ALEPH data in Key4HEP?

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Introduction

A rather long one...

The LEP Physics Program

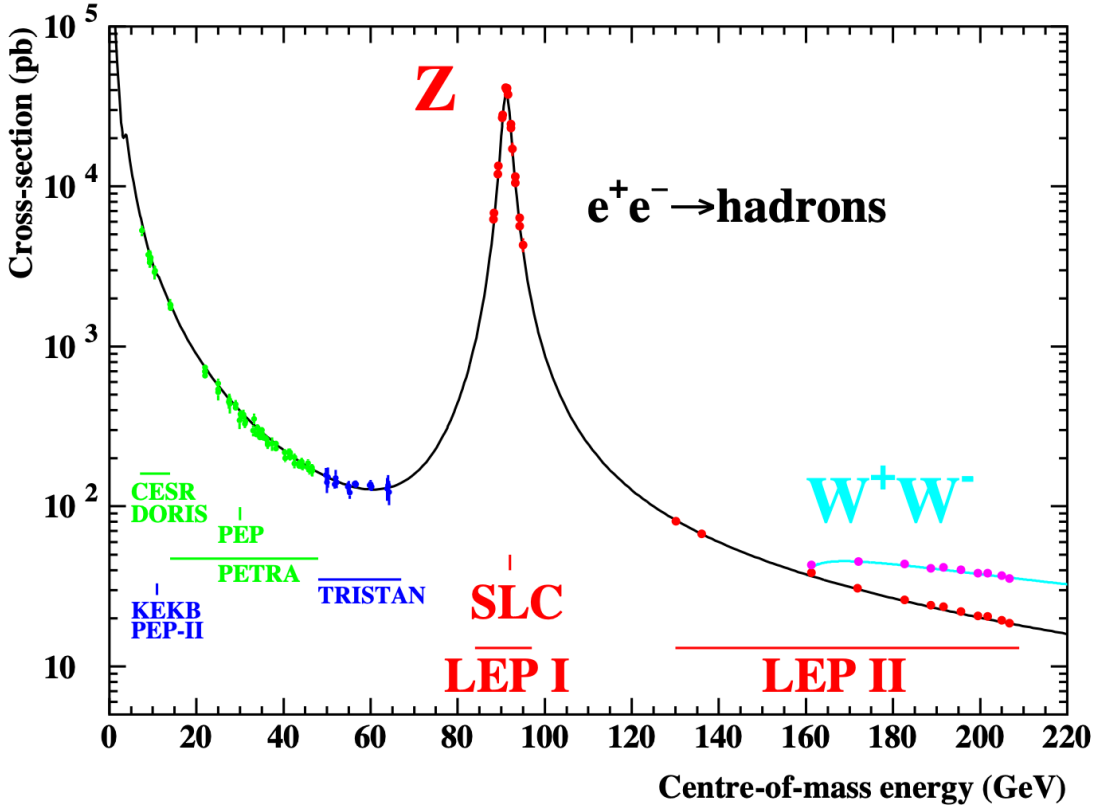
LEP runs

Phase 1 (1989-1995) :

The Z production ~ 91 GeV

Phase 2 (1996-2000):

The W-pair production 200 GeV

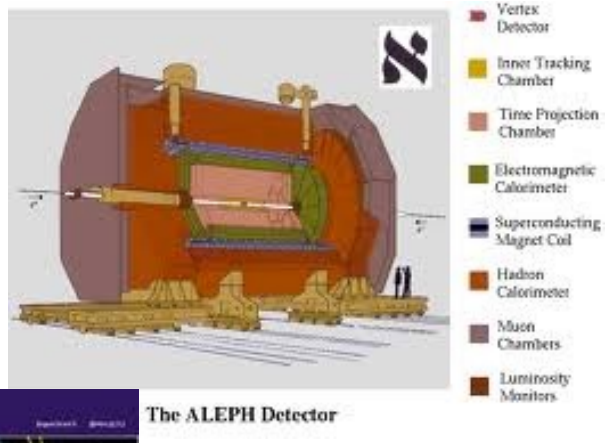


1500 physicists in 4 experiments at LEP:

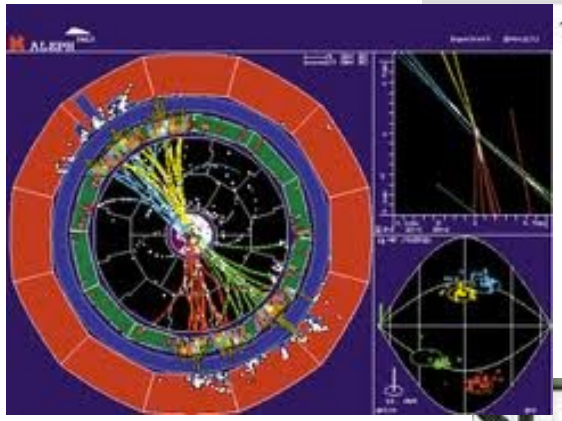
ALEPH, DELPHI, L3 and OPAL

The ALEPH Experiment

- The ALEPH Experiment is a typical “onion” experiment…
- Vertex detector and tracking, solenoid magnet, calorimetry and muon system
- Successful Energy (Particle) Flow reconstruction
- More than 300 papers were published by the ALEPH Collaboration



The ALEPH Detector



The ALEPH Data – Statistics –

Collected data

Center-of-mass energy (GeV)	Integrated luminosity (pb^{-1})	Number of representative events
91	200	$4\times10^6\ e^+e^- \rightarrow q\bar{q}$ $500\times10^3 e^+e^- \rightarrow \ell^+\ell^-$
133	12	$8000\ e^+e^- \rightarrow W^+W^-$
161	11	
172	10	
183	57	
189	174	
200	208	
206	216	

The ALEPH Data – Data Package –

Last blessed environment (Blessed = blessed for physics) is Linux SL6.

(Validation bit to bit, no recompilation needed)

- GCC 3.4
- G77 3.4
- LIBC6
- 32-bit emulation
- All the SW ALEPH uses have a CC license

  We can recompile everything on 64 bit, but no validation is available…

The ALEPH Data – Data Format –

BOS bank: fortran data structures
(Memory management system)

ADAMO DDL

```
FRFT
    :   'Global Geometrical track FiT
        NR=0.(JUL)\
        Number of words/track\
        Number of tracks'
  STATIC
   = (InverseRadi   = REAL [*,*],
      TanLambda     = REAL  [*,*],
      Phi0          = REAL  [0.,6.3],
      D0            = REAL  [-180.,180.],
      Z0            = REAL  [-220.,220.],
      Alpha         = REAL  [-3.15,3.15],
      EcovarM(21)   = REAL  [*,*],
      Chis2         = REAL [0.,*],
            egFree  = INTE [0,63],
      nopt          = INTE [0,149]
);
```

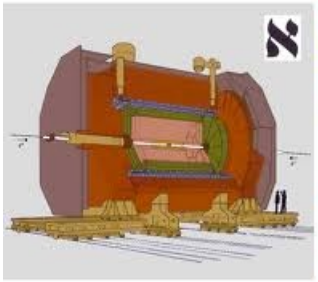
C++ CLASS

```
class FRFT {
public:
// default constructor
  FRFT() {}

  float  InverseRadi;
  float  TanLambda;
  float  Phi0;
  float  D0;
  float  Z0;
  float  Alpha;
  float  EcovarM[21];
  float  Chis2;
  int  numDegFree;
  int  nopt;
};
```

