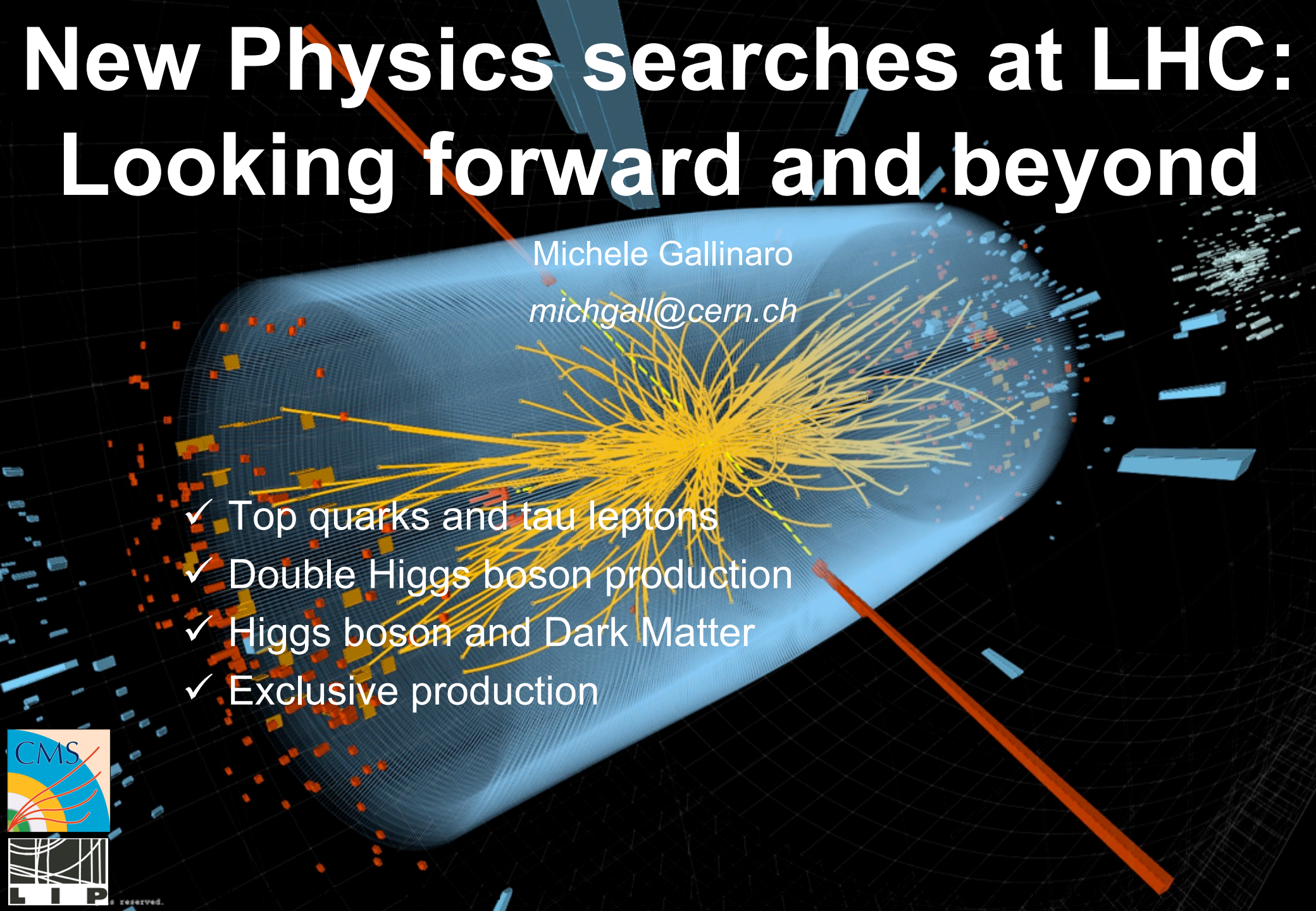
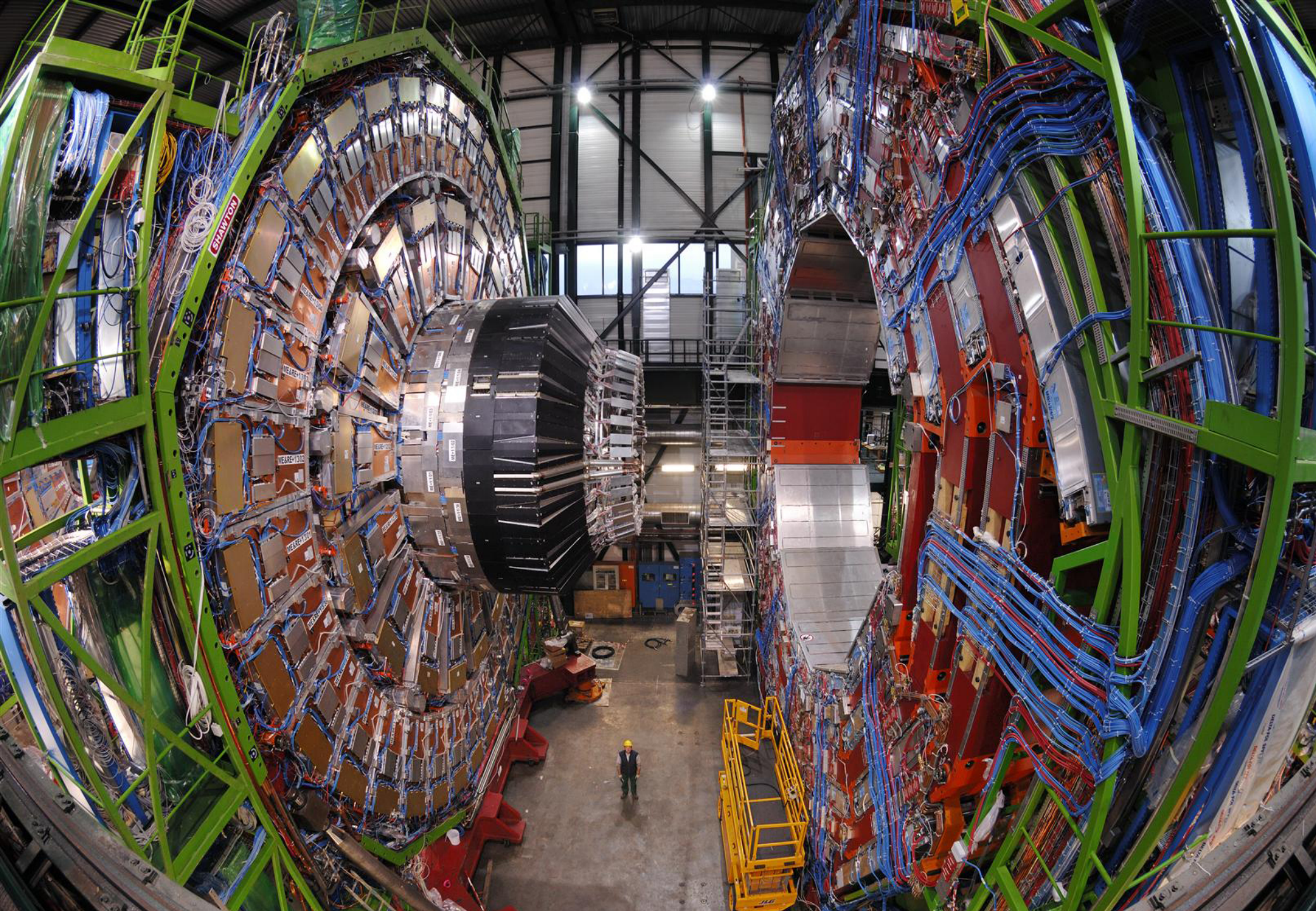
New Physics searches at LHC: Looking forward and beyond

