

# HEPMDB

## High Energy Physics Model Database

**Alexander Belyaev**

**Southampton University & Rutherford Appleton LAB**



Durham, IPPP

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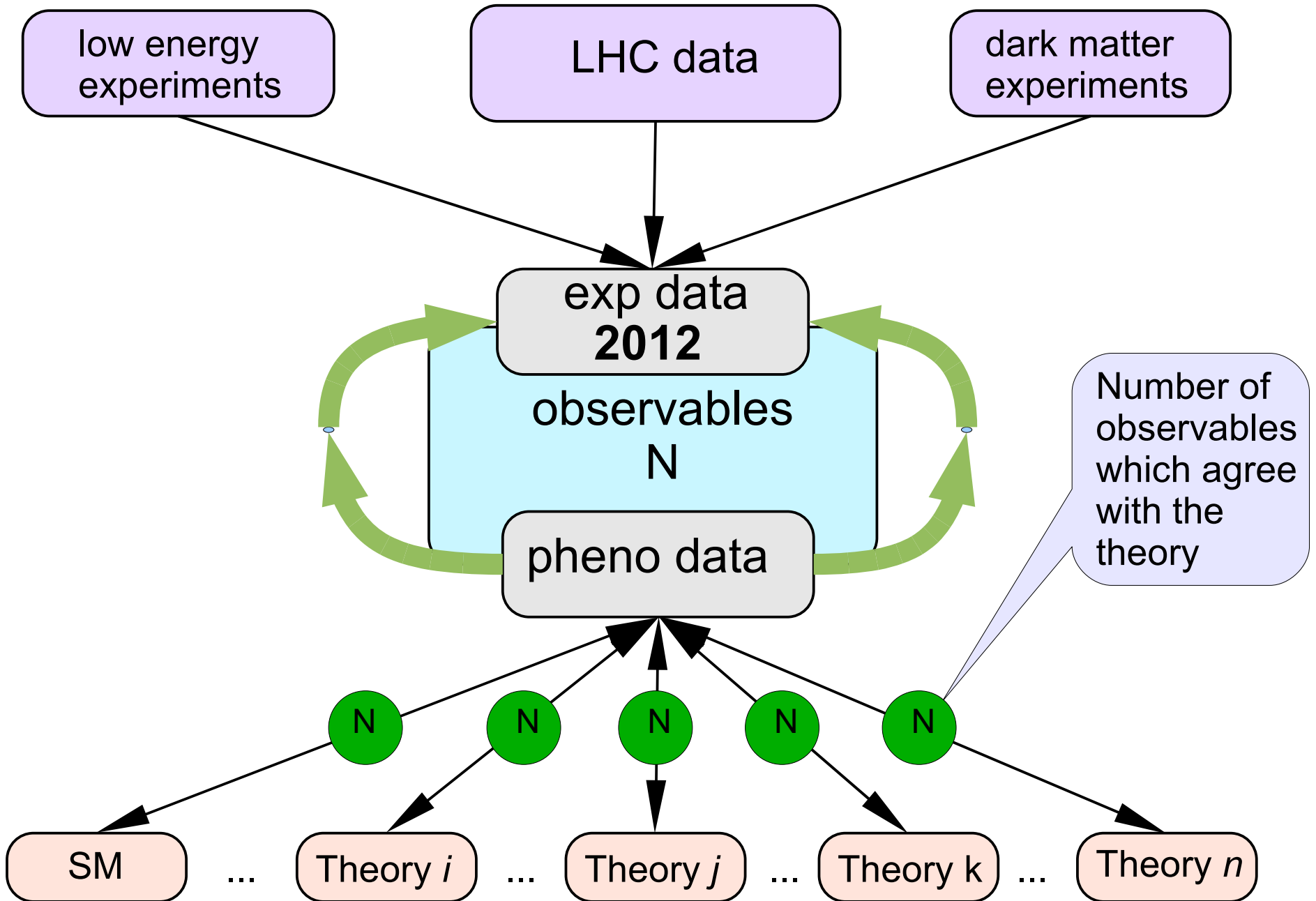
mini-workshop on HEPMDB



