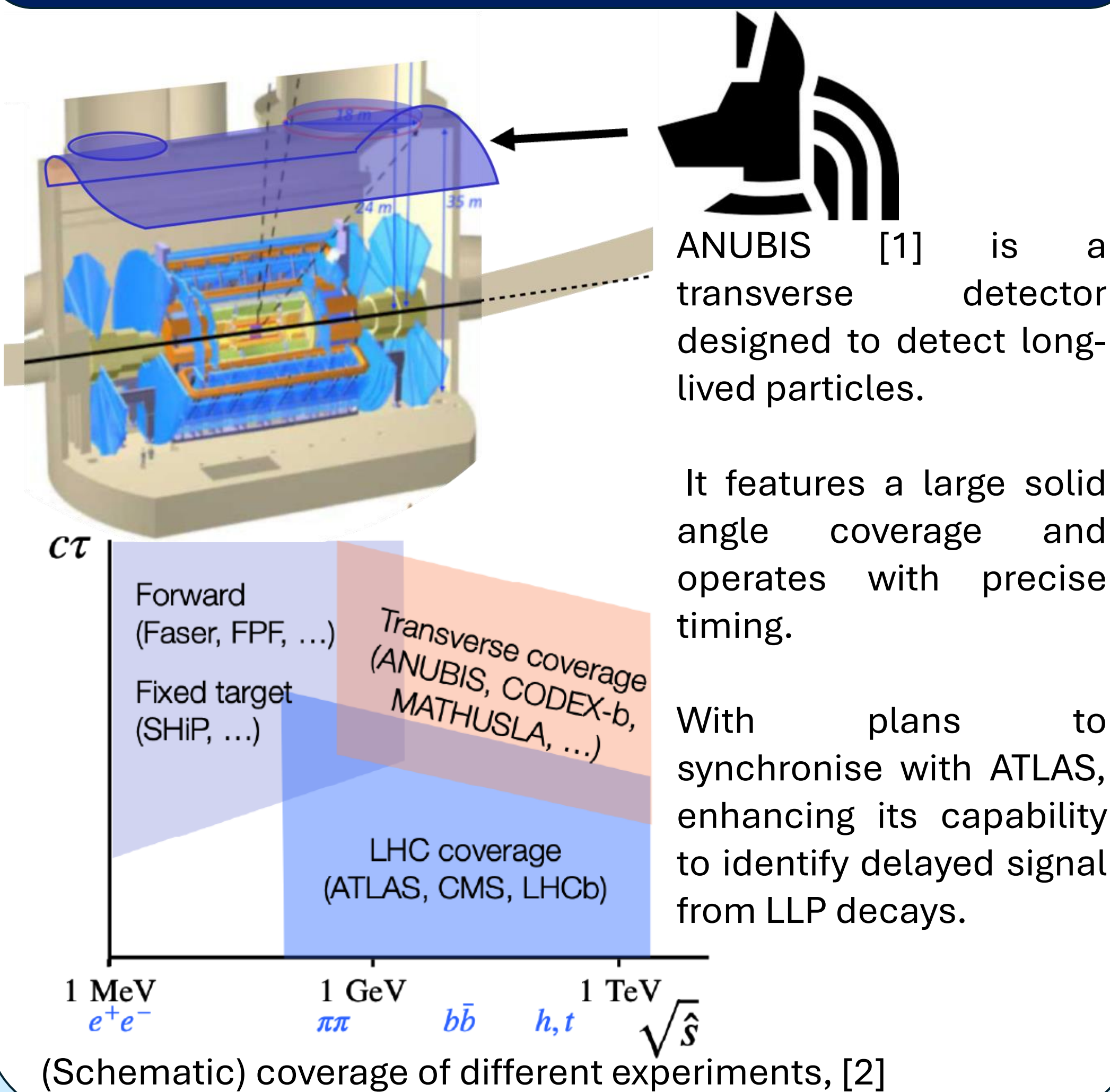# Exploring the Projected Sensitivity of the ANUBIS detector to exotic LLP models

