Boosted Higgs and Top Yukawa Coupling

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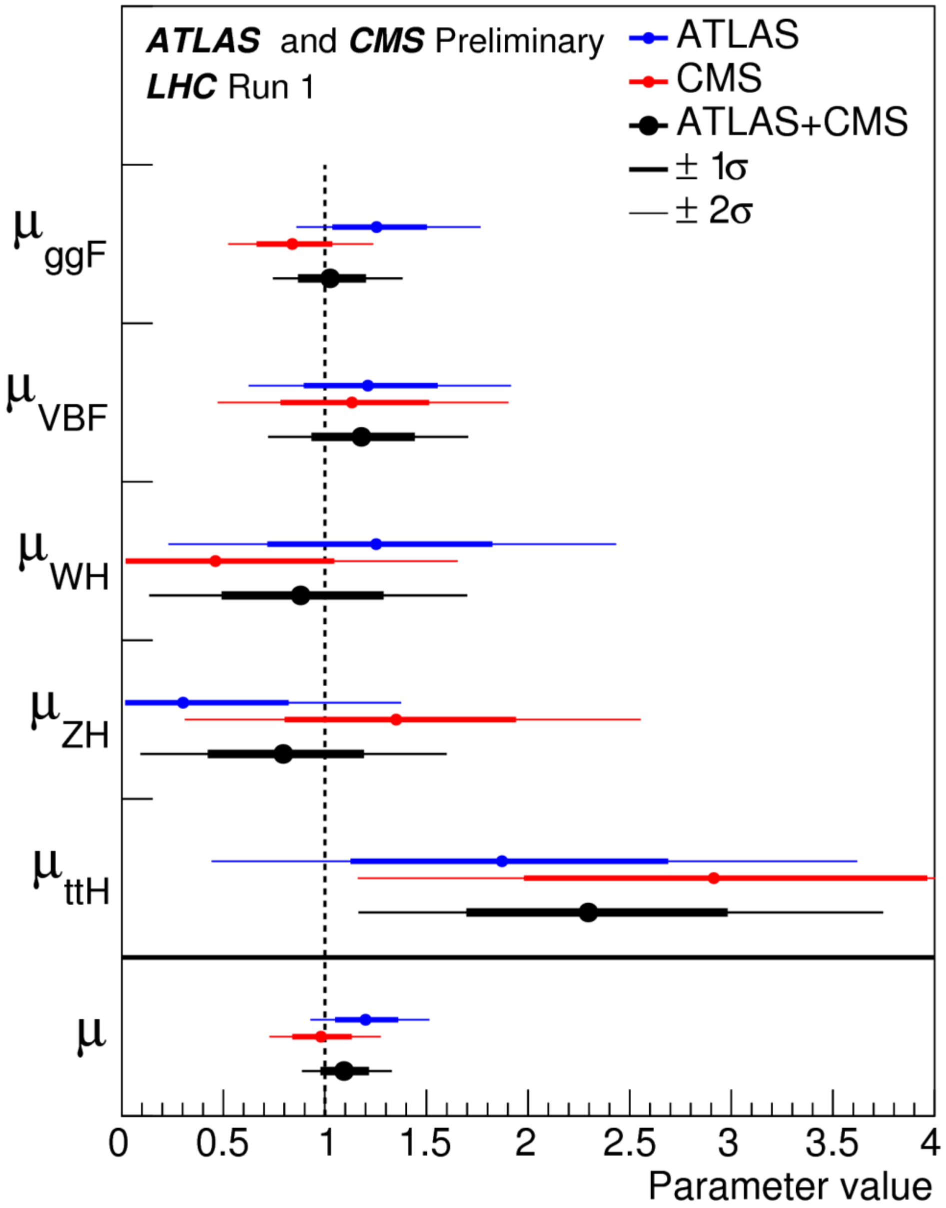
Background - Problem

