Diphoton and photon +b/c production

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On behalf of the CDF Collaboration

Outline

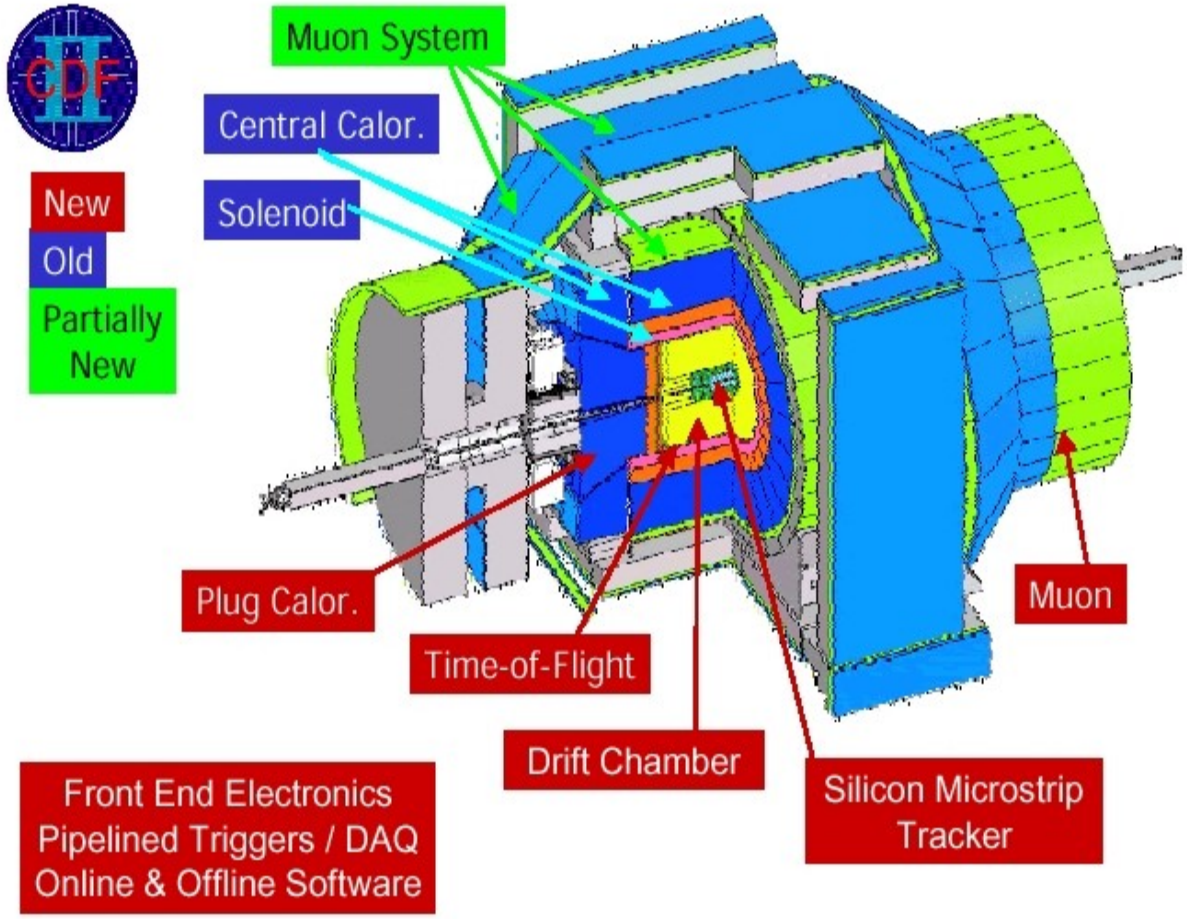
- **The CDF detector**
  - Overview
  - Integrated luminosity
  - Photon identification
- **Diphoton production**
- **Photon + b/c production**

CDF Detector

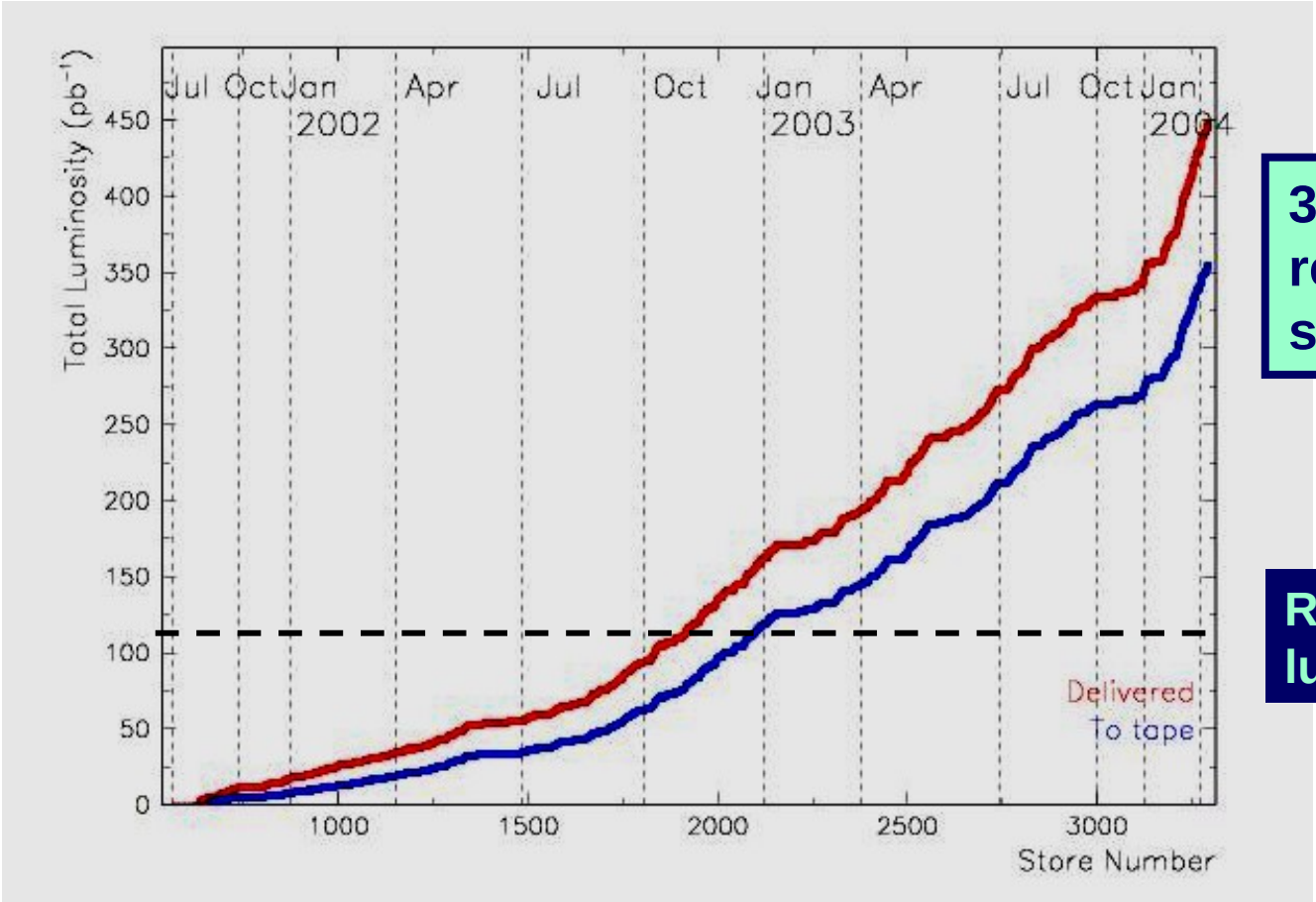
Run 2:

New tracking detectors

Calorimetry coverage extended



CDF luminosity

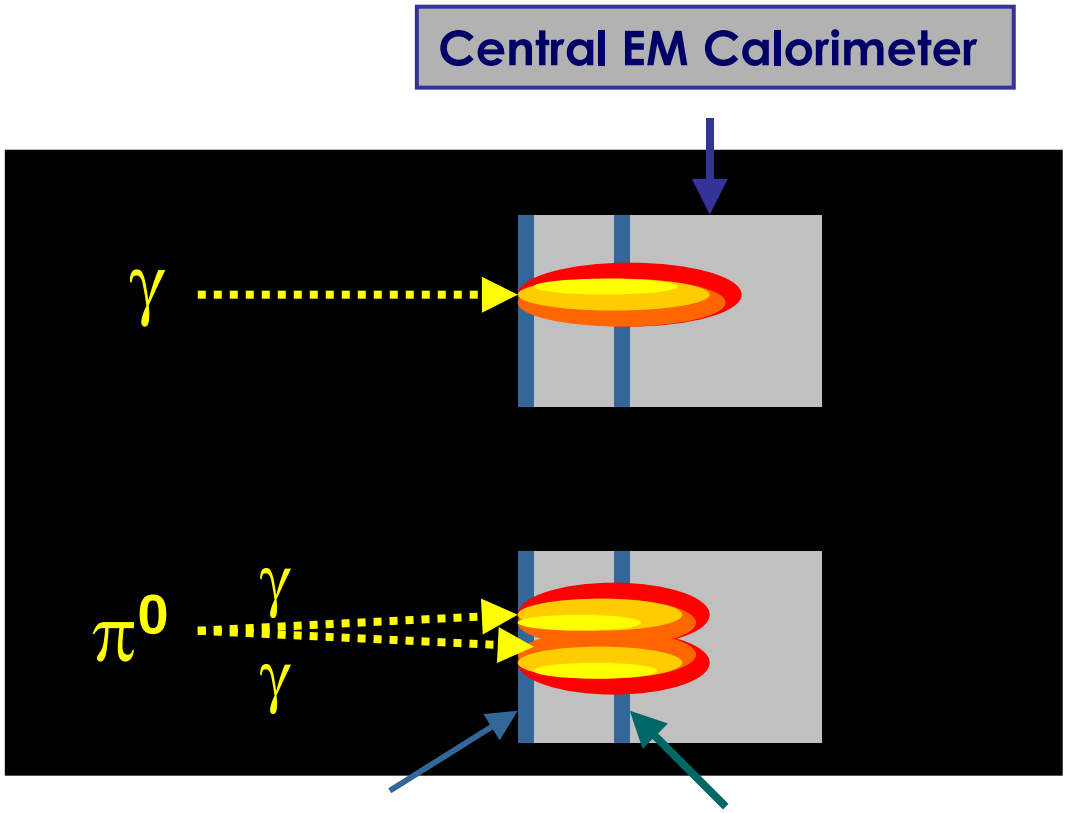


300 pb^{-1} recorded so far

Run 1 lumi

Between ~67 and 207 pb^{-1} used in analyses presented here

γ identification at CDF



Signal: Isolated electromagnetic showers in the calorimeter, no associated track

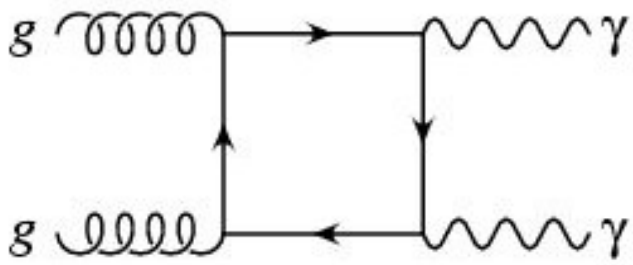
Background: $\pi^0 \to \gamma\gamma$, Also K^0_s, η decays

$\gamma + \gamma$ production

Test of QCD

Background to $H \rightarrow \gamma\gamma$

Possible signature of New Physics (eg. Supersymmetry)



