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Using CheckMATE and Fritz to set automatised LHC constraints

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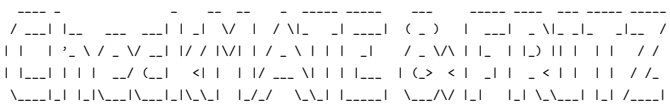
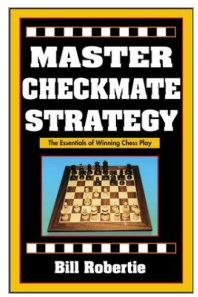
DESY Theory Workshop

October 1, 2015

Outline

♙ The Past ♕ The Present ♘ The Future





♕ The Past ♕

♔ Remember:

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What ~~do we want?~~

does Jamie want?

Write the Lagrangian down

Press "Enter"

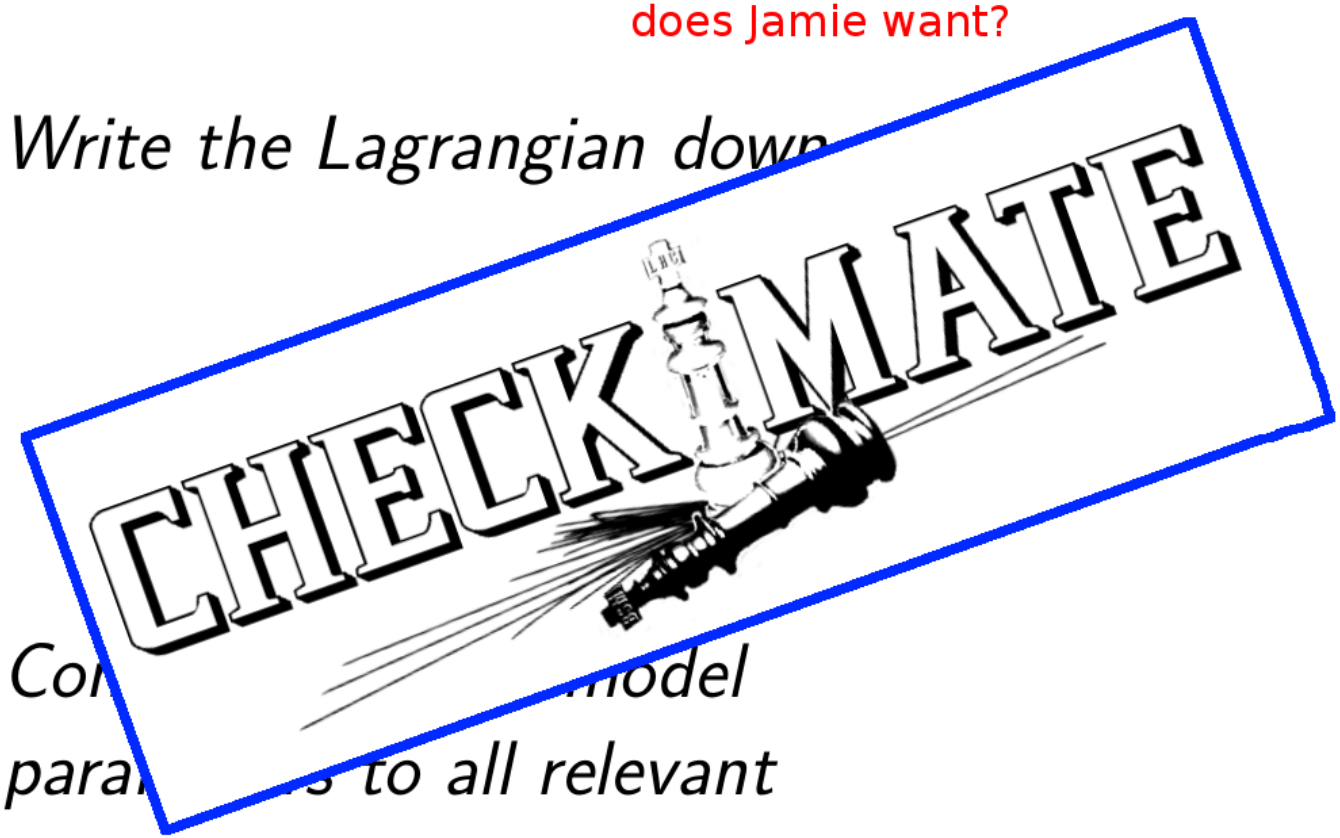
Computer fits the model parameters to all relevant observables

Remember:

What ~~do we want?~~

does Jamie want?

