

OpenMAPP activity and progress

e-infrastructure for HEP meta-analysis and reinterpretation

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for the
OpenMAPP collaboration

LHC BSM WG Reinterpretation subgroup
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OpenMAPP



University
of Glasgow

Outline

- ❖ **What is OpenMAPP?**
 - Work packages and tasks
- ❖ **The analysis-data and logic ecosystem**
- ❖ **Analysis combination**
- ❖ **Projects**
 - HEPData, CERN/DataCite DOIs
 - Rivet and Contur, CheckMATE, MadAnalysis, HackAnalysis, ColliderBit, SModelS, ADL, ...
 - Interfacing to HS3, Spey, ...
- ❖ **Outlook**

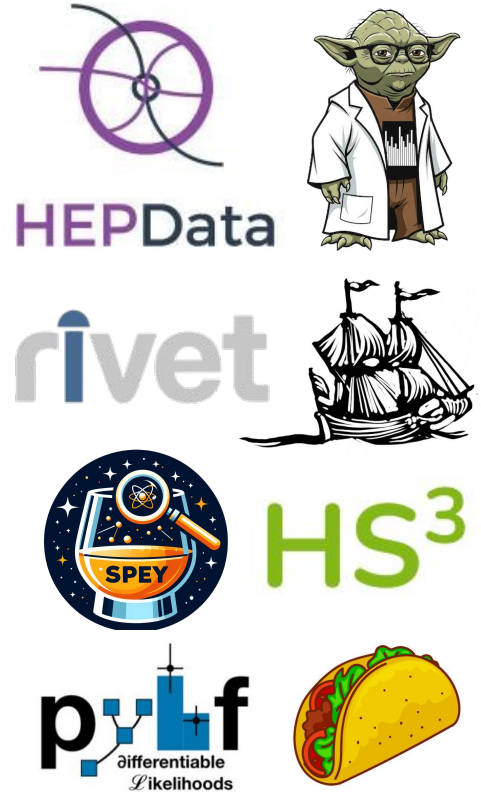


Open**MAPP**



MC reinterpretation tools

- ❖ A “market” of tools to reinterpret MC has sprung up
- ❖ **HEPData** as main data source
 - Mainly numerical “**primary data**”, i.e. histograms, event counts, errors & correlations
 - Less structured storage of auxiliary files ⇒ increasingly semantics-aware, e.g. queryable tools
- ❖ “Full” REANA/RECAST or open data not the focus
 - Most current recast impact via **lightweight** re-analysis
 - **Rivet**, **MadAnalysis**, **CheckMATE**, **GAMBIT**, **HackAnalysis**
 - ⇒ **SModelS**, **Contur**, etc. likelihood interpretations
- ❖ **Statistical models**: **pyhf**, **Spey**, **HS3**, **YODA**, **TACO**...
- ❖ **Can we combine these tools’ different strengths?**



Where OpenMAPP comes in

- ❖ **Reinterpretation doesn't just need good intentions: also infrastructure, coordination, and technical standards**
- ❖ [OpenMAPP](#) = UK-France-Poland-Turkey project, funded 2024-2027 by CHIST-ERA international e-infrastructure grant
- ❖ Teams representing/connected to most lightweight reinterpretation frameworks + ATLAS, CMS and theory
- ❖ Main work packages / tasks:
 - **WP1:** discoverability — linking tools and databases
 - **WP2:** interoperability — common inputs and outputs
 - **WP3:** combination — unified physics inference
- ❖ **Project RAs and students (finally) fully recruited!** Meetings and collaboration, e.g. [Oct workshop](#) ⇒ **I'll report on year #1**



Open**MAPP**



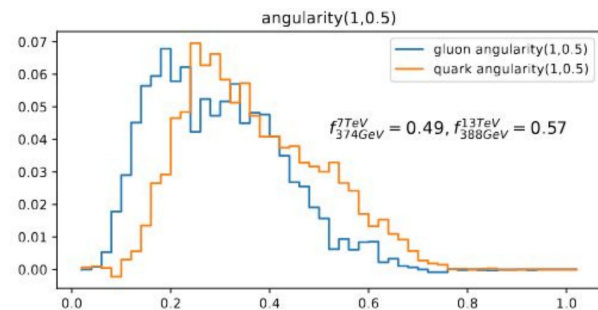
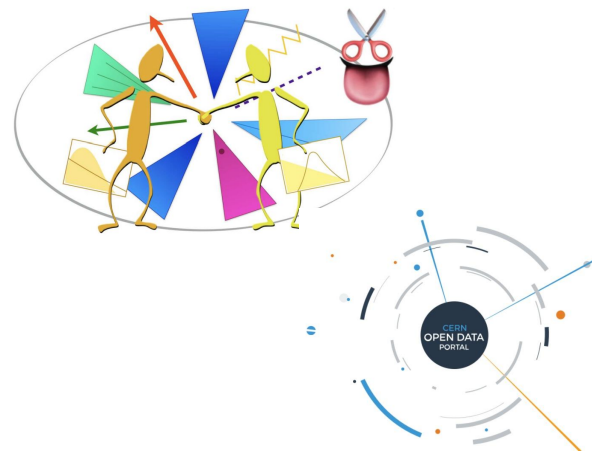
WP1: discoverability

