Universidade do Minho
Escola de Ciências

LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

Probing the Standard Model and Beyond at the LHC

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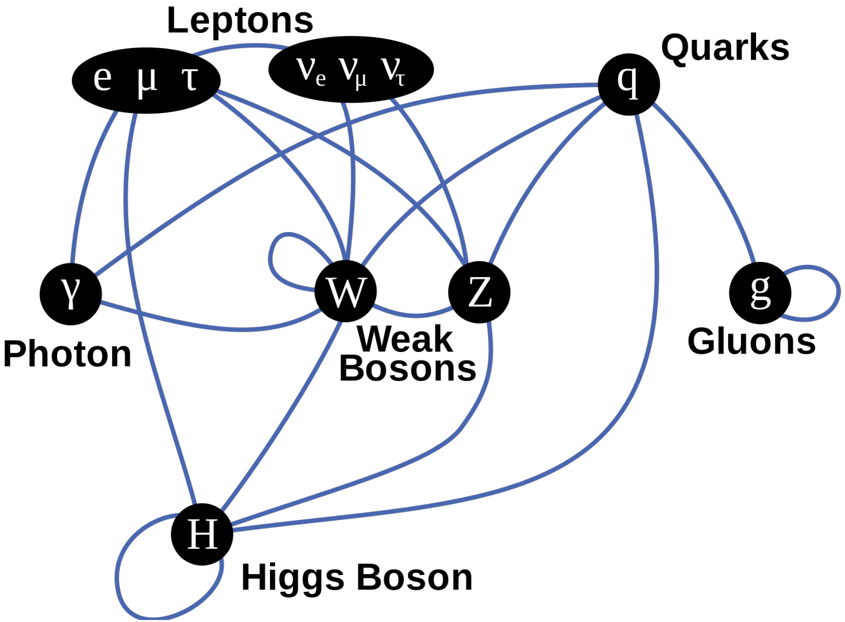
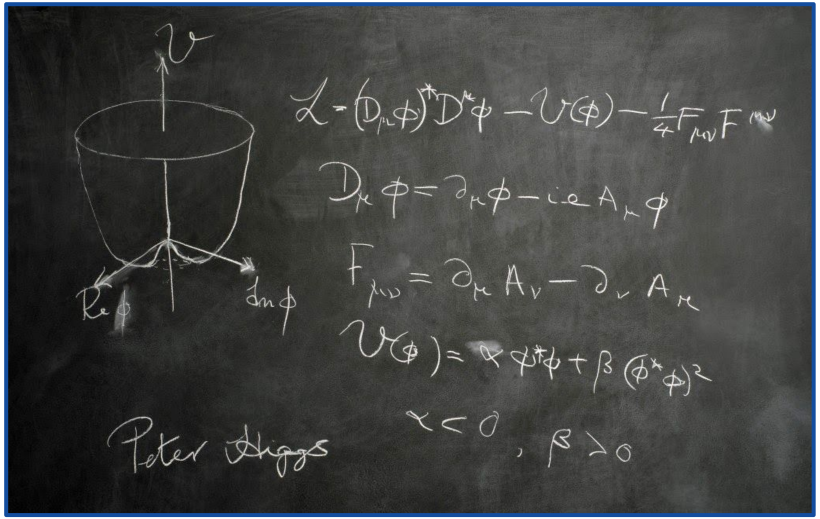
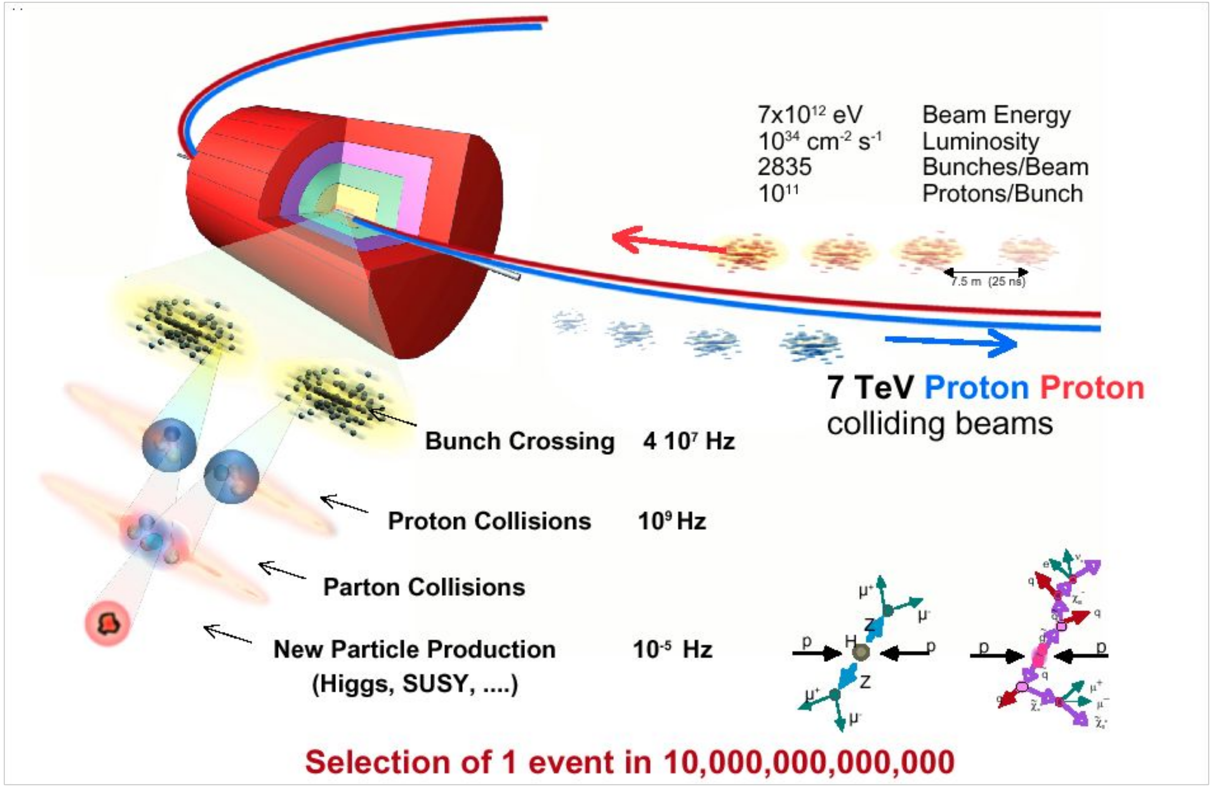
The Standard Model of Particle Physics
particles & interactions





The Standard Model of Particle Physics
probing it at colliders



The Large Hadron Collider
and its detectors

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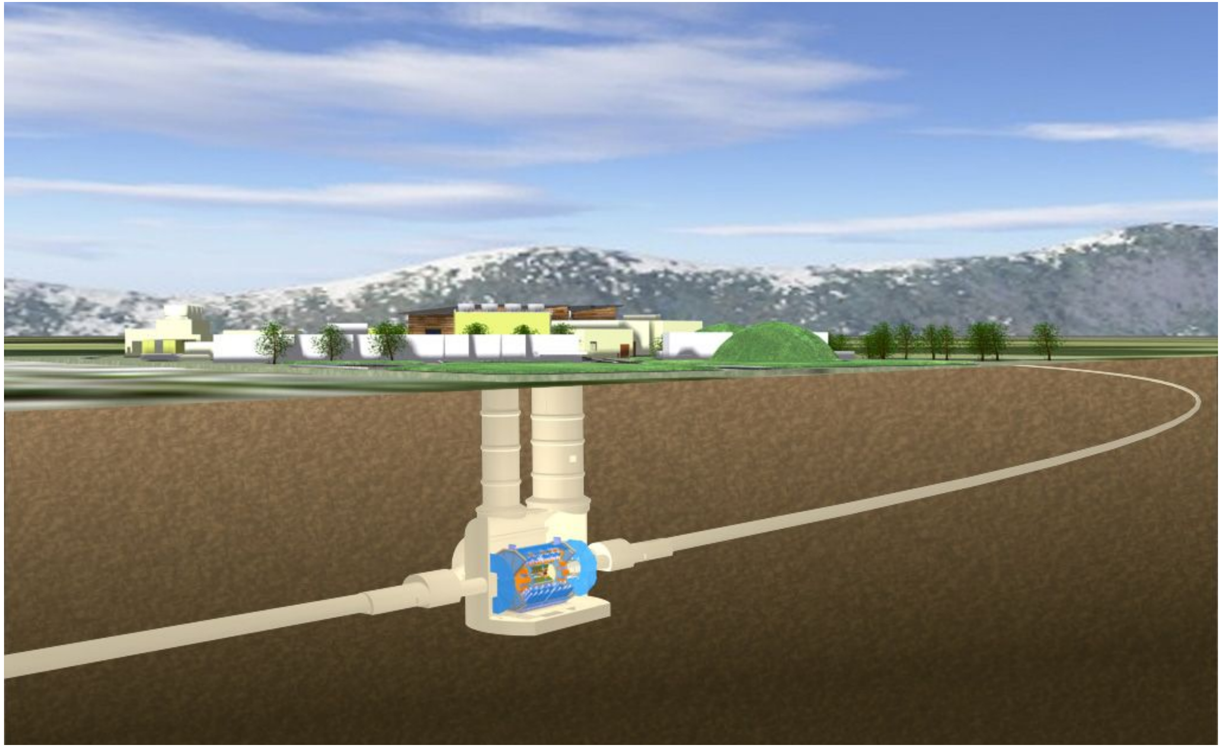

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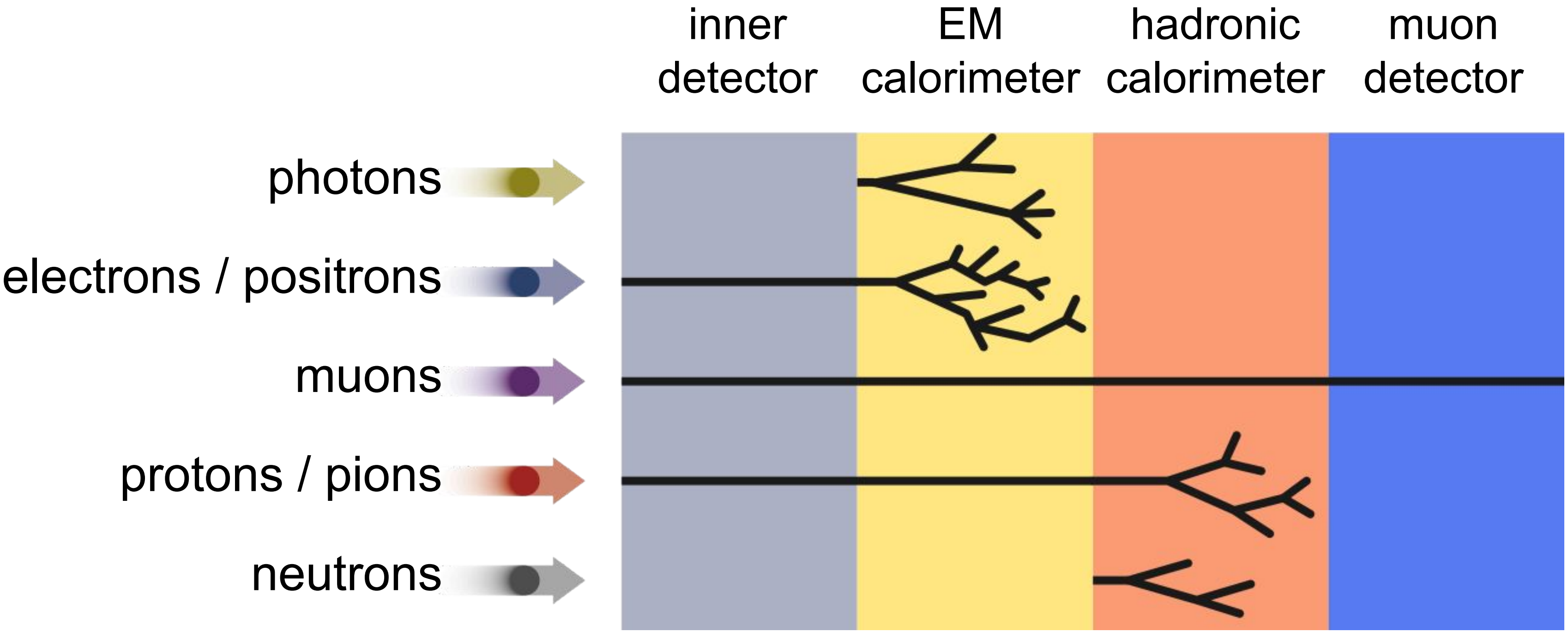

