Cascade developer meeting

Conferences

- We should have a clear strategy how we deal with talks which cover common results:
  - talk should be given on behalf of the group
  - slides should be circulated well in advance before the talk to allow for feedback
  - proceedings should be written on behalf of group

Status on Z+j paper

- Z+j correlation paper on arXiv: 2204.01528
  - send to EPJC (including references to Z+j TMD calculations)
  - Referee comments received on 29 April

Referee question 1

1) I find it inconvenient when a method is described only by means of references to previous publications (see in particular section 2). In order to help the reader, I would suggest to spend some sentences trying to elucidate more clearly the salient features of the method, and make this section self-contained.

ANSWER:

to be done

Referee question 2

2) Regarding the matching to NLO, for initial-state radiation the MC@NLO method is applied by means of subtraction terms that are conceived for the HERWIG6 shower. Although CASCADE3 and HERWIG6 share the same kind of angular-ordered branching algorithm, in order to be allowed to use the HERWIG6 subtraction terms without spoiling NLO accuracy, one should make sure that the actual first emission in HERWIG6 coincides with that in CASCADE3, including for instance so called dead-zones. Could the authors show that the first emission of CASCADE is identical as that of HERWIG6?

ANSWER:

Armando: Although we can try to show with a plot that the phase space coverage of the PB first radiation reproduces that from HERWIG, I think this is not really necessary if we show explicitly that the formulas used for the radiation kernel are the same. This we should discuss.

Referee question 2

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ANSWER:

We show the pt and eta distribution of the 2,3,4 jet in Z+j NLO using LHE files with H6 subtractions terms. The effect of final state radiation is discussed in the reply to question 3.

The distributions agree within scale uncertainties Moreover the distributions agree within variations of the parton shower cut parameters in H6.

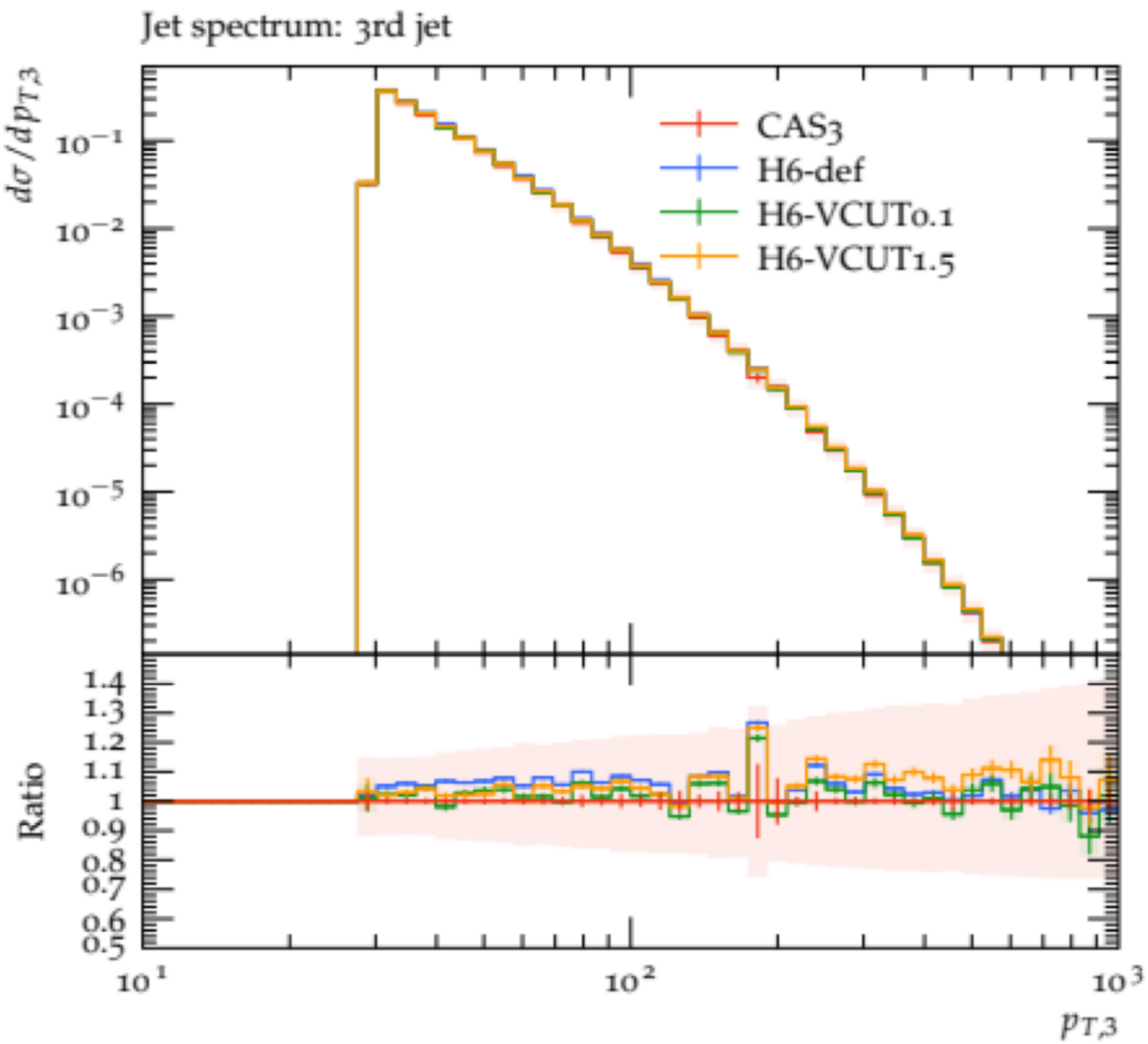
The dead cone plays a role only for low scales: $z_m = 1 - (q_0/q)^2$ since for heavy quarks q0=m_Q, for the high pt jets we are considering here, the dead cone is not important.