- ❖ **Plethora of independent toolkits**, with **differing emphases/philosophies**. No mass rewrite!
 - But we can **better join the dots between them**, making reinterpretation data **FAIRer**
- ❖ **Common JSON schema** for [analysis declaration](#). Read and reported by HEPData from standard URLs on reint-tool websites
- ❖ **Re-analysis DOI schema** via CERN's DataCite account
 - ⇒ reliable URL endpoints for (versioned) analysis-implementation linking and citation
- ❖ **Enhanced HD metadata** ⇒ [data-table/column semantic roles](#)
- ❖ **HEPData JSON** from query API: should be able to receive structured data as an interrogable return format from a query URL, cf. InspireHEP. **ElasticSearch integration needed... cp from Inspire?**



WP1: discoverability

- ❖ **Contur & HEPData** leading storage of **theory estimates**, especially expensive precision SM: **bidirectional linking**
 - Need an Inspire ID for a theory publication to back-link to expt record: a sane requirement!
- ❖ **ADL/CutLang declarative analysis:**
 - New **script** to retrieve HEPData tables for counts, cutflows and efficiencies, and convert to ADL
 - > 80% efficiency compatibility with HD seen
 - **ADL public database being established**
- ❖ Also in WP1, use of open data:
 - Rivet/CheckMATE TACO using ATLAS open MC
 - And use of **CMS open data for SM jet studies** ⇒
 - **Building mini/reco-HepMC's from CMS open MC?**



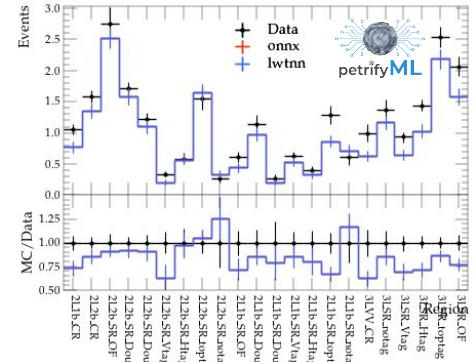
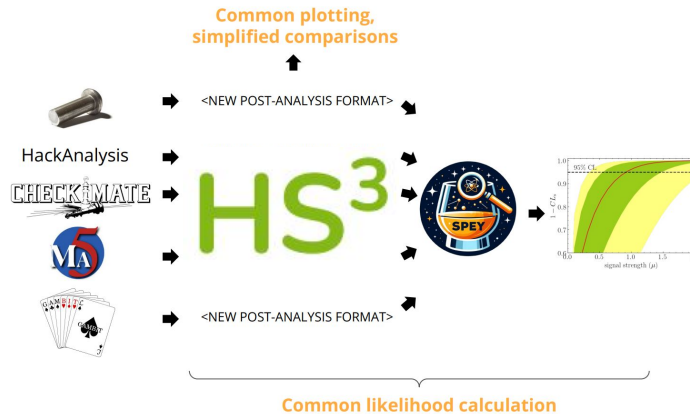
WP2: interoperability

- ❖ **Petrify-ML:** extensions and [release note](#) for ML preservation
 - [Python package](#) converts BDTs & NNs→ONNX or standalone code. Preserves + minimises dependencies
 - ML interfaces, e.g. ONNXRuntime in packages

