Summary of LHC EWWG discussion on HEPData recommendations

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Talk to ALICE collaboration, 20 Jan 2020

Who am I?

- Post-doc at University College London, member of ATLAS collaboration
  - Previously at Imperial College, member of CMS between 2013-2017
  - Co-convener for the ATLAS Generator Infrastructure and Tools subgroup of the Physics Modelling Group
- Giving this talk on behalf of the LHC Electroweak Working Group (Jets +Bosons):
  - We have been discussing how to propagate correlations and use them for tuning etc
  - Naturally lead to discussion on reviewing and agreeing conventions for HEPData uploads across experiments
  - Spoke to ATLAS/CMS/LHCb SM/Generators groups already : recommendations well received !

Context

- Analysis preservation is increasingly important discussion in HEP
  - (in pp) new and ambitious goals of combinations, recasting, EFT fits etc...
  - many recommendations also apply to heavy ions too!
- Are we routinely storing enough information on HEPData to efficiently re-use the measurements we make at the LHC?

  --> Not always! **small policy shifts can boost impact of analyses**

- Prompted by discussion on correlations, **LHCEWWG**: Dec 18, Feb 19, July 19

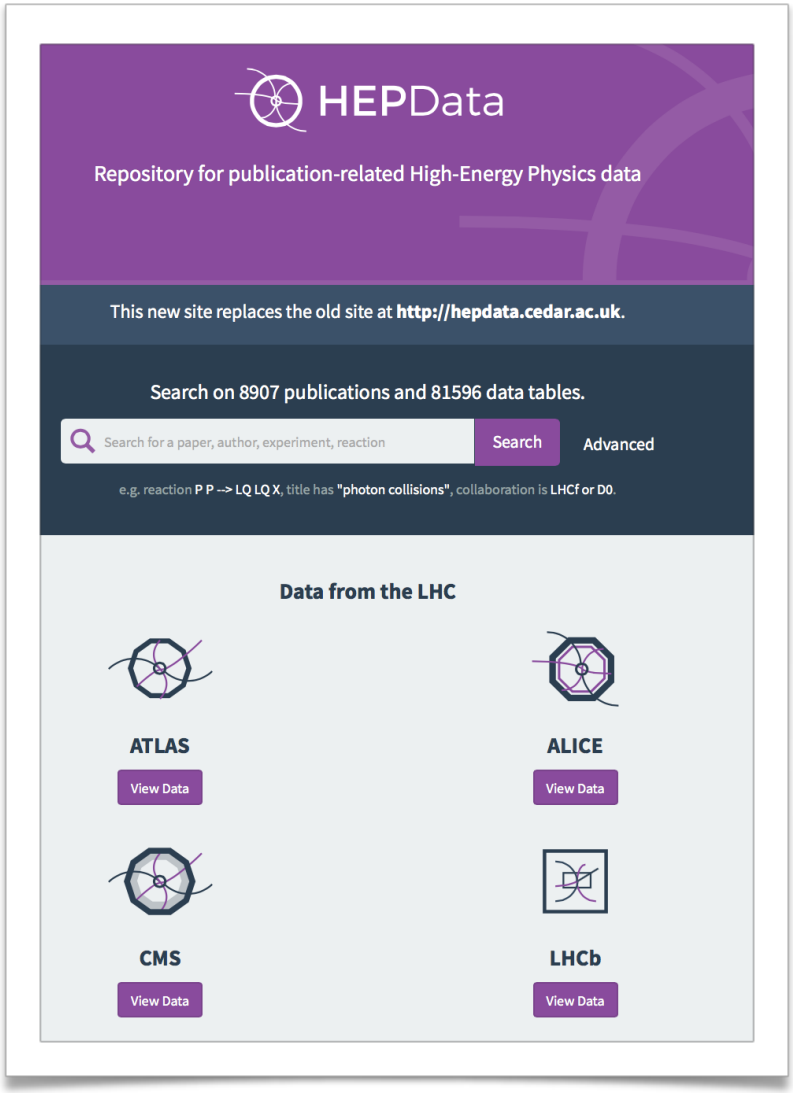
- Attempt to **formalise recommendations** and **document them in** note **to be agreed <u>between LHC experiments</u>**
  - Give **<u>recommendations on conventions to follow</u>** depending on what level of re-interpretation is needed

