

Stress-testing the Standard Model using the Effective Field Theory formalism

P5 town hall at SLAC

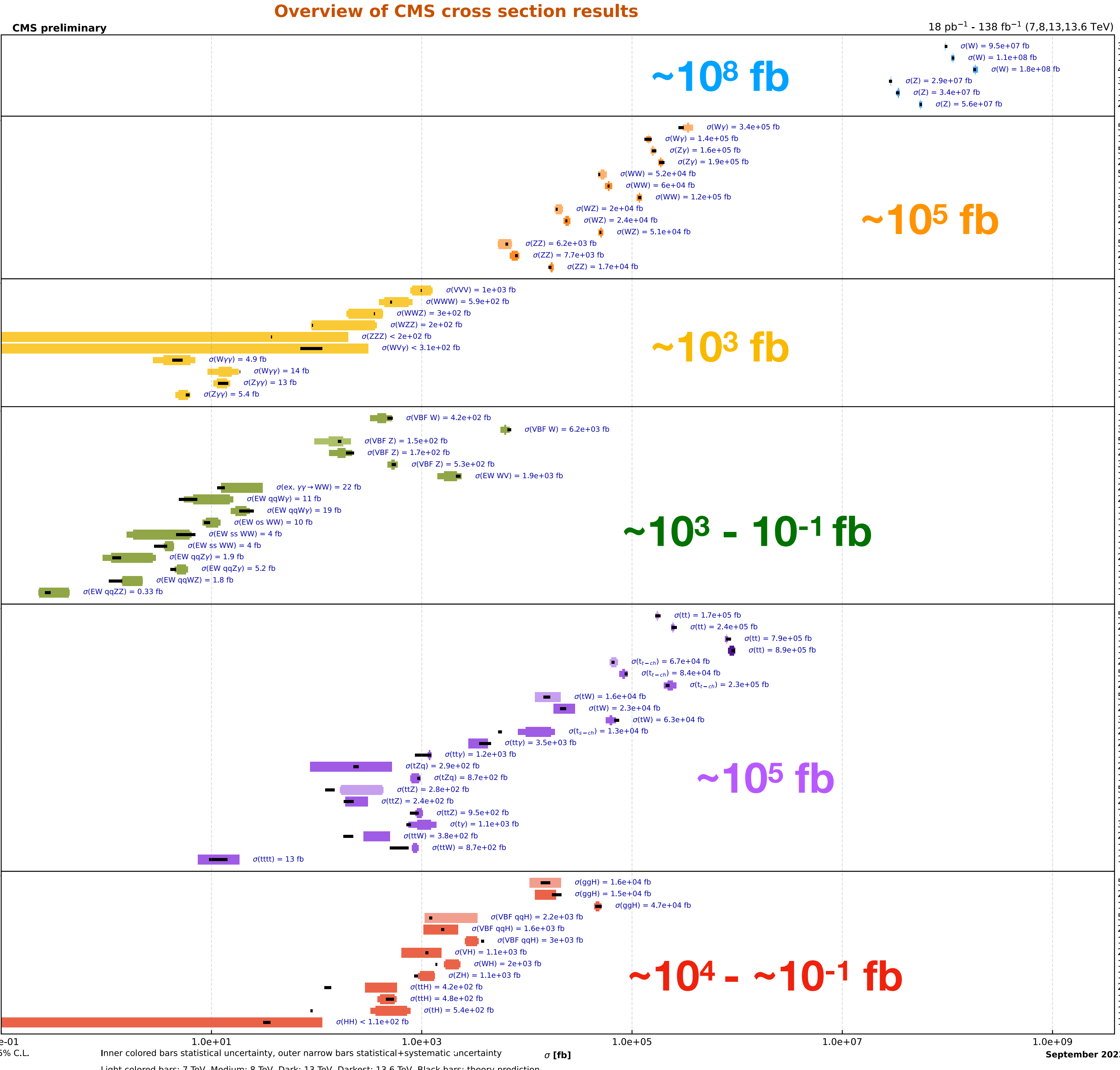
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