Hans Wenzel

Resume:

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1 Apr. 2000 - present: Computer Professional at FNAL

Currently I am the "LPC Offline Coordinator" where LPC stands for LHC Physics Center which was established at Fermilab in April 2004:
http://www.uscms.org/LPC/LPC.htm.
I am also the User services coordinator for the CMS experiment serving as a liaison between the Fermilab tier 1 computing facility and the USCMS physics users community. In this function I am in constant contact with the different physics and test beam groups to collect their computing requirements and make sure they are met by the facility.

Over the last years I have been interested in developing user computing for CMS making use of inexpensive farms consisting of commodity PC running the Linux operating system. This involved all aspects of getting a computing farm up and running:
- the design of Linux based computing farms and infrastructure,
- evaluating components,
- purchasing the computing equipment,
- overseeing installation and commissioning,
- performance testing and optimization,
- developing necessary software components.

At Fermilab we are serving a dual mission of supporting physicists and doing R&D toward a fully functional prototype Tier 1 Regional Center for CMS. Fermilab is in a unique position where we can learn from the experience of the Run II experiments (CDF and D0) currently taking data. Therefore I maintained close relationships with the Run II experiments (e.g. joint working groups). Many of the products selected for Run II (the FBSNG batch system, dCache, Enstore) are also in use by CMS.

The main focus of my R&D work are in-depth studies of modern file systems, logical volume management on large scale disk farms, load balancing, dynamic partitioning of cluster computing resources and evaluation of new CPU architectures as they become available.

1.1 User Computing

I developed and operated the CMS User Analysis Farm (UAF). The current UAF is a farm running the LINUX operating system providing interactive and batch computing for users. Load balancing, resource and process management are realized with FBSNG, the batch system developed at Fermilab. Currently the UAF has more than 200 registered users. It has been in use for more than 2 years and has been constantly upgraded during this time providing more CPU, network bandwidth, disk and mass storage space. In most cases this upgrades could be performed without interrupting the service. Currently the farm consists of more than 50 dual CPU boxes that are all connected via Gigabit Ethernet. More information can be found on the UAF User Computing web page:
http://www.uscms.org/SoftwareComputing/UserComputing/UserComputing.html
To attract users to the UAF I prepared several tutorials which guide the users through all necessary steps from parallel Monte Carlo Event generation to analyzing the fully reconstructed data. The tutorials were part of the workshops organized by the LPC. The tutorials

were very well attended (http://agenda.cern.ch/displayLevel.php?fid=371). All the tutorial material and scripts are available on-line on the UAF web page and from the feed back it seems that they are in constant use. Our experiences with the UAF were presented at: CHEP 2004 Interlaken, Switzerland, Sept. 27 - Oct. 1 2004.

I produced large data samples for the different FNAL and LPC physics and detector groups and participated in the analysis (e. g. "Higgs bosons in the dijet spectrum of black hole decays at CMS", CMS internal node: CMS-IN-04/027, Aug. 1st, 2004). We were able to mix in "pile up" events served by dCache to simulate different LHC luminosity scenarios.

1.2 Conferences

- Together with Kaori Maeshima we organized the "IV International Symposium on LHC Physics and Detectors", May 1-3 2003 at Fermilab. I was involved in all aspects of organizing the event including inviting speakers and serving as webmaster, session chair and editor of the proceedings.
  http://conferences.fnal.gov/lhc2003

- Helped organizing the GEANT 4 tutorial at Fermilab.
  http://conferences.fnal.gov/g4tutorial/
  I installed GEANT 4 on the CMS farm and helped students setting up simulations of the CMS calorimeter. This studies were compared with the test beam data of 2004.

1.3 Committees and working groups

- EURYI-expert: scientific evaluation of proposals for EURYI-Awards.
- Farm evaluation group: Panel of experts representing the various experiments at Fermilab. We are evaluating different vendors regarding their hardware and software expertise to provide Fermilab with computing farms. Currently we are evaluating AMD 64 Bit Opterons for the use in the CMS experiment.
- convened "The LPC EDM working group," which was charged with evaluating the functionality and performance of the current CMS offline framework and event data model (EDM).
- convened "The LPC Software Environment working group", which was charged with evaluating the software environment needs of the LPC.

1.4 Software development

- provided the CMS muon group with the experiment independent part of the CDF on-line framework so that they could use it for data quality monitoring in the 2004 test beam.

- was the librarian for OSCAR which is a GEANT 4 based simulation of the CMS detector.