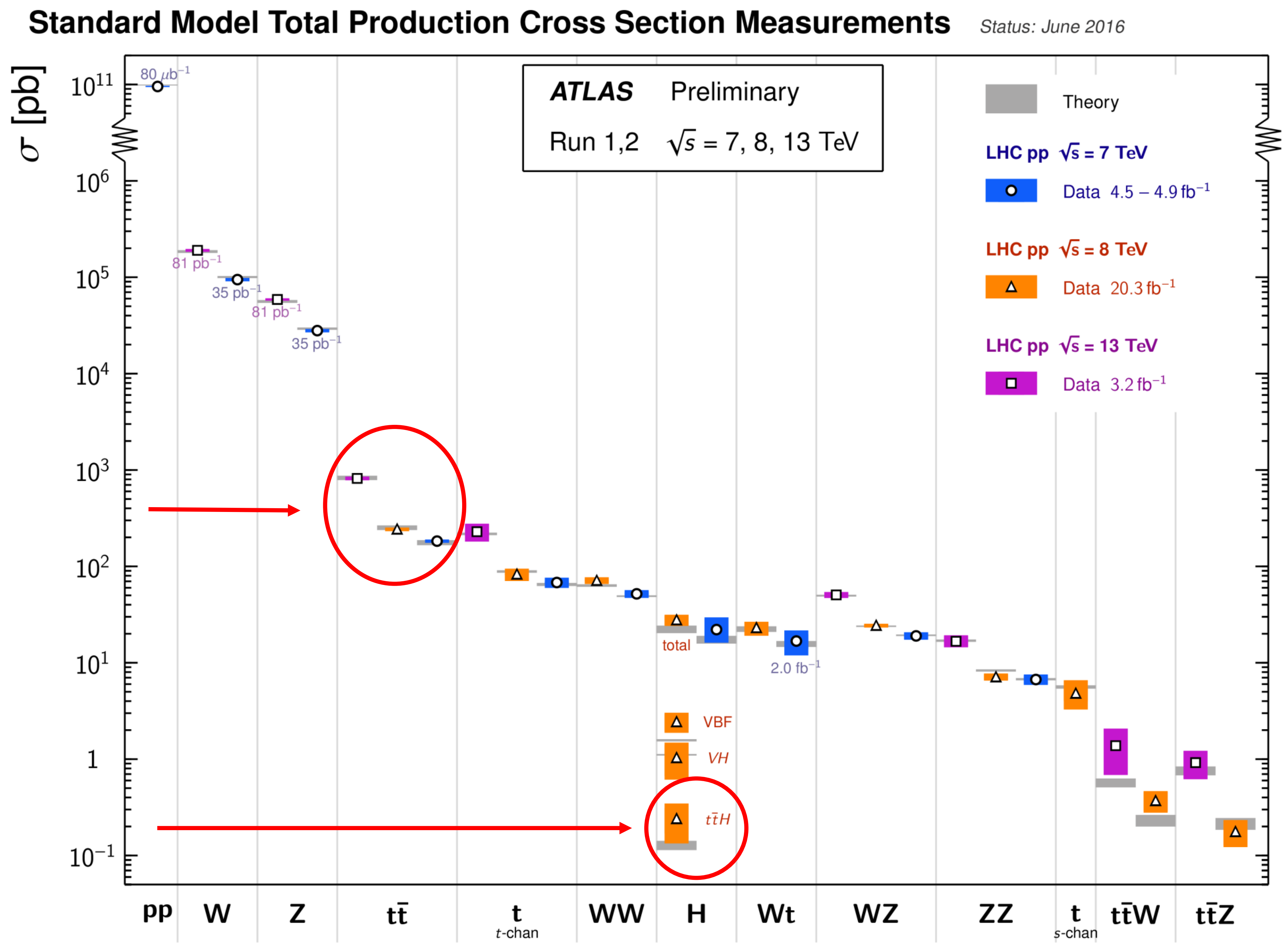
- Many Higgs coupling constants have been measured with relatively good precision (i.e. small uncertainties)

- Higgs top quark coupling measurement has an uncertainty of ~50%

- Why?
  - Small ttH cross section
  - Lots of background -> hard to isolate



ATLAS and CMS Preliminary
LHC Run 1
ATLAS
CMS
ATLAS+CMS
± 1σ
± 2σ
μ ggF
μ VBF
μ WH
μ ZH
μ ttH
μ
0
0.5
1
1.5
2
2.5
3
3.5
4
Parameter value


Standard Model Total Production Cross Section Measurements
Status: June 2016
ATLAS Preliminary
Run 1,2 √s = 7, 8, 13 TeV
Theory
LHC pp √s = 7 TeV
Data 4.5 – 4.9 fb⁻¹
LHC pp √s = 8 TeV
Data 20.3 fb⁻¹
LHC pp √s = 13 TeV
Data 3.2 fb⁻¹
σ [pb]
80 μb⁻¹
81 pb⁻¹
35 pb⁻¹
81 pb⁻¹
35 pb⁻¹
total
2.0 fb⁻¹
VBF
VH
tt̄H
pp
W
Z
tt̄
t
t-chan
WW
H
Wt
WZ
ZZ
t
s-chan
tt̄W
tt̄Z