http://arxiv.org/abs/hep-ex/9911015v1

Data workflows

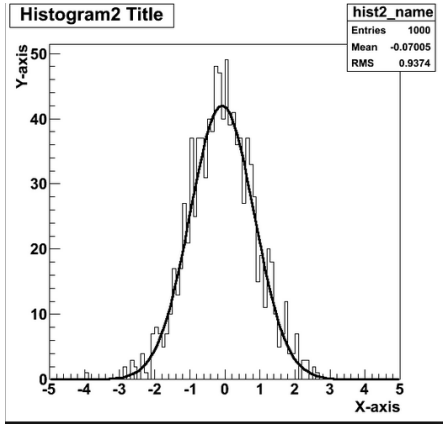


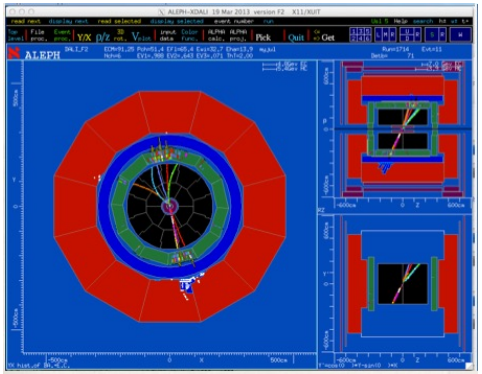
RAW DATA

Reconstructed data

Real DATA

Simulated Events





Fortran + HBOOK

User Code

Kinematic Simulation

Particle/Matter Simulation

Reconstructed Simulated Events

Various tools

Geant3 based

The Energy (Particle) Flow

- The FORTRAN Analysis Framework is Object Oriented (!)

- The Reconstructed Objects are linked to form high level particles

KEFOTY (I)
Type of energy flow objects (exclusive list, no double counting):

- 0 = Charged Track (Pion assumed, not identified either e or mu)
- 1 = Electron
- 2 = Muon
- 3 = Track from a standard V0 (either Λ, K^0_s or γ conversion) from the YV0V package
- 4 = Electromagnetic (γ or π^0)
- 5 = ECAL hadron/residual
- 6 = HCAL element
- 7 = LCAL element (No Particle Identification available for LCAL)
- 8 = SICAL element (No Particle Identification available for SICAL)

KEFOLE (I)
PECO number of associated ECAL object
KEFOLT (I)
FRFT number of associated charged track
KEFOLH (I)
PHCO number of associated HCAL object
KEFOLC (I)
PCOB number of associated calorimeter object
KEFOLJ (I)
EJET number of associated jet

The LTDP and Open Data Program

Computing Environment via emulation approach

- Currently using uCERN-VM (CVMFS)

Data to be served via POSIX to the executables

- Current approach /eos (but also other systems)

Statement on the use of Aleph data for long-term analyses.

The Aleph Collaboration

The data collected by the Aleph experiment in the years 1990-2000 have been archived to allow their use for physics analyses after the closure of the Collaboration. The archiving includes the last set of simulated events and the most updated version of the analysis software.

Limitations.

The available information is not sufficient to repeat all analyses, particularly when systematic effects play an important role as, for instance, for precision measurements in the electroweak sector. Examples of physics analyses that cannot be repeated on archived data are

- The measurement of the Z lineshape
- The measurement of the W mass
- The measurement of the tau polarization
- The measurement of leptons and quarks forward-backward asymmetry
- Most heavy flavour measurements, such as the measurement of R_b, of the CKM matrix elements, of B_d and B_s oscillations
- The searches for the Higgs boson
- Many searches in the Susy sector

Authorized Users.

The use of archived Aleph data is authorized to former members of the Aleph Collaboration and their collaborators. The use of a subset of data for teaching and pedagogical purposes, under the guidance of former members of the Collaboration, is allowed.

Authorship.

