LH accord 2013
photon isolation

Motivation

- Let to the experiment use the standard cone approach, because is solid (simple) and well understood

- Let to the theory use the smooth cone approach, because is a way to reach the highest level of accuracy for many calculations

Vγ production [NNLO] M. Grazzini, S. Kallweit, D. Rathlev, A. Torre (2013), (2015)

γγ production [NNLO] Catani, LC, de Florian, Ferrera, Grazzini (2011)

γγ + 2Jets [NLO] T. Gehrmann , N. Greiner , G. Heinrich (2013) ;Z. Bern, L.J. Dixon, F. Febres Cordero, S. Hoeche, H. Ita, D.A. Kosower, N. A. Lo Presti, D. Maitre (2013)

γγ + (up to) 3Jets [NLO] S. Badger, A. Guffanti, V. Yundin (2013)

3 main ways to deal with photons

- Full result: Fragmentation at the same “level” than the direct part

- LO Fragmentation approach: two different methods (depending in the way in which you count the “effective” powers of alpha_s in the fragmentation function)

- Smooth cone: The Frixione criterion removes the collinear fragmentation functions (in general the collinear emissions)

Questions, works...

- From the study of γγ production: How can we extend the previous LH studies to processes in which we only know the result with LO fragmentation?

- How easily could NLO fragmentation contributions to Vγ final states be implemented in the PHOX generators way?

- In γγ production we learnt that we have to be very careful when we compare smooth cone with LO fragmentation. For which other processes could the NLO fragmentation be important?

- Which are the differences between the two approaches including fragmentation?

- Why the unexpected behaviour of the Xsection in function of the isolation parameter (using LO fragmentation) appear strongly in diphoton production (e.g not in γγ+j) ?

Questions, works...

- For other processes (not diphoton) with final state photons, the behaviour of the Xsection and the LO fragmentation method is consistent when we vary Etmax or ε.

- Thinking beyond fixed order tools: Can we have a comparison between the standard and smooth approaches with the PS tools? e.g for Wγ, Zγ

In PS tools fragmentation is not a purely collinear process

- It is possible to extract information in the same way that we did in LH 2013 with these tools? (about the region in which the fragmentation is not important)

- And this information can directly be applied to FO tools?

Isolation criteria comparison

[Les Houches 2013: Physics at TeV Colliders: Standard Model Working Group Report]

Diphoton Production

For the next slides: **[For all the cases we use the same set of isolation parameters]**

Xsection [NLO] = **Direct [NLO] + Frag [NLO]** (Isolation Criterion: Standard, Democratic, Frixione, etc.)

Xsection [NLO] = Direct [NLO] ~~+ Frag [NLO]~~ (Isolation Criterion: Frixione)

Xsection [NLO] = Direct [NLO] + **Frag [LO]** (Isolation Criterion: Standard, Democratic, Frixione, etc.)

The calculation of fragmentation contributions is very difficult:

We can find calculations in which the fragmentation component is considered at one level less than the direct component.

