Global fits with

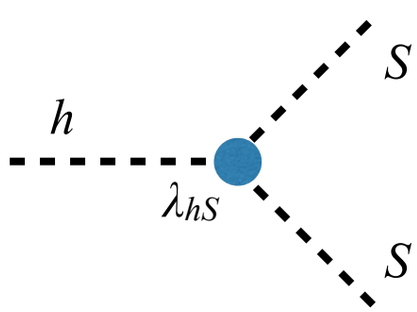
Jonathan Cornell, on
behalf of the collaboration

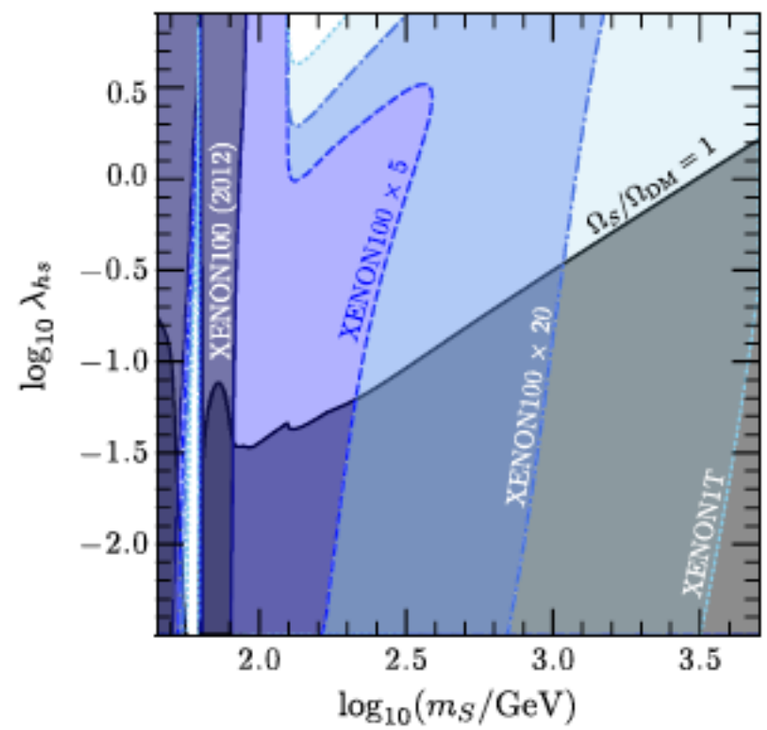
McGill

- There is a menagerie of new physics models.

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

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:

$$\mathcal{L} = \mathcal{L}_{\mathrm{Collider}} \mathcal{L}_{\mathrm{DM}} \mathcal{L}_{\mathrm{Flavor}} \cdots$$

- 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!

