Monthly CLFV coffee hour

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Welcome to our monthly CLFV coffee hour

While the Snowmass process is on pause, we wanted to stay in contact and keep exchanging on the physics we like.

We decided to organize a monthly coffee hour – to be held every last Thursday of the month until the summer – to host a free form environment to discuss broad CLFV physics, related or not to Snowmass.

We will try to propose a conversation topic every meeting, but you should feel free to steer the discussion in any direction you like or ask (difficult) questions. Feel free to send suggestions for the next coffee hours.

This event won't be recorded, but we will try to post a brief summary on the indico page.

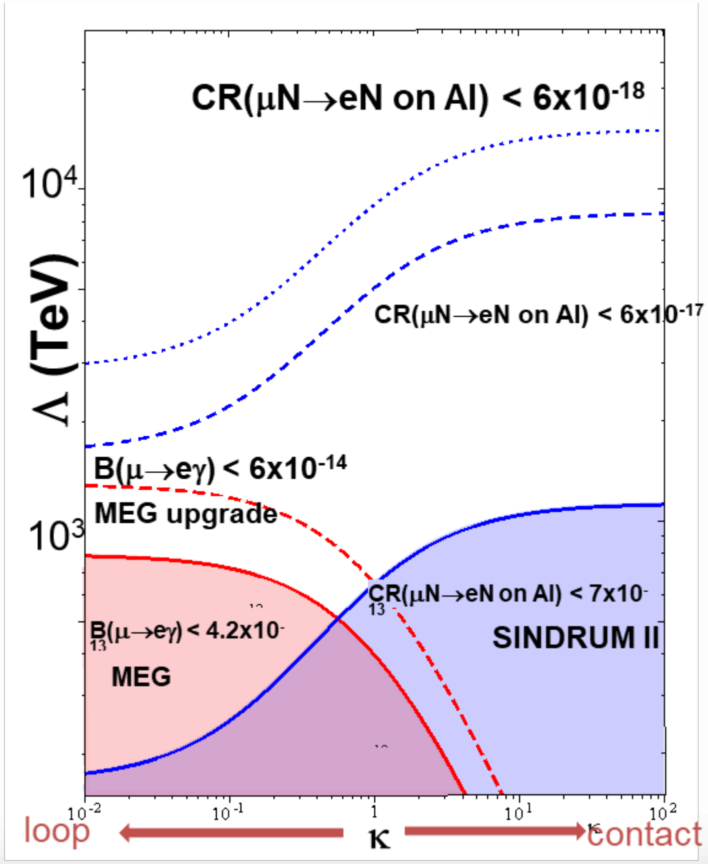
Today's topic: ideas on presenting experimental reaches and sensitivities to facilitate theoretical interpretations.

Enjoy your coffee (or glass of wine for our European friends)

The original "Kappa plot" from de Gouvea and Vogel (arXiv:1303.4097)

$$\mathcal{L}_{\rm CLFV} = \frac{m_\mu}{(1+\kappa)\Lambda^2}\bar{\mu}_R\sigma_{\mu\nu}e_L F^{\mu\nu} + \frac{\kappa}{(1+\kappa)\Lambda^2}\bar{\mu}_L\gamma_\mu e_L(\bar{u}_L\gamma^\mu u_L + \bar{d}_L\gamma^\mu d_L)$$

Λ: effective mass scale of new physics κ: relative contribution of the contact term



Questions

1. what information do experimentalists and theorists want to share, and how could it be presented?
2. what do you like, or not, about kappa-plots?
3. what could be improved in kappa plots?
4. Do you have other questions ?
5. ...

How to make a theoretically well-defined kappa plot?

(from Sacha's cookbook)

1. Start from data: restrictive bounds/excellent sensitivity to few processes. Currently for $\mu^+ \to e^+ e^- e^+$, $\mu^+ \to e^+\gamma$ and $\mu^- \to e^-$ on Au

   In EFT, there are to many operators ... so use observables as basis for operator subspace probed by observables,

   e.g. $\mu^+ \to e^+\gamma$ independently probes $\overline{e_L}\sigma_{\alpha\beta}\mu_R F_{\alpha\beta}$, $\overline{e_R}\sigma_{\alpha\beta}\mu_L F_{\alpha\beta}$

   so can probe two directions in operator space: $\mathbf{v}_{\mu \to e_L\gamma}$, $\mathbf{v}_{\mu \to e_R\gamma}$.

2. (theorists like loops) subtracting loopy fuzz from operators allows to see which interactions (on shorter distance scales) could give the operator (many contact interactions can mediate dipole via loop diagrams...).

   For instance, subtracting loops between m_μ and m_W causes $\mathbf{v}_{\mu \to e_L\gamma}$, $\mathbf{v}_{\mu \to e_R\gamma}$ to change length. And rotate in operator space— if stay orthogonal, just technical theory detail.

