Prospects for new physics in τ→lμμ at current and future colliders

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Motivation

µ

 τ^-

 μ^+

 τ^-

 \tilde{l}_i

 $\tilde{\chi}^0_k$ *k*

 τ^-

 Δ^{--}

 μ^+

µ

µ

 μ^+

 μ^+

 $\tilde{\chi}^0_l$ *l* \tilde{l}_j

 μ^+

µ

 μ^+

 δ^{--}_B *R*

 μ^+

 μ^+

 Δ^{--}

Flavour violation observed in the quark and neutrino sectors

No charged lepton flavour violation (LFV) in the SM

Many models predict observable LFV rates, e.g. additional Higgs triplets or supersymmetry Figure 1: Characteristic Feynman diagrams for the decay ⌧ ⌥ ! *µ±µ*⌥*µ*⌥ in (a) the

A typical feature of seesaw models for neutrino masses \overline{f} future, a circular *e*+*e* collider with a centre-of-mass energy on the *Z* resonance could and projected limits on the \mathcal{U}^+

Current & proposed colliders could improve sensitivity to τ flavour violation by several orders of magnitude Figure 1: Characteristic Feynman diagrams for the decay ⌧ ⌥ ! *µ±µ*⌥*µ*⌥ in (a) the

LHC experiments should give the best sensitivity to τ→3μ over the next few years s liivity to t \rightarrow s μ over the Hext few years of magnetic symmetric future, a circular *e*+*e* collider with a centre-of-mass energy on the *Z* resonance could

We investigate the prospects for experimental $\tau \rightarrow$ $\mu\mu$ constraints and corresponding constraints on parameters in Seesaw Models, the LRSM, and the MSSM η ilai t \rightarrow iµµ constraints and corresponding ⌧ ⌥ ! *µ±µ*⌥*µ*⌥ for each model is shown in Fig. 1. For the computations of the branching equivalent limits for ⌧ ⌥ ! *e±µ*⌥*µ*⌥ and ⌧ ⌥ ! *e*⌥*µ*⌥*µ±*. 3 Standard Model extensions with lepton flavour violating interactions

Overview

e+ e- colliders

Best sensitivity is at e⁺e-colliders due to clean environment

Belle and Babar set limits on all six τ→3l decays 720 million τ-lepton pairs analyzed at Belle, 430 million at BaBar pected BG events (*N*BG). We find that better sensitivity is obtained nd Babar set limits on all six τ→3l decay: odrastical in the state of the total contract the *N*BG from 1 to 1.1 to 1. $\overline{\rm n}$ di t $\overline{\rm c}$ pton pairs analyzeu at Delle, 400

Very low background, ≲0.1 events Good selection efficiency, 7.6-10.1% a factor of 2.5. oackground, ≲0.1 events and an expected B scribed above. In this case, the branching fraction obtained from

Current upper limits on B(τ→3μ): 2.1 x 10⁻⁸ (Belle) & 3.3 x 10⁻⁸ (BaBar) m_{μμμ} (GeV/ć) U^\bullet (**DaDaI**) and the branching fraction U^H for U^H for each individual U^H I_{unnor} limite on $R(\tau_1, \ldots, \tau_{\text{unor}}) \cdot 2$ **1** × **10−8** (**Rol** upper illillis on $D(1 - \delta\mu)$. Z. I X 10^o (Dei

Belle-II will have 50x the luminosity in 2025 will boye EQ the luminesity in 2025 *WIII HAVE OOX THE IUITIIHOSITY IIT ZOZO*

Our conservative projection scales the background by 50 lection criteria, in the Feldman–Cousins approach [30] the upper iservative projection scales the backgro

Our optimistic projection maintains the current background levels assuming **with the number of expected back-off** additional rejection and a 10% loss in acceptance imistic projection maintains the current background levels assuming were well as the state of the state of the uncertainty. The upper limit on the branching fraction (*B*) is then ng 106, is obtained from the number of the *N_T* $\frac{1}{2}$ the integrated luminosity of 782 fb−¹ and the cross section of KKMC [31] to be στ τ = *(*0*.*919±0*.*003*)* nb. The 90% C.L. upper limwe choose the selection criteria description containstance to minimize $\frac{1}{2}$ ial rejection and a TU%

