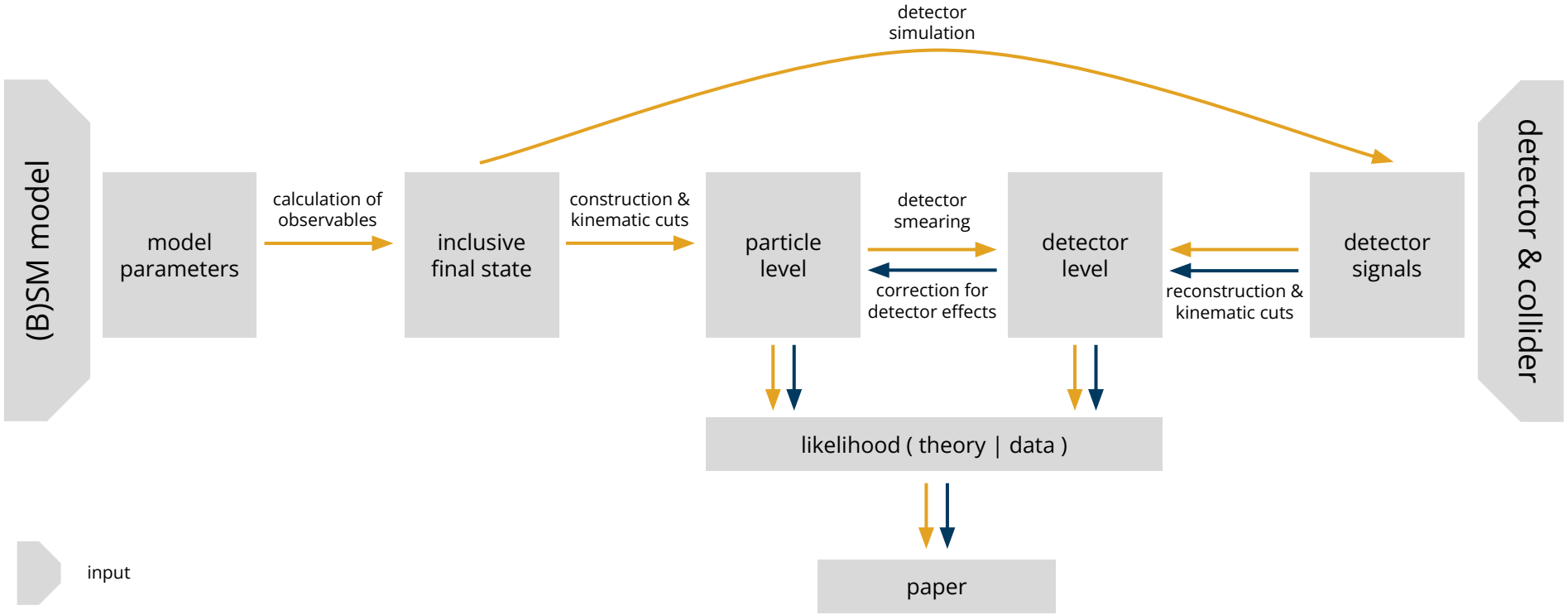
Analysis Preservation in ATLAS

Reinterpretation Forum Workshop 2025

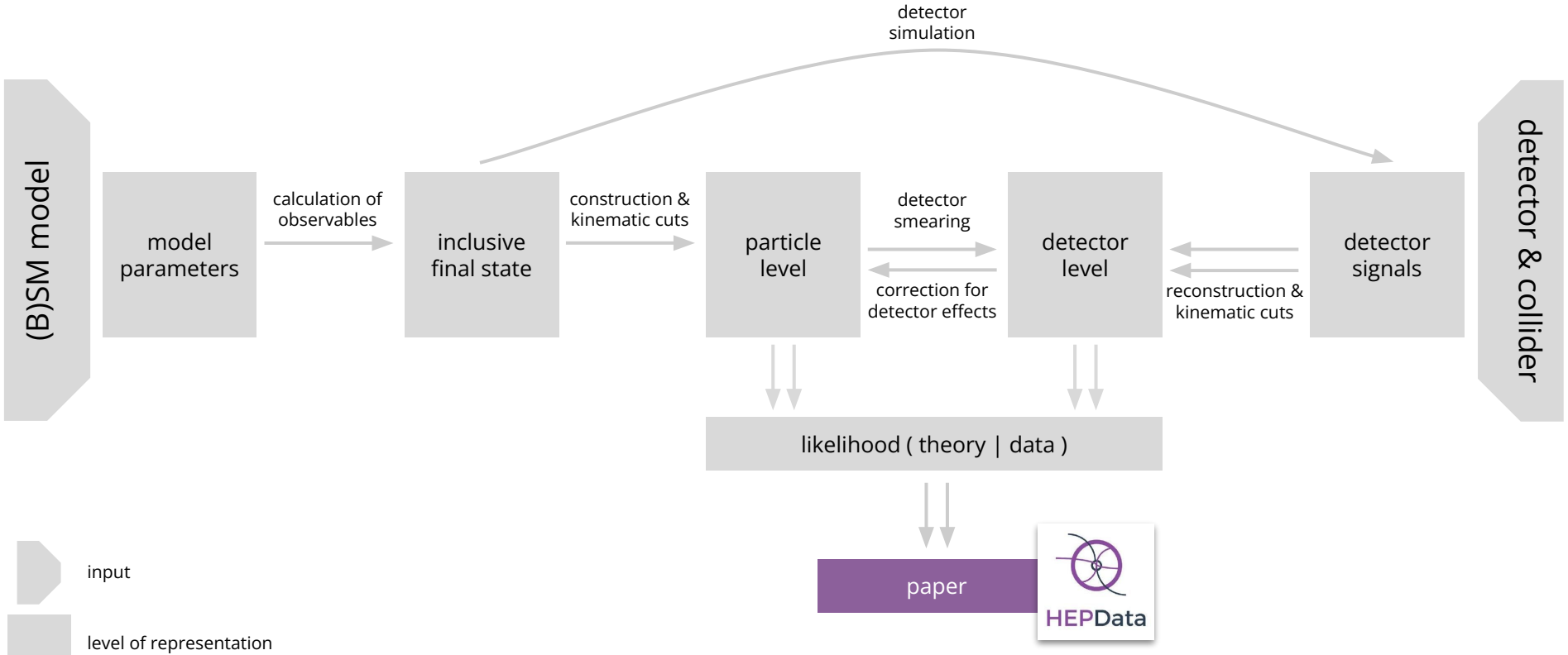
Martin Habedank o.b.o.
the ATLAS Collaboration
26th February 2025

