Analysis plans

P. Gay
LPC Univ. B. Pascal -IN2P3

Introduction

- Physics analysis will be the final canvas where the detector optimization has to be performed
  - Contribution to detector optimization

- Up to now, Physics analyses have been performed with (more or less realistic) fast smeared simulation

- By the way, a huge progress has been done on software tools

(talks from Franck, Mark, Sonia in that session)

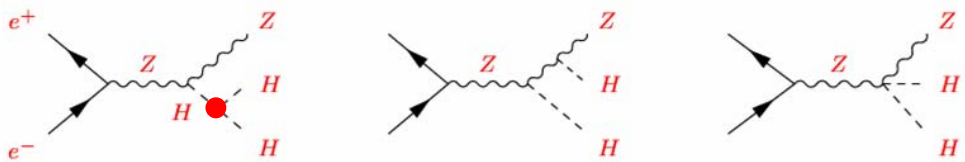
How is it possible to perform Physics analysis with the present software

How to move to the Physics analysis

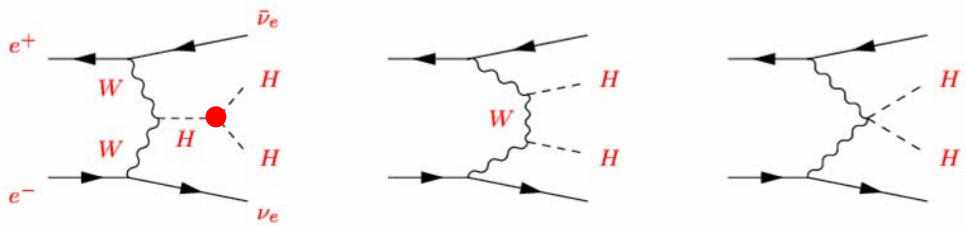
- **Several and different benchmarks are needed** **(see talk from Marco)**

