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Dynamical electroweak symmetry breaking by quasiconformal technicolor models

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Contents

- Motivation
- Technicolor

  Weinberg; Susskind
- Quasiconformal / walking technicolor

  Eichten & Lane; Holdom
- Viable models vs. precision data
- Conclusion & Outlook

Motivation

Why the Higgs?

- gauge invariance
- renormalisability
- unitarity

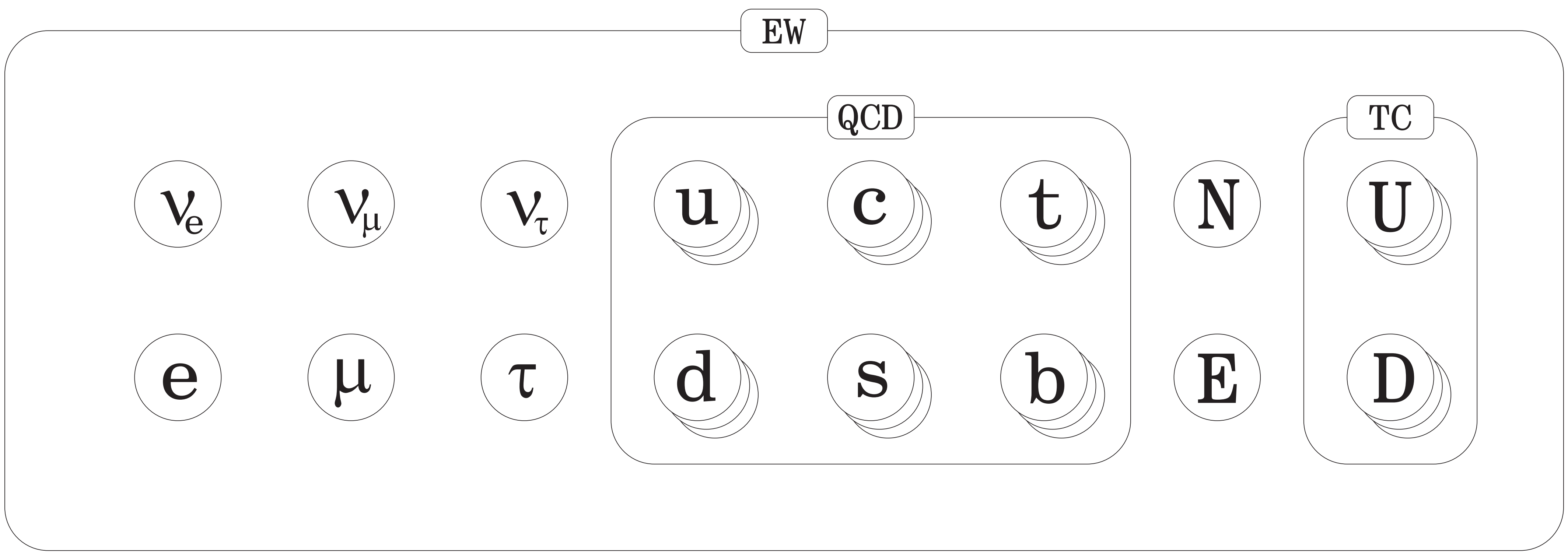
Motivation

Why not the Higgs?

- as yet undiscovered and first and only scalar
- on all other occasions: composite scalars
- ad hoc negative mass term
- quadratic divergencies

Technicolor

$$\mathcal{G} = SU(N)_{\mathrm{TC}} \times SU(3)_{\mathrm{QCD}} \times SU(2)_{\mathrm{L}} \times U(1)_{\mathrm{Y}}$$



$$\underbrace{f_\pi}_{O(10^2\,\mathrm{MeV})} \quad \longmapsto \quad \underbrace{\Lambda_{\mathrm{ew}}}_{O(10^2\,\mathrm{GeV})}$$