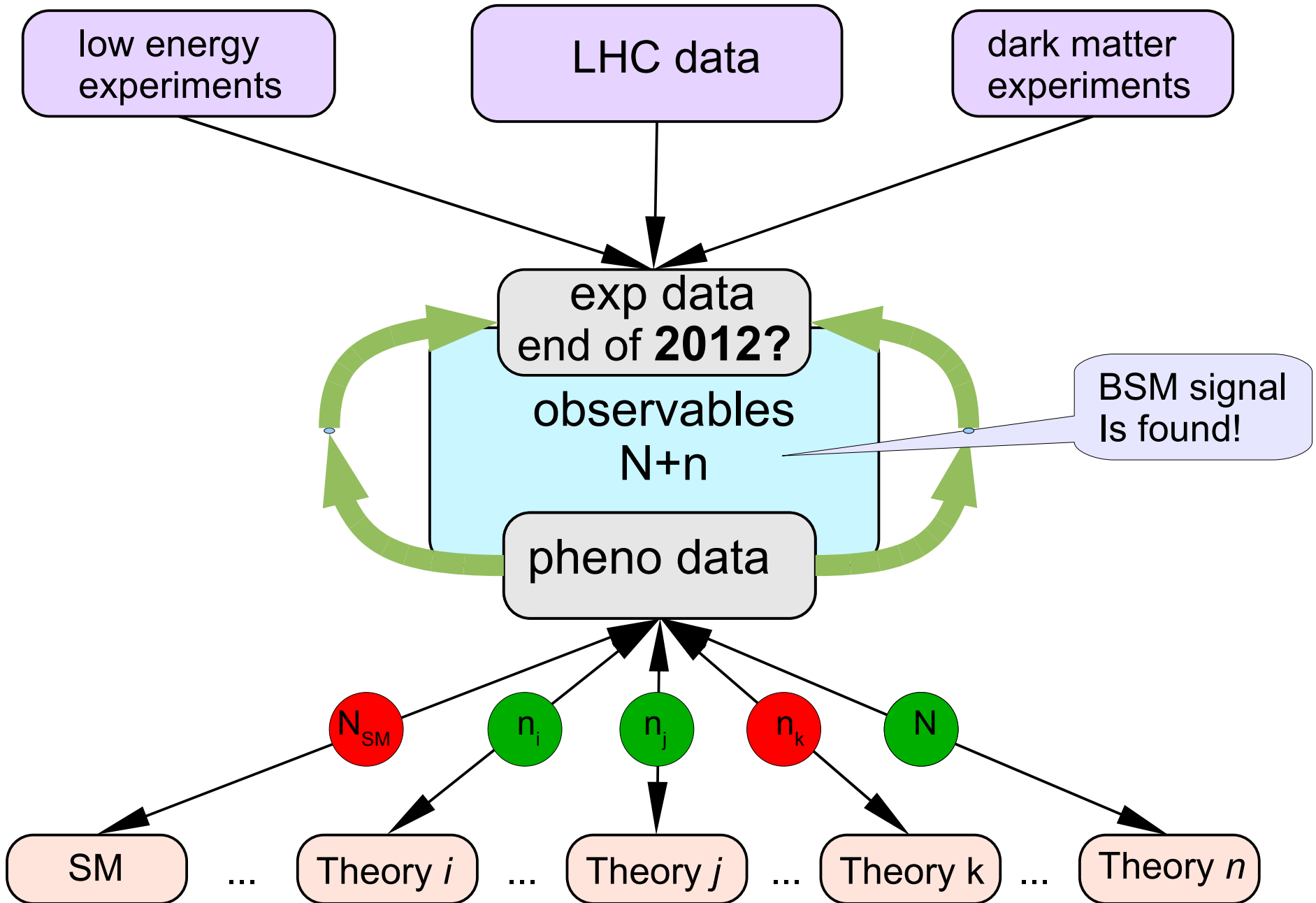
# OUTLINE

- **Pre-History of HEPMDB**
- **HEPMD, present status**
- **Short Tutorial**
- **Future plans**

