

Event Processing

Stephen J. Gowdy
SLAC

Andrea Dell'Acqua
CERN

Computing in High Energy Physics 2004
Interlaken
1st October 2004

Overview

- Contributions
- Application Areas
 - Simulation
 - Trigger Algorithms
 - Data Models
 - Reconstruction
 - Graphics
 - Analysis Tools
- Observations, thoughts, questions

Contributions

- 48 Parallel Talks
 - No time to talk about everything said in 20 mins, which pick a few samples in each area
- 34 Posters
 - Not going to talk about posters

LOG Generator

P. Bortolotti (University of Florida)

2 September 2004

Review of Recent Applications of the FLUKA MC in High Energy and Accelerator Physics

2 September 2004

Geant 4

Precision Electromagnetic Physics in Geant4
Atomic-Relaxation Models

http://www.g4.org/Geant4/index.html

Adding Kaons to the Bertini Cascade Model

Dennis Wright (SLAC) and Aatos Huickinen (HIP)
Interlaken, Switzerland
27th September - 1st October, 2004

FASOS : a Fast Monte-Carlo Simulation for CMS

Flavia Bianchi (CERN)
CHEP 2004, Interlaken 27/09/04

Ion transport simulation using Geant4 hadronic physics

Kai Takami (SLAC)
And Geant4 Hadronic Working Group

GEANT4: Status and recent developments

John Apostolakis, CERN
Makoto Asai, SLAC
for the Geant4 Collaboration

Overview and new developments on Geant4 electromagnetic physics

V.Vanochenko for Geant4 EM group
CHEP 04
Interlaken, Switzerland
27 September 2004

Update on the Status of the FLUKA Monte Carlo Transport Code (Including Space Applications)

2 September 2004

Synergia: A Modern Tool for Accelerator Physics Simulation

P. Spentzorovic & J. Amundson
CHEP 2004, Interlaken
September 27, 2004

Physics Validation of the Simulation Packages in a LHC-wide effort

Alberto Ribon
CERN PH/SFT
on behalf of the LCD Simulation Physics Validation group

ATLANTIS: An Event Display for the ATLAS Experiment

CHEP, Interlaken, 30th September 2004

CHiral - 3D massless partons

Invariant Phase Space
Quark-Gluon String Pictures
http://webhome.crk.or.jp/~chiral/CHiral_Preview.html
Mikhail Kosov for CHEP September 2004

Panoramix

A visualization environment for LHCb

The GeoModel Toolkit for Detector Description

The GeoModel
Mark Taylor
University of Edinburgh

The Virtual Geometry Model

I. Hrivnacovic
20th Group
Conference for Computing in High Energy and Nuclear Physics, September 30 September 2004

IGUANA Interactive Graphics Project: Recent Developments

CHEP04

The ZFX Global Tracking Trigger Barrel Algorithm

Mark Sutton
University College London
30th September 2004
On behalf of the ZFX-L0T1 group
2004 Workshop, University of Glasgow, MSPH, University of Oxford
University College London, Yale

Fast reconstruction of tracks in the inner tracker of the CBM experiment

Mark Kralj
The CBM Collaboration
University of Zagreb, Croatia
University of Jyväskylä, Finland
University of Mainz, Germany
University of Tübingen, Germany
University of Würzburg, Germany
University of York, UK
University of Zürich, Switzerland

The New BaBar Analysis Model

David Nathan Brown
Lawrence Berkeley National Lab
Representing the BaBar computing group

Mesh Reconstruction in CMS

Full Event Reconstruction in Java

"From 0 to analysis in 15 minutes!"
Norman Graf (SLAC)
for the LCD development team
CHEP 04
Interlaken, Switzerland
Sep. 30, 2004

Test of ATLAS Inner Detector Reconstruction Software Using Combined Test Beam Data

Mark Jose Costa, Wolfgang Leißig
on behalf of the ATLAS Inner Detector Software Group

Track reconstruction in high density environment

I. Belikov, P. Hristov, M. Ivanov, T. Kühr, K. Safarik
CERN, Geneva, Switzerland

Python-based Physics Analysis Environment for LHCb

G. Basso, M. Frank, P. Mato, E. de Oliveira, A. Tsagaropoulos, I. Belyan
CHEP 2004, Interlaken, Switzerland

Writing Extension Modules (Plugins) for JAS 3

Mark Donatzenmann
Timo Hoffmann
Wolfgang Leißig
Max Turr
CHEP2004, 27 September-1 October 2004, Interlaken, Switzerland

WIRED 4 An extensible generic Event Display

Mark Donatzenmann
SLAC, Stanford, U.S.A.
CHEP2004, 27 September - 1 October
Interlaken, Switzerland

JASSimApp plugin for JAS3: Interactive Geant4 GUI

Satoshi Wada (SLAC) - presenter
Donatzenmann, M. (SLAC)
Johnson, T. (SLAC)
Kobayashi, S. (Osaka University of Education)
Makino, K. (DESY)
Nagayama, S. (Osaka University of Education)
Sakai, E. (Osaka University of Education)
Tani, H. (SLAC)
Yoshida, H. (Osaka University of Education)

Self-Filling Histograms: A toolkit for object-oriented histogram filling

Seely List, University of Wuppertal
A. Basso, E.EL Zurich
CHEP '04
Interlaken, Sept. 30 2004

- Introduction: What is an SFH?
- Design Specs: Why have we developed it?
- Simple Examples: How does it work?
- Basic Abstractions: The main ideas inside SFH
- An advanced Example
- Conclusions & Outlook

A Toolkit for Statistical Data Analysis

M. Mair, A. Pichler, M. U. Pfl, A. Böhm, P. Thurner
CHEP 2004
Interlaken, 30.09.2004
http://www.g4.org/Geant4/Tools/STAT/Statistics

Fast tracking for the ATLAS LVL2 Trigger

Nikos Konstantinidis
University College London
UCL
On behalf of the ATLAS TDAQ Group

Bayesian Approach for Combined Particle Identification in ALICE Experiment at LHC.

