Saturation and coherence effects in the modified KGBJS equation

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Motivation

- **The CCFM equation – coherence effects**
  - Angular ordering
  - Exclusive states
  - A model for unintegrated PDFs
- **Including nonlinear saturation effects**
  - Study interplay between them
  - Extension to moderate *x*

The CCFM equation

$$\mathcal{F}(x,\mathbf{k},\bar{\mathbf{q}}^2) = \mathcal{F}(x,\mathbf{k},\bar{\mathbf{q}}_0^2) + \frac{\bar{\alpha}_S}{\pi} \int\limits_{\bar{\mathbf{q}}_0^2}^{\mathbf{q}'^2} \frac{d^2\bar{\mathbf{q}}}{\bar{\mathbf{q}}'^2}$$

$$\int\limits_{x}^{1-\frac{Q_0}{|\mathbf{q}'|}} \frac{dz}{z} \mathcal{F}(x/z,\mathbf{k}',\bar{\mathbf{q}}'^2) \left(\frac{\Delta_{NS}(\mathbf{k}^2,(z\bar{\mathbf{q}}')^2)}{z} + \frac{1}{1-z} \right) \Delta_S(\mathbf{q}'^2_0,(z\bar{\mathbf{q}}')^2)$$

- Connecting DGLAP and BFKL
- Angular ordering
- Sudakov and Non-Sudakov formfactors

The KGBJS equation

- Attempt to include non-linear effects similar to BK equation

$$\frac{\partial f(Y,\mathbf{k})}{\partial Y} = \frac{\bar{\alpha}_S}{\pi}\int \frac{d^2\mathbf{k}'}{(\mathbf{k}-\mathbf{k}')^2}\left\{f(Y,\mathbf{k}') - \frac{\mathbf{k}^2}{\mathbf{k}'^2+(\mathbf{k}-\mathbf{k}')^2} f(Y,\mathbf{k})\right\} - \frac{\bar{\alpha}_S}{2\pi}\int d^2\mathbf{k}'\,\delta^{(2)}(\mathbf{k}')\, f(Y,\mathbf{k})\, f(Y,\mathbf{k}-\mathbf{k}')$$

$$\begin{aligned}\tilde{\mathcal{F}}(x,\mathbf{k},p) &= \tilde{\mathcal{F}}_0(\mathbf{k}) \\ &+ \bar{\alpha}_S \int \frac{d^2\bar{\mathbf{q}}'}{\bar{\mathbf{q}}'^2}\int_x^{1-\frac{Q_0}{|\bar{\mathbf{q}}'|}} dz \left(\tilde{\mathcal{F}}(x/z,\mathbf{k}',|\bar{\mathbf{q}}'|) - \delta(\bar{\mathbf{q}}'^2-\mathbf{k}^2)(\bar{\mathbf{q}}'^2)\tilde{\mathcal{F}}^2(x/z,\bar{\mathbf{q}}',|\bar{\mathbf{q}}'|)\right) \\ &\times\ \theta(p-z|\bar{\mathbf{q}}'|)\mathcal{P}(z,\mathbf{k},\mathbf{q})\Delta_S(p,z|\bar{\mathbf{q}}'|,Q_0)\end{aligned}$$