Department of Physics, Cavendish Laboratory, University of Cambridge, United Kingdom
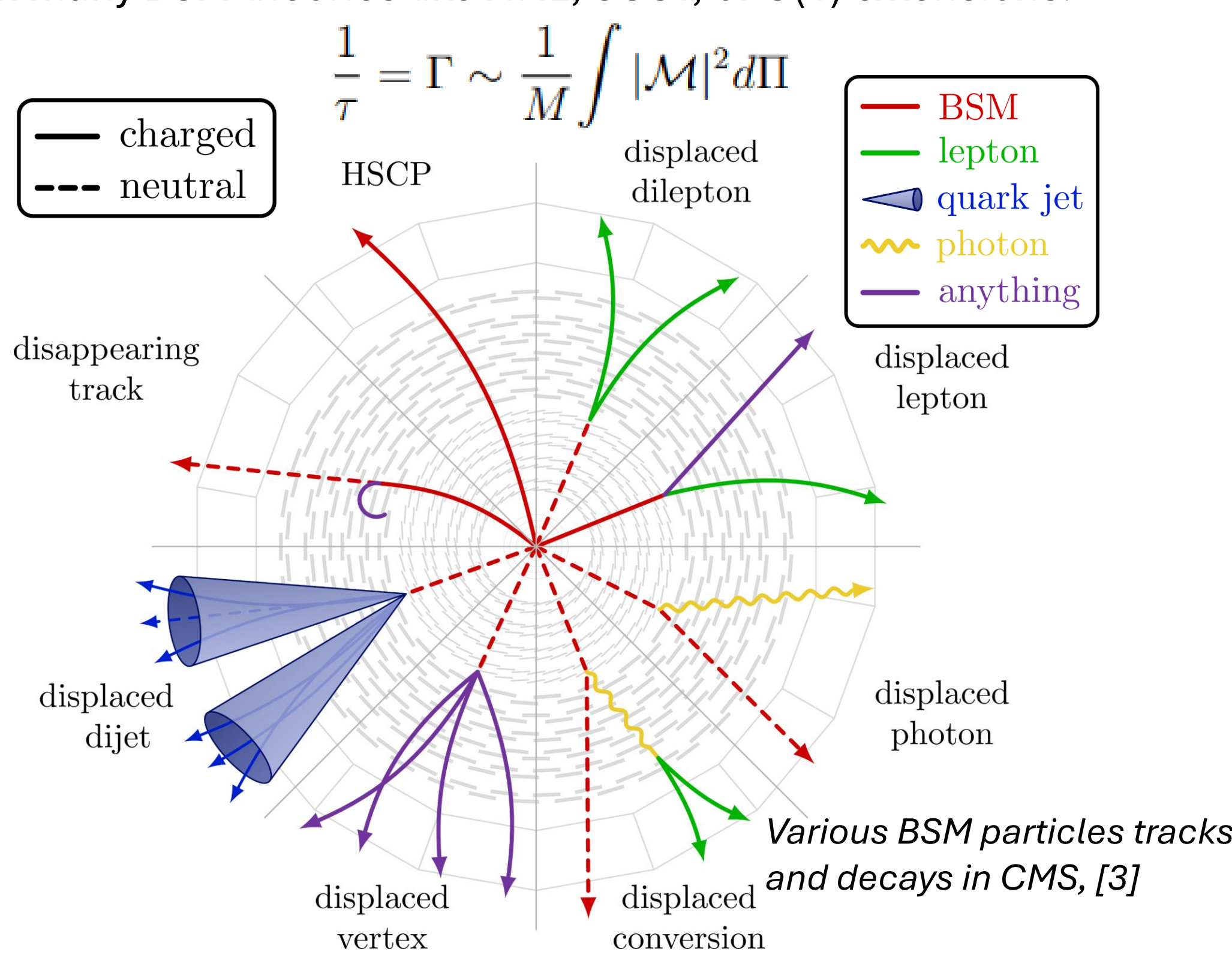*Théo Reymermier @ EPS HEP 2025*

ANUBIS INTRODUCTION

ANUBIS [1] is a transverse detector designed to detect long-lived particles.

It features a large solid angle coverage and operates with precise timing.

With plans to synchronise with ATLAS, enhancing its capability to identify delayed signal from LLP decays.