- have been looking into the CMS tracking code and have written an ORCA (CMS reconstruction program) module to access the track information and to store the information into a ROOT Tree for studies related to tracking.
- for tracking studies as well as studies of the electron and muon reconstruction I developed a particle gun application which allows to shoot single particles into the simulated CMS detector that then are simulated and processed through the entire reconstruction chain. To save CPU time (e.g. for studies only relating to tracking) it is possible to kill particles in Geant 4 before they enter the calorimeter:
http://www.uscms.org/SoftwareComputing/UserComputing/ParticleGun.html
- in Fall 2000 I developed software to run large Monte Carlo productions for the CMS experiment using Linux computing farms as well as Sun Solaris smp machines. The programs developed at Fermilab were chosen as the base for the production tools used throughout the CMS experiment.
- served as liaison between and the CMS Jets/Met physics analysis group and the CMS MonteCarlo production group and maintained a repository of data cards for simulation and event generators in CVS.

1.5 Evaluations of computing hardware and software

1.5.1 CPU Evaluation

At Fermilab we are Continuously evaluating new computing platforms especially the 64 Bit dual and single core processors that now are available. I was part of the various Fermilab task forces charged with evaluating new processor technologies for use at Fermilab and in the CMS experiment. The public report of the task force can be found at:
http://www-oss.fnal.gov/scs/public/qualify2005/opteron_external.ps
In addition I published the following CMS notes: **IN2005_030** and **IN2005_012**.

1.5.2 Modern file systems and disk based storage solutions

We have evaluated several modern file-systems and storage solution. To do that we attached evaluation units provided by different vendors to a Linux farm. We defined performance metrics and developed several test suites to measure and evaluate the performance of this systems. The results were presented at HEPIX 2003 in Amsterdam and can be found at:
http://www.nikhef.nl/hepix/pres/wenzel.ppt
http://www-oss.fnal.gov/projects/disksuite/

1.5.3 Large scale disk farms

One major research area is related to high performance and reliable data servers which have to be smoothly integrated between the production farm nodes, the user analysis nodes and the back-end tertiary storage services (Enstore). The primary intention is to let them act as a transparent cache by making a multi-terabyte server farm look like one coherent and homogeneous storage system. dCache available as part of the centrally maintained mass storage services at Fermilab, seems to offer many of the desired features. We evaluated dCache and dfarm and results can be found in the HEPIX 2003 presentation.

1.5.4 LVM

For user space and to manage the disk space for the different physics groups we investigated LVM (Logical Volume Manager). LVM supports volume management of disk and disk subsystems by grouping arbitrary disks into volume groups. We have tested the features and robustness of LVM on a test system with very promising results.

1.5.5 Load balancing and dynamic partitioning of cluster computing resources

Another major research area are load balancing and dynamic partitioning of cluster computing resources especially for interactive use. Currently PC's running Linux offer the best price/performance ratio. Therefore several scenarios to make the architecture of a Linux cluster completely transparent to end users (physicists) were investigated.

- The MOSIX operating system is designed to make a cluster look like an smp machine. MOSIX is a software that was specifically designed to enhance the Linux kernel with cluster computing capabilities. MOSIX operates silently - its operations are transparent to the applications. The algorithms of MOSIX are decentralized. We deployed MOSIX on a test farm and found is easy to install and to configure using the provided installation scripts. In the end we decided not to use MOSIX for the following reasons:
  - it is a specialized Kernel and it requires additional effort to compile and enable other Kernel modules required by CMS software (e.g. AFS).
  - some processes (utilizing socket, shared memory) don't migrate. Unfortunately the CMS reconstruction applications belong to this class. This severely limits the use of MOSIX for the CMS experiment.
  - in our tests the MOSIX filesystem which makes the local FS transparently available on all cluster nodes did not perform very reliably resulting in poor performance of IO intensive processes.
  - main development branch seized to be open source (the open MOSIX project has been founded since then).
- FBSNG (Fermilab Batch System Next Generation) has been used very successfully in CMS Monte Carlo production. In the solution we developed the user connects via ssh or telnet into a gateway node, consequently the log in triggers a process which creates an interactive batch job on one of the farm nodes. We modified FBSNG to adapt it to the use as an interactive system and wrote scripts replacing the usual login shell. We decided to use this approach for the UAF with FBSNG as a single software product

for interactive as well as batch computing, minimizing the administrative overhead and allowing us to dynamically assign resources (nodes) to batch, user batch and user interactive queues.

- LVS Linux Virtual Server.
- load balancing based on networking switch.

