

# ILC study for degenerate scalars suppressing dark-matter–nucleon scattering in a singlet extension of the SM

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in collaboration with  
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(Ochanomizu U.)

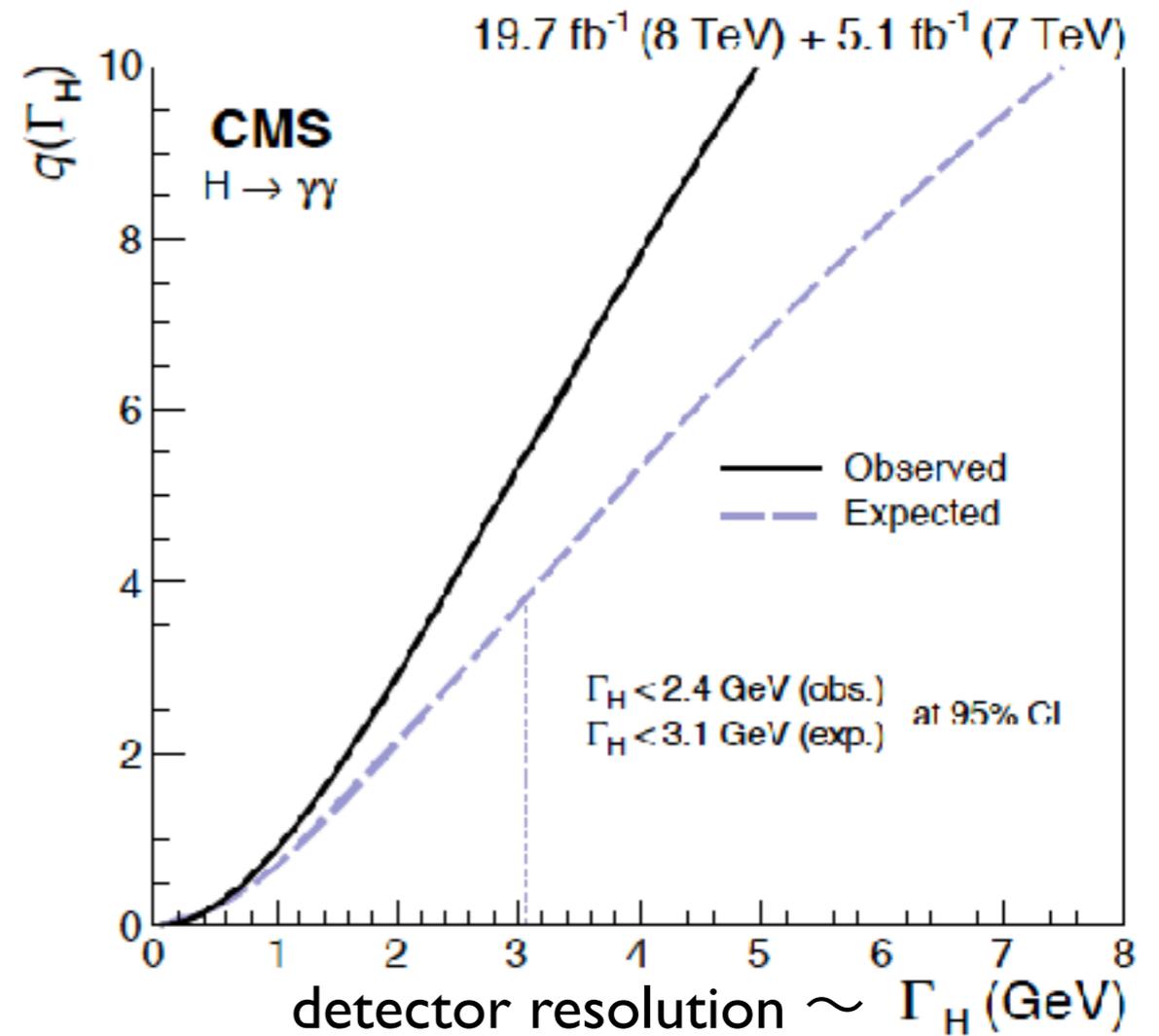
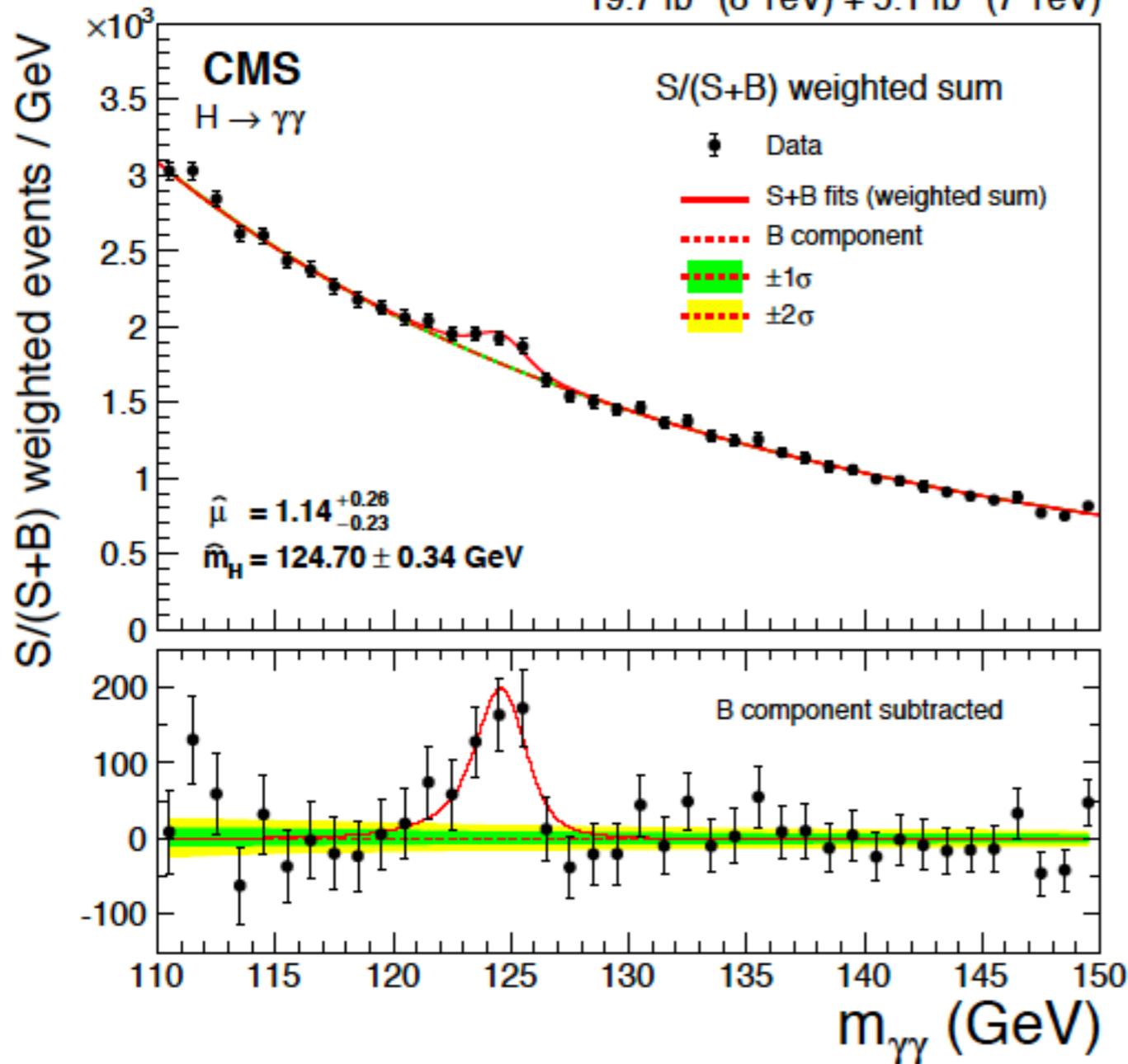
[work in progress]



