Accessing the Data

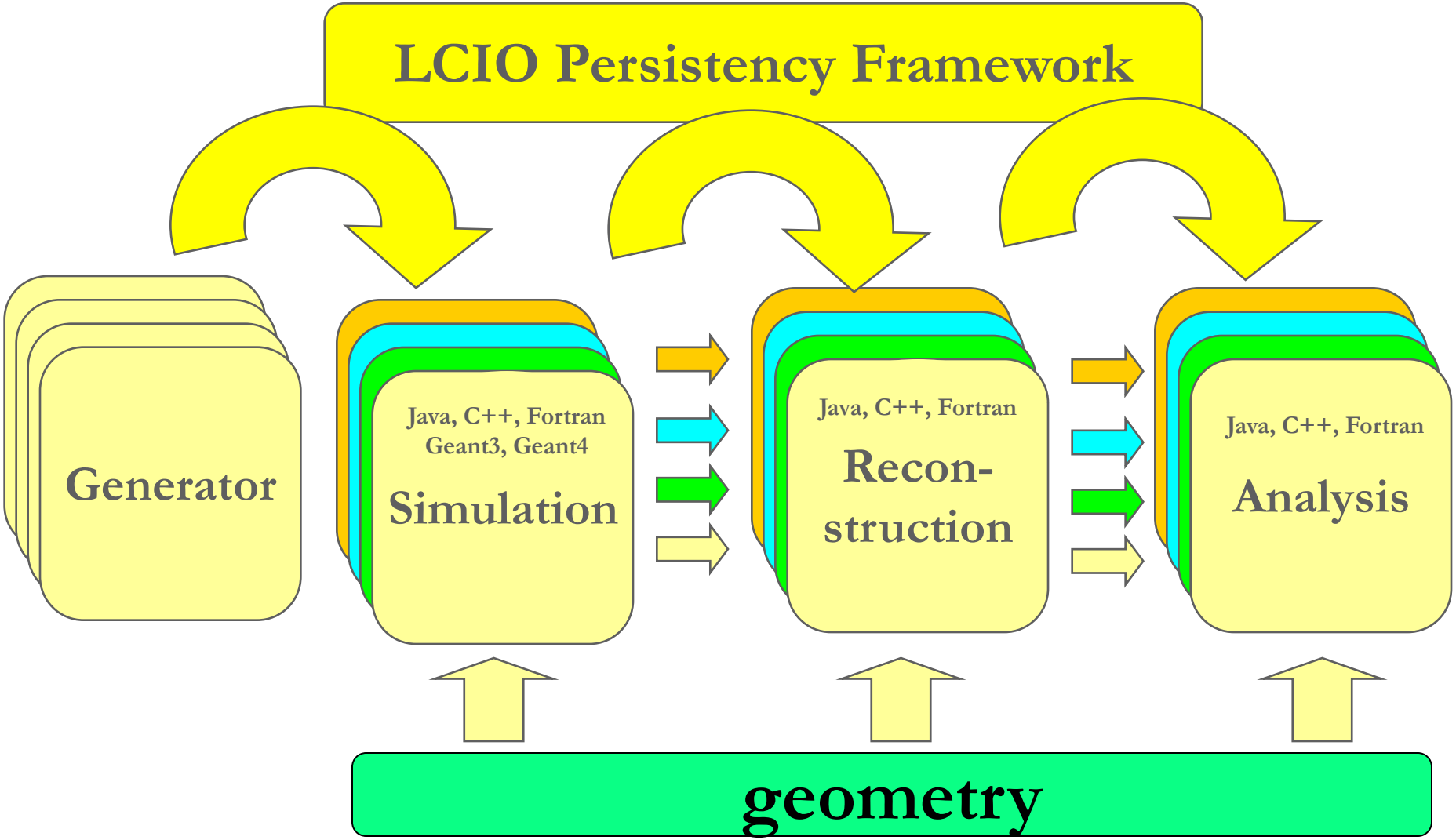
Norman Graf (SLAC)

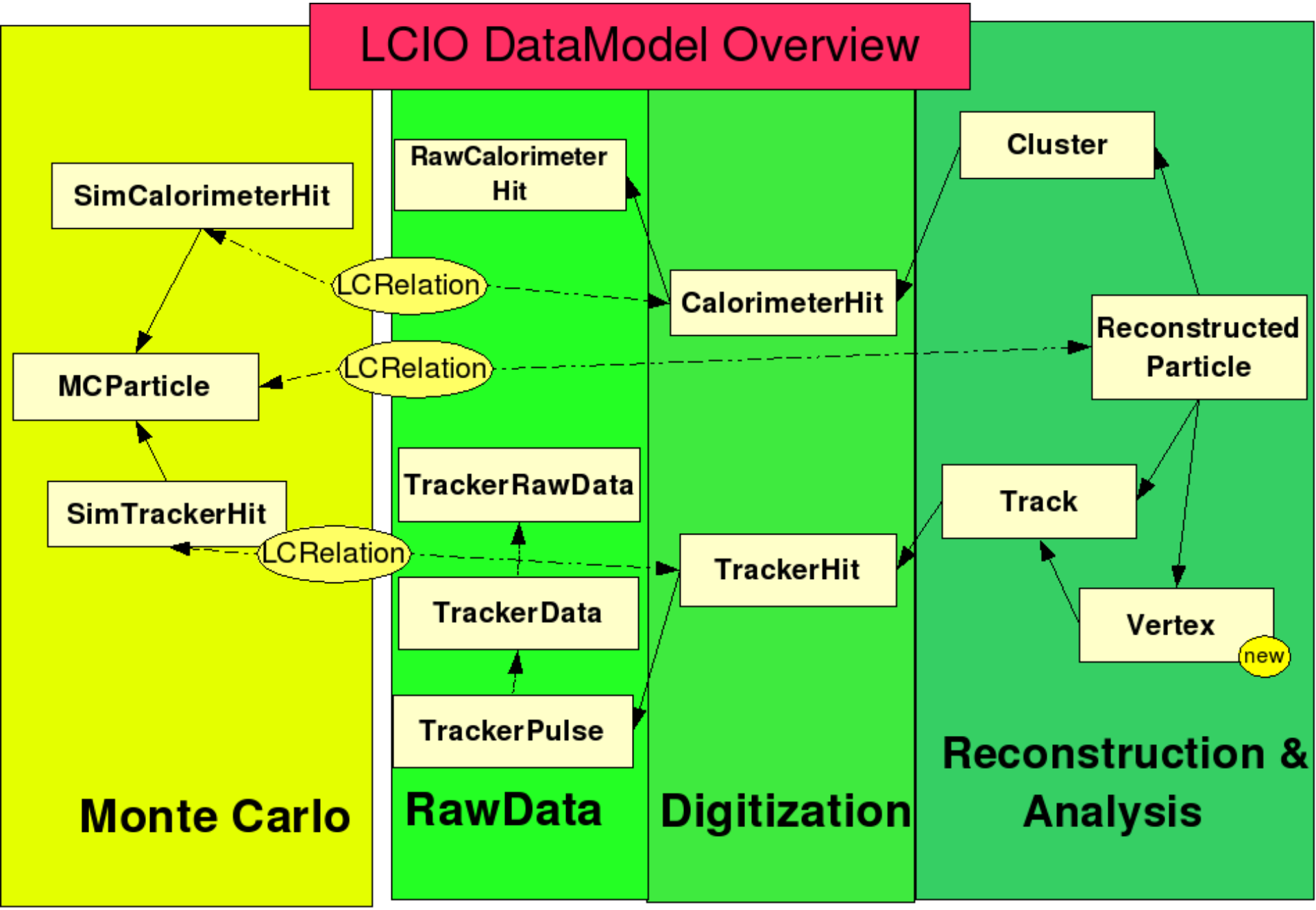
HPS Collaboration Meeting
JLab, D-Day, 2013

