Session 2: Tools & MC
BSM modelling and interpretation: summary

Conveners:
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Les Houches BSM, 28 June 2019

BSM tools ~~& MC~~

❖ As predicted, activity focused on application and refinement of tools… not really BSM MC, since toolchain is very mature

❖ Main project areas:
  ➢ Using public bin-correlation data
  ➢ ~First search+measurement combinations
  ➢ Recasting folded dilepton search (interference)
  ➢ Identifying best signal region combinations
  ➢ Comparing recast toolkits (LH2017 lives!)
 ➢ Plotting ~~world domination~~ a common analysis framework

+ LLP and analysis language status discussions
+ reinterpretation status review: Overleaf link
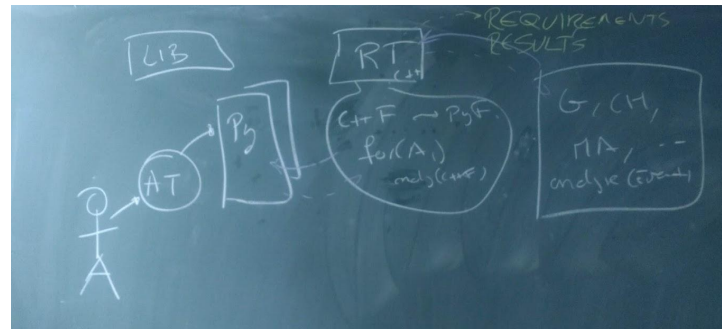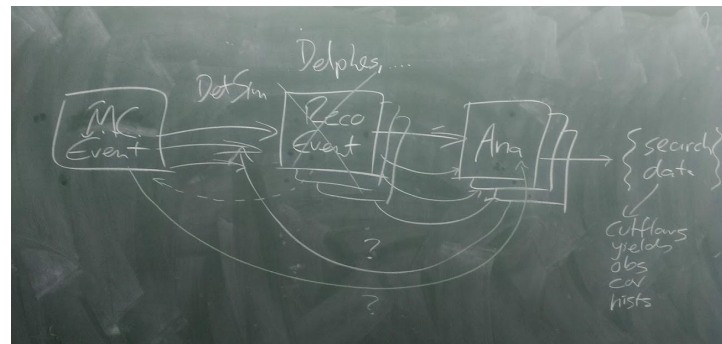
Building & using likelihoods

❖ Second-order (i.e. covariance) likelihood correlations available for many analyses ⇒ measurements *and* searches

❖ Now learning to use them efficiently

❖ HepData & Rivet data format enhanced to pass info: now used "automatically" by Contur:

❖ Gambit also learning: likelihood profiling for better convergence, SL analytics → better guesses:

❖ Populating SRs also problematic: discussions on dynamic aggregation, fit regularisation, MC biasing

Buckley, Butterworth, Corpe, Kvellestad, Waltenberger, Yallup

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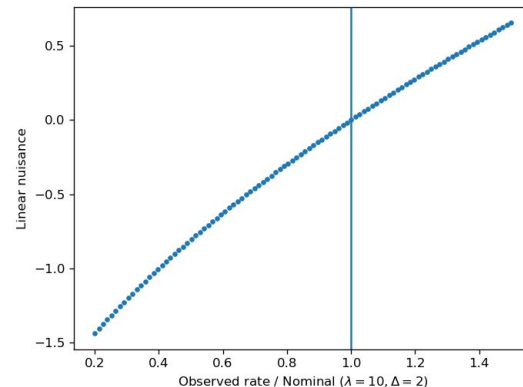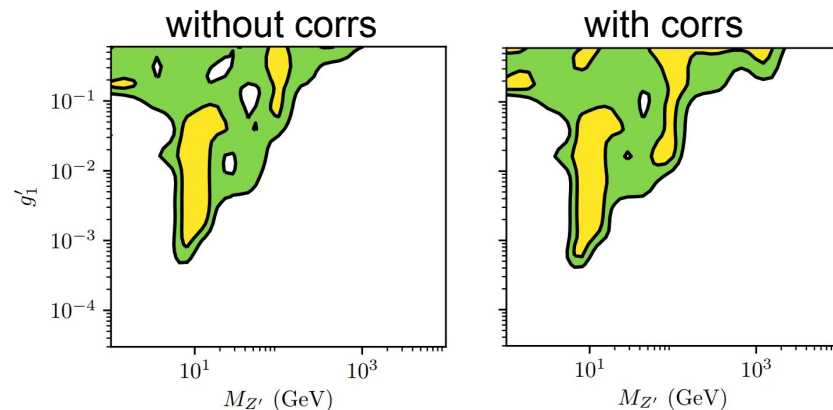
BSM limits from "SM" measurements

