Detector qualification with Higgs bosons in the jets and missing energy final state

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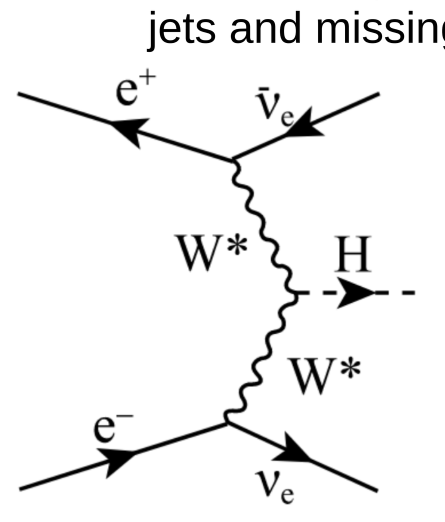
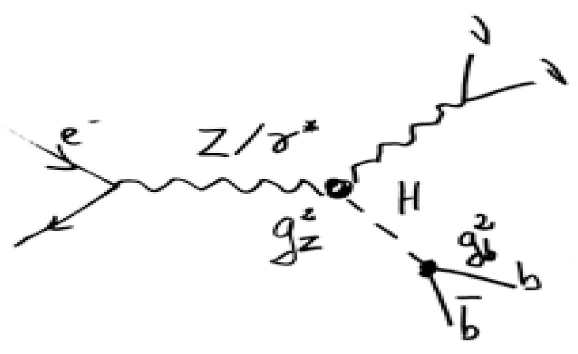
Motivation

- Higgs couplings can be precisely measured at FCC-ee
- Need a measurement of the Higgs cross-section x branching ratio in as many channels as possible
- The effect of different detector components on the precision of these measurements are important for the development of efficient detectors
- In this work, detector effects are studied for a final state with jets and missing energy.



Vector Boson Fusion (VBF)

