



Higgsino Dark Matter at Collider

based on arXiv:1703.09675

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Collaboration with

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What is Higgsino?

Higgsino is

- (pseudo) Dirac fermion
- Hypercharge $|Y|=1/2$
- SU (2) doublet $\begin{pmatrix} \tilde{H}_u^+ \\ \tilde{H}_u^0 \end{pmatrix}, \begin{pmatrix} \tilde{H}_d^0 \\ \tilde{H}_d^- \end{pmatrix}$
- $<1 \text{ TeV}$ $\Omega h^2 \simeq 0.1 \left(\frac{m_{\tilde{H}}}{1.1 \text{ TeV}} \right)^2$

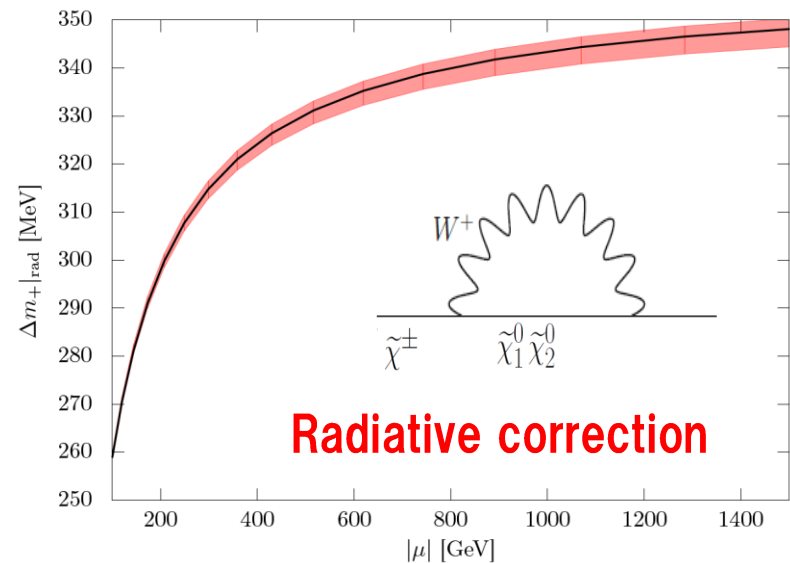
Higgsino Spectrum (with heavy gaugino)

$$\begin{pmatrix} \tilde{H}_u^+ \\ \tilde{H}_u^0 \end{pmatrix}, \begin{pmatrix} \tilde{H}_d^0 \\ \tilde{H}_d^- \end{pmatrix} \longrightarrow \tilde{\chi}_1^0 \quad \tilde{\chi}_2^0 \quad \tilde{\chi}^\pm$$

