

Experimental Challenges: Raising a few issues for discussion

Xabier Cid, Universidade de Santiago de Compostela

Monica D'Onfrio, University of Liverpool

Keith Ulmer, University of Colorado

WG3 Experimental Conveners

Introduction

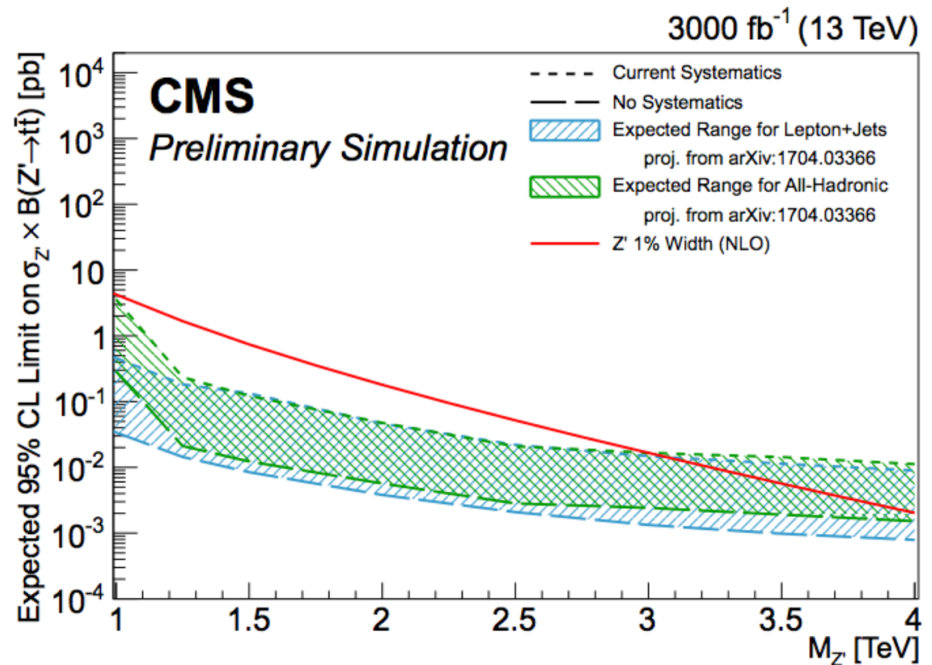
- ◆ Projections for HL-LHC and (especially) HE-LHC are inherently theoretical endeavors—we don't have the data yet...
- ◆ But these will eventually become experimental measurements, and there are real experimental inputs to make the projections realistic
- ◆ We'd like to discuss here some of these issues, along with potential commonalities to help facilitate useful projections

How to do projections

- ◆ The simplest thing is to extrapolate from current results
 - ◆ Can capture the statistical uncertainties well
 - ◆ Must make assumptions about systematic uncertainties

- ◆ Example: $t\bar{t}$ resonance search

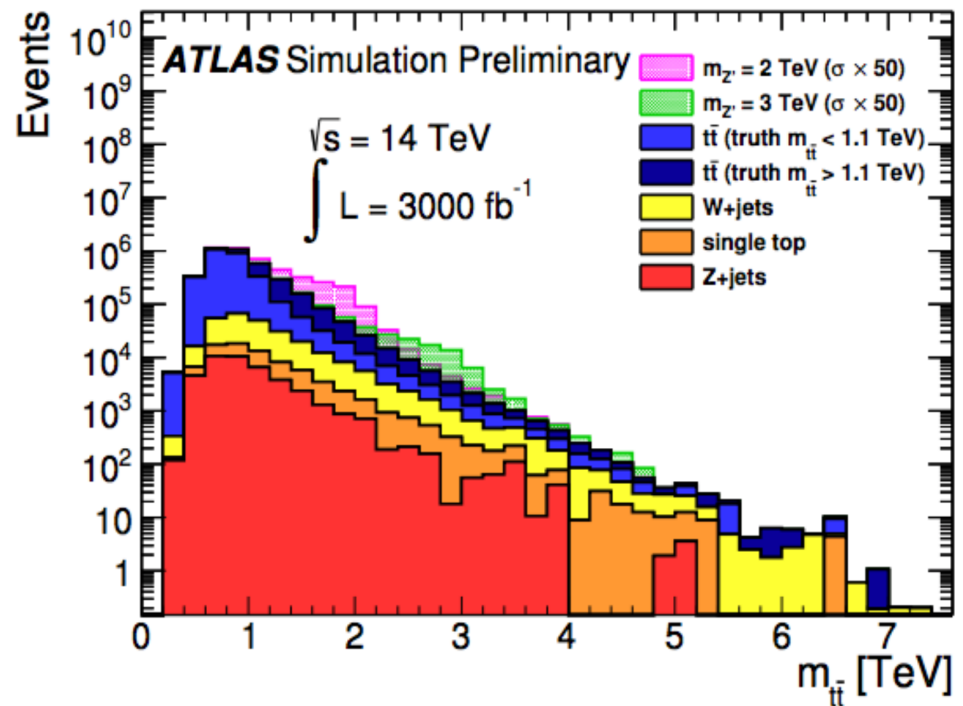
- ◆ Uses exact simulation and event selection as 13 TeV search
- ◆ Scale signal and SM cross sections up to 14 TeV and yields up to 3000 fb^{-1}
- ◆ Present multiple scenarios for size of projected systematic uncertainties