LCIO

- Event Data Model and binary persistency format
- Identify the key elements for an event data model appropriate to an HEP experiment.
- Target a simple IO format
  - provide reference implementations in several languages
  - document it well enough to ensure future readability
- Keep the event data model and IO separate
- KISS
  - “Simplify, simplify, simplify” Thoreau
  - “Make everything as simple as possible, but not simpler.” Einstein

LCIO Motivation




LCIO DataModel Overview
SimCalorimeterHit
MCParticle
SimTrackerHit
LCRelation
LCRelation
LCRelation
RawCalorimeter Hit
TrackerRawData
TrackerData
TrackerPulse
CalorimeterHit
TrackerHit
Cluster
Reconstructed Particle
Track
Vertex
new
Monte Carlo
RawData
Digitization
Reconstruction & Analysis

LCIO Online Documentation

Overview (LCIO API D ×

lcio.desy.de/v02-01-02/doc/api/index.html

Overview Package Class Tree Deprecated Index Help

PREV NEXT FRAMES NO FRAMES

LCIO API
Version v02-00

LCIO
Version v02-00

LCIO - a persistency framework for linear collider simulation studies.

See:

Description

ReconstructedParticle ×

lcio.desy.de/v02-01-02/doc/api/index.html

LCIO API
Version v02-00

All Classes

Packages

hep.lcio.data
hep.lcio.event
hep.lcio.example
hep.lcio.exceptions
hep.lcio.implementati

LCRunListener
LCStrVec
LCTools
LCWriter
MCParticle
MergeCommandHanc
MergeFileParameters
MergeTestEvents
MergeUtil
MiniJob
ObjectComparator
ParticleID
PrintCommandHandle
Printer
RandomEvent
RandomEventComma
RandomEventTest
RawCalorimeterHit
ReadOnlyException
RecJob
ReconstructedParticl
RunCommandHandle
SelectCommandHanc
SimCalorimeterHit
SimJob
SimTrackerHit
SIODump
SIODump
SIODumpCommandH
SIOFactory
SIOTrackerPulse
SIOVersion

hep.lcio.event

Interface ReconstructedParticle

All Superinterfaces:
Cloneable, LCObject

All Known Implementing Classes:
IReconstructedParticle

```
public interface ReconstructedParticle
extends LCObject
```

The LCIO reconstructedParticle.

Version:
$Id: ReconstructedParticle.aid,v

Author:
gaede

Method Summary

void	addCluster(Cluster Add a cluster that
void	addParticle(Reconst Add a particle that
void	addParticleID(Parti Add a ParticleID
void	addTrack(Track trac Add a track that h
float	getCharge() Charge of the reco
List	getClusters() The clusters that h
float[]	getCovMatrix()

LCIO - Users manual ×

lcio.desy.de/v02-01-02/doc/manual_html/manual.html#SECTION00030000000000

Installation

Getting LCIO

If LCIO is not yet installed at your site you can get a recent copy from the SVN repository as follows *bash*:

```
svn co svn://svn.freehep.org/lcio/tags/v01-60 lcio/v01-60 # checkout release v01-60
svn co svn://svn.freehep.org/lcio/trunk lcio/trunk # checkout trunk
```

Requirements

In order to build LCIO you need to have a Java VM (version 1.4 or higher) installed on your platform. This is true even if you only want to install the C++ version as the API-files are generated from an abstract description for Java and C++ using the AID [4] tool. The build scripts used in LCIO also require that `gcc` and `gmake/make` are installed.

The C++ version of LCIO is developed and tested under Linux (SL4 and SL5 32 and 64bit) and also builds under Windows/Cygwin or MacOSX.

As the -ansi compiler flag is used it should be fairly easy to port it to other platforms with an ANSI compliant C++ compiler.

Building LCIO

There are two build tools that can be used to build LCIO: maven and CMake [12]. CMake [12] has been introduced in version v01-11 to facilitate cross plattform support for the C++ version.

Building LCIO with CMake

If you want to use CMake for building LCIO you need at least CMake version 2.6.

If you want to build LCIO using CMake, make sure that the cmake command is in your path, e.g.

```
export PATH=Path_to_CMake/bin:$PATH
```

LCIO: IMPL::Reconstru ×

lcio.desy.de/v02-01-02/doc/doxygen_api/html/cl

Main Page | Namespaces | Classes | Files | Related Pages

Class List | Class Hierarchy | Class Members

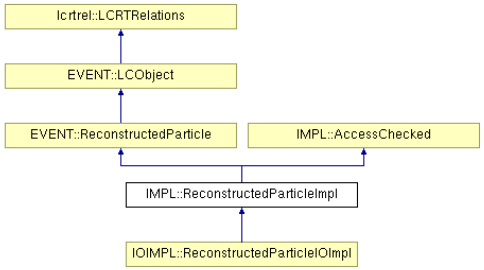
IMPL::ReconstructedParticleImpl

IMPL::ReconstructedParticleImpl Class Reference

Implementation of ReconstructedParticle. More...

```
#include <IMPL/ReconstructedParticleImpl.h>
```

Inheritance diagram for IMPL::ReconstructedParticleImpl:



List of all members.

Public Member Functions

	ReconstructedParticleImpl () *Default constructor, initializes values to 0.*
virtual	~ReconstructedParticleImpl () *Destructor.*
virtual int	id () const *Returns an object id for internal (debugging) use in LCIO.*

I have an LCIO File. Now what?

