Scale uncertainty in the “multi-leg@NLO” era

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and
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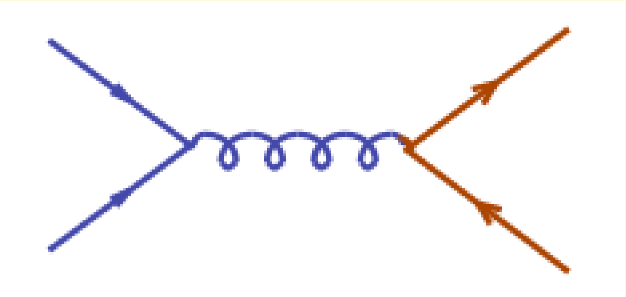
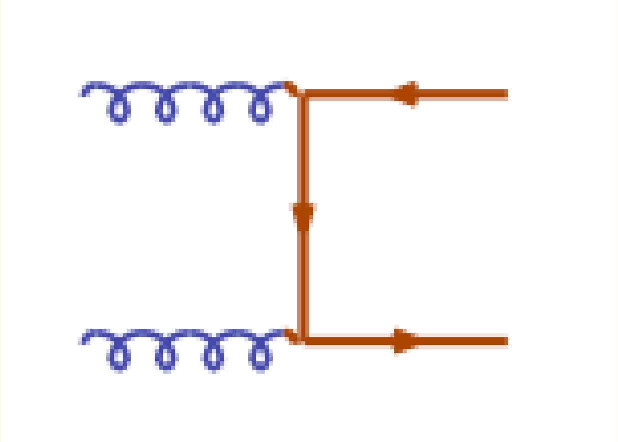
$2\rightarrow 1$, $2\rightarrow 2$ processes

- Typical NLO scale uncertainties for 1-scale processes are of order 10%:
  - inclusive jet E_T
  - $\sigma(tt)$
- Exceptions:
  - $\sigma(bb)$ (onset, at $O(\alpha_S^3)$, of new processes not present at LO)
- Scale dependence defined by varying $\mu_0/2 < \mu < 2\,\mu_0$, with $\mu_R=\mu_F$
  - Procedure *relatively* well defined for final states with a single scale μ_0, although choice of μ_0 affected by overall factor ambiguity



