Longitudinally Polarised Hadroproduction of Heavy Quarks

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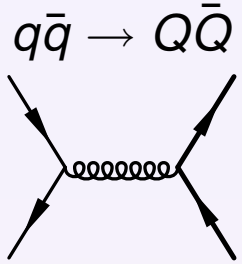
Outlines

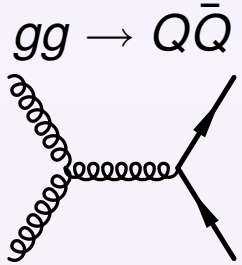
Leading order diagrams

In LO: Heavy quark production proceeds through two subprocesses:

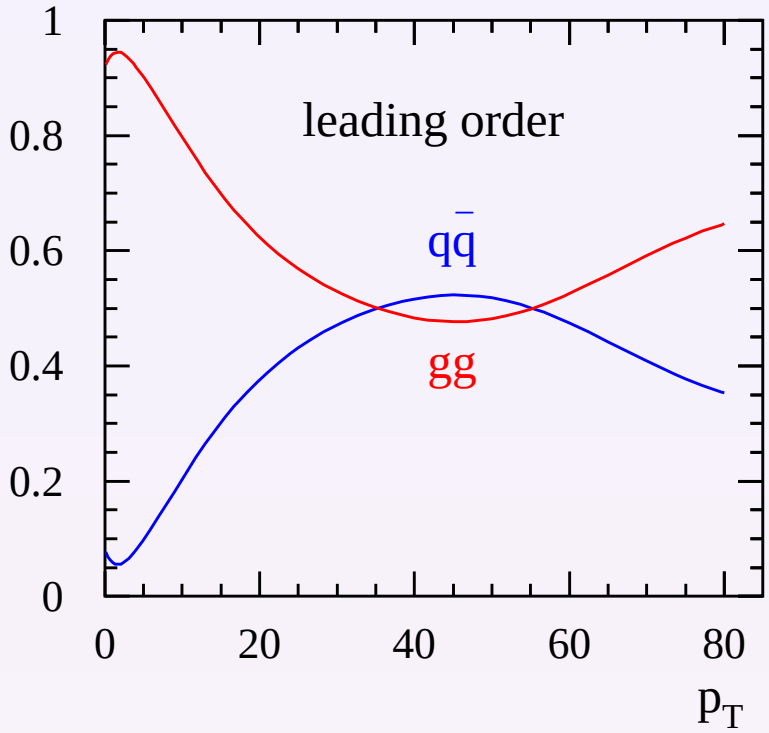
- quark–antiquark annihilation,



- gluon–gluon fusion,



Relative amounts of these subprocesses for RHIC, $\sqrt{S} = 200$ GeV (CTEQ6):



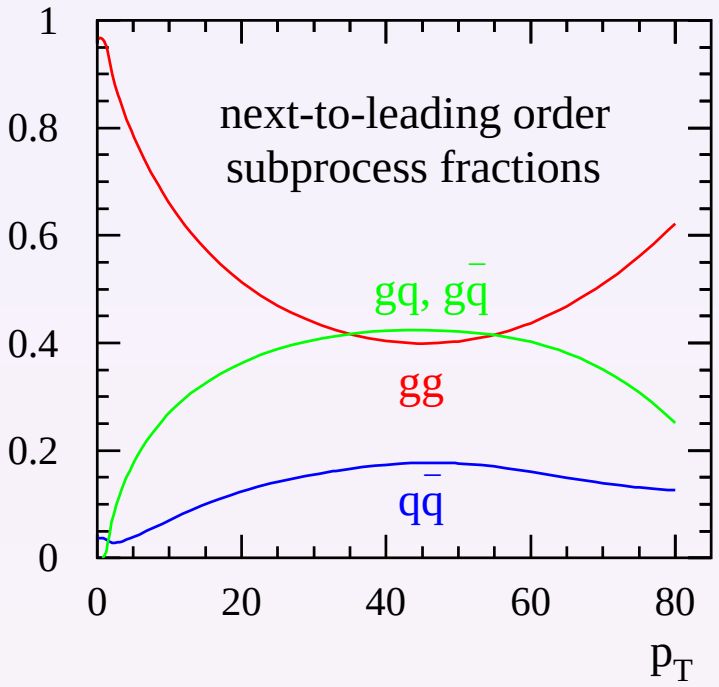
Heavy quark production at NLO

NLO corrections

- Lots of real and virtual corrections to the LO subprocesses
- Genuine new subprocess of gluon–(anti-)quark fusion: $g + q(\bar{q}) \rightarrow Q + \bar{Q} + q(\bar{q})$

