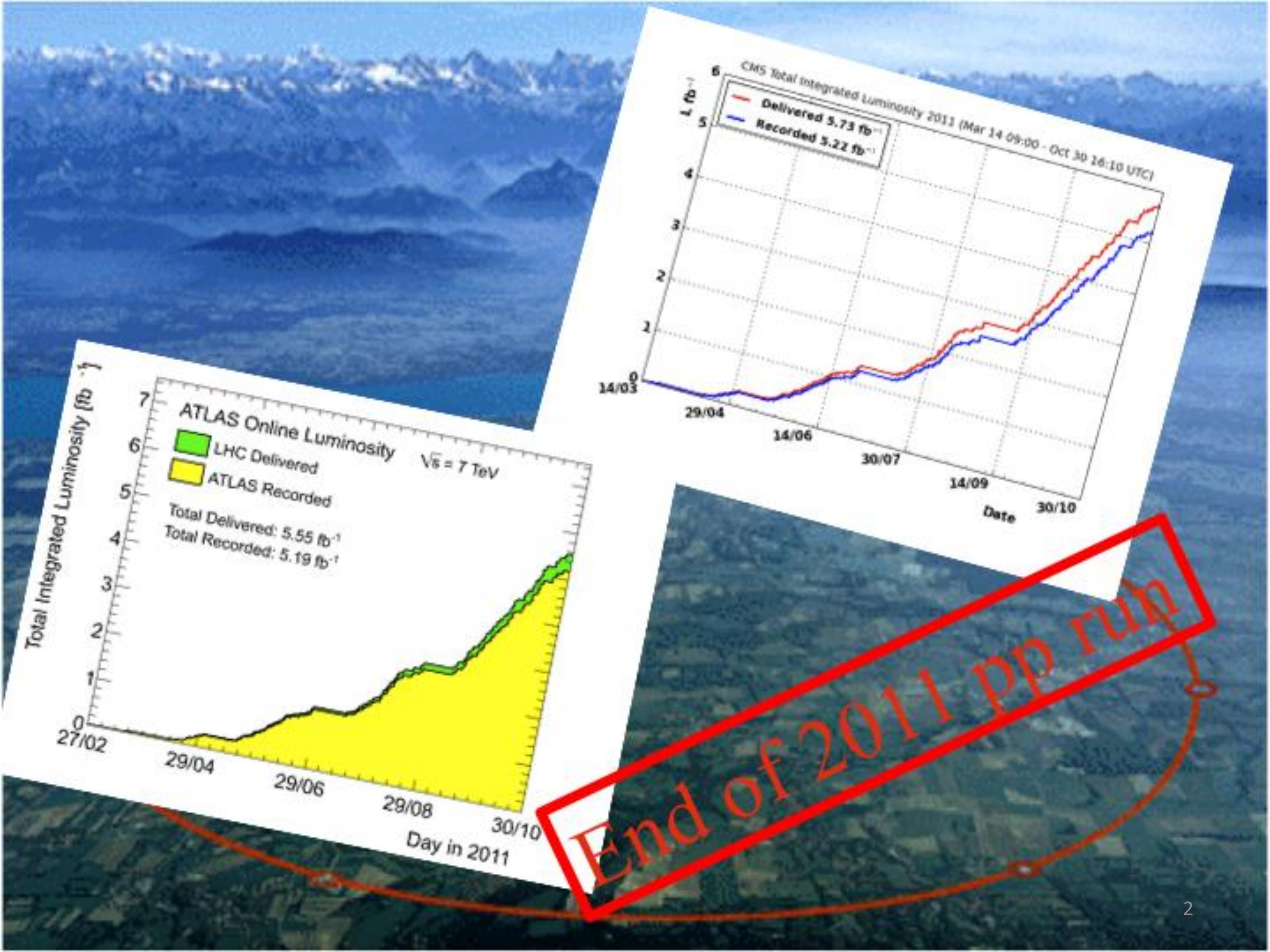
