HZTool and Rivet

Toolkit and Framework for the Comparison of Simulated Final States and Data at Colliders

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Presented by B. M. Waugh

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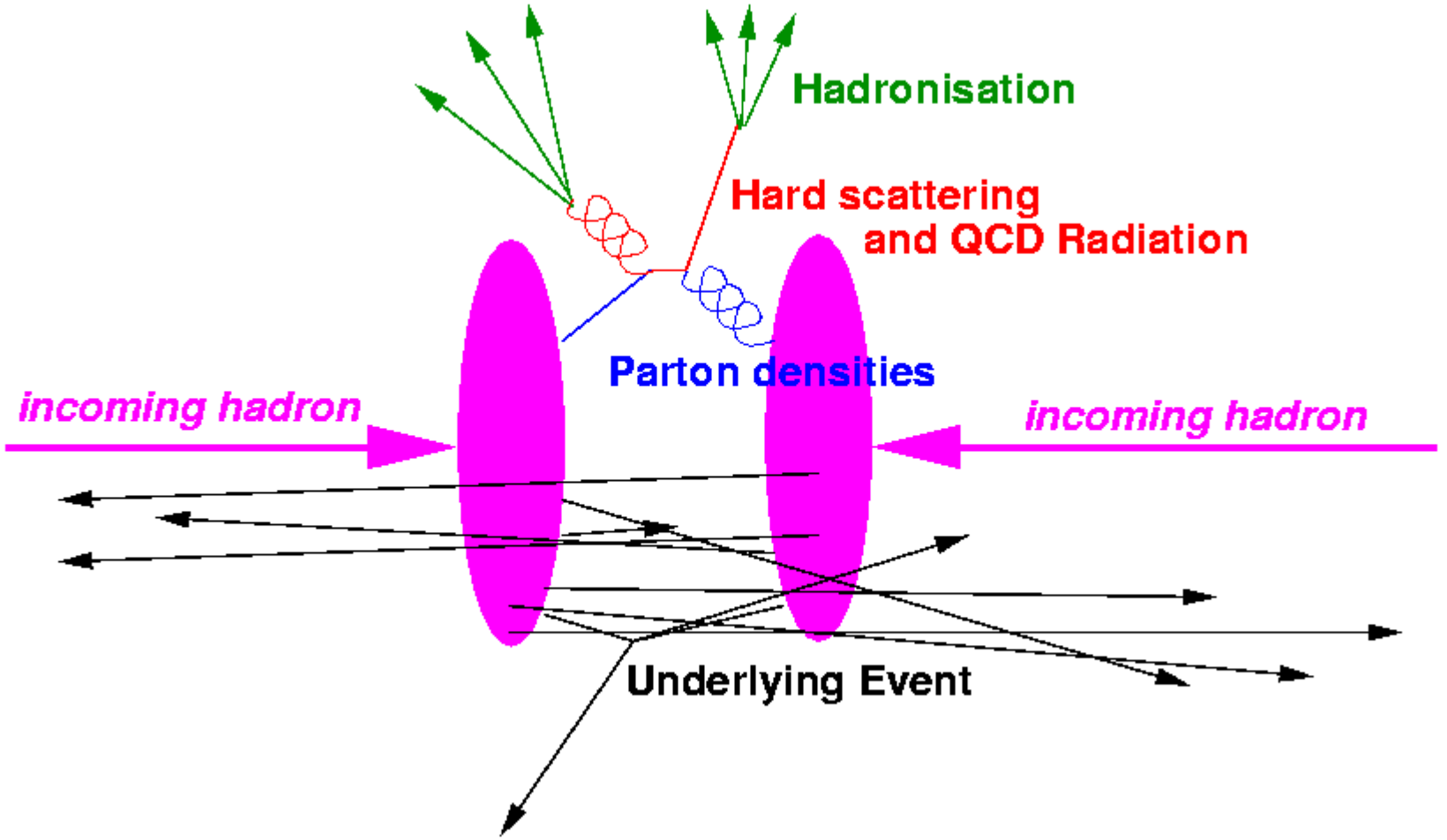
Overview

- Introduction: the physics problem
- CEDAR: the wider programme
- HZTool: the existing solution
- Rivet: the new improved solution
- Outlook

The physics problem

- Standard Model predictions have high accuracy
- But not everything can be predicted from first principles
  - hadronic final state
  - non-perturbative QCD, fragmentation, hadronization, PDFs, underlying event
  - complicated observables, jets, kinematic cuts...
- Need phenomenological models for event generators
  - parametrize PDFs
  - model fragmentation, multiple interactions...

