Towards Next Generation Global Fits Including LHC Simulations

Abram Krislock

Oskar Klein Centre, Stockholm University

Partikeldagarna 2013

Outline

Motivation

... Why global fits?

A New Global Fit Framework

... Why have a new one??
... Okay, so what's GAMBIT?
... Who is working on GAMBIT?

LHC Simulation within a Global Fit

... Why not just use the limits?
... Are you nuts?!

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... Why global fits?

Standard Model *must* be incomplete

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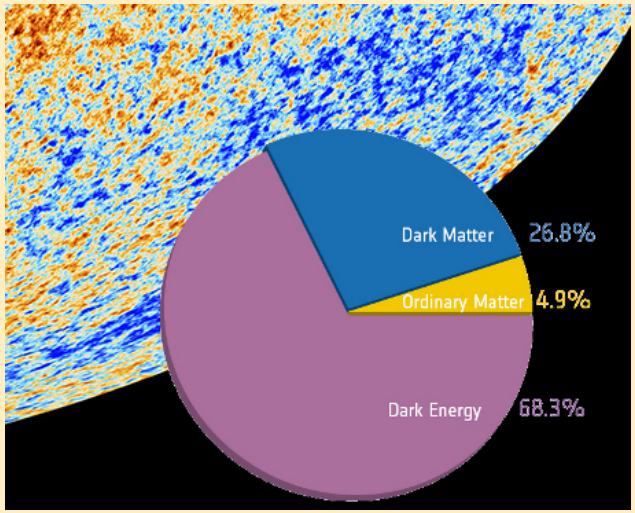

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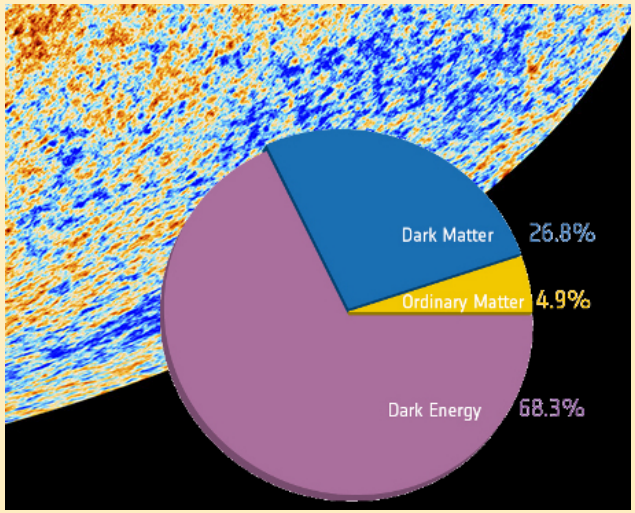

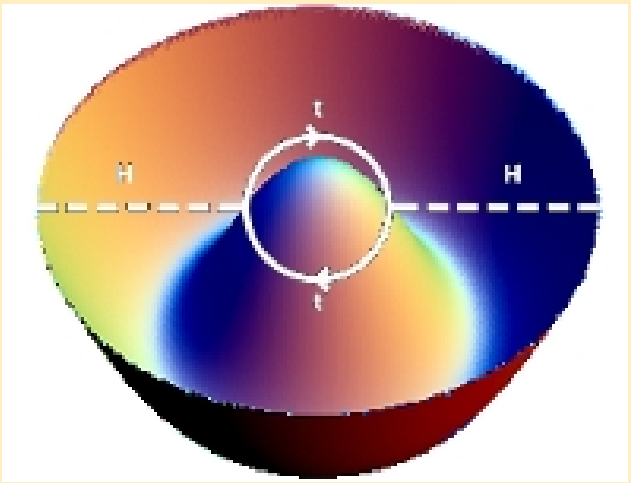

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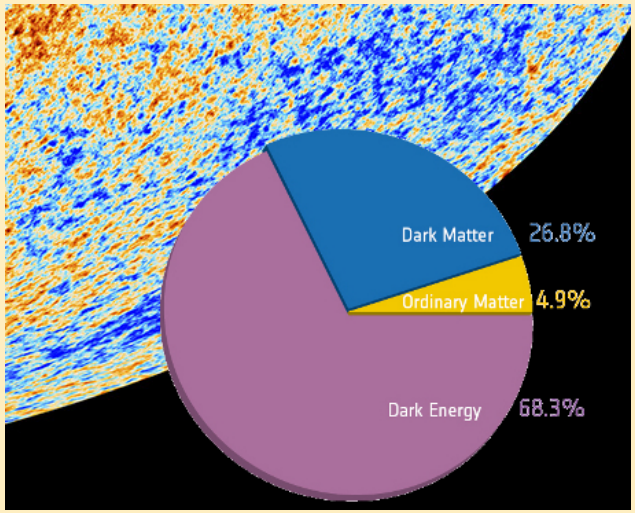

