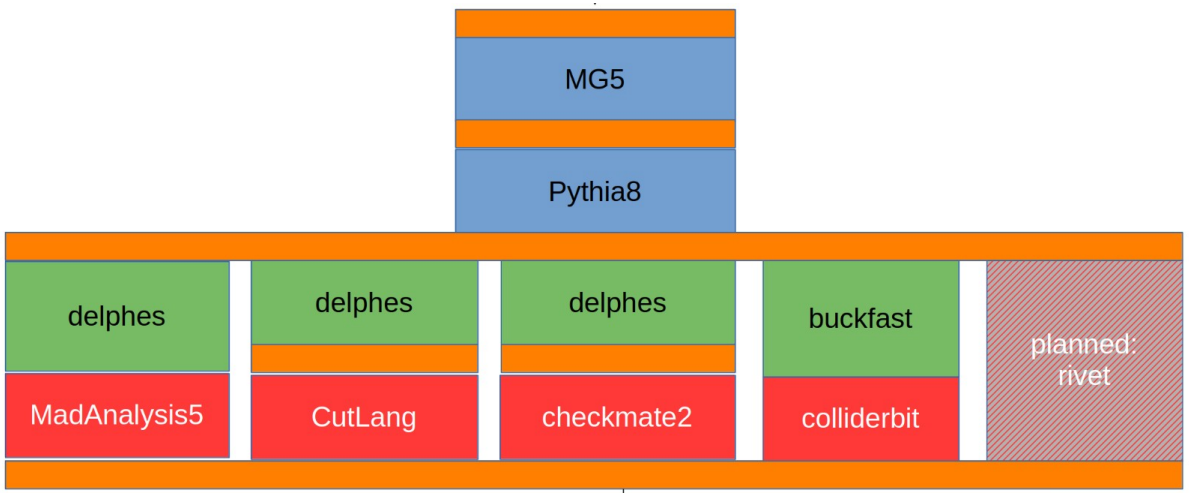
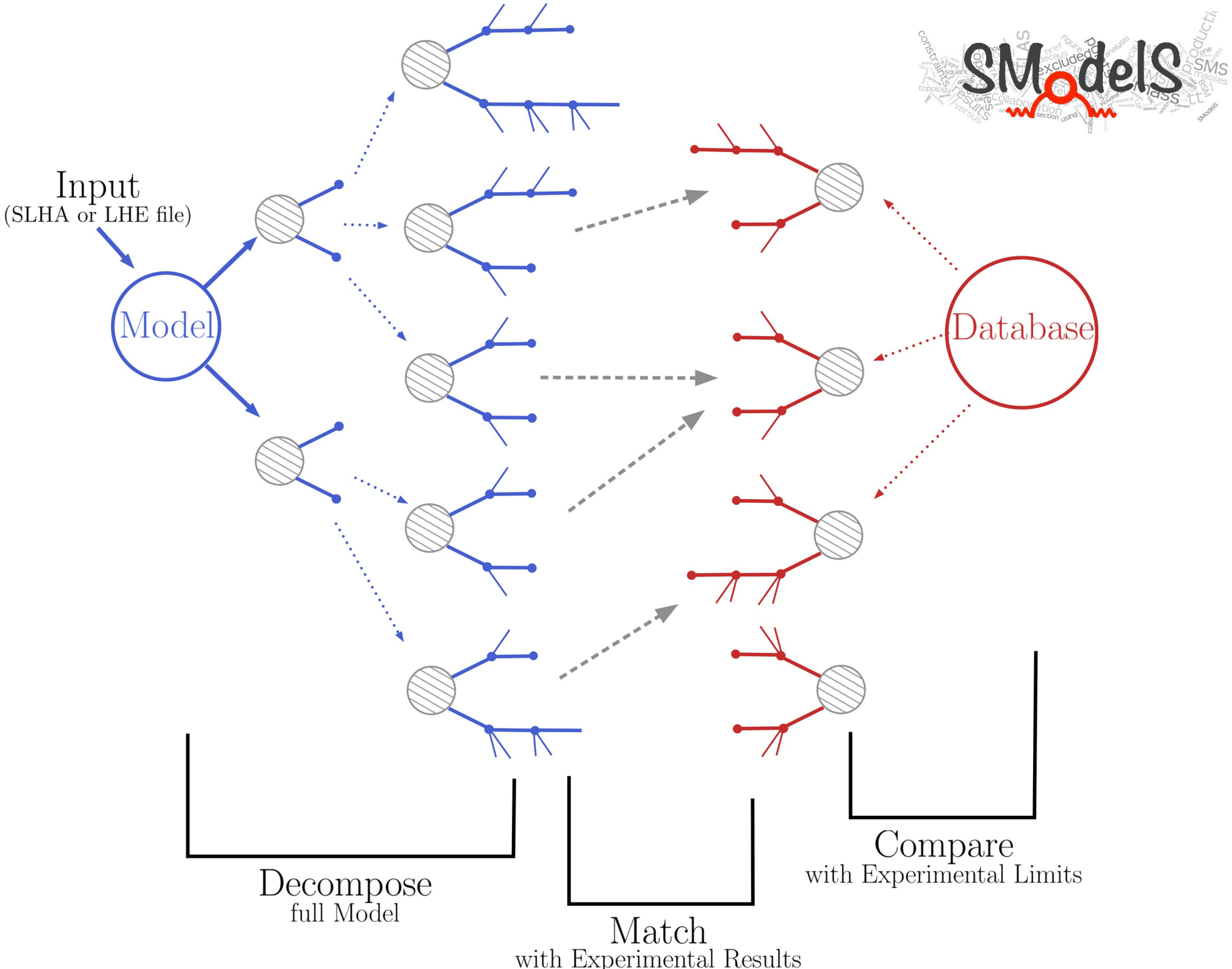
# Creating Efficiency Maps for SModelS