The KGBJS equation

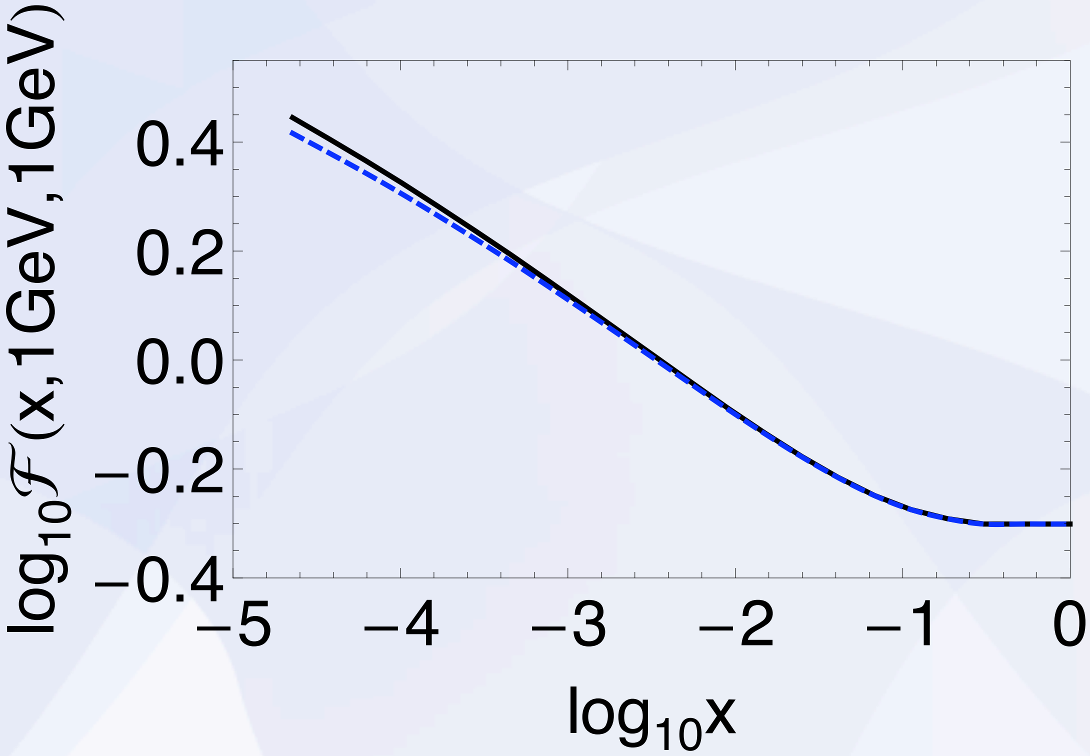
- Attempt to include non-linear effects similar to BK equation

$$\frac{\partial f(Y,\mathbf{k})}{\partial Y} = \frac{\bar{\alpha}_S}{\pi}\int \frac{d^2\mathbf{k}'}{(\mathbf{k}-\mathbf{k}')^2}\left\{ f(Y,\mathbf{k}') - \frac{\mathbf{k}^2}{\mathbf{k}'^2 + (\mathbf{k}-\mathbf{k}')^2} f(Y,\mathbf{k})\right\} - \frac{\bar{\alpha}_S}{2\pi}\int d^2\mathbf{k}'\,\delta^{(2)}(\mathbf{k}')\, f(Y,\mathbf{k})\, f(Y,\mathbf{k}-\mathbf{k}')$$

$$\tilde{\mathcal{F}}(x,\mathbf{k},p) = \tilde{\mathcal{F}}_0(\mathbf{k}) + \bar{\alpha}_S \int \frac{d^2\bar{\mathbf{q}}'}{\bar{\mathbf{q}}'^2} \int_x^{1-\frac{Q_0}{|\bar{\mathbf{q}}'|}} dz \left(\tilde{\mathcal{F}}(x/z,\mathbf{k}',|\bar{\mathbf{q}}'|) - \delta(\bar{\mathbf{q}}'^2 - \mathbf{k}^2)(\bar{\mathbf{q}}'^2)\tilde{\mathcal{F}}^2(x/z,\bar{\mathbf{q}}',|\bar{\mathbf{q}}'|)\right) \times\ \theta(p - z|\bar{\mathbf{q}}'|)\mathcal{P}(z,\mathbf{k},\mathbf{q})\Delta_S(p, z|\bar{\mathbf{q}}'|, Q_0)$$

