

Recasting LLP searches with GAMBIT

Anders Kvellestad, University of Oslo

on behalf of the GAMBIT Collaboration

CERN, 16 May 2018



UiO : **University of Oslo**



I. Introduction: GAMBIT & ColliderBit



GAMBIT: The Global And Modular BSM Inference Tool

gambit.hepforge.org

EPJC **77** (2017) 784

arXiv:1705.07908

- Fast definition of new datasets and theoretical models
- Plug and play scanning, physics and likelihood packages
- Extensive model database – not just SUSY
- Extensive observable/data libraries
- Many statistical and scanning options (Bayesian & frequentist)
- *Fast* LHC likelihood calculator
- Massively parallel
- Fully open-source

ATLAS

LHCb

Belle-II

Fermi-LAT

CTA

CMS

IceCube

XENON/DARWIN

Theory

F. Bernlochner, A. Buckley, P. Jackson, M. White

M. Chrzęszcz, N. Serra

F. Bernlochner, P. Jackson

J. Conrad, J. Edsjö, G. Martinez, P. Scott

C. Balázs, T. Bringmann, M. White

C. Rogan

J. Edsjö, P. Scott

B. Farmer, R. Trotta

P. Athron, C. Balázs, S. Bloor, T. Bringmann,

J. Cornell, J. Edsjö, B. Farmer, A. Fowlie, T. Gonzalo,

J. Harz, S. Hoof, F. Kahlhoefer, S. Krishnamurthy,

A. Kvellestad, F.N. Mahmoudi, J. McKay, A. Raklev,

R. Ruiz, P. Scott, R. Trotta, A. Vincent, C. Weniger,

M. White, S. Wild



31 Members in 9 Experiments, 12 major theory codes, 11 countries
+ extended «GAMBIT Community» of collaborators



GAMBIT

What's in the box?

Core

- Models

EPJC, arXiv:1705.07908

Physics modules

- ColliderBit: *fast* LHC sim, Higgs searches, LEP SUSY limits
- DarkBit: relic density, gamma ray signal yields, ID/DD likelihoods
- FlavBit: wide range of flavour observables & likelihoods
- SpecBit: spectrum objects, RGE running
- DecayBit: decay widths
- PrecisionBit: precision BSM tests

EPJC, arXiv:1705.07919

EPJC, arXiv:1705.07920

EPJC, arXiv:1705.07933

EPJC, arXiv:1705.07936

Statistics and sampling

- ScannerBit: stats & sampling (Diver, MultiNest, T-Walk, ++)

EPJC, arXiv:1705.07959

Backends (external tools)