Projected range of limits on B(τ→3μ) is (4.7-10) x 10⁻¹⁰ at **Belle-II** and from the number of *N*_τ \sim 100 fb $^{-1}$ and the cross section of 782 fb $^{-1}$ and the cross section of 782 *e*d range of limits on B(τ→3µ) is (4.7-10) and *^e*[−]*µ*+*µ*[−], τ -pairs and *qq*¯ for τ [−] → *µ*−*µ*+*µ*[−], *^e*[−]*µ*⁺*e*[−] and

 τ pair production, which is calculated in the updated in the updated version of updated version of updated version of τ

its on the branching fractions *B(*τ [−] → ℓ−ℓ+ℓ−*)* are in the range between 1*.*5×10−⁸ and 2*.*7×10−⁸ and are summarized in Table 2.

τ − β−β−β−β−β−1
|- β−||
|-

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ing the systematic uncertainty $\left| \begin{array}{c} B(t) \to \ell \ell^+ \ell^- \end{array} \right| \leq \frac{2N_{\tau \tau} \epsilon}{2N_{\tau \tau} \epsilon}$ $(\tau^- \to \ell^- \ell^+ \ell^-) <$ *s*⁹⁰ 2*N*τ τ ε *,* (1)

, (1)

its on the branching fractions *B(*τ [−] → ℓ−ℓ+ℓ−*)* are in the range between 1*.*5×10−⁸ and 2*.*7×10−⁸ and are summarized in Table 2.

cays into the leptons using 782 fb−1 of data. No events are ob-1 of data. No events are ob-1 of data. No events

Hadron colliders **232** Page 10 of 25 Eur. Phys. J. C (2016) 76 :232 /32) π400 *ATLAS* SB data (loose) /32) π¹⁰⁰⁰ *ATLAS* SB data (loose)

HL-LHC: τ-leptons yields increase by factors of 15 (luminosity) & 1.8 (cross section) We estimate LHCb constraints will be in the range (1.5-11) x 10⁻⁹ ov factors o sidebands are shown as *hollow circles*, while the *loose* signal MC events are shown as *light solid grey area*. The *tight*+*x>x*⁰ data in the sidebands are shown as the *solid black circles*, while the *tight*+*x>x*⁰ signal λ is not constraint is not constrained to the SRS is not constrained \overline{a} *ATLAS* selection) ⁰ SB data (tight+x>x 25 selection)

ATLAS constraint of $B(\tau \rightarrow 3\mu) < 3.8 \times 10^{-7}$ with 8 TeV data

Use W boson decays with BDT to reduce background to 0.2 events

HL-LHC to provide a factor of >100 luminosity and 1.6 in cross section Backgrounds and triggering will be a substantial challenge region (SB) for the *tight*+*x>x*⁰ selection. The *line* shows the result of unal crialiende to the SB range definition, the \sim and the fit function choice. The *solid grey area* shows the signal shape **Fig. 6** The three-muon mass distribution in the range [1450*,* 2110] MeV shown for the *tight*+*x>x*⁰ selection by *solid* EPJC 76, 232 (2016)

We estimate the ATLAS limits on B(τ→3µ) will be in the range (1.8-8.9) x 10⁻⁹ on R*(x*1*)* of varying the sideband ranges definition. The dif- $(0, \mathbf{v}, \mathbf{A} \cap \mathbf{0})$ the *tight*+*x>x*⁰ selection

Future circular colliders

100 TeV pp collider would have a W boson cross section ~7x that of the LHC

Assuming a similar background rejection and efficiency to ATLAS, we project B(τ➝3μ) constraints in the range **(3-30) x 10-10** for 3 ab-1 of luminosity