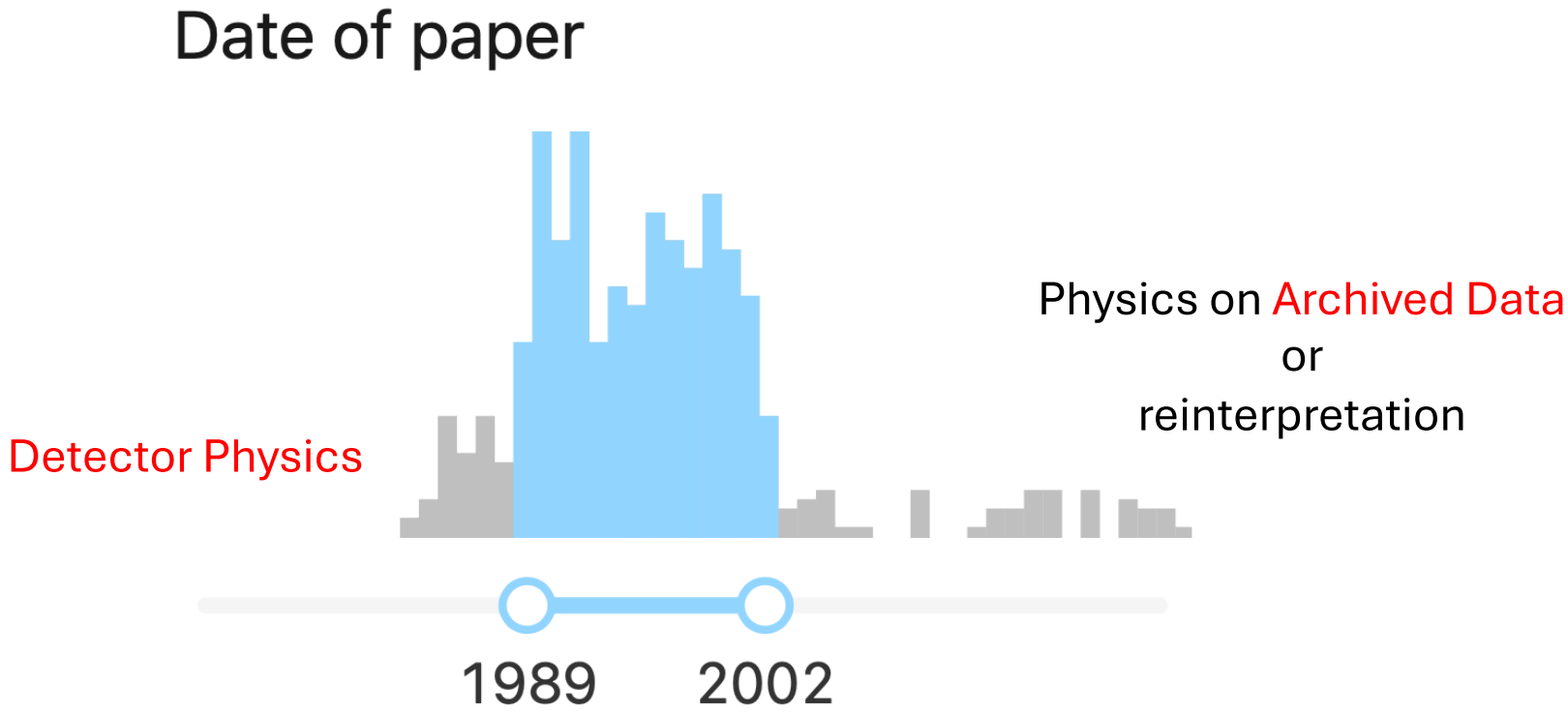
The publication of results based on archived Aleph data is not allowed until 1 year after the official termination of the Collaboration, foreseen for the end of 2004. The authors of the analysis take full responsibility for the publication. Any figure, plot or table using Aleph data should contain the label “ALEPH Archived Data”. A reference to the present document “Statement on the use of Aleph data for long-term analyses” must be present in the publication.

Approved by the Aleph Steering Committee
CERN
4 December 2003

Physics Results Post LEP run

Submitted on 15 Jan 2024: **Two Types of Gluons in QCD: Re-interpretation of ALEPH and CMS Gluon Jet Data** https://doi.org/10.48550/arXiv.2401.08704

Submitted on 8 Dec 2023: **Long-range near-side correlation in e^+e^- Collisions at 183-209 GeV with ALEPH Archived Data** https://doi.org/10.48550/arXiv.2312.05084



Motivation

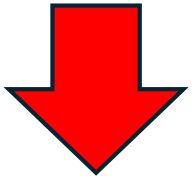
The shopping list...

