



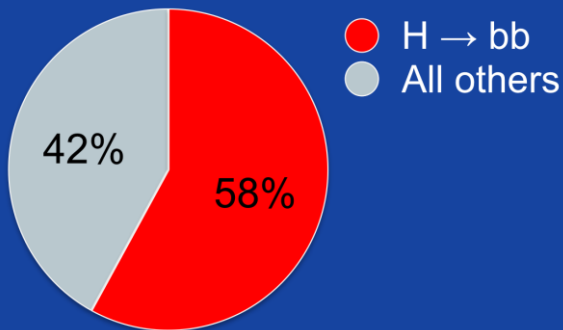
LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

[LIP Summer Projects 2018]

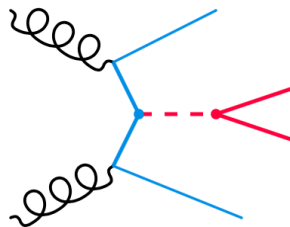
Physics @ LHC:
**Precision measurements
& searches beyond the SM**

Higgs Boson couplings to heavy quarks

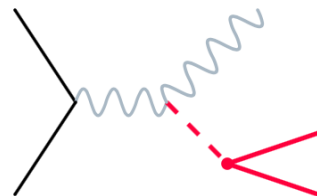
- Top and bottom have largest quark couplings to Higgs
- First evidence last year
- Decay branching ratios:



ttH

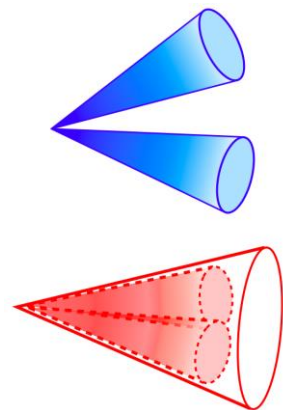
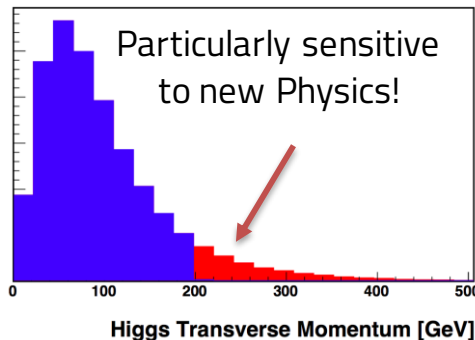


W/ZH



PROJECT

Study advanced data analysis techniques to improve sensitivity to boosted Higgses!

