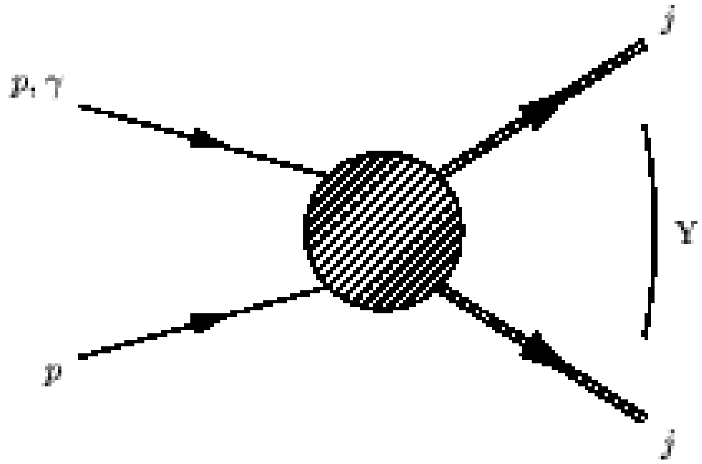
Gaps between Jets

Albrecht Kyrieleis

Dublin, March 2005

jet + gap + jet



⇒ Better understanding of

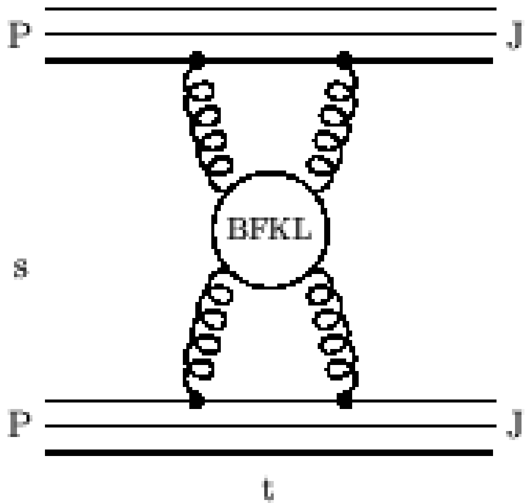
- QCD in the high energy limit
- QCD radiation in "gap" events

⇒ 2 approaches

1. BFKL

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

Mueller/Tang; Motyka/Martin/Ryskin



gap=nothing, color singlet exchange,

$\rightarrow$ 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 $< Q_0$

$\rightarrow$ resummation of $(\alpha_s L)^n$, $\quad L = 2\ln\frac{Q}{Q_0} \ll Y$, $\quad Q = p_{T\,jet}$

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

method:

Factorisation of hard cross section into soft (physics below scale Q_0) and hard function Collins/Soper/Sterman

The 2 approaches

$Y \gg L$
BFKL
$(\alpha_s Y)^n$

$Y \ll L$
$\mathbf{LLQ_0}$
$(\alpha_s L)^n Y^m, \quad m < n$

Combination desirable
$\longrightarrow$ Combined resummation,
at least: smooth interpolation

add both order by order ?

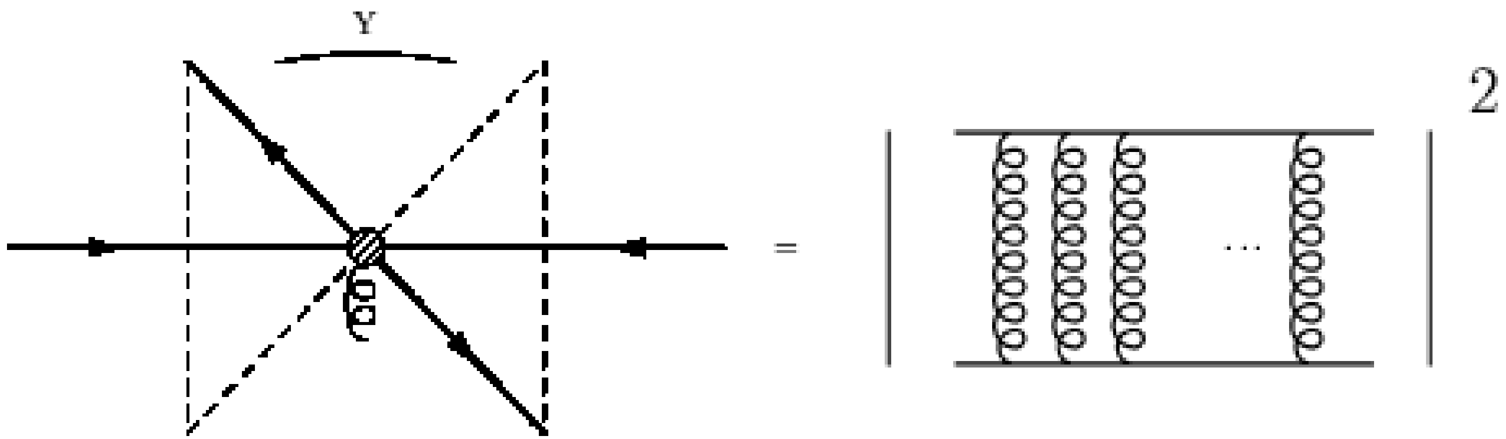
$\longrightarrow$ BFKL at each order IR-divergent
$\longrightarrow$ double counting