❖ **Again a lot of interest in testing BSM models vs the Rivet/Contur measurement collection**

❖ Testing vs. light pseudoscalar

❖ h→WW apparent sensitivity to 2HDM+pseudoscalar DM model flagged b-tag veto issues. Still learning details about how to make analyses interpretable

❖ Correlations set to make many changes… with care

❖ More studies ongoing: tttt, compressed SUSY, …

Butterworth, Kar, Pani, Van Beekveld, Yallup, …
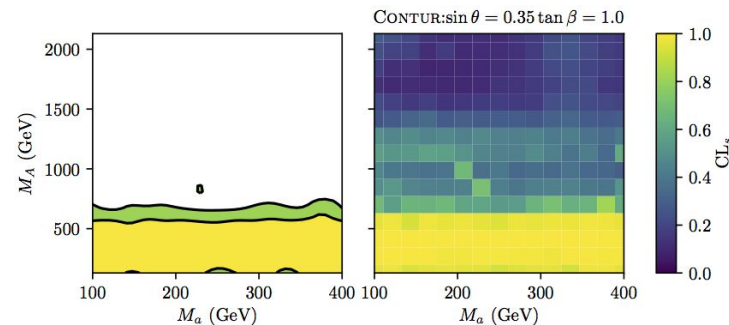
With CMS H → WW (above) and without (below), though other analyses may have same issue
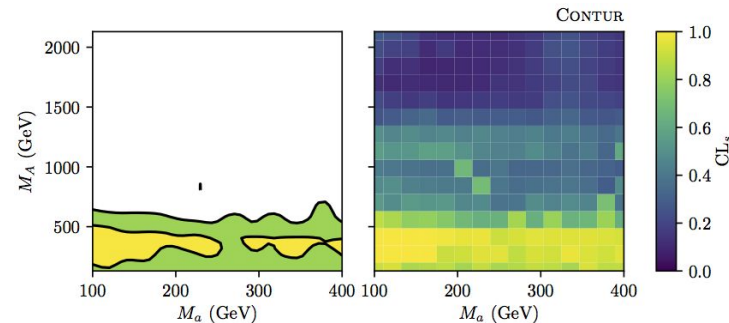
Search/measurement combination

❖ **First steps to combine search results (and control data) with measurements in Contur likelihoods**

❖ **ATLAS 3/fb 0-lepton jet+MET SUSY** (HepData)
7 SRs, and differential m_{eff} data for each!
Try 100% corr systematics, vs. unfolded MET+jets

0L+MET search   J+MET measurement
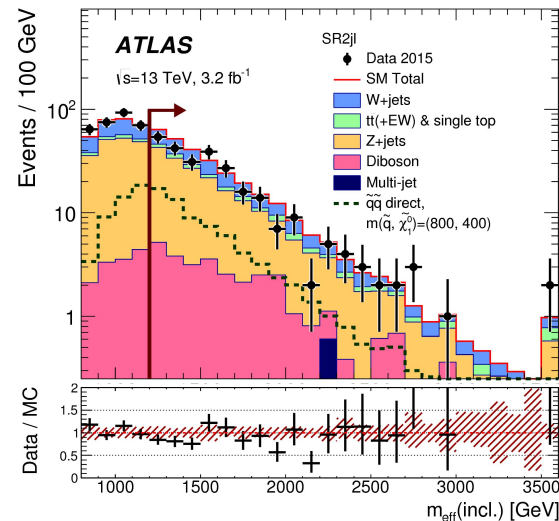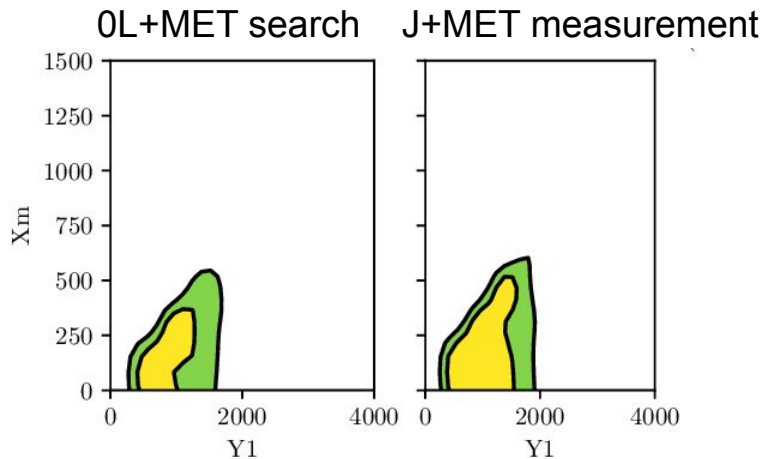
❖ Compatible reach to measurement.
Update to 36/fb measurement.
How about some corr data, ATLAS? 😉

