SESSION A: DATA ANALYSIS & PRESENTATION

PAPERS

A123

A Fast Track Finder

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Speaker: Yepes, Pablo
Keywords: algorithms, analysis, C++, desktop computing

An algorithm for fast track pattern recognition in a high track density medium is presented. The code was developed for heavy ion experiments with thousands of tracks to be reconstructed. Its main features are an optimized data organization and a conformal mapping to speed up fitting procedures. The algorithm is applied to a generic collider detector. Reconstruction times of a few hundred microseconds per track are achieved while obtaining good track finding efficiencies and momentum resolutions.

A126

On the kinematic reconstruction of multiparticle events

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Speaker: Bukin, Alexander
Keywords: algorithms, analysis

Kinematic reconstruction of multiparticle events with special parameterization of likelihood function is considered. For those cases when approximate form of angular part of likelihood function is acceptable, the analytical solution for optimal general rotation was found, that allows to decrease the total number of free parameters by three rotation angles and strongly simplifies the likelihood function profile.

A169

On the treatment of energy loss in track fitting

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Speaker: Fruehwirth, Rudolf
Keywords: algorithms

The energy loss of electrons in matter is characterized by a distribution which is strongly non-Gaussian. The Kalman filter is therefore not the optimal track fitting procedure. We show that the estimation of momentum can be improved by using non-linear methods like the Gaussian-sum filter and the Metropolis–Hastings algorithm. We report results of a simple simulation experiment and comment on the respective merits of these methods.

systems will automatically optimize data storage based on access patterns to provide efficient data retrieval for CMS physicists throughout the collaboration.

* Software: Our software solution is based on a hierarchy of types of software, with a professionally engineered framework into which physics modules may be inserted; on a greater reliance on software engineering to cope with the increasing complexity of the software systems; and on new modern programming languages and methods which provide tools for solving our software problems, in particular for now C++ and Object Oriented Programming.
* People: In order to make use of the talents of our highly dispersed collection of physicists, we will make use of new methods for managing software activities, for code management and distribution, and for collaborating at a distance. These methods may require greater discipline than software activities have required in the past, but the payoff in increased productivity for the experiment should be well worth it.

A final key element of our plan is to manage the transition from current programming practices to the new languages, programming methodologies, data access methods and collaboration tools that will be in widespread use when the experiment runs but will need to be creatively phased in during the period of detector construction as detector design, simulation, and test beam activities continue to require continuous computing support.

A210

OPAL, an Open Physical Analysis Language

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Speaker: Shamov, Andrei
Keywords: analysis, programming languages, software tools

The last fifteen years of HEP showed that the PAW program developed in CERN is an excellent tool for data analysis. A drawback of it is the existence of the two different languages an user has to use. Writing the KUIP macro, one is lacking of the FORTRAN power and flexibility. Writing FORTRAN code for COMIS, one can not employ convenient KUIP commands and has to call of HBOOK and HPLOT routines directly.
The author attempted to invent a single language which includes simple and convenient commands for histogram booking, filling and plotting together with most important FORTRAN-77 operators. The best way to solve the problem was developing of an OPEN language expandable with user-defined commands. OPAL has extended DCL-like syntax with qualifiers and multi- level command parameters allowing to describe almost all FORTRAN-77 operators.
The OPAL compiler/interpreter can be linked with any application. To introduce a language statement an user should call the subroutine to describe the syntax and supply the procedure performing the actions required. The user can predefine a set of variables, arrays and functions which will be available in interactive sessions together with dynamically created objects.
On the base of OPAL the XBOOK interface to HBOOK, HPLOT and HIGZ packages was developed. XBOOK uses specific approach to histogram filling which allows to control the filling process interactively and speeds it up. OPAL and XBOOK are used a few years in on-line and off-line applications for CMD-2 and KEDR experiments at BINP storage rings. At the moment they are available under VAX/VMS only.

