

$$\begin{array}{lcl}
 H_1 \begin{pmatrix} 2 \\ \frac{1}{2} \end{pmatrix}_+ & \leftarrow & \text{SM Higgs doublet} \\
 H_2 \begin{pmatrix} 2 \\ \frac{1}{2} \end{pmatrix}_- & \leftarrow \text{parity} & \leftarrow \text{New Higgs doublet}
 \end{array}
 \left. \vphantom{\begin{array}{l} H_1 \\ H_2 \end{array}} \right\} \text{couple to } \delta, Z, W^\pm$$

$$\begin{array}{c}
 Q \quad u \quad D \quad L \quad \bar{E} \\
 \hline
 \text{SM charge, parity } +
 \end{array}
 \quad
 \begin{array}{c}
 N \\
 \text{SM singlet parity } "-" \\
 (\sim \text{sterile } \nu)
 \end{array}$$

such that the only possible Yukawa for H_2 is

$$\mathcal{L} \supset y \bar{L} N \hat{H}_2 + h.c.$$

$$\begin{pmatrix} 2 \\ -\frac{1}{2} \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix}_- \begin{pmatrix} 2 \\ \frac{1}{2} \end{pmatrix}$$

$$SU(2) \quad 2 \otimes 1 \otimes 2 \supset 1$$

$$U(1)_Y \quad -(\frac{1}{2}) \otimes 0 \otimes \frac{1}{2} = 0$$

$$Z_2 \quad + \otimes - \otimes - = +$$

$$y(\bar{\nu}, \bar{e}) N \begin{pmatrix} H_2^0 \\ -H_2^- \end{pmatrix} \sim y \begin{pmatrix} \bar{\nu} N H_2^0 \\ -\bar{e} N H_2^- \end{pmatrix} + h.c.$$

The H_2^0 doesn't have $V\bar{E}V \rightarrow$ No seesaw.

if $m_N < m_{H_2}$, \Rightarrow N could be the DM candidate

if m_N light. (say $\lesssim \text{keV}$) \rightarrow Warm DM candidate

$$\begin{array}{c}
 N \\
 \swarrow \\
 M \text{ --- } H^- \nearrow e^- \\
 \nwarrow \quad \nearrow \\
 \quad N
 \end{array}$$

• then your Michael parameter calculation needs to include the start- ν mass.

• for $L\bar{\nu}_\mu$ if $M_{H_2} \gtrsim 110 \text{ GeV}$.

then it can't be produced on-shell.

• For DM

