Dark Matter in the Left-Right Twin Higgs Models

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In collaboration with E. Dolle, J. Goodman

Outline

- Twin Higgs Model
  - Twin Higgs mechanism
  - Left-right Twin Higgs model
- Dark Matter
  - Relic density

Twin Higgs mechanism

Higgs as pseudo-Goldstone boson of a global symmetry

Its mass is protected against radiative corrections

- Little Higgs mechanism: collective symmetry breaking
- Twin Higgs mechanism: discrete symmetry

Mirror symmetry

Type IA TH: Chacko, Goh, Harnik, hep-ph/0506256
Type IB TH: Chacko, Nomura, Papucci, Perez, hep-ph/0510273
phenomenology: R. Barbieri, T. Gregoire and L. Hall, hep-ph/0509242

Left-right symmetry

Type II TH: Chacko, Goh, Harnik, hep-ph/0512088

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Left-right Twin Higgs model

- Global U(4) , with subgroup $SU(2)_L \times SU(2)_R \times U(1)_{B-L}$ gauged
- Left-right symmetry: $g_L = g_R$ ($y_L = y_R$)

A linear realization

$$H = \begin{pmatrix} H_L \\ H_R \end{pmatrix}$$

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7 GB

$$U(4) \to U(3)$$

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↓ EWSB

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Twin Higgs mechanism

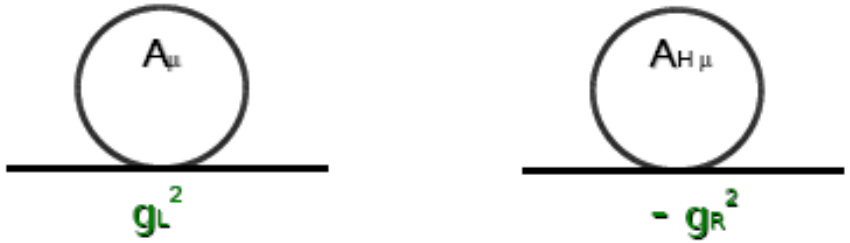
Quadratic divergence forbidden by left-right symmetry

$$\Delta V = \frac{9}{64\pi^2} g_L^2 \Lambda^2 H_L^\dagger H_L + \frac{9}{64\pi^2} g_R^2 \Lambda^2 H_R^\dagger H_R$$

$g_L = g_R = g$

$$\Delta V = \frac{9}{64\pi^2} g^2 \Lambda^2 (H_L^\dagger H_L + H_R^\dagger H_R) = \frac{9}{64\pi^2} g^2 \Lambda^2 H^\dagger H$$

U(4) invariant, does not contribute to the mass of GB



Log contribution: $$\Delta V = \frac{g^4}{16\pi^2} \log\left(\frac{\Lambda}{gf}\right) (|H_L|^4 + |H_R|^4)$$

$m_H \sim g^2 f / (4\pi)$, natural for $f \sim$ TeV

Left-right Twin Higgs model

EW precision constraints on $SU(2)_R$ gauge boson mass $\Rightarrow$ $f > 2$ TeV

Introduce another Higgs field that <u>only couples to gauge sector</u>

which has a larger VEV

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$\hat{H}_1^{\pm}$, $\hat{H}_2^0$

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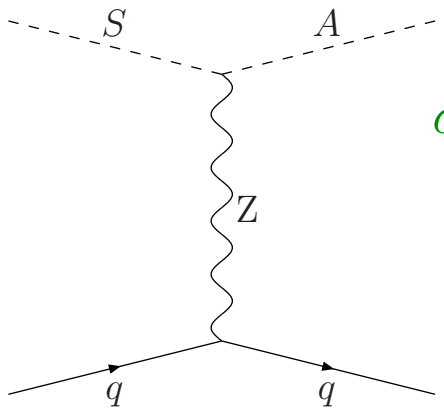
$\hat{f} > f$

Dark Matter

$\hat{H}_2^0 = S + iA$

Similar to the dark matter scenario in
R. Barbieri, L. Hall, V. Rychkov, hep-ph/0603188
L. Honorez, E. Nezri, J. Oliver, M. Tytgat, hep-ph/0612275

- $|m_S - m_A| >$ a few GeV to avoid constraints from DM direct detection



$$\sigma_{SI(Z)} = \frac{G_F^2 m_N^2}{2\pi}(N - (1 - s_W^2)Z)^2 \sim 10^{-31}\mathrm{cm}^2$$

