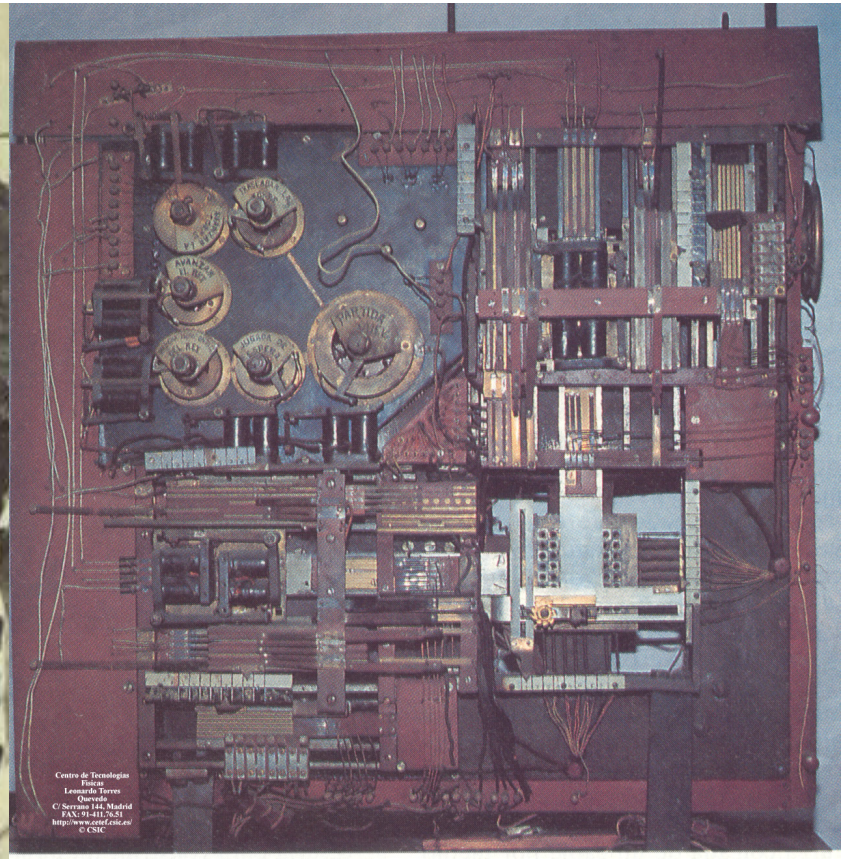
♔ CheckMATEing BSM Physics ♔



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DFG Terascale

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♔ Contents

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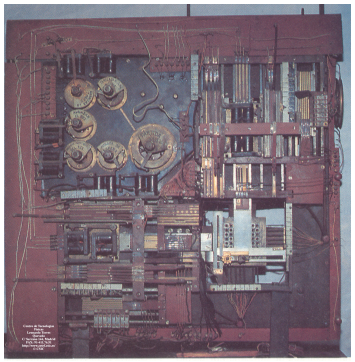
Checks Models At Terascale Energies

`http://checkmate.hepforge.org/`



User Mode

- ♙ Data Input
- ♕ Data Procession
- ♘ Data Output

Opening the Box

- Overview ♖
- Analysis Manager ♘
- Future Features ♗

♕ User Mode ♕

The Idea

*"The idea is to create a program:
You just enter a model, press a button, and it tells you whether collider results exclude your model or not."*

"Sounds great! Let's do it!"

♔ ~~The Idea~~ The Reality

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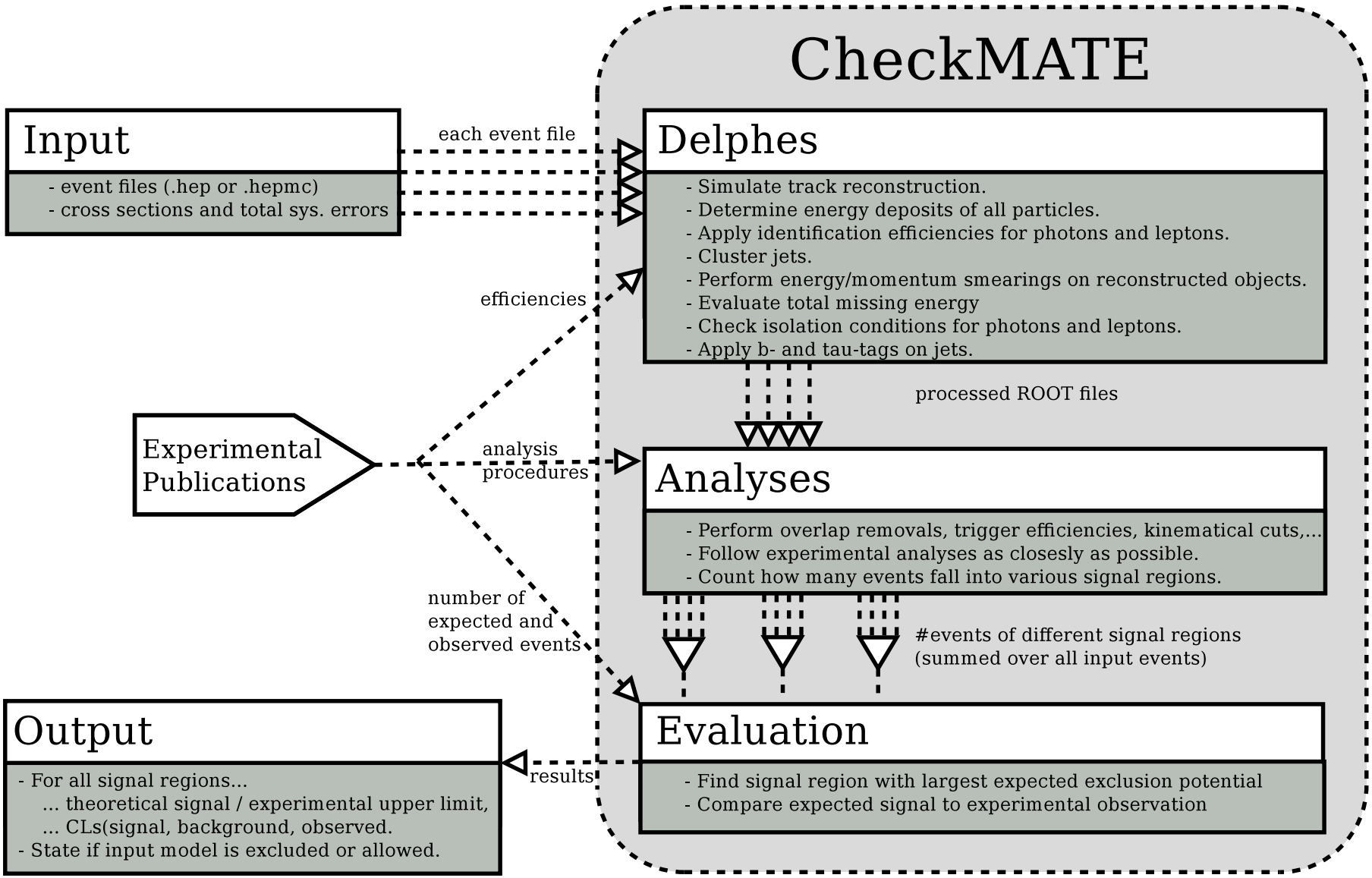
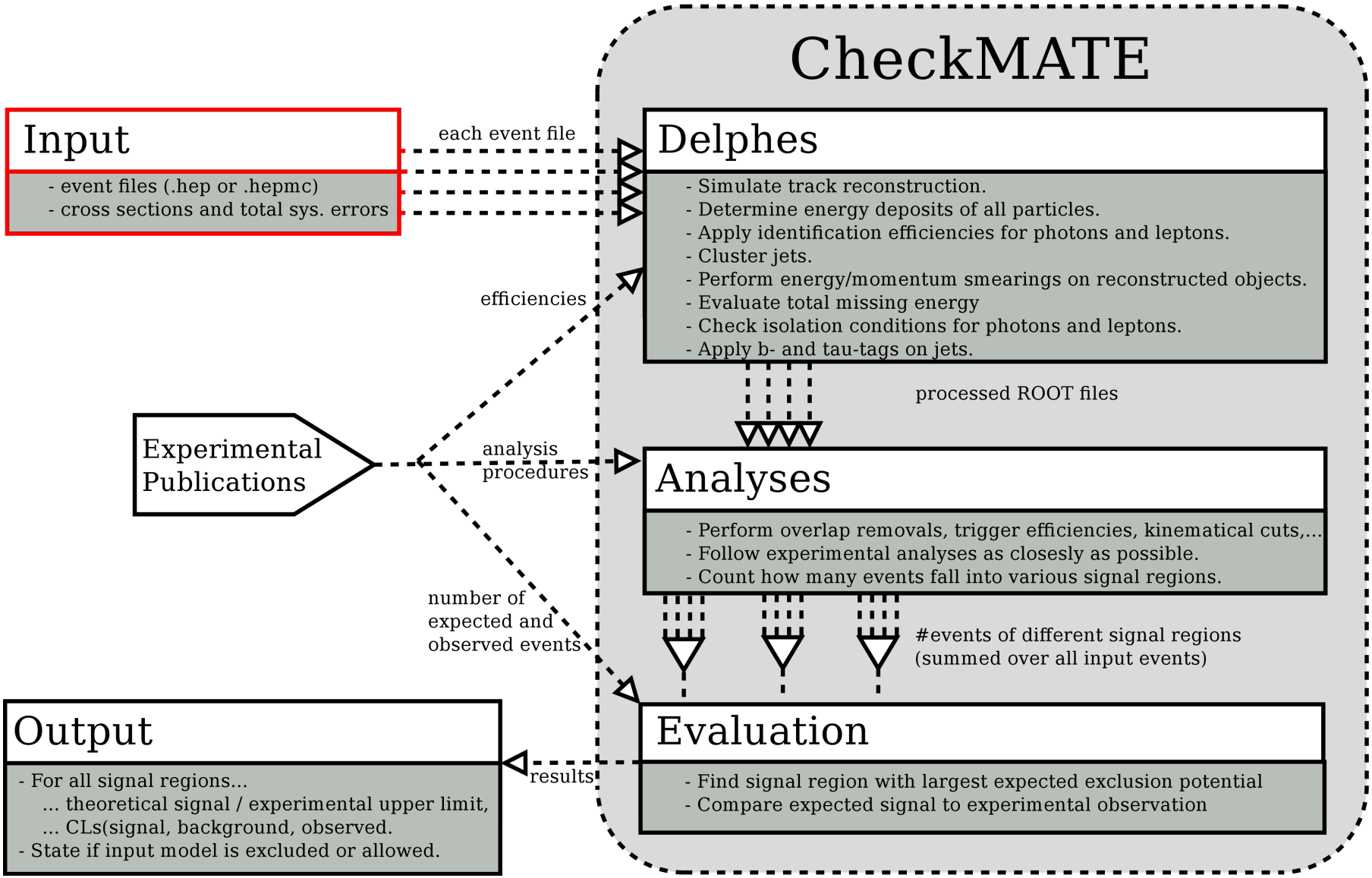
"We have created a program:
You just enter event files and cross sections of your model, press a button, and it tells you whether collider results exclude your model or not."