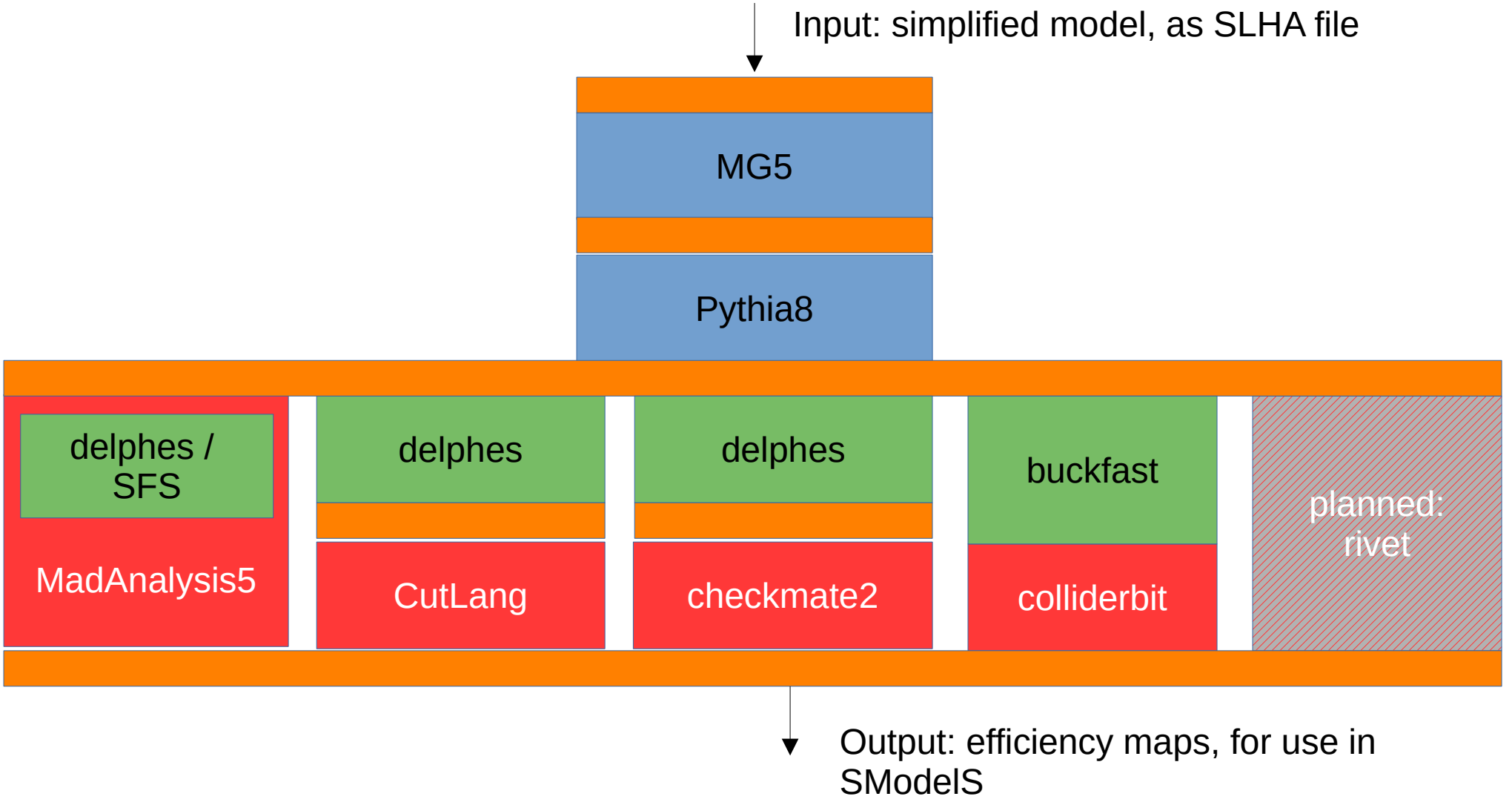


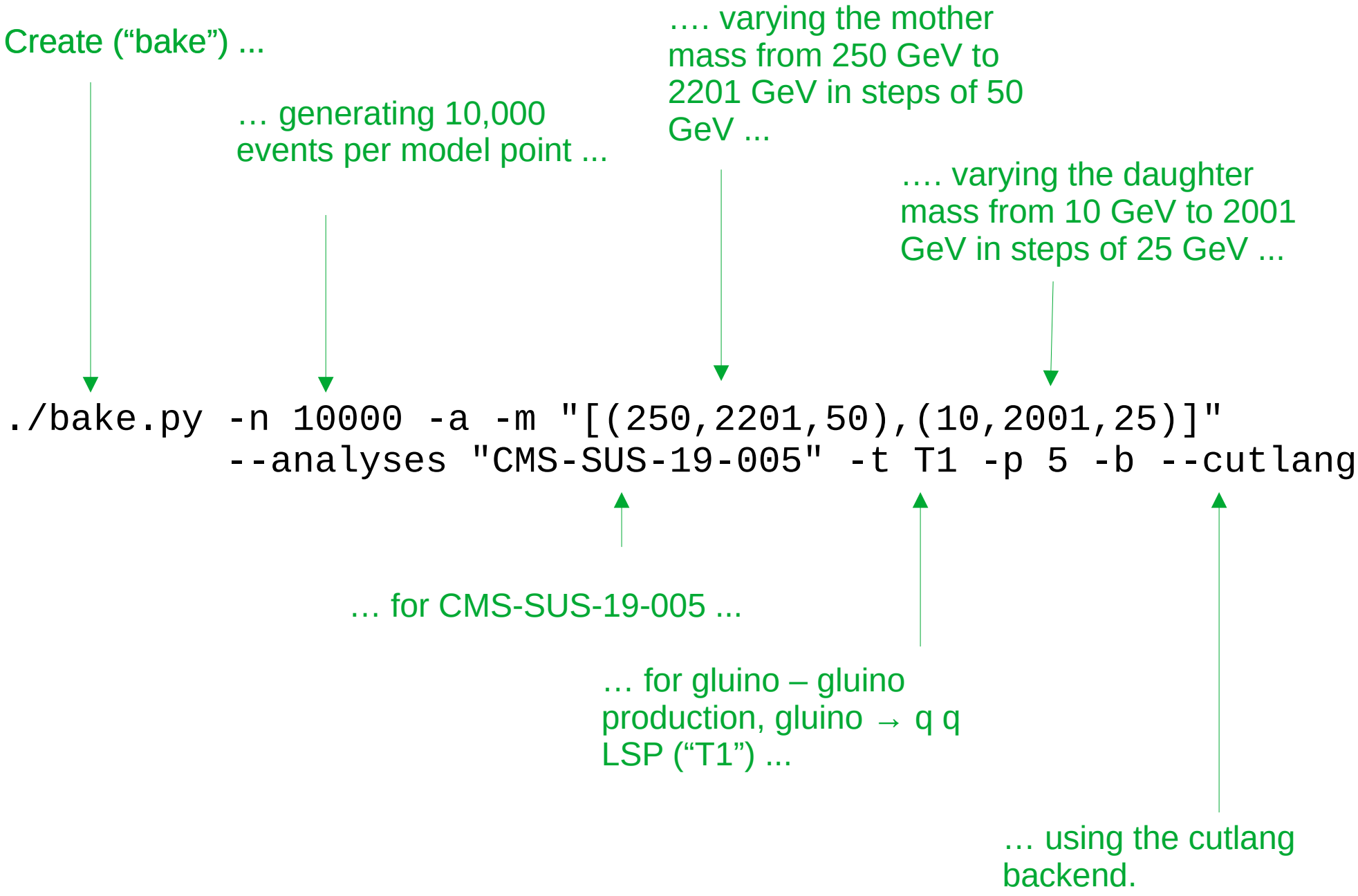

MMA (Grenoble) and WW (Vienna)

Reinterpretation Workshop, Grenoble, June 2024


SModelS
Input
(SLHA or LHE file)
Model
Database
Decompose
full Model
Match
with Experimental Results
Compare
with Experimental Limits

# Tool Chains


Input: simplified model, as SLHA file
MG5
Pythia8
delphes / SFS
MadAnalysis5
delphes
CutLang
delphes
checkmate2
buckfast
colliderbit
planned: rivet
Output: efficiency maps, for use in SModelS
em-creator code (python)
event generation / hadronization
detector simulation
analysis recast


Create (“bake”) ...
… generating 10,000 events per model point ...
…. varying the mother mass from 250 GeV to 2201 GeV in steps of 50 GeV ...
…. varying the daughter mass from 10 GeV to 2001 GeV in steps of 25 GeV ...
./bake.py -n 10000 -a -m "[(250,2201,50),(10,2001,25)]"
--analyses "CMS-SUS-19-005" -t T1 -p 5 -b --cutlang
… for CMS-SUS-19-005 ...
… for gluino – gluino production, gluino → q q LSP (“T1”) ...
… using the cutlang backend.

# Technicalities

Inputs: MG5 process cards + SLHA files

MG5/pythia8: needed to force specific gauge boson decays, for Monte Carlo statistics

