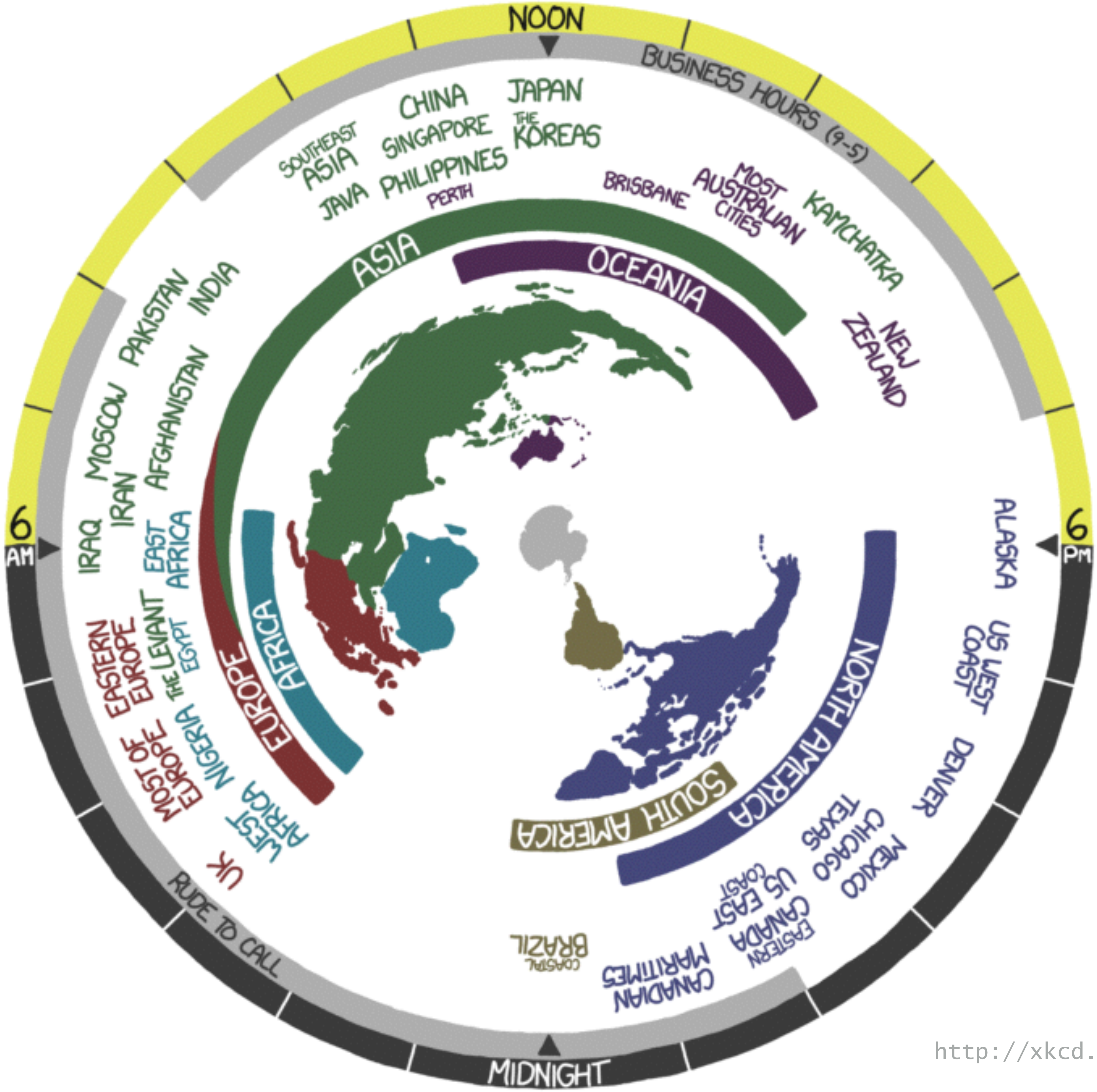
Herwig++ for BSM

David Grellscheid, IPPP Durham

MC4BSM 2014, Daejeon

Thanks for slide contributions to Simon Plätzer, Peter Richardson, Alix Wilcock



http://xkcd.com/now

Herwig++ details

- General purpose MC event generator
  many matrix elements natively; underlying event;
  initial/final state parton showering; Powheg matching;
  cluster hadronization; individually modelled hadron/tau decays;
  QED radiation

- 30-year history in its F77 implementation;
  Hw++ is a complete redesign from ground up.

- currently ~20 collaboration members
  in Durham, Karlsruhe, Manchester, DESY, London, Cambridge

- Main reference: arXiv:0803.0883, 1101.2599
  `http://herwig.hepforge.org/`

ThePEG

Toolkit for high energy physics event generation

[Leif Lönnblad]

ThePEG

Toolkit for high energy physics event generation

[Leif Lönnblad]

Herwig++

Box of physics implementations

ThePEG

Toolkit for high energy physics event generation

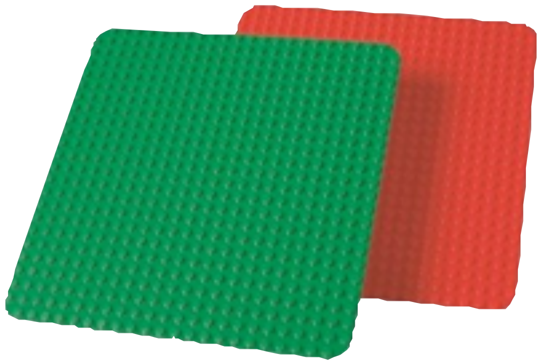
[Leif Lönnblad]

Herwig++

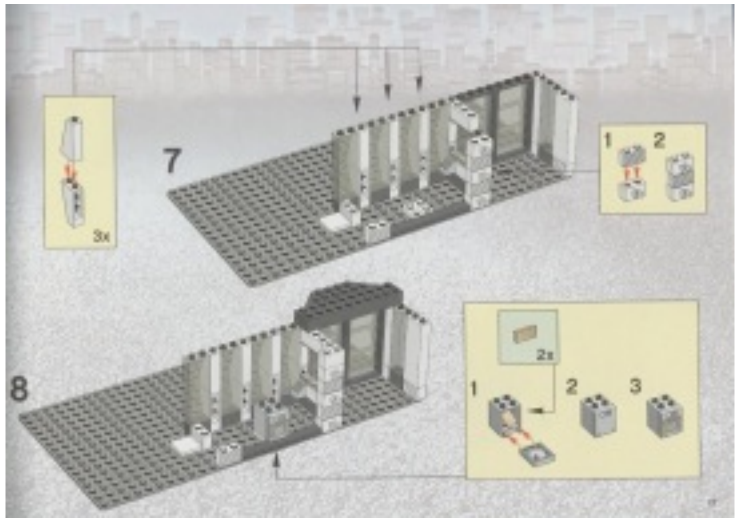
Box of physics implementations

Each building block is a compiled C++ class

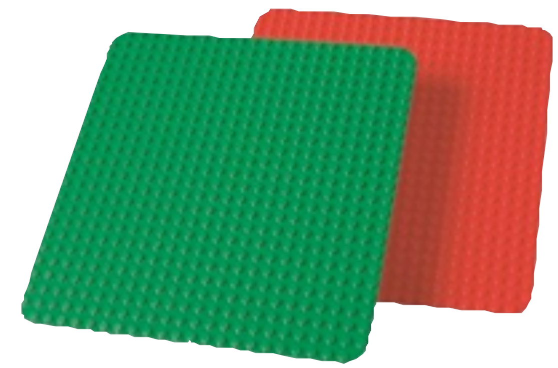
ThePEG Repository



plaintext
setup files



ThePEG Repository



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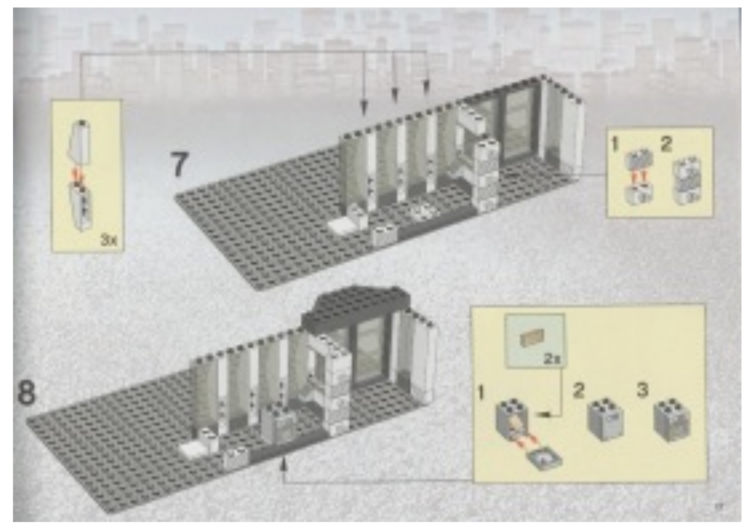
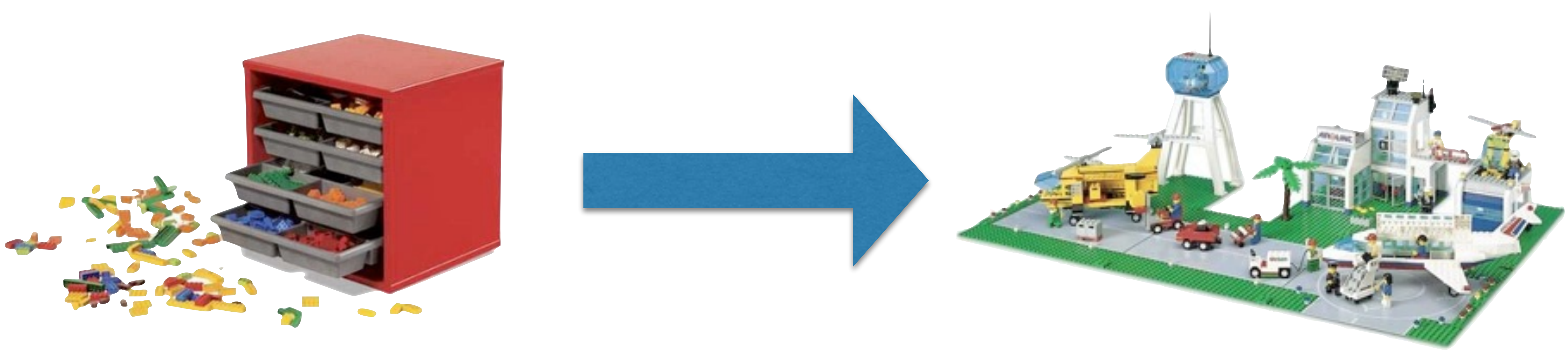
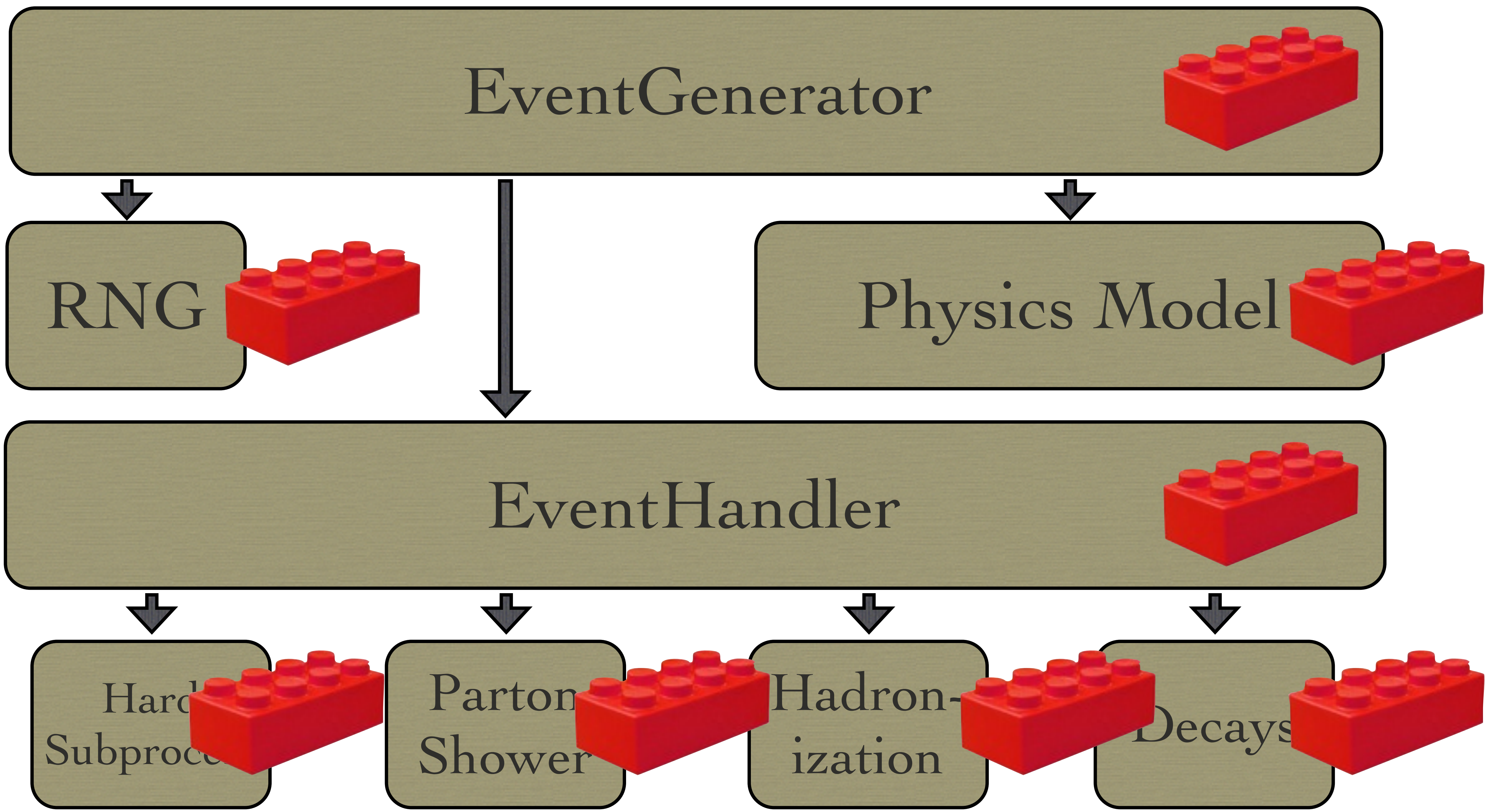




no more compilation needed here

Default Setup



Default Setup

```
create ThePEG::StandardEventHandler /Herwig/LHCHandler
set    LHCHandler:LuminosityFunction FixedLHCLuminosity

insert LHCHandler:SubProcessHandlers[0] /Herwig/SimpleQCD
set    LHCHandler:CascadeHandler        /Herwig/ShowerHandler
set    LHCHandler:HadronizationHandler  /Herwig/ClusterHadHandler
set    LHCHandler:DecayHandler          /Herwig/DecayHandler
[...]

create ThePEG::EventGenerator /Herwig/LHCGenerator ThePEG.so
set    LHCGenerator:EventHandler /Herwig/LHCHandler
[...]

set LHCHandler:BeamA /Herwig/Particles/p+
set LHCHandler:BeamB /Herwig/Particles/p+
set FixedLHCLuminosity:Energy 14000.0
[...]
```

Default Setup

```
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set    LHCHandler:LuminosityFunction FixedLHCLuminosity

insert LHCHandler:SubProcessHandlers[0] /Herwig/SimpleQCD
set    LHCHandler:CascadeHandler        /Herwig/ShowerHandler
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set    LHCHandler:DecayHandler          /Herwig/DecayHandler
[...]

create ThePEG::EventGenerator /Herwig/LHCGenerator ThePEG.so
set    LHCGenerator:EventHandler /Herwig/LHCHandler
[...]

set
set
set
[...
```

Arbitrary user extensions use dlopen():

```
create DGrell::Myclass /DGrell/Myclass DGrellHwPlugin.so
```

Main code never needs recompilation.

