Summary of C02 Group

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Tokyo Metropolitan University

March 8, 2022
Workshop on "Exploration of Particle Physics & Cosmology with ν“
@ Chiba City Life Long Learning Center theatre

Members of C02 group

Principal Investigator

TSUMURA, Koji	Kyushu U.

Co-Investigator

YASUDA, Osamu	Tokyo Metropolitan U.
SATO, Joe	Saitama U. -> Yokohama Nat. U.
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SUGIYAMA, Hiroaki	Toyama Prefect. U.

Collaborators

Kyushu U.
- YAMATSU, Naoki

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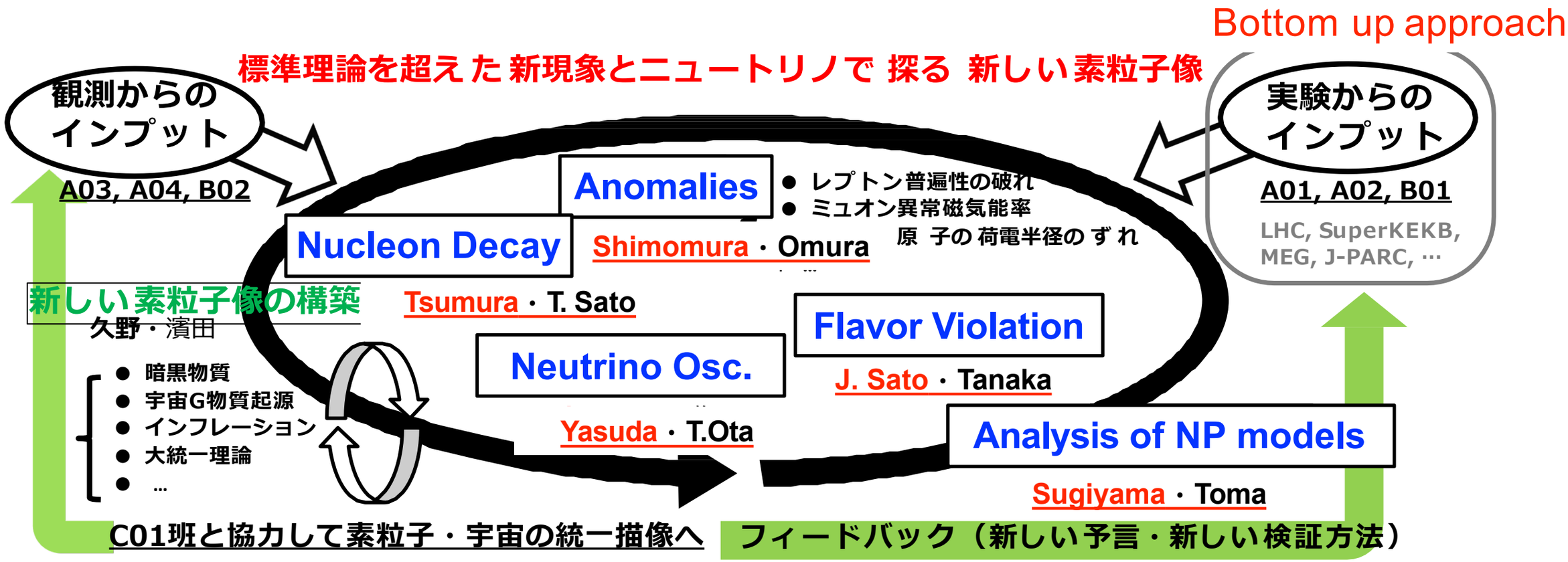
- TAKANISHI, Yasutaka
- YANG, Masaki
- ASAI, Kento
- KAKIZAWA, Hiroaki
- KASUYA, Ryuta
- NAGAYAMA, Mirai
- HONDA, Kei
- SUGAWARA, Kohei
- SAKAI, Yuhei
- SATO, ikuya

C02 group

New phenomena beyond the SM and

New particle picture explored through neutrinos



新学術成果報告会の津村さんのスライドより

Nucleon Decay : Tsumura

- B# violation as PQ mechanism (Ohata, Takeuchi, Tsumura)

  PRD104, 035026 (2021)

