Photon production at hadronic colliders

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LAPTH
CNRS/Université de Savoie

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Outline

- Inclusive photon production
- Production at fixed target
- Isolation criterion
- Production at colliders
- Conclusion

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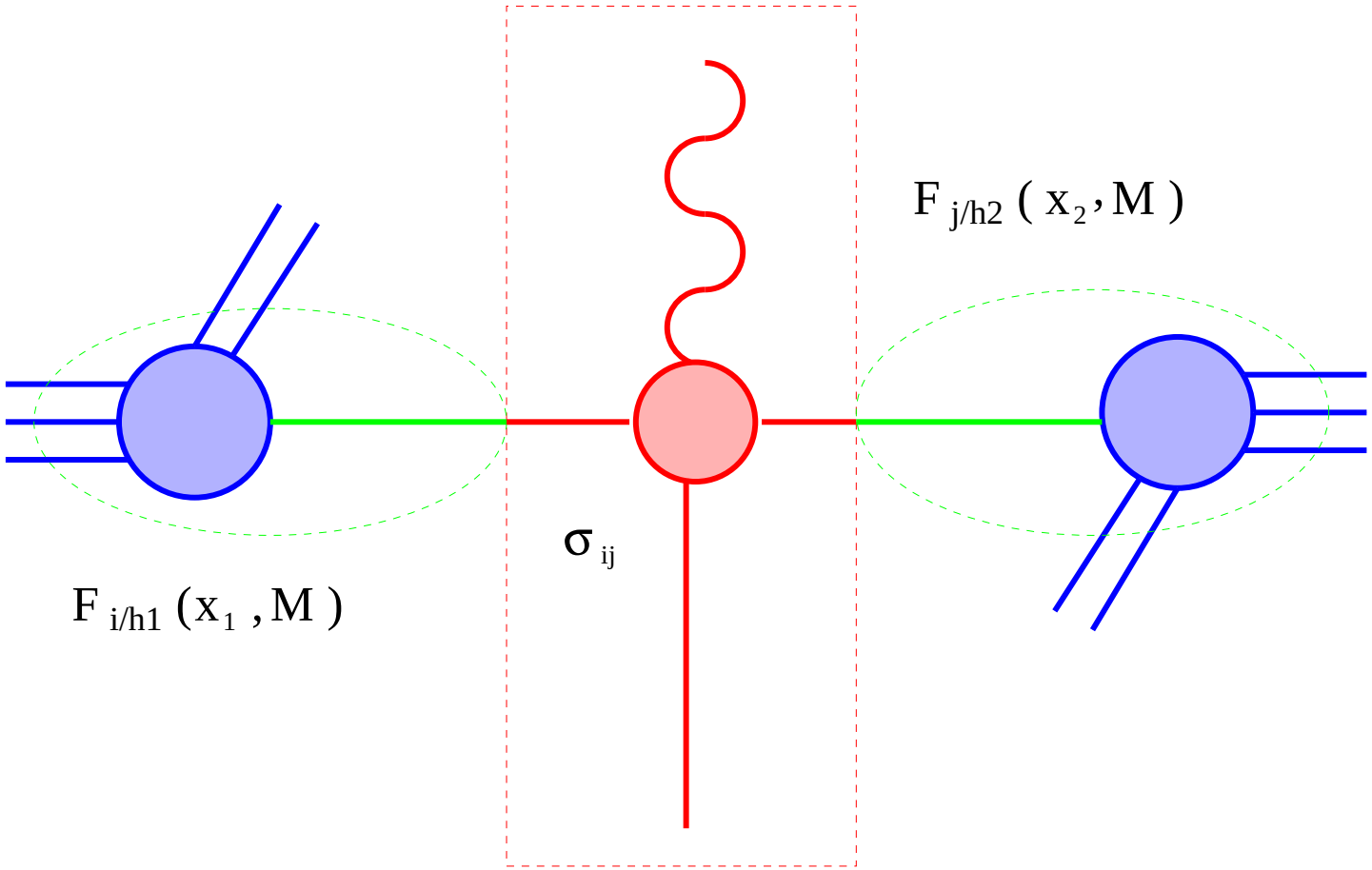
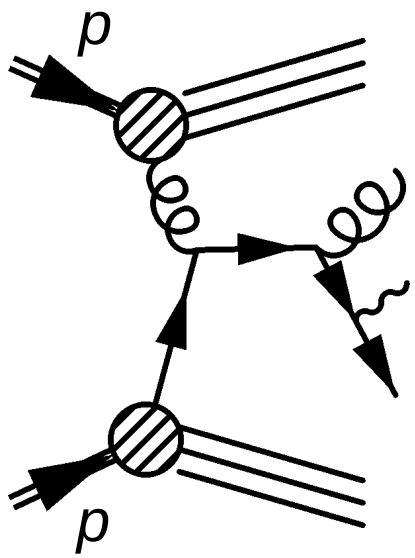
Inclusive photon production

