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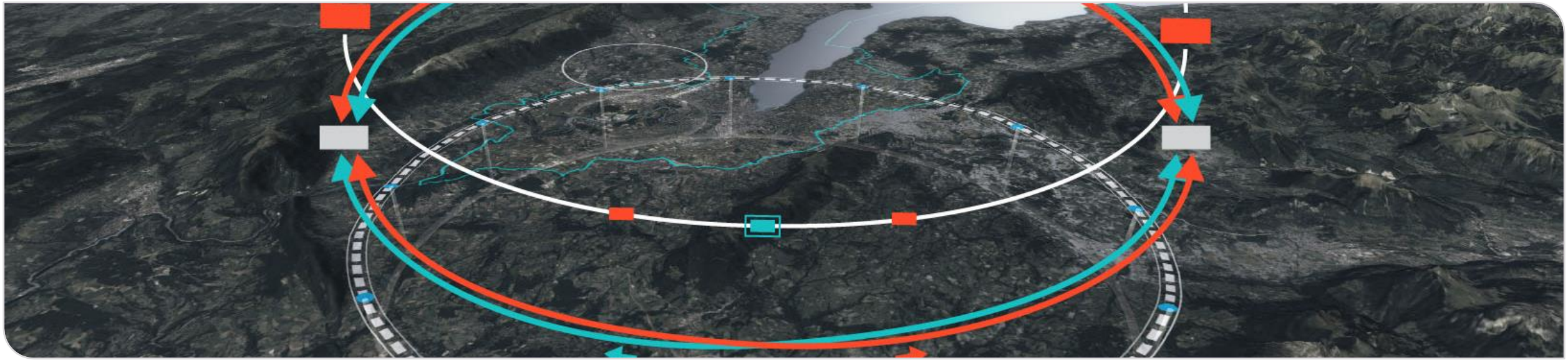
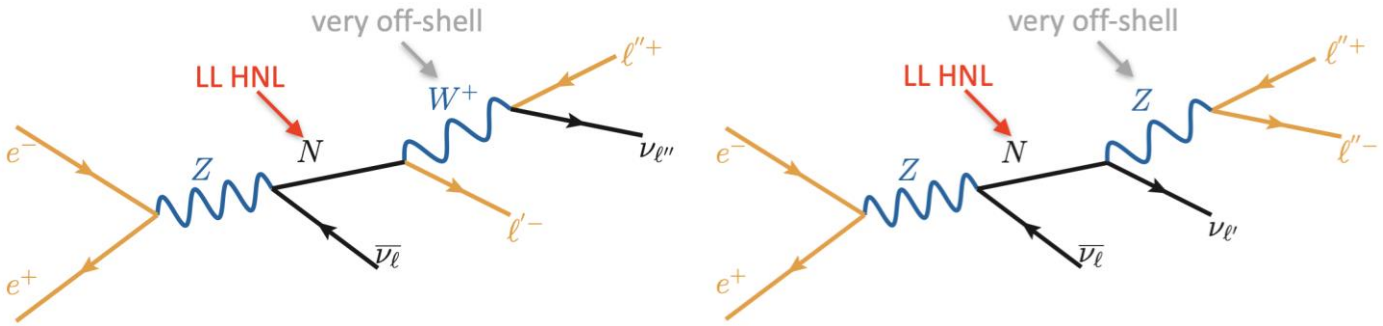
HEAVY NEUTRAL LEPTONS SEARCH IN A REALISTIC NEUTRINO OSCILLATION MODEL AT FCC-ee