Proposed circular **e+e- collider** could have a run at the Z-boson resonance

55 ab-1 of luminosity at four interaction points would provide 300 trillion τ-lepton pairs

Based on LEP searches, we assume negligible background & 40-80% acceptance, and project B(τ➝3μ) limits in the range **(5-10) x 10-12** for such a collider

Type-II Seesaw model In addition to the Yukawa Lagrangian, the Higgs triplet interacts with the SM Higgs and gauge bosons through the scalar potential and the kinetic Lagrangian. For a complete description of the scalar potential and the other interactions, see [88]. The trilinear interaction of the with the SM Higgs doublet is governed by the following Lagrangian: \blacksquare note that an equivalent description of the Type-II seesaw is with the triplet Higgs field \blacksquare that gets integrated out and generates the dimension-5 operator *LiLjHH/*⇤ with the coecient *Cij* = *Yµ/M*² . The Yukawa Lagrangian generates the following interaction The neutral component ⁰ has the vacuum expectation value (vev) *v*, and generates the Majorana masses of the light neutrinos *M*⌫. The interaction of with the two lepton doublets is given by, The neutral component ⁰ has the vacuum expectation value (vev) *v*, and generates the

Type-II Seesaw adds a Higgs triplet to the SM doublet: *V L L V L L L L L L* gives rise to lepton number violation in this model, which is model, which in *Y L*_Y (++) α (++) α Here, *cannot to the SM doublet:* α is the *i*² is the Yukawa α is the Yukawa α is the Yukawa α matrix. The light neutrino mass matrix is proportional to the vev *v*, with *Lace CA* (*C*) μ *L* μ *L*

Yukawa terms lead to lepton number violation and LFV: The simultaneous presence of *Y* and *Y* gives rise to lepton number violation in this model, while the o↵-diagonal elements in *Y* Iwa terms lead to lepton number violation and LFV: matrix. The light neutrino mass matrix is proportional to the vev *v*, with

Neutrino masses are given by $M_{\nu} = \sqrt{2} Y_{\Delta} v_{\Delta}$ with the two charged $\Delta = \frac{\mu_{\Delta} v_{\Phi}}{2}$ and Δ

asses are given by

\n
$$
w_{\mu} = \sqrt{2}Y_{\Delta}v_{\Delta}
$$
\n
$$
v_{\Delta} = \mu_{\Delta}v_{\Phi}^{2}/(\sqrt{2}M_{\Delta}^{2})
$$
\n
$$
V(\Phi, \Delta) = \mu_{\Delta}\Phi^{T}i\tau_{2}\Delta^{\dagger}\Phi + \text{h.c.}
$$
\n**See-saw mechanism**

\n
$$
\Delta^{-1} \left(\sum_{\mu=1}^{\infty} \mu_{\mu} \right)
$$

, (3.7)

