(very) Light charginos and Higgs couplings

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Motivation

We have discovered the Higgs boson!
A program is underway to measure its couplings

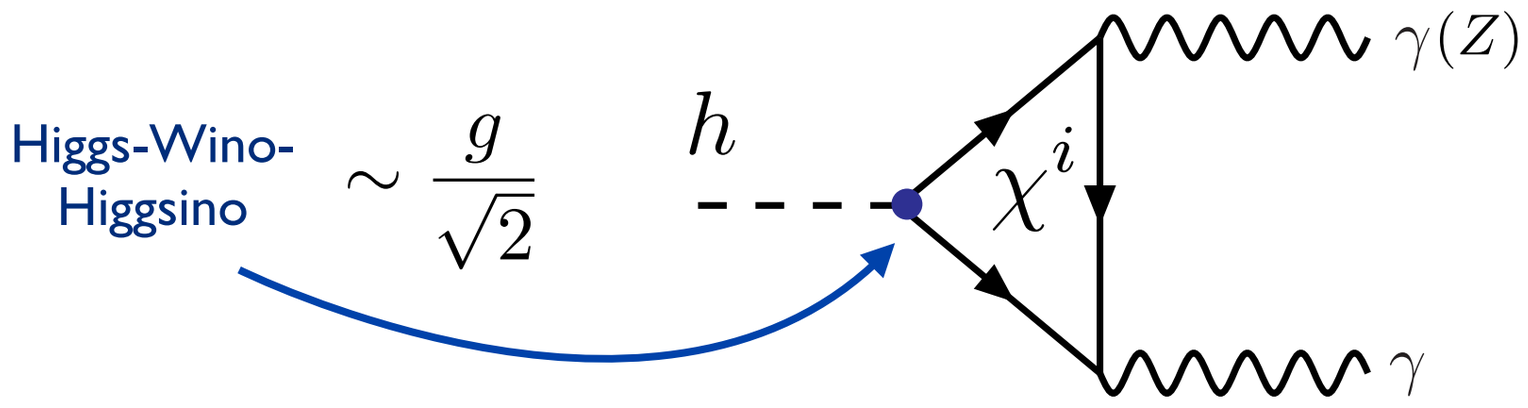
It is important to understand the range of possible deviations in the Higgs couplings in motivated BSM models

I'll focus on charginos in the MSSM -
less studied, typically smaller corrections to Higgs couplings

Interplay of Higgs coupling measurements &
direct chargino searches

Chargino contribution to the loop-induced couplings $h-\gamma-\gamma$ and $h-Z-\gamma$.

[Djouadi, Driesen, Hollik, Kraft '97]



Weak gauge coupling - generically do not obtain large deviations from SM

Low energy theorem:

$$\mathcal{L} \supset \frac{\alpha\, b_\chi}{16\sqrt{2}\pi v}\xi_\chi h\, F_{\mu\nu}\, F^{\mu\nu}$$

$$\mathbf{X} = \begin{pmatrix} M_2 & g v_u \\ g v_d & \mu \end{pmatrix}$$

$$\xi_\chi = 2\left(\frac{\partial}{\partial \log v_u} + \frac{\partial}{\partial \log v_d}\right)\log\det \mathbf{X}$$

