ALEPH DATA IN EDM4HEP

Reasons, current status and future prospects

Gerardo Ganis, Marcello Maggi, Juraj Smiesko, Jacopo Fanini

06.11.2024

Motivations

FCC

- EDM4hep test: to use the new Event Data Model for the first time with real, non simulated data
- **Training on real data:** to give physicists the opportunity to train by analyzing real data, with a view to FCC-ee
- New analysis and optimization of algorithms: to apply and test new analysis techniques (e.g. machine learning algorithms) on LEP data
- **Data preservation:** to conserve the possibility and capacity of extracting new science from the data
- Validation of simulations tools

See also: M. Maggi, <u>ALEPH data in Key4HEP</u> G. Ganis, <u>Opportunities offered by LEP data@EDM4hep</u>

Jacopo Fanini

ALEPH Data Reminder

LEP and ALEPH

• LEP

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- e⁺e⁻ collider
- Phase 1 ('89-'95): Z production @ ~91 GeV
- Phase 2 ('96-'00): W-pair production @ ~160-209 GeV
- 4 experiments: DELPHI, L3, OPAL and...

• ALEPH

- Typical "onion" experiment: vertex detector, tracking, solenoid magnet, calorimetry, muon system
- Luminosity
 - o LEP1: 200 pb⁻¹
 - o LEP2: 688 pb⁻¹
- Statistics:

$$\circ ~~ \sim 4 \ge 10^6 ~e^+e^- \rightarrow q \bar{q} ~, \sim 8 \ge 10^3 ~e^+e^- \rightarrow W^+W^-$$









• Several formats:

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- **RAW**: direct information from detector, no reconstruction
- POT: reconstructed data
- DST: as POT, but without noise and background
- Mini-DST: high level analysis results, scaled, integerized and compressed
- Sizes (LEP1 data sample):
 - RAW: 2063 GB
 - POT: 975 GB
 - DST: 154 GB
 - Mini-DST: 38 GB

Computing environment

- Last binary build: Linux SLC4
- Last functional environment: Linux SLC6 (bit to bit validation, no recompilation needed)
 - GCC 3.4, G77 3.4
 - CERN Library 2005
 Available at /cvmfs/aleph.cern.ch
- These environments can still be recreated on today's Ixplus (AlmaLinux9) via Apptainer/Singularity + CernVM

```
[jfanini@lxplus973 ~]$
[jfanini@lxplus973 ~]$ aleph-slc6
Welcome to ALEPH @ SLC6
HOME = /afs/cern.ch/user/j/jfanini/public/aleph
WORKDIR = /afs/cern.ch/user/j/jfanini
ALEPHGIT = /afs/cern.ch/user/j/jfanini/public/aleph/GIT
Singularity SLC6:/afs/cern.ch/user/j/jfanini>
```

Conversion Chain

Workflow



ר FCC

Focus on Mini-DST files

- Reduced format created from DST for space saving
- One run record per run and at least one event record per run
 - Event records: tracks, vertices, calorimetric objects, energy flow and jets, *γ*, *e*, *μ* identification, HV detector status, trigger
- Both Mini-DST and DST available on EOS at /eos/experiment/aleph
- Possible next step: direct access to DST files



Workflow



ALPHA

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- The ALeph PHysics Analysis tool (ALPHA) has been used to loop over the ALEPH Mini-DST banks and print out them directly
- Some issues:
 - Two types of banks: linear and tabular
 - In Mini-DST data are stored scaled and integerised, then ALPHA use them to fill POT/Julia banks, where data are mainly floats (and some strings)
 - Some correction/calibration data are hardcoded in ALPHA algorithms and not included in the data banks

```
SUBROUTINE DUMPBANKI(NAME, UNIT, IER)
      TMPL TCTT
                  NONE
#include "qdecl.h"
#include "gcde.h"
      CHARACTER*4 NAME
      INTEGER
                  UNIT, IER
C - Local variables
                  I, J
      INTEGER
      INTEGER
                  NLINK, IBK, IBANK, NROWS, NCOLS, NAMIND
C - ALPHA macros
#include "qmacro.h"
      IER = 0
C - Connect to the bank
      IBK= NAMIND(NAME)
      IF( IBK.EQ.0 ) THEN
        WRITE(*,*) 'DUMPBANK: Bank ', NAME, ' cannot be found! '
        IER = 1
        RETURN
      FND TF
      IBANK = IW(IBK)
C - Number of rows
      NROWS = LROWS(IBANK)
      NCOLS = LCOLS(IBANK)
      WRITE(UNIT, *) NAME, NROWS, NCOLS
C - LOOD
      COUNTER = 3
      DO I=1,NROWS
        DO J=1, NCOLS-1
              WRITE(UNIT, 1001) ITABL(IBANK, I, J)
        END DO
           WRITE(UNIT, 2001) ITABL(IBANK, I, NCOLS)
      END DO
 1001 FORMAT(I20, $)
 2001 FORMAT(120)
      RETURN
      FND
```