We consider:

- gap $\equiv k_T < Q_0$ in interjet region, LLQ_0 ($\rightarrow$ strongly ordered $k_\perp$)
- high energy limit

and calculate σ_{gap} via the **Theorem**:

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



$k_{\perp i} > Q_0$

$|y_i| < Y$

σ_{gap} differs from 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

Combined cross section that includes σ_{gap} and σ_{bfkl} is finite only for the first few orders in α_s

Matching BFKL ('all orders')

summing all orders we find

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

as $Q_0 \to 0$ or $Y \to \infty$: $\quad \mathcal{A}_{\text{gap},1}(Q_0) \longrightarrow \mathcal{A}_{\text{gap},1}(0) \;=$ finite!

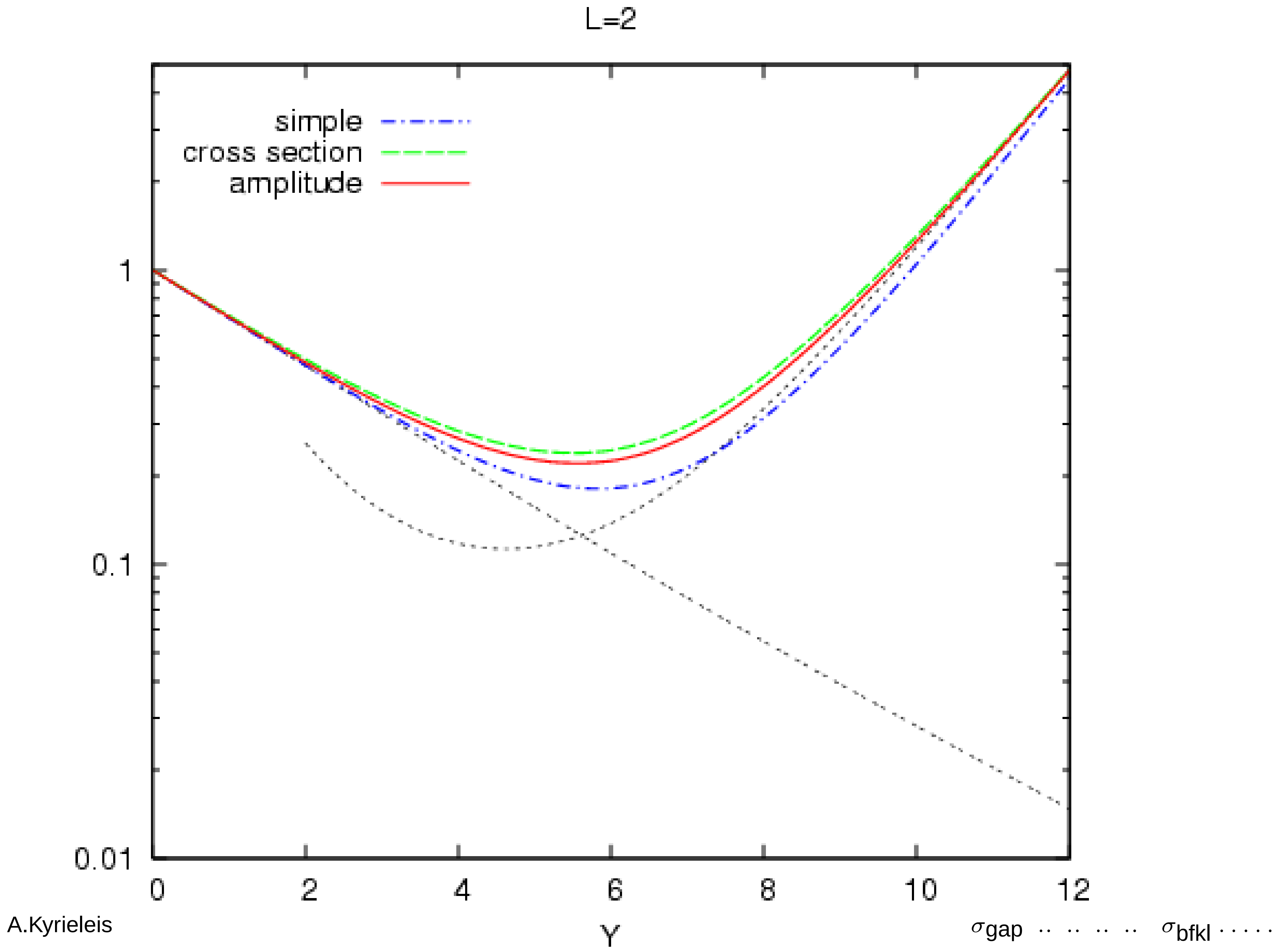
and : $$\boxed{\mathcal{A}_{\text{bfkl}}\big|_{Y\to 0} \;=\; \mathcal{A}_{\text{gap},1}(0) \;=\; \mathcal{A}_{\text{gap}}(Q_0)\big|_{Y\to\infty}}$$

