

# Bridge to the Future

**Elizabeth H. Simmons**

Distinguished Professor of Physics, UC San Diego  
Gordon Godfrey Visitor, UNSW

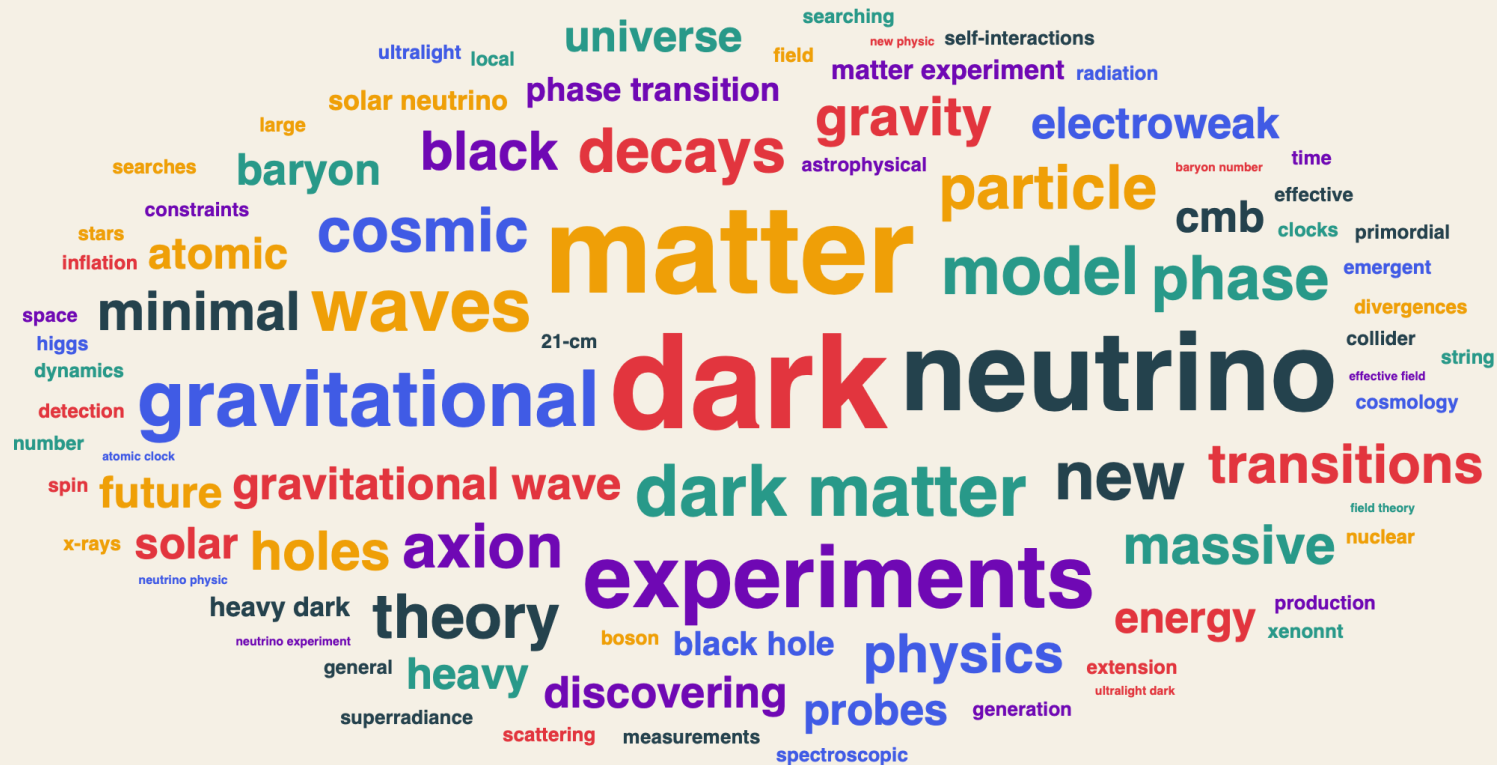
PPC 2026 · Gordon Godfrey Conference  
UNSW Sydney  
4 September 2026



# Introduction

*How to Capture the Essence of the International Conference on  
Interconnections Between Particle Physics and Cosmology?*

## Common Names?



# Our True Interconnections Run Deeper

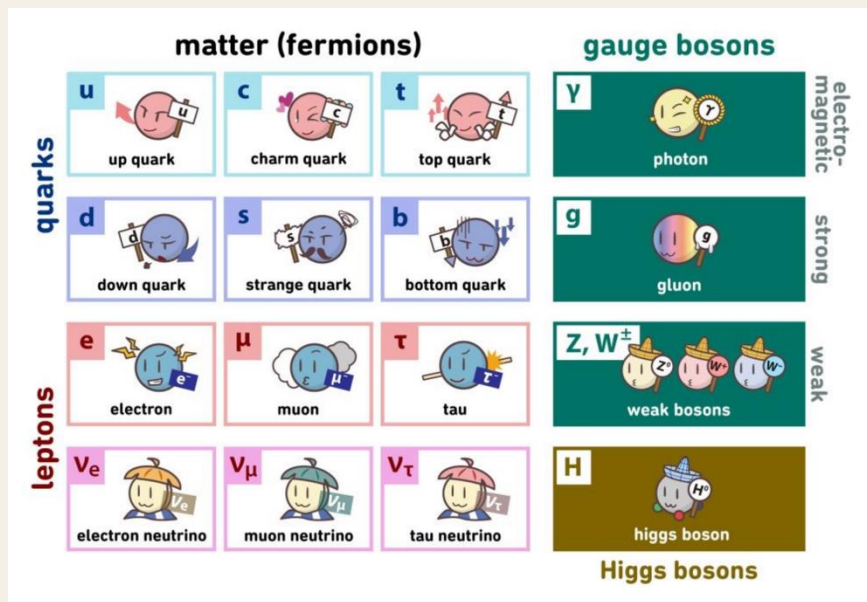
*“What's in a name? That which we call a rose By any other name would smell as sweet.”*

— William Shakespeare, *Romeo and Juliet* (Act 2, Scene 2)

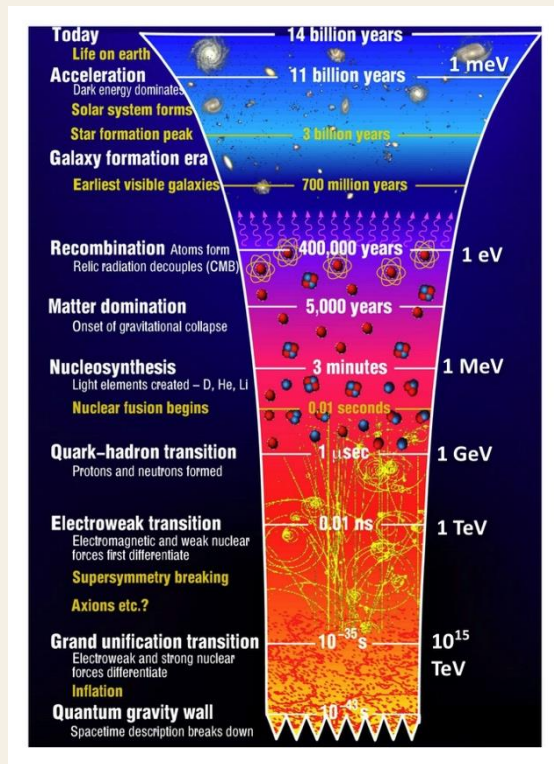
# 1. Looking Beyond Our Standard Models

*We pursue the outstanding questions our Standard Models are not structured to address.*

# Our Standard Models...

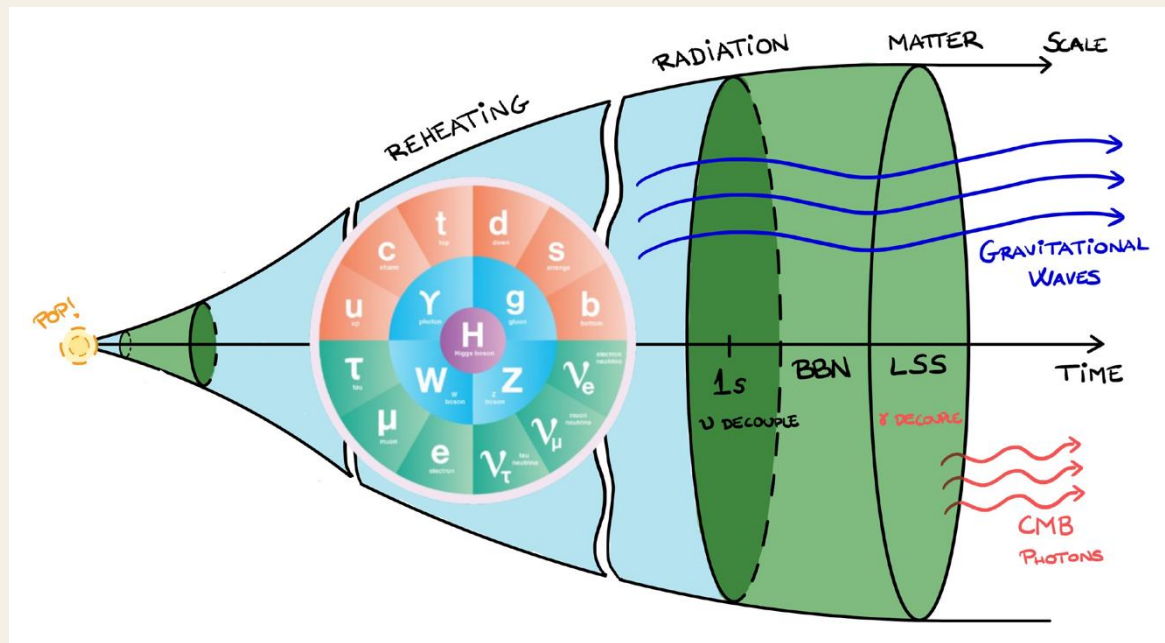


S. Okawa (slide 2)  
Minimal flavor violation and dark matter



T. Tait (slide 2)  
Precision Nuclear Theory for Big Bang Nucleosynthesis from an EFT Built out...

# ... Are Related



J. Rubio (slide 2)

*Reheating from Curvature: Higgs Dynamics after Inflation*

# Our Open Questions Are Entangled

$\Lambda$ CDM is an extremely successful model for  $d \gtrsim \mathcal{O}(\text{Mpc})$ . But:

- Core-cusp problem
  - predic.  $\rho_{\text{dm}} \propto r^{-1}$  vs  $\rho_{\text{dm}}^{\text{obs}} \propto r^0$
- Diversity problem
  - large variations in density profiles
- “Missing satellites problem”
  - lack of a rich halo substructure
- Too-big-to-fail problem
  - largest substructures fail to form stars

G. Dalla Valle Garcia (slide 3)

*Heavy Dark Baryons: Self-Interactions and the Dark Matter-Baryon...*

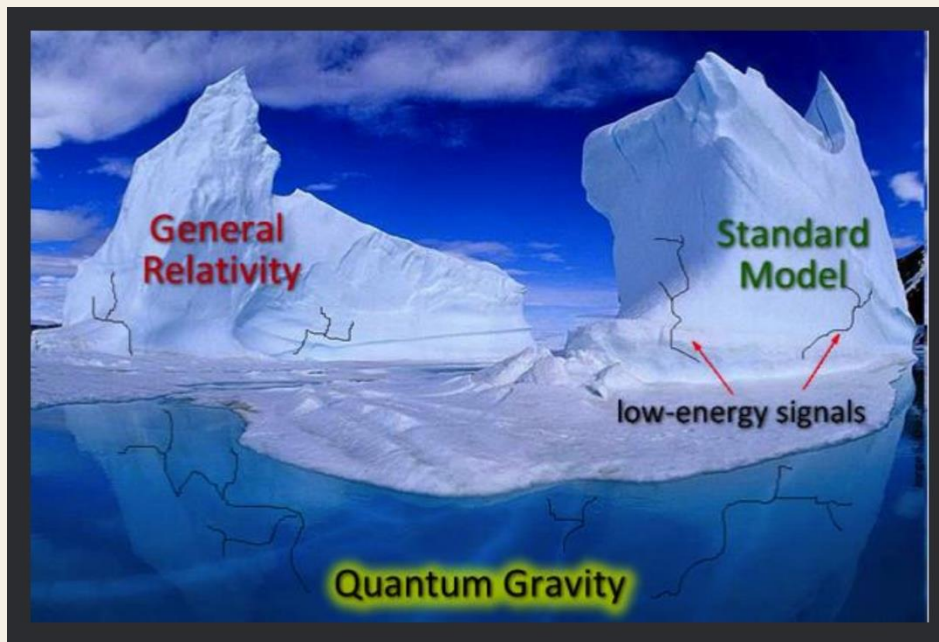
## MULTIPLE MOTIVATIONS

- Hierarchy Problem
  - composite Higgs/technicolor
- Flavor Hierarchy Problem
  - warped extra dimensions(holography)
  - partial compositeness
- Strong CP Problem
  - high-quality QCD axions (composite axions)
- Dark-GUTs (baryon-DM coincidence)