$\mu_0 \sim 2\, m_Q$, $\sqrt{s}$



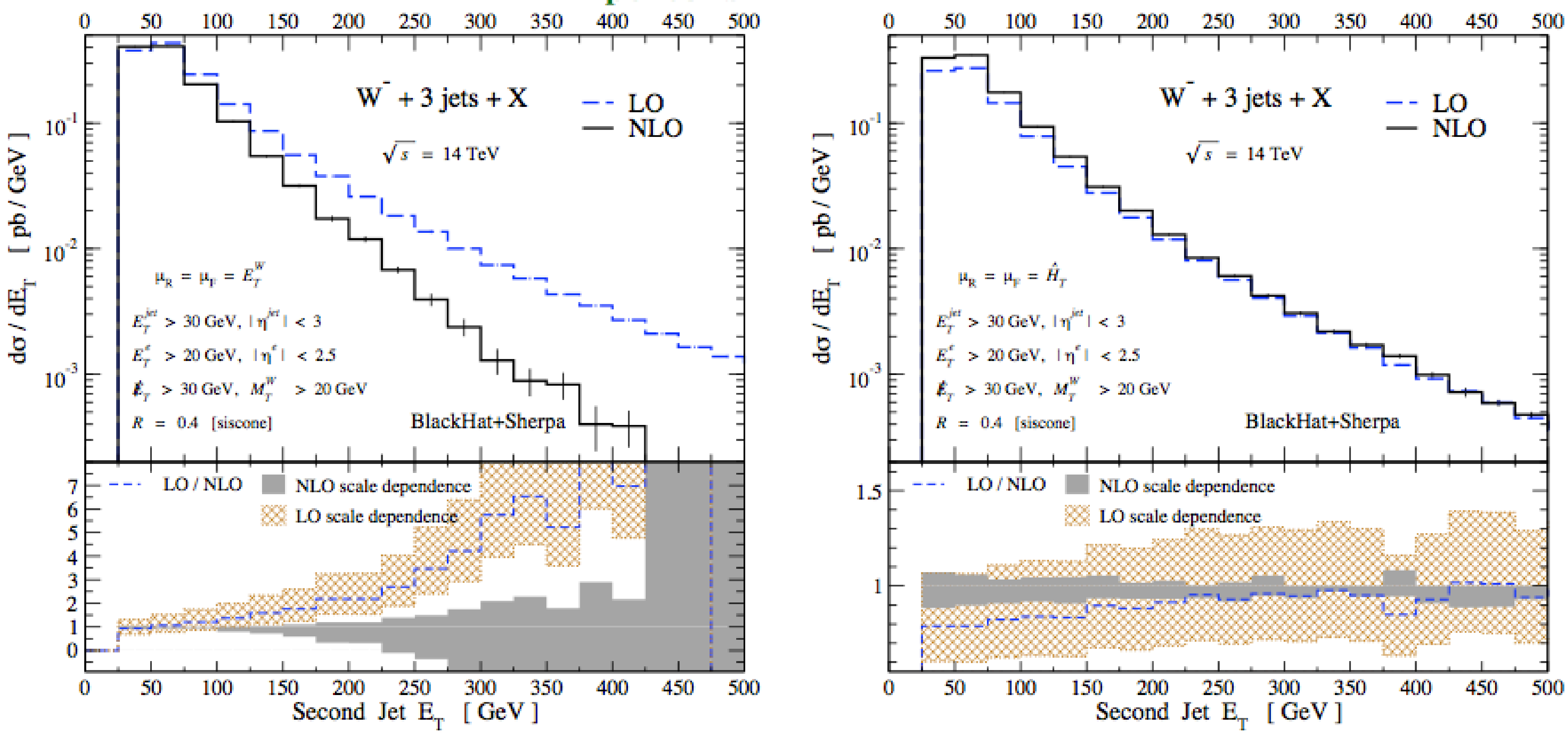
$\mu_0 \sim m_Q$, E_T

$2 \rightarrow n$ processes

- Multi-leg processes differ from $2 \rightarrow 1,2$ for at least two reasons
  - higher powers of α_S ; for $\sigma \sim \alpha_S^n$