1.6 Physics analysis

I did Monte Carlo studies simulating the LHC or Tevatron beam conditions and developed an alogrithmn which uses the d-ϕ-z correlations of tracks reconstructed in the Silicon vertex detector to estimate the beam parameters: z_0, β^* and emittance: ϵ. The advantage of this method is that no fitting of the primary vertex is required.

Currently we are doing a search for the decays $B_{sd} \rightarrow e\mu$ with the CDF experiment. This is an improvement of the analysis we did in run I. This B-meson decay is forbidden in the Standard Model and would be a signal for new physics beyond the standard model. Compared to run I we use more data, we use the data sample provided by the SVT two track trigger and we use the $B \rightarrow 2$ hadrons signal as a reference signal to avoid having to understand the absolute efficiency of the SVT trigger. So far this looks very promising and we should be able to improve the limit by several orders of magnitude.

I developed a fitting program which allowed to combine different data sets statistically correct to be used in the measurement of B meson lifetimes. The fitting uses object oriented techniques based on the ROOT software package. This work allowed us to improve the CDF Run I B-meson lifetime. This resulted in a Ph.D thesis (Universität Karlsruhe) and was published in Physical Review D:
"*Measurement of B Meson Lifetimes using fully Reconstructed B Decays produced in p $\bar{p}$ Collisions at $\sqrt{S}$ = 1.8-TEV*", The CDF Collaboration (D. Acosta et al.).
Phys. Rev. D**65**, 092009, 2002.

1.7 Teaching

I gave several hands-on tutorials. The material can be downloaded and the instructions can be found on the web at:
http://www.uscms.org/SoftwareComputing/UserComputing/NewTutorial.html

In addition I worked closely with students doing various CMS studies. The CMS software environment is very complex and since it is in development it is changing rapidly. This can be very intimidating for students therefore I always tried to be available for students visiting Fermilab. I set up simple examples where results from generator Level studies then can be compared to results after all detector and trigger effects are included and the event is fully reconstructed. Nowadays many tools for detector simulation, the simulation of physical processes and the visualization of the processes are available (GEANT4). So one exercise

I liked to do with students was to take a book on particle detectors find out what are the interesting plots for calorimetry and see if we could reproduce the measurements in the book with our simulations. This really gives a good understanding on what is going on and one gets an idea what quantities should be measured in a test beam to characterize the detector.

I volunteered for the "Ask A Scientist" program giving tours of the CDF experiment a well as the Feynman computing center.

2 Jan. 1997 - Mar. 2000: Universität Karlsruhe

I joined Prof. Thomas Müller's group in Karlsruhe in January 1997. At the time Karlsruhe was not member of the CDF experiment. We presented a proposal to the CDF collaboration board to join the experiment which was accepted making Karlsruhe the only German University in the CDF experiment.

2.1 Software development

For the CDF Run II upgrade I worked on the on-line monitoring. CDF started Run II with a significantly different detector, trigger system, data format and software environment. Therefore, the programs which served to monitor the data stream during Run I had to be rewritten. For this purpose together with Kaori Maeshima and a small group from Waseda University (Japan) and Karlsruhe we developed a framework based on the ROOT package. We had a lot of fun although with the collaborators in different time zones there was never a convenient meeting time for everyone. We still managed to work very efficiently by making use of videoconferencing, collaborative tools and splitting the tasks into logical blocks. The framework uses a client/server architecture and allows real time remote access while data taking. This is realized via Unix sockets or a WWW server and a specialized Browser Application. The code is running on all three platforms supported by CDF namely IRIX/OSF/LINUX. I served as librarian for this package. Most of the CDF online monitoring framework is independent of the experiment and has since been adopted by other experiments like MINOS and CMS.

Software activities included the porting of CDF vertex fitting code from FORTRAN to C++. In addition,together with a diploma student we developed C++ classes allowing Run 1 Tracking banks to be read out. This enabled us to do some simple physics analysis within the CDF Run II (C++) framework using CDF Run I data.

2.2 Hardware

At the beginning of 1999 I got involved in the testing of silicon detectors for the intermediate silicon layer (ISL) Run II upgrade of CDF. In 1998 together with a Ph.D student we developed a readout system for the SVX3 chip using very cost effective electronics and a PC running Linux.

2.3 Physics analysis

As a member of CDF my main physics interest were in the field of b and top-physics where I could benefit from my knowledge of the SVX tracking. I was mainly working on b-lifetimes, rare b-decays and $B\bar{B}$ - mixing. While performing searches for rare b-decays I became interested in physics beyond the standard model. Precision measurements of rare b-decays provide tests of physics beyond the Standard Model. In 1998 I concluded three analysis resulting in publications in Physical Review.