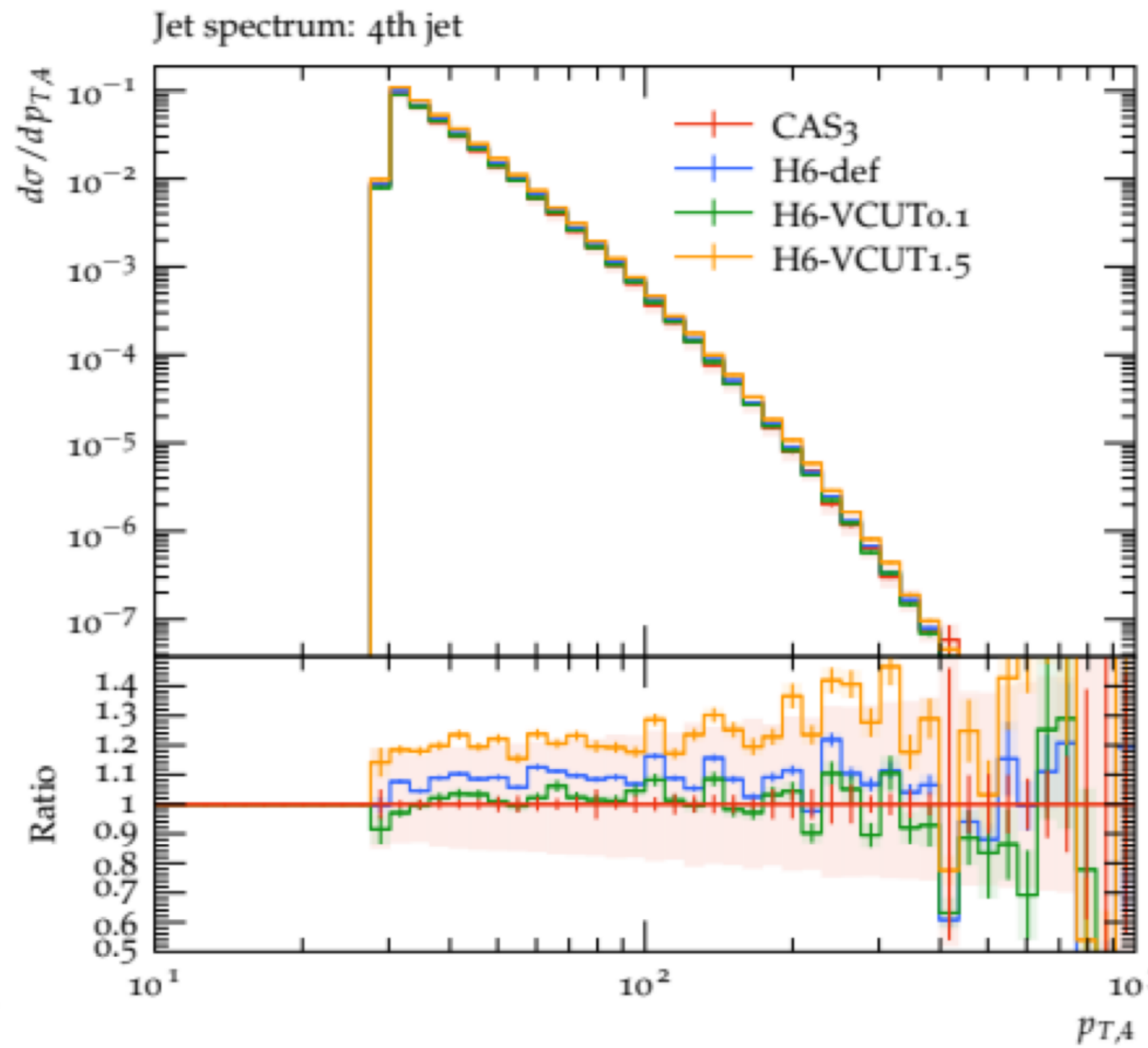
For initial state PS, the evoultion is performed using massless quarks (only a threshold is included), therefor z_m is always large and no dead cone is simulated. In final state PS, a dead cone is included via Pythia6 shower, including mass limits. But the effect is not really visible here.

Full checks: transverse momentum

- Z+j MCatNLO with H6 subtraction terms
  - with H6 ((default, VQCUT=VGCUT=0.1 (1.5))
  - with CAS3

$$z < 1 - Q_i^2/E_i^2$$
$$\text{with } Q_i = m_i + Q_0$$
$$\text{and } Q_0 = \texttt{VQCUT}, \texttt{VGCUT}$$

