Feedback from discussion on fiducial and particle-level based measurements at the SM@LHC conference

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Introduction

- Fiducial and particle-level based measurements have long history in HEP measurements

- Standardized tools to easily compare measured data to theory predictions (Hztool, Rivet)

- In TopLHC working group past discussion on detailed particle definition
  between the experimentalists and the theorists

- Aim was to arrive at particle-level definitions suitable for NLO-based Monte Carlo generators
  with small model dependence and allowing to reconstruct complex final states
  Results are summarized in this twiki page more recent work just presented by Alberto/Kevin

- Discussion with ATLAS and CMS on particle definitions for Run-II

- In April 2015 this proposal was discussed in a wider community at the SM@LHC conference

- Lively discussion at the start and the end of the conference
  Present experts on QCD, electro-weak physics and top physics

Guiding principles

Presented Guidelines

- Define observable in theoretical safe and unambiguous way
- Measure observables correcting for detector effects minimizing the dependence on the MC model
- Measure within detector acceptance (fiducial region) to avoid model dependent large extrapolations
- Define “truth” objects, e.g. stable particles entering the detector,

  as close as possible to physics objects reconstructed in the detector
- Stay practical: fiducial region only for main effects
- Use operational definitions based on “truth”-objects to define complex observables
- Provide separately corrections to “parton-level” or “total cross-sections” to ease theory comparisons

  and provide a benchmark for future corrections derivation

Comments:

- NNPDF collaboration stressed that corrections to parton-level are needed for their work

- Need more studies on how backgrounds are subtracted from measurement
  provide various levels: total fiducial cross-section, background subtracted
  for measurement where background uncertainties are large.

- Provide tools like Rivet and versioned code (be explicit about MC versions)
  (will be added)

“Total” fiducial cross section with background subtraction

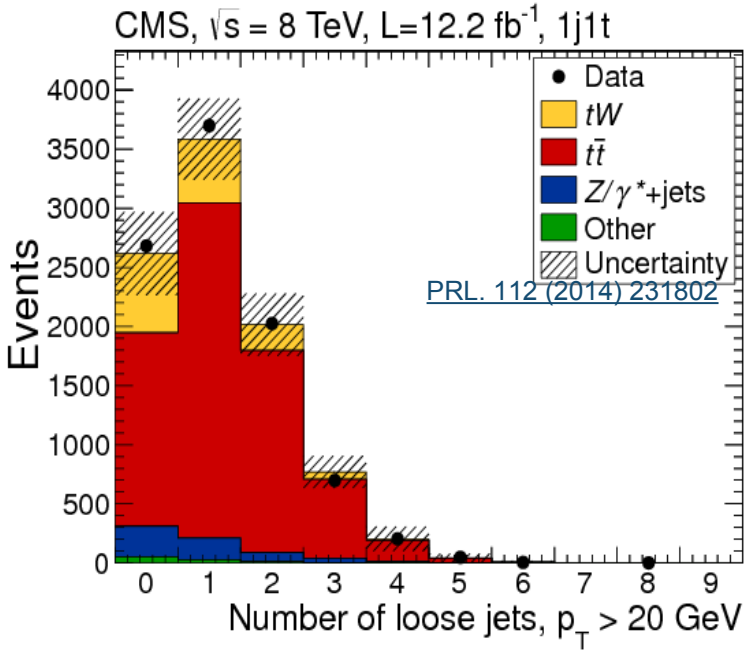
Interesting proposal for measurement with large background with large uncertainties:

Subtract only instrumental background, e.g. fake leptons from multi-jet background

Measure 1) “total” fiducial cross section defined by operational definition (not separated in Sig/Bkg)

2) Fiducial cross section of process of interest, e.g. single top production

Example: Single top tW production



See also similar proposal by R Frederix in TopLHC meeting

Beside theoretical difficulty to draw the line between tW production and ttbar production at NLO
tW analysis has ttbar high background
in low jet multiplicity region (usually not measured)
→ Could measure “partial fractions”
tW/(tW+ttbar) and ttbar/(tW+ttbar)

Experimentally challenging, since acceptance might depend on signal and background fraction

Object definitions - General considerations

TopLHC WG settled on, e.g.
"lepton and photons not from hadron decays" to select leptons from W-decay and
"b-jets associated to B-hadron" etc.