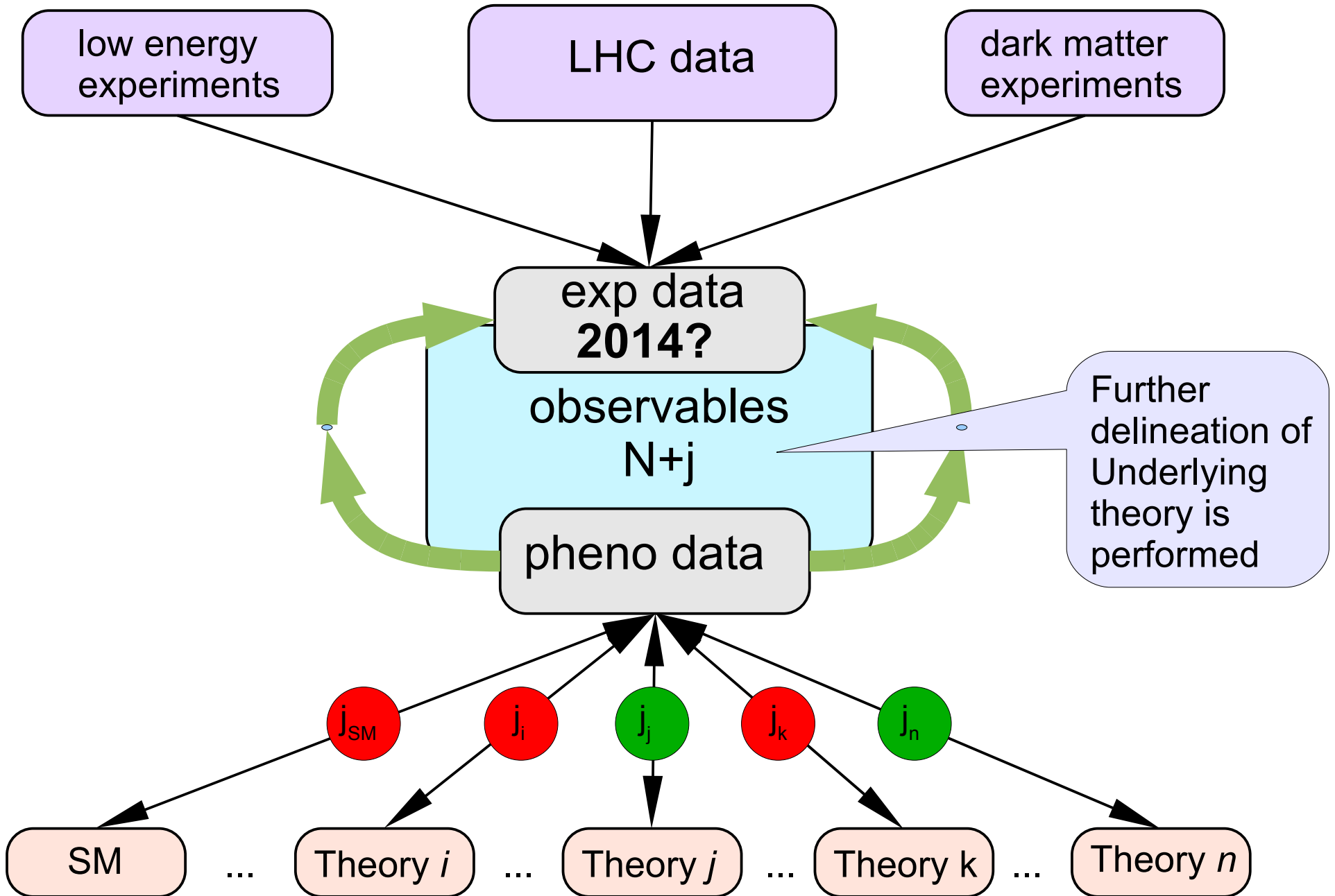
# Possible scenario in the near future



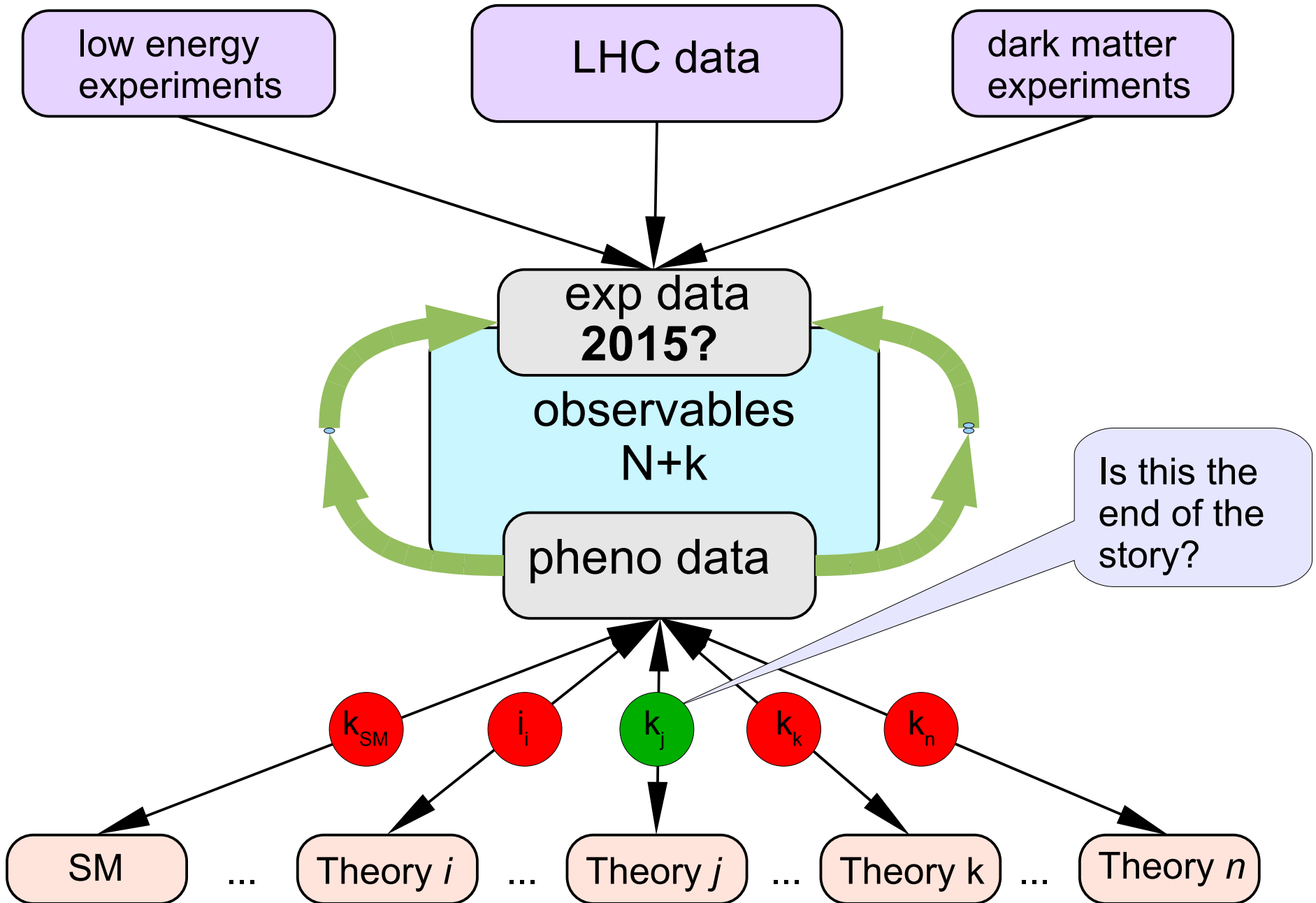
# Possible scenario in the near future



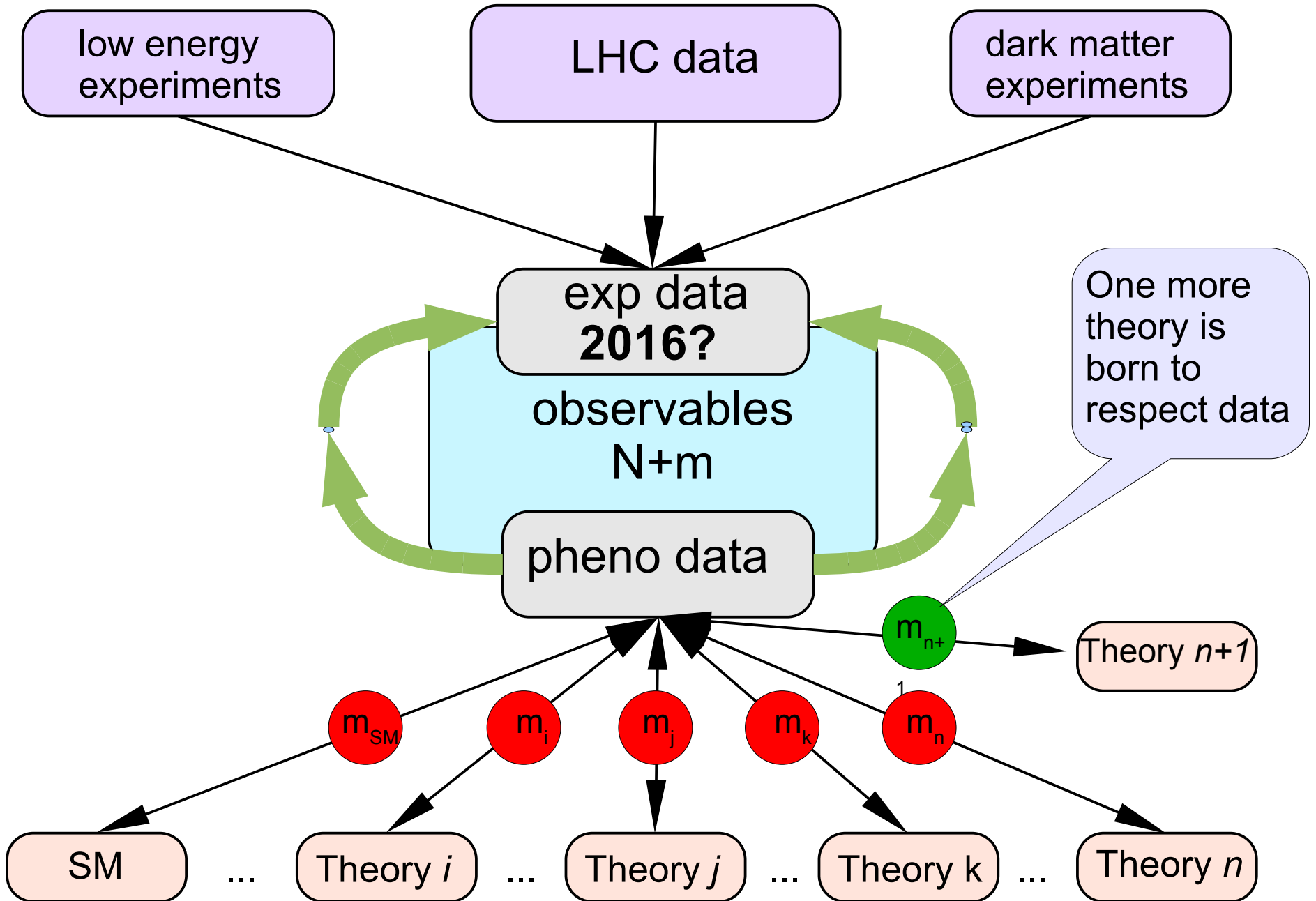
# Possible scenario in the near future



# Possible scenario in the near future



# Possible scenario in the near future



# What underlying theory should explain?

***The Nature of  
Electroweak Symmetry  
Breaking***

***The origin of  
matter/anti-matter  
asymmetry***

