

A search of a new physics in the double Higgs production

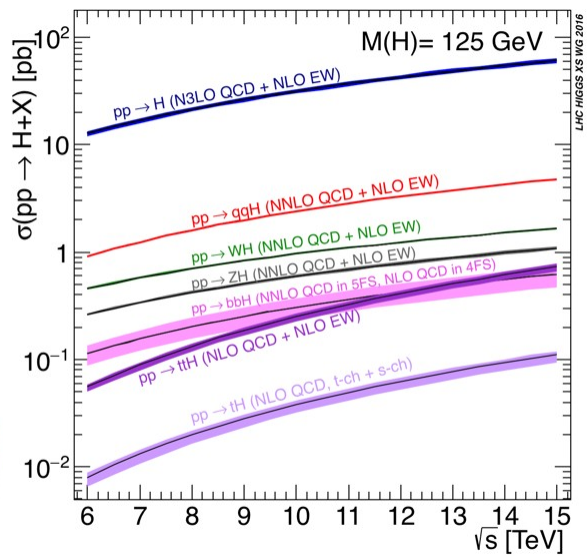
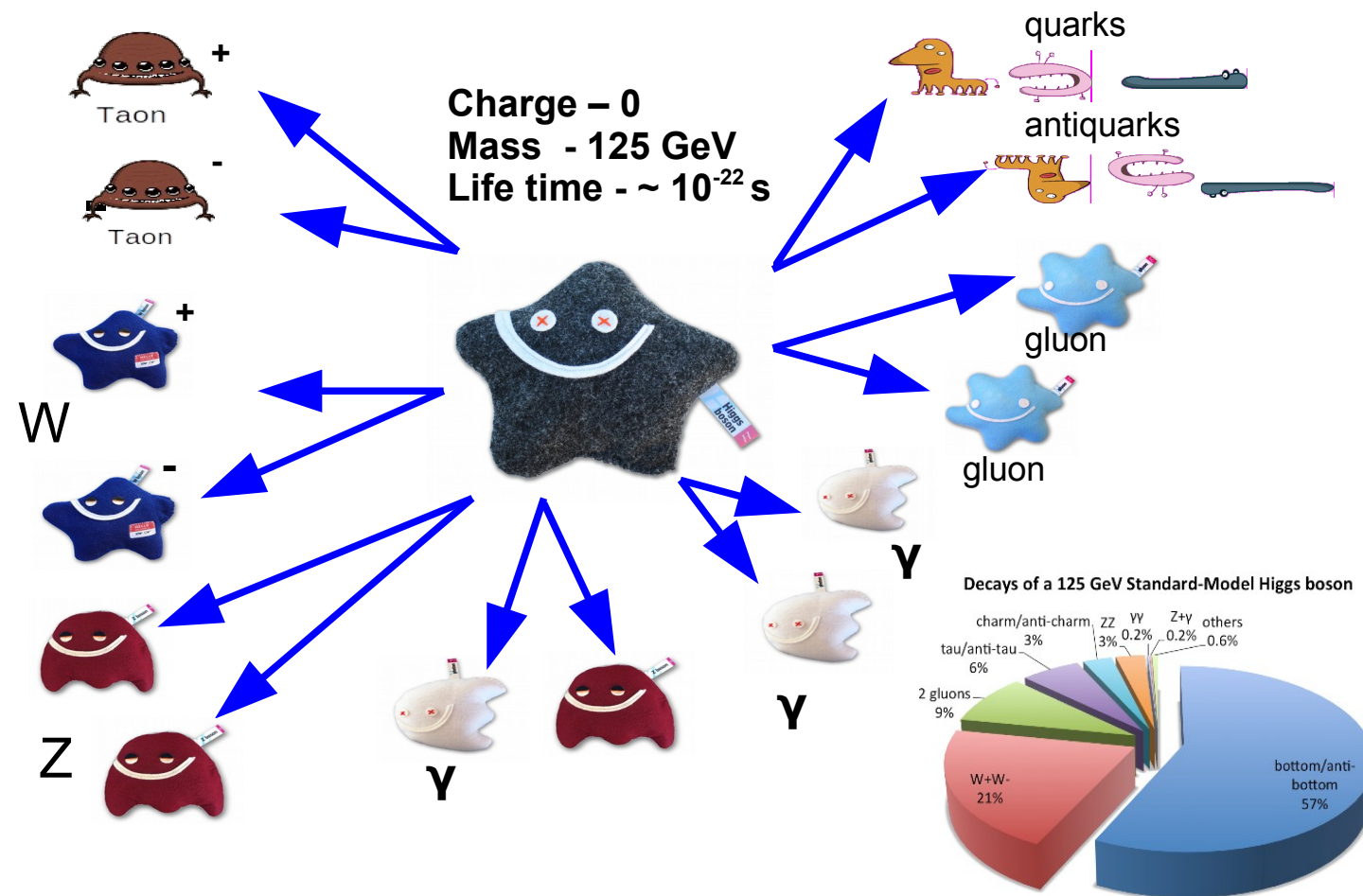
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The Higgs boson