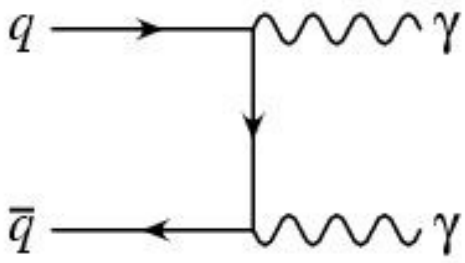
Low $M_{\gamma\gamma}$

γ_1 (γ_2) Et > 14 (13) GeV inside $|\eta|<1$

Subtract background

Measure cross-section as function $M_{\gamma\gamma}$

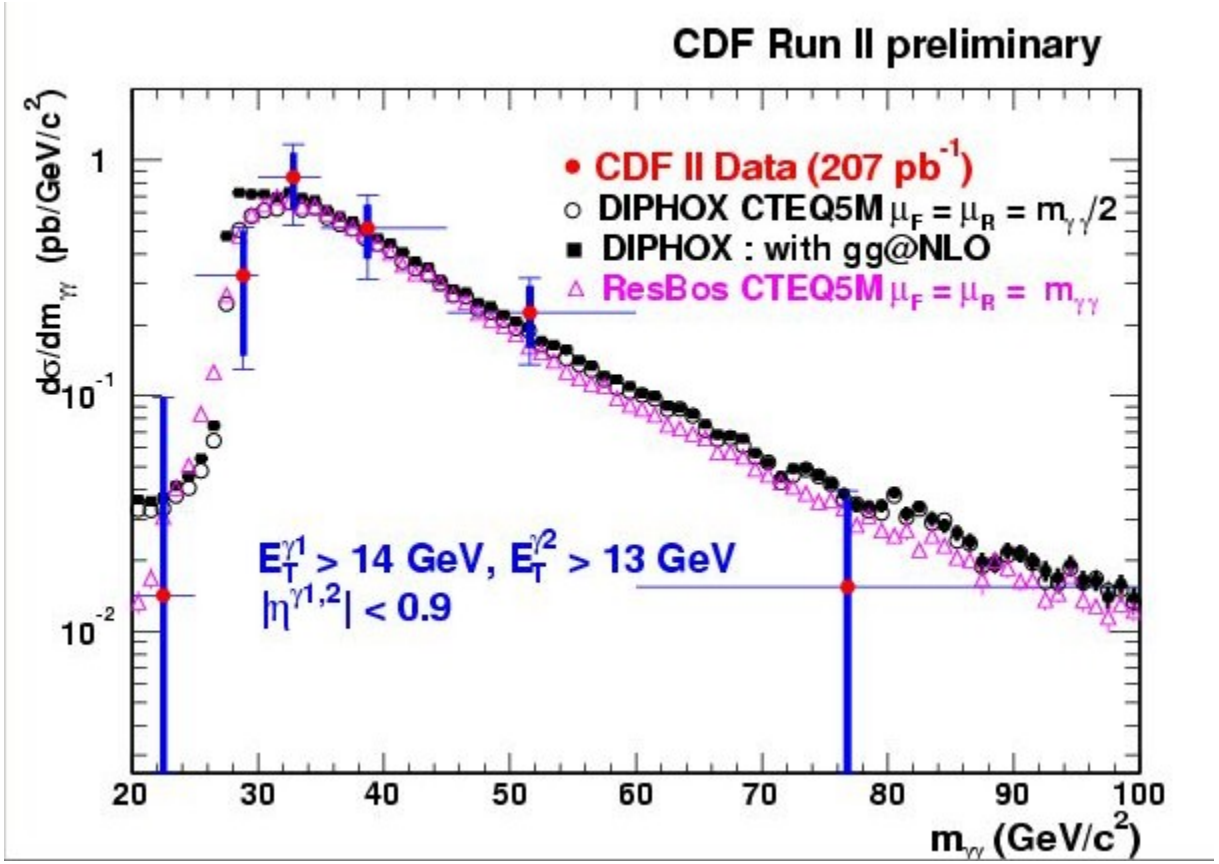
Compare to NLO (DIPHOX, Resbos)



High $M_{\gamma\gamma}$

$\gamma + \gamma$ production

Results consistent with NLO predictions



$\gamma + \gamma$ production

DIPHOX includes NLO fragmentation

ResBos just LO

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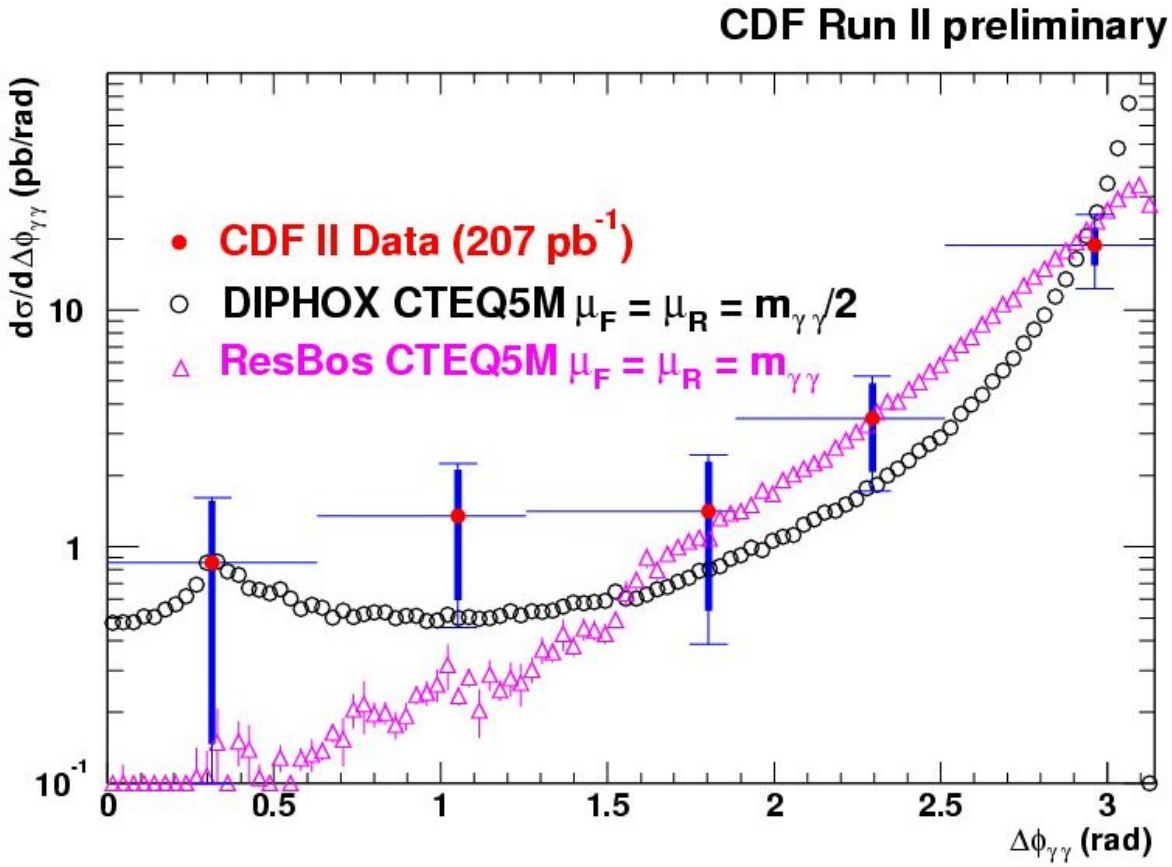
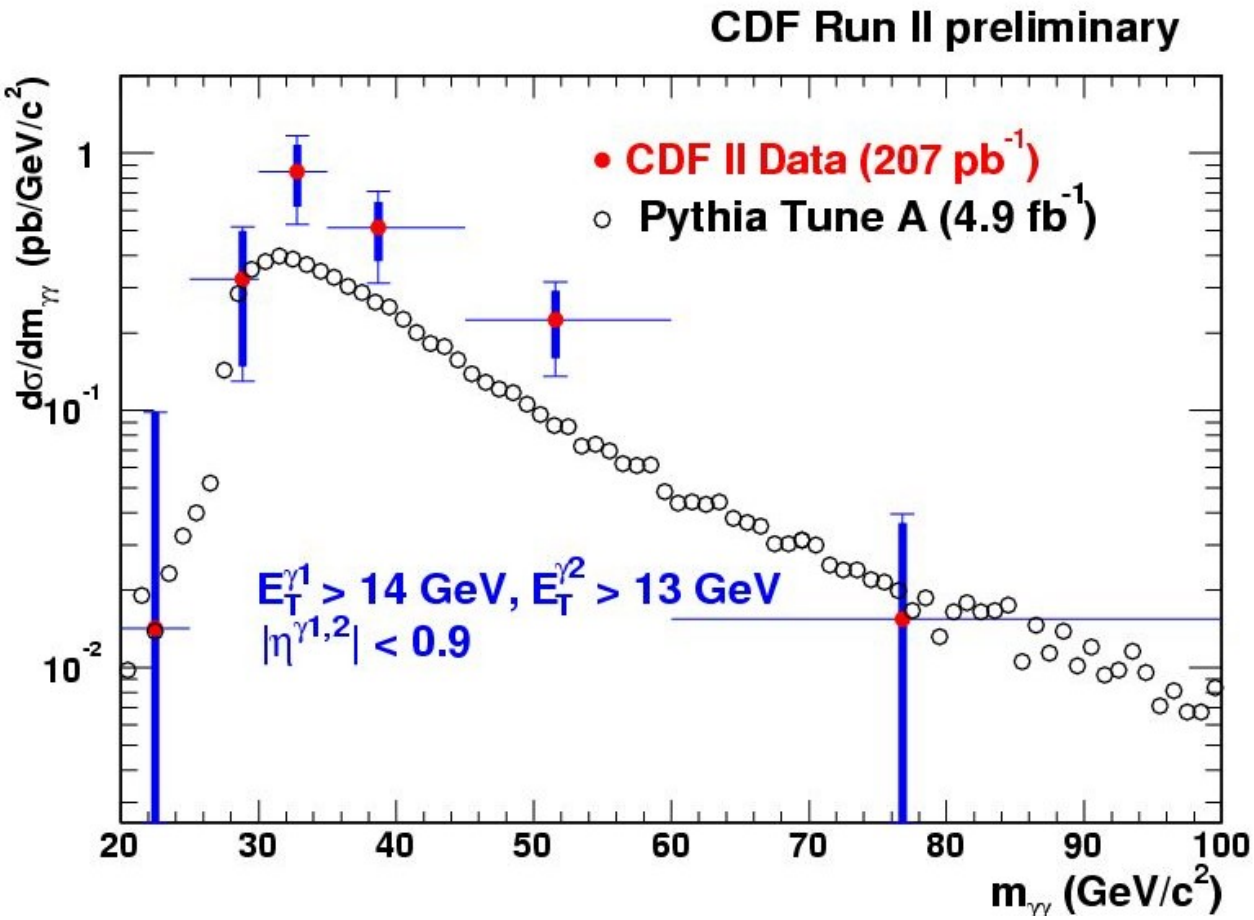


