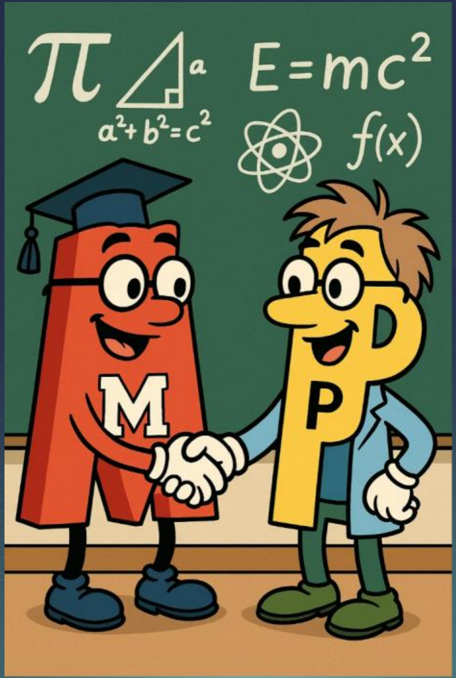
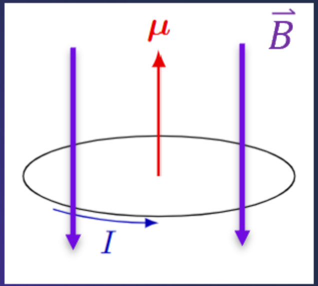
The τ g-2 at future collider

ZeQiang Wang

UCLouvain, CP3



What is g-2?



$$\vec{\mu} = I\vec{A}$$

$$E = -\vec{\mu} \cdot \vec{B}$$

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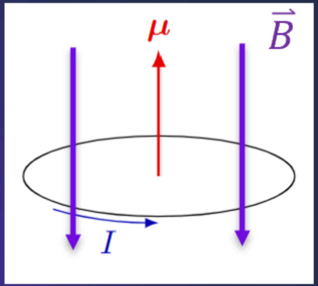

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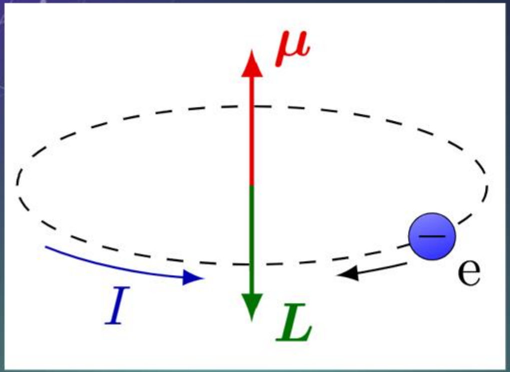

$$\vec{\mu} = -\frac{e}{2m}\vec{L}$$

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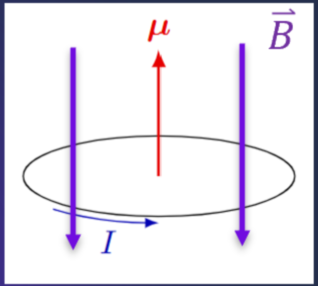

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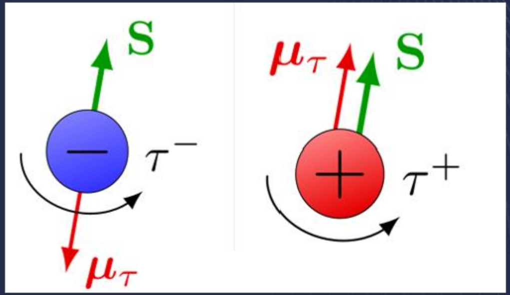
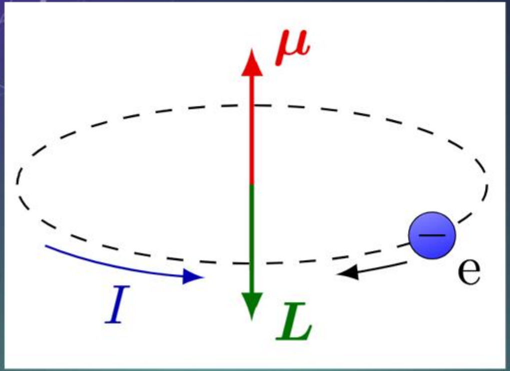
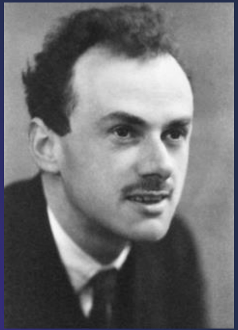




$$\vec{\mu} = -\frac{e}{2m}\vec{L} \quad \Longrightarrow \quad \vec{\mu} = g\frac{e}{2m}\vec{S}$$

The g-factor relates the magnetic dipole moment and its spin angular momentum

What is g-2?