Caveat

- I'm not a heavy ions expert, so I apologise if some of the recommendations I'll talk about today are not relevant to you!
- The purpose of this talk is also to gather feedback:
  - If you have suggestions or comments about what is/is not applicable to heavy ions, I'll be very grateful!
  - That way we can make this document useful for the heavy ion community as well as p-p

What are the current recommendations?

In this section I'll highlight some of the pitfalls of the current ALICE HEPdata uploads..



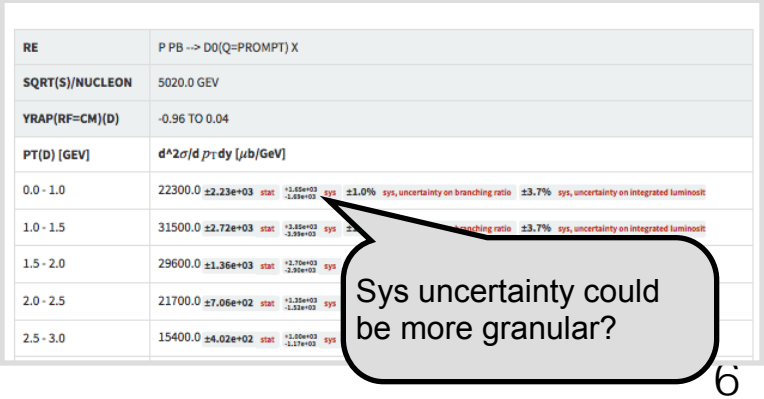
Existing practice

- Good practice to define fiducial volume/ region of measurement (eg **Rivet Routine**)
  - This was only present in one HEPData entry I could find...
  - But hopefully recent release of Rivet 3.0.1 (many Heavy-Ion developments!) will help improve the situation?

- Give results with uncertainties in each bin. Separate stat vs syst uncertainties at minimum. Stat/syst not enough to model correlations if re-interpretation is to be trusted!

π^0 and η production at 8 TeV pp [link] but there are very few others with Rivet Routines

Measurement of D0, D+, D*+ and D+S production in Pb Pb [link]



RE	P PB --> D0(Q=PROMPT) X
SQRT(S)/NUCLEON	5020.0 GEV
YRAP(RF=CM)(D)	-0.96 TO 0.04
PT(D) [GEV]	d^2σ/d $p_T$dy [μb/GeV]
0.0 - 1.0	22300.0 ±2.23e+03 stat +1.65e+03 -1.63e+03 sys ±1.0% sys, uncertainty on branching ratio ±3.7% sys, uncertainty on integrated luminosit
1.0 - 1.5	31500.0 ±2.72e+03 stat +1.85e+03 -3.99e+03 sys ±3 ...ranching ratio ±3.7% sys, uncertainty on integrated luminosit
1.5 - 2.0	29600.0 ±1.36e+03 stat +2.70e+03 -2.90e+03 sys
2.0 - 2.5	21700.0 ±7.06e+02 stat +1.35e+03 -1.32e+03 sys
2.5 - 3.0	15400.0 ±4.02e+02 stat +1.00e+03 -1.17e+03 sys

Sys uncertainty could be more granular?

Existing practice

- If strong correlations... 2 options:
  a) explicit covariance or correlation matrix OK only if measurement never intended to be combined with other measurements.
  I didn't see any examples of covariance matrices in the ALICE entries

- b) give breakdown of signed(!) effect of each NP. Can then rebuild covariance matrix if each uncertainty is defined as correlated/uncorrelated

- Prefer to use b) since a) implicitly symmetrizes, and information to correlate with other measurements is insufficient.

