

# Understanding uncertainties of resolved photon structure in a photon collider

Hengrui Zhan  
hzhan2@hawk.iit.edu



Based on M.S. thesis, and forthcoming paper with **Zack Sullivan**

# Outline

## 1 Background

- Introduction to linear photon colliders
- Resolved photon process
- The purpose of the research
- Simulation methods

## 2 Analysis of the results

- Breakdown of the total background
- Uncertainties of resolved photon process
- Deeper look into the double resolved processes
- Analysis for the uncertainties of total background

## 3 Conclusion

# Why we need the linear photon collider?

Why linear?

*A linear collider can avoid severe **synchronization radiation loss** in storage rings, and hence can produce photon beams with high energy.*

Why we need a linear photon collider?

*The photon collider was proposed to measure  $h\gamma\gamma$  **coupling** precisely in  $\gamma\gamma \rightarrow h \rightarrow b\bar{b}$  **channel**.*

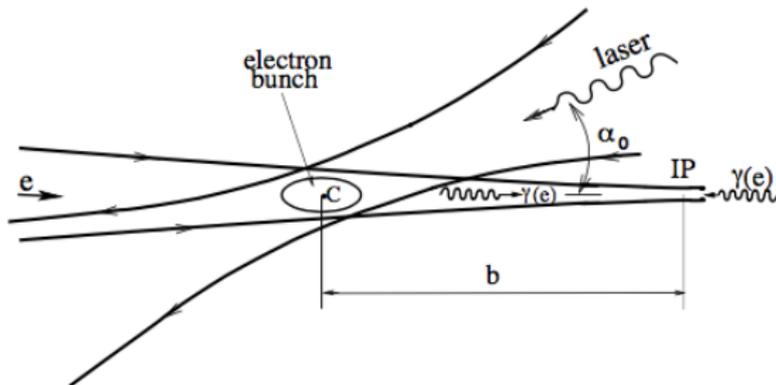
# Major process in a photon collider

**Conversion point (CP):**

*Laser photons Compton backward scatter electrons to create high-energy photons. Produced photons can gain portion of energy up to 80%*

**Interaction point (IP):**

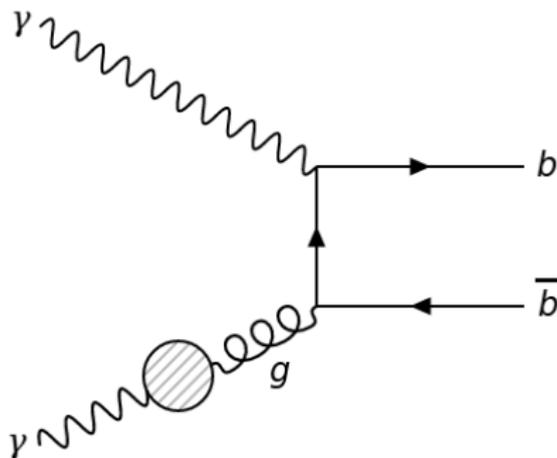
- direct process  $\gamma\gamma \rightarrow b\bar{b}$
- single resolved process  $\gamma h \rightarrow b\bar{b}$
- double resolved process  $b\bar{b} \rightarrow b\bar{b}$ ,  $bb \rightarrow b\bar{b}$ ,  $\bar{b}\bar{b} \rightarrow b\bar{b}$



# Resolved photon process

What is **resolved photon process**?

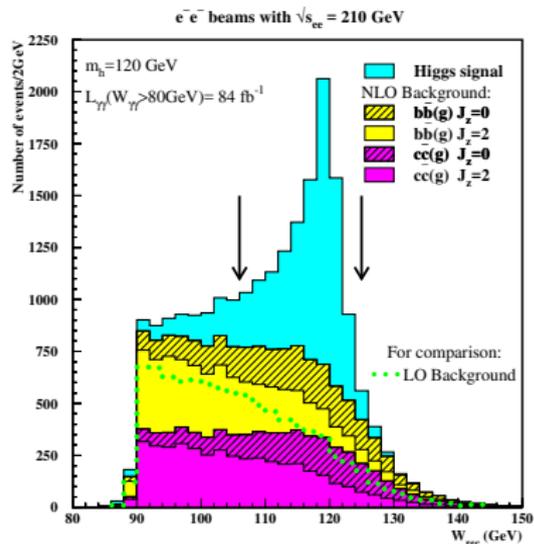
When the energies of the photons are really **large**, the photon can **interact with the vacuum** and split into **quarks, anti-quarks and gluons**. These photons are termed “**resolved**” photons. The process where a produced quark, anti-quark or gluons interact with a photon is called “**single resolved process**”. The process where two produced particles interact is called “**double resolved process**.”