  - Systematic study of “PQ symmetry = Baryon number symmetry”
  - (Solution to Strong CP problem)
  - Predict various B# violating processes
    - Proton decay [dim 6, dim 7 operator]

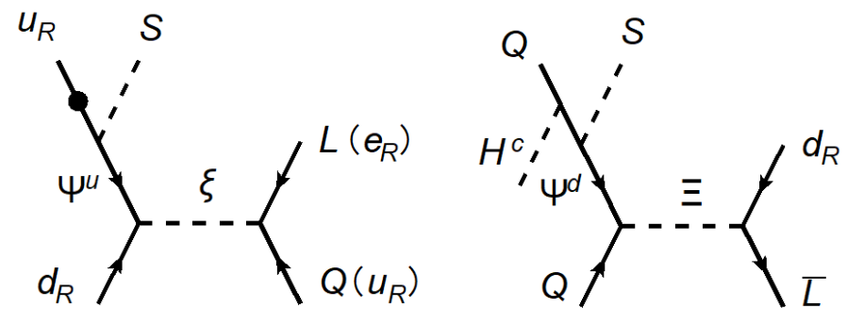
      (PQ = B-L or B+L)

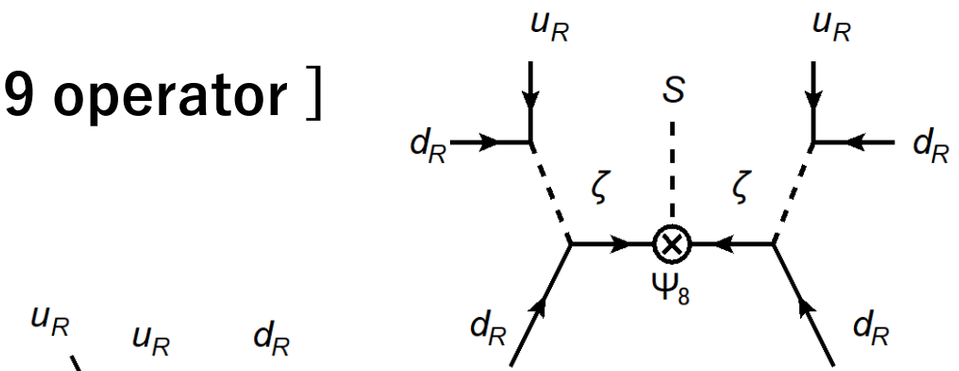
    - Neutron–Anti-neutron oscillation [dim 9 operator]

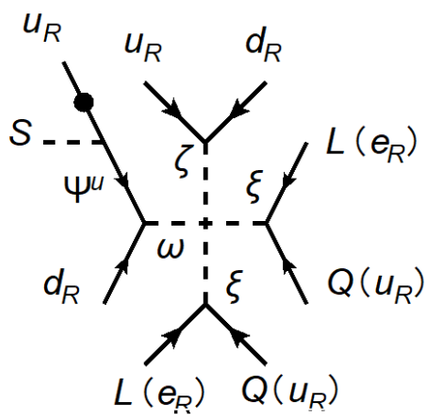
      (No ΔB=1 proton decay)

    - Di-nucleon decay [dim 12 operator]

      (No ΔB=1 proton decay)







