GAMBIT

C Balázs
on behalf of the
GAMBIT
Collaboration

MONASH University
ANCORA IMPARO

Australian Government
Australian Research Council

CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

ATLAS and CMS showed hints of a resonance at 750 GeV.

In six months hundreds of explanations followed.

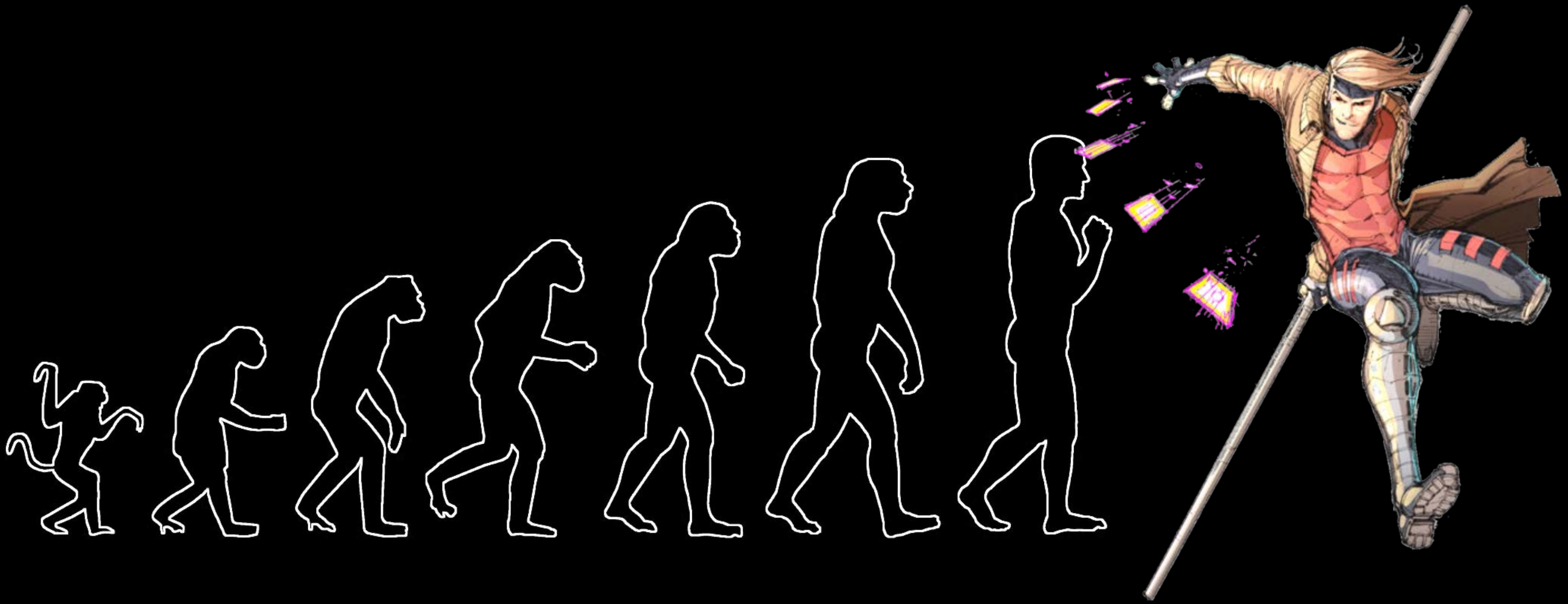
At most one of the proposed models may be correct.

No one knows which one.

Nobody knows how feasible the proposed theories are.

We need a robust tool to assess model plausibility.

GAMBIT



The Global and Modular BSM Inference Tool

Outline

What is GAMBIT?

What does GAMBIT do?

What is inside GAMBIT?

What governs GAMBIT?

What… ever?

What is GAMBIT?

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gambit

/ˈgambɪt/

noun

1. an act or remark that is calculated to gain an advantage, especially at the outset of a situation.
   "his resignation was a tactical gambit"
   synonyms: stratagem, machination, scheme, plan, tactic, manoeuvre, move, course of action, line of action, device, operation; More

2. (in chess) an opening move in which a player makes a sacrifice, typically of a pawn, for the sake of a compensating advantage.
   "he tried the dubious Budapest gambit"

3. a fictional Marvel Comics character who has the superpower to control kinetic-potential energy and extremely skilled in card-throwing and the use of a staff.
   "woo Gambit done his mamma proud"

4. Global And Modular BSM Inference Tool: the global analysis engine for statis
   hypothesis assessment
   "this is GAMBIT - all resistance is futile"