$$= -\frac{2g^2 v^2 \sin 2\beta}{M_2\mu - \frac{1}{2}g^2 v^2 \sin 2\beta}$$

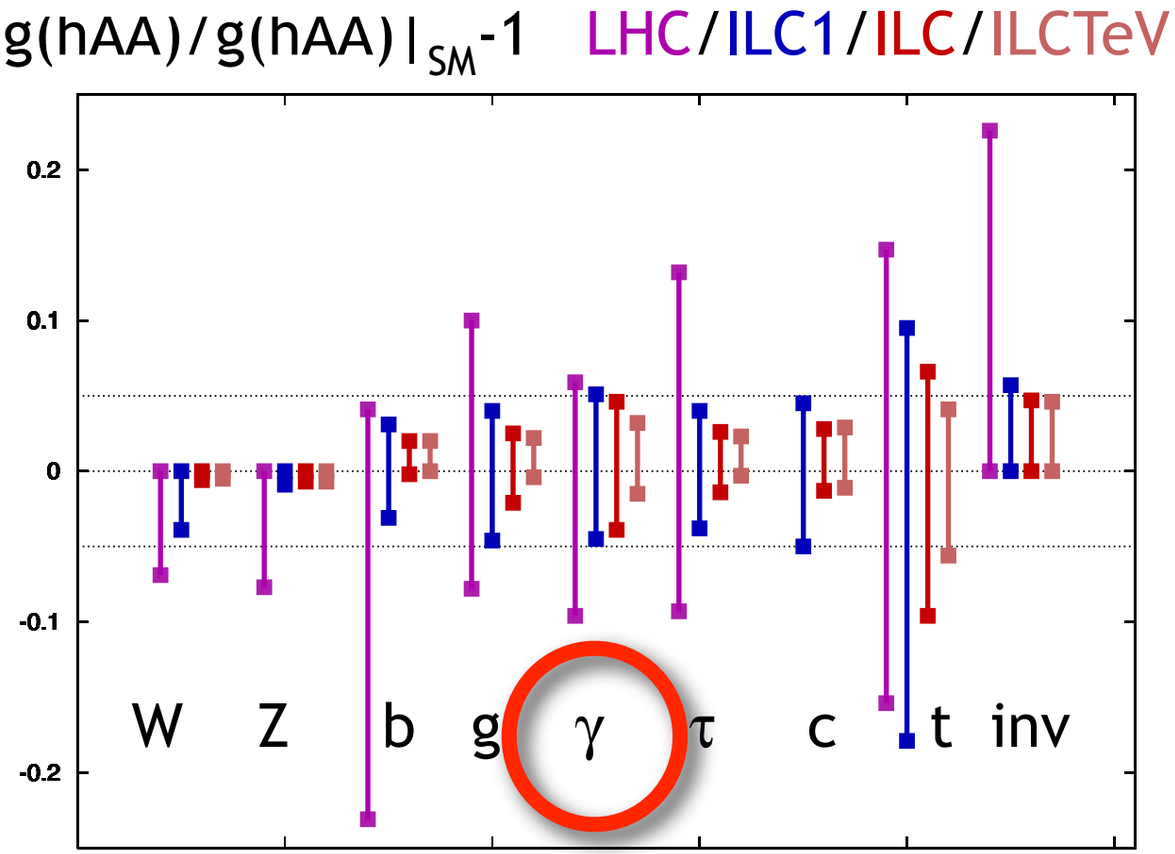
maximized for $\tan\beta \to 1$

also need $m_{\tilde{\chi}^+}$ light, $M_2 \sim \mu$

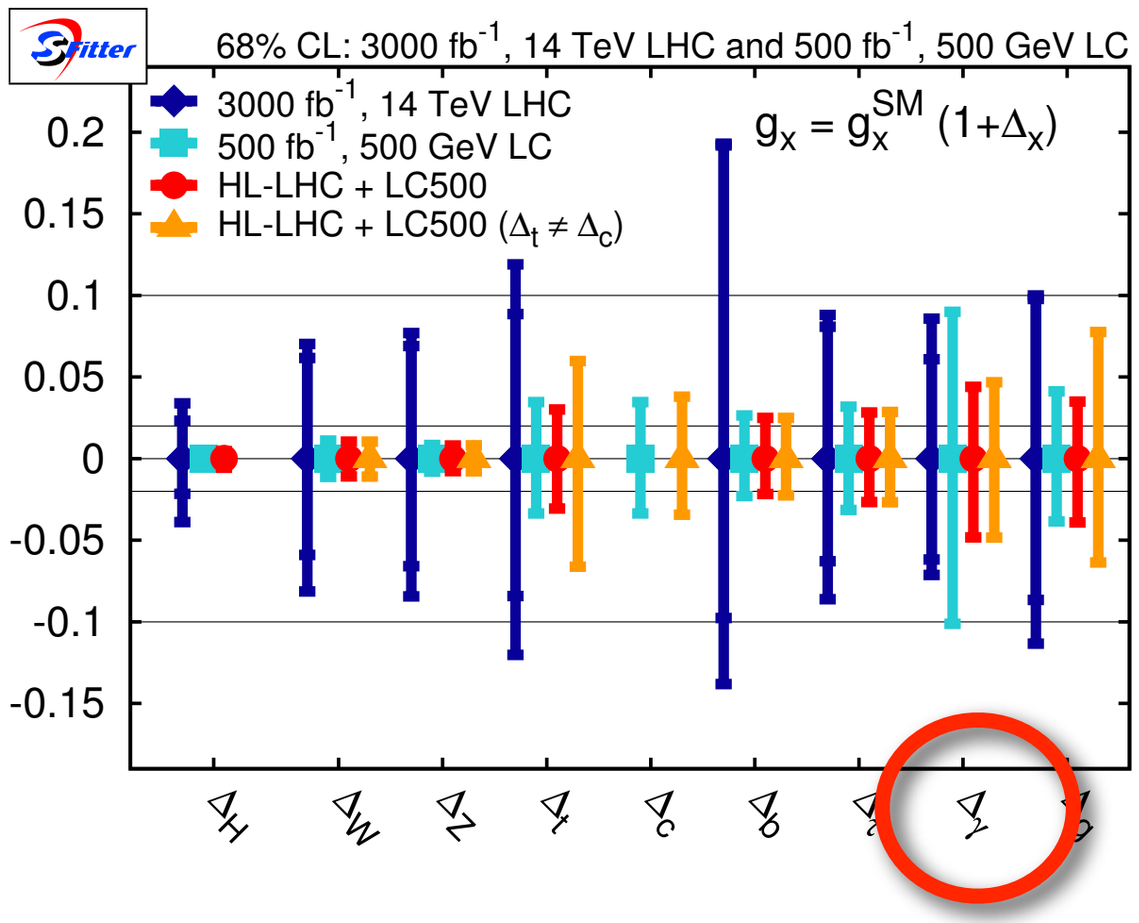
What level of precision can we hope to achieve?