The need for NLO corrections:

- Large corrections in unpolarised case known (Nason et al., Beenakker et al.)
- Reduced dependence on unphysical (renormalisation and factorisation) scales



Determination of Δg

Heavy quark production in longitudinally polarised collisions:

- Sensitivity to Δg through gluon–gluon fusion
- Provides determination of Δg, completely independent of single-inclusive pion/jet production studied so far
- In pQCD: less partonic subprocesses than for pion/jet production
- However, experimentally very challenging
- Δg suggested to be small (e.g., DSSV)
  $\Longrightarrow$ expect very small spin asymmetries

Structure of the calculation

- Complication: one has to match calculation on the parton level with the detection of heavy quarks in experiment
- Heavy quarks are usually detected through their decay products

General structure of a pQCD calculation for HQ cross sections

$$pp \overset{(1)}{\to} Q \overset{(2)}{\to} Mesons \overset{(3)}{\to} decay(e^{\pm}, \mu^{\pm})$$

- (1): calculable in pQCD (making use of the factorisation theorem);
  NLO state of the art:
  - unpolarised: Nason et al.; van Neerven et al.
  - polarised: Bojak, Stratmann; Riedl, Stratmann, Schäfer

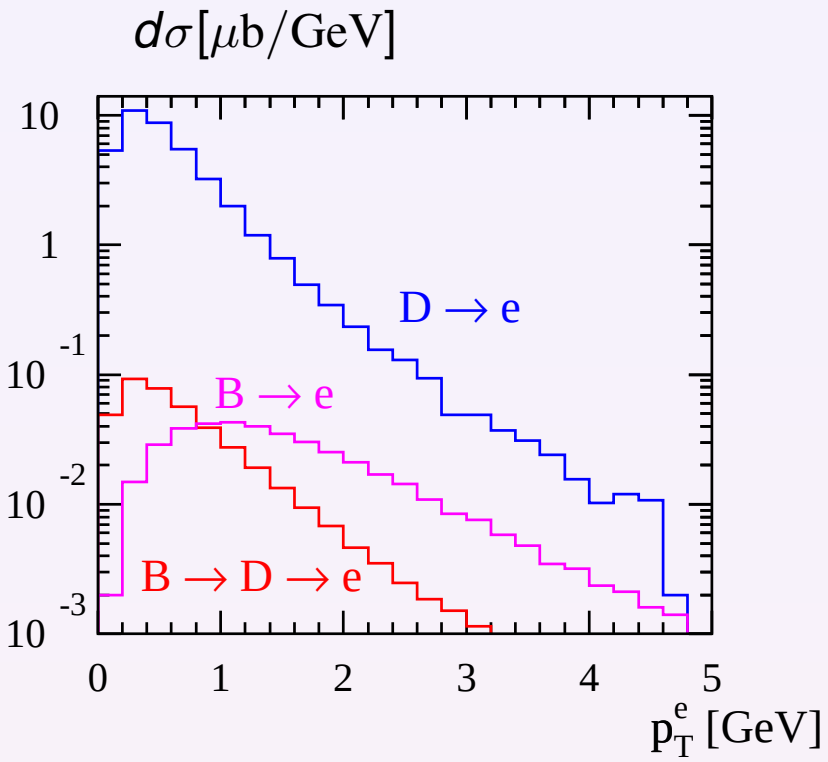
  FONLL: + resummation of quasi-collinear logs at NLL (unpol.): Cacciari et al.
- (2): non-perturbative fragmentation (from data): Cacciari et al.
- (3): leptonic decay spectrum from e^+e^- data (CLEO, BaBar, . . .)

