

# The CEDAR Project

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## Abstract

We describe the plans and objectives of the CEDAR project (Combined e-Science Data Analysis Resource for High Energy Physics) newly funded by the PPARC e-Science programme in the UK. CEDAR will combine the strengths of the well established and widely used HEPDATA database of HEP data and the innovative JetWeb data/Monte Carlo comparison facility, built on the HZTOOL package, and will exploit developing grid technology. The current status and future plans of both of these individual sub-projects within the CEDAR framework are described, showing how they will cohesively provide (a) an extensive archive of Reaction Data, (b) validation and tuning of Monte Carlo programs against these reaction data sets, and (c) a validated code repository for a wide range of HEP code such as parton distribution functions and other calculation codes used by particle physicists. Once established it is envisaged CEDAR will become an important Grid tool used by LHC experimentalists in their analyses and may well serve as a model in other branches of science where there is a need to compare data and complex simulations.

## THE PHYSICS PROBLEM

Particle physics experiments at high-energy accelerators provide a wealth of data on the final state in electron-positron, lepton-proton and proton-(anti)proton interactions. These data represent a triumph for the Standard Model, particularly in precision electroweak measurements and the verification of the QCD sector to an impressive degree of precision.

Despite these successes, several aspects of high-energy collisions are still poorly understood, often due to technical difficulties in the calculation of non-perturbative or complex perturbative effects. Such lack of understanding can be a limiting factor in the accuracy of new measurements. Examples with particular relevance to the LHC include parton distribution functions (PDFs) in hadrons, hadronisation in the final state, multijet production and “underlying events”. Fig. 1 illustrates some of these processes in a complex high energy event. All these processes are calculated and/or modelled in Monte Carlo simulation and calculation programs that employ fits to existing data. Consistent tuning of the free parameters of these models, and confirmation of the physics assumptions they contain, is a non-trivial matter since the measurements are made with a vari-

ety of colliding beams, in many different regions of phase space, and for many complex observables.

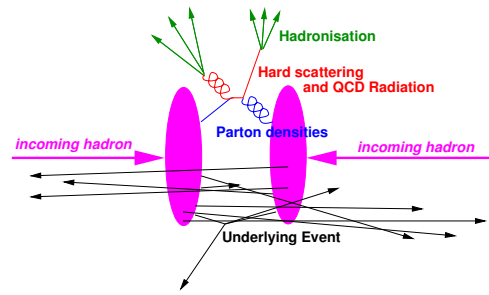


Figure 1: The complexity of a collision process.

## THE SOLUTION – CEDAR

A solution to the above problem will be provided by CEDAR, a project newly funded by the PPARC e-Science programme in the UK, which will construct a resource for particle physics enabling the predictions of Monte Carlos, and other calculation programs, to be easily compared with real data. CEDAR will allow the parameters of the models to be varied and to be simultaneously compared to as wide a range of data distributions as is necessary to maintain global consistency. These global comparisons are vitally important as it is quite possible to obtain a good fit to a new set of data but at the same time lose the quality of fit to other existing data.

CEDAR will combine the strengths of the established and widely used HEPDATA database [1] of high-energy physics data and the innovative JetWeb data comparison facility [2], and will exploit developing Grid technology.

In short:-

$$CEDAR = JetWeb + HEPDATA + more...$$

The individual parts, including the “...more” are described below.

### JetWeb

JetWeb is a WWW interface, developed at UCL, which provides a facility for direct comparison between the predictions of Monte Carlo programs and measured physics distributions from experiments. It is based upon the HZTOOL program [3] which generates the physics distributions from a given Monte Carlo program by calculating the