Default Setup

```
create ThePEG::StandardEventHandler /Herwig/LHCHandler
set    LHCHandler:LuminosityFunction FixedLHCLuminosity

insert LHCHandler:SubProcessHandlers[0] /Herwig/SimpleQCD
set    LHCHandler:CascadeHandler         /Herwig/ShowerHandler
set    LHCHandler:HadronizationHandler   /Herwig/ClusterHadHandler
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[...]

set LHCHandler:BeamA /Herwig/Particles/p+
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[...]
```
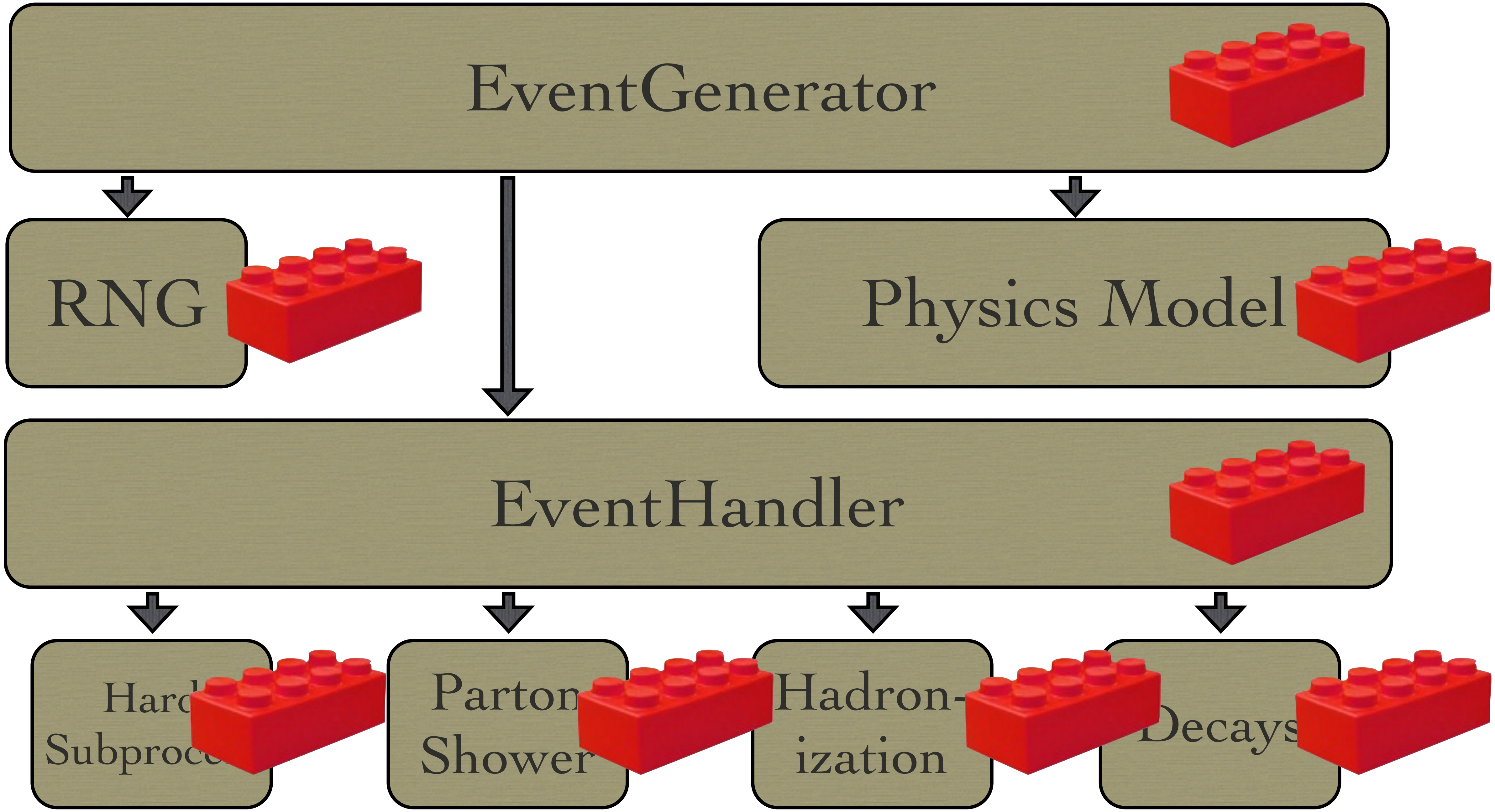
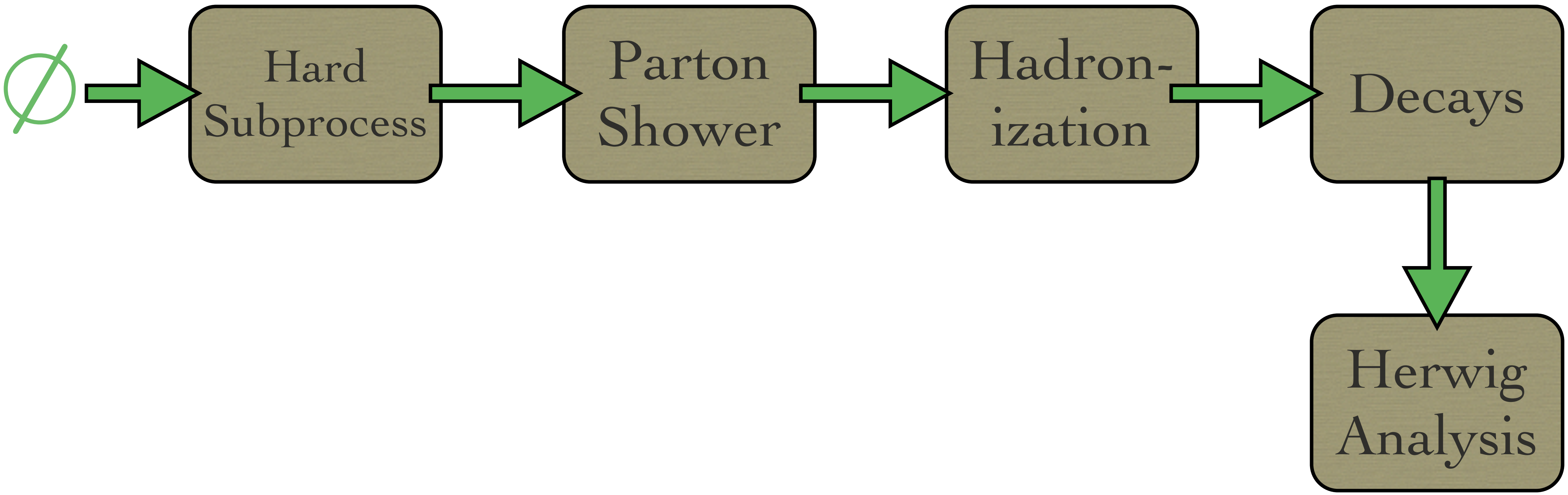
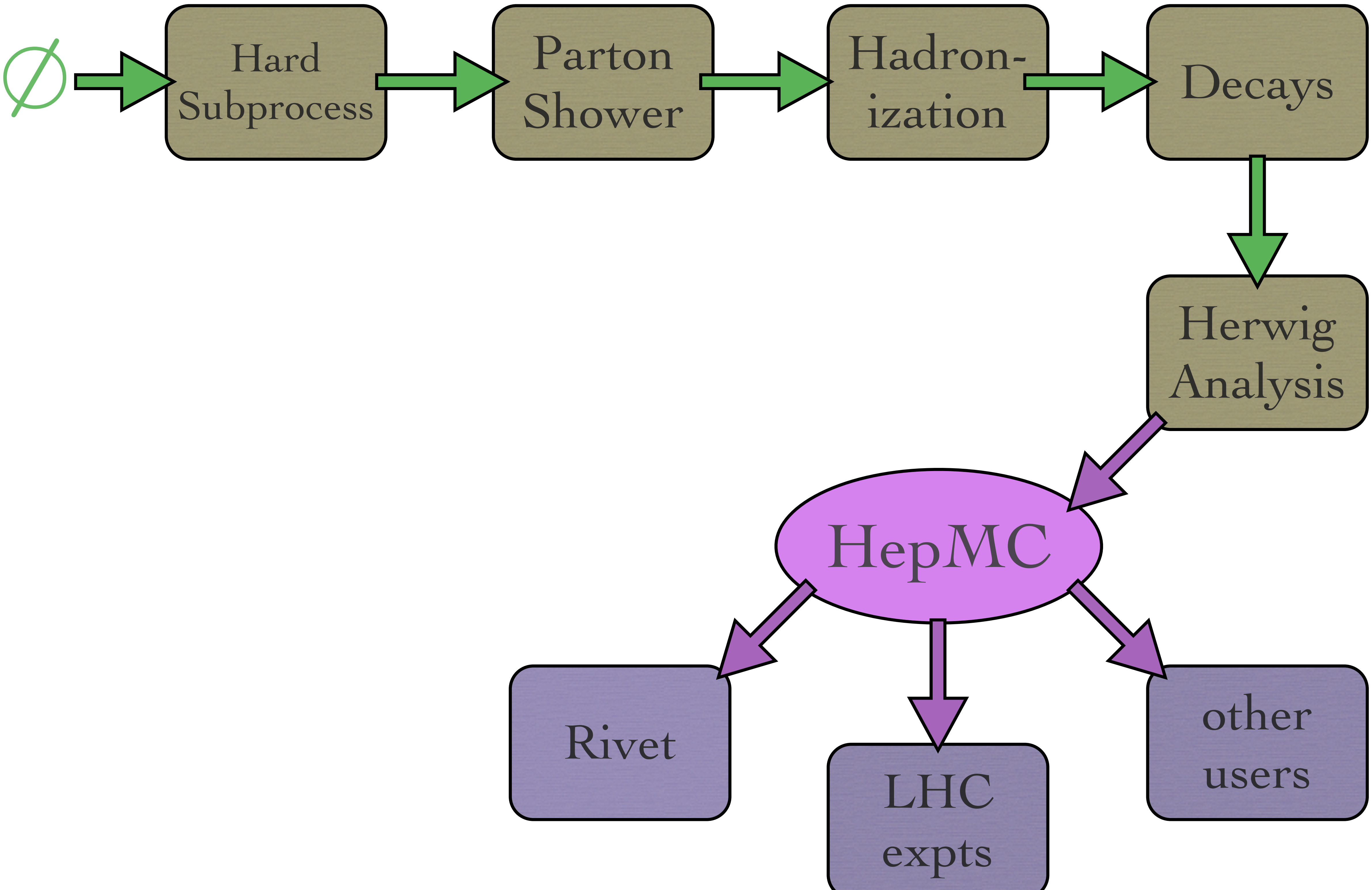

Default Setup



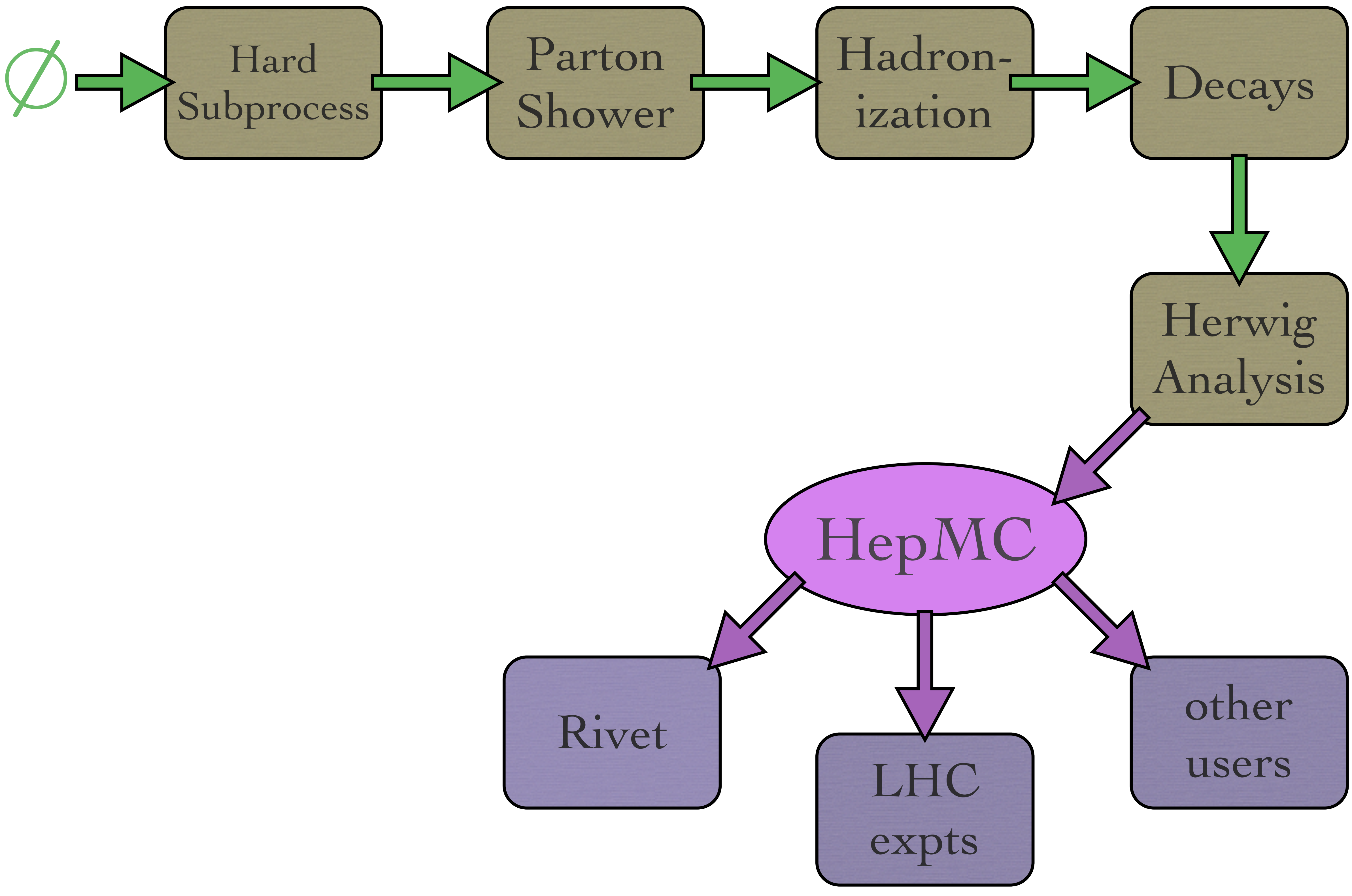
Event record flow



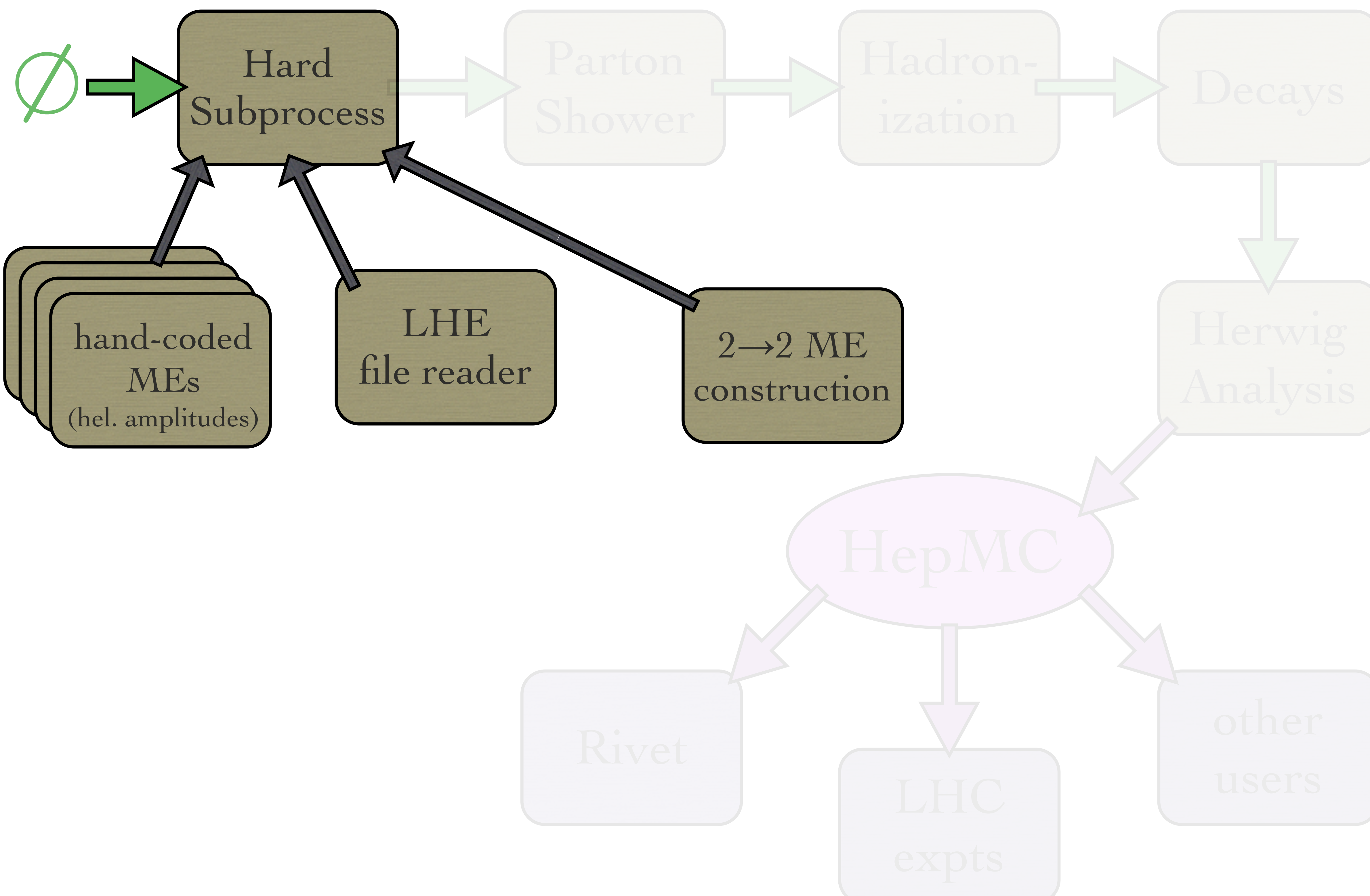
Event record flow



Event record flow



Event record flow



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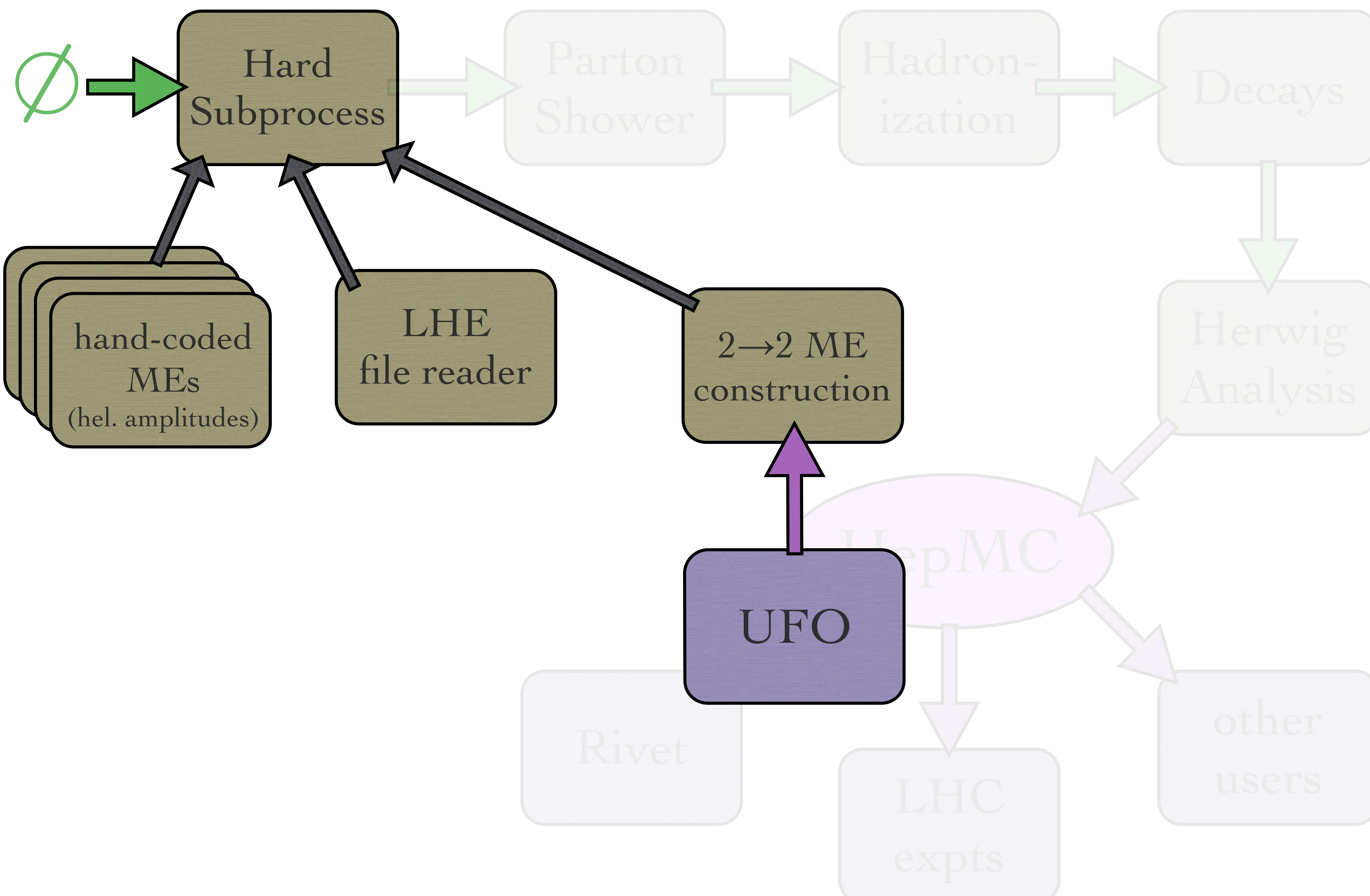

BSM model handling

- Make use of existing Lorentz structures in helicity amplitude formalism
- Use UFO converter or hand-code *vertices* for the new model, and *model class* to hold parameter values
- Automatic determination of $2 \to 2$ MEs,
  and $1 \to 2$ and $1 \to 3$ decays, with full spin correlation
- Have: MSSM (with SLHA reader), UED, Randall-Sundrum gravitons, Z', anomalous hVV, …

Vertex Classes

- The Feynman rules are coded as Vertex classes inheriting from one of the already implemented spin structures, e.g. for a new vector coupling only need to supply c, g_L and g_R:

$$\bar{\psi} c \gamma^\mu \left[g_L P_L + g_R P_R \right] \psi \epsilon_\mu$$

- The interactions in new physics models can then be implemented by supplying the couplings in the model.