Buckley, Butterworth, Corpe, Yallup

Search/measurement complementarity

Parameter	#5 Best fit	#6 Heavy winos
$M_1(Q)$	−69.1 GeV	89.6 GeV
$M_2(Q)$	162.8 GeV	348.0 GeV
$\mu(Q)$	281.7 GeV	−173.2 GeV
$\tan\beta(m_Z)$	52.7	30.0
$m_{\tilde\chi_1^0}$	67.3 GeV	83.2 GeV
$m_{\tilde\chi_2^0}$	158.9 GeV	174.7 GeV
$m_{\tilde\chi_3^0}$	299.0 GeV	188.9 GeV
$m_{\tilde\chi_4^0}$	315.7 GeV	392.4 GeV
$m_{\tilde\chi_1^\pm}$	159.4 GeV	171.3 GeV
$m_{\tilde\chi_2^\pm}$	319.5 GeV	392.8 GeV

- Testing two benchmark points from GAMBIT EW-MSSM fit vs CONTUR measurements, and also some minimally-fine-tuned scenarios from arXiv:1906.10706

- Low-mass EWinos & large mass splittings → enhanced production of on-shell gauge bosons
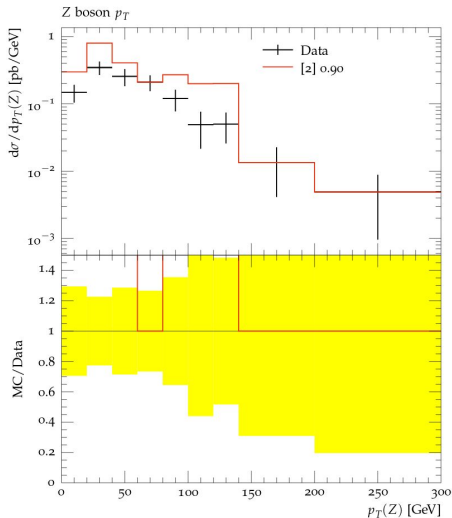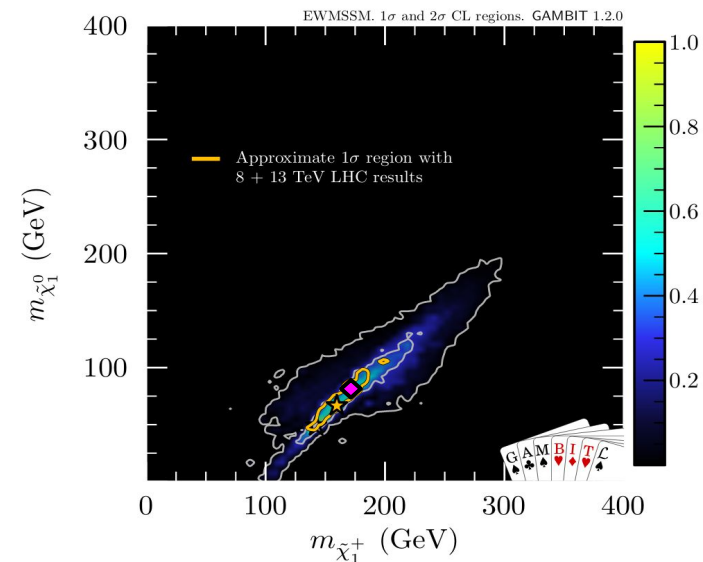
- Looks like measurements *can* constrain the param region preferred by the search results

- Motivates connecting CONTUR to GAMBIT for global fits. Work started…

Dilepton mass spectrum reinterpretation

❖ **No 13 TeV DY yet: gap in current measurement reach wrt searches**

❖ But ATLAS 13 TeV full 140/fb dilepton resonance search publishes fine-binned mass spectra and detailed smearing info