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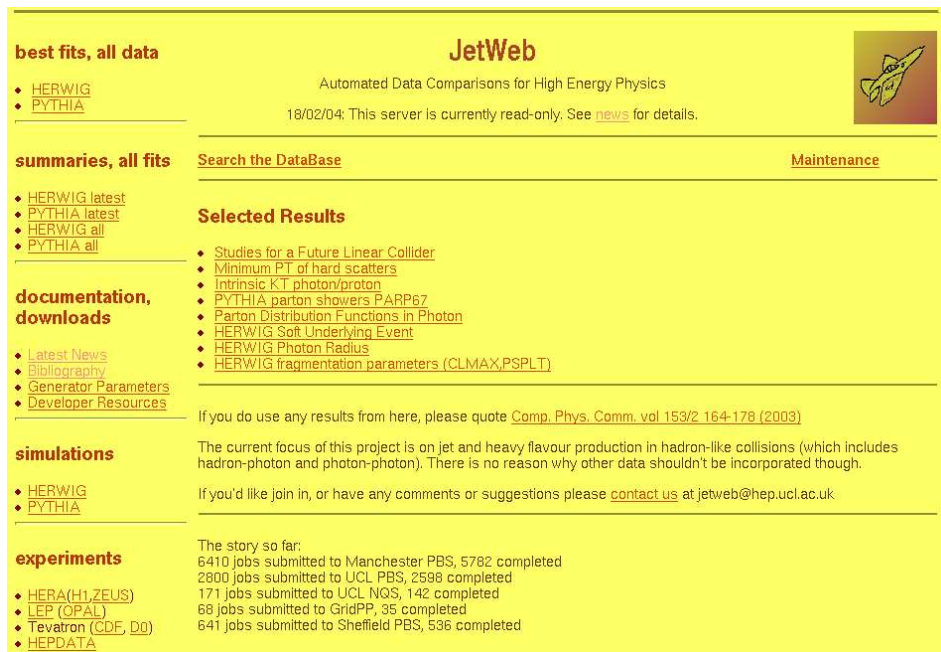


Figure 2: The JetWeb home web page

relevant variables and applying the cuts used in the published measurements.

The JetWeb interface allows the user to request and display quantitative comparisons of chosen Monte Carlo models with any number of measured data distributions. In this way the compatibility with the older data sets can be maintained when tuning to new data sets.

Since the generation of Monte Carlo events to calculate the predicted distributions to the required accuracy is a very compute intensive operation, JetWeb maintains a database (MySQL) of Monte Carlo generated data which can queried, or added to at user request, thus increasing the available statistics. JetWeb is already “grid-enabled” and has submitted its Monte Carlo jobs to GridPP with successful outcomes, as well as directly using the computer systems at UCL, Manchester and Sheffield.

Fig. 2 shows the JetWeb WWW home page which provides the user with the starting point to begin a new fit, or to search the JetWeb database for results from previous fits.

Fig. 3 show the main components of the JetWeb server. Interaction with the user is via two Java Servlets, running in a Tomcat servlet container linked to an Apache web server: the Searcher servlet provides the the standard functions available to a general user; the Maintainer provides additional functions, such as adding new data, to the JetWeb administrators.

At the heart of JetWeb is the Java Object Model (JOM) which contains the properties and interactions of the Model, Papers, Plots and Fits. (In this context a Model means a unique generator version and set of parameters.) Data is converted between formats via this model, e.g. from Database to HTML display. The JOM interacts with the JetWeb database, a MySQL database which stores exper-

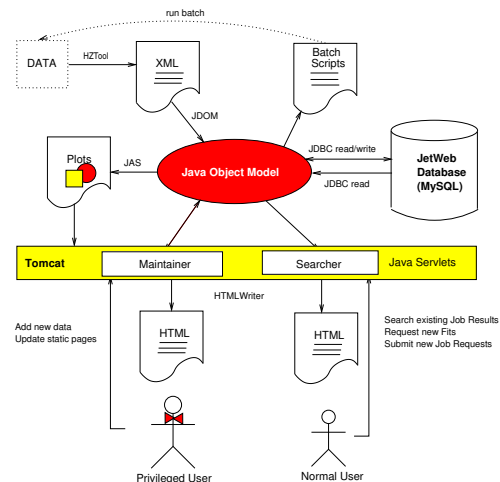


Figure 3: The various components of JetWeb

imental data as well as predictions from various models. The predictions are generated by running the Monte Carlo generators within the HZTOOL package, and the results are available to the user who requested the run and to any future user who makes a similar request.

At present, the size of the JetWeb database is restricted by the relatively small proportion of experimental data distributions which have HZTOOL routines to generate the predicted distributions from Monte Carlos generators.

CEDAR will do the following for JetWeb:-

- Re-design HZTOOL in OO structured C++ for long term maintenance and development. This is vitally important as new HEP code, and in particular new Monte Carlos, are being written using C++ in such

**HEPDATA: REACTION DATA Database**

...containing numerical values of HEP scattering data such as total and differential cross sections, fragmentation functions, structure functions, and polarisation measurements, from a wide range of experiments. It is compiled by the Durham Database Group (UK) with help from the COMPAS group (Russia), and is updated at regular intervals.

[Reaction Database HELP](#)
[Full User Guide](#)
[Use register](#) to tell us who you are, or [feedback](#) to send us any comments, suggestions or complaints.

