CHARGED HIGGS BOSON ANALYSIS AT FCC-HH

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FCC-hh Physics Analysis Meeting, 02 March 2018

Signal Process

We study charged Higgs boson at FCC-hh

- generate signal events (10k):
  - Production $p\,p \rightarrow t\,h^-+X$ Pythia8
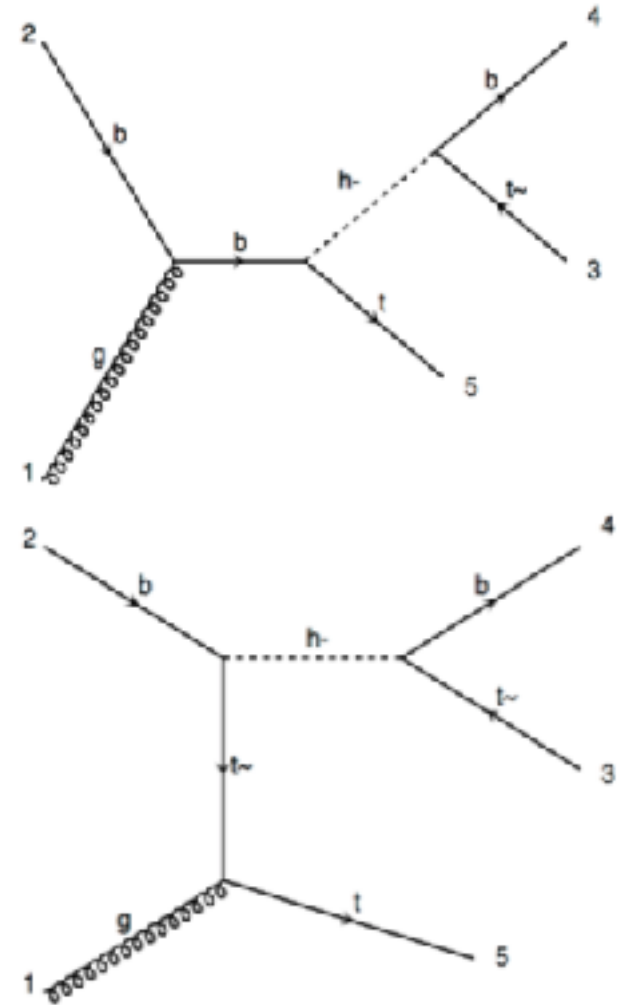 - Decay $th^- \rightarrow t\bar{t}b \rightarrow W^+W^-bbb$ $\rightarrow f_1f_2'f_3f_4'bbb$

  (further decays and hadronization within Pythia8)
  - Parameter m_H in the range [500 – 2000] GeV, tan(beta)=10, cos(beta-alpha) = 0.

Signal channels:

- 3bjet + 4j (where W->2j) – full had.
- **3bjet + 2j + 1lepton + MET (where W(1)->lν, W(2)->2j) – single lepton**
- 3bjet + 2l +MET (where W->lν) - dilepton

Main diagrams for subprocess bg -> th- $\rightarrow$ tt~b

FCCSW and Samples

Analysis steps

- **FCCSW**
  - Signal events are generated with **Pythia8** within FCCSW. Background LHE events are generated with **MG5** for further hadronization and showering through Pythia8 within FCCSW
  - Fast detector simulation is performed with **Delphes** for parametric card FCChh.tcl
  - Event selection is applied on those samples with **Heppy**. Flat ntuples are produced with observables of interest and analyzed with Heppy
  - Gen-level and Reco-level plots are produced with python scripts – Heppy writes a tree.root file – Root
- **Signal samples (10k)**
  - pp→tH⁻→ttb→WWbbb (mass = 500, 1000, 2000 GeV)
- **Background samples (10k)**
  - * pp→tt   * pp→ttb   * pp→ttj
  - * pp→WWbbb   * pp→WWjjj

Event generation (Pythia8)

Detector simulation (Delphes)

Event selection (Heppy)

Ntuple, plots (gen-level, reco-level)

Cross Sections

Signal (Pythia8 with generator level defaults), parameters: tanβ=10, cos(β-α)=0

Mass (GeV)	Cross section (pb)	Events (k=10^3)
500	45.120	10k
1000	6.198	10k
2000	0.661	10k

Background (MG5 with generator level defaults)

Background	Cross section (pb)	Events
pp→tt	2.607×10^4	10k
pp→ttj	4.037×10^4	10k
pp→ttb	4.906×10^2	10k
pp→WWbbb	5.136×10^2	10k
pp→WWjjj	6.171×10^2	10k

Event Selection

Event selection and signal reconstruction

○ Events with the presence of (# objects)

- at least 5 jets
- at least 2 bjets

  Single leptonic

- one muon or electron
- significant MET
- **focus: 2j+3bj+1l+MET**
    or ≥5j+l+MET

· at least seven jets

· at least 2 bjets

· **focus: 4j+3bj**
        or ≥7j

  Full hadronic

○ Events for a reconstructed top (invariant mass of *lvb*) by combining the reconstructed W boson (invariant mass of lepton and neutrino or two jets) and bjet candidate.