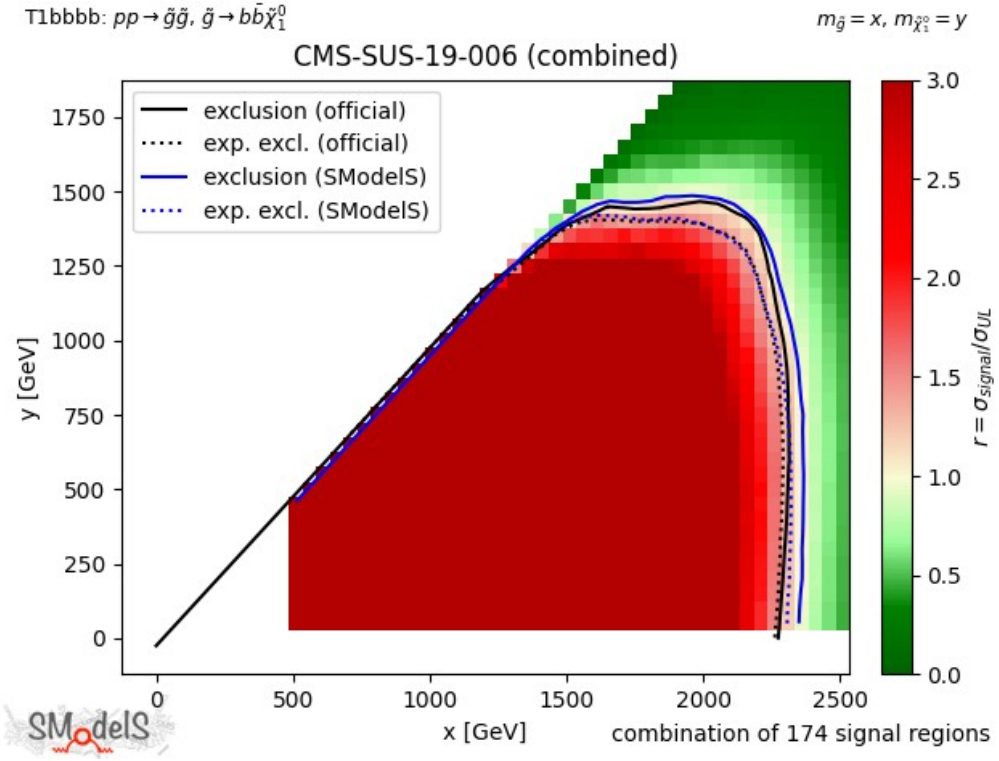
Needed to use “biased production” in MG5/pythia8 to improve Monte Carlo statistics, [ATLAS-SUSY-2018-22, TRV1]

delphes: needed tweaking for some dark matter models [ATLAS-SUSY-2018-22, TRV1]

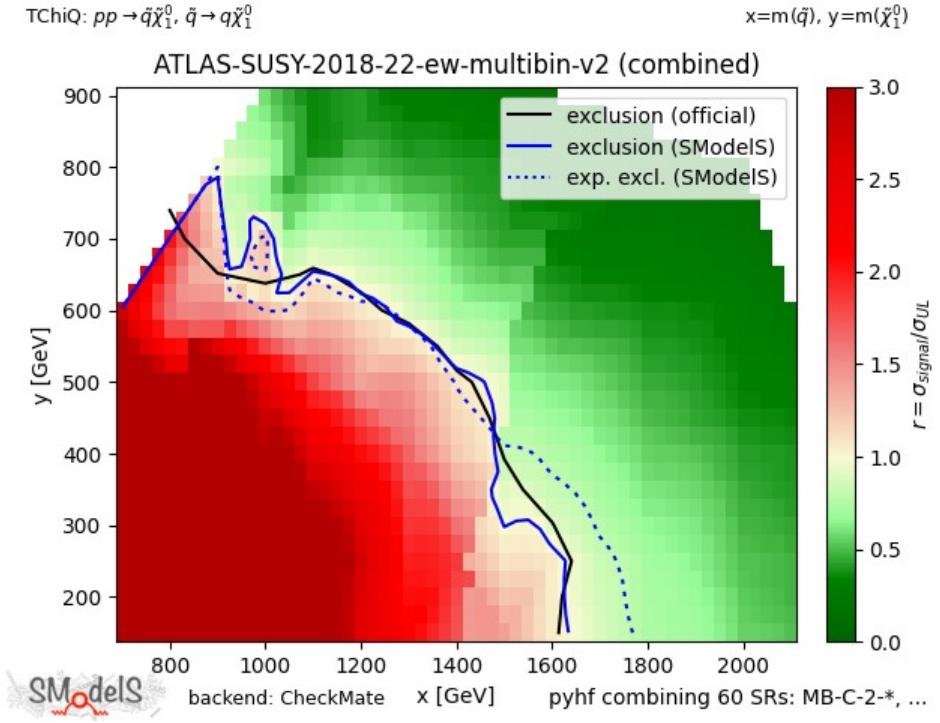
checkmate2: needed to use a special git branch for a specific analysis [ATLAS-SUSY-2018-22, TRV1]