Workflow



Text exchange format

- Data stored in POT/Julia banks are printed in the text exchange format as integers values
- It has been decided to use a simple text file:
 - Easy to produce, directly by Fortran routines
 - Easy to read, directly by C++ routines
 - Allows to remove a layer of code (with respect, e.g., to JSON)

 Hand-written code for reading the text file and filling EDM4hep data structures

Workflow



NFCC

Text reader and EDM4hep writer

- C++ functions and programs for
 - Reading the intermediate exchange text file through a dedicated library
 - Converting the integer values in floats (<u>IEEE-754</u>) or strings
 - Filling some EDM4hep data structures and relations
- Using EDM4hep nightlies, first stable release is expected soon

```
// Function to convert an integer to a float with IEE754
float intToFloat(uint32_t intRepresentation) {
    union {
        uint32_t i;
        float f;
      } converter;
      converter.i = intRepresentation;
      return converter.f;
}
```

Workflow



EDM4hep structures

- EDM4hep, part of <u>Key4hep</u> <u>framework</u>, might become a general and standard data format for data structures and file format of future experiments
- One-to-one correspondence between a particle from Particle Flow algorithm and an EDM4hep ReconstructedParticle



- Conversion goal: energy flow, vertexes w/ covariances, tracks w/ covariances, calo objects, ...
- Next step: convert Monte Carlo data, which have also the truth information

• Even with little data, things can be tricky...



Workflow



FCCAnalysis

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- Common framework for FCC-related analyses, taking EDM4hep input ROOT files and producing histograms
- Based on **ROOT RDataFrame** for the construction of the computational graph
- Actions are lazy evaluated
- Some analysis routines are pre-defined, users can define their own directly as JIT compiled C++ functions/functors
- It is still under development to meet the needs of the FCC community

Simple analysis: E_{TOT}



Same approach has been performed with subsets at E ~ 89 GeV and E ~ 93 GeV. This allow to
estimate the hadronic cross section as

$$\sigma = \frac{\# ev.}{\mathcal{L}}$$

 $\sigma_{had@89GeV} = (9.8 \pm 0.1) \text{ nb}^*$

 $\sigma_{had@91GeV} = (30.5 \pm 0.4) \text{ nb}^*$ * the error is the statistical error $\sigma_{had@93GeV} = (\mathbf{14.4} \pm \mathbf{0.1}) \, \mathbf{nb}^*$

06.11.2024

Data sizes

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- Taking as example the file /eos/experiment/aleph/LEP1/DATA/MINI/1995/Y15223.44.AL
 - Original file: 314 MB
 - Text file: 1.6 GB
 - Zipped text file: 272 MB
 - EDM4hep ROOT file: 155 MB
- Caveat: EDM4hep file contains only a small part of the data dumped in the text file
 - Further data size evaluation needed



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Validation

Validation results and plans - preliminary

• A comparison of old/new formats for CLASS 16 selection has been done, applying the selection to EDM4hep converted data using FCCAnalysis: first results are promising

file	#ev. (FCCAnalysis)	#ev. (ALPHA)	diff. %
1992/Y15222.40.AL	22990	22981	0.04%
1993/Y15223.10.AL	21316	21316	0.00%
1994/ZD4007.1.AL	10525	10524	0.01%
1995/Y15223.28.AL	30320	30314	0.02%
1995/Y15223.44.AL	23189	23187	0.01%

• Next steps:

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- Investigate the origin of the differences
- Perform a full ALEPH analysis via FCCAnalysis (or ROOT) and compare the results with the same analysis performed in the past using Fortran-only routines

Validation with MIT

- A group from MIT re-analyzed a subset of ALEPH data in recent years, thanks to M. Maggi
 - CLAS 16 hadronic events (≥ 5 charged particles)
 - High level informations: reconstructed particles from particle flow, V0s, dE/dX

