Understanding LIGHT

Why we need a terascale photon collider

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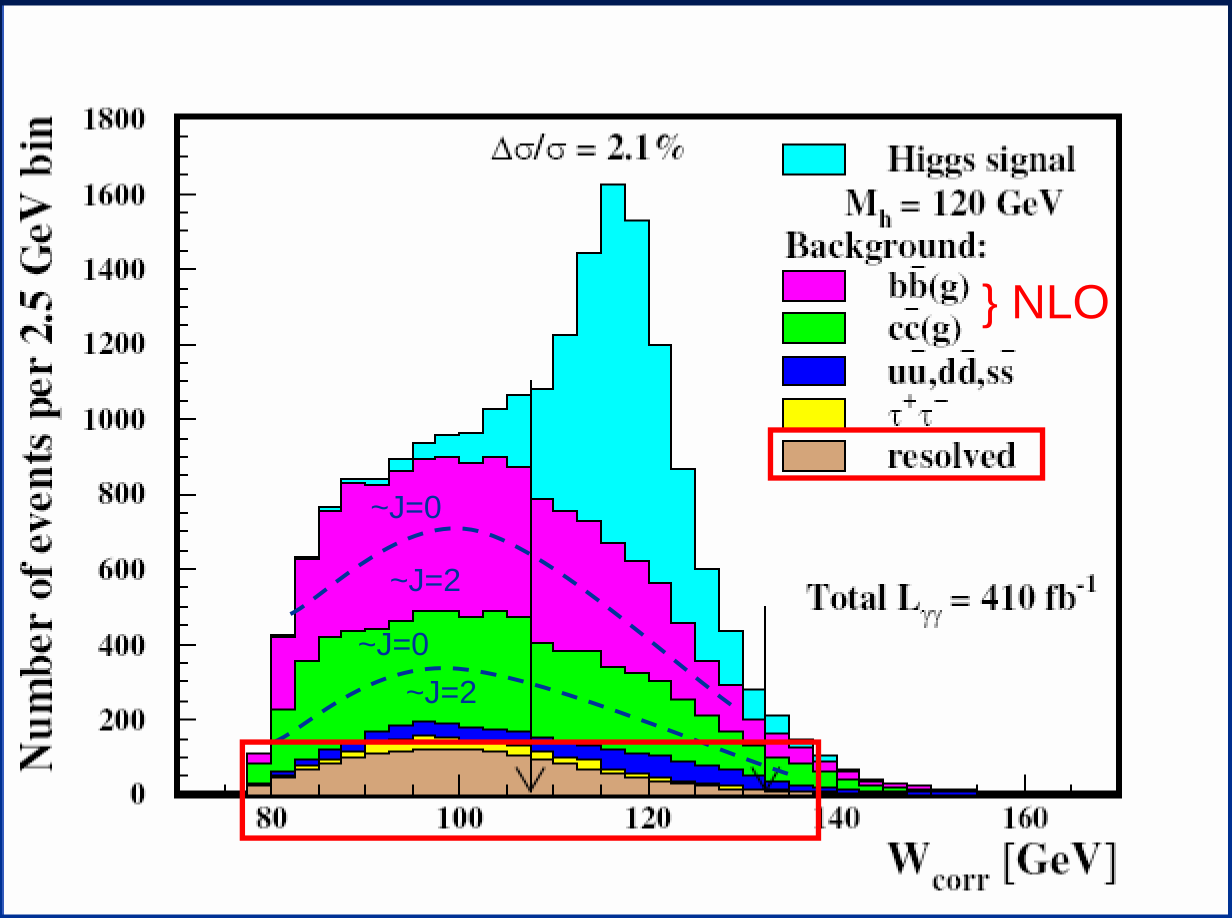
Outline

1. Precision Higgs — the usual suspect
2. $b\bar{b}$ production as a window on light
3. What can we say about it now?
4. Conclusions

Precision Higgs



Measure:

$\Gamma(h\to\gamma\gamma)$~2%

$\Gamma_{tot}(h)$ ~10%

- NLO bb/cc:
  J=0 ≈ J=2
  - J=0 really LO
- How big is the resolved term?