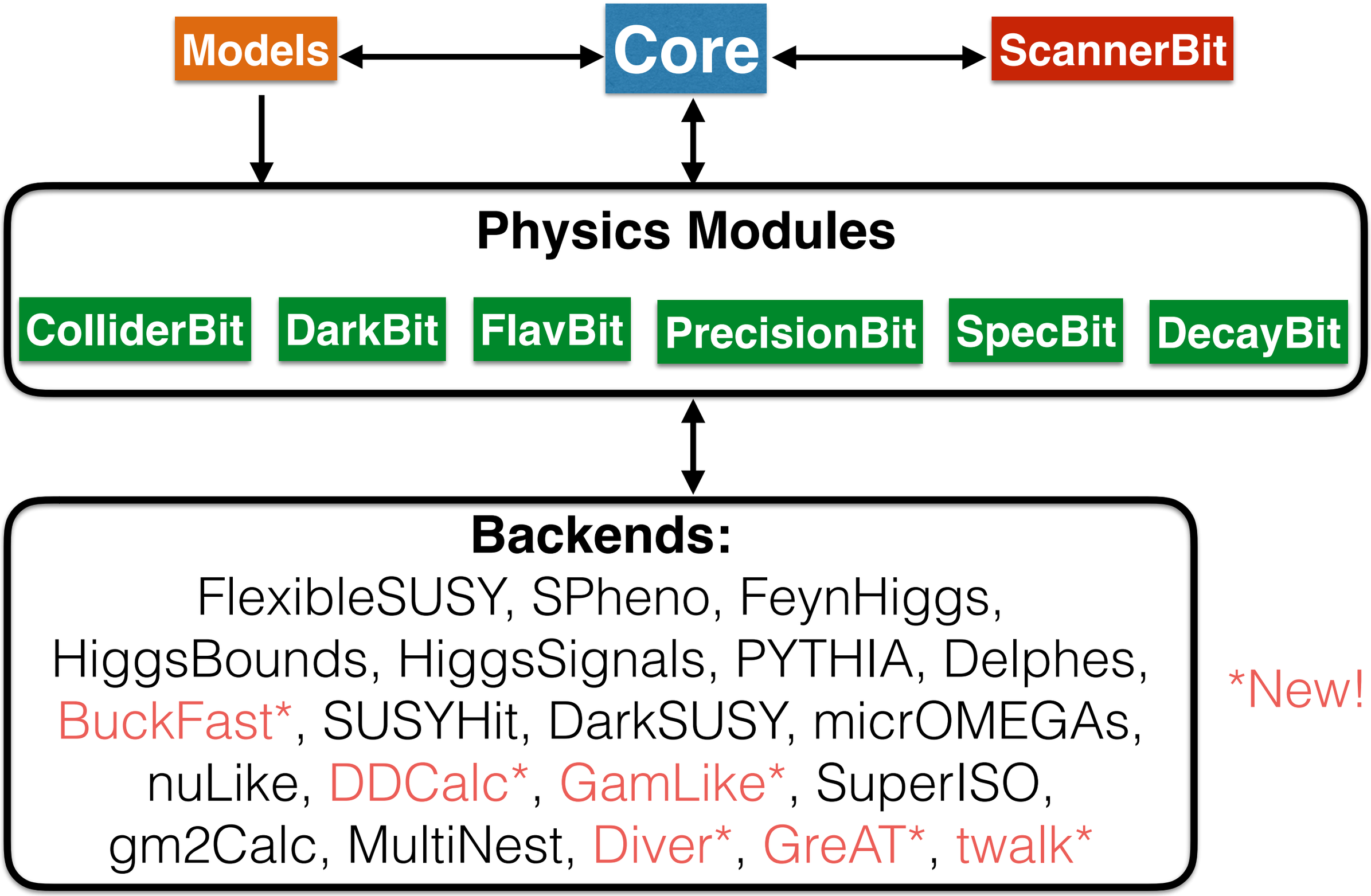
The Collaboration

P. Athron, C. Balázs, F. Bernlochner, T. Bringmann, A. Buckley, M. Chrzaszcz, J. Conrad, J. Cornell, J. Edsjö, B. Farmer, T. Gonzalo, S. Hoof, P. Jackson, F. Kahlhoefer, A. Krislock, A. Kvellestad, F. Mahmoudi, G. Martinez, J. McKay, M. Pato, A. Raklev, C. Rogan, R. Ruiz, P. Scott, N. Serra, R. Trotta, C. Weniger, S. Wild, M. White (L. Dal, A. Putze, A. Saavedra, C. Savage)

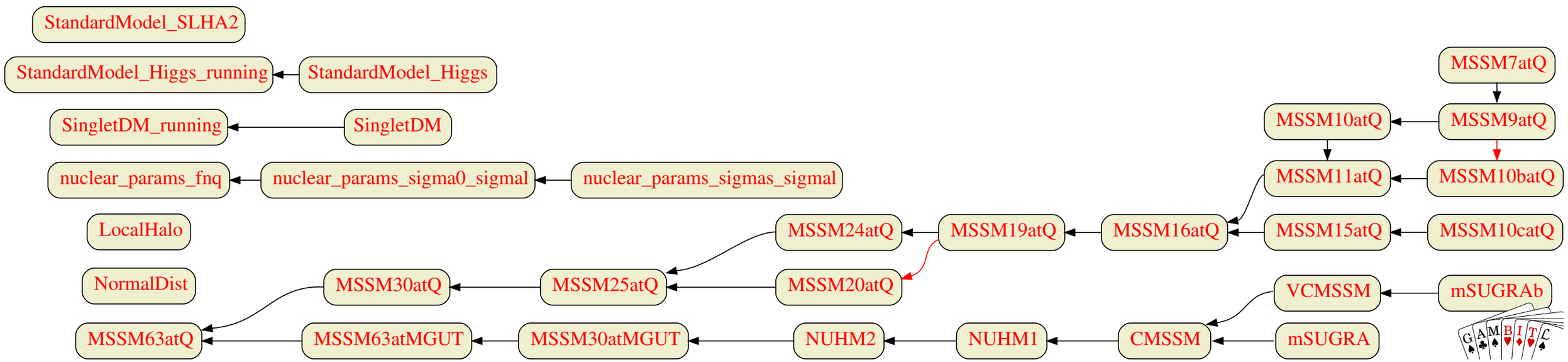
29 members 10 countries 9 experiments

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

Code Structure

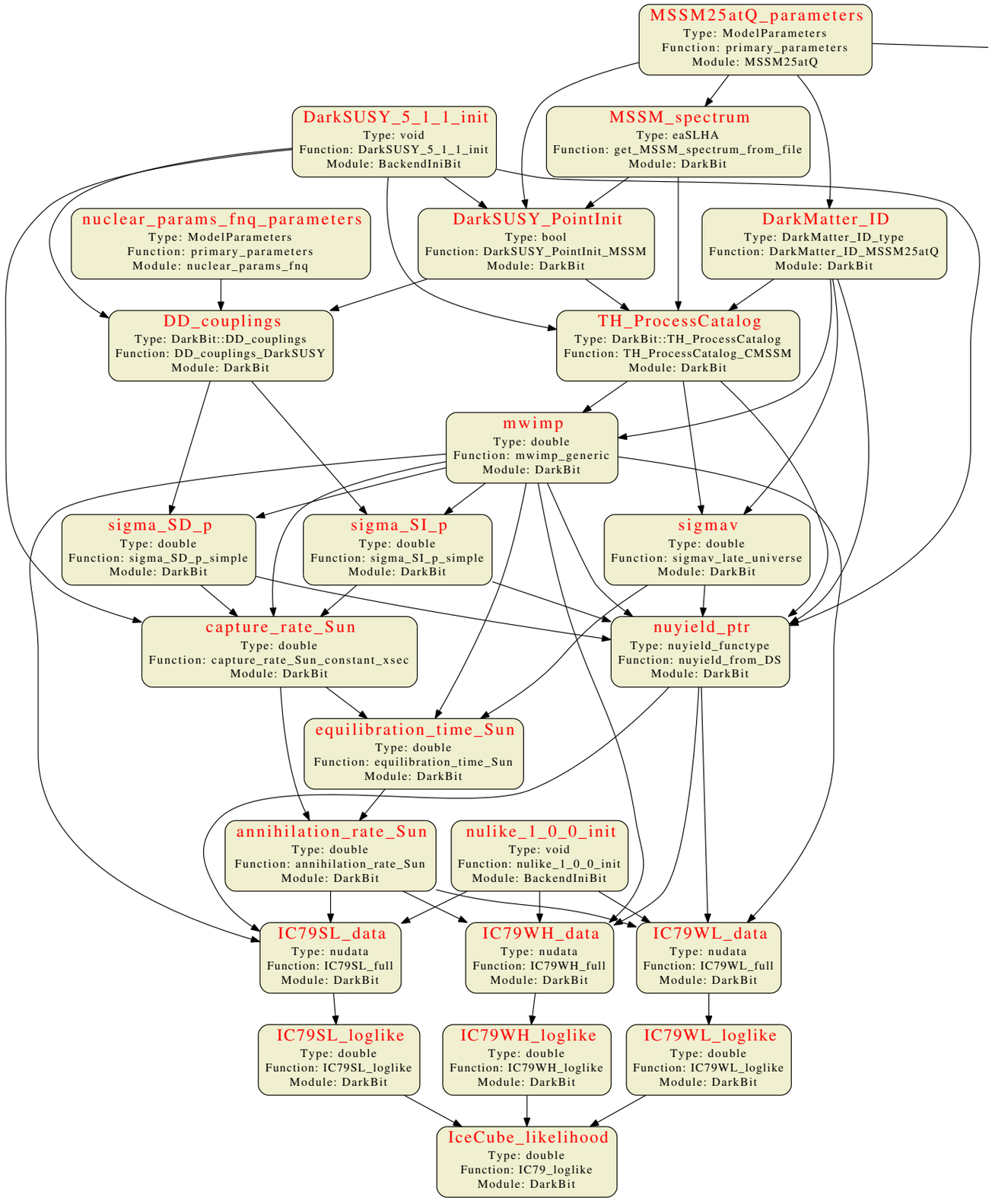


Hierarchical Model Database



- 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.

