Karlsruhe Institute of Technology

WG2: Extrapolation of limits and the Unitarity bound

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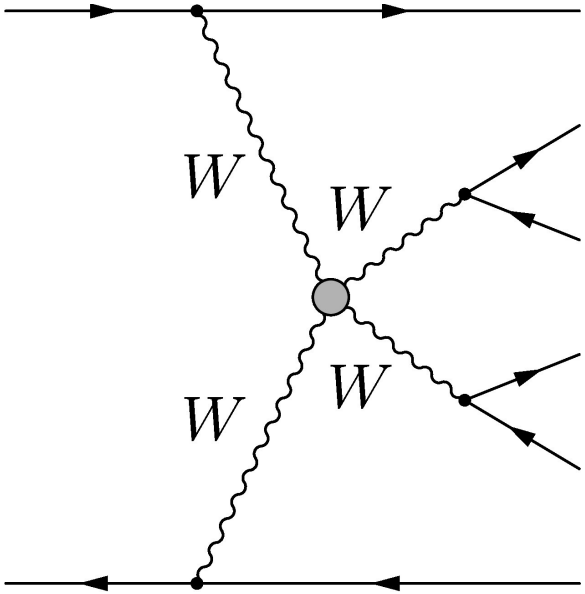
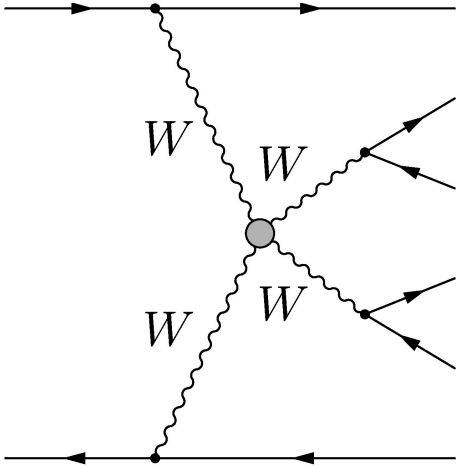


Regularization Schemes

- Issue: EFTs are *effective* theories, not UV complete
  => cross sections violate unitarity at high shat
- Not a conceptual problem: presumably cured by unknown UV completion

- Problem is low sensitivity of experiments:
  Total cross section low even if VV-cross section beyond unitarity bound
  => need unphysical VV amplitude to get observable effect



- What to do?

Dealing with low Sensitivity

- Checking previous paper (8TeV, https://arxiv.org/abs/1410.6315)

Operator coefficient	Exp. lower	Exp. upper	Obs. lower	Obs. upper	Unitarity limit
$F_{S,0}/\Lambda^4$	−42	43	−38	40	0.016
$F_{S,1}/\Lambda^4$	−129	131	−118	120	0.050
$F_{M,0}/\Lambda^4$	−35	35	−33	32	80

- “Vertrauen ist gut, Kontrolle ist besser!”
  - Quoted unitarity limits for WW channel only
  - FM0 violates unitarity much earlier for neutral channels
- Have another look
  - Will we ever be able to get enough sensitivity?

Extrapolation

- Looking at two scenarios

- Low Background:
  - Limit on observed number of events is constant
  - Limit on cross section scales linearly with lumi
  - Limit on coupling scales as sqrt(lumi) ($\sigma \sim aQGC^2$)

- High Background
  - Limit on observed number of events scales with backround uncertainty (sqrt(lumi))
  - Limit on cross section scales linearly with sqrt(lumi)
  - Limit on coupling scales as sqrt(sqrt(lumi)) ($\sigma \sim aQGC^2$)

- Assume ultimately ~3000fb^{-1} data
  - ~100 times 2016 lumi

Comparison

- 13TeV limits from: SMP-17-004
- Unitarity limits done with: VBFNLO form factor tool
  (tried to keep compute time reasonable => good to within 50%)

Operator	Unitarity limit	13TeV data limit	Extrapolation (optimist)	Extrapolation (pessimit)
FS0	0.002	7.7	0.77	2.4
FS1	0.001	20	2	6.3
FM0	0.001	6	0.6	1.9
FM1	0.004	8	0.8	2.5
FM6	0.002	11	1.1	3.4
FM7	0.009	12	1.2	3.9
FT0	0.0002	0.6	0.06	0.19
FT1	0.0006	0.25	0.025	0.08
FT2	0.0006	0.8	0.08	0.25

Summary

- Best case scenario: FT1, background free
  => still off the unitarity limit by a factor of ~40

- Can potentially expect some improvement in data-danalysis, but a factor of 40 is very ambitious

- Sensitivity to aQGCs in full non-unitarized EFTs not any time soon

- Solutions:
  - Conceive theory predictions which do not violate unitarity
    => ad hoc unitarization?
    => beyond EFT?

  - Study channels, where shat is measureable
    => allows for a well defined range in shat for the analysis
    => unitarity bounds much less stingent if maximum shat is lower
    => usually not the most sensitive channels