

A Few Hi-Lumi Triggering Questions

A big bread-and-butter challenge

- Pile-up: 1 GeV per R=0.5 jet per vertex
 - 2/3 tracks, 1/3 neutrals
- This affects (at trigger level)
 - Isolation of electron, photon, muon, **especially tau**
 - Jet energy resolution and thresholds
 - MET resolution and thresholds
- VBF?

Trigger and pile-up

- How early in the trigger can the tracks from the non-hard vertex be removed?
 - FTK at ATLAS (entire tracker reconstructed just after L1)
- Can anything more be done to remove the neutrals?
 - Timing would be crucial tool – good argument for 10 ps timing in forward
 - Central? Conversions, decays, shower shape?
 - Fraction of converted photons will go **down** if tracker design is less massive
 - K_S decays?
 - Novel use of ECAL/HCAL/tracking?!

Track trigger

- Since no L1 tracking at CMS outside $\eta < 2.5$, and HGCAL only goes to 3 how to best trigger on VBF + Higgs (both SM and non-SM decays)?
- ATLAS options?

Higgs-driven thinking

- Are there SM signals that require more expansive triggering than Higgs
- Are there non-SM signals that require more expansive triggering than Higgs?
 - Non-SM 125GeV Higgs
 - Squeezed, Degenerate...
 - Light scalars
- VBF triggering slate – covers most signatures
- What can you do with $gg \rightarrow h$ that is better?
 - Centimeter lifetimes triggering
 - $bb \tau \tau$

More issues to consider

- Any systematic improvements in $t\bar{t}$, diboson, $t\bar{t}+X$, other SM
 - Is anything known? Needs theory study?
- Do we need forward b-tagging for $b\bar{b}H$, single top(+H)
 - Needs a theory study?
- Degenerate $SU(2)$ multiplets \rightarrow track stubs
 - CMS loses dE/dx in Phase 2 altogether
 - ATLAS: FTK now has dE/dx at L1.5 – but HL-LHC?

Triggering opportunities

Boosted objects

- Boosted W/Z/t/h
 - Jet mass
 - Jet substructure
- New light boosted object
 - Muon pair
 - Electron pair
 - Tau pair
 - Photon pair
- New late-decaying object (makes jet with narrow subjets)
 - Trackless jet with crisp substructure

New forward calorimeter
and tracking?

Triggering opportunities

- If precision timing (10-100 ps) is available
 - Neutral pileup reduction (10 ps) [maybe not crucial for isolation/energy scale]
 - Decay of slow object
 - Decay of displaced object at oblique angles

Triggering opportunities

- Displaced objects
 - Vertexing out to beampipe at L1?
 - Combine trackless jet (L1) with special outside-in tracking (>L1)
 - Other vertexing beyond beampipe?
- Unusual tracking
 - High dE/dx track [not at CMS!]
 - (even a stub)?
 - Vertex with >50 tracks
 - Not in a jet, not flat in η

If signal isn't self-triggering, association

- Lepton+X
- VBF+X
- Other all-hadronic
 - Jet + X, Jet + MET + X
 - MET+X
 - HT+X
 - How does L1 tracking help?
 - Use the high statistics of HL-LHC to go out on boosted tails for more measurements?

Unbiased triggering

(volunteers from other collisions in same bunch crossing)

- FTK: L1.5 ATLAS tracking trigger 2017+
 - J. Alison: Note this looks at full bunch crossing at 100 kHz = 1/400 of all data
 - Unbiased, prescale, can find
 - Compare: W+Higgs, lepton trigger → 1/300 of all H bosons guaranteed
- At 1 MHz (300 kHz), could look at 1/40 (1/130) of all data
 - Can such an unbiased look at so much data be useful?
 - E.g. Higgs decays to boosted tau pairs in a bunch crossing with a photon candidate?
 - E.g. A vertex with >50 tracks in a bunch crossing with a tau candidate?

Case Studies: Not discovered before HL-LHC

- Non-SM Higgs Decays
 - Several soft objects + VBF
- Compressed scenarios (for SUSY or anything else)
 - Colored + MET [ISR jet + MET]
 - Colorless + MET [ISR photon + MET – can we push down the threshold at L1? L2?]
- Low-Mass Low-Rate resonances or edges in taus
- Electroweak-produced objects decaying to taus + MET
 - (lepton + multiple isolated tracks?)
 - Classic: Higgsinos
- light scalar at 37 GeV decaying to b's, taus

Case Studies: We discover something first

- We discover a gluino and things to which it decays
 - Where are the heavy inos?
 - Where are the extra Higgs bosons?
 - Small degeneracies in the spectrum?
 - We discover something completely bizarre before HL-LHC
 - Long-lived particles
 - With a track
 - Without a track
 - Macroscopic quirks
 - Microscopic quirks
- Can we cope?