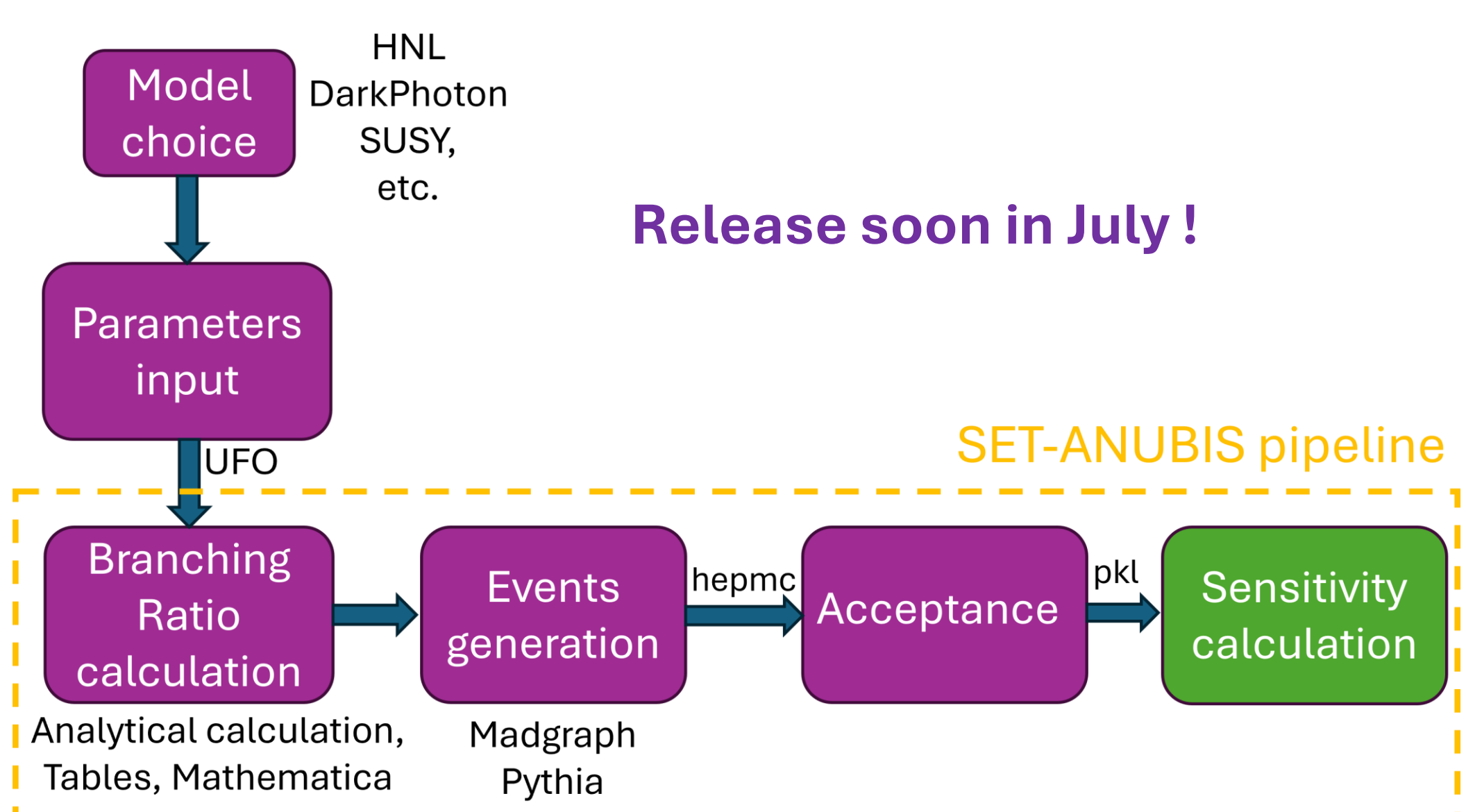(Schematic) coverage of different experiments, [2]

LLP PHENOMENOLOGY

Long-Lived Particles (LLPs) are particles with a very long lifetime, large enough that they may escape detectors like ATLAS without detection if they're neutral. These particles are predicted in many BSM theories like HNL, SUSY, or U(1) extensions.

$$\frac{1}{\tau} = \Gamma \sim \frac{1}{M} \int |\mathcal{M}|^2 d\Pi$$

Various BSM particles tracks and decays in CMS, [3]

SET-ANUBIS FRAMEWORK

Release soon in July !

The **SET-ANUBIS** framework has been developed to perform sensitivity calculations on a transverse detector like ANUBIS, with models that involve LLPs. It includes Branching ratio calculations, using different methods (Madgraph, python scripts, Mathematica, MARTY *[5]* , etc.), event generation (Pythia8, Madgraph) and selection using cuts based on the detector geometry.
This framework has been fully tested on HNL models and is currently being tested for other types of models, before its release.