" That's useful!"

Overview: Data Flow



Input


CheckMATE
Input
- event files (.hep or .hepmc)
- cross sections and total sys. errors
each event file
Delphes
- Simulate track reconstruction.
- Determine energy deposits of all particles.
- Apply identification efficiencies for photons and leptons.
- Cluster jets.
- Perform energy/momentum smearings on reconstructed objects.
- Evaluate total missing energy
- Check isolation conditions for photons and leptons.
- Apply b- and tau-tags on jets.
efficiencies
processed ROOT files
Experimental Publications
analysis procedures
Analyses
- Perform overlap removals, trigger efficiencies, kinematical cuts,...
- Follow experimental analyses as closesly as possible.
- Count how many events fall into various signal regions.
number of expected and observed events
#events of different signal regions (summed over all input events)
Output
- For all signal regions...
... theoretical signal / experimental upper limit,
... CLs(signal, background, observed.
- State if input model is excluded or allowed.
results
Evaluation
- Find signal region with largest expected exclusion potential
- Compare expected signal to experimental observation

Input: Minimal Case


```
[Mandatory Parameters]
Name: My_New_Run
Analyses: atlas_conf_2013_047

[gluinogluino]
XSect: 3.53*FB
XSectErr: 1e-5*PB
Events: /scratch/gg/events.hep
```

Required

- Name
- At least one analysis
- At least one `[process]` with at least one item in `Events` (.hep or .hepmc), one total cross section and a total estimate on the *systematic* error

Input: Extended Cases


```
[Mandatory Parameters]
Name: My_New_Extended_Run
Analyses: atlas_conf_2013_035,
          atlas_conf_2013_049,
          atlas_conf_2013_047,
          atlas_conf_2013_089

[gluinogluino]
XSect: 3.53*FB
XSectErr: 1e-5*PB
Events: gg.hep
```

Optional

- More analyses (Delphes still runs only once but then the analyses are processed one by one)

Input: Extended Cases

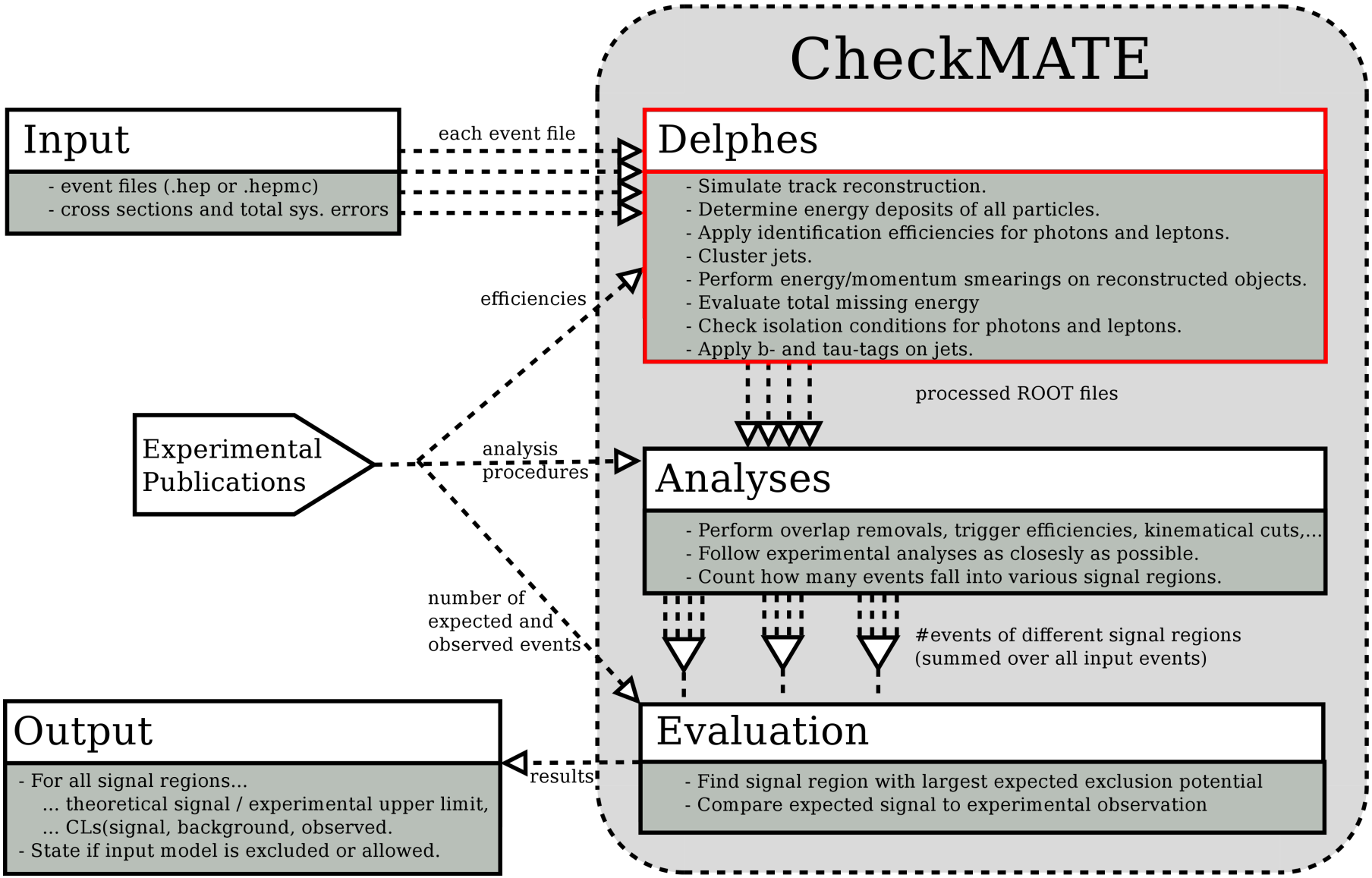

```
[gluinogluino]
XSect: 3.53*FB
XSectErr: 1e-5*PB
Events: gg1.hep, gg2.hep

[squarksquark]
XSect: 4.64*FB
XSectErr: 2e-5*PB
Events: ss1.hep, ss2.hep
```