The physics problem illustrated



Why is it a problem?

- Verify underlying theory against data
  - need to check sensitivity to details of model
- Interpreting data
  - correction for detector effects
  - interpolation and extrapolation
  - systematic errors
- Designing new experiments
  - colliders and detectors

The physics problem (2)

- Models have many parameters
  - free or weakly constrained
  - need to tune to data
- Measurements made in very different regimes
  - beam particles and energies
  - phase space
  - choice of observables
- Tuning to one data set can spoil agreement with others
- Tune simultaneously to many measurements

(Default) HERWIG predictions at 500 GeV

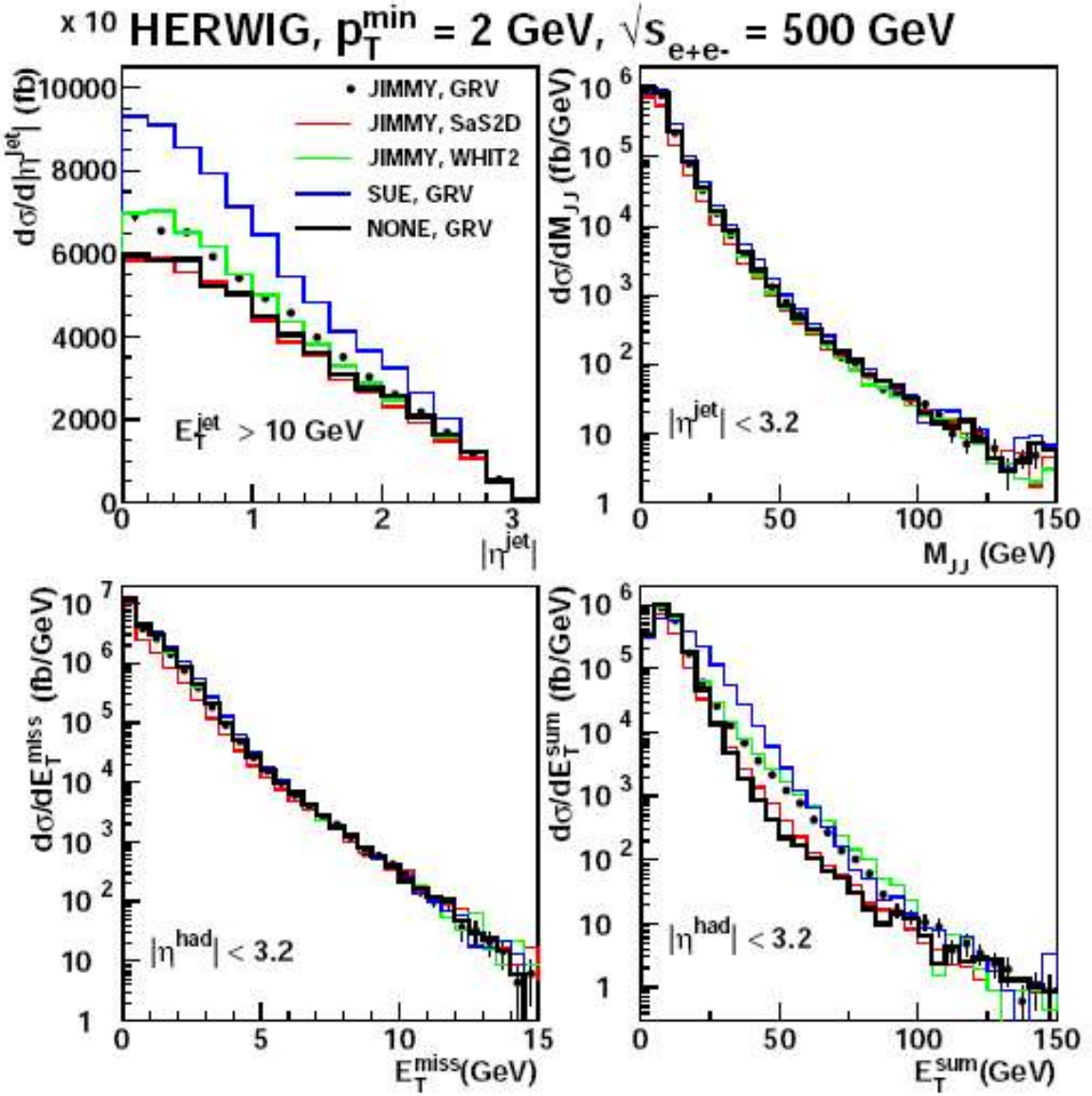
Default HERWIG prediction used with changes in underlying event and photon PDF.

