Decoding BSM from data: the 2nd meeting

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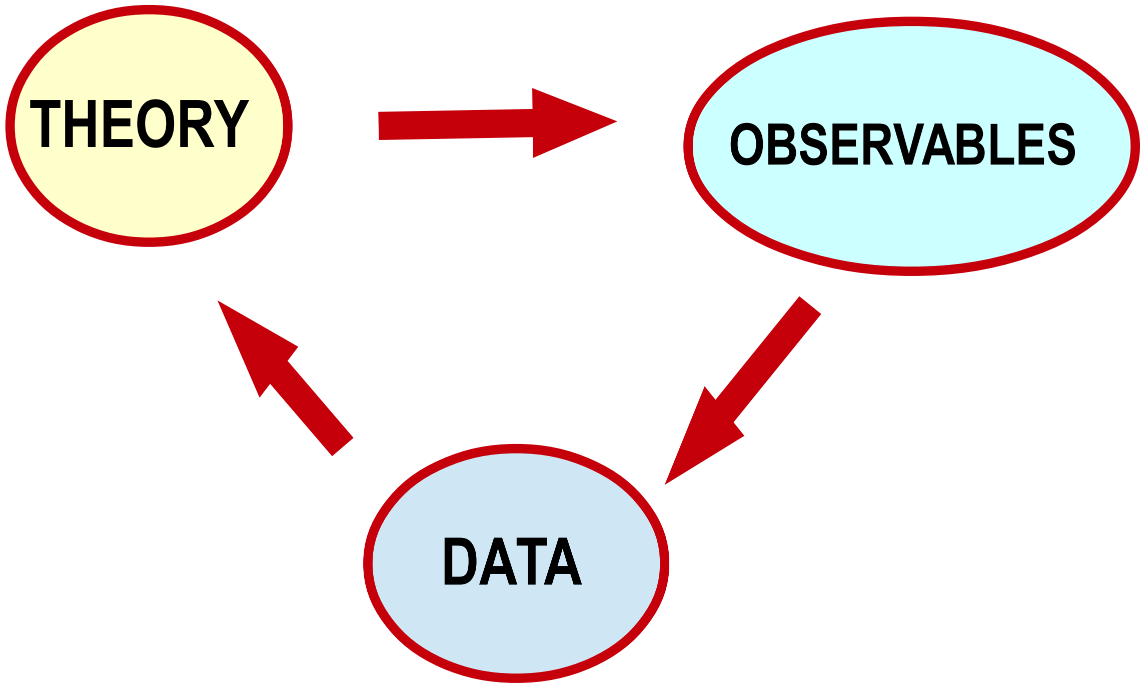
May 11, 2017
Imperial College

