Session 2: Tools & MC

BSM modelling and interpretation: summary

Conveners:
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Benjamin Fuks, LPTHE / Sorbonne Université

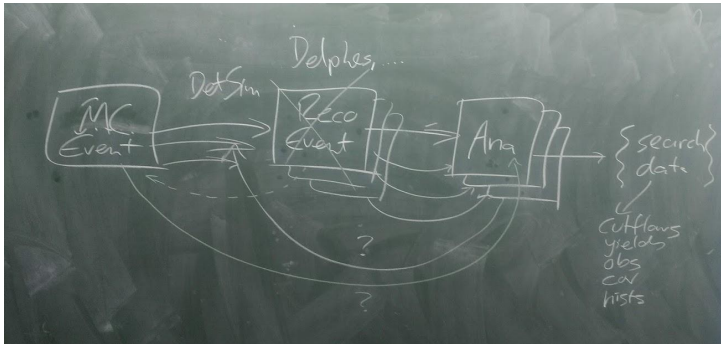
Les Houches BSM, 28 June 2019

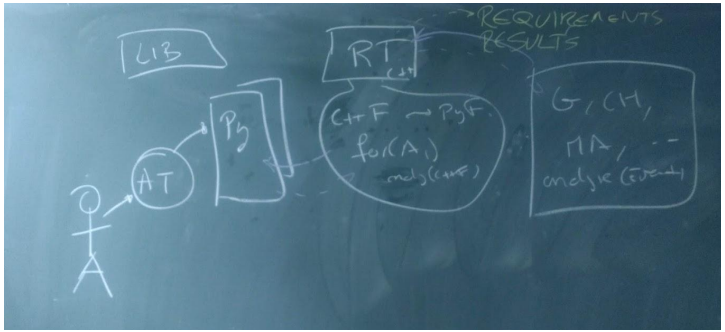
BSM tools ~~& MC~~

- 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

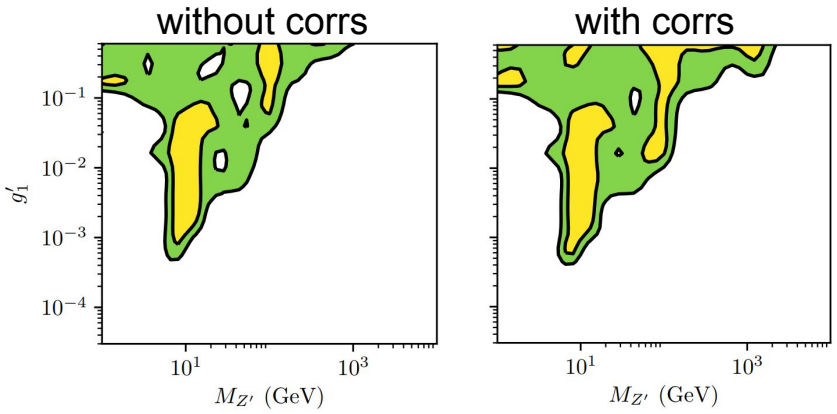
+ LLP and analysis language status discussions
+ reinterpretation status review: Overleaf link



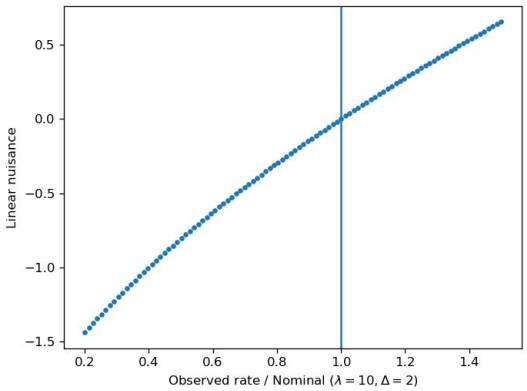


Building & using likelihoods

- 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:



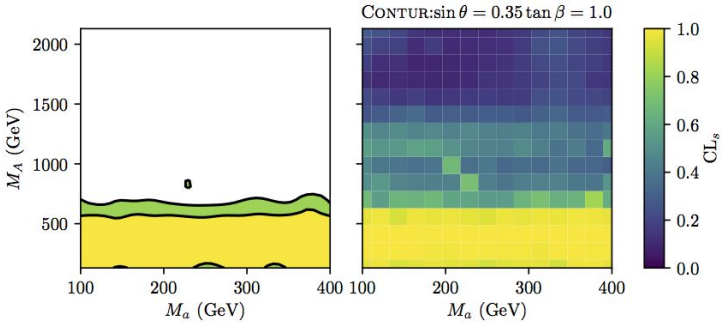
- Gambit also learning: likelihood profiling for better convergence, SL analytics → better guesses:
- Populating SRs also problematic: discussions on dynamic aggregation, fit regularisation, MC biasing

Buckley, Butterworth, Corpe, Kvellestad, Waltenberger, Yallup

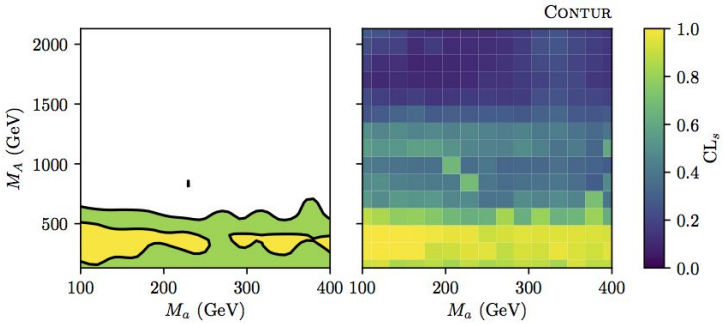
BSM limits from “SM” measurements

- 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, ...



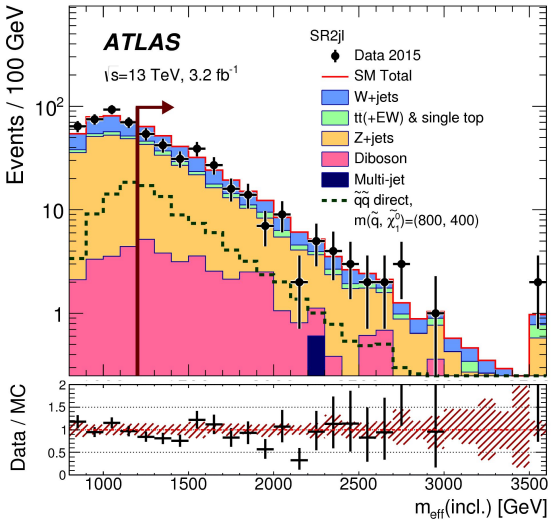
With CMS H → WW (above) and without (below), though other analyses may have same issue