What to learn

Training on real data on real condition

- New techniques
- New analysis methods
- New analyses
- New Monte Carlo optimization Vs Data
- LEP Vs FCC-ee

EDM4Hep/Key4HEP



toward a standard Common analysis framework

Technical Issues

Making it concrete, finally...

The Higher Level

```
#-------- Track
  edm4hep::Track:
    Description: "Reconstructed track"
    Author: "F.Gaede, DESY"
    Members:
      - int32_t type                    //flagword that defines the type of track.Bits 16-31 are used internally
      - float chi2                      //Chi^2 of the track fit
      - int32_t ndf                     //number of degrees of freedom of the track fit
      - float dEdx                      //dEdx of the track.
      - float dEdxError                 //error of dEdx.
      - float radiusOfInnermostHit      //radius of the innermost hit that has been used in the track fit
    VectorMembers:
      - int32_t subdetectorHitNumbers   //number of hits in particular subdetectors.Check/set collection
                                        //variable TrackSubdetectorNames for decoding the indices
      - edm4hep::TrackState trackStates //track states
      - edm4hep::Quantity dxQuantities  // different measurements of dx quantities
    OneToManyRelations:
      - edm4hep::TrackerHit trackerHits //hits that have been used to create this track
      - edm4hep::Track tracks           //tracks (segments) that have been combined to create this track
```

