

Bloc 3 Summary

Outside the Box Triggering/Analysis

ExperLHC16

Matt Strassler

May 17, 2016

Blok 3 Summary

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Block 3 Summary

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Blocq 3 Summary

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Blocq 3 Summary

Outside the Box Triggering/Analysis

ExperLHC16

Huge thanks to co-convener Caterina Doglioni

Matt Strassler
May 17, 2016

Topics that arose

- Scouting/Trigger-Level Analysis (TLA)
- Data Parking/Delayed Data Stream
- Triggers using FTK/Tracking
- Triggers using Substructure
- Analysis with Clutter

- Long-Lived Particles (LLP) decaying in flight

- Millicharged Particles

Comments in orange boxes were added to slides as a result of discussion that occurred during the talk

Miscellaneous General Triggering

Discussed briefly or at greater length:

- Trackless jets – no tracks above x pT
 - Not fully exploited?
 - In presence of VBF jets or other trigger objects?
 - How does this interplay with increasing pileup?
- VBF triggering
 - Inclusive (VBF jets + anything)versus
 - Semi-exclusive (e.g. VBF jets + a soft lepton, a soft photon, trackless jet...)
- Jets made entirely from photons (“photon-jets”)
 - No HCAL deposition
 - Fail photon requirements – not enough ECAL energy in a photon-like cluster
 - QCD background from all-pi-zero/eta jets

Photons to Trigger on Monojet Events

Photons to Trigger on Monojet Events

- Highly efficient as long as the background is blue



- Excellent for slow long-lived objects of very high mass

This idea attracted a lot of attention...