New Physics model

- Implementing a new model in Herwig++ is then simply a matter of:
  - implementing a new model class which inherits from the Herwig++ Standard Model class and stores or calculates any parameters needed in the model;
  - implementing the Vertex classes, specifying the interactions in the model;
  - specifying the particle content of the model.
- Still requires coding for each model, but if UFO description is available, fully automatic using the `ufo2herwig` command and `make`.

BSM features

- The current release includes:
  - UFO model converter
  - full spin correlations;
  - simulation of off-shell effects;
  - simulation of 2->2 process;
  - simulation of two-, three- and some four-body decays;
  - some 2->3 processes for BSM Higgs physics;
  - Small Δm weak decays using tau hadronic currents;
  - allows different vertex Lorentz structures to be easily handled;
  - Wide range of models MSSM, NMSSM, RS, ADD, Sextet, Little Higgs (with or w/o T-parity), Leptoquarks, UED …

Preview of Herwig++ developments

Planned release: Autumn 2014

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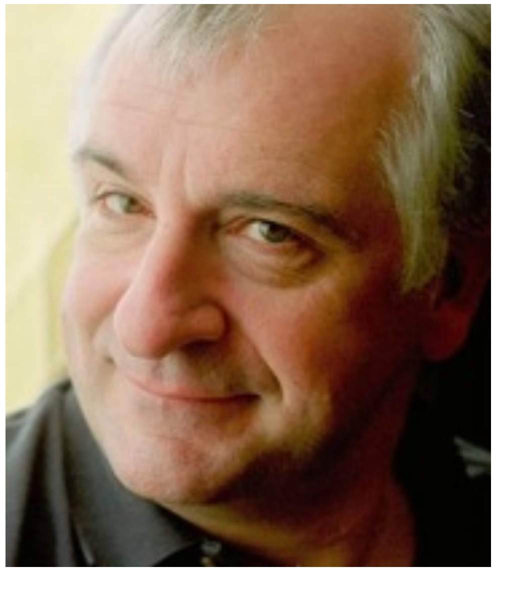
Planned release: Autumn 2014

"I love deadlines. I love the whooshing noise they make as they go by."



Matchbox development.

[J. Bellm, N. Fischer, S. Gieseke, SP, D. Rauch, C. Reuschle + A. Wilcock, P. Richardson]

Automated LO and NLO cross sections for Herwig++

- Run out of the box, steering as before. No LHE file detour needed
- Include matching to angular ordered and dipole shower.
- Provide all necessary functionality for (N)LO merging.

Include reasonable and consistent evaluation of shower and scale uncertainties.
$\rightarrow$ Integrated, coherent framework.

Continuation and generalization of dipole shower plus NLO developments.

[SP & S. Gieseke – Eur.Phys.J. C72 (2012) 2187]

Closely tied to structural improvements and extensions of ThePEG.
Major milestone for Herwig++ 3.0 $\equiv$ Herwig 7 efforts.

Partial beta tester available in Herwig++ 2.7.x, much more to come in 2.8.x.

Matchbox development.

$$\sigma_{\rm NLO} = \int_n {\rm d}\sigma_{\rm LO} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle \\ |\mathcal{M}_{n,0}|^2 \end{pmatrix} + \int_n \left[{\rm d}\sigma_{\rm V} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle, |\mathcal{M}_{n,1}\rangle \\ 2{\rm Re}(\langle \mathcal{M}_{n,0}|\mathcal{M}_{n,1}\rangle) \end{pmatrix} + \int_1 {\rm d}\sigma_{\rm A} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle \\ |\mathcal{M}^{ij}_{n,0}|^2 \end{pmatrix} \right]$$
$$+ \int_{n+1} \left[{\rm d}\sigma_{\rm PS} \begin{pmatrix} P(\tilde{q}), D(p_\perp) \\ R_{\rm ME}(p_\perp) \end{pmatrix} - {\rm d}\sigma_{\rm A} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle \\ |\mathcal{M}^{ij}_{n,0}|^2 \end{pmatrix} \right]$$
$$+ \int_{n+1} \left[{\rm d}\sigma_{\rm R} \begin{pmatrix} |\mathcal{M}_{n+1,0}\rangle \\ |\mathcal{M}_{n+1,0}|^2 \end{pmatrix} - {\rm d}\sigma_{\rm PS} \begin{pmatrix} P(\tilde{q}), D(p_\perp) \\ R_{\rm ME}(p_\perp) \end{pmatrix} \right]$$

Interfaces at amplitude level

- Color bases provided, including interface to `ColorFull`.
  [M. Sjödahl, SP]
- Spinor helicity library and caching facilities.
- MadGraph5.
  [MadGraph & J. Bellm, S. Gieseke, SP, A. Wilcock]
- Some in-house calculations and parts of `HJets++`.
  [F. Campanario, T. Figy, SP, M. Sjödahl]

Interfaces at squared amplitude level

- Dedicated interfaces.
  [HEJ & SP]
  [nlojet++ & J. Kotanski, J. Katzy, SP]
- BLHA2.
  [GoSam & J. Bellm, S. Gieseke, SP, C. Reuschle]
  [NJet & SP]
  [OpenLoops & J. Bellm, S. Gieseke]
  [VBFNLO & K. Arnold, S. Gieseke, SP]

Matchbox infrastructure

based on [SP & S. Gieseke – Eur.Phys.J. C72 (2012) 2187]

- Process generation and bookkeeping, integration.
- Automated Catani-Seymour dipole subtraction.
- Diagram-based mutli-channel phase space.

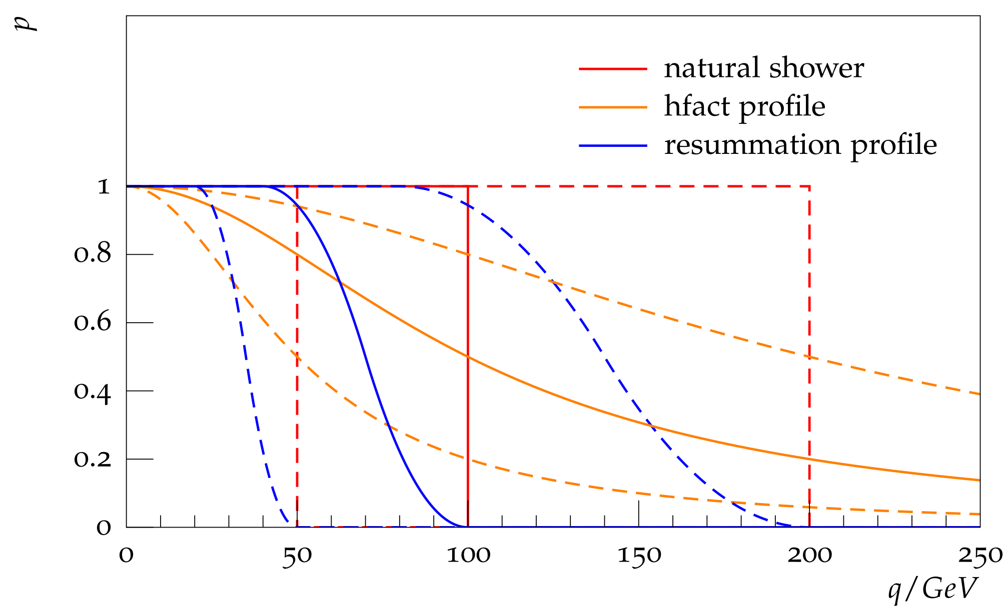
Shower plugins

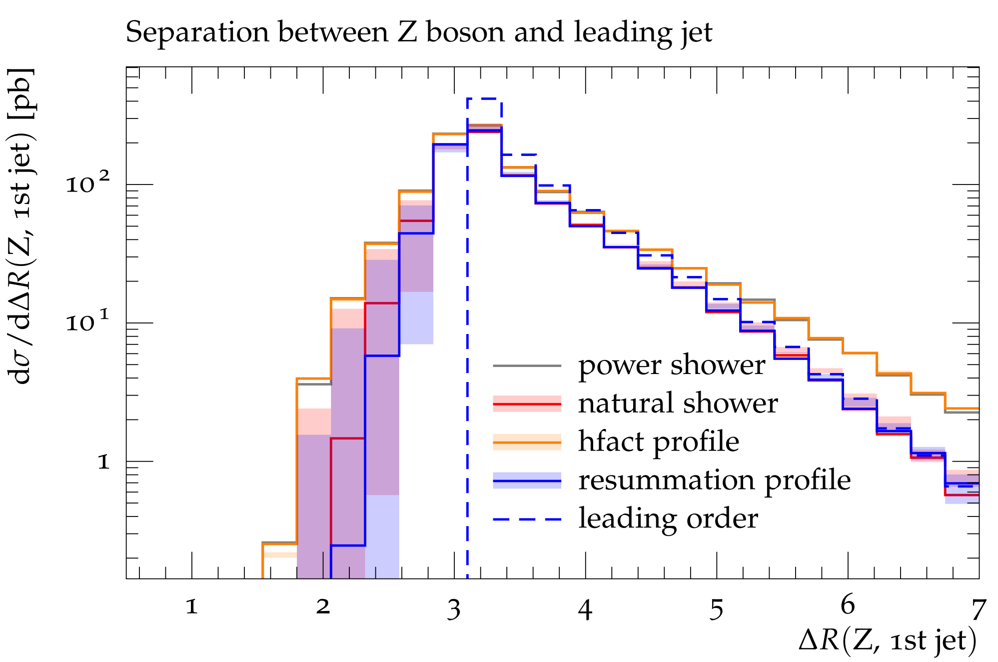
matching details & uncertainties [SP – in preparation]

- Dipole shower $D(p_\perp)$.
- Angular ordered shower $P(\tilde{q})$.
- ME correction $R_{\rm ME}(p_\perp)$, including adaptive sampling.

Matchbox-based activities.

Shower & matching uncertainties [SP]





(N)LO merging

[J. Bellm, S. Gieseke, SP]

- 'Unitarized' merging approach.

  [Lönnblad, Prestel –JHEP 1303 (2013) 166]

  [SP – JHEP 1308 (2013) 114]

- Smoothly integrated, no extra event files or external codes to run.

(VBF) Higgs phenomenology @ NLO+PS

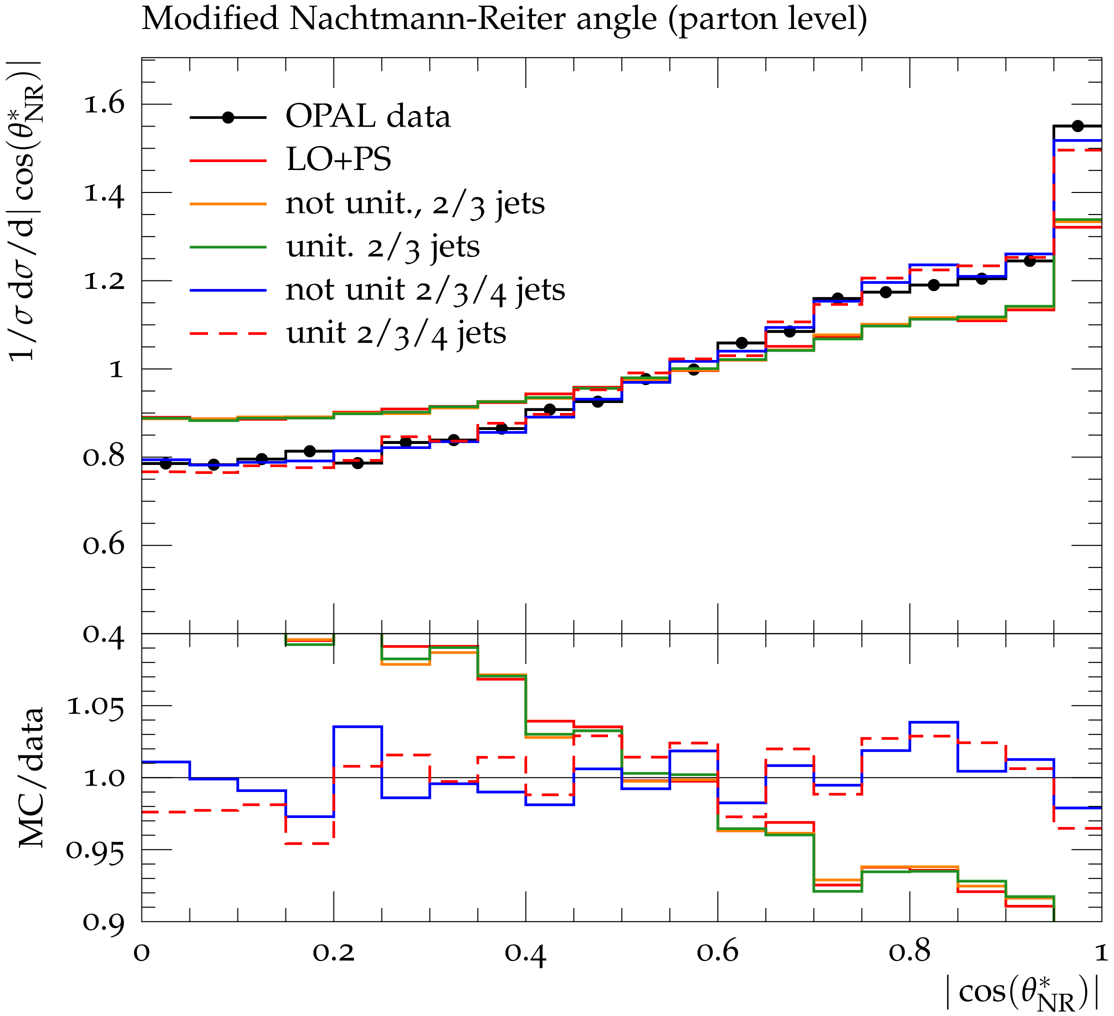
[S. Gieseke, SP + M. Rauch]

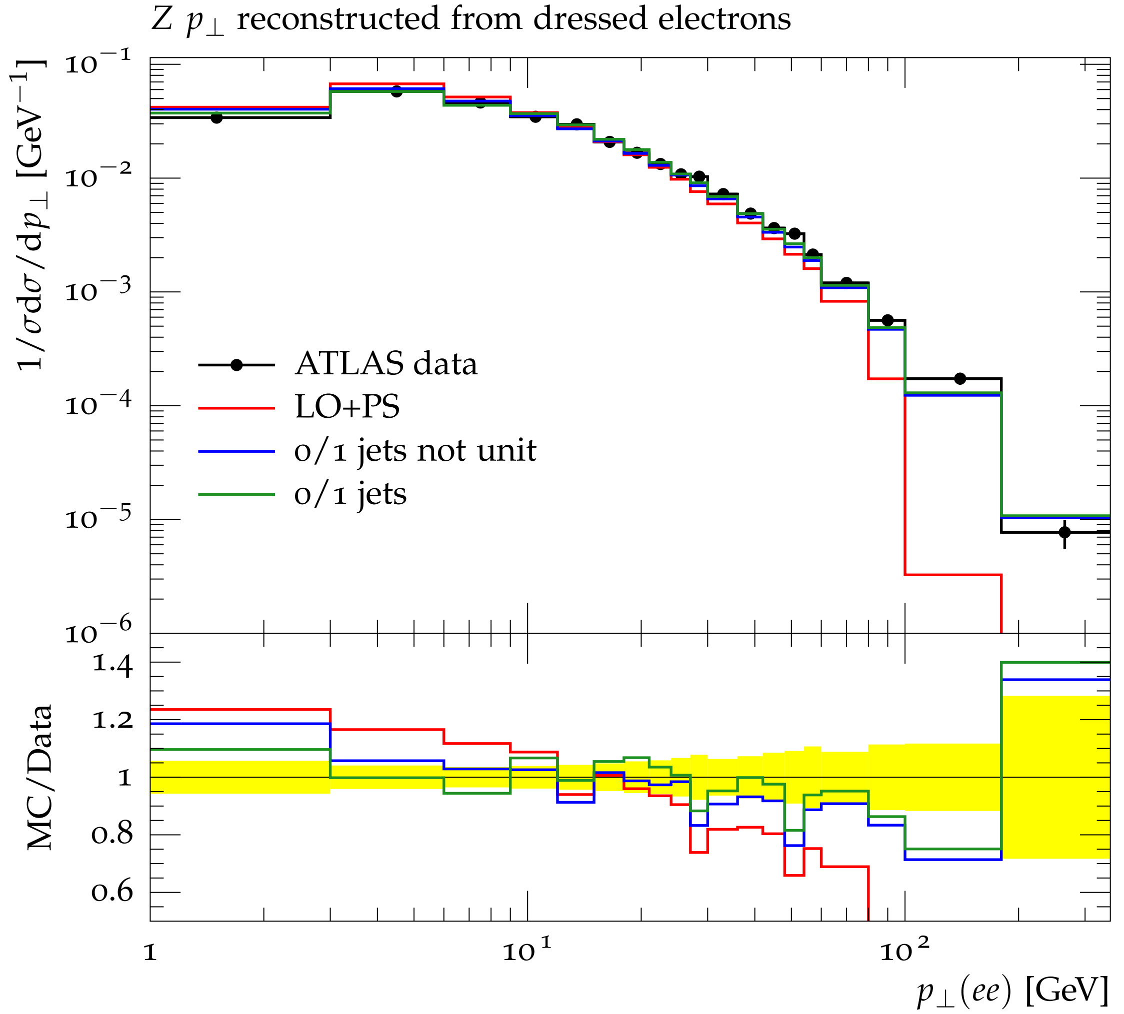
[SP + F. Campanario, T. Figy, M. Sjödahl]

- Interface to VBFNLO for all relevant signals and backgrounds, including anomalous couplings.
- Signal predictions without VBF approximation from `HJets++`.