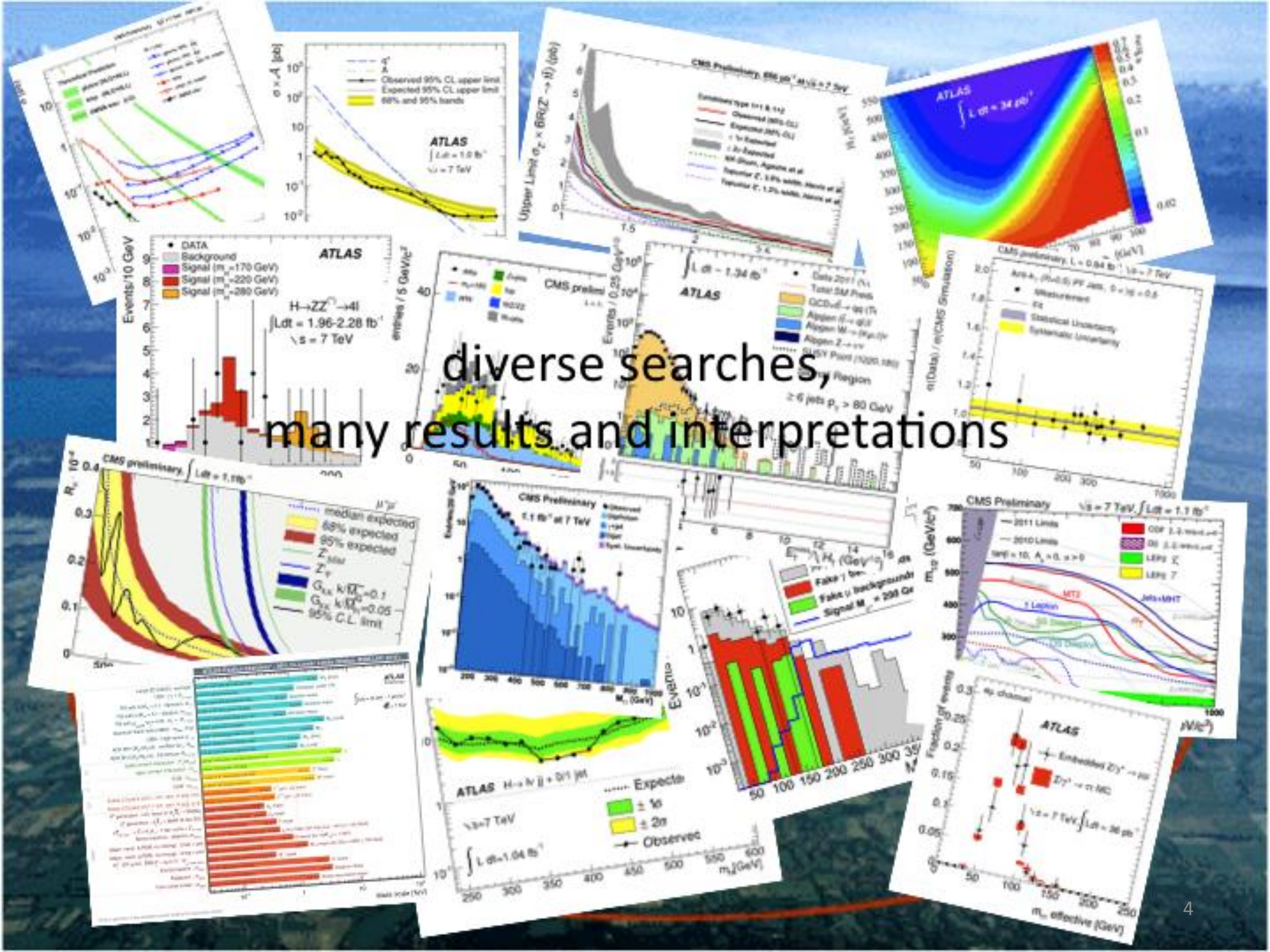