 Δ^{--}

 μ^+

µ

 μ^+

 τ^-

The partial decay width is $\Gamma(\tau^{\mp} \to \mu^{\pm} \mu^{\mp} \mu^{\mp}) = \frac{m_{\tau}^{5}}{192\pi}$ $\frac{m_\tau^5}{192\pi^3} |C_{\tau\mu\mu\mu}|^2 \;, \;\;\;\; C_{\tau\mu\mu\mu} = \frac{Y_{\tau\mu}Y_{\mu\mu}}{m_{\Delta^{\pm\pm}}^2} = \frac{M_\nu}{2}$ $m_{\Delta^{\pm \pm}}^2$ $=\frac{M_{\nu}(\tau,\mu)M_{\nu}(\mu,\mu)}{2^{2}+2}$ $2v_{\Delta}^2m_{\Delta^{\pm\pm}}^2$ The Higgs triplet carries lepton number +2. The simultaneous presence of *Y* and *µ* $\Gamma(\tau^{\mp} \to \mu^{\pm} \mu^{\mp} \mu^{\mp}) = \frac{m_{\tau}}{4.88 \times 10^{9}} |C_{\tau \mu \mu \mu}|^{2}$, $C_{\tau \mu \mu \mu} = \frac{4 \tau \mu^{2} \mu \mu}{2} = \frac{m_{\nu} V(\tau, \mu) m_{\nu} (\mu, \mu)}{2 \times 2}$ give rise to flavour violation. The flavour violation 192π V ^{*V*} V *M*(τ *u*)*M*(μ) τ $\Gamma(\tau^{\mp} \to \mu^{\pm} \mu^{\mp} \mu^{\mp}) = \frac{m_{\tau}^2}{100 \pi^2} |C_{\tau \mu \mu \mu}|^2 \;, \quad C_{\tau \mu \mu \mu} = \frac{I \tau \mu I \mu \mu}{m^2} = \frac{M \nu (I, \mu) M \nu (\mu, \mu)}{2 m^2 m^2}$ note that an equivalent description of the Type-II seesaw is with the $\overline{Y} \times \overline{Y} = M(\tau, \mu)$ partial decay width is $\Gamma(\tau^+ \to \mu^+ \mu^+ \mu^+) = \frac{1}{192 \pi^3} |C_{\tau \mu \mu \mu}|^2 \ , \quad C_{\tau \mu \mu \mu} = \frac{1}{m_{\Delta+\pm}^2} = \frac{1}{2 v_{\Delta}^2}$

Type-II Seesaw model *^µ* and the doubly charged Higgs mass coming from Belle are *^µ* ⁷*.*⁸ ⇥ ¹⁰⁹ GeV and $\mathcal{L}_{\mathcal{A}}$ FCC-ee could constrain the doubly charged Higgs mass up to *m±±* 4*.*6 TeV and 14*.*5

Diagonalize neutrino mass matrix with the PMNS matrix $U_{\rm P}^{\rm T} M_{\nu} U_{\rm P} = M_d$ mixing matrix *U*^P has the following form:

$$
P = \begin{pmatrix} c_{12} c_{13} & s_{12} c_{13} & s_{13} e^{-i\delta} \\ -c_{23} s_{12} - s_{23} s_{13} c_{12} e^{i\delta} & c_{23} c_{12} - s_{23} s_{13} s_{12} e^{i\delta} & s_{23} c_{13} \\ s_{23} s_{12} - c_{23} s_{13} c_{12} e^{i\delta} & -s_{23} c_{12} - c_{23} s_{13} s_{12} e^{i\delta} & c_{23} c_{13} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha_1} & 0 \\ 0 & 0 & e^{i\alpha_2} \end{pmatrix}
$$

 U

–9– δ: Dirac CP violating phase α1,2: Majorana phases

esters. Furthermore, is the Dirac C_P violating phase and **Phase and Phase and Phase and Majorana** phases. Constraints on δ vs θ_{12} using v_{Δ} = 10⁻¹⁰ GeV and m_{Δ_{++}} = 8 TeV or 10.3 TeV:

Left-right symmetric model m matri \cap mood *M^L M^D* ! $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}$ The matrix given in Eq. (3.12) can be diagonalised by a 6.12 unitary matrix as follows: $\overline{}$ f⌫ 0 *LY* ⇡ ^p2*v^R* 2*v^R* ¯*l R*++ *^R l^R* + h*.*c*. ,* (3.18) where *V^R* is the diagonalising matrix for the heavy neutrino mass matrix *MR*, *V ^T ^R MRV^R* = f*R*, and *V* ⇠ *V^R* [96]. A detailed discussion on LFV for this model for all other modes where *V^R* is the diagonalising matrix for the heavy neutrino mass matrix *MR*, *V ^T ^R MRV^R* = Ω fr vioht ovmonotrio $\epsilon \rightarrow 1$. $\epsilon \rightarrow 1$ \overline{M} *M^L M^D M*^T *^D M^R* . model In the seesaw approximation, the seesaw approximation, this leads to the following light and heavy neutrino mass

