Recasting activities at LH2017

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Abstract
The scope of this report, therefore, is to document the advancements obtained so far on the recasting activities and attempt a first benchmark to compare different tools to reproduce several ATLAS and CMS analysis results.

1. Introduction

Searches for new physics constitute a basic ingredient of the LHC physics program. Their large number and variety pose severe challenges to both the experimental and theory communities. In fact, hundreds of searches are performed by different collaborations, several final states are used, new ideas on how to probe new models and non-trivial signatures and improve the sensitivity of existing searches constantly emerge. The ultimate goal of this effort is to discover new physics if such exists within the reach of the LHC, and to test the widest possible range of hypothetical new physics models.

A typical analysis defines quantities that aid in classifying the event as signal or background: for example the properties of analysis objects such as jets, electrons, muons, etc., or global event variables such as object multiplicities, transverse momenta, transverse masses, etc. An analysis can be very complex and feature many intricate definitions of object and event variables, some of which cannot be expressed in closed algebraic form and must be defined algorithmically. This complexity renders the task of visualizing, understanding, developing and interpreting analyses increasingly challenging.

One obvious way to cope with the complexity is to devise ways to enforce absolute clarity in the description of analyses. A discussion was started in the Les Houches PhysTeV workshop in 2011, and continued thereafter within a wider group of LHC physicists, in order to determine what information is crucial for describing an analysis. The outcome of this discussion was reported in the ”Recommendations for Presentation of LHC Results” [1, 2, 3], and has been embraced by many LHC physicists.

The current practice in our community is to write an analysis in non-public computer codes, which often rely on event objects specific to the experimental collaboration in question, and then make public a description of the analysis via journal publications or other documents.

These efforts, which merit our great appreciation, have significantly increased the scientific value of many important experimental results.

There is significant precedent for the effectiveness of such community standards. Several accords have been established to standardize the communication of physics modeling information, notably the Les Houches Event Accord (LHE) [4, 5] and the SUSY Les Houches Accord (SLHA) [6, 7]. These, respectively, standardize the description of hard-process particles in simulated collision events, and the details of all the parameters that define a BSM model point. Both accords are widely used in high-energy physics and have greatly helped to simplify and make more efficient the communication between physicists. In recent years, the need for a standardized format was also underscored, i.e. an “analysis description accord”, capable of describing the contents of an analysis in an unambiguous way, which can be fully exploited by the whole particle physics community. The accord must be capable of describing all object and event selections, as well as quantities such as efficiencies, analytic and algorithmic observables, and advanced multivariate selections. In the Les Houches PhysTeV workshop in 2015, a dedicated discussion has been initiated on how such an accord can be realized [3]. The important motivations and use-cases for a standard analysis description accord were envisaged as: analysis preservation, Analysis design, analysis review and communication, interpretation studies and analysis reimplementation,easier comparison of analyses. In addition, there are several desirable features which would further improve the utility of the accord, which, however, may be nontrivial to simultaneously fulfill. The features required for the success of such an accord would be divided into basic requirements (public availability, completeness, longevity, correctness and validatability) and desirable features (human readability and writeability, self-contained, language independence, framework independence, support for combination of analyses). Other proposals in this direction have been realized [8, 9].

Several discussions and progresses have been made, but the proposal is not yet final and has not been widely adopted yet.

The scope of this report, is to document the advancements obtained so far on the recasting activities and attempt a first benchmark to compare different tools to reproduce several ATLAS and CMS analyses' results provided through HEPDATA [10]. To trust the reliability of this recasting approach, we realize feasibility studies of the implementation and portability of complicated MVA techniques (BDT, NN,. . .) into the recasting frameworks featuring different approaches like detector smearing (DELPHES [11]) results and simple object smearing.

Further improvements in the presentation of the results and their recastability will be to provide correlations signal systematics, as well as the possibility to provide a few key observables unfolded. Finally, it would be interesting in the future to try using particle-level measurements to constrain models.

2. Benchmarking/Comparisons

- Implementation of analyses of increasing complexity in the Analysis Description Format (LHADA Proposal) and in (BSM) Rivet and their comparison.
- Choose an analysis of ATLAS or CMS which has cutflow and detector effects provided in some form, and possibly is already been implemented in the recasting codes CheckMate/MadAnalysis/Rivet/ATOM.
- Implement the same analysis in LHADA and then use the dedicated parsers to provide the analysis for the recasting codes.
- Reproduce the NP interpretation of the original paper (=validation implementation).
- Recast the analysis for an other new physics model and compare the results.
- Go to point one and choose a more complicated analysis. . .

it would be interesting to see how Delphes performance looks without analysis-specific cards, since a lot of people (outside the "big" recasting groups) are using it that way.

