Non-Sudakov Form-factor in CMC (MMC)

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October 25th, 2006

The project is supported by EU grant MTKD-CT-2004-510126,
realized in the partnership with CERN PH/TH Division and by the Polish Ministry
of Scientific Research and Information Technology grant No 620/E-77/6.PR
UE/DIE 188/2005-2008

Introduction

- CMC/MMC set of MCs for single evolution evolves gradually from DGLAP towards CCFM:
- *z*-dependent *alpha_S*
- Rapidity ordering
- *kT*-dependent *alpha_S*
- **Last missing CCFM element is being added today: non-Sudakov form-factor (pure gluonstrahlung)**
- Remark: in the present MMC/MMC gluonstrahlung segments are interleaved with the quark-gluon transitions, hence we are going towards CCFM with Q-G transitions (LO)
- I shall recollect definition of the non-Sudakov form-factor in the literature, in our notation, and present first numerical result from CMC with NS formfactor

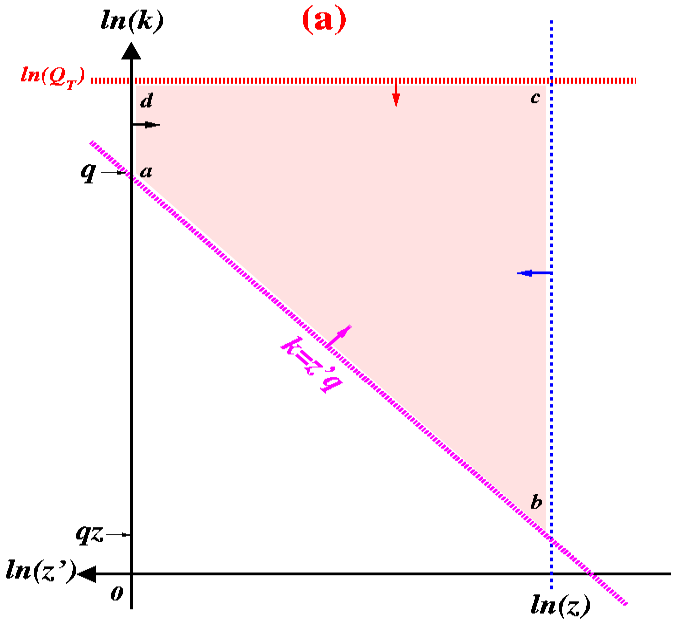
Kwiecinski, Martin, Sutton, PRD52 (1995)

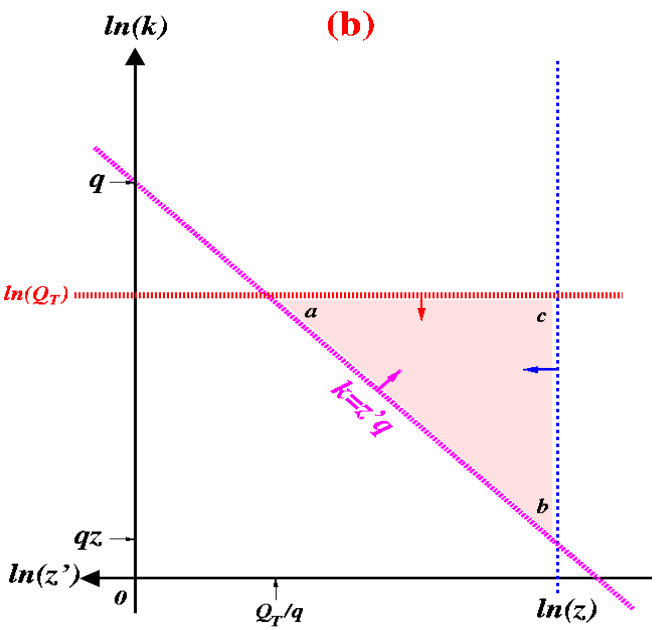
$$\Delta_{\rm NS}(z,q,Q_T) = \exp\left(-\bar{\alpha}_S \int_z^{z_0} \frac{dz'}{z'} \int \frac{dk^2}{k^2}\Theta(Q_T^2-k^2)\Theta(k-z'q)\right)$$
$$= \exp\left[-\bar{\alpha}_S \ln\left(\frac{z_0}{z}\right)\ln\left(\frac{Q_T^2}{z_0 z q^2}\right)\right],$$

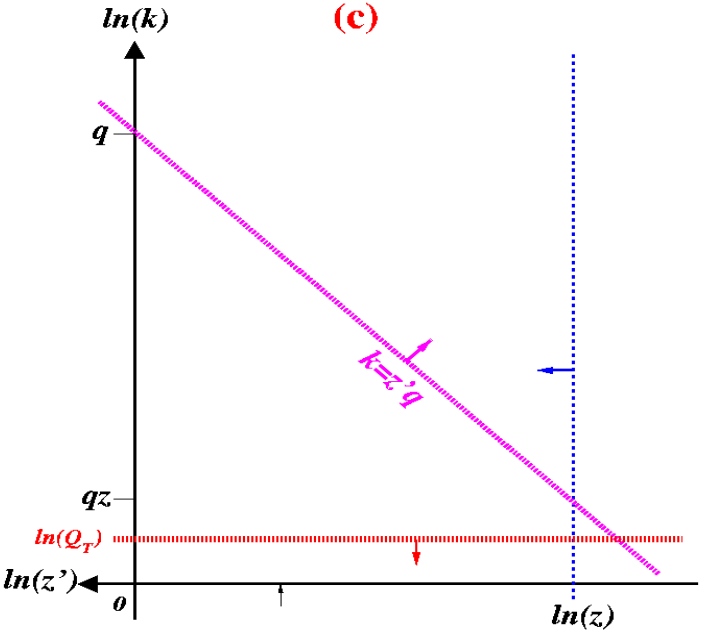
where $Q_T = |\boldsymbol{q}_T + \boldsymbol{q}'_T + \boldsymbol{q}''_T + \cdots|$.

$$z_0 = \begin{cases} 1 & \text{if } (Q_T/q) \geq 1\ , \\ Q_T/q & \text{if } z < (Q_T/q) < 1\ , \\ z & \text{if } (Q_T/q) \leq z. \end{cases}$$

(a) trapezoid
(b) triangle
(c) null







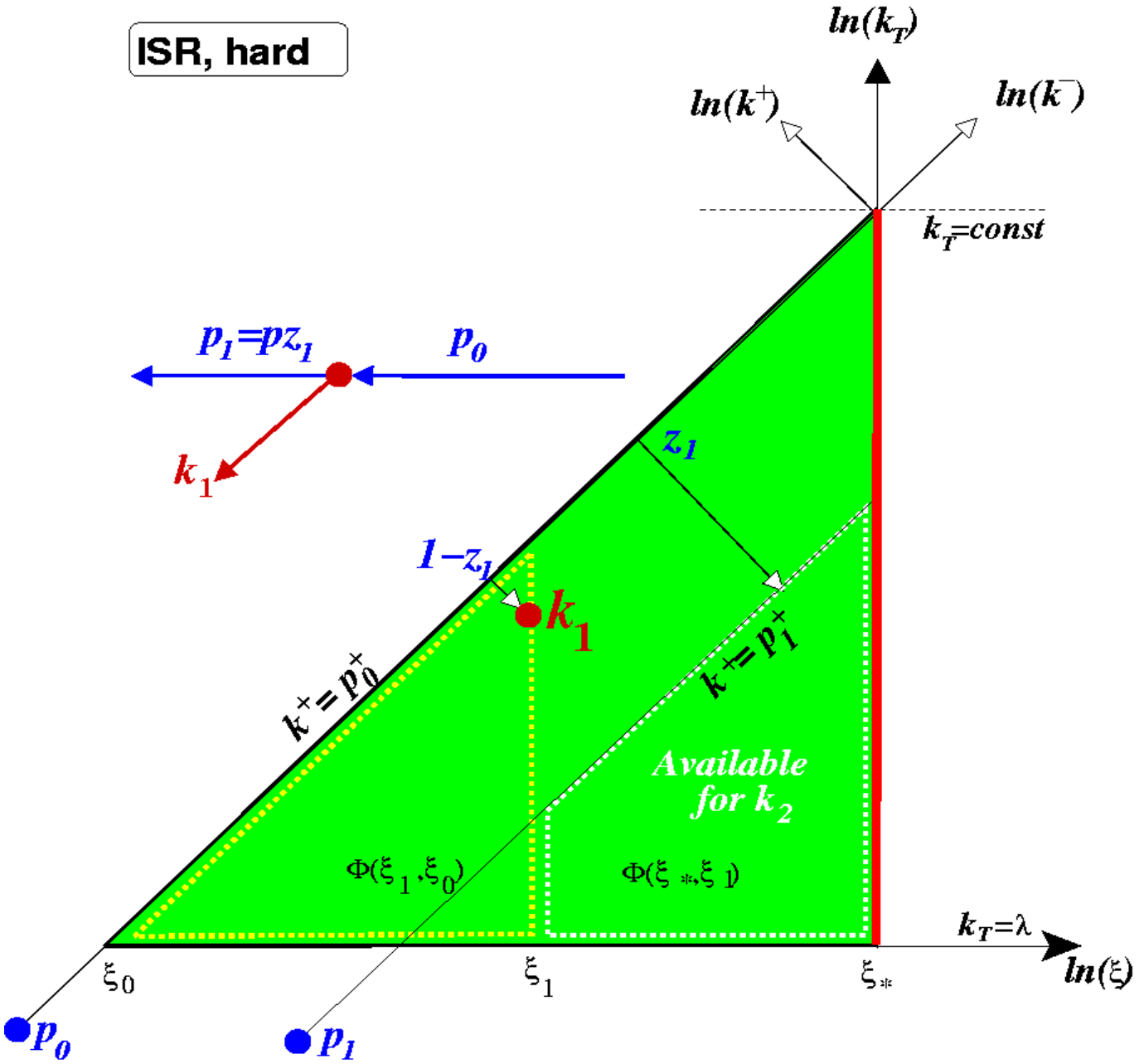
$$I_{\rm NS} = 2\bar{\alpha}_S \int\int \frac{dz'}{z'}\frac{dk}{k}\theta(Q_T-k)\theta(k-z'q)\theta(z'-x)\theta(1-z')$$

(a) trapezoid: $Q_T > q$, $z_0 = 1$, $I_{\rm NS} = \bar{\alpha}_S \ln\frac{1}{z}\ln\frac{Q_T^2}{zq^2}$
$= \bar{\alpha}_S \ln\frac{1}{z}\left(\ln\frac{Q_T}{q} + \ln\frac{Q_T}{zq}\right)$,

