Status of disappearing track search with E_T^{miss}

Viktor Kutzner[1], Sam Bein[1], Alex Tews[1], Isabell Melzer-Pellmann[2], Akshansh Singh[2], Seh Wook Lee[3], Sang-il Pak[3], Sezen Sekmen[3],

[1]Hamburg, [2]DESY, [3]Kyungpook

August 16, 2019

Universität Hamburg

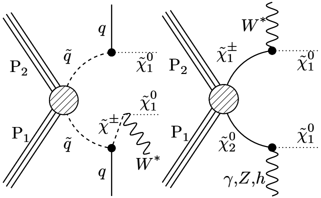
Updates with disappearing tracks with E_T^{miss}

1. Concept refresh
   - $\rightarrow$selection, search regions, and targeted signal models
2. general updates
   - update to track tags with loosened BDTs
   - revisiting fake background closure
   - extend prompt background method to include pions
   - non-pion contamination in $m_{\tau\tau}$
3. some changes to the analysis approach seem warranted, so we've made a couple of modifications
   - dropping veto on muons (event-level veto, not object-level)
   - splitting 1-track bins according to high-low track mass observable
4. Signal models and simulation
   - $\rightarrow$ some interesting features seen in the MC

Previous updates given in inclusive SUSY meeting **link 1 link 2**

Key analysis features

- Select quality tracks with missing outer hits (DT)
- Catagorize tracks into short (pixel hits only) and long (pixel and strips hits)
- Select events with one or more DT's with various topologies
- Bin search in jet multiplicity to maintain sensitivity to a range of models



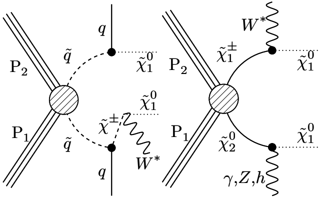
- Split signal bins into high and low de/dx categories

Signal regions

S.R. number	E_T^{miss}	n_{jets}	$n_{\text{b-tags}}$	n_{short}	n_{long}
1 a,b	250-400	1	any	0	1
2 a,b				1	0
3 a,b		2-5	0	0	1
4 a,b				1	0
5 a,b			≥1	0	1
6 a,b				1	0
7 a,b		≥6	0	0	1
8 a,b				1	0
9 a,b			≥1	0	1
10 a,b				1	0
...					
21 a,b	>700	1	any	0	1
22 a,b				1	0
23 a,b		2-5	0	0	1
24 a,b				1	0
25 a,b			≥1	0	1
26 a,b				1	0
27 a,b		≥6	0	0	1
28 a,b				1	0
29 a,b			≥1	0	1
30 a,b				1	0
31	200-400	≥1	any	$n_{\text{short}} + n_{\text{long}} > 1$	
32	>400				

Updated tag

- Before: fully informed BDT (with dxy)
- Now: “uninformed” BDT without dxy
- Now: BDT $> 60 * d_{xy} + 0.05$ (long tracks);
- analogous cut function for short tracks
- similar signal efficiency as with informed BDT



plot of uninformed BDT vs dxy (old BDT>x)
plot of uninformed BDT vs dxy (new cut function)

Non-prompt closure

- Use fake rate transfer factor

$$\mathcal{F} = \frac{P(n_{DT}^{SL} = 1|\vec{x})}{P(n_{DT}^{CR} = 1|\vec{x})}$$

$$\vec{x} = H_T, n_{pvtx}$$

data/MC comparison in CR
closure plot vs NJets or MHT

- SL (signal-like): BDT $> 60 * d_{xy} + 0.05$
- CR (fake control): BDT $< 60 * d_{xy} + 0.05$

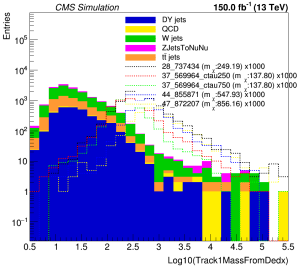
figure of 2-d map

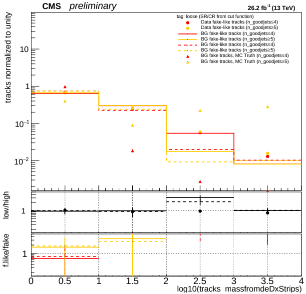
Incorporation of de/dx

- use pixel-only and strips-only "harmonic2" average (I_h)
- compute mass using relation from arXiv:1101.1645
    - $I_h = K\frac{m^2}{p^2} + C$
    - $K = 2.579 \pm 0.001$ MeV cm^{-1} c^2 and C $= 2.557 \pm 0.001$ MeV cm^{-1}
- calibration study of pixel de/dx P. Asmuss master thesis **link**

