Publishing MC analysis codes

Andy Buckley
University of Glasgow

7th BSM reinterpretation forum meeting
CERN, 13 Dec 2022

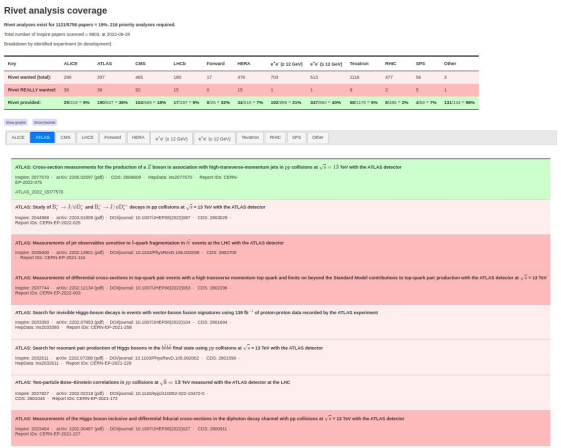

If you build it,
they will come

Publishing analysis codes

- **(Non-)availability of analysis codes is a game-changer**
  - Most BSM model exploration requires running some signal-model BSM sample(s) through reproductions of the experimental event-analysis
  - ⇒ yield estimates (modulo MC stats and systs) ⇒ likelihoods ⇒ recast limits, etc.
- **For most purposes this means lightweight codes**
  - RECAST etc. crucial for sci record, internal reproducibility and combinations, full-detail reanalyses
  - For pheno community & big adaptive scans, analysis-point turnaround needs to be short
  - Also essential to have programmatic validation material: many pheno efforts burn-out on the reproduction effort with custom process for each analysis
- **Many promising initiatives; how to support?**
    - Rivet programme in ATLAS and CMS measurements
    - Rivet for heavy-ion (ALICE, STAR/PHENIX)
    - SimpleAnalysis from ATLAS SUSY (modulo questions about det-sim validation)
    - Some MadAnalysis5 publication from CMS
    - CMS use of Rivet library to define fiducial physics objects!
  - Coverage very dependent on area / conveners
  - How to effectively incentivize? Needs to be clearly value-adding, not a *post-hoc* procedural irritant

Issues raised

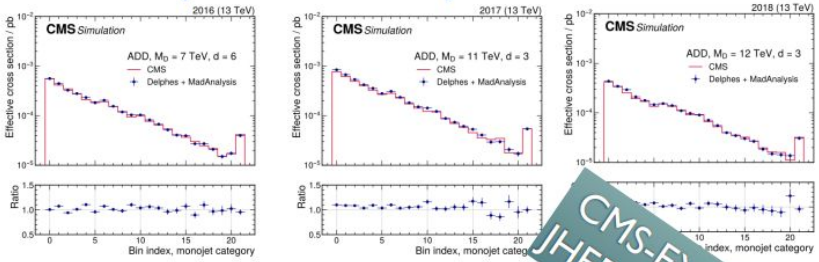
- **Excellent talks yesterday and today highlighting issues**
  - Feedback on why analyses sometimes aren't used / usable
  - Why differences in physics-area coverage? (After prioritizing)
  - Push to preserve (multiple) theory/background predictions, too
- **Validation and longevity**
  - Cutflows in umpteen different formats and conventions…
  - Non-numeric data (PDF tables)
  - Reference points: which UFO / BSM config? Which jet config? How to report for easy/automatic checking (and estimate approx error).
  - Could we preserve and link reference MC *samples*?
  - What effective detector biases? MA5 uses custom Delphes per analysis… (ML?) routes to easily estimate and preserve?
- **Incentivisation**
  - Reducing technical barriers: which aspects are hardest?
  - Not Invented Here phenomenon: no One Common Framework, but are there issues *requiring* the internal experiment toolkits?
  - What initiatives / career rewards would encourage data-reuse?



CMS searches perspective

from Sitian Qian

- CMS example with MadAnalysis5 Publication



CMS-EXO-20-004
JHEP 11 (2021) 153

B.5 Analysis implementation in MADANALYSIS

The MADANALYSIS package is a framework for the reinterpretation of existing analyses in terms of arbitrary new physics models [27]. The framework provides the infrastructure for the implementation of event selections that can be run over simulated signal events. Once an implementation is available, it is indexed in a public database that allows users to automatically download and execute it [28].

In order to promote this analysis for reinterpretation, we implement the selection for the monojet category of this analysis in MADANALYSIS. A total of 66 analysis regions are defined, with each of the regions representing one recoil bin in one data taking year. The selections applied for the 2016 and 2017 data sets are identical, and additional criteria are applied to the 2018 data set, where mitigation requirements are used because of a localized problem in the hadron calorimeter.