$\tilde{\chi}^\pm$

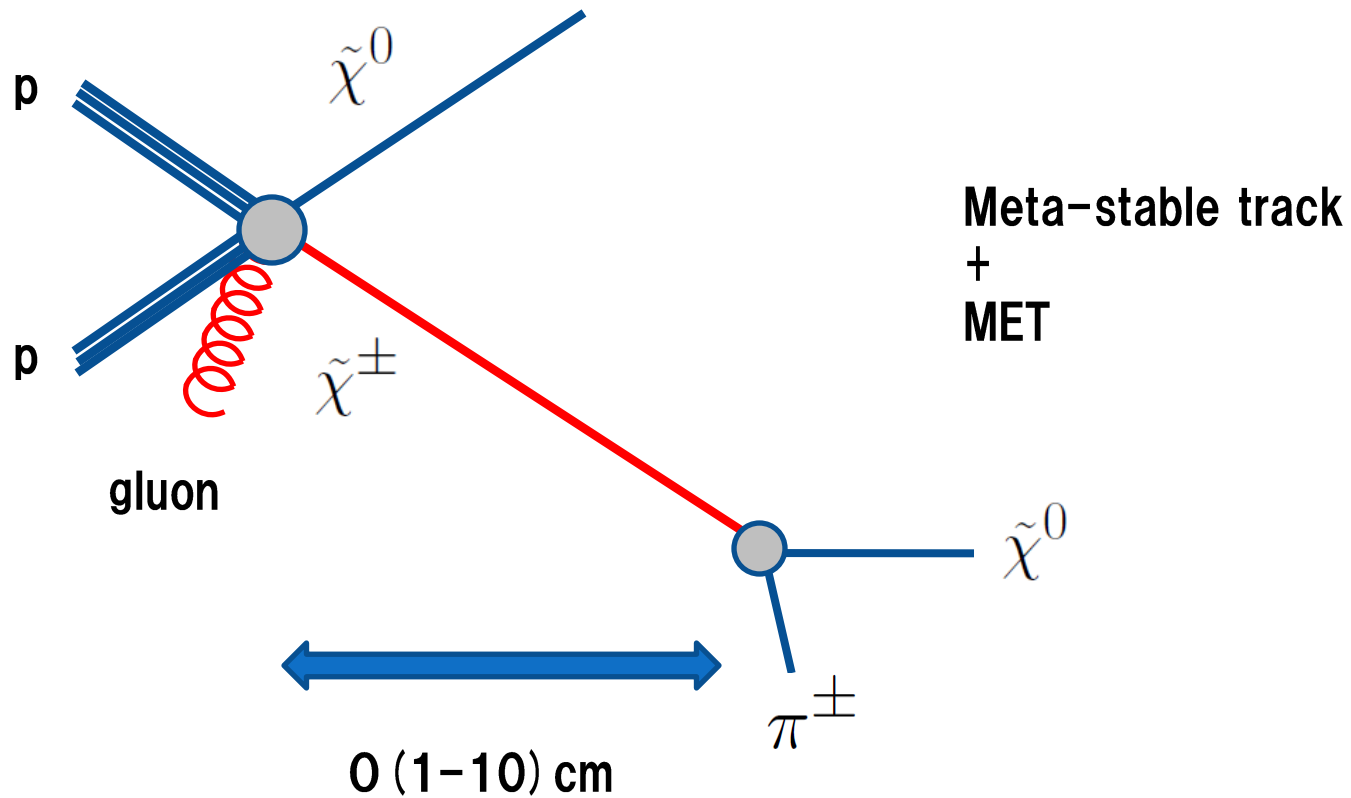
$\tilde{\chi}_2^0$

$\tilde{\chi}_1^0$



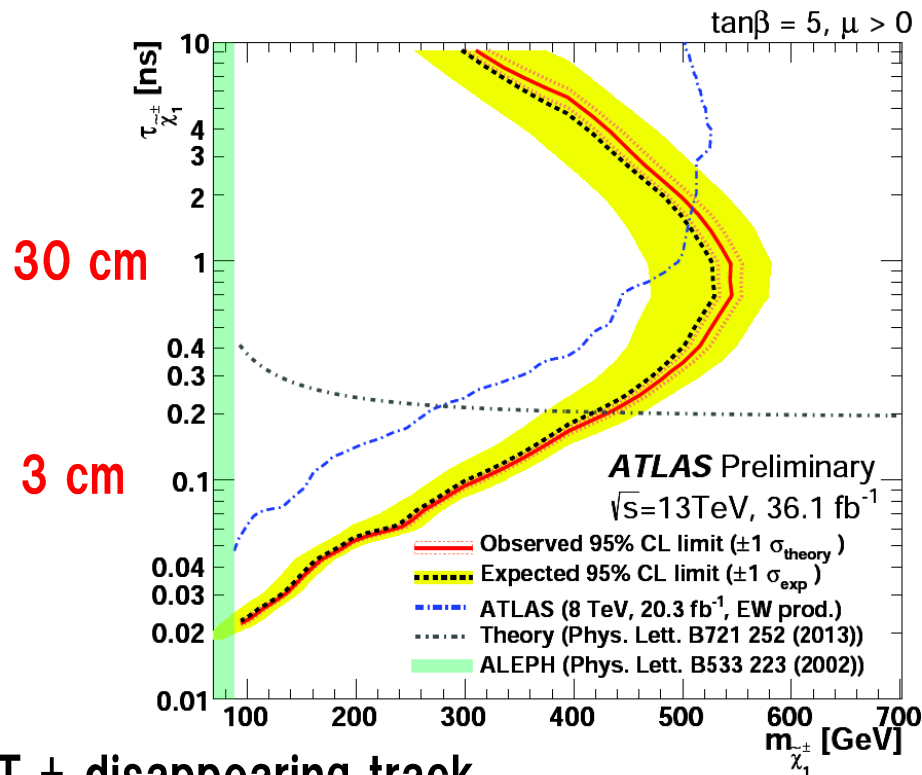
$$c\tau(\tilde{\chi}^\pm \rightarrow \tilde{\chi}^0 \pi^\pm) = 1.1 \text{ cm} \left(\frac{\Delta m_+}{300 \text{ MeV}} \right)^{-3} \left[1 - \frac{m_{\pi^\pm}^2}{\Delta m_+^2} \right]^{-1/2}$$

LHC Signals



Current Constraint (wino)

So far, LHC investigates **Wino** case



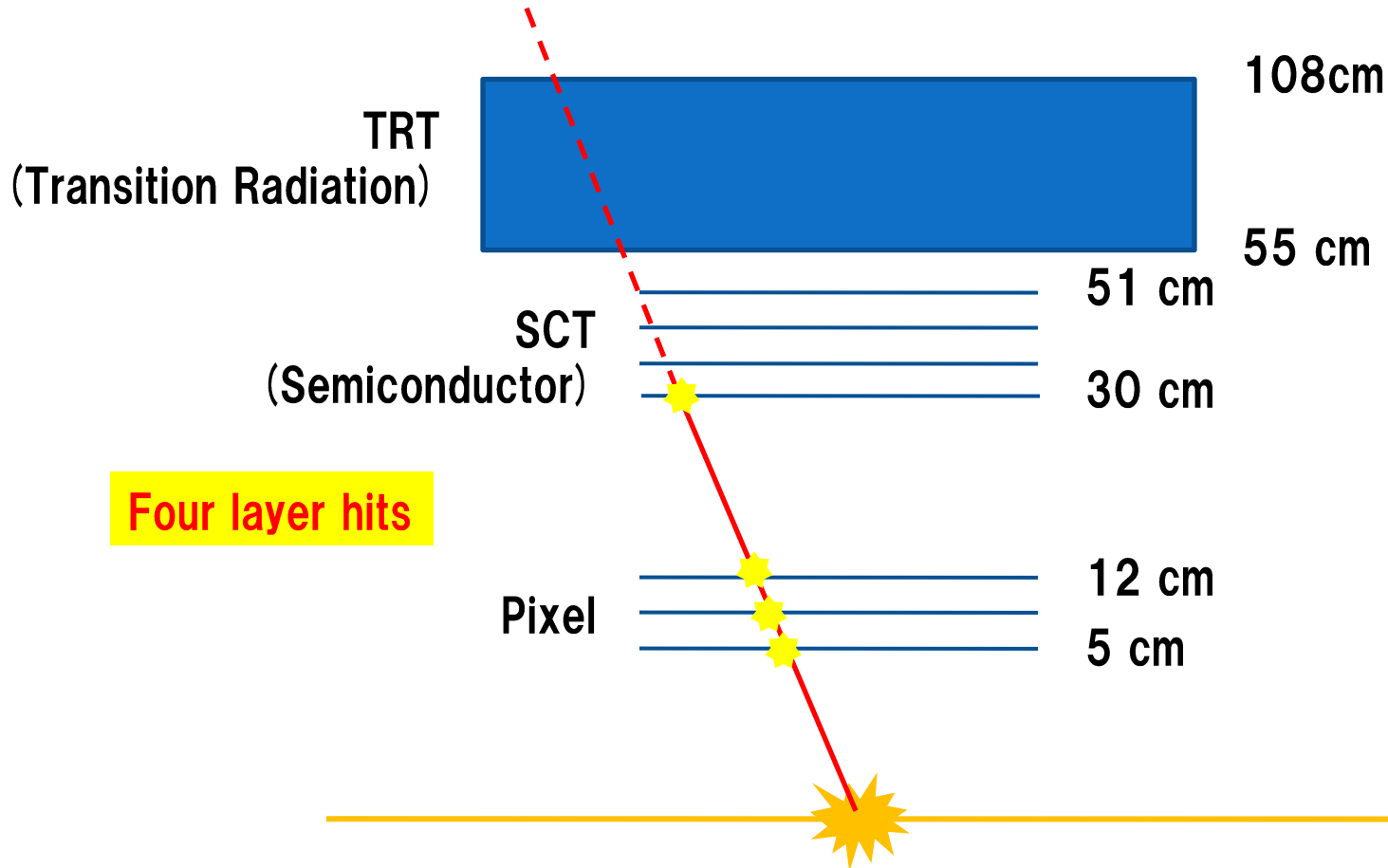
MET + disappearing track

$$\begin{pmatrix} \widetilde{W}^+ \\ \widetilde{W}^0 \\ \widetilde{W}^- \end{pmatrix} \text{ Mass difference } \sim 160 \text{ MeV}$$