…

# Validation in SModelS



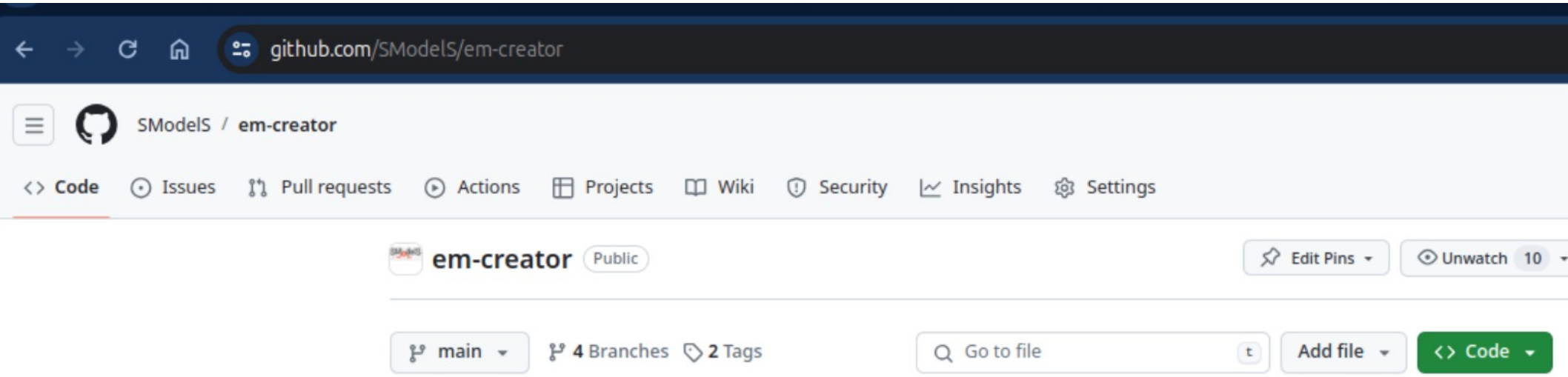

CMS-SUS-19-006: MA5, with covariance matrix




ATLAS-SUSY-2018-22: checkmate2, pyhf

# Code Base

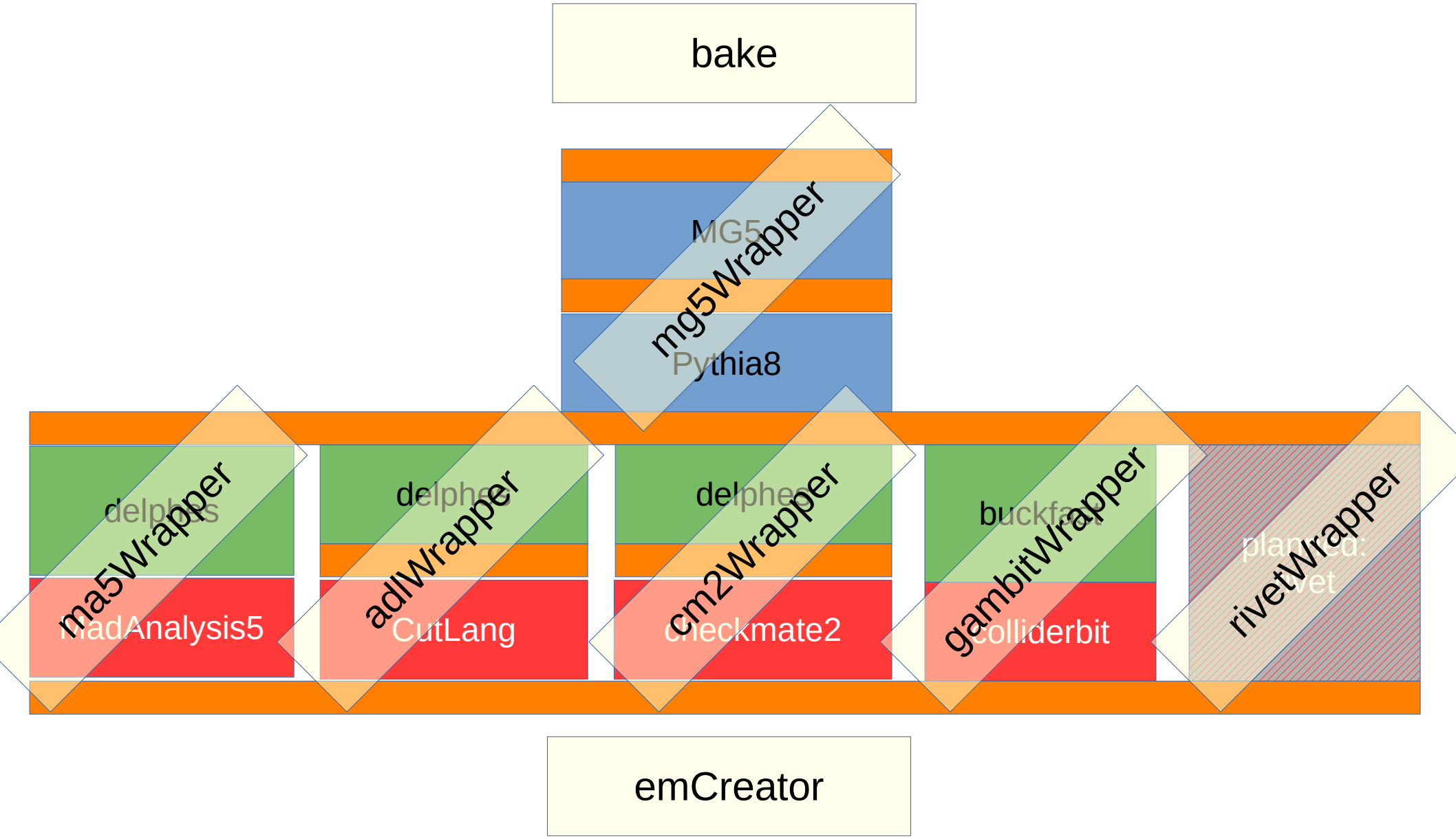
on github:




**code public but not (yet?) published:**

- not (yet?) polished code base
- no documentation (apart from docstrings)
- no guarantees
- no user support

# Code Structure



# Problems

Trying to automate the builds of the toolchains, but there are almost always issues:

- special version of tool Y needed for analysis / topology X
- incompatibilities between versions of tools
- incompatibilities with compiler versions
- often we need to “hack” the tools a little (see previous slide)

- Recasts are sometimes incomplete:
  At times, not all signal regions could be validated → cannot easily validate the SmodelS implementation

