

Assessing the  
**correlation**  
between  
**MadAnalysis and Rivet**  
implementations

Reinterpretation Forum Workshop 2025



University  
of Glasgow



OpenMAPP

Martin Habedank  
27th February 2025

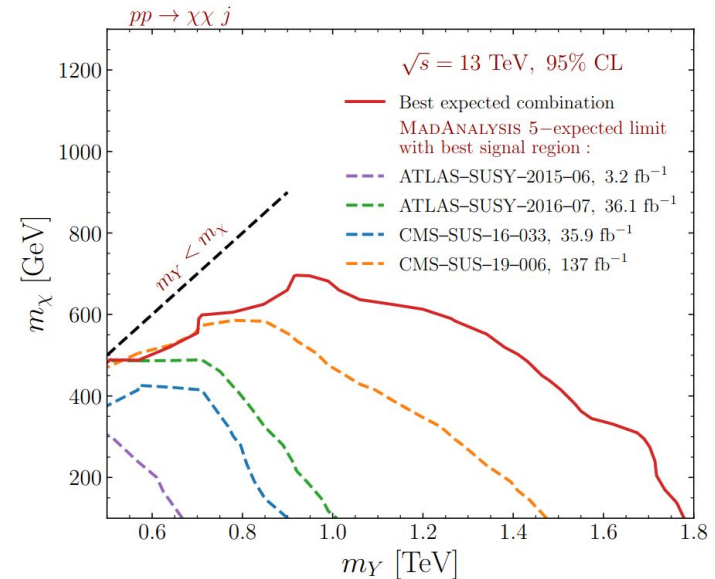
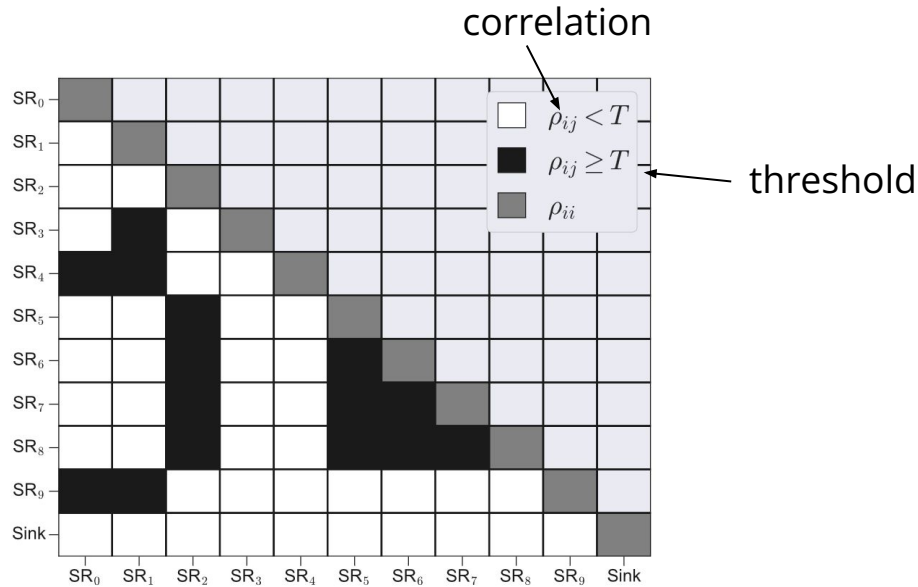


**H E A L T H**

**A D V I S O R Y**

**The following expresses my very own perspectives from a pheno point of view.**

- Cross-validation between implementations of analyses in different tools
- → Contur uses manual separation into orthogonal pools by e.g. multiplicity
- TACO method: → SciPost Phys. 14, 077 (2023)
  - Statistically combined multiple → MadAnalysis/→ SModelS analyses





## REI WG – plans and action items (2/2)

- \* Enhance visibility and recognition for auxiliary material provision  
→ [RAMP seminars](#), ideally in active collaboration with the other WGs. *[organisers needed]*
- \* Generally interact with other LPCC WGs, be as transversal a group as possible, have [joint sessions](#) in addition to [generic REI workshops](#).  
(frequency of meetings t.b.d.)
- \* On the pheno side, provide [active feedback](#) to the experiments.
- \* Work on [interoperability](#) of tools.

→ Sabine Kraml @ Mon (LHC BSM WG)

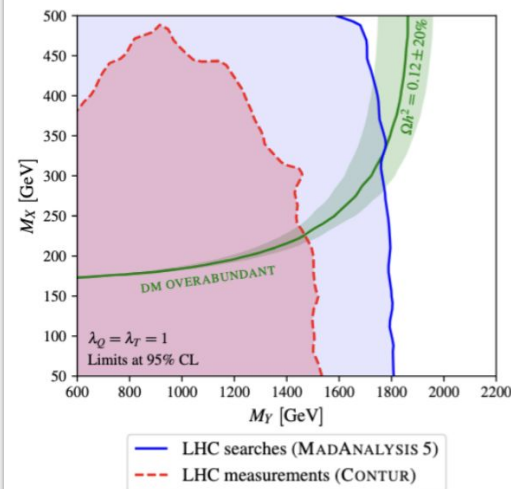
▶ Run events against all searches/measurements implemented in

- ▶ MadAnalysis5 v1.9.60
- ▶ CheckMATE v2.0.34
- ▶ Rivet v3.1.5/Contur v2.2.1

and calculate cross section  $\sigma_{95}$  needed to exclude the events at 95% CL

→ Manuel Kunkel @ Tue

95% CONTUR exclusion and MA5 exclusion



→ Clarisse Prat @ Tue



## Correlation/ Overlap



→ MadAnalysis



→ Rivet

# The case

# How to find a suitable analysis for the study

Martin Habedank

7



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analysis:Rivet AND analysis:MadAnalysis

Search

Reset search

Advanced

JSON

Max results ▾ Sort by ▾ Reverse order ▾

Showing 2 of 2 results

Date



« 1 »

Collaboration

ATLAS 1  
CMS 1

Subject\_areas

hep-ex 2

Phrases

Supersymmetry 2  
Inclusive 1  
Proton-Proton Scattering 1  
SUSY 1  
hadronic 1

[Next 5](#) [Show 7](#)

Reactions

P P -> GLUINO GLUINO X 1

## [Rivet Analysis](#) [MadAnalysis](#) [SModels](#) Search for supersymmetry in multijet events with missing transverse momentum in proton-proton collisions at 13 TeV

The CMS collaboration Sirunyan, Albert M ; Tumasyan, Armen ; Adam, Wolfgang ; *et al.*

Phys.Rev.D 96 (2017) 032003, 2017.

[Inspire Record 1594909](#) [DOI 10.17182/hepdata.79412](#)

A search for supersymmetry is presented based on multijet events with large missing transverse momentum produced in proton-proton collisions at a center-of-mass energy of  $\sqrt{s} = 13$  TeV. The data, corresponding to an integrated luminosity of 35.9 inverse femtobarns, were collected with the CMS detector at the CERN LHC in 2016. The analysis utilizes four-dimensional exclusive search regions defined in terms of the number of jets, the number of tagged bottom quark jets, the scalar sum of jet transverse momenta, and the magnitude of the vector sum of jet transverse...

0 data tables match query

## [Rivet Analysis](#) [MadAnalysis](#) [SModels](#) Search for squarks and gluinos in final states with jets and missing transverse momentum at $\sqrt{s} = 13$ TeV with the ATLAS detector

The ATLAS collaboration Aaboud, Morad ; Aad, Georges ; Abbott, Brad ; *et al.*

Eur.Phys.J.C 76 (2016) 392, 2016.

[Inspire Record 1458270](#) [DOI 10.17182/hepdata.74253](#)

A search for squarks and gluinos in final states containing hadronic jets, missing transverse momentum but no electrons or muons is presented. The data were recorded in 2015 by the ATLAS experiment in  $\sqrt{s} = 13$  TeV proton-proton collisions at the Large Hadron Collider. No excess above the Standard Model background expectation was observed in  $3.2 \text{ fb}^{-1}$  of analyzed data. Results are interpreted within simplified models that assume R-parity is conserved and the neutralino is the lightest supersymmetric particle. An exclusion limit at the 95% confidence level on the mas...

0 data tables match query

« 1 »

→ Query link

# How to find a suitable analysis for the study



The screenshot shows the HEPData search interface. At the top, the search bar contains the query "analysis:Rivet AND analysis:MadAnalysis". Below the search bar, there are filters for "Max results", "Sort by", and "Reverse order". The search results are displayed in a list format, with the first result highlighted. The first result is titled "Search for supersymmetry in multijet events with missing transverse momentum in proton-proton collisions at 13 TeV" and is associated with the CMS collaboration. The second result is titled "Search for squarks and gluinos in final states with jets and missing transverse momentum at  $\sqrt{s} = 13$  TeV with the ATLAS detector" and is associated with the ATLAS collaboration. The interface also includes a sidebar with filters for Date, Collaboration, Subject\_areas, Phrases, and Reactions.