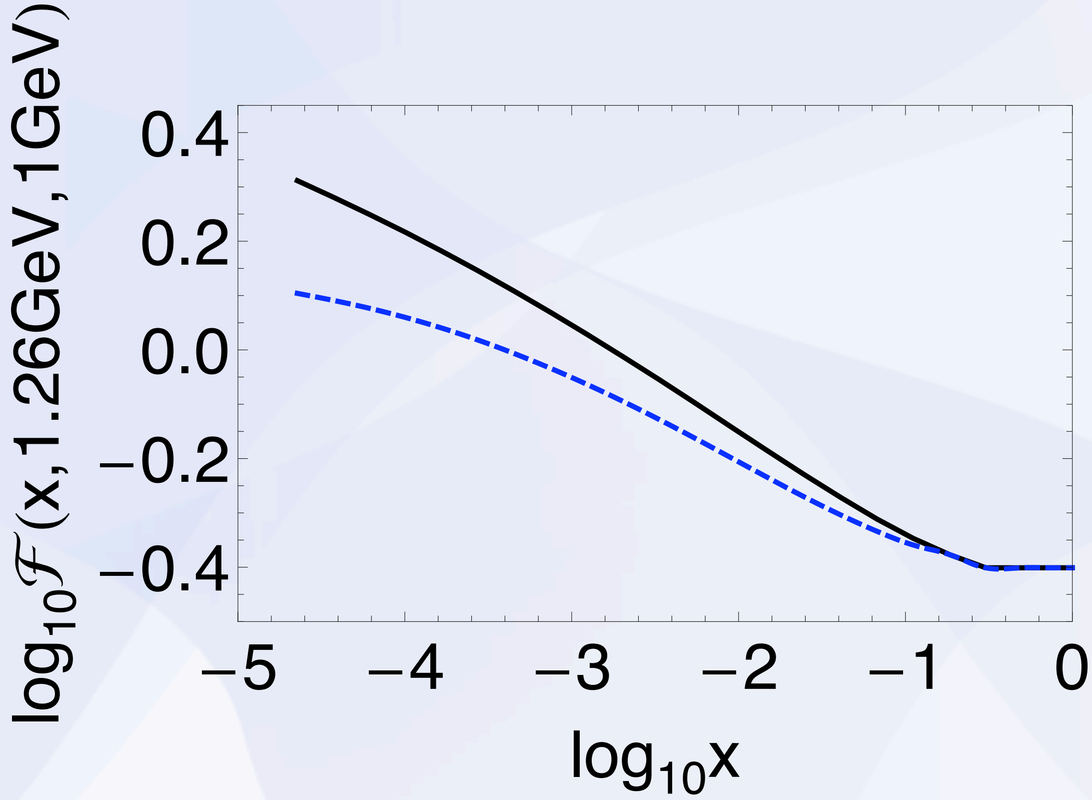
Numerical results

- *x*-distribution with **k**=1 GeV



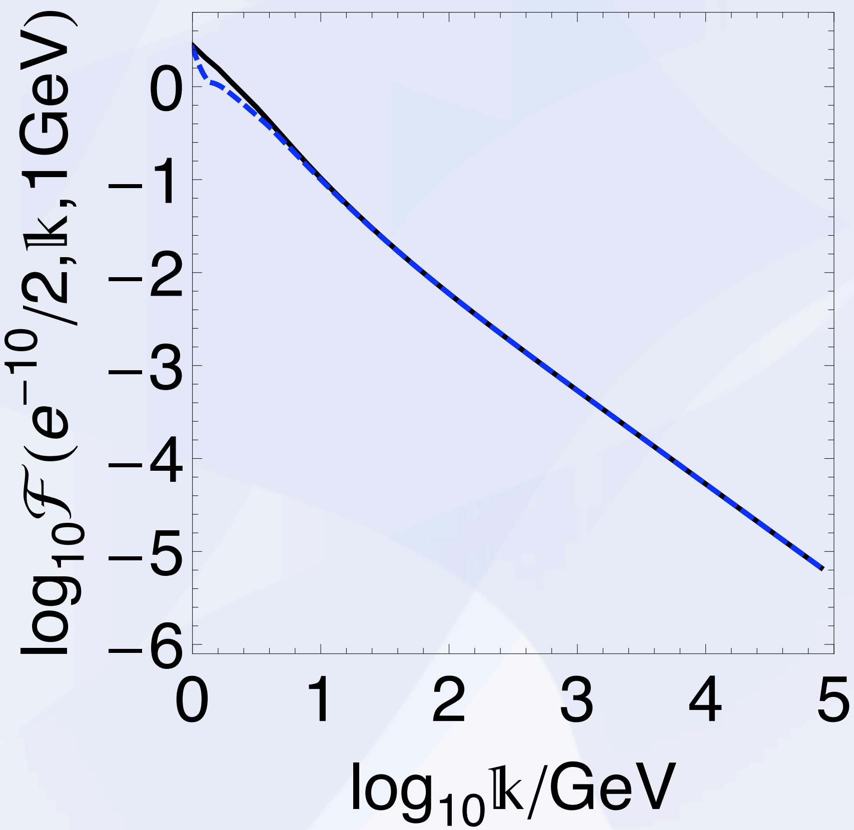
Numerical results

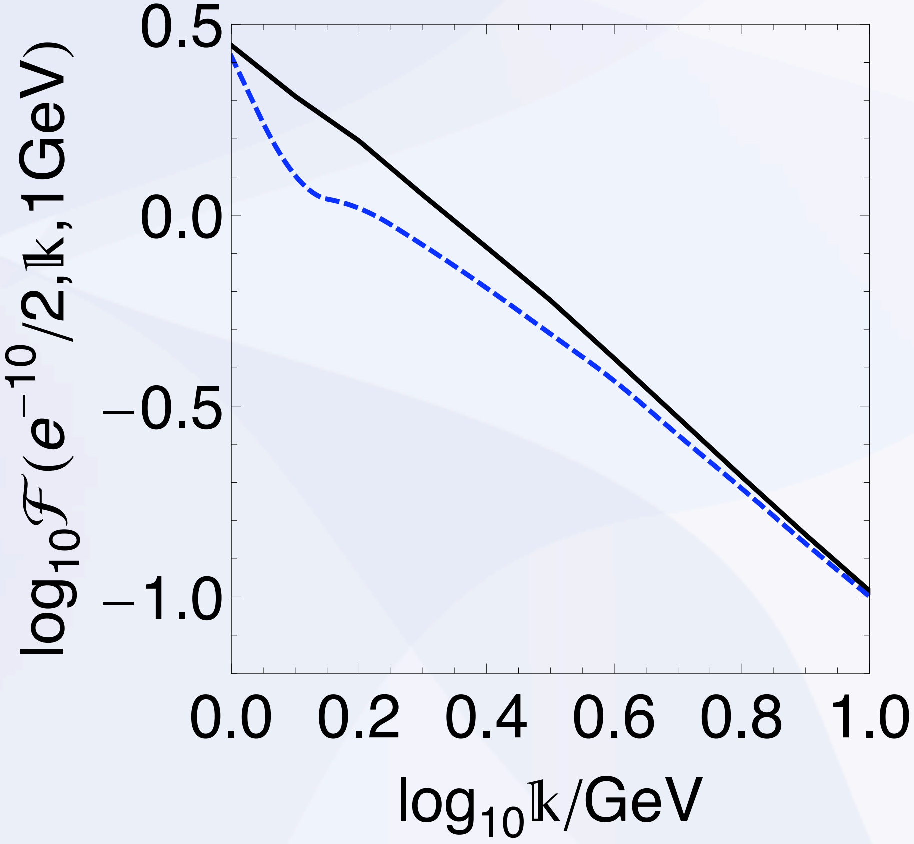
