Report WG3

New Vector Bosons

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Warning:

This is not a regular talk

Aim of the working groups:

"Evaluating the implications of recent results from the LHC, and elsewhere, for TeV-scale physics, and to discuss the impact of these results on the future strategy for particle physics."

"The results will be summarised in a document, to be submitted as input to the planned 2012 update of the European Strategy for Particle Physics."

WG3 ~ BSM \ (WG1 U WG2)

This Section: New Vector Bosons

1. Model-independent description

- Introduction

- Quantum numbers
- Couplings
- Mixing
- Width

- Current limits

Spin 1 multiplets

Color	1					8		
Isospin	1		2	3		1		3
Hypercharge	0	1	$-\frac{3}{2}$	0	1	0	1	0
Symbol	$\mathcal{B}$	$\mathcal{B}^1$	$\mathcal{L}$	$\mathcal{W}$	$\mathcal{W}^1$	$\mathcal{G}$	$\mathcal{G}^1$	$\mathcal{H}$
Charges	0	± 1	$\pm 1, 2$	$0, \pm 1$	$\pm 0, 1, 2$	0	± 1	$0, \pm 1$

Color	3					$\bar{6}$	
Isospin	1		2		3	2	
Hypercharge	$\frac{2}{3}$	$\frac{5}{3}$	$\frac{1}{6}$	$-\frac{5}{6}$	$\frac{2}{3}$	$\frac{1}{6}$	$-\frac{5}{6}$
Symbol	$\mathcal{U}^2$	$\mathcal{U}^5$	$\mathcal{Q}^1$	$\mathcal{Q}^5$	$\mathcal{X}$	$\mathcal{Y}^1$	$\mathcal{Y}^5$
Charges	$\pm\frac{2}{3}$	$\pm\frac{5}{3}$	$\pm\frac{1}{3}, \frac{2}{3}$	$\pm\frac{1}{3}, \frac{4}{3}$	$\pm\frac{1}{3}, \frac{2}{3}, \frac{5}{3}$	$\pm\frac{1}{3}, \frac{2}{3}$	$\pm\frac{1}{3}, \frac{4}{3}$

$$\mathcal{L}_V = -D_\mu V_\nu^\dagger D^\mu V^\nu - D_\mu V_\nu^\dagger D^\nu V^\mu + M_V^2 V_\mu^\dagger V^\mu$$

$$\mathcal{L}_{V-\mathrm{SM}} = -V^{\mu\dagger} \sum_k g_V^k j_\mu^{Vk} + \mathrm{h.c.}$$

2. Expectations from (classes of) models

• Gauge group: pattern of symmetry breaking determines quantum numbers

• Size of couplings and some masses fixed in GUT
• If associated to hierarchy problem, expected at LHC scale
• If involved in EWSB, couple mainly to longitudinal gauge bosons, Higgs and top (more difficult to see)
• In partial compositeness scenarios, small lepton couplings (same conclusion from EWPT) and large top couplings.
• With ...-parity, no single production

Tight relation to Higgs results

Higgs with nonstandard couplings

↓

Elementary or composite extra vector (or scalar) bosons at TeV scale well motivated by perturbative unitarity

3. LHC:discovery

Make quantitative (approximate) statements

Be as model-independent and general as possible

i) Make simplifying assumptions
ii) Try to work in model-independent fashion (within assumptions)
iii) Present in a unified way the discovery reach for foreseen collider energies and luminosities

Make simplifying assumptions

- Only one extra *vector* boson contributes
- Single production
- Narrow resonance
- Drell-Yan production
- Decay into dilepton and dijet

Work in (roughly) model-independent fashion, within assumptions

- For each channel, concentrate in production:

$$\begin{aligned} N_s &= \sigma_{V'}(pp \to X)\, A_X\, \epsilon_X\, L \\ &= \sigma(pp \to V')\, \mathrm{BR}(V' \to X)\, A_X\, \epsilon_X\, L \\ &= g^2 \sigma^{g=1}(pp \to V')\, \mathrm{BR}(V' \to X)\, A_X\, \epsilon_X\, L \end{aligned}$$

Narrow width approx.

