How to Read a Scientific Paper

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Reading a scientific paper is an **ACTIVE** task. It requires thinking critically as you read.

- You will often have to read a paper more than once
- You often will not read a paper straight through
- Different sections of a typical paper:

1. Abstract
2. Introduction
3. Details of measurement
4. Results
5. Conclusion
6. References

Abstract

- This is a **paper summary**
- A (tiny) bit of background & motivation
- Summarizes findings and main results
- Summarizes main conclusions

Abstract from HEP

Abstract

A search for the Standard Model Higgs boson in proton-proton collisions with the ATLAS detector at the LHC is presented. The datasets used correspond to integrated luminosities of approximately 4.8 fb^{-1} collected at $\sqrt{s}$ = 7 TeV in 2011 and 5.8 fb^{-1} at $\sqrt{s}$ = 8 TeV in 2012. Individual searches in the channels $H \to ZZ^{(*)} \to 4\ell$, $H \to \gamma\gamma$ and $H \to WW^{(*)} \to e\nu\mu\nu$ in the 8 TeV data are combined with previously published results of searches for $H \to ZZ^{(*)}$, $WW^{(*)}$, $b\bar{b}$ and $\tau^+\tau^-$ in the 7 TeV data and results from improved analyses of the $H \to ZZ^{(*)} \to 4\ell$ and $H \to \gamma\gamma$ channels in the 7 TeV data. Clear evidence for the production of a neutral boson with a measured mass of 126.0 ± 0.4 (stat) ± 0.4 (sys) GeV is presented. This observation, which has a significance of 5.9 standard deviations, corresponding to a background fluctuation probability of 1.7×10^{-9}, is compatible with the production and decay of the Standard Model Higgs boson.

Note the terminology: Terms are often specific to each subfield

Introduction

- Details **b**
- Gives re… …g on and why the…
- Poses th… …red in the paper
- So: **wha… …what they authors**

1. Introduction

The Standard Model (SM) of particle physics [1–4] has been tested by many experiments over the last four decades and has been shown to successfully describe high energy particle interactions. However, the mechanism that breaks electroweak symmetry in the SM has not been verified experimentally. This mechanism [5–10], which gives mass to massive elementary particles, implies the existence of a scalar particle, the SM Higgs boson. The search for the Higgs boson, the only elementary particle in the SM that has not yet been observed, is one of the highlights of the Large Hadron Collider [11] (LHC) physics programme.

Indirect limits on the SM Higgs boson mass of $m_H <$ 158 GeV at 95% confidence level (CL) have been set using global fits to precision electroweak results [12]. Direct searches at LEP [13], the Tevatron [14–16] and the LHC [17, 18] have previously excluded, at 95% CL, a SM Higgs boson with mass below 600 GeV, apart from some mass regions between 116 GeV and 127 GeV.

- Details hc … ng their results
- Should hc … can duplicate
- This is a di … as it can be highly tec

The SM Higgs boson production processes considered in this analysis are the dominant gluon fusion ($gg \rightarrow H$, denoted ggF), vector-boson fusion ($qq' \rightarrow qq'H$, denoted VBF) and Higgs-strahlung ($qq' \rightarrow WH, ZH$, denoted WH/ZH). The small contribution from the associated production with a $t\bar{t}$ pair ($q\bar{q}/gg \rightarrow t\bar{t}H$, denoted $t\bar{t}H$) is taken into account only in the $H \rightarrow \gamma\gamma$ analysis.

For the ggF process, the signal cross section is computed at up to next-to-next-to-leading order (NNLO) in QCD [22–28]. Next-to-leading order (NLO) electroweak (EW) corrections are applied [29, 30], as well as QCD soft-gluon re-summations at up to next-to-next-to-leading logarithm (NNLL) [31]. These calculations, which are described in Refs. [32–35], assume factorisation between QCD and EW corrections. The transverse momentum, p_{T}, spectrum of the Higgs boson in the ggF process follows the HqT calculation [36], which includes QCD corrections at NLO and QCD soft-gluon re-summations up to NNLL; the effects of finite quark masses are also taken into account [37].

