Summer Student Talk:
W-tagging for 1-lepton SUSY searches at ATLAS

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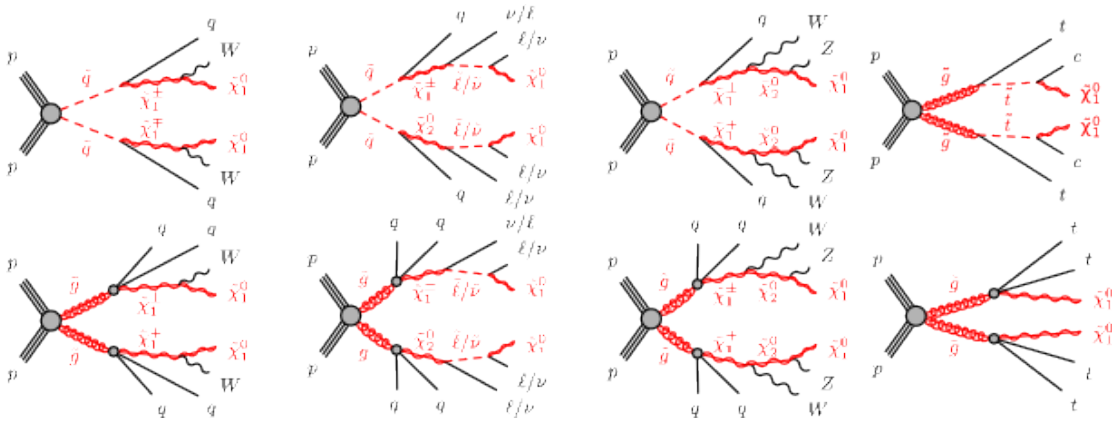
Introduction - SUSY search

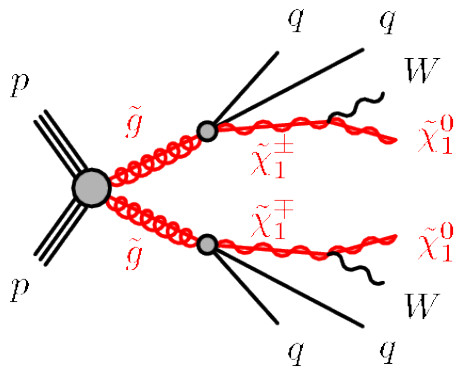
- Lots of possible SUSY processes ('signal'), with lots of free parameters (masses), e.g. (arXiv: 1501.03555v2):



- typical SUSY signals expected to have many high p_T-objects in the final state including large missing momentum from the escaping LSP
- Search for *significant* enhancements in count of events in defined *Signal Regions* ('SR') compared to SM prediction ('background')
- Increasing of signal/BG-ratio by optimizing SR
  $\Rightarrow$ more sensitivity for SUSY-signal!
- Eventually discovery or exclusion (with certain statistical significance)

Introduction - inclusive 1-lepton channel

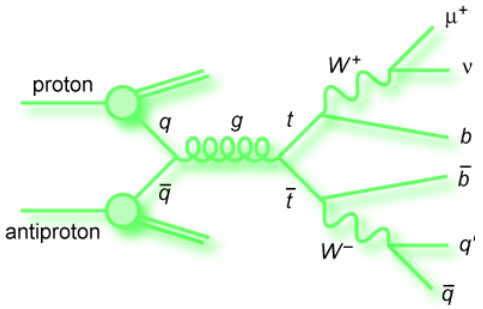
- Envisaged SUSY models have 2 W's in decay chain (arXiv:1501.03555):
  - one hadronically decaying: $W \to q\bar{q}'$
  - the other leptonically decaying: $W \to l\,\nu_l$

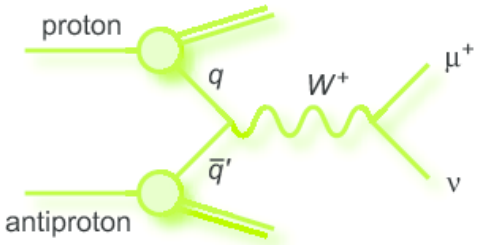


- SUSY particles are *heavy* (light already excluded!)

