

Which additional information has to be provided for measurements?

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LHC EW WG General Meeting, Dec 2019

Global Fits and Reinterpretation of SM Measurements Session

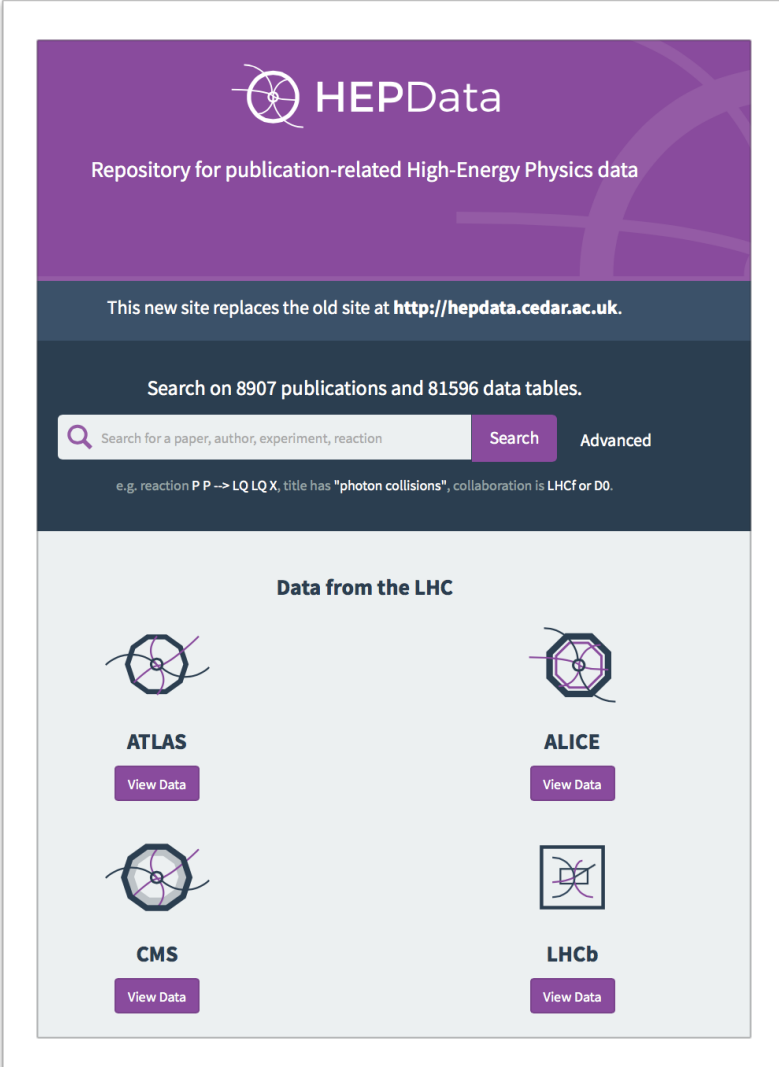
- Analysis preservation is increasingly important discussion in HEP
--> ***new and ambitious goals of combinations, recasting, EFT fits etc...***
- Are we routinely storing enough information on HEPData to efficiently re-use the measurements we make at the LHC?
--> ***Not always! ...And when we do, the expts follow different conventions... Areas where small policy shifts can boost impact of analyses***
- Prompted by discussion on correlations: [Dec 18](#), [Feb 19](#), [July 19](#)
Attempt **recommendation in [note](#) to be agreed between LHC expts**
 - Give **recommendations on conventions to follow** depending on what level of re-interpretation is needed
- Recommendations discussed in dedicated presentations to experiments
 - ATLAS (SM, HDBS, PMG groups) Oct-Dec 2019
 - CMS (Generator Group) Late Oct 2019
 - LHCb (QEE Group) Nov 2019
 - ALICE : planned discussion in Jan 2019

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I'll remind the recommendations , and will summaries some of the feedback from experiments so far

What are the current practices?

And how/why do they need to change?



The screenshot shows the HEPData website interface. At the top, the HEPData logo is displayed, followed by the text "Repository for publication-related High-Energy Physics data". Below this, a dark blue banner states: "This new site replaces the old site at <http://hepdata.cedar.ac.uk>".