Relevance of different decay channels at RHIC

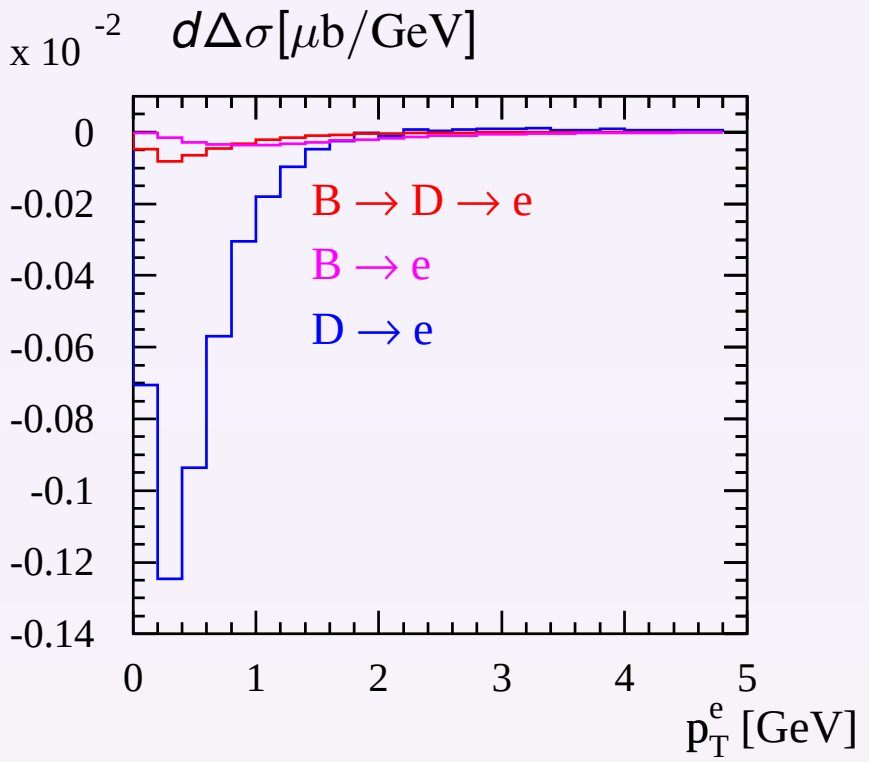
ALL RESULTS PRELIMINARY, $\mu = m$

- Single inclusive electron tag
  $\rightarrow d(\Delta)\sigma$ is a mixture of c's and b's
- Low p_T region dominated by charm production