- lcio command-line tool
- Java Analysis Studio (JAS3)
  - LCIO event browser
  - Wired event display
- org.lcsim
  - full access to the event data and geometry
  - Drivers give full access to reconstruction and analysis
  - Loadable within JAS3
  - output LCIO file or AIDA histograms/tuples
- root access via LCIO dictionary
- root access via pyroot
- python access via pyLCIO

lcio Command-Line Tool

```
> lcio
  usage: LcioCommandLineTool
  Commands:
  count
  siodump
  select
  merge
  compare
  random
  stdhep
  run
  concat
  validate
  print
  size
  split
   -h    Print lcio command-line tool usage.
   -v    Set the verbosity.
```

JAS3 LCIO Event Browser

JAS3

File Edit View Tuple Loop Window Help

- New
- Open File...
- Open Data Source
- Save Ctrl+S
- Save All
- Save As... Ctrl+A
- Compile F9
- Load...
- Run F2
- Print Setup...
- Print Ctrl+P
- Print Preview... Ctrl+Shift+P
- Recent Files
- Configuration
- Exit

- Plot Page
- Wired4 View
- Spreadsheet...
- Python Script
- Python Console
- Pnuts Script
- Pnuts Console
- Java File
- LCSim Event Browser
- LCSim Driver Statistics

nr_002_SLIC-v2r11p1_geant4-v9r3p2_QGSP_BERT_HPS-Proposal2014-v3-6pt6_readout_recon.slcio

View 1 × LCSim Event × LCSim Event ×

21067

- edMCParticles
- Hits
- sters
- s
- adoutHits
- ata
- TrackHitRelations
- TrackHits
- TrackMCRelations
- MCParticle
- MatchedTracks
- ReadoutTimestamps
- RotatedHelicalTrackHitRelations
- RotatedHelicalTrackHits
- RotatedHelicalTrackMCRelations
- SVTFittedRawTrackerHits
- SVTRawTrackerHits
- SVTShapeFitParameters
- SeededMCParticles
- StripClusterer_SiTrackerHitStrip1D
- TrackerHits
- TriggerBank
- MCParticleTree

LCIO Event Header

Run	0
Event	21067
Time Stamp	Thu Apr 11 17:51:17 EDT 2013
Detector Name	HPS-Proposal2014-v3-6pt6
Event Weight	1.0
IDRUP	0
SLIC Version	
Geant4 Version	

Collections

Name	Type	Size
ConfirmedMCParticles	org.lcsim.event.MCParticle	0
EcalCalHits	org.lcsim.event.CalorimeterHit	15
EcalClusters	org.lcsim.event.Cluster	4
EcalHits	org.lcsim.event.SimCalorimeterHit	130
EcalReadoutHits	org.lcsim.event.RawCalorimeterHit	15
FPGAData	org.lcsim.event.GenericObject	12
HelicalTrackHitRelations	org.lcsim.event.LCRelation	28
HelicalTrackHits	org.lcsim.event.TrackerHit	14
HelicalTrackMCRelations	org.lcsim.event.LCRelation	0
MCParticle	org.lcsim.event.MCParticle	12
MatchedTracks	org.lcsim.event.Track	2
ReadoutTimestamps	org.lcsim.event.GenericObject	3
RotatedHelicalTrackHitRelations	org.lcsim.event.LCRelation	14
RotatedHelicalTrackHits	org.lcsim.event.TrackerHit	14
RotatedHelicalTrackMCRelations	org.lcsim.event.LCRelation	0
SVTFittedRawTrackerHits	org.lcsim.event.LCRelation	79
SVTRawTrackerHits	org.lcsim.event.RawTrackerHit	79
SVTShapeFitParameters	org.lcsim.event.GenericObject	79
SeededMCParticles	org.lcsim.event.MCParticle	0
StripClusterer_SiTrackerHitStrip1D	org.lcsim.event.TrackerHit	36
TrackerHits	org.lcsim.event.SimTrackerHit	25
TriggerBank	org.lcsim.event.GenericObject	1

Instances

- HelicalTrackHits
- HelicalTrackHits

Apply immediately — Apply

Hide Types below level: 6

Hide Instances below level: 3

JAS3Tree × WIRED ×

Click to center point, Shift-Click to move center to point, Drag to instant translate.

Info panel 76.8/90.4MB

JAS3 LCIO Event Browser

JAS3

File Edit View Tuple Loop Window Help

New
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Run:1357 Event: 110

- Event
  - ConfirmedMCParticles
  - EcalCalHits
  - EcalClusters
  - EcalReadoutHits
  - FPGAData
  - FinalStateParticles
  - HelicalTrackHitRelations
  - HelicalTrackHits
  - HelicalTrackMCRelations
  - MatchedTracks
  - RotatedHelicalTrackHitRelations
  - RotatedHelicalTrackHits
  - RotatedHelicalTrackMCRelations
  - SVTFittedRawTrackerHits
  - SVTRawTrackerHits
  - SVTShapeFitParameters
  - SeededMCParticles
  - StripClusterer_SiTrackerHitStrip1D
  - TriggerBank
  - VertexedReconParticles

Collection: FPGAData size:7 flags:80000000

index	nInt	intValues	nFloat	floatValues	nDouble	doubleValues
0	2	[0,0]	0	[]	12	[20.730,20.680,0.0000,0.0000,20.770,20.930,0.0000,0.0000,20.980,21.070,...]
1	2	[1,0]	0	[]	12	[21.040,21.090,0.0000,0.0000,20.610,20.140,0.0000,0.0000,20.450,20.730,...]
2	2	[2,0]	0	[]	12	[20.550,20.500,0.0000,0.0000,21.290,21.340,0.0000,0.0000,22.110,21.700,...]
3	2	[3,0]	0	[]	12	[20.430,20.890,0.0000,0.0000,20.180,20.790,0.0000,0.0000,20.070,20.090,...]
4	2	[4,0]	0	[]	12	[20.180,20.160,0.0000,0.0000,20.640,20.660,0.0000,0.0000,20.890,20.790,...]
5	2	[5,0]	0	[]	12	[21.890,21.140,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,21.290,20.790,...]
6	2	[6,0]	0	[]	12	[20.430,20.550,0.0000,0.0000,21.000,21.090,0.0000,0.0000,20.110,20.140,...]

		0
		15
		4
		130
		15
		12
		28
		14
		0
		12
		2
		3
		14
		14
		0
SVTFittedRawTrackerHits	org.lcsim.event.LCRelation	79
SVTRawTrackerHits	org.lcsim.event.RawTrackerHit	79
SVTShapeFitParameters	org.lcsim.event.GenericObject	79
SeededMCParticles	org.lcsim.event.MCParticle	0
StripClusterer_SiTrackerHitStrip1D	org.lcsim.event.TrackerHit	36
TrackerHits	org.lcsim.event.SimTrackerHit	25
TriggerBank	org.lcsim.event.GenericObject	1

Instances
- HelicalTrackHits
- HelicalTrackHits

Apply immediately — Apply

Hide Types below level: 6

Hide Instances below level: 3

JAS3Tree × WIRED ×

Click to center point, Shift-Click to move center to point, Drag to instant translate.

