Brandenburgische Technische Universität Cottbus

Analysis of Higgs recoil mass accounting for background processes using MOKKA and MarlinReco

M. Ohlerich , A. Raspereza, W. Lohmann

LCWS 2007, Hamburg

Outline

- Introduction
- Analysis details
- Results
- further Considerations / Outlook

Our Collaboration

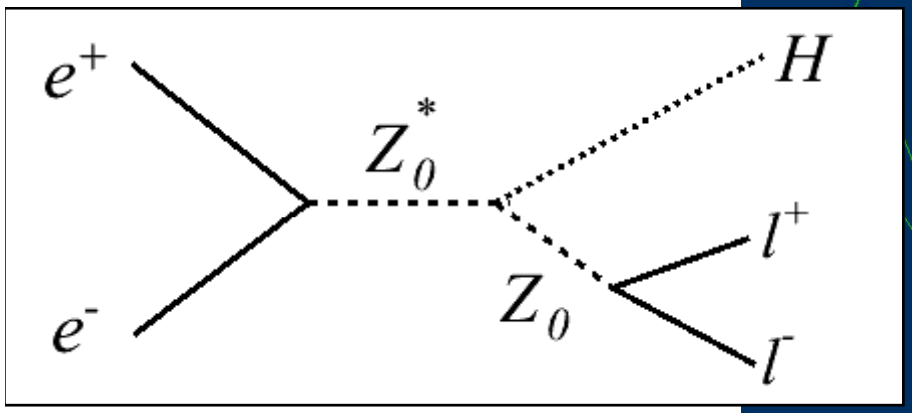
DESY (Zeuthen): W. Lohmann, M.O., A. Schälicke
(Hamburg): K. Wichmann

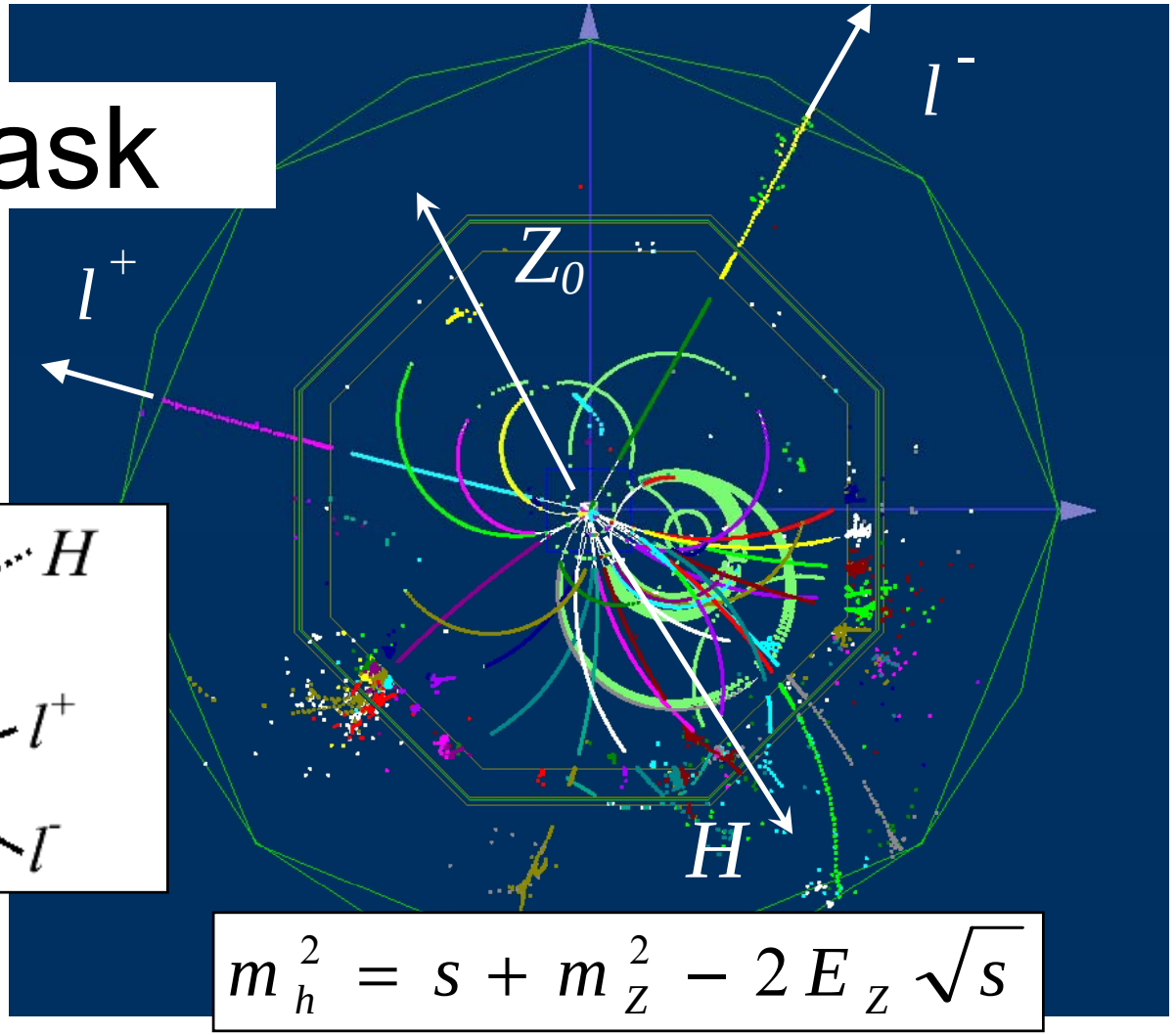
MPI (München): A. Raspereza

LAL (Orsay): H. Li, R. Pöschl, M. Ruan

Our Task

- Higgs-Strahlung-Process:





- Higgs-Recoil-Mass

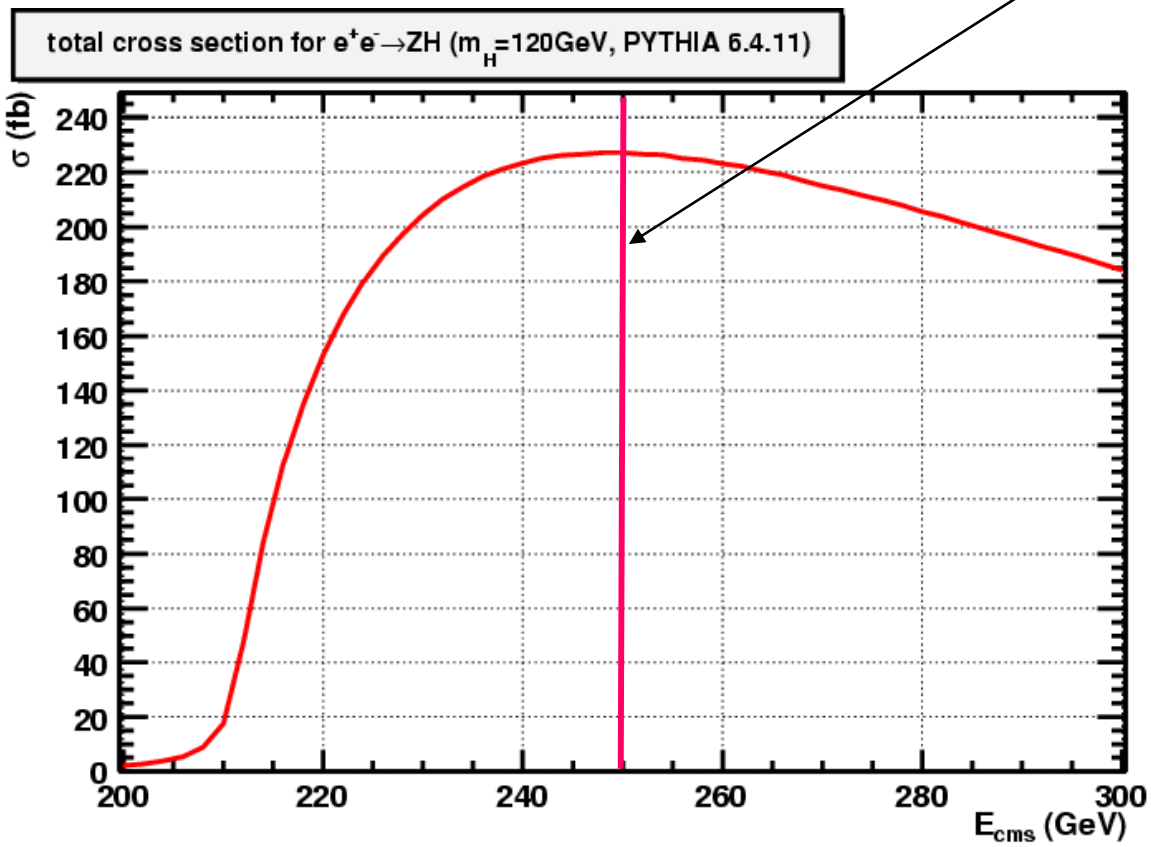
$$m_h^2 = s + m_Z^2 - 2 E_Z \sqrt{s}$$

- Coupling Strength (model independent)

