Precise Estimate of Chargino Decay

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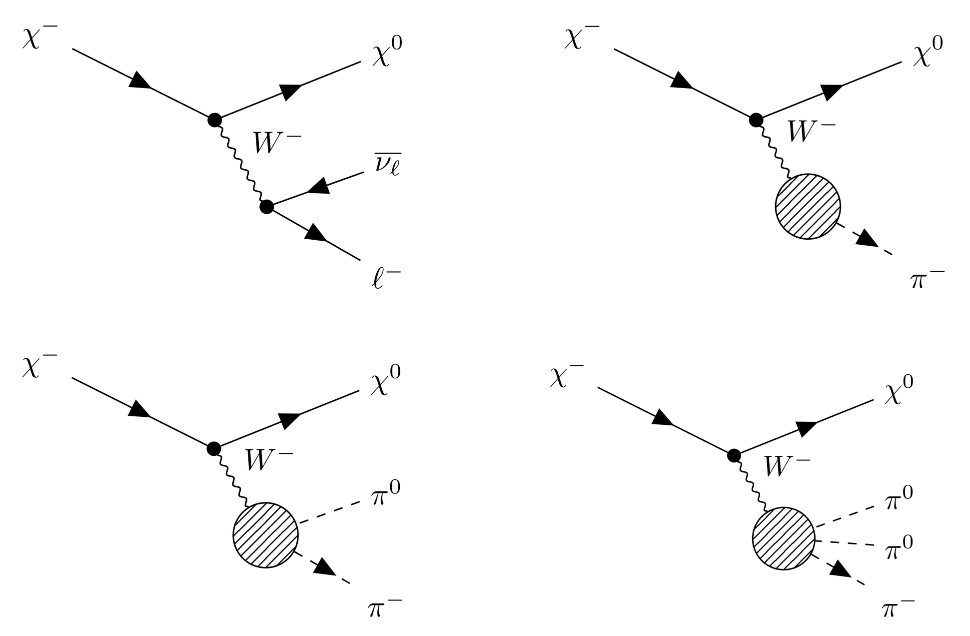
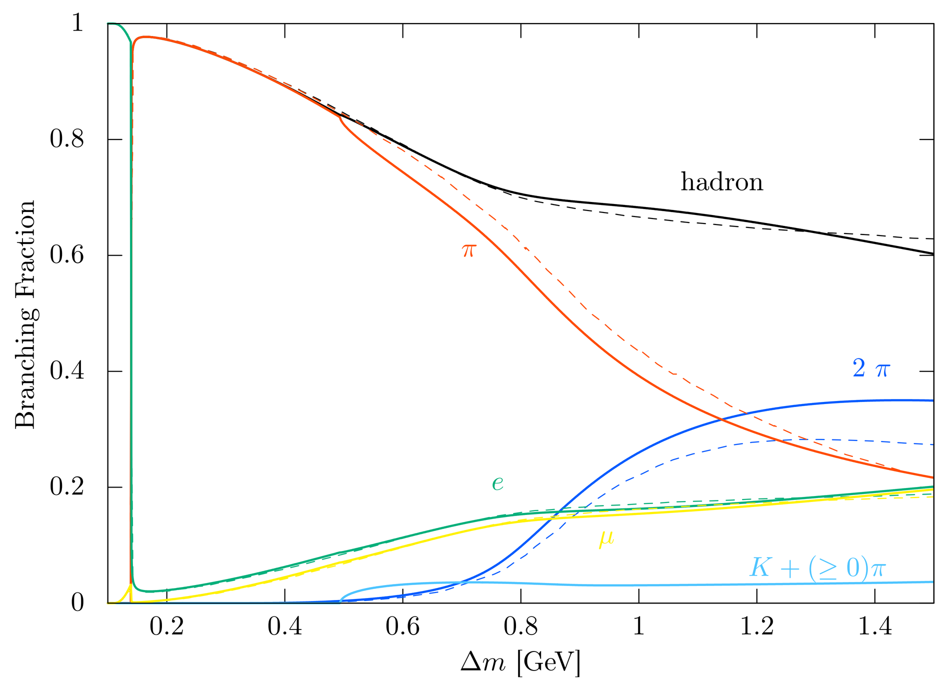
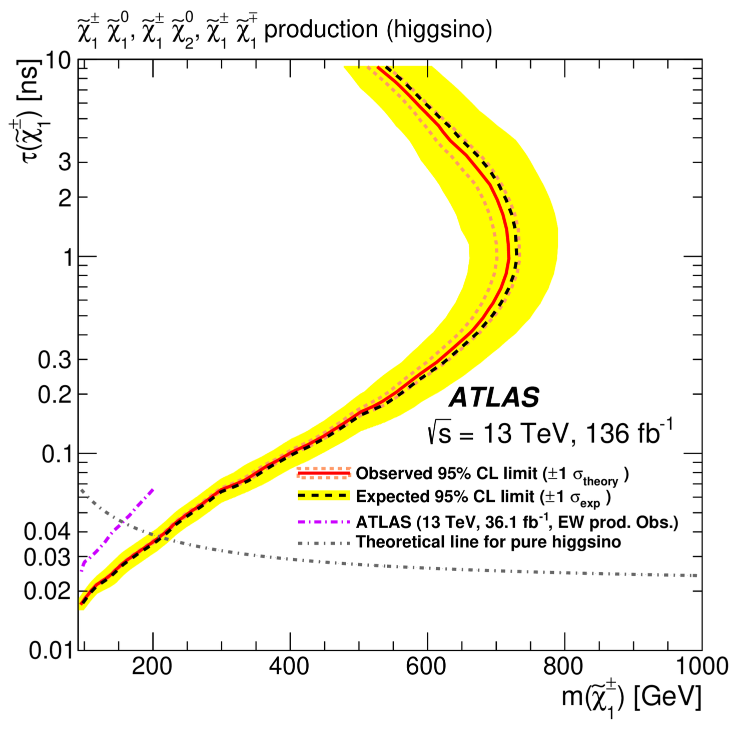
Chargino Decay and Collider Constraint