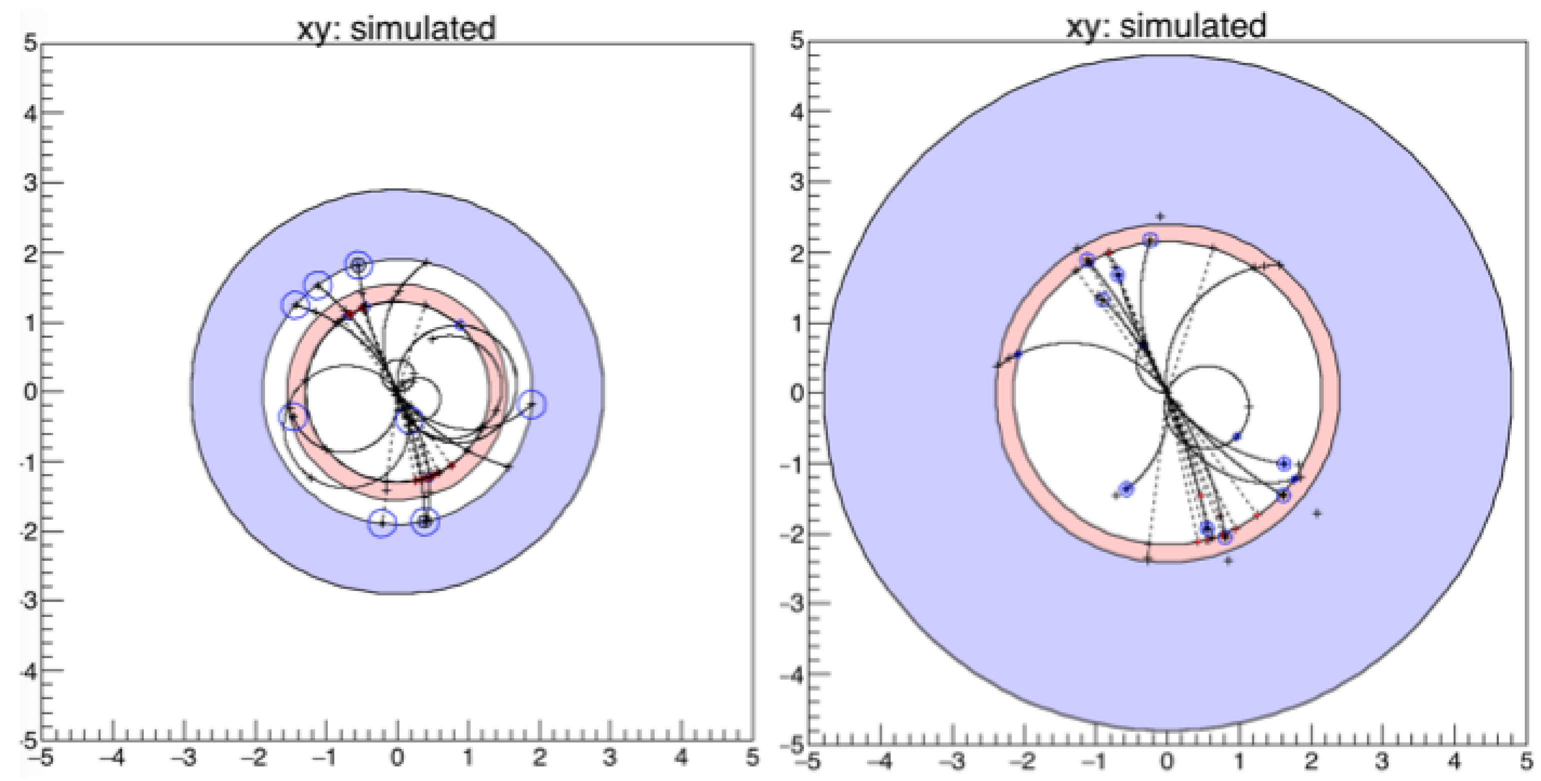


Higgsstrahlung

- PYTHIA 8.23 is used for the event generation
- Events are processed by a parametrised detector simulation (papas)

Detectors

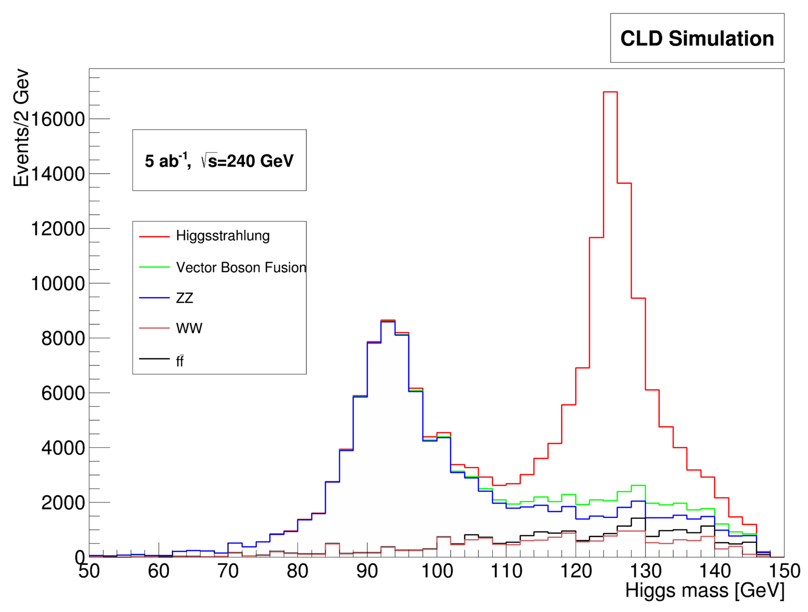
- Two detectors implemented in the papas simulation, CMS and CLD.
- The papas simulation is able to reproduce the results of the LEP3 note (arXiv:1208.1662v2) in many different channels.



papas simulation of the same event for CMS (left) and CLD (right) .