❖ Rivet code written: analysis simple, smearing functions less so! Feedback 😃

❖ Planned: use in Contur LQ/TFHM limits, and study of limit sensitivity enhancement via the interference dip

Di-muon mass spectrum

Bai, Buckley, Hrynova, Murray, Ruiz, Yallup
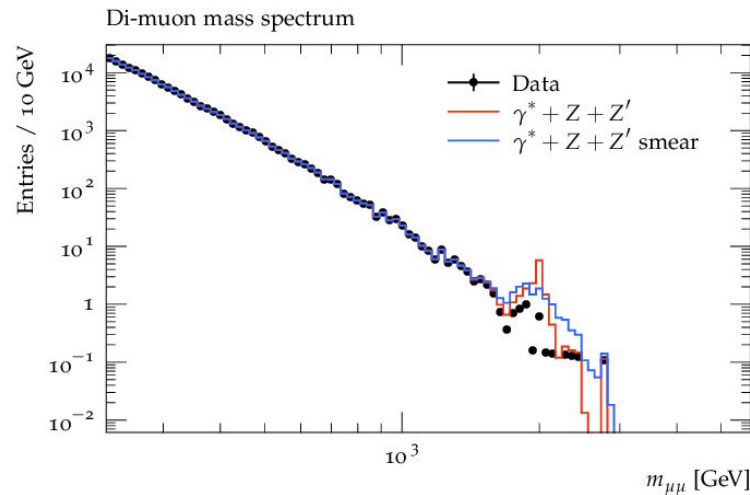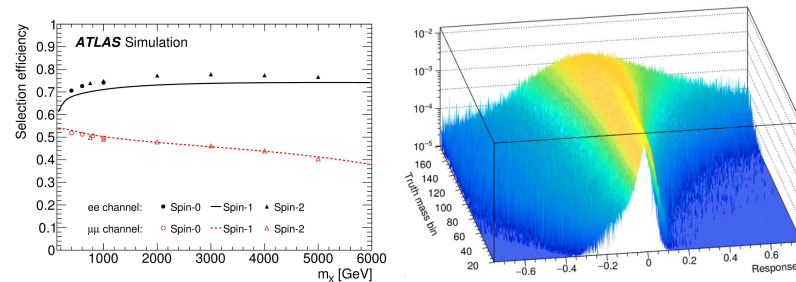
Analysis orthogonality

How much do searches overlap? Hard to determine at scale → try statistical approach

❖ **SModels**
→ Mass ranges for topologies in all SRs

❖ **MA5**
→ hacked v1.8 to provide per-event SR-fill info

❖ **Bootstrap method**
→ SR correlations

Buckley, Fuks, Kraml, Lessa, Reyes-Gonzalez, Waltenberger, Williamson
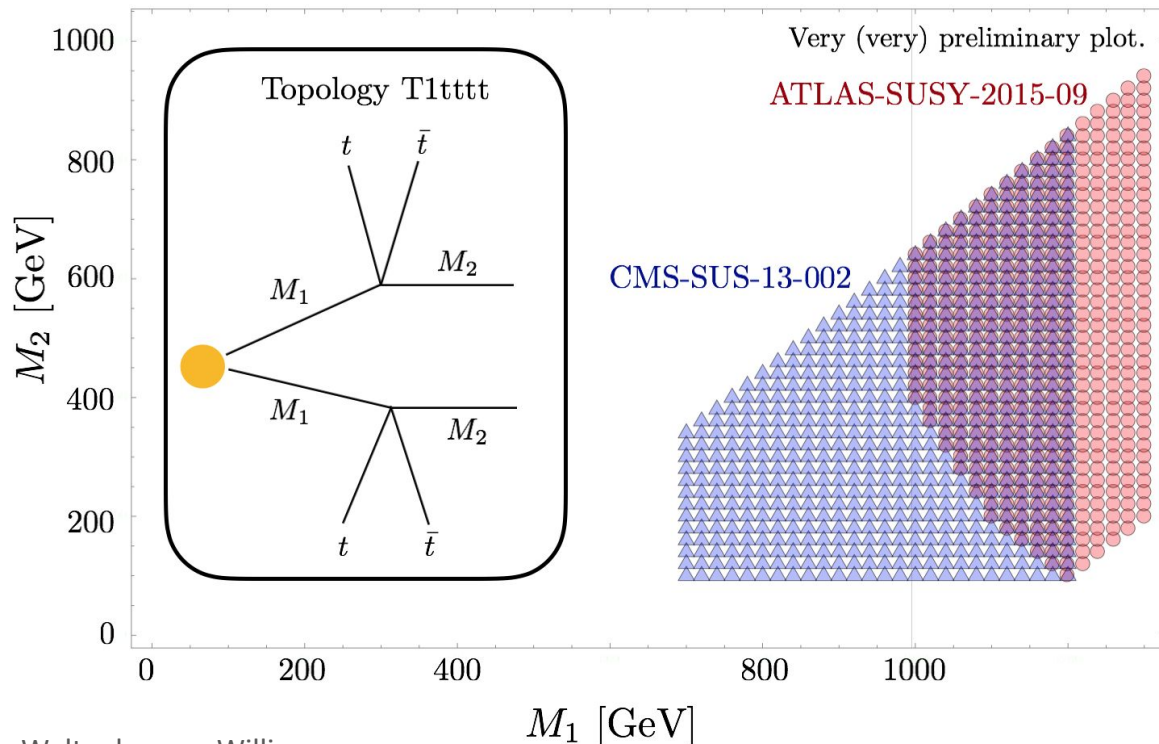
Collider recast framework comparisons