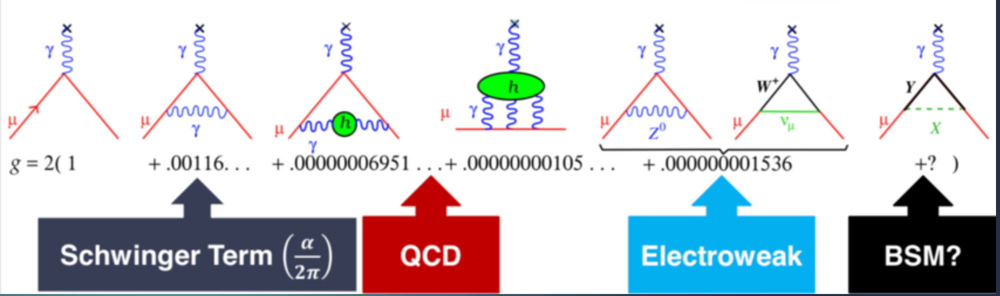


Dirac predicts **g=2**

Schwinger gives the term $\frac{\alpha}{2\pi}$

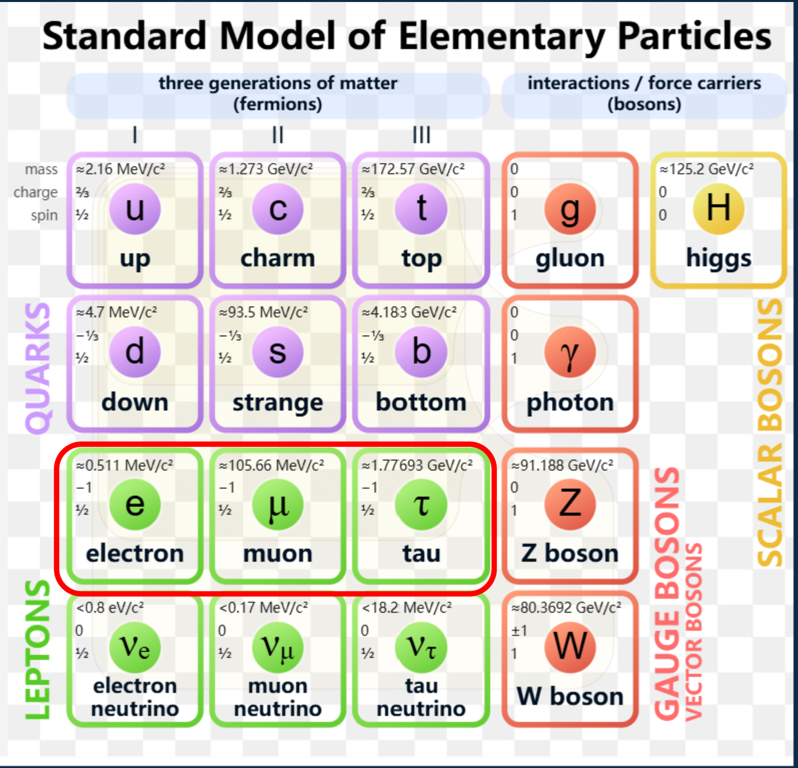
Higer-order quantum effects(QED, electroweak and hadronic contributions) slightly modify g, defining the **anomalous magnetic moment** :

$$a_l = (g - 2)/2$$



Any significant $\Delta a_l = a_l^{\text{exp}} - a_l^{\text{SM}}$ may hints new physics (BSM)

