# A fresh look of proton decay in SUSY SU(5)

Priyanka Lamba
CHEP, Indian Institute of Science

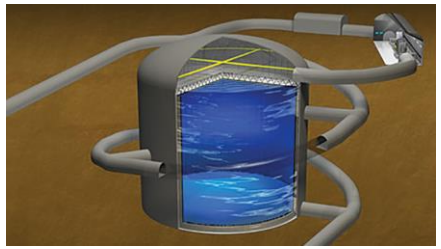
In collaboration Charanjit K. Khosa, Stephane Lavignac and Sudhir K. Vempati

2021 Meeting of the Division of Particles and Fields of the American Physical Society (DPF21)

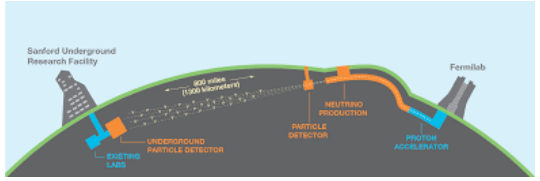
13/07/2021

# Motivation

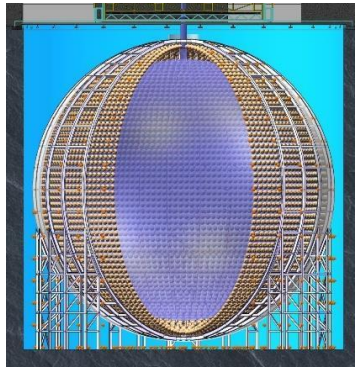
- In this decade, proton decay searches will be improved by O(10) by 3 different neutrino detectors and maybe discovery.



