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Data Storage and Model Validation in Particle Physics

Jonathan Butterworth

UCL High Energy Physics

DCC Information Day

16th Jan 2007 UCL

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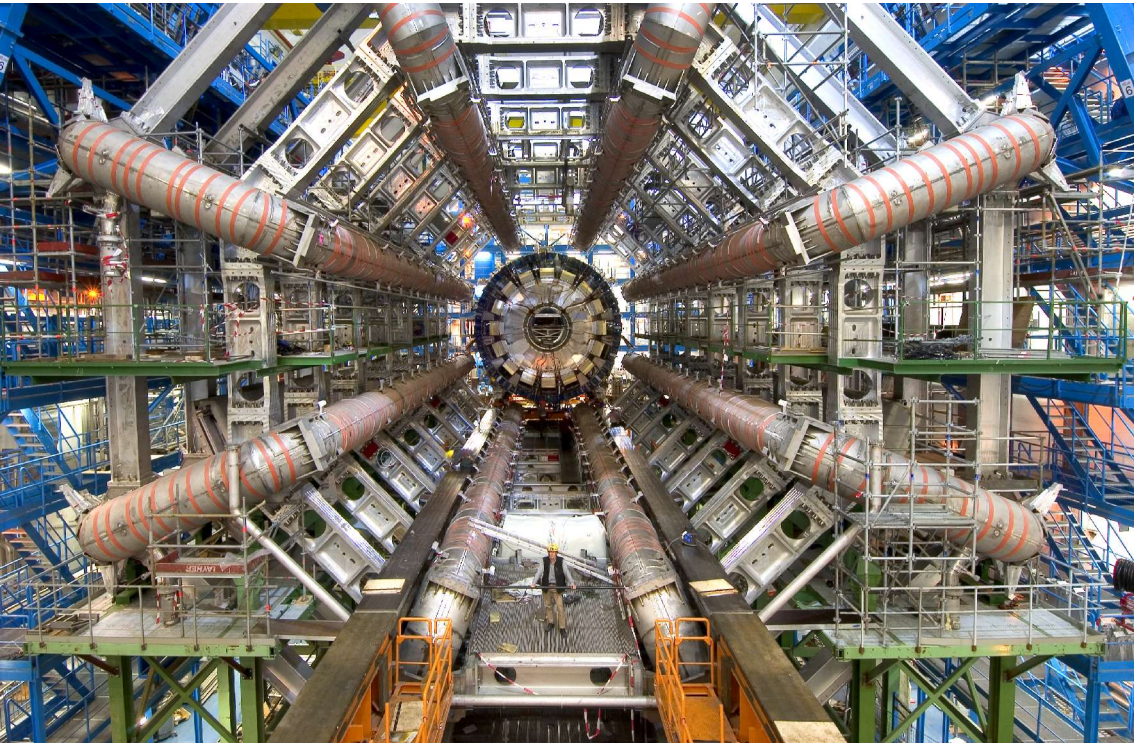
Particle Physics Data



- Most current particle physics data comes from (very) large experiments.
- e.g. ATLAS > 3000 Physicists.
- Raw data (after an online preselection) comes in at a rate of ~1 PetaByte per year.
- Also need similar sizes samples of simulated and reconstructed data.

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Particle Physics Data

- Experiments usually have a large suite of their own software, which is required in order to read & reconstruct their raw data
  - maintenance nightmare!
- Experiments usually have a lifetime of O(10) years
  - encourages some robustness and maintainablility
  - at least >1 person understands the system!
- To reconstruct the data, many calibration constants and other expert information are required
  - Usually an effort to have a “final reconstruction” and store the reconstructed data. Big challenge!
    - Is enough information stored to make it useful
    - Can it still be read?
    - Last one out, turn out the lights...