Chargino decays through weak interaction …





Collider constraints are sensitive to decay rates and BFs!

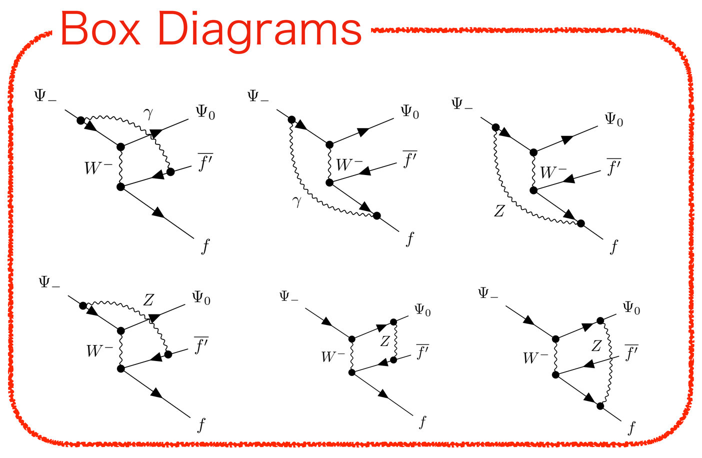


Universal Short-Distance Correction

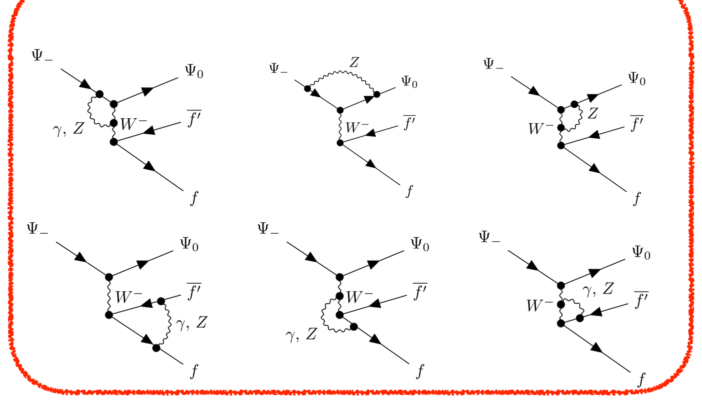
W-boson self energy

$$G_F^0 \to G_F^0 \times \left\{1 + \frac{\hat{\Sigma}^{1PI}_{WW}(0)}{m_W^2} + \frac{\alpha}{4\pi}\left[3\log\frac{m_W}{\mu_{IR}} + F_V^{\mathrm{Virtual(EW)}}\left(\frac{m_W}{m_{\chi^\pm}}\right)\right]\right\} \qquad G_F^0 = \frac{e^2}{4\sqrt{2}s_W^2 m_W^2}$$

