BSM Global Fits and

http://gambit.hepforge.org

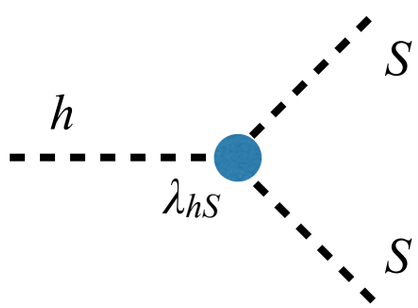
Jonathan Cornell, on
behalf of the collaboration

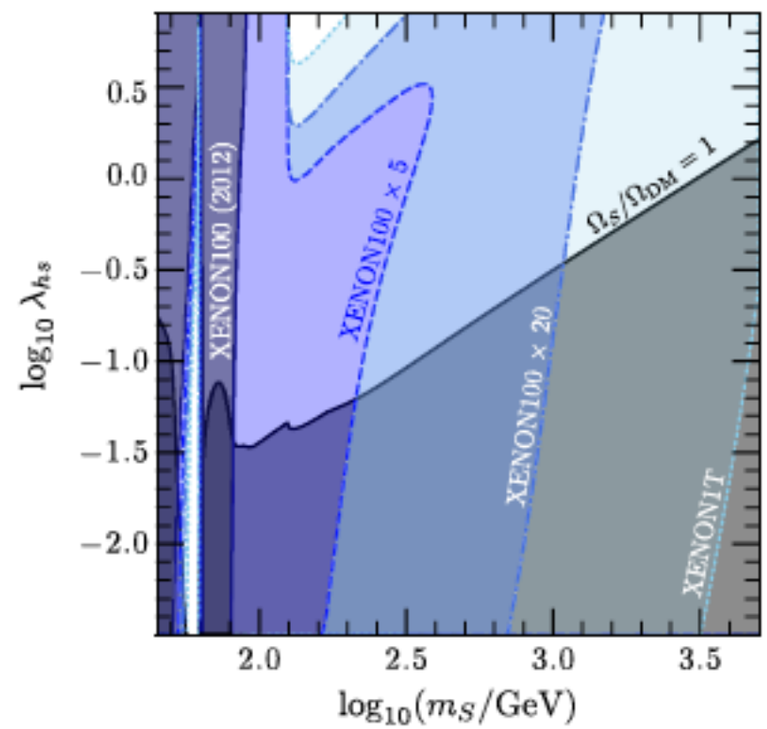
WEBER STATE
UNIVERSITY

Snowmass 2021 Computational Frontier Kickoff

- 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 *consistent* 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.
- Other codes exist to do this for BSM models: MasterCode, Fittino, SFitter, HEPFit...

GAMBIT: The Global And Modular BSM Inference Tool

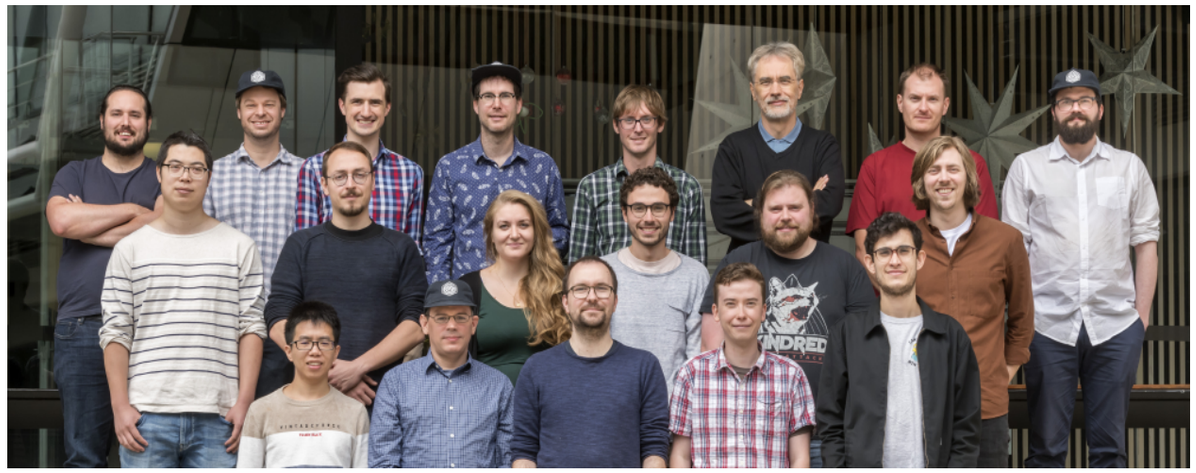
gambit.hepforge.org EPJC **77** (2017) 784 arXiv:1705.07908