(N)LO merging.

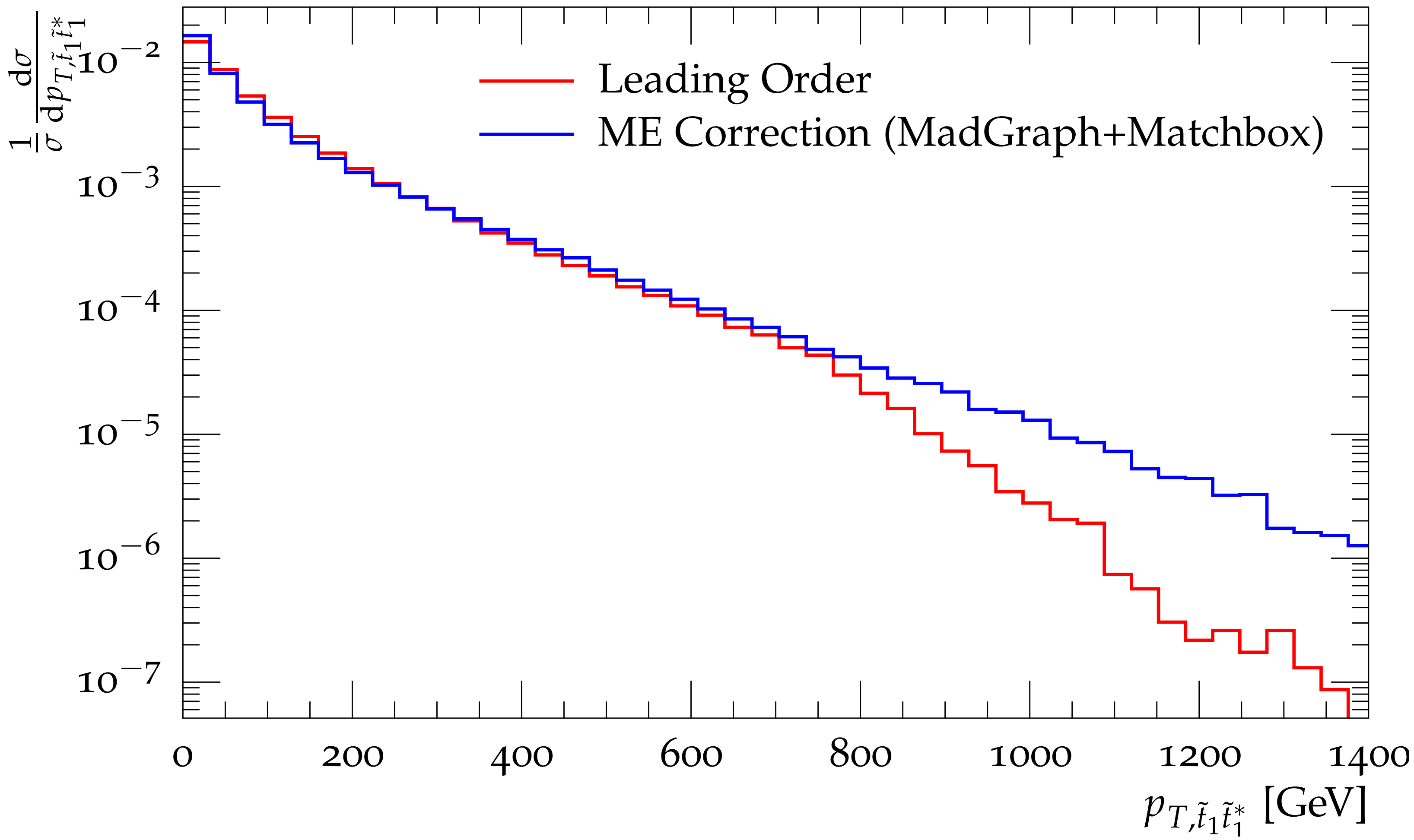
[J. Bellm, S. Gieseke, SP – work in progress]





Matchbox for BSM

[Alix Wilcock, Simon Plätzer, Peter Richardson]



pT in stop pair production,

standard Herwig++ ⇔ MadGraph+Matchbox

Use case:
Toolchain for BSM limits
SLHA / Herwig++ / Rivet

Use case:
Toolchain for BSM limits
SLHA / Herwig++ / Rivet

(full models, simulated to hadron level)

BSM setup

```
read   MSSM.model
set    HPConstructor:IncludeEW No

insert HPConstructor:Incoming 0 g
insert HPConstructor:Incoming 1 u
insert HPConstructor:Incoming 2 ubar
insert HPConstructor:Incoming 3 d
insert HPConstructor:Incoming 4 dbar

insert HPConstructor:Outgoing 0 ~u_L
insert HPConstructor:Outgoing 1 ~u_Lbar
insert HPConstructor:Outgoing 2 ~d_L
insert HPConstructor:Outgoing 3 ~d_Lbar

setup  MSSM/Model SPhenoSPS1a.spc
set    TwoBodyDC:CreateDecayModes No
set    ThreeBodyDC:CreateDecayModes No

#insert DecayConstructor:DisableModes 0 ~u_L->~chi_20,u;
#insert DecayConstructor:DisableModes 1 ~chi_20->~e_R-,e+;
```

arXiv:1102.5290

CERN-PH-EP-2011-022, Submitted to Phys. Lett. B

Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in $\sqrt{s} = 7$ TeV proton-proton collisions

The ATLAS Collaboration

Abstract

A search for squarks and gluinos in final states containing jets, missing transverse momentum and no electrons or muons is presented. The data were recorded by the ATLAS experiment in $\sqrt{s} = 7$ TeV proton-proton collisions at the Large Hadron Collider. No excess above the Standard Model background expectation was observed in 35 pb^{-1} of analysed data. Gluino masses below 500 GeV are excluded at the 95% confidence level in simplified models containing only squarks of the first two generations, a gluino octet and a massless neutralino. The exclusion increases to 870 GeV for equal mass squarks and gluinos. In MSUGRA/CMSSM models with $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$, squarks and gluinos of equal mass are excluded below 775 GeV. These are the most stringent limits to date.

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_{T} [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_{T} [GeV]	> 40	> 40	> 40	> 40
	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 100	> 100	> 100	> 100
Final selection	$\Delta\phi(\mathrm{jet}, \vec{P}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$	> 0.4	> 0.4	> 0.4	> 0.4
	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$	> 0.3	–	> 0.25	> 0.25
	m_{eff} [GeV]	> 500	–	> 500	> 1000
	m_{T2} [GeV]	–	> 300	–	–

Table 1: Criteria for admission to each of the four overlapping signal regions A to D. All variables are defined in §4.

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_T [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_T [GeV]	> 40	> 40	> 40	> 40
	E_T^{miss} [GeV]	> 100	> 100	> 100	> 100
Final selection	$\Delta\phi(\text{jet}, \vec{P}_T^{\text{miss}})_{\text{min}}$	> 0.4	> 0.4	> 0.4	> 0.4
	$E_T^{\text{miss}}/m_{\text{eff}}$	> 0.3	–	> 0.25	> 0.25
	m_{eff} [GeV]	> 500	–	> 500	> 1000
	m_{T2} [GeV]	–	> 300	–	–

Table 1: Criteria for admission to each of the four overlapping signal regions A to D. All variables are defined in §4.

	Signal region A	Signal region B	Signal region C	Signal region D
QCD	$7\ ^{+8}_{-7}$[u+j]	$0.6\ ^{+0.7}_{-0.6}$[u+j]	$9\ ^{+10}_{-9}$[u+j]	$0.2\ ^{+0.4}_{-0.2}$[u+j]
W+jets	50 ± 11[u] $^{+14}_{-10}$[j] $\pm\ 5[\mathcal{L}]$	4.4 ± 3.2[u] $^{+1.5}_{-0.8}$[j] $\pm 0.5[\mathcal{L}]$	35 ± 9[u] $^{+10}_{-8}$[j] $\pm 4[\mathcal{L}]$	1.1 ± 0.7[u] $^{+0.2}_{-0.3}$[j] $\pm 0.1[\mathcal{L}]$
Z+jets	52 ± 21[u] $^{+15}_{-11}$[j] $\pm\ 6[\mathcal{L}]$	4.1 ± 2.9[u] $^{+2.1}_{-0.8}$[j] $\pm 0.5[\mathcal{L}]$	27 ± 12[u] $^{+10}_{-6}$[j] $\pm 3[\mathcal{L}]$	0.8 ± 0.7[u] $^{+0.6}_{-0.0}$[j] $\pm 0.1[\mathcal{L}]$
$t\bar{t}$ and t	10 ± 0[u] $^{+3}_{-2}$[j] $\pm\ 1[\mathcal{L}]$	0.9 ± 0.1[u] $^{+0.4}_{-0.3}$[j] $\pm 0.1[\mathcal{L}]$	17 ± 1[u] $^{+6}_{-4}$[j] $\pm 2[\mathcal{L}]$	0.3 ± 0.1[u] $^{+0.2}_{-0.1}$[j] $\pm 0.0[\mathcal{L}]$
Total SM	118 ± 25[u] $^{+32}_{-23}$[j] $\pm 12[\mathcal{L}]$	10.0 ± 4.3[u] $^{+4.0}_{-1.9}$[j] $\pm 1.0[\mathcal{L}]$	88 ± 18[u] $^{+26}_{-18}$[j] $\pm 9[\mathcal{L}]$	2.5 ± 1.0[u] $^{+1.0}_{-0.4}$[j] $\pm 0.2[\mathcal{L}]$
Data	87	11	66	2

Table 2: Expected and observed numbers of events in the four signal regions. Uncertainties shown are due to "MC statistics, statistics in control regions, other sources of uncorrelated systematic uncertainty, and also the jet energy resolution and lepton efficiencies" [u], the jet energy scale [j], and the luminosity [$\mathcal{L}$].

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_T [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_T [GeV]	> 40	> 40	> 40	> 40
	E_T^{miss} [GeV]	> 100	> 100	> 100	> 100
[illegible]ion	$\Delta\phi(\text{jet}, \vec{P}_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4

8. Summary

This letter reports a search for new physics in final states containing high-p_T jets, missing transverse momentum and no electrons or muons. Good agreement is seen between the numbers of events observed in the four signal regions and the numbers of events expected from SM sources. Signal regions A, B, C and D exclude non-SM cross sections within acceptance of 1.3, 0.35, 1.1 and 0.11 pb respectively at 95% confidence.

	Signal r[illegible]	[illegible]	[illegible]	[illegible]
QCD	$7 ^{+8}_{-7}$[u[illegible]	[illegible]	[illegible]	[illegible]
W+jets	50 ± 11[illegible]	[illegible]	[illegible]	[illegible][j] $\pm 0.1[\mathcal{L}]$
Z+jets	52 ± 21[illegible]	[illegible]	[illegible]	[illegible][j] $\pm 0.1[\mathcal{L}]$
$t\bar{t}$ and t	$10 \pm 0[u] ^{+3}_{-2}[j] \pm 1[\mathcal{L}]$	$0.9 \pm 0.1[u] ^{+0.4}_{-0.3}[j] \pm 0.1[\mathcal{L}]$	$17 \pm 1[u] ^{+6}_{-4}[j] \pm 2[\mathcal{L}]$	$0.3 \pm 0.1[u] ^{+0.2}_{-0.1}[j] \pm 0.0[\mathcal{L}]$
Total SM	$118 \pm 25[u] ^{+32}_{-23}[j] \pm 12[\mathcal{L}]$	$10.0 \pm 4.3[u] ^{+4.0}_{-1.9}[j] \pm 1.0[\mathcal{L}]$	$88 \pm 18[u] ^{+26}_{-18}[j] \pm 9[\mathcal{L}]$	$2.5 \pm 1.0[u] ^{+1.0}_{-0.4}[j] \pm 0.2[\mathcal{L}]$
Data	87	11	66	2

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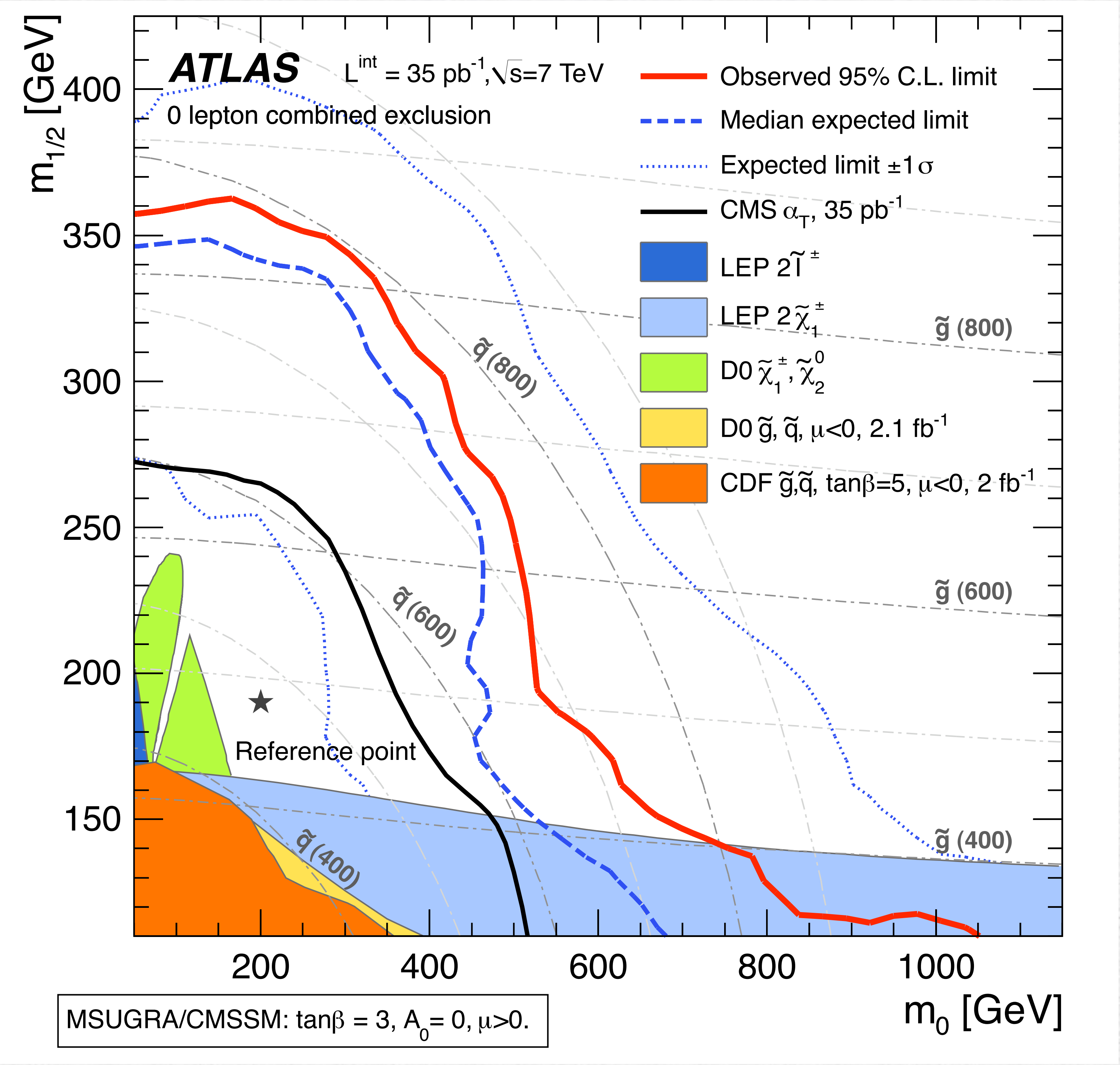
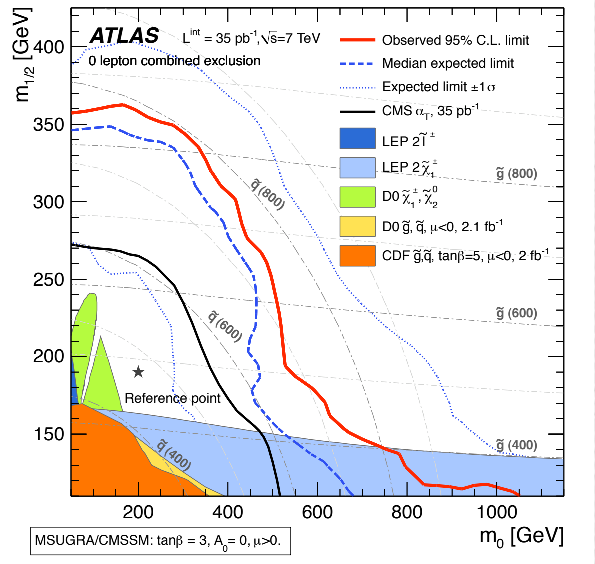


Figure 3: 95% C.L. exclusion limits in the $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$ slice of MSUGRA/CMSSM, together with existing limits [3, 4] with the different model assumptions given in the legend.



