Physics at the high luminosity LHC using the upgraded CMS detector

Higgs boson measurements and search for a vector-like top quark partner

Lata Panwar (Indian Institute of Science) on *behalf of the CMS Collaboration*, 2018 Winter LHCC meeting, 28 February 2018, CERN

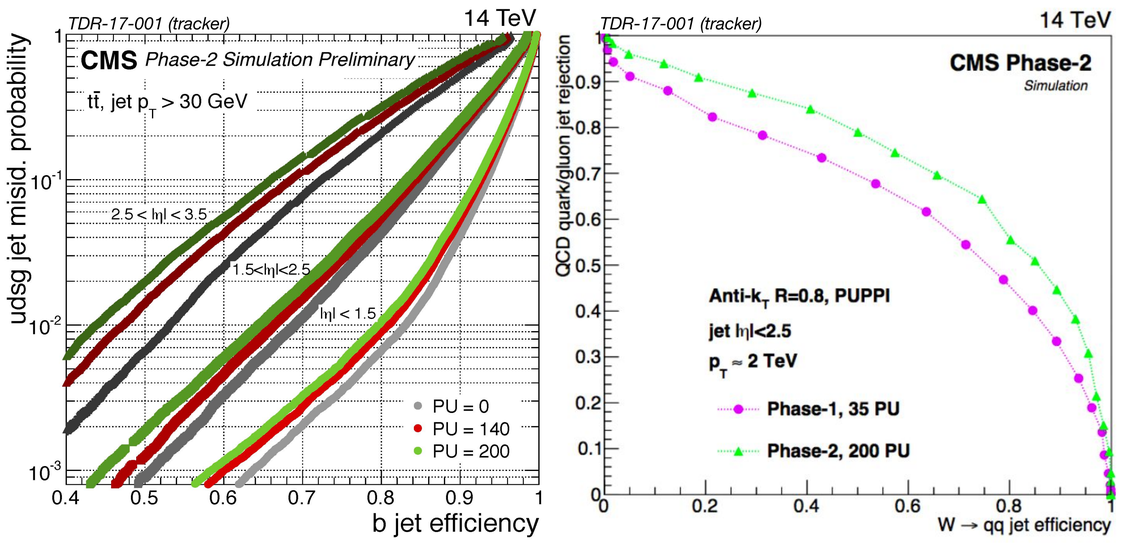
HIGH LUMINOSITY LHC PHYSICS GOALS

- Precision measurement of Higgs boson properties (~100 M Higgs boson produced)
- Extend the LHC discovery reach
- Precision measurement of Standard Model

PHYSICS OBJECT PERFORMANCE

Identification of jets forms an important component of most physics analyses:

- b-tagging of jets originating from b quarks.
- Jet substructure to identify highly Lorentz-boosted W, Z, and Higgs bosons and top quarks W→qq'~, H→bb~, t→qq'~b.