Approach

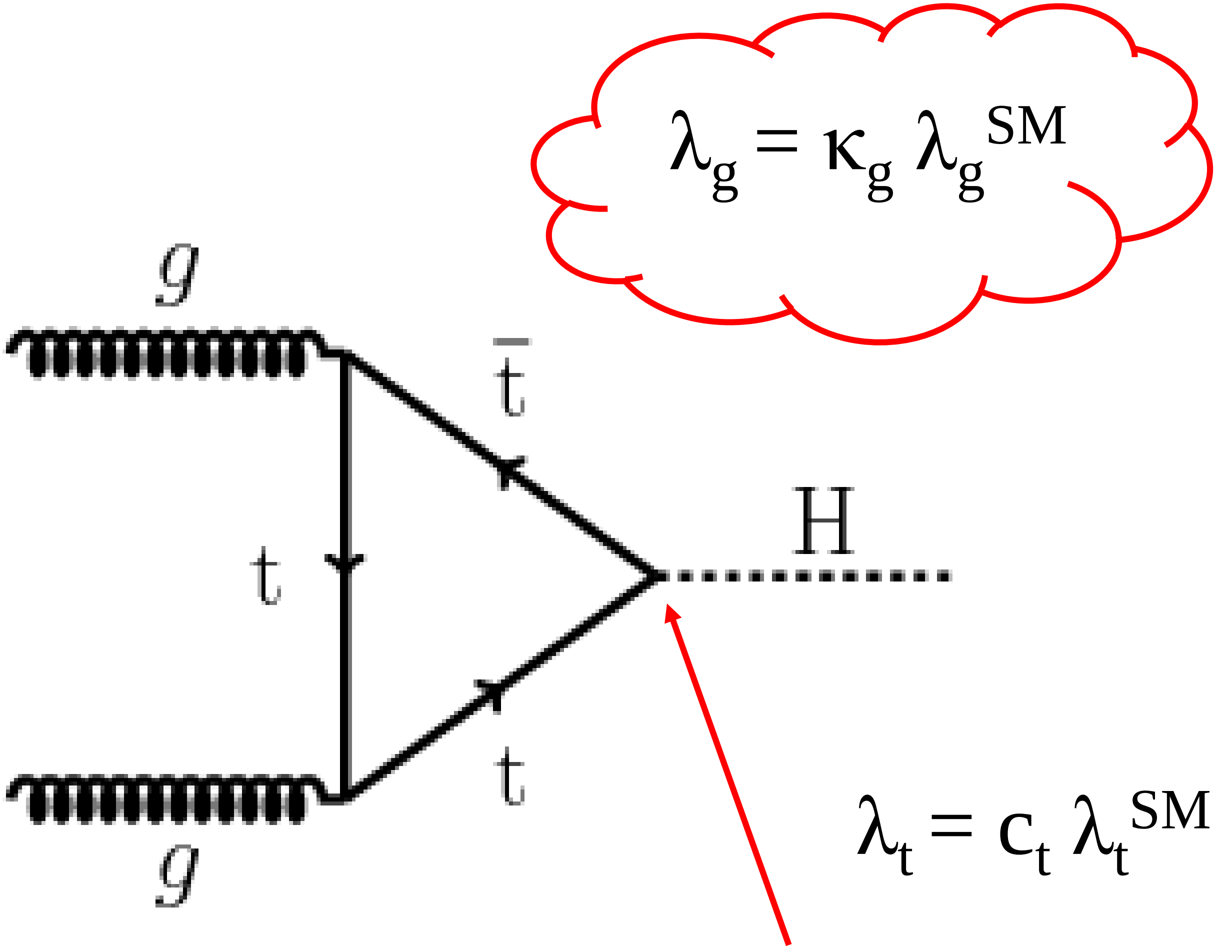
- Following Schlaffer et al. [arXiv:1405.4295v2]

- Look for Higgs produced along with a high-pT jet

- Look at different channels
  - Interested in $H \rightarrow 2l + p_T$ via $H \rightarrow \tau\tau$ and $H \rightarrow WW^*$
- Advantages
  - Background is easier to discriminate
- Disadvantages
  - Poor statistics after requiring boosted Higgs and two leptons

BSM physics

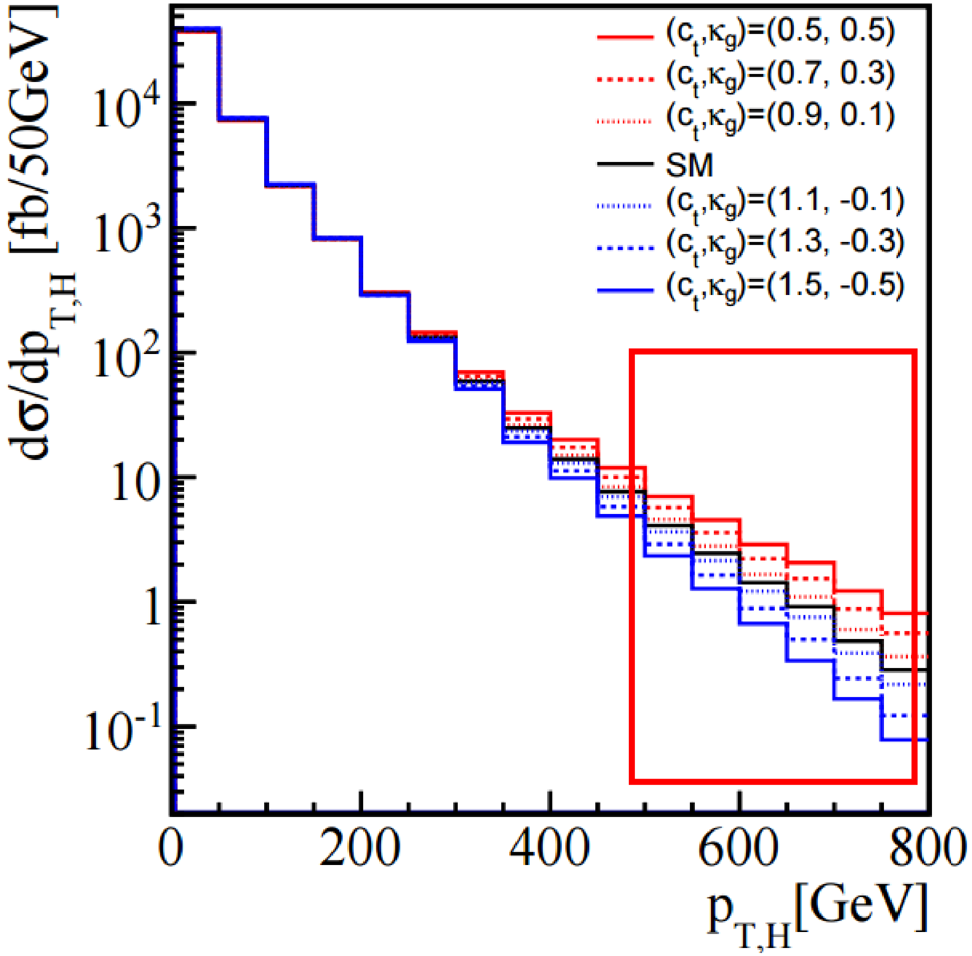
$\lambda_g = \kappa_g \, \lambda_g^{SM}$



$\lambda_t = c_t \, \lambda_t^{SM}$

Non-SM couplings can produce a SM-like Higgs cross section!