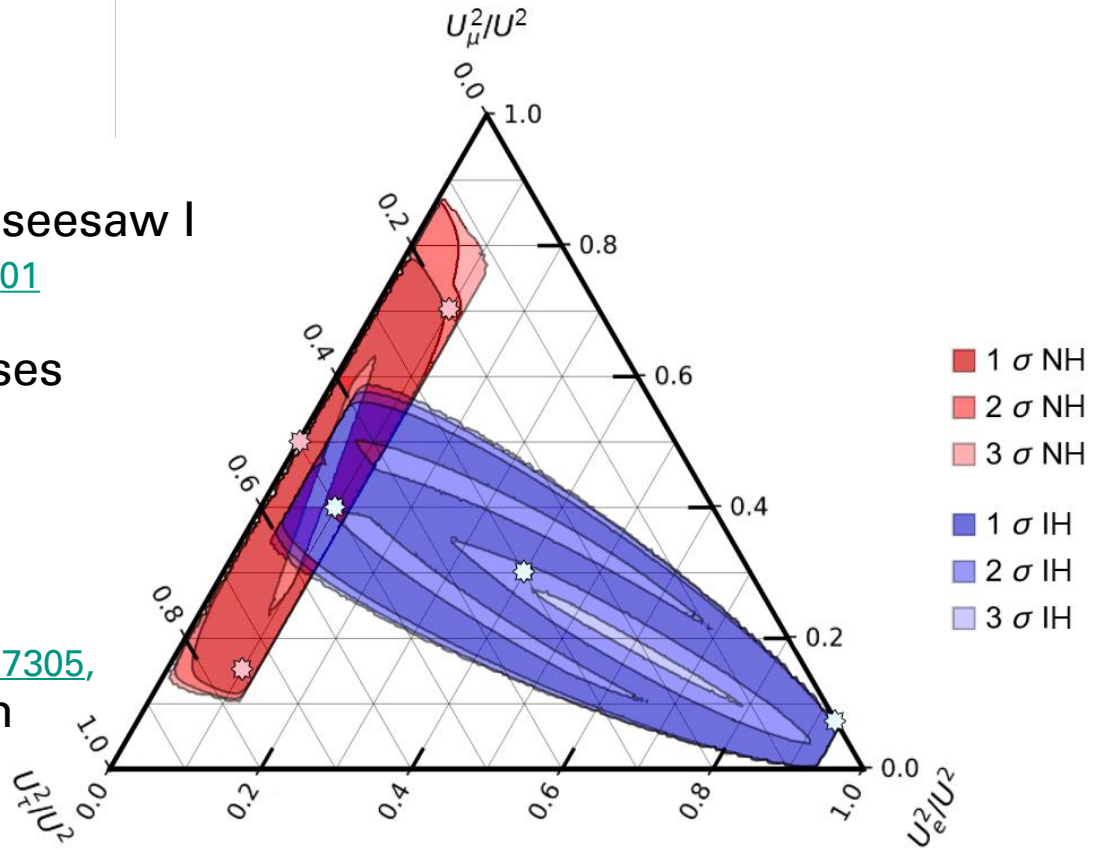
FCC LLP meeting, May 16th, 2024 - Sofia Giappichini
Markus Klute, Orlando Panella, Matteo Presilla, Xunwu Zuo



LONG LIVED HNLs



- Production of **two heavy neutrinos** (HNLs) in a realistic seesaw I model with couplings to all leptons Phys. Rev. Lett. 128, 051801
- Cross section is maximized with quasi-degenerate masses arXiv: 1712.07611
- Simulation of Majorana HNLs at FCC-ee, $\sqrt{s}$= 91 GeV, $\mathcal{L}_{int} = 180\ ab^{-1}$
- Madgraph5 (SM_HeavyN_CKM_AllMasses_LO arXiv:1411.7305, arXiv:1602.06957) + Pythia8 + Delphes with IDEA detector in FCCAnalyses with **winter 23 backgrounds**



SELECTION

Selection	Cuts Two electrons or muons with opposite charges, no photons, no jets
Reconstructed tracks	exactly 2
Invariant mass	$M(\ell, \ell') < 80$ GeV
Momentum of leptons	$p < 40$ GeV
Missing transverse momentum	$\not{p}_T > 11.5$ GeV
Cosine between the leptons	$\cos\theta > -0.8$

Table 1: Table of cuts applied in the same flavor selection.

