Study of WH production at LHC using different event generators

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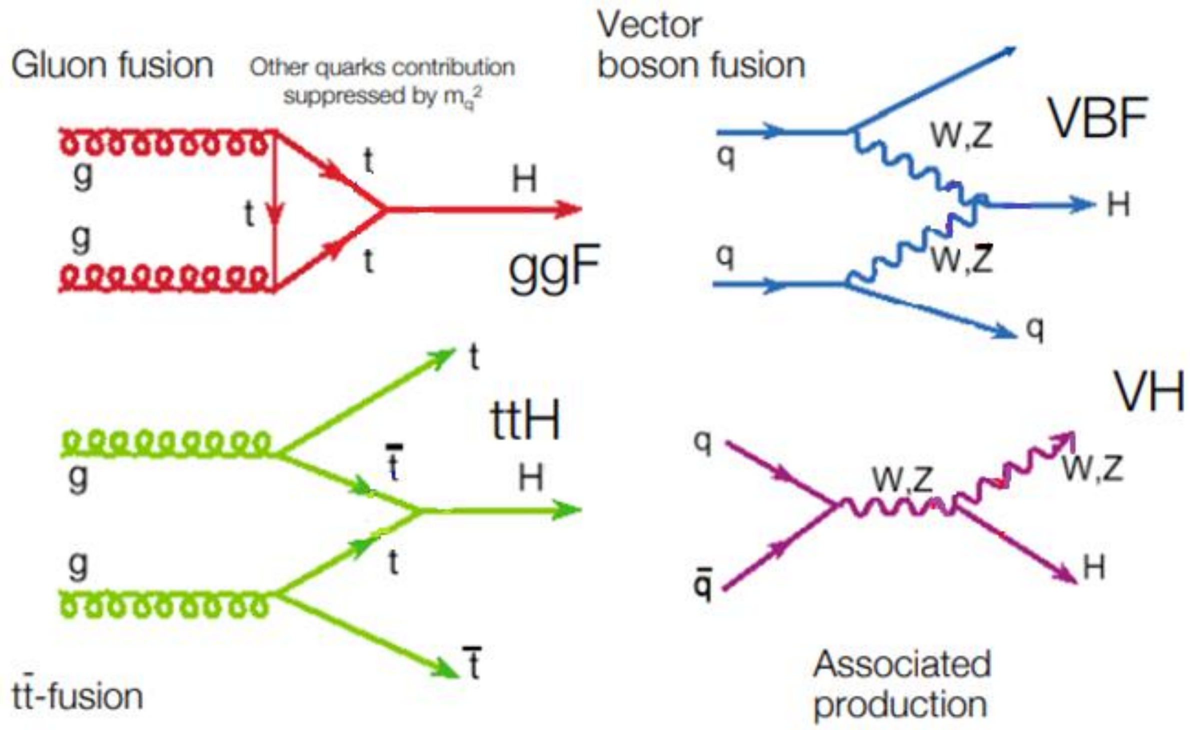
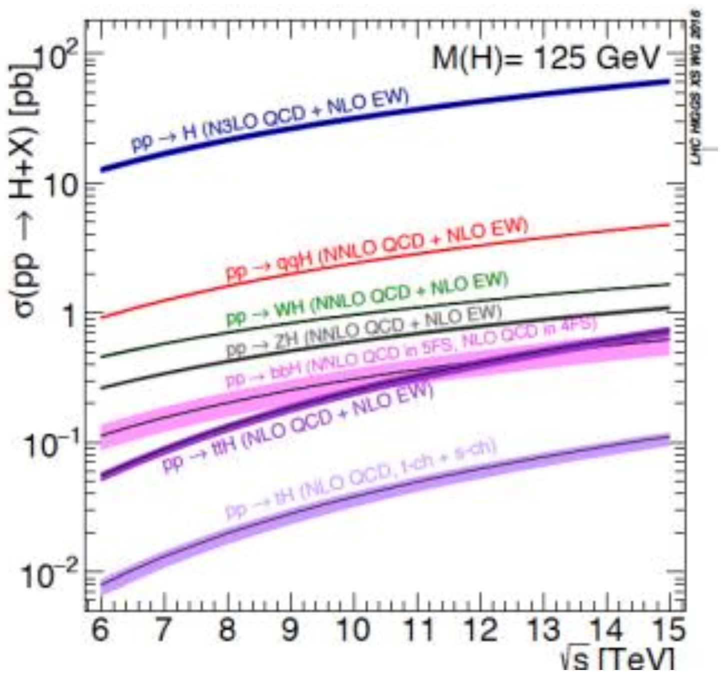
Outline