CMS Total Integrated Luminosity 2011 (Mar 14 09:00 - Oct 30 16:10 UTC)
Delivered 5.73 fb⁻¹
Recorded 5.22 fb⁻¹
L fb⁻¹
14/03
29/04
14/06
30/07
14/09
30/10
Date
ATLAS Online Luminosity
LHC Delivered
ATLAS Recorded
√s = 7 TeV
Total Delivered: 5.55 fb⁻¹
Total Recorded: 5.19 fb⁻¹
Total Integrated Luminosity [fb⁻¹]
27/02
29/04
29/06
29/08
30/10
Day in 2011
End of 2011 pp run

"Data are coming! Data are coming!"



diverse searches,

many results and interpretations

and diverse ideas,
diverse models
to be tested


We'd like to make
the most of the
LHC results

We discussed this question during the Les Houches Physics at TeV Colliders workshop in June 2011 and came up with a list of *recommendations for presenting the LHC results*.

The intent of these recommendations is to encourage a more systematic and clearer presentation of the LHC results, with the goal of fostering more and better science.

Many thanks to Sabine Kraml, Harrison Prosper, Kyle Kranmer, Filip Moortgat, Nazila Mahmoudi, Ben Allanach, Marta Felcini and many others for concrete contributions and suggestions.

The nature of recommendations

The most creative and productive usage of the LHC results can be achieved by the contribution of colleagues both inside and outside the collaborations to the effort. Therefore, we base our recommendations on the following principles

- What has been observed should be clear to a non-collaboration colleague
- How it has been observed should be clear to a non-collaboration colleague
- A competent non-collaboration colleague should be able to use the public results without the need to consult collaboration insiders.

Our recommendations fully recognize and respect the intellectual property rights of collaborations and individual scientists.

Results versus interpretation

We think it useful to distinguish between experimental results and their interpretation and suggest to use the following definitions for these terms:

- An experimental result is exclusively whatever is actually observed. It is the actual outcome, such as an event count or the measurement of a physical quantity.
- Interpretation is the act of comparing these experimental results/ measurements to predictions of physics models.

While an analysis may have been guided by a specific physics model, the experimental results are ideally independent from the physics model.

The nature of experimental results

Abstractly every analysis is simply a map:

Experimental (post-analysis) result

$$y = f(x)$$

Pre-detector data from particles before they interact with the detector (only available in simulation

Convolution of the
- detector response
- reconstruction
- analysis.

In the simplest case, this yields a count N. More generally, the results could be several counts or a sample of events each characterized by a set of measured quantities some of which may be complicated non linear functions of simpler ones.

Recommendations

Our recommendations fall into three broad categories

- Analysis description
- Detector modeling
- Analysis dissemination

Please note that the recommendations are not ordered according to importance.