unpolarised



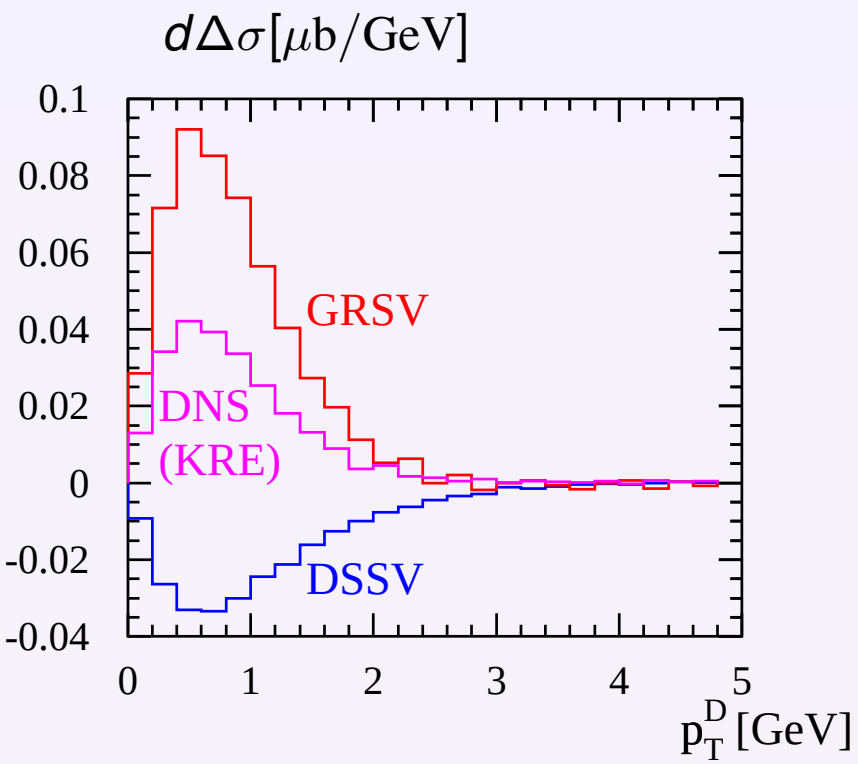
polarised



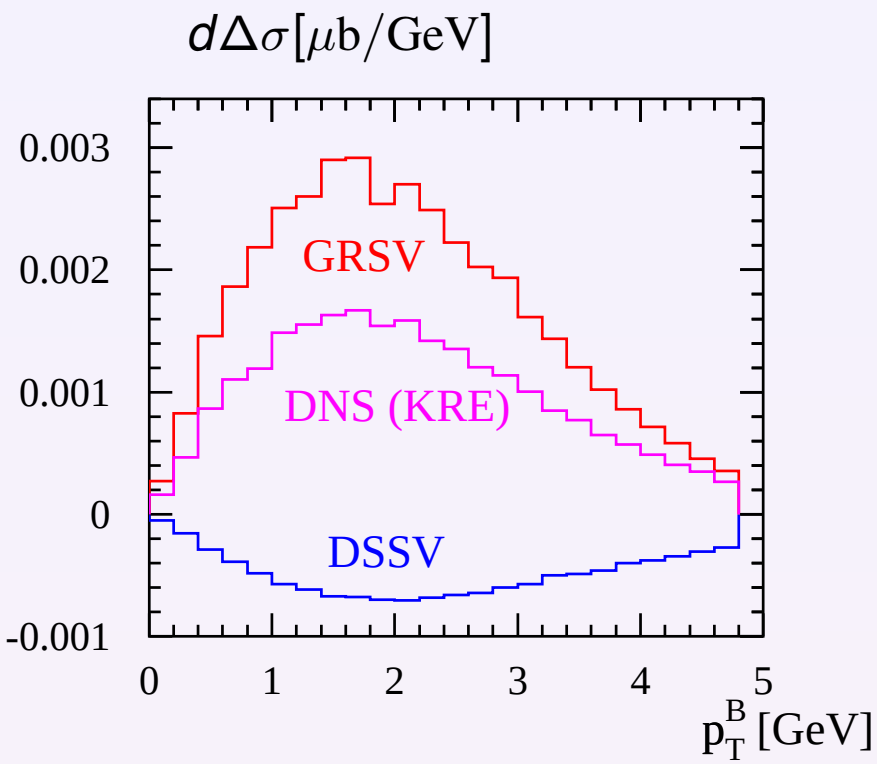
Sensitivity to polarised pdfs (meson level)

ALL RESULTS PRELIMINARY, $\mu = m$

D Mesons



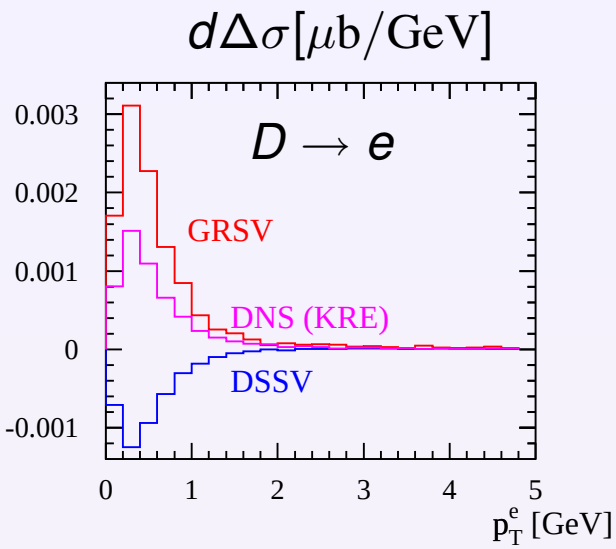
B Mesons

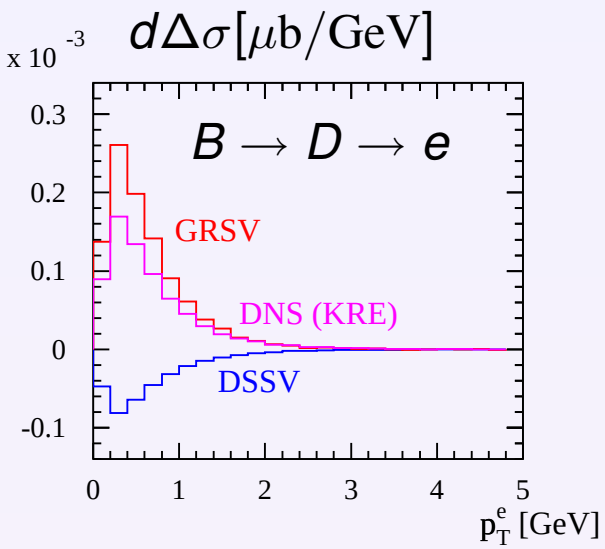


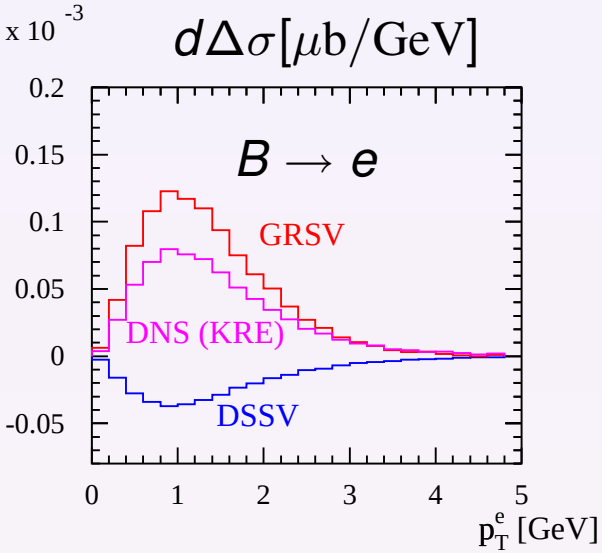
DSSV: very small $\Delta g \rightarrow$ large fraction of $q\bar{q}$ annihilation

