Muon collider detector R&D (mcdrd): computing resources and status

Hans Wenzel

May 8th 2013

U.S. DEPARTMENT OF ENERGY

Fermilab

Muon Collider Documentation

Created Confluence page:

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

Look for:

Documentation for Accessing MCD R&D Computing Resources

You can sign up here:

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

MCDRD: computing resources

- Virtual Organization (VO): mcdrd

  Sign up at: https://voms.fnal.gov:8443/voms/mcdrd

  (we have 250 dedicated slots on fermigrid and we are part of OSG)

- reference machine on the fermicloud: mcdrd.fnal.gov

  To get an account contact service desk and request a fermicloud account and request access to mcdrd.

- 1 TB of dedicated disk space on bluearc: /grid/data/mcdrd

- software installed in: /grid/data/mcdrd/sw

  detectors jas-assembly-0.9.9 jdk1.7.0_21 mac slic

  – e.g. To run slic:

```
. ../slic/v00-00/geant4/9.6.p01/bin/geant4.sh
/grid/data/mcdrd/sw/slic/v00-00/slic/HEAD/build/bin/slic -m run_Higgs.mac
```

- data available in: /grid/data/mcdrd/data

MCDRD: computing resources (cont.)

- requested (approved): 100TB in fermilab mass storage system (dcache, enstore) --> will write instructions once it's installed and working.
- Right now resources are limited but we can probably ask for more when we need it (easier to extend than start from scratch)

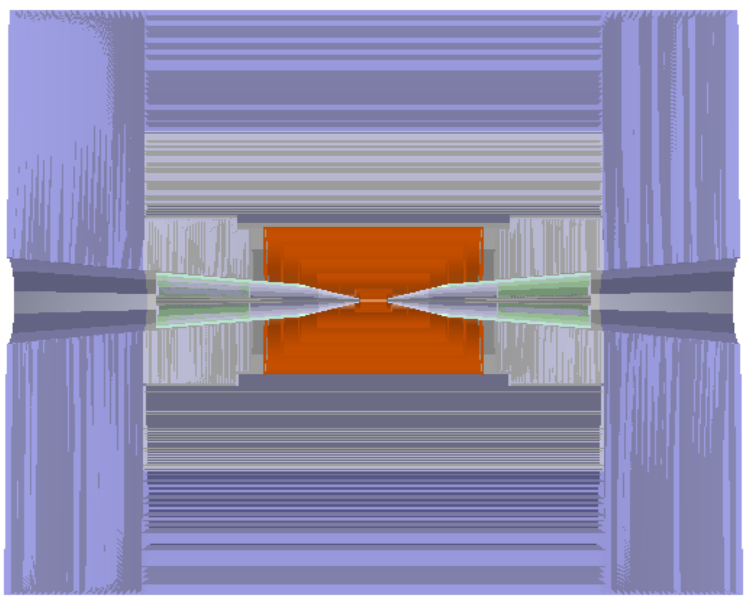
Changes to slic and Geomconverter

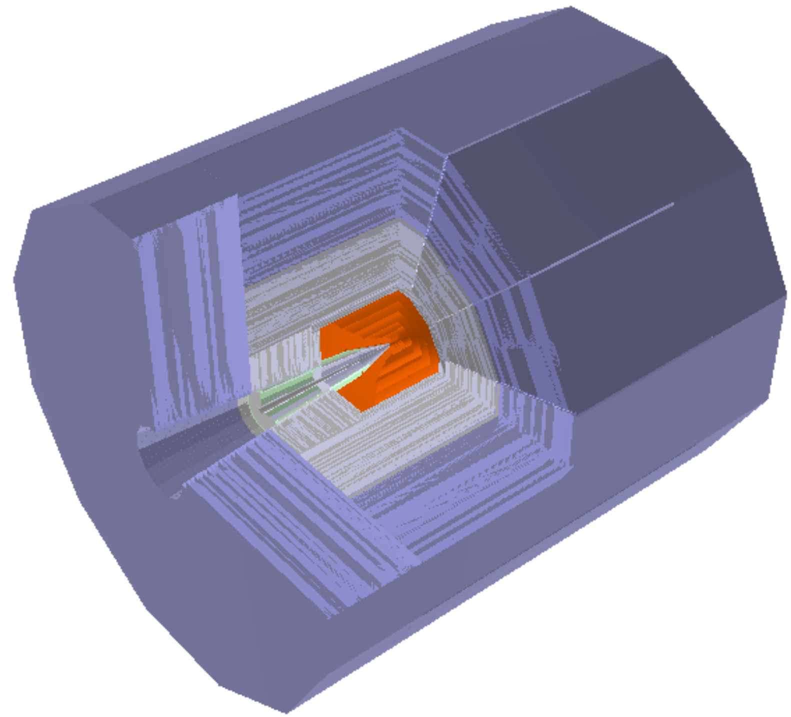
- Thanks to Jeremy:
- Slic now uses the latest version of geant 4 (4.9.6.p01) and new build system.
- Now optical properties can be specified in compact.xml and propagate to .lcdd and .gdml files.
- Simple switch allows to enable optical physics processes and change calorimeter into dual readout calorimeter (slow)
- Now we have the chance to kill particles entering a specific volume (e.g. the tungsten cone)

