

# Study for Top FCNC with Delphes Simulation

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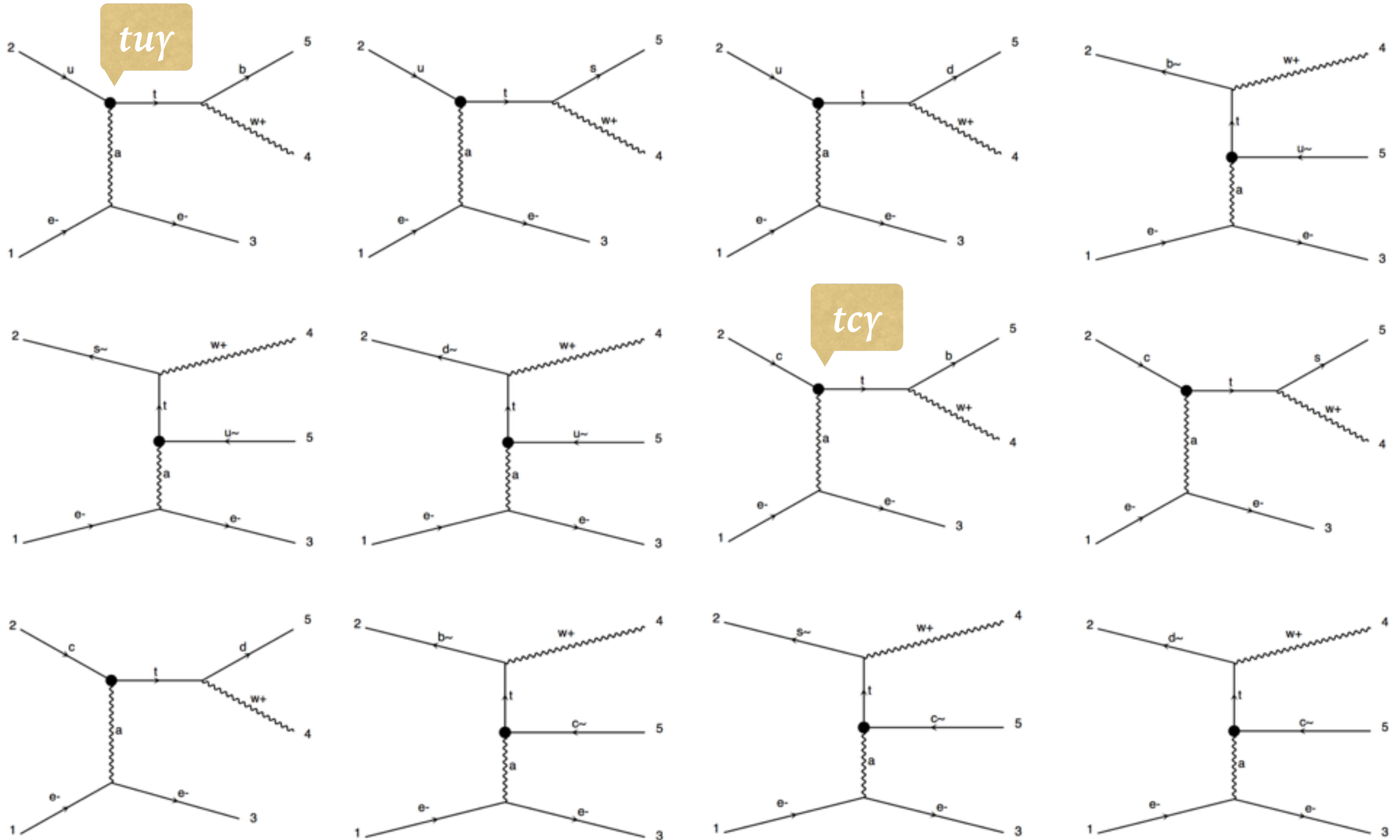
*TopFCNC Study Group*

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*Prepared for LHeC Higgs & Top Meeting, 5 December 2016*

# LHEC : DIAGRAMS FOR SIGNAL ( $e^-p \rightarrow e^-W^\pm q + X$ )



► Similar diagrams for process  $e^-p \rightarrow e^-W^- q + X$  with the interchange  $q \leftrightarrow q^*$

# LHeC : CROSS SECTIONS (S+B) FOR PROCESS $e^-p \rightarrow e^-W^\pm q + X$

Cross sections (pb) for process  $e^-p \rightarrow e^-wwq$  ( $ww = w^+w^-$ ) with top quark FCNC interaction at LHeC collider.