- **Focus (e.g.) on the Higgs self coupling measurement analysis**

double Higgs-strahlung: $e^+e^- \to Zhh$

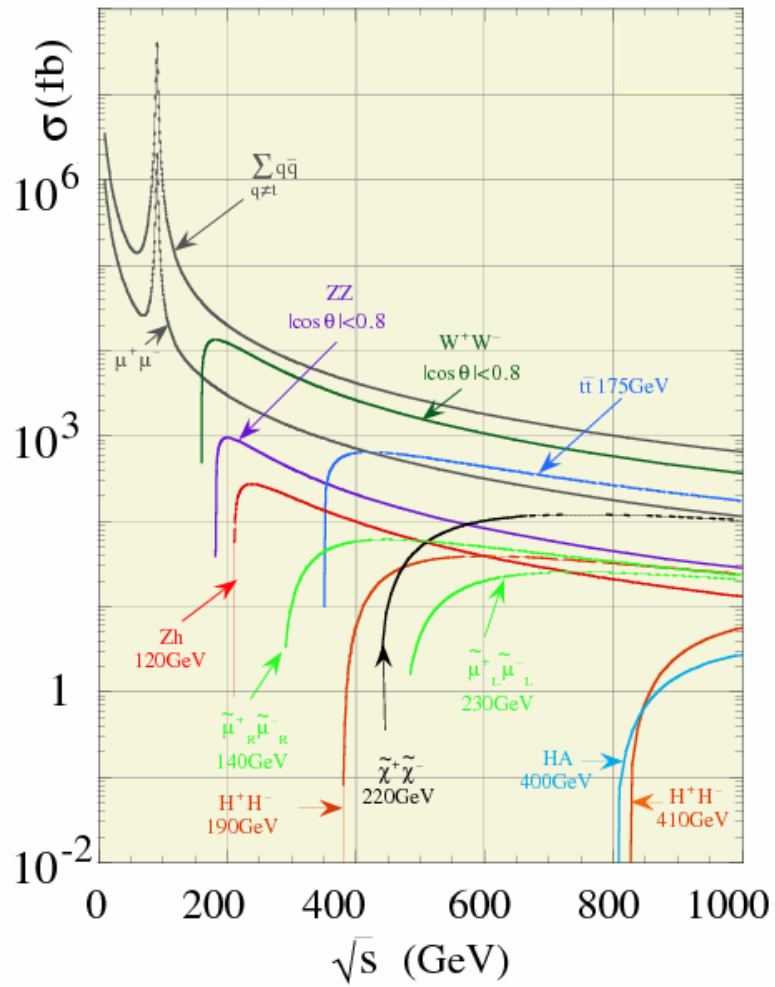


WW double-Higgs fusion: $e^+e^- \to \bar{\nu}_e\nu_e hh$



$\sqrt{s} = 800\ GeV$

Expected signal for 500fb-1 is ~100 events



Why Higgs self coupling measurement analysis ?

- important process for

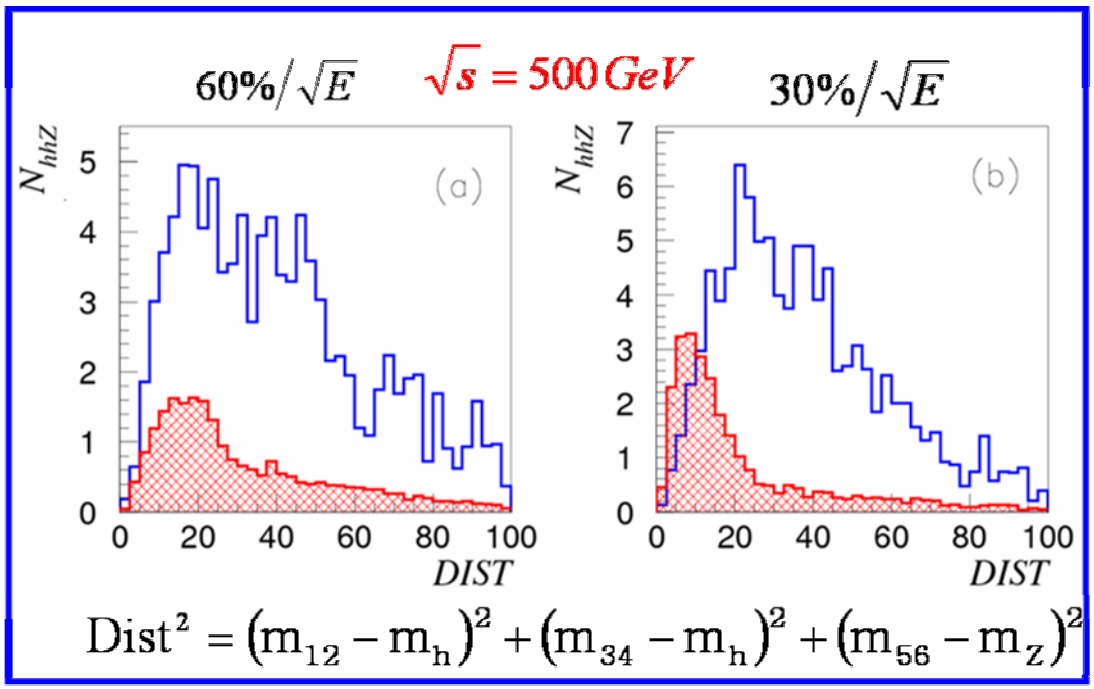
- **Physics consideration**
  - directly check the Higgs mechanism hypothesis

