Signals of left-right symmetry at LHC and precise one-loop low energy data

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Outline

1. Introduction – LR model
2. Constrains coming from muon decay
3. LHC results
4. Conclusions

Left-Right Model

- $SU(2)_R \times SU(2)_L \times U(1)_{B-L}$
- Interesting phenomenology
  - heavy gauge bosons $Z_2, W_2^{\pm}$, $M_{Z_2} = 0.783 v_R$, $M_{W_2} = 0.461 v_R$.
  - heavy neutrinos N_i, $m_{N_i} = \sqrt{2} h_{M_i} v_R$,
  - Higgs particles, neutral, charged and doubly charged. $\Rightarrow$ one bidoublet and two triplets.
  - Right triplet gets VEV: $v_R \Rightarrow$ LR symmetry broken to SM symmetry.
- v_R determines the energy scale. Usually it is assumed to be of order of few TeV.

(see e.g. for details P. Duka, J. Gluza and M. Zrałek, Ann. of Phys. **280** (2000) 336.)

Muon decay constrain parameter space of a model

$$\frac{G_F}{\sqrt{2}} = \frac{e^2}{8(1 - M_W^2/M_Z^2)M_W^2}(1 + \Delta r). \qquad (1)$$

$\Rightarrow$ calculate Δr in LR

$\Rightarrow$ do the matching with SM

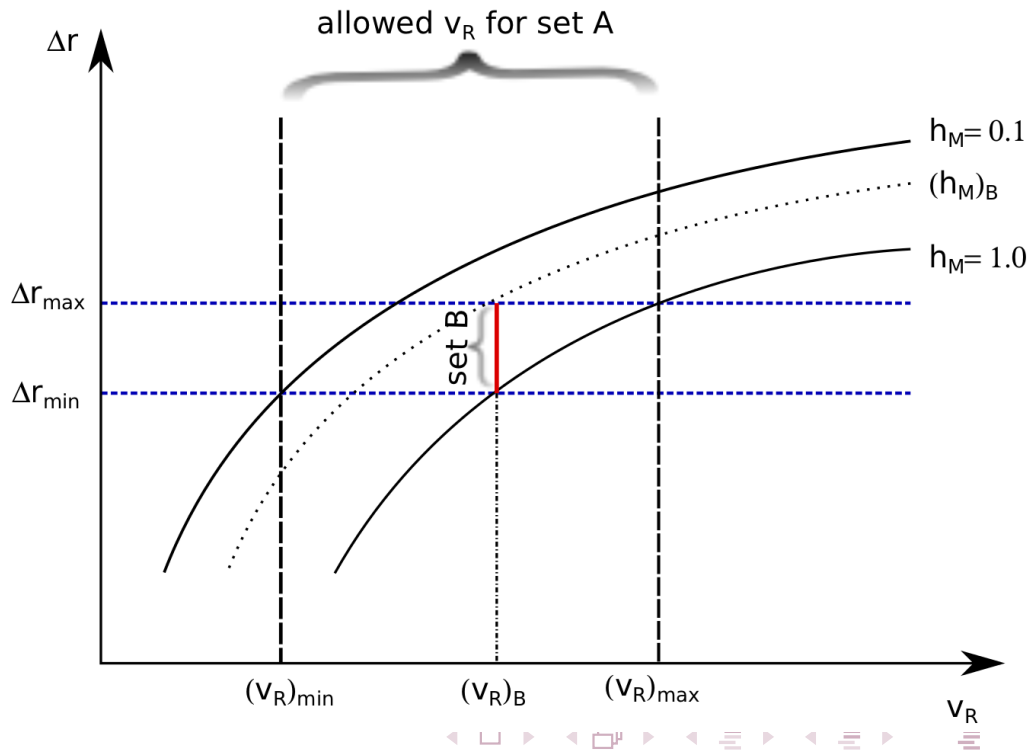
$\Rightarrow$ compare with data

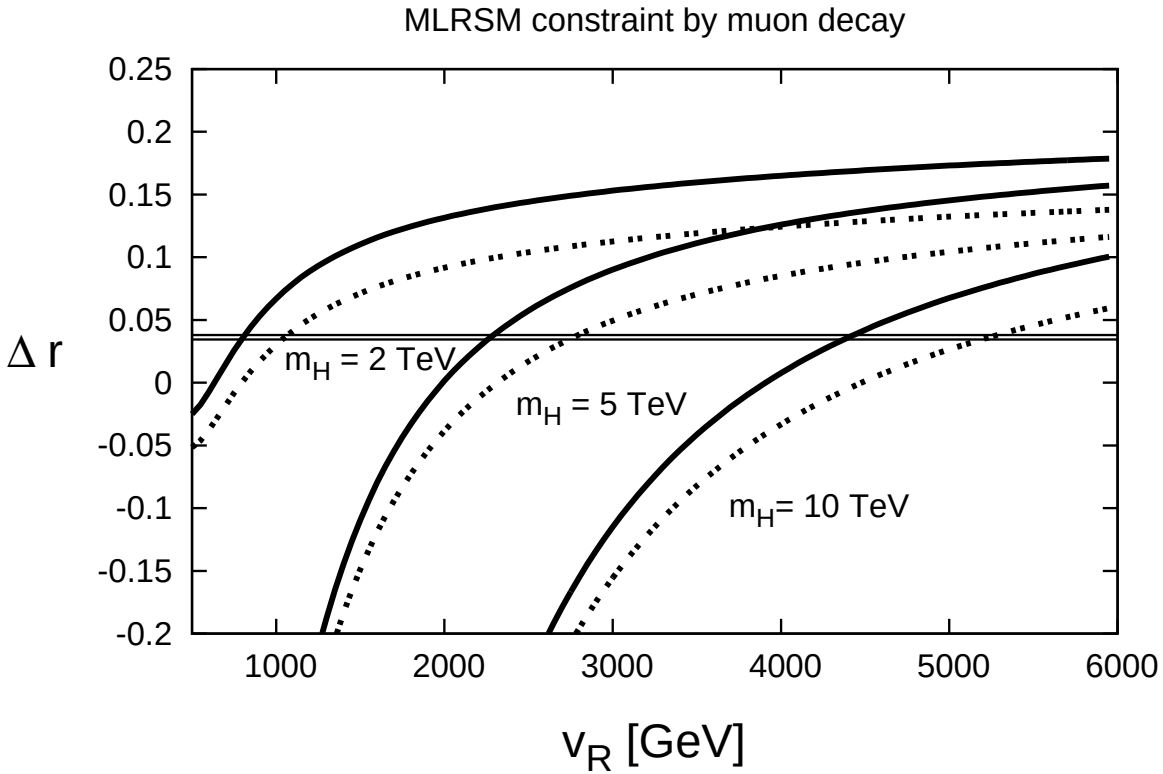
(see M. Czakon, J. Gluza,M. Zrałek, Nucl. Phys. **B573** (2000) 57 and

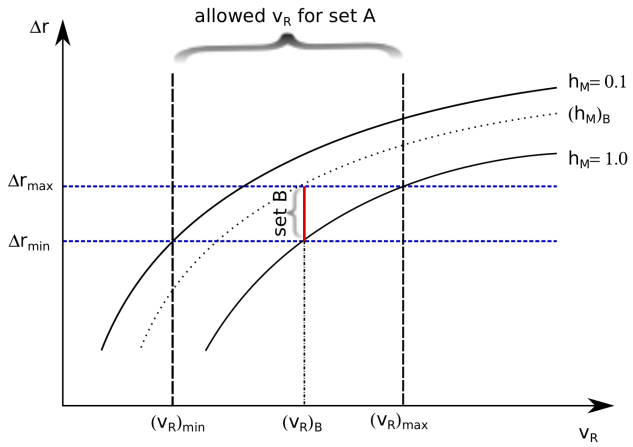
M. Czakon, J. Gluza,

J. Hejczyk, Nucl. Phys. **B642**

(2002) 157-172.)