Michele Gallinaro

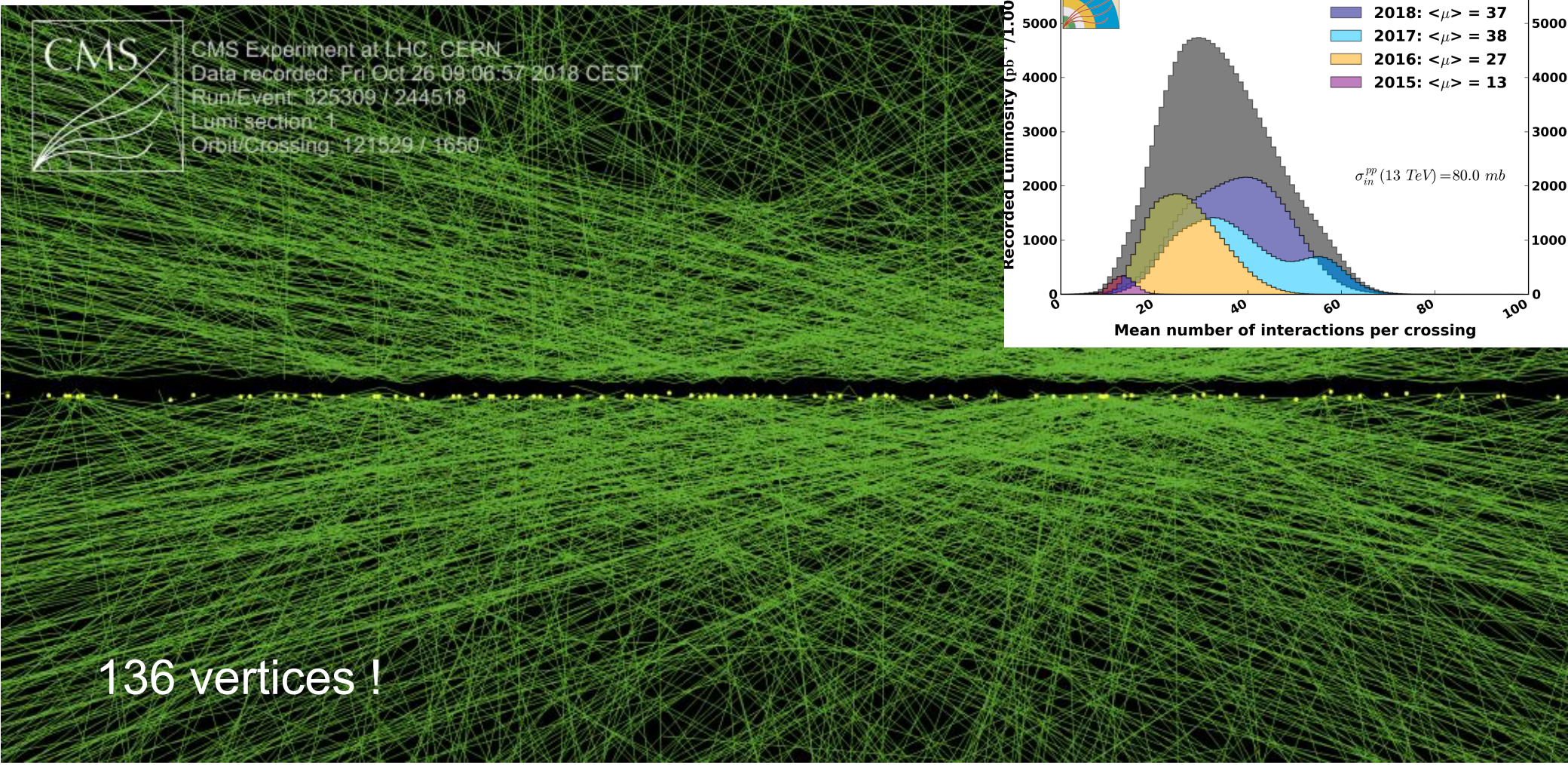
michgall@cern.ch



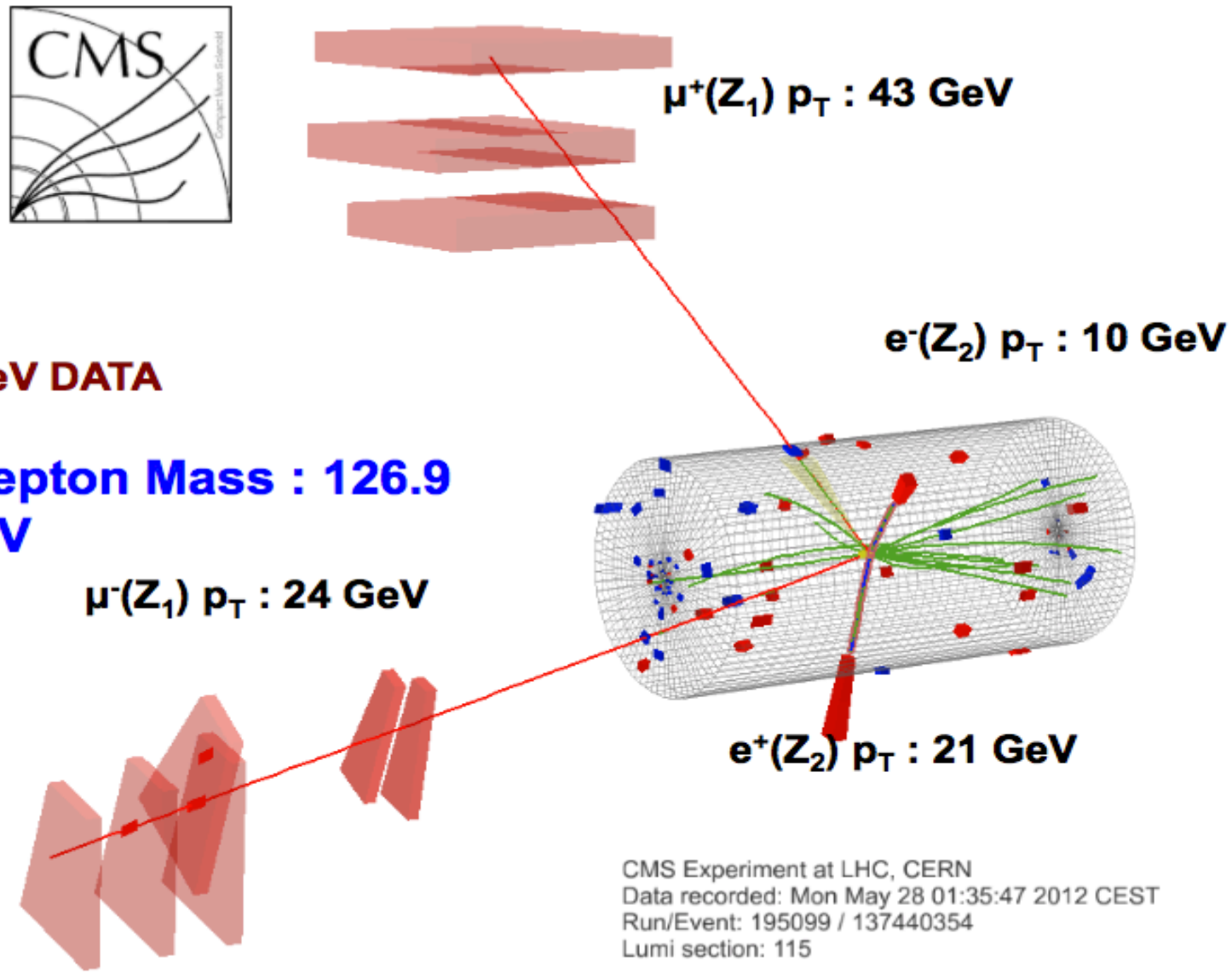
- ✓ Top quarks and tau leptons
- ✓ Double Higgs boson production
- ✓ Higgs boson and Dark Matter
- ✓ Exclusive production


SHAWTON