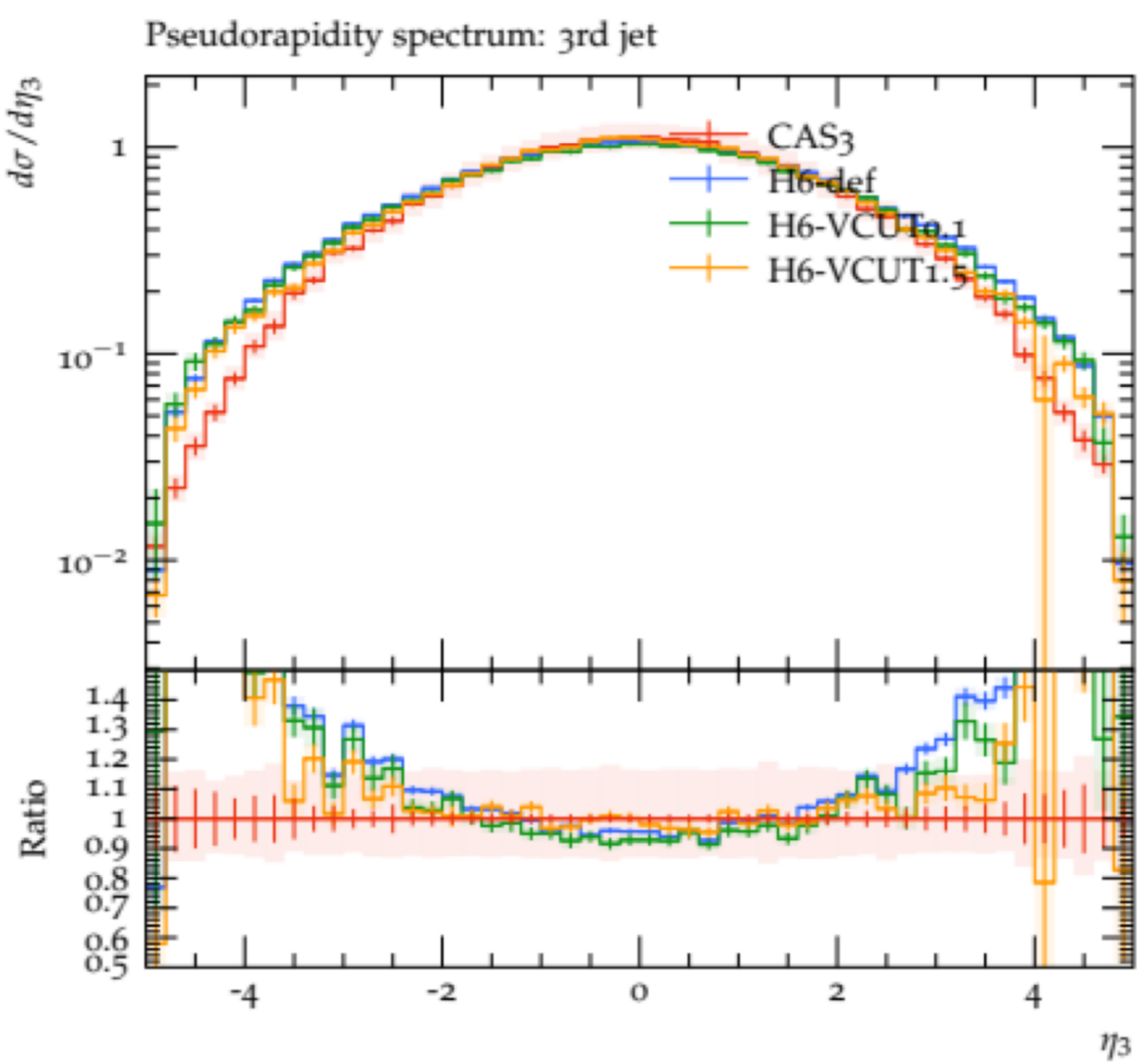


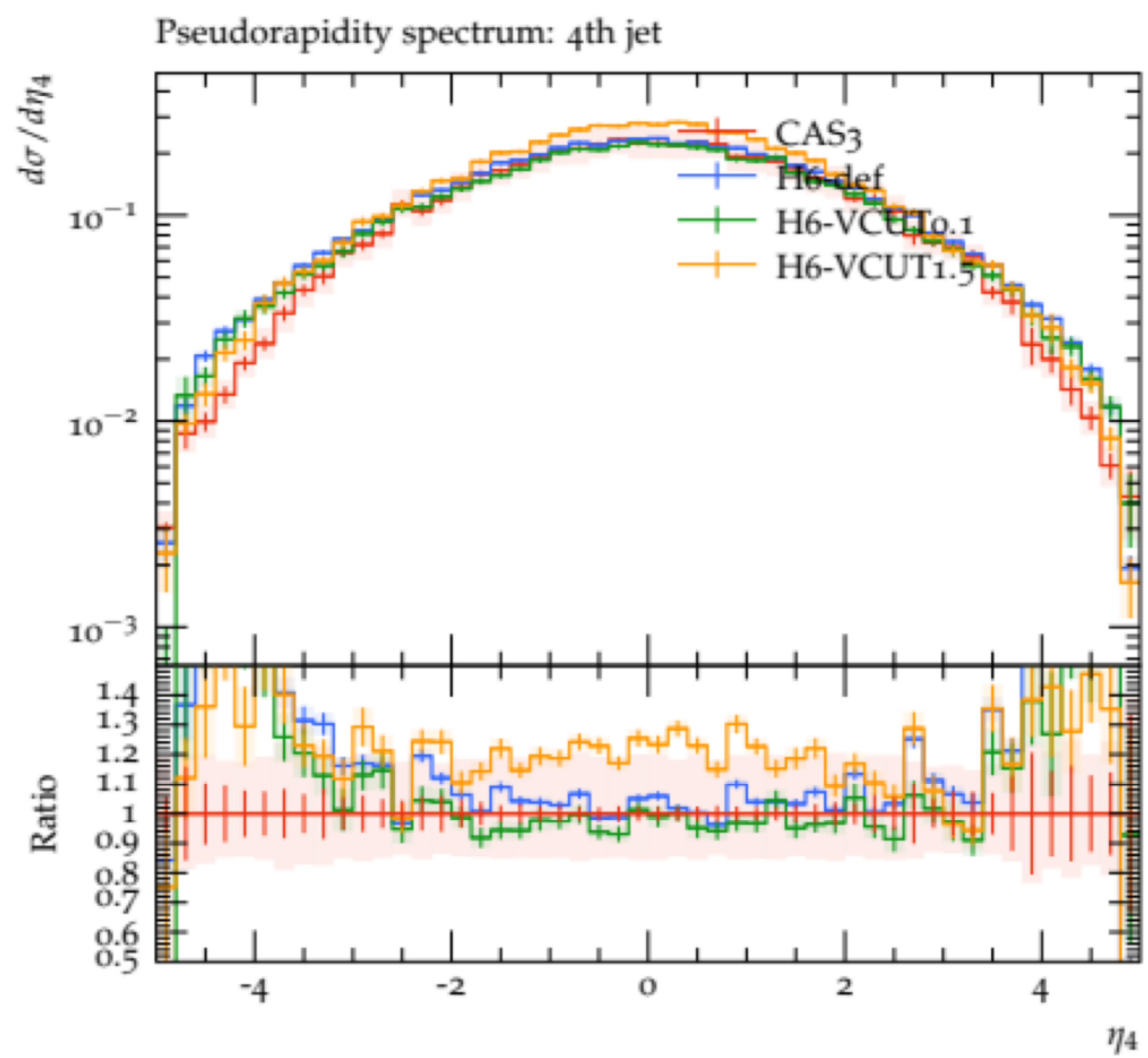


Full checks: jet rapidity

- Z+j MCatNLO with H6 subtraction terms
  - with H6 ((default, VQCUT=VGCUT=0.1 (1.5))
  - with CAS3

$$z < 1 - Q_i^2/E_i^2$$
$$\text{with } Q_i = m_i + Q_0$$
$$\text{and } Q_0 = \texttt{VQCUT}, \texttt{VGCUT}$$