Current CDMS limit: 10^{-42} cm^2

Avoid such constraints if $|m_S - m_A| >$ a few GeV

$\delta_1 = m_A - m_S$
$\delta_2 = m_{H1} - m_S$

- coannihilation of S, A, and $\hat{H}_1^{\pm}$

- Use MicrOMEGA to calculate the relic density

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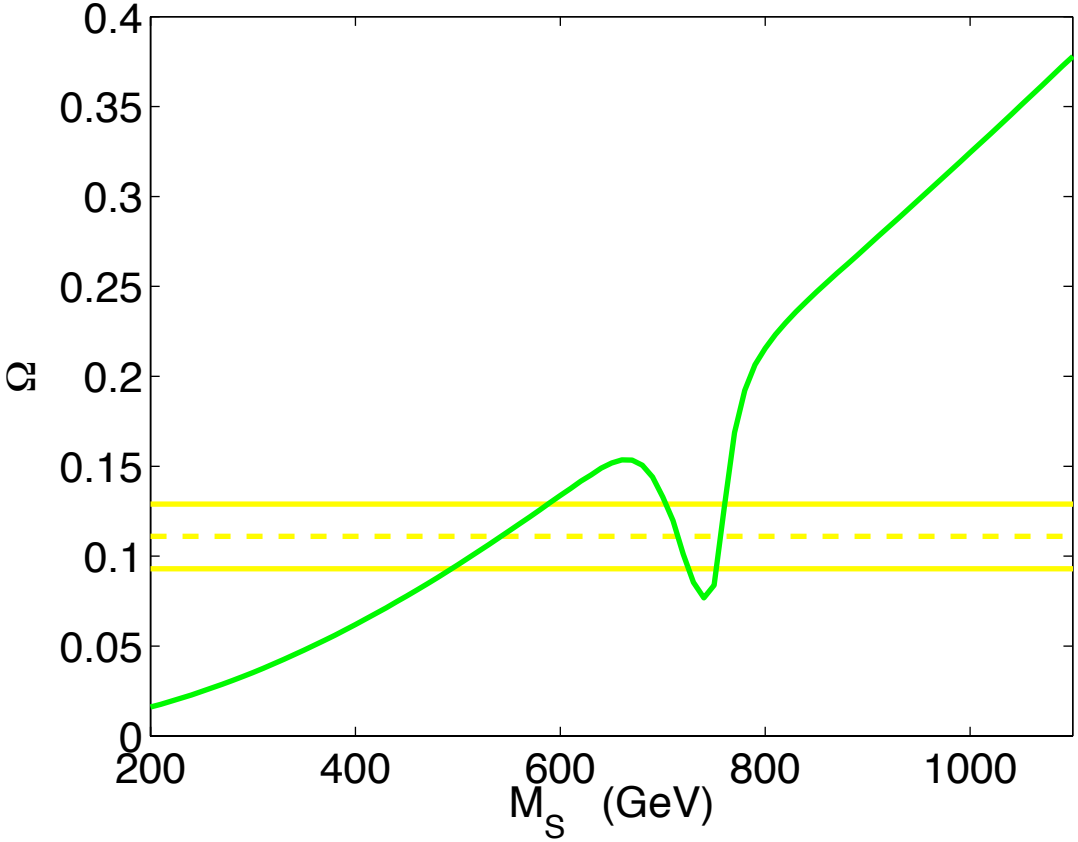

f=560 GeV $\delta_1 = 2\delta_2 = 2$ GeV

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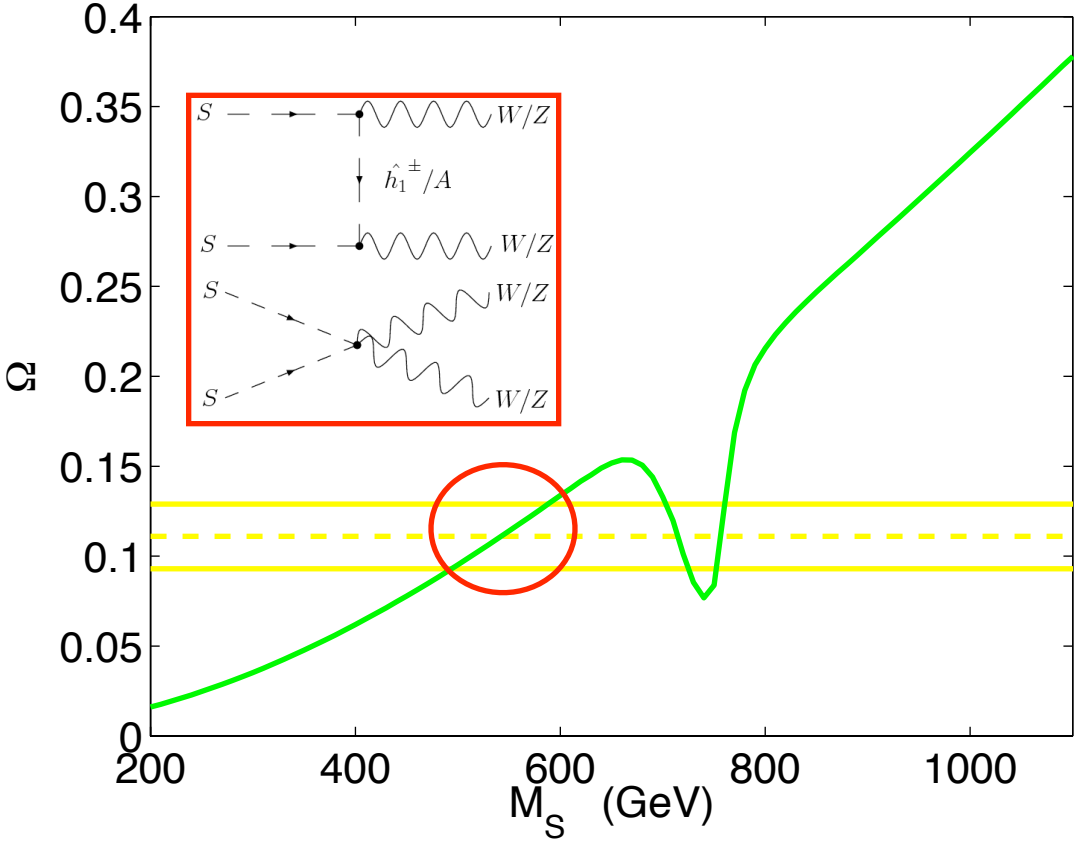

