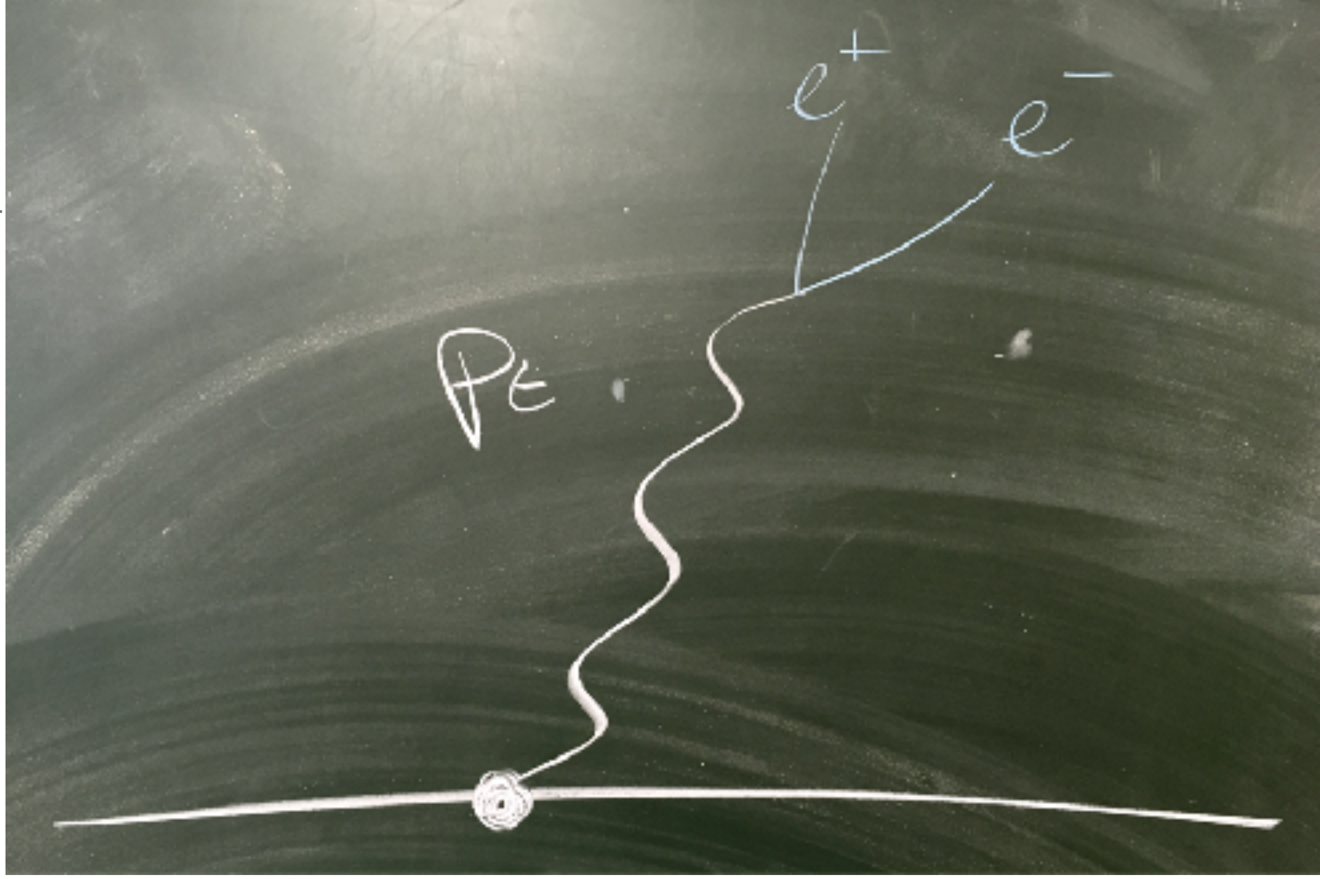
SCALE CHOICES

A SUBJECT WITH NO WIDELY ACCEPTED "RIGHT" ANSWERS, BUT SOME ARGUABLY WRONG ONES. NOT EVERYONE WILL AGREE WITH MY VIEWS…

Gavin Salam, CERN

prepared for ATLAS SM group discussion
4 May 2017

SCALE IN QED



- connected with the allowed range of photon virtualities
- larger allowed virtualities
  → larger "number" of final states
  → larger QED coupling (recall +ve beta-function)
- max virtuality ~ photon p_T
- correct scale ~ photon p_T
- In a "physical" scheme, photon p_T is exactly the right scale

SCALE IN QCD

- it's still connected with the allowed range of gluon virtualities
  - though -ve beta-function means you lose the interpretation in terms of allowed final states.

- When asking "what scale?", you should ask what are the gluon virtualities.