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GAMBIT collaboration

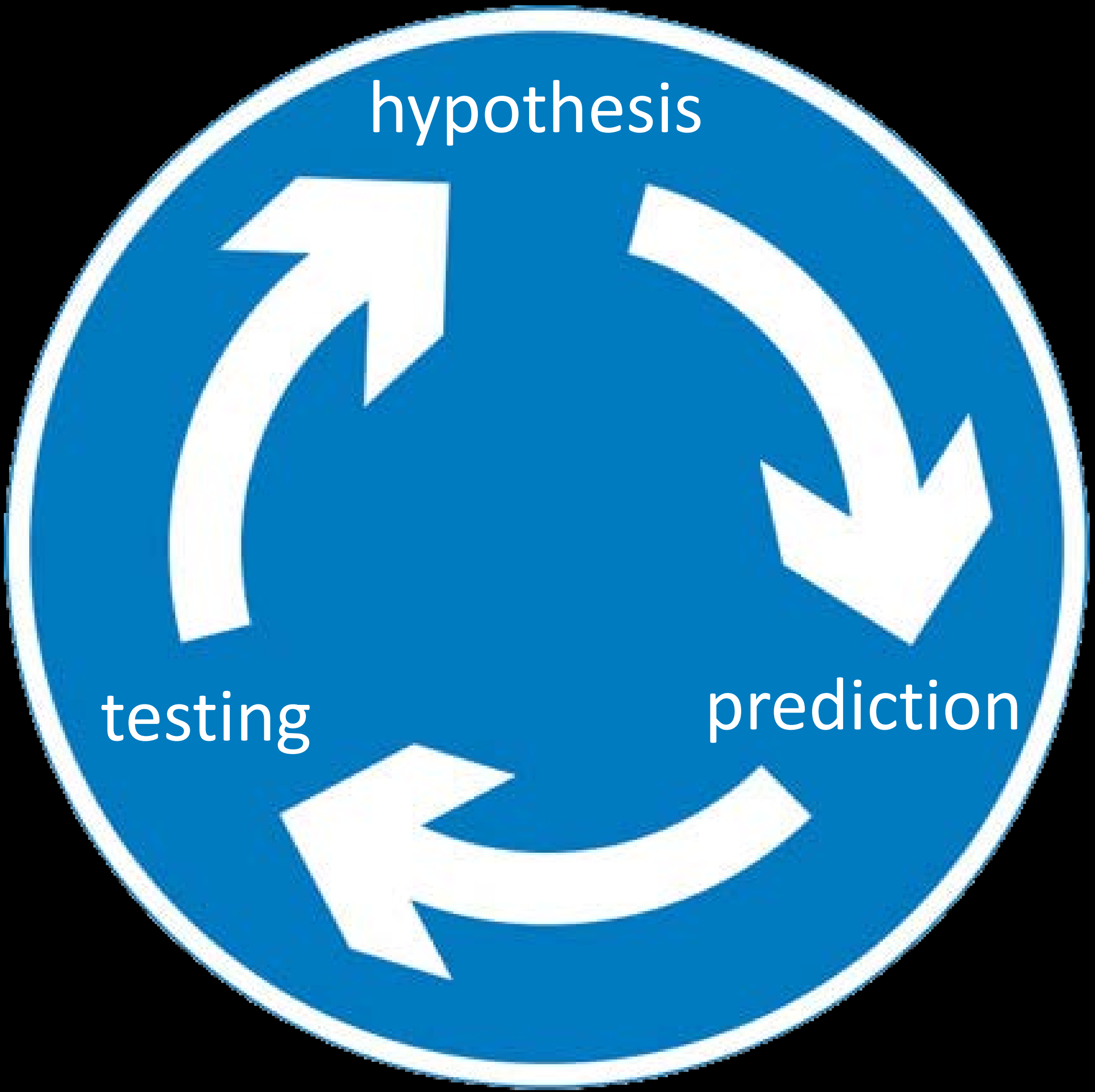
P. Athron, C. Balázs, T. Bringmann, A. Buckley, M. Chrzaszcz, J. Conrad, J. Cornell, J. Edsjö, B. Farmer, A. Fowlie, T. Gonzalo, S. Hoof, L. Hsu, P. Jackson, F. Kahlhoefer, A. Krislock, A. Kvellestad, F. Mahmoudi, G. Martinez, J. McKay, M. Pato, A. Putze, A. Raklev, C. Rogan, R. Ruiz, P. Scott, N. Serra,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

DarkSUSY, FlexibleSUSY, SoftSUSY, (SuperBayes), SuperISO, … & AMS-02, ATLAS, CDMS, CMS, CTA, DARWIN, DM-ICE, Fermi-LAT, HESS, IceCube, LHCb, XENON

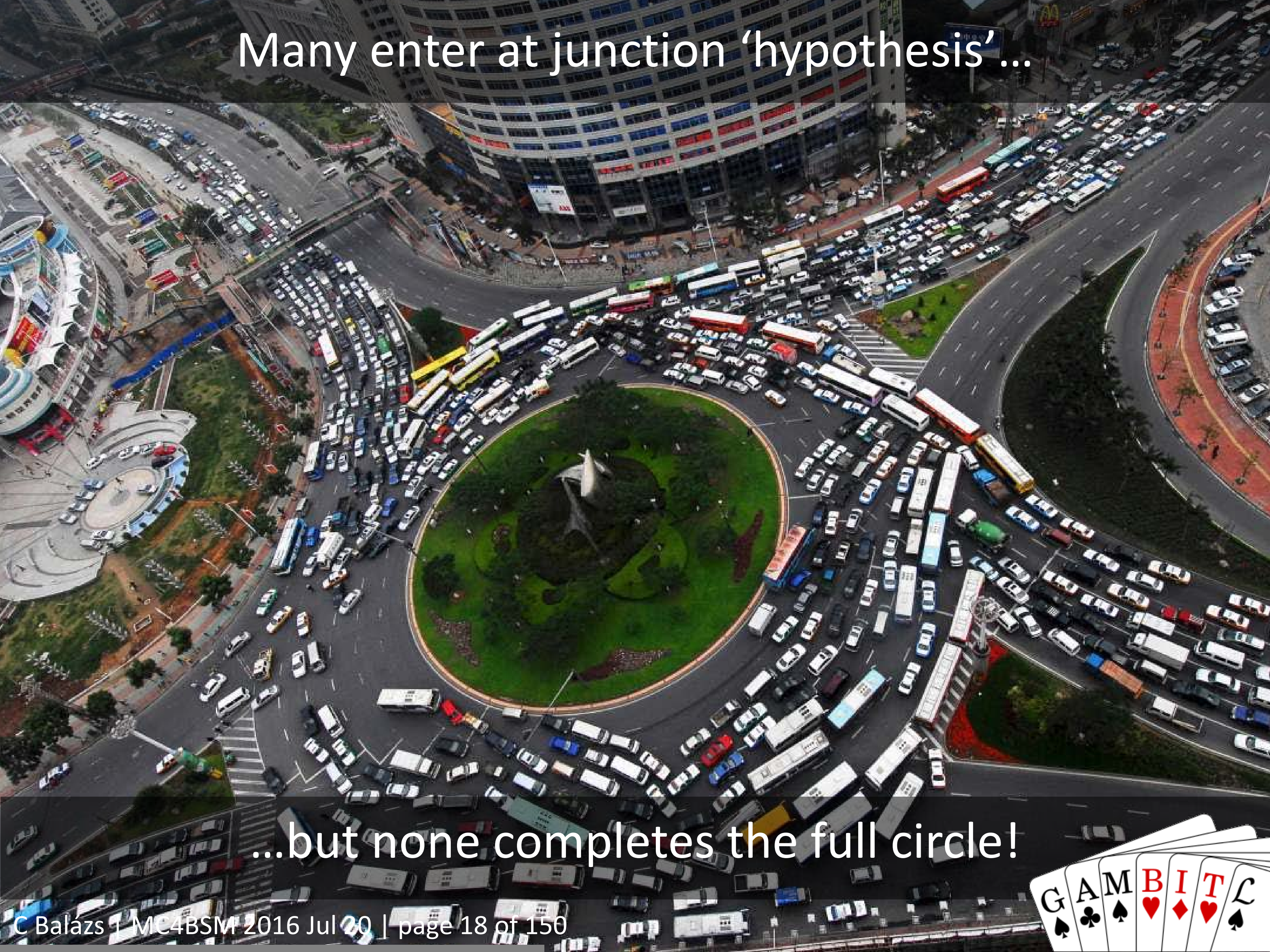
What does GAMBIT do?