The mcdrcal01 detector in org.lcsim

5T solenoidal field, radius=3.075m

Calorimeter dimensions:
Rmin: 1.36 m
Rmax: 3.07 m
Length: 2x3.702 m

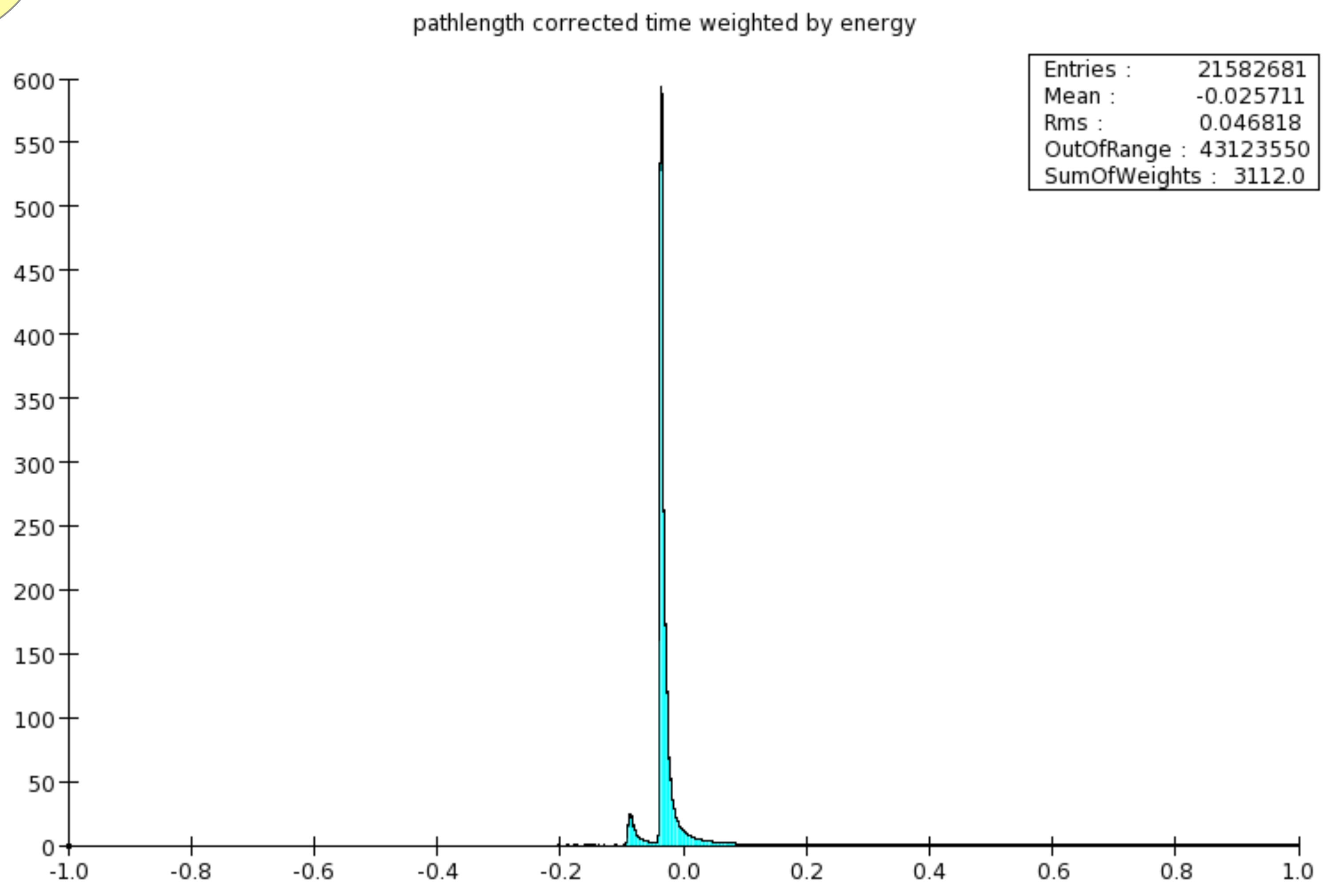




Calorimeter Properties for Barrel and Endcaps

	EM	Hadron	Muon
Material	BGO (PbF2)	BGO (PbF2)	Iron
Density [g/cm^3]	7.13 (7.77)	7.13 (7.77)	7.85
Cell size [cm^3]	1x1x2	2x2x5	10x10x10
Layers	10	30	22
Detector Depth [cm]	20	150	220
Radiation Length [cm]	1.1 (0.93)	1.1 (0.93)	1.76
Nuclear Interaction Length [cm]	22.7 (22.4)	22.7 (22.4)	16.8
Total Nr of IA length (em +had)	**7.5 (7.6)**		

Z'-> $e^+ e^-$

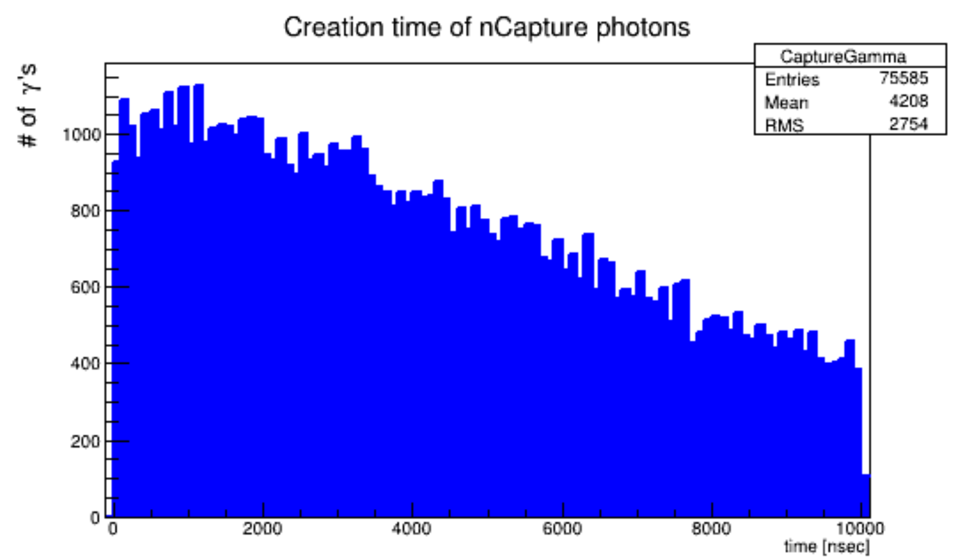

pathlength corrected time weighted by energy
Entries : 21582681
Mean : -0.025711
Rms : 0.046818
OutOfRange : 43123550
SumOfWeights : 3112.0
600
550
500
450
400
350
300
250
200
150
100
50
0
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0

Contribution of neutron Capture process in 5 GeV π^- showers

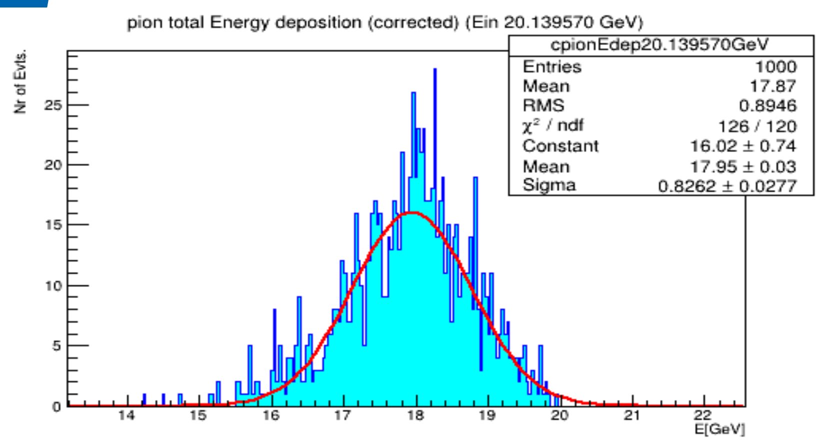
Response		Response due to nCapture		Fractional nCapture Response	
Ionization [GeV]	Cerenkov [# C phot.]	Ionization [GeV]	Cerenkov [# C phot.]	Ionization [%]	Cerenkov [%]
4.322	1.977E5	0.734	0.456E5	17	23