$\gamma + \gamma$ production

Poor agreement with (LO) Pythia



γ + b / γ + c production

Test of QCD (heavy flavour production)

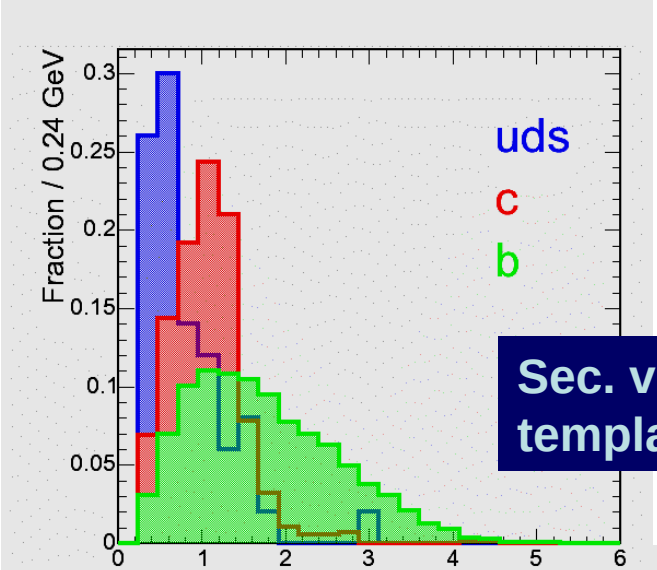
Charm content of proton

Possible signature of New Physics (eg. Supersymmetry)

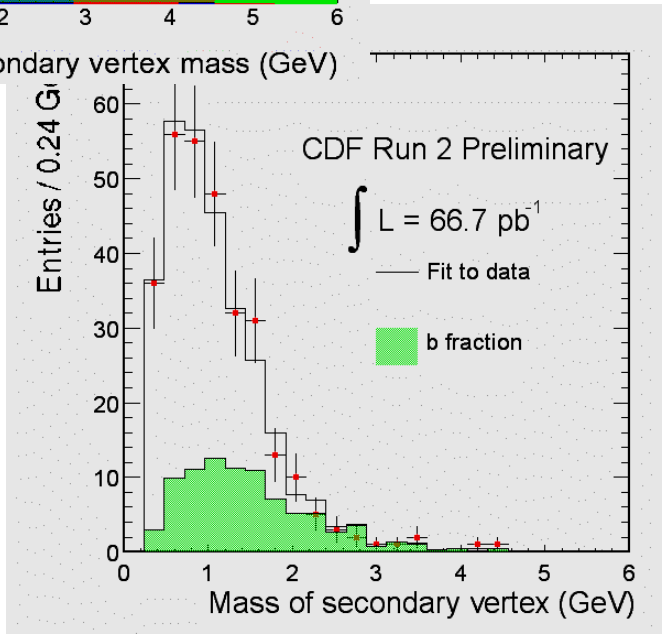
γ Et > 25 GeV ($|\eta|<1.0$) + jet with secondary vertex

Determine b, c, uds contributions (fit secondary vertex mass)