**Standard (Keyword) Search Method**

Enter search command:

then:   or  or ask for [HELP](#)

Search syntax: keyword {op} value {boolean keyword {op} value} {...} where "op" is =, >, <, >=, <=, (the default is =), and "boolean" is AND, OR, and NOT. {} indicates optional elements.

Example searches:

```

reac = gamma gamma/
reac = p p --> p p and obs = dsig/dt
exp deap/hera/ and obs f2
auth smith or auth jones (records with authors either smith or jones)
de out and year 1992
re ee e- --> lambda/ and obs sig
re pbac p --> jet/ and plab > 100
  
```

Note(1): the "/" at the end of values performs a right truncated search.  
 Note(2): searches are case insensitive.  
 Note(3): even identical keywords must be repeated in complex searches.

Keywords to use (select for specific help):  
[\[AUTH\]](#) [\[REF\]](#) [\[YEAR\]](#) [\[REAC\]](#) [\[ESP\]](#) [\[BEAM\]](#) [\[TARG\]](#)  
[\[OBS\]](#) [\[PLAB\]](#) [\[DE\]](#) [\[EXP\]](#)

Particle vocabulary: for help select first letter of name from below:  
[A](#)[B](#)[C](#)[D](#)[E](#)[F](#)[G](#)[H](#)[I](#)[J](#)[K](#)[L](#)[M](#)[N](#)[O](#)[P](#)[Q](#)[R](#)[S](#)[T](#)[U](#)[V](#)[W](#)[X](#)[Y](#)[Z](#)

(Output Text Size = )

**Other Methods of Search the Database**

- [Form Interface](#)  
A fill-in form for making simple queries of the data base.
- [Easy search method](#)  
Step-by-step through a search using a series of menus from initial states to final states and observables.
- Data Reviews**  
Compilations of selected sub-sets of data organized in an easy to locate format.
  - [Structure Functions in DIS](#) [\[HP\]](#)
  - [Single Photon Production in Hadronic Interactions](#) [\[HP\]](#)
  - [Two-Photon Reactions leading to Hadron Final States](#) [\[HP\]](#)
  - [Drell-Yan cross sections](#) [\[HP\]](#)
  - [Inclusive particle production data in e+e- Interactions](#) [\[HP\]](#)
  - [Hadronic Total Cross Section \(R\) in e+e- Interactions](#) [\[HP\]](#)
  - [Neutrino Cross Sections \(under development\)](#)

These Data Reviews are published in the IoP's, Journal of Physics G - Nuclear and Particle Physics. Electronic versions of the reviews can be obtained through the relevant [\[HP\]](#) links above.

**Pre-defined Event Shape/Jet Searches:**

- [Event Shapes \(Thrust, Oblateness etc...\)](#)
- [Event Shapes in E+ E- collisions](#)
- [Event Shapes in non-E+ E- collisions](#)
- [Jet production \(in any process\)](#)
- [Jet production in E+E- collisions](#)
- [Jet production in non-E+E- collisions](#)

to the HEPDATA home page

Figure 4: The HEPDATA Reaction Data page

ways.

- Incorporate new Monte Carlos. At present only HERWIG and PYTHIA are available.
- Use HEPDATA as the source of “real” data distributions, giving access to more data including (eventually) LHC data.
- Develop the Web and Grid interface to the model validator data.

It is stressed however that although direct access to the data from HEPDATA will increase the scope of experimental data available to JetWeb, it will always be necessary for any data to be used to have a corresponding HZTOOL (or some equivalent) routine. The CEDAR project will actively encourage the participation of the experimental community in producing these routines.

## HEPDATA

HEPDATA is a PPARC funded project which has been in existence now for over 25 years. Its principal aim has remained essentially the same over this period, namely to compile scattering data from all types of HEP reactions (cross sections, event shapes, polarisations, etc...) and to make the resulting compilations easily available to the whole community.

More recently other services such as the hosting of mirrors of the SLAC SPIRES databases and the Berkeley Particle Data Group (PDG) Review of Particle Physics (RPP) web pages in the UK, have been added to the HEPDATA operation. HEPDATA also provides a unique and comprehensive PDF code server with an on-line PDF calculation,

display and comparison facility. These are all accessible from the main HEPDATA home web page, shown in Fig. 4.

