Weekly Summary

- Higgs->invisible (Yuhang)

  -- Arrange python selection code

- Higgs-> ZZ (Lingteng)

  -- run the other channel (ZH/BGs/ …)

- Ryuta: attend the Higgs analysis/LGAD meetings
(reading documents related to the LGAD)

should this topic included in the "ATLAS" ?

Yuhang's work:

1.Learn python.

2. Modified sel_events.py file. The following is my main process.

```
def run(self):
    #Cut eventflow and fill histrogram
    self.cut(self.t_in)
    #Fill root branches after cutting
    self.fill_root(self.t_in)
    #record the select efficiency
    self.out_eff(self.t_in,self.N,self.infile)
    #Write
    self.h_evtflw.Write()
    self.t_out.GetCurrentFile().Write()
    self.outfile.Close()
```

3.Prepared JC topic.

Some (scattering) topic on the Higgs analysis

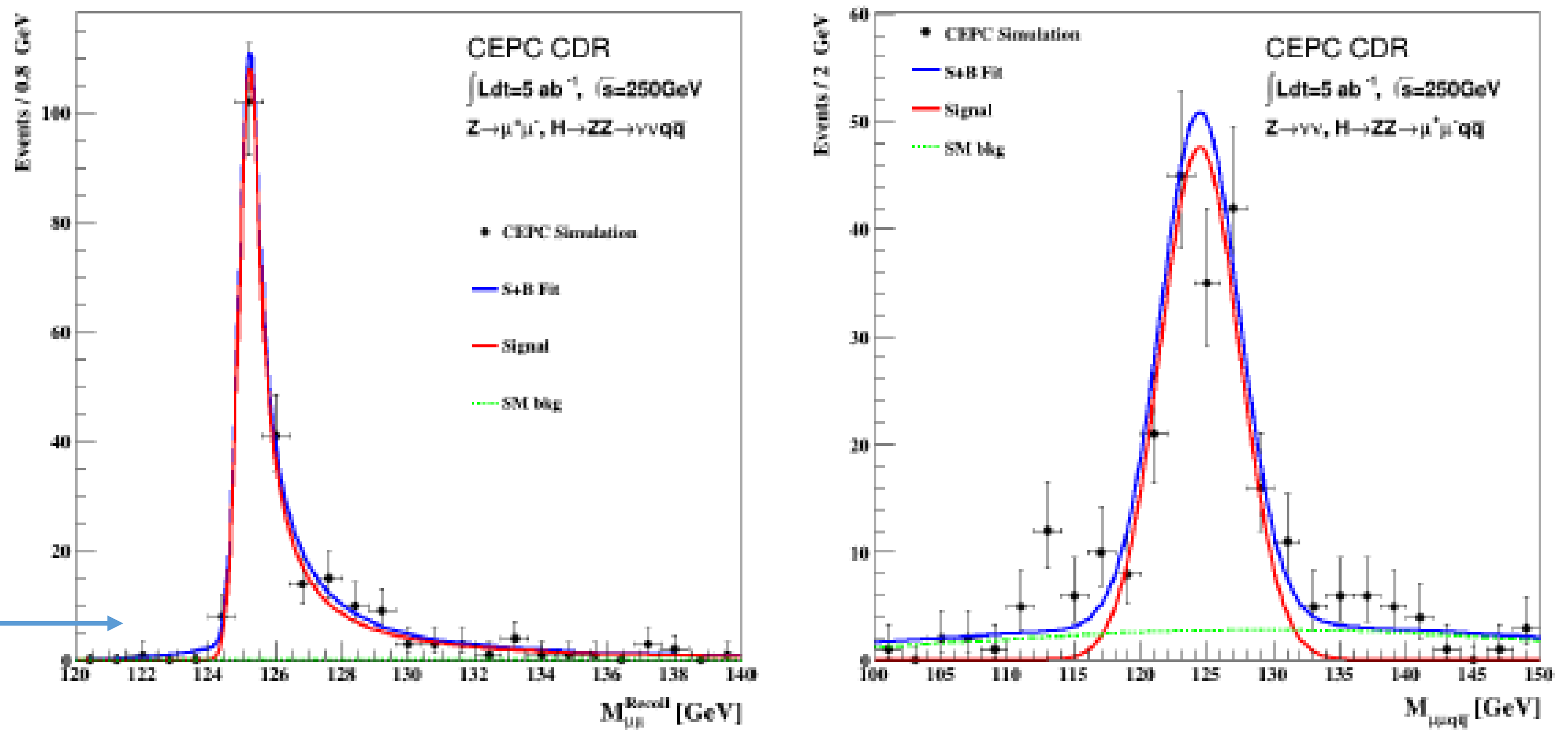
From “internal” document

Higgs->ZZ* channel

Total number of events @ $5ab^{-1}$
~ 120 events (Higgs->Z->qq, Z*->νν)
or 240 events (for both combination)

In my eye count, the signal has more than 180 events.

It is possible that both ZZ* decay combinations are used. Then,   I also (as Kaili) feel that the background is low.



(a) (b)

Table 6. Expected relative precision for the $\sigma(ZH) \times \mathrm{BR}(H \to ZZ^*)$ measurement with an integrated luminosity 5 ab^{-1}.

ZH final state		Precision
$Z \to \mu^+\mu^-$	$H \to ZZ^* \to \nu\bar{\nu}q\bar{q}$	7.3%
$Z \to \nu\bar{\nu}$	$H \to ZZ^* \to \ell^+\ell^-q\bar{q}$	7.9%
Combined		5.1%

Higgs width precision

$$\Gamma_H = \frac{\Gamma(H \to ZZ^*)}{\mathrm{BR}(H \to ZZ^*)} \propto \frac{\sigma(ZH)}{\mathrm{BR}(H \to ZZ^*)}$$