	CMS	CLD
Magnetic field [T]	3.8	2
Tracker radius [m]	1.3	2.15
b-tag efficiency	60%	80%
HCAL resolution @100 GeV	14.2%	5.5 %
ECAL resolution @100 GeV	0.8%	2%

$ZH \rightarrow \nu\bar{\nu}b\bar{b}$ at 240 GeV



Invariant mass of the dijet system after scaling and event selection.

Event selection

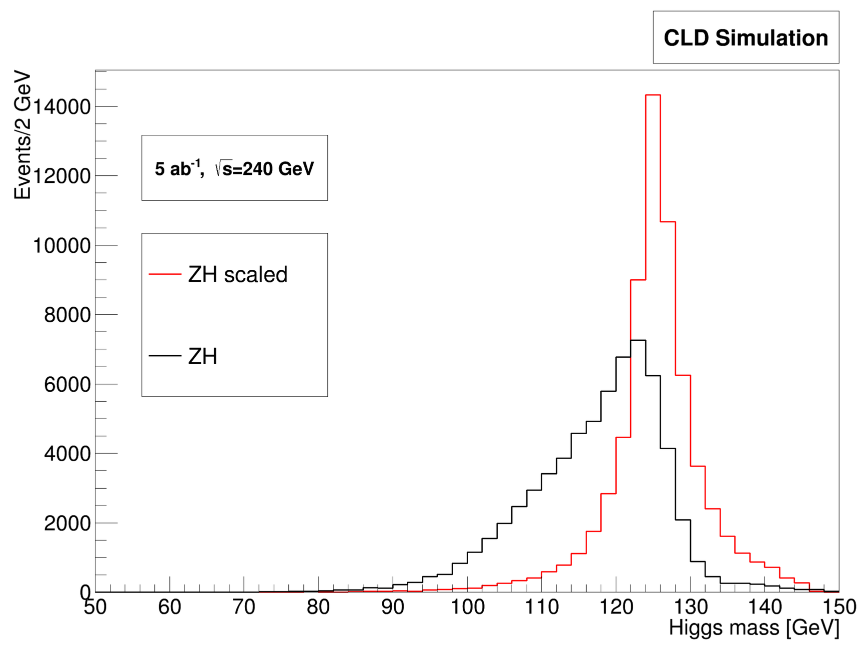
- Exclusive 2-jet reconstruction (ee k_t-algorithm)
- At least 1 jet is b-tagged
- 85 < missing mass [GeV] < 125
- Di-jet transverse momentum > 15 GeV
- Di-jet longitudinal momentum < 50 GeV
- Angle between the jets > 100°
- cross > 10

$$\text{cross} = \frac{180}{\pi} \cdot \arcsin\left(\frac{(\vec{p}_{jet1} \times \vec{p}_{jet2}) \cdot \hat{e}_z}{|\vec{p}_{jet1}| \cdot |\vec{p}_{jet2}|}\right)$$