g-2 for charged lepton



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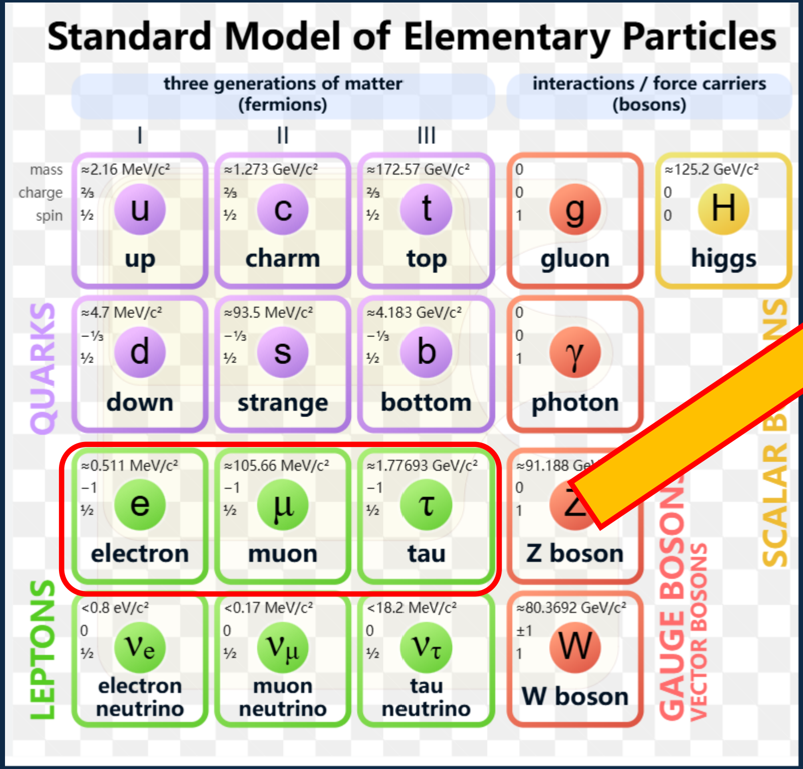

1 : 207 : 3477

Mass

Stable : $2.2 * 10^{-6}$s :$2.9 * 10^{-13}$s

Lifetime

Measure and calculate g-2

Difficulty

The current state of g-2 of charged Lepton

a_e^{SM}= 0.001159652182032(720)

$a_e^{\mathbf{Exp}}$= 0.00115965218059(13)

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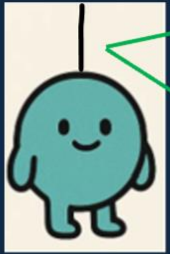

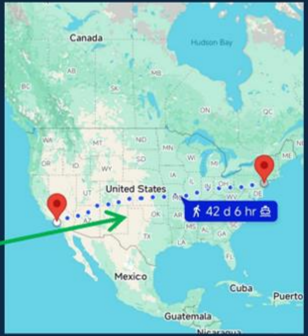

1985

pushed precision to 0.13 parts per trillion

"The precision of AMM like using the width of a human hair to measure the distance from Los Angeles to New York—over 3,000 miles"

Now

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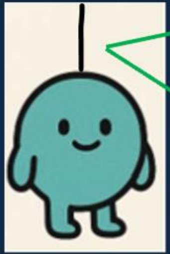

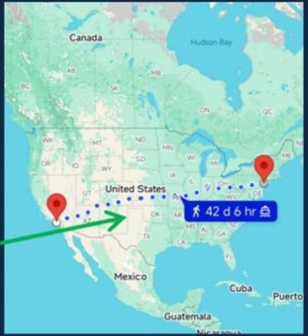

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Now

The most precise measurement in fundamental particle’s property.

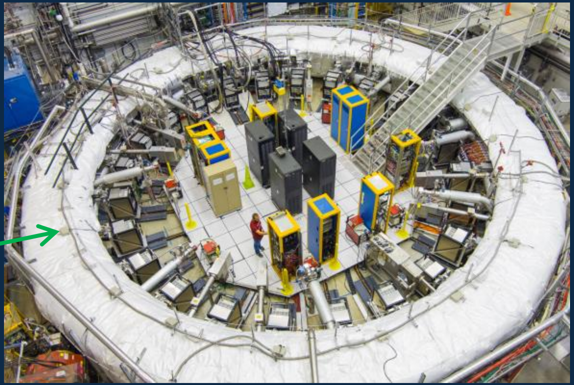
The current state of g-2 of charged Lepton