    - $[\Delta\sigma/\sigma]_{NLO} \sim (n+1)\ \alpha_S^2$
  - many, possibly very disparate, kinematical scales: what sets the *natural* value of μ_0 ?

Example

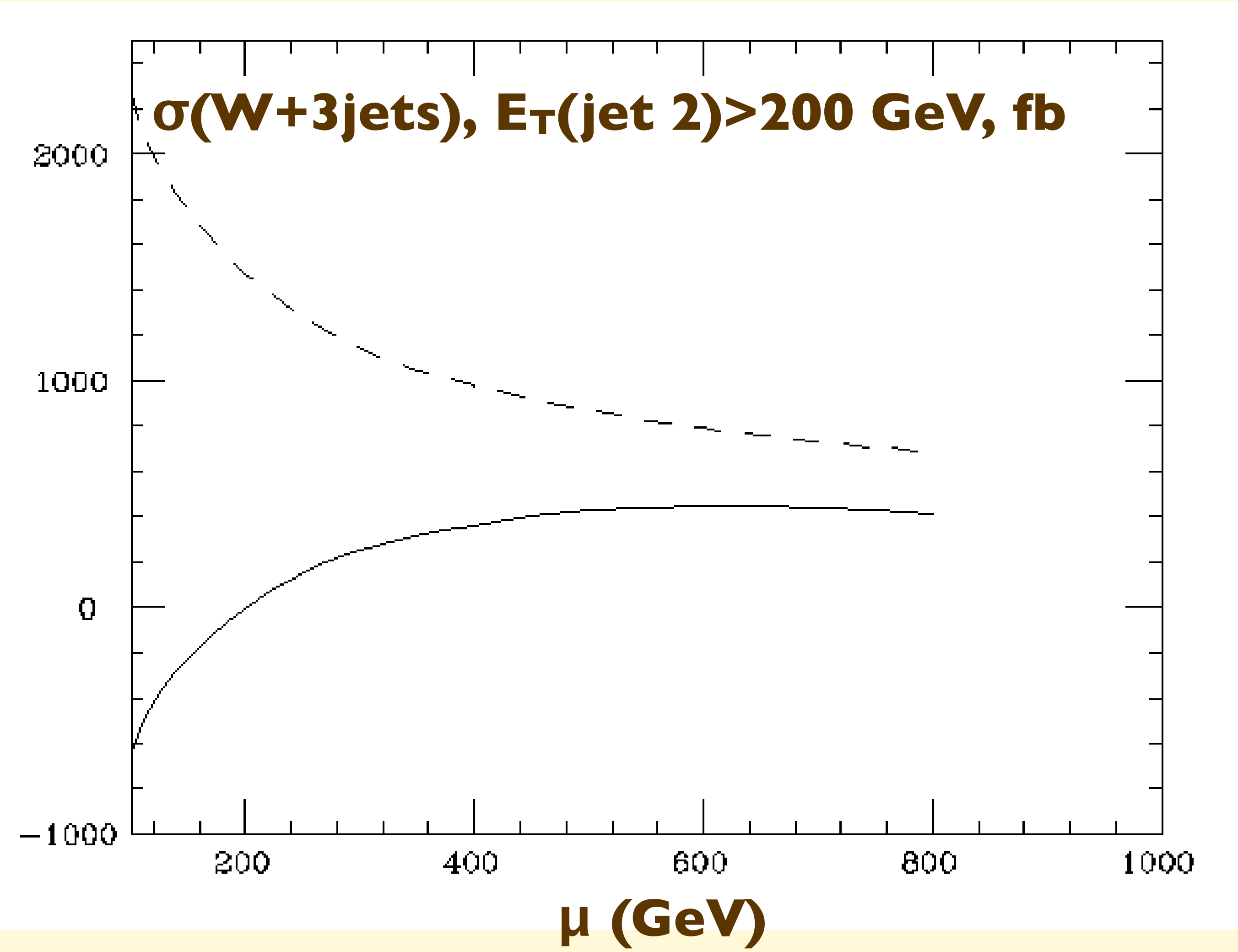
$$H_T = \sum_{\text{partons } i} E_T^i + E_T^e + E_{\text{miss }T}$$



