Constraining the Un-integrated PDFs status report ...

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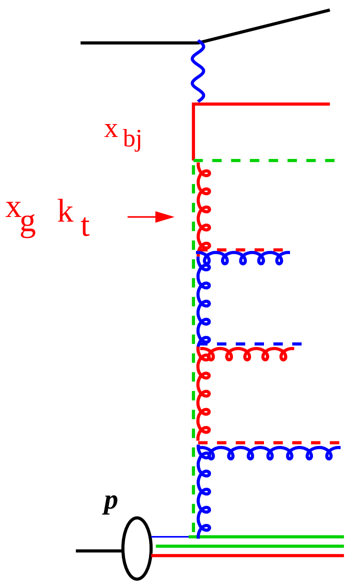
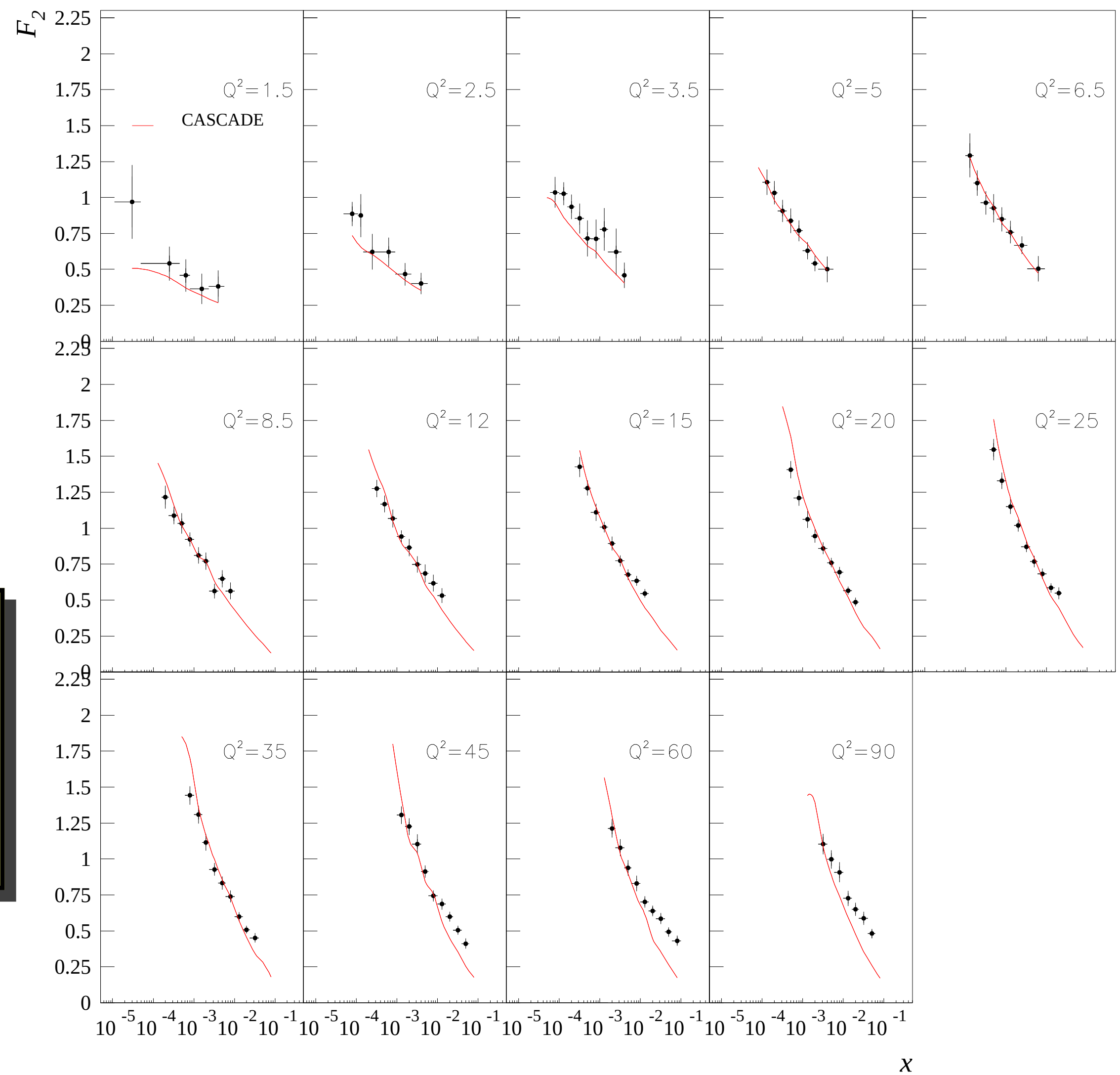
- check k_t and scale dependences of different processes
  - where to use inclusive measurements
  - where to use final state measurements
- restrict to gluon induced processes
  - heavy quark production at HERA and Tevatron
- aim to simultaneously describe measurements
- conclusion

Structure Function $F_2(x,Q^2)$

With $\sigma = \int dk_t^2 dx_g \mathcal{A}(x_g,k_t^2,\bar{q})\sigma(\gamma^* g^* \to q\bar{q})$ fit $F_2(x,Q^2)$