***Underlying  
Theory***

***The origin of  
Dark Matter  
and  
Dark Energy***

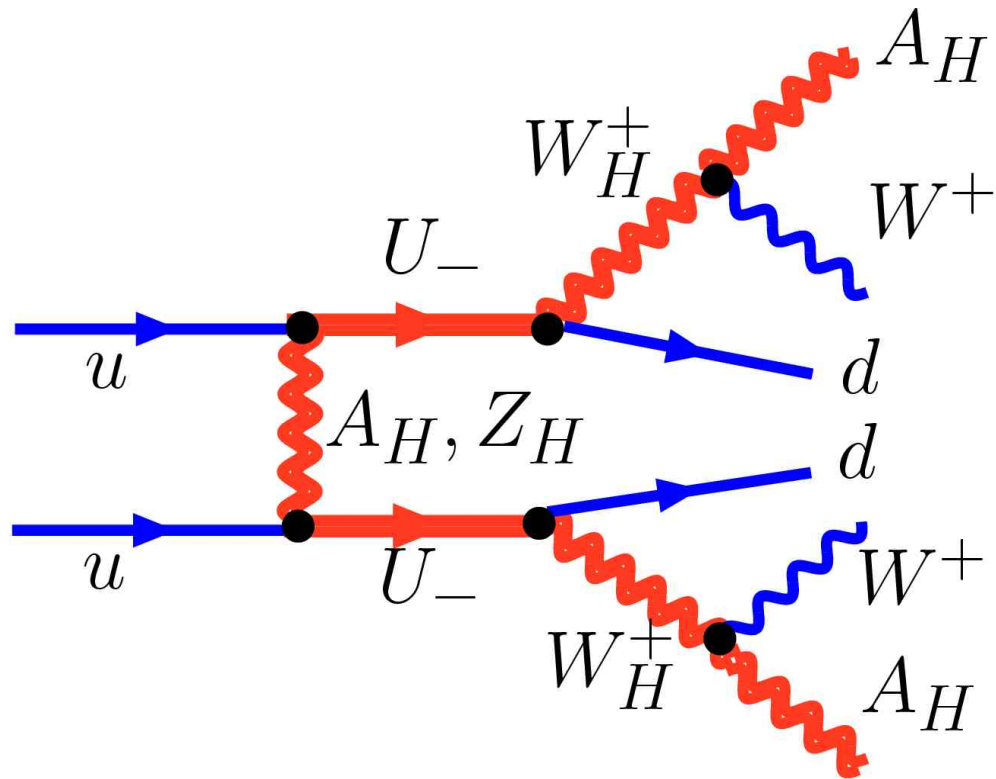
***The problem of  
hierarchy, fine-tuning,  
unification with gravity***



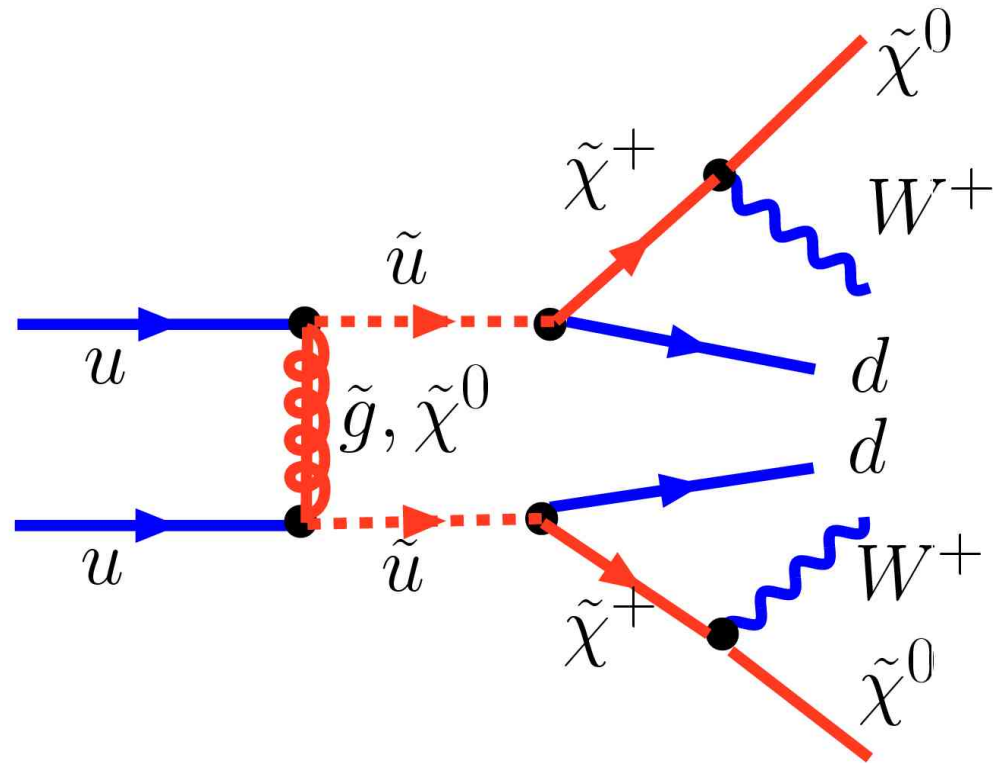
# Promising candidates for underlying theory ...

- **Supersymmetry:**
  - *cMSSM, MSSM, NMSSM,  $E_6$ SSM, ...*
- **Walking Technicolor**
- **Little Higgs models with T-parity**
- **Extradimensional Models:**
  - *Universal and Warp extra dimensions*

