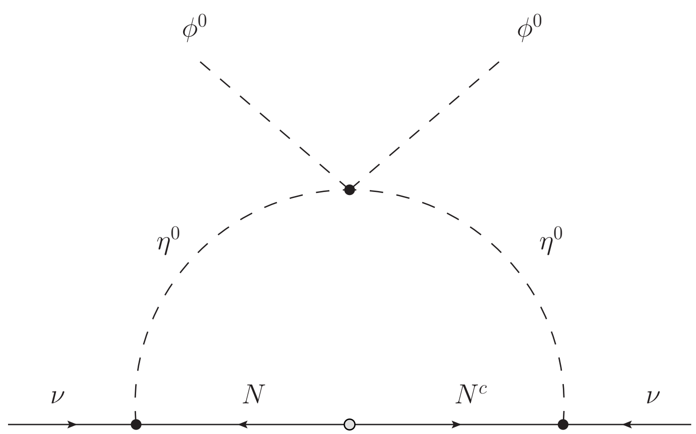
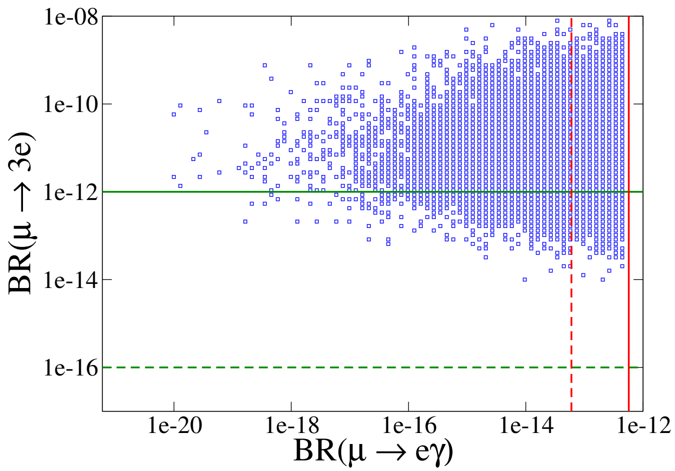
Dark matter, neutrino masses and LFV processes in the scotogenic model





Based on JHEP 1502 (2015) 144
with Avelino Vicente

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MPIK

2015

The scotogenic is the best known model of ν masses and dark matter

It contains only two new fields

Ma, 2006

$H_2 = \binom{H^{\pm}}{H^0 + iA^0}$, N_i

They are odd under a Z_2 symmetry

To prevent FCNC and stabilize the dm

It has been studied extensively

dark matter, ν's, collider

In this model, neutrino masses are generated radiatively at the 1-loop level

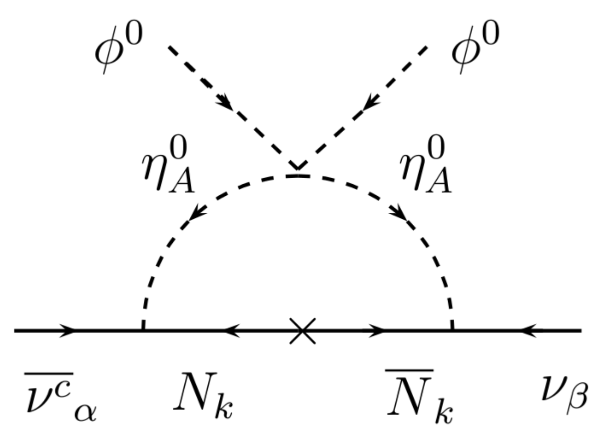
There is no Dirac mass term for neutrinos