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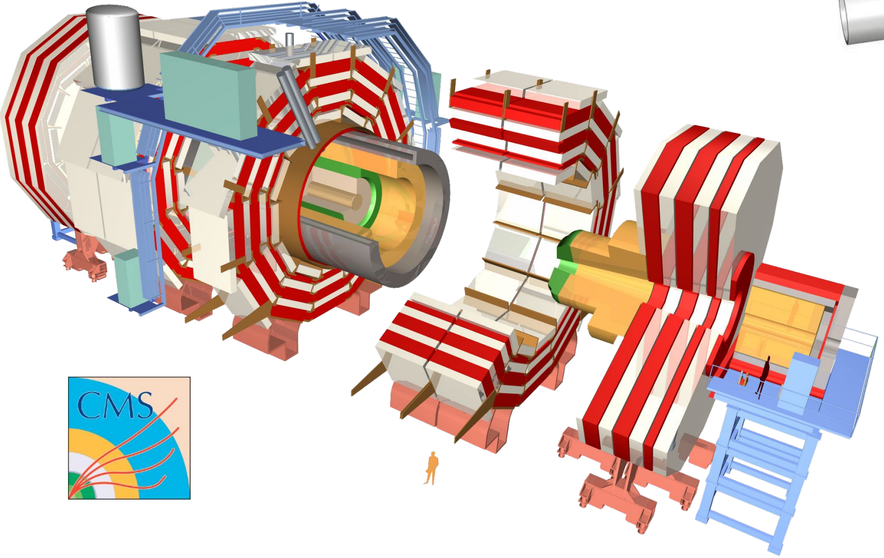
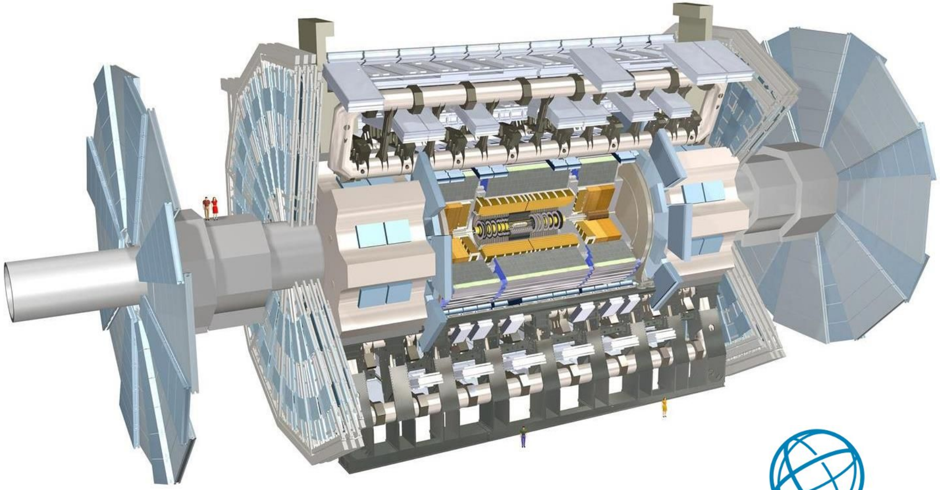
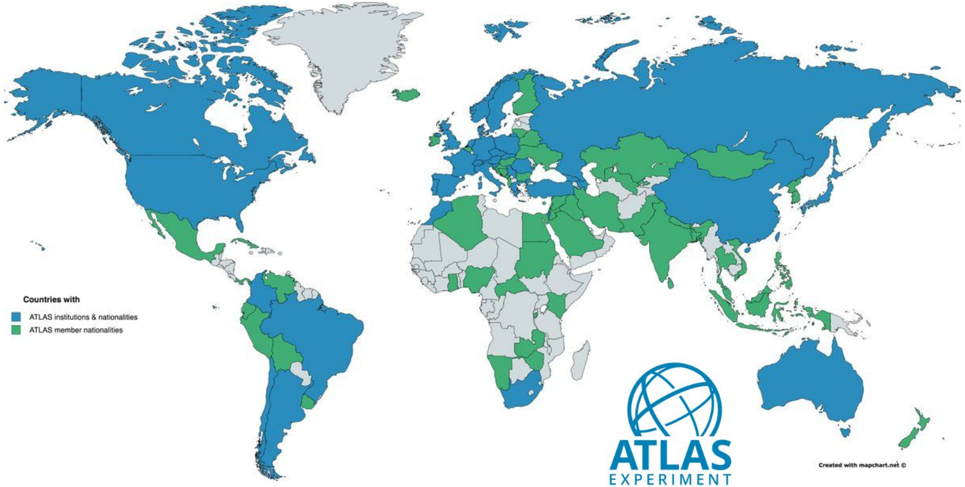


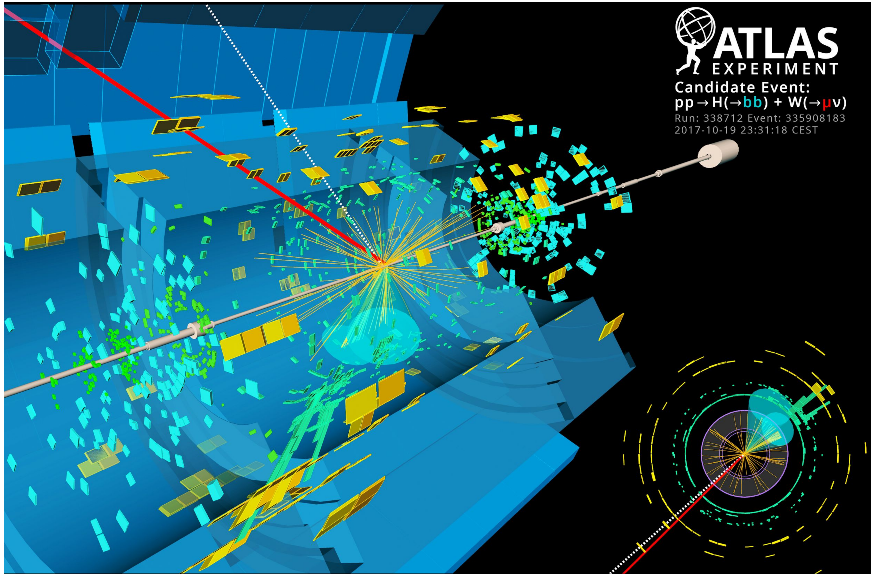


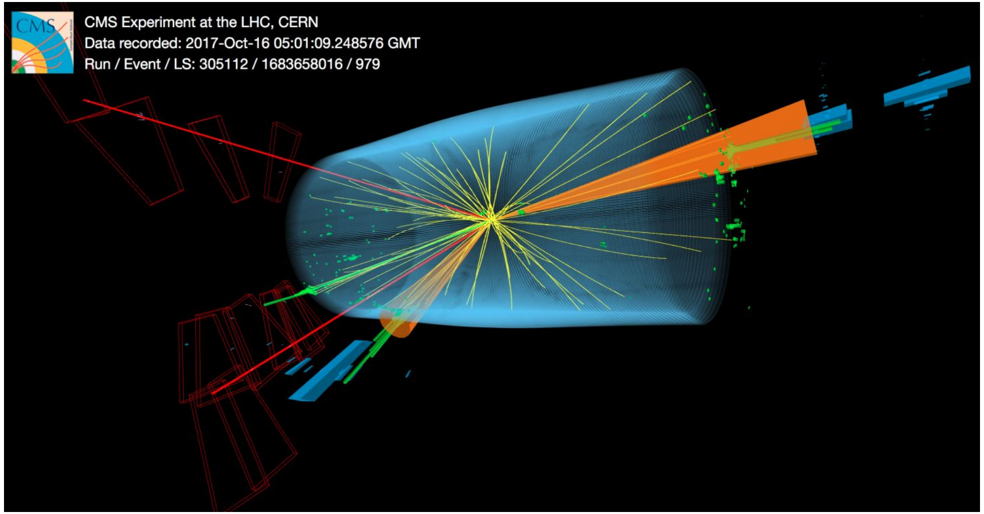
ATLAS EXPERIMENT

The Large Hadron Collider
and its collaborations

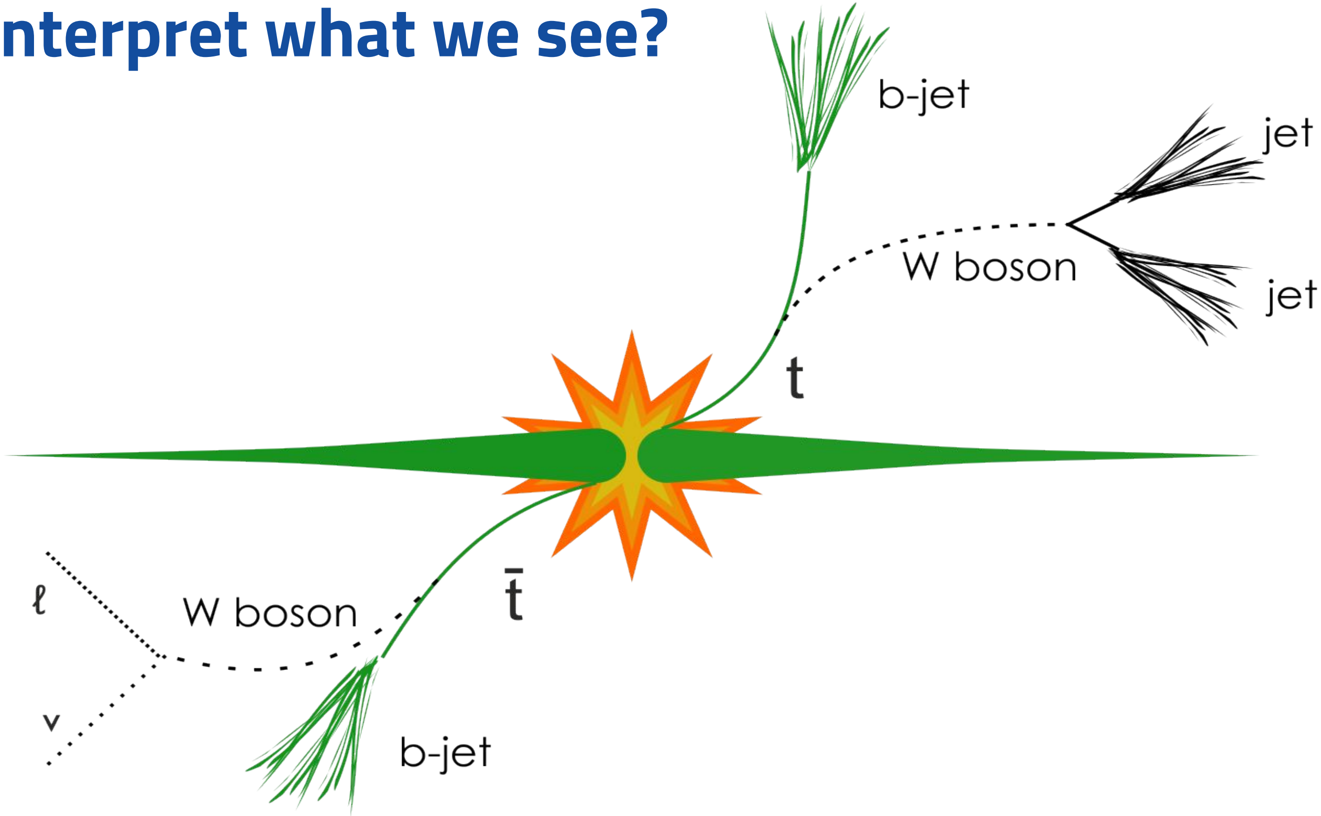


The Large Hadron Collider experiments
what do we see?





The Large Hadron Collider experiments
how to interpret what we see?