Pursuing two approaches

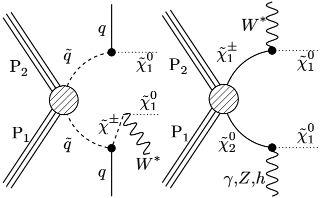
1. bin inclusively in jets and b-tagged jets, apply analysis MHT thresholds, fit mass distribution with a function
2. construct high/low mass template from "prompt-like" and "fake-like" control regions, use to split signal regions





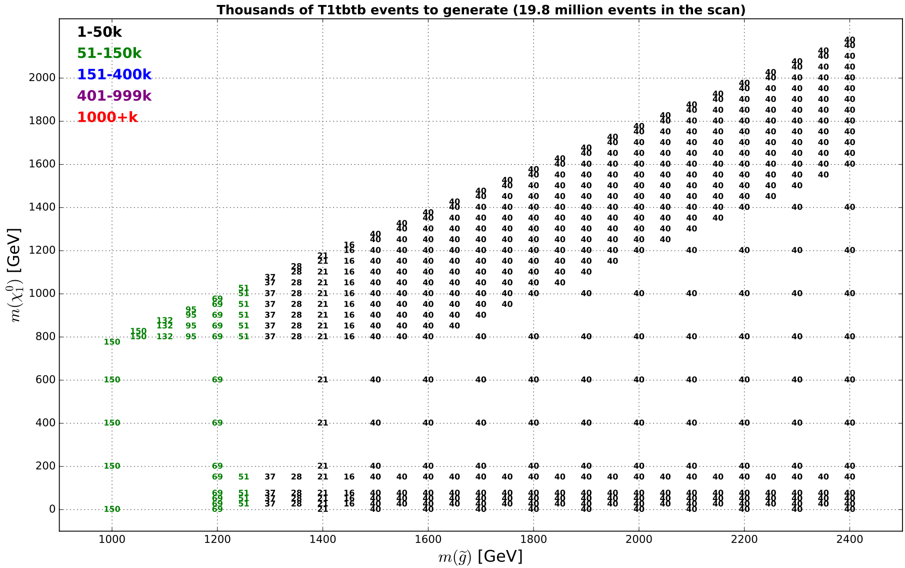
Status of signal

- We requested several samples in the spring (examples in next couple of slides)
- Samples were not produced for various reasons
- One factor is that FastSim now produces AOD's that contain the de/dx collections (now added)
- We would like to re-start these campaigns as soon as possible

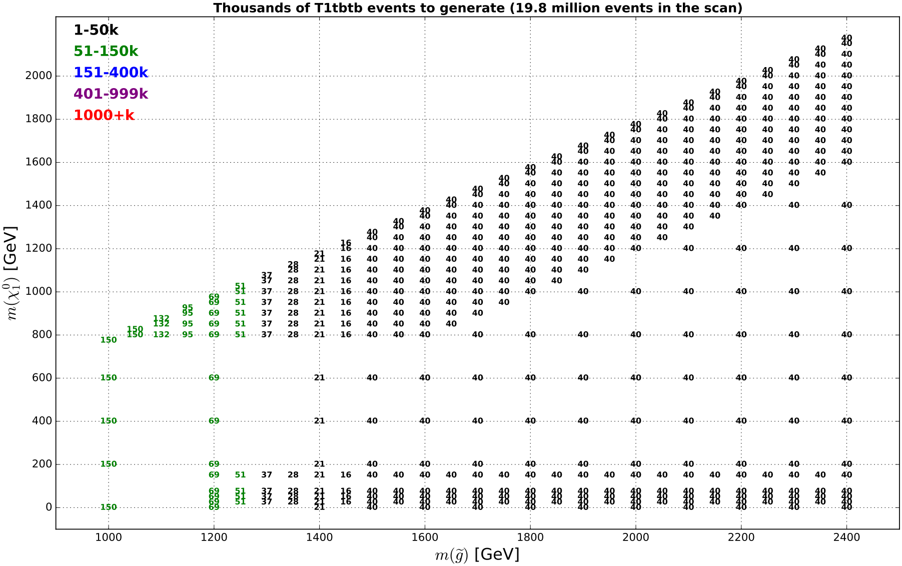


plots of fastsim de/dx

Model T1btbLL (requested)