Existing Translators

```
ALEPH_DATA RUN = 35482 EVENT    15 ECM =   91.650 GEV
 Primary vertex info flag =  4 vx = -0.0802 vy =  0.0308 ex =  0.0019 ey =  0.0000
px=   -0.375 py=   -0.045 pz=    0.035 m=    0.140 charge=  1.0 pwflag=  0 lock= 1 d0=   -0.725 z0=    1.155 ntpc= 16 nitc=  0 nvdet= 1 track=   1 de/dx code=0 (e-)  -6.56 (pi-)   0.45 (K-) -11.91 (p) -27.42
px=   -0.264 py=   -0.026 pz=    0.018 m=    0.140 charge= -1.0 pwflag=  0 lock= 1 d0=   -0.047 z0=    1.373 ntpc= 11 nitc=  2 nvdet= 2 track=   2 de/dx code=0 (e-)  -2.65 (pi-)   0.56 (K-) -10.64 (p) -24.37
px=    6.591 py=    1.108 pz=    0.591 m=    0.140 charge=  1.0 pwflag=  0 lock= 1 d0=   -0.009 z0=    1.338 ntpc= 17 nitc=  2 nvdet= 2 track=   3 de/dx code=0 (e-)  -3.14 (pi-)  -0.35 (K-)   2.04 (p)   3.41
px=   30.342 py=    4.278 pz=    1.145 m=    0.140 charge= -1.0 pwflag=  0 lock= 1 d0=   -0.006 z0=    1.337 ntpc= 15 nitc=  0 nvdet= 2 track=   4 de/dx code=0 (e-)  -2.00 (pi-)  -0.71 (K-)   0.68 (p)   1.75
px=   -7.908 py=   -1.061 pz=   -0.332 m=    0.140 charge= -1.0 pwflag=  0 lock= 1 d0=    0.009 z0=    1.331 ntpc= 21 nitc=  0 nvdet= 2 track=   5 de/dx code=0 (e-)  -3.45 (pi-)  -0.35 (K-)   2.26 (p)   3.85
px=   -2.927 py=   -0.017 pz=   -0.687 m=    0.140 charge= -1.0 pwflag=  0 lock= 1 d0=    0.004 z0=    1.343 ntpc= 18 nitc=  3 nvdet= 2 track=   6 de/dx code=0 (e-)  -2.84 (pi-)   0.40 (K-)   2.42 (p)   2.89
px=   -1.499 py=   -0.338 pz=    0.108 m=    0.140 charge=  1.0 pwflag=  0 lock= 1 d0=    0.424 z0=    0.932 ntpc= 20 nitc=  4 nvdet= 0 track=   7 de/dx code=0 (e-)  -5.40 (pi-)  -0.50 (K-)   0.95 (p)  -0.99
px=    1.498 py=    0.681 pz=    0.439 m=    0.140 charge=  1.0 pwflag=  0 lock= 1 d0=   -0.011 z0=    1.323 ntpc= 17 nitc=  2 nvdet= 2 track=   8 de/dx code=0 (e-)  -5.48 (pi-)   0.08 (K-)   1.94 (p)   0.09
px=   -3.652 py=   -0.185 pz=   -0.575 m=    0.140 charge=  1.0 pwflag=  0 lock= 1 d0=   -0.162 z0=    0.576 ntpc= 11 nitc=  2 nvdet= 0 track=   9 de/dx code=0 (e-)  -6.14 (pi-)  -3.43 (K-)  -1.60 (p)  -1.00
px=   -0.960 py=    0.049 pz=   -0.215 m=    0.140 charge= -1.0 pwflag=  0 lock= 1 d0=    0.008 z0=    1.325 ntpc= 14 nitc=  0 nvdet= 1 track=  11 de/dx code=0 (e-)  -4.47 (pi-)  -0.34 (K-)  -0.45 (p)  -4.05
px=    0.418 py=    0.139 pz=    0.306 m=    0.140 charge= -1.0 pwflag=  0 lock= 1 d0=   -0.193 z0=    1.345 ntpc= 15 nitc=  2 nvdet= 2 track=  13 de/dx code=0 (e-)  -6.66 (pi-)   1.31 (K-)  -6.34 (p) -19.28
px=    1.857 py=    0.245 pz=    0.030 m=    0.000 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=    0.822 py=    0.140 pz=    0.069 m=    0.000 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=    1.333 py=    0.117 pz=    0.260 m=    0.000 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=    0.959 py=    0.203 pz=    0.198 m=    0.000 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=    1.350 py=    0.585 pz=   -0.109 m=    0.000 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=   -2.373 py=   -0.260 pz=    0.081 m=    0.022 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=   -3.243 py=   -0.473 pz=    0.049 m=    0.001 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=   -2.128 py=    0.011 pz=   -0.584 m=    0.021 charge=  0.0 pwflag=  4 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
px=   -9.851 py=   -1.656 pz=   -0.410 m=    1.269 charge=  0.0 pwflag=  5 lock= 1 d0=   -1.000 z0=   -1.000 ntpc=  0 nitc=  0 nvdet= 0 track=   0 de/dx code=1 (e-)  -1.00 (pi-)  -1.00 (K-)  -1.00 (p)  -1.00
vx=    -7.49 vy=    -1.23 vz=     1.85 chi2 =    0.000 type=0 Ntrk=  2
 Track=     1 px=  -0.377 py=  -0.011 pz=   0.037
 Track=     2 px=  -0.259 py=  -0.059 pz=   0.013
vx=    -0.11 vy=     0.03 vz=     1.34 chi2 =    0.000 type=0 Ntrk=  2
 Track=     3 px=   6.585 py=   1.108 pz=   0.590
 Track=     4 px=  30.165 py=   4.248 pz=   1.137
vx=    -6.15 vy=    -0.76 vz=     1.79 chi2 =    0.000 type=0 Ntrk=  2
 Track=     7 px=  -1.505 py=  -0.311 pz=   0.108
 Track=     2 px=  -0.260 py=  -0.054 pz=   0.018
vx=    -5.00 vy=    -0.63 vz=     1.12 chi2 =    0.000 type=0 Ntrk=  2
 Track=     7 px=  -1.505 py=  -0.314 pz=   0.113
 Track=     5 px=  -7.907 py=  -1.084 pz=  -0.332
vx=    -1.95 vy=     0.02 vz=     0.90 chi2 =    0.000 type=0 Ntrk=  2
 Track=     7 px=  -1.502 py=  -0.327 pz=   0.114
 Track=     6 px=  -2.927 py=  -0.026 pz=  -0.687
vx=    -0.09 vy=     0.04 vz=     1.32 chi2 =    0.000 type=0 Ntrk=  2
 Track=     8 px=   1.498 py=   0.681 pz=   0.438
 Track=    13 px=   0.416 py=   0.145 pz=   0.307
primary vertex compatibility track   1 chi= -999.00 track   2 chi= -999.00
primary vertex compatibility track   3 chi= -999.00 track   4 chi= -999.00
primary vertex compatibility track   7 chi= -999.00 track   2 chi= -999.00
primary vertex compatibility track   7 chi= -999.00 track   5 chi= -999.00
primary vertex compatibility track   7 chi= -999.00 track   6 chi= -999.00
primary vertex compatibility track   8 chi= -999.00 track  13 chi= -999.00
END_EVENT
```