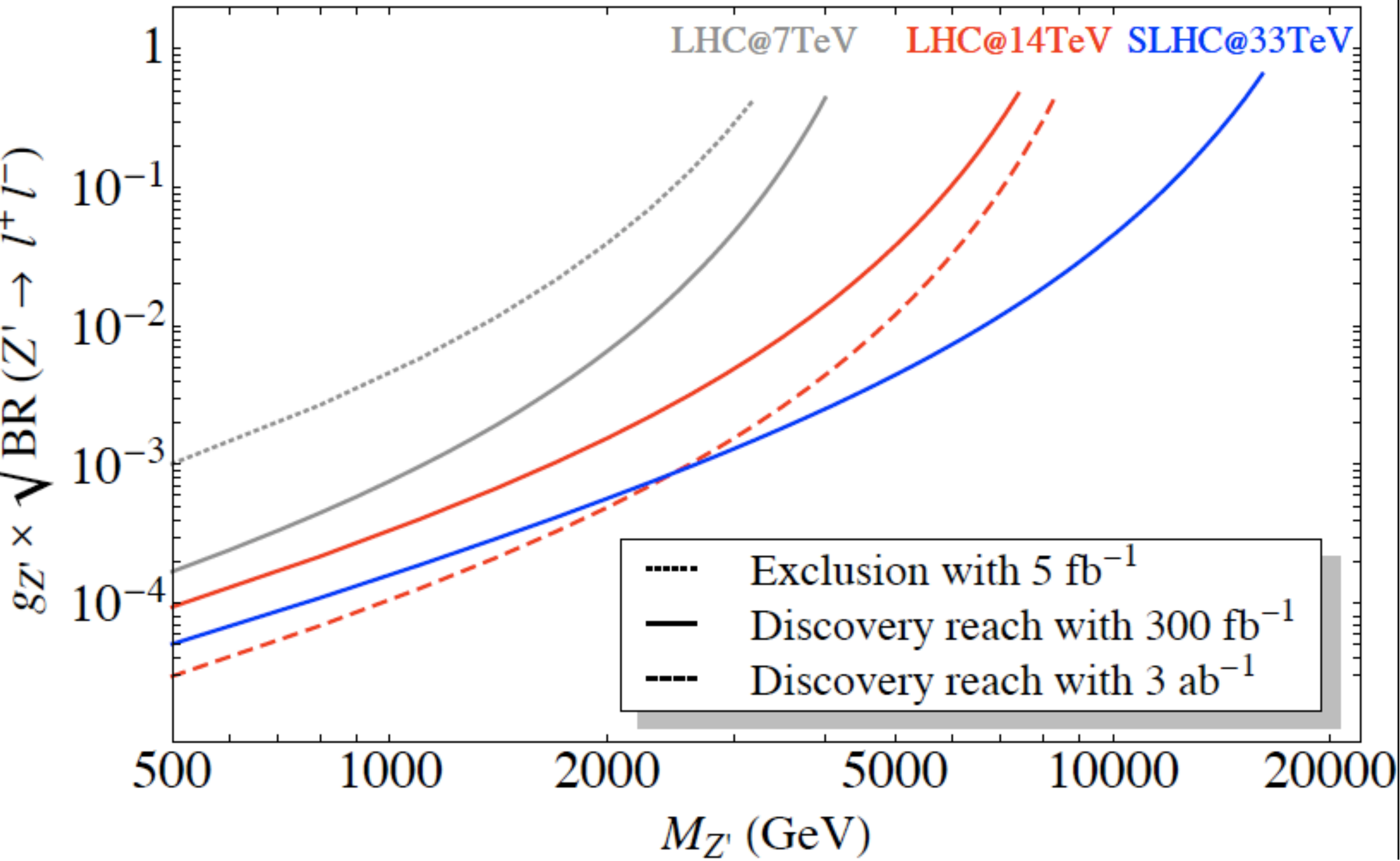
Coupling to quarks (assume LH & universal)

Branching ratio, depending on other couplings

- For each mass, luminosity, energy, and required sensitivity, find minimal value of $g^2\, \mathrm{BR}(V' \to X)$

Present in a unified way the discovery reach for foreseen collider energies and luminosities