$\Rightarrow$ search in events with high p_T

$\Rightarrow$ main SM-Background events are ttbar and W+Jets:





- Strategy: BG-Reduction via b-jet veto (rejection of ttbar-BG) plus hadronic W tagging (rejection of W+jet-BG)

B-tagging and Optimization

B-tagging:

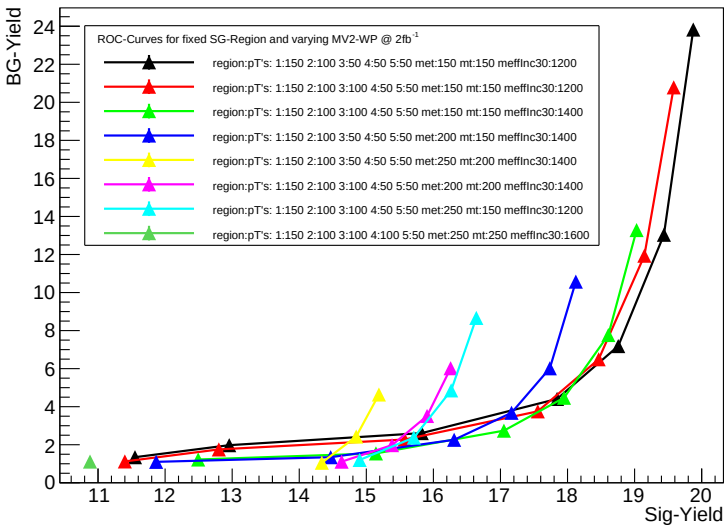
- *MV2*-variable: How likely is a jet to be a b-jet?
  if MV2(jet) $>$ threshold: mark jet as *b-tagged*
- Different thresholds *(Working points)* aiming for certain b-tagging efficiencies: (#(b-tagged jets)/#(b-jets))

SR-Optimization:

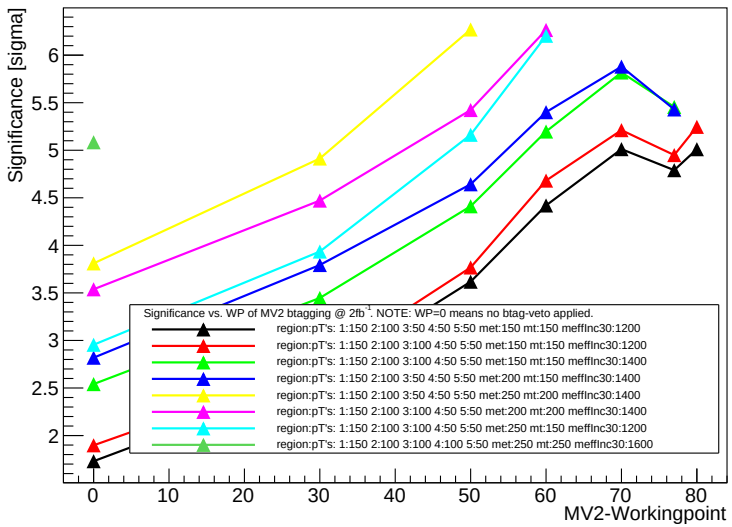
- Use MC to calculate Signal and BG-Yields for large number of SUSY model points
- Vary SR cuts (jet p_T, $\not{E}_T$, m_T, m_{eff}^{inc}, lepton p_T, b-tag WP) and calculate expected discovery significances

