

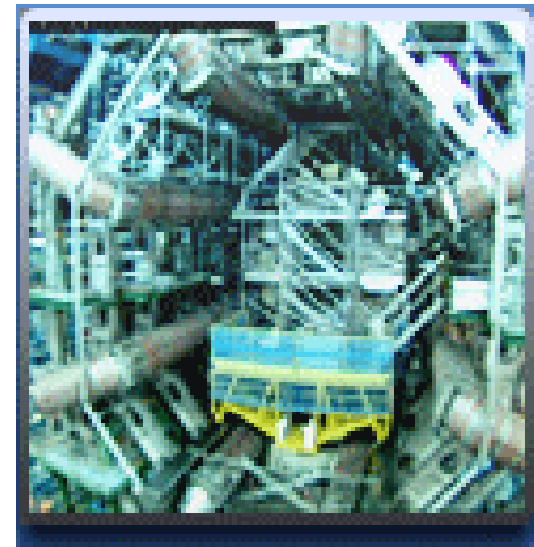
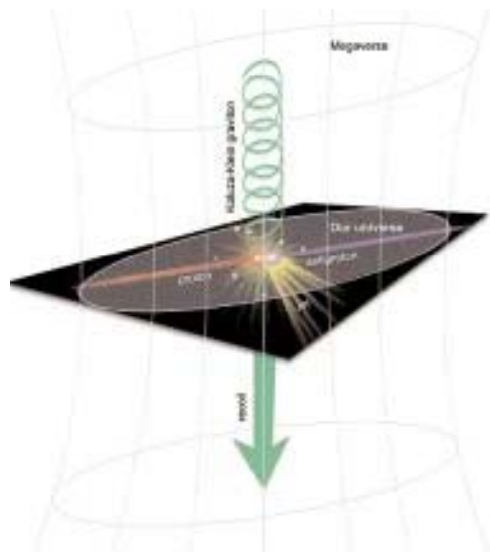
Theory Tools for New Physics Searches

MadGraph and MadEvent

Models



Data

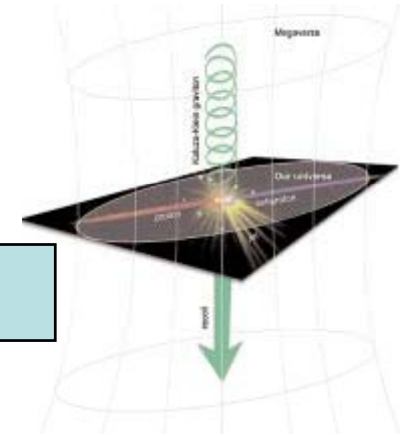


Tim Stelzer

University of Illinois

CTEQ May 2007

A Very Good Outline



Models

- Matrix Element

Alpgen

CompHEP

MadEvent

Sherpa

- Matching

VINCIA

MLM

CKKW

SCET

- Showers+Hadronization

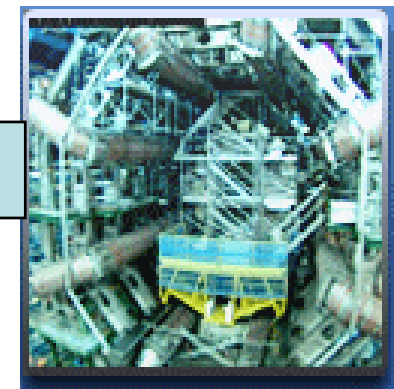
Pythia

HERWIG

Sherpa

- Issue + Results

Data



My Outline

Goal

“I don’t have enough time to try all of the event generators. Which ones should I use? J. Proudfoot CTEQ May 2007

Model ↔ Data

Goal: Provide a common infrastructure useful to both theorists and experimentalists for studying high energy physics collisions.