Dileptons

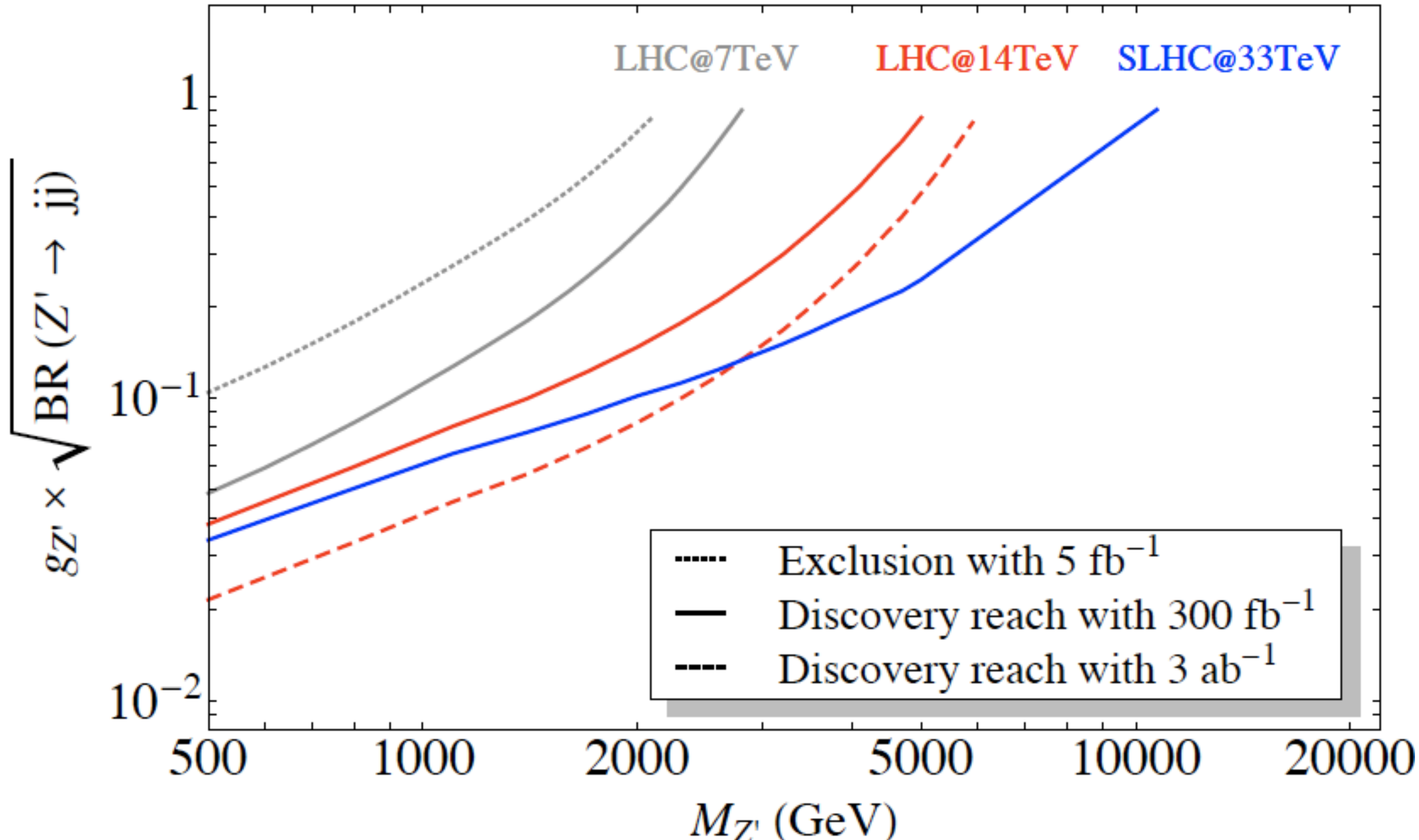


Negligible background → 5 events required for discovery, less than 3 for 95% C.L. exclusion

Extrapolation beyond NWA at large couplings

Present in a unified way the discovery reach for foreseen collider energies and luminosities

Dijets



Significant background → $S/\sqrt{B}=5$ required for discovery, less than 3 for 95% C.L. exclusion

Extrapolation beyond NWA at large couplings

3. LHC: measuring properties

- Spin
- Couplings

Quantum numbers

Discriminate models

14 TeV / 100 fb^{-1} GUT strength couplings	⇨	Not possible given existing limits

Need more luminosity or upgrade energy or...

4. Linear Collider

- If New Vectors (New Physics) found

- If light enough, scan/autoscan resonance
- Study their properties in clean enviroment

- If New Vectors (New Physics) not found

- Precision study of their indirect effects on electroweak observables

- Suitable for leptophilic (possibly light) vector bosons

4. Left out, but not forgotten

- Production by VBF
- Decay into gauge bosons
- Derivative couplings
- Non-resonant
- Broad resonances
- Pair production (e.g., leptoquarks)
- Scalars
- ...

Hopefully, the cases we study are, to some extent and in some cases, representative of the capabilities of present and future colliders to study new physics.