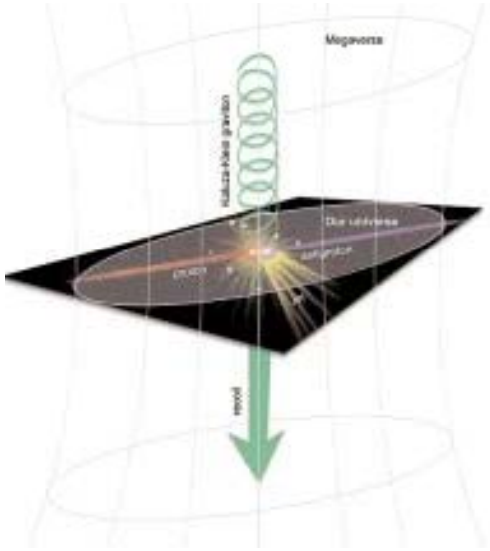
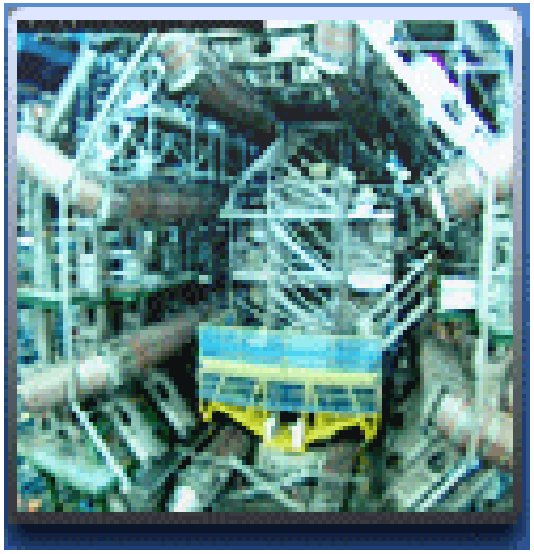
High Energy Physics Illinois