- Missing statistical model:
  If statistical model is missing, we cannot easily validate our implementation, nor can we make full use of the analysis / recast

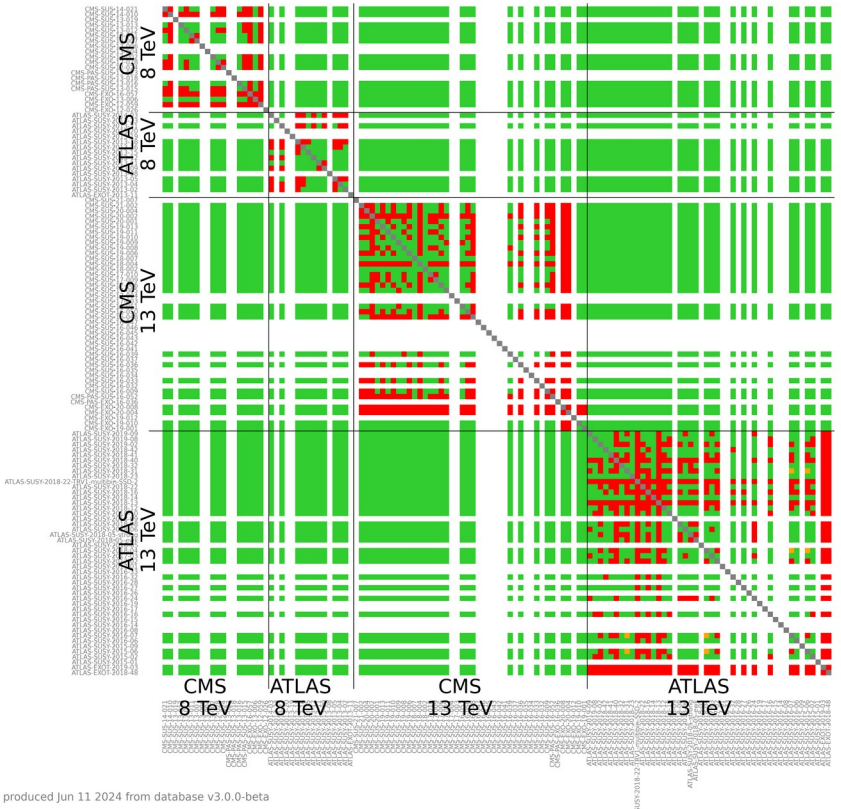
#193291057

# Ideas For Future

Marry EM-creator with TACO: estimate a huge binary acceptance matrix (BAM)
Using all recasts from all frameworks

- detector simulation different for different backends
  (or even no detector simulation in case of rivet)

- might be sufficient to work with generator level events



# Analyses available (13 TeV only, publications only)

## Colliderbit:

ATLAS-SUSY-2016-07
ATLAS-SUSY-2016-15
ATLAS-SUSY-2016-17
ATLAS-SUSY-2016-21
ATLAS-SUSY-2016-24
ATLAS-SUSY-2016-27
ATLAS-SUSY-2016-28
ATLAS-SUSY-2017-02
ATLAS-SUSY-2017-03
ATLAS-SUSY-2018-02
ATLAS-SUSY-2018-09
ATLAS-SUSY-2018-21
ATLAS-SUSY-2018-22
ATLAS-SUSY-2019-08
CMS-EXO-16-048
CMS-PAS-SUS-16-014
CMS-SUS-16-033
CMS-SUS-16-034
CMS-SUS-16-035
CMS-SUS-16-039
CMS-SUS-16-043
CMS-SUS-16-046
CMS-SUS-16-048
CMS-SUS-16-051
CMS-SUS-17-001
CMS-SUS-17-010
CMS-SUS-17-011
CMS-SUS-17-012
CMS-SUS-19-006
CMS-SUS-19-008
CMS-SUS-19-012
CMS-SUS-20-001

## MA5

ATLAS-EXOT-2015-03
ATLAS-EXOT-2016-25
ATLAS-EXOT-2016-27
ATLAS-EXOT-2016-32
ATLAS-EXOT-2018-30
ATLAS-SUSY-2015-06
ATLAS-SUSY-2016-07
ATLAS-SUSY-2018-04
ATLAS-SUSY-2018-06
ATLAS-SUSY-2018-17
ATLAS-SUSY-2018-32
ATLAS-SUSY-2019-08
CMS-B2G-17-014
CMS-EXO-16-010
CMS-EXO-16-012
CMS-EXO-16-022
CMS-EXO-17-009
CMS-EXO-17-015
CMS-EXO-17-030
CMS-EXO-19-002
CMS-EXO-20-004
CMS-HIG-18-011
CMS-SUS-16-033
CMS-SUS-16-039
CMS-SUS-16-048
CMS-SUS-16-052
CMS-SUS-17-001
CMS-SUS-19-006
CMS-TOP-17-009
CMS-TOP-18-003
ATLAS-EXOT-2018-05
ATLAS-EXOT-2018-06
ATLAS-SUSY-2016-07
ATLAS-SUSY-2017-04
ATLAS-SUSY-2018-31
CMS-EXO-16-022
CMS-EXO-19-010
CMS-SUS-16-048