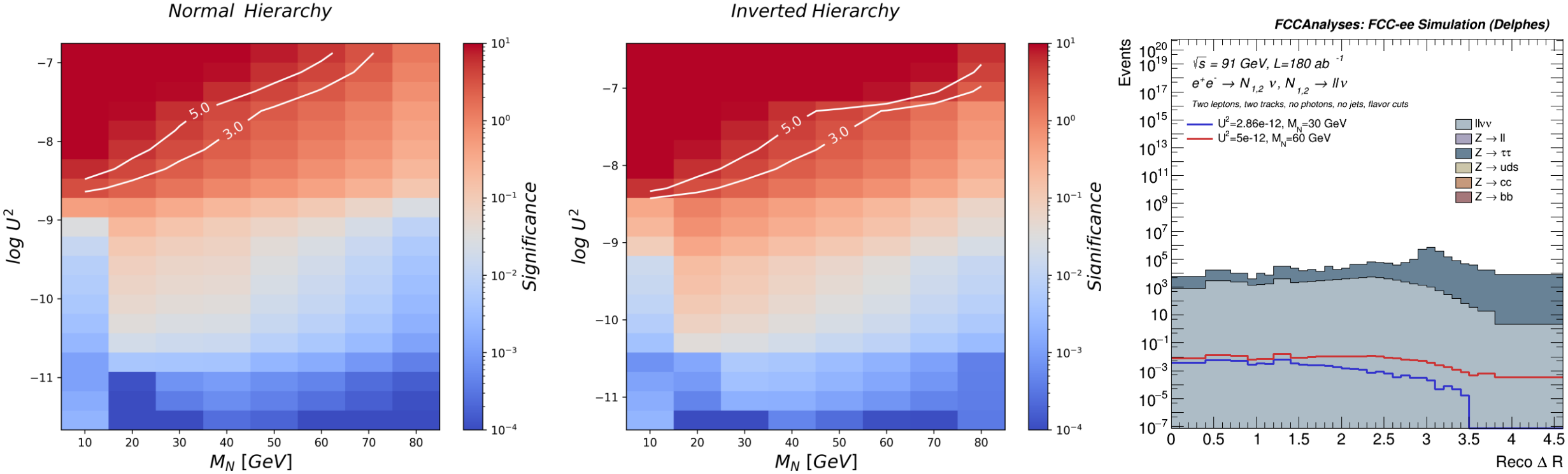
Selection	Cuts One electron and one muon with opposite charges, no photons, no jets
Reconstructed tracks	exactly 2
Invariant mass	$M(\ell, \ell') < 80$ GeV
Missing transverse momentum	$\not{p}_T > 7$ GeV
Cosine between the leptons	$\cos\theta > -0.8$

Table 2: Table of cuts applied in the different flavor selection.

- Only considering $\tau \to e\backslash\mu\nu\nu$
- Final state is two leptons (electrons or muons)
- Different selection based on flavor of final state leptons

ANALYSIS

- Shape-based analysis from ΔR with ML fit, statistical significance computed with COMBINE Higgs tool arXiv:2404.06614
- The results show improvement from previous studies using only the number of signal and background events