❖ **Aim:** verify tool approaches equally valid; inform future developments...

❖ MA5, CheckMATE, Gambit, Rivet, ADL

❖ Comparison on CMS SUS-16-048 paper
Soft leptons → custom efficiencies

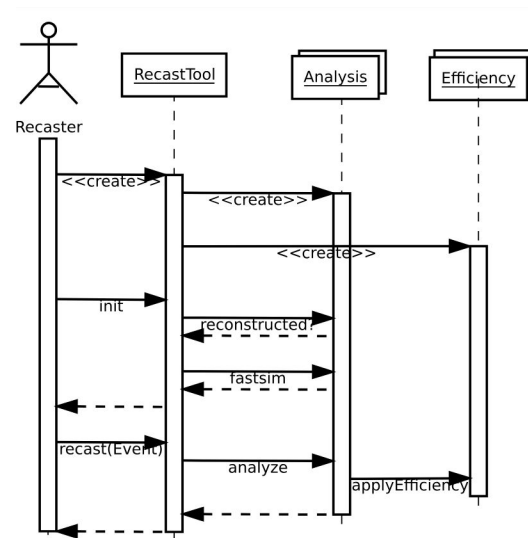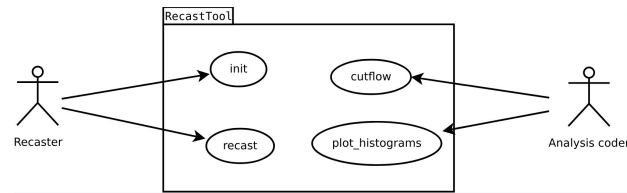❖ First results in on benchmark point; refinements and tests on more benchmarks, SRs, and ATLAS soft-lepton to come
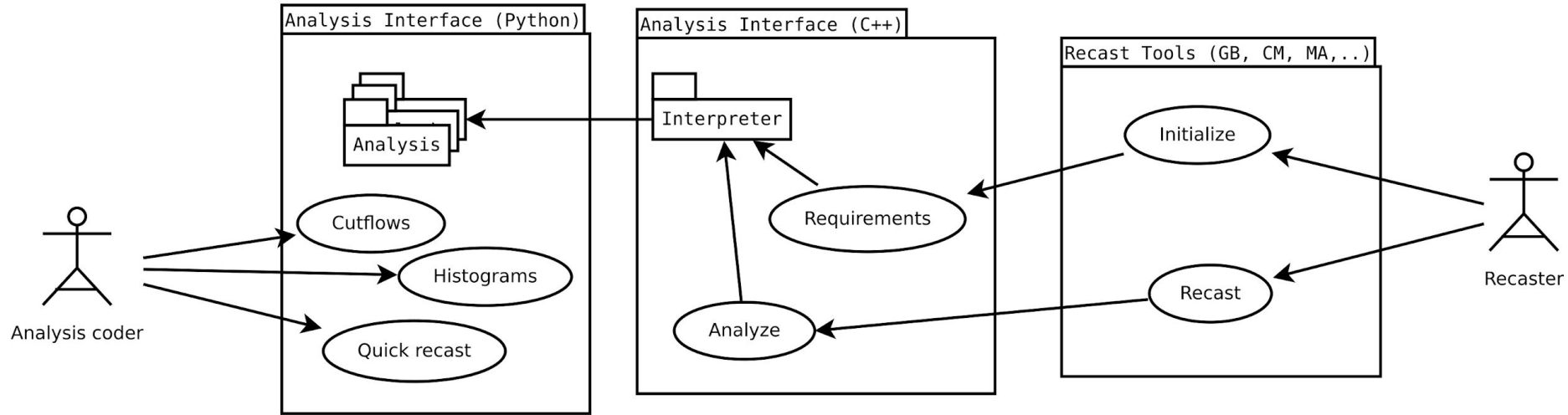
Buckley, Desai, Fuks, Gonzalo, Kvellestad, Gras, Ruiz de Austri, Sekmen
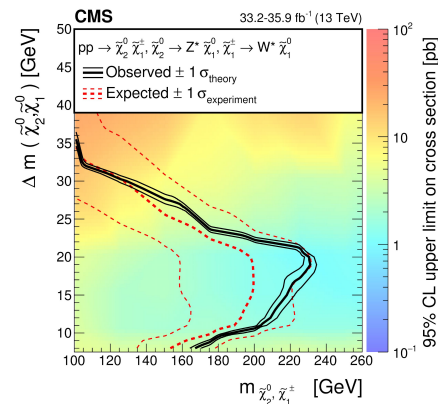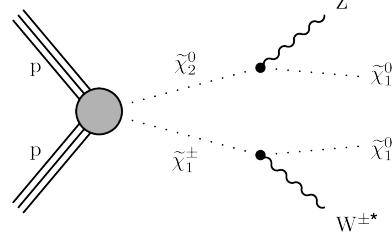

```
----------------------------------------------------------------
CUT FLOW: CMS_13TeV_2LEPsoft_36invfb
----------------------------------------------------------------
                                    CUT,     SCALED   GAMBIT/CMS
                             All events,     172004     1.00000
       2 $\mu$'s with $5 < p_{T} < 30$ GeV,  280.023    1.15378
                $\mu$'s oppositely charged,  237.366    1.08634
                   $p_{T}(\mu\mu) > 3$ GeV,  233.237    1.09091
                 $M(\mu\mu) \in [4,50]$ GeV, 185.764     1.7983
             $M(\mu\mu)$ veto [9,10.5] $GeV$,185.764     1.81765
               $125 < p^{miss}_{T} < 200$ GeV, 15.1364   1.54453