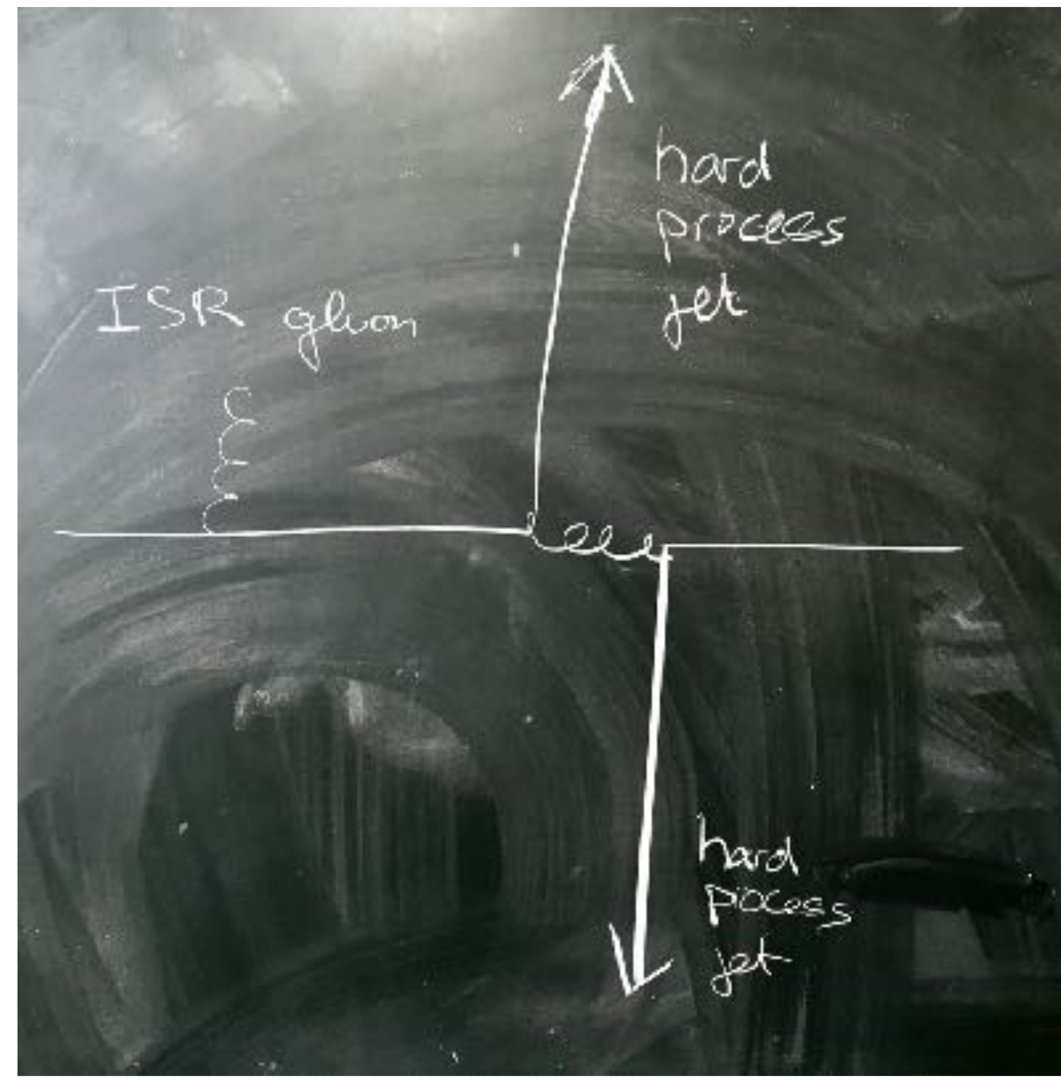
- The MSbar scheme is not a "physical" scheme.
  $\alpha_s(p_T)$ is full probability for emission of a gluon with trans.mom. p_T only in the CMW scheme

$$\alpha_s^{\mathrm{CMW}}(\mu) = \alpha_s^{\overline{MS}}(\mu)\left(1 + K\alpha_s^{\overline{MS}}(\mu) + \ldots\right)$$

$$K = \frac{1}{2\pi}\left[\left(\frac{67}{18} - \frac{\pi^2}{6}\right)C_A - \frac{5}{9}n_f\right] \simeq 0.55$$

FACTORISATION SCALE

- connected with the upper limit of allowed range of ISR p_T
- may not be the same as the virtuality range of the exchanged gluon
- but simplify leads people to choose the same scale for renormalisation and factorisation



MULTI-SCALE PROCESSES — THE MINLO LESSON

- If there is more than one scale in the problem (jets 1&2, v. jet 3), then you **cannot** view this as just a scale-choice problem.
- scales affect "single logarithms"

$$b_0^n \alpha_s^n \ln^n \frac{p_{t3}}{p_{t1}}$$

- and it's inconsistent to fiddle those with these without also addressing Sudakov double logarithms (parametrically larger)

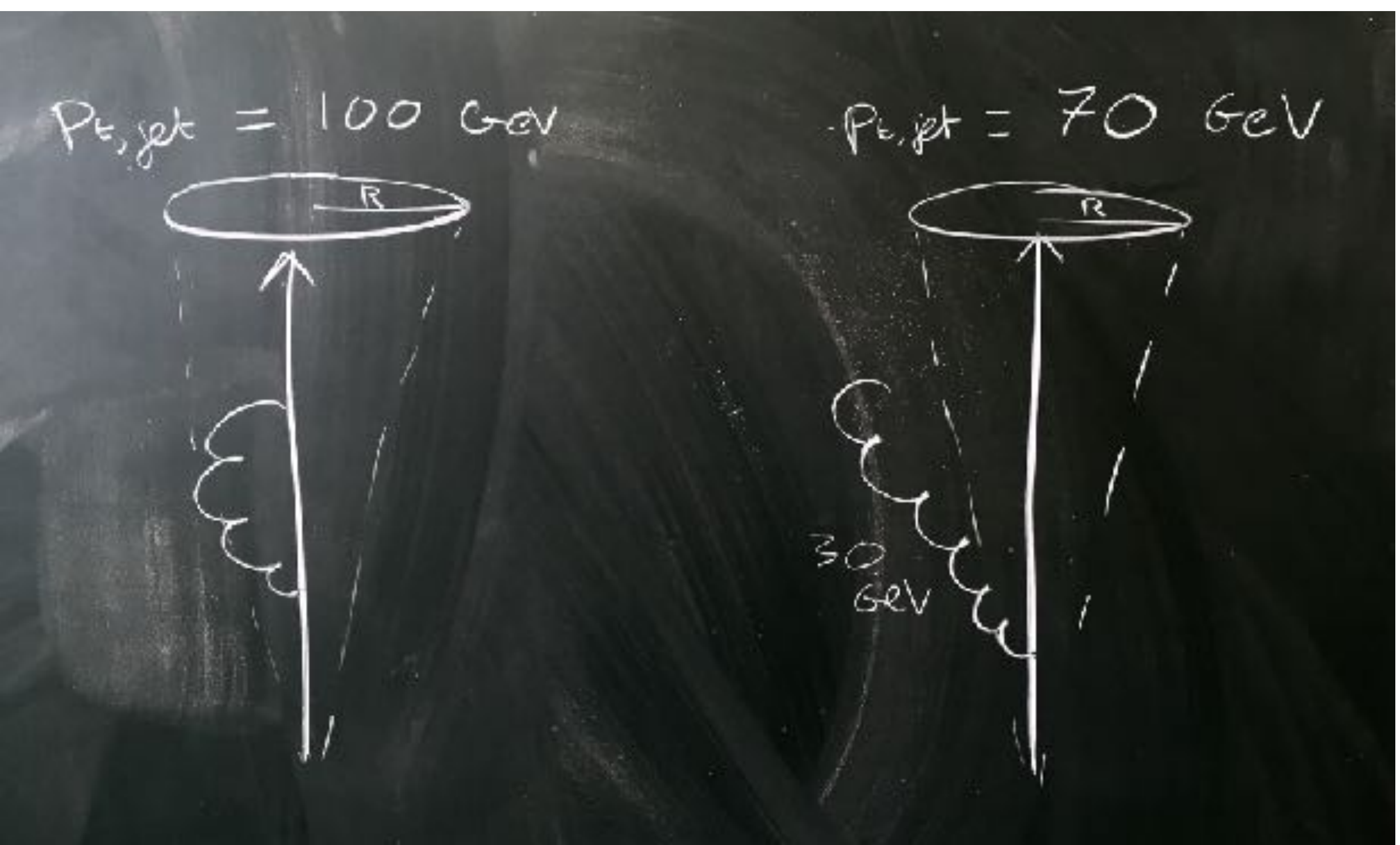
$$\alpha_s^n \ln^{2n} \frac{p_{t3}}{p_{t1}}$$