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Particle Physics Data

- There have been examples of good practice
  - e.g. Publications still from reanalysis 1980's data from DESY
- LEP data (<2000) still being analysed.
  - Will this continue with new people?
- What will happen to Tevatron and HERA data (finishing 2009, 2007)?
  - To be decided.

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Related Problem

- Publications often involve comparison of complex variables to the results of detailed simulations.
- Can the simulations be redone if a new model comes along?
  - Often difficult.
  - Sometimes not enough information in the paper.
- Result is an under use of old data.

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Solutions

- CEDAR (Combined Escience Data Analysis Resource)
  - PPARC (and recently EU) funded set of software tools, the main aim of which is to couple validation tools for *physics Monte Carlo programs* (and other physics calculational) tools with *data.*
  - Durham + UCL
  - Code (Rivet) for repeating analysis on MC
  - Database (HepData) archive of high energy physics data
  - Portal and Library (JetWeb) for generating, storing and searching comparisons
- Also provides (since it needs them itself)
  - Lightweight code development environment (HepForge).
  - XML descriptions of HepData records and generator parameters (HepML, in collaboration with LCG Generators)

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HepForge

- Handy, lightweight development platform for small reusable HEP software projects.
- Important for archiving of maintained & validated software
- Pick and mix of services available:
  - Version control, bug/issue tracking, download/release management, web space, wiki, mailing lists, shell account...
  - Used by about 25 smallish software projects
- More info at
  - http://hepforge.cedar.ac.uk (or http://hepforge.org)

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HepData

- Data store for all HEP measurements
  - Has been in existence >20 years
  - Data from >1400 experiments
  - Correlated and linked online to the SPIRES publication database (SLAC)
- Current public version is in legacy Berkeley DB
- CEDAR have migrated it to a MySQL DB
  - long term maintenance
  - java object model
  - accessible to jetweb and others

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Rivet

- Robust Independent Validation of Experiment & Theory
- Approximately equivalent to a C++ replacement of pre-existing Fortran (HZTool, >10 years old, quite widely used)
  - Will make use of some existing external libraries (CLHEP, KtJet/FastJet etc)
- Rivet is independent of the physics simulation being used
  - performs analysis on a set of particles from a simulated collision.
- Outputs histograms for comparison to data from HepData and for inclusion in JetWeb.

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RivetGun

- RivetGun interfaces Rivet to a variety of physics programs which model high energy collisions.
- Plan to allow configuration of generators using HepML.
- Intended as a convenient standalone tool for MC developers, experimentalists and theorists, as well as a component of JetWeb.

Rivet and RivetGun

- Design and development ongoing
  - Framework there, but not much physics content yet.
  - First beta release with some useful functionality expected in the next few weeks.
- See http://hepforge.cedar.ac.uk/rivet and http://hepforge.cedar.ac.uk/rivetgun

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JetWeb

- Web and database server for archiving validated MC models.
- Use Rivet and its precursers, running on LCG, to generate simulated data analyses.
- Use HepML for describing validated physics models
- Use HepData as the single source for all measurements

