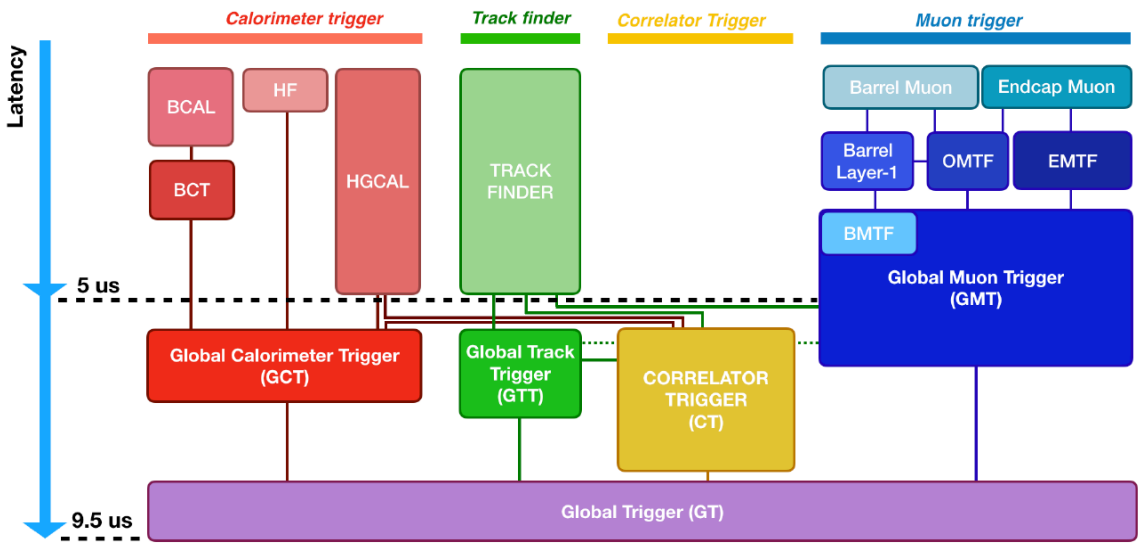
University of Colorado
Boulder


# Performing precision measurements and new physics searches at the HL-LHC with the upgraded CMS Level-1 Trigger

**Emily MacDonald on behalf of the CMS collaboration**
University of Colorado Boulder
e.macdonald@cern.ch

# CMS Phase-2 Trigger

- Upgrades to the Level-1 (L1) trigger
  - Improved electronics to handle the increased pileup (PU)
  - Add tracking to L1 trigger
  - Increase total latency 12.5 $\mu$s
    - Allows use of information from the tracker and high-granularity calorimeter information
    - Allows more time for algorithms, including higher-level object reconstruction and identification
  - Improved algorithms
    - More information (increase from 2 TB/s to 63 TB/s)
    - Potential for particle-flow (global event) reconstruction
    - Potential for machine learning based approaches

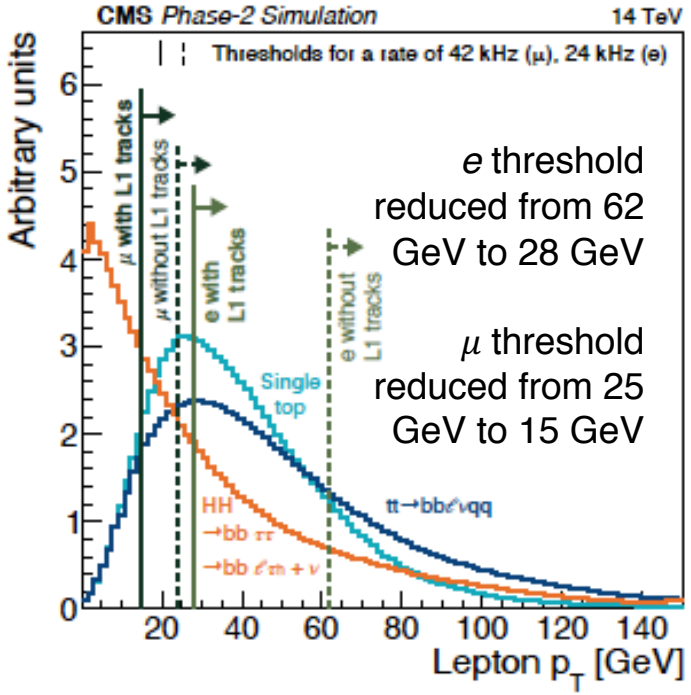



The CMS L1 Phase-2 upgraded trigger design

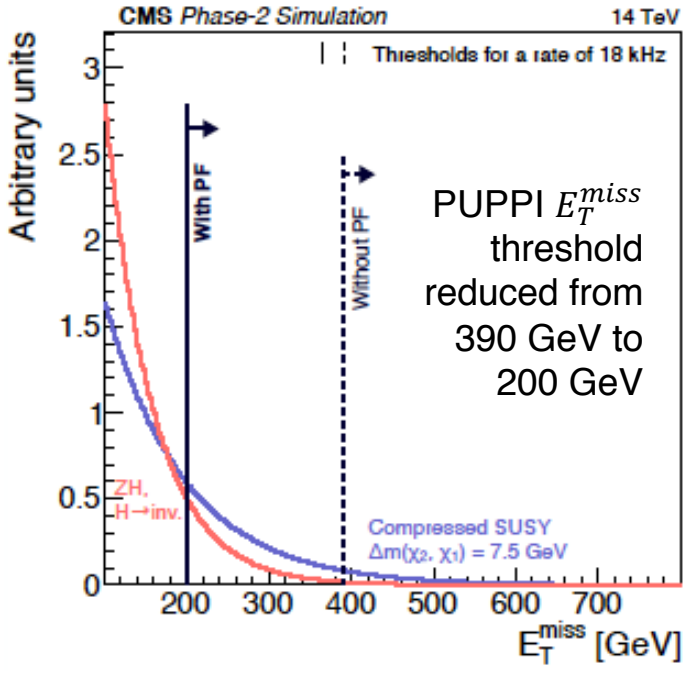
- **Maintain physics performance from Run 2**
  - Improved algorithms achieve lower rates, even in a more challenging PU environment
- **Increase physics reach**
  - Tracking at Level-1, particle-flow algorithms, and machine learning based approaches can reach a broader spectrum of physics analyses