Approach (cont'd)

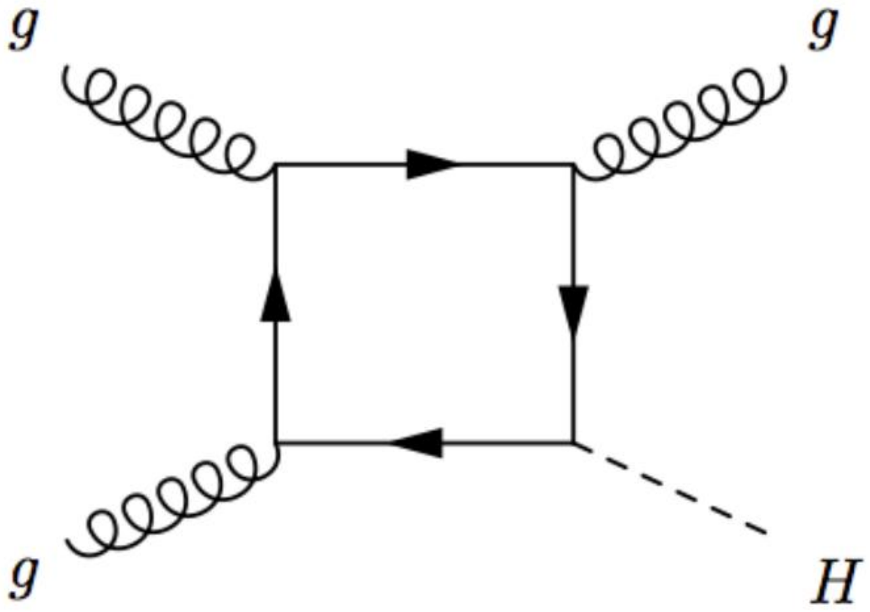


arXiv:1405.4295v2

Goals

- Make a projected measurement of Higgs cross section using this channel
  - Estimate required integrated luminosity for 5σ discovery

- Test SM hypothesis versus BSM (c_t, κ_g) = (0.5, 0.5)
  - Estimate required integrated luminosity for 95% CL exclusion to determine if this a viable channel for putting constraints on new physics that incorporates gluon coupling to the top loop.



Event Generation

- Leading background processes are Z+jets and ttbar
- Using MadGraph 5 + Pythia6 + Delphes3, simulated at leading order
  - HEFT model
  - 20 million p p > H j, H > ta+ ta-
  - 40 million p p > Z j, p p > Z j j, p p > Z j j j
  - 50 million p p > t t~ (yet to be incorporated)
- $\sqrt{s}$ = 14 TeV
- Generator level cuts:
  - $p_{T,l} > 10$ GeV
  - $p_{T,j} > 10$ GeV