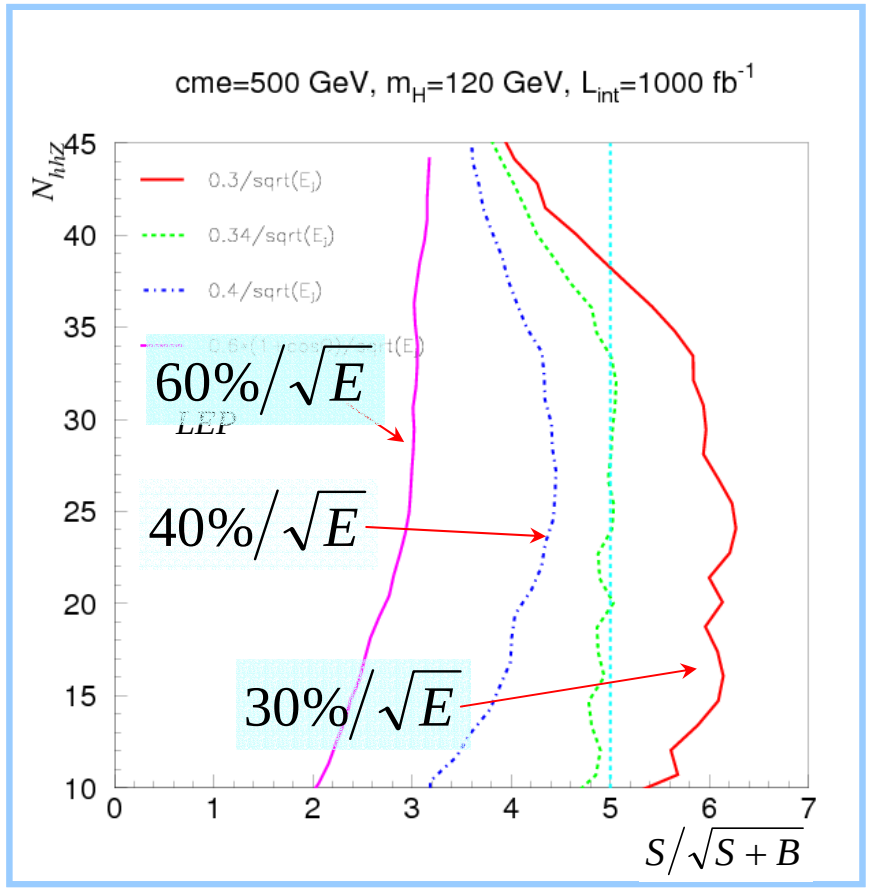
Unique @ ILC

But makes sense if precision on g_{hhh} below ~10%

- **Analysis considerations**
  - Cross section is **really low** (0.15 fb)
  - **Multi jets environment**
    - (6/4 jets if low Higgs mass, 10/8 jets if Higgs decays in W/Z pairs)
  - **b-quark content** is important, separation w/ charm seems to be mandatory
  - **High center of mass energy** is requested
    - WW fusion, end caps & forward region
  - Jet reconstruction (via **Pflow**) is essential
    - Background are multi boson production (WWZ, ZZZ, $\nu\nu$WW, $\nu\nu$ZZ, bWbW...)
  - Final state w/ (potentially) energy constraint (hhZ) and w/ **no energy constraint** ($\nu\nu$hh)

Impact of the Pflow resolution *(fast simulation)*





Any improvements done on the the detector will save data taking

40%->30% move from 4.5 to 2 years data taking

How to move to full simulation for such Physics analysis process ?

How to move to full simulation for Physics Analysis?

- **Direct solution : do everything with full simulation!**
  (including detector & reconstruction)

  - For signal as hhZ, $\nu\nu$hh does not seem to be a problem
  - background processes present huge cross sections
    - Produce them one time, and again for any change of the detector geometry! Do/redo it for at different centre of mass energies

  Enormous CPU and storage resources are mandatory

tt @800GeV represents 10^6 events for 2 ab^{-1}

a very minimal 'MC' statistics would be 5X10^6 for only one center of mass energy

- Or remove a part of the background with loose cuts at the generator level
  Introduces many biases ➔confidence on the result could be largely depreciated

How to move to full simulation for Physics Analysis?

Alternative

- **Elaborate a Realistic Fast simulation**

not a simple smearing of the particles with thresholds

Steps:

a) **Inputs information will come from full detector simulation and reconstruction algorithms derived from it**

b) **Tune Realistic Fast Simulation on signal until it reproduces the full simulation for complex objects (jets, dijets, b/c jets)**

Observables should be defined

c) **When the agreement is obtained ➔Run the whole background trough the Realistic Fast Simulation**

d) **move to the sophisticated Analysis method to extract the Physics with higher precision (fit, likelihood, multivariable analysis, etc)**

Parameterization mapping

For each set of geometry +reconstruction algorithms, elaborate a set of parametrisation which reflects performance

From simple to complex "objects"

