BSM Search using Higgs to Invisible Decay

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Outline

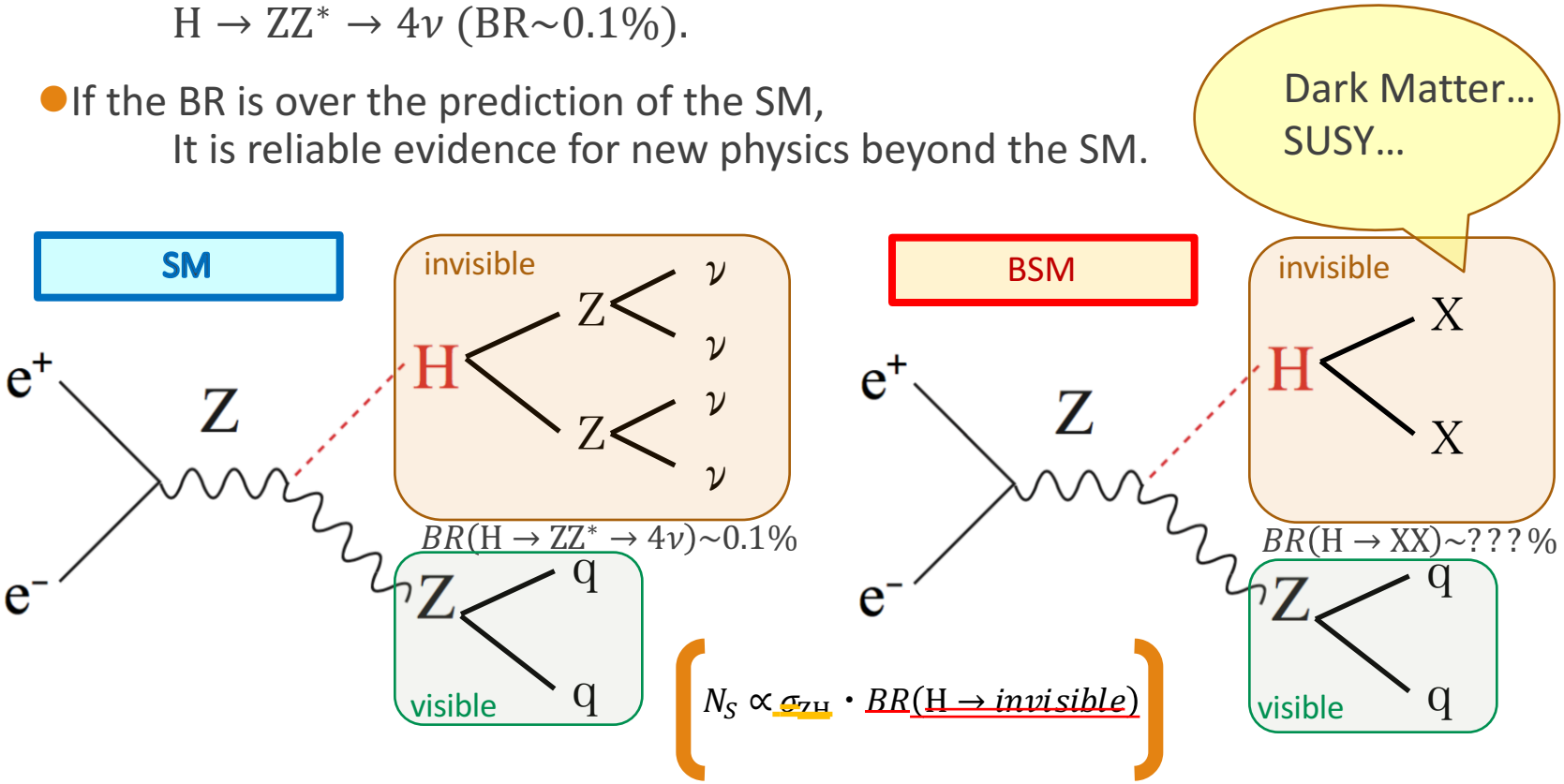
- Status
- Higgs to Invisible Decay
- Recoil Mass Method
- Plans