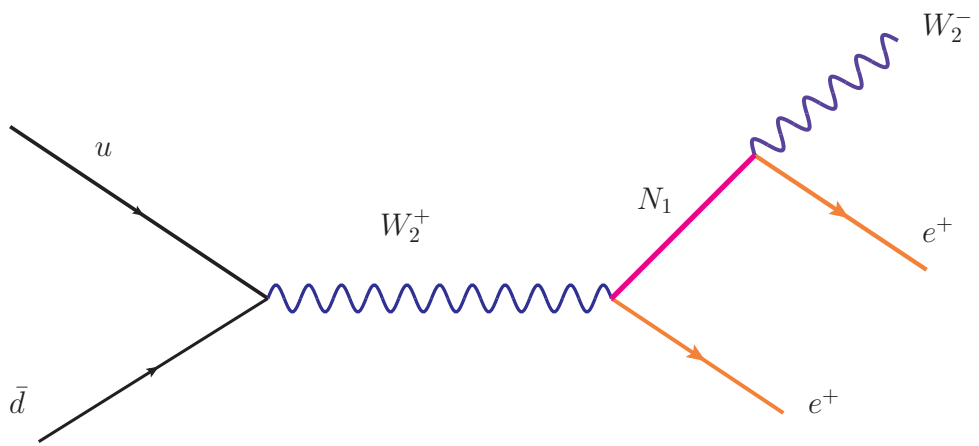
Δr as function of v_R for different masses of heavy Higgs particles 2 TeV, 5 TeV and 10 TeV. Dashed (solid) lines are for neutrino heavy masses with $h_M = 0.1$ ($h_M = 1$).

set A	$m_H = 3$	$m_H = 4$ TeV	$m_H = 5$ TeV	$m_H = 10$ TeV
v_R [GeV]	$(1337, 1702)$	$(1809, 2263)$	$(2257, 2795)$	$(4373, 5283)$
m_N [GeV]	$(189, 2350)$	$(256, 3131)$	$(319, 3872)$	$(618, 7338)$
set B	$m_H = 3$ TeV	$m_H = 4$ TeV	$m_H = 5$ TeV	$m_H = 10$ TeV
	$v_R = 1661$ GeV	$v_R = 2214$ GeV	$v_R = 2738$ GeV	$v_R = 5189$ GeV
m_N [GeV]	$(2231, 2349)$	$(2974, 3131)$	$(3717, 3872)$	$(7044, 7338)$