LLP SELECTION

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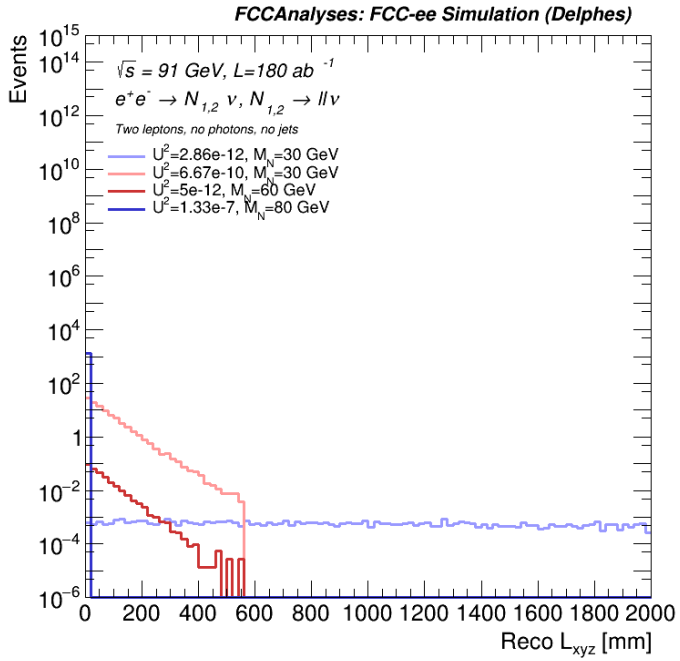
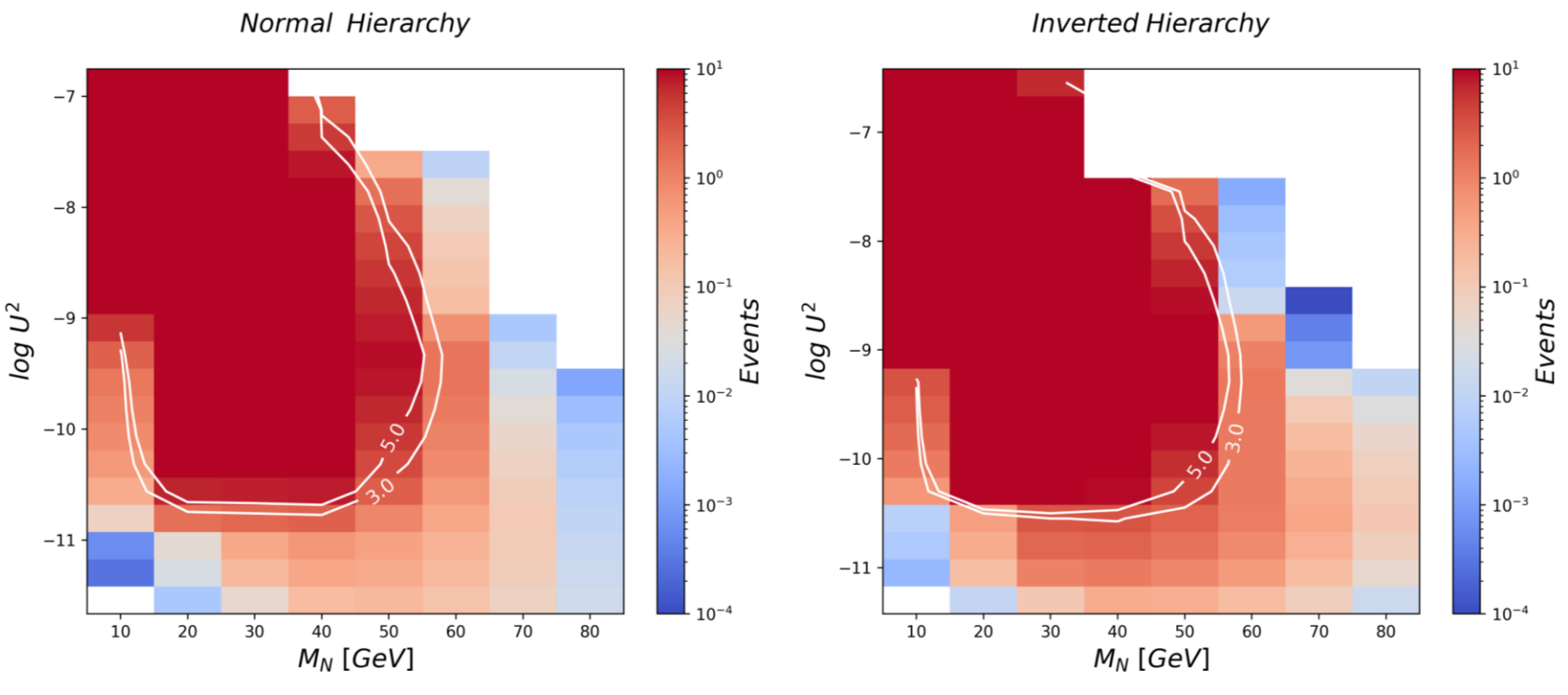
Table 2: Table of cuts applied in the different flavor selection.



