Global fits: the key to identifying new particles

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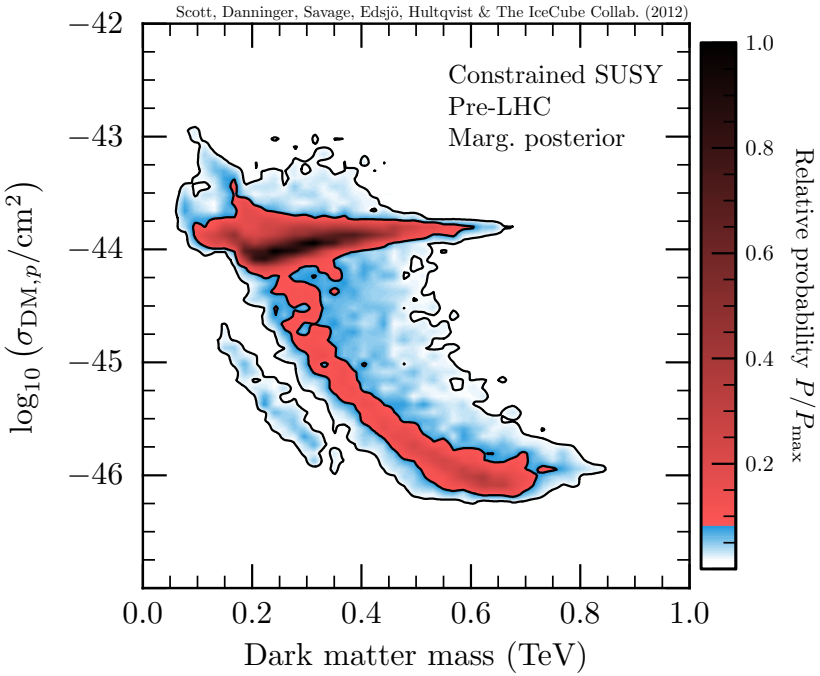

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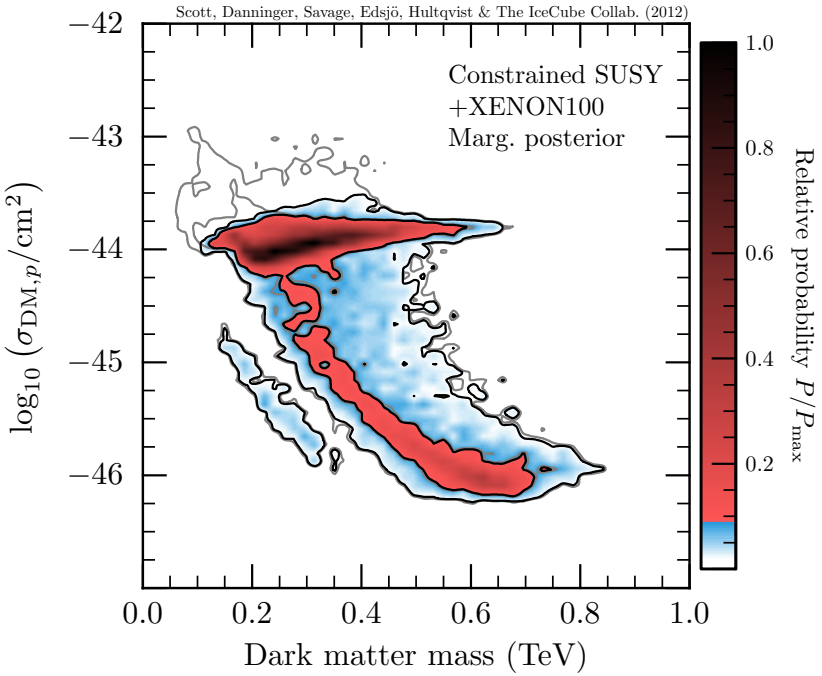

