Proposal of scale, mass and fragmentation defaults for Heavy Flavour QCD predictions at HERA

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- fragmentation parameters
- beauty and charm mass
- factorization/renormalization scales

to be chosen as theoretical external input
rather than fitted/adjusted in the cross section measurements (discussion?)

choice of fragmentation parameters

- ideally, fragmentation should be treated as "reverse of structure functions", i.e. implemented as part of perturbative QCD calculation with appropriate "fragmentation scale"
  - but often not practical

- 2nd best solution: treat fragmentation as "independent" of hard process
  - but beware: only soft part of fragmentation really universal !
    hard part (parton shower) depends on QCD scheme !

  => e.g. can be transferred between e+e- and HERA
  within consistent PS scheme (e.g. LO+PS, PYTHIA, differences in perturbative part and different kinematic ranges taken care of by implicit differences in parton showering)

  => can NOT be transferred directly between NLO schemes without PS at e+e- and HERA, or between different kinematic ranges (threshold vs. high pT)

choice of fragmentation parameters

see talk S. Fang

- we measured them for charm in FMNR !

  => use values suggested by high pT jet analysis

  => e.g. ε = 0.07±0.02

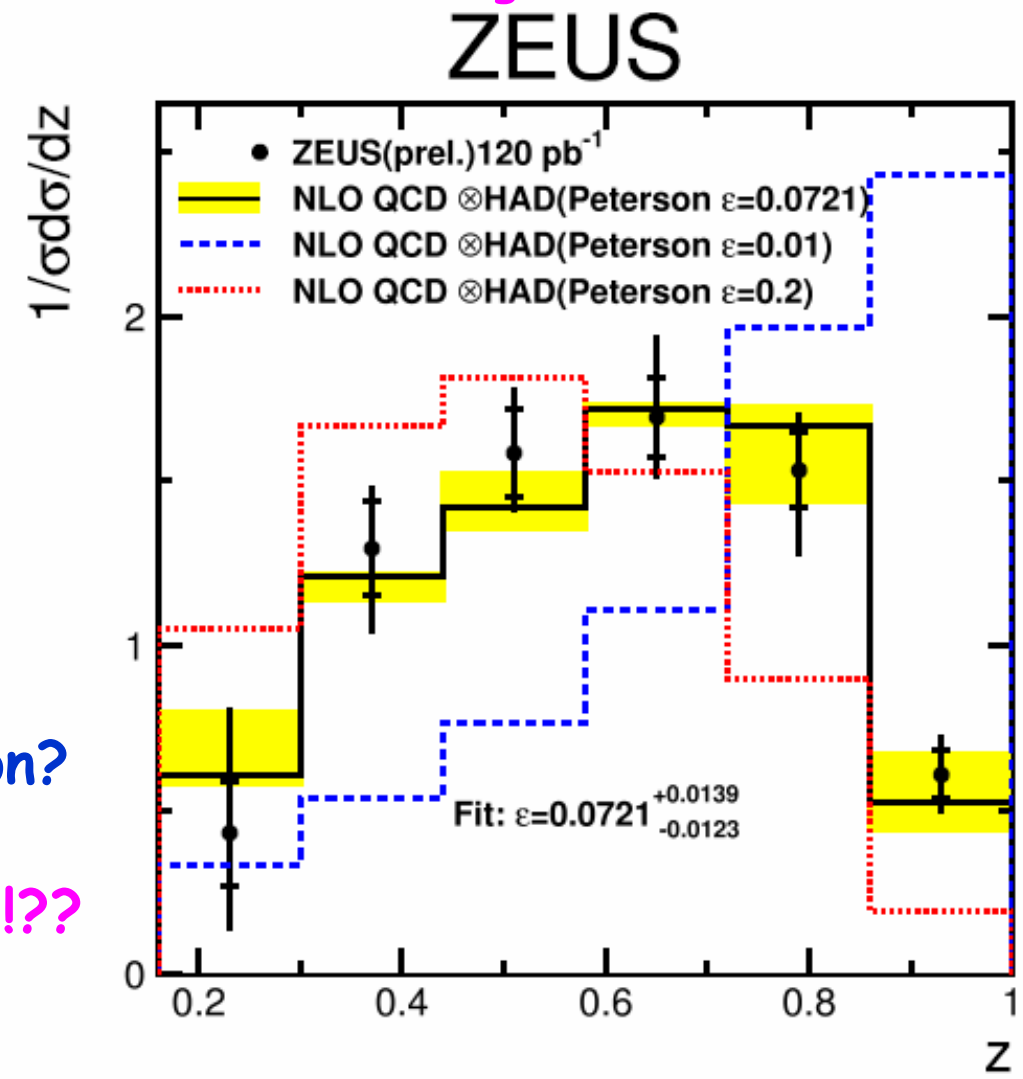
  (to be finalized)