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

$p_T^{\gamma\,hard} \geq 40\,\mathrm{GeV}$

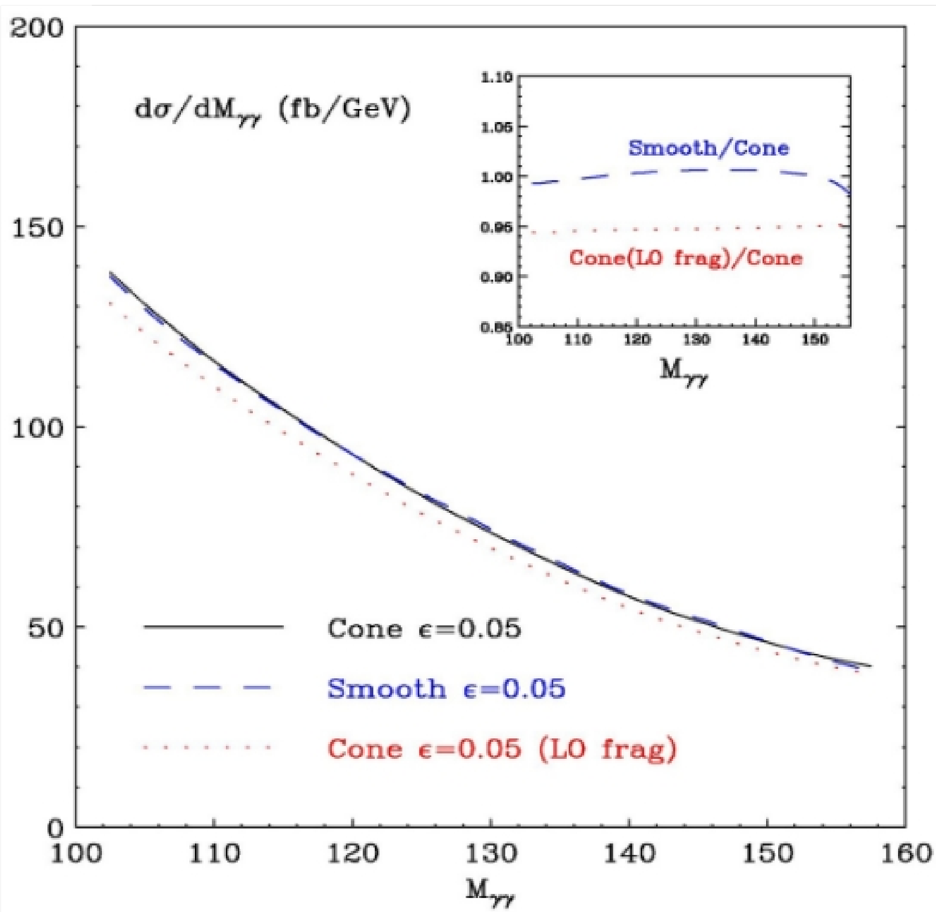
$p_T^{\gamma\,soft} \geq 30\,\mathrm{GeV}$

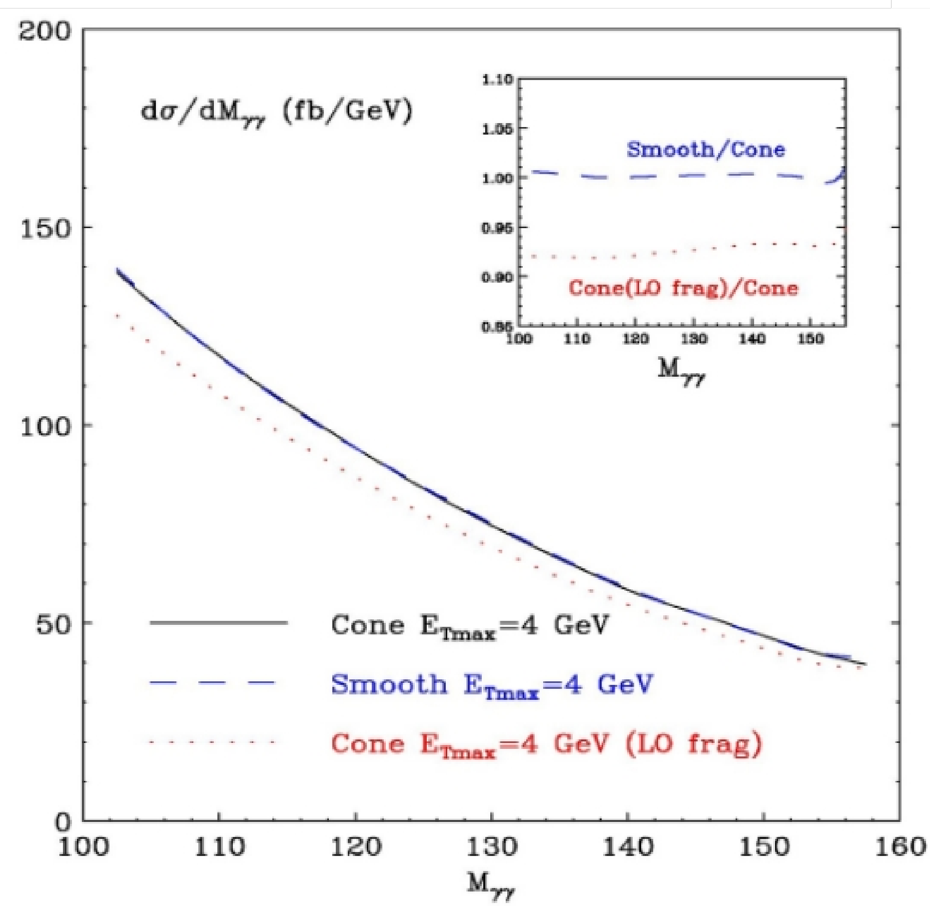
$100\,\mathrm{GeV} \leq M_{\gamma\gamma} \leq 160\,\mathrm{GeV}$ $|\eta^\gamma| \leq 2.5$ $R_{\gamma\gamma} \geq 0.45$

