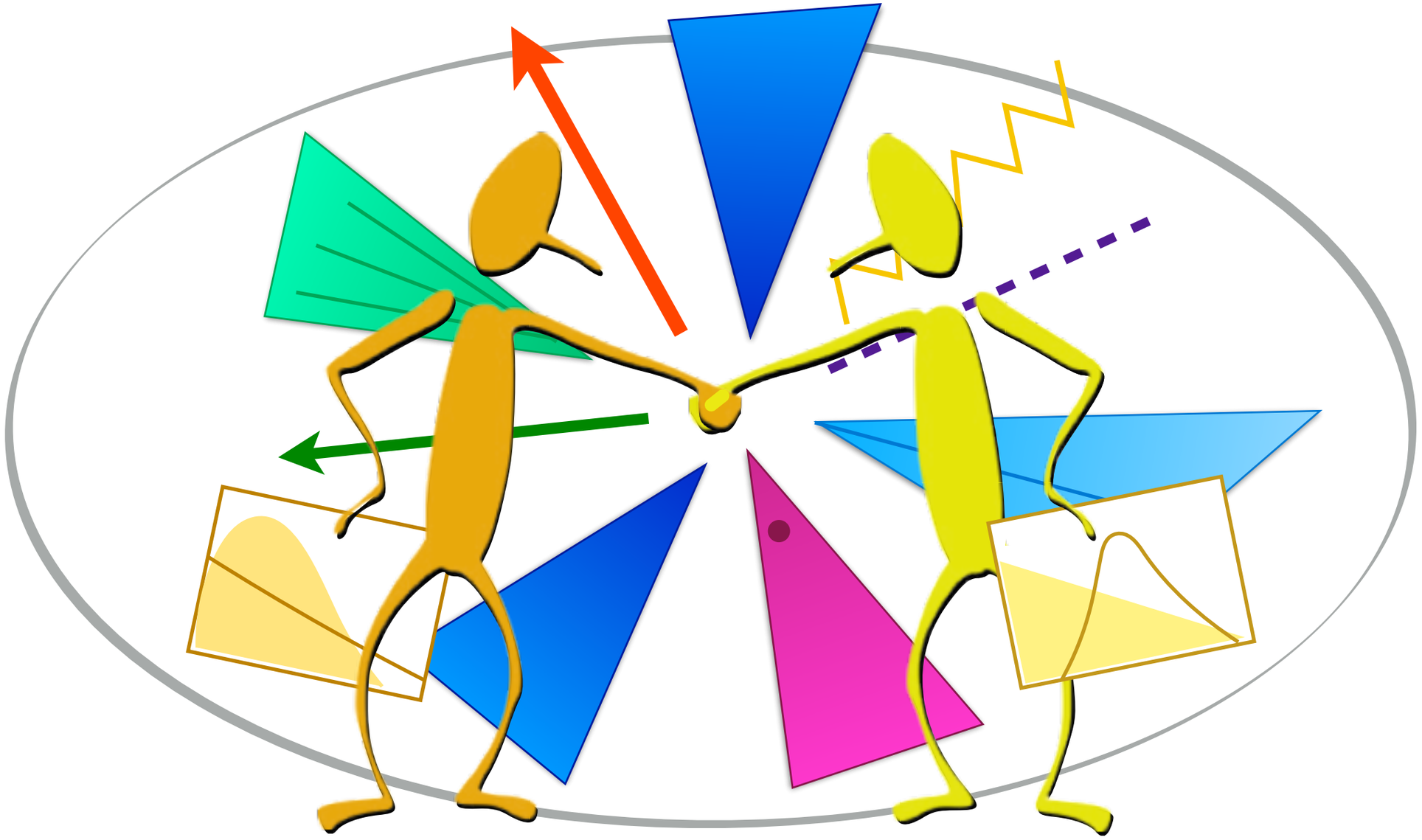

An analysis description accord for the LHC

Presenter: Sezen Sekmen (KNU)