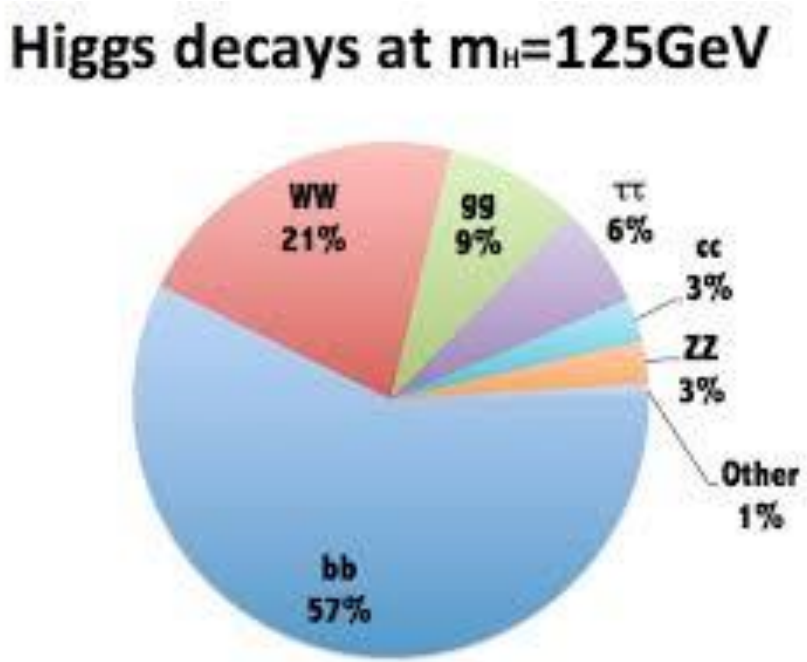
- Event generators
- Features of signal and background process
- Comparison of generators for signal
- CompHEP results
- PYTHIA8 results
- Conclusion

Higgs boson production mechanisms



Higgs boson production cross section and BR



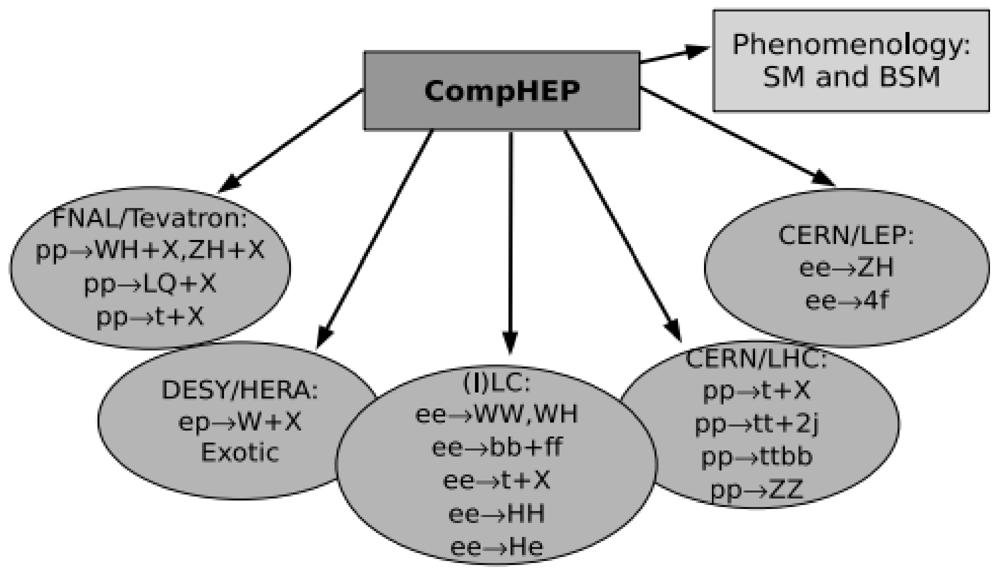


Generators

- *CompHEP (Matrix Element Monte Carlo Generator, produces parton-level events in tree-level approximation).*
- *PYTHIA (The program can be used to generate high-energy-physics 'events', i.e. sets of outgoing particles produced in the interactions of two incoming particles).*
- *POWHEG (The method that uses the POWHEG BOX computing environment to perform NLO calculations in Monte Carlo programs).*

CompHEP

- Constructs Feynman diagrams and their squared diagrams;
- Uses the Monte Carlo generator perform numerical computations;
- Stores results of the calculation in several ways;
- Calculates cross section, width, efficiency and can present various plots (angle, transverse momentum, energy, mass, rapidity, etc.) for generated events;
- Makes root file.



