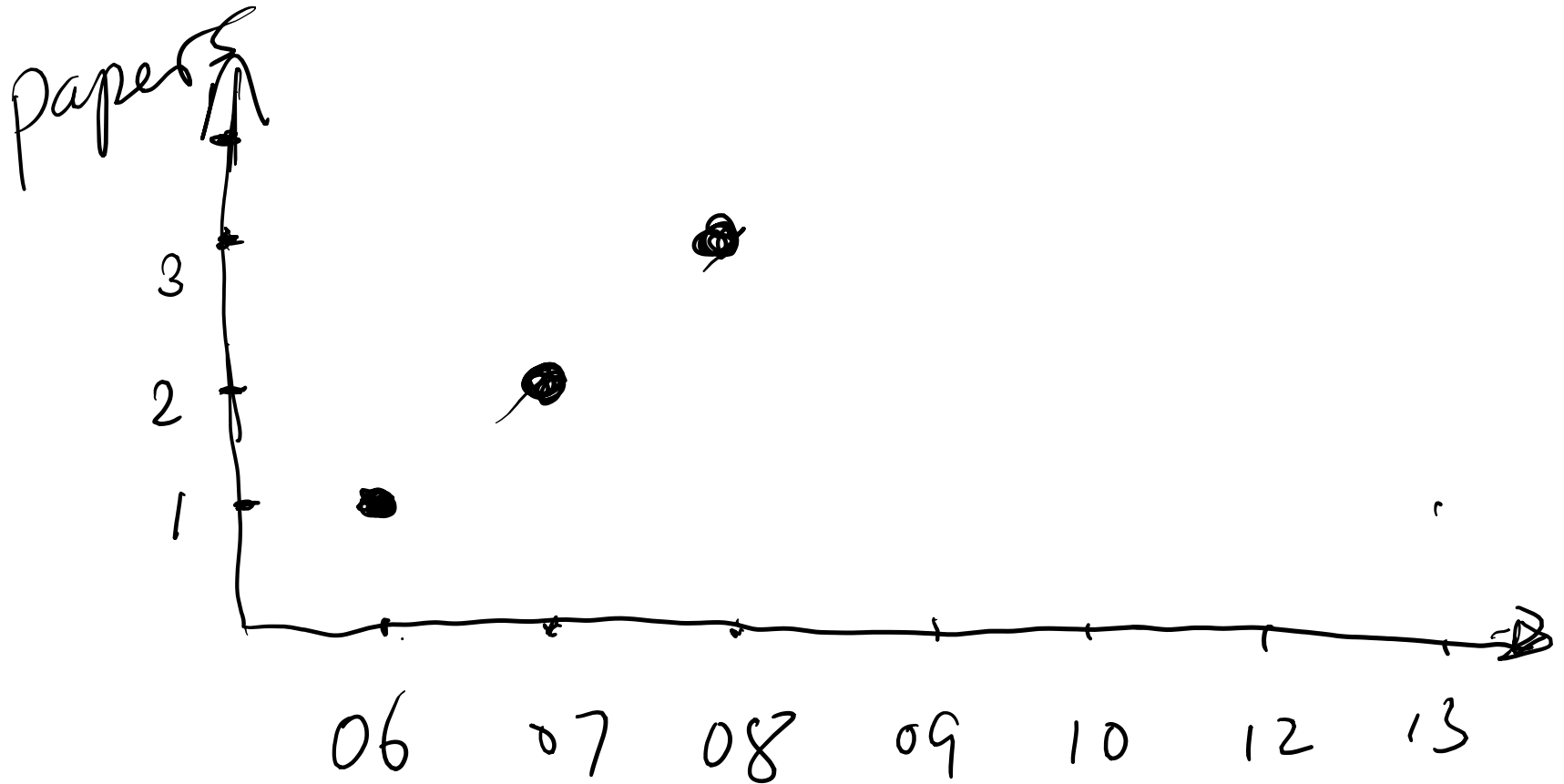
Congratulations & thanks to Rabi from Yongchao Zhang

Rabi's collaborators

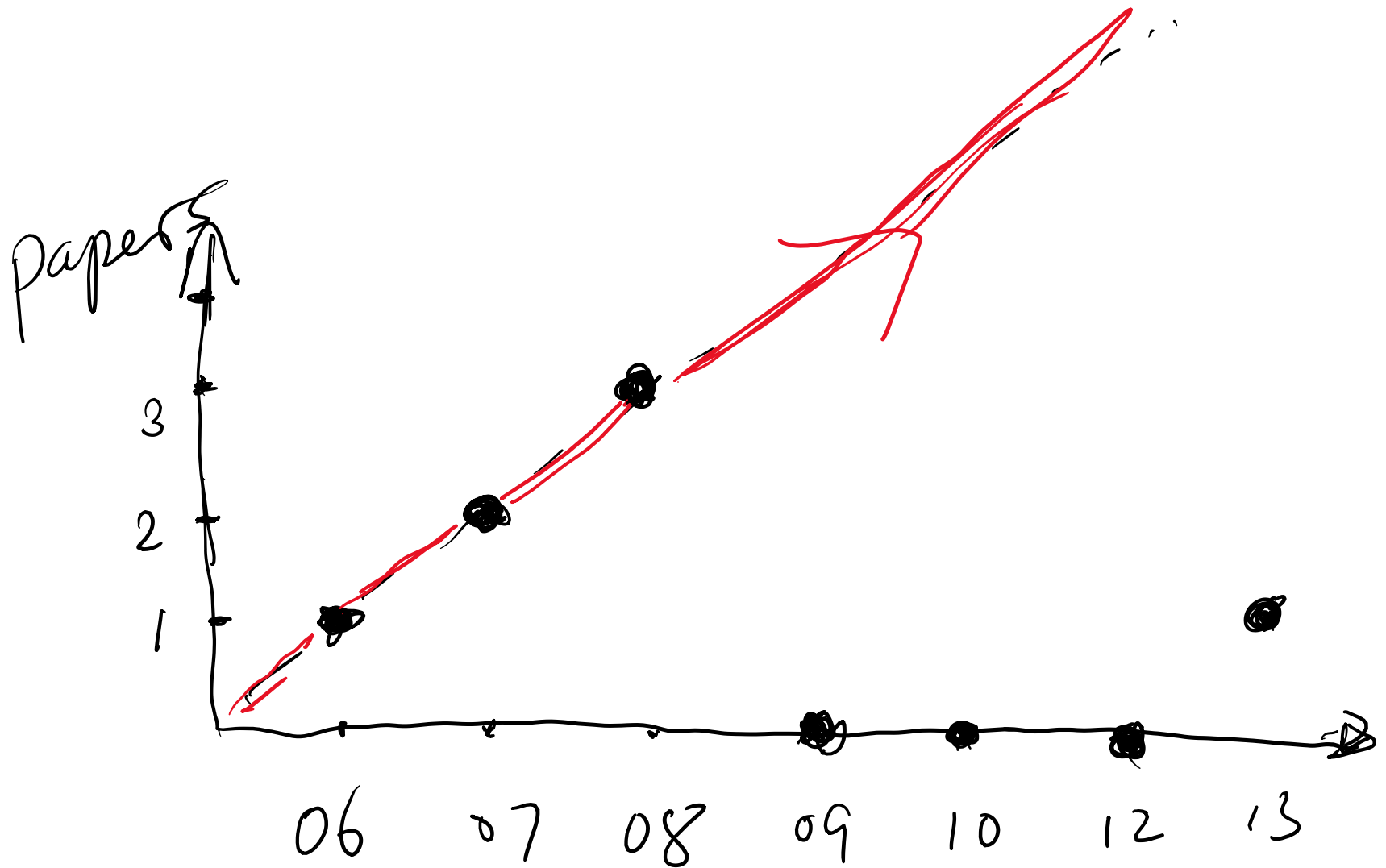
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<input type="checkbox"/> Yongchao Zhang	25
Including 2 PRL papers	
<input type="checkbox"/> Salah Nasri	15
<input type="checkbox"/> Mina K. Parida	12
<input type="checkbox"/> Robert E. Shrock	11
Show 90 more	

