JetWeb: a WWW interface and database for Monte Carlo tuning and validation

J M Butterworth, S Butterworth, B Waugh
presented by B Waugh at MC Tuning meeting, Fermilab, 2003-04-30

Outline of talk

- Physics motivation
- Software technology
- Object model
- Example application
- Demonstration
- Planned improvements
- Conclusion

Physics motivation

- Need to understand hadronic final state for current and future measurements.
- Some effects not calculable from first principles, e.g. hadronization.
- MC generators have many free parameters.
- Tuning to fit one data set can result in a poor description of other data.
- Better to tune to many data sets simultaneously.
- Want to:
  - automate comparisons as far as possible
  - avoid duplicating effort (and CPU usage)

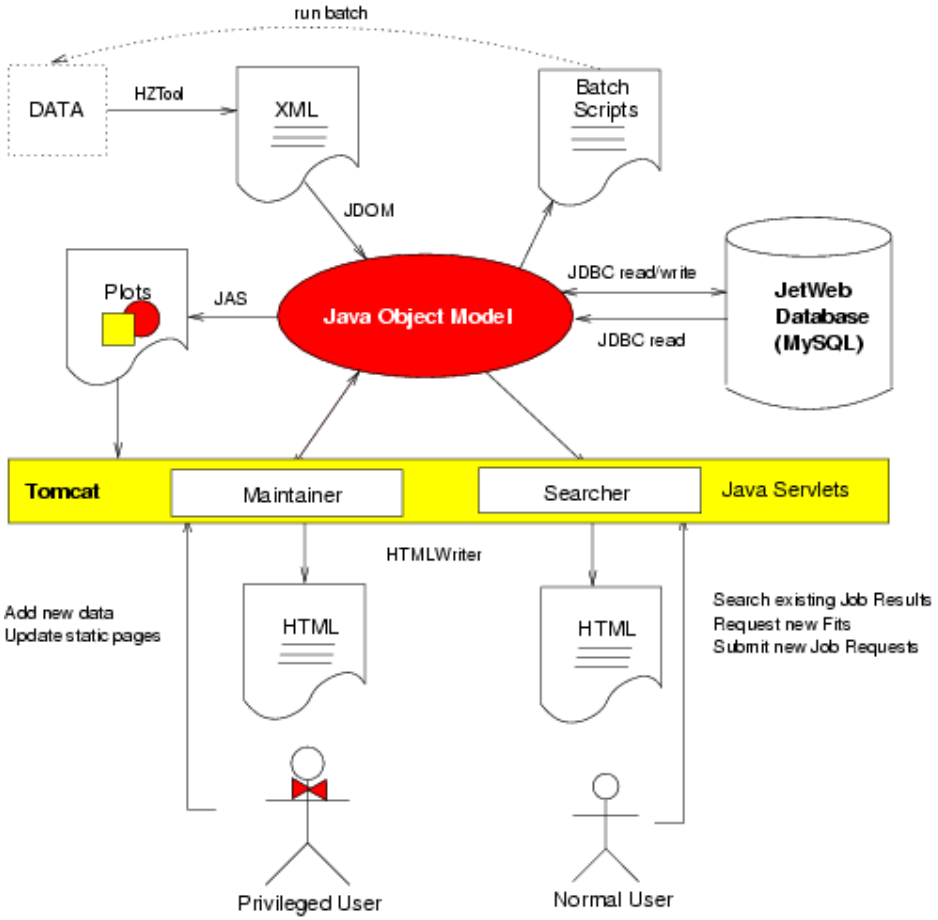
HzTool

- Fortran library: fills HBOOK histograms from generated events to compare with measurements.
- Developed in HERA Workshop:
  - J. Bromley et al., Future Physics at HERA, vol 1, 611-612
- Routine written in Fortran for each analysis.
- Range of data already included: H1, ZEUS, UA5, OPAL, CDF, D0. Contributing authors also from ATLAS and FLC. Need more!

JetWeb

- J Butterworth and S Butterworth: hep-ph/0210404
  - now also contributions from B Waugh
- Adds functionality to HzTool.
- Database of measurements, predictions and fits.
- Web front end allows:
  - search database
  - submit jobs to generate MC with chosen parameters
- Uses: Java servlets, MySQL relational database, XML, Java Analysis Studio (JAS).
- HzTool jobs can be submitted to a standard batch farm or to a grid.