Performing Analysis Preservation

Common approach of a physics analysis

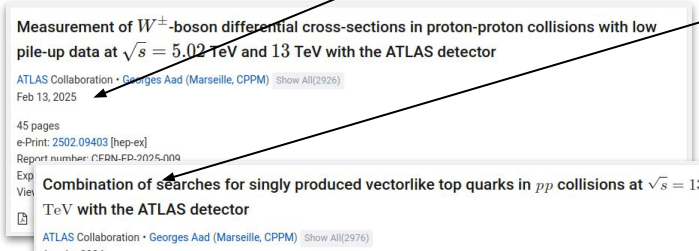


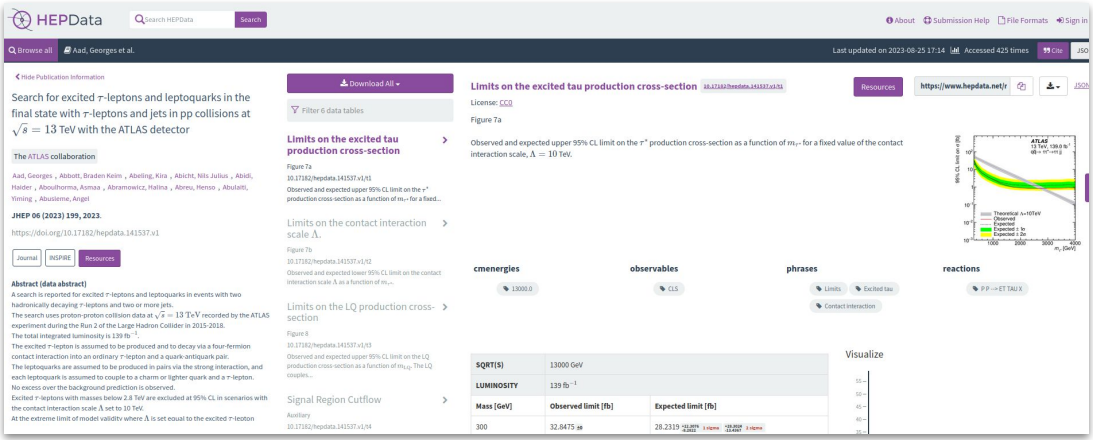
HEPData


detector simulation
(B)SM model
model parameters
calculation of observables
inclusive final state
construction & kinematic cuts
particle level
detector smearing
correction for detector effects
detector level
reconstruction & kinematic cuts
detector signals
detector & collider
likelihood (theory | data)
paper
HEPData
input
level of representation
steps for theory & experiment

HEPData

- Database of HEP experimental scattering data
- **Heavily encouraged by ATLAS for publication**
- 315 (1,423) papers published since last RiF workshop in 2022 (total)
  - 163 (771) have HEPData entry
  - Missing are often very recent or use previously published data





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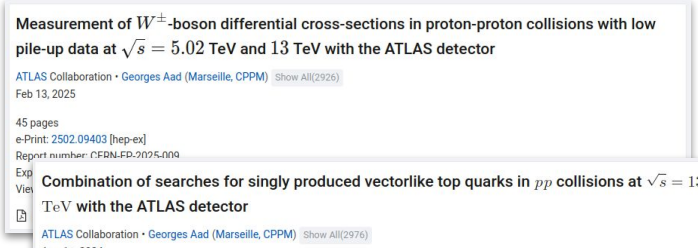
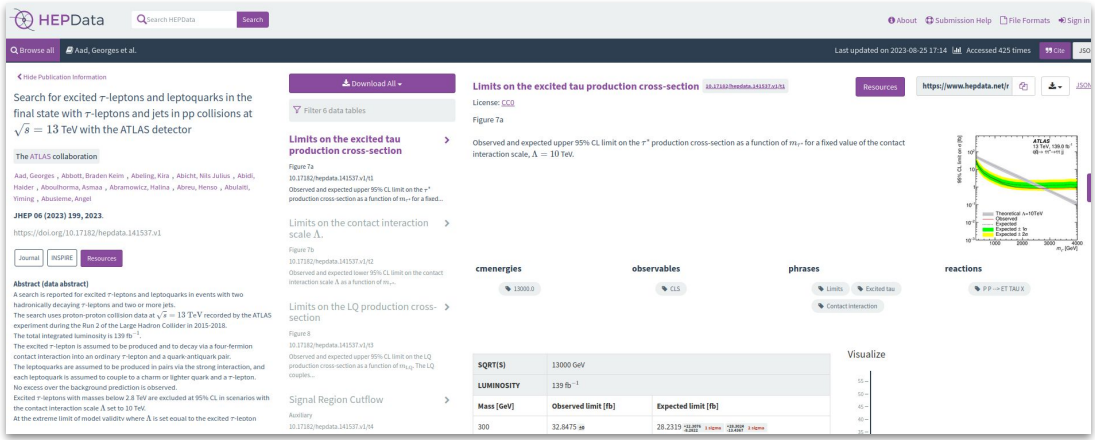
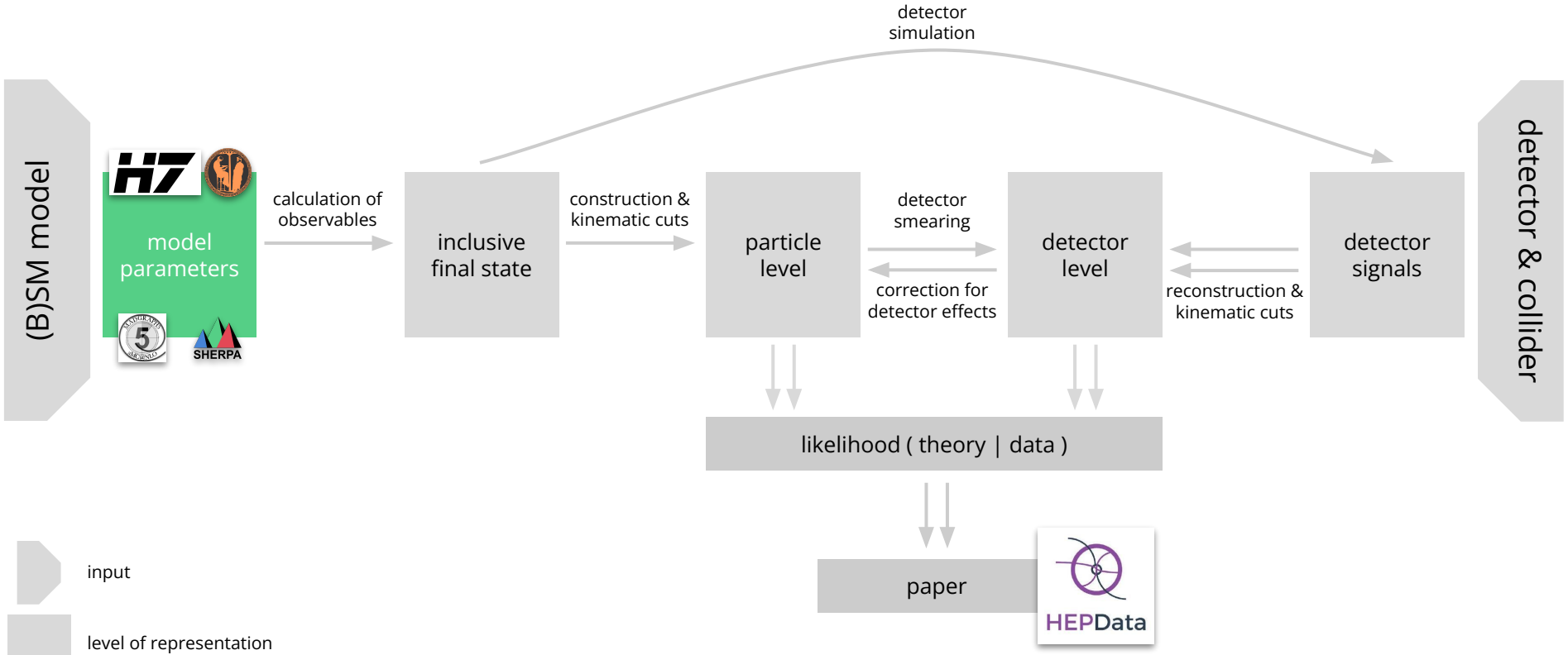
- 315 (1,423) papers published since last RiF workshop in 2022 (total)
  - 163 (771) have HEPData entry
  - Missing are often very recent or use previously published data
    - Let us know if something important is missing (ideally early after publication)!





