Rencontres de Moriond EW session, March 2014

Ultra-high energy neutrinos and W′, Z′ gauge bosons at the Pierre Auger Observatory

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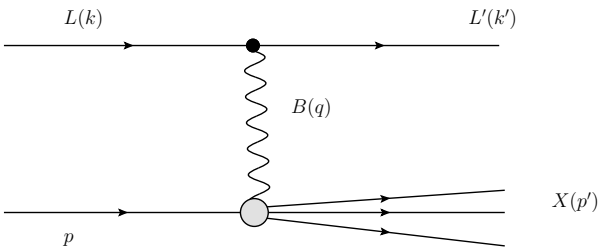
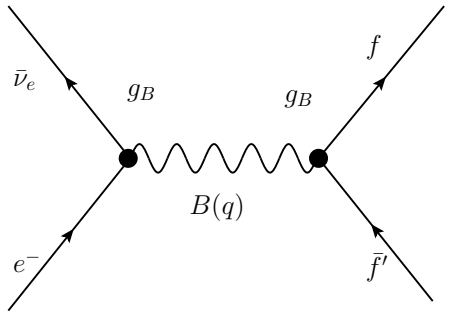
Introduction

- Sensitivity to heavy new resonances (downward-going neutrinos) ?

W/W′, Z/Z′ bosons @ PAO



Deep Inelastic Scattering (DIS), Glashow Resonance (GR) @ LO



- Ultra-high energy neutrino $\sim 10^{10}\mathrm{GeV} \Rightarrow \sqrt{s} \simeq 100\,TeV$
- GR peak below the PAO threshold in the SM $\Rightarrow$ contributes only in BSM models

Models studied

Definitions

- We consider models based on the extended gauge group: $G_{221} \equiv SU(2)_1 \times SU(2)_2 \times U(1)_X$
- New gauge bosons: W′, Z′
- Extra $SU(2)$ appear in $SO(10)$ and E_6 breaking

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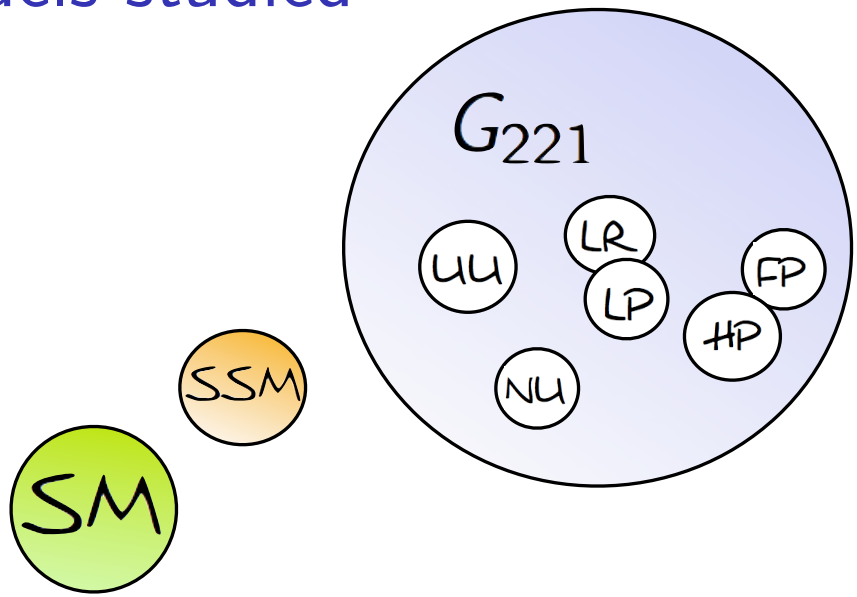
- New gauge bosons: W', Z'
- Extra $SU(2)$ appear in $SO(10)$ and E_6 breaking
- bottom up:
  - extended gauge group are viable extensions of the SM
  - additional $SU(2)$ is next to minimal

