Muon Collider Simulation in org.lcsim: overview, status and plans

- The mcdrcal00 detector in org.lcsim
- Documentation
- Data Samples

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Documentation

Created Confluence page:

https://confluence.slac.stanford.edu/display/MCPDS/Home

Currently:

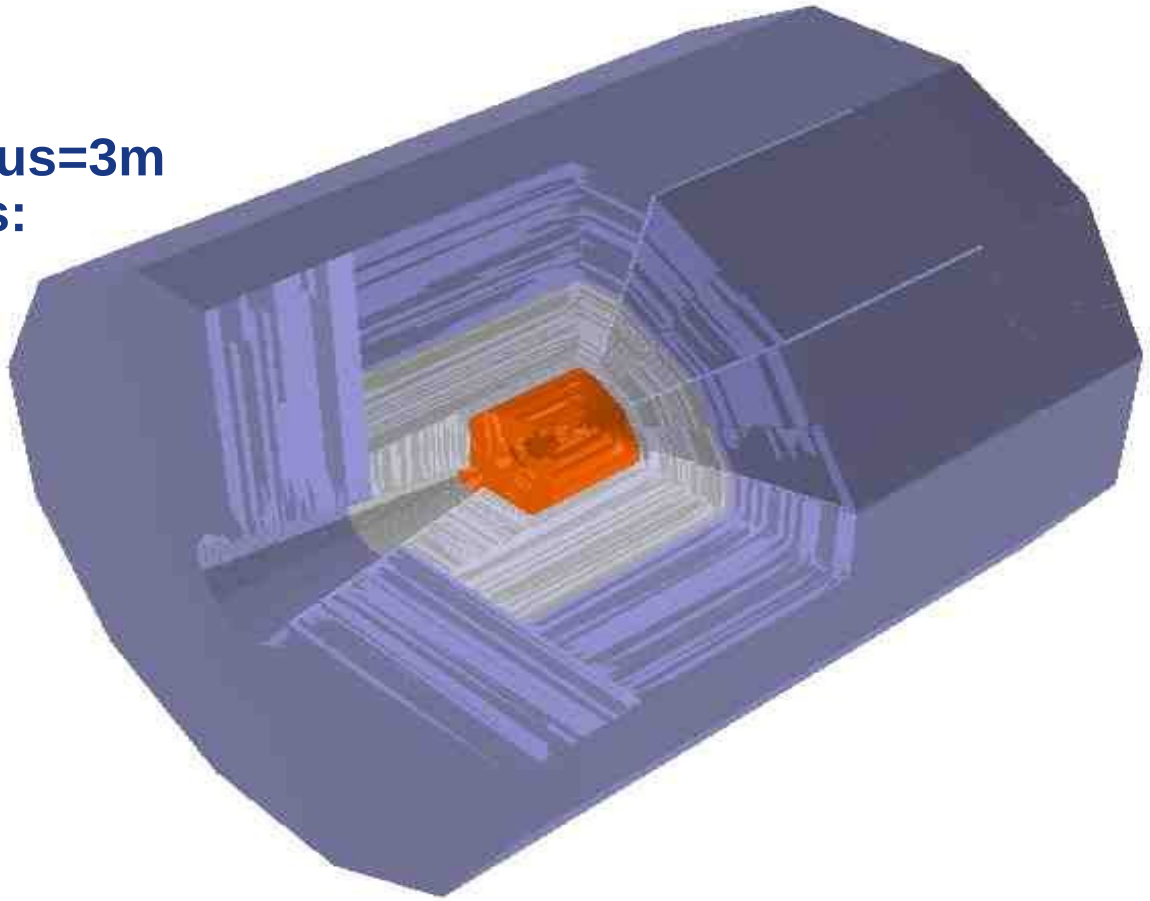
- Overview
- Event Generation
- Alex Timing studies

You can sign up here:

https://jira.slac.stanford.edu/signup/

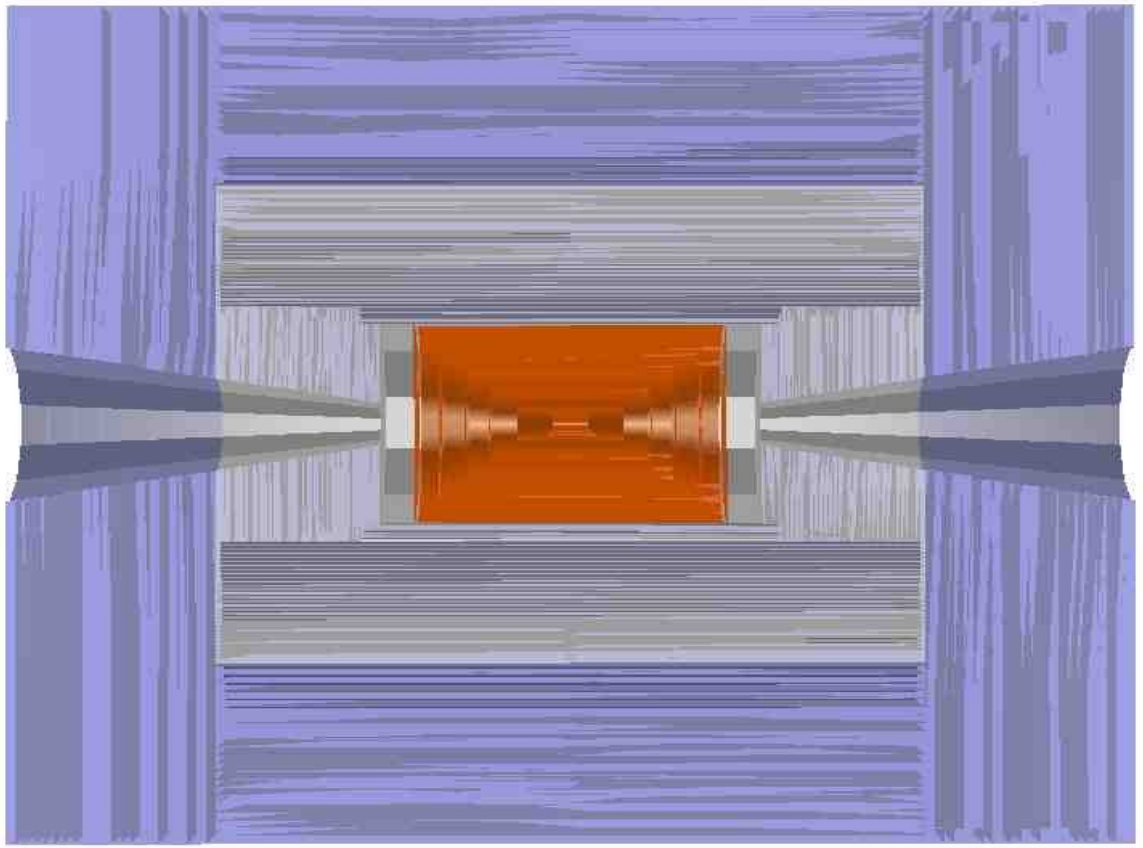
The mcdrcal00 detector in org.lcsim

5T solenoidal field, radius=3m
Calorimeter dimensions:
Rmin: 1.25 m
Rmax: 2.96 m
Length: 2x7.4 m



Detector description in CVS but can been found here (on detsim):
/ilc/sid/wenzel/muoncolliderdata/detectordescriptions