$$\boldsymbol{y_{ij}\, L_i N_j H_2 + M_N N N}$$

Lepton number violation requires $\lambda_5 \neq 0$

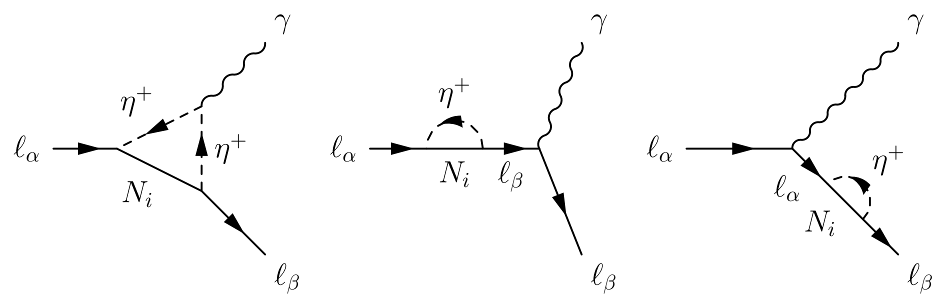
$$\frac{\boldsymbol{\lambda_5}}{\boldsymbol{2}} \left[(\boldsymbol{H_1^\dagger H_2})^{\boldsymbol{2}} + (\boldsymbol{H_2^\dagger H_1})^{\boldsymbol{2}} \right]$$

Neutrinos acquire masses at 1-loop

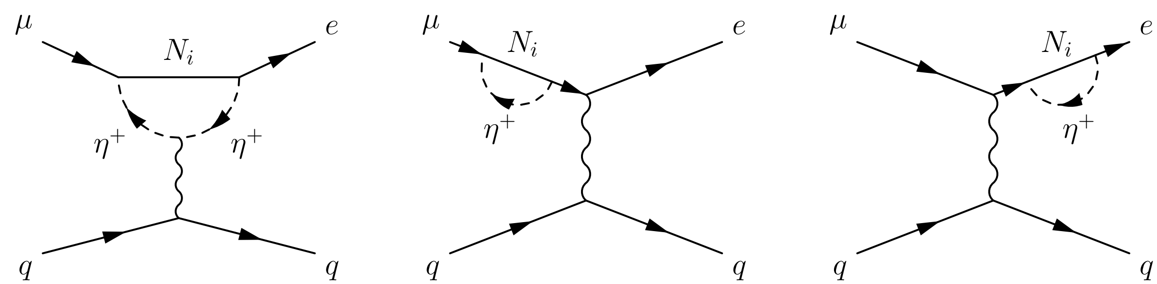


Lepton flavor violating processes are also induced at one-loop

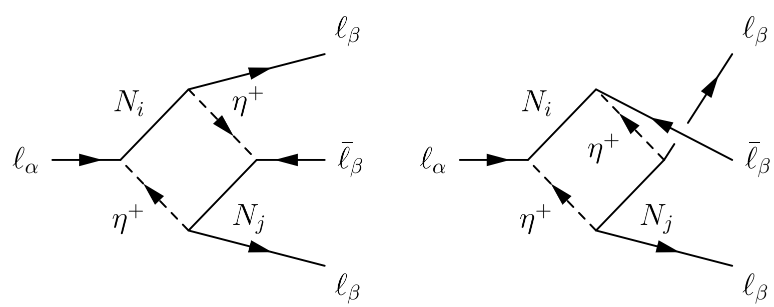
They are mediated by the charged scalar



They depend on y_{ij} but not on λ_5



Observable rates for $y_{ij} \sim \mathcal{O}(0.1 - 1)$



The lightest singlet fermion is a leptophilic dark matter candidate

It does not couple to quarks at tree-level

No direct detection bounds

It annihilates into leptons

$\sigma(NN \to \ell\bar{\ell}) \propto y^4$

$\Omega_{dm} \Rightarrow \mathcal{O}(1)$ Yukawas

Strong correlation with LFV and ν masses

through the Yukawas

The stringent bounds on LFV processes will be improved significantly in the near future

By about 10^4 for $\mu \to 3e$

By about 10^6 for CR(μ-e)

How will they affect the scotogenic model?

LFV Process	Present	Future
$\mu \to e\gamma$	5.7×10^{-13}	6×10^{-14}
$\tau \to e\gamma$	3.3×10^{-8}	$\sim 3 \times 10^{-9}$
$\tau \to \mu\gamma$	4.4×10^{-8}	$\sim 3 \times 10^{-9}$
$\mu \to eee$	1.0×10^{-12}	$\sim 10^{-16}$
$\tau \to \mu\mu\mu$	2.1×10^{-8}	$\sim 10^{-9}$
$\tau^- \to e^-\mu^+\mu^-$	2.7×10^{-8}	$\sim 10^{-9}$
$\tau^- \to \mu^-e^+e^-$	1.8×10^{-8}	$\sim 10^{-9}$
$\tau \to eee$	2.7×10^{-8}	$\sim 10^{-9}$
$\mu^-, \mathrm{Ti} \to e^-, \mathrm{Ti}$	4.3×10^{-12}	$\sim 10^{-18}$
$\mu^-, \mathrm{Au} \to e^-, \mathrm{Au}$	7×10^{-13}	
$\mu^-, \mathrm{Al} \to e^-, \mathrm{Al}$		$10^{-15} - 10^{-18}$
$\mu^-, \mathrm{SiC} \to e^-, \mathrm{SiC}$		10^{-14}