- I have been working with Rabi for almost 10 years, since I was a visiting student at Maryland in 2013/14.
- In the collaboration with Rabi, I have learnt too much on the left-right models, rich seesaw model phenomenologies, lepton flavor violation, stellar bounds on light particles, $n - n'$ oscillation etc.
- With Rabi, I have the chance to collaborate with many other colleagues, and finally got the faculty position in China.
- Looking forward to more fruitful collaborations with Rabi in the future.

Collaboration intensity



Collaboration intensity



A Model With Dynamical R-parity Breaking and Unstable Gravitino Dark Matter

Xiangdong Ji (Maryland U. and Peking U.), Rabindra N. Mohapatra (Maryland U.), Shmuel Nussinov (Tel Aviv U.), Yue Zhang (Peking U. and Maryland U.) (Aug, 2008)

Published in: *Phys.Rev.D* 78 (2008) 075032 • e-Print: 0808.1904 [hep-ph]

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 20 citations

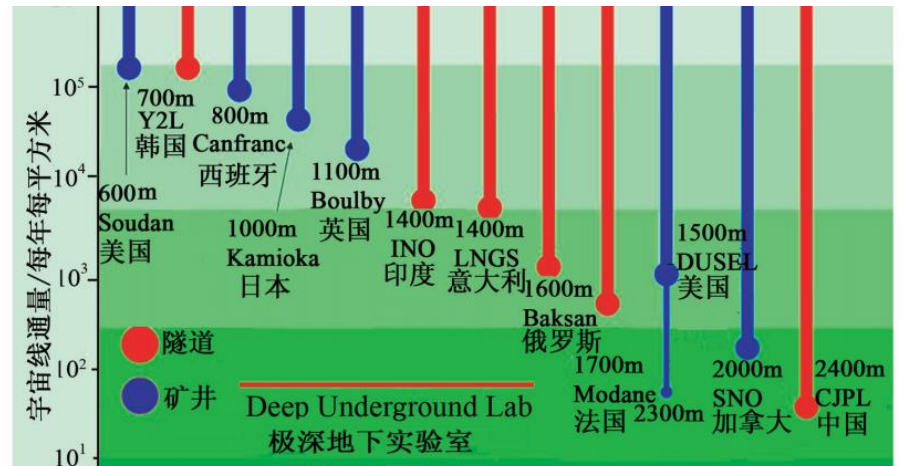
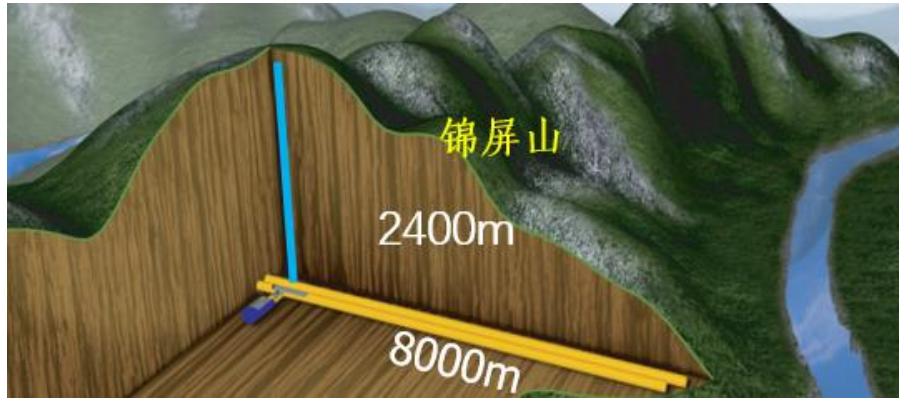
In 2009, initiated a collaboration to search for WIMP dark matter



- 🇨🇳 Shanghai Jiao Tong University (2009-)
- 🇨🇳 Peking University (2009-)
- 🇨🇳 Shandong University (2009-)
- 🇨🇳 Shanghai Institute of Applied Physics, CAS (2009-)
- 🇨🇳 University of Science & Technology of China (2015-)
- 🇨🇳 China Institute of Atomic Energy (2015-)
- 🇨🇳 Sun Yat-Sen University (2015-)
- 🇨🇳 Yalong Hydropower Company (2009-)
- 🇺🇸 University of Maryland (2009-)
- 🇺🇸 University of Michigan (2010-2016)

China Jinping Underground Laboratory

Deepest in the world ($1\mu/\text{week}/\text{m}^2$)
and Horizontal access!