- 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

Members of:
ATLAS, Belle-II, CLiC, CMS, CTA, *Fermi*-LAT, DARWIN, IceCube, LHCb, SHiP, XENON

Authors of:
DarkSUSY, DDCalc, Diver, FlexibleSUSY, gamlike, GM2Calc, IsaTools, nulike, PolyChord, Rivet, SoftSUSY, SuperISO, SUSY-AI, WIMPSim

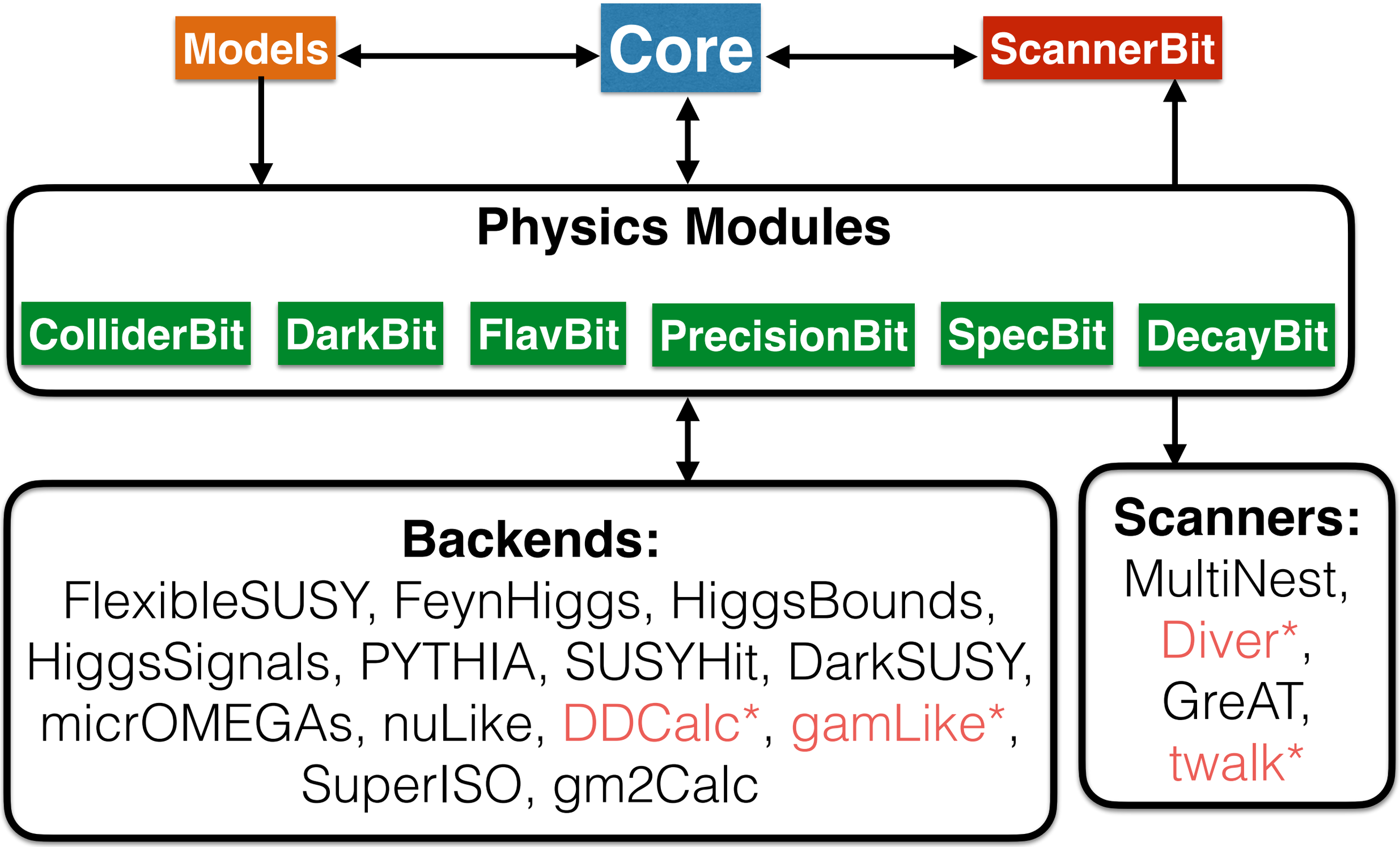
- Fast definition of new datasets and theories
- Plug and play scanning, physics and likelihood packages