Info panel 76.8/90.4MB

JAS3 LCIO Event Browser

JAS3

File Edit View Tuple Loop Window Help

New
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Run:1357 Event: 110

- Event
  - ConfirmedMCParticles
  - EcalCalHits
  - EcalClusters
  - EcalReadoutHits
  - FPGAData
  - FinalStateParticles
  - HelicalTrackHitRelations
  - HelicalTrackHits
  - HelicalTrackMCRelations
  - MatchedTracks
  - RotatedHelicalTrackHitRelations
  - RotatedHelicalTrackHits
  - RotatedHelicalTrackMCRelations
  - SVTFittedRawTrackerHits
  - SVTRawTrackerHits
  - SVTShapeFitParameters
  - SeededMCParticles
  - StripClusterer_SiTrackerHitStrip1D
  - TriggerBank
  - VertexedReconParticles

Collection: FPGAData size:7 flags:80000000

index	nInt	intValues	nFloat	floatValues	nDouble	doubleValues
0	2	[0,0]	0	[]	12	[20.730,20.680,0.0000,0.0000,20.770,20.930,0.0000,0.0000,20.980,21.070,...]
1	2	[1,0]	0	[]	12	[21.040,21.090,0.0000,0.0000,20.610,20.140,0.0000,0.0000,20.450,20.730,...]
2	2	[2,0]	0	[]	12	[20.550,20.500,0.0000,0.0000,21.290,21.340,0.0000,0.0000,22.110,21.700,...]
3	2	[3,0]	0	[]	12	[20.430,20.890,0.0000,0.0000,20.180,20.790,0.0000,0.0000,20.070,20.090,...]
4	2	[4,0]	0	[]	12	[20.180,20.160,0.0000,0.0000,20.640,20.660,0.0000,0.0000,20.890,20.790,...]
5	2	[5,0]	0	[]	12	[21.890,21.140,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,21.290,20.790,...]
6	2	[6,0]	0	[]	12	[20.430,20.550,0.0000,0.0000,21.000,21.090,0.0000,0.0000,20.110,20.140,...]

Run:0 Event: 21067

- Event
  - ConfirmedMCParticles
  - EcalCalHits
  - EcalClusters
  - EcalHits
  - EcalReadoutHits
  - FPGAData
  - HelicalTrackHitRelations
  - HelicalTrackHits
  - HelicalTrackMCRelations
  - MCParticle
  - MatchedTracks
  - ReadoutTimestamps
  - RotatedHelicalTrackHitRelations
  - RotatedHelicalTrackHits
  - RotatedHelicalTrackMCRelations
  - SVTFittedRawTrackerHits
  - SVTRawTrackerHits
  - SVTShapeFitParameters
  - SeededMCParticles
  - StripClusterer_SiTrackerHitStrip1D
  - TrackerHits
  - TriggerBank
  - MCParticleTree

Collection: EcalReadoutHits size:15 flags:8000000
ReadoutName: EcalHits

CellID	Amplitude	TimeStamp
3993869	5877	2688
199181	8418	2688
68109	4082	4544
4059661	7497	2688
195341	7720	0
199437	7869	2688
195597	15210	0
4059405	5205	2688
133645	6706	2688
195853	4435	0
65805	7348	960
130829	5983	1024
3994125	12339	2688
389901	130	6272
133901	7087	2688

Columns are sortable

Instances
- HelicalTrackHits
- HelicalTrackHits

Apply immediately Apply
Hide Types below level: 6
Hide Instances below level: 3

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Info panel 76.8/90.4MB

JAS3 LCIO Event Browser

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File Edit View Tuple Loop Window Help

Run:1357 Event: 110

- Event
  - ConfirmedMCParticles
  - EcalCalHits
  - EcalClusters
  - EcalReadoutHits
  - FPGAData
  - FinalStateParticles
  - HelicalTrackHitRelations
  - HelicalTrackHits
  - HelicalTrackMCRelations
  - MatchedTracks
  - RotatedHelicalTrackHitRelations
  - RotatedHelicalTrackHits
  - RotatedHelicalTrackMCRelations
  - SVTFittedRawTrackerHits
  - SVTRawTrackerHits
  - SVTShapeFitParameters
  - SeededMCParticles
  - StripClusterer_SiTrackerHitStrip1D
  - TriggerBank
  - VertexedReconParticles

Collection: SVTRawTrackerHits size:101 flags:80000000

ReadoutName: TrackerHits

Time	CellID	ADCValues
0	6601364736513	[3714,3772,3776,3755,3778,3738]
0	7700876364289	[4382,4343,4412,4417,4461,4407]
0	7838315317761	[4574,4535,4565,4473,4493,4550]
0	8388071131649	[4599,4570,4746,4762,4646,4598]
0	6876242643457	[4067,4021,4095,4082,4188,4183]
0	7975754271233	[4567,4560,4531,4534,4489,4424]
0	8525510085121	[4635,4595,4678,4650,4684,4645]
0	7563437410817	[4246,4230,4337,4381,4316,4226]
0	8662949038593	[4651,4674,4733,4634,4692,4757]
0	6618544605697	[4045,3889,4056,4114,4157,4199]
0	7168300419585	[4340,4311,4319,4279,4352,4382]
0	8267812047361	[4538,4565,4651,4685,4698,4707]
0	7305739373057	[4265,4270,4367,4366,4369,4291]
0	7855495186945	[4385,4321,4391,4414,4369,4406]
0	7443178326529	[4298,4225,4319,4386,4356,4336]
0	7992934140417	[4418,4408,4573,4471,4495,4650]
0	8542689954305	[4769,4650,4773,4841,4741,4785]

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osal2014-v3-6pt6

		Size
		0
		15
		4
		130
		15
		12
		28
		14
		0
		12
		2
		3
		14
		14
RotatedHelicalTrackMCRelations	org.lcsim.event.LCRelation	0
SVTFittedRawTrackerHits	org.lcsim.event.LCRelation	79
SVTRawTrackerHits	org.lcsim.event.RawTrackerHit	79
SVTShapeFitParameters	org.lcsim.event.GenericObject	79
SeededMCParticles	org.lcsim.event.MCParticle	0
StripClusterer_SiTrackerHitStrip1D	org.lcsim.event.TrackerHit	36
TrackerHits	org.lcsim.event.SimTrackerHit	25
TriggerBank	org.lcsim.event.GenericObject	1