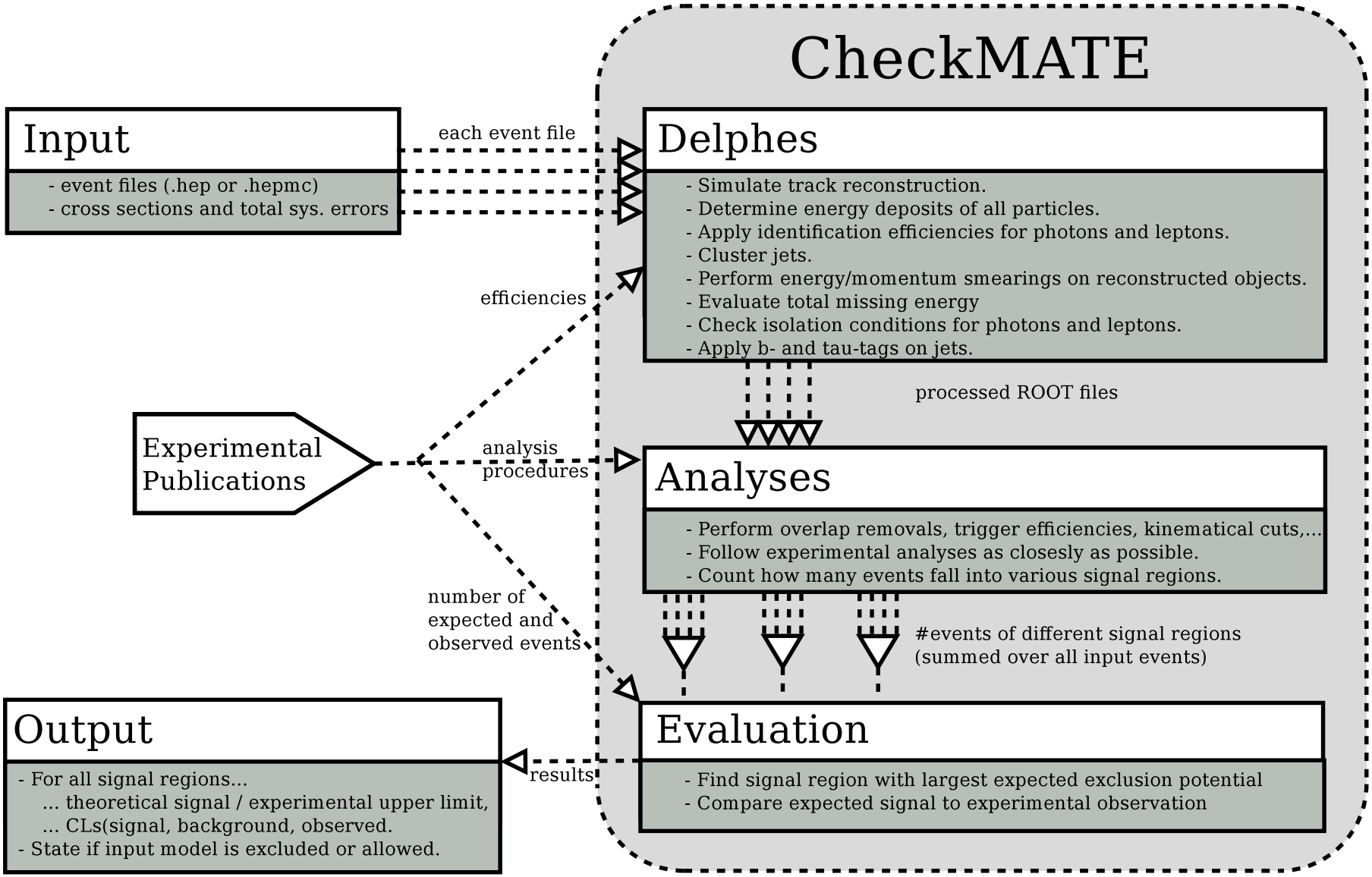
Write the Lagrangian down



Co… …model

para… …s to all relevant observables

In Theory: How does it work?



Example Input: Natural NMSSM

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```
Name: NMSSM_600_200
Analyses: atlas

[gluinopair]
XSect: 0.239E-01 PB
XSectErr: 0.00575 PB
Events: /scratch/11428609[184].pbs.baf.lan/herwig/gluinopair.hepmc

[stop1pair]
XSect: 0.794E-02 PB
XSectErr: 0.00149 PB
Events: /scratch/11428609[184].pbs.baf.lan/herwig/stop1pair.hepmc

[sbottom1pair]
XSect: 0.620E-02 PB
XSectErr: 0.00119 PB
Events: /scratch/11428609[184].pbs.baf.lan/herwig/sbottom1pair.hepmc
```

Required Input Information

- Which analyses?
- Which `[process]` was simulated for which `Events` (.hep or .hepmc) and what is $\sigma \pm \Delta\sigma$?

♔ Example Output: Nat. NMSSM