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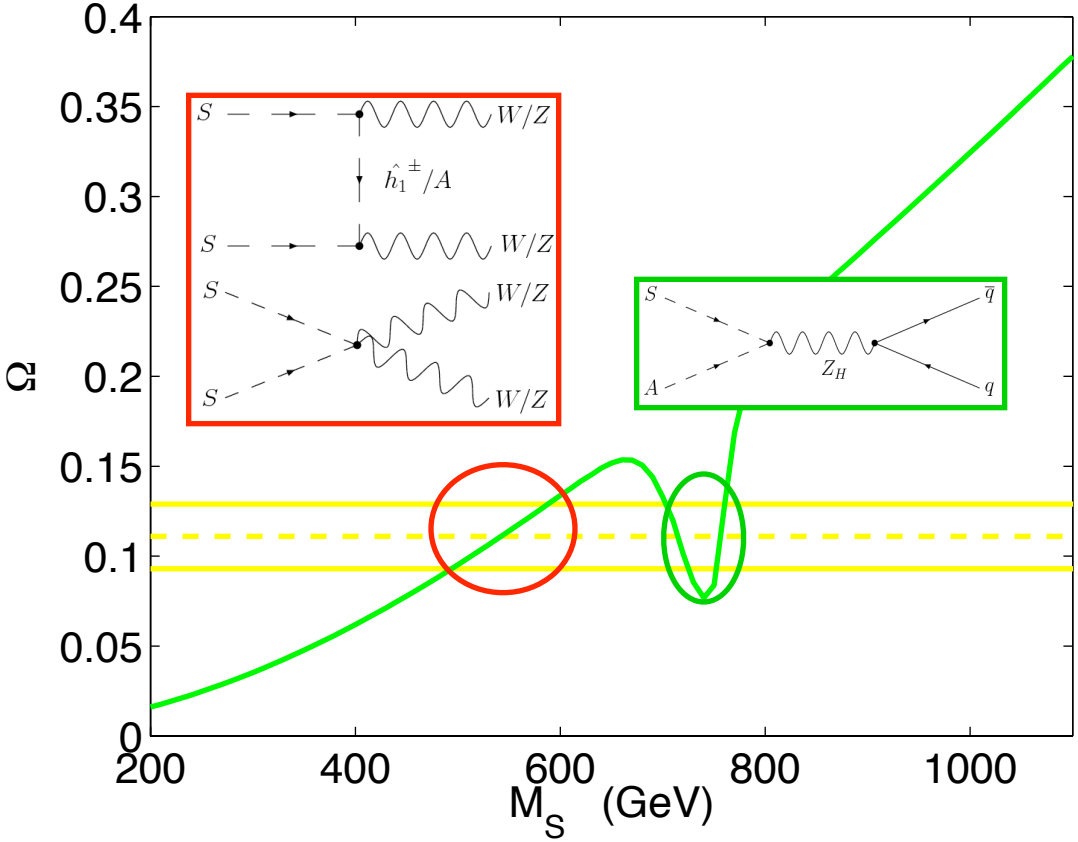

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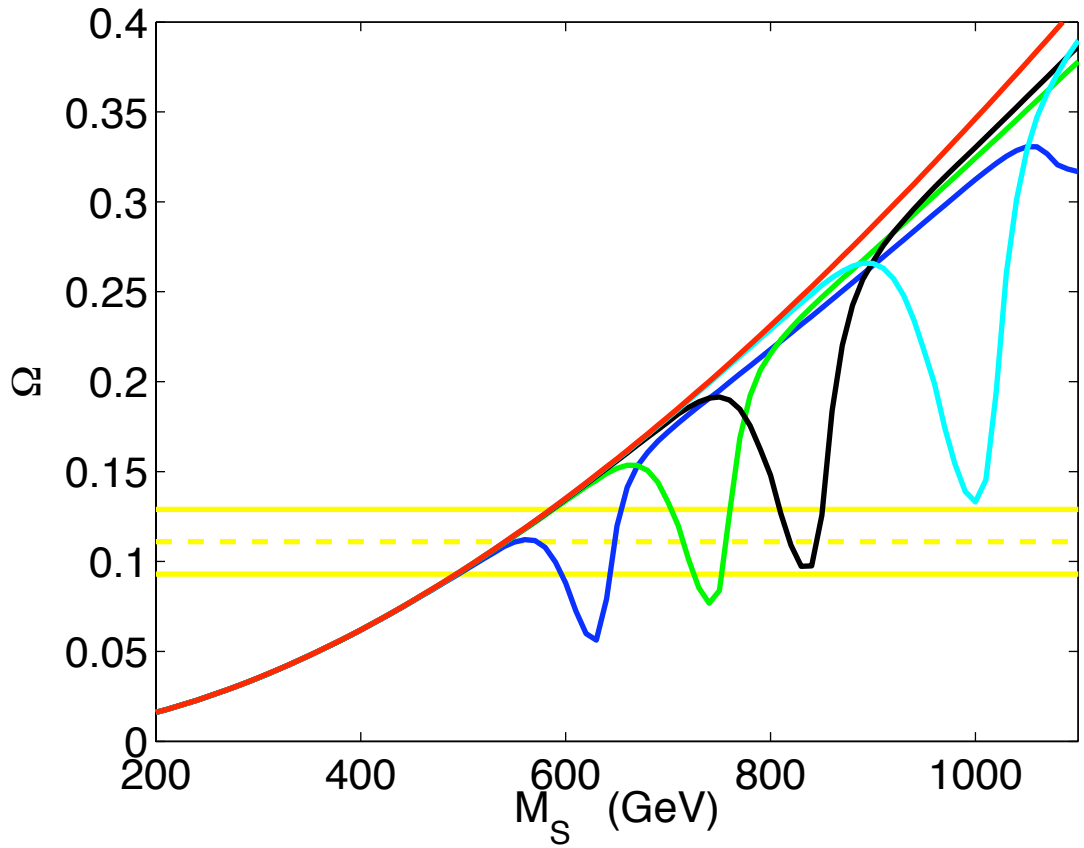