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

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

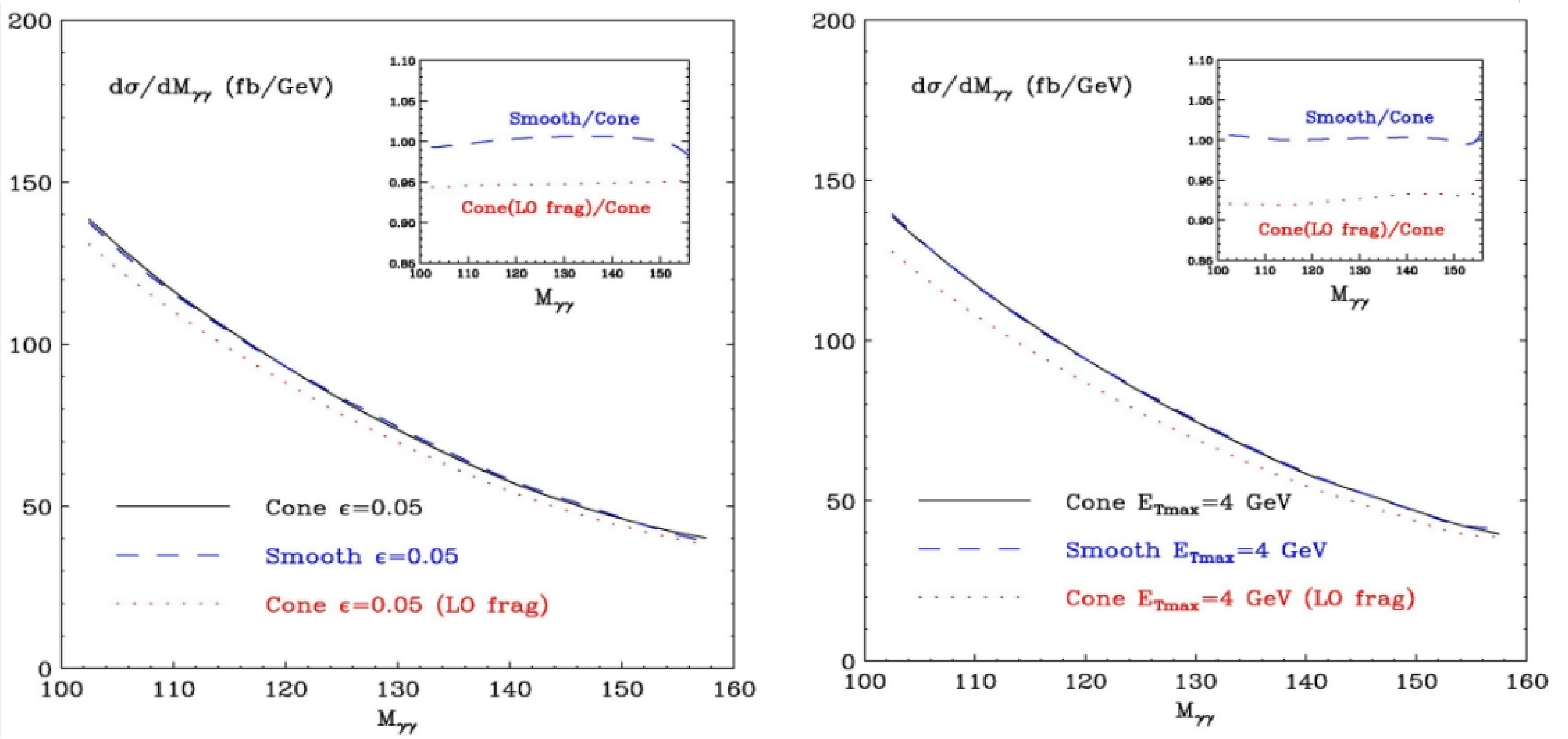
$E_{T\,max}^{had} = 4\,\mathrm{GeV}$





L.C , D. de Florian 2013

Be carefull to make conclusions here
It is not true that the smooth approach gives a larger Xsection
See the Full NLO result with Fragmentation