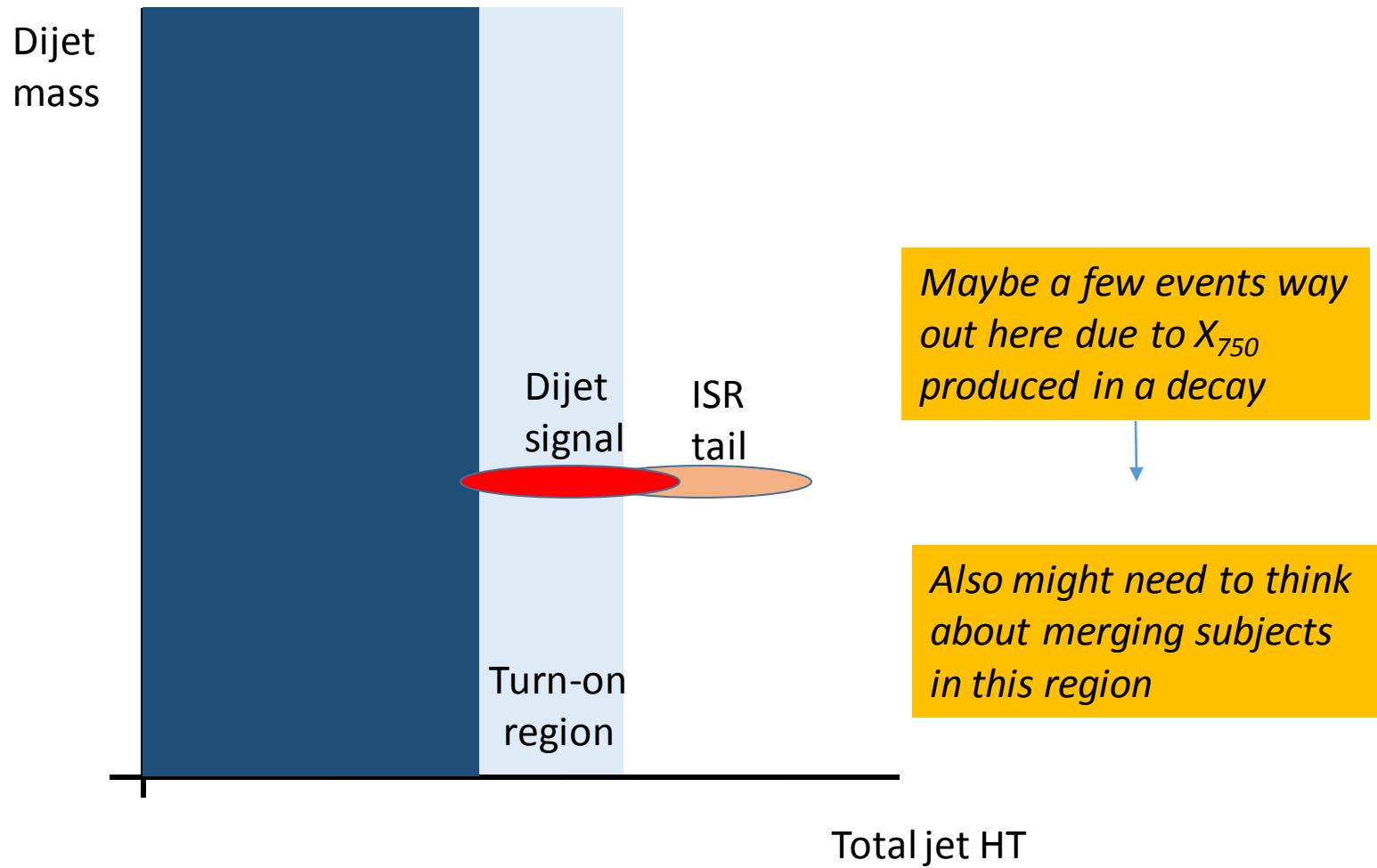
Scouting/TLA

CMS: 2015

- Calorimeter jets: $HT > 250$ GeV, no parking - efficient at $HT > 300$ GeV
- Particle flow (PF) jets: $HT > 450$ GeV, data parked
- PF dimuon: parked
 - L3 (online, muon and track info combined) $pT_{\text{muon}} > 3$ GeV,
 - L1 seed: $pT_{\text{mu1}} > 12$, $pT_{\text{mu2}} > 5$ GeV;
 - Invariant mass > 10 GeV, to remove the upsilon. The resolution is good.

ATLAS: somewhat similar plans but not as public

- Until L1 topo trigger available, HT trigger more limited than CMS
- Jets
 - Dijets
 - **750!!!** Move away from HT turn-on curve using ISR recoil?
 - Pairs of dijets, pairs of trijets



To Add to Scouting/TLA

- JP Chou: Scouting is great for bump hunts at low mass
 - Note MET resolution is bad
 - Sideband analysis means fewer worries about scouted backgrounds
- Idea: add searches for low-mass dilepton, diphoton bumps/edges
 - Example:
 - Trigger on VBF + [1 lepton or 1 photon and/or MET]
 - Look for pairs of leptons or photons; save scouted
 - Offline look for invariant mass peak
 - But note dimuon scouting already low
 - Still, good for photons.
 - Question: technical issues with photons in scouting?
 - Usage: $h \rightarrow DM + (a \rightarrow \text{photons}) + \dots$; DM + dark photon
 - Example
 - Trigger on Jet + [1 lepton or 1 photon and/or MET]
 - Usage: DM + dilepton or diphoton resonance

In fact this is a use case for the dimuon scouting!!

Probably only photon scouting needs to be added.

Slide added

Questions were raised about scouting in general and here specifically

- Questions as to whether the efficiencies for photons could be understood well enough to allow for good and believable limits to be set;
 - ...while it was pointed out that even knowledge of efficiencies at, say, 30% could still allow new limits on physics for which no limits currently exist
 - ... it was questioned whether even 30% knowledge of efficiencies for photons could be established
- It was pointed out that prescaled triggers that allow comparison of off-line and on-line reconstruction are used even in the case of dijets
 - ... and complaints were raised that from the management point of view, scouting was originally supposed to be, literally, “scouting” and not searches with limits and discovery potential
 - and that the need for more and more bandwidth and trigger pathways to determine efficiencies and validate any excess was not necessarily easy to justify
- In any case the diphoton opportunity exists and should be studied by scouting experts.

To Add to Scouting/TLA

- Other ideas

- Example: Inclusive VBF? + what?
 - b's? gamma's?
 - Trackless jets?
 - Jets with substructure? Jet with mass > 30 GeV?
- Example: softer photon threshold?
 - Usage: Multiple parton scattering studies?
 - Trigger: gamma + 3 jets
 - If back-to-back gamma + jet, store:
 - Offline: look at 2nd and 3rd jet
 - $W \rightarrow \text{gamma} + \text{pi}^+$ (SM test)
 - $Z \rightarrow \text{gamma} + (a \rightarrow \text{bb})$

SM tests and scouting hasn't been thought about much – may be a bad mismatch in required precision but worth some thought

Also:

*$Z \rightarrow 3 \text{ photons}$,
 $\text{Higgs} \rightarrow 4 \text{ photons}$
could be scouted*

FTK (and other fast tracking)