Recent collaborators:
P Athron, C Balázs, A Beniwal, S Bloor, T Bringmann, A Buckley, J Eliel Camargo-Molina, C Chang, M Chrzaszcz, J Conrad, J Cornell, M Danninger, J Edsjö, B Farmer, A Fowlie, T Gonzalo, P Grace, W Handley, J Harz, S Hoof, F Kahlhoefer, N Avis Kozar, A Kvellestad, P Jackson, R Jardine, A Ladhu, N Mahmoudi, G Martinez, M Prim, F Rajec, A Raklev, J Renk, C Rogan, R Ruiz, I Sáez Casares, N Serra, A Scaffidi, P Scott, P Stöcker, W Su, J Van den Abeele, A Vincent, C Weniger, M White, Y Zhang

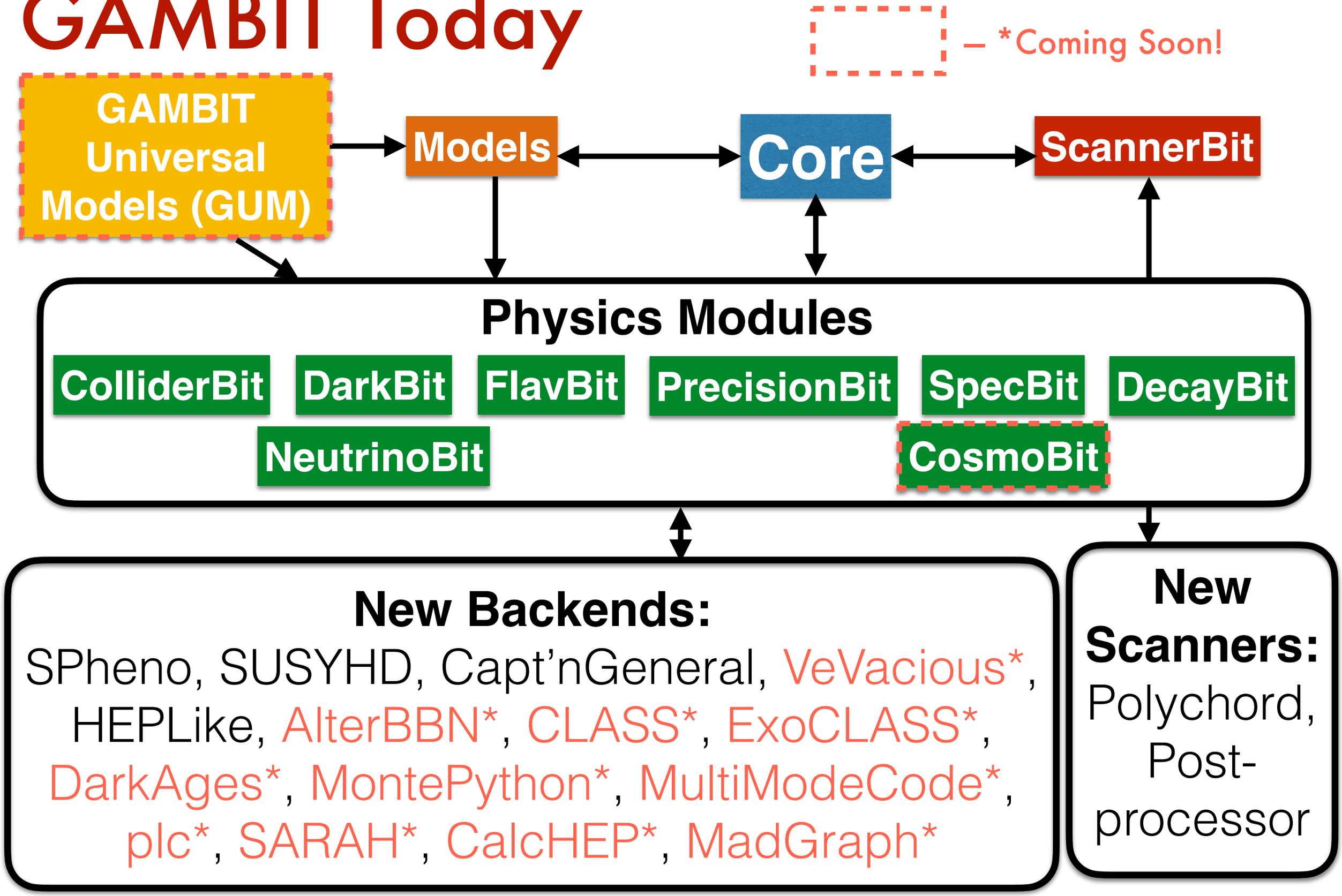
40+ participants in 11 experiments and 14 major theory codes