I. Belikov, P. Hristov, M. Ivanov, T. Kühr, K. Safarik
CERN, Geneva, Switzerland
I. Belikov
CHEP 2004, Interlaken, 30 Sep 2004

Offline Software for the ATLAS Combined Test Beam

Ade Fariello - INFN Roma3
On behalf of the ATLAS Combined Test Beam Offline Team
R. Bignelli, B. Costa, B. Di Girolamo, R. Sella, R. Steinhilber, B. Suhrmann, C. Padella, R. Fetsch, S. Roesch, A. Soldati

A Gaussian-sum Filter for vertex reconstruction

T. Speer - University of Zurich
R. Frühwirth - RWMPY Vienna
Computing in High Energy Physics
Interlaken
30th September 2004

Kinematic fit and decay chain reconstruction library for CMS

Ernst Prakhov, Ph.D. thesis
Ph.D. Advisor: Frank W. Steuber

Genetic Programming and Its Application to HEP

Computing in High Energy and Nuclear Physics 2004
30 September 2004
Edu W. Tsionas
University of York
and
YORKS Collaboration

High Level Trigger of CMS

UCL

- HLTT requirements
- General Architecture
- Evaluation Sequence
- HLTT Strategy
- Configuration of HLTT
- Handling the HLTT Data
- HLTT Implementation
- Conclusion

Fast tracking for the ATLAS LVL2 Trigger

Nikos Konstantinidis
University College London
UCL
On behalf of the ATLAS TDAQ Group

Detector simulation for the ATLAS experiment: status and outlook

2 September 2004

The Kanga Event Store for BaBar

Mathias Strode
Fakultät Universität Bochum
for the BaBar Computing Group
CHEP 2004, Interlaken

An Object-Oriented Simulation Program for CMS

CHEP 2004
30 September 2004

The Virtual Monte-Carlo status and applications

R. Basso, P. Carnazza, A. Pichler, T. Pöhl, A. Böhm, E. Nagayama, M. Frank, P. Thurner, A. Böhm

Implementation and Performance of the High-Level Trigger electron and photon selection for the ATLAS experiment at the LHC

MARCO DIAS GOMES
On behalf of the ATLAS TDAQ group
CHEP 2004
Interlaken, 1st October 2004

Event Data Model in ATLAS

Alberto Ribon (CERN)
On behalf of the ATLAS TDAQ Collaboration
CHEP 2004
Interlaken

H100 - an analysis framework for H1

Judith Katzy (DESY)
for the H1 collaboration

A New STAR Event Reconstruction Chain

Claudia A. Pruneanu, M. Calderin, B. Hippelke, J. Leifert, and A. Rose
STAR Collaboration
Physics and Astronomy Department
Rutgers State University

Using the Reconstruction Software, ORCA, in the CMS Data Challenge

L'orque
0,46 €
Sophie Wyss, Princeton University

Using the Reconstruction Software, ORCA, in the CMS Data Challenge

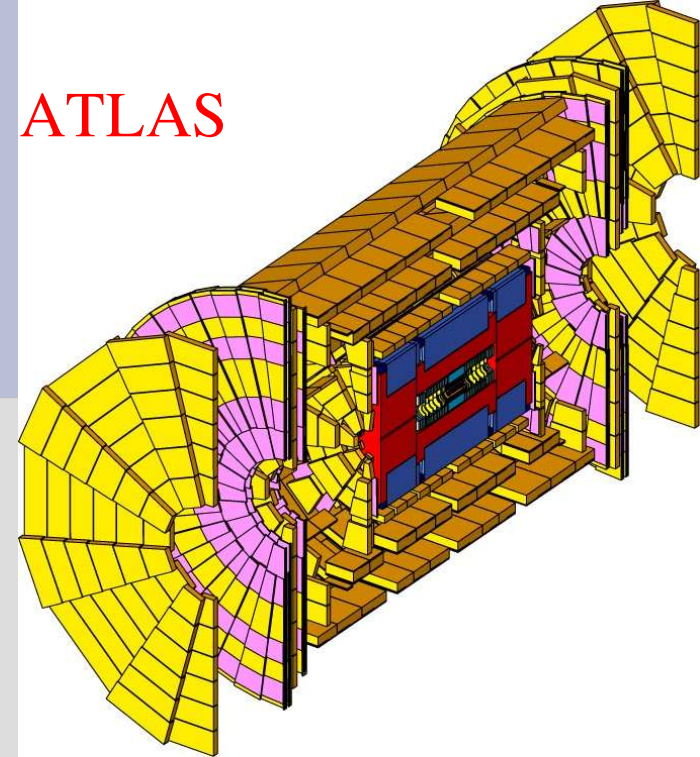
L'orque
0,46 €
Sophie Wyss, Princeton University

Using the Reconstruction Software, ORCA, in the CMS Data Challenge

L'orque
0,46 €
Sophie Wyss, Princeton University

Simulation

- Switching from GEANT3 to GEANT4
 - Both CMS and ATLAS have now switched
 - ALICE and STAR also considering FLUKA
 - Source code to be available “soon”
 - Comparisons to data show similar agreements as GEANT4
- Fast simulations a must
 - For CMS reduce minutes to < 1 s



Sliced view of CMS barrel

Parameterized Simulations

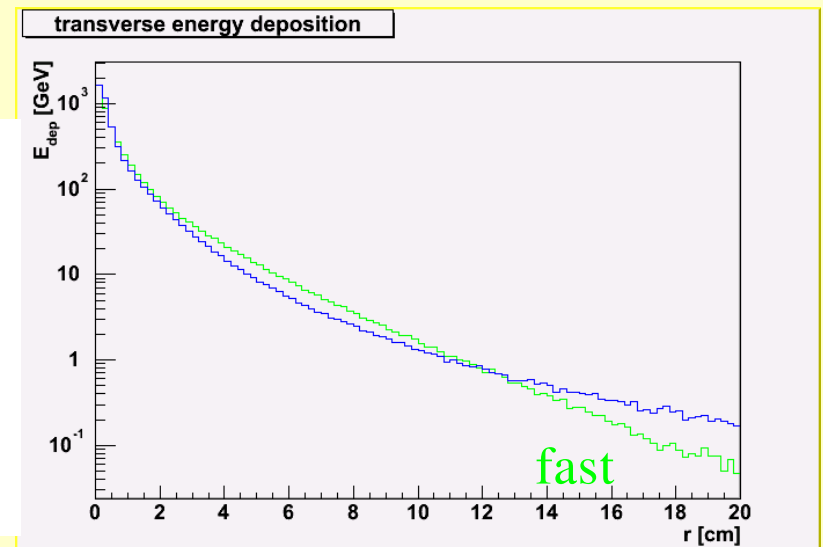
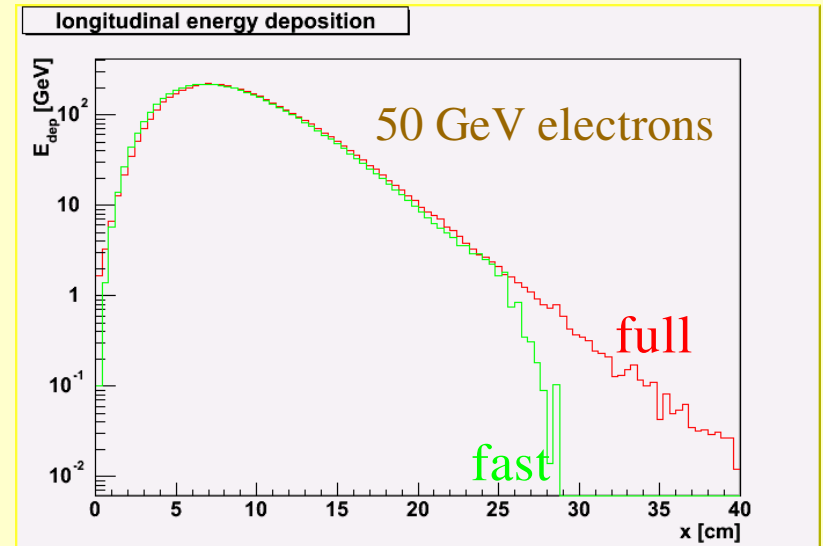
G4FLASH