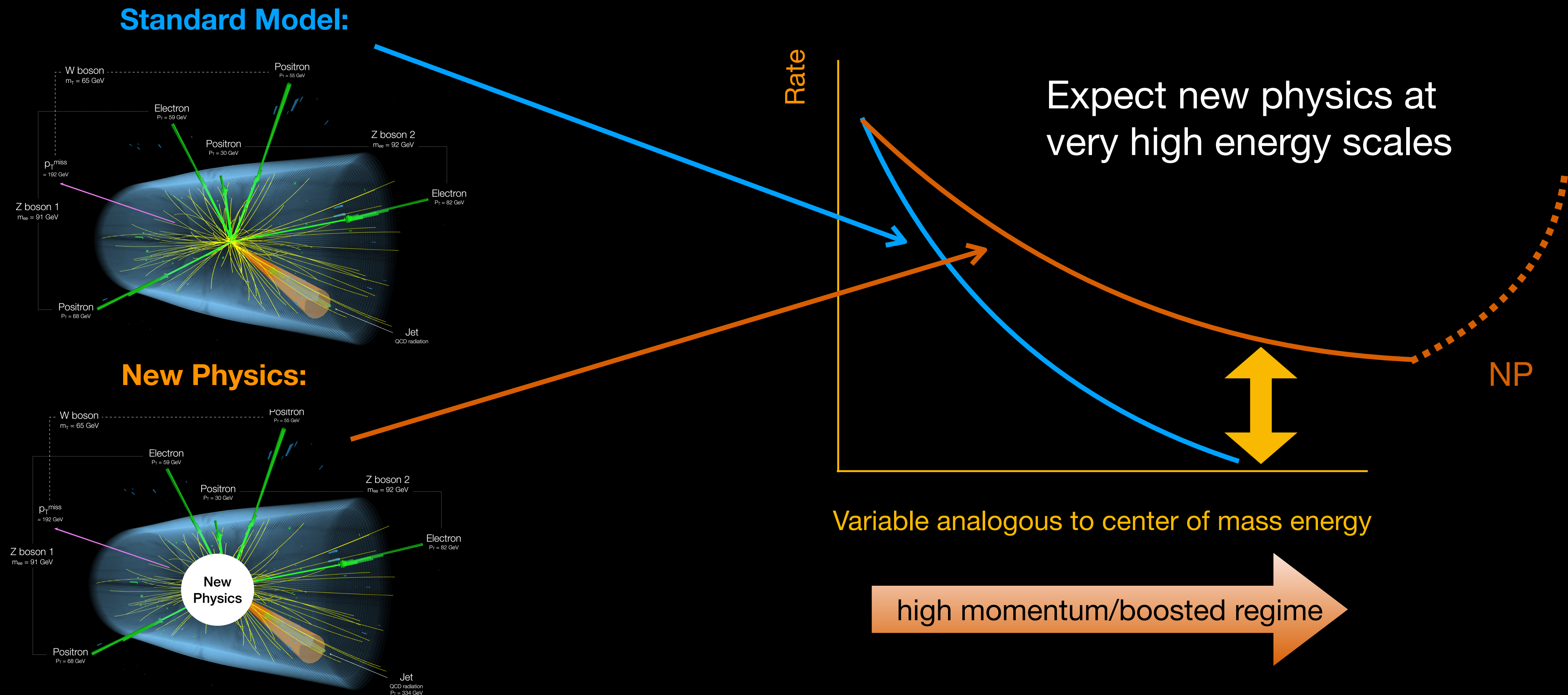
Spans 10 orders of magnitude Spans 14 orders of magnitude when inelastic cross sections are taken into account