Precision of H->ZZ*

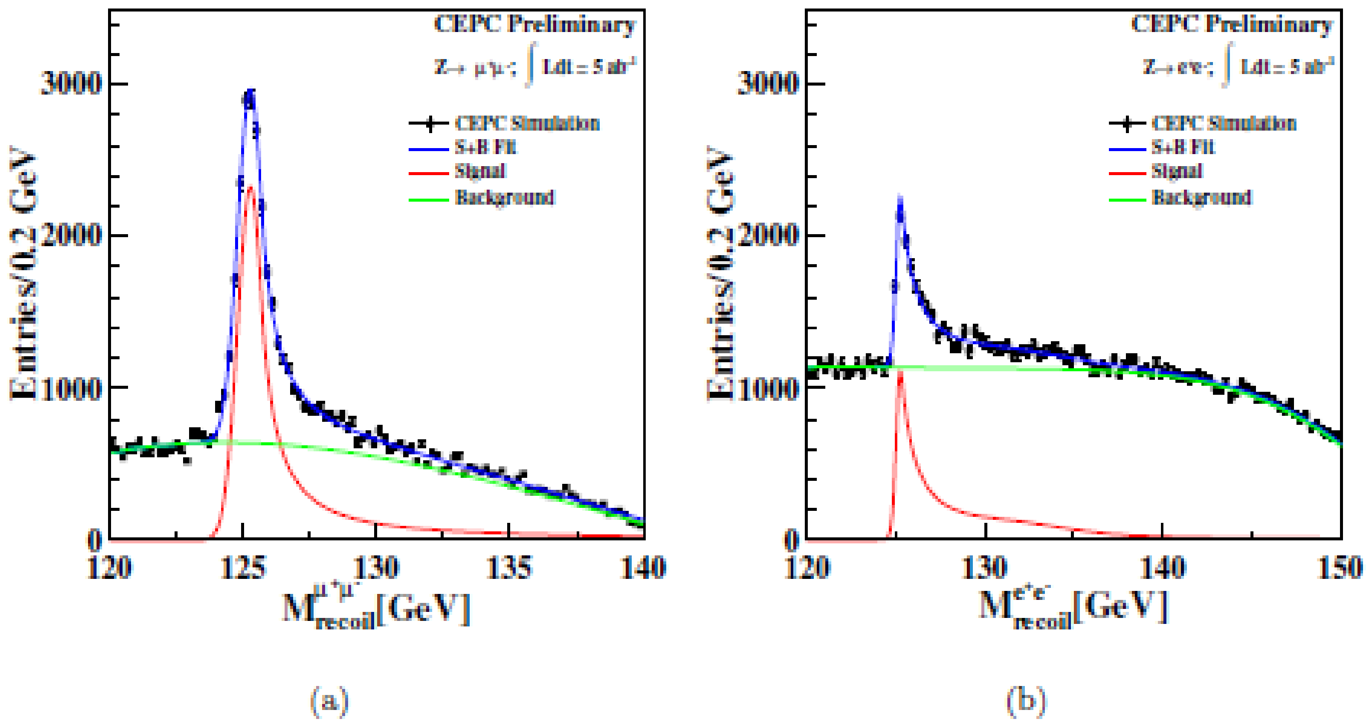


Figure 4. The recoil mass spectra of $e^+e^- \to ZX$ candidates for (a) $Z \to \mu^+\mu^-$ and (b) $Z \to e^+e^-$ with an integrated luminosity of 5 ab^{-1}.

… though I do not follow the exact formula of the relationship between the partial width and the cross section yet