"This is equivalent to measuring the length of a football field to a precision of one-tenth the thickness of a human hair"

$$a_\mu^{SM} = 0.00116591810(43)$$

$$a_\mu^{Exp} = 0.00116592059(22)$$

measure

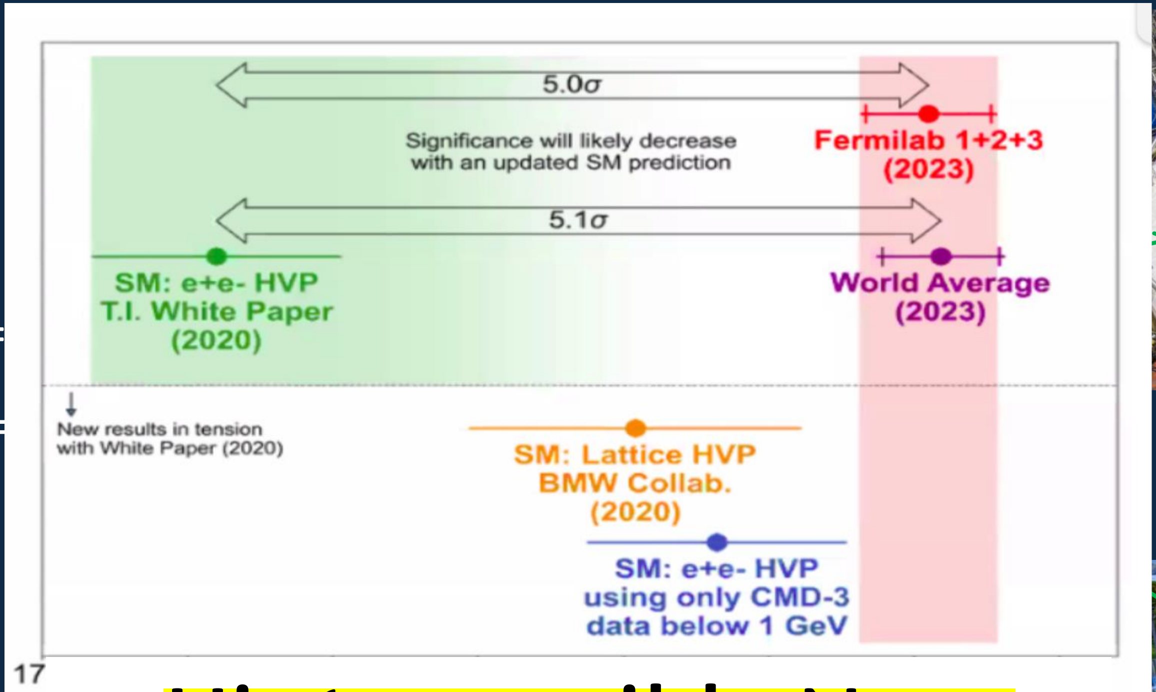


precision to up to 0.2 parts per million

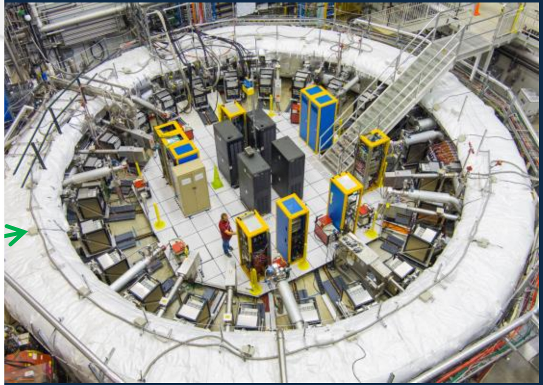
The current state of g-2 of charged Lepton

$a_\mu^{\mathrm{SM}} =$

$a_\mu^{\mathrm{Exp}} =$



Hints possible New Physics



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The current state of g-2 of charged Lepton

"Short lifetime prevented precise measurements of its g-2, but large mass hints larger Δa_l deviations may anticipate"

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$a_\tau^{\mathrm{Exp}} = 0.0009^{+0.0032}_{-0.0031}$