March, 18, 2009



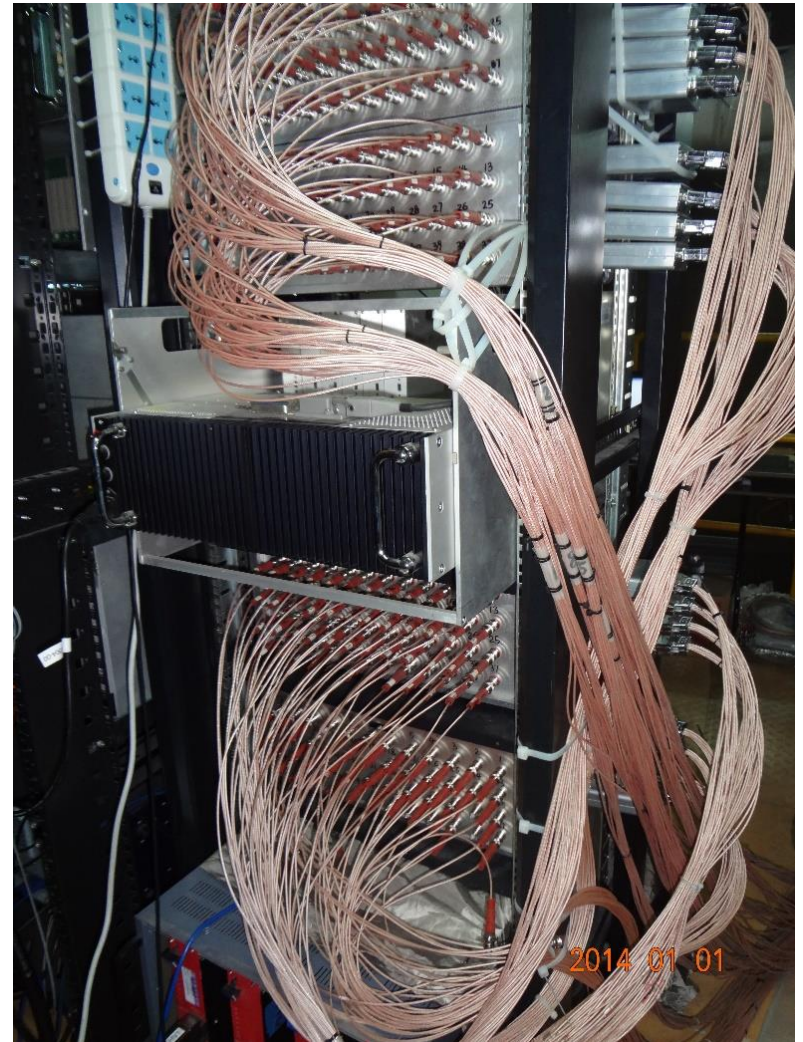
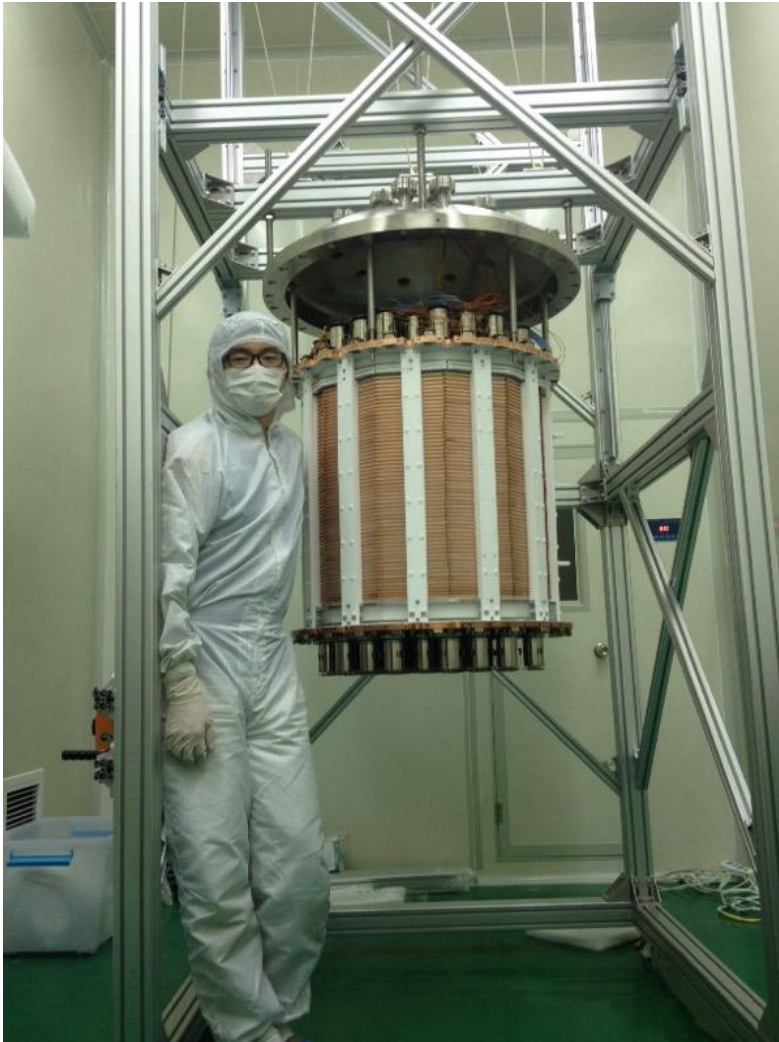
An expert in cryogenics?



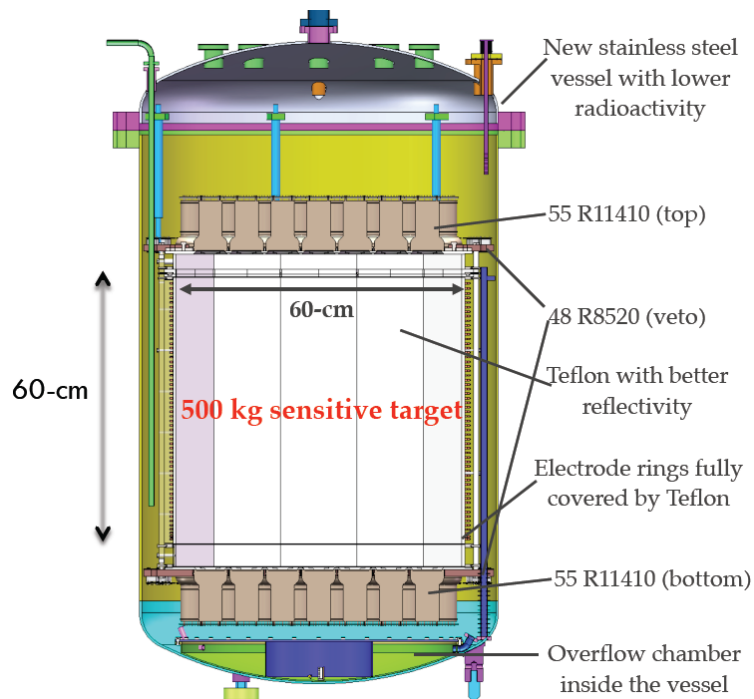
PandaX-II detector (2015)

Andi Tan, graduate student from UMD

Now a Dicke fellow at Princeton U. (Ptolemy Exp)



PandaX-II Detector



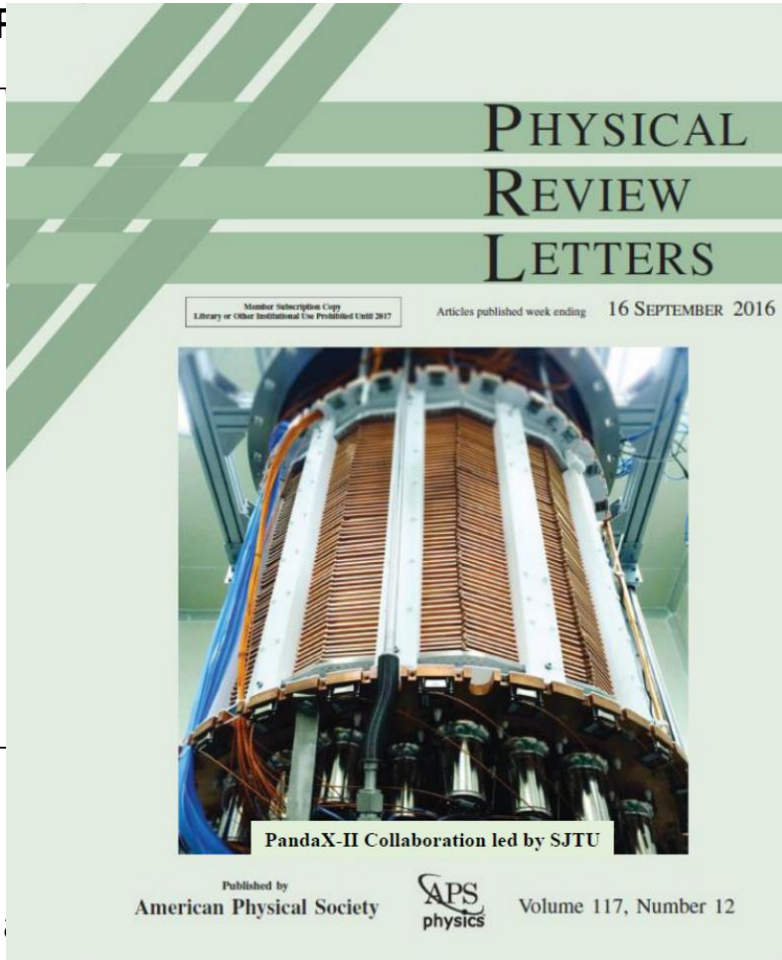
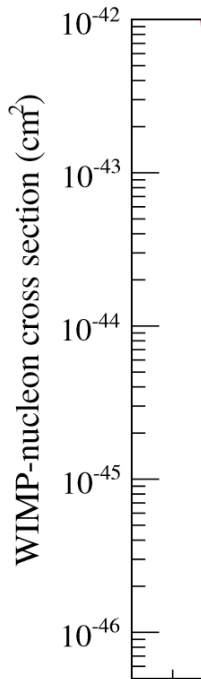
- 60 cm x 60 cm cylindrical TPC
- 580-kg of LXe in sensitive region, 1.2-ton LXe in total
- 55 top + 55 bottom R11410 3" target PMTs (split -ve and +ve HV)
- 24 top + 24 bottom R8520 1" VETO PMTs