User Levels

- Model to Data

Comprehensive

- Flexible User Levels

- Comprehensive

Infrastructure

- Infrastructure

Goal

Model ↔ Data

Pythia

Inclusive

Matching

User Levels

Comprehensive

Infrastructure

```

input_card.dat - Notepad
File Edit Format View Help
# Begin PROCESS # This is TAG. Do not modify this line

pp>e-ve~ @0      # First Process
QCD=99           # Max QCD couplings
QED=2            # Max QED couplings
end_coup         # no more couplings for this proc

pp>e-ve~j @1     # Second Process
QCD=99           # Max QCD couplings
QED=2            # Max QED couplings
end_coup         # no more couplings for this proc

pp>e-ve~jj @2    # Third Process
QCD=99           # Max QCD couplings
QED=2            # Max QED couplings
end_coup         # no more couplings for this proc

pp>e-ve~jjj @3  # Fourth Process
QCD=99           # Max QCD couplings
QED=2            # Max QED couplings
end_coup         # no more couplings for this proc

done             # no more procs

# End PROCESS # This is TAG. Do not modify this line
#-----*
# Model information                               *
#-----*
# Begin MODEL # This is TAG. Do not modify this line
sm
# End  MODEL # This is TAG. Do not modify this line
#-----*
# Start multiparticle definitions                 *
#-----*
# Begin MULTIPARTICLES # This is TAG. Do not modify this line
P uu~dd~ss~cc~g
J uu~dd~ss~cc~g

```

Goal

Model ↔ Data

Pythia

Inclusive

Matching

User Levels

Web

Local

Addict

Comprehensive

Infrastructure

User Levels

- **Web-User**
 - Generate process and events on web.
Download events for further analysis
- **Local User**
 - Download source for process, modify and run on local machines.
- **Addict**
 - Set up entire system for local process and event generation

Goal

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User Levels



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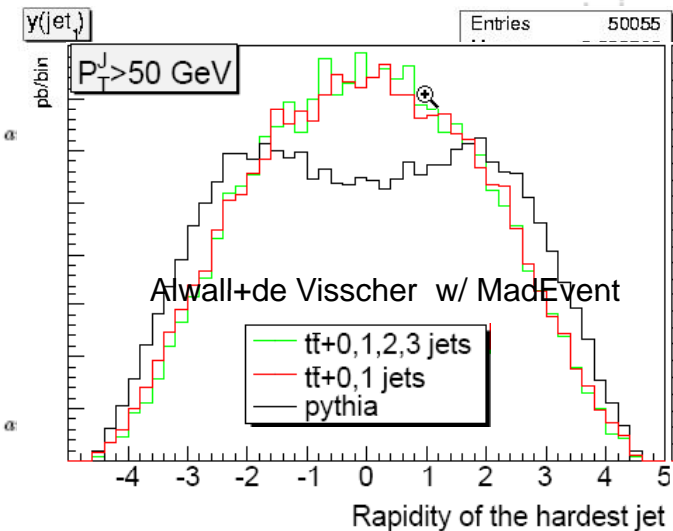
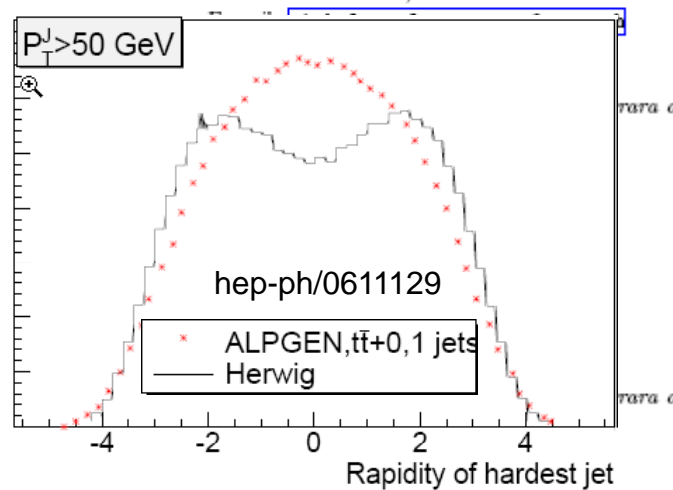
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Matching matrix elements and shower evolution for top-pair production in hadronic collisions

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ABSTRACT: We study the matching of multijet matrix elements and shower evolution in the case of top-pair production in hadronic collisions at the Tevatron and at the LHC. We

Goal

Model ↔ Data

Pythia
Inclusive
Matching

User Levels

Web
Local
Addict

Comprehensive

SM
MSSM
HEFT
User Mod
MadRules

Infrastructure

Comprehensive

- Signals and Backgrounds calculated with same tool for multiple analysis.
- Reduces overhead
- Reduces errors
- Each Analysis needs Multiple Checks