Direct



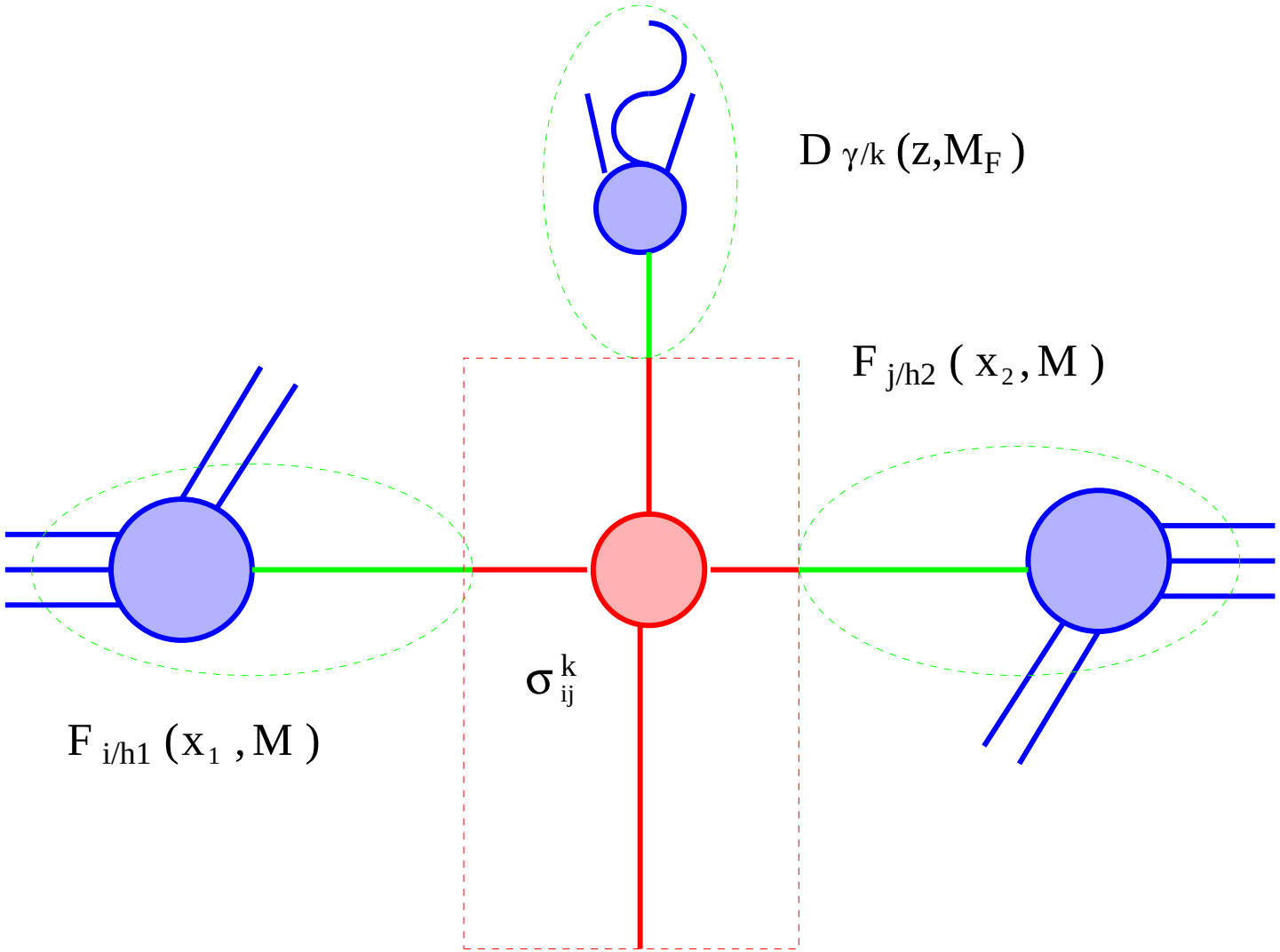
Inclusive photon production
Additional component for photon production

$O(\alpha_s)$:



Inclusive photon production

Fragmentation



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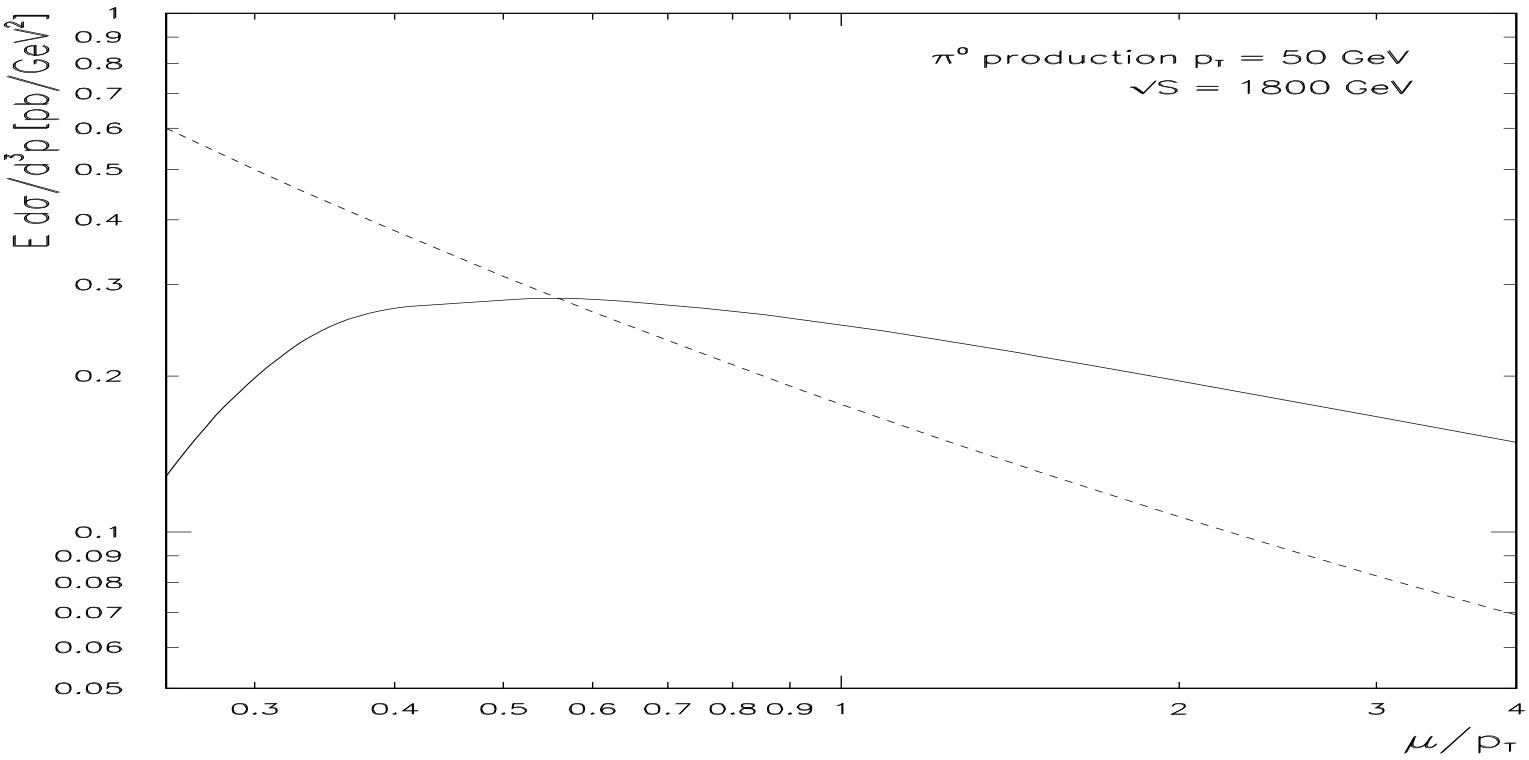
Inclusive photon production