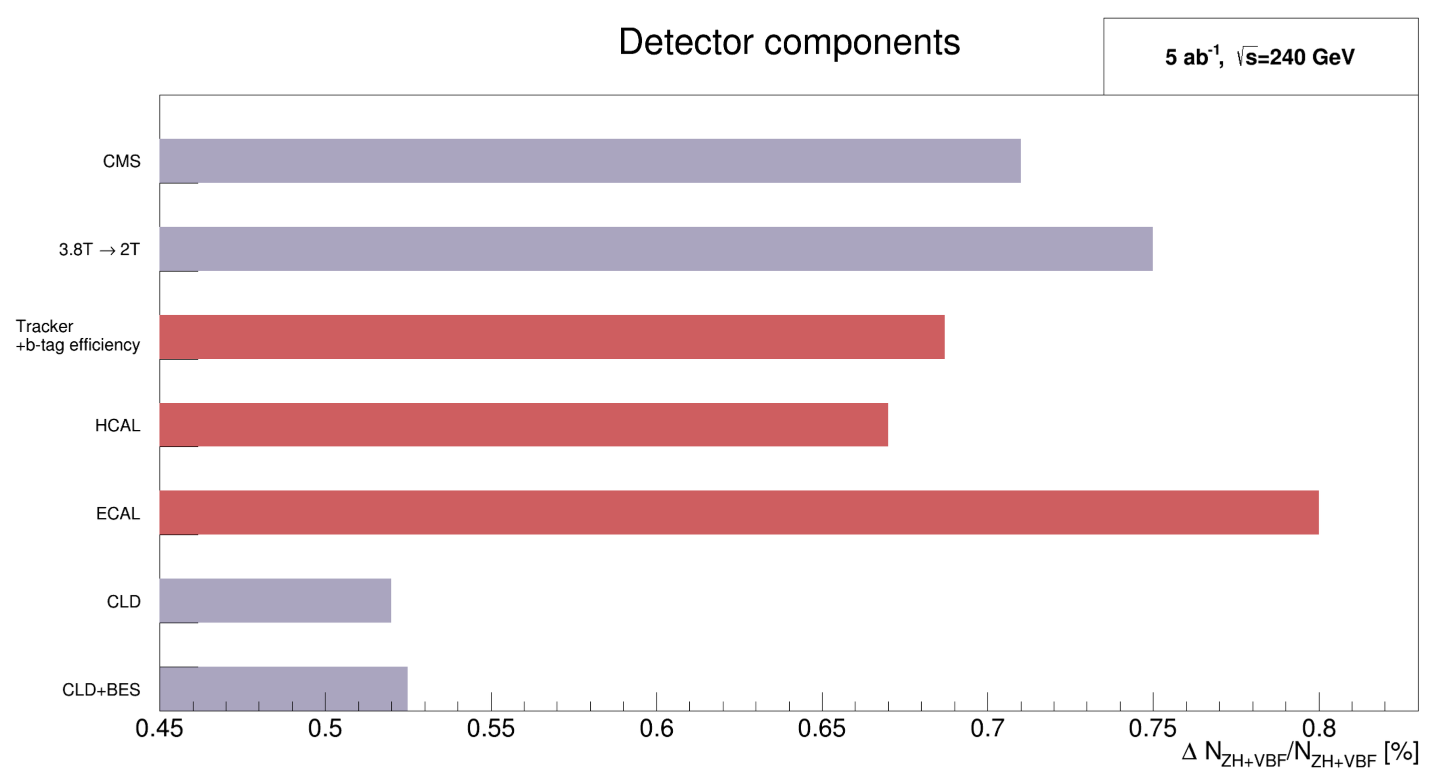
Scaling

- The Higgs mass is computed after scaling both jets with a common factor, to fix the missing mass to m_Z (large improvement in resolution)

$$m_Z^2 = (p_{miss}^{rescaled})^2$$



Impact of the scaling on Higgsstrahlung (ZH).