Models studied



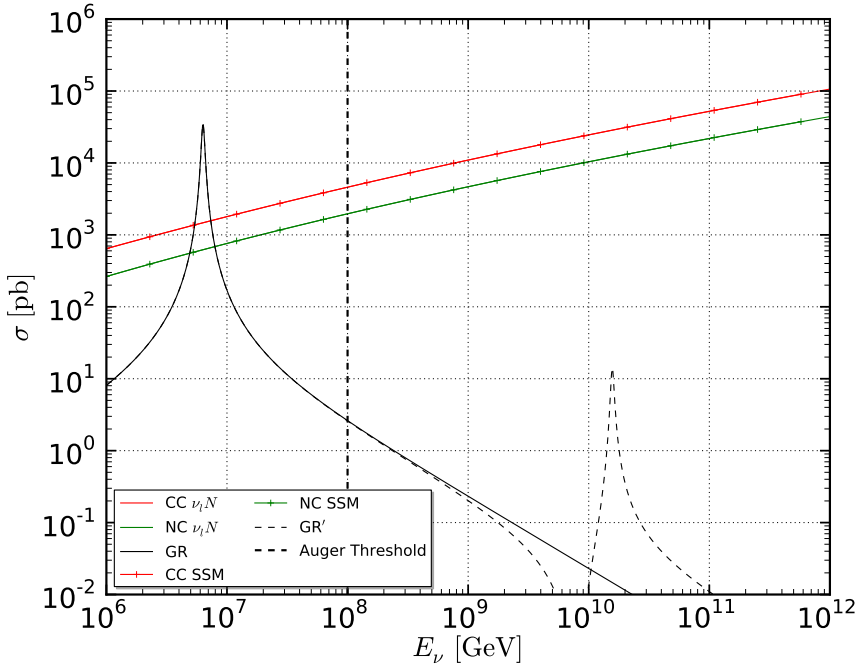
UU : Un-unified
NU : Non-universal
HP : Hadro-phobic
FP : Fermio-phobic
LR : Left-Right
LP : Lepto-phobic
SSM : Sequential SM

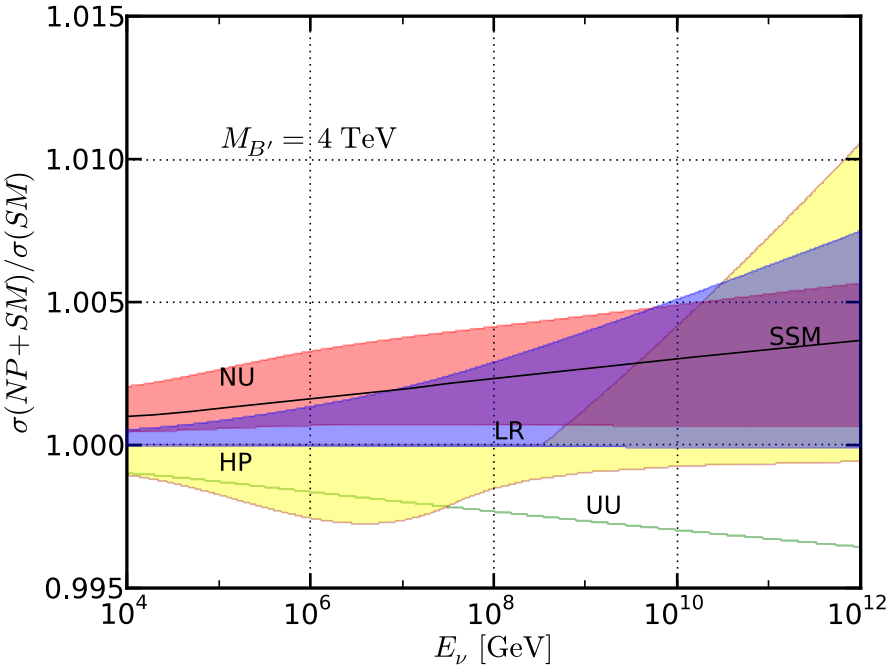
SSM, a heavy copy of the SM i.e. $M_{B'} = \alpha M_B$

G_{221}

- Breaking Pattern, Higgs Sector, Charge Assignment
  $\Rightarrow UU, NU, LR/LP, HP/FP$

Results on cross sections





- Resonant contribution negligible
- SSM DIS lies on top of the SM

- Scanned over the parameters
- Modification up to 1%

Conclusion

- We have studied the impact of W′, Z′ on downward-going neutrinos cross sections ⇒ too small
- Observed at the LHC ⇒ no impact on UHE neutrino events
- Any deviation in UHEN event rates ⇒ another explanation

