Search for Light Higgs Boson in Top Quark Decays

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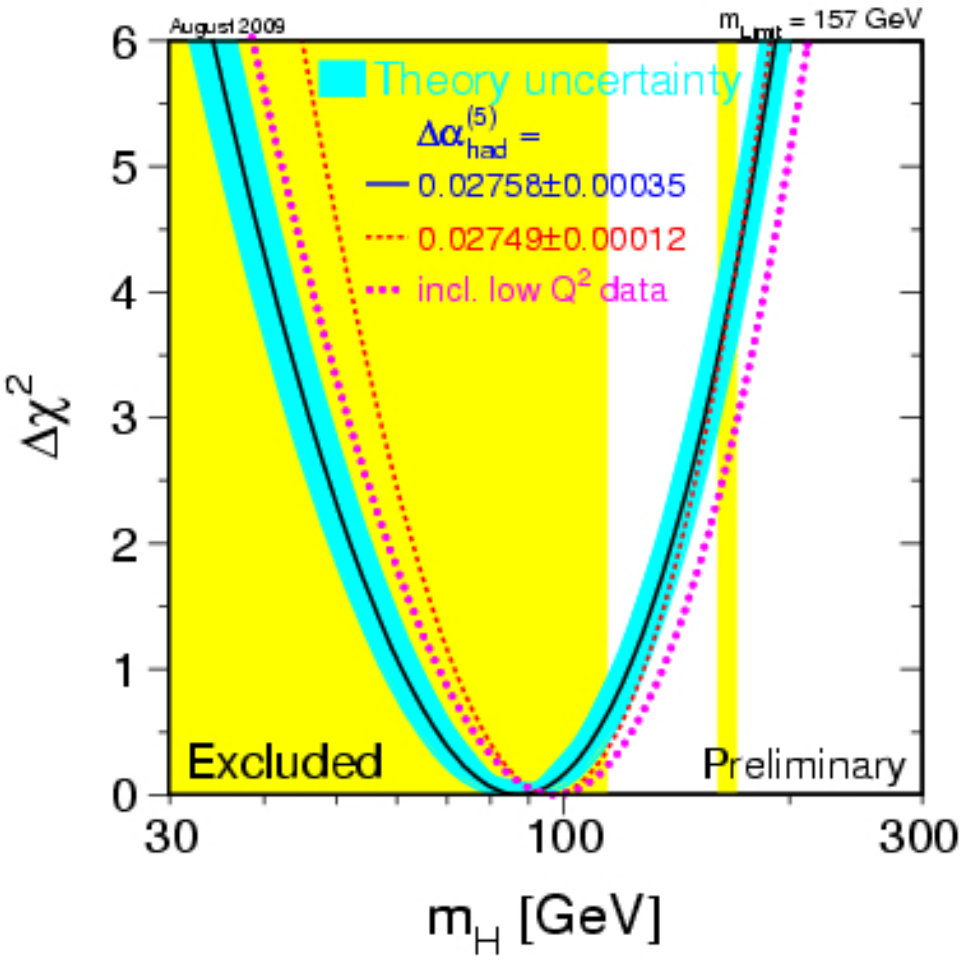
SM or SM-like Higgs



- Higgs with a mass near 160 Gev is our best shot
- Even if we were lucky and the evidence for Higgs was observed in this region that would introduce a tension in the electroweak fit

  => Call for Physics Beyond Standard Model
- EWK precision data prefers Higgs mass in a region directly excluded by LEP

Theoretical Motivations

- New Higgs decay modes could impact the interpretation of LEP results
- In a natural extension to MSSM --- **NMSSM** ---

