Reinterpretation enhancements in Rivet v4

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LHC Reinterpretation WG, CERN
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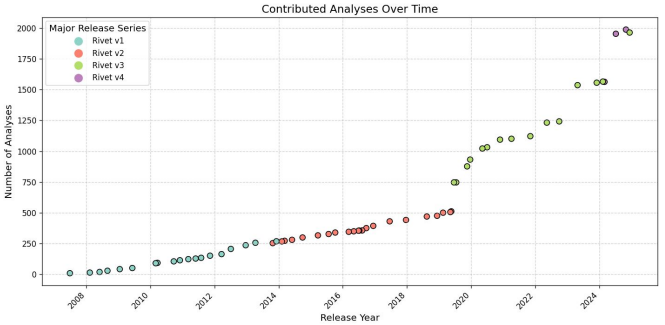
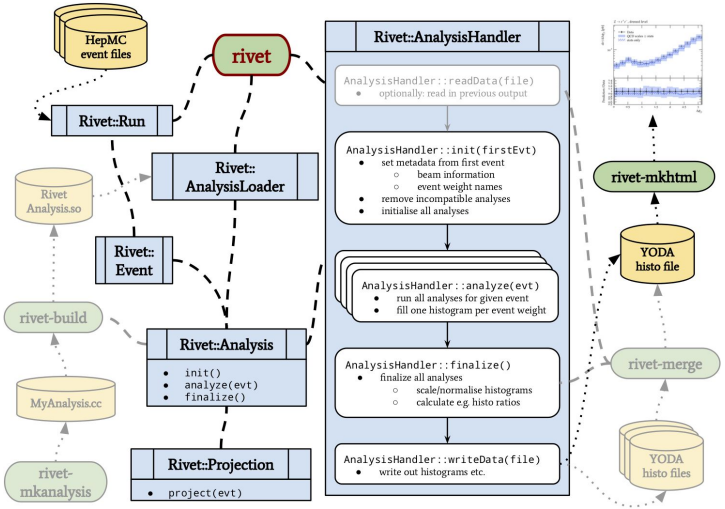
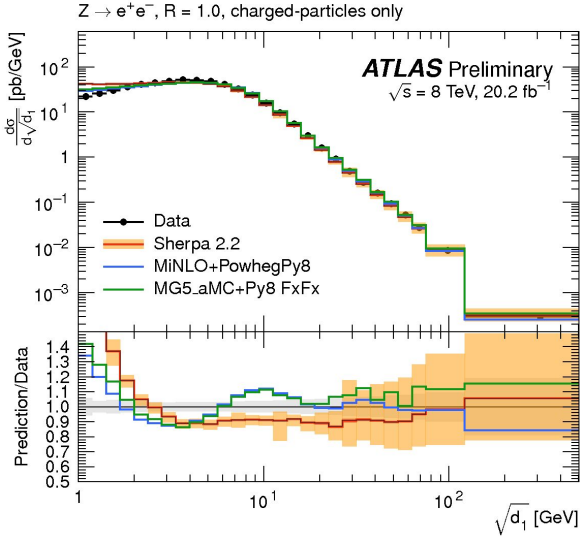
Rivet

- **Standard public analysis framework for LHC "measurement physics"**
  - C++ core, Python command-line tools & plotting
  - HEPData integration, auto systematics weights
  - Automatic computation caching with *projections*
  - ***2000+* analyses!**