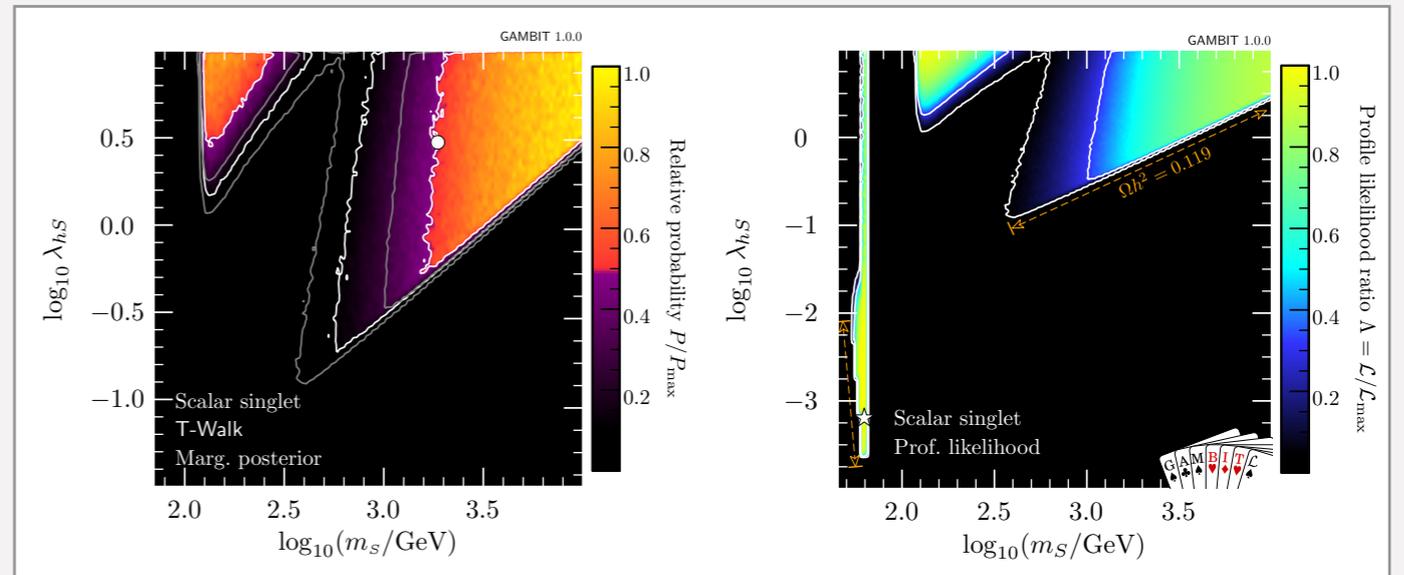


GAMBIT

First physics results

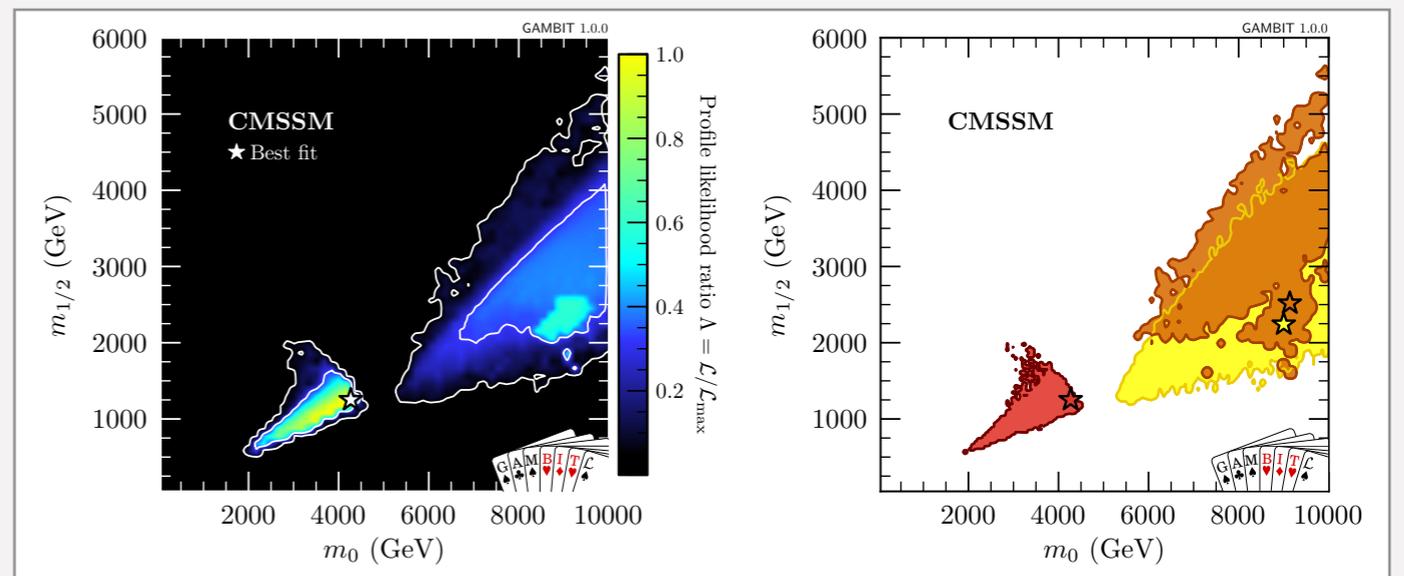
- **Scalar singlet dark matter**

[arXiv:1705.07931](https://arxiv.org/abs/1705.07931)



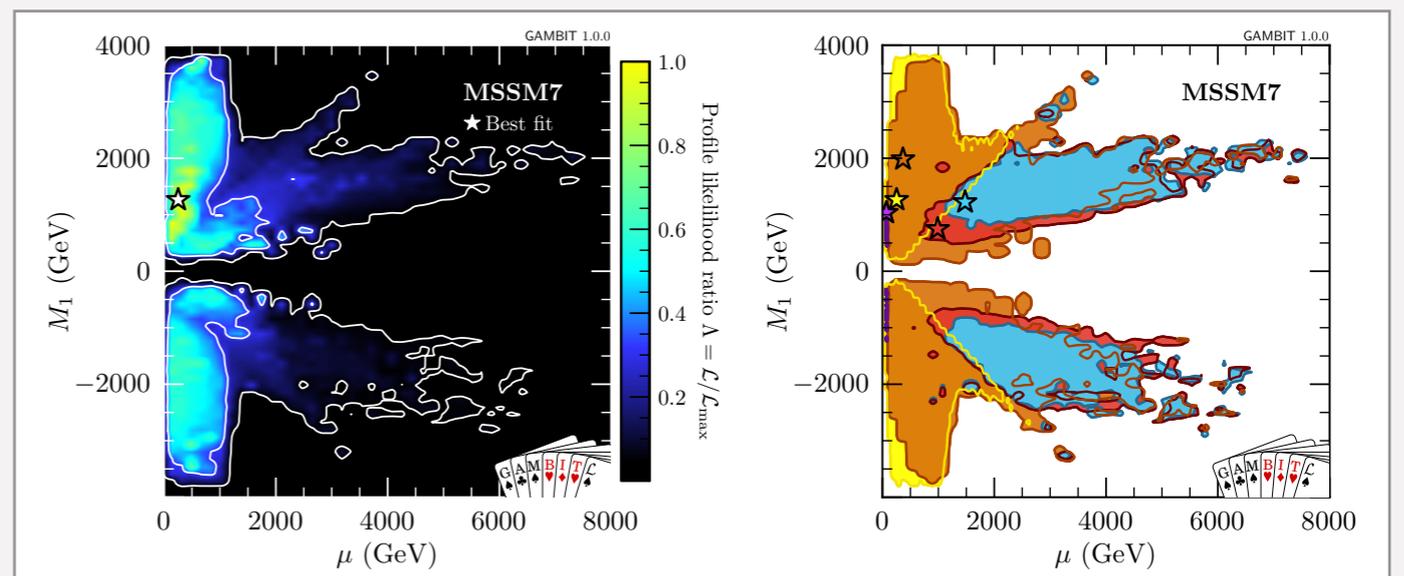
- **GUT-scale MSSM**
CMSSM, NUHM1, NUHM2

[arXiv:1705.07935](https://arxiv.org/abs/1705.07935)