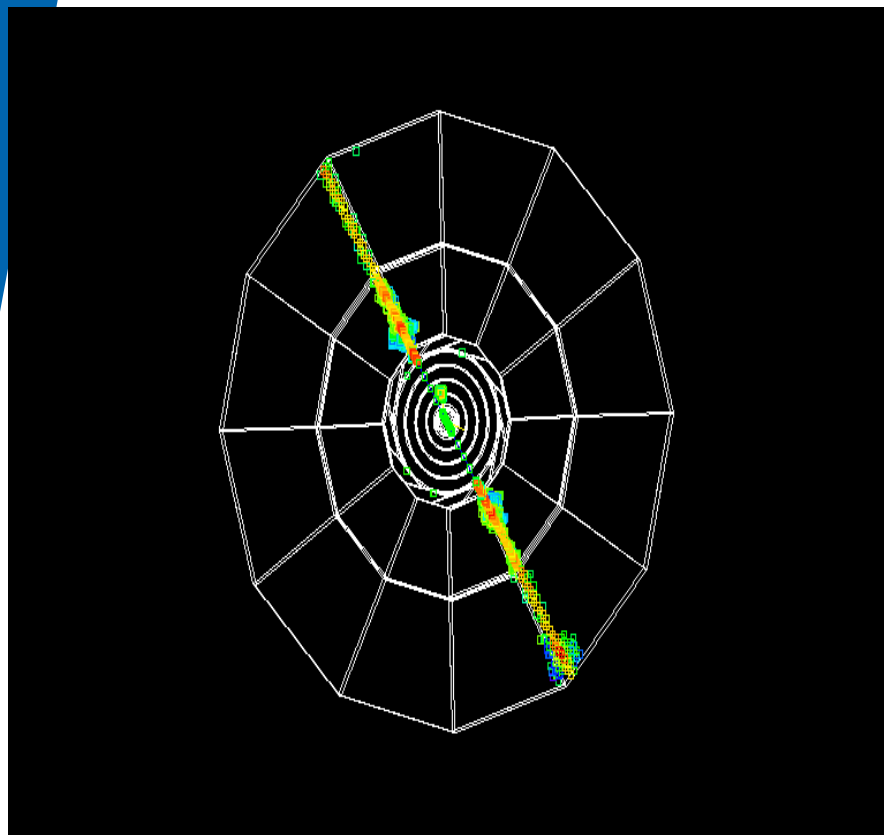
The mcdrcal00 detector in org.lcsim

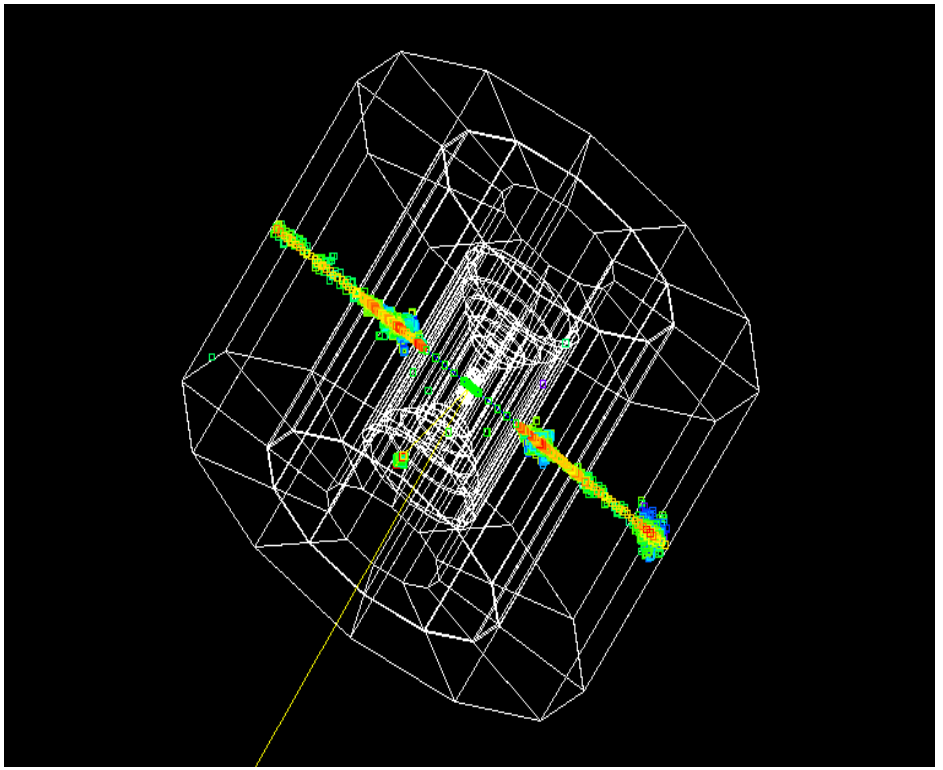


Calorimeter Properties for Barrel and Endcaps

NUM LAYERS	**EM**	**Hadron**	**Muon**
Material	BGO (PbF2)	BGO (PbF2)	Iron
Density {g/cm^3}	7.13	7.13	7.85
Cell size {cm^3}	1x1x2	2x2x5	10x10x10
Layers	10	30	22
Detector Depth {cm}	20	150	220
Radiation Length	1.1 cm	1.1 cm	1.76 cm
Nuclear Interaction Length	22.7 cm	22.7 cm	131.9 g/cm^2 16.8 cm

$Z' \rightarrow \mu^+\mu^-$





Caveats

- Tungsten cone commented out-> showers developing in the cone required a lot of CPU --> Need sensitive detector that registers particles that enter but then kills them.
- No Material for coil included
- Jas3 can't display all calorimeter shapes used for mcdrcal00 (but we can see the hits)
- Not enough iron to return flux of 5T solenoidal field
- Simulation of DR (cerenkov photons) is very slow due to the use of the Geant 4 G4Cerenkov process. Calculating the number of produced in the optical calorimeter sensitive detector class will speed up the process significantly. Currently the datasets are without optical processes enabled.

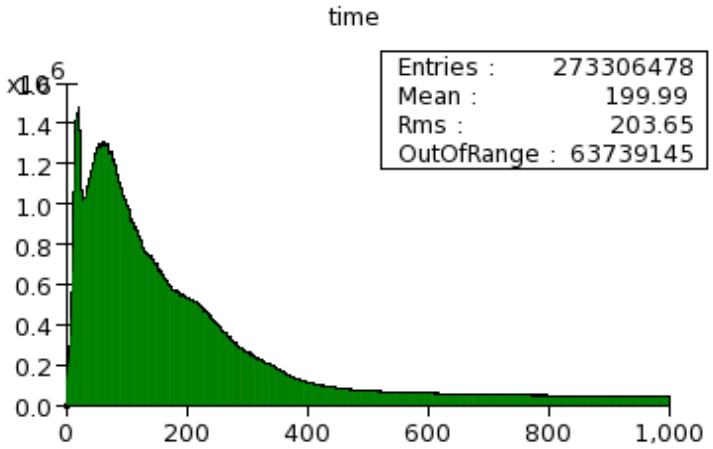
Data samples

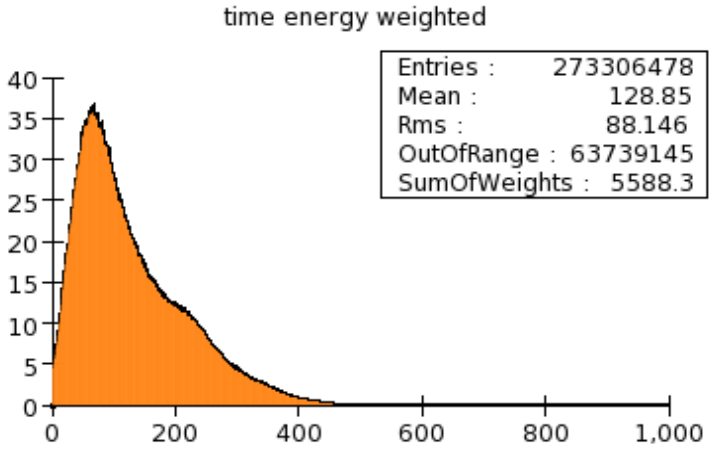
Fully simulated events on detsim (replacement of ilcsim and ilcsim2):

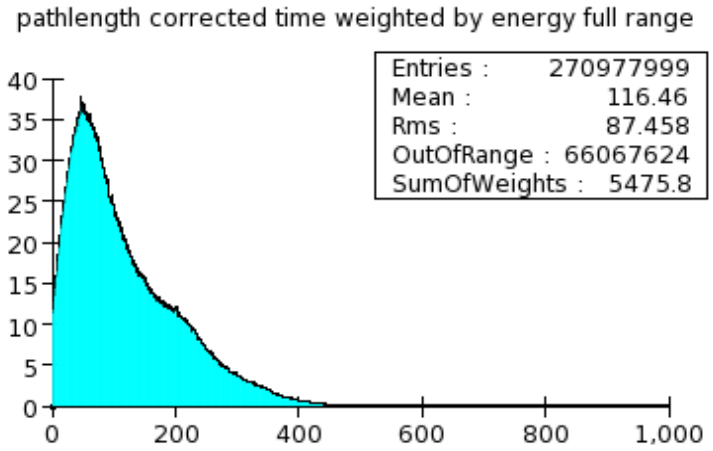
/ilc/sid/wenzel/muoncolliderdata/slcio/bgr