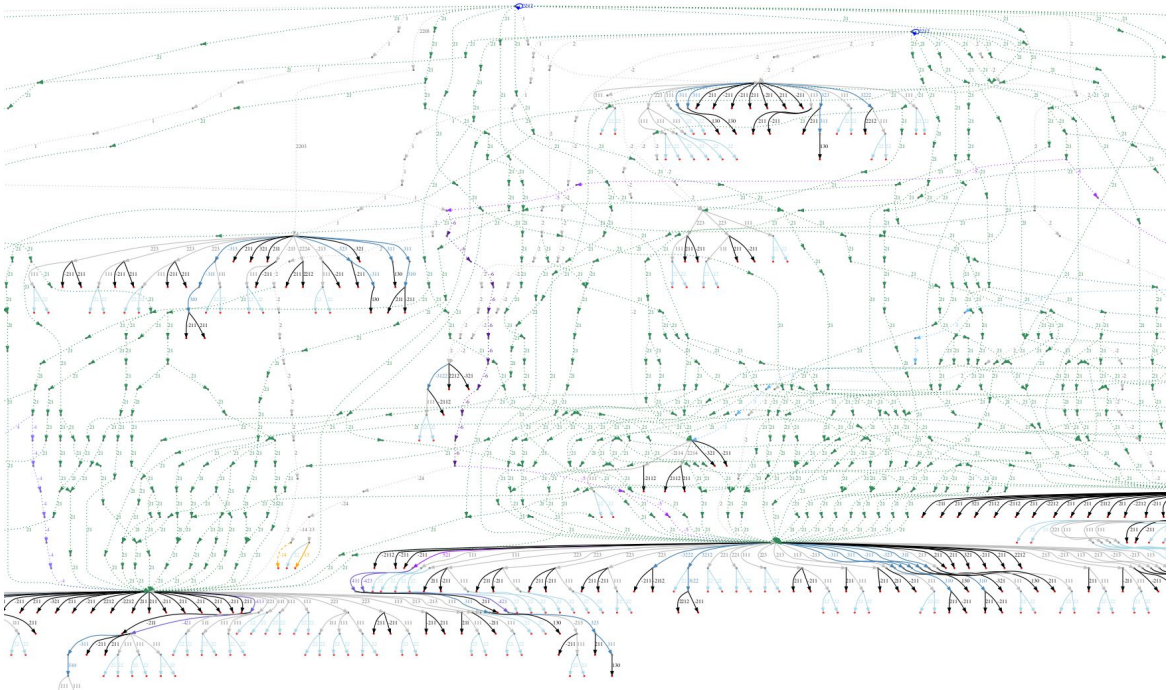






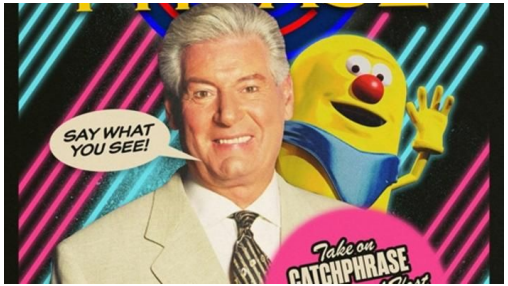
Inside Rivet

- Put simply, Rivet replicates the experiments' event analysis on "truth" MC.



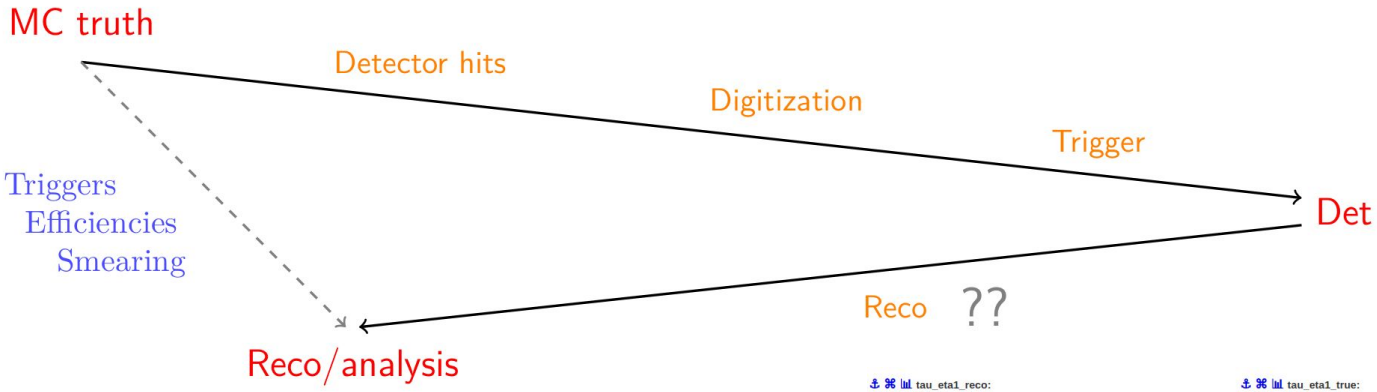
MC event graphs are complex, and full of pitfalls! So we put the expertise and standard methods in one place.