Subtract bkg, find cross-section as fn. γ Et

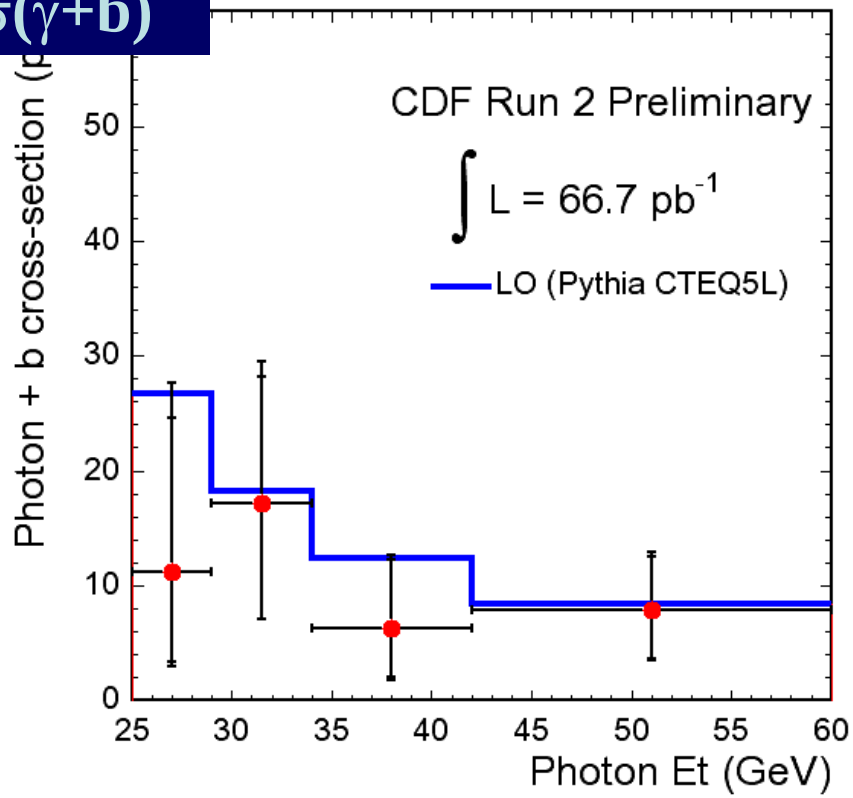


Sec. vertex mass templates

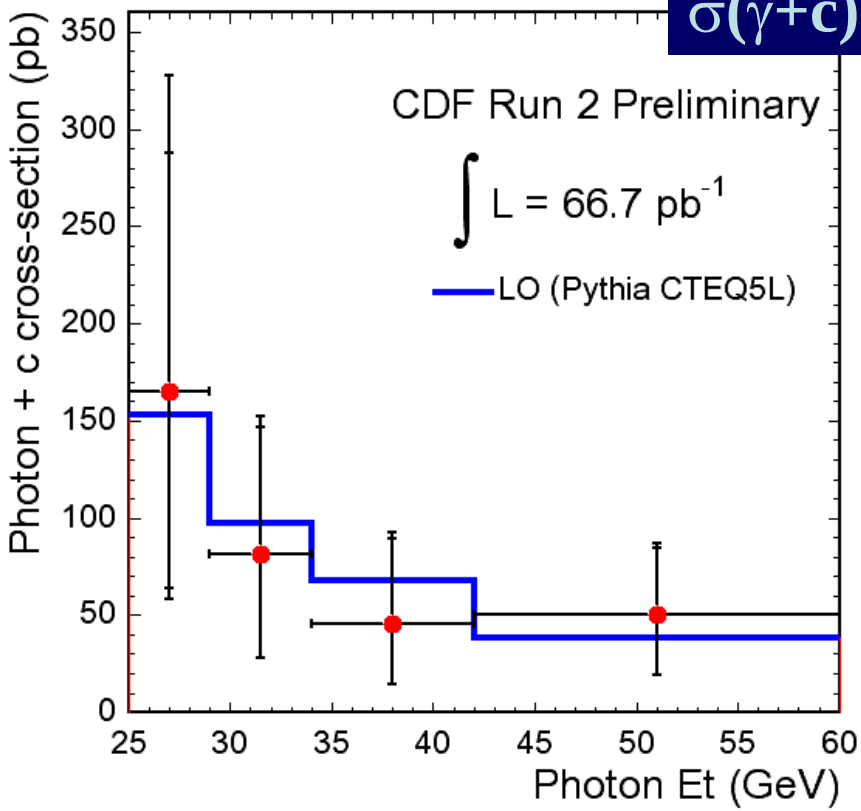


γ + b / γ + c production

σ(γ+b)



σ(γ+c)