$$g_{hAA} = (1 + \Delta_A) g^{\rm SM}_{hAA}$$

[Peskin '12]



[Klute et al. '13]



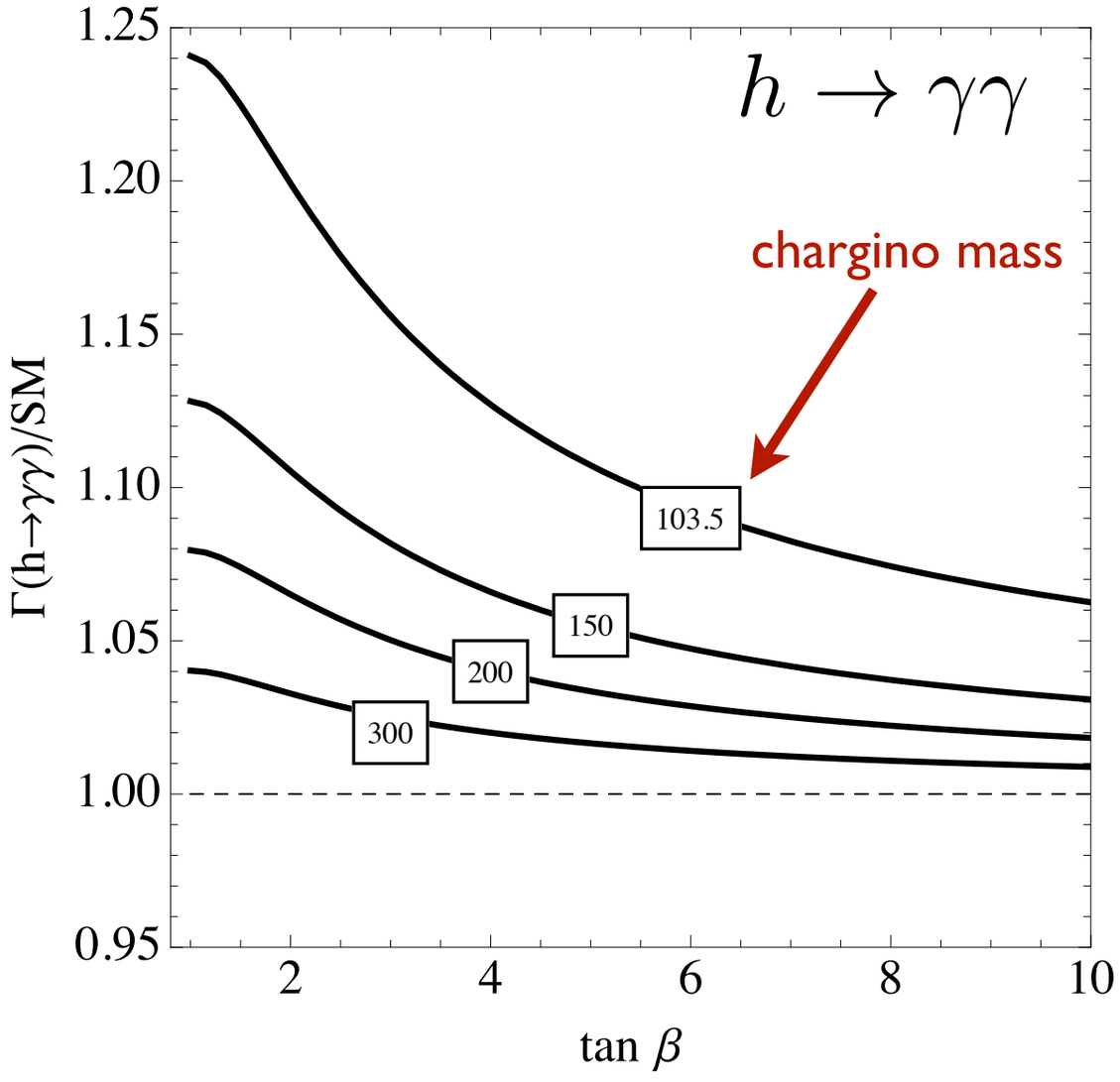
For $h\gamma\gamma$, LHC: ~ 5-10% level
Future facility: ~ few % level