L.C , D. de Florian 2013

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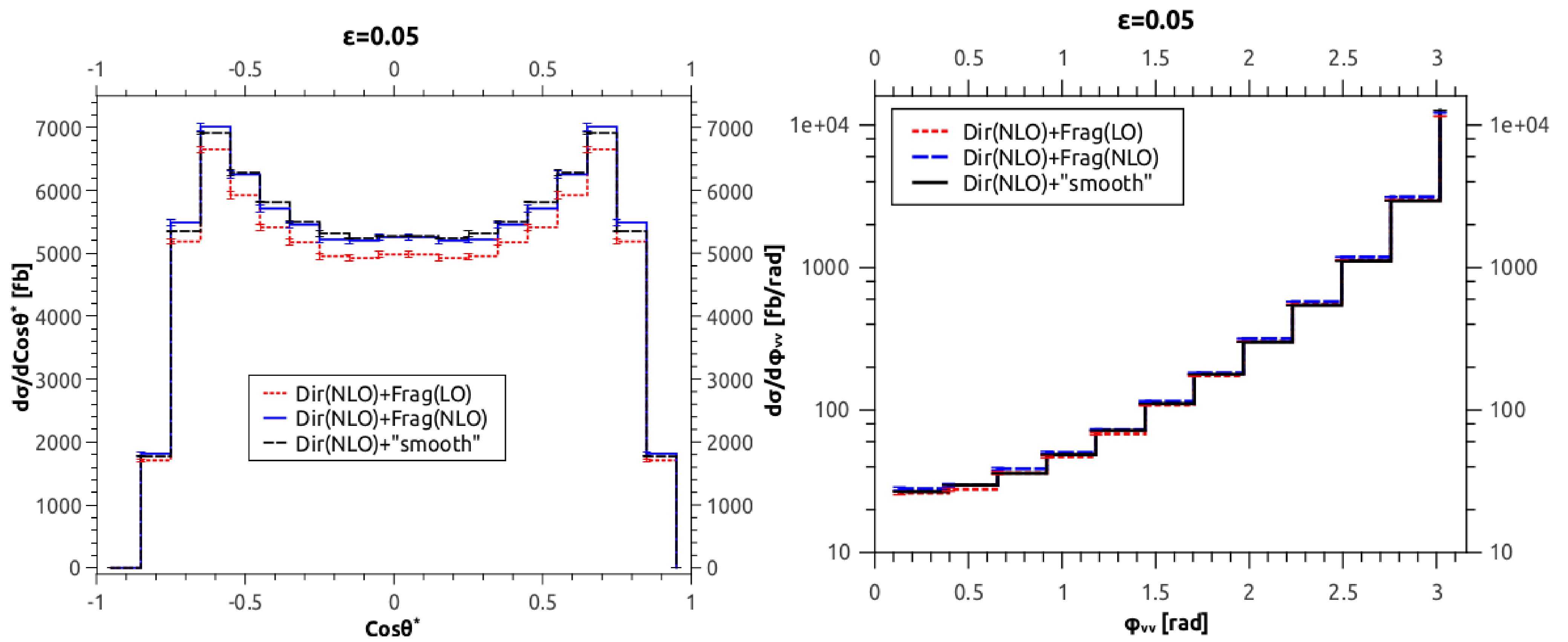
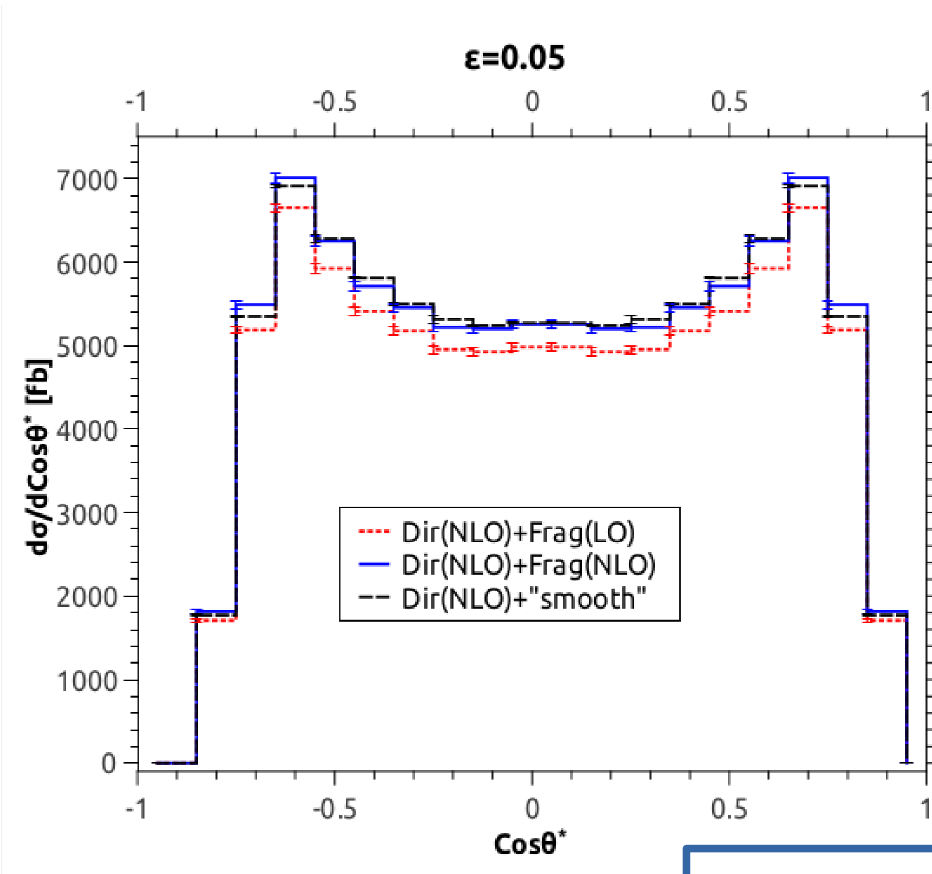