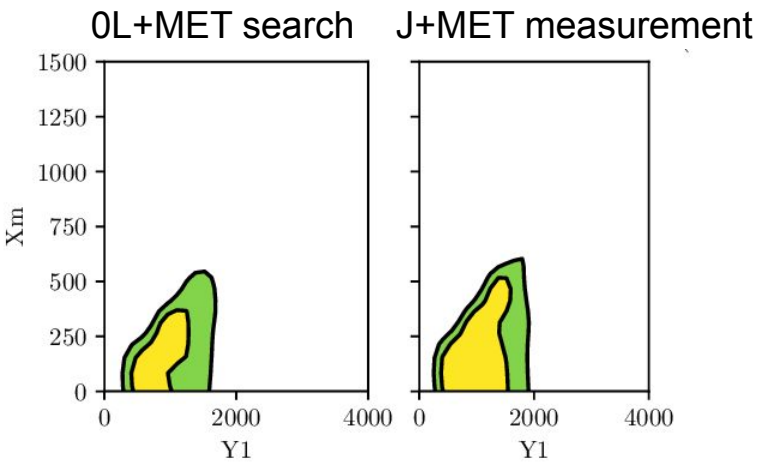


Search/measurement combination

- 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





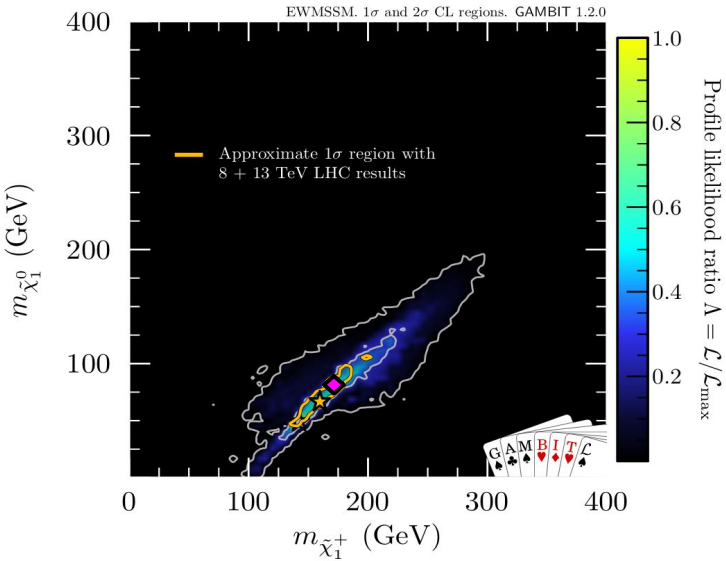
- Compatible reach to measurement.
  Update to 36/fb measurement.
  How about some corr data, ATLAS? 😉

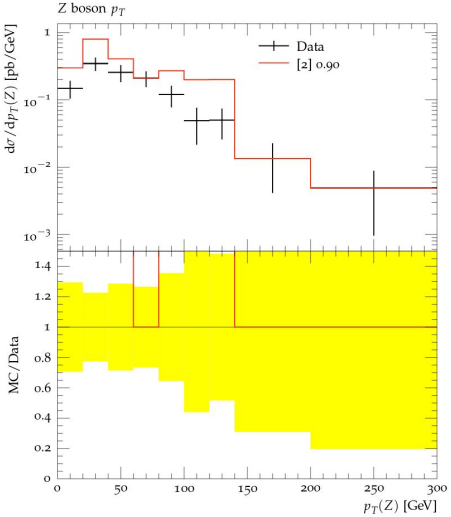
Buckley, Butterworth, Corpe, Yallup

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
  $\longrightarrow$ enhanced production of on-shell gauge bosons

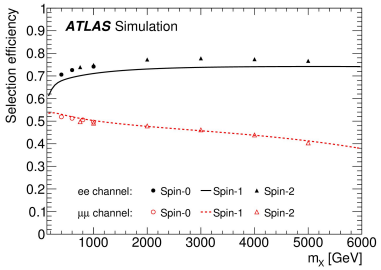


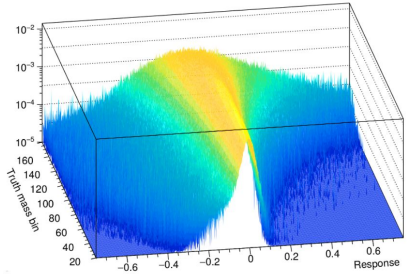


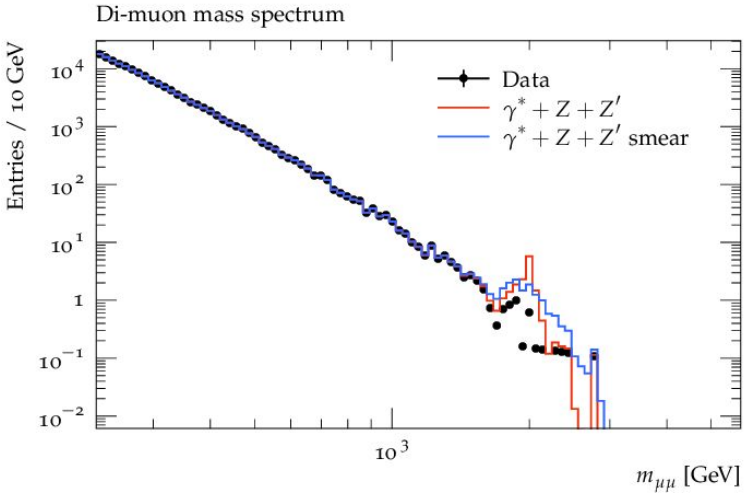
- Looks like measurements *can* constrain the param region preferred by the search results
- Motivates connecting CONTUR to GAMBIT for global fits. Work started...