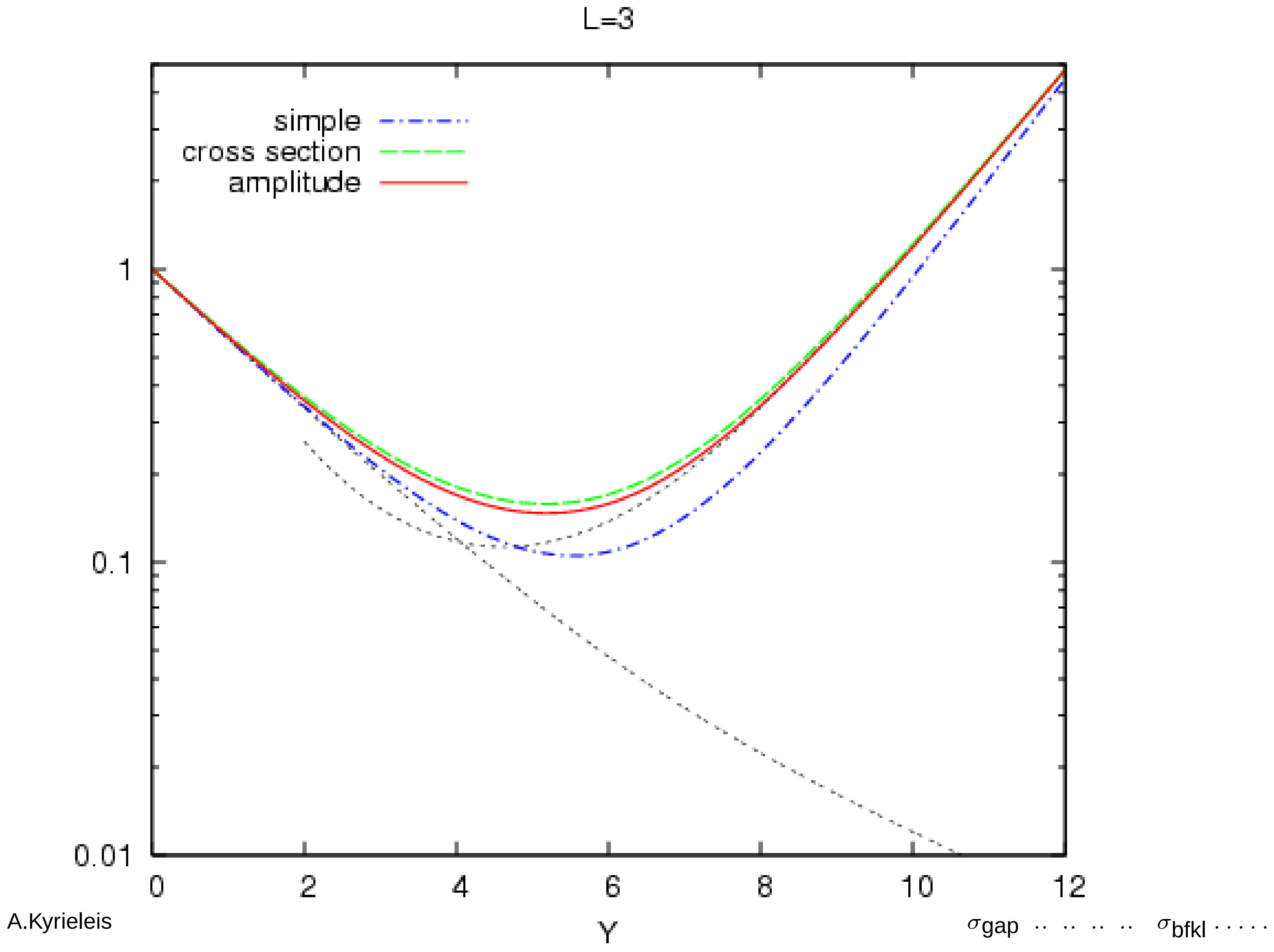
$\Rightarrow$This allows to combine σ_{gap} and σ_{bfkl} to all orders (hep-ph/0502086)