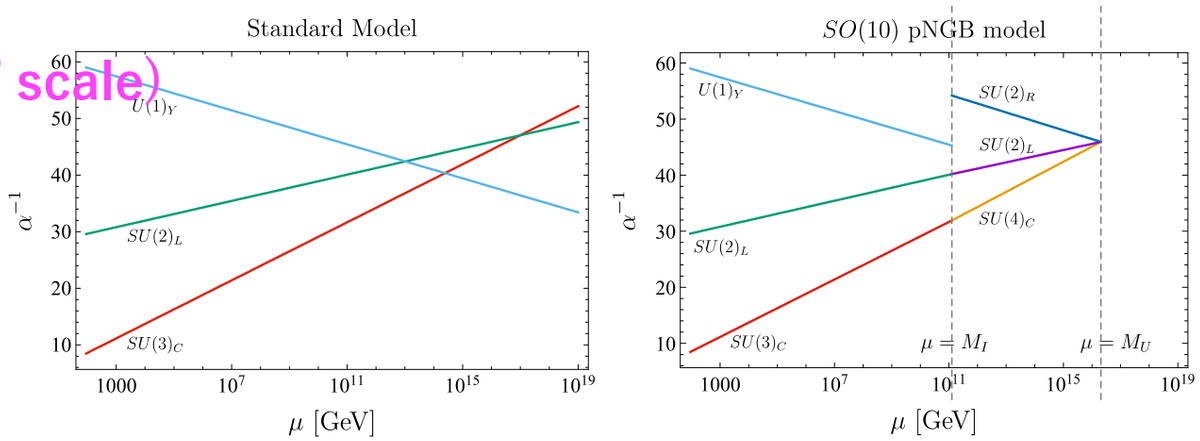
Dark Matter : Tsumura

- pNGB DM inspired by GUT (Abe, Toma, Tsumura Yamatsu)

  See Yamatsu-san's talk, PRD104, 035011 (2021)

  - Natural suppression of DM direct detection (velocity suppressed interaction)
  - Long-lived DM (controlled by GUT scale)
  - Gauge coupling unification

    Light (~50GeV) DM



- LFV mediator for DM (Asai, Miyao, Okawa, Tsumura in progress)
  - Natural suppression of DM direct detection (no interaction with electron)
  - Renormalizable model → Possible direct detection at 1-loop
  - (solution to muon g-2 anomaly)

Neutrino Oscillation : Yasuda

- **Search for sterile neutrinos by IceCube shower events**

  (**Wang, Yasuda , PTEP2022 023B04**) → Yabin Wang's talk

  Observation of no dip in the shower events at a future IceCube-type facility can give constraint on θ_{14}

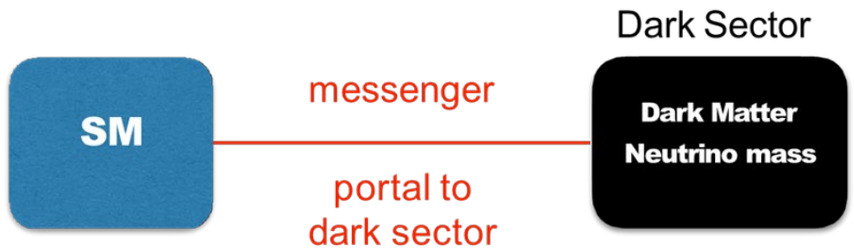
- **Sensitivity to atmospheric ν measurement at HK with general NSI**

  The neutron-electron ratio is slightly different between core and mantle. Study of sensitivity to atm. ν measurement at HK (in progress)

LFV decays of dark sector particles : Asai, Shimomura

- **Constraint on charged LFV decays of dark portal sector (Araki, Asai, Shimomura, JHEP 11 (2021) 082)**
- **Dark sector: A scenario for DM**
- **Possible origin for ν mass & mixing from dark sector**