f=1000 GeV
f=700 GeV
f=610 GeV
f=560 GeV
f=500 GeV

$\delta_1 = 2\delta_2 = 2$ GeV

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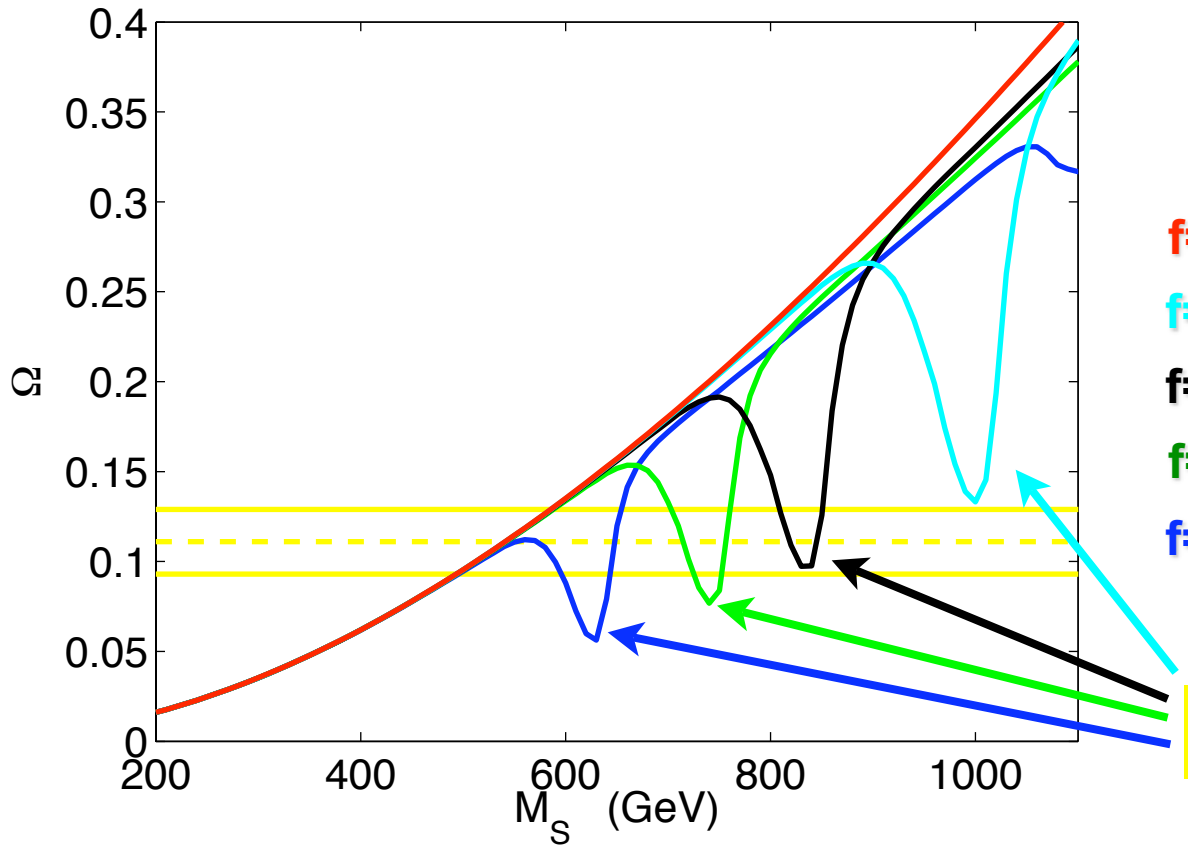