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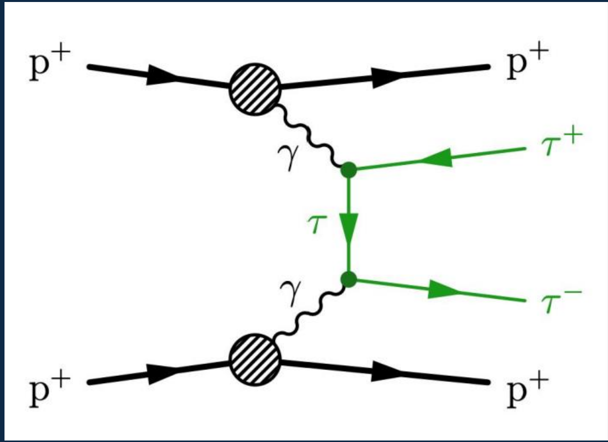
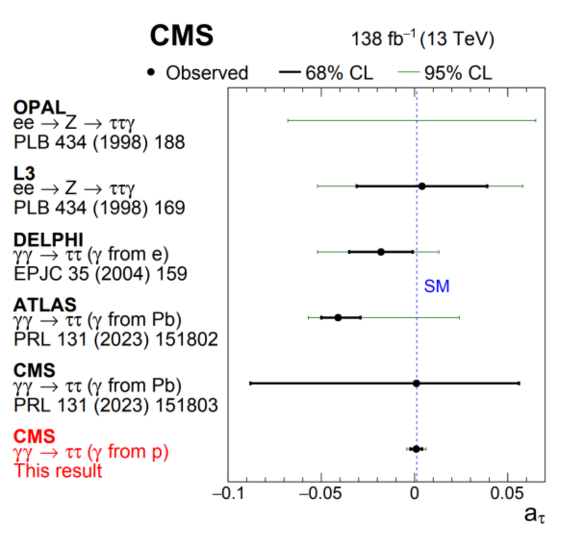
LHC probes magnetic moments through γγ→ττ



Improving LEP limits on tau g-2 by a factor of five!!



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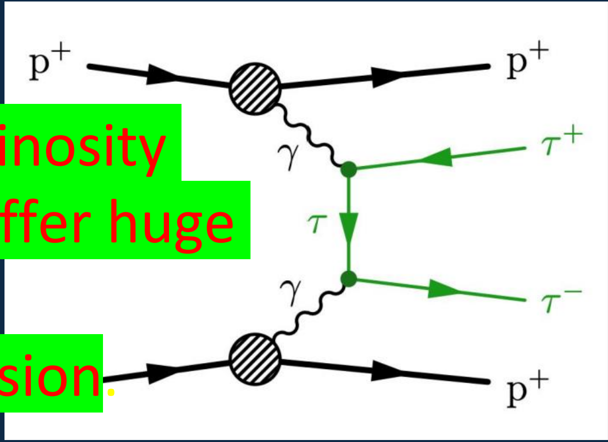

High-energy and luminosity future colliders will offer huge improvements in tau production and precision.

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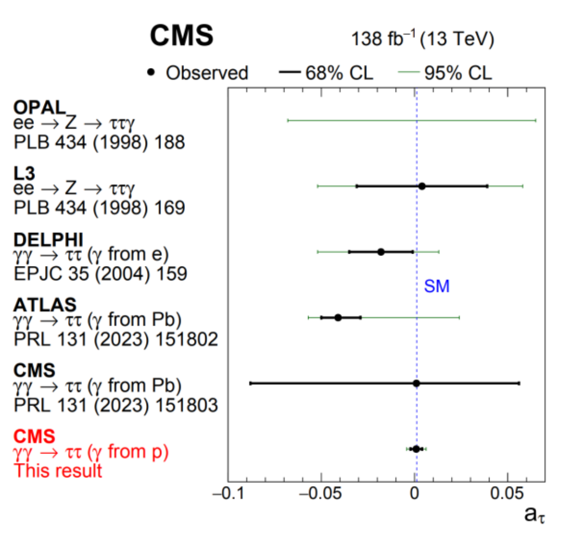
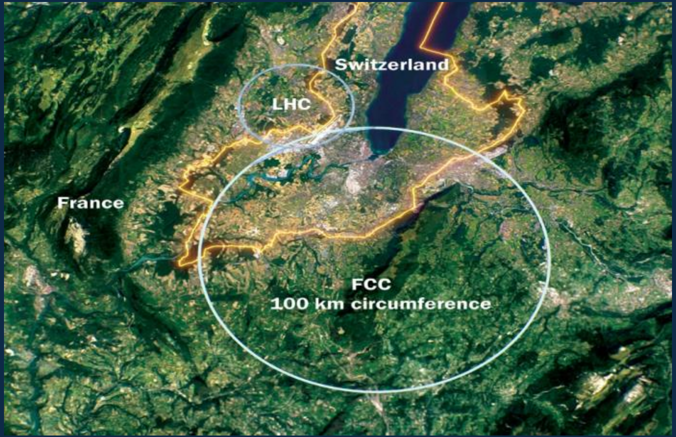