# 125 GeV resonance

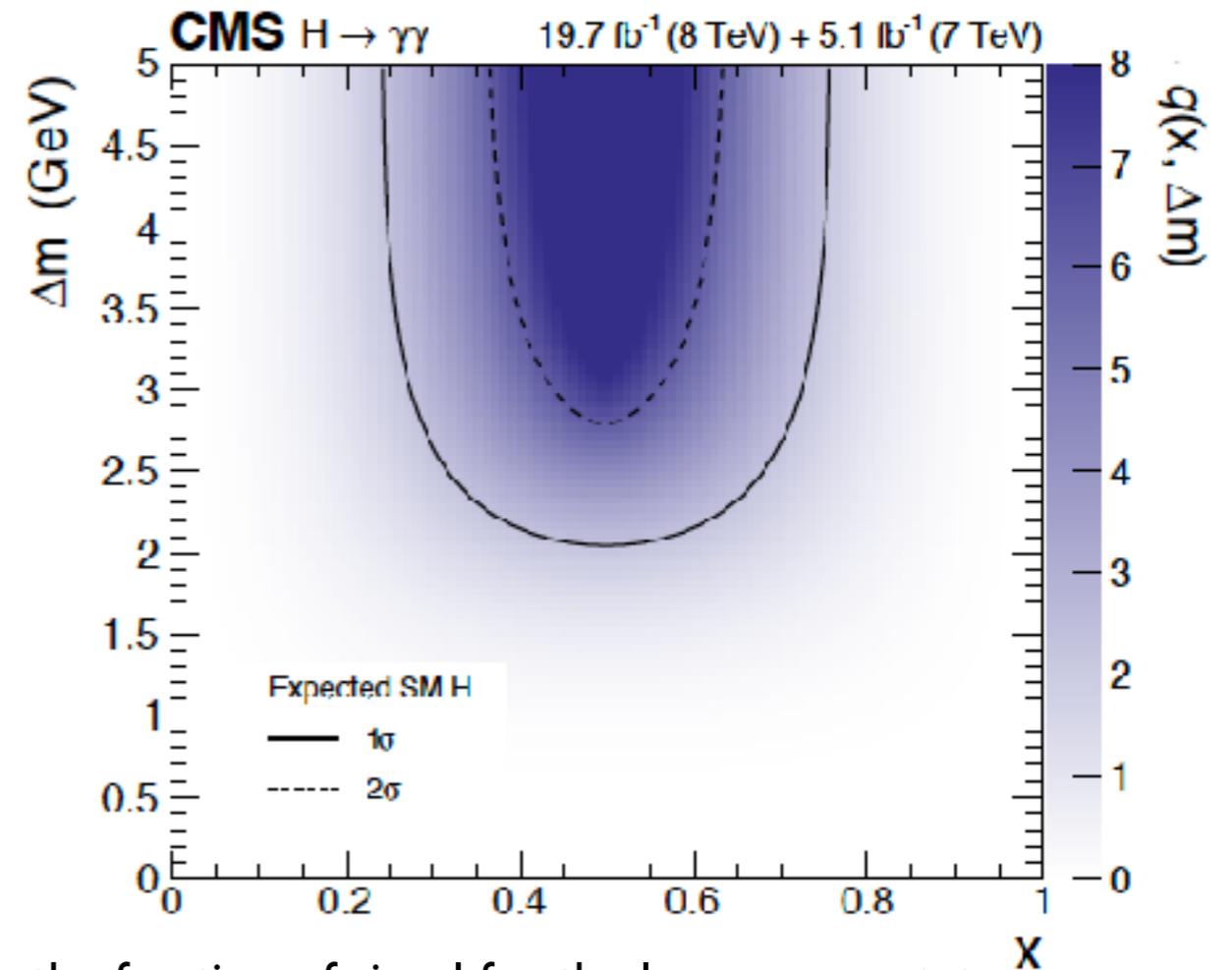
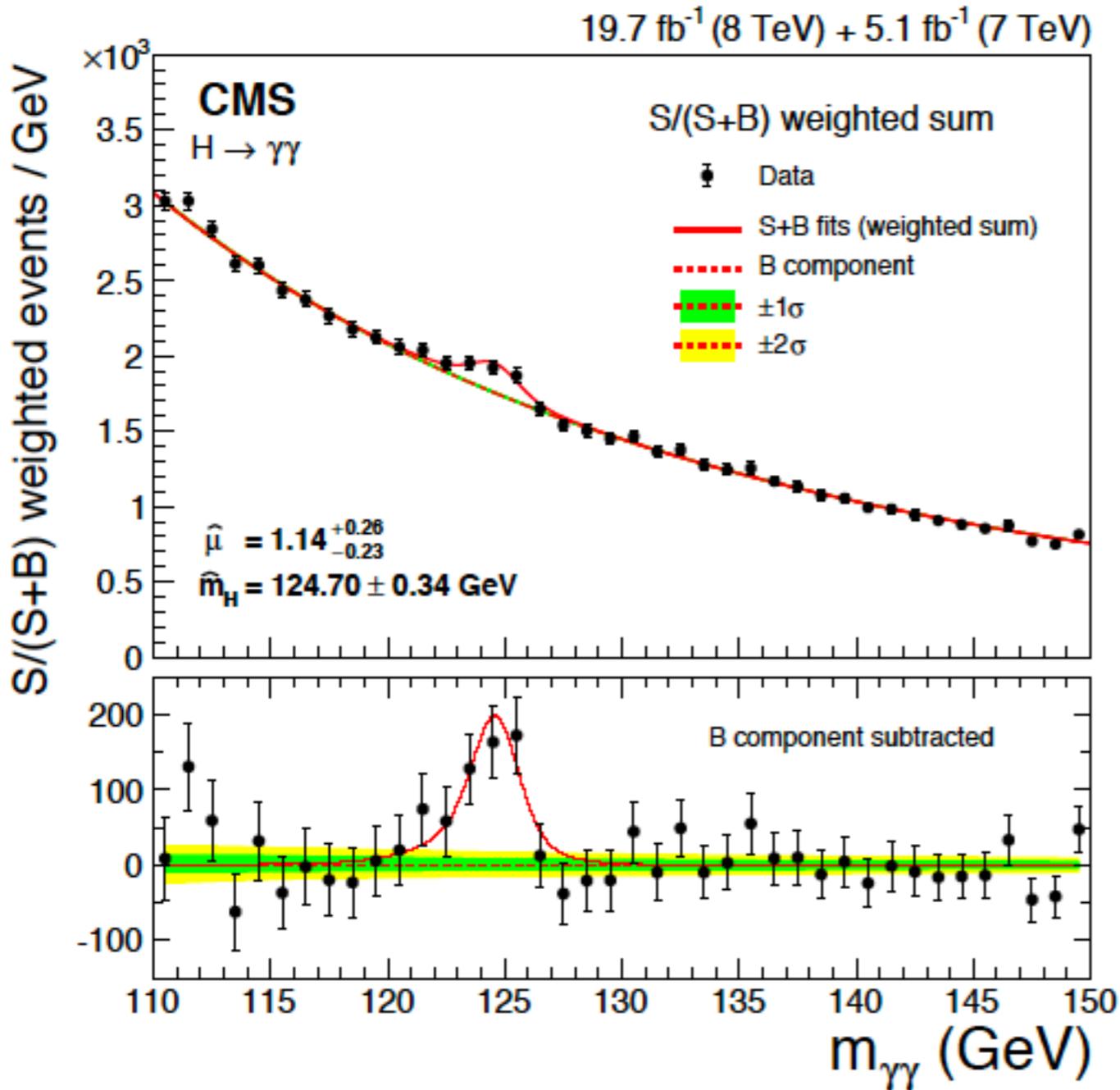
CMS [1407.0558]