HIGGS LIMITS
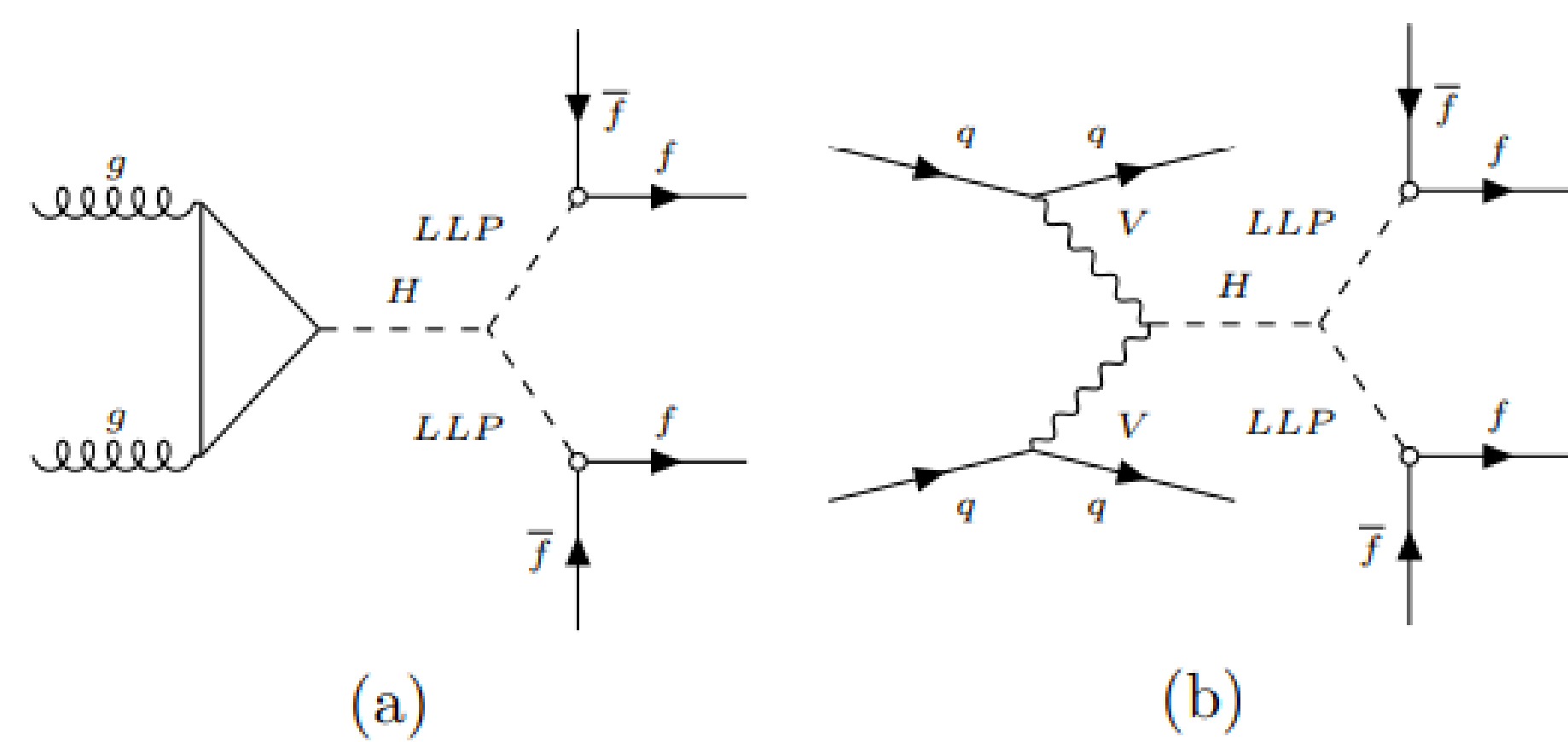
Higgs production and decay via (a) GGF (b) VBF
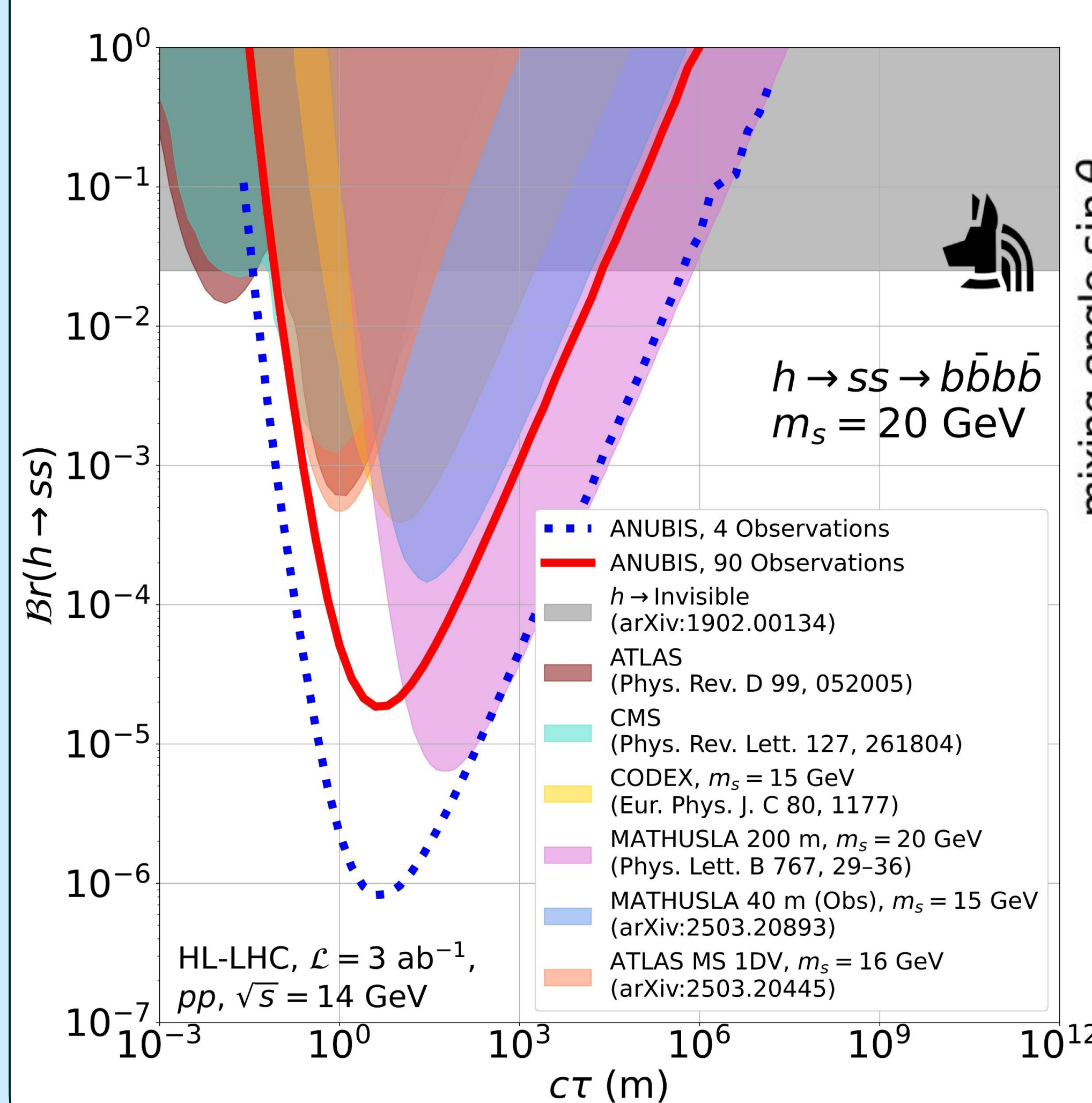
This analysis is based on 10 million simulated Higgs boson events from ATLAS samples.

