# 2gamma isolation

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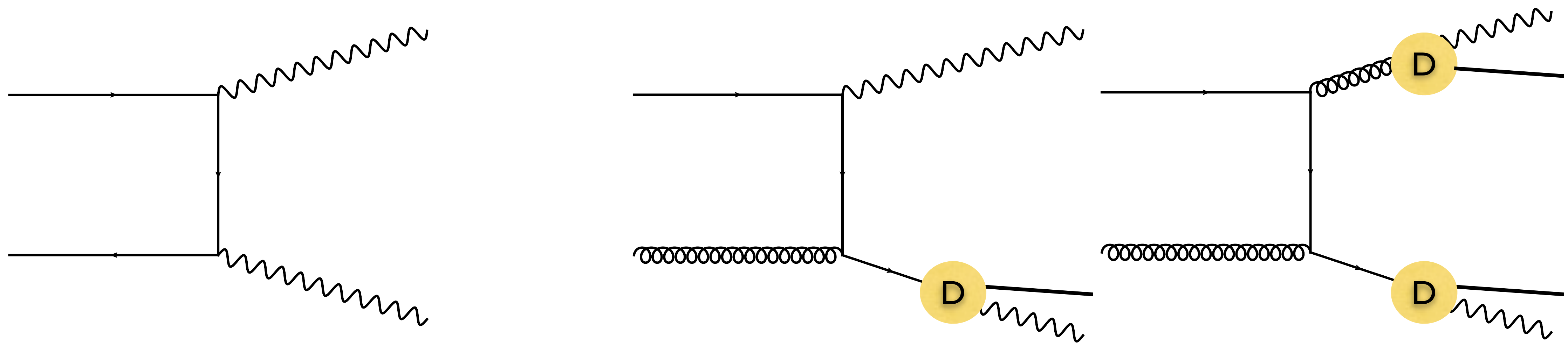
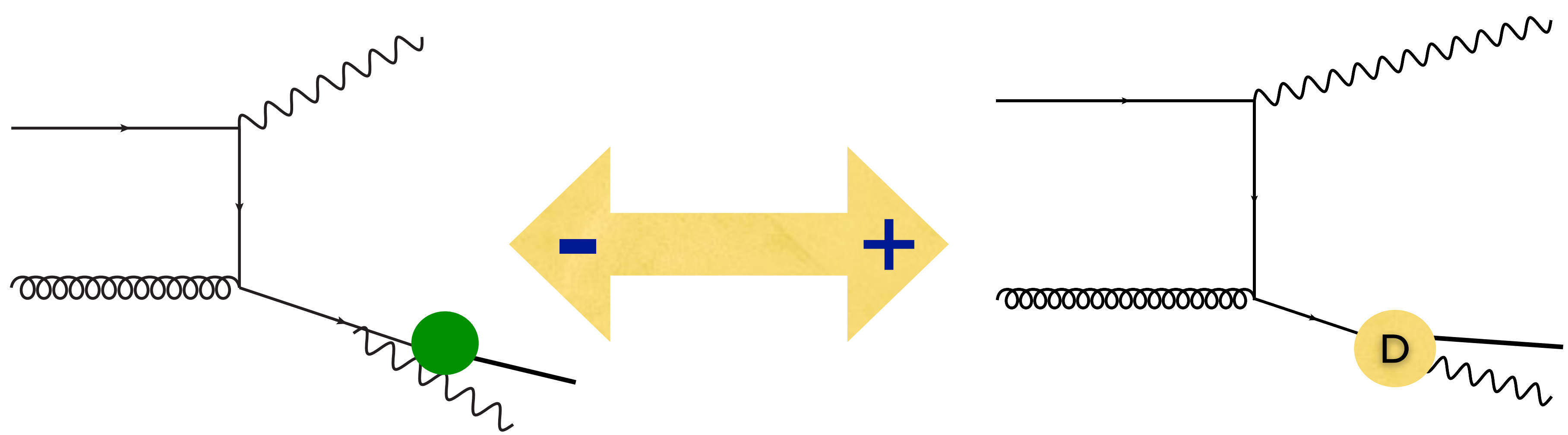
# Two mechanisms for photon production




Direct (point-like) | Single and double resolved (collinear fragmentation)