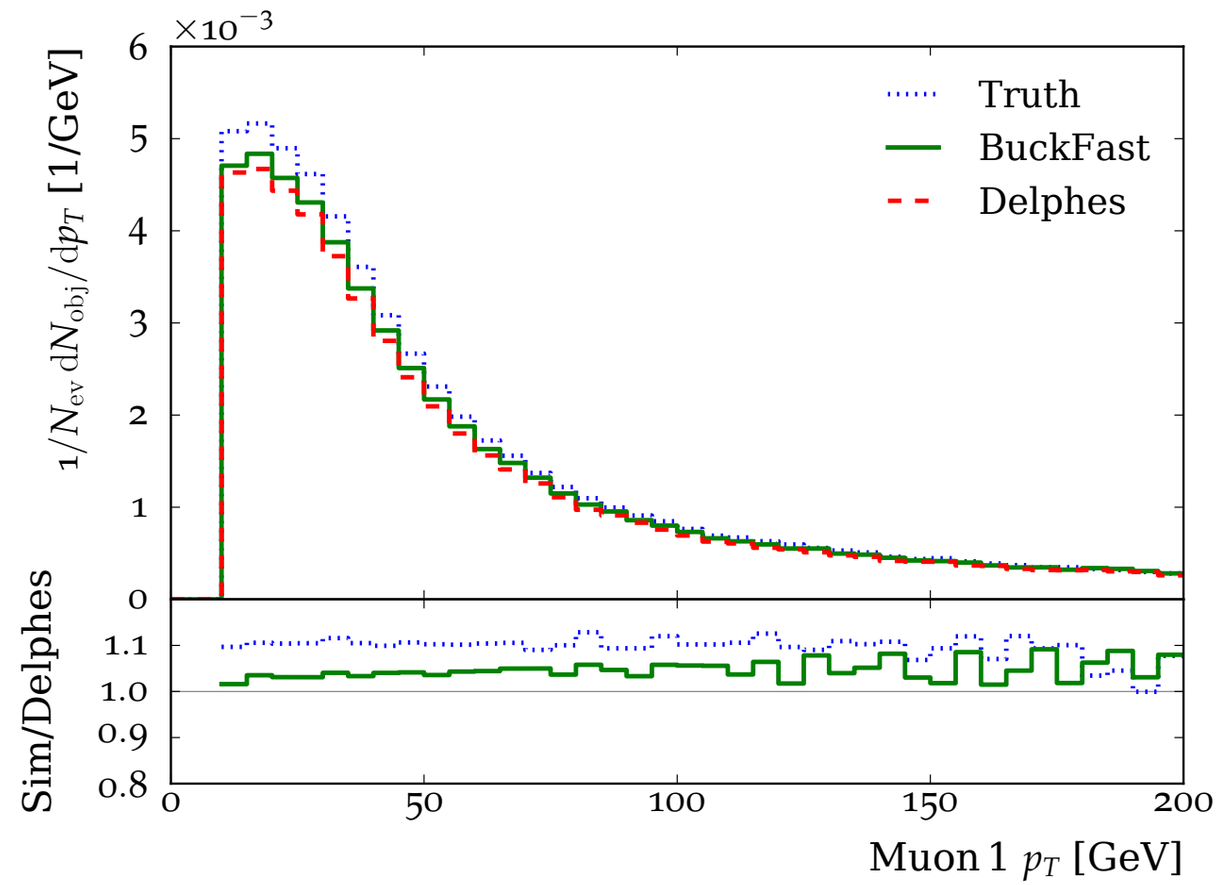
Dependency Resolution



- 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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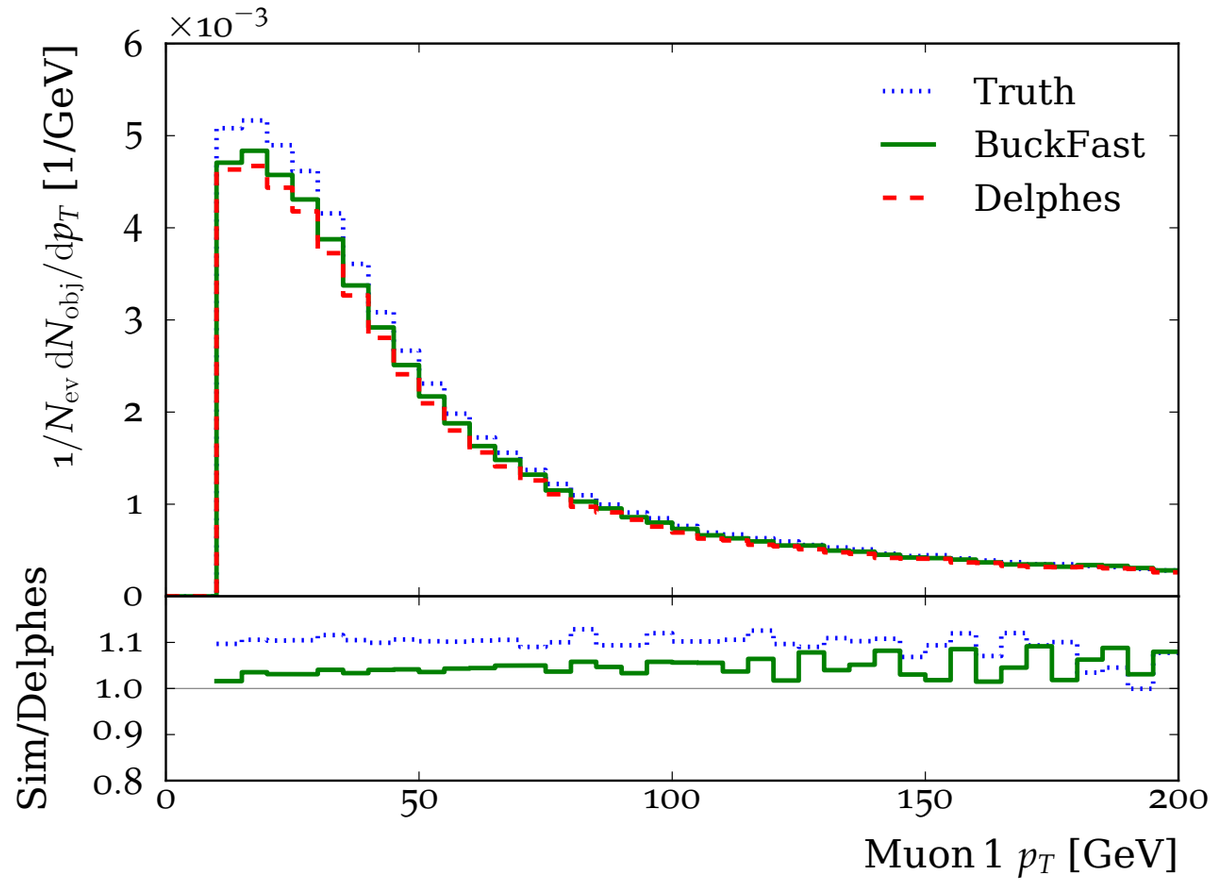

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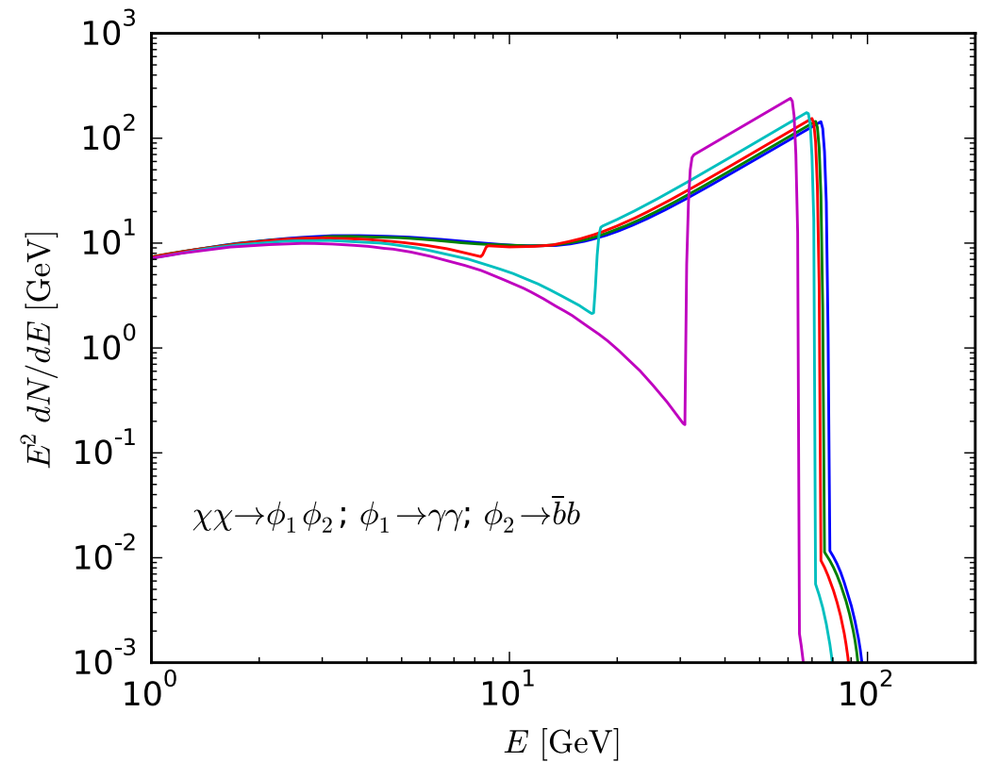
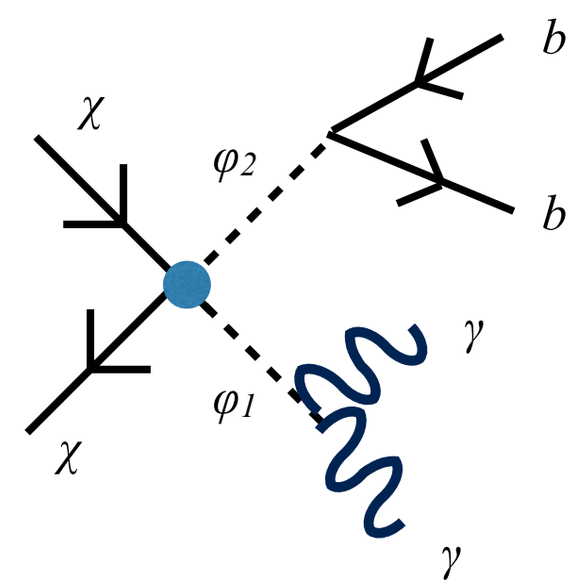
Run II results to be added soon!

