A New Method For Measuring Higgs Mass at ILC

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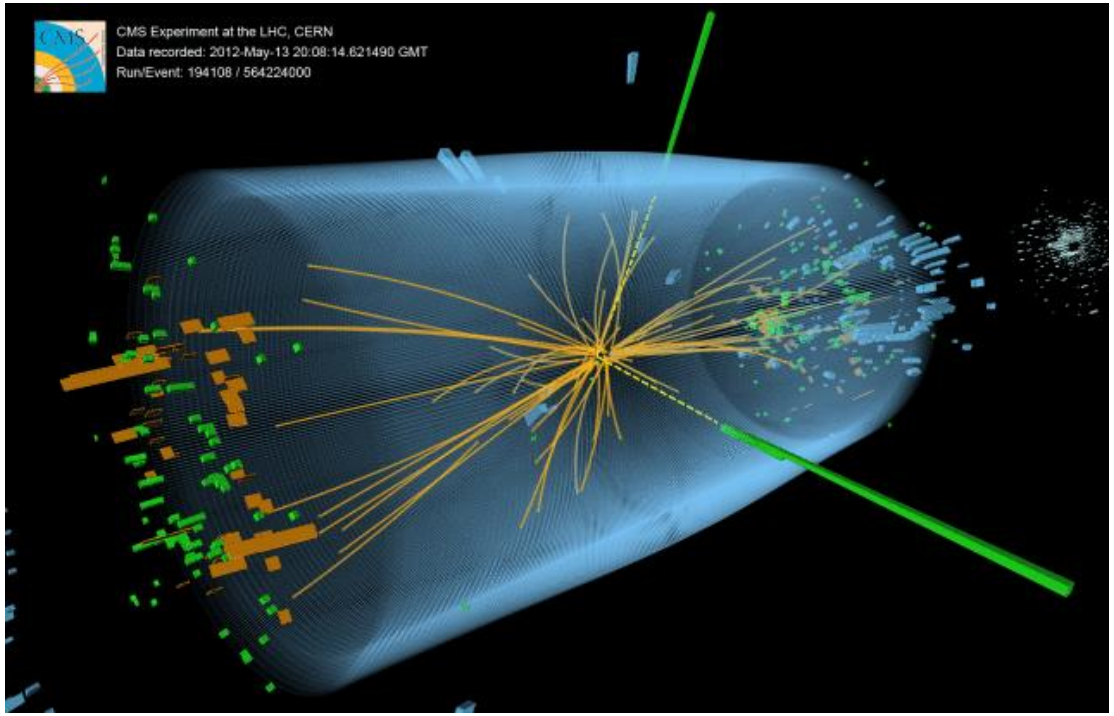
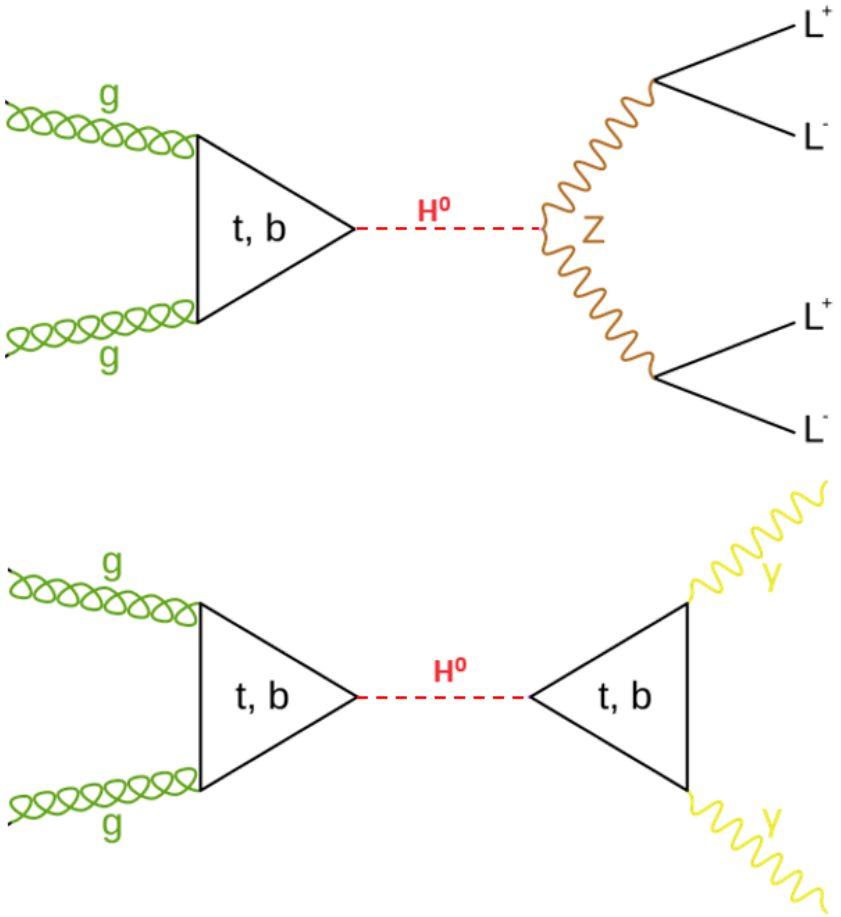


