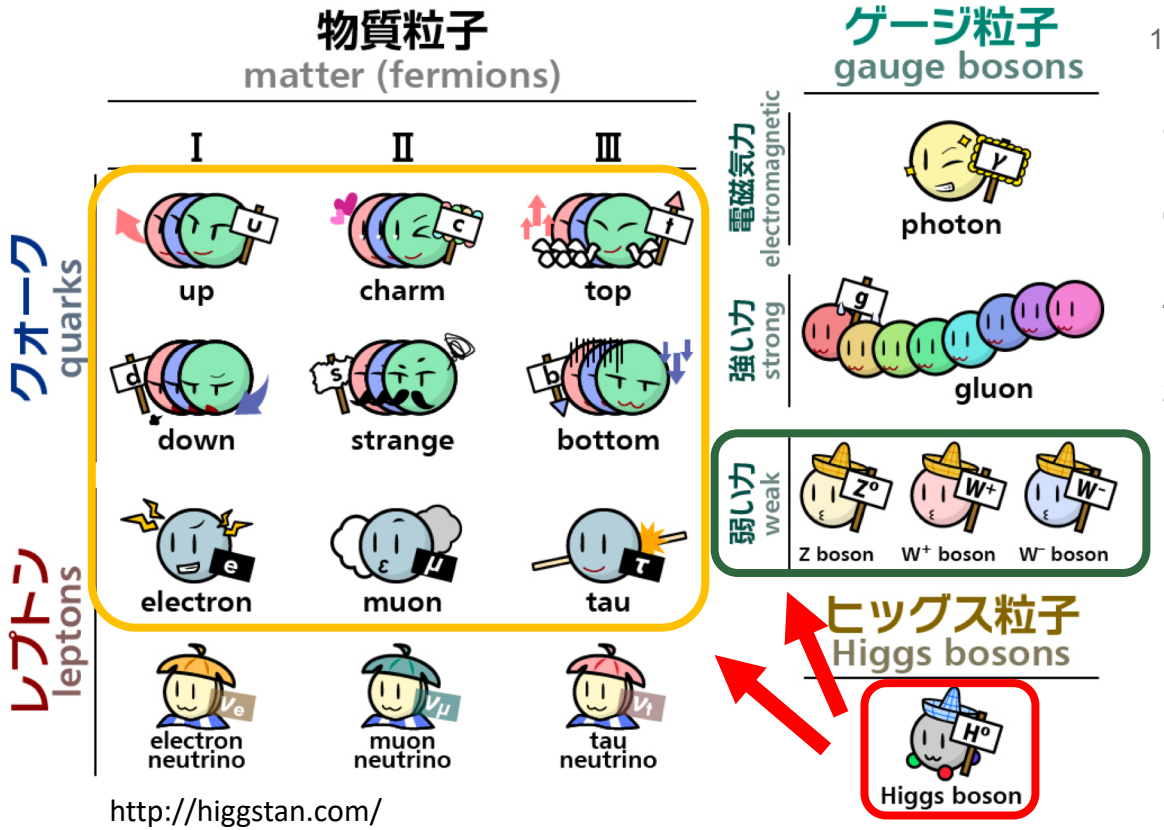
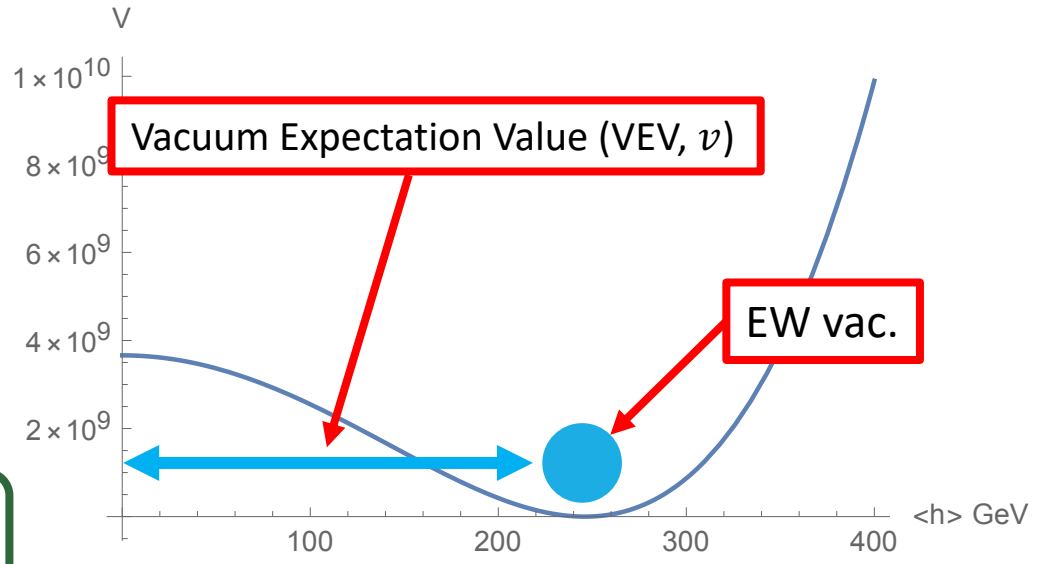
GPPU