HEPData

About Submission Help File Formats Sign in

analysis:Rivet AND analysis:MadAnalysis Search Reset search Advanced JSON

Max results Sort by Reverse order Showing 2 of 2 results

Date

Collaboration

Subject\_areas

Phrases

Reactions

analysis used in the following

**Rivet Analysis MadAnalysis SModels** Search for supersymmetry in multijet events with missing transverse momentum in proton-proton collisions at 13 TeV

The CMS collaboration Sirunyan, Albert M ; Tumasyan, Armen ; Adam, Wolfgang ; *et al.*

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0 data tables match query

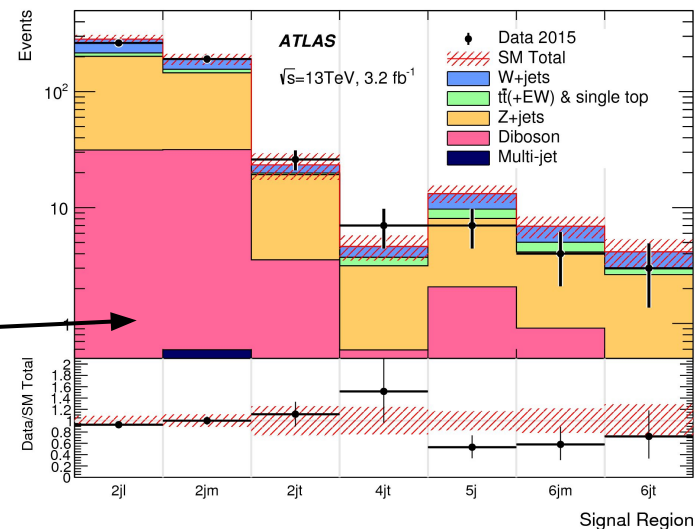
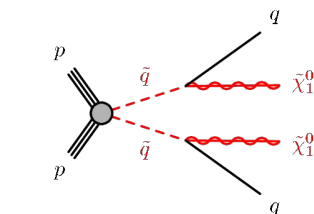
→ Query link





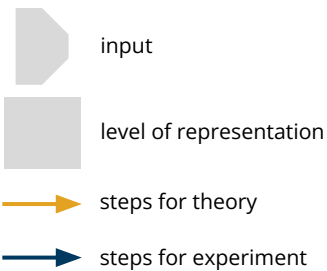
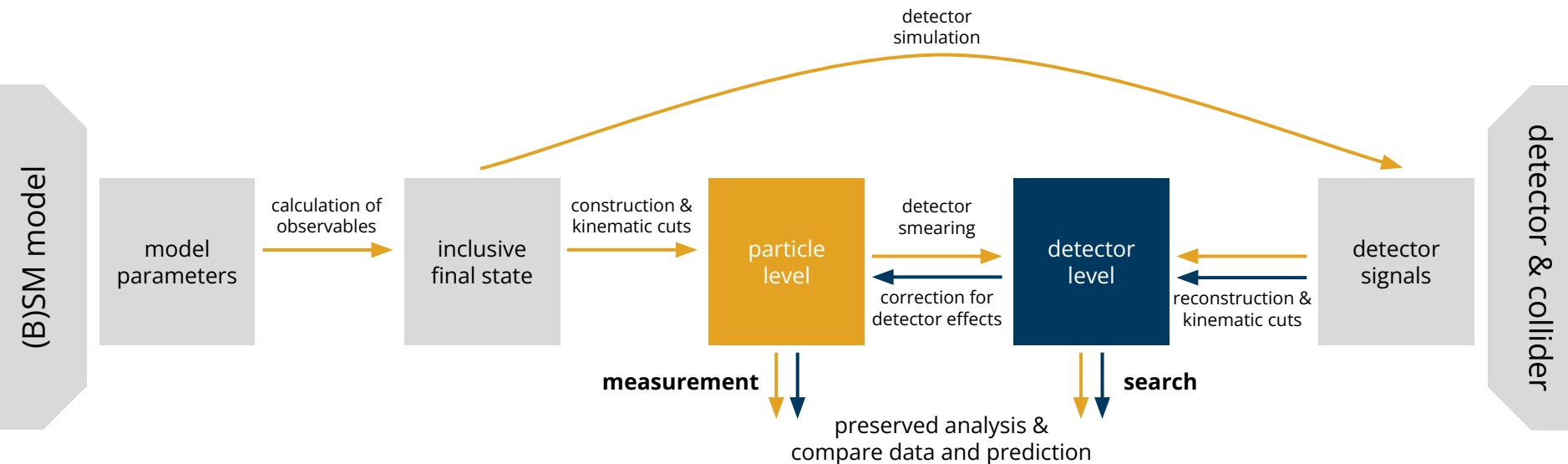
## Search for squarks and gluinos in final states with jets and missing transverse momentum at $\sqrt{s}=13$ TeV with the ATLAS detector

- [Webpage:SUSY-2015-06](#),  $L=3.2 \text{ fb}^{-1}$
- Selects events with
  - $E_T^{\text{miss}} > 200 \text{ GeV}$
  - No leptons**
- Signal regions based (a.o.) on inclusive jet multiplicity
- Published results on **detector level**
- Provided cutflow



Selections	gluino pair $m(\text{gluino}, N1)=(1600, 0) \text{ GeV}$	gluino pair $m(\text{gluino}, N1)=(1100, 700) \text{ GeV}$	squark pair $m(\text{squark}, N1)=(1000, 400) \text{ GeV}$
$N_{\text{gen}}$	10000	30000	20000
Pre-selection, $E_T^{\text{miss}} > 200 \text{ GeV}$ , $p_T(\text{jet}_1) > 200 \text{ GeV}$	9018	17314	16956
Jet multiplicity	9018	17298	16704
$\min(\Delta\phi(E_T^{\text{miss}}, \text{jet}))$ cut	5497	12359	13211
$p_T(\text{jet}_2)$ cut	5426	6399	9851
$E_T^{\text{miss}}/\sqrt{H_T}$ cut	2919	2203	6361
$m_{\text{eff}}(\text{incl.})$ cut	2913	1636	5761

# Common approach of a physics analysis



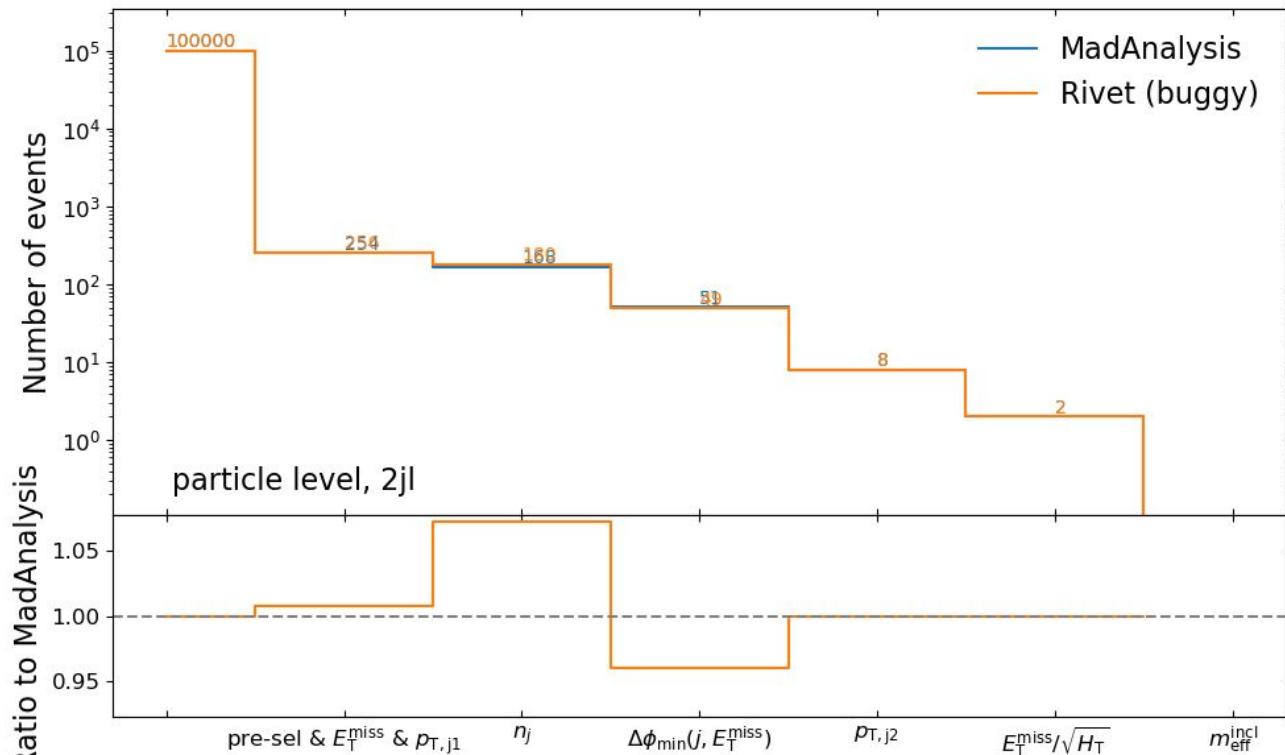


- Sample: → Sherpa v3.0.0 **W+jets**
- Tools:
  - → MadAnalysis v2.0.4\_beta
    - Uses Delphes for estimation of detector effects
    - Achieved "particle level" representation by using smearing (SFS card) with perfect efficiencies if within detector acceptance
  - → Rivet v4.0.0
    - Uses smearing for estimation of detector effects
- Correlations estimated with → TACO
- All code available → here