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$m_S \sim m_{ZH}/2$

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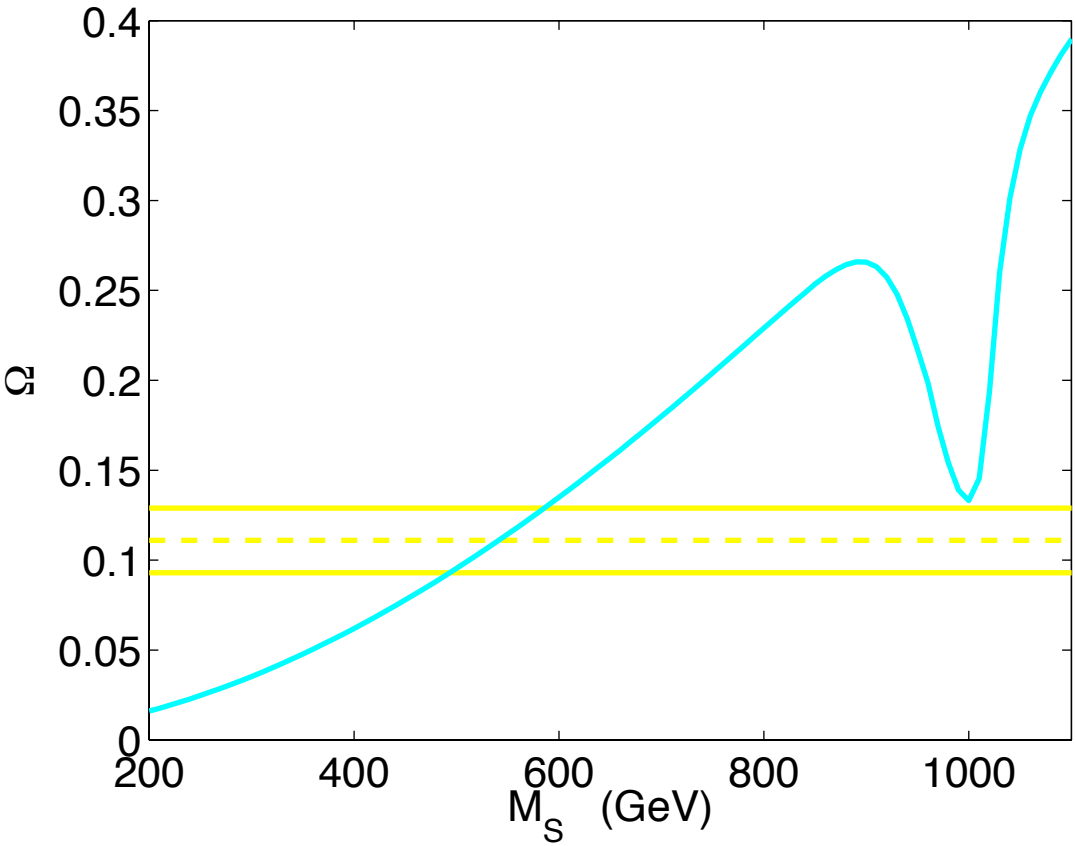

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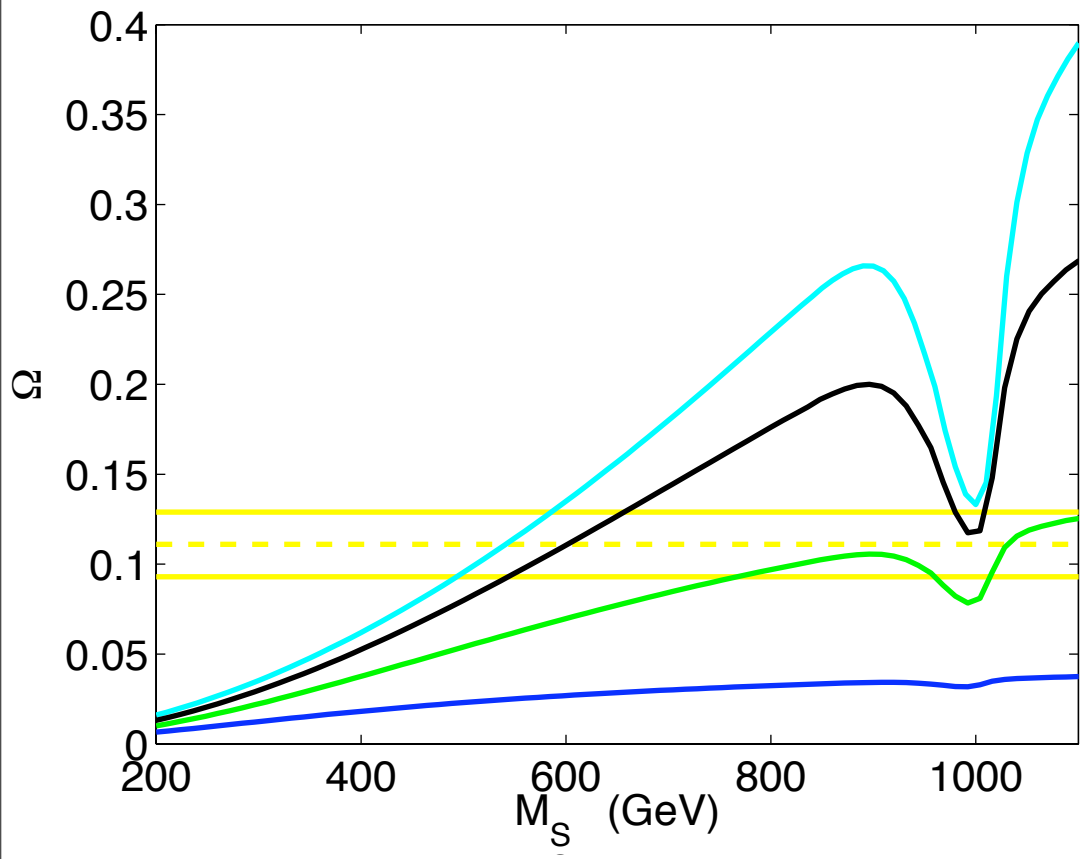