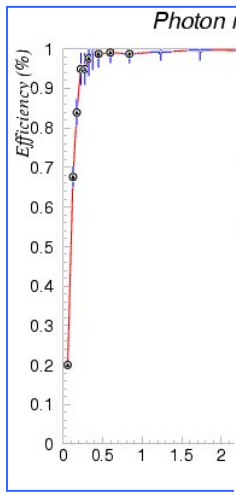
Isolated particles : efficiencies, resolutions, Identification, satellites, …according energy, direction

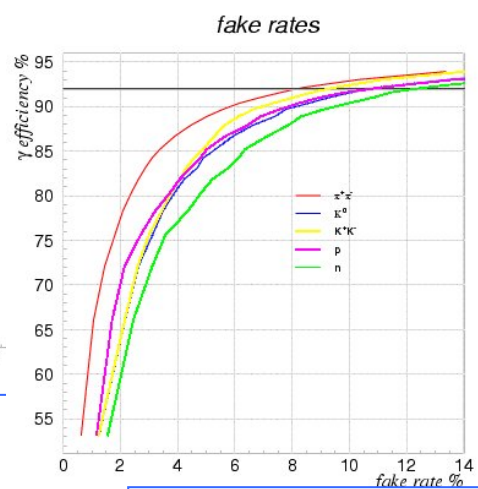
Couples of particles : (e.g. π/γ h/γ□...)

efficiencies, resolutions, fake rates, according to their energy, directions, separation between them

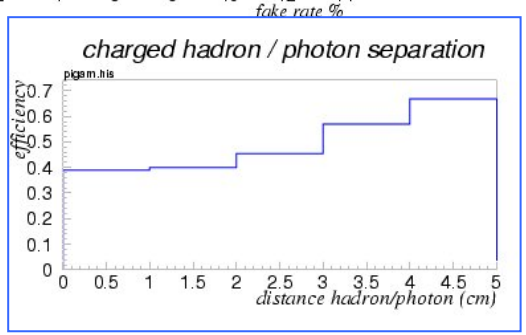
Followed by jets

Similar things for flavor tag



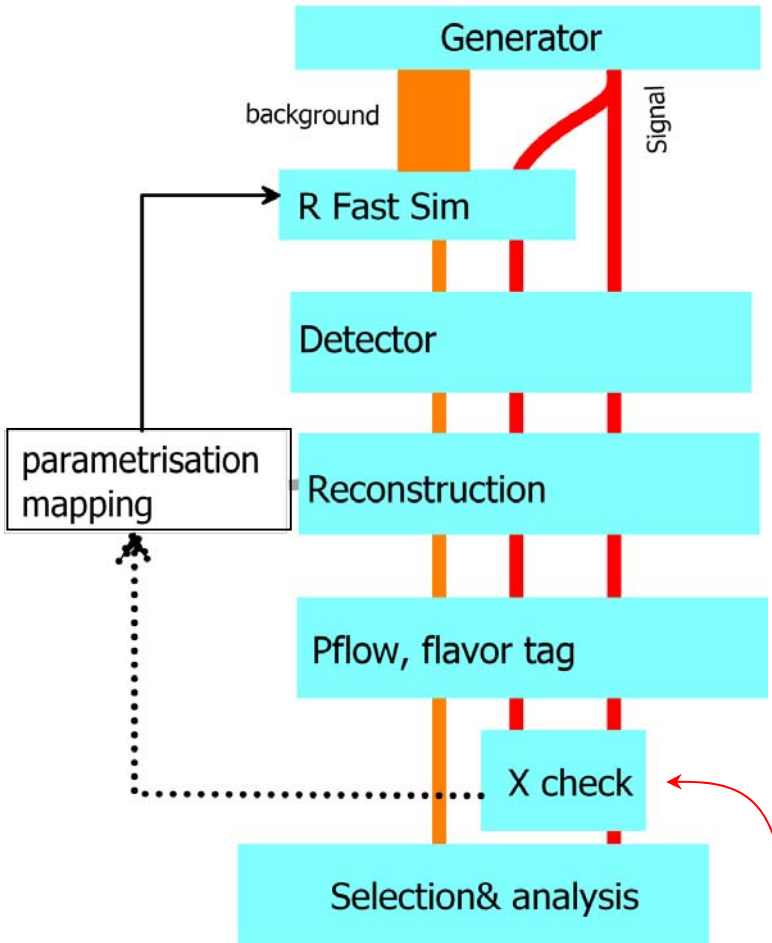


With full simulation of detector and reconstruction of WW @ 800 GeV



To reflect the benchmark processes the spectrum of particles may be extract from generated events & work face to the real situation we have to deal with

