Institute of Physics in Prague and the DZero experiment

For more than 10 years, physicists from Institute of Physics in Prague participate in the DZero collaboration. The DZero experiment detects remnants of proton-antiproton collisions provided by the Tevatron collider in Fermilab. Before the start up of Large Hadron Collider at the end of year 2009, the Tevatron with its $\sqrt{s}$=1.96 TeV center of mass energy was providing the most energetic hadron-hadron collisions in the world. The DZero results are thus at the frontiers of the particle physics. Among the most prominent ones are: precise measurements of mass of W boson and top quark, observation of oscillations between meson B_s and its antiparticle, observation of single top production, and new limits on mass of Higgs boson.

This document briefly describes our main contributions to the experiment from building muon high voltage fanouts for the detector upgrade, running large computer facility used for massive DZero detector simulations, up to the physics results we were working on during those ten years. Here our focus was on jet physics: we significantly contributed to the first two jet papers from the upgraded DZero detector and we were heavily involved in the calibration of jets energies. We were also proud to host the DZero Collaboration Workshop here in Prague in 2008. This is not a comprehensive list of all our activities in DZero. We also took part in tests of silicon detectors (Vaclav Vrba and Michal Tomasek), in building and installation of muon detector (Milos Lokajicek and Stanislav Nemecek) and its calibration system (Alexander Kupco), and in development software for calculation luminosity of data samples used in physics analyzes (Alexander Kupco).

Muon high voltage fanout

We contributed to the DZero detector upgrade by building high voltage fanouts for muon detector. They were designed and built here in our institute, see Fig. 1, and they were installed in Fermilab in 1999. They successfully operate up to now. *Responsible persons:* Milos Lokajicek and Zdenek Kotek.

Fig. 1: Technician Zdenek Kotek is checking the muon high voltage fanouts before their shipment to Fermilab

Computing

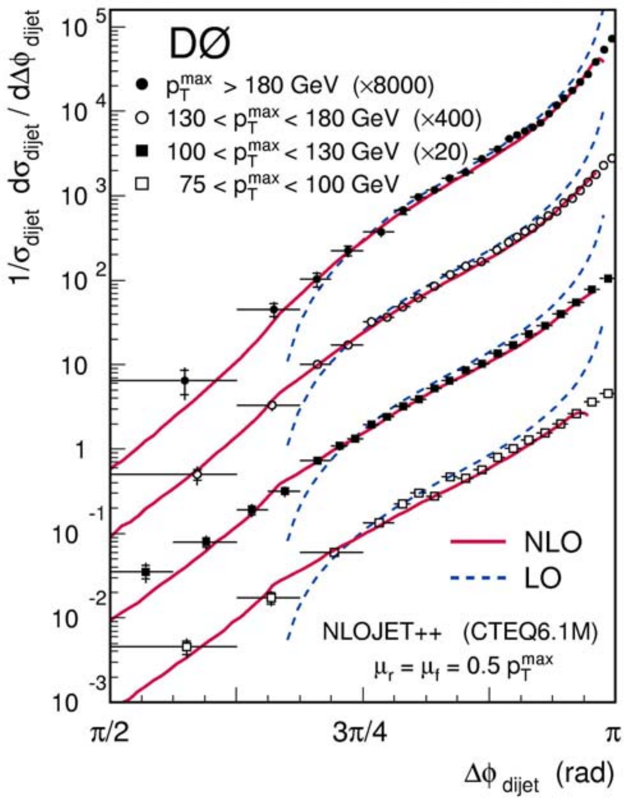
Demand for computing power necessary for data reconstruction and Monte Carlo detector simulations is so high and the collaboration decided that all detector simulations will be performed outside of Fermilab. We joint this effort among the first in year 1999. What started with just five computers developed, at the end, into large computer facility Regional Center for Particle Physics placed in our institute, see Fig. 2. The facility is used not only by the DZero experiment but also by the rest of high energy physics community, like LHC experiments or astroparticle experiment Auger. More information about our computing center can be found here: http://www.particle.cz/farm/.

In year 2009, more than 100 million events were simulated here in Prague and about 10TB of data were transferred to Fermilab and stored there on tapes. It represents 10% of total Monte Carlo production of the whole DZero experiment and our contribution was the third largest one among all computer centers supporting DZero computing. Our colleagues from Charles University and Czech Technical University are helping us with operating the computer farm and with running the DZero detector simulations.
Responsible persons: Milos Lokajicek is leading our computing effort. The computing center is operated by SAVT, responsible person is Jiri Chudoba, technicians Tomas Kouba, Jan Kundrat, Jiri Horky, Lukas Fiala, and Jan Svec as DZero liaison.

Fig. 2: Computer farm in Institute of Physics in Prague used for Monte Carlo simulations of the DZero detector.