○ Further steps

- isolation criteria for electron or muon
- rejection of events with additional muon or electron candidates
- removal of electrons or muons if they are separated from the nearest jet by ΔR<0.4

Cuts-set1

- For reconstruction of top mass from **W(leptonic) and bjet**

Object	Requirement
Single muon or electron	p_T>30 GeV, $|\eta|$<3
At least five jets	p_T>30 GeV, $|\eta|$<3
At least two bjet (Nbjet>=2)	p_T>30GeV, $|\eta|$<3
Missing p_T	p_T>20 GeV
Lepton(l), jets separation	$\Delta R(l,j)$>0.4 and $\Delta R(j,j)$>0.4
Reconstructed top mass	130<m_{wb}<200 GeV
Reconstructed H± mass	$|m_{tb} - m_{H\pm}|$<0.1*$m_{H\pm}$

Cuts-set2

- For reconstruction of top mass from **W(hadronic) and bjet**

| Object	Requirement
At least seven jet (Njet>6)	p_T>30 GeV, $|\eta|$<3
At least three bjet (Nbjet>2)	p_T>30 GeV, $|\eta|$<3
Jets separation	ΔR(bjet,j)>0.4 and ΔR(j,j)>0.4
Reconstructed top mass	130<m_{wb}<200 GeV
Reconstructed H$\pm$ mass	$|m_{tb} - m_{H\pm}|$<0.1*$m_{H\pm}$