The future collider



Why FCC-ee?

- Super high Luminosity at GeV scale
- High Precision Measurements
- Relatively Mature Technology
- Low hadronization background
- Clean experimental environment
- EPA(Equivalent Photon Approximation)
- ……….

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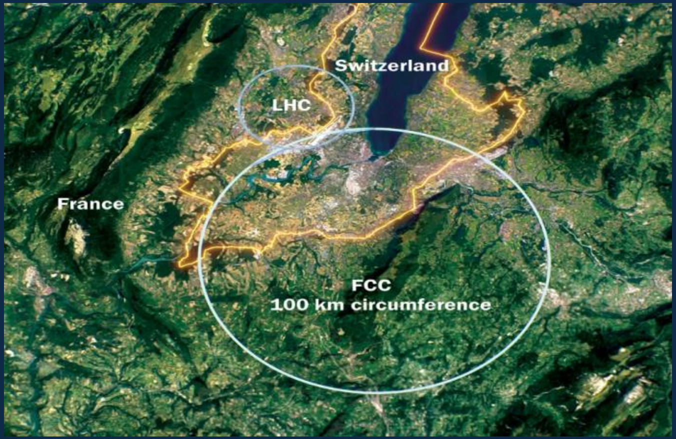

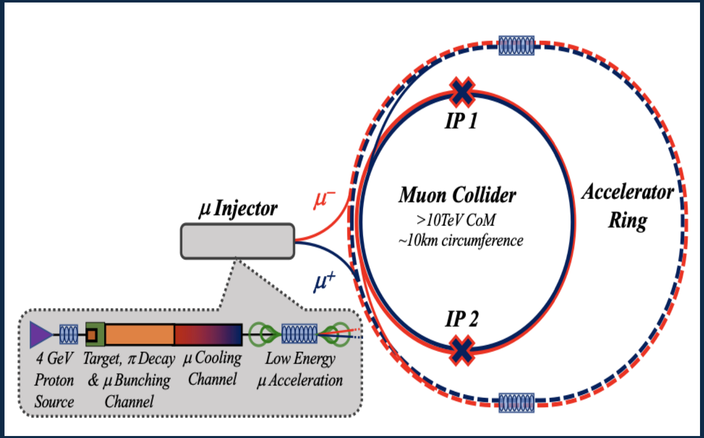

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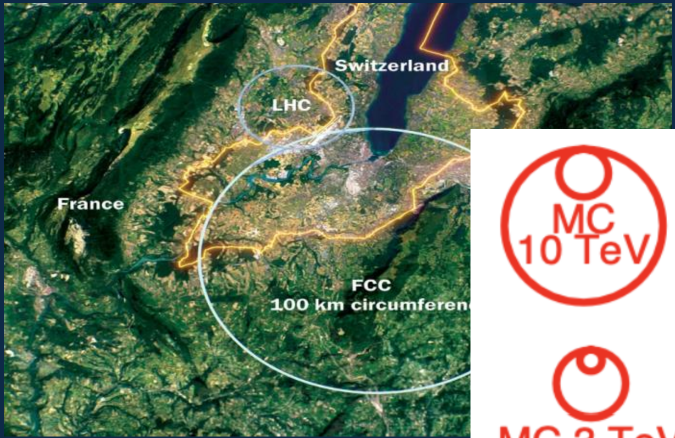
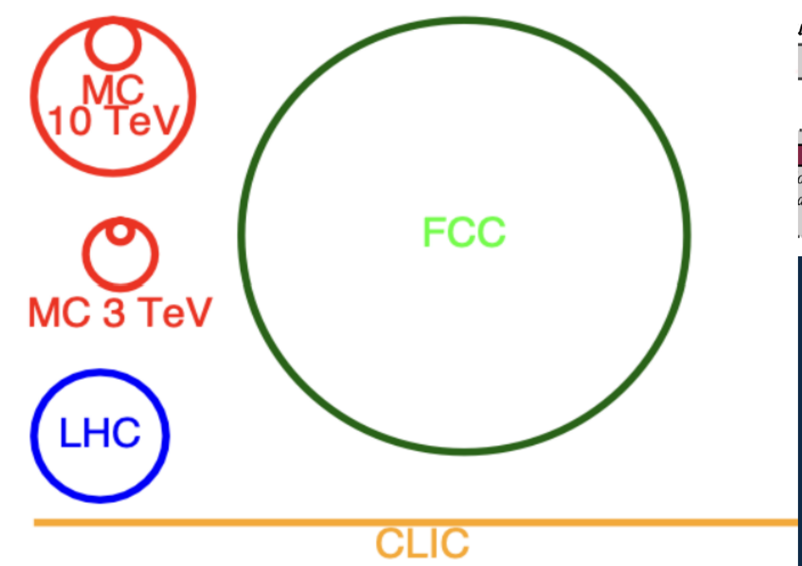
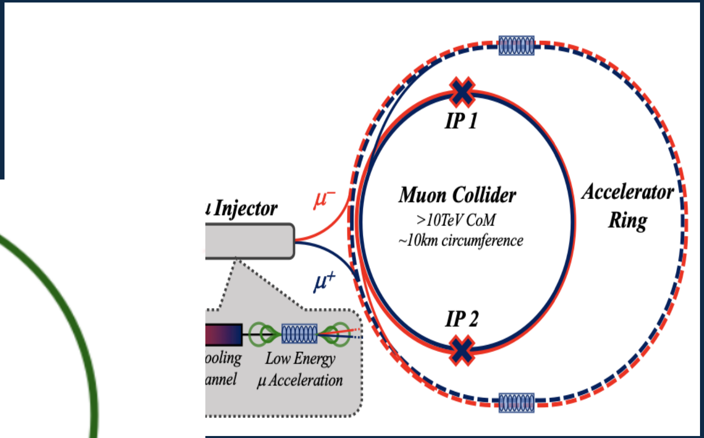
Why Muon Collider?

- High-energy and Luminosity
- A promising candidate for the energy frontier at TeV scale
- ECM efficient in μ+μ- annihilation
- Less radiation than e+e- collider
- Much smaller beam-energy spread
- A smaller and a circular machine is possible
- ....

The future collider







- **Both high luminosity FCC-ee and high energy muon collider can offer a stronger sensitive environment to investigate new physics affecting the tau anomalous magnetic moment.**

