New Physics searches at LHC: Looking forward and beyond

opportunities with the CMS group

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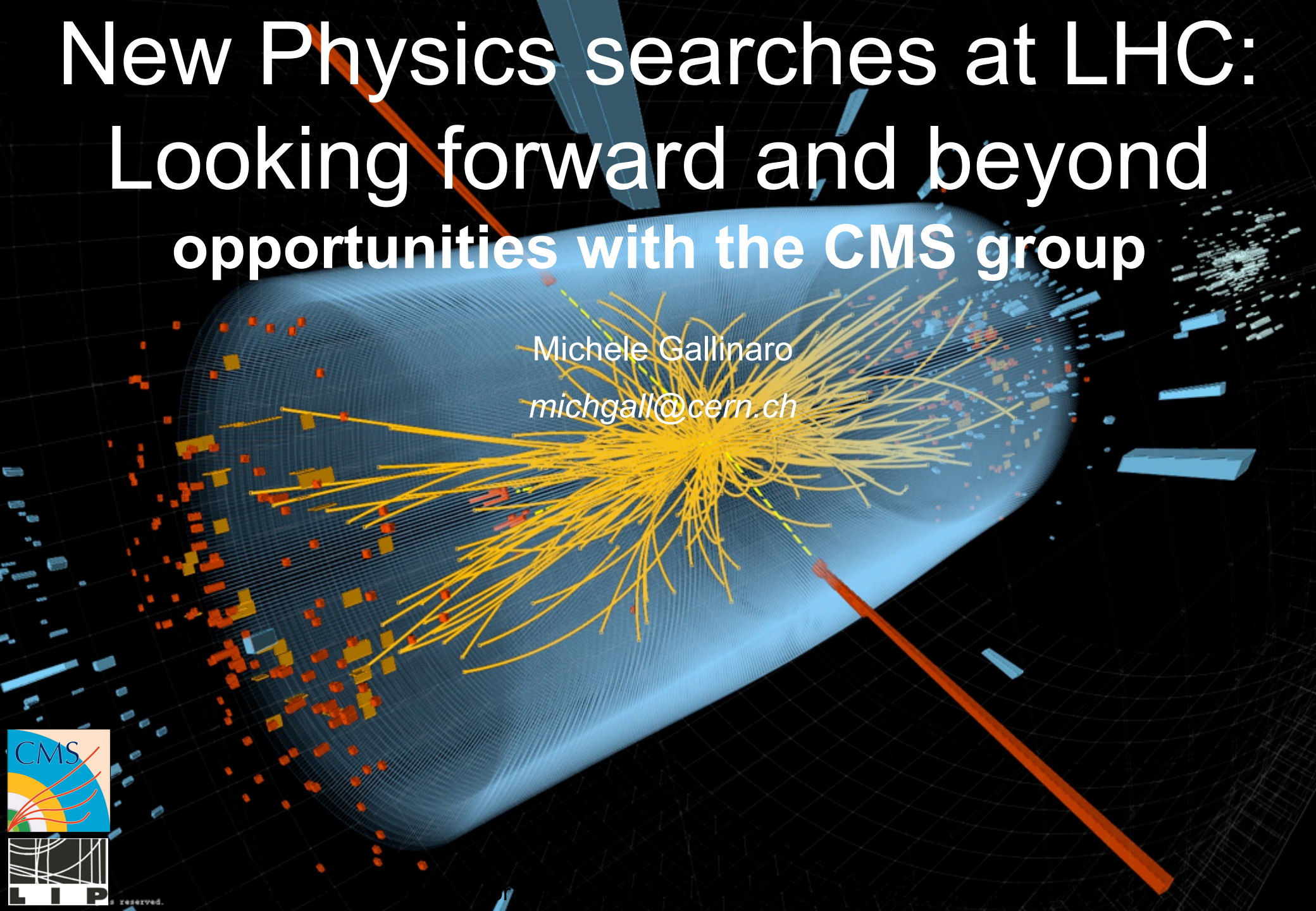
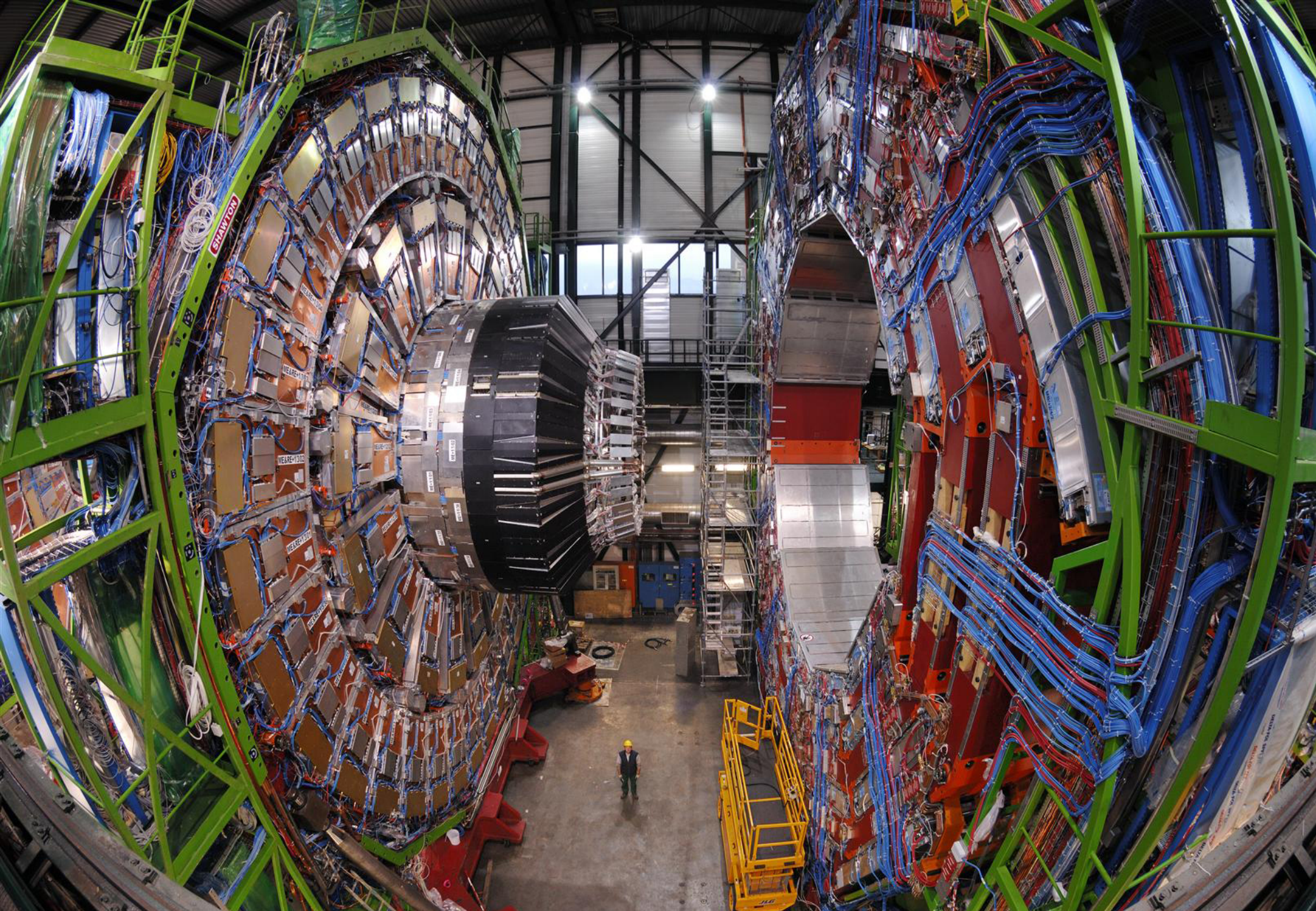
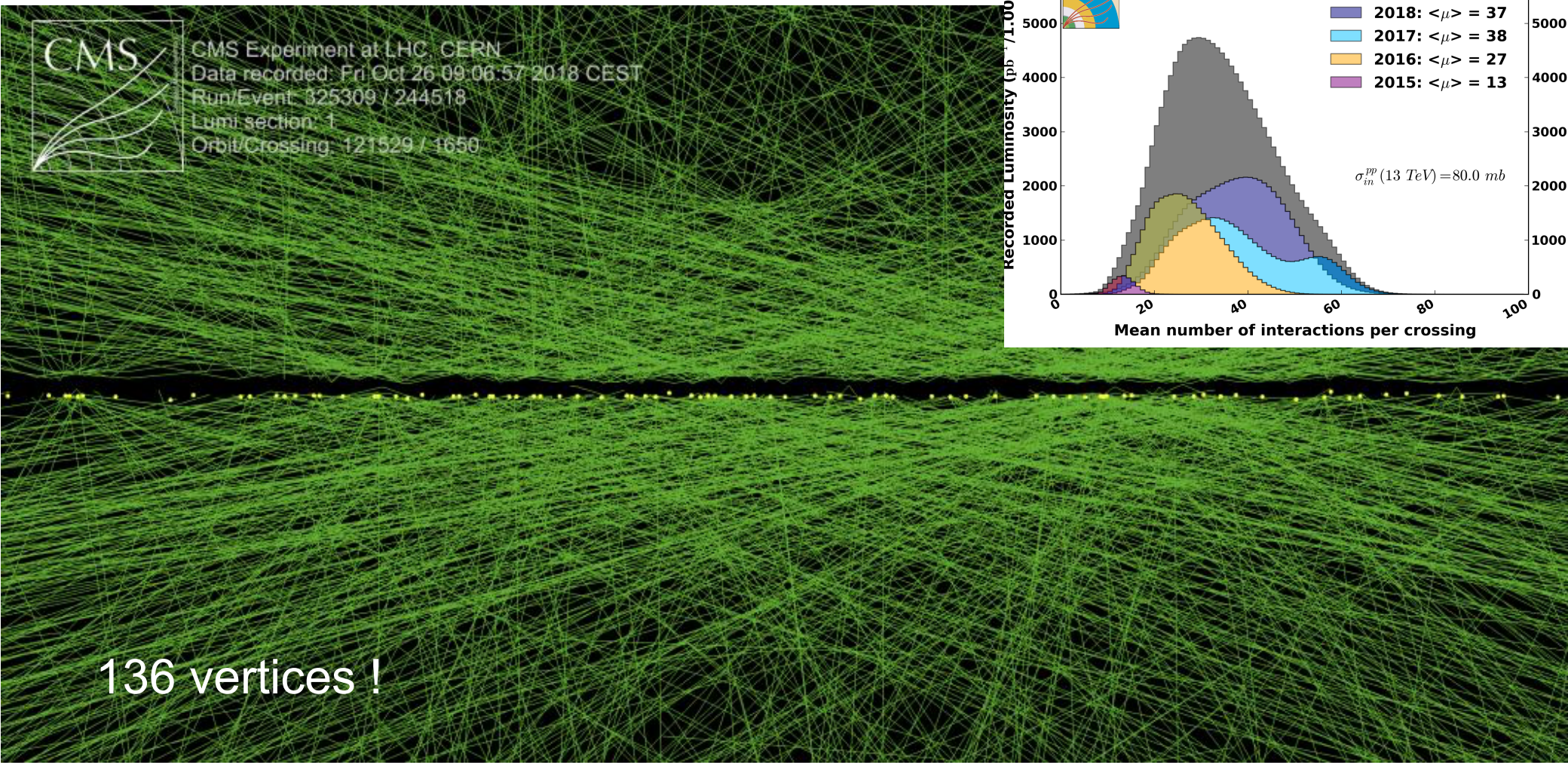
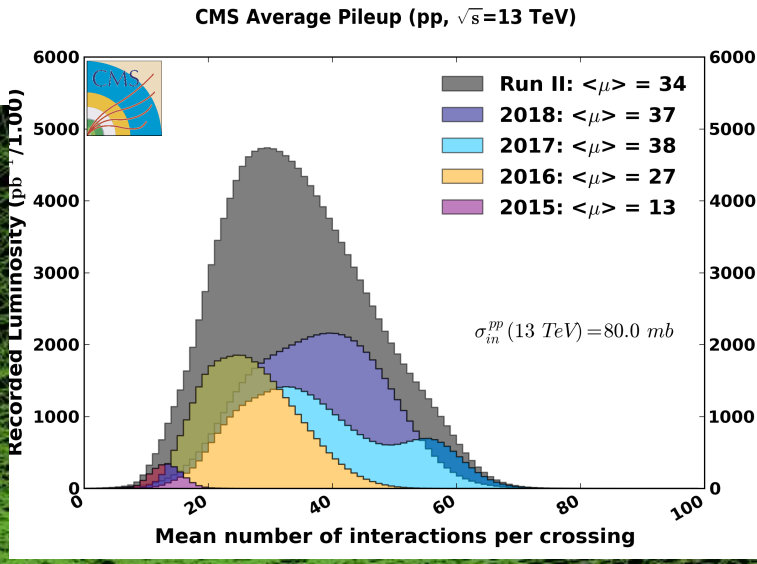