…in a challenging environment



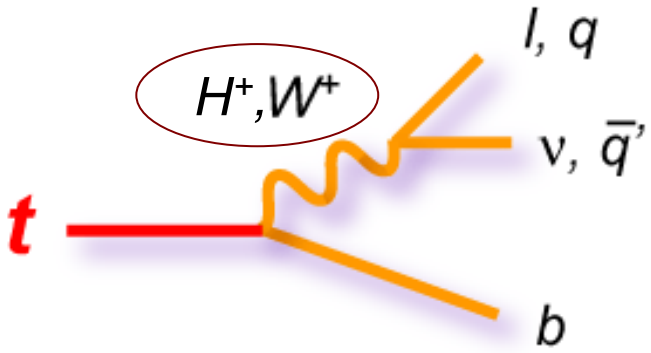
Higgs candidate event

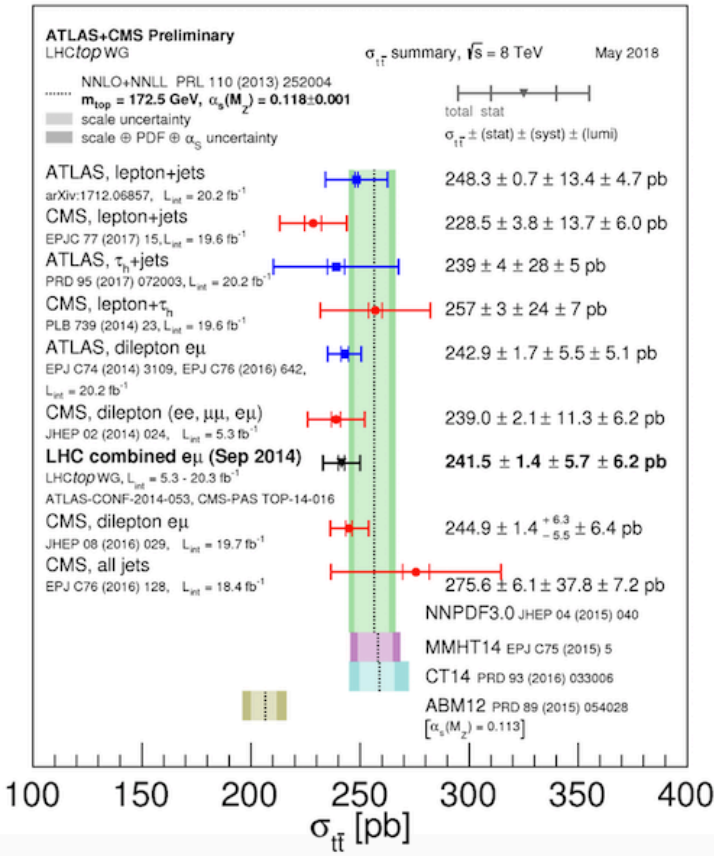


Top quarks and tau leptons

A. Toldaiev

- Lepton flavor anomaly: 3 experiments measure ~4σ deviation from SM expectations