$$g_{ZZH}^2 \propto \sigma = N / L \varepsilon$$

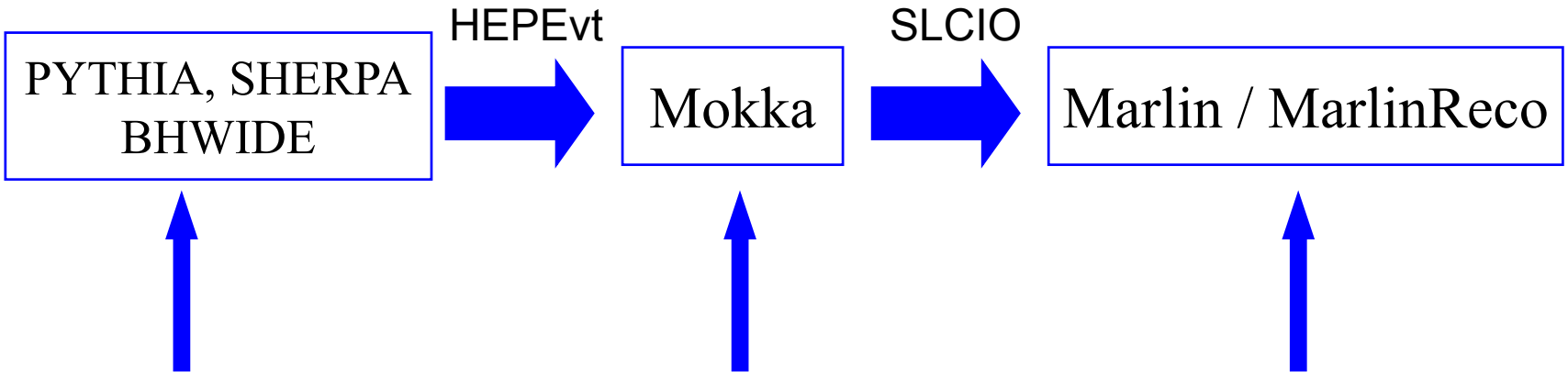
For Our Studies ...

SM - Higgs boson: m_H = 120 GeV, E_{cms} = 250 GeV



Simulation Process

Software for ILC / LDC (LDC01Sc)



- create events
- include BS, ISR, FSR

- detector-simulation

- full reconstruction of isolated leptons
  - dilepton reconstruction
    - Higgs Recoil Mass + Analysis

Signal + BG Processes (E_{cms}= 250 GeV)

$e^+e^- \rightarrow ZH \rightarrow llX$

$e^+e^- \rightarrow ZZ \rightarrow llX$

$e^+e^- \rightarrow \mu^+\mu^-(\gamma)$

$e^+e^- \rightarrow W^+W^-$

$e^+e^- \rightarrow \tau^+\tau^-(\gamma)$

$e^+e^- \rightarrow e^+e^-(\gamma)$

m_H = 120 GeV

PYTHIA

BHWIDE

Maybe better approach for BG in consistent way:

$e^+e^- \rightarrow e^+e^-\bar{f}f$

$e^+e^- \rightarrow \mu^+\mu^-\bar{f}f$

$e^+e^- \rightarrow \mu^+\mu^-e^+e^-$

SHERPA

$e^+e^- \rightarrow \mu^+\mu^-(\gamma)$

$e^+e^- \rightarrow e^+e^-(\gamma)$

$e^+e^- \rightarrow \tau^+\tau^-(\gamma)$

PYTHIA / BHWIDE

Detailed Analysis Steps

MarlinReco

reconstructed particles with particle ID,
isolated leptons (10˚),
polar angle cut ($|\cos\theta_{lepton}|<0.95$),
μ- and e-pair collections
+ selected pair with $m_{dilepton}$ closest to m_Z

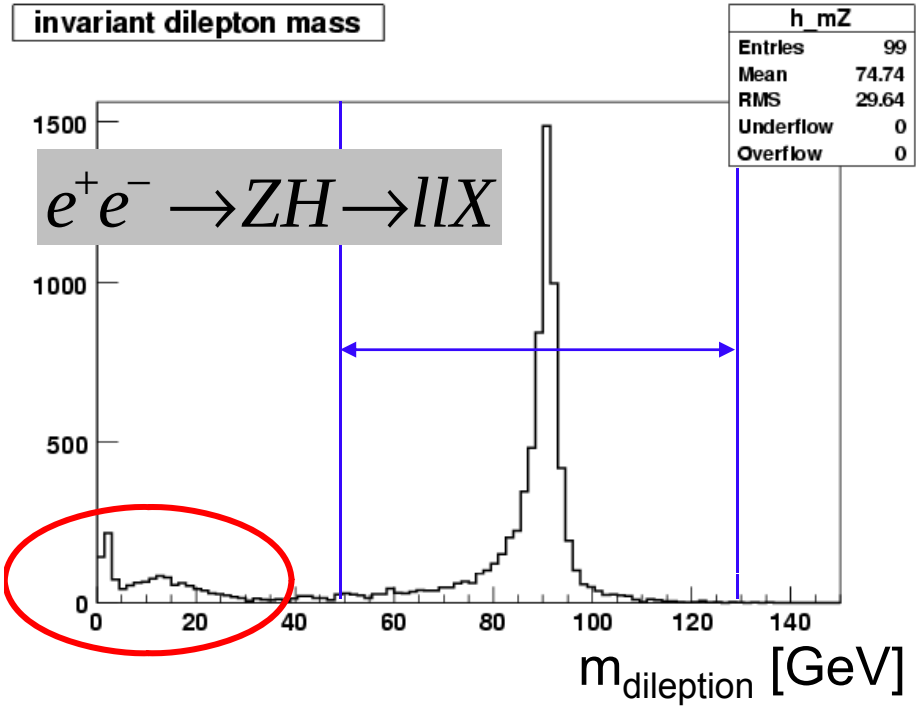
Analysis step 1
with ROOT

loose cuts on polar angle, invariant mass,
recoil mass, acollinearity, acoplanarity
to reduce background & fake events