Reinterpreting the results of new physics searches at the LHC
CERN, 15-17 June 2016

For a more enhanced LHC impact

the more we wish to enhance the LHC outcome,
the more systematically accessible the following need be:

- Data: Ongoing efforts by the LHC experiments to make their data public and accessible
- Simulation: Mostly Delphes, Rivet simulation, Falcon…
- Results: Experimental papers, HepData, twikis…
- Analyses: Experimental papers, code snippets including object or event variable definitions, interpretation frameworks designed by the pheno community, Rivet implementations, RECAST, …

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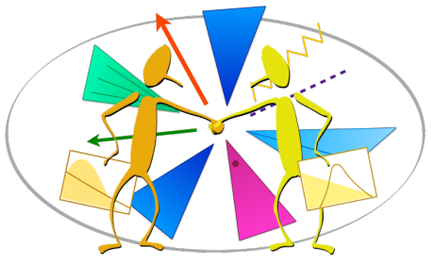
What can we do to further build
on the current practice?



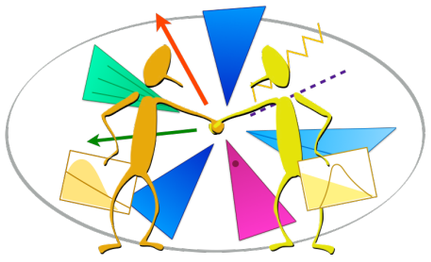
An LHC analysis description accord

We can design an analysis description accord for the LHC,

- which is an LHC standard capable of describing the contents of an analysis in an unambiguous way.
  - analysis details include all object and event selections, as well as quantities such as efficiencies, analytic and algorithmic observables, and advanced multivariate selections.
- which should be exploited by the whole LHC physicists to abstract, visualize, validate, combine, reproduce, interpret, and communicate the contents of LHC analyses.

Earlier similar efforts proved to be very successful and useful:

- Les Houches Event Accord
- SUSY Les Houches Accord



An LHC analysis description accord

We thoroughly discussed this concept at:

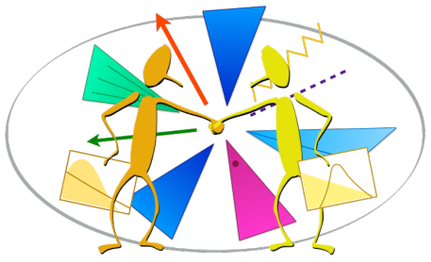
- The Les Houches PhysTeV 2015 workshop (10-19 Jun 2015)
- A dedicated workshop at LPSC Grenoble (25-26 Feb 2016)

The outcome is summarized in Les Houches 2015 new physics WG report (arXiv:1605.02684)

Towards an analysis description accord for the LHC

D. Barducci, A. Buckley, G. Chalons, E. Conte, N. Desai, N. de Filippis, B. Fuks, P. Gras, S. Kraml, S. Kulkarni, U. Laa, M. Papucci, C. Pollard, H. B. Prosper, K. Sakurai, D. Schmeier, S. Sekmen, D. Sengupta, J. Sonneveld, J. Tattersall, G. Unel, W. Waltenberger, A. Weiler.

Abstract: We discuss the concept of an “analysis description accord" for LHC analyses, a format capable of describing the contents of an analysis in a standard and unambiguous way. We present the motivation for such an accord, the requirements upon it, and an initial discussion of the merits of several implementation approaches. With this, we hope to initiate a community-wide discussion that will yield, in due course, an actual accord.



Motivations for an accord - I

Analysis preservation

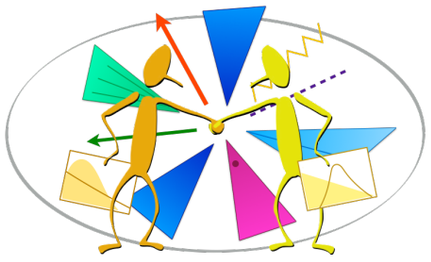
- Full details of an analysis usually only exists in the dedicated analysis frameworks, which can be lost as the original analysts become unavailable.
- A stable and universal accord ensures analysis preservation and a stronger LHC legacy.