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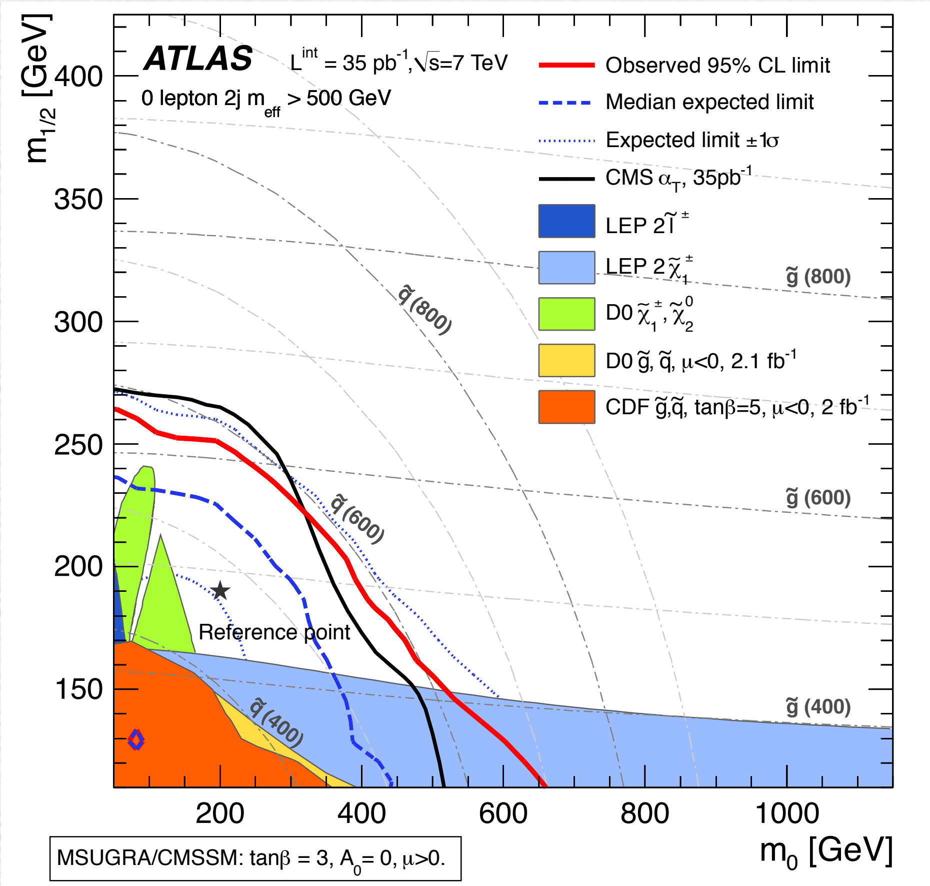
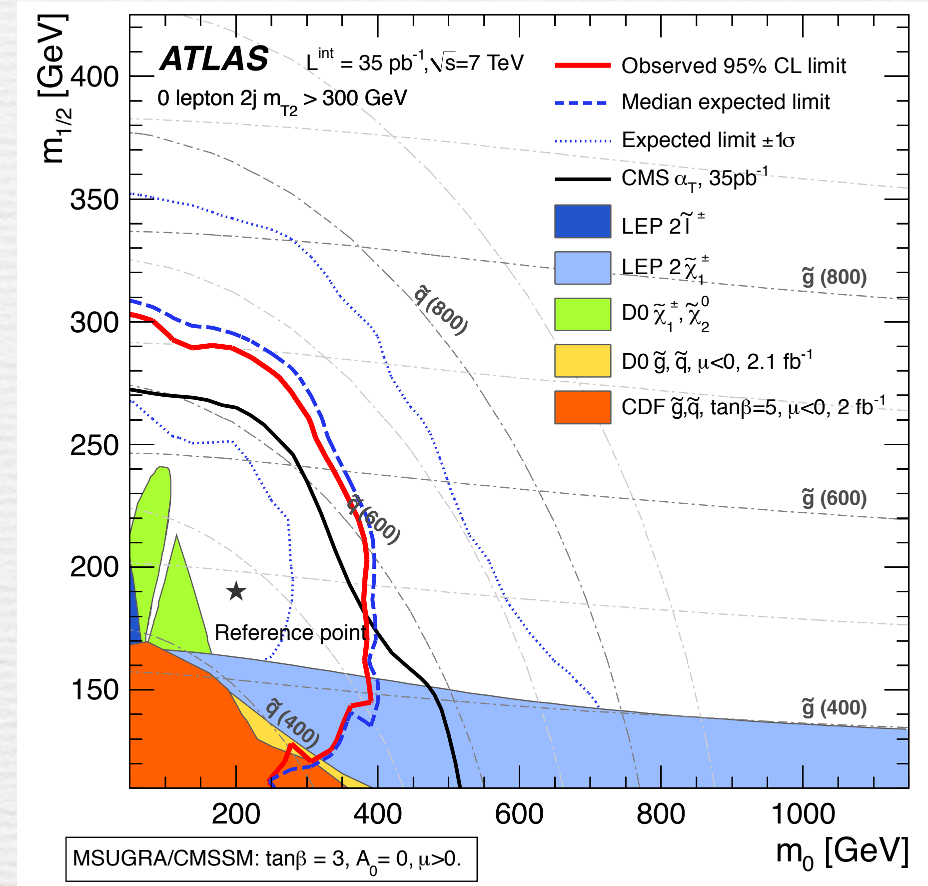


A

1.3 pb

B

0.35 pb



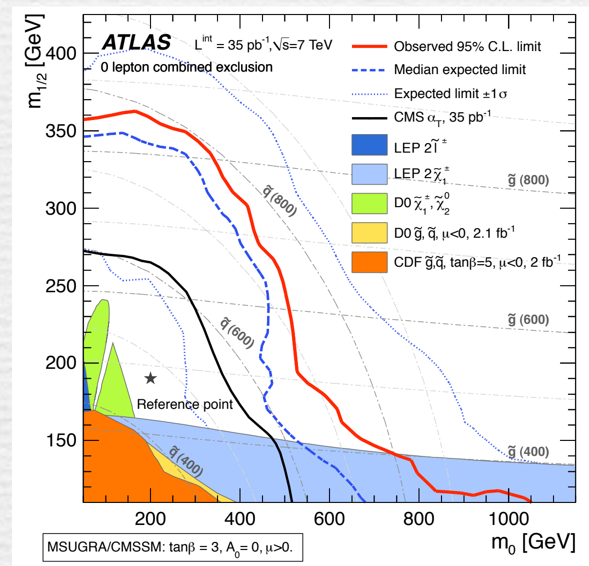
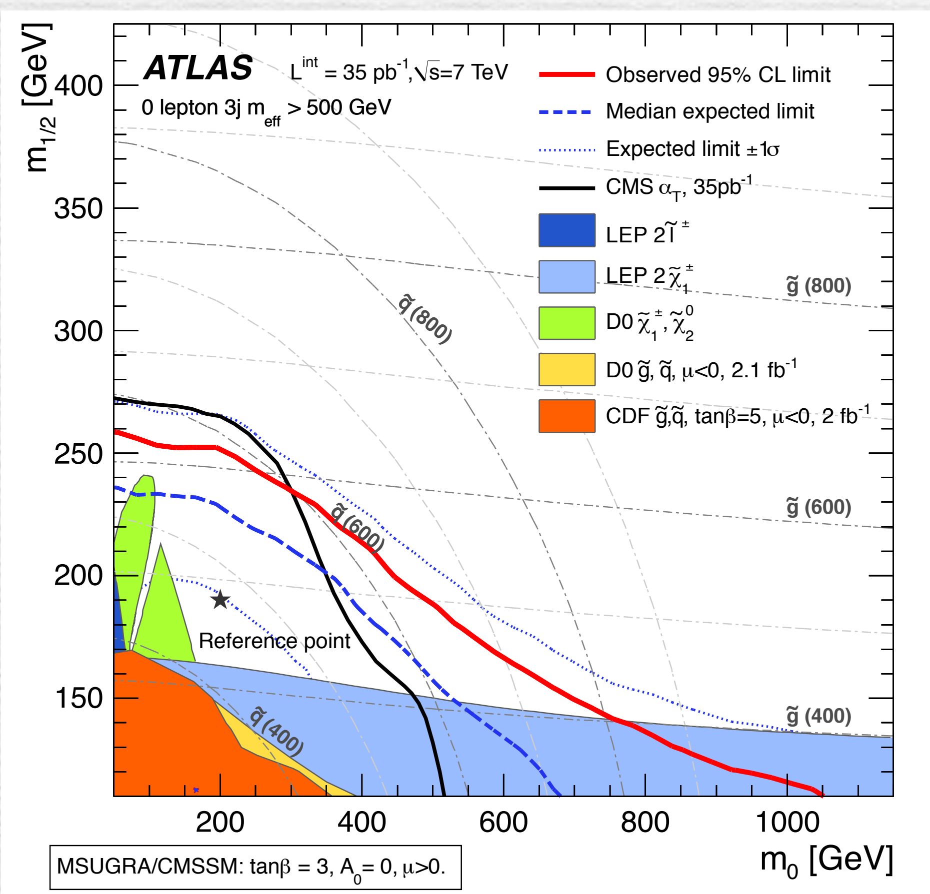


Figure 3: 95% C.L. exclusion limits in the $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$ slice of MSUGRA/CMSSM, together with existing limits [3, 4] with the different model assumptions given in the legend.

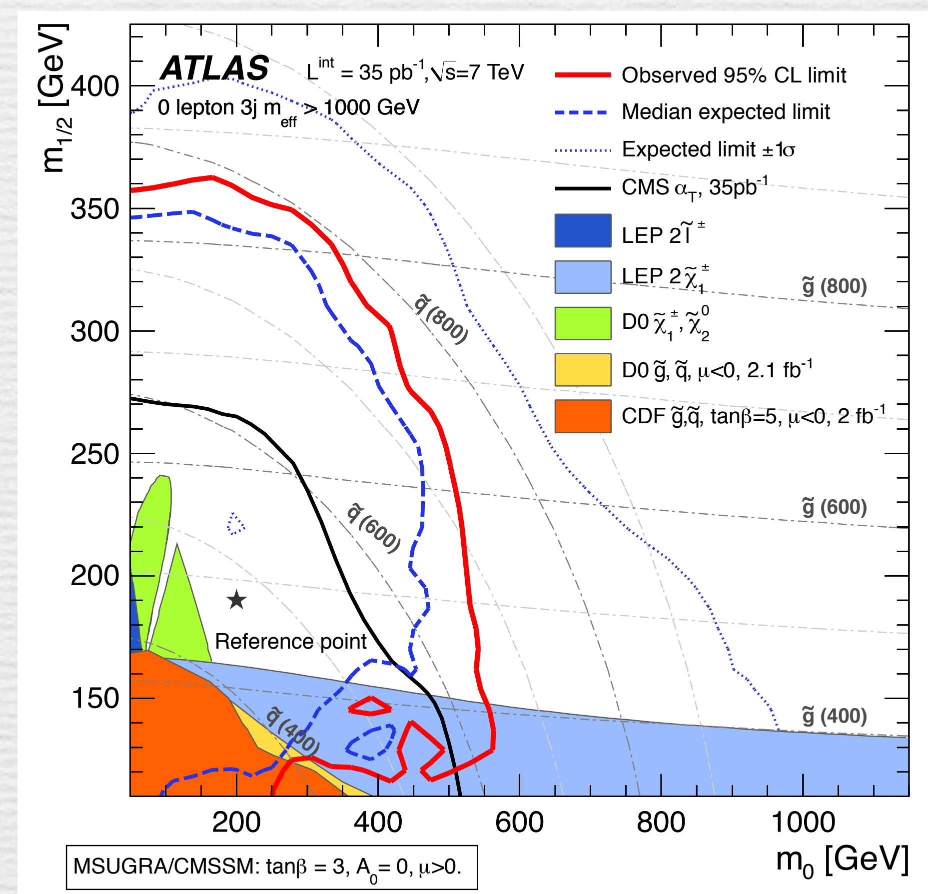


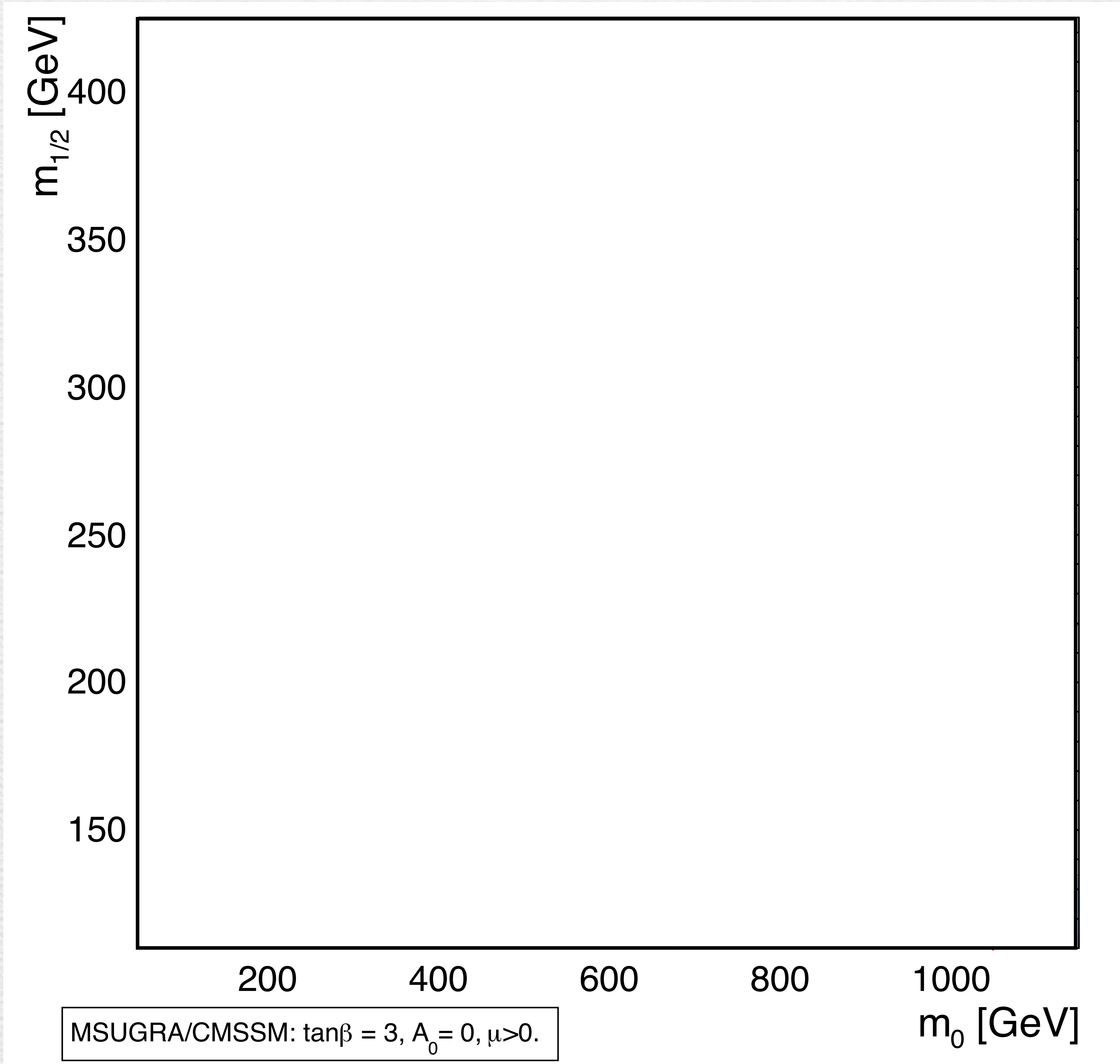
1.1 pb

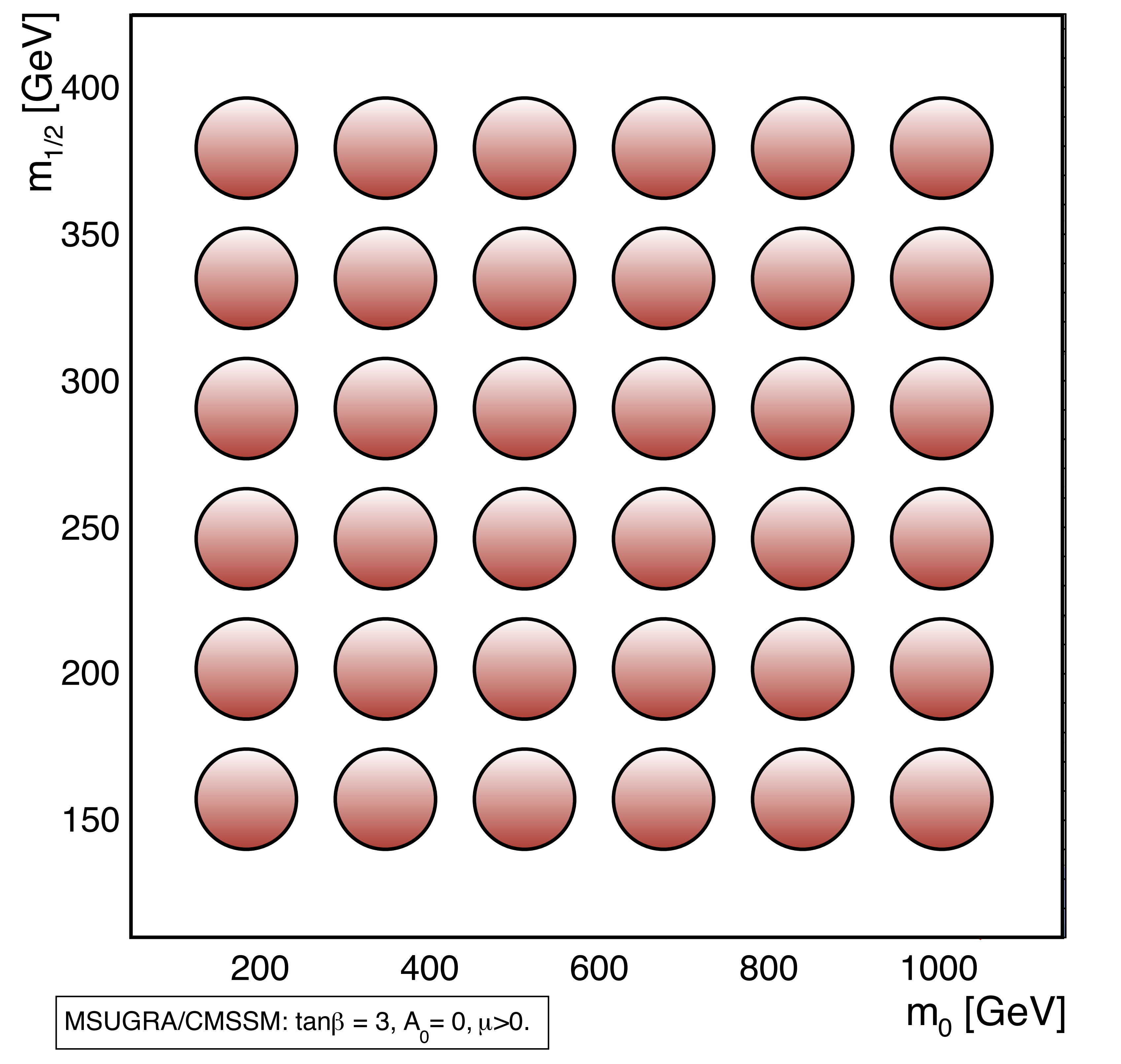
C

0.11 pb

D




$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0= 0, μ>0.



$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0= 0, μ>0.