# Reduced trigger thresholds

- L1 trigger menu can maintain the physics performance from the current running (Run 2), even at 200 PU
- Many of the upgraded trigger algorithms achieve lower rates
  - Releases bandwidth to allow for some lower thresholds
  - Choose thresholds to increase the acceptance for key physics signals (i.e. energy sums, lepton $p_T$, jets)



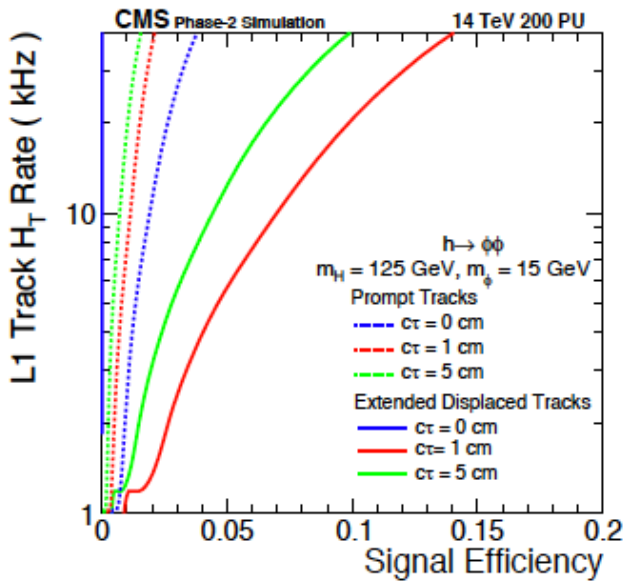

Use of tracking at L1 drastically reduces the $p_T$ thresholds for electrons and muons

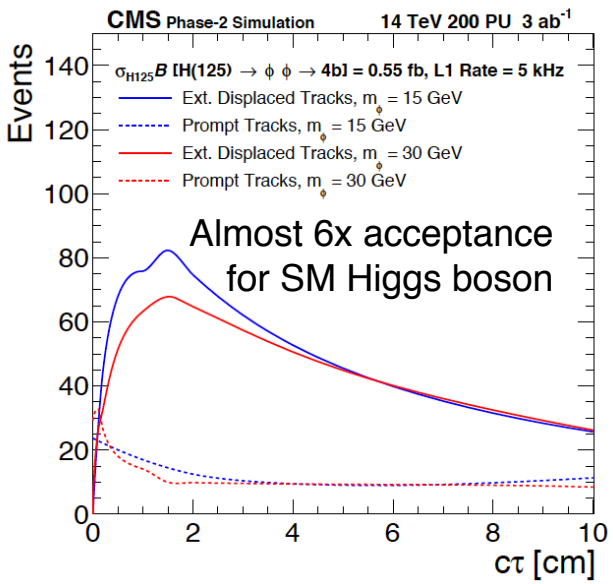



Use of particle-flow algorithms reduces the threshold for missing transverse energy by almost 200 GeV

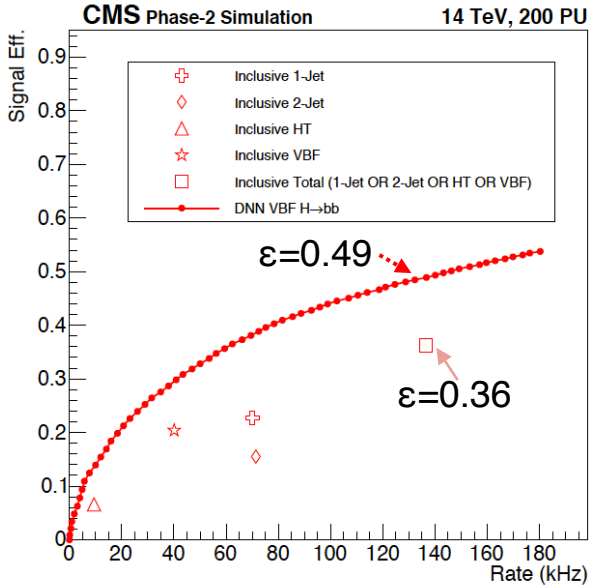
# New physics searches

- Displaced jets:
  - An extension of the L1 track-finding, clustered tracks without a beamspot constraint
  - Provides a new handle to trigger on Beyond the Standard Model (BSM) physics, such as exotic decays of the SM Higgs




- Particle-flow and machine learning:
  - The $\tau$ trigger algorithm is based on a particle-flow approach combined with a dedicated neural network discriminator
  - Improved energy resolution of hadronic objects provided by particle-flow reconstruction is beneficial to the development of triggers targeting specific signatures such as VBF




A deep neural net outperforms all cut-based algorithms for an inclusive VBF $H \to b\bar{b}$ trigger