$$\pi^\pm \longmapsto W_L^\pm$$

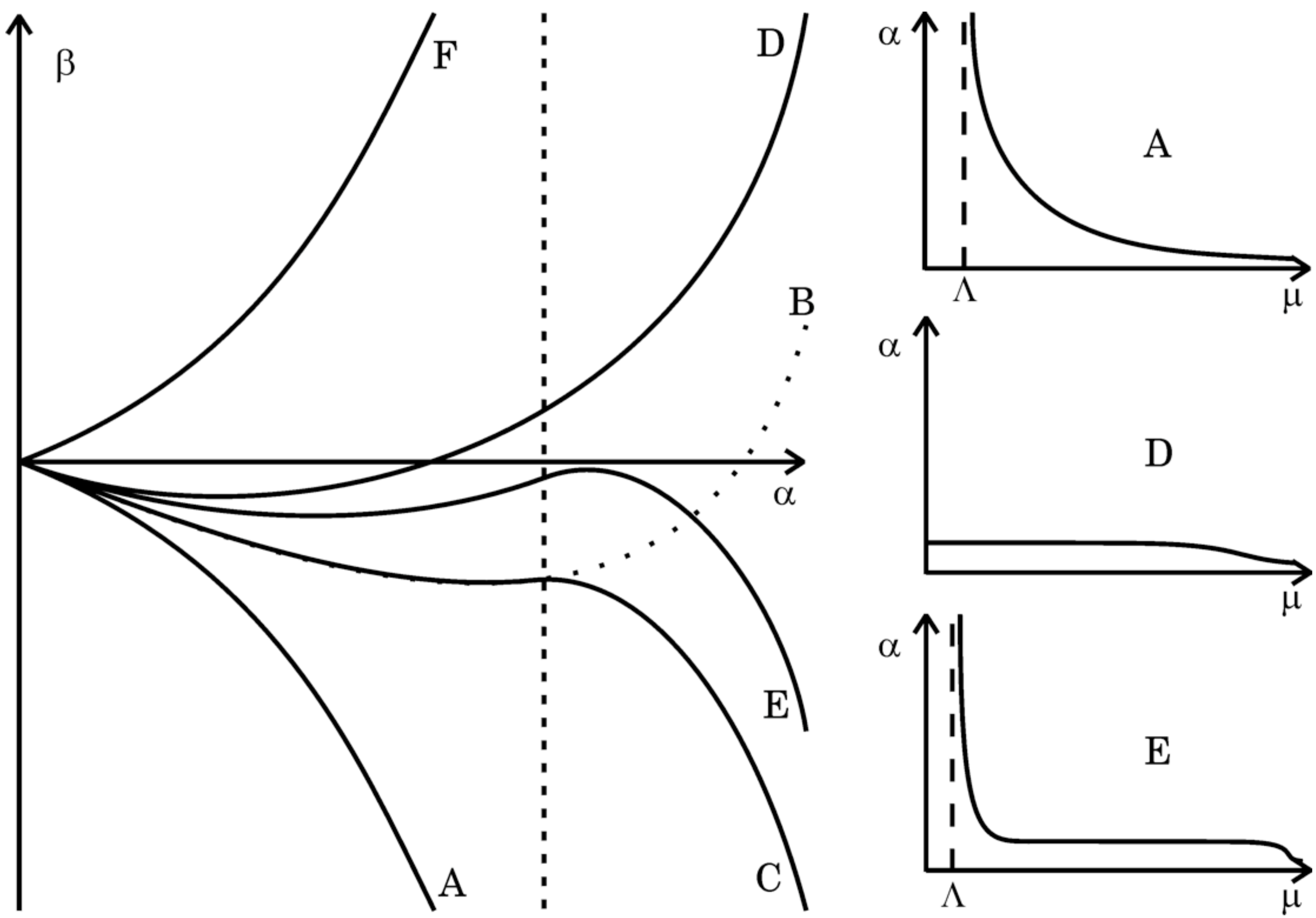
$$\pi^0 \longmapsto Z_L^0$$

Technicolor

Shopping list

- quasiconformal dynamics (walking)
- oblique parameters $\Rightarrow$ small matter content
- high masses for extra Nambu-Goldstone modes
- stability of the vacuum allignment