Scale dependence of W+3jets

(Courtesy of Giulia Zanderighi)

sqrt(s) =14 TeV [PP]
jet algorithm SISCone (R = 0.4, f = 0.5)
pt_j > 30 GeV
l eta_j l < 3
pt_lept > 20 GeV
l eta_lept l < 2.5
ptmiss > 30 GeV
mtw > 20 GeV



LO

mu[Gev]	sigma [fb]
100	2255
200	1475
400	975
800	686

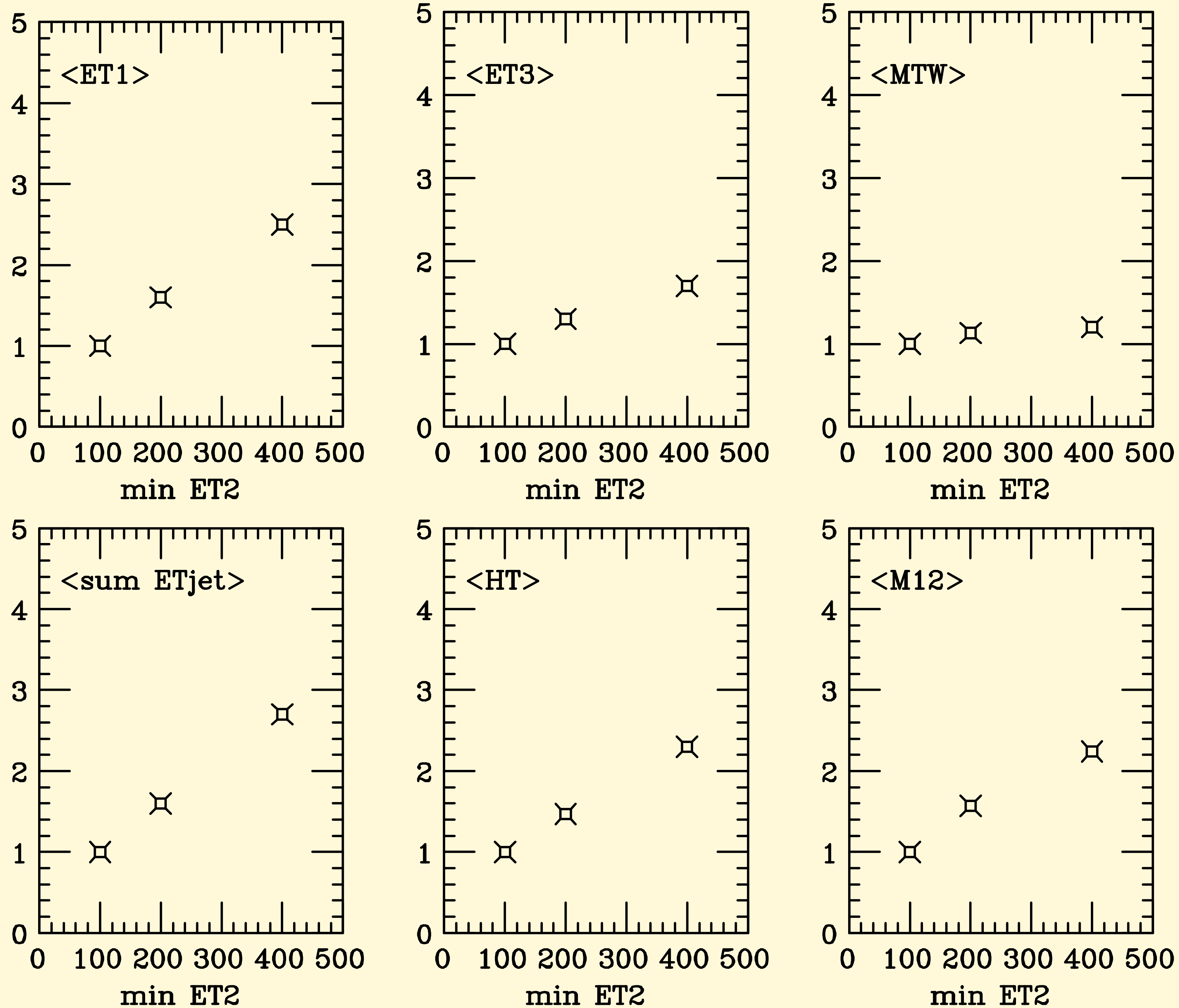
NLO

mu[Gev]	sigma [fb]
100	-632
200	-4
400	364
800	416

Evolution of average kinematical quantities with min(E_{T2})

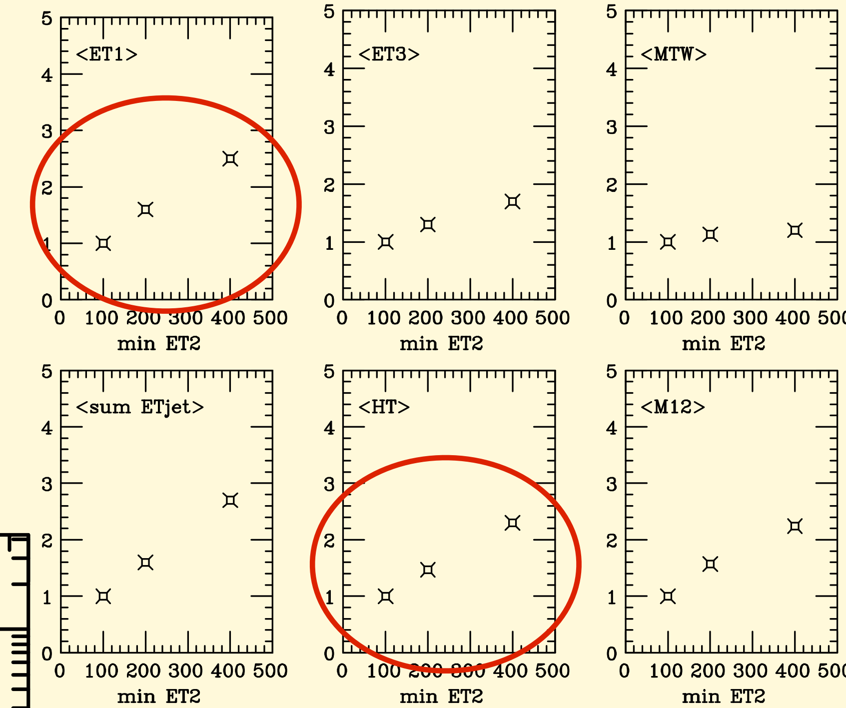
Slope changes vs scale variation are mostly driven by the "slope" of μ_0