Too much trust in MC record ?

Why not having operational definition like
highest-pt isolated lepton within eta region etc. as in experimental selection
e.g. NNLO W+gamma with gamma->ll Which lepton to take ?

Interesting proposal in the spirit of fiducial definitions, but:
- Stable particle in event record are measurable quantities and agreement data/MC can be quantified
  Therefore it is ok to use detailed definition like "Take the last hadron containing b-quarks in the decay chain"
- Complex topologies like W+gamma->nu lll need operational definitions, does not contradict lepton definition
- Operational definitions for simple objects might decorrelate hard scattering process and particle-definition

Lepton definitions

- General support for “not-from-hadron”
  → needs to be test in more configurations

- Dressed electron generally supported, Born thought to be too much model dependent
  → Dressed leptons are ok for top physics, for precision single lepton measurements
  (at least) corrections to Born should be provided (my opinion)

- For muons some people argued that bare (lepton after QED correction as it appears in event record) is more close to detector (as stated by ALICE)
  → This needs more detailed discussions inside the collaborations with performance group to settle issue

- Need in general more work on isolation:
  “Lepton can be extrapolated, photon more work needed”
  ATLAS and CMS need to be more explicit on isolations in publications
  Support for operational isolation definition

  → Details on isolation given in Rivet routine and with clear definition of physics objects
  → Lepton isolation can be well measured in situ and has therefore correction has small uncertainties
  → Fiducial lepton isolation cut might introduce unnecessary sensitivity to soft physics effects
  → For photon isolation best theoretical definition and what is used currently in experiments does not match

Jet definitions

Use neutrinos as jet inputs ?

- is against fiducial principle to define measurements close to detector objects
- excluding neutrinos will make reconstruction of overall event more difficult
  (parton <-> hadron correlation, reconstruction of jets and Etmiss)
- Best treatment depends on model uncertainty on b-hadron decays with respect to required precision
  Using EVTGEN will reduce uncertainty (discussed in last TopLHC meeting)
  Systematically compare existing measurements, e.g. from e^+e^- and LHC-B
  E_{Tmiss} in b-hadron decays and fragmentation functions

-LHC-B person provided interesting LHC-B publication on B-fragmentation measurement
All these measurement are exclusive reconstructing baryons and mesons (ratios),
for the neutrino issue we need inclusive measurement of E_{Tmiss}

Jet definitions

- Use of jet area method for pile-up subtraction based on event-by-event pt density
  effectively introduces dependence on underlying event (UE) model
  particles from UE are effectively subtracted via the jet area method on detector level
  and added back via detector unfolding, since on particle-level pile up is not included.

More studies needed.

Possible solution is to run jet area method also on particle-level

Folding vs unfolding

Discussion point:
go beyond unfolded cross section and RIVET ? provide analysis code and Delphes simulation and/or folding matrices. Think about input and output for such a framework or analysis with Rivet.

There is a wish in the community that the collaboration provide more data and tools
→ This is a discussion with a much wider scope, e.g. see discussion on data preservation

In my opinion the easiest way is to provide data unfolded for detector effects with data and detailed systematics uncertainty break-down and statistical correlation matrices in HEpData
and provide Rivet routines to calculate the theory predictions.
May be it is limited in scope, but is straight-forward.

Summary

Interesting discussion on particle-definition at SM@LHC conferences.

Hope that this triggered some more thinking.] in wider community.

Definition of the particle-level objects seem to converge.

More studies are needed on complex issues:

- lepton and photon isolation and lepton-jet overlap treatment
- treatment of neutrinos as input to jet and E_{Tmiss}
- best use of jet area pile-up subtraction method for measurements
- operational definition for complex observables (ttbar, ttV, VV, VVV etc.)