19.7 fb<sup>-1</sup> (8 TeV) + 5.1 fb<sup>-1</sup> (7 TeV)



cf.  $\Gamma_H \text{ (SM)} \sim 4 \text{ MeV}$

# Single H or 2 near mass-degenerate H ?

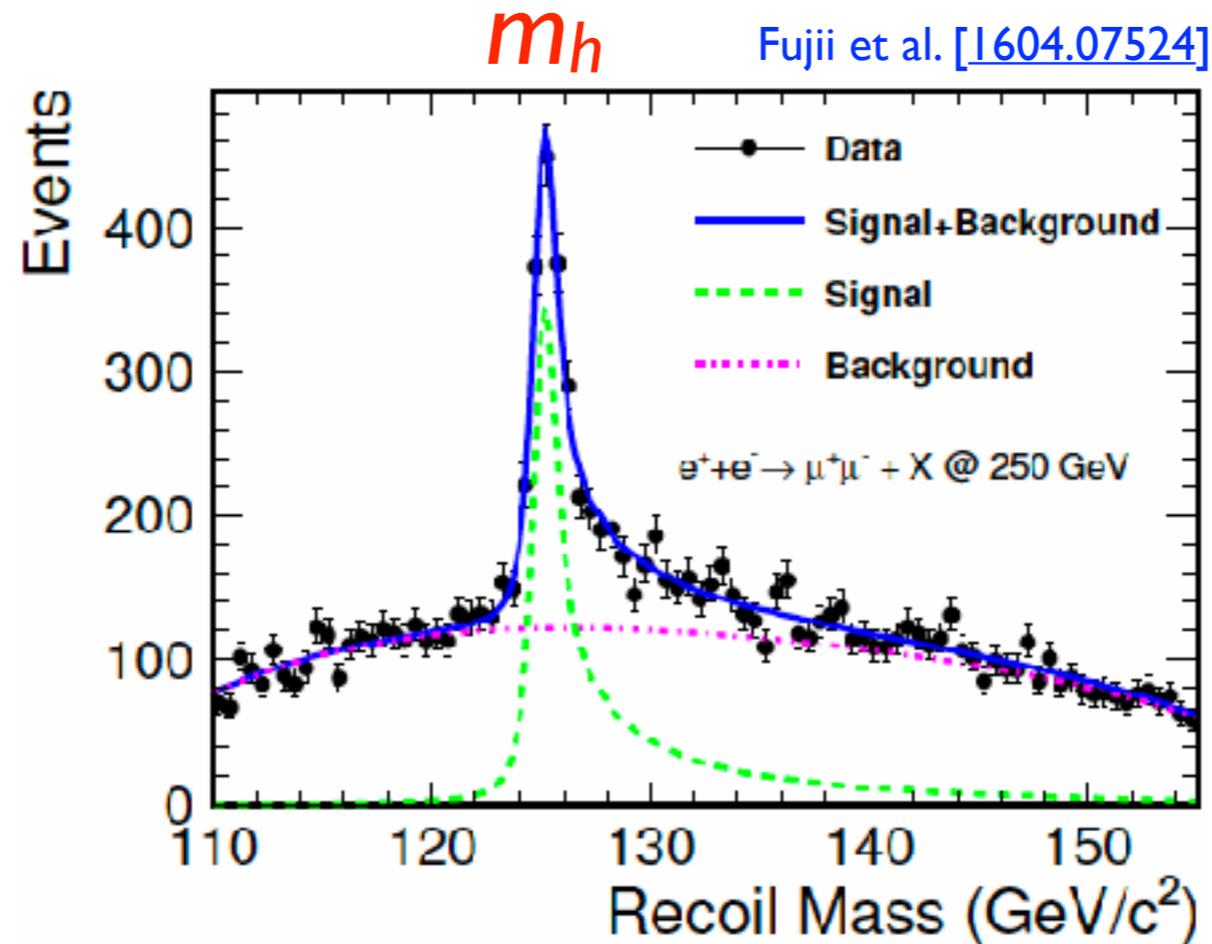


the fraction of signal for the lower mass state

At the LHC, two near mass-degenerate Higgs bosons with  $\Delta m < 3$  GeV can not be distinguished from the single-state Higgs boson (SM).

