The CMS Level-1 tau lepton and Vector Boson Fusion triggers for the LHC Run II

THE LHC RUN II
After a long shutdown, the LHC started the Run II in 2015 at a centre-of-mass energy of 13 TeV. In 2017, it reached typical instantaneous luminosities of 1.5x10^34 cm^-2 s^-1 and an average pileup of 57 collisions per bunch crossing.

THE CMS DETECTOR
CMS is a multi-purpose detector, consisting of sub-detectors installed concentrically with respect to the interaction point and designed specifically to characterize different kinds of particles. In 2017, it recorded 41 fb^-1 of data for Physics analysis.

THE L1 TAU ALGORITHM
- The \( \tau \) localized energy deposits in the calorimeters are identified through dynamic clustering.
- Secondary clusters from \( \tau \) decays are merged into a single candidate.
- The energy is calibrated to improve the \( \tau \)'s scale and resolution.
- Isolation criterion is applied to reject quark and gluon background.
- Pileup is estimated and subtracted based on the energy deposition in the central part of the detector.

THE LEVEL-1 TAU TRIGGER
Outstanding performance for the typical L1 thresholds, reaching 95% efficiency at 50 GeV threshold used in H→\(\tau\tau\nu\) analysis.

PERFORMANCE IN 2017 (1)
Excellent pileup resilience throughout 2017 data-taking thanks to the pileup estimator already present at L1.

THE LEVEL-1 VECTOR BOSON FUSION TRIGGER
The VBF process contributes as ~10% to the Higgs boson production and has a very characteristic signature:
- VBF jets with high invariant mass and large angular separation.
- Higgs boson decay products in central region.
- Thanks to the trigger upgrade, invariant masses can be computed at L1 and, while the usual trigger strategies target the decay mode, the VBF trigger is specific for the production mode.
- Using the VBF trigger as a complement to the classic triggers, the phase-space is expanded and the sensitivity to VBF is improved.

THE L1 VBF STRATEGY
L1 trigger selection for VBF production
- at least one jet with \( E_T > X \)
- at least two jets with \( E_T > Y \) and \( m_T > Z \)

PERFORMANCE IN 2017 (2)
The \( X = 115 \) GeV, \( Y = 40 \) GeV, and \( Z = 620 \) GeV selection, used throughout 2017, provided 43% additional VBF \( H \to \tau\tau \) events with an excellent efficiency that matches that predicted by simulations.

CONCLUSIONS
During Run II, CMS has benefited from a new L1-trigger architecture that has enabled the design of high performance \( \tau \) seeds as well as L1 algorithms directly targeting the VBF Higgs boson production mode. Both demonstrated outstanding performance in 2017 and have already been updated to cope with the harsh experimental conditions of the LHC in 2018.

REFERENCES: