UNIVERSITY of ROCHESTER

Lepton Decay Angular Distribution Coefficients of Drell-Yan Process at CMS

Jiyeon Han (University of Rochester)

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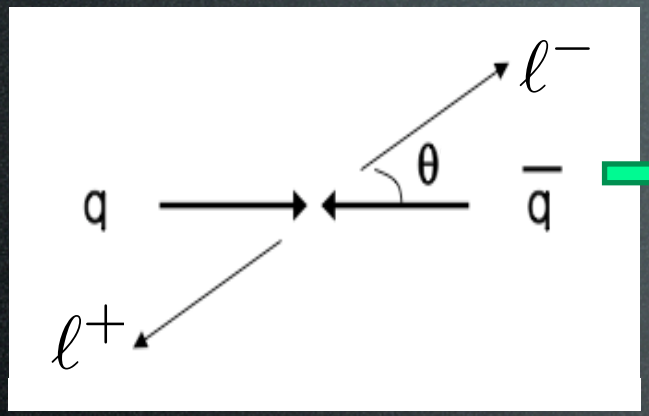
Introduction

- Lepton decay angle (θ, ϕ) in Collins-Soper(CS) frame

$q\bar{q} \rightarrow Z/\gamma^* \rightarrow \ell^+\ell^-$



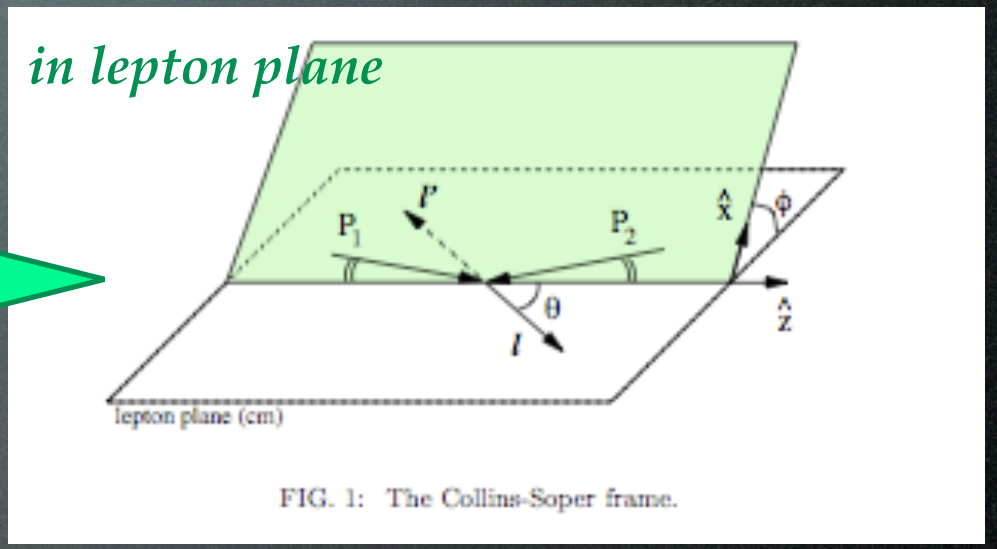


FIG. 1: The Collins-Soper frame.

- Differential cross section of lepton decay angle (θ, ϕ) in CS

$$\frac{d\sigma}{dP_T^2 dy d\cos\theta d\phi} \propto (1+\cos^2\theta) + \frac{1}{2}A_0(1-3\cos^2\theta) + A_1 \sin 2\theta \cos\phi + \frac{1}{2}A_2 \sin^2\theta \cos 2\phi + A_3 \sin\theta \cos\phi + A_4 \cos\theta + A_5 \sin^2\theta \sin 2\phi + A_6 \sin 2\theta \sin\phi + A_7 \sin\theta \sin\phi$$

- $(1+\cos^2\theta)$ → *LO term*
- $\frac{1}{2}A_0(1-3\cos^2\theta)$ → *$\cos^2\theta$: higher order term*
- $A_1 \sin 2\theta \cos\phi + \frac{1}{2}A_2 \sin^2\theta \cos 2\phi + A_3 \sin\theta \cos\phi$ → *(θ, ϕ) terms*
- $A_4 \cos\theta$ → *LO term : determine A_{fb}*
- $A_5 \sin^2\theta \sin 2\phi + A_6 \sin 2\theta \sin\phi + A_7 \sin\theta \sin\phi$ → *very small terms*

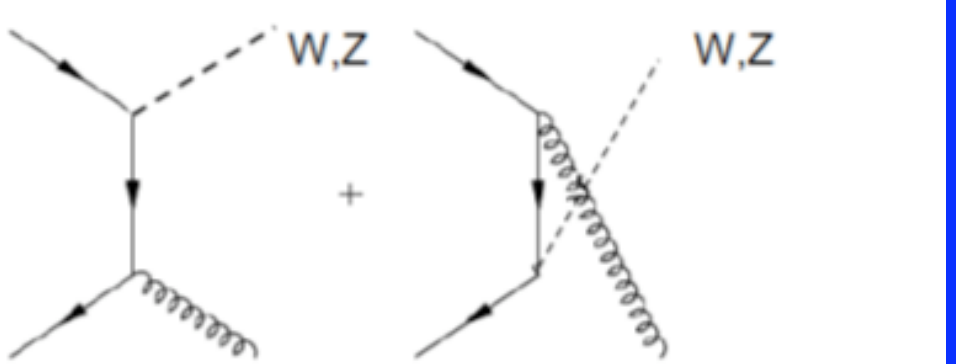
* * * All higher order terms are zero at $P_T = 0$

Physics Motivation

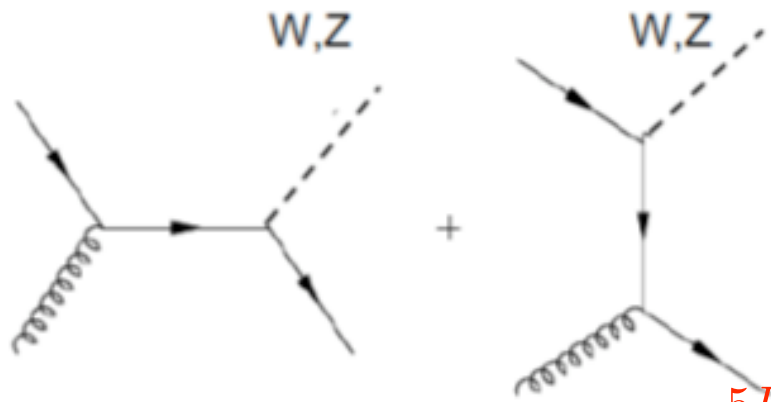
- The differential cross section of $q\bar{q} \to Z/\gamma^* \to \ell^+\ell^-$ at LO

$$\frac{d\sigma}{dM_{\ell\ell}dcos\theta} = N \times [(1+\cos^2\theta) + A_4\cos\theta]$$

- $pp \to Z/\gamma^* \to \ell^+\ell^- + X$ process in NLO : has finite boson P_T



Annihilation diagram $A_0 = A_2 = \dfrac{P_T^2}{M_{\ell\ell}^2 + P_T^2}$

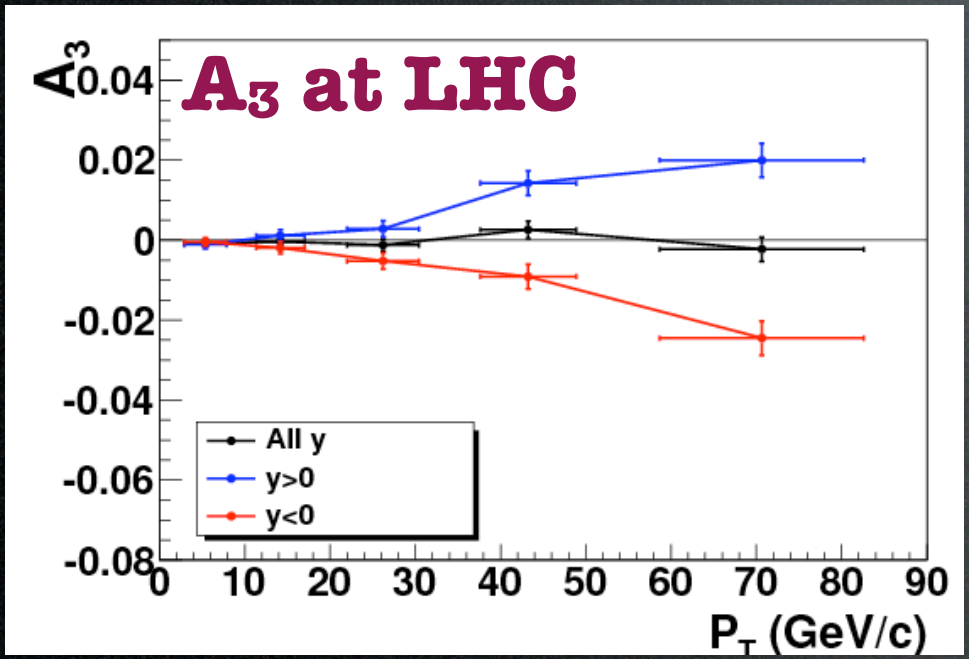


Compton diagram $A_0 = A_2 = \dfrac{5P_T^2}{M_{\ell\ell}^2 + 5P_T^2}$

- A_0 and A_2 prediction in P_T is different in each process
- A measurement of the angular distribution in P_T provide a detailed test of the production
- Lam-Tung relation (A_0=A_2) tests a spin of gluon
  : only valid for vector gluons (spin=1)