GAMBIT Circa 2017



*Developed alongside GAMBIT

GAMBIT Today

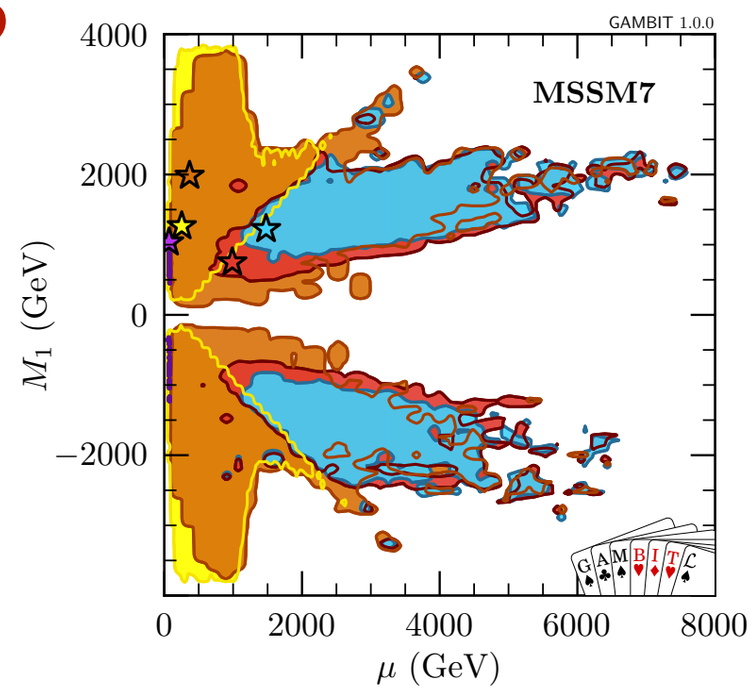


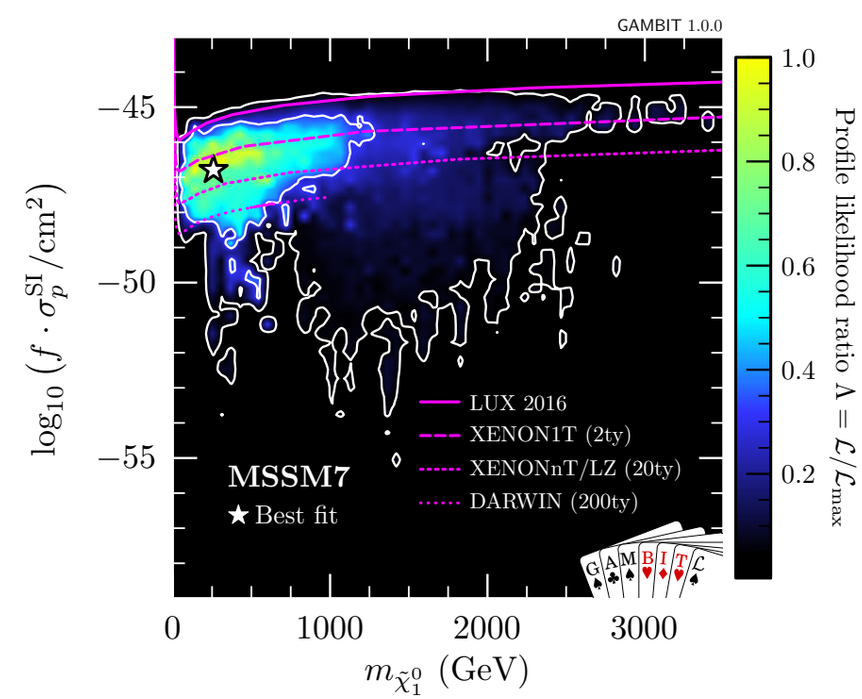
+ continued expansion and updating of existing physics modules and backends