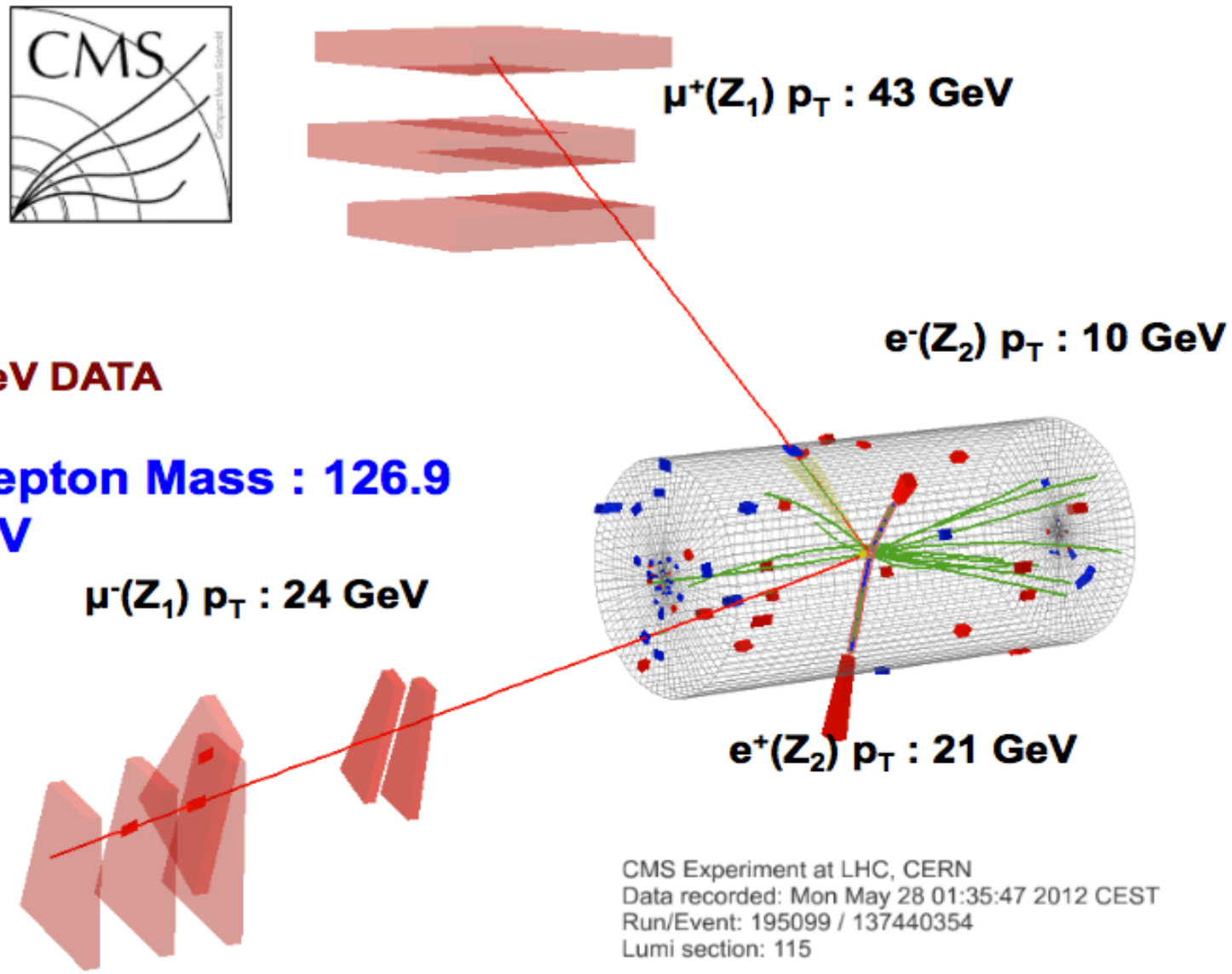

SHAWTON

…in a challenging environment





Higgs candidate event

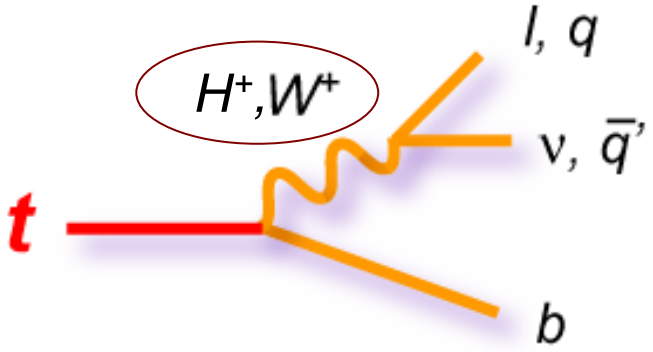


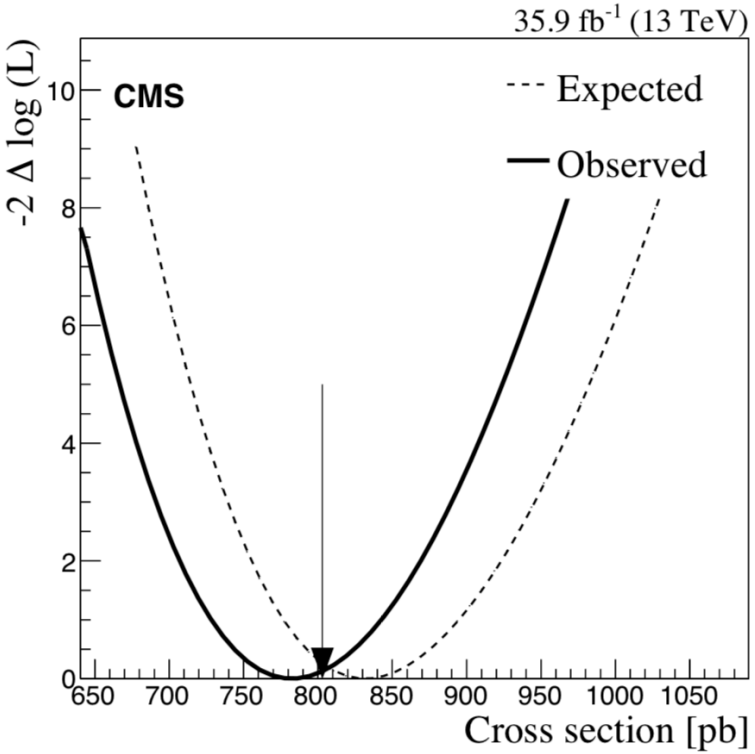
Top quarks and tau leptons

arXiv:1911.13204

A. Toldaiev