**How about at the ILC?**

# Recoil mass at the ILC

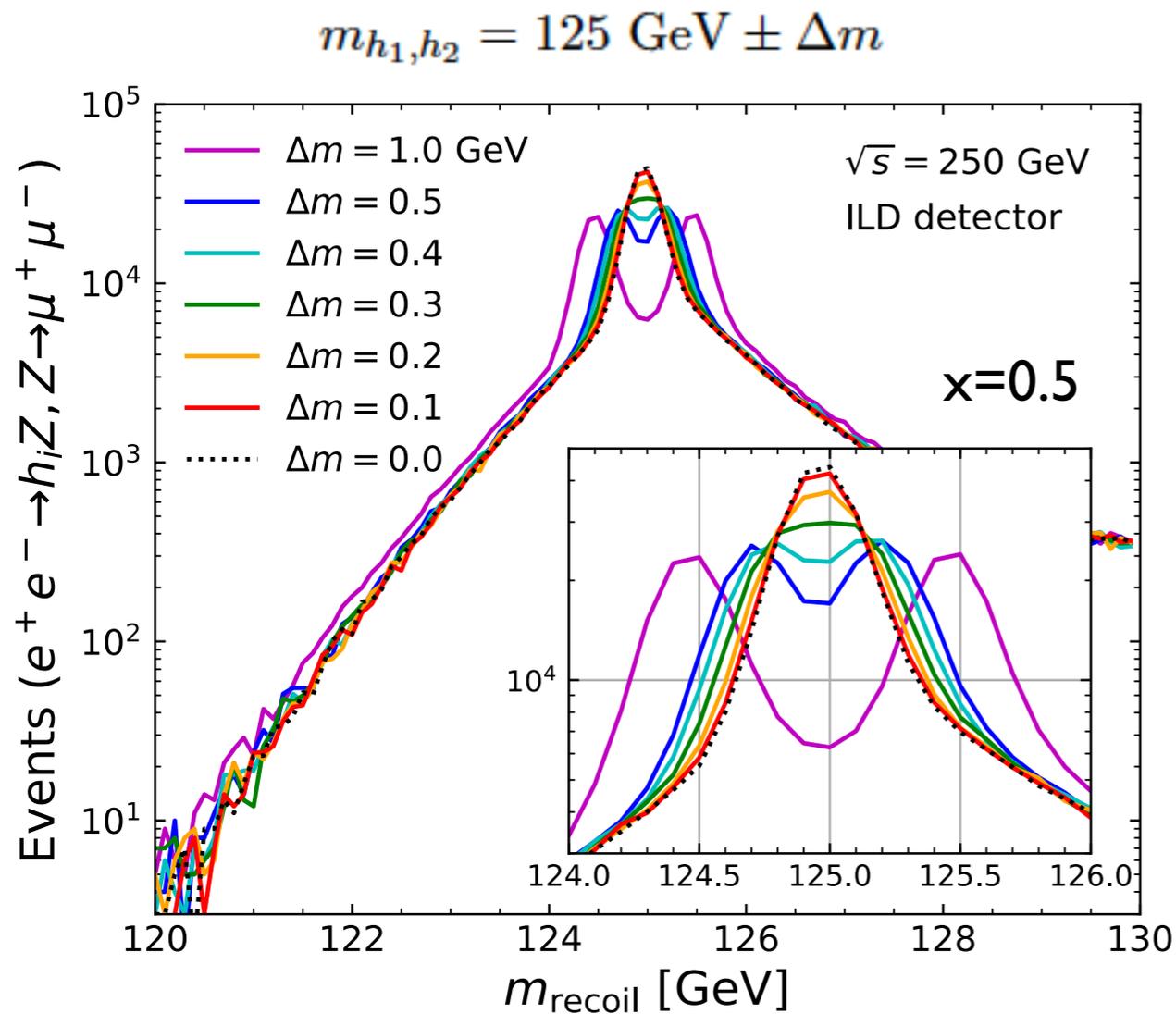


$\Delta m_H \sim 0.04 \text{ GeV}$   
@250/fb

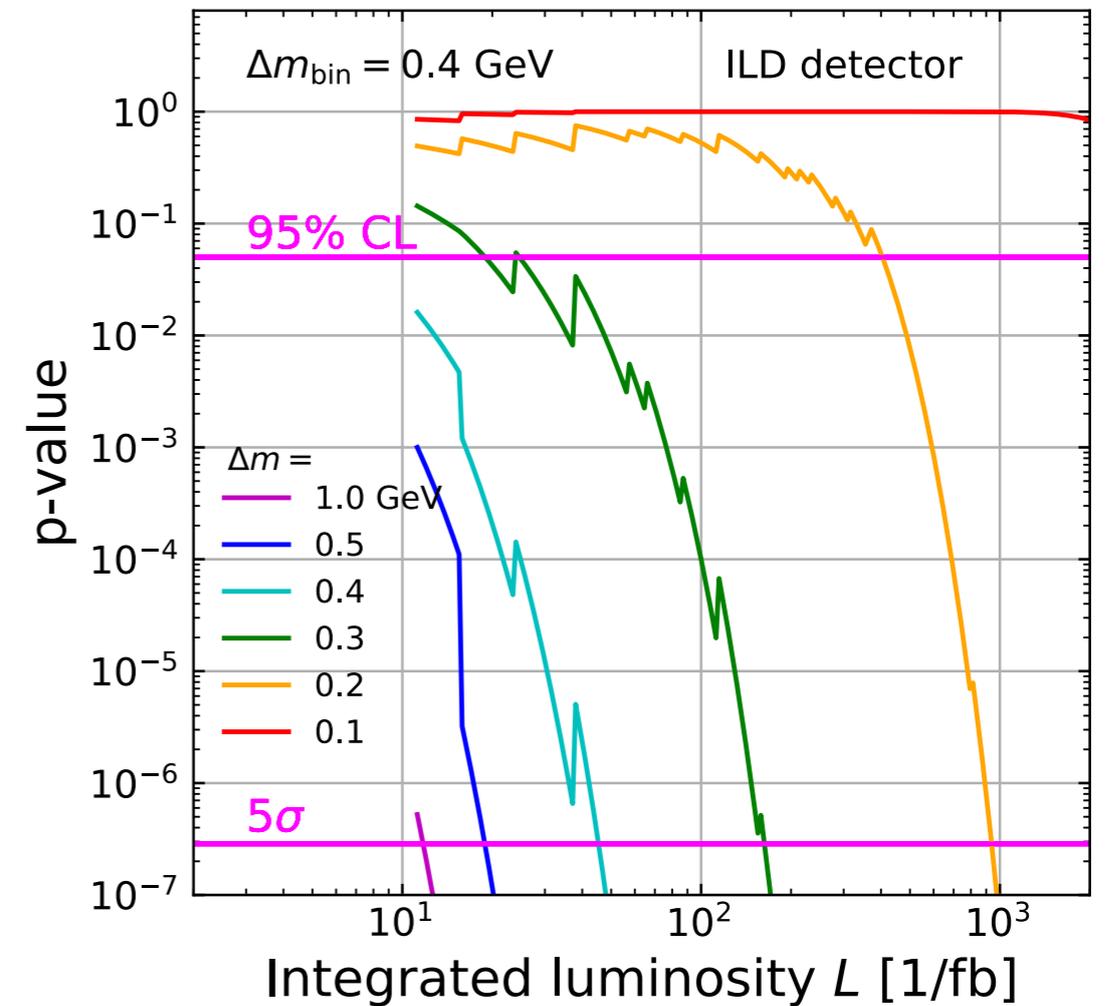
$$M_{\text{rec}}^2 = (\sqrt{s} - E_{1+1-})^2 - |\vec{p}_{1+1-}|^2$$

Precise measurement of the Higgs boson mass

# 2 near mass-degenerate Higgs bosons



$$\chi^2 = \sum_{i=1}^N \frac{(n_{\text{CxSM}}^i - n_{\text{SM}}^i)^2}{n_{\text{SM}}^i}$$