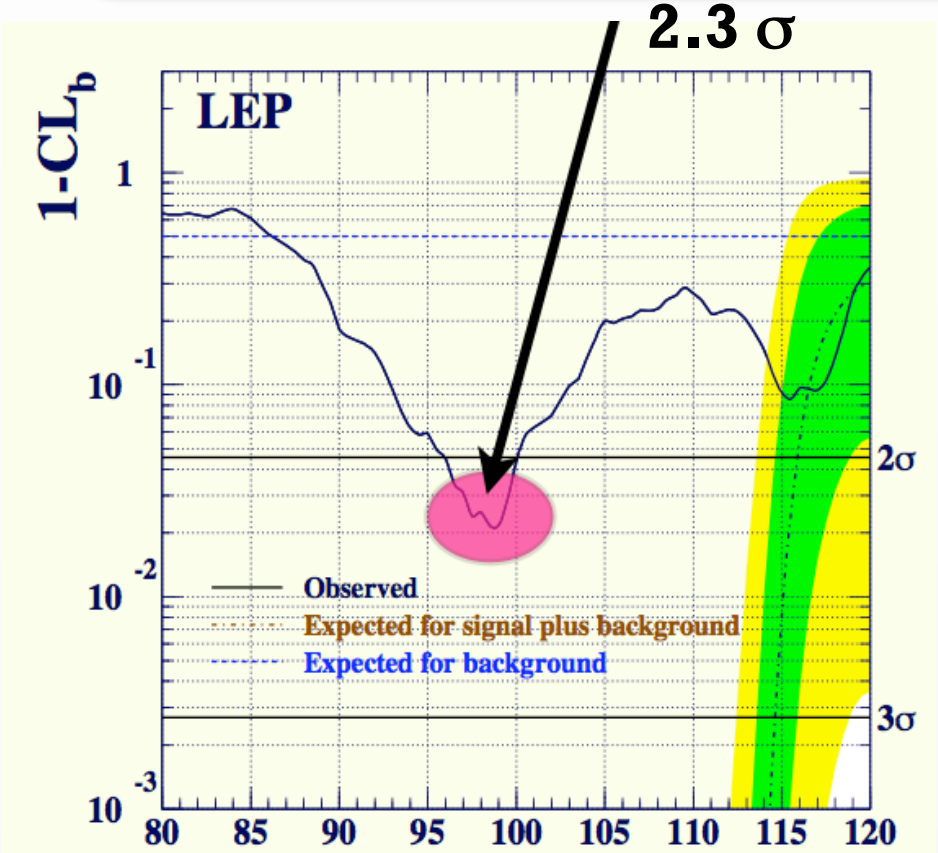
  Light Higgs (A with mass

  $m_A < 2m_b$) arises, which is not experimentally excluded

R. Dermisek and J. Gunion PRL 79, 055014 (2009)

R. Dermisek and J. Gunion PRD 81, 075003 (2010)

Experimental Motivations



- New Higgs decay modes could impact the interpretation of LEP results
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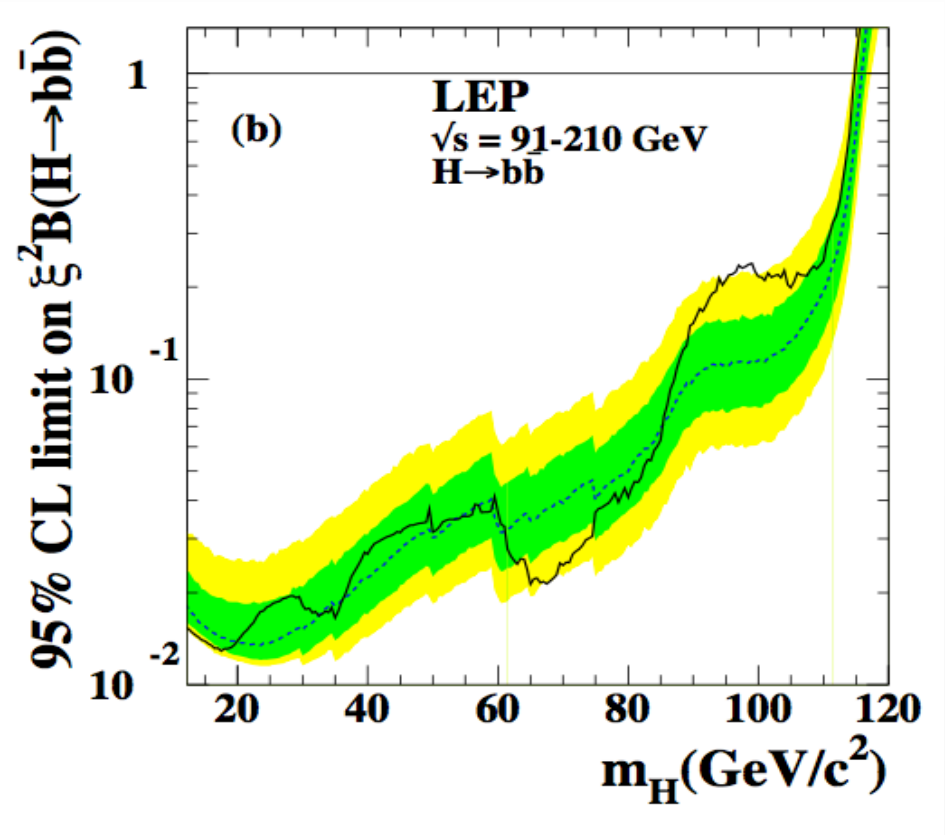
Mode	SM modes	2τ or $2b$ *only*	$2j$	$WW^* + ZZ^*$	$\gamma\gamma$	$\not{E}$	$4e, 4\mu, 4\gamma$
Limit (GeV)	114.4	115	113	100.7	117	114	114?
Mode	$4b$	4τ	any (e.g. $4j$)	$2f + \not{E}$			
Limit (GeV)	110	86	82	90?			

J. Gunion et al. ARNPS 58, 75 (2008)

Experimental Motivations



- New decay mode H-> AA with A -> ττ could sufficiently change Br(H->bb) to avoid LEP limits