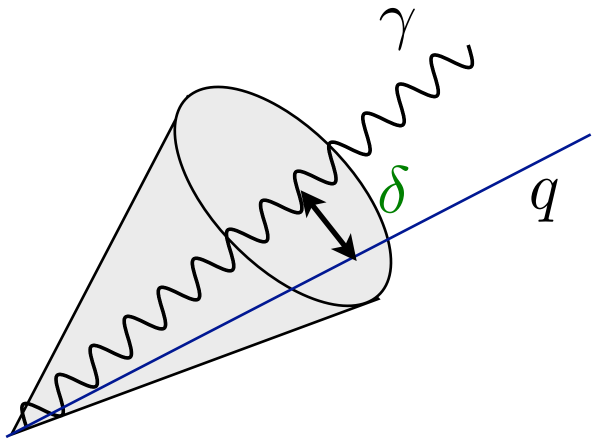
Separation between them NOT physical in general (beyond LO)




collinear divergence → Cancelled by fragmentation

Still talk about direct and resolved at NLO and beyond:
$\overline{\text{MS}}$ factorization scheme (convention)

+ frag. fact. scale
dependence of each term




## Standard Photon Isolation

$$E_T^{had}(\delta) \leq E_{T\,max}^{had}$$

## Smooth Photon Isolation

S.Frixione

$$E_T^{had}(\delta) \leq E_{T\,max}^{had}\ \chi(\delta)$$

$$\chi(\delta) = \left( \frac{1-\cos(\delta)}{1-\cos(R_0)} \right)^n$$

$\leq 1$

only soft emission allowed if collinear to photon

- no quark-photon collinear divergences
- no fragmentation component (only direct)
- Direct contribution well defined

More restrictive than usual cone : lower limit on cross section (close for small R)

In real (TH)life... how much different? NLO comparison $R_0 = 0.4 \quad n = 1$

CMS Higgs cuts at 7 TeV

Standard: direct+fragmentation (Diphox)

| $E_{T\,max}^{had}$ | standard/smooth |
|---|---|
| 2 GeV | < 1% |
| 3 GeV | < 1% |
| 4 GeV | 1% |
| 5 GeV | 3% |
| 0.05 $p_T$ | < 1% |
| 0.5 $p_T$ | 11% |

if isolation tight enough, hardly any difference between standard and smooth cone

# Check less inclusive observables: any significant difference?

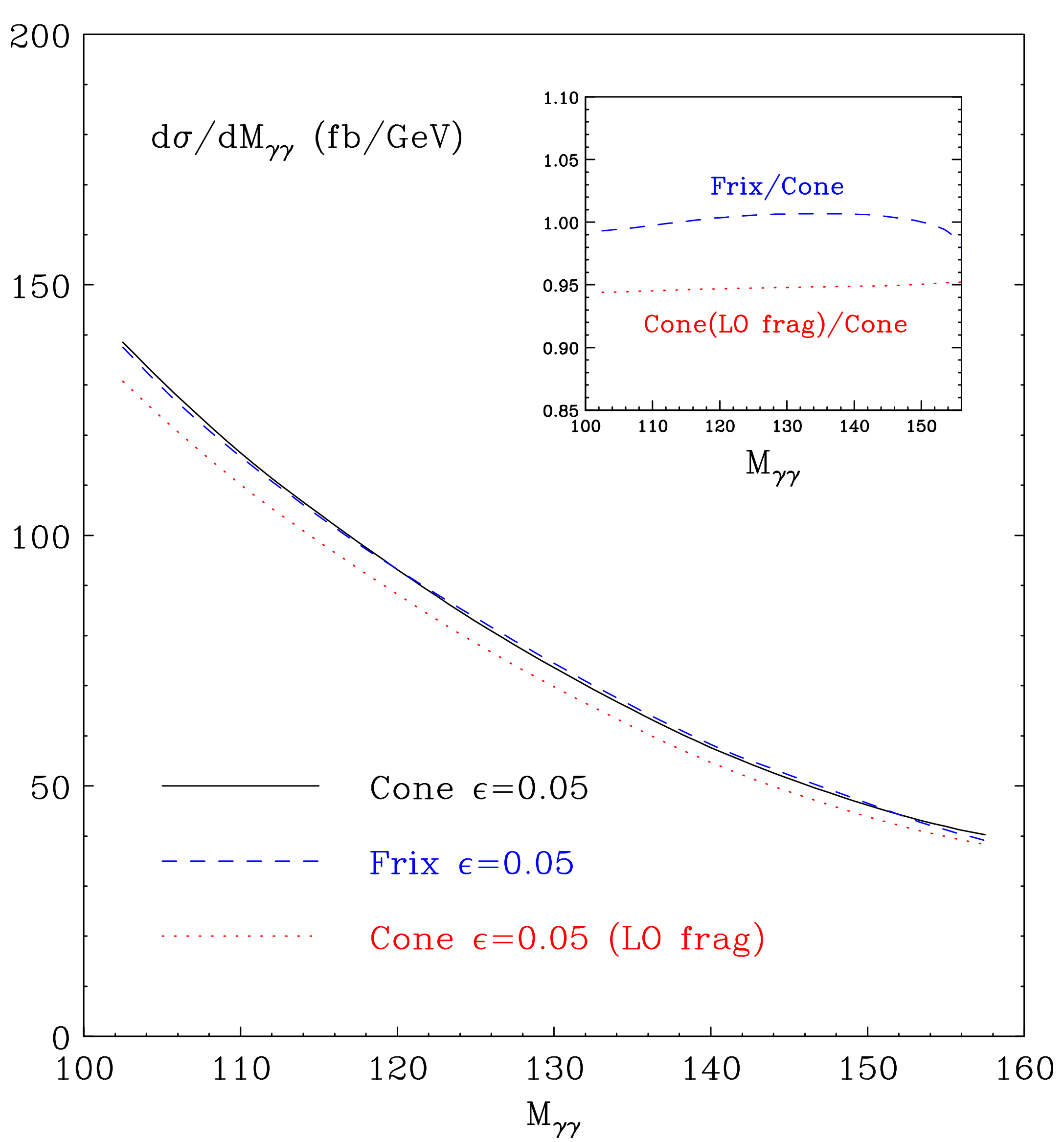
**Diphoton production** $\sqrt{s} = 8\,\mathrm{TeV}$ **CTEQ6M** $\mu_F = \mu_R = M_{\gamma\gamma}$