For the VBF process, full QCD and EW corrections up to NLO [38–41] and approximate NNLO QCD corrections [42] are used to calculate the cross section. Cross sections of the associated WH/ZH processes (VH) are calculated including QCD corrections up to NNLO [43–45] and EW corrections up to NLO [46].

- Describes
- Explains th

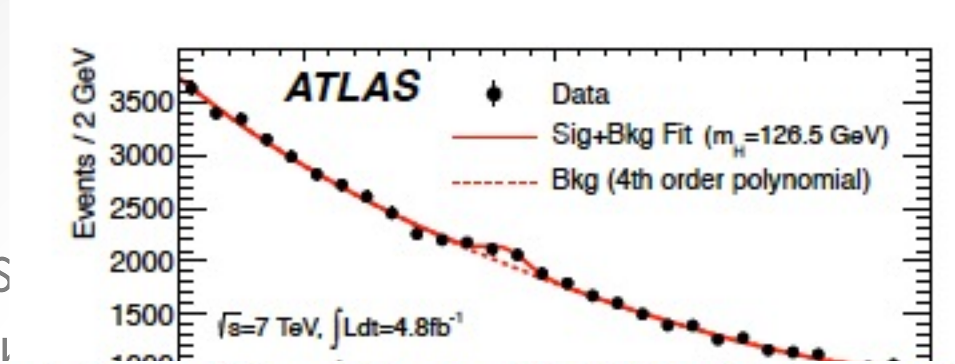
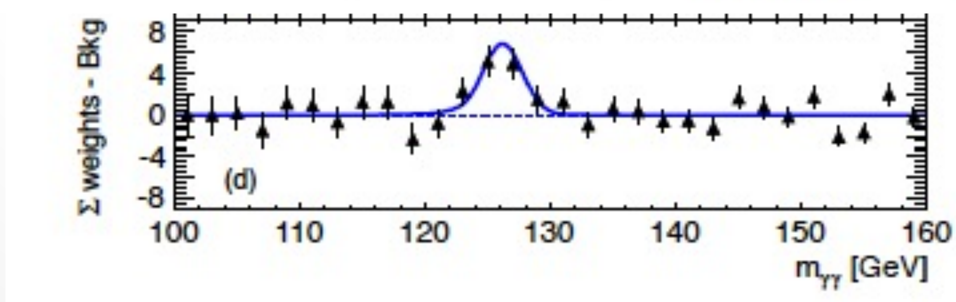


Table 7: Characterisation of the excess in the $H \to ZZ^{(*)} \to 4\ell$, $H \to \gamma\gamma$ and $H \to WW^{(*)} \to \ell\nu\ell\nu$ channels and the combination of all channels listed in Table 6. The mass value m_{max} for which the local significance is maximum, the maximum observed local significance Z_l and the expected local significance $E(Z_l)$ in the presence of a SM Higgs boson signal at m_{max} are given. The best fit value of the signal strength parameter $\hat{\mu}$ at m_H = 126 GeV is shown with the total uncertainty. The expected and observed mass ranges excluded at 95% CL (99% CL, indicated by a *) are also given, for the combined $\sqrt{s}$ = 7 TeV and $\sqrt{s}$ = 8 TeV data.