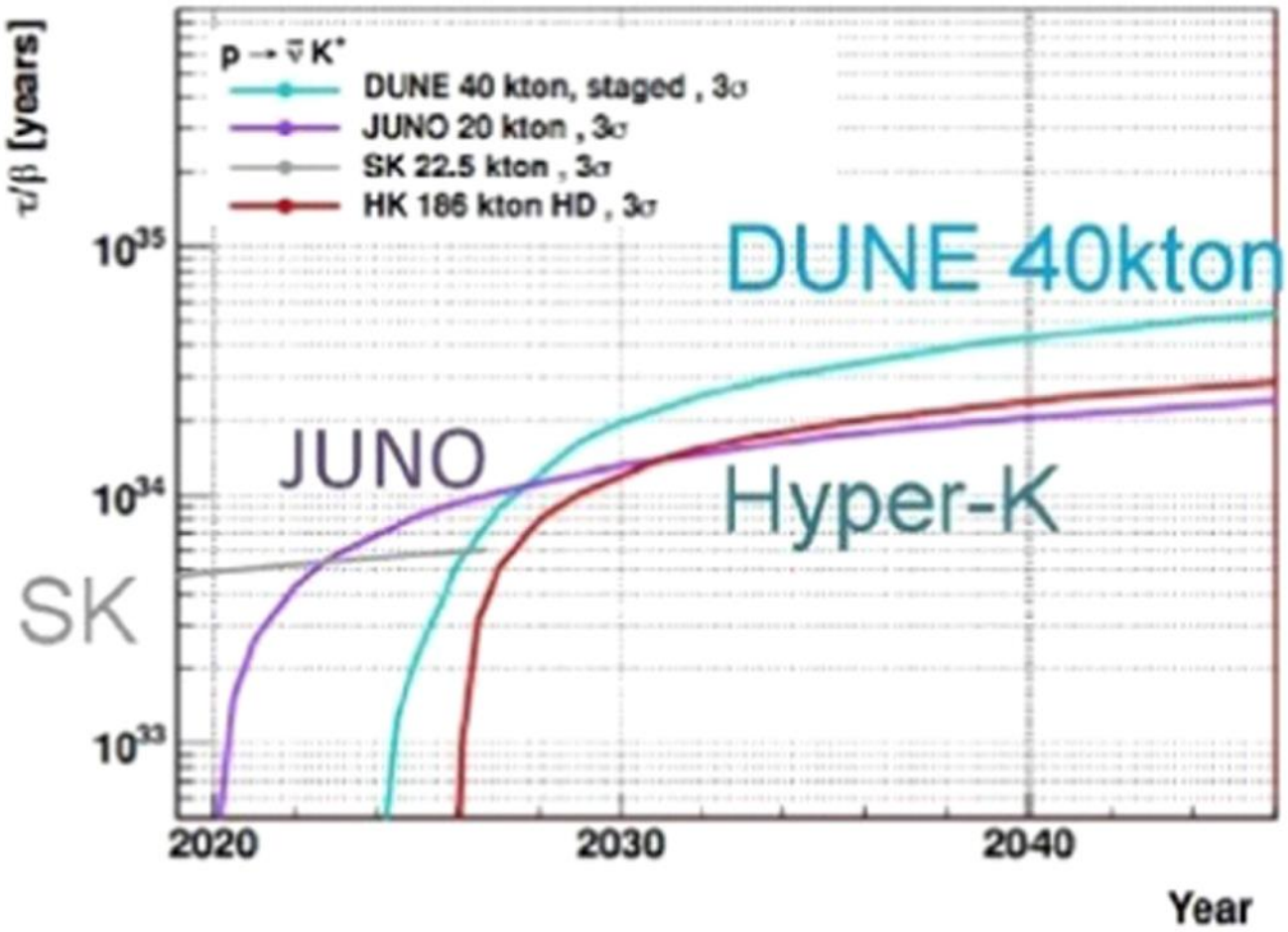
Hyper-K: 185 Kton water in Japan




DUNE: 40 Kton Liquid Argon in US



JUNO: 20 kton Liquid Scintillator in China




arXiv:1805.04163

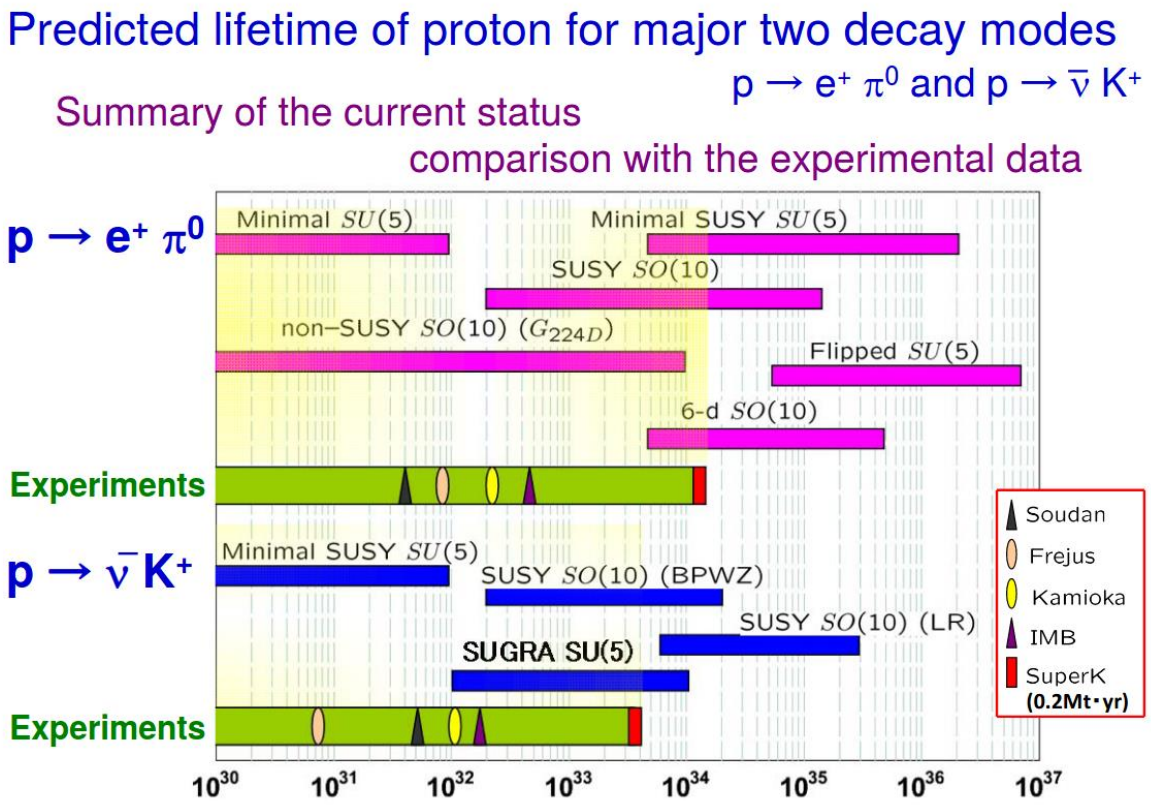
# Motivation

- Low Energy SUSY is pushed towards heavy scale from different experiments especially by flavour measurements and LHC.

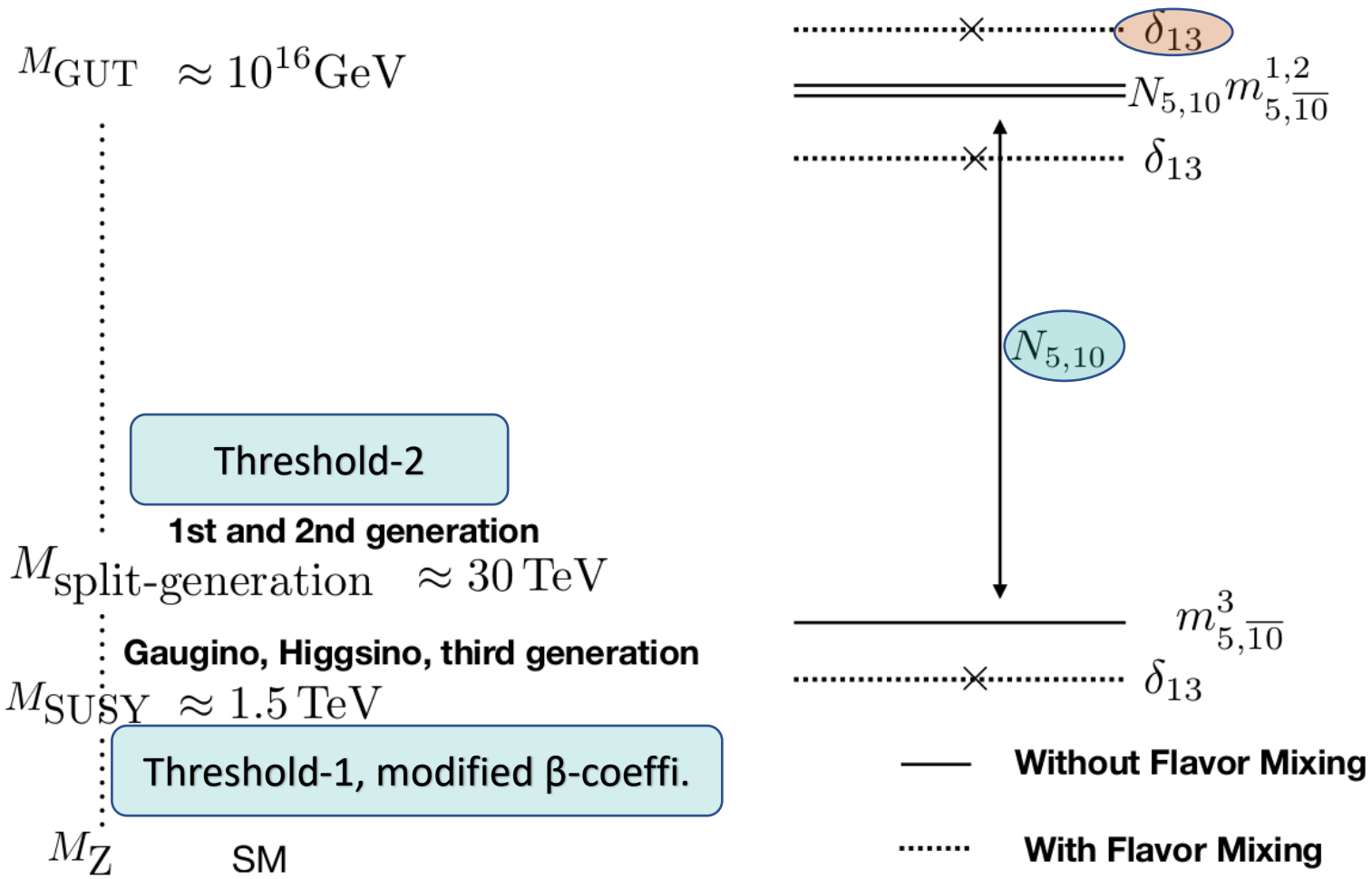
- Proton decay is really sensitive for gauge couplings and gauge unification scale. Precision calculation for gauge unification is required.
- Effect of flavour violation in Soft terms is also important in proton decay.