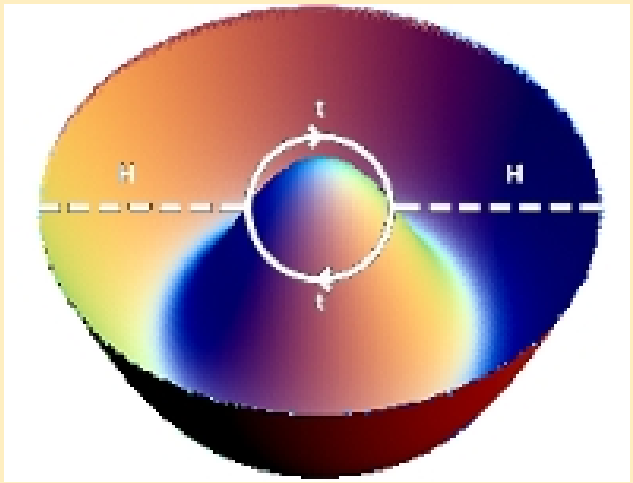

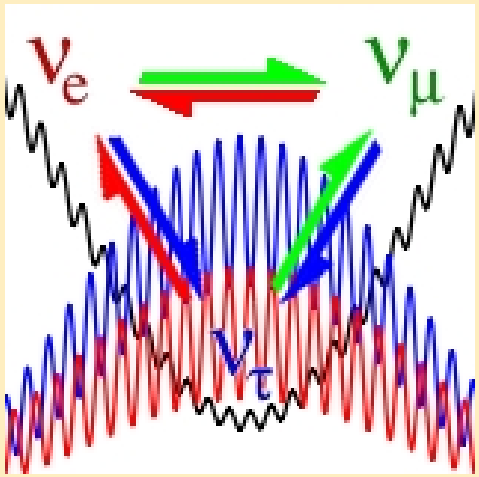

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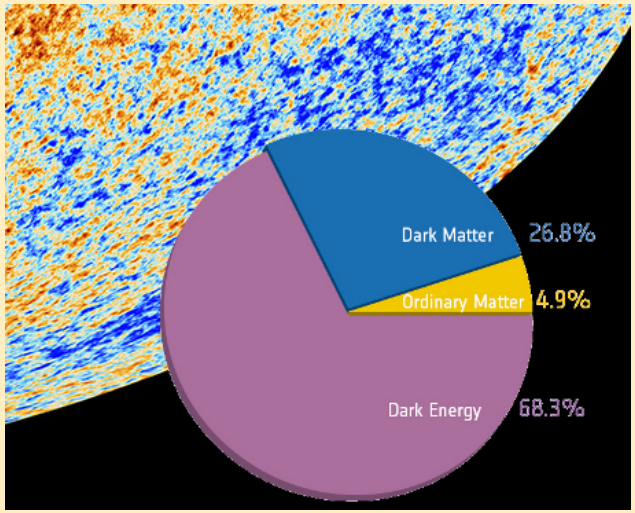

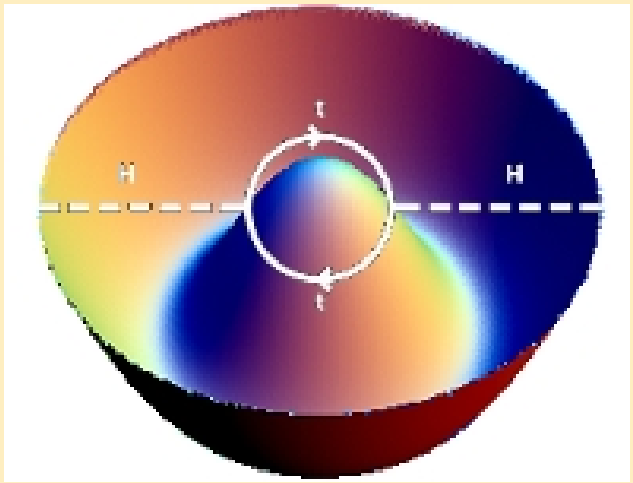

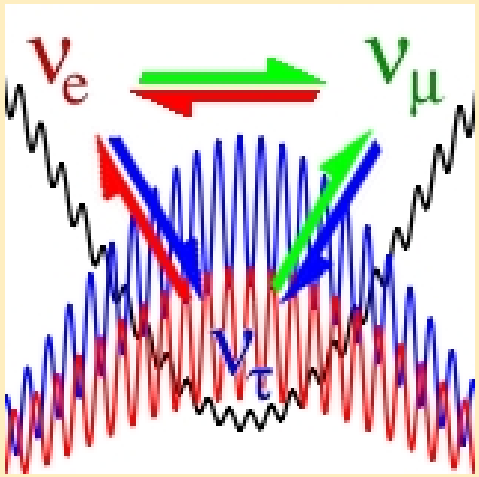

Beyond the Standard Model

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[ERROR : BSM not found!!]

Many experiments have set many limits on various BSM scenarios.

"Considering those limits, how does my model fare? Is it ruled out?"