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





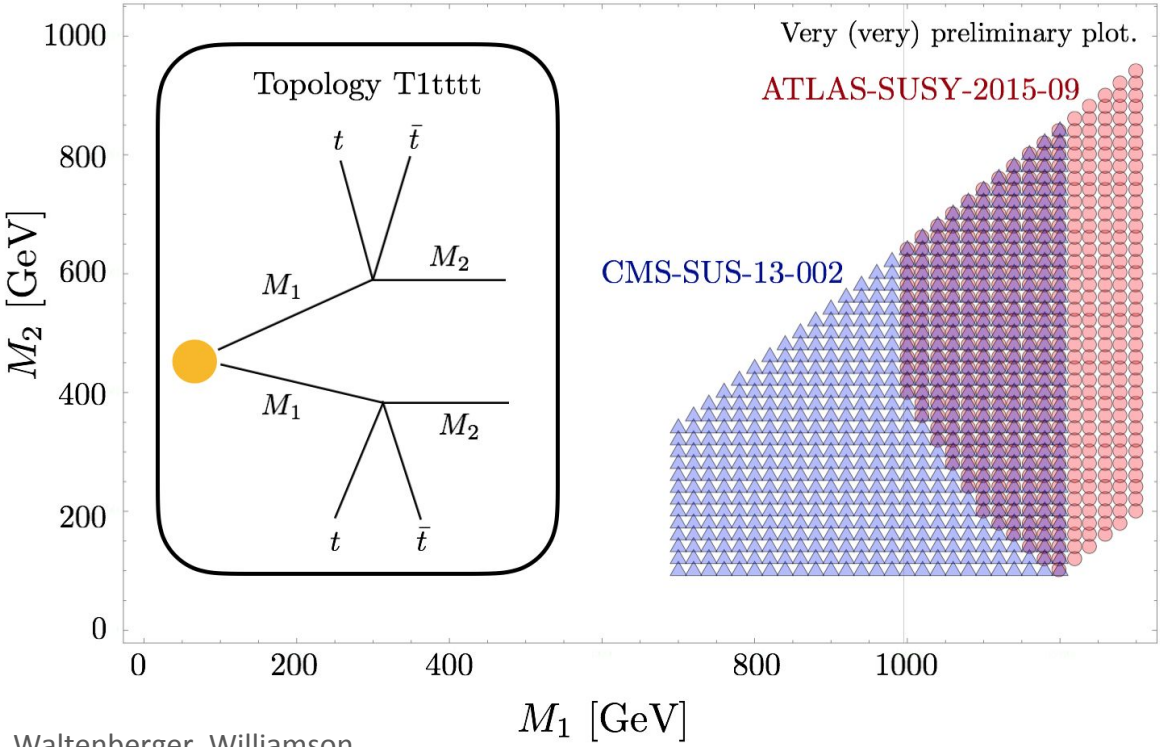


Bai, Buckley, Hrynova, Murray, Ruiz, Yallup

Analysis orthogonality

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

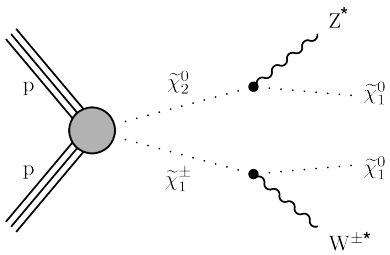
- **SModels**
  → Mass ranges for topologies in all SRs
- **MA5**
  → hacked v1.8 to provide per-event SR-fill info
- **Bootstrap method**
  → SR correlations