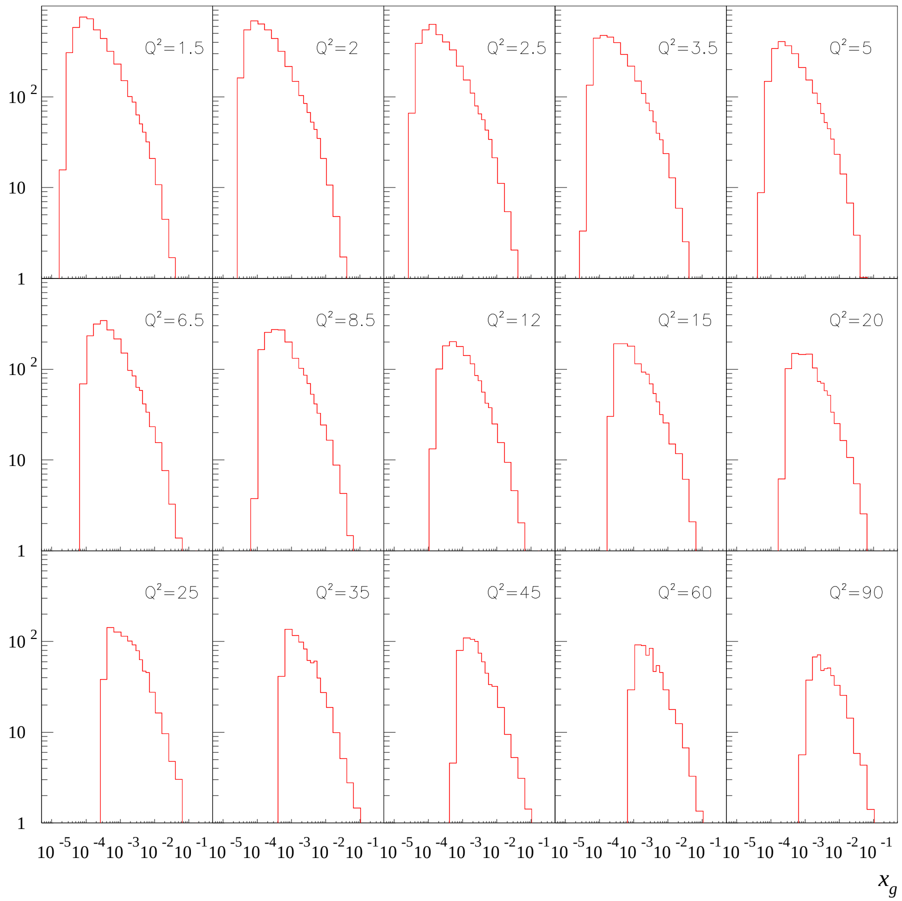
un-integrated gluon density

$x\mathcal{A}(x,k_t^2,\bar{q})$

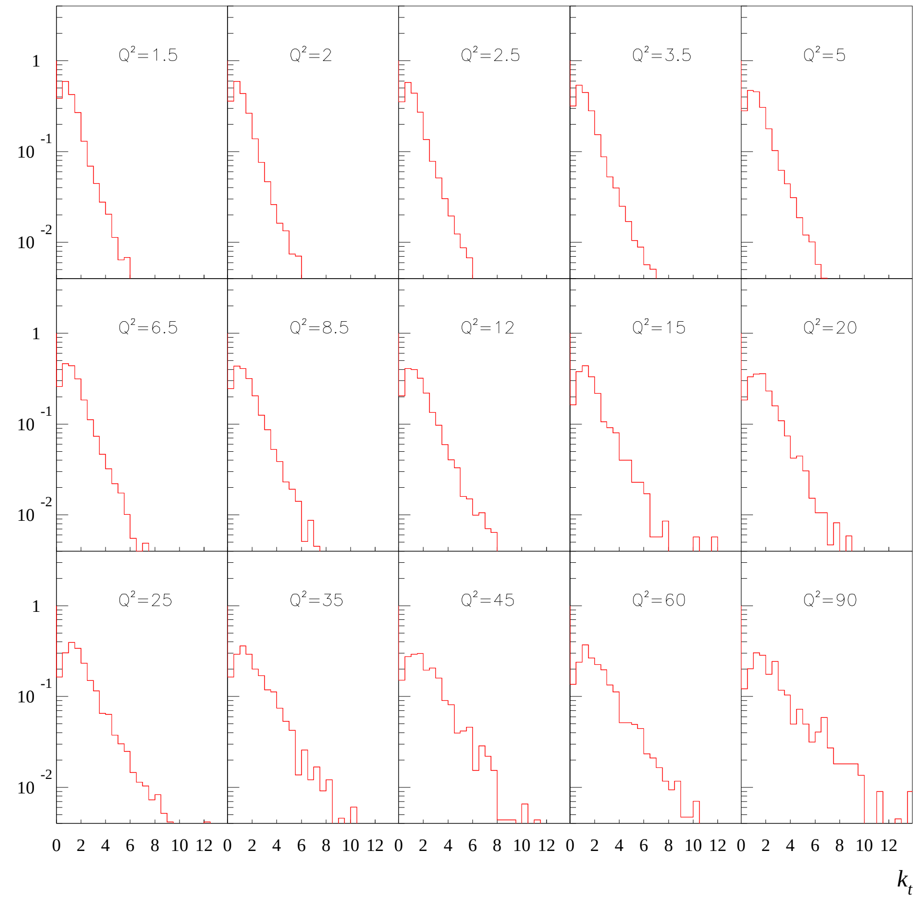
obtained from fit to F_2

$F_2(x,Q^2)$ kinematic plane for x_g and k_t

x_g



k_t



$F_2(x,Q^2)$ covers significant region in $x_g \gtrsim 10^{-4}$

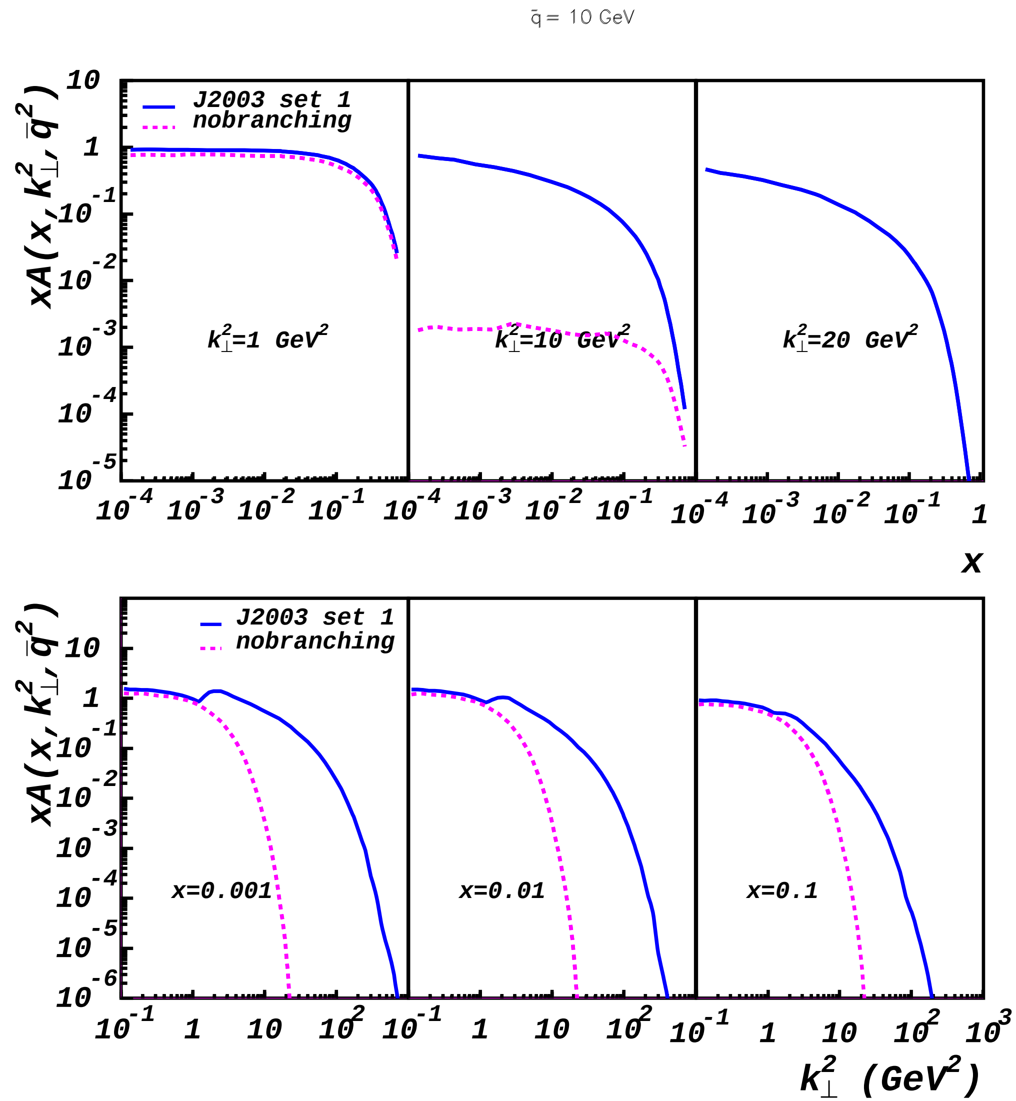
BUT mainly sensitive to small k_t region ... initial condition...

$F_2(x, Q^2)$ and unintegrated gluon !

- F_2 sensitive to small k_t
- F_2 measure of
  - initial k_t distribution
  - non-branching probablity

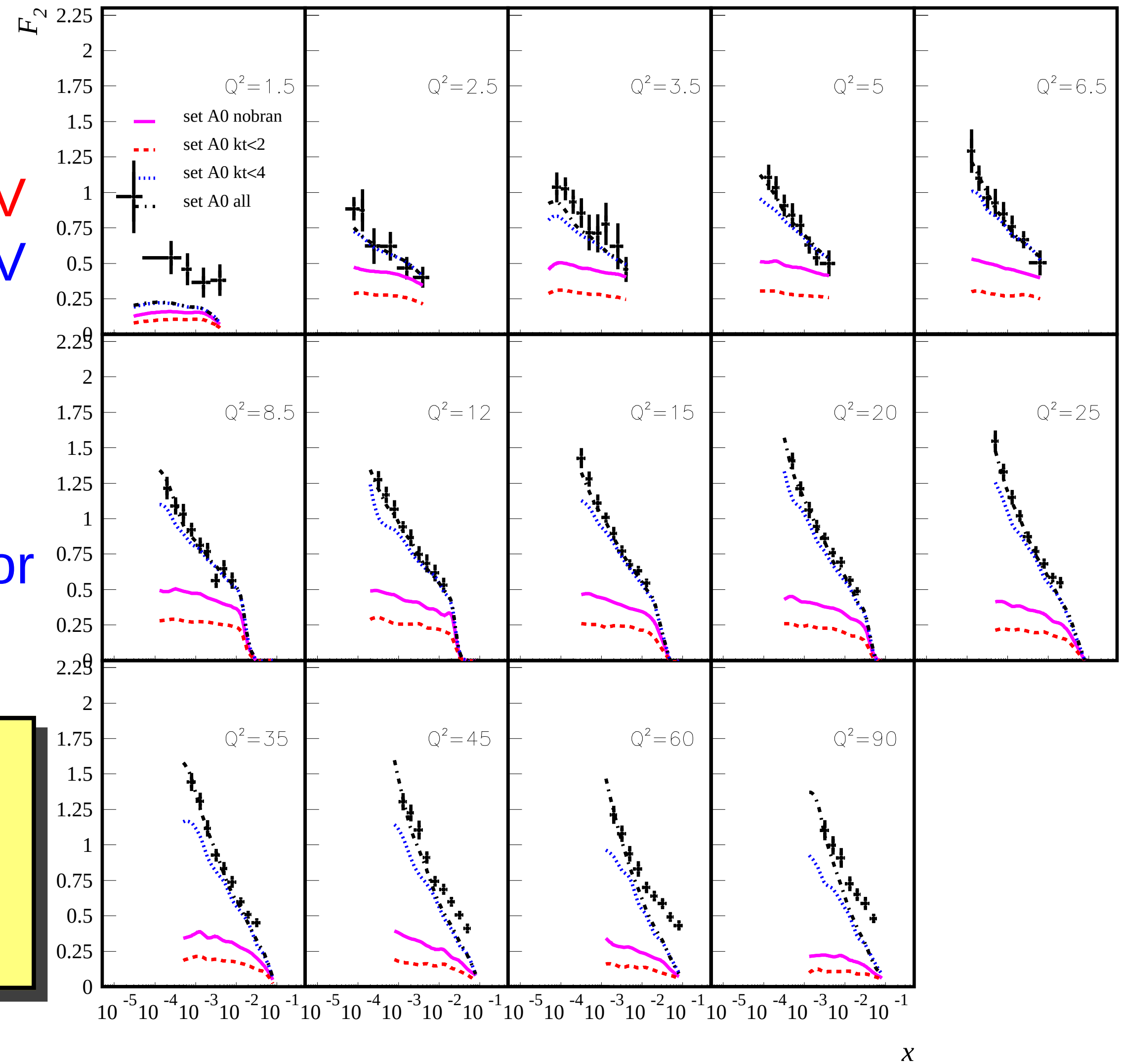
$$\mathcal{A}(x, k_t, \bar{q}) = \mathcal{A}_0(x, k_t)\Delta_s(\bar{q}, Q_0) + \int \frac{dz}{z}\frac{d^2q}{q^2}\Delta_s(\bar{q}, zq)\cdot\tilde{P}(z, ...)\mathcal{A}\left(\frac{x}{z}, k_t', q\right)$$