Event recorded with the CMS detector in 2012 at a proton-proton centre of mass energy of 8 TeV,Image: CERN

LHC: pp collider at TeV energies in CERN (European Council for Nuclear Research)

Search for Higgs Boson at ATLAS and CMS experiments started in 2012 and a discovery at 5 sigmas was found later

Higgs Production at LHC



- 2 Clean decay channels are selected
- Direct Measurement of Higgs mass from the observed decay products

The ILC: International Linear Collider

20kms e^+e^- collider in mountains of Japan proposed as Higgs factory and explore high energy regions

Initial upgrade up to 500GeV and an additional upgrade to 1TeV may also be possible later

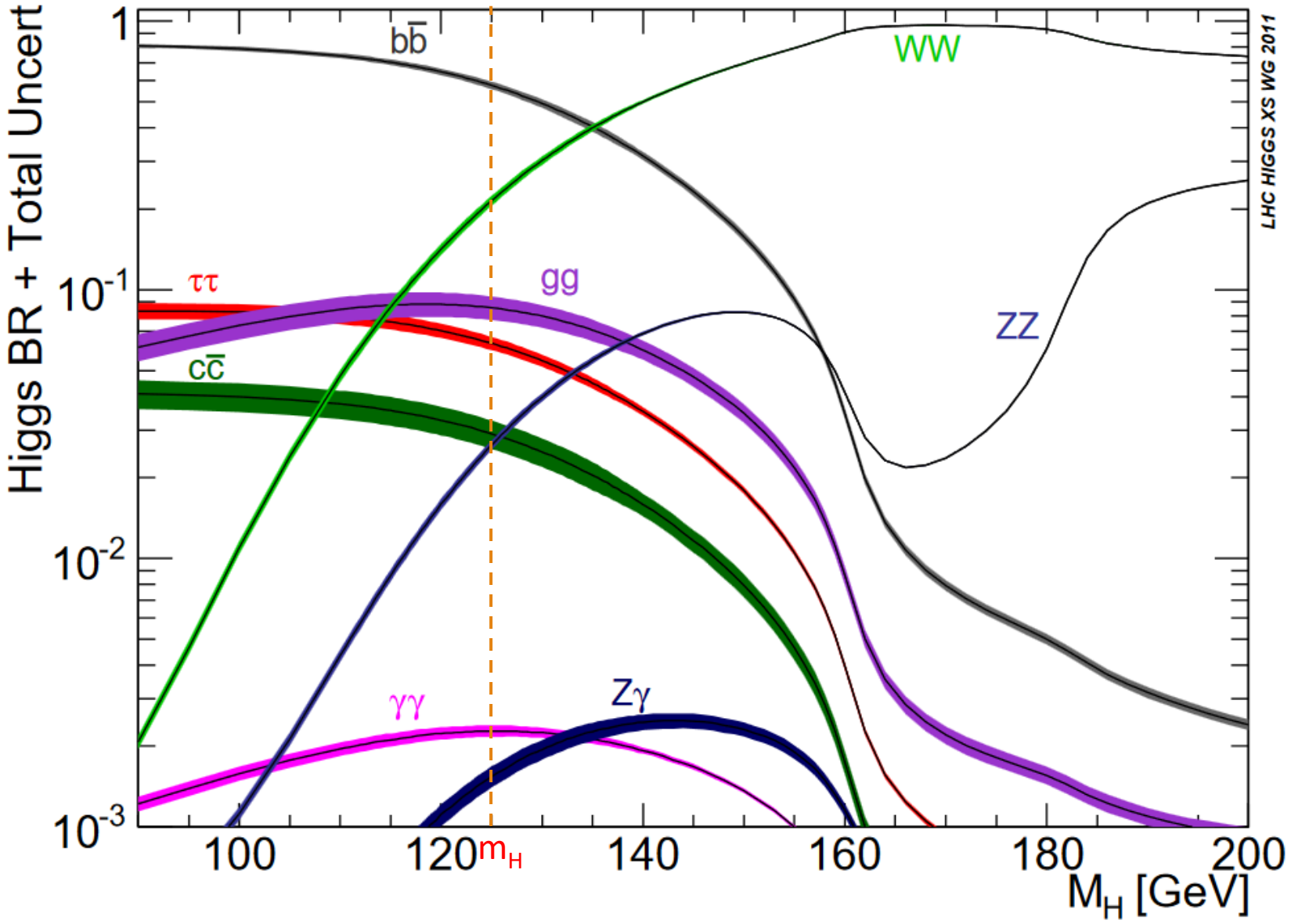
ILC for collisions at 250GeV with upgrades to 500GeV and up to 1TeV possible. (linearcollider.org)