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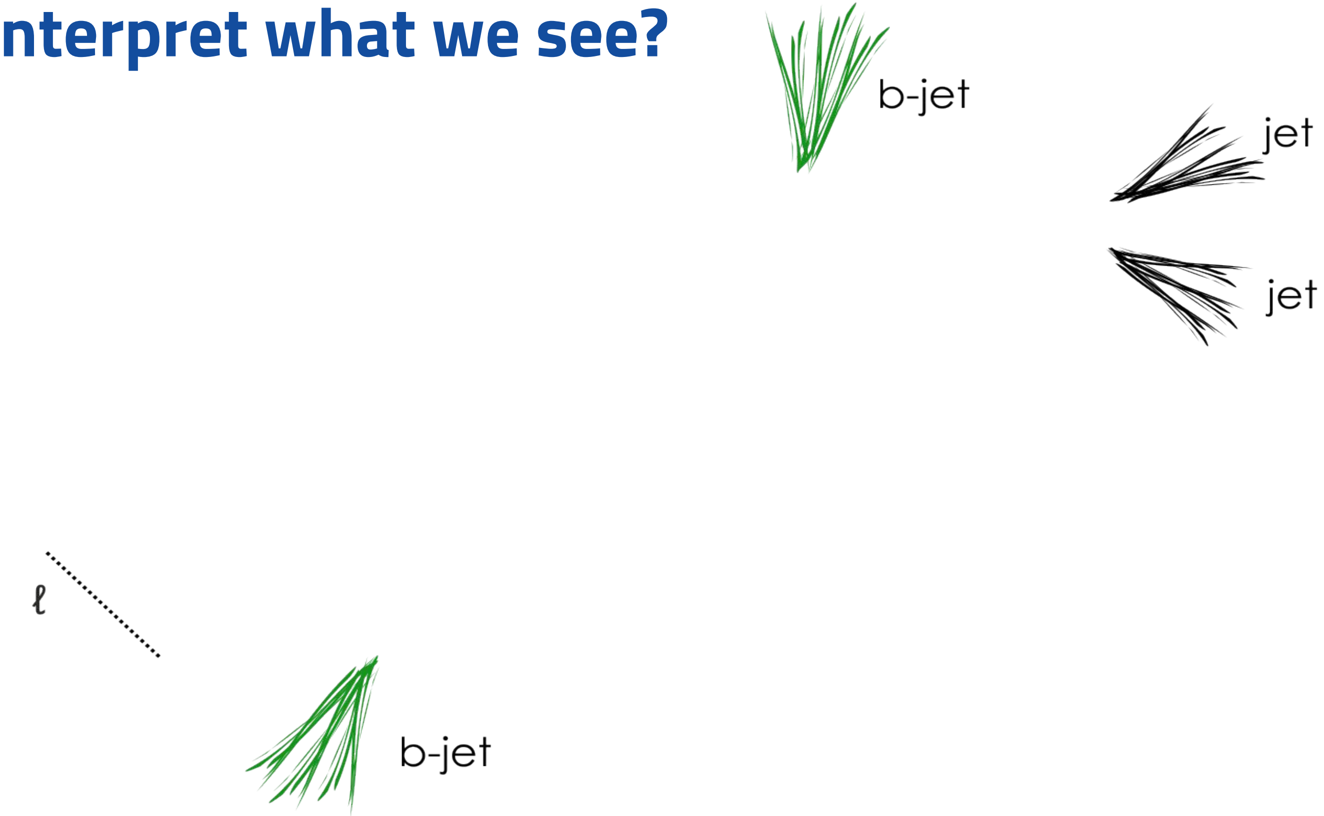
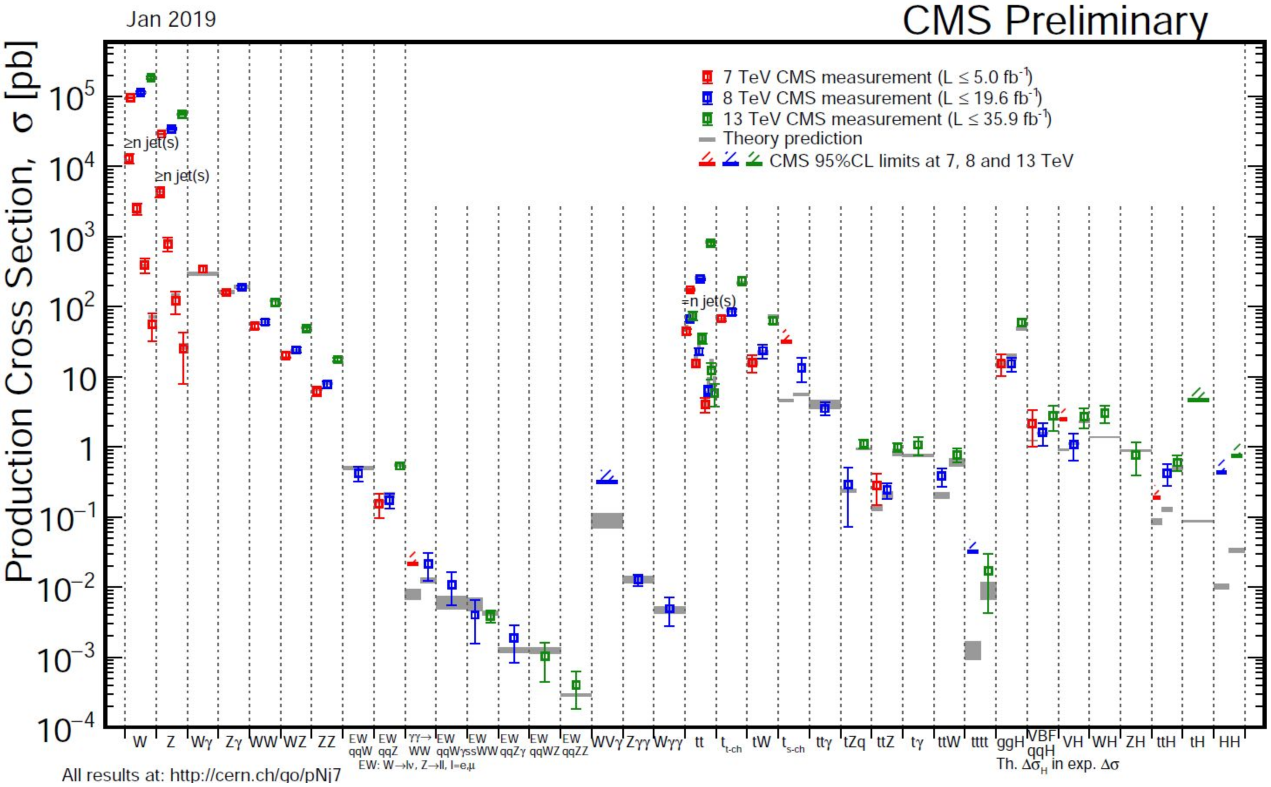


What can we do with the LHC data?

probe the Standard Model !

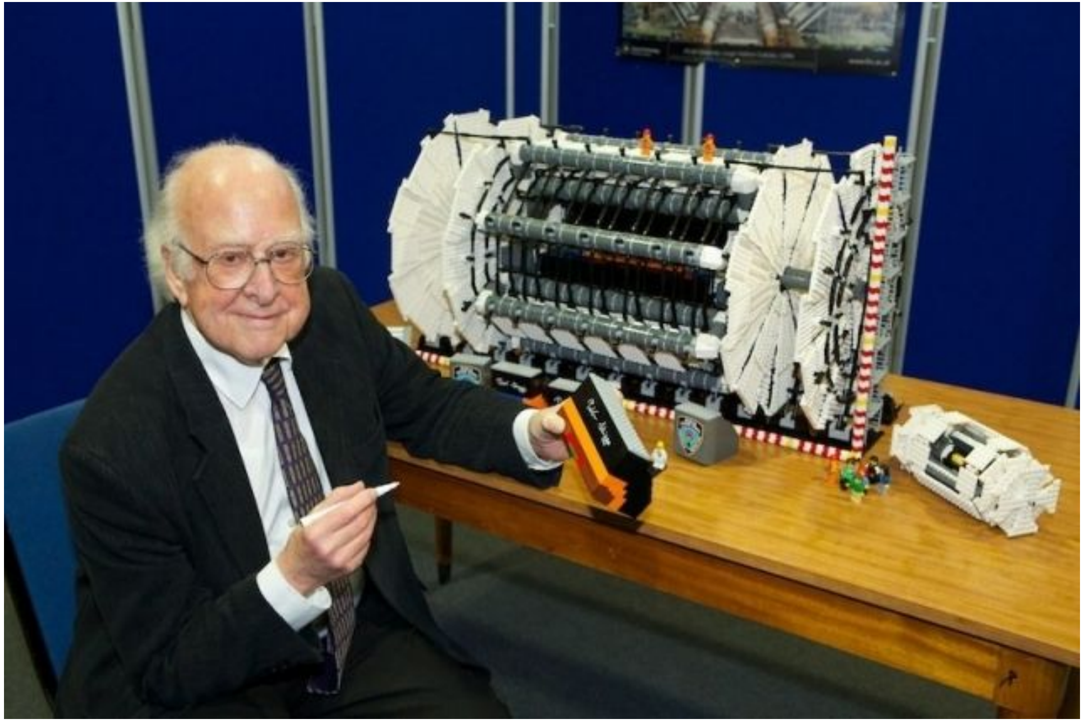
Comparing with theory predictions

excellent agreement



What can we do with the LHC data?

probe the Standard Model - Higgs boson properties



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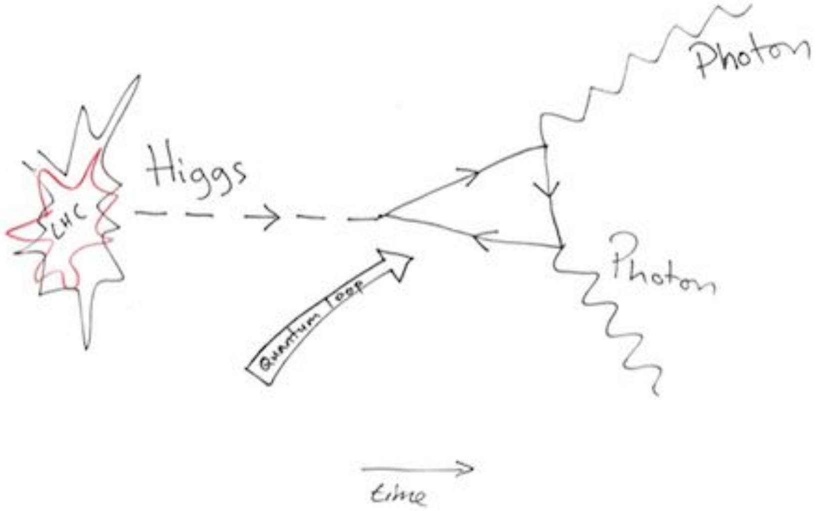