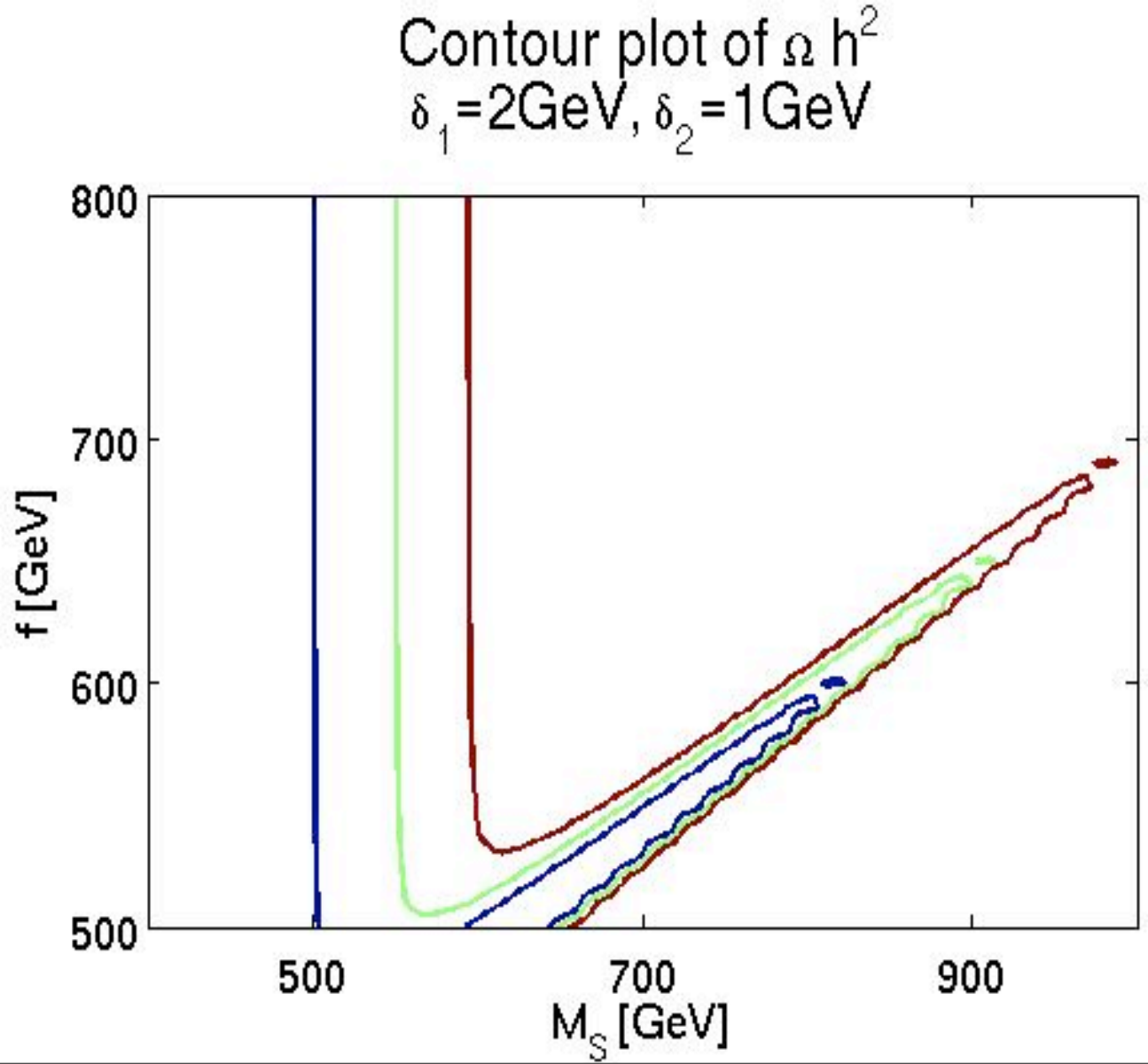
f=700 GeV $\delta_1 = 2\delta_2 = 2$ GeV