Angular Distribution at CMS (LHC)

- LHC is a pp collider : don't know the quark direction
  - y direction of Z boson is used to decide a quark direction
    - More probable that the valance quark carries more momentum
  - Dilution effect :
    - The possibility of wrong direction determination remains
    - The dilution effect decreases in high y
- Angular coefficients in y

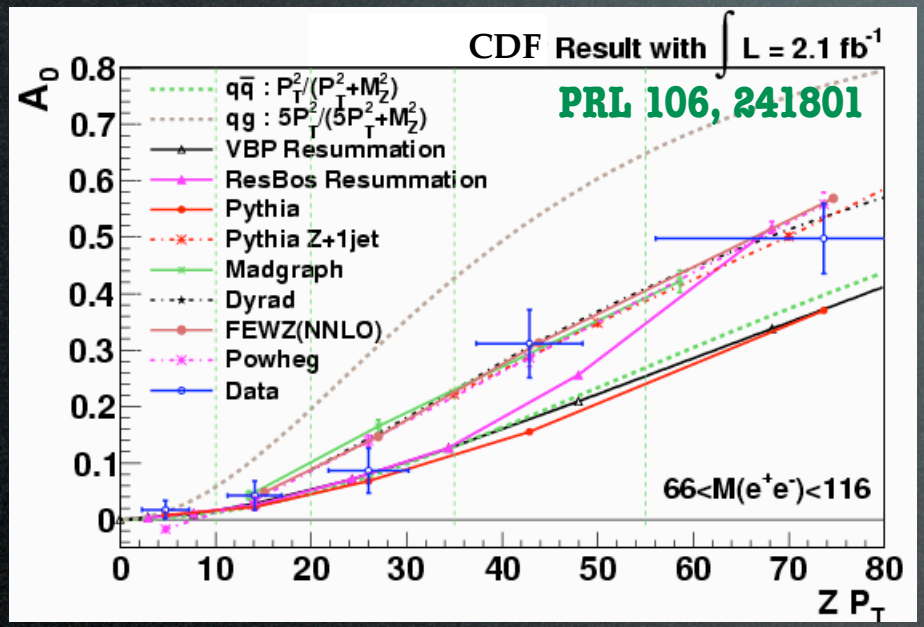


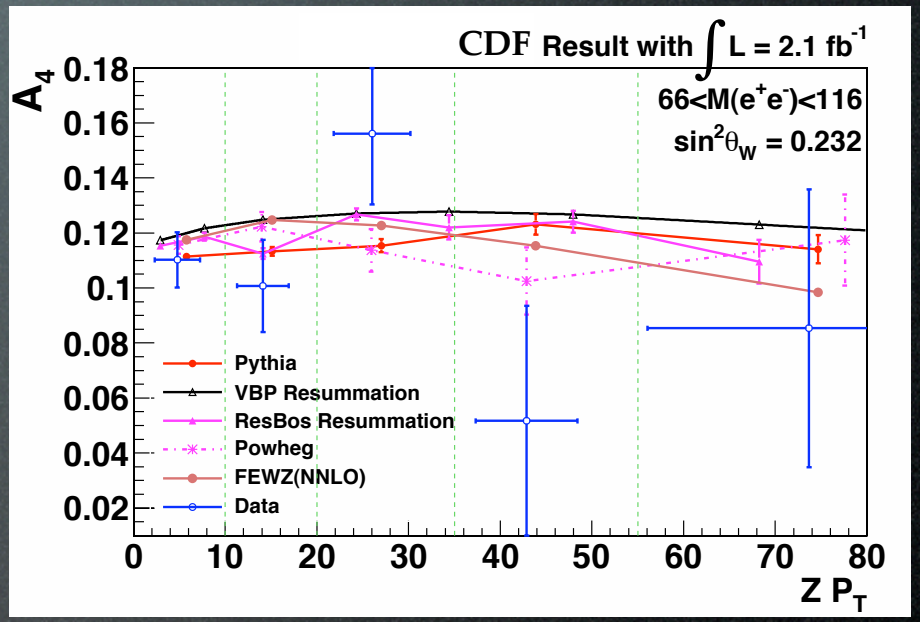
- A_0 and A_2 in Compton process has y and PDFs dependence
- A_1, A_3, A_4 also has y dependence
- Can reduce dilution effect in high y

➠ Angular measurement in y provides better understanding of the mechanism !!