$\Rightarrow$ Find SR with optimal discovery-significance

ROC-Curves

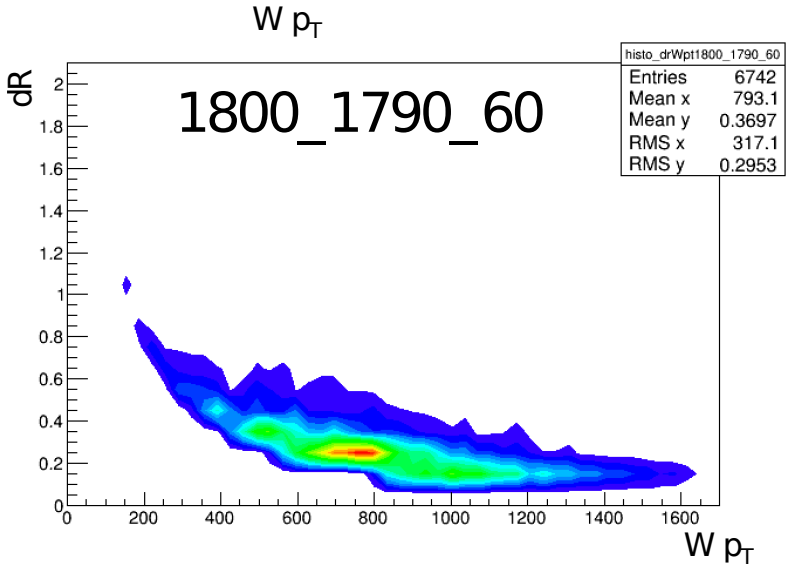


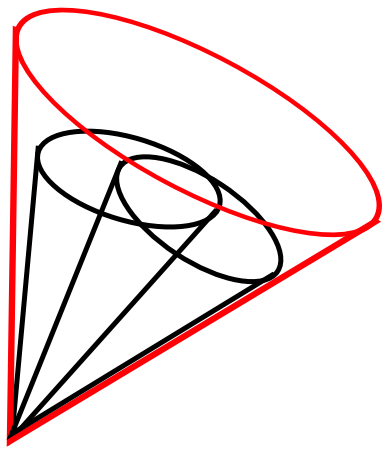
Significance vs. WP



W-tagging

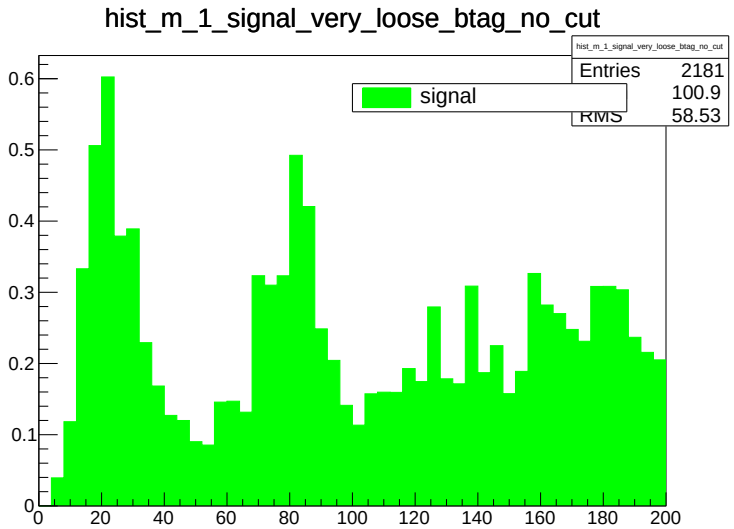
- Large SUSY-masses $\Rightarrow$ high p_T $\Rightarrow$ Ws are *boosted*
  $\Rightarrow$ decay products close in angle ($\propto 2m/P_T$).
- Jets not resolved by jet clustering algorithm (anti-k_t,C/A,...) with 'normal' R-parameter (e.g. $R = 0.6$)
- Reclustering of close-by standard jets as single *large-R jet*
  Examination of *fat-jet* substructure
  $\Rightarrow$ enables W-tagging.