- **Weak-scale MSSM7**

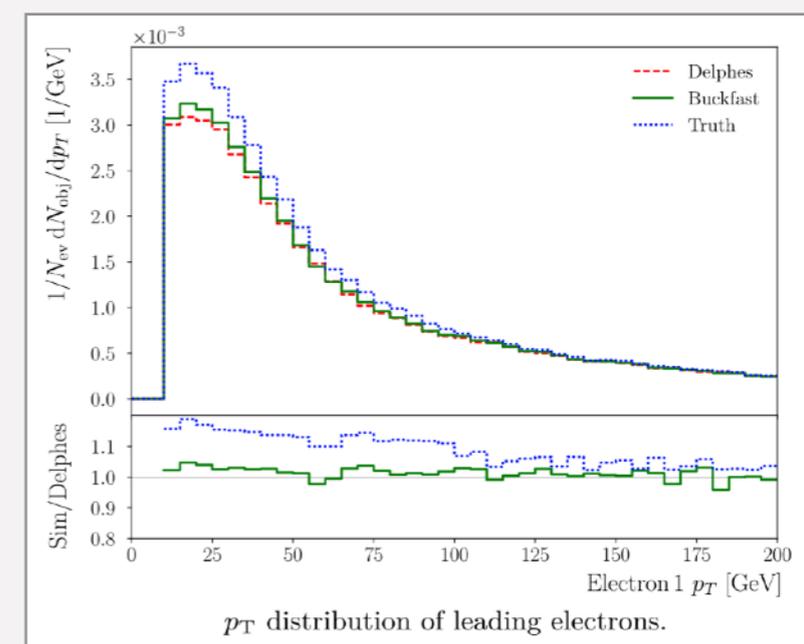
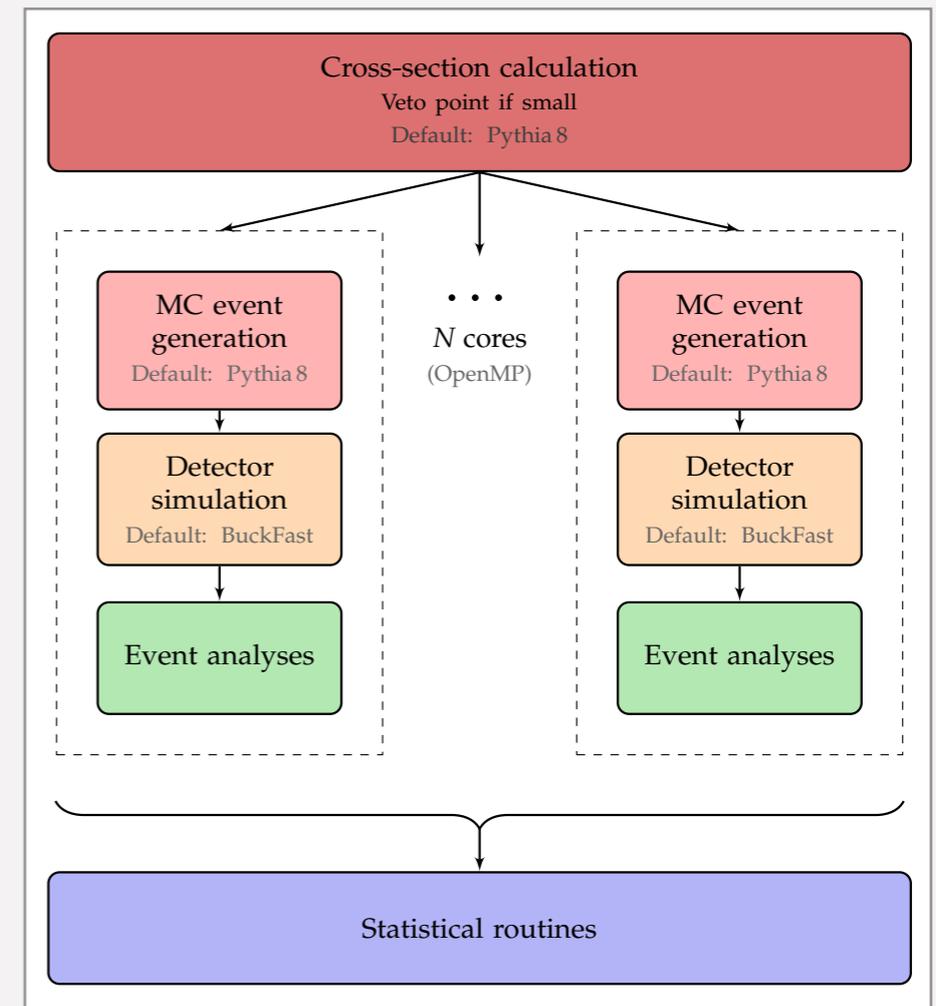
[arXiv:1705.07917](https://arxiv.org/abs/1705.07917)



■ \tilde{t}_1^\pm co-annihilation
 ■ A/H funnel
 ■ $\tilde{\chi}_1^\pm$ co-annihilation
 ■ \tilde{b}_1 co-annihilation
 ■ h/Z funnel

ColliderBit

- **Higgs:** Connect HiggsBounds and HiggsSignals as backends (more to come)
- **LEP limits (SUSY):** Calculate $\sigma \times BR$ and check against published limits
- **LHC particle searches:** Full Poisson likelihood from fast MC simulation of LHC searches
 - Parallelized MC event generation and analysis loop inside ColliderBit
 - Event generation with Pythia 8
 - Fast detector simulator: BuckFast (4-vector smearing)
- **Focus on speed,** as required for use in global fits



[arXiv:1705.07919]