Beyond the Standard Model

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Global Fits and Statistical Inferencing

Simple BSMs with very few parameters

- Overlap limits from different experimental searches
- Statistically combine limits: Composite Likelihood
- See “surviving parameter space”

Complicated BSMs with many parameters

Absolutely need *Global Fits*!!

- Smart scanning algorithms to scan huge parameter spaces!!
- Proper treatment of input uncertainties: Nuisance parameters!!
- Interpretation: Bayesian / Frequentist??
- Projection to interesting parameter planes.

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... Why have a new global fit framework??

Existing global fit frameworks have shortcomings:

SuperBayeS, Fittino, MasterCode, ...

- ¬ Restricted to either Bayesian or Frequentist interpretations
- ¬ Restricted to a particular model (SUSY)
- ¬ Restricted to a particular set of theory tools
- ¬ Sub-optimal scanning algorithms
- ¬ Only direct use or simple extrapolation of LHC and Astrophysics limits
- ¬ Sometimes a black box... Codes are not made public

Thus, we have started work on GAMBIT.

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... Okay, so what's GAMBIT?

Global And Modular BSM Inference Tool

Design principles of GAMBIT: Flexibility and Modularity

- Entire GAMBIT framework designed to be as easy as possible to add additional
  - Models
  - Experimental data sets and limits
  - Scanning algorithms
- Frequentist or Bayesian methods with customizable
  - Likelihoods
  - Priors
  - Nuisance parameters
- Intuitive interface connecting GAMBIT with external physics tools
- Plug'n'play swapping of physics tools, scanners, and likelihoods
- Open source release

$$\mathcal{L}_{\text{GAMBIT}} = \mathcal{L}^{\text{DM}}_{\text{Direct}} \times \mathcal{L}^{\text{DM}}_{\text{Indirect}} \times \mathcal{L}^{\text{DM}}_{\text{Relic}\Omega} \times \mathcal{L}_{\text{LHC}} \times \mathcal{L}_{\text{Flavor}} \times \mathcal{L}_{\text{Higgs}} \cdots$$

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... Who is working on GAMBIT?

22 Members from 13 Institutes:

The GAMBIT Collaboration

C. Balázs, T. Bringmann, A. Buckley, J. Conrad, J. Cornell, L. A. Dal, J. Edsjö, B. Farmer, P. Jackson, A. Krislock, A. Kvellestad, F. N. Mahmoudi, G. Martinez, A. Putze, A. Raklev, C. Rogan, A. Saavedra C. Savage, P. Scott, N. Serra, C. Weniger, M. White

8 Experiments:

Fermi-LAT, IceCube, ATLAS, LHCb, HESS, AMS-02, CTA, DARWIN

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... Why not just use the limits?

ATLAS and CMS SUSY searches

- CMSSM / mSUGRA limits
- Simplified Model limits

Can the limits really apply...? Generally not!!

- ¬ nuSUGRA, other ~~SUSY~~ schemes
- ¬ PMSSM
- ¬ BSM, not SUSY, but SUSY-like signals

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Simulation Required

To perform a global fit of a particular model...

Monte Carlo LHC Simulation Chain

... For each and every point within your likelihood scan.

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$\{\sigma_{\text{prod}},\ \mathcal{B}\}_{\text{processes}}$

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PROSPINO
VBFNLO
etc.

SPheno
MadGraph 5
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Delphes 3
PGS4
etc.
↓
{Analyses}

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... Are you nuts?!

Yes.

... Are you nuts?!

Yes.

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... But not so nuts: Speed Tricks

How to get more speed?

Monte Carlo LHC Simulation Chain

$$\{\sigma_{\text{prod}},\ \mathcal{B}\}_{\text{processes}}$$

↓

Parallelized
Collision Events
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How to get more speed?

- Speed up σ_{prod} calculation

Monte Carlo LHC Simulation Chain

LO σ_{prod} conservative $\Leftarrow$ $\{\sigma_{\text{prod}},\ \mathcal{B}\}_{\text{processes}}$ $\Rightarrow$ Neural Network Fast NLO σ_{prod}

$\downarrow$

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↙		↓		↘
Parallelized		**Parallelized**		**Parallelized**
Collision Events		**Collision Events**		**Collision Events**
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ISR & FSR		**ISR & FSR**		**ISR & FSR**
↓		↓		↓
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- Turn off parts of Monte Carlo, then tune analyses

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Parallelized Collision Events		**Parallelized Collision Events**		**Parallelized Collision Events**
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~~ISR & FSR~~		~~ISR & FSR~~		~~ISR & FSR~~
↓		↓		↓
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↓		↓		↓
~~Detector Sim~~		~~Detector Sim~~		~~Detector Sim~~
Perform Analyses		Perform Analyses		Perform Analyses

Each trick reduces time for $\mathcal{L}_{\text{LHC}}$.

Summary

- GAMBIT is coming!
- Flexibility & Modularity
- Open Source & Customizability
- Smart & Fast LHC Simulations
  - Speedy σ_{prod} calculations
  - Process dependent parallelization
  - Simplified Monte Carlo

PMSSM-25

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