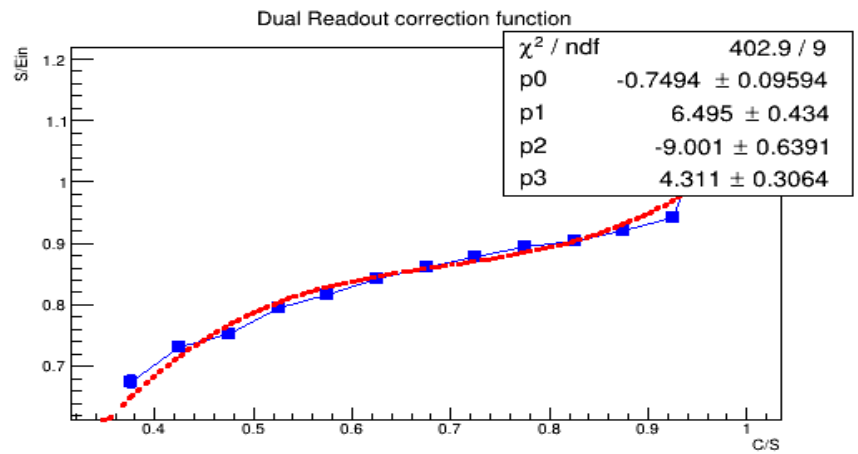
n→ thermalize → neutron Capture → γ → visible Energy

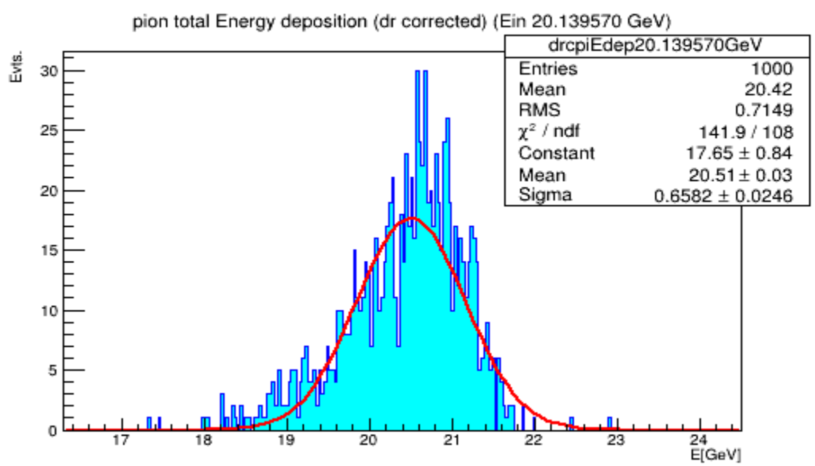
(mean Time: 4.2 μ sec)



Effect of dual read out correction: all contributions no gate



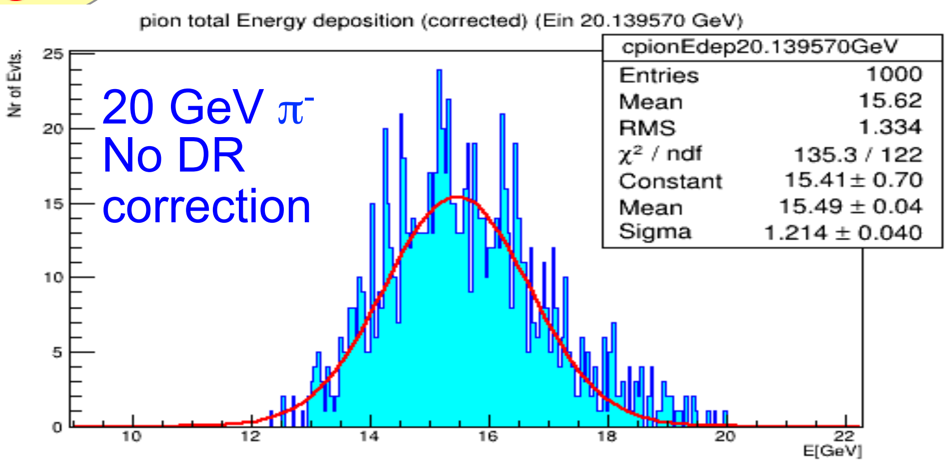


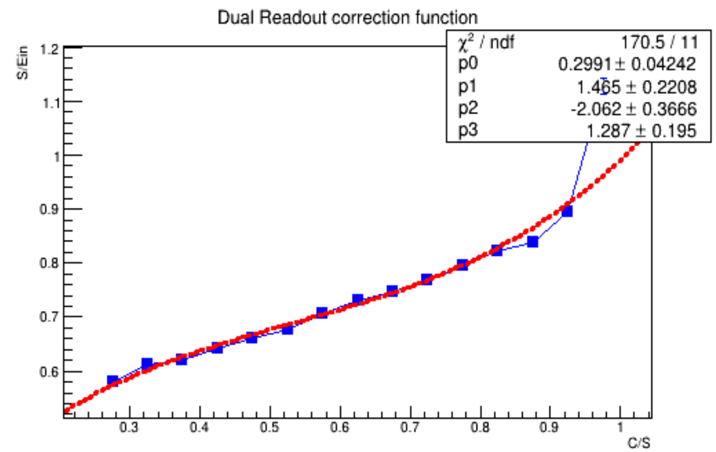


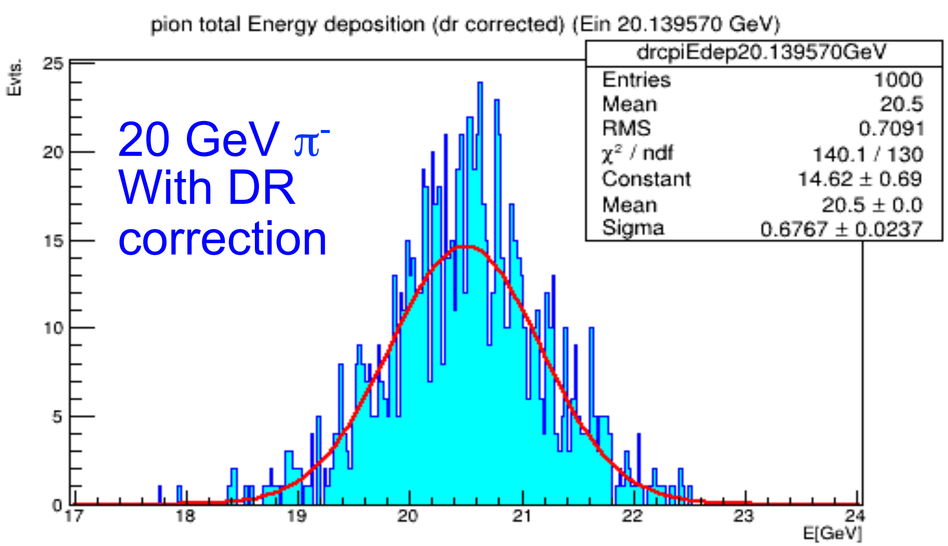
Before Dual Read out correction:
Mean: 17.95 GeV
σ: 0.826 +/-0.03GeV