→Portal sector can have charged LFV interactions

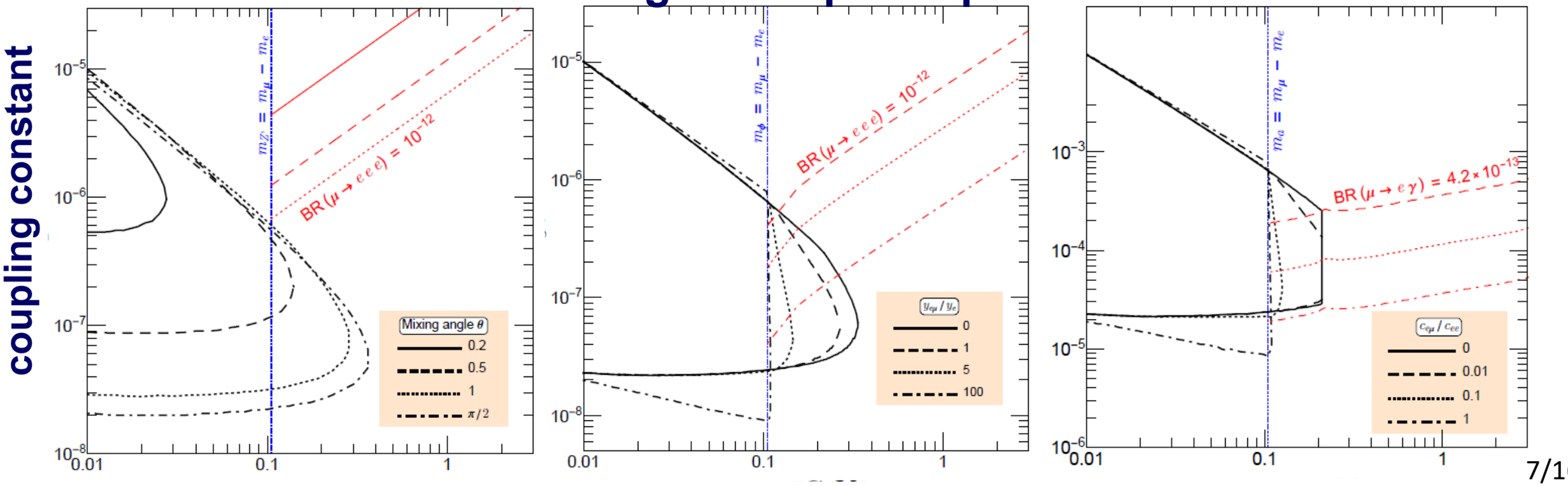


- **How much can we get info on origin for ν mass & mixing in dark sector through LFV decays of portal particles**

→Clarify the current constraint: One from electron beam dump exp. (E137) is the strongest because portal are long-live particles.

- **Sensitivity of FASER experiment to LFV decays of portal particles is currently under study**

Excluded region for portal particles



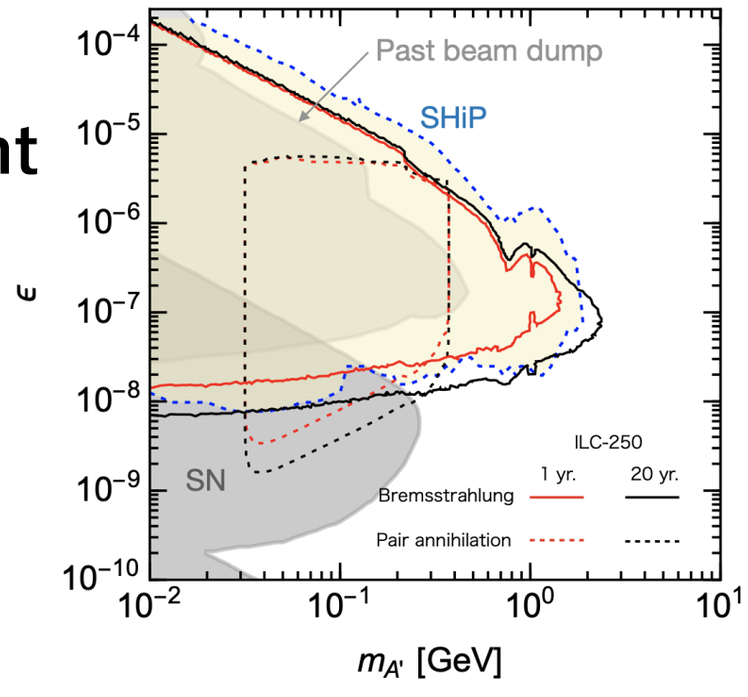
New Particle Search: Asai

1. **Search for leptophilic gauge bosons at ILC beam dump**
   Asai, Moroi, Niki, PLB 818 (2021) 136374
2. **Search for dark photon, ALP, light scalar at ILC e^- & e^+ beam dumps**
   Asai, Iwamoto, Sakaki, Ueda, JHEP 09 (2021) 183