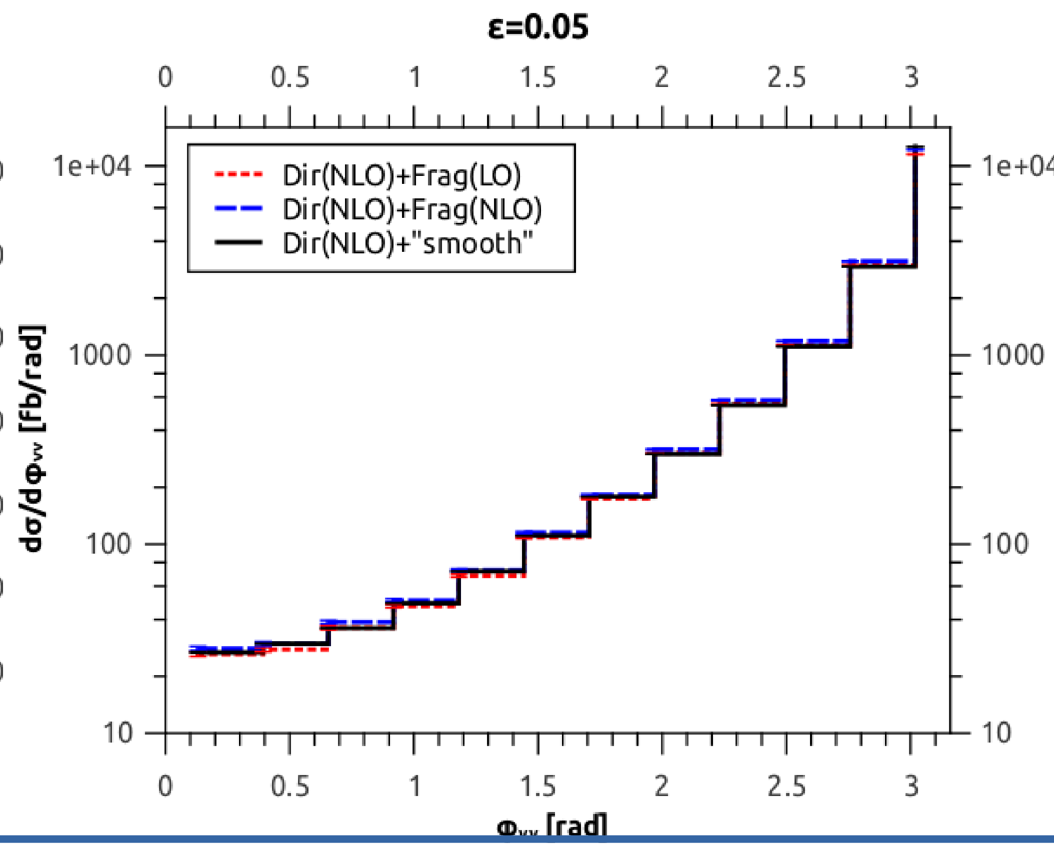
L.C , D. de Florian 2013

Same Features for all distributions

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

Cone + LO fragmentation component worse than 5%