Implementation of fast EM shower simulation in Geant4/OSCAR, using GFLASH parameterized showers (spot density)
- *tuning in progress*

Timing studies

Electron energy	Time/event full simulation	Time/event fast simulation
1 GeV	0.8 s	0.5 s
10 GeV	1.9 s	0.6 s
100 GeV	16 s	0.7 s
300 GeV	57 s	1.0 s

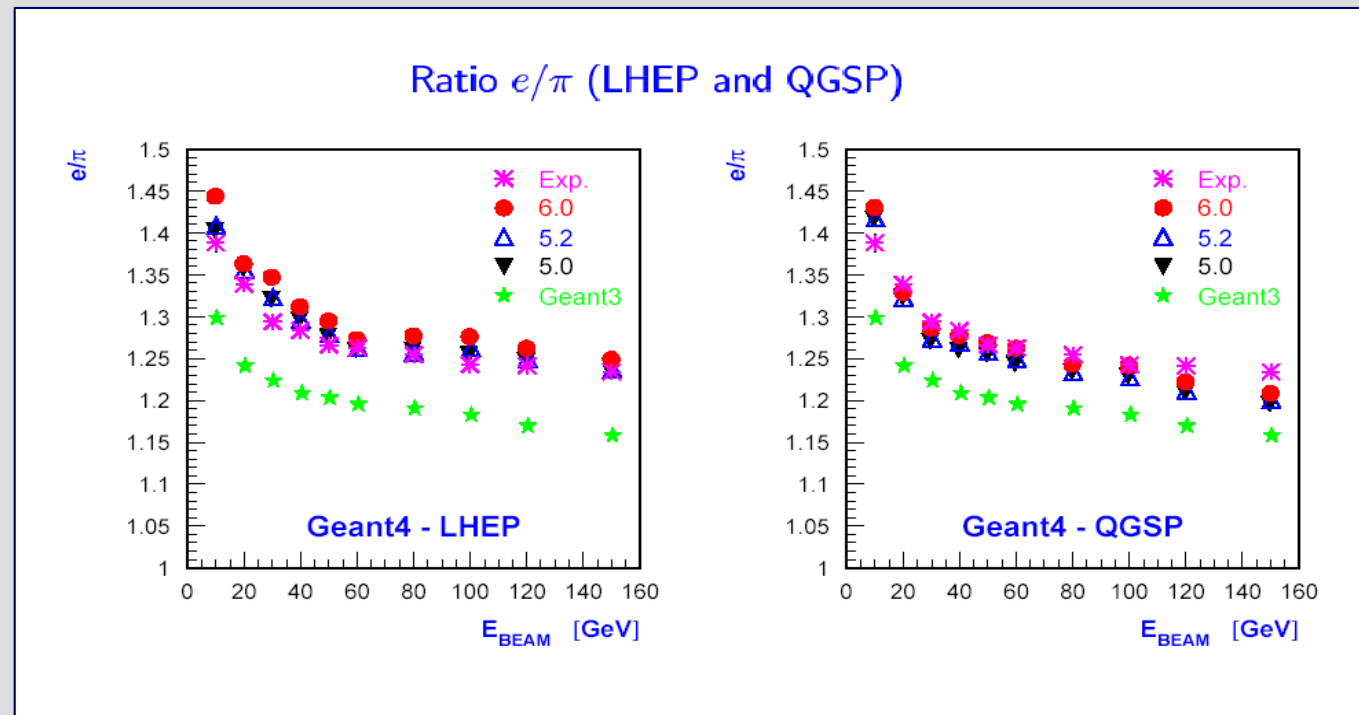
Geant4 6.2



Simulation (Cont.)

- A lot of work done on data validation
 - EM is “now at percent level, working on per mil”
- Most data/GEANT3/GEANT4 comparisons favour G4
 - but not all

ATLAS Calorimeter



Acceptance suite for Standard EM package

- ▶ To insure stability of results with time
- ▶ To control performance
- ▶ Is based on extended electromagnetic examples
- ▶ **G4EmCalculator is an interface to dE/dx and cross sections**
- ▶ Control on summary numbers:
 - Average energy deposition
 - Shower shape
 - Scattering angles
- ▶ Tests on cross sections and dE/dx
- ▶ Comparison of histograms (in project)



Συnergia

Summary

- Synergia is a distributable beam dynamics framework
 - incorporates and extends existing codes
 - provides job management system
 - documentation & test suite
- Already used for beam studies
- Will be extended to include more physics
 - requires some framework development

Trigger Algorithms

- Seeing some commonality in algorithms and software between high level trigger and offline reconstruction
- Work going on in optimising speed various ways
 - Fast algorithms
 - Limiting to regions of interest
 - And ...