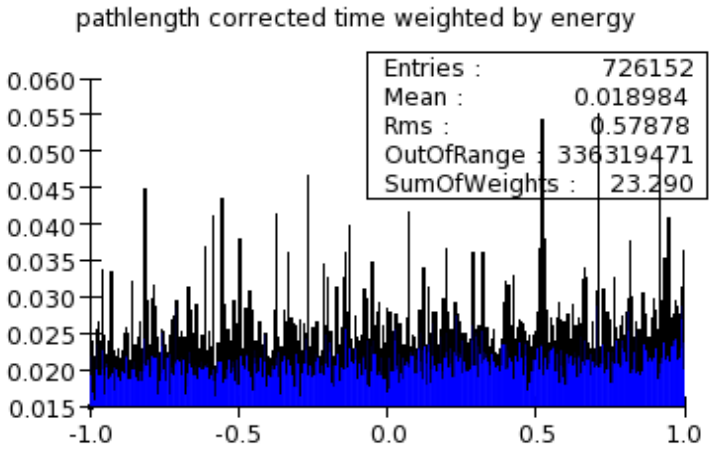
/ilc/sid/wenzel/muoncolliderdata/slcio/signal

Zp3TeVtoee.slcio
Zptomumu_3TeV_mcdrcal00.slcio

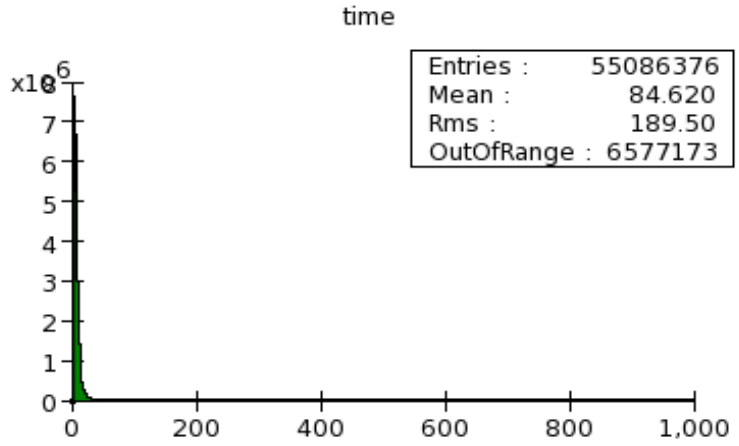

time
Entries : 273306478
Mean : 199.99
Rms : 203.65
OutOfRange : 63739145
x10^6
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1,000

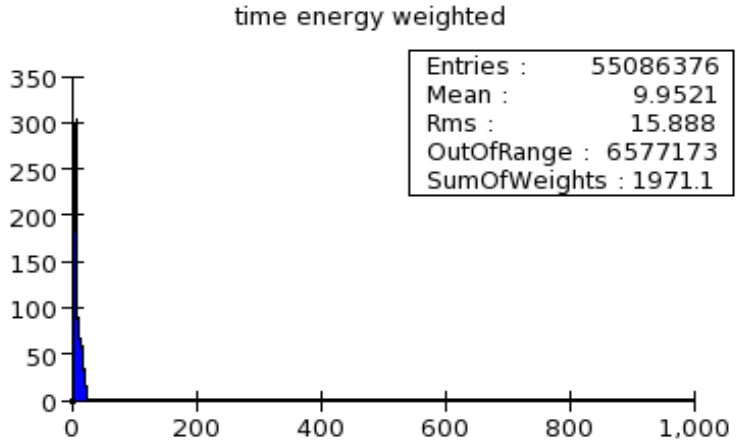

time energy weighted
Entries : 273306478
Mean : 128.85
Rms : 88.146
OutOfRange : 63739145
SumOfWeights : 5588.3
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1,000

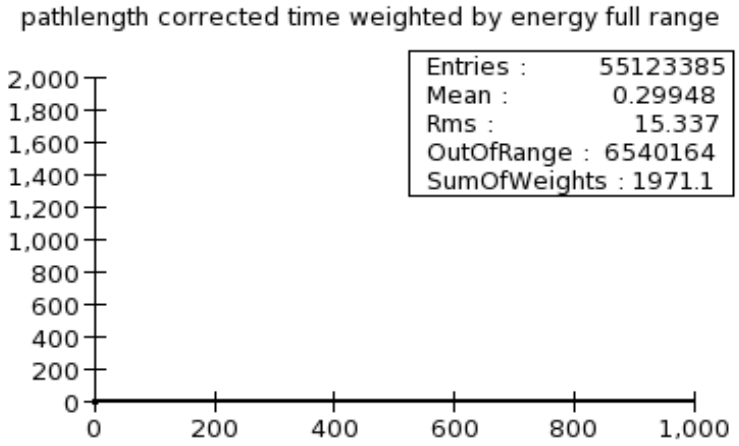

pathlength corrected time weighted by energy full range
Entries : 270977999
Mean : 116.46
Rms : 87.458
OutOfRange : 66067624
SumOfWeights : 5475.8
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1,000