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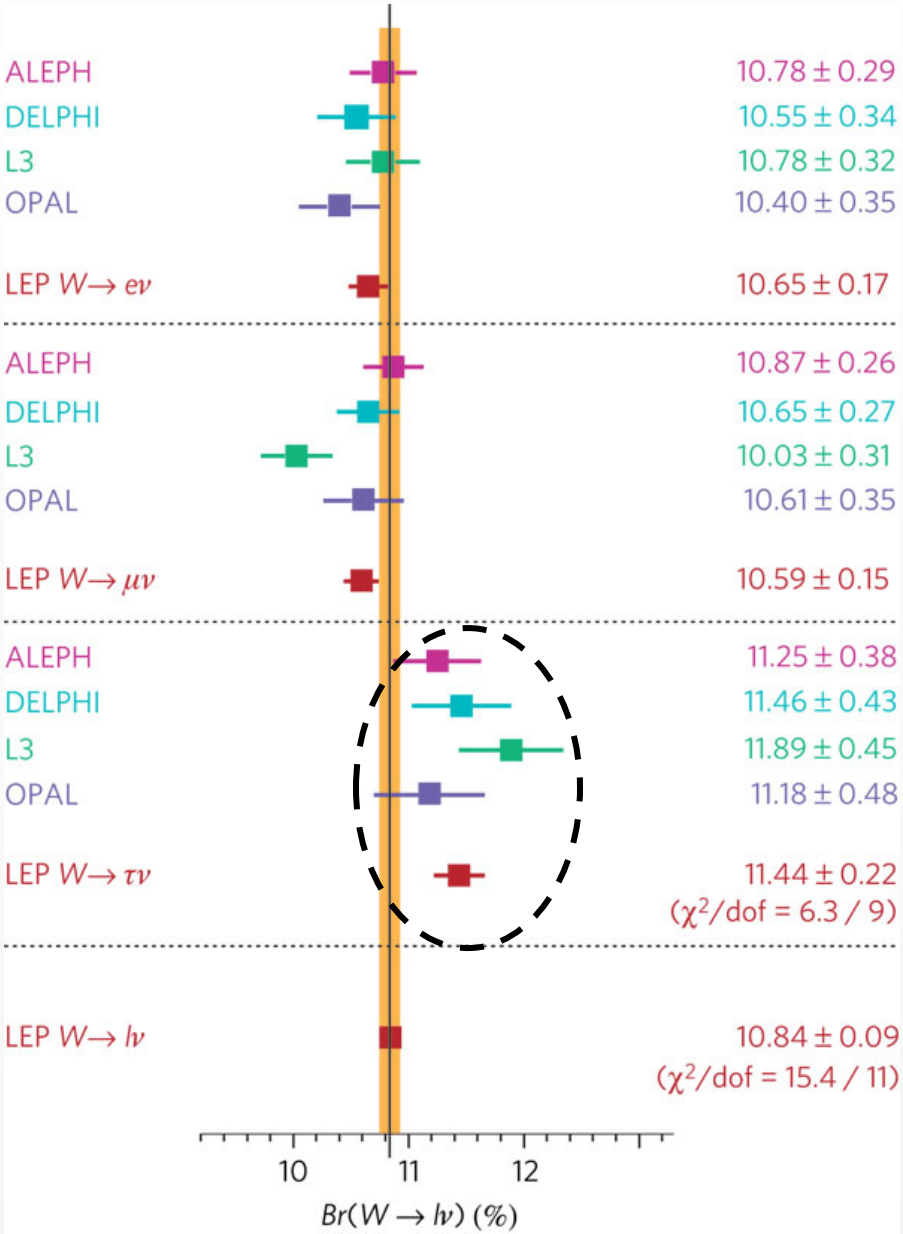
Experimental Motivations

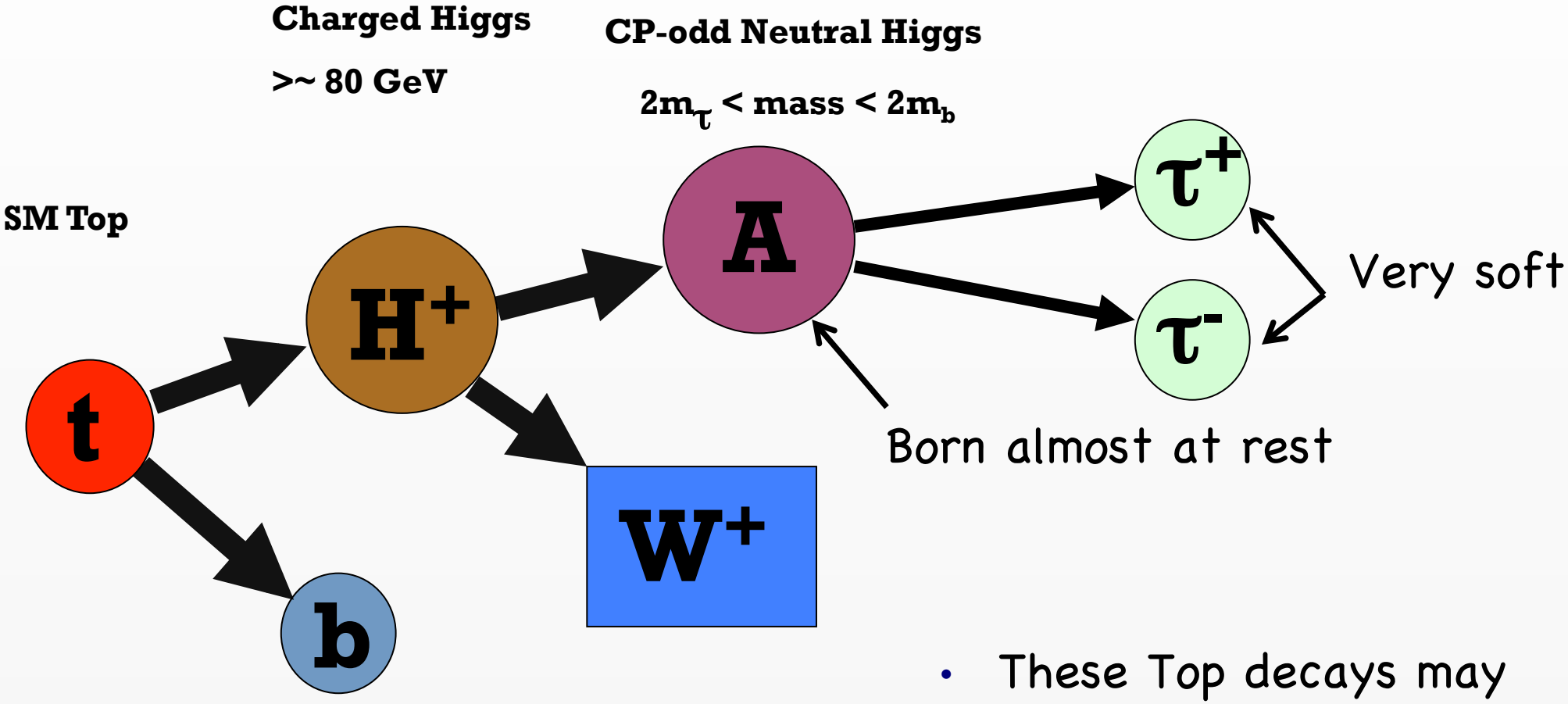


- W branching ratios measured at LEP using WW production are 2.8 σ discrepant
- Possibly evidence for charged Higgs pair production with subsequent decays:

  $H^+ \rightarrow \tau\nu$
- If so, H^+ mass should be just above W mass

R. Dermisek, arXiv:hep-ph/0807.2135

Top Decays



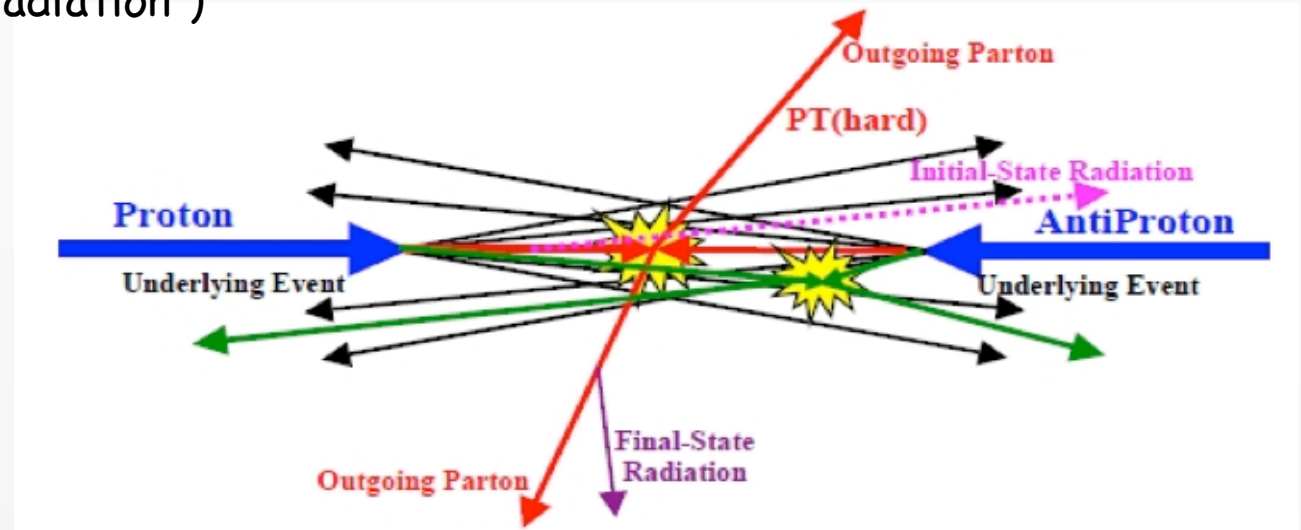
- These Top decays may become possible and can be easily missed in standard analyses

R. Dermisek, arXiv:hep-ph/0807.2135

Search Strategy

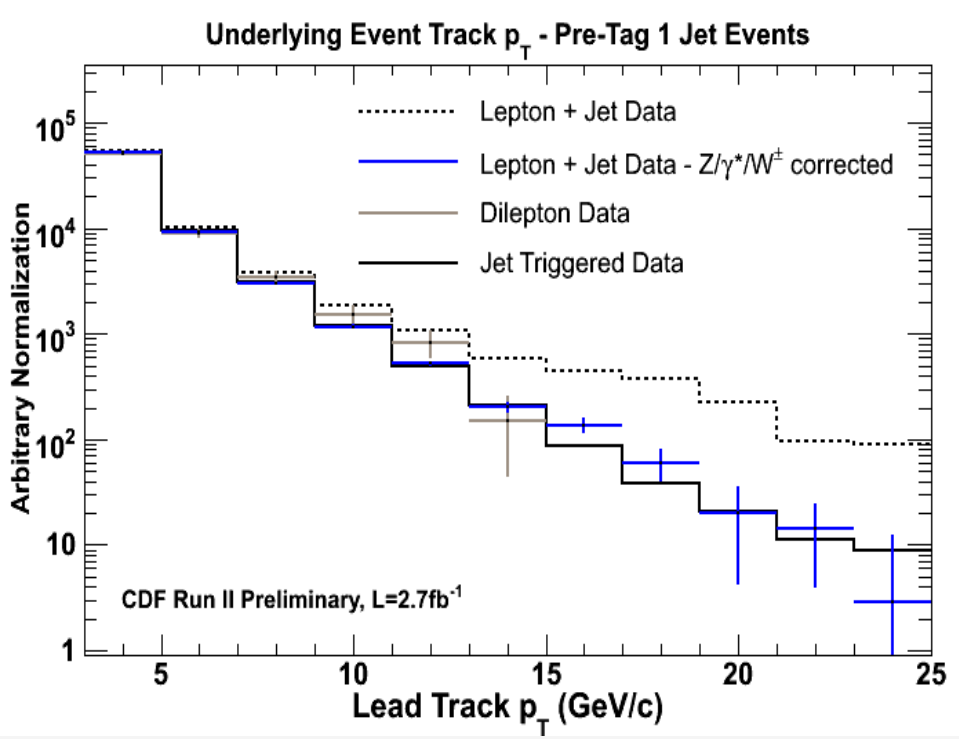
- The tau identification at low-pt is not very efficient
- We search for very soft isolated tracks (p_T = [3,20] GeV)