The LRSM adds an SU(2)R Higgs doublet and triplet to the minimal Type-II Seesaw model In the seesaw approximation, this leads to the following light and heavy neutrino mass The LRSM adds an $SU(2)_R$ Higgs doublet and triplet to the r two scalar triplets and one bi-doublet field, that after left-right and electroweak symmetry and electroweak symmetry *A* an SU(2)_R Higgs doublet and triplet to the minimal *n*al Type-II Seesaw mc

$$
-\mathcal{L}_Y = h\bar{\psi}_L \Phi \psi_R + \tilde{h}\bar{\psi}_L \tilde{\Phi} \psi_R + f_L \psi_L^{\mathrm{T}} C i\tau_2 \Delta_L \psi_L
$$

$$
+ f_R \psi_R^{\mathrm{T}} C i\tau_2 \Delta_R \psi_R + \text{h.c.} ,
$$

$$
M_R = \sqrt{2} v_R f_R
$$

$$
-\mathcal{L}_Y = h\bar{\psi}_L \Phi \psi_R + \tilde{h}\bar{\psi}_L \tilde{\Phi} \psi_R + f_L \psi_L^{\mathrm{T}} C i\tau_2 \Delta_L \psi_L
$$

$$
M_{\nu} \approx M_L - M_D M_R^{-1} M_D^{\mathrm{T}} = \sqrt{2} v_L f_L - \frac{\kappa^2}{\sqrt{2} v_R} h_D f_R^{-1} h_D^{\mathrm{T}} + f_R \psi_R^{\mathrm{T}} C i\tau_2 \Delta_R \psi_R + \text{h.c.} ,
$$

$$
M_R = \sqrt{2} v_R f_R
$$

where *C* is the charge-conjugation matrix, and in the conjugation matrix, and in the charge-conjugation of the contract of th LFV can be mediated by either doubly charged Higgs bos where \mathcal{Q} $\frac{1}{2}$ ², *^M^L* ⁼ ^p2*vLf^L* and the Dirac mass is *^M^D* ⁼ *^hD* ⁼ LFV can be mediated by either doubly charged Higgs boson The Yukawa interaction of the doubly charged Higgs with the two charged leptons that **LIV CALL DE LITEGRATEGRATE BY ENTIEL GOUDLY CITE** tree-level LFV processes. We follow a simplified approach by judiciously choosing the parameter space, where the doubly charged Higgs arising from *^R* is lighter than the The scalar potential for the LRSM has the following form [97–99]: ¹ +² ², *^M^L* ⁼ ^p2*vLf^L* and the Dirac mass is *^M^D* ⁼ *^hD* ⁼ The mass matrix given in Eq. (3.12) can be diagonalised by a 6⇥6 unitary matrix as follows:

$$
\mathcal{L}_Y = f_L \bar{l}_L^c \delta_L^{++} l_L + f_R \bar{l}_R^c \delta_R^{++} l_R \ + \text{h.c.}
$$

s of the Higg potential for doubly charged Higgs boson *,* (3.15) We note that imposing the discrete parity or charge conjugation as a symmetry along with The relevant terms of the Higgs potential for doubly charged Higgs boson masses are tential for τ doubly cl g gs potential for doubly charged Higgs boson masses are

$$
V(\Phi, \Delta_L, \Delta_R) = +\rho_1 \left[\text{Tr} \left[\Delta_L^{\dagger} \Delta_L \right] \right]^2 + \rho_1 \left[\text{Tr} \left[\Delta_R^{\dagger} \Delta_R \right] \right]^2 + \rho_3 \text{Tr} \left[\Delta_L^{\dagger} \Delta_L \right] \text{Tr} \left[\Delta_R^{\dagger} \Delta_R \right]
$$