$m_0,\ m_{1/2},\ A_0 = 0,\ \tan\beta = 3,\ \mu > 0$

$$m_0,\ m_{1/2},\ A_0 = 0,\ \tan\beta = 3,\ \mu > 0$$

$\downarrow$

Softsusy

B.C. Allanach

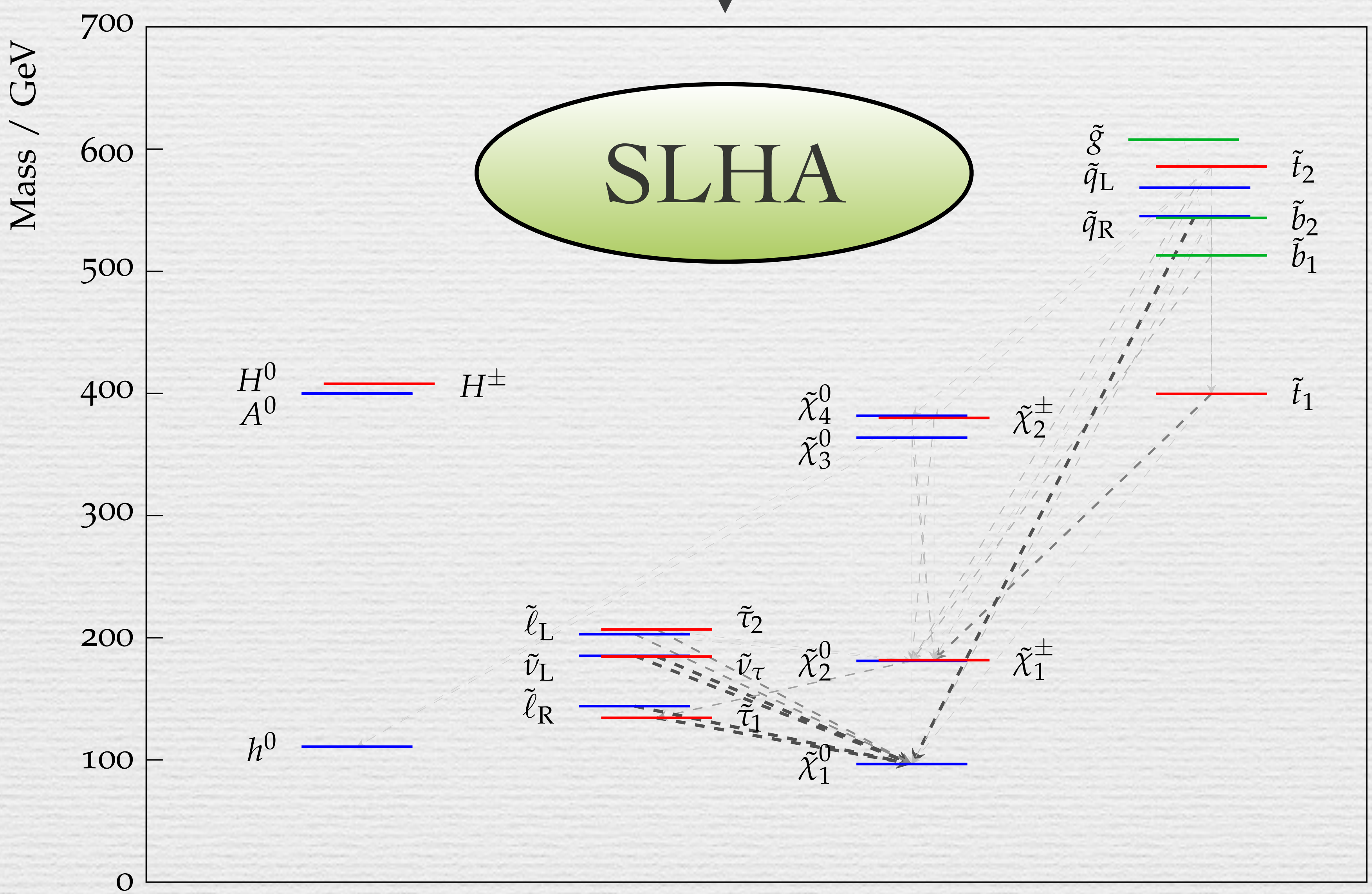
$$m_0,\ m_{1/2},\ A_0 = 0,\ \tan\beta = 3,\ \mu > 0$$

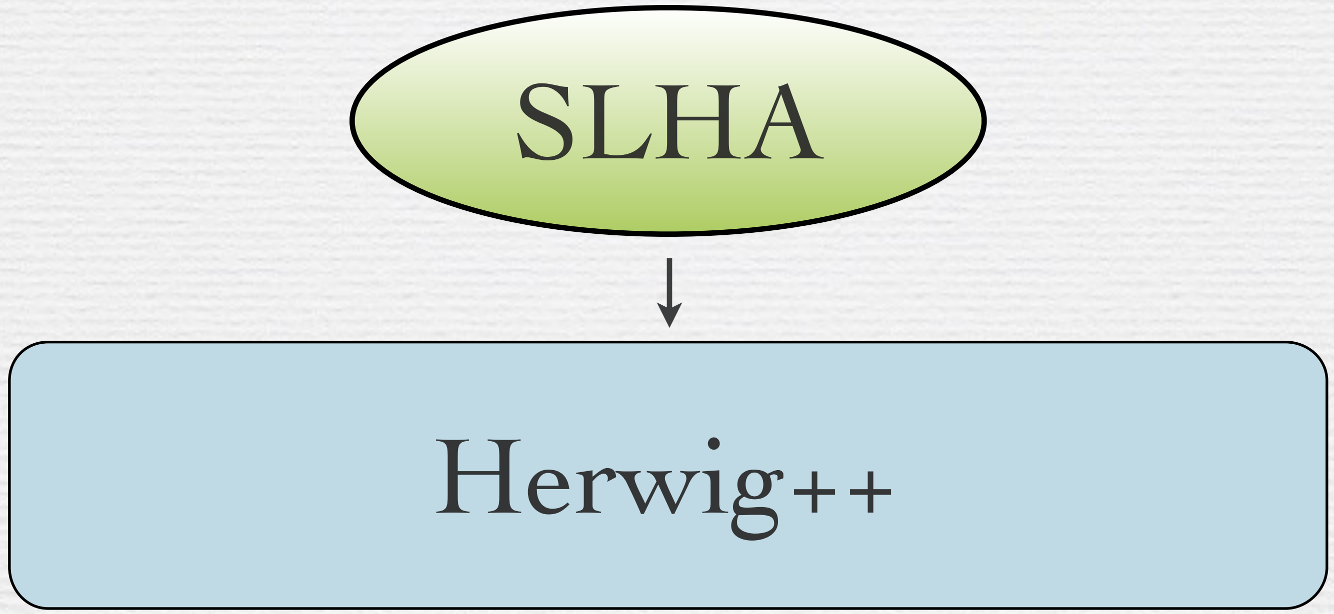
↓

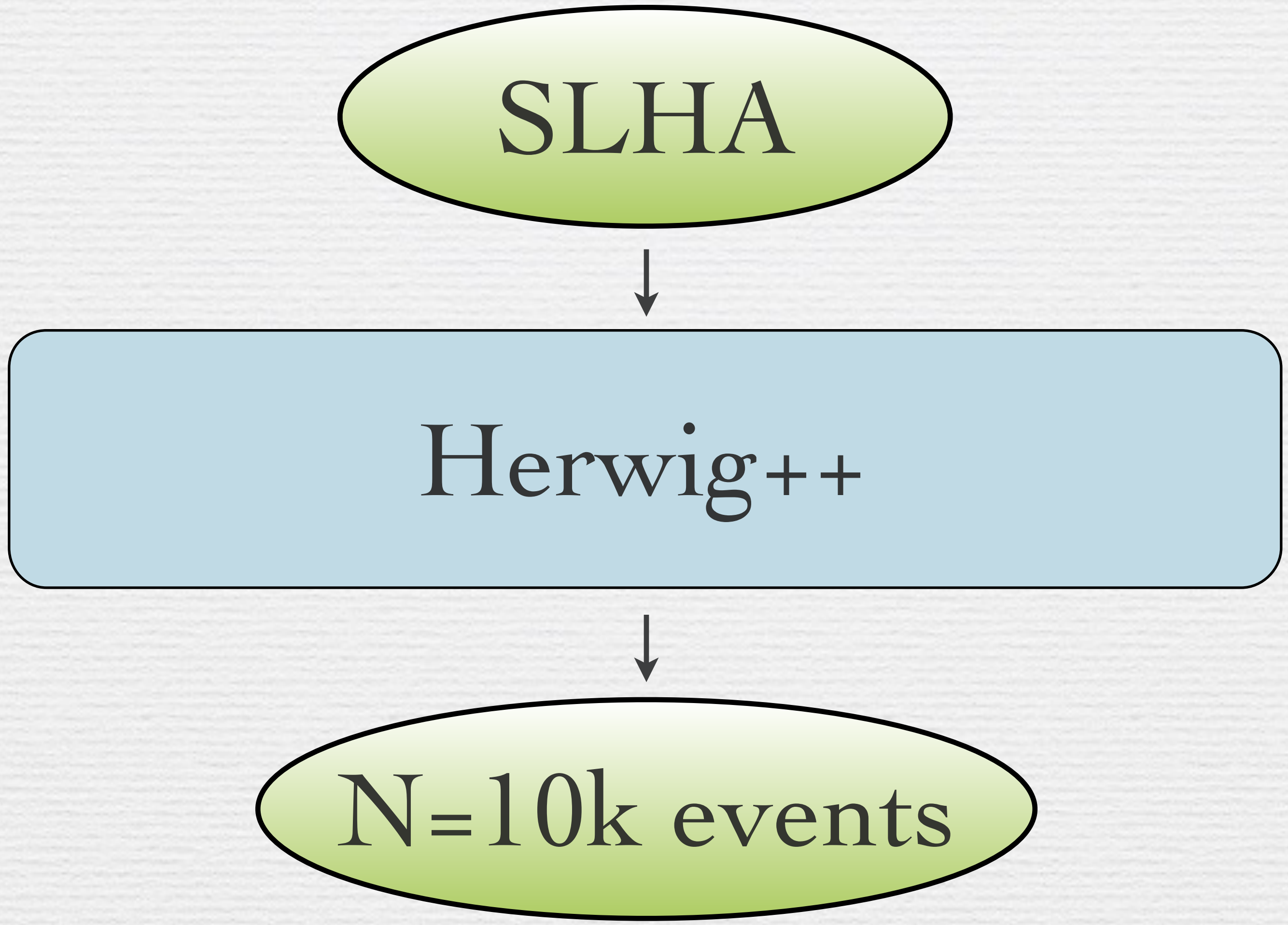
Softsusy

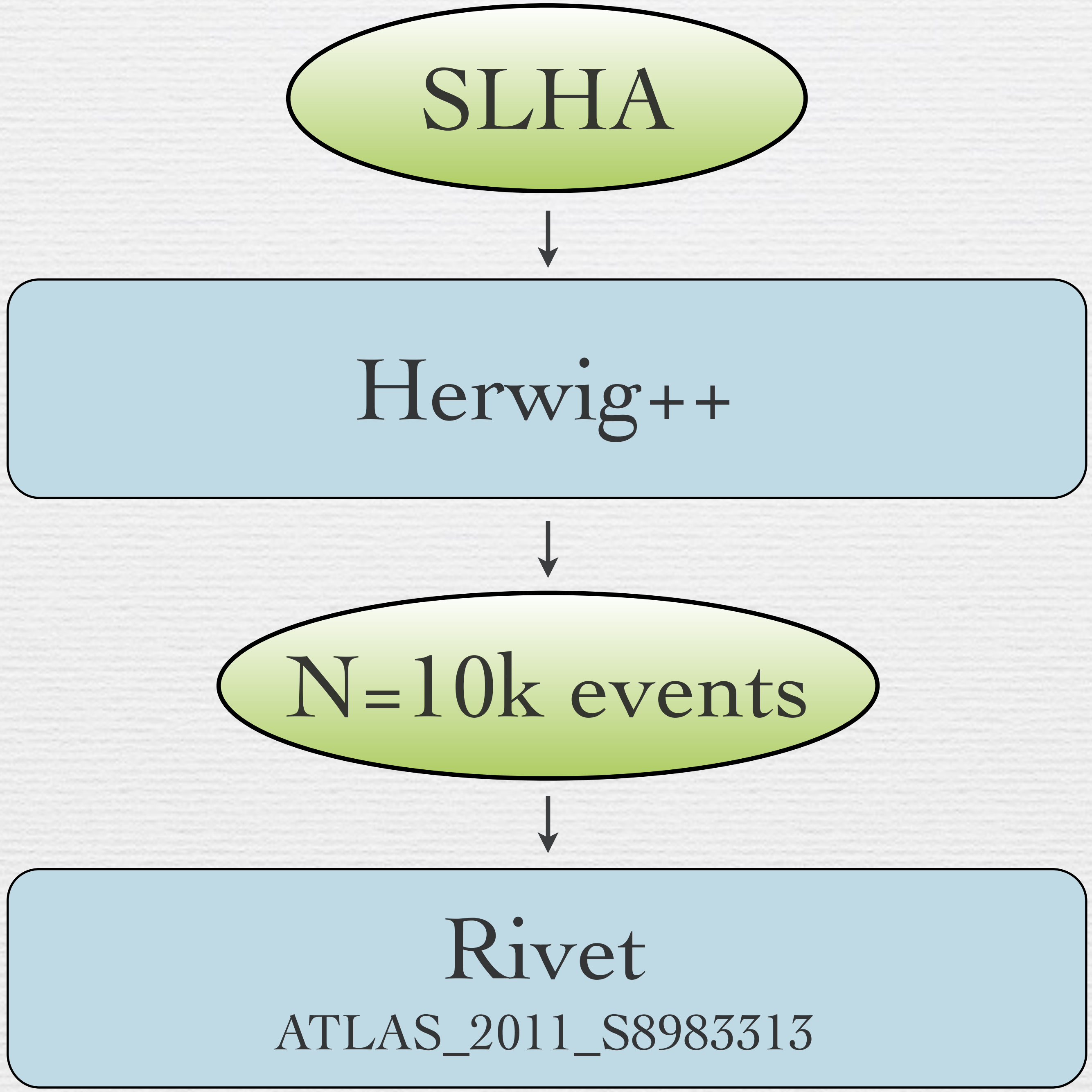
B.C. Allanach

↓




SLHA
Herwig++


SLHA
Herwig++
N=10k events


SLHA
Herwig++
N=10k events
Rivet
ATLAS_2011_S8983313

one SUSY point gives 4 counts

8. Summary

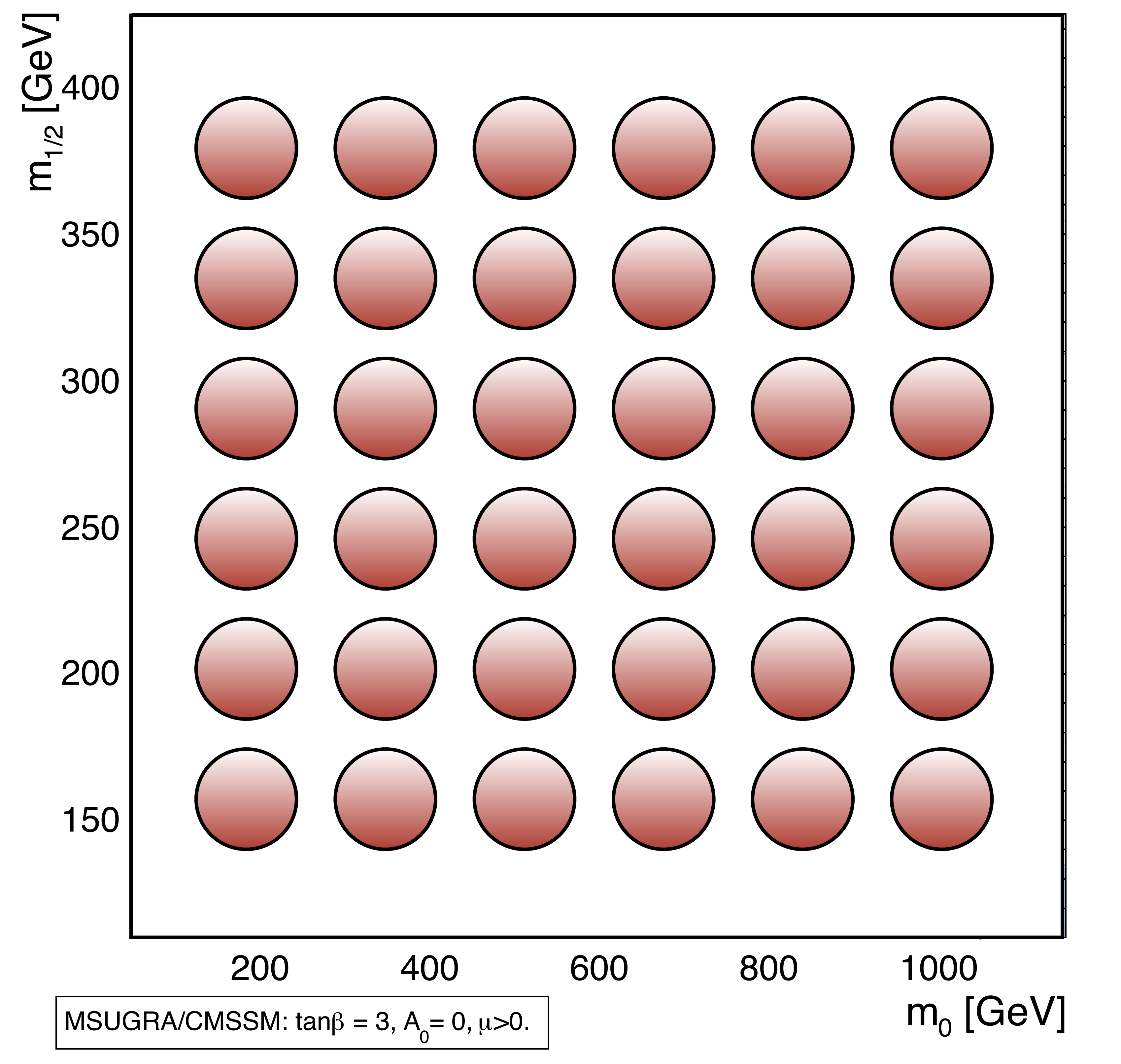
This letter reports a search for new physics in final states containing high-p_{T} jets, missing transverse momentum and no electrons or muons. Good agreement is seen between the numbers of events observed in the four signal regions and the numbers of events expected from SM sources. Signal regions A, B, C and D exclude non-SM cross sections within acceptance of 1.3, 0.35, 1.1 and 0.11 pb respectively at 95% confidence.