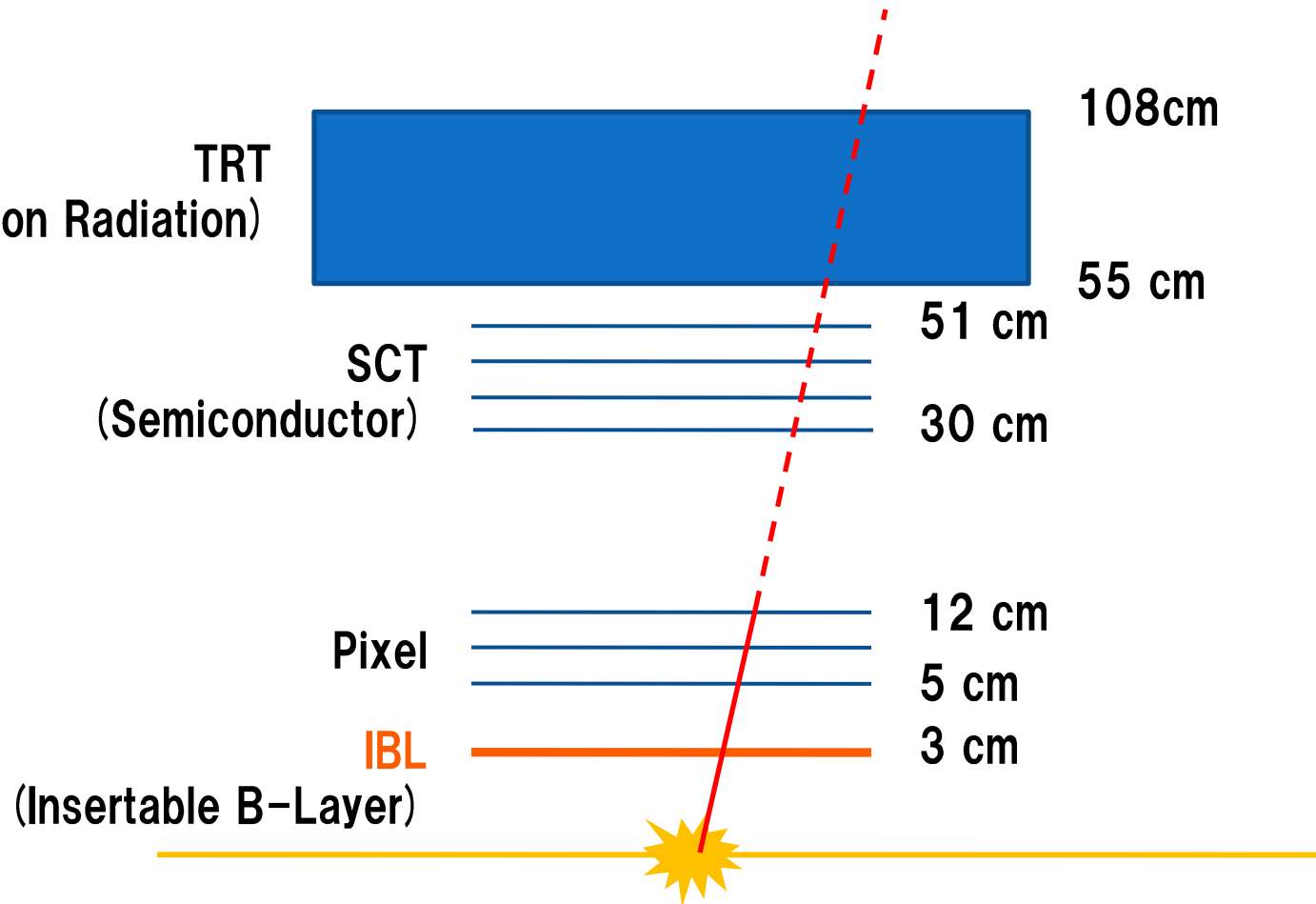
$$c\tau(\widetilde{W}^\pm \rightarrow \widetilde{W}^0 \pi^\pm) \simeq 7 \text{ cm} \left(\frac{\Delta m}{165 \text{ MeV}} \right)^{-3}$$