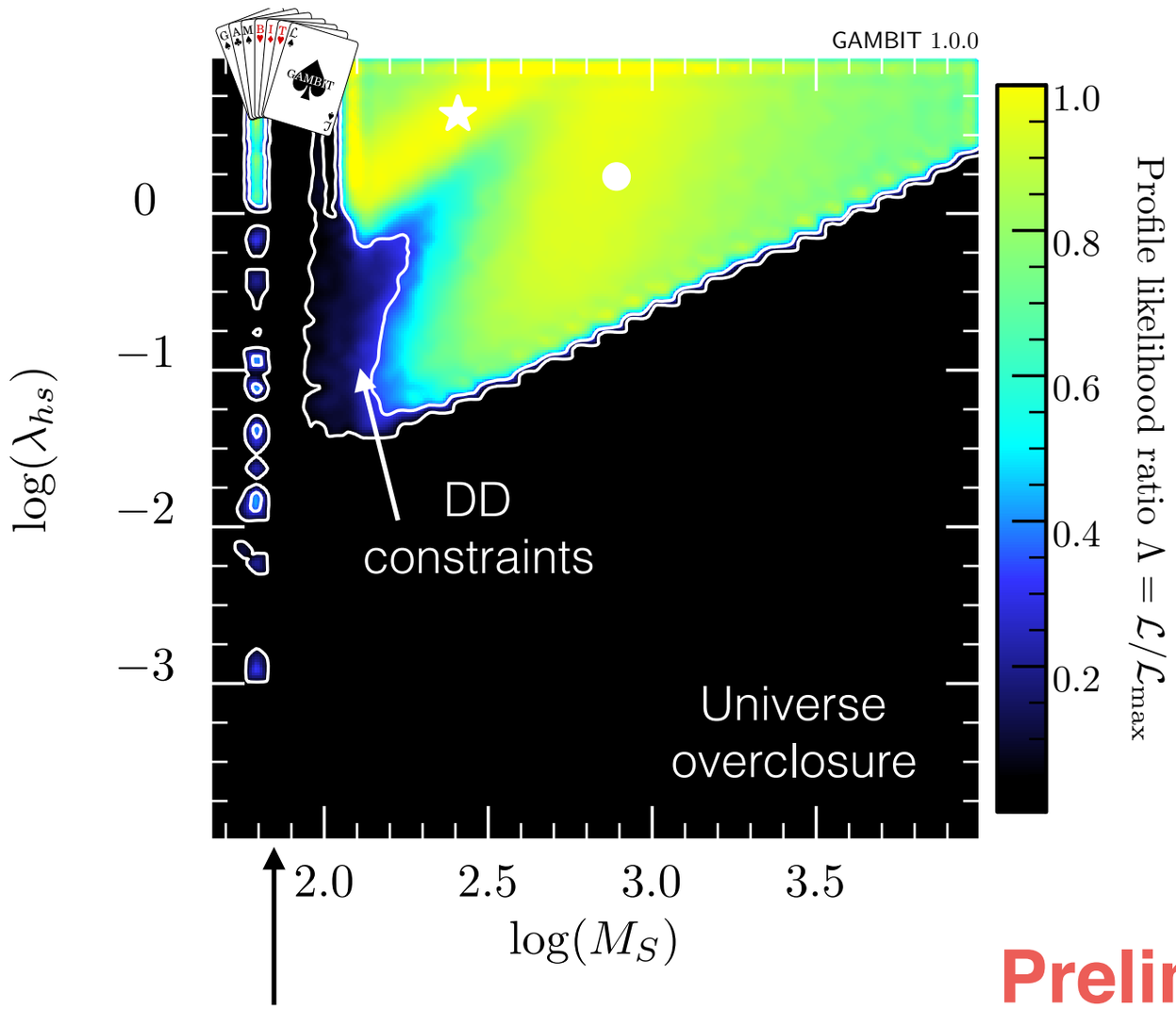
Dark Bit

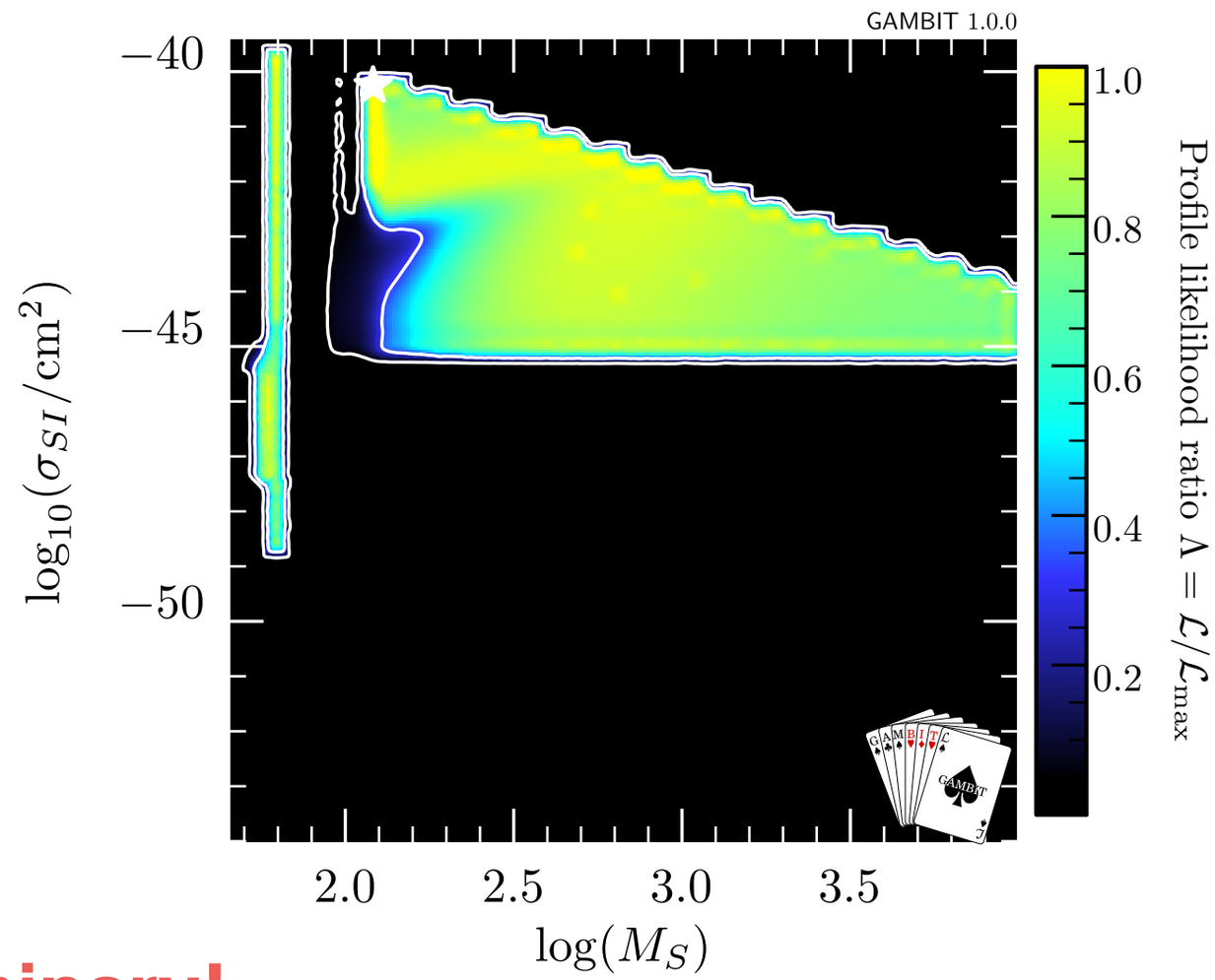
- Framework for calculation of relic density for general WIMP model.
- DM search likelihoods:
  - Direct detection (LUX, Xenon100, SIMPLE)
  - Gamma rays from DM annihilation in dwarf spheroidal galaxies (Fermi-LAT) and the galactic center (HESS)
  - Neutrinos from DM annihilation in the sun (IceCube)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



