Gaps between Jets in the High Energy Limit

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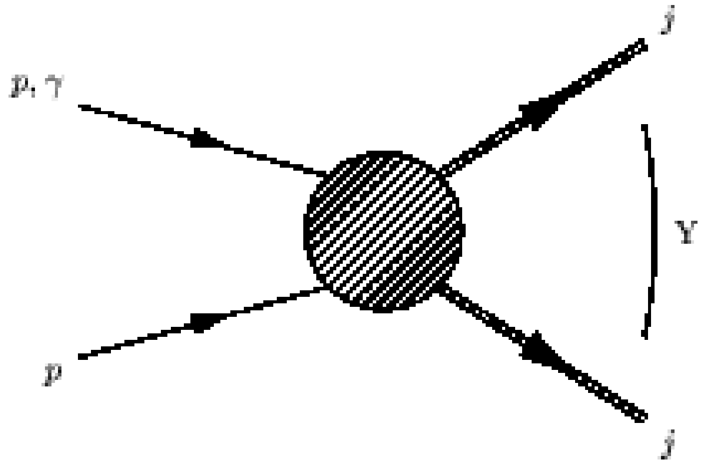
h h $\rightarrow$ jet + gap + jet



$\Rightarrow$ Better understanding of

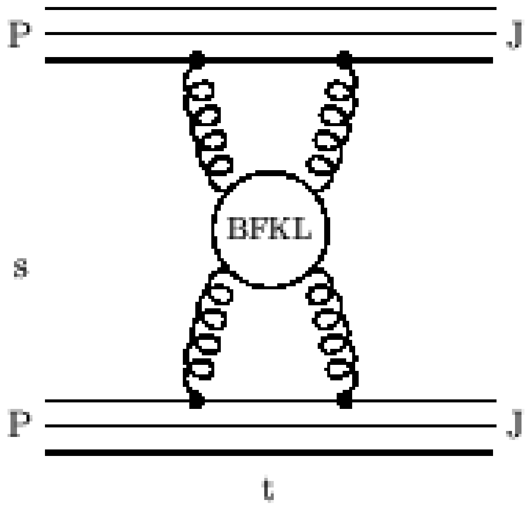
- QCD in the high energy limit
- QCD radiation in “gap” events

$\Rightarrow$ 2 approaches

1. BFKL

p p $\rightarrow$ 2 jets via non-forward BFKL exchange

Mueller/Tang; Motyka/Martin/Ryskin



gap=nothing, color singlet exchange,

$$\rightarrow \text{resummation of } (\alpha_s Y)^n\,, \quad Y = \ln s/|t|$$

Application to Tevatron: Cox/Forshaw/Lönnblad; Engberg/Ingelmann/Motyka

2. Leading-Log-Q_0 (LLQ_0)

gap $\equiv$ (interjet transvere energy $< Q_0$)

$$L = \ln \frac{Q^2}{Q_0^2}\,, \quad Q = p_{T\,jet}$$

Using the Collins/Soper/Sterman formalism (CSS)

$\rightarrow$ resummation of $(\alpha_s L)^n Y^m\,,\; m \leq n$

(Tevatron/Hera) Oderda/Kucs/Sterman; Appleby/Seymour

The 2 approaches

$Y \gg L$	$Y \ll L$
BFKL	**LLQ$_0$**
$(\alpha_s Y)^n$	$(\alpha_s L)^n Y^m$

Unification desirable
$\longrightarrow$ Combined resummation,
1.step: fixed order combination, smooth interpolation

add both order by order ?

$\longrightarrow$ BFKL at each order IR-divergent
$\longrightarrow$ double counting

$$\boldsymbol{qq \to qq + X \;, \quad |k_{T,X}| < Q_0}$$

We work in the :