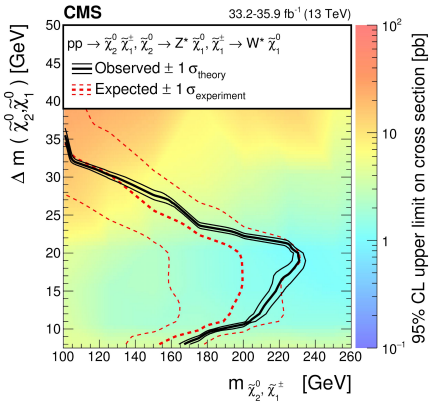


Buckley, Fuks, Kraml, Lessa, Reyes-Gonzalez, Waltenberger, Williamson

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



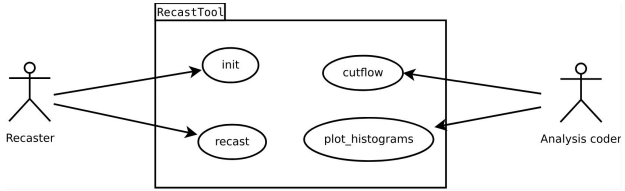


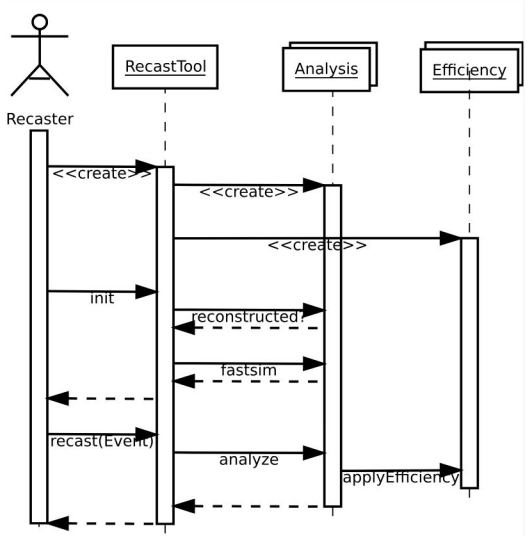

```
-----------------------------------------------------------------------
CUT FLOW: CMS_13TeV_2LEPsoft_36invfb
-----------------------------------------------------------------------
                                   CUT,          SCALED   GAMBIT/CMS
                             All events,          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
-----------------------------------------------------------------------
```

Buckley, Desai, Fuks, Gonzalo, Kvellestad, Gras, Ruiz de Austri, Sekmen

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!!)



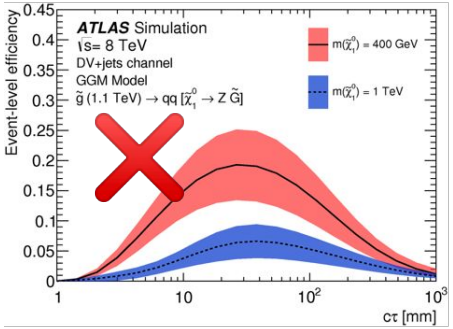


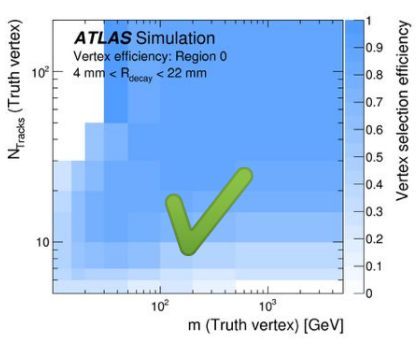
Long-lived particle searches

- 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

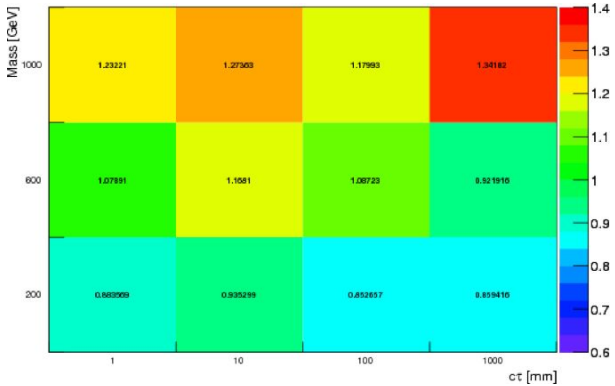




- Recasting with displaced jets: ~~open problem~~

  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



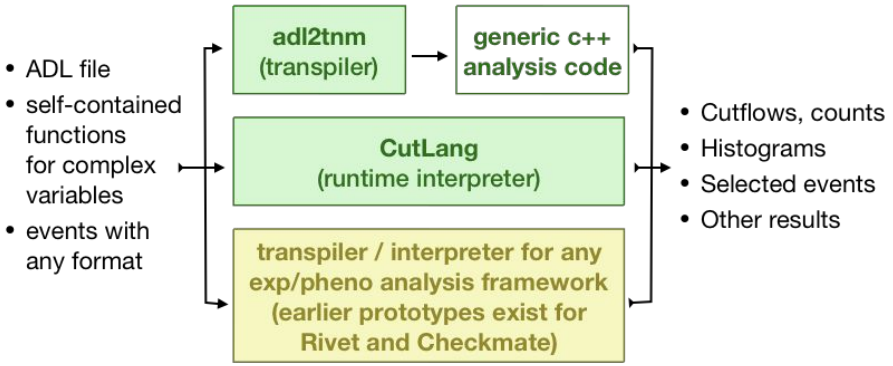
CMS 8 TeV displaced lepton search

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



(Prosper), Sekmen, Waltenberger

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** 😀