Instances

- HelicalTrackHits
- HelicalTrackHits

Apply immediately — Apply

Hide Types below level: 6

Hide Instances below level: 3

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Info panel 76.8/90.4MB

JAS3 LCIO Event Browser

JAS3

File Edit View Tuple Loop Window Help

Run:1357 Event: 110

Event
- ConfirmedMCParticles
- EcalCalHits
- EcalClusters
- EcalReado
- FPGAData
- FinalState
- HelicalTra
- HelicalTra
- HelicalTra
- MatchedT
- RotatedHe
- RotatedHe
- RotatedHe
- SVTFitted
- SVTRawT
- SVTShape
- SeededMC
- StripClust
- TriggerBa
- VertexedR

Collection: SVTRawTrackerHits size:101 flags:80000000

ReadoutName: TrackerHits

Time	CellID	ADCValues

Run:1357 Event: 110

Event
- ConfirmedMCParticles
- EcalCalHits
- EcalClusters
- EcalReadoutHits
- FPGAData
- FinalStateParticles
- HelicalTrackHitRelations
- HelicalTrackHits
- HelicalTrackMCRelations
- MatchedTracks
- RotatedHelicalTrackHitRelations
- RotatedHelicalTrackHits
- RotatedHelicalTrackMCRelations
- SVTFittedRawTrackerHits
- SVTRawTrackerHits
- SVTShapeFitParameters
- SeededMCParticles
- StripClusterer_SiTrackerHitStrip1D
- TriggerBank
- VertexedReconParticles

Collection: SVTShapeFitParameters size:101 flags:80000000

index	nInt	intValues	nFloat	floatValues	nDouble	doubleValues
0	0	[]	0	[]	7	[-14.010,1.2676,1593.2,32.679,48.279,NaN,140.59]
1	0	[]	0	[]	7	[-14.822,1.1757,1641.9,29.537,49.989,NaN,197.71]
2	0	[]	0	[]	7	[-17.088,1.2553,1639.6,28.590,50.094,NaN,187.41]
3	0	[]	0	[]	7	[-14.117,1.0621,1734.9,29.009,50.122,NaN,179.34]
4	0	[]	0	[]	7	[-14.390,1.2565,1522.9,29.644,50.491,NaN,202.10]
5	0	[]	0	[]	7	[-17.494,1.2527,1669.5,28.542,50.178,NaN,149.71]
6	0	[]	0	[]	7	[-15.052,1.1393,1667.7,28.841,49.827,NaN,204.42]
7	0	[]	0	[]	7	[-14.458,1.2065,1553.5,28.983,50.403,NaN,144.41]
8	0	[]	0	[]	7	[-14.827,1.1447,1670.9,29.306,49.846,NaN,206.43]
9	0	[]	0	[]	7	[-13.357,1.2458,1510.7,30.751,49.773,NaN,236.87]
10	0	[]	0	[]	7	[-16.331,1.2660,1612.7,29.089,50.674,NaN,199.41]
11	0	[]	0	[]	7	[-13.067,1.0593,1645.9,28.648,50.319,NaN,221.30]
12	0	[]	0	[]	7	[-14.435,1.1600,1642.9,29.430,50.596,NaN,165.00]
13	0	[]	0	[]	7	[-15.660,1.2467,1571.8,28.812,50.367,NaN,184.60]
14	0	[]	0	[]	7	[-14.682,1.2271,1554.0,29.201,50.426,NaN,187.42]
15	0	[]	0	[]	7	[-13.472,1.1135,1622.2,29.166,50.324,NaN,229.60]
16	0	[]	0	[]	7	[-15.372,1.0976,1766.5,28.891,50.260,NaN,244.68]
17	0	[]	0	[]	7	[-13.869,1.2304,1527.2,29.644,50.827,NaN,154.41]
18	0	[]	0	[]	7	[-13.552,1.1262,1604.8,29.056,50.389,NaN,152.14]

		Size
		0
		15
		4
		130
		15
		12
		28
		14
		0
		12
		2
		3
		14
		14
		0
		79
		79
		79
		0
		36
		25
TriggerBank	org.lcsim.event.GenericObject	1

Instances
- HelicalTrackHits
- HelicalTrackHits

Apply immediately — Apply

Hide Types below level: 6

Hide Instances below level: 3

JAS3Tree × WIRED ×

Click to center point, Shift-Click to move center to point, Drag to instant translate.

Info panel 76.8/90.4MB

JAS3 LCIO Event Browser

JAS3

File Edit View Tuple Loop Window Help

Run:1357 Event: 110

Event
- ConfirmedMCParticles
- EcalCalHits
- EcalClusters
- EcalReado
- FPGAData
- FinalState
- HelicalTra
- HelicalTra
- HelicalTra
- MatchedT
- RotatedHe
- RotatedHe
- RotatedHe
- SVTFitted
- SVTRawT
- SVTShape
- SeededMC
- StripClust
- TriggerBa
- VertexedR

Collection: SVTRawTrackerHits size:101 flags:80000000

ReadoutName: TrackerHits

Time	CellID	ADCValues

Run:1357 Event: 110

Event
- ConfirmedMCParticles
- EcalCalHits
- EcalClusters
- EcalReadoutHits
- FPGAData
- FinalStateParticles
- HelicalTrackHitRelations
- HelicalTrackHits
- HelicalTrackMCRelations
- MatchedTracks
- Ro
- Ro
- Ro
- SV
- SV
- SV
- Se
- Str
- Tri
- Ve

Collection: SVTShapeFitParameters size:101 flags:80000000

index	nInt	intValues	nFloat	floatValues	nDouble	doubleValues	Size
0	0	[]	0	[]	7	[-14.010,1.2676,1593.2,32.679,48.279,NaN,140.59]	0
1	0	[]	0	[]	7	[-14.822,1.1757,1641.9,29.537,49.989,NaN,197.71]	15
2	0	[]	0	[]	7	[-17.088,1.2553,1639.6,28.590,50.094,NaN,187.41]	4
3	0	[]	0	[]	7	[-14.117,1.0621,1734.9,29.009,50.122,NaN,179.34]	130
4	0	[]	0	[]	7	[-14.390,1.2565,1522.9,29.644,50.491,NaN,202.10]	15
5	0	[]	0	[]	7	[-17.494,1.2527,1669.5,28.542,50.178,NaN,149.71]	12
6	0	[]	0	[]	7	[-15.052,1.1393,1667.7,28.841,49.827,NaN,204.42]	28
7	0	[]	0	[]	7	[-14.458,1.2065,1553.5,28.983,50.403,NaN,144.41]	