PYTHIA

PYTHIA is one of the most used event generators. PYTHIA 8 offers

- Beams: p/p¯, n/n¯, π0±, γ, e ±, μ ±, νℓ/ν¯ℓ, 4He, 6Li, 12C, heavy ions;
- Perturbative QCD: May combine multiple NLO calculations of different parton multiplicity consistently w/o overlap. Moving to higher-order showers;
- Multiparton interactions: Regularized partonic 2->2 scatters competing with showers for phase space. Fully embedded with diffraction.
- Fragmentation: Lund string hadronization with two tunneling options,collective string effects, hadronic decay MEs & fits, and hadron rescattering.
- Nuclear structure: Ion beams only.

POWHEG

The POWHEG method was conceived to overcome certain limitations in MC@NLO.
Advantages:

• Separates the NLO calculation from the Shower stage;

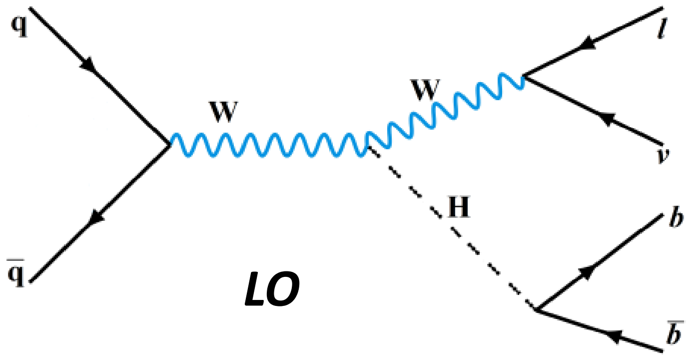
• It can generate positive weighted events;

• Better treatment in the soft limit.

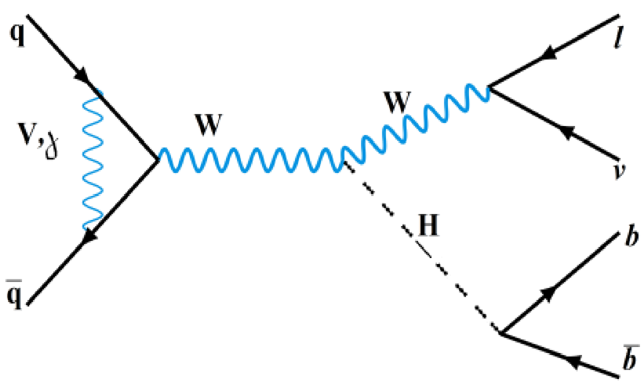
Some details of the signal process generation

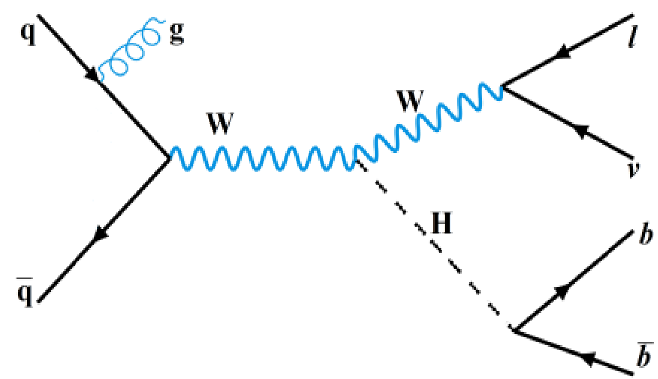
	CompHEP	PYTHIA8	POWHEG
# event	320000	320000	310000
Type of calculation	LO	LO	NLO
Parton-distribution function (PDF)	CTEQ6l1	CTEQ6l1	CTEQ6M

Feynman diagrams for WH process



LO





NLO as EW and QCD corrections to the LO

Signal and background processes

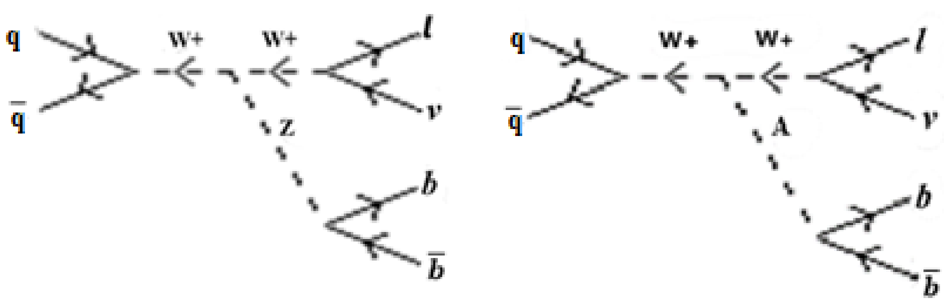
$pp \rightarrow WH \rightarrow l\nu b\bar{b}$