Higgs mass is a crucial input parameter in partial widths in $H \rightarrow ZZ^*$ and $H \rightarrow WW^*$ coupling

Very sensitive to m_H measurement:

$$\frac{\Delta\Gamma(H \rightarrow ZZ^*)}{\Gamma(H \rightarrow ZZ^*)} = 16 * \frac{\Delta m_H}{m_H} \qquad \frac{\Delta\Gamma(H \rightarrow WW^*)}{\Gamma(H \rightarrow WW^*)} = 14 * \frac{\Delta m_H}{m_H}$$

For a 0,1% - 0,5% precision, an uncertainty of 16-80MeV is the aim for m_H



Branching Ratios for our processes:

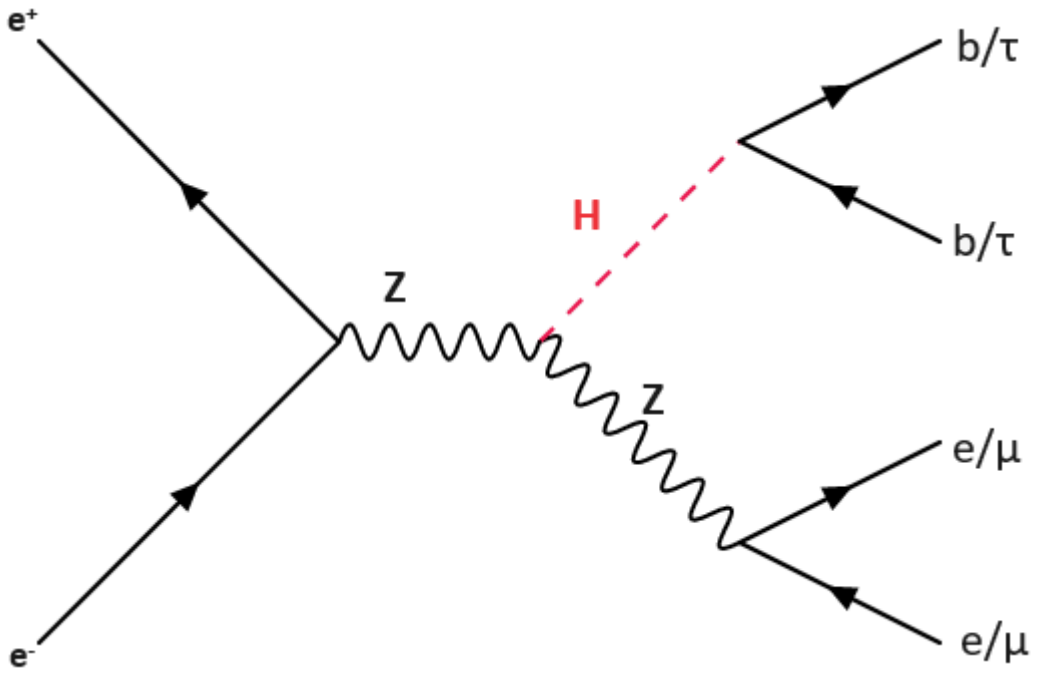
For H boson:

$H \rightarrow b\bar{b}$	58,2%
$H \rightarrow WW^*$	*25,7%*
H→gg	8,6%
$H \rightarrow \tau^+\tau^-$	6,3%

And Z boson:

7% for $Z \rightarrow \mu^+\mu / e^+e^-$

II- The New Method



Classical method of recoil mass in ILC: Z decay products recoil against H boson: 14MeV uncertainty expected with recoil mass.