```
~: ./CheckMATE NMSSM_setupfile.txt
```

♔ Example Output: Nat. NMSSM

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```
~: ./CheckMATE NMSSM_setupfile.txt


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

[... roughly 2 minutes per 5k events later ... ]

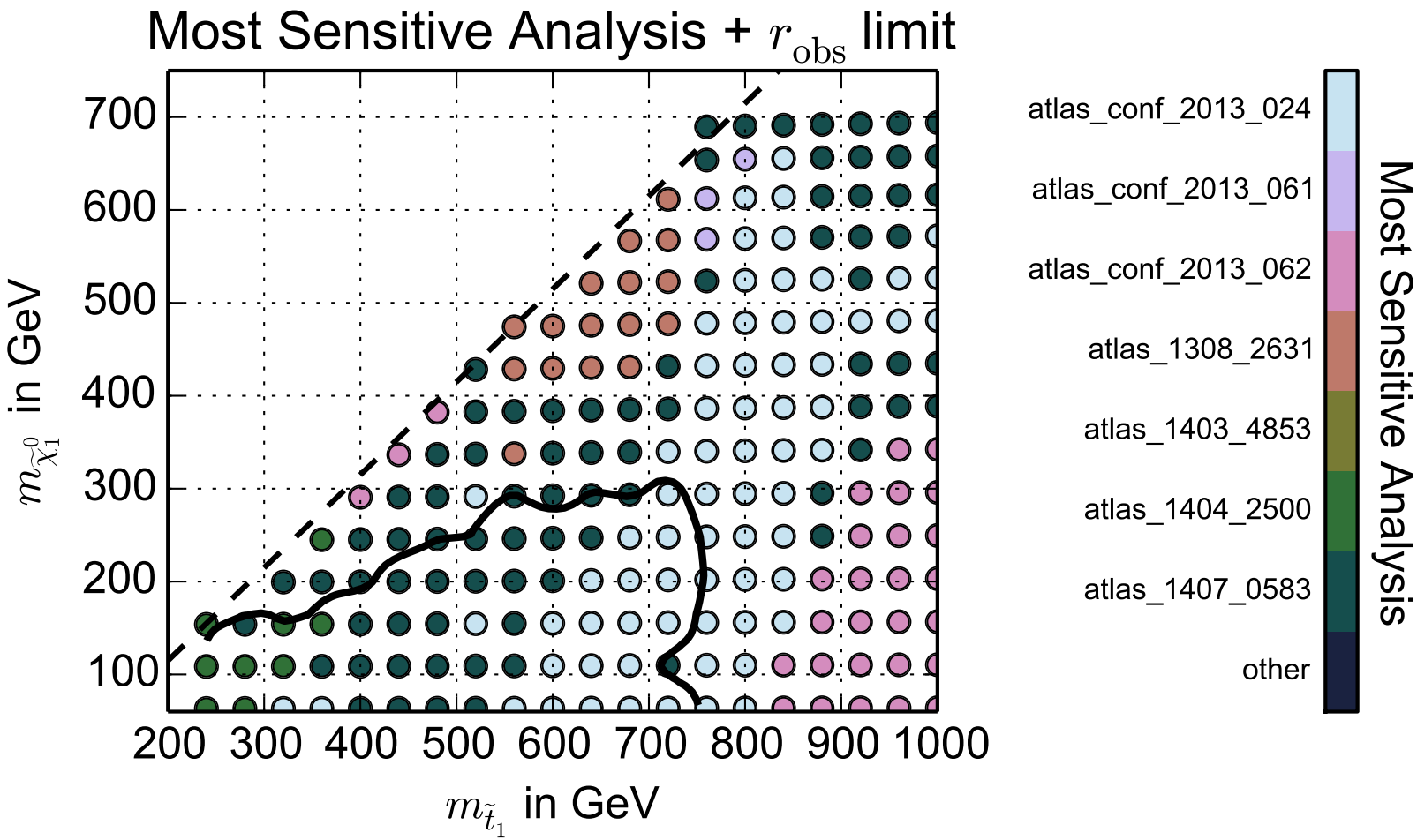
************************************
*******      EVALUATION      *******
************************************

Test: Calculation of r = signal/(95%CL limit on signal)
Result: Excluded
Result for r: r_max = 3.45937
SR: atlas_conf_2013_061 - SR1L6JB
```

Hidden (but available) information

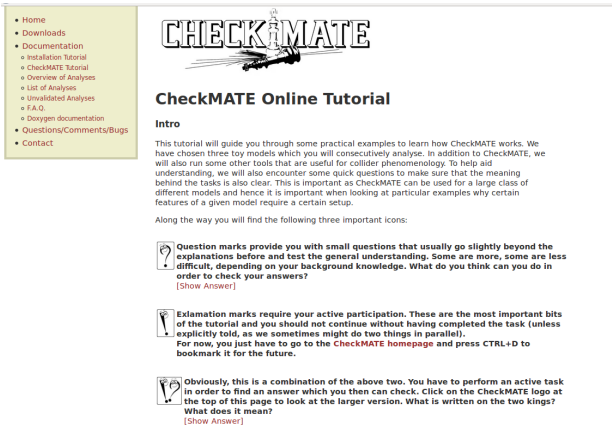
- events processed by detector simulation
- individual results for all analyses, signal regions and input files