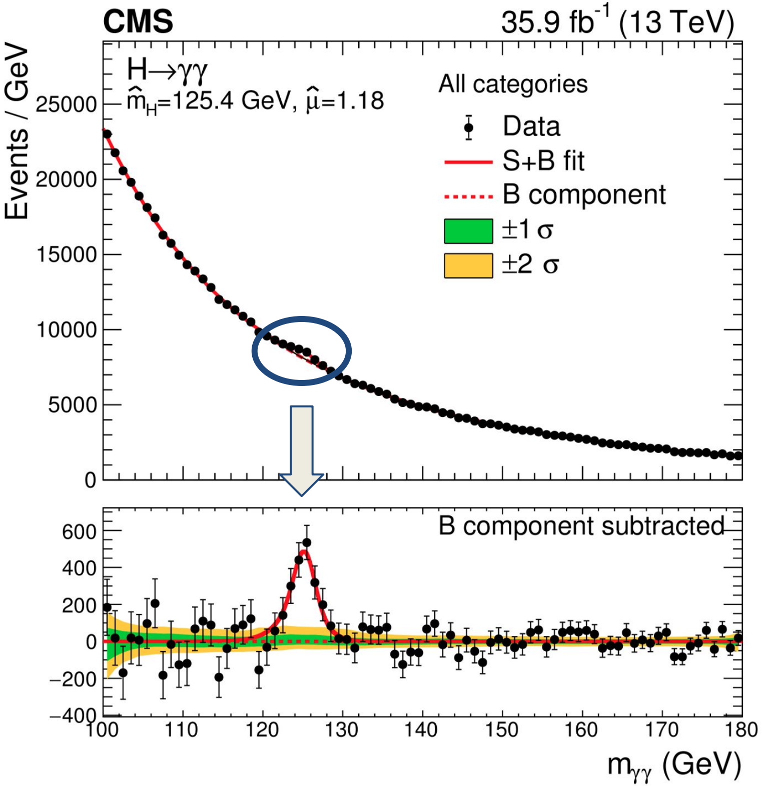

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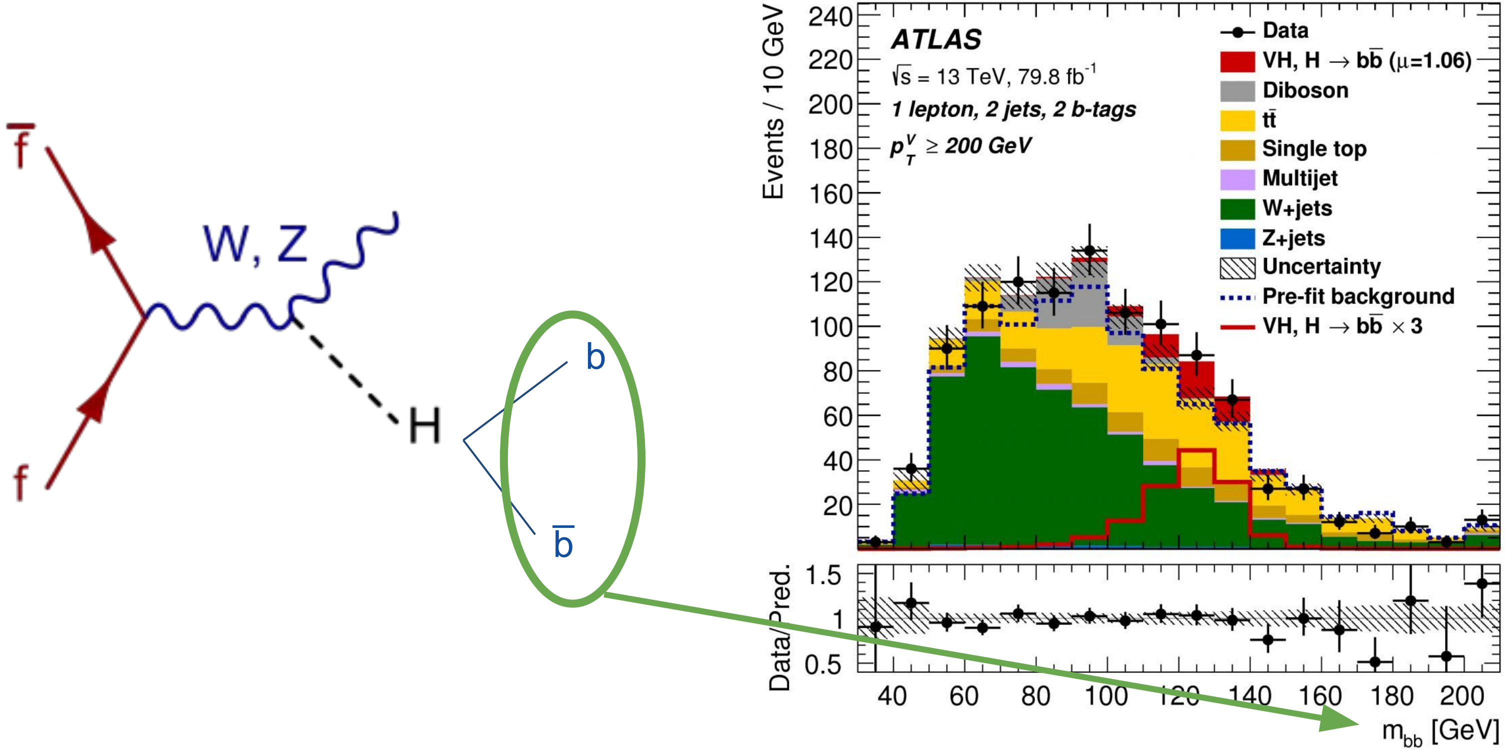

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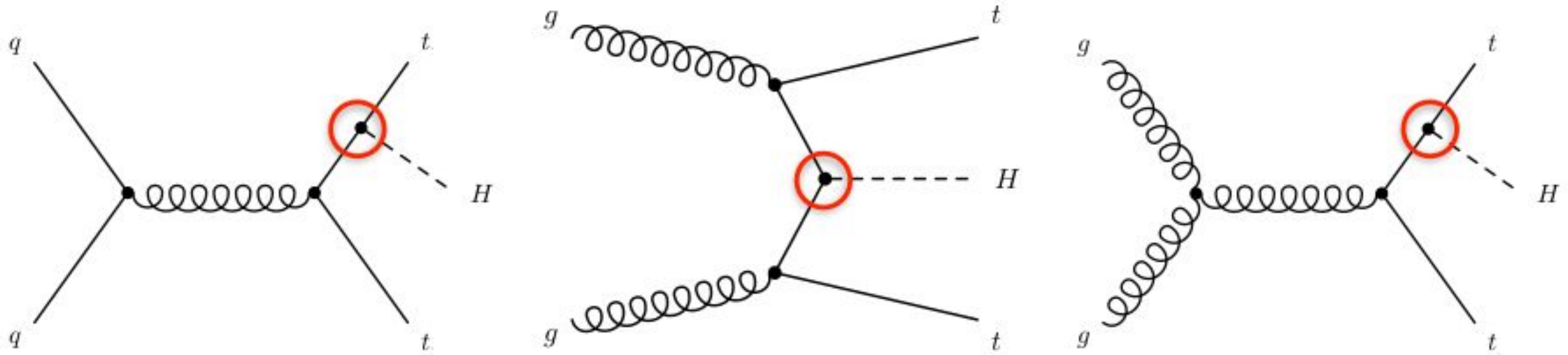

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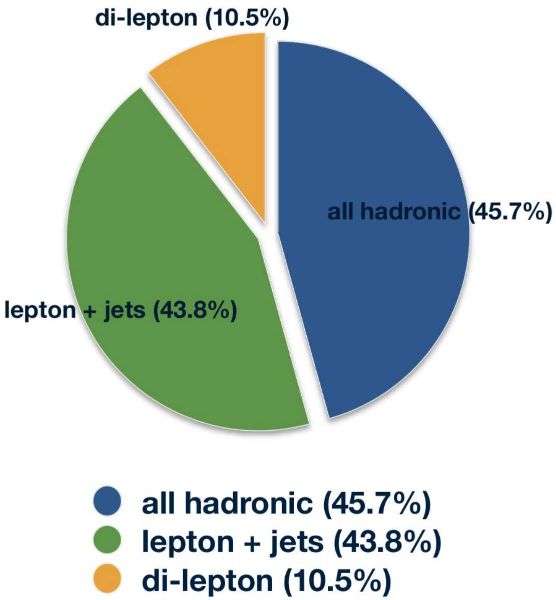
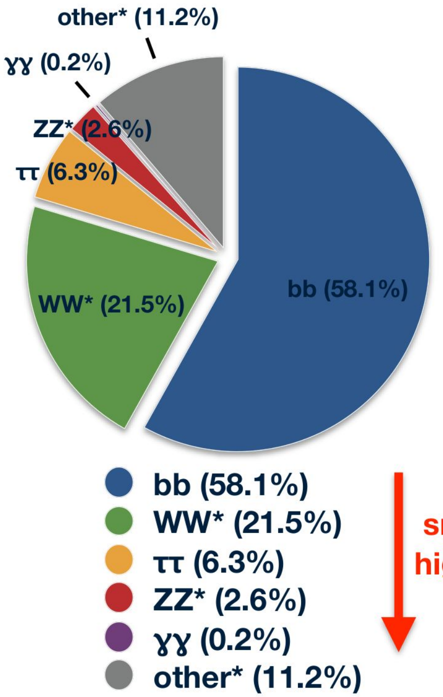
ttbar decay BRs



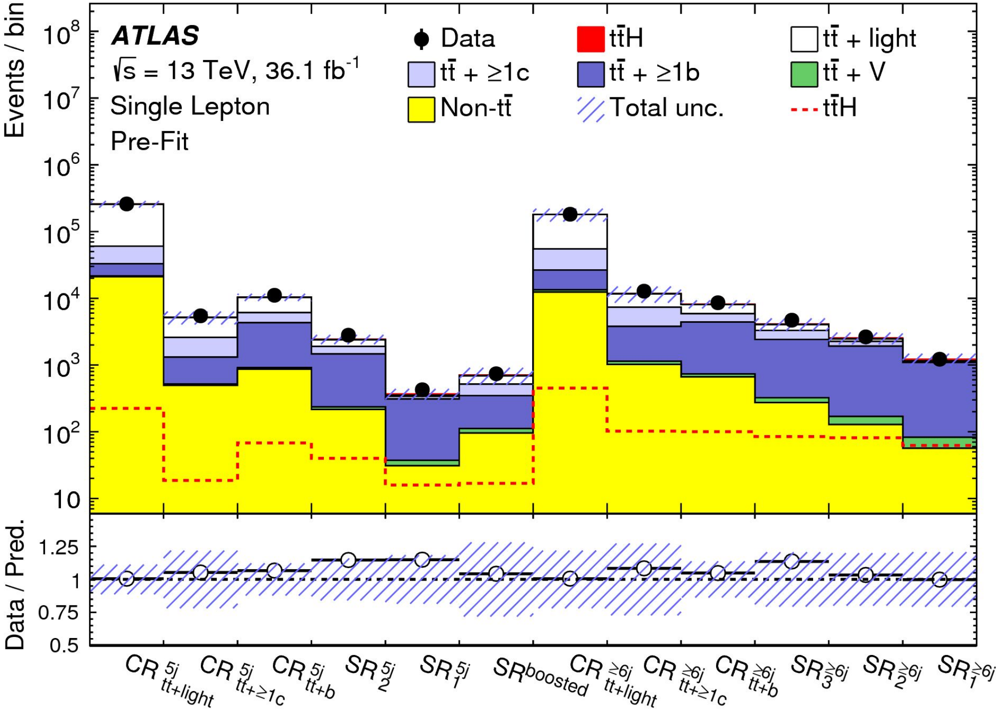
Higgs decay BRs



smaller BR, higher purity (generally)

What can we do with the LHC data?

probe the Standard Model - Higgs boson properties

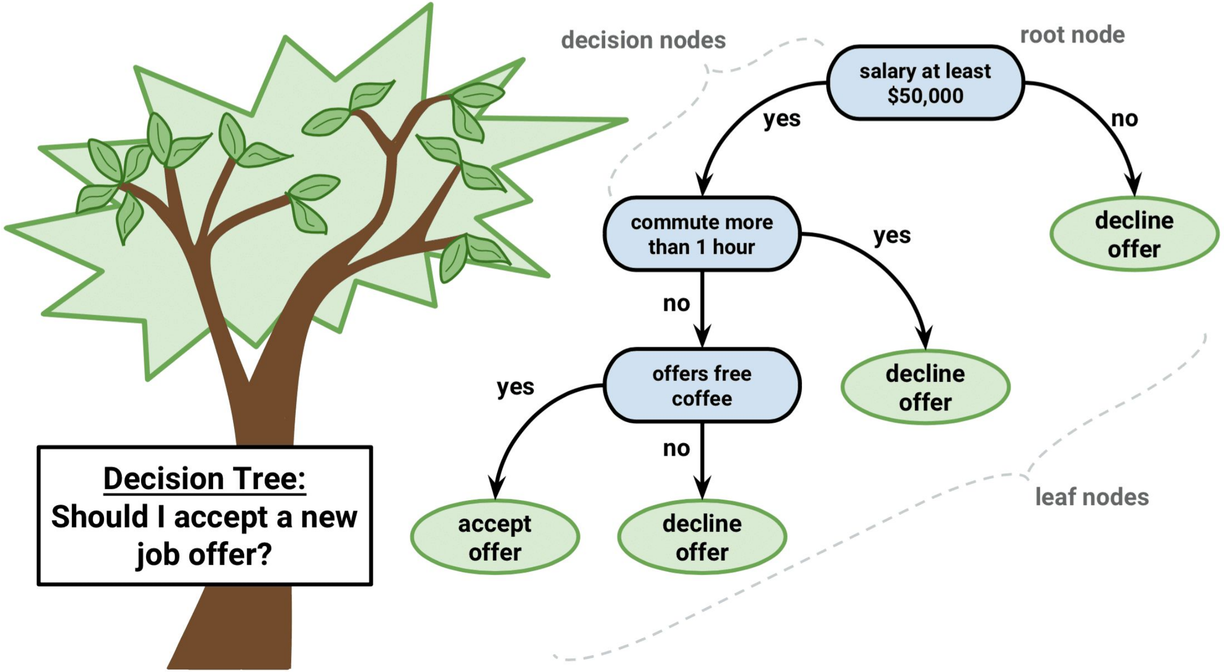


What can we do with the LHC data?

probe the Standard Model - Higgs boson properties

machine learning:

decision trees



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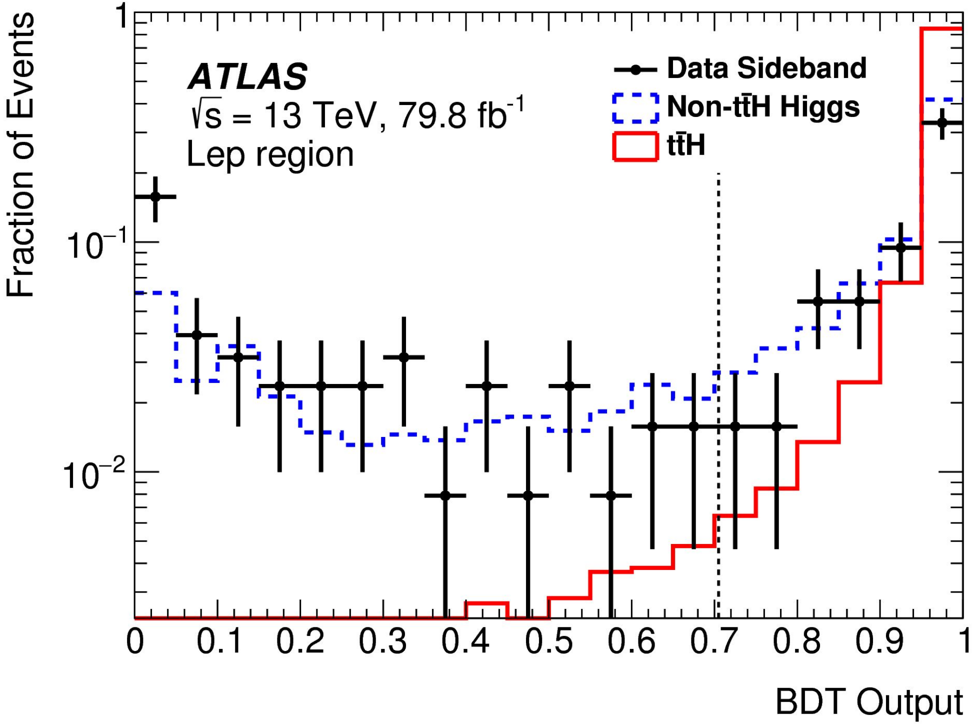