Why NLO?

$$\frac{\partial}{\partial \ln(M)} \left(\frac{d\,\sigma}{d\,\vec{P}_{T\,\gamma}\,d\,y_{\gamma}} \right) = O(\alpha_s^{n+1})$$



- $\hat{\sigma}_{ij}^{(1)}$ contains other logarithmic terms such as $\ln(\hat{x}_T)$, $\ln(1-\hat{x}_T)$, ... where $\hat{x}_T = 2P_{T\gamma}/\sqrt{\hat{s}}$.
  - when $P_{T\gamma}$ is close to $\sqrt{S}/2$, the extra gluons are forced to be soft $\rightarrow$ large logarithms of infra-red origin
  - when $P_{T\gamma} \ll \sqrt{S}$, two scale problem, in this regime, the assumptions of the QCD improved parton model may not be valid $\rightarrow$ The Altarelli-Parisi evolution may be not valid.
- assumption that the γ produced is collinear to the parent parton $\rightarrow$ inter jet activity cannot be described by this type of calculation
- the fragmentation functions are extracted from $e^+ e^-$ data in a range $.1 < z < .8$. What are the errors due to FF?

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- Large domain of energies experimentally studied.
- Used to constrain the proton gluon density
  $\sigma_{q+g\to\gamma+X} \gg \sigma_{q+\bar{q}\to\gamma+X}$ (but banished from the PDF fits)
- probe of energy loss processes in quark-gluon plasma

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Inclusive photon production
NLO codes

	type of code	Direct	Fragmentation
INCNLO (*)	I/FO	NLO	NLO
Vogelsang, Gordon (*)	I/FO	NLO	NLO
Owens et al.	G/FO	NLO	LO
Frixione, Vogelsang	G/FO	NLO	LO
JETPHOX (*)	G/FO	NLO	NLO

I : Inclusive
G : Generator
FO : Fixed Order

(*) http://lapth.in2p3.fr/PHOX_FAMILY/main.html

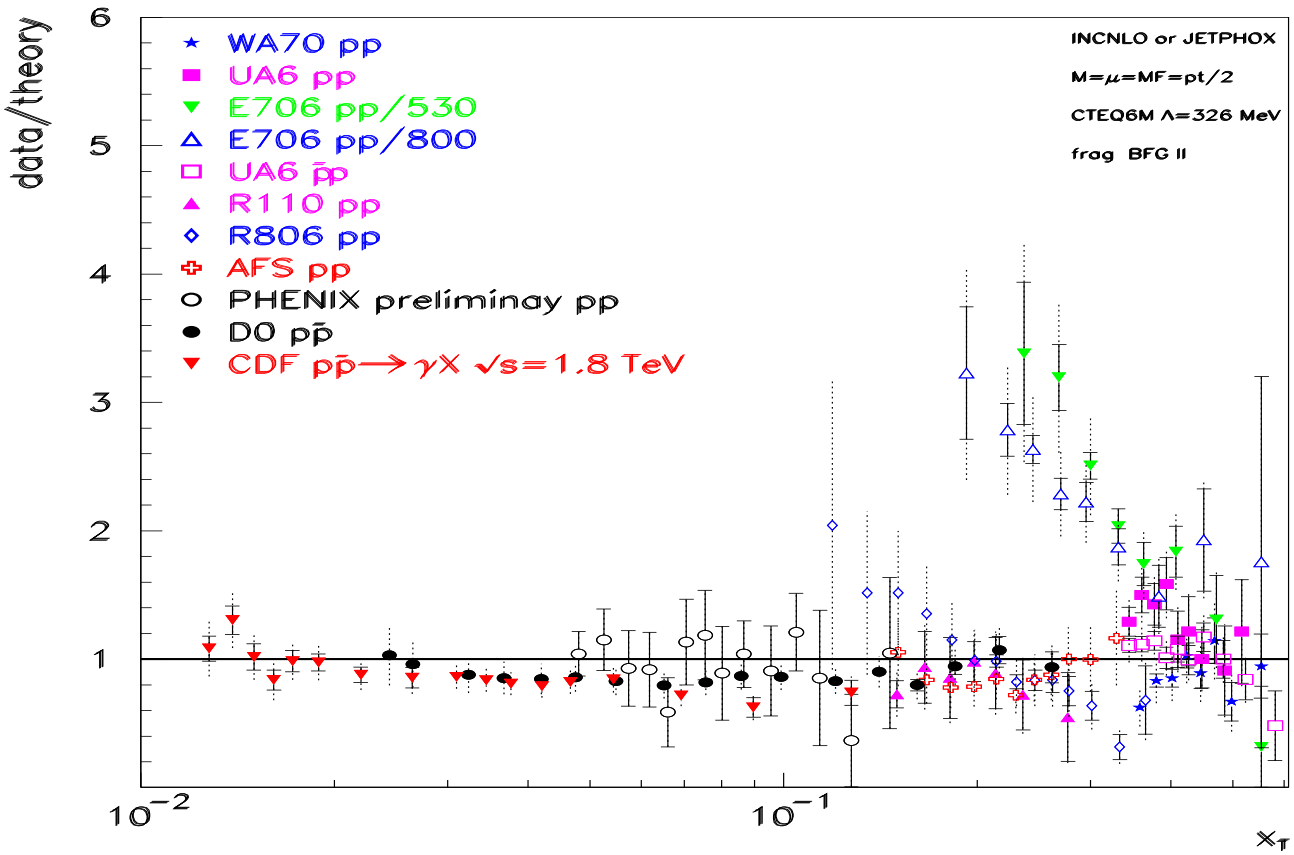
Threshold resummation:(*) Catani et al., Vogelsang, Sterman
(*) Kidonakis, Owens

Production at fixed target

Comparison with existing data

Disagreement between data and theory

$23 \leq \sqrt{S} \leq 1800$ GeV: fixed target + ISR data + Tevatron data



Production at fixed target
Comparison with existing data

Disagreement between data and theory or disagreement among experimental data???