Optional

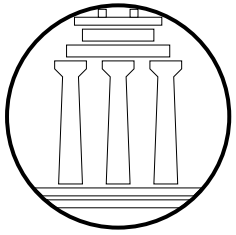
- Many event files for one process (are processed one by one, normalised *in total* to the given cross section)
- Events for different processes with individual cross sections and errors (are processed one by one, normalised events *independently added* in the end)

Step 1: Delphes



Delphes 3.0.10 Standard

- Simulates tracking and energy deposition
- Applies identification efficiencies for photons and leptons
- Clusters jets
- Performs energy/momentum smearings of all reconstructed objects
- Evaluates total missing energy
- Checks isolation conditions for photons and leptons
- Applies b-/ tau-tag on jets



DELPHES
fast simulation

Extra Features / Improvements

- Added identification and isolation flags
- Tuned to better represent ATLAS detector

Detector Tunings — Examples

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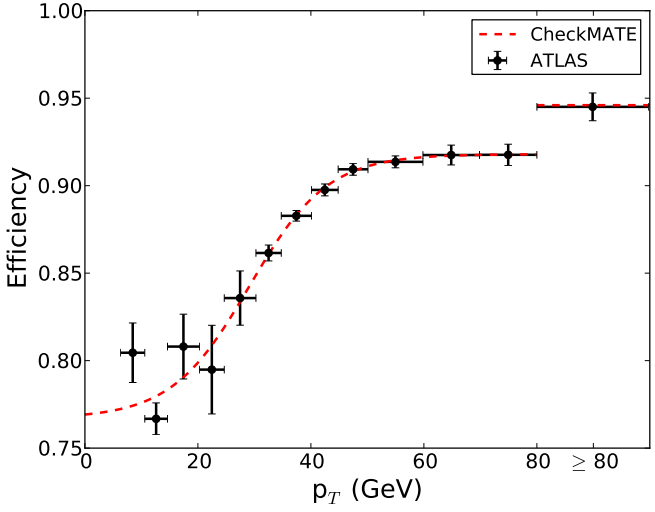
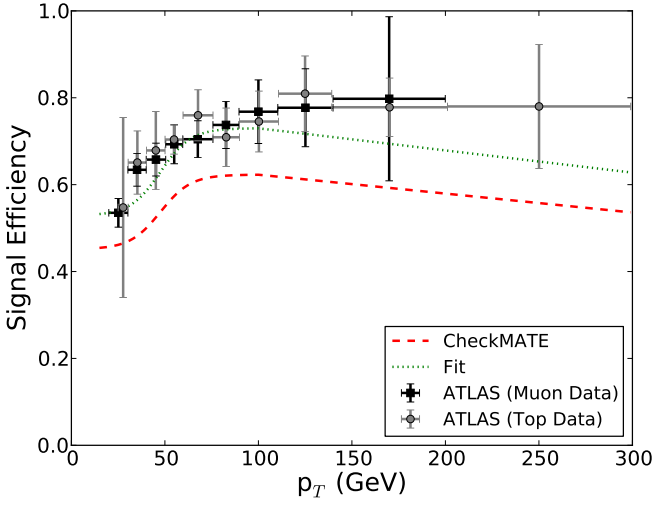
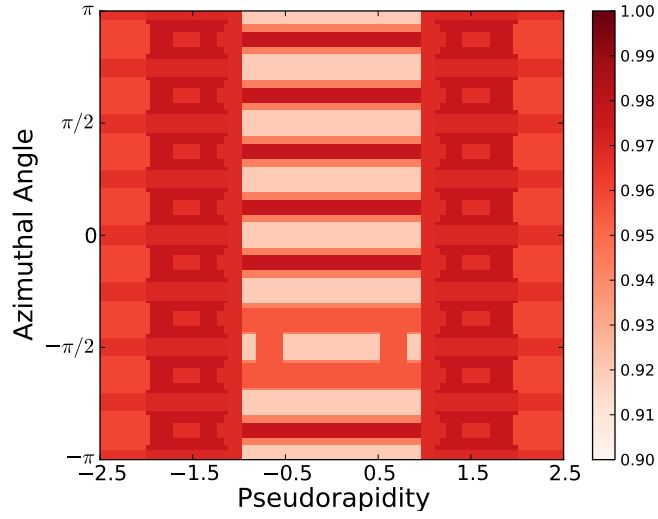
Electrons

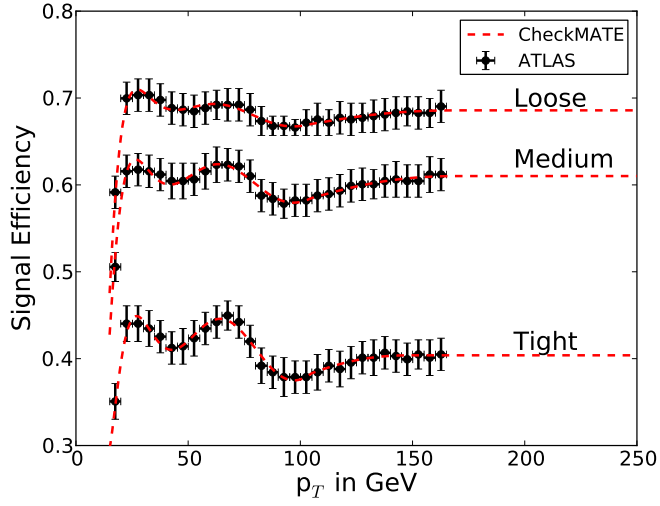




Jets from a b–quark

Muons





Jets from a τ–lepton

Input and Setup

- The user has declared, which analyses should be considered
- Every analysis comes with a list of required objects:
  - Efficiency and isolation for electrons, muons and photons
  - Parameters for jet algorithm (p_{min}^{T}, ΔR)
  - If/Which τ IDs are used
  - If/Which b IDs are used
- CheckMATE will *automatically* find and merge all analyses' settings, load the required Delphes modules and runs on each input event file *once*, regardless of the number of analyses