The scientific method

The scientific method (simplified)

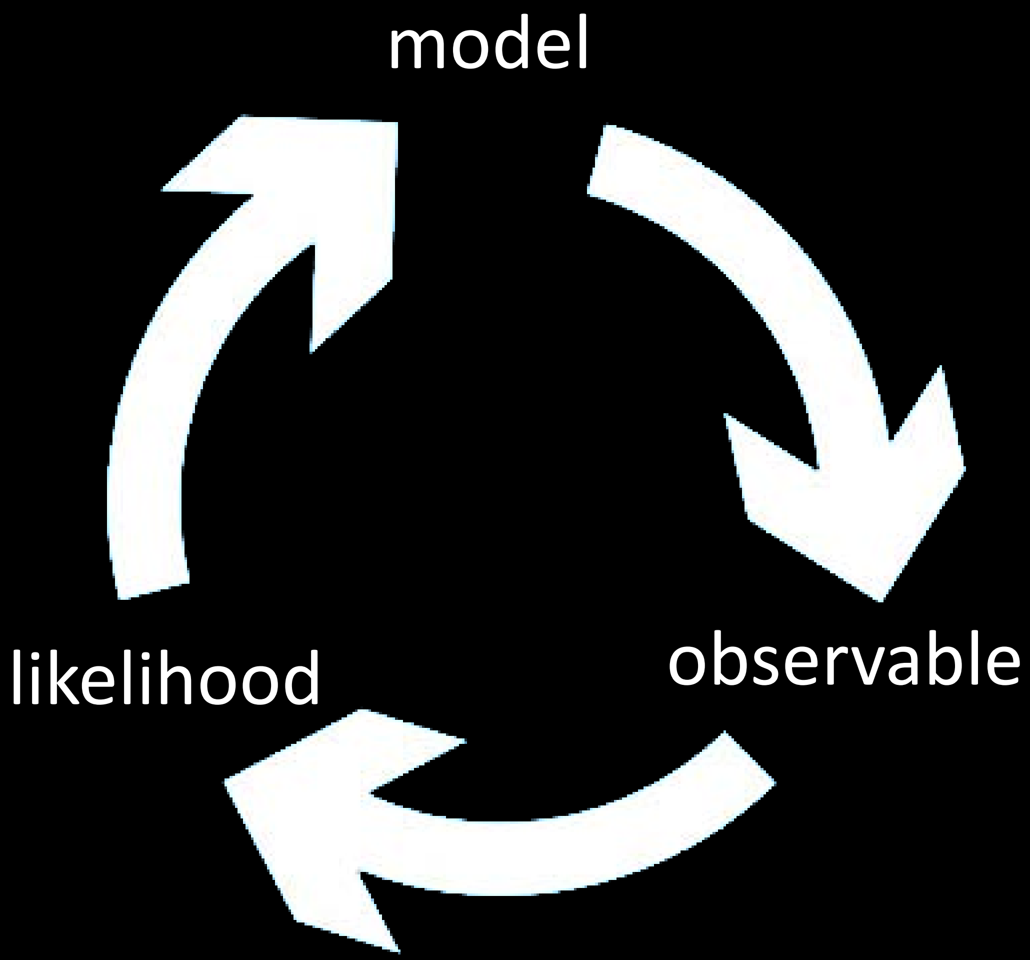


Many enter at junction ‘hypothesis’…



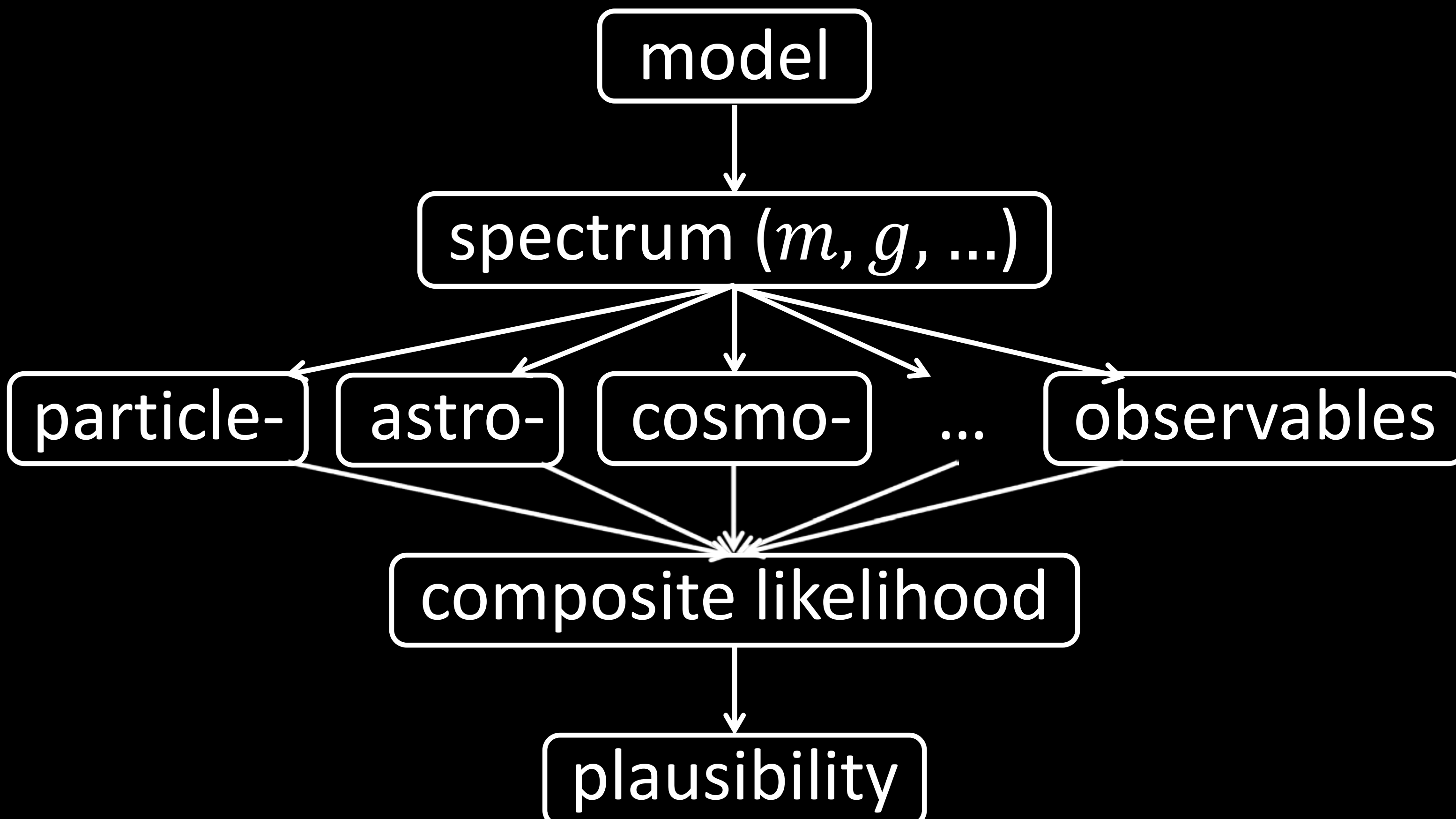
…but none completes the full circle!