$pp \rightarrow WZ \rightarrow l\nu b\bar{b}$ is irreducible background for our signal process

$pp \rightarrow Wb\bar{b} \rightarrow l\nu b\bar{b}$ is one of the main backgrounds for our signal process

where $l = e^{\pm}$ or $\mu^{\pm}$.

Beam energy: 6500GeV.



a) b)

Figure. Feynman diagrams for the first background process: $q\bar{q} \rightarrow WZ \rightarrow l, \bar{\nu}, b, \bar{b}$ (a) and for the second background process: $q\bar{q} \rightarrow Wb\bar{b} \rightarrow l, \nu, b, \bar{b}$ (b).

Event selection

Main variables and applied cuts:

- Transverse momentum of a charged lepton, b- and anti b-quarks must be greater than 25 GeV, and for neutrinos - greater than 20 GeV.
- Pseudorapidity of the charged lepton, b- and anti-b-quarks should be within [-2.5, +2.5].
- Transverse momentum of the W boson must be greater than 150 GeV.

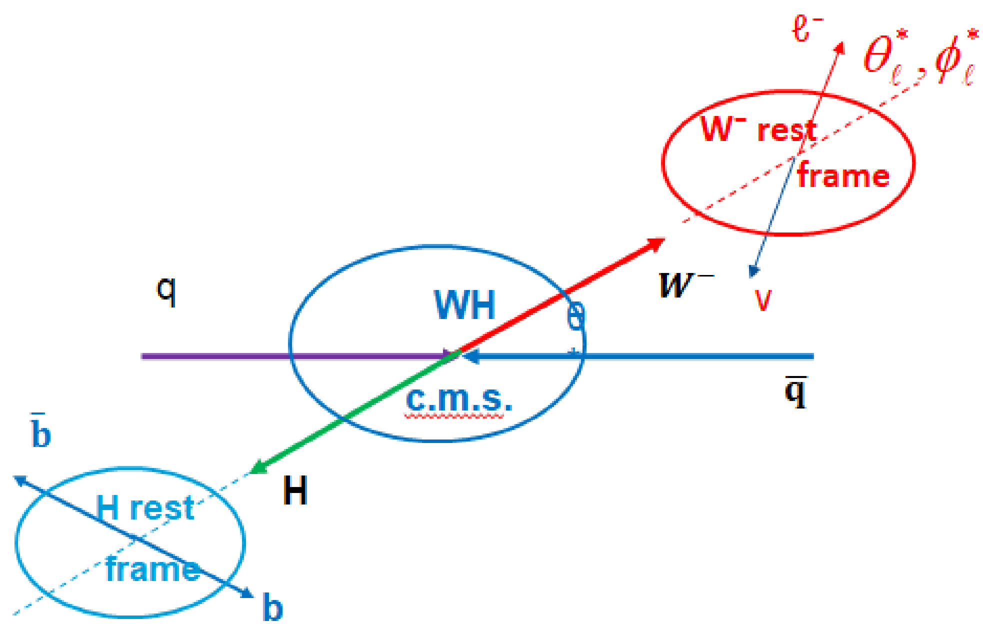
Determination of some useful variables

To determine angle of the charged lepton in W rest frame relative to the W direction in WH or WZ, Wg center of mass system for the signal and background:

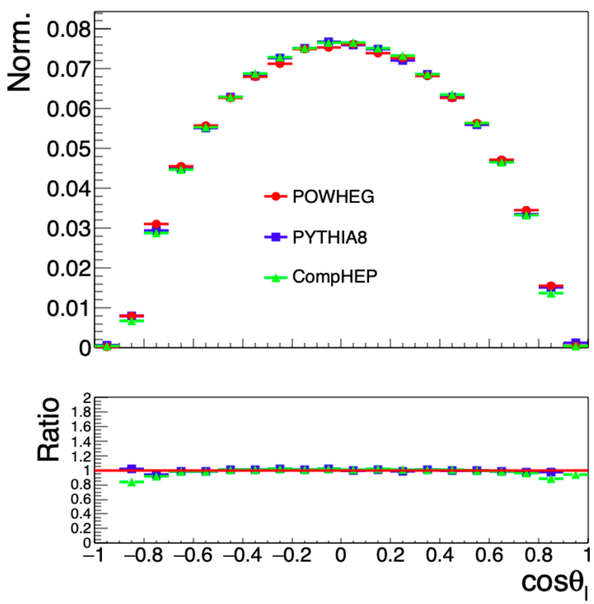
-We have to transform all momenta from laboratory system to the WH center-of-mass frame.