ALEPR DATA RUL = 35482 EVENT 15 EOK = 91.658 GEV Primary vertex infor Tag = 4 were = 0.002 yr = 0.0000 0.000 kr = 0.0010 kr = 0.0000 0.000 kr = 0.0000 kr = 0.0000 0.000 kr = 0.0000 0.0000 kr														
Primity vertex info (lag = 4 vx = -0.882 vf = 0.083 ex = 0.001 ey = 0.0804 pre 0.358 pr 0.035 mr 0.045 chrms = 0.097 hay = 0.087 have 0.054 chrms = 0.097 hay 0.055 mr 0.045 chrms = 0.047 hay 0.055 mr 0.045 chrms = 0.047 hay 0.055 mr 0.047 hay 0.055 mr 0.045 chrms = 0.047 hay 0.055 mr 0.047 hay 0.055 mr 0.045 chrms = 0.055 mr 0.045 chrms = 0.047 hay 0.055 mr 0.045 chrms = 0.055	ALEPH_DATA RUN = 3	5482 EVENT	15 ECM = 9	01.650 GEV										
px 0.375 py -0.385 py -0.386 px 0.486 px 0.426 pr140 0 lock 1 db -0.725 pc -1.73 pr120 lock 1 mode 0.775 pc 0.7	Primary vertex in	fo flag = 4	vx = -0.0802	vy = 0.0308 ex	= 0.0019 ey	= 0.0000								
pp: -0.26 pp: -0.26 pp: -0.26 pp: -0.26 pp: -0.26 pp: -0.26 pp: -0.56 pp: -0.57 pp: -0.57 pp: -0.57 pp: -0.56 pp: -0.56 pp: -0.57 pp: -0.56 pp: -0.56 pp: -0.56 pp: -0.57 pp: -0.56 pp: -0.56 pp: -0.57 pp: -0.56 pp: -0.5	px= -0.375 py=	-0.045 pz=	0.035 m=	0.140 charge=	1.0 pwflag=	0 lock= 1 dθ=	-0.725 z0=	1.155 ntpc= 16 nitc=	0 nvdet= 1 track=	l de/dx code=θ (e-) -6.56 (p	-) 0.45 (K-)	-11.91 (p)	-27.42
px 6.501 py 4.188 px 0.100 http://dx 0.100 http://dx 0.000 px 0.000	px= -0.264 pv=	-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=θ (-) -2.65 (p	-) 0.56 (K-)	-10.64 (p)	-24.37
pp: 0.342 pp: 4.278 pp: 1.48 pp: 0.100 thrsge - 1.0 pr1age 0.000 the	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 () 3.14 (p	-) -0.35 (K-)	2.04 (p)	3.41
pp: -7.988 py -0.81 py -0.81 py -0.81 py -0.82 py -0.81 py -0.83 pz -0.84 py -0.85 py -0.86 py -0.48 py -0.85 py -0.86 py -0.48 py -0.85 py -0.86 py -0.48 py -0.85 py -0.86 py <td< td=""><td>px= 30.342 py=</td><td>4.278 pz=</td><td>1.145 m=</td><td>0.140 charge=</td><td>-1.0 pwflag=</td><td>θ lock= 1 dθ=</td><td>-0.006 20=</td><td>1.337 ntpc= 15 nitc=</td><td>0 nvdet= 2 track=</td><td>4 de/dx code=θ (</td><td>-) -2.00 (p</td><td>-) -0.71 (K-)</td><td>0.68 (p)</td><td>1.75</td></td<>	px= 30.342 py=	4.278 pz=	1.145 m=	0.140 charge=	-1.0 pwflag=	θ lock= 1 d θ =	-0.006 20=	1.337 ntpc= 15 nitc=	0 nvdet= 2 track=	4 de/dx code=θ (-) -2.00 (p	-) -0.71 (K-)	0.68 (p)	1.75
pp: -0.87 pp: -0.87 pp: -0.87 pp: -0.88 pp: -0.88 pp: -0.88 pp: -0.88 pp: -0.55 pp:	px= -7.908 py=	-1.061 pz=	-0.332 m=	0.140 charge=	-1.0 pwflag=	0 lock= 1 d0=	0.009 20=	1.331 ntpc= 21 nitc=	0 nydet= 2 track=	5 de/dx code=0 (-) -3.45 (p	-) -0.35 (K-)	2.26 (p)	3.85
pp: 1.489 pp: 0.338 pp: 0.138 pp: 0.138 pp: 0.149 cores 0.120 cores 0.032 ntpc=20 ntc. 4 modet=0 track 7 do/dx codee(e) 5.40 (pc) 0.632 (p) 0.532 (p) pp: 1.690 pp: 0.138 pp: 0.149 cores 0.140 cores 0.140 cores 0.140 cores 0.11 core 1.225 pp: 7 do/dx codee(e) 5.44 (p) 0.333 (p) 0.570 ntpc=11 nttc. 2 modet=0 track 9 do/dx codee(e) 5.44 (p) 0.333 (p) 0.162 pp: pp:<0.155 pp:	px= -2 927 py=	-0.017 pz=	-0.687 m=	0 140 charge	-1 0 pwflag=	0 lock= 1 d0=	0 004 70=	1 343 ntpc= 18 nitc=	3 nydet= 2 track=	6 de/dx code=0 (-) -2.84 (n	-) 0.40 (K-)	2 42 (n)	2 89
px 1.468 px 0.681 px 0.680 px 0	nx1 499 nv-	-0.338 pz=	0.108 m-	0 140 charge-	1 0 pwflag-	0 lock= 1 d0=	0 424 20-	A 932 ntpc= 20 nitc=	A nydet- A track-	7 de/dx code=0 (-) -5.40 (p	-) -0.50 (K-)	0.95 (p)	-0.00
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pre -0.160 pre -0.201 mc -0.211 mc -0.100 mc -0.401 mc	px= 1.450 py=	0.001 pz=	0.575 m-	0.140 charge=	1.0 pwflag=	0 lock= 1 d0=	0.162 70-	0.576 ntpc= 11 nitc=	2 nvdet= 2 track=	0 do/dx code=0 (-) -5.40 (p.) 3.43 (K)	1.54 (p)	1 00