# Signatures could look alike

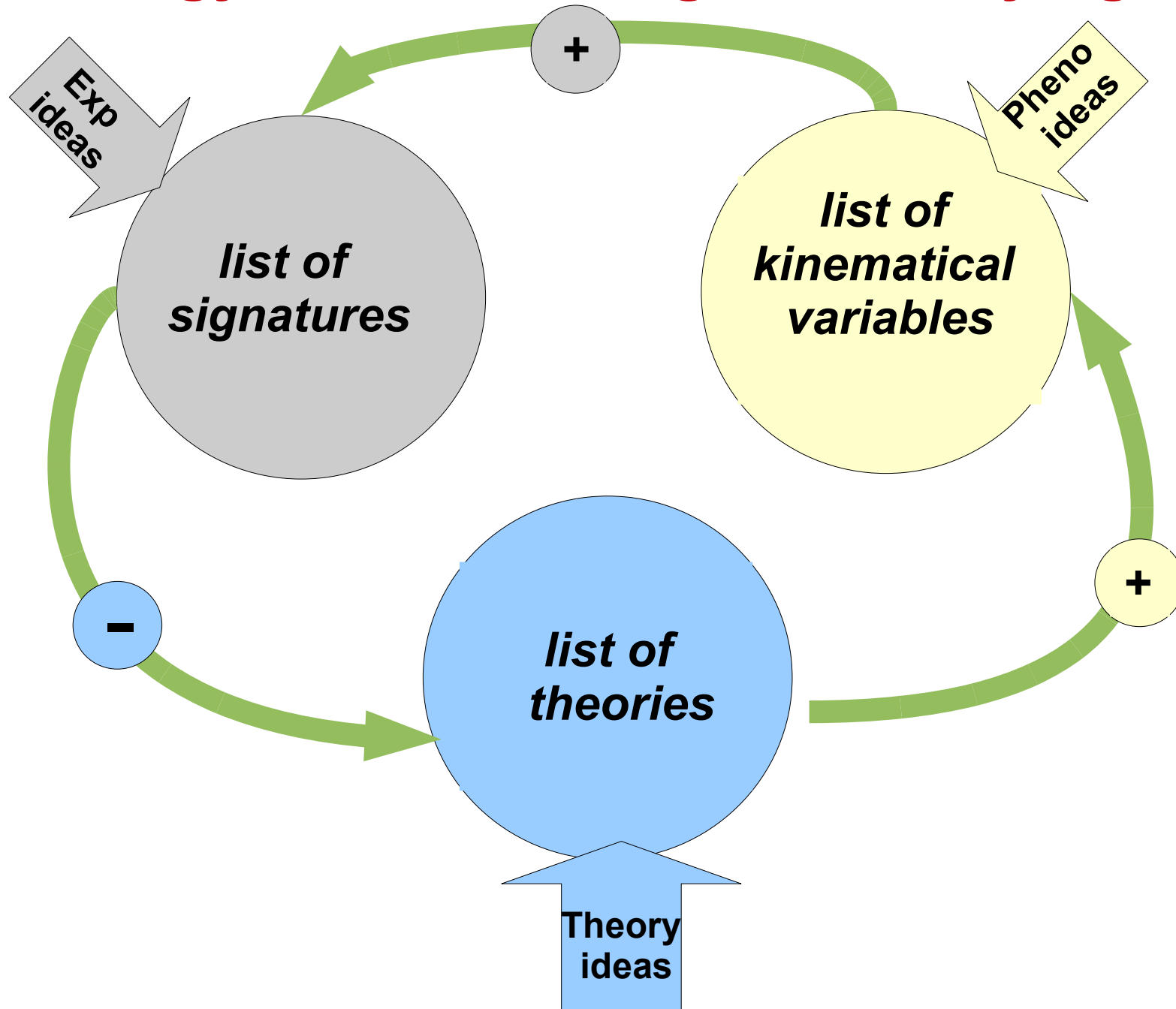


**LHT**

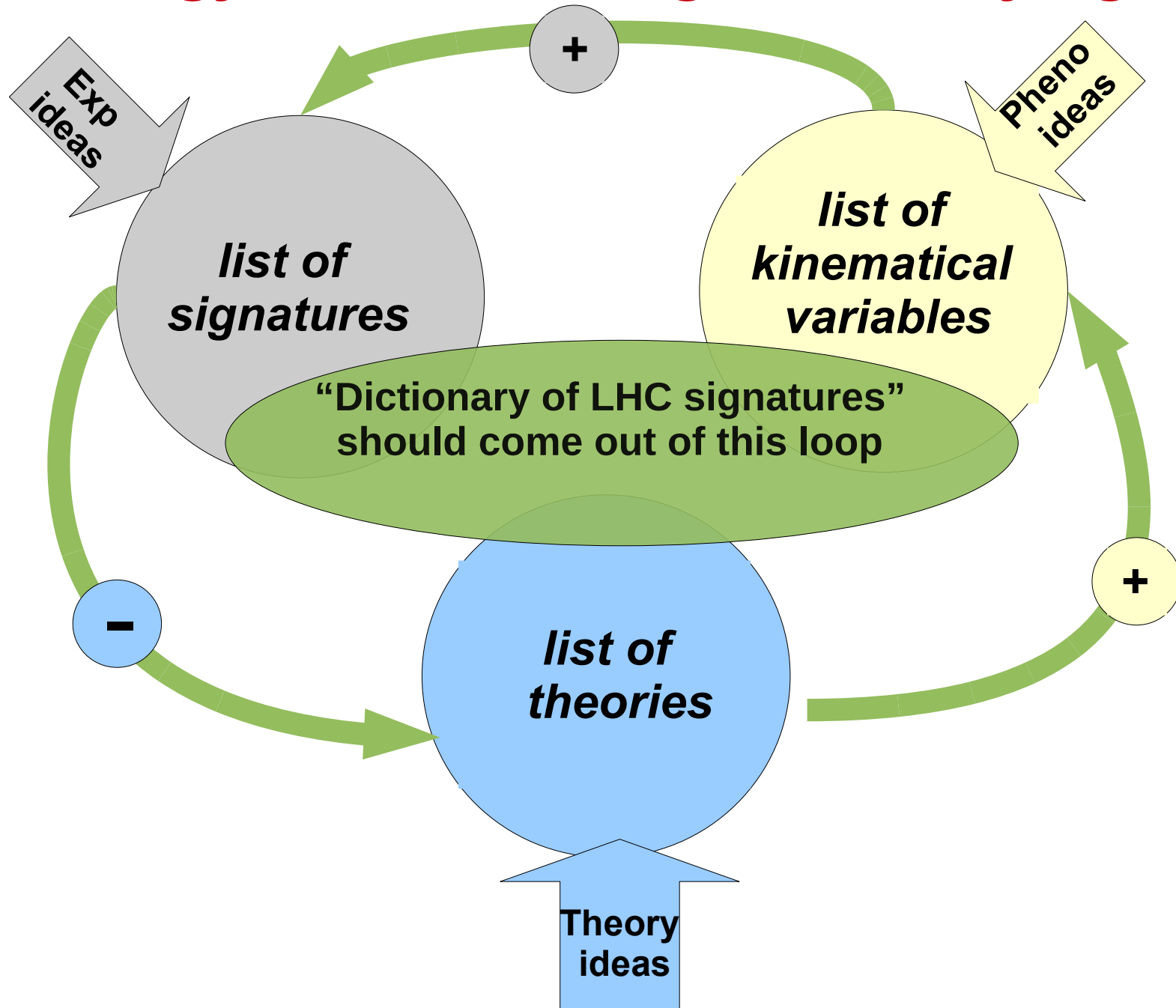


**SUSY**

# The strategy for delineating of underlying theory



# The strategy for delineating of underlying theory



# First Steps towards “Dictionary”

A.B., Aresh Datta, Rohini Godbole, Bruce Mellado, Andreas Nyffeler, Chara Petridou, D.P. Roy, Pramana 72:229-238,2009. e-Print: arXiv:0806.2838 [hep-ph]

Variables	SUSY (MSSM)	LHT	UED
Spin	heavy partners differ in spin by 1/2	heavy partners have the same spin, no heavy gluon	heavy partners have the same spin
Higher level modes	NO heavy partners	NO heavy partners	YES heavy partners
$N_{l+l+}/N_{l-l-}$	$R_{SUSY} < R_{LHT}$	$R_{LHT}$	$R_{UED} \simeq R_{LHT}$
SS leptons rates	from several channels: SS heavy fermions, Majorana fermions	only from SS heavy fermions	only from SS heavy fermions
$R = \frac{N(\cancel{E}_T + jets)}{N(\nu's + \cancel{E}_T + jets)}$	$R_{SUSY}$	$R_{LHT} < R_{SUSY}$	$R_{UED}$ to be studied
b-jet multiplicity	enhanced (FP)	not enhanced	not enhanced
Single heavy top	NO	YES	YES via KK2 decay
polarization effects	$tt + \cancel{E}_T$ $\tau\tau + \cancel{E}_T$ to be studied to be studied	to be studied to be studied	to be studied to be studied
Direct DM detection rate	high (FP) low (coann)	low (Bino-like LTP)	typically low for $\gamma_1(5D)$ DM [22] typically high for $\gamma_H(6D)$ DM [22]

**It was realised that  
“Dictionary of LHC Signatures”  
in the form of various tables is not  
enough to accommodate all models  
and their signatures**

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**---**

**High Energy Physics Model Database  
[HEPMDB]**



# High Energy Physics Model Database

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## About HEPMDB

HEPMDB is created to facilitate the connection between High Energy theory and experiment, to store and validate theoretical models, to develop dictionary of the model signatures aimed to identify the fundamental theory responsible for signals expected at the LHC. HEPMDB is also designed for collecting different signatures for its models as well as respective experimental efficiencies. Using this information HEPMDB will be able to compare its BSM model predictions with LHC data which and would allow to discriminate an underlying theory. The database is in the development stage and your input in the 'Forum' section is highly appreciated. Database collects Particle Physics Models. These models are supposed to be public and represent themselves a set of Feynman Rules which can be in form of input for any of Matrix Element generators such as CalcHEP, CompHEP, FeynArts, Madgraph, SHERPA, WHIZARD. HEPMDB has an entrance for Model authors -- 'Authors' -- where Authors can test and validate their models. To become an 'Author', you should register in a 'Register' section. 'Authors' are welcomed to also upload LanHEP or FeynRules source of their models.