Analysis design

- An accord abstracts the analysis from technical details. It provides a powerful route to explore analysis ideas, and directly develop and execute analyses.

Analysis review

- A universal accord familiar to the whole community, facilitates understanding and reviewing an analyses.



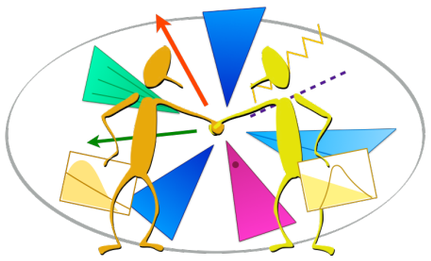
Motivations for an accord - II

Interpretation studies and analysis reimplementation

- A universal accord will make it easier for scientists of all backgrounds to understand an analysis in full detail needed for replication —> a far better interpretation of the LHC results, especially in case of discovery.

Easier comparison of analyses

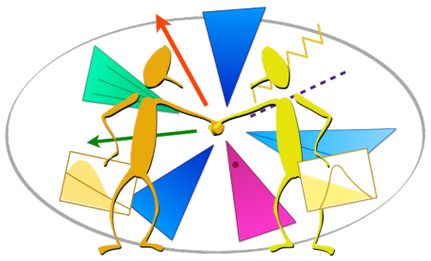
- An accord offers a practical and reliable way to compare definitions of search regions in different analyses which allow to
  - find disjoint regions and combine analyses
  - find unexplored final states and design dedicated analyses.



Disclaimer / use cases

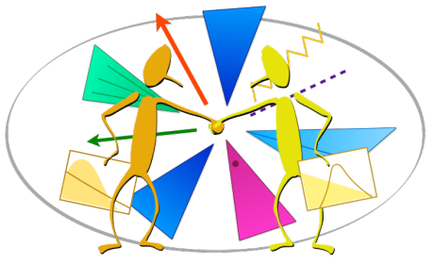
This accord should not be perceived as service from experimental community to the theory/pheno community. We all benefit from it!

- It indeed would make sharing information easier, hence, enhance the scope and quality of interpretation studies.
- BUT - it is equally beneficial for experimentalists as a tool to implement, execute, communicate, visualize and preserve their analyses internally in full detail.
- It can also be used for implementing new analysis ideas from the pheno side. Pheno papers could include an accord implementation of their analysis ideas, and experimentalists can start directly with these implementations.
- It can even be used by the curious public on open data, for understanding and contributing to our work!



Properties of the accord: Basic requirements

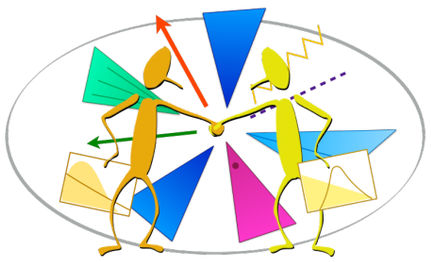
- Publicly available: Format or tools (not the content!) must be publicly available to the whole LHC physics community. Ultimate goal is to preserve analyses in an analysis database.
- Complete: The accord must be able to host all information needed for an accurate expression of an analysis.
- Long lasting: The accord must have a format stable enough to withstand evolutions in computing, and achieve backward-compatibility.
- Correct and validatable: Even the best programmers can make mistakes. So the accord should be programmatically parseable and runnable to allow automated validation of its contents and expected output.



Properties of the accord: Desirable features

- Human readable and writeable: Accord format should be simpler compared to equivalent analysis code.
- Self-contained: Better consist of a single file or a collection of files that can be archived in a single location.
- Language-independent: Flexibility of computer languages would obscure the analysis description. Moreover, evolution of languages is makes difficult to achieve a persistent accord.
- Framework-independent: Analysis teams use different frameworks, and a universal agreement is hard to achieve. Also, frameworks quickly evolve, so framework-independency would achieve a more robust accord.
- Supports combination of analyses: To easily combine analyses, accord should state how different analyses and search regions are correlated.