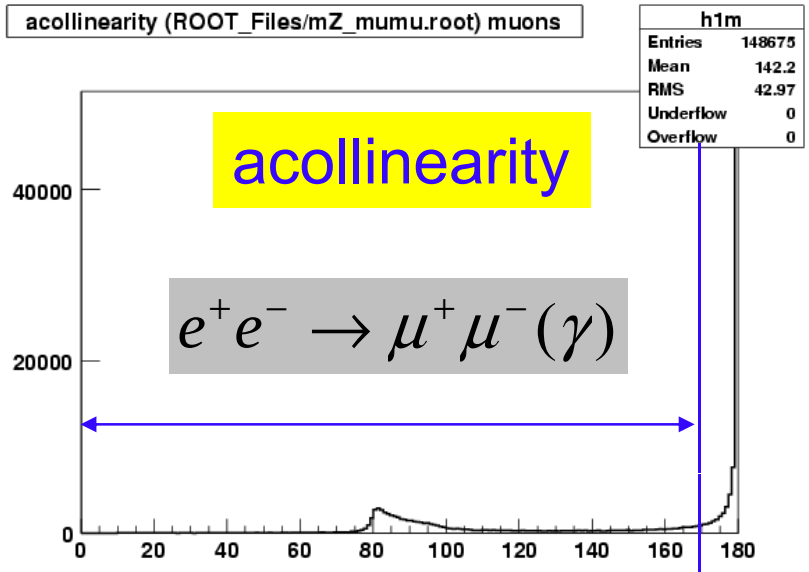
Analysis step 2
with ROOT

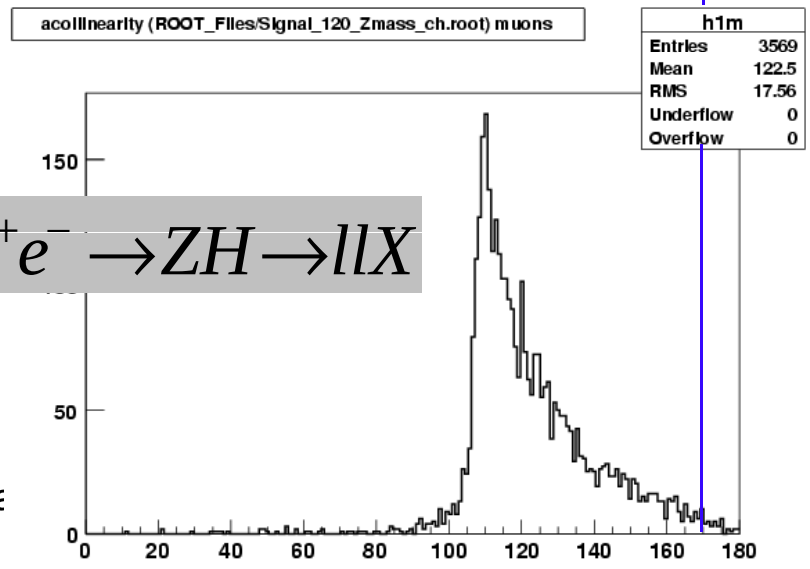
signal likelihood cut for e, μ channel
for improving Signal-to-BG ratio
⇨ as signal accepted events

Examples for cuts ...