Optimisation of the evaluation sequence

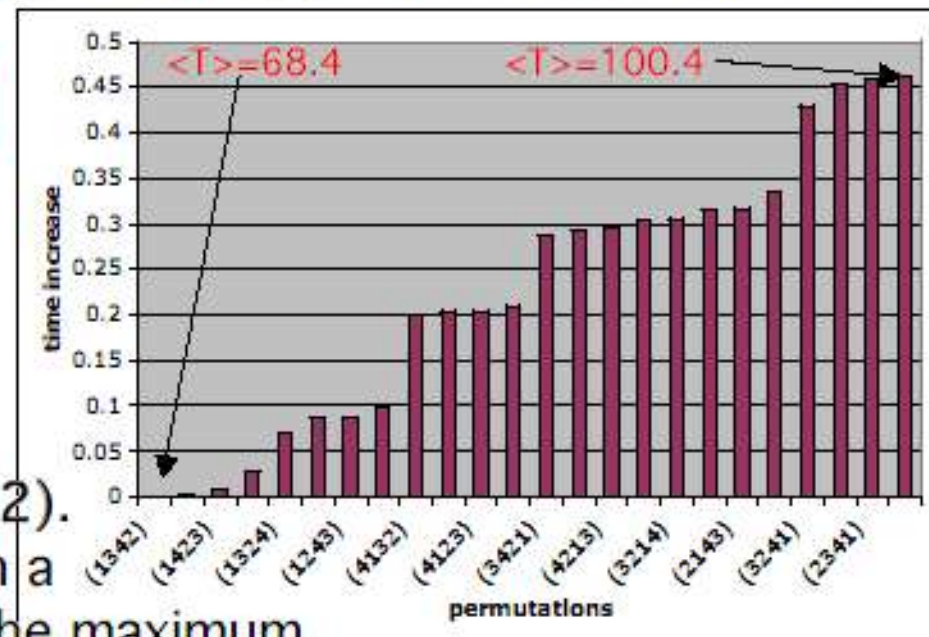
UCL

- Evaluation of all possible combination grows as $n!$
- Define an order between two sub trigger as:

$$\|kl\| < \|lk\| \equiv pa_k t_k + (1 - pa_k) pa_l (tr_k + ta_l) < pa_l t_l + (1 - pa_l) pa_k (tr_l + ta_k)$$

- Sort the sequence $\{k_1 \dots k_n\}$ according to the defined order.

bit	p_i	t_a	t_r
1	0.5	60	12
2	0.3	60	50
3	0.1	20	10
4	0.6	90	40



- Best combination is (1342). Other combination result in a time increase of 50% for the maximum

e/γ Selection – Triggering for Higgs Bosons

Results from the studies on single & double electron triggers were used to evaluate the HLT efficiency for selecting a fully simulated Higgs candidate in the range:

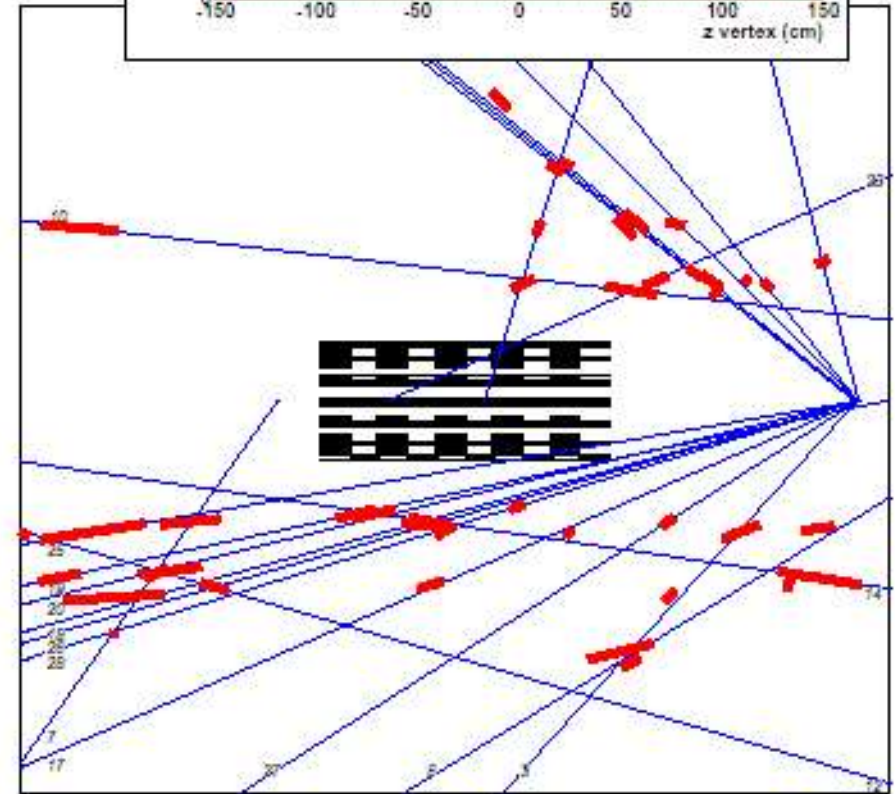
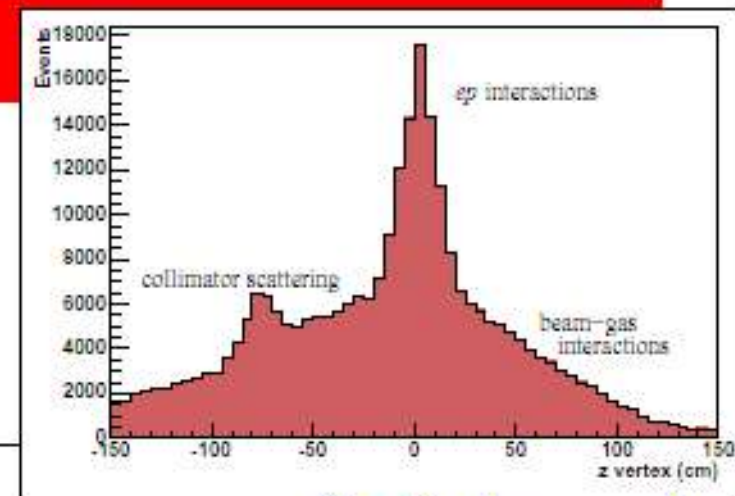
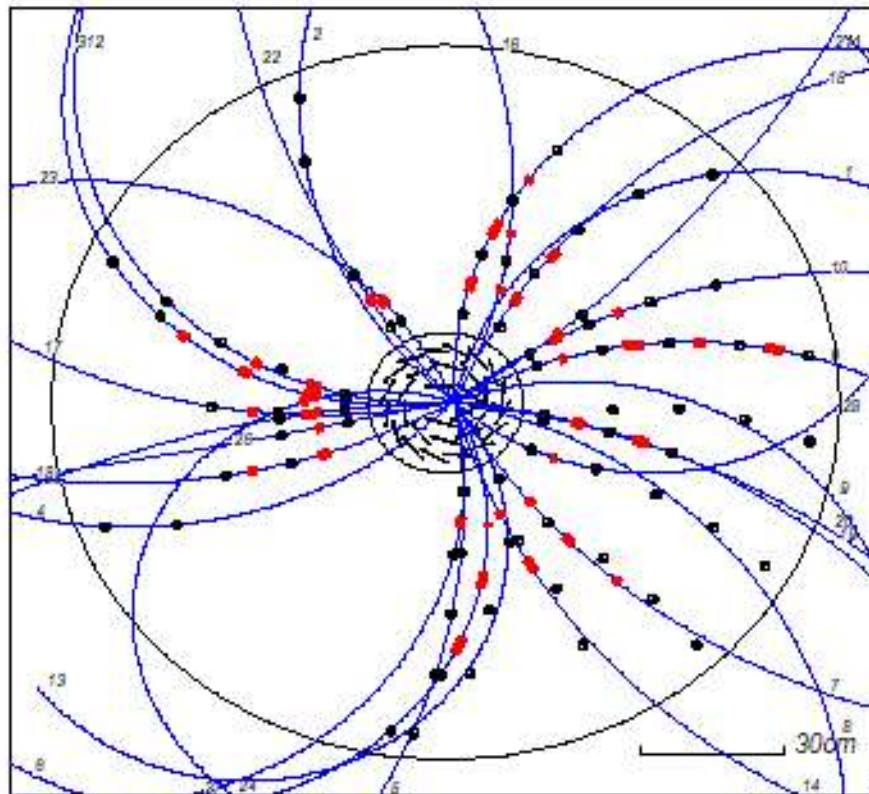
$$130 < m_H < 180 \text{ (GeV)}$$