Studied Processes are $e^+e^- \rightarrow ZH$, $Z \rightarrow L^+L^-$ and $H \rightarrow \tau^+\tau^-$ compared with $H \rightarrow b\bar{b}$

Methodology:

With only Transverse Momentum Conservation with p_1 and p_2:

$$\begin{pmatrix} p_1 \\ p_2 \end{pmatrix} = \frac{p_t}{\sin\phi_{12}} \begin{pmatrix} \frac{\sin(\phi-\phi_2)}{\sin(\theta_1)} \\ \frac{\sin(\phi_1-\phi)}{\sin(\theta_2)} \end{pmatrix}, \qquad \begin{aligned} p_1 \sin\theta_1 \cos\phi_1 + p_2 \sin\theta_2 \cos\phi_2 &= p_x \\ p_1 \sin\theta_1 \sin\phi_1 + p_2 \sin\theta_2 \sin\phi_2 &= p_y \end{aligned}$$

Advantages:

-No energy in the resulting mass formula,only angles and momentums

-Less uncertainty from Beamstrahlung, especially at higher energies

-Complementary method with the Recoil Mass

Simulations

Whizard: Event Generator with ISR, Beamstrahlung and Parton showers and hadronization by with Pythia ➔ Monte Carlo events or Truth events

GEANT4: Simulates the detectors and the detection of Truth events

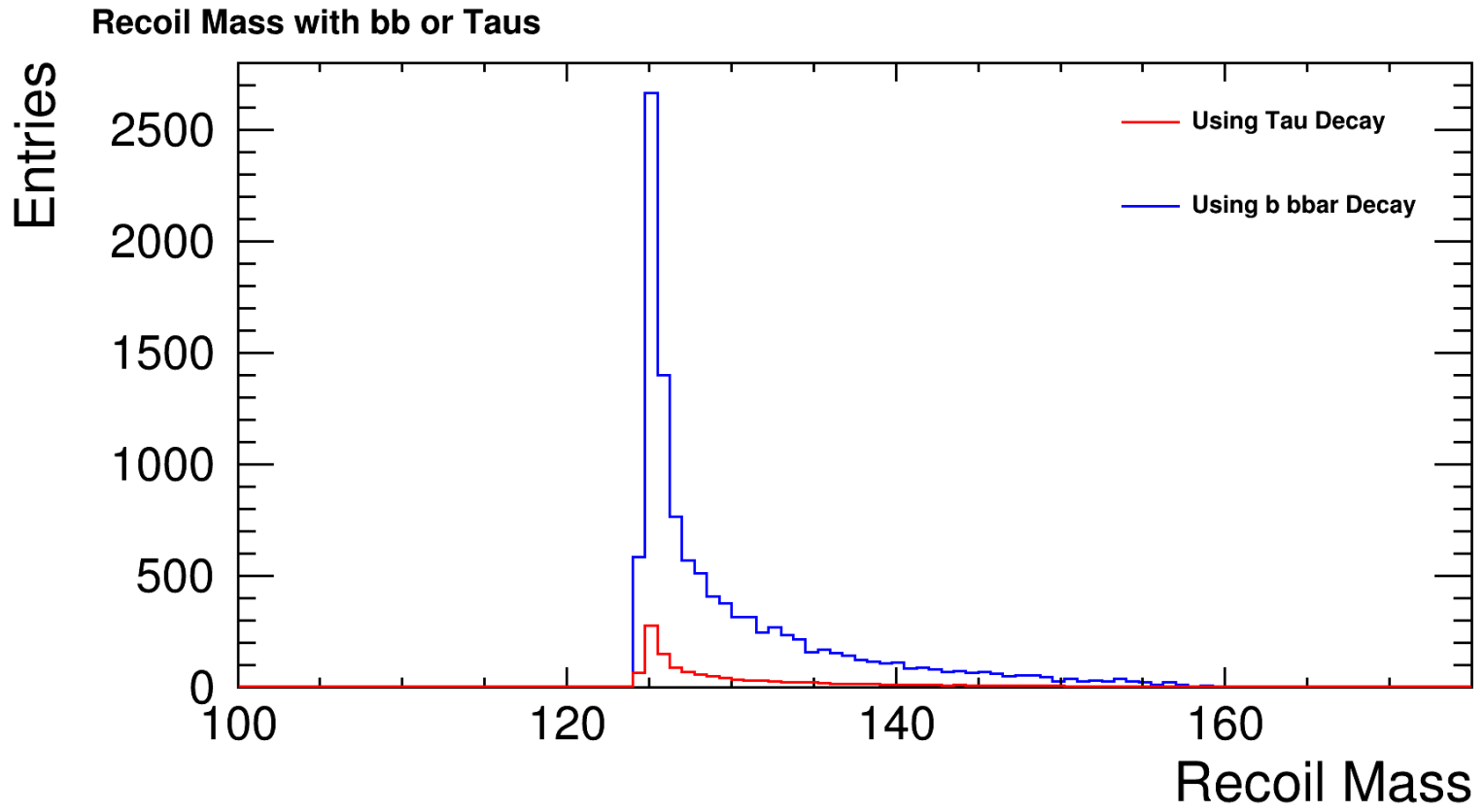
PandoraPFA and LCFIPlus: Full event reconstruction with digitization, particle flow analysis, jet clustering…