## Validation

Test and model validation will be available in the nearest future and would include the computing of theoretical predictions for your model on our site via submitting jobs into the High Performance Computing Cluster (HPCC) at University site. It will also allow to run Feynman Rules generators -- LanHEP and FeynRules through the HPCC. You will learn news about this option in 'Forum' section. HEPMDB also collects signatures of Particle Physics Models, for which we suggest to use keywords which 'Authors' supposed to assign to their models. The database of signatures is in the permanent development and is available in the 'Signatures' section. Information and links on relevant packages, e.g. Matrix Element generators or Feynman Rules generator is located in the section 'Tools'.

## News

### New database is available

2011-06-07 20:21:27

A new database is available to download from our system. It is possible to validate this model on our system as well.

[More »](#)

### IBM

2011-03-29 01:05:39

We now have confirmation from IBM that all the Iridis 3 racks will be arriving on the 26th September.

[More »](#)

### Iridis 3

# High Energy Physics Model Database

<https://hepmdb.soton.ac.uk/>

- **Developed at Southampton with support from IPPP, Durham**  
as a result of ideas discussed in the context of the “Dictionary of LHC signatures”, at the FeynRules workshop (April, 2010) and at the Mini-Workshop on Dynamical Symmetry Breaking models and tools (July 2010)
- **Further discussed at Les Houches Workshop, June 2011**

**High Energy Physics Model Database – HEPMDB. Towards decoding of the underlying theory at the LHC.**

*Maksym Bondarenko<sup>1</sup>, Alexander Belyaev<sup>1,2</sup>, Lorenzo Basso<sup>1,2,3</sup>, Edward Boos<sup>4</sup>, Vyacheslav Bunichev<sup>4</sup>, R. Sekhar Chivukula<sup>5</sup>, Neil D. Christensen<sup>6</sup>, Simon Cox<sup>7</sup>, Albert De Roeck<sup>8</sup>, Stefano Moretti<sup>1,2</sup>, Alexander Pukhov<sup>4</sup>, Sezen Sekmen<sup>8</sup>, Andrei Semenov<sup>9</sup>, Elizabeth H. Simmons<sup>5</sup>, Claire Shepherd-Themistocleous<sup>2</sup>, Christian Speckner<sup>3</sup>*

## Abstract

We present here the first stage of development of the High Energy Physics Model Data-Base (HEPMDB) which is already a convenient centralized storage environment for HEP models, and can accommodate, via web interface to the HPC cluster, the validation of models, evaluation of LHC predictions and event generation-simulation chain. The ultimate goal of HEPMDB is perform an effective LHC data interpretation isolating the most successful theory for explaining the LHC observations.

# Functions of HEPMDB (1)

- collects HEP models for various multipurpose Matrix Element (ME) generators like CalcHEP, CompHEP, FeynArts, MadGraph/MadEvent, AMEGIC ++/COMIX within SHERPA and WHIZARD.  
*Under “HEP models” we denote the set of particles, Feynman rules and parameters written in the format specific for a given package*
- collects models’ sources which can be used in the HEPMDB to generate HEP models for various ME generators using FeynRules or LanHEP which automate the process of generating Feynman Rules, particle spectra, etc..  
*For the moment, FeynRules supports formats for CompHEP, CalcHEP, FeynArts, GoSam, MadGraph/MadEvent, SHERPA and WHIZARD. Currently LanHEP works with CalcHEP, CompHEP, FeynArts and GoSam. Also, the latest LanHEP version 3.15 has an option under testing of outputting the model in UFO format which provides a way to interface it with MadGraph/MadEvent*
- allows users to upload their models and perform evaluation of HEP processes and event generation for their own models using the full power of the High Performance Computing (HPC) cluster behind the HEPMDB  
*This is one of the very powerful features of the HEPMDB: it provides a web interface to various ME generators which can then also be run directly on the HPC cluster. This way, users can perform calculations for any model from HEPMDB avoiding problems related to installing the actual software, which can sometimes be quite cumbersome*

# Functions of HEPMDB (2)

- allows to cross check and validate models for different ME generators.  
*similar functionality is also provided by the FeynRules web validation framework, however, the FeynRules web validation is mainly geared towards comparing FeynRules models and can use its knowledge of the model format to provide a throughout and highly automatized test procedure for those, while HEPMDB works in a more generic way and will provide access to more model formats at the price of slightly less automatization.*
- collect predictions and specific features of various models in the form of database of signatures and perform comparison of various model predictions with experimental data (to be developed)  
*There are a lot of different aspects related to this problem. This task includes a comprehensive development of a database of signatures as well as development of the format of presentation of these signatures. This format will be consistent with the format which will be used by the experimentalists for the presentation of the LHC data, discussed in the context of the “Les Houches Recommendations for the Presentation of LHC Results” activity.*
- allows to trace the history of the model modifications, and makes available all the versions of the model  
*Through this application, we stress the importance of reproducibility of the results coming from HEPMDB or from a particular model downloaded from HEPMDB.*

# Similar but qualitatively different related projects

- “Database of Numerical HEP scattering cross sections”  
<http://durpdg.dur.ac.uk/HEPDATA/REAC>  
collects various particle scattering process which are connected to experimental searches of different reactions
- “Signatures of New Physics at the LHC” web-site  
<http://www.lhcnewphysics.org/>  
collects various BSM signatures, their classification and related papers
- FeynRules and models database  
<http://feynrules.irmp.ucl.ac.be>  
collects various models implemented into FeynRules
- **HEPMDB can effectively collaborate with all projects above!**

# The current status of HEPMDB (1)

- Allows to find and download an existing HEP model. The search engine checks patterns in the fields:  
*Model, Authors, References, Abstract, Signatures and Information*

HEPMDB

High Energy Physics Models DataBase

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Search in HEPMDB



Show All Models

## Search Models :: Results for [MSSM]

1. **MSSM** [2011-06-21 10:54:07] hepmdb:0611.0028

*CalcHEP/MicrOMEGAs groups*

We present MSSM with SUGRA and AMSB scenario as well as MSSM with low energy input. Read file INSTALLATION for model installation and file CITE for references on scientific publications which pre...