3. In the subspace, current data excludes an ellipse — can plot it = kappa plots!

PSI Workshop

Physics case for a High Intensity (10^{10} μ/sec) continuous Muon Beam

⋆ you can not “attend” — only signing up to contribute is allowed ⋆

6-9 April, via zoom, 14h - 18h CET / 7AM - 11AM CT / 5AM – 9AM PT

Activitites divided into 10 cases ($\mu \rightarrow e\gamma$, $\mu \rightarrow eee$, cooling...)

https://indico.psi.ch/event/10547/

Back to Bertrand+Sacha's attempts at kappa plots :

To obtain 3-d subspace, suppose LH helicity of the electron. Then at experimental scale, the branching fractions / conversion rate are given by (eq.30 on p.11 of **2010.00317**):

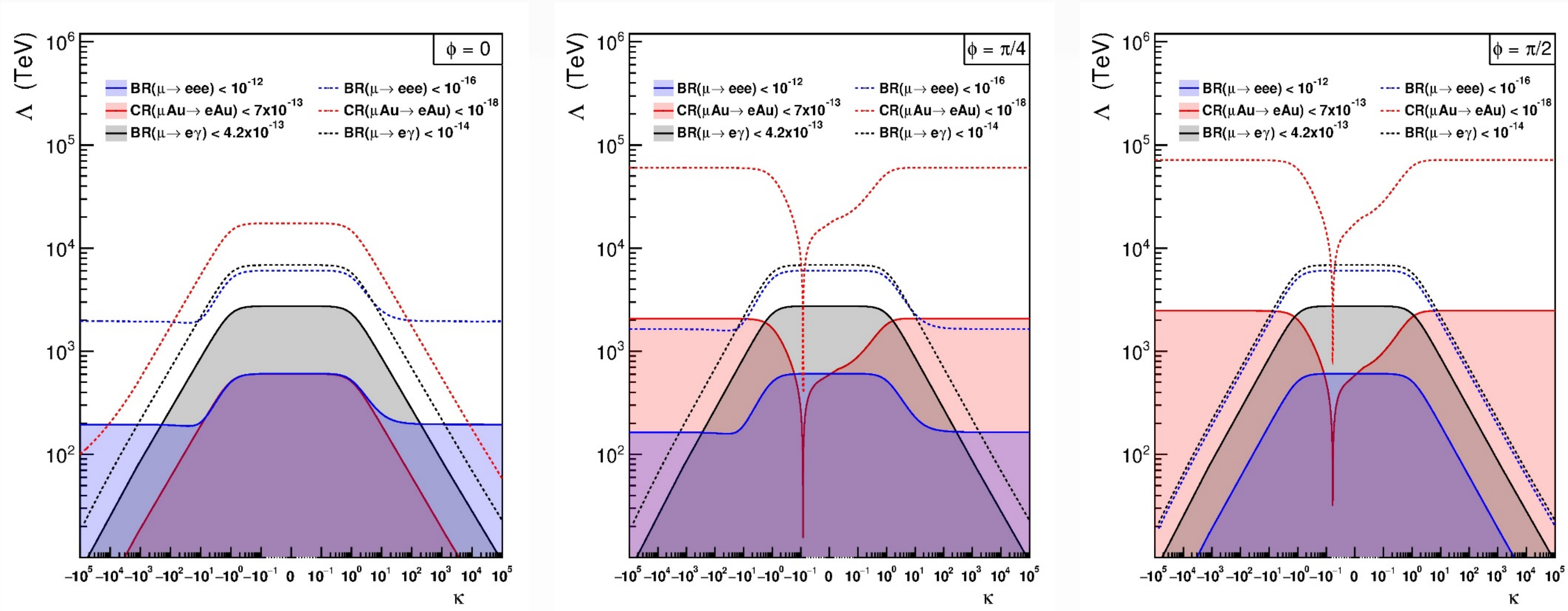
$$\begin{aligned}
BR(\mu \to e_L \gamma) &= 384\pi^2 |\vec{v}_{\mu\to e_L\gamma} \cdot \vec{C}|^2 = 384\pi^2 |\cos\theta|^2 \\
BR(\mu \to e_L \overline{e_L} e_L) &= |\vec{v}_{\mu_L \to e_L \overline{e_L} e_L} \cdot \vec{C}|^2 + 18.76 |\vec{v}_{\mu\to e_L\gamma} \cdot \vec{C}|^2 \\
&= 2|\sin\theta\cos\phi + 1.2\cos\theta|^2 + 18.76|\cos\theta|^2 \\
BR(\mu A \to e_L A) &= 300|\vec{v}_{\mu A \to e_L A} \cdot \vec{C}|^2 = 300|0.222\cos\theta + 9.08\sin\theta\sin\phi|^2 \quad ,
\end{aligned}$$

κ = sin(θ)/cos(θ) **sin(θ) = κ/sqrt(1+κ^2)** **cos(θ) = 1/sqrt(1+κ^2)**

κ tells you more or less the strength of the contact terms in $\mu^+ \to e^+e^-e^+$ and $\mu^- \to e^-$ and ϕ distinguishes the relative strength of these contact terms.