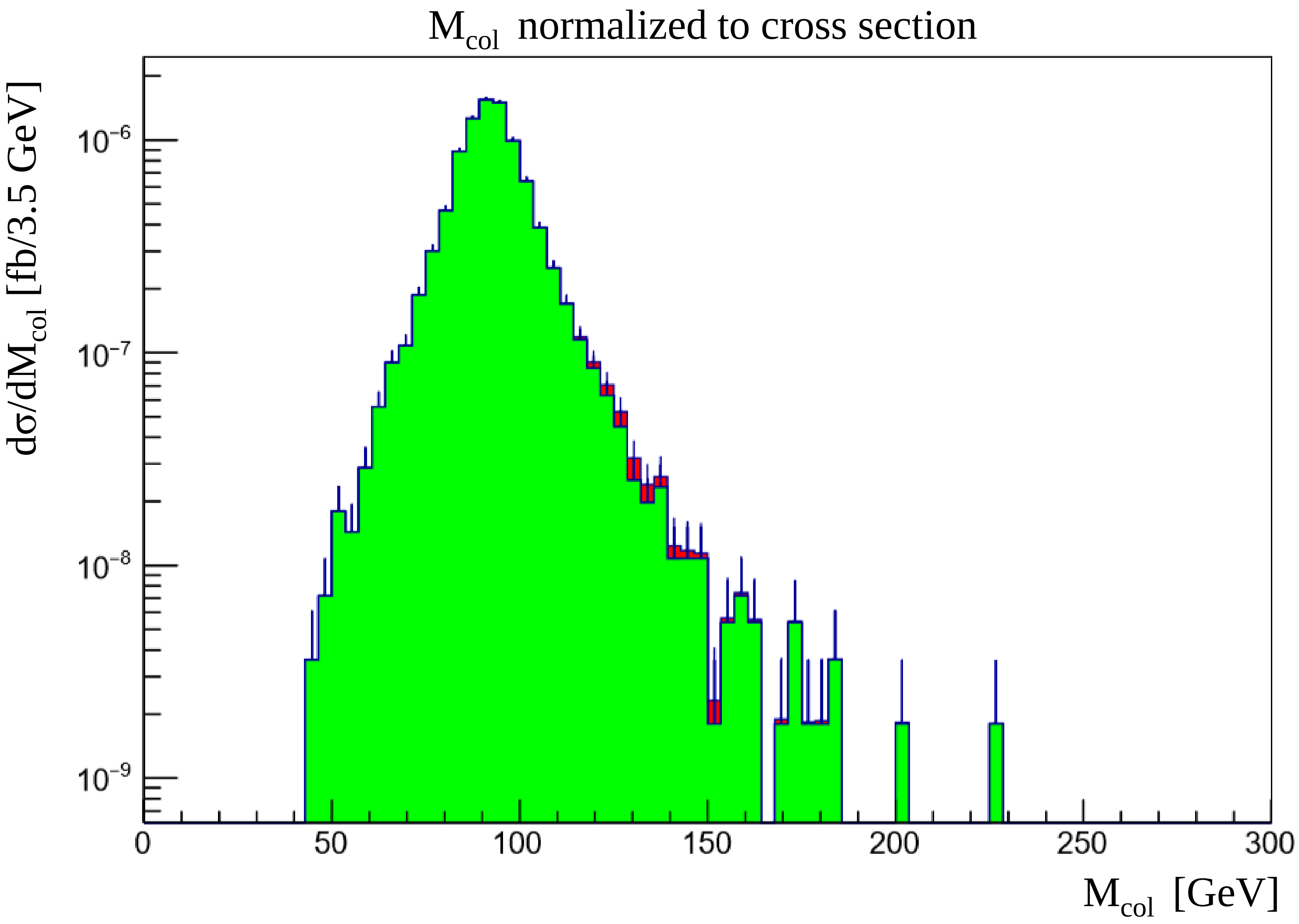
Higgs Measurement Results

- Good resolution between signal and background

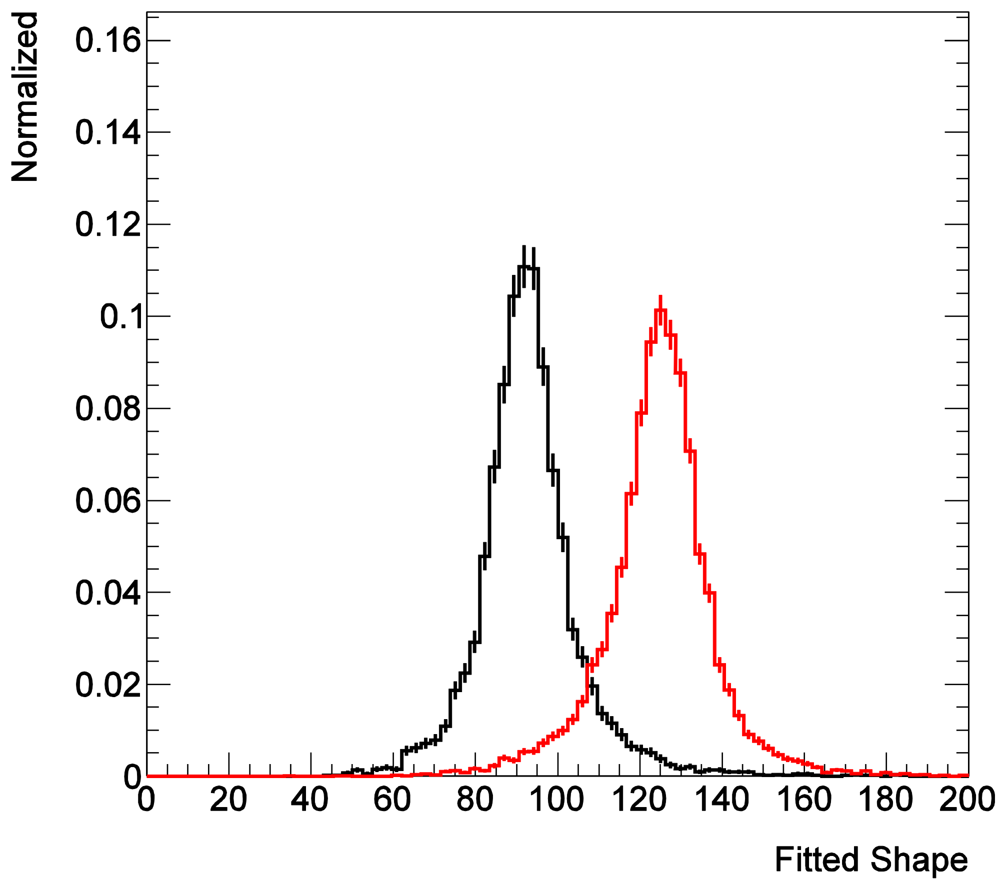
- $S / \sqrt{B}$ calculated for 300 1/fb is 1.262

Event rate (fb)	$H \rightarrow \tau\tau$	$Z \rightarrow \tau\tau$ + jets
$n_l = 2$	25.71	246.5
$m_{ll} > 20$ GeV	25.63	242.8
$p_{T,H} > 200$ GeV	20.33	236.1
$n_j = 1$ ($p_{T,H} > 200$ GeV)	0.6429	63.75
$n_b = 0$	0.5949	59.03
p_T inside leptons	0.5681	57.48
$M_{ll} < 70$ GeV	0.5074	48.53

Higgs Measurement Results (con'd)