Analysis description

Explicit description of the analysis

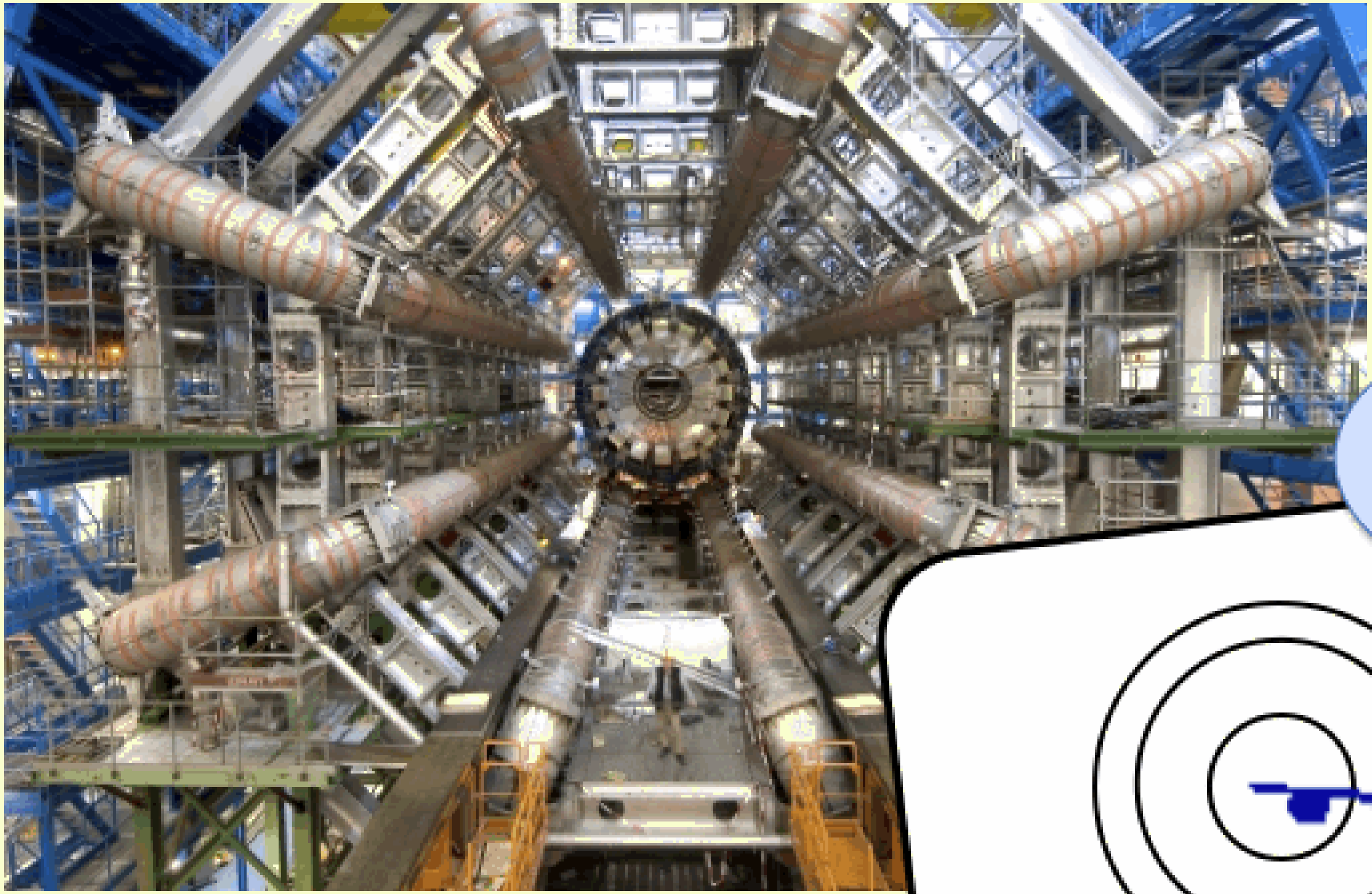
A clear description of an analysis is essential for its reproduction.