Monte-Carlo run cards

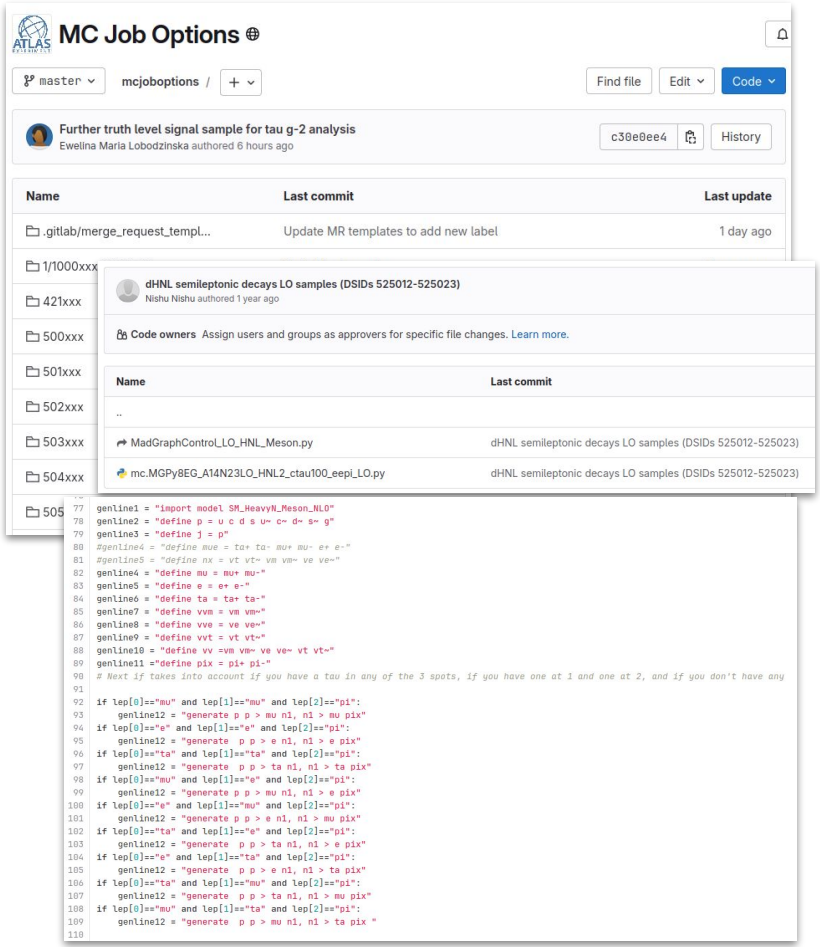


Monte-Carlo run cards

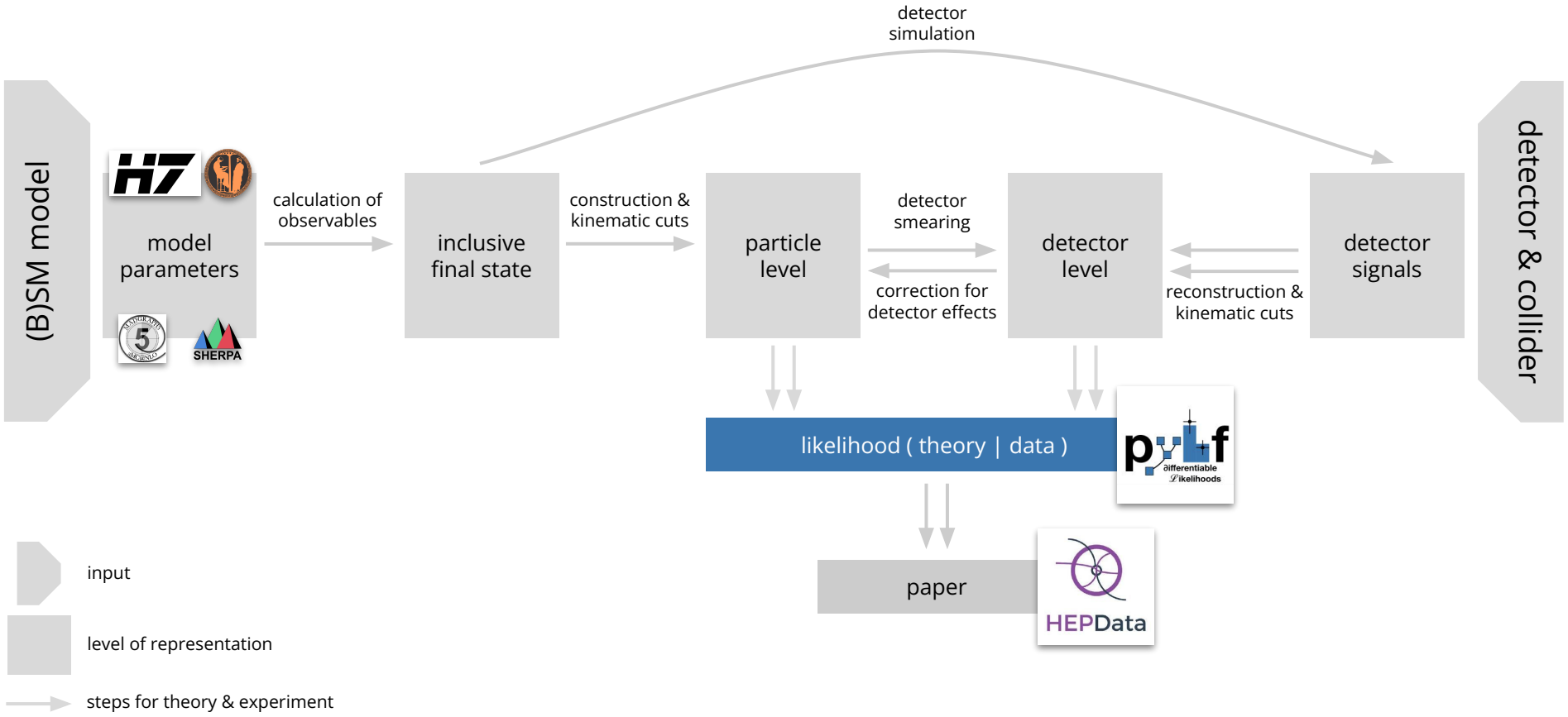
- Part of every ATLAS MC event request: **commit MC run card to git repository**
- **Fully public**:
  - Current run cards
  - Older run cards

SHERPA

MADGRAPH5 aMC@NLO



Likelihoods



Likelihoods

- ATLAS started providing simplified likelihoods on HEPData since 2019
- Details: ATL-PHYS-PUB-2021-038