Delphes within CheckMATE

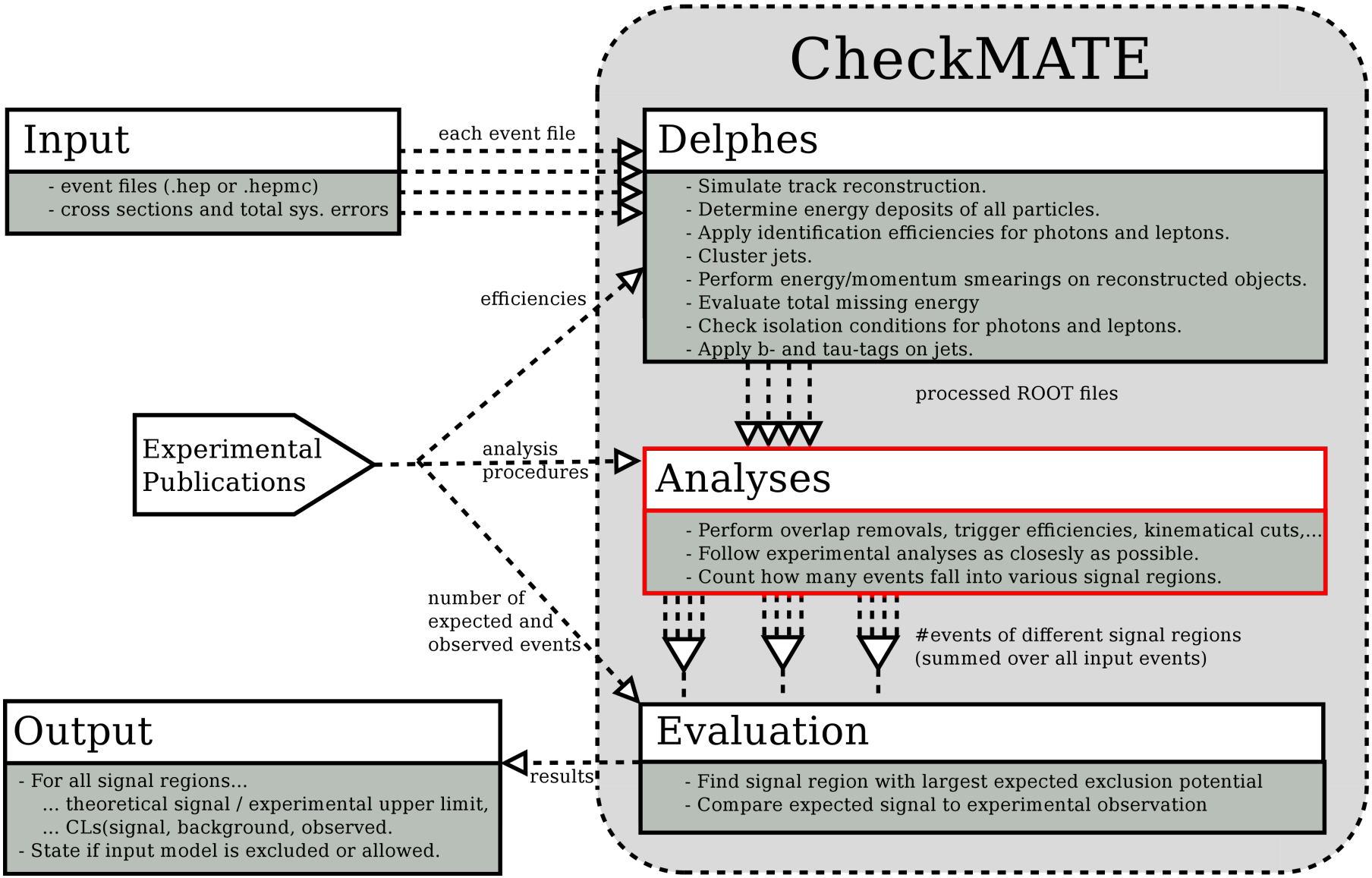
Input and Setup

- The user has declared, which analyses should be considered
- Every analysis comes with a list of required objects:
  - Efficiency and isolation for electrons, muons and photons
  - Parameters for jet algorithm (p_{min}^{T}, ΔR)
  - If/Which τ IDs are used
  - If/Which b IDs are used
- CheckMATE will *automatically* find and merge all analyses' settings, load the required Delphes modules and runs on each input event file *once*, regardless of the number of analyses

Output

- Delphes produces a ROOT output file for each input event file
- These are automatically processed by further CheckMATE units, but can be examined by user if desired

Step 2: Analyses



Analyses

A CheckMATE analysis does the following

- Choose the objects of interest (leptons, jets,...)
- Filter objects (efficiency and isolation flags, kinematical cuts, overlap removals, ...)
- Check event vetoes (Too many/few objects, trigger efficiencies, ...)
- Check various signal region criteria (total $\not{E}_T$, # and energy of objects, ...)
- Count number of input events that fall into each signal region

Analyses

A CheckMATE analysis does the following

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- Count number of input events that fall into each signal region

Output

- For each input file, store general information and
- for each SR, store Σ (weights) and Σ(weights^2) for the input events that passed the respective signal region cuts

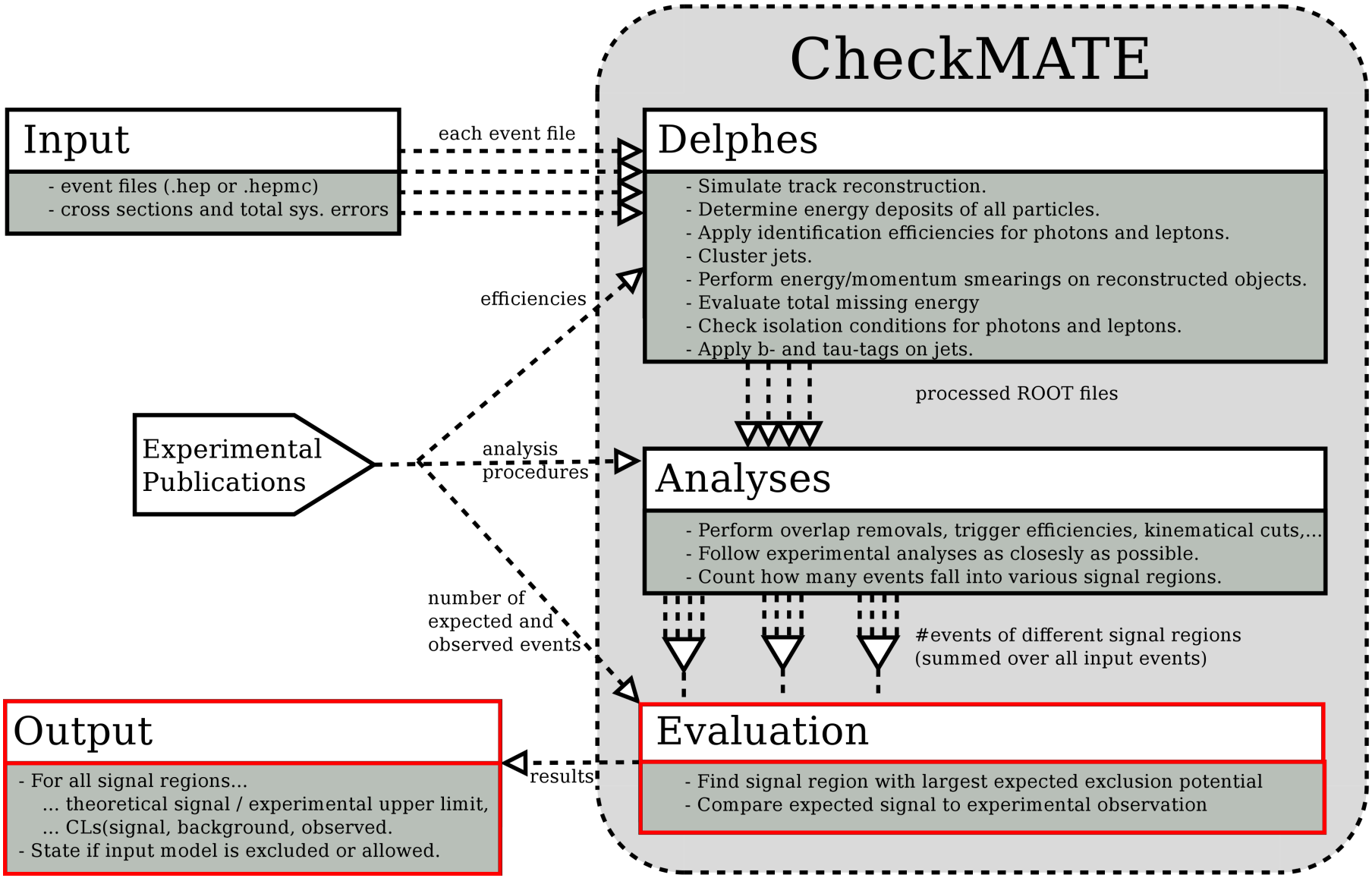
Example Output


```
# ATLAS
# ATLAS-CONF-2013-047
# 0 leptons, 2-6 jets, etmiss
# sqrt(s) = 8 TeV
# int(L) = 20.3 fb^-1

Inputfile:          /hdd/results/cMSSM/delphes/000_delphes.root
XSect:              4.35 fb
 Error:             1.22086 fb
MCEvents:           5000
 SumOfWeights:      5000
 SumOfWeights2:     5000
 NormEvents:        87.9518

SR   Sum_W   Sum_W2   Acc      N_Norm
AL   1315    1315     0.263    23.1313
AM   71      71       0.0142   1.24892
BM   98      98       0.0196   1.72385
BT   2       2        0.0004   0.0351807
CM   505     505      0.101    8.88313
CT   9       9        0.0018   0.158313
D    184     184      0.0368   3.23663
EL   613     613      0.1226   10.7829
EM   398     398      0.0796   7.00096
ET   149     149      0.0298   2.62096
```