The Higgs bosons were decayed into dark scalars using Pythia, which subsequently decayed into $b\bar{b}b\bar{b}$ jets.

An acceptance script was then applied to evaluate the detection potential of the Anubis model.

We define two benchmark background scenarios. 4 events for a background-free case, and 90 events for a conservative data-driven estimate based on rescaling an ATLAS analysis (arXiv:1811.07370).
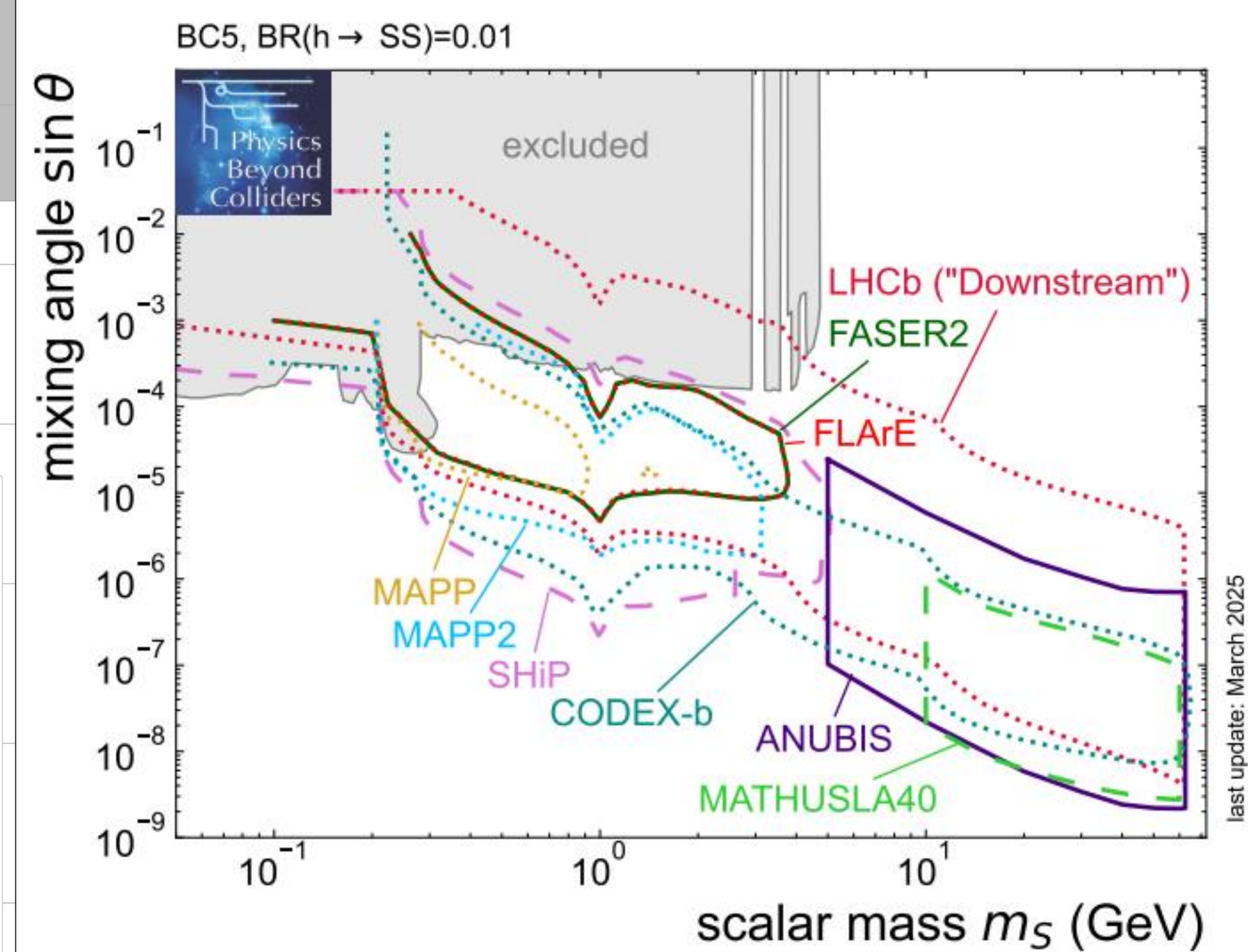
ANUBIS uniquely covers a large area of parameter space, while also being complementary to other experiments.