Dead Cone effect

- Dokshitzer, Y. L., Khoze, V. A., and Troian, S. I. (1991). Particle spectra in light and heavy quark jets, J. Phys. G, 17(), 1481
- Dead cone: $\Theta \leq \Theta_0 = m_Q / E_Q$

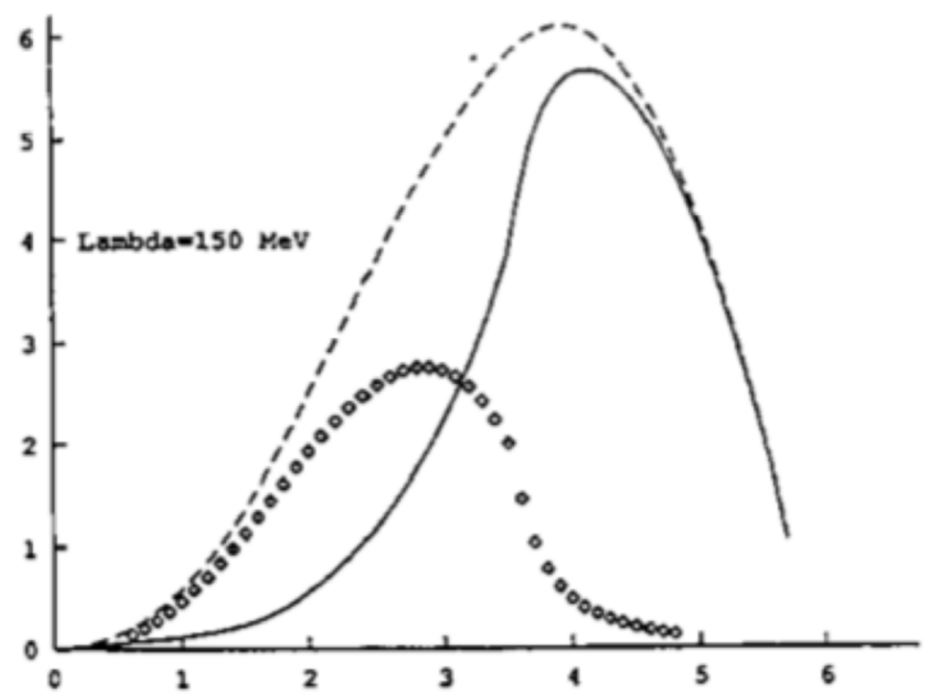
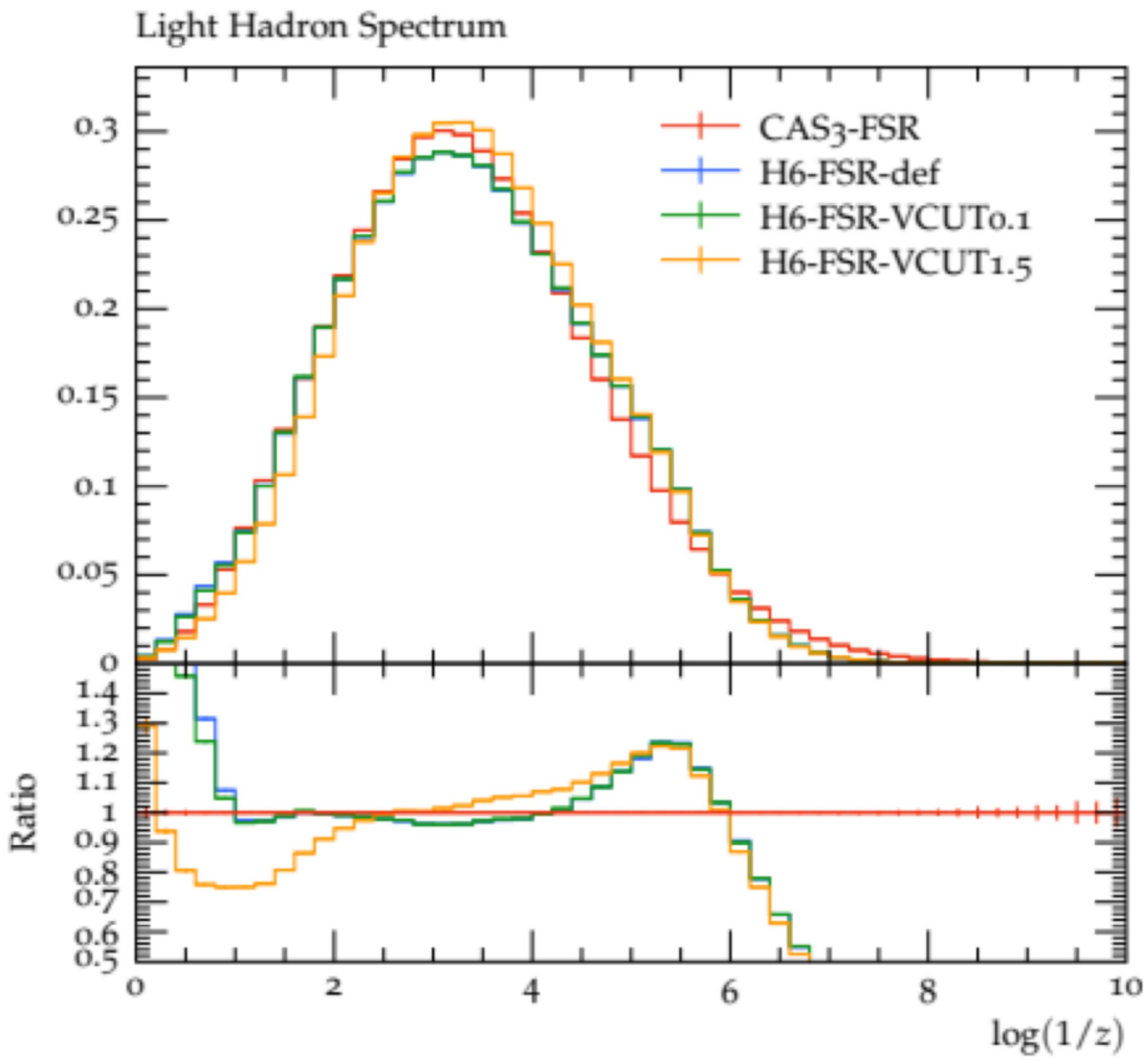


Figure 7. $\ln(1/x)$ spectrum of light hadrons accompanying the $b\bar{b}$ production (m_b =5 GeV) at $W = 2*45$ GeV (full curve) compared with the light-q-jets (broken curves). Points show the 'dead cone' subtraction.

