GAMBIT

The Global And Modular Beyond-the-standard-model Inference Tool

Jonathan Cornell, on behalf of the GAMBIT Community

WEBER STATE UNIVERSITY

THE IMPORTANCE OF GLOBAL FITS

The search for BSM particle physics has become a cross-disciplinary endeavor, making use of results from colliders, precision measurements, astrophysical searches, and cosmological probes. To make the most robust and complete statements about the validity of new physics theories and the preferred values of their parameters, these experimental results must be combined consistently in a global fit.

WHAT IS GAMBIT?

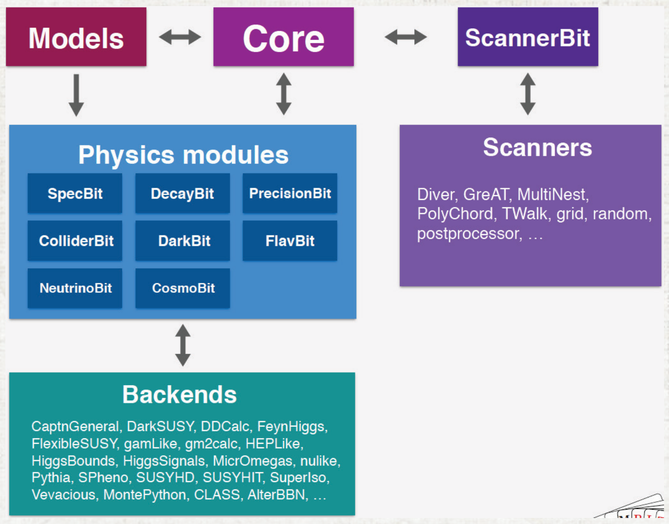
GAMBIT (arXiv:1705.07908) is an open-source framework for undertaking global fits. It is used to recast a range of experimental results to determine the constraints on an arbitrary BSM theory, and can undertake scans to determine the best fit regions of those theories' parameter spaces. From the beginning, GAMBIT was designed around the concepts of *modularity*, *flexibility*, and *extensibility*. Features of the code include:

- A large (and growing) database of particle physics models.
- An extensive library of observables/likelihoods that can easily be enabled or disabled for a particular scan.
- Tools for interfacing with external codes written in many languages (Fortran, C, C++, Python, Mathematica)
- Many statistical options – Bayesian/frequentist, likelihood definitions, scanning algorithms.
- Extensive parallelization using both OpenMP and MPI, to allow for scanning of large parameter spaces.
- A modular codebase that allows for the easy addition of new observables, likelihoods, and scanners.
- Automated addition of new particle physics models via the GAMBIT Universal Model machine (GUM) (arXiv:2107.00030).

CODE STRUCTURE

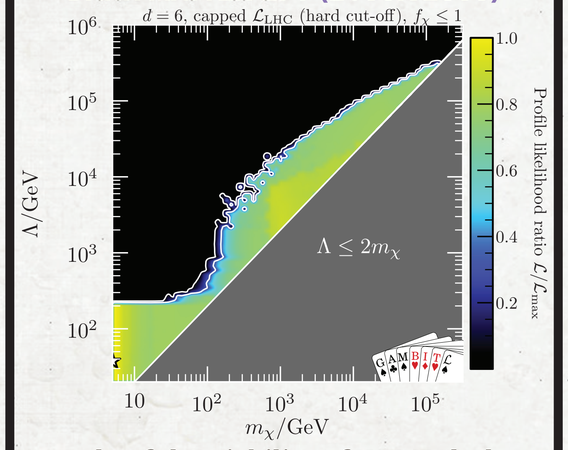
GAMBIT currently ships with 8 physics modules, or "Bits":

- **DarkBit** — WIMP and ALP density calculations, event rates and likelihoods for indirect and direct searches (arXiv:1705.07920)
- **ColliderBit** — LHC and LEP searches for new particle production, Higgs constraints (arXiv:1705.07919)
- **FlavBit** — Flavor physics, particularly B decays. Likelihoods from LHCb measurements. (arXiv:1705.07933)
- **PrecisionBit** — SM likelihoods, muon g–2, precision BSM tests (*e.g.* W mass) (arXiv:1705.07936)
- **NeutrinoBit** — Measurements of active neutrino mixing and searches for right handed neutrinos (arXiv:1908.02302)
- **CosmoBit** — Cosmic microwave background measurements, big bang nucleosynthesis, and large scale structure observables (arXiv:2009.03286)
- **SpecBit** — Generic BSM spectrum object, providing RGE running, masses, mixings, etc. via interchangeable interfaces to different RGE codes (arXiv:1705.07936)
- **DecayBit** — Decay widths for all relevant SM & BSM particles (arXiv:1705.07936)