Quasiconformal dynamics



β-function

Technicolor

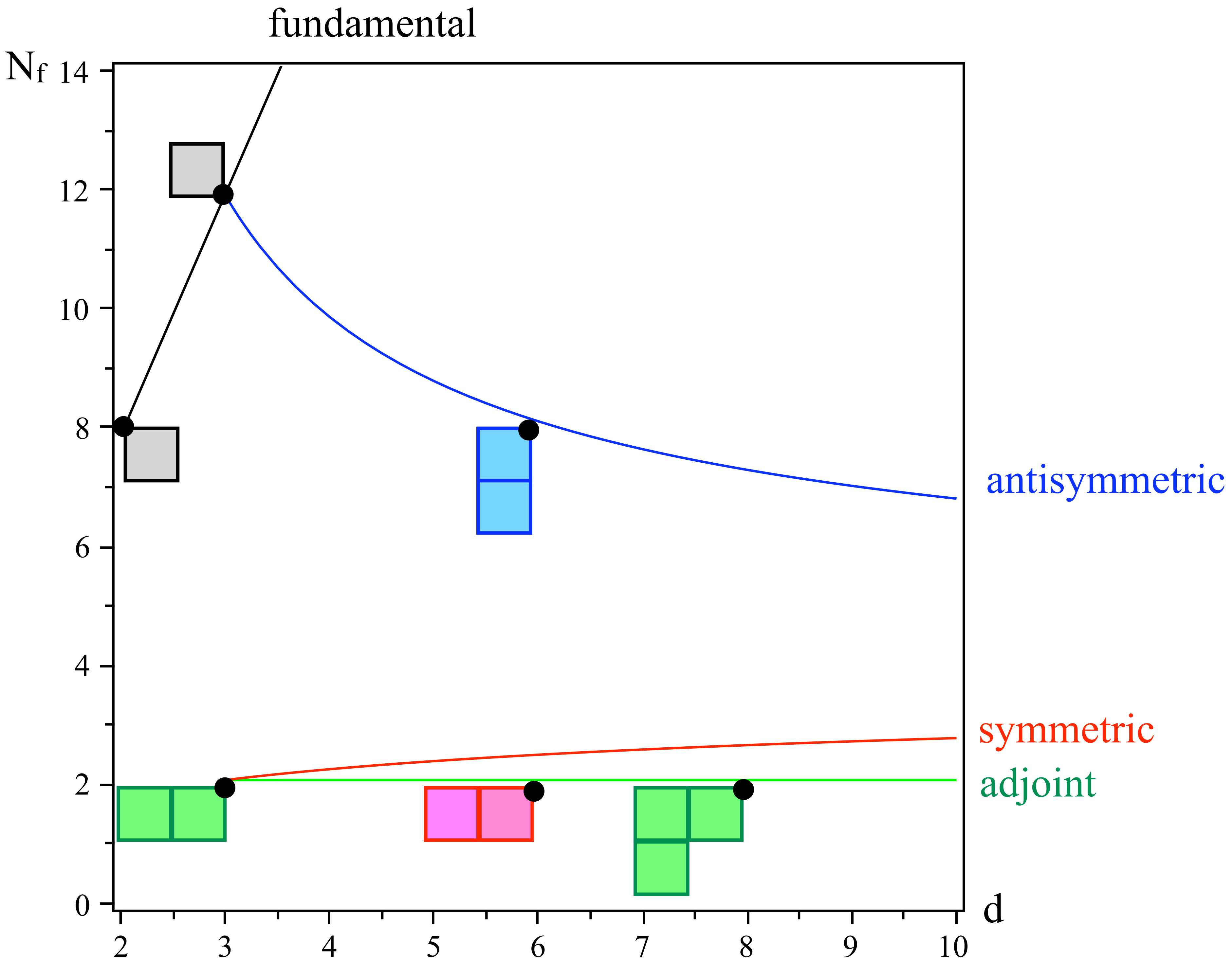
Repertoire

- gauge group (number of colors)
- number of flavors
- representation

$\rightarrow$ phase diagram

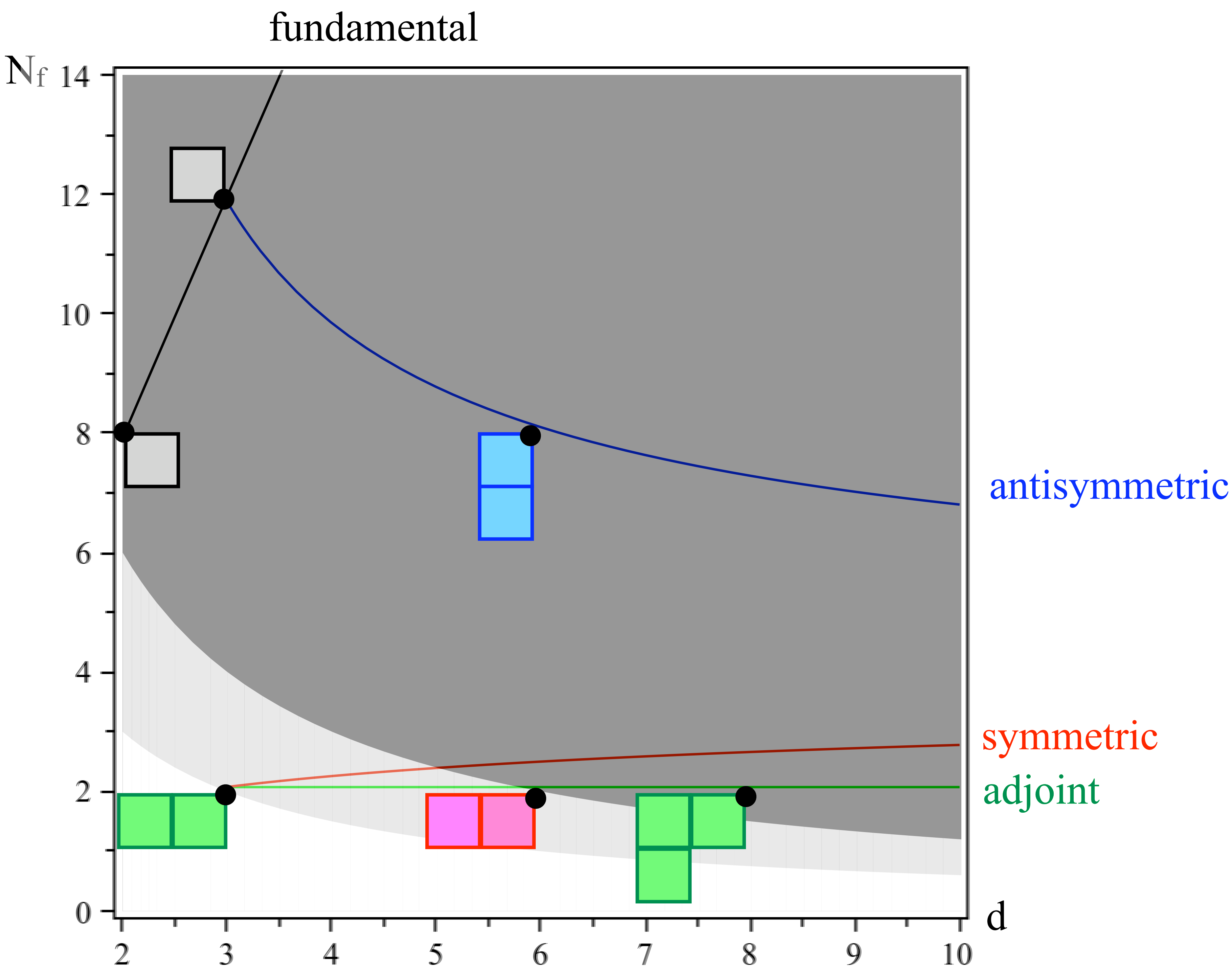
- partially gauged technicolor
- gauge groups other than SU(N)