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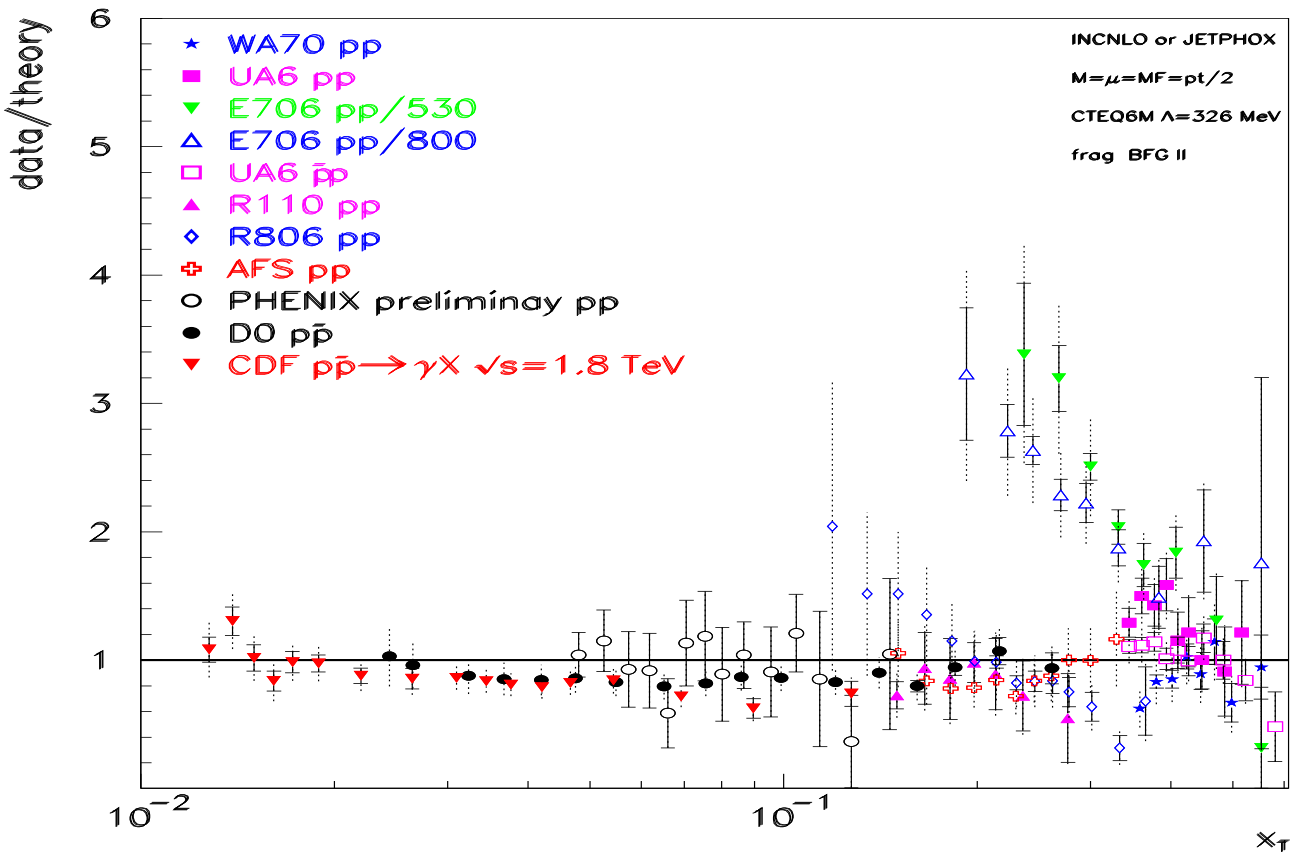

Summation of logs of infra-red origin $\ln(1-\hat{x}_T)$ (Catani, Nason, Vogelsang) and even conjoint summation of $\ln(1-\hat{x}_T)$ and $\ln(\hat{x}_T)$ (Sterman, Laenen, Vogelsang).

To get agreement with E706 experiments, a large non perturbative input (intrinsic k_T) is needed but incompatible with other experiments . . .

Re-add of photon data in the PDF fits???? (d'Enterria,Ichoux)

Production at fixed target
Source of uncertainties

Apart from the PDF :

- Knowledge of photon fragmentation function
- isolation criterion (no more inclusive!)

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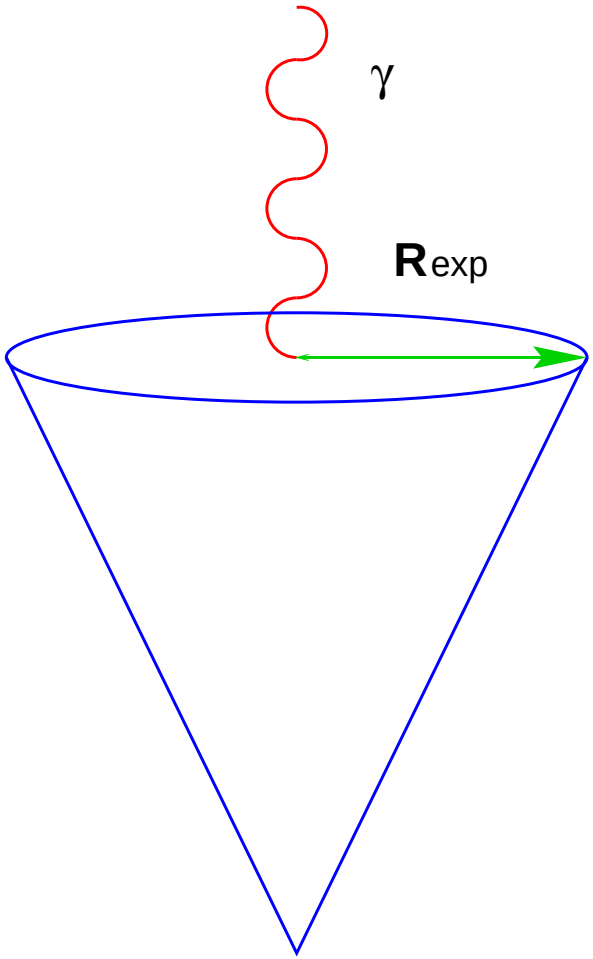
Isolation criterion
Standard criterion