Category	Process	Energy	Reference
Electroweak	W	7 TeV	JHEP 10 (2011) 132
	W	8 TeV	PRL 112 (2014) 191802
	W	13 TeV	SMP-15-004
	Z	7 TeV	JHEP 10 (2011) 132
	Z	8 TeV	PRL 112 (2014) 191802
Z	13 TeV	SMP-15-011	
di-Boson	Wγ	7 TeV	PRD 89 (2014) 092005
	Wγ	13 TeV	PRL 126 252002 (2021)
	Zγ	7 TeV	PRD 89 (2014) 092005
	Zγ	8 TeV	JHEP 04 (2015) 164
	WW	7 TeV	EPJC 73 (2013) 2610
	WW	8 TeV	EPJC 76 (2016) 401
	WW	13 TeV	PRD 102 092001 (2020)
	WZ	7 TeV	EPJC 77 (2017) 236
	WZ	8 TeV	EPJC 77 (2017) 236
	WZ	13 TeV	Submitted to JHEP
tri-Boson	ZZ	7 TeV	JHEP 01 (2013) 063
	ZZ	8 TeV	PLB 740 (2015) 250
	ZZ	13 TeV	EPJC 81 (2021) 200
	VVV	13 TeV	PRL 125 151802 (2020)
	WWW	13 TeV	PRL 125 151802 (2020)
	WWZ	13 TeV	PRL 125 151802 (2020)
	WZZ	13 TeV	PRL 125 151802 (2020)
	ZZZ	13 TeV	PRL 125 151802 (2020)
	WVy	8 TeV	PRD 90 032008 (2014)
	Wyy	8 TeV	JHEP 10 (2017) 072
VBF and VBS	VBF W	8 TeV	JHEP 11 (2016) 147
	VBF W	13 TeV	EPJC 80 (2020) 43
	VBF Z	7 TeV	JHEP 10 (2013) 101
	VBF Z	8 TeV	EPJC 75 (2015) 66
	VBF Z	13 TeV	EPJC 78 (2018) 589
	EW WV	13 TeV	Submitted to PLB
	ex. γγ → WW	8 TeV	JHEP 08 (2016) 119
	EW qqWγ	8 TeV	JHEP 06 (2017) 106
	EW qqWγ	13 TeV	SMP-21-011
	EW os WW	13 TeV	Submitted to PLB
	EW ss WW	8 TeV	PRL 114 051801 (2015)
	EW ss WW	13 TeV	PRL 120 081801 (2018)
	EW qqZγ	8 TeV	PLB 770 (2017) 380
	EW qqZγ	13 TeV	PRD 104 072001 (2021)
	EW qqWZ	13 TeV	PLB 809 (2020) 135710
EW qqZZ	13 TeV	PLB 812 (2020) 135992	
Top	tt	7 TeV	JHEP 08 (2016) 029
	tt	8 TeV	JHEP 08 (2016) 029
	tt	13 TeV	Accepted by PRD
	tt	13.6 TeV	TOP-22-012
	t _l -ch	7 TeV	JHEP 12 (2012) 035
	t _l -ch	8 TeV	JHEP 06 (2014) 090
	t _l -ch	13 TeV	PLB 72 (2017) 752
	tW	7 TeV	PRL 110 (2013) 022003
	tW	8 TeV	PRL 112 (2014) 231802
	tW	13 TeV	JHEP 10 (2018) 117
	t _s -ch	8 TeV	JHEP 09 (2016) 027
	tty	8 TeV	JHEP 10 (2017) 006
	tty	13 TeV	Submitted to JHEP
	tZq	8 TeV	JHEP 07 (2017) 003
	tZq	13 TeV	Submitted to JHEP
	ttZ	7 TeV	PRL 110 (2013) 172002
	ttZ	8 TeV	JHEP 01 (2016) 096
	ttZ	13 TeV	JHEP 03 (2020) 056
ty	13 TeV	PRL 121 221802 (2018)	
ttW	8 TeV	JHEP 01 (2016) 096	
ttW	13 TeV	TOP-21-011	
tttt	13 TeV	EPJC 80 (2020) 75	
Higgs	ggH	7 TeV	EPJC 75 (2015) 212
	ggH	8 TeV	EPJC 75 (2015) 212
	ggH	13 TeV	Nature 607 60-68 (2022)
	VBF qqH	7 TeV	EPJC 75 (2015) 212
	VBF qqH	8 TeV	EPJC 75 (2015) 212
	VBF qqH	13 TeV	Nature 607 60-68 (2022)
	VH	8 TeV	EPJC 75 (2015) 212
	WH	13 TeV	Nature 607 60-68 (2022)
	ZH	13 TeV	Nature 607 60-68 (2022)
	ttH	8 TeV	EPJC 75 (2015) 212
ttH	13 TeV	Nature 607 60-68 (2022)	
tH	13 TeV	Nature 607 60-68 (2022)	
HH	13 TeV	Nature 607 60-68 (2022)	