A214

Hadronic Interactions in GEANT4

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Speaker: Wellisch, Johannes-Peter
Keywords: C++, object-oriented methods, simulation, simulation tools

Simulation of hadronic showers has been a field of strong activity for many year. Today we face the challenge to maintain through a change in software technology the knowledge and experience collected

A198

Superresolution algorithms in discrete detectors and its testing for the silicon drift detectors data

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Presenter: Kosarev, E.L.
Keywords: algorithms, analysis, data acquisition systems

It is shown that the recovery of particle coordinates by detectors with intrinsic resolution determined by the point spread function and finite size of detector bins can be reduced to solution of the standard deconvolution integral equation with modified point spread function. Two approaches is proposed and investigated for this problem: parametric and nonparametric ones. Algorithms based on maximum likelihood method [1] and its testing for both approaches are given. It was shown that both algorithms can resolve the coordinate of particles with resolving power better than the size of detector bin and the point spread function characteristic scale. It was also demonstrated that superresolution efficiency of the parametric algorithm is attained the Cramer-Rao limit and the Shannon's limit for the nonparametric algorithm [2]. Some examples are presented for the silicon drift detector used at CERES/NA45.

[1] G.Akakishiev, G.A.Ososkov et al. Cherenkov ring fitting techniques for the CERES RICH detectors. *Nucl. Instrum. Methods Phys. Res., A*, Vol.371, No.1-2, pp.243-247, 1996
[2] E.L.Kosarev. Shannon's superresolution limit for signal recovery. *Inverse Problems*, Vol.6, No.1, pp.55-76, 1990

A212

LCE, Light Collection Efficiency simulation tool

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Presenter: Shamov, Andrei
Keywords: simulation, simulation tools

The LCE code simulates main physical processes essential for light collection in Cherenov and scintillation detectors: light reflection and absorption on detectors walls, absorption and scattering of light in radiators and light guides, re-emission of light by wave length shifters.
For simulation in the LCE frame a detector must be described as the set of blocks, the space regions limited by pieces of plains of second order surfaces. Each blocks must have constant optical parameters. These parameters can have arbitrary depen- dence on the light wave length.
As input language LCE employs the specialized version of OPAL (Open Physical Analysis Language), the command language develop- ed in BINP for data acquisition and analysis systems of the KEDR and CMD-2 detectors. The language includes most important FORTRAN-77 operators and can be expanded by an user at the link- ing stage or interactively.
OPAL is used both for the detector description and the simu- lation process control. Using of OPAL allows one easily describe complex detector, dynamically (without program relinking) speci- fy dependence of the optical parameters on the wave length and simulate physical processes or their modes which were not foreseen in the program.
LCE was used for design of the Cherenkov counter for KEDR and BaBar detectors. The simulated detector parameters are in agree- ment with the measured ones. Currently it is available under VAX/VMS only.

A298

ATGEN interface to event generation and analysis: structuring and reusing common procedures

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Presenter: Amorim, Antonio
Keywords: simulation, simulation tools, GUI's, world-wide collaboration, WWW applications

Event generators will play and important role in extracting the physical meaning of LHC data. The ATGEN package interfaces to generators of both the parton shower (PHYTHIA,ISAJET,HERWIG) and matrix elements type (NJETS,VECBOS) in a manner that tries to simplify the required changes in user behavior to go from one generator to the other while strictly respecting their physics contents. It allows data to be stored and feed both into the GEANT detector simulation and analysis.
While the analysis is easily extensible to the different generators, creating large problem specific user routines does not encourage the writing of reusable code that could be shared efficiently, helping to define relevant detailed analysis information.
To obviate this problem, generic analysis routines are included in the package and their input control statements form the prototype of a syntax that selects particles in the event record and computes the required kinematic variables including reconstructed decays. Event selection at generation level is implemented by requiring that particles meeting specified conditions must be present. Simple parameterisations of detector performances are also available. Although some very specific problems still have to be coded in the user routines, one finds that simple input statements can do large chunks of the analysis automatically, structuring the procedures in reusable form.
The interface input syntax has to cope with both a large number of options and parameters to tune each event generator and the specificity of driving the user analysis for different channels. Using WWW, a simple CGI graphic tool was designed that assists in building the input statements while providing direct links to the generator documentation. It is also managing a database of user procedures that further simplifies the diffusion of relevant detailed information on analysis for each channel.
The long time scale involved in LHC stresses the importance of being able to reproduce previously simulation data implying, as part of our work, a code management mechanism for the different generators.
The importance of event generation for LHC, together with the necessity to spread the task oven an unprecedented large community of users, makes it necessary to have the tools to avoid lengthy user specific code whose options may not be structured and documented. The ATGEN program, together with its CGI interface are a first attempt to evaluate the requirements of a future system were abstraction and reusability together with directly documented tuning should be the main goals. An option being investigated would evolve the CGI interface into a simple case tool, writing user code according to the specified options that may be compatible with future OO class libraries.