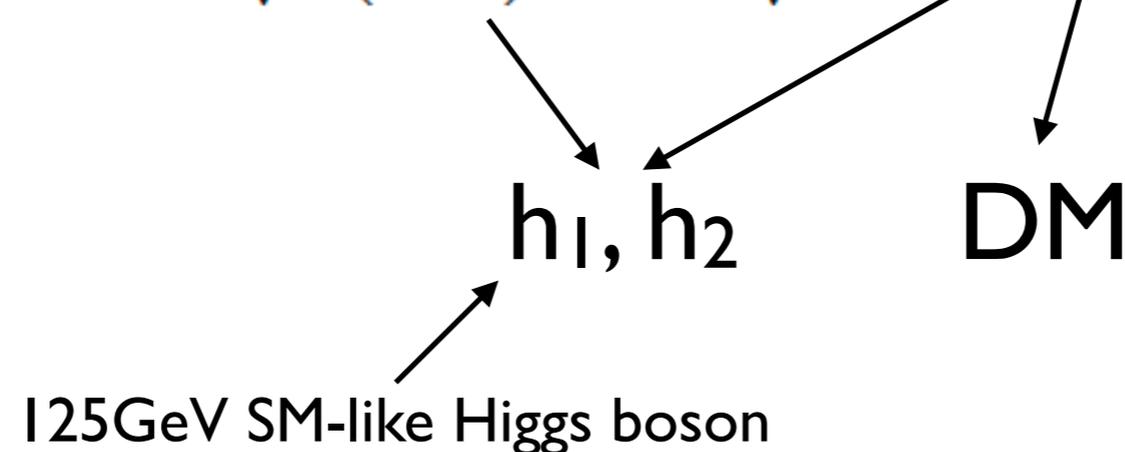
We can explore two near mass-degenerate Higgs boson at the ILC if  $\Delta m > 0.2 \text{ GeV}$ .

# Theoretical motivation to study such a degenerate scenario

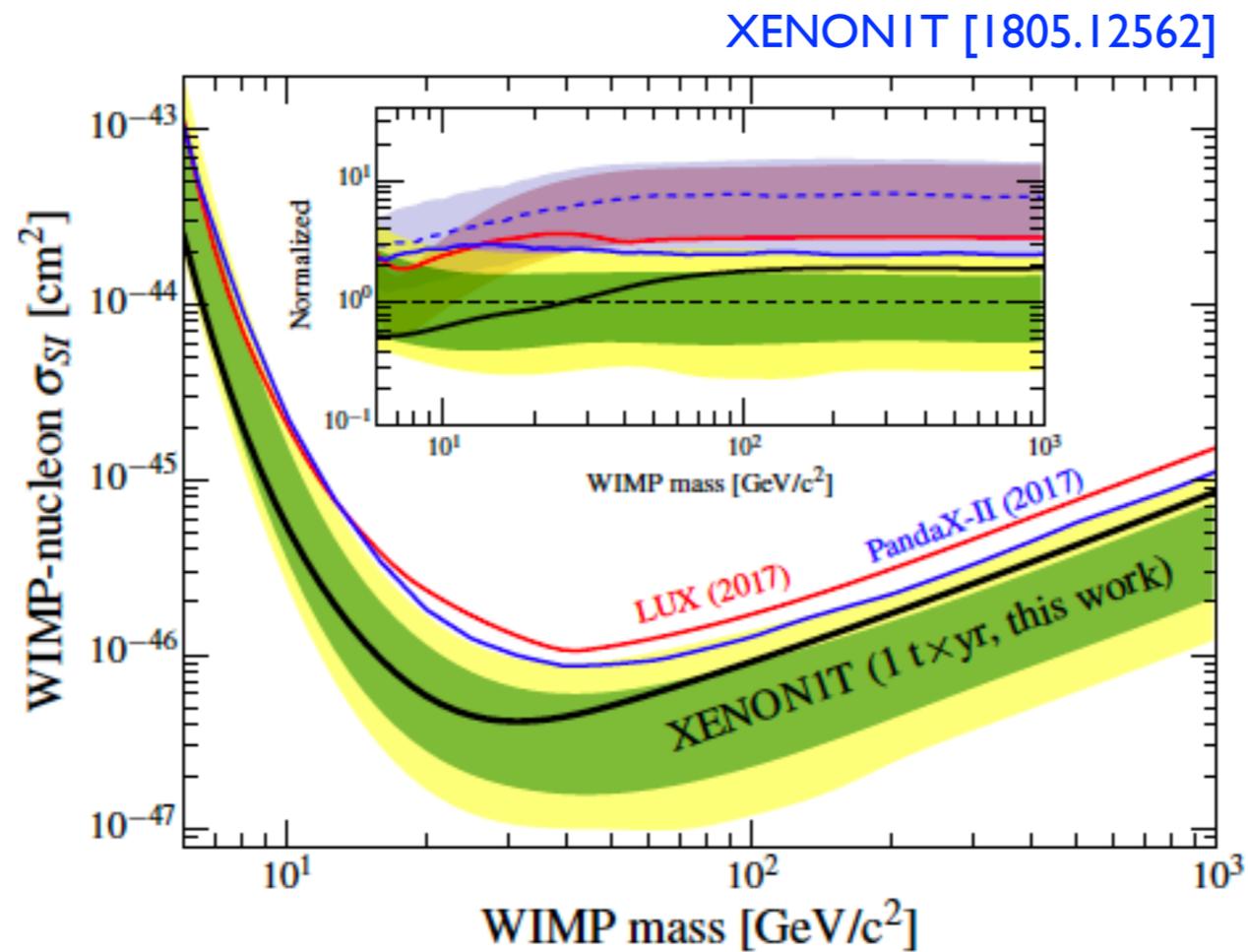
- **CxSM** : A complex singlet extension of the SM with a softly broken U(1) symmetry