$p_T^{\gamma\,hard} \geq 40\,\mathrm{GeV}$ $\quad 100\,\mathrm{GeV} \leq M_{\gamma\gamma} \leq 160\,\mathrm{GeV}$ $\quad |\eta^\gamma| \leq 2.5$ $\quad R_{\gamma\gamma} \geq 0.45$

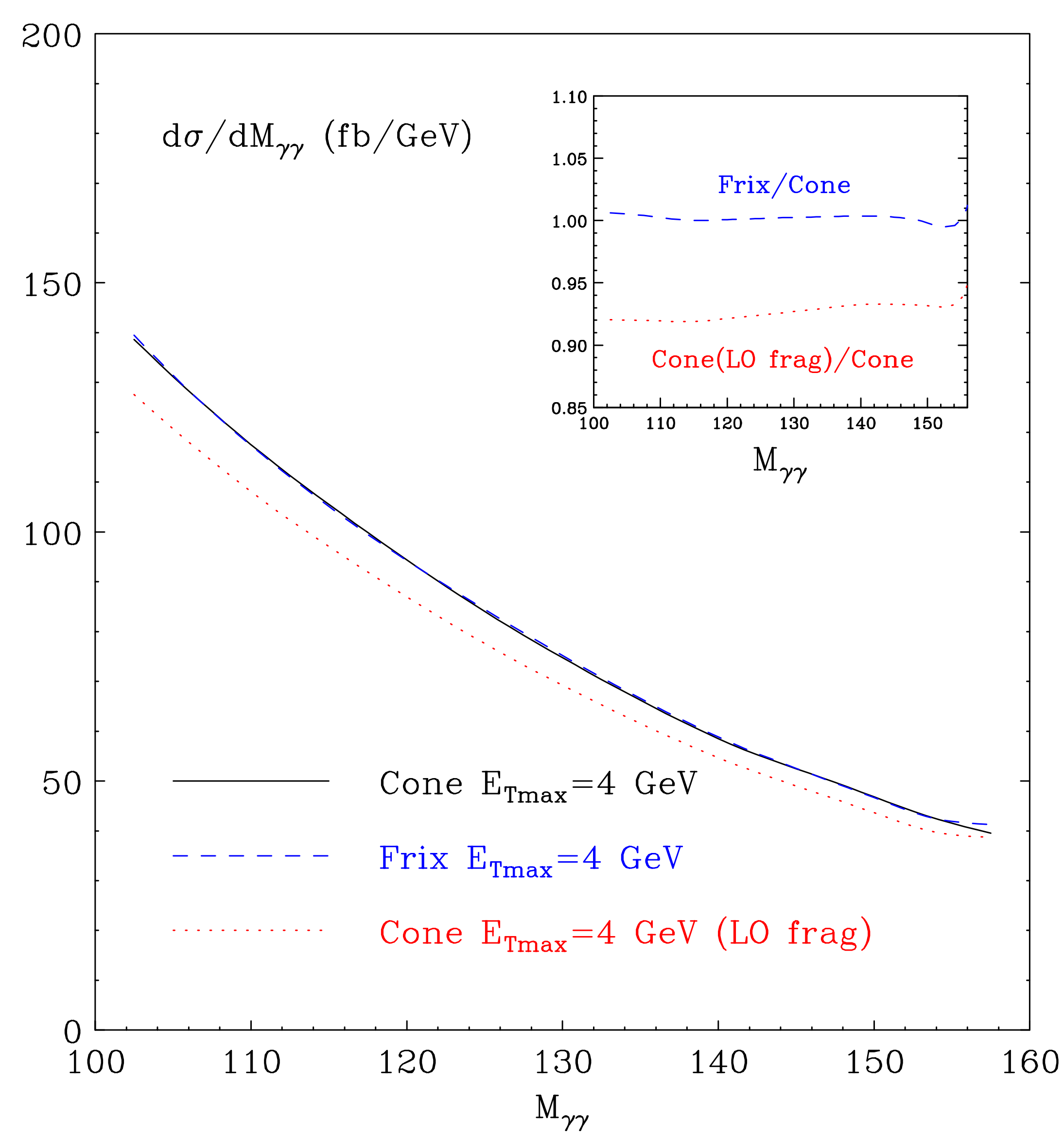
$p_T^{\gamma\,soft} \geq 30\,\mathrm{GeV}$