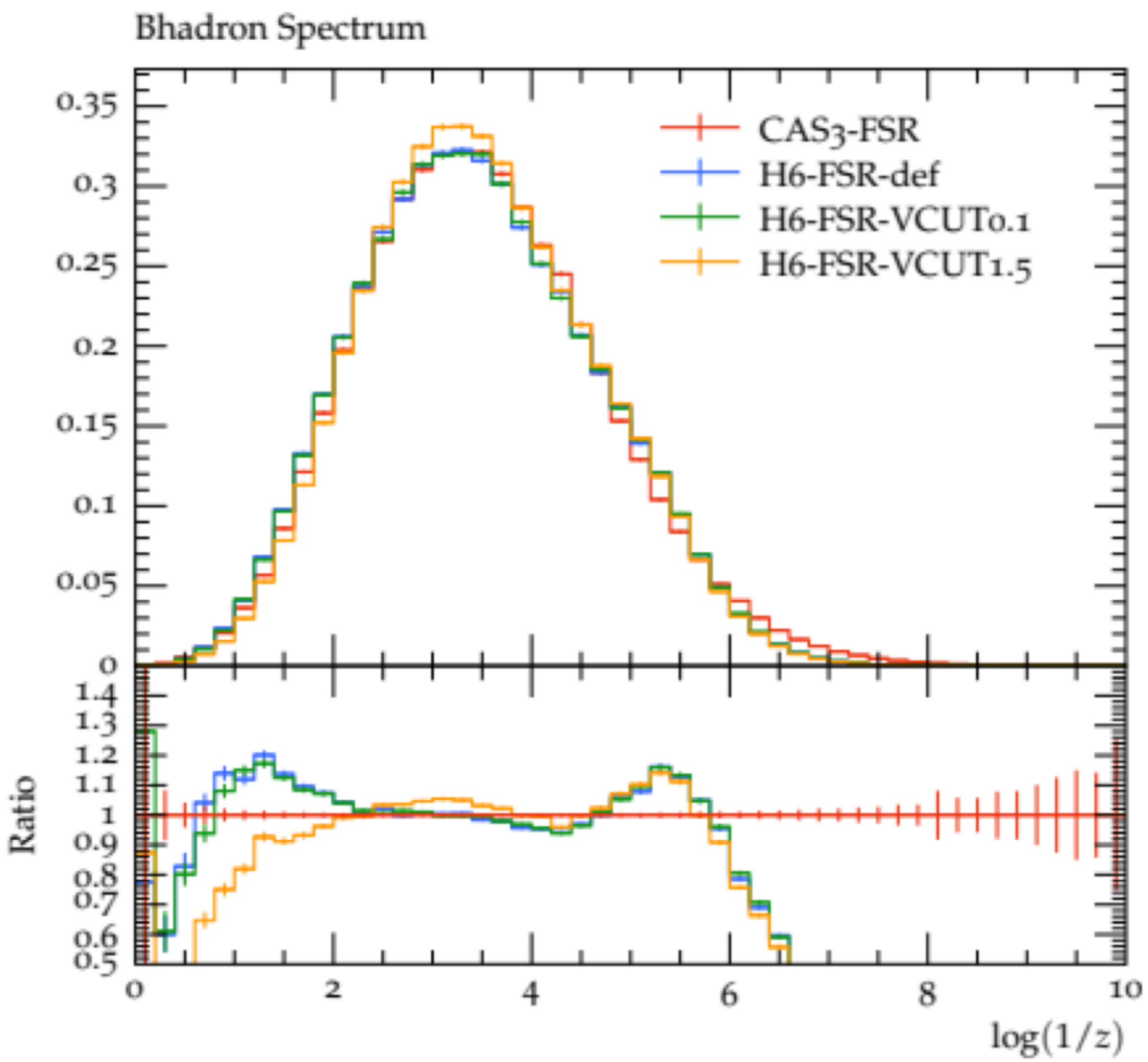
- Investigate energy spectrum of light and heavy quark jets