JetWeb overview



Object model

- Java classes correspond (more or less) to tables in database.
- Data: papers contain plots contain points.
- Model = generator/version + parameters
  - several models can be equivalent for a particular collider, e.g. proton PDF irrelevant to e+e- data, so introduce class *logparms* = *model* + *collider*
- Predicted plots/points
- Fit: comparison between data and model
  - Normalized to fit selected data (default: high Et)
  - Chi-squared calculated for various data sets

Using JetWeb

- Start at http://jetweb.hep.ucl.ac.uk
- Search the database: possibilities include
  - select MC generator and parameters, and compare predictions with a range of data;
  - select data set of interest and find models giving a good description of these data;
  - more generally: restrict some MC parameters while allowing others to vary, and compare predictions with all available data or a subset.
- Use ready-made searches under *Selected Results*.
- Best fit pages are automatically updated.

Searching the database

- Select generator(s) of interest
- Restrict parameters as required, or leave them free
  - Common: ptmin, underlying event model, PDFs, kt
  - Generator specific
- Choose order of results (e.g. find best fit to charm date)
- *Get results!* (eventually)
- If nothing in DB matches your request, you can submit a request to generate some new MC.

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JetWeb

Automated Data Comparisons for High Energy Physics

best fits, all data

- HERWIG
- PYTHIA

summaries, all fits

- HERWIG latest
- PYTHIA latest
- HERWIG all
- PYTHIA all

documentation, downloads

- Bibliography
- Latest News
- Javadoc
- CVS Server
- Generator Parameters

simulations

- HERWIG
- PYTHIA

experiments

- HERA(H1,ZEUS)
- LEP (OPAL)
- Tevatron (CDF, D0)

Search the DataBase **Maintenance**

Selected Results

- Studies for a Future Linear Collider
- Multiparton interactions/underlying event
- Intrinsic KT photon/proton
- PYTHIA parton showers PARP67
- Parton Distribution Functions in Photon
- HERWIG fragmentation parameters (CLMAX,PSPLT)

If you do use any results from here, please quote hep-ph/0210404

The current focus of this project is on jet and heavy flavour production in hadron-like collisions (which includes hadron-photon and photon-photon). There is no reason why other data shouldn't be incorporated though.

If you'd like join in, or have any comments or suggestions please contact us at jetweb@hep.ucl.ac.uk

The story so far:
6108 jobs submitted to Manchester PBS, 5572 completed
238 jobs submitted to UCL NQS, 237 completed
12 jobs submitted to the Grid, 9 completed

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Search the JetWeb DataBase

NB: If you make a wide-ranging search it will take a minute or two for the results to return. Please be patient.

Get results | Clear Form | Sort results by: Fit (All ET) | Select plots to be included

Common parameters

Generator
- Herwig v6.400 [x]
- Herwig v6.100 [ ]
- Pythia v6.206 [ ]

Minimum transverse momentum of hard scatters (GeV) [ ]

Underlying event model(Integer 0-5) [1]
More info

Photon PDF
- GRVLO [ ]
- SaS1D [ ]
- SaS2D [ ]
- WHIT2 [ ]

Proton PDF
- GRVLO [ ]
- CTEQ5L [ ]
- CTEQ4L [ ]

Intrinsic transverse momentum in photon (PYTHIA) [1] (GeV)

Intrinsic transverse momentum in proton (HERWIG photon also) [1] (GeV)

Change Pythia Parameters | Change Herwig Parameters

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Results sorted by Fit (All ET)

Last updated 27-Apr-2003 at 15:46:44

HERWIG v6.400 run 09/03/2003 PDFs: Photon GRVLO Proton CTEQ5L PTMIN 3.0GeV UE JIMMY Photon kt:1.0 Proton kt:1.0 Scale **1.65**: Fit ID **637** : Plots etc

Combined:		Chi2/Dof: All: **4.47** High ET: **2.05** Low ET: **3.29** Jet Shape: **9.37** Charm: **4.64**
HERA	Lumi 54.0 pb^{-1}	Chi2/Dof: All: *4.39* High ET: *2.05* Low ET: *2.77* Jet Shape: *14.2* Charm: *4.64*
LEP	Lumi 1000.0 pb^{-1}	Chi2/Dof: All: *8.34* High ET: *?* Low ET: *5.7* Jet Shape: *22.87* Charm: *?*
Tevatron	Lumi 0.00015 pb^{-1}	Chi2/Dof: All: *1.58* High ET: *?* Low ET: *1.24* Jet Shape: *1.65* Charm: *?*