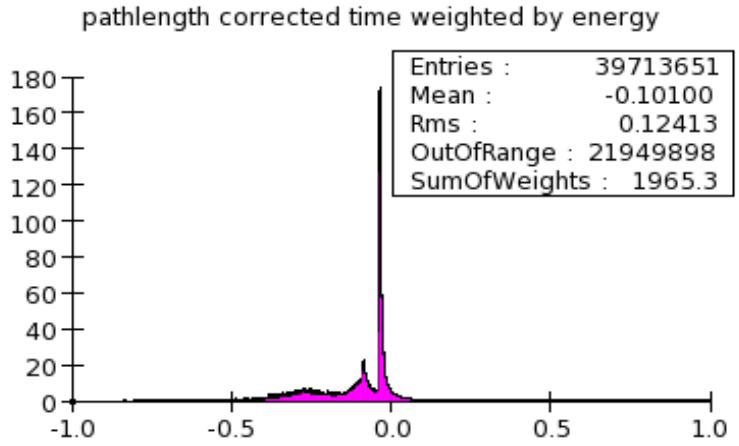

pathlength corrected time weighted by energy
Entries : 726152
Mean : 0.018984
Rms : 0.57878
OutOfRange : 336319471
SumOfWeights : 23.290
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
-1.0
-0.5
0.0
0.5
1.0

Z'->$\mu^+\mu^-$

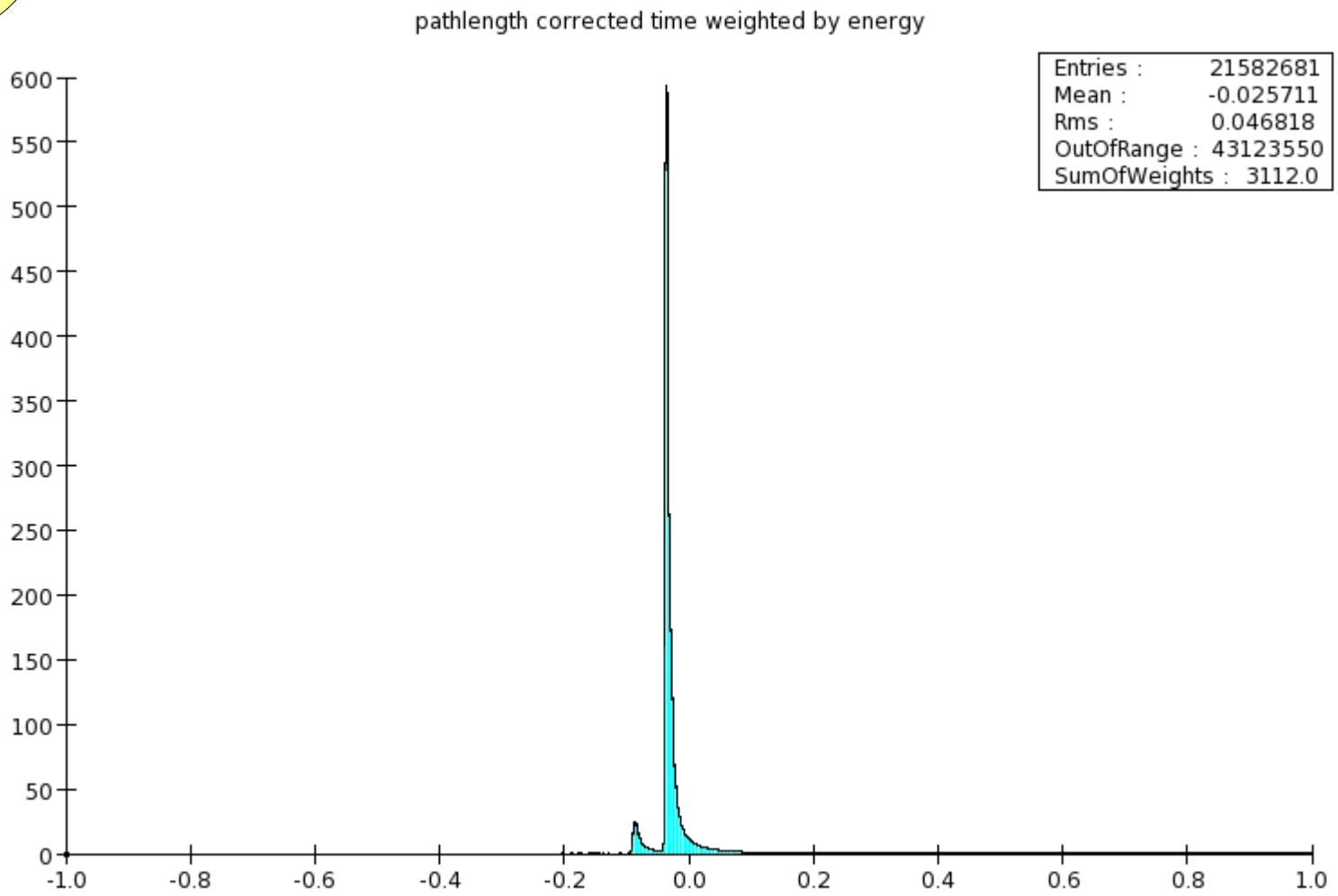

time
Entries : 55086376
Mean : 84.620
Rms : 189.50
OutOfRange : 6577173
x10^6
7
6
5
4
3
2
1
0
0
200
400
600
800
1,000


time energy weighted
Entries : 55086376
Mean : 9.9521
Rms : 15.888
OutOfRange : 6577173
SumOfWeights : 1971.1
350
300
250
200
150
100
50
0
0
200
400
600
800
1,000


pathlength corrected time weighted by energy full range
Entries : 55123385
Mean : 0.29948
Rms : 15.337
OutOfRange : 6540164
SumOfWeights : 1971.1
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0
200
400
600
800
1,000


pathlength corrected time weighted by energy
Entries : 39713651
Mean : -0.10100
Rms : 0.12413
OutOfRange : 21949898
SumOfWeights : 1965.3
180
160
140
120
100
80
60
40
20
0
-1.0
-0.5
0.0
0.5
1.0