Status

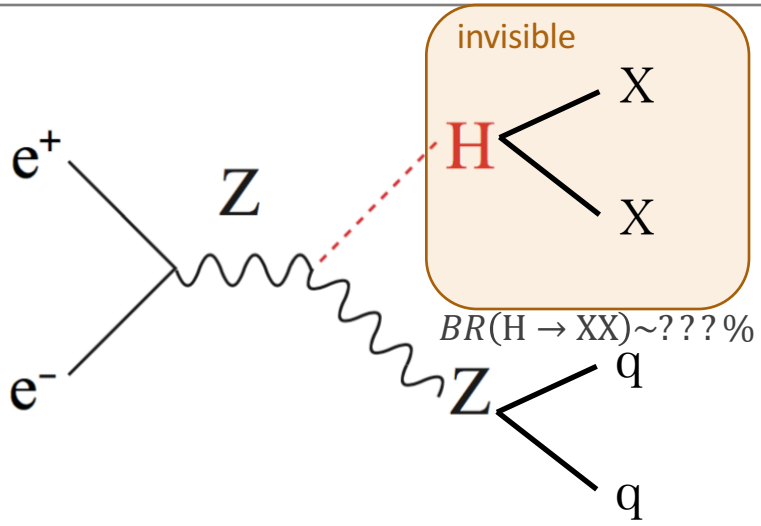
- I became a master course 1st year student this April, and joined ILC physics group.
- I plan to study BSM Search using Higgs to Invisible Decay.
- First, in order to understand analysis method, I reproduced Higgs recoil mass study of J.Yan.
- Now I moving to study of Higgs to invisible.

Higgs to Invisible Decay

- In the SM, Higgs decays invisibly through the process
  $\mathrm{H} \rightarrow \mathrm{ZZ}^{*} \rightarrow 4\nu$ (BR~0.1%).
- If the BR is over the prediction of the SM,
  It is reliable evidence for new physics beyond the SM.



Signal feature



- Two-Jet
- Invisible particle exist
- $M_{qq} \approx M_Z$ $(BR(\mathrm{Z} \to qq) \sim 70\%)$
- $M_{recoil} \approx M_{Higgs}$

Major Backgrounds

The major backgrounds have the final states qqll,qqlv,qqvv.

1. ZZ semileptonic
2. WW semileptonic
3. $\mathrm{Z}\nu_e\nu_e, \mathrm{Z} \to \mathrm{qq}$
4. $\mathrm{W}\nu_e\nu_e, \mathrm{W} \to \mathrm{qq}$