# Particle Level

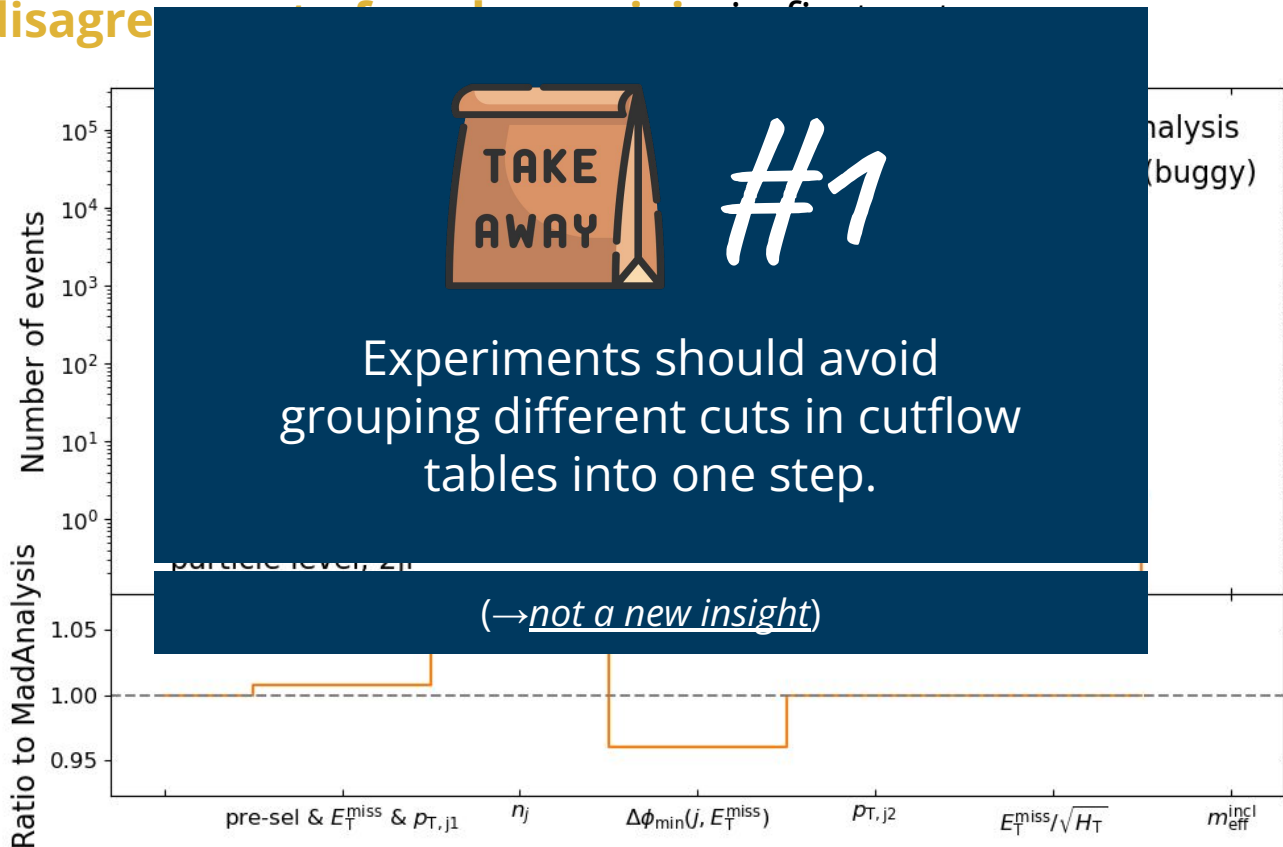


- On particle level, without overlap removal
- Some **disagreement of unclear origin** in first cuts



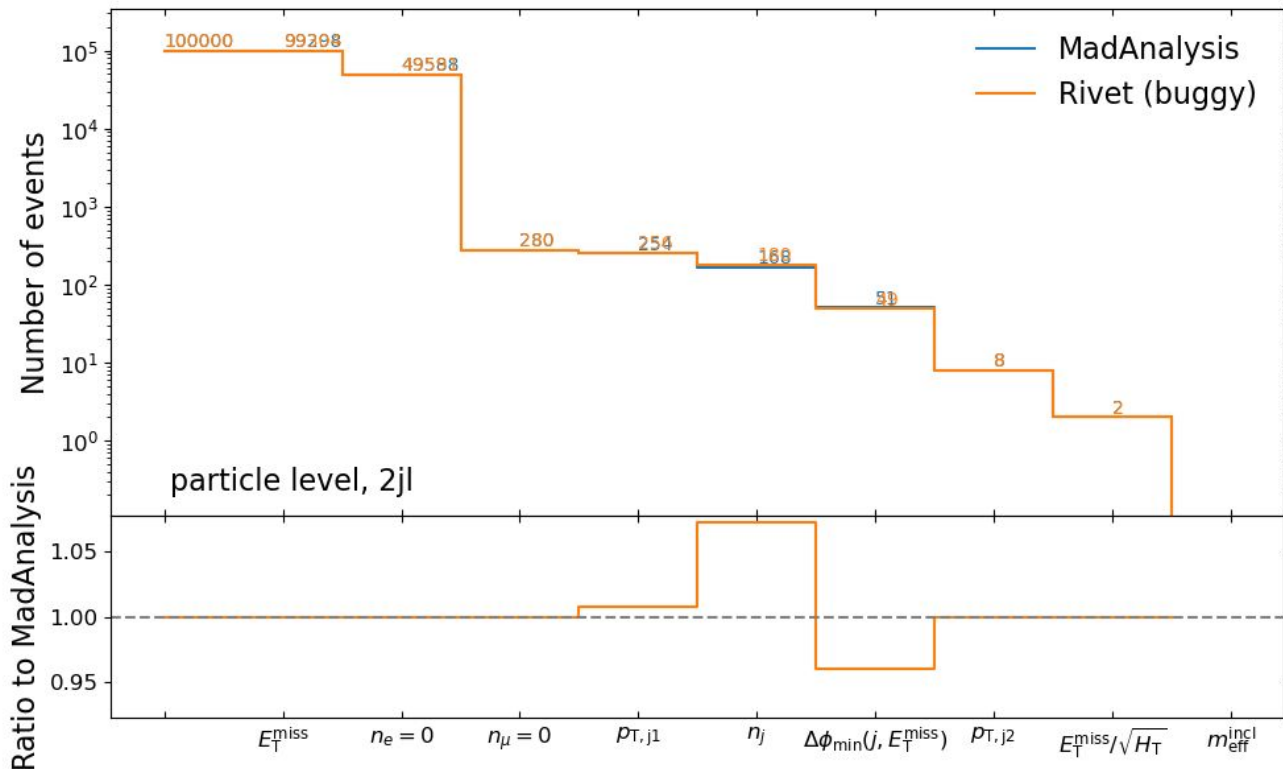


- On particle level, without overlap removal
- Some **disagreement** between different cutflow analyses





- On particle level, without overlap removal, **extended first cutflow cut**
- **Disagreement** (mostly) from **jet multiplicity**





- On particle level, without overlap removal, extended first cutflow cut
- Disagreement (mostly) from jet multiplicity

## What is the problem?


Jet definition in Rivet implementation:

✘: Was - include prompt muons (JetMuons::ALL)

✔: Should be - include only muons from decay (JetMuons::DECAY)

## Why was this not detected before?

- Cutflow didn't include muon multiplicity (=0) cut
- Cutflow samples were for signal only (=0 leptons)



Selections	gluino pair $m(\text{gluino}, N1)=(1600, 0)$ GeV	gluino pair $m(\text{gluino}, N1)=(1100, 700)$ GeV	squark pair $m(\text{squark}, N1)=(1000, 400)$ GeV
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$m_{\text{eff}}$ (incl.) cut	2913	1636	5761





- On particle level, without overlap removal, extended first cutflow cut
- Multiplicity



## #2

Experiments should include all cuts in cutflows.

Why

Jet d

x: W

✓: S

Why

- Cutflow didn't include reverse multiplicity
- (→not a new insight)