Screensho

Knowledge

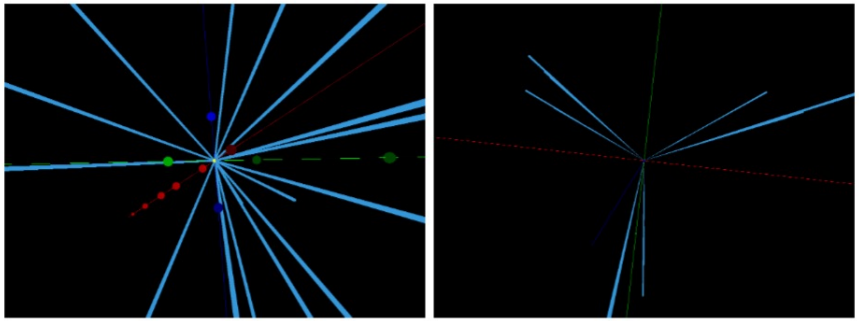
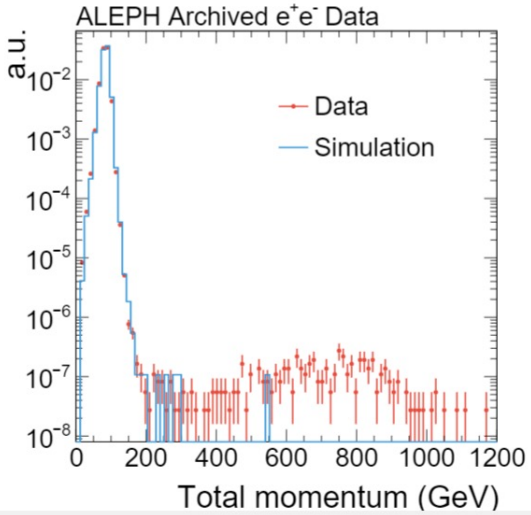


Figure 1: Example of the "Mercedes-Benz" events. The thin lines indicate the axes (x = red, y = green, z = blue). Light blue lines are the particles, with the length proportional to the momentum of the particle. The particles are all around 40 GeV. The right panel show the view from the $-z$ direction. Each of the three branches typically has 4-7 particles.



ALEPH 88-79
TPCCAL 88-01
A. Voigtlander et al.
7.7.1988

Using the Laser Calibration System to Measure Drift Velocity and Electric Field in the ALEPH-TPC

A. Voigtlaender-Tetzner
M. Schmelling
University of Mainz

The Data Production Issue

Existing MC datasets can be translated to EDM4Hep

New MC generators requires the use of the entire ALEPH SW stack

VM or containers ingesting events with shared format (HepMC)

Fast Simulation approach ? (which existed in ALEPH)

What is needed

1. Translator:
EDM files with just high-level information is already a test for EDM4Hep to be the general event descriptor

2. Catalogue:
A new Data Discovery System is envisaged possibly with FAIR metadata

3. Embedment:
Hide the complexity of the MC Production

Already with step one:

Make Real physics studies on Real Data

Final remarks

1. ALEPH data are available
2. ALEPH expertise is still available

ALEPH data are an excellent opportunity:

- To work on realistic condition
- To train in view of the future data taking
- Produce physics

EDM4Hep/Key4Hep

can be validated as a common standard