## cm2

CMS-PAS-SUS-15-011
CMS-SUS-16-025
CMS-SUS-16-039
CMS-SUS-16-048
CMS-SUS-19-005
CMS-SUS-19-006
CMS-SUS-19-006
CMS-SUS-21-002
ATLAS-SUSY-2015-09
ATLAS-SUSY-2015-06
ATLAS-SUSY-2015-02
ATLAS-SUSY-2016-14
ATLAS-SUSY-2016-15
ATLAS-SUSY-2016-07
ATLAS-SUSY-2016-27
ATLAS-SUSY-2016-24
ATLAS-SUSY-2018-04
ATLAS-SUSY-2019-09
ATLAS-SUSY-2018-10
ATLAS-SUSY-2018-12
ATLAS-SUSY-2018-16
ATLAS-SUSY-2018-22
ATLAS-SUSY-2018-31
ATLAS-SUSY-2018-32
ATLAS-SUSY-2019-02

## ADL/CutLang

ATLAS-EXOT-2016-32
ATLAS-SUSY-2019-08
CMS-SUS-16-032
CMS-SUS-19-006
ATLAS-EXOT-2018-08
ATLAS-SUSY-2019-09
CMS-SUS-16-033
CMS-SUS-19-007
ATLAS-EXOT-2018-30
ATLAS-SUSY-2019-22
CMS-SUS-16-035
CMS-SUS-19-012
ATLAS-EXOT-2018-46
CMS-B2G-16-024
CMS-SUS-16-037
CMS-SUS-19-013
ATLAS-EXOT-2019-03
CMS-B2G-20-001
CMS-SUS-16-041
CMS-SUS-20-001
ATLAS-EXOT-E6
CMS-B2G-20-002
CMS-SUS-16-042
CMS-SUS-20-003
ATLAS-SUSY-2018-09
CMS-B2G-20-009
CMS-SUS-16-043
CMS-SUS-21-002
ATLAS-SUSY-2018-10
CMS-B2G-21-002
CMS-SUS-16-046
CMS-SUS-21-009
ATLAS-SUSY-2018-11
CMS-EXO-19-010
CMS-SUS-16-047
CMS-TOP-16-006
ATLAS-SUSY-2018-16
CMS-EXO-20-004
CMS-SUS-16-048
ATLAS-SUSY-2018-22
CMS-FTR-21-010
CMS-SUS-16-049
ATLAS-SUSY-2018-30
CMS-SUS-18-004
ATLAS-SUSY-2018-32
CMS-SUS-16-017
CMS-SUS-19-005

# Statistical Models in the SModelS Database

| ID | Short Description | $\mathcal{L}$ [fb$^{-1}$] | $UL_{obs}$ | $UL_{exp}$ | EM | comb. |
|---|---|---|---|---|---|---|
| ATLAS-EXOT-2018-48 | di-top resonance | 139.0 | ✓ | ✓ | | |
| ATLAS-EXOT-2019-03 | dijet resonance | 139.0 | ✓ | ✓ | | |
| ATLAS-SUSY-2018-04 | 2 hadronic $\tau$ | 139.0 | ✓ | | ✓ | PyHF |
| ATLAS-SUSY-2018-05 | $2\ell$ + jets, EWK | 139.0 | ✓ | | ✓ | PyHF |
| ATLAS-SUSY-2018-06 | $3\ell$, EWK | 139.0 | ✓ | ✓ | ✓ | |
| ATLAS-SUSY-2018-08 | 2 OS $\ell$ | 139.0 | ✓ | | ✓ | |
| ATLAS-SUSY-2018-09 | 2 SS $\ell$ | 139.0 | ✓ | | | |
| ATLAS-SUSY-2018-10 | $1\ell$ + jets | 139.0 | ✓ | | ✓ | |
| ATLAS-SUSY-2018-12 | $0\ell$ + jets | 139.0 | ✓ | ✓ | ✓ | |
| ATLAS-SUSY-2018-13 | displaced jets | 139.0 | | | ✓ | SLv1 |
| ATLAS-SUSY-2018-14 | displaced vertices | 139.0 | | | ✓ | PyHF |
| ATLAS-SUSY-2018-16 | 2 soft $\ell$ + jets, EWK | 139.0 | ✓ | ✓ | ✓ | PyHF |
| ATLAS-SUSY-2018-22 | multi-jets | 139.0 | ✓ | | ✓ | |
| ATLAS-SUSY-2018-23 | $Wh(\gamma\gamma)$, EWK | 139.0 | ✓ | ✓ | | |
| ATLAS-SUSY-2018-31 | 2 $b$-jets + 2 h | 139.0 | ✓ | | ✓ | PyHF |
| ATLAS-SUSY-2018-32 | 2 OS $\ell$ | 139.0 | ✓ | | ✓ | PyHF |
| ATLAS-SUSY-2018-40 | 2 $b$-jets + 2 h | 139.0 | ✓ | ✓ | ✓ | |
| ATLAS-SUSY-2018-41 | hadr. EWK | 139.0 | ✓ | ✓ | ✓ | SLv1 |
| ATLAS-SUSY-2018-42 | charged LLPs, dE/dx | 139.0 | ✓ | ✓ | ✓ | |
| ATLAS-SUSY-2019-02 | 2 soft $\ell$, EWK | 139.0 | ✓ | | ✓ | SLv1 |
| ATLAS-SUSY-2019-08 | $1\ell + h(bb)$, EWK | 139.0 | ✓ | | ✓ | PyHF |
| ATLAS-SUSY-2019-09 | $3\ell$, EWK | 139.0 | ✓ | ✓ | ✓ | PyHF |