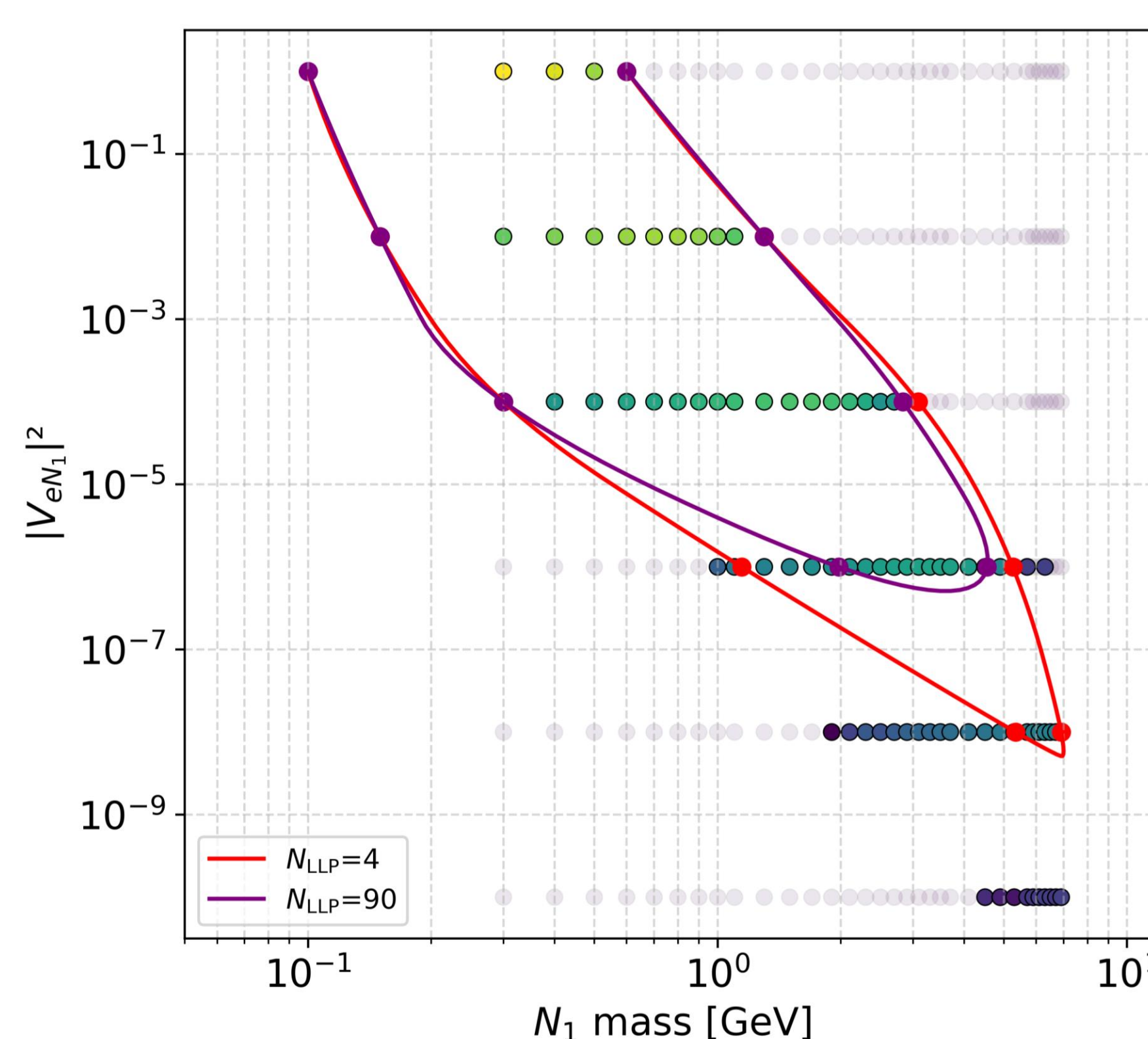## HEAVY NEUTRAL LEPTONS (HNL) LIMITS
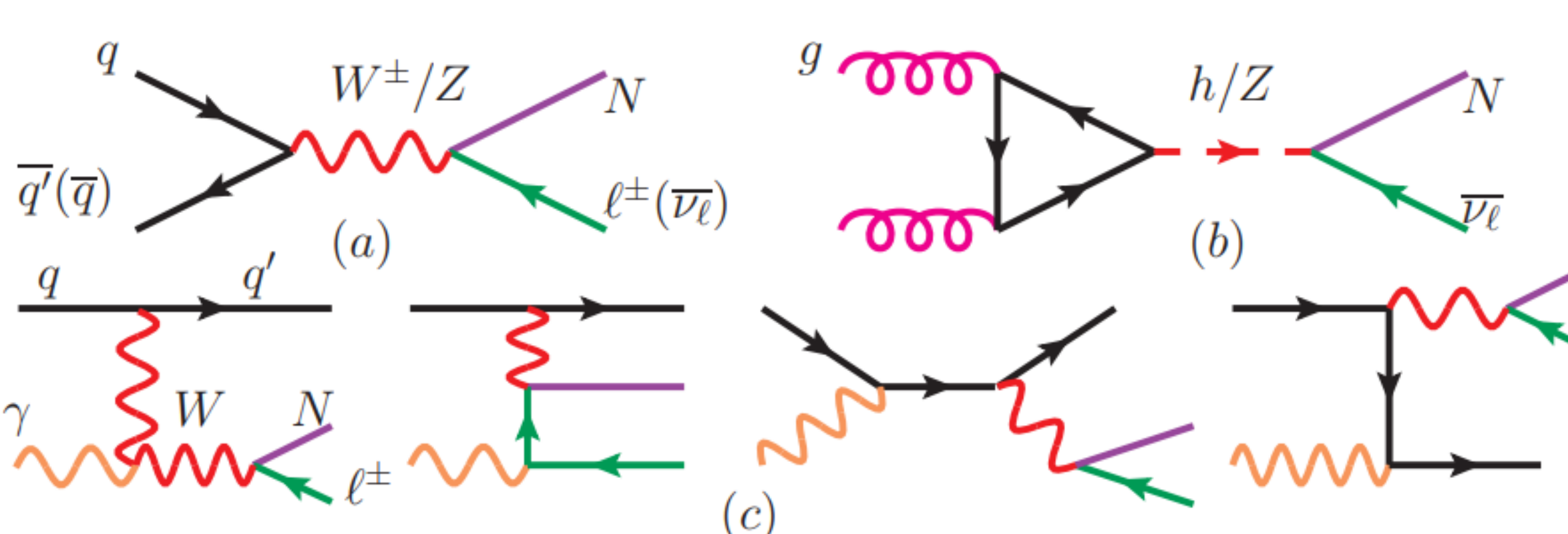