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p= 0.135 pr 0.105	px= -0.900 py=	0.049 µz=	-0.215 III=	0.140 charge=	-1.0 pwrtag=	0 lock= 1 d0=	0.008 20=	1.325 htpc= 14 hittc=	2 nudet 2 track	11 de/dx code=0 (2-) -4.47 (p.	-) -0.34 (K-)	-0.45 (p)	-4.05
p= 1.35 pp= 0.23 pz 0.20 mp 0.80 pz	px= 0.418 py=	0.139 pz=	0.300 m=	0.140 charge=	-1.0 pwrtag=	0 LOCK= 1 00=	-0.193 20=	1.343 htpc= 13 hitc=	2 NVGEL= 2 LTACK=	13 de/dx code=0 () -0.00 (p.	-) 1.51 (K-)	-0.34 (p)	-19.26
px= 0.362 py= 0.409 pz= 0.309 m= 0.000 charge= 0.00 priag= 1000 rbc= 0 node= 0 rack 0 dedx code= (e) -1.00 (b) -1.00 (b) <td< td=""><td>px= 1.857 py=</td><td>0.245 pz=</td><td>0.050 m=</td><td>0.000 charge=</td><td>0.0 pwrtag=</td><td>4 LOCK= 1 d0=</td><td>-1.000 20=</td><td>-1.000 htpc= 0 hitc=</td><td>0 hvdet= 0 track=</td><td>0 de/dx code=1 (</td><td>2-) -1.00 (p.</td><td>-) -1.00 (K-)</td><td>-1.00 (p)</td><td>-1.00</td></td<>	px= 1.857 py=	0.245 pz=	0.050 m=	0.000 charge=	0.0 pwrtag=	4 LOCK= 1 d0=	-1.000 20=	-1.000 htpc= 0 hitc=	0 hvdet= 0 track=	0 de/dx code=1 (2-) -1.00 (p.	-) -1.00 (K-)	-1.00 (p)	-1.00
px 0.335 py 0.417 pz 0.400 rm/ge 0.900	px= 0.822 py=	0.140 pz=	0.069 M=	0.000 charge=	0.0 pwrtag=	4 LOCK= 1 d0=	-1.000 Z0=	-1.000 ntpc= 0 nitc=	0 hvdet= 0 track=	0 de/dx code=1 (e-) -1.00 (p:	-) -1.00 (K-)	-1.00 (p)	-1.00
px= 0.595 py= 0.205 py= 0.198 m= 0.000 charge= 0.00 rdrg= 1.000 rds= 1.000 rds= 0 rdds	px= 1.333 py=	0.117 pz=	0.260 m=	0.000 charge=	0.0 pwrlag=	4 LOCK= 1 d0=	-1.000 ZO=	-1.000 ntpc= 0 nitc=	0 nvdet= 0 track=	0 de/dx code=1 (e-) -1.00 (p:	-) -1.00 (K-)	-1.00 (p)	-1.00
px 1.350 py 0.855 pz -0.109 m 0.000 charge= 0.0 prliag= 4 lock 1 de= -1.000 ze= -1.000 rpc= 0 nitc= 0 nodet= 0 track 0 de/ax code=1 (e= -1.00 (p1)1.00 (p1)	px= 0.959 py=	0.203 pz=	0.198 m=	0.000 charge=	0.0 pwrtag=	4 LOCK= 1 d0=	-1.000 Z0=	-1.000 ntpc= 0 nitc=	0 hvdet= 0 track=	0 de/dx code=1 (2-) -1.00 (p:	-) -1.00 (K-)	-1.00 (p)	-1.00
px = -2.372 py = -0.810 pz = 0.881 m = 0.622 charge= 0.8 purtags 4 locks 1 de = -1.000 zp = -1.000 ntpc = 0 ntc = 0 nvdet= 0 tracks 0 de/dx code=1 (e-) -1.00 (p1)1.00 (K) - 1.00 (p)1.00 pz = -2.228 py = 0.611 pz = -6.584 m = 0.621 charge= 0.8 purtags 4 locks 1 de = -1.000 zp = -1.000 ntpc = 0 ntc = 0 nvdet= 0 tracks 0 de/dx code=1 (e-) -1.00 (p1)1.00 (K) - 1.00 (p) - 1.00 rx = -7.49 ry = -1.237 vz = 1.85 cht2 = 0.000 trpc= 0.8 purtags 5 locks 1 de = -1.000 zp = -1.000 ntpc = 0 ntc = 0 nvdet= 0 tracks 0 de/dx code=1 (e-) -1.00 (p1)1.00 (K) - 1.00 (p) - 1.00 rx = -7.49 ry = -0.279 ry = -0.615 pz = 0.417 racks 2 px = -0.259 py = -0.659 pz = 0.418 pz = 0.377 racks 2 px = -0.259 py = -0.659 pz = 0.418 pz = 0.377 racks 2 px = -0.259 py = -0.6159 pz = 0.100 rtpc = 0 ntrk = 2 rracks 1 px = 0.377 racks 2 px = -0.259 py = -0.619 pz = 0.100 trpc = 0 trk = 2 rracks 1 px = 0.377 racks 2 px = -0.260 py = -0.616 pz = 0.418 rx = 2 rracks 2 px = -0.260 py = -0.619 pz = 0.138 rx = 0.378 rx = 0.000 trpc = 0 trk = 2 rracks 2 px = -0.260 py = -0.614 pz = 0.000 trpc= 0 trk = 2 rracks 2 px = -0.260 py = -0.614 pz = 0.138 rx = 0.000 trpc = 0 trk = 2 rracks 7 px = -1.505 py = -0.314 pz = 0.308 rx = 2 rracks 7 px = -1.505 py = -0.314 pz = -0.328 rx = -0.408 rx = 2 rracks 7 px = -1.505 py = -0.260 ry = -0.627 rx = 0.000 trpc=0 Ntrk 2 rracks 6 px = -2.927 py = -0.260 py = -0.627 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 py = -0.314 pz = -0.302 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 py = -0.260 ry = -0.627 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 ry = -0.314 pz = -0.302 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 ry = -0.216 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 ry = -0.216 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 ry = -0.227 rx = 0.104 rx = 0.000 trpc=0 Ntrk 2 rracks 7 px = -1.505 ry = -0.216 rx = 0.000 trpc=0 Ntrk 2 rracks 7 rx = 1.95 ry = -0.206 rx = -0.307 rracks 7 rx = -1.99.00 rrack 2 rrack 8 px = 1.498 py = 0.621 pz = 0.307 rracks 7 rx = -1.99.00 rrack 2 r	px= 1.350 py=	0.585 pz=	-0.109 m=	0.000 charge=	0.0 pwflag=	4 LOCK= 1 dΘ=	-1.000 ZO=	-1.000 ntpc= 0 nitc=	0 nvdet= 0 track=	0 de/dx code=1 (e-) -1.00 (p	-) -1.00 (K-)	-1.00 (p)	-1.00