For different combinations of trigger items, we checked the Higgs selection efficiency with respect to an initial sample*

Trigger	Luminosity	H → e _e (130GeV)
e25i	<i>Low(startup)</i>	96.5 ± 0.2
2e15i	<i>low</i>	95.8 ± 0.2
e25i or 2e15i	<i>low</i>	96.7 ± 0.2
e30i	<i>design</i>	96.0 ± 0.4
2e20i	<i>design</i>	94.5 ± 0.4
e30i or 2e20i	<i>design</i>	95.5 ± 0.3

Event Topology – Real Data (contd)

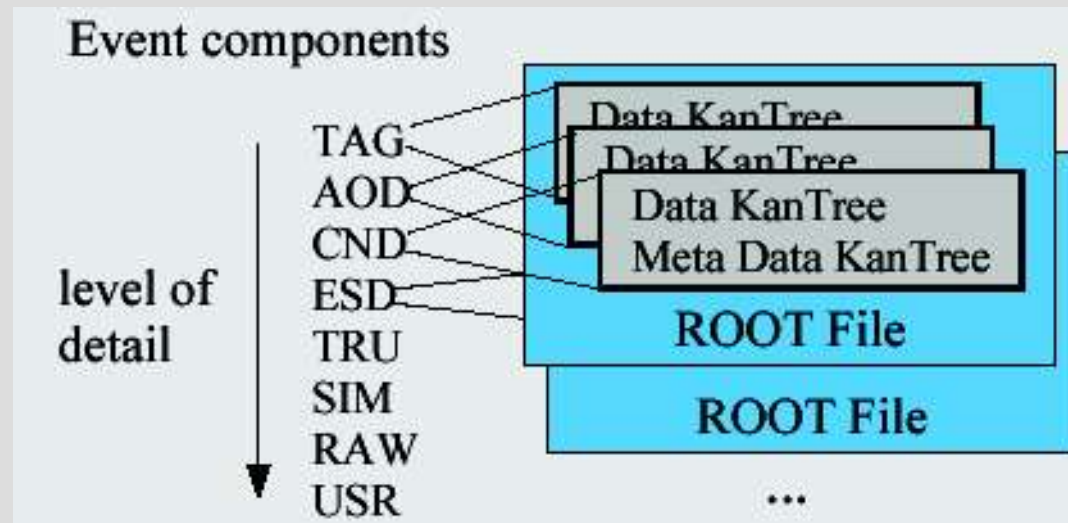
- Beamgas scattering from -80cm collimator.



Data Models

- Heard about two data models
 - BaBar's Computing Model 2
 - ATLAS Event Data Model

172: ... Kanga Event Store for BaBar
Component layout in files



150: Event Data Model in ATLAS

Distinct objects in different levels

Track

One of the most important elements in the ATLAS EDM is the common **Track** (an **ESD** level object).

It must work in a wide range of applications, from
online (where speed is important)
alignment studies (which need detailed information)
reconstruction

Tracks at **ESD** level consist of fitted measurements on multiple surfaces

It is the *output* from the fitters, and is the *input* to the combined reconstruction.

All reconstruction packages use the same track class.

For **AOD**, something more lightweight is needed: **TrackParticles** are created from Tracks:

Contain summary information about parent track (number of hits on track etc)

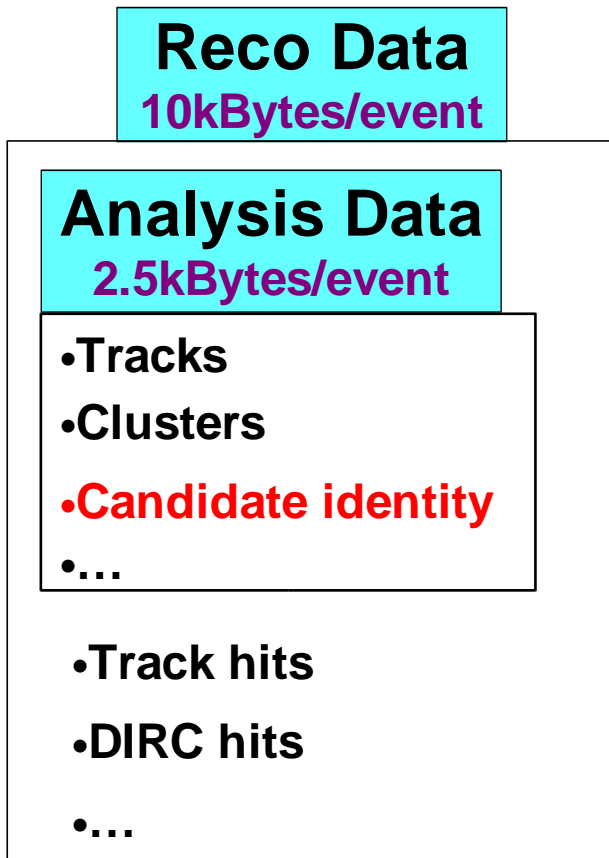
Are physics analysis objects, with 4-momenta (the class inherits from I4Momentum – in general AOD objects inherit from I4mom, and IParticle etc.)