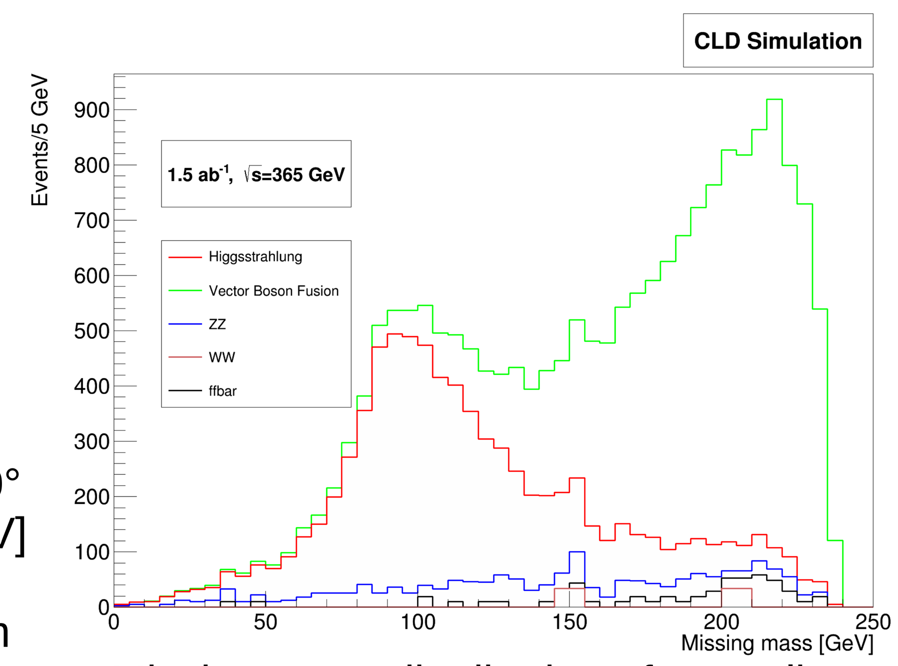


Uncertainty of signal (ZH+VBF) yield for the different detector variations. For the 3 red bars the CMS detector with a magnetic field of 2T is changed by replacing the corresponding component with the one from CLD, and changing the outer parts to prevent overlapping. The effect of Beam Energy Spread (BES) is neglegible due to the modest resolution of this decay channel.

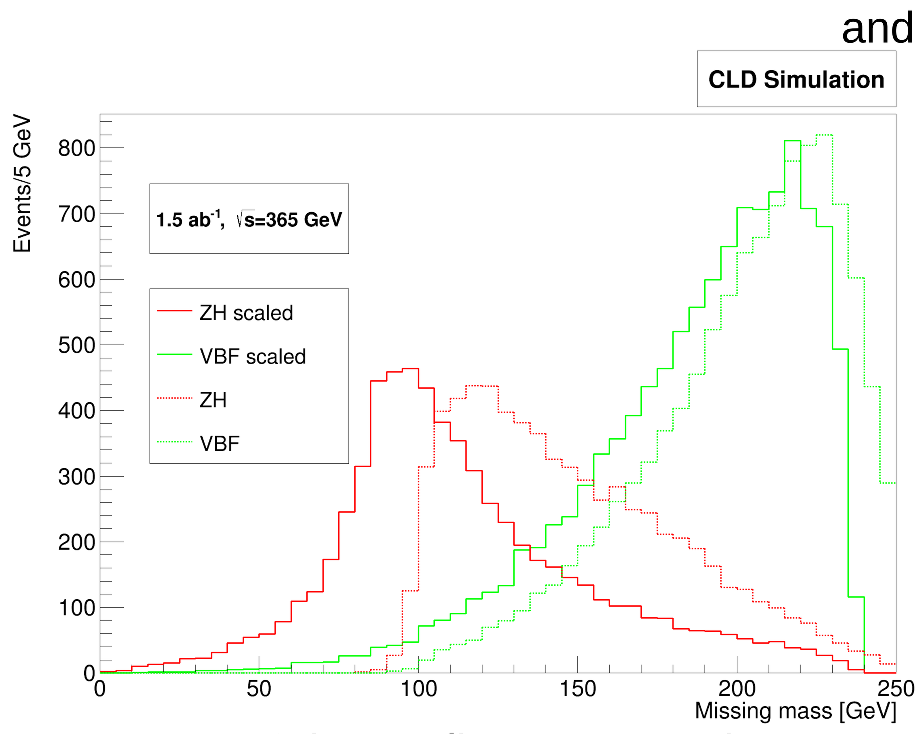
VBF at 365 GeV

Event selection

- Exclusive 2-jet reconstruction (ee k_t-algorithm)
- Both jets are b-tagged
- 90 < Visible mass [GeV] < 130
- 100 < Visible Energy [GeV] < 190
- 20 < Di-jet transverse momentum [GeV] < 140
- 70°< Angle between the jets < 170°
- Di-jet longitudinal momentum [GeV] < 130
- Angle between jet plane and beam axis > 10°



Missing mass distribution after scaling and event selection.