After DR correction:
Mean: 20.5 GeV
σ: 0.66+/-0.02 GeV

Effect of dual read out correction: γ 's from neutron Capture discarded





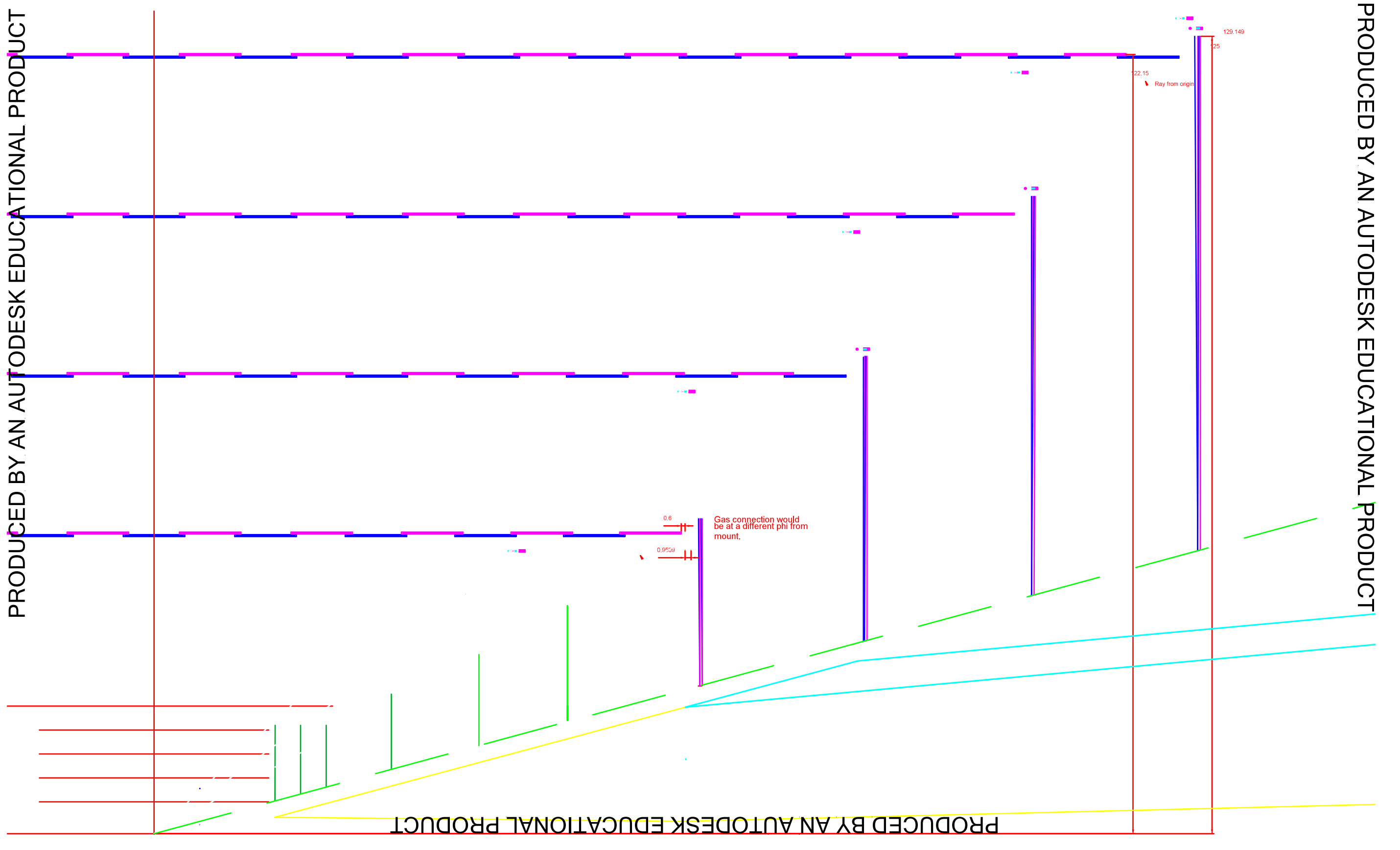


Before Dual Read out correction:
Mean: 15.5 GeV
(reduced by 13.6 %)
σ: 1.21+/-0.04 GeV

After DR correction:
Mean: 20.5 GeV
σ: 0.68+/-0.02 GeV

Mcdrcal01: Tracker

Simplified geometry: cylinders and disk no segmentation



Vertex Detector barrel

Layer	Pitch rphi	pitch z	sensor thickness	low Z	High Z	Radius
1	20	20	75	-20	20	5.40
2	20	20	75	-20	20	9.45
3	20	20	75	-20	20	13.49
4	20	20	75	-20	20	17.55
5	20	20	75	-30	30	21.59

Vertex Detector Disks

Layer	Pitch rphi	pitch ra	sensor thicknes:	Z	er radius	Radius
1	50	50	100	20.5	5.5	18.35
2	50	50	100	24.8	6.7	18.35
3	50	50	100	29.15	7.9	18.35
4	50	50	100	40	10.9	23.6
5	50	50	100	55	14.1	30.32
6	50	50	100	70	19.2	38.6

Tracker Barrel

Layer	Pitch rphi	pitch z	sensor thicknes:	low Z	High Z	Radius
1	100	1000	200	-91	91	50
2	100	1000	200	-119	119	77
3	100	1000	200	-147	147	103
4	100	1000	200	-175	175	130

Tracker Disks

Layer	Pitch rphi	pitch ra	sensor thicknes:	Z	er radius	Radius
1	100	1000	200	92	25.2	53.3
2	100	1000	200	120.75	32.7	80.8
3	100	1000	200	149	40.4	108
4	100	1000	200	177	48	135