px = -3.243 py = -0.473 pz = 0.449 m = 0.081 charge= 0.8 pwrlag= 4 locks l de -1.080 zb = -1.080 rbc = 0 nite = 0 nwdet= 0 track = 0 de/ax code=1 (e) -1.06 (p1)1.08 (K) - 1.08 (p) -1.08 px = -3.243 py = -0.155 pz = -0.418 m = 1.269 charge= 0.8 pwrlag= 4 locks l de -1.080 zb = -1.080 rbc = 0 nite = 0 nwdet= 0 track = 0 de/ax code=1 (e) -1.08 (p1)1.08 (K) - 1.08 (p) -1.08 vx = -7.48 / py = -0.577 py = -0.611 pz = 0.807 Track = 1 px = -0.259 py = -0.655 pz = 0.011 ze = 0.000 type=0 Ntrk = 2 Track = 2 px = -0.259 py = -0.559 py = -0.511 pz = 0.590 Track = 4 px = 30.165 py = 4.248 pz = 1.137 vx = -5.08 vy = -0.655 py = -0.511 pz = 0.000 type=0 Ntrk = 2 Track = 7 px = -1.256 py = -0.519 py = -0.519 p = -0.518 vx = -5.08 vy = -0.657 py = -0.511 pz = 0.108 vx = -5.08 vy = -0.657 py = -0.512 p = 0.000 type=0 Ntrk = 2 Track = 5 px = -7.967 py = -1.084 pz = 0.112 vx = -0.59 py = -0.512 py = -0.518 pz = 0.118 vx = -0.69 vy = -0.654 py = -0.512 p = 0.000 type=0 Ntrk = 2 Track = 7 px = -1.565 py = -0.311 pz = 0.108 vx = -1.95 vy = -0.719 py = -0.114 = 0.113 Track = 7 px = -1.562 py = -0.317 pz = 0.114 Track = 7 px = -1.562 py = -0.327 pz = 0.114 Track = 0 py = 0.604 type=0 Ntrk = 2 Track = 1 py = 0.616 py = 0.612 = 0.000 type=0 Ntrk = 2 Track = 0 py = 0.645 py = 0.612 = 0.000 type=0 Ntrk = 2 Track = 1 py = 0.626 py = 0.	px= -2.373 py=	-0.260 pz=	0.081 m=	0.022 charge=	0.0 pwflag=	4 lock= 1 dθ=	-1.000 ZO=	-1.000 ntpc= 0 nitc=	0 nvdet= 0 track=	0 de/dx code=1 (e-) -1.00 (p	-) -1.00 (K-)	-1.00 (p)	-1.00
pr - 2.128 py = 0.611 pz - 0.584 m = 0.621 charge= 0.8 pwTlag= 4 locks 1 de - 1.000 ze - 1.000 ntpc- 0 nitc= 0 nvdet= 0 tracks 0 de/dx code=1 (e-) -1.00 (p1-) -1.00 (K-) -1.00 (p) -1.00 (x-) -1.00 (p) -1.00 (y-) -1.00 (y	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 (p:) -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 locke 1 d0= -1.000 z0= -1.000 ntpc= 0 ntc= 0 nvdet= 0 track= 0 de/dx code=1 (e-) -1.00 (p1-) -1.00 (k-) -1.00 (p) -1.00 (y-) -1.00 (y-	px= -2.128 py=	0.011 pz=	-0.584 m=	0.021 charge=	0.0 pwflag=	4 lock= 1 dΘ=	-1.000 z0=	-1.000 ntpc= 0 nitc=	0 nvdet= 0 track=	0 de/dx code=1 (e-) -1.00 (p:) -1.00 (K-)	-1.00 (p)	-1.00
<pre>vx - 7.49 vy - 1.23 vz 1.85 ch2 = 0.000 type=0 Ntrk 2 Track 1 px - 0.37 py - 0.01 pz 0.037 Track 3 px - 0.259 py - 0.659 pz 0.013 vx - 0.11 vy 0.03 vz 1.34 ch2 = 0.000 type=0 Ntrk 2 Track 4 px 30.165 py - 1.08 pz - 0.590 Track 4 px 30.165 py - 0.76 vz 1.179 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.311 pz 0.108 Track 2 px - 0.76 vz 1.179 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.555 py - 0.314 pz 0.113 Track 7 px - 1.555 py - 0.314 pz 0.113 Track 7 px - 1.555 py - 0.314 pz 0.132 Track 7 px - 1.555 py - 0.324 pz 0.000 type=0 Ntrk 2 Track 7 px - 1.555 py - 0.314 pz 0.133 Track 6 px - 2.927 py - 0.826 pz - 0.080 type=0 Ntrk 2 Track 6 px - 2.927 py - 0.826 pz - 0.000 type=0 Ntrk 2 Track 8 px 1.498 py 0.621 vz 0.132 ch12 = 0.000 type=0 Ntrk 2 Track 8 px - 1.498 py - 0.631 pz 0.148 Track 6 px - 2.927 py - 0.826 pz - 0.307 Track 7 px - 1.555 py - 0.314 pz 0.113 Track 6 px - 2.927 py - 0.826 pz - 0.000 type=0 Ntrk 2 Track 7 px - 1.555 py - 0.314 pz 0.134 Track 8 px - 1.498 py = 0.631 pz 0.438 Track 1 px 0.416 py 0.631 pz 0.438 Track 1 px 0.416 py 0.618 pz 0.439 Track 1 px 0.416 py 0.618 pz 0.438 Track 1 px 0.41</pre>	px= -9.851 py=	-1.656 pz=	-0.410 m=	1.269 charge=	0.0 pwflag=	5 lock= 1 dΘ=	-1.000 z0=	-1.000 ntpc= 0 nitc=	0 nvdet= 0 track=	0 de/dx code=1 (e-) -1.00 (p:	-) -1.00 (K-)	-1.00 (p)	-1.00