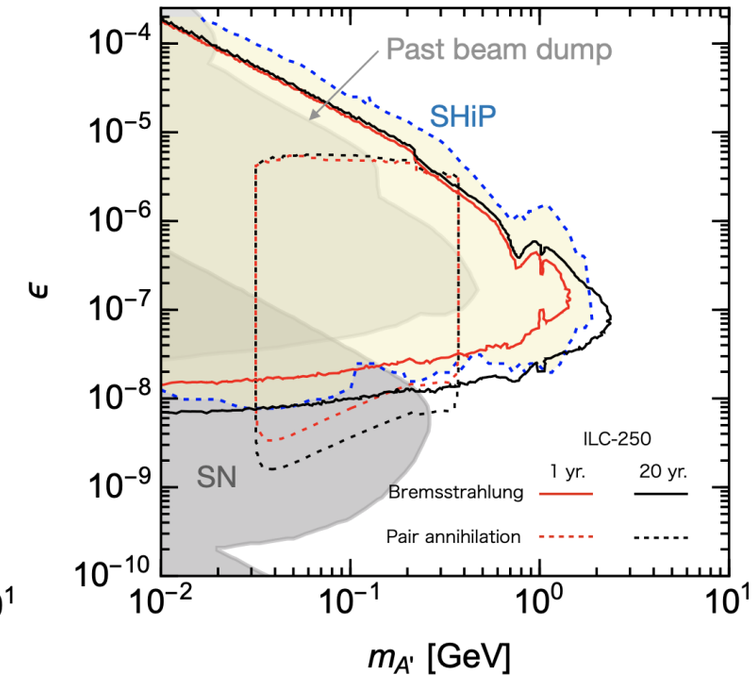
BSM particles with light mass & small coupling to SM

➡ **Long-lived**

➡ **ILC beam dump experiment has a great sensitivity**



(a) electron beam dump



(b) positron beam dump

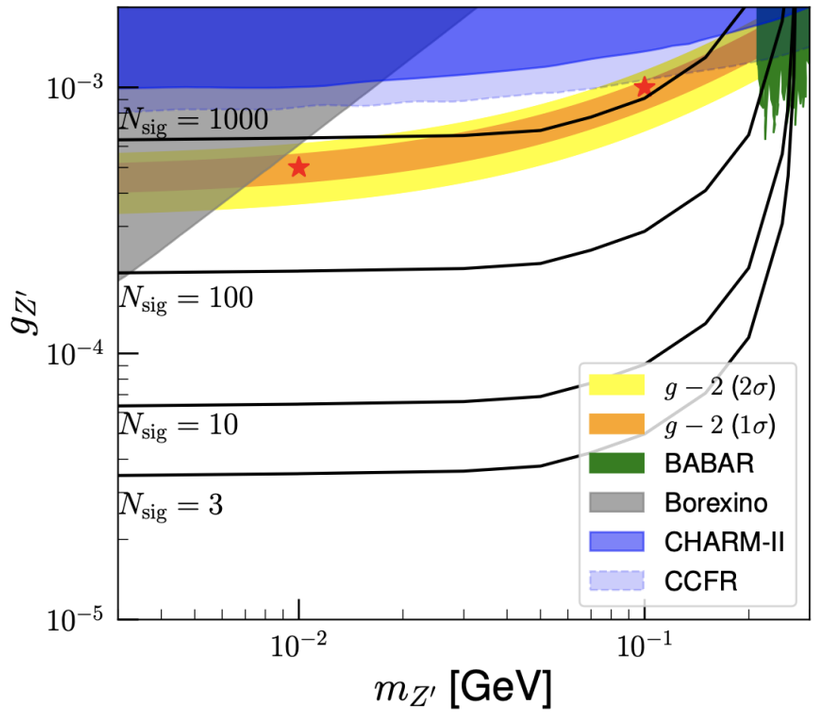
New Particle Search: Asai

3. Search for $L_\mu - L_\tau$ gauge boson at MUonE experiment

Asai, Hamaguchi, Nagata, Tseng, Wada, arXiv : 2109.10093 [hep-ph]