Some Results

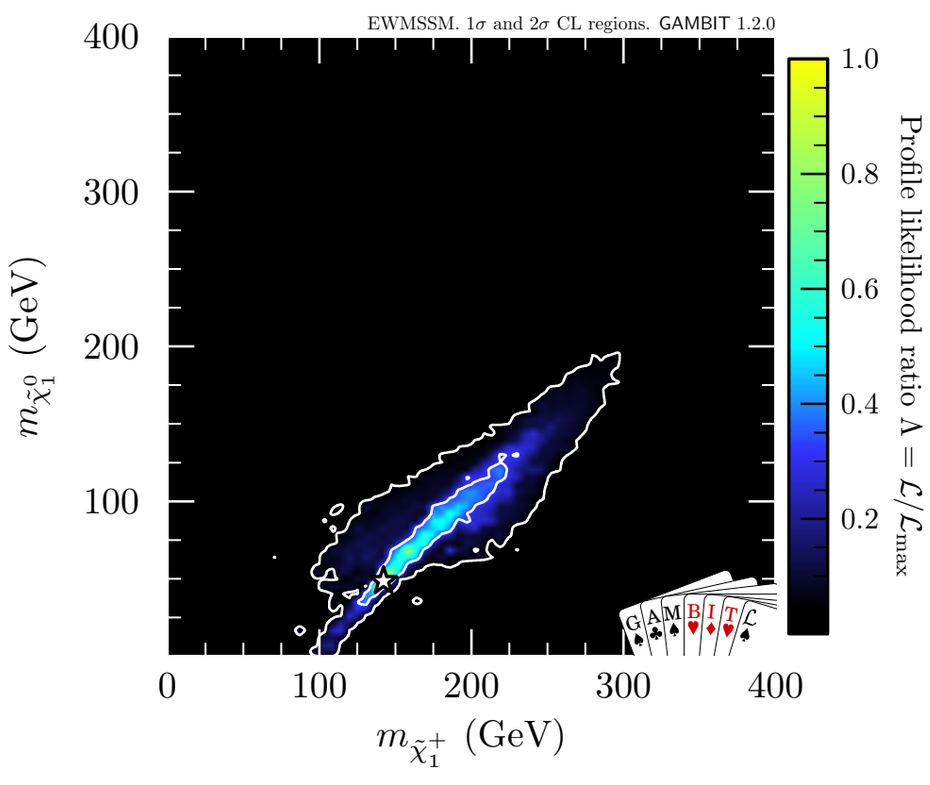
- $\tilde{t}_1$ co-annihilation
- A/H funnel
- $\tilde{\chi}_1^{\pm}$ co-annihilation
- $\tilde{b}_1$ co-annihilation
- h/Z funnel