fake signals due to
low energy electrons



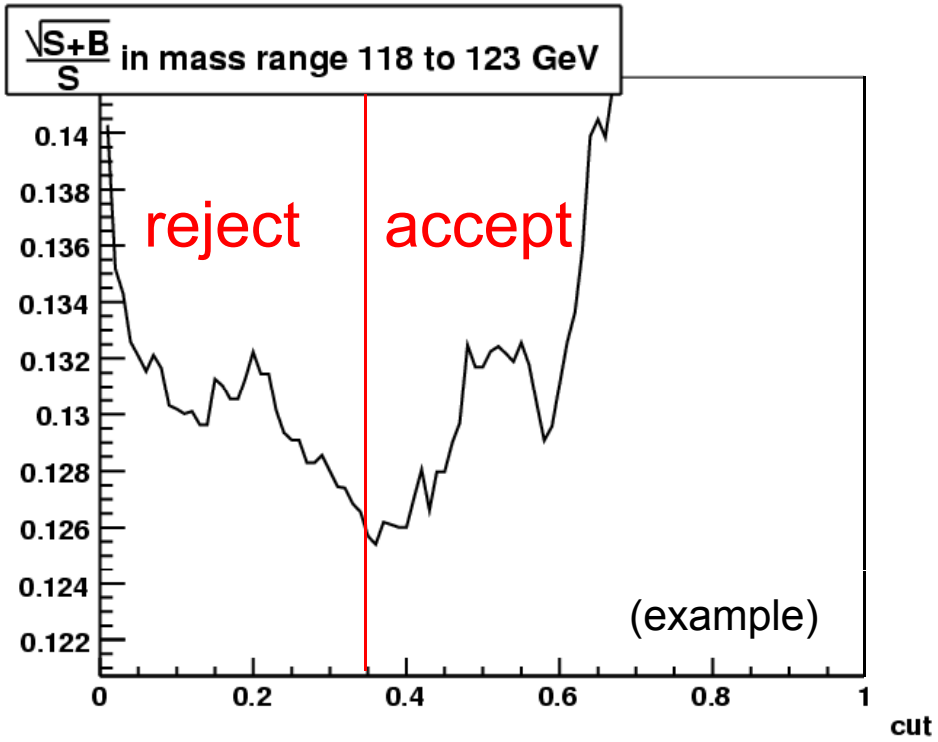


Signal Likelihood Cut

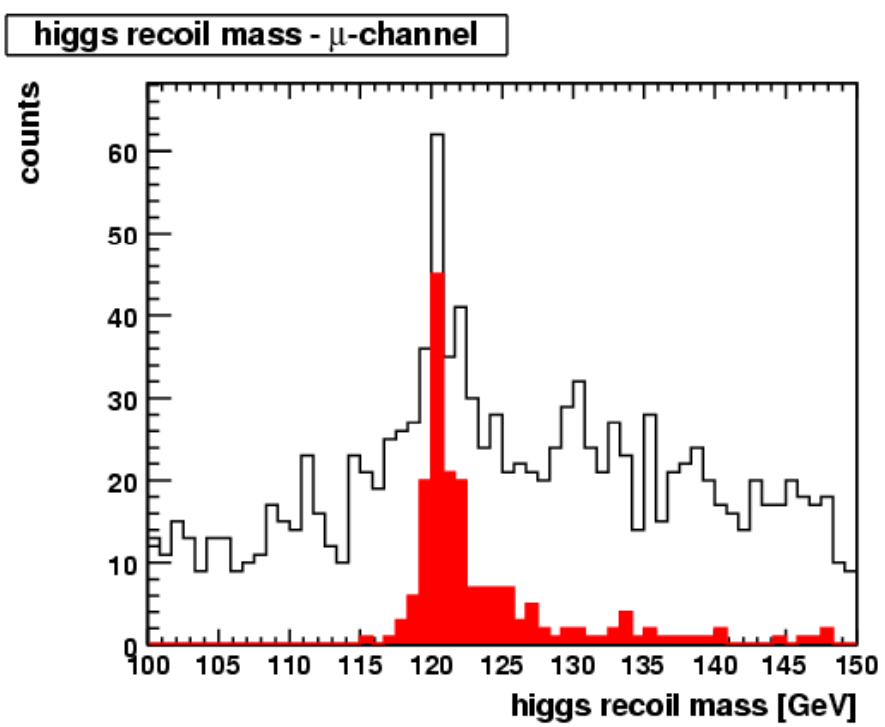
Likelihood variables: acollinearity, acoplanarity,
invariant dilepton mass, missing p_T
polar angle of lepton and dilepton

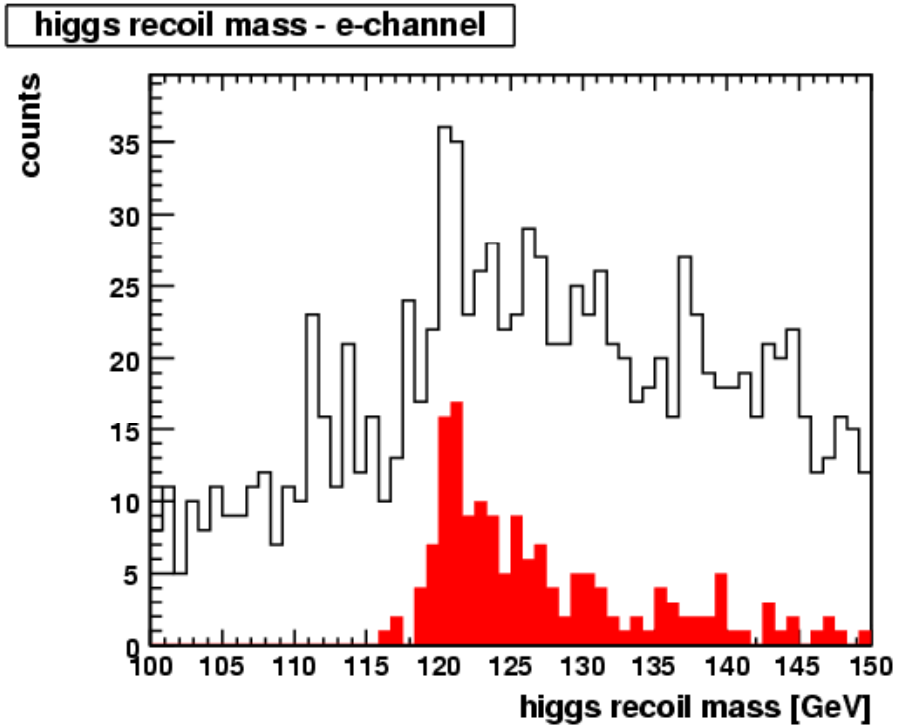
Likelihood classes: 1 Signal class, several BG classes