The idea is to process the same events in the different geometries (for different concept detectors, if possible)



Common sample

Analysis methods such as

- **constrained fits of boson masses,**
- **flavor tagging**

have to be tested in multi jet environment w/ full simulation

hhZ may be a good test

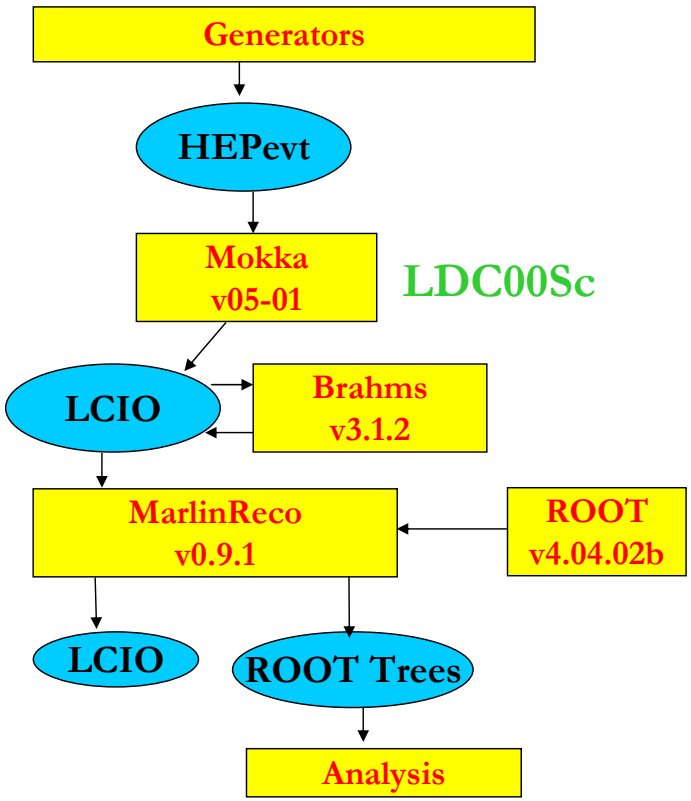
Check the agreement between Realistic Fast Simulation and Full simulation on Pflow & flavor tag performance

From generator to analysis

Or

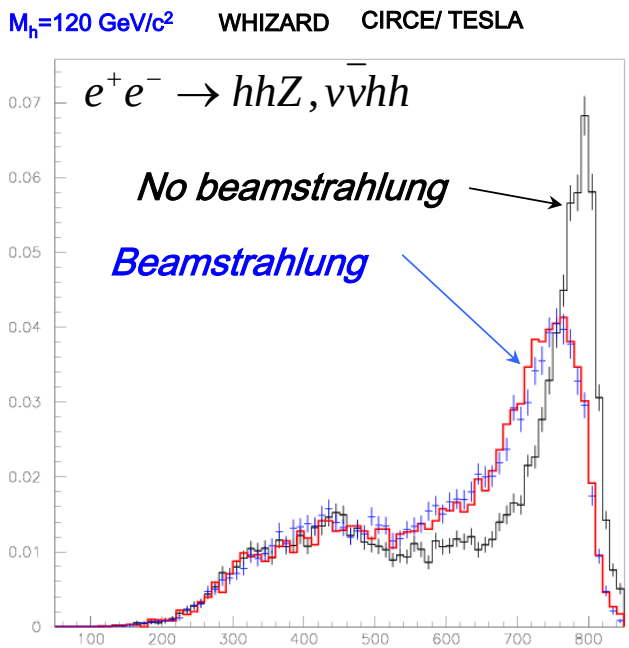
"Evaluate the possibility to draw a Physics analysis with the present software"