P. Nieżurawski, A. F. Żarnecki, M. Krawczyk
presented by J. Ciborowski

WE DO NOT UNDERSTAND

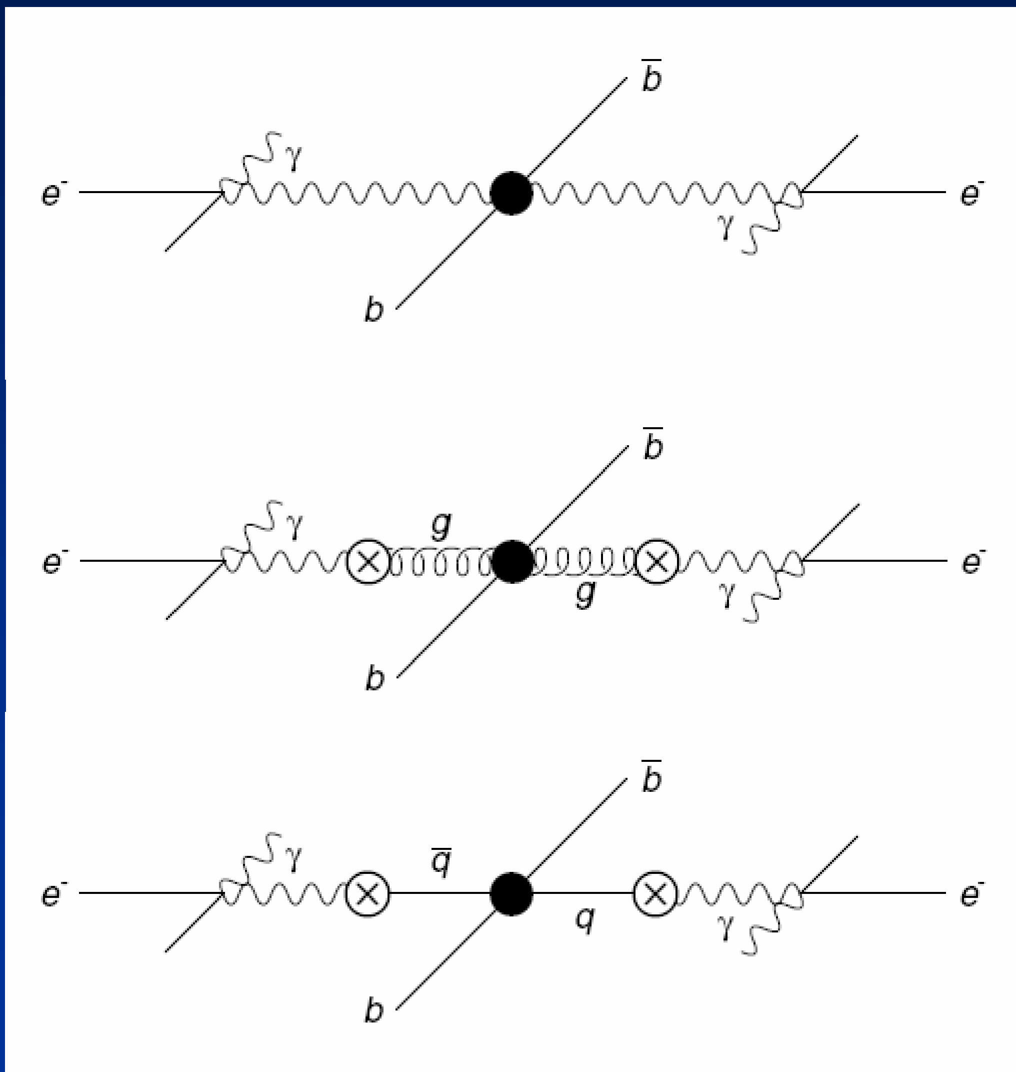
LIGHT

WE DO NOT UNDERSTAND

(the apparent structure of)

LIGHT

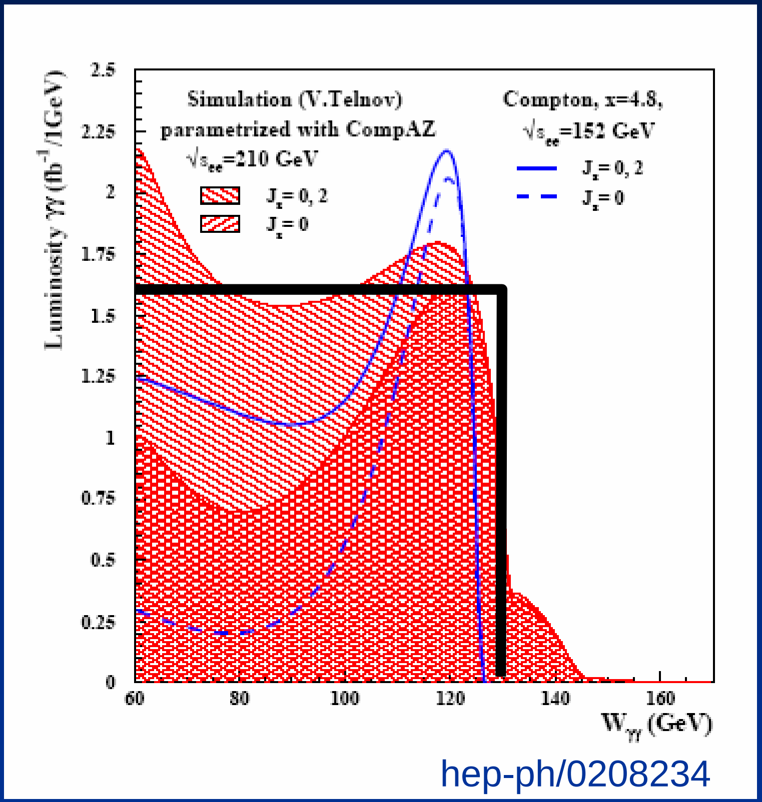
$b\bar{b}$ production through direct and resolved photons



Direct

Resolved

Photon spectrum and simulation



Full $\gamma\gamma$ spectrum is flatter than predicted by Compton scattering alone.

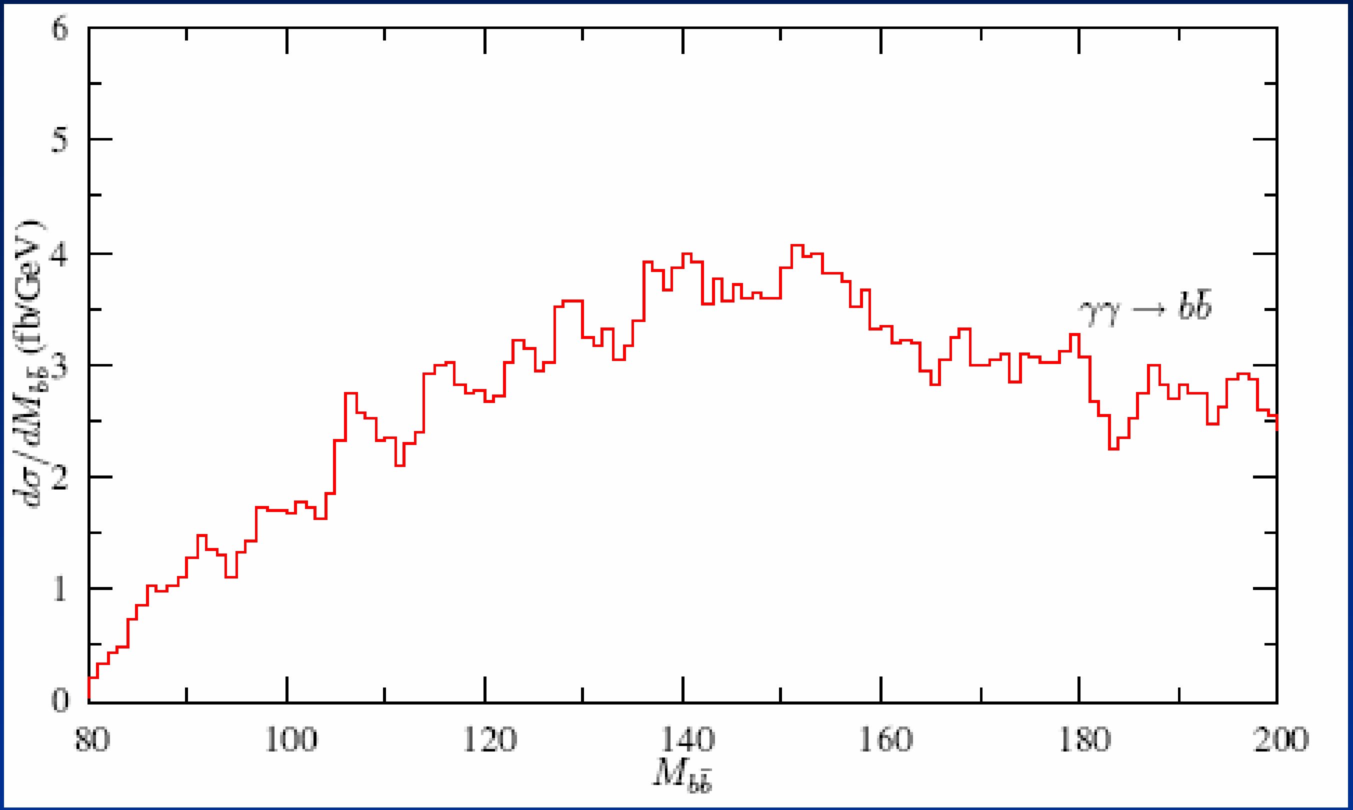
- $\sqrt{S_{ee}}$ = 500 GeV
  - $W\gamma\gamma$ = 50-400 GeV
  - $E\gamma$ = 25-200 GeV, using a flat spectrum
  - Results insensitive to actual shape
- Cuts

