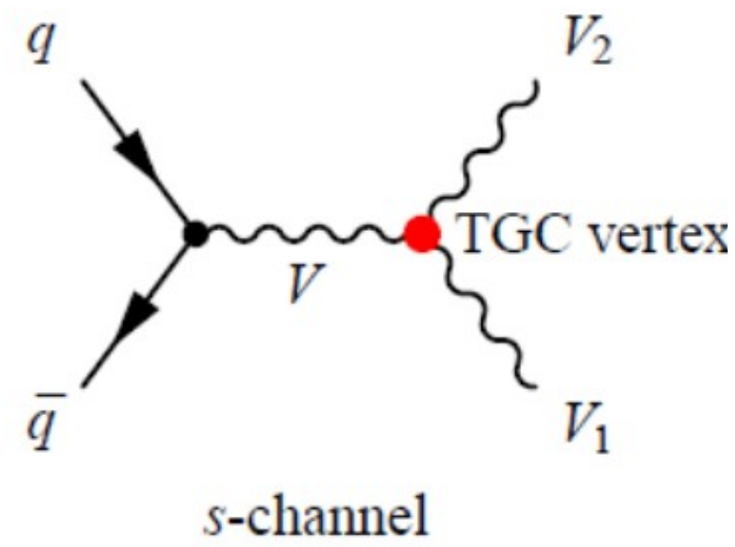
Experimental Issues in aTGC extraction



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Outline

- Effective theory: usage and assumptions
  - Form Factor approach
- Binning issues: Toy MC study
- aTGC combination
- MC generators

Effective Lagrangians

- Generic and model-independent effective Lagrangian parametrization
  - *assumption*: new physics is not directly observed, i.e. the scale of new physics Λ lies above the energy of the experiments
  - low energy particle spectrum (SM particle spectrum) is not changed

$$\mathcal{L}_{eff} = \sum_n \frac{1}{\Lambda^n} \sum_i \alpha_i^{(n)} \mathcal{O}_i^{(n)}$$

$O_i^{(n)}$: operators with dimension [mass]$^{n-4}$

$\alpha_i^{(n)}$: coupling coefficients

- Advantage of the effective Lagrangian:
  - reliable bounds on the coupling coefficients α_i can be obtained
- Drawbacks of the effective Lagrangian:
  - infinite number of terms suggesting lack of predictability
  - radiative corrections that grow with Λ

Effective Lagrangians

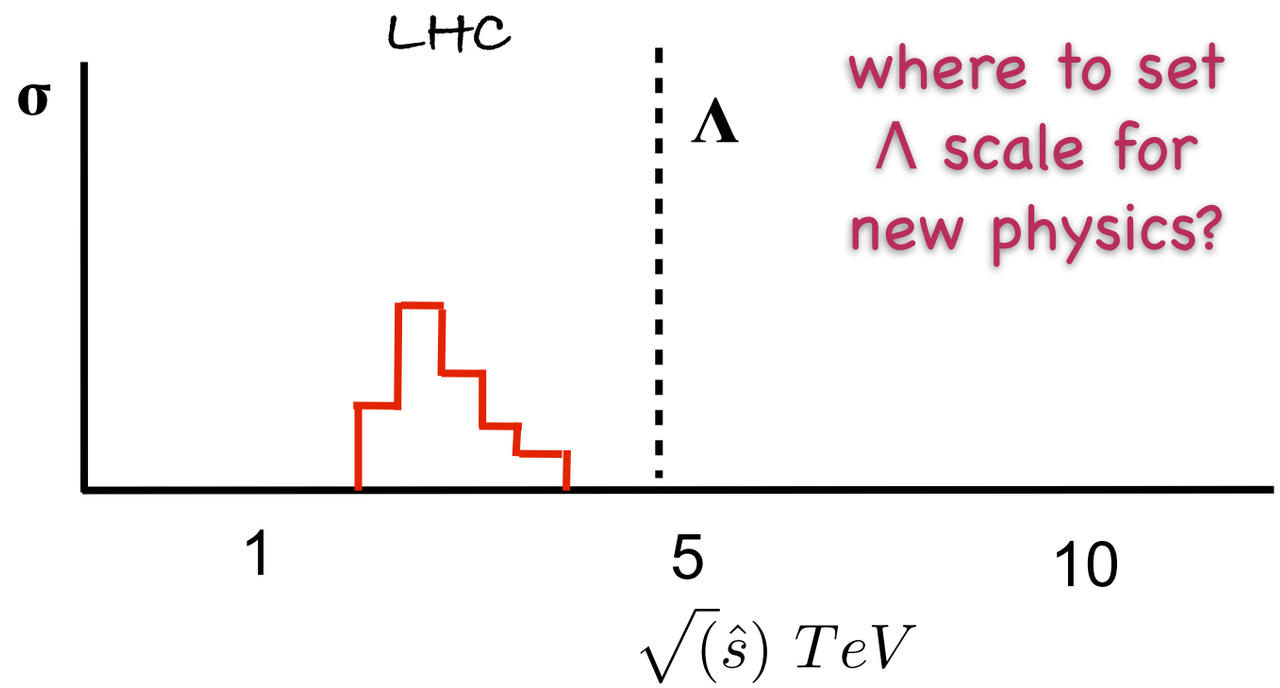
- Tree level unitarity violation near and above Λ
- To avoid this violation a model-dependent approach is needed:

  (contradictory to the model-free approach of the effective Lagrangian)
  - the correct high-energy particle spectrum must be known and used to define the Lagrangian
  - OR Form Factors can be added to the effective couplings

$$\alpha \rightarrow \alpha(\hat{s}) \equiv \frac{\alpha}{(1+\hat{s}/\Lambda_{FF}^2)^n}$$

about form factors:

J. Ellison, J. Wudka: Study of Trilinear Gauge Boson Couplings at the Tevatron Collider (arXiv:hep-ph/9804322v2)
U. Baur, D. Rainwater: Probing neutral gauge boson self-interactions in ZZ production at hadron colliders (PhysRevD. 62.113011)
J. Wudka: The meaning of anomalous couplings (arXiv:hep-ph/9606478v1)



Issues with respect to the current approach

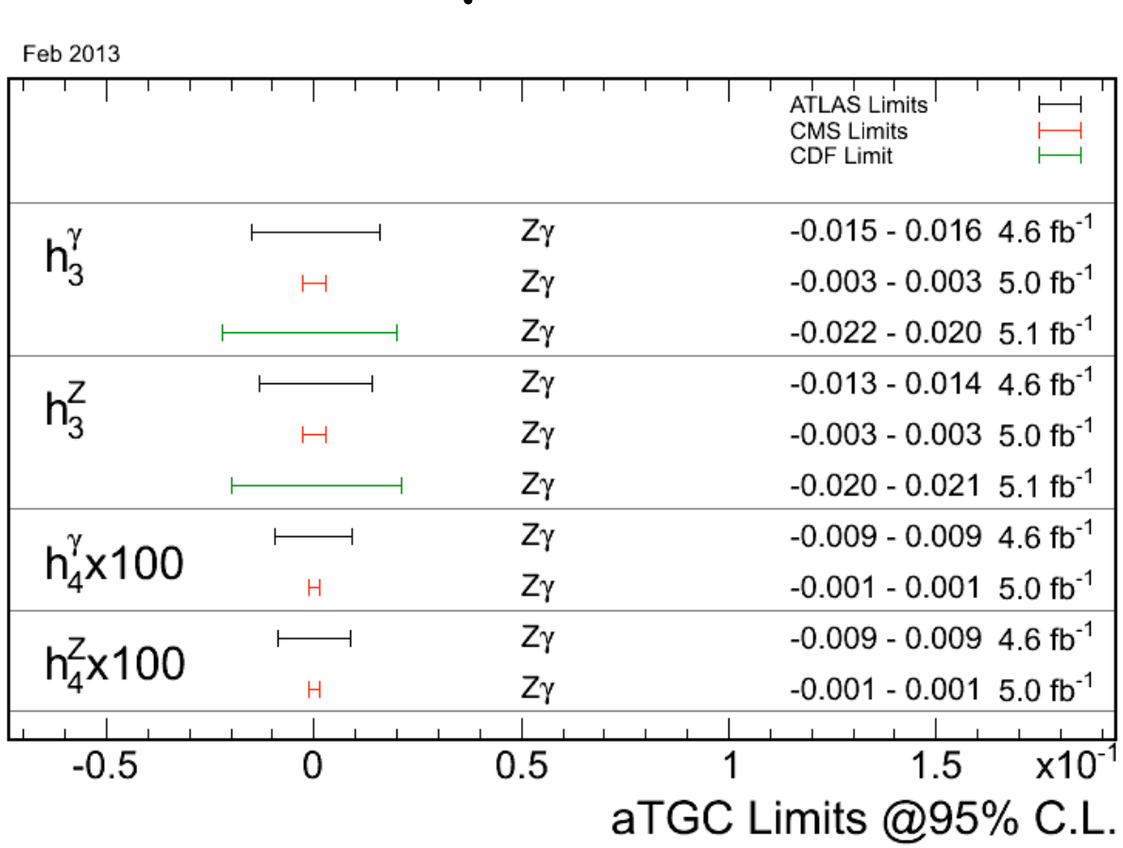
- Why use a dipole form factor in the first place?
  - Other possibilities are proposed in the literature, this is the simplest
- Introducing a dipole form factor to avoid unitarity violation leads to different scales for different aTGC
  - Contradicts with the idea of a generic method however needed when effective Lagrangians are used
  - Which cut-off scale should be used for combination of different diboson channels?
  - One cut-off scale makes it easier to combine and compare results
- Could limits be given as a function of Λ (step-function)?
  - One set of (Λ,n) is enough for theoretical conclusions to be drawn, one can go from one set of (Λ,n) to another