All "reasonable" parameter settings.

Large spread in predictions, even at high energies.

How accurately do we know QCD production?

Not very well!



presented by Matthew Wing at MC4LHC workshop

The physics problem (3)

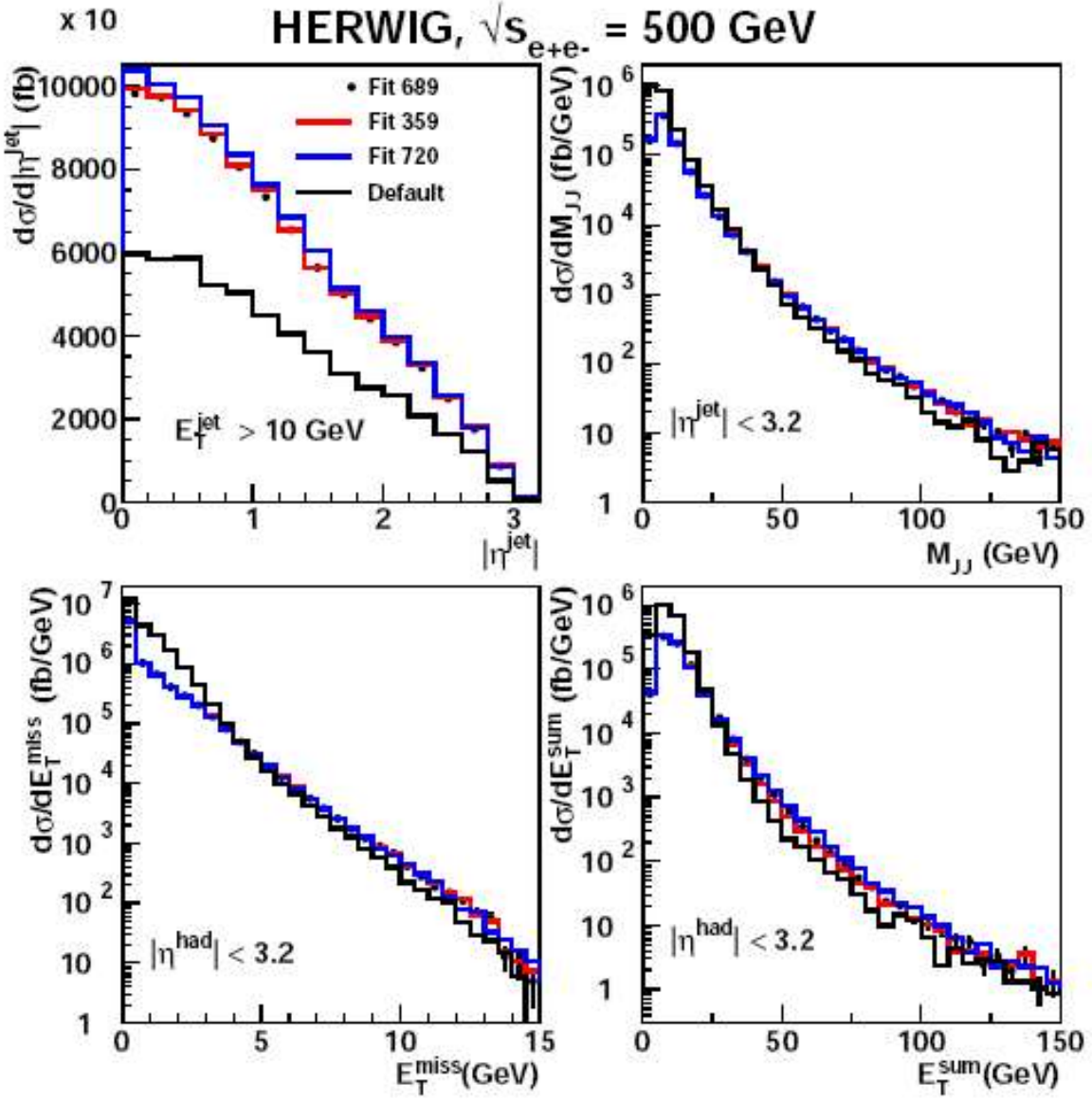
- Automate the process
  - saves large amounts of effort
  - results are reproducible
- Need to understand data
  - published paper not always good enough
  - data available in HEPDATA
  - subroutine to produce comparable plots from MC
  - use final state data only: can use for any MC
  - Preserve access to “old” data