PandaX-II experimental hall



SI cross section limit

90% limit (F

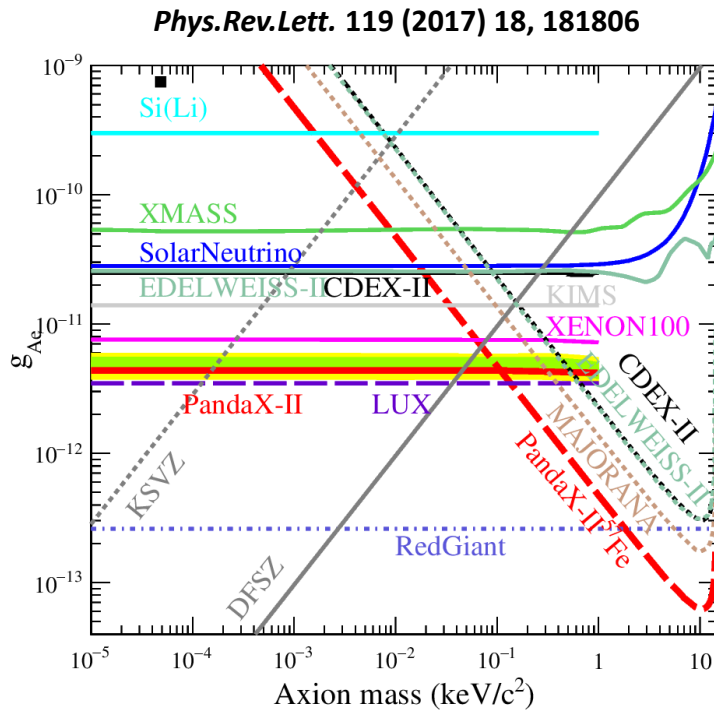


Released
2016

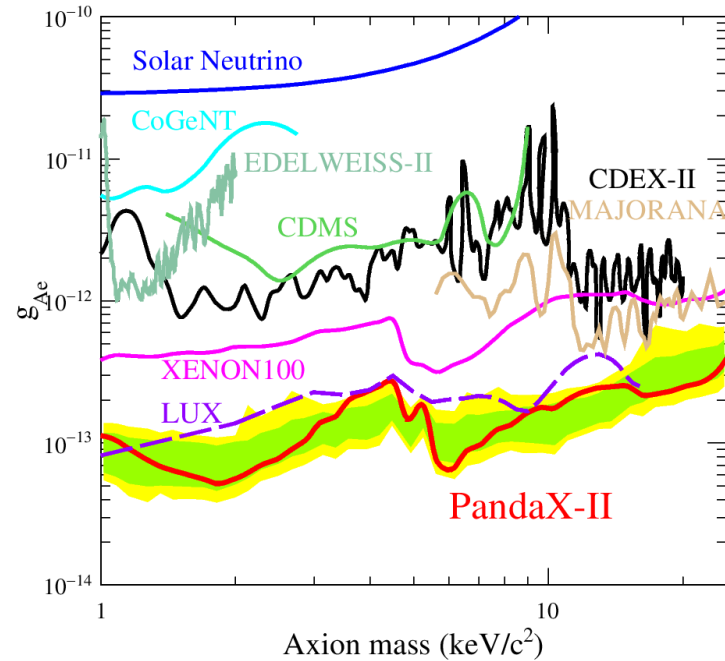
- Minimum exclusion:
 $2.5 \times 10^{-46} \text{ cm}^2$ @ 40
 GeV/c^2 , improved
x10 from run 8,
>x2 from LUX 2015
- This is the **first** low
background result
from PandaX-II, a
long life (~500 live-
day) ahead of this!