$\delta_1 = 2\delta_2 = 5$ GeV

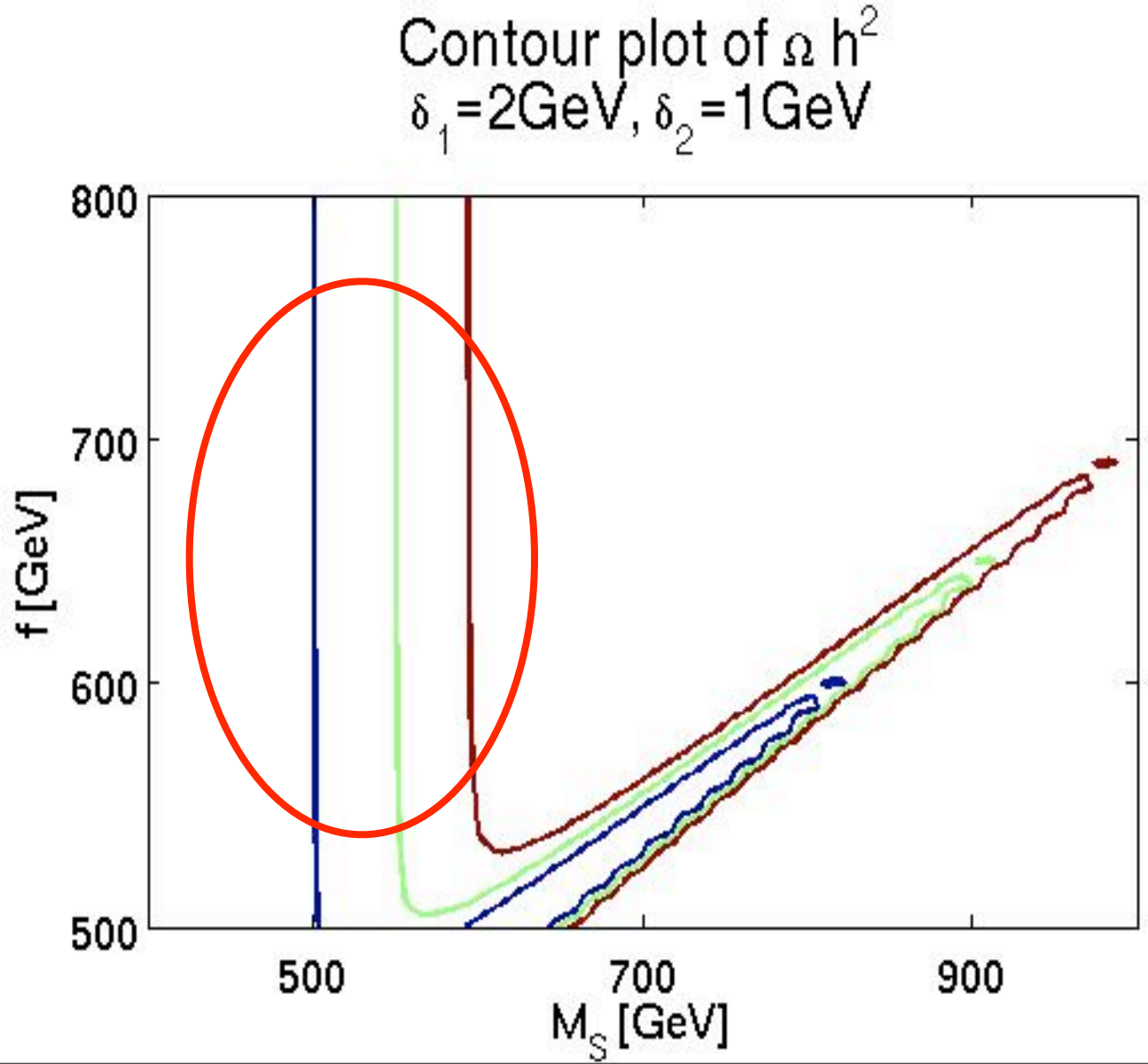
$\delta_1 = 2\delta_2 = 10$ GeV

$\delta_1 = 2\delta_2 = 20$ GeV

Dark Matter


Contour plot of Ω h²
δ1=2GeV, δ2=1GeV
800
700
600
500
f [GeV]
500
700
900
MS [GeV]