Track 1 px = 0.37 py = 0.611 pz = 0.637 Track 2 px = 0.25 py = 0.655 py = 0.611 pz = 0.637 Track 3 px = 0.555 py = 1.184 ch2 = 0.000 type=0 Ntrk 2 Track 4 px = 30.165 py = 4.248 pz = 1.137 Vx = -0.15 yy = -0.75 py = -0.311 pz = 0.100 type=0 Ntrk 2 Track 7 px = -1.565 py = -0.311 pz = 0.108 Vx = -5.60 vy = -0.63 vz = 1.12 ch12 = 0.000 type=0 Ntrk 2 Track 5 px = -0.260 vy = -0.63 vz = 0.108 Vx = -5.60 vy = -0.63 vz = 0.128 vz = 0.108 Vx = -5.90 vy = -0.63 vz = 0.128 vz = 0.108 Track 5 px = -7.907 py = -1.184 pz = 0.113 Track 5 px = -7.907 py = -0.134 pz = 0.114 Track 7 px = -1.565 py = -0.317 pz = 0.114 Track 6 px = -0.279 py = -0.327 pz = 0.114 Track 7 px = -1.569 vy = 0.637 Track 7 px = -1.598 py = -0.317 pz = 0.114 Track 6 px = -0.297 py = -0.687 Vx = -0.69 vy = 0.94 tyz = 1.32 ch12 = 0.000 type=0 Ntrk 2 Track 7 px = -1.598 py = -0.317 pz = 0.114 Track 6 px = -0.297 py = -0.1587 pz = 0.377 Track 7 px = -1.598 py = 0.637 Vx = -1.99 vy = 0.626 py = 0.687 Vx = -1.99 vy = 0.645 py = 0.687 Vx = -1.99 vy = 0.645 py = 0.415 pz = 0.377 Track 7 px = -1.598 py = 0.616 tyz = 0.408 type=0 Ntrk 2 Track 7 px = -1.598 py = 0.617 vz = 0.990 vt rack 2 chi = -990.68 primary vertex compatibility track 7 chi = -990.60 track 2 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 2 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 2 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 2 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 3 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 3 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 3 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 3 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 4 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 4 chi = -990.60 primary vertex compatibility track 7 chi = -990.60 track 4 chi = -990.60 primary vertex compatibility track 7	vx= -7.49 vy=	-1.23 vz=	1.85 chi2	= 0.000 type	=0 Ntrk= 2									
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Track= 1 px=	-0.377 py=	-0.011 pz=	0.037										
<pre>vx - 0.11 vy = 0.63 vz = 1.34 ch12 = 0.000 type=0 Ntrk 2 Track 4 px 30.165 py 4.248 pz 1.137 vx - 0.15 vy - 0.76 vz 1.79 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.511 pz = 0.108 vx - 5.00 vy - 0.63 vz = 1.12 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.311 pz = 0.108 vx - 5.00 vy - 0.63 vz = 1.12 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.312 pz = 0.018 vx - 5.00 vy - 0.63 vz = 1.12 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.312 pz = 0.114 Track 5 px - 7.907 py - 1.084 pz - 0.332 vx - 1.95 vy 0 0.02 vz = 0.90 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.562 py - 0.327 pz - 0.114 Track 6 px -2.927 py - 0.128 pz - 0.637 vx - 1.969 vy 0 0.64 vz = 0.90 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.562 py - 0.327 pz - 0.114 Track 5 px - 1.400 py - 0.640 type 0.681 pz - 0.437 track 5 px - 1.400 py - 0.640 type=0 Ntrk 2 Track 7 px - 1.562 py - 0.327 pz - 0.114 Track 5 px - 1.400 py - 0.640 type=0 Ntrk 2 Track 7 px - 0.690 vy - 0.64 typ - 0.641 pz - 0.437 track 7 px - 1.562 py - 0.327 pz - 0.114 Track 7 px - 1.562 py - 0.327 pz - 0.114 Track 7 px - 1.562 py - 0.327 pz - 0.114 Track 7 px - 1.562 py - 0.455 pz - 0.367 track 7 px - 1.562 py - 0.455 pz - 0.367 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 1.562 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 py - 0.455 pz - 0.457 track 7 px - 0.455 pz -</pre>	Track= 2 px=	-0.259 py=	-0.059 pz=	0.013										