-Then we rotate the direction of the W-boson so that it coincides with the z-direction.

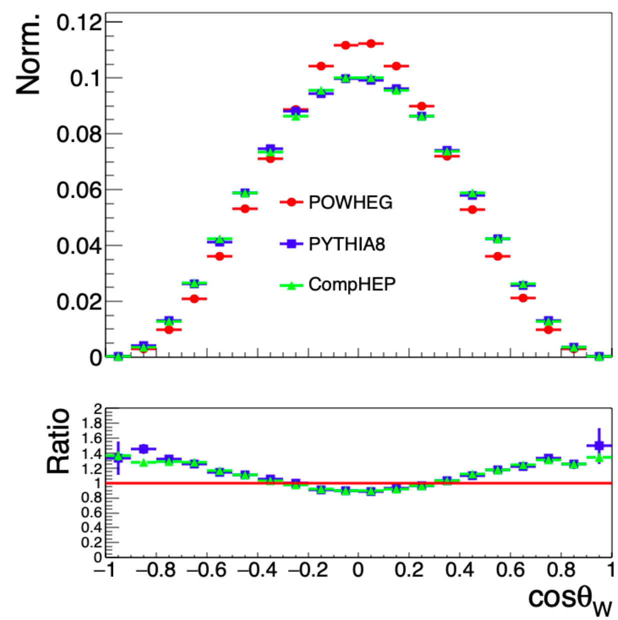
-Finally, we transform momentum of W boson along the z- axis to rest frame of W-boson.



Comparison of generators using some kinematic variables



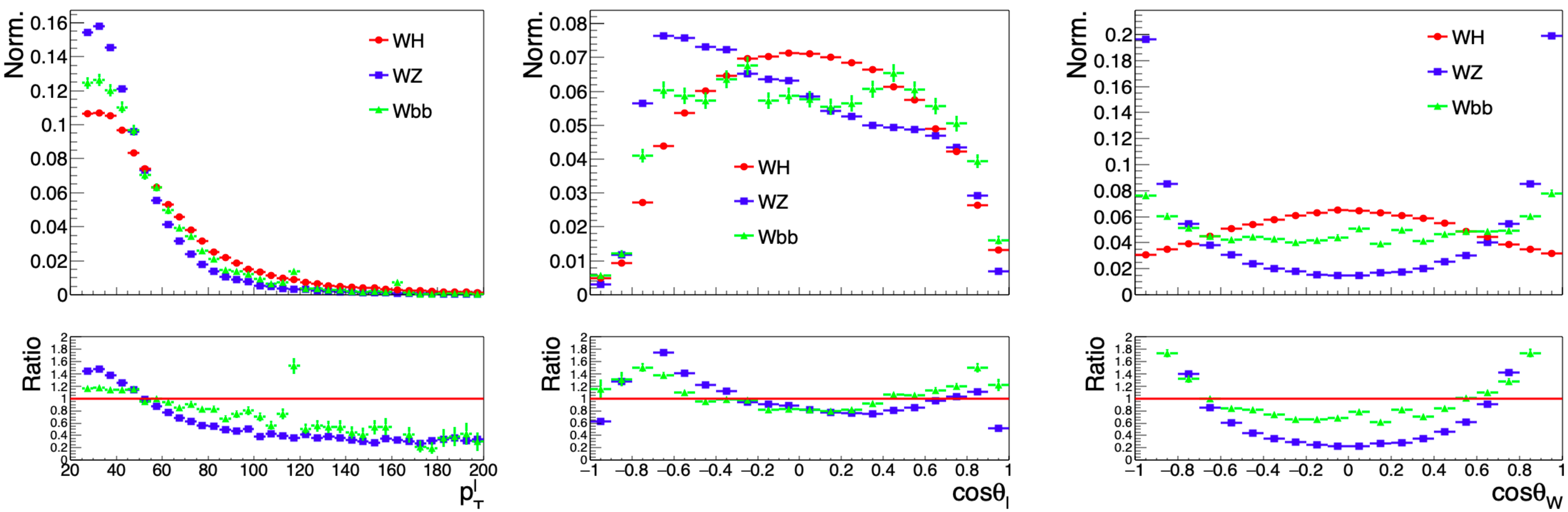
a)



b)

Distributions of (*a*) the cosine of the charged lepton angle in the *W* rest frame relative to the *W* direction in the $q\bar{q}$ c.m.f. and (*b*) the cosine of the *W*-boson polar angle from the collision axis in the $q\bar{q}$ c.m.f. for different generators.

