Dark Radiation Confronting LHC in Z' Models

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Elementary Particles IMPRS

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UNIVERSITAT DE BARCELONA

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- Extra U(1)$'$ through E_6 models:

$$E_6 \to SO(10) \times U(1)_\psi \to SU(5) \times U(1)_\chi \times U(1)_\psi \to$$

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- parametrized by β mixing angle:
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- $Z - Z'$ mixing angle δ set to 0

  (for $M_{Z'} \lesssim 1TeV$ $\delta \sim O(10^{-3})$*, and decreases with higher masses.)*

Right-handed neutrino carry a non-zero U(1)′ charge

	$\sqrt{40}Y_\chi$	$\sqrt{24}Y_\psi$
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$\Rightarrow$ **These light or massless RH neutrinos may be a new form of Dark Radiation.**

Relating Particles and Cosmology

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- New light states contribute to the effective number of neutrinos as:

$$\Delta N_{\text{eff}} = \frac{8}{7}\sum_{B}\frac{g_B}{2}\left(\frac{T_B}{T_{BBN}}\right)^4 + \sum_{F}\frac{g_F}{2}\left(\frac{T_F}{T_{BBN}}\right)^4$$

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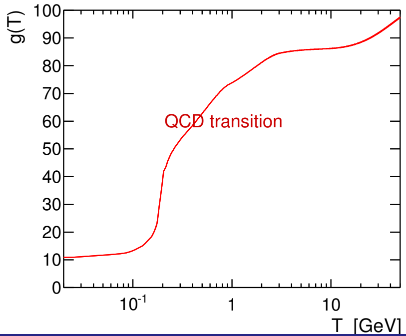

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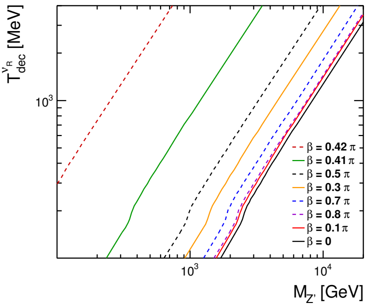

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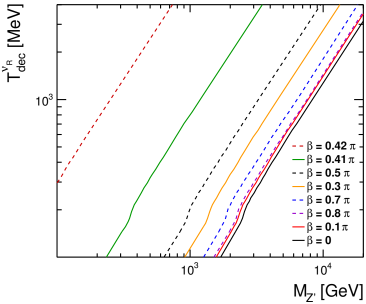

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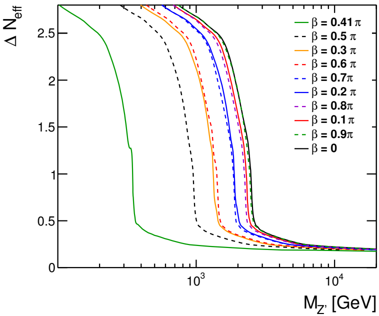

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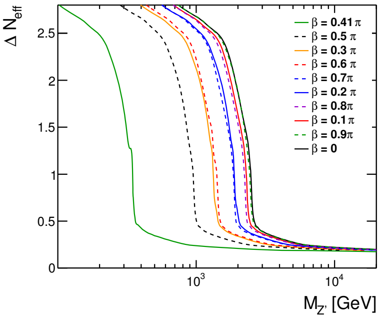

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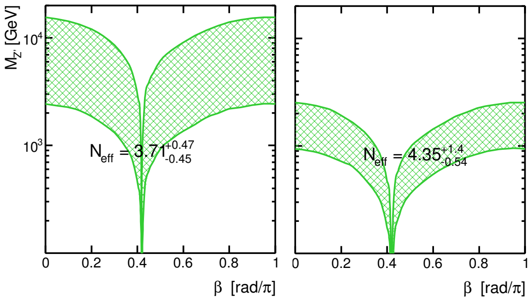

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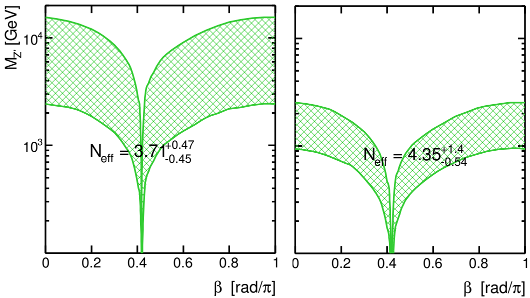

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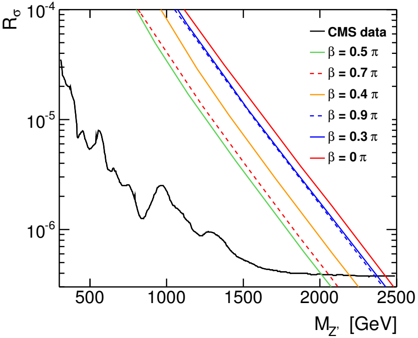

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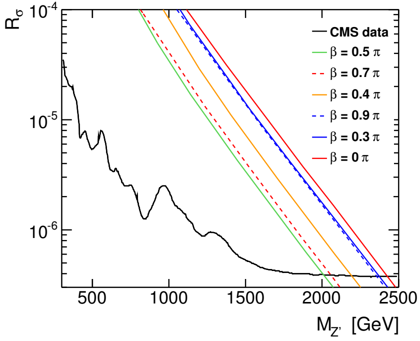

Cosmological and LHC constraints on E_6 models

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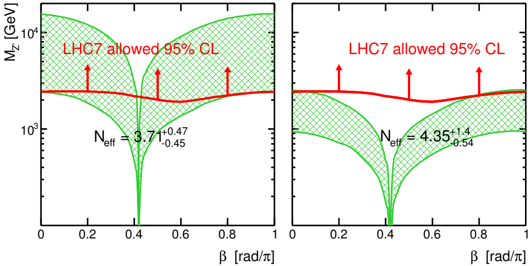

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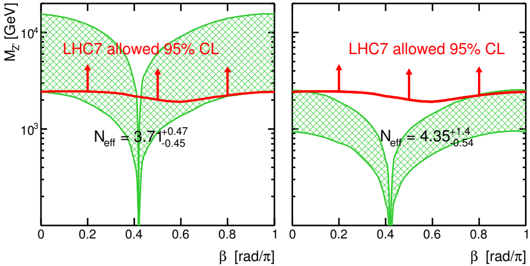

$\Delta N_{\rm eff}^{max}$	1.16	0.48	0.37	0.30	0.22	0	0.27	0.36	0.43	0.98	1.18
for $\frac{\beta}{\pi}$	0.00	0.10	0.20	0.30	0.40	0.419	0.50	0.60	0.70	0.80	0.90

$\Rightarrow$ Most of M$_{Z'}$ values require a lower amount of dark radiation (for right panel).

Conclusions

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- The additional radiation depends on the time of decoupling of the RH neutrinos with the other SM particles (i.e. $M_{Z'}$).
- With 95% CL:
  - $\Delta N_{eff} \geq 1.25$ excluded for all β
  - $\Delta N_{eff} \sim 0.5$ excluded for all $0.1 < \frac{\beta}{\pi} < 0.75$

Further constraints on dark radiation are forseeable for higher LHC energies and new cosmological data.

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Vielen Dank!

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