Model T1tbtb (requested)



Conclusions and outlook

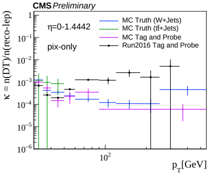
- Background methods show improvement in 2016 and 2017 MC
- Dropping muon veto should help pick up sensitivity to some long-lived scenarios
- Indications that mass(de/dx) is invariant w.r.t. event topology, differs between fake and prompt tracks
- Still need to study masks for 2017 and 2018 data
- Still need to re-do data-validation studies with the new tag

Backup

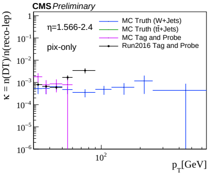
Prompt background: κ

electrons

short - barrel

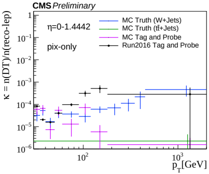


short - endcap

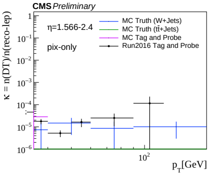


muons

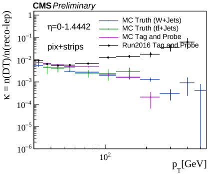
short - barrel



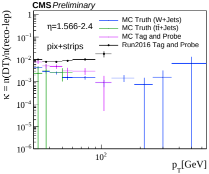
short - endcap



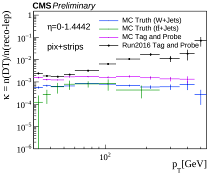
long - barrel



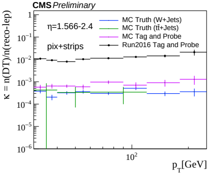
long - endcap



long - barrel

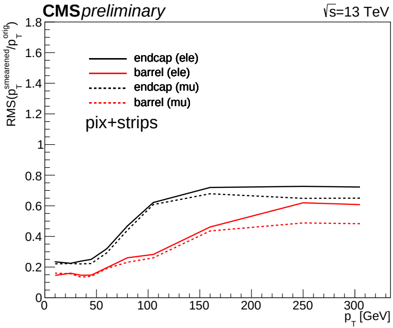


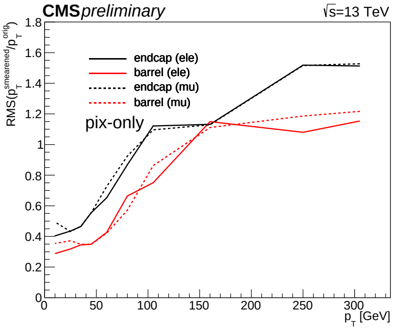
long - endcap



black: tag/probe in data; violet: tag/probe in MC; blue: MC truth (W+Jets); green: MC truth ($t\bar{t}$+jets);

smearing functions (global)

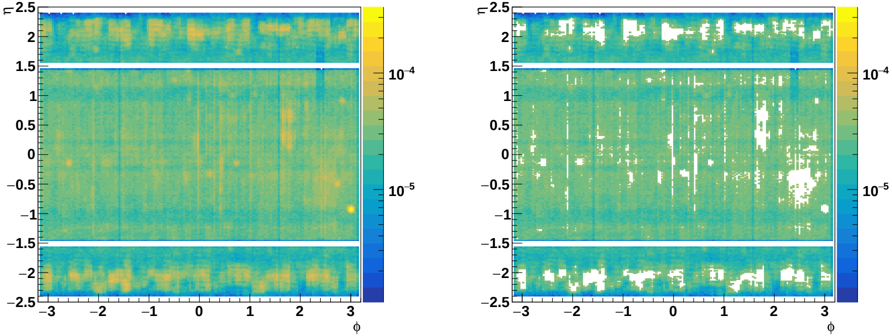




Masks

An eta/phi mask seems appropriate - veto tracks that fall within white area below, defined by bins with a normalized occupancy $> 0.5 * 10^{-4}$