Tracker for Run1

8 TeV selection

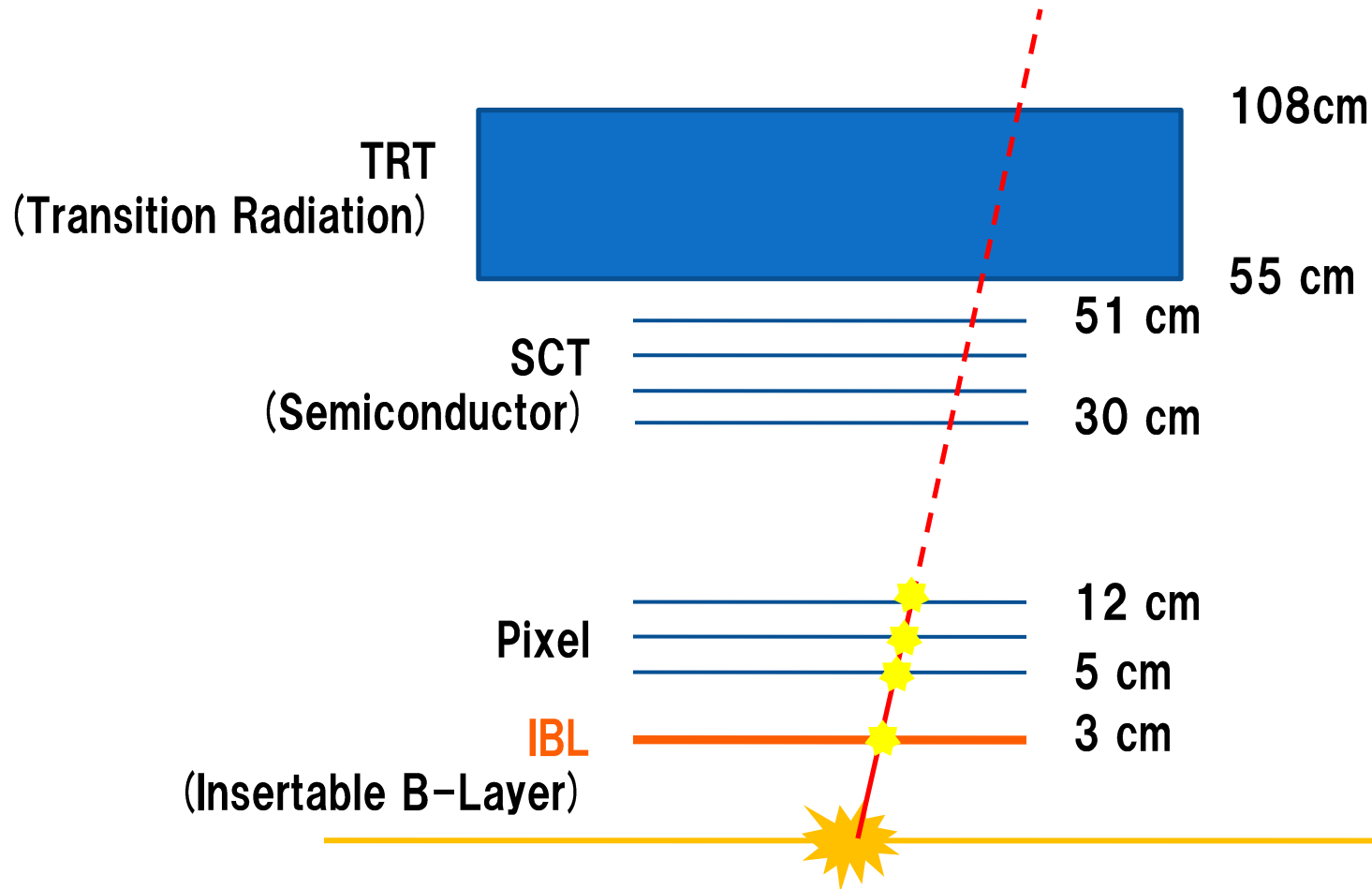


Tracker for Run2

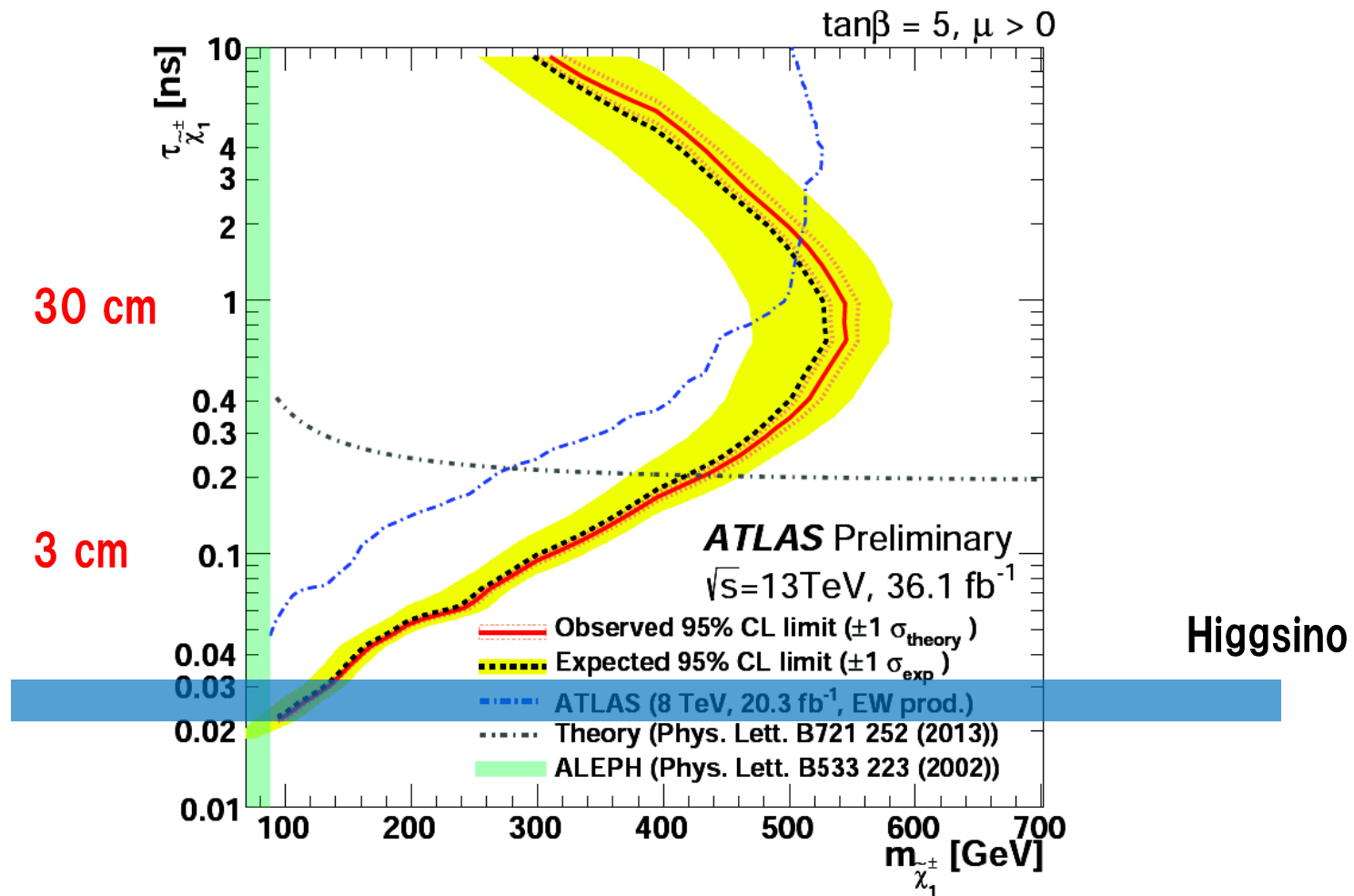