| ID | Short Description | $\mathcal{L}$ [fb$^{-1}$] | $UL_{obs}$ | $UL_{exp}$ | EM | comb. |
|---|---|---|---|---|---|---|
| CMS-EXO-19-001 | non-prompt jets | 137.0 | | | ✓ | |
| CMS-EXO-19-010 | disappearing track | 101.0 | | | ✓ | |
| CMS-EXO-19-012 | dijet resonance | 137.0 | ✓ | | | |
| CMS-EXO-20-004 | spin1 and spin0 mediator | 137.0 | | | ✓ | SLv1 |
| CMS-EXO-20-008 | di-b resonance | 138.0 | ✓ | ✓ | | |
| CMS-PAS-EXO-16-036 | HSCP | 12.9 | ✓ | | | |
| CMS-PAS-SUS-16-052 | ISR jet + soft $\ell$ | 35.9 | ✓ | | ✓ | SLv1 |
| CMS-SUS-16-009 | $0\ell$ + jets, top tag | 2.3 | ✓ | ✓ | | |
| CMS-SUS-16-032 | 2 $b$- or 2 $c$-jets | 35.9 | ✓ | | | |
| CMS-SUS-16-033 | $0\ell$ + jets | 35.9 | ✓ | ✓ | ✓ | |
| CMS-SUS-16-034 | 2 SFOS $\ell$ | 35.9 | ✓ | | | |
| CMS-SUS-16-035 | 2 SS $\ell$ | 35.9 | ✓ | | | |
| CMS-SUS-16-036 | $0\ell$ + jets | 35.9 | ✓ | ✓ | | |
| CMS-SUS-16-037 | $1\ell$ + jets with MJ | 35.9 | ✓ | | | |
| CMS-SUS-16-039 | multi-$\ell$, EWK | 35.9 | ✓ | | ✓ | SLv1 |
| CMS-SUS-16-041 | multi-$\ell$ + jets | 35.9 | ✓ | | | |
| CMS-SUS-16-042 | $1\ell$ + jets | 35.9 | ✓ | | | |
| CMS-SUS-16-043 | $W$ $h(bb)$, EWK | 35.9 | ✓ | | | |
| CMS-SUS-16-045 | 2 $b$-jets + 2 $h(\gamma\gamma)$ | 35.9 | ✓ | | | |
| CMS-SUS-16-046 | high-$p_T$ $\gamma$ | 35.9 | ✓ | | | |
| CMS-SUS-16-047 | $\gamma$ + jets, high $H_T$ | 35.9 | ✓ | | | |
| CMS-SUS-16-048 | soft OS $\ell$ | 35.9 | | | ✓ | SLv1 |
| CMS-SUS-16-050 | $0\ell$ + top tag | 35.9 | ✓ | ✓ | ✓ | SLv1 |
| CMS-SUS-16-051 | $1\ell$ stop | 35.9 | ✓ | ✓ | | |
| CMS-SUS-17-003 | 2 $\tau$ | 35.9 | ✓ | | | |
| CMS-SUS-17-004 | EWK comb. | 35.9 | ✓ | | | |
| CMS-SUS-17-005 | $1\ell$ + jets, top tag | 35.9 | ✓ | ✓ | | |
| CMS-SUS-17-006 | jets + boosted $h(bb)$ | 35.9 | ✓ | ✓ | | |
| CMS-SUS-17-009 | SFOS $\ell$ | 35.9 | ✓ | ✓ | | |
| CMS-SUS-17-010 | $2\ell$ stop | 35.9 | ✓ | ✓ | | |
| CMS-SUS-18-002 | $\gamma$ + ($b$-)jets, top tag | 35.9 | ✓ | ✓ | | |
| CMS-SUS-18-004 | 2–3 soft $\ell$ | 137.0 | ✓ | ✓ | | |
| CMS-SUS-18-007 | 2 $h(\gamma\gamma)$, EWK | 77.5 | ✓ | ✓ | | |
| CMS-SUS-19-006 | $0\ell$ + jets, $\not{H}_T$ | 137.0 | ✓ | ✓ | ✓ | SLv1 |
| CMS-SUS-19-008 | $2\text{–}3\ell$ + jets | 137.0 | ✓ | ✓ | | |
| CMS-SUS-19-009 | $1\ell$ + jets, $\not{H}_T$ | 137.0 | ✓ | ✓ | | |
| CMS-SUS-19-010 | jets + top- and $W$-tag | 137.0 | ✓ | ✓ | | |
| CMS-SUS-19-011 | $2\ell$ stop | 137.0 | ✓ | ✓ | | |
| CMS-SUS-19-013 | jets + boosted $Z$ | 137.0 | ✓ | ✓ | | |
| CMS-SUS-20-001 | SFOS $\ell$ | 137.0 | ✓ | ✓ | | |
| CMS-SUS-20-002 | stop combination | 137.0 | ✓ | ✓ | | |
| CMS-SUS-20-004 | 2 $h(bb)$, EWK | 137.0 | ✓ | ✓ | ✓ | SLv2 |
| CMS-SUS-21-002 | hadr. EWK | 137.0 | ✓ | ✓ | ✓ | SLv1 |
| CMS-SUS-21-007 | $1\ell$ + top- or $W$-tag | 138.0 | ✓ | | | |