Light – heavy quark particle spectra

- Light jet spectra

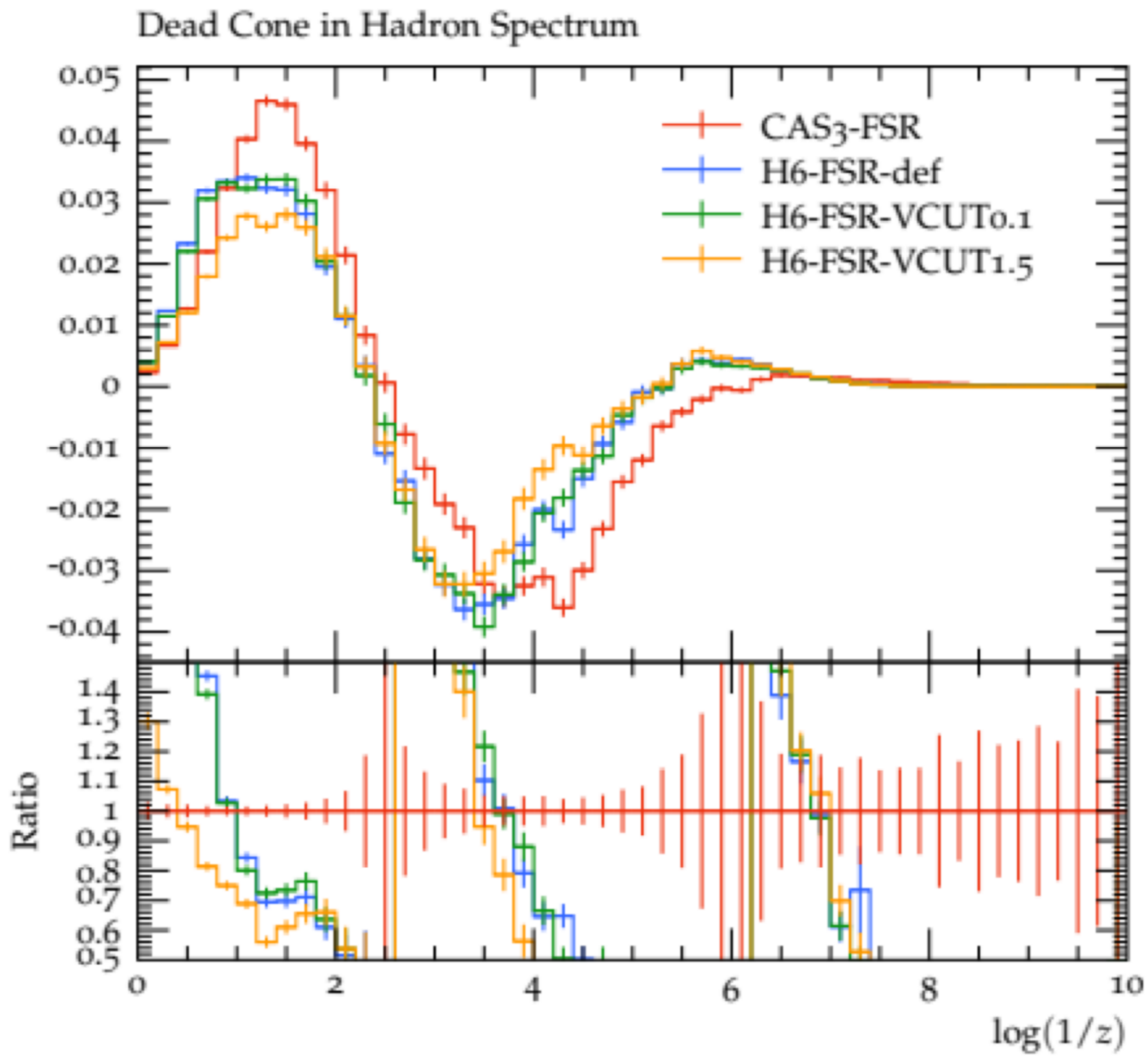


- heavy quark spectra



Dead Cone

- difference of light – heavy quark spectra



- Small effect, similar in CAS3 and H6

Referee question 3

3) Still on the matching, in the CASCADE3 reference [34] one can read that final-state radiation (FSR) is performed using the relevant PYTHIA6 routines. The subtraction terms for the MC@NLO matching should then be the HERWIG6 ones for initial-state radiation (ISR) (assuming CASCADE3 = HERWIG6 in that case), and the PYTHIA6 ones for FSR. Have the authors implemented such a mixed set of subtraction terms, or have they activated special options to this aim in MadGraph5_aMC@NLO?
I urge the authors to discuss this point explicitly in the letter: from the current text, it seems the HERWIG6 subtraction terms are applied to FSR as well, which would spoil NLO accuracy in presence of FSR.

ANSWER:

Armando: This is a more tricky one. It is true that having pythia6 final state shower while using herwig6 subtraction terms is inconsistent, however, the jet is defined with a cone radius of 0.4, so at the observable level it probably does not matter much the systematic error of the different subtraction term for the final state, as this contribution happens mostly in the collinear region which is integrated over in the jet. It is certainly not enough to phrase it in words so one would need to show some plot.

Referee question 3

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I urge the authors to discuss this point explicitly in the letter: from the current text, it seems the HERWIG6 subtraction terms are applied to FSR as well, which would spoil NLO accuracy in presence of FSR.

ANSWER:

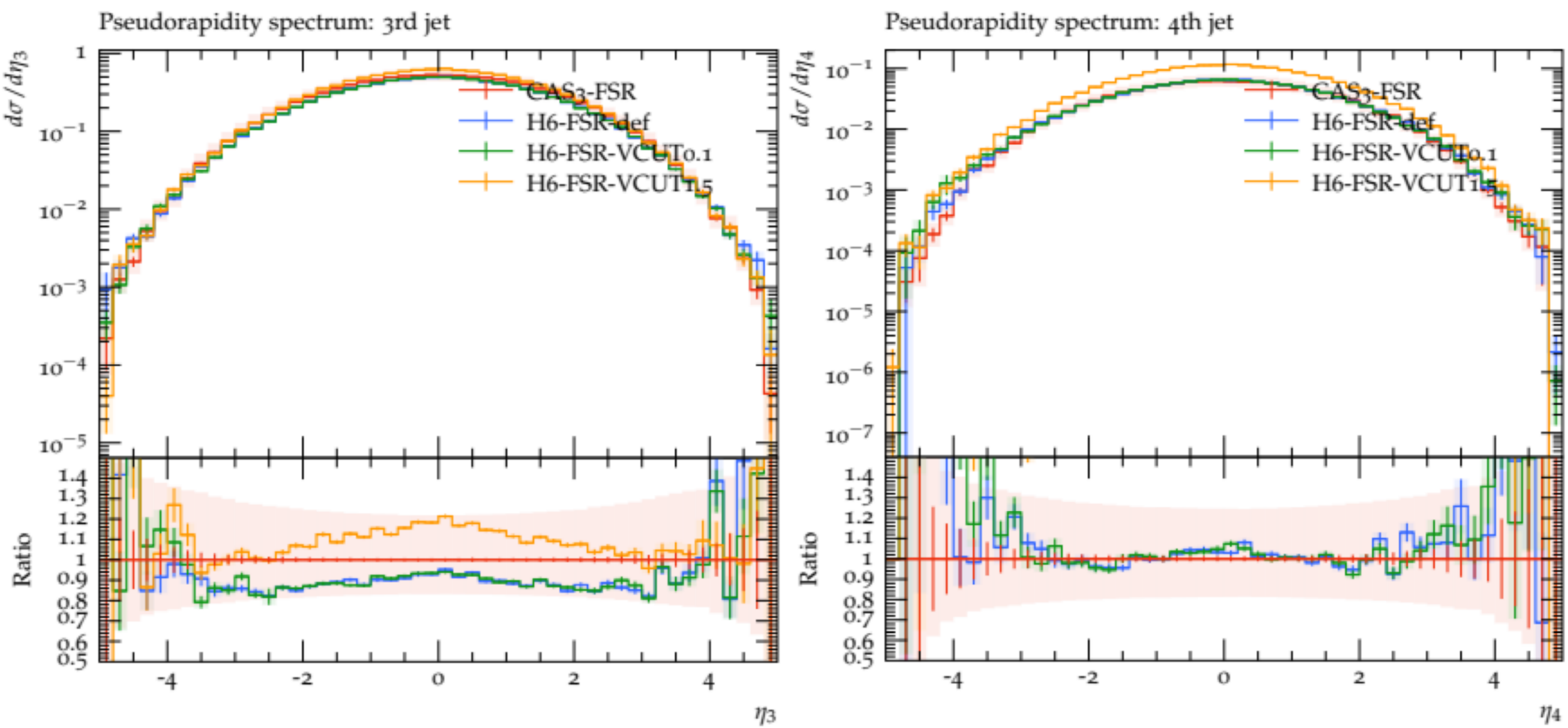
We investigate jet distributions in Z+j NLO (LHE files generated with H6 subtraction terms), where we only allow for final state radiation (which is of course unphysical).