  E_{Tb} > 40 GeV, $|\eta_b| < 4$

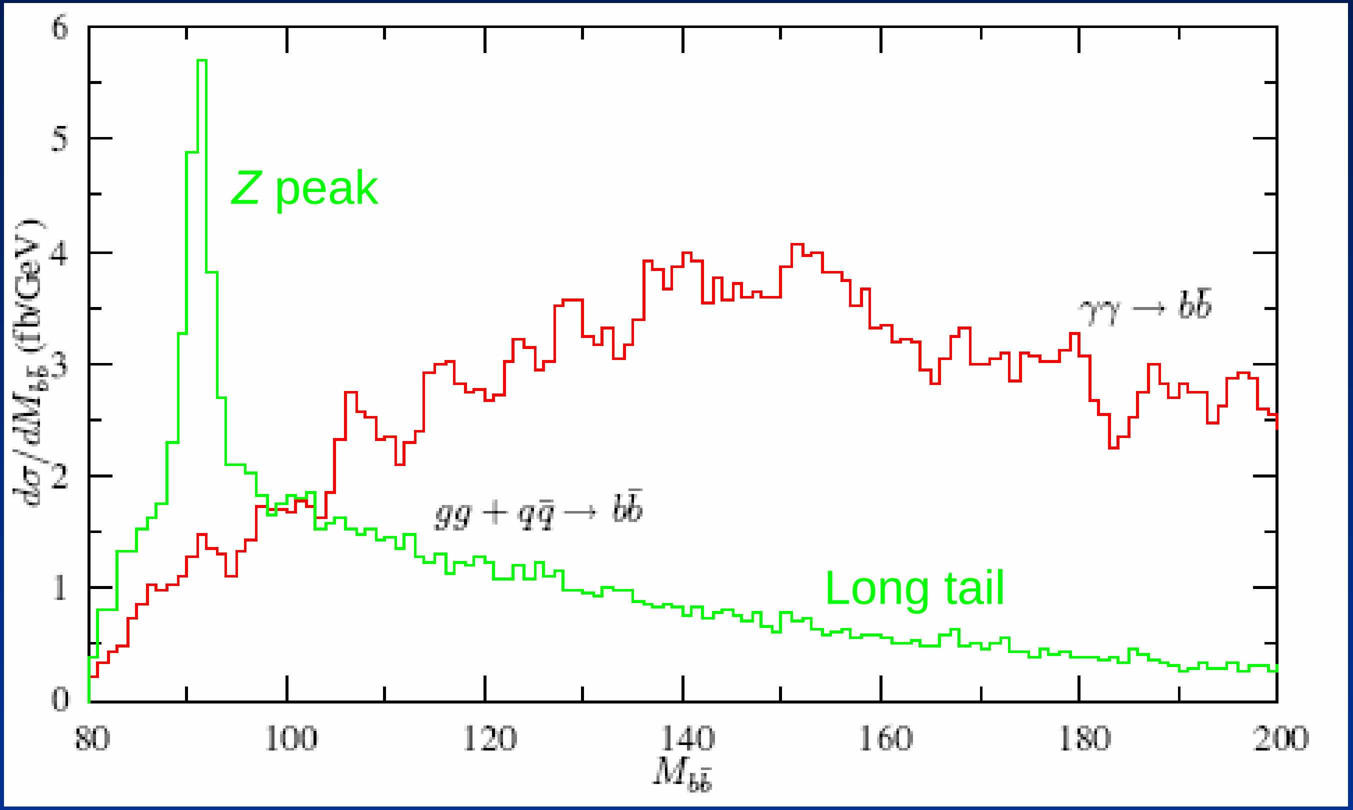
  ΔR_{iso} = 0.1

  M_{bb} > 80 GeV

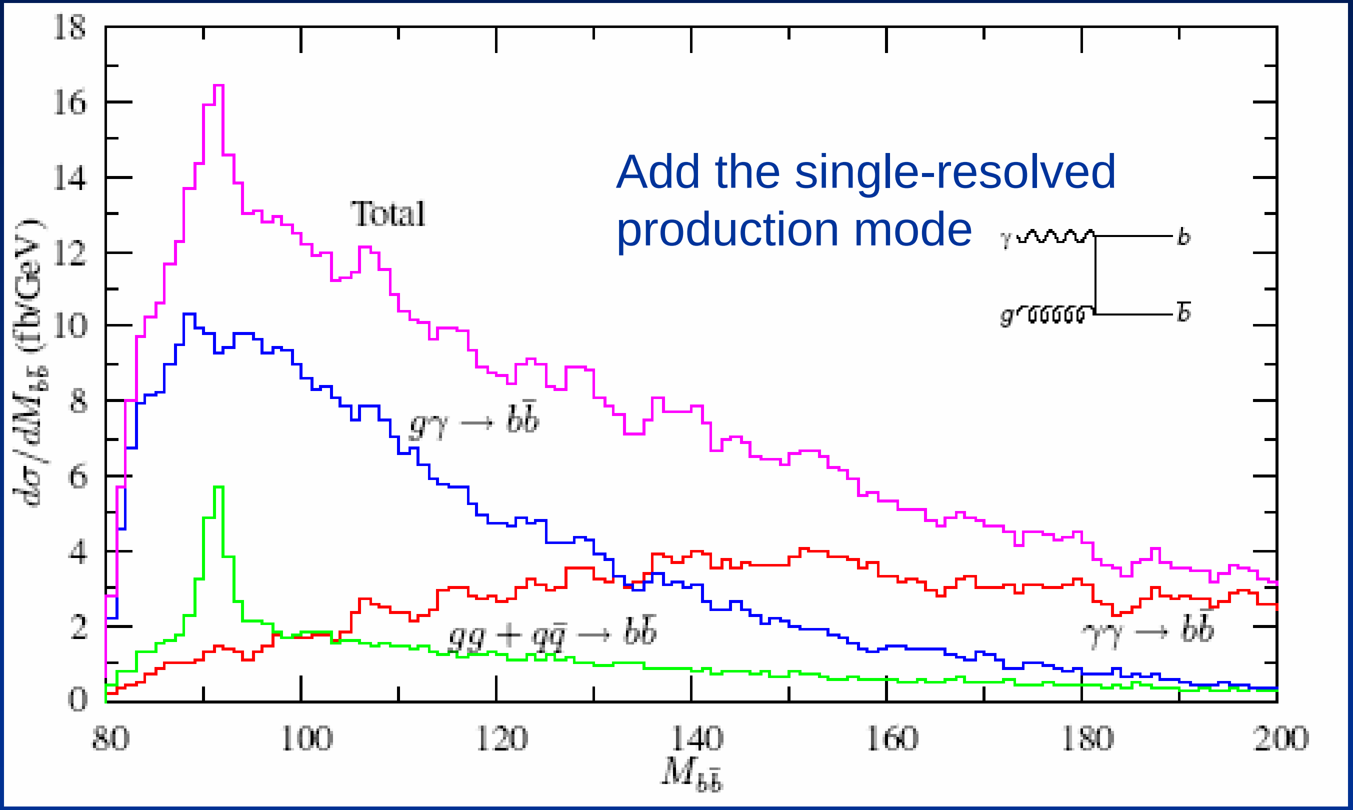
bb cross section



bb cross section



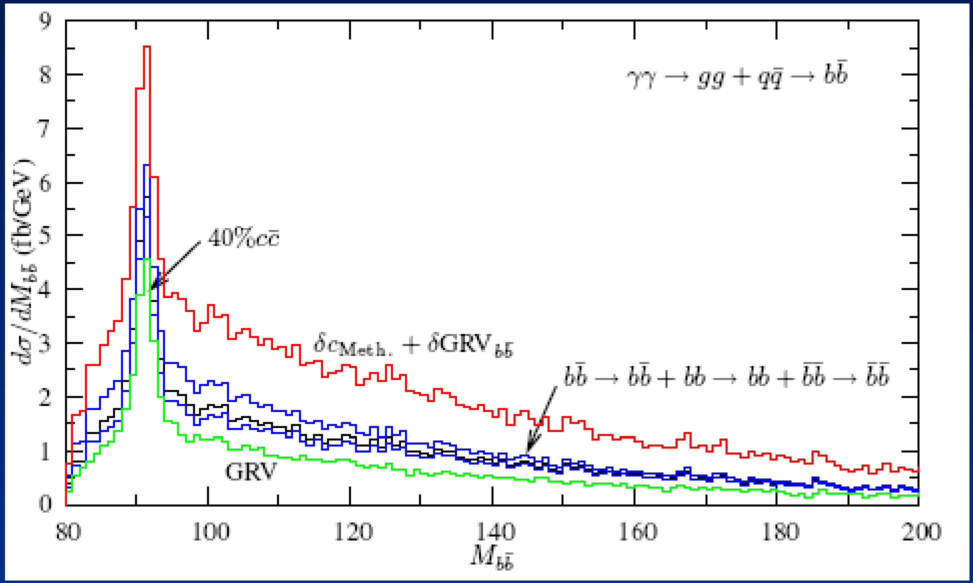
bb cross section



The single-resolved mode completely dominates the cross section below $\sim \frac{1}{3} W_{\gamma\gamma}^{\max}$.

Uncertainty in resolved-resolved cross section