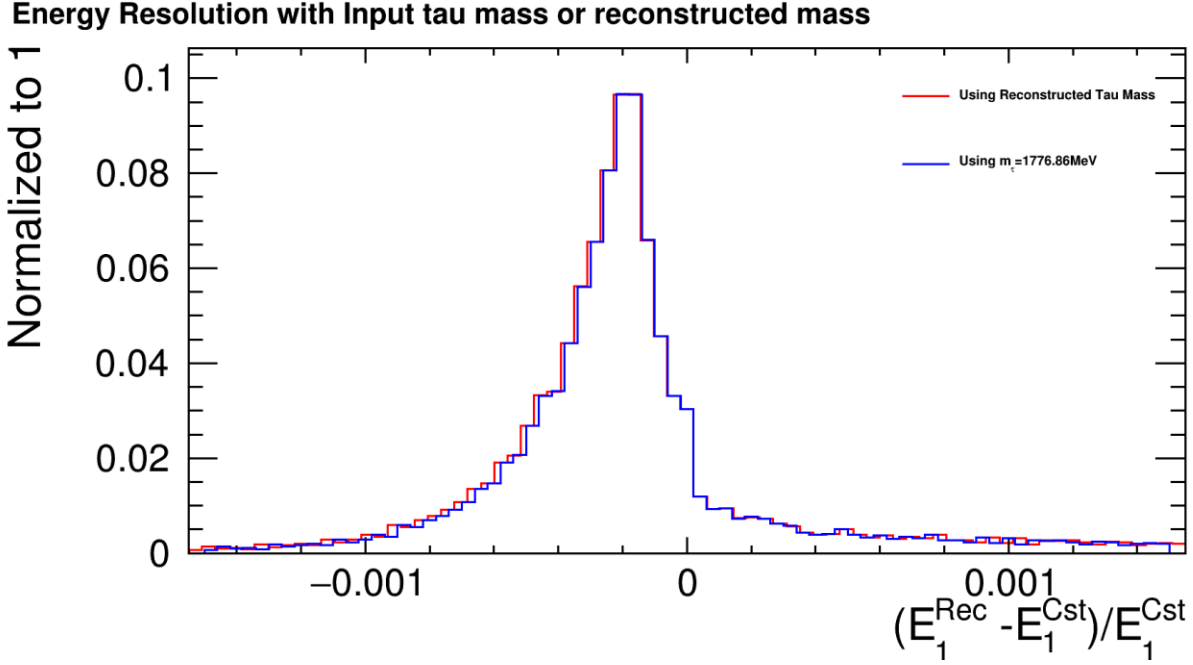
Then: Physics Analysis with ROOT

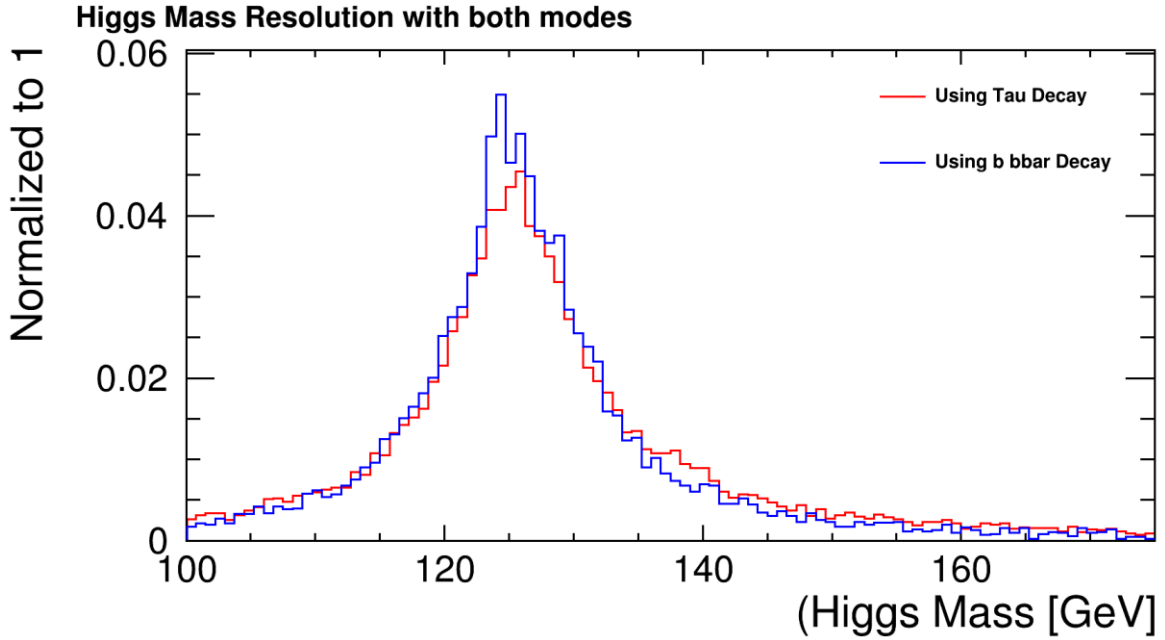
III-Results Obtained

Recoil Mass is less precise because of asymmetricity and long tail

Less Entries in the Tau Channel as expected so statistical errors and all graphs will be normalized to 1 after.