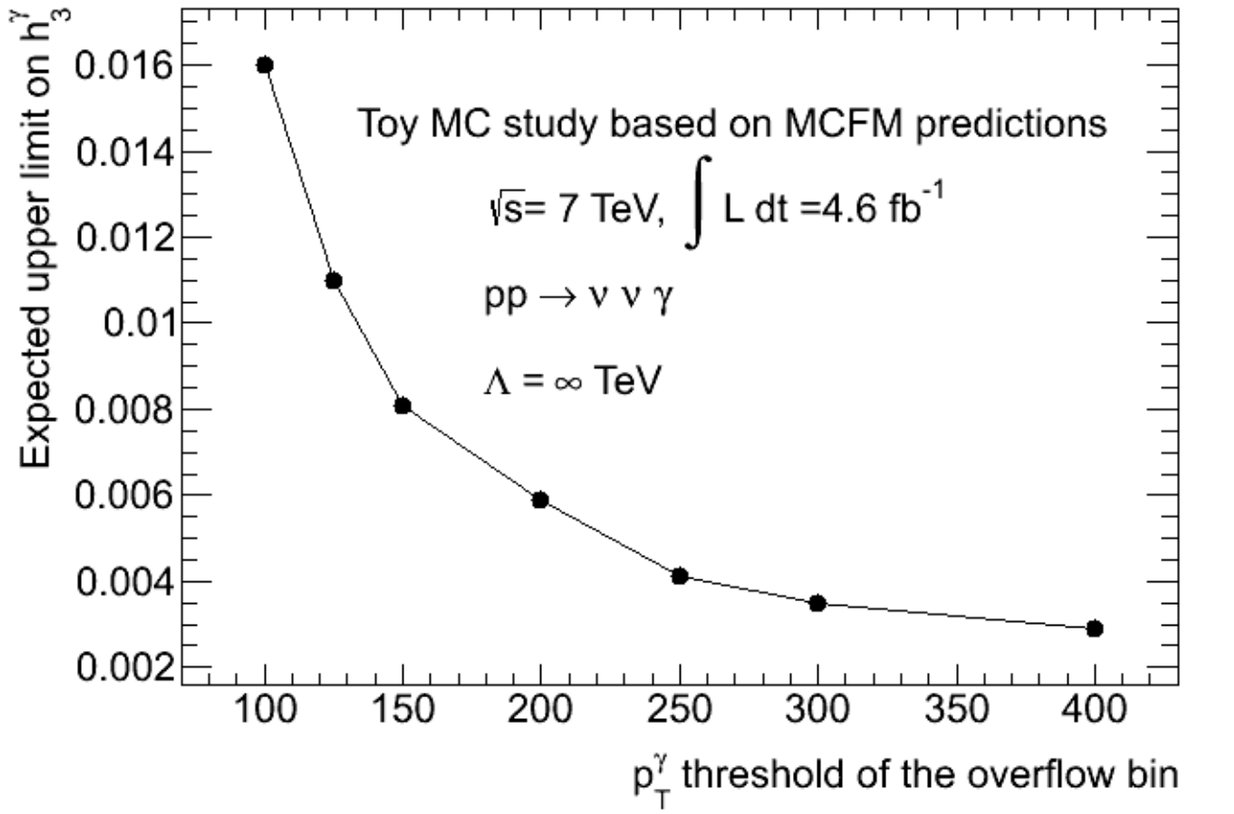
Issues with respect to the binning

- In case binned fits are performed:
  - ATLAS and CMS use different binnings for their results