Short summary of the first meeting on BSM decoding from data

https://indico.cern.ch/event/615733/

- The solution of the inverse problem is a big challenge



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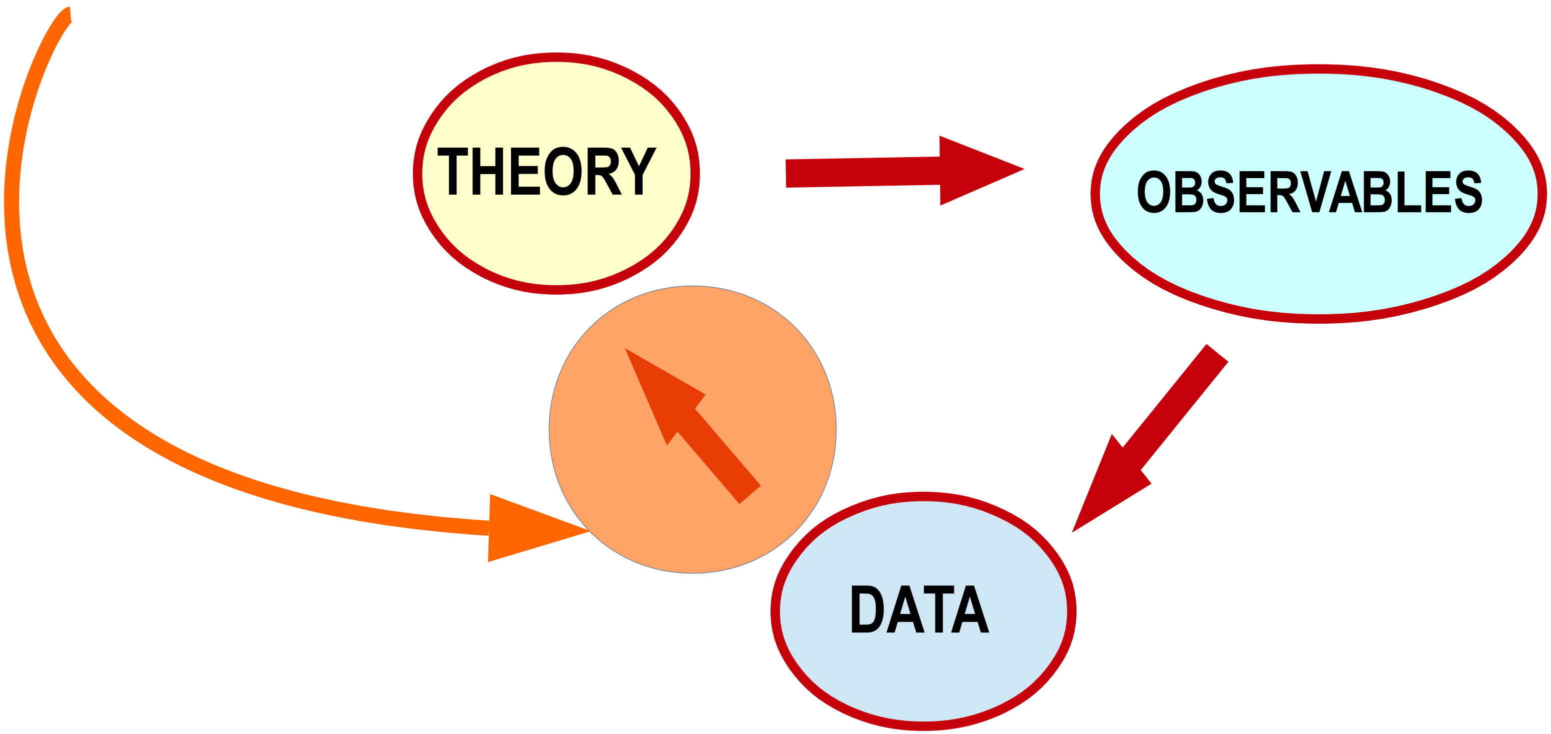