Search channel	Dataset	m_{max} [GeV]	Z_l [σ]	$E(Z_l)$ [σ]	$\hat{\mu}(m_H = 126$ GeV)	Expected exclusion [GeV]	Observed exclusion [GeV]
$H \to ZZ^{(*)} \to 4\ell$	7 TeV	125.0	2.5	1.6	1.4 ± 1.1		
	8 TeV	125.5	2.6	2.1	1.1 ± 0.8		
	7 & 8 TeV	125.0	3.6	2.7	1.2 ± 0.6	124–164, 176–500	131–162, 170–460
$H \to \gamma\gamma$	7 TeV	126.0	3.4	1.6	2.2 ± 0.7		
	8 TeV	127.0	3.2	1.9	1.5 ± 0.6		
	7 & 8 TeV	126.5	4.5	2.5	1.8 ± 0.5	110–140	112–123, 132–143
$H \to WW^{(*)} \to \ell\nu\ell\nu$	7 TeV	135.0	1.1	3.4	0.5 ± 0.6		
	8 TeV	120.0	3.3	1.0	1.9 ± 0.7		
	7 & 8 TeV	125.0	2.8	2.3	1.3 ± 0.5	124–233	137–261
Combined	7 TeV	126.5	3.6	3.2	1.2 ± 0.4		
	8 TeV	126.5	4.9	3.8	1.5 ± 0.4		
	7 & 8 TeV	126.5	6.0	4.9	1.4 ± 0.3	110–582 113–532 (*)	111–122, 131–559 113–114, 117–121, 132–527 (*)



Conclusions

- The **interpretation section**
- Analyze
- Explains

10. Conclusion

Searches for the Standard Model Higgs boson have been performed in the $H \to ZZ^{(*)} \to 4\ell$, $H \to \gamma\gamma$ and $H \to WW^{(*)} \to e\nu\mu\nu$ channels with the ATLAS experiment at the LHC using 5.8–5.9 fb^{-1} of pp collision data recorded during April to June 2012 at a centre-of-mass energy of 8 TeV. These results are combined with earlier results [17], which are based on an integrated luminosity of 4.6–4.8 fb^{-1} recorded in 2011 at a centre-of-mass energy of 7 TeV, except for the $H \to ZZ^{(*)} \to 4\ell$ and $H \to \gamma\gamma$ channels, which have been updated with the improved analyses presented here.

The Standard Model Higgs boson is excluded at 95% CL in the mass range 111–559 GeV, except for the narrow region 122–131 GeV. In this region, an excess of events with significance 5.9 σ, corresponding to $p_0 = 1.7 \times 10^{-9}$, is observed. The excess is driven

What is the point of a paper?

A paper is written as a means of archiving and storing information derived from an experiment

A paper isn't meant to tell you a story, or maintain your interest- that's not how it's written (sadly)