A B C D

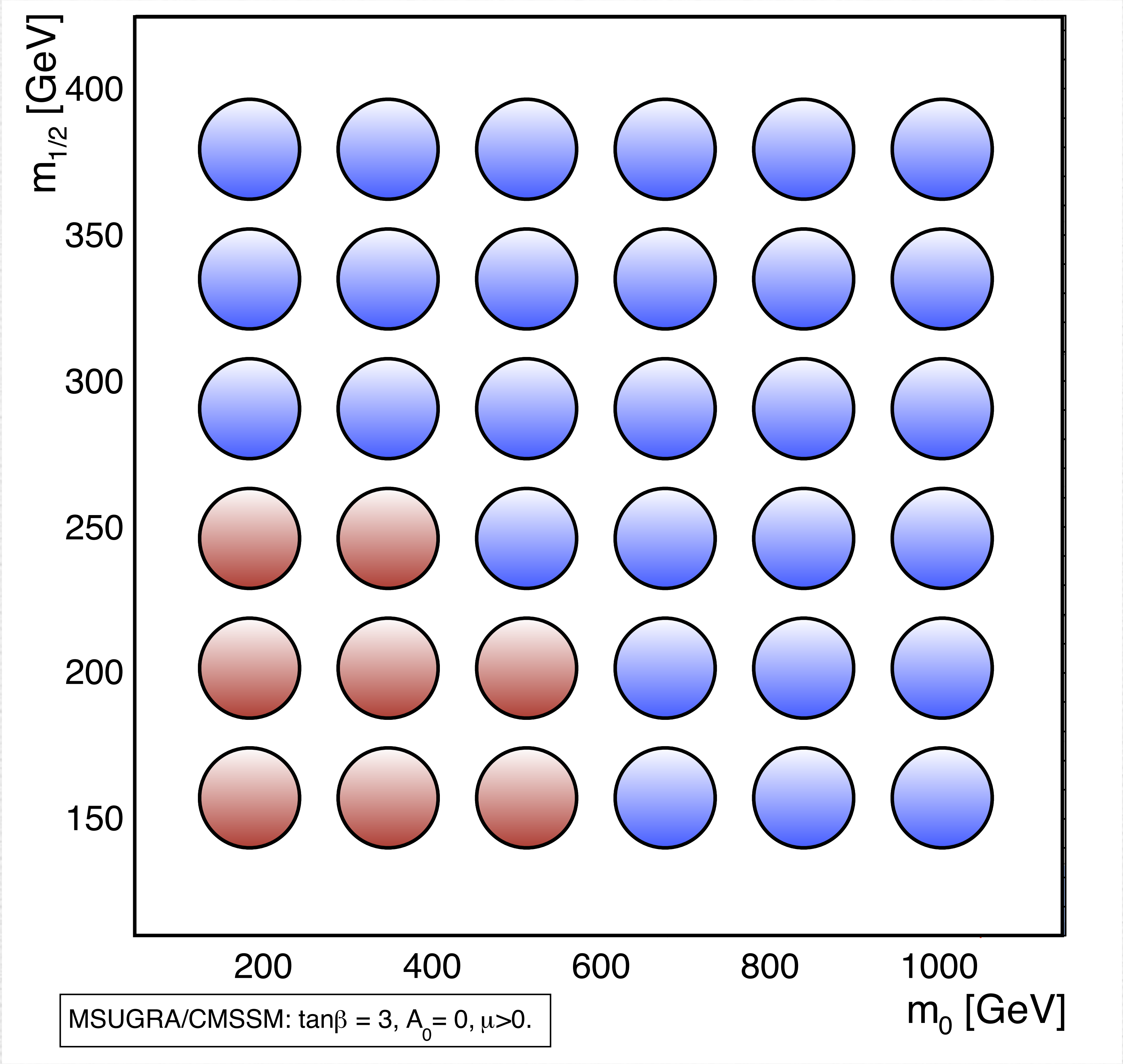
$$\sigma_{\mathrm{A}} = \frac{A}{N}\,\sigma$$

$$\sigma_{A} < 1.3\,\mathrm{pb}?$$

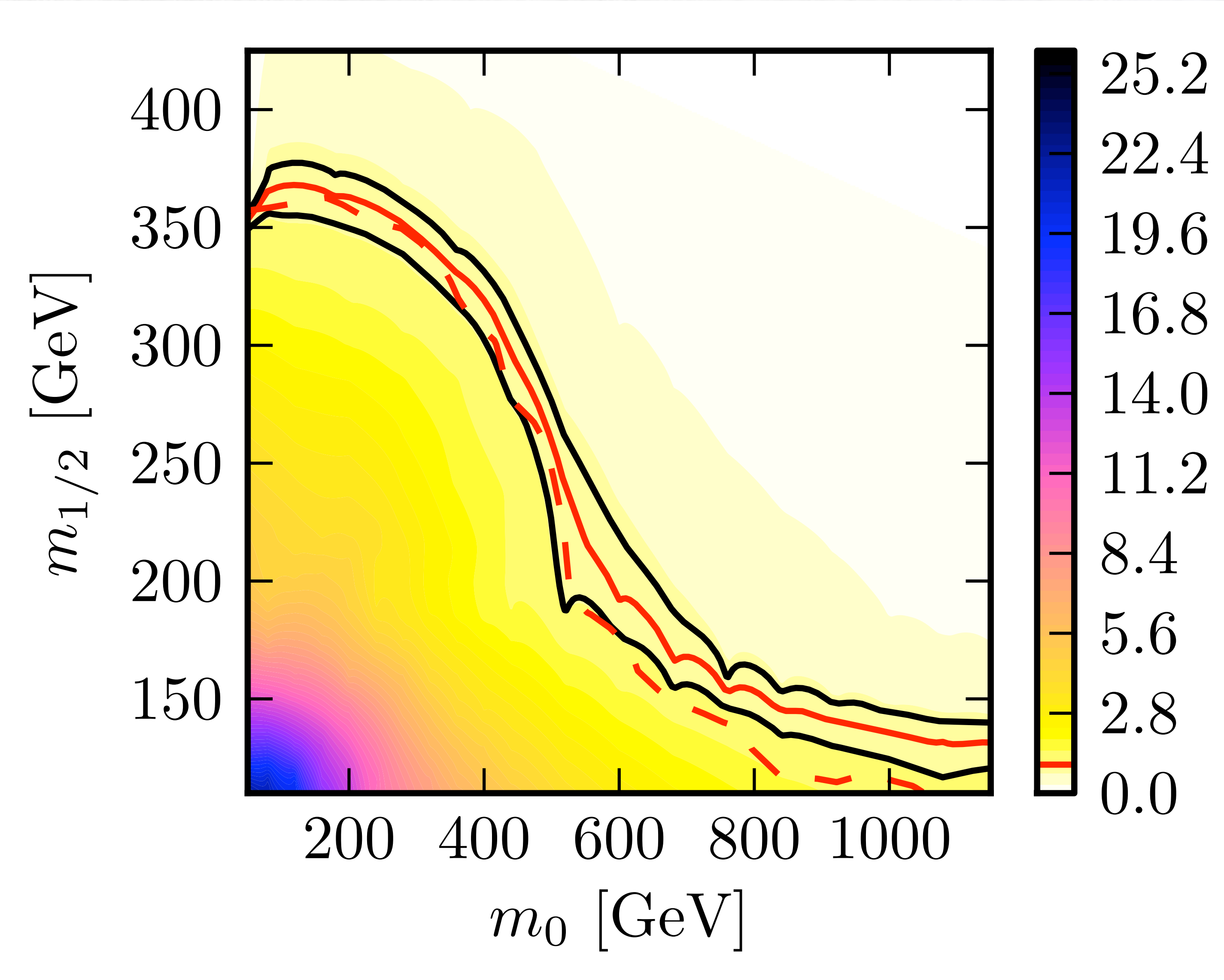
Cross-section:
use LO Herwig++ result
or NLO value from Prospino



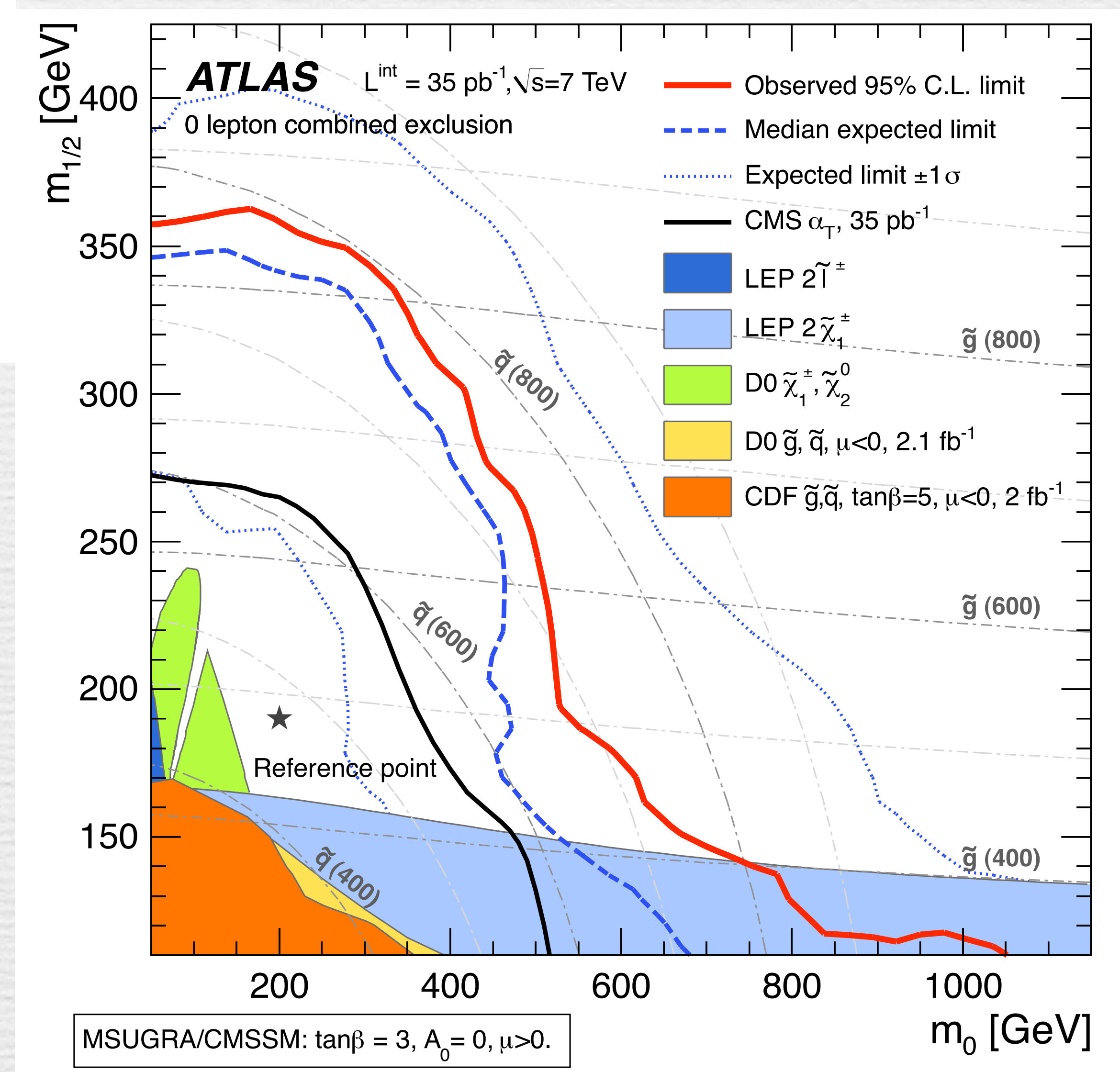
$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: $\tan\beta = 3$, $A_0 = 0$, $\mu > 0$.



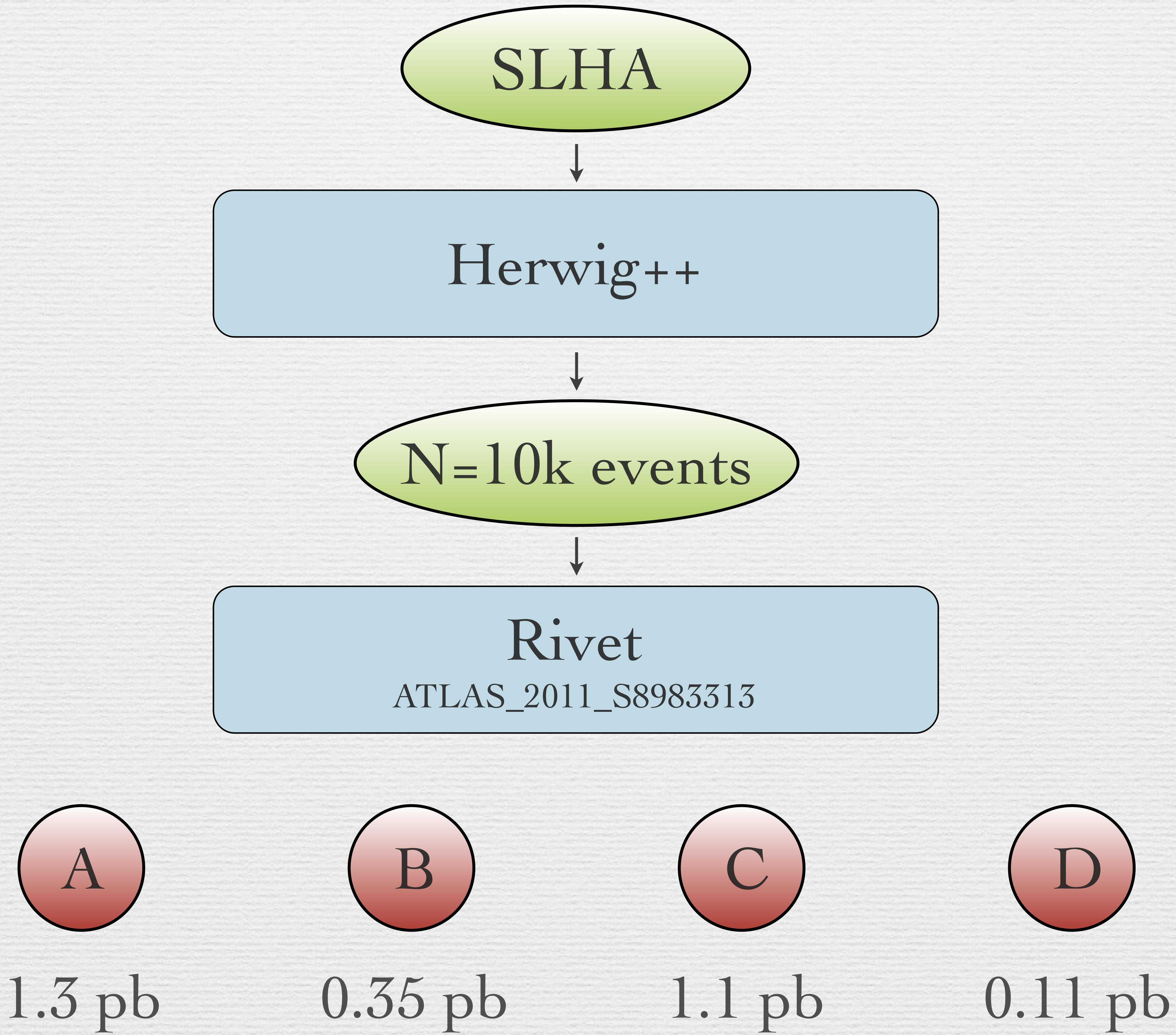
$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0= 0, μ>0.



400
350
300
250
200
150
$m_{1/2}$ [GeV]
200
400
600
800
1000
m_0 [GeV]
25.2
22.4
19.6
16.8
14.0
11.2
8.4
5.6
2.8
0.0



ATLAS
L^{int} = 35 pb^{-1}, $\sqrt{s}$=7 TeV
0 lepton combined exclusion
Observed 95% C.L. limit
Median expected limit
Expected limit ±1σ
CMS α_T, 35 pb^{-1}
LEP 2$\tilde{l}^{\pm}$
LEP 2$\tilde{\chi}_1^{\pm}$
D0 $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^0$
D0 $\tilde{g}$, $\tilde{q}$, μ<0, 2.1 fb^{-1}
CDF $\tilde{g}$,$\tilde{q}$, tanβ=5, μ<0, 2 fb^{-1}
$\tilde{g}$ (800)
$\tilde{g}$ (600)
$\tilde{g}$ (400)
$\tilde{q}$ (800)
$\tilde{q}$ (600)
$\tilde{q}$ (400)
Reference point
$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0= 0, μ>0.


