Scales variation for DIS in HERAFITTER

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Scales setup in FFNS and VFNS

The possibility to setup factorisation scale have been implemented for following schemes : FF, FF ABM, ACOT Full, ACOT chi, ZMVFNS
Scale are setting by the following formula :
$\mu^2 = scalea1 \times (Q^2 + scaleb1 \times 4m_q^2)$
Where scalea1, scaleb1 and m_q are set by user

Scheme	Factorisation scale	Renormalisation scale	muf variation
ZMVFNS	Q^2	Equal factorisation	implemented
RT	Q^2	Equal factorisation	not possible
ACOT ZM	Q^2	Equal factorisation	log tems missing
ACOT Chi	Q^2	Equal factorisation	implemented
ACOT Full	Q^2	Equal factorisation	implemented
FF	Q^2+4mq^2	Equal factorisation	was implemented
FF ABM	Q^2+4mq^2	Equal factorisation	implemented

Unification scales setup for FF, FF ABM, ACOT schemes and ZMVFNS

$\mu^2 = scalea1 \times (Q^2 + scaleb1 \times 4m_h^2)$

$aq2 \times \mu^2 = Q^2 - bq2 \times m_h^2$ QCDNUM(ZMVFNS,FF),ACOT,

$\mu^2 = hqscale1in \times Q^2 + hqscale2in \times 4m_h^2$ OPENQCDRAD

MassHQ = 'mc' or 'mb' - setting up a mass of which quark will be used (QCDNUM,ACOT) QCDNUM(ZMVFNS,FF) coefficients will be calculated from unified in read_steer.f :

aq2 = $\frac{1}{scalea1}$

bq2 = $\frac{-4 \times scaleb1 * m_q}{scalea1}$

For OPENQCDRAD, ACOT (in read_steer.f) :

hqscale1in = scalea1

hqscale2in = scalea1 $\times$ scaleb1

Also information about factorisation scale that is being used in fit is added to screen and will appear before start of minimisation.

How it will look like in steering.txt file :

```
*
* (Optional) choose the factorisation scale for HQs
* tuned via parameters:    mu_f^2 =scalea1 * (  Q^2 + scaleb1 * 4*m_h^2 )
* Available for 'FF', 'FF ABM' options 'ACOT Full' and 'ACOT chi' options
&HQScale
   scalea1    = 1.,
   scaleb1    = 1.
   MassHQ = 'mc' ! (available: mc, mb), relevant for 'FF', 'ZMVFNS', 'ACOT Full' and 'ACOT chi'.
&End
```

Notification during initialization :

```
 ZMSTF: words used =    163239
 factorisation scale for heavy quarks is set to  sqrt(   1.00000000000000      *Q^2 +    1.00000000000000      * 4m_c^2 )
Initialize theory for datasets
 NO APPLGRIDs INITIALIZED
```

Checks of scales setup implementation in QCDNUM and ACOT ZM

ACOT package provides ZM MSbar scheme which allows for checks wit QCDNUM ZMVFNS scheme.

- Different treatment for scale variations, however when consistently used the results agree for LO.
- At NLO 'ACOT ZM' and 'ZMVFNS' are the same for scale = Q^2 but different for variation of scale (difference coming from missing NLO terms for 'ACOT ZM' [Thank to Fred Olness for clarification!], no scale variation for this scheme so far will be implemented).

Summary

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- Scale setup for FF, FF ABM, ACOT Full, ACOT Chi and ZMVFNS was implemeted and tested
- Everything works as expected. Observed discrepancy for scales variation between ZMVFNS and ACOT ZM were due to missed terms in ACOT ZM scheme.
- Scales variation implementation for ACOT Full, ACOT chi, ZMVFNS, FF (QCDNUM) and FF ABM (QCDRAD) is ready to be submitted to the trunk.

Thanks to Ringaile, Marco, Voica, Sasha and Fred

BACKUP