The main content area features a search bar with the text "Search on 8907 publications and 81596 data tables." and a search input field containing "Search for a paper, author, experiment, reaction". To the right of the search bar are buttons for "Search" and "Advanced". Below the search bar, an example search query is provided: "e.g. reaction P P -> LQ LQ X, title has 'photon collisions', collaboration is LHCf or D0."

The section titled "Data from the LHC" displays four experiment logos: ATLAS, ALICE, CMS, and LHCb. Each logo is accompanied by a "View Data" button.

Existing recommendations



- Define fiducial volume of measurement (eg **Rivet Routine**) Often comes years later, or not at all! Documenting analysis logic w/ code snippet is vital for preservation
- Give results with uncertainties for in each bin. Separate stat vs syst uncertainties at minimum. Stat/syst not enough to model correlations if re-interp is to be trusted
- Use exact names given by CP groups for error sources/nuisance parameters (NPs)
This is not always respected

[ATLAS SM measurement from 2017](#), but still no rivet routine!

Measurement of $WW/WZ \rightarrow \ell\nu qq'$ production with the hadronically decaying boson reconstructed as one or two jets in pp collisions at $\sqrt{s} = 8$ TeV with ATLAS, and constraints on anomalous gauge couplings

The ATLAS collaboration

Aaboud, Morad , Aad, Georges , Abbott, Brad , Abdinov, Ovsat , Abeloos, Baptiste , Abidi, Syed Haider , AbouZeid, Ossama , Abraham, Nicola , Abramowicz, Halina , Abreu, Henso

No Journal Information, 2017

<https://doi.org/10.17182/hepdata.78399>

INSPIRE

Resources

[LHCb Forward W/Z production measurement](#) from 2016, only stat+syst+lumi breakdown

RE	PP-->W+<MU+ NUMU>JET X	PP-->W-<MU- NUMUBAR>JET X	PP-->Z0<MU+MU-> JET X
	σ_{W^+j} [pb]	σ_{W^-j} [pb]	σ_{Zj} [pb]
	56.9 ±0.2 stat ±5.1 syst ±0.7 syst,lumi	33.1 ±0.2 stat ±3.5 syst ±0.4 syst,lumi	5.71 ±0.06 stat ±0.27 syst ±0.07 syst,lumi

[CMS 13 TeV jet substructure measurements](#) in tt: with full uncertainty breakdown!

$\frac{d^0}{d^0}$ (N)	incl	bottom
0 - 3.0	0.032603 ±0.00016275 stat,Stat -0.00048105 +0.00057333 syst,jec_SubTotalPileUp_up,jec_SubTc	0.025586 ±0.00040941 stat,Stat -0.00033805 +0.00012629 syst,jec_SubTotalPileUp_up,jec_SubTc
	-0.00030539 +0.00025237 syst,jec_SubTotalPt_up,jec_SubTotalP	-0.00040186 +0.00013767 syst,jec_SubTotalPt_up,jec_SubTotalP
	-0.00053812 +0.00049466 syst,jec_SubTotalRelative_up,jec_Sub'	-0.0007672 -0.00018921 syst,jec_SubTotalRelative_up,jec_Sub'

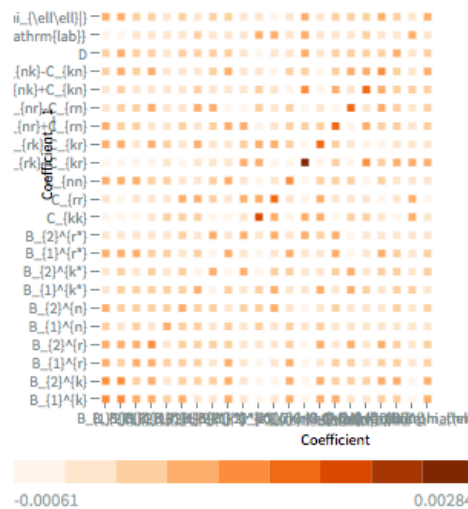
Existing recommendations

- If strong correlations...
 - explicit covariance or correlation matrix
 OK only don't intend to combine with other measurements
 - give breakdown of signed(!) effect of each NP. Can then rebuild covariance matrix
- Prefer to use b) since a) implicitly symmetrizes, and information to correlate with other measurements is insufficient.