M_{col} normalized to unity

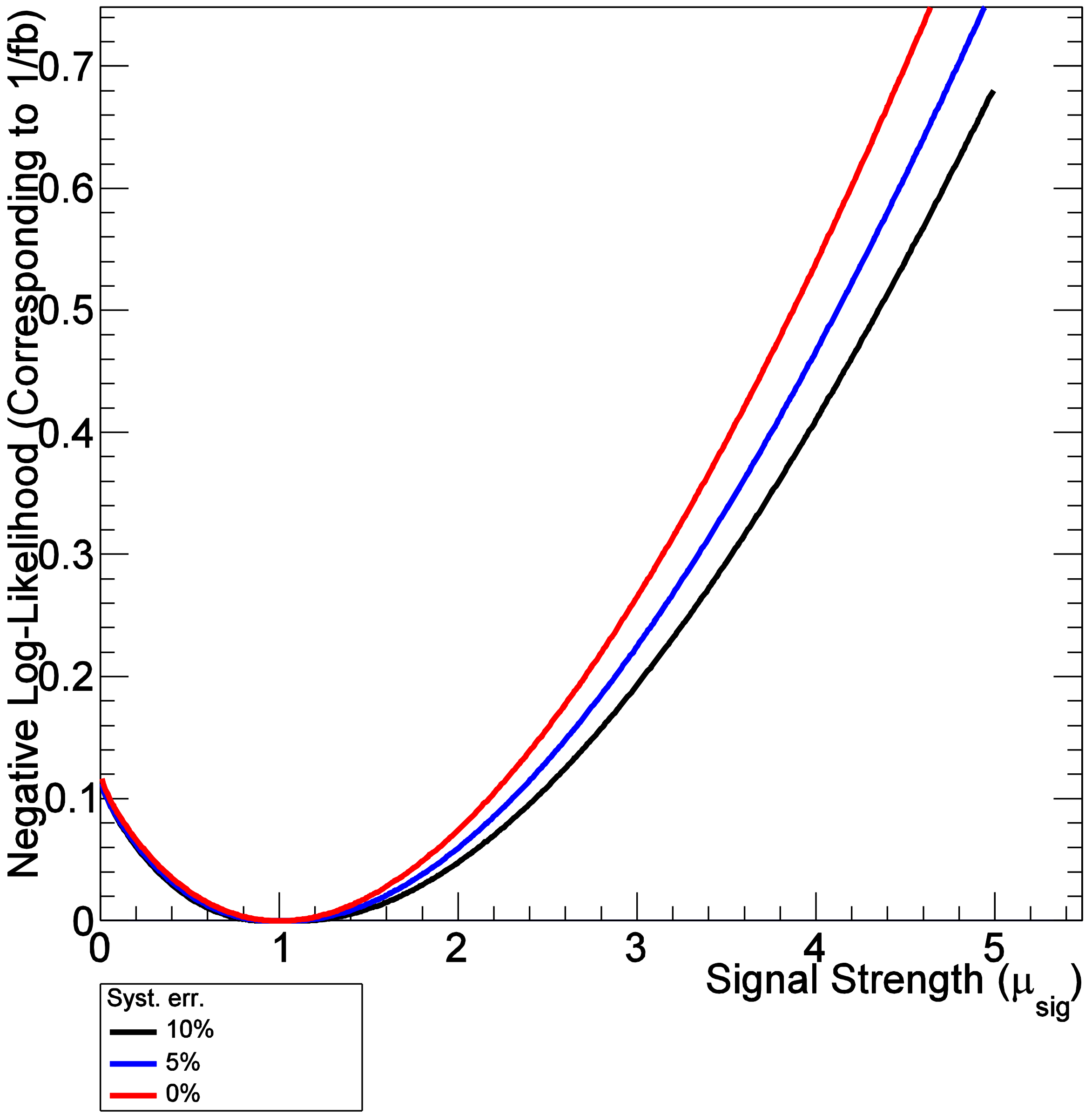


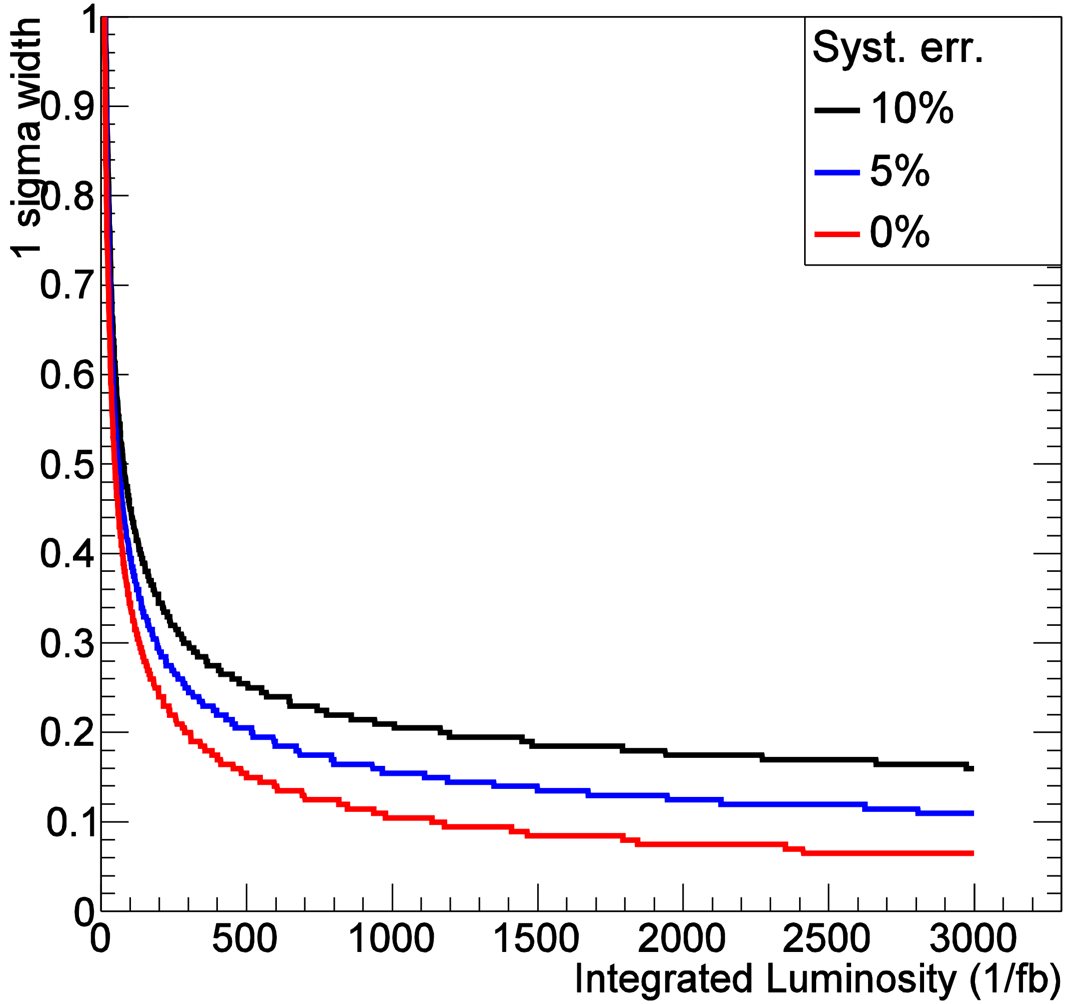
M_{col} [GeV]