A391

Event reconstruction algorithm for BGO endcap calorimeter of CMD-2 detector

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Presenter: Kazanin, Vasilii
Keywords: algorithms, analysis, simulation, trigger algorithms

An event reconstruction algorithm for BGO endcap calorimeter of CMD-2 detector is described. Detector operates on VEPP-2M electron-positron collider with c.m. energy range from 0.36 to 1.4 GeV.
The calorimeter consists of two endcaps, built of rectangular BGO crystals. Crystal size is $25*25*150mm^3$ that corresponds to 13.5 radiation length for normal incidence. Total number of crystals in the calorimeter is 680. The presence of 1T magnetic field caused the use of vacuum phototriods for light readout. They can operate in high magnetic field, but their current gain is about 10 only, instead of $10^5 - 10^7$, typical to PMT.
The low gain and relatively low lightoutput for BGO crystals cause substantial electronic noise level of

about 1 MeV per channel in average. The contribution of electronic noise to energy resolution is especially important for CMD-2 calorimeter due to low energy of photons to be detected. Maximum photon energy is 700 MeV, while in the most interesting reactions, such as radiative decays of light vector mesons, photons have typical energies of 100 MeV. Due to these reasons a special algorithm with detailed noise consideration is needed. Algorithm has been realized as a set of subroutines included into general CMD-2 event reconstruction program. The main feature of this algorithm is that selection criteria are tuned individually for each crystal as a function of measured electronic noise. Noise measurement is performed during data taking approximately once per week. Two selection criteria for triggered crystals are used in the algorithm: absolute energy deposition and ratio of signal to electronic noise sigma. Soft selection marks crystal hits. Reconstruction of event in the calorimeter begins with the formation of cluster nuclei. Cluster nucleus is formed of standing side by side crystals, which have passed hard selection. Afterwards cluster is built from cluster nucleus by adding all neighbouring crystal hits. To prevent information loss all crystal hits which don't belong to any cluster are saved separately. Energy, position and other parameters of clusters are calculated after each stage.
Reconstruction program uses HEPDB data base to extract calibration data, noise data and parameters of calorimeter data storage. Reconstruction code is used on SGI Super Server Challenge-L. The algorithm has been tested with simulated events and has been applied to elastic electron-positron scattering and cosmic events. Preliminary energy resolution for endcap calorimeter is 6% for 510 MeV electrons produced by elastic scattering. Algorithm provides good resolution and stability.

A397

An Object-Oriented Approach to Vertex Fitting

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Presenter: Mitaroff, Winfried
Keywords: algorithms, analysis, application programming, C++, object-oriented methods

The analysis of data from a high-energy collider like LEP, HERA, BaBar or LHC requires sophisticated statistical methods in order to exploit the precision of modern complex detectors. The high spatial resolution of semiconductor vertex detectors has made it possible to identify and fit secondary vertices and their associated tracks from decays as short-lived as b hadrons.
For this task, a package has been developed by one author (W.M.) for the DELPHI detector at LEP, based on the robust "M-estimator". Its superiority over conventional estimation methods (least squares resp. Kalman filter) has been shown with simulated and real data in an earlier study [1].
The package, originally written in Fortran-77, is presently being recoded by one author (P.S.) in C++ using the CLHEP class library, with the aim of a general-purpose detector-independent tool for an OO environment like the one defined by the emerging LHC++ standards.
[1] Fruhwirth, Kubinec, Mitaroff, Regler: Comp.Phys.Comm. 96 (1996) 189.