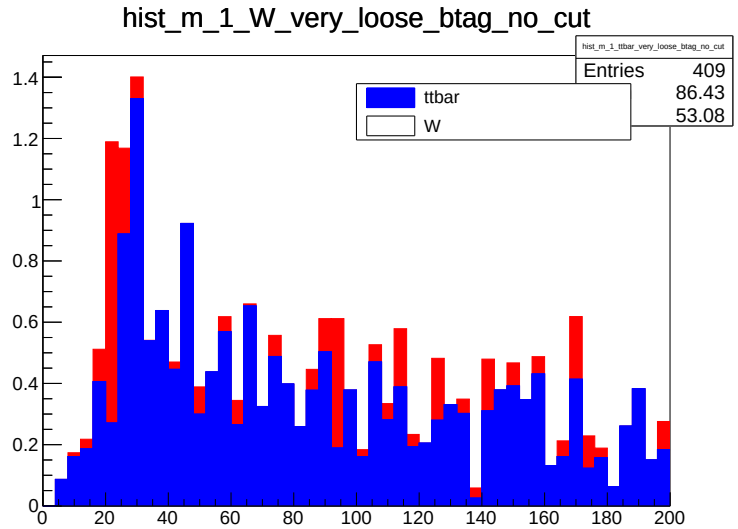


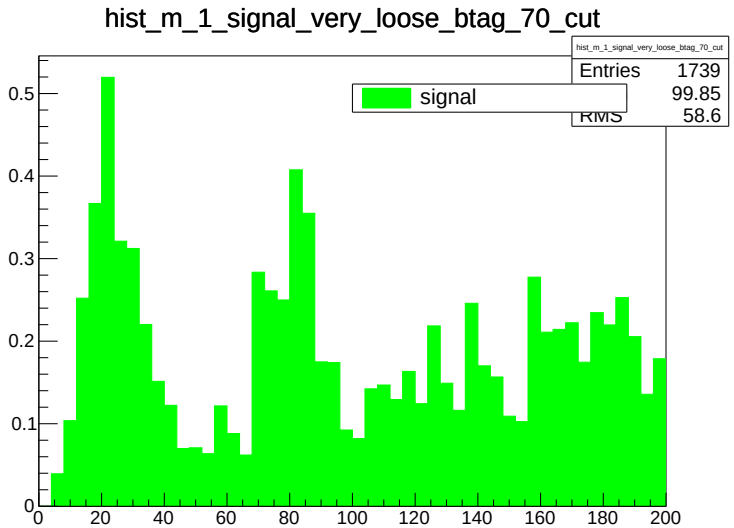


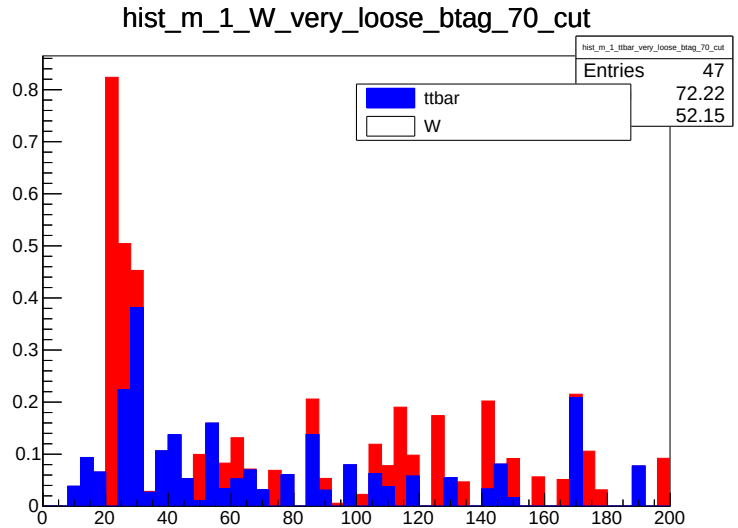
W-tagging

- Most straightforward tagging variable: invariant jet mass
- Cut on mass window around $m_W \approx 80.4$