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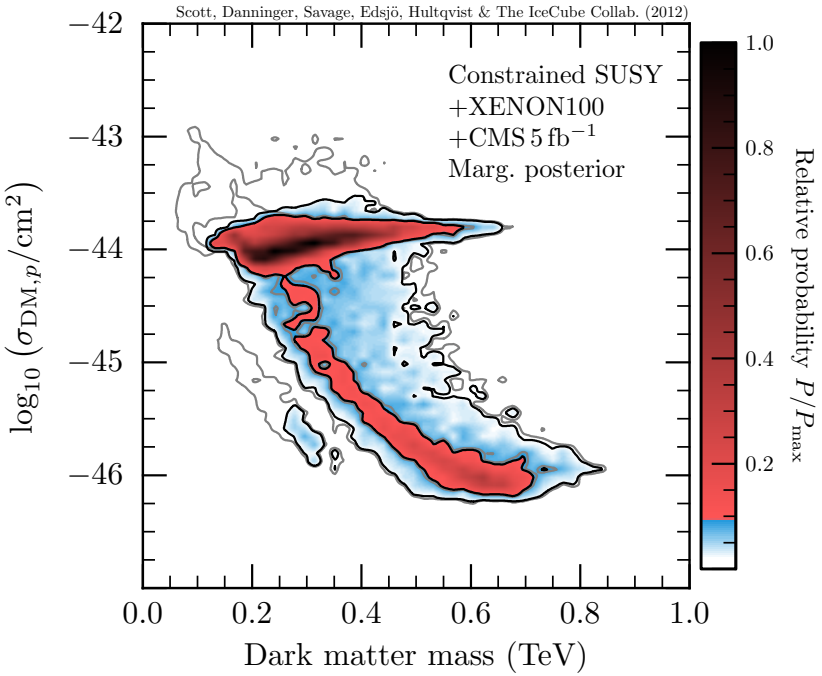

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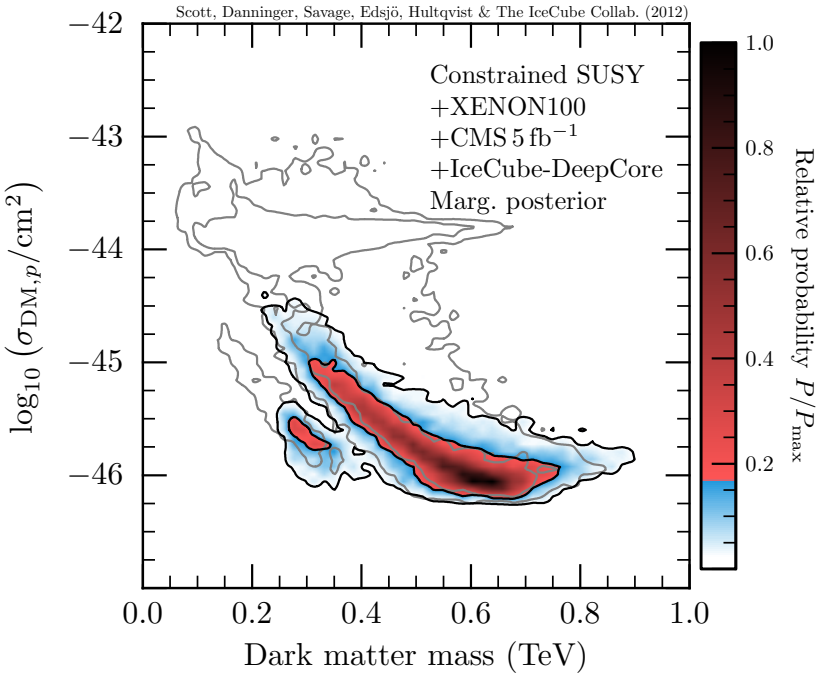