$$V = \frac{m^2}{2}|H|^2 + \frac{\lambda}{4}|H|^4 + \frac{\delta_2}{2}|H|^2|S|^2 + \frac{b_2}{2}|S|^2 + \frac{d_2}{4}|S|^4 + \left( a_1 S + \frac{b_1}{4} S^2 + \text{c.c.} \right)$$

$$H = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v+h \end{pmatrix}, \quad S = \frac{1}{\sqrt{2}}(v_S + s + i\chi)$$

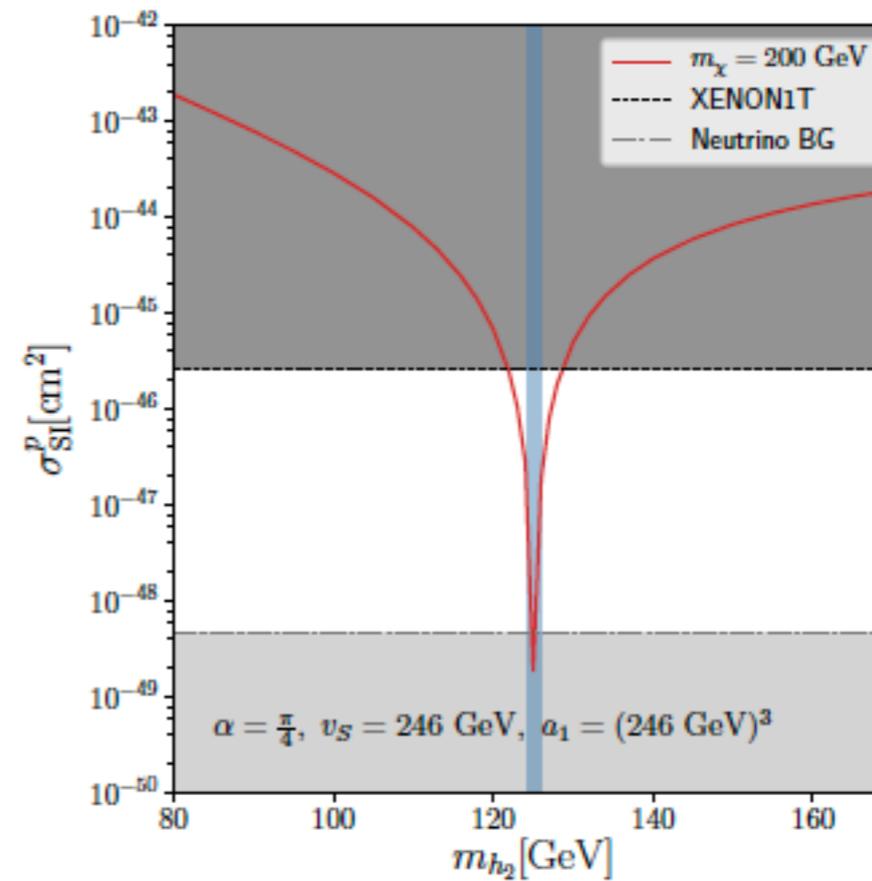
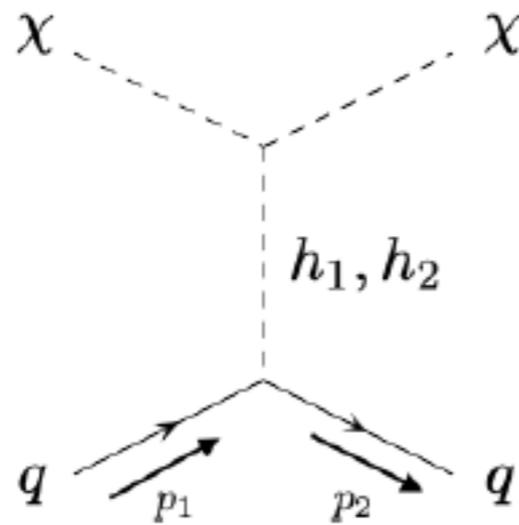


# Strong constraints from DM direct detection experiments



Can we avoid such strong constraints in the CxSM?

# Suppression of the DM-quark scattering amplitudes



Yes, if the two scalars are nearly degenerate.

# Summary

- CxSM is one of the simplest extensions of the SM, which contains an additional Higgs boson and a DM candidate.
- If  $m_{h1} \sim m_{h2}$ , we can avoid strong constraints from DM direct detection experiments due to the suppression of the DM-nucleon scattering amplitudes.
- Such a degenerate-scalar scenario can be tested at the ILC by using the recoil mass technique.