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

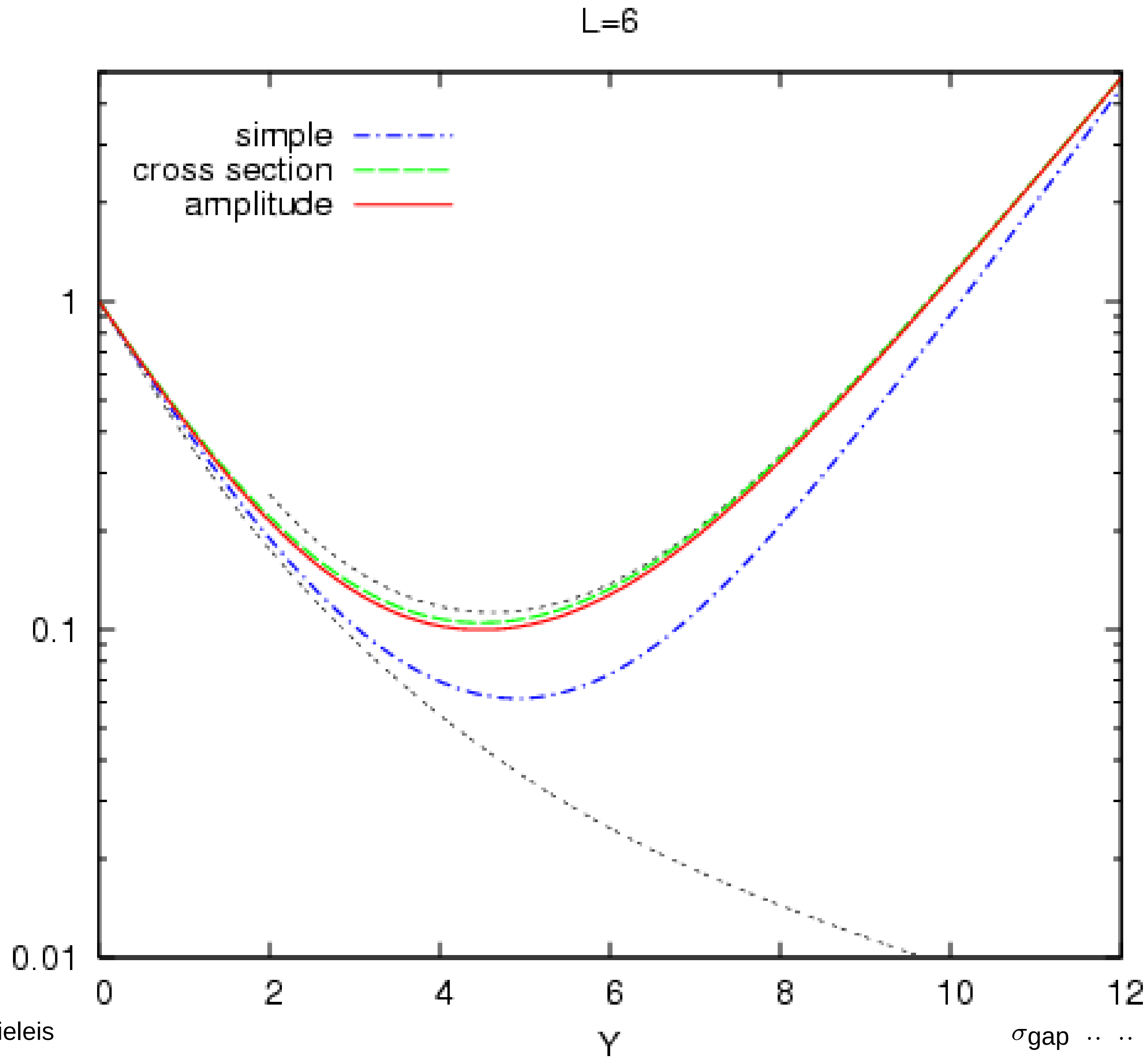
$$\sigma_{\text{comb}} = \sigma_{\text{gap}} + \sigma_{\text{bfkl}} - \sigma_I \quad , \quad \sigma_I \sim \left|\mathcal{A}_{\text{gap},1}(0)\right|^2$$

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}



L=3
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} · · · · ·

Outlook

- Simultaneous resummation of leading logs of s and Q_0

$\rightarrow$ unambiguous combination of LLQ_0 and BFKL

- $p\,p \rightarrow j + H + j + X, \quad E_x < Q_0$ (GF)
  - important for Higgs production via WBF
  - veto on interjet activity typically large $\rightarrow$ resummation of $\ln Q_0$