Run:1357 Event: 110

Event
- ConfirmedMCParticles
- EcalCalHits
- EcalClusters
- EcalReadoutHits
- FPGAData
- FinalStateParticles
- HelicalTrackHitRelations
- HelicalTrackHits
- HelicalTrackMCRelations
- MatchedTracks
- RotatedHelicalTrackHitRelations
- RotatedHelicalTrackHits
- RotatedHelicalTrackMCRelations
- SVTFittedRawTrackerHits
- SVTRawTrackerHits
- SVTShapeFitParameters
- SeededMCParticles
- StripClusterer_SiTrackerHitStrip1D
- TriggerBank
- VertexedReconParticles

Collection: HelicalTrackHits size:6 flags:0

Position	CovMatrix	dEdx	Time	Type
[-12.588,-39.388,508.32]	[402.05,9.7829,.49994,-12.293,-.30512,.37602]	1.0297E-5	23.050	3
[42.412,-32.177,306.35]	[400.53,19.589,1.9656,-12.473,-.63310,.38894]	8.2804E-6	21.111	3
[23.360,-34.069,306.97]	[400.54,19.590,1.9657,-12.473,-.63314,.38895]	1.3834E-5	22.056	3
[22.939,-32.157,306.94]	[400.53,19.589,1.9656,-12.473,-.63310,.38894]	9.5869E-6	24.782	3
[3.8868,-34.049,307.55]	[400.54,19.590,1.9657,-12.473,-.63314,.38895]	1.5140E-5	25.727	3
[26.317,-28.519,106.64]	[400.50,19.695,1.9863,-12.474,-.63676,.38907]	1.0590E-5	30.192	3

Instances
- HelicalTrackHits
- HelicalTrackHits

Apply immediately

Hide Types below level:

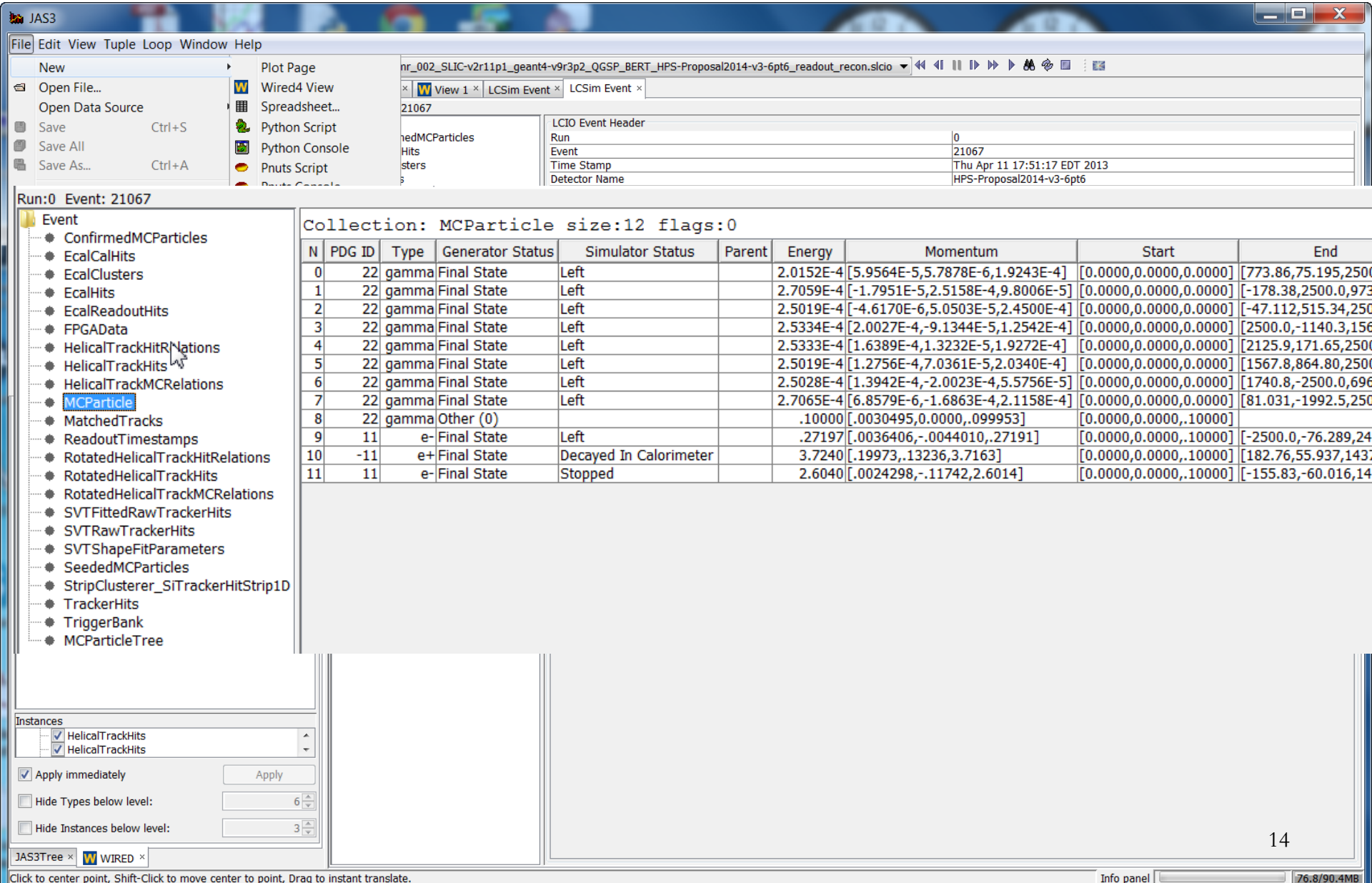
Hide Instances below level: 3

JAS3Tree × WIRED ×

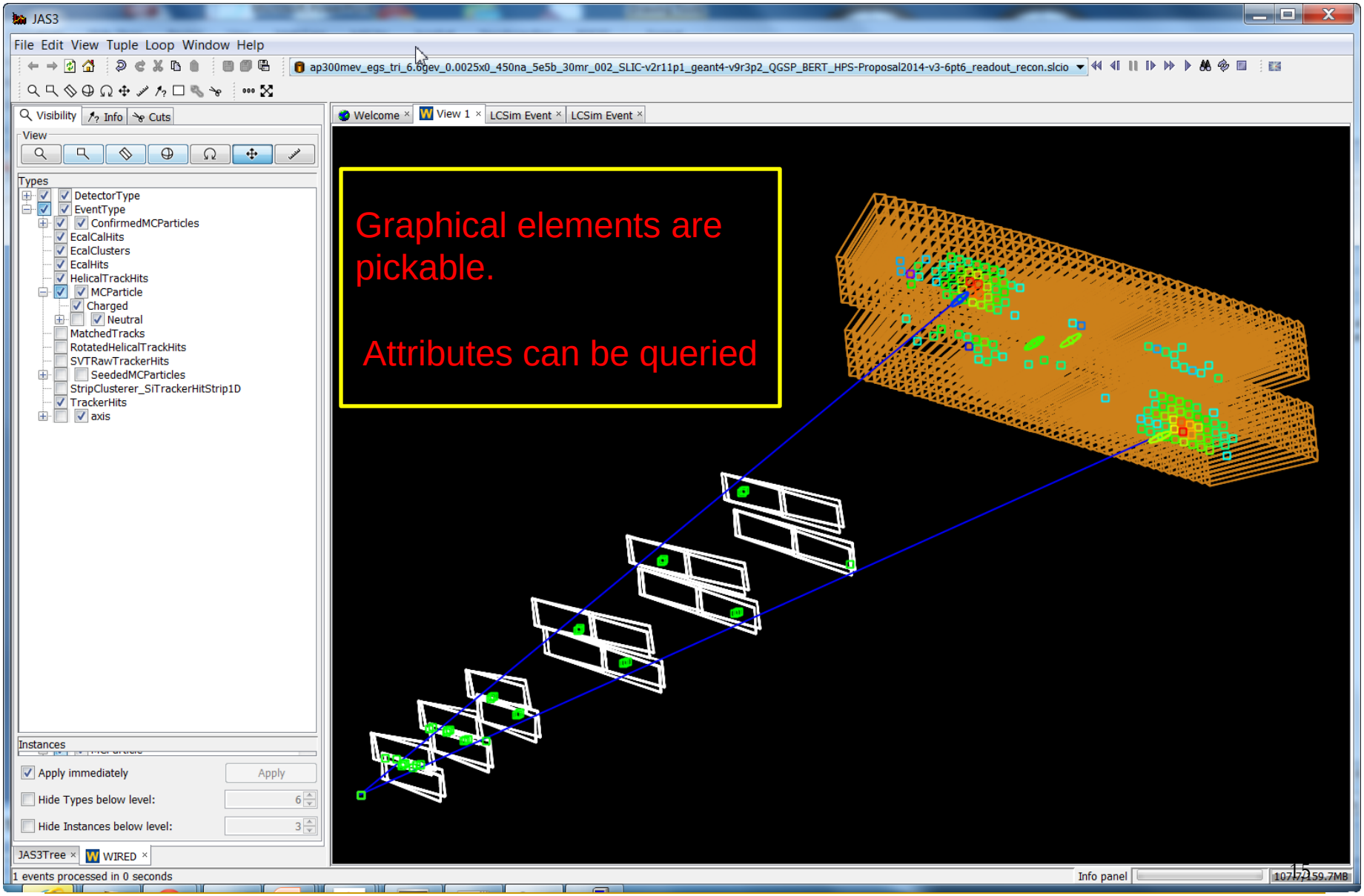
Click to center point, Shift-Click to move center to point, Drag to instant translate.

Info panel 76.8/90.4MB

JAS3 LCIO Event Browser



Wired Event Display



JAS3 + org.lcsim + Wired + AIDA

- Can also load and execute analysis Drivers from within JAS3
  - Collections added to the Event can be viewed in Wired or inspected in the LCIO event browser
- Support for scripting with full access to org.lcsim
  - jython
  - pnuts
- AIDA histograms and tuples can be created, analyzed, written out for further analysis, etc.
  - AIDA histograms can also be written out in native root format.

Accessing LCIO from root

- ROOT dictionaries available for LCIO since v2
- Compile LCIO with BUILD ROOTDICT=ON
- Start interactive root session, load the dictionaries and use LCIO classes

```
gSystem->load("$LCIO/lib/liblcio.so");
gSystem->load("$LCIO/lib/liblcioDict.so");
IO::LCReader* reader = IOIMPL::LCFactory().getInstance().createLCReade
reader->open("test.slcio");
EVENT::LCEvent* event = reader->readNextEvent();
while (event) {
    std::cout << event->getRunNumber() << std::endl;
    event = reader->readNextEvent();
}
reader->close();
```

Accessing LCIO from pyroot

- If ROOT is installed with python we get the LCIO python bindings for free!
- Compile LCIO with BUILD ROOTDICT=ON
- Start interactive python session, import ROOT, load the dictionaries and use LCIO classes

```
from ROOT import gSystem
gSystem.load("$LCIO/lib/liblcio.so")
gSystem.load("$LCIO/lib/liblcioDict.so")
from ROOT import IOIMPL
reader = IOIMPL.LCFactory().getInstance().createLCReader()
reader.open("test.slcio")
event = reader.readNextEvent()
while event:
    print event.getEventNumber()
    event = reader.readNextEvent()
reader.close()
```

Automatic Loading of Dictionaries

- `pyLCIO` package adds automatic loading of dictionaries on import
- Transparent import of the LCIO namespaces (identical to import from ROOT)

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Making LCIO Objects Iterable

- Add proper `__iter__()` method to relevant LCIO classes on import

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```
from pyLCIO import IOIMPL
reader = IOIMPL.LCFactory().getInstance().createLCReader()
reader.open("test.slcio")
for event in reader:
    print event.getEventNumber()
reader.close()
```

Making LCIO Objects Iterable

- Add proper `__iter__()` method to relevant LCIO classes on import

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from pyLCIO import IOIMPL
reader = IOIMPL.LCFactory().getInstance().createLCReader()
reader.open("test.slcio")
for event in reader:
    print event.getEventNumber()
reader.close()
```

- LCEvent acts like a list of tuples

```
for collectionName, collection in event:
    print collectionName, collection.getNumberOfElements()
```

Making LCIO Objects Iterable

- Add proper `__iter__()` method to relevant LCIO classes on import

```
from pyLCIO import IOIMPL
reader = IOIMPL.LCFactory().getInstance().createLCReader()
reader.open("test.slcio")
for event in reader:
    print event.getEventNumber()
reader.close()
```

- LCEvent acts like a list of tuples

```
for collectionName, collection in event:
    print collectionName, collection.getNumberOfElements()
```

- LCCollection acts like a list

```
for element in collection:
    print element
```

Enhanced Object Interfaces

- Avoid use of c-style arrays, e.g. `double[]`
- Decorate LCIO classes automatically on import depending on existing methods
- Add `getVariableVec()` that returns `TVector3` for all methods that return `double[3]`, e.g. `getPositionVec()` for all classes with `getPosition()`
- Similarly add `setVariableVec(TVector3)` to all IMPL classes
- Add `getLorentzVec()` that returns `TLorentzVector` to all classes that support `getMomentum()` and `getEnergy()`

