Di-Gauge Boson Production in ATLAS

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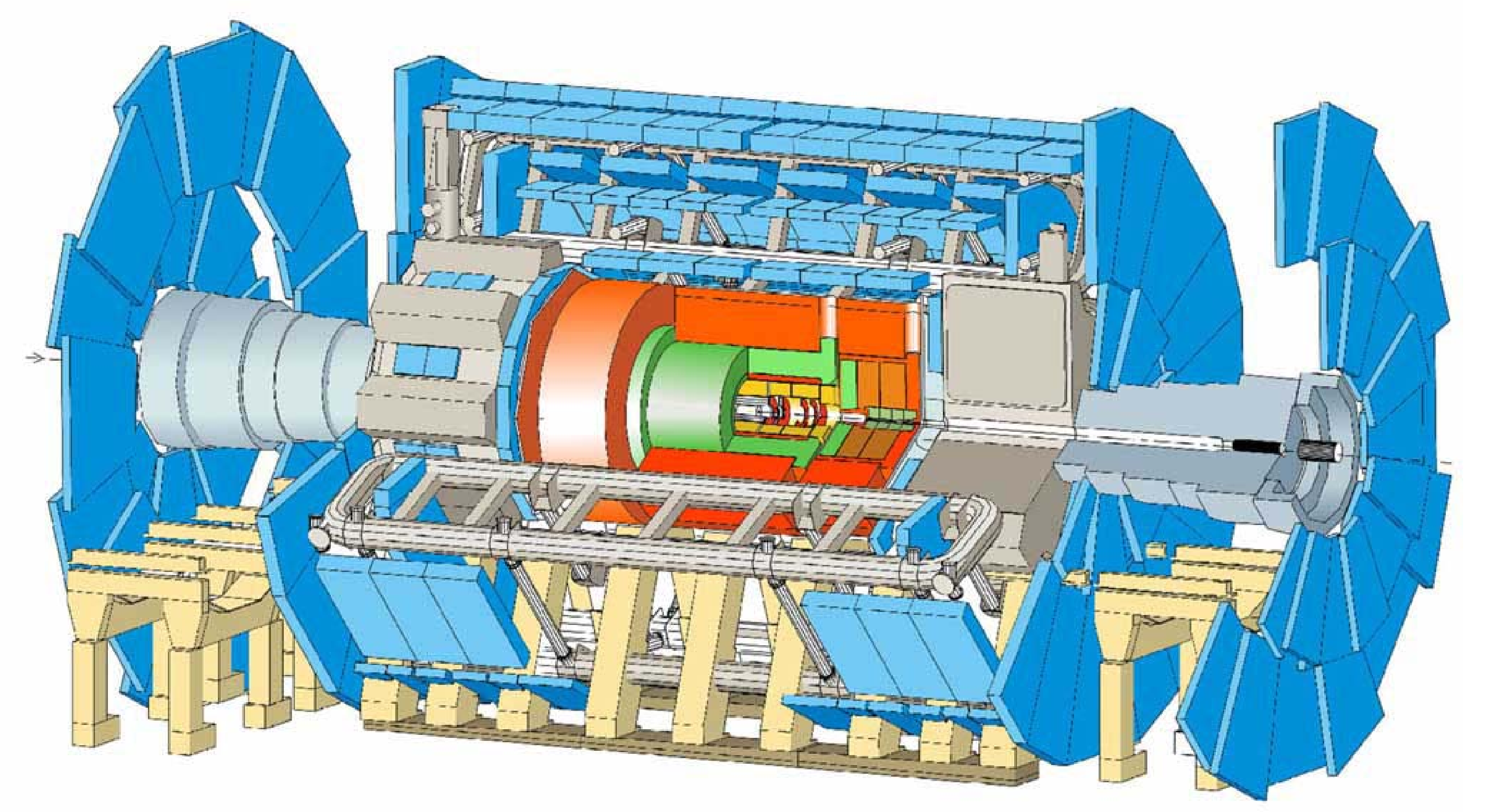
For the ATLAS collaboration