- Lepton flavor anomaly: 3 experiments measure small deviation from SM expectations





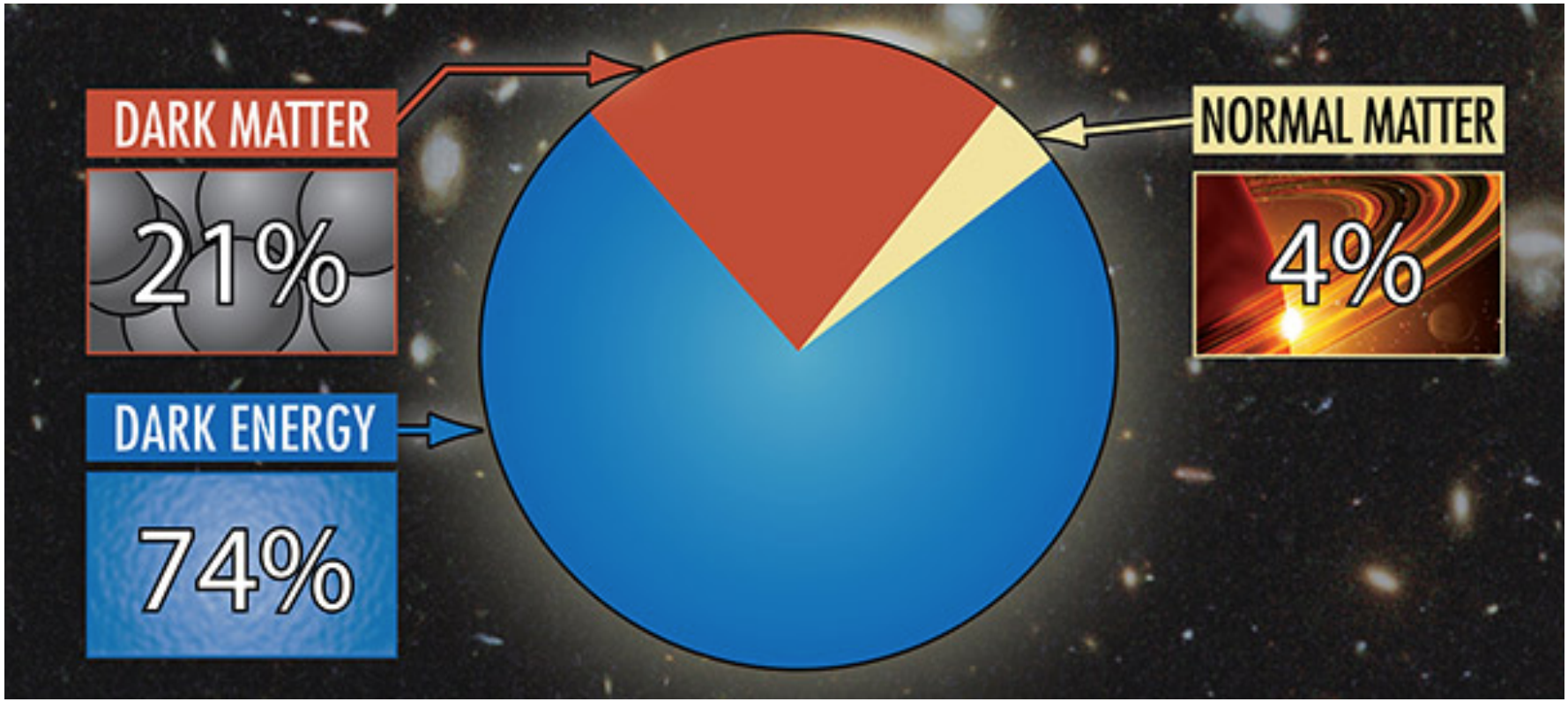
- Study tau leptons in top quark decays
- Measure cross section, study event kinematics
- Lepton flavor universality in top quark events