- CJK2 LO PDFs
  - Error calculation is based on Hessian matrix method

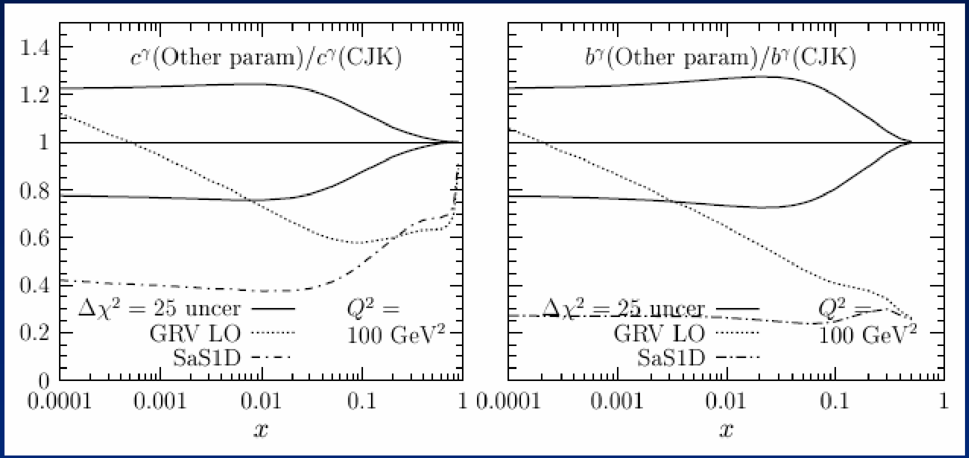


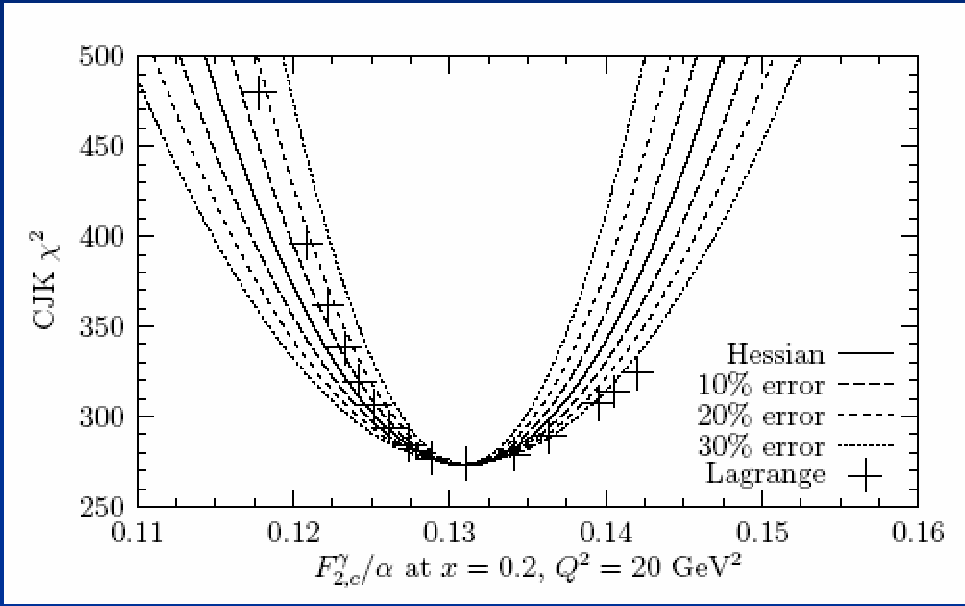
- For observables use a "modified tolerance method" ZS, PRD 66, 075011 (02)

$$\delta\sigma_{\pm} = \frac{T}{10}\sqrt{\Sigma_i\left(\sigma_i - \sigma_0\right)^2\big|_{\sigma_i > \sigma_0}}$$

  - Assumes fit parameters can be mapped to a hypersphere – Hessian distribution.