Not all requirements and features are simultaneously achievable!



Different approaches to an accord

	Analysis description language	Pseudocode (or real standalone code)	Analysis framework code +metadata
Definition	New language tailored for analysis description. Requires parser.	Express full detail in pseudocode or actual executable code	Standard public analysis framework.
Pros	Easiness, control, human readability	Algorithmic completeness	Algorithmic completeness, unambiguous, validatable.
Cons	difficult to express full algorithmic detail	Pseudocode not runnable. Full code not universal and human readable.	Not universal and human readable.

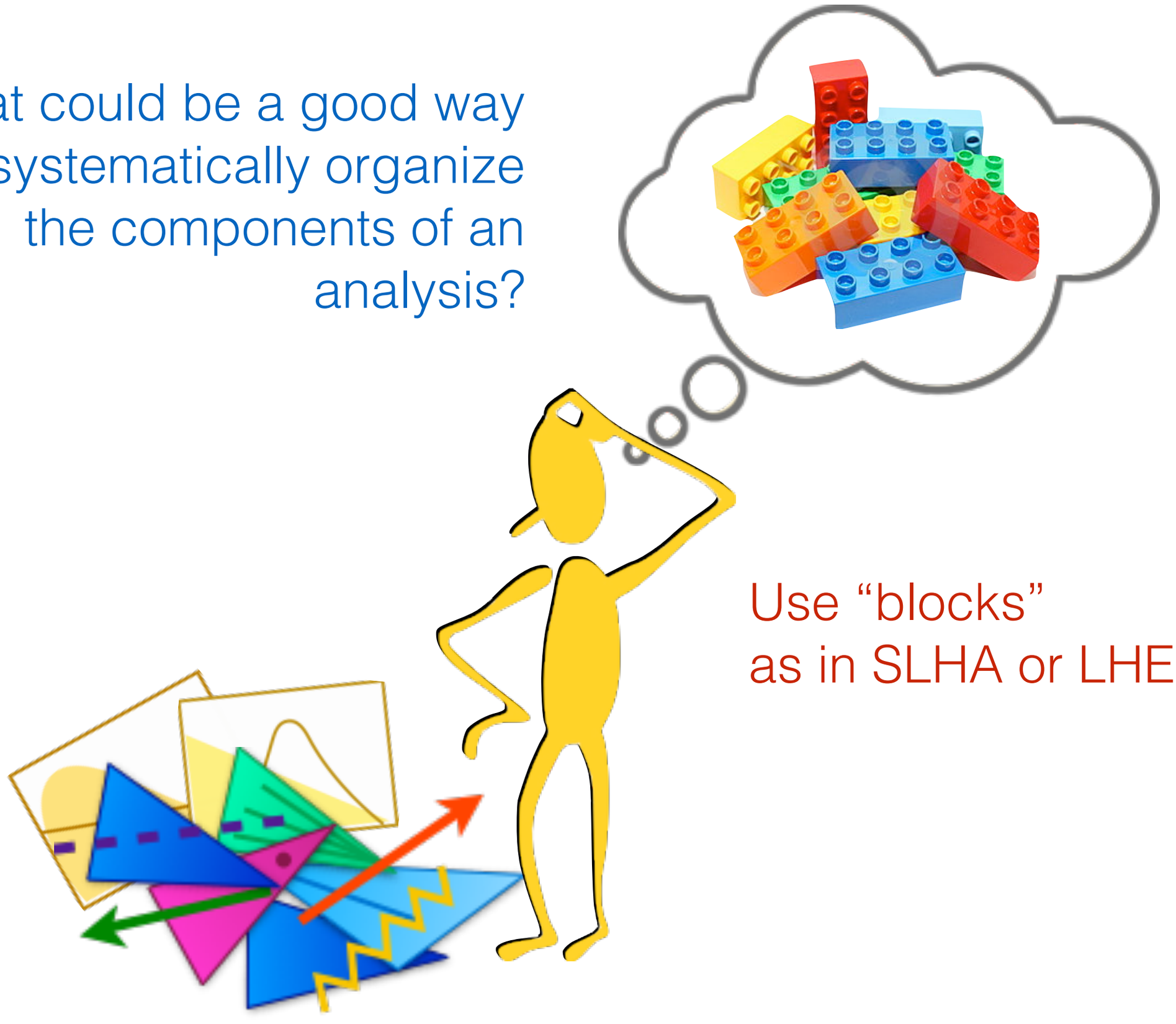
Questions to discuss: Which one is the optimal solution?
Is there a 4th approach that is far better?