- what is contribution from $k_t \gtrsim 2$ GeV ?



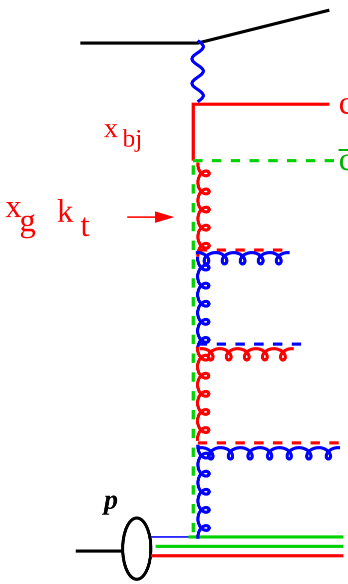
k_t dependence in $F_2(x, Q^2)$

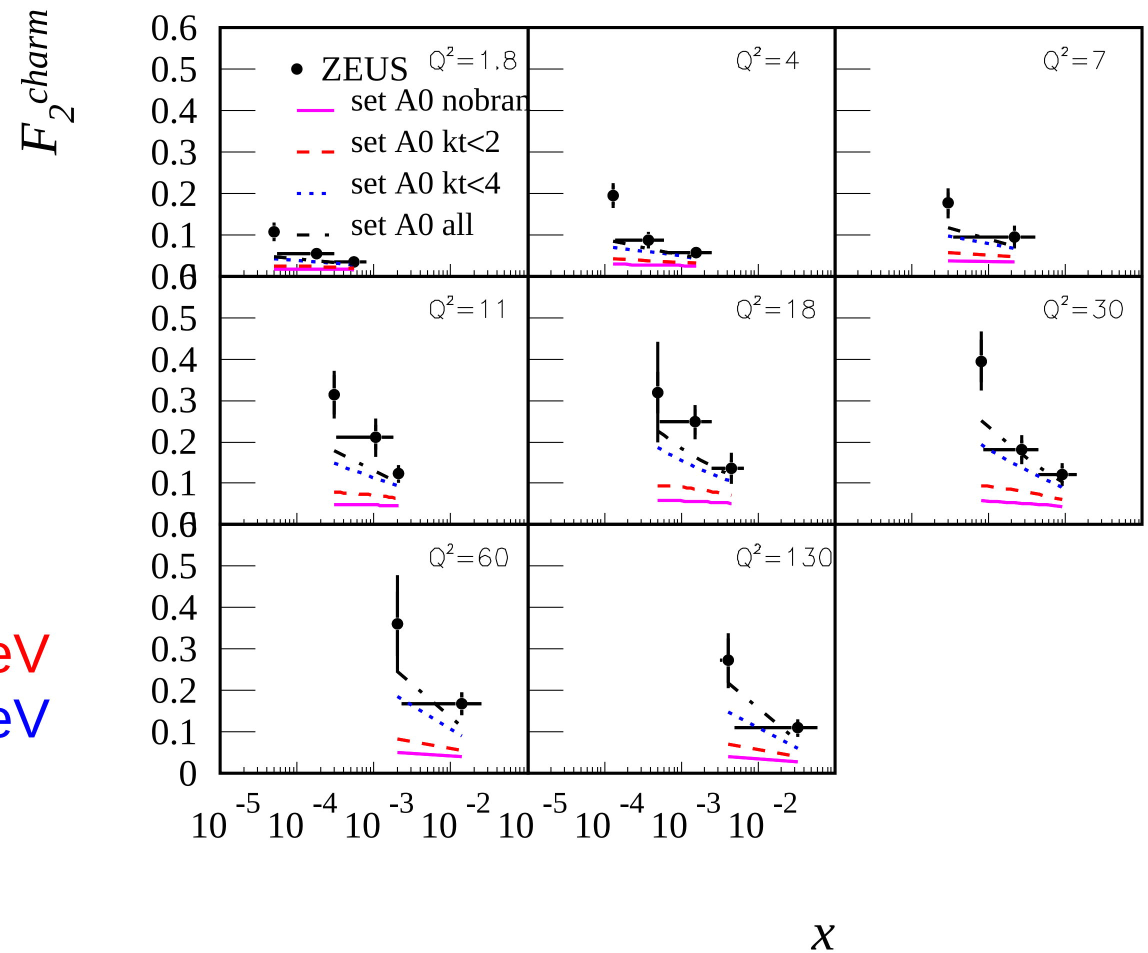
- check sensitivty on k_t
  - nobran contribution
  - contribution with $k_t < 2$ GeV
  - contribution with $k_t < 4$ GeV
  - all
- $k_t > 4$ GeV contributes very little to F_2 !!!
- $1 < k_t < 4$ GeV responsible for rise of F_2 !!!



- $F_2(x, Q^2)$ can constrain:
  - small $k_t < 4$ GeV region
  - range of $x_g \gtrsim 10^{-4}$