Dijet azimuthal decorrelation

DZero Collaboration (V.M. Abazov et al)
Measurement of dijet azimuthal decorrelations at central rapidities in p anti-p collisions at √s = 1.96 TeV
Phys. Rev. Lett. 94:2218018, 2005



Quantum Chromodynamics (QCD) is a theory that describes strong interactions among elementary particles. Although it is complete and based on fundamental principles of nature, it is often difficult to apply to specific situations. Nevertheless, comparing approximate calculations from QCD with experiment data offers a way to improve our descriptions of the strong force. For example, when two partons (quark or gluon constituents of protons) smash into one another, they usually emerge back-to-back from the viewpoint of the incoming protons. When additional partons are also produced, QCD predicts how the angle between the two most energetic ones should change.

Fig. 3: The measured distribution of azimuthal angle between the two most energetic jets in proton-antiproton collisions

The signature for outgoing partons corresponds to collimated sprays of particles (remnants of quarks or gluons, referred to as jets) that can be measured through the energy they deposit in the detector. DZero has studied the angle between the two most energetic jets in proton-antiproton collisions, and finds (see Fig. 3) that the emission of extra partons affects the angle between the most energetic jets exactly as predicted from what is referred to as perturbative QCD (labeled NLO in the figure). This kind of information provides a deeper understanding of QCD, better tools for obtaining more reliable calculations, and thereby more sensitivity for gauging any departures from theory that could signal the presence of new physical phenomena.
Responsible persons: Alexander Kupco was main author of the analysis and paper.

Inclusive jet cross section

DZero Collaboration (V.M. Abazov et al)
Measurement of the inclusive jet cross section in ppbar scattering at sqrt(s)=1.96 TeV
Phys. Rev. Lett. 101, 062001 (2008)

Jets, collimated sprays of particle, are fingerprints of violently scattered proton constituents, quarks and gluons. In events where the jets are produced with large transverse momenta, we can study proton structure at scales thousand times smaller than proton actual size. Data, see Fig. 4, confirm the validity of quantum chromodynamics (a theory of strong interaction) and the assertion that the proton's constituents, quarks, appear point-like even at those small distances. Thanks to careful calibration of jet energies, data provide new information about proton content, especially about gluons that carry significant part of the proton momentum.

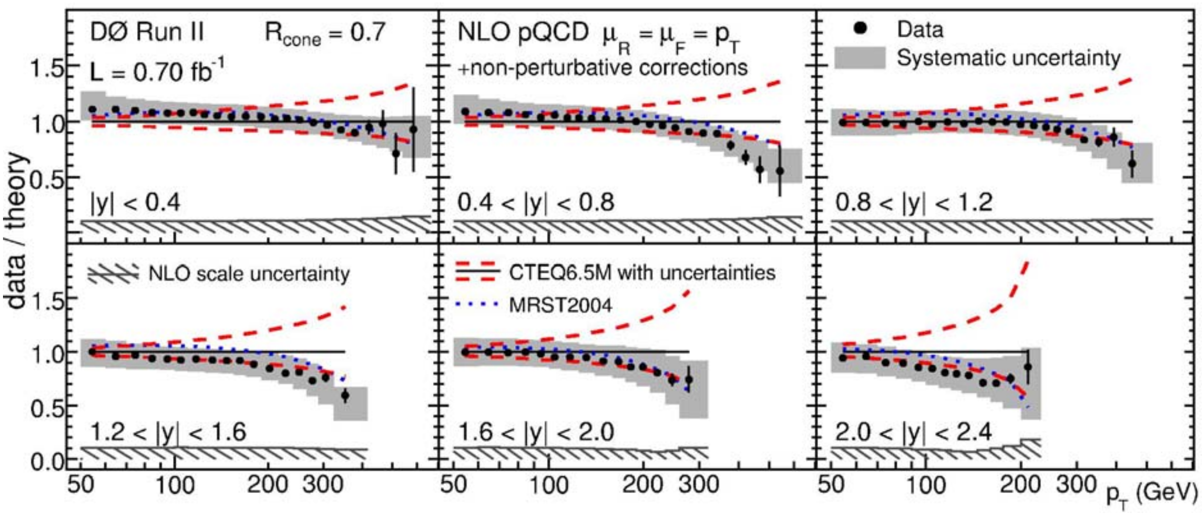


Fig. 4: Comparison of measured jet production with theoretical prediction of quantum chromodynamics.

Precise energetic calibration was crucial in order to obtain this result. Our Prague group which includes colleagues from Charles University and Czech Technical University played an important role in the derivation of jet energy scale. At the end we were able to calibrate jet energies with almost 1% precision, a level not reached at hadron colliders before. Uncertainty in jet energy calibration is usually dominant systematic uncertainty for most of the measurements, since jets are almost always present in the final state at hadron colliders. Our contribution thus had a large impact on the quality and precision of many other published DZero results.

Responsible persons: Alexander Kupco was one of the main authors of this paper. He was also responsible for the derivation of calorimeter response to jets and evaluation of correlations in jet energy scale uncertainty. Later on, he was co-leading the effort of Jet Energy Scale group as one of the conveners.