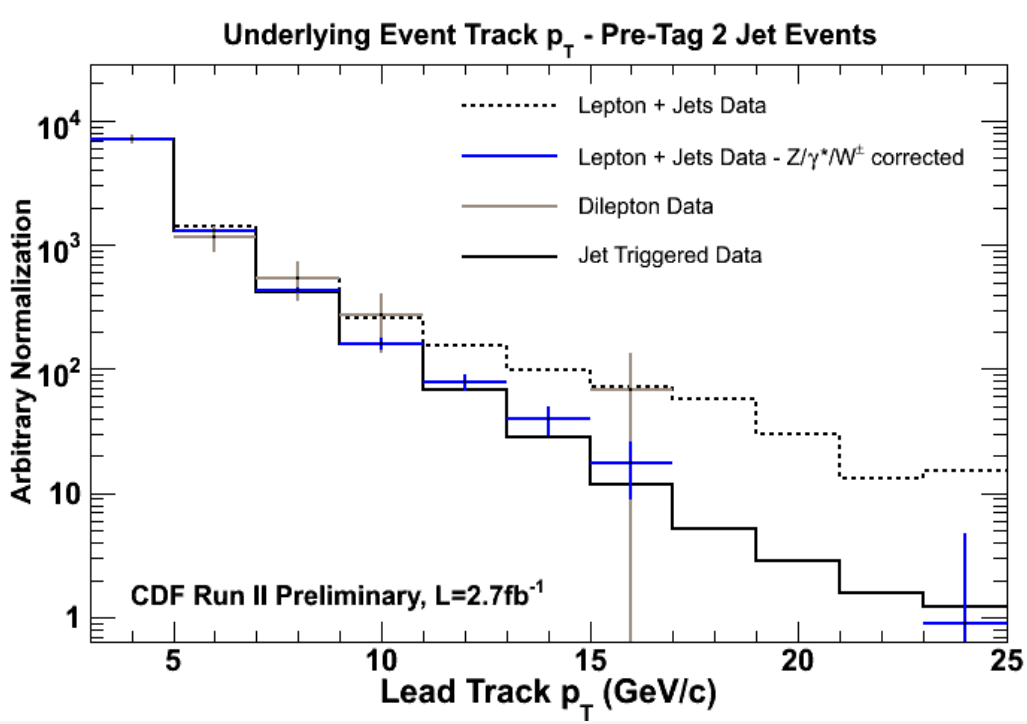
- Main background:
  - Soft parton interactions (Underlying Event)
    - Additional ppbar interactions
    - The same hard-scatter interaction (tracks from Initial and Final state radiation)



Underlying Event Track Modeling

- Model p_T spectrum of Underlying Event tracks using data
- Study track P_T spectrum in multi-jets, Z events, and lepton+1,2 jets events (correcting for Z/γ^* tracks)
- The rate is slightly different but P_T spectra in different data samples agree with each other