$L_\mu - L_\tau$ gauge boson motivated by muon $g-2$

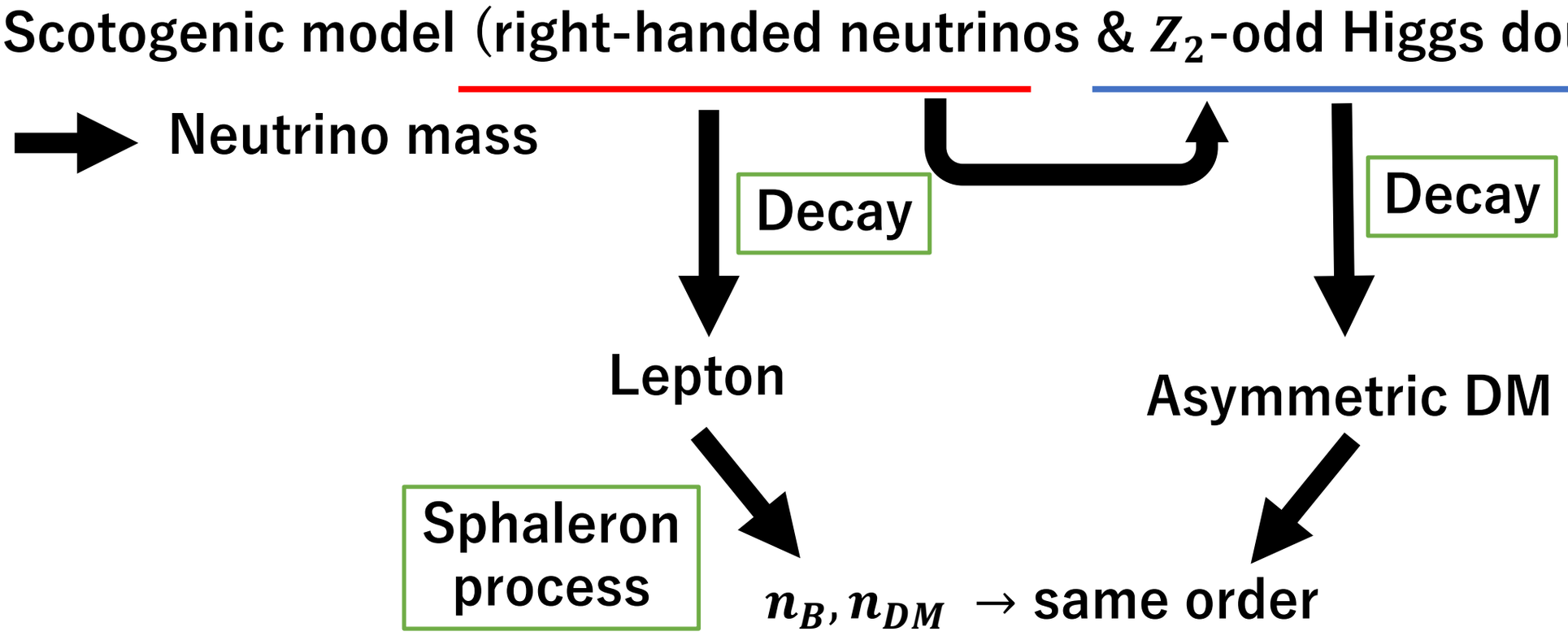
➡ Favored parameter region motivated by $g-2$ can be searched by MUonE experiment



Neutrino mass, Baryon asymmetry & DM:
Asai, Sakai, Sato,Takanishi

1. **Cogenesis of baryon & DM asymmetries in extended scotogenic model**

Asai, Sakai, Sato, Takanishi, in preparation → Sakai's talk



Indirect Detection of DM:
Nagayama, Sato,Takanishi, Tsunemi

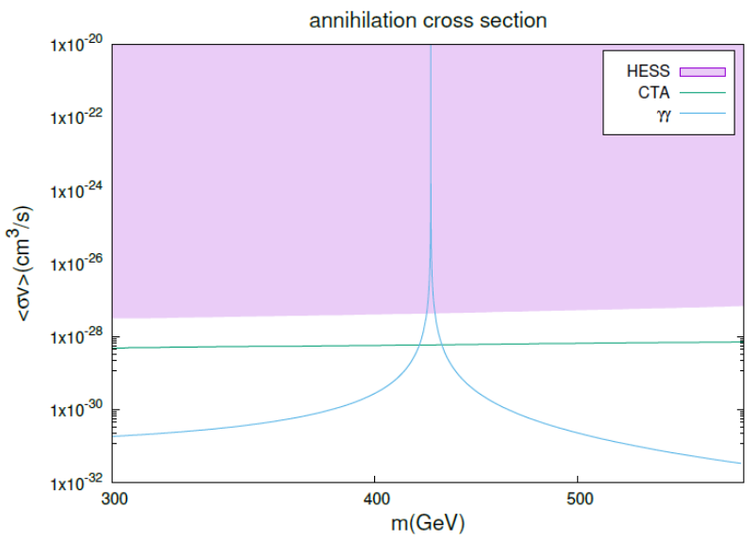
Sensitivity of indirect detection of Neutralino dark matter by Sommerfeld enhancement mechanism