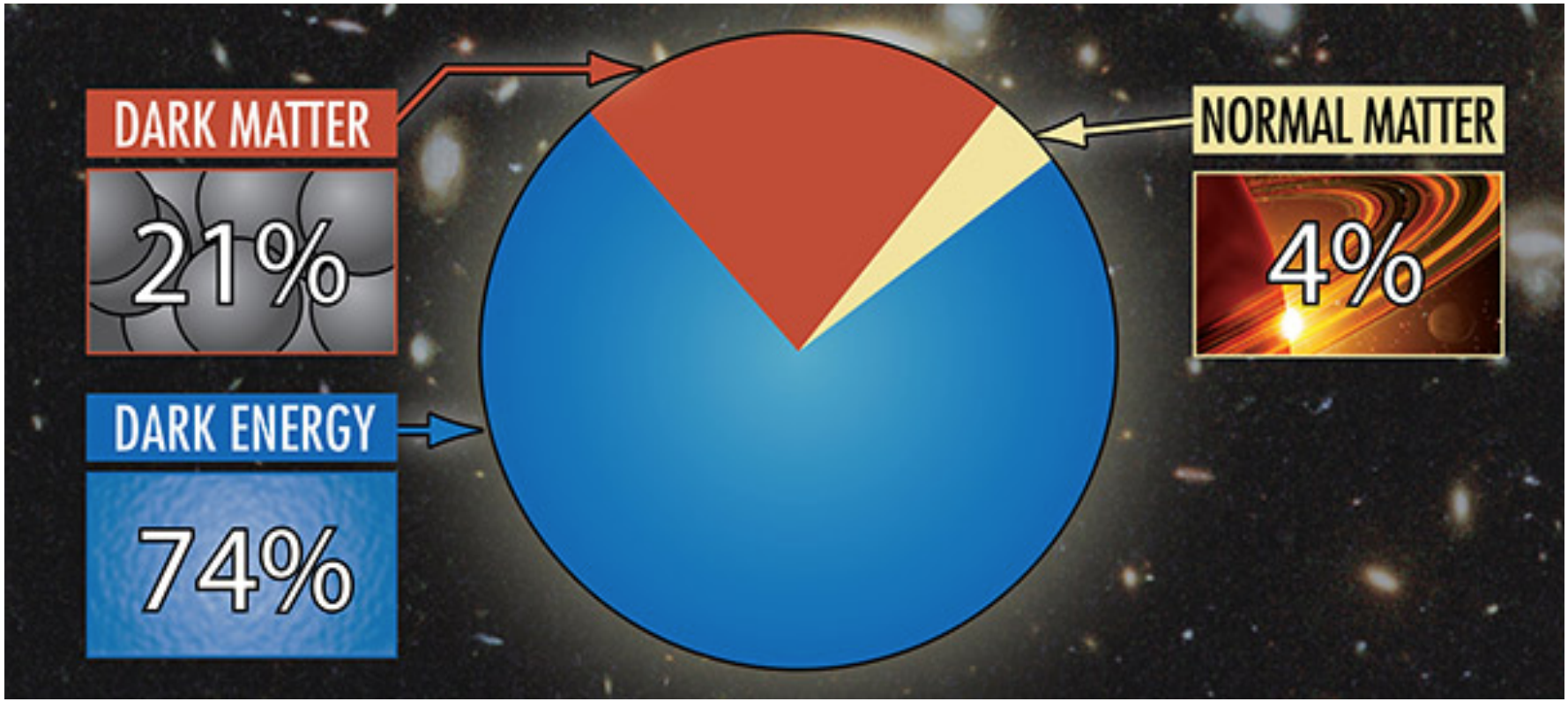
- Study tau leptons in top quark decays
- Measure cross section, study event kinematics
- Lepton flavor universality in top quark events

W^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\ell^+\nu$	[b]	(10.86 ± 0.09) %		–
$e^+\nu$		(10.71 ± 0.16) %		40192
$\mu^+\nu$		(10.63 ± 0.15) %		40192
$\tau^+\nu$		(11.38 ± 0.21) %		40173

BR(τ)/BR(e/μ) = ?

Dark matter and energy

- What is that accounts for 96% of the Universe? Nobody knows.
- It is one of the greatest mysteries of Science

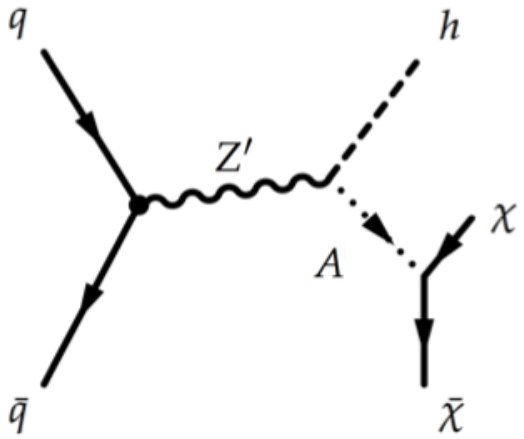


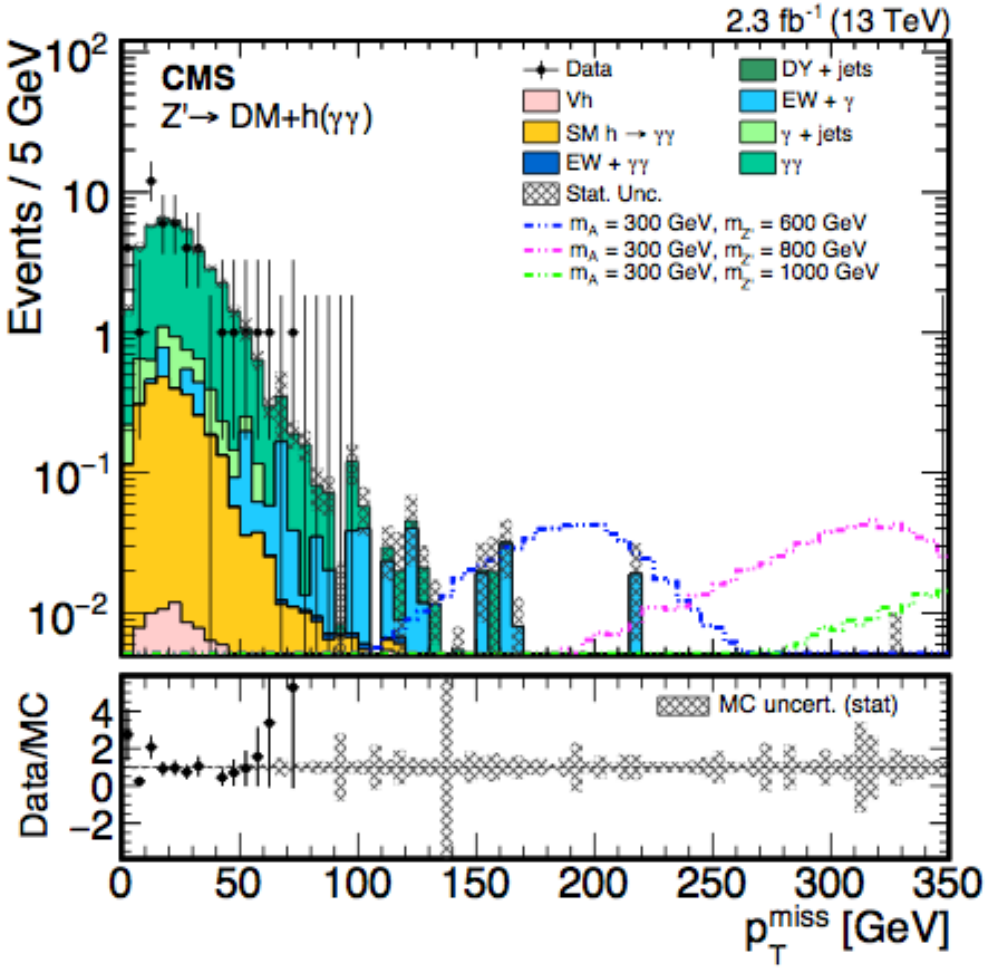
Higgs + Dark Matter

arXiv:1703.05236, arXiv:1812.07964

J. Goncalves et al.

- DM search with H(→ZZ)
- Generic search: pp→X+MET
- Model independent search
  - –Signature: h(→ZZ/bb/γγ)+MET