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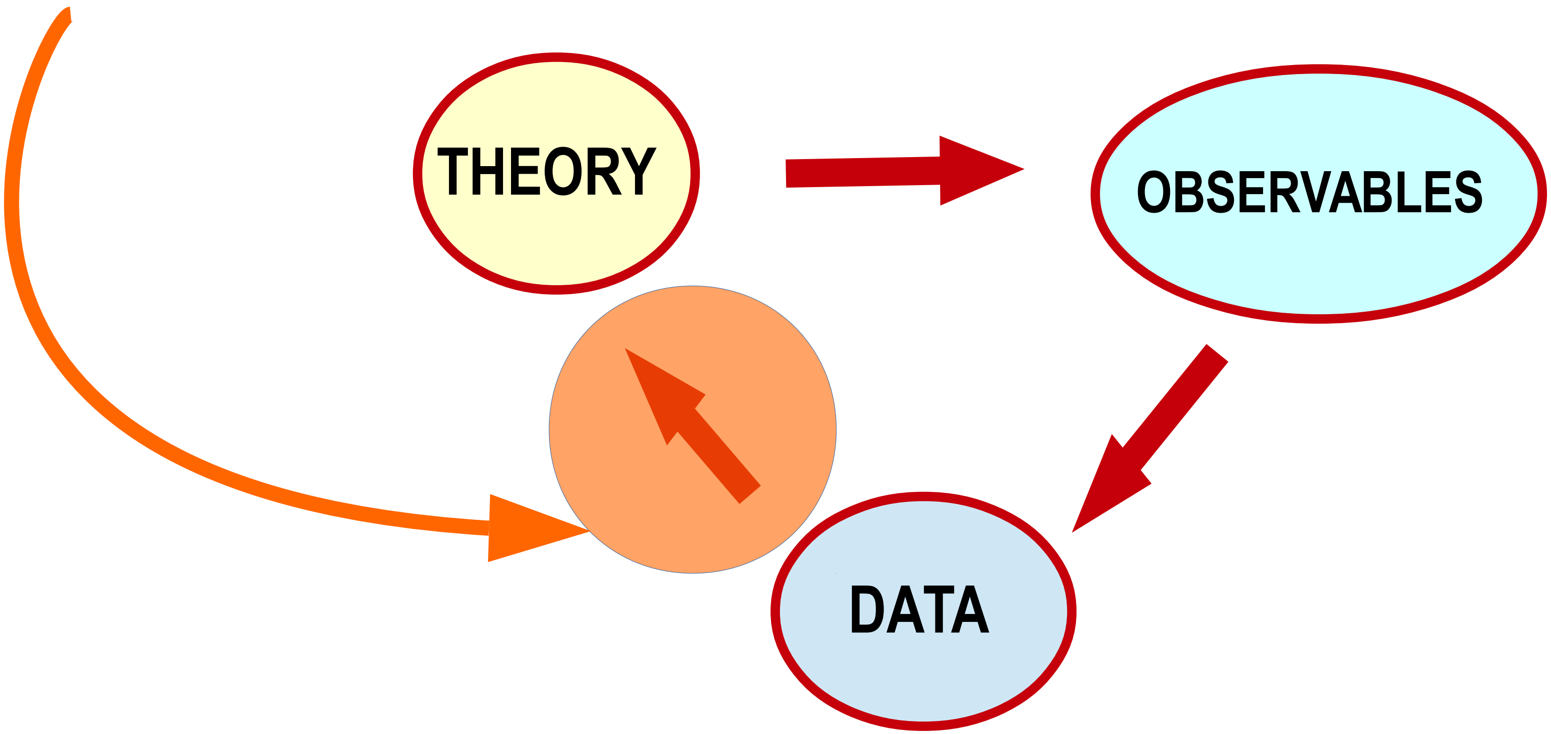