G. Dalla Valle Garcia (slide 7)

*Heavy Dark Baryons: Self-Interactions and the Dark Matter-Baryon...*

# Others Lurk Beneath the Surface

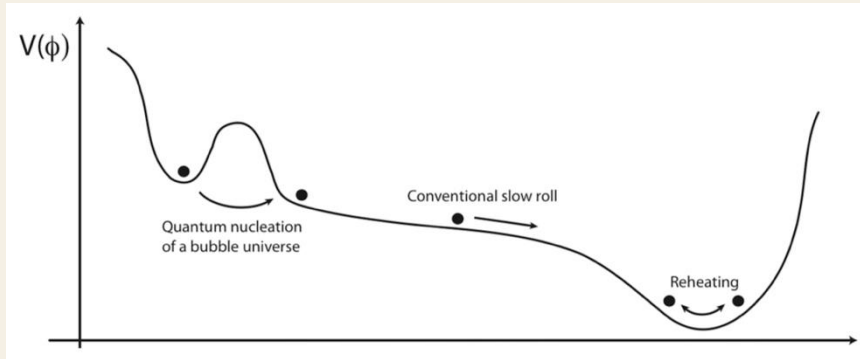


T. Kahniashvili (slide 6)  
*Pulsar Timing Arrays as Probe of Massive Gravity*

## 2. Phase Transitions and Cosmological Timelines

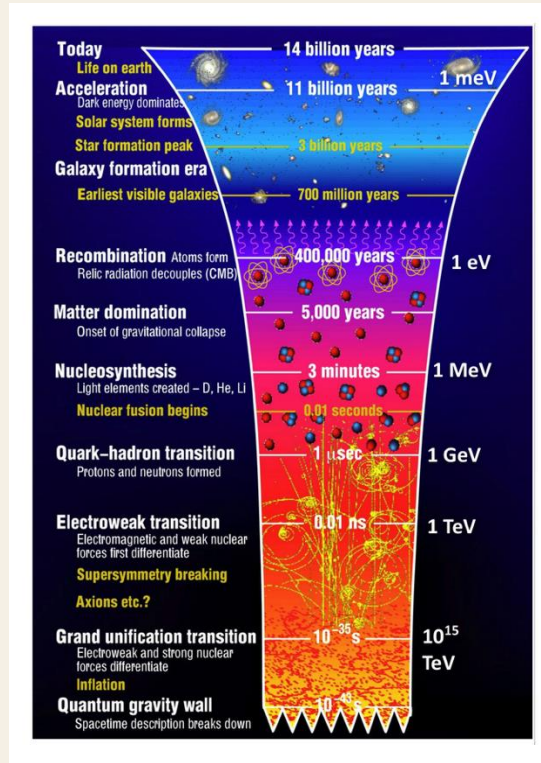
*Traces of symmetries and transition relics provide common interpretive frameworks and valuable hints about underlying dynamics.*

# A History of Transitions



J. Maheshwari (slide 4)

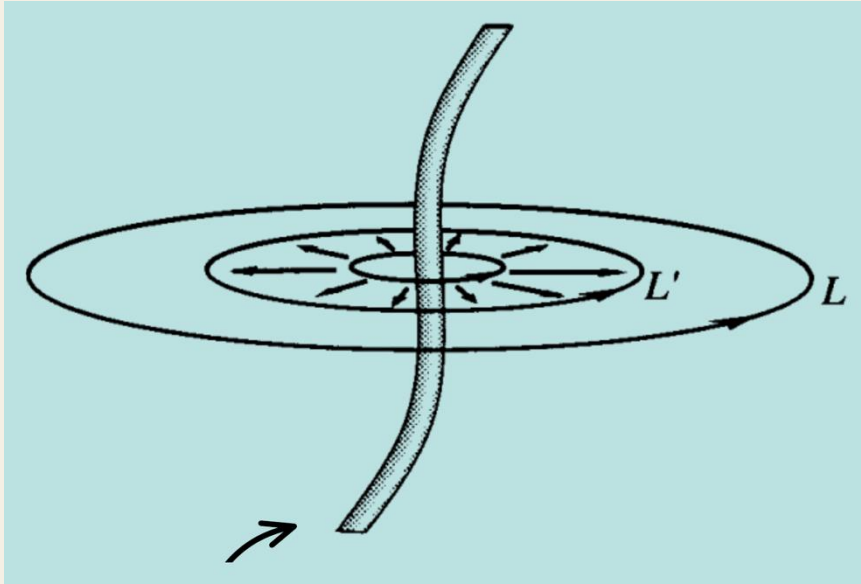
*Did our universe collide with another universe? Latest results from the Planck...*



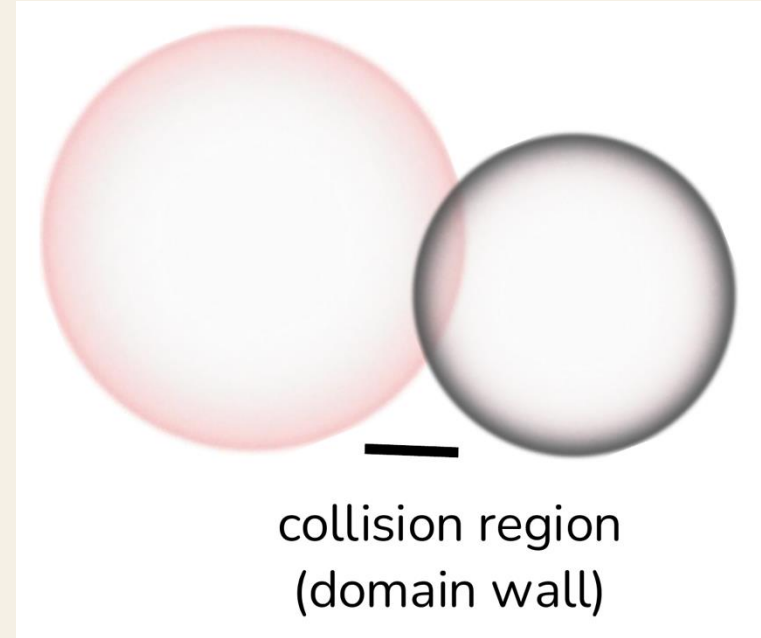
T. Tait (slide 2)

*Precision Nuclear Theory for Big Bang Nucleosynthesis from an EFT Built out...*

# Transition Remnants

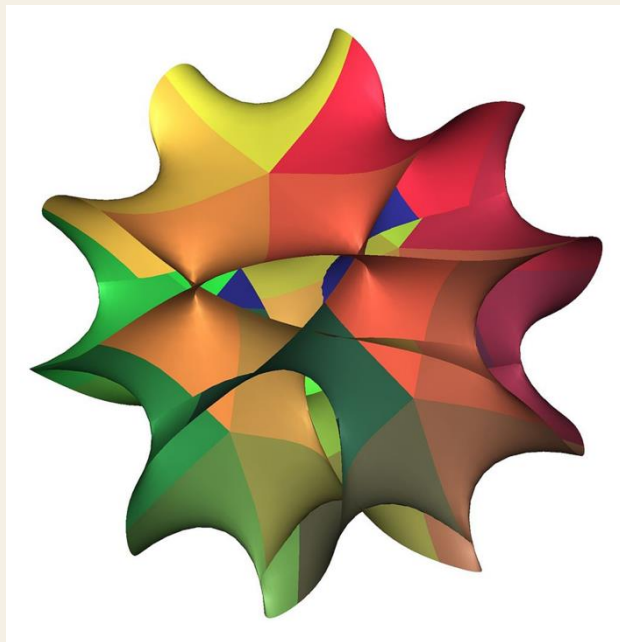


N. Nazeef (slide 3)  
*Cosmic String Wakes and How to Find Them*



J. Maheshwari (slide 23)  
*Did our universe collide with another universe? Latest results from the Planck...*

# Underlying Symmetries

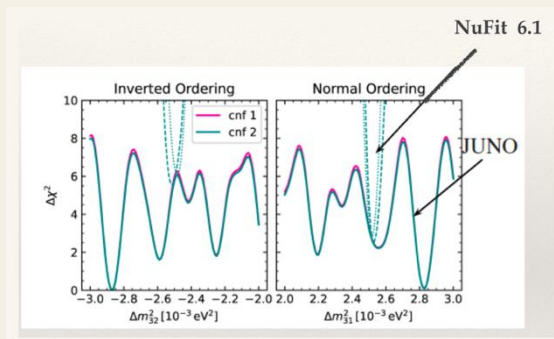


F. Chadha-Day (slide 5)  
*Discovering the String Axiverse*

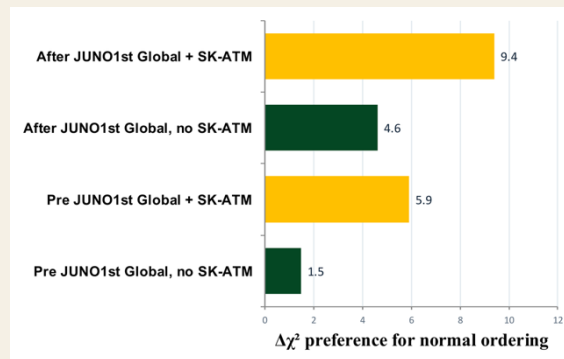
# 3. Ubiquitous Candidate Particles

*The diverse states we study have tremendous overlap.*

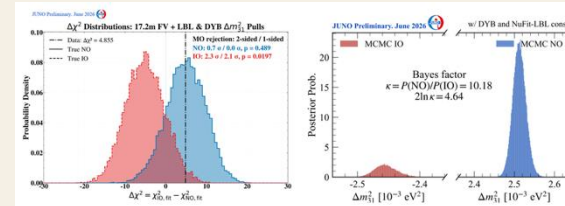
# Neutrino Masses and Orderings



S. Goswami (slide 28)  
*Neutrinos: oscillations and beyond*

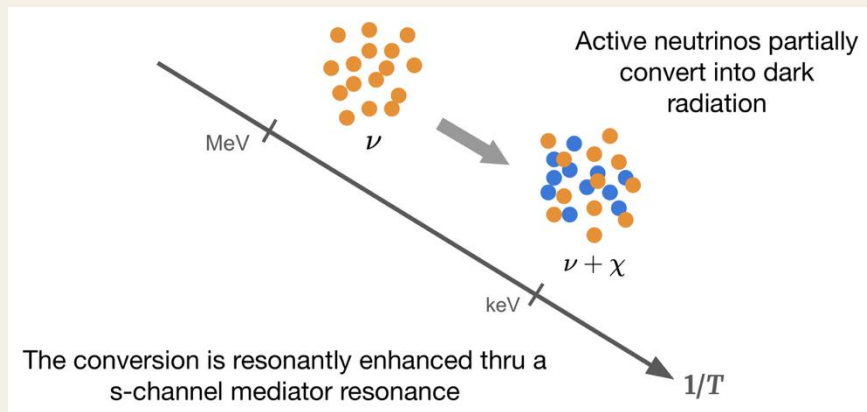


W. Wang (slide 12)  
*Neutrino experiments*



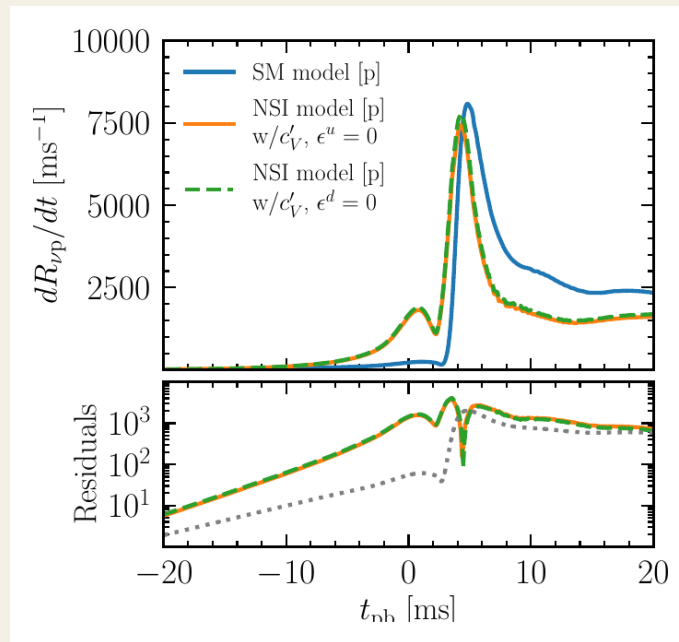
W. Wang (slide 34)  
*Neutrino experiments*

# Even Less Standard Neutrinos



A. Das (slide 11)

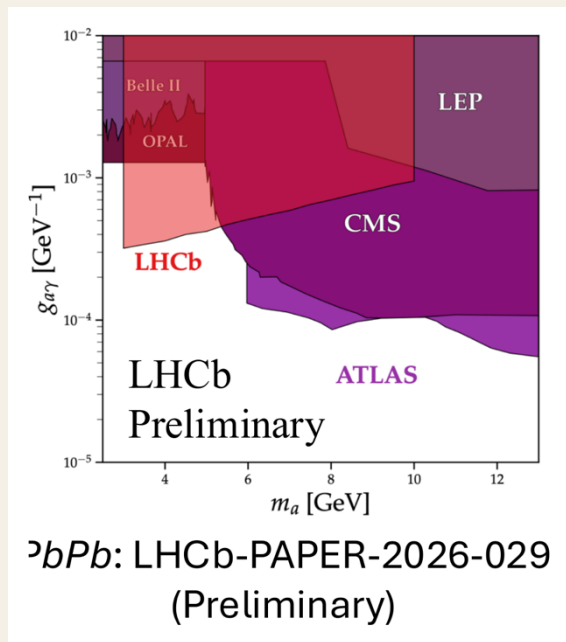
*Dark radiation can mimic self-interacting neutrinos in the early universe*



A. Suliga (slide 22)

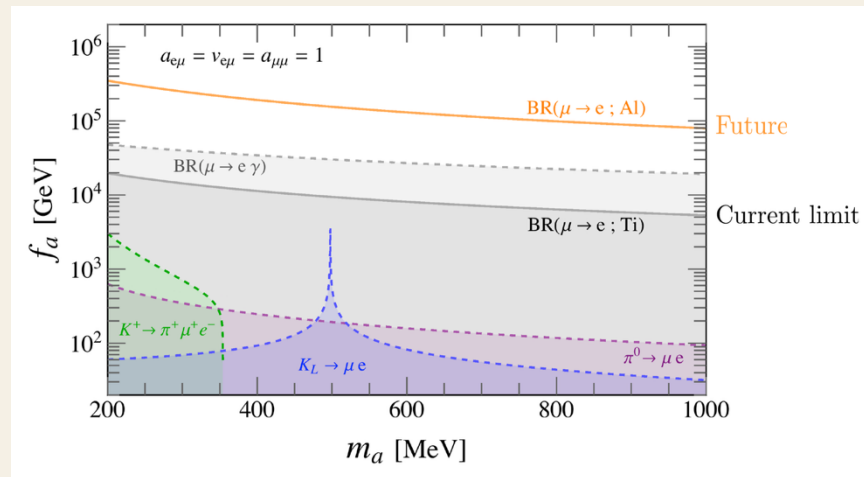
*Astrophysical Neutrinos Uncover the Nature of the Sources and Decode New...*

