

LPCC workshop on

Likelihoods for LHC Searches

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$$\mathcal{L}(\theta) = p(x_0 | \theta)$$

Why likelihoods?

The **statistical model** of an analysis provides the **complete mathematical description** of that analysis.

It relates the observed quantities x to the parameters θ through the probability density $p(x | \theta)$.

The **likelihood** $L(\theta) = p(X_0 | \theta)$ is the probability density $p(x | \theta)$ evaluated at the observed values X_0 of the observables x .

A likelihood is the starting point of any serious interpretation.

Why this workshop?

The goals of the workshop are to

- educate the LHC community about the scientific utility of likelihoods
 - describe and discuss real world examples of likelihoods in LHC physics, in particular in Higgs and BSM searches.
- move towards realizing the Les Houches Recommendations for the Presentation of LHC Results (3a, 3b, 3c).

Searches for New Physics: Les Houches Recommendations for the Presentation of LHC Results

S. Kraml, B.C. Allanach, M. Mangano, H.B. Prosper, S. Sekmen (editors),
C. Balazs, A. Barr, P. Bechtle, G. Belanger, A. Belyaev, K. Benslama,
M. Campanelli, K. Cranmer, A. De Roeck, M.J. Dolan, T. Eifert, J.R. Ellis,
M. Felcini, B. Fuks, D. Guadagnoli, J.F. Gunion, S. Heinemeyer,
J. Hewett, A. Ismail, M. Kadastik, M. Kraemer, J. Lykken, F. Mahmoudi,
S.P. Martin, T. Rizzo, T. Robens, M. Tytgat, A. Weiler

“We present a set of recommendations for the presentation of LHC results on searches for new physics, which are aimed at providing a more efficient flow of scientific information between the experimental collaborations and the rest of the high energy physics community, and at facilitating the interpretation of the results in a wide class of models. Implementing these recommendations would aid the full exploitation of the physics potential of the LHC.”

arXiv:1203.2489, Eur.Phys.J. C72 (2012) 1976

Recommendations on analysis dissemination: Basic requirements

Recommendation 3a: *Provide all crucial numbers regarding the results of the analysis, preferably in tabulated form in the publication itself. Further relevant information, like fit functions or distributions, should be provided as auxiliary material.*

Addendum to 3a: *For multi-bin results, provide an ensemble of sets of the numbers B , δB , L , δL , Q , k , etc in the auxiliary information. These would be created by sampling from the various experiment-specific systematic effects, such as the jet energy scale, jet energy resolution, etc. Results should be quoted without inclusion of systematic/theoretical uncertainties external to the experiment.*

B: BG estimate, **L:** Luminosity estimate, **Q:** Observed number of events in the control region, **k:** expected BG in control region / expected BG in signal region

Recommendations on analysis dissemination: Full likelihood

Recommendation 3b: *When feasible, provide a mathematical description of the final likelihood function in which experimental data and parameters are clearly distinguished, either in the publication or the auxiliary information. Limits of validity should always be clearly specified.*

Recommendation 3c: *Additionally provide a digitized implementation of the likelihood that is consistent with the mathematical description.*

What is in this workshop?

- **Day 1 (Introduction)**: Lectures on likelihoods; introduction to the likelihoods in LHC searches; recommendations on the Higgs results.
- **Day 2 (Tools & Higgs)**: **HistFactory**, **Roofit** and workspaces; detailed description of the $h \rightarrow ZZ \rightarrow 4l$ likelihood in ATLAS; detailed discussion on Higgs combination in ATLAS and CMS
- **Day 3 (BSM & publication)**: Recommendations on BSM results and likelihoods; BSM likelihoods in ATLAS and CMS; **panel discussion** on systematic storage and publication of experimental results and likelihoods with representatives from **INSPIRE**, **HepData**, **Roofit** and **Roostats**.

Note that the workshop will be recorded.

Possible questions: Higgs and BSM likelihoods

- What likelihoods are available or being made available for the Higgs studies and BSM searches?
- What are the examples of analyses that go beyond a single count?
- What are the precise and detailed descriptions of the likelihoods?
- What are the assumptions underlying the likelihoods (e.g. is signal negligible in the sideband)?
- What are the approximations that were made?
- How exactly are the nuisance parameters treated?

Possible questions:

Tools for likelihoods and publication of likelihoods

- What tools are available now for publishing experimental results?
- How much effort is required to use these tools by “normal people” (i.e., not Kyle)
- What further developments are planned?
- Who have used these tools and how (e.g., are they used by theorists)?
- What support exists for users?

Workshop output

We intend to have a **results document** that

- summarizes the main ideas and elements of the workshop
- acts as a guide for publishing experimental results, including likelihoods

Thanks!

We thank the **LHC Physics Centre at CERN (LPCC)** for hosting this workshop.

We further thank LPCC for financially supporting 2 RooStats developers.

We thank the **TH Secretariat** for organizing the coffee breaks!

Let's have a fruitful workshop!

Long talks in this workshop are meant to be

detailed

sloooooooooow

and in-ter-rupt-ed

for clarifications and thoughtful discussions

We're looking forward to lots of discussions.

Your ideas and contributions are very welcome.

Thanks!