+ $\rho_2 \text{Tr} \left[\Delta_L \Delta_L \right] \text{Tr} \left[\Delta_L^{\dagger} \Delta_L^{\dagger} \right] + \rho_2 \text{Tr} \left[\Delta_R \Delta_R \right] \text{Tr} \left[\Delta_R^{\dagger} \Delta_R^{\dagger} \right]$
+ $\rho_4 \text{Tr} \left[\Delta_L \Delta_L \right] \text{Tr} \left[\Delta_R^{\dagger} \Delta_R^{\dagger} \right] + \rho_4 \text{Tr} \left[\Delta_L^{\dagger} \Delta_L^{\dagger} \right] \text{Tr} \left[\Delta_R \Delta_R \right]$
 $\alpha_1 \text{Tr} \left[\Phi^{\dagger} \Phi \right] \text{Tr} \left[\Delta_L^{\dagger} \Delta_L + \Delta_R^{\dagger} \Delta_R \right] + \alpha_3 \text{Tr} \left[\Phi \Phi^{\dagger} \Delta_L \Delta_L^{\dagger} + \Phi^{\dagger} \Phi \Delta_R \Delta_R^{\dagger} \right] + \dots$

 $\frac{1}{\sqrt{1-\epsilon}}$

^M^R ⁼ ^p 2*vRf^R ,* (3.14) *^L^Y* ⁼ *^fL*¯*^l L*++ *^L ^l^L* ⁺ *^fR*¯*^l R*++ mediates the LFV processes ⌧ ⌥ ! *µ±µ*⌥*µ*⌥ and ⌧ ⌥ ! *e±µ*⌥*µ*⌥ is given by, *chequire δ*²⁺⁺ to have a large mass since it is larger than neutral Higgs bosons that must have a larger to a variate that must *^R l^R* + h*.*c*. .* (3.17) have a large mass to avoid flavour changing currents in the quark sector *A PARAIRA ALIXANTA in the* atord harbar brianging barron **decay meas sines** it is lerger than poutral *x* + 20 + 11200 011100 11 10 121 you than mount
avoid flavour changing currants in the gu i io iaigoi triamnoatiai $\frac{1}{3}$ *z* equire δι⁺⁺ to *h* mass to avoid f lavour cl *k*4 anging cu $rr \approx$ *k*2 $\overline{}$ r changing currents $\frac{1}{2}$ \mathcal{L} + 3) \mathcal{L} + 3) \mathcal{L} *k*2 + ،
۱۱۰ $\overline{}$,
′r∠ *k*2 nts in the quark sect Flavour changing currents in the quark sector *larger than neutral Higgs bosons that must*

$$
M_{H_1^0}^2 = M_{A_1^0}^2 \approx \alpha_3 \frac{v_R^2 k_+^2}{2 k_-^2} , \qquad M_{H_3^0}^2 = M_{A_2^0}^2 \approx (\rho_3 - 2\rho_1) \frac{v_R^2}{2} \qquad \qquad M_{\delta_L^{\pm \pm}}^2 \approx (\rho_3 - 2\rho_1) \frac{v_R^2}{2} + \alpha_3 \frac{k_-^2}{2}
$$

Left-right symmetric model ✓ ¹ + 4*k*² 1*k*² 2 (2² + 3)+4⁴ *k*1*k*² ◆ *,* [100–103]. To avoid the flavour-changing neutral Higgs (FCNH) constraints, the neutral 1 *AU A H A* are *H A A A H A* <u>It oyn in neutral Higgs state</u> heavy Higgs searches at the LHC. In the Higgs spectrum, we consider the Higgs spectrum, we consider the case w neutral Higgs bosons demand a large value of the symmetry breaking scale *v^R* [103]. In η i cwiminiairki motos the can be can be obtained on the can be obtained on the best and the heavy neutrino masses and the \sim

Consider two benchmark scenarios where $\delta_{R^{++}}$ has a somewhat lower mass nark sc anarios, whara sott has a somawhat lower mass $\sum_{i=1}^{n}$ *Compairion where δ_R⁺⁺ has a somewhat lower mass*

Minimal supersymmetric standard model mechanism that ensures a suppression of o<code>diagonal terms in the slepton mass matrix, the slepton </code> their presence can induce a misalignment in flavour space between the lepton and slepton mass matrices, which cannot mechanism that ensures a suppression of o<code>diagonal terms in the slepton mass matrix, the slepton </code> their presence can induce a misalignment in flavour space between the lepton and slepton aporoji mirot mal supersymmetric standard more lepton masses, ✓*^W* is the weak mixing angle, *m^Z* is the *Z* boson mass, tan = *v*2*/v*¹ with