- Adding requirements on the reconstructed vertex:
  - $\chi^2 < 10$
  - $L_{xy} < 2000\, mm$
  - $|z| < 2000\, m$
  - $|d_0| > 0.55\, mm$ to finally suppress all MC background events

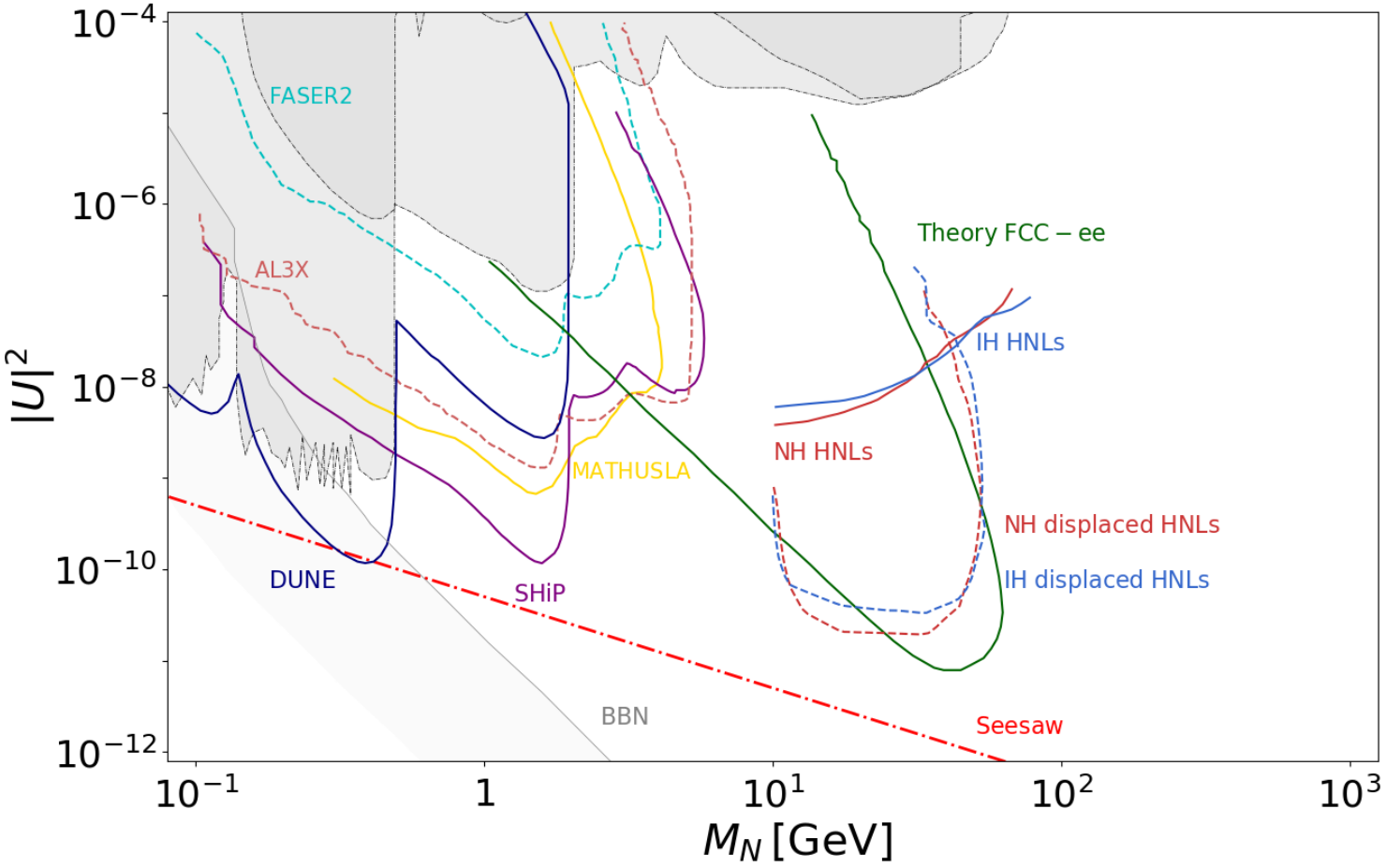
LLP EVENTS

- In this case, we're taking the expected number of events after the cuts
- White areas correspond to zero events



SUMMARY

- Comparison (different models!) with exclusion limits, other experiments and theoretical prediction
- Curves for S=5 from the shape analysis and 3 events for the displaced selection



OUTLOOK

- These are the final results, we are going to publish a preprint on the Arxiv soon
- Also a poster at FCC week in San Francisco (Xunwu will be there)