* CMS installed similar module

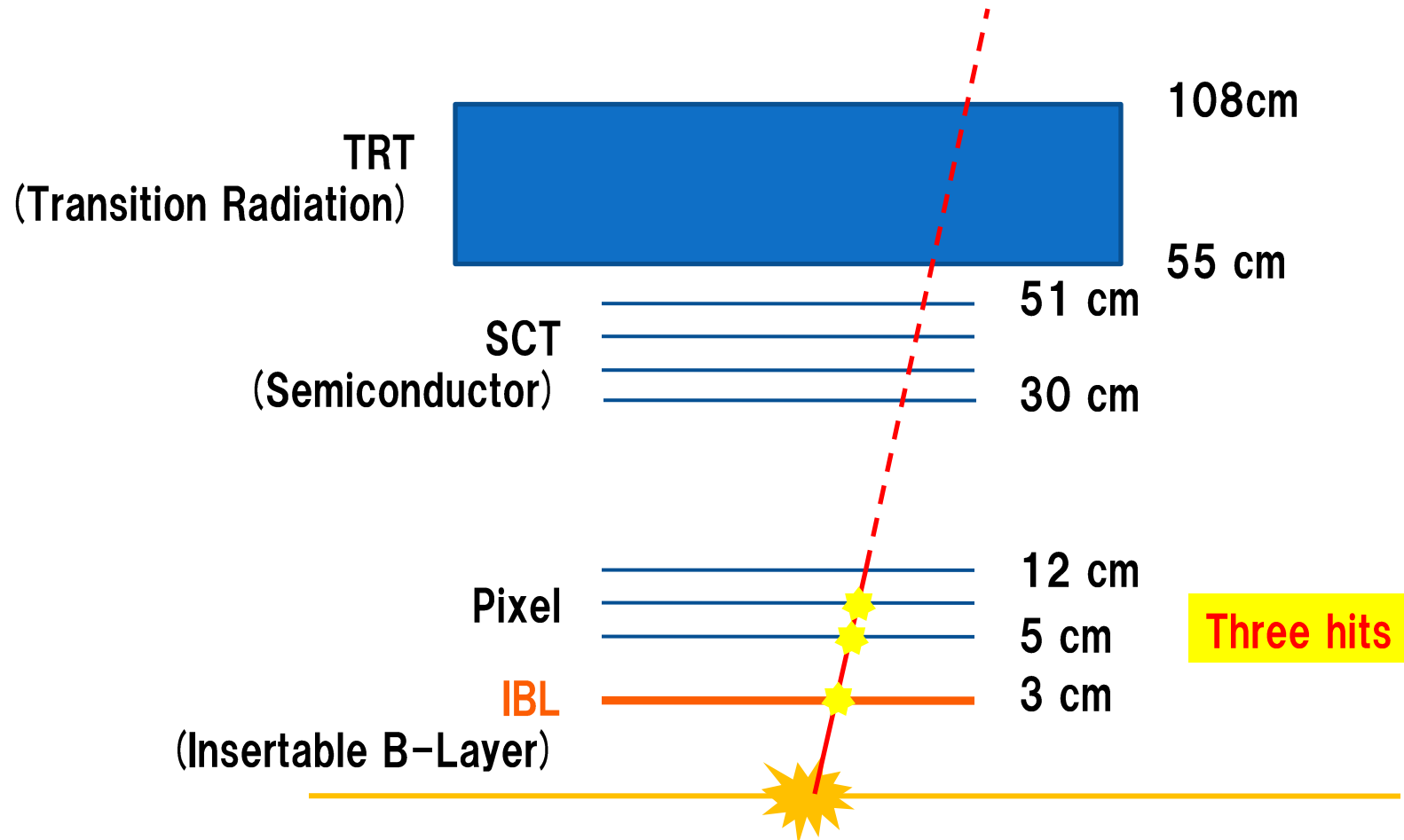
Tracker for Run2



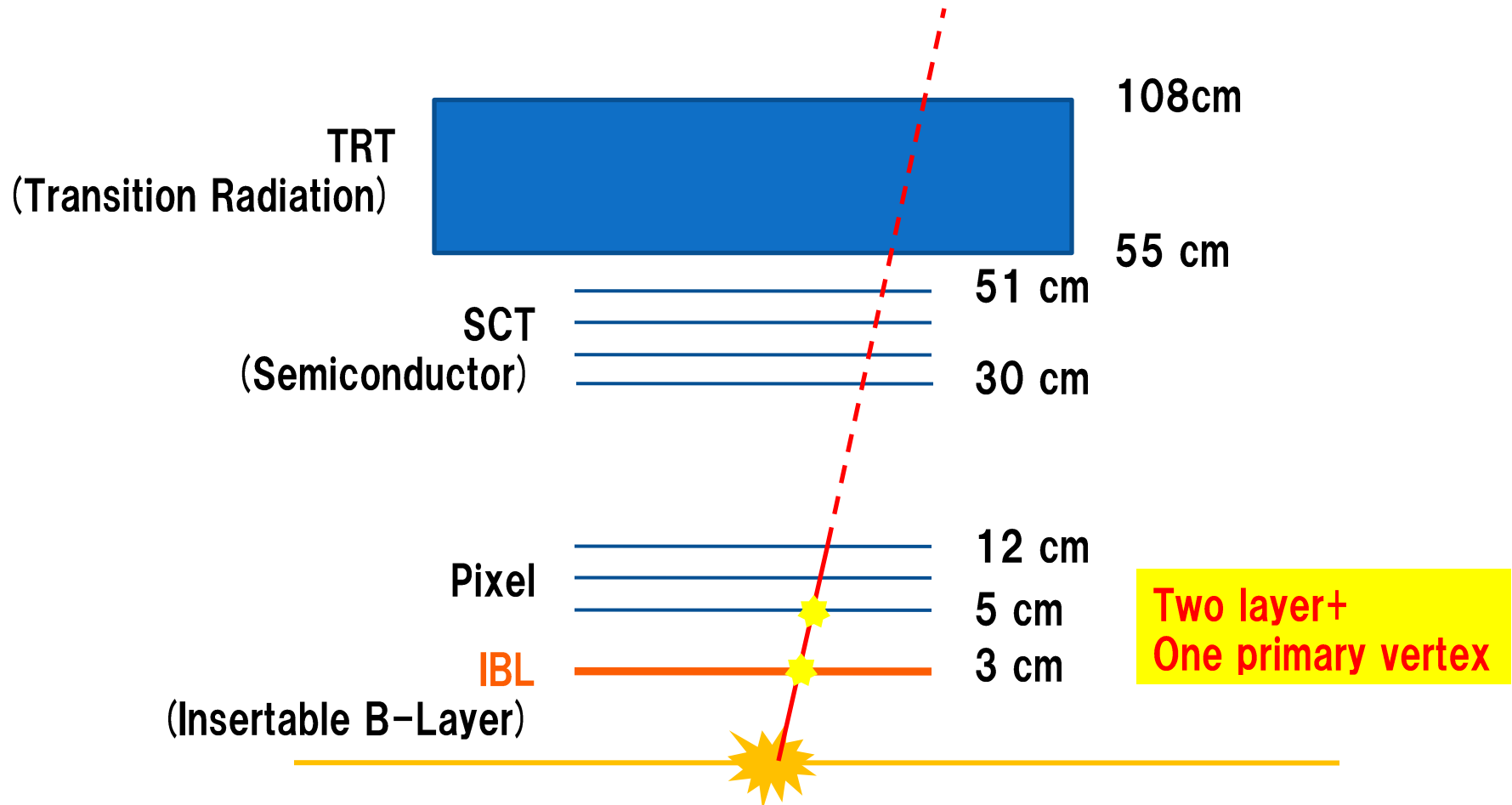
Current Constraint (wino)