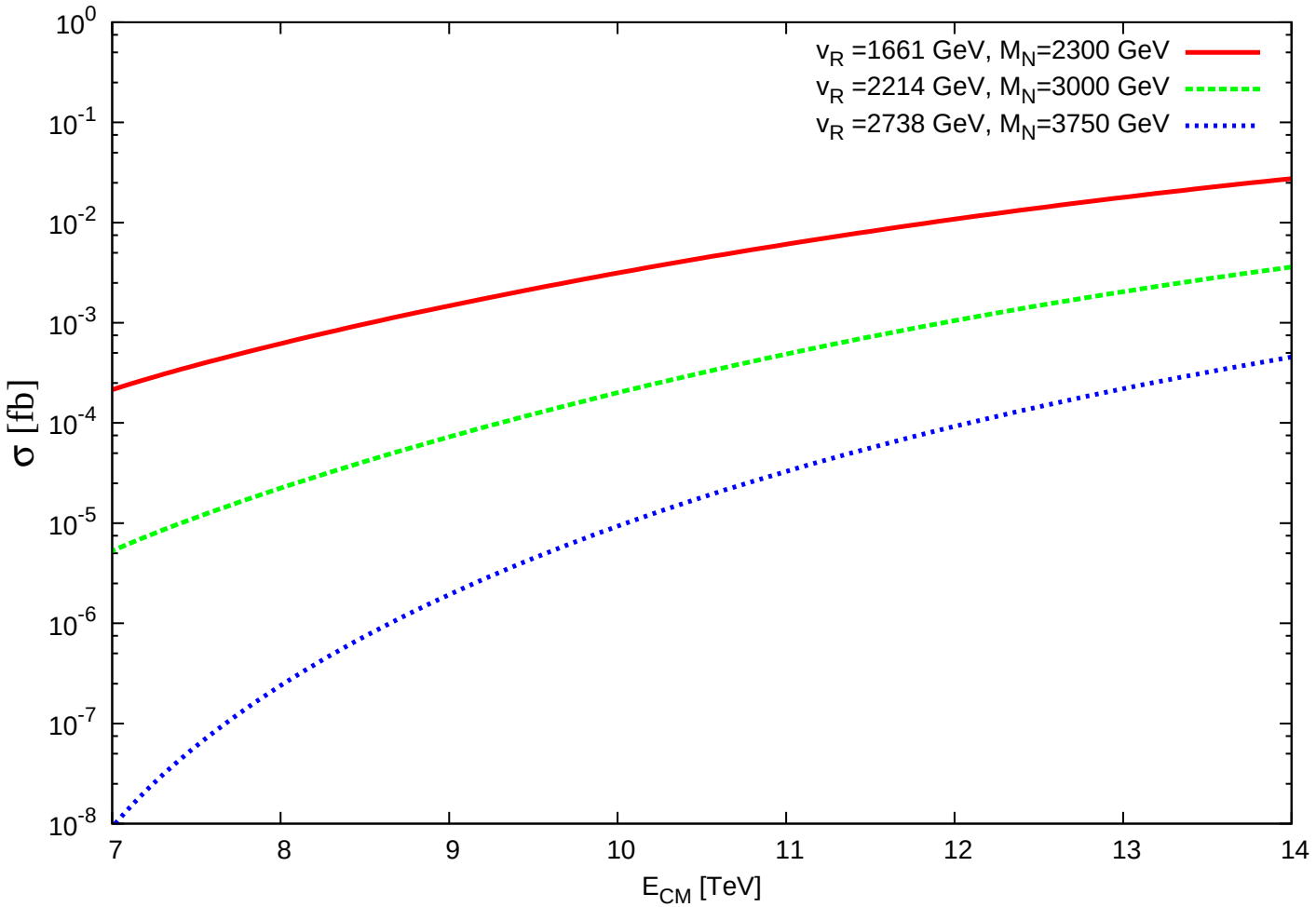
Table: **Set A.** Values of v_R which for various Higgs masses give Δr in agreement with the data. The ranges come from varying heavy neutrino masses in the domain $h_M \in (0.1, 1)$.
Set B. v_R is fixed in addition, leaving as the only free MLRSM parameter the neutrino mass m_N.