MSSM-7 (arXiv:1705.07917)

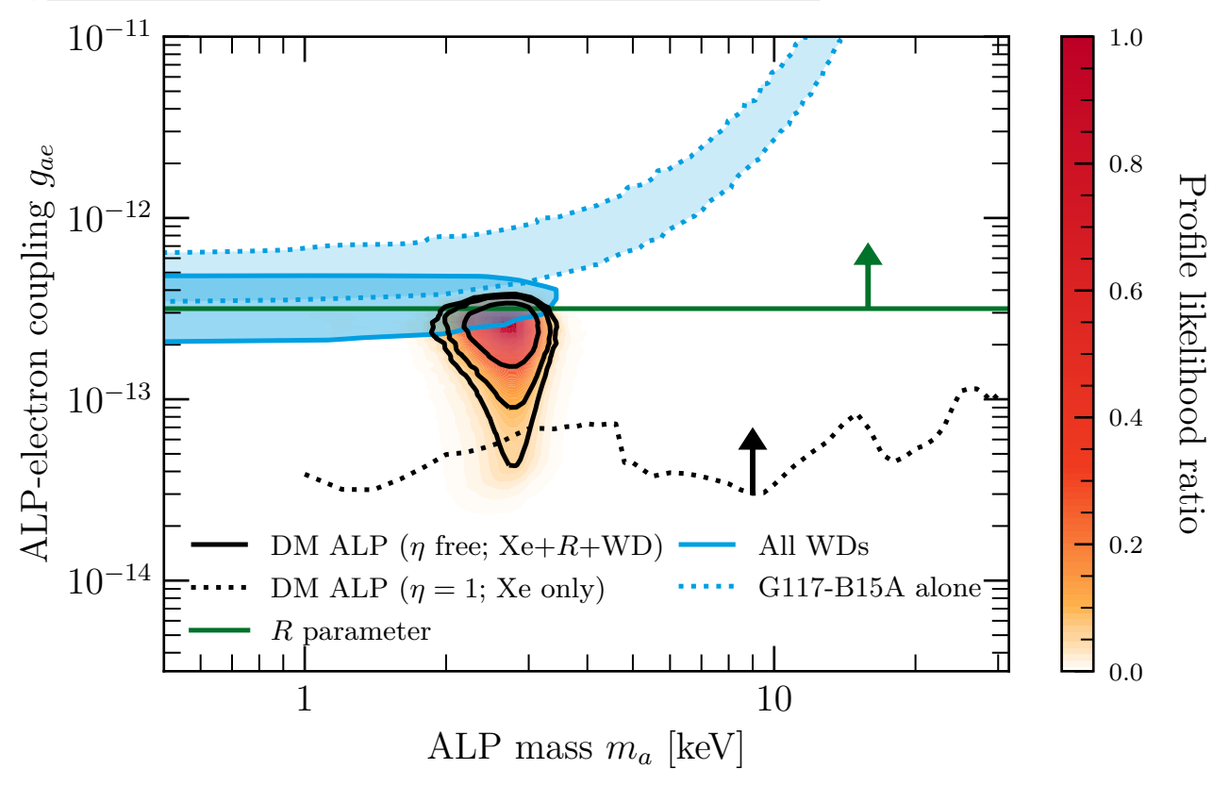




Light Electroweakinos and the LHC (arXiv:1809.02097)



ALPs and Xenon1T (arXiv:2007.05517)