Step 3: Evaluation



Evaluation

Input and Setup

- We have number of expected signal $S \pm \Delta S$ in each signal region
- CheckMATE has a reference card with experimental results:
  - observed events O
  - expected background plus uncertainty $B \pm \Delta B$
  - (in most cases) translated 95% upper limit on signal S^{95}_{max}

User can choose

- Directly compare S to S^{95}_{max}
- If $r^{c} = \frac{S - 2\Delta S}{S^{95}_{\text{max}}} > 1$: Excluded!
- Quick and easy for limit setting

- Evaluate $\text{CL}_s(O, B, \Delta B, S, \Delta S)$
- If $\text{CL}_s < 0.05$: Excluded!
- Slower, but limits can be set to different confidence levels

Evaluation

Input and Setup

- We have number of expected signal $S \pm \Delta S$ in each signal region
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- Evaluate $\text{CL}_s(O, B, \Delta B, S, \Delta S)$
- If $\text{CL}_s < 0.05$: Excluded!
- Slower, but limits can be set to different confidence levels

Result

- Choose signal region with strongest *expected* exclusion ($O = B$)
- Use its *observed* result to state final "excluded" or "allowed"

ATLAS Reference

Signal Region	**A-loose**	**A-medium**	**B-medium**	**B-tight**
Total bkg	4700 ± 500	122 ± 18	33 ± 7	2.4 ± 1.4
Observed	5333	135	29	4
S^{95}_{obs}	1341.2	51.3	14.9	6.7
S^{95}_{exp}	$1135.0^{+332.7}_{-291.5}$	$42.7^{+15.5}_{-11.4}$	$17.0^{+6.6}_{-4.6}$	$5.8^{+2.9}_{-1.8}$

Example

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ATLAS Reference

Signal Region	A-loose	A-medium	B-medium	B-tight
Total bkg	4700 ± 500	122 ± 18	33 ± 7	2.4 ± 1.4
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atlas_conf_2013_047_r_limits

SR	S	dS_stat	dS_sys	dS_tot	S95_obs	S95_exp	r^c_obs	r^c_exp
AL	37.36	0.61	4.10	4.15	1341.20	1135.00	0.02	0.03
AM	5.34	0.22	0.55	0.59	51.30	42.70	0.08	0.10
BM	7.41	0.25	0.77	0.81	14.90	17.00	0.39	0.34
BT	0.86	0.07	0.10	0.12	6.70	5.80	0.09	0.11
CM	17.82	0.43	1.99	2.04	81.20	72.90	0.17	0.19
CT	2.40	0.12	0.28	0.31	2.40	3.30	0.75	0.54
D	12.14	0.34	1.29	1.33	15.50	13.60	0.61	0.70
EL	21.26	0.46	2.35	2.39	92.40	57.30	0.18	0.29
EM	16.14	0.40	1.79	1.83	28.60	21.40	0.44	0.59
ET	7.95	0.28	0.87	0.91	8.30	6.50	0.74	0.95

Example

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ATLAS Reference

Signal Region	A-loose	A-medium	B-medium	B-tight
Total bkg	4700 ± 500	122 ± 18	33 ± 7	2.4 ± 1.4
Observed	5333	135	29	4
S^{95}_{obs}	1341.2	51.3	14.9	6.7
S^{95}_{exp}	$1135.0^{+332.7}_{-291.5}$	$42.7^{+15.5}_{-11.4}$	$17.0^{+6.6}_{-4.6}$	$5.8^{+2.9}_{-1.8}$

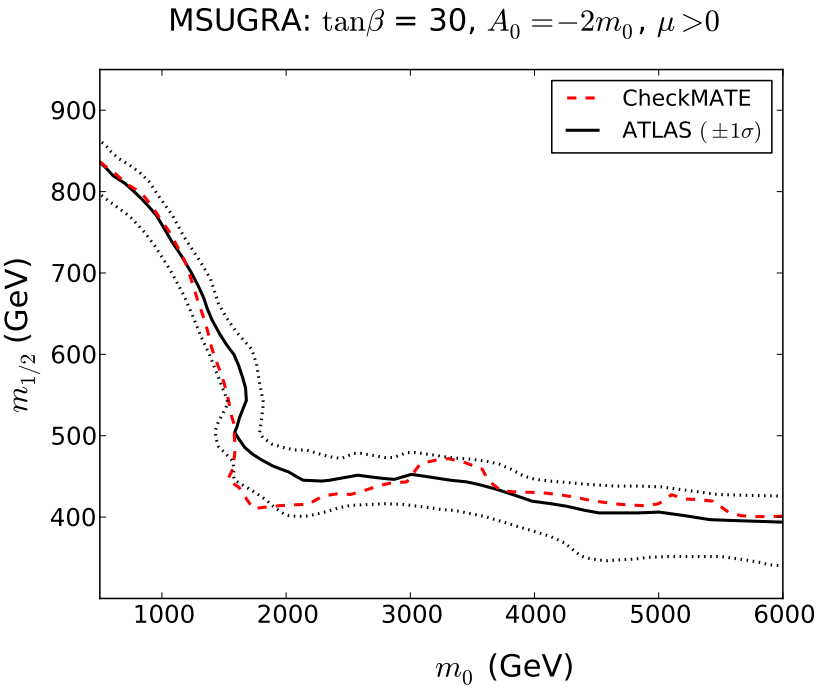
Result

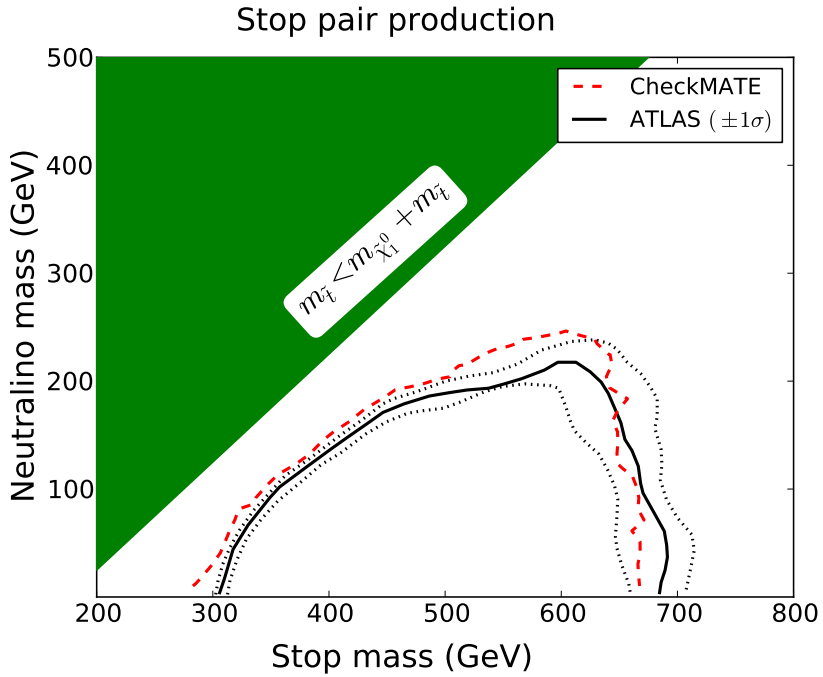
```
Result: Allowed
Result for r: r_max = 0.74
SR: atlas_conf_2013_047 - ET
```