Can be used for vertex finding, but not re-fitting etc.

Different levels are the same object

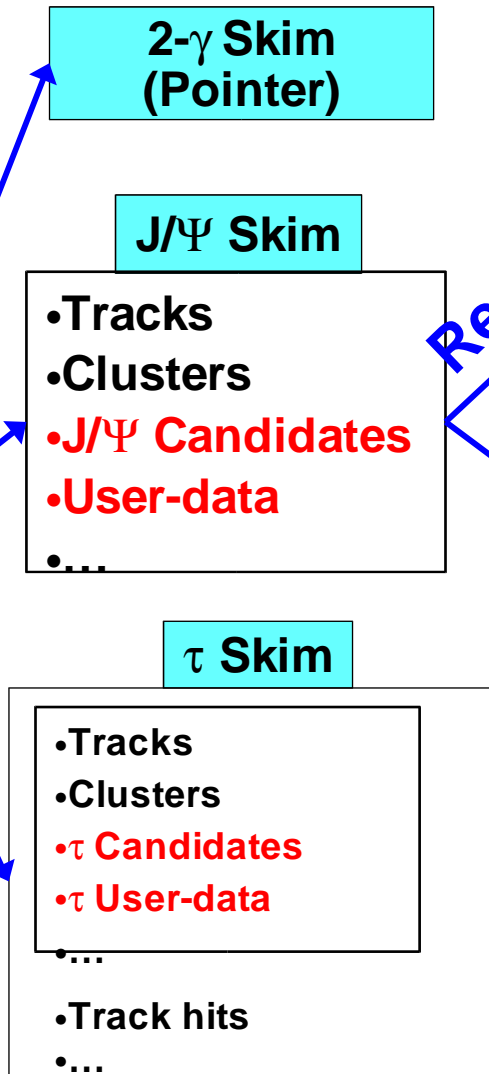
CM2 Analysis Model

Reconstruction

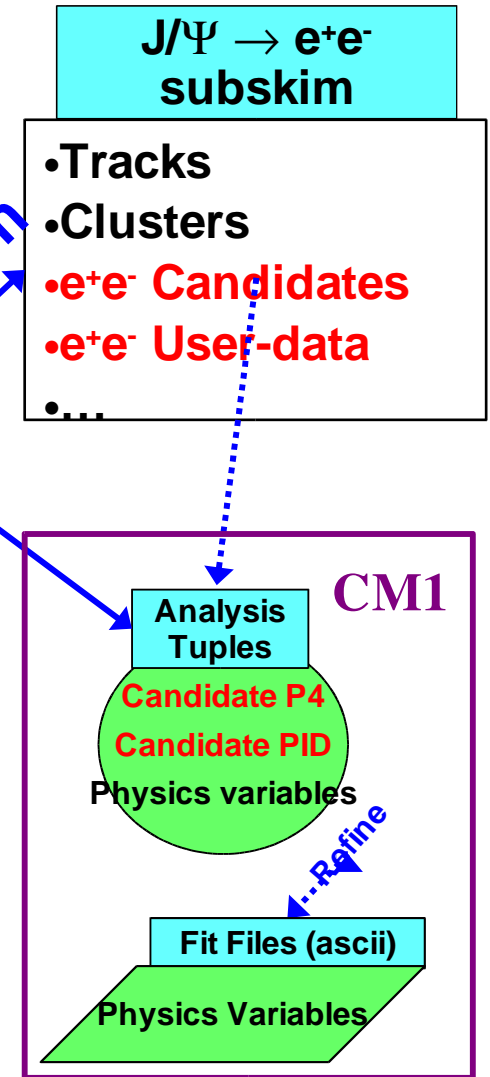


See Talk 172 for event design details

'Skim'



Analysis



Reconstruction

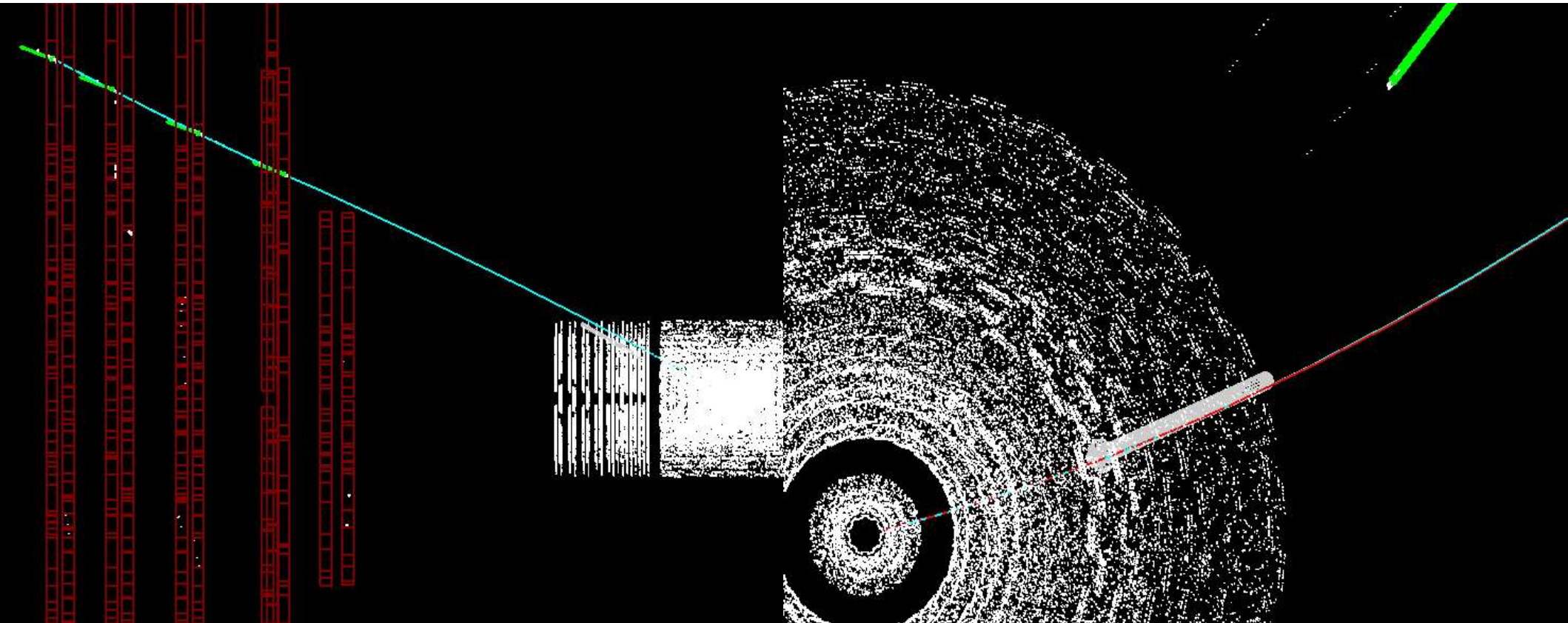
- Various track finding algorithms reported
 - Some optimised for speed
 - Others to deal with high multiplicity environments
- Much discussion also on the Vertex finding and fitting algorithms
- 405: Event Reconstruction in Java
 - Used for North American work on International Linear Collider currently
 - Believed to be only 20-30% slower than C++