HERWIG v6.400 run 09/03/2003 PDFs: Photon SaS2D Proton CTEQ5L PTMIN 3.0GeV UE JIMMY Photon kt:1.0 Proton kt:1.0 Scale **1.65**: Fit ID **639** : Plots etc

Combined:		Chi2/Dof: All: **5.0** High ET: **2.03** Low ET: **3.06** Jet Shape: **11.57** Charm: **7.44**
HERA	Lumi 56.0 pb^{-1}	Chi2/Dof: All: *5.02* High ET: *2.03* Low ET: *2.72* Jet Shape: *17.49* Charm: *7.44*
LEP	Lumi 1700.0 pb^{-1}	Chi2/Dof: All: *8.82* High ET: *?* Low ET: *4.8* Jet Shape: *30.94* Charm: *?*
Tevatron	Lumi 0.00015 pb^{-1}	Chi2/Dof: All: *1.58* High ET: *?* Low ET: *1.24* Jet Shape: *1.65* Charm: *?*

HERWIG v6.400 run 16/02/2003 PDFs: Photon SaS2D Proton CTEQ5L PTMIN 3.0GeV UE JIMMY Photon kt:1.0 Proton kt:1.0 Scale **1.7**: Fit ID **395** : Plots etc

Combined:		Chi2/Dof: All: **7.5** High ET: **1.96** Low ET: **3.4** Jet Shape: **22.28** Charm: **6.47**
HERA	Lumi 50.0 pb^{-1}	Chi2/Dof: All: *7.06* High ET: *1.96* Low ET: *2.93* Jet Shape: *30.54* Charm: *6.47*
LEP	Lumi 1700.0 pb^{-1}	Chi2/Dof: All: *9.3* High ET: *?* Low ET: *5.36* Jet Shape: *30.94* Charm: *?*
Tevatron	Lumi 0.00006 pb^{-1}	Chi2/Dof: All: *8.97* High ET: *?* Low ET: *1.22* Jet Shape: *9.62* Charm: *?*

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JetWeb Fit No:637

HERWIG v6.400 run . Model ID:300. Normalisation determined using default high ET data.

Date of last fit:09/03/2003
Examine the fitted papers
HERA fit
LEP fit
Tevatron fit

Request higher statistics for HERA Submit
Request similar data Get form
Search for similar data Get form
Maintenance Get form

Combined this for all fitted experiments: Chi2/Dof at an overall scale factor of 1.65)

- All: **4.4749185**
- High ET: **2.0478753**
- Low ET: **3.2853087**
- Jet Shape: **9.372099**
- Charm: **4.6443128**

Parton distribution functions: Photon GRVLO Proton CTEQ5L
PTMIN (Minimum transverse momentum for hard scatters) 3GeV
Underlying Event Model JIMMY
Intrinsic KT in the photon is:1.0
Intrinsic KT in the proton is:1.0
Parton shower cutoff is:2.5
Photon radius:1.0
Proton radius:3.0
PHad:300
Fragmentation parameters CLMAX,PSPLT(1),(2):3.35,1,1
PRSOF:0
QCDLAM:0.18
VQCUT:0.48
BTCLM:1
IOPREM:1

Fitted Papers:

Chi2 Total	Per Dof	Title
351.6336447	7.6442097	Inclusive Jet Differential Cross Sections in Photoproduction at HERA
40.6701284	2.7113419	Dijet Cross Sections in Photoproduction at HERA
26.9284618	1.9234616	Measurement of Di-jet Cross-Sections in Photoproduction and Photon Structure
478.6847314	3.5722741	Measurement of Dijet Photoproduction at High Transverse Energies at HERA
67.5617204	1.1852933	Measurement of Three-jet Distributions in Photoproduction at HERA
176.4838848	4.6443128	Measurement of inclusive D*+- and associated dijet cross sections in photoproduction at HERA
49.2810874	1.0485338	High-ET Inclusive Jet Cross Sections in Photoproduction at HERA
58.1101643	0.7646074	Dijet Cross Sections in Photoproduction at HERA