We studied the parameter space of this model and obtained a large sample of viable points

We used the most general form of the Yukawas

$y_{ij} \to$ Casas-Ibarra

We took into account all relevant constraints

Dark matter: N_1 (freeze-out)
EW data, colliders,...

We computed the rates for different LFV processes

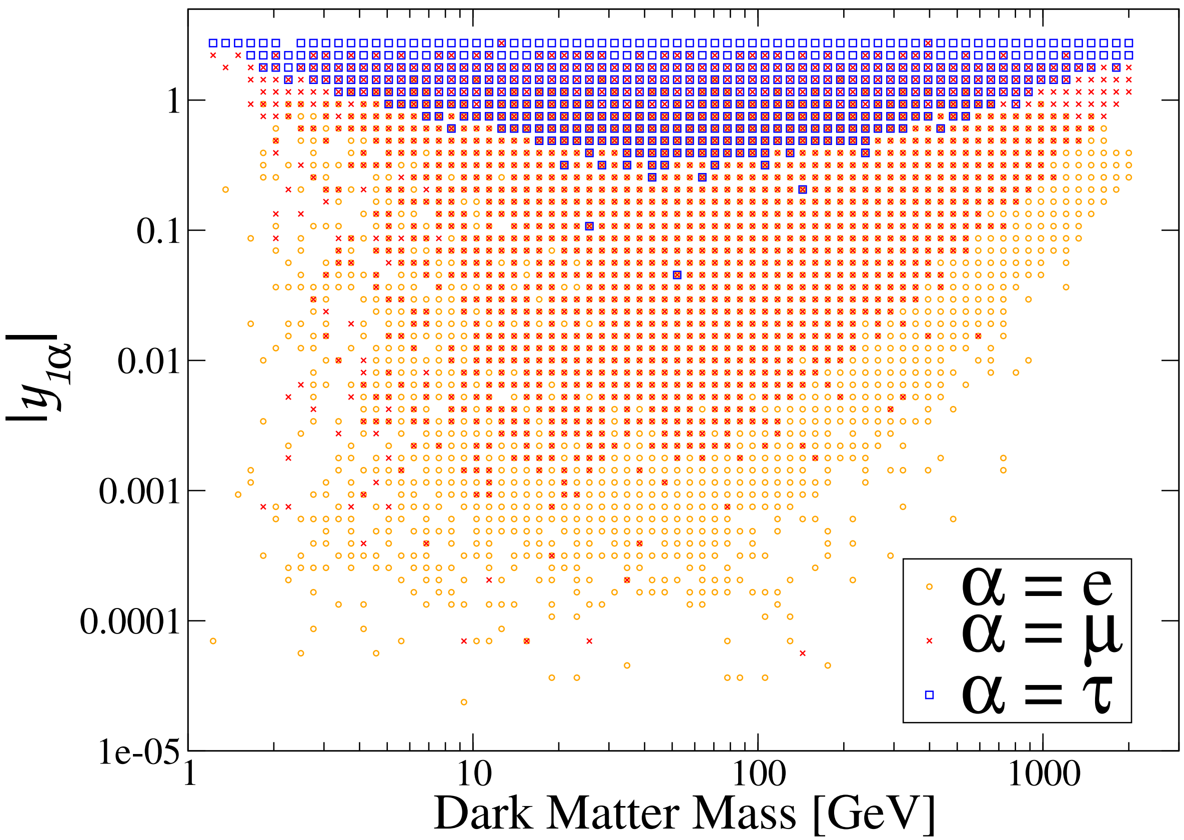
$\underline{\mu \to e\gamma}, \mu \to 3e, CR(\mu\text{-}e)$
$\tau \to \mu\gamma, \tau \to e\gamma, \tau \to 3\mu$