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

$$R_{\ell\tau_h/\ell\ell} = 0.973 \pm 0.009\,(\text{stat}) \pm 0.066\,(\text{syst})$$

Dark matter and energy

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

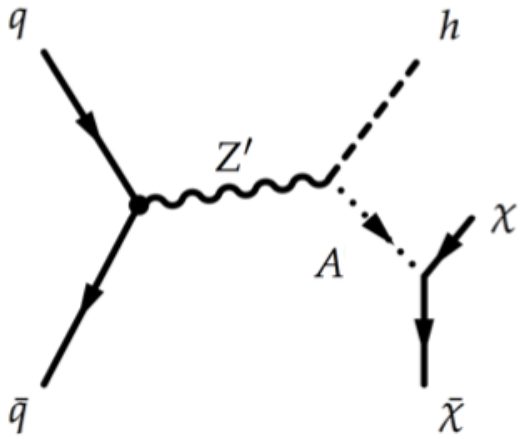


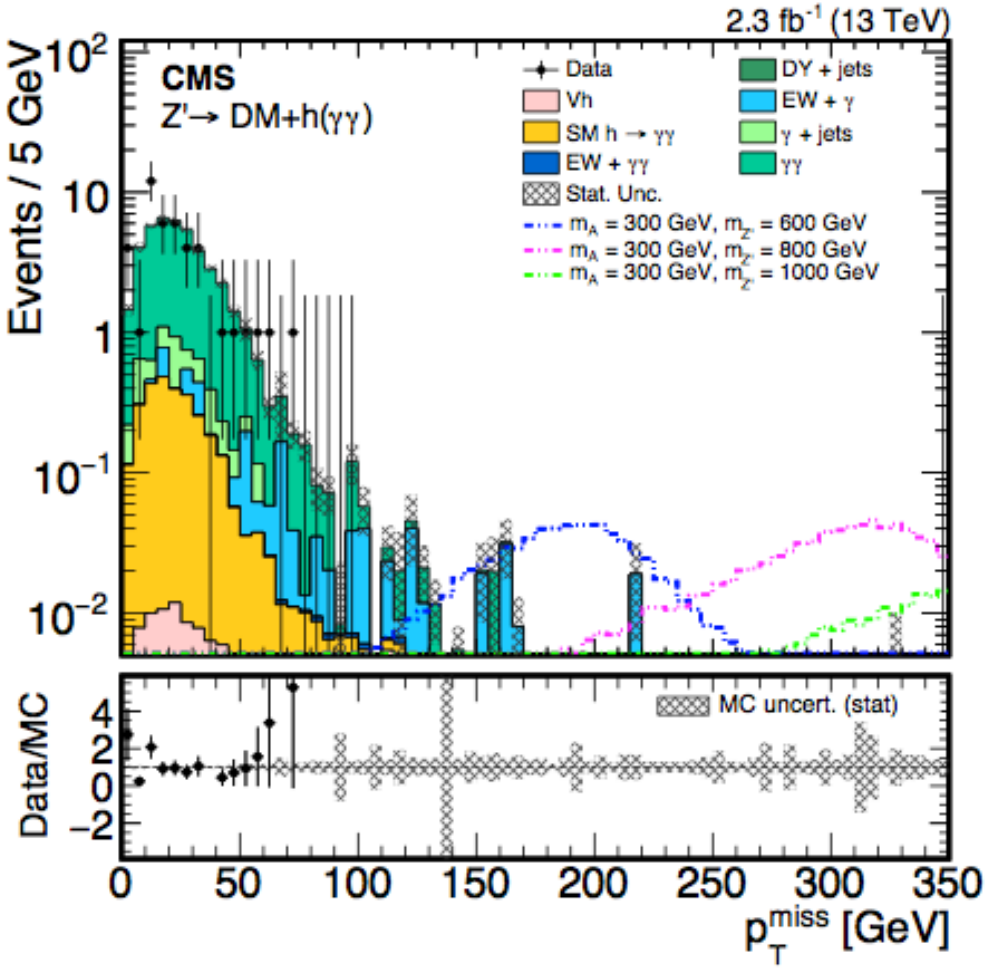
Higgs + Dark Matter

arXiv:1908.01713

J. Goncalves et al.

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

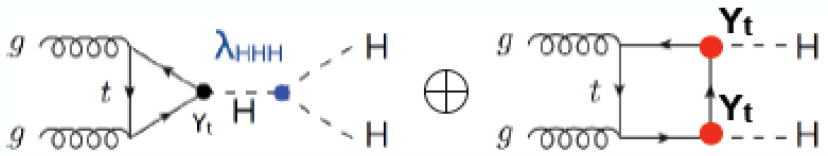




- Signal events at large MET

Double Higgs production

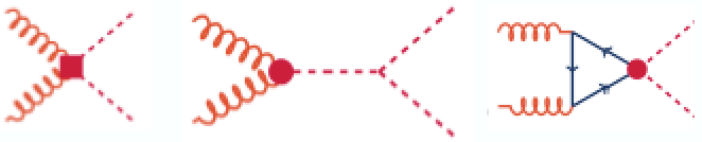
Main probe for trilinear Higgs coupling λ_{HHH}. Diagrams interfere destructively in SM