- Numerical codes have to modified for precision in heavy scale SUSY.

- Revisit of SUSY GUT models required.



# Set-up

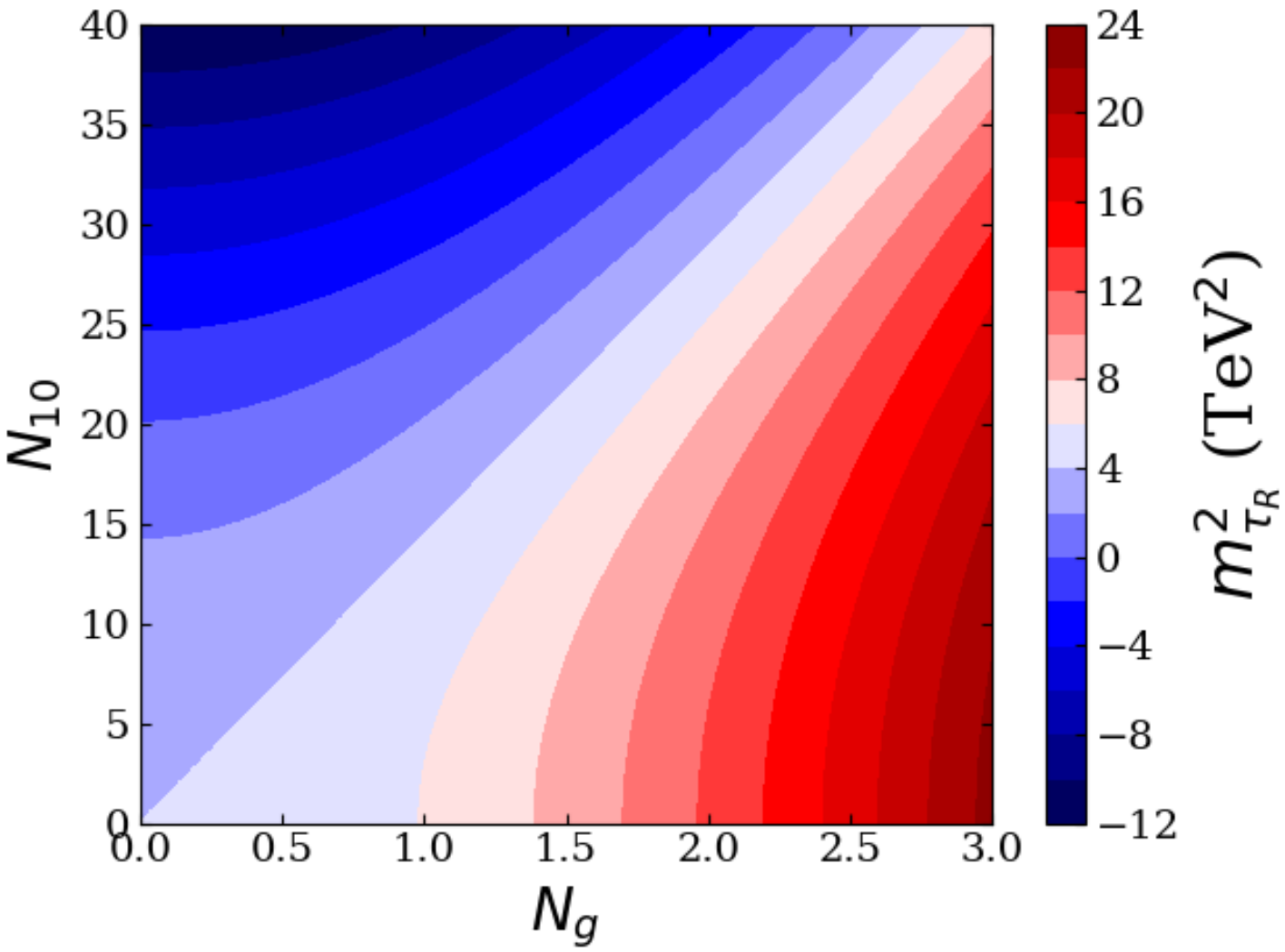



## Questions

- Can we decouple first two generation completely?
- How much running of gauge coupling will effect in this set-up??
- Threshold correction??
- How proton decay will effect due to flavour violation?


Refs:
L. Randall and M. Reece
H. Murayama and A. Pierce
N. Nagata and S. Shirai

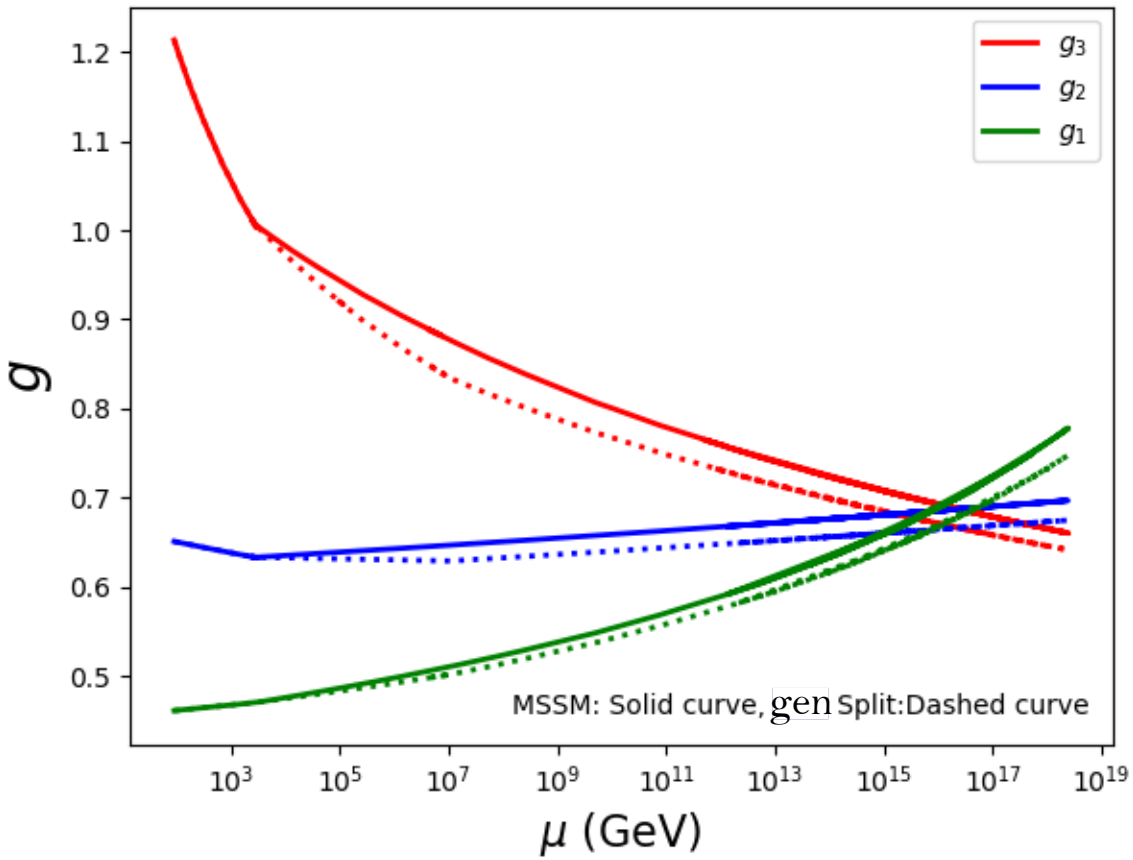
# Can first two generation scalars completely decouple?