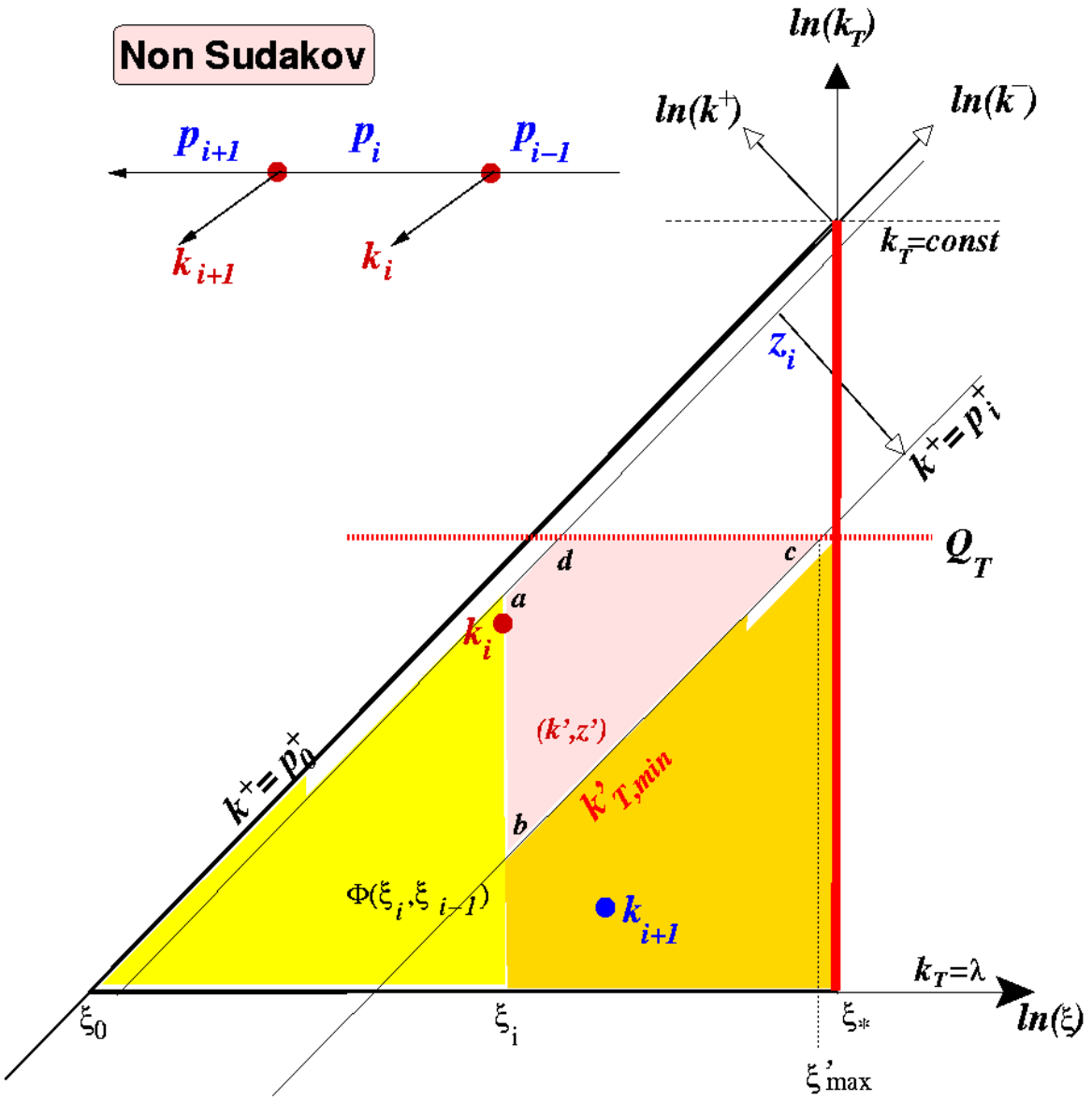
(b) triangle: $qz < Q_T < q$, $z_0 = Q_T/q$, $I_{\rm NS} = \bar{\alpha}_S \ln^2\frac{Q_T}{qz}$,