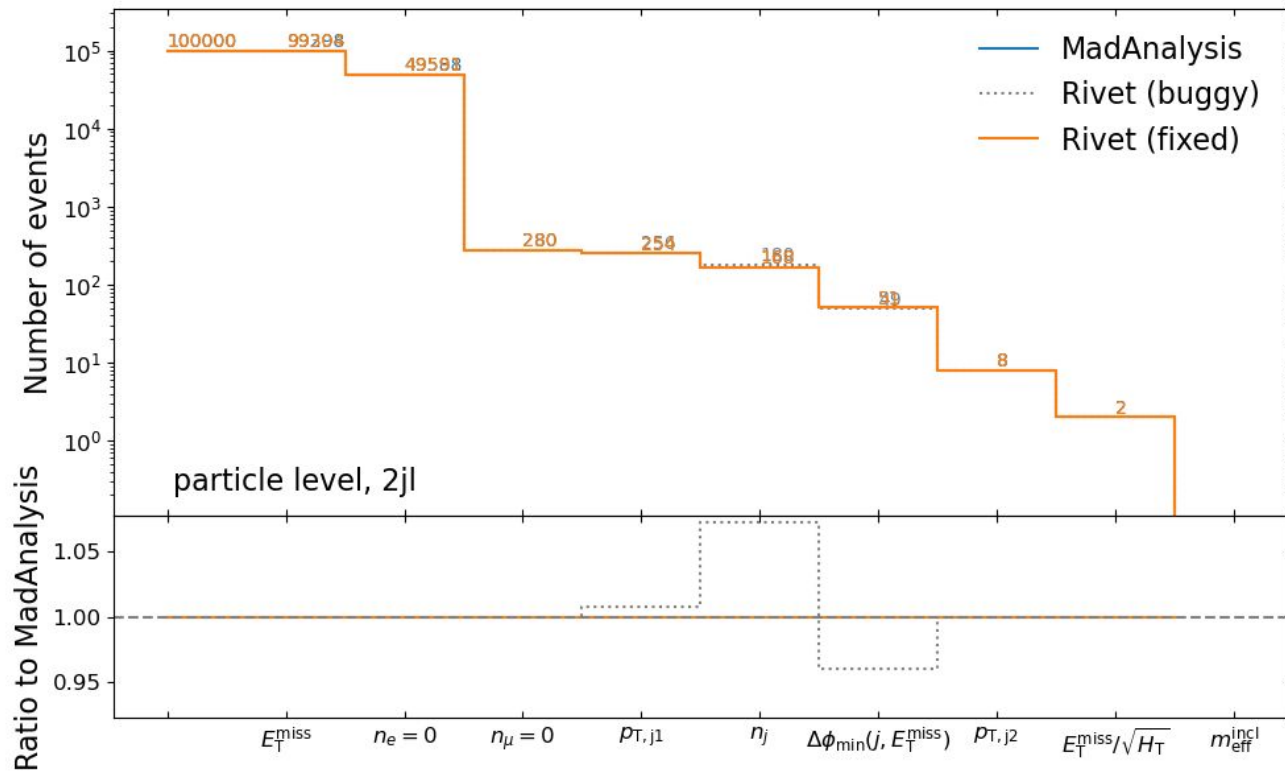


## #3

Experiments should provide cutflows for multiple *different* MC samples (e.g. incl. backgrounds).

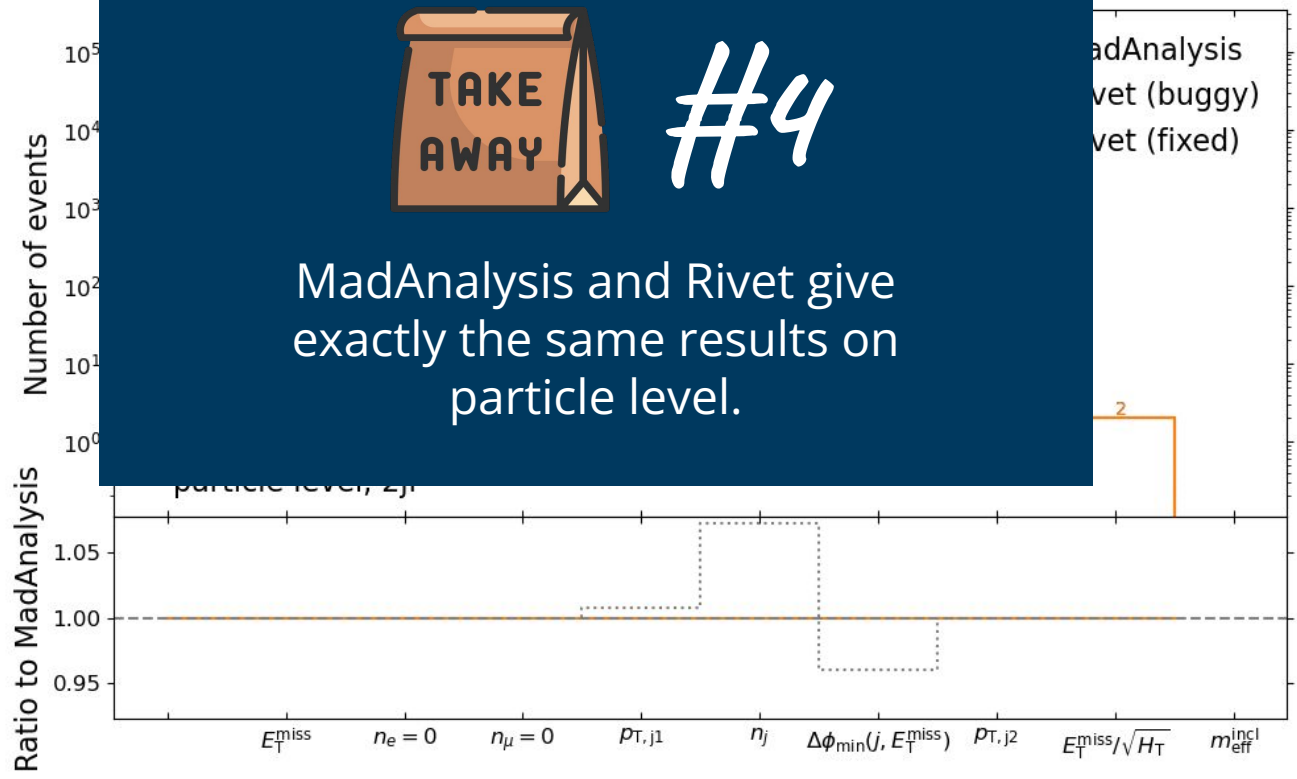


- On particle level, without overlap removal, extended first cutflow cut
- Fixed jet definition in Rivet → **Perfect agreement!**



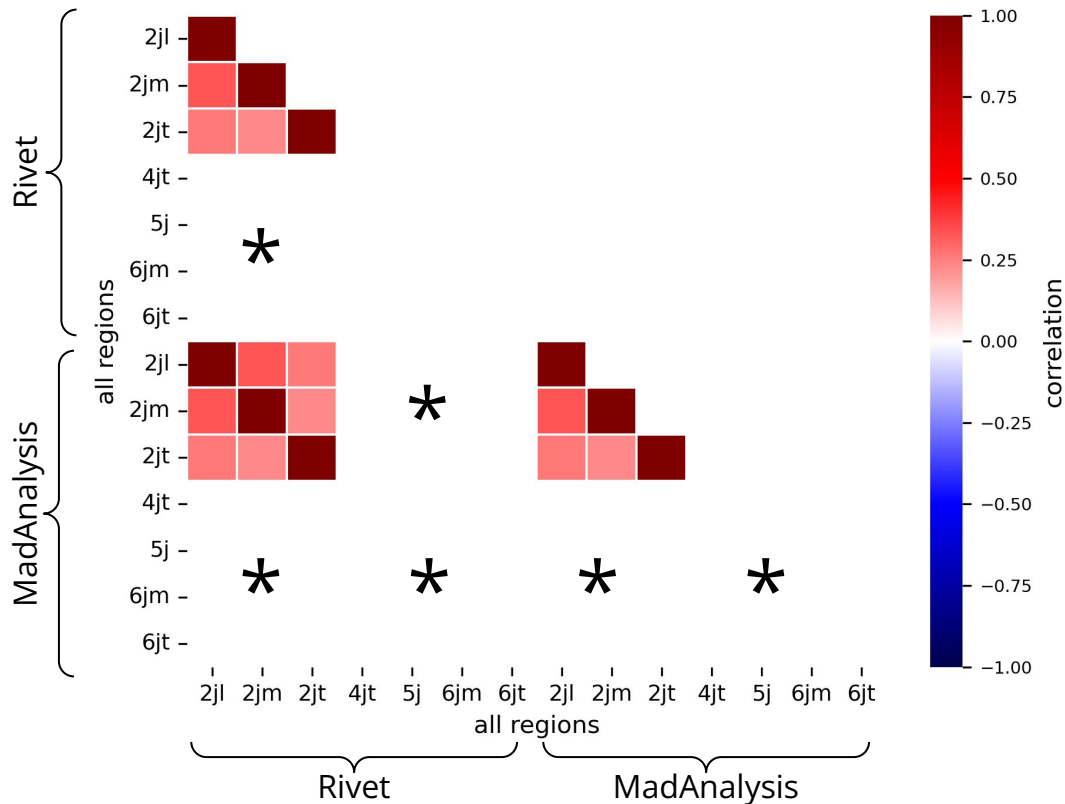


- On particle level, without overlap removal, extended first cutflow cut
- Fixed jet definition