Z'-> e^+ e^-


pathlength corrected time weighted by energy
Entries : 21582681
Mean : -0.025711
Rms : 0.046818
OutOfRange : 43123550
SumOfWeights : 3112.0
600
550
500
450
400
350
300
250
200
150
100
50
0
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0

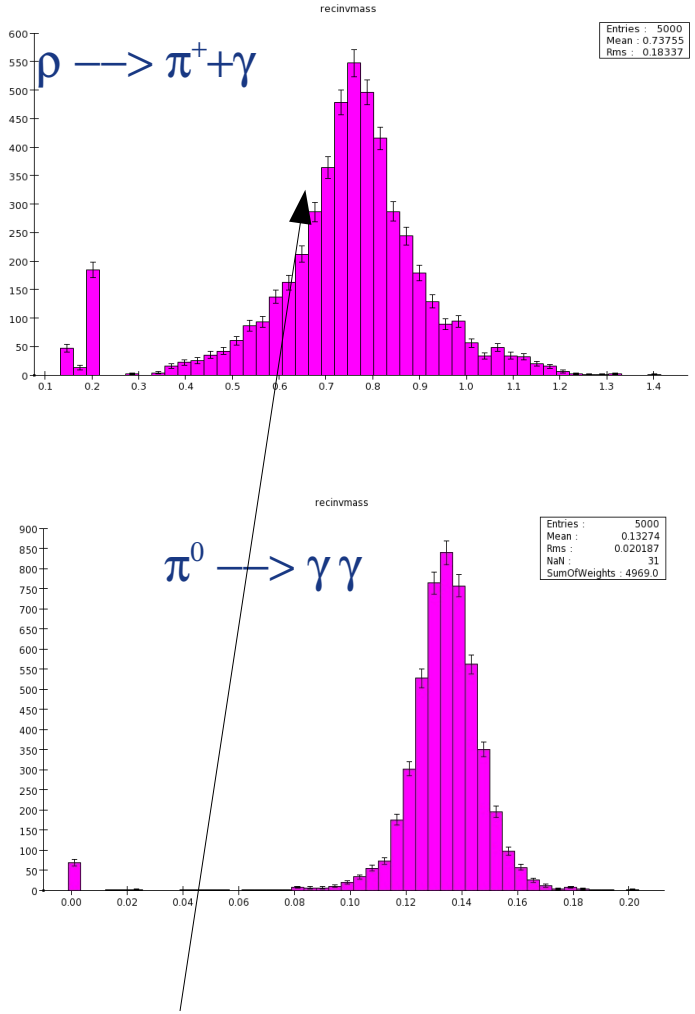
Plan

- Implement sensitive detector that counts the cerenkov photons.
- Implement sensitive detector for the tungsten cone
- Generate single particle data samples.

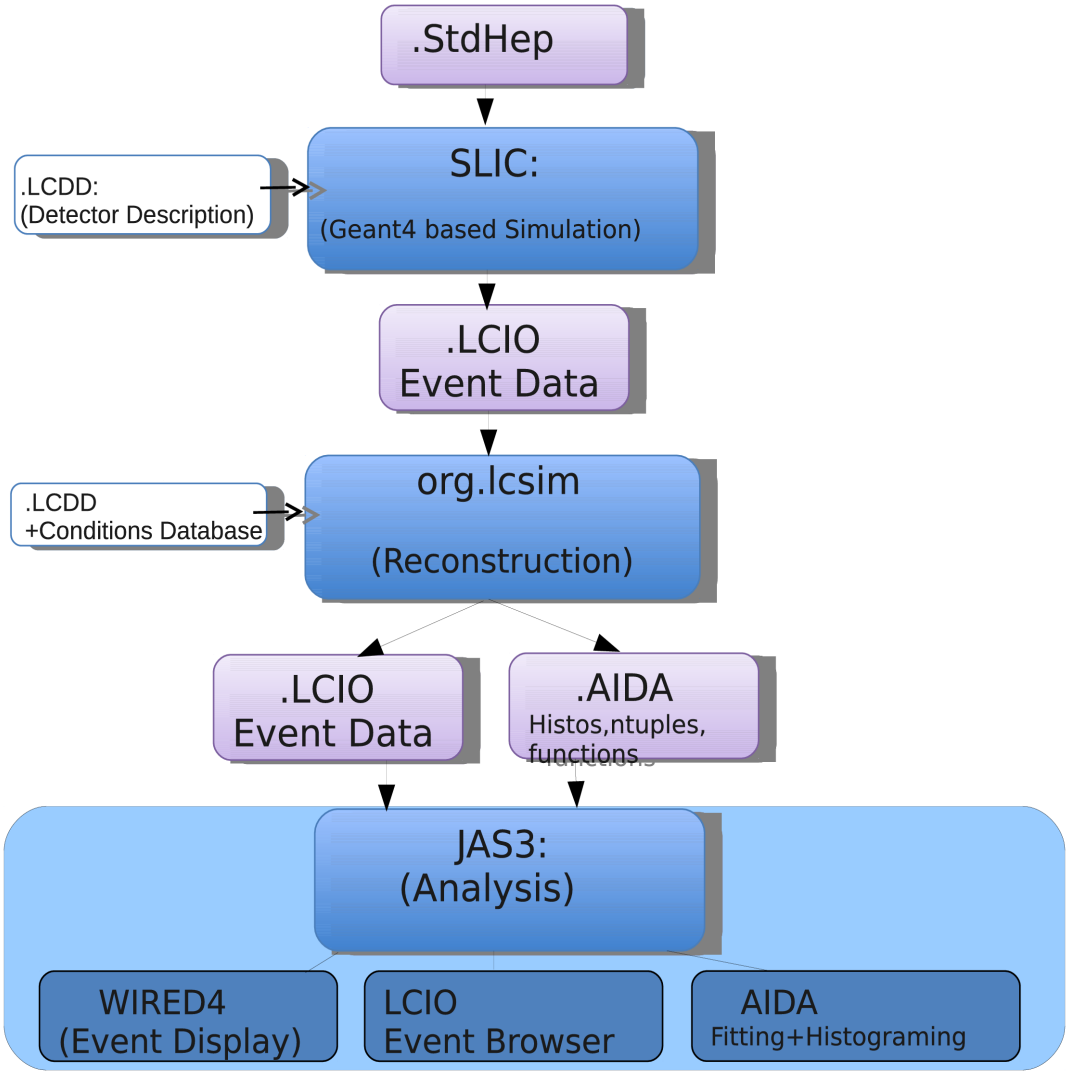
- We need:
  - a functional and 'realistic' detector description
  - To add timing information to the calorimeter Hits
  - To add Background events
  - org.lcsim drivers to run the reconstruction and analysis
  - collect data cards for physics processes of interest (defined benchmarks) + backgrounds thereof
  - documentation to guide physicist through all the steps. Confluence might be a good place for that.

