SLIC Dual Read out Tutorial

Introduction

This page collects information about a total absorption dual readout calorimeter as implemented in SLIC. You will find information about the detector parameters, how to run the simulation, where data sets and programs to analyze the data can be found. The dual read out/ optical processes group meets every Tuesday at 9 am in the Quarium wh 8th floor. It is possible to dial in by phone or follow the meeting via skype. The agenda page can be found on the following web page:
http://ilcagenda.linearcollider.org/categoryDisplay.py?categId=151

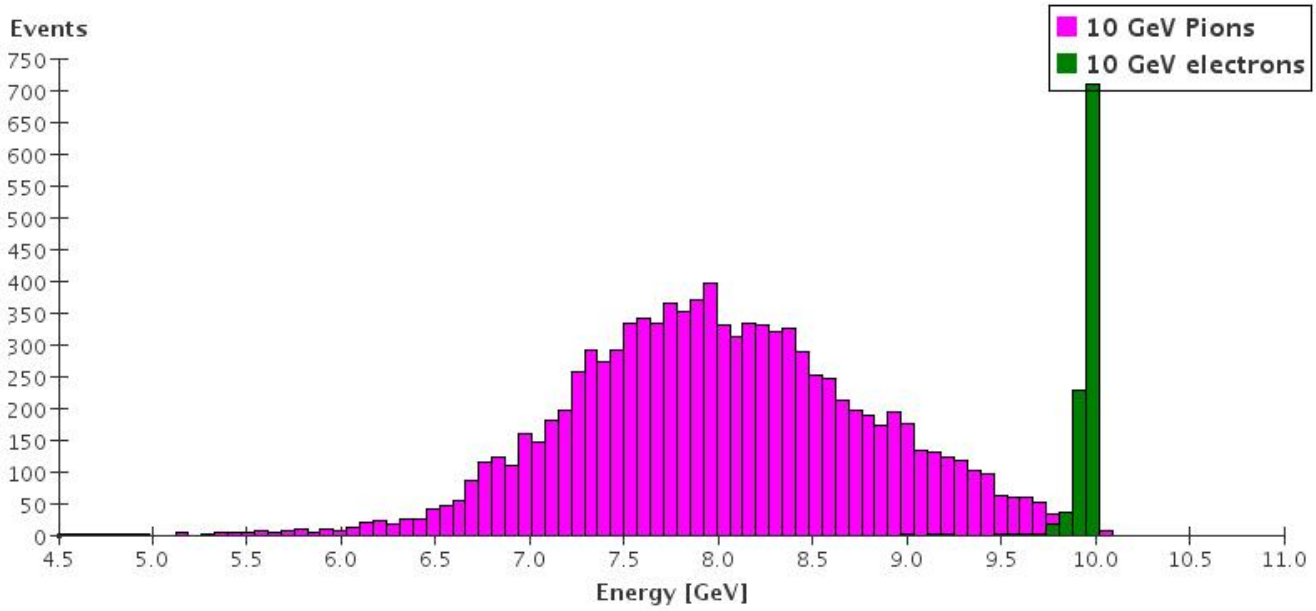
Principle of a dual read out calorimeter

The response of a calorimeter is very different for e+, e- and photons compared to hadrons. For e+, e- and photons the total energy of the incoming particle is converted into detectable kinetic energy of electrons leading to excellent energy resolution for electrons/photons. Hadrons on the other hand break nuclei and liberate nucleons/nuclear fragments. Even if the kinetic energy of the resulting nucleons is measured, the significant fraction of energy is lost to overcome the binding energy. Fluctuations of the number of broken nuclei dominate fluctuations of the observed energy leading to a relatively poor energy resolution for hadrons.This is demonstrated in the figure below where the ionization loss of a 10 GeV Pion is compared with the ionization loss of a 10 GeV electron. In both cases we use a simple Iron block as an absorber that contains the entire shower.

Large number of broken nuclei:
- Large number of slow neutrons
- Small fraction of energy in a form of neutral pions.