- ❖ **Common framework steering?**

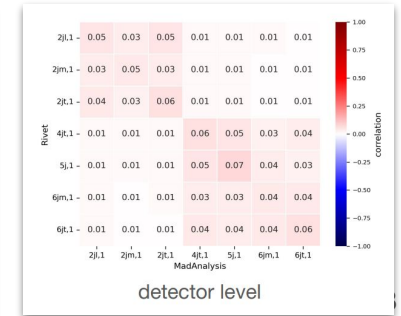
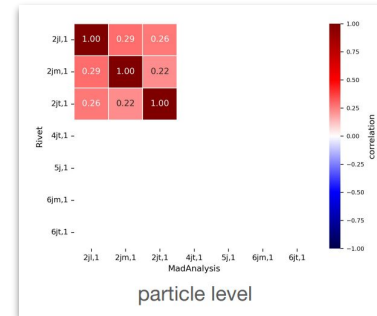
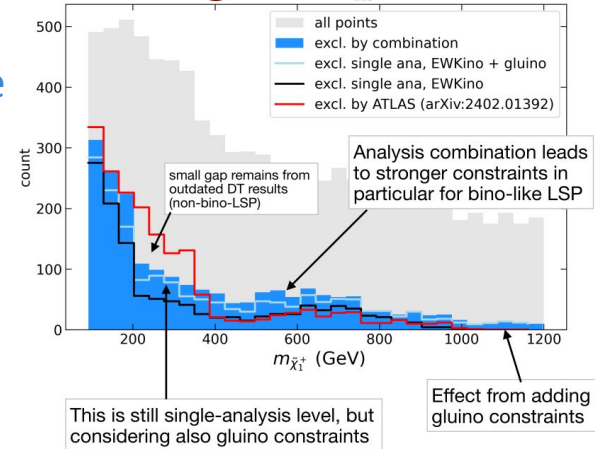
- **EM creator:** extend from SModelS to a general workflow: MG, Pythia, Delphes, CutLang, (Rivet) steps prototyped
- Common internal format: **HS3?**

“Non-partisan”, ideal for integration with likelihoods. Extension needed for full HEPData data-uncertainties?



WP3: combination

- ❖ Correlations are key info for reinterpretation
 - At absolute minimum, **need programmatically actionable binary information about (non-)overlaps**
- ❖ And perhaps much more, e.g. TACO method used in SModelS, e.g. **recent pMSSM reinterpretation**
 - Uses event correlations to estimate Pearson correlations between SRs \Rightarrow optimal non-overlapping combinations.
 - Reint tools (MA, Rivet, CheckMATE, ...) adapted to output event-by-event bin-population data
- ❖ Realised that **random-sampling approach to detector efficiencies accidentally decorrelates** (and can artificially correlate, too!)
 - Studies (re)starting to understand if this effect can be offset, or minimised



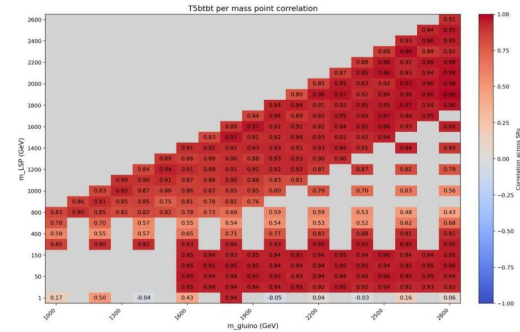
WP3: combination

❖ ADL correlations studied for HEPData integration: generally >80% consistency with published acceptances

❖ ADL and ColliderBit both have syntaxes to define SRs, e.g.

- `=2L + 0SSF + 1DY + >=2J + MET + MT2` : exactly two leptons (e/mu) in an opposite-sign, same-flavour pair, consistent with Drell-Yan gamma or Z poles, at least two jets, and requiring large missing momentum and stransverse mass;
- `2L + !DY + >=2J + MET + !MJJ` : exactly two e/mu, not from Drell-Yan dilepton masses if same-flavour, at least two jets, significant missing momentum, small dijet mass;
- `=1L + 2B + !TH + MET + MT + H` : exactly one e/mu, exactly two b-jets, no hadronic taus, significant MET and transverse mass, event compatible with a Higgs;
- `>=2SSL + >=2B + >=6J + MET` : at least two same-sign lepton pairs, at least two b-jets, at least 6 jets, and significant missing momentum.

- Can static analysis flag “missing” topologies?
- ADL team working on Unsloth LLM to train for both overlap studies and ADL generation from paper text
- Gambit: more analytic approach with set intersections and graph hierarchy building



Summary / outlook

- ❖ Many grassroots reinterpretation efforts ⇒ significant BSM-pheno impact, from searches and measurements
- ❖ Slowing of data and significance gains ⇒ combination of all available analyses and tools is essential
 - Also aligns with key sustainability goals like preserving analysis logic in a publicly usable form... beyond open data
 - Remember: sustainability ⇒ reinvestment!
- ❖ **OpenMAPP** joins the main public reinter toolkits together in working on common e-infrastructure and methods
 - for preservation of reusable analysis logic, and linking tools and data for reinterpretation
 - admin-delayed start-up, but the project is making good progress and deploying developments. Watch for more!