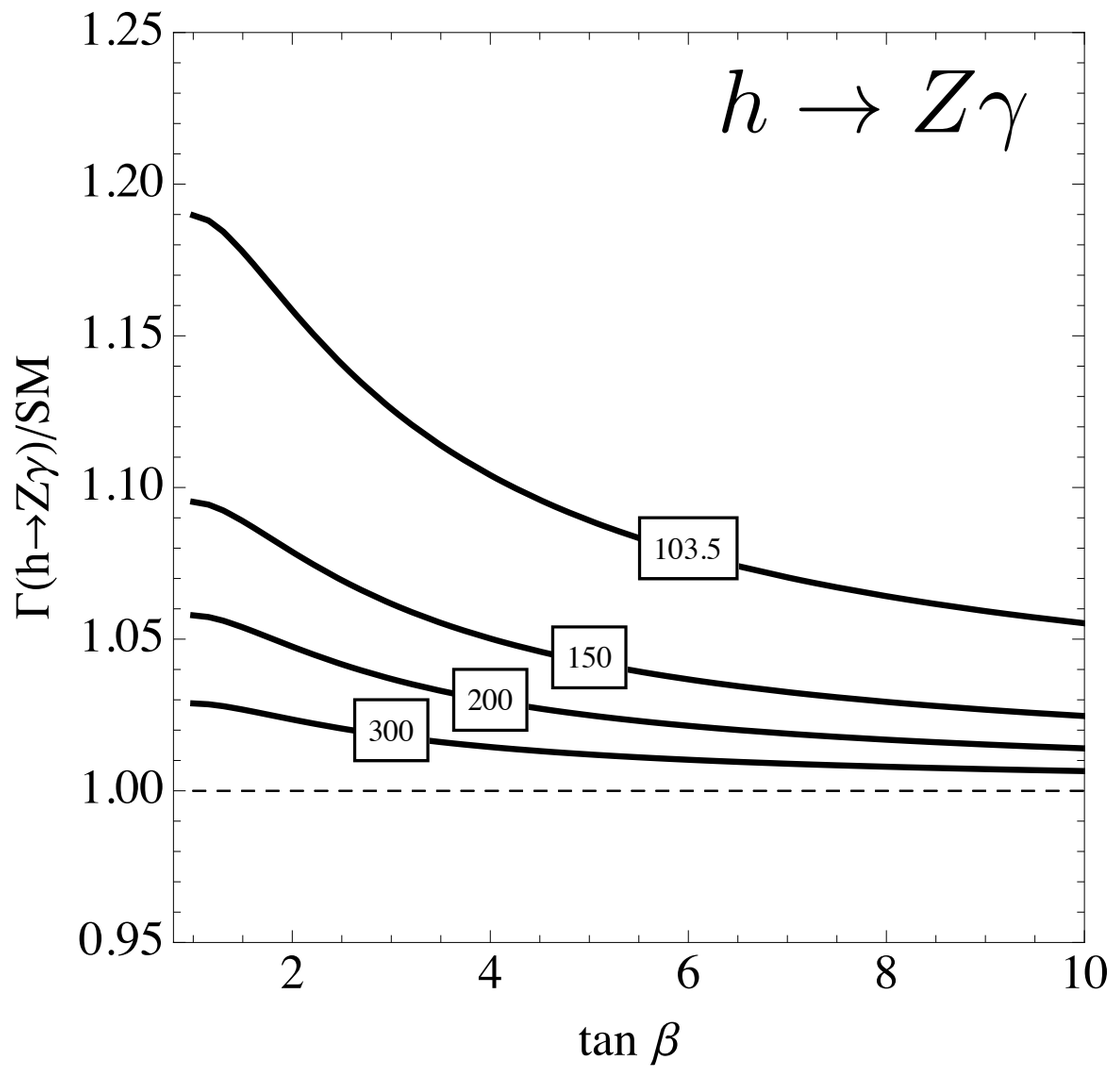
(x 2 in rates)

Noticeably absent is $h\gamma Z$; should be revisited!

Maximum deviations for $m_{\chi^+} \gtrsim 100\ \mathrm{GeV} \quad (M_2 = \mu)$

[see also Casas et al., 1305.3274]