2.4 Teaching

I organized the tutorial groups for the nuclear and particle physics course at the University of Karlsruhe. To keep things interesting I chose problems and examples relating to actual events. Since nowadays all students have access to powerful PC's I also provided programs to solve some of the problems numerically and to visualize the results. I supervised students in laboratory courses where again PC's can be a very powerful tool in analyzing the data measured during the hands on session. I supervised one Diploma student (topic: "Search for single top "), and one Ph.D student (topic: "Measurement of the b-lifetime using exclusive B-decays").

2.5 Committees

Representing CDF in the Physics Analysis Software Joint Project which evaluates software tools for Run II (http://runiicomputing.fnal.gov/runiiweb/pas.html). Computing representative for the Karlsruhe CDF group.
God Parent for various CDF analysis.

3 Dec. 1993 - Dec 1996: Post doctoral fellow at LBL

3.1 Software development

As part of the CDF validation and calibration group I was responsible for Valplots, a software package which checks the quality and for possible bugs (e.g. use of wrong calibration constants) of the offline reconstruction of data. The package looks for physics objects like electrons, muons, Jets, J/ψ or detector oriented quantities like tracks in the vertex or central tracking detectors. The same batch job resulted in the calculation, with high precision, of the beam profile and position using the silicon vertex detector (SVX). In addition, the Luminosity of each file was calculated. Using data provided by Valplots one could also track the long term performance of the detector and understand e.g. the degrading tracking performance with higher integrated and instantaneous luminosities. Besides developing monitoring programs one had to develop DEC/DCL scripts to run large jobs on thousands of tapes.

3.2 Hardware

Together with Richard Kadel I worked on developing a photo-detector for detecting light in the vacuum ultra violet with high efficiency. The detector was required to work in high magnetic fields. We proposed this device for a Cerenkov detector system to improve the CDF particle identification capabilities for Run II. We tested different designs and analyzed various photo-cathode materials (KCl, CsI), different gases and different detection methods including micro gap chambers. This study required the building of a test set up consisting of vacuum system, UV-spectrometer, computer control and DAQ.

3.3 Physics Analysis

Until November 1995 I served as convener of the CDF B mixing group. Together with Manfred Paulini I organized a small workshop at LBL to bring together all groups within CDF intending to work on $B\bar{B}$-mixing and to organize the effort.

I volunteered to serve as a so called 'ACE' (person who runs the DAQ during shifts). In addition I served as God Parent for three different analyses.

I was mainly working on b-lifetimes, rare b-decays and $B\bar{B}$ - mixing leading to publications in 1998.

4 <u>Feb. 1990 - Nov. 1993:</u> Working on my Ph.D thesis

During this period I worked on my Ph.D thesis as part of Giorgio Bellettini's CDF group at INFN Pisa Italy. The first year I was working in Pisa. Then in July 1991 I started to work as a guest scientist at Fermilab. This allowed me to be present during the final preparations for the Run I of the Tevatron. I was involved in the commissioning of the SVX detector which included the analysis of cosmic ray events before we got beam and analyzing beam data once the Tevatron started.

4.1 Software development

For CDF Run 1 I developed software to reconstruct tracks and vertices in the Silicon Vertex detector (SVX). The SVX detector was the first silicon vertex detector operating successfully at a hadron collider and played a central role in the discovery of the top quark and in developing a very successful b-physics program competing with and complementing the b-physics programs at e^+e^- machines.

The tracking algorithm used a progressive method. The algorithm starts with tracks from the outer tracker and updates the fit with hits found in the Silicon Tracker. The developed code worked fast and reliably throughout the duration of Run I. This work also included documenting the algorithm and bank structure as well as developing and running test suites to authenticate the functionality of the software. I was also involved in other aspects of SVX software like simulation, alignment, defining and validating the geometry, hit generation and the bank structure.

I also developed several programs to measure various performance parameters of the SVX detector (e.g. alignment, signal/noise ratio, Landau distributions, tracking efficiency, Hall effect shifts, detection of inefficient area in the detector etc.). This work was documented in several NIM articles.

I developed software to determine the position and other parameters of the Tevatron beam and maintained a data base where this information was stored. This information was used in many physics analyses as an estimate of the primary interaction vertex.

All the code was developed on VAX/VMS platforms using FORTRAN. I served as librarian for the SVX code repository.

4.2 Physics analysis

I did several Monte Carlo physics studies regarding top and b-physics for CDF and LHC. My Ph.D thesis was the first physics result of Run 1a fully utilizing the SVX detector and the first b-lifetime measurement at a hadron collider.