Box Diagrams



Vertex Corrections



\+ Wave functions

Replament of G_F^0 with $G_F \simeq 1.166\times10^{-5}\,\mathrm{GeV}^{-2}$ removes W-boson self-energy, because

$$G_F^0 = G_F\times(1-\Delta r), \quad \Delta r|_{\text{1-loop}} = \frac{\hat{\Sigma}^{1PI}_{WW}(0)}{m_W^2} + \frac{\alpha}{4\pi}\left(\frac{6}{s_W^2} + \frac{7-4s_W^2}{s_W^4}\log c_W\right)$$

Encapsulation of short-distance corrections:

$$G_F^0 \to G_F \times \sqrt{S_{EW}^{\chi}(\mu_{IR})}\,;$$

$$S_{EW}^{\chi}(\mu_{IR}) = 1 + \frac{\alpha}{4\pi}\left[6\log\frac{m_W}{\mu_{IR}} + 2F_V^{\mathrm{Virtual(EW)}}\left(\frac{m_W}{m_{\chi^\pm}}\right) - 2\left(\frac{6}{s_W^2} + \frac{7-4s_W^2}{s_W^4}\log c_W\right)\right] + O(\alpha^2)\,.$$

On-shell matching defines the effective Fermi theory:

$$\mathcal{L}_{FF} = -2\sqrt{2}G_F\left(\overline{\Psi}_0\gamma^\mu\Psi_-\right)\left(\overline{\Psi}_f\gamma_\mu P_L\Psi_{f'}\right) + (\mathrm{CT})$$

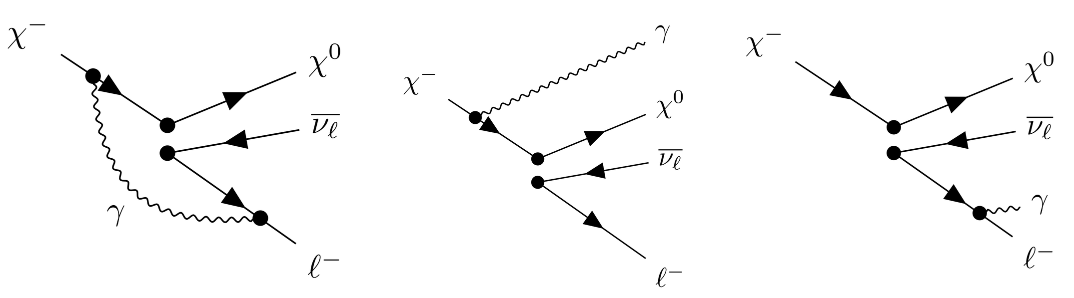
Leptonic Mode

Effective Fermi Theory

$$\mathcal{L}_{FF}^{\text{lepton}} = -2\sqrt{2}G_F\left(\overline{\Psi}_{\chi^0}\gamma^\mu\Psi_{\chi^-}\right)\left(\bar{\ell}\gamma_\mu P_L\nu_\ell\right)$$

$$\delta\mathcal{L}_{FF}^{\text{lepton}} = -2\sqrt{2}\delta_V G_F\left(\overline{\Psi}_{\chi^0}\gamma^\mu\Psi_{\chi^-}\right)\left(\bar{\ell}\gamma_\mu P_L\nu_\ell\right) - 2\sqrt{2}\delta_A G_F\left(\overline{\Psi}_{\chi^0}\gamma^\mu\gamma_5\Psi_{\chi^-}\right)\left(\bar{\ell}\gamma_\mu P_L\nu_\ell\right)$$

Determined by EW theory



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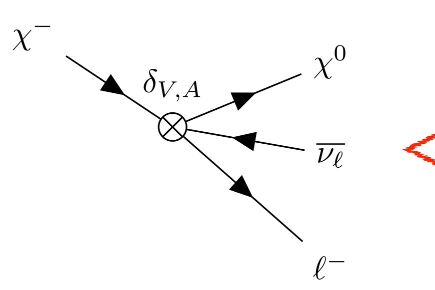


Inherits short-distance corrections

$$\Gamma_{\text{1-loop}}(\chi^-\to\chi^0\ell^-\bar{\nu}_\ell(\gamma)) = \Gamma_{\text{tree}}^{\ell,m_\ell=0} f\left(\frac{m_\ell}{\Delta m}\right) S_{EW}^{\chi,\text{lep}}\left[1 + \frac{\alpha}{4\pi}g\left(\frac{m_\ell}{\Delta m}\right)\right]$$

Lepton mass effect @tree-level

Long-distance correction @NLO

Single Pion Mode

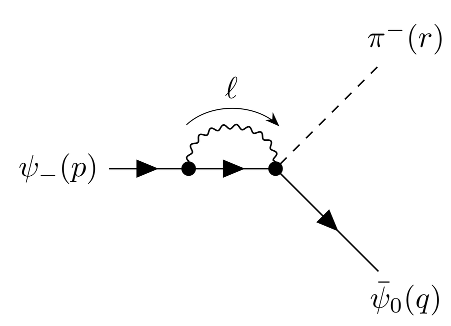
Pion's shift symmetry ensures that the decay amplitude is suppressed by Δm

$$\mathcal{L}_{CC}^{\text{pion}} = -\sqrt{2}\,G_F V_{ud}^* F_\pi\left(\partial_\mu\pi^-\right)^* \times \overline{\Psi}_{\chi^0}\gamma^\mu\Psi_{\chi^-} + \text{h.c.}$$

$p \sim \Delta m$

But QED corrections break the symmetry:

$$\partial_\mu \to D_\mu = \partial_\mu - ieA_\mu$$



mass correction to the Wino

$m_\chi/\Delta m$ enhancement???

→ Cured by appropriate determination of CTs

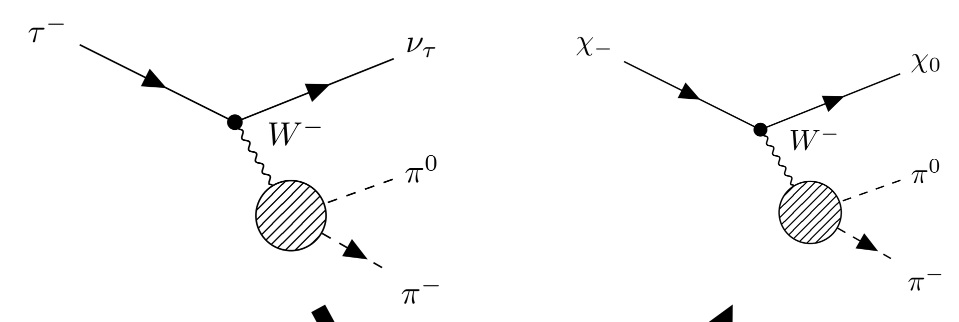
$$\mathcal{L}_Y = e^2\Big\{\frac{1}{\sqrt{2}}F_0^2G_F\Big[Y_1\overline{\Psi}_{\chi^-}\gamma_\mu\Psi_{\chi^0}\langle u^\mu\{\mathcal{Q}_R,\mathcal{Q}_W\}\rangle + \hat{Y}_1\overline{\Psi}_{\chi^-}\gamma_\mu\Psi_{\chi^0}\langle u^\mu\{\mathcal{Q}_L,\mathcal{Q}_W\}\rangle$$
$$+ Y_2\overline{\Psi}_{\chi^-}\gamma_\mu\Psi_{\chi^0}\langle u^\mu[\mathcal{Q}_R,\mathcal{Q}_W]\rangle + \hat{Y}_2\overline{\Psi}_{\chi^-}\gamma_\mu\Psi_{\chi^0}\langle u^\mu[\mathcal{Q}_L,\mathcal{Q}_W]\rangle$$
$$+ Y_3 m_\chi\overline{\Psi}_{\chi^-}\Psi_{\chi^0}\langle\mathcal{Q}_R\mathcal{Q}_W\rangle$$
$$+ iY_4\overline{\Psi}_{\chi^-}\gamma_\mu\Psi_{\chi^0}\langle\mathcal{Q}_L^\mu\mathcal{Q}_W\rangle + iY_5\overline{\Psi}_{\chi^-}\gamma_\mu\Psi_{\chi^0}\langle\mathcal{Q}_R^\mu\mathcal{Q}_W\rangle + h.c.\Big]$$
$$+ \hat{Y}_6\overline{\Psi}_{\chi^-}(i\partial\!\!\!/ - eA\!\!\!/)\Psi_{\chi^-} + \hat{Y}_7 m_\chi\overline{\Psi}_{\chi^-}\Psi_{\chi^-}\Big\}\,.$$

We have to determine the following combination of the LECs by matching this with the Fermi theory:

$$\frac{\delta\Gamma_\chi^\pi}{\Gamma_\chi^\pi} - \frac{\delta\Gamma_\pi}{\Gamma_\pi} \supset e^2\left[-\hat{Y}_6 - \frac{4}{3}(Y_1+\hat{Y}_1) - 4\left(Y_2+\hat{Y}_2 - \frac{m_{\chi^\pm}}{\Delta m_\pm}Y_3\right)\right]$$

Multi-Meson Mode

We can obtain info of hadronization from tau lepton decay [Chen et al., hep-ph/9607421]



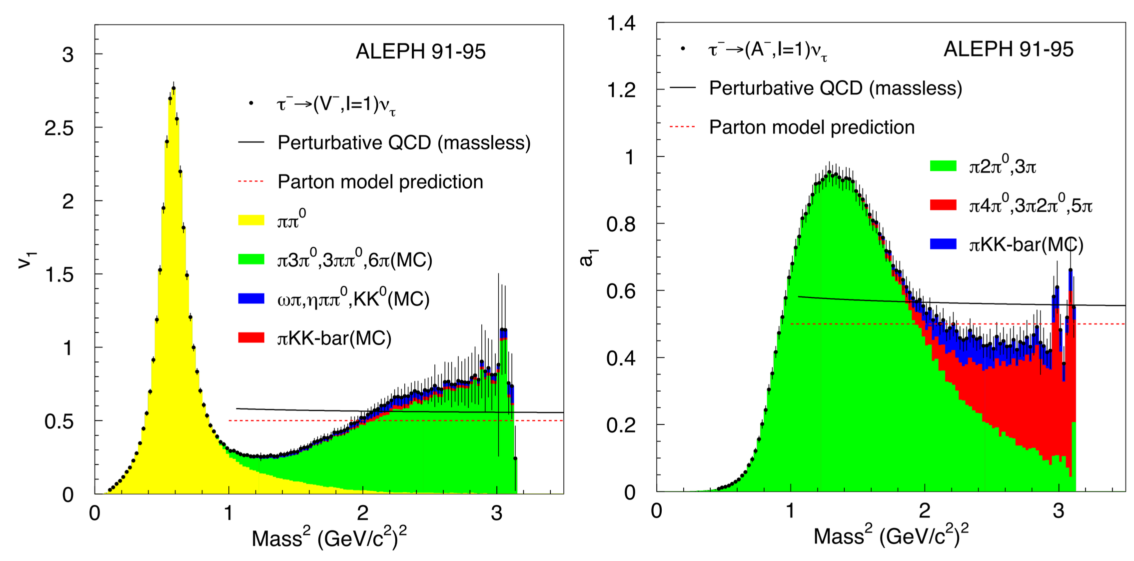
Extract mass distributions

Interpolate or parametrize data

$$\langle\pi^-\pi^0|\bar{d}\gamma^\mu u|0\rangle$$

Nonperturbative QCD encoded

Mass distributions [ALEPH Collaboration]



Numerical Results (Preliminary)