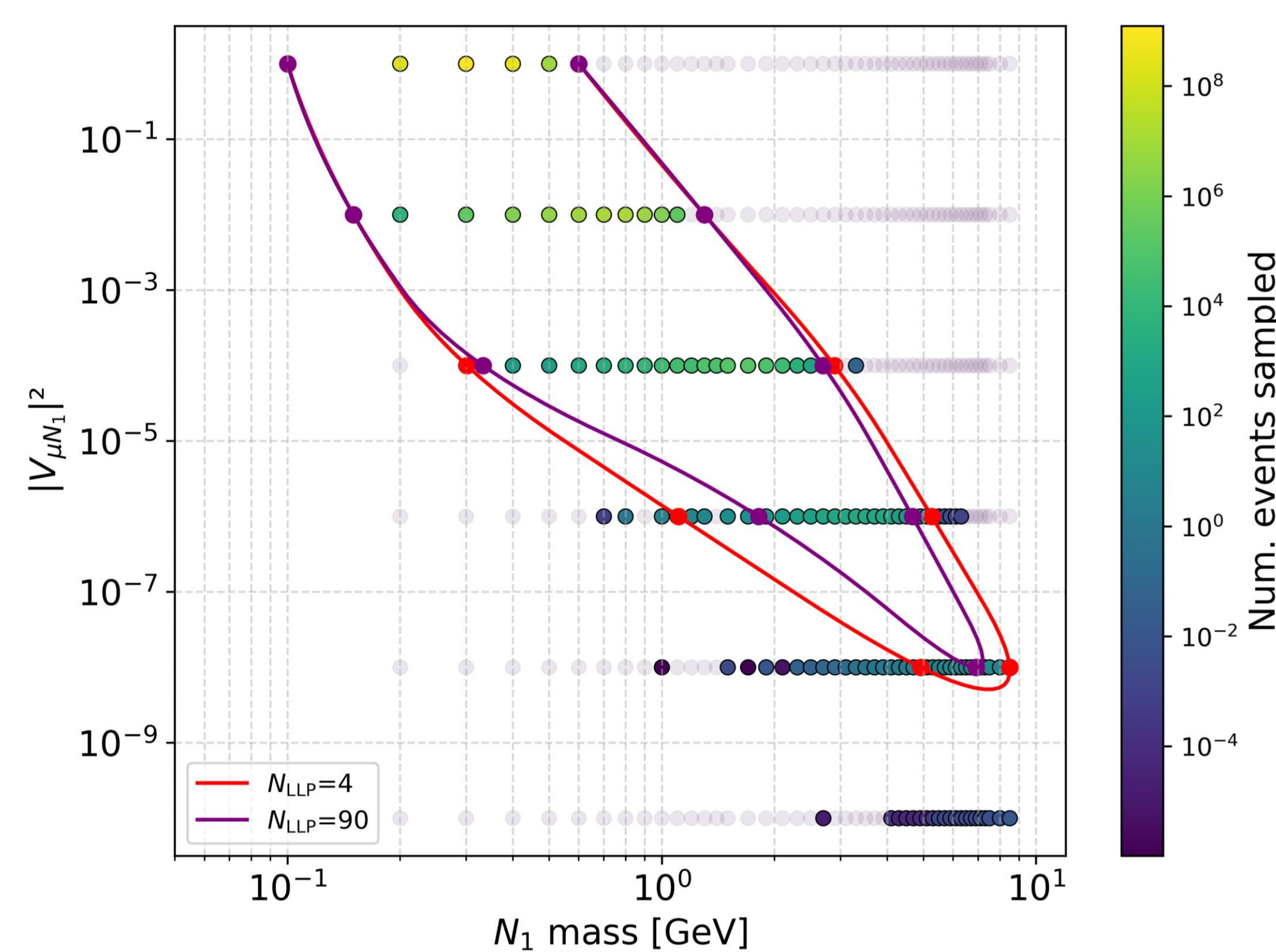(a) Drell-Yan, (b) gluon-gluon fusion, (c) W-gamma, [4]