Nagayama, Sato, Takanishi, Tsunemi 2102.04128 [hep-ph]

Long-lived stau NLSP as a solution of Li problem Stau NLSP

- **tight degeneracy with neutralino DM**
- **decay through tiny flavor violating coupling**

Large enhancement of DM annihilation cross section due to Sommerfeld effect



Hubble Tension:
Asai, Honda, Kasuya, Sato, Shimomura, Yang

Resolving the Hubble tension in a U(1)$L_\mu - L_\tau$ model with the Majoron

Araki, Asai, Honda, Kasuya, Sato, Shimomura, Yang
PTEP 2021 (2021) 10, 103

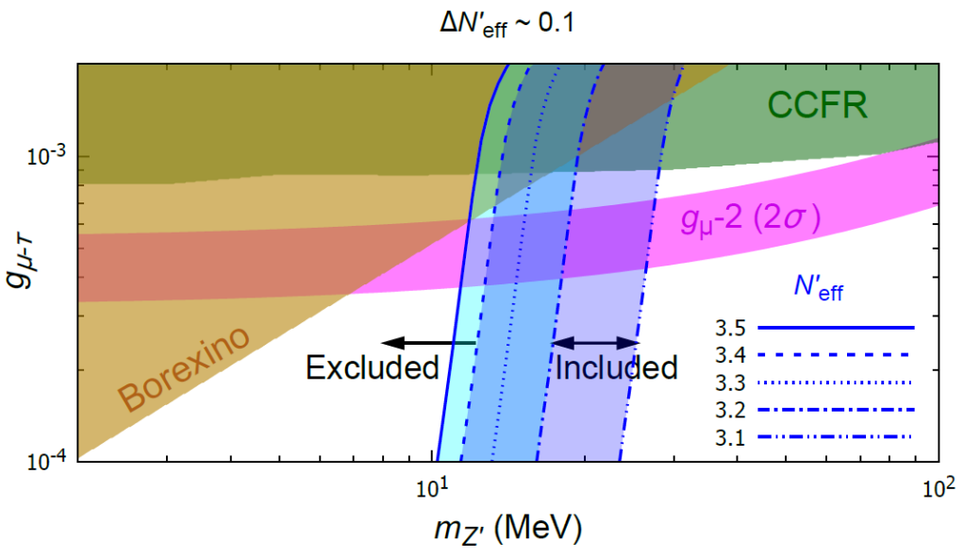
➡ **IceCube gap, Hubble tension, and muon g-2**

UV completion of Lμ-Lτ model

(in general) predict light scalar boson (Majoron)

Includeing its effect what happens
for Hubble Tension

Further discussion is going on (with new comer)



Grand-Grand Unification: Sato

Unification of Lμ-L τ and the standard model gauge group

Joe Sato, 2106.01520 [hep-ph]