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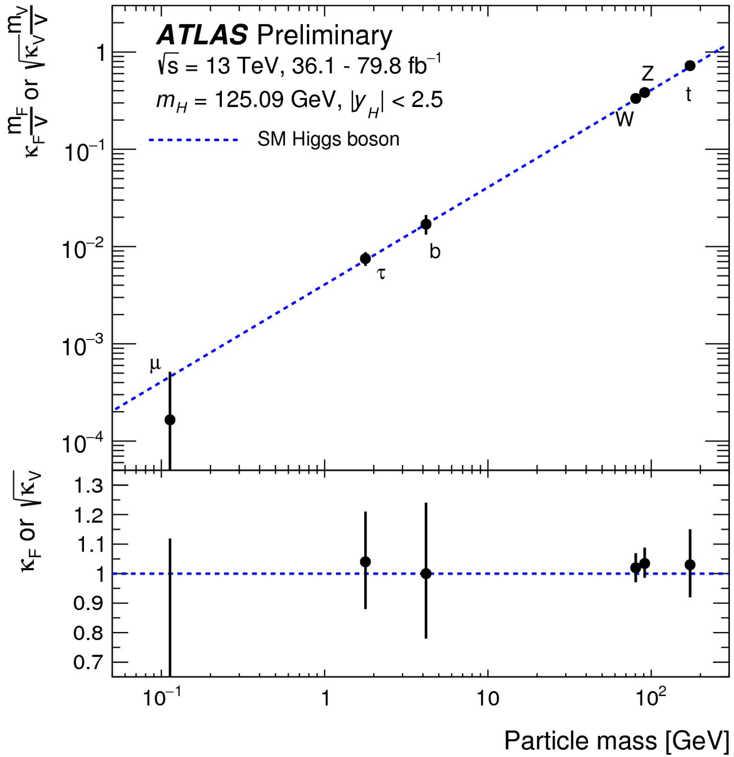

What can we do with the LHC data?

probe the Standard Model - and search for new phenomena beyond it!

- Why should we search for new physics beyond the Standard Model?
  - we *must* leave no stone unturned in data
  - … and we have good motivations to think that new physics exists
    - mass hierarchy of the fermions
    - matter/anti-matter asymmetry
    - dark matter
    - …

What can we do with the LHC data?

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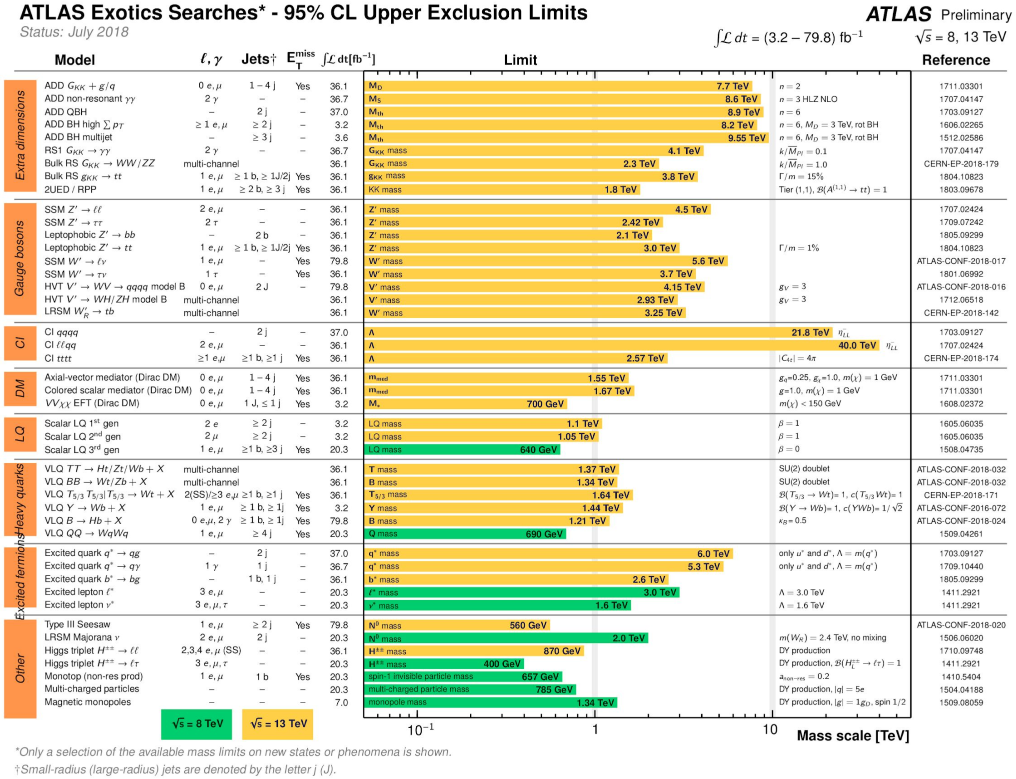
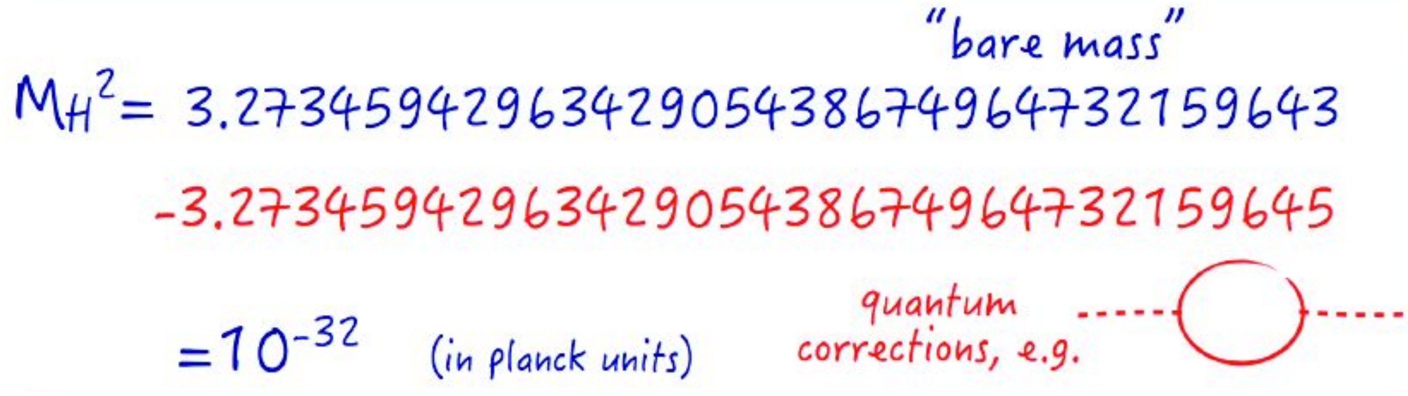


What can we do with the LHC data?

probe the Standard Model - and search for new phenomena beyond it!

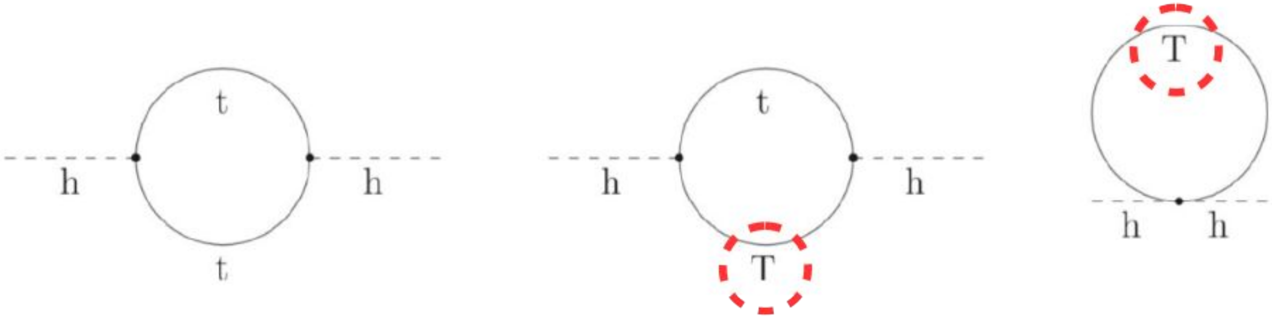
- If we assume that the Standard Model is the low energy limit of a more general theory at higher energy
    - the Higgs boson mass can be calculable (and not a free parameter):



searching for the unknown

an example: the hierarchy problem

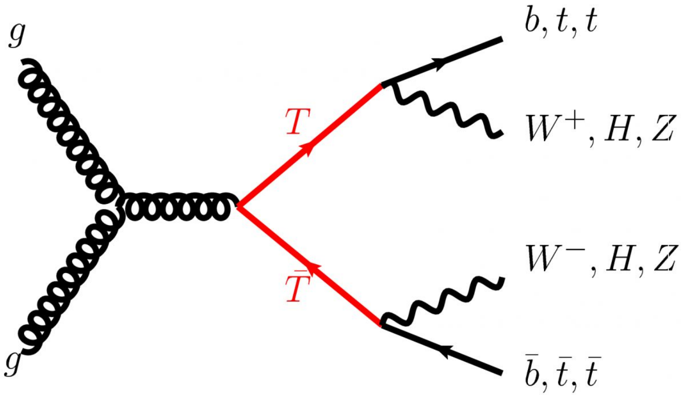
- The *natural* solution for this balancing in mass without fine-tuning is to have counter terms originating from new heavy particles (top partners)

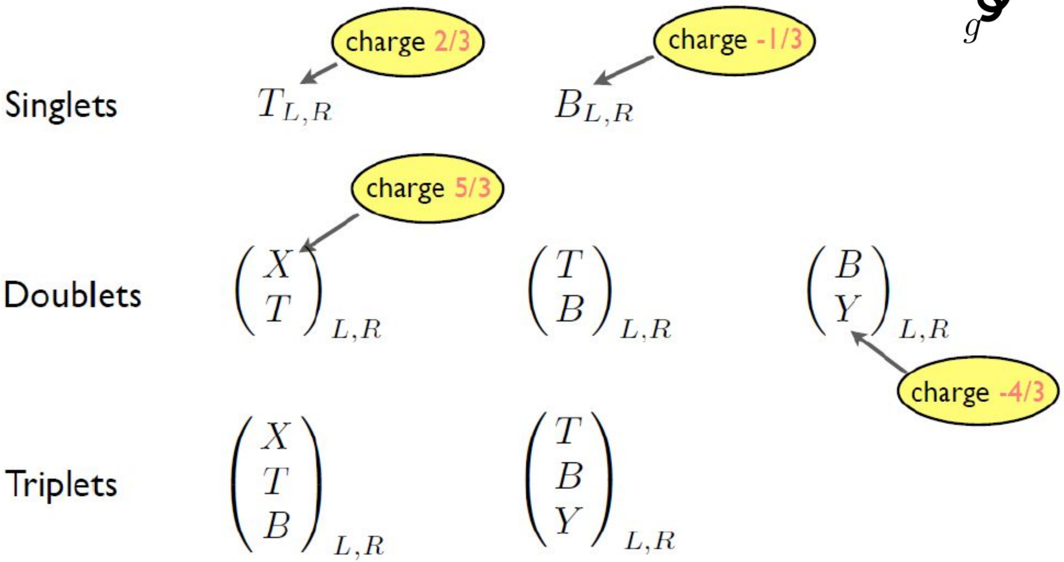


$M_H^2 \sim 10 - 9 = 1$ (in units of ~100 GeV squared)

searching for the unknown

an example: vector-like quarks





searching for the unknown

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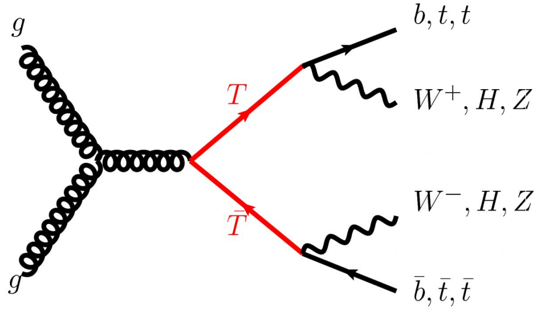
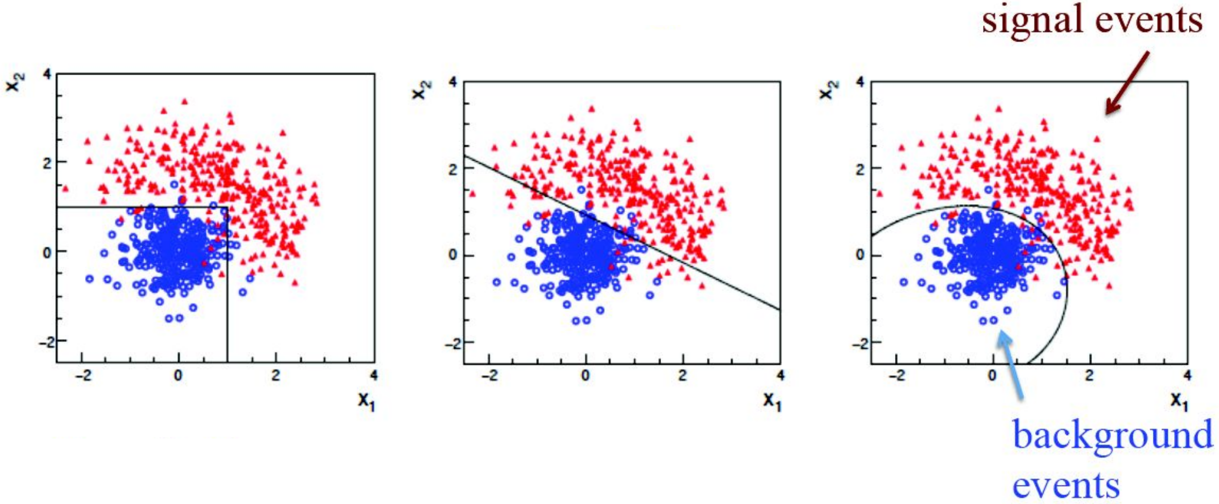