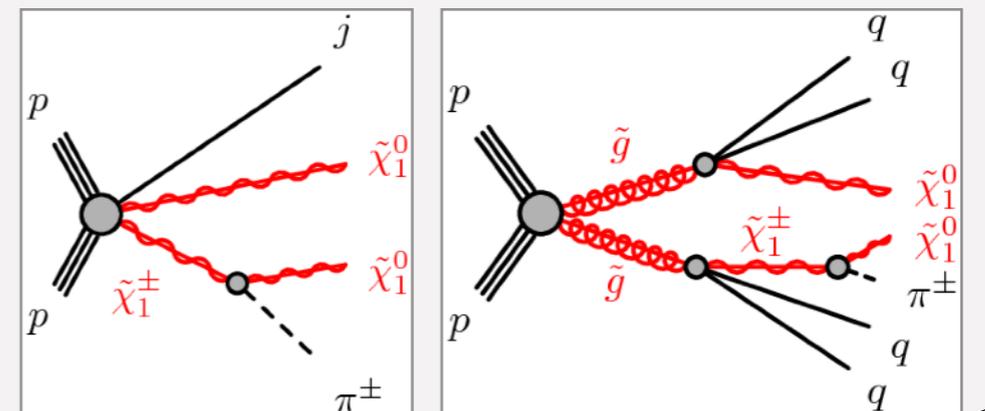
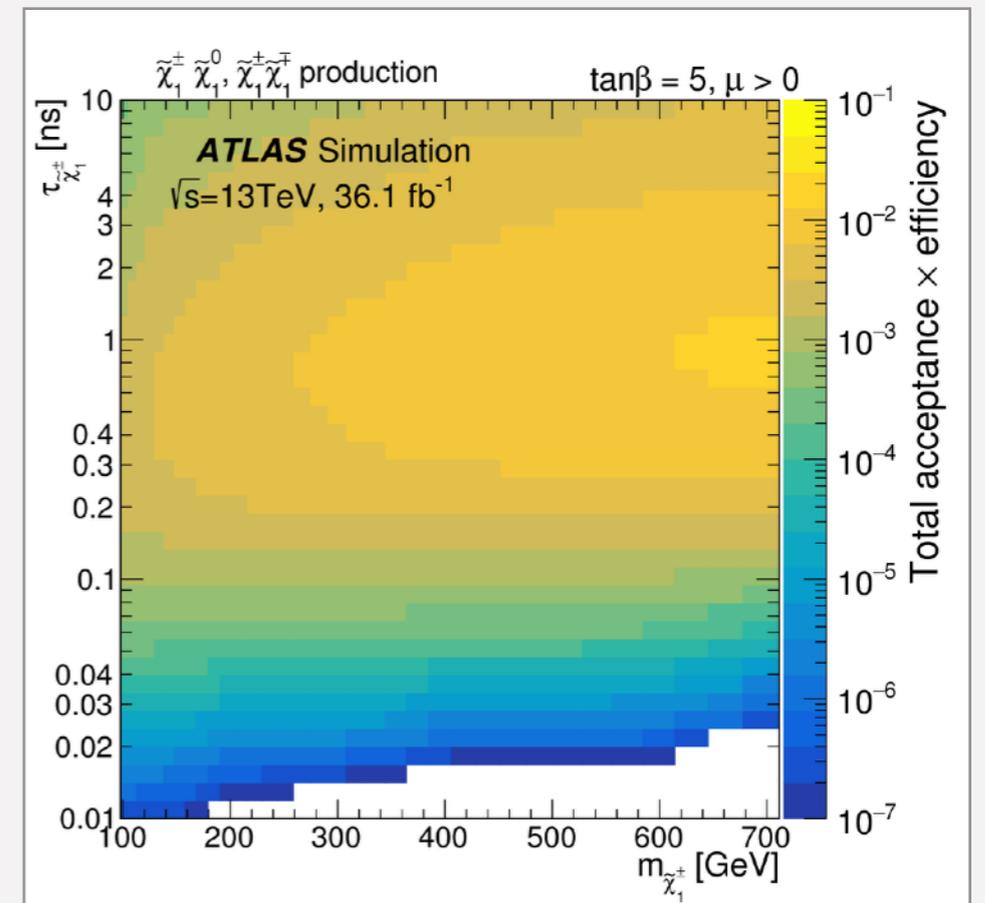
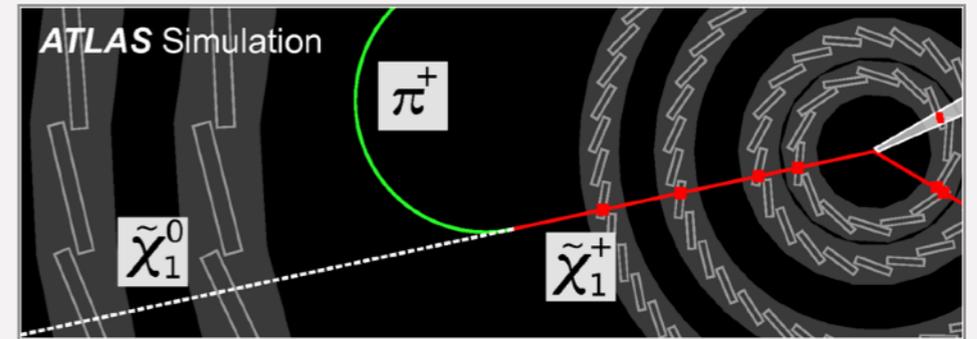