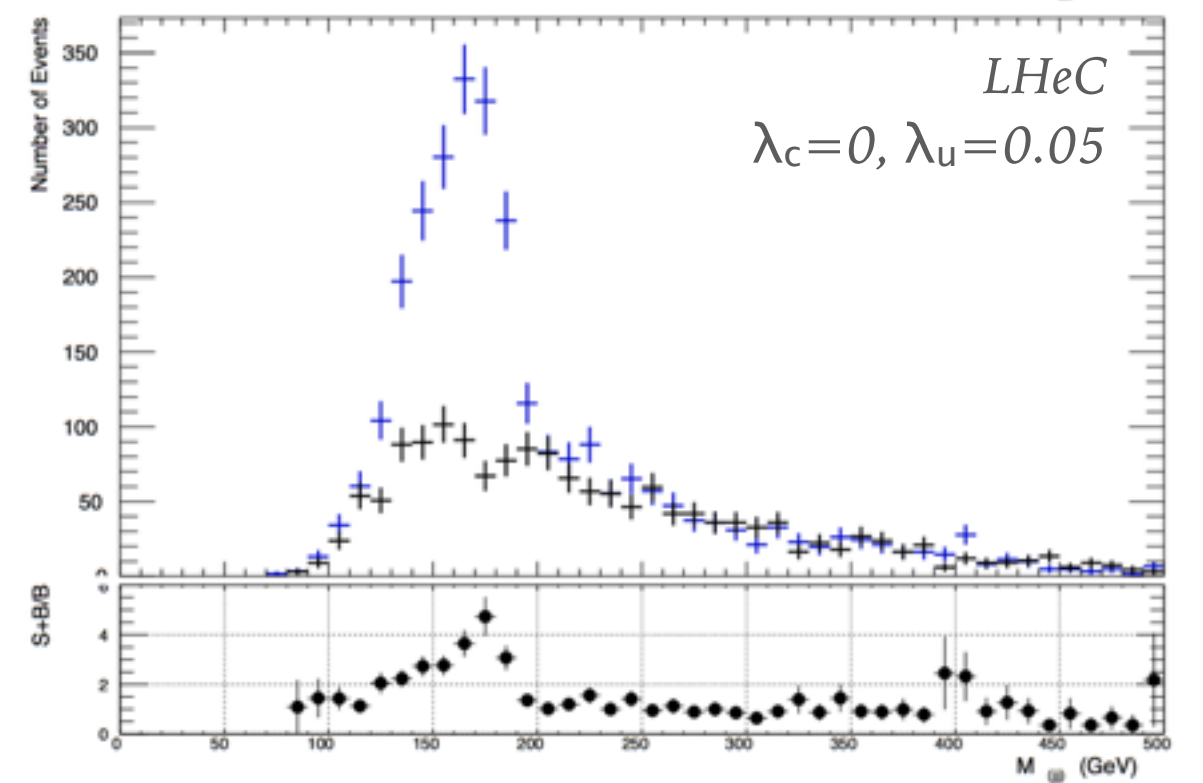
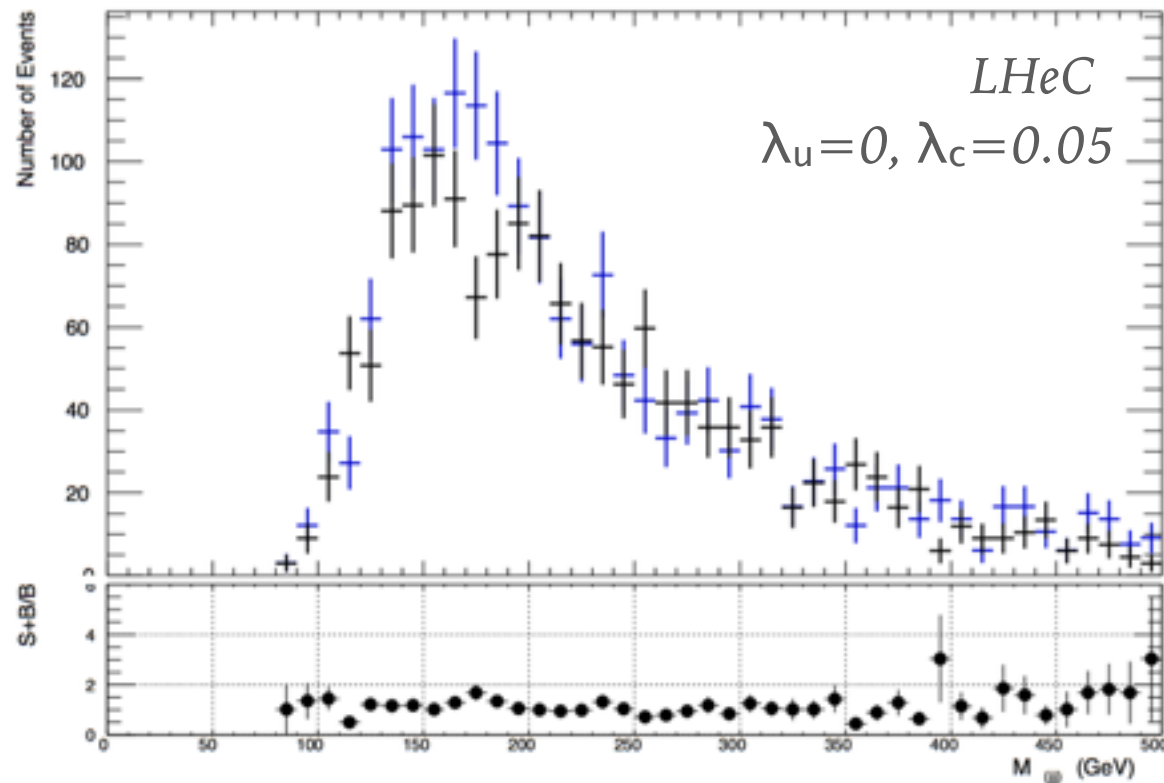
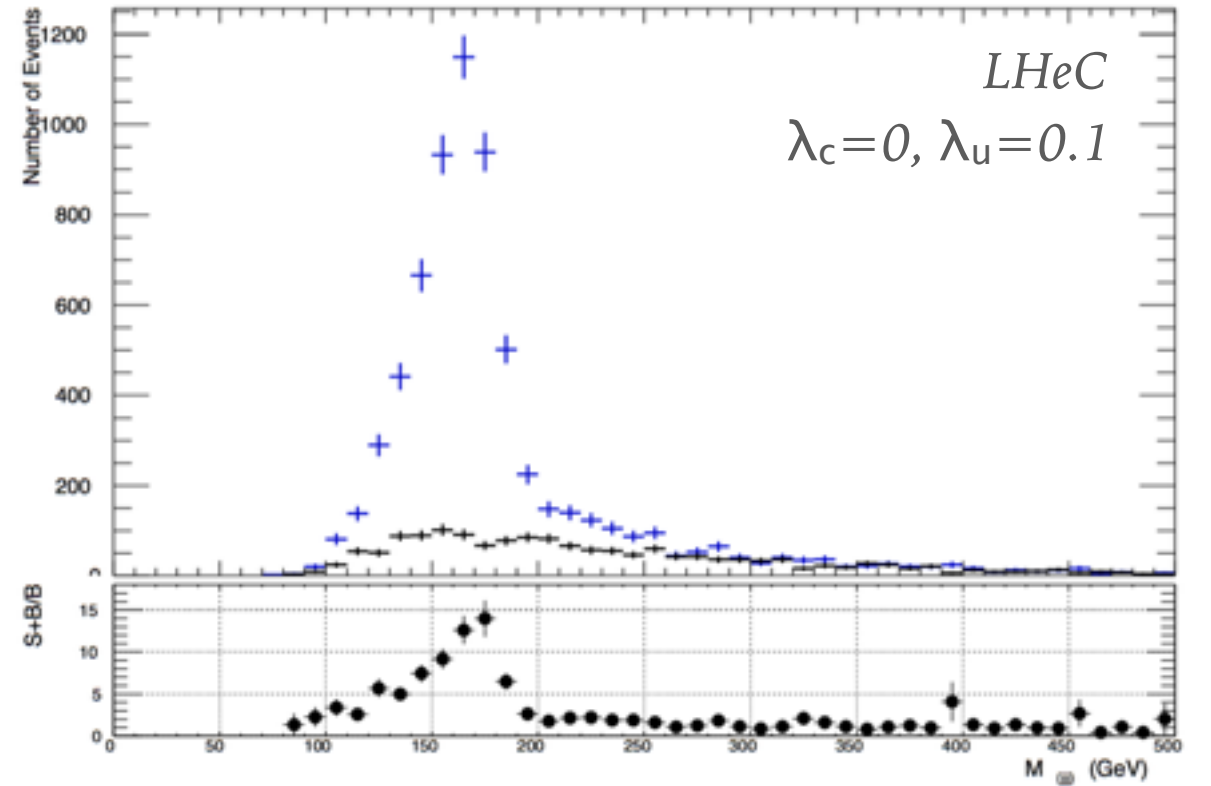
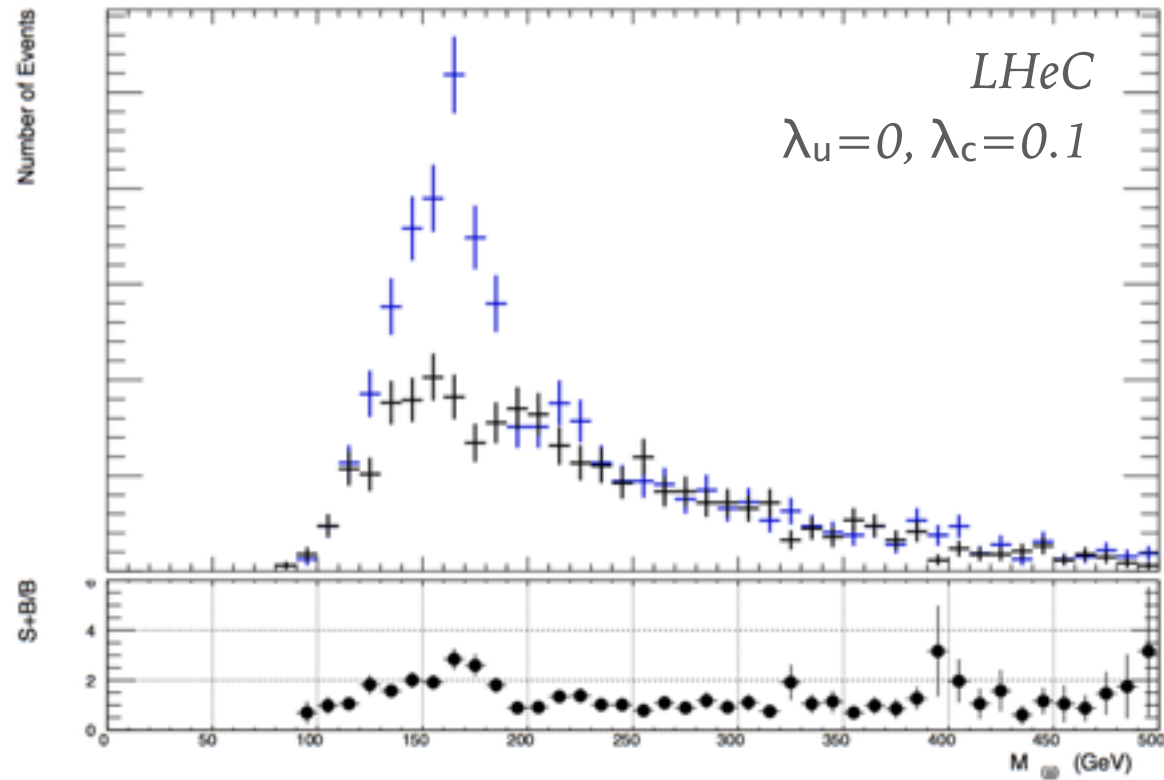
LHeC (60x7000)	$\lambda=0.1$	$\lambda=0.01$	$\lambda=0.001$
$\lambda_c=0$	3.119	2.306	2.301
$\lambda_u=0$	2.404	2.299	2.297