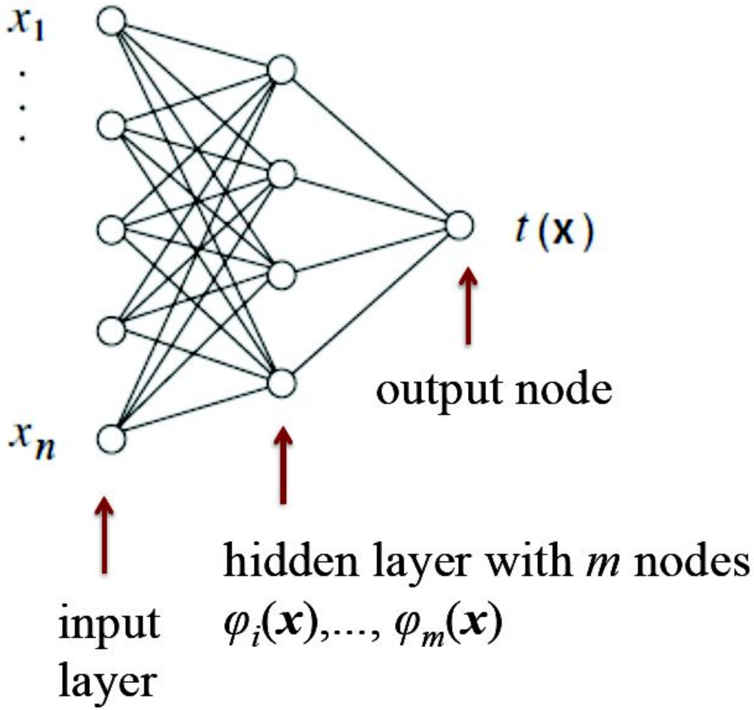
- Many different topologies
- Looking for extremely small signals

- *Advanced analysis methods are mandatory!*



searching for the unknown

an example: use of neural networks for classification problems



Each line in the graph represents a constant whose value is adjusted using the training data.

searching for the unknown

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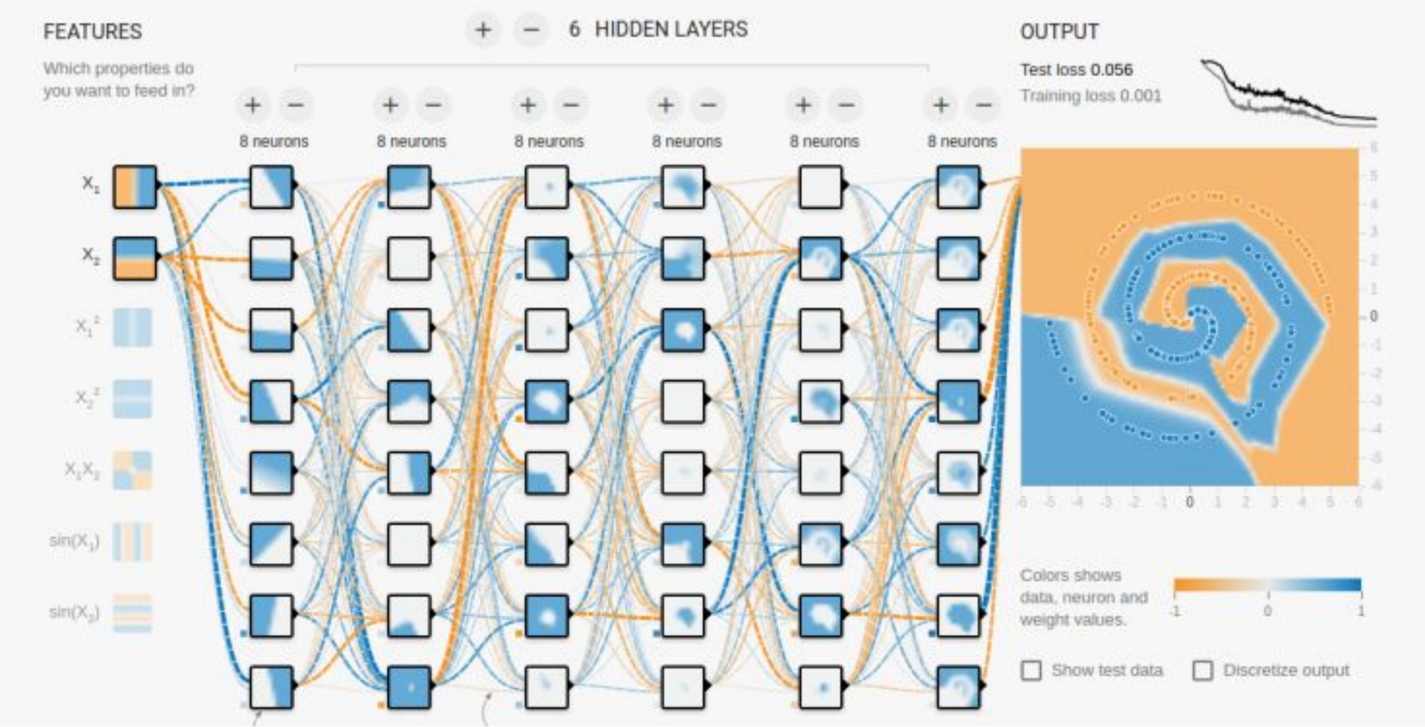
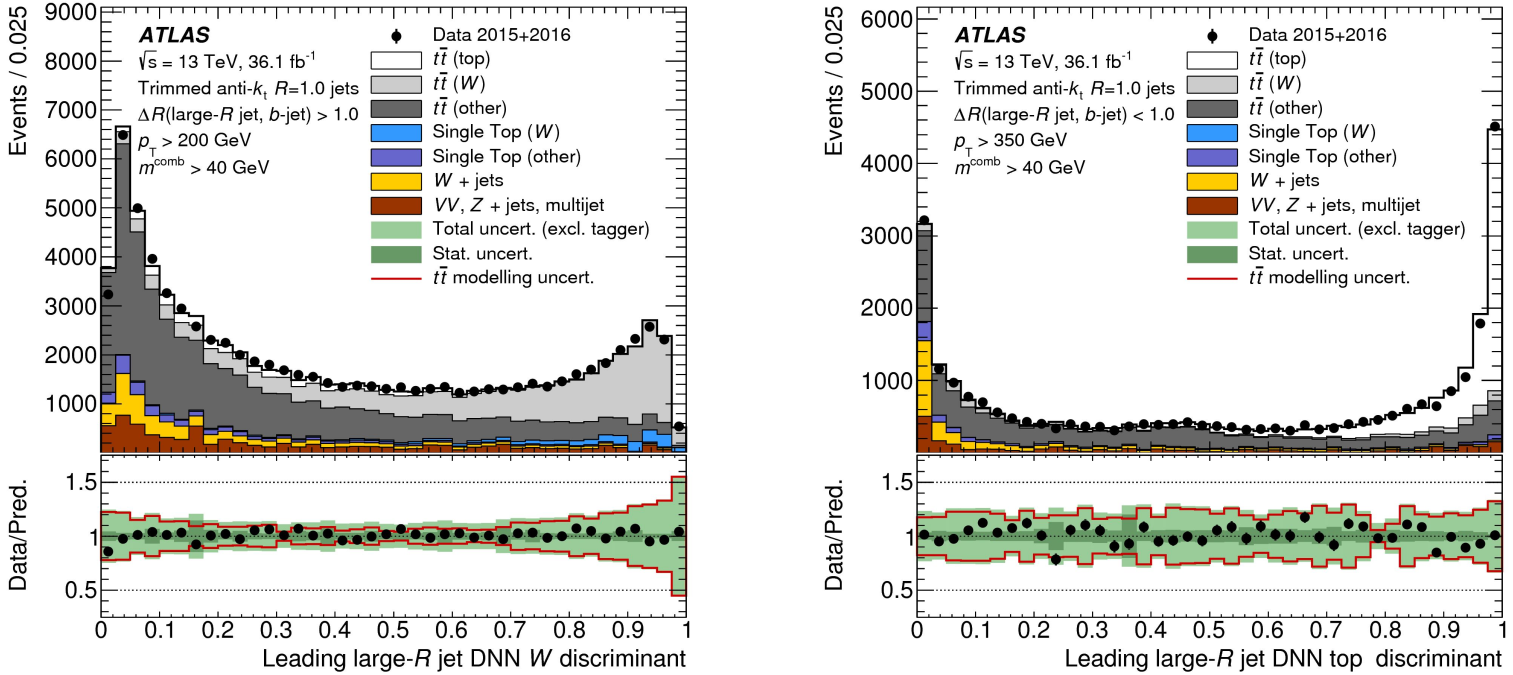


searching for the unknown

an example: use of neural networks in searches



searching for the unknown

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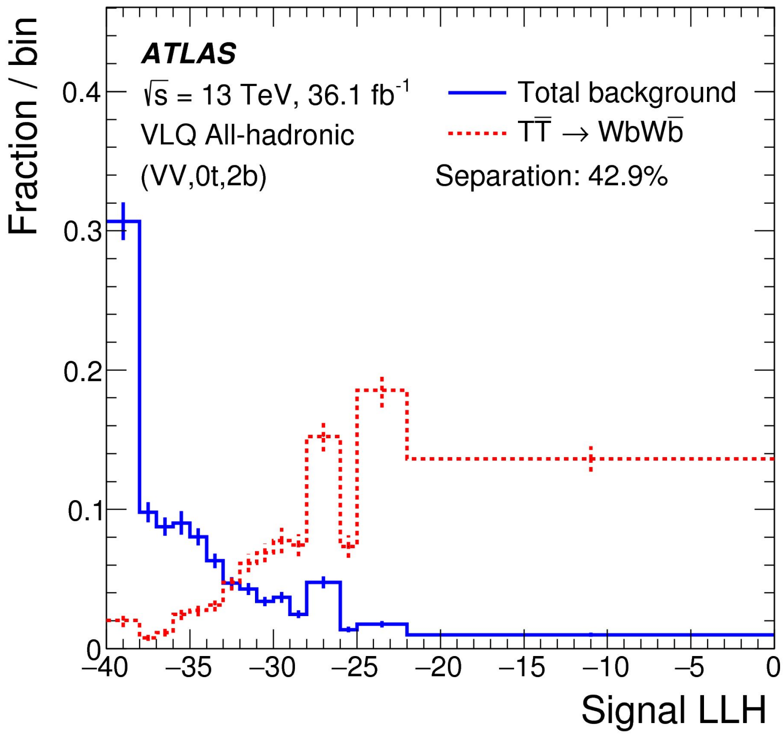