- Uses pyHF (HistFactory) JSON
  - 16 (40) published models since last RiF (total)
  - Retrievable as JSON
  - Can be directly interpreted by SModelS and MadAnalysis5

$$p(\text{theory}|\text{data}) \sim p(\text{data}|\text{theory}) \otimes p(\text{theory})$$

new result! *what we provide* *your new model*

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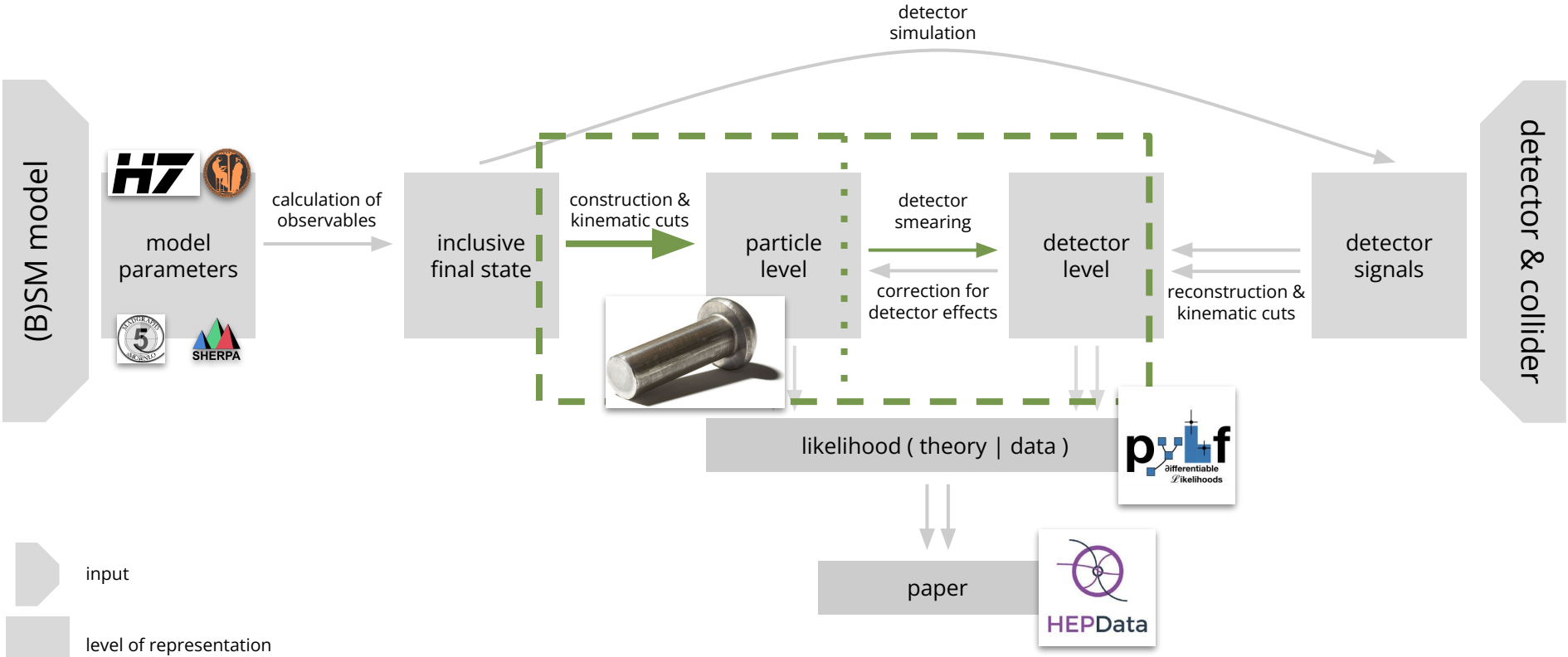
What should the interplay with HS^3 and CMS Combine be?