A proposal based on the “analysis description language” way:

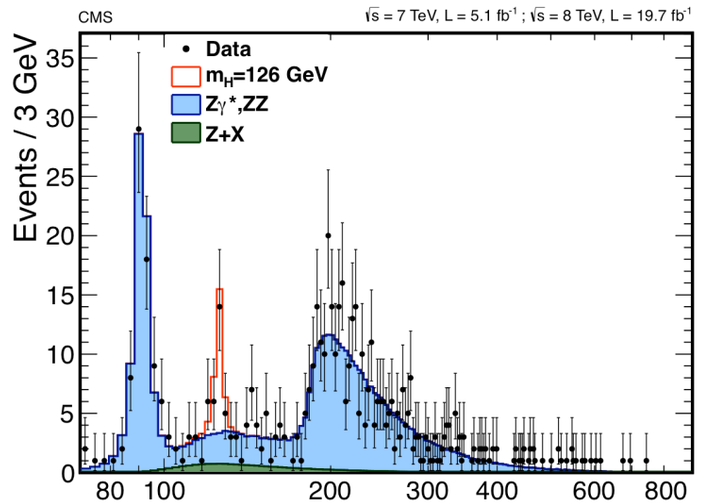
What could be a good way to systematically organize the components of an analysis?

One proposal based on an analysis description language:

What could be a good way to systematically organize the components of an analysis?



Use “blocks”
as in SLHA or LHE.



A proposal for a Les Houches Analysis Description Accord

D. Barducci, G. Chalons, N. Desai, N. de Filippis, P. Gras, S. Kraml, S. Kulkarni, U. Laa, M. Papucci, H. B. Prosper, K. Sakurai, D. Schmeier, S. Sekmen, D. Sengupta, J. Sonneveld, J. Tattersall, G. Unel, W. Waltenberger, A. Weiler.

Abstract: We present the first draft of a proposal for “a Les Houches Analysis Description Accord" for LHC analyses, a formalism that is capable of describing the contents of an analysis in a standard and unambiguous way independent of any computing framework. This proposal serves as a starting point for discussions among LHC physicists towards an actual analysis description accord for use by the LHC community.

LH 2015 New Phys WG report (arXiv:1605.02684)

A proposal for a “LHADA”

This first LHADA proposal aims to primarily fulfil

- human readability
- computer language independence.
- framework-independence, BUT…

This approach does not oppose analysis frameworks.
On the contrary, it aims to offer a standard analysis input to frameworks (just like SLHA does to SUSY calculators).
It gives us the freedom to develop or use whatever framework we like!

It consists of

- a plain text file describing the analysis, which uses a dedicated language with a strict set of syntax rules and a limited number of operators.
- library of self-contained functions encapsulating variables nontrivial to express (e.g. MVAs, advanced kinematic variables, …)

Analysis description file syntax

An analysis description file is a plain text file that consists of easy-to-read blocks with a key value structure.

```
blocktype blockname
  # general comment
  key value
  key2 value2
  key3 value3 # comment about value3
```

- Allows clear separation of individual analysis components.
- Same key can appear multiple times.
- 5 types of blocks (for now): `info` `function` `object` `cut` `table`
- 18 keywords (for now):

```
apply  arg  bin  code  columns  cut  doc  entry  function
hepdata  info  object  reject  select  table  take  type  weight
```

- Can be automatically converted into any computing language format.