Likelihood cut optimized for best signal-to-BG ratio:



Spectra after Likelihood cut (50 fb^{-1})





muon channel as expected more significant

strong smearing effects for electrons

Losses in Analysis

After Marlin:

Correctly reconstructed events:	~ 68.8 %
wrong pre-selected pairs:	~ 0.3 %
rejected by lepton polar angle cut:	~ 11.0 %
rejected by isolation criterion:	~ 13.7 %
no assignment:	~ 6.2 %

(but seem homogeneously distributed among above)

After loose cuts: ~ 50 %

After signal likelihood cut (perfect separation between channels):

e-channel:	~ 35.7 %
μ-channel:	~ 44.2 %

background reduction efficiency

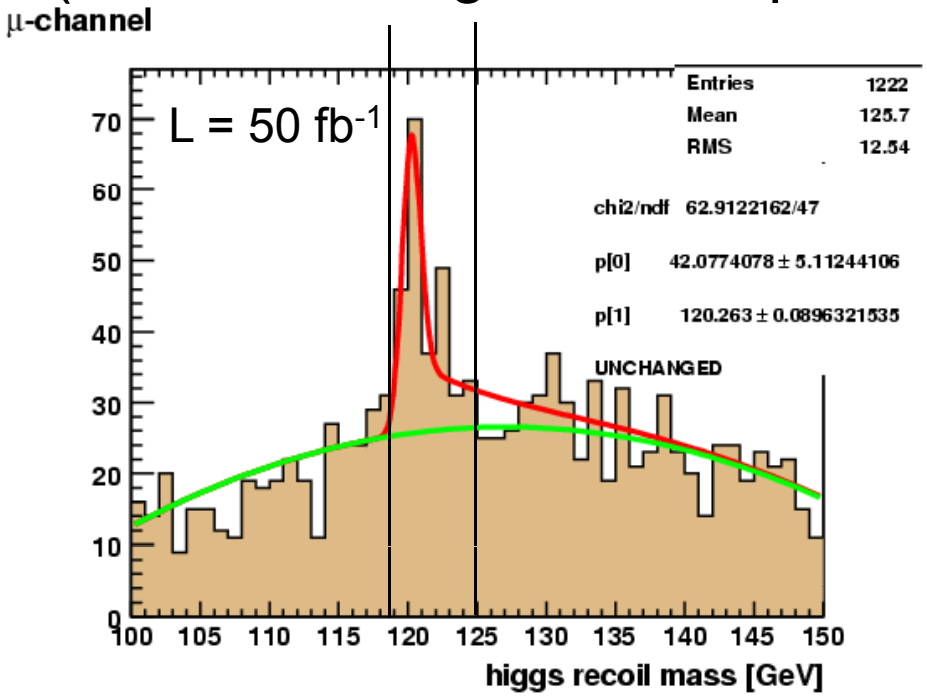
total number of generated background events: 607312

		after MarlinReco	after cuts	after likelihood
$e^+e^- \to WW$	e-ch.	16762 (100 %)	2867	278 (1.6 %)
	μ-ch.	8488 (100 %)	2347	280 (3.3 %)
$e^+e^- \to ZZ$	e-ch.	5548 (100 %)	2675	304 (5.5 %)
	μ-ch.	4424 (100 %)	2653	386 (8.7 %)
$e^+e^- \to e^+e^-$	e-ch.	11277 (100 %)	4803	233 (2.1 %)
	μ-ch.	0	0	0
$e^+e^- \to \mu\mu$	e-ch.	71	0	0
	μ-ch.	126026 (100 %)	6975	492 (0.4 %)
$e^+e^- \to \tau\tau$	e-ch.	9716	196	1
	μ-ch.	3973 (100 %)	125	11 (0.3 %)

total: 1985

Parameter Extraction - X-section

(Gaussian + right side Exponential) + BG curve



Error on X-section:

$$\frac{\delta\sigma}{\sigma} = \frac{\text{error of norm}}{\text{norm}} \approx 12.1\%$$

(for muons only!)

---

mass window: 119 -125 GeV

$$\frac{\delta\sigma}{\sigma} = \frac{\sqrt{S+B}}{S}$$

	selection efficiency	BF(Z→ll)	X-section
e :	17.7%	0.03366	252.1 fb ± (18.7%)
μ :	32.0%	0.03367	242.6 fb ± (12. 5%)