Results (cont'd)

- Negative log likelihood analysis
  - H_0 is background only
  - H_1 is background + SM higgs

- 5σ discovery at 250 fb^{-1}




1 sigma width
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
500
1000
1500
2000
2500
3000
Integrated Luminosity (1/fb)
Syst. err.
10%
5%
0%

$(c_t, \kappa_g) = (0.5, 0.5)$ model

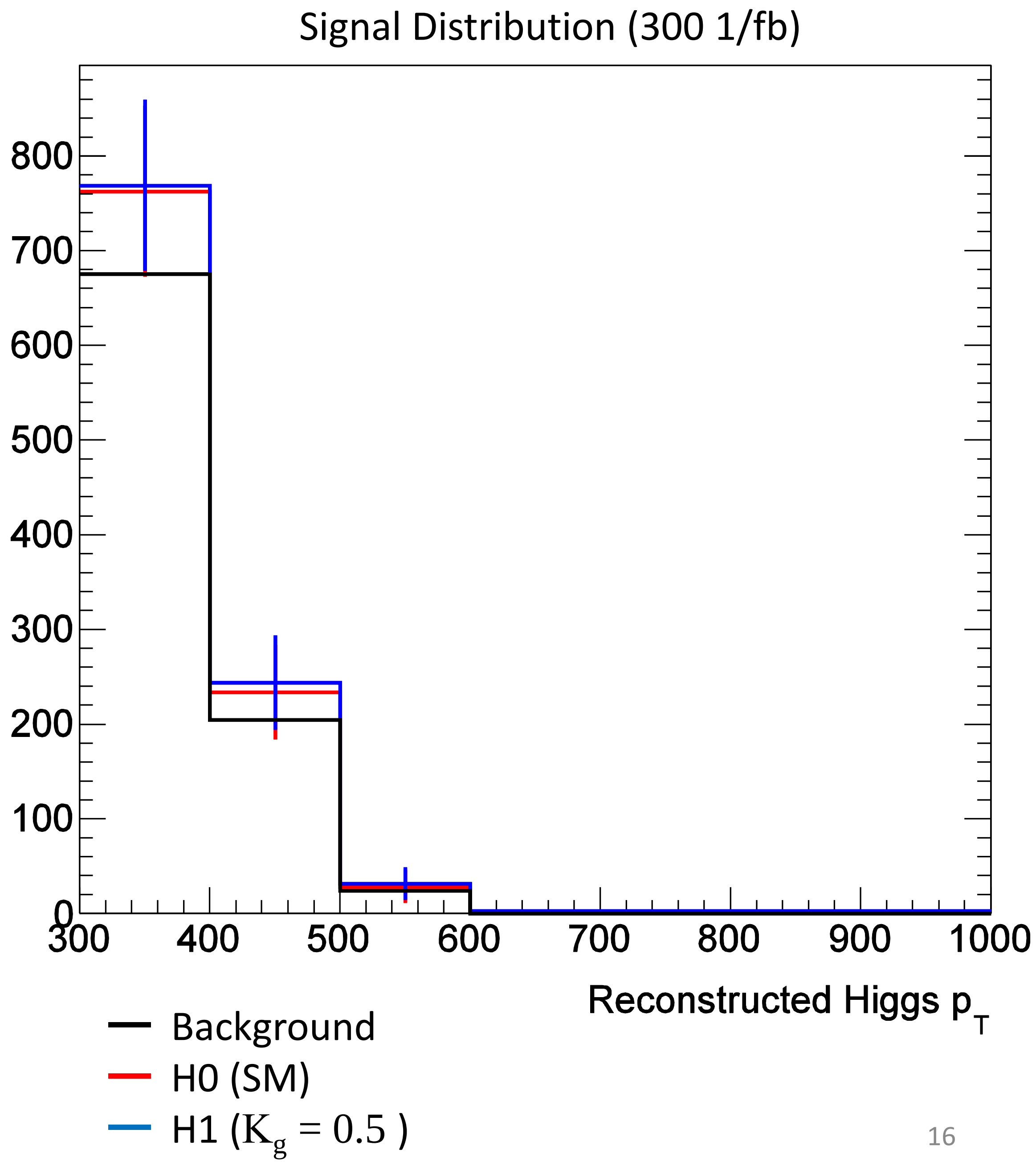
Question: Assuming the SM Higgs, how well can we exclude the case where $(c_t, \kappa_g) = (0.5, 0.5)$?