Test done in context of LDC



Relevance of the generators is discussed in the Physics group,

take care of the impact of the beamstrahlung, ISR, MDI



Marlin Reco processors

- **processors used to perform the analysis** (only pragmatic solution, not definitive)
  - Tracker Hit digitization -> VTXDigi, FTDDigi, TPCDigiProcessor
  - Calo Hit digitization -> SimpleCaloDigi
  - Track reconstruction -> TrackCheater
  - Cluster Reconstruction -> TrackwiseClustering
  - Matching Cluster to Track -> Wolf
  - Pflow -> Wolf
  - Jet clusterisation -> SatoruJetFinder
  - Shape variables -> ThrustReconstruction, Sphere, Fox

Preliminary Comments

- **no flavor tag yet interfaced**
- **soft track reconstruction**
- **matching simulated/recons object**
- **Jet Clusterisation 6, 10 jets is a delicate topic**
  - **Different situation compare to Z pole or LEP2**
  - **Need a deep study (remark already valid w/ fast simulation)**
  - **May have a large impact on result**

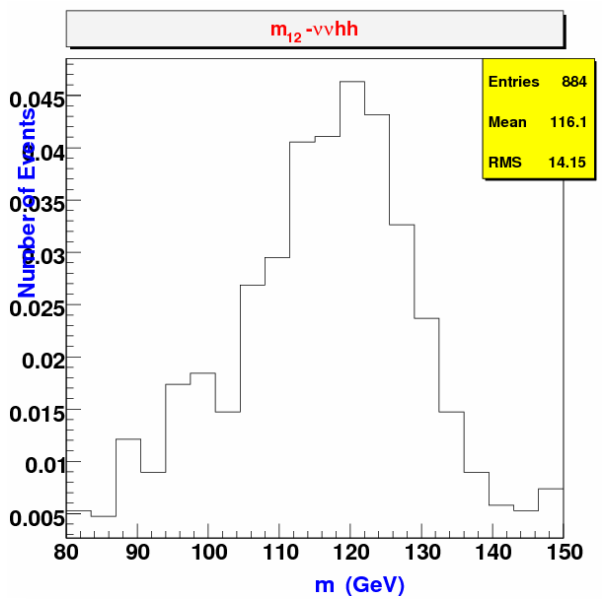
Very preliminary Analysis

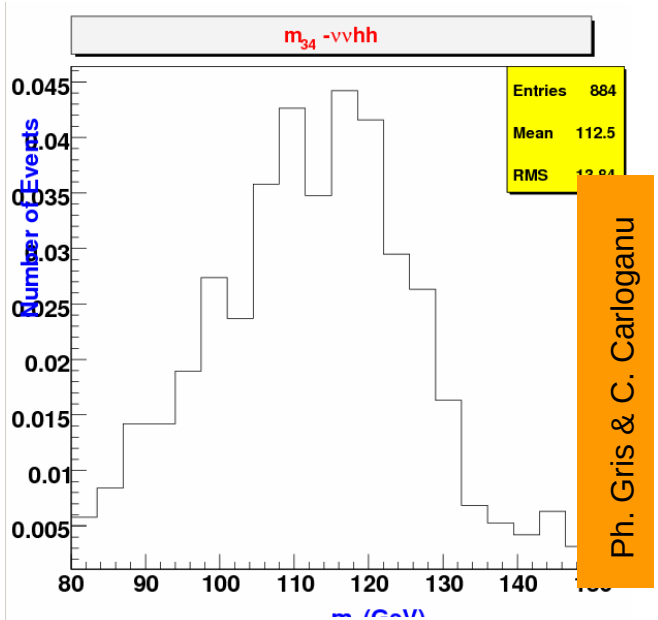
Full simulation

$$e^+e^- \rightarrow \bar{\nu}_e \nu_e hh$$

$$\sqrt{s} = 800 GeV$$

- 4 b jets
- Beamstrahlung
- No constraints
- No selection cuts





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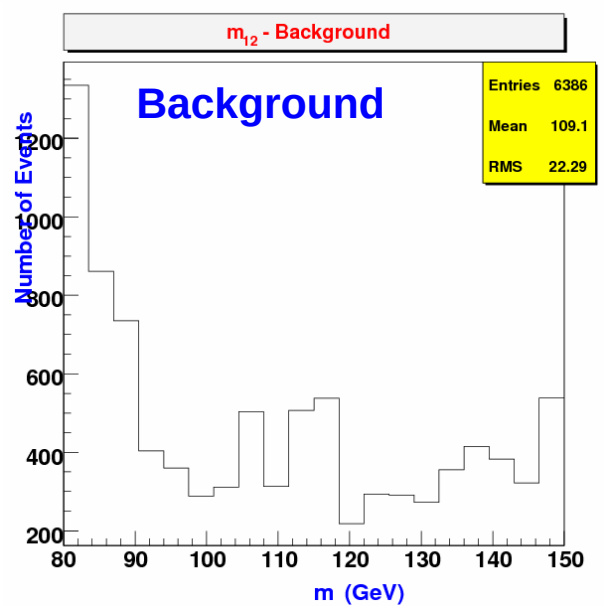
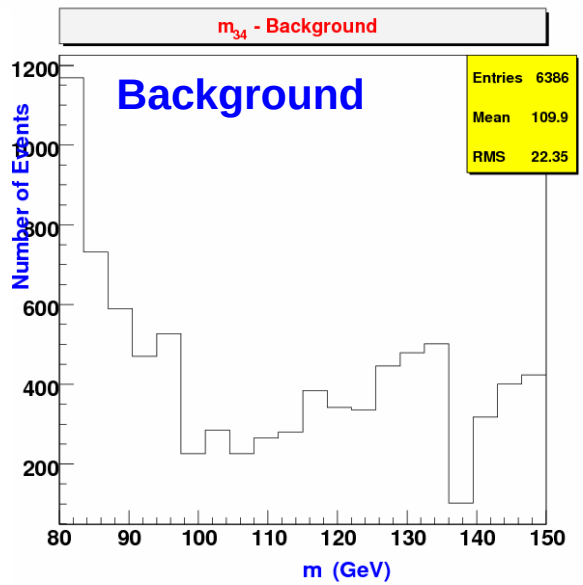
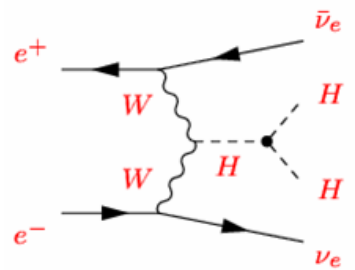


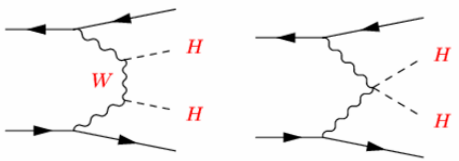


Background "full simulation"
~0.3 fb-1 simulated

tth	1k
ttZ	1k
tt	1k
hZ	1k
eeZZ	1k
WW	1k
WWZ	1k

$e^+e^- \to \bar{\nu}_e \nu_e hh$





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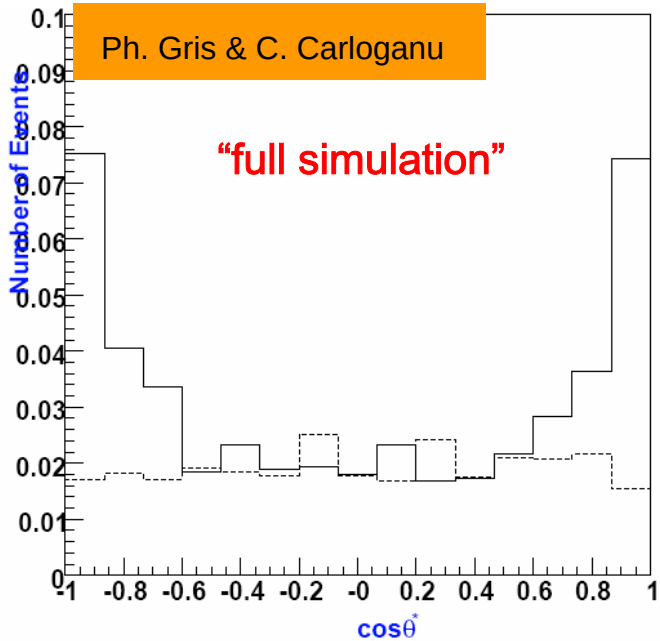