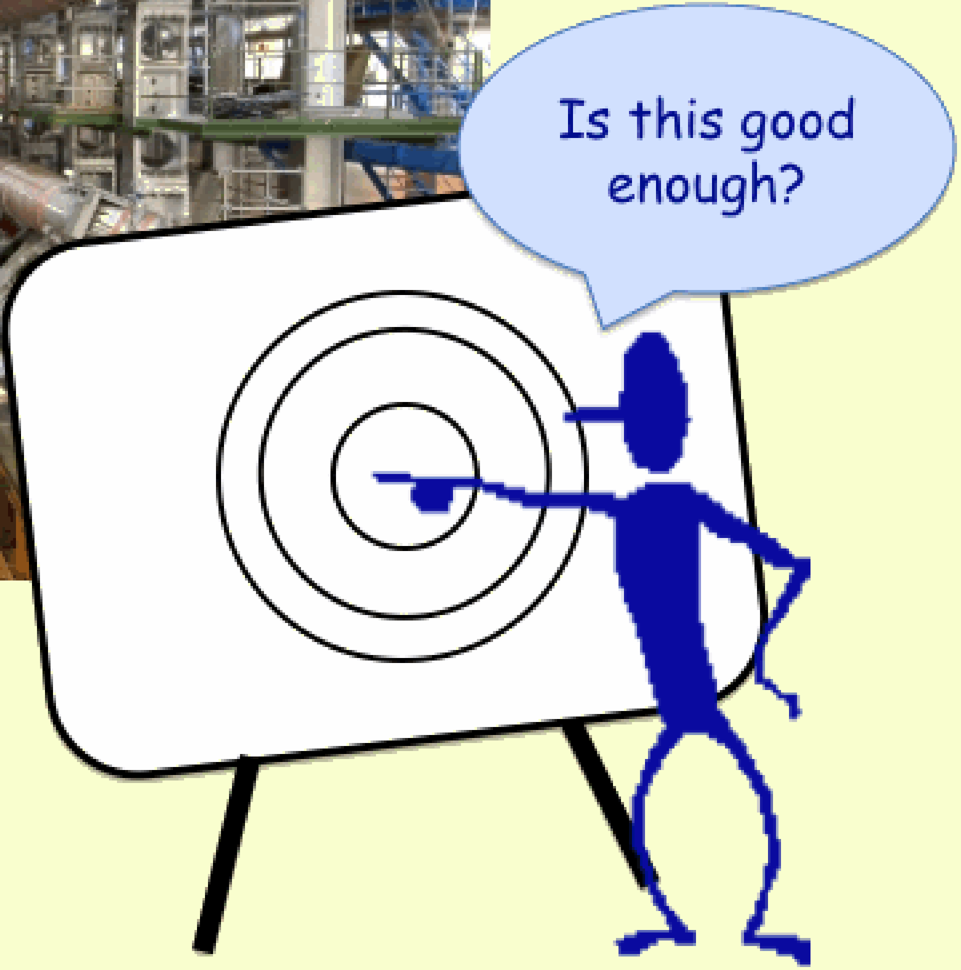
Recommendation 1: *Provide a clear, explicit, preferably tabulated description of the analysis in publications. A concrete way to validate the completeness, and clarity, of the description is to encourage colleagues not involved in the details of the analysis, to try to reproduce the results of an interpretation that is intended to be published by the collaboration along with the experimental results.*

Analysis database

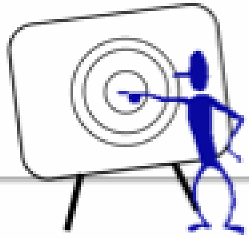
Recommendation 2: *Provide an analysis database where all the experimental results can be systematically stored together with all necessary information about the analyses, including well-encapsulated functions, such as MVA functions if they are needed.*

While the following is not listed as a recommendation, we suggest a move in that direction. It would be extremely useful, and elegant, to design the infrastructure of analyses in a highly modular fashion so that cuts that define event selections, or object definitions, or codes that perform kinematic reconstructions, or that compute the variables on which an analysis is based, are all encapsulated in well-defined functions that are independent of the provenance of the data they use. This is possible if collaborations foster the discipline of decoupling such functions from their internal software infrastructure and then adding such functions to the analysis database.





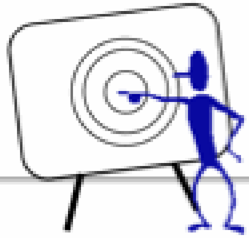
Detector modeling



Detector simulation

We need a public, reliable, easy-to-use and preferably fast simulation package endorsed and maintained by the LHC experimental collaborations. This is especially crucial while interpreting results in terms of models with many parameters and large parameter spaces.