Axion search

Solar axions

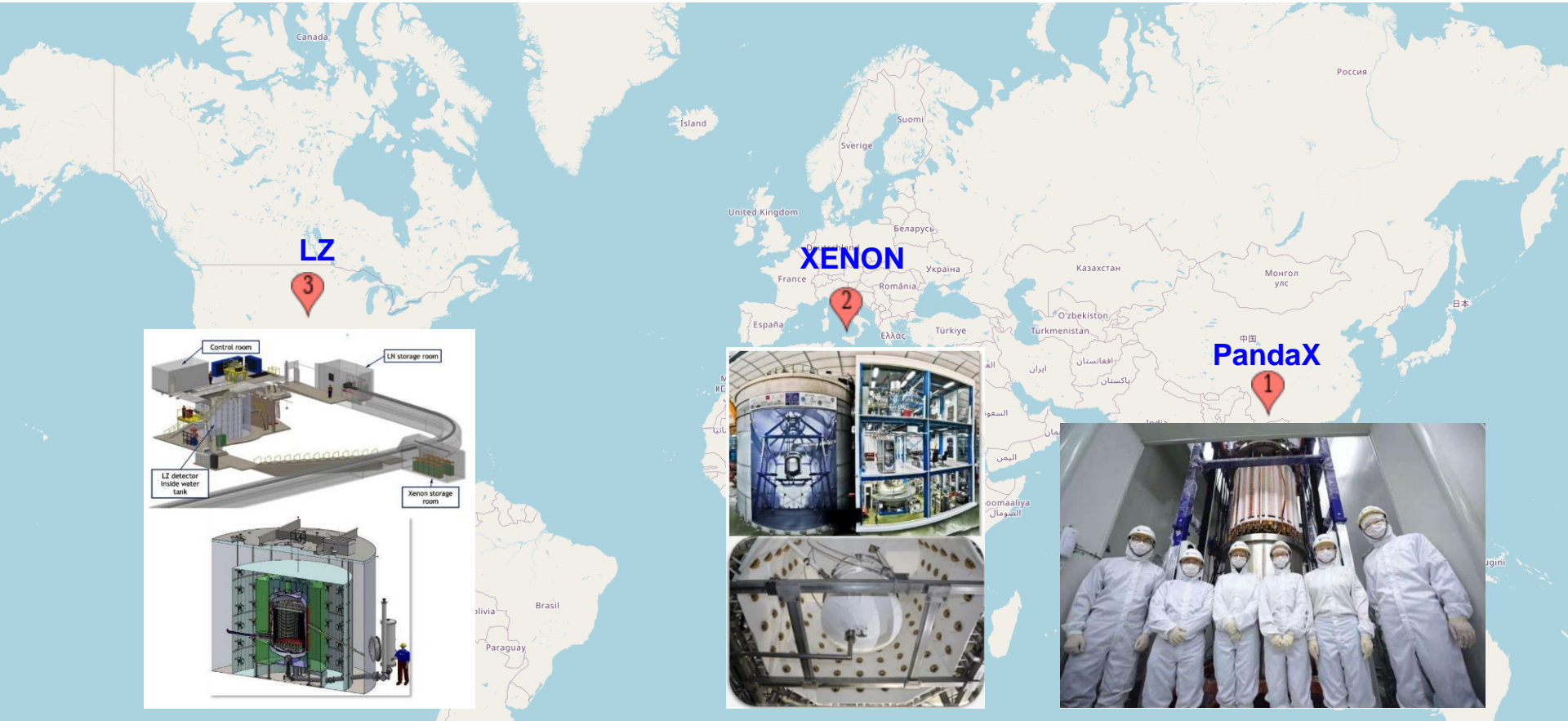


Galactic ALPs



Among the leading axion search on axion-electron coupling using direct detection experiments

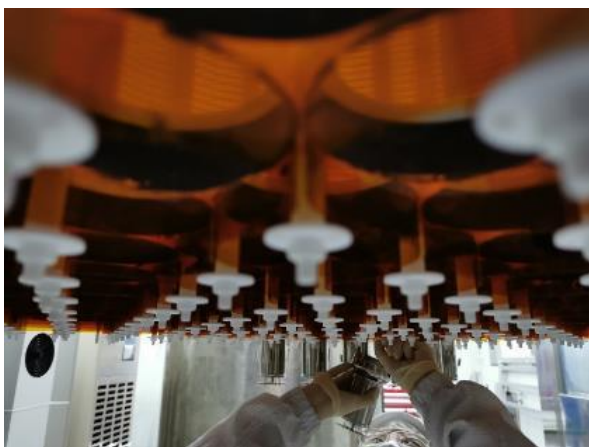
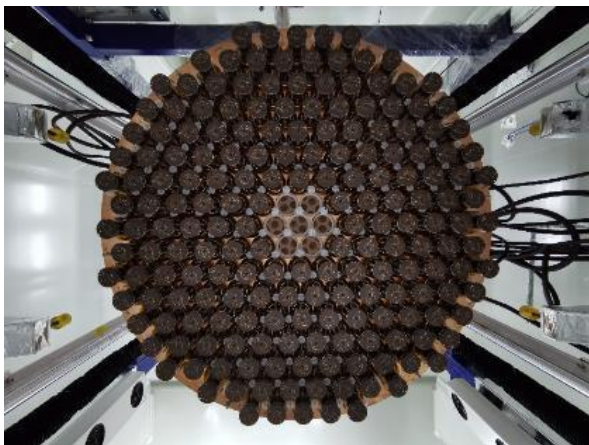
The big-three xenon DM experiments