So you'll have to read a scientific paper a bit differently…

Often have page limits so every sentence/word is important

How I read a paper

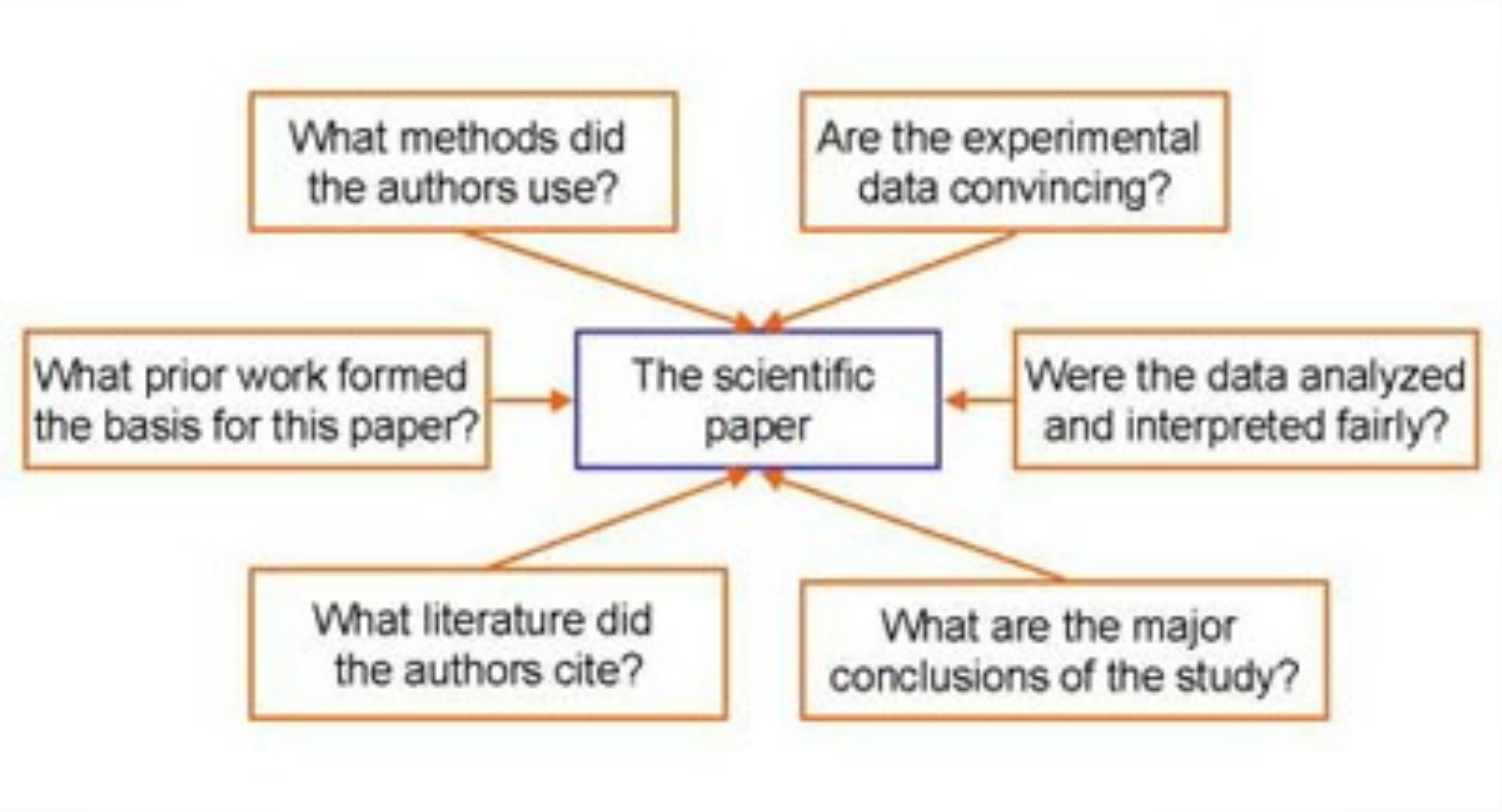
1. Start with the abstract- it's a great summary!
2. Read the Intro and conclusions - Similar to the abstract but with more details
3. Try to figure out which plots correspond to each conclusion and examine those plots
4. Now I'm ready to read the paper through as it's written- I have some baseline idea of what the main points are and which plots are important
5. Think about the main measurement posed in the paper and the results. Do I understand them.
6. If I can't, I read the paper again!

Questions to ask yourself as you read a paper

- What specific problem does this research address?
- What are the specific findings? Am I able to summarize them succinctly?
- What evidence supports the findings? Do I believe the evidence/methods?
- Is there an alternative explanation to the findings presented? Has this been addressed?
- How do these findings relate to what I'm working on/interested in?
- How might I apply these methods/results to my work?

Hard work to read papers

- I often find that I can only read a few papers before I need a break
- Often start skimming the paper so not really understanding it
- Often need to stop reading paper to look up reference for additional details
- If trying to reproduce results, I often need to read paper many many times to fully understand all of the details
- We often have paper reading sessions with students and it is not uncommon to only get through 1 paragraph in an hour.



What methods did the authors use?
Are the experimental data convincing?
What prior work formed the basis for this paper?
The scientific paper
Were the data analyzed and interpreted fairly?
What literature did the authors cite?
What are the major conclusions of the study?