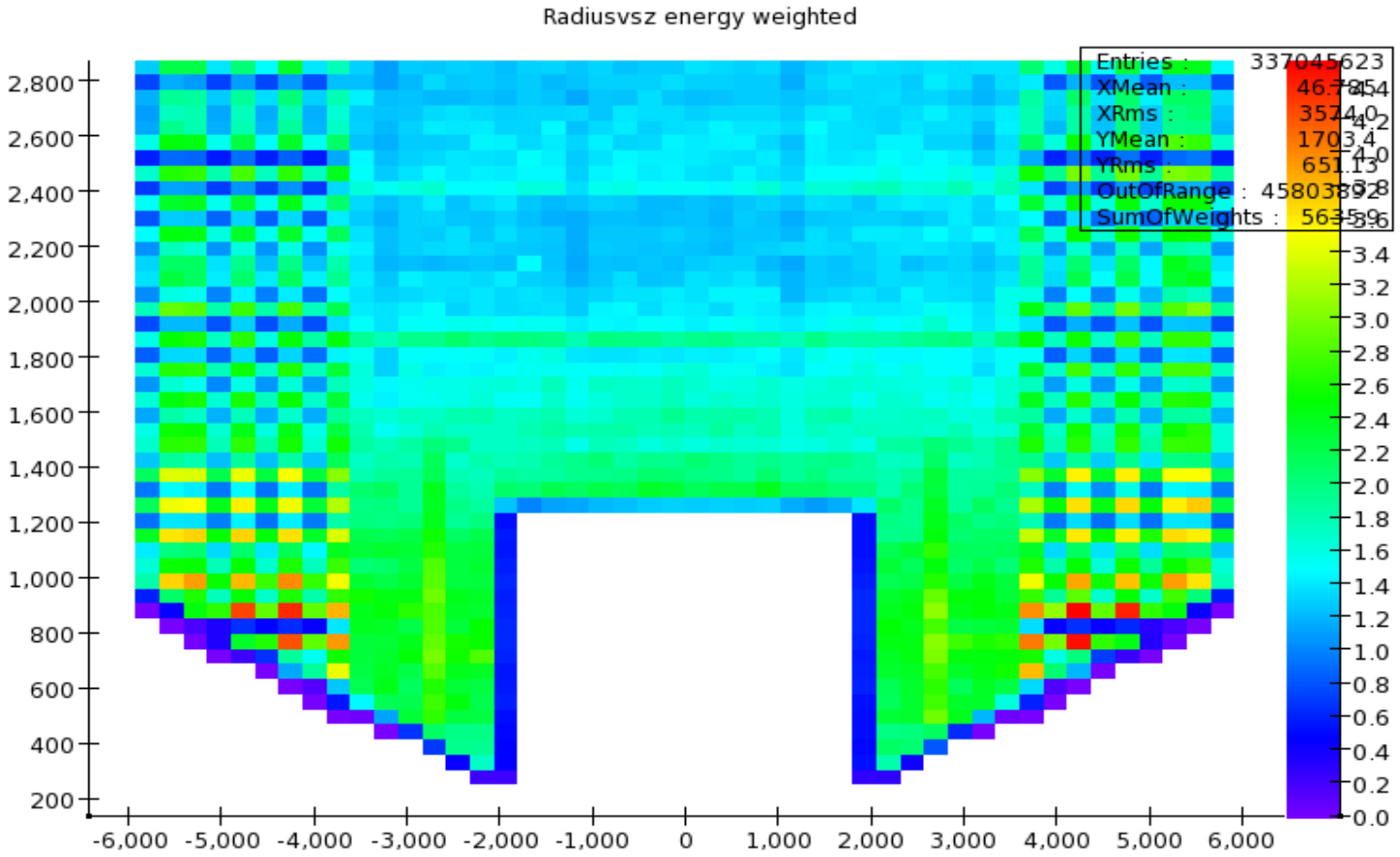
Status

- Get entire chain running at Fermilab (together with Alex Conway, YK student and Norman Graf)
  - Event generation (pythia)
  - Simulation (SLIC)
  - Event reconstruction (lcsim.org)
  - Analysis (jas3)
  - Documentation (confluence pages)
- But: Detector description was not complete:
  - Had to create tracker description, steering file for digitization.
- Even bigger BUT: it's buggy simulation hangs for anything more complicated than single event files.