Dark Matter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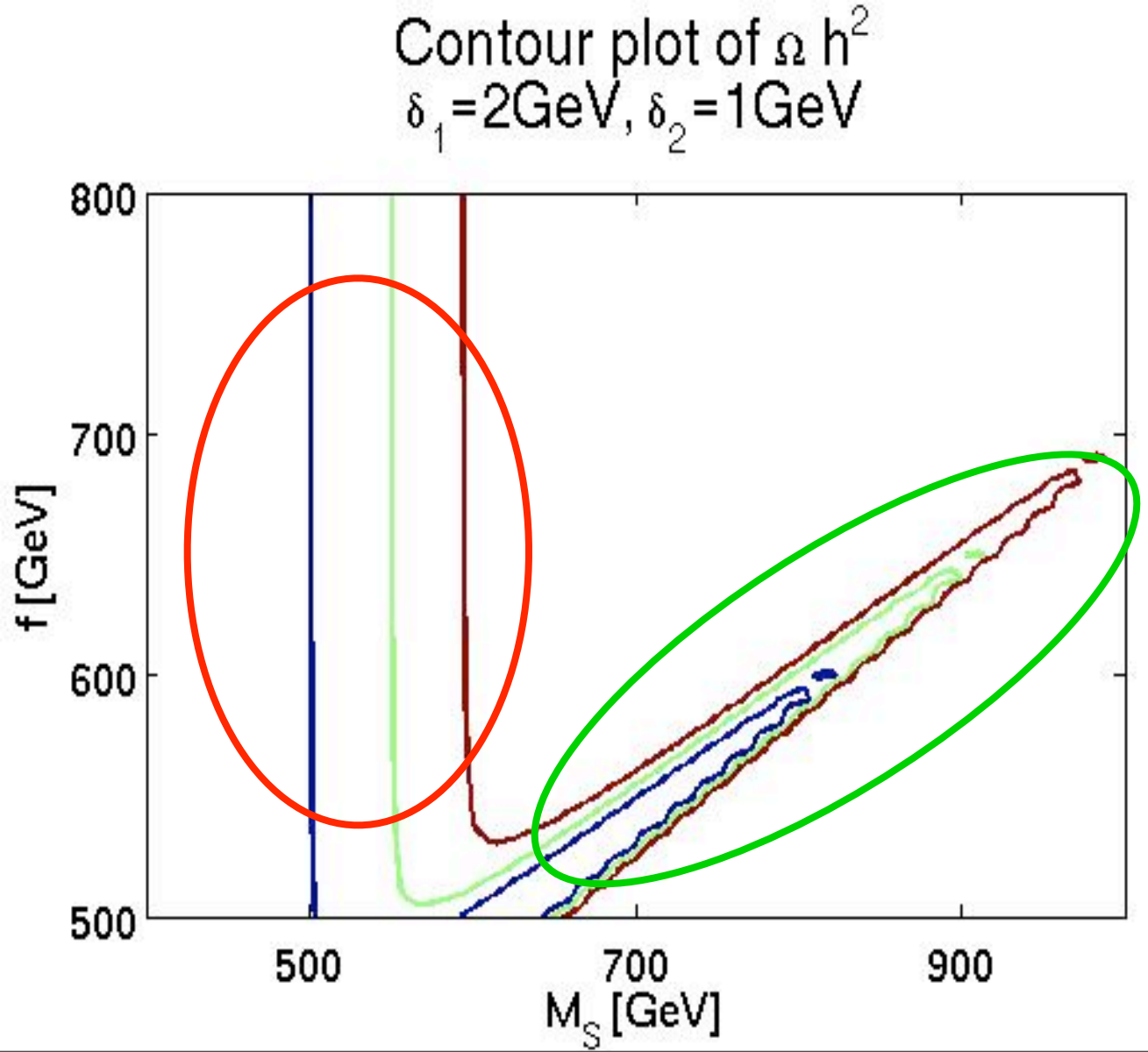
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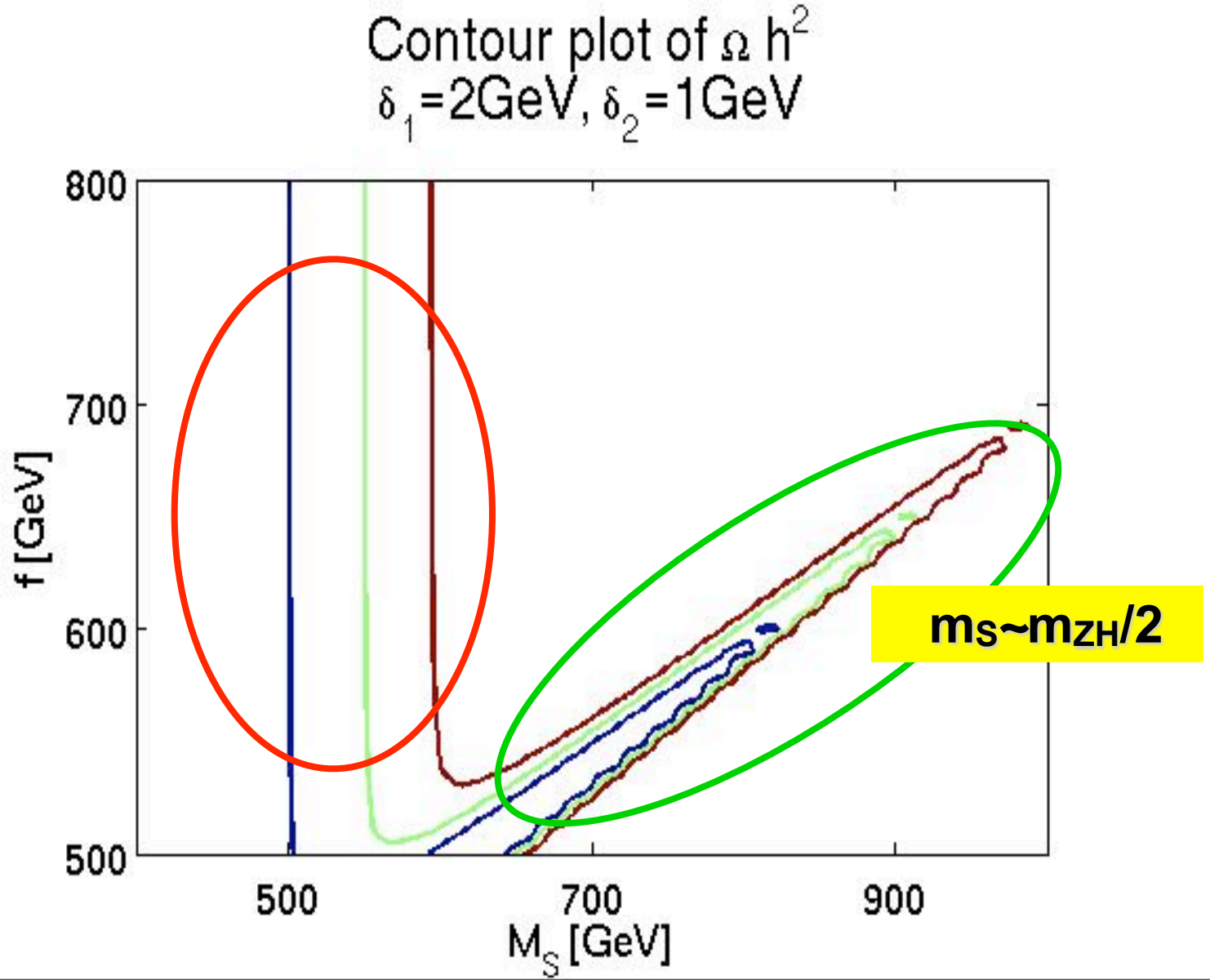
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mS~mZH/2

Conclusions

- Left-right twin Higgs model: Higgs as pseudo-goldstone boson

  quadratic divergence forbidden by left-right symmetry
- $\hat{H}_2^0$ (S or A) could be a good DM candidate
- There are two regions for right amount of relic density
  - * bulk region
  - * pole region: $m_S \sim m_{ZH}/2$
- Direct and indirect dark matter detection

  ⇒ see E. Dolle's talk next