Counter Cut-flow

```
S500 - Counter cut_flow :
All events                  10000         1.00      1.0000
At least 5 jets              9127         0.91      0.9127
At least 2 b-jets           8205         0.90      0.8205
Exactly 1 lepton            1734         0.21      0.1734
MET > 20 GeV                1631         0.94      0.1631       16% Accepted


S1000 - Counter cut_flow :
All events                  10000         1.00      1.0000
At least 5 jets              9537         0.95      0.9537
At least 2 b-jets           8788         0.92      0.8788
Exactly 1 lepton            1899         0.22      0.1899
MET > 20 GeV                1817         0.96      0.1817       18% Accepted


ttb-bkg - Counter cut_flow :
All events                  10000         1.00      1.0000
At least 5 jets              5047         0.50      0.5047
At least 2 b-jets           3963         0.79      0.3963
Exactly 1 lepton             467         0.12      0.0467
MET > 20 GeV                 431         0.92      0.0431       4.3% Accepted


ttbar-bkg - Counter cut_flow :
All events                  10000         1.00      1.0000
At least 5 jets              2730         0.27      0.2730
At least 2 b-jets           1526         0.56      0.1526
Exactly 1 lepton              57         0.04      0.0057
MET > 20 GeV                  55         0.96      0.0055       0.5% Accepted
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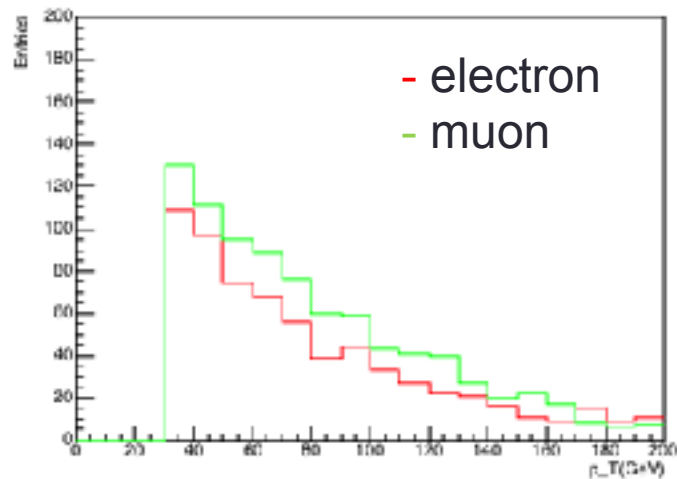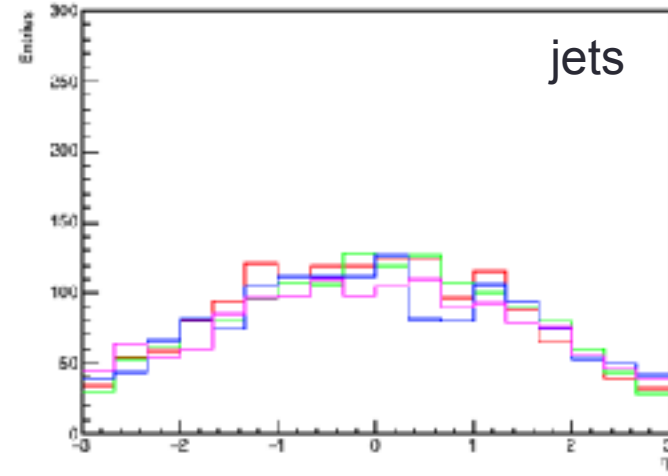