EUTelescope Workshop on testbeam data analysis and reconstruction, DESY 2013

Igor Rubinskiy
Mokka simulations for testbeam (GEANT4)
DESY, 26-03-2013
ILCSoft includes a package for full detector simulation.
- detector description in Geant4
  - define detector volumes, check that there are no overlapping volumes
  - subdetectors are nested volumes, defined relative to parent volume
- Geant4 is a library, unlike Geant3
  - one needs to write his own simulation executable based on the detector description (prev.bullet)
- options
  - ALLPIX
    - external to ILCSoft,
    - track scattering/energy deposit simulation
      + Si digitiser development
    - output: LCIO collection compatible to RAW data from EUDAQ
  - Mokka
    - part of ILCSoft,
    - track scattering/energy deposit simulation only
    - digitiser has to be implemented with a Marlin processor
      - EUTeIMAPSdigi processor in EUTelescope
    - more generic → possible to use ALLPIX as shared library
EUTelescope real data flow:
- start with data conversion from EUDAQ RAW format to LCIO
- array of pixels for each plane (detector): matrix column, matrix row, (signal, timing)
EUTelescope – framework for testbeam data analysis

EUTelescope real data flow:
- start with data conversion from EUDAQ RAW format to LCIO
- array of pixels for each plane (detector): matrix column, matrix row, (signal, timing)
  → clustering, hitmaker, track fit

Legend:
- Telescope + DUT data
- Condition DB collections
- EUTelescope library (Marlin) processors

I.Rubinskiy, DESY

Mokka simulations for testbeam
EUTelescope – framework for testbeam data analysis

EUTelescope real data flow:
- start with data conversion from EUDAQ RAW format to LCIO
- array of pixels for each plane (detector): matrix column, matrix row, (signal, timing)
  → clustering, hitmaker, track fit: real data needs hotpixel suppression/alignment

Legend:  
- Telescope + DUT data
- Condition DB collections
- EUTelescope library (Marlin) processors

I.Rubinskiy, DESY

Mokka simulations for testbeam
EUTelescope – framework for testbeam data analysis

EUTelescope data flow for simulated data:
- input is coming from Mokka
- LCIO collection of energy deposits in a sensitive layer (Detector)

Legend:
- Telescope + DUT data
- Condition DB collections
- EUTelescope library (Marlin) processors

ILCSoft Mokka (Geant4) → ILCSoft: LCIO format

Clustering

- pixel collections
- cluster collections

Hitmaker → cluster global coordinates (X,Y,Z in mm)

Hit collections

Track fit over reconstructed (and well aligned) hits

Track collection

Initial alignment

- a list of hot/noisy/broken pixels
- a list of initial “pre-”alignment X,Y shifts
- precise alignment (Millepede II)
- a list of “fine-”alignment X,Y,Z shifts, α,β,γ rotations

DUT analysis

Hitmaker → cluster global coordinates (X,Y,Z in mm)

Track fit over reconstructed (and well aligned) hits

Track collection

Initial alignment

- a list of hot/noisy/broken pixels
- a list of initial “pre-”alignment X,Y shifts
- precise alignment (Millepede II)
- a list of “fine-”alignment X,Y,Z shifts, α,β,γ rotations

DUT analysis
EUTelescope – framework for testbeam data analysis

EUTelescope data flow for simulated data:
- input is coming from Mokka
- LCIO collection of energy deposits in a sensitive layer (Detector)

ILCSoft Mokka (Geant4)

ILCSoft: LCIO format

pixel collections

cluster collections

Hitmaker → cluster global coordinates (X,Y,Z in mm)

hit collections

Track fit over reconstructed (and well aligned) hits

track collection

Clustering

a list of hot/noisy/broken pixels

Hotpixel suppression and alignment not really needed for simulated “data”

a list of “fine”-alignment X,Y,Z shifts, α,β,γ rotations

DUT analysis

Legend:
- Telescope + DUT data
- Condition DB collections
- EUTelescope library (Marlin) processors

I.Rubinskiy, DESY

Mokka simulations for testbeam
EUTelescope – framework for testbeam data analysis

EUTelescope data flow for simulated data:
- input is coming from Mokka
- LCIO collection of energy deposits in a sensitive layer (Detector)

Legend:
- Telescope + DUT data
- Condition DB collections
- EUTelescope library (Marlin) processors

I.Rubinskiy, DESY
Mokka simulations for testbeam
The GENT4 geometry description got more material:

The 6 Mimosa26 setup (per every Mimosa layer)
- 2 capton foil layers 50 um thick each
- plane numbering scheme: beam direction → plane 0,1,2,3,4,5

The 6 Mimosa26 + 1 FEi4 in addition to capton foil has THICK non sensitive layer
- 200 um for the chip + 300 um of Aluminium for support/cooling
- numbering scheme: beam → plane 0,1,2,20(FEI4),3,4,5

The energy range spans:

<table>
<thead>
<tr>
<th>Energy (GeV)</th>
<th>1 track per event</th>
<th>100 / event</th>
<th>300 / event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (e+)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>6</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>120 (pi+)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

evts/run: 100 000 1000 334
Expecting 10K tracks – blue (6Mimosa26), red (6Mimosa26+1FEI4) Dependence on the Finder Radius (DAFFitter only)
Looking at plane2 biased residuals (DAFFitter)

RMS-vs.FinderRadius and Mean-vs.FinderRadius

I.Rubinskiy, DESY

Mokka simulations for testbeam
Looking at plane2 biased residuals (DAFFitter) – next to 1FEI4 in the center of the telescope
RMS vs. FinderRadius and Mean vs. FinderRadius

I. Rubinskiy, DESY
Mokka simulations for testbeam
Looking at plane2 biased residuals scatter plot RMS-vs-Mean - one energy contains also points for different Finder Radius (see slides 4,5)
ILCSoft::Mokka - GEANT4 simulation

Tracking efficiency studies for a variety of beam energies and multiplicity
Fixed configuration: 6 Mimosa26 (6x50 μm Si) and 1 DUT (1x500 μm Si)

1 $\pi^+$/ event

100 $e^+$/ event
ILCSoft::Mokka - GEANT4 simulation

Tracking efficiency studies for a variety of beam energies and multiplicity
Fixed configuration: 6 Mimosa26 (6x50 $\mu$m Si) and 1 DUT (1x500 $\mu$m Si)

Tests with DAF fitter (EUTelDafFitter)

Track reconstruction tests on Simulated data

<table>
<thead>
<tr>
<th>location</th>
<th>particle type</th>
<th>beam energy, GeV</th>
<th>N particles per spill (=per event)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonn</td>
<td>e</td>
<td>1</td>
<td>90-95, 80-95, 50-90</td>
</tr>
<tr>
<td>DESY</td>
<td>e</td>
<td>5</td>
<td>&gt;98, 85-95, 70-90</td>
</tr>
<tr>
<td>SLAC</td>
<td>e</td>
<td>15</td>
<td>&gt;98, 85-95, 70-90</td>
</tr>
<tr>
<td>CERN</td>
<td>$\pi$</td>
<td>120</td>
<td>&gt;98, 85-95, 70-90</td>
</tr>
</tbody>
</table>

Tracks with better $\chi^2$ – least efficient
Simulation:
Assume ZERO intrinsic resolution of Mimosa26, still 50 um Si thickness + 2 capton foils (50 um each), ~40% of Mimosa26

Unbiased residuals - “smilie” plot

\[ \sigma_{\text{s meas.}} = X \text{ track fit} - X \text{ true MC} \]
Known installation pitfalls

- tests on Ubuntu 12.04 64 bit

- ILCSOft v01-15
  - Geant4 9.5.p02
    - compilation cmake based
    - packages Coin3D, SoXt for nice visualisation (option)
    - xerces for xml parser (option)
  - Mokka
    - v08-00-03
    - needs MySQL server 5.0.x (not 5.5!)

- ALLPIX, few preparations
  - apt-get install libxerces-c2-dev libssl-dev libboost-dev swig
  - need g++ \leq 4.4,
    - g++ 4.5 or 4.6 does not work
      - complains for invalid xerces references
Summary:
- Mokka as simulation framework is a bit of more work on deploying and supporting MySQL database
- DAF fitter track reconstruction 99% for 1 track per event is at 90-95% (100 tracks/event) and goes down to 80-90% for 300 tracks per event.

Current (tentative) plan:
- include Geant4/Mokka as optional package
- develop EUTelescope processor based on ALLPIX digitiser library
- prepare more test cases with well defined testbeam geometries
  - known energies and material distribution
    ranging from 1 GeV electrons to 120 GeV pions
    For beam lines Bonn, DESY, SLAC, CERN)
- nightly control over the reconstruction chain performance
- add more tests with alignment and tracking GBL

- contributions are welcome!