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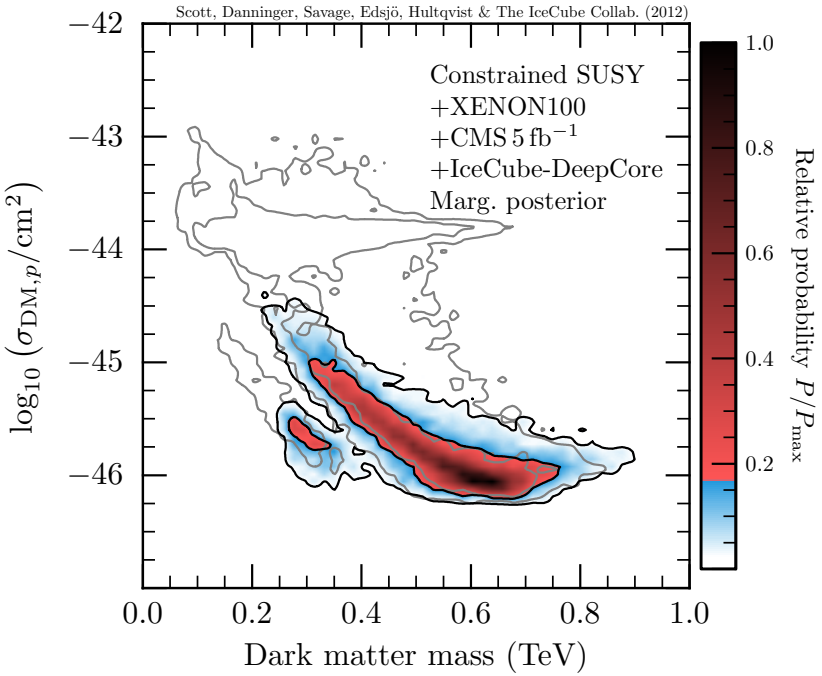

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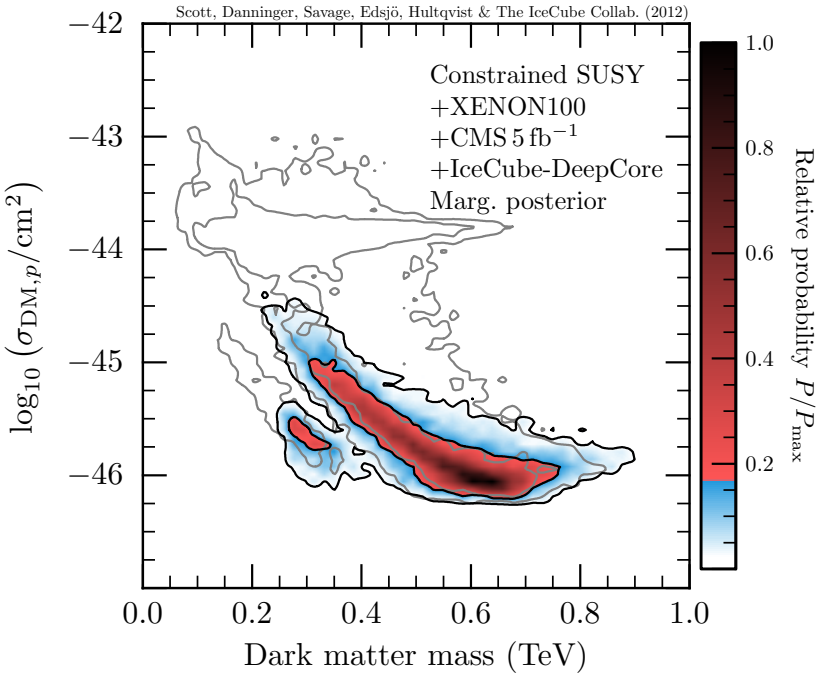

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This example is a gross simplification – the devil is in the detail.