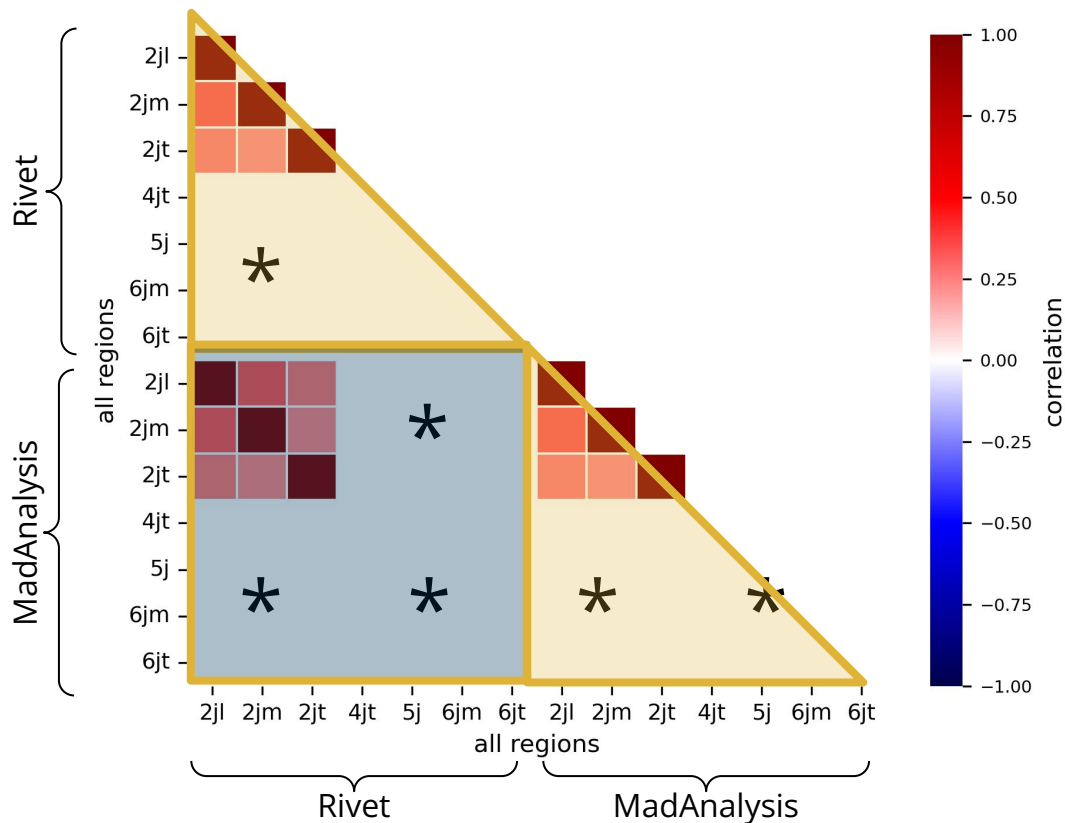
- On particle level, without overlap removal, extended first cutflow cut
- **Correlation:**



\* no events passed event selection



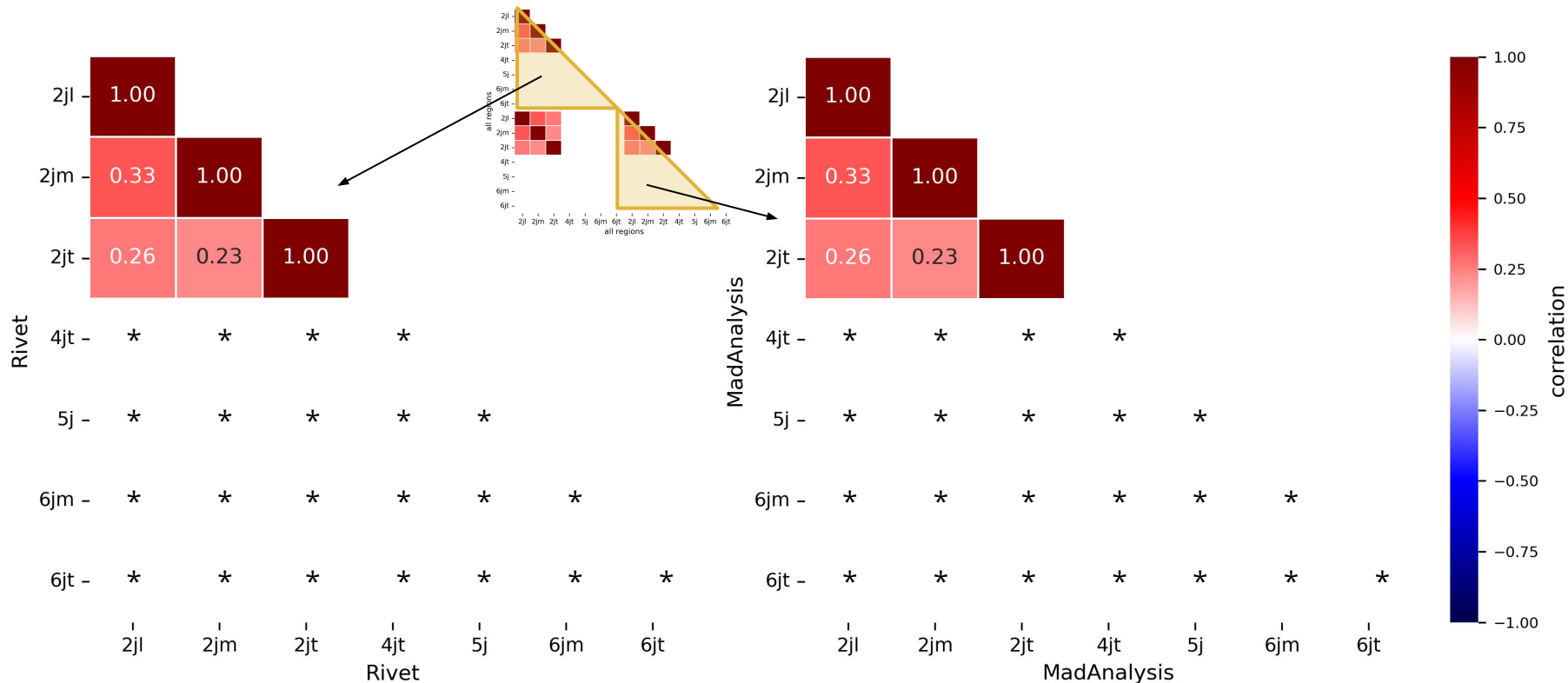
- On particle level, without overlap removal, extended first cutflow cut
- **Correlation:**



\* no events passed event selection



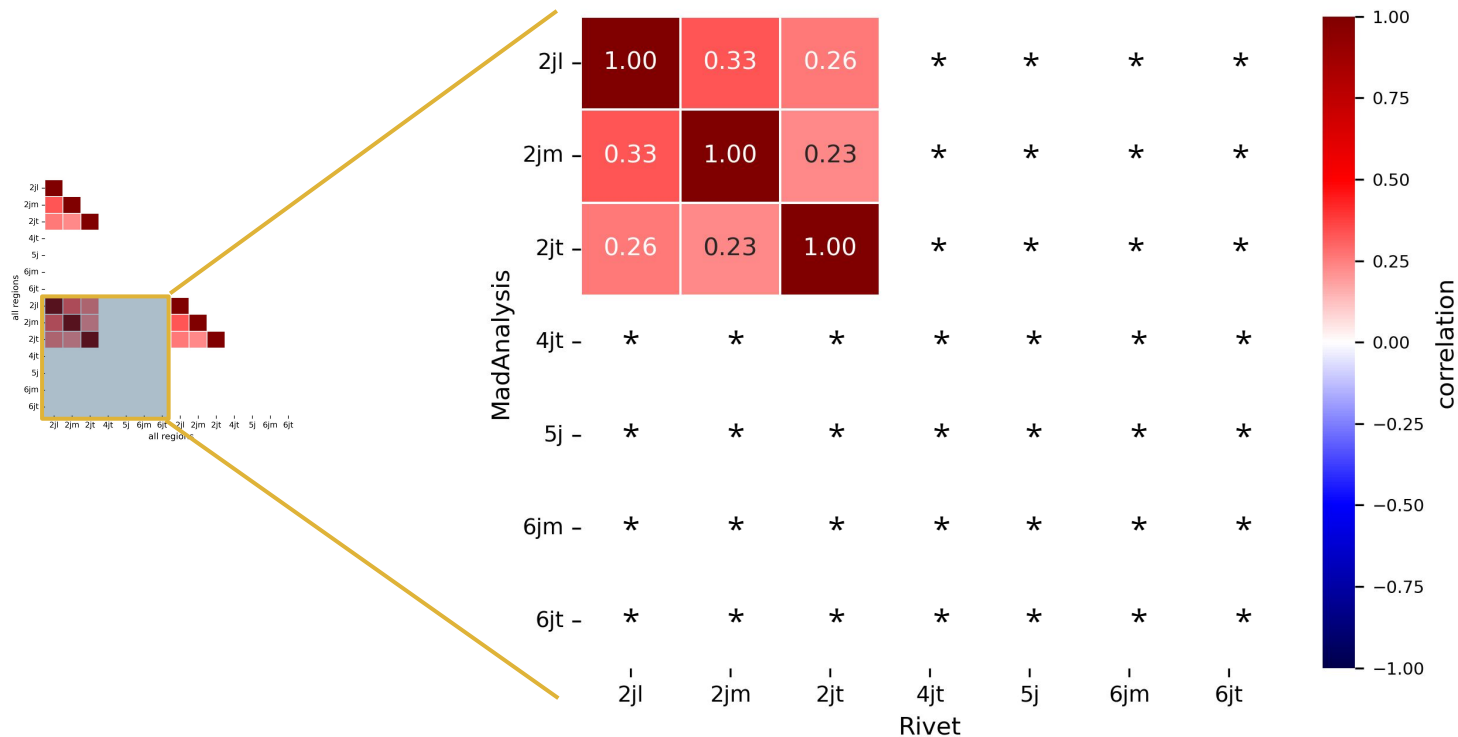
- On particle level, without overlap removal, extended first cutflow cut
- Self-correlation** looks **healthy** but **sparse**



\* no events passed event selection



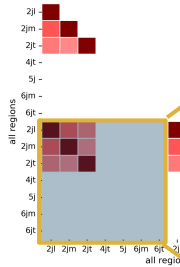
- On particle level, without overlap removal, extended first cutflow cut
- **Selected events** are **perfectly correlated** between MadAnalysis and Rivet




\* no events passed event selection



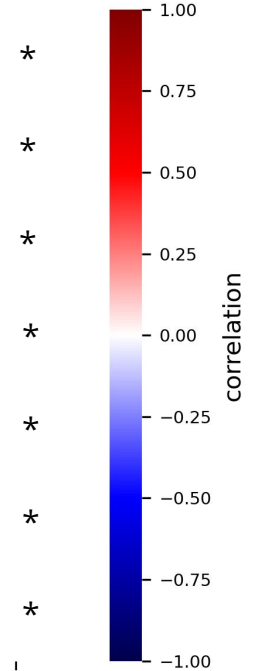
- On particle level, without overlap removal, extended first cutflow cut
- Selected events** ... analysis and Rivet





Treating regions as uncorrelated across different tools based on a correlation can work!