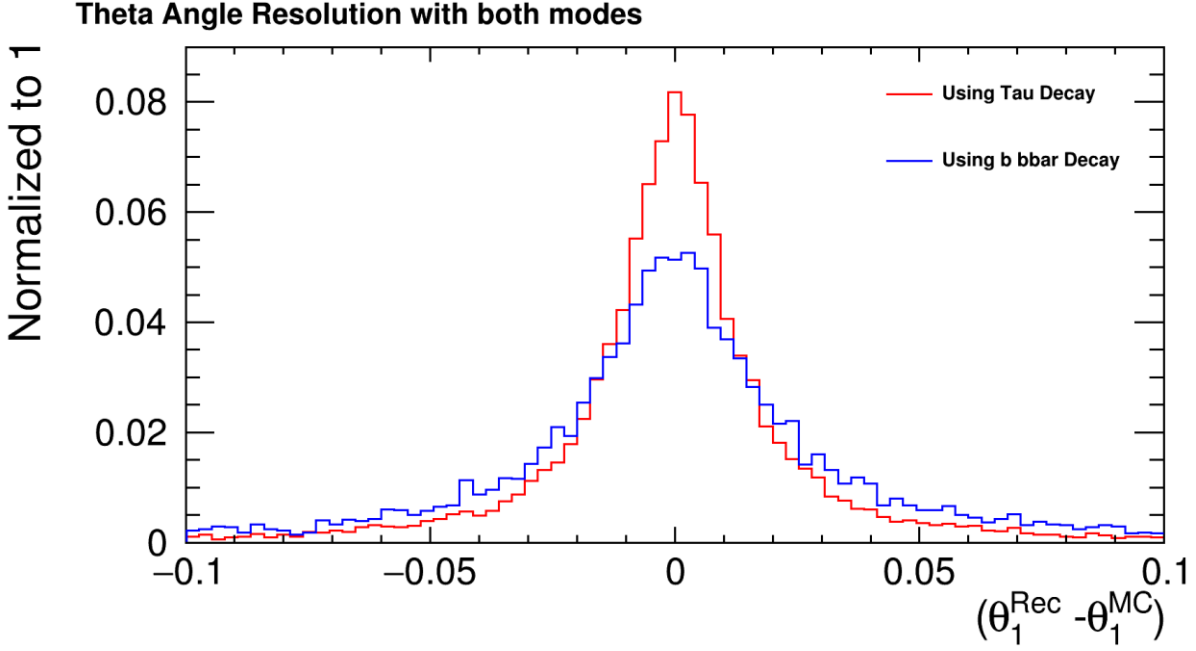


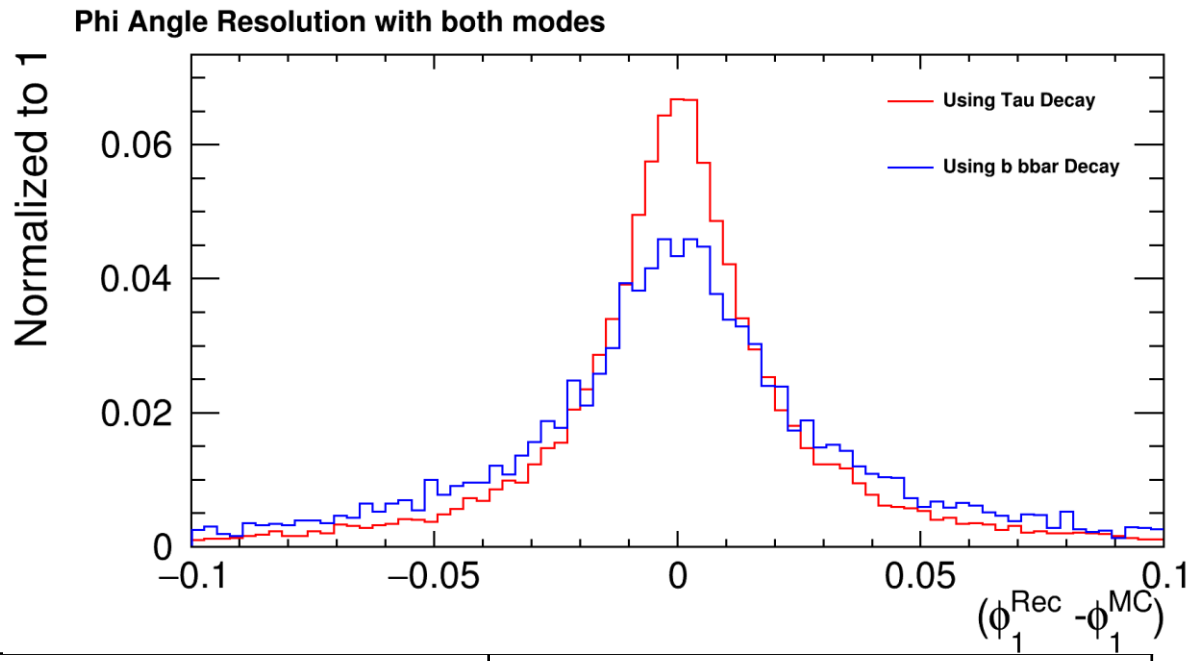


All data is computed for both of the H decay products and shown for only 1 here.

Relative Resolution for m_H and Absolute Resolution for angles are fitted with Gaussians with ROOT to get the errors of each channel

The distributions are similar in each cases for bb and Taus with the bbar more peaked.





Resolution	θ_1 [degree]	ϕ_1 [degree]	Δm_H [GeV]
Using $b\bar{b}$	0,80±0,03	0,92±0,02	4,17±0,16
Using $\tau^+\tau^-$	0,67±0,01	0,73±0,01	4,51±0,14

With a 2000fb^{-1} Luminosity, cross sections from whizard, 100% efficiency and the $\mu\mu$ channel for Z decay,

The error $\partial m_H = \frac{\Delta m_H}{\sqrt{N}}$ is then ~20MeV for $b\bar{b}$ and ~100 MeV $\tau^+\tau^-$

IV-Conclusion:

The tau channel is not precise enough so missing neutrinos should be taken into account for the measure of m_H.

Both modes are valid and provide an additional method to get Higgs Mass without using the recoil mass or direct reconstruction

Work left to do:

$Z \rightarrow e^{+}e^{-}$ channel should be clean enough to be added to the study and get more entries especially to Tau modes.

Taking into account the produced neutrinos to improve the algorithm for 1-prong events and 3 prong events and ignore the wrong classification of 2-prong events (Misclustering errors)

Study significance with Backgrounds added

Thank You For Your Attention

Bibliography:

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linearcollider.org, ILC site