上海交通大学PandaX暗物质与中微子实验平台



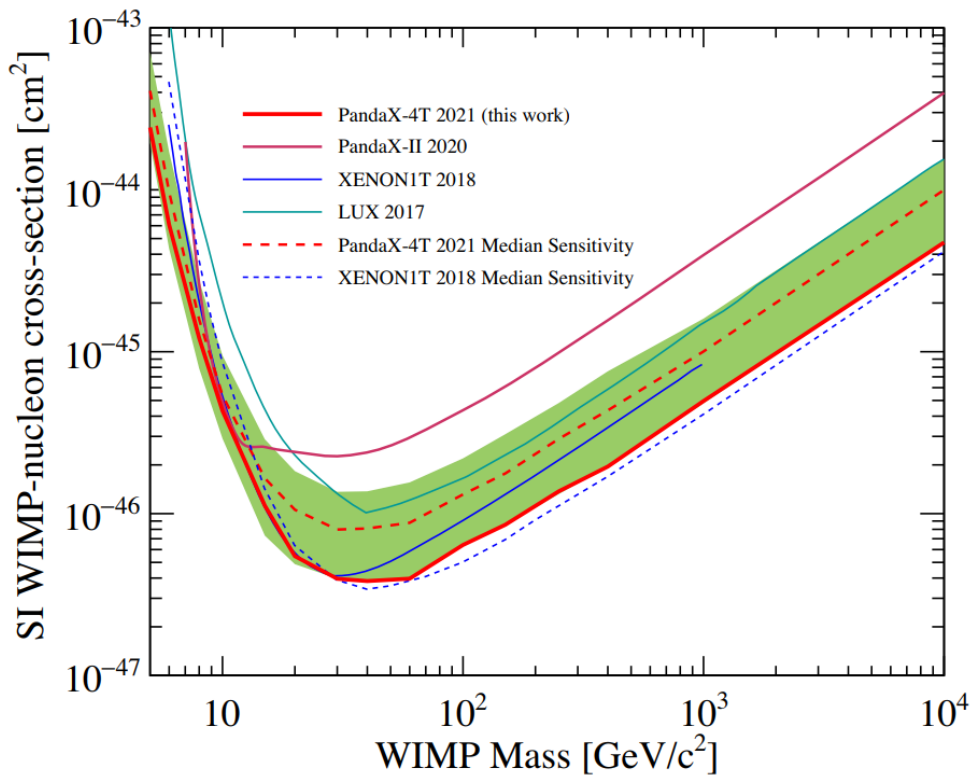
4T-TPC installation



Ultrapure water filling



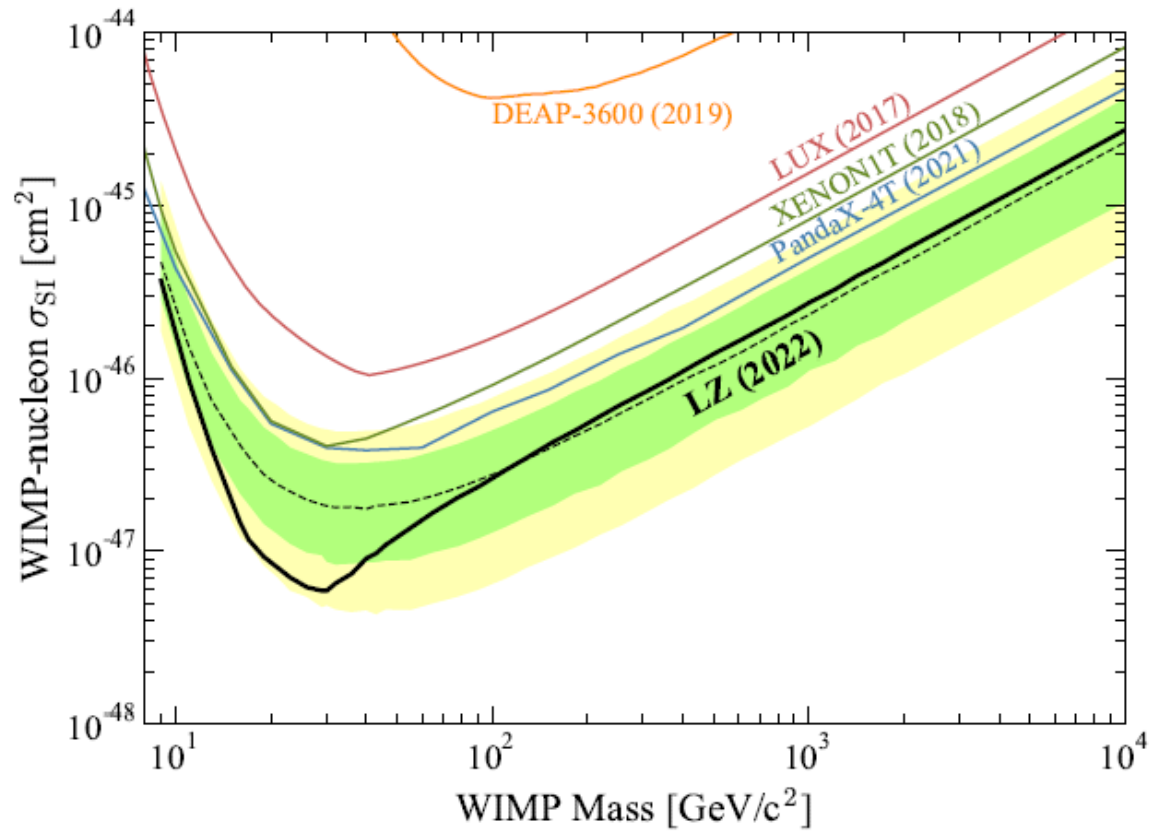
WIMP-nucleon SI exclusion limits



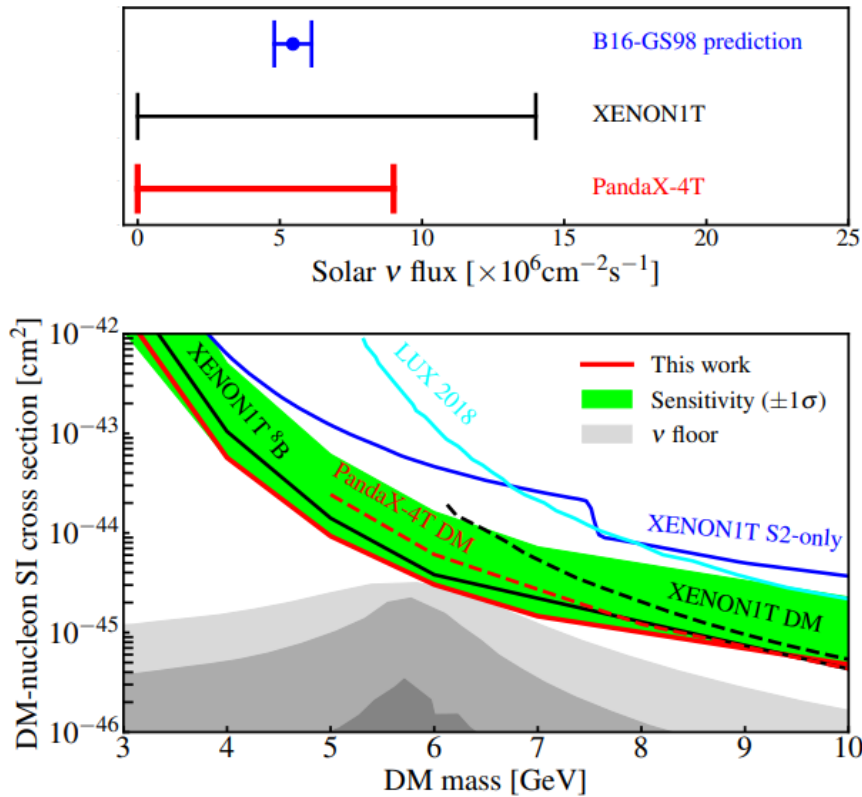
PRL 127, 261802 (2021)

- Exposure: 0.63 tonne•year
- Sensitivity improved from PandaX-II final analysis by **2.6** times (40 GeV/c²)
- Strongest exclusion limit to date (downward background fluctuation by -1σ)

LZ results in summer, 2022



^8B & low mass WIMP results



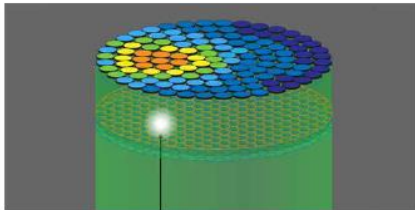
- Leading constraint on ^8B flux using coherent elastic neutrino nucleus scattering
- Can cast constraint on neutrino-nucleus interactions
- Assuming nominal ^8B background, also set tightest low mass WIMP-nucleon SI interaction limit between 5 and 10 GeV/c^2

This Week in *Physics Magazine* — October 17, 2022

RESEARCH NEWS

Potential Dark Matter Signal Gives Way to New Limits

October 13, 2022

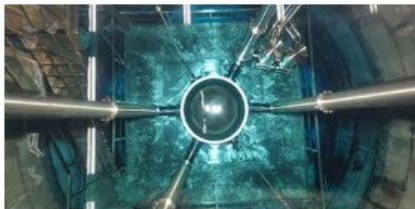


Results from two leading dark matter experiments—XENONnT and PandaX-4T—rule out an enigmatic signal detected in 2020 and set new constraints on dark matter particle candidates consisting of light fermions, respectively.