    Trigger. Implemented as efficiency.,       9.83863   1.78884
                                 ISR jet,      9.39142    1.77197
                       $H_{T} > 100$ GeV,      9.39142    2.29059
     $0.6 < p^{miss}_{T}/H_{T} < 1.4$,         3.57768   0.96694
                              b-tag veto,      2.23605    0.74535
                    $M(\tau\tau)$ veto,        1.78884    0.66253
$M_{T}(\mu_{x},p^{miss}_{T})$, x = 1,2 < 70$ GeV, 1.78884  0.81311
----------------------------------------------------------------
```

Universal recast interface

❖ **Enthusiasm among toolkit developers to join forces MA5, CheckMATE, Gambit, Rivet; ADL interest**

❖ Single "industry standard" code, with best ideas from each: unambiguous target for experiments Ambitious but do-able!

❖ Several discussions to establish core ideas: separation of truth from reco events via analysis declarations, Python-based analyses, parallel C++ access

❖ **Design:** Google doc for brainstorming **Code:** https://gitlab.com/lhrecast/unicast *(naming competition open, see wiki!!)*

Ruiz de Austri, Buckley, Corpe, Desai, Fuks, Gonzalo, Gras, Kvellestad, Lessa

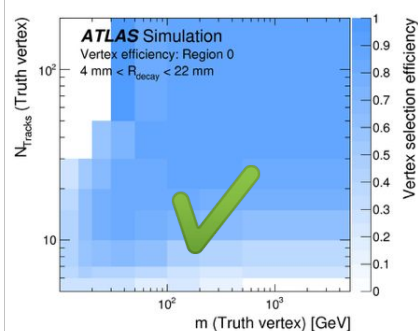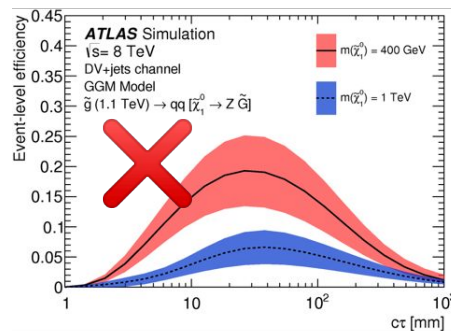# Universal recast interface... v2 already!