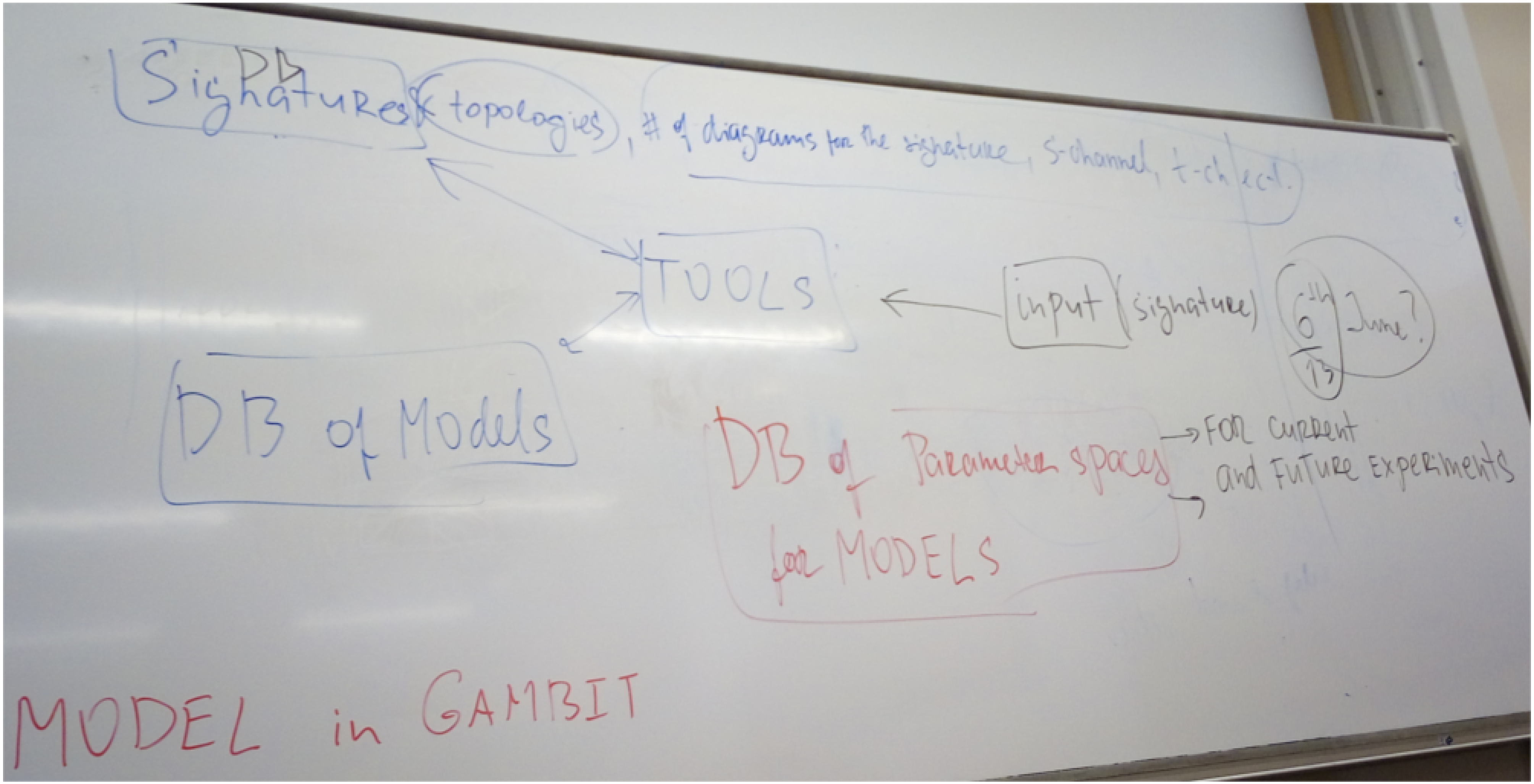
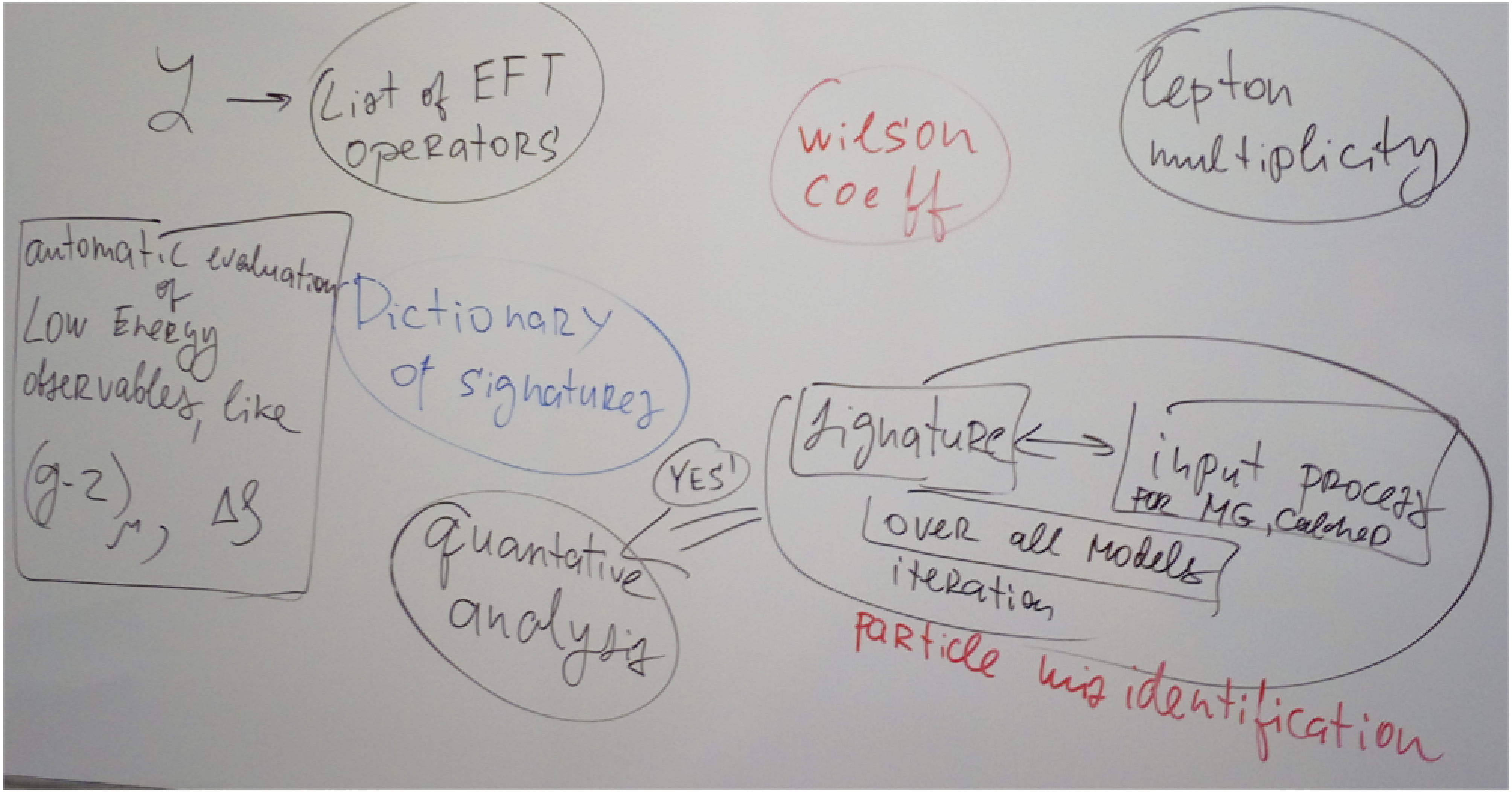