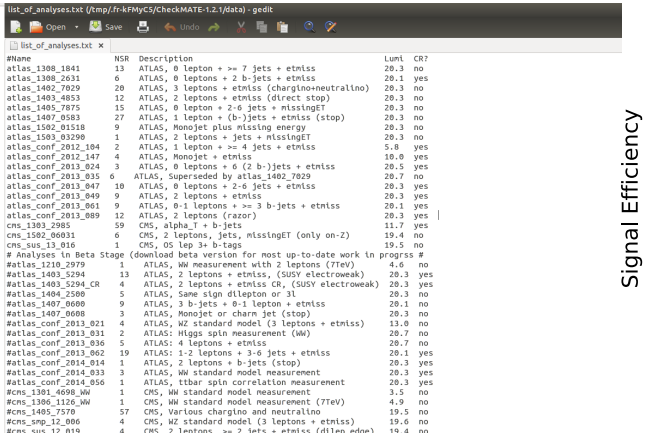
Example Result: Nat. NMSSM

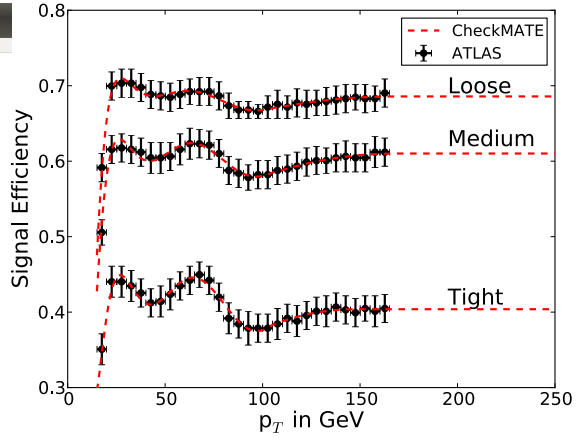


Check arXiV in the next few days to rea about the physics behind this plot!

Other features







- online installation and usage tutorial (<- *Especially designed for collider-pheno rookies*)
- 20 (35) analyses with > 200 (300) signal regions in public (beta) version
- `AnalysisManager` allows users to write their own analyses (e.g. for 13/14/100 TeV studies)
- well tuned detector simulation for ATLAS with detailed efficiency curves for reconstruction and identification effifciencies
- model-independent applicability

Studies citing and using CheckMATE

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- (*studies of various SUSY manifestations*)
- "LHC τ-Rich Tests of Lepton-specific 2HDM for $(g-2)_\mu$"

  Chun, Kang, Takeuchi, Tsai
- "Distinctive Heavy Higgs Decays"

  Holdom, Ratzlaff
- "Probing Radiative ν Mass Generation through Monotop Production"

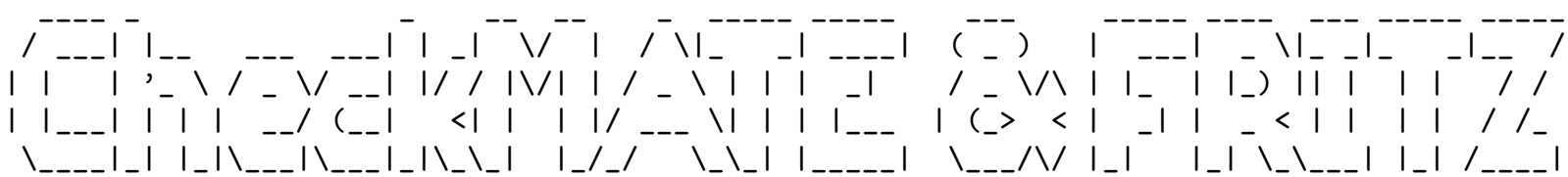
  Ng, de la Puente
- "LHC Phenomenology of SO(10) Models with Yukawa Unification"

  Anandakrishnan, Bryant, Raby
- "Hidden Photons with Kaluza-Klein Towers"

  Jaeckel, Roy, Wallace

Be creative!

♕ The Present ♕



2 Issues we wanted to solve

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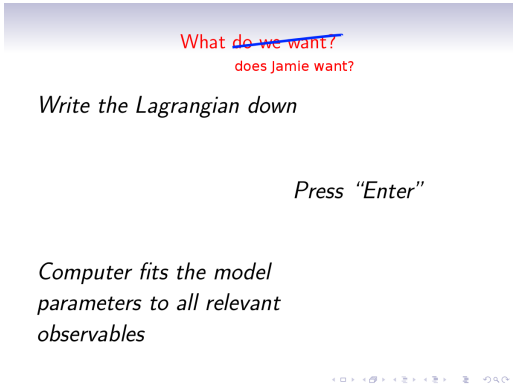
We want to start early in the chain



Goal $\longleftrightarrow$ Reality

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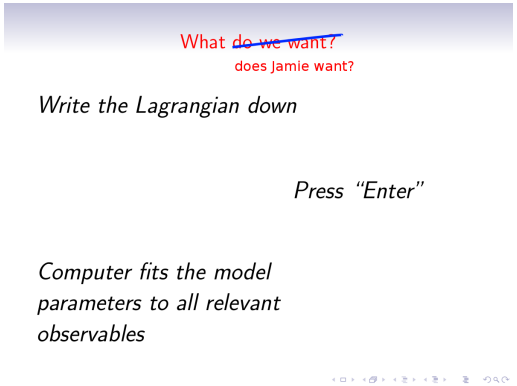

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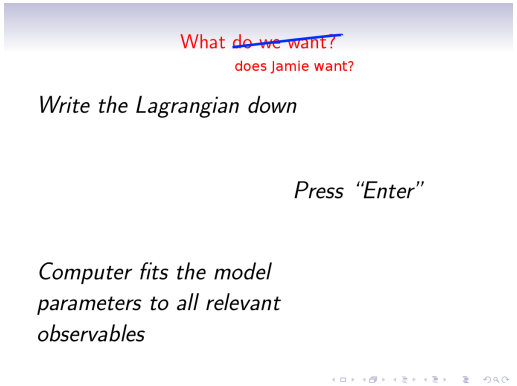

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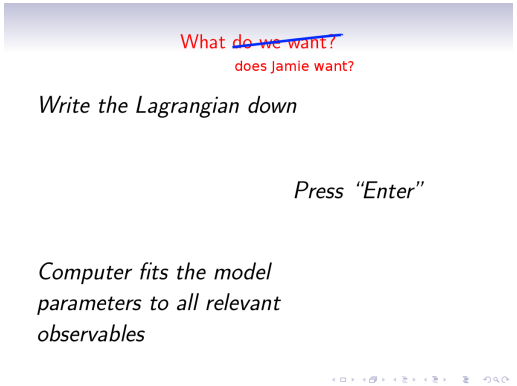

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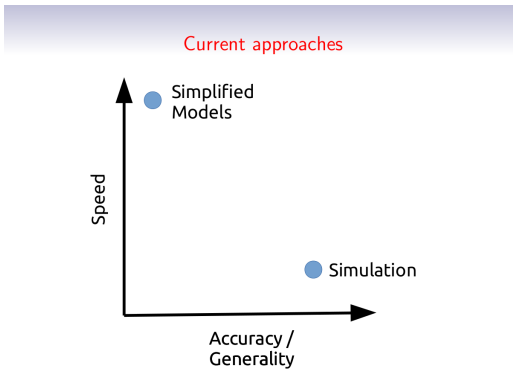

Goal $\longleftrightarrow$ Reality

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[... roughly 2 minutes per
5k events later ... ]
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2 Issues we wanted to solve

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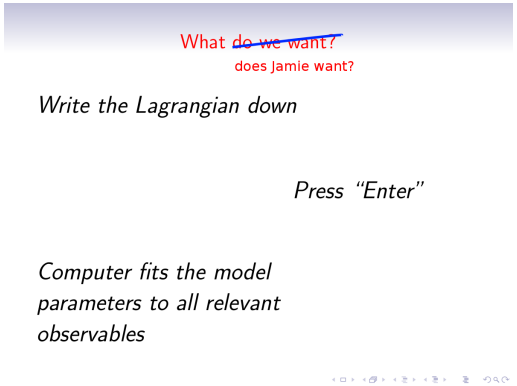

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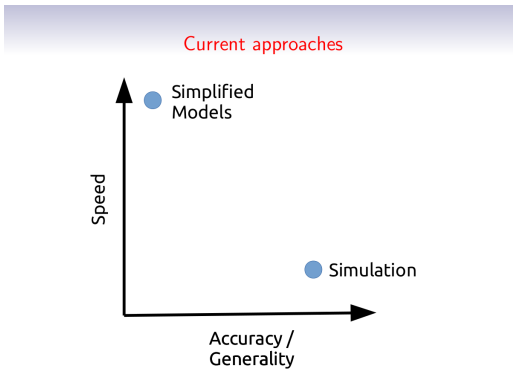

Simulations are slow

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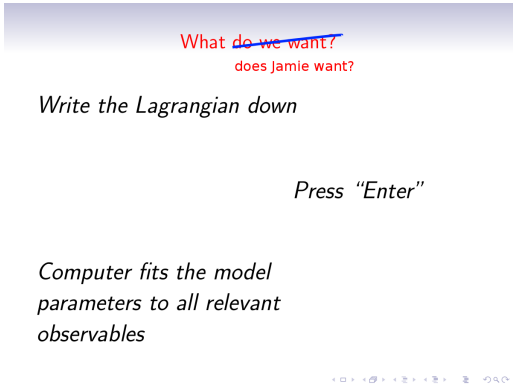

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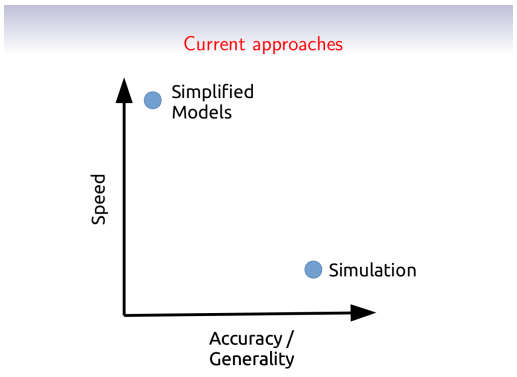

Simulations are slow

Try to speed up whatever possible

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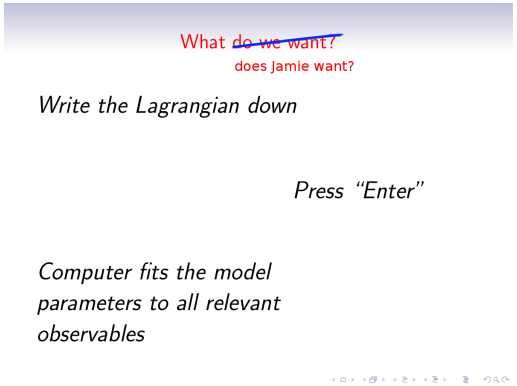