[Recent CMS tt measurement](#) which included covariance matrix directly

Measurement of the top quark polarization and $t\bar{t}$ spin correlations using dilepton final states in proton-proton collisions at $\sqrt{s} = 13$ TeV

Coefficient	Coefficient__1	Systematic covariance for all coefficients
B_1^k	B_1^k	0.0004253623247
B_2^k	B_1^k	0.0003758444934
B_1^r	B_1^k	4.24559268e-05
B_2^r	B_1^k	7.046833802e-05
B_1^n	B_1^k	2.113294779e-05

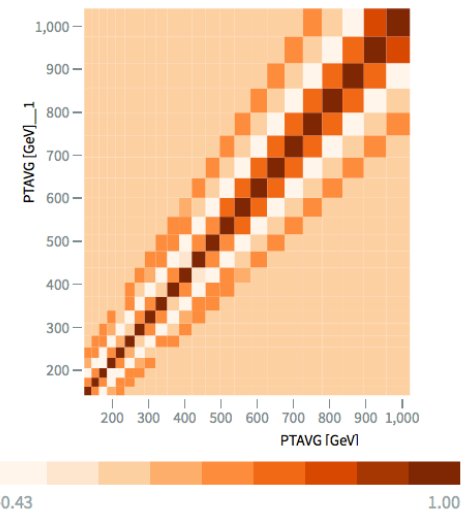


[Recent ATLAS measurement](#) which included covariance matrix directly

Measurement of the triple-differential dijet cross section in proton-proton collisions at $\sqrt{s} = 8$ TeV and constraints on parton distribution functions

PTAVG [GeV]	PTAVG [GeV]__1	Covariance matrix element
133.0 - 153.0	133.0 - 153.0	1.0
133.0 - 153.0	153.0 - 174.0	0.08
133.0 - 153.0	174.0 - 196.0	-0.22

Visualize



Existing recommendations



- Statistical correlations from **bootstrap method**, store either replicas or correlation matrix.
Replicas best for future combinations but need make TH*DBootstrap code public
- Theory predictions not usually in HEPData
Exception: when theory predictions complicated/intensive to be produced
Policy from time when bkg calculations were cheap. No longer the case! A shift here can boost our impact
- *(For searches: exclusion limits + necessary info to emulate analysis (e.g kinematic distributions, signal acceptances and selection efficiencies)*
Rivet can now preserve searches w/ custom smearing+efficiency capabilities

ATLAS SUSY search where SM background predictions are given

	DATA	SM BACKGROUND	SIGNAL
SQRT(S)	13000.0 GEV		
m_{eff}(incl.) [GeV]	Events / 200 GeV		
900.0 (bin: 800.0 - 1000.0)	53.0 ± 7.28	38.76 ± 1.912 stat <small>+3.279 -3.354 sys</small>	4.565 ± 0.8682
1100.0 (bin: 1000.0 - 1200.0)	184.0 ± 13.56	153.0 ± 3.87 stat <small>+23.52 -28.52 sys</small>	34.24 ± 2.322
1300.0 (bin: 1200.0 - 1400.0)	192.0 ± 13.86	176.4 ± 4.933 stat <small>+16.08 -18.53 sys</small>	47.85 ± 2.673
1500.0 (bin: 1400.0 - 1600.0)	163.0 ± 12.77	132.8 ± 3.616 stat <small>+19.59 -20.34 sys</small>	38.96 ± 2.668
1700.0 (bin: 1600.0 - 1800.0)	113.0 ± 10.63	89.99 ± 2.567 stat <small>+19.14 -22.83 sys</small>	27.76 ± 2.622
1900.0 (bin: 1800.0 - 2000.0)	61.0 ± 7.81	51.19 ± 2.164 stat <small>+3.891 -4.698 sys</small>	11.71 ± 1.205

Rivet plugin for an ATLAS SUSY search

Rivet analyses reference

ATLAS_2016_I1458270

0-lepton SUSY search with 3.2/fb of 13 TeV *pp* data

Experiment: ATLAS (LHC)

Inspire ID: 1458270

Status: VALIDATED

Authors:

Updated HEPData Recommendations

Defines 3 scenarios for levels of information to provide on HEPData

Gives concrete recommendations for the format of objects which are to be stored

Hopefully can be used by experiments to update internal recommendations (process has started within ATLAS!)