# LHEC : APPLIED CUTS FOR ANALYSIS

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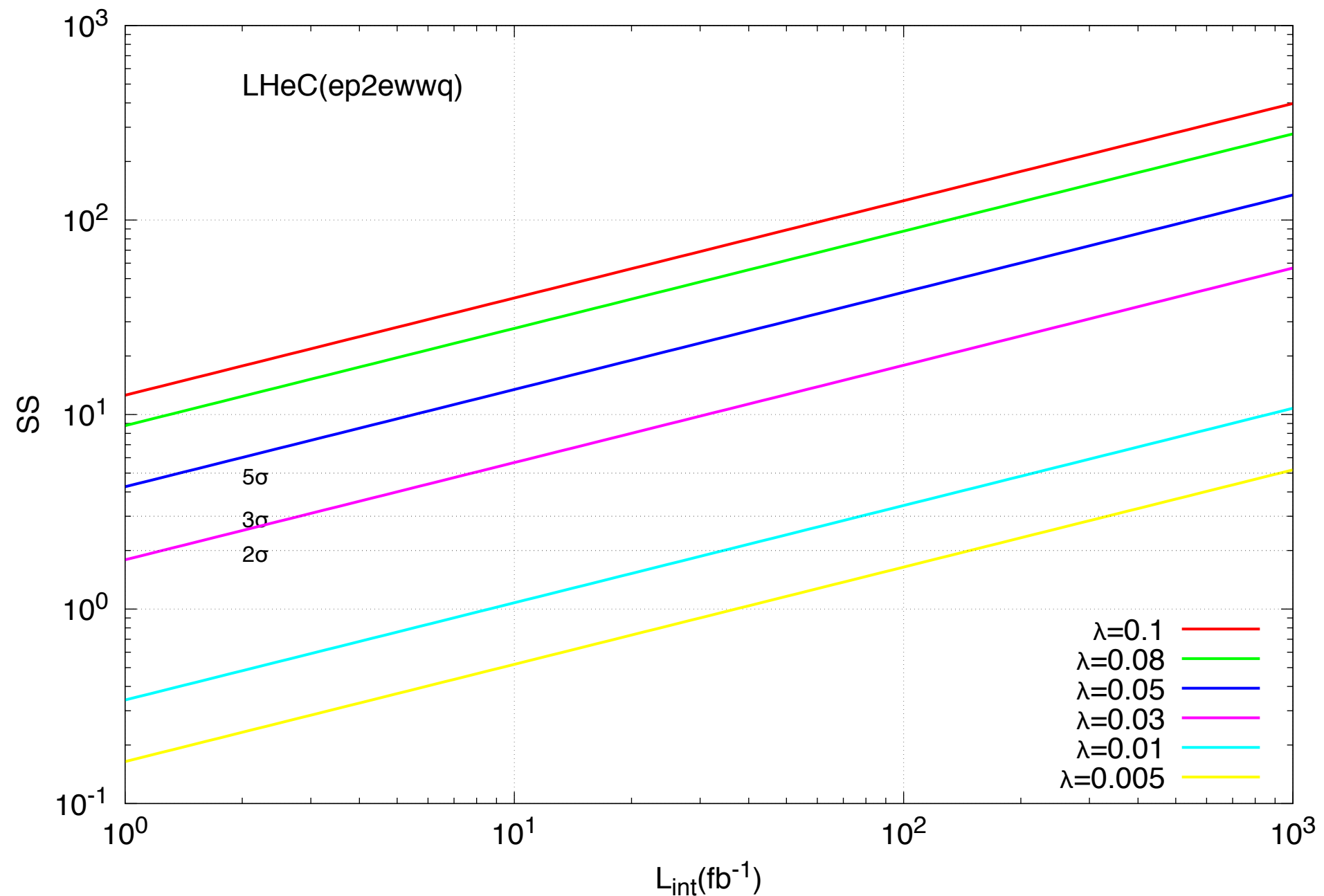
- For the analysis we use preselection cuts and the cuts for further background suppression
  - Cut-0 : at least one electron and three jets (preselection with default MG5 cuts)
  - Cut-1 : require one of three jets as being b-tag
  - Cut-2 : b-tagged jet has transverse momentum  $p_T > 35$  GeV and other jets have  $p_T > 25$  GeV, and electron has  $p_T > 20$  GeV
  - Cut-3 : all jets have pseudo-rapidity  $-4.0 < \eta < 0$  for LHeC,  $-5.0 < \eta < 0$  for FCC-ep; and electron has  $-2.5 < \eta < 2.5$
  - Cut-4 : invariant mass of two jets within  $50 < m_{jj} < 90$  GeV (for W-boson)
  - Cut-5 : invariant mass of three jets (for top) between  $130 < m_{bjj} < 200$  GeV