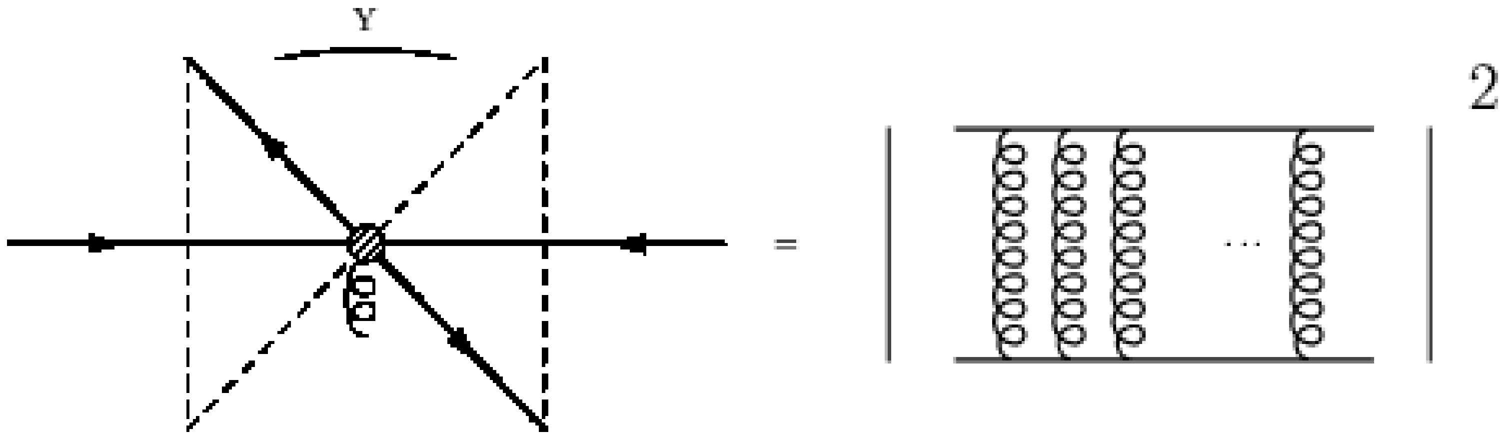
- LLQ_0-approximation ($\to$ strongly ordered $k_\perp$)
- high energy limit

and calculate the all-orders cross section

$$\sigma_{\text{gap}} \equiv \frac{d\sigma(\hat{s}, Q_0, Y)}{dQ^2}$$

via a Theorem

The Theorem



$k_{\perp i} > Q_0$

$|y_i| < Y$

$$\sigma_{\text{gap}} = \left|\mathcal{A}_{\text{gap}}(Q_0)\right|^2$$

- we include the imaginary parts of the loop integrals

$$\rightarrow \text{resummation of } \alpha_s^n L^n Y^n \left(1, \left(\frac{\pi^2}{Y^2}\right), \left(\frac{\pi^2}{Y^2}\right)^2 \ldots\right)$$

- σ_{gap} differs from the full LLQ_0 result by $\lesssim$ 10 % (for L $<$ 7)

Matching BFKL (fixed order α_s)

- $\sigma_{\text{gap}} \sim \left|\mathcal{A}_{\text{gap}}(Q_0)\right|^2$ (transverse momenta $> Q_0$)
- $\sigma_{\text{bfkl}} \sim |\mathcal{A}_{\text{bfkl}}|^2$ divergent at fixed order, resummed result finite

($\mathcal{A}_{\text{gap}}, \mathcal{A}_{\text{bfkl}} = 2 \to 2$ amplitudes)

'Common' piece of $\mathcal{A}_{\text{gap}}(Q_0)$ and $\mathcal{A}_{\text{bfkl}}$:

$\mathcal{A}_{\text{gap},1}(0) \equiv \mathcal{A}_{\text{gap}}(Q_0 = 0)$, color singlet exchange, leading-Y, divergent at fixed order

We calculate the combined cross section that includes σ_{gap} and σ_{bfkl} without double counting (finite only up to $\mathcal{O}(\alpha_s^5)$)

Matching BFKL ('all orders')

summing all orders we find

$$\mathcal{A}_{\text{gap},1}(Q_0) \ \sim\ \mathcal{A}^{(0)}\frac{\pi}{Y}\left[1 - exp\left(-\frac{N_c\alpha_s}{\pi}\,Y\,L\right)\right] \quad , \qquad L = 2\ln Q/Q_0$$