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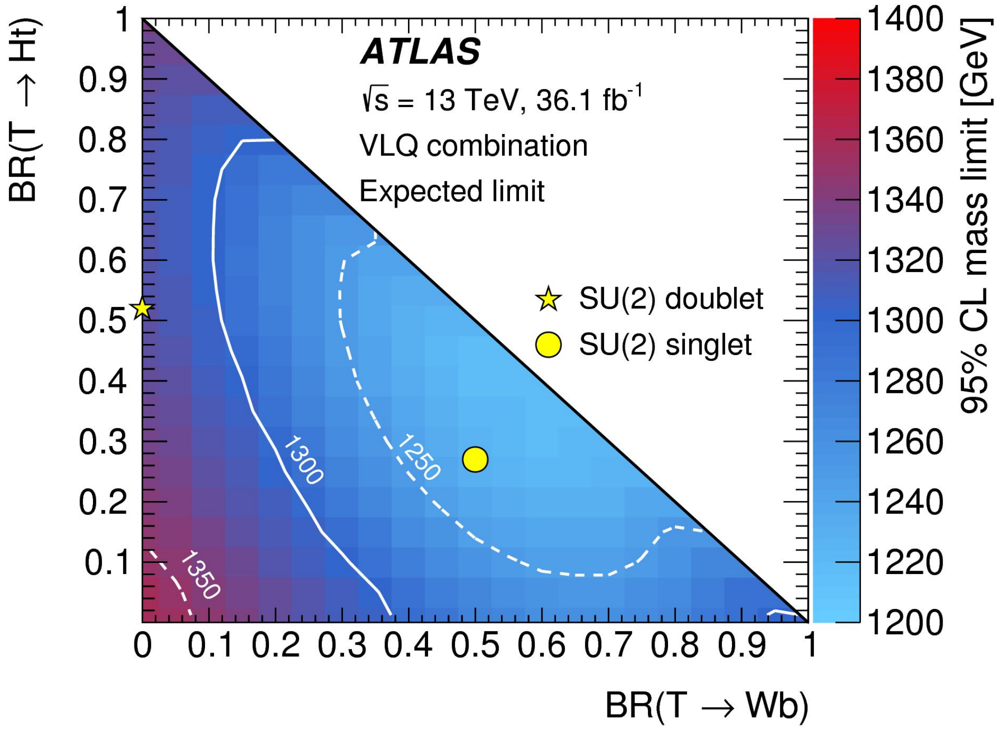
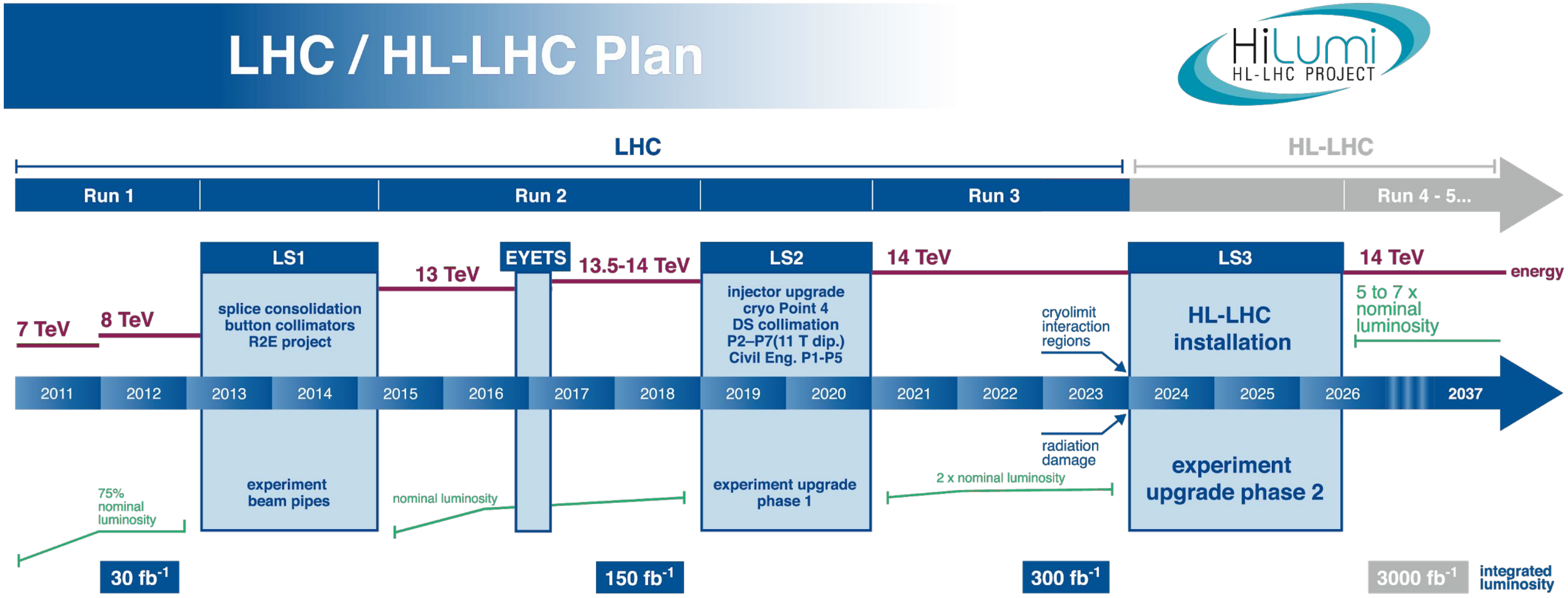


What's next?
LHC and beyond



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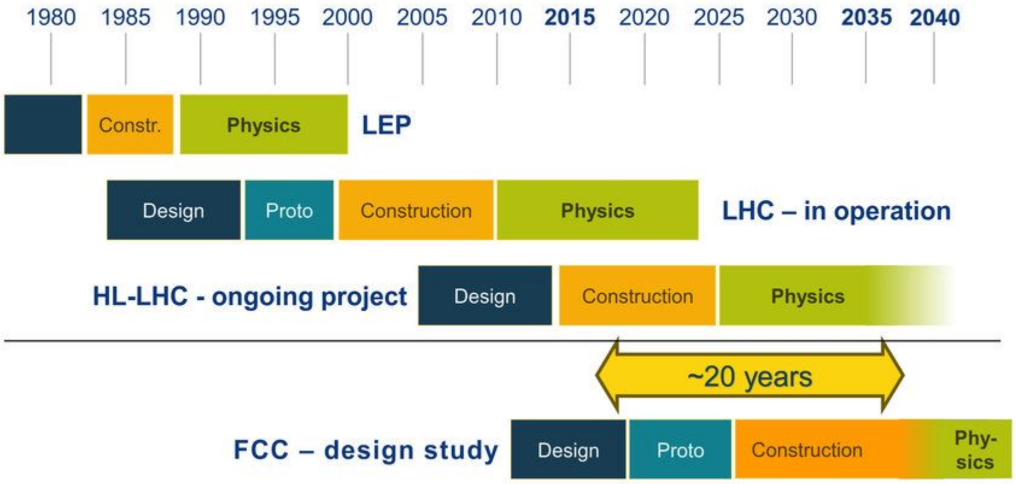
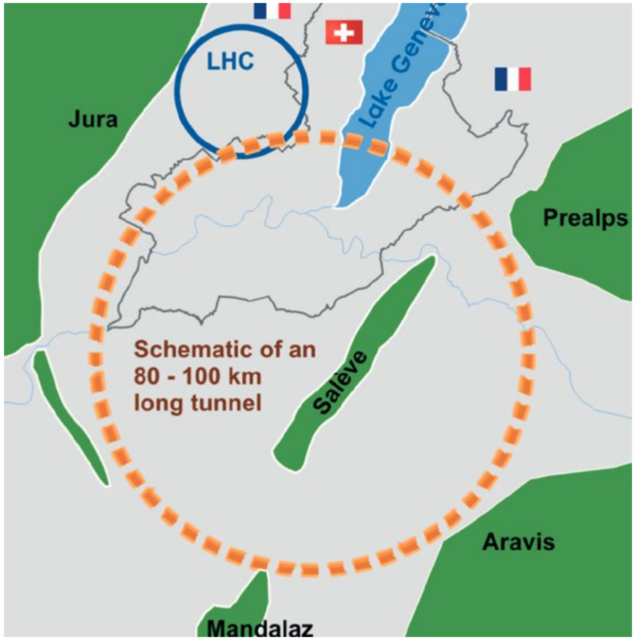




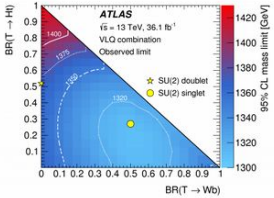
If you want to know more and keep an eye on the latest news…

physics briefings

https://atlas.cern/updates/briefing
https://cms.cern/cms-updates

Physics Briefing

Could a new type of quark fix the “unnaturalness” of the Standard Model?

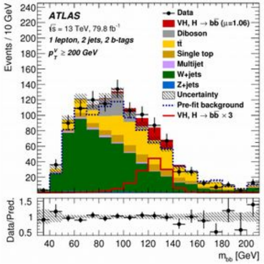


While the discovery of the Higgs boson at the Large Hadron Collider (LHC) in 2012 confirmed many Standard Model predictions, it has raised as many questions as it has answered. For example, interactions at the quantum level between the Higgs boson and the top quark ought to lead to a huge Higgs boson mass, possibly as large as the Planck mass (>10^{18} GeV). So why is it only 125 GeV? Is there a mechanism at play to cancel these large quantum corrections caused by the top quark (t)? Finding a way to explain the lightness of the Higgs boson is one of the top (no pun intended) questions in particle physics.

Read more →

Physics Briefing

Higgs boson observed decaying to b quarks – at last!

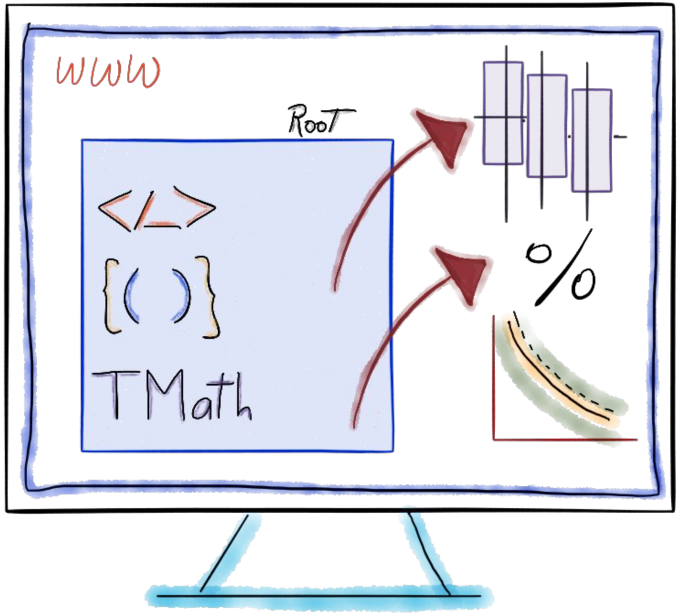


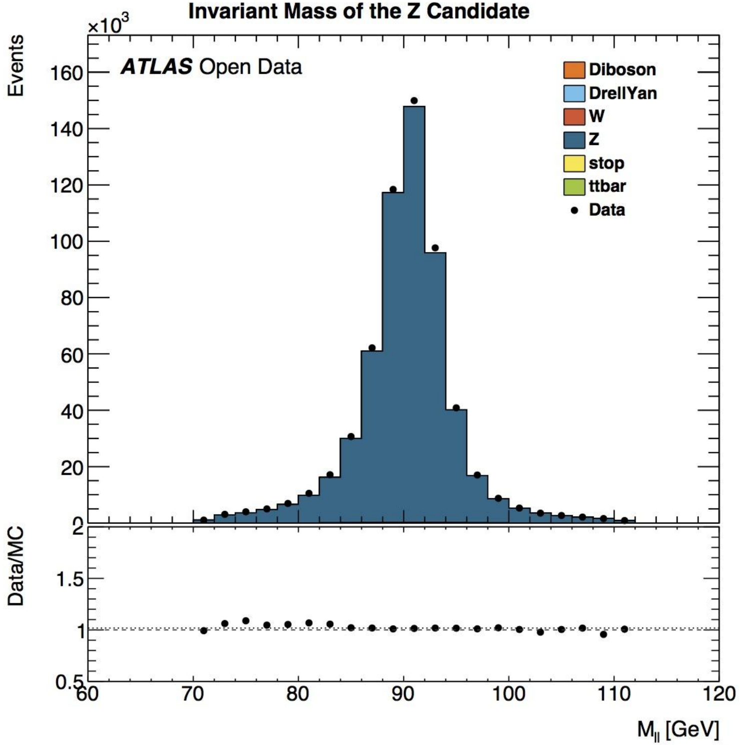
Today, at the 2018 International Conference on High Energy Physics in Seoul, the ATLAS experiment reported a preliminary result establishing the observation of the Higgs boson decaying into pairs of b quarks, furthermore at a rate consistent with the Standard Model prediction.