6jm -	*	*	*	*	*	*
6jt -	*	*	*	*	*	*
	2j	2jm	2jt	4jt	5j	6jm
	Rivet					



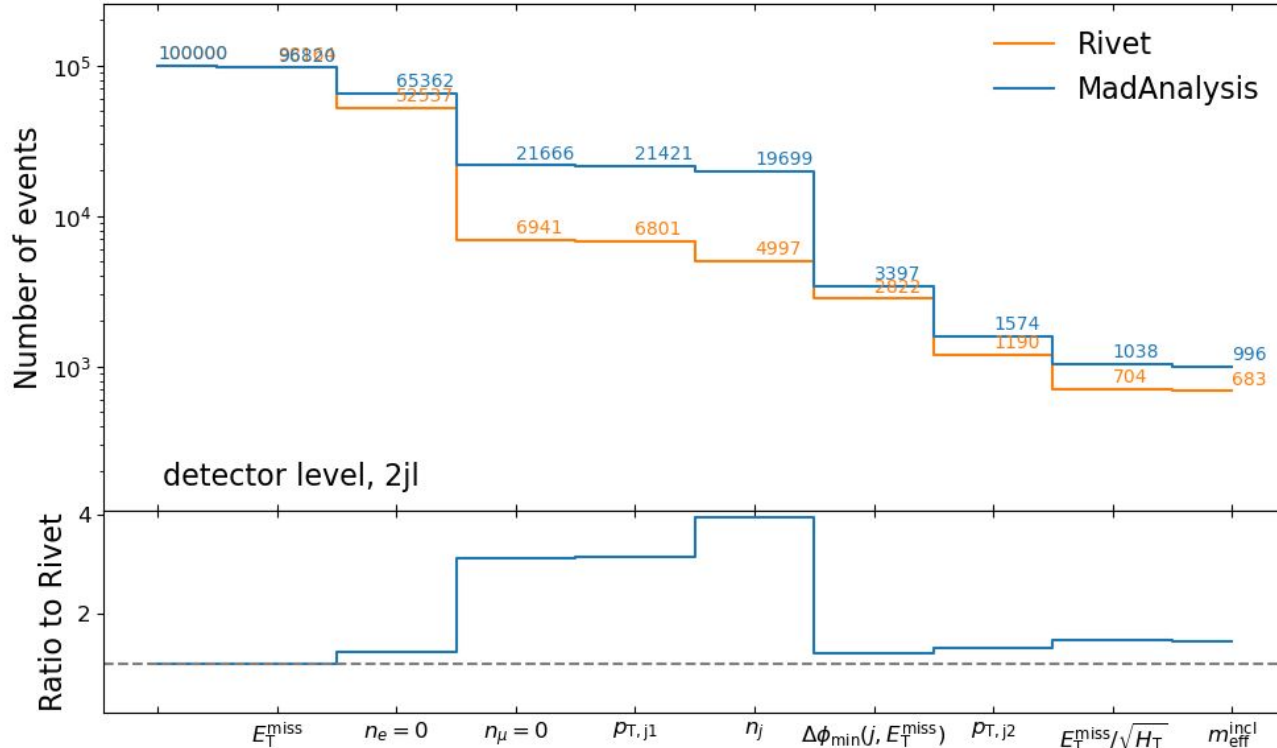
\* no events passed event selection



# Detector Level



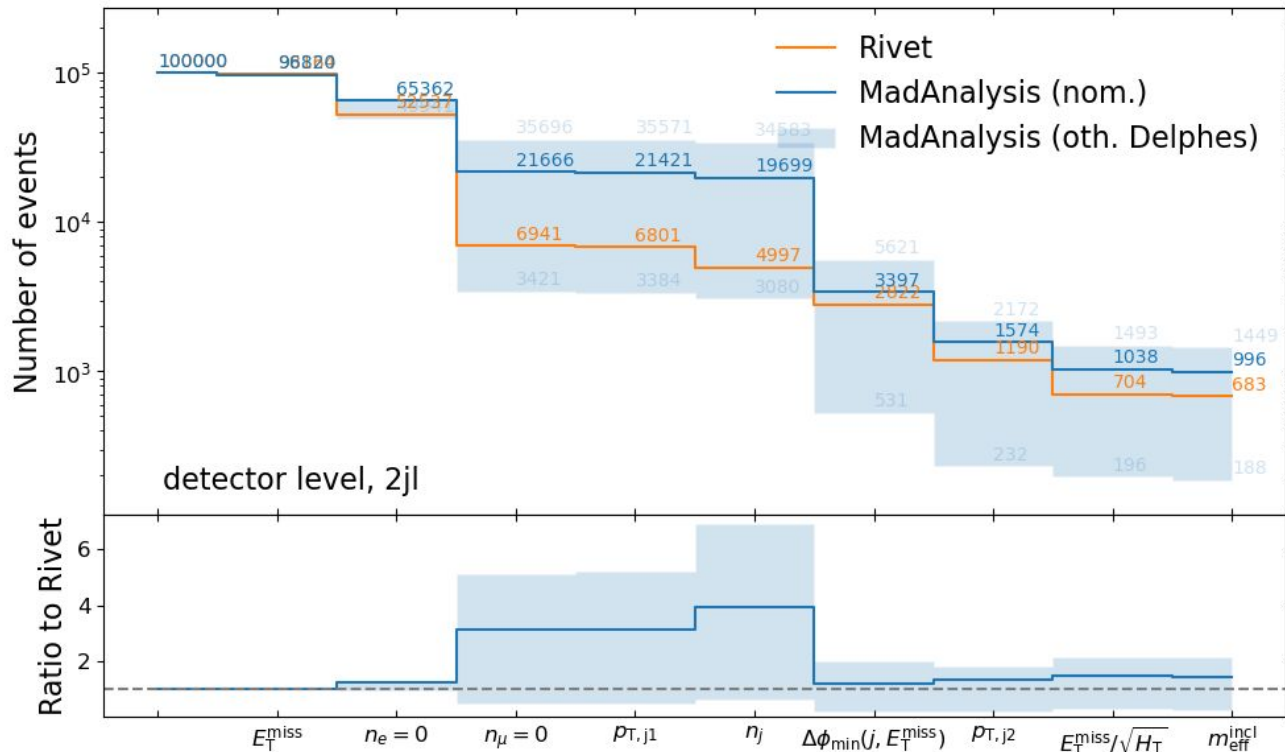
- On **detector level**, with overlap removal, fixed jet definition
- More events passing due to lepton efficiency
- **Considerable disagreement** of unclear origin



# Cutflow challenge - detector level, fixed, ext.

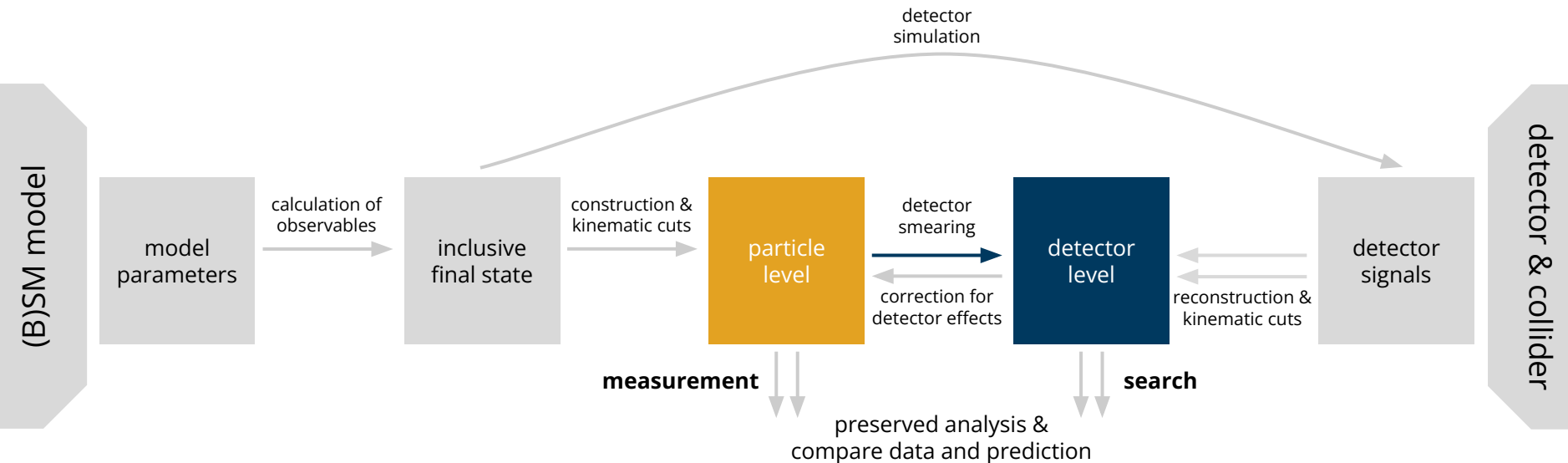






- On **detector level**, with overlap removal, fixed jet definition
- Testing different\* Delphes cards → would **explain disagreement**