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	vx= -0.11 vy=	0.03 vz=	1.34 chi2	 0.000 type 	=0 Ntrk= 2									
Tracke 4 px 30.165 py 4.248 pz 1.137 vx= 6.15 yy= -0.75 py -0.311 pz 0.108 Tracke 7 px= -1.565 py= -0.311 pz 0.108 vx= 5.08 vy= -0.63 vz= 1.12 cht2 = 0.008 type=0 Ntrk 2 Tracke 7 px= -1.565 py= -0.314 pz 0.113 Tracke 5 px= -7.967 py= -1.084 pz= -0.132 vx= 1.95 vy= 0.62 vz= 0.96 cht2 = 0.008 type=0 Ntrk 2 Tracke 7 px= -1.562 py= -0.321 pz= 0.114 Tracke 6 px= -2.927 py= -0.327 pz= 0.114 Tracke 7 px= -1.562 py= 0.327 pz= 0.114 Tracke 7 px= -1.569 vy= 0.96 tracke 2 cht2 = 0.008 type=0 Ntrk 2 Tracke 7 px= -1.562 py= 0.327 pz= 0.114 Tracke 6 px= -2.927 py= -0.327 pz= 0.114 Tracke 1 px= 0.416 py= 0.681 pz= 0.437 Tracke 1 px= 0.416 py= 0.415 pz= 0.307 primary vertex compatibility track 7 chi= -999.08 track 2 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 2 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 6 chi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 1 bchi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 1 bchi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 1 bchi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 1 bchi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 1 bchi= -999.08 primary vertex compatibility track 7 chi= -999.08 track 1 bchi= -999.08 primary vertex compatibility track 7 chi= -999.08 primary vertex c	Track= 3 px=	6.585 py=	1.108 pz=	0.590										
<pre>vx - 6.15 vy= -0.76 vz= 1.79 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.319 pz - 0.018 vx - 5.06 vy= -0.626 py - 0.054 pz - 0.018 vx - 5.06 vy= -0.626 py - 0.054 pz - 0.000 type=0 Ntrk 2 Track 7 px - 1.565 py - 0.314 pz - 0.113 Track 5 px - 7.907 py - 1.084 pz - 0.327 vx - 1.95 vy= 0.62 vz= 0.90 ch12 = 0.000 type=0 Ntrk 2 Track 7 px - 1.505 vy= 0.825 pz - 0.314 pz - 0.113 Track 6 px - 2.927 py - 0.825 pz - 0.147 = 0.100 Track 7 px - 1.505 vy= 0.825 pz - 0.314 pz - 0.132 Track 8 px - 1.498 py= 0.625 pz - 0.167 vx - 0.06 vy= 0.04 vz= 1.32 ch12 = 0.000 type=0 Ntrk 2 Track 8 px - 1.498 py= 0.451 pz - 0.347 Track 8 px - 1.498 py= 0.451 pz - 0.348 Track 1 px - 0.416 py= 0.145 pz - 0.347 Track 1 px - 0.160 py= 0.145 pz - 0.347</pre>	Track= 4 px=	30.165 py=	4.248 pz=	1.137										
Track 7 px = -1.505 py = -0.511 pz = 0.108 Track 7 px = -1.505 py = -0.511 pz = 0.108 Vx = -5.60 vy = -0.63 vz = 1.12 cht2 = 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 cht2 = 0.000 type=0 Ntrk 2 Track 7 px = -1.502 py = -0.312 pz = 0.114 Track 6 px = -2.927 py = -0.327 pz = -0.687 Vx = -0.69 vy = 0.64 by = 0.601 type=0 Ntrk 2 Track 7 px = -1.502 py = -0.327 pz = -0.687 Vx = -0.69 vy = 0.456 py = 0.455 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 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 5 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 4 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 7 chi = -999.00 track 6 chi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 6 chi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility track 7 chi = -999.00 track 1 bchi = -999.00 primary vertex compatibility tra	vx= -6.15 vy=	-0.76 vz=	1.79 chi2	= 0.000 type	=0 Ntrk= 2									
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See also: Yi Chen et al., <u>First</u> <u>measurement of anti-kT jet</u> <u>spectra and jet substructure</u> <u>using the archived ALEPH</u> <u>e+e- data at 91.2 GeV, 41st</u> ICHEP Yi Chen, <u>Revisiting the</u> <u>ALEPH Archived e+e- Data</u>, CERN EP Seminar