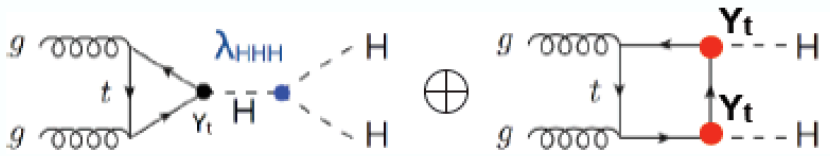




- Signal events at large MET

Double Higgs production

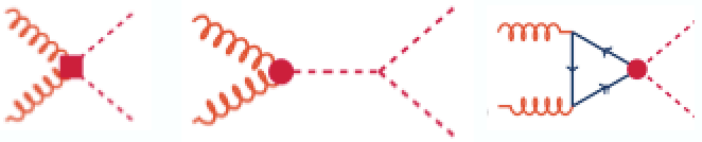
Main probe for trilinear Higgs coupling λ_{HHH}. Diagrams interfere destructively in SM



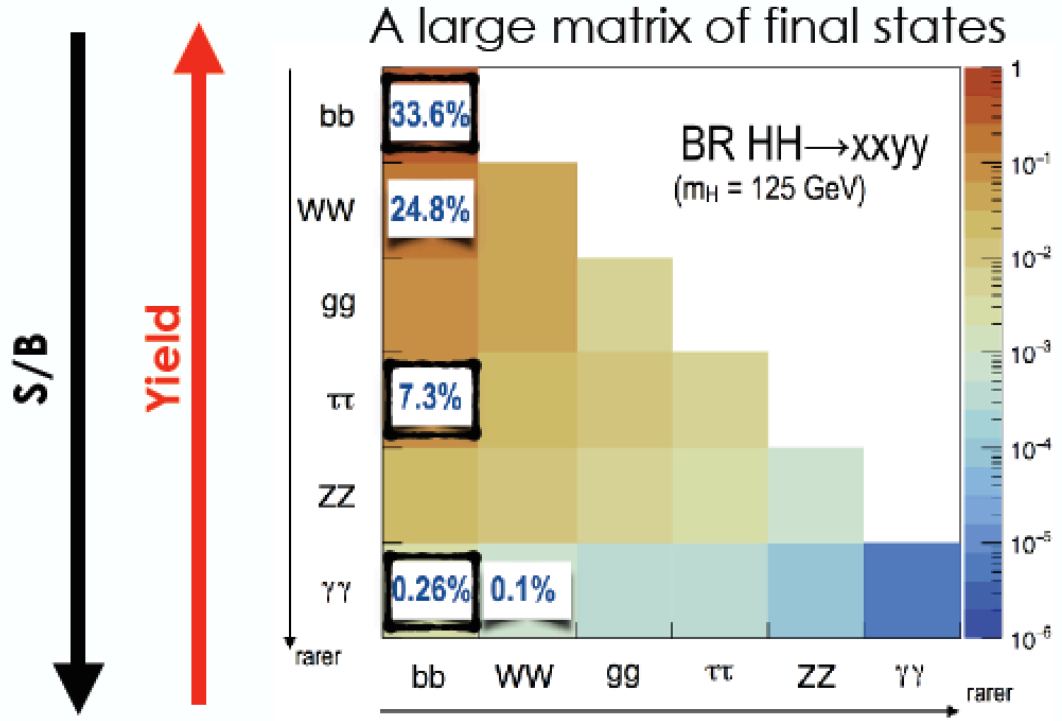
$\sigma_{gg\to HH} = 33.49^{+4.3}_{-6.0}$ (scale) ± 2.1 (PDF) ± 2.3 (α_s) fb

[13 TeV, NNLO + NNLL with top mass effects, HXSWG, arXiv:1610.07922]

sensitive to possible BSM contributions



A large matrix of final states



bbbb largest statistics

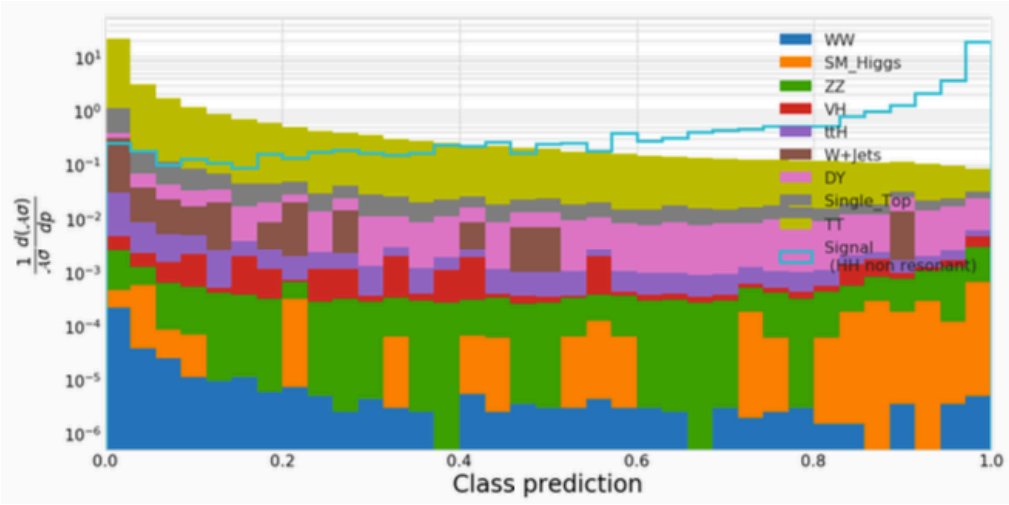
bb(γγ,ττ) good compromise between statistics and S/B