From “internal” document

How about the final result from Maoqiang ?

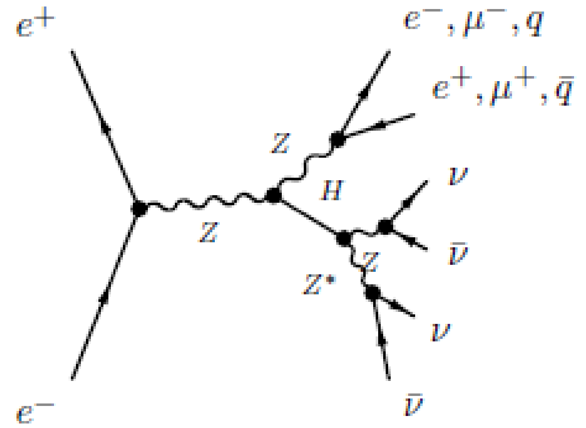


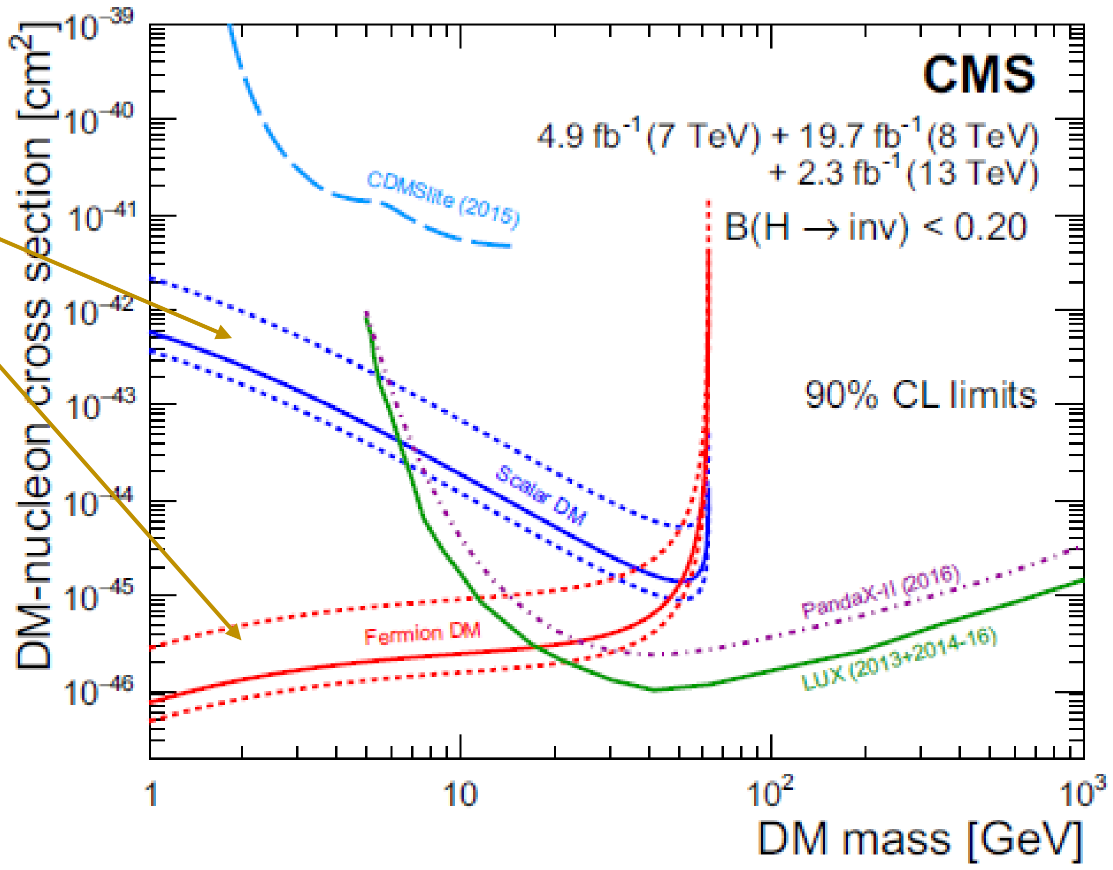
Figure 13. ZH production with the invisible $H \to ZZ^* \to \nu\bar{\nu}\nu\bar{\nu}$ decay in the SM.