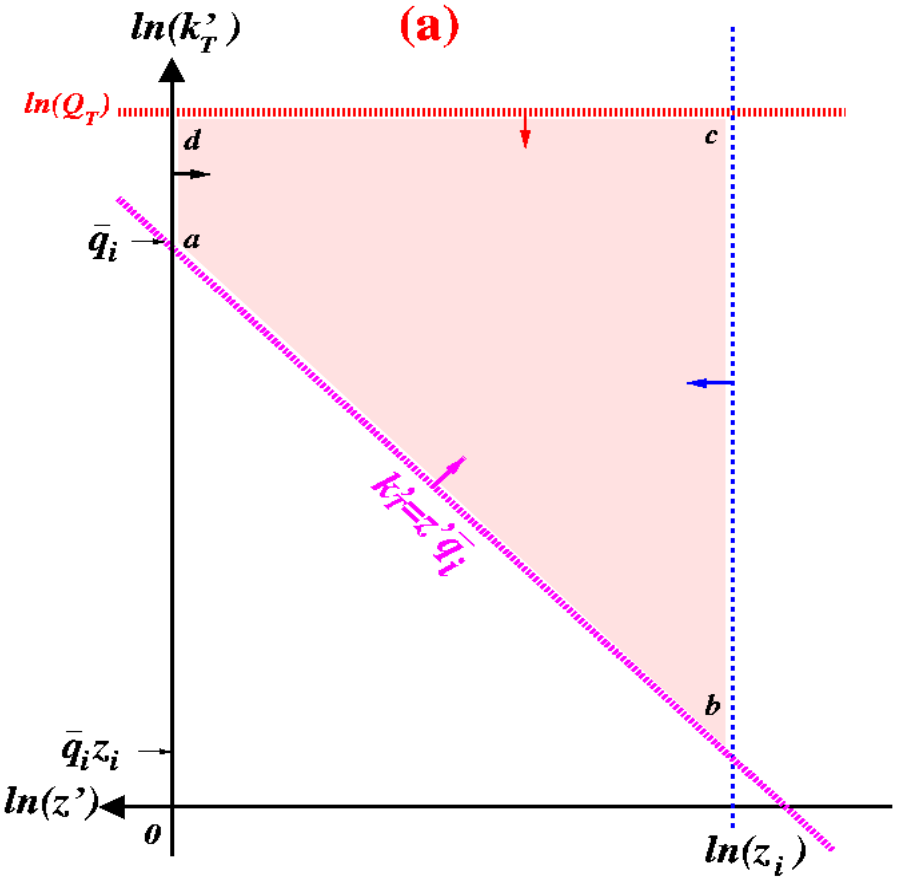
(c) null: $Q_T < qz$, $z_0 = z$, $I_{\rm NS} = 0$.