- It involves developing and connecting tools and database of signatures

Developing and connecting tools and database of signatures



Developing and connecting tools and database of signatures



Developing and connecting tools and database of signatures

- **Database of Signatures**
  - the problem of what do we call signature:
    - object characterization – di-lepton, MET, etc
    - topology – resonance, forward jet etc, can be described by the number of diagrams with certain topologies – s-channel, t-channel etc
    - particles multiplicty

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  - complete theory
  - series of the effective operators and related Wilson coefficients
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Developing and connecting tools and database of signatures

- **Database of Signatures**
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- **BSM formulation**
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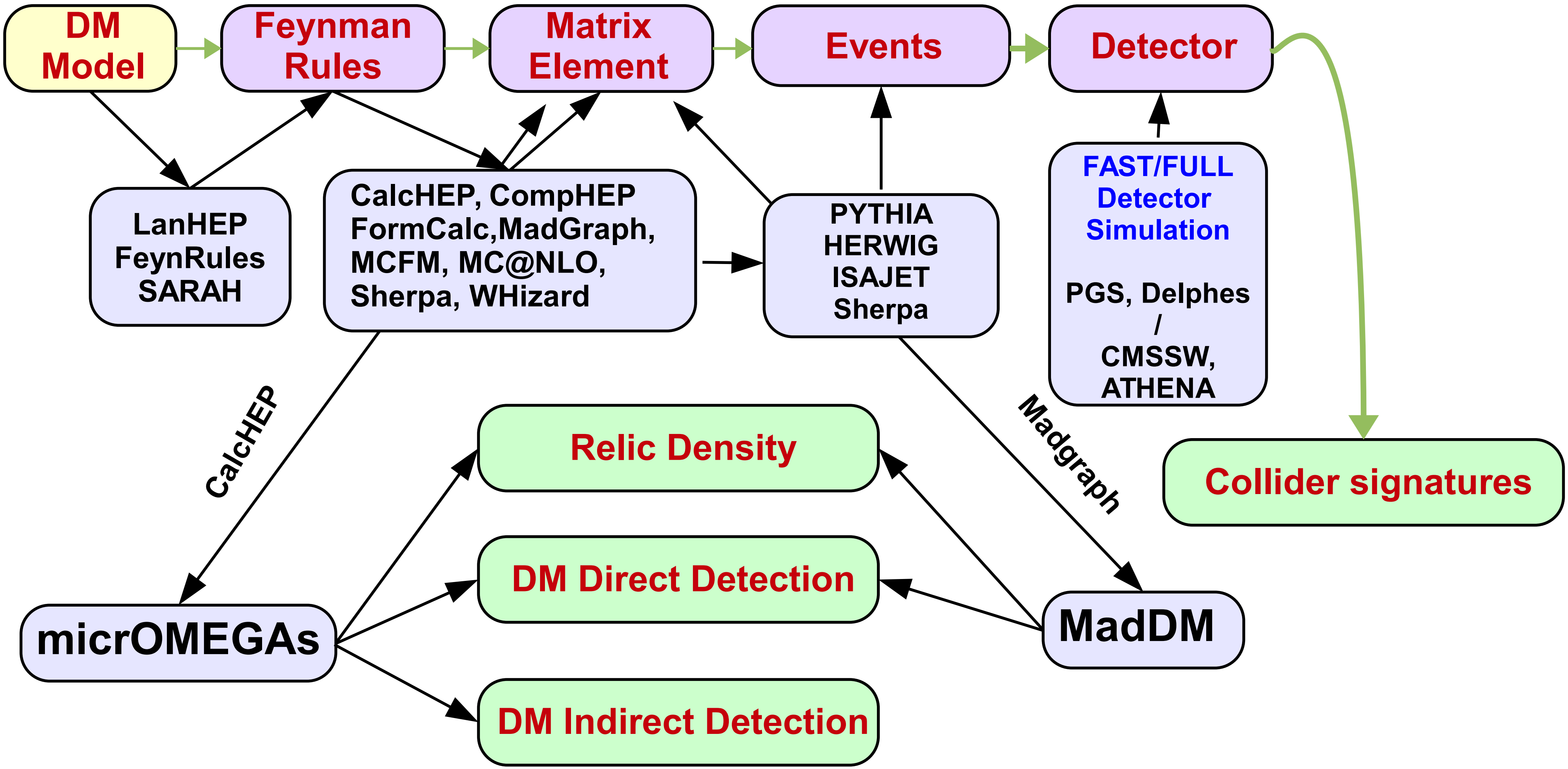
  - series of the effective operators and related Wilson coefficients
  - …
- **Problem of finding Signature ↔ Model correspondence**
  - scan over all models and signatures
    - qualitative and quantitative analysis
    - defining the input process
    - defining parameter space, possibly creating and connecting DB of the parameter spaces for models
    - taking into account particles misidentification
  - developing new tools, e.g. automatic evaluation of $(g-2)_\mu$, $\Delta\rho$, …