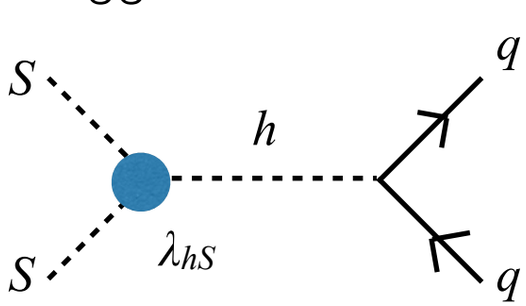


Scalar Singlet DM





Preliminary!

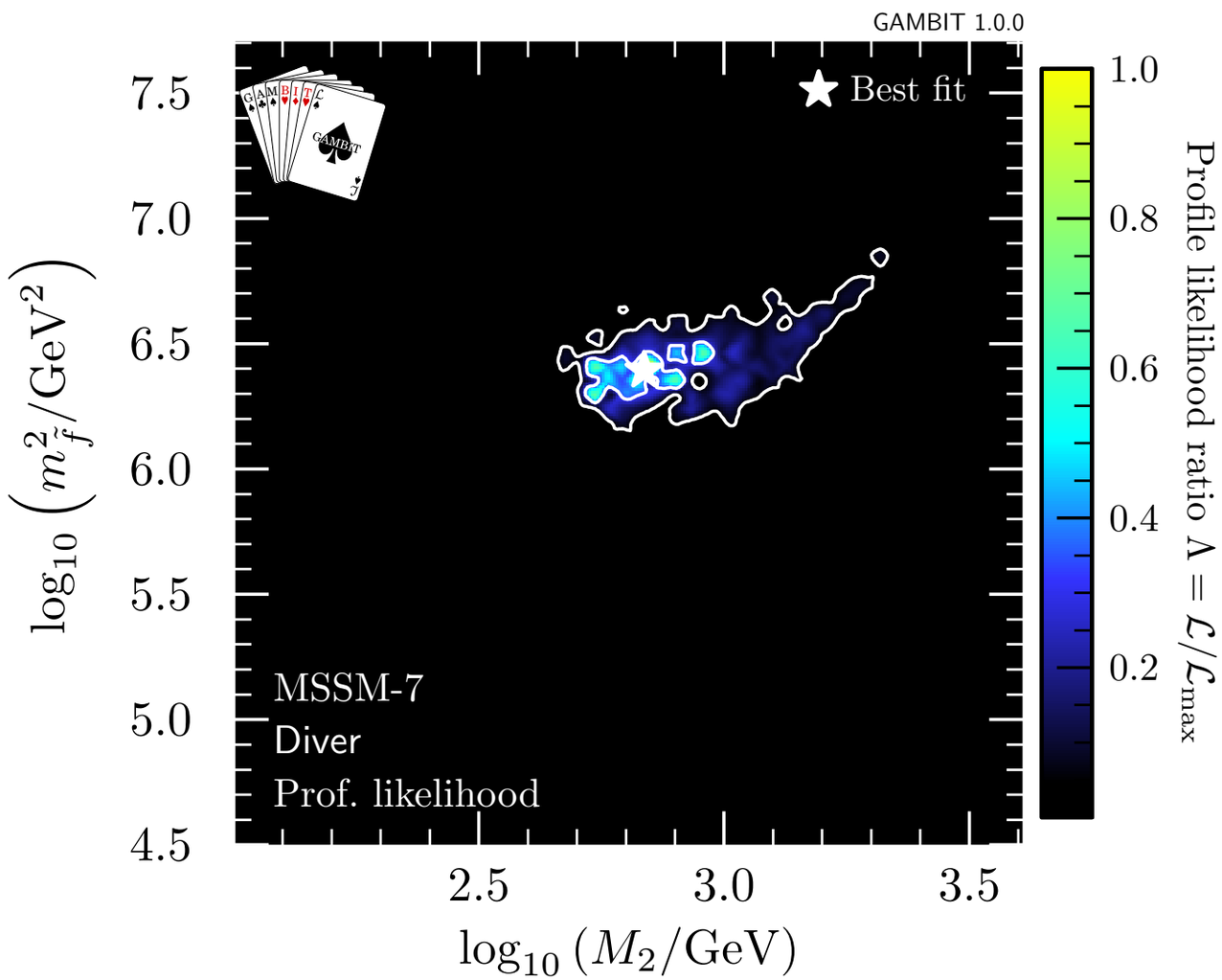


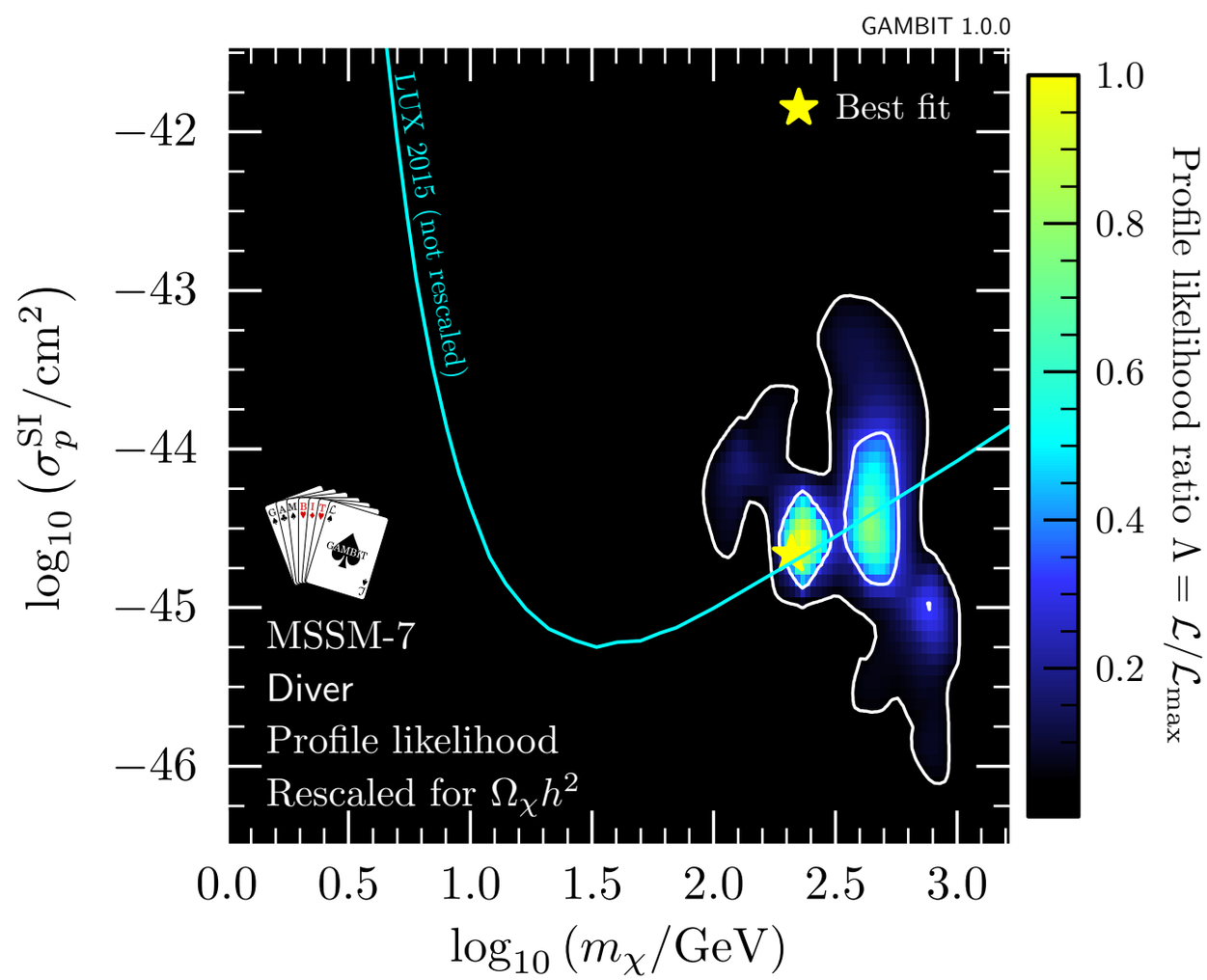
- 2 model parameters (λ_{hS}, M_S)
- 9 SM parameters (m_h, m_q, G_F, α_S, α_{EM}), 2 nuclear parameters (σ_s,σ_l), local DM density (ρ_0)

MSSM-7

$$M_2, M_{H_d}, M_{H_u}, \tan\beta, m^2_{\tilde{f}}, A_{d_3}, A_{u_3}$$

Very Preliminary!