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Inclusive Jet Differential Cross Sections in Photoproduction at HERA

Physics Letters B 342 (1995) 417-432

Code author(s): Mark Hayes
Contact: J.Butterworth@ucl.ac.uk

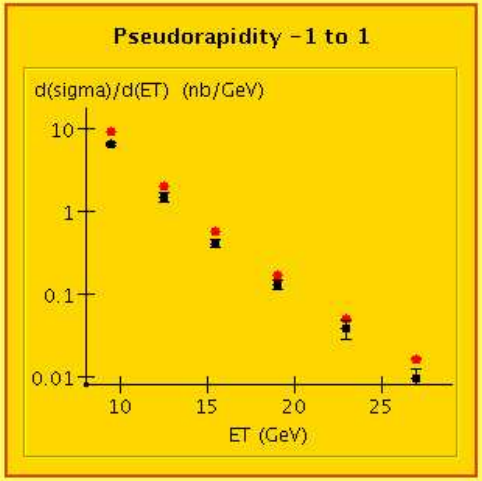
Pseudorapidity -1 to 1

Chi2 Contribution: (chi2 / DoF): 110.823 / 6

Data (black) was scaled by: 1.2000000476837158
The model (red) was scaled by 1.65

This data is relevant for : All jets: Low ET Jets

Pull for each point:
{77.713} {7.772} {13.451} {5.471} {1.507} {4.91}



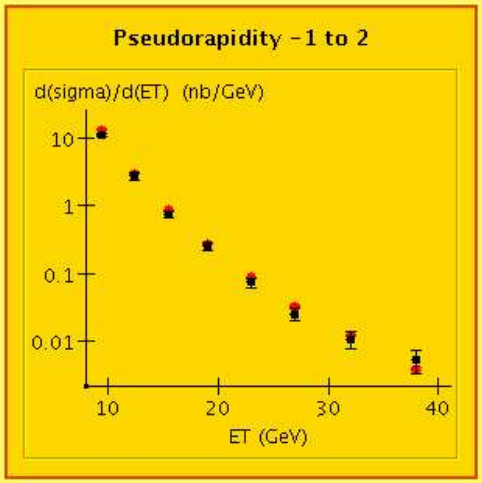
Pseudorapidity -1 to 2

Chi2 Contribution: (chi2 / DoF): 25.731 / 8

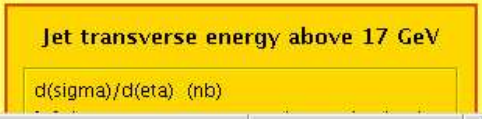
Data (black) was scaled by: 1.2000000476837158
The model (red) was scaled by 1.65

This data is relevant for : All jets: Low ET Jets

Pull for each point:
{16.683} {0.55} {3.791} {0.373} {1.324} {2.347} {0.141} {0.522}



Jet transverse energy above 17 GeV



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JetWeb data request form

Set your parameters

Submit the request | Clear Form | Generate data for: HERA | Weighted events? ☐

Common parameters

Generator	Minimum transverse momentum of hard scatters (GeV)	Underlying event model(Integer 0-5)	Photon PDF	Proton PDF	Intrinsic transverse momentum in photon (PYTHIA) (GeV)	Intrinsic transverse momentum in proton (HERWIG photon also) (GeV)
Herwig v6.400 ☑	3.0	1 More info	GRVLO ☑	GRVLO ☐	1.0	1.0
Herwig v6.100 ☐			SaS1D ☐	CTEQ5L ☑		
Pythia v6.206 ☐			SaS2D ☐	CTEQ4L ☐		
			WHIT2 ☐			

Herwig Parameters

PHAD 300.0	PHRAD 1.0	PRRAD 3.0	QSPAC 2.5	PRSOF 0.0	IOPREM 1
BTCLM 1.0	QCDLAM 0.18	VQCUT 0.48	CLMAX 3.35	PSPLT1 1.0	PSPLT2 1.0

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Applications

- Tune and validate MC models.
- Select suitable parameters for use in measurements at existing colliders.
- Predict QCD background at Future Linear Collider (J Butterworth and M Wing).
- Work on LHC (Atlas tuning) underway.