Currently draft recommendations doc

Recommendations for preservation on analyses on HEPData by the LHC experiments

LHC Electroweak Working group

9th September 2019

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3 Scenarios for re-interpretation

- Identify different levels of recommendations, depending on the analysis type and how re-interpretable it needs to be:

Scenario A - Maximum Re-interpretability

Scenario B - Approximate Re-interpretability

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Best case - aims to provide maximal information for reinterpretations.
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Bare minimum for a search to be re-interpretable

- **For precision analyses:** for future combinations, measurements of SM parameters, PDF fitting... Enough info for exact combination
- **Phase space definition: Rivet analysis** must be provided
 - If results only at detector level, Rivet analysis should still be provided, with adequate smearing and efficiency tables
- **Stat correlations: Bootstrap Replicas** attached to HEPData entry
- **Syst correlations uncertainty breakdown,** = effect of each NP on each bin
-> can convert to cov matrix + correlate w/ other measurements
- **Background:** include **SM prediction from latest MC generators** w/ breakdown of theory uncertainty if possible
- If likelihood fit used: **post-fit values of the NPs in each bin**

- **For standard measurements or searches** to be re-interpreted approximately. E.g generator tuning , and recasting of searches
- **Phase space definition: Rivet analysis** must be provided
 - If results only at detector level, Rivet analysis should still be provided, with adequate smearing and efficiency tables
- **Statistical correlations: correlation matrices.** *Can't infer corrs between analyses, but OK if re-interpreting result in isolation*
- **Systematic correlations: uncertainty breakdown,** = effect of each NP on each bin -> cov matrix + correlate w/ other measurements
 - OR, cov matrix for each distribution: e.g. for simplified likelihoods
- **Background:** include **SM prediction from latest MC generators** w/ breakdown of theory uncertainty if possible

- **Minimum amount of info** for result to be re-used meaningfully.
e.g if **only rough estimate of MC/data agreement or sensitivity to new models** needed
- **Phase Space Definition**: Ideally, **Rivet routine...** if not...
 - **detailed description of the region of interest**
 - **per-object efficiency tables**
 - **explicit definitions of each variable used in the selection,**
 - **cutflows of the effect of each selection** on well-defined signals
- **Statistical correlations**: omitted if negligible bin migrations.
Stat error per bin still needed (assumed uncorrelated between bins)
- **Systematic correlations**: **uncert breakdown** or explicit cov matrices
- **Background**: **SM bkg prediction of MC generators**, w/ breakdown of theory uncertainty if possible

Feedback from Experiments so far...



- Possibility to include directly the Likelihood in the `pyhf` framework. Potentially more powerful than uncertainty breakdown ?
- Should we be considering “industry-standard” data types like Pandas?
- Relationship of HEPData+Rivet vs RECAST ?
- Will the TH*DBootstrap classes (currently ATLAS-only) be made public (*yes, ATLAS Pub note to accompany public git repo in the new year*)
- Are SM predictions always necessary (eg LHCb?)
- Analysis contacts uploading HEPData entries need to ensure that the uncertainty breakdowns are reviewed by the collaboration before being made public -> include in supplemental/aux material
- Could we include BDT xml files on HEPData in the case of ML techniques ?
- Give links to examples of HEPdata routines where things have been done well (show best practice!)

- What additional info is needed to achieve our global fit/re-interp goals?
- LHC EW WG is reviewing recommendations for HEPData to answer these questions. Recommendations document in preparation...
- Recent developments are excellent opportunity to review status and see what we can do better
--> maximise impact of our measurements and searches !
- In particular, we should be more diligent about:
 - preserving analysis logic in Rivet routines in a timely manner
 - preserving correlations between bins (stat, syst)
 - including state of the art SM predictions in HEPData
- Next steps: experiments to try to use the recommendations doc to review their internal practices: so that everyone is on the same page.
 - ATLAS have already started this process.

Backup