SLHA
Herwig++
N=10k events
Rivet
ATLAS_2011_S8983313
A
B
C
D
1.3 pb
0.35 pb
1.1 pb
0.11 pb

New Constraints on Gauge Mediation and Beyond from LHC SUSY Searches at 7 TeV

Matthew J. Dolan, David Grellscheid, Joerg Jaeckel, Valentin V. Khoze and Peter Richardson

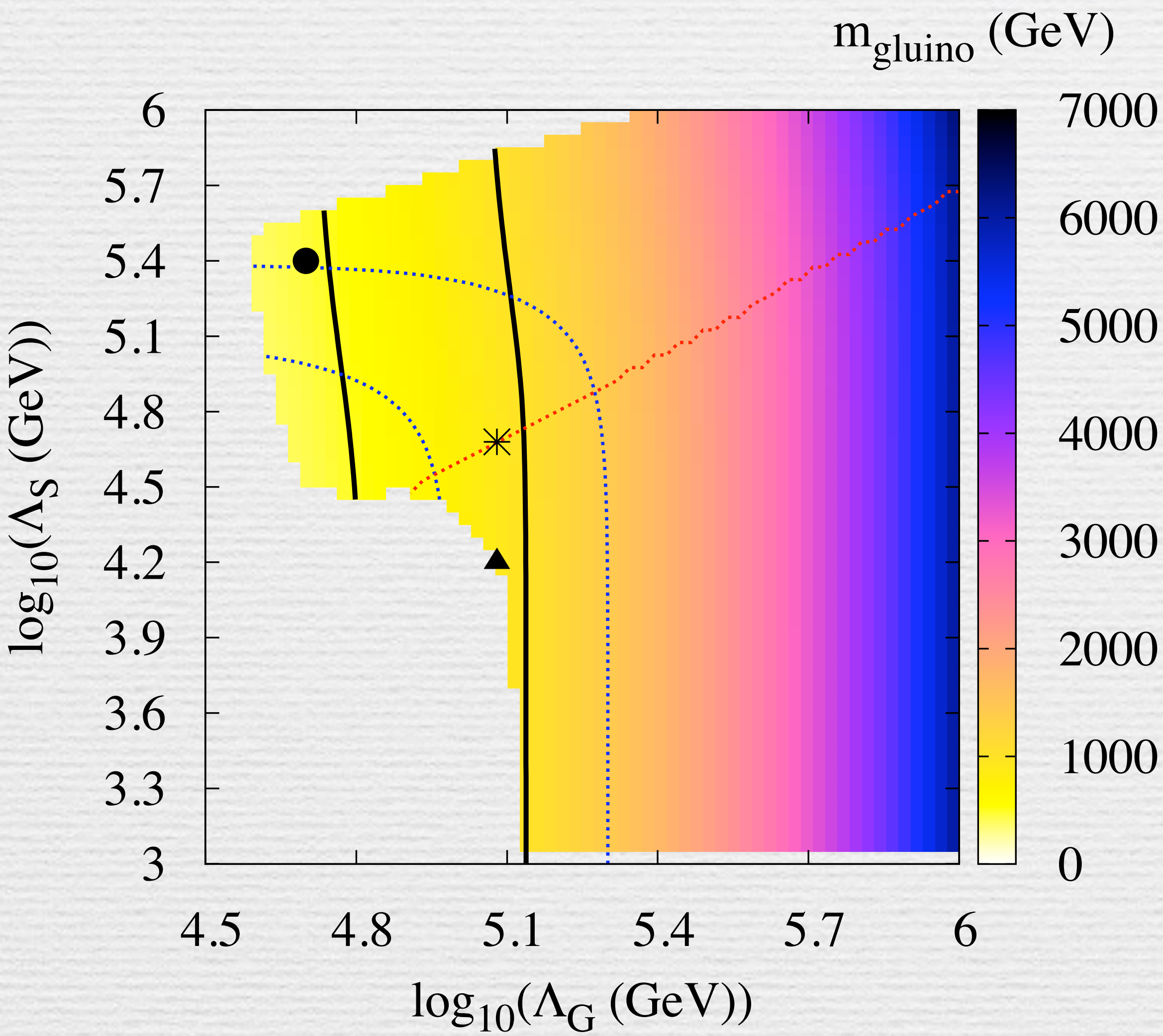
Institute for Particle Physics Phenomenology, Department of Physics, Durham University, Durham DH1 3LE, United Kingdom

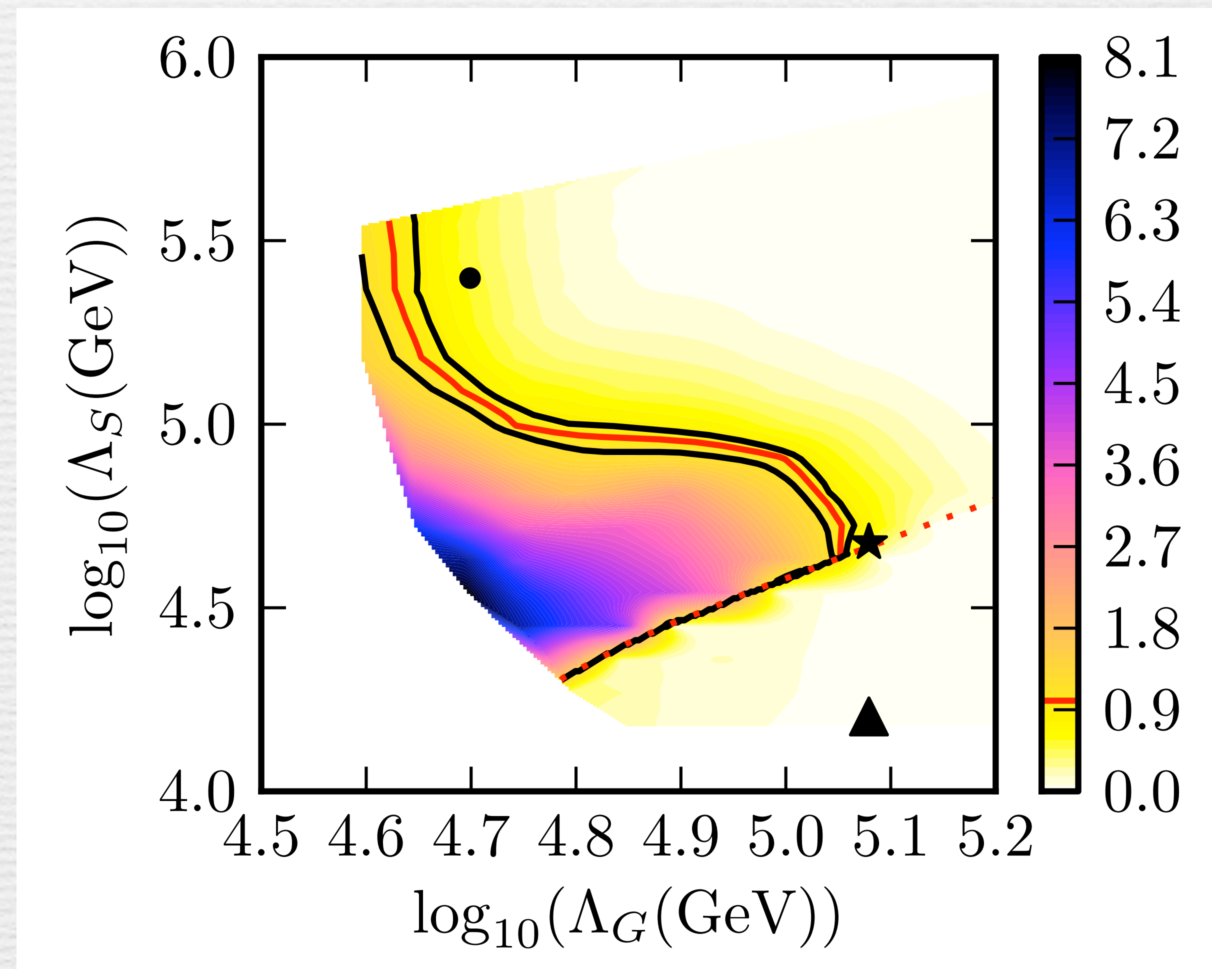
arXiv:1104.0585

Pure general gauge mediation

Λ_G Gaugino mass scale

Λ_S Scalar mass scale





$$M_{\text{mess}} = 10^{14}\,\text{GeV}$$

Future directions

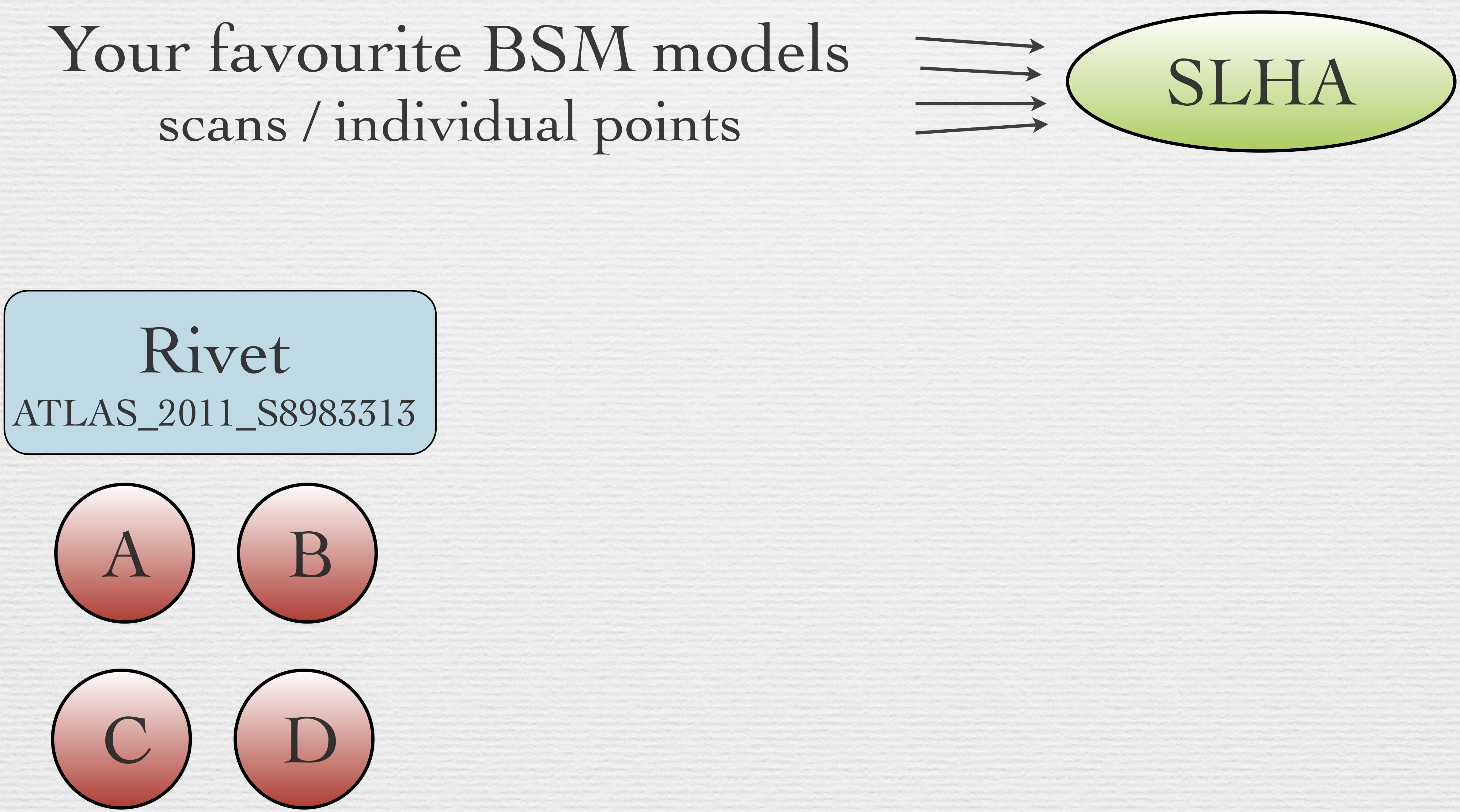
Your favourite BSM models
scans / individual points

SLHA

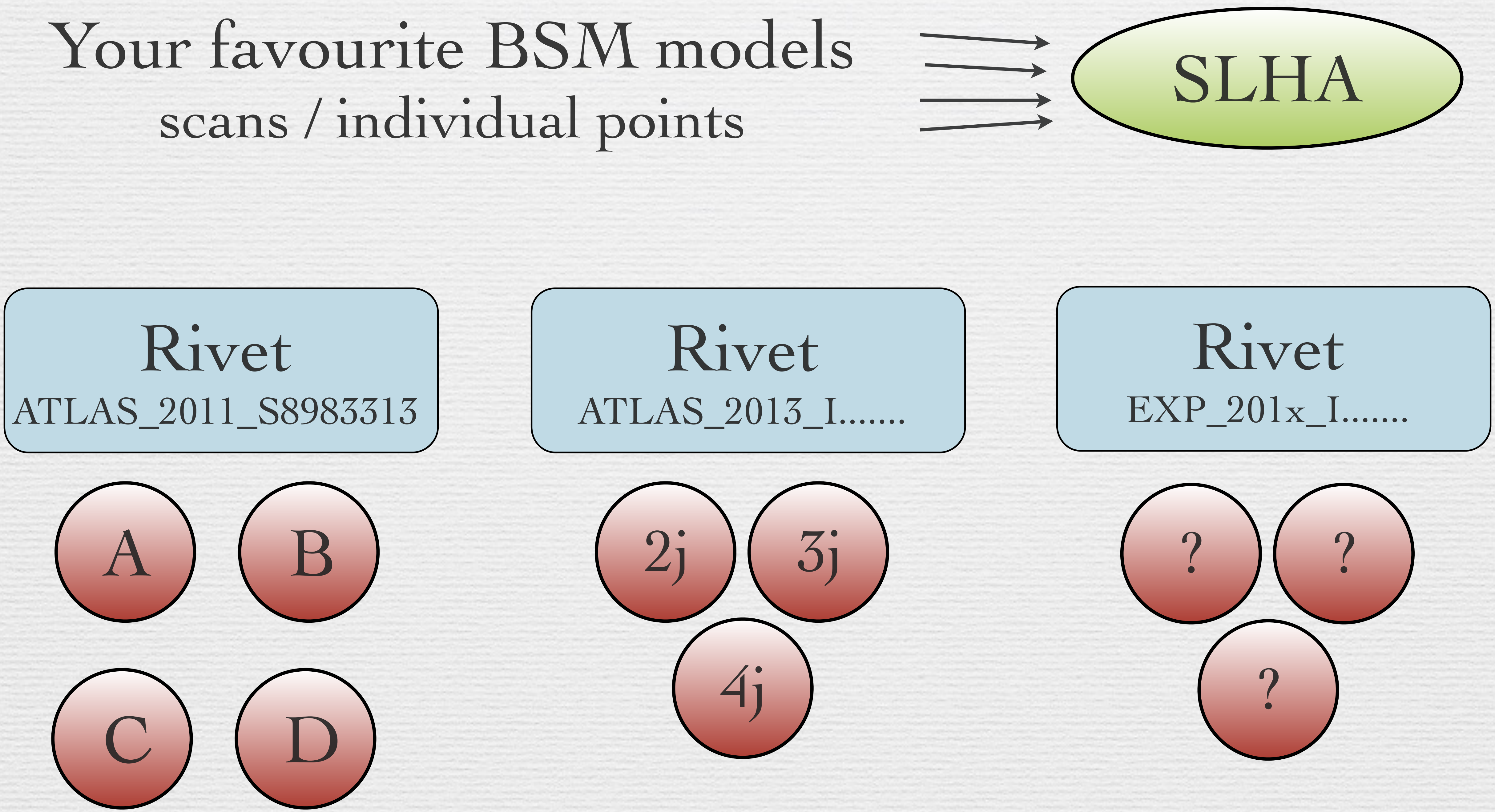
Future directions

Your favourite BSM models
scans / individual points

Future directions



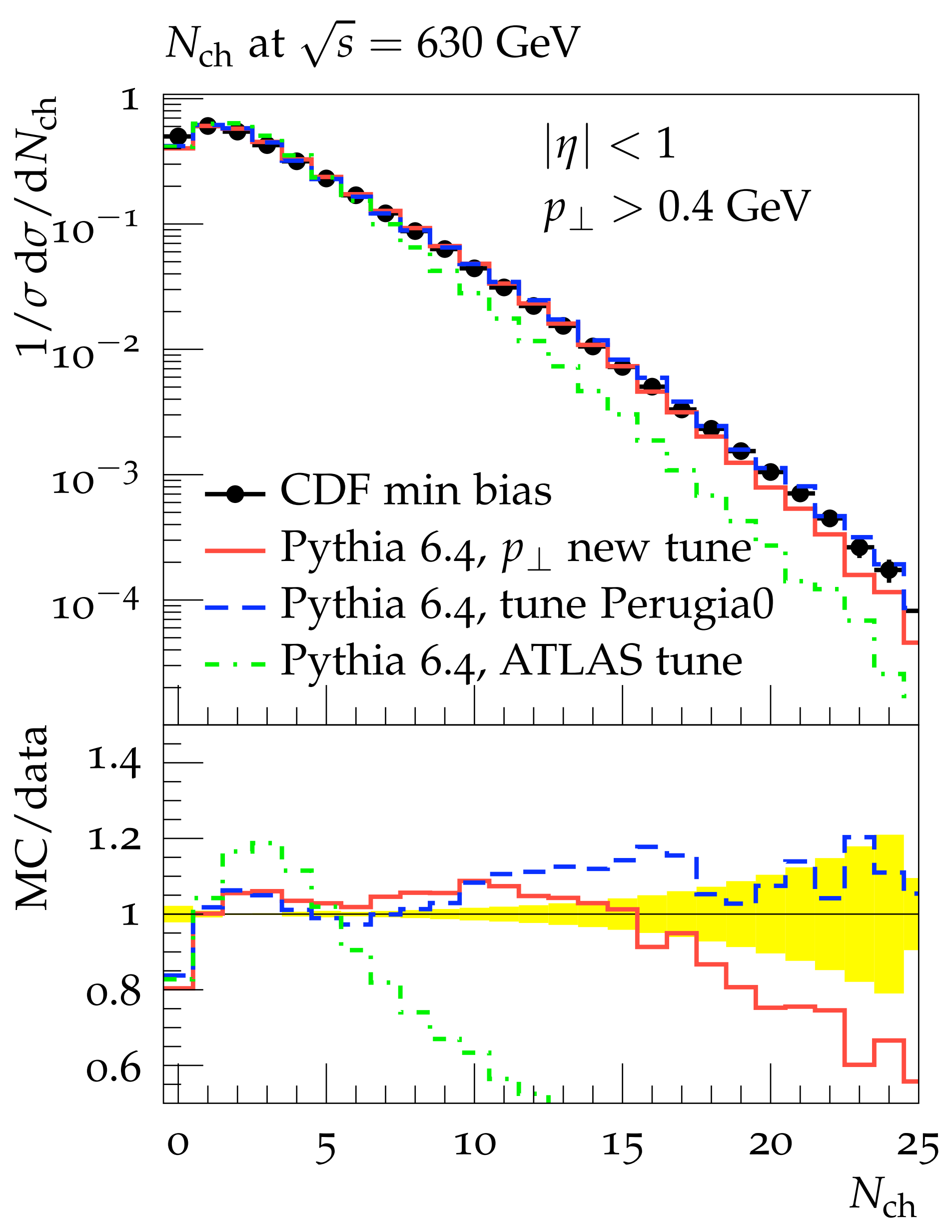
Future directions



Rivet (slide from 2009)

Tool for generator validation and comparisons with data:

- Analyses can be implemented in Rivet and applied to MC
- Uses HepMC ⇒ generator-independent, perfect for comparisons
- Many key analyses are already implemented; many more to come.
- Important for keeping your data alive: Publish your numbers corrected to hadron level and implement your analysis in Rivet.



Rivet today

- Standard analysis record, used by all expt. SM groups
- Analyses contributed directly from experiments
- implements event selection criteria directly from each published paper (~275 so far), compares to HepData
- enforces explicit statement of event selection, in the past often missing from publication write-ups
- Carefully made generator-independent
- Objects are hadron-level jets, leptons, E_miss, …;
  mistagging rates are applied if analysis requires

Rivet FAQ: Why no detector sim?

- Wrong for modern SM results, the results are published hadron-level
- Turns out also not needed for BSM searches, hadron-level works well enough in vast majority of cases
- Fast detector sim can give misleading confidence:
  - ➡ If observable is robust against detector effects: OK either way
  - ➡ If observable is *not* robust against detector effects: problem shifted: need to validate fast sim specifically

more on Herwig++ and Rivet in the tutorials…

…or ask me anytime!