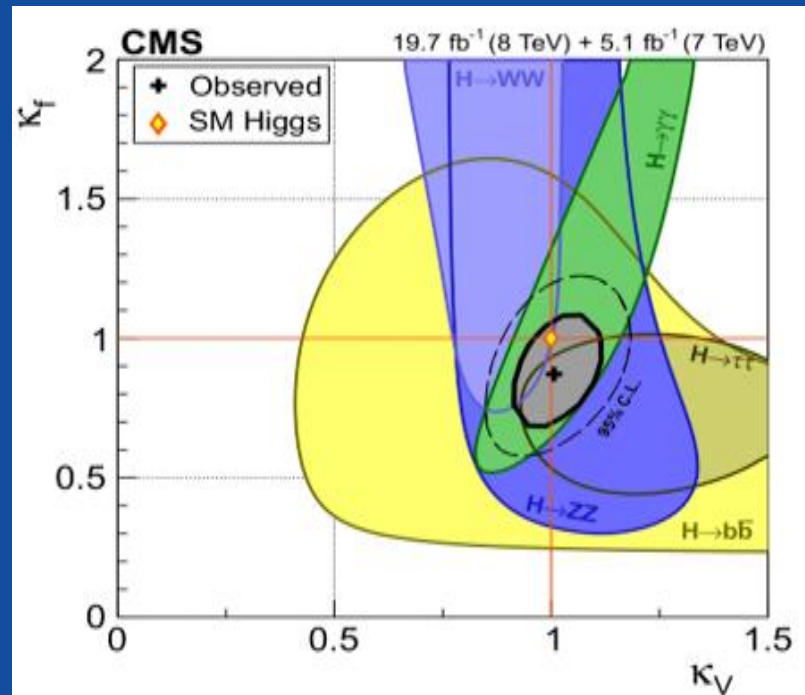


High transverse momentum Higgs decays within one jet of particles

➡ FIND JET SUBSTRUCTURE

Higgs couplings: H -> 2 taus with ML

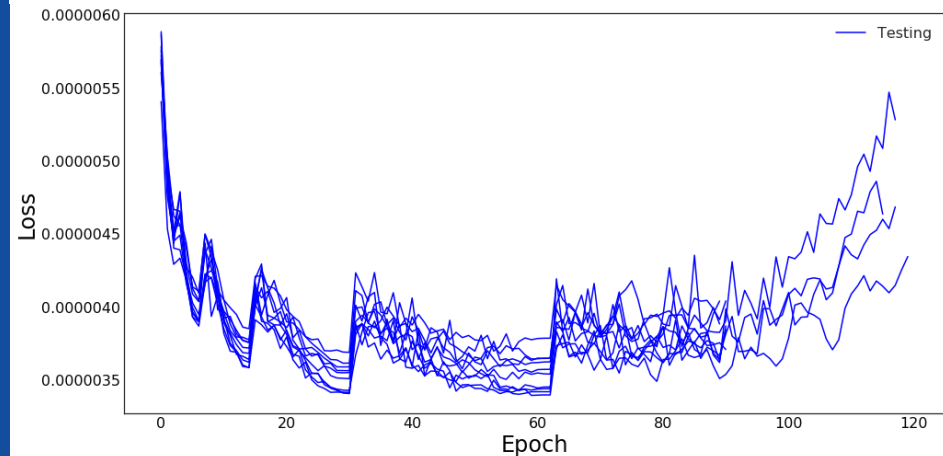
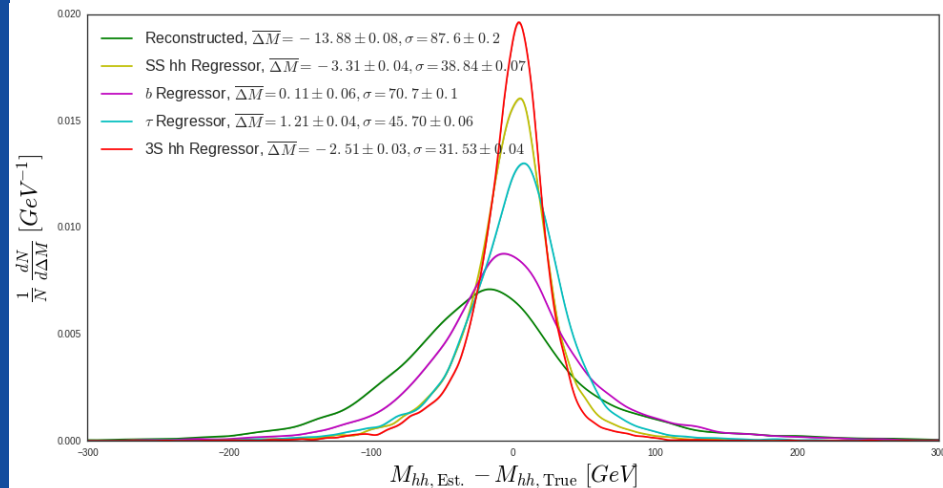
- "Strength" with which Higgs couples to fermions & bosons of SM
- **Are Higgs couplings within the SM ?** If not: Would show up in "details" of couplings: **Measure couplings with best precision:** Highest purity of Signal
- Promising decays of the Higgs: **H -> 2 taus**
- **Train a multiclass NN with Keras:** Use full information (1-D & 2-D): Optimally characterize signal versus several SM backgrounds



Separate at best
Signal
from
Background

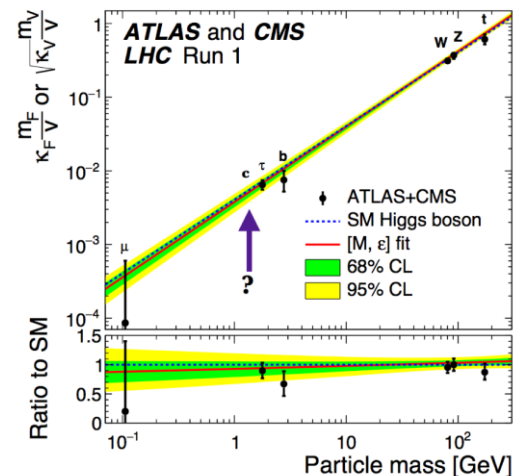
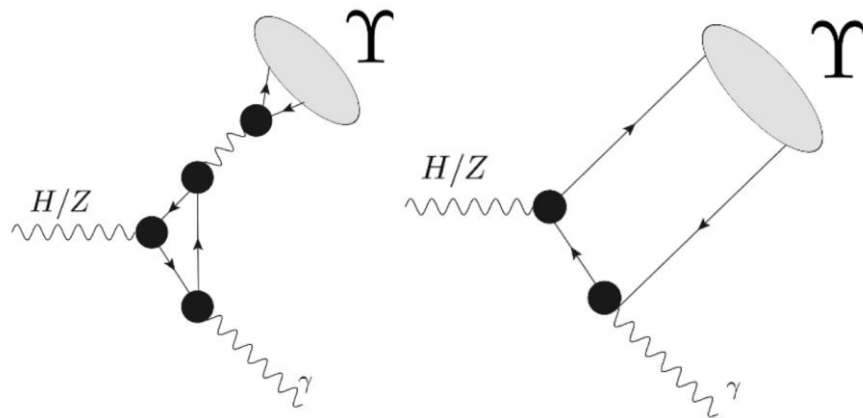
Di-Higgs searches with Machine Learning