# Axion-Like Particles



S. Collaviti (slide 36)

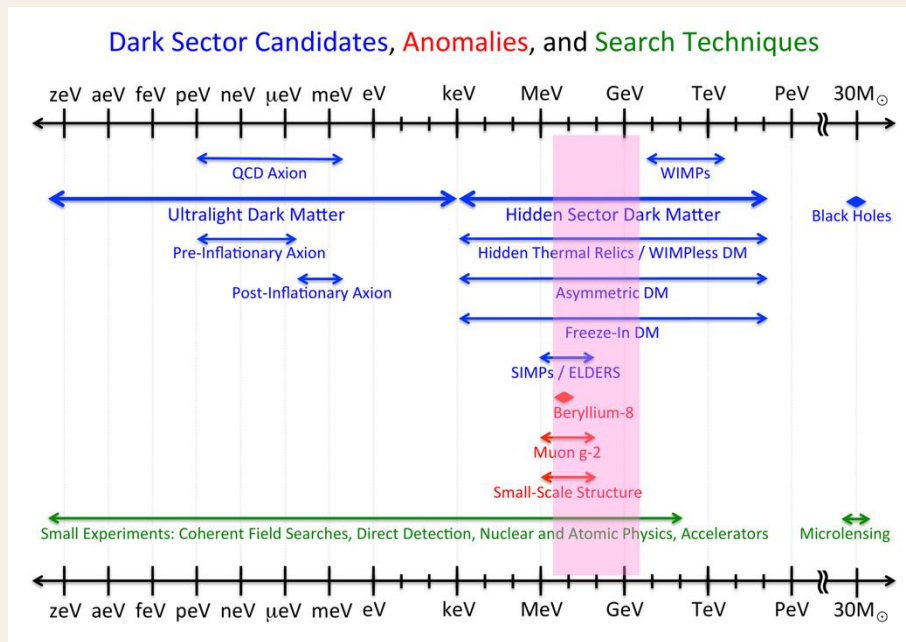
Recent results on dark sector searches and rare decays at LHCb



K. Fuyuto (slide 26)

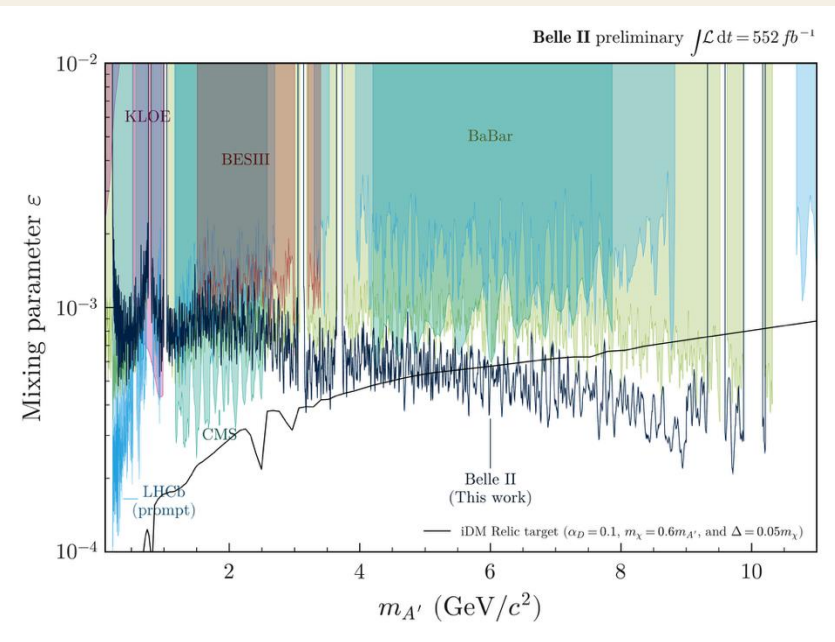
Searching for muon to electron conversion

# Dark Sectors and Mediators

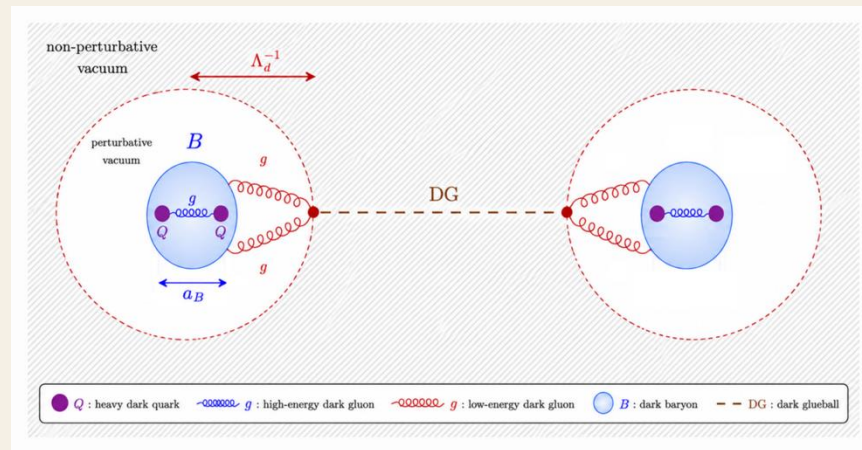


R. Lebouchier (slide 4)  
*Recent results from Belle-II*

# Dark Photon and Baryon

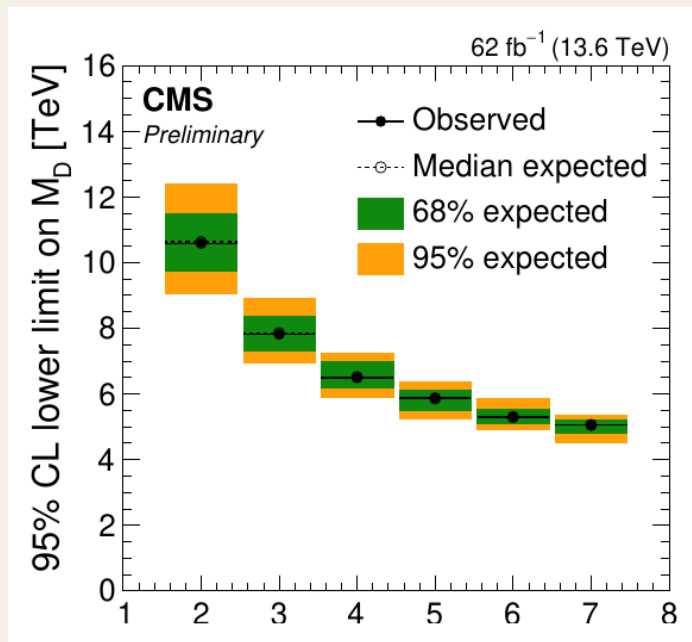


R. Lebouchier (slide 14)  
*Recent results from Belle-II*



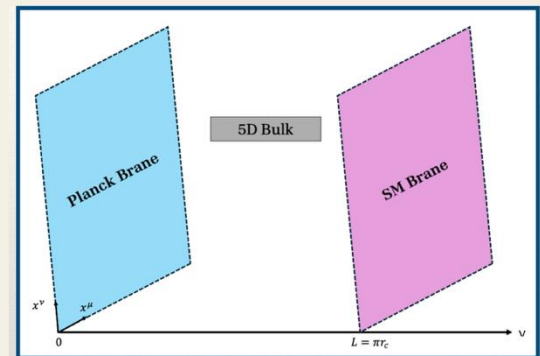
G. Dalla Valle Garcia (slide 9)  
*Heavy Dark Baryons: Self-Interactions and the Dark Matter-Baryon...*

# Extra Dimensions and Resulting New States



H. Potti (slide 10)

Recent Results from ATLAS and CMS Searches for Dark Matter

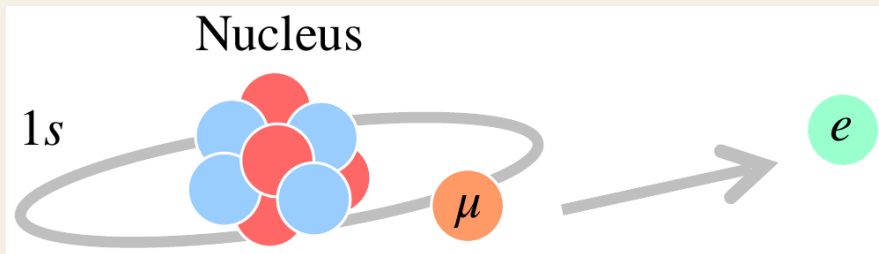


$$h_{\mu\nu}(x, y) = \sum_{n=0}^{\infty} h_{\mu\nu}^{(n)}(x) \psi_n(y)$$

J. Gill (slide 10)

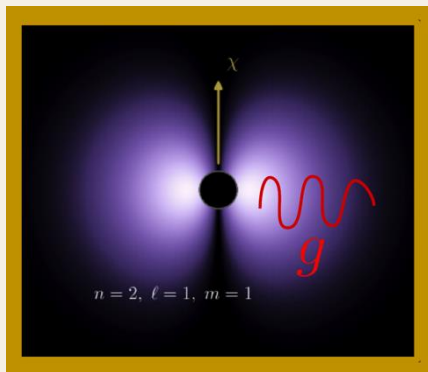
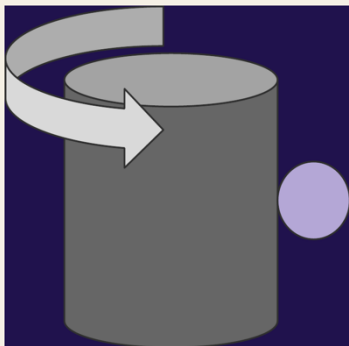
Randall-Sundrum Models and Multibrane Extension

# Exotic Atoms



K. Fuyuto (slide 12)

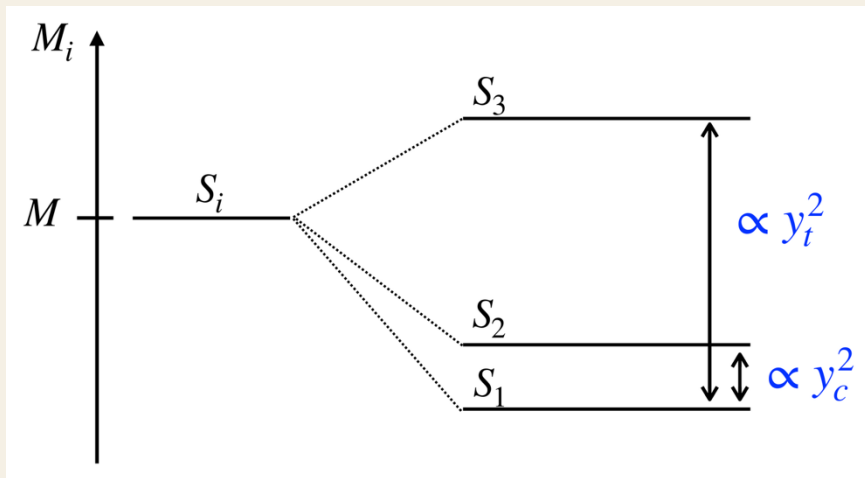
*Searching for muon to electron conversion*



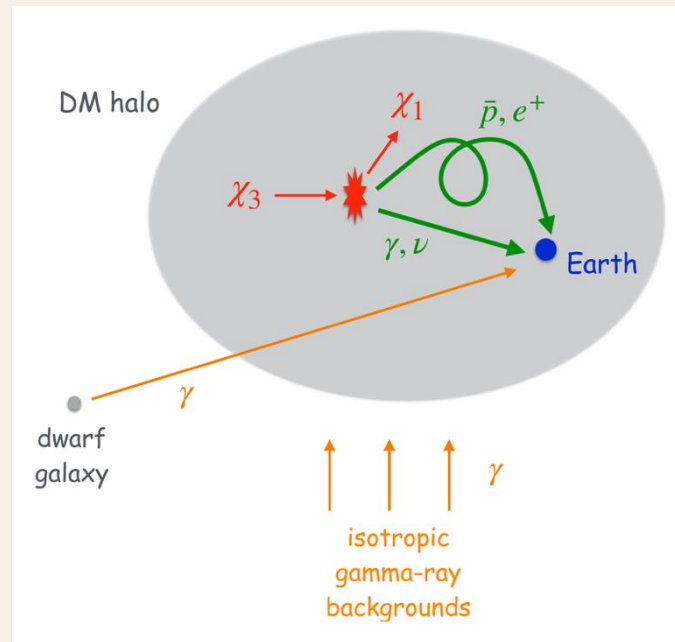
O. Ning (slides 5 and 13)

*Crowdsourcing Gravitational Waves from...*

# Flavored Dark Matter Decays

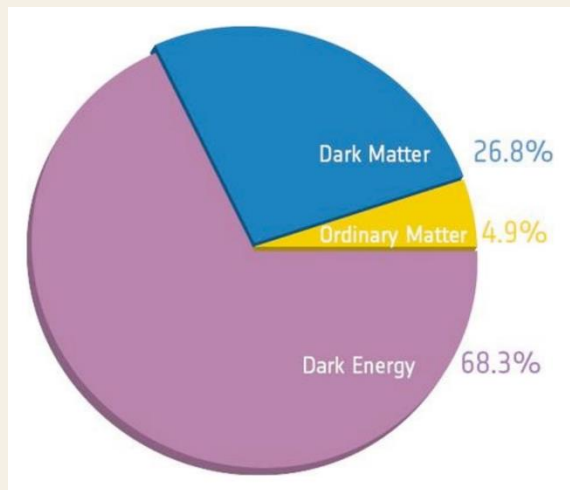


S. Okawa (slide 32)  
Minimal flavor violation and dark matter



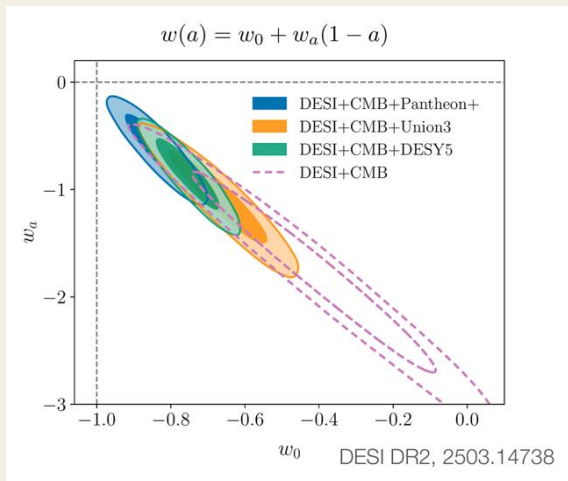
S. Okawa (slide 35)  
Minimal flavor violation and dark matter