k_t dependence in $F_2^c(x, Q^2)$

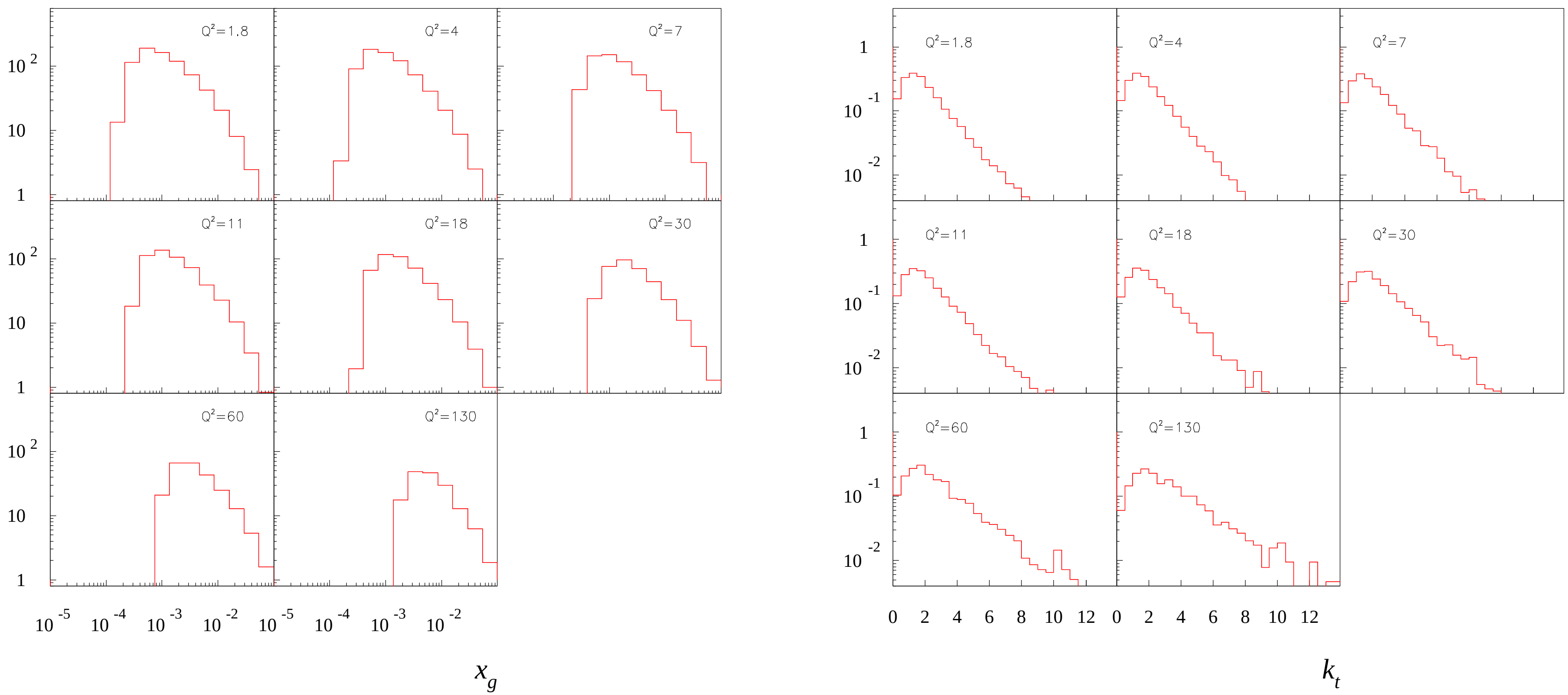




- check sensitivty on k_t
  - nobran contribution
  - contribution with $k_t < 2$ GeV
  - contribution with $k_t < 4$ GeV
  - all
- $k_t < 2$ GeV contributes very little to F_2^c !!!
- $2 < k_t$ GeV significant for F_2^c !!!

$F_2^c(x, Q^2)$ kinematic plane for x_g and k_t

x_g k_t



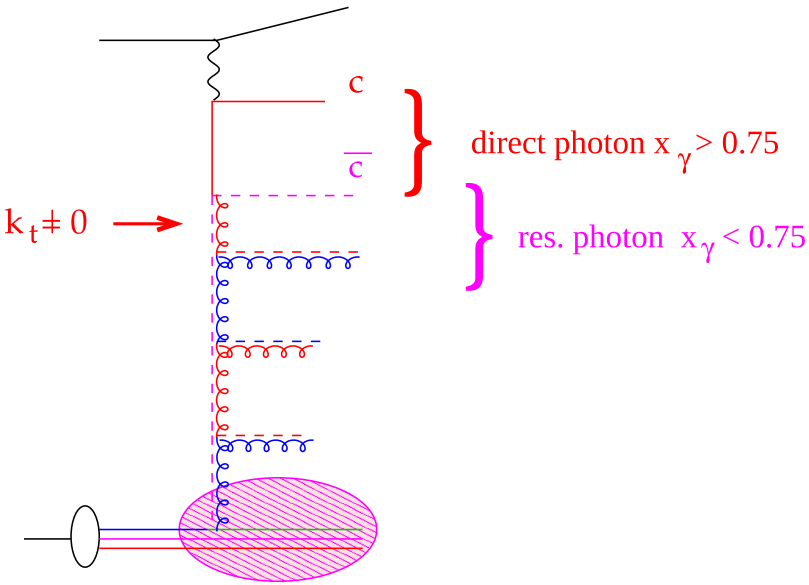
$F_2^c(x, Q^2)$ covers significant region in $x_g \gtrsim 10^{-3}$

AND sensitive to $k_t \gtrsim 2$ GeV region

Potential to better constrain un-integrated gluon !!!

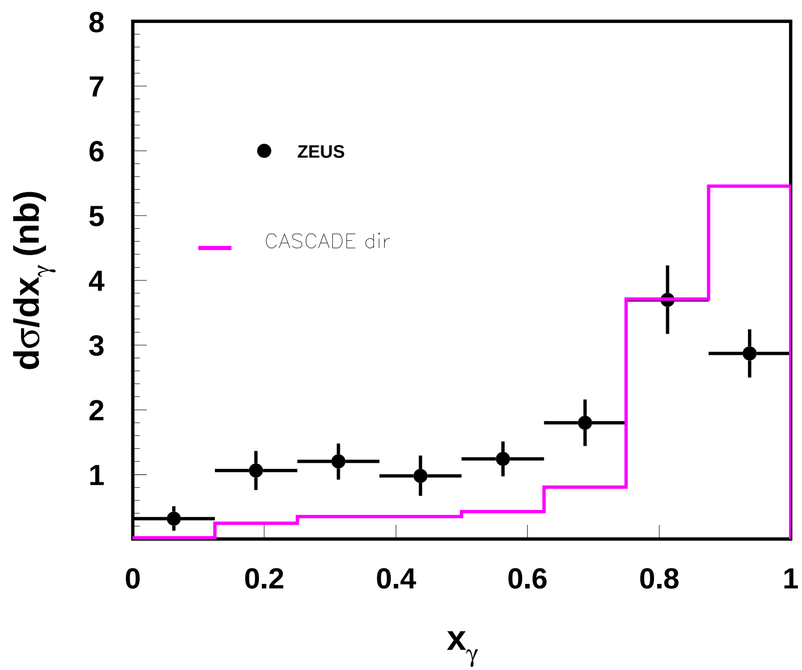
Unintegrated gluon density with heavy quarks

- identify one charm quark (D^*)
- reconstruct jets



- **reconstruct x_γ**
- **x_γ related to k_t**

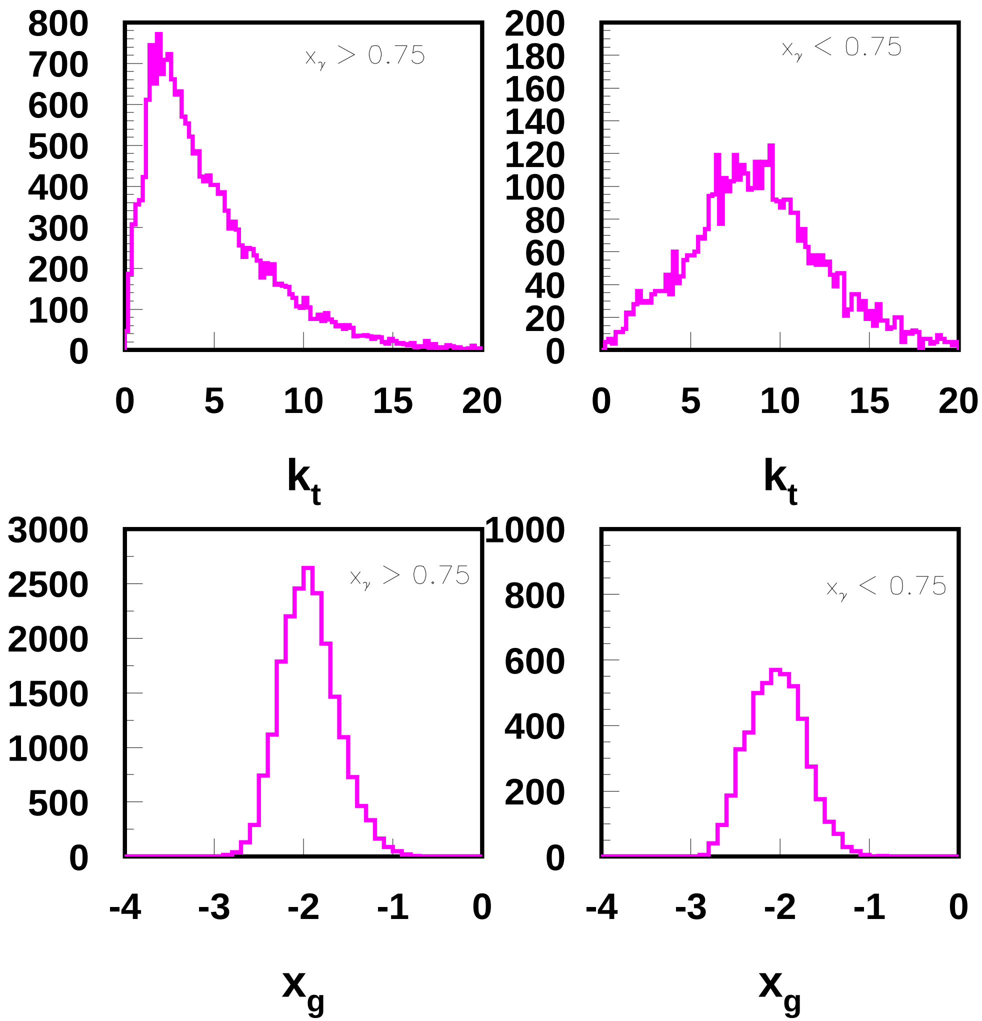
- $Q^2 < 1$, $0.2 < y < 0.9$, $p_t^D > 2$ GeV, $|\eta^D| < 1.5$, $E_t > 7(6)$ GeV, $|\eta| < 2.4$