HP-UX).
At its core the ROC component is built on an interpreter for the Tcl scripting language. The Tcl interpreter is extended by the Itcl package which allows for an object oriented approach to Tcl scripting. More importantly the Itcl package allows Tcl methods to be directly linked to C functions, thus providing the speed and optimization necessary for certain critical ROC functions. In our implementation the Tcl core handles standard file and database access as well as inter-process "control" communication while embedded C procedures handle high speed data transport and buffer management.
By itself the CODA ROC software can be used as a stand-alone data acquisition system. Two separate readout "lists" can be dynamically loaded into the ROC as part of its configuration. The primary list contains routines necessary to access the Front-end hardware as well as interrupt service routines that can be driven by multiple external trigger sources. The optional secondary readout list contains routines that asynchronously take events from the primary list and perform some user specified analysis (e.g. compression, sparsification, histogramming etc.). The modified events are finally passed to the third stage of the ROC where they are output to a user specified option such as a disk file (local or nfs) or a network data link to a CODA Event Builder component.
In this talk we will present details on the software architecture of the ROC and it's real-time performance in several supported hardware platforms including both 680X0 and PowerPC 60X VME single-board CPU's (from Motorola and Radstone). Readout performance from FASTBUS (via the Struck SFI/340) and CAMAC (via the Kinetic Systems 3922/2917) will also be presented.

B399

High Performance Computing Nodes Using a DEC Alpha Processor and a T9000 Transputer

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Presenter: Heeley, Roger
Keywords: data acquisition systems, switches (eg ATM, trigger systems)

The T9000 Transputer has been used successfully in the CPLEAR experiment at CERN to perform on-line event reconstruction. Its computational performance was found to be poor compared to the latest generation of microprocessors. However, when integrated into networks using STC104 packet switches, it achieves a scalable communications performance which compares favourable with current distributed memory computers.
Modern state of the art microprocessors offer high computational performance, several hundred MIPS or MFLOPS, using high clock speeds and pipelined superscaler architectures, but lack scalable multiprocessor communications capabilities.
A high performance computing node has been designed and constructed using a T9000 Transputer as a communications controller for a DEC Alpha 21066A microprocessor. Such a hybrid node combines the two complementary strengths of the two processors into a so called TransAlpha module.
The event reconstruction program used by the CPLEAR experiment has been ported to the TransAlpha and successfully run on a small network. Its real time performance and reliability have been demonstrated. The approach adopted by the TransAlpha modules is being further investigated within the framework of the ATLAS experiment.

B401

Data Acquisition System of SND experiment

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Presenter: Bukin, Alexander
Keywords: control systems, data acquisition systems, trigger systems, large systems

Data Acquisition System created for the experiments with a non magnetic Spherical Neutral Detector (SND) at the VEPP-2M collider at Budker Institute of Nuclear Physics (BINP) in Novosibirsk is presented.

Electron-positron collider VEPP-2M is the world only machine in a pre-phi-factory era, operating in the energy range 2E from 0.4 to 1.4 GeV, covering the energies of resonance production of lightest quarkonia: rho, omega, phi. The maximum luminosity of the collider depends on its energy, and at the energy of 2E=1000 MeV is equal to $3 * 10^{30} cm^{-2} * sec^{-1}$. SND began data acquisition in the early 1995. The physical program of the experiments requires to collect several tens of inverse picobarn during two years of operation.

The readout part of the SND data acquisition system is based on the fast bus-based electronics KLUKVA, developed in BINP specially for the purposes of the detectors CMD-2, KEDR and SND. The system has a three-lever trigger. The first two levels (FLT & SLT) are implemented in hardware. They are tightly integrated with the timing and control scheme of KLUKVA readout electronics. The Third Level Trigger (TLT) is implemented as a special fast computer code running on the main data acquisition computer. This trigger checks and rejects events background before recording. In addition TLT identifies collinear events of BhaBha scattering and two gamma annihilation. These events are used to monitor collider luminosity. The electronics of the other parts of the system is housed in CAMAC crates.