Charged-particle production as a function of multiplicity and transverse spherocity [link]

SQRT(S)	13 TEV		
ETARAP	-0.8 - 0.8		
RE	P P --> CHARGED X		
pT [GEV/C]	**d^2N/dEtadpT [C/GEV (X')]**	**d^2N/dEtadpT [C/GEV (IX')]**	**d^2N/dEtadpT [C/GEV (VIII')]**
0.15 - 0.2	4.446e+00 ±3.247e-03 stat ±3.116e-01 sys,total ±2.916e-01 sys,uncorrelated	8.091e+00 ±5.746e-03 stat ±2.353e-01 sys,total ±1.618e-01 sys,uncorrelated	1.082e+01 ±9.454e-03 stat ±3.251e-01 sys,total ±2.164e-01 sys,uncorrelated

- Statistical correlations as correlation matrix. Bootstrap Replicas (see backup) best for future combinations but need make TH*DBootstrap code public [Overkill in the ALICE case?]

Proposed LHC-wide HEPData Recommendations

Public note to be agreed between expts

Defines 3 scenarios for levels of information to provide on HEPData

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

Currently still a draft, iterating with LHCEWWG conveners

Recomendations for preservation on analyses on HEPData by the LHC experiments

LHC Electoweak Working group

24th October 2019

Contents

3 Scenarios for re-interpretation

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

3.1 Scenario A - Maximum Re-interpretability
3.2 Scenario B - Approximate Re-interpretability
3.3 Scenario C - Minimum Requirements for Analysis Preservation
3.4 Results which cannot be re-interpreted

Best case - aims to provide maximal information for reinterpretations. Should be gold standard for precision measurements

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Bare minimum for a search to be re-interpretable

C - Bare Minimum

- **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

- **Analysis logic preservation**: 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 *[N/A for Heavy Ions yet?]*

B - Approximate Re-interpretability

- For standard measurements or searches to be **re-interpreted approximately**. E.g **generator tuning ,** and **recasting of searches**

- **Analysis logic preservation**: **Rivet analysis** must be provided **at the same time as the preprint !**
  - 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 *[N/A for Heavy Ions yet?]*

A - Maximum Re-interpretability

- **For precision analyses**: for **future combinations**, **measurements of SM parameters, PDF fitting...** Enough info for exact combination

- **Analysis logic preservation**: **Rivet analysis** must be provided **at the same time as the preprint !**
  - 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 -> cov matrix + correlate w/ other measurements
- **Background**: include **SM prediction from latest MC generators** w/ breakdown of theory uncertainty if possible *[N/A for Heavy Ions yet?]*
- If likelihood fit used: **post-fit values of the NPs in each bin**

Summary

- LHC EW WG is reviewing recommendations for HEPData. Recommendations document in preparation...

- Recent developments are excellent opportunity to review status and see what we can do better
  --> **maximise impact** of our measurements
  --> **Agree conventions across experiments**!

- In particular:
  - we should be more diligent about **preserving analysis logic/fiducial volume in e.g. Rivet routines**
  - we should be careful to **give full uncertainty breakdown** instead of just stat vs syst
  - we should **provide SM generator predictions** in the HEPData entry if possible *[N/A for Heavy Ions yet?]*

Summary

- LHC FW WG is reviewing recommendations for HEPData
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Comments and feedback are very very welcome !

Backup

The Bootstrap Method

- Bootstrap histograms: like regular histograms, but each time histogram is filled, a certain number (normally ~ 1000) of replicas are also filled, where the filled weight is varied according to a random weight drawn from a Poisson distribution.
- The random number seed is set uniquely by the run and event number of the event in question. -> statistical uncertainty and correlations can be correctly evaluated when combining results between different analyses, from the same or different collaborations.
- The replicas can be attached to the additional material of the HEPData entry. This has been done for example here:
  https://www.hepdata. net/record/ins1604271
  https:// www.hepdata.net/record/ins1604271
- Root extension for these classes exists in ATLAS: we are working to make this code public!