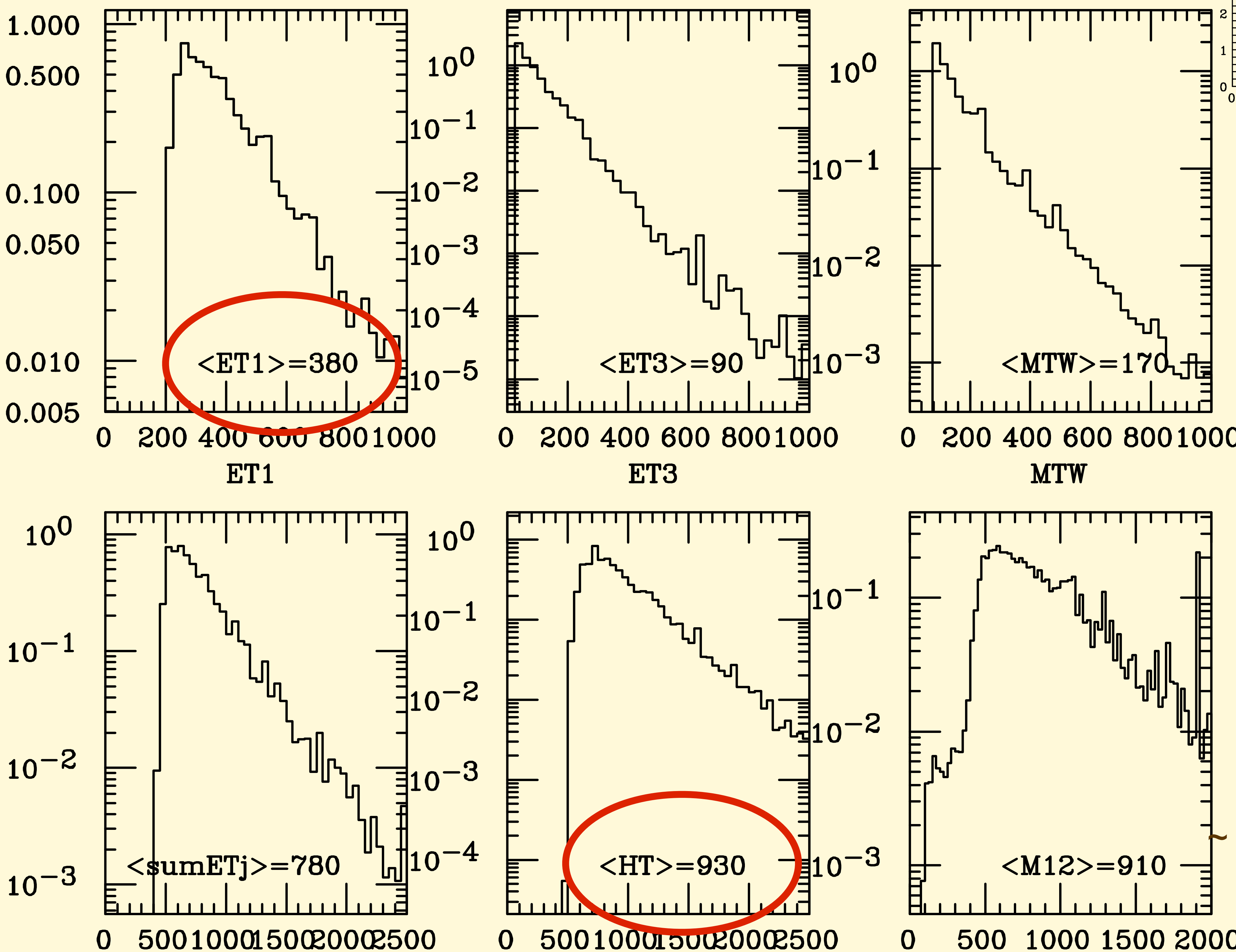
$\langle \mu_0 \rangle$ = avg(μ_0) [E_{T2}>minE_{T2}] / avg(μ_0) [E_{T2}>100GeV]



However, μ_0 choices with the same slope may have very different numerical values.

For events with E_{T2} > 200 GeV





NLO

	mu[Gev]	sigma [fb]
	100	-632
~ $\langle E_{Tl} \rangle$ / 2 ~	200	-4
~ $\langle E_{Tl} \rangle$~$\langle H_T \rangle$/2 ~	400	364
~ $\langle H_T \rangle$ ~	800	416

For discussion:

- Need some better understanding of what defines the "**right range"** for scale-dependence studies
- Need, at least, to establish some common convention, to ensure coherence in presenting theoretical systematics to the experimentalists