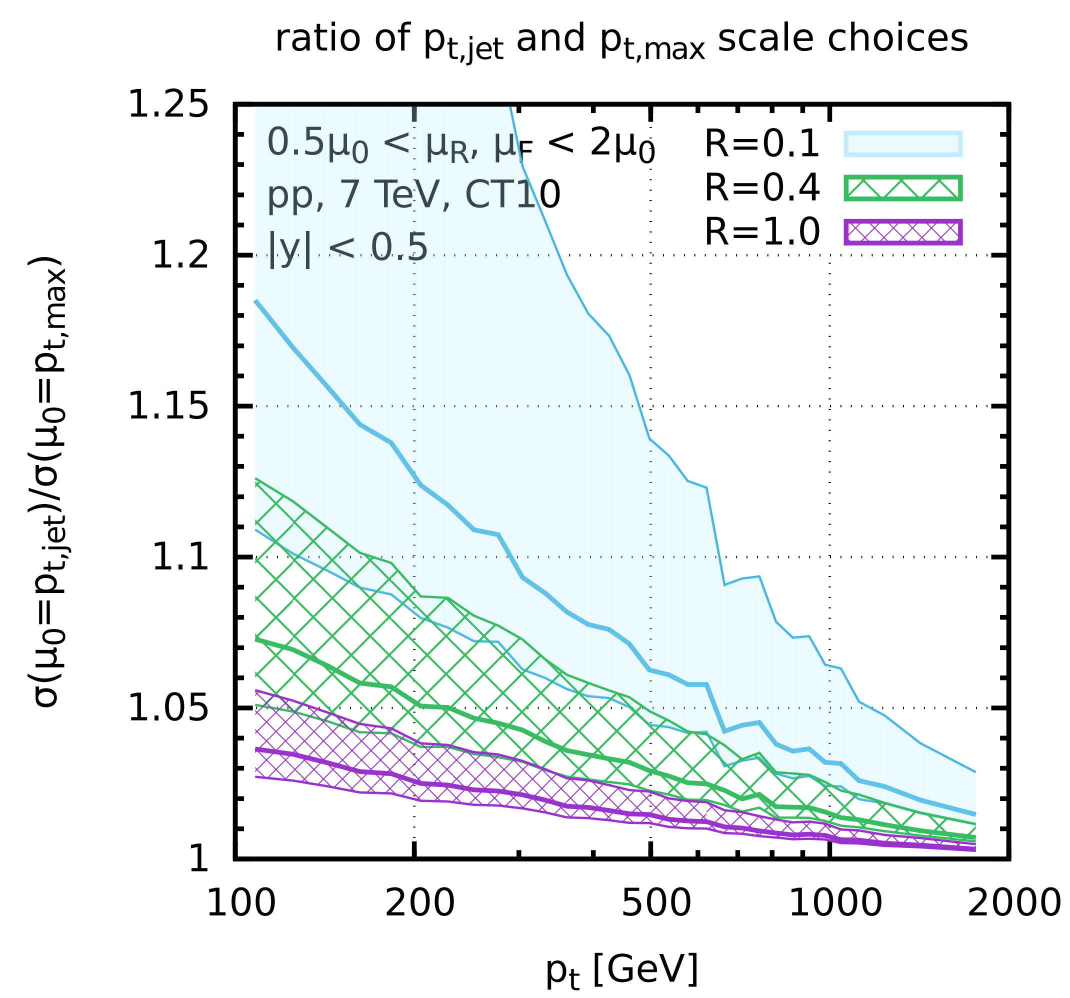
- **My view: design your analysis so it isn't a multiscale problem (e.g. require $p_{t3} > p_{t1}/2$)**

REAL-VIRTUAL CANCELLATION

- Real and virtual infinities are supposed to cancel
- It's quite easy to get artefacts from non-cancellation of nominally finite (but enhanced) parts
- E.g. difference between $p_{t,jet}$ and $p_{t,max}$ gets enhanced by logs of R for small R jets

Dasgupta, Dreyer, GPS, Soyez, 1602.01110





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- **What would I try for dijet topologies? Independently of R used in analysis, the average of the p_t's of the two hardest R=1 jets** [needs adaptation for cases with heavy particles]

CONVERGENCE ILLUSIONS(?)

- A good scale will give good convergence **if** you've understood all the other physics that's going on in your process.
- Adjusting the scale just to get good convergence can lead you to choices that don't make physical sense
- E.g. the following works nicely for large y* dijet systems

$$p_T^{leading\ jet}\ exp(0.3\ y^*)$$

but it doesn't make physical sense because nowhere is there a gluon with virtuality » p_{Tjet} . (Because t-channel dominates)

Instead? I'd check if the negative σ issues seen for large y* (with $\mu = p_{T,jet}$?) disappear with R=1 — then explanation is not scale choice, but R choice

CONCLUSIONS

- Physical principles can help understand what not to do:
  - multi-scale problems need double log resummation, not just some clever scale choice (choose your observable so as not to be multi-scale)
  - looking at real–virtual cancellation may provide a guide
  - think about the virtualities in propagators — if a scale choice is wildly different from those, then it's wrong
- More "experimentation" (i.e. thinking & playing with scales) is probably still needed, especially in light of the NNLO inclusive jet results