Caveats

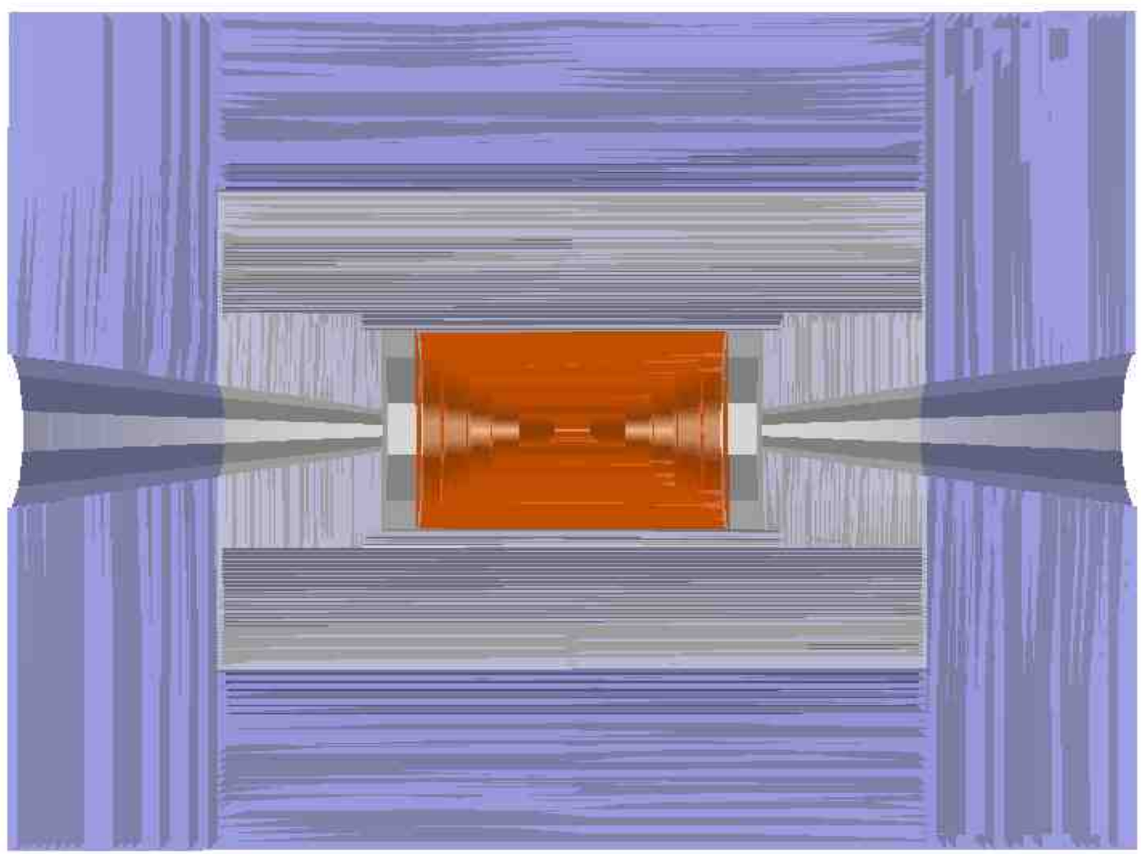
- New detector description still needs to be copied to .lcsim/cache by hand!
- No Material for coil included
- Not enough iron to return flux of 5T solenoidal field
- Simulation of DR (Cerenkov photons) is very slow due to the use of the Geant 4 G4Cerenkov process. Calculating the number of produced in the optical calorimeter sensitive detector class will speed up the process significantly. Currently the data sets are without optical processes enabled.

Near term plan

- Check the detector description!
- Implement sensitive detector that counts the Cerenkov photons in slic and replaces use of G4Cerenkov.
- Provide scripts to run slic on fermigrid.
- Then generate single particle, Higgs, SM bgr. and machine bgr. once available.

Backup slides

The mcdrcal00 detector in org.lcsim



Plan

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

Data samples

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

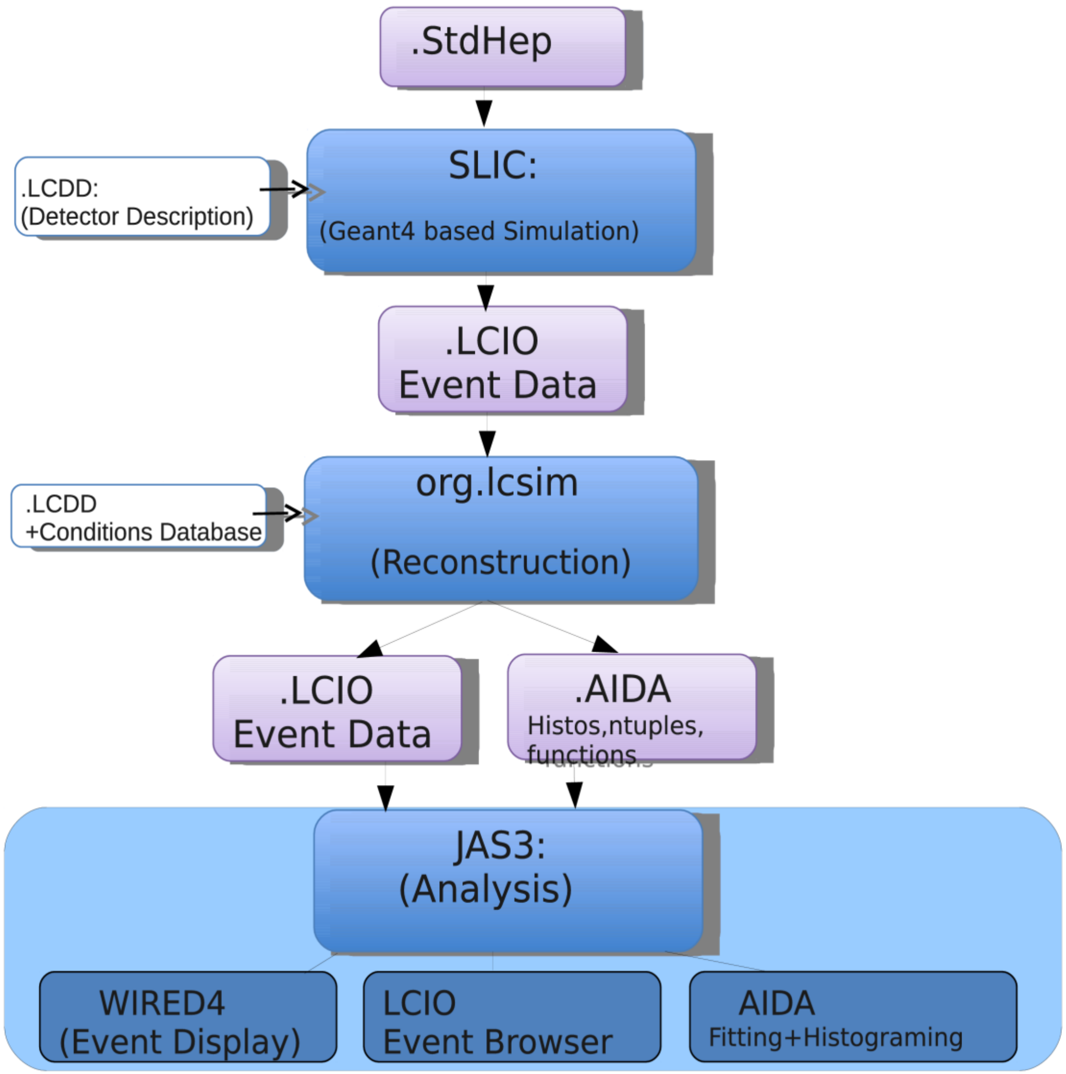
/ilc/sid/wenzel/muoncolliderdata/slcio/bgr