The tau g-2 based on SMEFT framework

- $e^+e^- \rightarrow \tau^+\tau^-$
- $\gamma\ \gamma \rightarrow \tau^+\tau^-$(EPA)

→ **Process Electron Colliders （FCC-ee）**

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- $\gamma\ \gamma \to \tau^+\tau^-(\mathbf{EPA})$

→ **Process Electron Colliders（FCC-ee）**

All possible high-energy processes at Muon Collider:

- $\mu^+\mu^- \to \tau^+\tau^-$
- $\mu^+\mu^- \to \tau^+\tau^- h\ \ (\mu^+\mu^- \to \tau^+\tau^- \mathrm{z})$

→ **Offer a direct and highly sensitive for measuring for tau g-2**

- $\mu^+\mu^- \to \mu^+\mu^-\tau^+\tau^-$
- $\mu^+\mu^- \to \tau^+\tau^-\bar{\nu}\nu$
- $\mu^+\mu^- \to \mu^+\tau^-\ \bar{\nu}_\tau\nu_\mu(\mu^-\tau^+\ \bar{\nu}_\mu\nu_\tau)$

→ **Large cross-section driven by VBF**

The tau g-2 based on SMEFT framework

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- $\mu^+\mu^- \to \mu^+\mu^-\tau^+\tau^-$
- $\mu^+\mu^- \to \tau^+\tau^-\bar{\nu}\nu$
- $\mu^+\mu^- \to \mu^+\tau^-\ \bar{\nu}_\tau\nu_\mu(\mu^-\tau^+\ \bar{\nu}_\mu\nu_\tau)$