- Currently
 - ATLAS can run high quality tracking for L1 **Regions of Interest**, > 100 (?) GeV.
 - CMS can run high quality tracking for L1 accept, at a rate of ???
- FTK (ATLAS 2016-2017)
 - **full** track reco for every L1Accept, ~100 kHz, available to higher level trigger
 - IP efficiency flat to 2mm displacement; won't take find highly displaced trks
 - online: decrease thresholds: background removed due to extra track info
 - Scouting/tla: have more track info calculated already in early stages –
 - can scout low pT b-jets, taus, even MET
- Allows object improvements:
 - online pileup rejection, jet resolution, MET
 - finding/counting isolated tracks
 - displacement information

Possible Applications of FTK

- Isolated tracks
 - Run tau trigger off tracks not CALO
 - Select events based on isolated tracks
 - Boosted di-tau, di-mu from pair of stiff isolated tracks?
- Displaced tracks
 - B's
 - LLPs
- Trackless jets: Seed for long-lived particle trigger
 - Time saved from standard tracking; use for HLT outside-in tracking?
- VBF: after L1 HT trigger, associate one or two VBF-like jets to vertex
- Jet+MET+ high dE/dx track [Possibly in Scouting/TLA]
 - L1: Jet + MET
 - L1.5-L2 Use FTK/early tracking to select isolated track stub
 - Scouting/TLA: Save high p_T track (stub) with high dE/dx
 - Usage: Degenerate chargino/neutralino
 - Usage: Decay in flight of new charged particle

Much of this may be overoptimistic. Level 2 trigger path has to request specific information from FTK; multiple staged requests difficult? or impossible?

Biggest benefit of FTK may be rapid rejection in standard triggers, esp w/ pileup, allowing more bandwidth for other triggers

Hard/Soft Analysis [Clutter]

- Example: Microscopic Quirks
 - Particles with both SM and hidden charge
 - Hidden gauge group confining w/ unbreaking flux tube
 - Pair production of quirks:
 - Produced above threshold: quirkonium forms
 - Radiate excess energy down to ground state – soft particles
 - Soft radiation: cloud of pions, or photons, or soft jets
 - Annihilation – hard particles
 - Hard annihilation: resonance in dijets, dileptons, W gamma, etc.
- Strategies:
 - Select events with too many tracks or too few, or many soft jets
 - Then look in di-object resonance search for bump
 - Data driven background: lepton + MET events? Signal Monte Carlo?
 - **750!!!!** *Quirky MC needed for 750 GeV ? For general searches, yes; but to test this for known resonance, no -- especially since any MC will be crude anyway*
- Question: Use FTK to reduce thresholds?

cf. Luty et al.; Strassler & Zurek; Chacko et al.;

Harnik&Wizansky 0810.3948
Signals of New Physics in the Underlying Event

Triggering and Substructure

- Existing trigger object at CMS: jet mass, following trimming
 - L1 HT ($|\eta| < 2.5$) or jet p_T
 - HLT: after particle flow, find jet with trimmed mass $>$ minimum (30-60 GeV)
- Other boosted objects implemented
 - Boosted dimuon, ditau with modified isolation
- ATLAS: Fat jet trigger ($\Delta R = 1$)
 - Di-fat-jet searches have been done
- Run 3: central calo will have full granularity at L1
 - substructure possible very early
- Go lower in mass, to find unknown boosted $X \rightarrow jj$?
 - Up to now, actual sub-jets not used at trigger level
 - N-subjettiness highly correlated with jet mass
 - Multiple massive jets?

Raised/discussed but no notable progress

- Scouting/TLA
 - Gamma + jets, tau + jets: can lower threshold, but what's the signal?
 - Rare Z decays? Rare h decays?
 - But – if mass reco is easy (leptons, photons), scouting effective, but so is standard triggering
- Substructure
 - Combine tracklessness and substructure to find displaced decays to dijets?
- Parasitic Detectors
 - MilliQan (Izaguirre, Hill talk)
 - Something for other LLPs
- Real online analysis (faster even than scouting) [cf. LHCb]

Summary of Blokque 3

- Some ideas for Scouting/TLA
 - searches for low-mass dilepton, diphoton bumps/edges
 - In VBF, or Jet + MET, or ...
 - Inclusive VBF or VBF + X?
 - SM: multiparton scattering, rare W/Z decays
- Some ideas for applications of FTK
 - Exploit immediately association of most central VBF jet to vertex
 - Triggering based on isolated track(s) vs. narrow calorimeter object
 - Trackless jets – is there now time for inside-out tracking?
 - Jet + MET + isolated high dE/dx track?
- Not much new for substructure (yet)
 - Methods to lower mass threshold to allow search for new light objects?
- Revival (needed!) of old ideas for bump-hunt amid soft clutter

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On to Bloch 4!