Phase diagram



D[3] & Sannino, Phys.Rev.D75(2007)085018

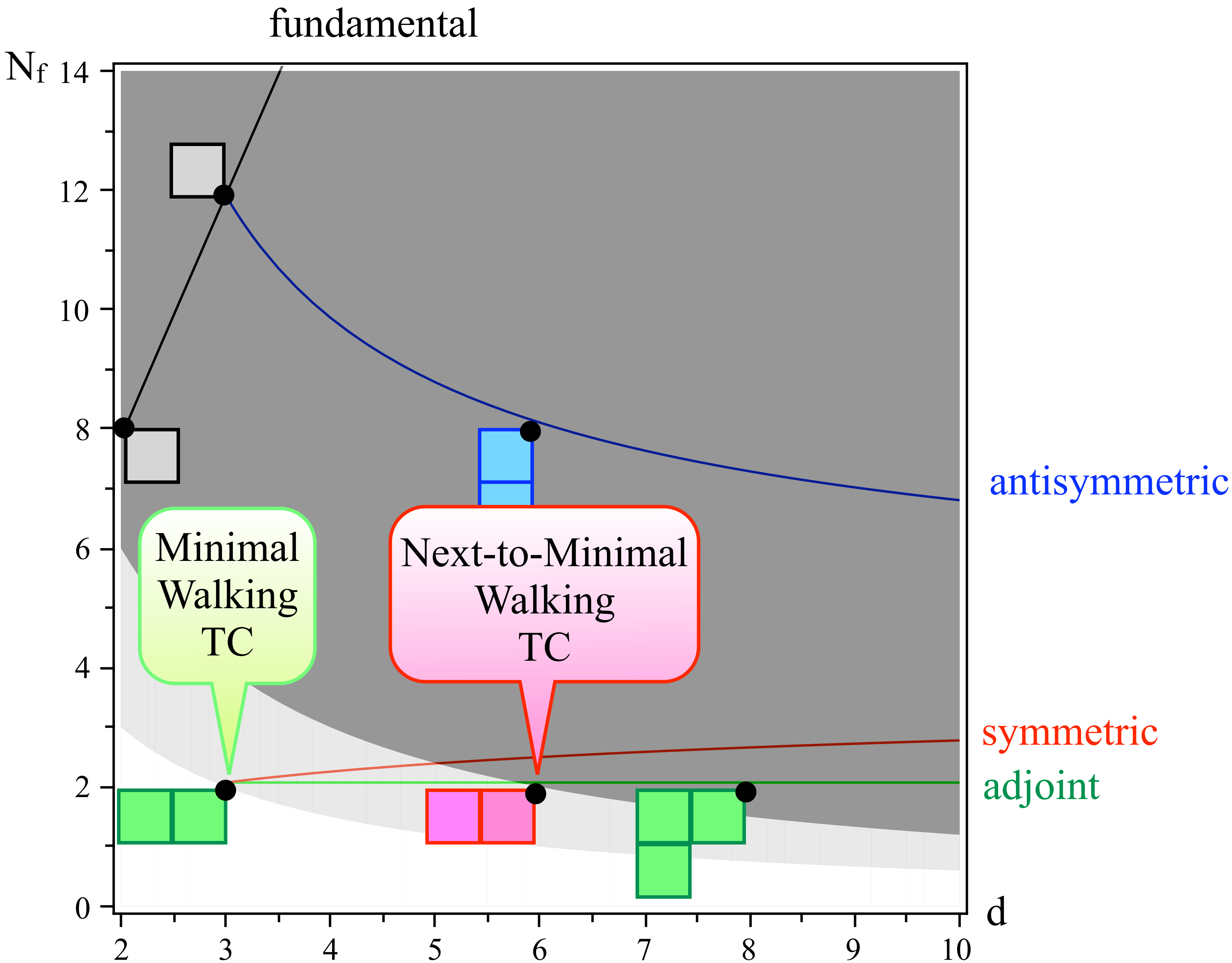
S parameter



$$S_{\rm pert} = \frac{d_{\rm R} N_f^g}{12\pi}$$

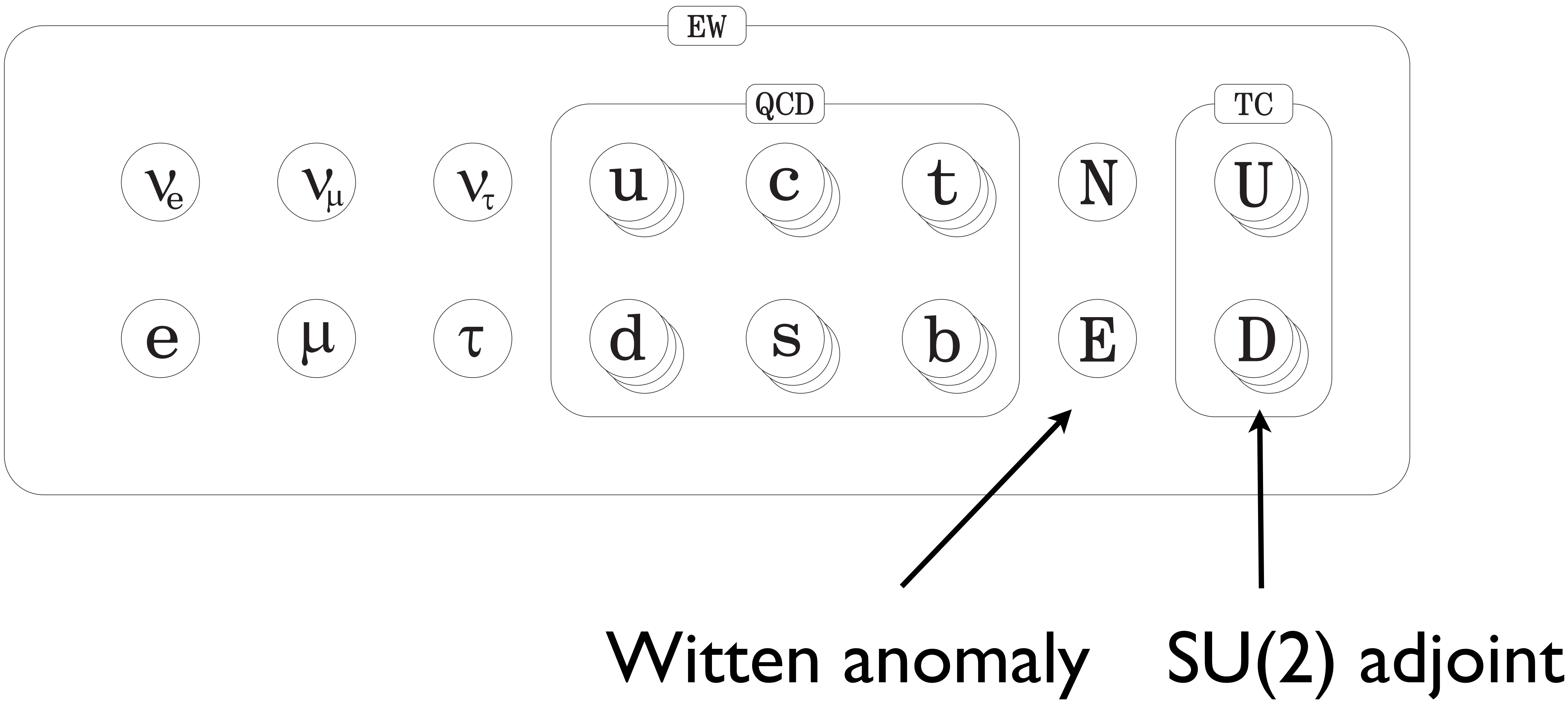
D[3] & Sannino, Phys.Rev.D75(2007)085018