Fujitani Yoshio
Particle theory and cosmology group

Higgs and Vacuum in particle physics



http://higgstan.com/



Higgs has non-zero VEV

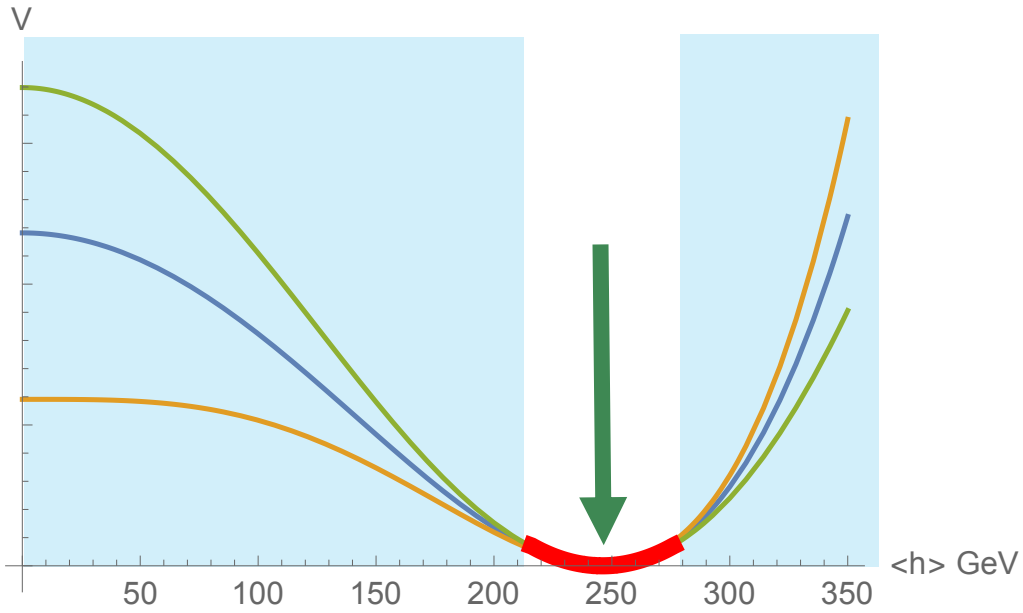
- Vac. breaks EW sym.
- Fermions and W, Z have mass

Vacuum structure of the Higgs

$$V = 0 \times h + \frac{1}{2} m_h^2 h^2 + \frac{1}{6} \lambda_{hhh} v h^3 + \cdots$$

$\frac{dV}{dh}$ $\frac{d^2V}{dh^2}$ $\frac{d^3V}{dh^3}$

observed unknown



We only know near Vac. -> Global shape of pot. is unknown

Classically Scale Invariant (CSI) model

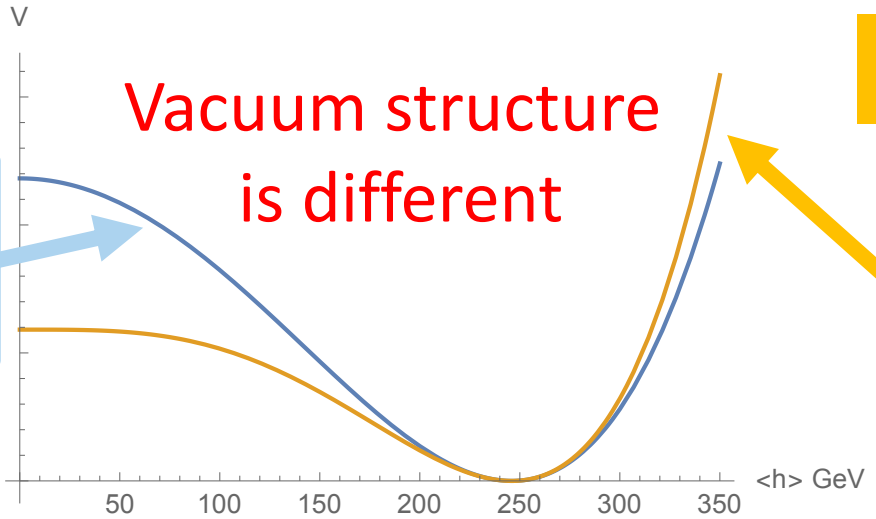
SM $\mu_H^2 \to 0$

Higgs portal

Singlet Scalar

SM

Tree level Sym. Breaking
Polynomial-pot.