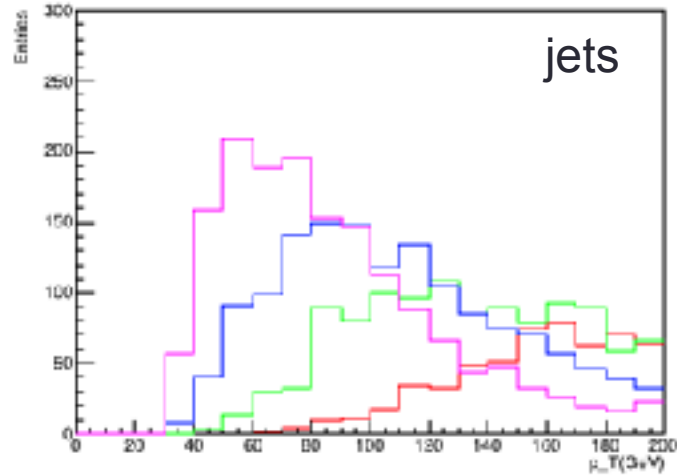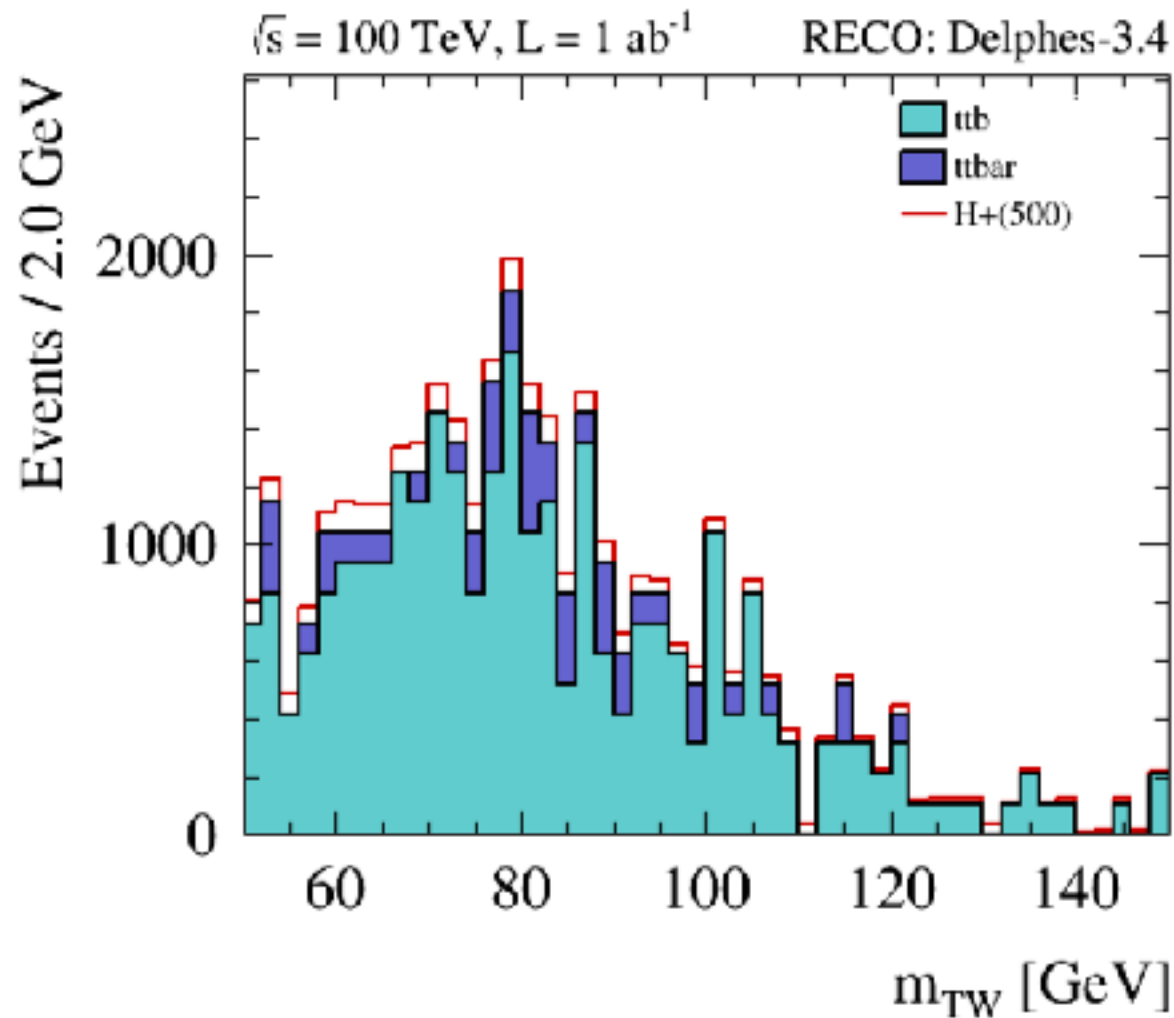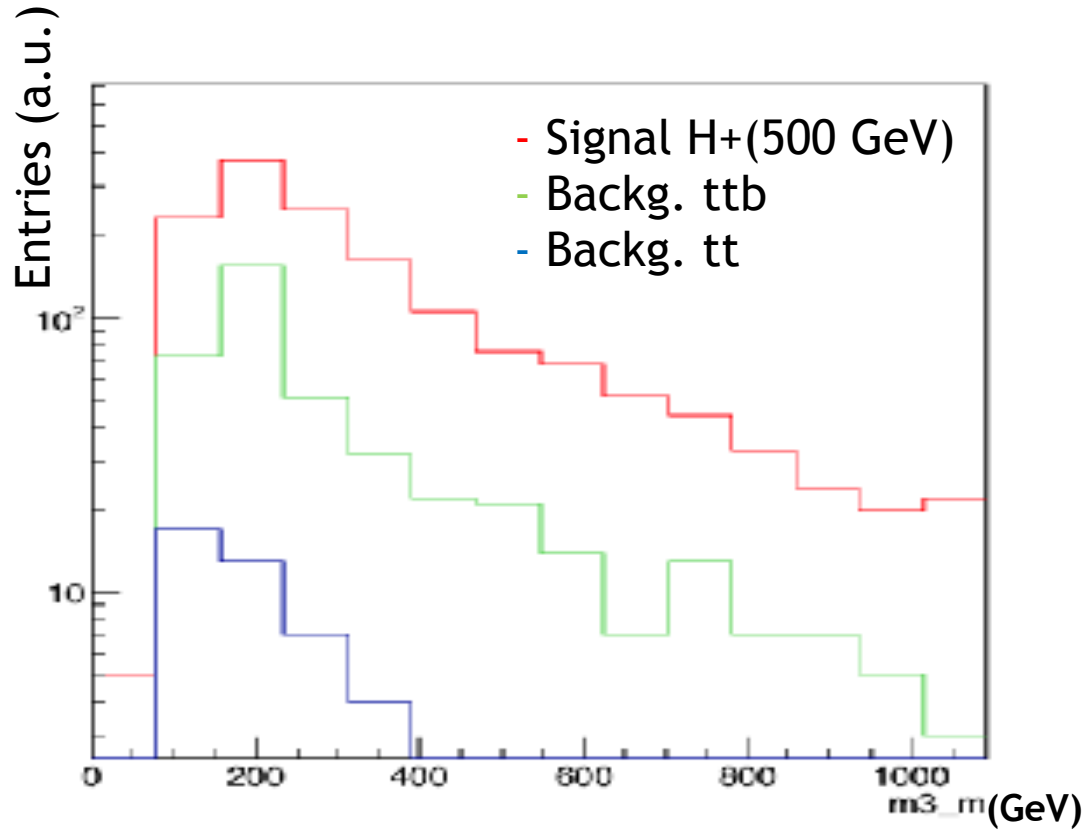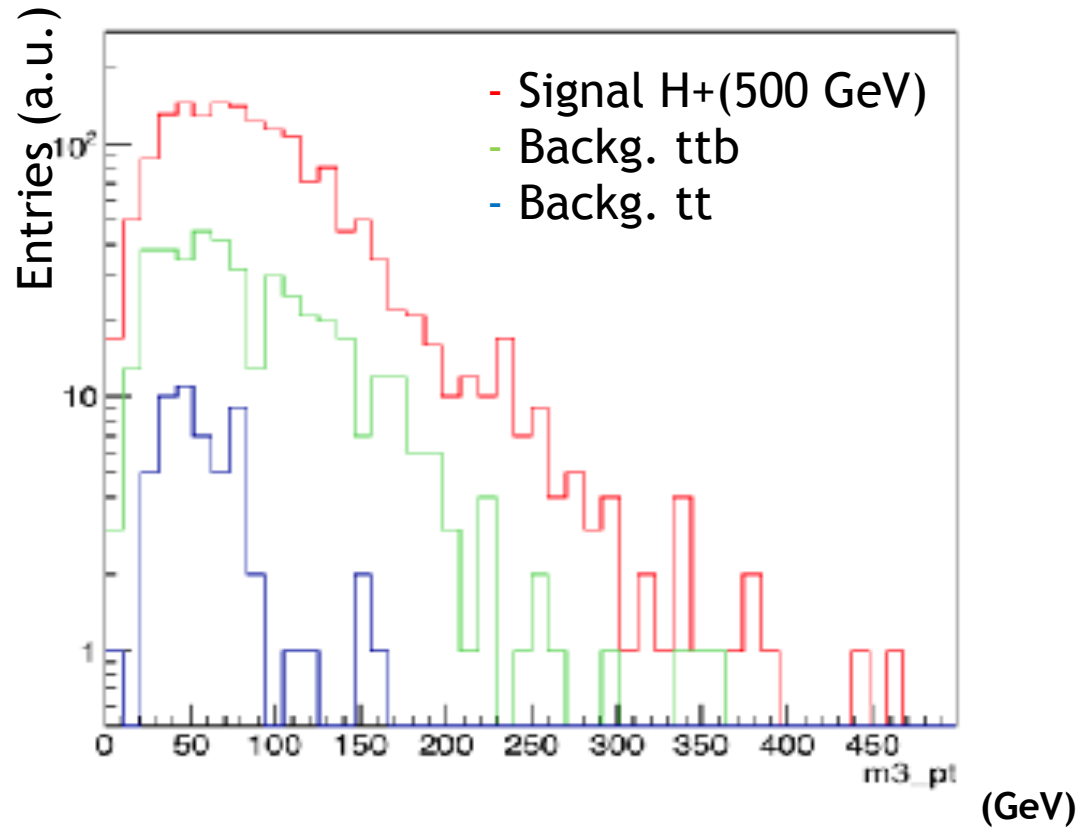
Kinematic distributions (signal)
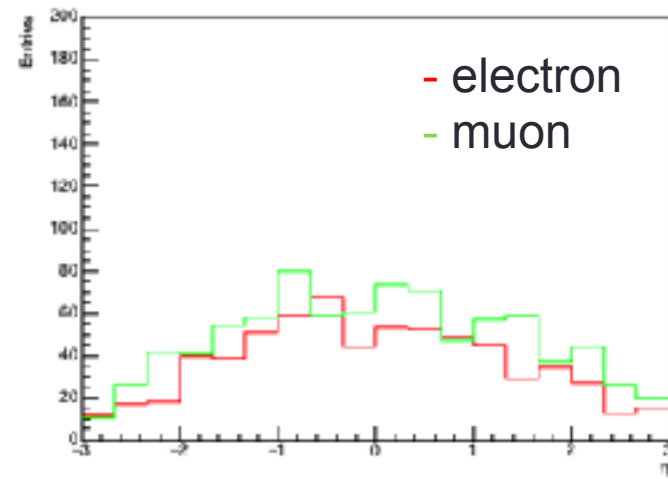
m$_{TW}$ distributions from signal and background

Hadronic top mass – shape (m3)

Hadronic top pT – shape (m3_pt)

- Signal H+(500 GeV)
- Backg. ttb
- Backg. tt

NEXT STEPS

- Continue the analysis

- Present the charged Higgs reconstruction (from top and bjet) after cut optimization

- Calculate the signal and background events within mass intervals $|m_{H-} - m_{tb}| < 0.1\ m_{H-}$ and statistical significance for observability of the signal

- Compare the potential with HL-LHC and HE-LHC

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