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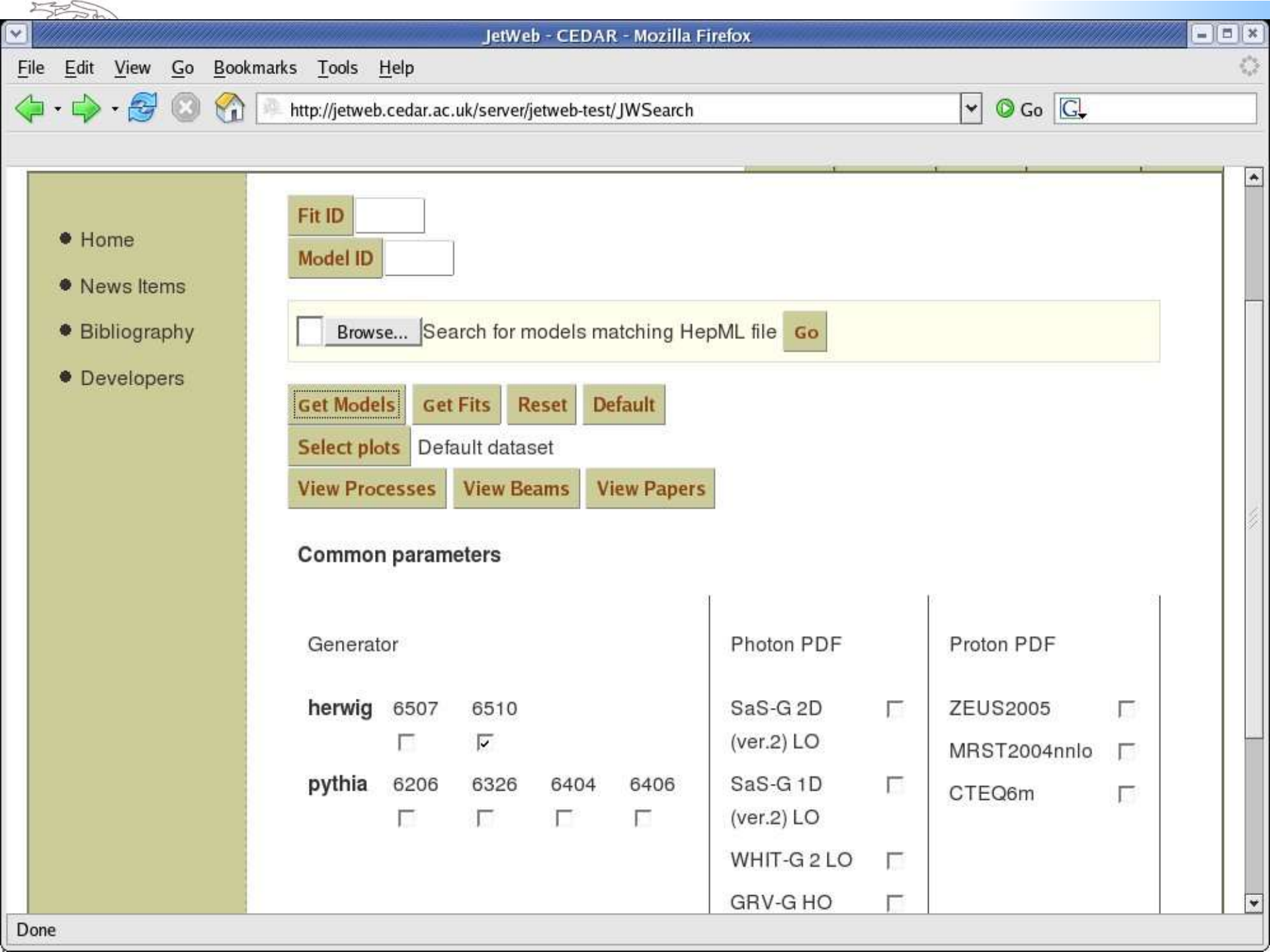
JetWeb Goals