FLC study (from talk by M Wing)

(Default) predictions at 500 GeV

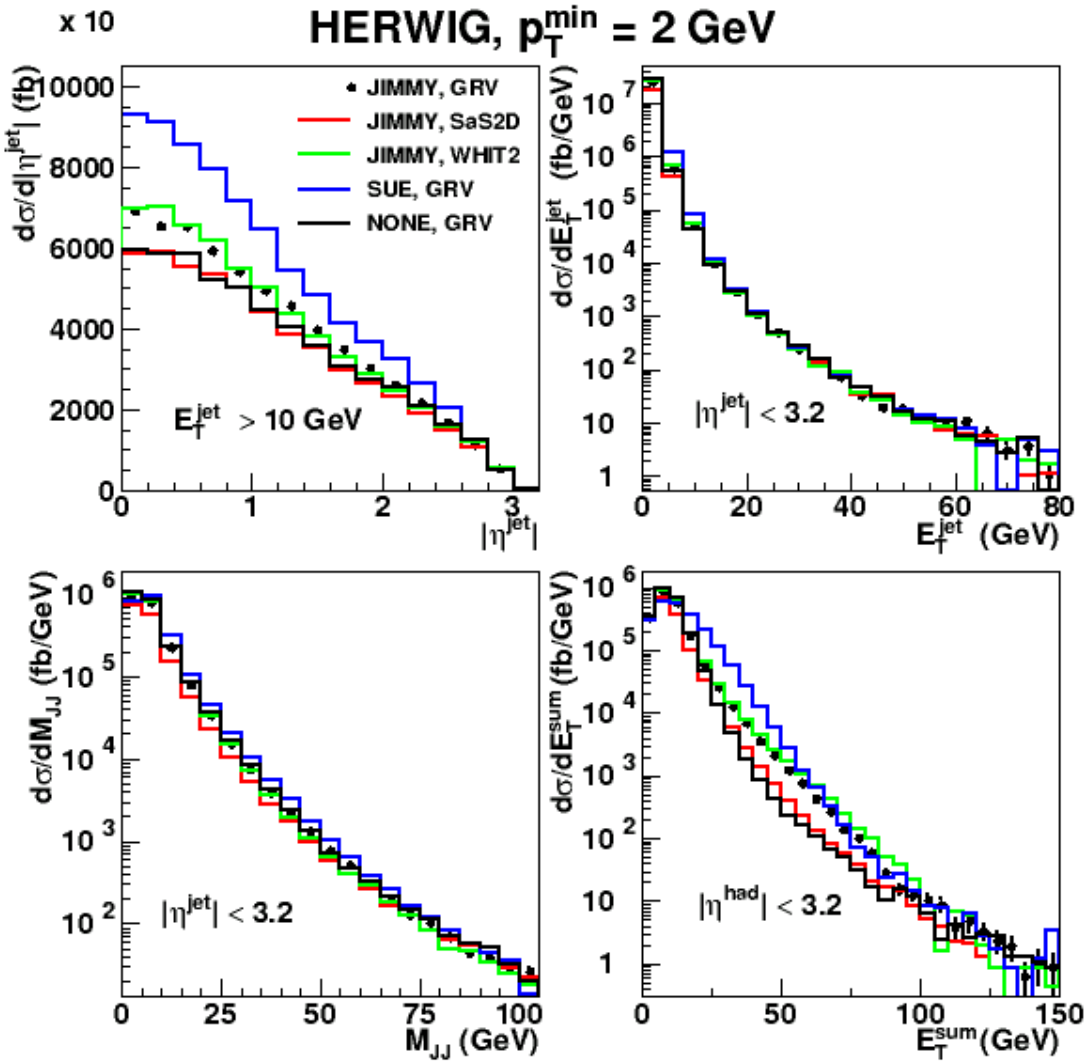
Default HERWIG prediction used with changes in underlying event and photon PDF.

All "reasonable" parameter settings.

Large spread in predictions, even at high energies.

How accurately do we know QCD production?

Not very well!