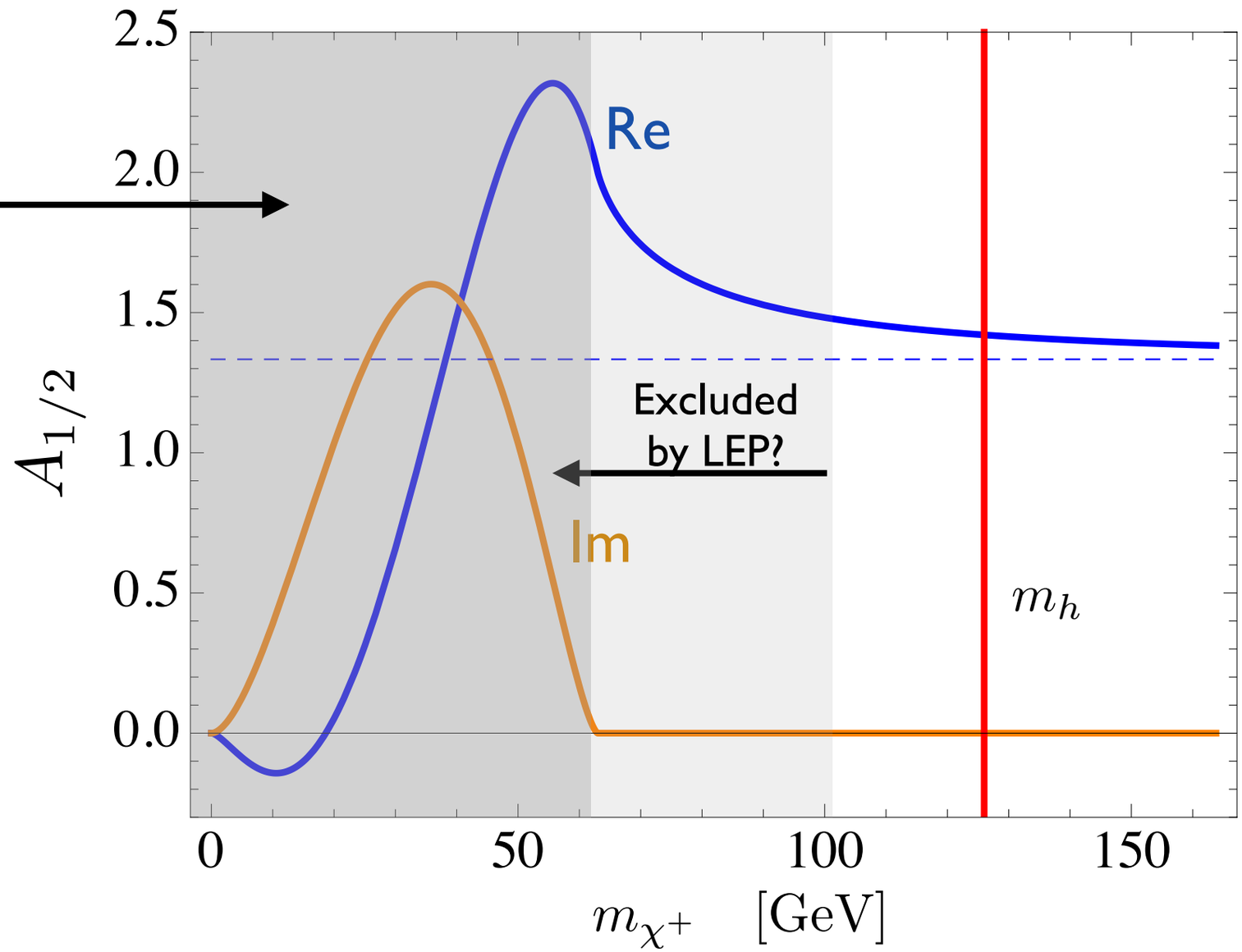
LHC Higgs coupling measurements probe $m_{\tilde{\chi}_+} \lesssim 150\,\mathrm{GeV}, \ \tan\beta \lesssim 6$

Future facility Higgs measurements probe $m_{\tilde{\chi}_+} \lesssim 200\,\mathrm{GeV}, \ \tan\beta \lesssim 20$