GAMBIT
(simplified)

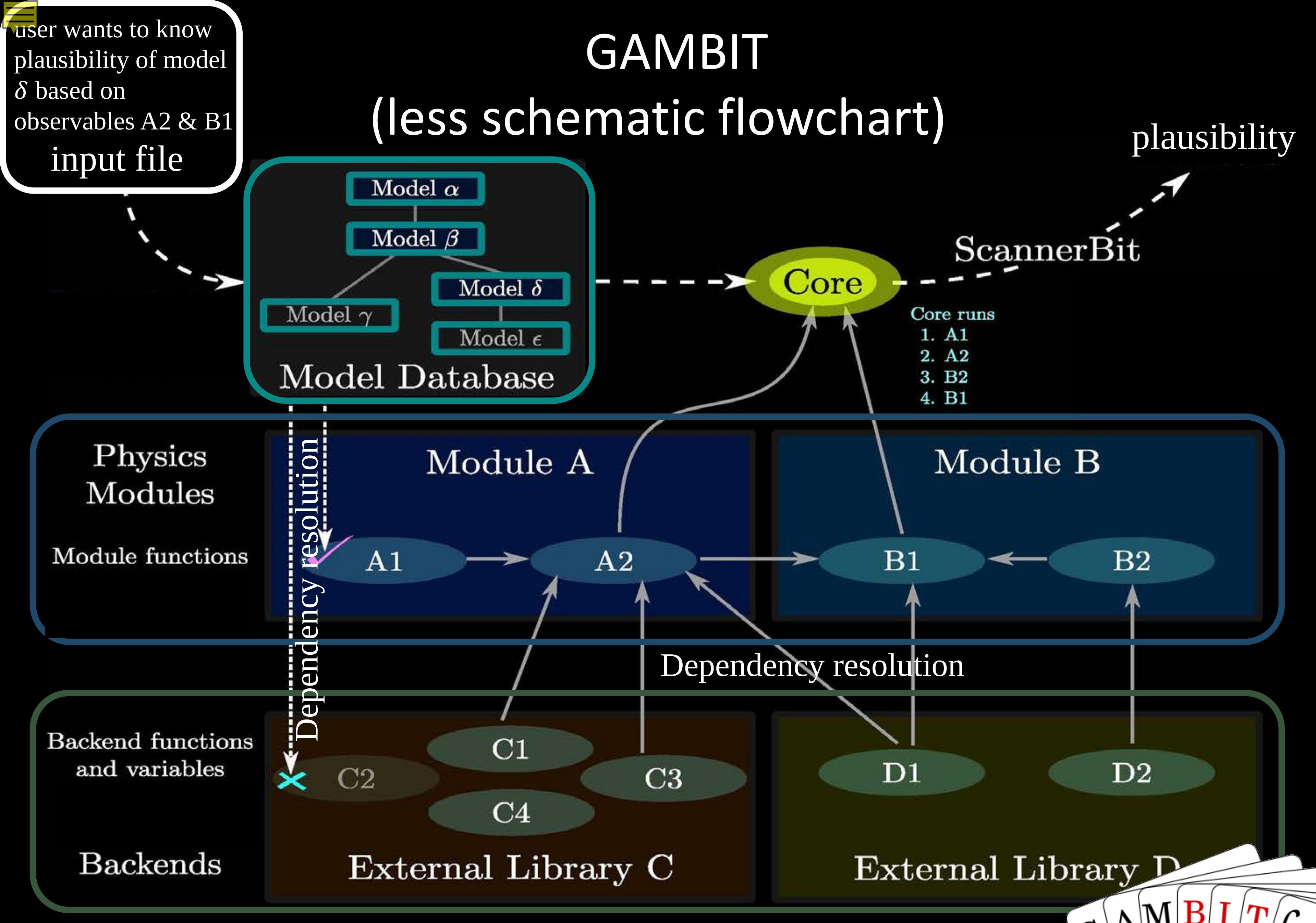


What’s inside GAMBIT?