2. Current work: Simulation-less LLP recasting



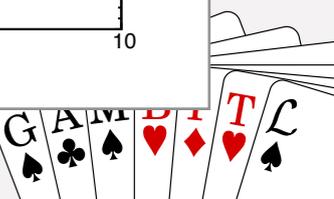
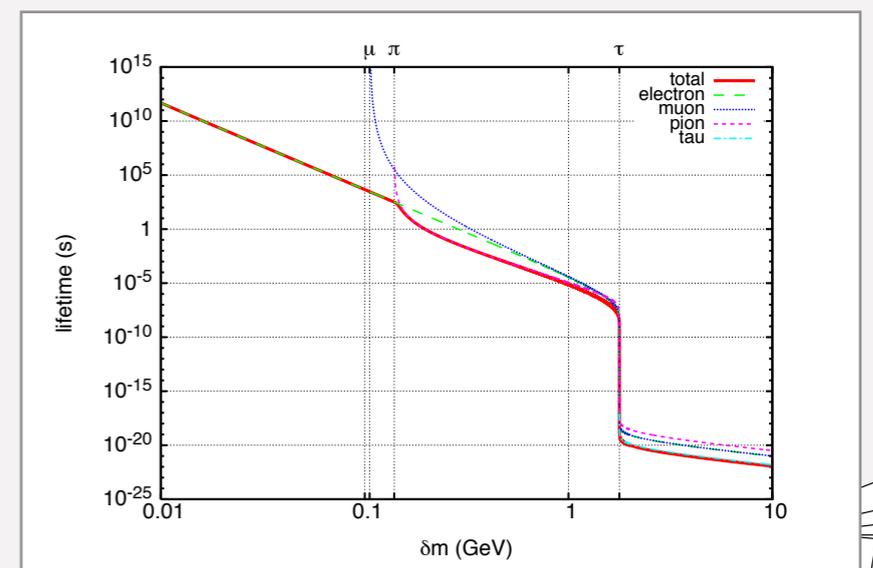
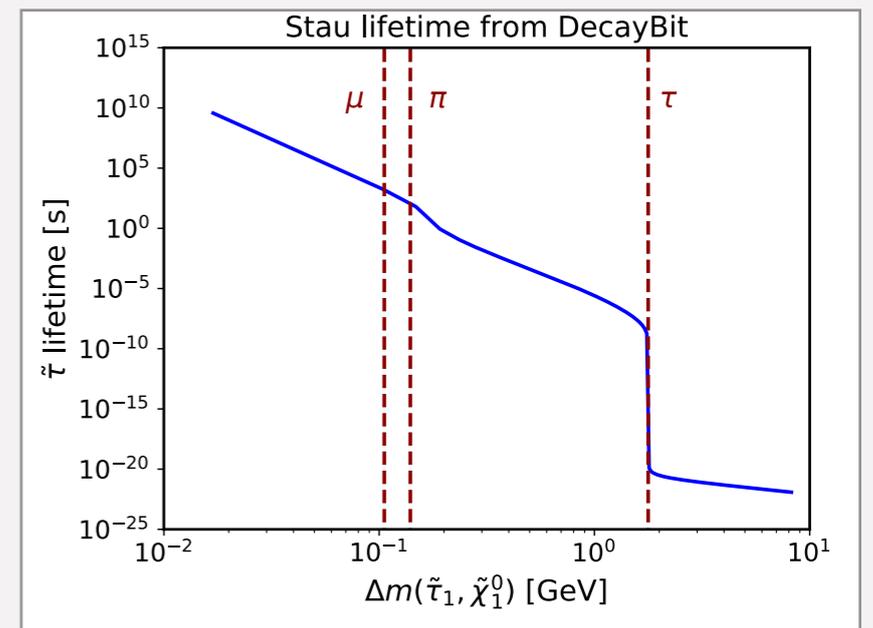
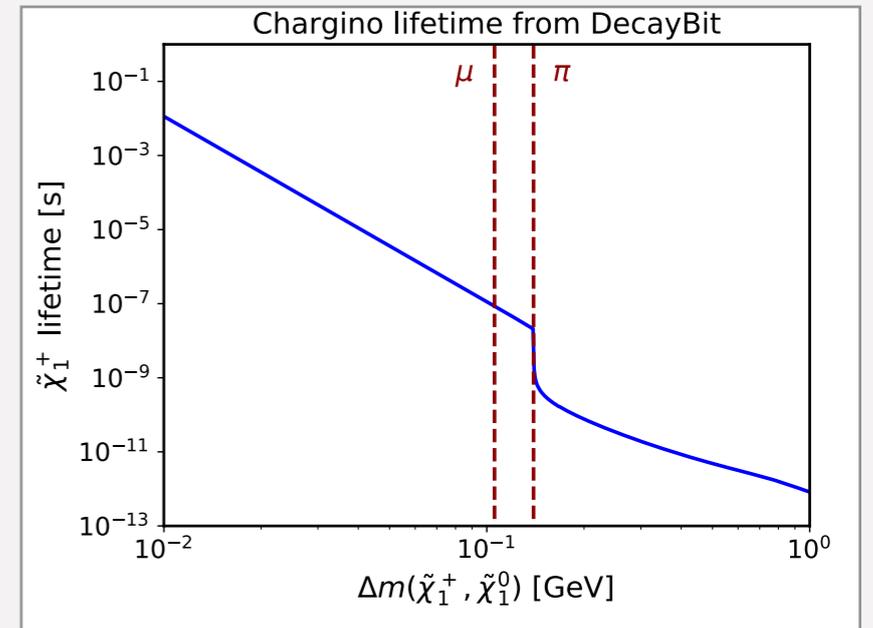
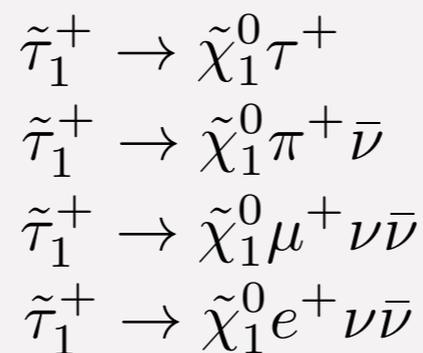
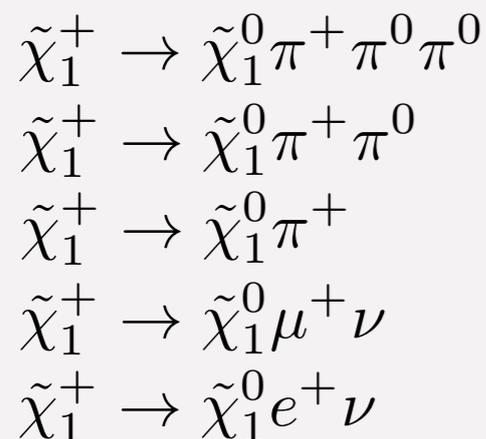
Simulation-less recasts

- GAMBIT needs to do everything needed for a BSM global fit, starting from the BSM theory parameters
- Get mass and lifetime predictions from SpecBit and DecayBit
- Production cross-section in ColliderBit
- Signal-specific maps of acceptance x efficiency from experimental analysis, in the plane of the LLP mass and lifetime
A lot of very useful material provided on HepData!
- No event generation or detector simulation needed — perfect for large global fits
- Full Poisson likelihood, not only comparison to 95% CL limit
- First target: ATLAS disappearing track search for long-lived charginos (arXiv:1712.02118)