**full NLO Cone (DIPHOX) vs Cone with LO fragmentation vs NLO Smooth**

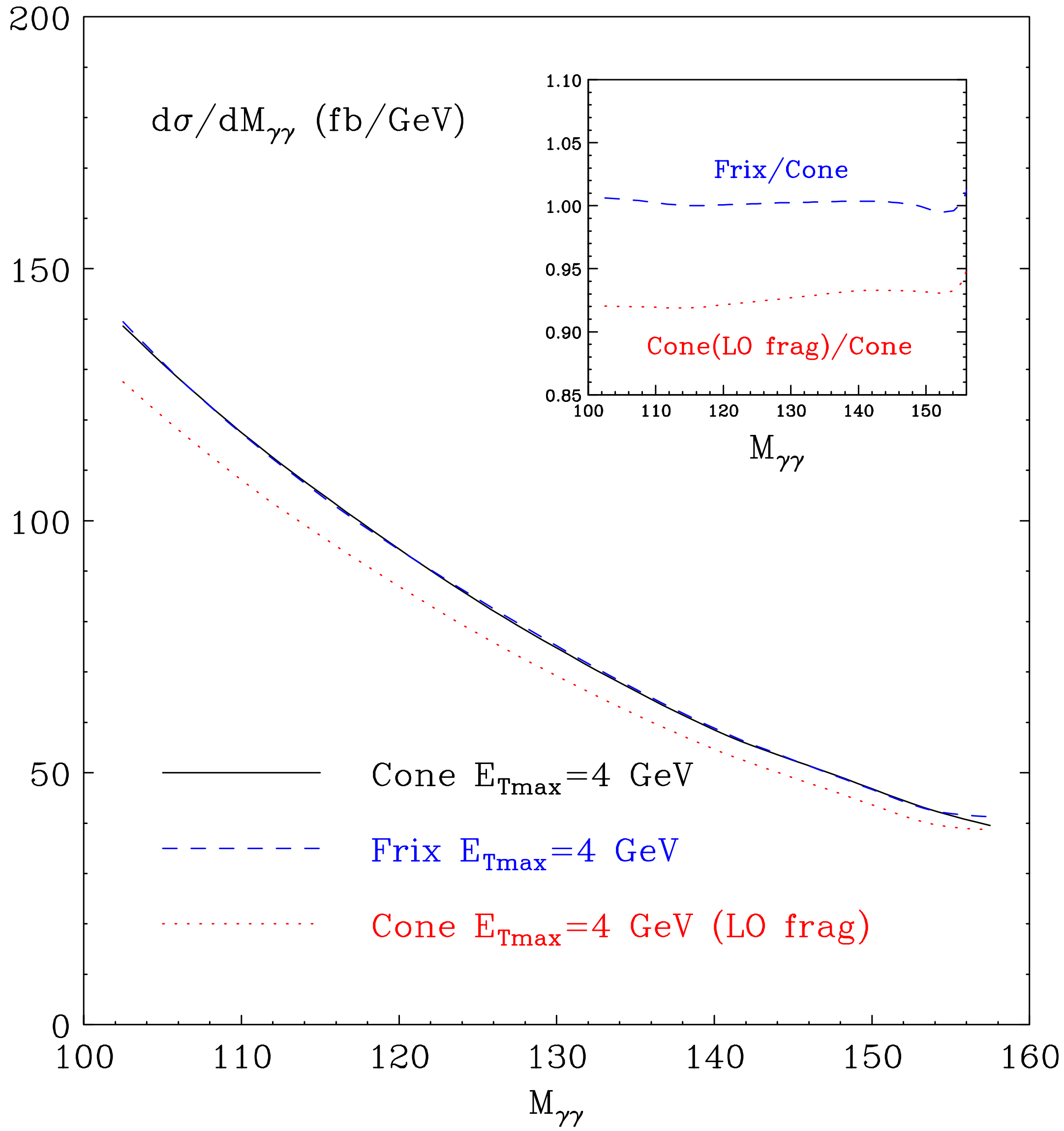
$E_{T\,max}^{had} = \epsilon\, p_T^\gamma \quad \epsilon = 0.05$