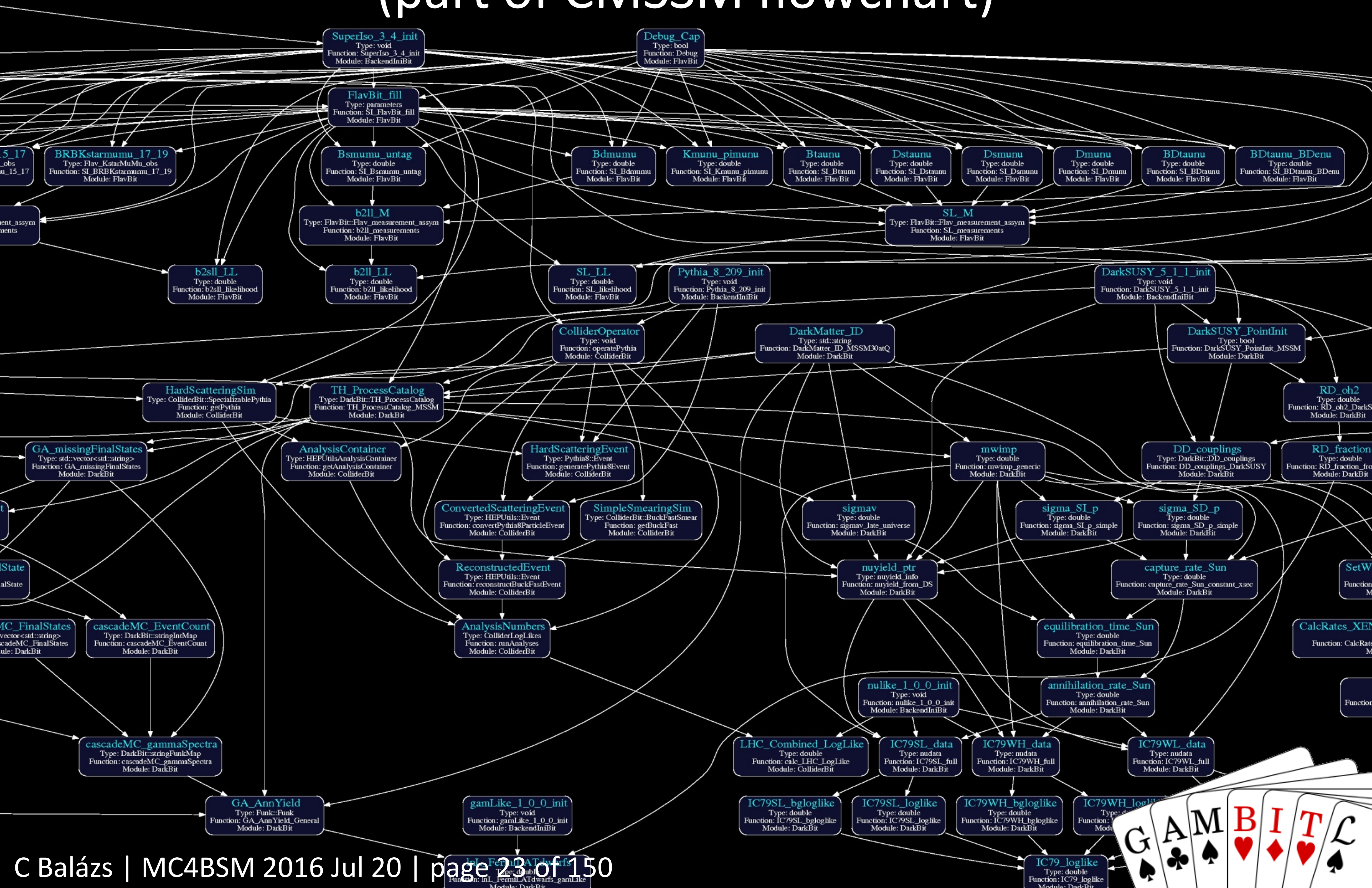
GAMBIT
(very schematic flowchart)



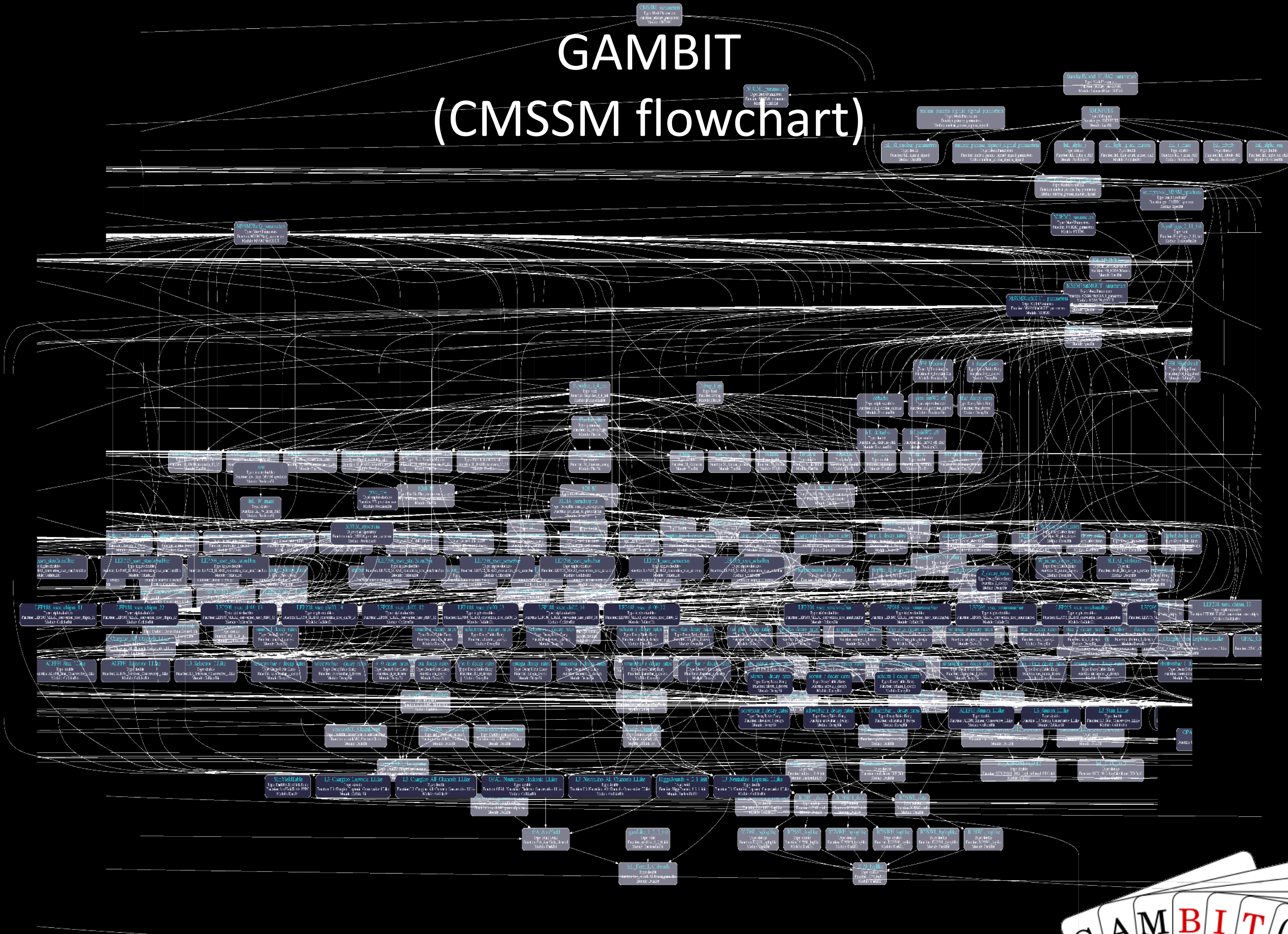
GAMBIT
(less schematic flowchart)



