$\tau^- \to \pi^- \eta \bar{\nu}_\tau$ QED one-loop effects.

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Cinvestav

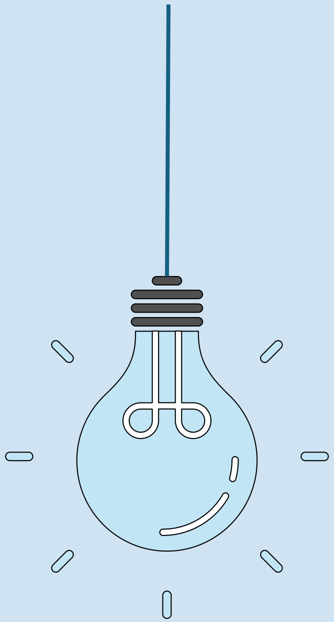
Searches of new physics

High precision measurements.

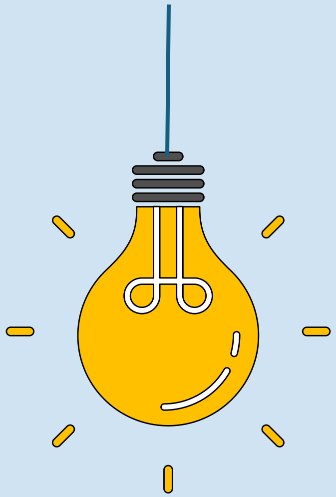
Suppressed processes within the standard model.

Look for forbidden processes.

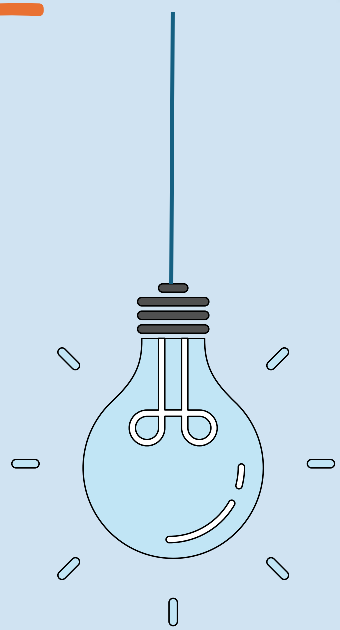
Searches of new physics



High precision measurements



Suppressed processes within the standard model.



Look for forbidden processes

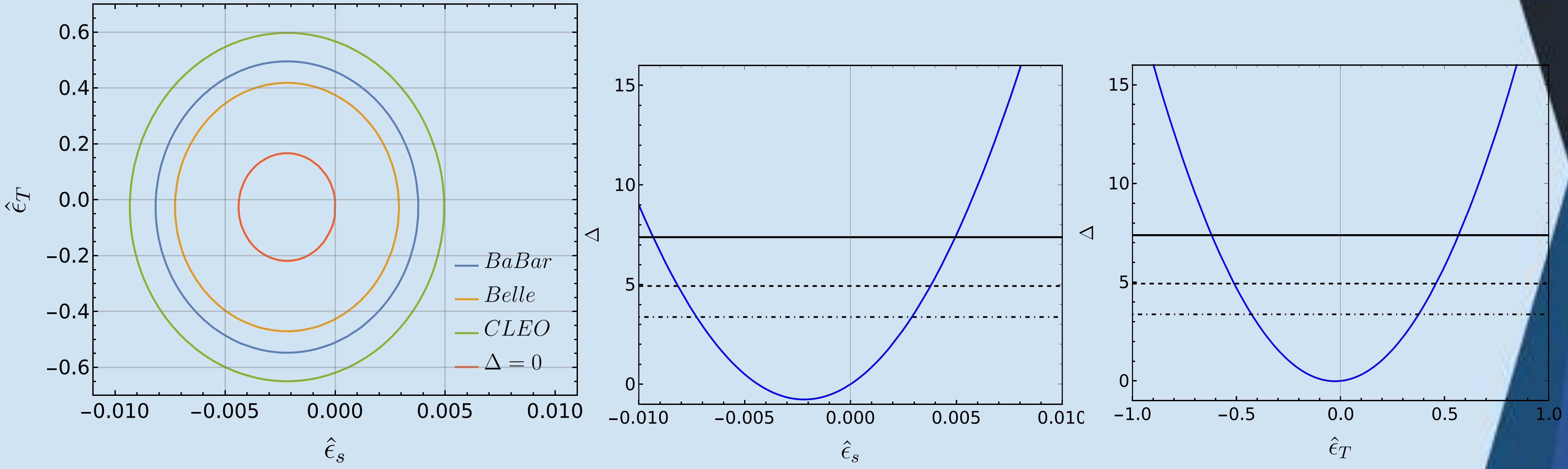
Why $\tau^- \to \pi^- \eta \bar{\nu}_\tau$?

Proposed by C. Leroy and J. Pestieau. (1978)

$$\mathcal{G} = \mathcal{C}\, e^{i\,\mathcal{I}_2}$$

$$\mathrm{BR}(\tau^- \to \pi^- \eta \nu_\tau) < 7.3 \times 10^{-5} (\mathrm{Belle})$$

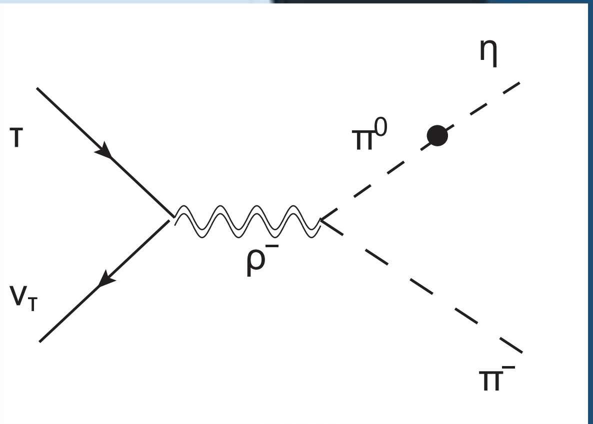
- Analysis in JHEP12(2017)027 (EFT perpective).

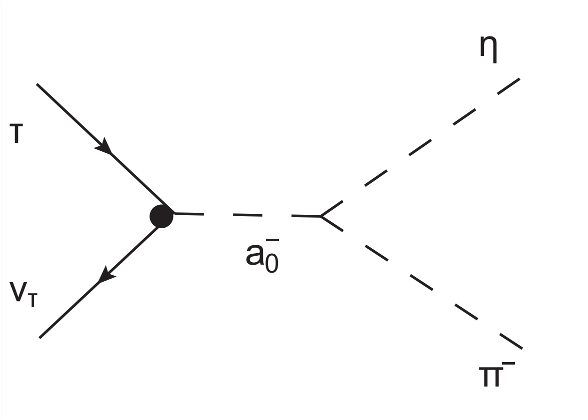


Previous calculations

$$\epsilon_{\pi\eta} = \frac{\sqrt{3}}{4}\frac{m_d - m_u}{m_s - \bar{m}} \approx (1.21 \pm 0.23) \times 10^{-2}$$

Ref.	$BR \times 10^5$
* (1982) Tisserant, Truong (ρ, a_0 contributions)	1.86
* (1987) Bramon, Narison, Pich (ρ, a_0 contributions)	1.62
(1994) Neufeld, Rupertsberger (NLO ChPT)	1.21
*(2008) Nussinov, Soffer ($\bar{q}q$ model)	1.36
(2010) Paver, Riazuddin (ρ, ρ', a_0, a_0' VMD)	[0.4,2.9]
*(2012) Volkov, Kostunin (NJL model)	0.48
(2014) Descotes-Genon, Moussallam (ChPT + analyticity)	0.33
(2016) Escribano, Gonzalez, Roig (RChT-3 coupled channels)	1.67 ± 0.09

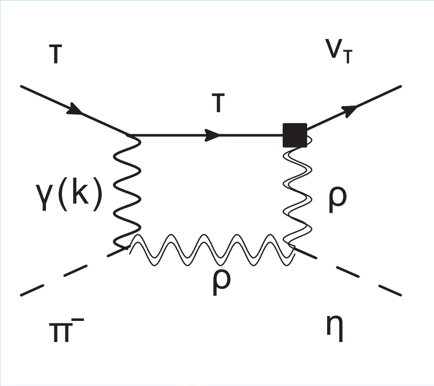


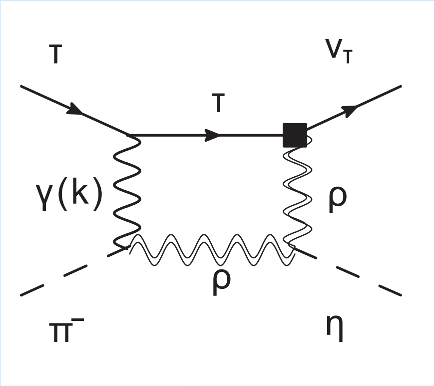


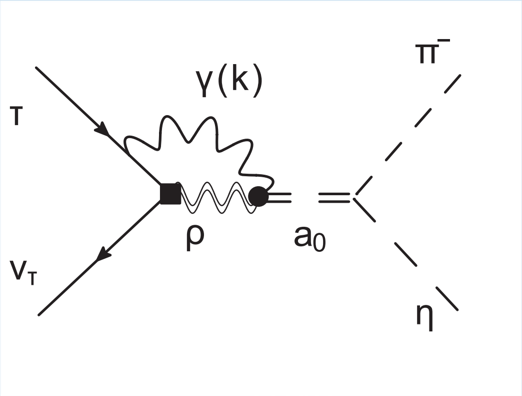
QED one-loop

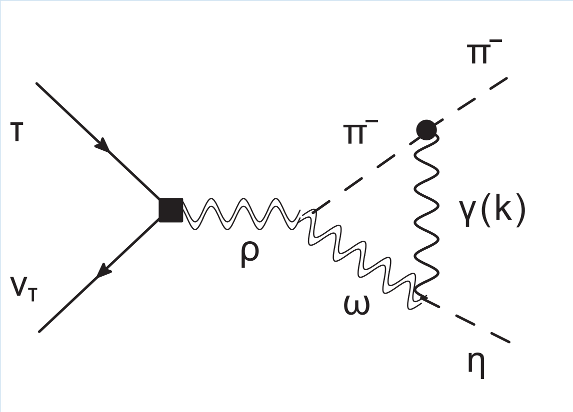
$$\boxed{\mathcal{F}_i(k^2) = \frac{m_\rho^2}{m_\rho^2 - k^2}}$$

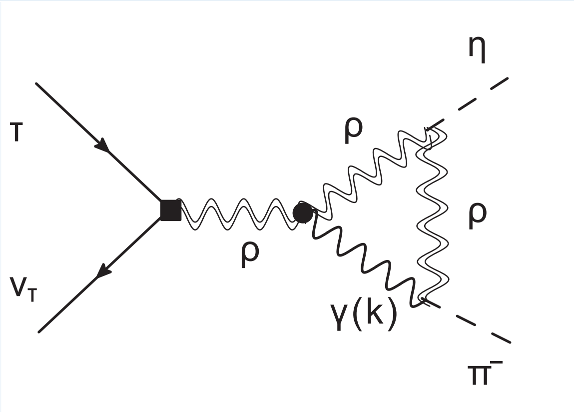
$$\langle \eta(p_\eta)\pi^-(p_\pi)|\bar{d}\gamma_\mu u|0\rangle = -\sqrt{2}\left[\left(q'_\mu - \frac{\Delta_{\eta\pi}}{s}q_\mu\right)F_+(s,t) + \frac{\Delta_{\eta\pi}}{s}q_\mu\, F_0(s,t)\right]$$

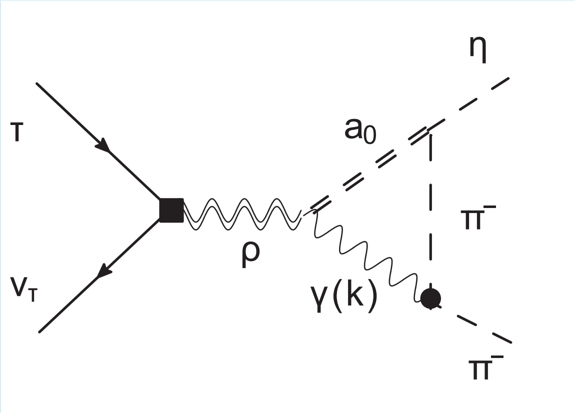


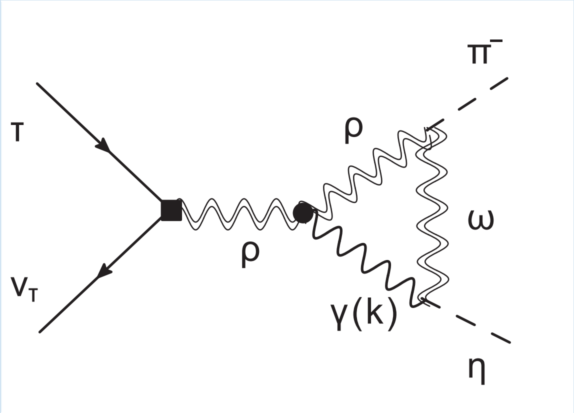












Deviation from tree-level prediction.

$$\Delta(\pi\eta) \equiv \frac{|\mathrm{BR}_{\mathrm{d-u+e.m.}}(\pi\eta) - \mathrm{BR}_{\mathrm{d-u}}(\pi\eta)|}{\mathrm{BR}_{\mathrm{d-u}}(\pi\eta)} = (13.5^{+4.0}_{-3.0} \pm 2.8)\%\,.$$

$$\epsilon_{\pi\eta} = \frac{\sqrt{3}}{4}\frac{m_d - m_u}{m_s - \bar{m}} \approx (1.21 \pm 0.23) \times 10^{-2}$$

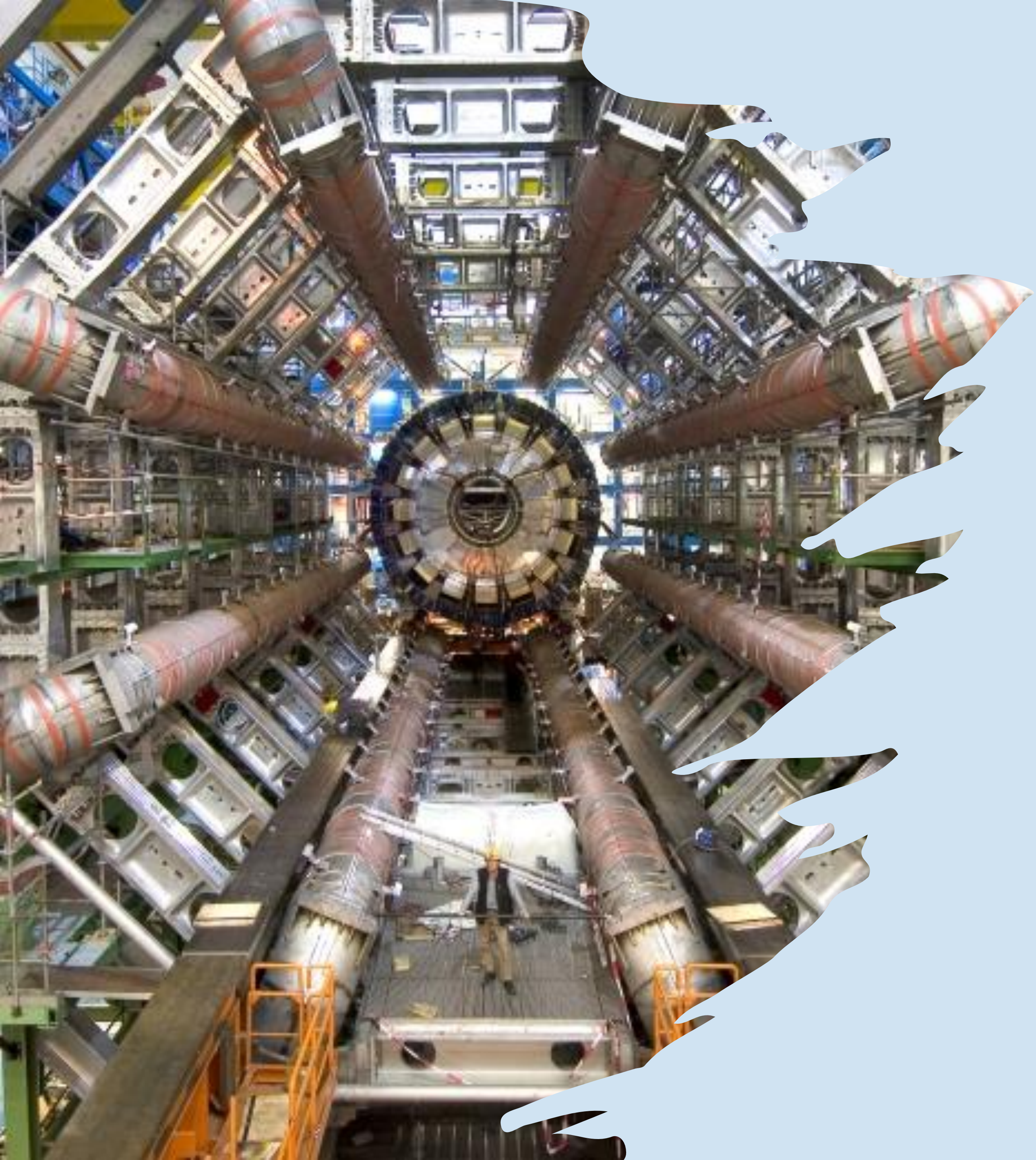
Diagram	$BR(\tau^- \to \pi^-\eta\nu_\tau)_S$	$BR(\tau^- \to \pi^-\eta\nu_\tau)_V$	$BR(\tau^- \to \pi^-\eta\nu_\tau)$
e. m.	1.64×10^{-7}	4.15×10^{-8}	2.15×10^{-7}
d-u	1.20×10^{-5}	2.47×10^{-6}	1.46×10^{-5}
d-u + e. m.	1.34×10^{-5}	3.14×10^{-6}	1.65×10^{-5}

Eta prime analysis.

$$\epsilon_{\pi\eta'} = (3 \pm 1) \times 10^{-3}$$

$$\boxed{\Delta(\eta'\pi) \equiv \frac{|\mathrm{BR}_{\mathrm{d-u+e.m.}}(\eta'\pi) - \mathrm{BR}_{\mathrm{d-u}}(\eta'\pi)|}{\mathrm{BR}_{\mathrm{d-u}}(\eta'\pi)} = (78^{+2}_{-4} \pm 38)}$$

Diagram	$BR(\tau^- \to \pi^-\eta'\nu_\tau)_S$	$BR(\tau^- \to \pi^-\eta'\nu_\tau)_V$	$BR(\tau^- \to \pi^-\eta'\nu_\tau)$
Total e. m.	1.73×10^{-8}	2.92×10^{-9}	2.08×10^{-8}
d-u	5.76×10^{-8}	2.15×10^{-9}	5.97×10^{-8}
d-u + e. m.	9.70×10^{-8}	8.63×10^{-9}	1.06×10^{-7}



Conclusions

- We studied the leading electromagnetic contribution to the IB observable $\tau\to\pi^{-}\eta\nu_{\tau}$.
- Taking into account both IB sources, e.m and quark masses, we compute the interference in order to show the impact of those new contribution shown at present work.
- We find that those photon contributions can be as large as 13 % for the $\pi^-\eta$ channel (78% for the $\pi^-\eta'$ channel) of the total contribution for the input parameters used in this work.