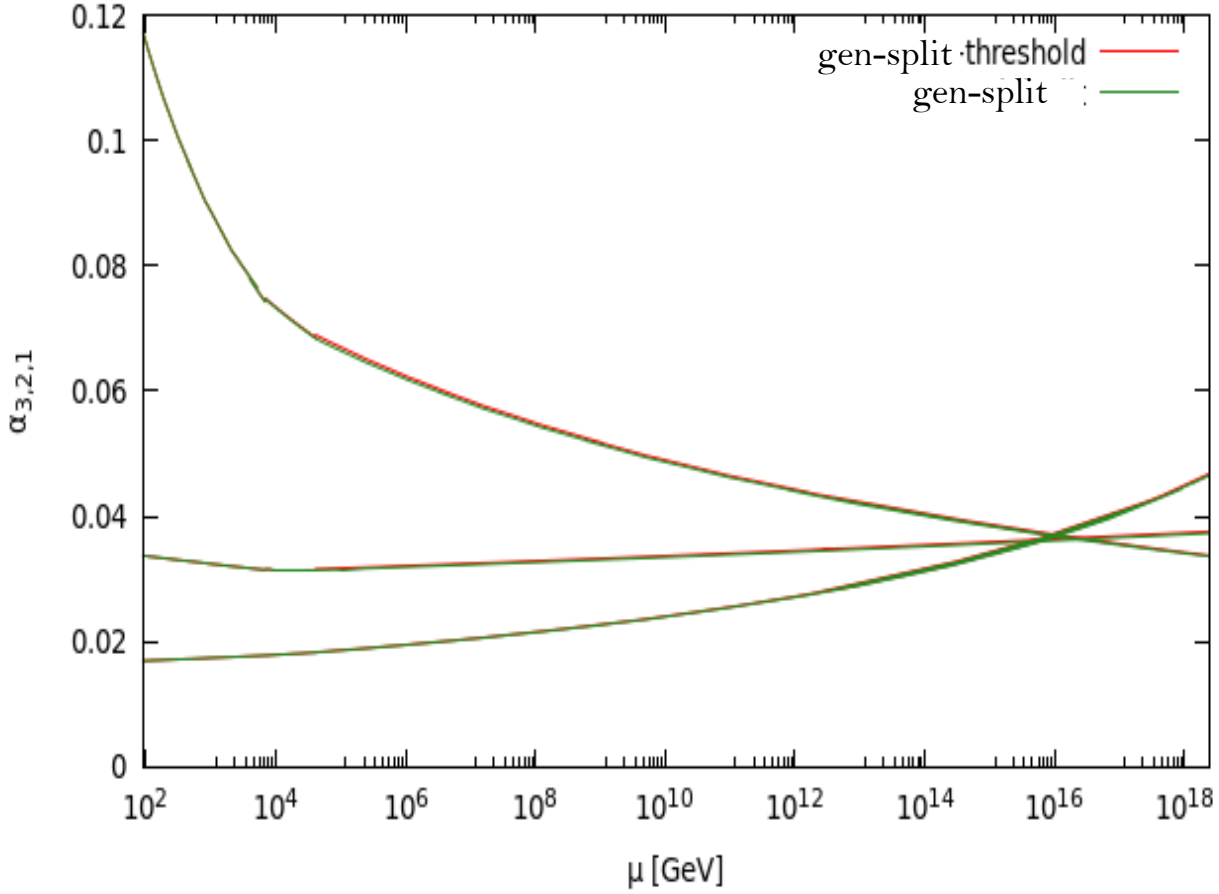

Refs: N. Arkani-Hamed and H. Murayama, 1997 && K. Agashe and M. Graesser, 1999

# Results: Gauge unification in generation-split scenario

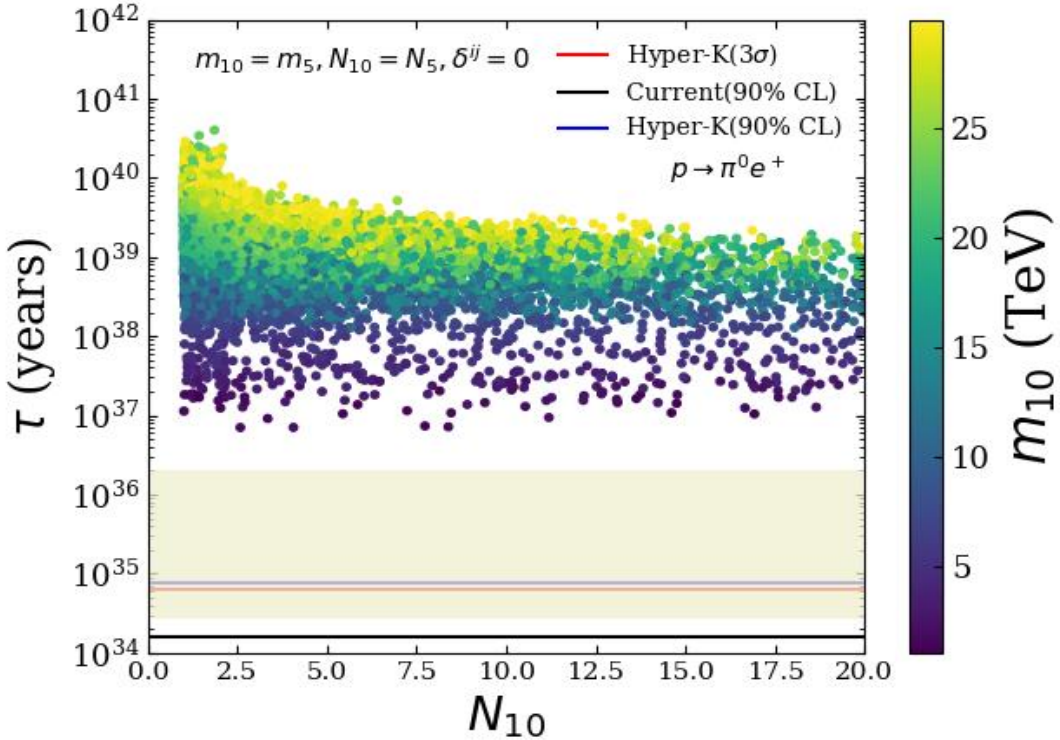