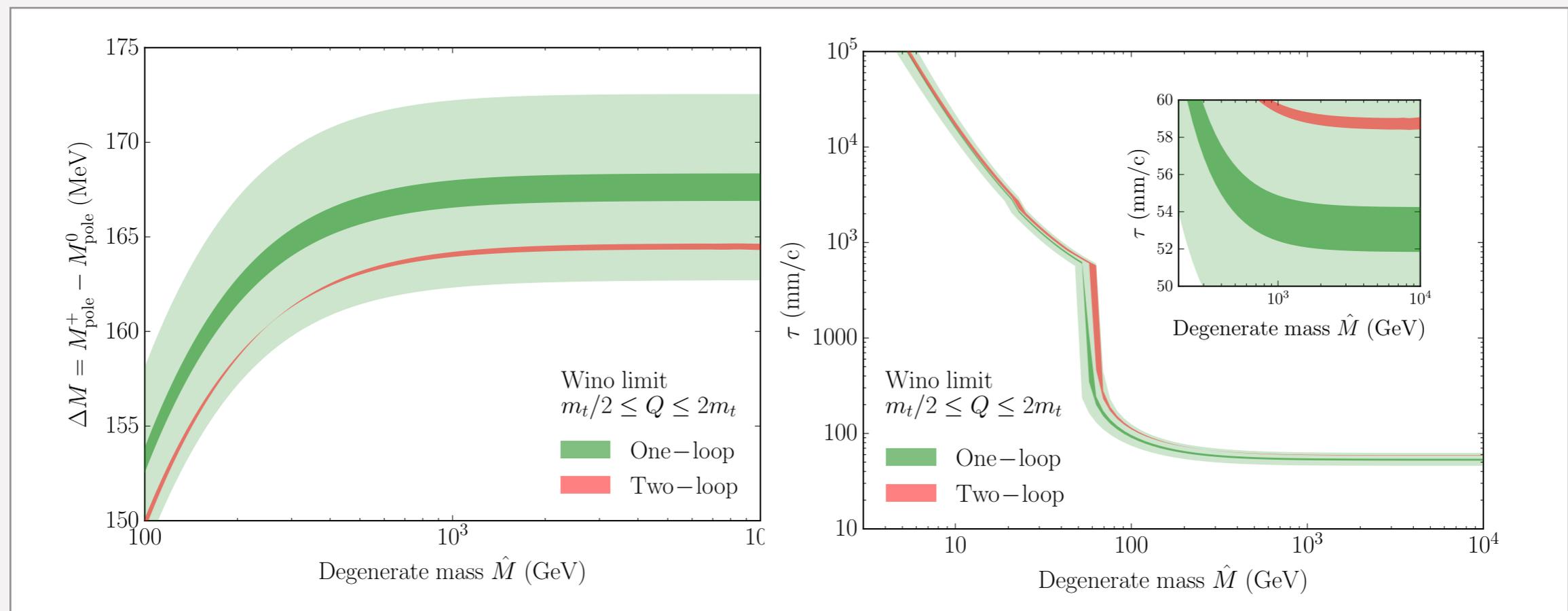
Mass and lifetime

- Masses from SpecBit
(via FlexibleSUSY or SPheno)
- Lifetime from DecayBit calculations of decay widths at small mass splittings (not included in SDECAY)
- Chargino and stau decays implemented so far
[C.-H. Chen et al \[PRD, arXiv:hep-ph/9607421\]](#)
[T. Jittoh et al \[PRD, arXiv:hep-ph/0512197\]](#)
- *Future:* Also connect SOFTSUSY-4 to SpecBit & DecayBit



Mass and lifetime

- *Todo:* Refine chargino lifetime with two-loop calculation of chargino–neutralino mass splitting (wino limit)