Slepton generational mixing is a general feature and can induce LFV matrix has the following form: *M*₂ *M*₂ *M*₂ *M*₂ *M*₂ *M*₂ ol mixing is a gone in T symbol. The flavour violation is a symbol. The flavour violation in the *LEV* and continued to **RV** and to respond to \mathbb{R} and \mathbb{R} and \mathbb{R} and to \mathbb{R} and \mathbb{R} and \mathbb{R} and \mathbb{R} and \mathbb{R} a o↵-diagonal terms in the soft masses *m*² *L ij* ˜ and *^m*² (a) (b)

we havour-violating and havour-conservi *M*² *†* ˜*l LR ^M*² ˜*l RR*! where each of the *M*₂ Mass matrices have flavour-violating and flavour-conserving terms with the MSSM the MSSM the MSSM the South Armedian matrix of the south of the south 3 model in the south 3 model as **M**₂ Marrier in the electroweak basis (12), where α and β and β **13** *Mass matrices have flavour-violary entity and the decay* μ

 $M_{\tilde{i}}^2$ $_{\tilde{i}}$ $_{\tilde{j}}$ $_{\tilde{j}}$ $_{\tilde{j}}$ $_{\tilde{k}}$ $_{\tilde{j}}$ $_{\tilde{k}}$ $_{\tilde{j}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{\tilde{i}}$ $_{\tilde{j}}$ $_{\tilde{k}}$ $_{\tilde{j}}$ $_{\tilde{k}}$ $_{\tilde{j}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{\tilde{k}}$ $_{$ Parametrize off-diagonal entries as $\delta_{ij}^{AB} \equiv \frac{m_{IAB\,ij}}{m_{IAB}}$ $m_{\tilde{A}_i} m_{\tilde{B}_j}$ and $m_{\tilde{A}_i} m_{\tilde{B}_j}$ and the corresponding values of $m_{\tilde{A}_i} m_{\tilde{B}_j}$ and $m_{\tilde{A}_i} m_{\tilde{B}_j}$ with \tilde{A}_j with \tilde{A}_j $\delta^{AB}_{ij} \equiv$ $M^2_{\tilde{l} \, AB \, ij}$ $m_{\tilde{A}_i} m_{\tilde{B}_j}$ (a) $\frac{1}{m}$ $\frac{1}{m}$ $\frac{1}{m}$ $\frac{1}{m}$ $T^*A_i T^*B_j$ (b) the Model

SU(2) Higgs doublets, and *µ* is the Higgsino mass term. Here, *ij* is the Kronecker delta *v*¹ = h*H*1i and *v*² = h*H*2i being the two vacuum expectation values of the corresponding Vary slepton masses:

i $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$

 τ^-

 \tilde{l}_i

 $\tilde{\chi}^0_k$ *k* μ^+

 μ^+

 $\tilde{\chi}^0_l$ *l* \tilde{l}_j

 μ^+

µ

µ

 μ^+

Summary

LFV is a general feature of neutrino seesaw mechanisms and of supersymmetry

Expect \sim 2 orders of magnitude improvement in $B(\tau\rightarrow l\mu\mu)$ in the next decade

*LHC should have the best sensitivity to B(*τ➝*3*μ*) for the next few years* LHC could also be competitive in $B(\tau \rightarrow e^{+}\mu^{-}\mu^{-})$

Future circular e+e- collider could improve sensitivity by another two orders of magnitude

12

In the **Type-II Seesaw model** Belle-II could probe the CP-violating phase

In the LRSM, increasing sensitivity to $B(\tau \rightarrow l\mu\mu)$ will probe smaller values of $m_N/m_{\delta R++}$

In the MSSM increasing sensitivity to B(τ→lμμ) will probe smaller mixing values