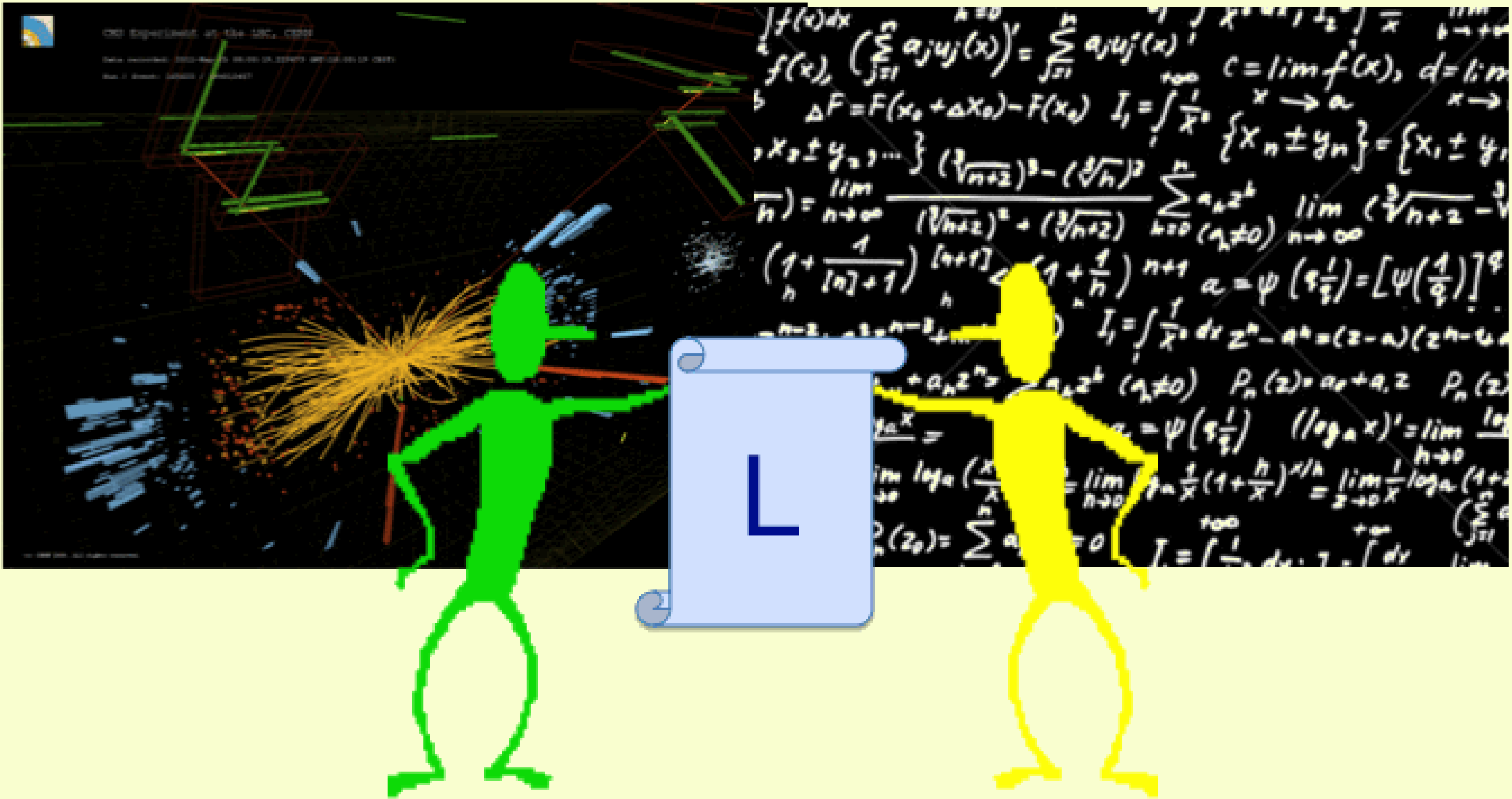
Recommendation 3: *Provide and maintain a public simulator developed by the collaboration, or provide official support of an existing one. The public simulator should provide the mapping from the pre-detector data to the post-reconstruction data.*



Efficiency maps

Analyses often use different definitions of analysis objects, (e.g. different electron isolation criteria), or different definitions for triggers (e.g. different missing ET thresholds which lead to different turn-on curves). A well-understood way to hide such complexity from a potential analyst is to provide efficiency maps for each candidate object. Indeed, experiments are providing efficiency maps along with some analyses. But, these are generally provided as plots, which presents an obstacle.