# Dark Energy Evolution



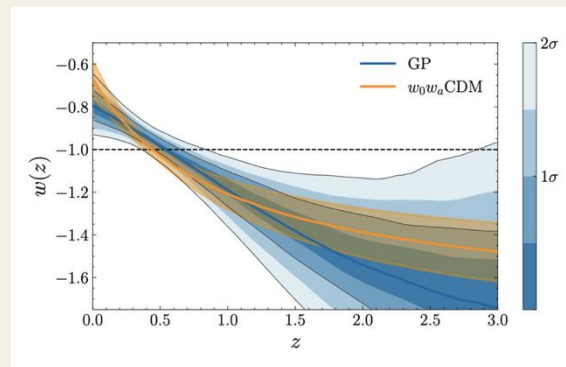
L. Wang (slide 4)

*Axion monopole interaction and time-varying...*



L. Wang (slide 6)

*Axion monopole interaction and time-varying...*



C. Howlett (slide 14)

*Cosmology with large-scale spectroscopic surveys*

# No Mention of

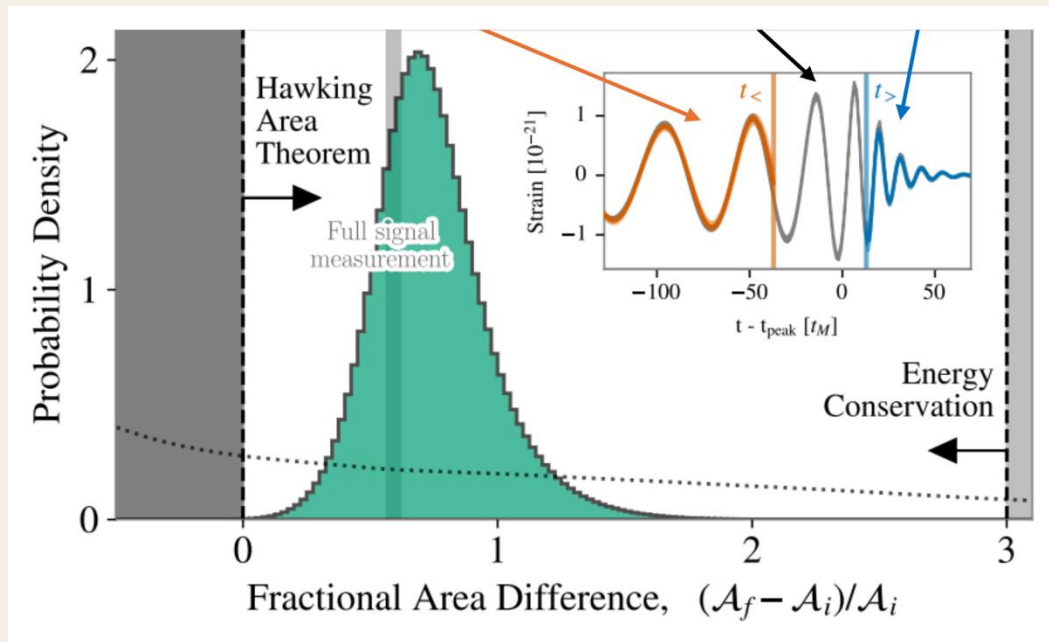
## Slipstream Wormholes and Strong-Force Neutrinos



# 4. Revealing the Invisible

*We probe what was once thought beyond reach.*

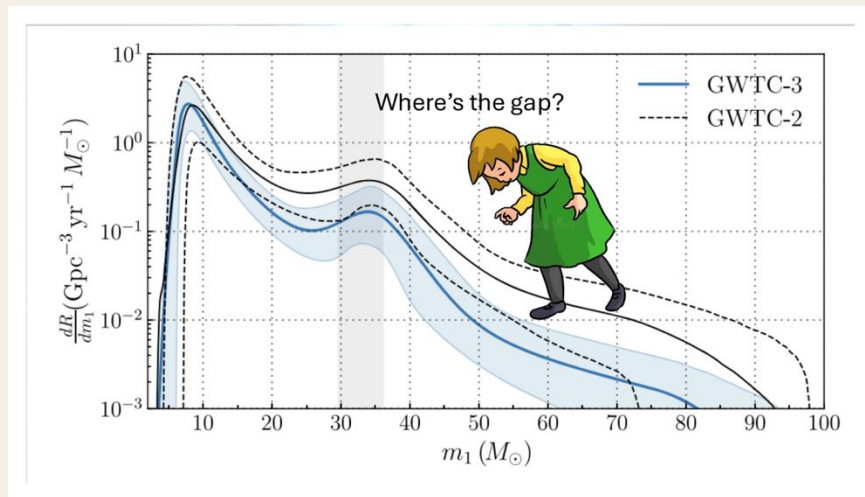
# A Stealthy Black Hole Property



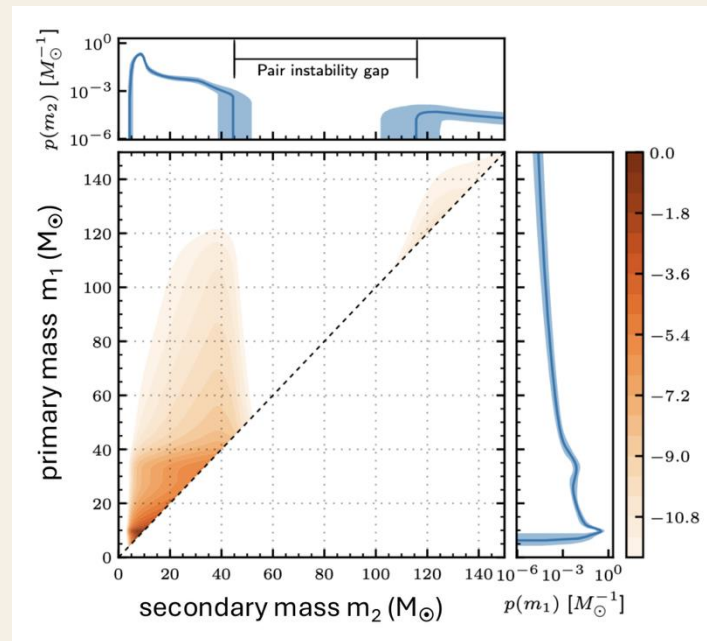
E. Thrane (slide 19)

*Recent highlights from LIGO-Virgo-KAGRA*

# A Doubly-Hidden BH Binary Property

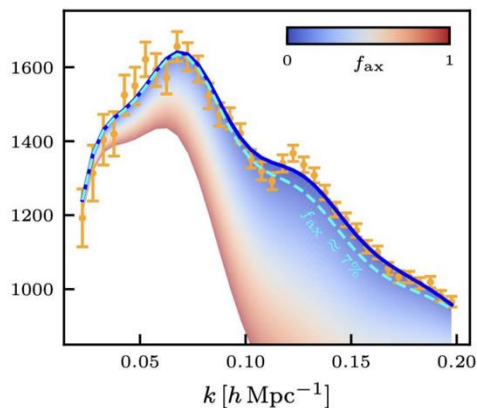


E. Thrane (slide 11)  
Recent highlights from LIGO-Virgo-KAGRA



E. Thrane (slide 12)  
Recent highlights from LIGO-Virgo-KAGRA

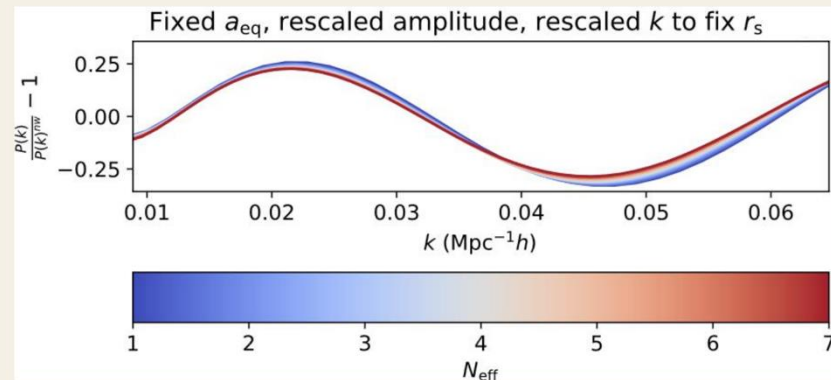
# Large-Scale Observables Reflect Ghostly Particles



ULAs and other DM candidates can modify the non-linear galaxy power spectrum

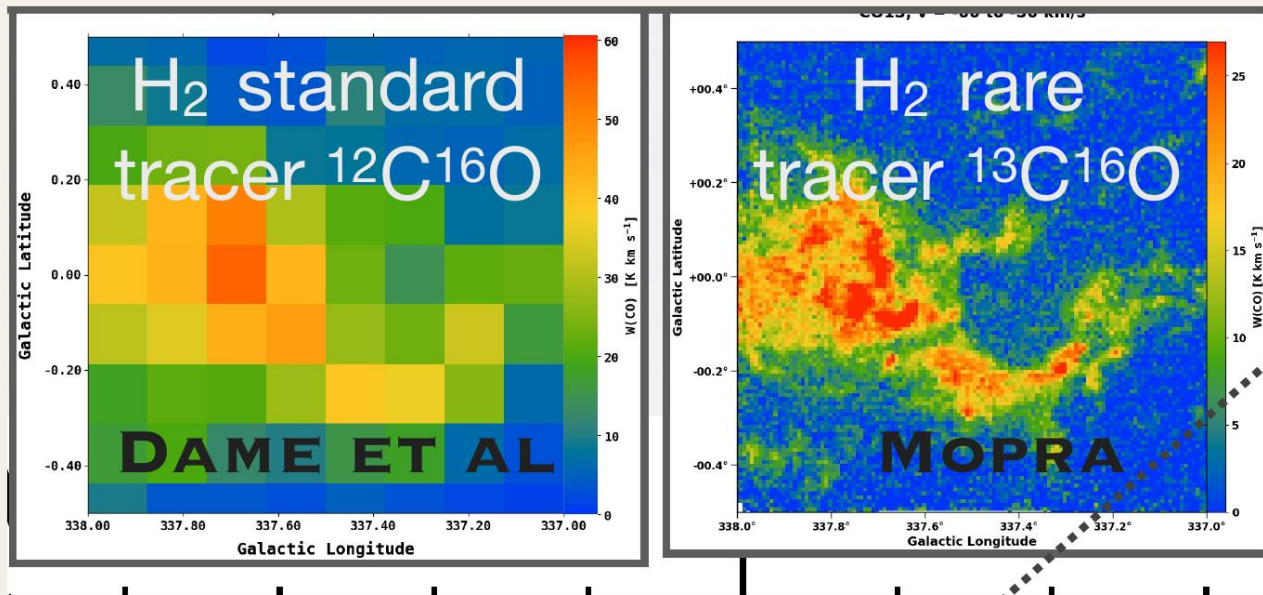
C. Howlett (slide 22)  
*Cosmology with large-scale spectroscopic surveys*

Neutrinos can also be seen as a phase-shift in the BAO



C. Howlett (slide 19)  
*Cosmology with large-scale spectroscopic surveys*

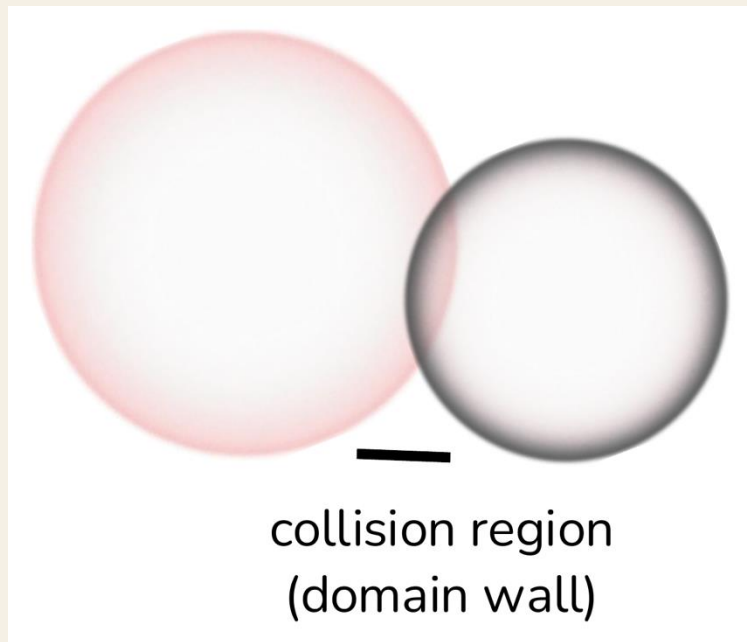
# Isotopologues Reveal Cold H2



S. Murgia (slide 12)

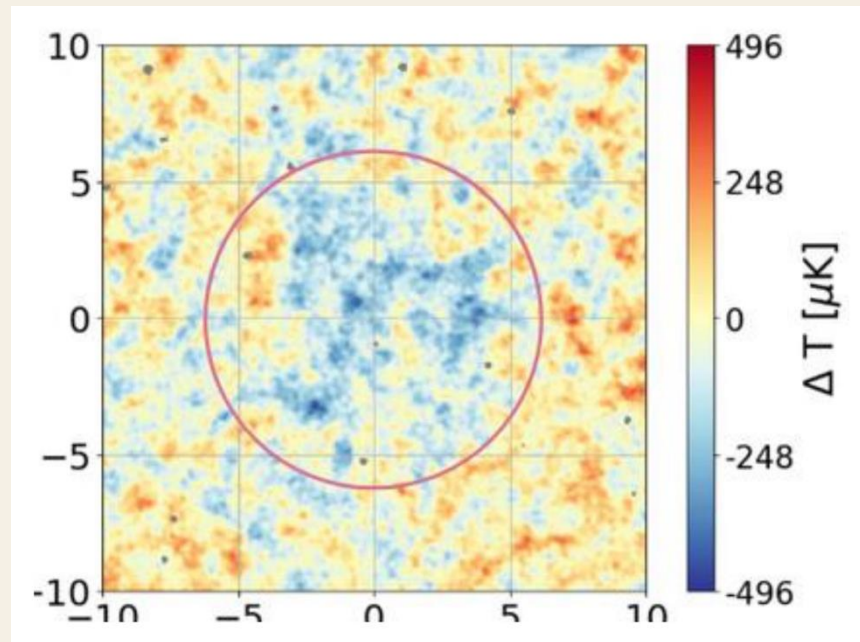
*Astrophysical probes of dark matter*

# Seeing Another Universe?



J. Maheshwari (slide 23)

*Did our universe collide with another universe? Latest results from the Planck...*