Charm in $\gamma p \to D^* + jet$ production

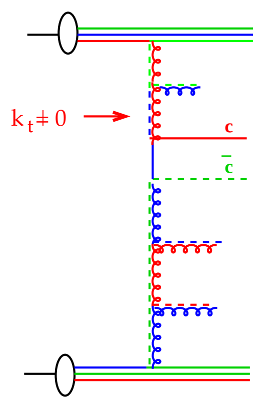
D^* photo - production (ZEUS Coll. EPJC 6 (1999) 67)

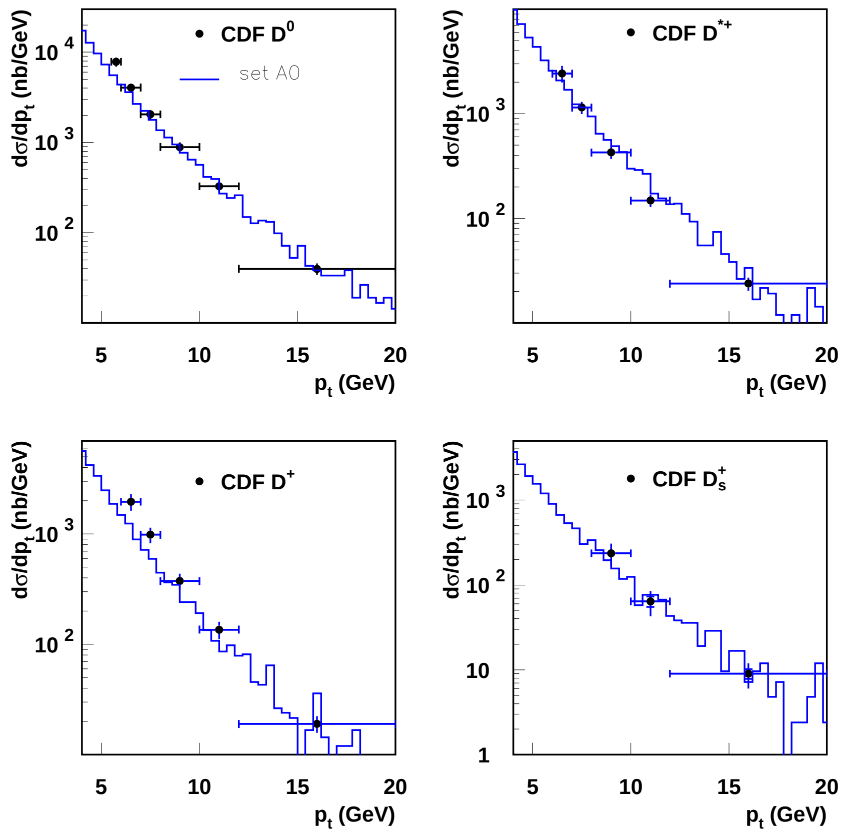
- $Q^2 < 1$, $0.2 < y < 0.9$, $p_t^D > 2$, $|\eta^D| < 1.5$, $E_t > 7(6)$ GeV, $|\eta| < 2.4$

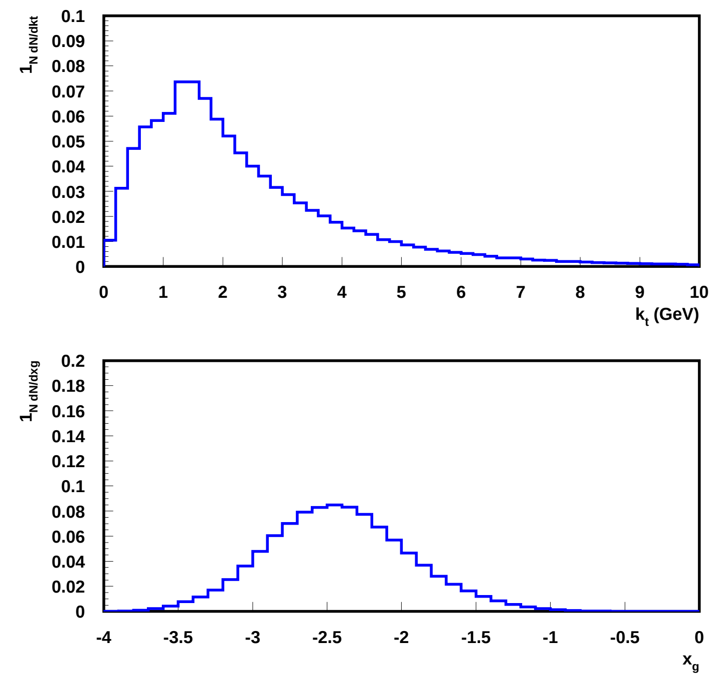


- truly perturbative region
- x_γ in D^* production
  - direct γ $k_t \sim 1 - 2$ GeV
  - res. γ $k_t \sim 7 - 9$ GeV
  - both at same x_g
- combine inclusive F_2^c with $D^* + Jet$
  - constrain un-integrated gluon

$c\bar{c}$ production at Tevatron

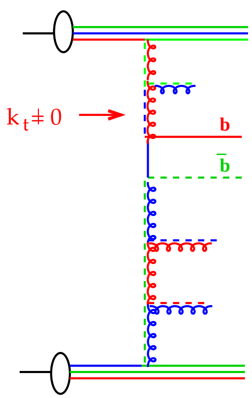


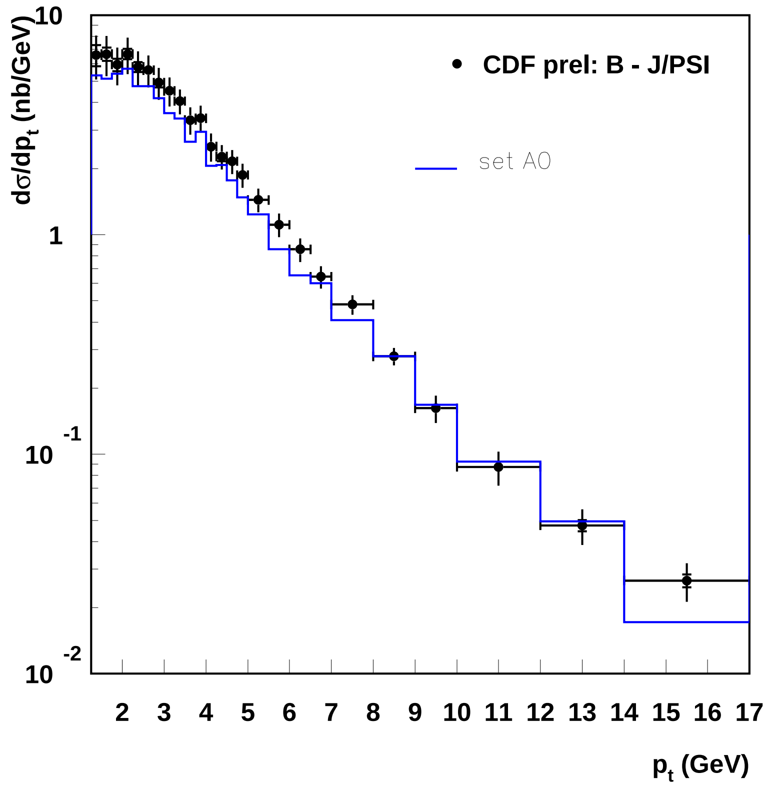


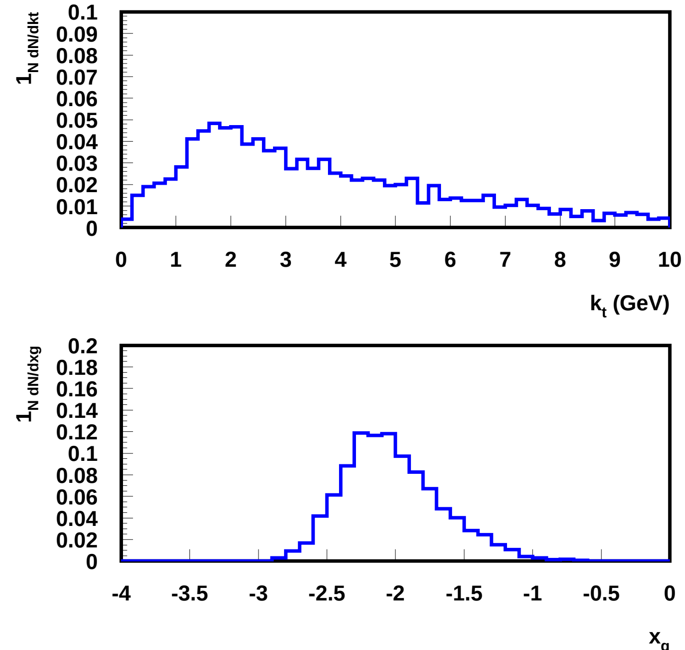


- sensitive to $x_g \sim 0.005$ and $k_t \sim 2$ GeV
- similar range in k_t as in charm photoproduction at HERA
- BUT different x_g range !!!