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

Zp3TeVtoee.slcio
Zptomumu_3TeV_mcdrcal00.slcio

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) --> implement new optical calorimeter
  - 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)


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

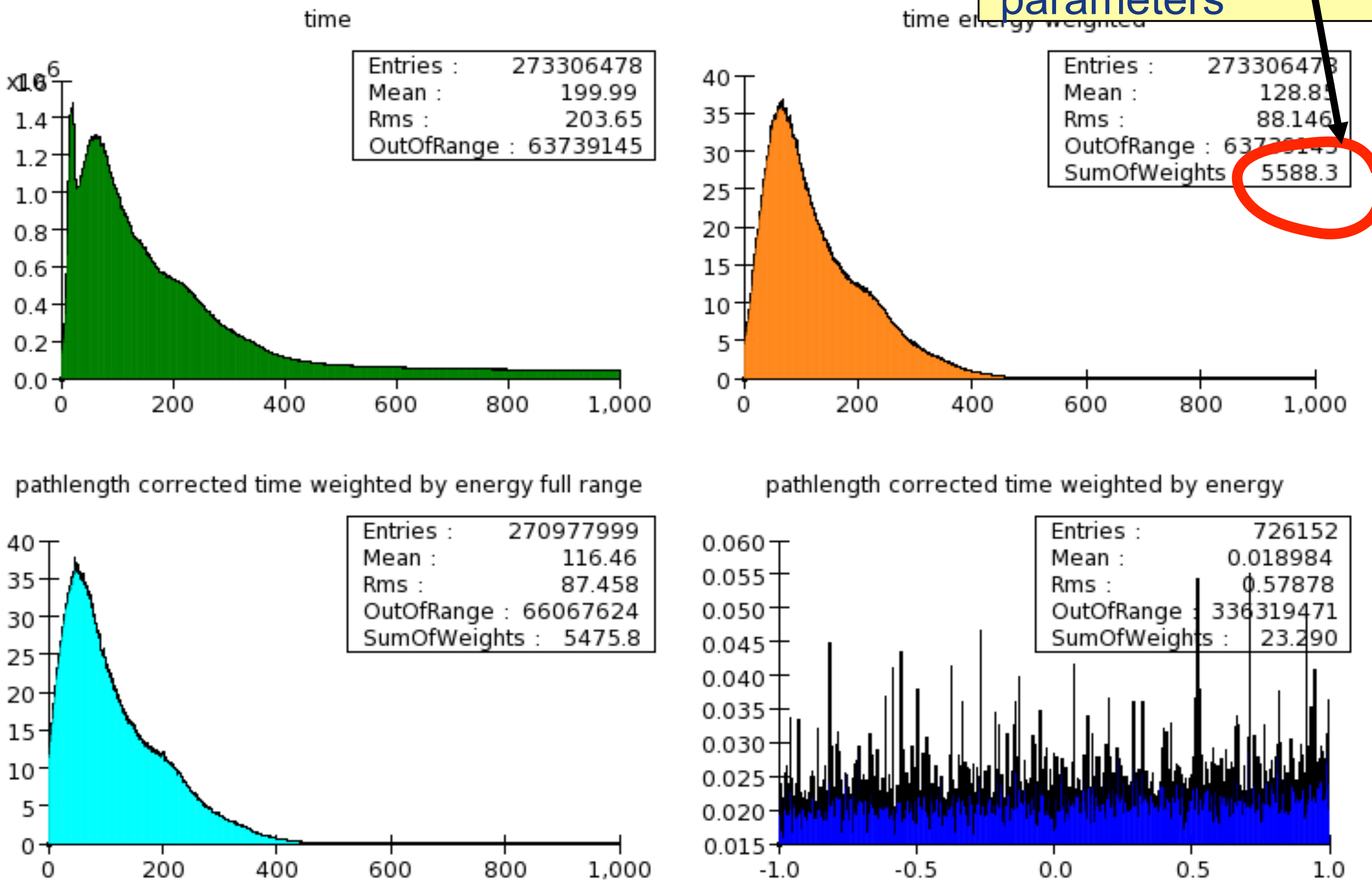
Machine Backgrounds

Precision Physics @ muon collider depends on the the ability to get the machine induced BGR. (caused by muon dacay) under control

- Optimize machine parameters, proper shielding, IR, MDI
- Detector design and choice of technology--> detector simulation critical to determine detector parameters and study how it affects physics performance. Dealing with the large bgr is a huge computational problem

Timing of bgr. Hits in the Calorimeter

TeV's of energy deposited
In about 500 nsec
Exact amount varies a
lot depending on machine
parameters