The dark matter annihilates dominantly into third family leptons

$\mu \to e\gamma$ requires small $y_{1e}, y_{1\mu}$

The Yukawas satisfy $|y_{1e}| \lesssim |y_{1\mu}| \lesssim |y_{1\tau}|$

No viable models for $M_{N_1} \gtrsim 2$ TeV

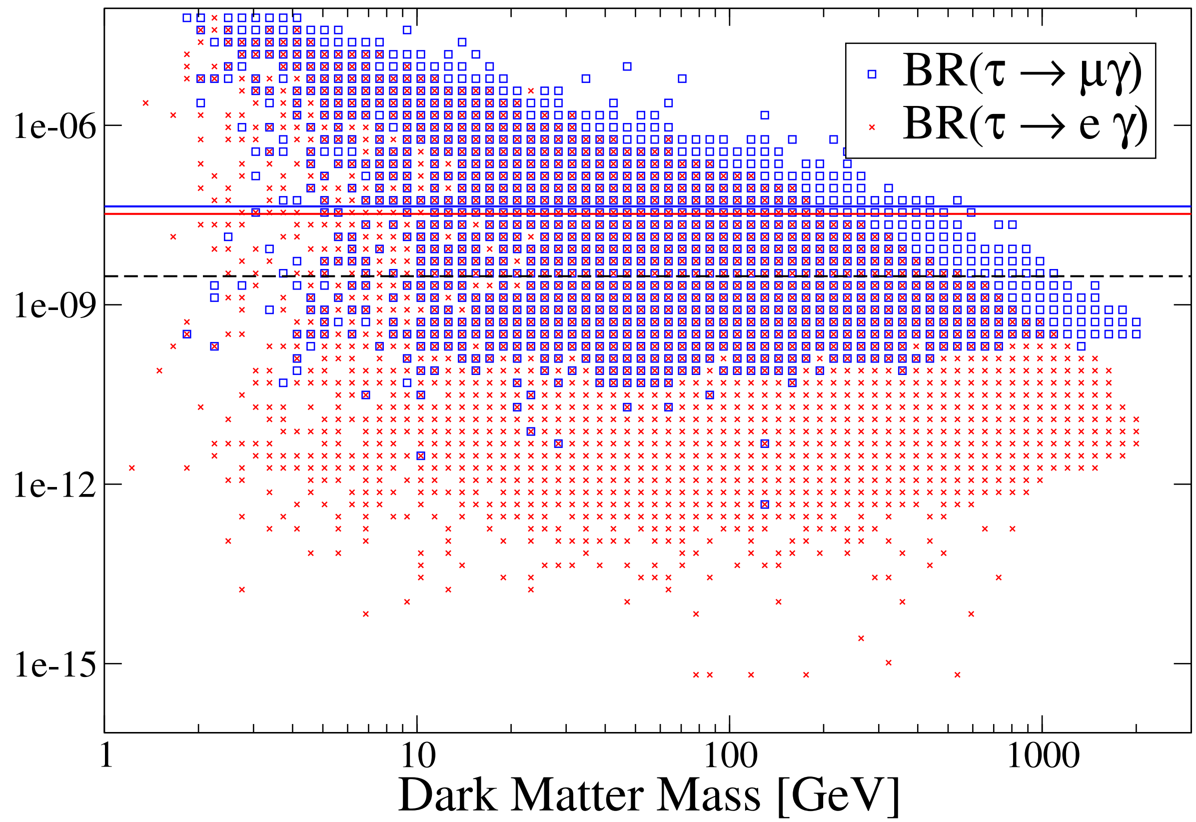


Current bounds on LFV τ decays can be violated

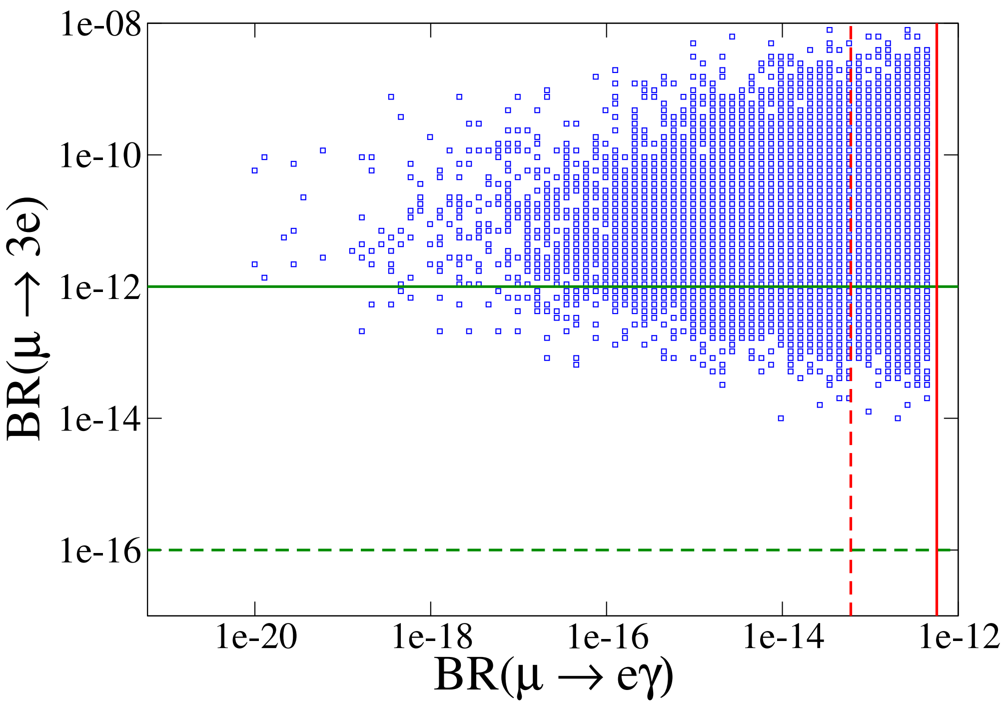
They are more relevant at low dm masses