# LHeC : (S+B)/B RATIO PLOT



# LHEC : SS PLOT

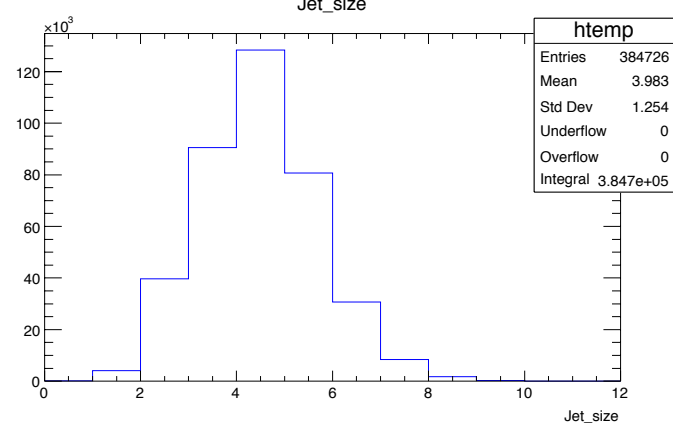
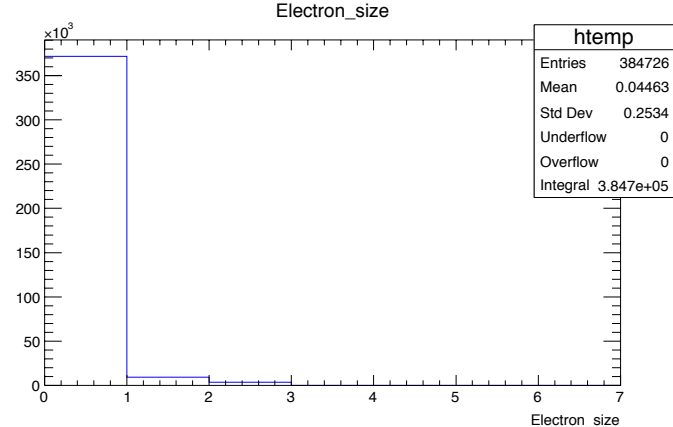
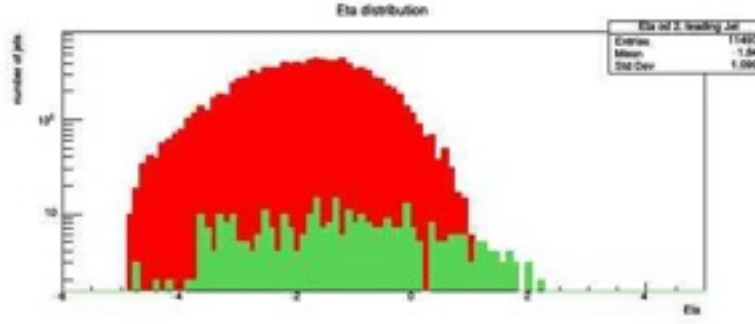
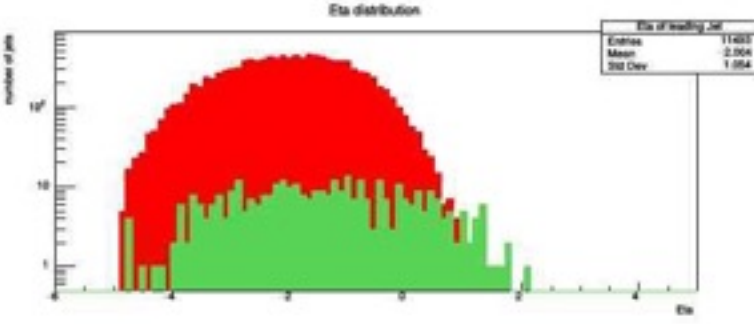
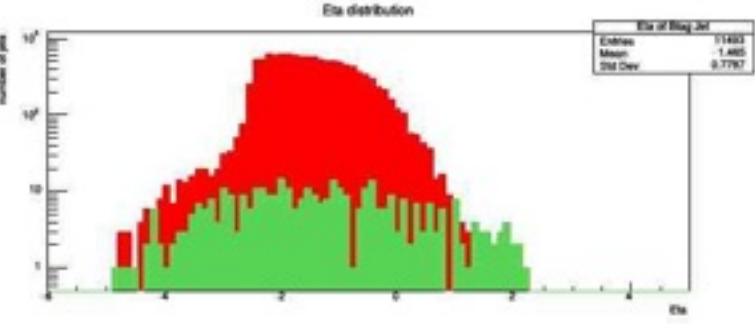
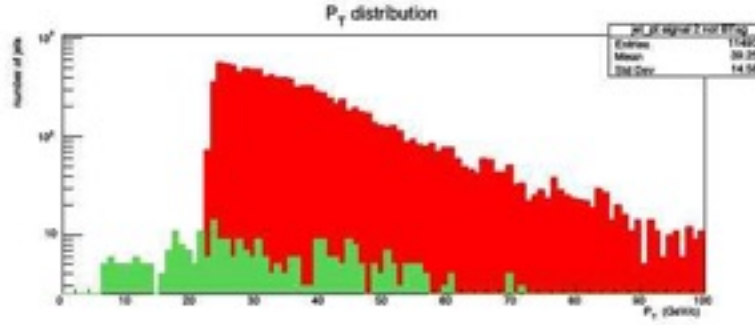
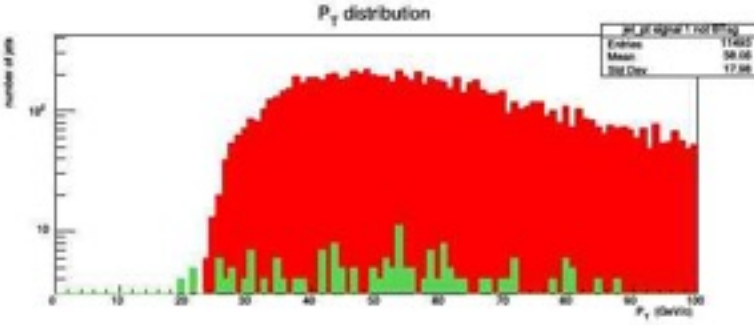