CJK2 vs. GRV / Hessian vs. Lagrange

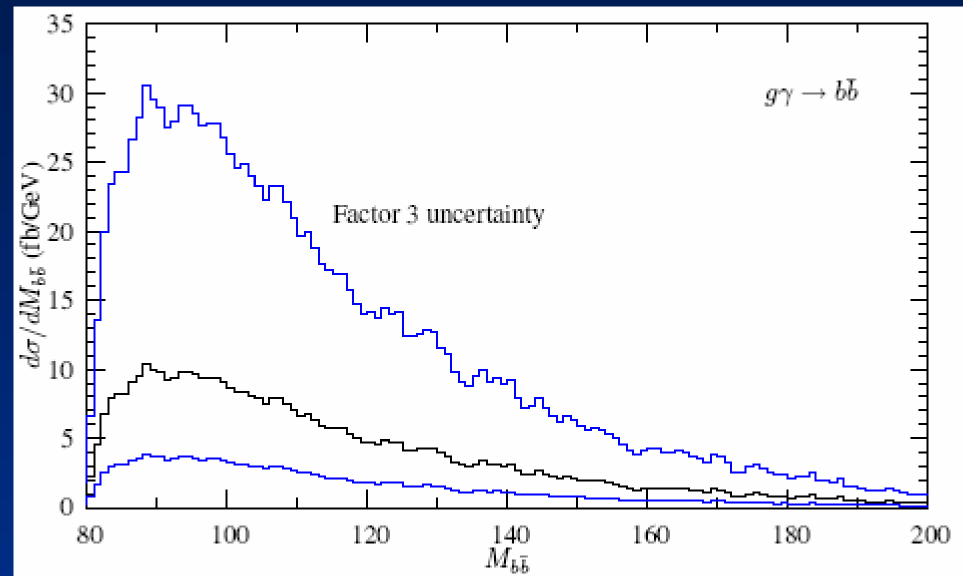




- *c*, *b* PDFs differ significantly at large *x*. Well beyond estimated uncertainties.
- Already at 4 GeV, the *c* (*b*?) are not really Hessian any longer.

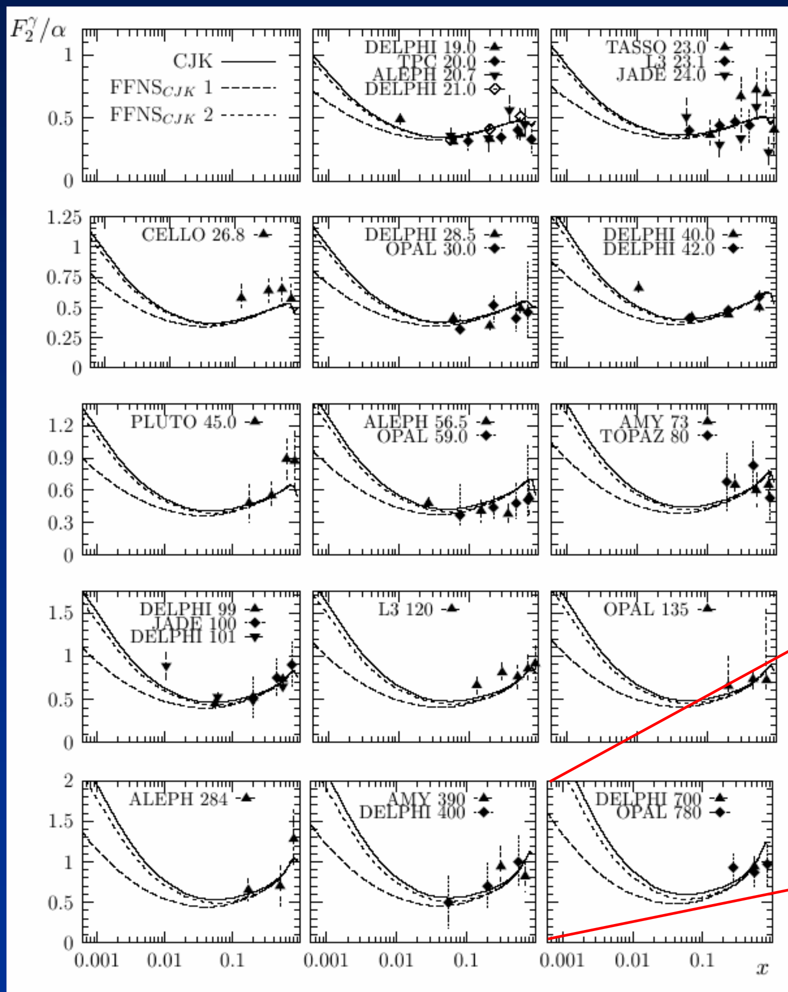
Uncertainty in $g\gamma \to b\bar{b}$

- Huge uncertainty in the gluon PDF.
  - Very little data to constrain it.
- Tolerance T is much larger for the gluon.



