# Summary of the Topical Workshop on top differential distributions (prior to Top2014)

Cannes, 26-28 Sep 2014

Alexander Mitov

**Cavendish Laboratory** 

UNIVERSITY OF CAMBRIDGE

#### The organizational aspect

- ✓ Talks spread over 3 days (2 full days really):
  - Friday afternoon, Saturday, Sunday morning
- ✓ Plenty of time for discussions; talks to guide the discussions.
- ✓ ~25 participants
- Organizers: Michael Czakon, Juan Rojo and Alexander Mitov
- ✓ All talks available from the webpage:

http://indico.cern.ch/e/top-differential-distributions-2014

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for making the Workshop possible

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### The physics case

- Scope of the workshop: LHC physics of the next few years not just immediate future!
- ✓ We are entering the precision physics stage of top physics but also LHC physics in general
- ✓ What does this mean?
- ✓ The idea of the Workshop is to help synchronize various developments in order to build solid cross-foundation for a culture of precision physics, not just individual bits and pieces. (but we don't want to regulate science! ☺)

# Workshop structure

- ✓ The program was split into several "tracks" that all point into the precision direction
  - ✓ NNLO calculations
  - ✓ Realistic final states
    - NLO with various approximations for treating top decay
    - ✓ Showers
  - ✓ The take of experimentalists
  - ✓ PDF's
  - ✓ Approximate higher order calculations
  - ✓ BSM physics: the cross-talk with top physics

#### The main physics goals

# ✓ QCD related goals:

- ✓ Fixed order fully differential calculations:
  → great, but what about soft/collinear resummation, top decay, shower?
- A major question in QCD is how important are yet higher orders. Top has always been a front runner in perturbative QCD. Compare/validate approximate results with known exact results and draw conclusions.

#### ✓ Examples:

- devise scale setting procedures that work well, even if in the context of a particular observable/final state.
- ✓ sophisticated error estimates, etc.

## The main physics goals

#### ✓ Cross talk:

#### ✓ Experiment:

- What can theory do for experiment?
- How can experiment help theory?
- What experiment really needs from theory?

#### ✓ PDF

- Extraction and validation of pdf sets from top distributions.
- ✓ Is top decay relevant here?
- ✓ BSM physics. A major "potential customer". I think it is still largely unexplored.
- ✓ I hear comments like:

"top uncertainties are a major impediment to setting limits in searches"

Sounds great, but how do we put this to work in a systematic way?

 What should we compute that is of interest (to bSM people) and how the interested (bSM) people know what is computed (or even better – what *can* be computed)?

EW corrections: are they readily available and easy to include in th/exp analyses?

- Computed yes, available not really, in a useful way no.
- Can be redone nowadays, perhaps the only question is how to do that so it is useful to combine with QCD and use in analyses. Feedback welcome.

✓ Ratios 7,8 and 13,14: specific ideas for what to compute and measure. With motivation please..

 Talk by J. Rojo: while x-section agree well (th/exp) but the 8TeV/7TeV ratio is not that good. Is the ratio (and its errors) taken correctly? (Recall M. Czakon's talk today).

✓ The role of top decay: when it matters (much)?

- By now we know well that in the bulk of distributions NWA is good. Tails and other special kinemics regions need special attention (all NLO talks).
  Multi-particle correlations can be affected, too.
- S. Prestel told us that when resonances are decaying beyond NWA, showers can be tricky.
- J. Winter suggested a new variable that might be useful in the context of tt+many jets. So far studied only for W+jets → <u>Need for fully merged NLO samples</u>





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 $\checkmark$  The role of top decay: when it matters much and when not so much (cont.)

• tt+jets: gap fraction (talk by M. Schulze). I'd add here that we should not expect perfect agreement with MC's! Once all is under control the exp/MC can serve as an estimate of non-perturbative corrections form final state interactions. See Mitov, Sterman '12

- M. Worek told us about an exciting new development in FO/shower calculations: • Work towards developing a shower that goes beyond the LL approximation **DEDUCTOR**(Nagy, Soper) + **HELAC-NLO**
- Another potential problem (seen at NNLO level): recoil modeling (P.Nason in TopWG2014). •

 $\checkmark$  Shapes of diff distributions: validate approximations; data is quite precise already.

- Shapes matter very much in searches (F. Blekman)
- Same pointed out by R. Frederix in the context of M<sub>II</sub> distribution
- PDF's (more later) •
- Open question: we now have fiducial x-section measurements; can NNLO differential • distributions (with stable tops) be useful there?

Trans-TeV physics: what is actually needed there? What are the issues?

- One thing I learned is that data and searches go as high as 3TeV (in LHC8) which is well beyond our last NNLO bin (1TeV). How to go about that?
- Role of QCD resummation and EW corrections remains an enigma there (likely to be quite important). Eventually must be carefully studied.
- How well do we distinguish/separate tt from single top? Is this a bottleneck of a sort and what needs to/can be done about it?
  - Not a clear conclusion (recall previous session). Eventually high precision will help.

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- My question regarding BSM: what physics can be done with high precision top physics that cannot be done with, say, Madgraph?
  - Example recent work on stealth stop Czakon, Mitov, Papucci, Ruderman, Weiler '14
    ATLAS '14
  - In top physics we are well equipped to search for deviations from SM, not so much to focus on specific searches.
  - Specific models can be a guidance (talk by J. Santiago) but in my view they are too ambiguous for our current level of precision and sophistication.
- ✓ Did not really talk about top mass there was/is plenty of activity there... Juste, Mantry, Mitov, Penin, Skands, Varnes, Vos, Wimpenny '13 Moch, Weinzierl, Alekhin, Blümlein2, de la Cruz, Dittmaier, Dowling et al '14
  - We can expect qualitative jump here only once we have NNLO differential production with top decay. Until then we should focus on theory biases (measurements are fine).

# ✓ Super fun session on PDF's.

- Interesting problem: NLO x-section from sigma<sub>tot</sub> and sigma<sub>diff</sub> differ substantially (A. Sarkar).
- PDF's might have outsize role in BSM searches at large mass. Top data should help!
- Need absolute normalization of sigma<sub>diff</sub> !
- Ongoing work for fast software between PDF and partonic calculations.
- There are noticeable deviations → between PDF groups in sigma<sub>diff</sub>



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✓ The joy for the theorists was the session on approximate calculations ☺

- Very good discussions and presentations (Papanastasiou, Forte).
- Very nice step in using approx\_NNLO results in a fully differential MC with top decay
- Much better understanding of the nature of NNLO approximations (and beyond)
- From the case of dijets we learned (J. Pires) that dijets and approxNNLO for dijets do not agree well.
- So far no NNLO dijets (or approximate NNLO dijest) in NNLO fits
- One day, when we have both NNLO top and full NNLO dijets we might/should try to understand scale setting at generic kinematics.
- ✓ What we learned from our experimental colleagues?
  - Shapes, shapes, shapes.
  - Trigger might be important is there important physics that might be sensitive to this?
  - The boosted regime becomes important to have under control. Correlates nicely with boosted top techniques but also with precision calculation.
  - Don't stop at 1 TeV; a lot of interesting physics starts at 1.5 TeV ☺
- ✓ BSM physics (F. Blekman, J. Santiago)
  - One important lesson (Santiago): X->tt+Y could not look like a bump at all
  - Not just tt but tt+X rates could be affected seriously by BSM decays

Thank you!