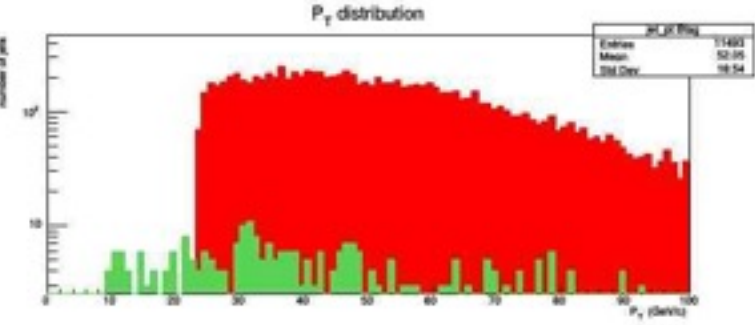
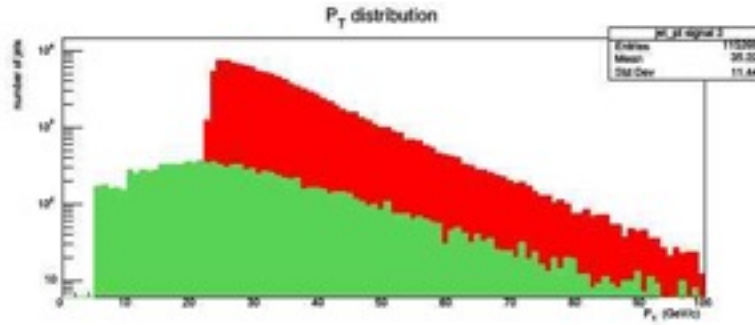
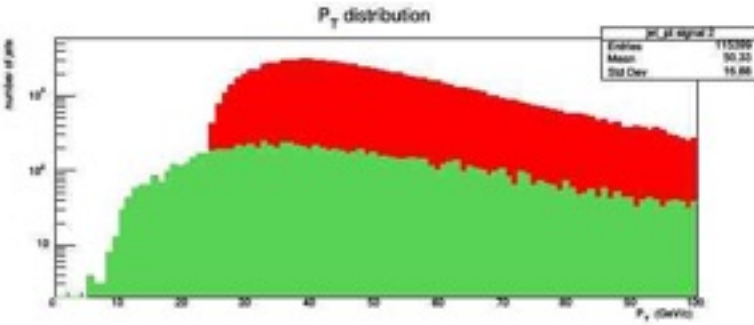
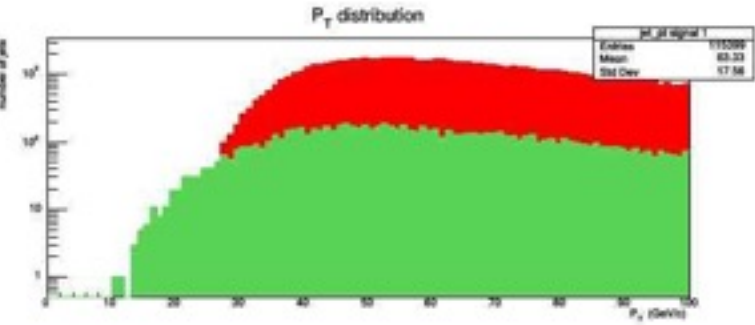
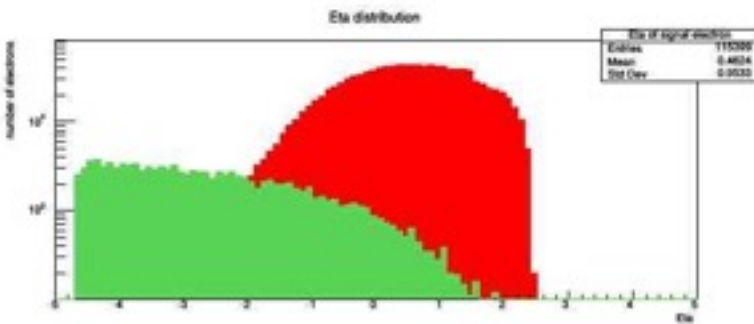
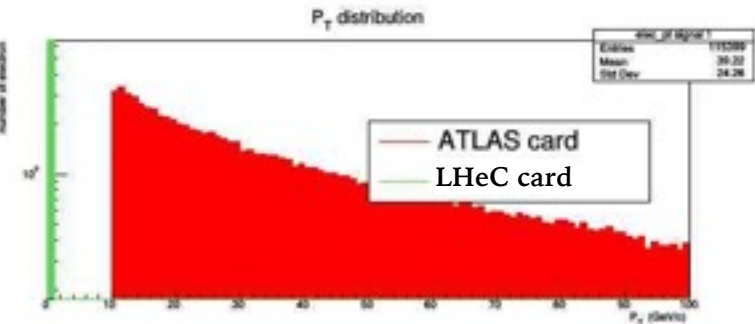
Statistical significance ( $SS = \sqrt{2(S+B)\ln(1+S/B)-S}$ ) for  $e-p > e-bjj$  with  $tq\gamma$  FCNC interactions.