Very few broken nuclei:
- Small number of slow neutrons
- Large fraction of energy in a form of neutral pions.

Eem/Etot ~ ECherenkov/Eionization
'EM' shower => Relativistic electrons => Lots of Cherenkov light
Hadronic shower => Most particles below the Cherenkov threshold
Use this fact to correct hadron response



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Reconstruction of jet-jet invariant mass in a segmented total absorption dual read out calorimeter is investigated in a specific example of the crystal-based calorimeter for the SiD detector. The detector geometry is defined and the detector simulation is carried out within the geant 4 based SLIC (Simulation for LInear Collider) framework.
The analysis programs are developed in JAVA within the JAS3 (Java Analys Studio) environment.

Correlation between the total observed ionization energy and the electromagnetic component of the shower, as measured by the Cherenkov component. The calibration factor K is determined by the requirement that K×ECherenkov = Eionization for electrons.

The CCAL02 detector

Is an implementation of a daul read-out, total absorption crystal calorimeter made of BGO crystals. CCAL02 is based on the SID02 geometry but the space currently occupied by ECAL/HCAL Barrel/Endcap is replaced by the Crystal calorimeter. All other detectors (tracking etc.) as they are. ECAL deep enough to contain most EM showers.
The following table lists the properties of some crystal materials.

Material	Density	Radiation length	Interaction length
	[g/cm3]	[cm]	[cm]
BGO	7.13	1.12	21.88
PbWO4	8.3	0.9	18.
SCG1-C	3.36	4.25	45.6

The following table lists the parameters of the ccal02 calorimeter:

				BGO		PbWO4	
Detector	Layers	Thickness /layer	Segmentation	X0	Lambda	X0	Lambda
		[cm]	[cmxcm]				
ECAL Barrel	8	3	3x3	21.4	1.1	27	1.3
HCAL Barrel	17	6	6x6		4.7		5.7
Total Barrel	25				5.8		7
ECAL EndCAP	8	3	3x3	21.4	1.1	27	1.3
HCAL EndCAP	17	6	6x6		4.7		5.7
Total EndCAP	25				5.8		7

How to run the simulation

The shell script below demonstrates how to run slic using the ccal02 geometry. Note for a dual readout calorimeter it is important that the /physics/enableOptical flag is set otherwise no Cherenkov photons will be created!

```
#!/bin/tcsh -f
echo start
/bin/date
set current = 0
@ current = $1
echo $current
cat > optical_K0L_10GeV.mac << +EOF
/physics/enableOptical
/generator/filename /ilc/ild/wenzel/ccal02/stdhep/K0L_Theta90_10GeV-${current}-5000.stdhep
/lcio/path /ilc/ild/wenzel/ccal02/slcio
/lcio/filename K0L_Theta90_10GeV-${current}-5000
/lcio/fileExists delete
/lcdd/url /ilc/ild/wenzel/ccal02/ccal02/ccal02.lcdd
/run/initialize
/run/beamOn 5000
+EOF

echo optical_K0L_10GeV.mac
echo start
/bin/date
/grid/app/CherSimDist_may2009/SimDist/scripts/slic.sh -m  optical_K0L_10GeV.mac
/bin/date
echo done
```

A example how to run this on fermigrid is the following:

```
universe = grid
type = gt2
globusscheduler = fngp-osg.fnal.gov/jobmanager-condor
executable = ./slic_grid_K0L_10GeV.csh
transfer_output = true
transfer_error = true
transfer_executable = true
environment = "ClusterProcess=$(Cluster)-$(Process)"
log = slic_grid.log.$(Cluster).$(Process)
notification = NEVER
output = slic_grid.out.$(Cluster).$(Process)
error = slic_grid.err.$(Cluster).$(Process)
stream_output = false
stream_error = false
ShouldTransferFiles = YES
WhenToTransferOutput = ON_EXIT
globusrsl = (jobtype=single)(maxwalltime=999)
Arguments = $(Process)
queue 4
```