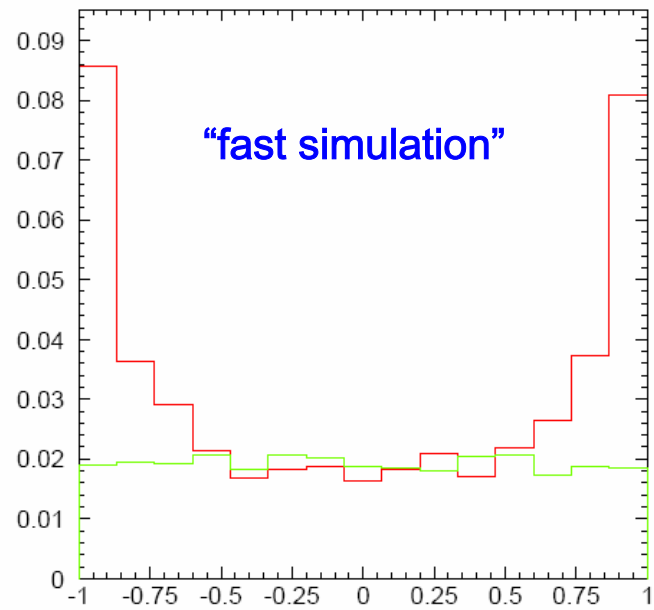

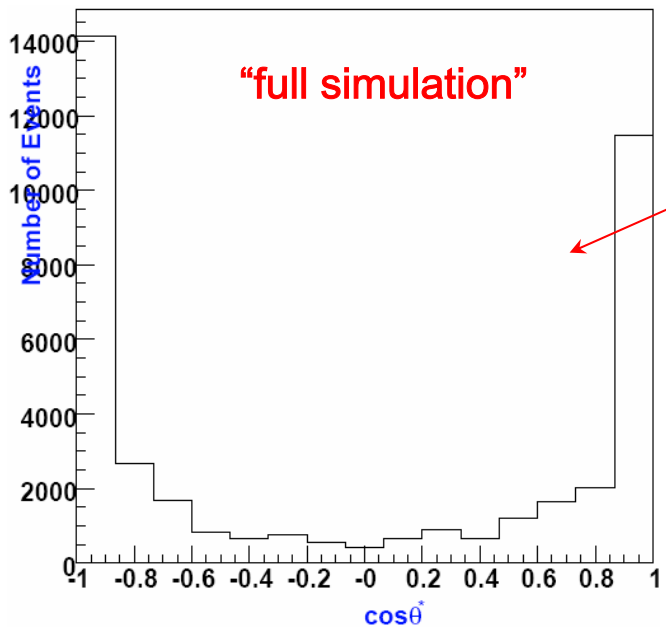

signal

background

Plots given for 10fb-1

Contribution sensitive to g_{hhh} is only a part of the hhZ and $\nu\nu$hh final states

Summary

on the example of hhZ and $\nu\nu$hh Physics analysis

- **Framework to perform Physics Analysis in full simulation is there**
- **Basic tools are "mostly" there (an interface w/ Flavor tag is important)**

- **Pflow, flavour-tag need to be tested in a multijet environment @ 500 GeV and higher energy**
- **Performance of constrained mass fit have be tested with full simulation**
  - **e.g. Separe hhZ from WWZ, or from ZZZ w/ help Pflow,flavor tag and CF**

- **A realistic Fast Simulation(*) have to be elaborate to deal with the huge amount of background to be analysied ➔Common Physics analysis tool**

- **hhZ @500 GeV and $\nu\nu$hh@800 GeV are excellent candidates for the exercise**
- **It would be a step to progress on the challenging measurement of the self Higgs coupling and detector optimization**

(*) Realistic means "which reproduces the full simulation detector&recosntruction"