~ 4% of 1 bunch crossing, no Bethe Heitler muons

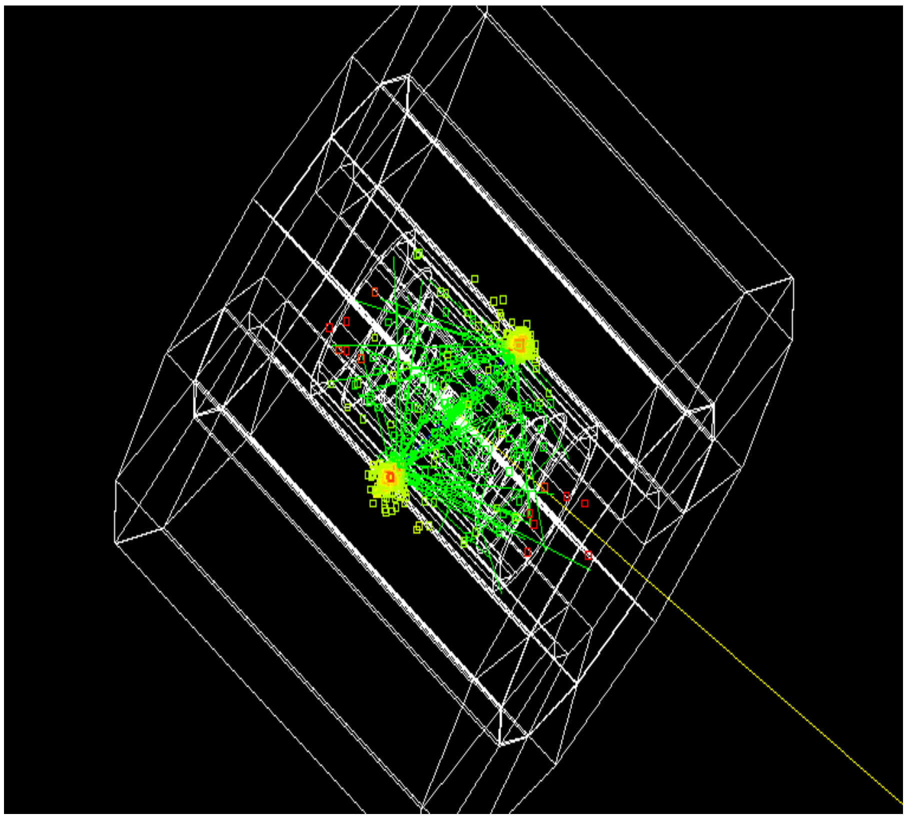
Getting muc off the ground

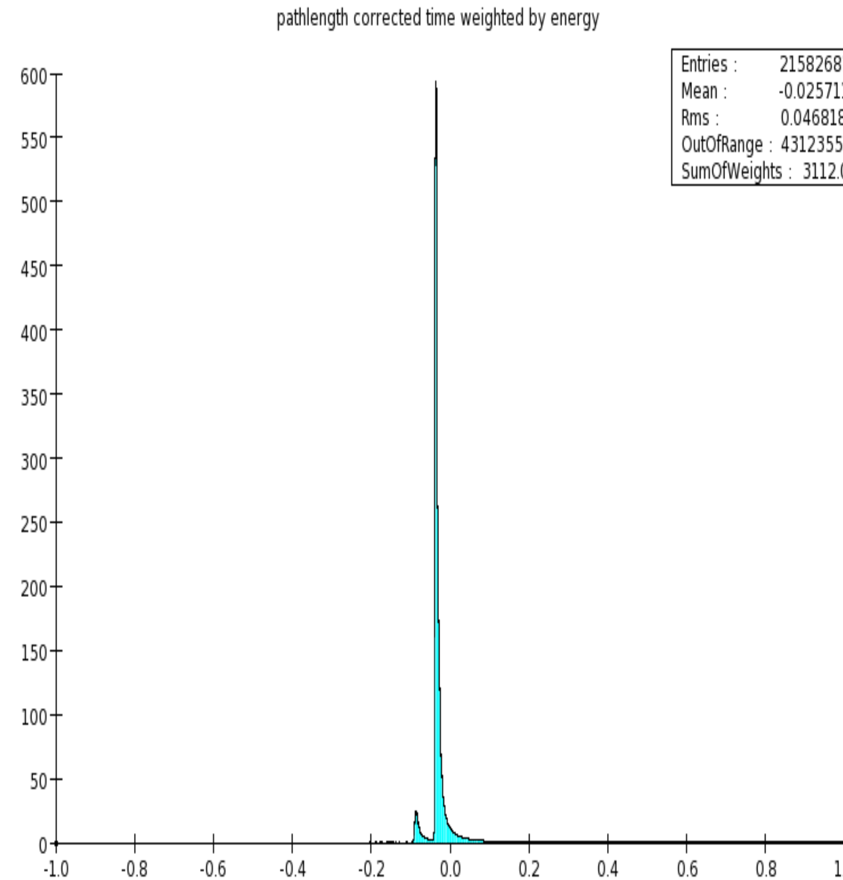
- Need dedicated disk area for muon collider data samples, muon collider software (currently SID)

(may be migrate some of the ilc disk space)