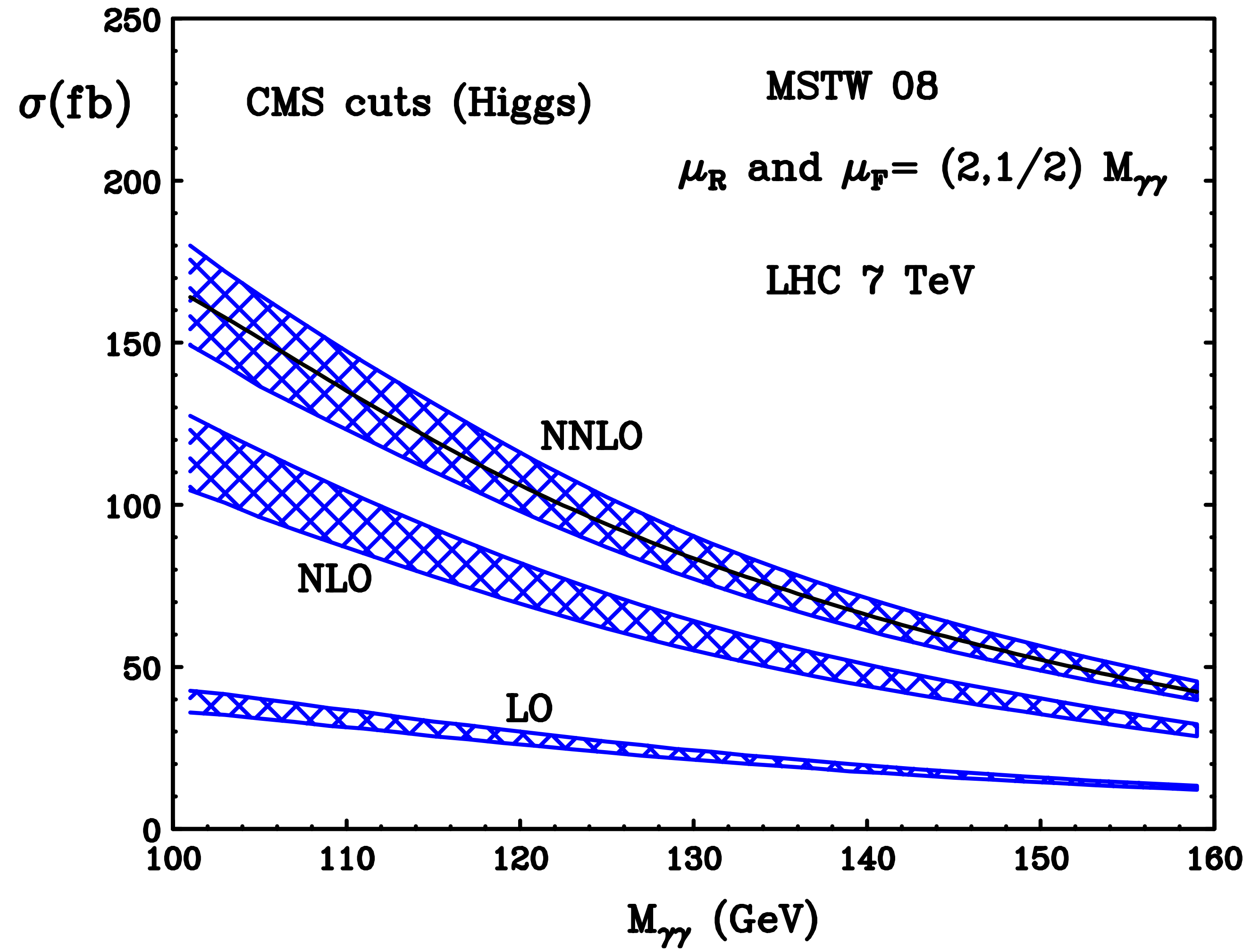

$E_{T\,max}^{had} = 4\,\mathrm{GeV}$



# Cone/Smooth ~ 1% effect at NLO

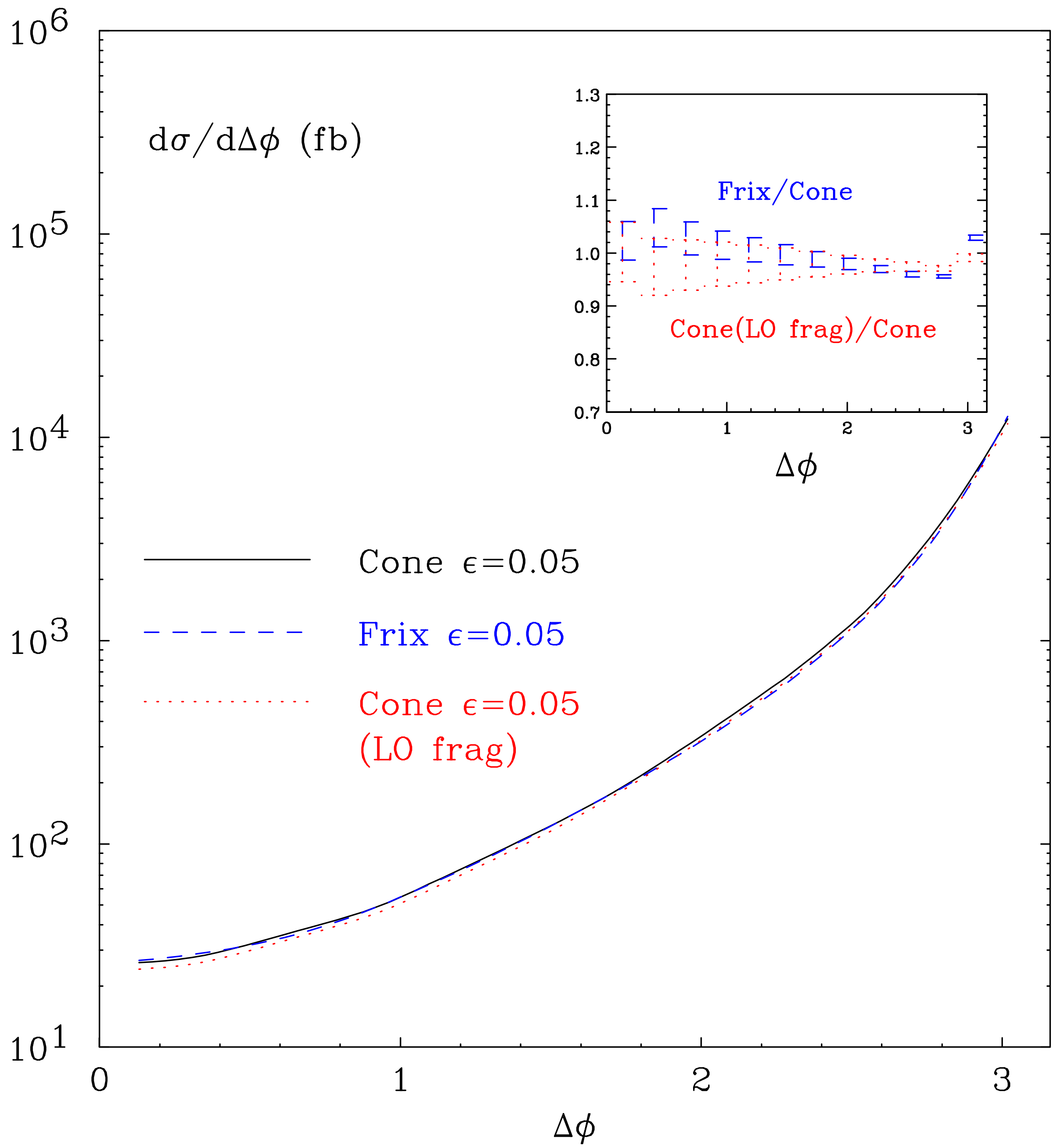


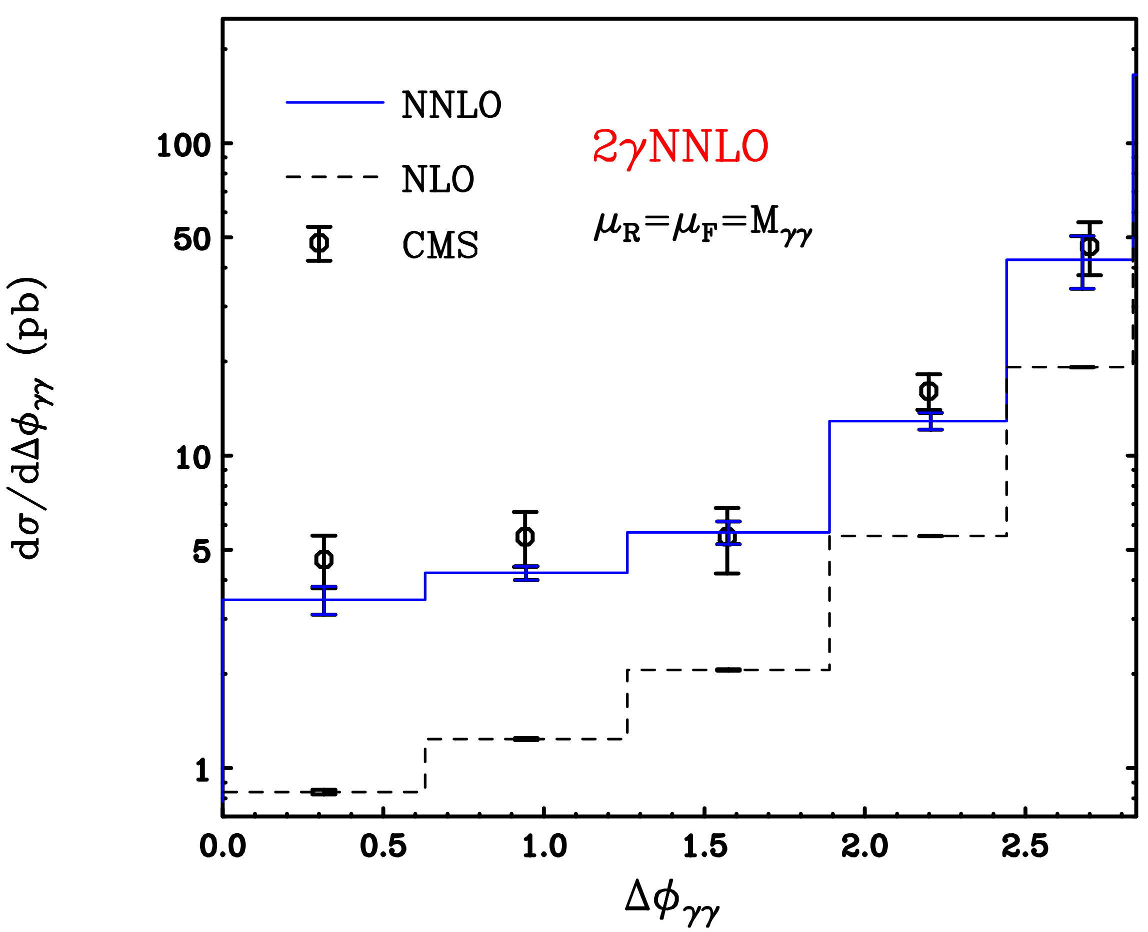

# But Smooth allows to reach NNLO were corrections are >40%



# Azimuthal Distribution

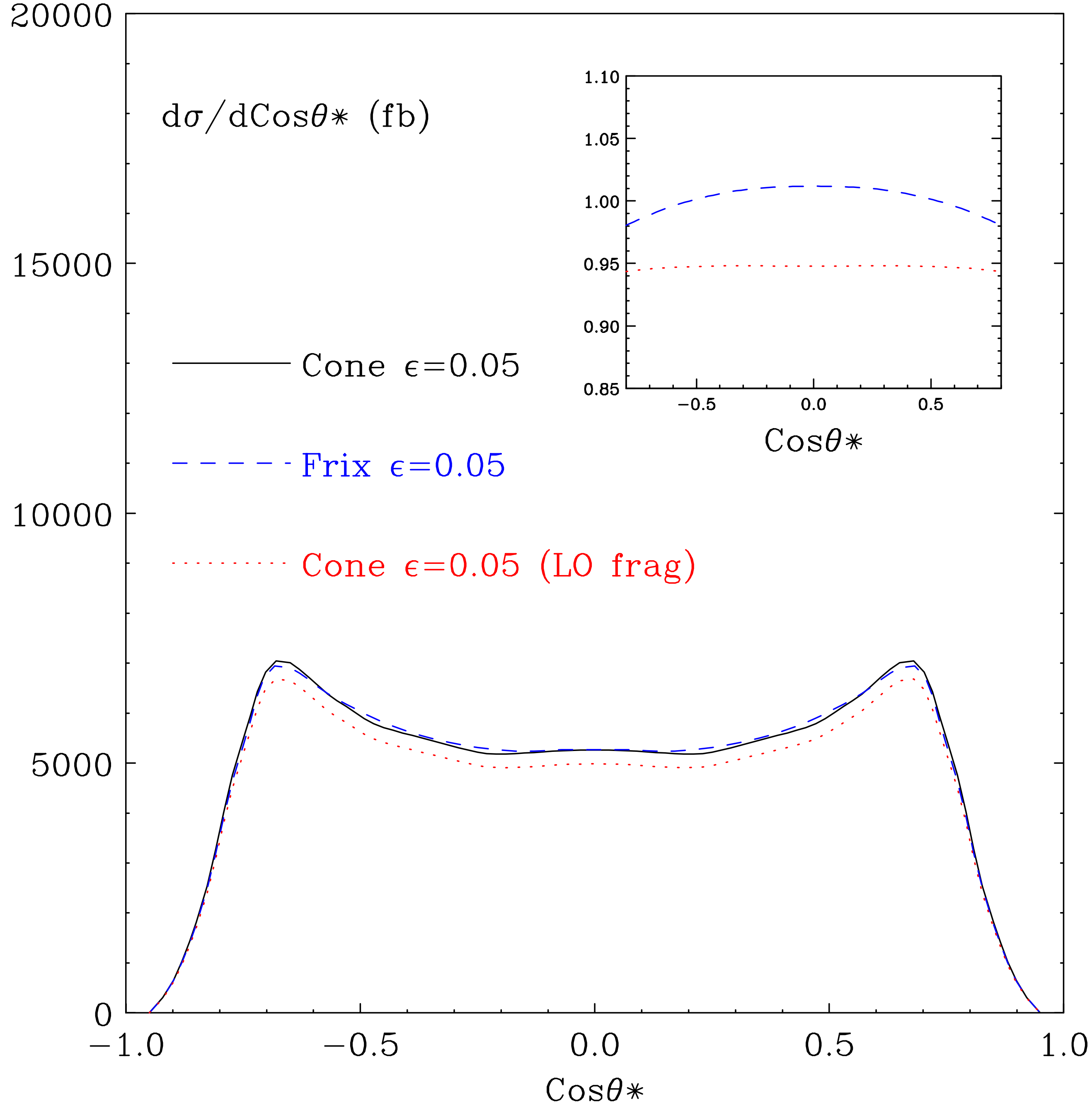
Usually claimed that "fragmentation effects" large at small azimuth




Still some statistical fluctuations (short run..)