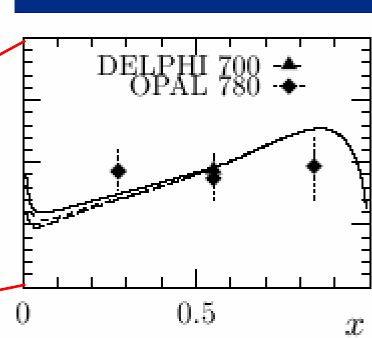
	$T(G^\gamma)$	$T(d^\gamma)$	$T(u^\gamma)$	$T(s^\gamma)$	$T(F_2^\gamma)$
$1 \leq Q^2 \leq 100$ GeV^2	4.5	7.0	7.0	3.4	8
$1 \leq Q^2 \leq 1000$ GeV^2	14.0	7.0	7.0	3.4	10.5
$1 \leq Q^2 \leq 200000$ GeV^2	138.0	7.0	7.0	3.4	20.0

Summary of fit data

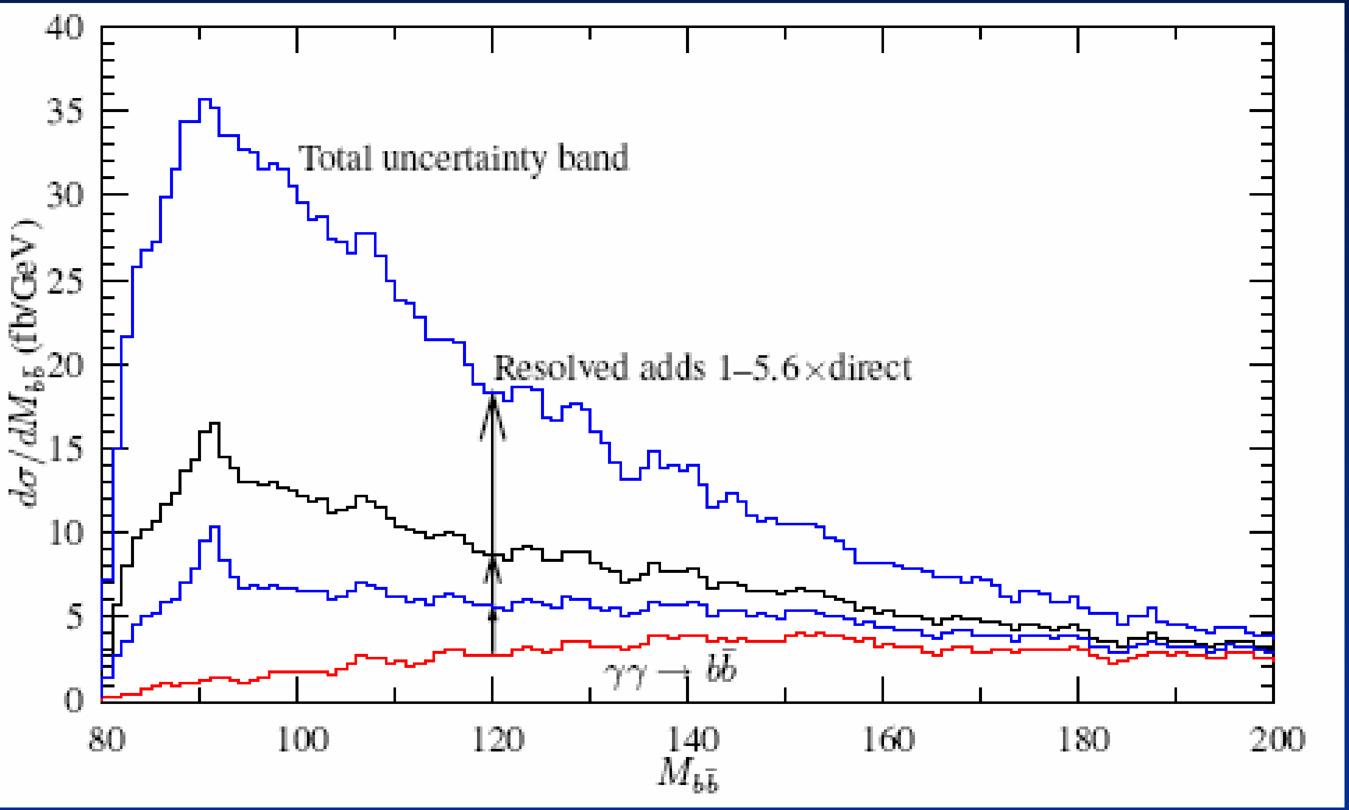


model	χ^2 (182 pts)	χ^2/DOF
CJK	273.7	1.537

- Full F_2^γ fit is <1% consistent
- At ~90 GeV, only 1 point actually fits
  - Mostly *u*, *c* quarks here