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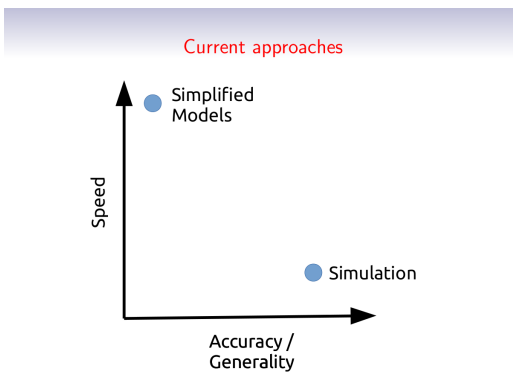
♘ **FRITZ** = **F**lexible **R**apid **I**nteractive **T**ool **Z**ipper ♘

We want to be fast



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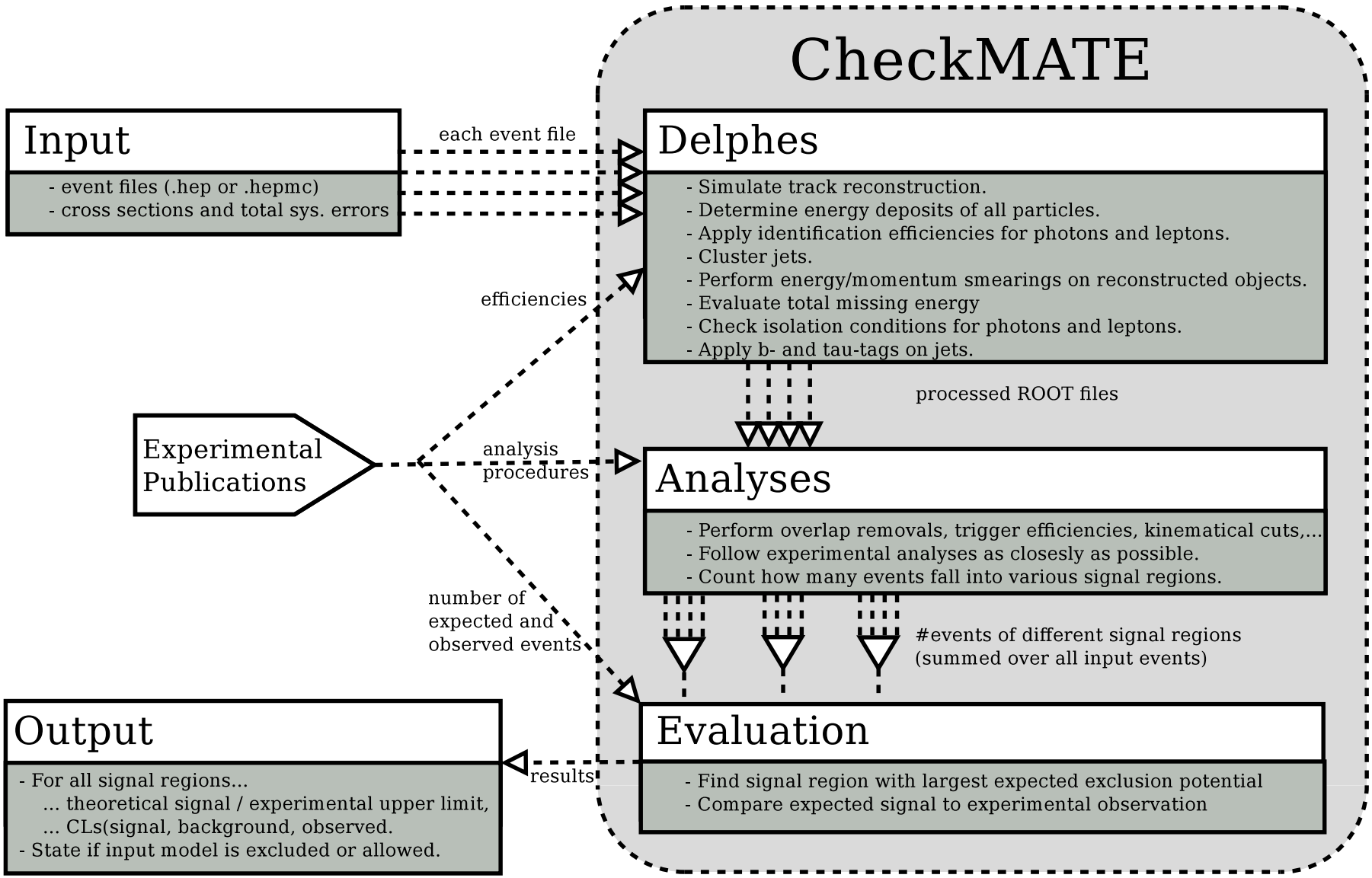
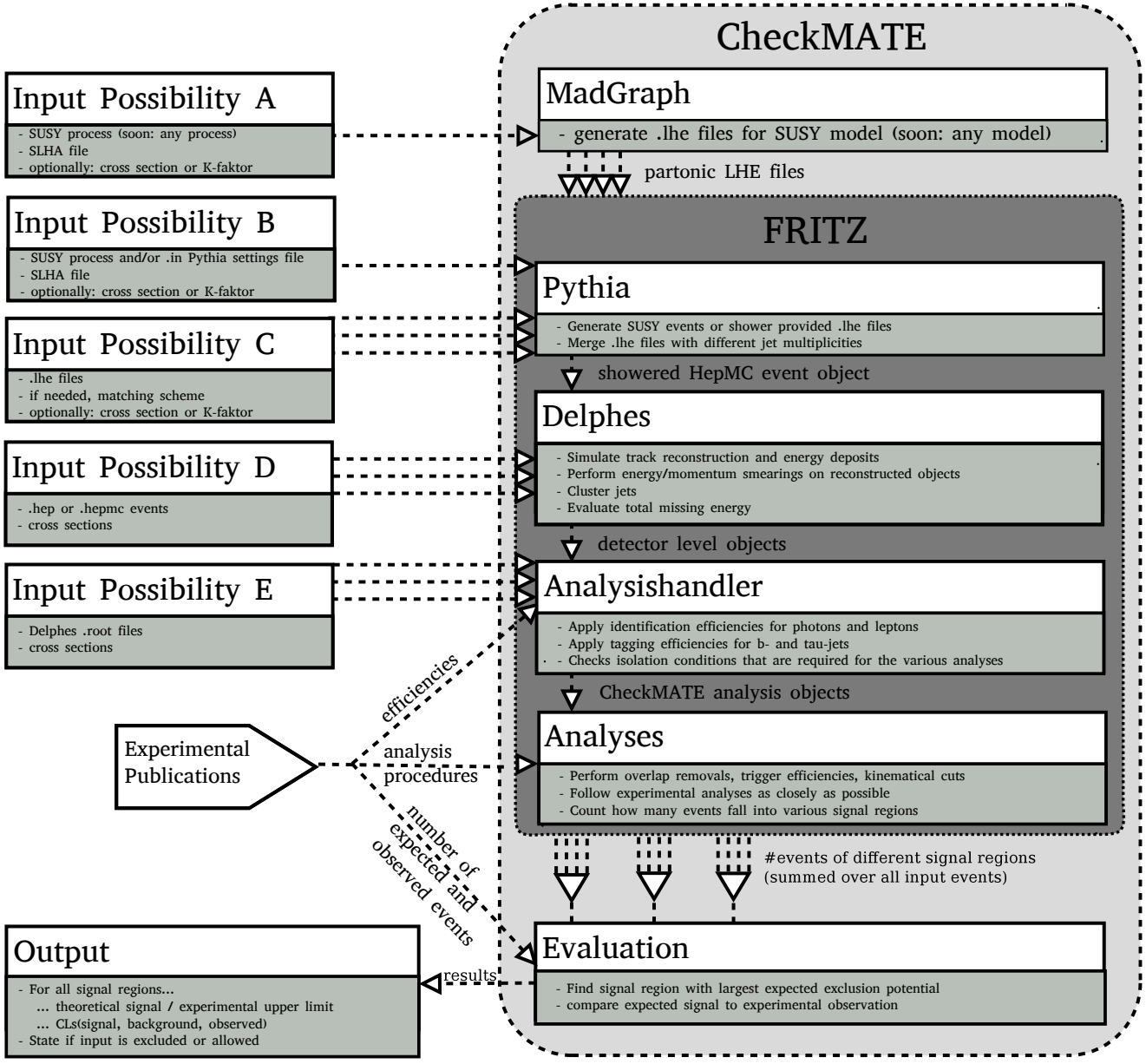
Old...