β- Coefficient corrections

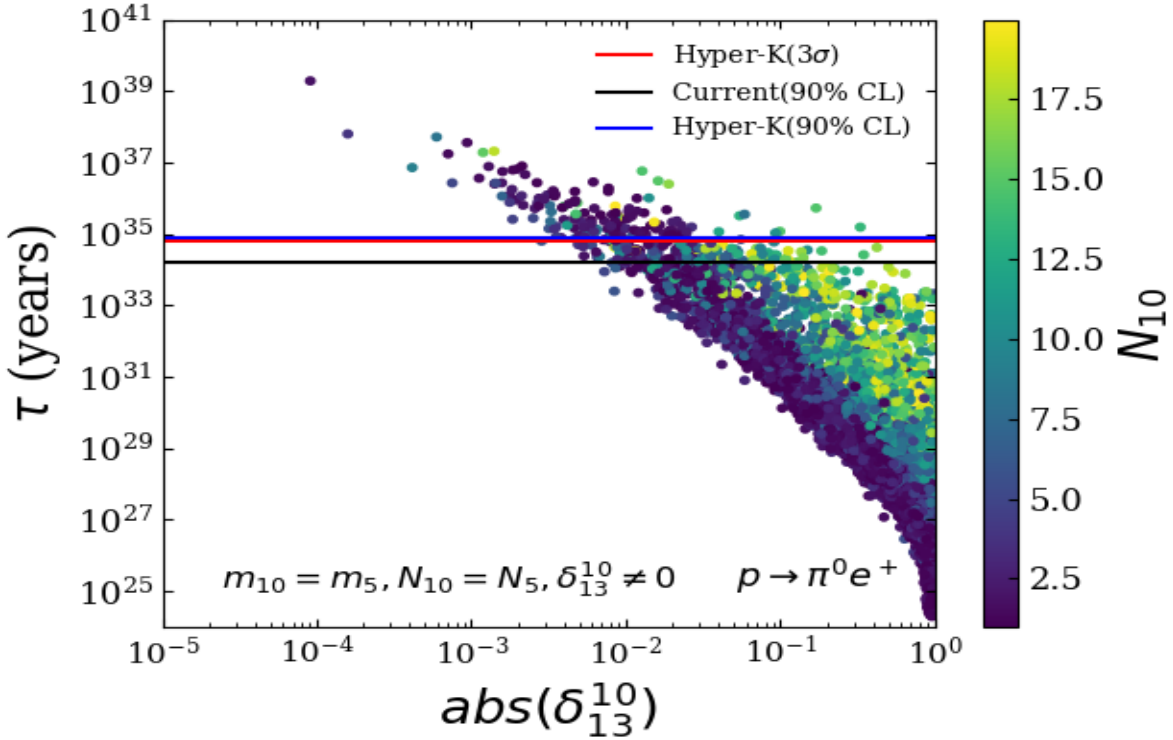



Threshold corrections

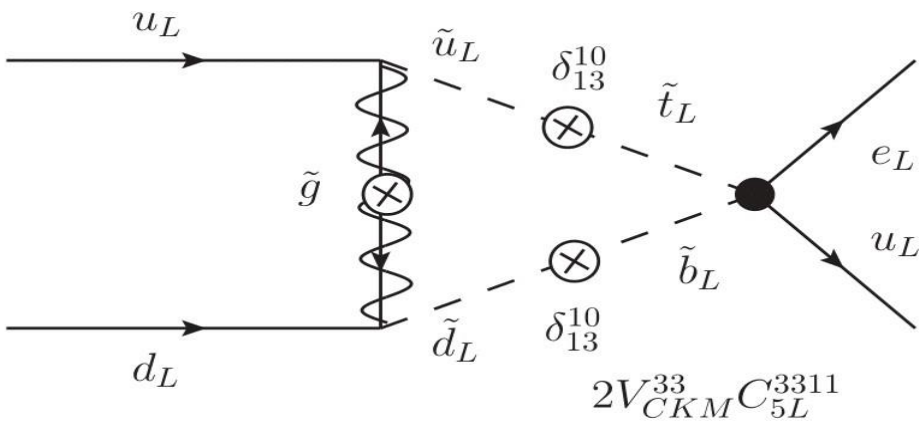


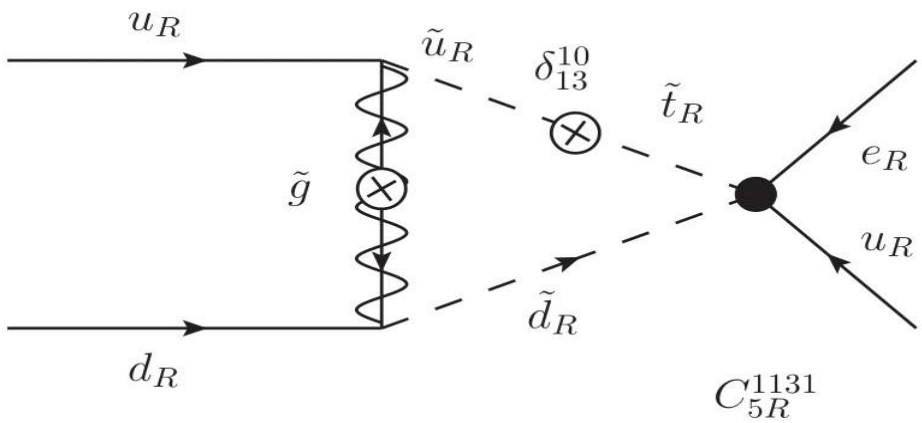
# Results: Partial Mean Life with and without $\delta$'s:



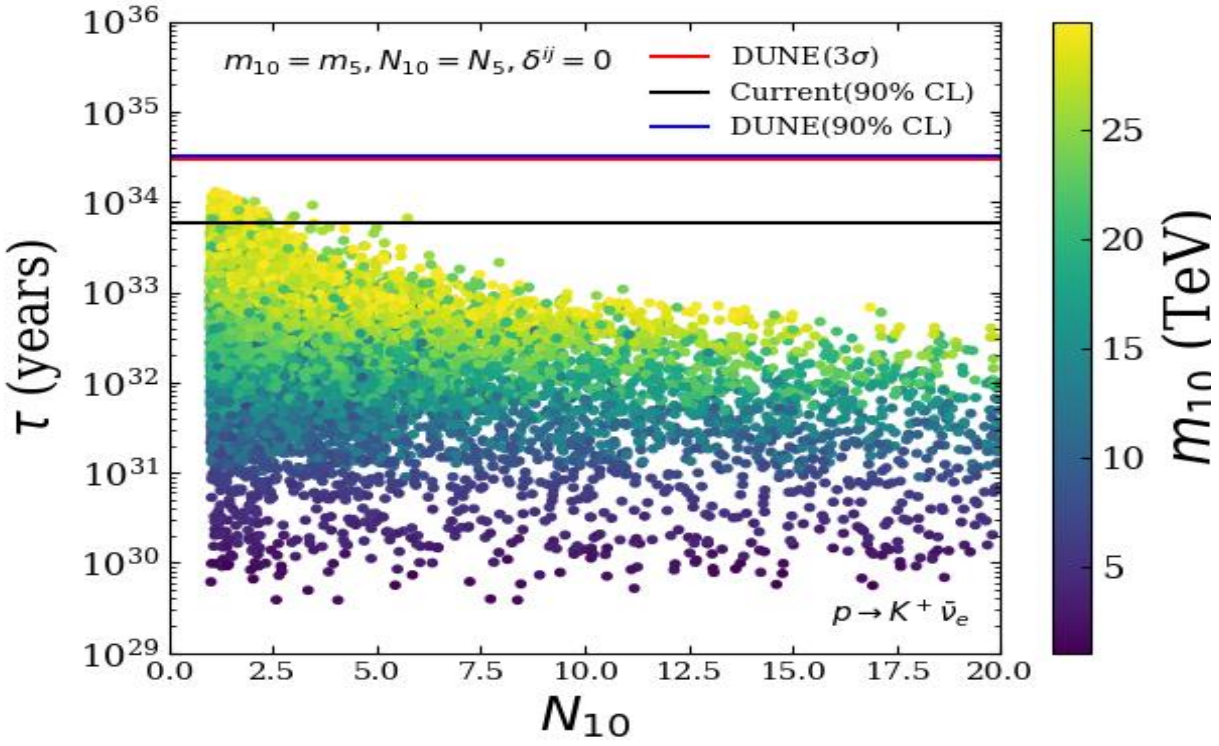



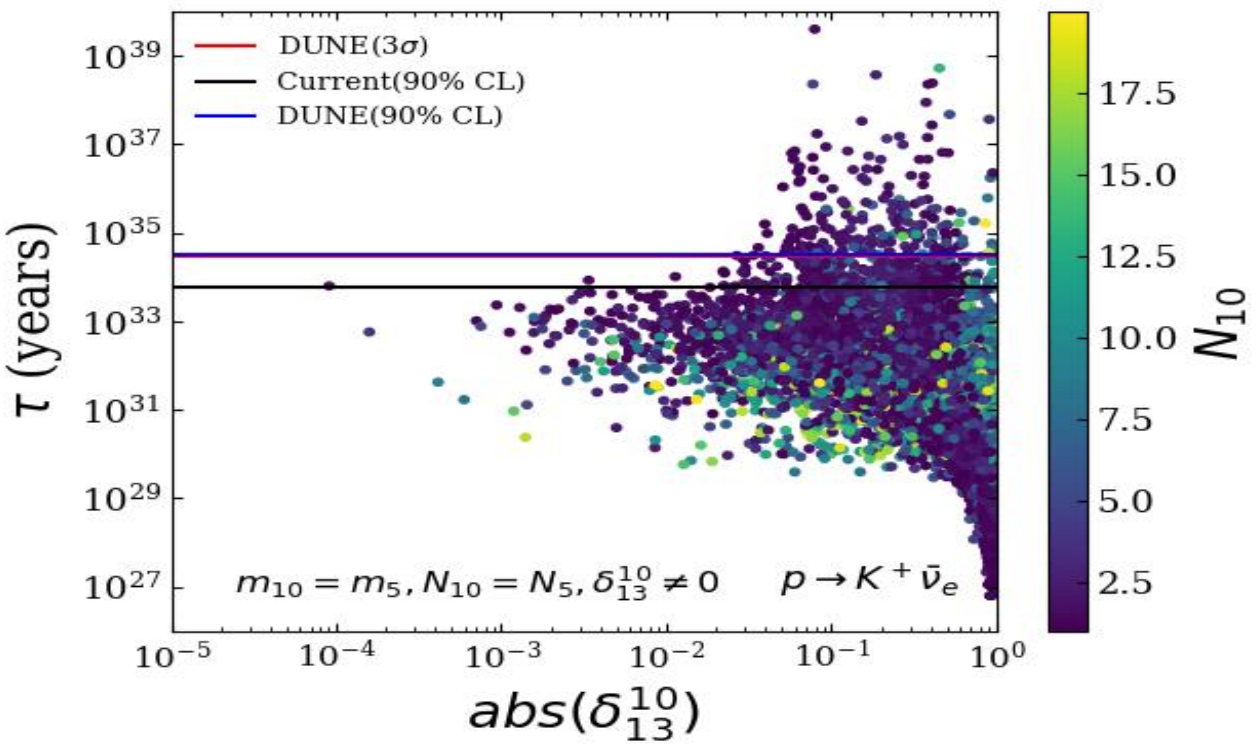

Gluino dressing diagram due to $\delta$'s in first third genration:



# Results: Partial Mean Life with and without $\delta$'s:



# Summary

- Gauge unification scale does not change with this spectrum and Exact Unification still holds, after taking thresholds correctly into account.

- The decay mode $p \to e^+ \pi^0$, which has sensitivity beyond that of DUNE and Hyper-K, is brought within the reach of these experiments in this model.