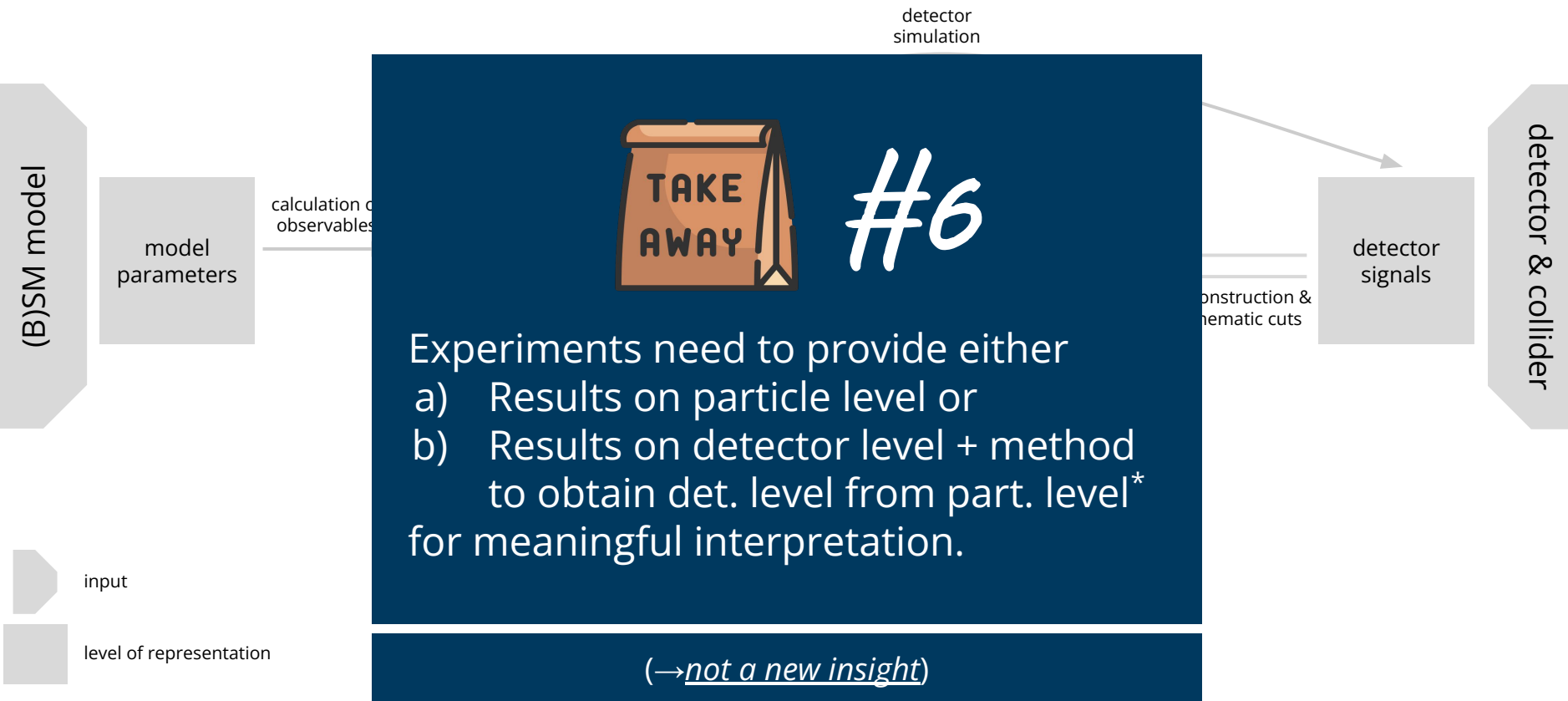


\* all delphes cards used by MadAnalysis that are more recent than the card used nominally for the analysis

# Common approach of a physics analysis



-  input
-  level of representation
-  steps for theory or experiment
-  needed from experiment



input

level of representation

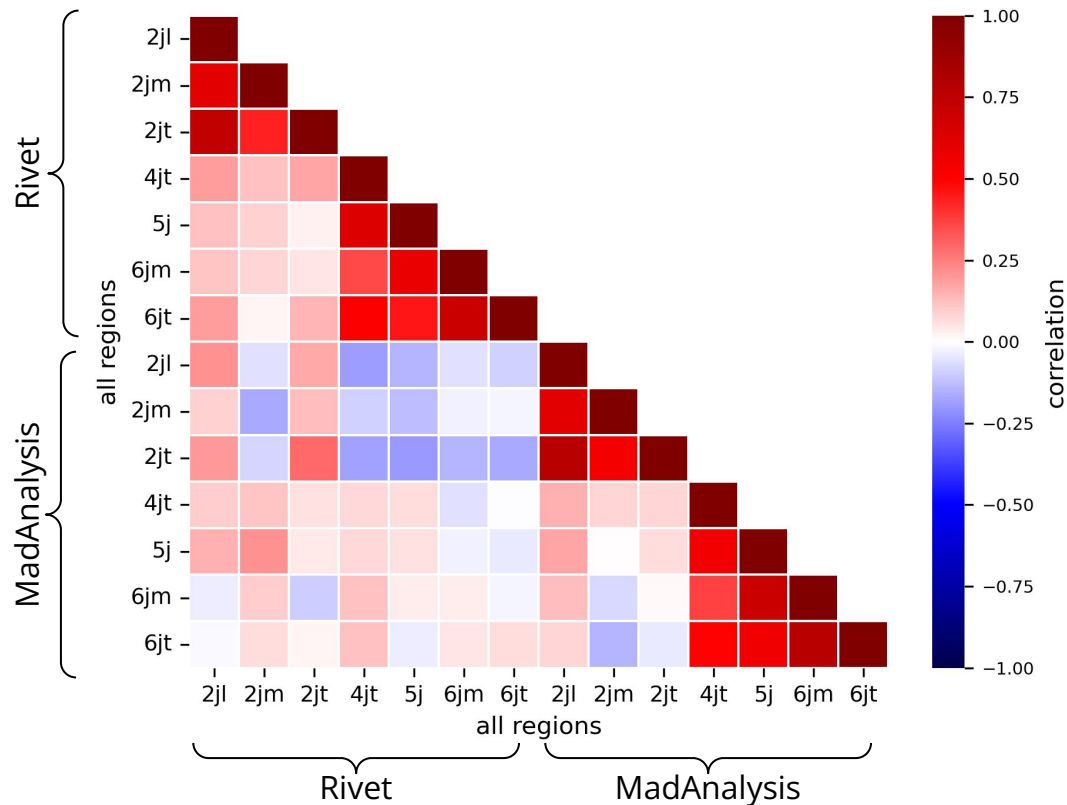
steps for theory or experiment

needed from experiment

\* it doesn't really matter whether smearing functions, delphes cards, efficiency maps, folding matrices, ... as long as there is *something*



- On detector level, with overlap removal, fixed jet definition
- **Correlation:**