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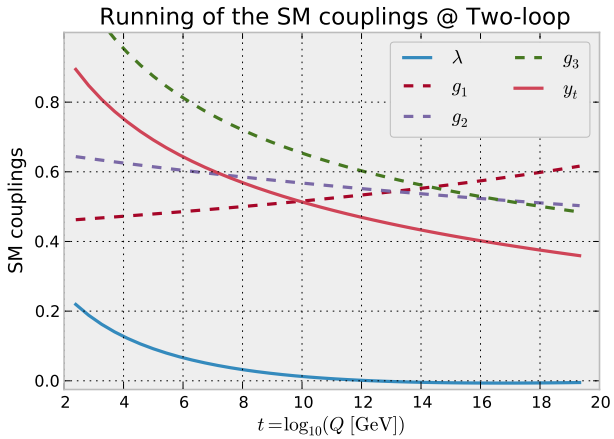
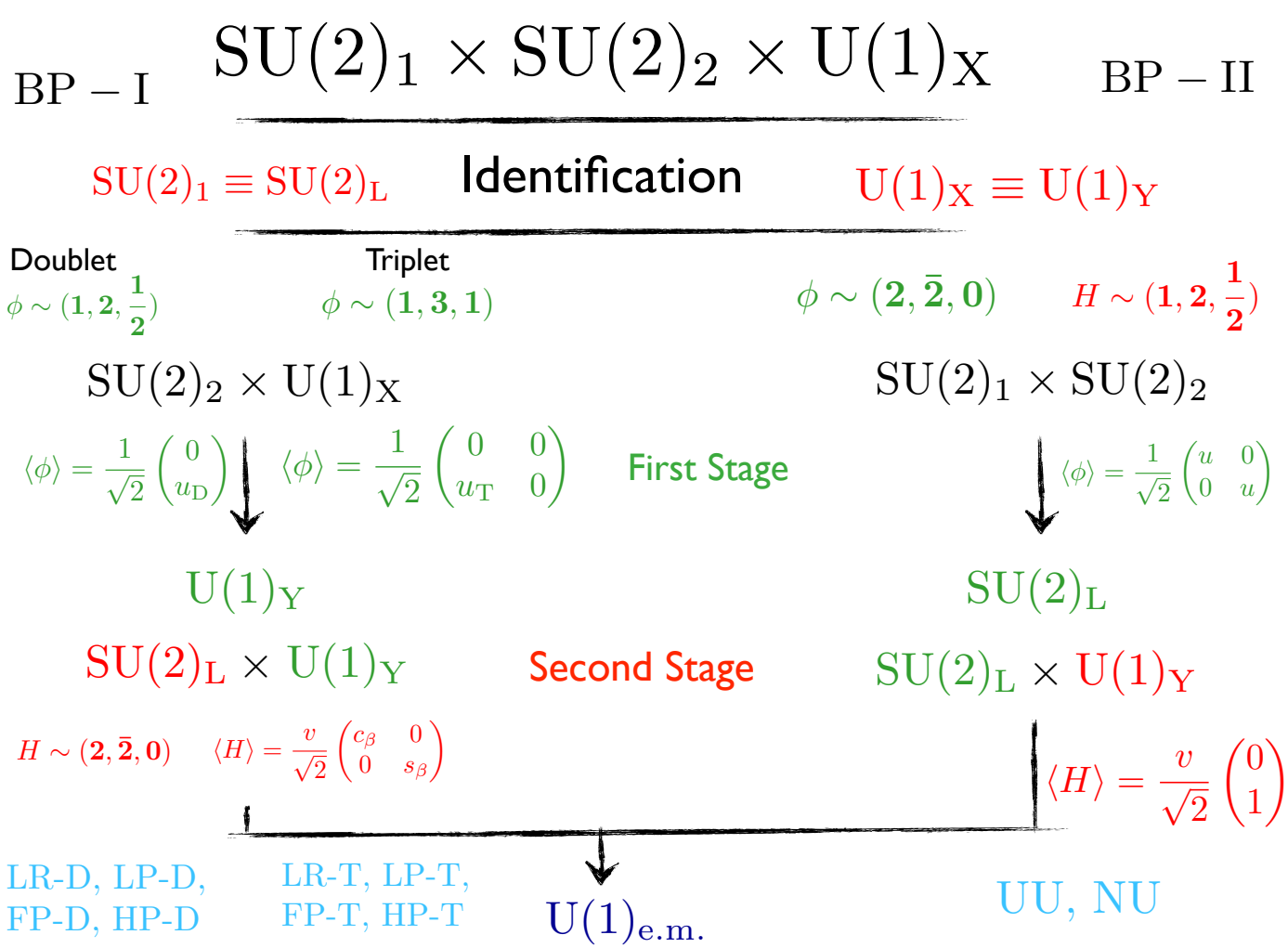
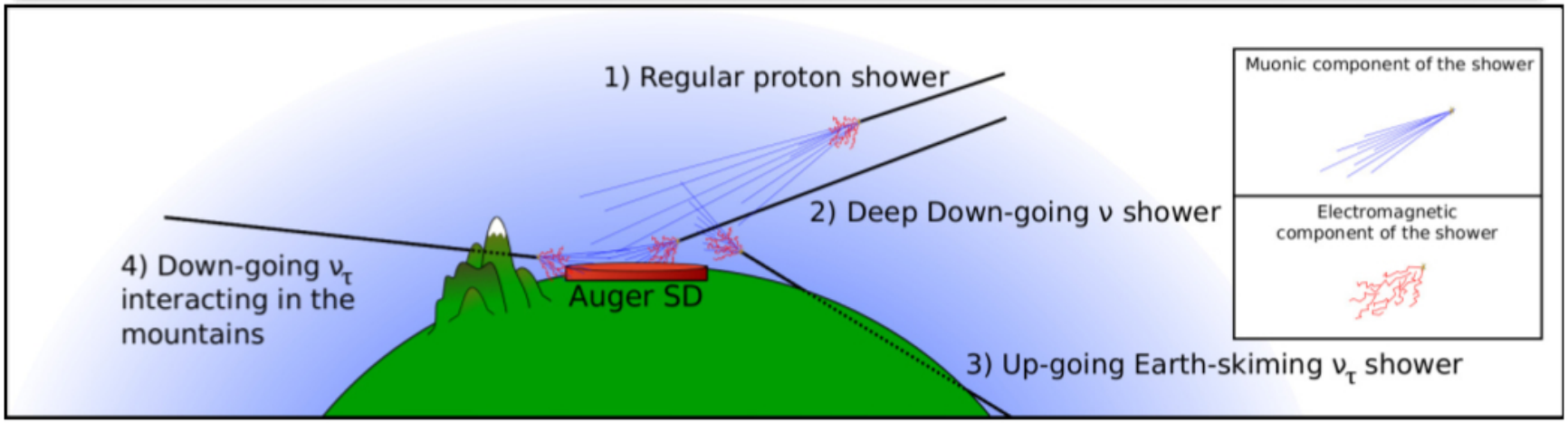
Python Renormalization Group Equations @ Two-Loop