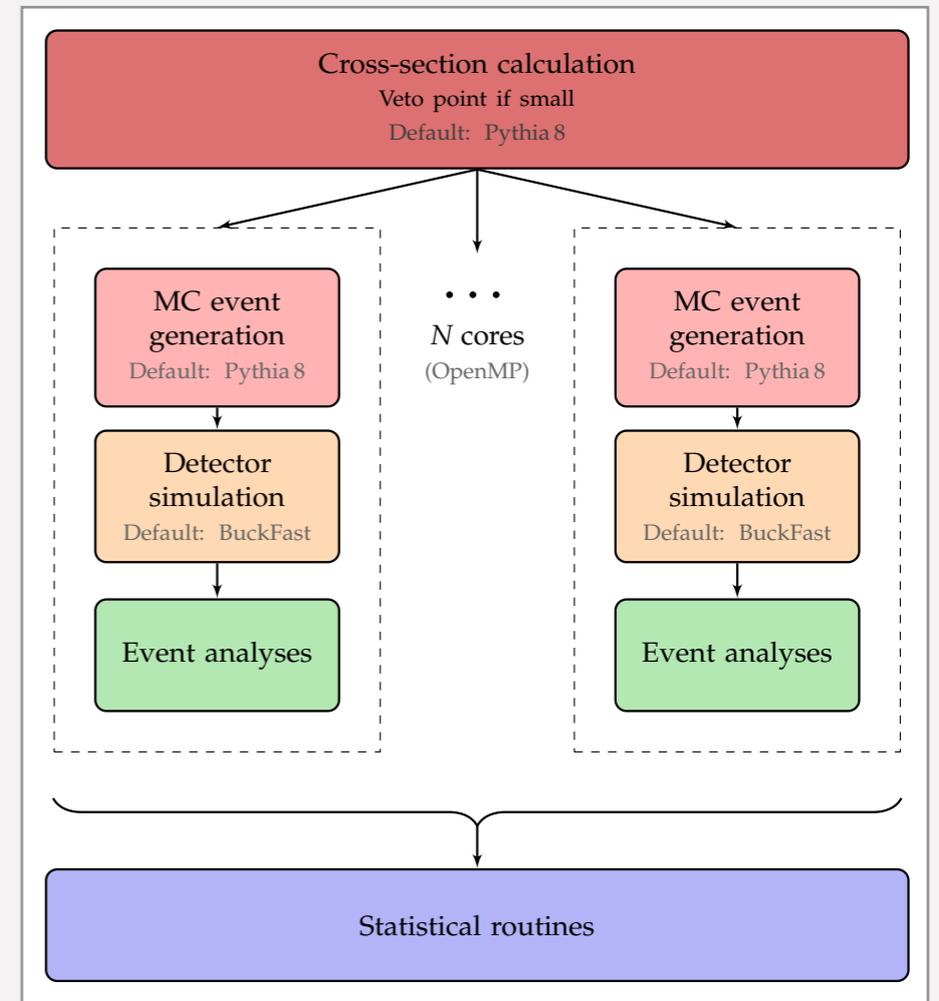


J. MacKay, P. Scott [PRD, arXiv:1712.00968]



Cross-sections and ColliderBit structure

- *Currently:*
 - Tree-level cross-sections from Pythia8
- *Ongoing work:*
 - Detach cross-section calculation from the parallelized event generation in ColliderBit
 - Allow cross-section input from external codes
 - Fast evaluation of NLO SUSY cross-sections (interface to *EWK-fast* when released)
 - Add simulation-less analyses as a new category of analyses in ColliderBit

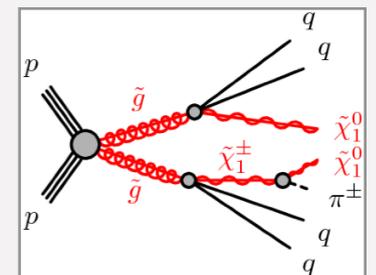
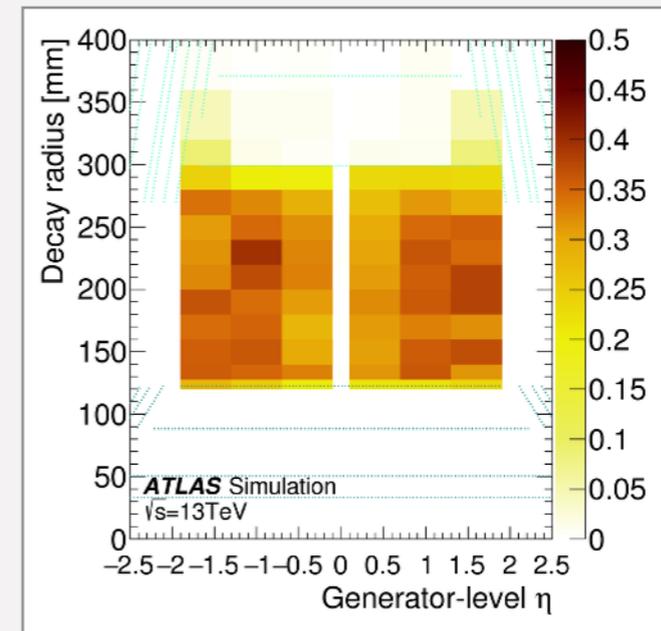
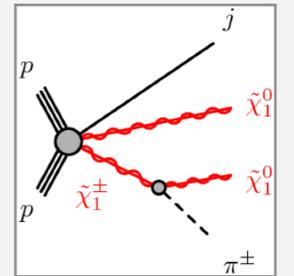
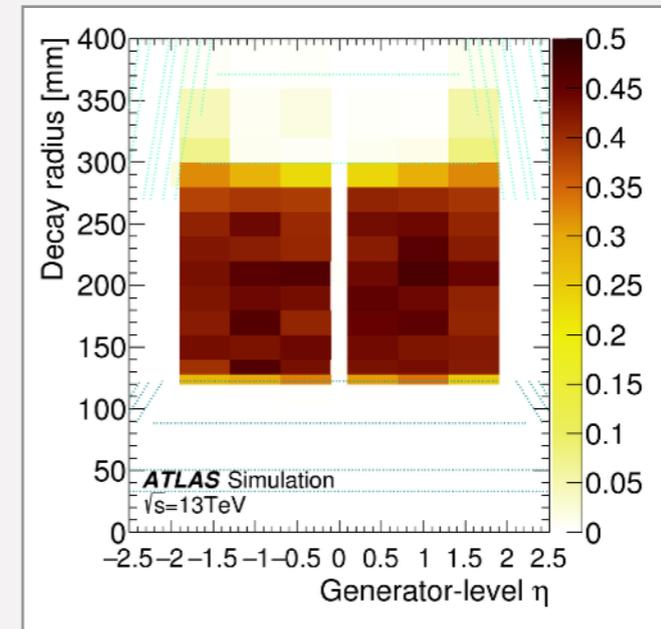


3. Next step: Event-level LLP recasting



Next step: Event-level LLP recasting

- Use generator-level efficiency maps in decay radius and eta — code in place for doing this
- Slight tweaking of Pythia for decays at very small mass splittings
- ColliderBit uses Pythia (for speed) — expect less accurate, but conservative, results for signals relying on ISR
- Extend the ColliderBit analysis framework to include decay radius information



Conclusion and outlook

- GAMBIT is new and open-source tool for BSM global fits (not only SUSY)
- Ongoing effort to implement LLP searches in ColliderBit
- *Focus on speed* — intended for use in large-scale global fits with GAMBIT
- Starting with the simplest case: simulation-less recasting of SUSY LLP searches
- Some decay width calculations implemented, to be extended and refined
- Work ongoing on cross-section evaluations and extending the ColliderBit structure
- Next step: move on to event-level LLP recasting