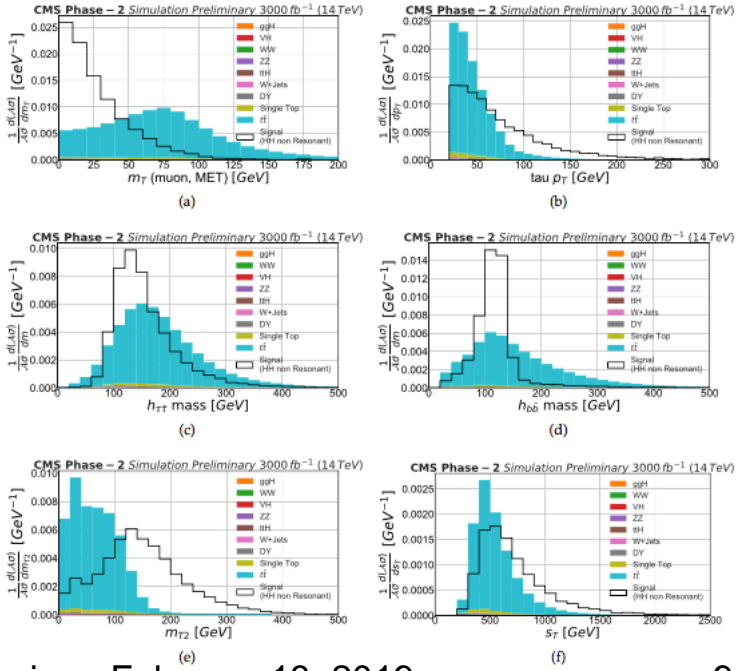
Advanced Analysis Techniques

arXiv:1902.00134

M. Bengala, R. Santo, G. Strong

1) Select HH events in different categories: $\mu\tau_h$bb, e$\tau_h$bb, and $\tau_h\tau_h$bb
2) Train classifier consisting of an ensemble of deep neural networks (DNN) on half of MC data to classify signal and background events using final-state features
3) Apply classifier to other half of MC data
4) Treat the classifier prediction as a summary statistic of the data and infer the signal strength via a combined hypothesis test for each decay-channel category
5) 52 pre-processed features are used to define each event

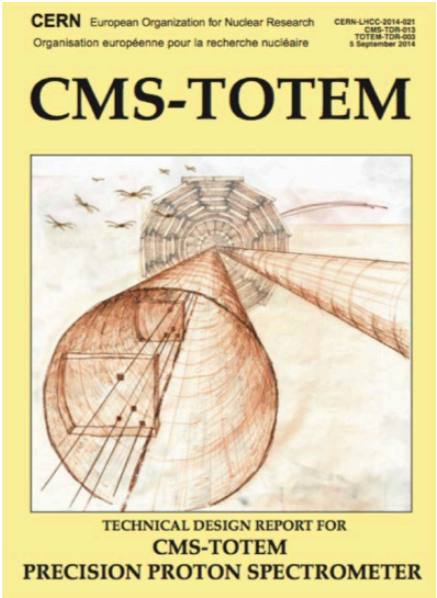


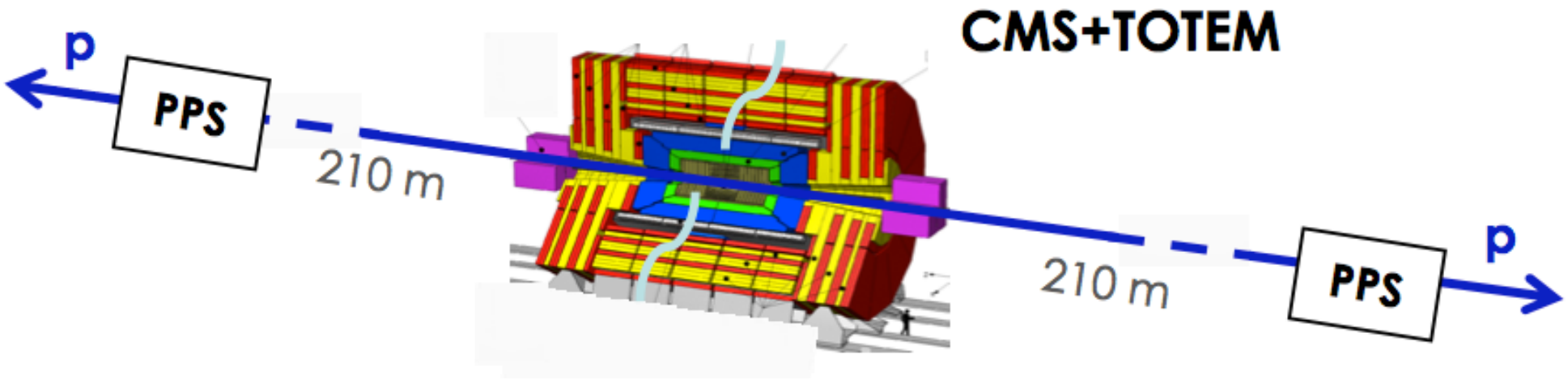


Looking forward: exclusive processes

CERN-LHC-2014-021

- Precision Proton Spectrometer (PPS) aims at measuring the surviving scattered protons on both sides of CMS in standard running conditions
- Precise timing and tracking detectors
- PPS data combined with those of central detector
- Collected ~100/fb of data in 2016-2018