3. How to validate the analyses

4. The analysis frameworks and tools

In this section we describe the analysis frameworks and tools used for the comparison and benchmarking

4.1 CheckMate

CheckMATE takes simulated event files in .hep or .hepmc for any model as input and simply returns if the underlying model is "excluded" or "allowed" after performing a detector simulation and testing various implemented analyses. The embedded AnalysisManager makes it easy to add current and prospective future LHC results from ATLAS and CMS which have not yet been implemented. Detector effects are considered by Delphes extended by tuned efficiency functions for lepton reconstruction and flavour tagging. The soon-to-be published version 2.0 adds the possibility of using Pythia8 to generate SUSY

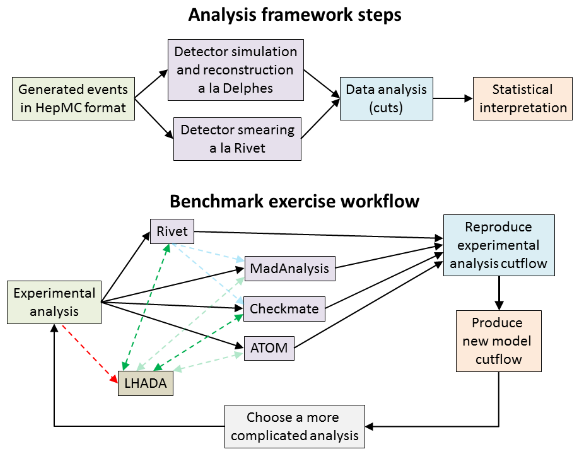

Fig. 1: Search reach for the $\mu\gamma\not{E}_T$ signal (as defined in the text) for 300 fb^{-1} integrated luminosity at the LHC.

events on-the-fly or to shower provided .lhe files for any model. Currently, the collaboration is working on an extension to enable the on-the-fly simulation of events for any model.

4.2 MadAnalysis

MadAnalysis 5 is a generic user-friendly framework for phenomenological investigations at particle colliders, i.e. to perform physics analyses of Monte Carlo event files. Its Public Analysis Database (PAD)comprises a growing collection of LHC analyses, which have been implemented in the MadAnalysis 5 framework for the purpose of recasting. Delphes3 is used for the detector simulation. For each implemented analysis, a detailed validation note is provided. The PAD follows an open-source policy; contributed codes are published and citable via Inspire. The framework is currently being extended to provide a full recast chain, from Madgraph to limit setting.

4.3 Rivet

Originally developed as a toolkit for the validation of Monte Carlo event generators, Rivet (Robust Independent Validation of Experiment and Theory) has become a standard for documenting [unfolded] SM measurements. The LHC experiment top and Higgs groups are also increasingly providing Rivet routines for their analyses. Rivet analyses are written in a user-friendly subset of C++11, and are picked up at runtime as ”plugin libraries”; they can be executed on an event stream either through a Python script interface, or by direct code interfacing to a C++ API. The original SM-focused requirement of unfolded observables made Rivet inappropriate for BSM searches (other than those using just jets and MET) until the addition of detector-smearing/efficiency machinery in Rivet 2.5.0. This detector machinery provides equivalent efficiency effects to a Delphes-type simulation, and imitates the less important kinematic smearing of physics objects to within a few percent. A novel feature is that the Rivet detector implementation allows jet algorithms, lepton and b-tagging operating points, full-detailed object isolation algorithms, and resolutions/efficiencies to be specific to each analysis’s procedure and event-selection. This allows more accurate detector modelling and more robust analysis preservation than ”global” detector simulations, hence addresses some experiment concerns re. requests for ”official fast-sim” tools. The aim is to encourage Rivet code provision direct from BSM data analysers, as is already the case for SM results: additional tools to assist BSM analysis implementation are being added on request.

4.4 Generic Analysis Description Proposal

Brief description of the Generic Analysis Description Proposal

5. Analyses benchmarking, comparisons and results

5.1 arxiv:1605.03814 - Jets+MET - ATLAS - 13 TeV

Brief description of the ATLAS analysis Jets+MET at 13 TeV (arxiv:1605.03814). Results are reported in table 1.