Candidates



D³ & Sannino, Phys.Rev.D75(2007)085018

Minimal walking technicolor

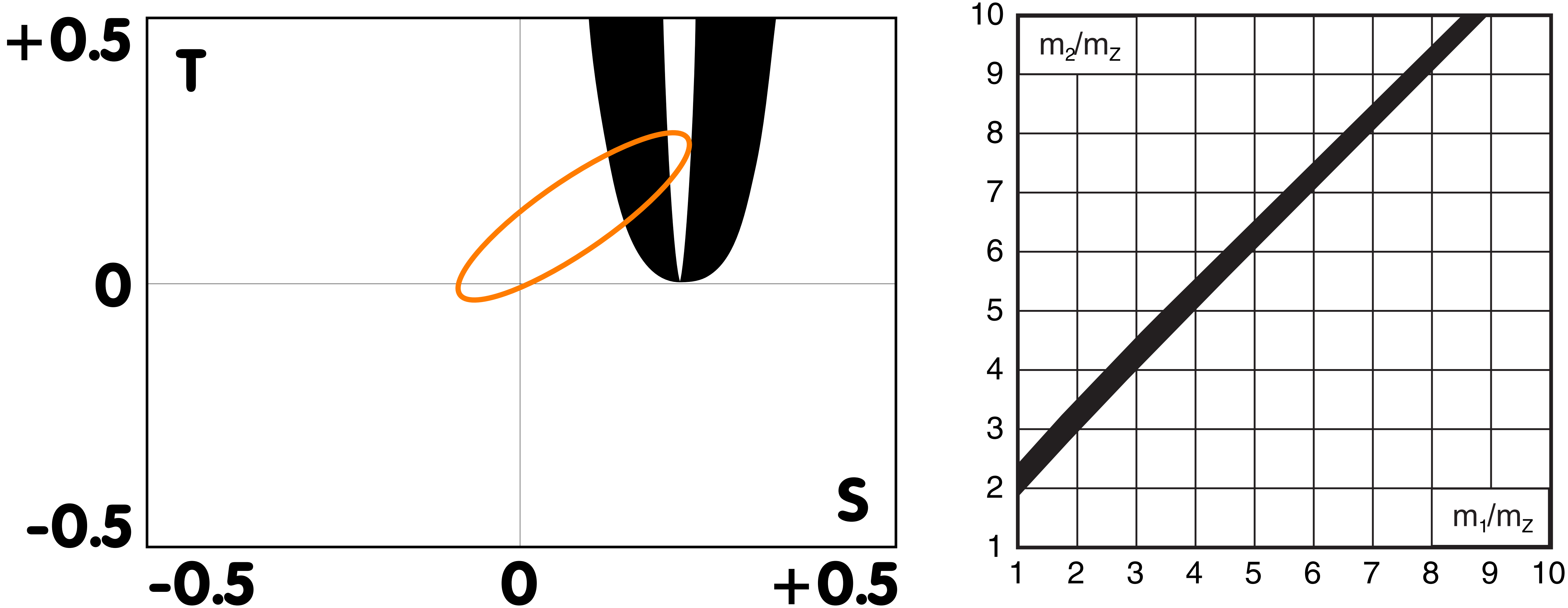


gauge anomaly cancellation ⇒ hypercharge assignment

D[3], Sannino & Tuominen, Phys.Rev.D72:055001,2005

Minimal walking technicolor

standard model like



D[3], Sannino & Tuominen, Phys.Rev.D73:037701,2006

ALEPH, DELPHI, L3, OPAL, SLD Collaborations and LEP Electroweak Working Group and SLD Electroweak Group and SLD Heavy Flavour Group, Phys.Rept.427:257,2006