Needs Tracking and calorimetry


.StdHep
SLIC:
(Geant4 based Simulation)
.LCDD:
(Detector Description)
.LCIO
Event Data
org.lcsim
(Reconstruction)
.LCDD
+Conditions Database
.LCIO
Event Data
.AIDA
Histos,ntuples,
JAS3:
(Analysis)
WIRED4
(Event Display)
LCIO
Event Browser
AIDA
Fitting+Histograming

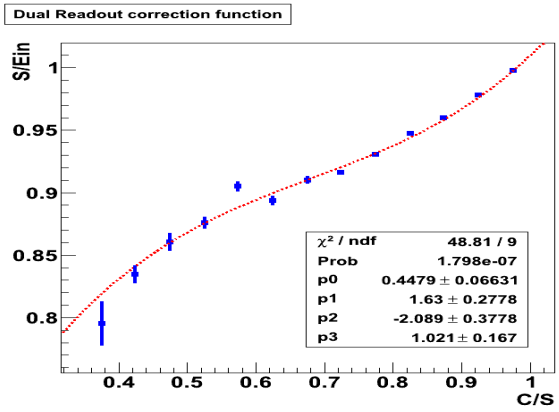

Radiusvsz energy weighted
Entries : 337045623
XMean : 46.78
XRms : 3514.0
YMean : 1703.4
YRms : 651.13
OutOfRange : 45803892
SumOfWeights : 56355.6
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-6,000
-5,000
-4,000
-3,000
-2,000
-1,000
0
1,000
2,000
3,000
4,000
5,000
6,000
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

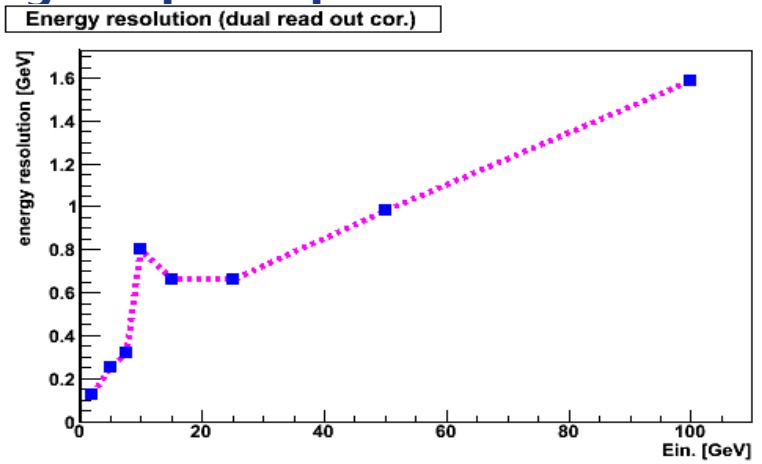
Plan

- Need a working detector model for the muon collider (Work with SLAC). Challenge is to deal with backgrounds while maintaining high precision (can it be done?). Needs detailed studies
- Calorimeter:
  - Dual readout (need to study how timing will affect the resolution after dual readout correction is applied)
  - Raja type: (digital sampling calorimeter with traveling time gate, software compensation)
- Tracker:
  - More like LHC than ILC, double or triple layers might be needed to help with pattern recognition. Need fast timing to reject background --> this will all come at a price (material budget)
- Once we have it: debug, biggest challenge will be to deal with the huge backgrounds and getting them into the simulation. (much more challenging than pile up at LHC and that was already difficult)

DRCalRoot: Geant 4 standalone application,

allows to do detailed tracing of optical photons.

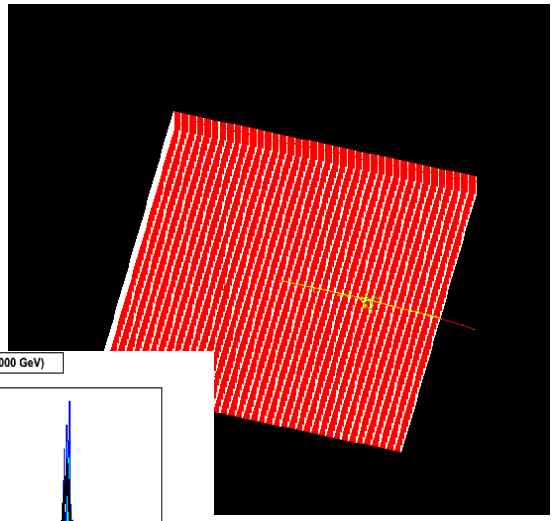


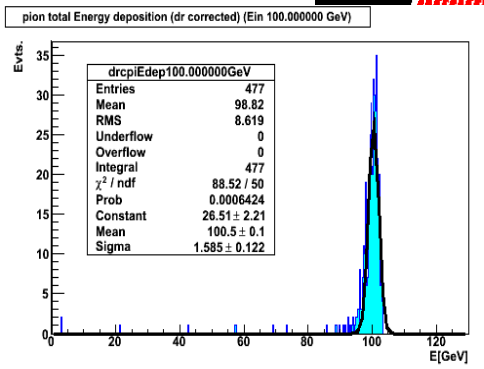


Crystal size in x,y,y: 5 cm
Nr. of cells in x,y,z: 40
Crystal Material : G4_BGO
Crystal Density : 7.13 [g/cm3]
Crystal interaction length: 22.6937 [cm]
Crystal radiation length: 1.11801 [cm]
Crystal total length (z,y,z): 200 [cm]
interaction length (z): 8.81301

(ignore material of silicon photo dets.
total # of IA length: 0.0524555)

Physics list: (the infamous) QGSP_BERT
No thresholds, no clustering





Customers: Giovanni, Anna, Mateo