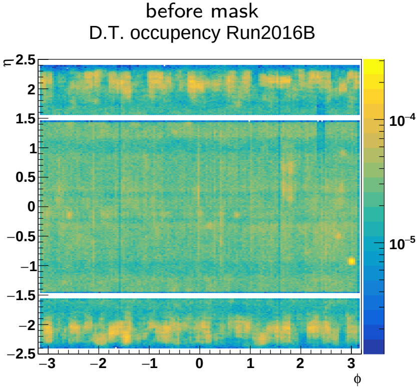
before mask — D.T. occupency Run2016 | after mask — D.T. occupency Run2016

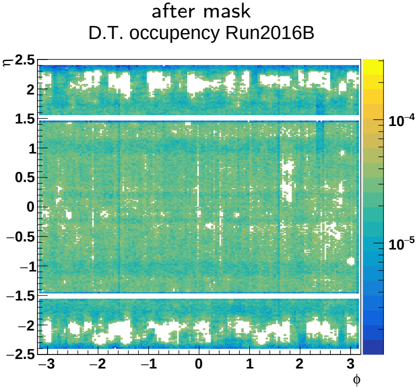


mask histograms are made available in Mattermost in rootfiles

Masks 2016B

Explore run-dependent masks, defined by bins with a normalized occupancy $> 0.5 * 10^{-4}$

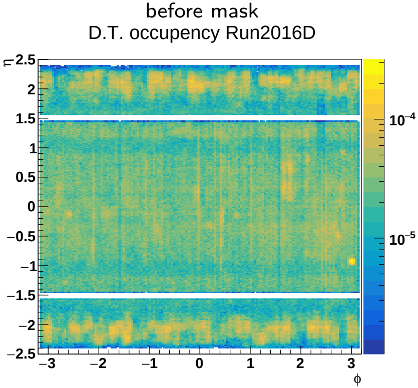


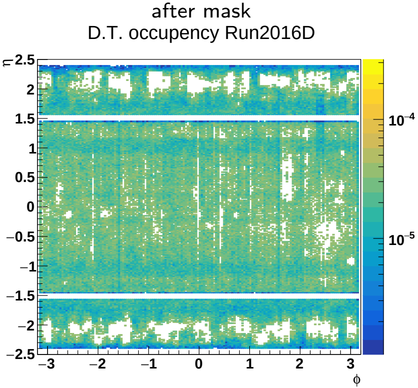


mask histograms are made available in Mattermost in rootfiles

Masks 2016D

Explore run-dependent masks, defined by bins with a normalized occupancy $> 0.5 * 10^{-4}$