Blocks: `info`

Provides general information about the analysis, e.g. publication information, benchmark scenarios, event generators used, validation material, etc.

(Minimally required or optional keys to be decided later.)

```
info analysis
  # Details about experiment
experiment ATLAS
id SUSY-2013-15
publication JHEP11(2014)118
sqrtS 8.0
lumi 20.0
arXiv 1407.0583
hepdata http://hepdata.cedar.ac.uk/view/ins1304456
```

Blocks: `function`

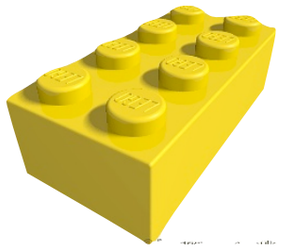
Defines all non-trivial operations that are calculated during the analysis.

- e.g.: advanced kinematic variables, e.g. transverse mass or variables created using machine learning methods, and filtering algorithms, e.g. lepton isolation definitions.

```
function function_name
  arg name1
  arg name2
  code link-to-code-repository
  doc link-to-documentation
```

arg: arguments to be respectively called by their names

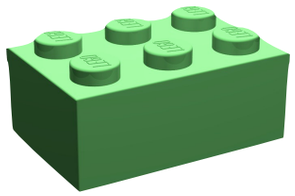
- Individual function codes can be automatically updated as languages evolve, but LHADA file itself stays constant and valid.
- Allows to create a library of reusable, sharable functions.



Blocks: function

```
function mT2
  # stransverse mass
  arg vis1 # First visible 4-momentum vector
  arg vis2 # Second visible 4-momentum vector
  arg invis # Invisible transverse 4-momentum vector
  arg mass # Assumed mass of the invisible particle
  doc http://inspirehep.net/record/617472?ln=en # original publ.
  code http://goo.gl/xLyfN0 # code example from oxbridge package
```

```
function isol
  # Sums up activity in the vicinity of a given candidate
  arg cand # object whose isolation is to be computed
  arg src # "calo", "tracks", "eflow"
  arg dR # dR cone to be probed
  arg relIso # divide by candidate's pt?
  code ...
  doc ...
```

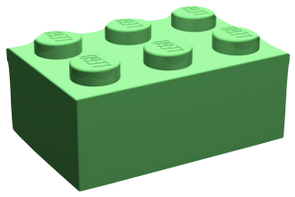


Blocks: `object`

Defines all objects that are used in event selection.

- Objects can be defined at the truth or detector level depending on the purpose of the analysis.
- Some objects can be processed versions of other objects (electron —> isolated electron)
- Some objects can be provided from external sources.

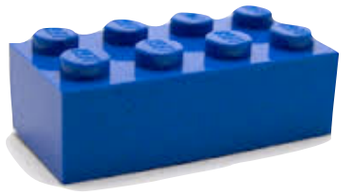
```
object jets
  # clustered jets from the calorimeter cells
  take external
  apply antikt(dR=0.4, ptmin=20, etamax=2.5)
  code ...
  doc ...
```



Blocks: `object`

```
object mu
  # Muons
  take external
  apply detector_muons(workingpoint=combined)
  select pt > 10
  select |eta| < 1.5
  select isol(src=tracks, dR=0.4, reliso=true)<0.1
  doc ...
```

```
object ele_l
  # loose electrons
  take external
  apply detector_electrons(workingpoint=loose)
  select pt > 5
  select |eta| < 2.5
  select isol(src=tracks, dR=0.4, relIso=true)<0.1
  reject overlaps(neighs=mu, dR=0.4)
  doc 10.1140/epjc/s10052-014-2941-0 # doi to ATLAS ID def.
```

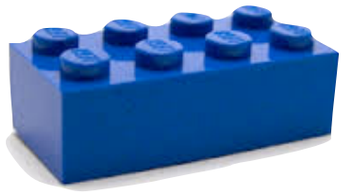


Blocks: `cut`

Defines event selection criteria that are applied to a given event in order to define analysis regions, e.g. preselection, signal, control.