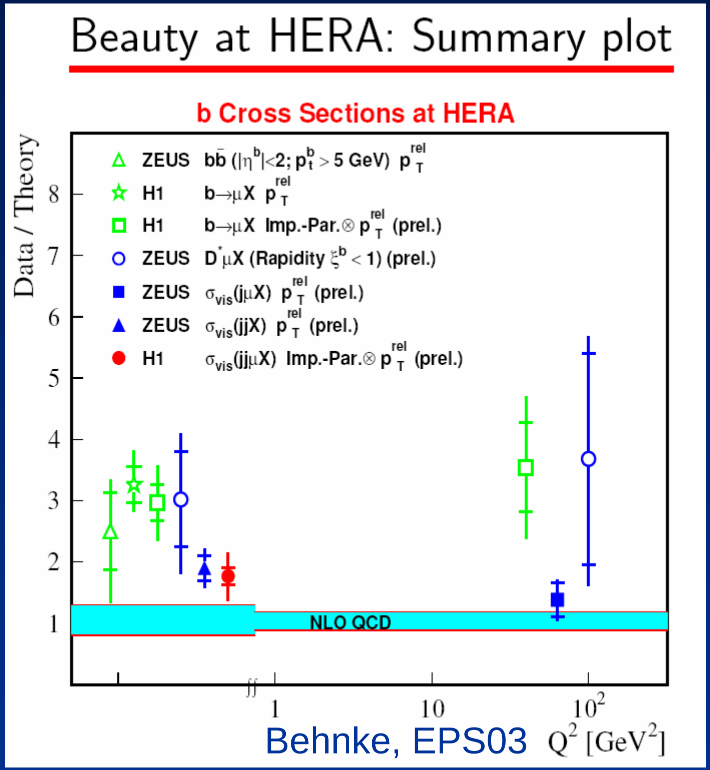


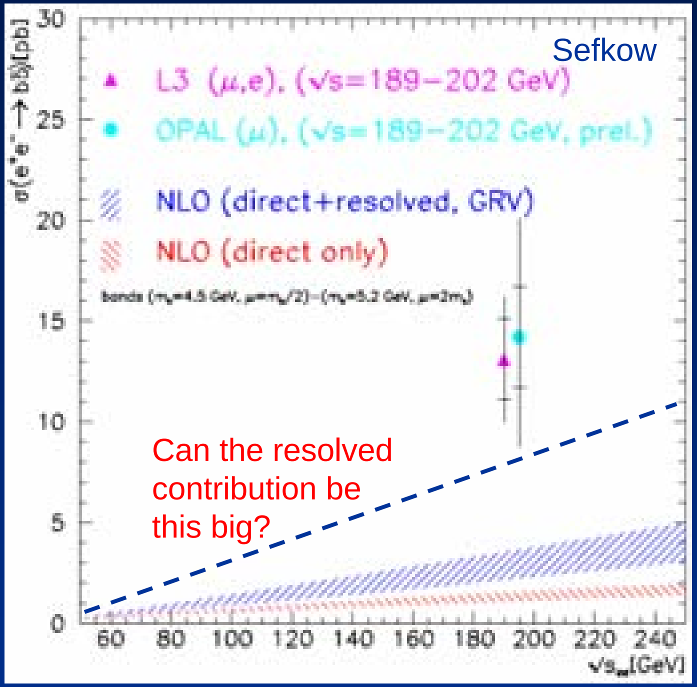
Total uncertainty for *bb*



- This will only be improved by direct measurement at a real photon collider.

$b\bar{b}$ at HERA / LEP





- Theory underestimates the cross section at both HERA and LEP by factors of 2-3!
- It seems likely this is partially due to additional resolved photons.

Conclusions

- Below $\sim \frac{1}{3} W_{\gamma\gamma}^{\max}$, theorists should think of $\gamma\gamma$ colliders as clean hadron colliders.
- In order to predict cross sections to better than factors of 5, we must measure the structure of the photon *in situ*.
- Today we do not understand LIGHT,

  but with a terascale photon collider,

  WE WILL

Extra Slides

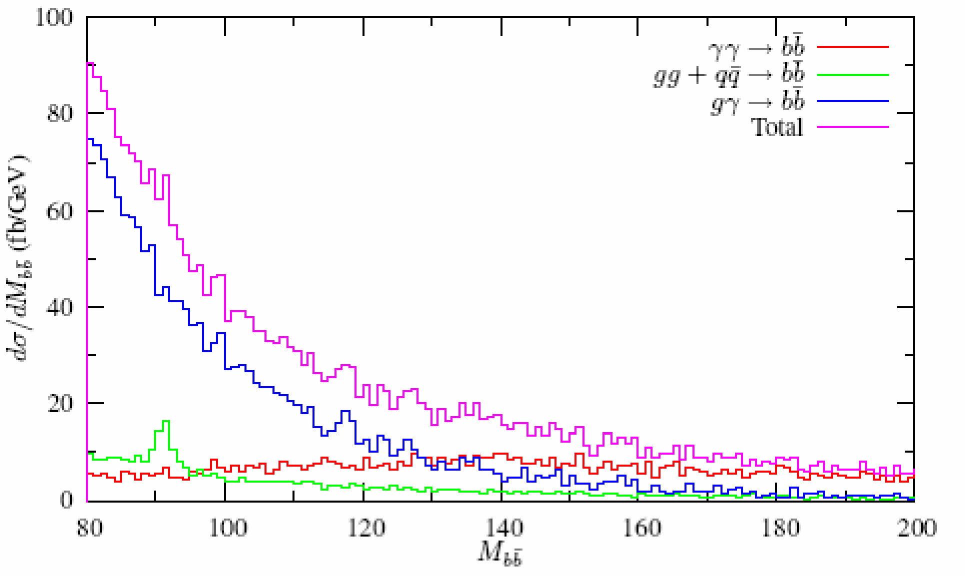
$b\bar{b}$ cross section with lower cuts

- S_{ee} = 500 GeV
  - $W_{\gamma\gamma}$ = 50-400 GeV
  - E_γ = 25-200 GeV, using a flat spectrum
- Cuts

  E_{Tb} > 15 GeV, $|\eta_b| < 4$

  $\Delta R_{iso} = 0.1$

  M_{bb} > 80 GeV



- Looser cuts fill in direct production near M_{bb} ~80 GeV, but $g\gamma \to b\bar{b}$ grows much more quickly.