Tools for theory → observables link



? CMB constraint on <σv>

"CMB constraints on Dark Matter models with large annihilation cross-section"
'09 Gallia, Iocco,Bertone, Melchiorri

Data → Theory link

- one the most challenging problem to solve – **the inverse problem of decoding of the underlying theory from signal**
  - requires database of models, database of signatures
  - requires smart procedure based on machine learning of matching signal from data with the pattern of the signal from data
- **HEPMDB (High Energy Physics Model Database)** was created in 2011 to make the first step towards this: **hepmdb.soton.ac.uk/phenodata**
  - recently has got a status of the permanent server at Southampton
  - convenient centralized storage environment for HEP models
  - it allows to evaluate the LHC predictions and perform event generation using CalcHEP, Madgraph for any model stored in the database
  - users can upload their own model and perform simulation – became a very attractive feature for all range of researchers
  - **no database of signatures yet** (is under development) – you input could play and important role
- As a HEPMDB spin-off the **PhenoData** project was created (Dan's talk) **hepmdb.soton.ac.uk/phenodata**
  - stores data (digitized curves from figures, tables etc) from those HEP papers which did not provide data in arXiv or HEPData, and to avoid duplication of work of HEP researchers on digitizing plots.
  - has an easy search interface and paper identification via arXiv, DOI or preprint numbers. PhenoData is not intended to be a replication of any existing archive

New/recent features of CalcHEP
(see attached PDF notes in Indico)

- **Default composites and saving of input**

```
Enter process:  p*,p* -> ~o1,~o1,p*
```

CalcHEP automatically substitutes 'p*' contents in the input line

```
composite  'p*' consists of:  G,u,U,d,D,s,S,c,C,b,B
```

In the same manner at first call of numerical session one gets default table

```
                 Composites
 Name   |> Comma separated list of particles
 p*     |G,d,u,U,D,s,S,c,C,b,B
```

and recommended Cuts

```
                 Cuts
!| Parameter | Min bound    | Max bound
%| T(p*)     | 50           |
%|J(p*,p*)   | 0.5          |
```

New/recent features of CalcHEP
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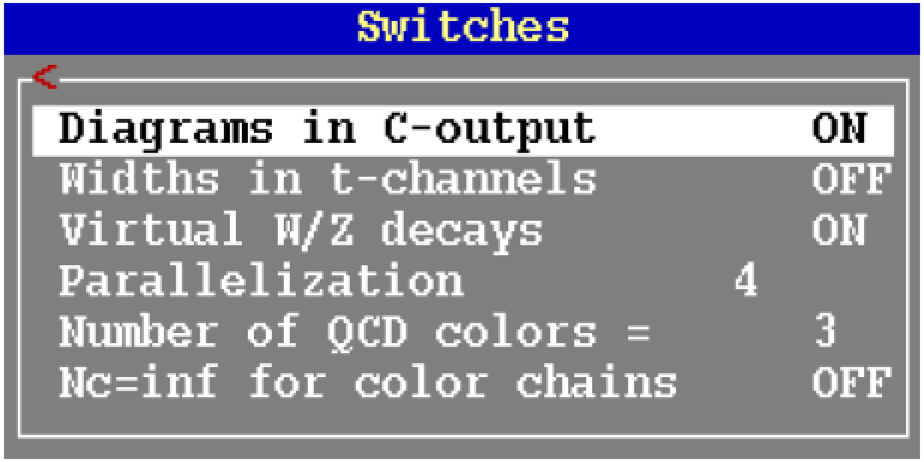
- **Parallel calculations**