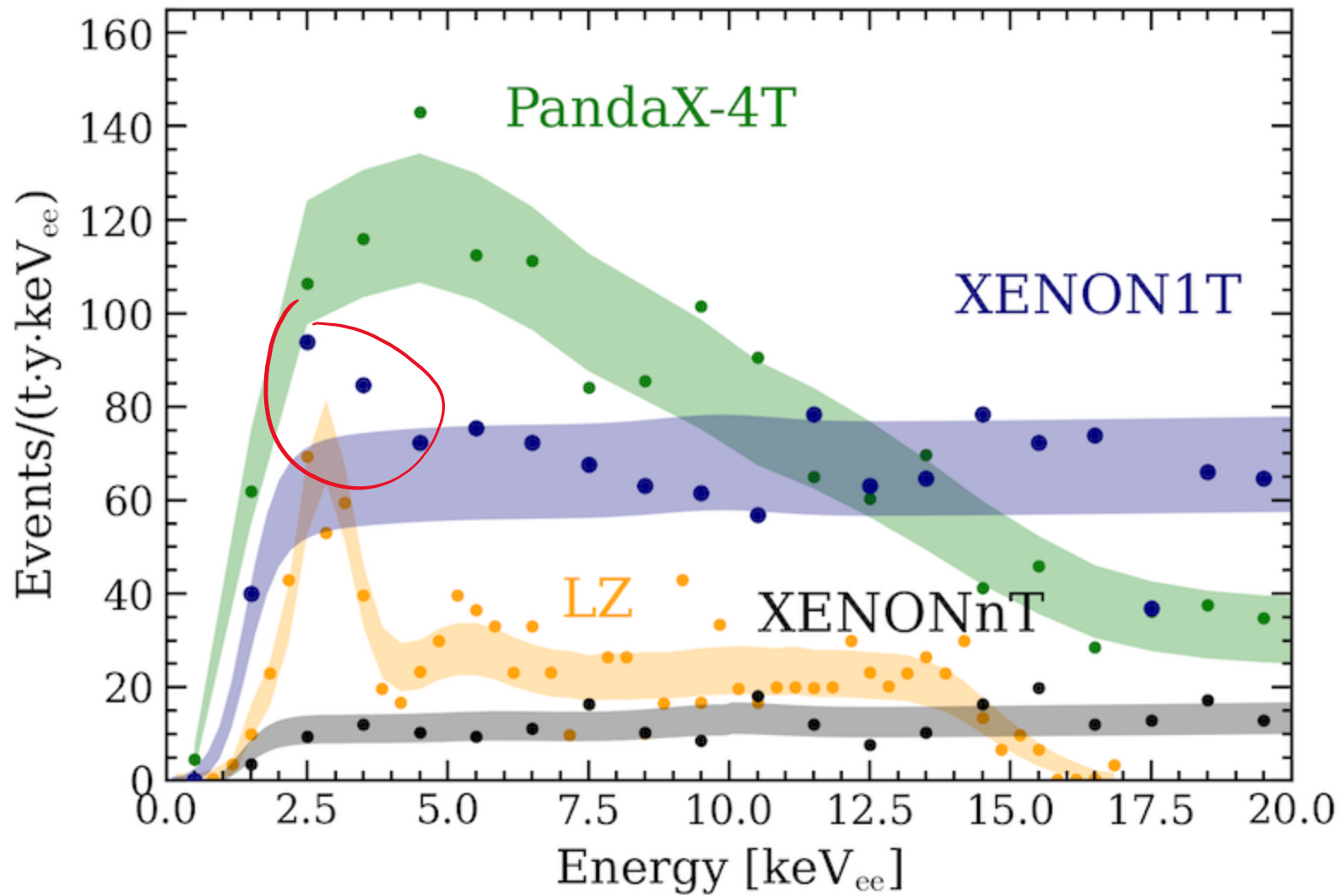
SYNOPSIS

An Absorbing Dark Matter Experiment

October 13, 2022

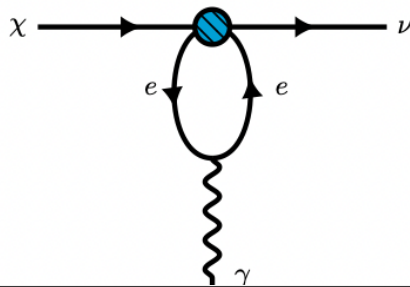


Researchers have analyzed the first data from a dark matter direct-detection experiment, searching for a form of dark matter known as fermionic dark matter via its absorption by nuclei.



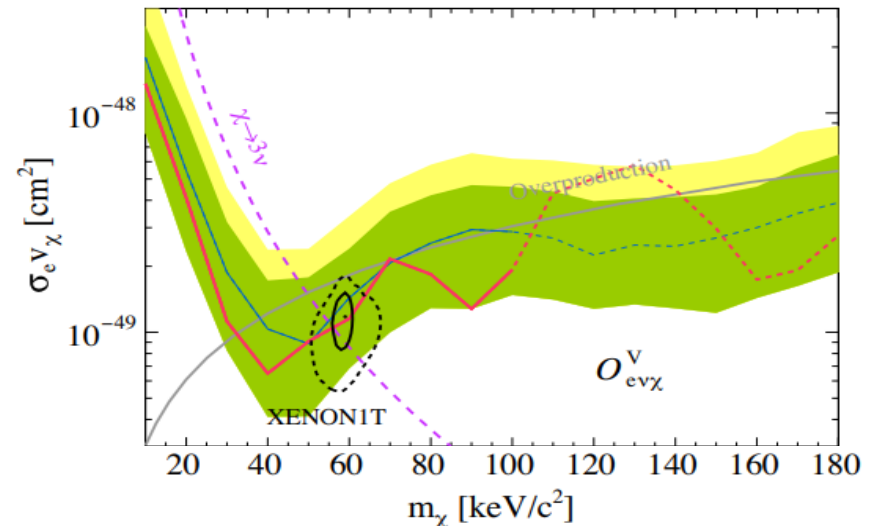
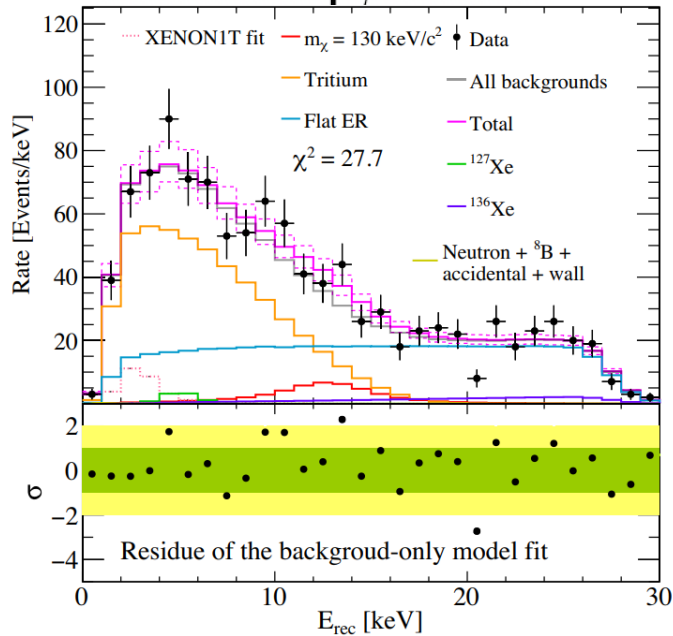
A light absorptive fermionic DM

D. Zhang *et al.* (PandaX Collaboration), “Search for light fermionic dark matter absorption on electrons in PandaX-4T,” **Phys. Rev. Lett. 129, 161804 (2022)**



$$\mathcal{O}_{e\nu\chi}^V \equiv (\bar{e}\gamma_\mu e)(\bar{\nu}_L\gamma^\mu\chi_L),$$

$$\mathcal{O}_{e\nu\chi}^A \equiv (\bar{e}\gamma_\mu\gamma_5 e)(\bar{\nu}_L\gamma^\mu\chi_L),$$



Absorption of Fermionic dark matter on Xe: $\tilde{\chi}^{(-)} + {}^A\text{Xe} \rightarrow \tilde{\nu}^{(-)} + {}^A\text{Xe},$

- L. Gu *et al.* (PandaX Collaboration), “First search for the absorption of fermionic dark matter with the PandaX-4T experiment,” **Phys. Rev. Lett. 129, 161803 (2022)**