$$\rightarrow \boxed{\mathcal{A}_{\text{gap},1}(0) = \text{ finite!}}$$

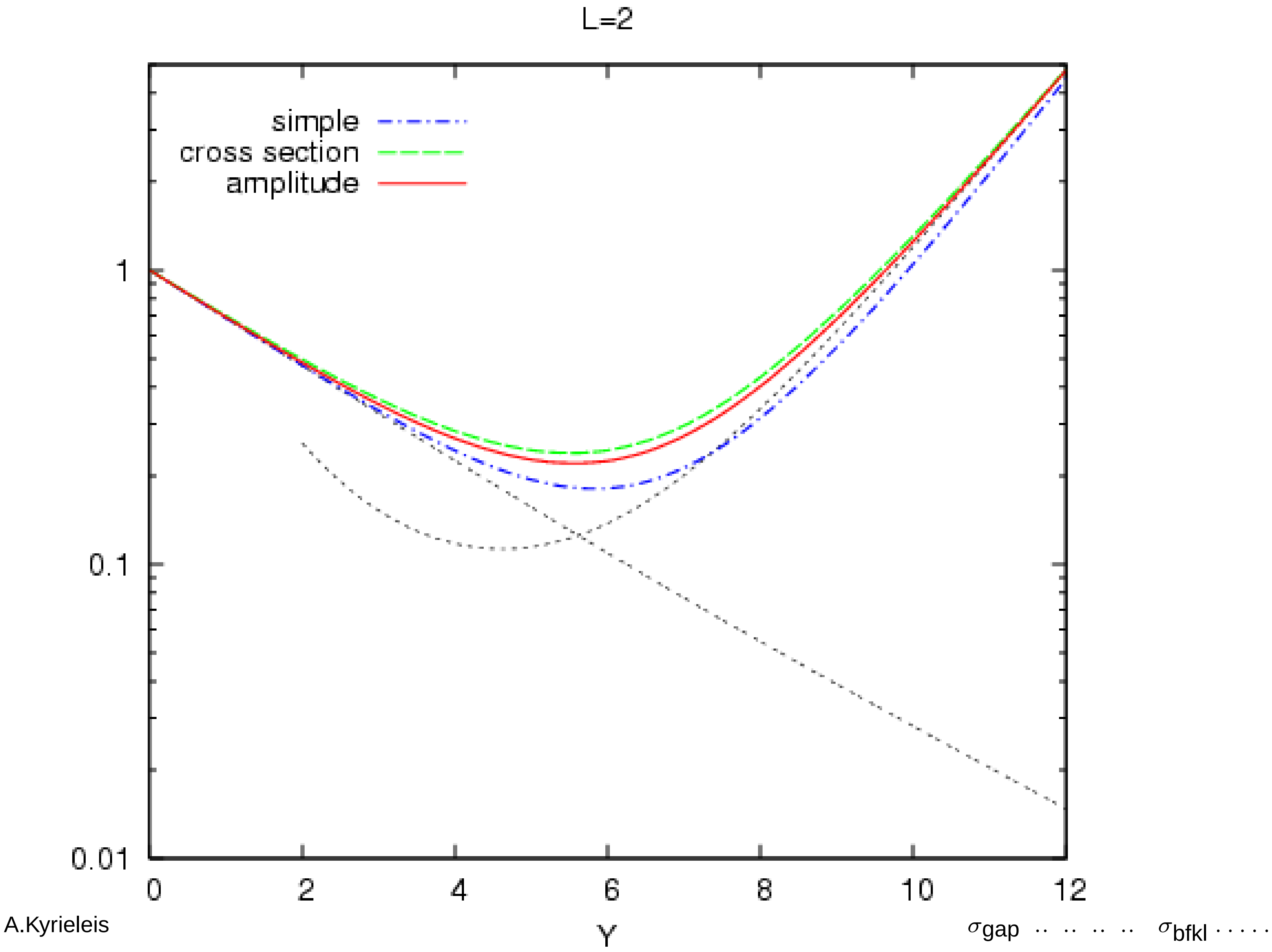
and : $$\boxed{\mathcal{A}_{\text{bfkl}}\big|_{Y\to 0} \ = \ \mathcal{A}_{\text{gap},1}(0) \ = \ \mathcal{A}_{\text{gap}}(Q_0)\big|_{Y\to\infty}}$$

$\Rightarrow$ This allows to combine σ_{gap} and σ_{bfkl} to all orders (hep-ph/0502086)