We apply H6 final state radiation and investigate the effect of changing the paramters for $z_m = 1 - (q_0/q)^2$, where q0 depends on the parton masses and a safety parameter (VQCUT and VGCUT) in H6. We vary these parameters and compare predictions to the ones obtained from CASCADE3 (using the Pythia6 final state shower with angular ordering veto).

The distributions agree within scale uncertainties and within the variation of the parameters in H6.

FSR checks: jet rapidity

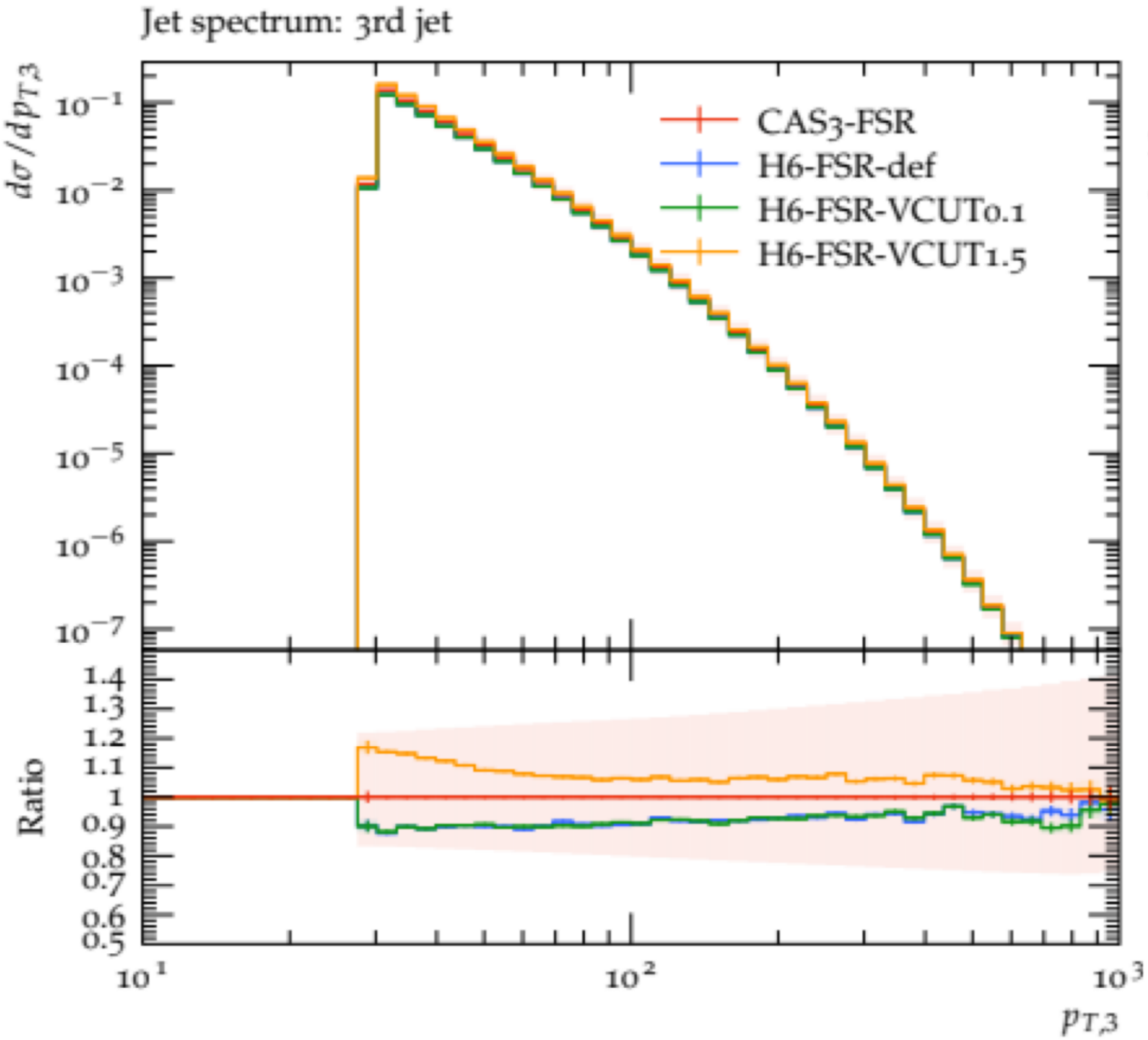
- Z+j MCatNLO with H6 subtraction terms
  - with H6 FSR (default, VQCUT=VGCUT=0.1 (1.5)
  - with CAS (P6) FSR