Single emission in rapidity-ln(kT) Sudakov plane

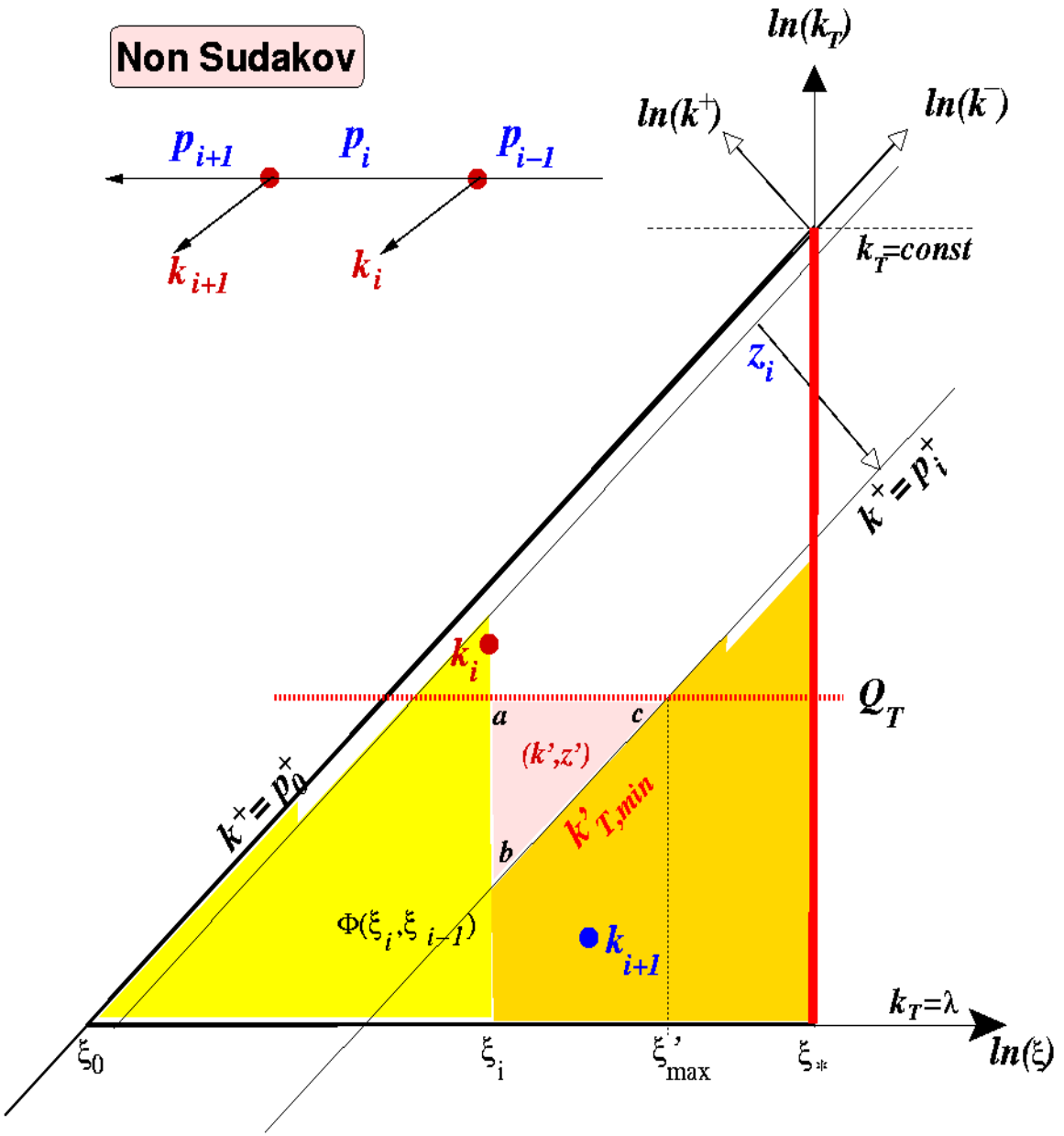


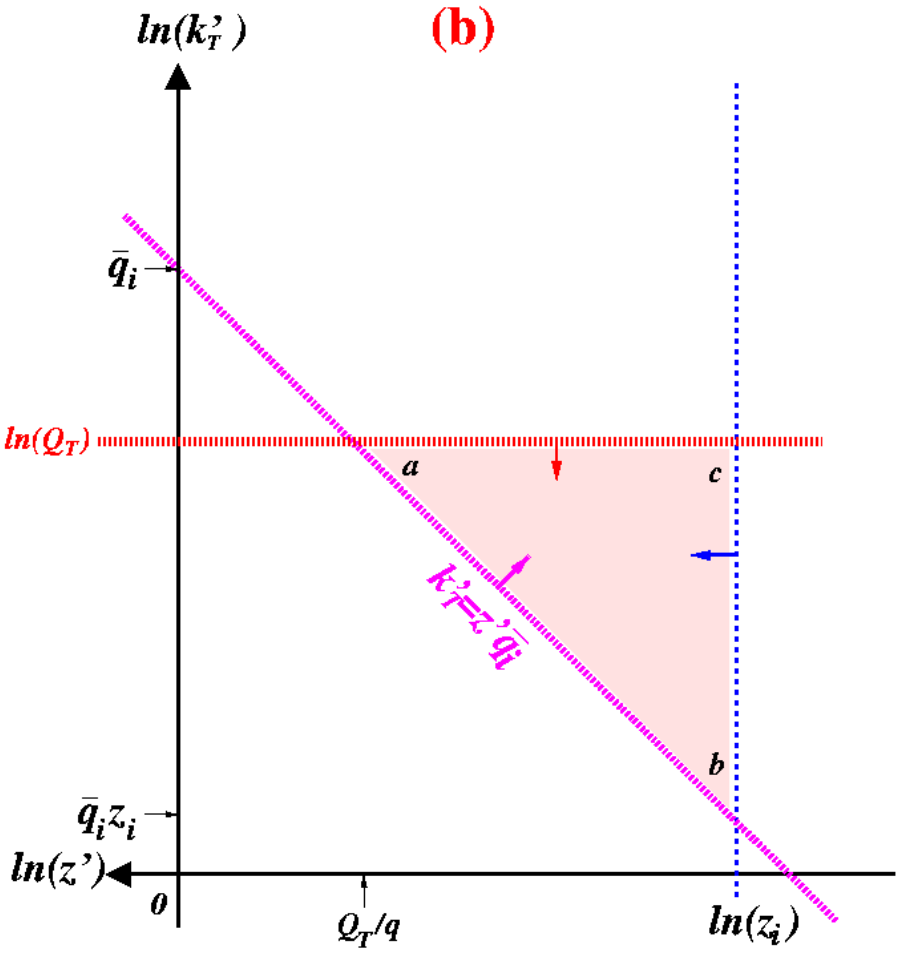
Non-Sudakov formfactor on the Sudakov plane