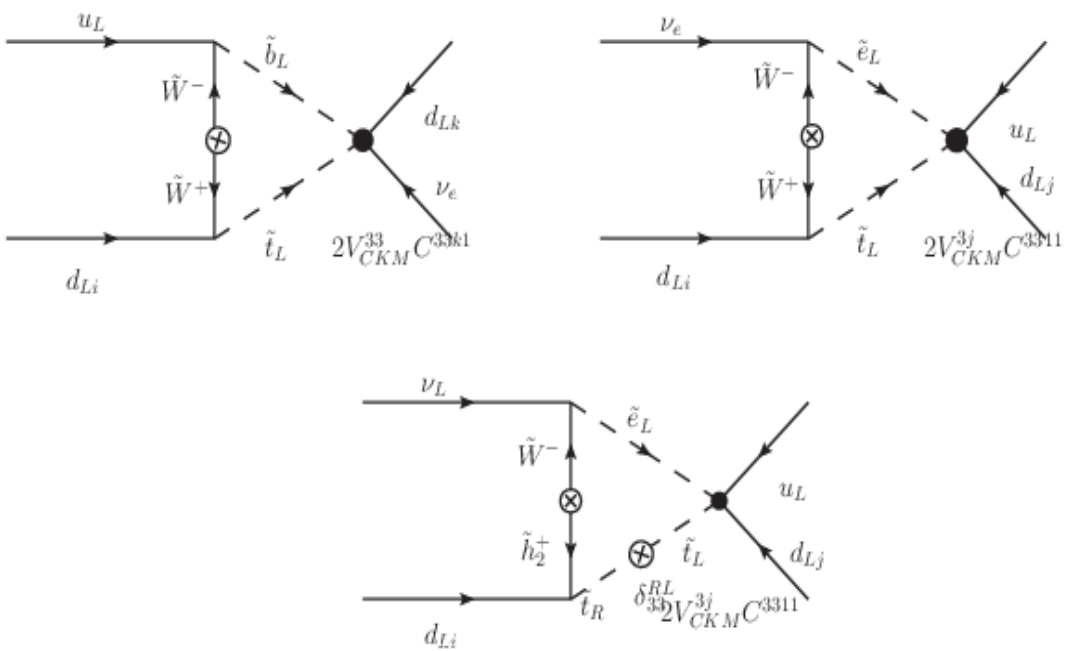
- The most dominating decay mode $p \to K^+ \bar{\nu}_e$ of this model, which essentially rules this model out for this range of masses, is now able to survive and further, interestingly, can be explored at DUNE and Hyper-K.

- SUSEFLAV_H is updated for two scale thresholds and mini-split beta coefficients, will be public soon.