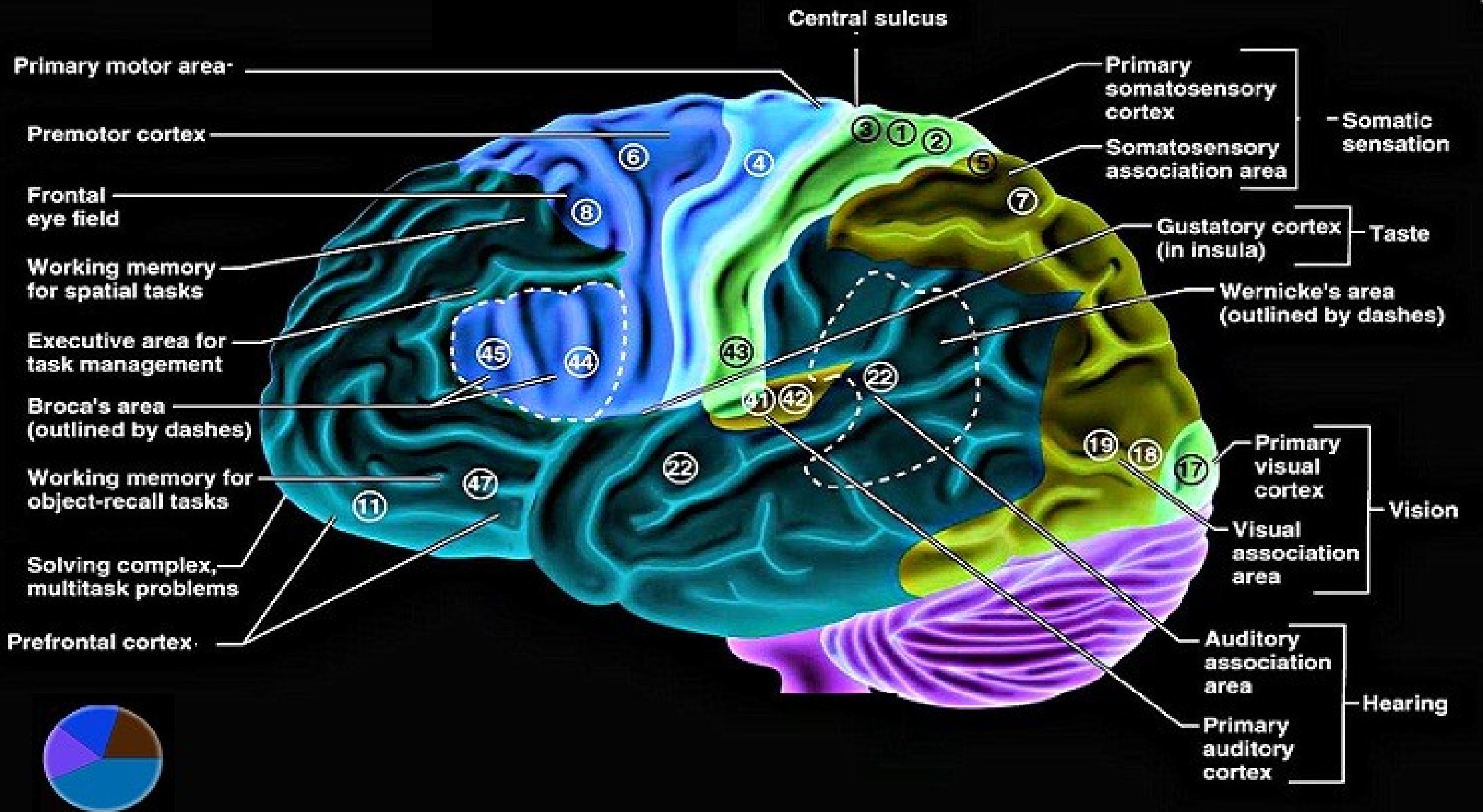
GAMBIT
(part of CMSSM flowchart)



GAMBIT
(CMSSM flowchart)