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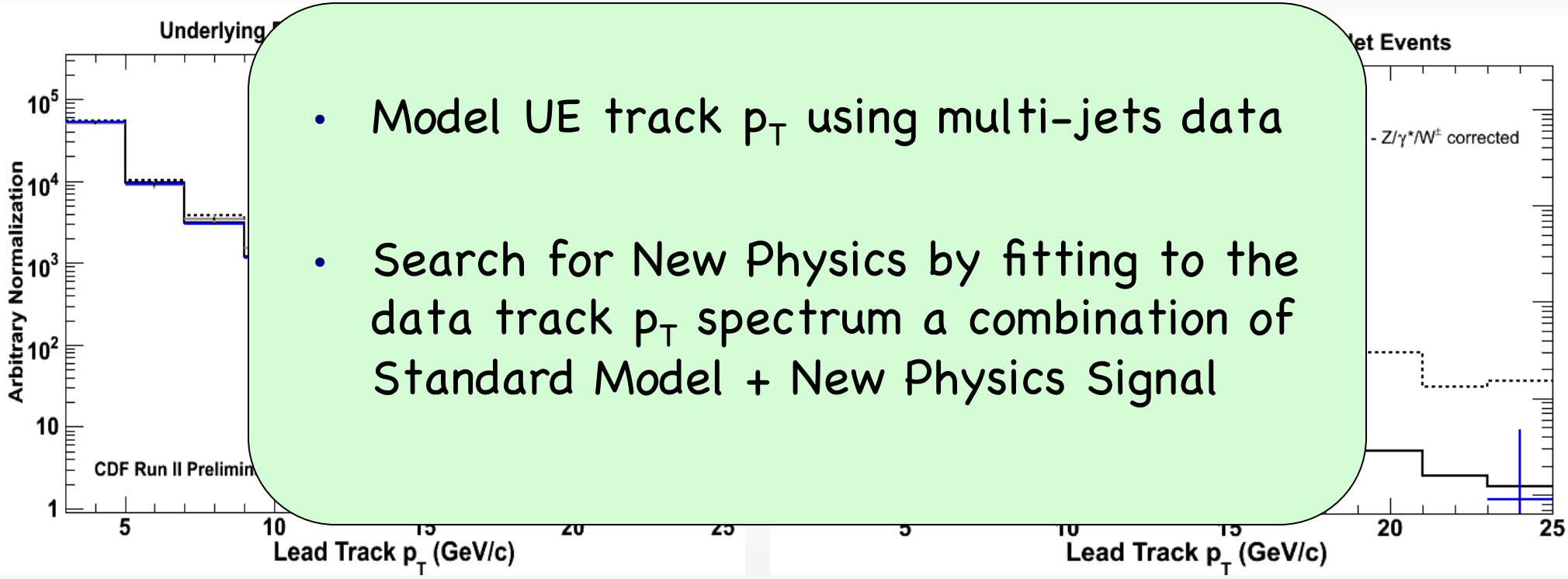
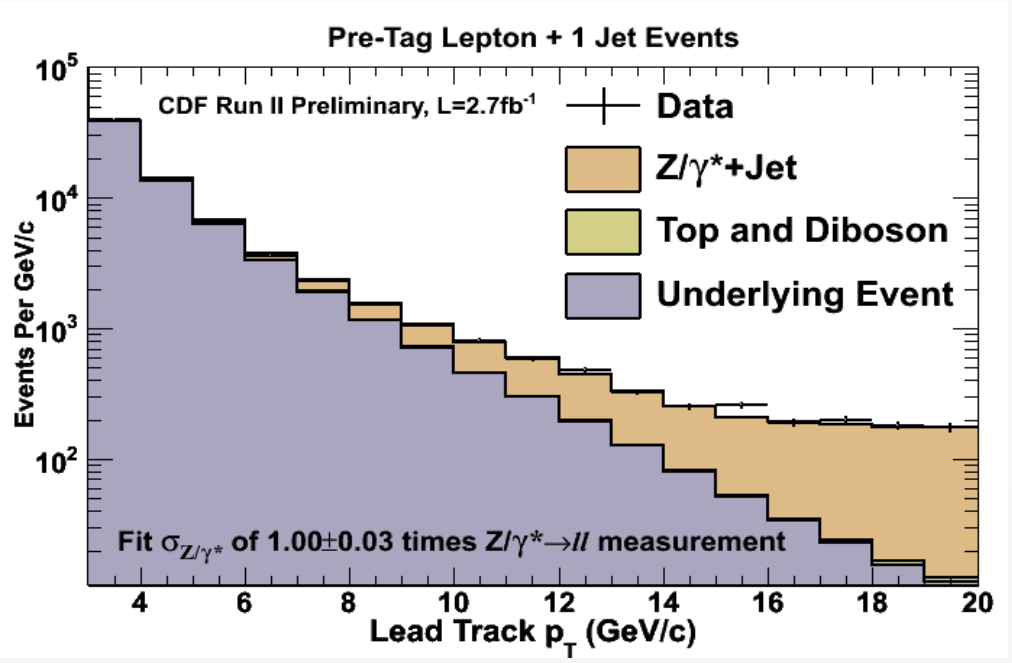
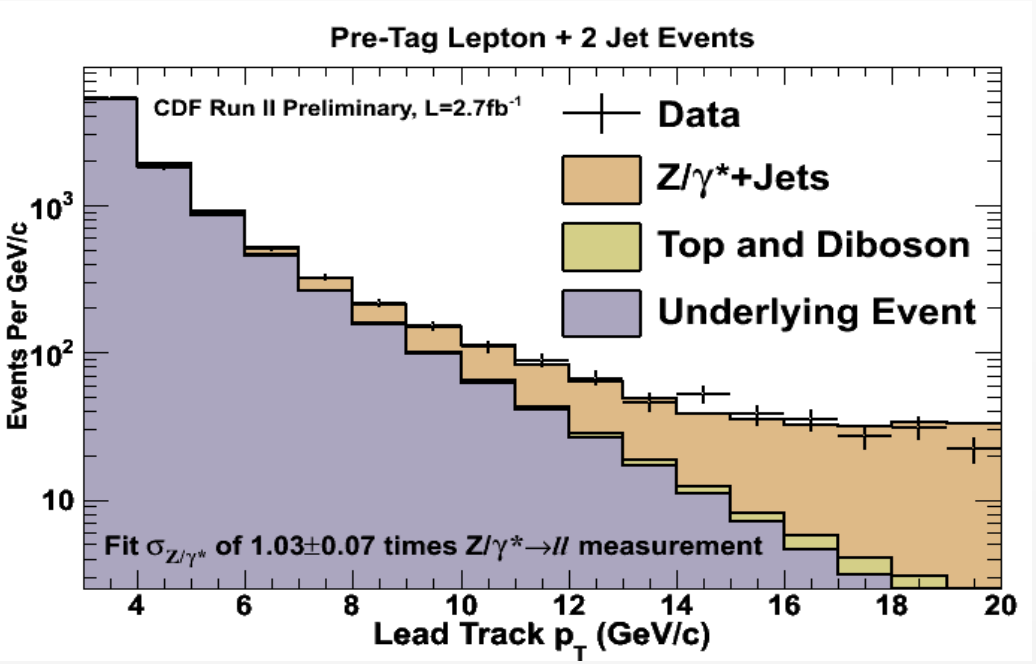


- Model UE track p_T using multi-jets data
- Search for New Physics by fitting to the data track p_T spectrum a combination of Standard Model + New Physics Signal