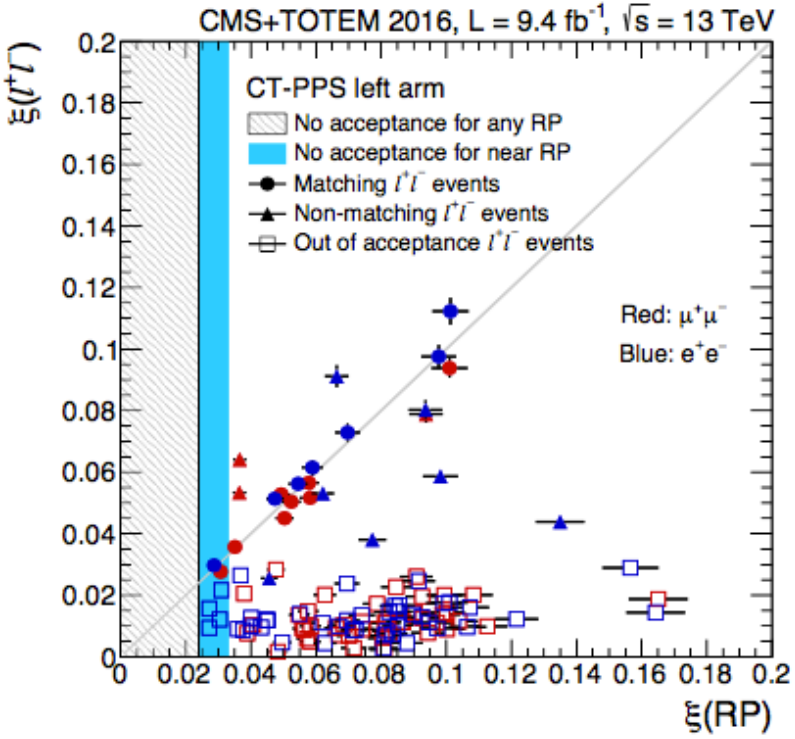


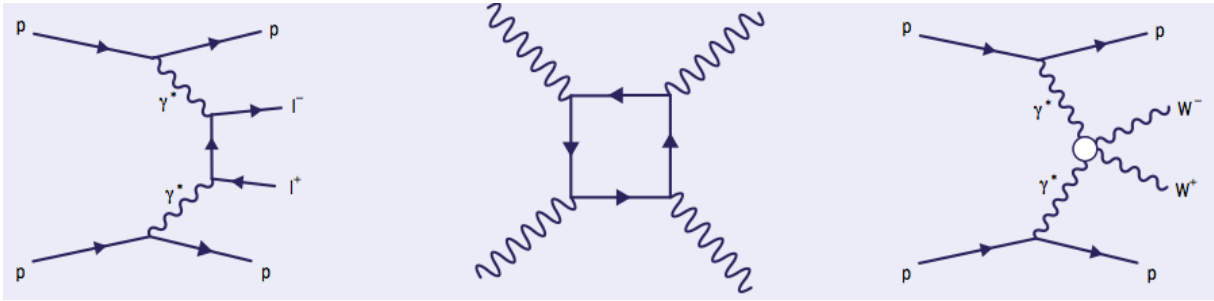


Exclusive production

- Central Exclusive Production
  - photon-photon collisions
  - gluon-gluon fusion in color singlet, $J^{PC}=0^{+}$
- High-mass system in central detector, together with very forward protons in PPS
  - momentum balance between central system and forward protons, provides strong kinematical constraints
  - Mass of central system measured by momentum loss of the two leading protons
- Couplings in SM are small and deviations from predictions may hint for NP
- Sensitive anomalous couplings ($\gamma\gamma$WW, $\gamma\gamma$ZZ, $\gamma\gamma\gamma\gamma$, and $\gamma\gamma$tt)
- Search for new BSM resonances

B. Lopes et al.

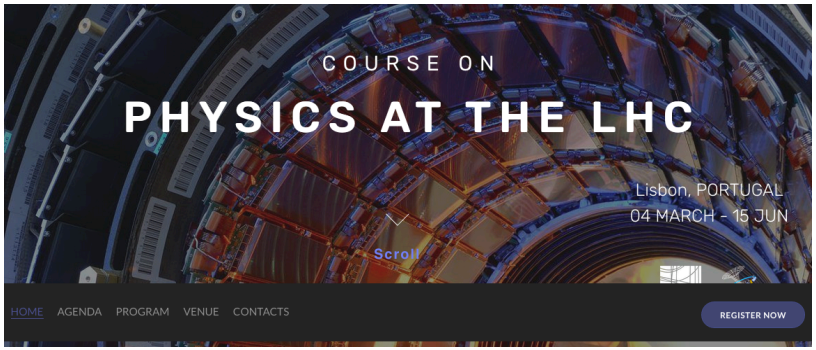


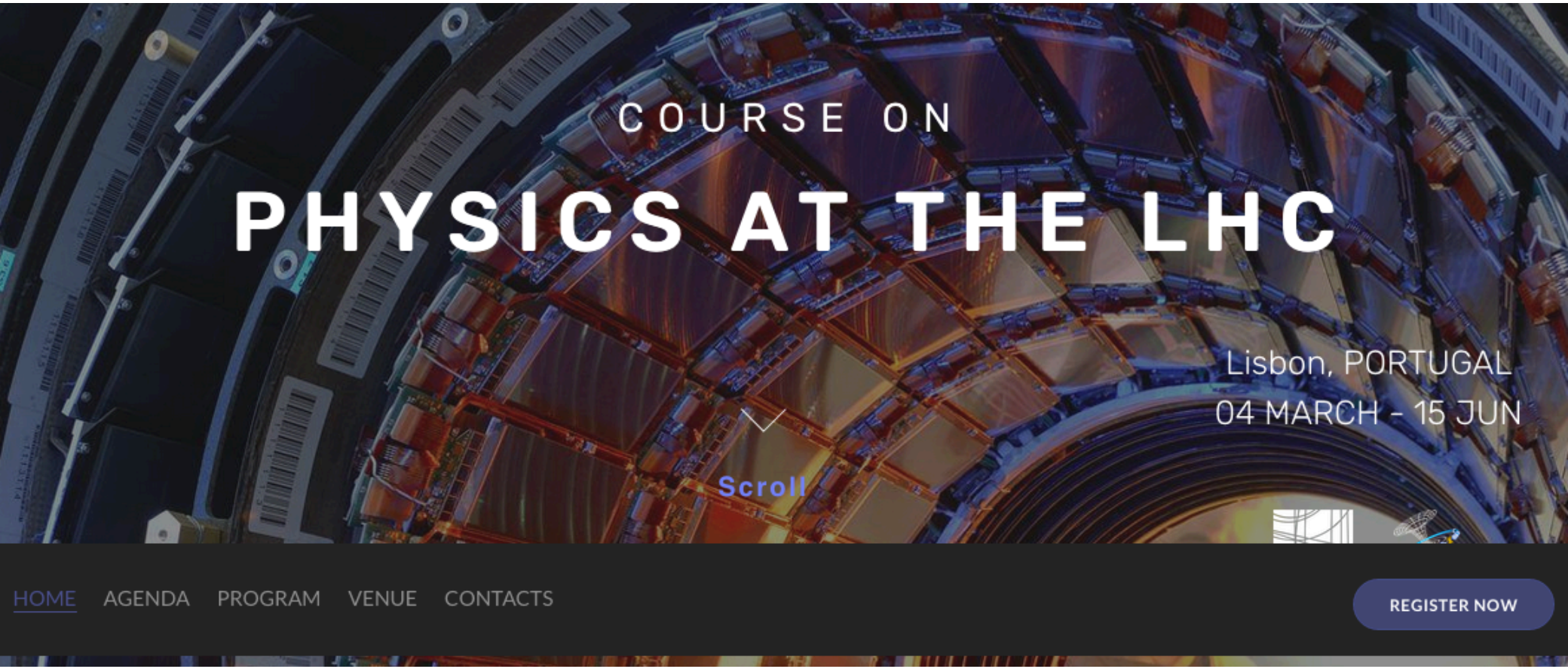


Thank you!