$E_T^{had} \leq E_{T\,max}$ inside
$(y - y_\gamma)^2 + (\phi - \phi_\gamma)^2 \leq R_{exp}^2$

Isolation criterion
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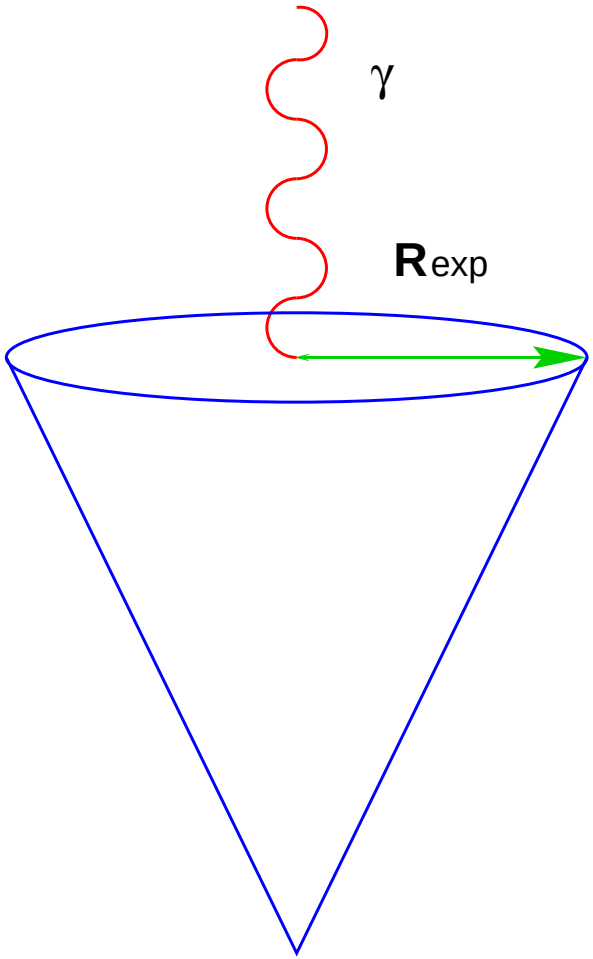

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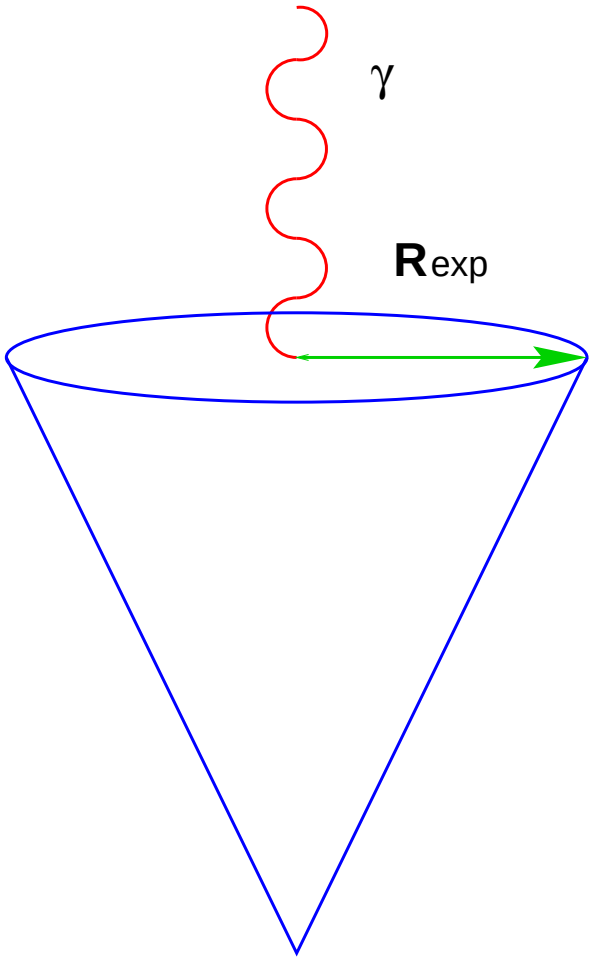

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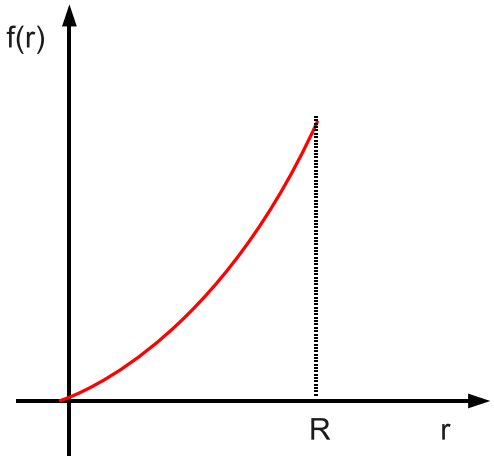
Underlying events, pile up, ...