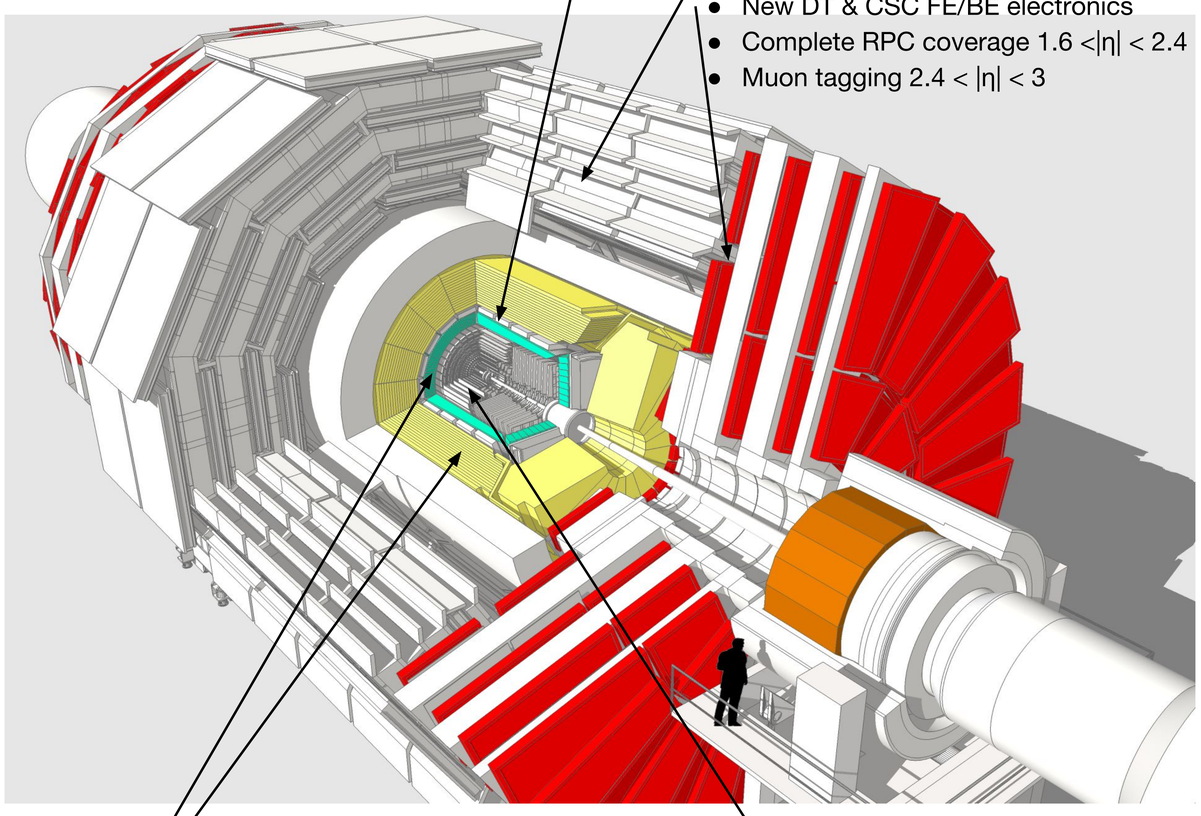
- Pileup is removed using PUPPI (Pile Up Per Particle Identification) (*arxiv:1407.6013*).
- The soft drop algorithm is used for the W jet mass and anti-k_T algorithm, with distance parameter 0.8, is used for the jet reclustering.

CMS PHASE-2

Trigger/HLT/DAQ
- Track Information in Trigger (Hardware)
- Trigger latency 12.5 μs - output rate 750kHz
- HLT output 7.5 kHz

Barrel EM calorimeter
- New FE/BE electronics with improved time resolution
- Lower operating temperature

Muon Systems
- New DT & CSC FE/BE electronics
- Complete RPC coverage 1.6 <|η| < 2.4
- Muon tagging 2.4 < |η| < 3



New endcap calorimeter
- Radiation tolerant
- High granularity: increased transverse and longitudinal segmentation
- Precise timing capabilities

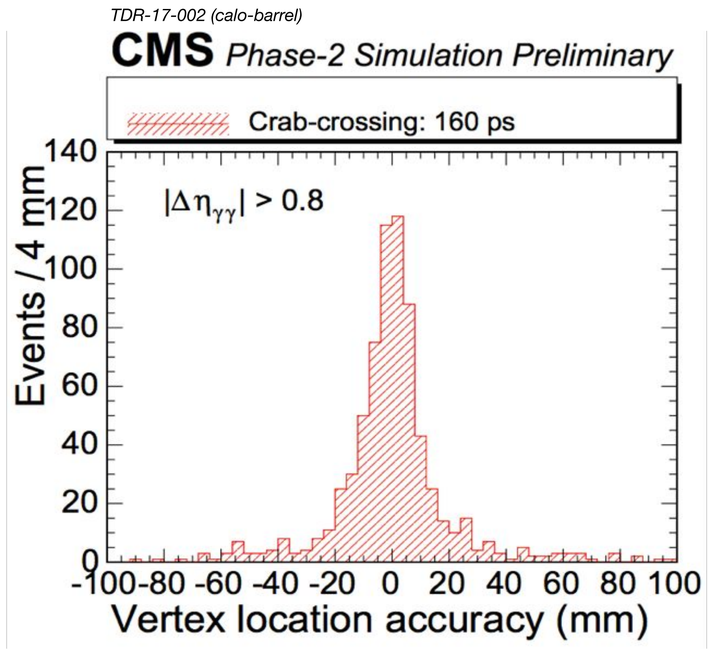
New Tracker
- Rad. tolerant, increased granularity, lighter
- 40 MHz selective readout in outer tracker for trigger
- Extended coverage to |η| ~ 3.8

