Publishing non-interpreted (model-independent) experimental results

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Characterization of New Physics

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I will present personal ideas of the authors, not official policies of the ATLAS & CMS Collaborations.

Overview

- Total *vs.* fiducial cross-sections
- Generated *vs.* reconstructed information
- Model-(in)dependence of experimental results
- Examples of experimental strategies to reduce model-dependence

Total *vs.* fiducial cross-sections

- Fiducial cross-section: partial effective cross-section for given signal topology in a restricted kinematical range
  - largely model-independent: interpretable *a posteriori* with any theoretical calculation
    - first and foremost, experiments should always publish this
    - but knowing true kinematical information is not trivial (next slide)
  - data analyzed but not interpreted
    - provides all the experimental facts but no explicit information about fundamental physics
- Total cross-section
  - experiments first interpret their data for benchmark theoretical models agreed by the community at large
    - also very important but fully model-dependent
  - difficult to re-interpret with other theoretical calculations, including those to come in the future
    - mapping to simplified models aims to address this aspect
    - experiments may publish more total cross-sections on demand
- Both approaches should be pursued

Generated *vs.* reconstructed information

- Preferred way: provide results in terms of *true* information, unfolded from experimental effects
  - true η and p_T corrected for resolution effects
  - leptons before final-state radiation (FSR)
  - jets at hadron level
    - hadron-level implies that theorists use parton shower generators (Pythia, Herwig, *etc.*)
    - parton level also possible but not rigorously defined (not an experimental observable)
  - missing transverse energy of undetectable particles
    - corrected for mis-reconstruction and resolution effects
      - dominated by true missing energy at high values
  - unfolding of involved variables can become complicated
    - for instance: multivariate outputs
- Alternative: publish reconstructed information and provide a public simulation program that can be used to connect to true information
  - see next slide

Public toy simulation of ATLAS & CMS

- Demand for super fast simulators of ATLAS & CMS by non-members
  - only for approximate studies
  - useful when published unfolded data is not available
    - *e.g.* to explore phenomenology at future luminosities
  - better work without big ATLAS/CMS software frameworks
  - high-speed is a real advantage for multi-parameter scans
- Delphes[1] and PGS[2] seem to be popular programs
  - rumor is that Delphes provides decent precision
  - maybe some parametrizations could be officially stamped by the ATLAS & CMS Collaborations?
- Another alternative: ATLAS/CMS could provide a public web interface for generic simulation requests
  - this was done by the DØ[3] and Fermi Collaborations
  - recent proposal: RECAST[4] (see talk by I. Yavin)

1: http://arxiv.org/abs/0903.2225
2: http://www.physics.ucdavis.edu/~conway/research/software/pgs/pgs.html
3: "Quaero", Phys. Rev. Lett. 87, 231801 (2001)
4: http://recast.it/

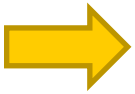
Model-(in)dependence of experimental information (I)

- Largely model-independent:
  - integrated luminosity
  - signal yield in a restricted kinematical region
    - identify and count signal events after some filtering
    - evaluate statistical and systematic uncertainties
  - signal reconstruction efficiency in the restricted kinematical region above
    - derived from control samples and detector simulation
    - constant for each decay topology at first order
      - divide data in binned sub-samples if necessary
    - residual model-dependence at 2^{nd} order:
      - lepton/jet isolation
      - η dependence
      - selection on number of particles (*e.g.* exactly one lepton)
      - multivariate analysis (?)

Sufficient to derive an effective fiducial cross-section

Model-(in)dependence of experimental information (II)

- Fully model-dependent:
  - absolute reconstruction efficiency
    - fraction of events outside the probed kinematical region must be derived from theoretical calculations and Monte-Carlo generators
  - total cross-section including all final states
    - B.F.(observed final-state) x cross-section is measured



Necessary to derive a total cross-section.

Examples of experimental strategies

The residual model-dependence of signal efficiency can be significantly reduced by using adequate analysis strategies.