Many talk about complementarity, far fewer walk the walk quantitatively → global BSM fits

My contributions to date

Global fits:

1. Inclusion of astroparticle experiments in global fits
   - first to include indirect searches for dark matter
   - the leading producer of astroparticle global fit likelihoods
2. Improvement of statistical and numerical methods in global fits
   - improved optimisation/search algorithms
   - investigated coverage properties

Related areas:

3. Cutting-edge gamma-ray indirect detection constraints (first Fermi dark matter paper, best Cherenkov Telescope Array predictions)
4. Developed *ultracompact minihalos* (of dark matter) as a research field
5. State-of-the art analysis of the scalar singlet dark matter model
6. Comprehensive work on impacts of dark matter on stellar structure and evolution
7. Comprehensive redetermination of the solar chemical composition
8. Proposed particle physics solutions to the solar abundance problem

Global fits in the current era

Lots of data flowing from LHC, direct and indirect dark matter detection experiments

$\rightarrow$ new "Implications of $\langle$*data X*$\rangle$ for supersymmetry" update every few months

Issues with current global fit codes:

- Strongly wedded to a few theories (e.g. constrained Minimal Supersymmetric Standard Model)
- Strongly wedded to a few theory calculators
- All datasets and observables basically hardcoded
- Rough or non-existent treatment of most experiments (astroparticle + collider especially)
- Sub-optimal statistical methods / search algorithms
- $\Longrightarrow$ *already hitting the wall on theories, data & computational methods*

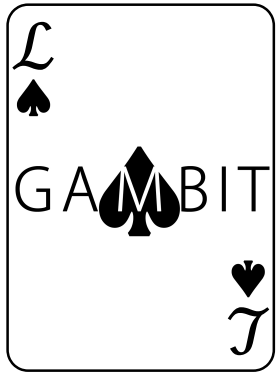
GAMBIT: a *second-generation* global fit code

GAMBIT: Global And Modular BSM Inference Tool

Overriding principles of GAMBIT: flexibility and modularity

- General enough to allow fast definition of new datasets and theoretical models
- Plug and play scanning, physics and likelihood packages
- Extensive model database – not just small modifications to simplest supersymmetric model!
- Extensive observable/data libraries (likelihood modules)
- Many statistical options – Bayesian/frequentist, likelihood definitions, scanning algorithms
- A smart and *fast* LHC likelihood calculator
- Massively parallel
- Full open-source code release

The GAMBIT Collaboration



22 Members, 13 Institutes
8 Experiments, 3 major theory codes

Fermi-LAT	J. Conrad, J. Edsjö, G. Martinez, P. Scott (leader)
CTA	C. Balázs, T. Bringmann, J. Conrad, M. White (dep. leader)
ATLAS	A. Buckley, P. Jackson, C. Rogan, A. Saavedra, M. White
IceCube	J. Edsjö, C. Savage, P. Scott
LHCb	N. Serra
HESS	J. Conrad
AMS-02	A. Putze
DARWIN	J. Conrad
Theory	C. Balázs, T. Bringmann, J. Cornell, L.-A. Dal, J. Edsjö, B. Farmer, A. Krislock, A. Kvellestad, F.N. Mahmoudi, A. Raklev, C. Savage, P. Scott, C. Weniger, M. White

Scientific outputs

The point is not just to write code – but to ***use*** it...

1. first comprehensive global analysis of supersymmetry
2. supersymmetric model comparison
3. non-supersymmetric theories: extra Higgs, extra dimensions, isospin-violating dark matter, etc

GAMBIT code will become the go-to package, and GAMBIT papers the go-to results, for combined interpretation of BSM physics searches in the future

Required Resources

From UU/TekNat:

- 1 $\times$ 3-year Postdoctoral fellow
- 1 $\times$ PhD student

Further postdocs and PhD students to be funded by applications to:

- Vetenskapsrådet
- K&A Wallenbergs Stiftelse (Wallenberg Academy Fellowship)

Summary of Pedagogical Experience

Teaching:

- *Numerical Methods in Physics* – 2011–13, grad/undergrad
  Created and lectured
- *The Very Early Universe* – 2013, grad
  Guest lecturer
- *Stellar Evolution* – 2011, undergrad
  Guest lecturer
- *Advanced Relativistic Quantum Field Theory* – 2009, grad
  Teaching assistant

Supervision:

- 4 PhD Students (2 complete)
- 4 Masters Students (all complete)
- 1 final-year undergrad student (complete)