  should be the same for HVQDIS (at high pT) !

  how to treat threshold region?

  (H1 measurement !)

  -> MC@NLO !??



- for beauty:
  to be rechecked
  (less sensitive)

choice of fragmentation parameters

solutions for NLO calculations:

- (re)parametrize separately to measurements for each kinematic region or
- use MC@NLO
  (parton showering + threshold treatment) or
- use FMNR x PYTHIA interface
  (threshold treatment)

unfortunately none of these available in DIS ...

-> RAPGAP? (talk H. Jung)

choice of m_b

- both FFNS and VFNS schemes use pole mass:

$$m_b(\text{pole}) = m_b(m_b)\,(1 + 4/3\ \alpha_s/\pi\,)$$
$$= m_b(Q)\,(1 + \alpha_s/\pi\ (4/3+\ln(Q^2/m_b^2))$$

note: $\ln(1/4) \sim -4/3 \Rightarrow m_b(\text{pole}) \sim m_b(m_b/2)$

leading order QCD

- in past, MRST used $m_b = 4.3$ GeV
- in past, CTEQ used $m_b = 4.5$ GeV
- HVQDIS uses $m_b = 4.75 \pm 0.25$ GeV
- recent measurement of pole mass (Kühn, HQET):
  $m_b \sim 4.8$ GeV $\pm\ O(\Lambda_{QCD})$
- agreement brokered by M. Cacciari (DIS/HERA-LHC):
  in future, everybody will use $m_b = 4.75$ GeV
- => use $m_b = 4.75 \pm 0.25$ GeV (as before)