Results consistent with LO

$\sigma(\gamma + c) / \sigma(\gamma + b)$

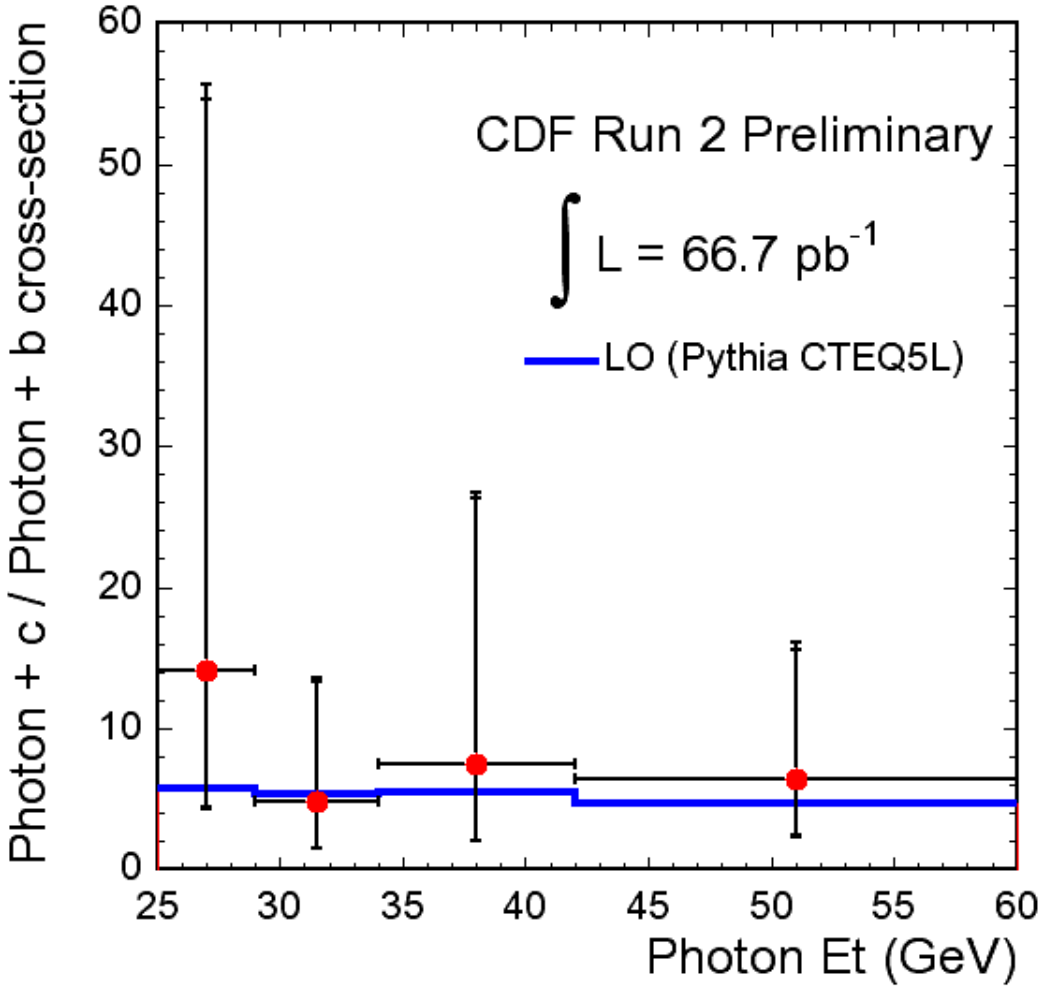
Ratio consistent with LO

Future Improvements

More statistics

Comparison to NLO

Limits on SUSY

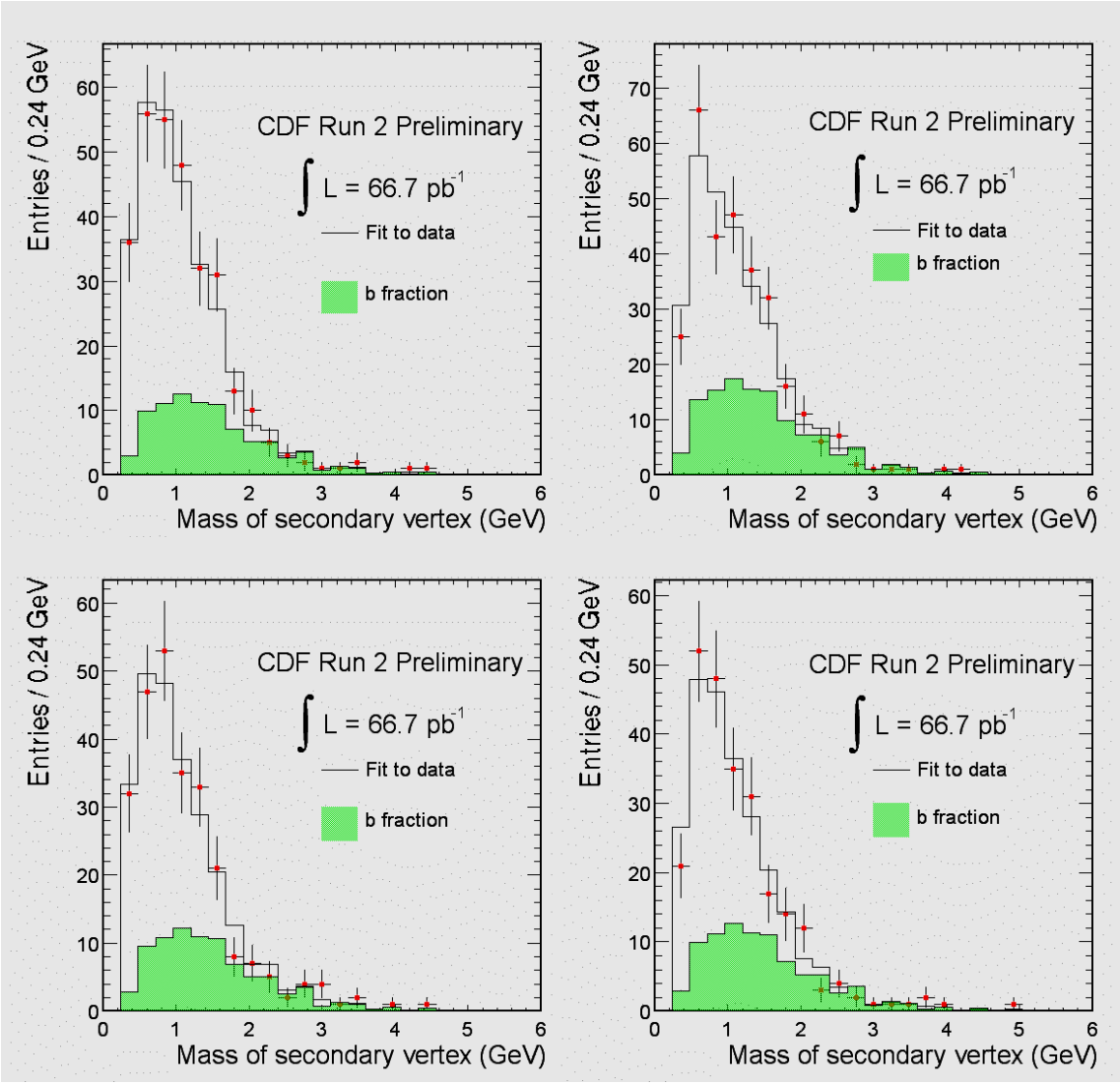


Conclusions

- **Diphoton production rate measured at CDF**
  - Agrees with NLO (DIPHOX, Resbos)
- **Photon + b, photon + c cross-sections measured at CDF**
  - Agree with LO (Pythia)
  - Currently statistically limited

Backup slides

γ + b / γ + c production



γ + b systematics

Systematic error (pb)	25 – 29 GeV	29 – 34 GeV	34 – 42 GeV	42 – 60 GeV
Tag efficiency	+1.7 –1.3	+2.6 –2.0	+0.9 –0.7	+1.1 –0.9
Photon id	± 0.2	± 0.1	< 0.1	± 0.1
Jet correction	± 0.5	± 0.5	± 0.1	± 0.1
Jet energy scale	+3.3 –1.4	+2.2 –2.1	+0.5 –0.3	+0.5 –0.4
B jet correction	± 0.2	± 0.3	± 0.1	± 0.1
CPR fake estimate	- 0.1	< 0.1	< 0.1	< 0.1
trigger	+2.5 –1.7	< 0.1	< 0.1	< 0.1
PDF	± 0.3	± 0.5	± 0.2	± 0.2
luminosity	+0.7 –0.6	+1.1 –1.0	+0.4 – 0.3	+0.5 –0.4
Final value* of $\sigma(b\gamma)$	**11.2 $^{+16.4}_{-8.2}$**	**17.2 $^{+12.3}_{-10.1}$**	**6.2 $^{+6.4}_{-4.4}$**	**7.9 $^{+5.0}_{-4.1}$**