Rivet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Rivet

- Providing a Rivet routine de-facto **requirement for ATLAS SM analyses**
- Preserves the **analysis logic**
  - Mostly used at particle level (unfolded data)
  - Only rarely used on detector level (yet!)
- 18 (212) new analyses since last RiF (total)

Rivet analyses reference

ATLAS_2024_I2809112

ttbb production at 13 TeV
Experiment: ATLAS (LHC)
Inspire ID: 2809112
Status: VALIDATED
Authors:

- Mahsana Haleem

References:

- Public page: ATLAS-STDM-2019-03
- arXiv: 2407.13473

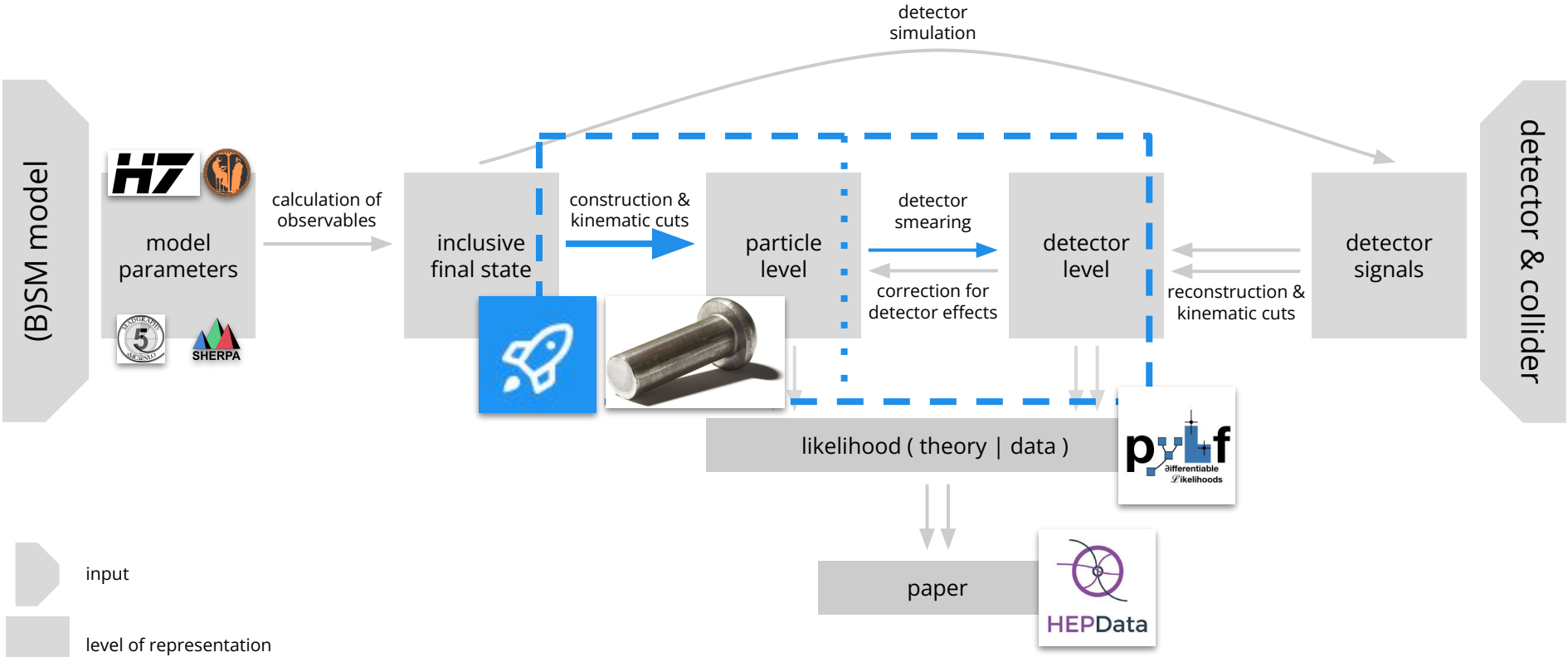
Beams: p+ p+
Beam energies: (6500.0, 6500.0) GeV
Run details:

- pp -> ttbb in the e-mu channel

Source code: ATLAS_2024_I2809112.cc

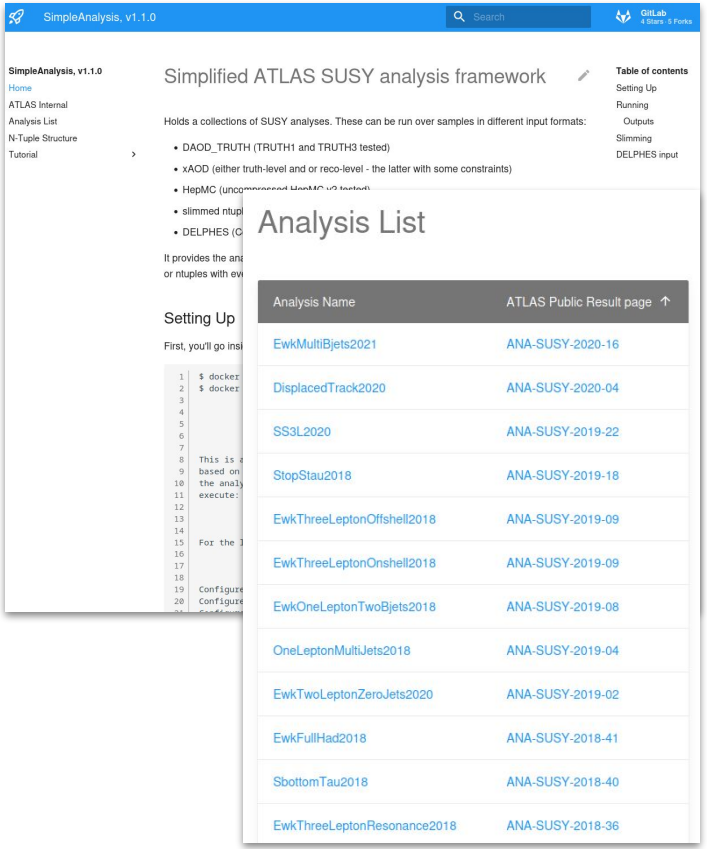
```
// -*- C++ -*-
#include "Rivet/Analysis.hh"
#include "Rivet/Projections/FastJets.hh"
#include "Rivet/Projections/FinalState.hh"
#include "Rivet/Projections/LeptonFinder.hh"
#include "Rivet/Projections/PromptFinalState.hh"
#include "Rivet/Projections/VetoedFinalState.hh"
#include "Rivet/Projections/MissingMomentum.hh"
#include "Rivet/Projections/InvisibleFinalState.hh"

namespace Rivet {


class ATLAS_2024_I2809112 : public Analysis {
 public:

  /// @brief ttbb production at 13 TeV
  RIVET_DEFAULT_ANALYSIS_CTOR(ATLAS_2024_I2809112);

  void init() {

    // Photons
    PromptFinalState photons(Cuts::abspid == PID::PHOTON);

    // Kinematic cuts for leptons
    const Cut cuts_lep = Cuts::pT > 25*GeV && Cuts::abseta < 2.5;

    // Muons
    PromptFinalState bare_mu(Cuts::abspid == PID::MUON, TauDecaysAs::PROMPT);
    LeptonFinder all_dressed_mu(bare_mu, photons, 0.1, cuts_lep);
    declare(all_dressed_mu, "DressedMuons");

    // Electrons
    PromptFinalState bare_el(Cuts::abspid == PID::ELECTRON, TauDecaysAs::PROMPT);
    LeptonFinder all_dressed_el(bare_el, photons, 0.1, cuts_lep);
    declare(all_dressed_el, "DressedElectrons");

    //Jet forming
    const InvisibleFinalState neutrinos(OnlyPrompt::YES, TauDecaysAs::PROMPT);

    VetoedFinalState vfs(FinalState(Cuts::abseta < 5.0));
    vfs.addVetoOnThisFinalState(all_dressed_el);
    vfs.addVetoOnThisFinalState(all_dressed_mu);
    vfs.addVetoOnThisFinalState(neutrinos);

    FastJets jet(vfs, JetAlg::ANTIKT, 0.4, JetMuons::ALL, JetInvisibles::ALL);
    declare(jet, "Jets");
```

SimpleAnalysis

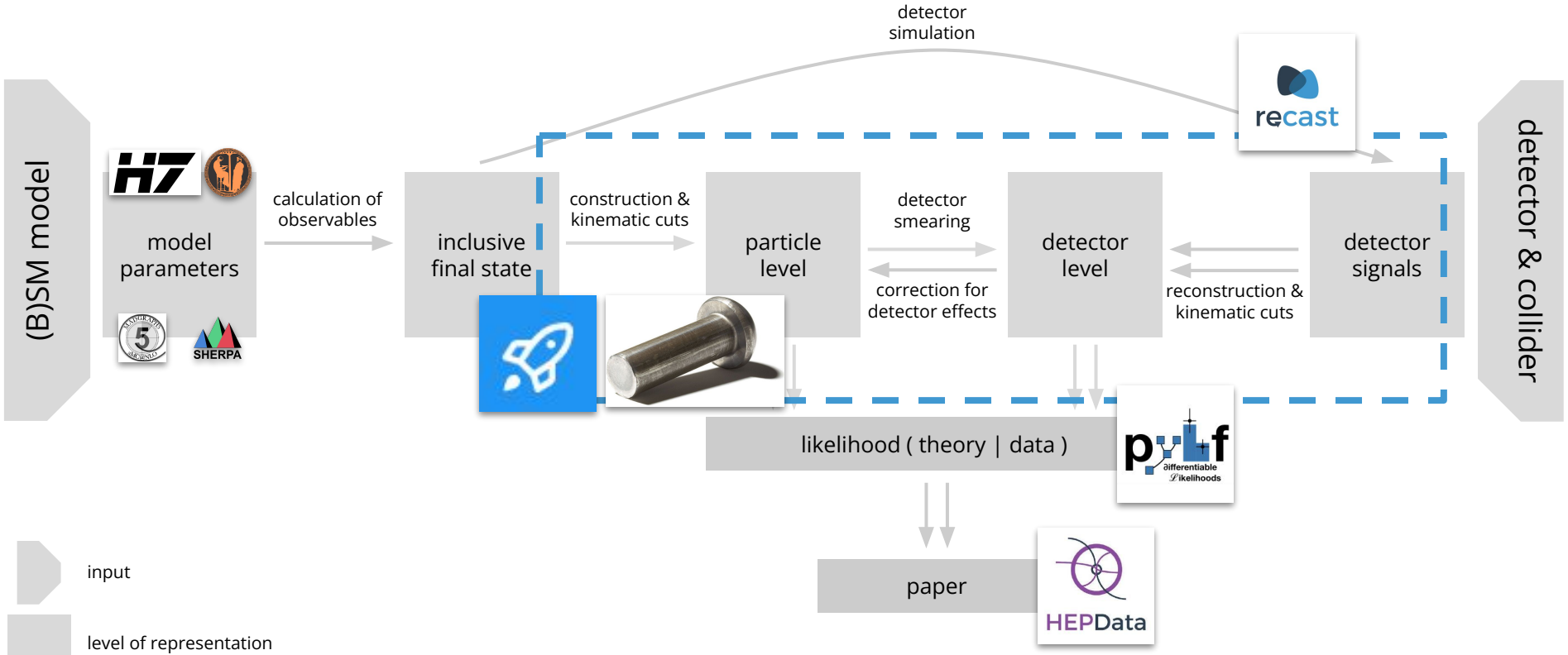


SimpleAnalysis

- SimpleAnalysis:
  - ATLAS tool, but usable outside ATLAS
  - ATL-PHYS-PUB-2022-017
- Preserves the **analysis logic**
  - Generally on particle level
  - Detector effects can be added: Public simulation like Delphes or internally by ATLAS fast simulation
- User-friendly input format: HepMC, ATLAS derivation (DAOD), ROOT n-tuple, Delphes
- 3 (76) new analyses since last RiF (total)
  - Only searches: supersymmetry & exotics



RECAST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RECAST

- **RECAST**:
  - ATLAS tool, software fully open source
  - Analysis implementations ATLAS-interal

- **Preservation of full analysis pipeline**
  - Preservation of original analysis pipeline for re-interpretaion
  - Contains full detector simulation information & original code/ workflow
  - Reinterpretation with full workflow + simulation effects

- 78 (122) new analyses since last RiF (total)

Yvonne's talk @ RiF 2022

→ We still want to do that! Let us know how this would be most useful to you!