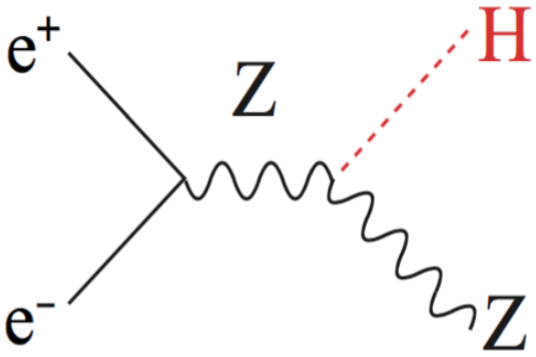
Recoil Mass Method

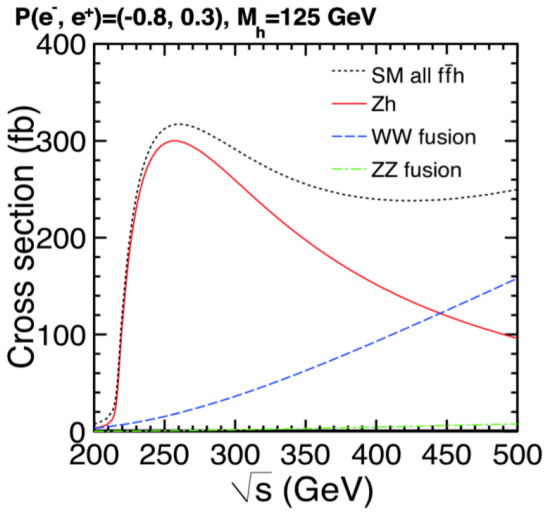
- For my study, I reproduced the study of Higgs Recoil Mass method.
- It is important for Higgs invisible decay study.
- Model independence
  - We can measure Higgs without the direct measurement of it.
  - Measure Higgs cross section and Higgs mass precisely.

$$\sigma_{\mathrm{ZH}} = \frac{N_S}{BR(\mathrm{Z} \to l^+l^-)\varepsilon_S L}$$

$$M^2_{rec} = (\sqrt{s} - E_{l^+l^-})^2 - |\vec{p}_{l^+l^-}|^2$$

- For this study, I used leptonic channel $Z \to l^+l^-$.
- For the search of BSM, I will also use hadronic channel $Z \to qq$.

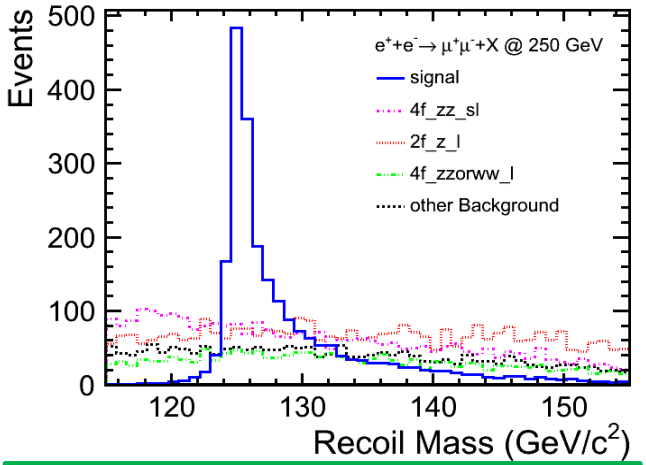




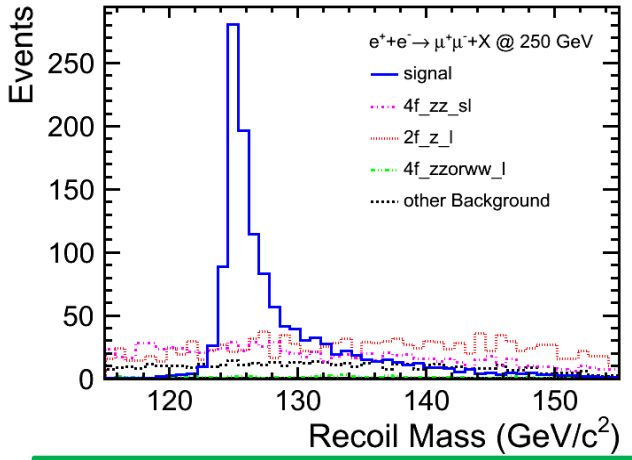
Reproduce Recoil Mass Result

Ref. ： J.Y. et al, arXiv:1604.07524

$e^- + e^+ \to \mu^- + \mu^+ + X$@250GeV



"Left":$P(e^-, e^+) = (-0.8, +0.3)$



"Right":$P(e^-, e^+) = (+0.8, -0.3)$

Isolated lepton selection

	μ ID	e ID
momentum and energy deposit	$p_{\text{track}} > 5$ GeV	$p_{\text{track}} > 5$ GeV
	$E_{\text{CAL,tot}}/p_{\text{track}} < 0.3$	$0.5 < E_{\text{CAL,tot}}/p_{\text{track}} < 1.3$
	$E_{\text{yoke}} < 1.2$ GeV	$E_{\text{ECAL}}/E_{\text{CAL,tot}} > 0.9$
impact parameter	$\lvert d_0/\delta d_0\rvert < 5$	$\lvert d_0/\delta d_0\rvert < 50$
	$\lvert z_0/\delta z_0\rvert < 5$	$\lvert z_0/\delta z_0\rvert < 5$