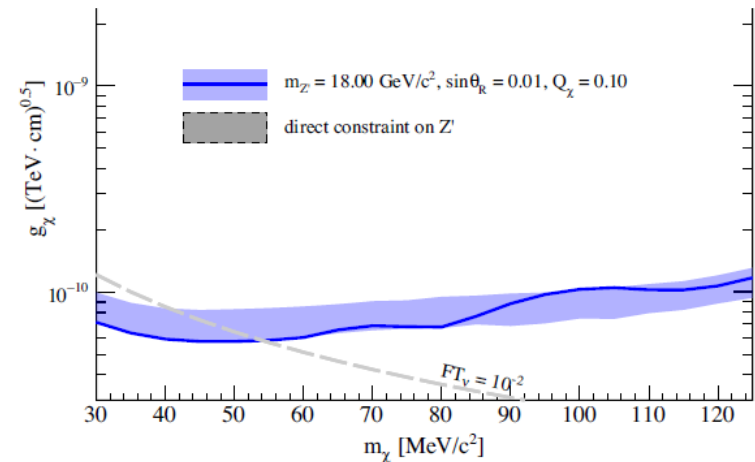
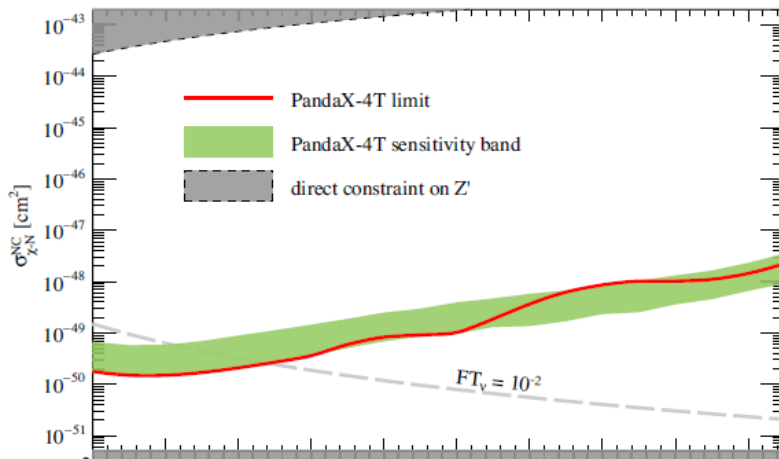
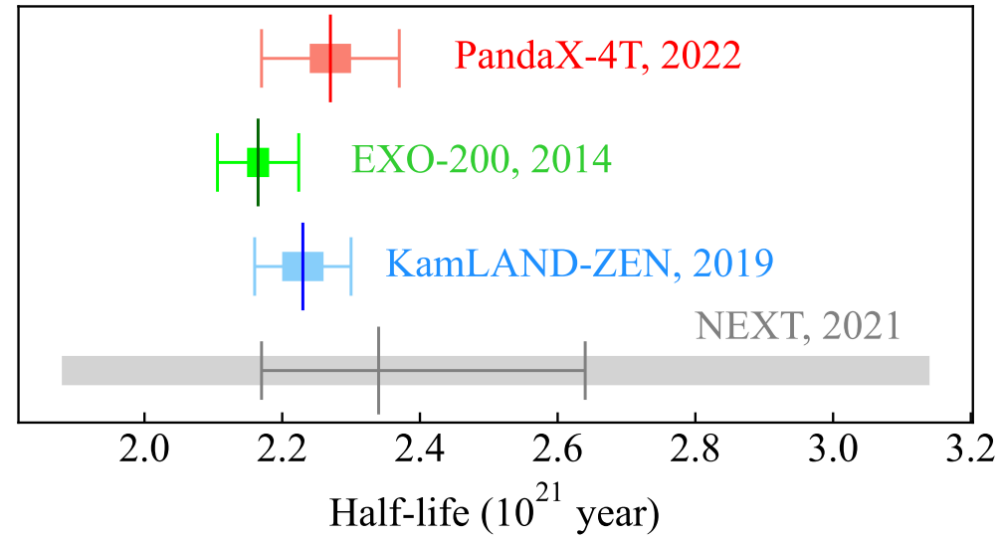
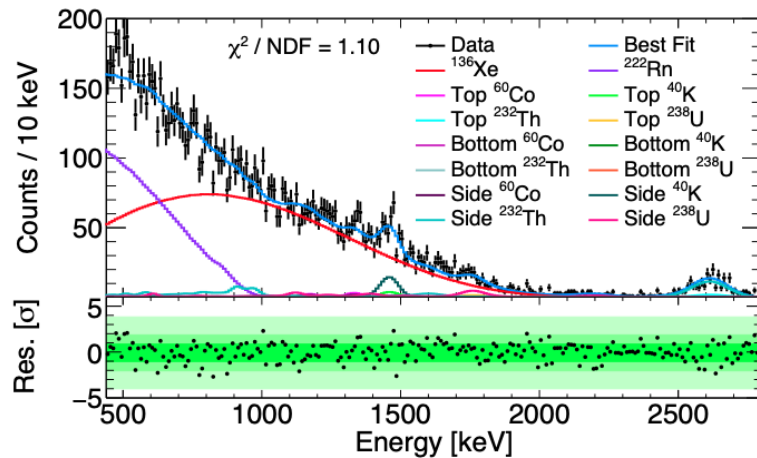


FIG. 6. The 90% CL upper limits vs m_χ for the absorption cross sections of fermionic DM from the PandaX-4T commissioning data. The green band represents $\pm 1\sigma$ sensitivity band. The gray shaded area describes the constraints from collider experiment for Z' [20,42]. The figure below displays limits and sensitivity bands vs m_χ for the U(1)' gauge coupling from the PandaX-4T commissioning data. The level of fine-tuning needed in the UV complete model to avoid rapid $\chi \rightarrow \nu\nu\nu$ decay is denoted with dashed gray contours labeled FT_ν .

Something nonzero: First measurement of $2\nu\text{DBD}$ with natural Xe detector



- ^{136}Xe DBD half-life: $2.27 \pm 0.03(\text{stat.}) \pm 0.10(\text{syst.}) \times 10^{21}$ year
- First such measurement with natural xenon [arXiv:2205.12809](https://arxiv.org/abs/2205.12809),
accepted by Research

Summary

- My collaboration with Rabi started 2006 led me an interesting excursion into particle theory (neutrino, GUT, SO(10), LR model, CP-violation, SUSY, dark matter...) and experiment (PandaX).
- Now back to nuclear theory, but I enjoyed very much this tunneling experience in BSM physics (~ "Alice in Wonderland").
- Enjoy the retirement life, Rabi. Soon will follow.

Congratulations and many thanks to Rabi from Xinmin Zhang, IHEP, Beijing

- After graduate from UCLA in 1991, I came to University of Maryland as a postdoc to work with Professor Rabi Mohapatra.
- With Rabi, I had been working on Leptogenesis and Electroweak baryogenesis in the Left-Right model, neutrino cosmology and electroweak phase transition. We wrote several papers together and I appreciate very much the collaboration.
- I came back to IHEP in China in 1996 and for the past several years I as the PI have been working on a CMB project, AliCPT (Ali CMB Polarization Telescope), which is a worldwide collaboration with more than 15 institutes and universities from China, USA and Europe.

Unique site

Tibet@5250m above sea level

Northern hemisphere

Unique sciences

- E / B mode science
- Foreground science

Targeting at Northern sky