227: Muon Reconstruction Software in CMS

Find potential muons in muon system

Extrapolate back to outside of inner tracker and interaction region

Open window for track reconstruction based on Level2 track



Cellular Automaton Method

1. NIM A329 (1993) 262
2. NIM A387 (1997) 433
3. NIM A489 (2002) 389
4. NIM A490 (2002) 546

Define :

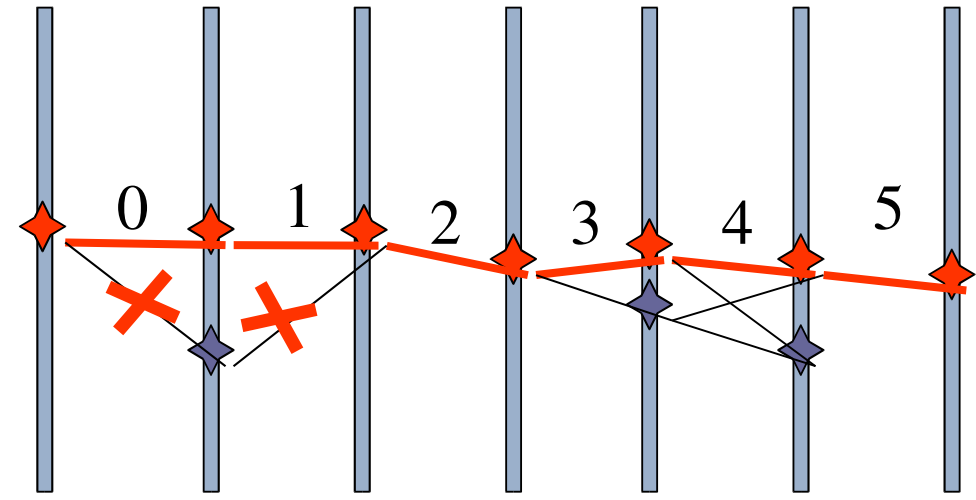
•CELLS	->	TRACKLETS
•NEIGHBORS	->	TRACK MODEL
•RULES	->	BEST TRACK CANDIDATE
•EVOLUTION	->	CONSECUTIVE OR PARALLEL

Being essentially **local and parallel** cellular automata **avoid exhaustive combinatorial searches**, even when implemented on conventional computers.

Since cellular automata operate with **highly structured information** (for instance sets of tracklets connecting space points), **the amount of data** to be processed in the course of the track search **is significantly reduced**.

Further **reduction of information** to be processed is achieved by **smart definition of neighborhood**.

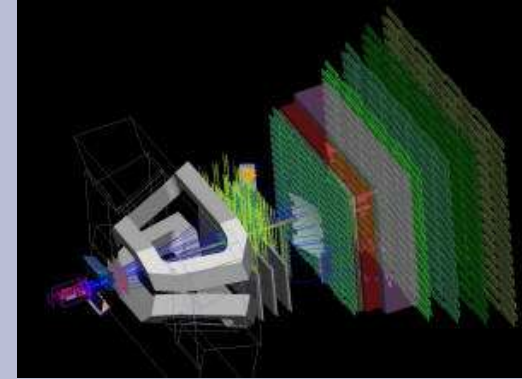
Usually cellular automata employ a **very simple track model** which leads to **utmost computational simplicity** and a **fast algorithm**.



Create tracklets

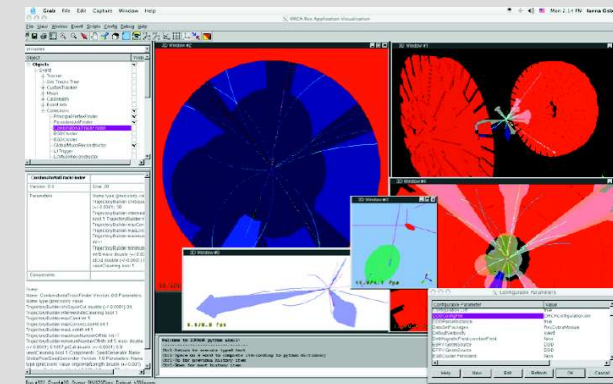
Collect tracks

Geometry

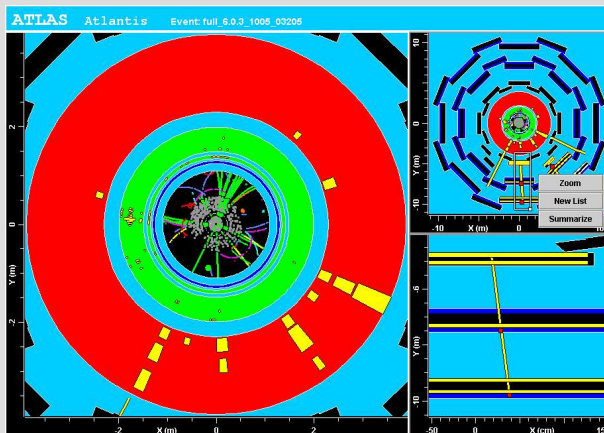


135: Panoramix ...