# The purpose of the research

Why do we need to study resolved photon processes?

- Initial predictions ignored resolved photon background to  $b\bar{b}$  jets
- Contributions from resolved photon processes are considered to be the major background of measurement.
- we still do not know how big is the resolved photon production of  $b\bar{b}$



Niezurawski, Zarnecki, Krawczyk,

hep-ph/0208234

# Simulation methods

How well can we predict that result?

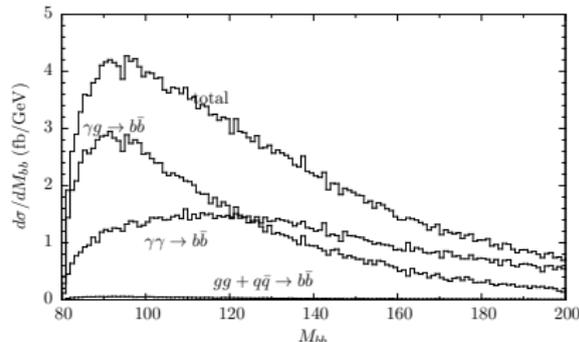
Solution: Create a new set of PDFs that combine photon luminosities with resolved photon PDF errors: call it "ECJK".

How **ECJK** works?

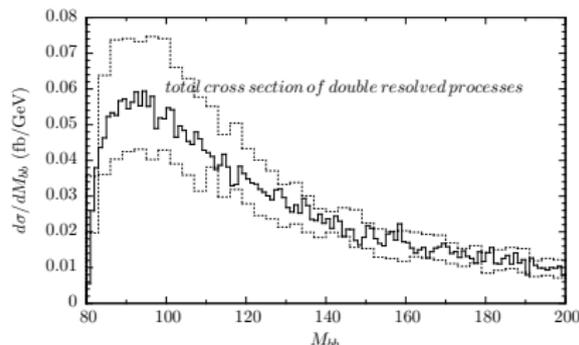
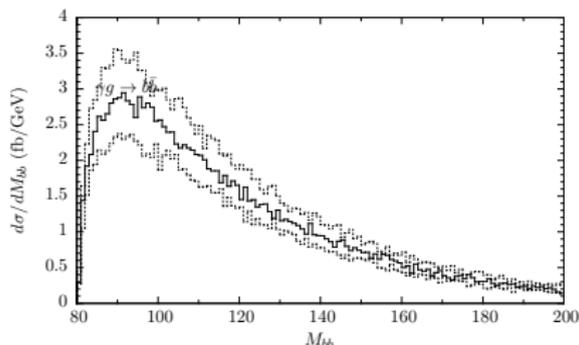
- For the **direct process**: **CompAZ** parametrization can provide the luminosity of the direct process. **CompAZ** is a routine of spectra parametrization which has considered nonlinear effect, angular correlation, electron rescattering, scattering of two laser photons.
- For the **resolved photon process**: Use **CompAZ** calculate the distribution of produced photon, then use **CJKL model** to calculate the luminosities of resolved photon process, based on the distribution of produced photons
- CTEQ generates the positive and negative uncertainties

# Breakdown of the total background

- electron beam energies: 250 GeV
- Cuts:  $p_{Tb} > 40$  GeV,  $|\eta_b| < 4$
- Construct  $M_{bb}$
- The **single resolved process** contribute most in the range from 80 GeV to approximately 120-130 GeV.
- The **direct process** contribute most after about 120-130 GeV.
- The **direct process** and **single resolved process** cross at higgs mass.
- The contribution from **double resolved process** is negligible compare to other two kinds of contributions