Isolation criterion
Criterion a la Frixione

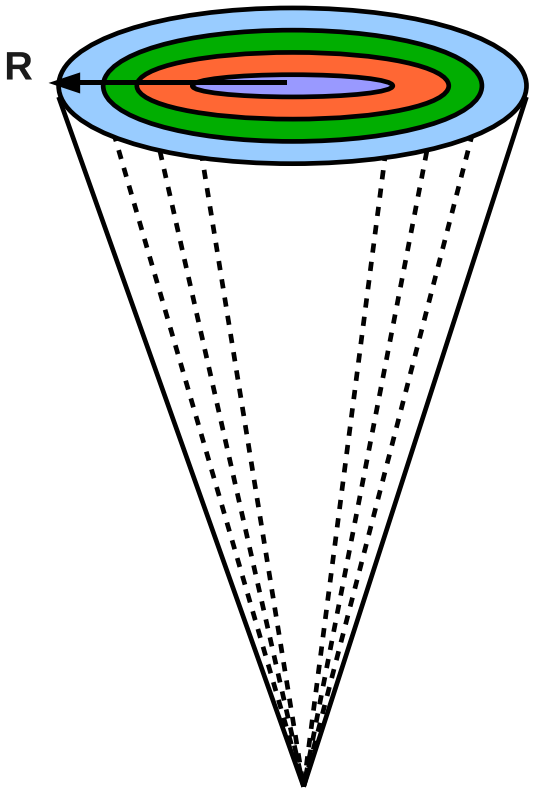


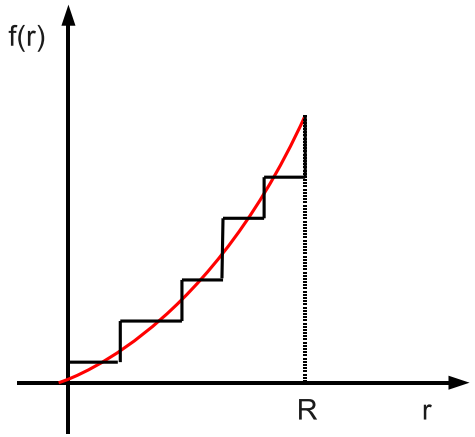
Other isolation criterion (S. Frixione)
where $E_{T\,had} < f(r)$

$f(r) \rightarrow 0$ when $r \rightarrow 0$ like r^{2n}

kill the fragmentation contribution

Isolation criterion
Discrete version

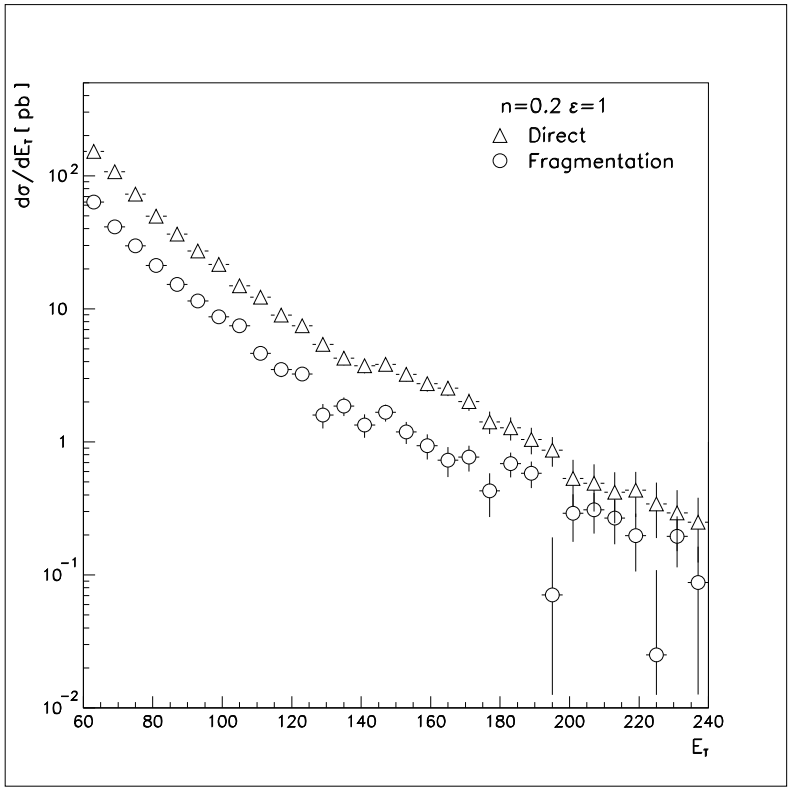


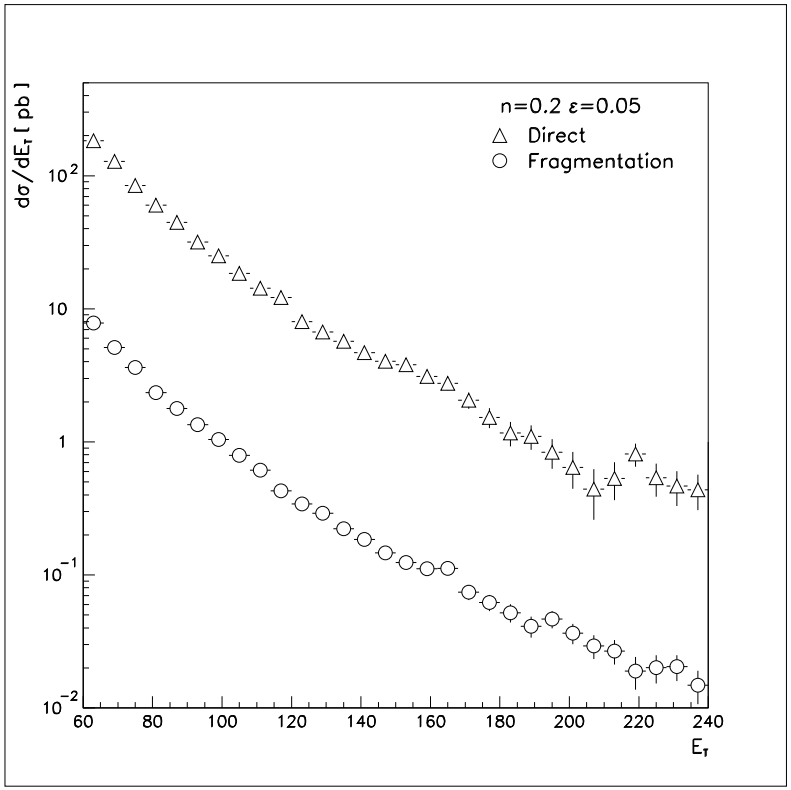


$$E^{j}_{T\,max} = \epsilon\, P_{T\,\gamma} \left(\frac{1-\cos(r_j)}{1-cos(R)} \right)^{n}$$