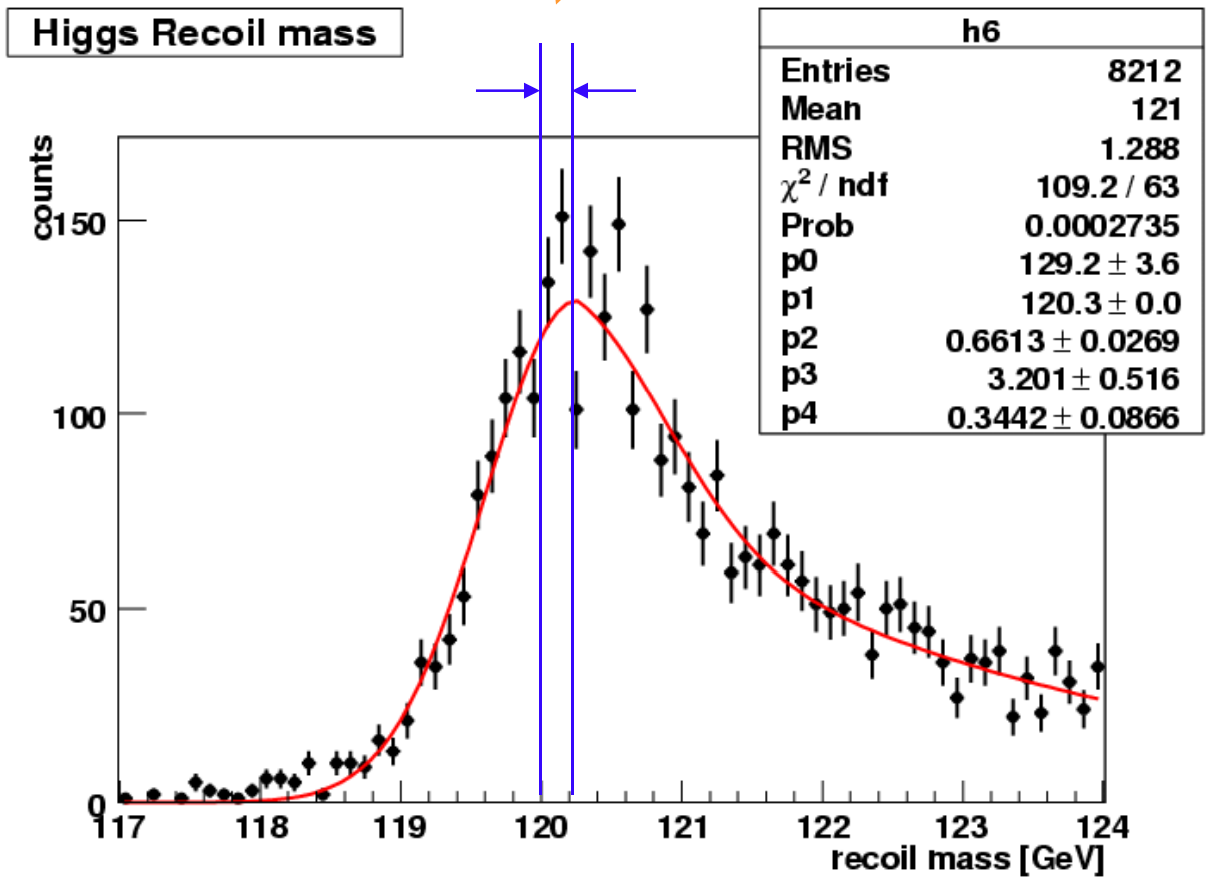
combined X-section: 245.4 fb ± (10.4%) (orig: 230 fb)

Parameter Extraction - Recoil mass

For Higgs recoil mass:
= mean of Gaussian

120.26 ± 0.0352 GeV

Bias!! (increases with E_{cms})