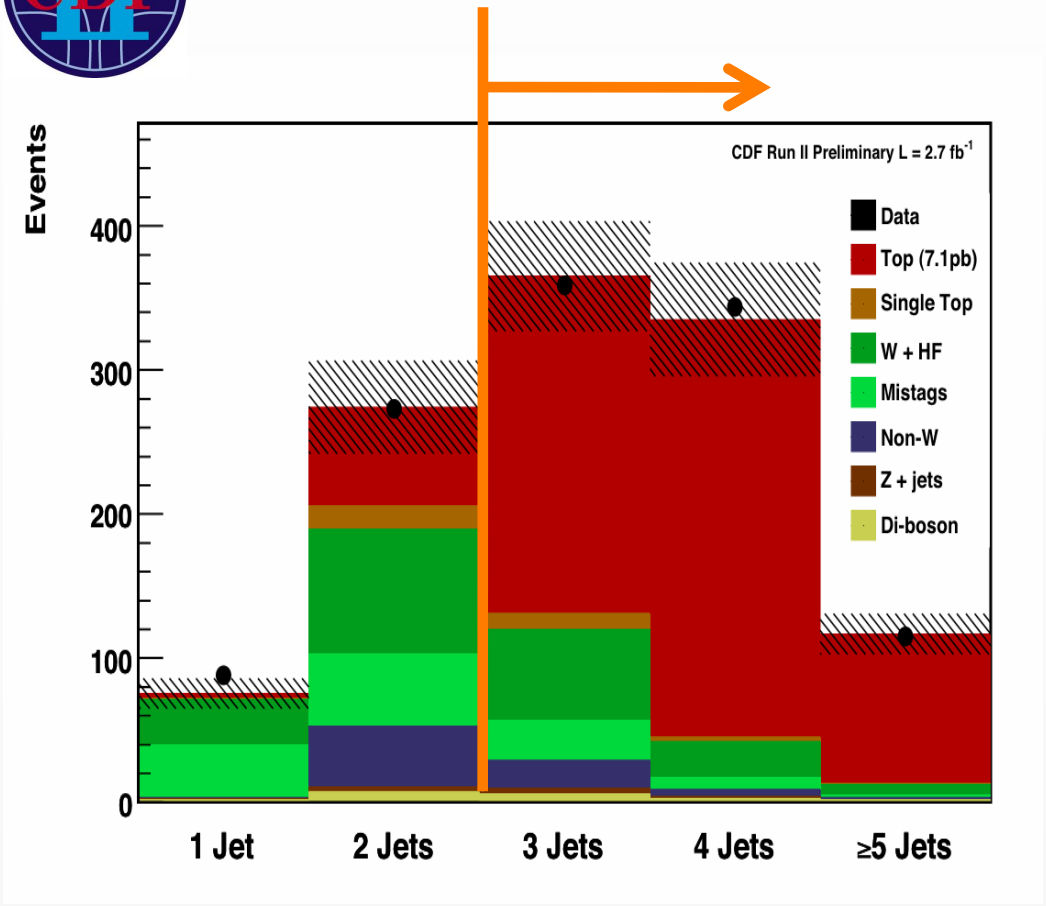
Control Regions Cross-Check

- Perform the fit in the Lepton + 1 and 2 jets region
- The Underlying Event track p_T is unconstrained
- The other main contribution is from Z/γ^* events where the second lepton fails the lepton identification requirements, but reconstructed as a soft isolated track
- Extract Z/γ^* cross section that matches our expectations





Signal Region

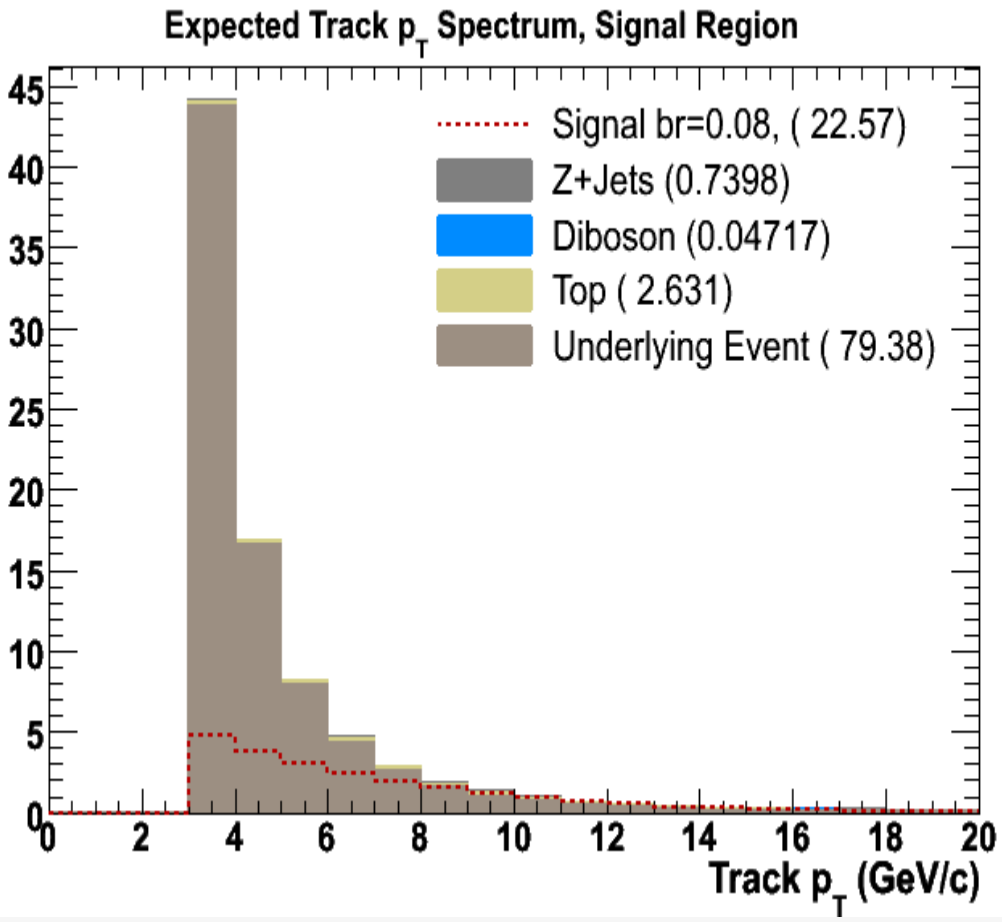


- "Standard" Top Lepton + Jets selecton used in physics analyses:

- 1 lepton (p_T > 20 GeV)
- Missing Et > 25 GeV
- >=3 jets (E_T > 20 GeV)
- >= 1 b-tagged jet

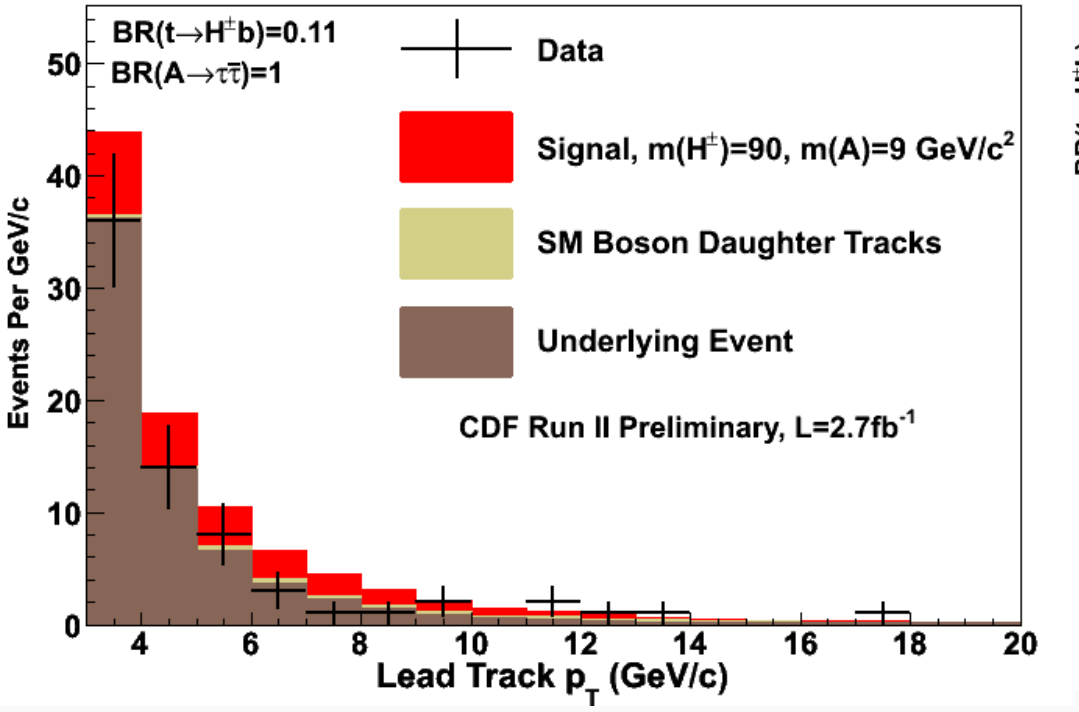
Signal Region

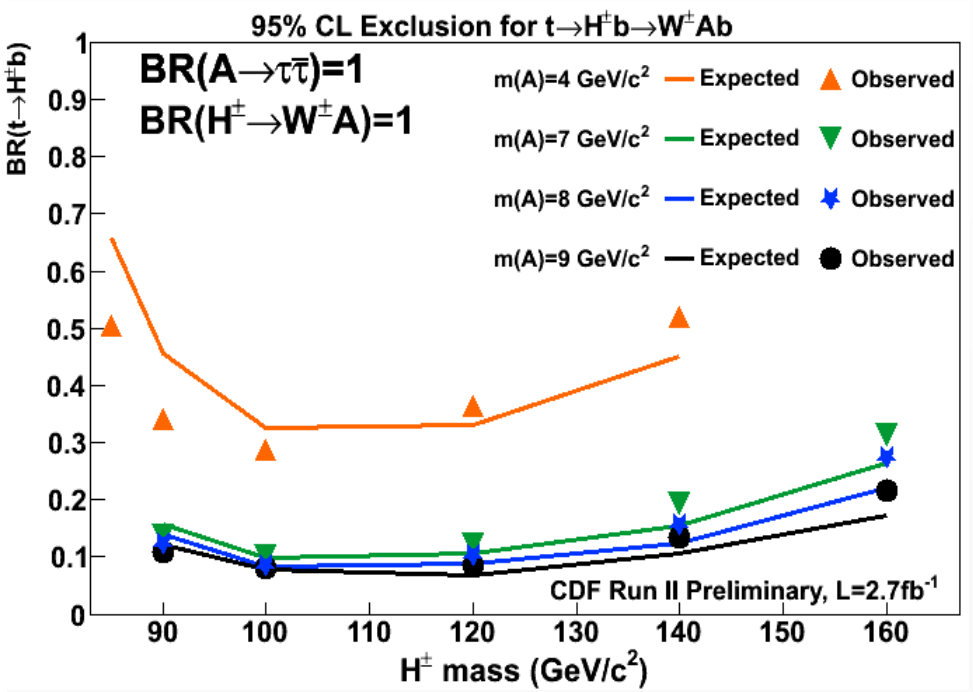
- In addition we require >=1 soft isolated track



- If there are more than 1 track, we always select highest p_T track
- We correct the signal template for the fact that UE track can have higher p_T than taus from A

Results





- We see no evidence for Light Higgs Boson in top quark decays
- We set the first limits on BR (t -> H^+b) in this decay mode

Conclusions

- We see no evidence for Light Higgs Boson A in top quark decays:
  - $t \rightarrow H^+b \rightarrow WbA \rightarrow Wb\tau\tau$
- We set the first limits on BR ($t \rightarrow H^+b$) in the considered decay mode