Program	Method
symbolic calculation of diagram	fork
writing of C-code	fork
compilation of C-code	not implemented
Vegas MC integration	threads
Generation of unweighted events	threads



New/recent features of CalcHEP
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- **Parallel calculations**
  - ***PBS mode***

```
Parallelization method:      pbs
Walltime : 5
Memory   : 4
email:        name@address
Max number of processes per node: 16
Max number of cpus:      10
```

  - ***local mode***

```
Parallelization method:  local
Max number of processes per node: 1
Max number of cpus:      16
```

New/recent features of CalcHEP
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- **New colour particles and vertices**

P1	P2	P3	color structure
3_a	$\bar{3}^b$		δ^a_b
6_{ab}	$\bar{6}^{cd}$		$(\delta^c_a\delta^d_b + \delta^d_a\delta^c_b)/2$
8_α	8_β		$\delta^{\alpha\beta}$
3_a	3_b	3_c	ϵ^{abc}
$\bar{3}^a$	$\bar{3}^b$	$\bar{3}^c$	$\bar{\epsilon}_{abc}$
8_α	8_β	8_γ	$-i\,f^{\alpha\beta\gamma}$
3_a	$\bar{3}_b$	8_γ	$\tau^{\gamma}{}^a_b$
6_{ab}	$\bar{6}^{cd}$	8_γ	$(\tau^{\gamma}{}^a_c\delta^b_d + \tau^{\gamma}{}^a_d\delta^b_c + \tau^{\gamma}{}^b_d\delta^a_c + \tau^{\gamma}{}^b_c\delta^a_d)/2$
6_{ab}	$\bar{3}^c$	$\bar{3}^d$	$(\delta^a_c\delta^b_d + \delta^a_d\delta^b_c)/2$
$\bar{6}^{ab}$	3_c	3_d	$(\delta^c_a\delta^d_b + \delta^d_a\delta^c_b)/2$