Theory Tools for New Physics Searches

MadGraph and MadEvent

Models ⟷ Data

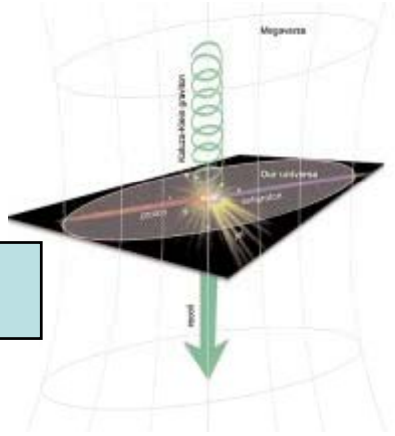




Tim Stelzer University of Illinois

CTEQ May 2007

A Very Good Outline



Models

- Matrix Element

Alpgen | CompHEP | MadEvent | Sherpa

- Matching

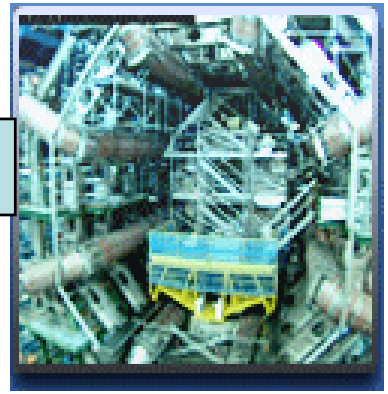
VINCIA | MLM | CKKW | SCET

- Showers+Hadronization

Pythia | HERWIG | Sherpa

- Issue + Results

Data



High Energy Physics Illinois

Goal

Model⟺Data

User Levels

Comprehensive

Infrastructure

My Outline

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

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

- Model to Data
- Flexible User Levels
- Comprehensive
- Infrastructure

- I
- I
- M

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
```

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

User Levels

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

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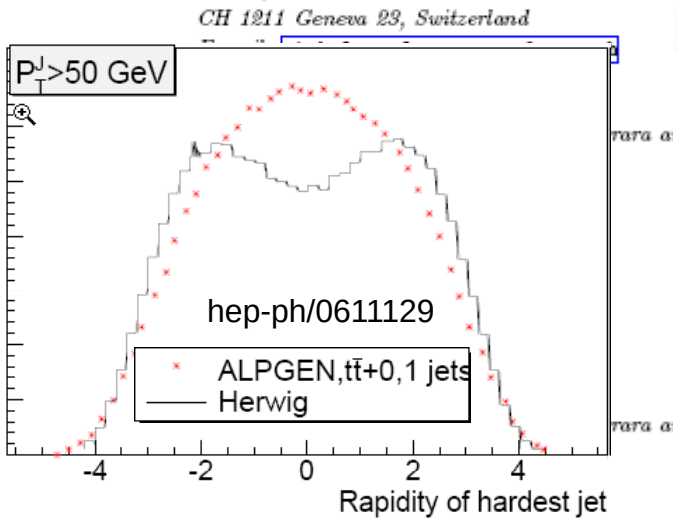
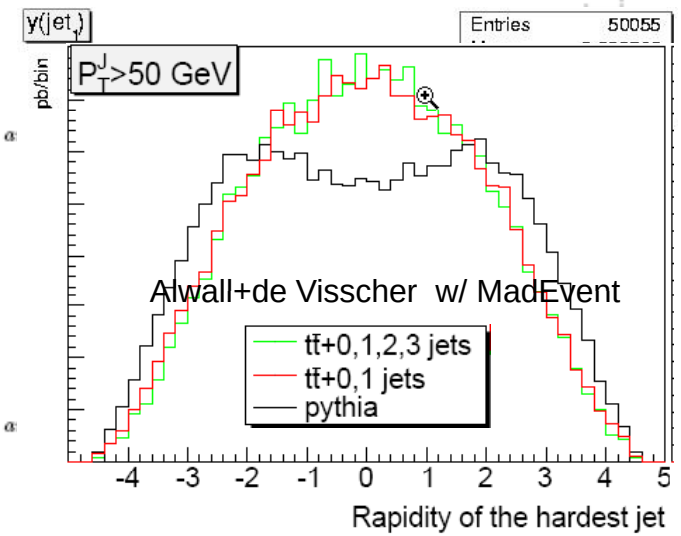




ABSTRACT: We study the matching of multijet matrix elements and shower evolution in

Comprehensive

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

Comprehensive

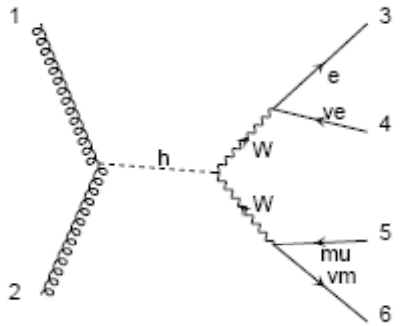