In order to validate the implementation, generator-level information from the simulated signal samples is fed into the DELPHES framework, which performs fast parameterized event simulation [99]. The MADANALYSIS implementation is then run based on the DELPHES output, and the final yields per signal region bin are compared to the signal prediction obtained from the CMS analysis framework.

The comparison is made using signal samples for the ADD interpretation, which are generated using PYTHIA, and are therefore relatively easy to reproduce. The resulting comparison of the final signal templates is shown in Fig. B.5 for a representative choice of parameter points. It is found that the DELPHES/MADANALYSIS-based result agrees with the CMS result to better than 20% in every bin. In most bins, the agreement is at the 10% or better level. While only a few parameter points are shown here, it has been verified that the agreement is similar for the full range of parameters. The level of agreement observed here is sufficiently good to enable reliable reinterpretation.

Such publication really helps outsiders to reuse our data !
Below arXiv: 2209.13266

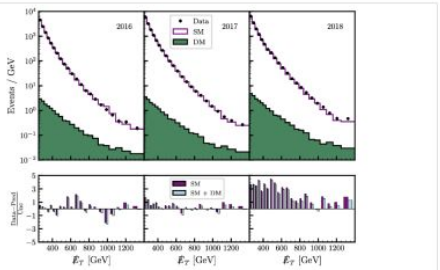


Fig. 5: Missing energy spectra for the CMS monojet search. The SM background prediction (purple) and the observed event counts (black) are taken from Ref [64]. The green distribution shows the signal prediction for the best-fit Dirac DM model. The bottom panel shows the residuals, defined as (data - prediction)/uncertainty for both the SM and the SM + DM predictions.

hadronization. We use the CKKW prescription to perform the matching between MadGraph and Pythia. We computed matrix elements for MadGraph starting from Universal FeynRules Output (UFO) files [90], generated with FeynRules [91] and employing a 5-flavour scheme. We used MadAnalysis 5 [92] to perform detector simulation and implement each of the ATLAS and CMS monojet analyses in order to compute ϵA. As this set of simulations is too computationally expensive to run during the global fit, we precomputed grids of the cross sections (σ) and ϵA factors for each LHC experiment in

CMS measurements perspective

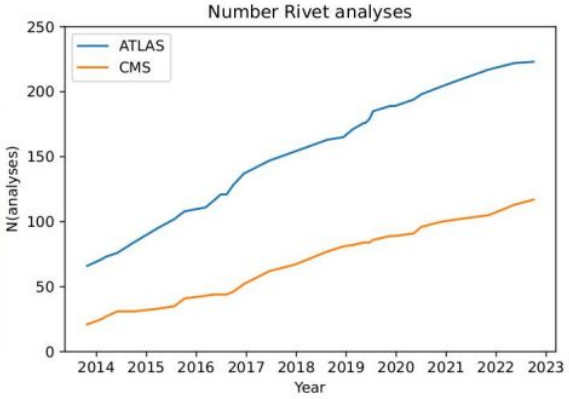
from Markus Seidel

RĪGAS TEHNISKĀ UNIVERSITĀTE

❖ CMS Rivet coverage

Key	ALICE	ATLAS	CMS	LHCb	Forward	HERA	e^+e^- (≥ 12 GeV)	e^+e^- (≤ 12 GeV)	Tevatron	RHIC	SPS	Other
Rivet wanted (total):	290	337	465	180	17	476	703	513	1118	477	56	3
Rivet REALLY wanted:	36	39	92	15	0	15	1	1	9	2	5	1
Rivet provided:	29/319 = 9%	190/527 = 36%	104/569 = 18%	17/197 = 9%	8/25 = 32%	34/510 = 7%	192/895 = 21%	347/860 = 40%	58/1176 = 5%	8/485 = 2%	4/60 = 7%	131/134 = 98%

[Link to full version]



Key	TOP	SMP	HIG	SUS	HIN	EXO	BPH	B2G	UNKNOWN
Rivet wanted (total):	63	84	65	54	86	89	14	33	10
Rivet REALLY wanted:	15	36	7	6	16	5	2	2	0
Rivet provided:	18/81 = 22%	78/162 = 48%	1/66 = 2%	3/57 = 5%	3/89 = 3%	4/93 = 4%	3/17 = 18%	0/33 = 0%	0/10 = 0%

[Link to full version, accessible for CMS members]