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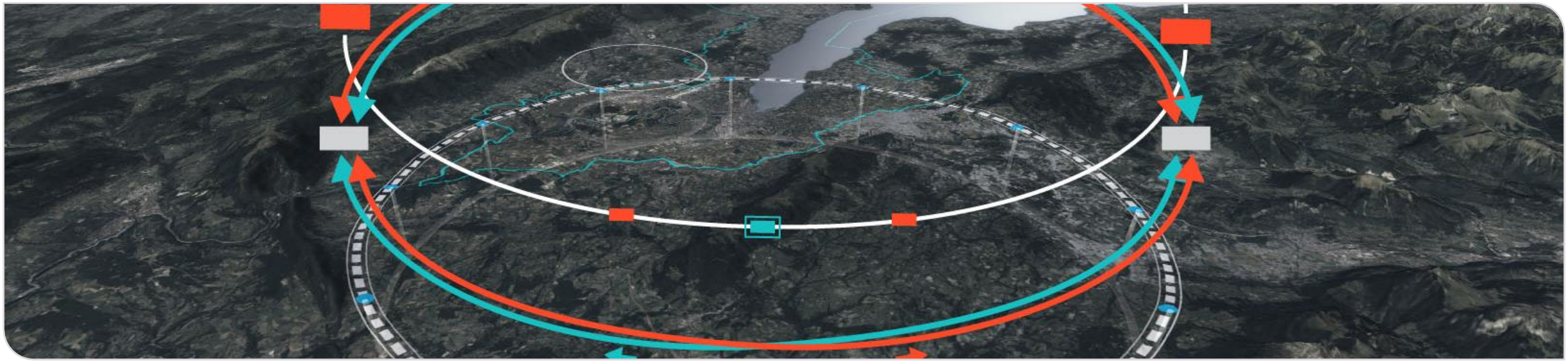
BACKUP