Comprehensive

Goal

Model ↔ Data

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Infrastructure

- Standard Model

X-sects (pb)	Number of jets						
$e^+\nu_e + n$ QCD jets	0	1	2	3	4	5	6
ALPGEN	5423(9)	1291(13)	465(2)	182.8(8)	75.7(8)	32.5(2)	13.9(2)
AMEGIC++	5441(8)	1287(7)	483(2)				
CompHEP	5485.8(6)	1287.5(7)	467.3(8)				
GR@PPA	5436.71 (3)	1278.23 (6)	832.85 (3)*				
HELAC/PHEGAS/ JetI	5349(143)	1275(12)	487(3)	212(2)			
MadEvent	5433(8)	1277(2)	464(1)	182(1)	75.9(3)		

X-sects (mb)	Number of jets				
jets	2	3	4	5	6
ALPGEN	331.7(3)	22.49(7)	4.81(1)	1.176(9)	0.330(1)
AMEGIC++	330.9(3)	24.2(3)			
ComHEP	334.8(1)	22.79(7)			
HELAC/PHEGAS/ JetI	331(3)	22.6(3)	4.7(1)	0.9(1)	
MadEvent	329(1)	22.3(1)	4.86(2)		

Goal

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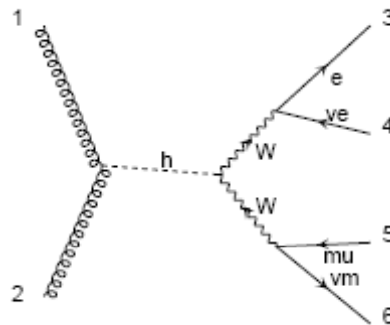
SM
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Infrastructure

Comprehensive

- Higgs Effective Field Theory

- Fabio Maltoni, Rikkert Frederix
- Effective ggH vertex from top quark loop



- Two Higgs Doublet Model (2HDM)

- Hichel Herquet and Simon de Visscher

Comprehensive

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Infrastructure

• MSSM

- David Rainwater, Tilman Plehn, Johan Alwall
- SUSY Les Houches Accord for Input
- Checked over 500 processes!

SPS	1a	1b	2	3	4	5	6	7	8	9
$\chi_1^+ \chi_1^-$	1.6	0.26	0.63	0.27	0.74	0.77	0.13	0.23	0.42	1.3
$\chi_1^+ \chi_2^-$	0.056	0.010	0.011	0.010	0.029	0.010	0.015	0.028	0.019	0.002
$\chi_2^+ \chi_2^-$	0.035	0.007	0.004	0.006	0.020	0.003	0.030	0.068	0.015	0
$\chi_1^+ \chi_1^+$	0.93	0.22	0.48	0.23	0.51	0.57	0.067	0.077	0.31	0.88
$\chi_1^+ \chi_2^+$	0.13	0.022	0.028	0.022	0.070	0.015	0.072	0.14	0.049	0.002
$\chi_2^+ \chi_2^+$	0.001	0	0	0	0.001	0	0.011	0.032	0.001	0
$\chi_1^- \chi_1^-$	0.28	0.056	0.13	0.058	0.14	0.16	0.017	0.020	0.083	0.25
$\chi_1^- \chi_2^-$	0.040	0.006	0.005	0.006	0.021	0.005	0.018	0.036	0.014	0.001
$\chi_2^- \chi_2^-$	0	0	0	0	0	0	0.002	0.007	0	0

Comprehensive

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- MSSM (Hagiwara et al. 2005)