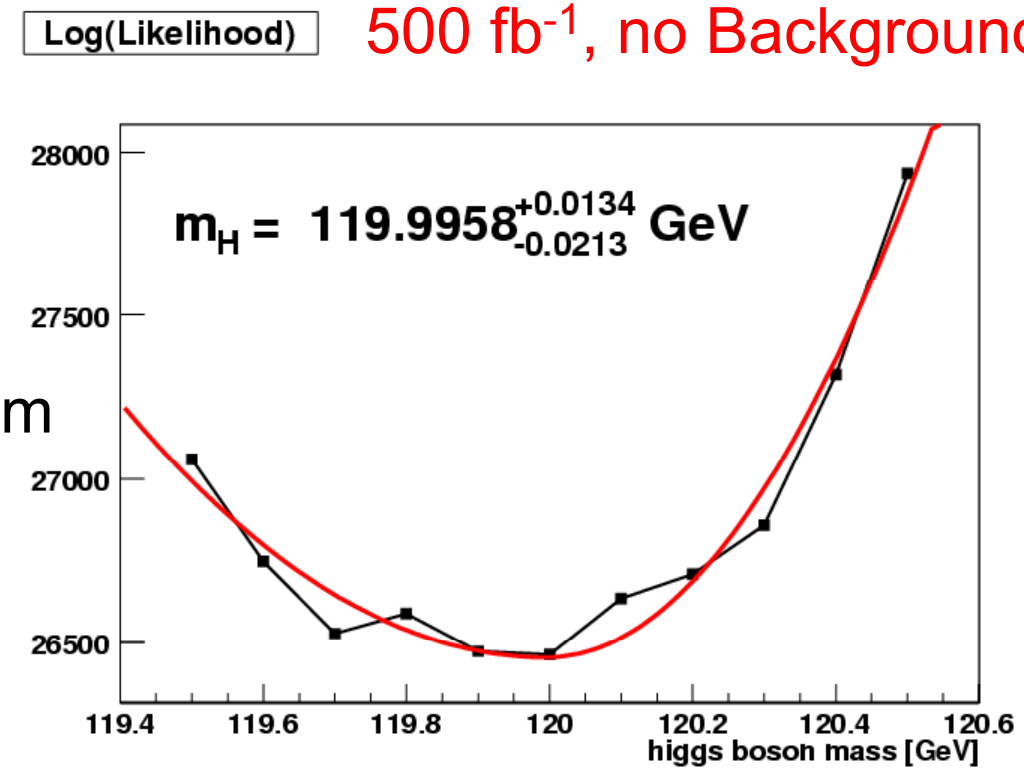
Higgs Recoil Mass

Event Generator : create samples for different Higgs mass values

Detector Simulation / Reco

Calculate the likelihood from histrogrammed spectra

No Bias



500 fb^{-1}, no Background

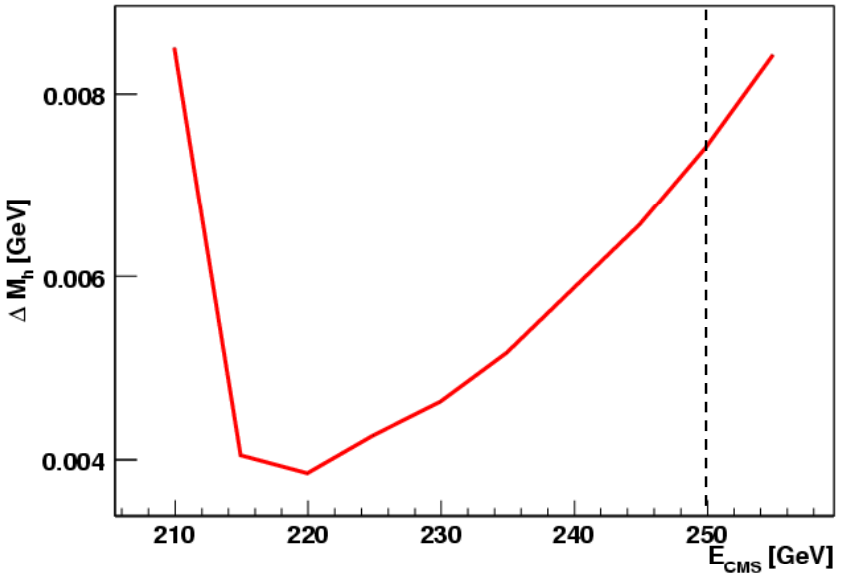
Errors due to parameter fitting reducible by higher MC statistics

Further Considerations

MC Toy: m_H = 120 GeV

for X-section all effects included
(ISR, FSR, momentum blur)
for mass width only momentum blur

error of recoil mass

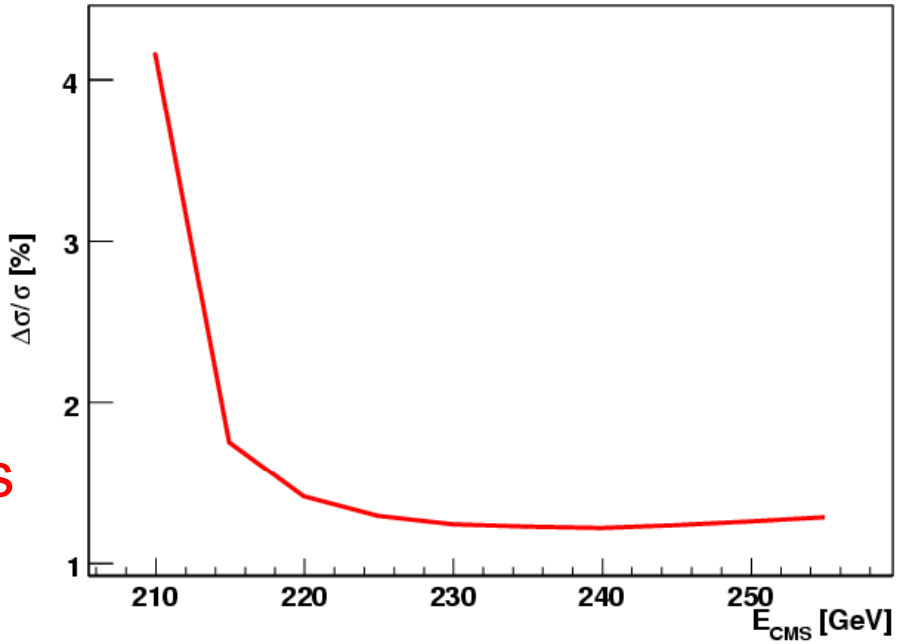


X-section improves (statistic)

momentum resolution improves

⇨ mass resolution improves

relative error of cross section



What can be done else?

- Include jet-decay events of Z into analysis
- Technical improvement of errors:
  polarization, $E_{cms} \rightarrow 230$ GeV
- Improved method for extraction of Higgs Recoil Mass

Thanks to our collaborators!