LHC Phenomenology

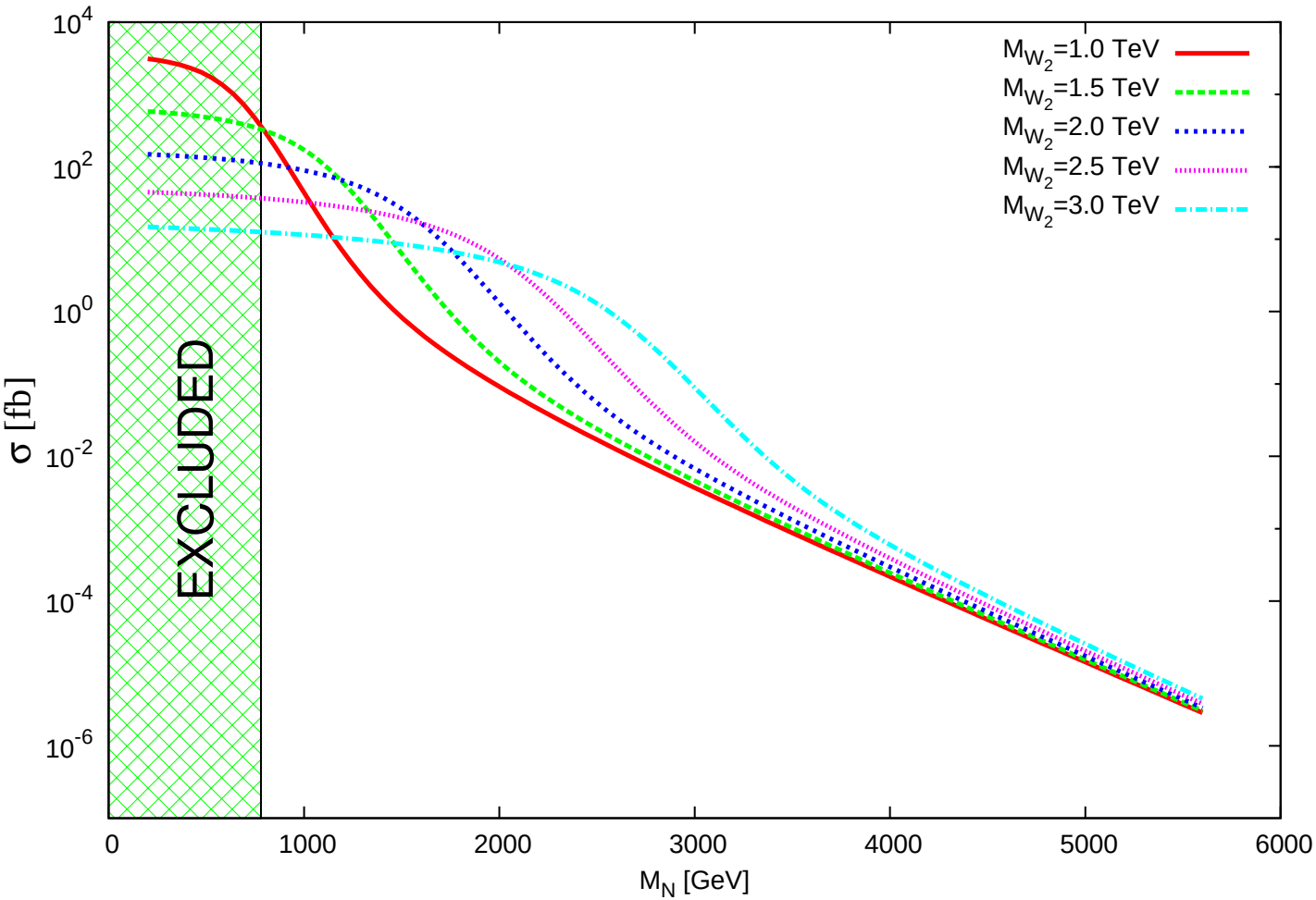
- LR model was implemented using FeynRules
- We calculated cross-sections using CalcHEP
- We consider different scenarios
  - degenerate neutrinos $M_{N_i} = M_{N_j}$
  - non–degenerate case