FLC study (from talk by M Wing)

(Fitted) predictions at 500 GeV

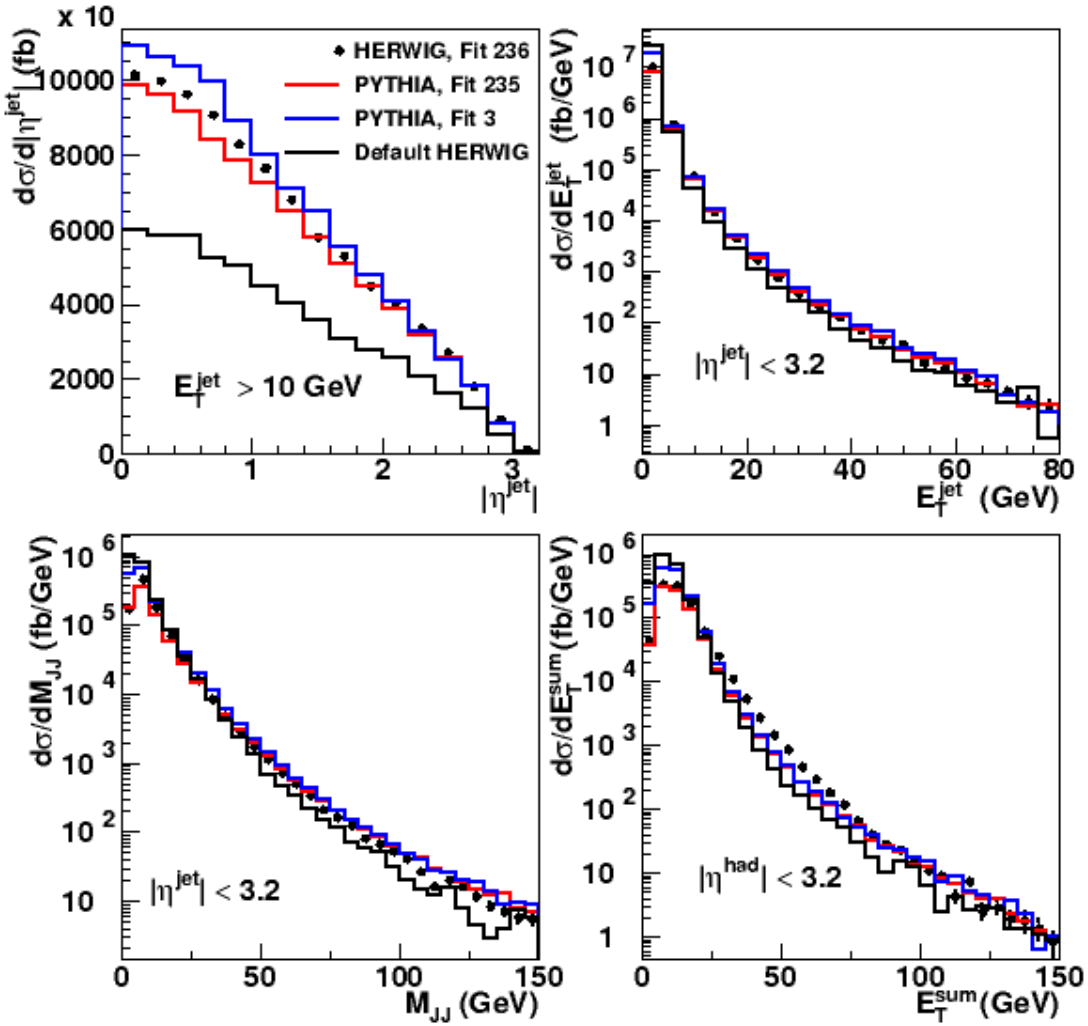
Again fits give similar results.

Spread is also reduced,
NB. predictions from two MCs

Significant differences to "default" prediction.

Predictions of QCD background known to much better accuracy.

These MC settings should be used in QCD background estimates for and colliders.



Planned improvements

- Way to compare models (find differing parameters) *in next release*
- Add more Pythia parameters (MSTJ, PARJ as well as MSTP, PARP) *in next release*
  - needed for validation of ATLAS DC1 model
- Easier to select plots for custom fits
- Add NLO calculations
- Integrate with HEPDATA database
- More use of Grid technologies for job submission and data access
- More data!

Conclusion

- Already a usable (and used) tool.
- Currently unfunded, short of effort.
- Need more data, i.e. more HzTool routines.
- User feedback is also appreciated (+ and -).
- Please help us to improve and expand JetWeb!