The screenshot shows the GAMBIT homepage. On the left is a navigation menu with the following items: Home, Results & Publications, Talks, Collaboration, Download, Source Code, Support (with sub-items: FAQ, Compiler matrix, Known issues, Documentation, Configuration examples, Report issue), Mailing list, Contact, Internal pages (with sub-items: Wiki, Git repos: gambit (dev fork), gambit_internal, gambit_results). To the right of the menu is a graphic of a fan of playing cards where the top card is the Jack of Spades, and the letters G, A, M, B, I, T are written on the cards. Below the graphic is the heading 'GAMBIT' and the subtitle 'The Global And Modular BSM Inference Tool'. The main text reads: 'Welcome to the GAMBIT homepage. GAMBIT is a global fitting code for generic Beyond the Standard Model theories, designed to allow fast and easy definition of new models, observables, likelihoods, scanners and backend physics codes. We have released GAMBIT to the public! Please check out the Source Code section and have fun with it! You can read more about GAMBIT in this Physics World article.'

gambit.hepforge.org



Backup slides

Getting started with GAMBIT

Clone git repository from GitHub

- github.com/patscott/gambit_1.1

Download tarballs

- hepforge.org/downloads/gambit

Pre-compiled version with Docker

- `docker run -it jmcornell/gambit`

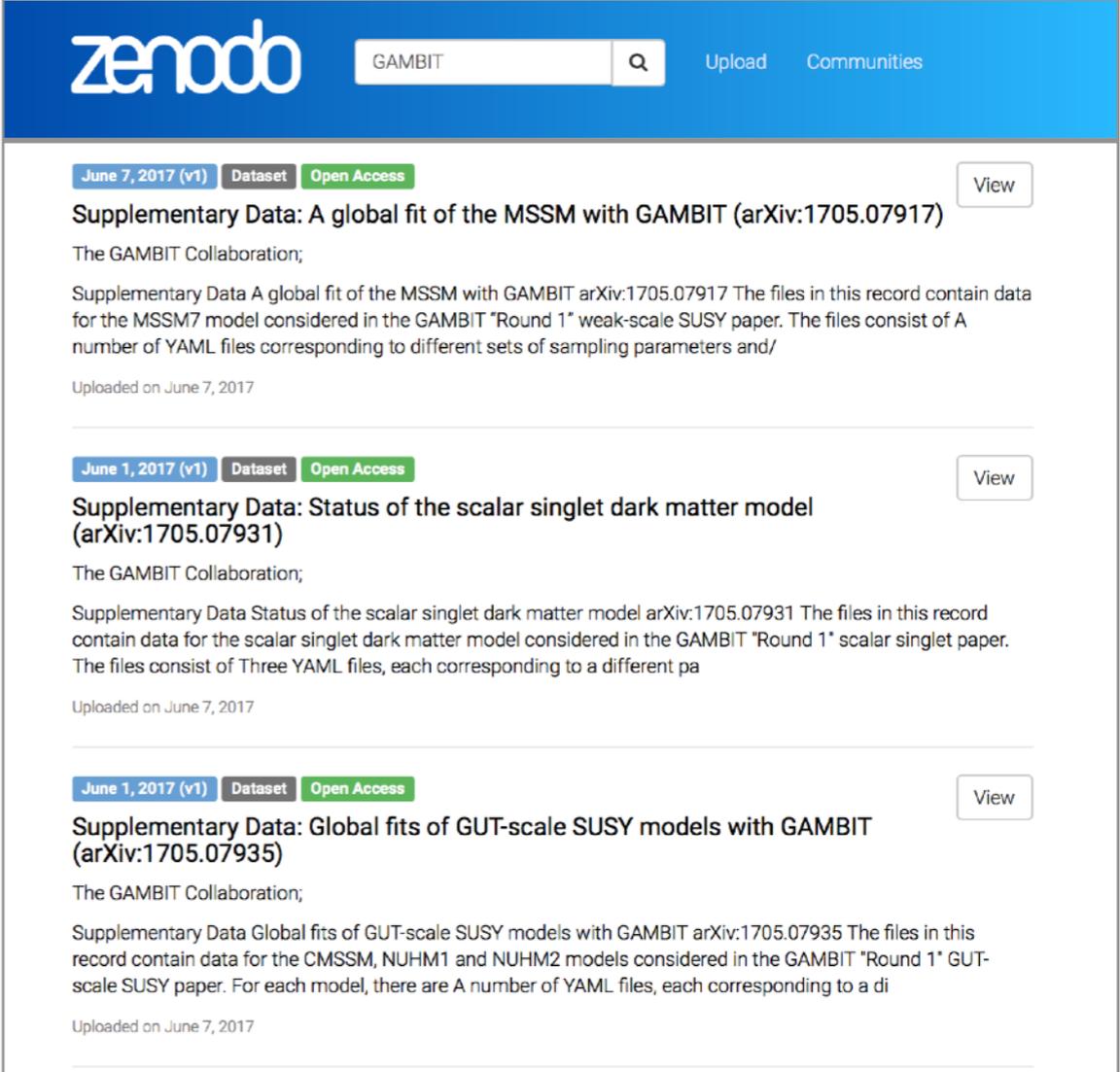
See quick start guide in arXiv:1705.07908

All results publicly available

Results available on zenodo.cern.ch

- Parameter point samples (hdf5 files)
- GAMBIT input files for all scans
- Example plotting routines

Links at gambit.hepforge.org/pubs



The screenshot displays the Zenodo website interface. At the top, the Zenodo logo is on the left, a search bar with 'GAMBIT' entered is in the center, and 'Upload' and 'Communities' links are on the right. Below the header, three dataset entries are listed, each with a 'View' button on the right. The first entry is titled 'Supplementary Data: A global fit of the MSSM with GAMBIT (arXiv:1705.07917)', dated June 7, 2017 (v1), and is a Dataset with Open Access. The second entry is 'Supplementary Data: Status of the scalar singlet dark matter model (arXiv:1705.07931)', dated June 1, 2017 (v1), also a Dataset with Open Access. The third entry is 'Supplementary Data: Global fits of GUT-scale SUSY models with GAMBIT (arXiv:1705.07935)', dated June 1, 2017 (v1), a Dataset with Open Access. Each entry includes a brief description of the data and the upload date.