Isolation criterion
Result

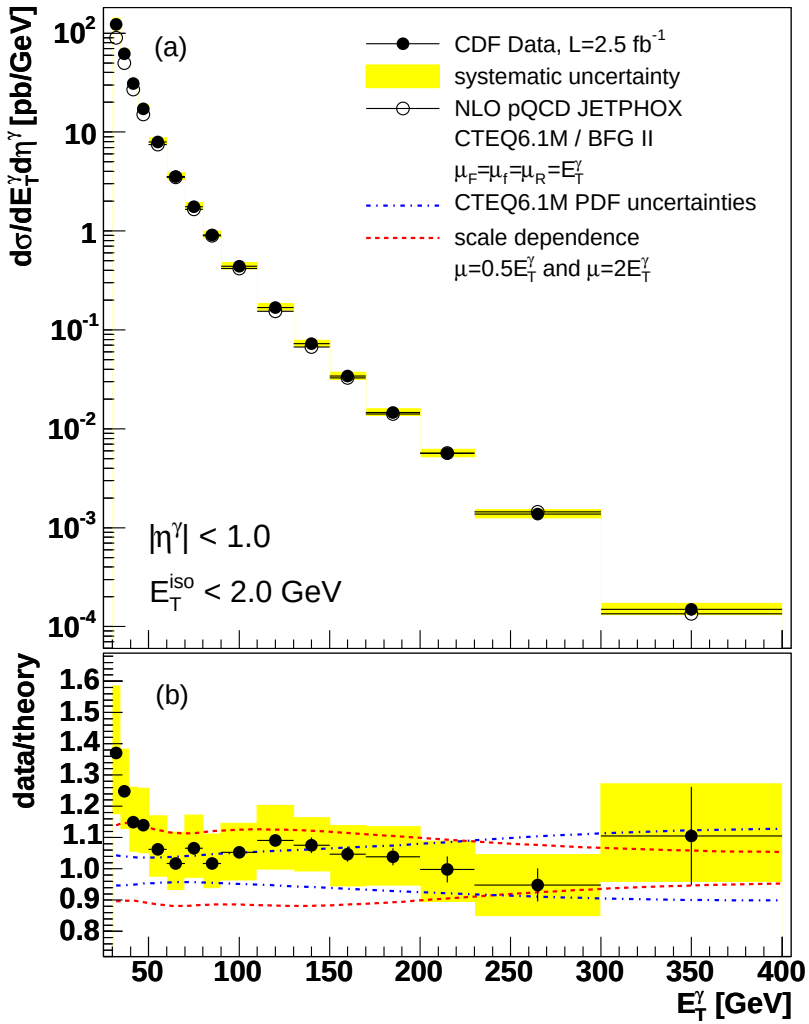
6 nested cones : 0.1, 0.16, 0.22, 0.28, 0.34, 0.4





Production at colliders

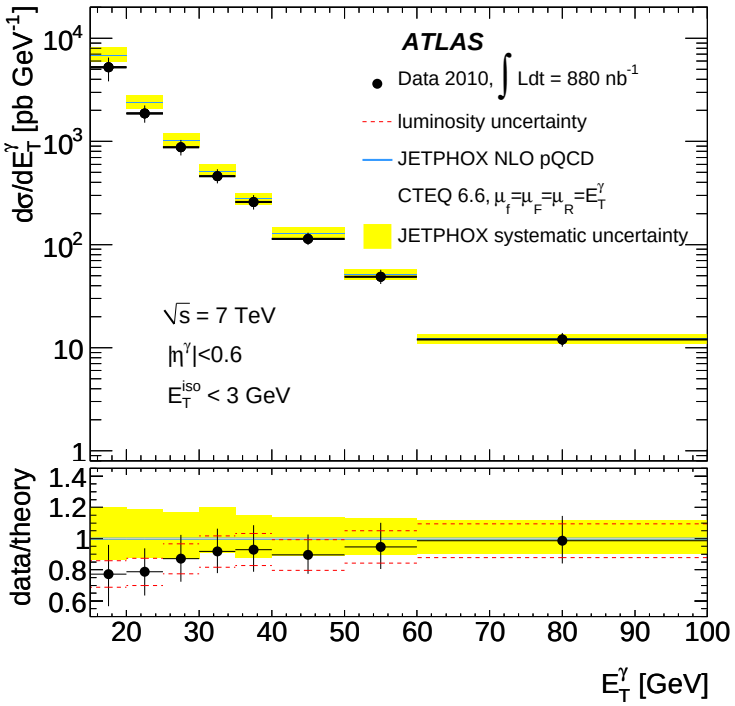
P_T distribution CDF

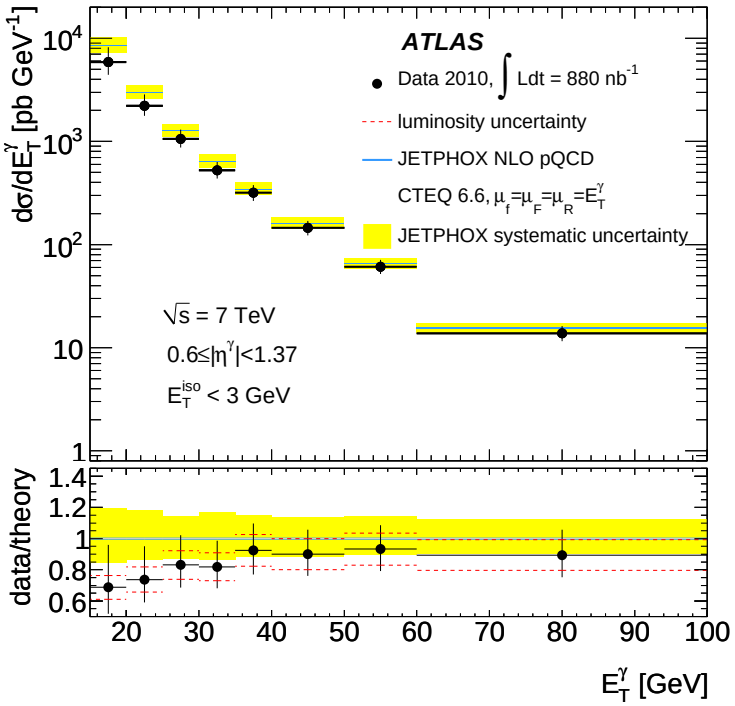


high energy resummation ($P_{T\,\gamma} << \sqrt{S}$) is negligible at Tevatron : G. Diana, J. Rojo and R. D. Ball (arXiv:1006.4250 [hep-ph])