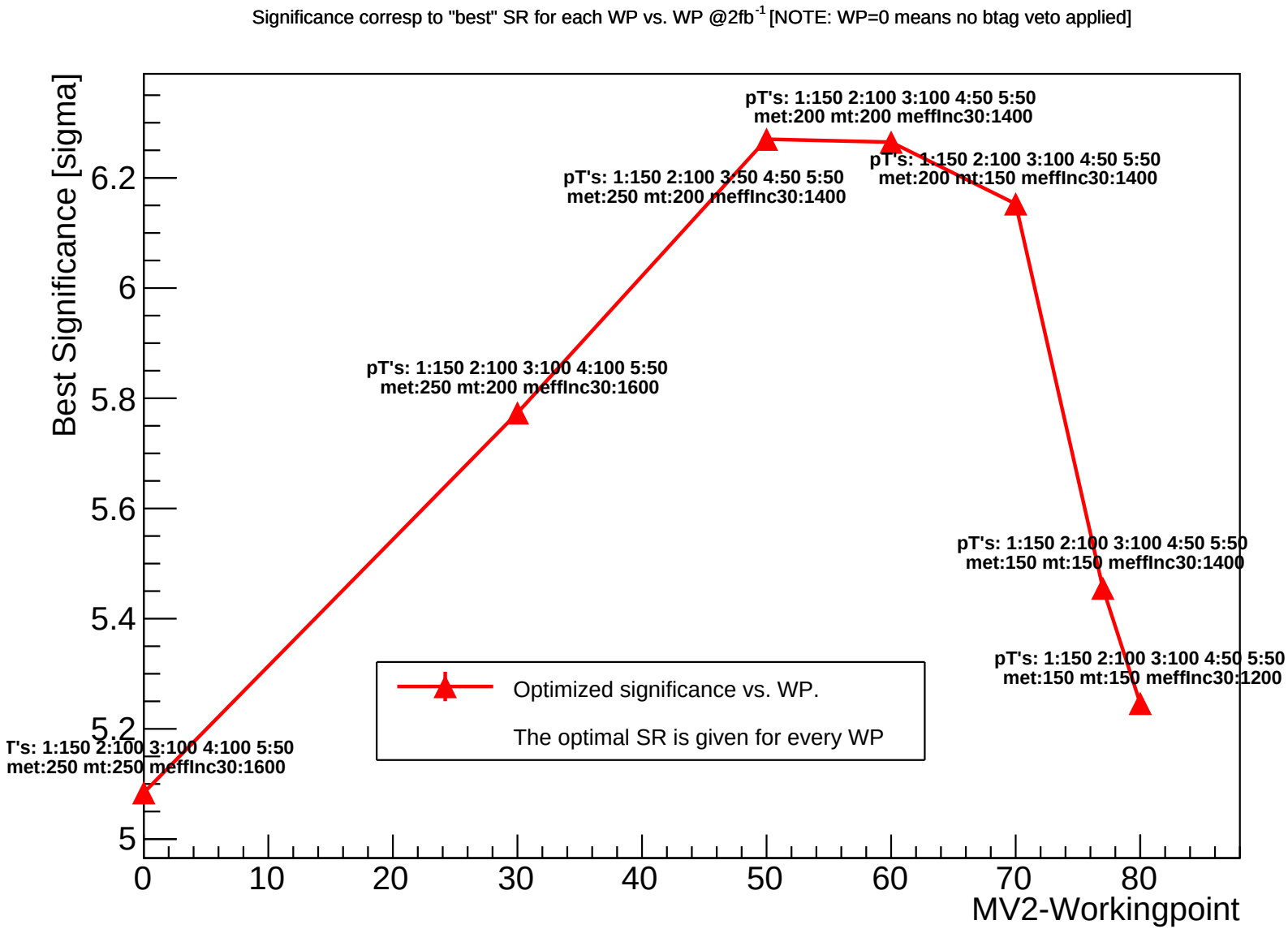




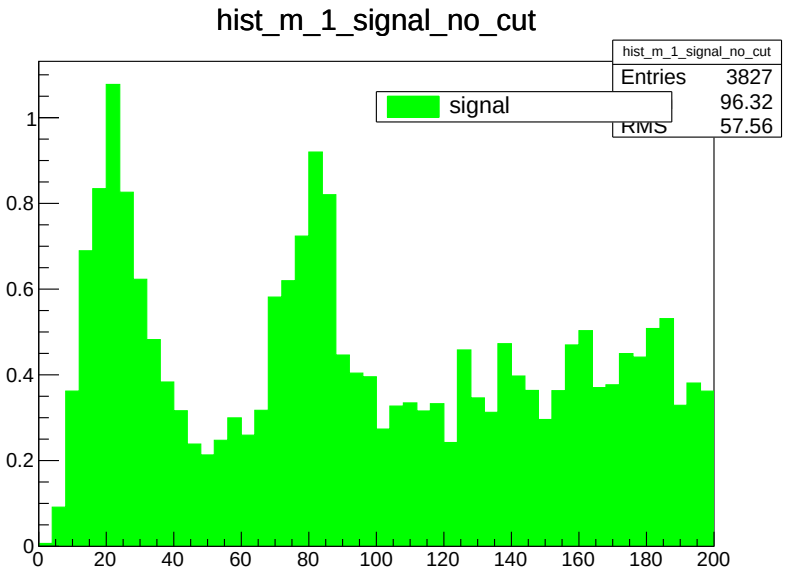
Outlook

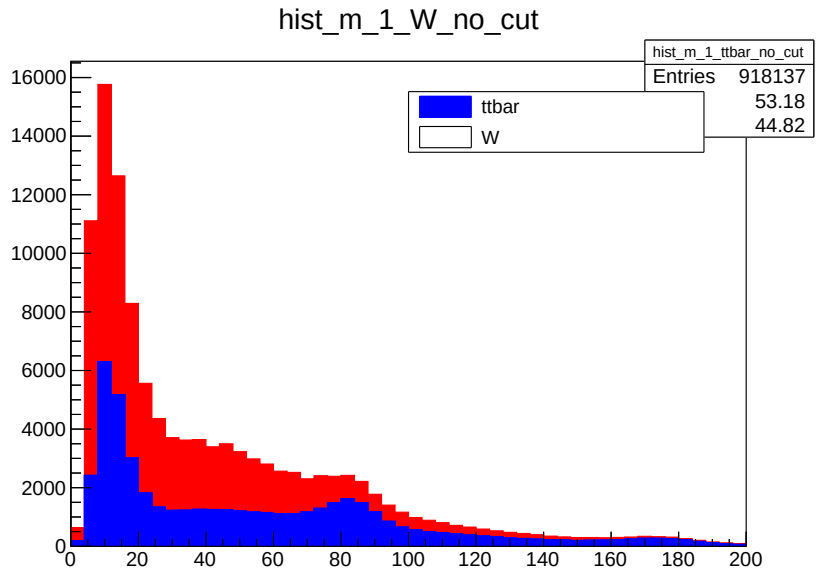
- Full optimization for more signal-models (SUSY-masses)
  $\Rightarrow$ including b-tag-veto AND W-tag-requirement WPs
- Sensitivity maps in e.g. $m_{\tilde{g}}$-$m_{\tilde{\chi}_1^0}$-space
- Exploitation of more W-tagging substructure variables
- Flat-efficiency b-tagging
- ...

BACKUP


Significance corresp to "best" SR for each WP vs. WP @2fb-1 [NOTE: WP=0 means no btag veto applied]
Best Significance [sigma]
MV2-Workingpoint
pT's: 1:150 2:100 3:100 4:50 5:50
met:200 mt:200 meffInc30:1400
pT's: 1:150 2:100 3:100 4:50 5:50
met:200 mt:150 meffInc30:1400
pT's: 1:150 2:100 3:50 4:50 5:50
met:250 mt:200 meffInc30:1400
pT's: 1:150 2:100 3:100 4:100 5:50
met:250 mt:200 meffInc30:1600
pT's: 1:150 2:100 3:100 4:50 5:50
met:150 mt:150 meffInc30:1400
pT's: 1:150 2:100 3:100 4:50 5:50
met:150 mt:150 meffInc30:1200
T's: 1:150 2:100 3:100 4:100 5:50
met:250 mt:250 meffInc30:1600
Optimized significance vs. WP.
The optimal SR is given for every WP

BACKUP


hist_m_1_signal_no_cut
hist_m_1_signal_no_cut
Entries 3827
96.32
RMS 57.56
signal
0 0.2 0.4 0.6 0.8 1
0 20 40 60 80 100 120 140 160 180 200


hist_m_1_W_no_cut
hist_m_1_ttbar_no_cut
Entries 918137
53.18
44.82
ttbar
W
0 2000 4000 6000 8000 10000 12000 14000 16000
0 20 40 60 80 100 120 140 160 180 200