- Two geometry packages and four visualisation suites
- One (mostly 2D), three 3D

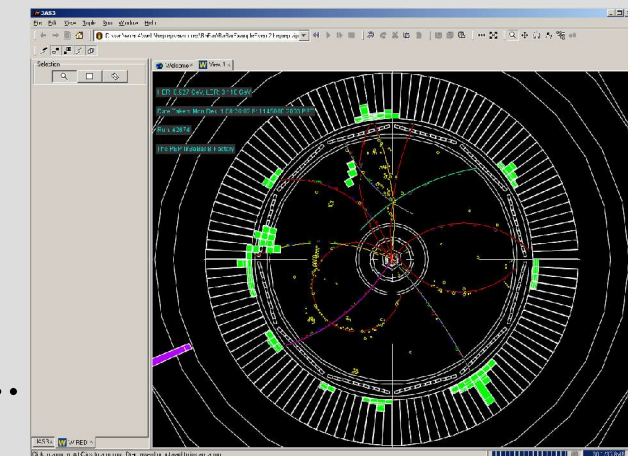


57: IGUANA ...



168: The Atlantis ...

395: Wired 4 ...



Conclusions

- The VGM introduces a general approach for conversion of geometries between specific geometry models
 - Geant4, Root TGeo, XML (AGDD, GDML)
 - This gives a possibility for a user of one specific package to use the tools supported by other packages:
 - Root TGeo => Virtual MC
 - XML (AGDD, GDML) => GraXML
- It also allows the user to define geometry independently from a specific geometry model
 - However this was not the main goal of the tool
- Available from
 - <http://ivana.home.cern.ch/ivana/VGM.html>

Analysis Tools

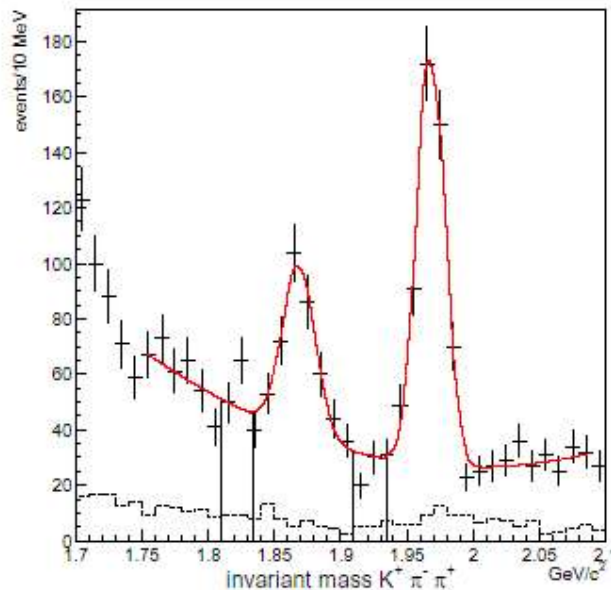
- 379: Python-based ... analysis ... for LHCb
 - No need for compilation
 - Ideal is one page of code for analysis
 - An example in the talk
- 347: ... BaBar Analysis Computing Model
 - Attempt to put all information in eventstore
 - Except the final fitting information
 - Users embracing new system

Evolved program shows where to look

Comparison with Cut Method

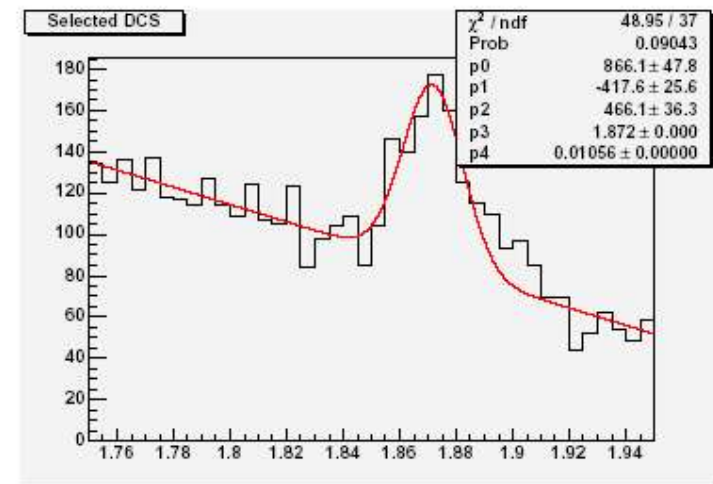
How does this compare with our normal method?

- From hep-ex/0407014, measured BR of $D^+ \rightarrow K^+ \pi^+ \pi^-$
- Not a direct comparison, not optimized on $S/\sqrt{S+B}$



D_s^+ also shown

- Similar signal to noise
- Cuts: Yield = 189 ± 24 events
- GP: Yield = 466 ± 36 events



LHC Experiments

- Many experiments making huge progress
 - Now have foundations for first system
- CMS & ATLAS produced $O(10M)$ events
 - $O(\text{day})$ worth of data but a big step
- Valuable experience from test beam(s)
 - (Only heard about ATLAS combined test beam)
 - Validating/tuning Monte Carlo
 - Detector and software experts find working relationships
 - Real data never quite the same as MC

Software Support

- Seems to be a growing “problem”
 - Upcoming experiments recognise the need
 - Ongoing experiments see loss of experts
 - Sited as one reason for FORTRAN -> C++ change
- Many reports of being memory leak free
 - Are we getting better at this?
- A couple mentions of issue of use vrs development
 - Want something stable but also need to deploy required features
 - Underscores need for at-scale test environments

Commercial/Closed Software

- Almost completely gone?
 - Did we hear the last gasp or are we missing something?
- Why?
 - Limits ability to respond to technology changes
 - At the whims of “vendor”
 - Could decide to change fee structure or no longer support product

Platforms

- Much of the software only works on Linux
 - Will this cause problems in the future?
- Alternatives?
 - Solaris
 - Has been around a while and still seen in “server” environment
 - Mac OS X
 - Growing popularity
 - Noticed on LCG poster they are now supporting this
 - Based on BSD and certainly different than Linux
 - Compiler is however the same
 - Well, could use Intel C++ on Linux

Collaboration on Software?

- Not much evidence for sharing software
 - Some good counter examples are ROOT, CLHEP and GEANT4, all “external” to experimental software itself though, not applications
- Most bad examples are copy and branch
 - eg EvtGen and BaBar Framework
- Can we do better?
- Should we?

OO Battle?

- Only legacy FORTRAN discussed
 - Still some being replaced, majority remaining seems to be physics generators
- Mostly C++
 - Some mention of going back to c?
- Java (still) mostly confined to graphics and event viewing
 - Places where performance isn't limiting factor
- Python becoming more popular
 - One big use is for quick “prototyping”

Conclusion

- Much progress in deploying initial LHC software
- Many “lessons learned” for everyone to share (or are we doomed to repeat them?)
- Very broad range of contributions
 - Trigger through analysis software
 - Only touched on a few talks, the rest are of course available on the web
- Validation seemed to be a recurring theme