	Rivet			MadAnalysis5			CheckMATE
Description	#evt	tot.eff	rel.eff	#evt	tot.eff	rel.eff	tot.eff
2jl cut-flow	31250	1	-	31250	1	-	
Pre-sel+MET+pT1	28592	0.91	0.91	28626	0.92	0.92	
Njet	28592	0.91	1	28625	0.92	1	
Dphi_min(j,MET)	17297	0.55	0.6	17301	0.55	0.6	
pT2	17067	0.55	0.99	17042	0.55	0.99	
MET/sqrtHT	8900	0.28	0.52	8898	0.28	0.52	
m_eff(incl)	8896	0.28	1	8897	0.28	1	
2jm cut-flow	31250	1	-	32150	1	-	1
Pre-sel+MET+pT1	28472	0.91	0.91	28478	0.91	0.91	0.91
Njet	28472	0.91	1	28477	0.91	1	0.91
Dphi_min(j,MET)	22950	0.73	0.81	22889	0.73	0.8	0.73
pT2	22950	0.73	1	22889	0.73	1	0.73
MET/sqrtHT	10730	0.34	0.47	10710	0.34	0.47	0.33
m_eff(incl)	10630	0.34	0.99	10609	0.34	0.99	0.32
2jt cut-flow	31250	1	-	31250	1	-	
Pre-sel+MET+pT1	28592	0.91	0.91	28626	0.92	0.92	
Njet	28592	0.91	1	28625	0.92	1	
Dphi_min(j,MET)	17297	0.55	0.6	17301	0.55	0.6	
pT2	17067	0.55	0.99	17042	0.55	0.99	
MET/sqrtHT	5083	0.16	0.3	5098	0.16	0.3	
Pass m_eff(incl)	4861	0.16	0.96	4889	0.16	0.96	
4jt cut-flow	31250	1	-	31250	1	-	1
Pre-sel+MET+pT1	28592	0.91	0.91	28626	0.92	0.92	0.91
Njet	27322	0.87	0.96	27128	0.87	0.95	0.87
Dphi_min(j,MET)	18929	0.61	0.69	18829	0.6	0.69	0.6
pT2	18715	0.6	0.99	18825	0.6	1	–
pT4	16610	0.53	0.89	16430	0.53	0.87	0.52
Aplanarity	11849	0.38	0.71	11395	0.36	0.69	0.36
MET/m_eff(Nj)	8334	0.27	0.7	7971	0.26	0.7	0.25
m_eff(incl)	7201	0.23	0.86	6972	0.22	0.87	0.21
5j cut-flow	31250	1	-	31250	1	-	1
Pre-sel+MET+pT1	28592	0.91	0.91	28626	0.92	0.92	0.91
Njet	21234	0.68	0.74	21185	0.68	0.74	0.68
Dphi_min(j,MET)	14294	0.46	0.67	14292	0.46	0.67	0.45
pT2	14146	0.45	0.99	14289	0.46	1	–
pT4	13229	0.42	0.94	13228	0.42	0.93	0.42
Aplanarity	9836	0.31	0.74	9576	0.31	0.72	0.3
MET/m_eff(Nj)	4643	0.15	0.47	4506	0.14	0.47	0.13
m_eff(incl)	4620	0.15	1	4476	0.14	0.99	0.13
6jm cut-flow	31250	1	-	31250	1	-	1
Pre-sel+MET+pT1	28592	0.91	0.91	28626	0.92	0.92	0.91
Njet	13235	0.42	0.46	13236	0.42	0.46	0.41
Dphi_min(j,MET)	8520	0.27	0.64	8553	0.27	0.65	0.26
pT2	8436	0.27	0.99	8551	0.27	1	–
pT4	8135	0.26	0.96	8217	0.26	0.96	0.25
Aplanarity	6365	0.2	0.78	6307	0.2	0.77	0.19
MET/m_eff(Nj)	2675	0.09	0.42	2665	0.09	0.42	0.08
m_eff(incl)	2670	0.09	1	2656	0.08	1	0.08
6jt cut-flow	31250	1	-	31250	1	-	
Pre-sel+MET+pT1	28592	0.91	0.91	28626	0.92	0.92	
Njet	13235	0.42	0.46	13236	0.42	0.46	
Dphi_min(j,MET)	8520	0.27	0.64	8553	0.27	0.65	
pT2	8436	0.27	0.99	8551	0.27	1	
pT4	8135	0.26	0.96	8217	0.26	0.96	
Aplanarity	6365	0.2	0.78	6307	0.2	0.77	
MET/m_eff(Nj)	3900	0.12	0.61	3839	0.12	0.61	
m_eff(incl)	3715	0.12	0.95	3672	0.12	0.96	

Table 1: 1605.03814 cut flow

5.2 arxiv:1704.03848 - Monophoton - ATLAS - 13 TeV

Brief description of the ATLAS analysis Monophoton at 13 TeV (arxiv:1704.03848). Results are reported in table 2.

5.3 CMS-SUS-16-039 - 3 leptons + MET - CMS - 13 TeV

Brief description of the CMS analysis 3 leptons + MET at 13 TeV (CMS-SUS-16-039).

	Rivet			MadAnalysis5		
Description	#evt	tot.eff	rel.eff	#evt	tot.eff	rel.eff
Initial	1198	1	-	1198	1	-
ETmiss $>$ 150 GeV	798.3	0.67	0.67	736	0.61	0.61
Photon w/ ET $>$ 150 GeV	703.5	0.59	0.88	700	0.58	0.95
Pass Tight photon	598.1	0.50	0.85	658	0.55	0.94
Pass Isolated photon	598.1	0.50	1.00	620	0.52	0.94
Pass $\delta\phi$(gamma,MET) $>$ 0.4	597.5	0.50	1.00	596	0.50	0.96
Pass MET/sqrt(SET) $>$ 8.5	538.2	0.45	0.90	-	-	
Pass Jet veto	476.8	0.40	0.89	461	0.38	0.77
Pass Lepton veto	475.5	0.40	1.00	460	0.38	1.00

Table 2: 1704.03848 cut flow

5.4 arxiv:1706.04402 - 1 lepton + MET + Jets (¿=1b) - CMS - 13 TeV

(topness variable?) Brief description of the CMS analysis 1 lepton + MET + Jets ($>= 1b$) (topness variable) at 13 TeV (arxiv:1706.04402).

CONCLUSIONS

We are cool.

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