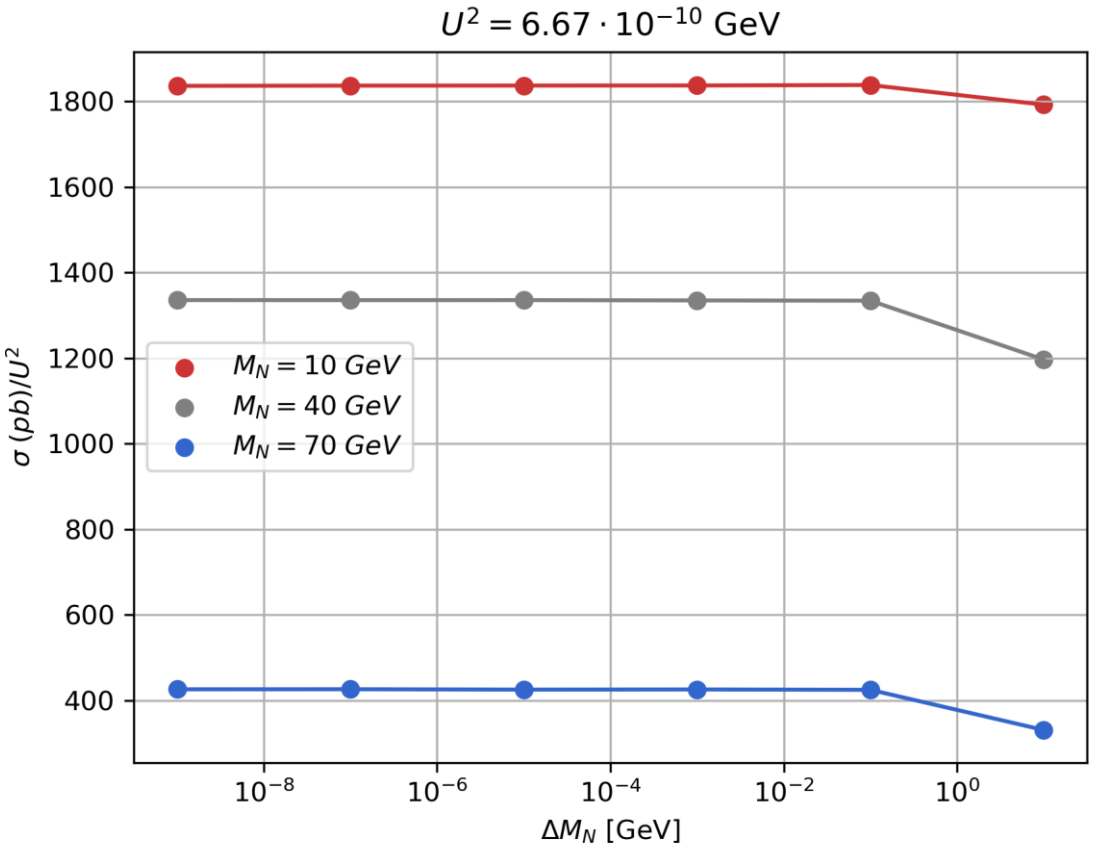
Parameter space

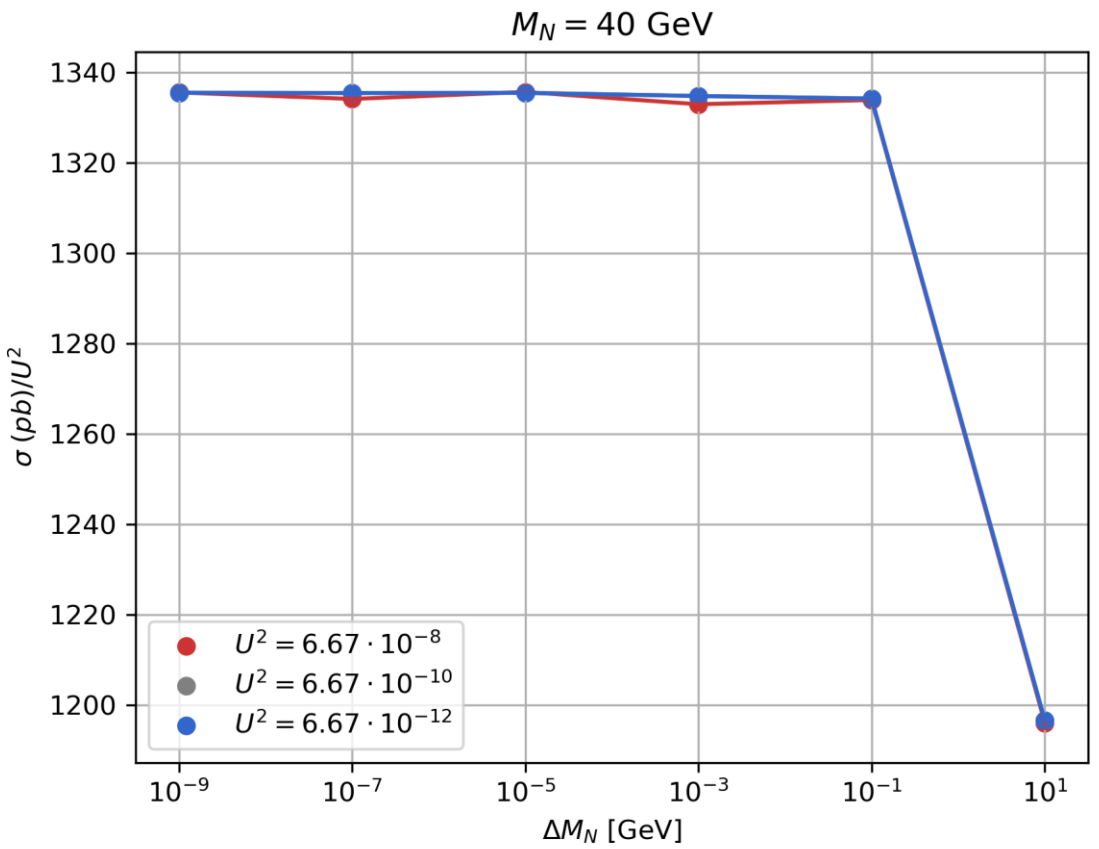
- Symmetry in type I see-saw:

$$\Delta M_{1,2} \ll \frac{M_1 + M_2}{2} \rightarrow U_{\ell 1} \simeq i U_{\ell 2}$$