OpenMAPP

Backup...

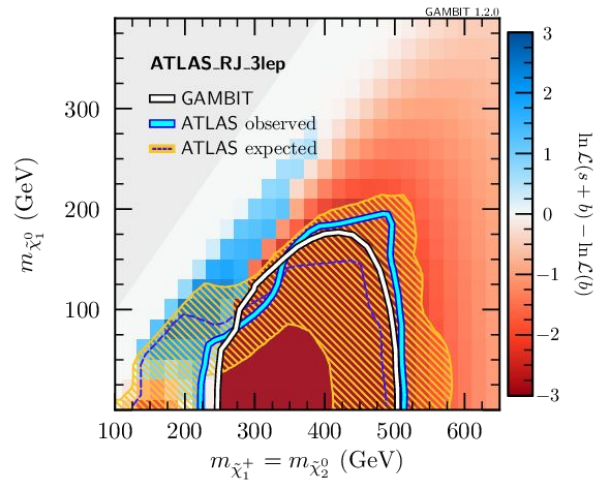
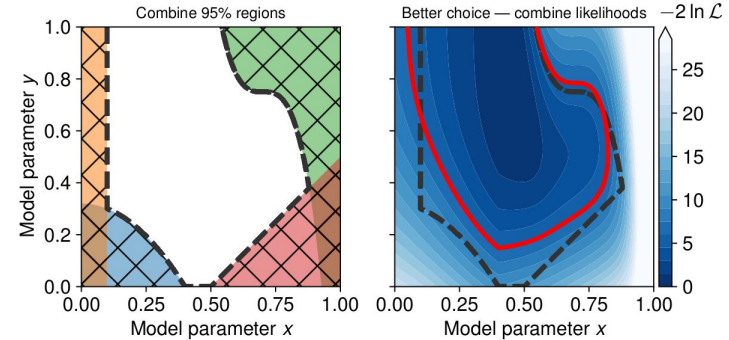
Composite likelihoods & computational tools

❖ Composite likelihoods are essential

- Exclusion overlays misrepresent, and restrict to specific, few-param models: need to combine analyses coherently

❖ Marketplace of (public) tools for all aspects

- **Event generation:** UFO + MG5/Sherpa/Herwig/Pythia/...
- **Detector emulation:** Delphes/Rivet/MA5/ColliderBit fast-sims
- **Analysis:** Rivet, MadAnalysis5, ColliderBit, CheckMATE (different current emphases re. search, measurement, LLPs)
- **Likelihood evaluation:** above, plus Contur, SModelS
- **(Global) fits / param scanners:** Gambit, MasterCode, SFitter, HEPfit, SMEFIT, Contur, EFTfitter, ...



Independent signals

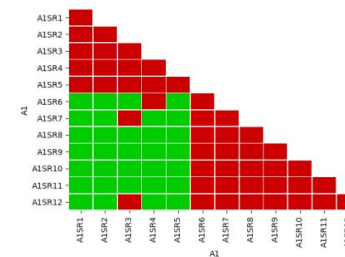
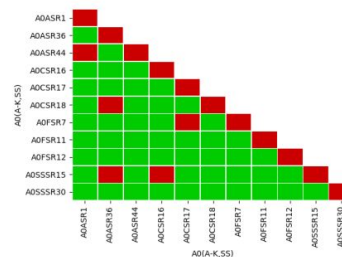
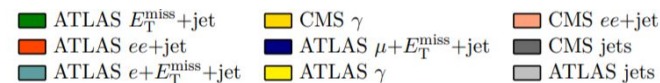
❖ Much of Contur's power comes from signature coverage

➤ Whatever your topology, chances are there's a measurement sensitive to it. For some models, one is already enough!

➤ But these observables are not optimised to any BSM model \Rightarrow typically weaker than a dedicated (model-specific) search

Secondary power comes from combination

➤ Need to know which analyses are independent and can be trivially combined \Rightarrow group analyses in statistically orthogonal "pools". Use (expected) most-constraining pool element for setting limits; correlation data \rightarrow "bigger elements" than single bins