- Build up database of validated models using wide range of existing data
- Add new *physics generators* and *data* rapidly as they appear.
- Users add their own new parameter settings.
- Add more user front-end facilities for interactive tuning and analysis.
- See http://jetweb.cedar.ac.uk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View Beams
View Papers
Common parameters
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pythia 6206 6326 6404 6406
Photon PDF
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WHIT-G 2 LO
GRV-G HO
Proton PDF
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MRST2004nnlo
CTEQ6m
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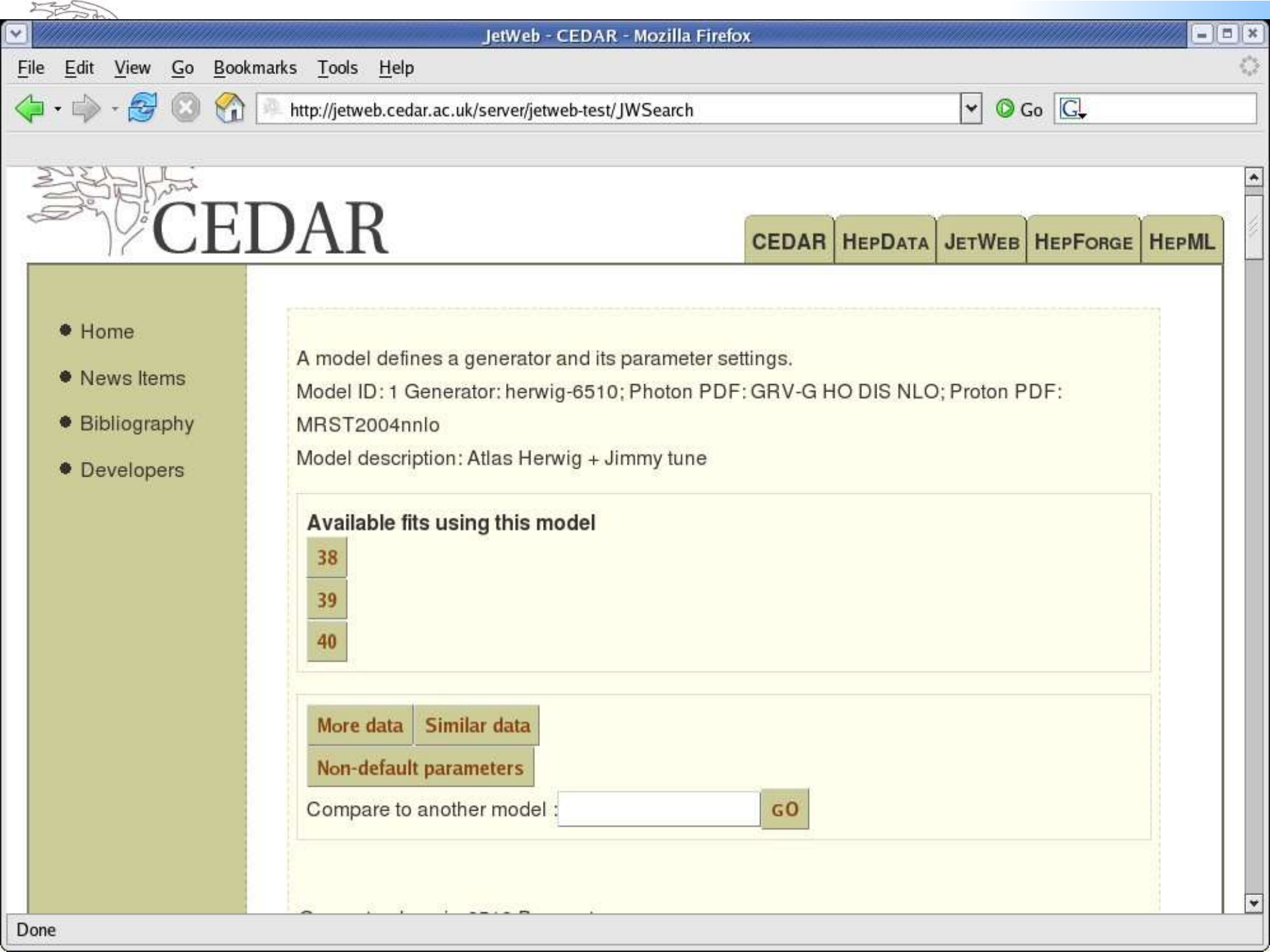
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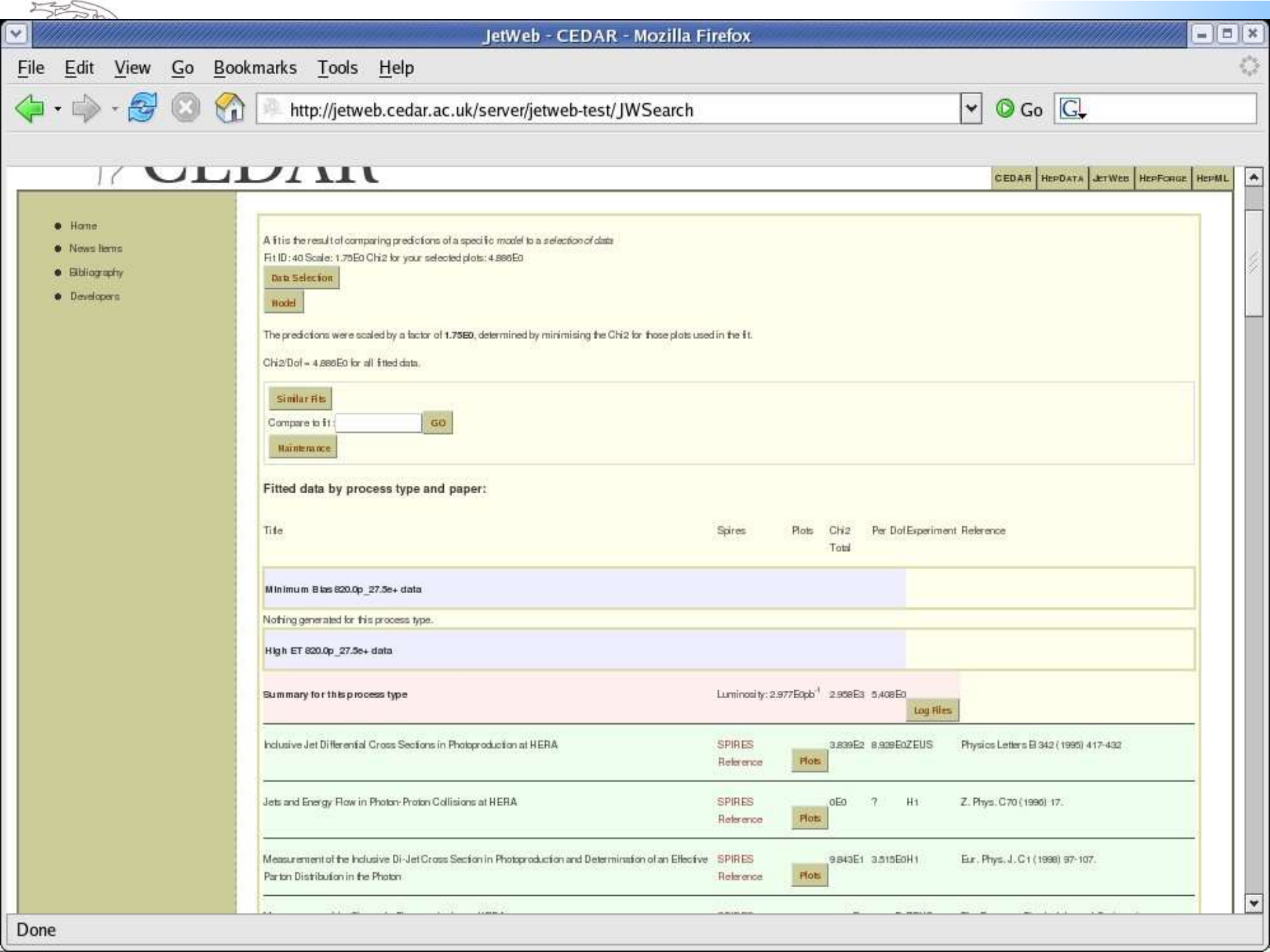
Developers
A model defines a generator and its parameter settings.
Model ID: 1 Generator: herwig-6510; Photon PDF: GRV-G HO DIS NLO; Proton PDF: MRST2004nnlo
Model description: Atlas Herwig + Jimmy tune
Available fits using this model
38
39
40
More data
Similar data
Non-default parameters
Compare to another model :
GO
Done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http://jetweb.cedar.ac.uk/server/jetweb-test/JWSearch
Go