$b\bar{b}$ production at Tevatron $b \to J/\psi$

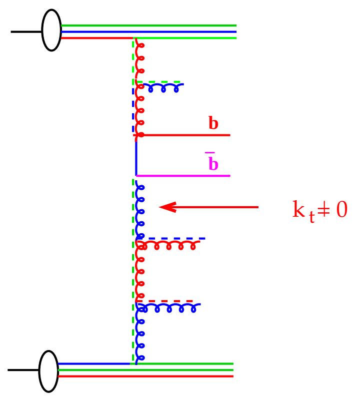


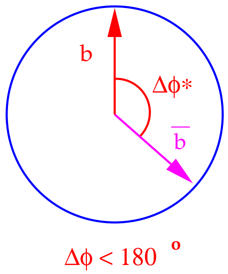




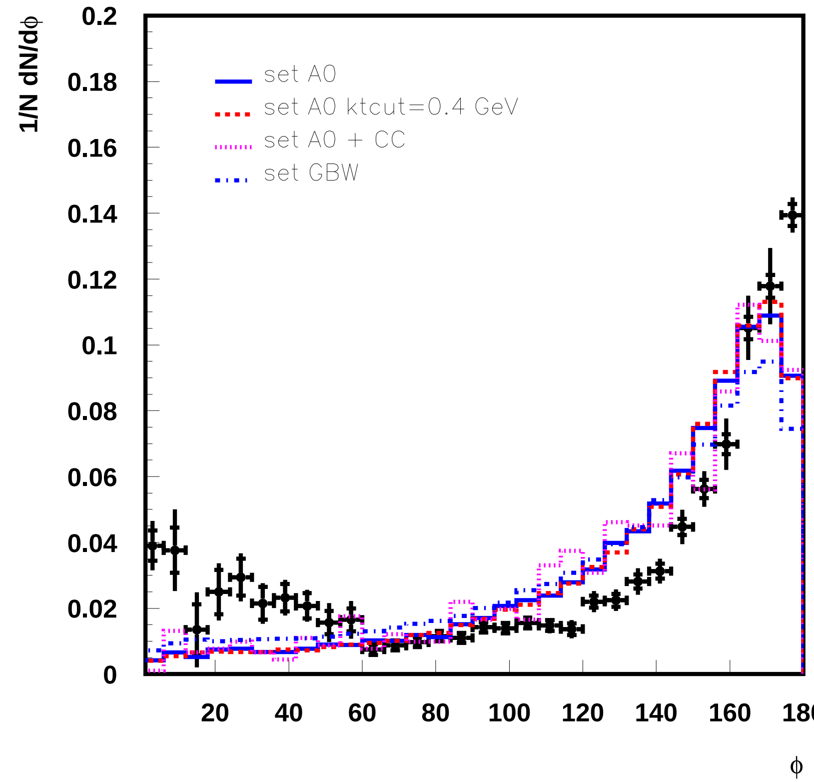
- sensitive to $x_g \sim 0.01$ and $k_t \sim 2$ GeV
- similar range as direct charm photoproduction at HERA
- BUT different factorisation scale !!!

$b\bar{b}$ $\Delta\phi$ distribution



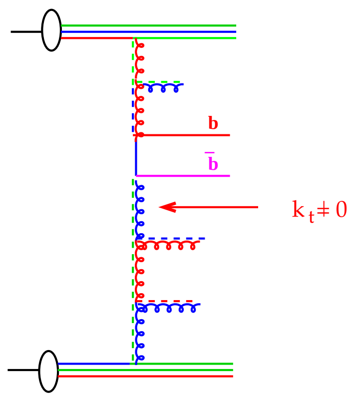


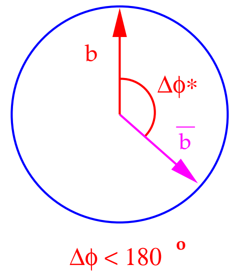
- no effect from changing:
  - splitting fct
  - initial condition
  - k_t-cutoff in cascade
  - applying consistency constraint

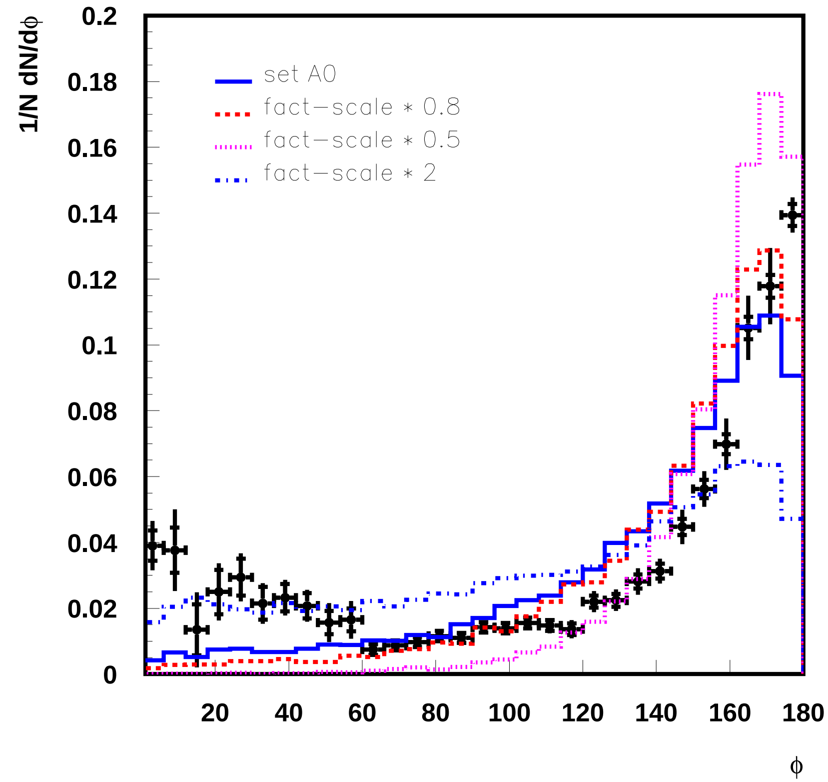


- $\Delta\phi$ is sensitive to shape of k_t distribution
- different initial conditions show similar behavior