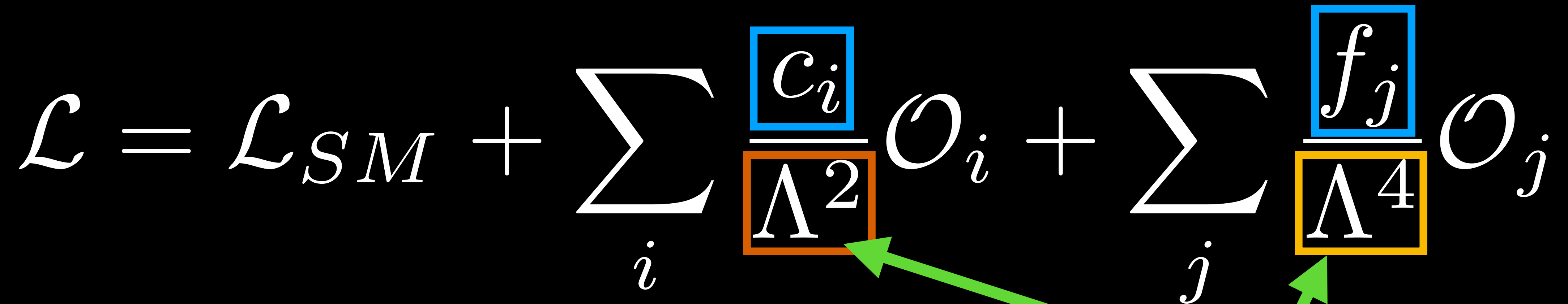


Potential nature of new physics

- Look for appearance of new physics **indirectly** in interactions

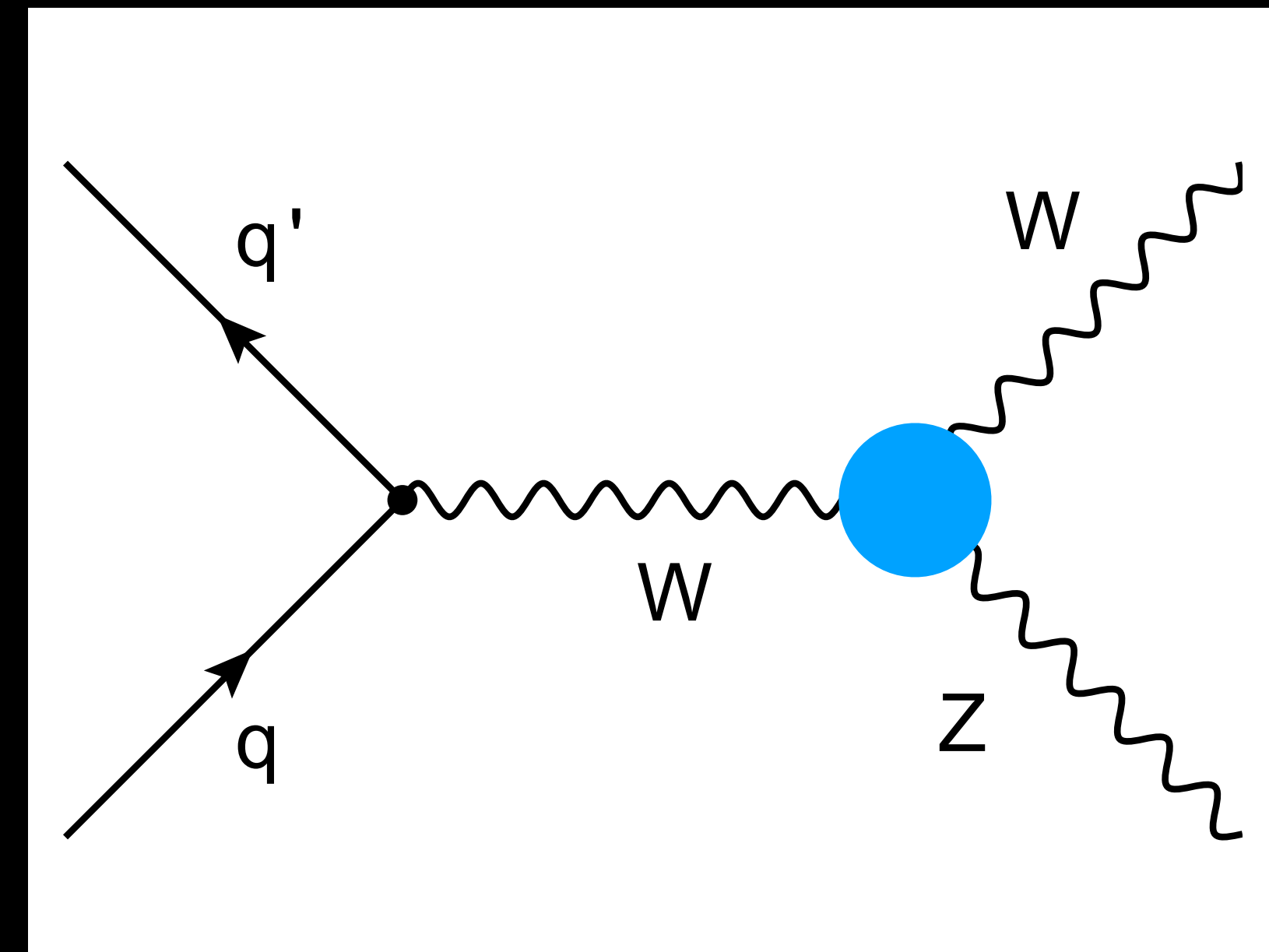
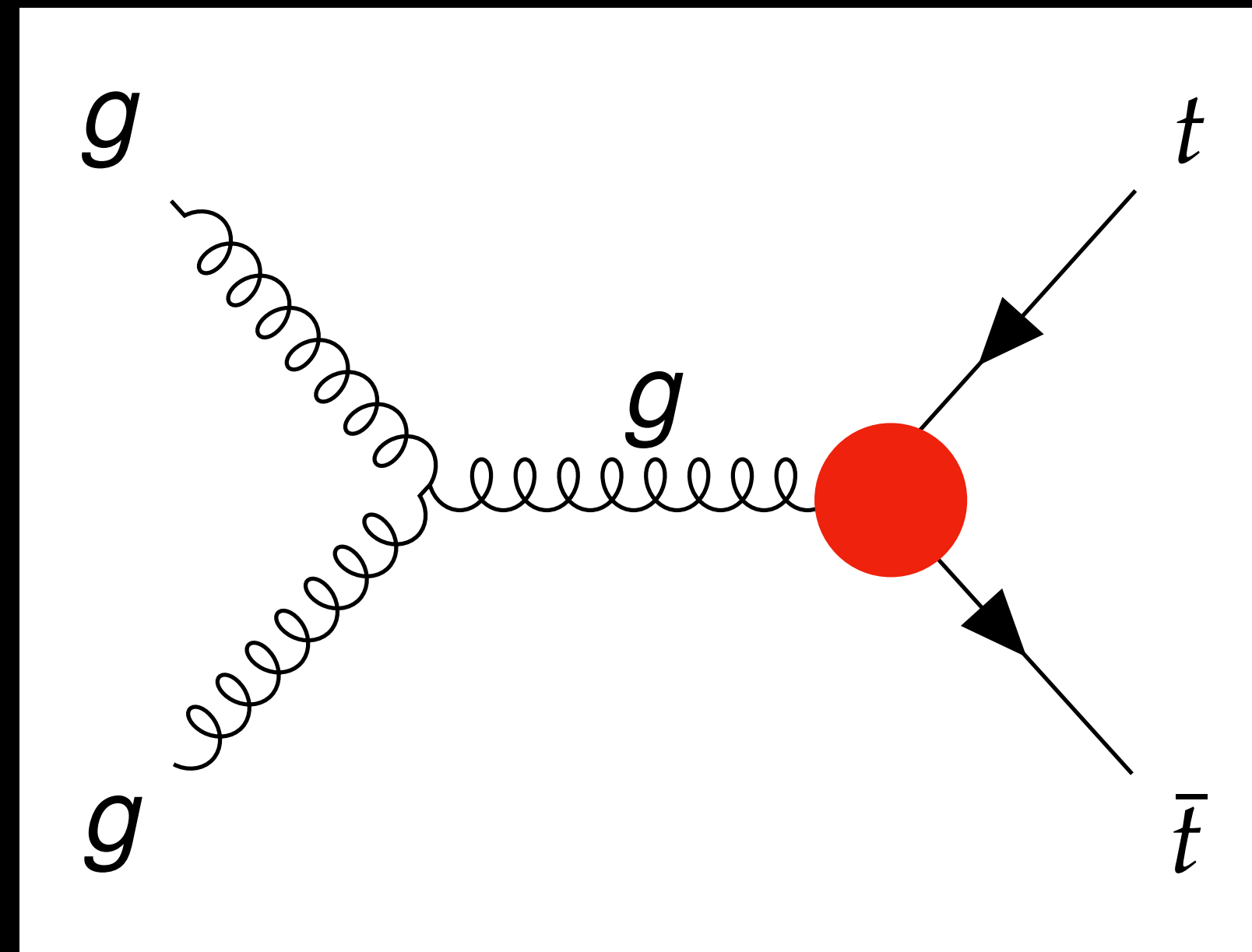