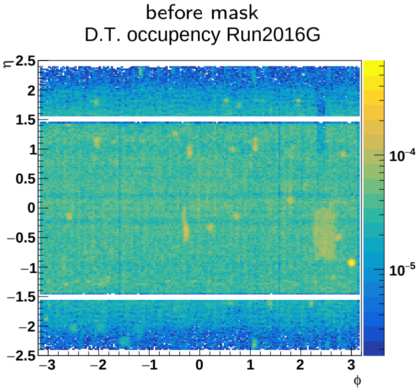


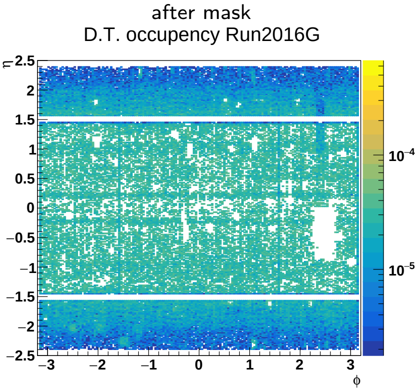


mask histograms are made available in Mattermost in rootfiles

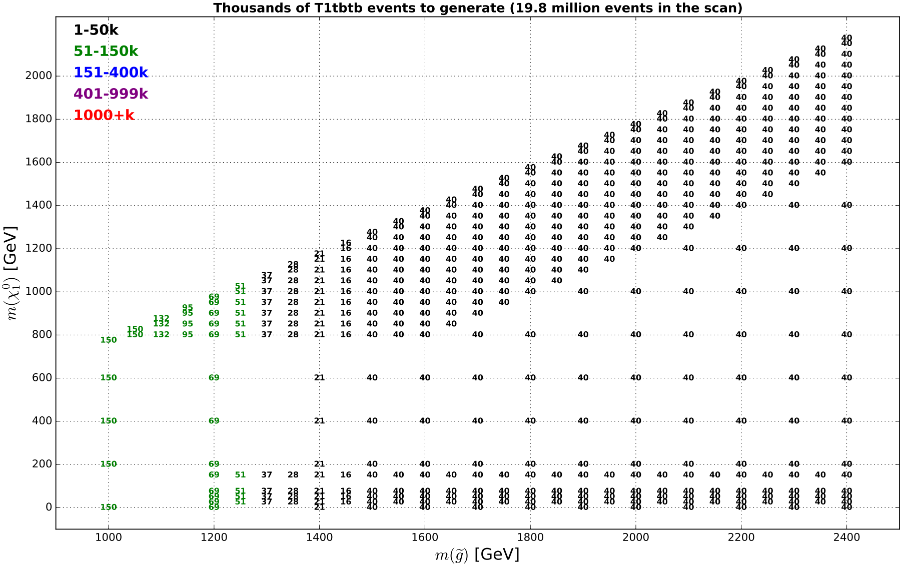
Masks 2016G

Explore run-dependent masks, defined by bins with a normalized occupancy $> 0.5 * 10^{-4}$





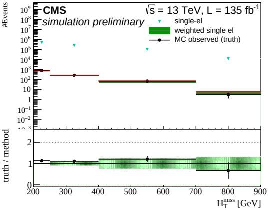
Model T1btbLL (requested)



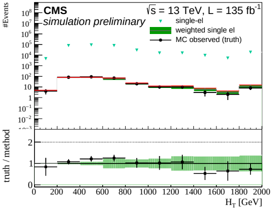
Electron background closure

"n-1" post-baseline plots using W+jets and $t\bar{t}$-jets

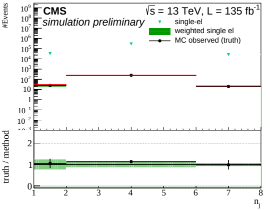
MHT



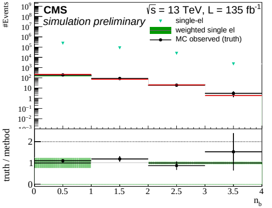
min($\Delta\phi$(jets, MHT))



n(jets)



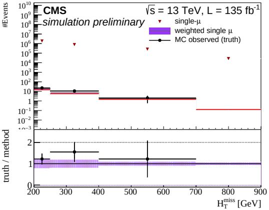
n(b-tags)



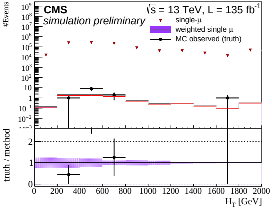
Muon background closure

"n-1" post-baseline plots using W+jets and $t\bar{t}$-jets

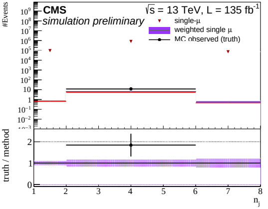
MHT



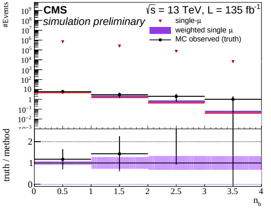
min(Δϕ(jets, MHT))



n(jets)