- Apply a mass window cut
  - Only look at events with $|M_{col} - m_H| < 15$ GeV
  - This improves our signal to background by a factor of 10

- Scale cross sections according to the new model
  - Scalings from Schlaffer et al.
- Look at higher pT bins

Results for $(c_t, \kappa_g) = (0.5, 0.5)$

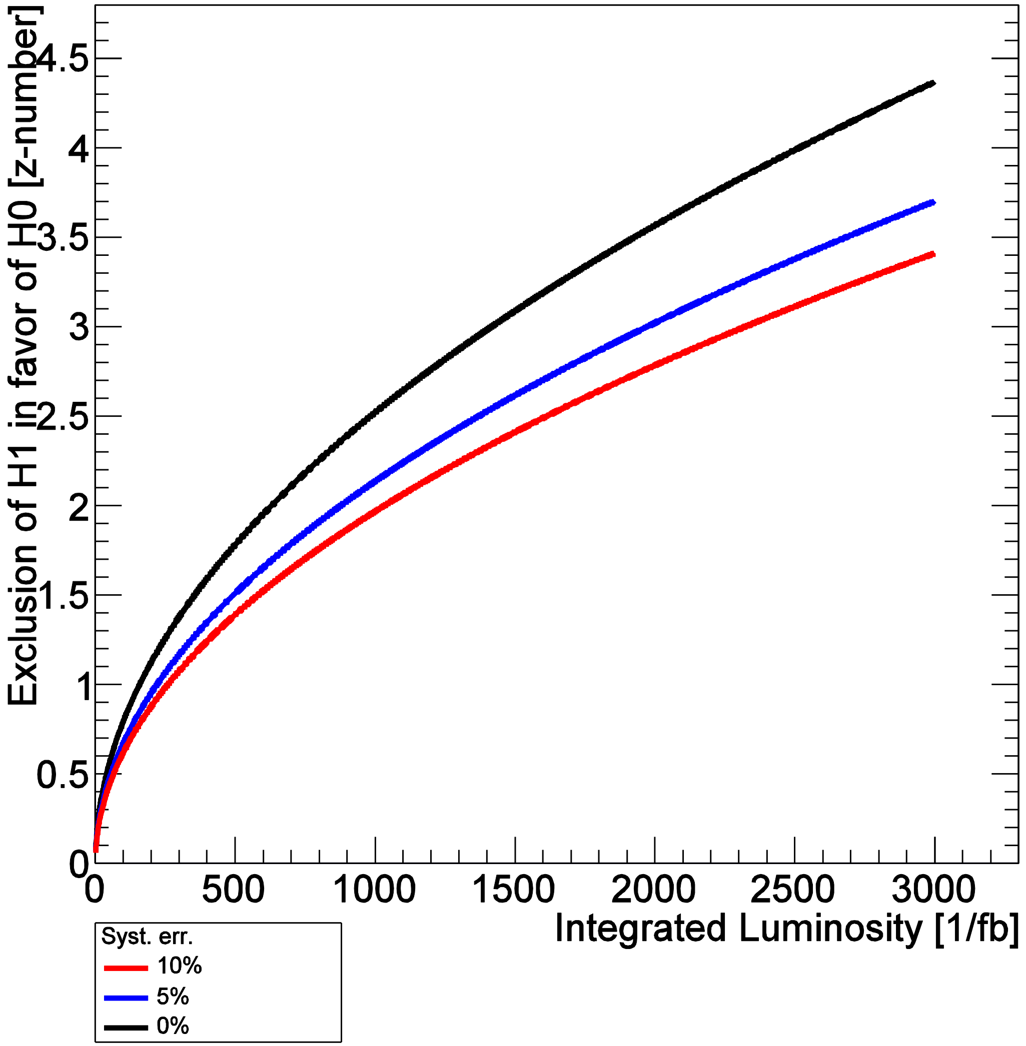
- Small shape difference in low pT bins
  - Hard to distinguish between hypotheses
- Difference between signal hypotheses increases in higher pT bins
- However, we have no data in in those ranges



$(c_t, \kappa_g) = (0.5, 0.5)$ CLs

- Assuming no systematic error, we can expect
  - 83% CL exclusion at 300 1/fb
  - 90% CL exclusion near 400 1/fb
  - 95% CL exclusion near 600 1/fb

- More realistically, with 10% syst. err. we expect
  - 72% CL exclusion at 300 1/fb
  - 90% CL exclusion near 7001/fb
  - 95% CL exclusion near 1000 1/fb



Conclusions

- The dilepton boosted Higgs channel is sensitive enough to discover the SM Higgs in the near future

- However, exploration of BSM physics using this channel requires significantly more data than we will have in the near future

- Analysis using this channel is long term