Minimal walking technicolor

Nambu-Goldstone modes

$$SU(2)_L \times SU(2)_R \to SU(2)_V$$ NMWT

$$\{U\bar{D}, D\bar{U}, (U\bar{U} - D\bar{D})/\sqrt{2}\} \mapsto \{\pi^+, \pi^-, \pi^0\} \mapsto \{W_L^+, W_L^-, Z_L^0\}$$

$$SU(4) \to SO(4)$$ MWT

additionally

$$UU, DD, UD$$

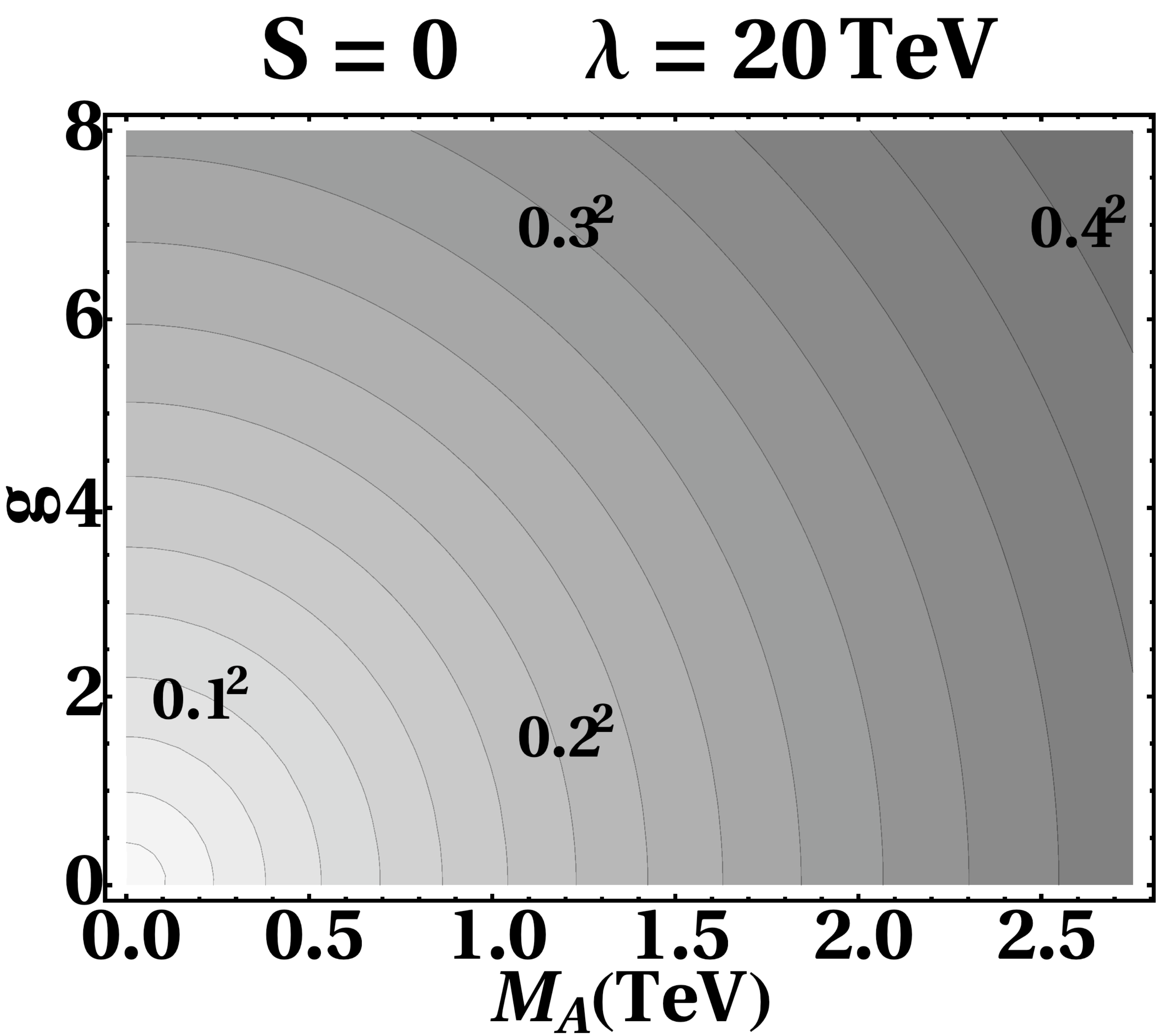
$$\bar{U}\bar{U}, \bar{D}\bar{D}, \bar{U}\bar{D}$$

→ Dark matter

adjoint representation

$$UG, DG, \bar{U}G, \bar{D}G$$

Minimal walking technicolor



Pion masses

y	$\hat{m}^2_{\Pi_{UU}}$	$\hat{m}^2_{\Pi_{DD}}$	$\hat{m}^2_{\Pi_{UD}}$
0	1	1	0.53
$+1$	2.87	1	1.47
-1	1	2.87	1.47

masses outside excluded range

vacuum allignment stable!

NMWT:
no extra pions

D[3] & Järvinen, Phys.Rev.D79:057903,2009

Conclusion

Shopping list

- quasiconformal dynamics (walking) ✓
- oblique parameters $\Rightarrow$ small matter content ✓
- high masses for Nambu-Goldstone modes ✓
- stability of the vacuum allignment ✓

$$\Rightarrow$$

Dynamical electroweak symmetry breaking by quasiconformal technicolor models is feasible.