Read more →

open data ATLAS

http://opendata.atlas.cern



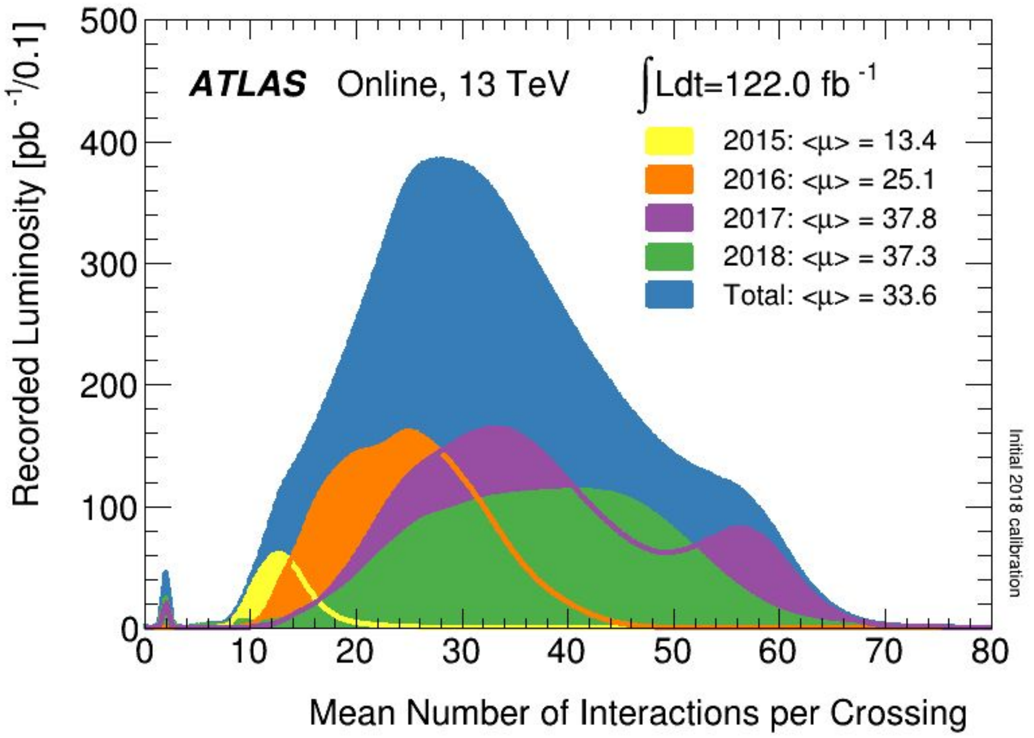


Thanks for your attention

Questions?

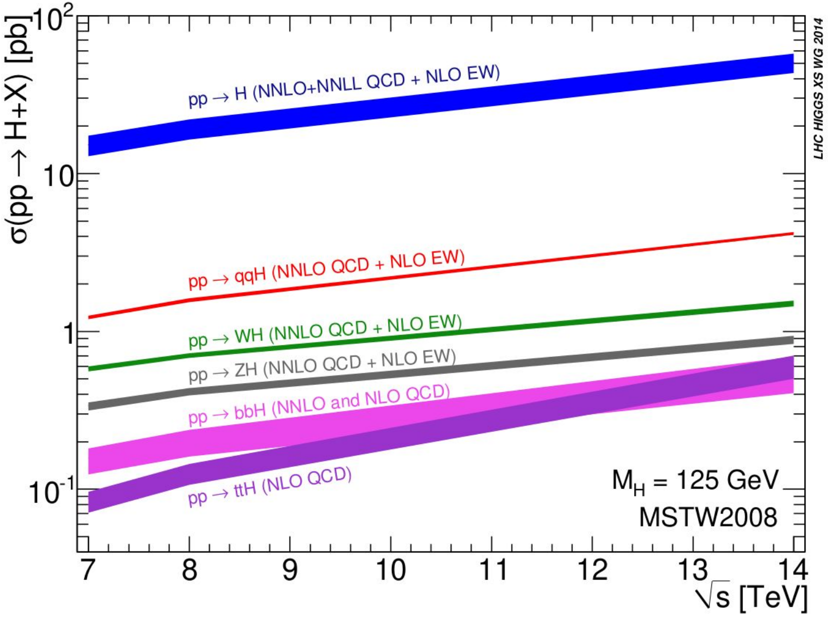
you can always reach me at nfcastro@lip.pt

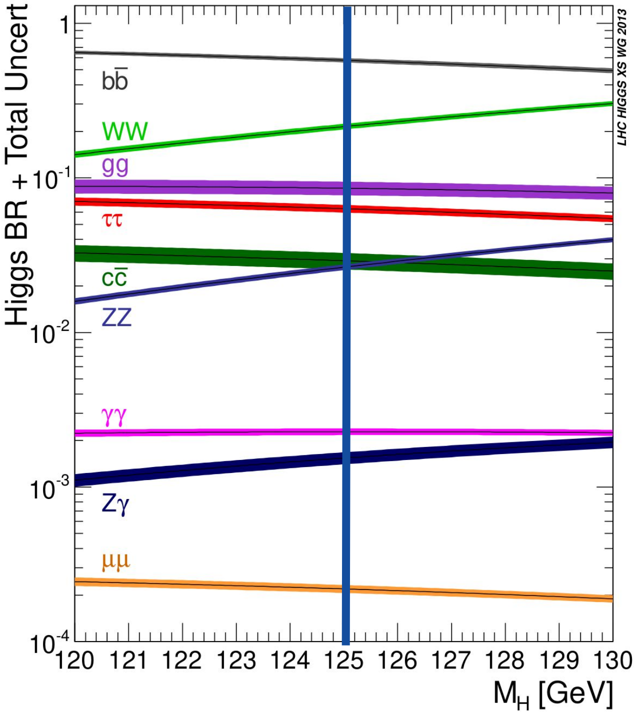
When you ask for more data...
... more data is what you get!



What can we do with the LHC data?

probe the Standard Model - Higgs boson properties





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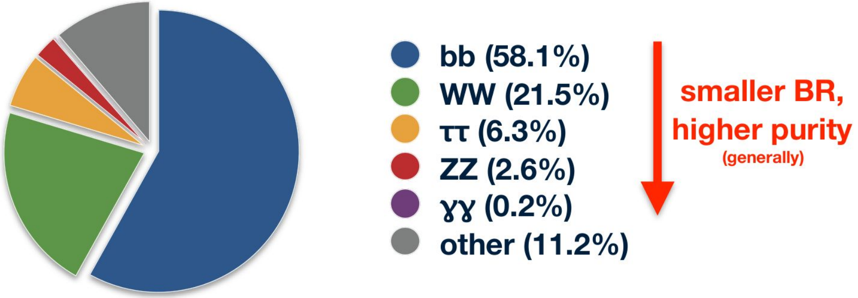

Channel	Dataset	Reference
ttH(bb)	36.1 fb^{-1}, 13 TeV	Phys. Rev. D 97, 072016
ttH multi-lepton (mostly H→WW* and H→ττ)	36.1 fb^{-1}, 13 TeV	Phys. Rev. D 97, 072003
ttH(ZZ*→4l)	79.8 fb^{-1}, 13 TeV	CERN-EP-2018-138 submitted to PLB
ttH(γγ)	79.8 fb^{-1}, 13 TeV	
ttH combination	36.1 - 79.8 fb^{-1}, 13 TeV	

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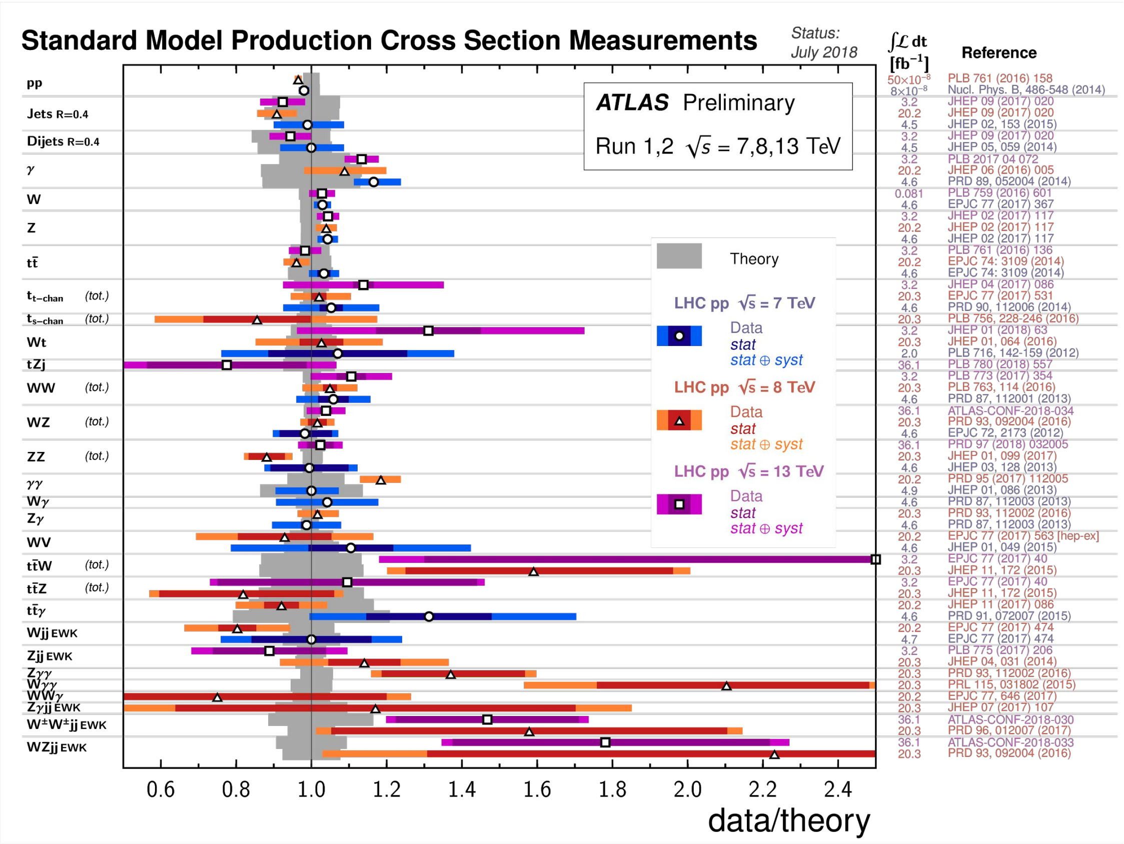
probe the Standard Model !

Comparing with theory predictions

excellent agreement



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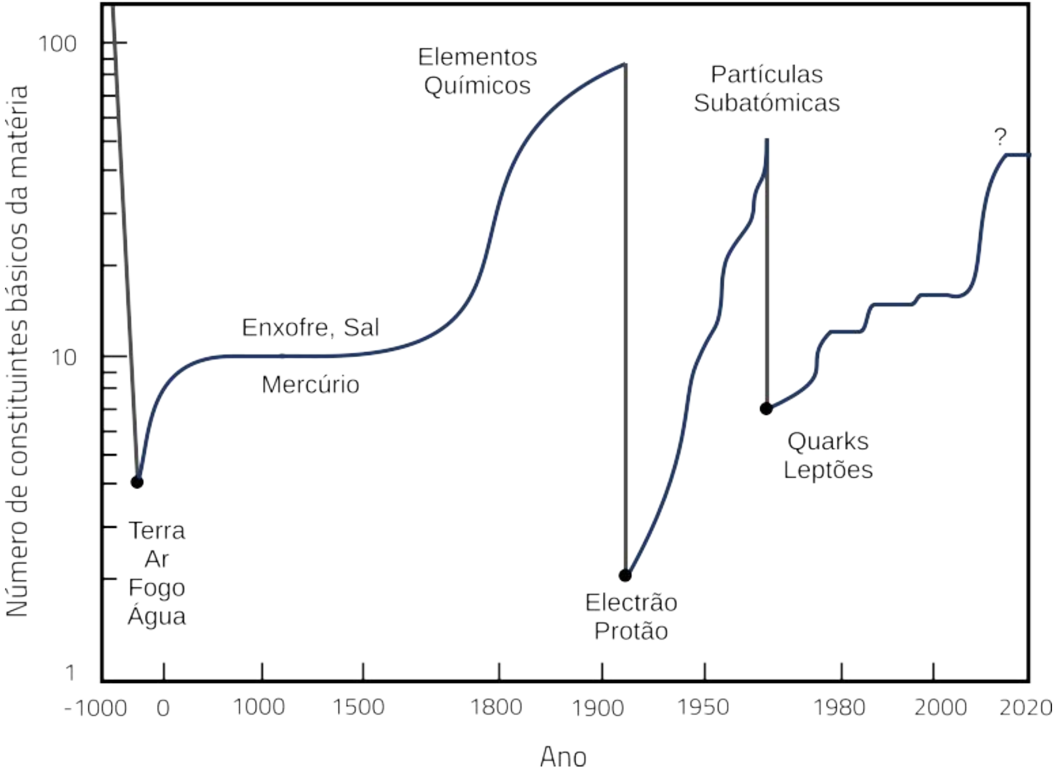

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