atlas_conf_2013_047_r_limits

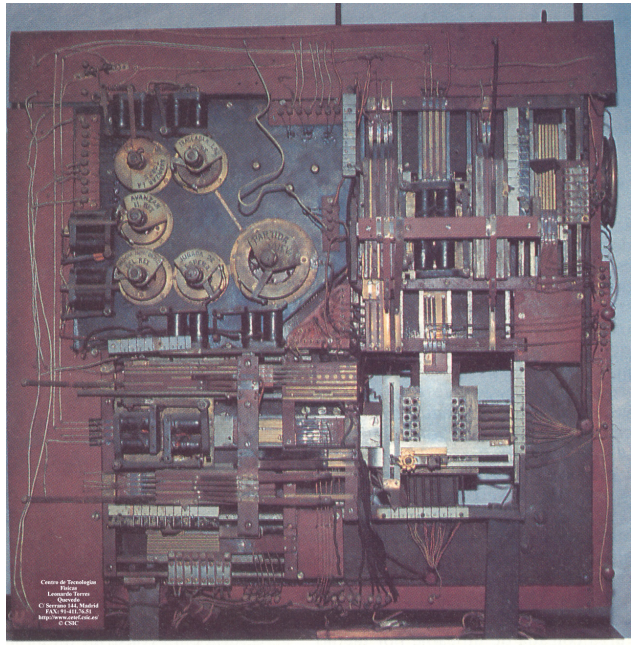
SR	S	dS_stat	dS_sys	dS_tot	S95_obs	S95_exp	r^c_obs	r^c_exp
AL	37.36	0.61	4.10	4.15	1341.20	1135.00	0.02	0.03
AM	5.34	0.22	0.55	0.59	51.30	42.70	0.08	0.10
BM	7.41	0.25	0.77	0.81	14.90	17.00	0.39	0.34
BT	0.86	0.07	0.10	0.12	6.70	5.80	0.09	0.11
CM	17.82	0.43	1.99	2.04	81.20	72.90	0.17	0.19
CT	2.40	0.12	0.28	0.31	2.40	3.30	0.75	0.54
D	12.14	0.34	1.29	1.33	15.50	13.60	0.61	0.70
EL	21.26	0.46	2.35	2.39	92.40	57.30	0.18	0.29
EM	16.14	0.40	1.79	1.83	28.60	21.40	0.44	0.59
ET	7.95	0.28	0.87	0.91	8.30	6.50	0.74	0.95

Validation


MSUGRA: $\tan\beta$ = 30, $A_0 = -2m_0$, $\mu > 0$
CheckMATE
ATLAS ($\pm 1\sigma$)
900
800
700
600
500
400
$m_{1/2}$ (GeV)
1000
2000
3000
4000
5000
6000
m_0 (GeV)


Stop pair production
CheckMATE
ATLAS ($\pm 1\sigma$)
$m_{\tilde{t}} < m_{\tilde{\chi}_1^0} + m_t$
500
400
300
200
100
Neutralino mass (GeV)
200
300
400
500
600
700
800
Stop mass (GeV)

♕ Opening the Box ♕



The Analysis Manager


```
##Name                NSR  Description                                    Lumi  CR?  #
# atlas_1210_2979     1    ATLAS, WW measurement with 2 leptons (7TeV)     4.6   no  #
# atlas_1308_2631     6    ATLAS, 0 leptons + 2 b-jets + etmiss           20.1  yes #
# atlas_1402_7029     20   ATLAS, 3 leptons + etmiss (chargino+neutralino) 20.3  no  #
# atlas_1403_4853     12   ATLAS, 2 leptons + etmiss (direct stop)        20.3  no  #
# atlas_1403_5294     13   ATLAS, 2 leptons + etmiss, (SUSY electroweak)  20.3  yes #
# atlas_1404_2500     5    ATLAS, Same sign dilepton or 3l                20.3  no  #
# atlas_1407_0583     27   ATLAS, 1 lepton + (b-)jets + etmiss (stop)     20.3  no  #
# atlas_1407_0600     9    ATLAS, 3 b-jets + 0-1 lepton + etmiss          20.1  no  #
# atlas_1407_0608     3    ATLAS, Monojet or charm jet (stop)             20.3  no  #
# atlas_conf_2012_104 2    ATLAS, 1 lepton + >= 4 jets + etmiss            5.8  yes #
# atlas_conf_2012_147 4    ATLAS, Monojet + etmiss                        10.0  yes #
# atlas_conf_2013_021 4    ATLAS, WZ standard model (3 leptons + etmiss)  13.0  no  #
# atlas_conf_2013_024 3    ATLAS, 0 leptons + 6 (2 b-)jets + etmiss       20.5  yes #
# atlas_conf_2013_031 2    ATLAS: Higgs spin measurement (WW)             20.7  no  #
# atlas_conf_2013_036 5    ATLAS: 4 leptons + etmiss                      20.7  no  #
# atlas_conf_2013_037 6    ATLAS, 1 lepton + (b-)jets + etmiss (stop)     20.7  no  #
# atlas_conf_2013_047 10   ATLAS, 0 leptons + 2-6 jets + etmiss           20.3  yes #
# atlas_conf_2013_049 9    ATLAS, 2 leptons + etmiss                      20.3  yes #
# atlas_conf_2013_061 9    ATLAS, 0-1 leptons + >= 3 b-jets + etmiss      20.1  yes #
# atlas_conf_2013_062 19   ATLAS: 1-2 leptons + 3-6 jets + etmiss         20.1  yes #
# atlas_conf_2013_089 12   ATLAS, 2 leptons (razor)                       20.3  yes #
# atlas_conf_2014_014 1    ATLAS, 2 leptons + b-jets (stop)               20.3  yes #
# atlas_conf_2014_033 3    ATLAS, WW standard model measurement           20.3  yes #
# cms_1303_2985       59   CMS, alpha_T + b-jets                          11.7  yes #
# cms_1301_4698_WW    1    CMS, WW standard model measurement              3.5   no  #
# cms_1306_1126_WW    1    CMS, WW standard model measurement (7TeV        4.9   no  #
# cms_smp_12_006      4    CMS, WZ standard model (3 leptons + etmiss)    19.6  no  #
# cms_sus_12_019      2    CMS, 2 leptons, >= 2 jets + etmiss (dilep edge) 19.4  no  #
#################################################################################
```

The Analysis Manager

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```
##Name                 NSR  Description                                    Lumi  CR?  #
# atlas_1210_2979      1    ATLAS, WW measurement with 2 leptons (7TeV)     4.6   no  #
# atlas_1308_2631      6    ATLAS, 0 leptons + 2 b-jets + etmiss           20.1  yes #
# atlas_1402_7029      20   ATLAS, 3 leptons + etmiss (chargino+neutralino) 20.3  no  #
# atlas_1403_4853      12   ATLAS, 2 leptons + etmiss (direct stop)        20.3  no  #
# atlas_1403_5294      13   ATLAS, 2 leptons + etmiss, (SUSY electroweak)  20.3  yes #
# atlas_1404_2500      5    ATLAS, Same sign dilepton or 3l                20.3  no  #
# atlas_1407_0583      27   ATLAS, 1 lepton + (b-)jets + etmiss (stop)     20.3  no  #
# atlas_1407_0600      9    ATLAS, 3 b-jets + 0-1 lepton + etmiss          20.1  no  #
# atlas_1407_0608      3    ATLAS, Monojet or charm jet (stop)             20.3  no  #
# atlas_conf_2012_104  2    ATLAS, 1 lepton + >= 4 jets + etmiss            5.8  yes #
# atlas_conf_2012_147  4    ATLAS, Monojet + etmiss                        10.0  yes #
# atlas_conf_2013_021  4    ATLAS, WZ standard model (3 leptons + etmiss)  13.0  no  #
# atlas_conf_2013_024  3    ATLAS, 0 leptons + 6 (2 b-)jets + etmiss       20.5  yes #
# atlas_conf_2013_031  2    ATLAS: Higgs spin measurement (WW)             20.7  no  #
```

What do I need to add a new analysis on my own?