Production at colliders

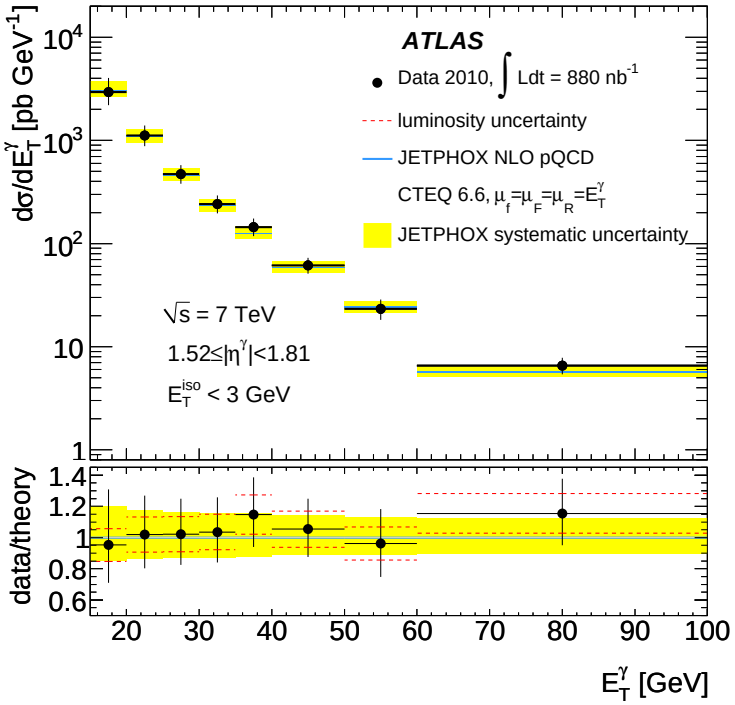
P_T distribution ATLAS





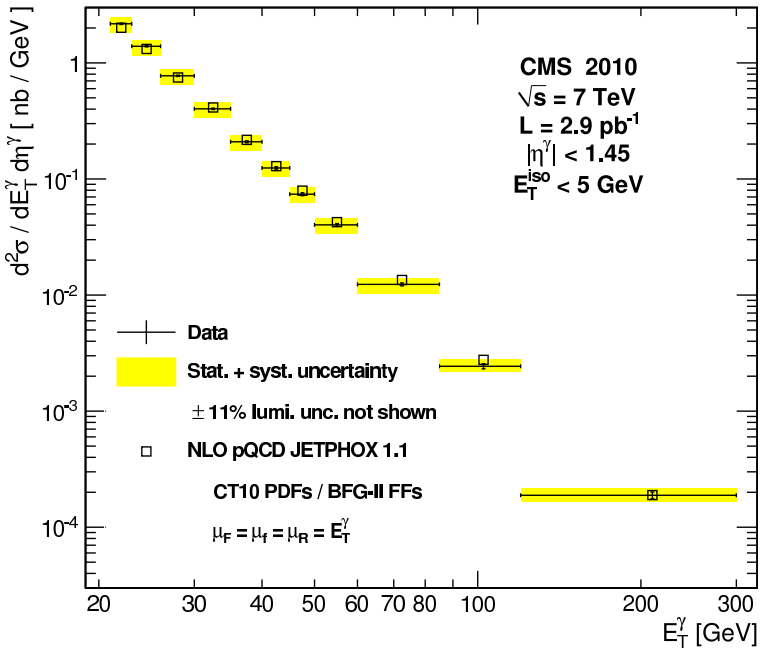
Production at colliders

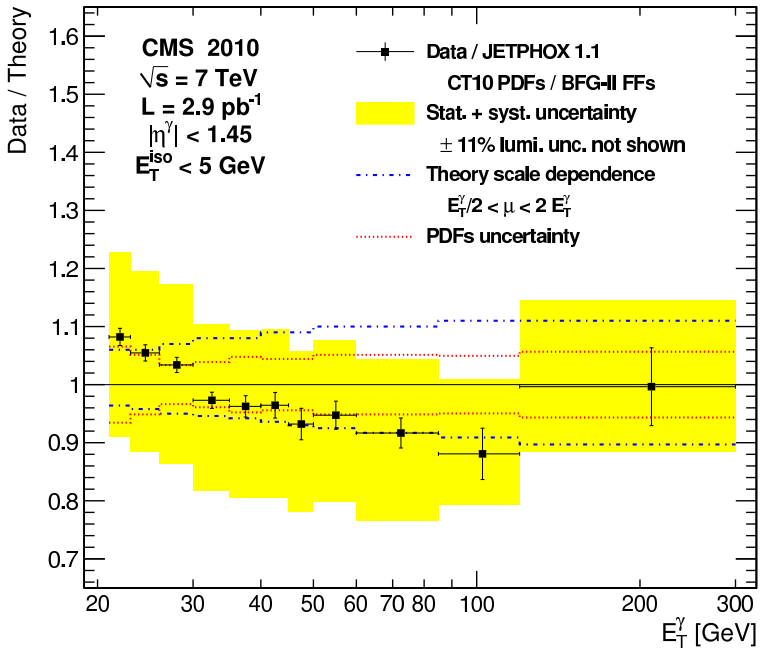
P_T distribution ATLAS (bis)



Production at colliders

P_T distribution CMS





Conclusion

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- More work to know as accurately as possible the uncertainties coming from photon fragmentation functions and isolation criteria

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