brain chart



Central sulcus
Primary motor area
Premotor cortex
Frontal eye field
Working memory for spatial tasks
Executive area for task management
Broca's area (outlined by dashes)
Working memory for object-recall tasks
Solving complex, multitask problems
Prefrontal cortex
Primary somatosensory cortex
Somatosensory association area
Somatic sensation
Gustatory cortex (in insula)
Taste
Wernicke's area (outlined by dashes)
Primary visual cortex
Visual association area
Vision
Auditory association area
Primary auditory cortex
Hearing
3
1
2
5
7
6
4
8
45
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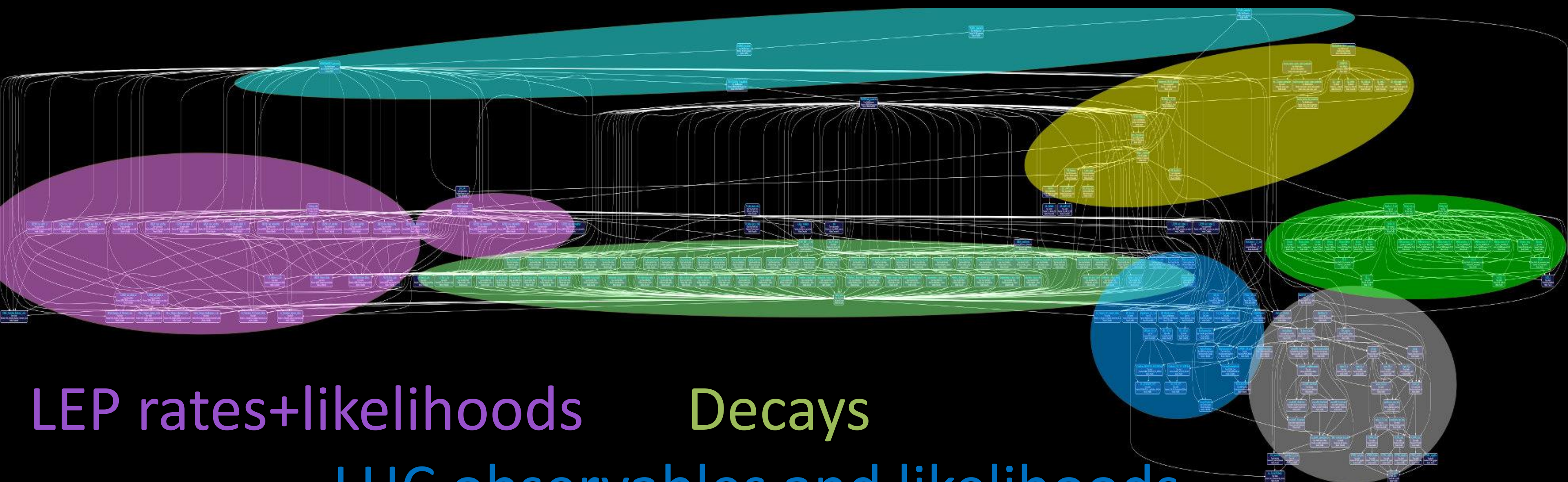
GAMBIT dependency chart

Model parameter translations Precision calculations



LEP rates+likelihoods Decays

LHC observables and likelihoods

DM direct, indirect and relic density

Flavour physics observables

What governs GAMBIT?

GAMBIT principles
No more hard coded interfacing!

- global, modular, flexible
- model database: SM, SUSY, nucl., astro- & beyond!
- comprehensive observable (data+likelihood) libraries
- general, fast definition of new models and datasets
- plug&play observable, likelihood calculators, scanners
- many statistical options (Bayesian, freq., sampling)
- massively parallel execution on a laptop or on a supercomputer
- open-source, maintained, developed code

GAMBIT modularity
No more hard coded interfacing!

- auto downloading, configuring, compiling backends
- dynamic loading of C++ classes from backends
- automatic dependency resolution
- mix and match backend selection
- all-in or module standalone modes
- mixed mode (MPI+openMP), multi-level, mostly automated parallelization
- diskless generalisation of Les Houches Accords
- flexible output streams: ASCII, databases, HDF5, …
- all-in or module standalone modes

GAMBIT modularity
No more hard coded interfacing!

GAMBIT language: C++ syntax, GAMBIT instructions

```
#define MODULE FlavBit
START_MODULE

  #define CAPABILITY Kmunu_pimunu                 // Observable: BR(K->mu nu)/BR(pi->mu nu)
  START_CAPABILITY
    #define FUNCTION SI_Kmunu_pimunu              // Name of specific function providing the observable
    START_FUNCTION(double)                        // Function calculates a double precision variable
      DEPENDENCY(FlavBit_fill, parameters)        // Needs some other function to caluclate FlavBit_fill data
      BACKEND_REQ(Kmunu_pimunu, (libsuperiso), double, (struct parameters*)) // Needs a function from a backend
      BACKEND_OPTION( (SuperIso, 3.4), (libsuperiso) )                       // Backend must be SuperIso v3.4
      ALLOW_MODELS(MSSM78atQ, MSSM78atMGUT)       // Can be used with GUT-scale or other-scale MSSM-78, and all their children
    #undef FUNCTION
  #undef CAPABILITY
```

- define a new capability (e.g. calc. observable)
- declare: dependencies
  backend requirements
  allowed models
- more advanced declarations available

Model database

- model hierarchy: models are defined by their parameters and relations to each other
- models can inherit from parent models
- points in child models can be automatically translated to ancestor models
- friend models also allowed (cross family translation)
- model dependence of every module/backend function is tracked (safety)

Models presently available in GAMBIT

SM+S
MSSM (up to 63 parameters)
various astro- models (e.g. DM distr.)

Coming soon:
SM+X
MSSM+S
non-SUSY models
cosmology models
and more…

Modules presently available in GAMBIT

- SpecBIT: generic interface to spectrum generator[generator]s (BSM spectrum object, RGE running, …)
- DecayBIT: SM+MSM decay table (total widths, BFs, …)
- ColliderBIT: LEP, LHC (ATLAS/CMS H+SUSY) cross sections, limits by MC event generation + fast sim (custom, OpenMP parallelised Pythia 8; 10^5 events on 8 cores in seconds)
- DarkBIT: DM obs. (abundance, (in)direct detection, helioseismology, CMB), LUX & IceCube $\mathcal{L}$

Modules presently available in GAMBIT

- FlavorBIT: flavor obs., uncert.s, LHCb $\mathcal{L}$
- PrecisionBIT: EWPOs ($g-2, sin^2\theta, m_W, \ldots$)
- ScannerBIT: MultiNest (nested samp.), Diver (diff. evolution), twalk (population MC), GreAT (MCMC)
- statistics: evidence, posterior probability, profile likelihood (planned: full Neyman)
- BITs can run as a standalone or in a full GAMBIT run
- more to come: astro-, cosmo-, … modules