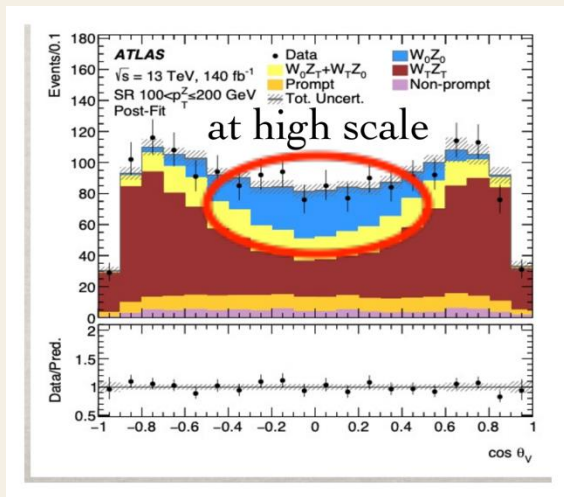
J. Maheshwari (slide 44)

*Did our universe collide with another universe? Latest results from the Planck...*

# 5. Contending with Backgrounds

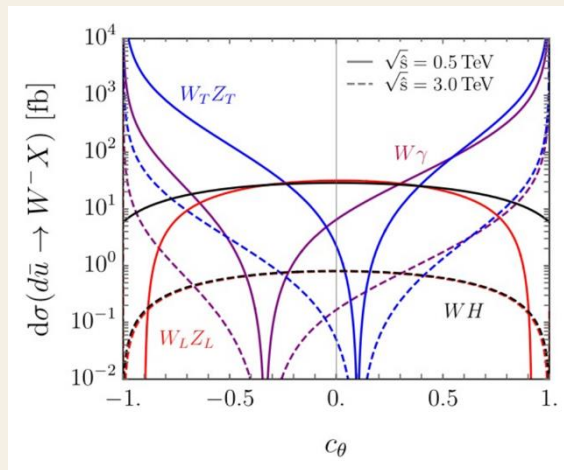
*Many wily strategies are being tested and shared.*

# Measure Where the Background's Low



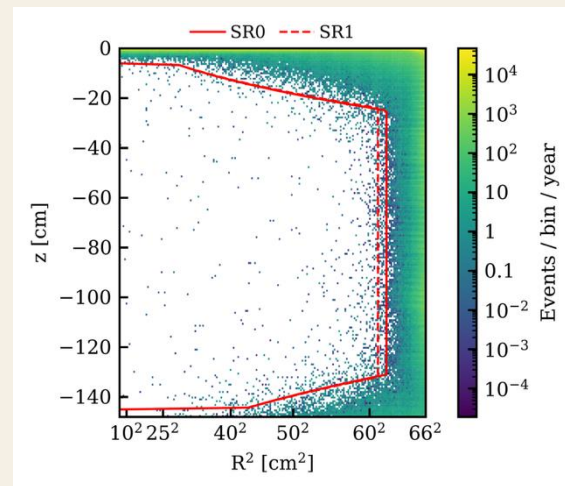
T. Han (slide 6)

Electroweak Symmetry Restoration at High...



T. Han (slide 14)

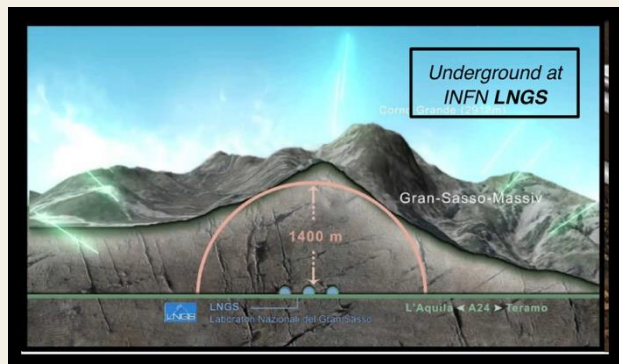
Electroweak Symmetry Restoration at High...



J. Ye (slide 10)

Solar neutrino physics with XENONnT

# Prevent or Bound the Uncertainties



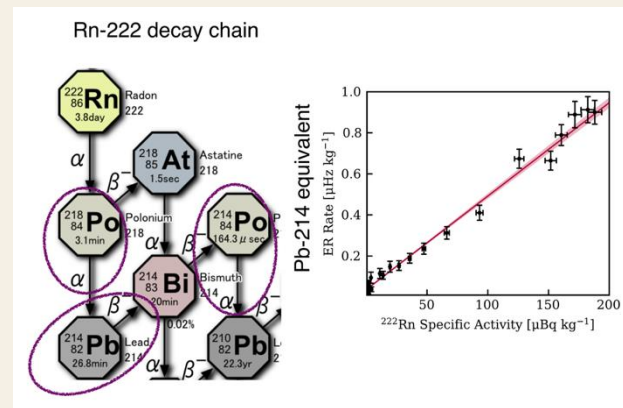
B. Andrieu (slide 3)

*Latest results from XENONnT on dark matter...*



J. Ye (slide 14)

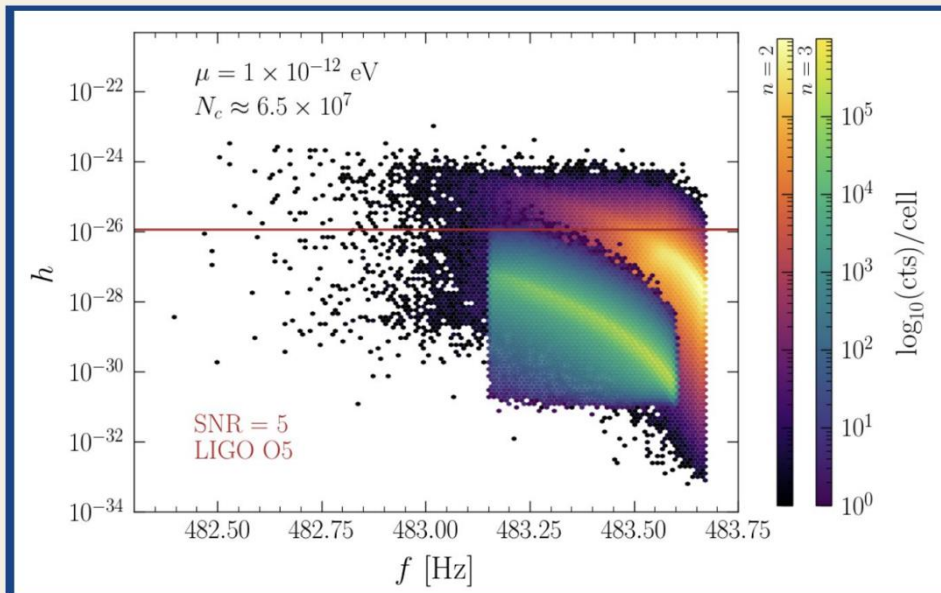
*Solar neutrino physics with XENONnT*



J. Ye (slide 15)

*Solar neutrino physics with XENONnT*

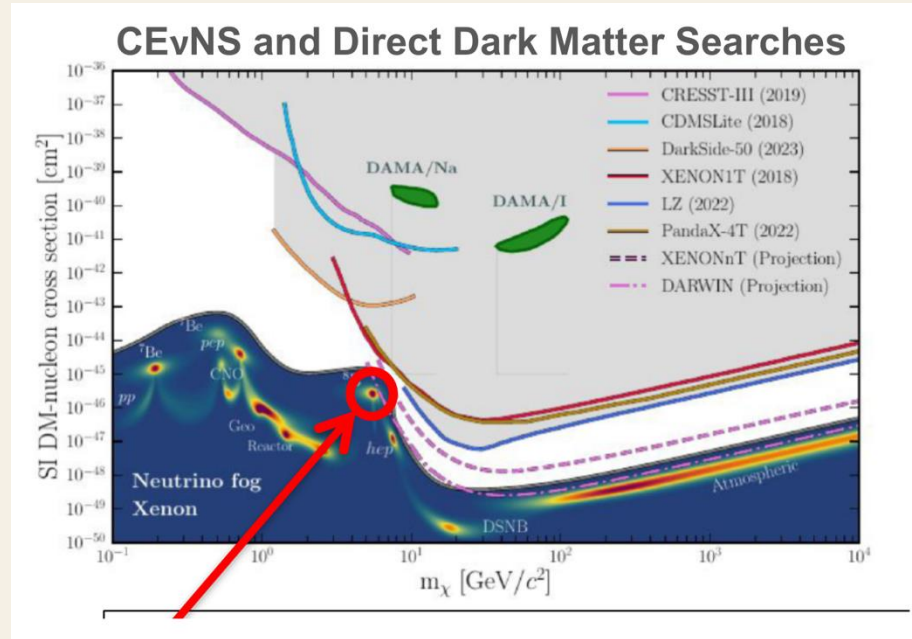
# An Ensemble May Have More Tractable Uncertainties



O. Ning (slide 21)

*Crowdsourcing Gravitational Waves from Superradiance: Black Holes as Extreme Axion Laboratories*

## Sometimes You Just Gotta Go There



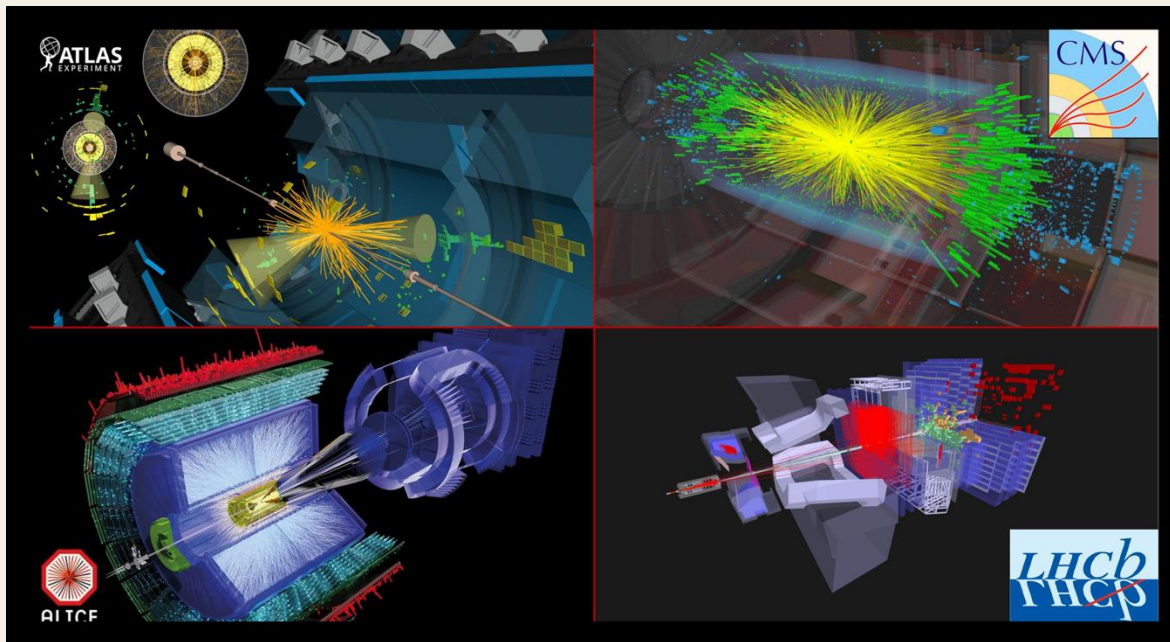
B. Andrieu (slide 7)

Latest results from XENONnT on dark matter search and solar neutrinos

## 6. Physical Economy

*We multi-task, repurpose, combine, and recycle our approaches and data.*

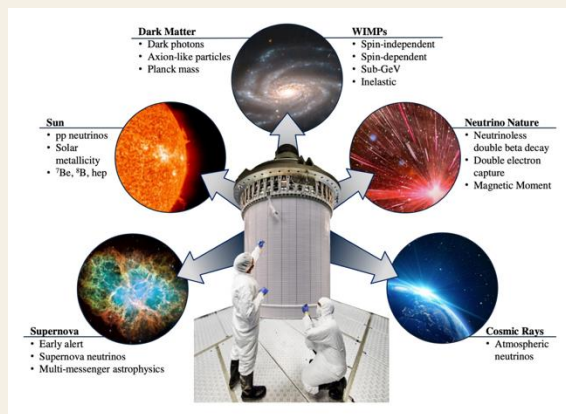
# Multipurpose Collider Detectors...