$$\nu_\ell = \sum_{m=1}^{3} U_{\ell m} \nu_m + \sum_{m'=1}^{n} V_{\ell m'} N_{m'}^c$$

Only one HNL in our study !

- minChargedPt : 5.0 GeV
- minJetPt : 15.0 GeV
- DeltaR(LLP, charged) > 0.5
- DeltaR(LLP, jets) > 0.5
- Event's MET > 30 GeV

electron exclusion limits for the ANUBIS detector. Production from Drell-Yan, gluon-gluon fusion and W-gamma combined.

muon exclusion limits for the ANUBIS detector. Production from Drell-gluon fusion and W-gamma combined.

REFERENCES

[1] Oleg Brandt et al., ANUBIS Proposal, 2019, arXiv:1909.13022v2
[2] ANUBIS Collaboration, 2026 ESPPU input from the ANUBIS collaboration, 2025, arXiv:2504.03195v1
[3] J. Antonelli's presentation, ICHEP 2016
[4] Celine Degrande et al., Fully-Automated Precision Predictions for Heavy Neutrino Production Mechanism at Hadron Colliders, 2016, arXiv:1602.06957
[5] G. Uhlrich et al., MARTY – Modern Artificial Theoretical physicist: A C++ framework automating symbolic calculations Beyond the Standard Model, 2020

CONCLUSION

The ANUBIS detector offers a promising avenue for probing a wide class of LLPs. Sensitivity studies performed on benchmark scenarios, such as Higgs portal and HNL, demonstrate its strong discovery potential. To support these analyses, we have developed the SET-ANUBIS framework, which enables efficient automation of the full sensitivity workflow. This tool paves the way for extending the analysis to a broader range of new physics models.