$b\bar{b}$ $\Delta\phi$ distribution



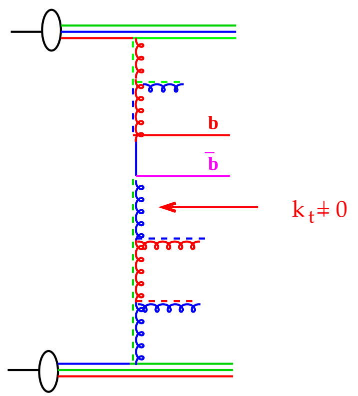


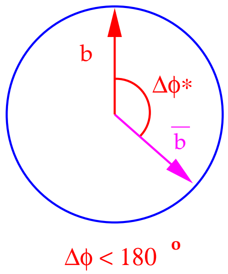


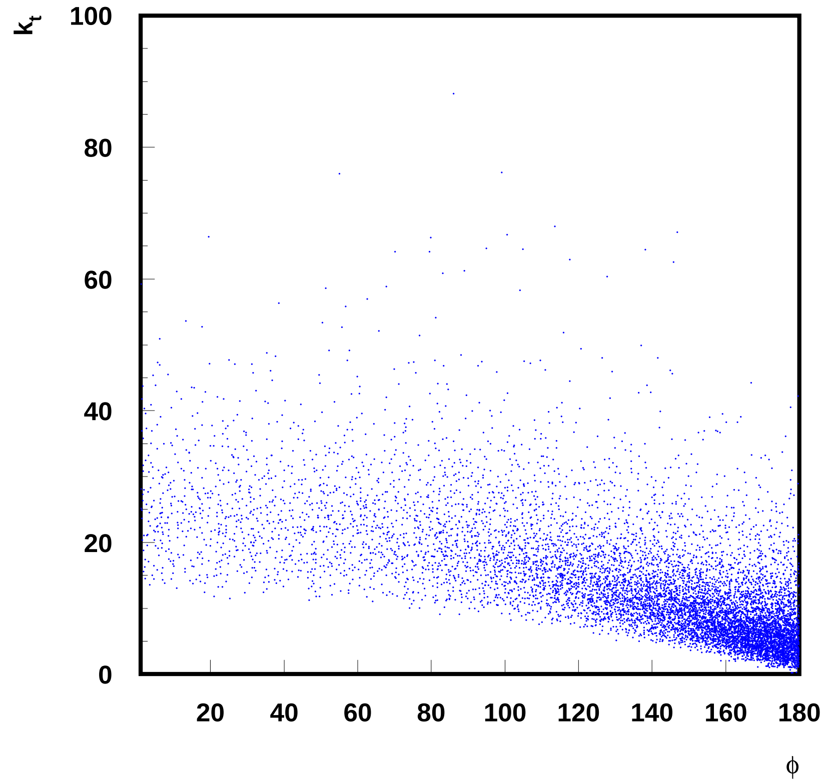
- no effect from changing:
  - splitting fct
  - initial condition
  - k_t-cutoff in cascade
  - applying consistency constraint
- effect from length of evolution
  fact. scale

- $\Delta\phi$ is sensitive to shape of k_t distribution
- different initial conditions show similar behavior

$b\bar{b}$ $\Delta\phi$ distribution







- no effect from changing:
  - splitting fct
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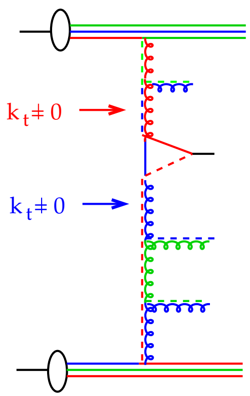
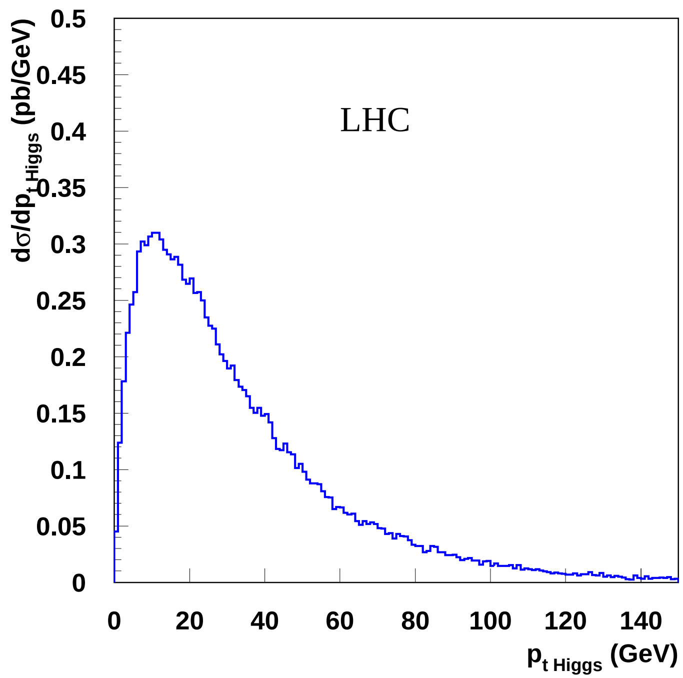
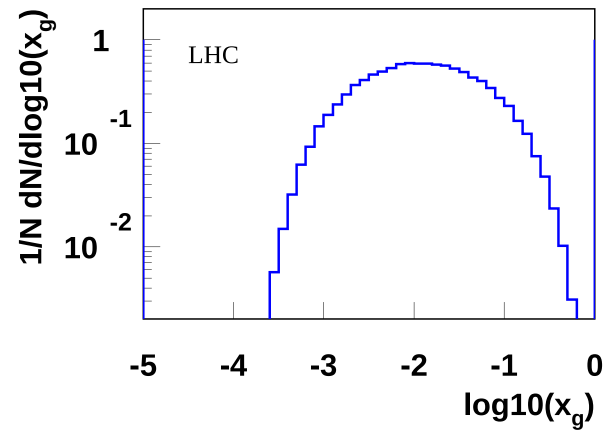
  - k_t-cutoff in cascade
  - applying consistency constraint
- effect from length of evolution
  fact. scale

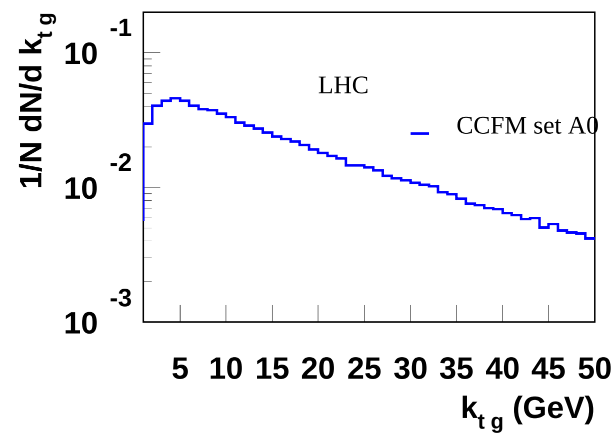
- $\Delta\phi$ is sensitive to shape of k_t distribution
- different initial conditions show similar behavior
- $\Delta\phi$ is sensitive to large k_t