- Need Muon Collider VO for grid submission + dedicated slots on fermigrid

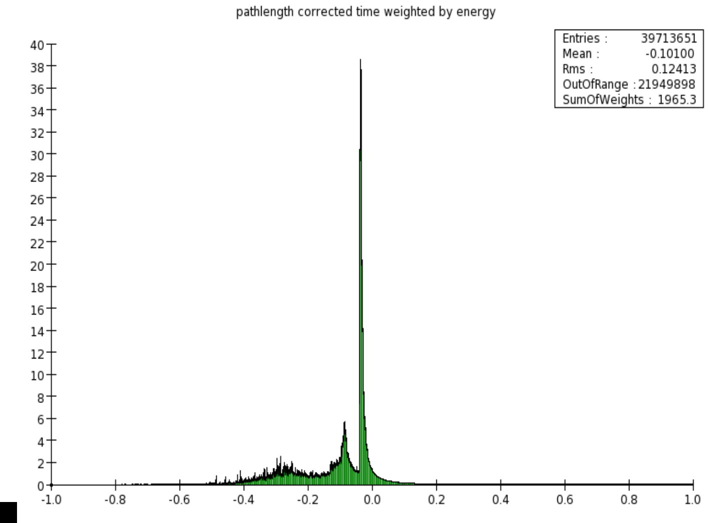
Z'(3TeV) -> e^+e^-

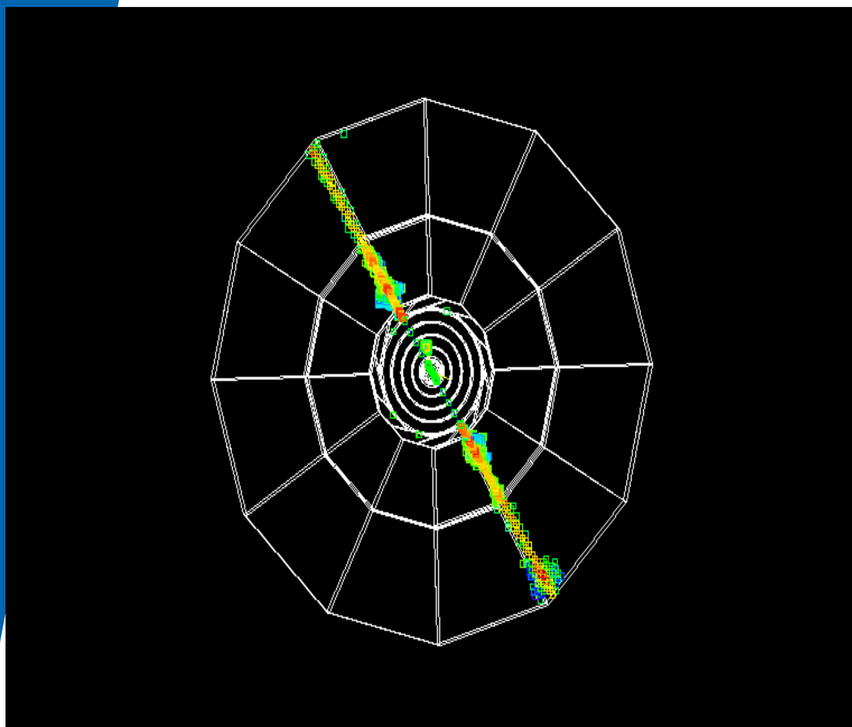


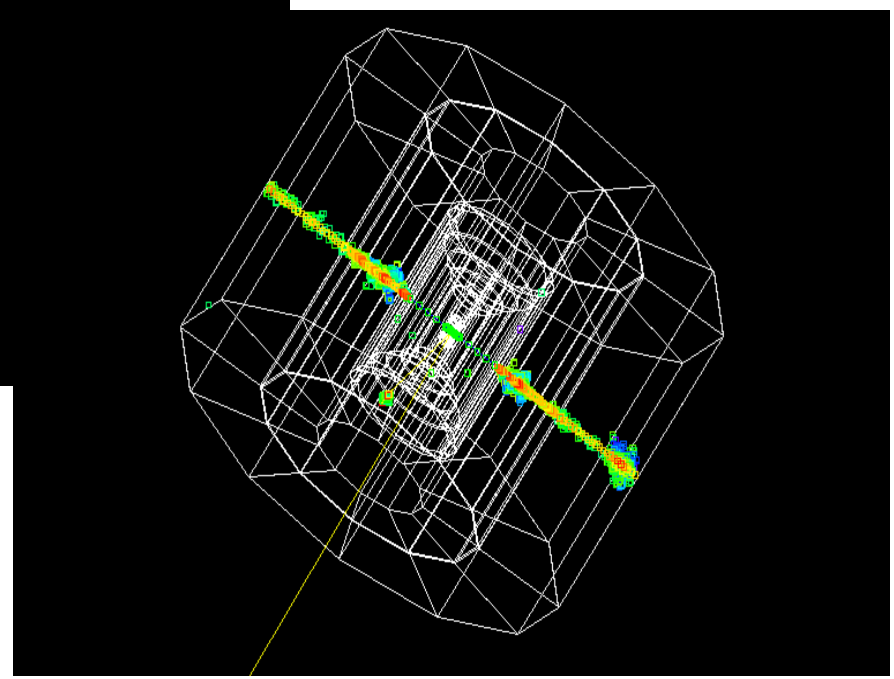


Fight time correct time weighted by energy
Range +/- 1 nsec

Z'(3TeV)->m$^+$m$^-$

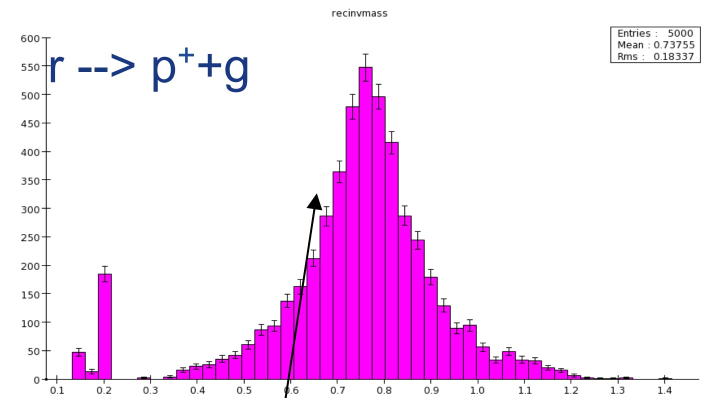

pathlength corrected time weighted by energy
Entries : 39713651
Mean : -0.10100
Rms : 0.12413
OutOfRange : 21949898
SumOfWeights : 1965.3
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

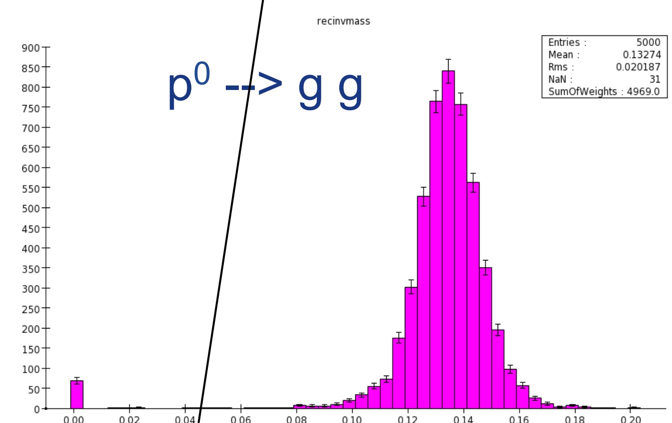




Analysis chain

- 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)



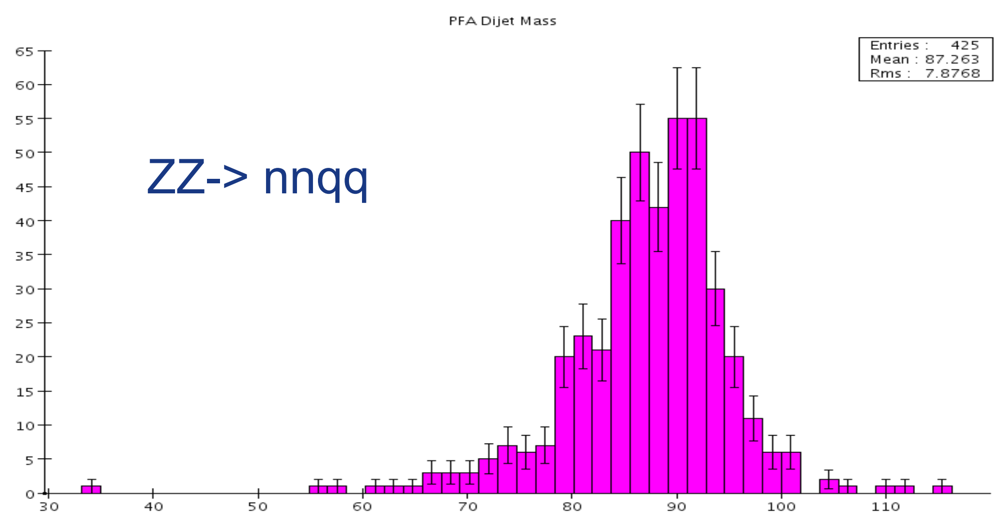


Needs Tracking and calorimetry

Invariant mass reconstruction

Steve Magill, Alex Conway, Hans Wenzel (ccal02)

Steps are as follows: Find jets--> apply dual readout correction--> correct for magnetic field contribution to invariant mass (global correction) --> use PFA algorithm to assign tracks to calorimeter clusters and use track for invariant mass calculation if match passes stringent requirement (avoid confusion term in PFA)



Invariant mass reconstruction (cont)

Code is in CVS: Steve Magills contrib area name of the driver is: PFADRSelect. (but needs zip file with the correct conditions data)