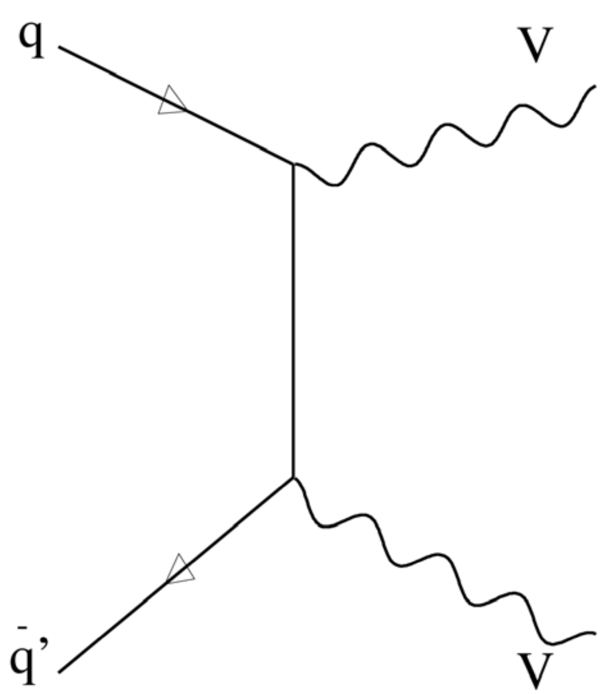
The ATLAS Detector

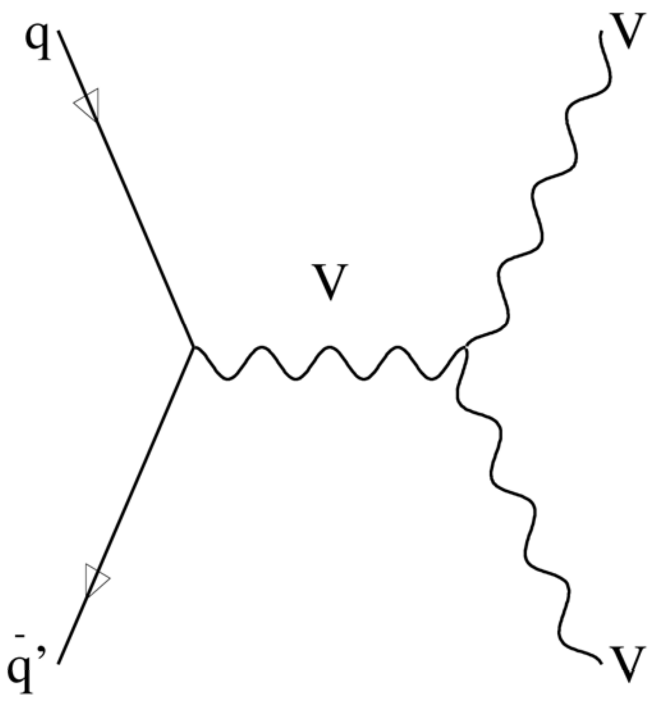


Leading Di-Boson Production

Di-Boson: WW, WZ and ZZ

Where V = Vector Boson





Di-Boson total Cross-Sections

- WW = 120pb measurable at Low luminosity
- WZ = 52pb
- ZZ = 16pb measurable at high luminosity

Motivation and Research Plan

- Test SM at the highest LHC energy
- Background for Higgs search
- Measure cross sections
- Measure triple gauge couplings
- Measure polarization of bosons
- Put limits on Anomalous triple gauge couplings

Cross sections

- Possible to measure at early stage
- Need a few fb^{-1}
- Precision will improve with time
- Need to know structure functions

Triple Gauge Couplings

- The most general $WW\gamma, WWZ$ effective Lagrangian has 14 couplings
- Using only C and P conserving terms and assume QED gauge invariance we are left with 5 couplings:

$$g_1^Z = 1,\ \kappa_{\gamma,Z} = 1$$

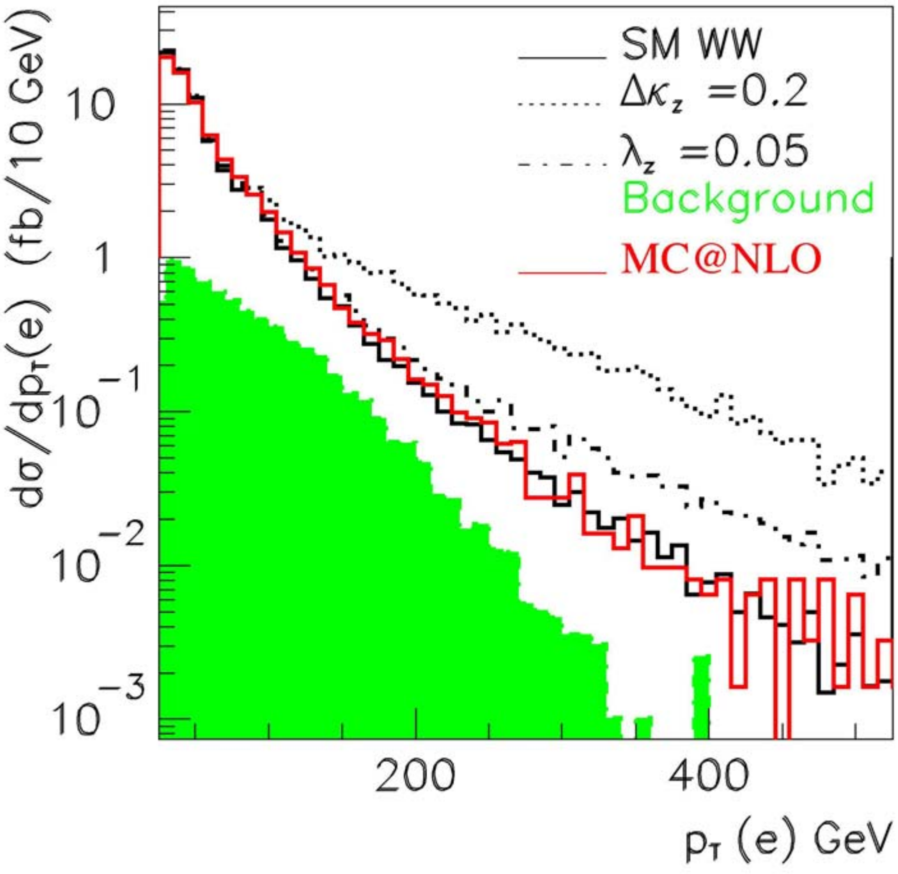
$$\lambda_{\gamma,Z} = 0$$

Triple gauge couplings

-Look at WW process

-Distribution of lepton Pt

- Results from Lj.Simic, I.Mendas, N.Vranjes and D.S.Popovic, ATL-PHYS-PUB-2006-001



Triple Gauge couplings

- The Likelihoods:

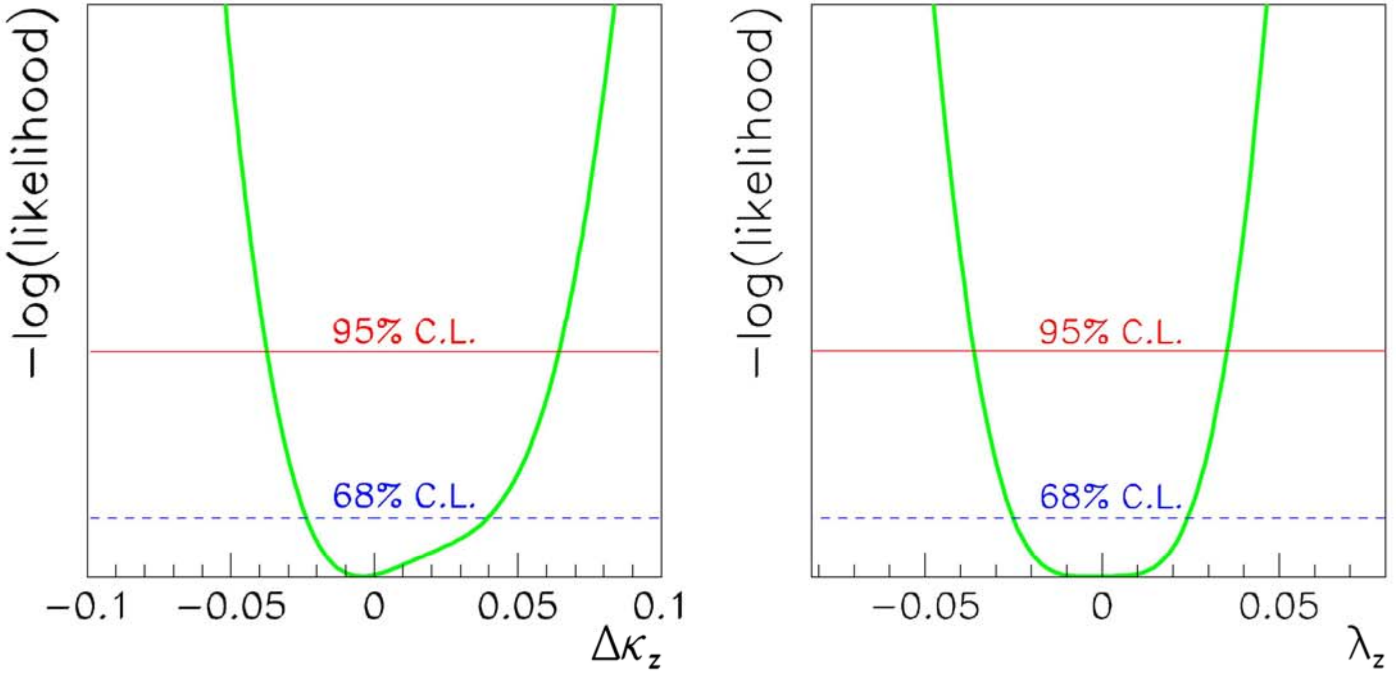


Fig. 9: The negative log likelihood curves (statistical contribution only) as a function of WWZ couplings $\Delta\kappa_Z$ and λ_Z, for the integrated luminosity of 30 fb $^{-1}$ and formfactor scale, Λ =2 TeV.

95% Confidence Limits

For Luminosity of 30 fb^{-1}

- For each couplings assume others at SM value

$-0.033 < \Delta\kappa_Z < 0.069$

$-0.031 < \lambda_Z < 0.041$

$-0.24 < \Delta g_1^Z < 0.33$

$-0.10 < \Delta\kappa_\gamma < 0.13$

$-0.08 < \lambda_\gamma < 0.07$

LEP2 Results: constraints:

$$\Delta\kappa_Z = \Delta g_1^Z - \Delta\kappa_\gamma \tan^2\theta_W$$

$$\lambda_Z = \lambda_\gamma$$

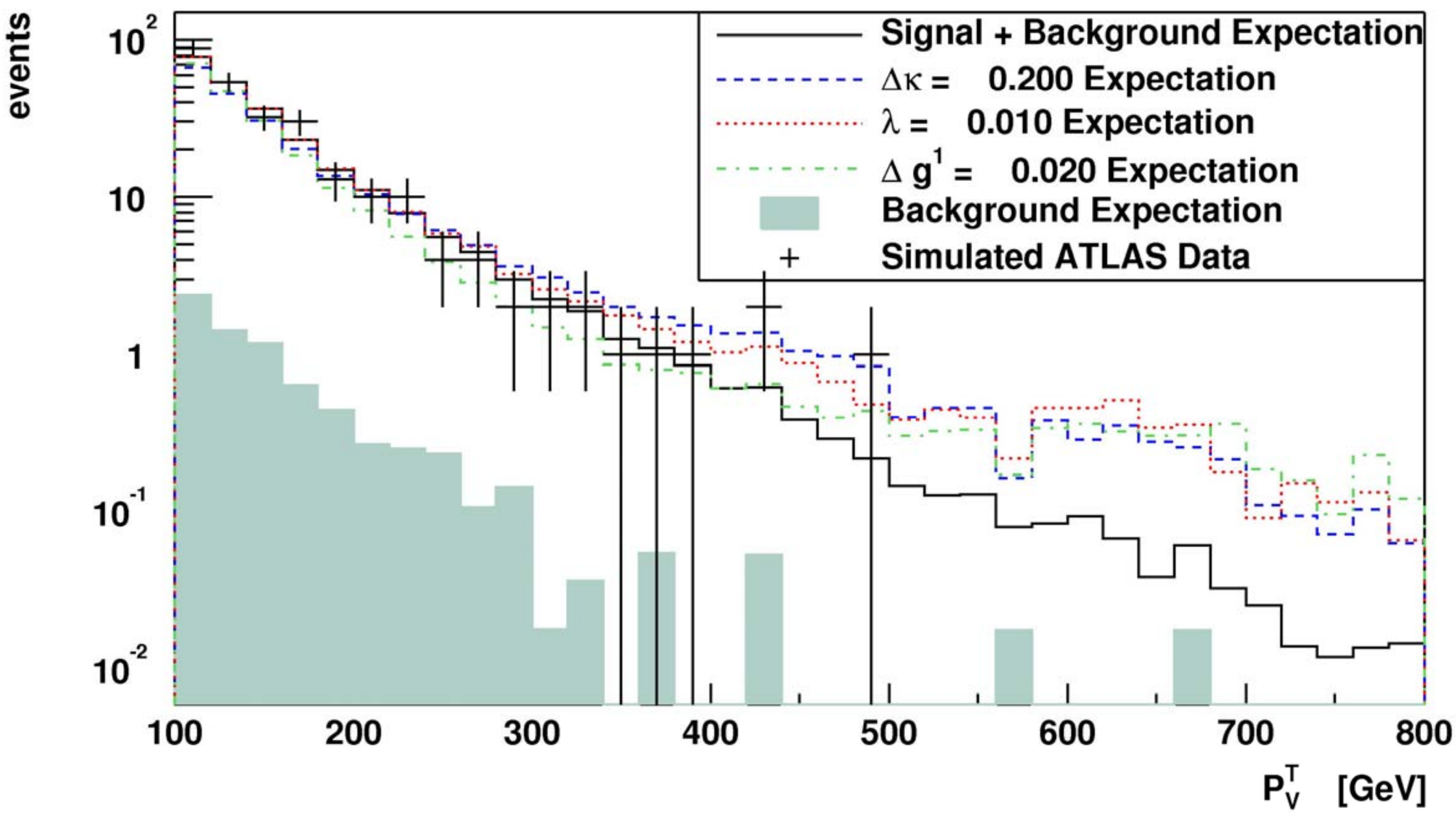
$-0.051 < \Delta g_1^Z < 0.034$

$-0.105 < \Delta\kappa_\gamma < 0.069$

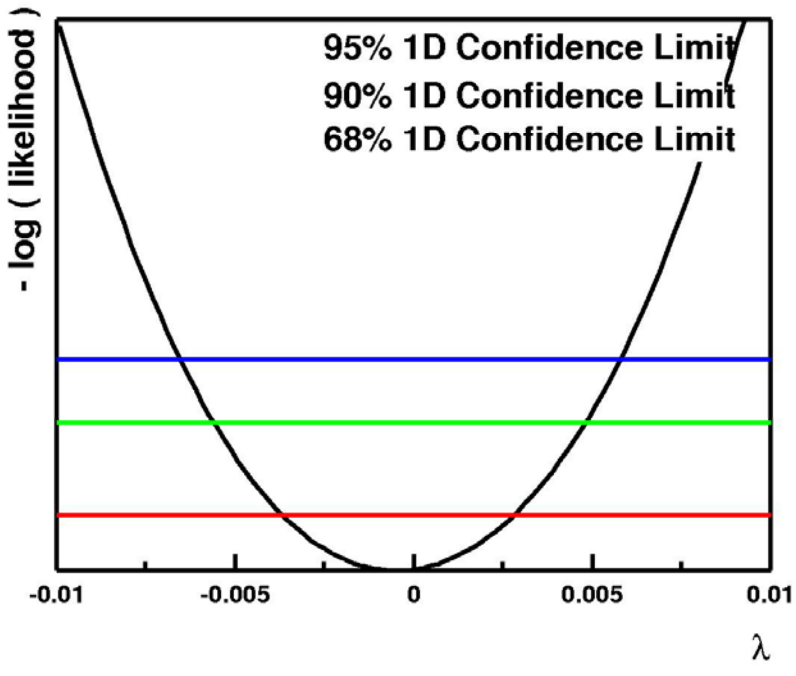
$-0.059 < \lambda_\gamma < 0.026$

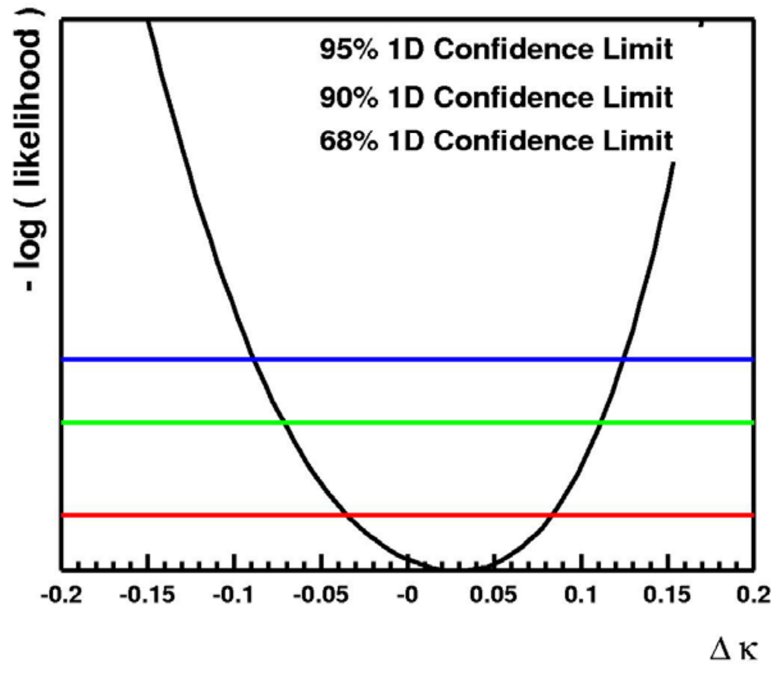
In the WZ case:

Pt Z distribution: **M.Dobbs and M.Lefebvre,ATL-PHYS-2002-023**



Likelihoods:





95% Confidence Limits

For 30 fb^{-1}

$$-0.0065_{STAT}, -0.0032_{SYST} < \lambda_Z < +0.0066_{STAT}, +0.0031_{SYST}$$

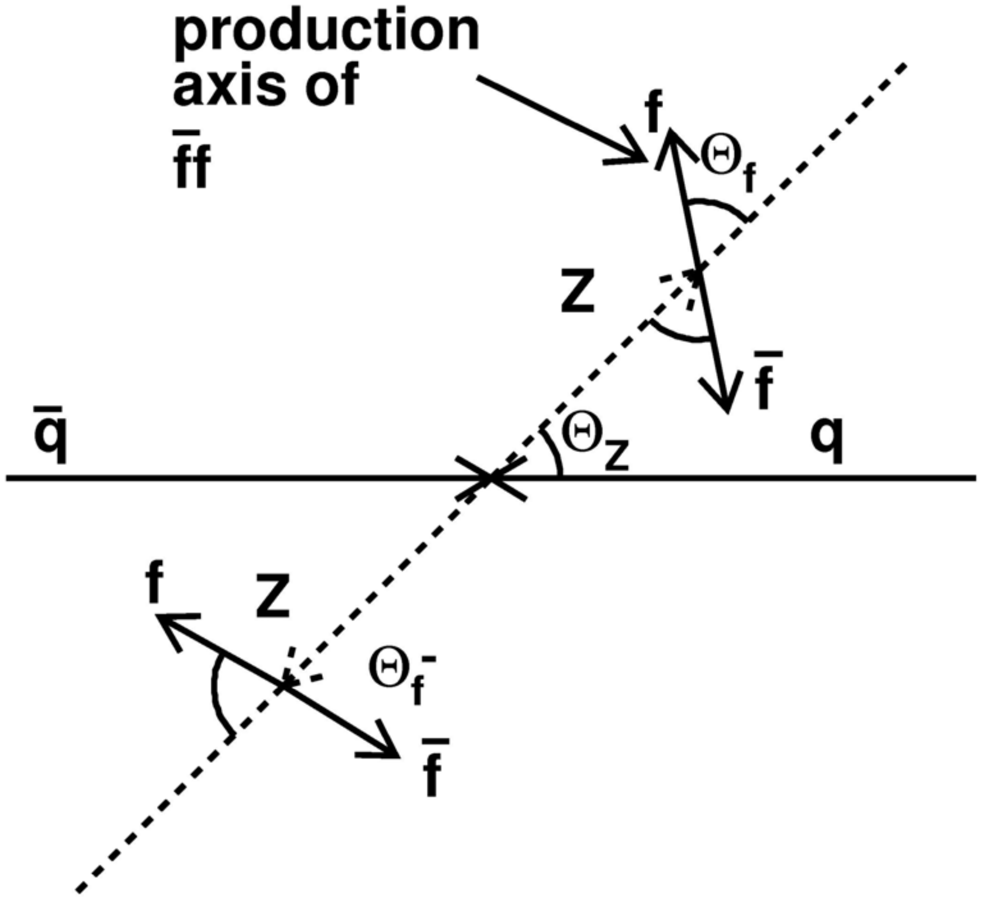
$$-0.1000_{STAT}, -0.024_{SYST} < \Delta\kappa_Z < +0.12_{STAT}, +0.024_{SYST}$$

$$-0.0064_{STAT}, -0.0058_{SYST} < \Delta g_Z^1 < +0.010_{STAT}, +0.0058_{SYST}$$

ZZ Polarization

- Z polarization: longitudinal and transverse
- At LHC unique opportunity to observe and study longitudinal Z
- Do this by studying the angular distribution of the Z decay products, $COS\theta_f$

Angular variables



Looking at $\cos\theta_f$

- In the Z rest frame:
- The differential cross section is given by:

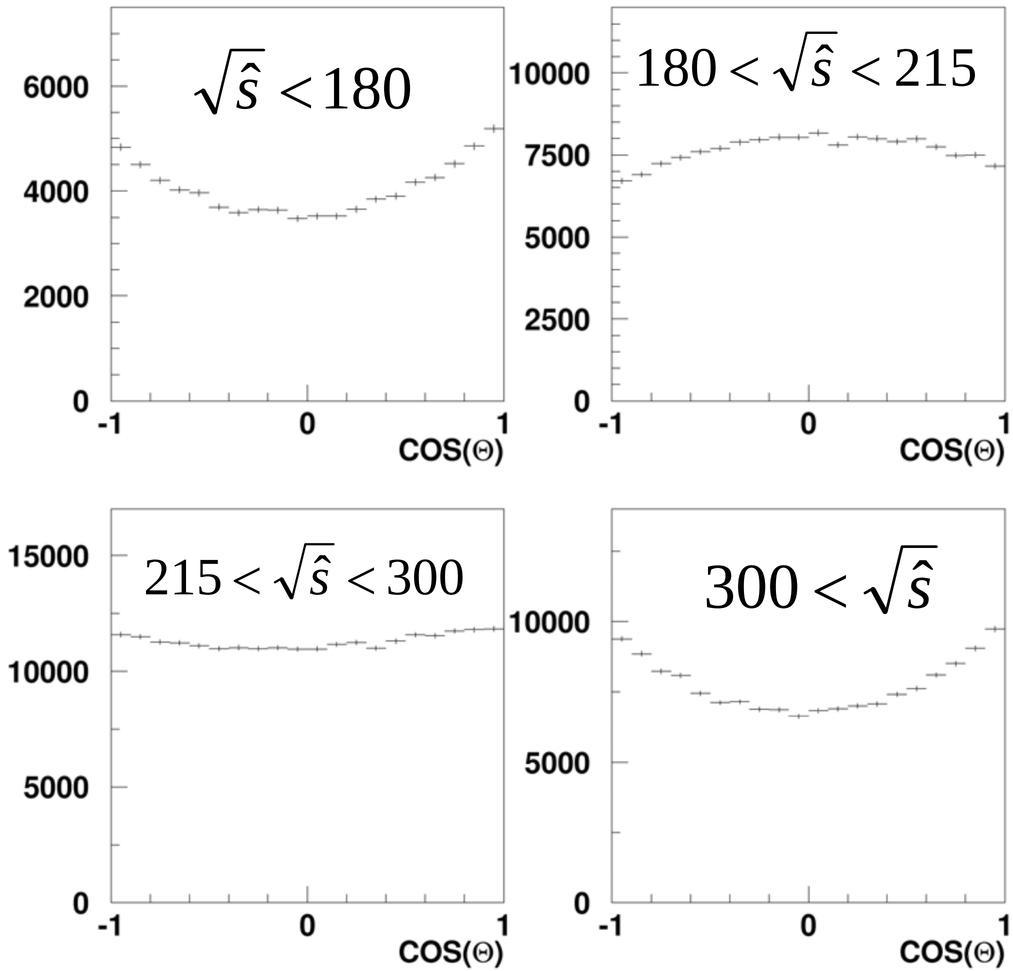
$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta_f}=\frac{3}{4}\rho_T\left(1+\cos^2\theta_f\right)+\frac{3}{4}\rho_L\sin^2\theta_f$$

- Where ρ_T,ρ_L are the diagonal elements of the spin density matrix(SDM) $\rho_T+\rho_L=1$
- Extract ρ_T,ρ_L from the data
- ρ_L corresponds to longitudinal Z polarization

Z polarization

- ρ depends on the Z production angle and on the ZZ invariant mass , $\sqrt{\hat{s}}$
- At fixed pp energy collisions large range of $\sqrt{\hat{s}}$
- Opportunity to study Z polarization dependence with $\sqrt{\hat{s}}$
- Make measurements in bins of $\sqrt{\hat{s}}$

$\cos\theta_f$ In bins of $\sqrt{\hat{s}}$

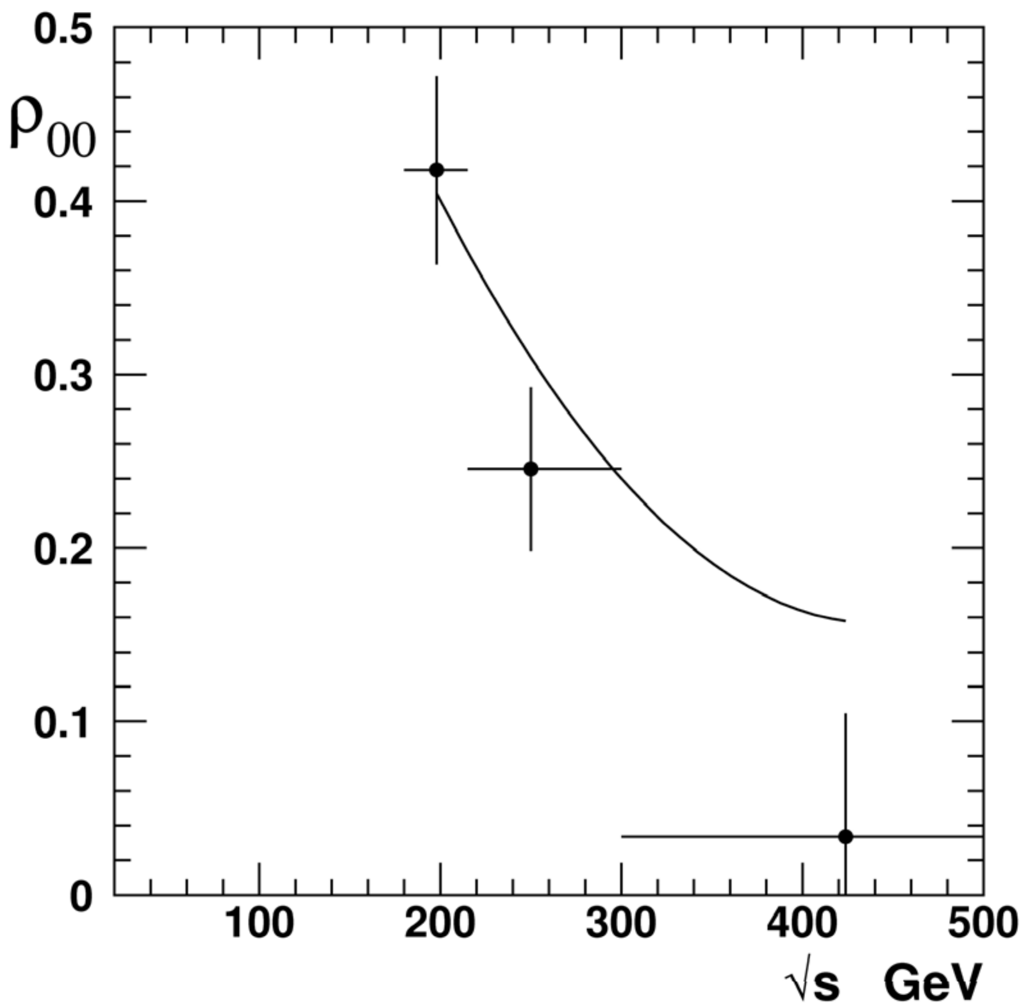


Note:

-Shape changes with energy

-Reflects different polarization of the Z

ρ_{00} as a function of $\sqrt{\hat{s}}$ for 100 fb^{-1}



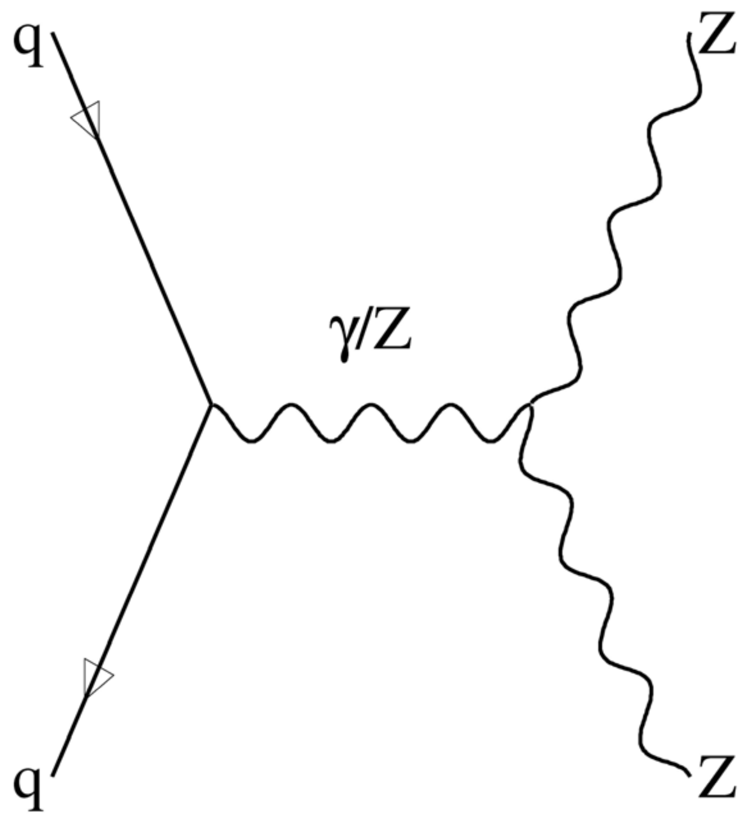
-Including correction for detector

-The error include systematics due to proton structure function

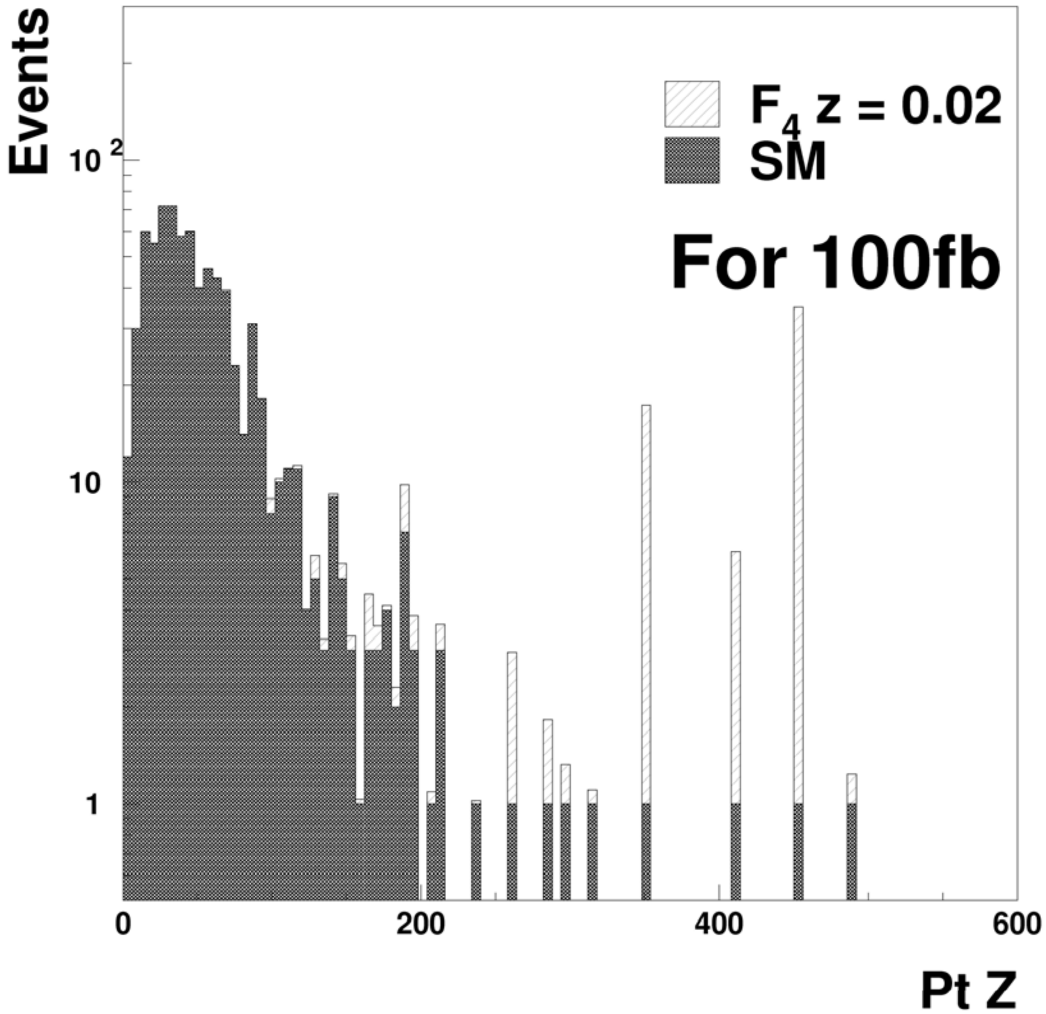
Neutral Triple Gauge Couplings

In the ZZ case:

Forbidden in SM



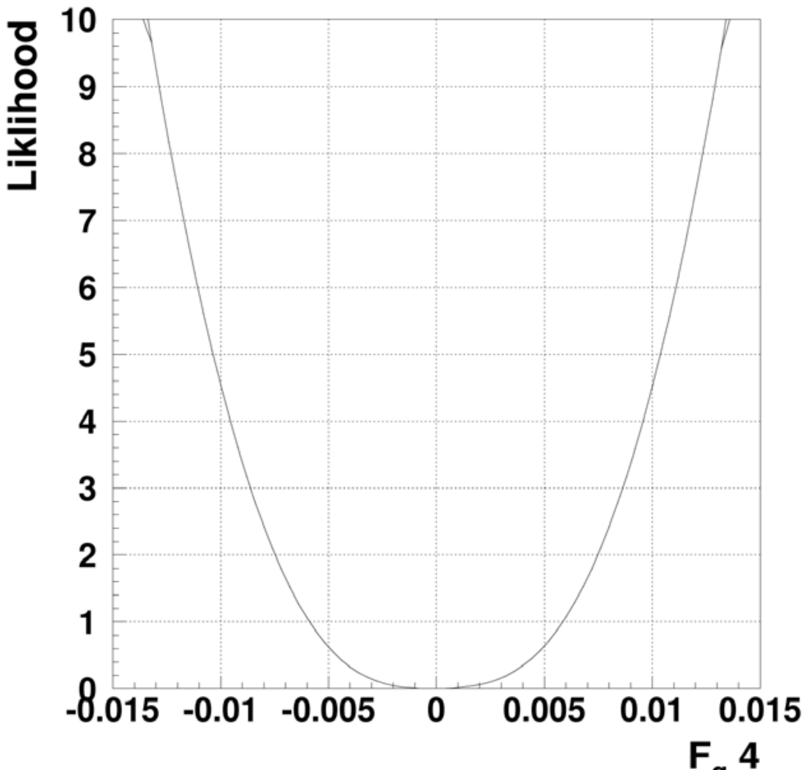
Z Pt distribution

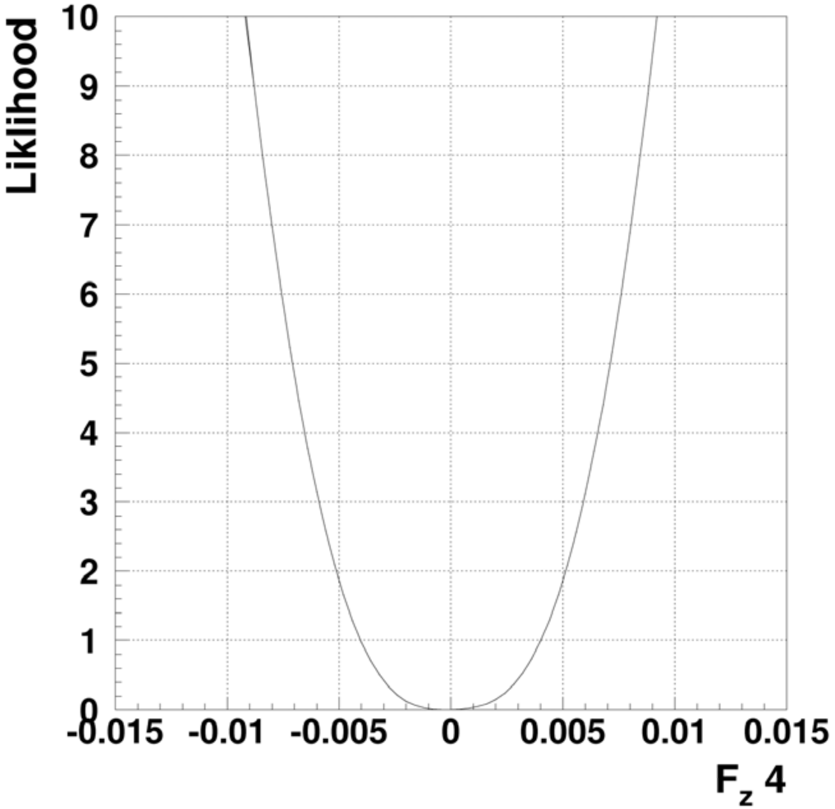


Likelihoods and 95% C.L.

$$-0.0051 < f_4^Z < 0.0051 \qquad -0.0053 < f_5^Z < 0.0055$$

$$-0.0075 < f_4^\gamma < 0.0075 \qquad -0.0078 < f_5^\gamma < 0.0078$$





Comparison to LEP2

- ZZ: Great improvement from LEP2
- The improvement in ZZ is due to strong energy dependence of anomalous TGC contribution to ZZ production
- e.g F_4^Z limit 0.005 at LHC, c.f. 0.3 at LEP2
- For 30 fb^{-1}, WW sensitivity compatible with LEP2

Summary

- TGC limits for WW,WZ and ZZ processes are presented
- Limits improved from LEP2
- Possible to make ZZ polarization measurement at high luminosity