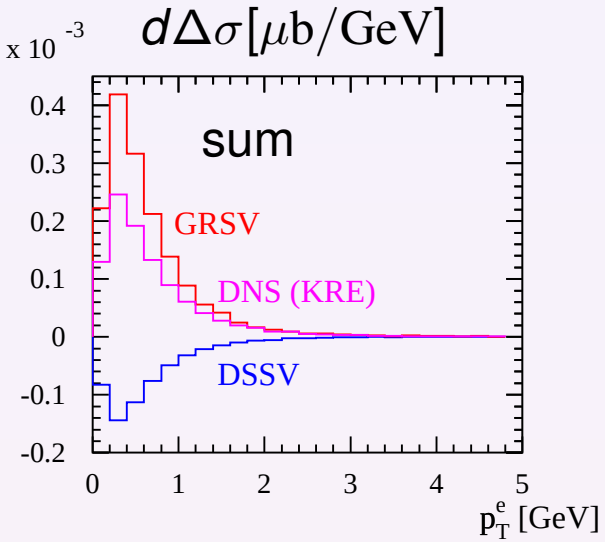
Sensitivity to polarised pdfs (decay electron level)

ALL RESULTS PRELIMINARY, $\mu = m$







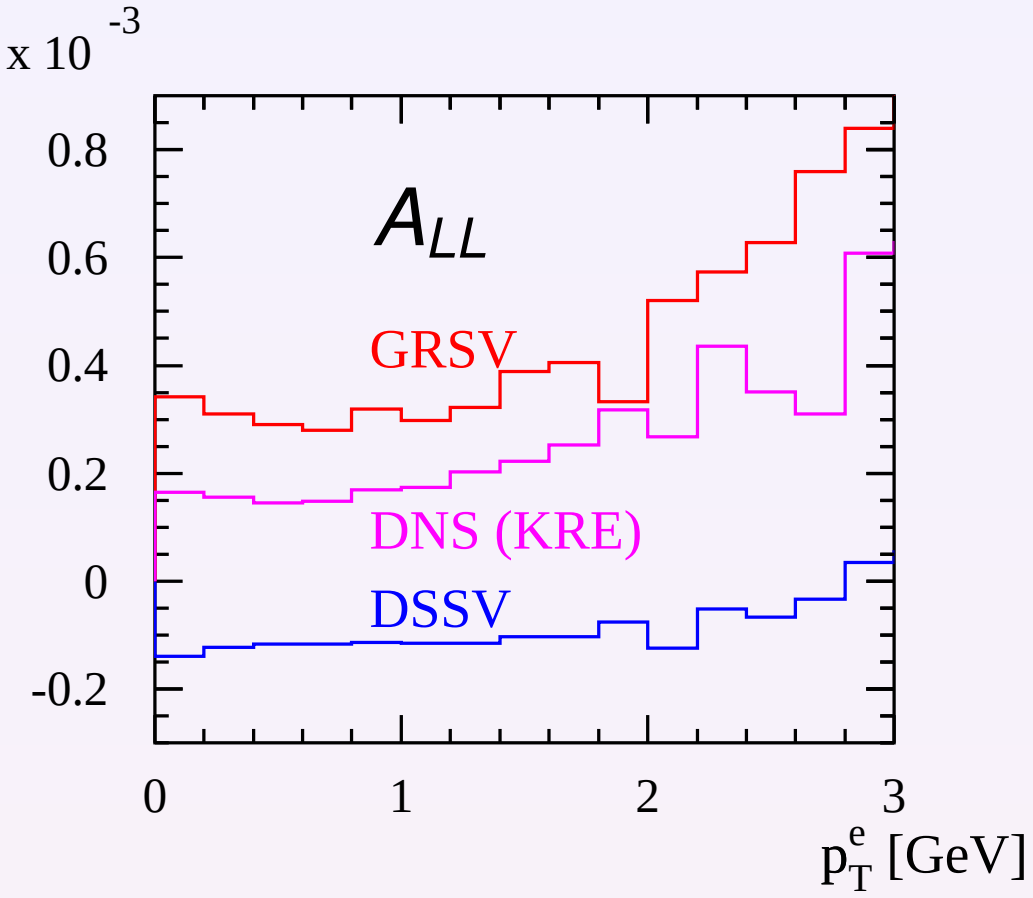


pdf dependence of the different channels in $pp \rightarrow Q \rightarrow e$

Spin asymmetry A_{LL}(decay electron level)