- select and reject are boolean keys.
  Complex logical statements are possible.
- modular selection: a cut block itself can be considered as a boolean constraint in another block
- weight key enables event reweighting
- bin key enables binning of analysis regions

```
cut preselect
  # Pre-selection cuts
  weight triggerefficiency(leptonpt = lep[1].pt)
  reject lep.size > 1
  select lep[1].pt > 75
  select jets.size > 2
```



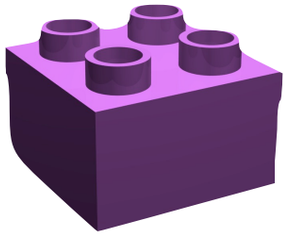
Blocks: `cut`

```
cut leadjets_1
  select jets[1].pt >= 60
  select jets[2].pt >= 40

cut SRBtoF
  select preselect
  select leadjets_2
  bin met.pt = 100,125,150,200
```

```
cut noZ
  # define a region outside the Z mass range
  select mll < 70 or mll > 100

cut razor
  # Define the ladder-like razor region
  select (MR>100 and R2>0.8) or (MR>300 and R2>0.5) or
(MR>500 and R2>500)
```

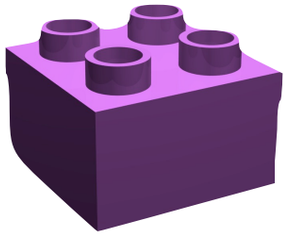


Blocks: `table`

Tabular collection of numerical information related to the analysis.

Examples: analysis results, cutflows, histograms, numerical efficiencies or other numerical functions, etc.

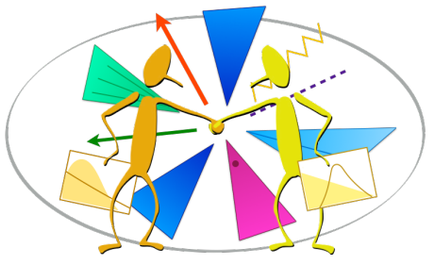
```
table results_events
  # Table for basic observed-signal and background events
type events
columns name obs bkg dbkg
entry SRA 3452 3452 59
entry SRBtoF[0] 1712 1720 161
entry SRBtoF[1] 313 295 50
entry SRBtoF[2] 201 235 34
```



Blocks: `table`

```
table result_corr
  # Correlation matrix for signal regions
  type corr
  columns name SRA SRBtoF[0] SRBtoF[1] SRBtoF[2] SRBtoF[3]
  entry SRA 1 0.2 0.1 0.15 0.14
  entry SRBtoF[0] 0.2 1 0.5 0.4 0.3
  entry SRBtoF[1] 0.1 0.5 1 0.3 0.2
  entry SRBtoF[2] 0.15 0.4 0.3 1 0.7
  entry SRBtoF[3] 0.14 0.2 0.2 0.7 1

table result_bkg
  # Breakdown of background in different signal regions
  type bkg
  columns name Z_jets Z_jets_err W_jets W_jets_err ...
  entry SRA 1726 254 1151 178 ...
  entry SRBtoF[0] 856 89 571 76 ...
  entry SRBtoF[1] 157 27 105 18 ...
  entry SRBtoF[2] 101 19 67 12 ...
  entry SRBtoF[3] 1009 156 674 56 ...
```



Towards an accord

We would all benefit from an analysis description accord

- Experimentalists
- Theorists/phenomenologists
- The curious public.

Let us continue the discussion together to reach the best solution for all of us!

First LHADA proposal

Primary design goal: universality through framework independence, and accessibility through human readability.

Aims to provide standard analysis description input for analysis frameworks.

A consistent analysis description language syntax + sharable library of functions.