Best lepton pair

$$\chi^2\left(M_{l^+l^-}, M_{\text{rec}}\right) = \frac{\left(M_{l^+l^-} - M_Z\right)^2}{\sigma^2_{M_{l^+l^-}}} + \frac{\left(M_{\text{rec}} - M_H\right)^2}{\sigma^2_{M_{\text{rec}}}}$$

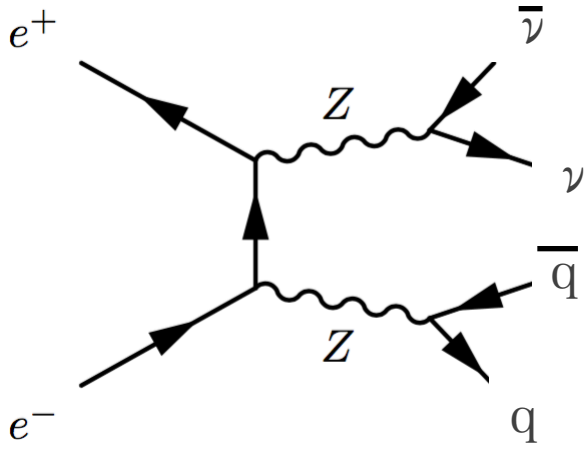
Cut	signal	2f_l	4f_l	4f_sl	total BG	Significance
0.Pre-Cut	2440	2638950	226080	77046	2942620	1.42
1.Lepton ID(muon)	2439	637356	61474	24060	722890	2.86
2.M_ll ∈[73,120]GeV	2382	430593	40072	22265	492929	3.39
3.p_T ∈[10,70]GeV	2335	82272	30227	15666	128164	6.46
4.|cos θ mis|<0.98	2335	42828	29955	15664	88447	7.74
5.BDT>-0.25(MVA)	2333	12822	19906	9058	41785	11.1
6.Evis>10GeV	2330	12422	5470	9058	26950	13.6
7.window	2314	3600	3688	3672	10959	20.1