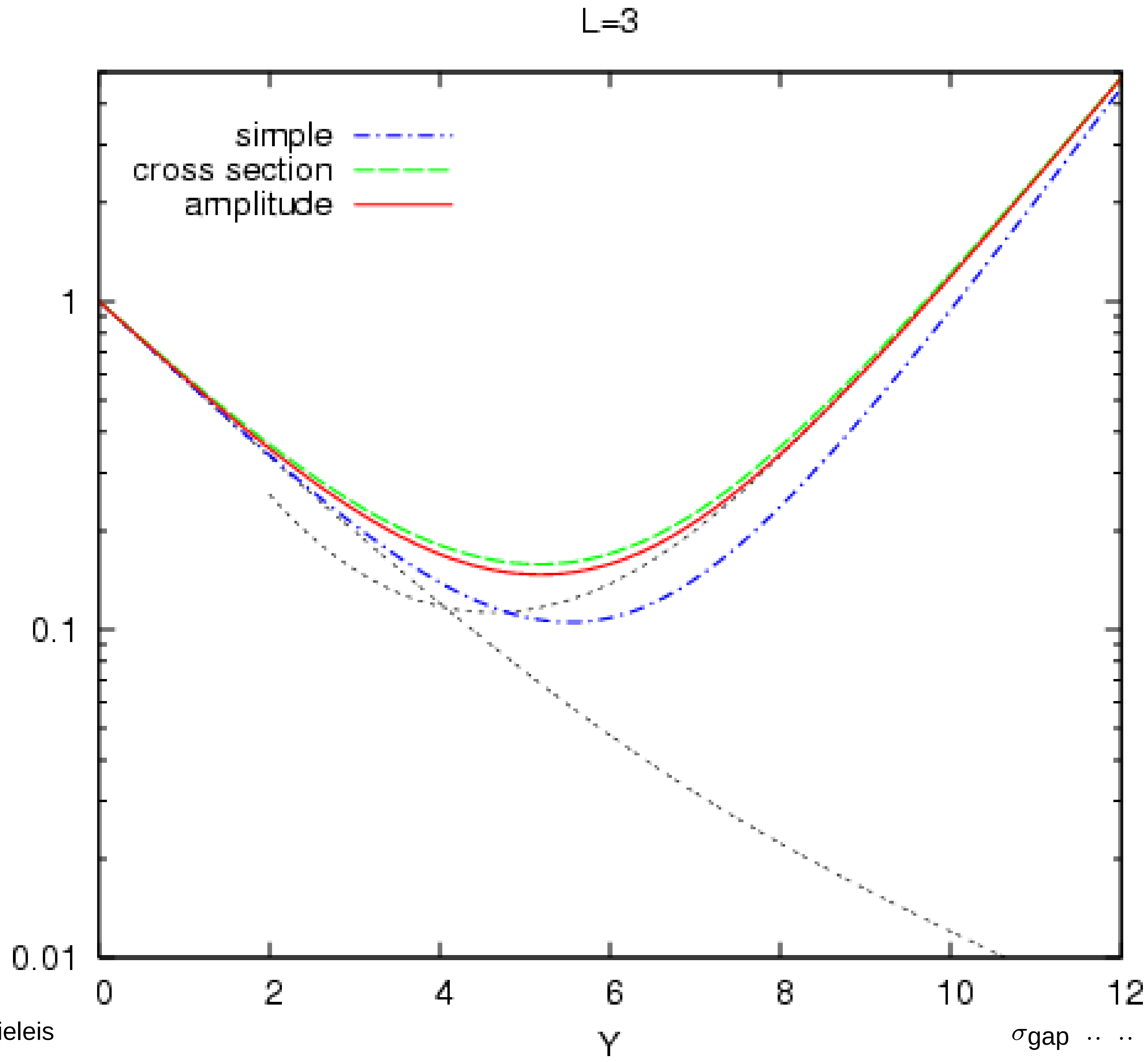
e.g.: $$\sigma_{\text{comb}} \sim \left|\mathcal{A}_{\text{gap}}(Q_0) + \mathcal{A}_{\text{bfkl}} - \mathcal{A}_{\text{gap},1}(0)\right|^2$$ or

$$\sigma_{\text{comb}} = \sigma_{\text{gap}} + \sigma_{\text{bfkl}} - \sigma_I \quad , \quad \sigma_I \sim \left|\mathcal{A}_{\text{gap},1}(0)\right|^2$$