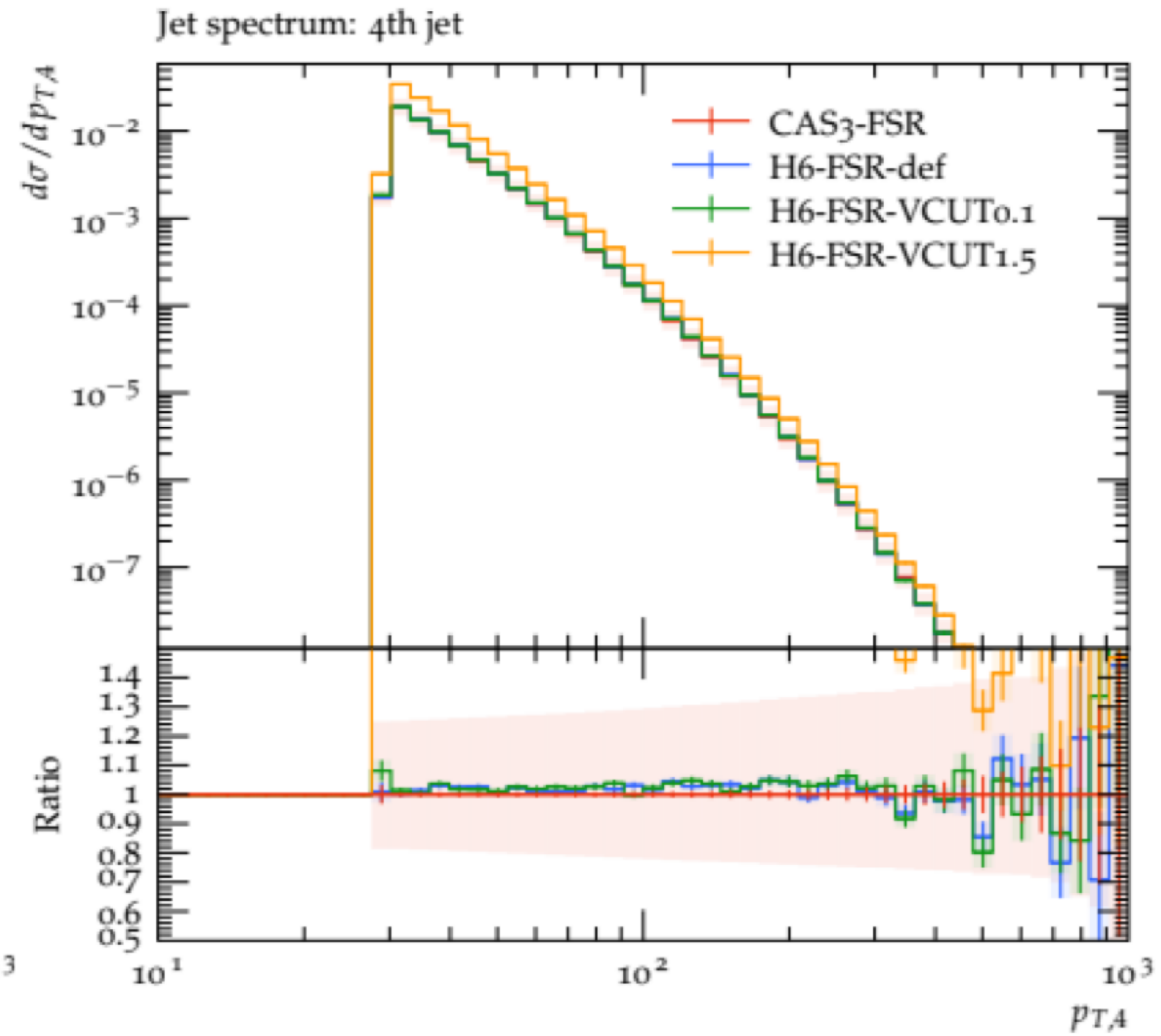


FSR checks: transverse momentum

- Z+j MCatNLO with H6 subtraction terms
  - with H6 FSR (default, VQCUT=VGCUT=0.1 (1.5)
  - with CAS (P6) FSR

The parton showers are terminated as follows. For partons there is a cutoff of the form $Q_i = m_i + Q_0$, where m_i ($i=1,\ldots,6$ for d,u,s,c,b,t) is set by the relevant mass parameter RMASS(i) and Q_0 is set by the quark and gluon virtuality cutoff parameters VQCUT and VGCUT (see section 5). Showering from any parton stops when a value of ξ below Q_i^2/E_i^2 is selected for the next branching. For heavy quarks, the condition $\xi > Q_i^2/E_i^2$ corresponds to the "dead cone" mentioned above.





Referee question 4

4) The dominance of the qq channel over the qg one at pt(leading) > 1 TeV is arguable. From figure 4 this happens almost at 2 TeV for dijet, and beyond the displayed range for Z+j, so I would suggest to rephrase.

ANSWER: The argument is that the qq plays a more important role at high pt

Referee question 5

5) Although the analysis of ISR justifies the stronger correlation at high pt(leading) with respect to low pt(leading), in the letter there seems to be no conclusive argument explaining the similarity between the dijet and Z+j distributions at large DPhi. Could the authors add some statements on this, perhaps before discussing the matching scale?

ANSWER: the point is the gg vrs qq channel

Referee question 6

6) I don't understand the discussion on the interpretation of the matching scale. In pt-ordered showers the matching scale limits the hardness (pt) of the first emission. Being pt-ordered, the subsequent emissions are limited by the first, and in turn by the matching scale. Could the authors clarify why this would be different for angular and pt showers?
I'm also slightly surprised that the matching scale variation is quite smaller for CASCADE3 than for PYTHIA8, as the two tools have NLO+PS accuracy. Given the amount of approximations underlying the method I don't think this is necessarily an indication of enhanced robustness, rather of uncertainty underestimate.

ANSWER:

Armando; I think here the referee does not see that in our case the PS is not responsible for the recoil of the hard system, it is instead the PB-TMD evolution. This means that in collinear approaches changing the matching scale has a big impact on the final recoil observed, while in our case it does not happen. Part of the uncertainty in our case was therefore transferred to the TMD, but we have to remember that the iTMD is subjected to a fit to data == constrain of uncertainties. The collinear showers are unconstrained == larger uncertainty.

Referee question 7

7) It seems the proposed strategy to measure factorisation-breaking effects only uses the high pt(leading) region. How would the measurement at low pt(leading) be used then? Could the authors give some more information on this?
Moreover, for this measurement to be effective, the equality between Dphi distributions at high pt(leading) in Z+jet and dijet should be stable against perturbative corrections, which would be established using more accurate resummation tools and higher fixed orders. Could the authors explain if/why this feature is expected to hold at higher orders as well?

ANSWER:

Armando: We are proposing an experimental measurement/observable to assess differences coming from different long range correlations in two different processes (Z+j and j j). We have a well established framework that takes care of resummation and non-perturbative effects (not long range correlations). So, we use what we have as pseudo-data to show what the method/experiment is giving as result.

AOB

- Further news ?