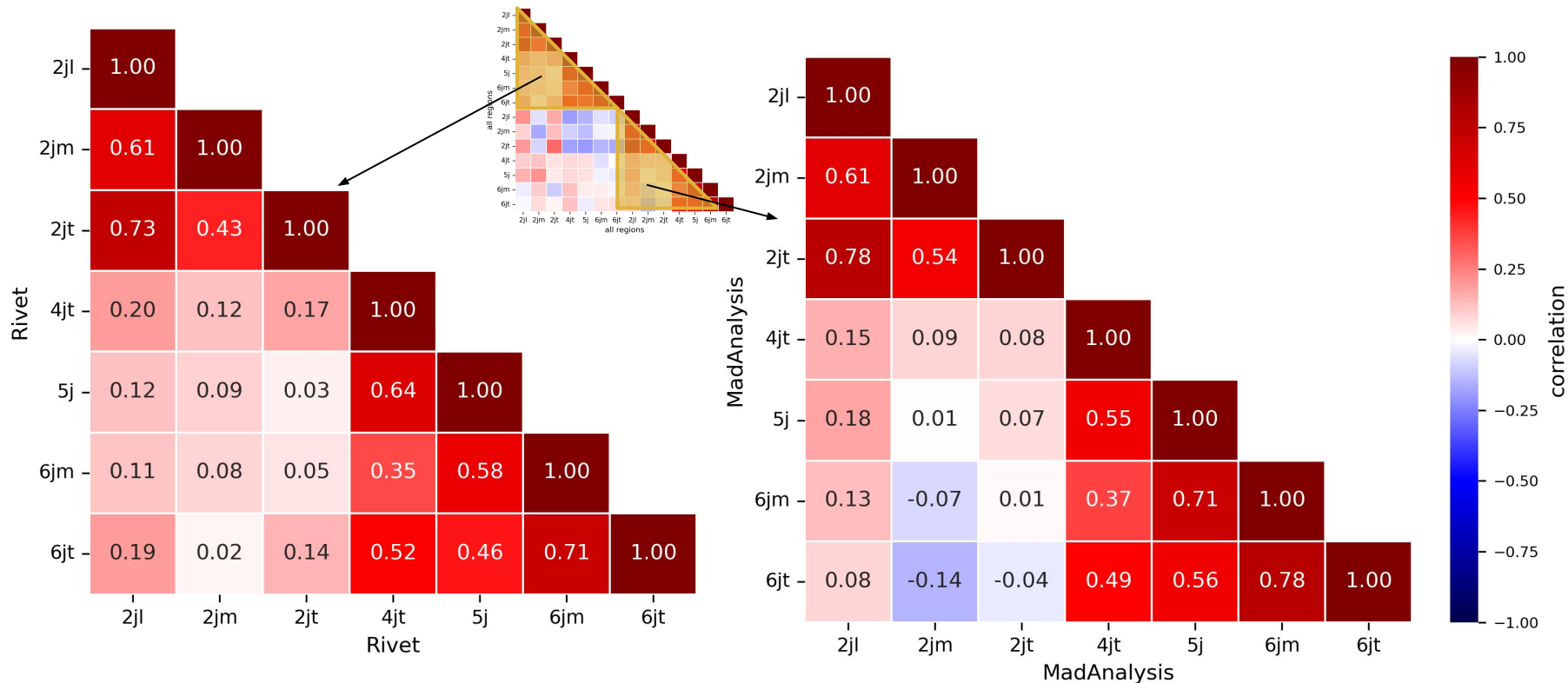


\* no events passed event selection

# Correlation - detector level, fixed

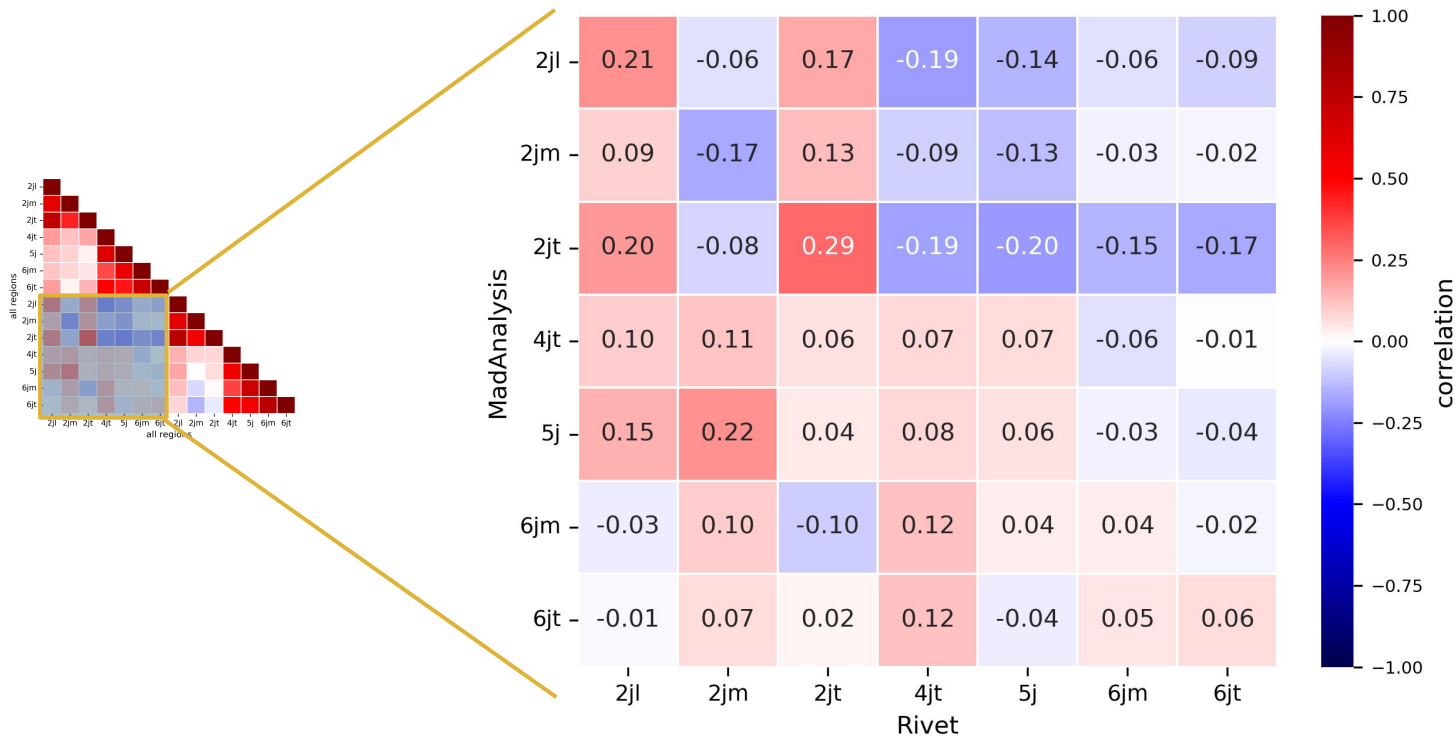


- On detector level, with overlap removal, fixed jet definition
- **Self-correlation** looks **healthy**





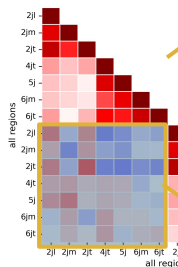
- On detector level, with overlap removal, fixed jet definition
- Selected events have **small, non-zero correlation** between MA/ Rivet







- On detector level
- Selected event



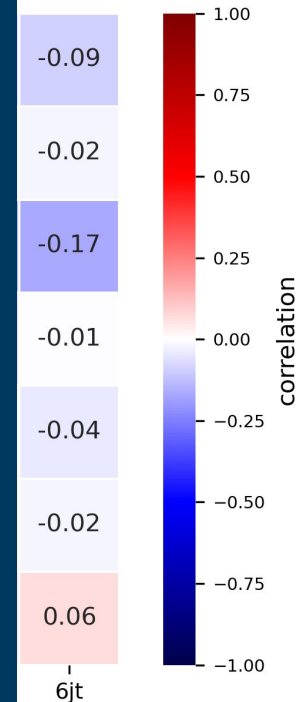
#56

Treating regions as uncorrelated  
across different tools based on a  
correlation can work!

*But:*

Need caution at detector level.  
Correlation thresholds across tools on  
detector level should at least be  
 $< 0.04$ .

on MA/ Rivet



# Summary



## Key take-aways:

1. Experiments should
  - a. **avoid grouping different cuts** in cutflow tables into one step.
  - b. **include all cuts** in cutflows.
  - c. provide cutflows for **multiple different MC samples**.
  - d. provide either
    - i. **Results on particle level** or
    - ii. **Results on detector level + method to obtain det. level from part. level.**
2. MadAnalysis and Rivet give
  - a. exactly the same results on particle level.
  - b. very different results on detector level.
3. Treating events **across tools as correlated**:
  - a. **Can work!**
  - b. Needs caution at detector level, corr. thresholds should not exceed 0.04.

**Backup**



Requirement	Signal Region						
	2jl	2jm	2jt	4jt	5j	6jm	6jt
$E_T^{\text{miss}} [\text{GeV}] >$	200						
$p_T(j_1) [\text{GeV}] >$	200	300	200				
$p_T(j_2) [\text{GeV}] >$	200	50	200	100			
$p_T(j_3) [\text{GeV}] >$	–			100			
$p_T(j_4) [\text{GeV}] >$	–			100			
$p_T(j_5) [\text{GeV}] >$	–				50		
$p_T(j_6) [\text{GeV}] >$	–					50	
$\Delta\phi(\text{jet}_{1,2,(3)}, \mathbf{E}_T^{\text{miss}})_{\text{min}} >$	0.8	0.4	0.8	0.4			
$\Delta\phi(\text{jet}_{i>3}, \mathbf{E}_T^{\text{miss}})_{\text{min}} >$	–			0.2			
$E_T^{\text{miss}} / \sqrt{H_T} [\text{GeV}^{1/2}] >$	15		20	–			
Aplanarity $>$	–			0.04			
$E_T^{\text{miss}} / m_{\text{eff}}(N_j) >$	–			0.2	0.25		0.2
$m_{\text{eff}}(\text{incl.}) [\text{GeV}] >$	1200	1600	2000	2200	1600	1600	2000



## W+jets sample

- 100k (cutflows) or 950k (correlation) events
- Enhanced for high transverse momentum
- Run card:

```
BEAMS: 2212
BEAM_ENERGIES: 6500

MI_HANDLER: None
FRAGMENTATION: None

PROCESSES:
- 93 93 -> 90 91 93{1}:
  CKKW: 20
  2->2:
    Enhance_Function: VAR{(PPerp2(p[2])/10000)*(PPerp2(p[3])/10000)}
  2->3:
    Enhance_Function: VAR{(PPerp2(p[2])/10000)*(PPerp2(p[3])/10000)*(PPerp2(p[4])/10000)}

HARD_DECAYS:
  Enabled: true
  Decay_Tau: true

SELECTORS:
- [PTmis, 200, E_CMS]

EVENT_OUTPUT:
- HepMC3[events.hepmc]
HEPMC3_IO_TYPE: 2
```



## Particle level

	2jl	2jm	2jt	4jt	5j	6jm	6jt
MadAnalysis	15	20	1	0	0	0	0
Rivet	15	20	1	0	0	0	0

## Detector level

	2jl	2jm	2jt	4jt	5j	6jm	6jt
MadAnalysis	9352	17363	5154	427	373	144	151
Rivet	6165	12863	3171	229	170	56	70

**each of 950k events**