typical example: $Z\gamma$

CMS set more stringent limits compared to ATLAS



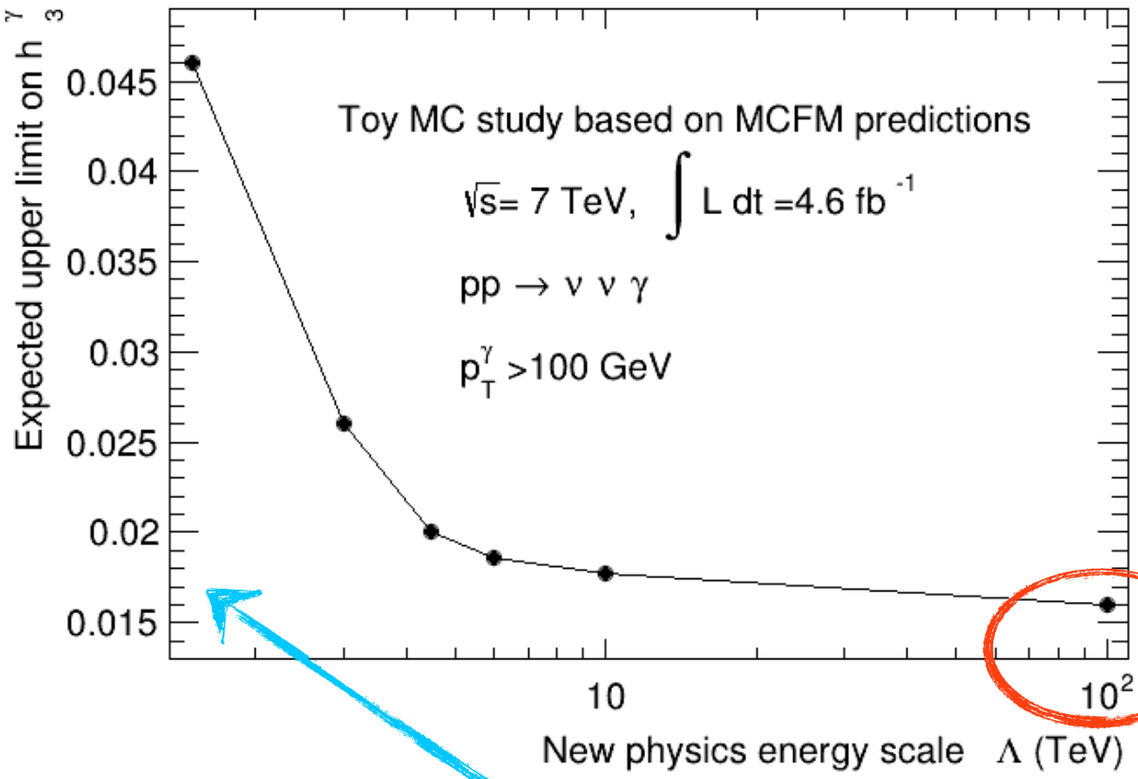


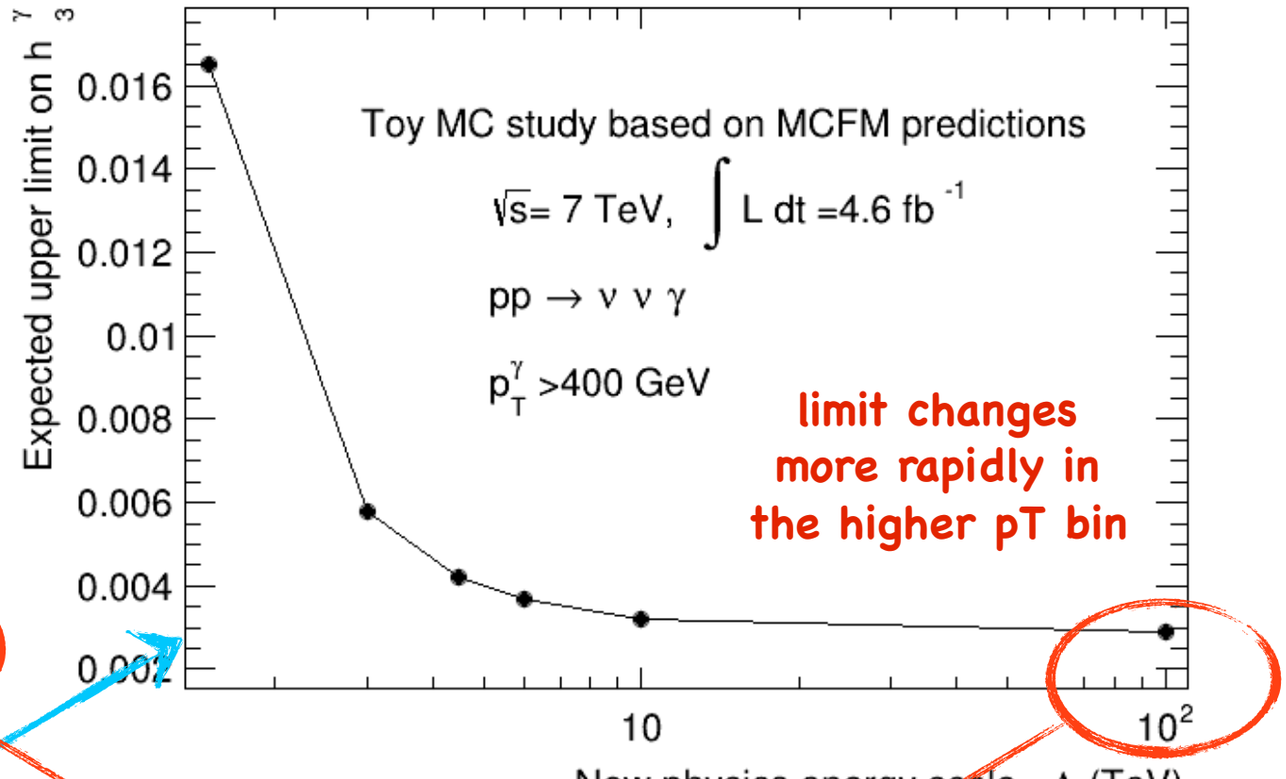
ATLAS can improve by a factor of 5 the current results if raising the pT bin threshold of the overflow bin from 100GeV to 400GeV