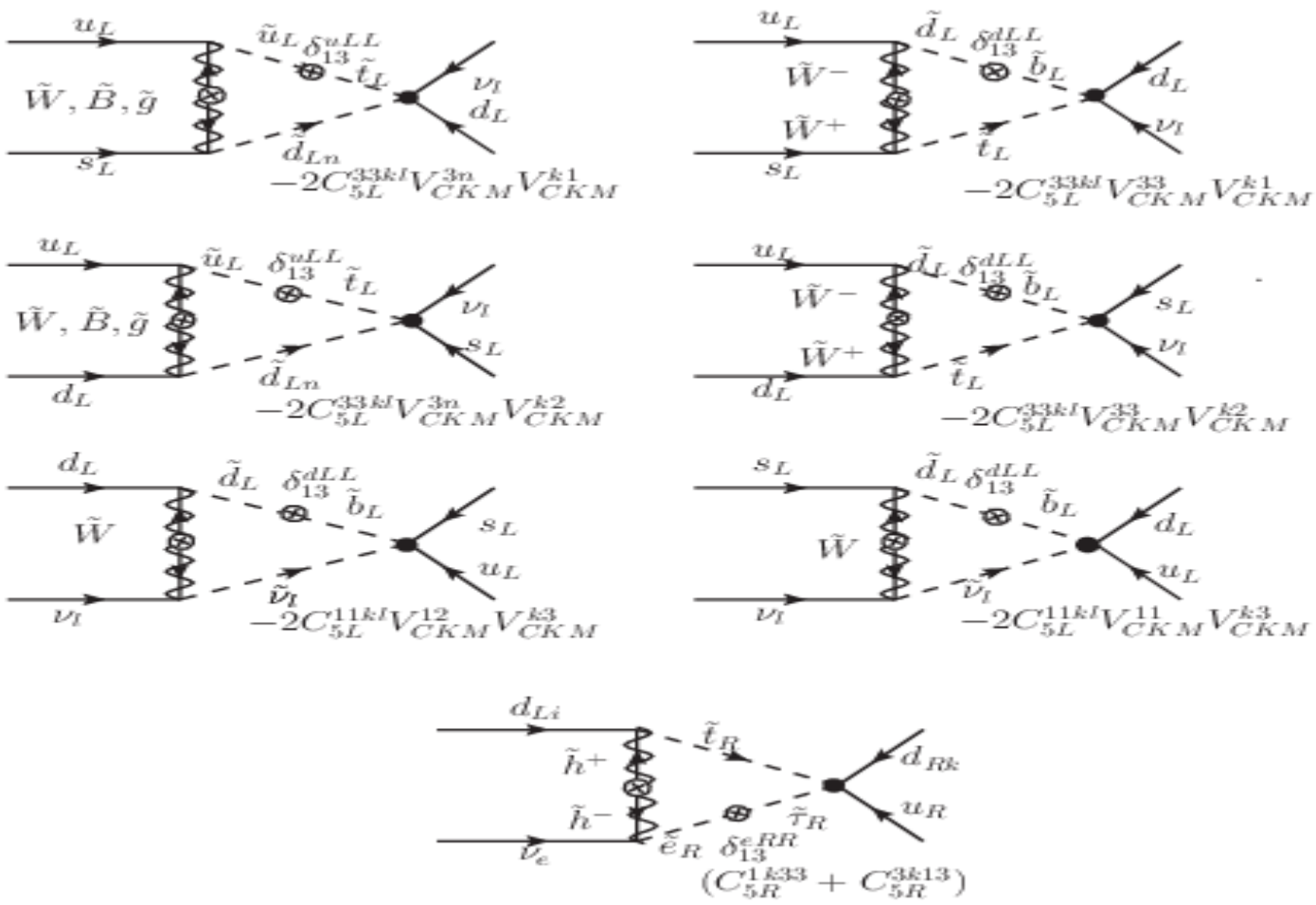
*Thank You*

# Backup-slides

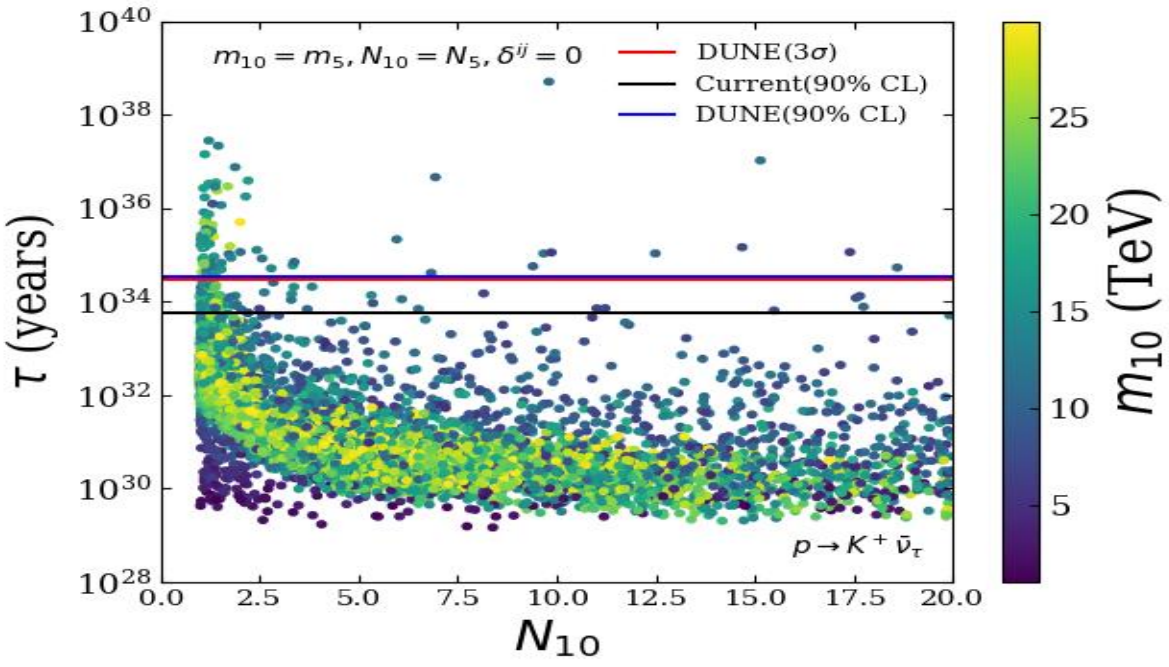
Dressing Diagrams for $p \to K^+\bar{\nu}_e$ without $\delta$'s:

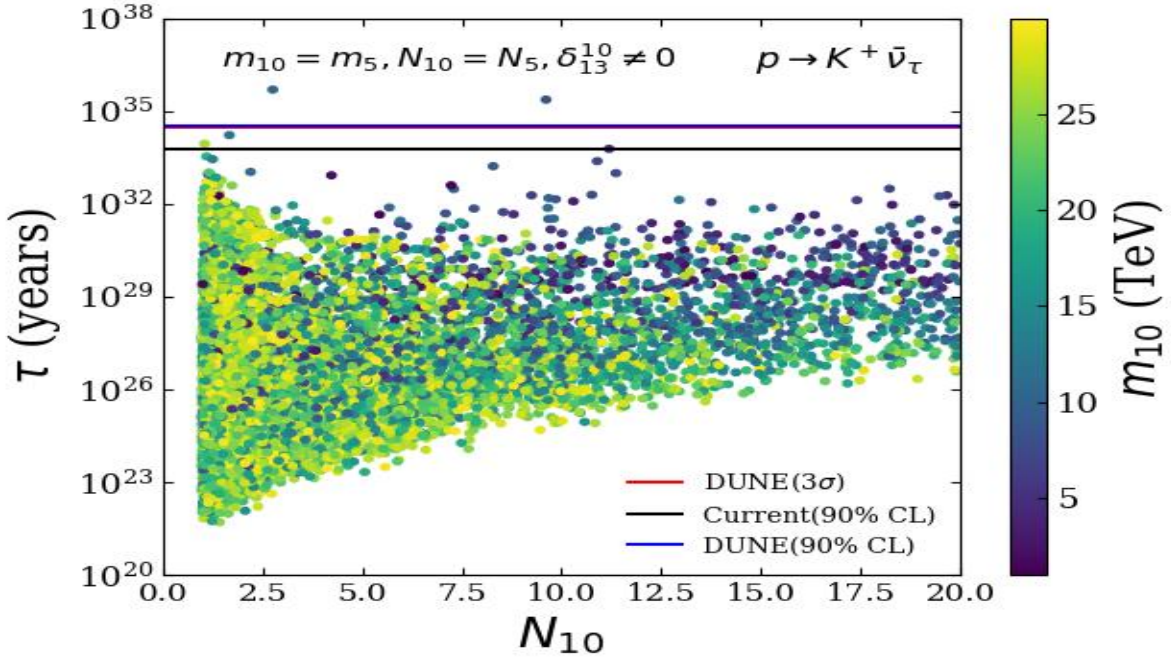



Dressing Diagrams for $p \to K^+\bar{\nu}_e$ with $\delta$'s:



# Backup-slides



# Backup-slides

$\beta$-coefficients of gauge couplings for split generation scale which is at third generation scalar masses:

One-loop:

$$b_a = (79/15 \quad -1/3 \quad -13/3)$$

Two-loop:

$$B_{ab} = \begin{pmatrix} 407/75 & 21/5 & 176/15 \\ 7/5 & 89/3 & 16 \\ 22/15 & 6 & 58/3 \end{pmatrix} \qquad C_a^{u,d,e} = \begin{pmatrix} 18/5 & 14/5 & 18/5 \\ 6 & 6 & 2 \\ 4 & 4 & 0 \end{pmatrix}$$

Can first two generation scalars completely decouple ?

| p Decay Modes | Partial mean life ($10^{33}$ years) | | |
|---|---|---|---|
| | Current (90% CL) | Future ($3\sigma$ discovery) | Future (90% CL) |
| $p \to \pi^0 e^+$ | 16 | DUNE: 15 (25)<br>Hyper-K: 63 (100) | DUNE: 20 (40)<br>Hyper-K: 78 (130) |
| $p \to K^+ \bar{\nu}$ | 5.9 | JUNO: 12 (20)<br>DUNE: 30 (50)<br>Hyper-K: 20 (30) | JUNO: 19 (40)<br>DUNE: 33 (65)<br>Hyper-K: 32 (50) |