Rise of the form factor as $m_f \to m_h/2$

$h \to \chi^+\chi^-$

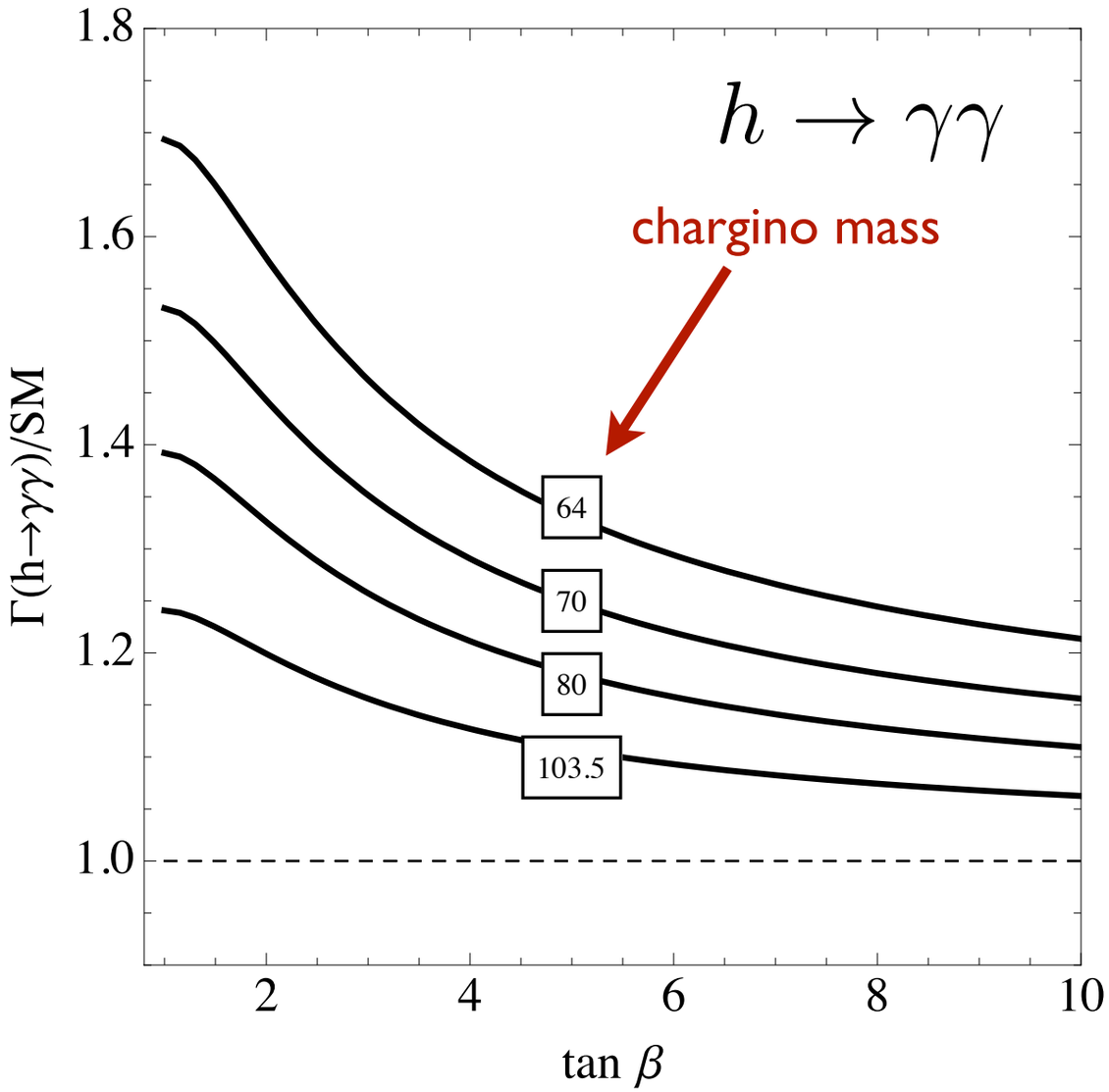
with O(1) branching

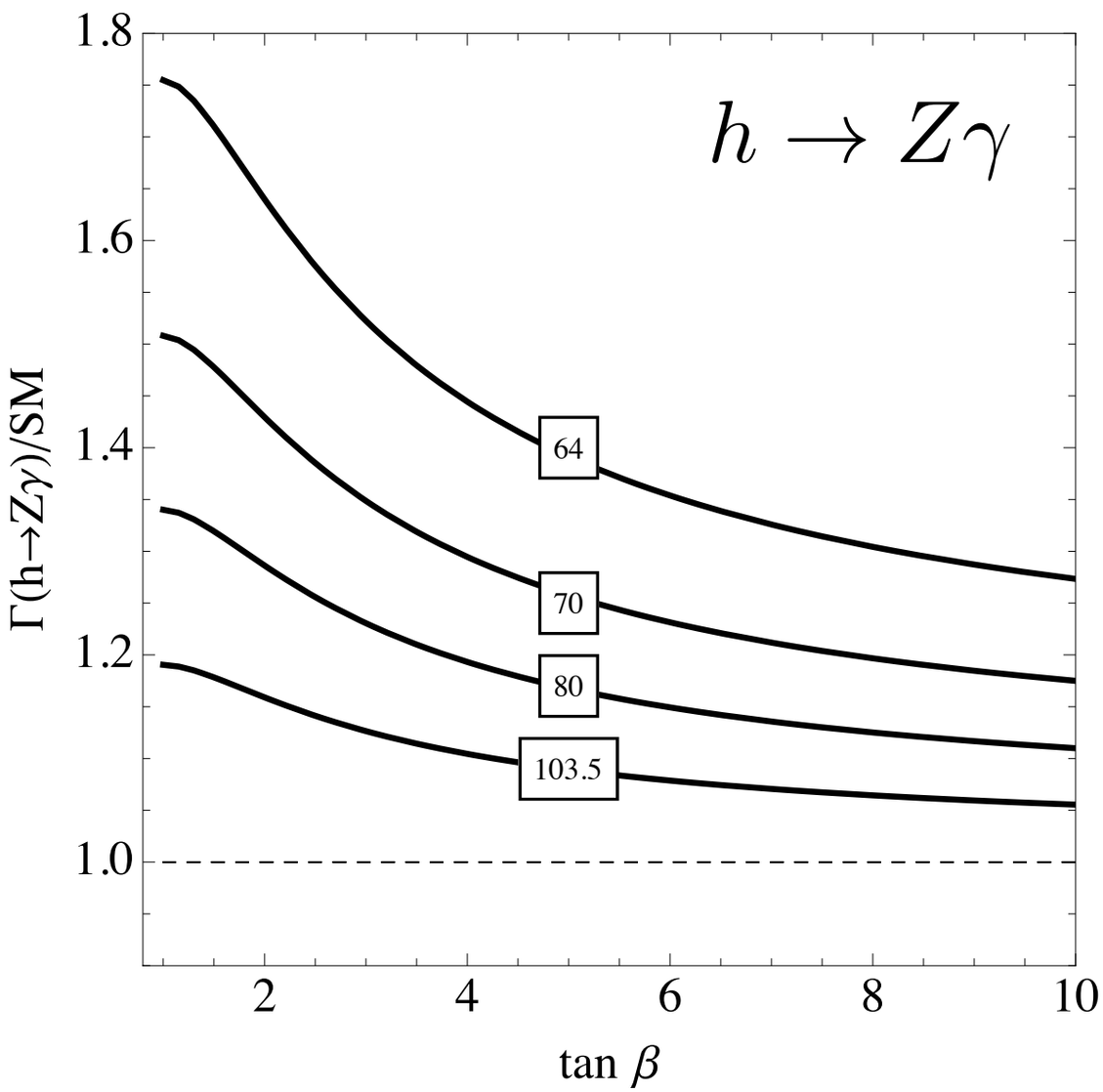


Charginos hiding at LEP?