- Large data sample available: ~150fb^{-1}
- Several interesting analysis topics available (Top, DM, HH, Exclusive processes)
- Strong involvement of students (several Master and PhD theses)

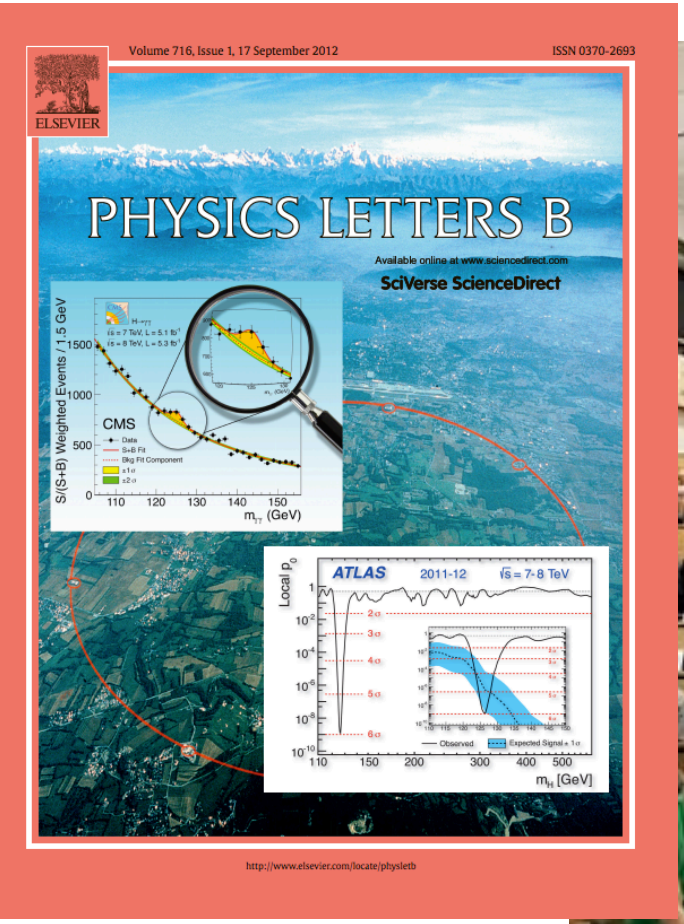
⇒ Join! Your contribution will make the difference!




COURSE ON
PHYSICS AT THE LHC
Lisbon, PORTUGAL
04 MARCH - 15 JUN
Scroll
HOME
AGENDA
PROGRAM
VENUE
CONTACTS
REGISTER NOW

backup

2012: A new boson discovery

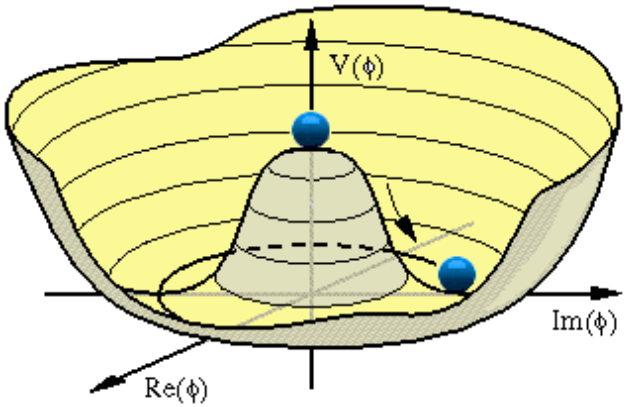


standard model of elementary particles

- Discovery of the Higgs boson marks the triumph of the SM

⇒ However, even with the inclusion of the Higgs boson, SM is an incomplete theory

Higgs self-coupling

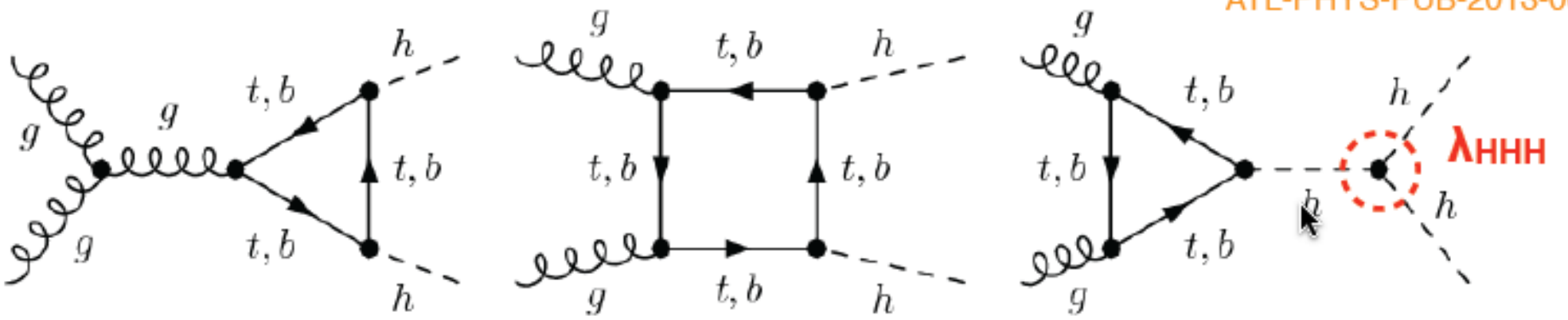


$$V(h) = \mu^2 \frac{h^2}{2} + \lambda \frac{h^4}{4}$$ Higgs potential

$$\lambda h_0^2 \eta^2 + \frac{\lambda}{4}\eta^4 + \lambda h_0 \eta^3$$ After spontaneous symmetry breaking

- The strength of triple and quartic couplings is fully fixed by the potential shape

ATL-PHYS-PUB-2013-007



Deep Neural Network

Data are fed to deep neural networks (DNN) to build a classifier

- Basic classifier:

→ DNN with 3 hidden layers (100 neurons each)

→ Output layer of a single neuron

→ Ensemble of 10 networks trained on 50% of the data, using cross-validation, for 65 epochs

- Models pre-trained without sample weights
- Models weighted according to loss on validation data

→ Remaining data used to test the classifier and optimise the thresholds

- Train on low-level final-state features plus multiplicity features

→ final set of 52 selected features