- *x*-distribution with **k**=1.26 GeV



Numerical results

- *kt*-distribution





Modification

$z \in \langle x, 1-Q_0/q \rangle$

$\Rightarrow$

$q > Q_0/(1-z)$

$\Rightarrow$

If $k < Q_0/q$, $\delta(q-k)=0$

$\Rightarrow$ 0 damping

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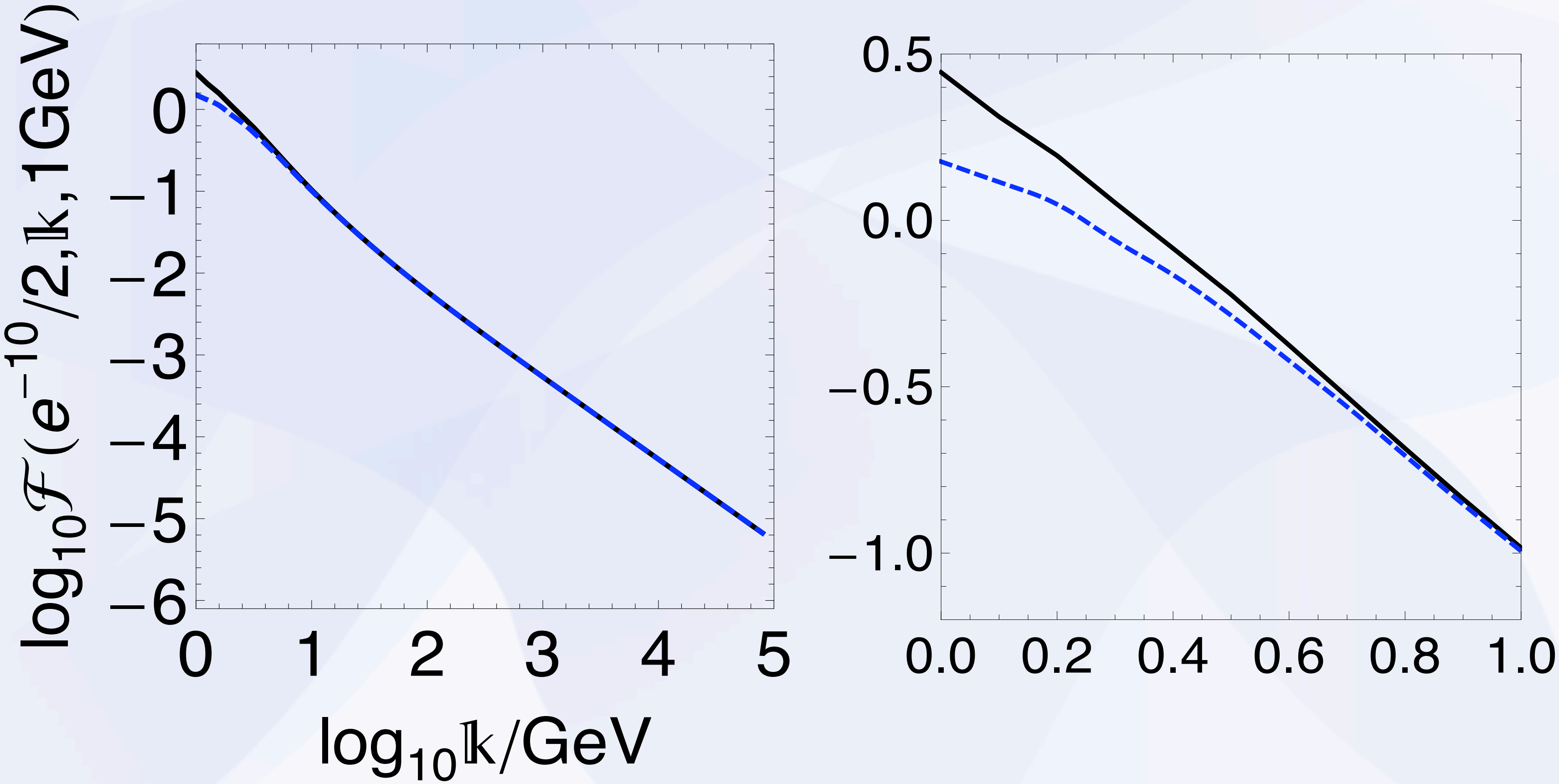
Instead of $\delta(q-k)$
$\delta(q-k/(1-z))$