```
# atlas_conf_2014_033  3    ATLAS, WW standard model measurement           20.3  yes #
# cms_1303_2985        59   CMS, alpha_T + b-jets                          11.7  yes #
# cms_1301_4698_WW     1    CMS, WW standard model measurement             3.5   no  #
# cms_1306_1126_WW     1    CMS, WW standard model measurement (7TeV       4.9   no  #
# cms_smp_12_006       4    CMS, WZ standard model (3 leptons + etmiss)    19.6  no  #
# cms_sus_12_019       2    CMS, 2 leptons, >= 2 jets + etmiss (dilep edge) 19.4 no  #
#########################################################################################
```

The Analysis Manager


```
##Name                NSR  Description                                    Lumi  CR?  #
# atlas_1210_2979     1    ATLAS, WW measurement with 2 leptons (7TeV)     4.6   no   #
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# atlas_1404_2500     5    ATLAS, Same sign dilepton or 3l                20.3  no   #
# atlas_1407_0583     27   ATLAS, 1 lepton + (b-)jets + etmiss (stop)     20.3  no   #
# atlas_1407_0600     9    ATLAS, 3 b-jets + 0-1 lepton + etmiss          20.1  no   #
# atlas_1407_0608     3    ATLAS, Monojet or charm jet (stop)             20.3  no   #
# atlas_conf_2012_104 2    ATLAS, 1 lepton + >= 4 jets + etmiss            5.8  yes  #
# atlas_conf_2012_147 4    ATLAS, Monojet + etmiss                        10.0  yes  #
# atlas_conf_2013_021 4    ATLAS, WZ standard model (3 leptons + etmiss)  13.0  no   #
# atlas_conf_2013_024 3    ATLAS, 0 leptons + 6 (2 b-)jets + etmiss       20.5  yes  #
# atlas_conf_2013_031 2    ATLAS: Higgs spin measurement (WW)             20.7  no   #
```

What do I need to add a new analysis on my own?

- Ability to answer questions
- Some understanding of C++

```
# atlas_conf_2014_033  3    ATLAS, WW standard model measurement           20.3  yes  #
# cms_1303_2985        59   CMS, alpha_T + b-jets                          11.7  yes  #
# cms_1301_4698_WW     1    CMS, WW standard model measurement             3.5   no   #
# cms_1306_1126_WW     1    CMS, WW standard model measurement (7TeV       4.9   no   #
# cms_smp_12_006       4    CMS, WZ standard model (3 leptons + etmiss)    19.6  no   #
# cms_sus_12_019       2    CMS, 2 leptons, >= 2 jets + etmiss (dilep edge) 19.4 no   #
##########################################################################################
```

Running the Analysis Manager

- Run `make AnalysisManager; /bin/AnalysisManager`

```
 ____ _                 _    __  __    _  _____ _____
/ ___| |__   ___  ___| | _|  \/  |  / \|_   _| ____|
| |   | '_ \ / _ \/ __| |/ / |\/| | / _ \ | | |  _|
| |___| | | |  __/ (__|   <| |  | |/ ___ \| | | |___
 \____|_| |_|\___|\___|_|\_\_|  |_/_/   \_\_| |_____|

                /\  _  _ |   _. _  |\/| _  _  _  _  _ _
               /--\| )(_||\/_)|_)  |  |(_|| )(_|(_)(-|
                         /                     _/

What do you want?
  -(l)ist all analyses,
  -(a)dd a new analysis to CheckMATE,
  -(e)dit analysis information,
  -(r)emove an analysis from CheckMATE
```

Adding an analysis

```
    a
This will collect all necessary information to create a full analysis and
Takes care for the creation and implementation of the source files into the code.
Please answer the following questions.
Attention: Your input is NOT saved before you finish this questionnaire

1. General Information to build analysis
  Your Name (to declare the analysis author):
    Guybrush Threepwood
  Your Email:
    threepwood@pirates.arr
  Analysis Name:
    atlas_conf_2013_047X
  Description (short, one line):
    ATLAS, 0 leptons + 2-6 jets + etmiss
  Description (long, multiple lines, finish with empty line:
    ATLAS
    ATLAS-CONF-2013-047
    0 leptons, 2-6 jets, etmiss
    sqrt(s) = 8 TeV
    int(L) = 20.3 fb^-1
  Luminosity (in fb^-1):
    20.3
```

Adding an analysis

```
2. Information on Signal Regions
  List all signal regions (one per line, finish with ';;' on a new line):
     11
     21
  [...]
  You now have to add the numbers for each of the given signal regions.
    11
      obs:
         100
      bkg:
         90
      bkg_err:
         15
    21
      obs:
         200
      bkg:
         180
      bkg_err:
         30
  [...]
```

Adding an analysis

```
3. Settings for Detector Simulation
3.1: Miscellaneous
  To which experiment does the analysis correspond? (A)TLAS, (C)MS
     A
3.2: Electron Isolation
  Do you need any particular isolation criterion? [(y)es, (n)o]
     y
  Isolation 1:
    Which objects should be considered for isolation? [(t)racks, (c)alo objects?
       t
    What is the minimum pt of a surrounding object to be used for isolation? [in GeV]
       5
    What is the dR used for isolation?
       0.4
    Is there an absolute or a relative upper limit for the surrounding pt? [(a)bsolute, (r)elative]
       a
    What is the maximum surrounding pt used for isolation [in GeV]?
       20

  Do you need more isolation criteria? [(y)es, (n)o]
     n
3.3: Muon Isolation
  Do you need any particular isolation criterion? [(y)es, (n)o]
     n
3.4: Photon Isolation
  Do you need any particular isolation criterion? [(y)es, (n)o]
     n
```

Adding an analysis

```
3.5: Jets
  Which dR cone radius do you want to use for the FastJet algorithm?
     0.4
  What is the minimum pt of a jet? [in GeV]
     10
  Do you need a separate, extra type of jet? [(y)es, (n)o]
     n
  Do you want to use b-tagging? [(y)es, (n)o]
     y

  b-Tagging 1:
    What is the signal efficiency to tag a b-jet? [in %]
       70
  Do you need more b tags? [(y)es, (n)o]
     y

  b-Tagging 2:
    What is the signal efficiency to tag a b-jet? [in %]
       40
  Do you need more b tags? [(y)es, (n)o]
     n

  Do you want to use tau-tagging? [(y)es, (n)o]
     n
```

Adding an analysis

```
      - Variable values saved in /hdd/sandbox/managertest/data/atlas_conf_2013_047X_var.j
      - Created source file    /hdd/sandbox/managertest/tools/analysis/src/atlas_conf_2013_047X.cc
      - Created header file    /hdd/sandbox/managertest/tools/analysis/include/atlas_conf_2013_047X.h
      - Updated Makefile
      - Updated main source    main.cc
      - Reference file created
      - List of analyses updated
Analysis atlas_conf_2013_047X has been added successfully!
Run 'make' from the main CheckMATE folder to compile it!
```

And that's it!

- A simple `make` will add the analysis to the framework
- Of course, the actual analysis code still has to be written by the user (imagine if this could be automatised...)

Some example lines