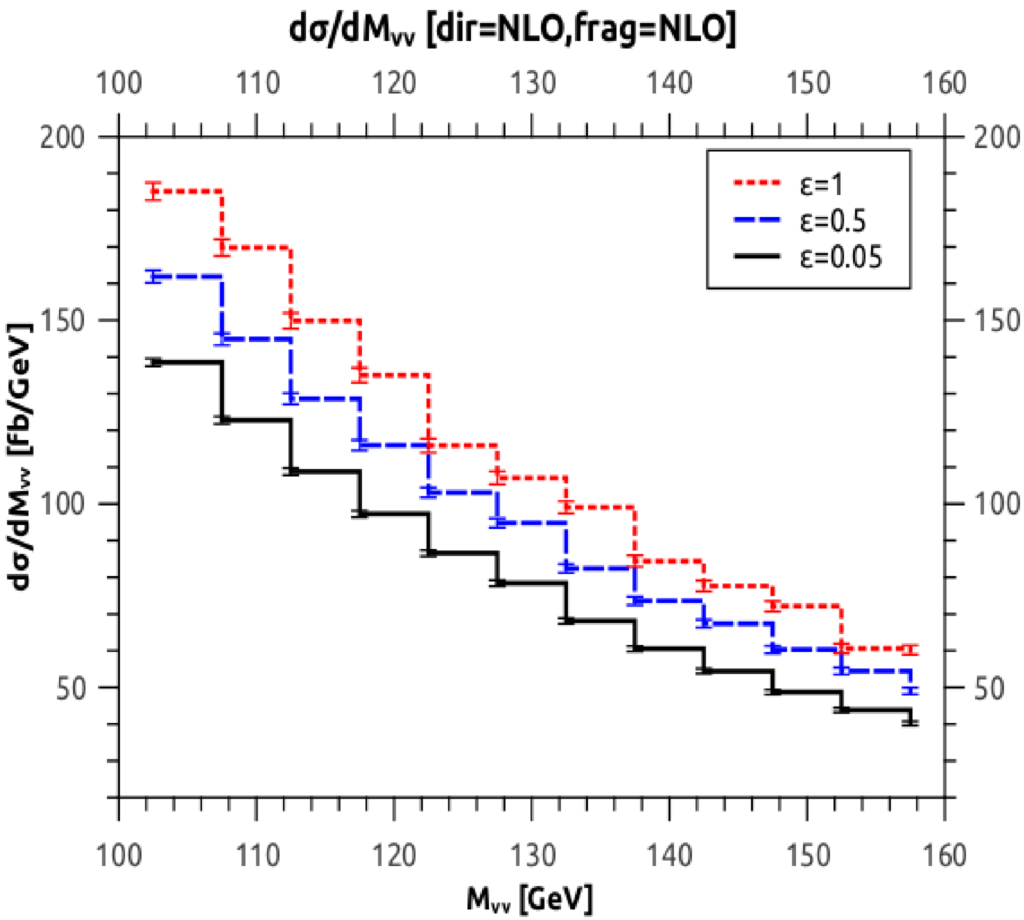


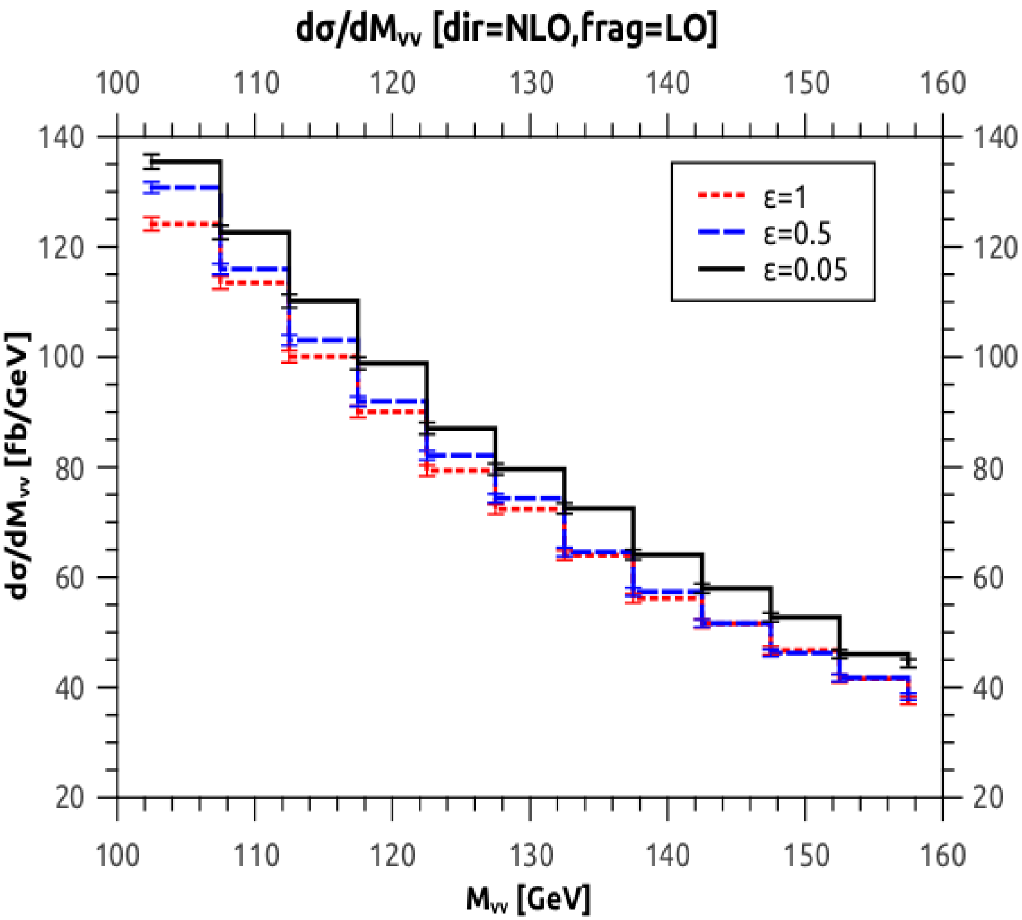
L.C , D. de Florian 2013

Be carefull to make conclusions here
It is not true that the smooth approach gives a larger Xsection
See the Full NLO result with Fragmentation