- Flexible project dependent of students' experience and interests. Possible work:
- Use neural-networks to classify particle collisions to search for the rare process of di-Higgs production
- Improve estimation of particle kinematics using deep-learning regression
- Apply un-supervised clustering techniques to identify event categories
- Up to 2 students
- Up to 2 months: July-September
- Prior ML experience not required
- Some familiarity with python and Linux/MacOS useful



Higgs rare decays

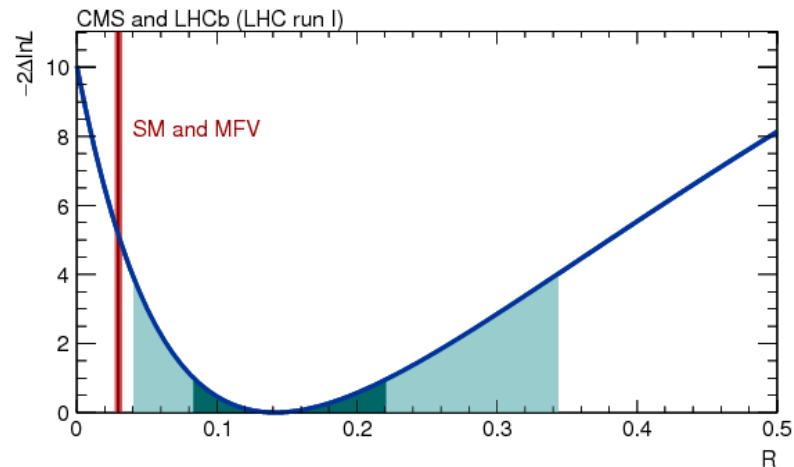
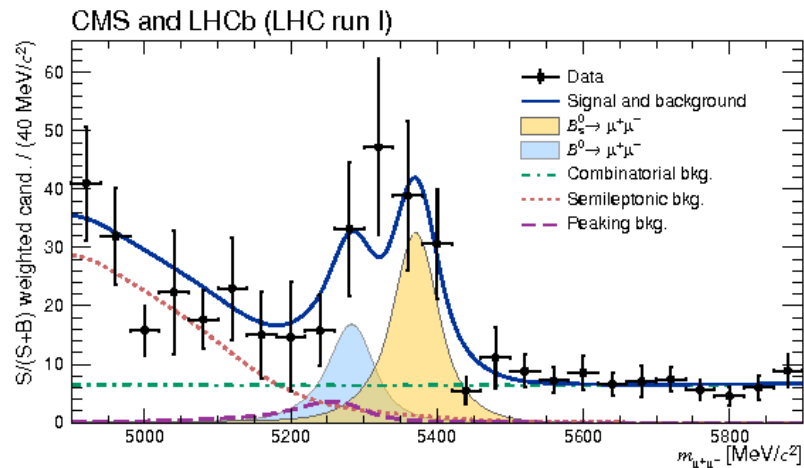
- Study Higgs (and Z) boson rare decays
- These processes are rare in the standard model, sensitive to new physics
- Search conducted with LHC data collected by the CMS experiment
- Observation would allow to measure quark Yukawa couplings (Hqq) --> to test whether the observed particle is the SM Higgs
- Z is benchmark for Higgs analogous process
- Up to 2 students
- Up to 2 months: July-September



Rare beauty decays

- The golden rare decays of neutral B mesons to a muon pair constitute a flagship LHC physics process
- It is highly sensitive to physics scenarios beyond the standard model
- The student will join the analysis team pursuing the study of this rare decay at LIP using recent LHC data
- The project will involve the characterization and separation of competing physics processes.

- Up to 2 students
- Up to 2 months: July-September



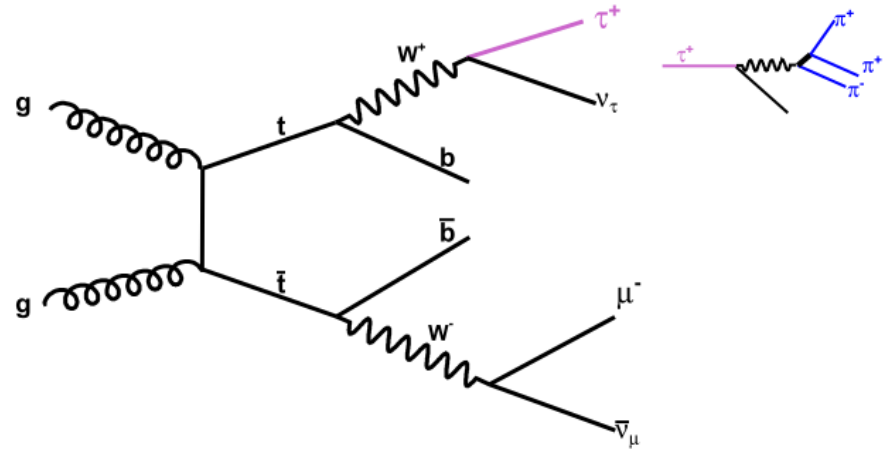
Tests of lepton universality in top-quark pair decays