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


CheckMATE
Input Possibility A
- SUSY process (soon: any process)
- SLHA file
- optionally: cross section or K-faktor
Input Possibility B
- SUSY process and/or .in Pythia settings file
- SLHA file
- optionally: cross section or K-faktor
Input Possibility C
- .lhe files
- if needed, matching scheme
- optionally: cross section or K-faktor
Input Possibility D
- .hep or .hepmc events
- cross sections
Input Possibility E
- Delphes .root files
- cross sections
Experimental Publications
efficiencies
analysis procedures
number of expected and observed events
MadGraph
- generate .lhe files for SUSY model (soon: any model)
partonic LHE files
FRITZ
Pythia
- Generate SUSY events or shower provided .lhe files
- Merge .lhe files with different jet multiplicities
showered HepMC event object
Delphes
- Simulate track reconstruction and energy deposits
- Perform energy/momentum smearings on reconstructed objects
- Cluster jets
- Evaluate total missing energy
detector level objects
Analysishandler
- Apply identification efficiencies for photons and leptons
- Apply tagging efficiencies for b- and tau-jets
- Checks isolation conditions that are required for the various analyses
CheckMATE analysis objects
Analyses
- Perform overlap removals, trigger efficiencies, kinematical cuts
- Follow experimental analyses as closely as possible
- Count how many events fall into various signal regions
#events of different signal regions (summed over all input events)
Evaluation
- Find signal region with largest expected exclusion potential
- compare expected signal to experimental observation
results
Output
- For all signal regions...
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... CLs(signal, background, observed)
- State if input is excluded or allowed