Note: the μ-e conversion rate is not symmetric with respect to cos(θ), so you really need to plot it from 0 to π.

Limits on the new physics scale Λ as a function of κ, ϕ



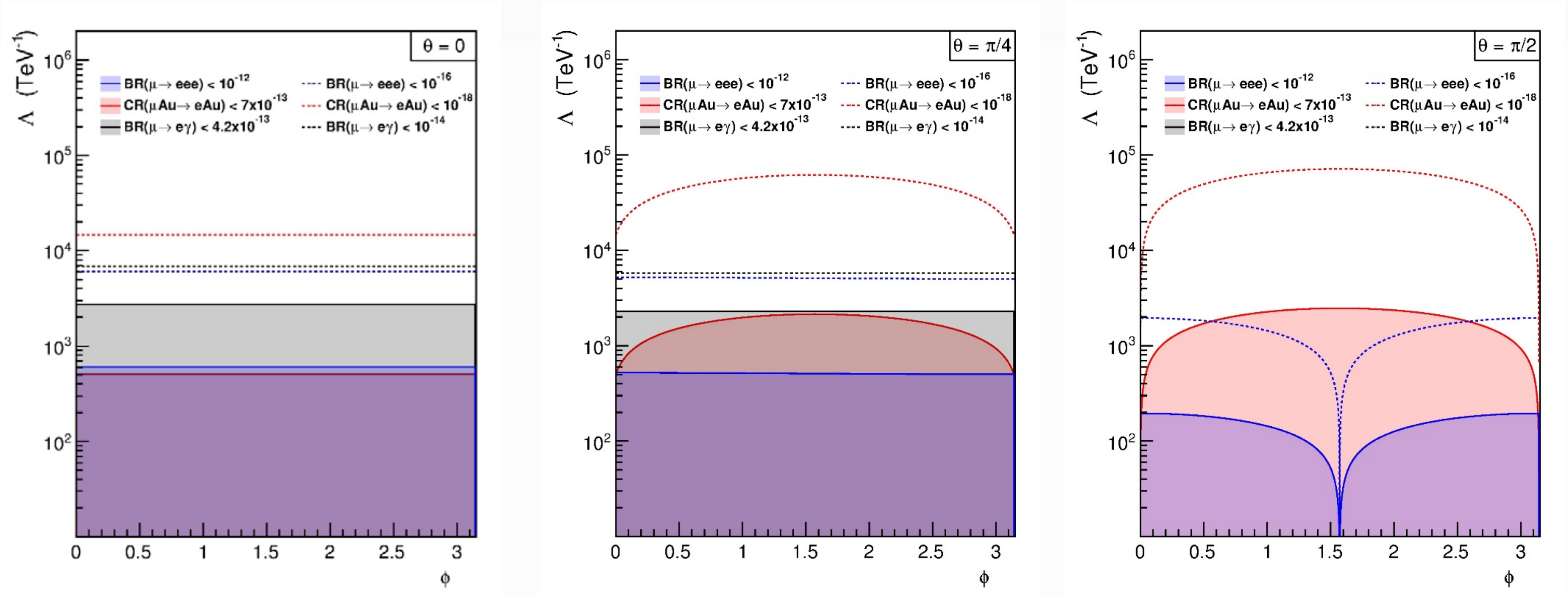
Note that the dipole contribution ensures that $\mu^+ \to e^+\gamma$ ($\mu^+\to e^+e^-e^+$) branching fraction is not vanishing at ϕ=0 (ϕ=π/2)

Note I: this is a pseudo-logarithmic scale (hence broken axis near zero)

Note II: if you want to compare with the plots from de Gouvea, just look at the region κ>0