Outlook

- Dark matter candidates
- Models beyond MWT & NMWT
- AdS/CFT methods

D^3 & Kouvaris, PRD78(2008)055005, PRD79(2009)075004
D^3, Järvinen & Kouvaris, work in progress

- Potential signals at LHC

Belyaev, Foadi, Frandsen, Järvinen, Sannino, Pukhov, PRD79(2009)035006

Next-to-minimal walking TC

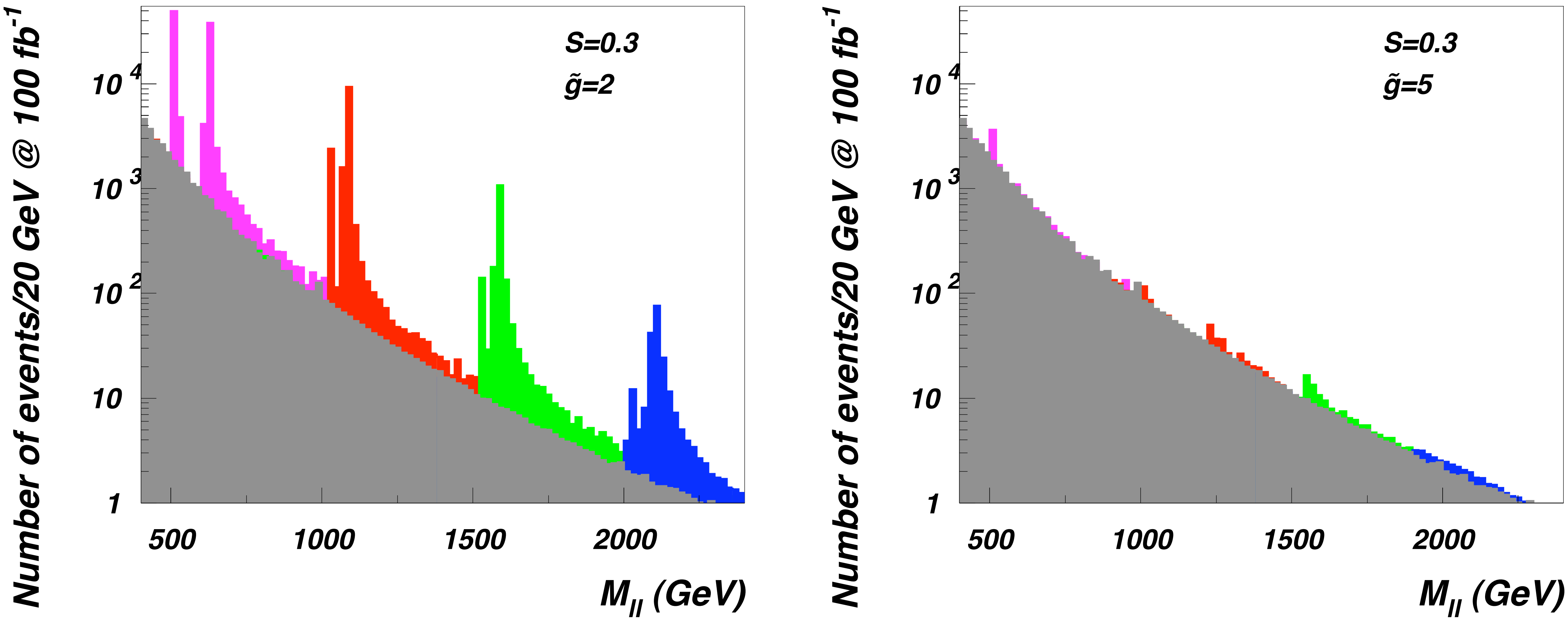


FIG. 9: Dilepton invariant mass distribution $M_{\ell\ell}$ for $pp \to R^0_{1,2} \to \ell^+\ell^-$ signal and background processes. We consider $\tilde{g} = 2, 5$ respectively and masses $M_A = 0.5$ Tev (purple), $M_A = 1$ Tev (red), $M_A = 1.5$ Tev (green) and $M_A = 2$ Tev (blue).