New example inputs

Example 1: Use Pythia on SLHA

```
Name: MSSM_GluinoPair
Analyses: atlas & 8TeV
SLHAFile: testspectrum.slha

[gluinopair]
Pythia8Process: p p > go go~
KFactor: 1.5   # Optional!
XSectErr: 10 %  # Optional!
```

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Example 2: Use Pythia on `.lhes`

```
Name: MSSM_GluinoPair
Analyses: atlas & 8TeV
Merging: ckkwl
Scale: 30
MaxJets: 2

[Zjets]
Events: test_events/zRes_0jet_1k.lhe, test_events/zRes_1jet_1k.lhe, test_events/zRes_2jet_1k.lhe
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New example inputs

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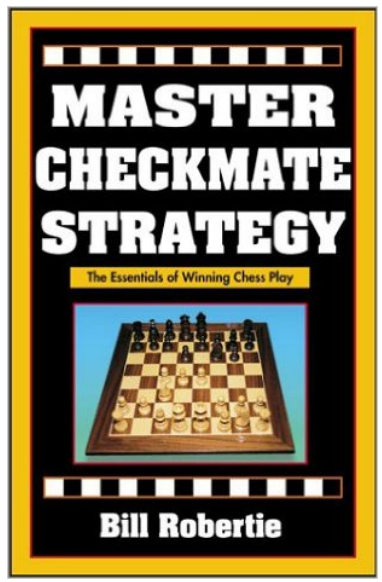
CheckMATE still stays simple to use:

Just type `./CheckMATE inputfile.txt`, *Hit Enter*, and CheckMATE will tell you the answer.

♕ The Future ♕


MASTER
CHECKMATE
STRATEGY
The Essentials of Winning Chess Play
Bill Robertie

Future developments

Release Plans

- What I have shown is all already implemented and well tested
- Proper user manual has to be written
- Soon, a beta version will go public
- CheckMATE 2.0 should be released within this year!

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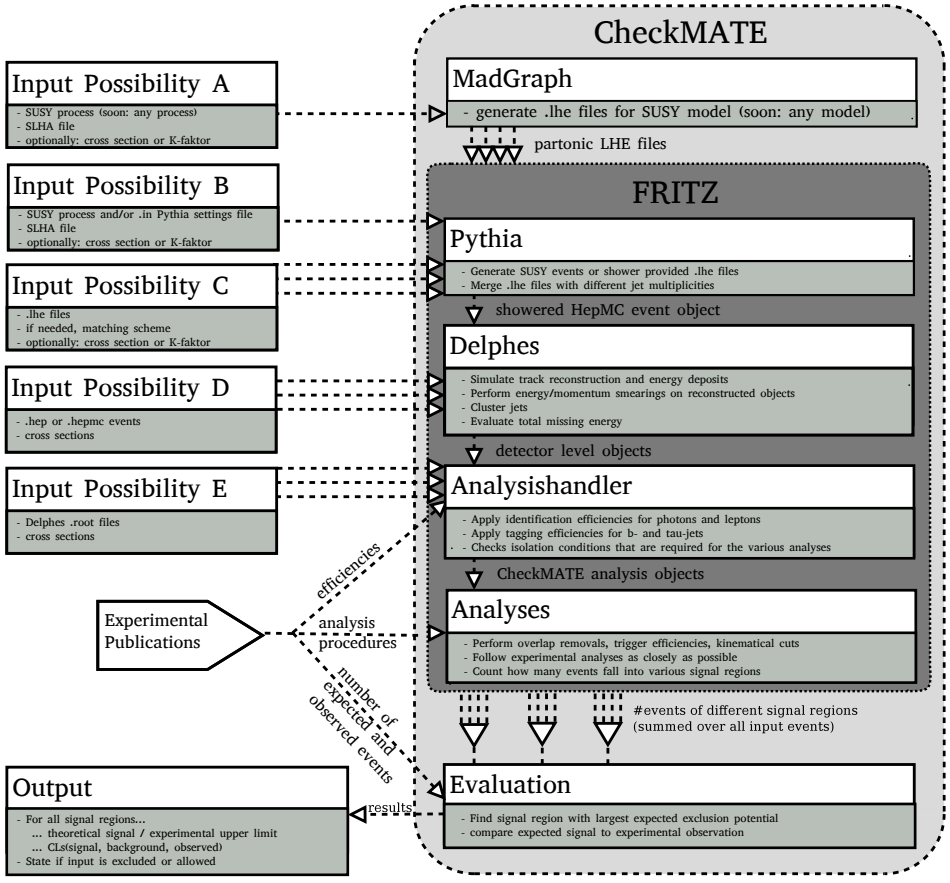
Development Plans

- Link to MadGraph to be able to simulate any model given its UFO file
- Assist user in deciding which processes to generate
- Build in methods to perform parameter scans conveniently
- Maybe find some smart algorithms to speed up these scans (see e.g. Jamie's talk)

Conclusions



- CheckMATE is easy to use to test any model against various LHC results
- CheckMATE + Fritz will take workload from the user by at the same time giving him flexibility
- CheckMATE 2.0 will be faster than ever

http://checkmate.hepforge.org/