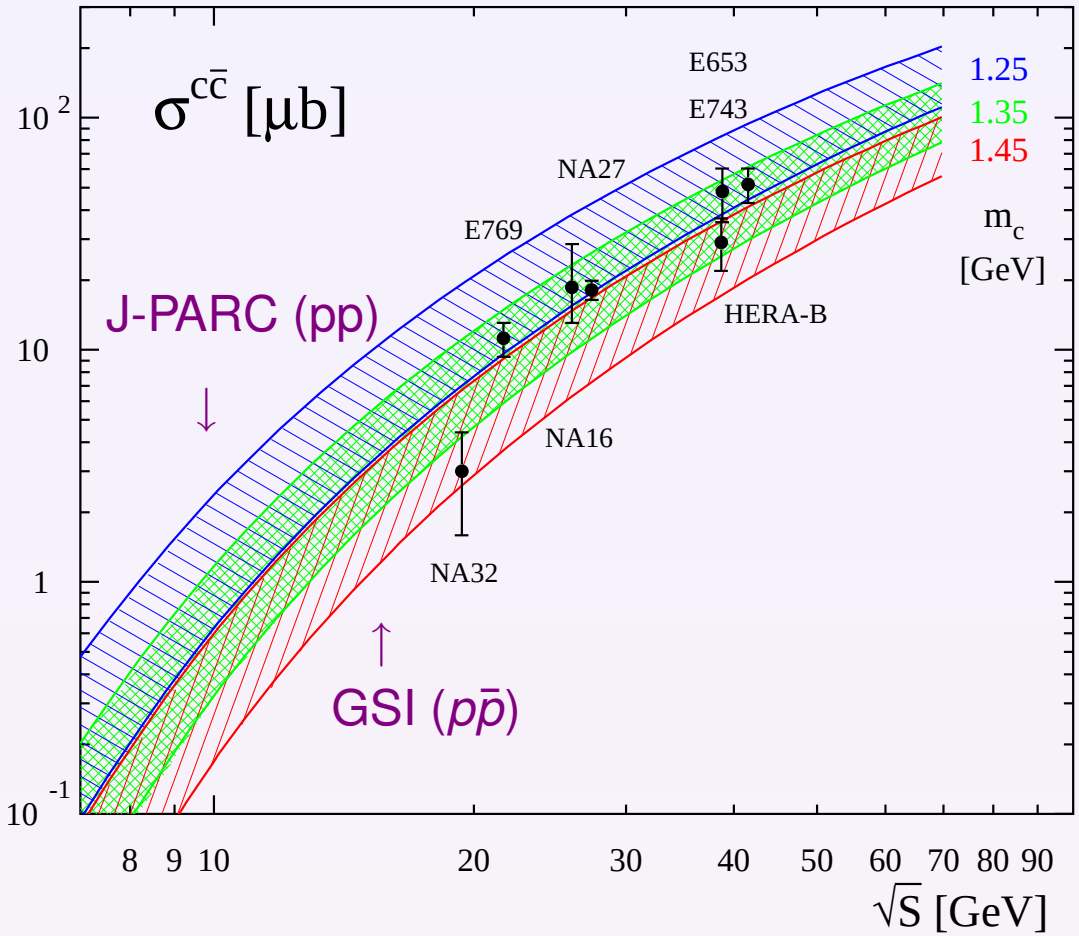
ALL RESULTS PRELIMINARY, $\mu = m$

- Spin asymmetry very small $\rightarrow$ experimentally very challenging
- Sensitivity to gluon polarisation



HQ at small $\sqrt{S}$: GSI and J-PARC projects

Total charm cross section (proton–proton)

