

Fat jets

Tilman Plehn

Physics case

Higgs tagging

Top tagging

Fat jets for $t\bar{t}H$ production

Tilman Plehn

Heidelberg University

Pheno, 5/2010

Physics case

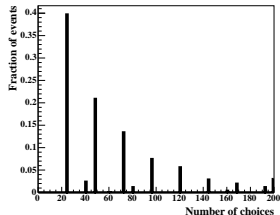
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Long death of $t\bar{t}H, H \rightarrow b\bar{b}$ [Michael's talk — Cammin & Schumacher, CMS-TDR and Atlas-CSC worse]

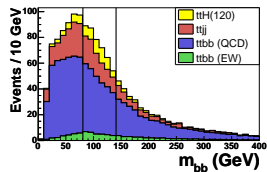
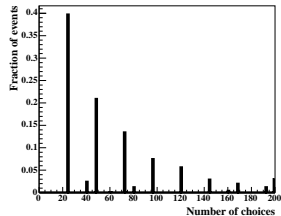
- trigger: $t \rightarrow bW^+ \rightarrow b\ell^+\nu$
reconstruction and rate: $\bar{t} \rightarrow \bar{b}W^- \rightarrow \bar{b}jj$
- continuum background $t\bar{t}b\bar{b}, t\bar{t}jj$ [know at NLO]
- no chance:
 - 1- combinatorics: m_{bb} from $pp \rightarrow 4b_{tag} 2j \ell\nu$



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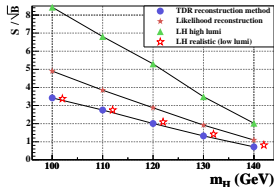
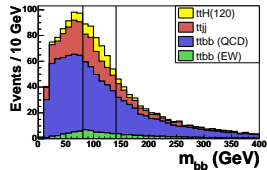
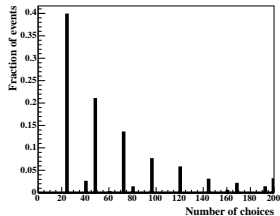
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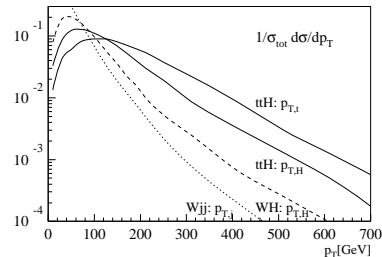
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- not a chance:
 - 1- combinatorics: m_H in $pp \rightarrow 4b_{tag} 2j \ell\nu$
 - 2- kinematics: peak-on-peak
 - 3- systematics: $S/B \sim 1/9$ [S/\sqrt{B} irrelevant]



Higgs tagging

New strategy for $H \rightarrow bb$ [Butterworth, Davison, Rubin, Salam; Adam's and Michael's talks]

- desperately needed for light Higgs [2/3 of all Higgses; inclusive CMS $S/B \sim 1/80$]
- S: large m_{bb} , boost-dependent R_{bb}
- B: large m_{bb} only for large R_{bb}
- S/B: ask for large m_{bb} and small R_{bb}
boosted Higgs $R_{bb} \sim 2m_H/p_T \sim 0.8$



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⇒ non-trivial challenge to jet algorithms

jet definition	σ_S/fb	σ_B/fb	$S/\sqrt{B_{30}}$
C/A, $R = 1.2$, MD-F	0.57	0.51	4.4
k_{\perp} , $R = 1.0$, y_{cut}	0.19	0.74	1.2
SISCone, $R = 0.8$	0.49	1.33	2.3

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Higgs tag in $t\bar{t}H$ [TP, Salam, Spannowsky]

- uncluster one-by-one: $j \rightarrow j_1 + j_2$
 - 1- unbalanced $m_{j_1} > 0.8m_j$ means QCD; discard j_2
 - 2- soft $m_{j_1} < 30$ GeV means QCD; keep j_1
- **double b tag**
three leading $J = p_{T,1}p_{T,2}(\Delta R_{12})^4$ vs m_{bb}^{filt}
no mass constraint — side bin
possibly add't balance criterion
- QCD jets everywhere
underlying event and pileup deadly
filter reconstruction jets [Butterworth-Salam]
decay plus one add'l jet at $R_{\text{filt}} \sim R_{jj}/2$
reconstruct masses w/ QCD jet
- $S/B \sim 1/2$, so 5σ for 100 fb^{-1} makes sense

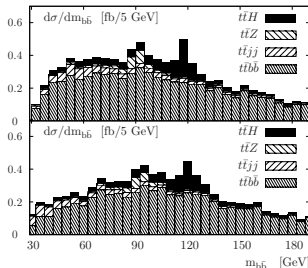
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Higgs tag in $t\bar{t}H$ [TP, Salam, Spannowsky]

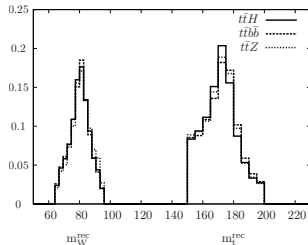
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Top tagging

Standard Model top tagger [TP, Salam, Spannowsky, Takeuchi]

- known for heavy resonances [Johns Hopkins, Stony Brook, Princeton, Washington, Atlas]
- cool for $t\bar{t}H$: fat Higgs and top jets
- start like Higgs tagger [but $R=1.5$]
- **kinematic selection** [filtered]
 - $m_t^{\text{rec}} = 150 \dots 200 \text{ GeV}$
 - $m_W^{\text{rec}} = 60 \dots 95 \text{ GeV}$
 - helicity angle large [learn from single tops]
- no check with side bands
- QCD tag typical for signal



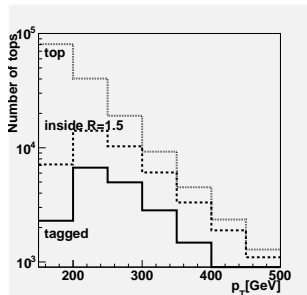
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Results and challenges

- focus on $p_T < 400 \text{ GeV}$
 - $\mathcal{O}(50\%+)$ efficiency for boosted tops
 - reconstruct top momentum?
 - identify three decay sub-jets?
- ⇒ **give us a little more time**



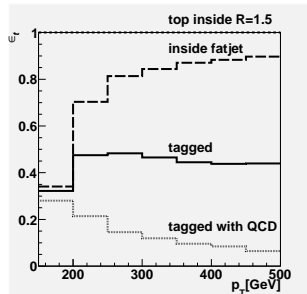
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Outlook

Top and Higgs tagging

- great success in VH production
- possible rescue of $t\bar{t}H$ production
- Higgs tag based on bottom tags and side bin
- top tag based on reconstructed masses

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