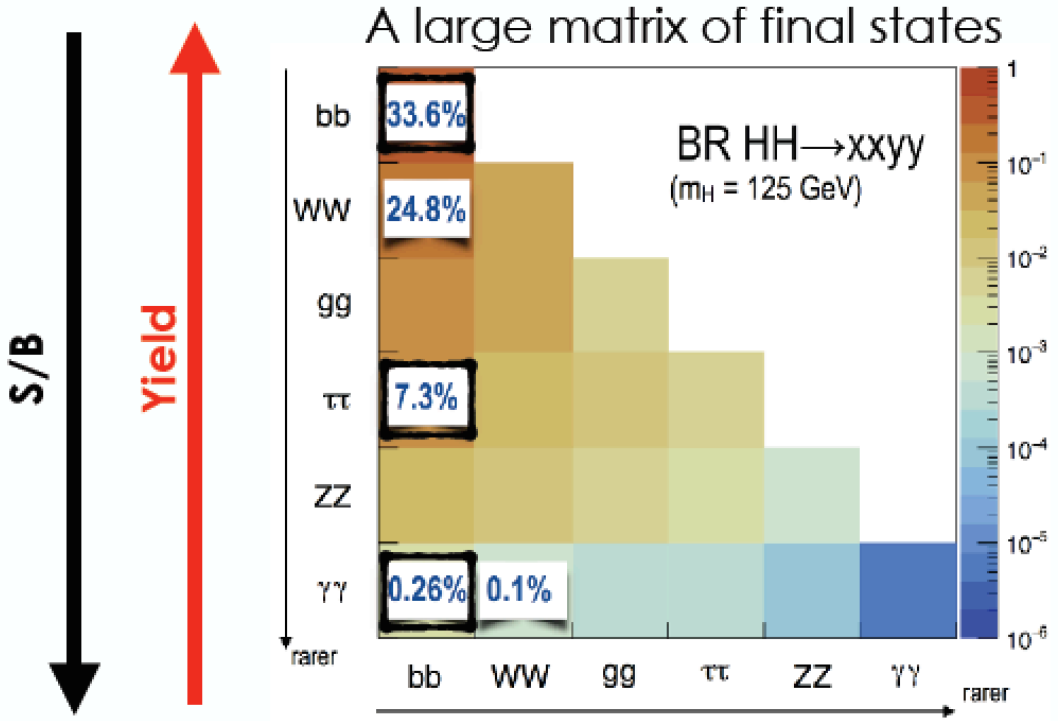
$\sigma_{gg\to HH} = 33.49^{+4.3}_{-6.0}$ (scale) ± 2.1 (PDF) ± 2.3 (α_s) fb

[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

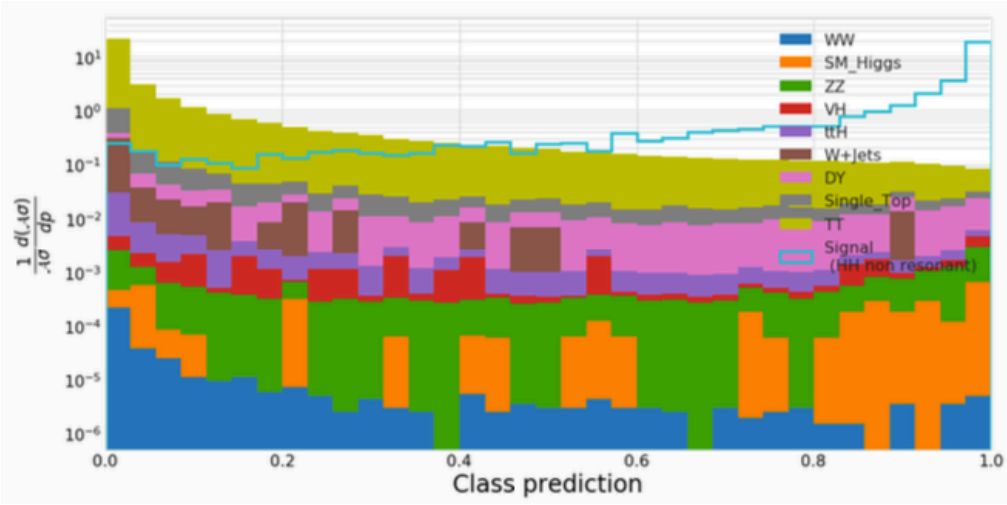
bb(γγ,ττ) good compromise between statistics and S/B