choice of m_c

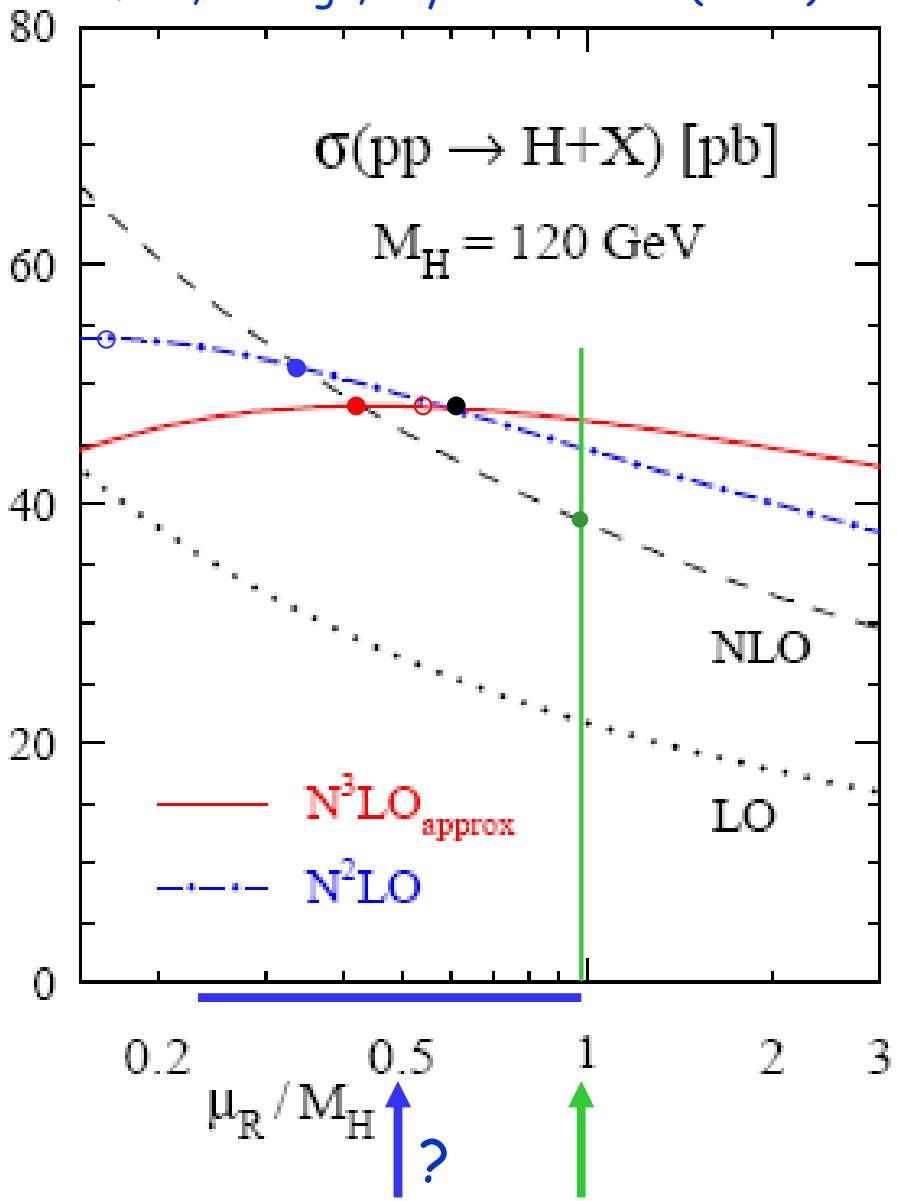
- again: pole mass! -> m_c ~ 1.3/1.35 GeV NOT OK
- "usual" values vary between 1.2 and 1.7 GeV
- so far, MRST use m_c = 1.4 GeV (and want to keep it, although too low)
- recent measurement of pole mass (Kühn, HQET):
  m_c ~ 1.65 GeV ± $O(\Lambda_{QCD})$
- => suggest to use m_c = 1.6 ± 0.25 GeV

  supported by some, but not yet really agreed
  => to be discussed!

  (recent summary plots with ZEUS-SFF, m_c = 1.5+-0.2 GeV)
- cross section reduction due to higher mass will partially compensate increase due to lower scale (next slides)

NLO scale choice? example: Higgs at LHC

S. Moch, A. Vogt, Phys.Lett. B631 (2005) 48



in principle **arbitrary**, but

fastest convergence, minimal sensistivity

NNLO stability:

- NNLO = NLO
- ○ $d\sigma_{NNLO}/d\mu = 0$

N³LO stability:

- N³LO = NLO
- N³LO = NNLO
- ○ $d\sigma_{NLO+NLL}/d\mu = 0$

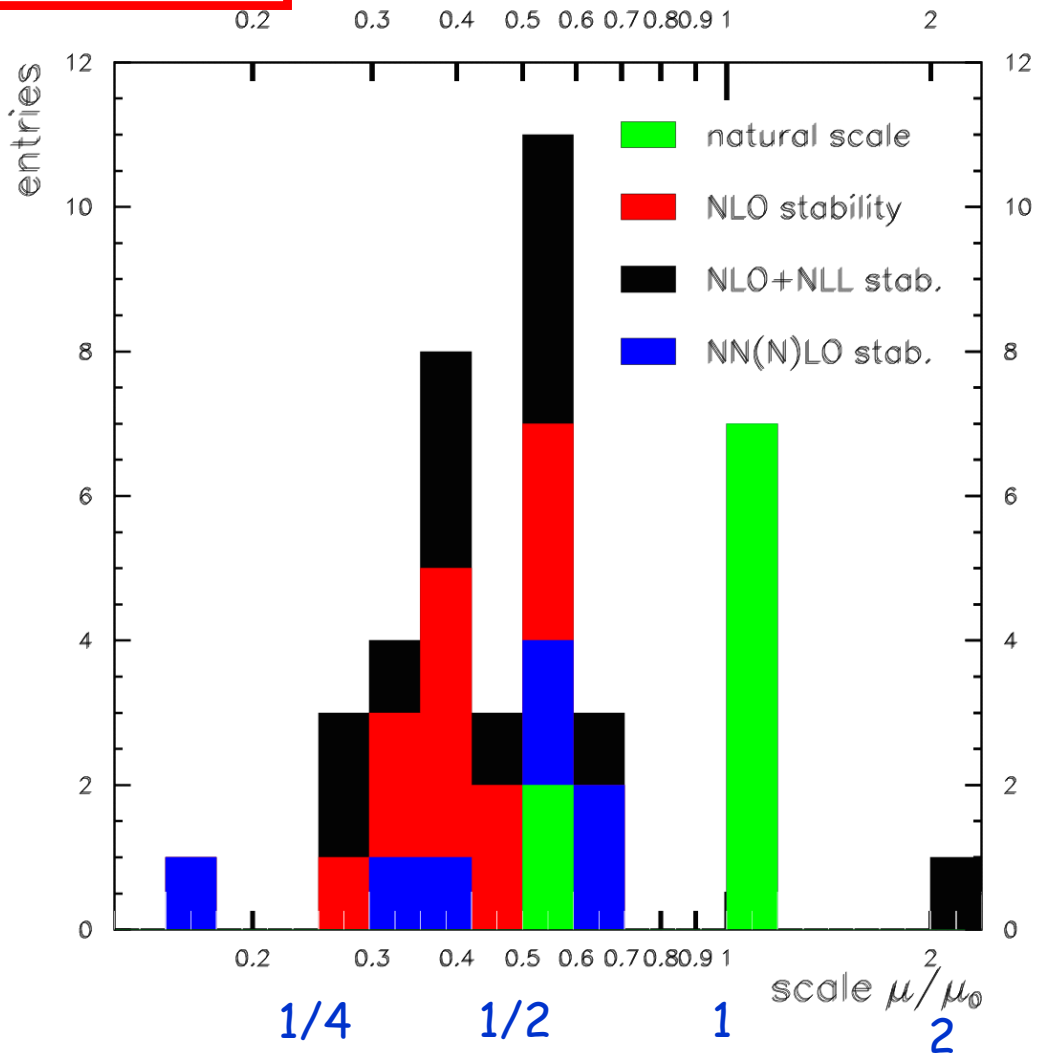
—— "natural" scale

NNLO/N3LO calculations, where available, often suggest ren./fact. scale ~ half "natural" scale for NLO

"optimal" ren./fact. scale from theory

$\mu_0/2 < \mu < 2\mu_0$ — "standard" scale range

$\mu_0/4 < \mu < \mu_0$ — **proposed new default**



NLO (NNLO) QCD survey of:

- beauty at Sp$\bar{p}$S, Tevatron, HERA-B
- top at Tevatron
- Z, H at LHC

  $\mu_0^2 = m^2 \; (+ \; p_T^2)$

- jets in γp and at Tevatron

  $\mu_0^2 = E_T^2$

summary of proposed default scales:

"natural" QCD scales for NLO calculations:

- $\mu_0^2 = E_T^2 = m^2+p_T^2$ for PHP (consensus)
- $\mu_0^2 = Q^2+E_T^2 = Q^2+m^2+p_T^2$ for DIS

-> same as PHP for Q^2-> 0

where

m = quark mass (=0 for light quarks)

p_T^2 = average relevant parton p_T^2 in Breit frame

(= lab frame for PHP)

Q^2 = photon virtuality (=0 for PHP)

DIS: could argue for $Q^2 + 4m^2$,
but then: what to use for PHP ?

⇒ default scale+variation ($\mu=\mu_F=\mu_R$):

$\mu_0/4 < \mu=\mu_0/2 < \mu_0$ as motivated in previous slides