# LHEC : COMPARISON DELPHES SIMULATION

Delphes simulation with:  
“delphes\_card\_LHeC\_hcal\_set9\_fixed.dat”  
“delphes\_card\_ATLAS.dat”



# FCC-EP : CROSS SECTIONS (S+B)

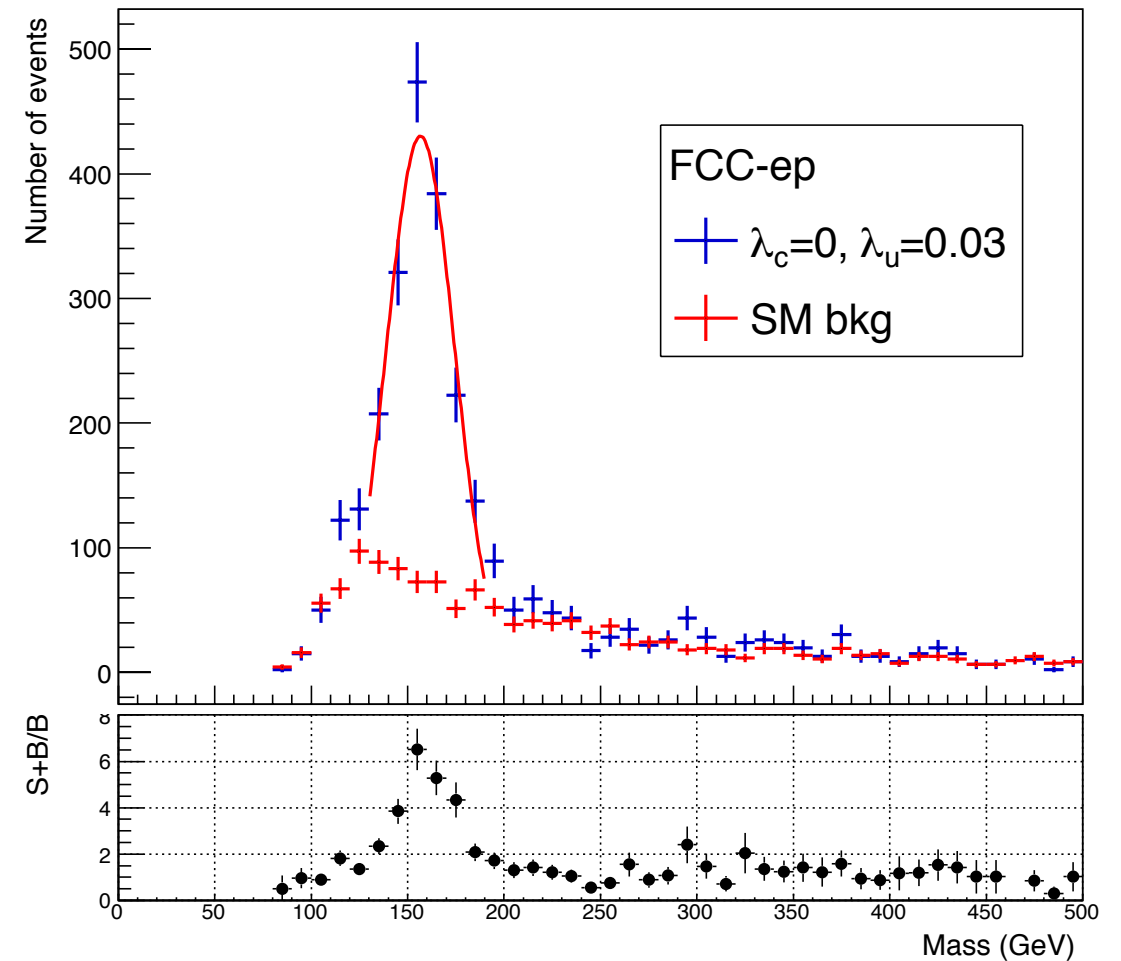
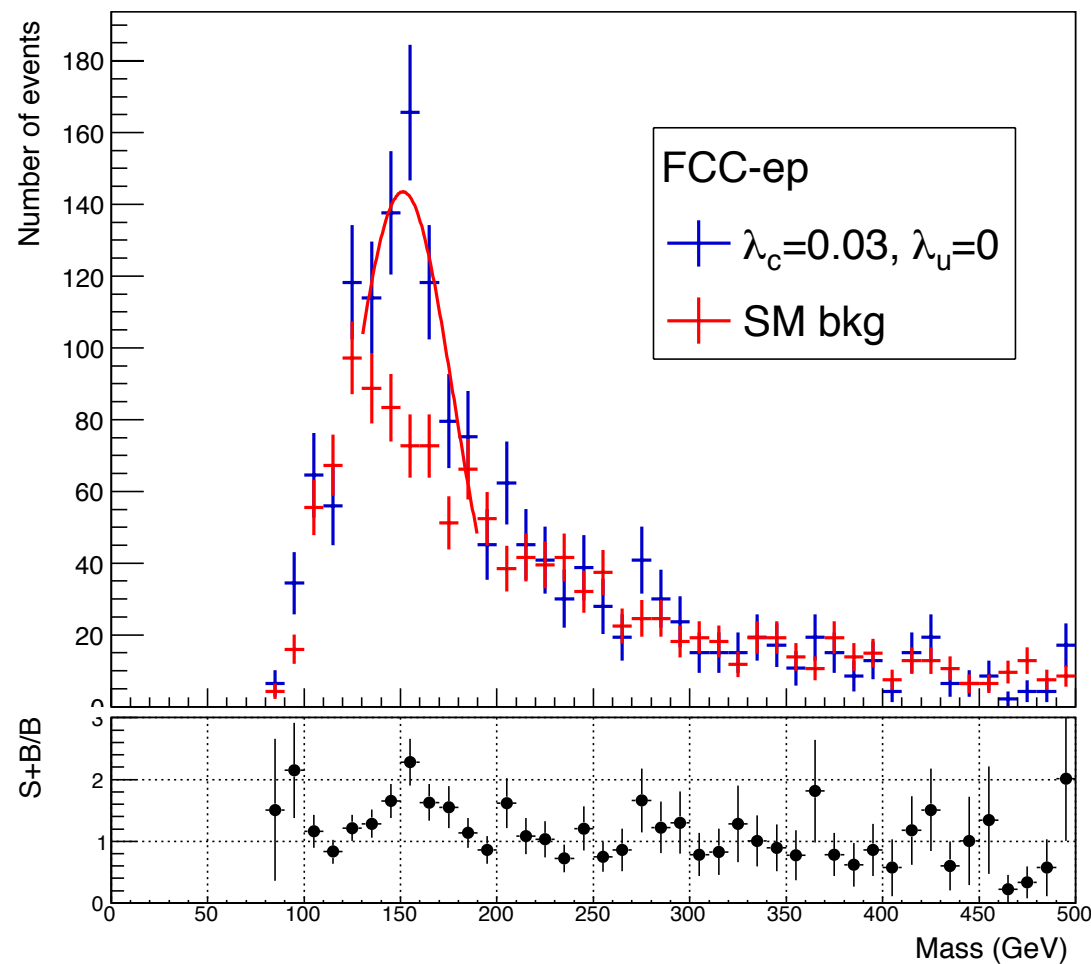
Cross sections for process  $e^- p \rightarrow e^- q w^+ / w^-$  (where  $w w = w^- w^+$  and  $q$  contains all quarks other than top quark) at FCC-ep. The results are presented in the last row for the case of  $\lambda_c = \lambda_u = \lambda$ .