Workflow - MIT



Strategy and preliminary results

- Since ROOT is the most widely diffused analysis framework in HEP, it is convenient to make the EDM4hep files easily analyzable with it
- A tutorial with an example to extract a flat ROOT TTree from the EDM4hep file using <u>EDM4hep Utilities</u> has been produced
- Users can define their functions to store in the TTree the relevant quantities for validation/analysis
- Positive preliminary feedbacks



Summary & Outlook

Summarizing: what has been done

- Found a way to access directly low level data (ALPHA)
- Defined a general **exchange format** for data extraction (text file)
- Filled EDM4hep structures and relations
- Began validation of the workflow
 - CLASS 16 cuts
 - Provided MIT colleagues with tools to do initial validation of the conversion chain
- Collected archeological information and tutorials on a <u>website</u> (beta version)

Set up a new chain of programs to convert the original ALEPH files (Mini-DST) to EDM4hep files, which can be analyzed with FCCAnalysis

\equiv ALEPH Documentation

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ALEPH Documentation, new and re-engineered

This site contains a collection of documentation about the data and software of the ALEPH experiment. It has been created in the context of the migration of ALEPH data to EDM4hep. This process is of paramunt importance in the framework of the future construction of a circular electron-positron collider because it will allow to test edm4hep, the new Event Data Model for collider experiments, with real, non simulated data. It is also a really important step for HEP data preservation, as it aims to conserve the possibility and capacity of extracting new science from the data. Finally, this conversion will give physicists the opportunity to train by analyzing events from e+e- collisions.

Since the proposal for the building of ALEPH dates back to 1981, an archeological work to recover existing software and documentation has been done, which result is documented in this pages. The new code written for the migration is also documented in these pages. Enjoy!

Work ahead

FCC

- Prepare for processing Monte Carlo data, including truth information
- Understand better the conventions to be used in the **EDM4hep production**
- Migrate **database with meta-data** (fill, run, luminosity, detector status, ...) to a modern backend and interface
 - Including new location of files on EOS
- Better quantify the average **size** of the intermediate text file and the EDM4hep output file
- Validate the workflow by repeating a full analysis previously done by ALEPH collaboration (and iterating with MIT)

Jacopo Fanini

06.11.2024

Thank you for your attention

In depth documentation

- Data Preservation in HEP: paper by DPHEP collaboration on data preservation reasons and strategies
- <u>ALEPH GitLab</u>: source code and some general information about the experiment
- <u>ALEPH website</u>: old public webpage of the ALEPH collaboration
- <u>ALPHA User's Guide</u>: description of ALPHA analysis routines
- <u>EDM4hep GitHub</u>: source code of the general Event Data Model