Belyaev, Foadi, Frandsen, Jarvinen, Sannino, Pukhov, PRD79(2009)035006

Next-to-minimal walking TC

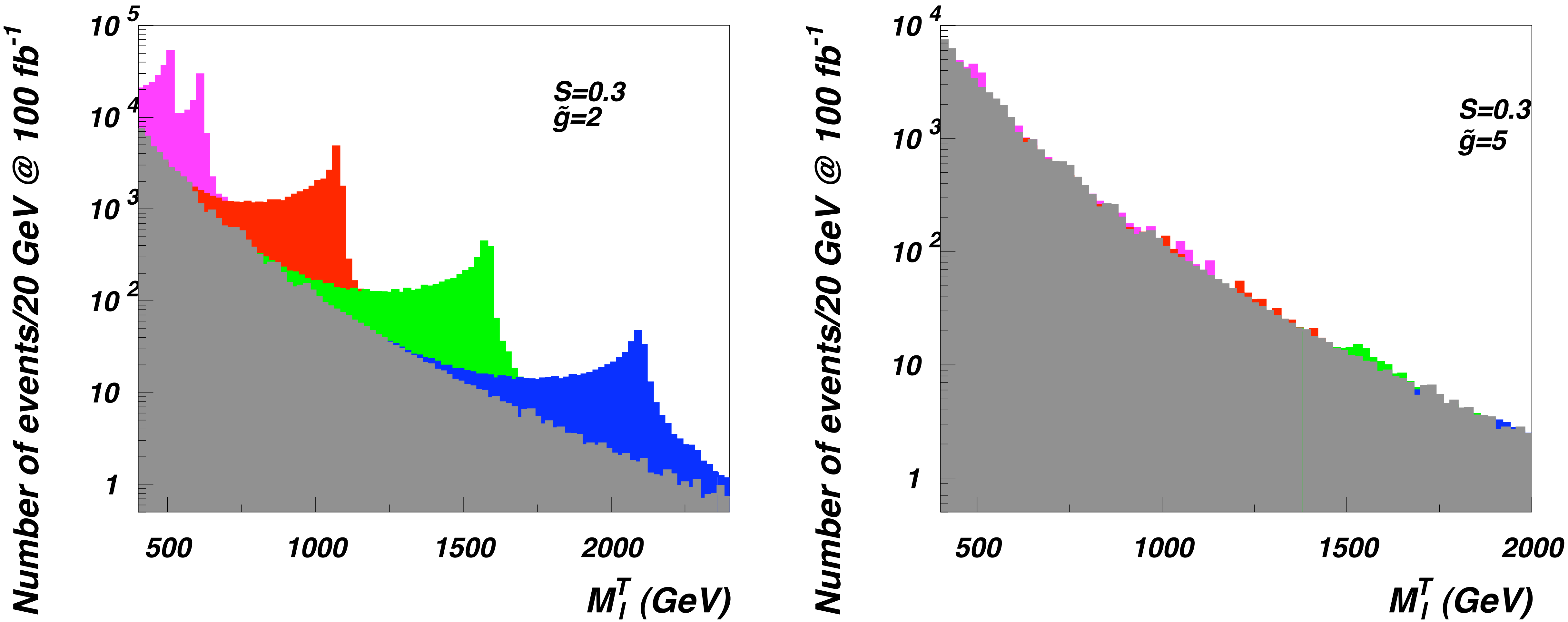


FIG. 10: M_ℓ^T mass distribution for $pp \to R_{1,2}^{\pm} \to \ell^{\pm}\nu$ signal and background processes. We consider $\tilde{g} = 2, 5$ respectively and masses $M_A = 0.5$ Tev (purple), $M_A = 1$ Tev (red), $M_A = 1.5$ Tev (green) and $M_A = 2$ Tev (blue).

Belyaev, Foadi, Frandsen, Jarvinen, Sannino, Pukhov, PRD79(2009)035006

Next-to-minimal walking TC

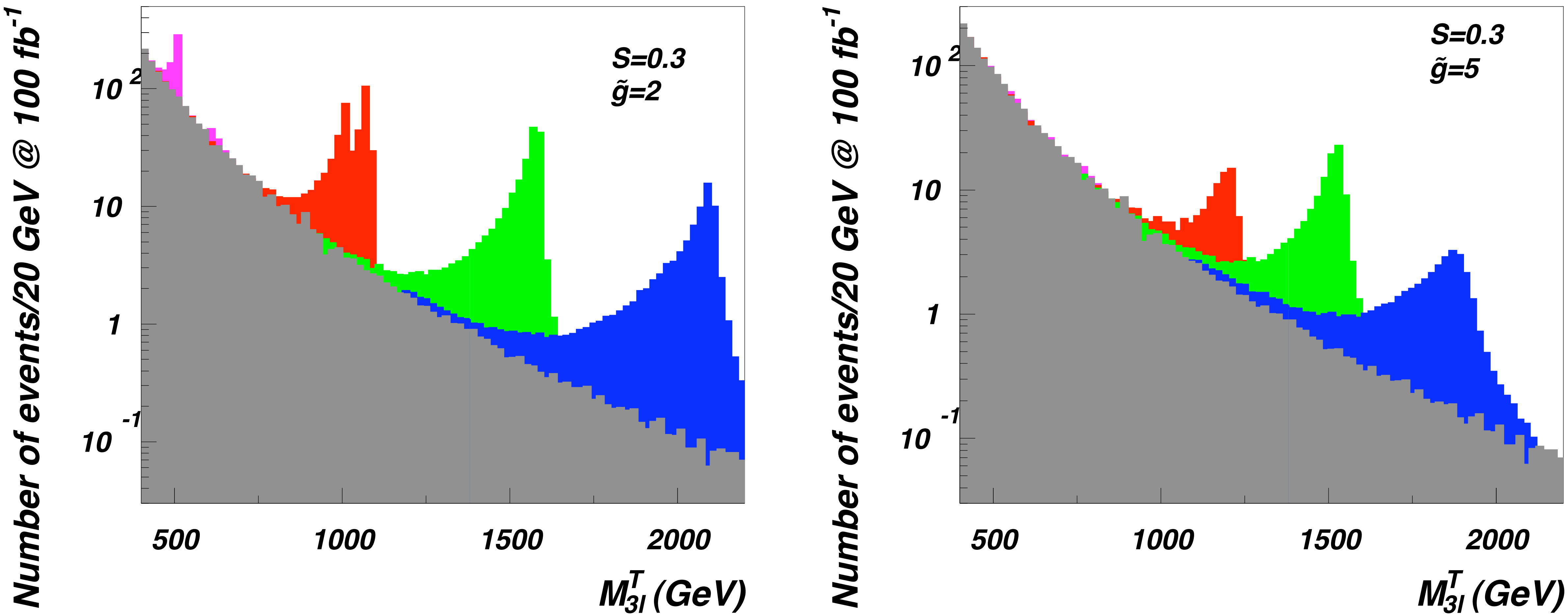


FIG. 11: $M^T_{3\ell}$ mass distribution for $pp \to R^{\pm}_{1,2} \to ZW^{\pm} \to 3\ell\nu$ signal and background processes. We consider $\tilde{g} = 2, 5$ respectively and masses $M_A = 0.5$ Tev (purple), $M_A = 1$ Tev (red), $M_A = 1.5$ Tev (green) and $M_A = 2$ Tev (blue).

Belyaev, Foadi, Frandsen, Jarvinen, Sannino, Pukhov, PRD79(2009)035006