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A fit is the result of comparing predictions of a specific model to a selection of data
Fit ID: 40 Scale: 1.75E0 Chi2 for your selected plots: 4.886E0
Data Selection
Model
The predictions were scaled by a factor of 1.75E0, determined by minimising the Chi2 for those plots used in the fit.
Chi2/Dof = 4.886E0 for all fitted data.
Similar Fits
Compare to fit:
GO
Maintenance
Fitted data by process type and paper:
Title
Spires
Plots
Chi2 Total
Per Dof
Experiment
Reference
Minimum Bias 820.0p_27.5e+ data
Nothing generated for this process type.
High ET 820.0p_27.5e+ data
Summary for this process type
Luminosity: 2.977E0pb-1
2.958E3
5.408E0
Log Files
Inclusive Jet Differential Cross Sections in Photoproduction at HERA
SPIRES Reference
Plots
3.839E2
8.929E0
ZEUS
Physics Letters B 342 (1995) 417-432
Jets and Energy Flow in Photon-Proton Collisions at HERA
SPIRES Reference
Plots
0E0
?
H1
Z. Phys. C70 (1996) 17.
Measurement of the Inclusive Di-Jet Cross Section in Photoproduction and Determination of an Effective Parton Distribution in the Photon
SPIRES Reference
Plots
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H1
Eur. Phys. J. C1 (1998) 97-107.
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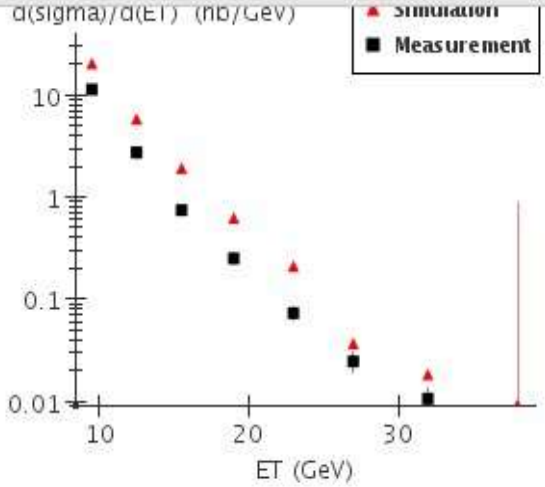