Prospect of the Measurement

- We extract the angular coefficients using max. log likelihood fit
- Event weighting technique is also tested for the measurement
  : Eur. Phys. J.C. by Arie Bodek (arXiv:0911.2850)





- The comparison of the result in LHC vs. Tevatron is useful to test the production mechanisms
  - LHC is expected to have more Compton process
  - Extract the fraction of Annihilation vs. Compton process (A_0, A_2)
  - $\sin^2\theta_W$ can be extracted from A_4 : A_4 in y increases sensitivity
  - Deviation from the expectation might be a hint of new physics

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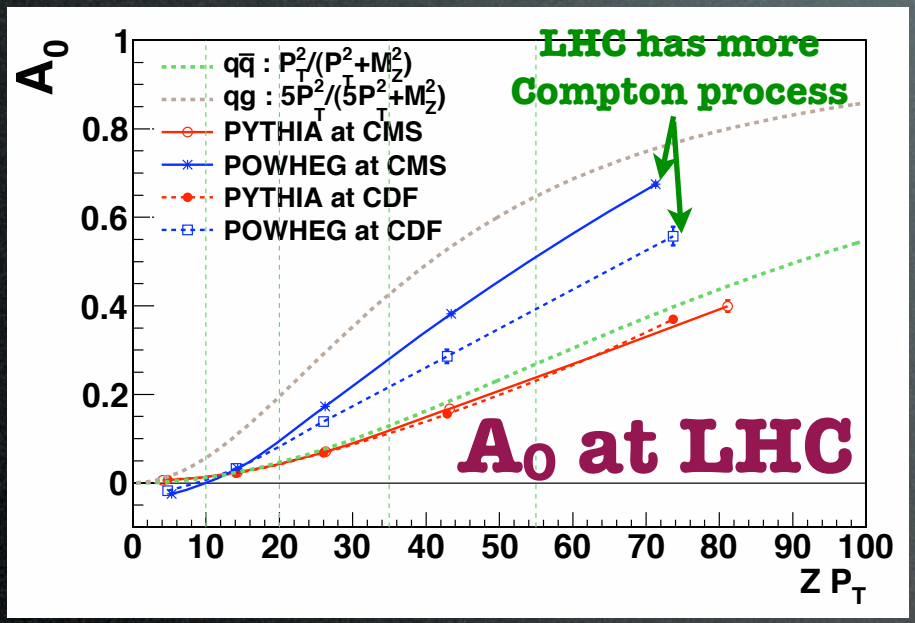

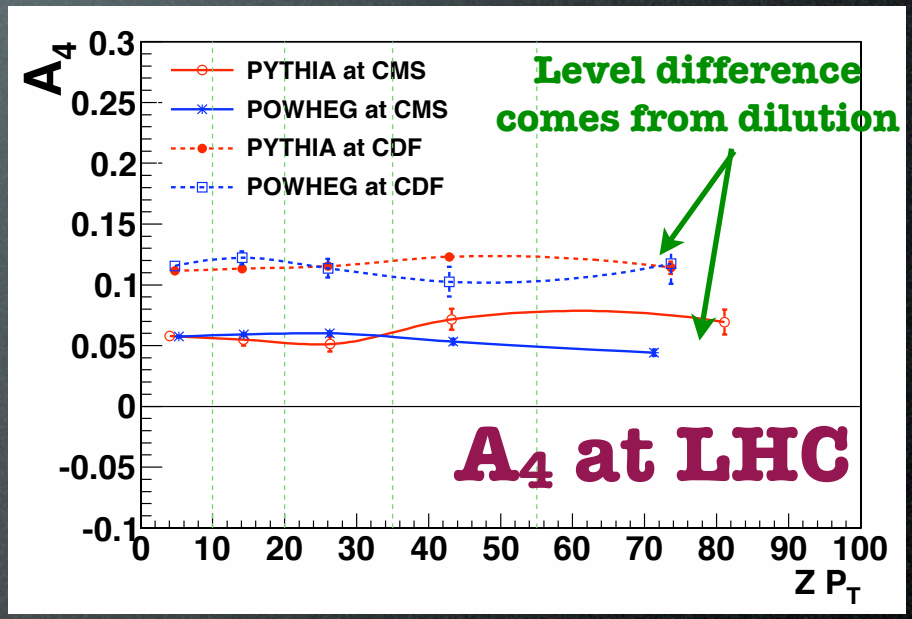

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