- Set $U_{1,2\mu}$ to three values $(1 \cdot 10^{\{-4,-5,-6\}})$ then use the ratio between the couplings to get the rest

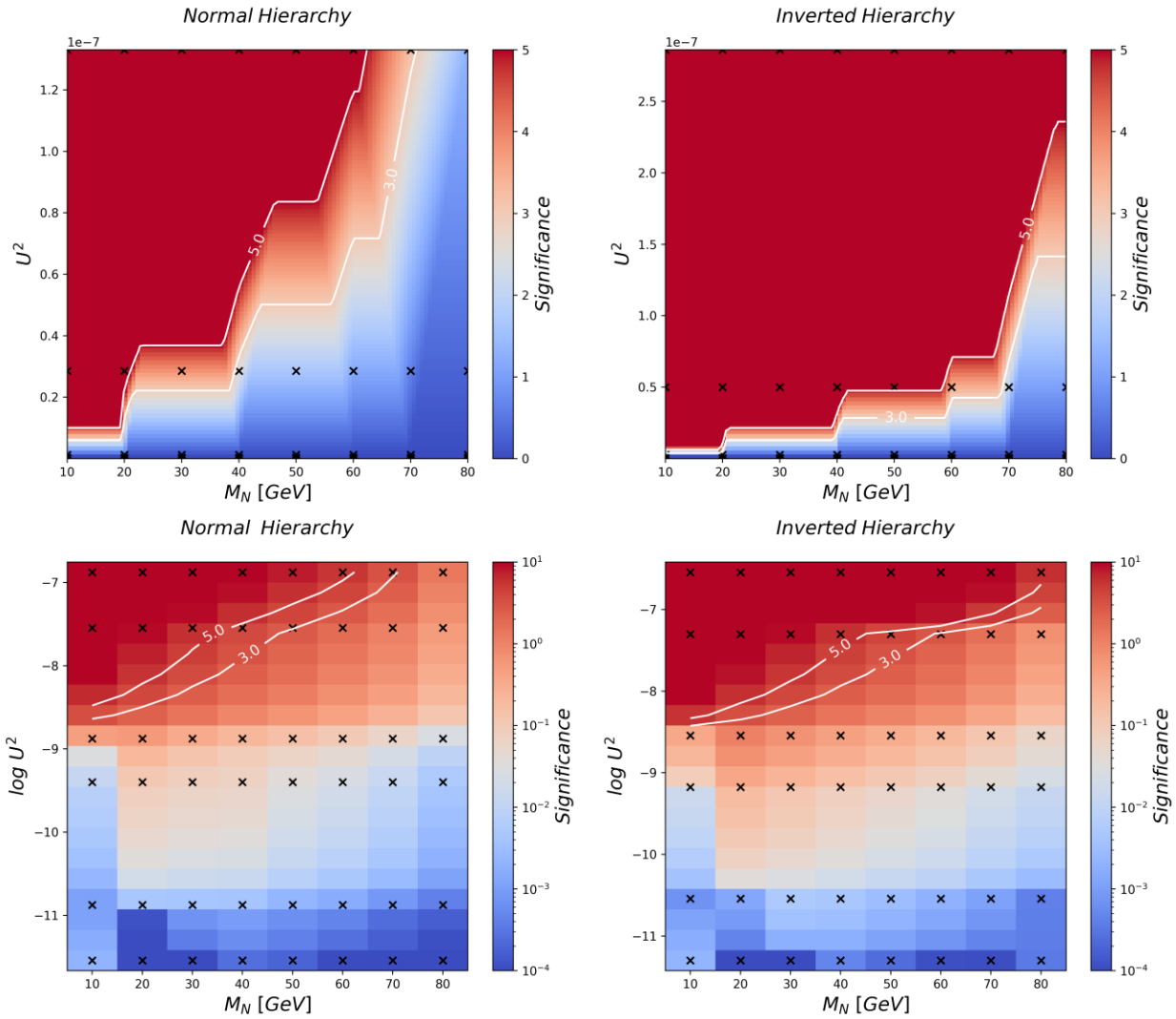
Difference between masses





Taken to be $\Delta M_N = 10^{-5}\ GeV$

Significance from ΔR



Event number background free