→ **Large cross-section driven by VBF**

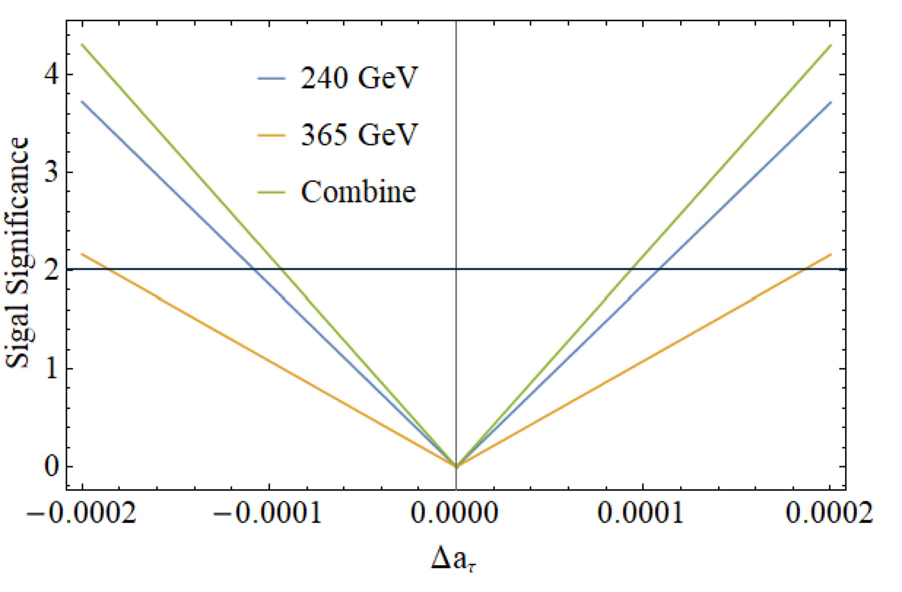
Improve the signal-to-background ratio and keep enough events

- **Considering the detection efficiency of MC.**
- **Optimize the cuts selection: Pt and M($\tau^+\ \tau^-$) Analysis**
- **Potential mistags of process**

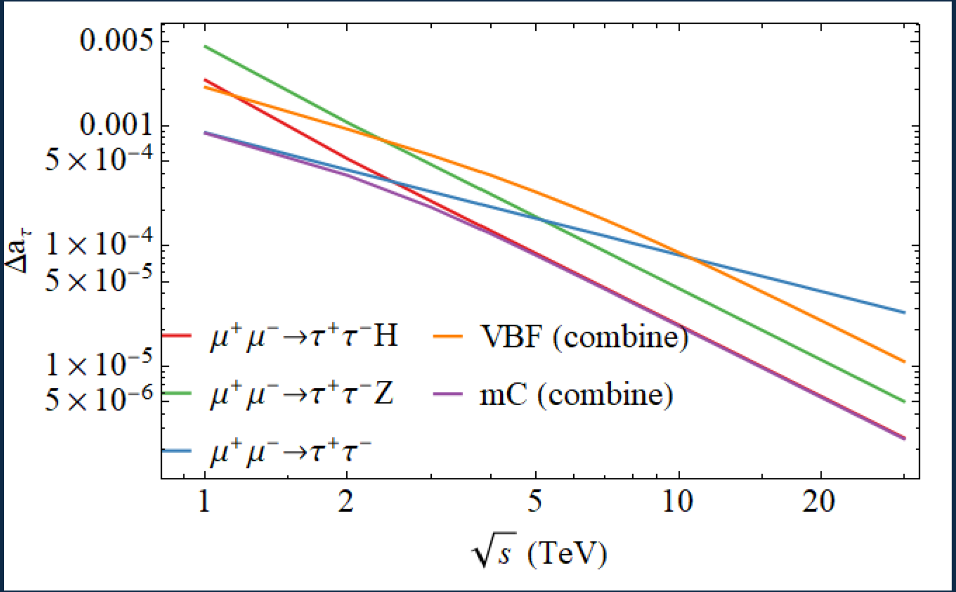
The g-2 of Tau at future collider

The combination of multiple processes and the sensitivity of Δa_τ

FCC-ee



Muon collider



Thanks!