Reading LCIO and StdHep Files

- IO::LCReader and UTIL::LCStdHepRdr now fulfill iterable interface

Reading LCIO and StdHep Files

- IO::LCReader and UTIL::LCStdHepRdr now fulfill iterable interface
- Offer two wrapper classes that streamline the interface of both readers
- Allow transparent loop over all input files

```
from pyLCIO.io.StdHepReader import StdHepReader
reader = StdHepReader("test.stdhep")
reader.addFile("test2.stdhep")
reader.addFiles(["test3.stdhep", "test4.stdhep"])
reader.addFileList("stdhepFiles.txt")
reader.skip( 10 )
for event in reader:
    print event.getEventNumber()
reader.close()
```

Event Loop and Analysis

- Provide a managed event loop similar to Marlin/`org.lcsim`
- Plug in user classes that are executed for each event
- Support LCIO and StdHep input using the new reader interface
- File type handled by event loop: `eventLoop.setFile( fileName )` independent of file type (determined by file extension)
- User class must inherit from `Driver` or implement: `startOfData()`, `process( event )`, `endOfData()`

Example Driver

```
from pyLCIO.drivers.Driver import Driver
from ROOT import TH1D, TCanvas

class McParticlePlotDriver( Driver ):
    def __init__( self ):
        Driver.__init__( self )
        self.histograms = {}

    def startOfData( self ):
        self.histograms['Energy'] = TH1D( 'Energy', 'Energy;Energy [GeV];Entries', 50, 0., 260. )
        self.histograms['Pt'] = TH1D( 'Pt', 'pT;p_T [GeV];Entries', 50, 0., 100. )
        self.histograms['PDGID'] = TH1D( 'PDGID', 'PDG ID;PDG ID;Entries', 1200, -600, 600. )
        self.histograms['GeneratorStatus'] = TH1D( 'GeneratorStatus', 'Generator Status;Generator Status;Entries

    def processEvent( self, event ):
        mcParticles = event.getMcParticles()
        for mcParticle in mcParticles:
            v = mcParticle.getLorentzVec()
            self.histograms['Energy'].Fill( v.Energy() )
            self.histograms['Pt'].Fill( v.Pt() )
            self.histograms['PDGID'].Fill( mcParticle.getPDG() )
            self.histograms['GeneratorStatus'].Fill( mcParticle.getGeneratorStatus() )

    def endOfData( self ):
        plots = []
        for histogramName in self.histograms:
            plot = TCanvas( 'c%s' % ( histogramName ), histogramName )
            self.histograms[histogramName].Draw()
            plots.append( plot )
        userInput = raw_input( 'Press any key to continue' )
```

$LCIO/examples/python/exampleDrivers/McParticlePlotDriver.py

Example Executable

```
from pyLCIO.base.EventLoop import EventLoop
from pyLCIO.drivers.EventMarkerDriver import EventMarkerDriver
from exampleDrivers.McParticlePlotDriver import McParticlePlotDriver
import sys, os

def McParticlePlots( fileName ):
    eventLoop = EventLoop()
    # Set the input file. The actual reader is determined from the file ending (stdhep or slcio)
    eventLoop.setFile( fileName )
    # Add a driver to print the progress
    markerDriver = EventMarkerDriver()
    markerDriver.setInterval( 1 )
    markerDriver.setShowRunNumber( False )
    eventLoop.add( markerDriver )
    # Add the driver that draws the MCParticle plots
    mcParticlePlotDriver = McParticlePlotDriver()
    eventLoop.add( mcParticlePlotDriver )
    # Skip some events if desired
    eventLoop.skipEvents( 0 )
    # Execute the event loop
    eventLoop.loop( -1 )

def usage():
    print 'Usage:\n  python %s <fileName>' % ( os.path.split( sys.argv[0] )[1] )

if __name__ == "__main__":
    if len( sys.argv ) < 2:
        usage()
        sys.exit( 0 )
    # Read the file name from the command line input
    fileName = sys.argv[1]
    McParticlePlots( fileName )
```

$LCIO/examples/python/McParticlePlots.py

XML Steering of Drivers (Experimental)

- Provide executable that parses an XML file and sets up the event loop
- At the moment very limited features - can be expanded if there is demand
- Run it: `python $LCIO/src/python/pylcio steering.xml`

```
<pylcio>
    <inputFiles>
        <file> test.slcio </file>
    </inputFiles>

    <control>
        <skipEvents>0</skipEvents>
        <numberOfEvents>-1</numberOfEvents>
        <printDrivers>True</printDrivers>
        <printStatistics>true</printStatistics>
    </control>

    <execute>
        <driver name="markerDriver"/>
        <driver name="mcParticlePlotDriver"/>
    </execute>

    <drivers>
        <driver name="markerDriver" type="pyLCIO.drivers.EventMarkerDriver.EventMarkerDriver">
            <interval> 1 </interval>
            <showRunNumber> False </showRunNumber>
        </driver>
        <driver name="mcParticlePlotDriver" type="exampleDrivers.McParticlePlotDriver.McParticlePlotDriver"/>
    </drivers>
</pylcio>
```

`$LCIO/examples/python/exampleSteering/McParticlePlots.xml`

Summary

- Python bindings work out of the box with ROOT LCIO dictionaries through pyROOT
- pyLCIO package for additional features
  - Automatic loading of ROOT and LCIO dictionaries on import
  - Added iterator methods to container and reader classes to allow *pythonic* loops
  - Additional accessor methods for LCIO classes to directly get `TVector3` and `TLorentzVector` where appropriate
  - Wrapper classes for LCReader and LCStdHepRdr to streamline interface
  - Managed event loop with driver/processor style plug-in of user code
  - XML steering of drivers (experimental)
- Use this for high level tasks like analysis, plotting and creation of tuples/trees
- Can not replace complex reconstruction algorithms in `org.lcsim`
- (Currently) no geometry information except raw cell IDs stored with hits

Requirements

- Install ROOT with python bindings
- Get LCIO version v02-04 or newer

- Compile with `BUILD_ROOTDICT=ON`
- Add ROOT and pyLCIO to python environment
  `export PYTHONPATH=$LCIO/src/python:$PYTHONPATH`
- Or simply source `$LCIO/setup.sh`

The data are out there…

- LCIO provides the Event Data Model and persistence format for HPS data.
  - Well documented API and binary IO format.
- Multiple language bindings and multiple toolkits exist to provide access to the data.
- Encourage all of you to look at the data and provide feedback on both the data quality and the functionality of the data analysis tools.
- Get involved!

Further Information

- Confluence wiki page at:

  https://confluence.slac.stanford.edu/display/hpsg/Simulation+and+Reconstruction+Software

- HPS Software mailing list:

  hps-software@slac.stanford.edu

- Issues/Bug tracker:
  https://jira.slac.stanford.edu/browse/HPSJAVA/