Chi2 Contribution: (chi2 / DoF): 5.236E1 / 6E0

Data (black) was scaled by: 1.2E0
The model was scaled by 1.75E0

Vector output of plotted data

For this fit, the simulated data was generated as

ID: 2 High ET in
820.0 GeV p - 27.5 GeV e+ collisions. More

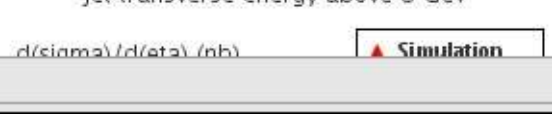
More

Pull for each point:

(3.25E-1) (2.279E0) (2.677E1) (9.924E0) (1.306E1) (0E0) (0E0) (1E-4)

(this plot not included in the fit)

Jet transverse energy above 8 GeV



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HepML

- XML Schemas to allow
  - exchange of parameters needed to reliably reproduce a particular generator run.
  - exchange of HepData records.
- Collaboration with LCG Generators (MCDB subproject).

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Summary

- Particle physics experiments produce a lot of data
- Some of it needs to be kept available for re-analysis
  - Maintenance of complex experimental software probably not a long term solution
  - Producing a “last word” reduced data set (final calibrations, enough flexibility to measure new things) is probably the best way forward
  - Important sociolgical and technical issues still to be addressed.
- Some of it is published in the form of distributions
  - Detailed knowledge of how they were made must be preserved
  - Storing this, and the data, online means more use is made of it.