(Fitted) HERWIG predictions at 500 GeV

Predictions significantly different from default

Note increased cross sections at high energies

Reduced spread in predictions



fitting to HERA photoproduction, LEP 2-photon, Tevatron jets

CEDAR

Combined E-science Data Analysis Resource

- CEDAR project will provide:
  - archive of data (HEPDATA)
  - tools for validating and tuning models, PDFs etc. (HZTool and Rivet)
  - web interface and database of models (JetWeb)
  - access to well defined versions of MC and other code (HepCode)
  - support for software developers (HepForge)
  - XML data formats for HEPDATA and for models
- Funded until 2008 by PPARC (UK Research Council)
- Two full-time postdocs plus contributions from many others

HZTool

- Fortran 77 library
- Developed as part of workshop on “Future Physics at HERA”, Hamburg 1995-96
- Contributions since then from many authors
- Merged some forked versions into CEDAR version
- Includes data from HERA, LEP, SPS, Tevatron
- More HERA data added during HERA/LHC workshop
- Ongoing work to include more LEP and Tevatron results

HZTool (2)

- Each analysis is represented by a subroutine
- Takes data from HEPEVT common block – generator independent
- Calculated quantities of interest and fills histograms
- Also fills histograms of experimental data
- Library includes utilities:
  - jet finders
  - event shapes
  - Lorentz boosts

Rivet

Robust Independent Verification of Experiment and Theory

- Object-oriented C++ framework to replace HZTool
  - easier to extend and maintain
  - easier to find authors for analysis routines
  - can use existing utilities: CLHEP, KtJet, XML...
- Use newer interfaces:
  - HEPMC (event record)
  - LHAPDF (PDFs)
  - AIDA (histograms)

Rivet Design (1)

- RivetHandler object is created for a MC run
- It is given a collection of Analysis objects
  - equivalent to analysis routines in HZTool
- Analysis uses Projections to calculate quantities
- A Projection (map: event → property) may
  - calculate a single number (x)
  - find jets in a given reference frame
  - apply kinematic cuts
  - be composed of other projections in a given order

Rivet Design (2)

- Projection instantiated when Analysis created, but only does calculations for given event on demand
- Results cached so e.g. jet-finder run only once
- Make use of existing libraries where possible
  - CLHEP
  - KtJet...
- Independent of experiment-specific code
- Histogramming will use AIDA interface
  - implementations exist in C++, JAVA, Python
  - not tied to one package

Rivet and Generators

- Rivet library has no generator dependencies
- Main programs and steering provided by RivetGun
  - equivalent to HZSteer
- Probably use GENSER (LCG) for generator access
  - should include generators of interest for LHC
  - should be widely deployed on LCG sites

Outlook

- HZTool
  - further development for new JetWeb release
  - then just add analysis routines
- Rivet
  - initial design in place
  - working on implementation
- CEDAR
  - HZTool, Rivet, JetWeb, HepData...
  - useful resource ready for LHC start-up
  - preparing for the ILC and beyond...

Further information

- CEDAR: http://www.cedar.ac.uk/
- HZTool: http://hepforge.cedar.ac.uk/hztool
- Rivet: http://hepforge.cedar.ac.uk/rivet