- Generates RGEs @ 2-loop for gauge field theories
- arXiv: 1309.7030
- visit our web page on hepforge


BP – I
$SU(2)_1 \times SU(2)_2 \times U(1)_X$
BP – II
$SU(2)_1 \equiv SU(2)_L$
Identification
$U(1)_X \equiv U(1)_Y$
Doublet
$\phi \sim (\mathbf{1}, \mathbf{2}, \frac{\mathbf{1}}{\mathbf{2}})$
Triplet
$\phi \sim (\mathbf{1}, \mathbf{3}, \mathbf{1})$
$\phi \sim (\mathbf{2}, \bar{\mathbf{2}}, \mathbf{0})$
$H \sim (\mathbf{1}, \mathbf{2}, \frac{\mathbf{1}}{\mathbf{2}})$
$SU(2)_2 \times U(1)_X$
$SU(2)_1 \times SU(2)_2$
$\langle\phi\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}0\\u_D\end{pmatrix}$
$\langle\phi\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}0 & 0\\u_T & 0\end{pmatrix}$
First Stage
$\langle\phi\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}u & 0\\0 & u\end{pmatrix}$
$U(1)_Y$
$SU(2)_L$
$SU(2)_L \times U(1)_Y$
Second Stage
$SU(2)_L \times U(1)_Y$
$H \sim (\mathbf{2}, \bar{\mathbf{2}}, \mathbf{0})$
$\langle H\rangle = \frac{v}{\sqrt{2}}\begin{pmatrix}c_\beta & 0\\0 & s_\beta\end{pmatrix}$
$\langle H\rangle = \frac{v}{\sqrt{2}}\begin{pmatrix}0\\1\end{pmatrix}$
LR-D, LP-D,
FP-D, HP-D
LR-T, LP-T,
FP-T, HP-T
$U(1)_{e.m.}$
UU, NU



- CR Hybrid detector: ground array telescope (Cherenkov) + Fluorescent light detector
- Can detect **neutrino induced** showers