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

Standard cone isolation → DIPHOX





L.C , D. de Florian 2013

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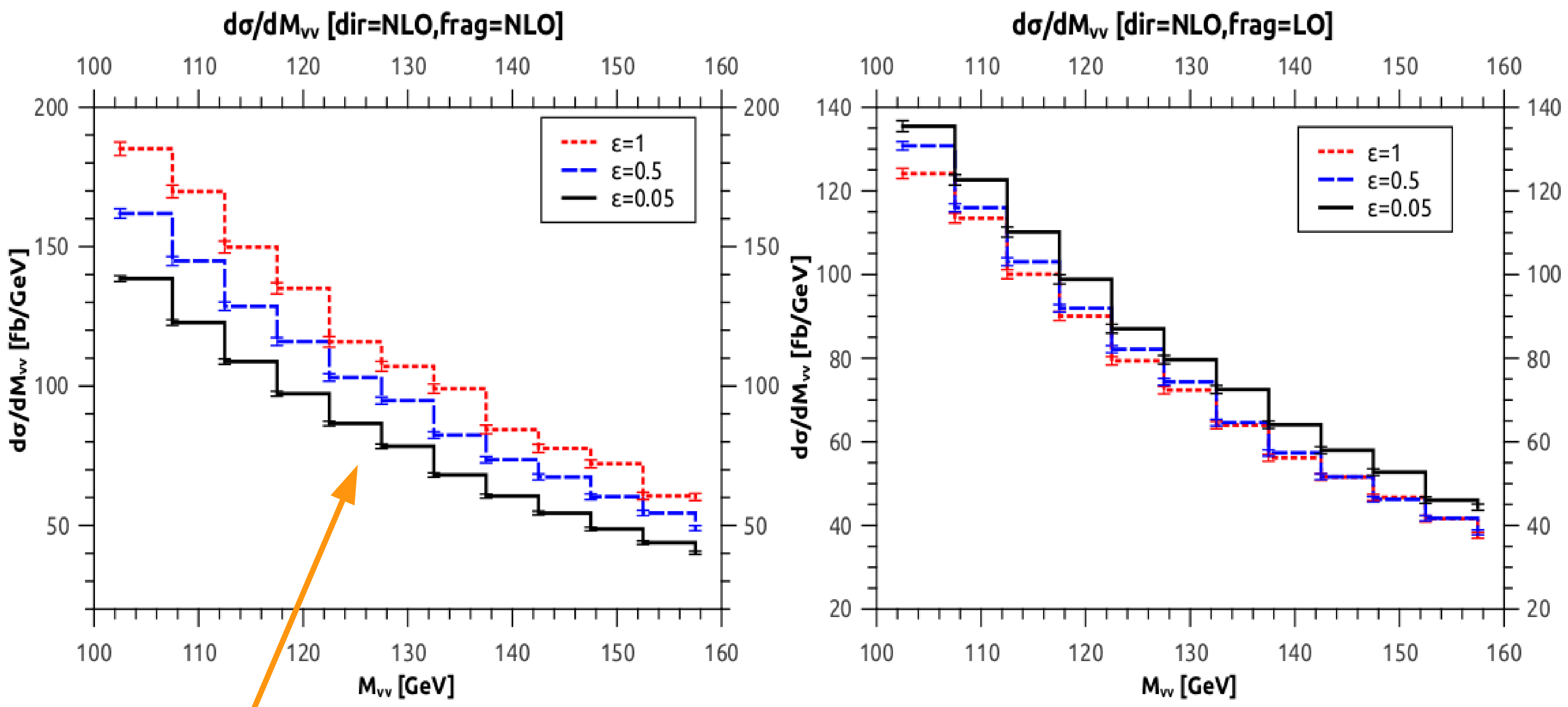