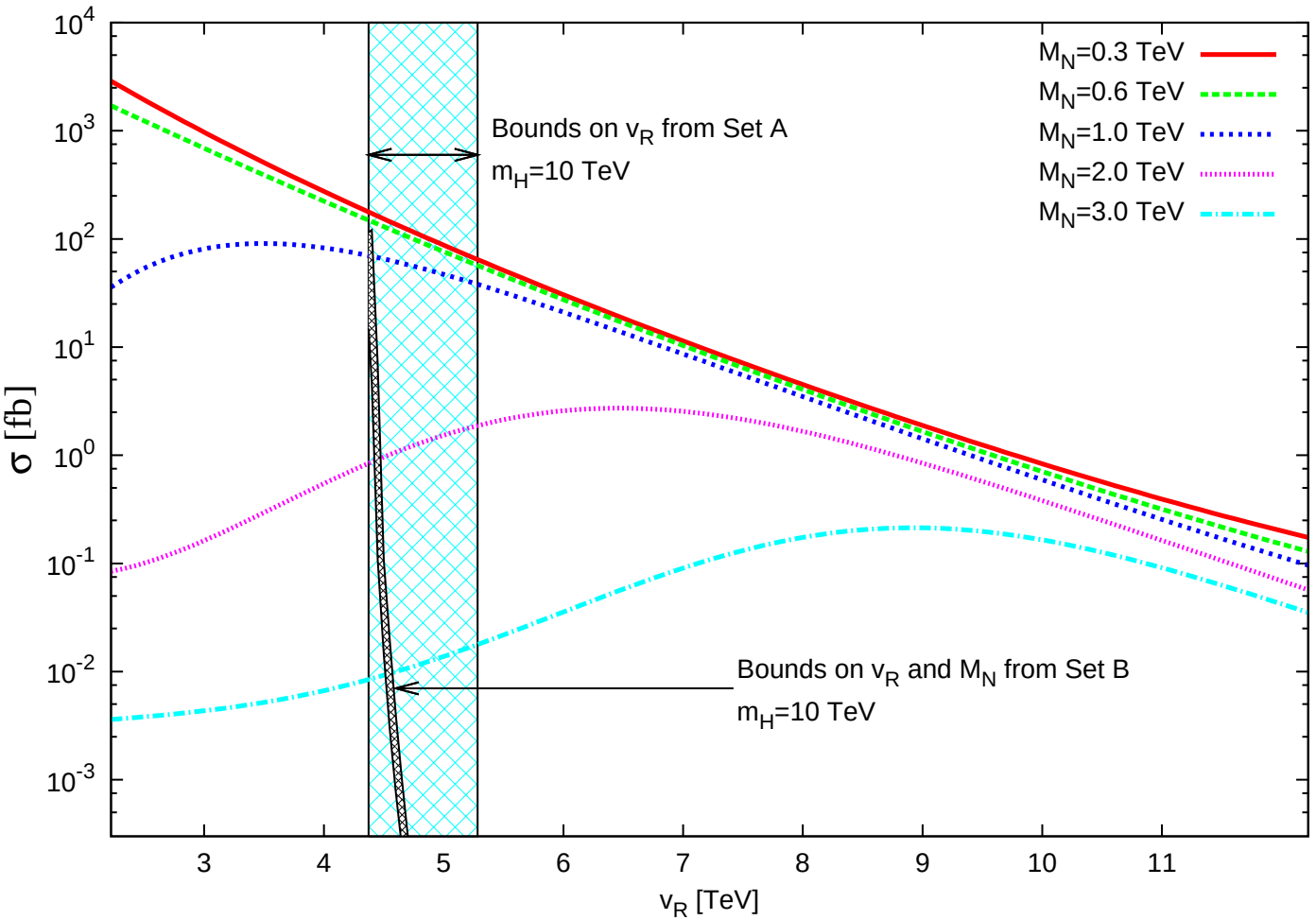
$pp \to N_4 e^{\pm} \to e^{\pm} e^{\pm} W_2^{\mp}$



$pp \to N_4 e^+$


10^4
10^2
10^0
10^{-2}
10^{-4}
10^{-6}
σ [fb]
EXCLUDED
0
1000
2000
3000
4000
5000
6000
M_N [GeV]
M_{W_2}=1.0 TeV
M_{W_2}=1.5 TeV
M_{W_2}=2.0 TeV
M_{W_2}=2.5 TeV
M_{W_2}=3.0 TeV

$pp \to N_4 e^+$


10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
σ [fb]
3
4
5
6
7
8
9
10
11
v_R [TeV]
M_N=0.3 TeV
M_N=0.6 TeV
M_N=1.0 TeV
M_N=2.0 TeV
M_N=3.0 TeV
Bounds on v_R from Set A
m_H=10 TeV
Bounds on v_R and M_N from Set B
m_H=10 TeV

Conclusions

- Low energy data are important in constraining models.
  $\rightsquigarrow$ Any New Physics searches require taking into account precision low energy data.
- Muon decay gives very strong restrictions for LR models.
- These constrains influence predictions for LR signals at LHC very much.
- Finding LR signals at LHC is not an easy task but still it is possible.
- Further studies are necessary – more constrains and different processes.