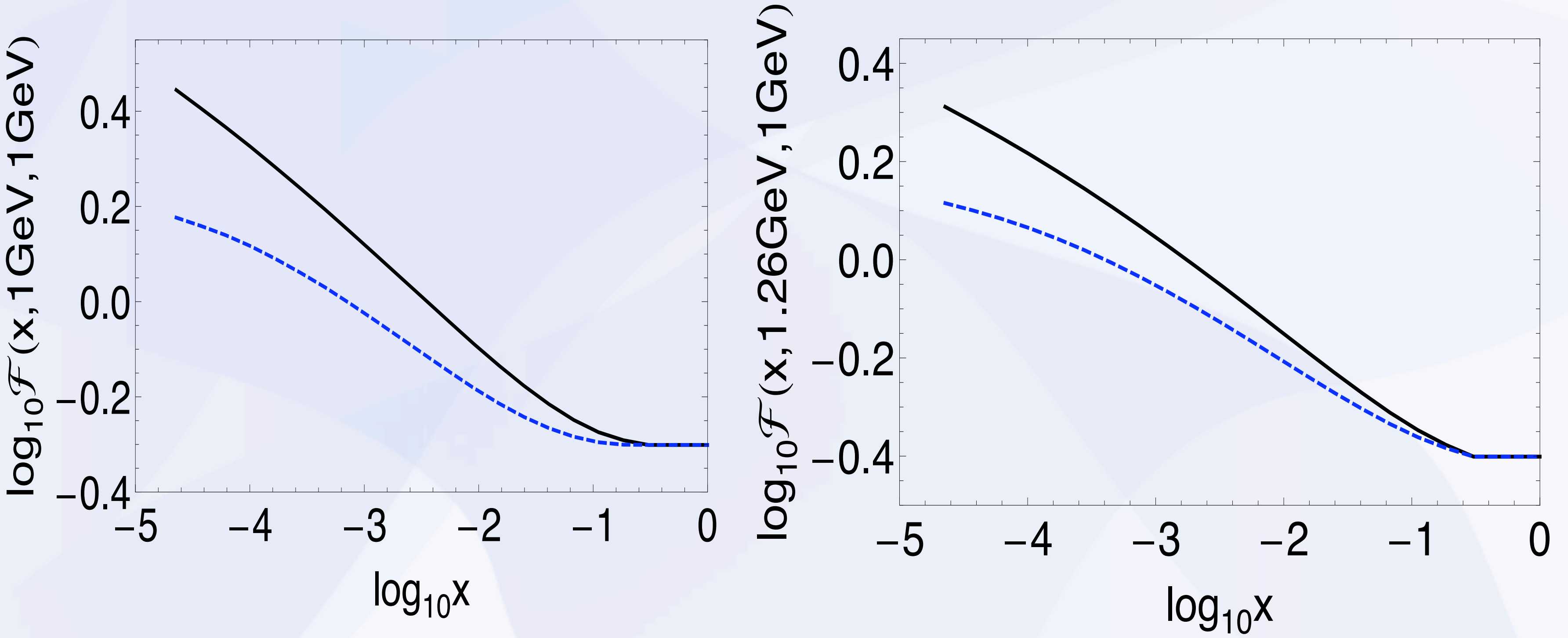
After modification

- *kt*-distribution



After modification

- *x*-distribution



Summary and Outlook

- Solutions of the KGBJS equation obtained
- Compared with linear CCFM
- Modification suggested

Next steps:

- Running coupling
- Saturation scale