Issues with respect to the binning

effect of different binning in detail

typical example: Zγ





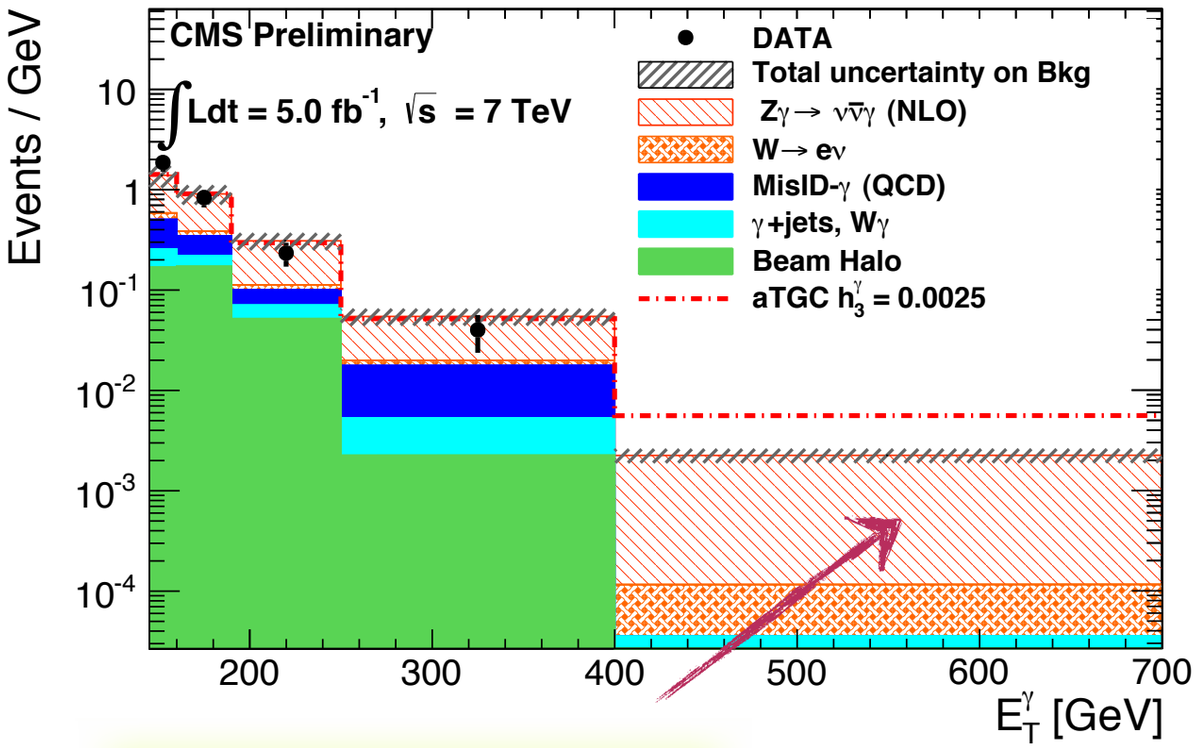
different limit

assuming the same Λ scale

Issues with respect to the binning

- High pT or high mass regions (~ in bins where $\hat{s}\uparrow$) where no candidates are found in data
  - Require a minimum number of events in the highest bin?

typical example: $Z\gamma$



no events found in the last bin

- ATLAS uses the same (ZZ, WZ) or similar (WW) binning for aTGC extraction and unfolded distributions
  - Make sure that we extract aTGC limits in bins with sufficient statistics and high purity with proper background estimation at a given luminosity
  - Theorists can reproduce our aTGC limits based on our unfolding results

Issues with respect to the binning

- A dedicated binning optimization study is particularly needed
  - Form Factor is suppressing the couplings in high pT bins (~ in bins where $\hat{s}\uparrow$), should the optimization be performed assuming no Form Factor (setting Λ scale to ∞)?
  - Optimal binning: combining a sufficient number of events and manageable errors in bins

Combination of limit results

- Combination of couplings among decay channels
  - Limits on WWγ aTGC couplings $\Delta\kappa_\gamma$ and λ_γ from Wγ/WW
  - Limits on WWZ aTGC couplings $\Delta\kappa_Z$, λ_Z and Δg_1^Z from WW/WZ
  - Limits on neutral ZγV, ZZγ and ZZγ, ZZZ TGC couplings h_3^V and h_4^V and f_4^V and f_5^V from Zγ and ZZ decay channels respectively
- Combination between CMS and ATLAS
  - Simultaneous fit on CMS and ATLAS data (unfolded distributions)?
  - Combine the likelihood function?
- Recent interesting paper: http://arxiv.org/pdf/1304.1151v1.pdf
  (Determining Triple Gauge Boson Couplings from Higgs Data)
  - Higgs coupling data to the vector bosons sensitive to the same aTGC parameters
  - Combination of aTGC and Higgs data for tighter constrains?

MC generators including TGC

- MC@NLO4: NLO in QCD (WZ, ATLAS)
  - aTGC for WZ with CP conserving couplings
  - event-by-event weights
- Sherpa: LO (ZZ - ATLAS and ZZ, Zγ, Wγ - CMS)
  - aTGC for all diboson processes with both CP conserving and CP violating couplings
  - reweighting with Baur-Rainwater (BR) or Baur-Han-Ohnemus (BHO) is possible
- MCFM (Z/Wγ - ATLAS and WW, WZ - CMS)
  - aTGC for WZ, WW, Wγ (CP conserving couplings), Zγ (both CP conserving and CP violating couplings)
- BHO (WW - ATLAS)
  - aTGC for all diboson processes except for ZZ
- Powheg Box
  - aTGC for WW and WZ

Summary

- Interesting Experimental Issues were raised looking for answers
  - Form Factors
  - Binning
  - Combination