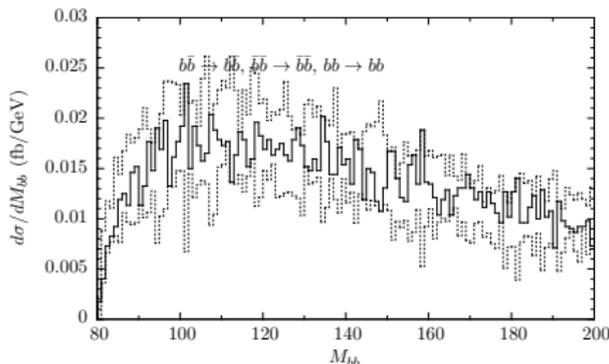
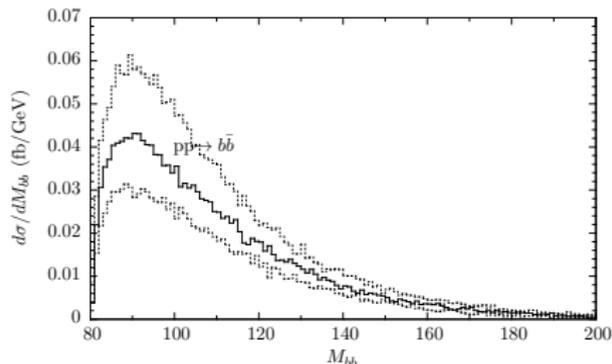


# Uncertainties of resolved photon process



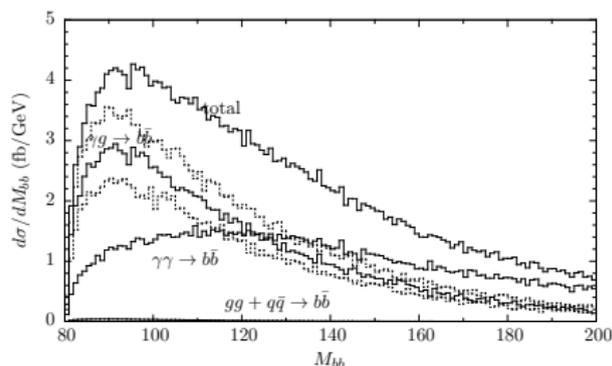
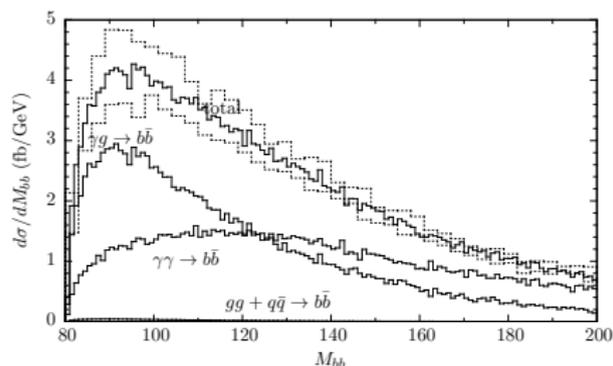
- All the **upper dash lines** represent the value with **positive errors**, while the **lower ones** represent the value with **negative errors**.
- The cross section of **single resolved process** achieves its **maximum** at about 90-100GeV. The **fractional uncertainty** remains **nearly constant** in the considered range
- The cross section of **double resolved process** achieves its **maximum** at about 90-100GeV. The **fractional uncertainty** does not remain stable in the considered range.

# Deeper look into the double resolved processes



- The parton-parton cross section ( $pp \rightarrow b\bar{b}$ ) is small, with a relatively constant fractional uncertainty.
- A significant contribution to the double-resolved process comes from  $b$  partons ( $b\bar{b} \rightarrow b\bar{b}$ ,  $bb \rightarrow bb$ ,  $\bar{b}\bar{b} \rightarrow \bar{b}\bar{b}$ ).
- The uncertainty prediction for  $b$ -initiated processes is poorly estimated.

# Analysis for the uncertainties of total background



- At 90GeV to 100GeV. The total background has **maximum value** of about 4.2fb/GeV, with **positive error** of about 0.6fb/GeV (about 14% of total background) and **negative error** of about  $-0.6$ fb/GeV
- The **direct process** does **not** contribute any uncertainty to the total background.
- The **single resolved process** contribute **most** of the uncertainty to the total background.

# Conclusion

- A new PDF for resolved photons (with errors) *including* photon spectra has been produced
- ECJK PDF sets will be publicly released this summer
- The model still need to be improved
- Photon colliders would provide a precise test of the  $h\gamma\gamma$  coupling
- Photon colliders can measure our uncertainty of photon structure!

Thank you for your attention!