** The errors quoted are the total error, consisting of both statistical and systematic contributions*

γ + c systematics

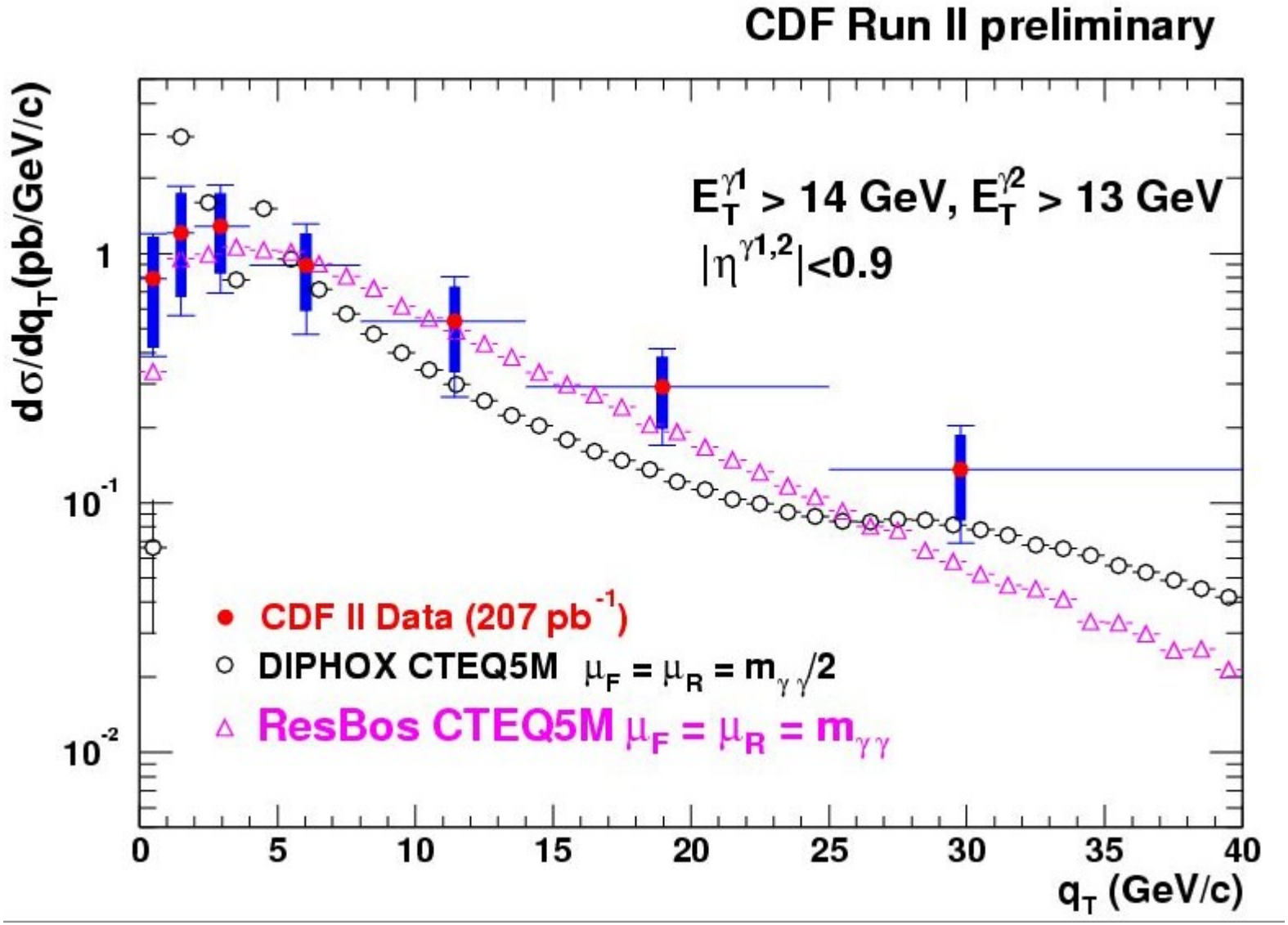
Systematic error (pb)	25 – 29 GeV	29 – 34 GeV	34 – 42 GeV	42 – 60 GeV
Tag efficiency	+26.5 –19.8	+13.1 –9.9	+7.4 – 5.6	+8.7 –6.4
Photon id	± 2.2	± 0.4	± 0.3	± 0.4
Jet correction	+7.9 –7.2	+2.5 –2.4	0.8	0.4
Jet energy scale	+48.0 –21.0	+10.4 –9.6	+3.5 –2.4	+2.9 –2.3
CPR fake estimate	- 0.6	- 0.1	- 0.2	+ 0.2
trigger	+37.3 –25.3	< 0.1	< 0.1	< 0.1
PDF	± 2.2	± 0.7	± 0.3	± 0.2
luminosity	+9.6 – 8.6	+5.0 –4.4	+2.8 –2.5	+3.0 –2.7
Final value* of $\sigma(c\gamma)$	**164.7 $^{+163.2}_{-106.5}$**	**81.1 $^{+71.0}_{-53.0}$**	**45.4 $^{+46.8}_{-31.3}$**	**50.0 $^{+37.3}_{-30.9}$**

** The errors quoted are the total error, consisting of both statistical and systematic contributions*

γ + c / γ + b systematics

Systematic error (pb)	25 – 29 GeV	29 – 34 GeV	34 – 42 GeV	42 – 60 GeV
B tag efficiency	- 1.2	- 0.6	- 1.0	- 0.8
C tag efficiency	+2.4 –1.8	+0.8 –0.6	+1.3 –0.9	+1.1 –0.8
B jet correction	± 0.2	± 0.1	± 0.1	± 0.1
CPR fake estimate	+ 0.1	< 0.1	- 0.1	< 0.1
Final value* of $\sigma(c\gamma)/\sigma(b\gamma)$	**14.1 +41.5 -9.8**	**4.8 +8.7 -3.3**	**7.4 +19.3 -5.4**	**6.4 +9.7 -4.1**

** The errors quoted are the total error, consisting of both statistical and systematic contributions*


CDF Run II preliminary
$E_T^{\gamma 1} > 14$ GeV, $E_T^{\gamma 2} > 13$ GeV
$|\eta^{\gamma 1,2}|<0.9$
CDF II Data (207 pb^{-1})
DIPHOX CTEQ5M $\mu_F = \mu_R = m_{\gamma\gamma}/2$
ResBos CTEQ5M $\mu_F = \mu_R = m_{\gamma\gamma}$
$d\sigma/dq_T$(pb/GeV/c)
q_T (GeV/c)
1
10^{-1}
10^{-2}
0
5
10
15
20
25
30
35
40