– David Rainwater, Tilman Plehn, Johan Alwall

$e^+e^- \rightarrow X$						
Final state	MADGRAPH/HELAS		O'MEGA/WHIZARD		AMEGIC++/SHERPA	
	0.5 TeV	2 TeV	0.5 TeV	2 TeV	0.5 TeV	2 TeV
$\tilde{e}_L \tilde{e}_L^*$	54.687(2)	78.864(6)	54.687(3)	78.866(4)	54.6890(7)	78.8670(8)
$\tilde{e}_R \tilde{e}_R^*$	274.69(2)	91.776(8)	274.682(1)	91.776(5)	274.695(3)	91.778(1)
$\tilde{e}_L \tilde{e}_R^*$	75.168(5)	7.237(1)	75.167(3)	7.2372(4)	75.1693(7)	7.23744(7)
$\tilde{\mu}_L \tilde{\mu}_L^*$	22.5471(7)	6.8263(2)	22.5478(9)	6.8265(3)	22.5482(2)	6.82638(7)
$\tilde{\mu}_R \tilde{\mu}_R^*$	51.839(2)	5.8107(2)	51.837(2)	5.8105(2)	51.8401(5)	5.81085(6)

~500 processes to check all Feynman rules
(CP and R-conserving, CKM=MSN=1)

e^+e^- , $e^- \bar{\nu}_e$, $e^- e^-$, $\tau^+ \tau^-$, $\tau^- \bar{\nu}_\tau$, $u\bar{u}$, $d\bar{d}$, $u\bar{u}$, $d\bar{d}$, $b\bar{b}$, $b\bar{t}$,
 W^+W^- , W^-Z , $W^- \gamma$, ZZ , $Z\gamma$, $\gamma\gamma$, gW^- , gZ , $g\gamma$, gg , ug , dg .

Goal

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Infrastructure

Comprehensive

- User Defined
 - Particles.dat
 - Interactions
 - Couplings
- UserMod
 - scripts for a
- MadRules
 - Mathematica

The image shows two overlapping Notepad windows. The top window, titled 'Particles.dat - Notepad', contains a header for a special data file and a list of particle codes. The bottom window, titled 'interactions.dat - Notepad', contains a list of interaction definitions for various particle pairs.

```

Particles.dat - Notepad
File Edit Format View Help
#This is a special data file which contains particles of the
#Standard Model. The format for entering new particles is.
#Particle codes taken from http://pdg.lbl.gov/2000/montecarlo/pp.pdf
#Name anti_Name Spin Linetype Mass Width Color Label Model
#xxx xxxx SFV WSDC str str STO str PDG-code
#
# Quarks
#
d d~
u u~
s s~
c c~
b b~
t t~
#
# Lepton
#
e- e+
mu- m+
ta- ta+
ve nu~e
vm nu~mu
vt nu~tau
#
# Boson
#
g g
Z Z
a a
#
w- w+
h h
#
# Group
# you ca
# The fo
# MULT
p uu~dd
j uu~dd-
interactions.dat - Notepad
File Edit Format View Help
#
# QCD interactions
#
d d g GG QCD
u u g GG QCD
s s g GG QCD
c c g GG QCD
b b g GG QCD
t t g GG QCD
#
g g g G QCD
#
g g g G G QCD QCD
#
g g
Z Z # QED interactions
a a #
w- w
h h d d a GAD QED
# u u a GAU QED
# Group s s a GAD QED
# you ca c c a GAU QED
# The fo b b a GAD QED
# MULT t t a GAU QED
p uu~dd e- e- a GAL QED
j uu~dd- mu- mu- a GAL QED
ta- ta- a GAL QED
    
```

Goal

Model ↔ Data

Pythia
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Infrastructure

Comprehensive

- **User Defined Models**
 - Particles.dat
 - Interactions.dat
 - Couplings
- **UserMod (Simon de Visscher)**
 - scripts for adding particles/interactions.
- **MadRules (Claude Duhr)**
 - Mathematica: Lagrangian-> MadEvent

Goal

Model ↔ Data

Pythia
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MadRules

Infrastructure

Infrastructure

- **Hardware**

- UIUC 40 node farm 4 TB
- CP³ 32 node farm
- Rome 32 node farm

- **People**

- Over 1000 registered users
- Great Collaborators
- Proposal increased user support

Summary

Goal

Model ↔ Data

Pythia

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Matching

User Levels

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Local

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Comprehensive

SM

MSSM

HEFT

User Mod

MadRules

Infrastructure

Provide a common infrastructure useful to both theorists and experimentalists for studying high energy physics collisions.

- Model to Data
- Flexible User Levels
- Comprehensive
- Infrastructure
- What would you find most helpful?