The scope of the HEPDATA database covers cross sections from all types of particle physics reactions. It is emphasised that it does not contain “particle properties” which fall into the domain of the RPP of the Berkeley PDG. It also not contain raw data such as found on DSTs of experiments. To appear in the database the data are generally in the final published form. Ideally, to be most useful, they should be fully corrected for acceptances and efficiencies and be model independent. The database contains data from around 10000 publications dating from early experiments in the 1970s to the present day data from the LEP, Tevatron and HERA collaborations. It is regularly added to and updated. The data are obtained from journals and preprints and direct from the experiments especially when data appear only in graphical form in a publication. In the latter case the authors of the paper are contacted to obtain the exact numerical values shown in the plot. It is very important that this is done at the time of the publication as experience has shown how difficult it is to obtain numerical values at a later date. Data are rarely read from plots due to the difficulty in getting accurate representations. Finally, verification of data entered into the database is always sought from the experimenters themselves.

At present the HEPDATA project uses a non proprietary database management system (BDMS - the Berkeley Database Management System), as it has since its inception. This is a hierarchical DBMS in which data are stored in a tree like structure with the paper as the main record unit and the all data tables in a particular publica-

tion stored within that one unit (a data record). While this DBMS has proved very resilient and stable over the years, it is clearly not suitable for the present purpose of directly interfacing with JetWeb, or with any other resource over the Internet/Grid.

CEDAR will do the following for HEPDATA:-

- Migrate the data from the HEPDATA BDMS hierarchical database to a MySQL relational database. Not only will this provide the necessary means to interface with JetWeb, and other resources if necessary, but it will also address the long term future needs of HEPDATA by using a DBMS which is more standard and maintainable than its present one.
- Integrate the new database into JetWeb as the source of its “real” data. This will expand the number of available data sets to which JetWeb has access.
- Make the new database available on the Internet/Grid as a networked database for general use. This will involve implementing and expanding on the existing functionality of the HEPDATA web search and display methods. Expansions envisaged include direct access to the data through the conventional networks and also via the “Grid”.
- Develop new methods of direct entry and validation of data by the experiments, thus making them in control of their own data. At present the entry and verification of data in the database is generally instigated and controlled by the HEPDATA personnel. In future CEDAR will seek methods and formats (e.g. XML) in which experiments can enter and maintain their own data in the database potentially using Grid technologies and access validation methods. It should also be noted that the development of an XML document format for transfer of particle physics data will be useful also for data output to the Grid etc. as well as input to HEPDATA.

### *more... HEPCODE*

As well as the improvements to JetWeb and HEPDATA and their integration as discussed in the previous sections, it is also the intention of CEDAR to provide access to current and validated versions of various HEP theory and experiment software used at present, and in the future LHC era. A partial list of such software includes JETRAD, DYRAD, EXCALIBUR, (DI)PHOX, ZFITTER, RACONWW and MADGRAPH. No central repository of such codes currently exists in an organised and consistent way at present and as such it will be of great benefit to the community.

A prototype version, HEPCODE, has been set up on the IPPP website (<http://www.ipp.dur.ac.uk/hepcode/>) at Durham which includes, as well as a table of available programs and links, a web form for submission of new codes to the repository.

## SUMMARY

In summary we list the various tasks the CEDAR project will be engaged upon:-

- Convert HEPDATA to a relational MySQL database.
- Modify JetWeb to access data direct from HEPDATA.
- Design and implement an OO replacement for HZTOOL.
- Extend the number of HZTOOL routines/models available in JetWeb.
- Include new generation C++ Monte Carlos.
- Develop CEDAR grid tools for automatic validation and data access.
- Develop standard document formats (e.g. XML) for experimental physics data and results, which can be used for example as methods for reaction data export/import from experiments, as well as being useful in a more general context.
- Develop a code repository for a wide range of HEP codes and integrate with the validation centre.
- Incorporate LHC and, eventually, ILC data.

Once established and running with all the latest codes and data sets, it is envisaged that CEDAR will become an important tool used by LHC experimentalists in their analyses. Other branches of science which have need to compare data and complex model situations may also find the techniques and tools used in CEDAR of benefit to their work.

## THE CEDAR TEAM

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A N Other - to be appointed from 1st April 2005

### Web Links:-

CEDAR - <http://cedar.ac.uk/>  
JetWeb - <http://jetweb.hep.ucl.ac.uk/>  
HEPDATA - <http://durpdg.dur.ac.uk/hepdata/>  
HZTOOL - <http://hztool.hep.ucl.ac.uk/>

## ACKNOWLEDGEMENTS

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## REFERENCES

- [1] <http://durpdg.dur.ac.uk/hepdata/>
- [2] J.M. Butterworth and S. Butterworth, *Comp. Phys. Comm.* vol 153/2 (2003) 164–178
- [3] J. Bromley et al., *Hamburg 1995/96, Future physics at HERA*, vol 1, 611–612