Postulated in 1964 by Peter Higgs, Francois Englert, and Rober Brout.

In 2012 the first observation of the Higgs boson at LHC by the ATLAS and CMS experiments



A double Higgs bosons production

HH decay mode	bb	WW	$\tau\tau$	ZZ	$\gamma\gamma$
bb	33%				
WW	25%	4.6%			
$\tau\tau$	7.4%	2.5%	0.39%		
ZZ	3.1%	1.2%	0.34%	0.076%	
$\gamma\gamma$	0.26%	0.10%	0.029%	0.013%	0.0005%

Double Higgs decay modes.
Fields marked by dashed line are represent di-Higgs production modes with leptons in a final state

The total cross-section for di-Higgs production is ~ 35 fb, but for multileptons in final state, the cross-section is < 1 fb. A 1000 times smaller than cross-section for single Higgs production.

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Do we have a chance to observe di-Higgs production at the LHC?

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Yes, we have*.

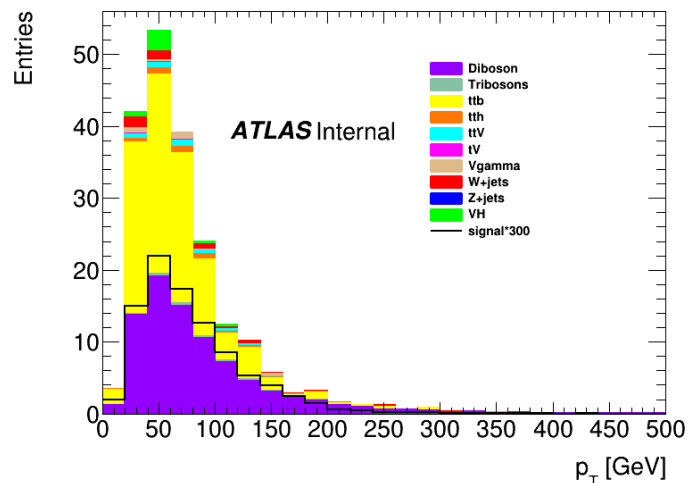
A lot of particle physics theoretical models predicting enhancement of the di-Higgs production at least 100 times with respect to the Standard Model.

An observation of the di-Higgs production can bring proof for a new physics.

* the chances are small but are worth it.

The goal of the task.

The main goal of the task is to find an optimal separation between signal and background processes.



The transverse momentum of a leading light lepton (e or muon).

Signal processes:

$$HH \rightarrow 1l (e, \mu) + 1\tau + X$$

$$HH \rightarrow 2l (SS) + 1\tau + X$$

$$HH \rightarrow \text{at least } 1l + \text{at least } 1\tau + X$$

How to separate:

- 1) Cut on different distribution and trying to reject as much as we can background processes.
- 2) Use machine learning method
 - in a minimal version, you will be using boosted decision tree or simple neural networks
 - in a more advanced version, a deep neural network will be used.

Thank you !