Table 8. Precision and 95% CL upper limit on BR($H \to$ inv) expected from a CEPC dataset of 5 ab^{-1}.

ZH final state		Precision	Upper limit
$Z \to e^+e^-$	$H \to$ inv	$(0.11 \pm 0.36)\%$	0.84%
$Z \to \mu^+\mu^-$	$H \to$ inv	$(0.11 \pm 0.26)\%$	0.62%
$Z \to q\bar{q}$	$H \to$ inv	$(0.11 \pm 0.24)\%$	0.59%
Combined		$(0.11 \pm 0.16)\%$	0.42%

Reference for Higgs->invisible

U.L. on the invisible branching fraction = 24%
(at 95% C.L.)



$$\sigma^{\mathrm{SI}}_{\mathrm{f-N}} = \frac{8\Gamma_{\mathrm{inv}} m_\chi^2}{m_{\mathrm{H}}^5 v^2 \beta^3} \frac{m_{\mathrm{N}}^4 f_{\mathrm{N}}^2}{(m_\chi + m_{\mathrm{N}})^2}, \qquad (5.2)$$

assuming a fermion DM candidate, where m_{N} is the average of the proton and neutron masses 0.939 GeV and $\beta = \sqrt{1 - 4m_\chi^2/m_{\mathrm{H}}{}^2}$. The Higgs vacuum expectation value v is taken to be 246 GeV. The dimensionless quantity f_{N} denotes the nuclear form-factor. The central values for the exclusion limits are derived assuming $f_{\mathrm{N}} = 0.326$, taken from ref. [93], while alternative values of 0.260 and 0.629 are taken from the MILC Collaboration [94]. The translation between Γ_{inv} and $\mathcal{B}(\mathrm{H} \to \mathrm{inv})$ uses the relation $\mathcal{B}(\mathrm{H} \to \mathrm{inv}) = \Gamma_{\mathrm{inv}}/(\Gamma_{\mathrm{SM}} + \Gamma_{\mathrm{inv}})$, where $\Gamma_{\mathrm{SM}} = 4.07$ MeV [47]. Figure 9 shows the 90% CL upper limits on the spin-independent DM-nucleon cross section as a function of the DM mass, assuming $m_{\mathrm{H}} = 125$ GeV, for the scalar and fermion DM scenarios. These limits are calculated using the 90%

From , "Search for invisible decays of the Higgs boson in pp collision at $\sqrt{s}$ = 7, 8, and 13 TeV"
The CMS collaboration, JHEP02(2017)135