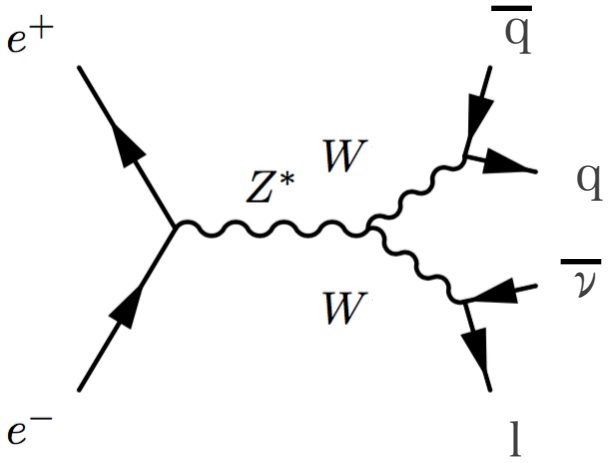
Plans

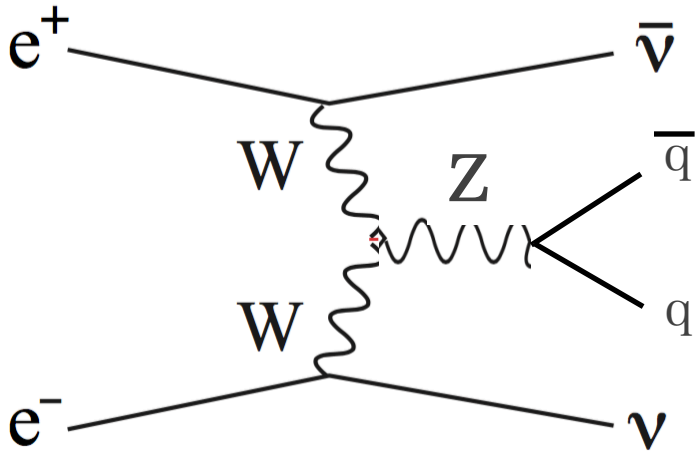
- Study analysis code
  - I will get the analysis code from Junping san
  - First, reproduce the leptonic channel, then hadronic channel
- Understand analysis method
  - Jet clustering algorithm
    - Apply to the hadronic channel
  - Kinematic Fitting
    - For good resolution
- Think of ways to improve measurement precision

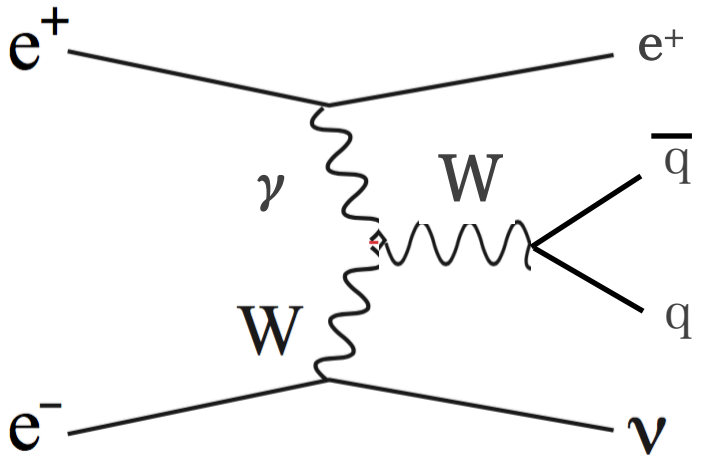
Back Up

Background









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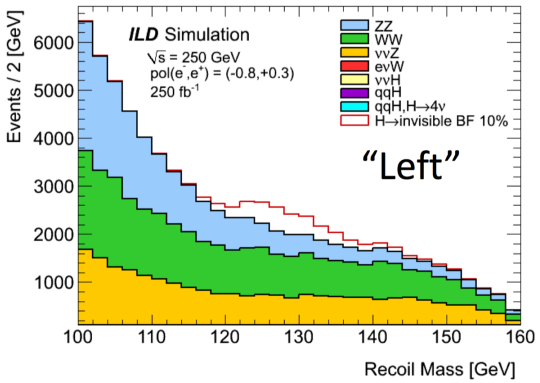
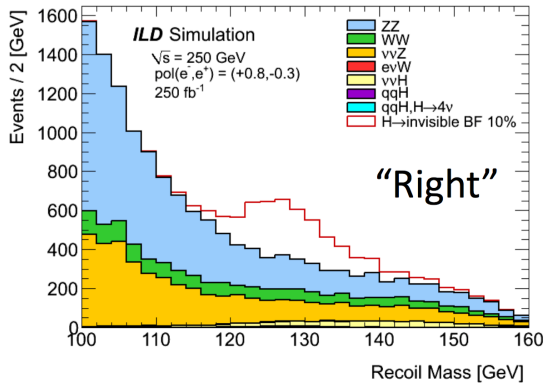
[先行研究]

引用:LCWS14 石川さんのスライドより





Signal

- Z由来のジェット対
- エネルギー損失がヒッグス質量に相当

Event Selection

1. jetの再構成[Durhamアルゴリズム]
2. 孤立レプトン除去
3. PFOの数、荷電粒子の飛跡数
4. jetからZ質量の再構成
5. Zの極角:$cos\theta_Z$
6. 反跳質量
7. 最尤法

by Toy MC

UL on BF [%]	"Left"	"Right"
250GeV	0.95	0.69
350GeV	1.49	1.37
500GeV	3.16	2.30