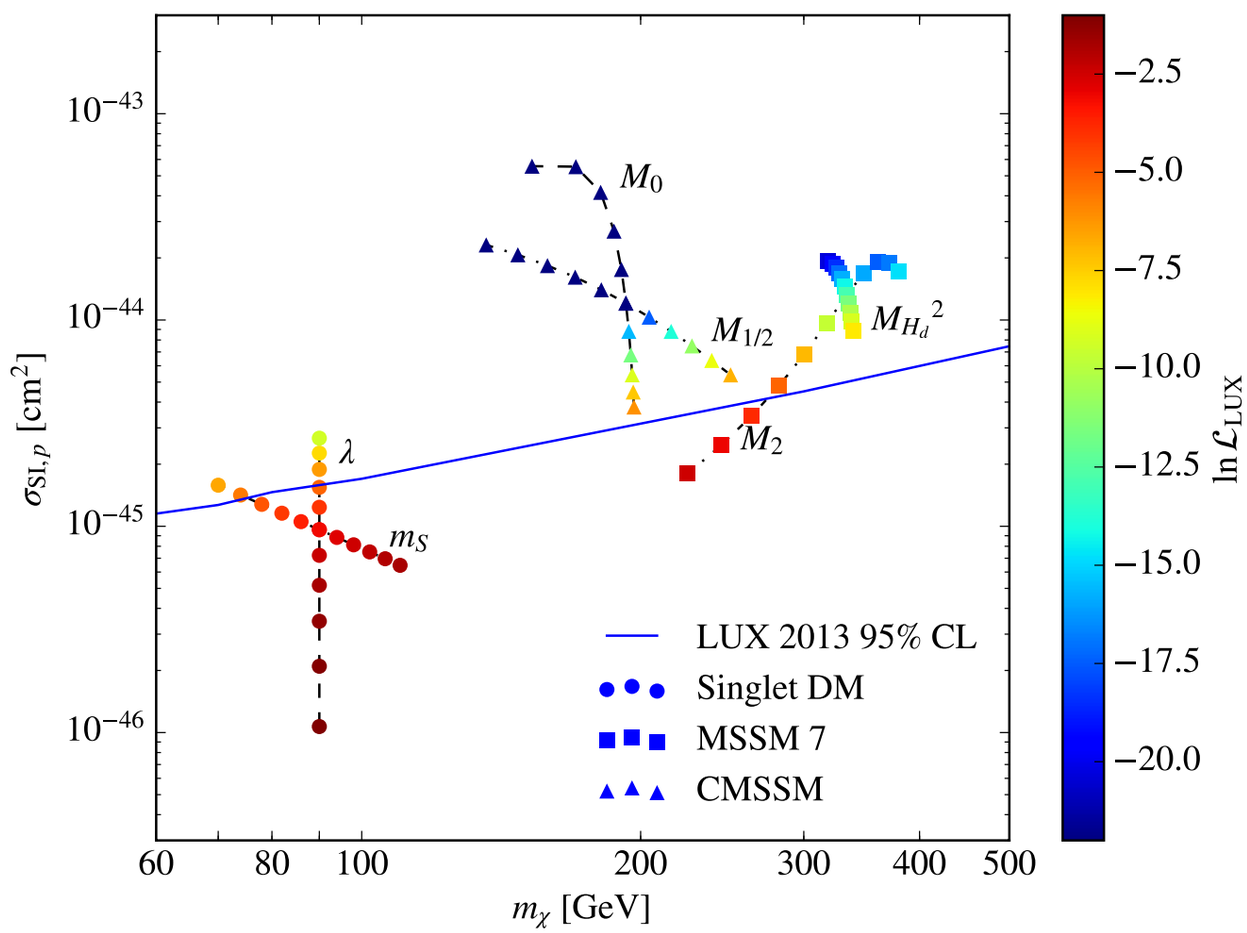


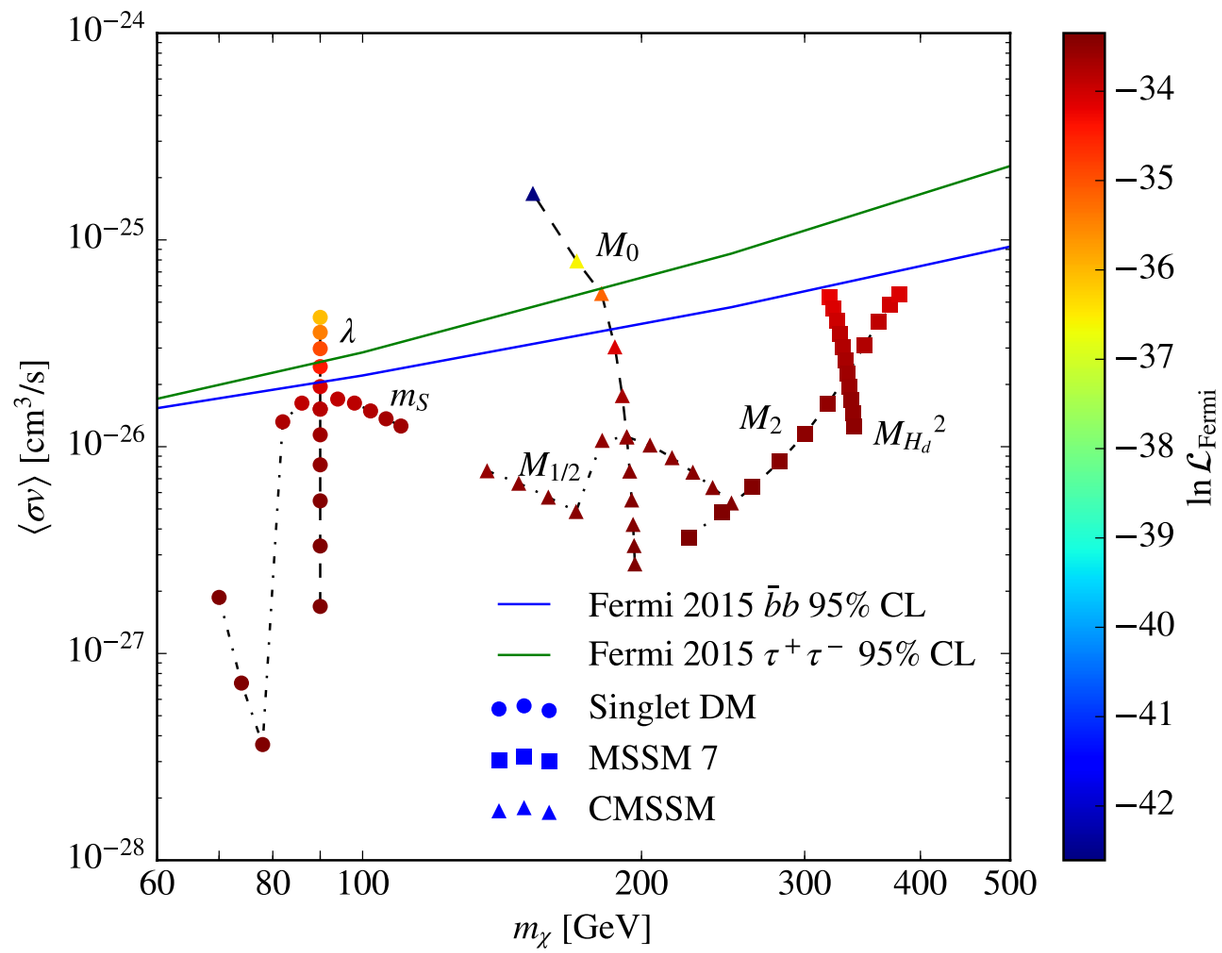
Conclusions

- 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


$\sigma_{\mathrm{SI},p}$ [cm^2]
m_χ [GeV]
$\ln \mathcal{L}_{\mathrm{LUX}}$
M_0
$M_{1/2}$
$M_{H_d}{}^2$
M_2
λ
m_S
LUX 2013 95% CL
Singlet DM
MSSM 7
CMSSM


$\langle \sigma v \rangle$ [cm^3/s]
m_χ [GeV]
$\ln \mathcal{L}_{\mathrm{Fermi}}$
M_0
λ
m_S
$M_{1/2}$
M_2
$M_{H_d}{}^2$
Fermi 2015 $\bar{b}b$ 95% CL
Fermi 2015 $\tau^+\tau^-$ 95% CL
Singlet DM
MSSM 7
CMSSM

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, Δρ etc.)

+ *ScannerBit* – manages stats, sampling and optimization

Bits can also be used as standalone codes.