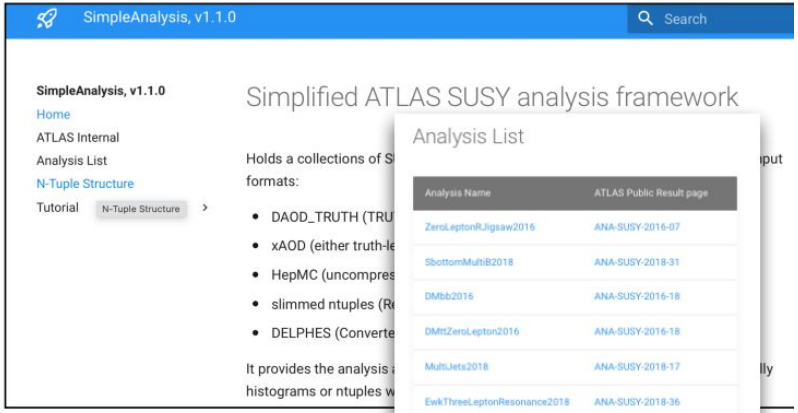
ATLAS searches perspective

from Yvonne Ng
plus Giordan's talk just now

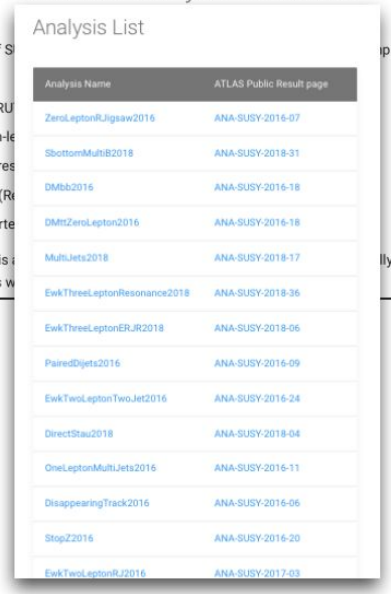
❖ Level 2: SimpleAnalysis

—Truth level pipeline preservation

- Preserves the analysis code pipeline
- Allow for reinterpretation up to the truth level
  - Detector effect can be added: public simulation like Delphes or internally by ATLAS fast simulation
- Experimentalist friendly input format (HepMC, DAOD, ROOT n-tuple, DELPHES)
- Large list of ATLAS SUSY analyses available:
- For **public use**: can be used external to ATLAS



SimpleAnalysis: Webpage



GitLab

Source Code

SimpleAnalysis PubNote

Available list of Analyses

ATLAS measurements perspective

from Matous Vozak

SHIFT OF MINDSET

We can focus on present and (both short and long term) future value of results and data

LHC

Unique and possibly last hadron colliding machine delivering highly energetic environments to study fundamental particles and interactions between them

DATA WE COLLECT

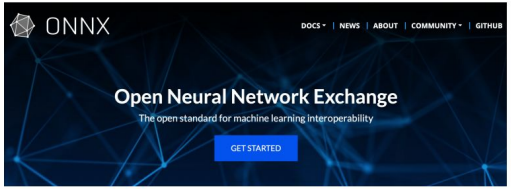
is well-preserved, long-term compatible can be easily reinterpreted, covers wide range of final states and phase spaces for present and future use,

AREAS FOR IMPROVEMENT AND FUTURE DIRECTIONS

1. **More detailed output**
   - Publishing full likelihoods
   - More metadata
   - Unbinned datasets
2. **More direct and organized effort in long-term compatibility of the results**
3. **Open discussion on collective goals before doing analyses on larger datasets (Run3 and Run4)**

Open questions / discussion topics

- **Technical**
  - What obstacles to routine preparation in data / code ecosystem?
  - ML preservations ⇒ validation and regression checks even more crucial (cf. ATLAS-SUS-2019-04 experience)
  - Stability and longevity: how can we ensure the code still does the right thing in 2040? 2050? Beyond? Curation or containers?
- **Validation**
  - Huge pain / obstacle to preservation: figuring out the reference models, add cutflow checkpoints in the code (→re-ordering…)
  - Building cutflows / control distributions into analyses? Link to HepData? Ref HepMC samples on Zenodo?
- **Social**
  - Valuing work that makes science reusable beyond The Paper
  - Current (experimental) perceptions?
  - Phenomenology input? Cross-community collaboration opportunities?
- **AOB?**



3 b-jets+	One Lepton MultiJets
Search for supersymmetry in final states with missing transverse momentum and three or more b-jets in 139 fb^{-1} of proton–proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector	Search for R-parity-violating supersymmetry in a final state containing leptons and many jets with the ATLAS experiment using $\sqrt{s}$ = 13 TeV proton–proton collision data
The ATLAS Collaboration	The ATLAS Collaboration
ANA-SUSY-2018-30 SA with Onnx	ANA-SUSY-2019-04 SA with Onnx

Two existing analyses already contain Onnx GitLab