Differences negligible compared to higher order effects !




Same feature for all distributions

Smooth cone @NLO ~ Cone @ NLO 1-2% level

Cone + LO fragmentation component worse than 5%

$$\chi(\delta) = \left(\frac{1-\cos(\delta)}{1-\cos(R_0)}\right)^n$$

Eric: that was proposed because it matches e+e- dynamics

In hadronic collisions better use something like

$$2\left(\cosh(\Delta y) - \cos(\Delta\phi)\right) \sim [(\Delta y)^2 + (\Delta\phi)^2] = r^2$$

$$E_T^{had} \leq E_{T\,max}^{had} \left(\frac{r}{R}\right)^{2n}$$

| | Isolation | $\sum E_T^{had} \leq$ | $\chi(r)$ | $\sigma_{total}^{NLO}$ (fb) |
|---|---|---|---|---|
| i | Frixione | 2GeV | $\left(\frac{1}{2} - \frac{1}{2}\cos(\frac{\pi r}{R})\right)$ | 3760 |
| ii | Frixione | 2GeV | $\left(\frac{1}{2} - \frac{1}{2}\cos(\frac{\pi r}{R})\right)^{0.5}$ | 3921 |
| iii | Frixione | 2GeV | $r/R$ | 3769 |
| iv | Frixione | 2GeV | $(r/R)^2$ | 3731 |
| v | Frixione | 2GeV | $\left(\frac{1-\cos(r)}{1-\cos(R)}\right)$ | 3724 |
| v | Standard | 2GeV | 1 | 3731 |

More homework: try a few more profiles (distributions)

Simple summary

- EXP: use (tight) Cone isolation — solid and well understood
- TH: use smooth cone with same R and $E_{Tmax}$ — accurate, better than using cone with LO fragmentation

Estimate TH isolation uncertainties using different profiles in smooth cone

# In cases, using LO fragmentation component can make things look very strange...

## Cone isolation (DIPHOX)