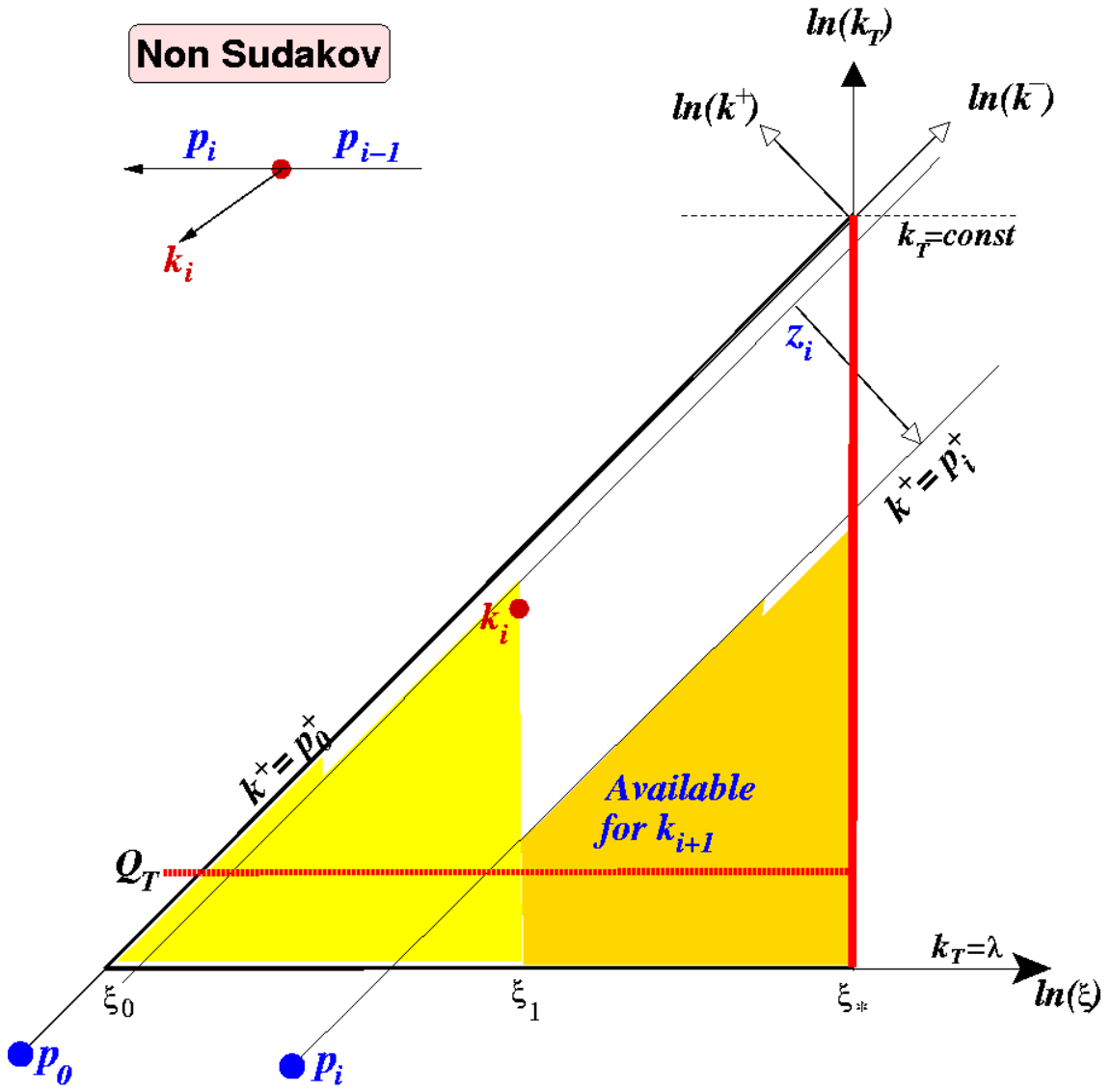


Non-Sudakov formfactor on the Sudakov plane

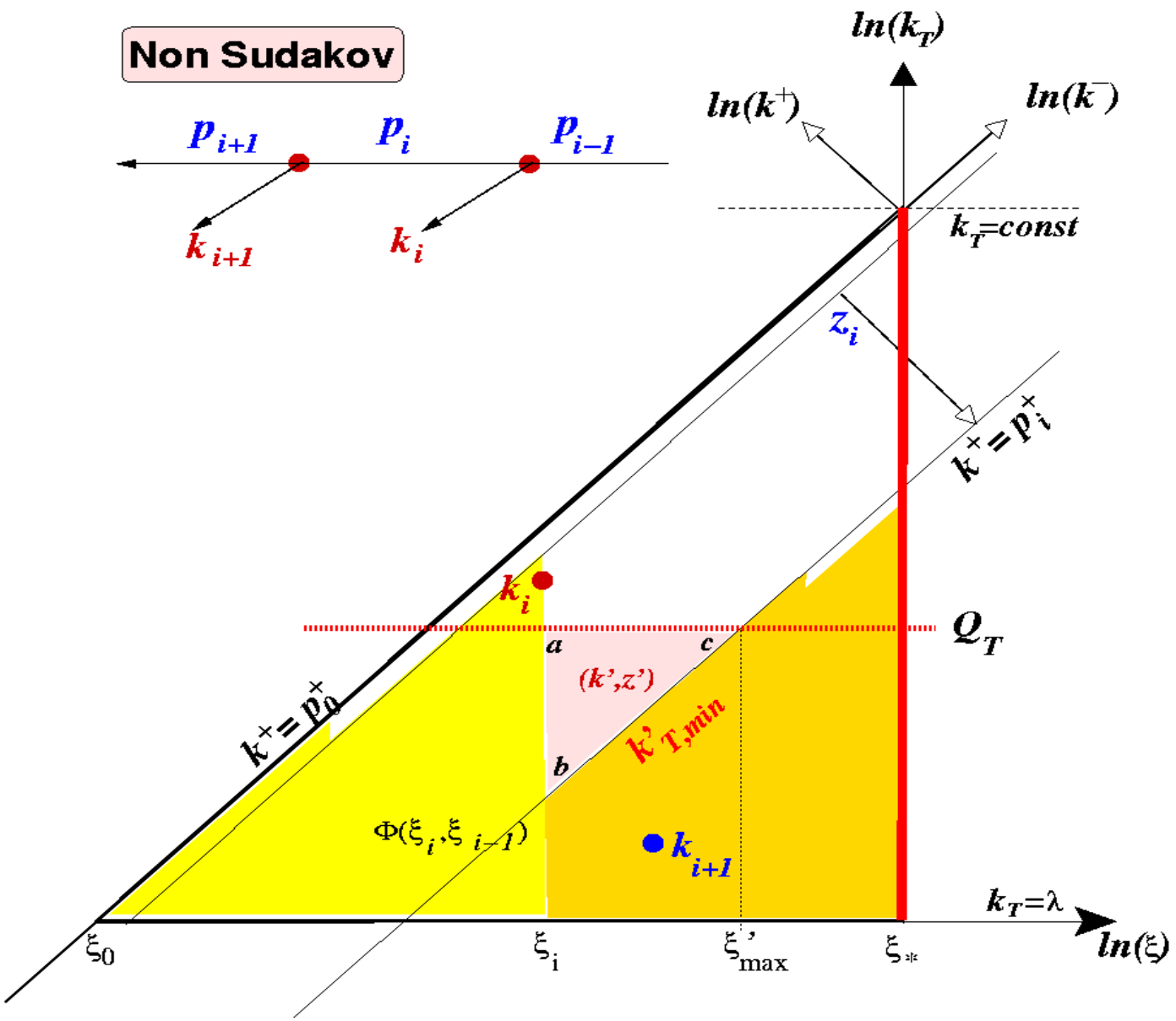




Non-Sudakov form-factor often does not contribute



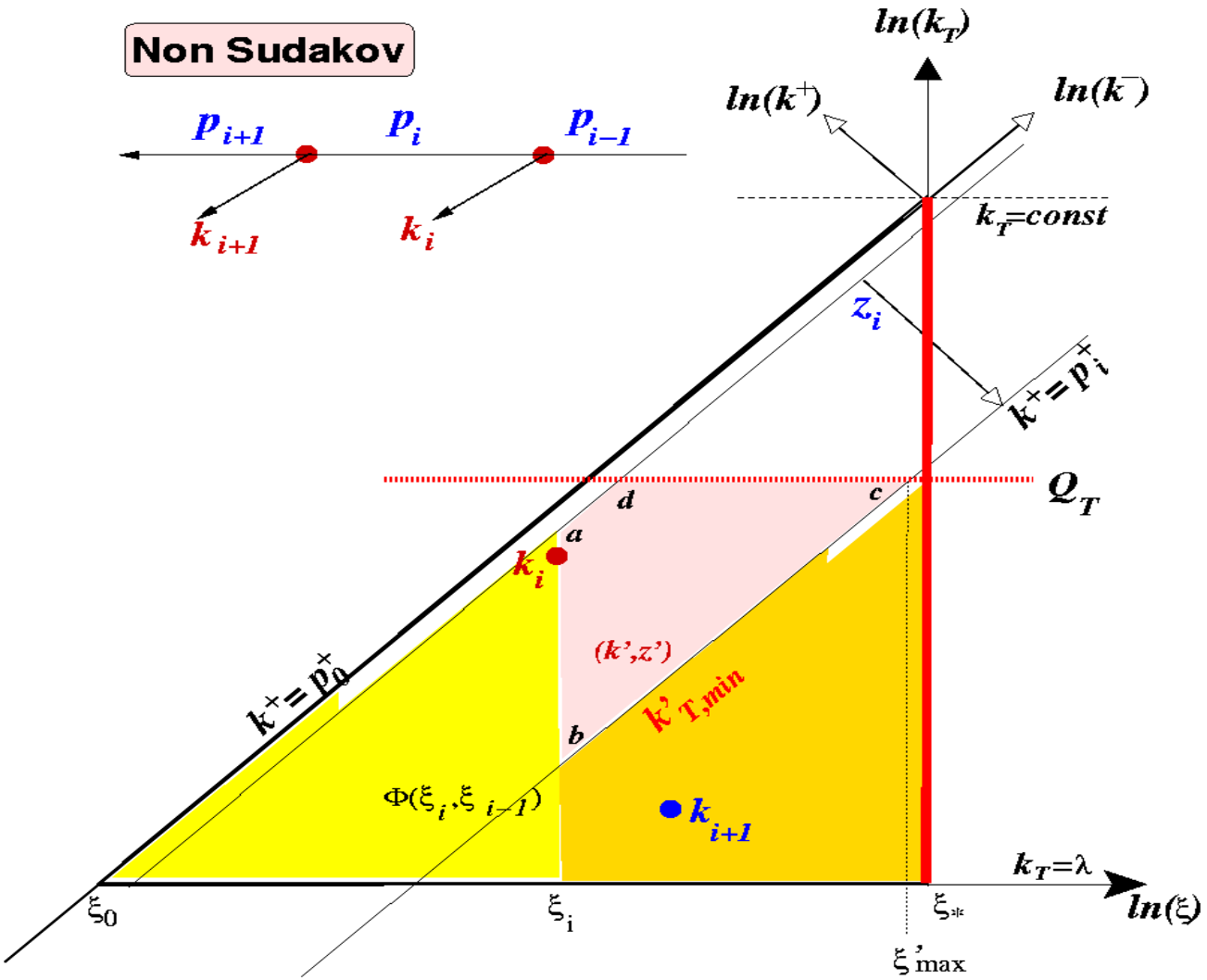
Triangle



$$I^b_{\rm NS} = 2\bar{\alpha}_S \int_{\xi_i}^{\xi'_{\rm max}} \frac{d\xi'}{\xi'} \int_{k'_{T,\rm min}}^{Q_T} \frac{dk'_T}{k'_T} = \bar{\alpha}_S \ln^2 \frac{\xi'_{\rm max}}{\xi_i} = \bar{\alpha}_S \ln^2 \frac{Q_T}{Q\xi_i\, x_i} = \bar{\alpha}_S \ln^2 \frac{Q_T}{\bar{q}_i\, z_i}$$

$$k'_{T,\rm min} = k^T_{i+1,\rm max} = Q\xi' x_i = \bar{q}\,' z_i\,, \;\; \xi'_{\rm max} = \frac{Q_T}{Q\, x_i}$$

Trapezoid



Non-Sudakov form-factor
in terms of our usual notation
in CMC/MMC

$$\text{(a)}\ Q_i^T > Q\xi_i\, x_{i-1}, \qquad I_{\rm NS}^{\rm trapez} = 2\bar{\alpha}_S\, \frac{1}{2}\left(\ln\frac{Q_T}{Q\xi_i x_i} + \ln\frac{Q_T}{Q\xi_i x_{i-1}}\right)\ln\frac{1}{z_i},$$