Higgs production at LHC



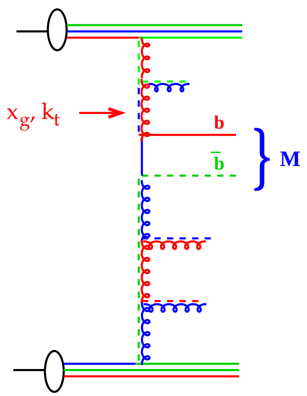


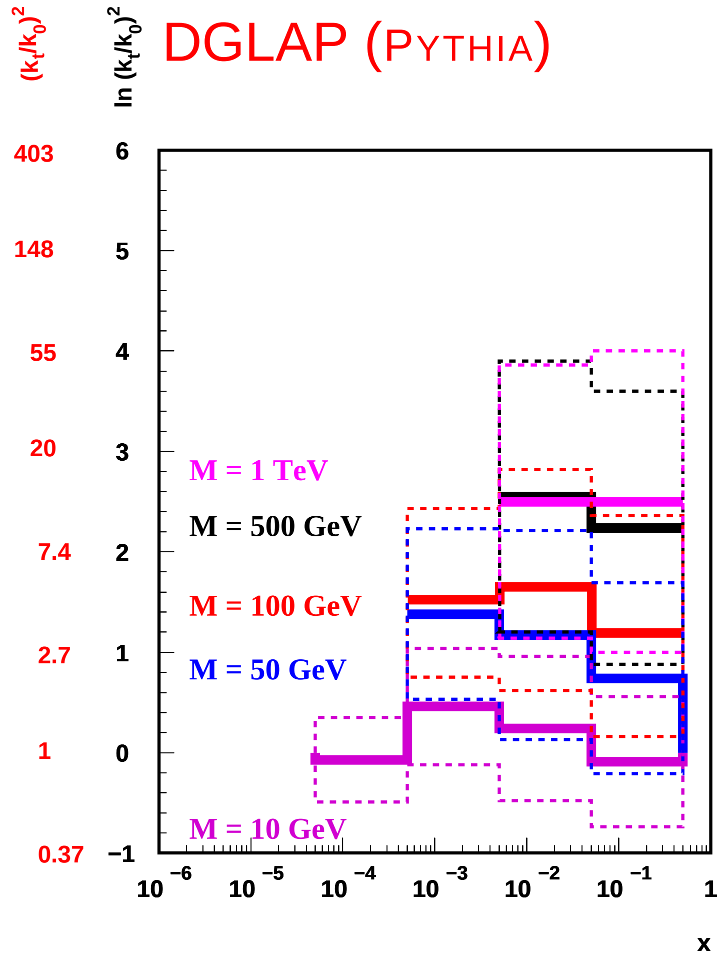


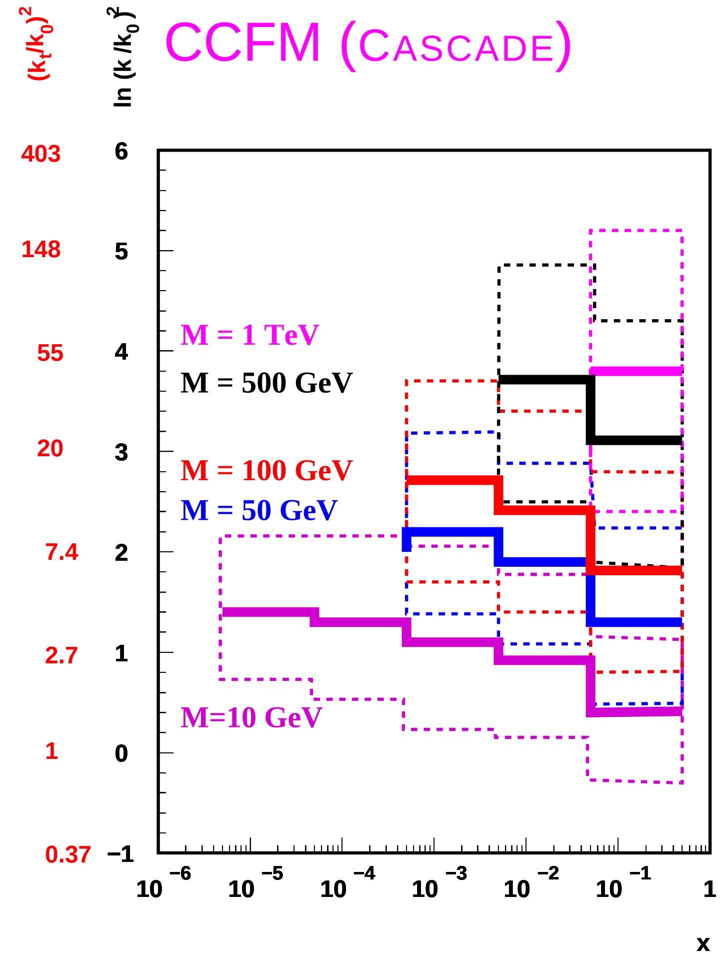


- sensitive to $0.001 < x_g < 0.1$ and $k_t \sim 2 - 10$ GeV
- similar k_t range as in heavy quark prod at HERA and Tevatron
- BUT at very different factorisation scale $\mu_f \sim m_{higgs}$!!!

Dependence of $\langle k_t \rangle$: DGLAP vrs CCFM



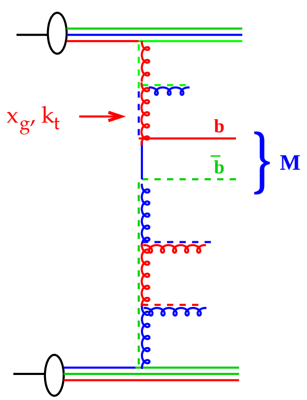


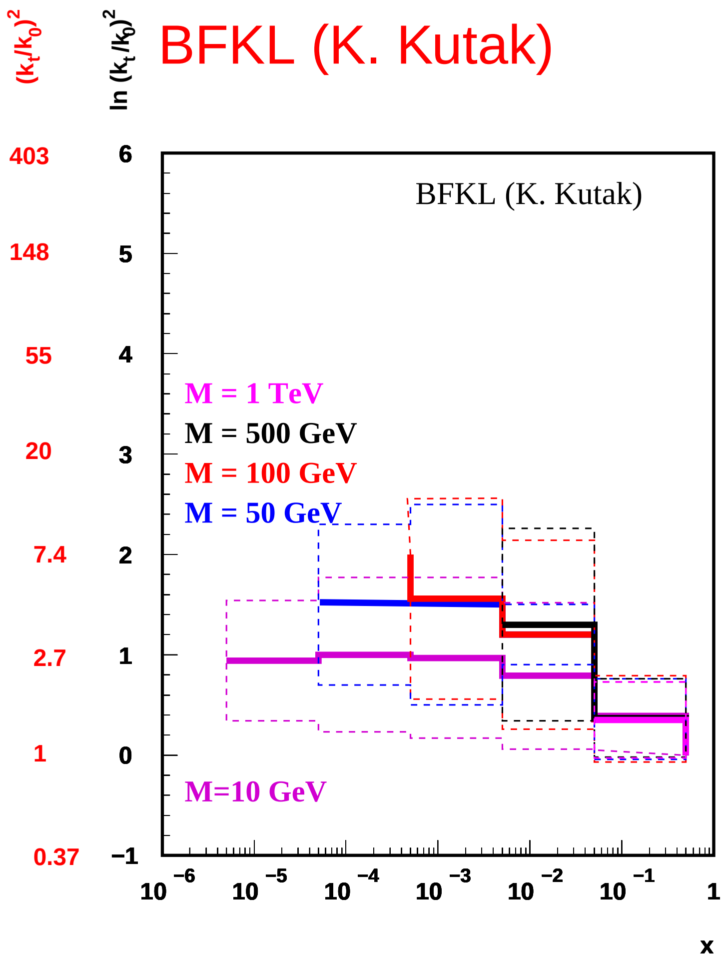


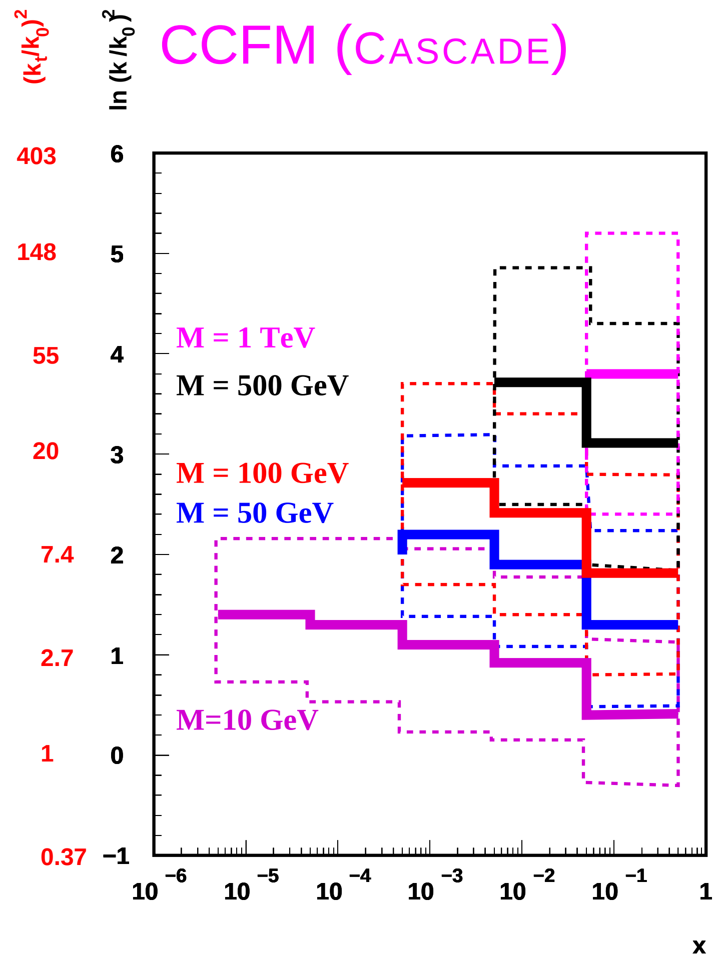
DGLAP has smaller $\langle k_t \rangle$'s than CCFM !!!!

☛ still above 1 GeV even at small x ... saturation still relevant ?

Dependence of $\langle k_t \rangle$: BFKL vrs CCFM







BFKL with consistency constraint... !!!! ☛ at low x similar to CCFM
BUT differences at larger M

Conclusions

- mapping of k_t - x_g plane:
  - F_2: concentrated at small $k_t < 4$ GeV $x_g \gtrsim 0.0001$
  - F_2^c: contribution from $k_t > 2$ GeV and $x_g \gtrsim 0.001$
  - charm photoprod at HERA: test $k_t \sim 1$ GeV and $k_t \sim 8$ GeV at same $x_g \sim 0.01$
  - charm at Tevatron: test $k_t \sim 1 - 3$ GeV at $0.001 < x_g < 0.01$
  - $\Delta\phi$ with bottom at Tevatron: test $k_t \sim 1 - 20$ GeV at $0.005 < x_g < 0.05$
- Need to understand better k_t spectrum of un-integrated gluon ...
- NEXT: combined fit to hadronic final state data from HERA & Tevatron

challenge to describe full range in x_g, k_t and μ_f