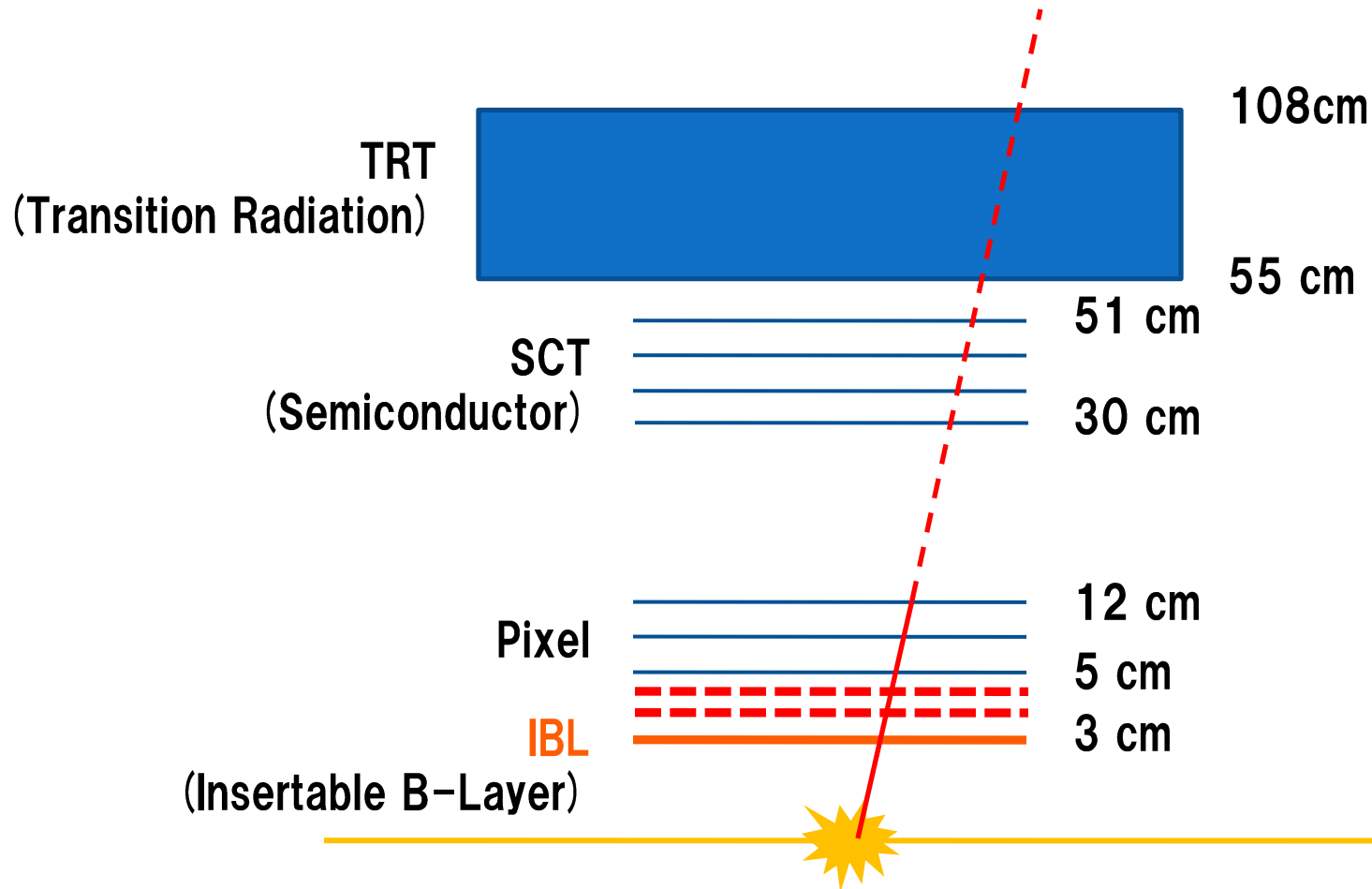
Tracking shorter



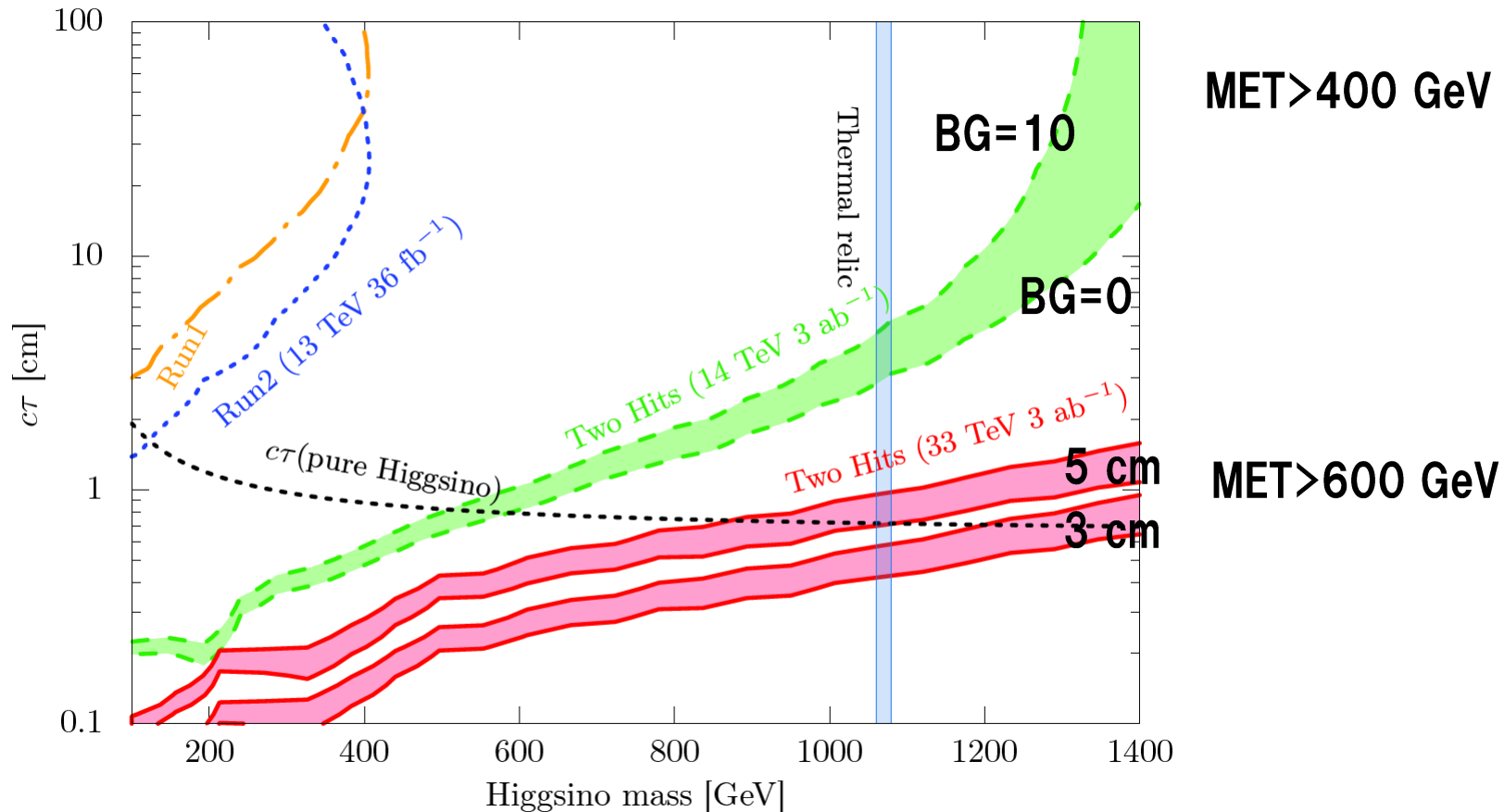
Tracking shorter



Tracker for Run???

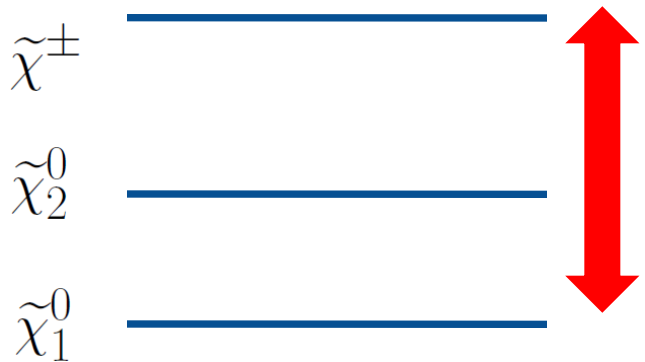


Prospects for Higgsino



Higgsino Spectrum (with light gaugino)

$$\begin{pmatrix} \tilde{H}_u^+ \\ \tilde{H}_u^0 \end{pmatrix}, \begin{pmatrix} \tilde{H}_d^0 \\ \tilde{H}_d^- \end{pmatrix} \longrightarrow \tilde{\chi}_1^0 \quad \tilde{\chi}_2^0 \quad \tilde{\chi}^\pm$$

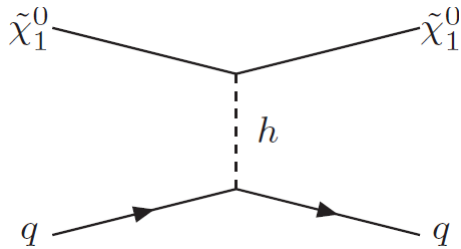


$$\Delta m \sim \frac{m_W^2}{m_{\text{gaugino}}} = O(1) \text{ GeV} \left(\frac{m_{\text{gaugino}}}{1 \text{ TeV}} \right)^{-1}$$

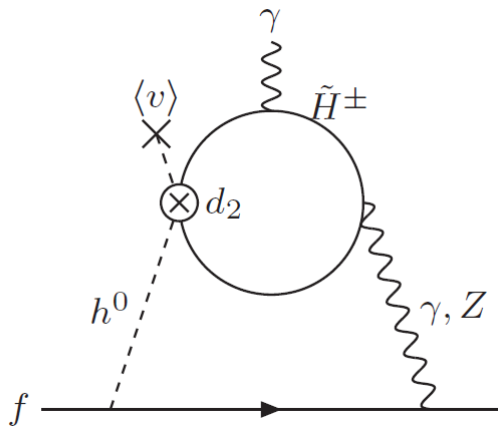
$$c\tau(\tilde{\chi}^\pm \rightarrow \tilde{\chi}^0 \pi^\pm) = 1.1 \text{ cm} \left(\frac{\Delta m_+}{300 \text{ MeV}} \right)^{-3} \left[1 - \frac{m_{\pi^\pm}^2}{\Delta m_+^2} \right]^{-1/2}$$