After Analysis Preservation

RAMP seminars

“**Reinterpretation: Auxiliary Material Presentation**” (TWiki)

- Given by LHC analysis teams who have published sufficient reinterpretation material.
- Focuses on the reinterpretation material
- Brings together providers and users of reinterpretation material
- Sometimes includes feedback reports from users
- 7 installments since last RiF, 9 contributions from ATLAS

Contur

- Automatically runs Contur on newly generated ATLAS MC signal samples (credit: Louie Corpe)

➔ Direct feedback of generated signal point is already excluded!

ATLAS Exotics AutoContur Table

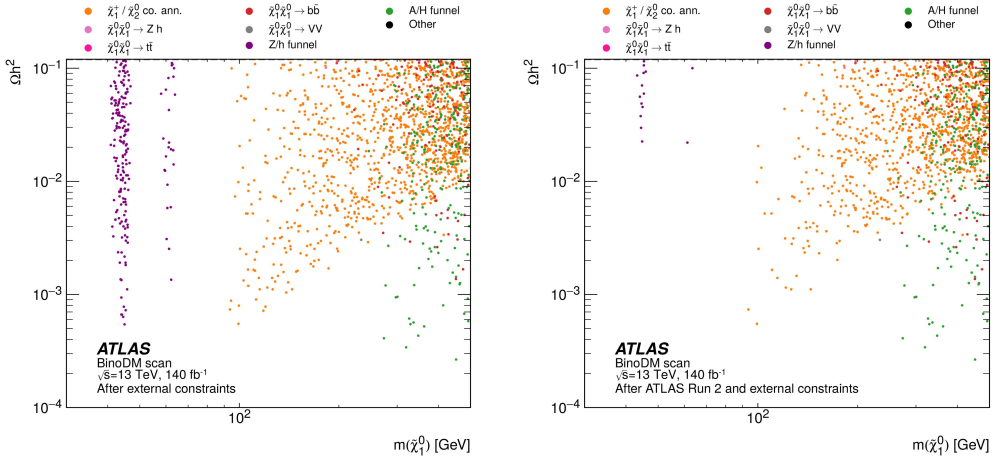
Enter regex to filter rows | Download Filtered Rows

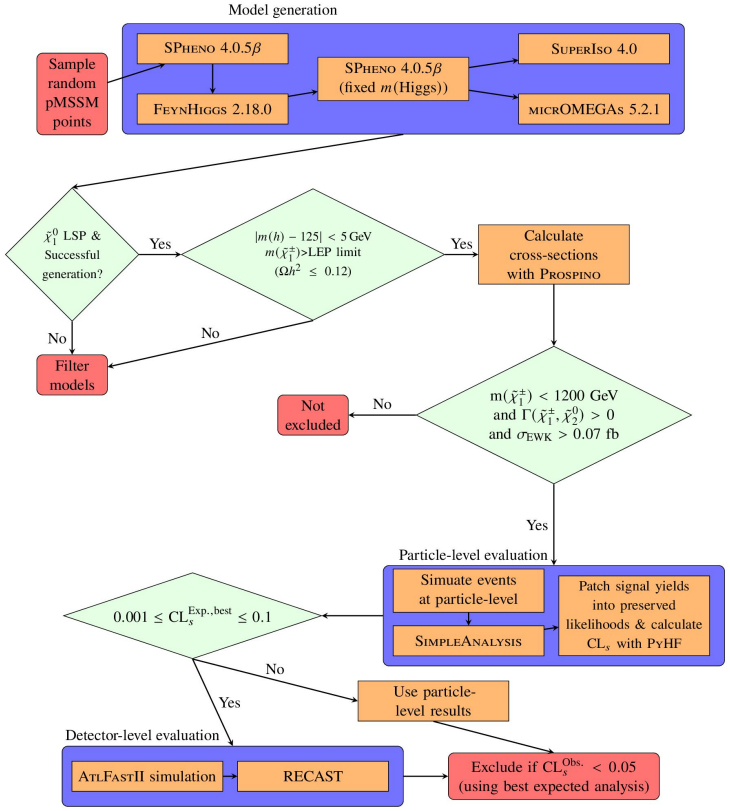
Campaign	DSID	Shortname	Nominal XS [pb]	CLs Exl (Obs)	CLs Exl (Exp)	Rivet Plots	Dominant Pool	Dominant Analysis	Projected 95%CL OBS excl [pb]	Projected 95%CL EXP excl [pb]	Projected 95%CL EXP excl at HL-LHC [pb]
mc15_13TeV	515130	MGPy8EG_A14N23LO_HNL1_ctau0p1_eee	3.5e+02	0.00	0.06	Plots	ATLAS_13_JETS	/ATLAS_2018_I1634970/d03-x01-y01 Inspire HEPData	3.5e+04 (mu=1e+02) CLs_extrap	3.5e+04 (mu=1e+02) CLs_extrap	3.3e+03 (mu=9.4) CLs_extrap
mc15_13TeV	515131	MGPy8EG_A14N23LO_HNL1_ctau1_eee	3.5e+03	0.00	0.00	Plots	ATLAS_13_JETS	/ATLAS_2018_I1634970/d01-x01-y01,/ATLAS_2018_I1634970/d02-x01-y01,/ATLAS_2018_I1634970/d03-x01-y01,/ATLAS_2018_I1634970/d04-x01-y01,/ATLAS_2018_I1634970/d05-x01-y01,/ATLAS_2018_I1634970/d06-x01-y01 Inspire HEPData	3.5e+05 (mu=1e+02) CLs_extrap	3.5e+05 (mu=1e+02) CLs_extrap	3e+05 (mu=86) CLs_extrap
mc15_13TeV	515132	MGPy8EG_A14N23LO_HNL1_ctau10_eee	3.5e+04	0.42	0.68	Plots	ATLAS_13_LLJET	/ATLAS_2022_I2077570/d01-x01-y01 Inspire HEPData	3e+06 (mu=87) CLs_extrap	3e+06 (mu=86) CLs_extrap	3.4e+03 (mu=0.097) CLs_extrap
mc15_13TeV	515133	MGPy8EG_A14N23LO_HNL1_ctau100_eee	3.5e+05	0.84	0.93	Plots	ATLAS_13_LLJET	/ATLAS_2022_I2077570/d03-x01-y01 Inspire HEPData	2.5e+06 (mu=7.2) CLs_extrap	1.4e+06 (mu=4) CLs_extrap	3.5e+03 (mu=0.01) CLs_extrap
mc15_13TeV	515134	MGPy8EG_A14N23LO_HNL1_ctau1000_eee	3.5e+06	0.99	0.94	Plots	ATLAS_13_JETS	/ATLAS_2018_I1634970/d01-x01-y01,/ATLAS_2018_I1634970/d02-x01-y01,/ATLAS_2018_I1634970/d03-x01-y01,/ATLAS_2018_I1634970/d04-x01-y01,/ATLAS_2018_I1634970/d05-x01-y01,/ATLAS_2018_I1634970/d06-x01-y01 Inspire HEPData	3.2e+06 (mu=0.9) CLs_extrap	8.6e+06 (mu=2.4) CLs_extrap	3.5e+04 (mu=0.01) CLs_extrap