S. Collaviti (slide 10)

*Recent results on dark sector searches and rare decays at LHCb*

# ... and Non-Collider Detectors



F. Gao (slide 32)

Dark Matter with Liquid Xenon Time Projection...

| Physics goals of HK <span style="float: right;">3</span>                                                                                 |                                                                                                                                     |                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| HK aims at revealing important physics feature                                                                                           |                                                                                                                                     |                                                                                                                                                  |
| <b>Neutrino oscillation</b><br>Oscillation properties will be measured based on <b>accelerator</b> and <b>atmospheric</b> neutrinos.<br> | <b>Neutrino astronomy</b><br><b>Solar, supernova, and supernova relic</b> neutrinos will be explored for astronomical research.<br> | <b>Nucleon decay</b><br><b>Proton decay or neutron decay</b> processes that violate baryon number will be searched to explore the GUT scale.<br> |
| Takuya Tashiro (ICRR)                                                                                                                    | PPC2026                                                                                                                             |                                                                                                                                                  |

T. Tashiro (slide 3)

HyperKamiokande

Neutrino astronomy: astrophysics cases

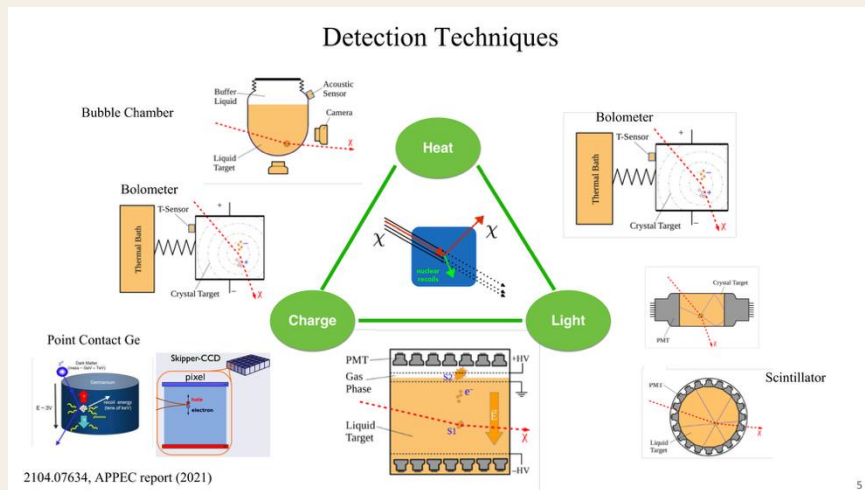
To learn more about DM searches, don't miss Rebecca's talk tomorrow at 15:15 in G01!

Francesco Filippini - PPC conference - Sydney - 02/09/2026 KM3NeT 3

F. Filippini (slide 3)

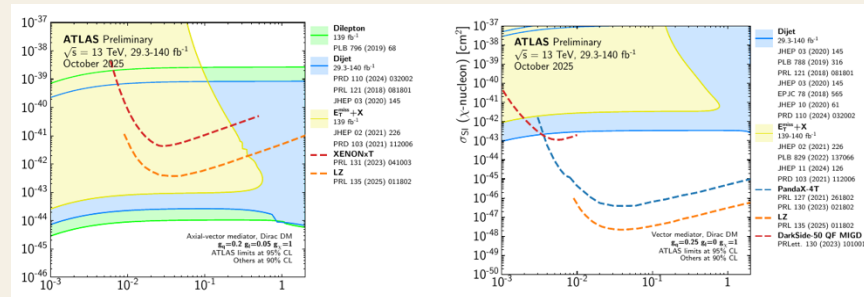
The KM3NeT neutrino detectors: status, results...

# Complementarity Within and Across the Two



F. Gao (slide 5)

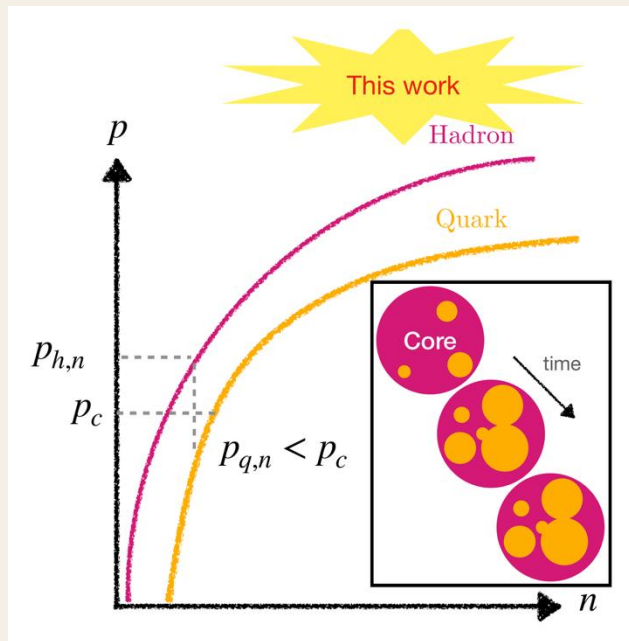
Dark Matter with Liquid Xenon Time Projection Chambers



H. Potti (slide 29)

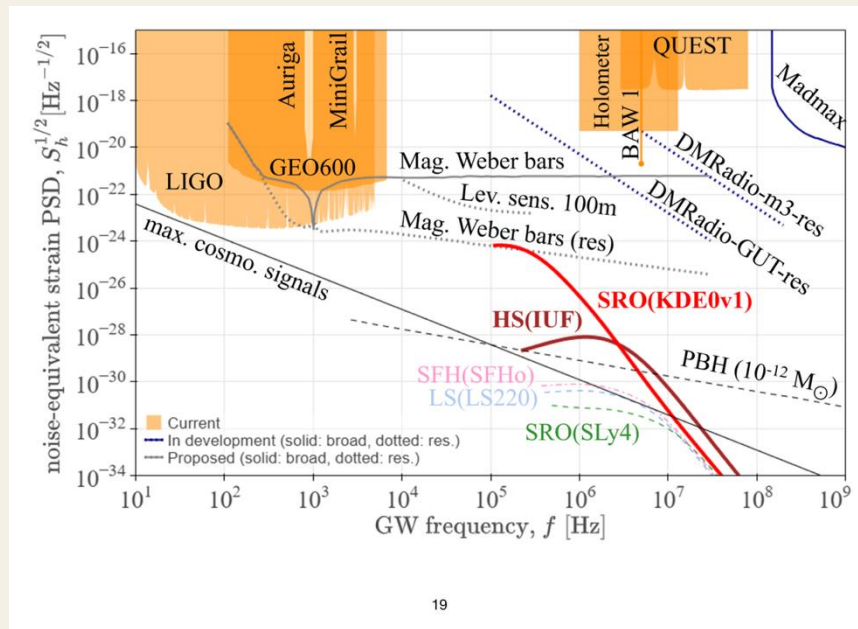
Recent Results from ATLAS and CMS Searches for Dark Matter

# Be Ready to Test Something Unexpected



J. van de Vis (slide 25)

High-Frequency Gravitational Waves from Phase Transitions in Nascent...



J. van de Vis (slide 43)

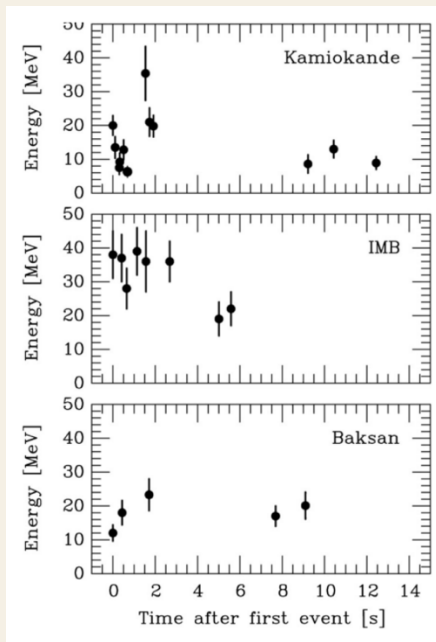
High-Frequency Gravitational Waves from Phase Transitions in Nascent...

# Pursue Multimessenger Opportunities



A. Suliga (slide 2)

*Astrophysical Neutrinos Uncover the Nature of...*



A. Suliga (slide 5)

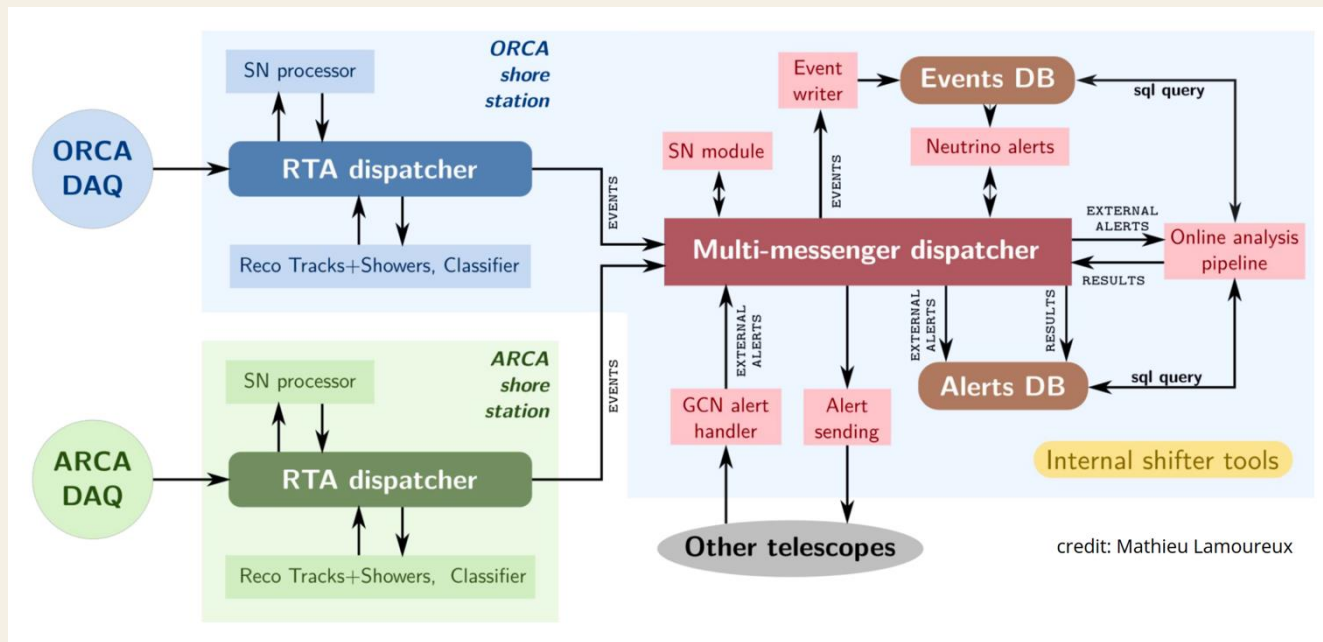
*Astrophysical Neutrinos Uncover the Nature of...*



A. Suliga (slide 4)

*Astrophysical Neutrinos Uncover the Nature of...*

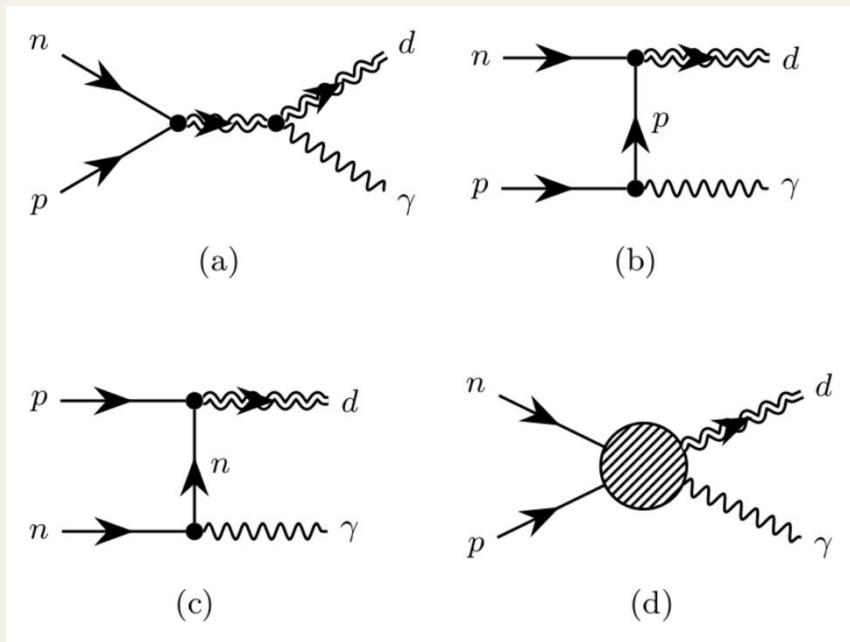
# Communicate to Collaborate



F. Filippini (slide 30)

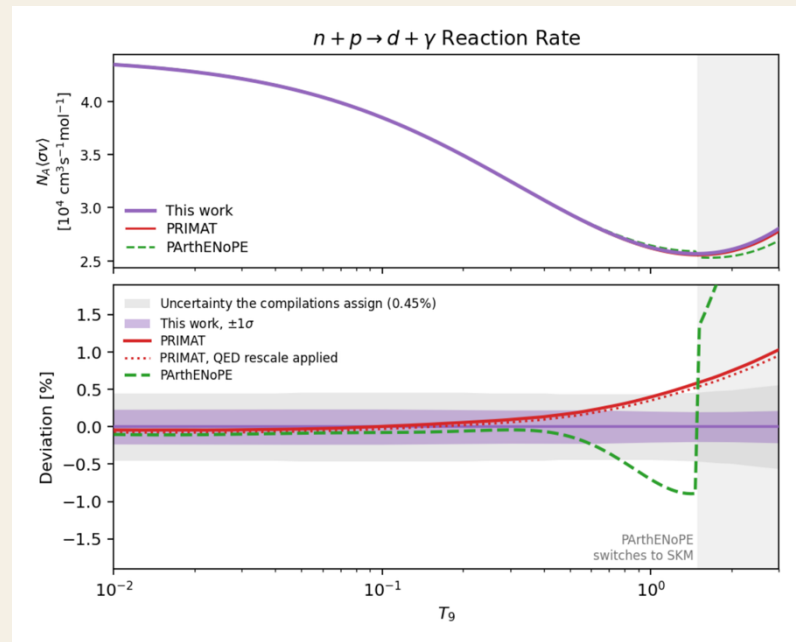
*The KM3NeT neutrino detectors: status, results and future perspectives*