Recommendation 4: *Provide efficiency maps (having dimensionality required by correlations) whenever possible, and provide them in standard functional forms that can be easily plugged into any public simulator.*



Analysis dissemination

The minimum requirement

Many published papers already present experimental results in a clear, concise manner. The recommendations below are intended to encourage and enhance this good practice

Recommendation 5: *Provide all crucial numbers.*

"The crucial numbers" depend on the nature of the analysis.

The minimum requirement for a single bin

N : the number of observed events in the signal region,
B : the background estimate,
δB : the background uncertainty,
L : the integrated luminosity estimate
δL : the integrated luminosity uncertainty.

If background estimate is the result of extrapolating from a control region to the signal region, following should also be included

Q : the number of events in the control region, either from real or simulated data,
δQ : the uncertainty in Q
k : the ratio of expected background in the control region to the expected background in the signal region. And if the uncertainty δk on k is not negligible, it should be included too.

For a multi-bin analysis, these numbers should be given for each bin.

Systematic uncertainties for multi-bin results

We need a way to consider systematic uncertainties in multi-bin analyses which takes into account the statistical dependencies across bins. it is common practice to include systematic uncertainties by integrating over systematic parameters. We include the following recommendation, which provides a straightforward way to perform this integration.

Recommendation 6: *For multi-bin results, provide an ensemble of sets of the numbers* B; δB; L; δL, Q, δQ, k, *etc. created by sampling from the various experiment-specific systematic effects, such as the jet energy scale (JES), jet energy resolution (JER), etc. Systematic uncertainties external to the experiment, such as uncertainties in parton distribution functions (PDFs), should not be included because they induce correlations across experiments. These uncertainties can be included at a later stage.*

The full likelihood - I

The statistical model of an analysis provides the complete mathematical description of that analysis. It relates the observed quantities o to the parameters x through the probability density $p(o|x)$.

The likelihood $p(O|x)$ is the probability density $p(o|x)$ evaluated at the observed values O of the observables o.

The likelihood ought to be the starting point for any serious interpretation.

Knowing the full likelihood is especially helpful for modeling the cases with non-Gaussian tails, when the uncertainties are large.

The full likelihood - II

Recommendation 7: *Provide the mathematical description of the full likelihood function in which experimental data and parameters are clearly distinguished. We recommend the convention of using upper case letters for experimental data and lower case letters for parameters.*

Recommendation 8: *Provide a ROOSTATS implementation of the likelihoods that is consistent with the mathematical description.*

Presentation of the interpretation of experimental results

Experiments commonly publish model interpretations of their search results. But interpretations are generally provided as plots, which create difficulties while trying to use them.

> Recommendation 9: *Provide the interpretation of experimental results (for example, a 95% CL exclusion curve in a model plane) in a more accessible manner, e.g., as lists of numbers, or self-contained functions, or histograms in a ROOT file.*


If I'd known they wanted me to use all this info – I would never have asked for it!
Julie

Conclusions

- We have shown a list of recommendations for presenting the LHC results, which were based on discussions during the Les Houches Physics at TeV Colliders workshop, in June 2011.
- A report on these recommendations is in its final stage of preparation.
- These recommendations intend to encourage a clearer and more systematic presentation of the LHC results, which, we hope, will lead to more productive and creative interpretation studies.
- We believe that our experimental colleagues will benefit at least as much as our theory colleagues, by following these recommendations.