Summary of the Software Tools and Detector Performance Parallel Sessions

Steve Aplin
DESY

IWLC 2010, Geneva
22nd October 2010

Overview

- Core Software
- Event Generation
- Detector Simulation Models
- Beam-Beam Background
- Tracking Detectors
- Vertexing
- Geant4 Studies
- PFA

Core Software Tools

Frank Gaede, IWLC 2010, CERN, Oct 18-22, 2010

iLCSoft pre-release v01-10-pre02

CED	v01-01
CEDViewer	v01-01-pre
CLHEP	2.0.4.2
CMakeModules	v01-10-pre
CondDBMySQL	ILC-0-9-1-pre
Druid	1.8
Eutelescope	v00-04-04
LCFIVertex	v00-04-pre
LCFI_MokkaBasedNets	v00-01
Marlin	v00-13-pre
MarlinPandora	v00-02
MarlinReco	'v00-19'
MarlinTPC	v00-06
MarlinUtil	v01-01-pre
Mokka	'mokka-07-06'
MokkaDBConfig	v02-01

Overlay	v00-07-04
PandoraPFA	v03-02-02
PandoraPFANew	v00-03
QT	4.2.2
RAIDA	v01-05-pre
SiliconDigi	v00-04-02
StandardConfig	v02-01
cernlib	2006
dcap	1.9.5-5
gear	v00-15-pre
gsl	1.8
lccd	v01-01-pre
lcio	v01-51-01
mysql	5.0.45
root	5.26.00b
KalTest	**v01-00**
KalDet	**v01-00**

- many packages changed (wrt v01-09)
- **some new added**

final release planned for next week

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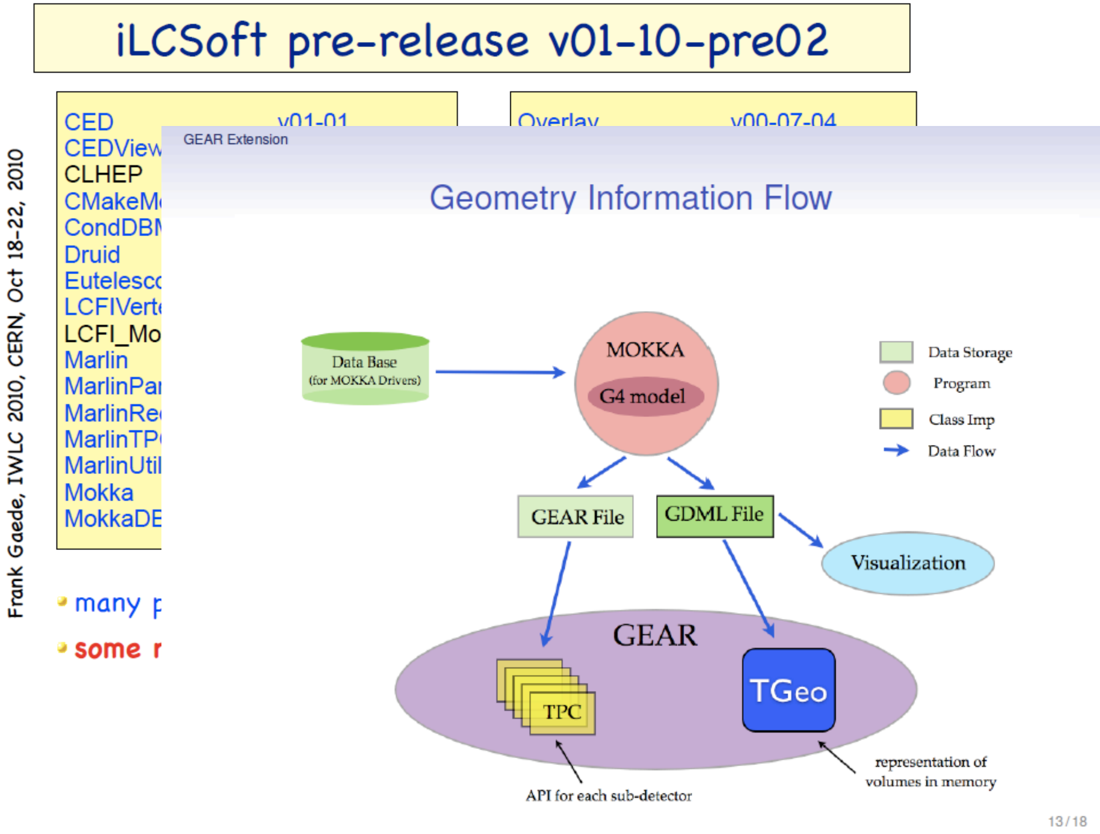
Core Software Tools