# Repurpose Theoretical Methods



T. Tait (slide 12)

*Precision Nuclear Theory for Big Bang Nucleosynthesis from an EFT Built out...*



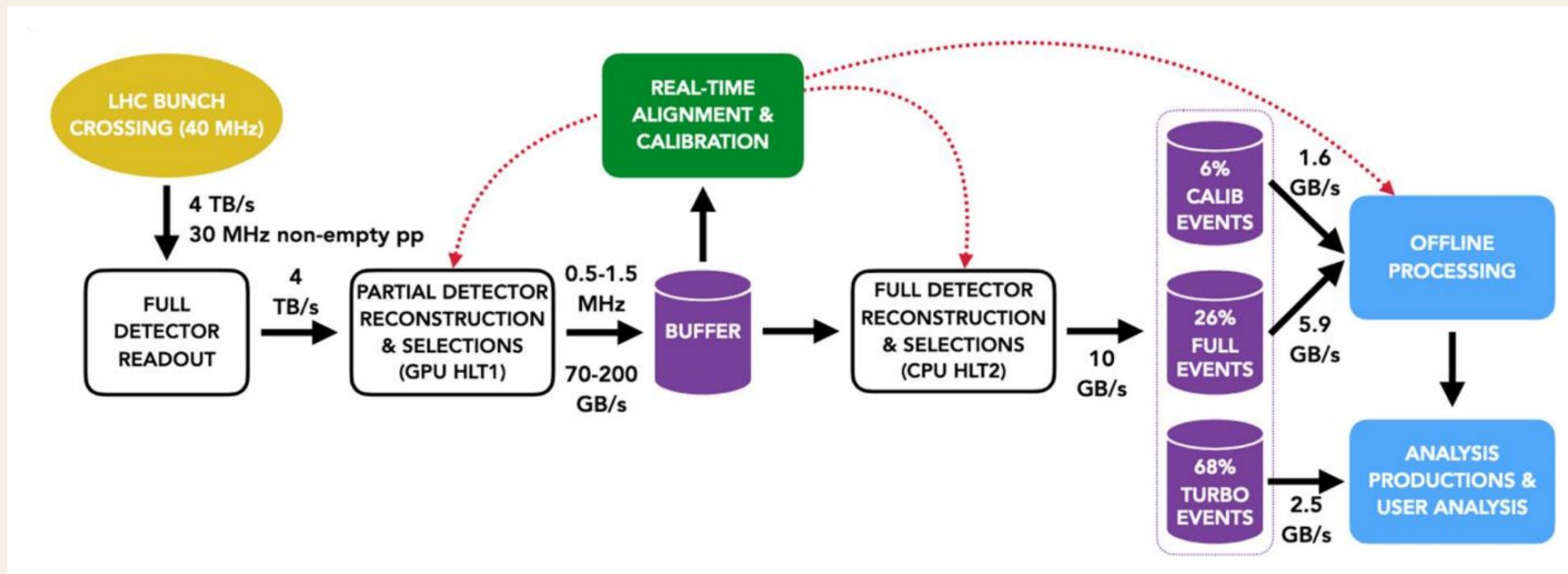
T. Tait (slide 23)

*Precision Nuclear Theory for Big Bang Nucleosynthesis from an EFT Built out...*

# 7. Sharper and Fresher Eyes

*We strategically pursue updated methods, new collaborators, and novel data sets.*

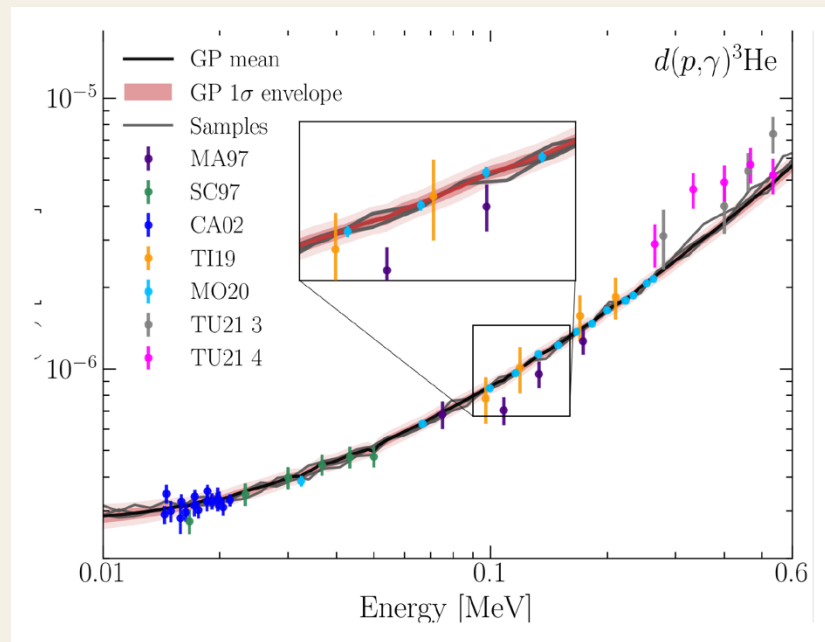
# Sometimes More Data Is the Answer



S. Collaviti (slide 16)

*Recent results on dark sector searches and rare decays at LHCb*

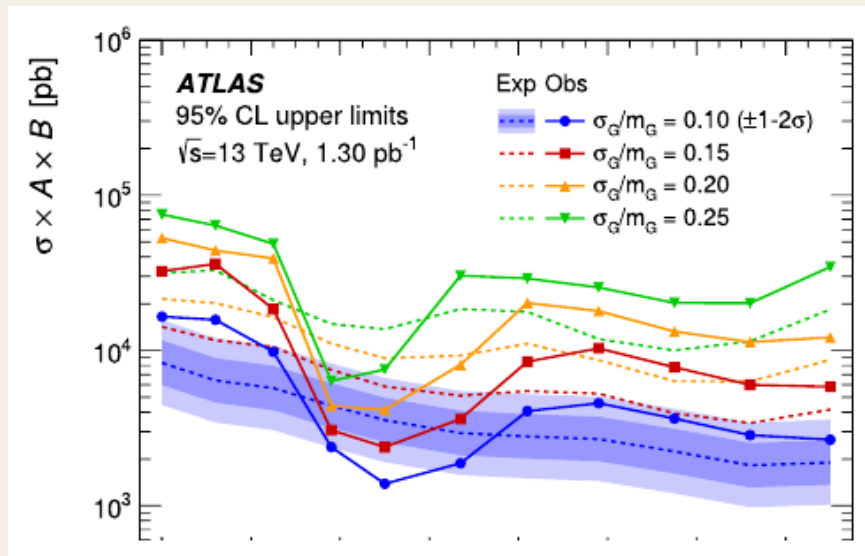
# Or an AI / ML Boost



T. Tait (slide 9)

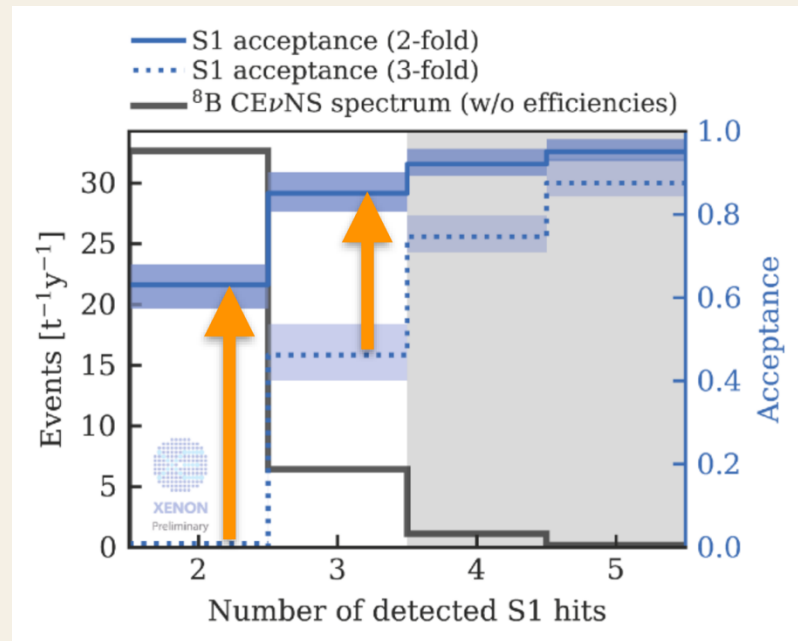
*Precision Nuclear Theory for Big Bang Nucleosynthesis from an EFT Built out of Amplitudes*

# But It Could Be a Noisier Environment



H. Potti (slide 37)

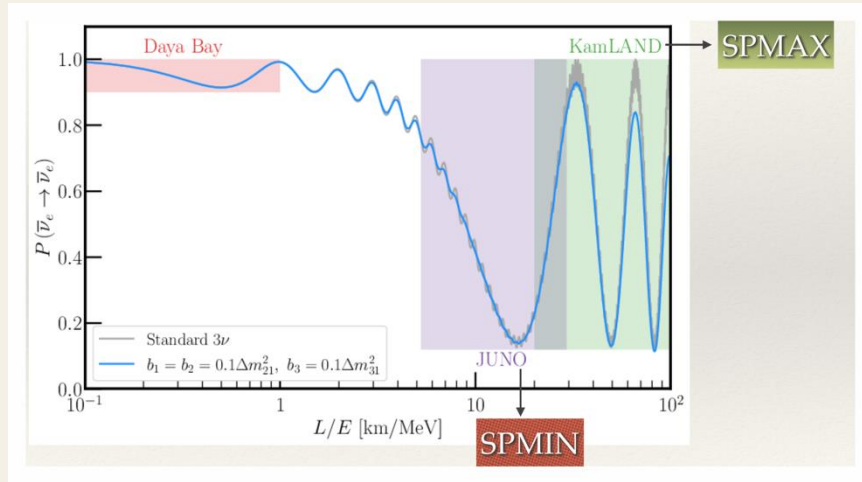
*Recent Results from ATLAS and CMS Searches for Dark Matter*



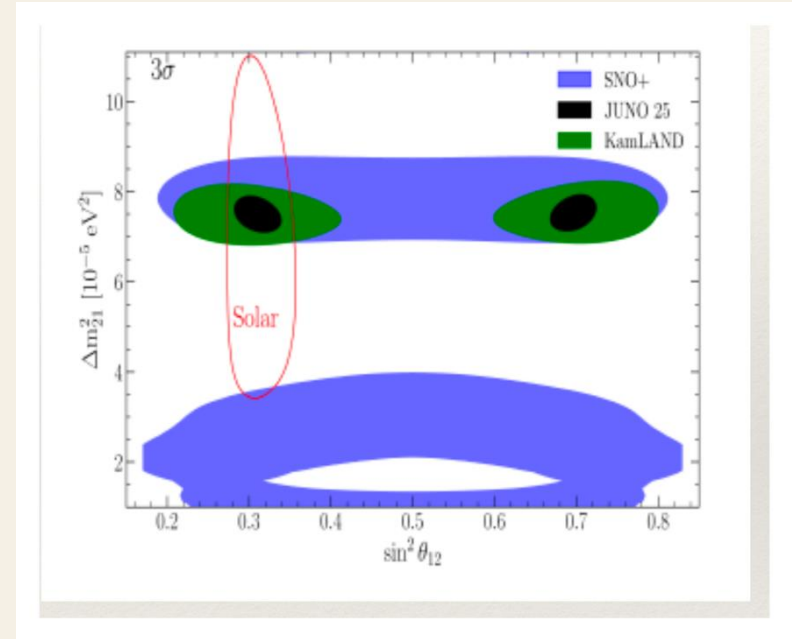
B. Andrieu (slide 8)

*Latest results from XENONnT on dark matter search and solar neutrinos*

# Site Selection



S. Goswami (slide 19)  
Neutrinos: oscillations and beyond



S. Goswami (slide 18)  
Neutrinos: oscillations and beyond

# Paying Close Attention to Spin

$$\rho(\hat{k}) = \frac{1}{4} \frac{d\sigma}{\sigma d\hat{k}} \left[ \mathbb{I}_4 + B_i^+(\hat{k}) \sigma_i \otimes \mathbb{I}_2 + B_i^-(\hat{k}) \mathbb{I}_2 \otimes \sigma_i + C_{ij}(\hat{k}) \sigma_i \otimes \sigma_j \right]$$