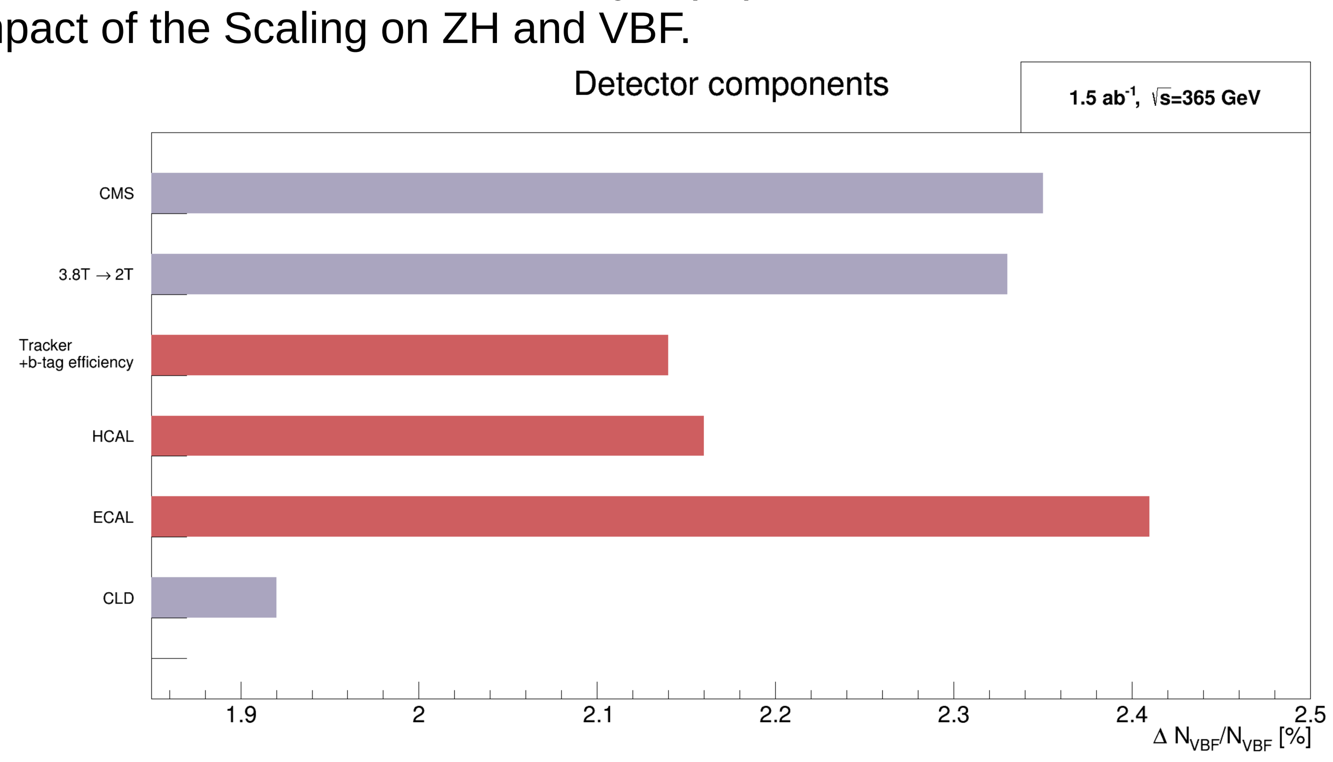


Impact of the Scaling on ZH and VBF.

Scaling

- To improve the seperation between ZH and VBF the jets in each event are scaled by a common factor:

$$\Upsilon = \frac{m_H}{m_{vis}}$$



Uncertainty of signal (VBF) yield for the different detector variations. For the 3 red bars the CMS detector with a magnetic field of 2T is changed by replacing the corresponding component with the one from CLD, and changing the outer parts to prevent overlapping.

Conclusion

Detector performance has a strong effect on the Higgs boson precision measurements for the channels studied. It was shown that this improvement is mainly due to both, a better jet energy resolution and an improved tracking/b-tagging performance.