2. **MSSM (Whizard)** [2011-12-30 04:38:49] hepmdb:1211.0047

*Christian Speckner*

MSSM model for Whizard...

3. **RPV MSSM** [2012-02-17 18:30:58] hepmdb:0212.0049

*Uploaded by Metin Ata, created by Benjamin Fuks*

(taken from FeynRules web page) Our implementation keeps all the flavour-violating and helicity-mixing terms in the Lagrangian and also all the possible additional CP-violating phases. In order to de...

# The current status of HEPMDB (2)

- one can upload a new model (upon user registration). The model can be uploaded in the format of any ME generator. Also, a user can upload the model source in FeynRules or LanHEP formats

## Model : MSSM

<http://hepmdb.soton.ac.uk/hepmdb:0611.0028>

### Authors

CalcHEP/MicroOMEGAs groups

### Added By

Alexander Belyaev

### References

G.~Belanger, F.~Boudjema, A.~Pukhov and A.~Semenov, *Comput. Phys. Commun.* 174, 577 (2006)[arXiv:hep-ph/0405253]  
A.~Djouadi, J.~L.~Kneur and G.~Moultaka, arXiv:hep-ph/0211331

### Abstract

Updated MSSM model for CalcHEP is uploaded (bug for SC constant in the file with dependences is corrected)

### Information

We present MSSM with SUGRA and AMSB scenario as well as MSSM with low energy input. Read file INSTALLATION for model installation and file CITE for references on scientific publications which present realization of the model.

### Tools

CalcHEP [model]

### Model History

[2011-12-02 15:01:19](#)  
[2011-10-14 13:40:10](#)

[Download Model File](#)

[Validate Model on HPCx](#)

[Edit Model](#)

### Reviews

# The current status of HEPMDB (3)

- allows to evaluate cross sections for user-defined processes for the chosen model and produce a respective LHE file with generated parton-level events. This file is becomes available for download once the process is finished.

*Currently, the HEPMDB allows the user to perform these calculations (using the HPC) for CalcHEP and WHIZARD models only.*

- produces ntuple files and allows to plot various kinematical distributions
- allows to update/add features and respective signatures specific to each model.

*These features and signatures can be used in the future to distinguish the model from others and connect it to the LHC signatures.*

- keeps track of the model changes, providing reproducibility for the results obtained with previous versions of the models uploaded to HEPMDB
- allows to collect feedback/remarks on particular model from users in Review section



# Future prospects for HEPMDB (months scale)

- The LanHEP and FeynRules packages will be added to provide model generation from model sources
- The MadGraph/MadEvent and CompHEP packages will be added.
- A systematic model validation process will be started and the respective pages will be added.
- The possibility to study events beyond the parton level will be carefully considered, up to detector simulation.  
One concrete possibility would be the chain  
LHE events -> HEPMC events -> FASTSIM events (ROOT format)  
For the FASTSIM package, Delphes seems a promising candidate.
- The structure of the database of signatures will be extended to deal with correlated signatures (i.e., whereby multiple signatures, or lacks thereof, must be accounted for simultaneously)

# Future prospects for HEPMDB (~year time scale)

- we plan to install the MicrOMEGAs package for evaluation of the dark matter relic density as well as to provide a possibility for scans of various model parameter spaces.
- the format for model predictions consistent with the format for presentation of the LHC data by experimentalists is planned.
- The question about including automatic tools for NLO evaluations is under discussion and will be developed further at the later stages of HEPMDB development.

# Tutorial

Search in HEPMDB

## About HEPMDB

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## Validation

Test and model validation will be available in the nearest future and would include the computing of theoretical predictions for your model on our site via submitting jobs into the High Performance Computing Cluster (HPCC) at University of Sussex. It will also allow to run Feynman Rules generators -- LanHEP and FeynRules through the HPCC. You will learn news about this option in 'Forum' section. HEPMDB also collects signatures of Particle Physics Models, for which we suggest to use keywords which 'Authors' supposed to assign to their models. The database of signatures is in the permanent development and is available in the 'Signatures' section. Information and links on relevant packages, e.g. Matrix Element generators or Feynman Rules generator is located in the section 'Tools'.

Search in HEPMDB

## Search Models :: Results for [Search in HEPMDB]

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*Uploaded by Metin Ata, created by Benjamin Fuks*  
(taken from FeynRules web page) Our implementation keeps all the flavour-violating and helicity-mixing terms in the Lagrangian and also all the possible additional CP-violating phases. In order to de...
- 3-site\_model (Whizard)** [2011-12-30 04:41:37] hepmdb:1211.0046  
*Christian Speckner*  
3-site model for Whizard...
- MSSM (Whizard)** [2011-12-30 04:38:49] hepmdb:1211.0047  
*Christian Speckner*  
MSSM model for Whizard...
- nMSSM** [2011-12-30 04:23:30] hepmdb:1211.0046  
*from CalcHEP group*

Search in HEPMDB

## Upload Model

Please fill the fields to add Model

Model Name:\*

Authors:\*

Summarise:\*

Description:

Model changed: False  
Gauge: Feynman

CalcHEP - Validation

```
#####  
# Process Info  
# Process specifies the process. More than #  
# one process can be specified. Cuts, #  
# regularization and QCD scale should #  
# be specified for each one. #  
# Decay specifies decays. As many decays #  
# as are necessary are allowed. #  
# Composite specifies composite particles #  
# present in the processes or decays. #  
#####  
Process: p,p->W+,Z  
Decay: W->l,e,n  
Decay: Z->l,e,n  
  
Composite: p,u,U,d,D,G  
Composite: l,e,mu,E,n,M  
Composite: n,ne,Ne,nm,Nm  
  
#####  
# PDF Info  
# Choices are:  
# cteq1 (anti-proton)  
# cteq1 (proton)  
# mrst2001o (anti-oron)
```

02/03/12 : 03:21:58 : You successfully sub  
02/03/12 : 03:21:01 : You dont have any jo  
02/03/12 : 03:21:00 : Logged in.

Load full batch Save

Menu - Go to HEPMDB - Help -

CalcHEP - Validation

Job #24161-----Friday 02nd of March 2012 03:23:29 AM-----

CalcHEP Numerical Details

Done!

Processes	sigma (fb)	PID	Time (hr)	N events
u,d->Z,W+	7.9869e+03	30347	0.00	609/609
D,u->Z,W+	8.0122e+03	30542	0.00	610/610
Total	1.5999e+04			1219/1219

Decays	width (GeV)	PID	Time (hr)	N events
W+>e,ne	2.2512e-01	31586	0.00	5101/5100
W->mu,mm	2.2512e-01	31846	0.00	5101/5100
Z->mu,mm	8.3982e-02	407	0.00	5101/5100
Z->tau,tt	8.3981e-02	899	0.00	5101/5100

Widths	PID	Time (hr)
Widths	1992	0.00
Total	2.4510e+02	0.01

02/03/12 : 03:23:30 : Job 24161 was finished.  
02/03/12 : 03:23:28 : Logged in.