[BB, Jung, Wagner, to appear]

Maximum deviation $(M_2 = \mu)$





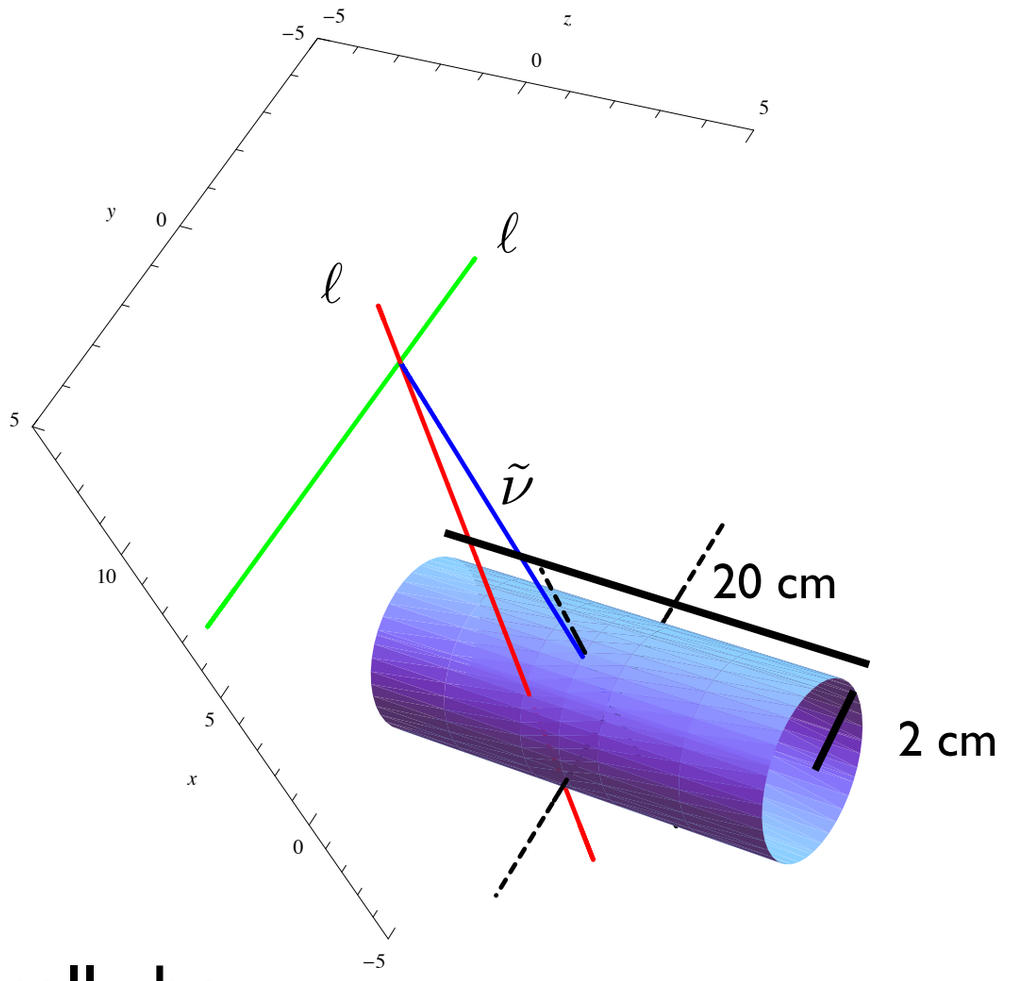
Much larger corrections are possible for $m_{\tilde{\chi}^+} \lesssim 100\,\mathrm{GeV}$

A scenario for hidden chargino: Displaced SUSY

[Graham, Kaplan, Rajendran, Saraswat, '12]