In particular, minimise "cheating": analyse based on *fiducial* final state:

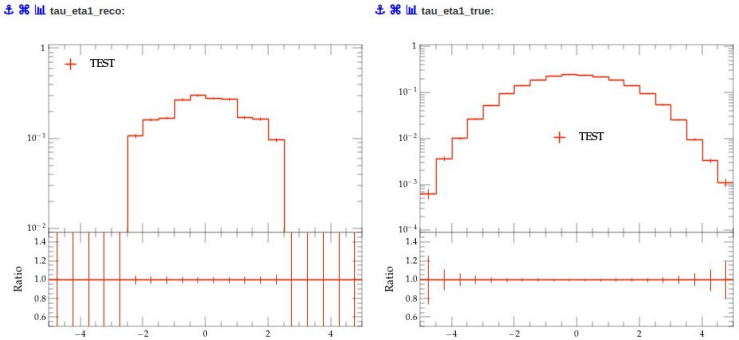


Detector emulation

- Rivet's reputation is for unfolded analyses (and as engine of Contur), but it has had "detector smearing" since 2017! Integrated with projections, justified by small effects

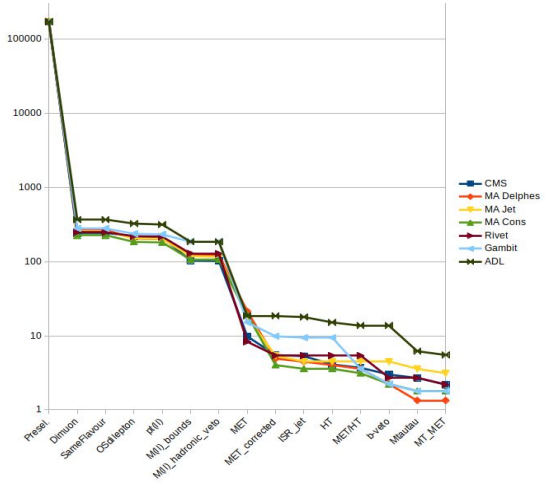


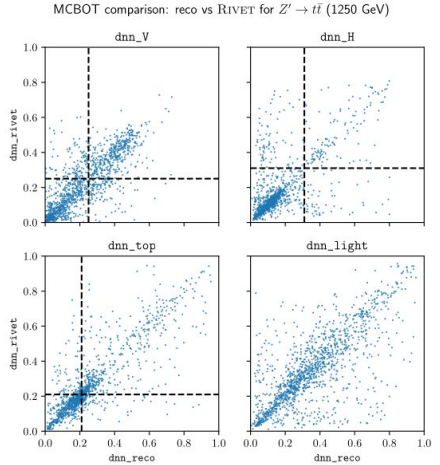
- capture key efficiencies and resolutions like Delphes, but analysis-specific
- flexibility allows detail like jet-substructure smearing, systematics studies, whatever…



Reco-level search recasting

- **Lots of activity in reinterpretations of BSM-search analyses with detector emulation**
  - efficient scaling-up to hundreds of analyses
  - phase-space-specific detector/efficiency functions (or Delphes cards) found necessary
- **Precision maybe 10%-20%**
  - on fast-falling spectra, small effect on CL's
  - sufficient to highlight regions of interest in new models ⇒ point experiments to re-test
- **Machine-learning classifiers** can be used via ONNX Runtime and a simple `getONNX()` function
  - not always necessary: tagging algs can be parametrised, maybe MC-level NN
  - object robustness / truth equivalence matters