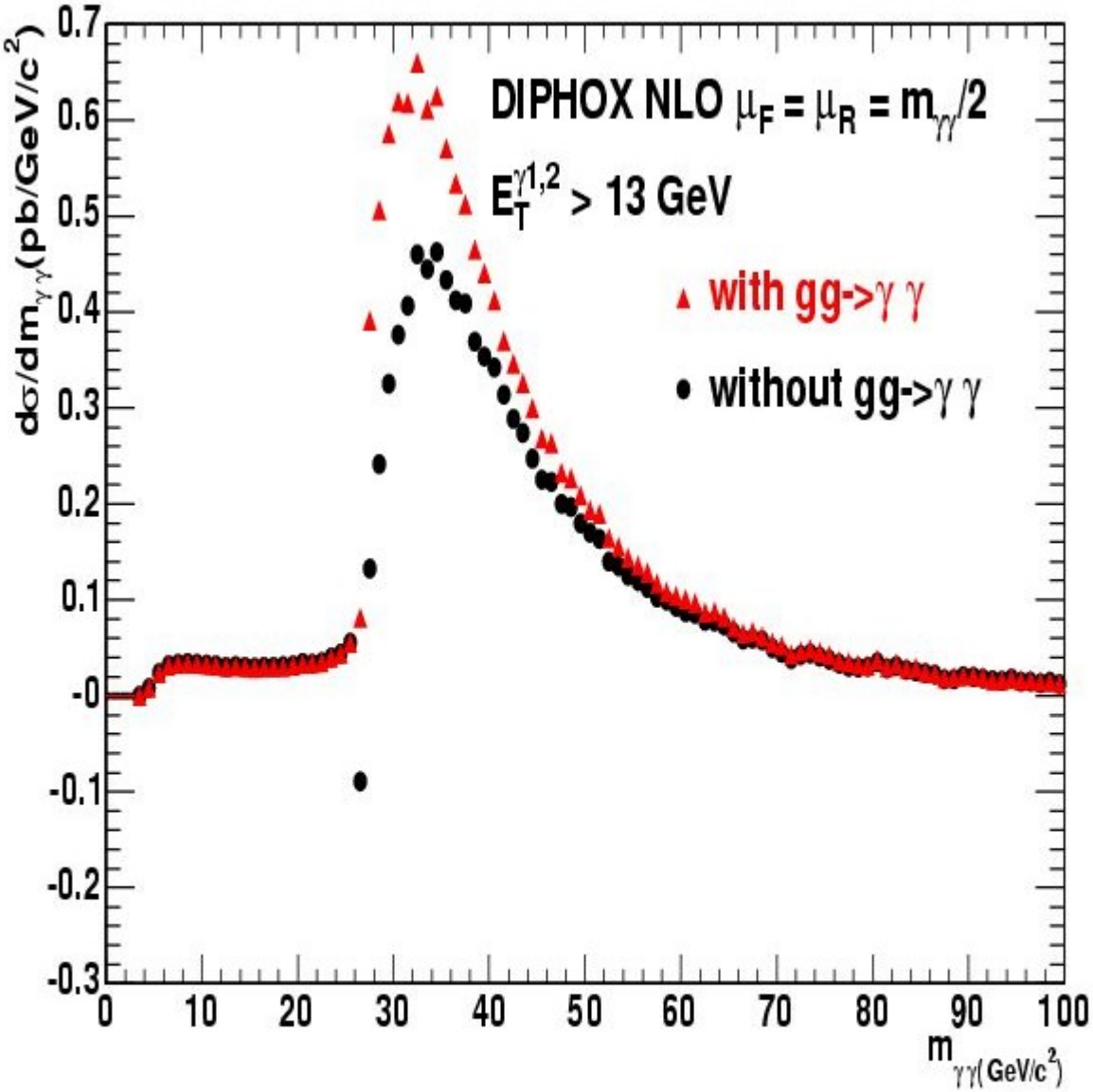


Figure 15: Invariant mass distributions by DIPHOX NLO predictions. The box contribution is negligible at high mass region. But there appears a singular point at the 26 GeV bin in the prediction without box contribution.

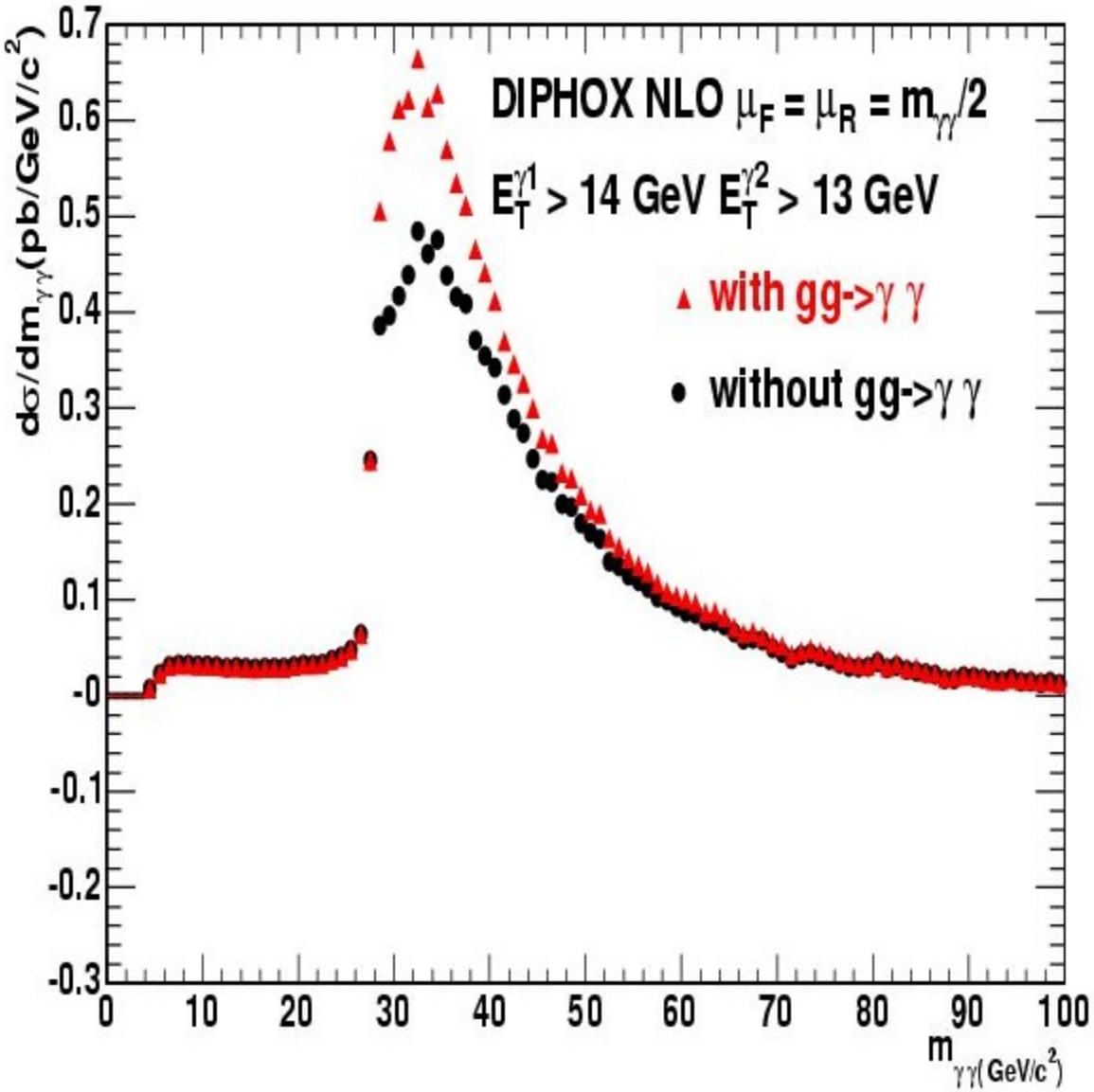


Figure 16: Invariant mass distributions by DIPHOX NLO predictions. No singular point on either of the two curves, with the asymmetric Et cut. We believe the prediction is more reliable with asymmetric cuts, and will adopt the asymmetric Et cut for data/theory comparisons.