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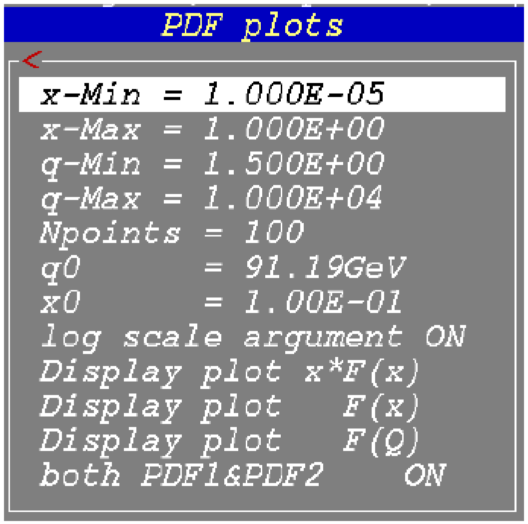
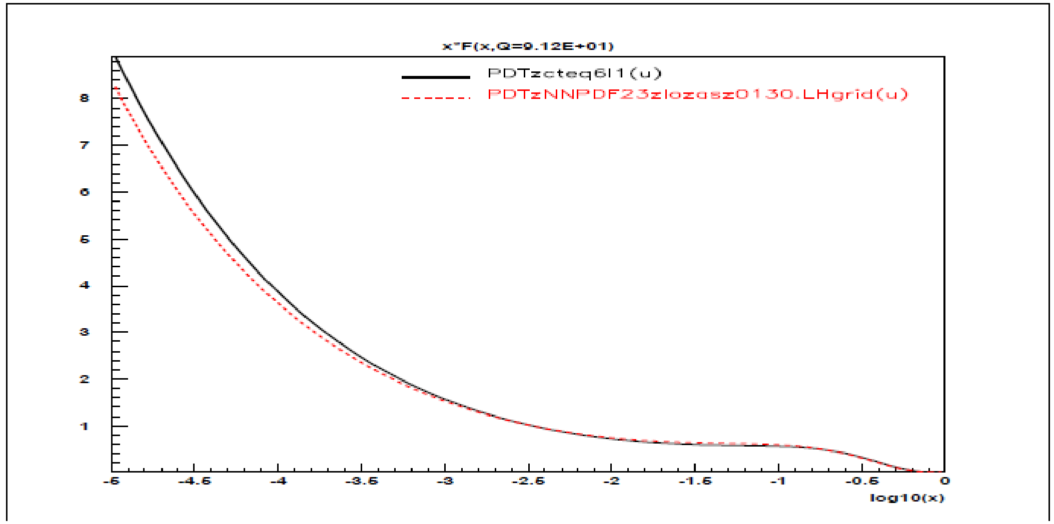
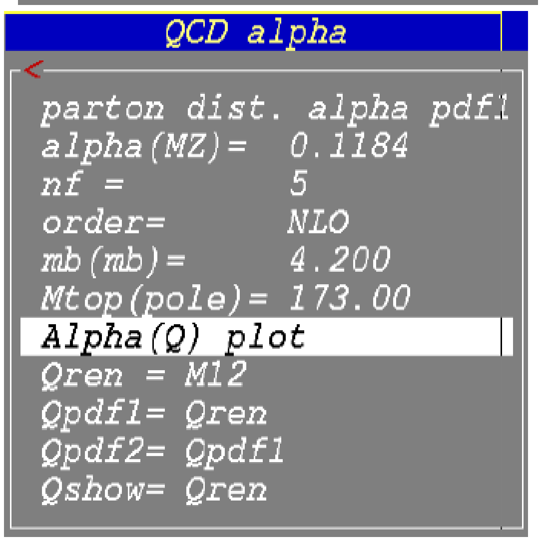
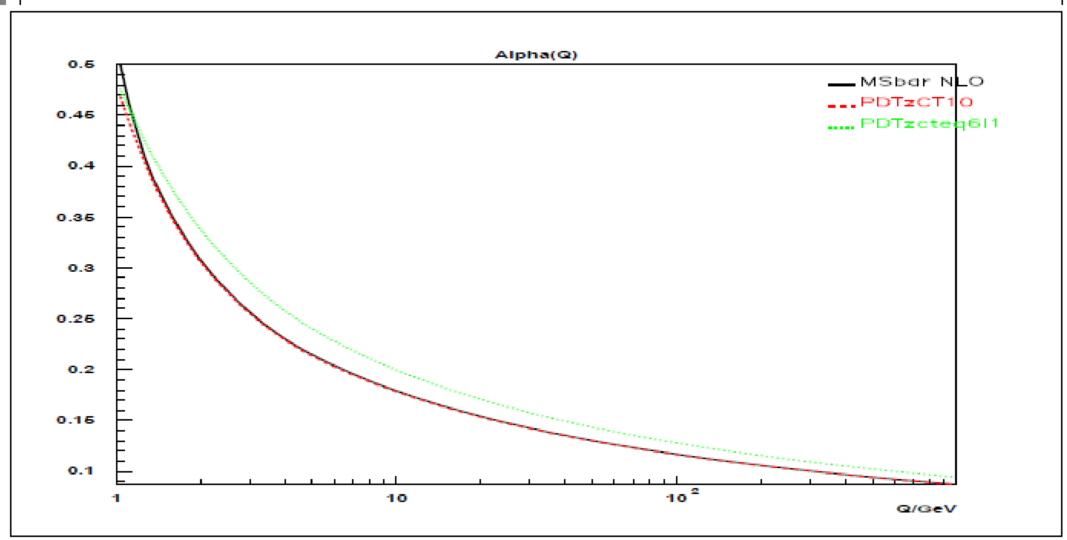
- **PDFs and visualisation**









New/recent features of CalcHEP
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- **Connection to Delphes**

LHE → CheckMate2

- No intermediate HEPMC files
- PYTHIA8, can control it via cards
- Delphes3, can control it via cards
- Produces root files
- Can use CM statistical analysis routines and check the signal exclusio
- One can produce muldi-dim scan at HEPMDB and direct lhe files to CM2

New/recent features of CalcHEP
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- **Calling CalcHEP from the C-code**

  see Azaria's talk (also on CalcHEP applicaiton)