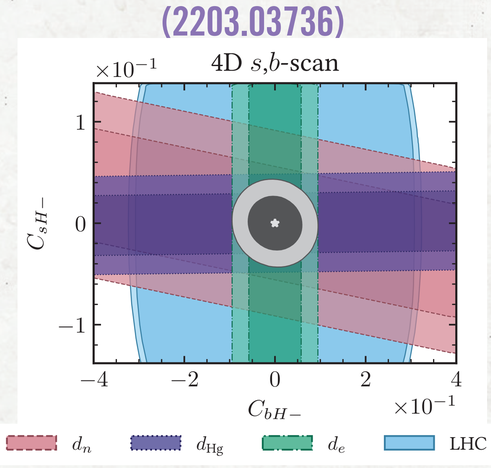
SELECTED PAPERS USING GAMBIT

DARK MATTER EFT (2106.02056)



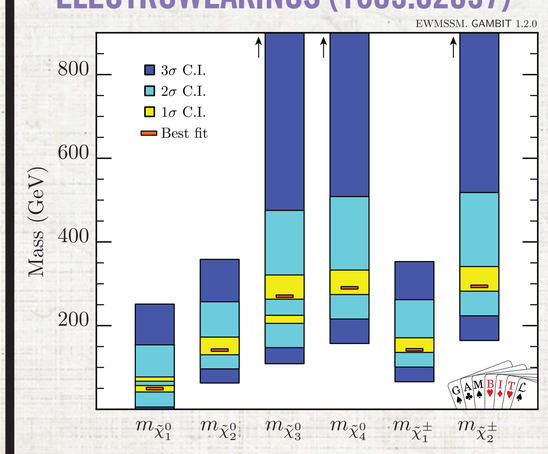
A study of the viability of WIMP dark matter when the interaction between the WIMPs and quarks can be described by dimension 6 and 7 effective field theory operators. While the LHC constrains low mass dark matter in this scenario and the relic density limits how high the scale of the new physics can be, ultimately the WIMP parameter space remains open up to high masses.

CP VIOLATING YUKAWA OPERATORS (2203.03736)



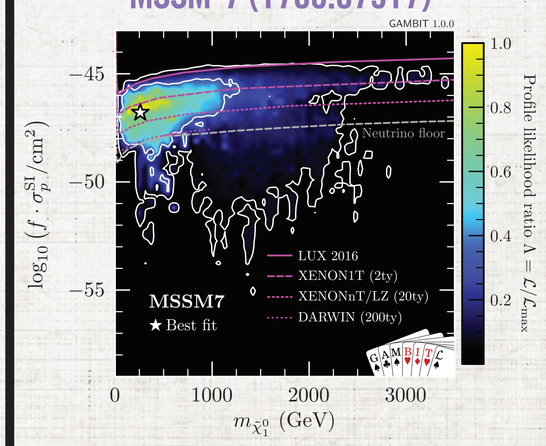
We explored constraints from the LHC and electric dipole moments on CP violation in the Higgs sector, which could be used to realize *e.g.* electroweak baryogenesis. We showed that allowing for CP violation in couplings of the Higgs to *multiple* SM fermion species substantially relaxes constraints from EDMs on individual Wilson coefficients.

ELECTROWEAKINOS (1809.02097)



This analysis focused on the neutralino and chargino sector of the MSSM. By considering the full phenomenology of this sector (rather than using simplified models), we showed that (at the time) multiple small excesses in LHC searches could be consistently explained by low mass electroweakinos.

MSSM-7 (1705.07917)



Taking the lightest neutralino to be a component of the dark matter, we fully mapped the preferred parameter space of a 7 parameter version of the weak-scale MSSM. We showed that much of this region should be accessible to future dark matter and collider searches.

MORE GAMBIT ANALYSES

In addition to the featured papers in the center, GAMBIT has been used to study many other new physics scenarios. They include:

- Axion-like particles (arXiv:2205.13549, 2007.005517 and 1810.07192)
- Cosmological constraints on neutrino masses (arXiv:2009.03287)
- Flavor EFT and B-physics anomalies (arXiv:2006.03489)
- Right-handed neutrinos (arXiv:1908.02302)
- Higgs portal dark matter (arXiv:1808.10465, 1806.11281, and 1705.07931)
- GUT-scale SUSY (arXiv:1705.07935)

THE GAMBIT COMMUNITY

A small subset of the people who have worked on this project over the past 10 years are shown above. In total, the GAMBIT community consists of over 50 physicists spread over 4 continents, representing a diverse cross section of the theory and experimental communities.

FOR MORE INFORMATION

Much more information and the code itself is available at our website:

`gambit.hepforge.org`

I can be reached at:

`jonathancornell@weber.edu`