ColliderBIT overview

- calculate limits by MC event generation + fast sim
  likelihood: inline systematic error marginalization via nulike
- cross sections supplied by MC generator backend
  planned: generic user supplied cross section option (now: NLO for SUSY, LO+LL others)
- add matrix elements using Madgraph/Pythia interface
  planned: interface ColliderBit to general matrix element calculators (e.g. Madgraph)
- custom, OpenMP parallelised Pythia 8 backended
  10^5 events on 8 cores in seconds
- Delphes, BuckFast backended
  thread-safe, fast detector simulation based on 4-vector smearing (matches Delphes well)
- custom event analysis framework
  “simulation blind” (event info from any source), uses HepUtils event, jet, particle classes
- LHC 8 TeV limits implemented
  implemented: ATLAS SUSY searches, CMS multilepton SUSY search, CMS DM searches
  easy to add custom analyses

DarkBIT overview

- abundance: relic density for general models
  MicrOmegas interface
  DarkSUSY interface: abstract the calculation
  i.e. feed in partial annihilation rates, coannihilations, resonances

- direct detection: limits from detector event numbers
- arbitrary direct detection couplings
  full q and v dependence of the cross section is kept

- indirect detection: arbitrary decay/annihilation fractions
- simulating decays “on the fly”

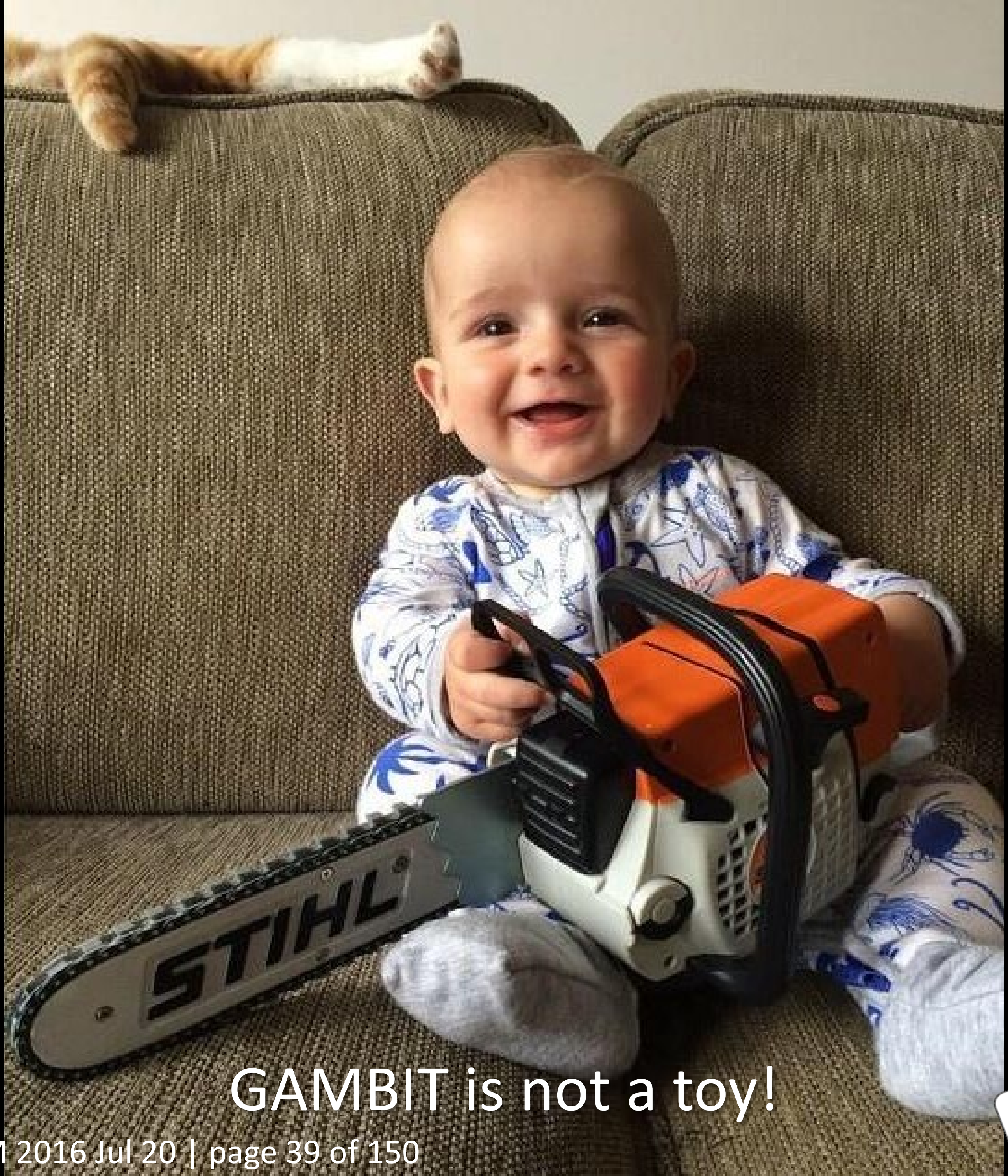
Backends presently available in GAMBIT

(BuckFast)
DDCALC
DarkSUSY
Delphes
FeynHiggs
FlexibleSUSY
gamLike
gm2Calc
HiggsBounds

HiggsSignals
micrOMEGAS
nuLike
PYTHIA
SUSYPope
SUSYHit
(Hdecay & SDecay)
SuperISO

planned: FeynRules, Madgraph, …

What is GAMBIT… not?



GAMBIT is not a toy!

GAMBIT is not…

…a toy

…the magic tool that calculates everything (yet)

…a universal observable calculator (yet)

…a tool that connects a Lagrangian to a likelihood (yet)

…not a replacement for your graduate student (yet)

GAMBIT release schedule

- 2016 Q3
  - final bug hunting
    - validation runs: SM+S & up to MSSM19
- 2016 Q4
  - publication of the GAMBIT “manual”
    - 6 papers (core, 4 major modules, scanner)
  - GAMBIT 1.0.0 goes public
    - codename 8@|)@$$
  - first GAMBIT physics papers:
    - SM+S, “CMSSM”s, MSSMnn, Sampling
- 2017 Q1
  - GAMBIT the movie released*

* “Fox still has the *X-Men* spin-off penciled in for an October 2016 release, but I wouldn’t count on it staying that way. An early 2017 release seems more likely at this time, perhaps even in February ala *Deadpool* this year.”

Summary

GAMBIT is like a conductor
assembling musicians into a coherent orchestra.

So far you wrote songs for individual instruments.

With GAMBIT you can start composing symphonies.