```
void Atlas_conf_2013_047::analyze() {
  missingET->addMuons(muonsCombined);
  electronsLoose = filterPhaseSpace(electronsLoose, 10., -2.47, 2.47);
  muonsCombined = filterPhaseSpace(muonsCombined, 10., -2.4, 2.4);
  jets = filterPhaseSpace(jets, 20., -2.8, 2.8);
  [...]
  jets = overlapRemoval(jets, electronsLoose, 0.2);
  electronsLoose = overlapRemoval(electronsLoose, jets, 0.4);
  if(!electronsLoose.empty())
    return;
  [...]
  double HT = 0.;
  for(int j = 0; j < jets.size(); j++)
    HT += jets[j]->PT;
  double mEffInc = missingET->P4().Et() + HT;
  [...]
  mEffA = missingET->P4().Et() + jets[0]->PT + jets[1]->PT;
  if (missingET->P4().Et()/mEffA > 0.2) {
    countCutflowEvent("AL1");
    if (mEffInc > 1000.)
      countSignalEvent("AL");
  }
  [...]
```

What we are currently working on

- ♖ Making the Analysis Manager even simpler and clearer
- ♖ Writing a Manual “How to add analyses to CheckMATE”

Sneak Peek

What we are currently working on

- Making the Analysis Manager even simpler and clearer
- Writing a Manual “How to add analyses to CheckMATE”

- Connecting to MadGraph + Pythia to actually take models and not event files as input

Sneak Peek

bctp Bethe Center for Theoretical Physics universitätbonn

What we are currently working on

- ♖ Making the Analysis Manager even simpler and clearer
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- ♗ Enhancing sensitivity by combining signal regions

♔ Sneak Peek

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- ♗ Enhancing sensitivity by combining signal regions

- ♕ Collaboration with other tools to make analyses interchangeable
- ♕ Creation of a new tool that combines CheckMATE with some fast model tests for SUSY

Summary

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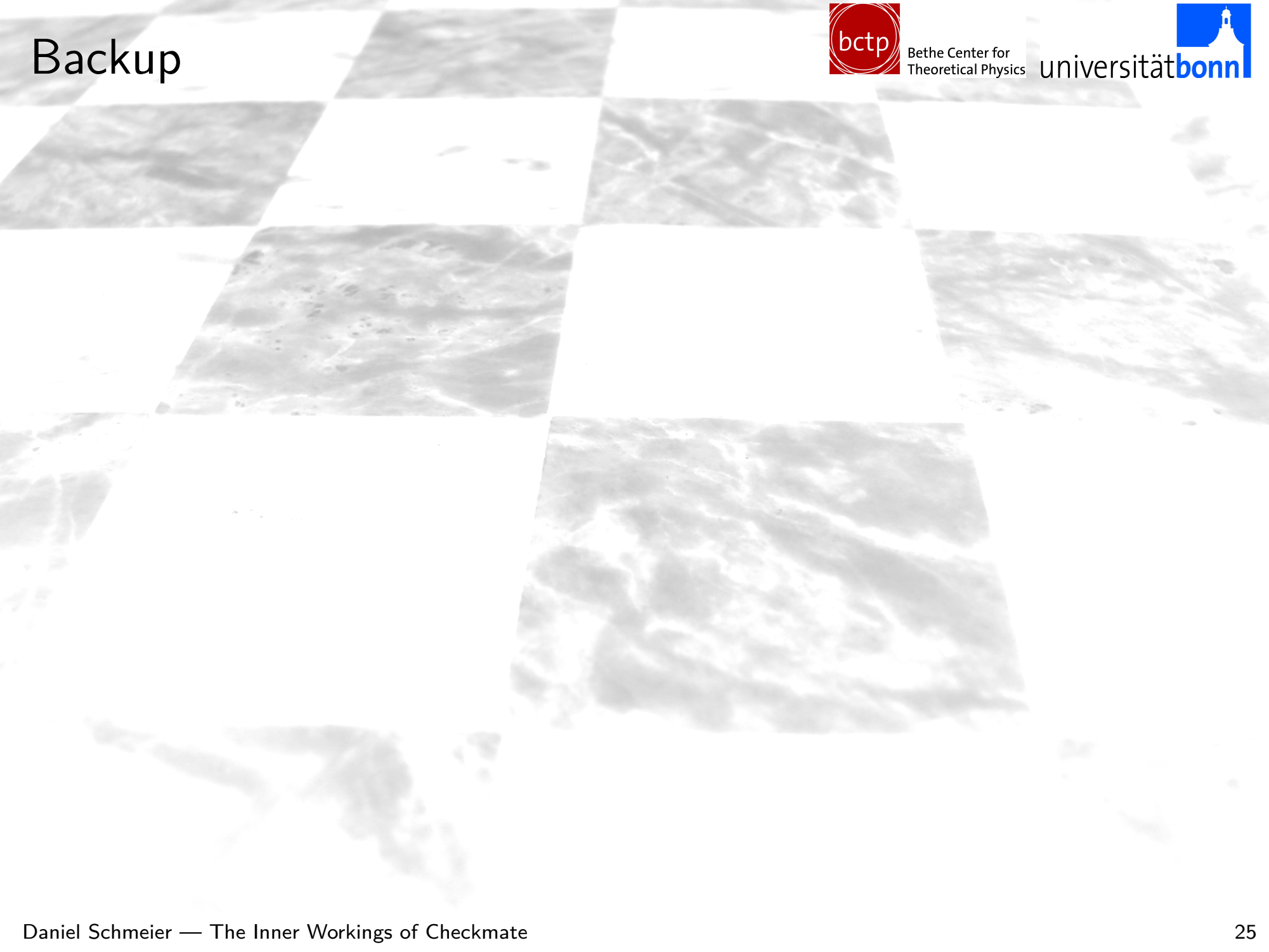
User Side

- Input: Event files, cross sections and expected systematic errors
- CheckMATE consequtively runs Delphes, performs the analyses and statistically evaluates the results
- It stores lots of intermediate results for the user to check and process otherwise
- Output: “Allowed” or “Excluded” in its most simple form

Developer Side

- Anyone can become a developer, thanks to the AnalysisManager
- The “fundamental” developers have many things in the pipeline
- $\longrightarrow$ Stay Tuned for CheckMATE 2.0 in 2015!

Backup



Combination to get $S \pm \Delta S$

Combine within each process p with given σ^p, $\Delta\sigma^p$

- Determine $\sum$ weights over all input files for p
- Normalise w.r.t $\mathcal{L}\sigma^p$ for S^p
- Determine normalised $\sqrt{\sum \text{weights}^2}$ for ΔS^p_{stat}
- Use $\mathcal{L}\Delta\sigma^p$ for ΔS^p_{sys}

Combine different processes

- Use $S = \sum_p S^p$
- Use $\Delta S_{\text{stat/sys}} = \sqrt{\sum_p (\Delta S^p_{\text{stat/sys}})^2}$
- Use $\Delta S = \sqrt{\Delta S^2_{\text{stat}} + \Delta S^2_{\text{sys}}}$

Output

- A table with, for each signal region, a list of all the above numbers

Example Output

Prefix	N_TotMC	AL	stat	sys	AM	stat	sys	BM	stat	sys	BT	stat
Process: gluino_pair												
000	10000.00	31.99	0.60	3.94	3.94	0.21	0.49	5.33	0.24	0.66	0.39	0.07
001	10000.00	32.84	0.61	4.04	4.04	0.21	0.50	5.49	0.25	0.68	0.41	0.07
Tot	20000.00	32.41	0.43	3.99	3.99	0.15	0.49	5.41	0.17	0.67	0.40	0.05
Process: gluino_squark												
002	10000.00	4.99	0.10	0.93	1.34	0.05	0.25	1.92	0.06	0.36	0.47	0.03
003	10000.00	5.00	0.10	0.93	1.43	0.05	0.27	1.92	0.06	0.36	0.42	0.03
Tot	20000.00	4.99	0.07	0.93	1.38	0.04	0.26	1.92	0.04	0.36	0.44	0.02
Tot	40000.00	37.41	0.43	4.10	5.37	0.15	0.56	7.33	0.18	0.76	0.84	0.05

Validation

Process	$\tilde{\chi}^+\tilde{\chi}^-$ production, slepton decay					
Point	$m(\tilde{\chi}^\pm) = 350$ GeV $m(\tilde{\ell}_L) = m(\tilde{\nu}) = 175$ GeV $m(\tilde{\chi}_1^0) = 0$ GeV					
	e^+e^-		$\mu^+\mu^-$		$e^\pm\mu^\mp$	
Source	ATLAS	C.–MATE	ATLAS	C.–MATE	ATLAS	C.–MATE
Generated events	40000	50000	40000	50000	40000	50000
Trigger	52 ± 1	50 ± 1	48 ± 1	49 ± 1	79 ± 1	74 ± 1
$e^\pm\mu^\pm$	48 ± 1	47 ± 1	45 ± 1	46 ± 1	74 ± 1	69 ± 1
Jet veto	20 ± 1	20 ± 0	19 ± 1	20 ± 0	30 ± 1	29 ± 1
$(p_{\mathrm{T}}^{\ell 1}, p_{\mathrm{T}}^{\ell 2}) > (35, 20)$ GeV	17 ± 1	17 ± 0	17 ± 1	17 ± 0	25 ± 1	25 ± 1
SR-$m_{T2,90}$	11.7 ± 0.4	11.4 ± 0.3	10.5 ± 0.4	10.6 ± 0.3	16.6 ± 0.5	16.4 ± 0.4
SR-$m_{T2,110}$	9.5 ± 0.4	9.4 ± 0.3	8.7 ± 0.4	8.7 ± 0.3	14.0 ± 0.5	13.5 ± 0.4

Table D.13: Cutflow validation for atlas_conf_2013_049, testing chargino pair production with extra decay into sleptons, assuming a massless lightest neutralino. Shown are the number of events after each selection cut, normalised to 20.7 fb^{-1}. Final error is from Monte Carlo statistics for both ATLAS and CheckMATE.