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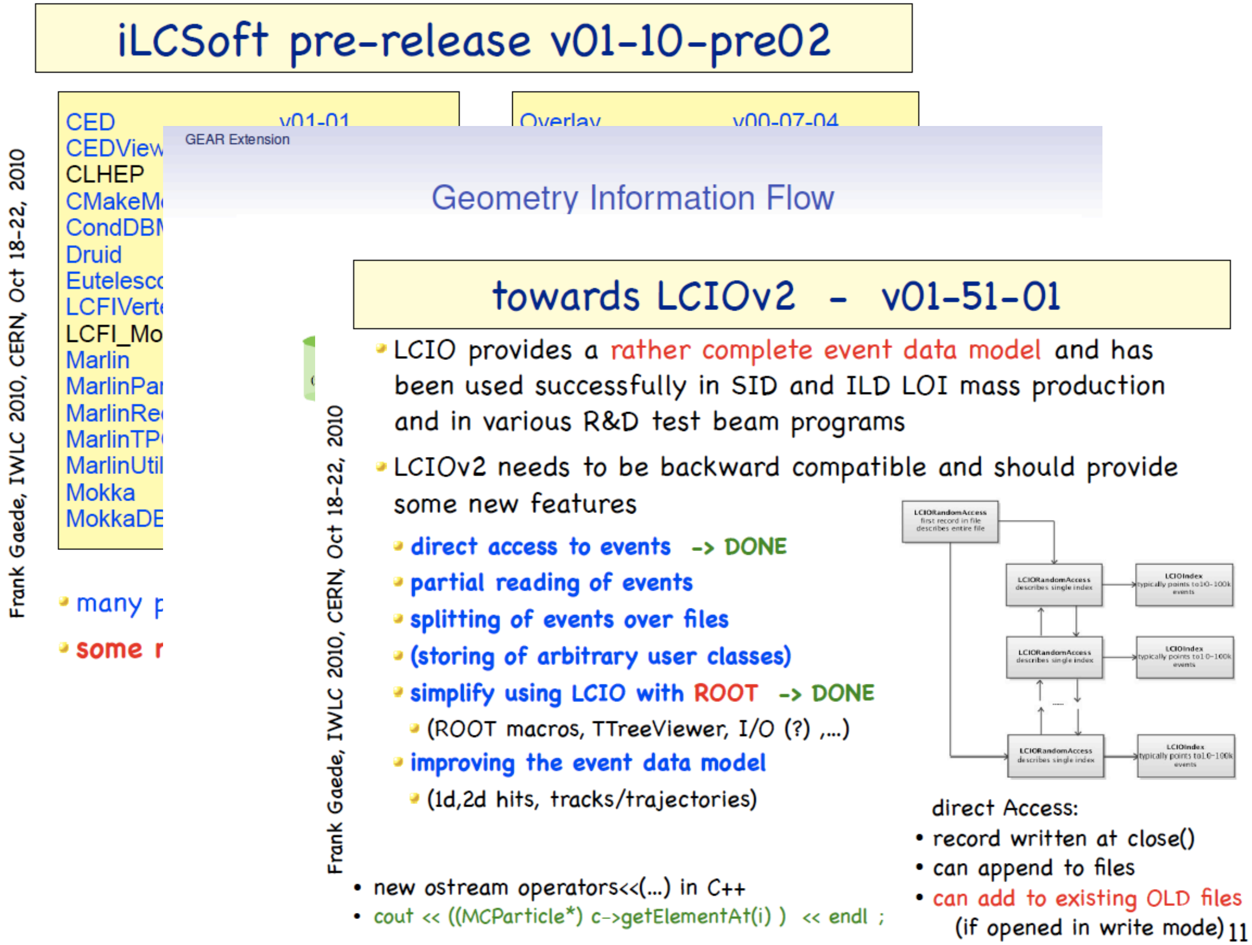
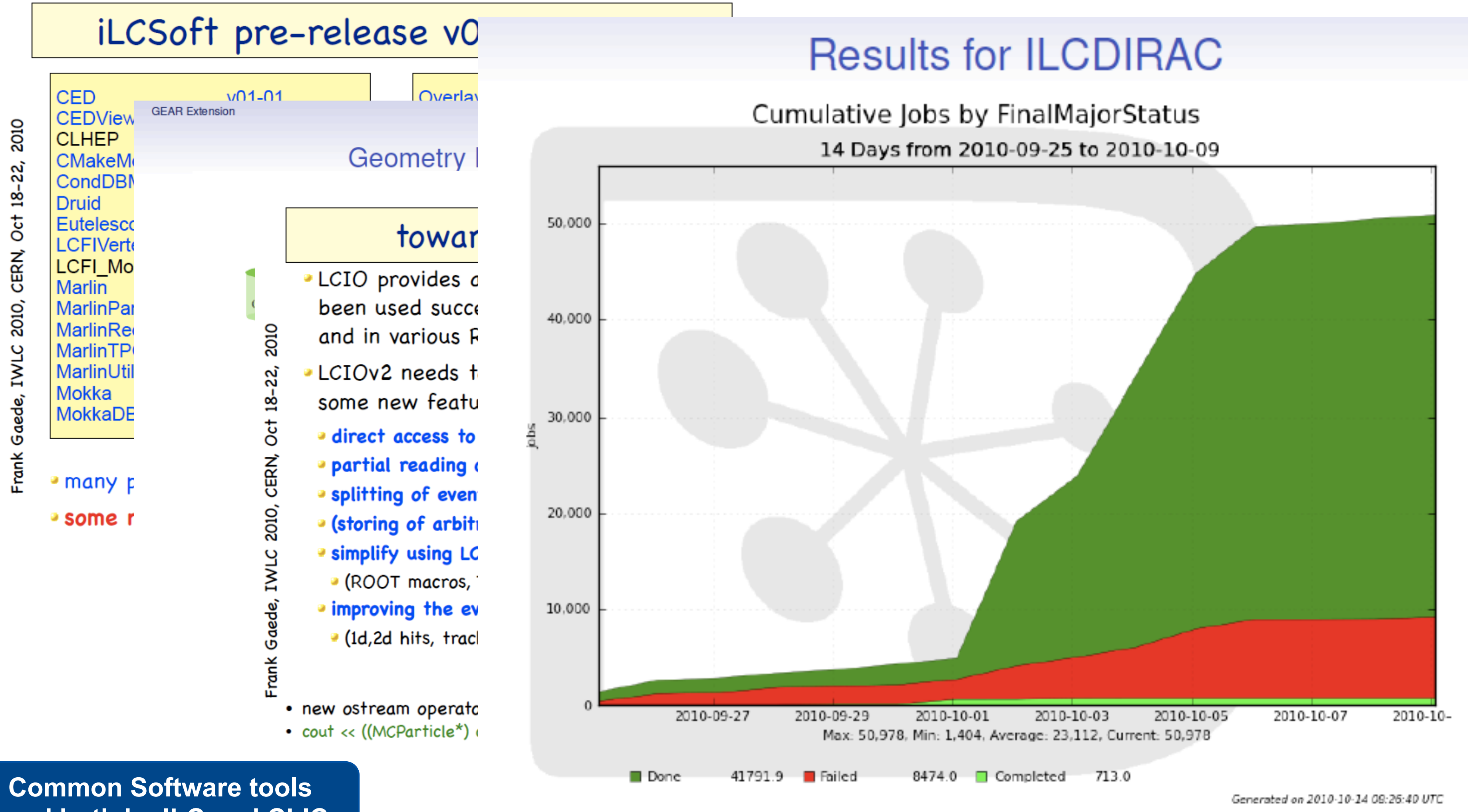