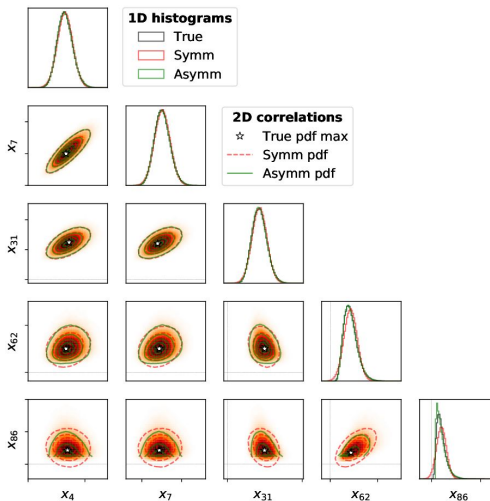
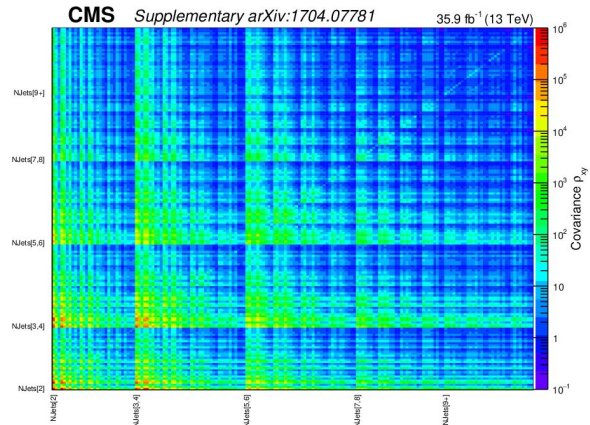
➤ More refined ideas possible for assessing orthogonality and correlation: TACO, later

Correlations

❖ Correlations are critical for correct combination

- From: modelling systematics, experiment systematics, statistics, *event-sharing*
- Without correlation knowledge, can only safely use one bin from each “analysis pool”: a waste of composite power
- Also important to stabilise fits: “flip-flopping”

RE	P P --> JETS
COS PHI	TEEC
-1 - -0.96	10.5165 ±0.00779481 stat +0.0117651 sys,jesNp1 +0.0034308 sys,jesNp2 + 71 more errors Show all -0.0113337
-0.96 - -0.92	0.716955 ±0.00468718 stat +0.00357606 sys,jesNp1 +0.00165822 sys,jesNp2 + 71 more errors Show all -0.00426249 -0.00199598
-0.92 - -0.88	0.322052 ±0.00299636 stat +0.00184137 sys,jesNp1 +0.000934961 sys,jesNp2 + 71 more errors Show all -0.00189796 -0.00104189

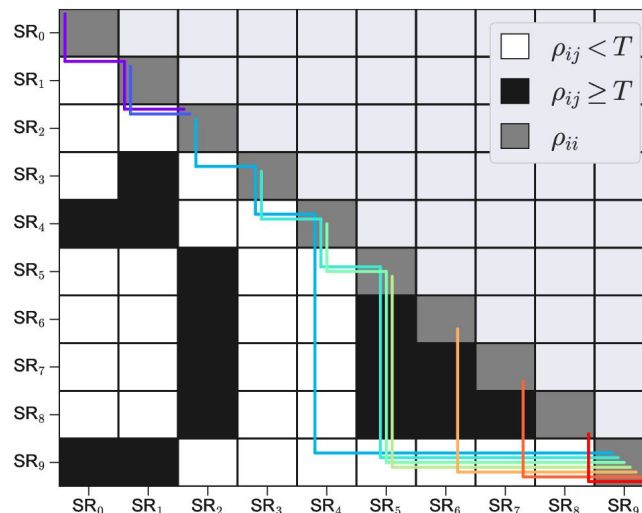
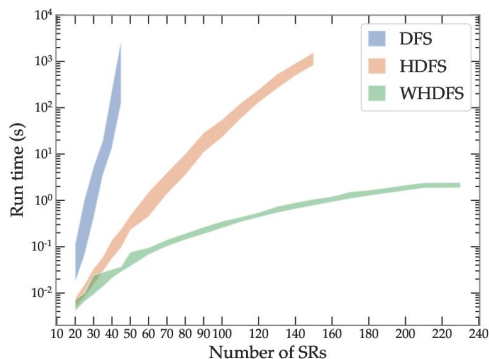


Maximum-info reinterpretations: TACO



❖ How can we identify measurement pools?

- Can't allow double-counting: statistical fluctuations could get multiplied and seem important / kill models
- Can we do better than Contur's manual analysis pools?
- Actually, we'd rather group at bin-level, and *for every physics model point we test*, identify the strategically best non-overlapping set of measurement bins
- This is what TACO does! Dynamic max-info combinations based on expected exclusion power.
- Nifty graph-based algorithm, too!



Finding max-length paths through this *overlap matrix* defines an optimal combination strategy