Higgsino with light gaugino

Light gauginos lead too short track. However

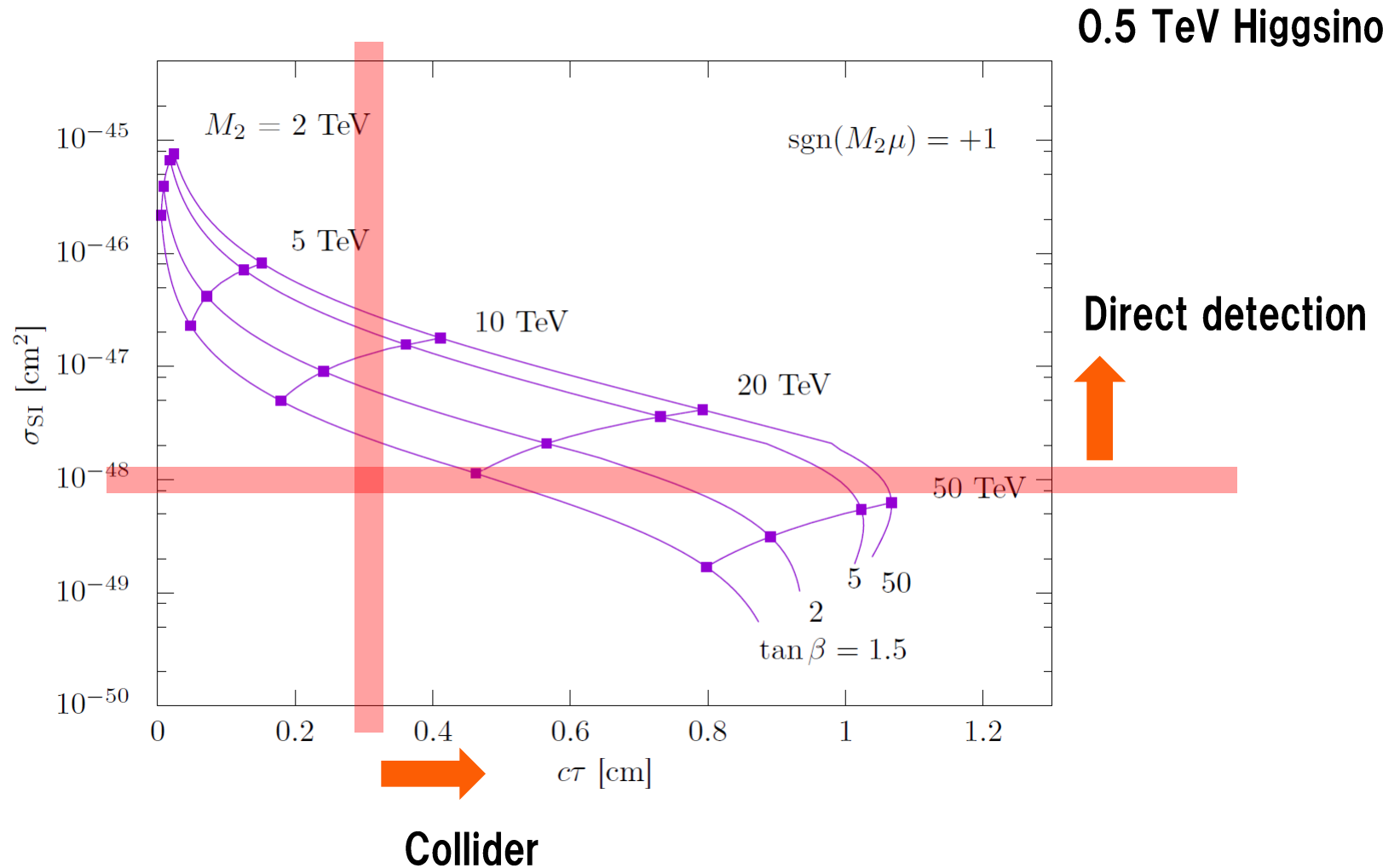


DM direct detection $\propto m_{\text{gaugino}}^{-2}$



SM fermion EDM $\propto m_{\text{gaugino}}^{-1}$

Interplay with DM direct detection



Strategy for Higgsino DM

EDM (if CPV)



SI detection



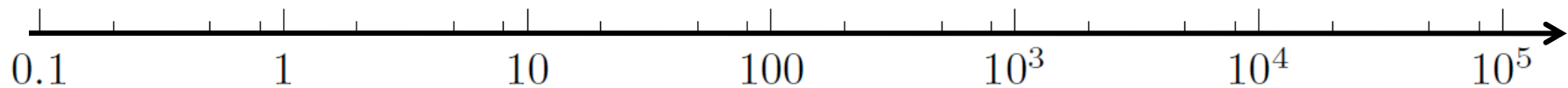
Inelastic DM detection



Soft lepton



Disappearing track

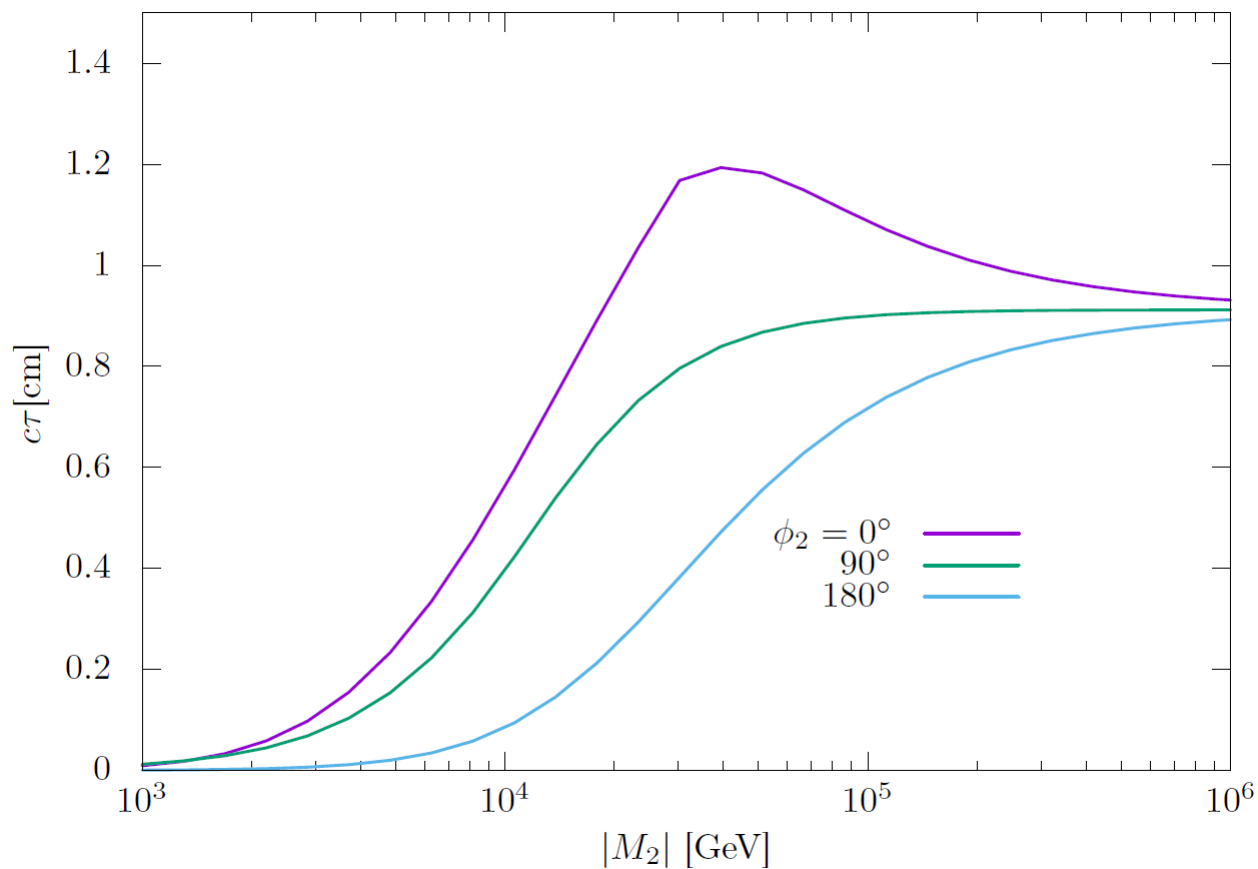


Gaugino mass [TeV]