CMS-FTR-16-005

A more precise alternative

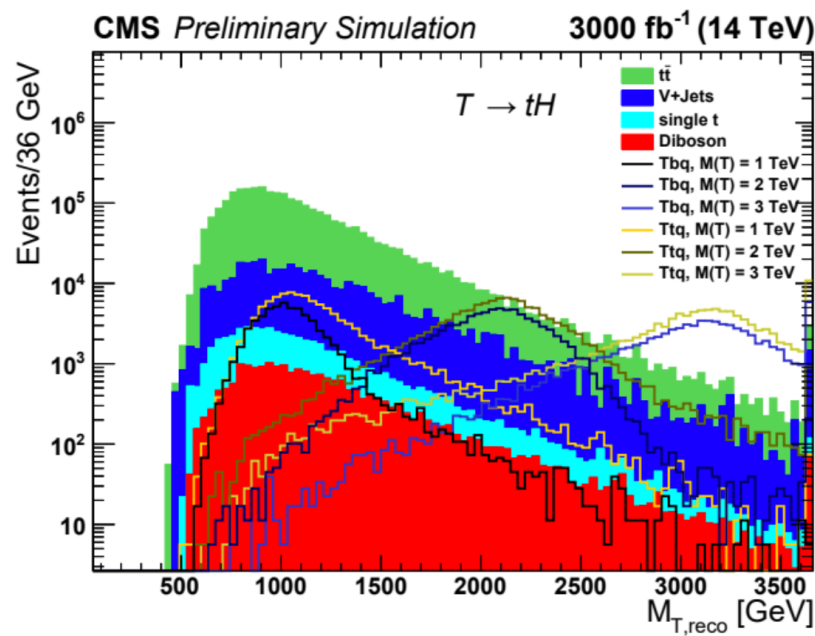
- ◆ Smear generator-level objects to emulate resolutions
 - ◆ Common choice within ATLAS
- ◆ Determine parameterized resolution functions from GEANT4 simulation of Phase 2 detector
- ◆ Better suited to future detector performance (HL-LHC)
- ◆ Example: $t\bar{t}$ resonance search
 - ◆ 14 TeV signal and SM events generated, but not simulated
 - ◆ Allows application of common resolution functions to broad range of physics cases



ATL-PHYS-PUB-2017-002
Boosted muon channel

Another more precise alternative

- ◆ Use DELPHES to simulate Phase 2 detector
 - ◆ Common choice within CMS
- ◆ Clearly, much better suited to future detector performance (HL-LHC)
- ◆ More computational work since simulation must be run for each search
- ◆ Example: Search for high mass tH resonance
 - ◆ Use jet resolutions from realistic event reconstruction (Particle Flow) and PU rejection (PUPPI)
 - ◆ Account for extended acceptance in e/μ



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Projection vs Analysis

- ◆ (Probably obviously) the more detailed the analysis, the better the sensitivity projection
 - ◆ Some relatively simple cases driven by statistics, known backgrounds, and systematic uncertainties can get away with a straightforward projection
 - ◆ Other cases require a more fully dedicated study, which obviously requires a bigger investment from analyzers
 - ◆ Details of updated detectors, dedicated selection requirements to adapt to higher lumi/energy, complex object reconstruction in high PU environment
 - ◆ Worth discussing here which classes of searches fall in each category to ensure we arrive at robust results (without unneeded complication and wasted time)
- ◆ A caveat: any future sensitivity study done now will not fully account for the creativity and innovation of the next ten years. We should be careful not to undersell our potential.

Modeling Rare Backgrounds

- ◆ Certain backgrounds may be negligible for current searches, but become relevant for HL and/or HE. How do we handle these? Are SM predictions good enough to know when each is relevant?
 - ◆ Multi-boson production (2, 3, 4, ...)
 - ◆ Multi-top production
 - ◆ V+many jets
 - ◆ Others...

How to be efficient

- ◆ There are many people working on these studies, but there are clearly more possible topics to study than people
- ◆ Can we as a working group come up with ways to be more efficient?
 - ◆ Common tools
 - ◆ Common signal benchmarks
 - ◆ Complementarity across experiments
 - ◆ Complementary strategies for generating and simulating many, many events at high PU
 - ◆ Coherency between experiments and between experiment and theory
 - ◆ We plan to provide a Delphes Card to represent an HL-LHC detector as an easy option for realistic detector effects
 - ◆ ...