FCC-ep (60x50000)	$\lambda=10^{-1}$	$\lambda=10^{-2}$	$\lambda=10^{-3}$
<i>coupling</i> ( $tu\gamma$ )	$1.072 \times 10^1$	$8.565 \times 10^0$	$8.589 \times 10^0$
<i>coupling</i> ( $tc\gamma$ )	$9.243 \times 10^0$	$8.539 \times 10^0$	$8.534 \times 10^0$
<i>coupling</i> ( $tu\gamma, tc\gamma$ )	$1.151 \times 10^1$	$8.641 \times 10^0$	$8.613 \times 10^0$



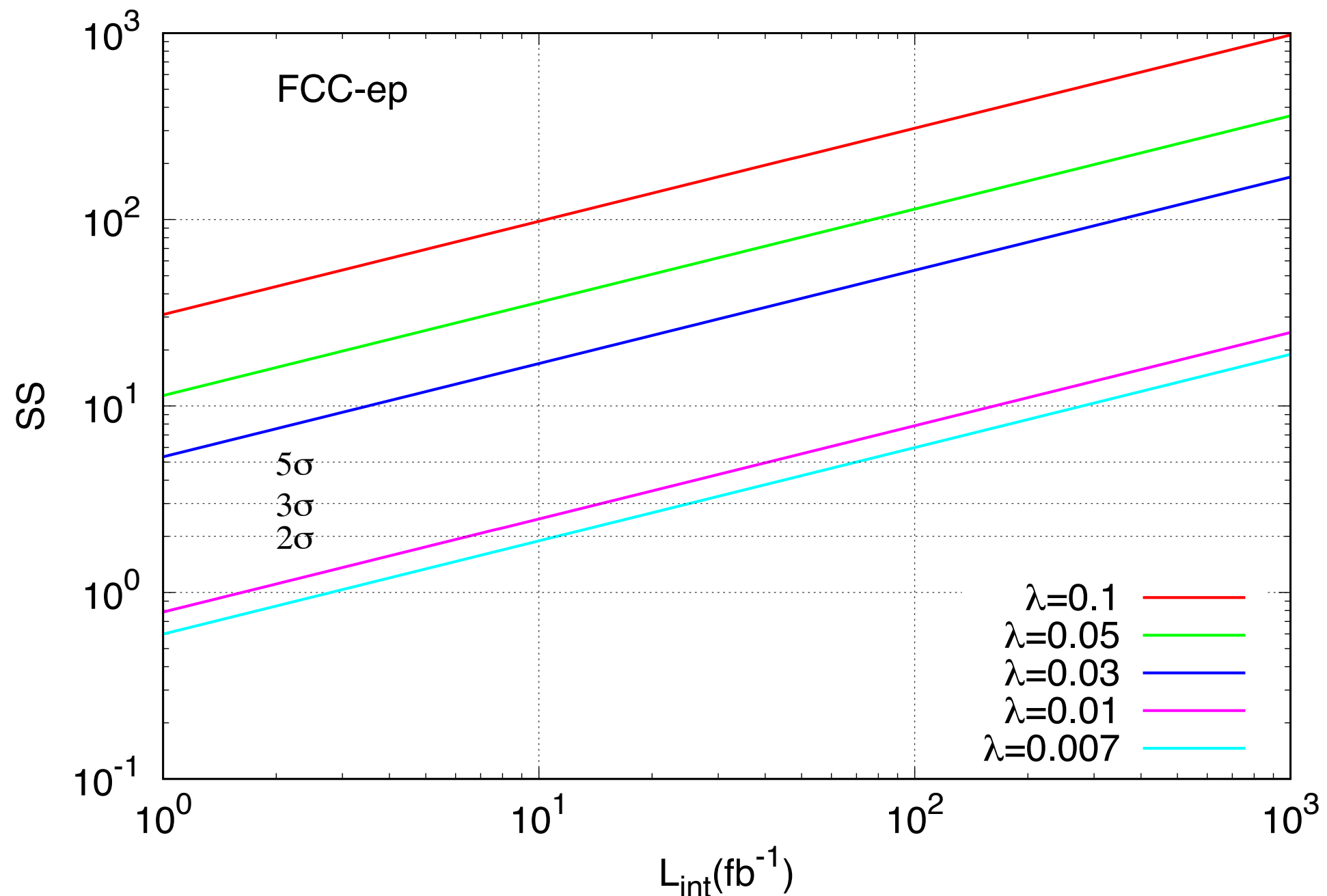
# FCC-EP : (S+B)/B RATIO PLOT

Top mass reconstruction from S+B and B events and the ratio plot of (S+B)/B. It is clear from the left and right panel of the figure that there is different sensitivity to FCNC coupling in the vertices  $t\bar{u}\gamma$  and  $t\bar{c}\gamma$ .



# FCC-EP : SS PLOT

Statistical significance ( $SS = \sqrt{[2(S+B)\ln(1+S/B)-S]}$ ) for  $e-p > e-bjj$  with  $tq\gamma$  FCNC interactions. Here we assume  $\lambda_u = \lambda_c = \lambda$ .



# SUMMARY

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- We study  $S+B$  and  $B$  for process: “ $e^- p \rightarrow e^- \nu \nu q$  NP=1” (where  $\nu\nu = \nu + \bar{\nu}$ )
- For detector simulation we use Delphes with cards:
  - delphes\_card\_FCC.dat (for FCC-ep studies)
  - delphes\_card\_LHeC.dat, but for comparison we use delphes\_card\_ATLAS.dat (for LHeC studies)
- For analysis, we use cut based method, top mass reconstruction, W mass reconstruction

- $(S+B)/B$  ratio plot for different couplings ( $\lambda_u, \lambda_c$ )
- SS vs luminosity plot for different coupling parameters

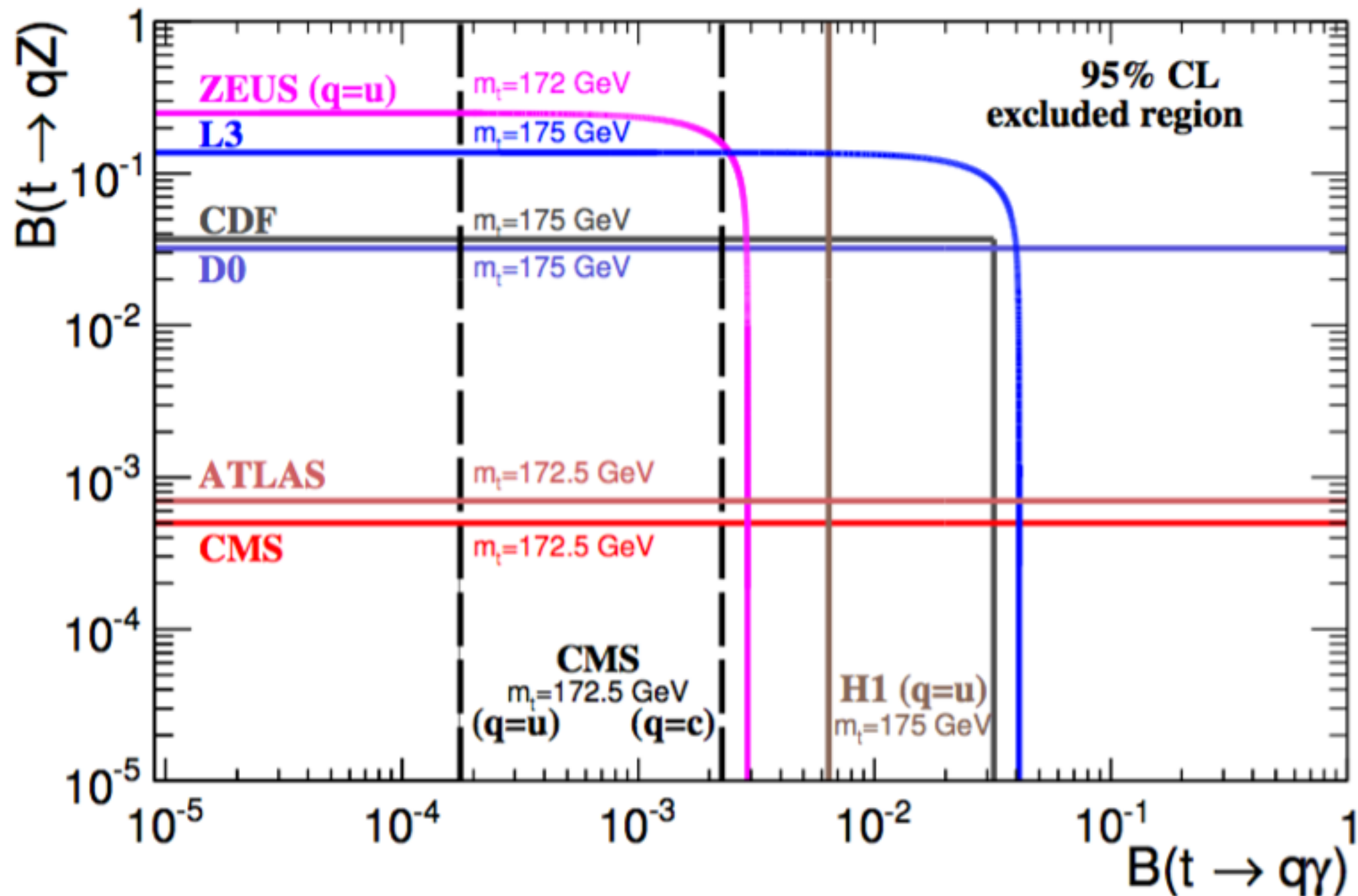
## *For next meeting:*

- *limits on branching BR( $t \rightarrow q\gamma$ )*
- *discussion on similar background*
- *discussion on the analysis details*
- *discussion on the results for Delphes LHeC card*
- *preparation for a note*

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# CURRENT LIMITS

CMS Collaboration, JHEP04(2016)035



*Measured upper limits on top FCNC  $tq\gamma$*