Thanks to Tomas Gonzalo

Long-lived particle searches

❖ Long-lived leptons in MA5, Delphes 3.4.2

Also see last Les Houches proceedings for independent recast of this search.

LLPs from the start in universal code

❖ Recasting with displaced jets: ~~open problem~~

See https://github.com/llprecasting/castingCodes for examples. This is a repository set up for collecting people's ad hoc recasting codes. (Please contribute!)
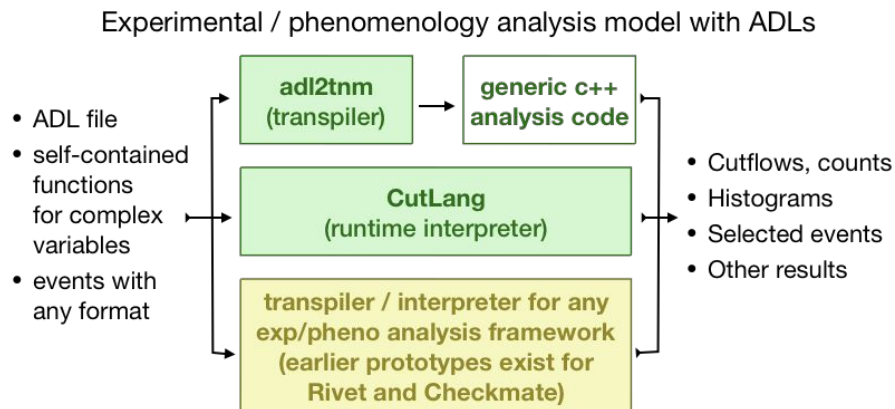
❖ Recommendations/requests to experiments:
  ➢ Object-level, not event-level efficiencies
  ➢ Report #fullsim/#effs test for each SR
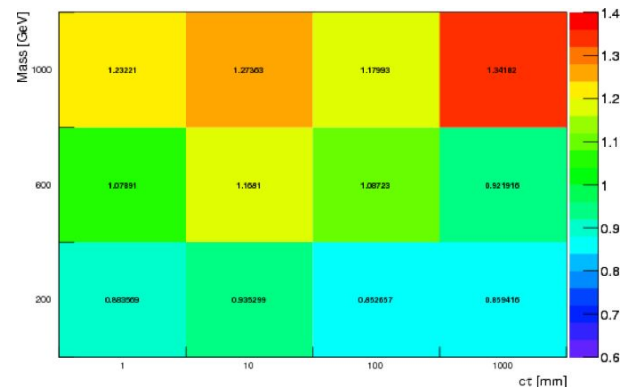
CMS 8 TeV displaced lepton search

Desai, Dutta, Fuks, Kraml, Reyes-Gonzalez, Ruiz, Sekmen, Williamson

Analysis description languages

❖ **Effort from LH2015 to develop a domain-specific language for LHC data analyses**

❖ Parsers and external discussions now, see [wiki](#) for links.

❖ Included in the recast tool comparison

❖ Using ADL cut descriptions to determine analysis overlap regions non-statistically. Target quick checks for analysis design.

Experimental / phenomenology analysis model with ADLs

- ADL file
- self-contained functions for complex variables
- events with any format

adl2tnm (transpiler) → generic c++ analysis code

CutLang (runtime interpreter)

transpiler / interpreter for any exp/pheno analysis framework (earlier prototypes exist for Rivet and Checkmate)

- Cutflows, counts
- Histograms
- Selected events
- Other results

Summary

❖ ***Lots* of activity in figuring out how best to use what we've got available.** Tools and data publication all maturing ⇒ lots of potential for exploitation

❖ Use of correlations and combined measurements + searches particularly active. The "two cultures" look set to meet in the middle: good!

❖ It's time for a single community recast code: important "negotiations" this week. Now coding time…

❖ *Another great week at LH! Thanks to all who participated: you were a pleasure to convene.*

❖ **It's not over yet** 😜