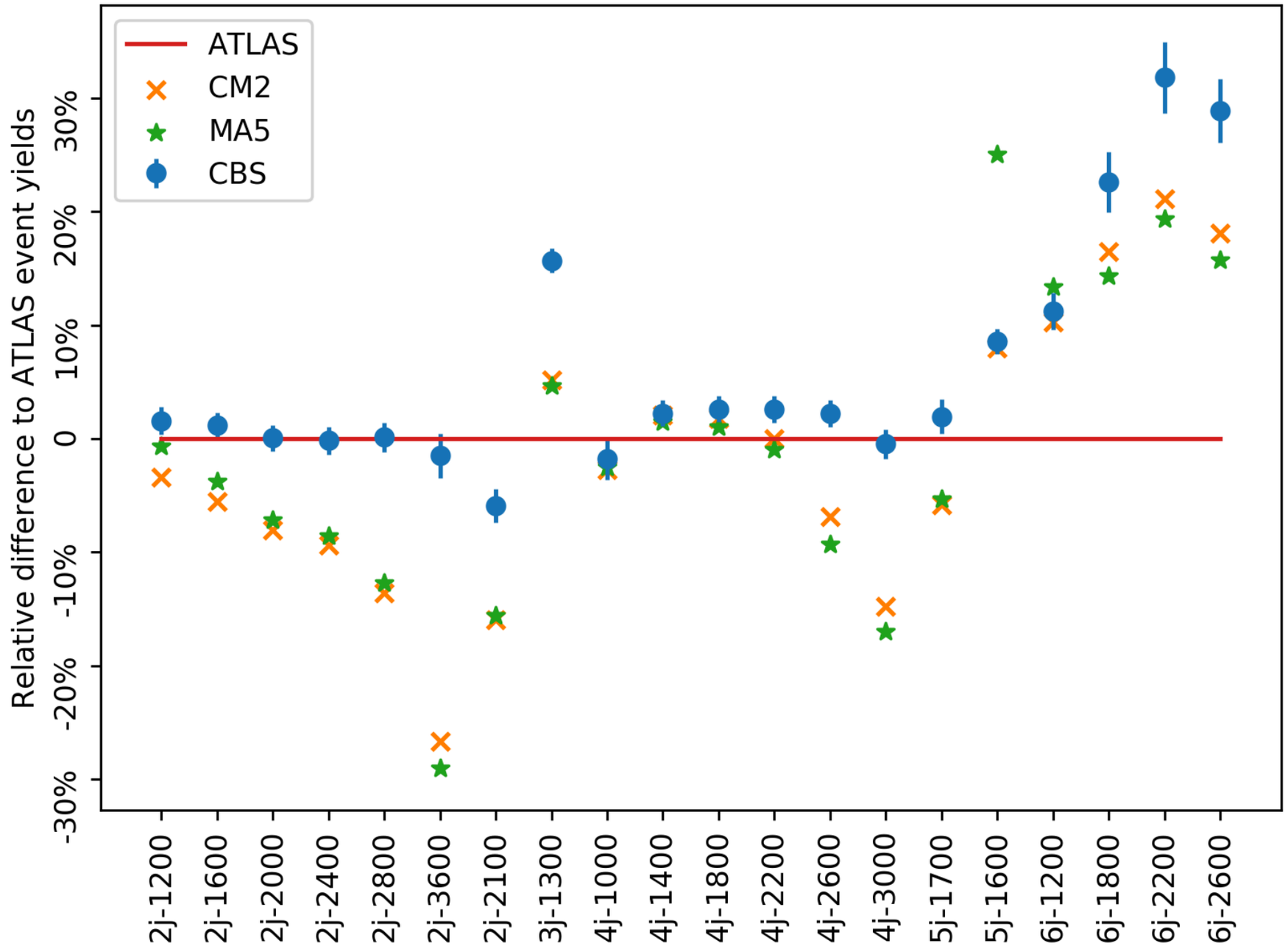


BSM Global Fit Challenges

- Larger parameter spaces become computationally difficult.
  - Machine learning?
  - Novel scanning algorithms?
- Occasional unclear or incomplete recast information. (See LHC Reinterpretation Forum Recommendations)
- Need to constantly update codes with latest experimental results for them to remain useful.
- Make code easier to use for the broader community outside our collaboration. (GUM will help)

Backups

arXiv:1712.02332 Yield Comparison



CM2 - CheckMate2, MA5 - MadAnalysis 5
CBS - ColliderBit Solo
(Courtesy of Yang Zhang)