- Lepton Universality: all leptons (electron, muon, tau) interact at exactly the same rate with other particles
- Current measurement of W decays to tau lepton with respect to other leptons shows a deviation from the hypothesis
- Precise measurement can be done in the large set of LHC events with top-quark pair decay
- **Join the development of the measurement in the CMS group of LIP**

$$\Gamma(\tau^+\nu)/\Gamma(e^+\nu)$$

$$\Gamma_4/\Gamma_2$$

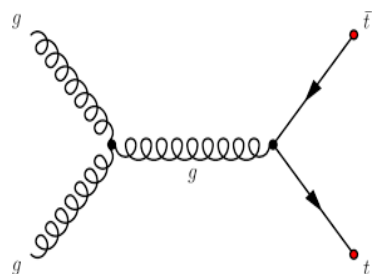
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.046 ± 0.023 OUR FIT				
0.961 ± 0.061	980	42 ABBOTT	00D D0	$E_{cm}^{p\bar{p}} = 1.8 \text{ TeV}$
0.94 ± 0.14	179	43 ABE	92E CDF	$E_{cm}^{p\bar{p}} = 1.8 \text{ TeV}$
1.04 ± 0.08 ± 0.08	754	44 ALITTI	92F UA2	$E_{cm}^{p\bar{p}} = 630 \text{ GeV}$
1.02 ± 0.20 ± 0.12	32	ALBAJAR	89 UA1	$E_{cm}^{p\bar{p}} = 546,630 \text{ GeV}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.995 ± 0.112 ± 0.083	198	ALITTI	91C UA2	Repl. by ALITTI 92F
1.02 ± 0.20 ± 0.10	32	ALBAJAR	87 UA1	Repl. by ALBAJAR 89



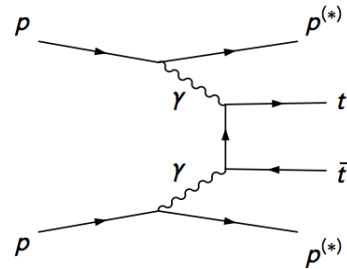
$$\sigma \sim 832 \text{ pb}$$

Search for exclusive top production with PPS

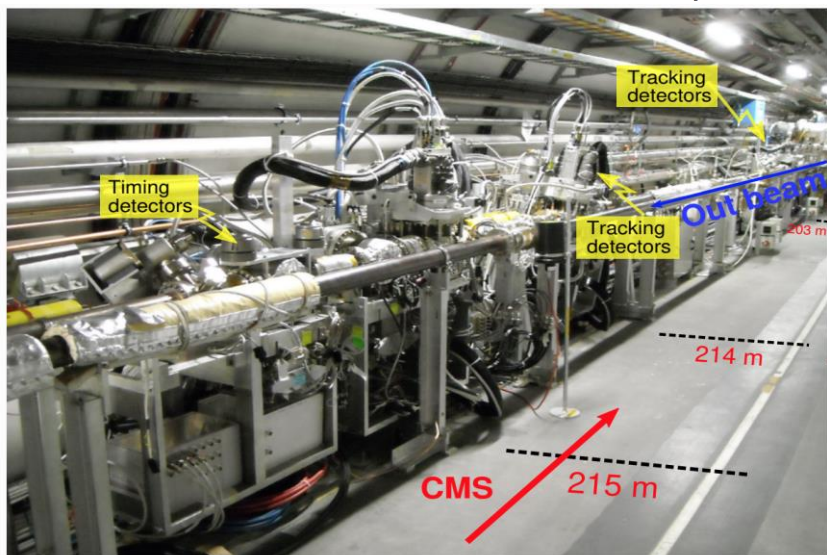
- Top: produced from scattering of proton constituents but, in very rare occasions, can be produced without dissociation from the proton:
- a. Never observed before
- b. Sensitive to anomalous couplings
- c. Potential for a mass measurement with high statistics
- **Join the search during this summer using data collected by CMS @ 13 TeV**



$$\sigma \sim 832 \text{ pb}$$



$$\sigma \sim 0.3 \cdot 10^{-3} \text{ pb}$$



CERN-LHCC-2014-021 / TOTEM-TDR-003 / CMS-TDR-13

Outgoing protons can be reconstructed in the PPS detector system (>200m away from CMS)