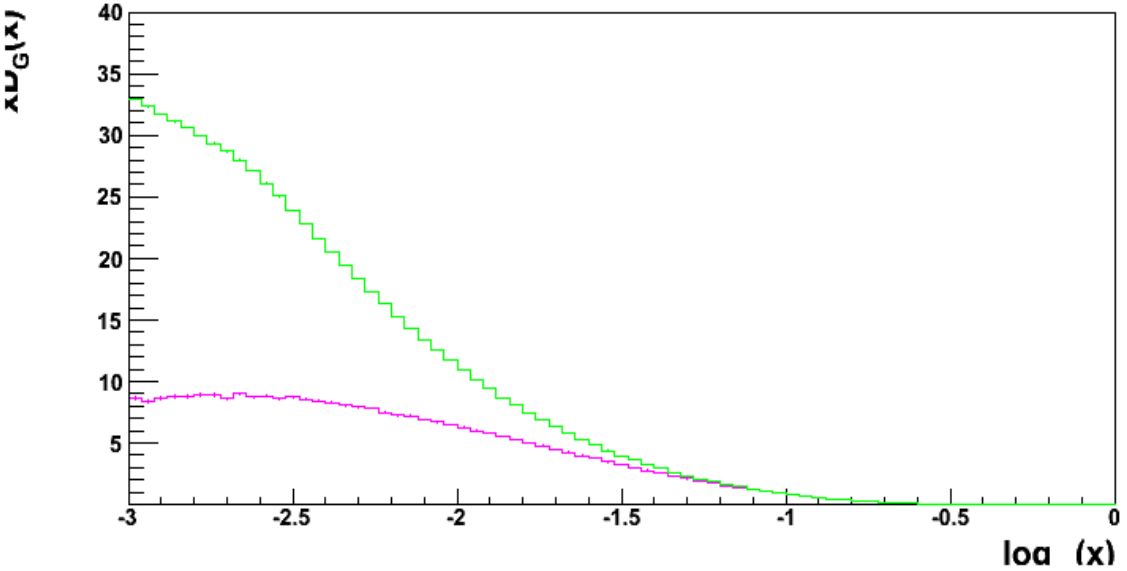
$$\text{(b)}\ Q\xi_i\, x_{i-1} > Q_i^T > Q\xi_i\, x_i, \quad I_{\rm NS}^{\rm triangle} = 2\bar{\alpha}_S\, \frac{1}{2}\ln^2\frac{Q_T}{Q\xi_i x_i},$$

$$\text{(c)}\ Q_i^T > Q\xi_i\, x_i, \qquad I_{\rm NS} = 0,$$

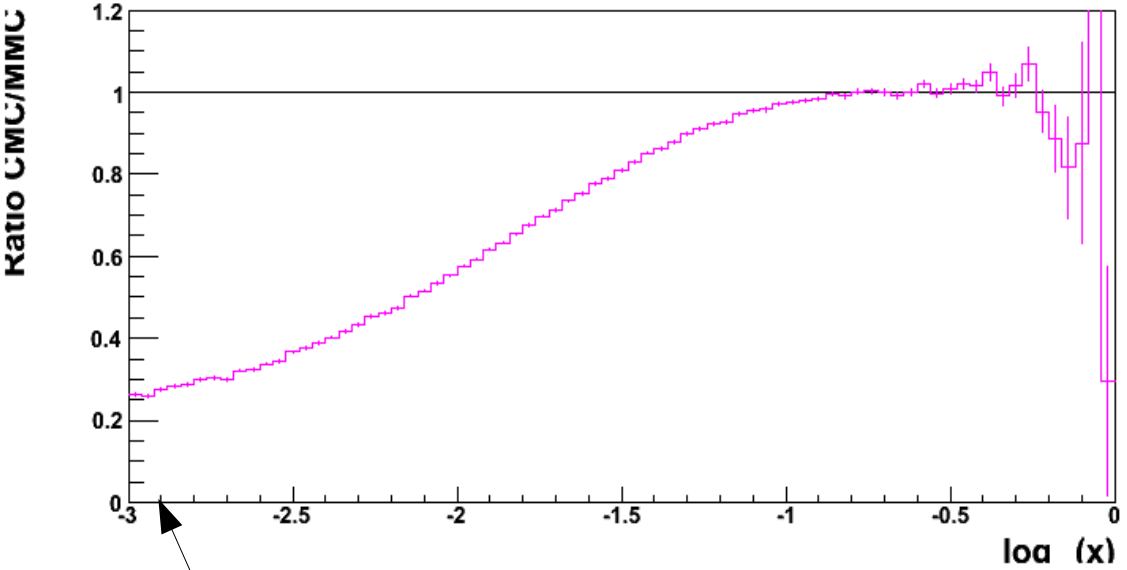
where $q_i = Q\xi_i = e^{t_i}$ (Marchesini uses $\bar{q}_i = Q\xi_i x_{i-1}$) and $Q_i^T \equiv p_i^T$.

1-st Numerical result

xD(x)



Ratio



x=0.001

x=1

Preliminary, 24h old!!!!

This is from Constrained MC.
Pure gluonstrahlung
from gluon emitter line.
Evolution from 1 to 500GeV.

Green curve without NS f-fact,
magenta with NS form-factor.

We see -75% effect at low x,
see ratio in the lower plot.

Summary

- We are for the first time fully compatible with “all-loop CCFM” for single evolution.
- This is done in CMC (extension to MMC is trivial)
- Next steps:

  - upgrade to Q-G transition in CMC (done in MMC)
  - exploit as a building block in 2-hemishere CMC for W/Z production.
- And keep in mind that the final aim is to use this CMC for DIS and/or for W/Z@LHC!