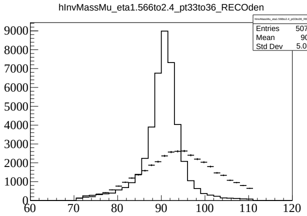


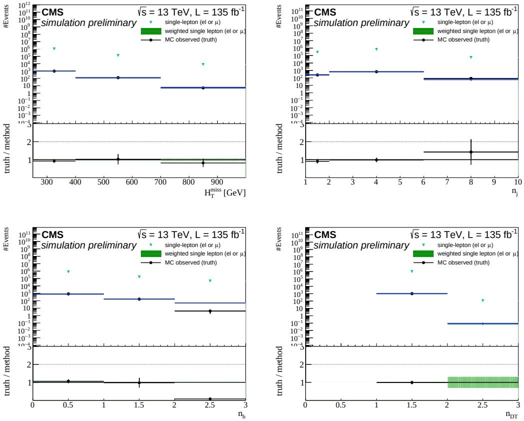
n(b-tags)



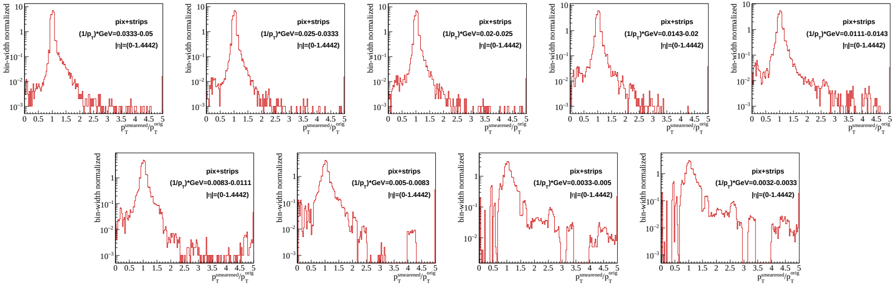
Prompt background: smearing dependence of κ

- Derive κ factors smearing quality probes
- Derive κ factors not smearing quality probes
- Make prediction with each version
- Impact is not large since only the tails of the invariant mass are changed

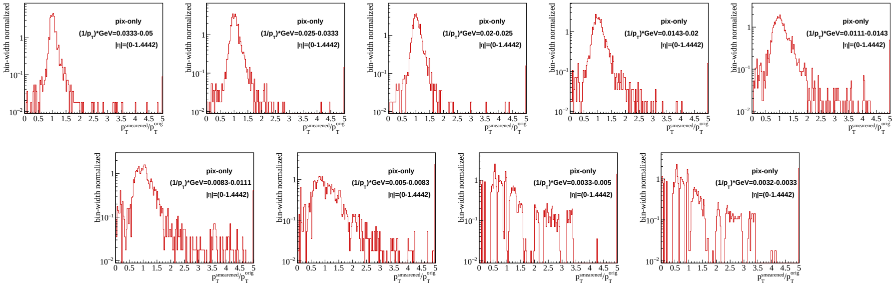




responses (pixel+strips) - barrel

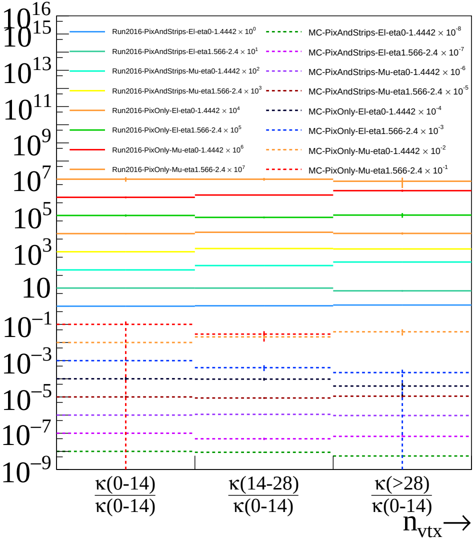


responses (pixel-only) - barrel



Prompt background: PU dependence of κ

- merge all p_T bins within a category of η, short/long, and electron/muon
- compute κ in data and MC in three bins of n(vtx)
- scale ratio to the first bin value, modulo a presentation factor: 10^n
- no dominant trend for data or MC



Systematics

- uncertainty in background predictions:
  - non-closure uncertainty
  - control region statistics (very small)
  - any additional systematic based on control region validation
- signal systematics:
  - standard systematics
    - JEC, JER
    - Pile-up
    - b-tagging and lepton scale factors
    - ISR systematic
    - FastSim MET correction
    - MC stats
  - disappearing electron scale factors