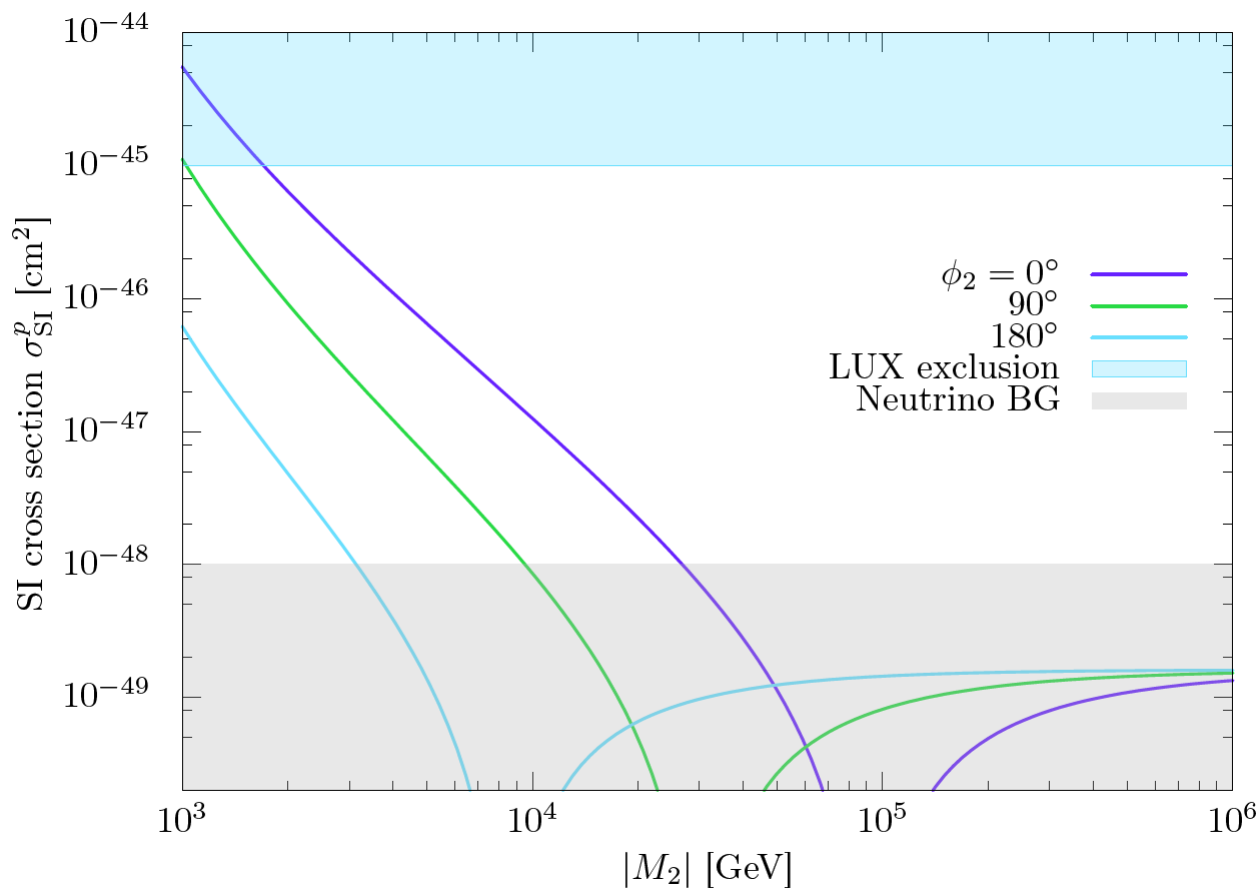
Summary

- **Higgsino DM is important target**
- **Improving tracker system is crucial**
- **DM direct detection and precision measurement cover blind spot for collider**

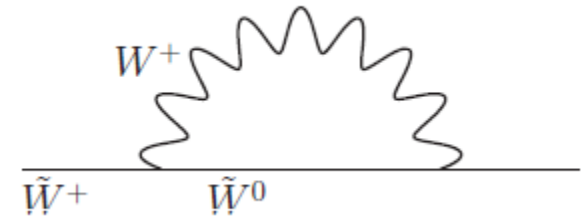
Decay Length



Interplay with DM direct detection



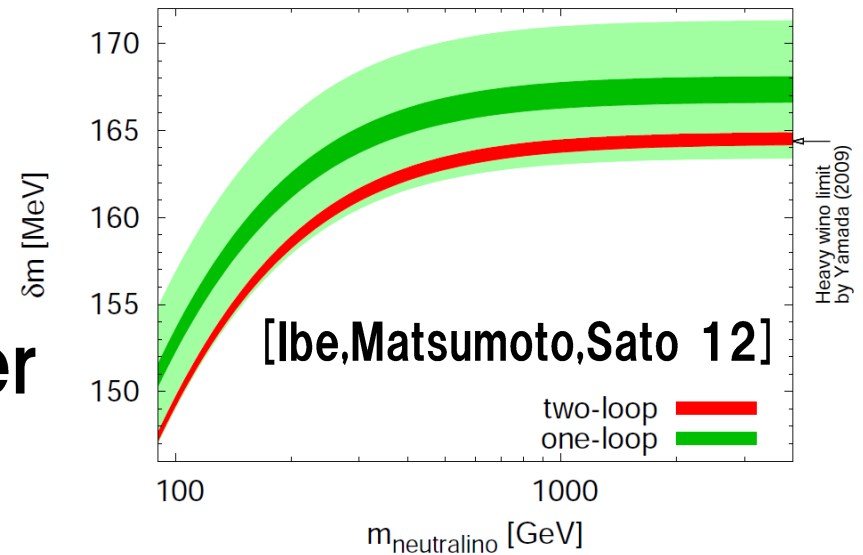
Wino Spectrum



Radiative correction



$\begin{pmatrix} \tilde{W}^+ \\ \tilde{W}^0 \\ \tilde{W}^- \end{pmatrix}$ Charged slightly heavier



$$c\tau(\tilde{W}^\pm \rightarrow \tilde{W}^0 \pi^\pm) \simeq 7 \text{ cm} \left(\frac{\Delta m}{165 \text{ MeV}} \right)^{-3}$$

Higgsino DM is tough