Right behaviour!!

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Les Houches accord 2013

[Les Houches 2013: Physics at TeV Colliders: Standard Model Working Group Report]

"LH tight photon isolation accord"

- 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

While the definition of "tight enough" might slightly depend on the particular observable (that can always be checked by a lowest order calculation), our analysis shows that at the LHC isolation parameters as $E_T^{max} \leq 5$ GeV (or $\epsilon < 0.1$), $R \sim 0.4$ and $R_{\gamma\gamma} \sim 0.4$ are safe enough to proceeed.

This procedure would allow to extend available NLO calculations to one order higher (NNLO) for a number of observables, since the direct component is always much simpler to evaluate than the fragmentation part, which identically vanishes under the smooth cone isolation.

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Considering that NNLO corrections are of the order of 50% for diphoton cross sections and a few 100% for some distributions in extreme kinematical configurations, it is far better accepting a few % error arising from the isolation (less than the size of the expected NNNLO corrections and within any estimate of TH uncertainties!) than neglecting those huge QCD effects towards some "more pure implementation" of the isolation prescription.

Recently, some calculations use the smooth cone isolation criteria to arrive at the highest level of accuracy:

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Backup slides

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

Standard cone isolation → DIPHOX

CMS [7 TeV]

	Code	$\sum E_T^{had} \leq$	σ_{total}^{NLO}(fb)	σ_{dir}^{NLO}(fb)	σ_{onef}^{NLO}(fb)	σ_{twof}^{NLO}(fb)	Isolation
a	DIPHOX	2 GeV	3746	3504	239	2.6	Standard
b	DIPHOX	3 GeV	3776	3396	374	6	Standard
c	DIPHOX	4 GeV	3796	3296	488	12	Standard
d	DIPHOX	5 GeV	3825	3201	607	17	Standard
e	DIPHOX	$0.05\ p_T^\gamma$	3770	3446	320	4	Standard
f	DIPHOX	$0.5\ p_T^\gamma$	4474	2144	2104	226	Standard
g	DIPHOX	*incl*	6584	1186	3930	1468	none
h	2γNNLO	$0.05\ p_T^\gamma\ \chi(r)$	3768	3768	0	0	Smooth
i	2γNNLO	$0.5\ p_T^\gamma\ \chi(r)$	4074	4074	0	0	Smooth
j	2γNNLO	2 GeV $\chi(r)$	3743	3743	0	0	Smooth
k	2γNNLO	3 GeV $\chi(r)$	3776	3776	0	0	Smooth
l	2γNNLO	4 GeV $\chi(r)$	3795	3795	0	0	Smooth
m	2γNNLO	5 GeV $\chi(r)$	3814	3814	0	0	Smooth

L.C , D. de Florian 2013

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

Standard cone isolation → DIPHOX

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Tighter criteria

Direct component increasing