pMSSM scan

ATLAS Run 2 searches for electroweak production of supersymmetric particles interpreted within the pMSSM

- *JHEP* 05 (2024) 106
- Enourmous technical achievement to use **fast analysis preservation** (SimpleAnalysis) and **full AP** (RECAST) to **systematically probe pMSSM**





Summary and Outlook

Topics covered in other talks

Make sure to listen to dedicated talks (or have a look if you missed them) for

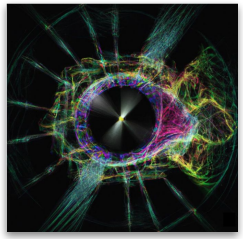
- Open Data: Wed, 9:00
- Open Event Generation: Wed, 9:45
- HS^3: Wed, 11:40
- ATLAS ML preservation updates: Wed, 17:00

Outlook

New, more standardised analysis workflows in EXOT and HMBS:

ntupling | **post-processing** | **statistical analysis**

TopCPToolkit



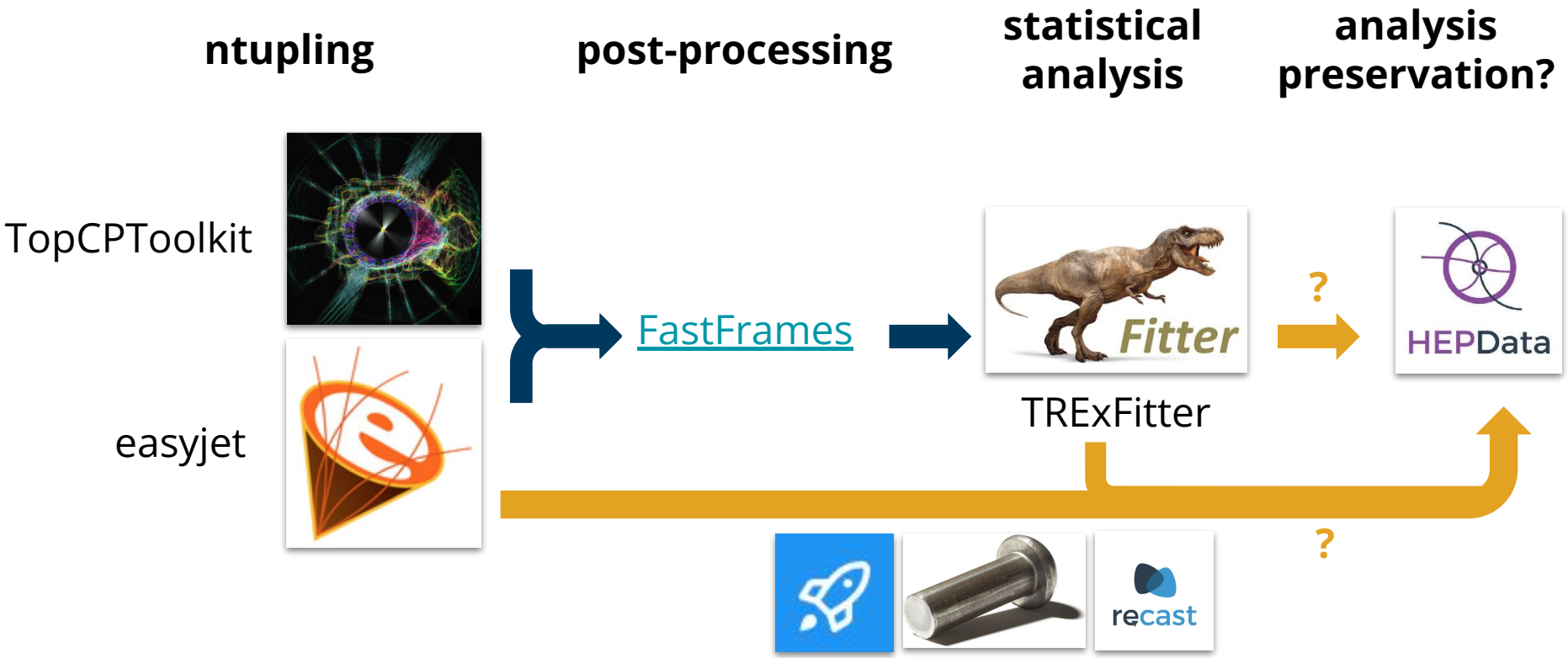
easyjet

FastFrames

TRExFitter

Outlook

New, more standardised analysis workflows in EXOT and HMBS:



Summary

- We’re very aware of use and impact of analysis preservation
- We want **fruitful exchanges with pheno community**!

➔ Try our best to provide as much and as useful information as possible!

- Unfortunately, our (person-power) resources are limited

➔ (Continue to) **let us know where we’re falling short** or could re-focus our efforts!

➔ Looking forward to the **work of the REI working group**!

Backup