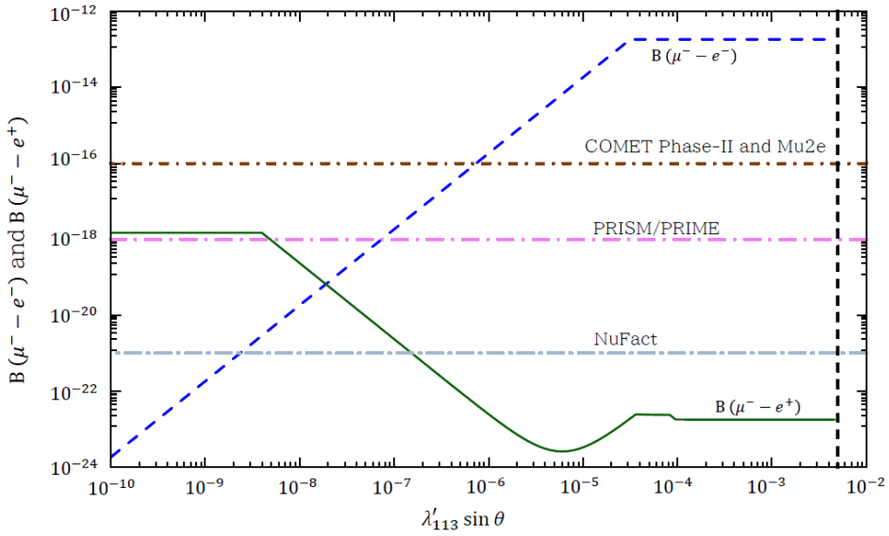
Trial to construct GUT with Lμ-L τ

New physics search using muonic atom: Sato, Sugawara

μ- → e- ＞VS μ- → e+

Sato, Sugawara, Uesaka, Yamanaka

In a class of models the latter can be larger than former



Data Analysis for COMET with ML: Sato, Sato

Sato, Sato and COMET collaboration

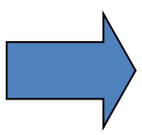
Energy estimation using machine learning, soon appear

Phenomenology with ν mass matrices:M. J. S. Yang

- **Diagonal Reflection Symmetries** M. J. S. Yang, Chin.Phys.C 45 (2021) 4, 043103

$$\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \equiv R,$$

$$R m^*_{u,\nu} R = m_{u,\nu}, \quad m^*_{d,e} = m_{d,e}.$$

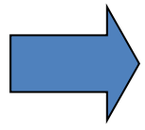


Reproduces M_q & M_l to precision of $O(10^{-3})$; $\delta_{CP} \doteqdot 203^\circ$, $\alpha 2,3 \sim 10^\circ$ up to π, Normal Ordering, $m_1 \doteqdot 2.5$ or 6.2 meV

+ universal four-zero texture

- **Model with DRS+universal four-zero texture+magic symmetry** M. J. S. Yang, PTEP 2022, 013B12

$$m_{\nu T} \equiv \begin{pmatrix} 0 & a & 0 \\ a & a+b & a+b \\ 0 & a+b & b \end{pmatrix} \qquad M_e = \begin{pmatrix} 0 & i\,C_e & 0 \\ -i\,C_e & \tilde{B}_e & B_e \\ 0 & B_e & A_e \end{pmatrix}$$



δ, α_2, α_3, m_1, θ_{12}, θ_{13} can be predicted

Systematic Analysis of massive ν model : Sugiyama

- **Classification according to combination of Yukawa int.**

  Test (reject) efficiently (too many) NP models ⟶ True NP model

- **Neutrino mass generation requires new Yukawa int. absent in the SM**
  (usually include new scalar bosons)

  ✦**tree-level : one neutrino Yukawa int.**
  ✦**loop-level : more than two types of Yukawa int.**

  Combination of the Yukawa int. is important.

- **Ignore interactions among the scalars ⇨ Classification independent of model details**

  ⟶ suitable for tests

work in progress

Under some simplification

✦**Majorana mass generation** (Kanemura, Sugiyama (2016))
✦**Dirac mass generation** (Kanemura, Sakurai, Sugiyama (2016))

Working on more general framework (particularly its relation to the quark sector) to cover more NP models and to complete the list of models including previously overlooked ones

✦**Its relation of B physics**
✦**Possible test for Majorana nature at LHC**

Summary

Many works are in progress.

New results will appear in the next year.

Neutrino Oscillation Yasuda

- **Constraint on ν_s from HE ν (Wang's talk)**
- **NSI for Atmospheric ν**

Nucleon Decay & DM Tsumura

- **pNGB DM inspired by GUT (Yamatsu's talk)**
- **B# violation as PQ mechanism**

Systematic Analysis of m_ν models Sugiyama

- **Yukawa int. and ν mass gen.**

Flavor Violation Sato

- **Hubble tension and (g−2)$_\mu$ anomaly**
- **Indirect Detection of DM**
- **GUT**

Anomalies Shimomura

- **LFV by electron beam dump experiments**
- **Sensitivity of FASER experiment to LFV**