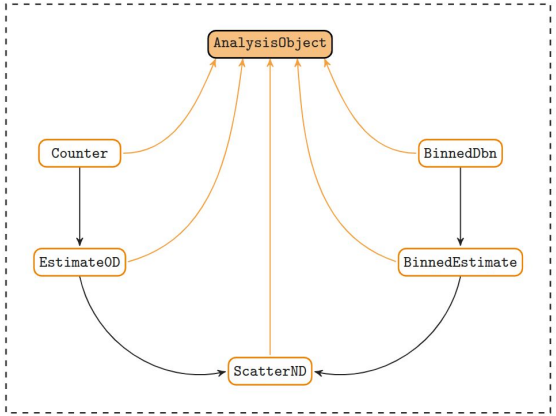




from Tomasz Procter

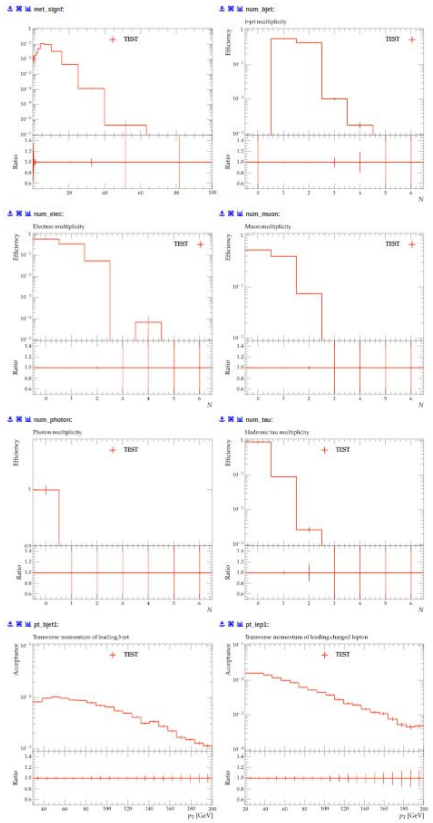
Enhancements in Rivet v4

- YODA2 — consistent differential histogramming
  - Arbitrary dimensionalities, high-dim overflows, and all mixes of continuous/discrete binning variables
  - Coherent scheme for reducing “live” to “inert” objects: implemented in HEPData output ⇒ ideal MC/data match
- HPC enhancements:
  - YODA objects and Rivet runs can be serialised across MPI
- Jet trimming and reclustering helpers:
  - `trimJetsFrac(jets["smallRJets"], 0.1)`
  - `reclusterJets<JetAlg::VARIABLER>(jets["smallRJets"], filter, ...)`
- Arbitrary HDF5 analysis aux data: `auxData(dsname)`
- MET significance: rework smearing functors
  - Rivet smearing is customisable via `Jet→Jet`, `Particle→Particle`, etc. functions
  - MET smearing split by params calculation vs smear-sampling ⇒ MET signf possible
- And a new simplified analysis interface…



Rivet “search analysis” API (in version 4.1.0, imminently)

- Provide an interface more similar to experiment/search-recast tools
  ⇒ reduce barriers to uptake/usage
  - ➢ Much of the projections-centric default Rivet interface is for precision-measurement full-detail control of object definitions
  - ➢ Search teams are more used to predefined collections, and the analyses are less sensitive to the detail…
  - ➢ So Rivet’s new SimpleAnalysis API provides pre-made objects
    ⇒ no projection setup, just call `electrons(), jets("AK4")`, etc.
  - ➢ Similarly, just call `met()/GeV, metSignf()` functions
- New consistent “families” of smearing functions, e.g. one-call `setDetSmearing(ATLAS_RUN2, MV2C20)` enables *all* `ATLAS_RUN2` resolutions & efficiencies, for all leptons, jet, MET, taggings, etc.
- Simple & generic overlap-removal recipe: `doSimpleOverlapRemoval();`
- All configurable… and “normal” Rivet power is always available



Summary

- **Despite reputation, Rivet isn't just for unfolded measurements! It includes powerful detector smearing**
  - Experiment and pheno search-analysis submissions very welcome
  - We're also happy to extend and improve: get in touch
- **Rivet version 4.0** added simple mechanisms to use ONNX, LWTNN, aux data, powerful and flexible YODA2 stats, and MPI serialisation
- **Rivet 4.1 is imminent: focus on features to help the search analyses preserve cf. the ~2000 measurements**
  - New, simplified analysis interface with predefined reco-level particle and jet collections, MET, etc. cf. ATLAS SimpleAnalysis / MA5 simple
  - MET smearing-function refactor allows MET-significance estimation
  - Jet reclustering was awkward, now trivial!
- **Please use it / get in touch!**