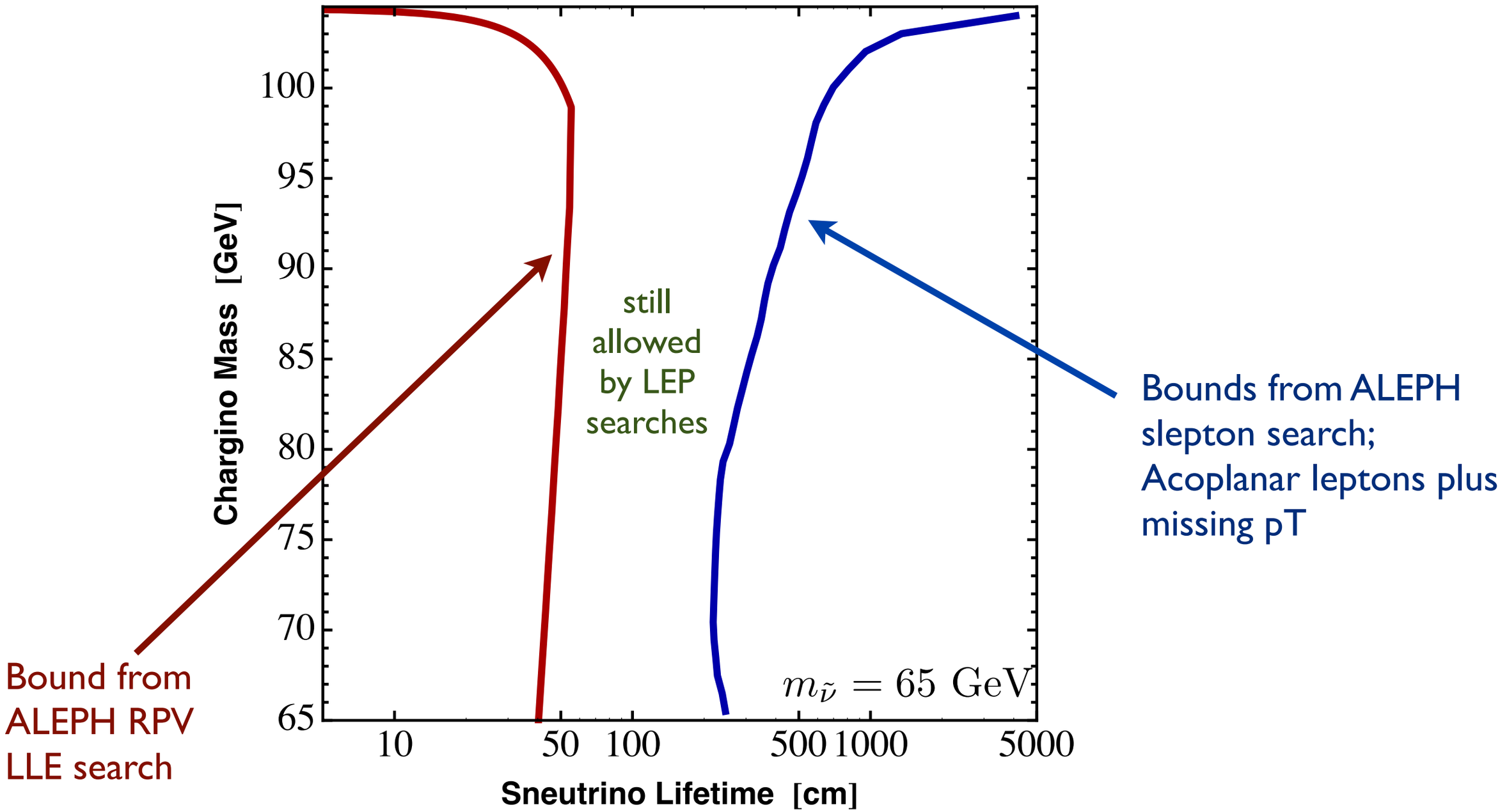
[BB, Jung, Wagner, to appear]

- Sneutrino LSP with displaced RPV decay
- Chargino NLSP, decay via $\chi^+ \to \ell^+ \tilde{\nu}$,
- LEP searches generically require charged track to point back to primary vertex.
- This requirement is not fulfilled if the LSP has a lifetime greater than ~ 10 cm
- Charged objects with bad tracks would typically be classified as neutral hadrons in reconstruction (not MET)
- Chargino pair production yields 2 prompt leptons, but RPV searches demand large number of "good" charged tracks



Bound on Chargino pair production [BB, Jung, Wagner, to appear]

- Example here assumes sneutrino decays through LLE, giving 6 lepton final states (4 leptons are displaced)
- Results will be qualitatively similar for LQD



Take home message for Snowmass:

- Light charginos are motivated, $\mu \sim m_Z$ is "natural",
- How can we probe such states?

Probing charginos through Higgs couplings

- LHC will indirectly probe $m_{\tilde{\chi}+} \lesssim 150\,\mathrm{GeV}, \;\; \tan\beta \lesssim 6$
- Future facility will indirectly probe $m_{\tilde{\chi}+} \lesssim 200\,\mathrm{GeV}, \;\; \tan\beta \lesssim 20$

Direct searches of charginos

- Direct searches typically do a better job of probing large $m_{\tilde{\chi}+}, \tan\beta$
- ... as long you do the search (e.g. displaced LSP not covered at LEP)
- LHC reach for charginos depends on spectrum, decay channels
- Linear collider reach essentially kinematic! (again, if you do the right search)

Very light charginos? (and very light charged particles in general?)

- Large contributions to $h \to \gamma\gamma, \gamma Z$
- Probably can be covered with LHC (or look again at LEP data!)