Global fits with

Jonathan Cornell, on behalf of the collaboration
• There is a menagerie of new physics models.

• One approach to determining their validity: overlay limits in parameter space:

\[ h \quad \lambda_{hS} \quad S \]

**Scalar Singlet DM Model**

Cline, et. al. (2013)

• But what if you have more complicated parameter spaces, or have many constraints, or what if we discover something…
Another approach: Global Fits

- Calculate a combined likelihood from all relevant experimental results:

\[ \mathcal{L} = \mathcal{L}_{\text{Collider}} \mathcal{L}_{\text{DM}} \mathcal{L}_{\text{Flavor}} \ldots \]

- Scan over the parameter space of theories to determine:

1. The best fit regions of parameter space of a particular theory.

2. Which theories give the best fit to the data.
**GAMBIT:** The **G**lobal **A**nd **M**odular **B**eyond-the-standard-model **I**nference **T**ool

The design philosophy is based on the concepts of **modularity and flexibility.**

- Large database of models, SUSY and others
- Extensive library of observables/likelihoods that can easily be enabled or disabled for a particular scan
- Tools for simple interfacing with external codes
- Many statistical options – Bayesian/frequentist, likelihood definitions, scanning algorithms
- Massively parallel, both OpenMP and MPI
- Easy to add new models, observables, likelihoods, and scanners!

29 members  10 countries  9 experiments

ATLAS, Belle-II, CTA, DARWIN, Fermi-LAT, HESS, IceCube, LHCb, Xenon
Code Structure

Physics Modules

- ColliderBit
- DarkBit
- FlavBit
- PrecisionBit
- SpecBit
- DecayBit

Backends:
- FlexibleSUSY, SPheno, FeynHiggs, HiggsBounds, HiggsSignals, PYTHIA, Delphes, BuckFast*, SUSYHit, DarkSUSY, micrOMEGAs, nuLike, DDCalc*, GamLike*, SuperISO, gm2Calc, MultiNest, Diver*, GreAT*, twalk*
Hierarchical Model Database

- Large and easily extensible model database.
- Models for BSM physics (SUSY / Singlet DM) and nuisance parameters (SM, DM halo, nuclear parameters). More BSM models to come!
- Model hierarchy allows for conversion between various parameterizations based on what is needed for a calculation.
Dependency Resolution

- Automatic generation of dependency tree for calculation of likelihoods and all necessary intermediate values.
- No redundancy — each needed quantity calculated once per point in the scan.
- Can change how calculations are done by specifying rules in input file.
Collider Bit

- Full analysis chain for doing LHC recasts (focus on speed):
  - Cross section calculation and event generation using parallelized version of Pythia
  - Fast detector simulation using 4-vector smearing (BuckFast)

*Currently includes (LHC 8 TeV):*

- ATLAS SUSY searches ($0l$, $0/1/2l \tilde{t}$, $b$ jets + MET, 2/3l EW)
- CMS multi-$l$ SUSY
- CMS DM (monojet)
- Higgs physics from HiggsSignals and HiggsBounds
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Run II results to be added soon!
Dark Bit

- Framework for calculation of relic density for general WIMP model.

- DM search likelihoods:
  - Direct detection (LUX, Xenon100, SIMPLE)
  - Gamma rays from DM annihilation in dwarf spheroidal galaxies (Fermi-LAT) and the galactic center (HESS)
  - Neutrinos from DM annihilation in the sun (IceCube)
  - New cascade decay Monte Carlo for calculation of indirect signals
Scalar Singlet DM

- 2 model parameters \((\lambda_{hS}, M_S)\)
- 9 SM parameters \((m_h, m_q, G_F, \alpha_S, \alpha_{EM})\), 2 nuclear parameters \((\sigma_s, \sigma_l)\), local DM density \((\rho_0)\)

Preliminary!
MSSM-7

$M_2, M_{H_d}, M_{H_u}, \tan \beta, m_{\tilde{f}}^2, A_{d3}, A_{u3}$

Very Preliminary!
Conclusions

• GAMBIT is many things:
  • A tool for global fits.
  • A likelihood library for searches for BSM physics.
  • An LHC recast tool.
  • A framework for calculating DM observables for new models.
  • and more…

• Code, scalar singlet DM, and MSSM papers coming soon!

• Public release will follow!
Backups
Dark Bit
The Other Bits

- **FlavBit** – flavor physics, particularly B decays. Likelihoods from LHCb measurements.

- **SpecBit** – generic BSM spectrum object, providing RGE running, masses, mixings, etc. via interchangeable interfaces to different RGE codes

- **DecayBit** – decay widths for all relevant SM & BSM particles

- **PrecisionBit** – SM likelihoods, muon $g-2$, precision BSM tests ($W$ mass, $\Delta \rho$ etc.)

+ **ScannerBit** – manages stats, sampling and optimization

**Bits can also be used as standalone codes.**