Effective Field Theory Framework

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i \frac{c_i}{\Lambda^2} \mathcal{O}_i + \sum_j \frac{f_j}{\Lambda^4} \mathcal{O}_j$$
The equation shows the Lagrangian L as the sum of the Standard Model Lagrangian L_SM and two sums of higher-dimensional operators. The first sum is over operators O_i with coefficients c_i and a denominator of Lambda squared. The second sum is over operators O_j with coefficients f_j and a denominator of Lambda to the power of four. In the original image, the c_i and f_j are enclosed in blue boxes, and the Lambda squared and Lambda to the power of four are enclosed in orange and yellow boxes, respectively. Two green arrows originate from the bottom of the equation, one pointing to the first bullet point and the other pointing to the second bullet point.

- Extend Standard Model Lagrangian in inverse powers of the *scale of new physics*
- **Operators of dimension-6** and **operators of dimension-8**
- Constraints computed on **multiplicative terms** associated with each of these operators → **Wilson Coefficients**

Using all measurements and interpreting in the Effective Field Theory Framework



Combine constraints from various sectors of Standard Model

Legacy of the LHC

- The Standard Model Effective Field Theory formalism is a systematic framework to characterize the potential nature of New Physics
- Constraints on the Wilson Coefficients from top, electroweak and jet measurements will be an important legacy of the LHC
- Can be combined with constraints from electroweak precision measurements (à la LEP)
- Provide important input for future experiments
- It is my request to the P5 committee to retain focus on precision measurements which then by extension can be used to describe deviations from Standard Model expectations in the language of the Effective Field Theory
- A successful partnership with the particle theory community is crucial from my (an experimentalist's) point of view