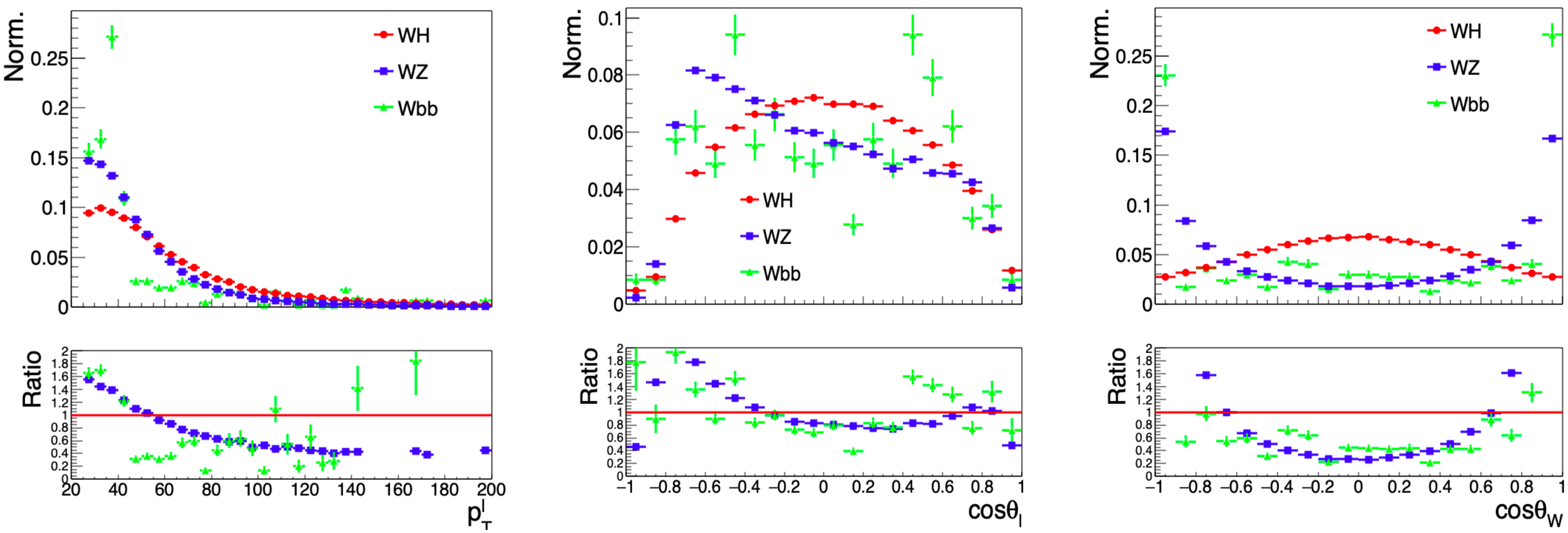
CompHEP results



a) b) c)

Distributions of the transverse momentum of the charged lepton (a), cosine of the charged lepton emission angle in the W rest frame relative to the W direction in the $q\bar{q}$ c.m.f. (b), and cosine (c) of the W-boson polar angle in c.m.f. of colliding $q\bar{q}$ for WH, WZ and $Wb\bar{b}$ events obtained from CompHEP.

PYTHIA8 result



a) b) c)

Distributions of the transverse momentum of the charged lepton (a), cosine of the charged lepton angle (b) in the W rest frame relative to the W direction in the $q\bar{q}$ c.m.f. and cosine (c) of the W-boson polar angle in c.m.f. of colliding $q\bar{q}$ for WH, WZ and $Wb\bar{b}$ events obtained from PYTHIA.

Conclusion

- Signal and background processes were generated using the CompHEP, POWHEG and PYTHIA generators.
- Monte Carlo data were processed in ROOT software.
- The shape of the distributions of variables for different generators are similar in the same processes .
- The shape of the distributions of variables for signal and background processes is very different.
- And these differences can be used in future analyses to suppress a large background contribution.

Thank you for attention!