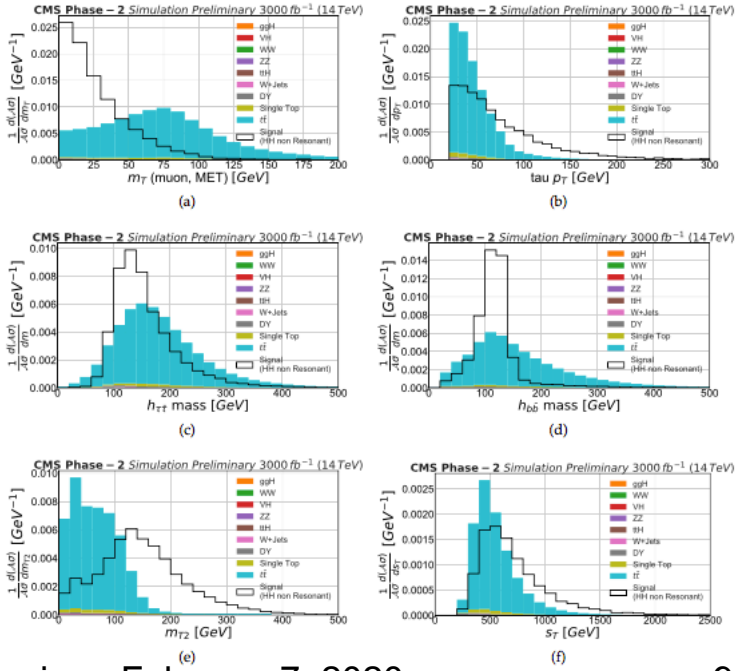
Advanced Analysis Techniques

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

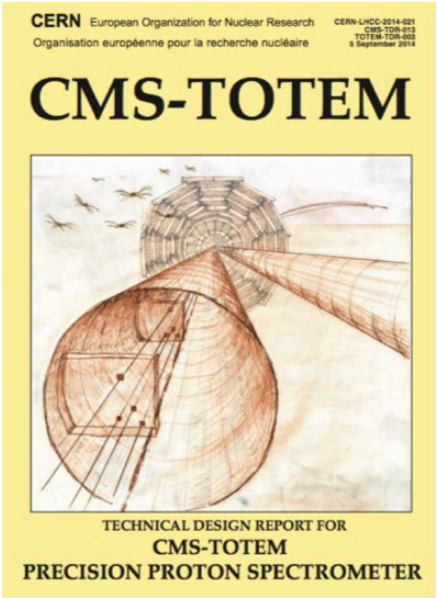


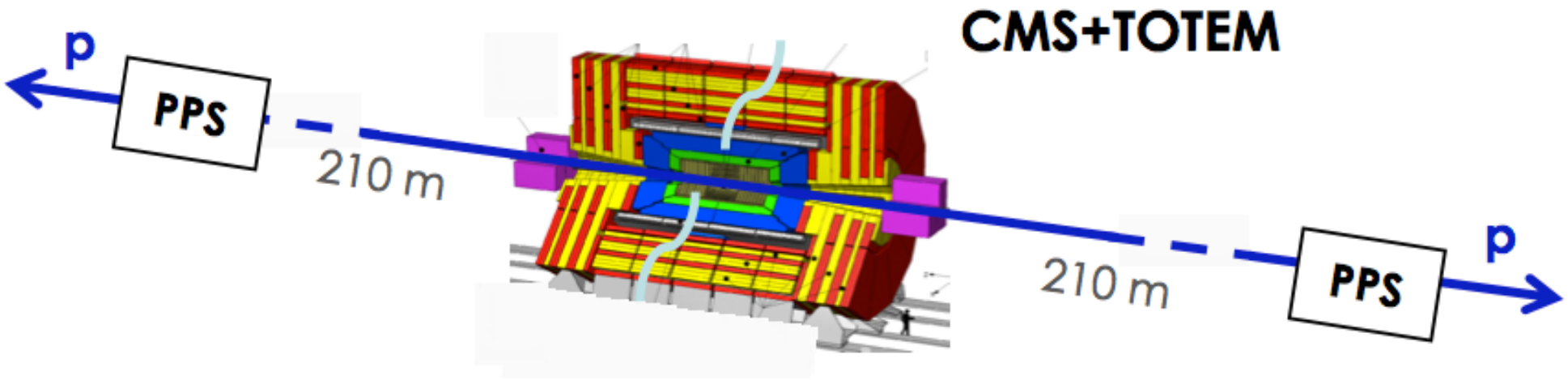


Looking forward: exclusive processes

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



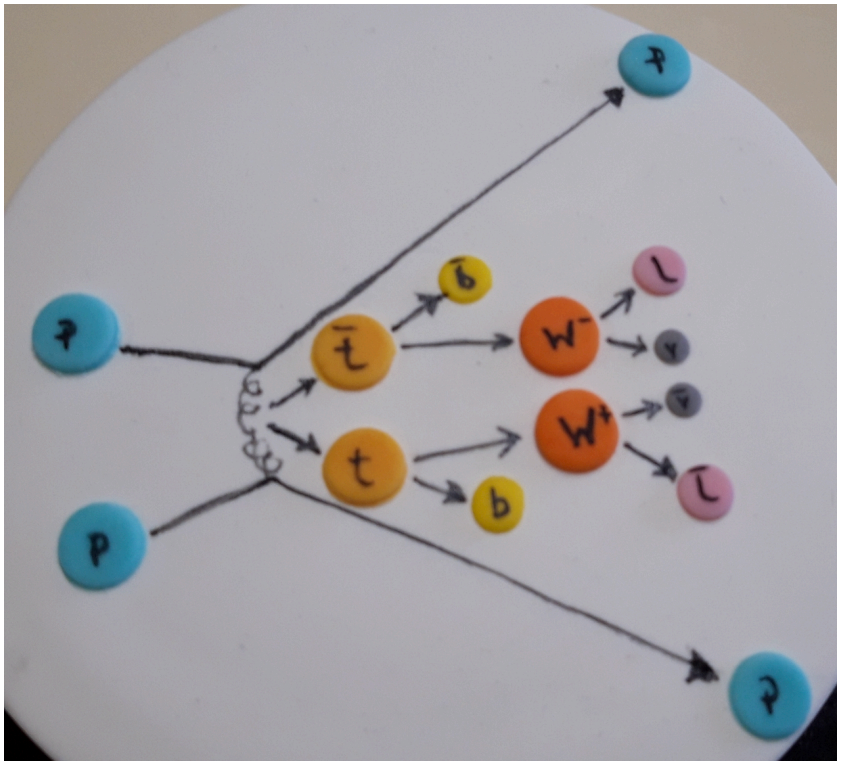


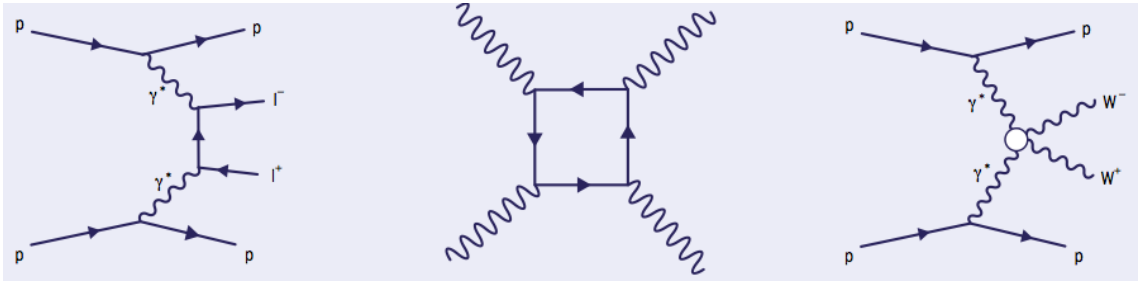
Exclusive production

arXiv:1803.04496

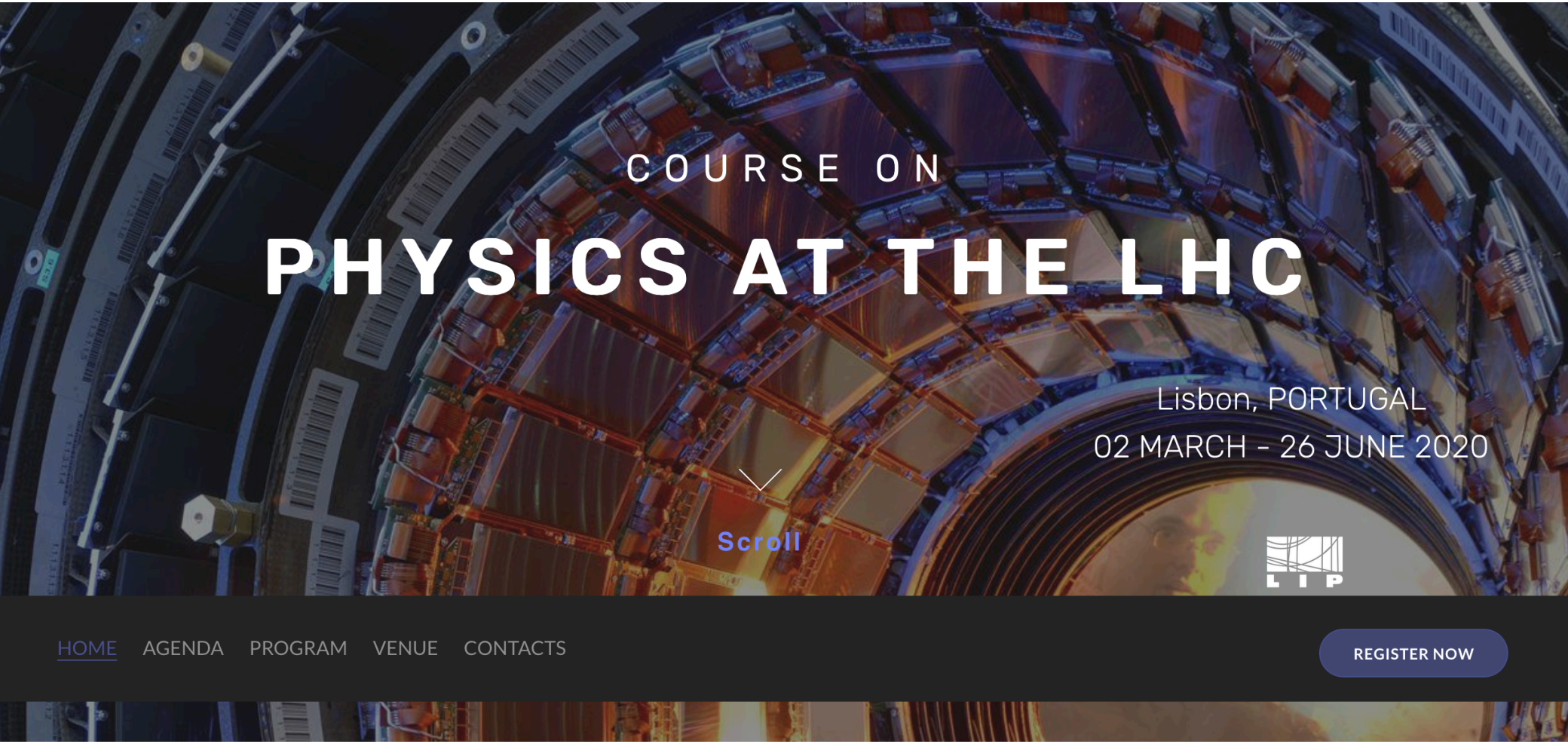
- Central Exclusive Production
  - photon-photon collisions
  - gluon-gluon fusion in color singlet, $J^{PC}=0^{+}$
- High-mass system in central detector, together with very forward protons in PPS
  - momentum balance between central system and forward protons, provides strong kinematical constraints
  - 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.





If you want to know more…



If you are interested, please register!

Thank you!

- Large data sample available: ~150fb^{-1}
- Several interesting analysis topics available (Top, Dark Matter, Higgs, Exclusive states, etc.)
- Strong involvement of students (several Master and PhD theses)

⇒ Join! Your contribution will make the difference!

If you are interested, please contact me: michgall@cern.ch