- Standard Model

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)		

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

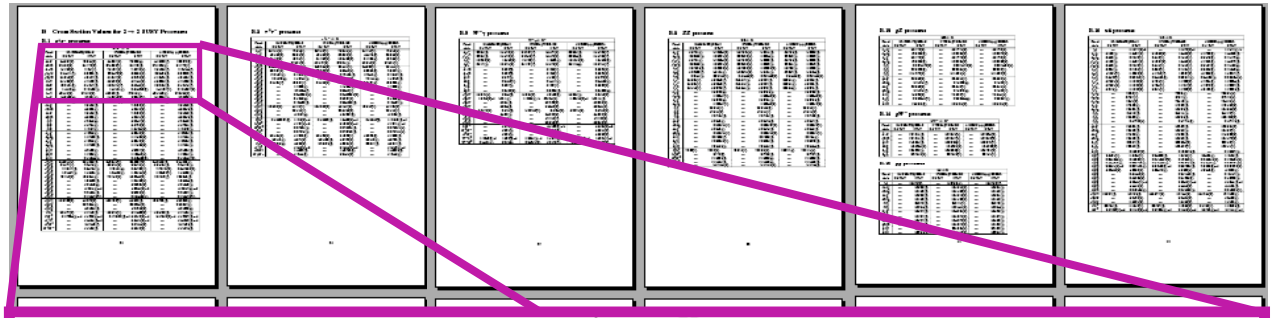
Comprehensive

- 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

- MSSM (Hagiwara et al. 2005)
  - David Rainwater, Tilman Plehn, Johan Alwall



$e^+e^- \to X$

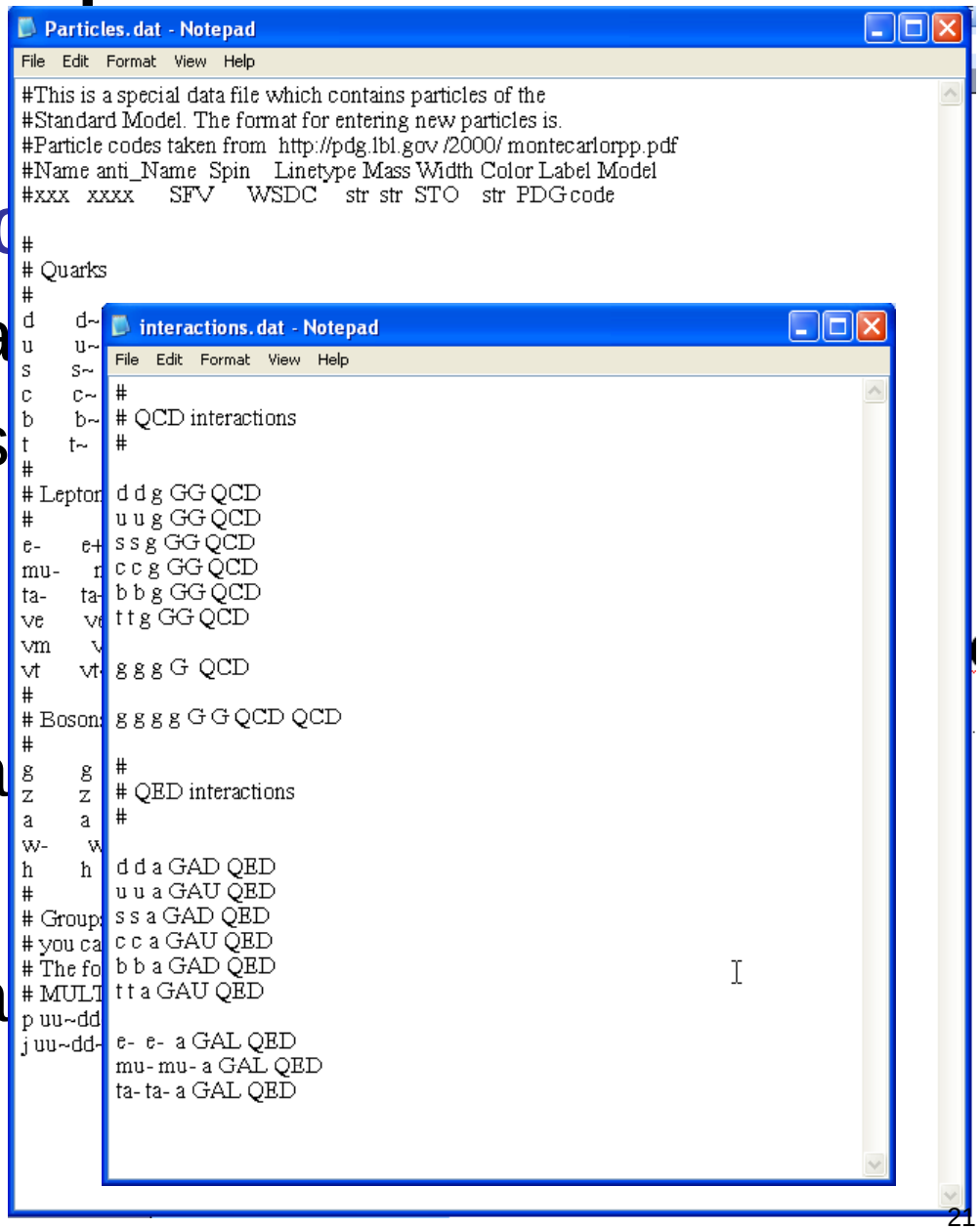
Final state	MADGRAPH/HELAS 0.5 TeV	MADGRAPH/HELAS 2 TeV	O'MEGA/WHIZARD 0.5 TeV	O'MEGA/WHIZARD 2 TeV	AMEGIC++/SHERPA 0.5 TeV	AMEGIC++/SHERPA 2 TeV
$\tilde{e}_L\tilde{e}_L^*$	54.687(2)	78.864(6)	54.687(3)	78.866(4)	54.6890(7)	78.8670(8)
$\tilde{e}_R\tilde{e}_R^*$	274.69(2)	91.776(8)	274.682(1)	91.776(5)	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)

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

Comprehensive

- User Defined
  - Particles.da
  - Interactions
  - Couplings
- UserMod
  - scripts for a
- MadRules
  - Mathmatica



Comprehensive

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

Infrastructure

- Hardware
  - UIUC 40 node farm 4 TB
  - CP^3 32 node farm
  - Rome 32 node farm
- People
  - Over 1000 registered users
  - Great Collaborators
  - Proposal increased user support

Summary

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?