Vacuum structure is different

CSI Foot et.al.,2007 Endo,Sumino 2015

Radiative Sym. Breaking
Logarithmic-pot.
Large deviation of λ_{hhh}
High predictability

Typical parameters of new physics

The easiest way to find NP, it is direct creation of new particle.
But it is very hard. The second way is precision experiment.

In general extended Higgs model, new scalar has SM gauge charge

↓ Yes

- See EW coupling
  (Yukawa, gauge)

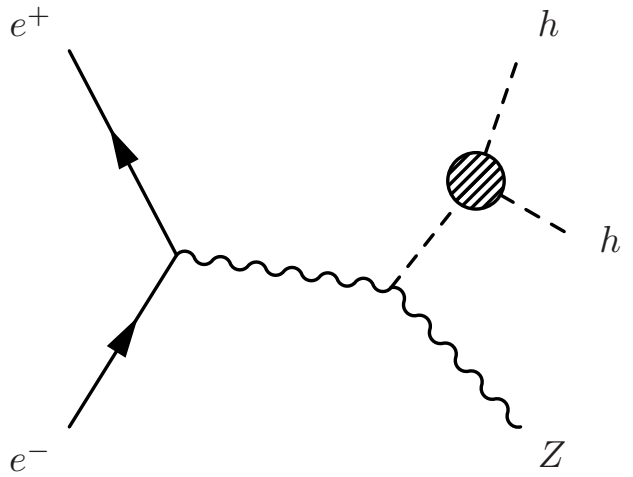
↓ No

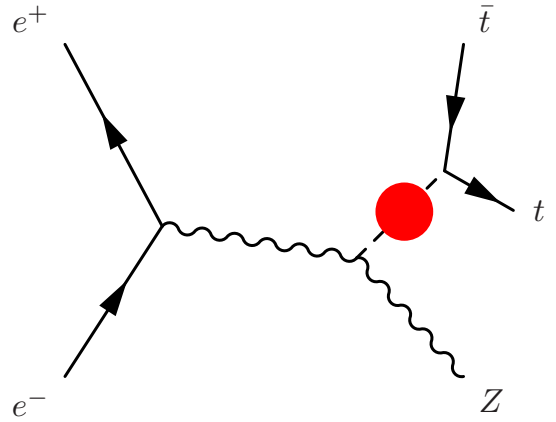
- See Higgs off-effect
  (Triple coupling, propagation)

The way to test CSI model

$$\Gamma^{\mathrm{CSI}}[H] = -V(H) + \left(\partial_\mu H\right)^\dagger (\partial^\mu H)\Gamma^{1,1}[H]$$
$$+H^\dagger(\partial^2 H)\Gamma^{1,2}[H] + O(\partial^3)$$

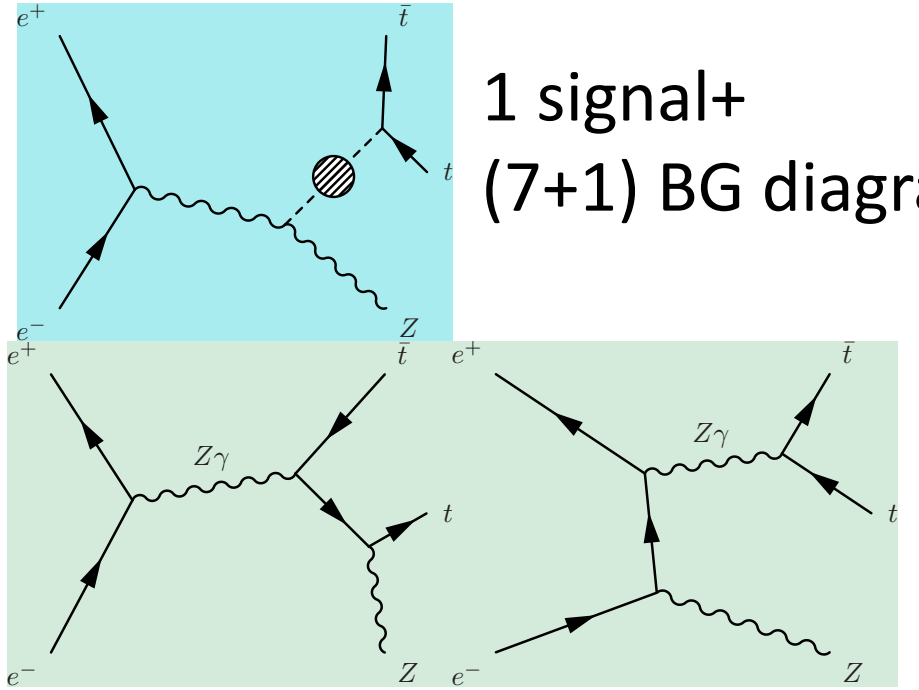
- $V(H)$
  - λ_{hhh}
- $\Gamma^{1,i}[H]$
  - $d\lambda_{hhh}/dq^2$ and $d\Sigma(q^2)/\mathrm{dq}^2$