CalcHEP - Validation

Standard Model

Whizard -

LHE

Number of events

MEFF(GeV)

Download [jpg] [eps] [pdf]

02/03/12 : 03:26:40 : NT\_maker test-single.ln  
02/03/12 : 03:26:51 : You dont have any job r  
02/03/12 : 03:25:27 : Logged in.

# Remarks on collecting models at HEPMDB

- there are numerous model implementations exist on the market (FeynRules team, LanHEP/CalcHEP/CompHEP teams, private implementations)
- they are highly complementary and useful
- HEPMDB is the natural place to accommodate all of them (also allows to private upload)

# Example of models created for CalcHEP

## ● SM + extensions

- ➔ SM
- ➔ B-L symmetric  $Z'$  with heavy Majorana neutrinos
- ➔ SM +  $Z'$
- ➔ general 2 Higgs doublet model
- ➔ 4th generation
- ➔ Excited fermions
- ➔ Model with contact interactions
- ➔ Standard Model + anomalous gauge boson couplings
- ➔ Model of strongly int EW sector (5 & 6 dim operators involving Sigma field)

## ● SUSY

- ➔ constraint MSSM
- ➔ general MSSM, with 124 free parameters
- ➔ NMSSM
- ➔ RPVMSSM
- ➔ left-right symmetric MSSM
- ➔ MSSM with CP violation
- ➔ E6MSSM

## ● Extra dimensions

- ➔ 5D UED with 2KK layers
- ➔ 6D UED with 2KK layers
- ➔ ADD = ADD
- ➔ RS = Randall Sundrum

## ● Leptoquarks

- ➔ Complete LQ model  
SU(3) $\times$ SU(1) $\times$ U(1) vector&scalar

## ● Technicolor & Higgsless

- ➔ Minimal walking technicolor
- ➔ TC with DM
- ➔ 3-site model
- ➔ Hidden Local symmetry model
- ➔ 4SM = general 4-site model

## ● Little Higgs

- ➔ Littlest higgs model with T-parity
- ➔ LHT + T-parity violation

# Models at FeynRules web-site

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## [Standard Model](#)

The SM implementation of FeynRules, included into the distribution of the FeynRules package.

---

## [Simple extensions of the SM \(10\)](#)

Several models based on the SM that include one or more additional particles, like a 4th generation, a second Higgs doublet or additional colored scalars.

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## [Supersymmetric Models \(4\)](#)

Various supersymmetric extensions of the SM, including the MSSM, the NMSSM and many more.

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## [Extra-dimensional Models \(4\)](#)

Extensions of the SM including KK excitations of the SM particles.

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## [Strongly coupled and effective field theories \(4\)](#)

Including Technicolor, Little Higgs, as well as SM higher-dimensional operators.

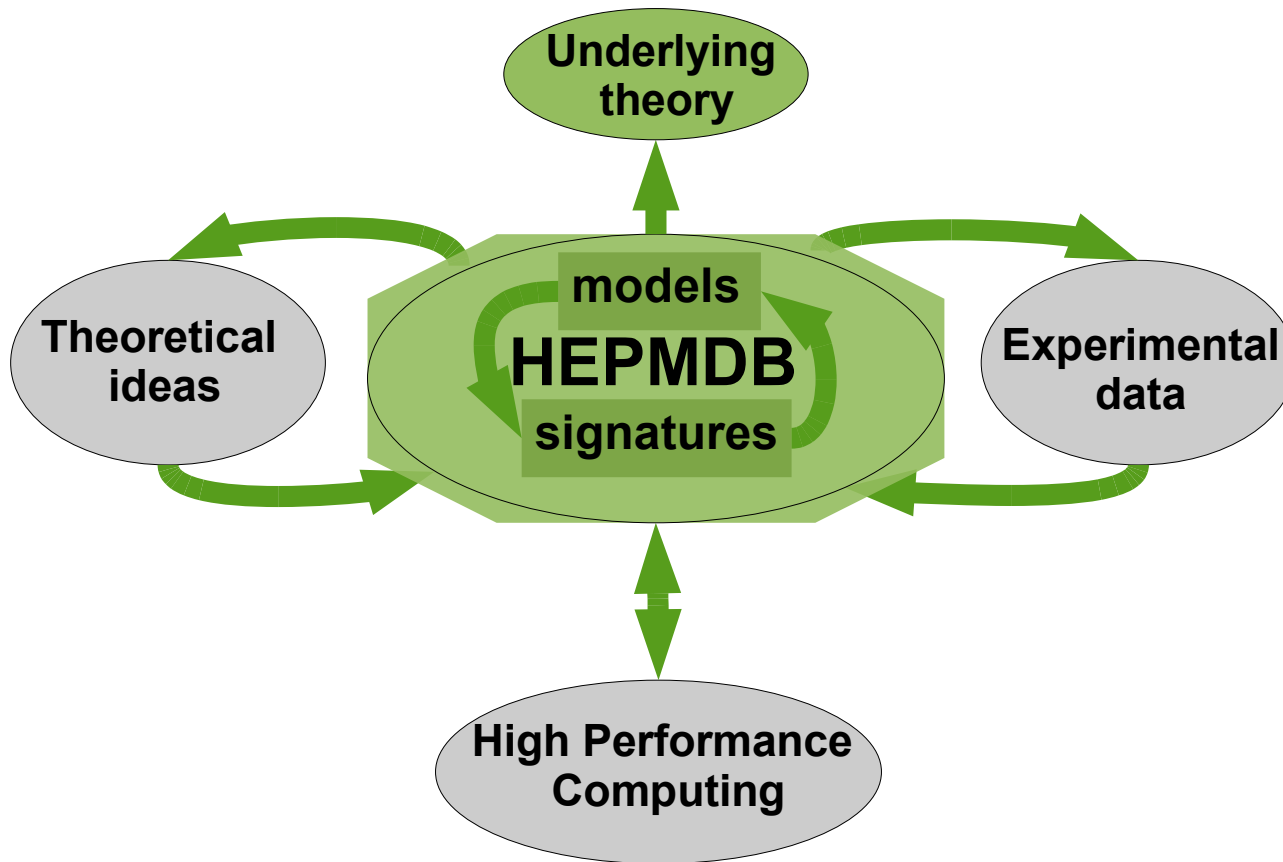
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## [Miscellaneous \(0\)](#)

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# Conclusions

- HEPMDB is already a convenient centralized storage environment for HEP models. Via web interface to the HPC cluster it allows to evaluate the LHC predictions and event generation-simulation chain
- we hope that starting from the present stage, HEPMDB development will be boosted further via involvement of the HEP community  
*(via direct involvement into HEPMDB, via various projects involving HEPMDB, via numerous comments/requests for HEPMDB features)*
- we think that in the near future the HEPMDB will also become a powerful tool for isolation of the most successful theory for explaining the LHC data



***THANK YOU!***