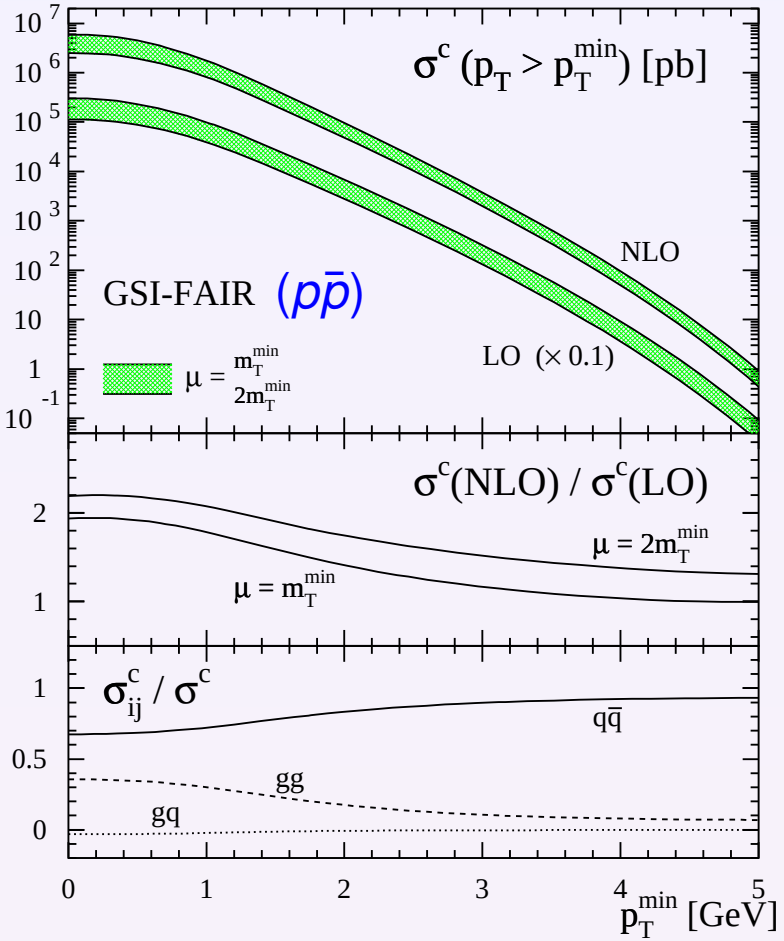


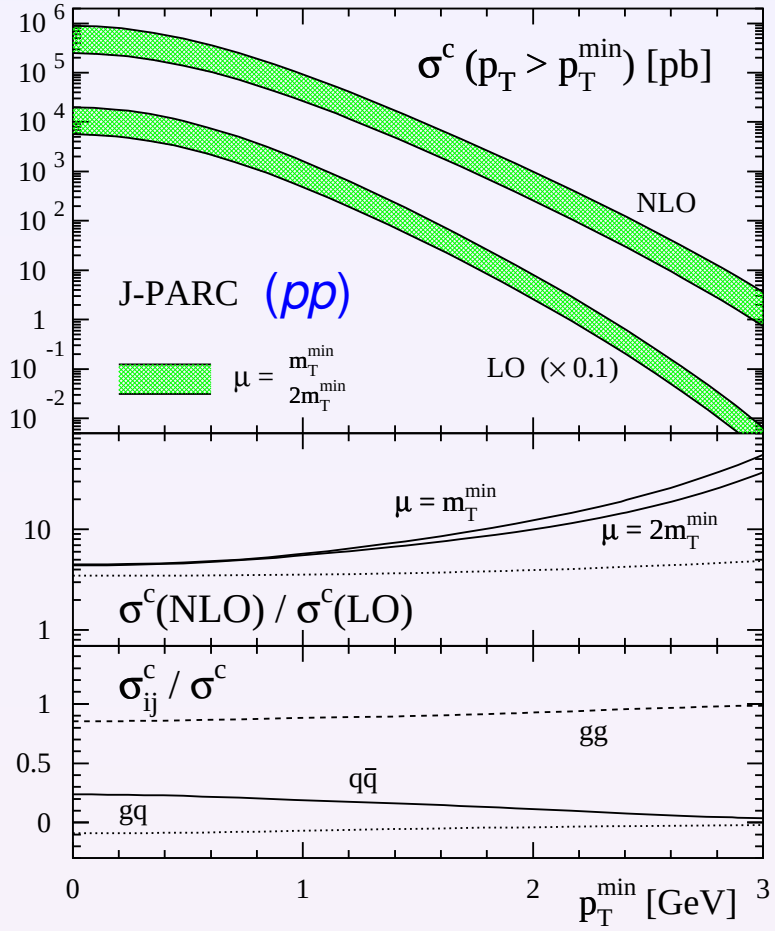
Significant uncertainties:

- charm mass
- choice of (renormalisation and factorisation) scales: here $m_c < \mu < 2m_c$