divergencies suppressed $\Rightarrow$ uncertainty in matching procedure

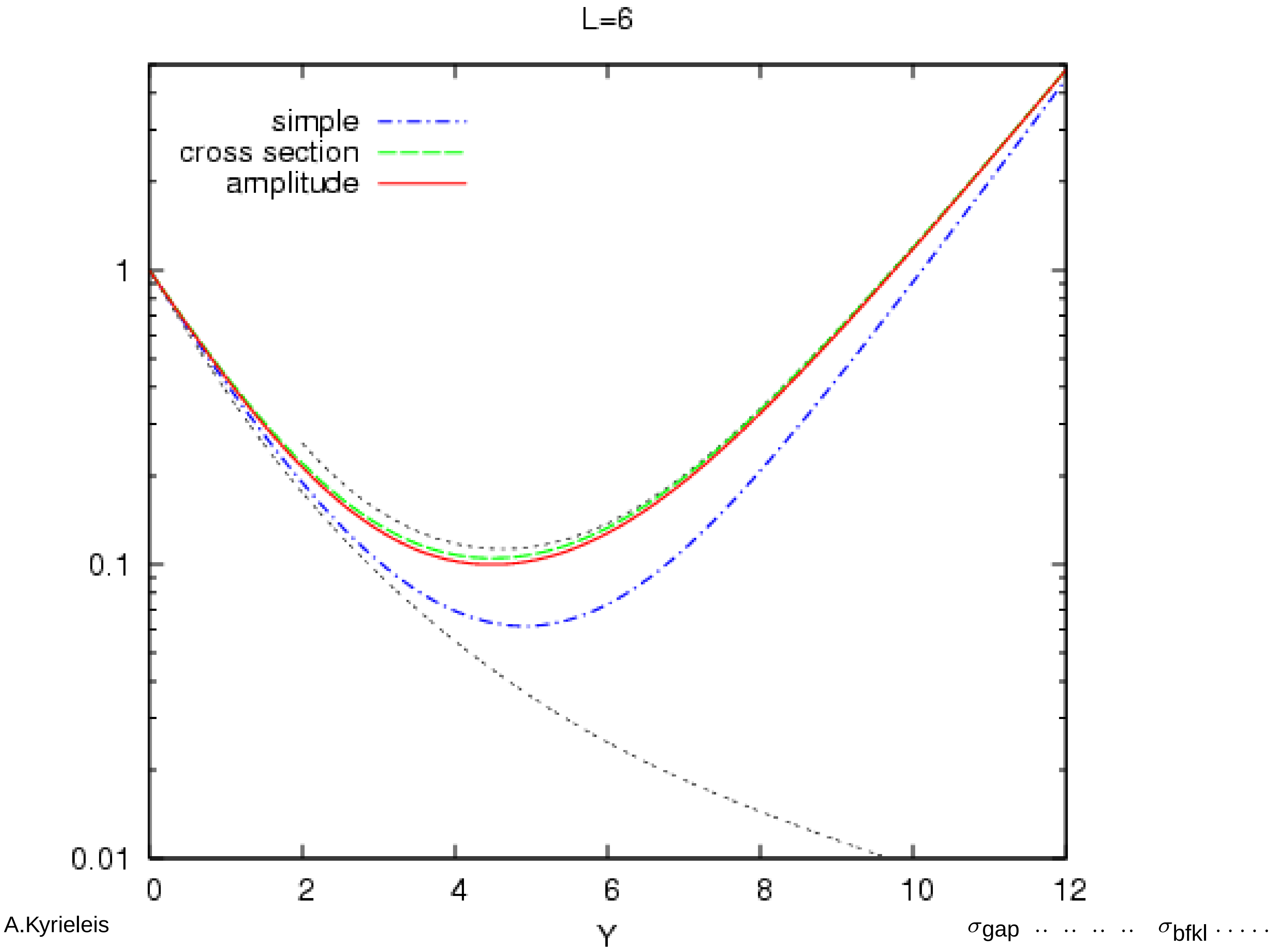


L=2
simple
cross section
amplitude
1
0.1
0.01
0
2
4
6
8
10
12
Y
A.Kyrieleis
σ_{gap}
σ_{bfkl}



A.Kyrieleis

σ_{gap} ·· ·· ·· ·· σ_{bfkl} · · · · ·



L=6
simple
cross section
amplitude
1
0.1
0.01
0
2
4
6
8
10
12
Y
A.Kyrieleis
σ_{gap} .. ..
σ_{bfkl} . . . . .

Summary

- first step towards unification of two major approaches to the jet-gap-jet process

- fixed order cross section that combines $BFKL$ and LLQ_0 results

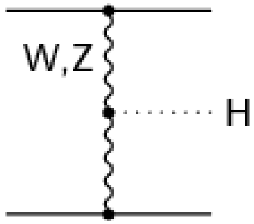
- 'all orders' matching schemes that interpolate between $BFKL$ and LLQ_0 without double counting

Outlook

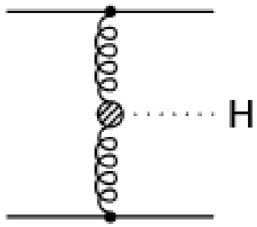
- Simultaneous resummation of leading logs of s and Q_0

$\rightarrow$ at each order α_s : cancellation of the divergences

- Important for discovery/couplings of Higgs :



  - most important background: GF:



  - veto on interjet activity typically large

$\Rightarrow$ resummation of $\ln Q_0$ in $p\,p \rightarrow jet + H + jet$ via GF