The software of the data acquisition system is implemented in a distributed computing environment, including two VAXservers and two VAXstations running under VAX/VMS operating system, SPARC and Pentium workstations running under UNIX. The software is designed according to the functional-modular approach. Some components were taken from the CERN/MODEL project, the others - were specially developed for the SND DAQ system purposes.

DAQ system consists of two layers. The front-end part of the system, requiring direct access to the detector electronics hardware is running on VAX-server, the main DAQ computer. The detector data are read from readout electronics into this computer via a specially designed interface module, then they are checked by TLT, and, finally, written into the output disk file. After the end of each run the new file is submitted to the remote recording system. Some portion of the events is used by built-in DAQ system processes to monitor the electronics and detector behavior. The remote recording system serving for the experimental data archiving and as interface to the OFFLINE data processing system is running on the VAX/VMS cluster consisting of two workstations. The back-end software is implemented at the UNIX workstations. This code implements the run control, online monitoring, and DAQ system parametrization.

The current version of the data acquisition system allows to process the detector events with a maximum rate up to 40 Hz. During the first years of experiments with SND there were acquired about 5 inverse picobarn of experimental data. In the nearest future the system will be upgraded in order to cope with planned substantial increase of the VEPP-2M luminosity.

B427

A creation of compact distributed data acquisition systems

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Presenter: Smirnov, Vitalij
Keywords: parallelization, communication, data acquisition systems, special architectures

For experimental researches on the world's first superconducting accelerator for relativistic nuclei Nuclotron alongside with such installation as the SPHERE spectrometer some rather small installations, numbering not more than 200 - 300 channels of registration are created. For organization of the data acquisition systems of these installations in majority of cases CAMAC modules are used. This circumstance allowes to use a lot of modules from stack of Laboratory and to decrease a price of systems. CAMAC crates are located near detectors and CAMAC crate controllers with embedded processor are used. A local network Ethernet combines all controllers and allows to load the programs and to transfer the data. Each of controllers works in parallel and carries out independent function of data acqiusition for some group of detectors and passes the data to the control workstation.

C235

Experimental Data Management System for SND Experiment

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Presenter: Bukin, Alexander
Keywords: data management, file systems, hierarchical storage management, mass storage

The Spherical Neutral Detector (SND) is a facility for experiments at the VEPP-2M e^+e^- collider in Novosibirsk, Russia. SND detector operates since 1995 at the energy region of 0.4-1.4 GeV.
Data aquisition and processing results from detector require an access to large data storage media (magnetic tapes). To provide simple and reliable access to the data on tapes the program for Experimental Data Management System was developed. The program is in use since September,1993.
Main features of the program: directory structure similar to VAX/VMS or UNIX, caching files in the disk buffer, directory tree based automatic allocation of magnetic tapes, automatic allocation of recorder using information about tapes and recorders type and placement, information tags for files.
Program is working in close interaction with both online and offline systems of the detector. Calibration constant data base of the detector is partially based on information provided by the program.
Overall structure of program, its interaction with other SND software components and experience in using of this program is presented.

C294

A Simple Realization of the Entity-Relationship Model of Data

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Presenter: Bukin, Alexander
Keywords: analysis, object-oriented methods, data management, event building

The FORTRAN77 program COCHA for the data structure management is described. COCHA provides a very simple implementation of the entity-relationship model of data, including dynamic memory management, the direct access of users to COCHA banks, the algebra of relationships, and the compact event presentation. COCHA was used to develop the reconstruction code for the Spherical Neutral Detector which is in operation at the e^+e^- collider VEPP-2M in Novosibirsk from 1995. An experience of using COCHA is discussed.

C300

Use of SONY PetaSite and DTF Helical Scan Tape Drive on KEK Central Computer UNIX Cluster

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Presenter: Morita, Youhei
Keywords: data management, hierarchical storage management, large systems, mass storage

A SONY PetaSite mass storage system is being used at KEK Central Computer UNIX workgroup cluster since January 1996. This hierarchical mass storage system has a total storage capacity of 20 TB, and twenty SONY DTF helical scan tape drives, each drive has I/O throughput speed of 12 MB/sec, are connected to