J. Liu (slide 4)

*Collider Spin Tomography with Missing Neutrinos*



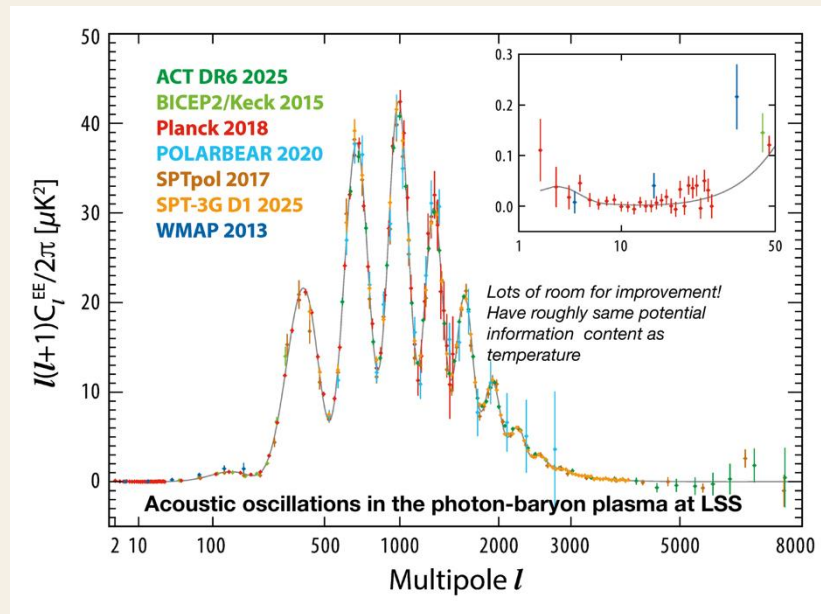
HERA



SKA

D. Agius (slide 17)

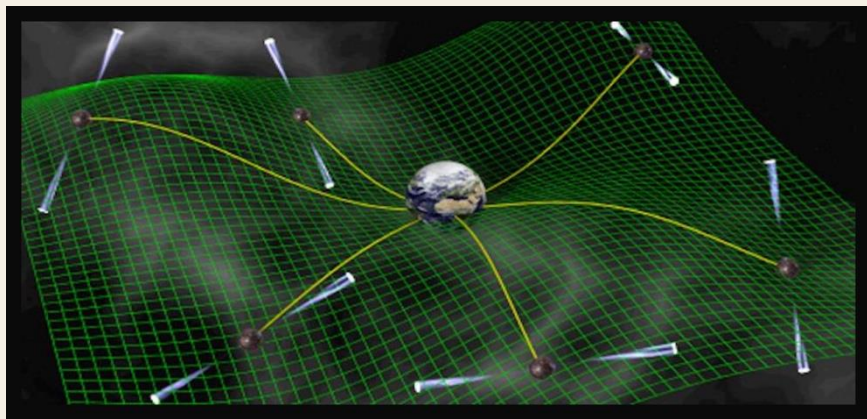
*21-cm constraints on Dark Matter*



C. Reichardt (slide 14)

*Overview of Cosmic Microwave Background...*

# Arrays of Sources... or Arrays of Detectors



T. Kahniashvili (slide 8)  
*Pulsar Timing Arrays as Probe of Massive Gravity*

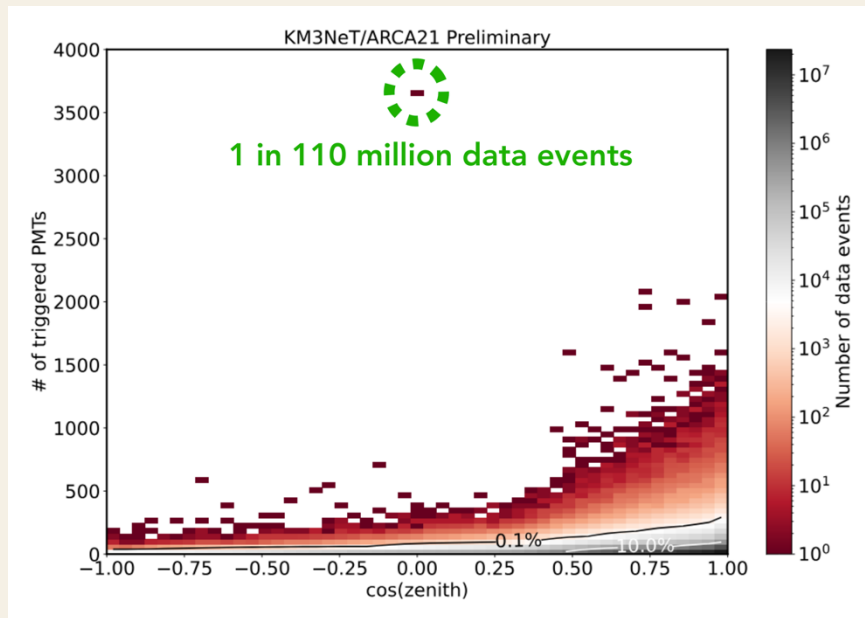


N. Rodd (slide 28)  
*Discovering Dark Matter at CTAO*

## 8. Open Horizons

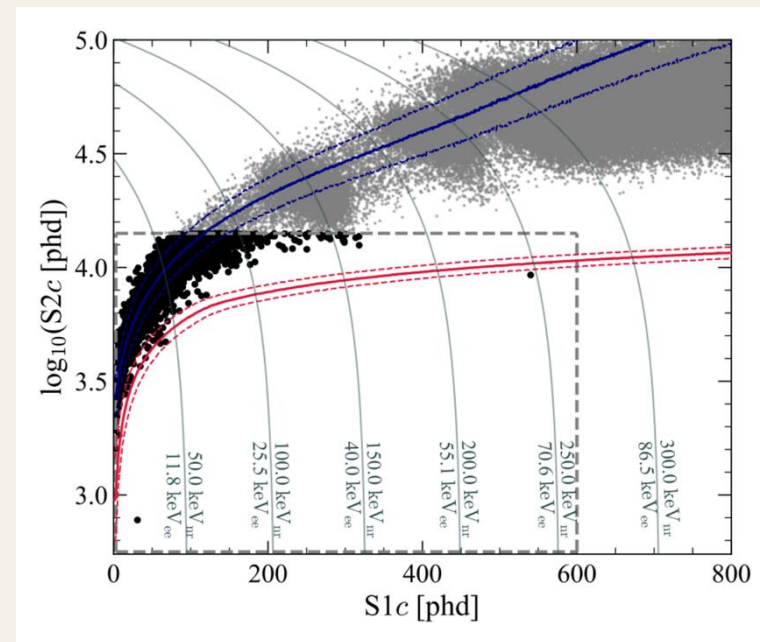
*Where do we find the new ideas and approaches to carry our field forward?*

# Extraordinary Events



F. Filippini (slide 32)

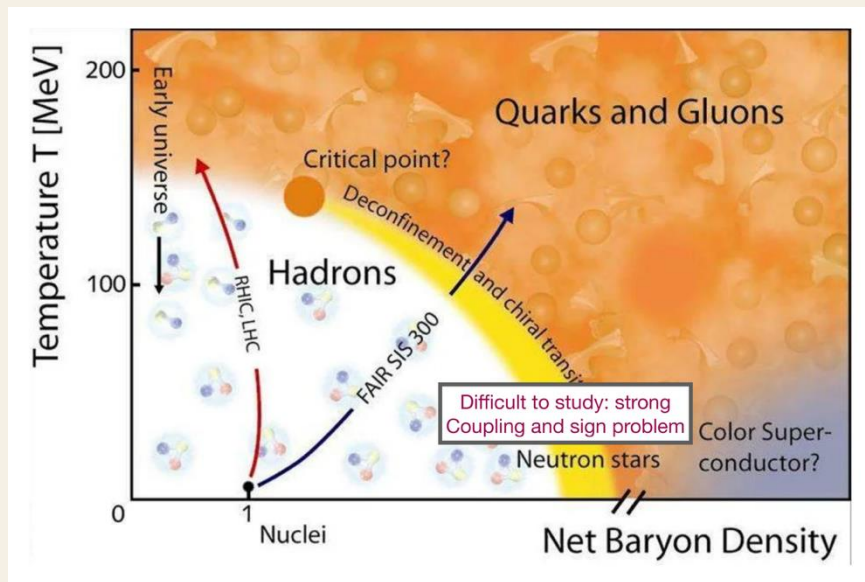
*The KM3NeT neutrino detectors: status, results and future perspectives*



N. Rodd (slide 6)

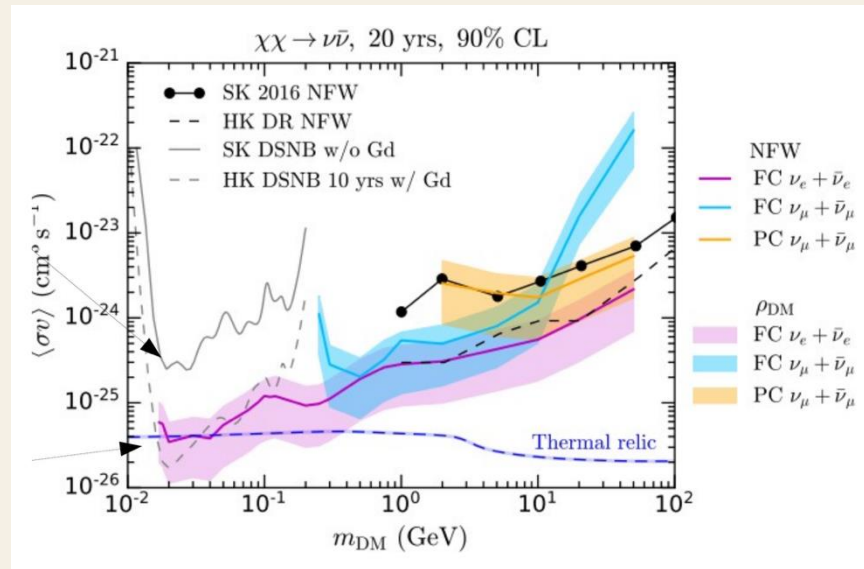
*Discovering Dark Matter at CTAO*

# Looking Elsewhere



J. van de Vis (slide 3)

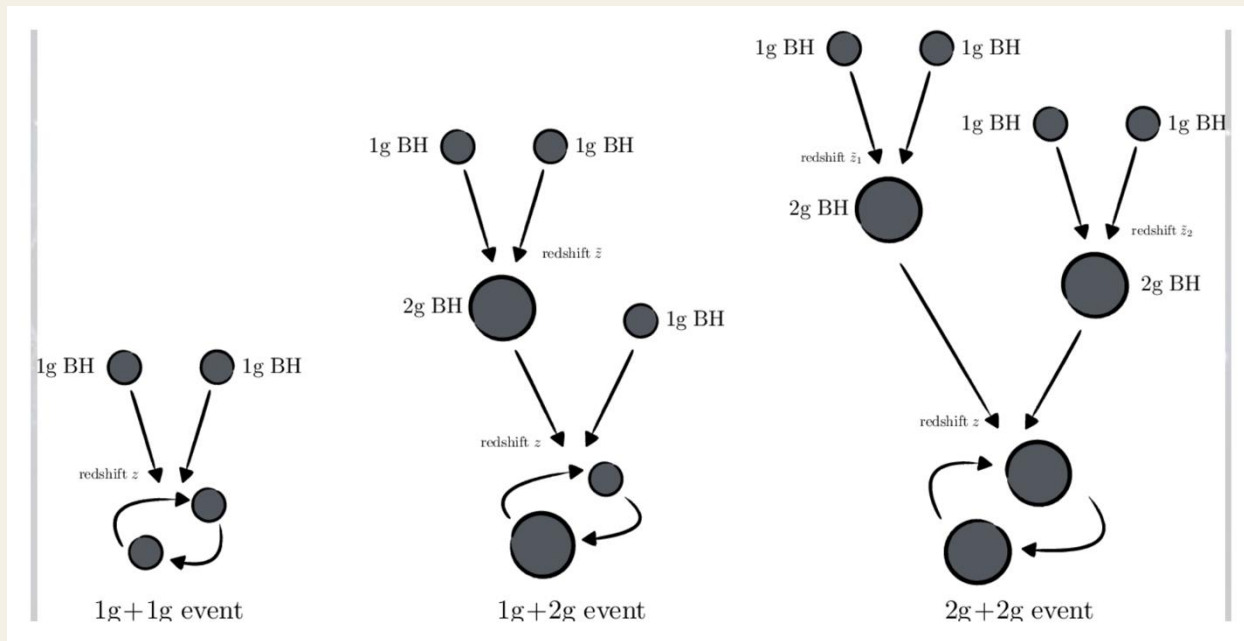
High-Frequency Gravitational Waves from Phase Transitions in Nascent...



M. Dolan (slide 16)

New Opportunities and Measurements in Neutrino Physics

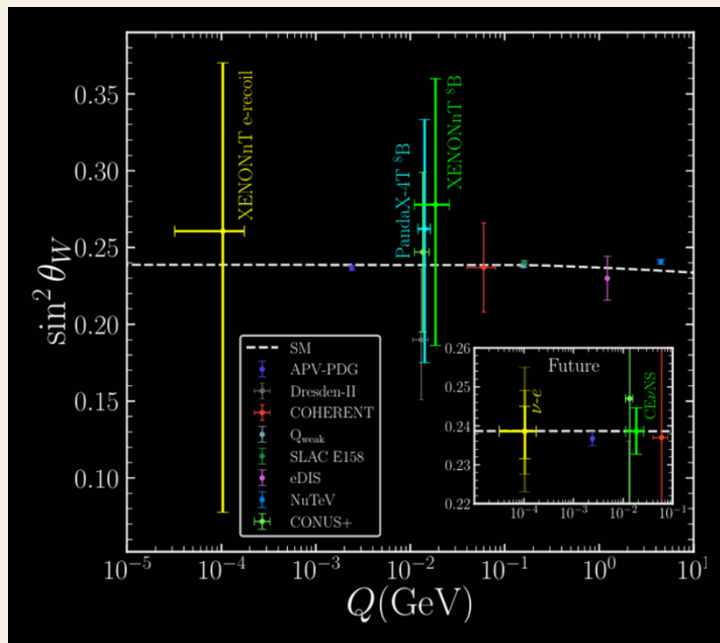
# Evading (or establishing) Rules



E. Thrane (slide 7)

*Recent highlights from LIGO-Virgo-KAGRA*

# Fresh Eyes on Familiar Sights



N. Williams (slide 7)

*Atomic ionisation from general scattering and absorption*

# Conclusion

*Our bridge to the future lies in the collaborations and innovations we celebrate here at PPC 2026.*

# Bridge to Our Interconnected Future

*“[Bridges] show the place where humankind encountered an obstacle and did not stop before it, but overcame and bridged it the way humankind could, according to understanding, taste, and circumstances.”*

— Ivo Andrić, “Mostovi” (“Bridges”) in “Staze, lica, predeli” (1963); English translation, Amela Kurtović, © 2005, CC BY-NC-ND 3.0, by permission of The Ivo Andrić Foundation.



# Let Us All Thank:

The organizers, staff, and graduate students who  
made PPC 2026 possible.

Fellow participants for the great talks, open minds,  
and lively interactions.