Two major motivations for upgrade
- Unprecedented radiation dose => replace end-cap calorimeters
- Much higher data flows => replace most of the readout systems

PHYSICS HIGHLIGHTS

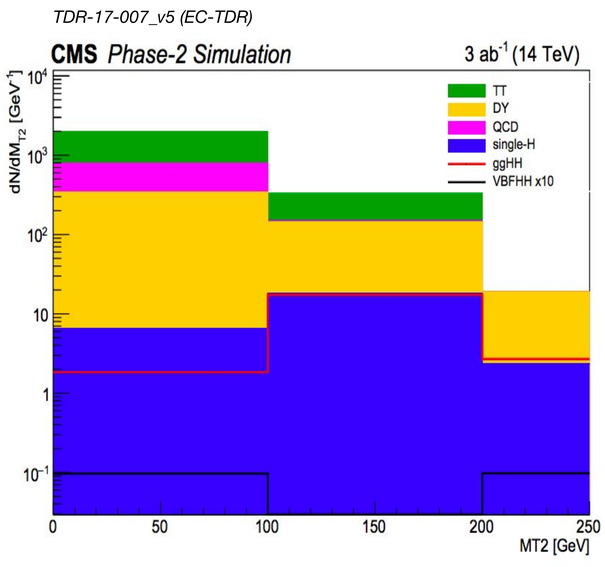
H→γγ

- Precise timing measurement of high energy photons with HGCal (High Granularity Calorimeter in endcap with increased longitudinal and transverse segmentation).



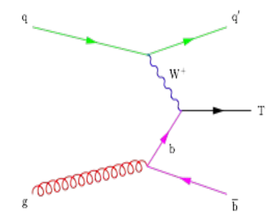
Di-Higgs production

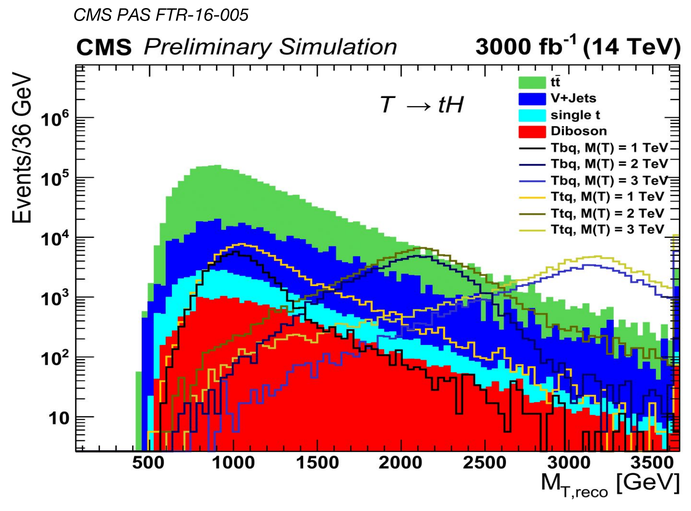
- **SM HH (non resonant):**
  Four projections:
  HH → γγbb
  HH → ττbb
  HH → VVbb
  HH → 4b
- Stransverse mass (M_{T2}) distribution of $\tau_h\tau_h$ events having two jets tagged as b-jets.



Vector-like quark T→tH

- Vector-like top quarks offer a solution to the low mass of the Higgs boson (Hierarchy problem).
- Single production dominates at high mass. The presence of a forward (high η) jet distinctive signature. Upgraded CMS calorimeter and tracker to improve forward jet identification at high pileup.





REFERENCES:
1. Phase-2 Upgrade of the CMS - Technical Design Report (tracker, calo-barrel, EC)
2. Estimated Sensitivity for New Particle Searches at the HL-LHC for ECFA 2016 - CMS PAS FTR-16-005