The phi plots for theta slices

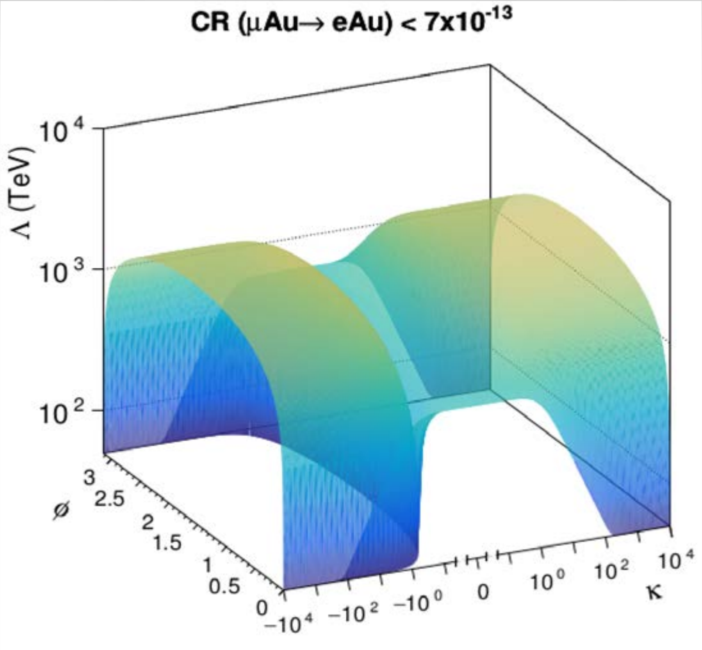
Limits on the new physics scale Λ as a function of θ, ϕ

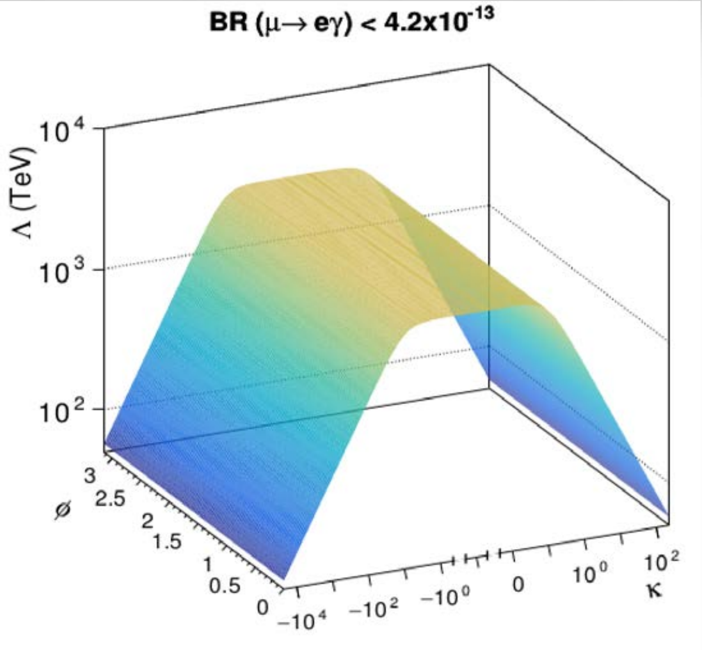


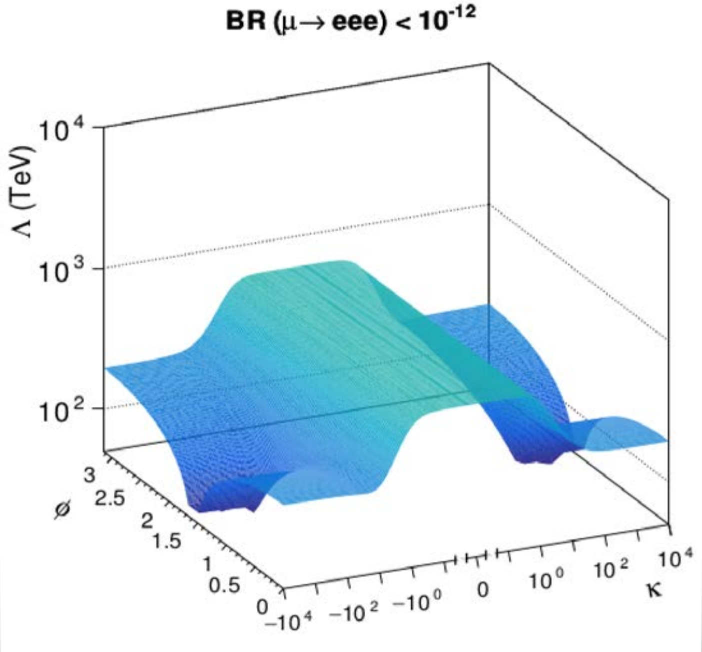
There exists a few points in the parameter space for which the BFs vanish:

- $BF(\mu^+ \to e^+\gamma)=0$ for $\theta=\pi/2$
- $BF(\mu^+ \to e^+e^-e^+)=0$ for $\theta=\pi/2$ and $\phi=\pi/2$
- $BF(\mu^- \to e^-$ on Au $)=0$ for $0.222\cos(\theta) + 9.08\sin(\theta)\sin(\phi)=0$

And in 3d?


CR (μAu→ eAu) < 7x10^-13
Λ (TeV)
ϕ
κ


BR (μ→ eγ) < 4.2x10^-13
Λ (TeV)
ϕ
κ


BR (μ→ eee) < 10^-12
Λ (TeV)
ϕ
κ