For more information about running jobs on the grid look at the following web page: http://confluence.slac.stanford.edu/display/ilc/How do I use the OSG Grid

Available Data sets

The Table below list all the data samples currently available at Fermilab. The files can be found on the following directory (on the bluearc system)

/ilc/ild/wenzel/ccal02/slcio_combined

File Name	Type of Events	Nr of Events
pi_Theta90_1GeV.slcio	single 1 GeV pions at theta 90 degrees	20000
pi_Theta90_2GeV.slcio	single 2 GeV pions at theta 90 degrees	20000
pi_Theta90_5GeV.slcio	single 5 GeV pions at theta 90 degrees	20000
pi_Theta90_10GeV.slcio	single 10 GeV pions at theta 90 degrees	20000
pi_Theta90_20GeV.slcio	single 20 GeV pions at theta 90 degrees	20000
pi_Theta90_50GeV.slcio	single 50 GeV pions at theta 90 degrees	20000
pi_Theta90_100GeV.slcio	single 100 GeV pions at theta 90 degrees	20000
electron_Theta90_1GeV.slcio	single 1 GeV electrons at theta 90 degrees	5000
electron_Theta90_2GeV.slcio	single 2 GeV electrons at theta 90 degrees	5000
electron_Theta90_5GeV.slcio	single 5 GeV electrons at theta 90 degrees	5000
electron_Theta90_10GeV.slcio	single 10 GeV electrons at theta 90 degrees	5000
electron_Theta90_20GeV.slcio	single 20 GeV electrons at theta 90 degrees	5000
electron_Theta90_50GeV.slcio	single 50 GeV electrons at theta 90 degrees	2432
electron_Theta90_100GeV.slcio	single 100 GeV electrons at theta 90 degrees	1215
neutrons_20GeV.slcio	single 20 GeV neutrons	200
n_Theta90_1GeV.slcio	single 1 GeV neutrons at theta 90 degrees	10000
n_Theta90_2GeV.slcio	single 2 GeV neutrons at theta 90 degrees	10000
n_Theta90_5GeV.slcio	single 5 GeV neutrons at theta 90 degrees	10000
n_Theta90_10GeV.slcio	single 10 GeV neutrons at theta 90 degrees	10000
n_Theta90_20GeV.slcio	single 20 GeV neutrons at theta 90 degrees	10000
nbar_Theta90_1GeV.slcio	single 1 GeV anti-neutrons at theta 90 degrees	9750
nbar_Theta90_2GeV.slcio	single 2 GeV anti-neutrons at theta 90 degrees	10000

nbar_Theta90_5GeV.slcio	single 5 GeV anti-neutrons at theta 90 degrees	10000
nbar_Theta90_10GeV.slcio	single 10 GeV anti-neutrons at theta 90 degrees	9700
nbar_Theta90_20GeV.slcio	single 20 GeV anti-neutrons at theta 90 degrees	9950
muon_Theta90_50GeV.slcio	single 50 GeV muons	5000
K0L_Theta90_1GeV.slcio	single 1 GeV K longs at theta 90 degrees	20000
K0L_Theta90_2GeV.slcio	single 2 GeV K longs at theta 90 degrees	20000
K0L_Theta90_5GeV.slcio	single 5 GeV K longs at theta 90 degrees	20000
K0L_Theta90_10GeV.slcio	single 10 GeV K longs at theta 90 degrees	20000
K0L_Theta90_20GeV.slcio	single 20 GeV K longs at theta 90 degrees	20000
K0L_Theta90_50GeV.slcio	single 50 GeV K longs at theta 90 degrees	20000
panpyZZnunubaruds-0-1000.slcio	ZZ -> neutrino neutrino jet jet	1000
Z0_Theta90_50GeV.slcio	single 50 GeV Z 's at theta 90 degrees	100000
W_0_100.slcio	single 0-100 GeV W 's	20000
W_100_200.slcio	single 100-200 GeV W 's	20000
pythiaZhiggs120_uds_4jets.slcio	associated Z Higgs production Z and Higgs decay into light quarks (jets)	4823