(Riedl, Stratmann, Schäfer: arXiv:0708.3010 [hep-ph])

GSI and J-PARC: unpolarised



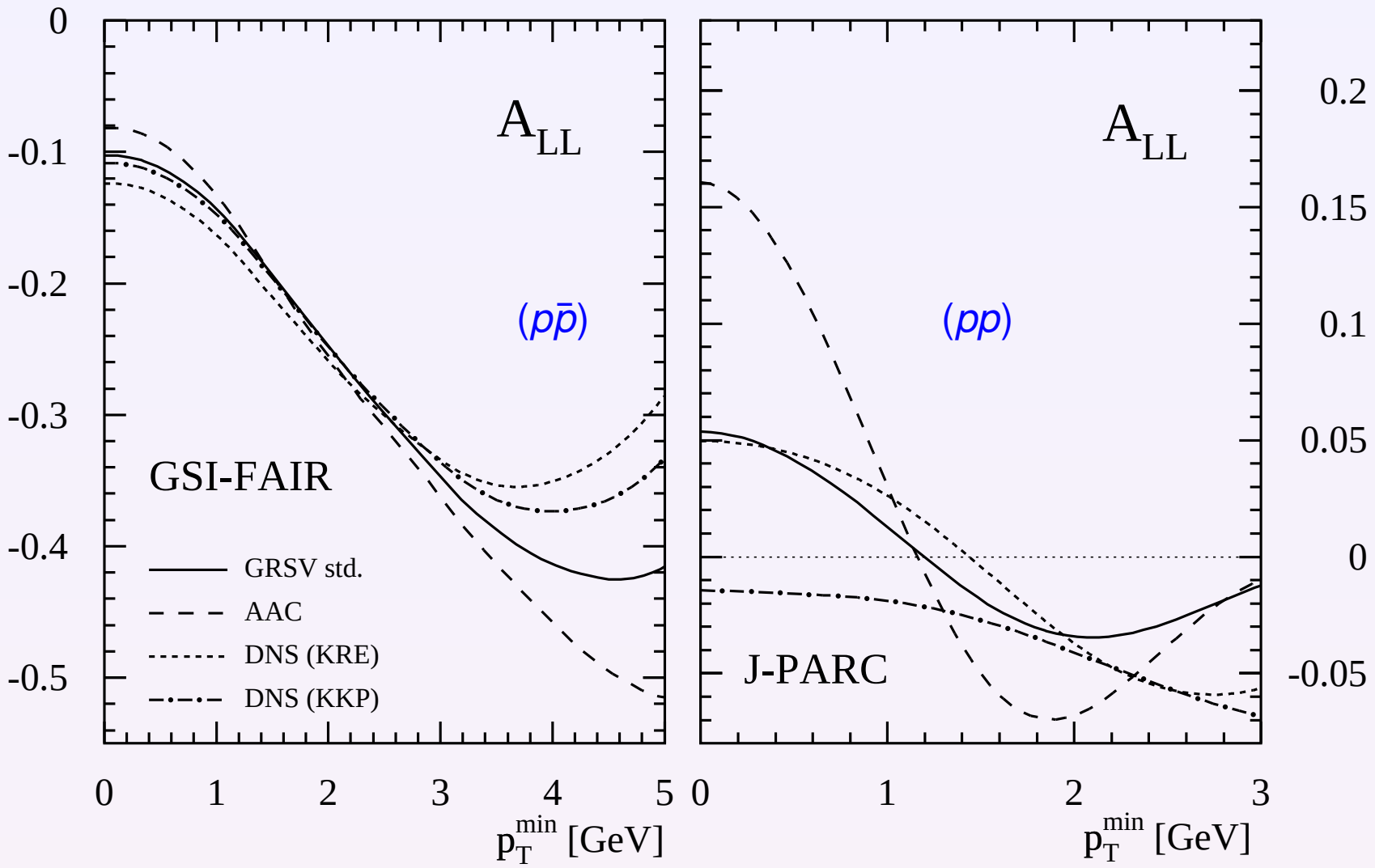


mainly valence–valence scattering

mainly gluon–gluon fusion

probed x-range roughly $0.2 < x < 1$

GSI and J-PARC



probes mainly valence quarks

probes both *sea* quarks and gluons

Summary and Outlook

New flexible MC code available very soon

- allows to study single-inclusive HQ production and $Q\bar{Q}$ correlations
- includes decay to lepton level

Results can be easily extended to photoproduction

- very relevant: already studied by COMPASS
- part of the physics case for a future EIC