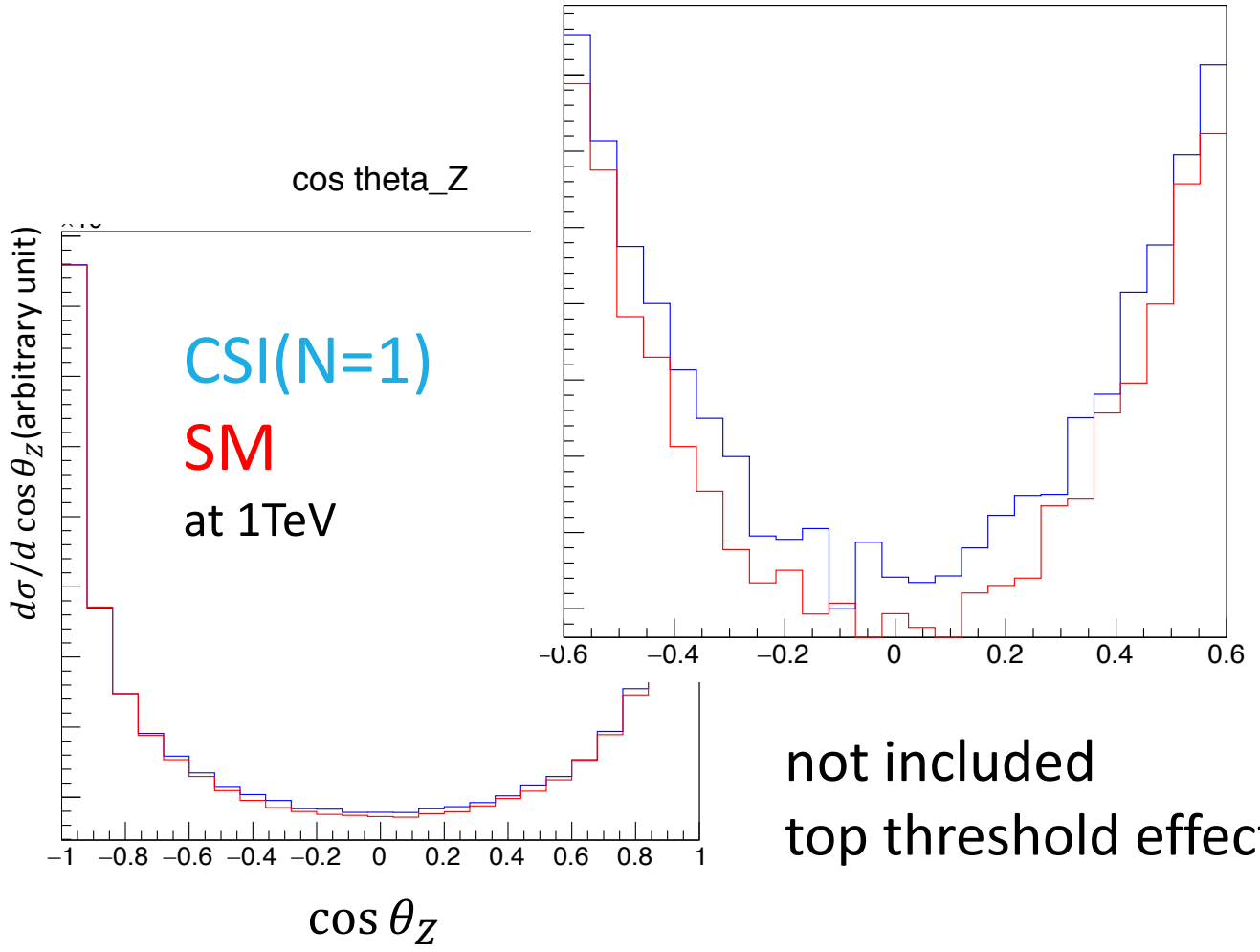


$e^+e^- \to Zt\bar{t}$

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



1 signal+
(7+1) BG diagrams



not included
top threshold effect

$\sigma^{e^+e^-\to Zt\bar{t}}_{|\cos\theta_Z|<0.6} = 3.922$fb, +3.4% from SM tree at 1TeV

Summary, research and Tasks

- CSI model has large deviation in physical processes.
- Higgs off-shell effect can be seen in $e^+e^- \to Zt\bar{t}$
- We can classify Higgs portal model
  by λ_{hhh}, $d\lambda_{hhh}/dq^2$ and $d\Sigma(q^2)/\mathrm{dq}^2$

- Meetings
  - NHWG(talk)
  - HPNP2019(poster)
- Plan of research in oversea
  - Remain 80 days