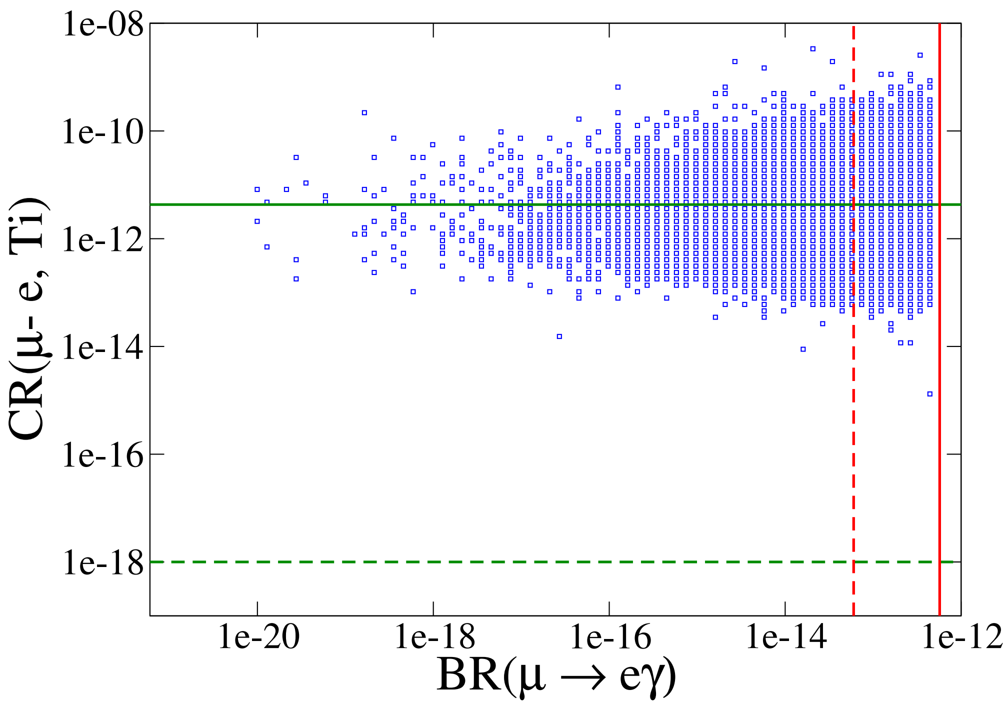
Viable models remain for all values of M_{N_1}

Future experiments can exclude more models



This scenario will be easily and entirely probed by future LFV experiments





The scotogenic model is a simple and viable scenario for physics beyond the SM

It can account for the dark matter

It gives rise to neutrino masses

It will be tested in LFV experiments