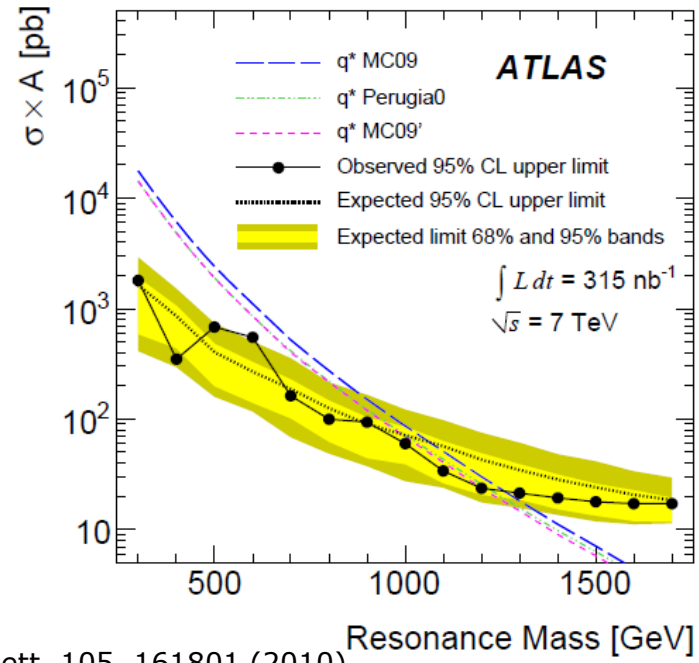
- reconstruction efficiency is not uniform in η
  - better detector performance in barrel than forward regions
  - problem: *generated* η distribution of signal is unknown
  - solutions:
    - apply η-dependent efficiency corrections
    - split dataset in η bins in which the generated distribution is effectively flat
- signal efficiency varies for different topologies
  - relax particle isolation requirements
  - use small jet cone size
  - combine several final states together, for example:
    - if only measuring yield of 1 lepton: $N_{1lep}=80$
      - generated signal can be a mixture of decays to 1,2,n leptons
    - but if measuring: $N_{1lep}=80$, $N_{2lep}=0$, $N_{3lep}=0$
      - then signal clearly comes only from decays to 1 lepton

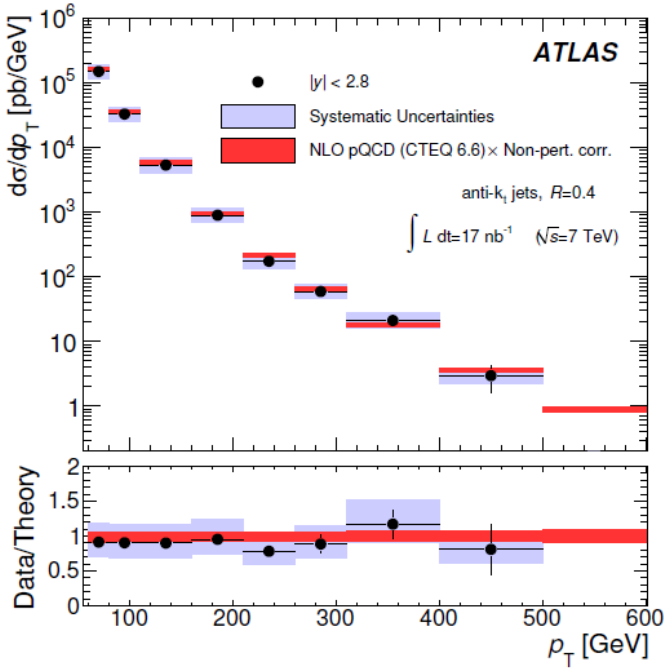
Examples of experimental strategies

- maximize the fraction of signal phase space where good S/B can be obtained
  - keeps measurement sensitive to as much signal models and topologies as possible
  - reduces uncertainty on absolute efficiency
  - use detector information as much as possible rather than cutting on phase space
    - *e.g.* "tight" particle identification, not "loose"
  - work hard to master the backgrounds instead of escaping with excessively tight kinematic cuts
    - even if difficult at background-dominated LHC experiments

Application so far in early measurements

- Selected ATLAS papers
  - model-independent search for dijets resonance[1]
    - published cross-section x signal acceptance
    - acceptance formulated in terms of reconstructed information
  - inclusive jet and dijets cross-section[2]
    - published fiducial cross-section for p_T>60 GeV and |y|<2.8
    - simple reco→true correction of jet p_T





1: Phys. Rev. Lett. 105, 161801 (2010)
2: http://arxiv.org/abs/1009.5908

Conclusions

- Factorize experimental results from their theoretical interpretation
  - publish new physics limits or observation in terms of model-independent fiducial cross-sections
    - interpretable with any calculation *a posteriori*
  - also publish total cross-sections for chosen models
- Factorize expertises/work of experimentalists and theorists
  - use unfolding algorithms to provide experimental results in terms of generated (*true*) information
  - alternatives (formulate theory in terms of reconstructed info):
    - ATLAS & CMS provide toy simulation programs that theorists use
    - ATLAS & CMS fulfill requests for simulating new models themselves