Common Software tools used both by ILC and CLIC

Core Software Tools



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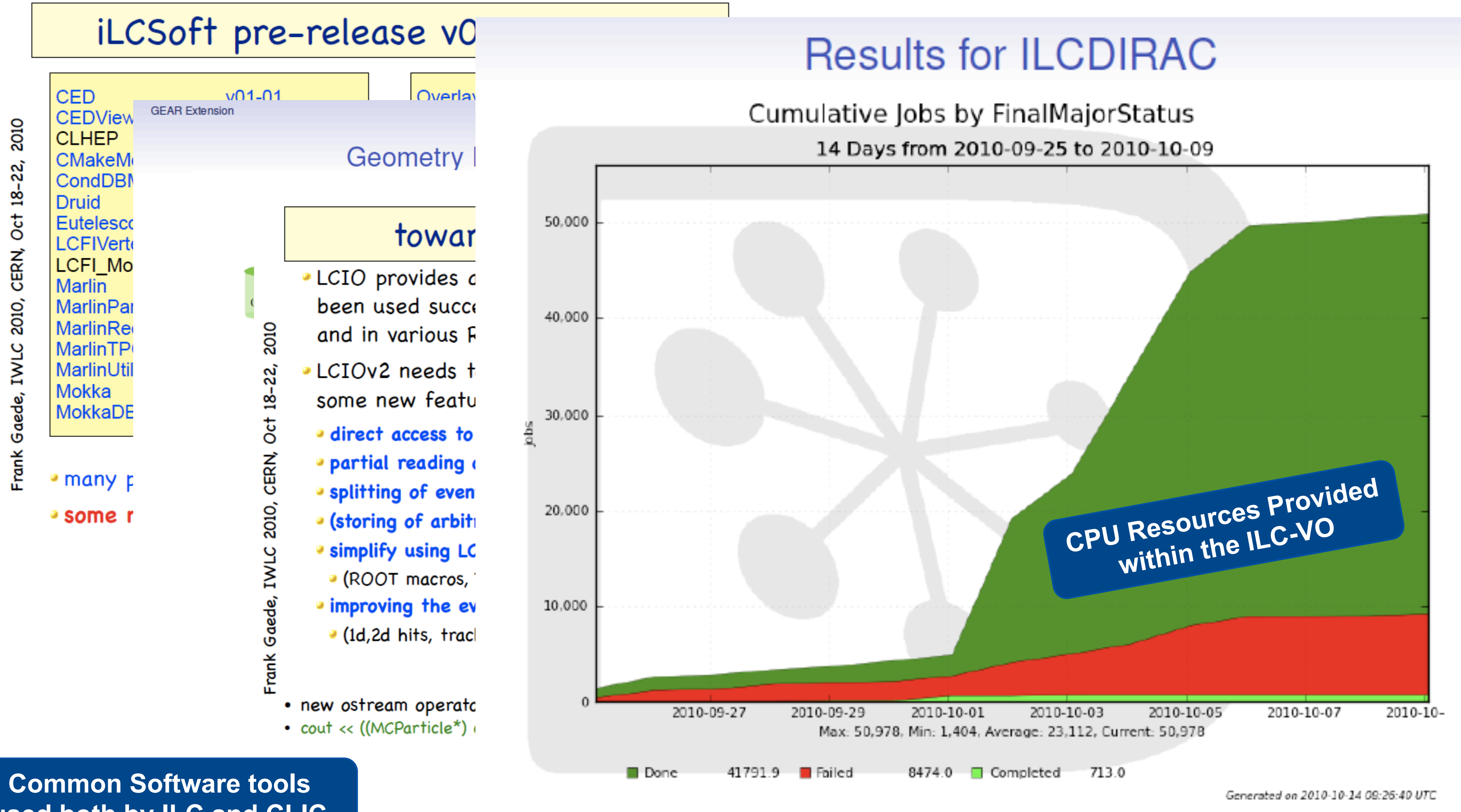

Common Software tools used both by ILC and CLIC

Event Generation

Generator choice

SM will be done with Whizard

- Whizard version by choice : 1.95. Has
  - CKM correct
  - Colour flow
  - Spin
- Latest version at the time of the decision was 2.0.2, but "Note that some of the features of WHIZARD 1 (esp. ILC) have not yet been re-enabled." (Whizard home-page).
- Fragmentation: Latest PYTHIA6 (6.422). PYTHIA8 is out but "To some extent this switch is nominal, since 8.1 does not yet offer a complete replacement of 6.4, and is not yet tested and tuned enough to be recommended for major production runs." (PYTHIA home-page).

Other generators

Non-Whizard generation

- physim for tth, ttz, and ttbb events, needed for the QCD enhancement effect at threshold.
- SUSY generators.
  - Need full event, knowing about ILC conditions, having polarised decays. None of the alternatives (SUSYGEN,ISAJET and SHERPA) can do this better than Whizard
- Bhabha generator: investigate GRACE, contacted authors.
- $\gamma\gamma$: PYTHIA. Tim has a consistent way to use PYTHIA instead of Whizard.
- Investigate Whizard-2.03: New format of input steering files makes a transition a mayor effort, and will not be pursued.

Tools for productions of generator samples

- Tim's scripts to run Whizard jobs at the SLAC batch server migrated to the KEK environment, and to DESY.
- An SVN project holding installation scripts (by MB) and process-description files has been set up at CERN by Stephane.
- As generation production will now be distributed → need conventions and "database"
- SiD: Fermi Pipeline system fits well, but not migratable Tim is preparing the interface.
- For CLIC, Stephane has integrated to the generation into DIRAC from LHCb.
- Probably ILD will do something similar with the new production system.
- In any case: An information file with file-locations, generator settings, etc. should be updated by each generation job. A proposal by Akiya is on the table.

Conclusions and outlook

- The Common Task Group for Generators has been formed, and is working.
- Whizard, the main work-horse of the SM simulation, has been updated to the most current, ILC-usable version.
- Most issues on list of needed amelioration has been solved, both technical and physics ones.
- A full production of samples for the 350 GeV study has been done at KEK, with tools migrated from SLAC. However, this was done with the old generator.
- The way to feed information from generation to the production database must be designed and tested.
- Investigation of non-Whizard generators for special processes is on going, but not yet conclusive.
- Larger scale test of the new Whizard version and the new tune of fragmentation will be needed

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Mikael Berggren (DESY-HH) Report from Common Task Group for Genera

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mmon Task Group for Genera IWLC 2010 13 / 19

Event Generation of

$\gamma\gamma \rightarrow hadrons$

Tim Barklow

Common Samples

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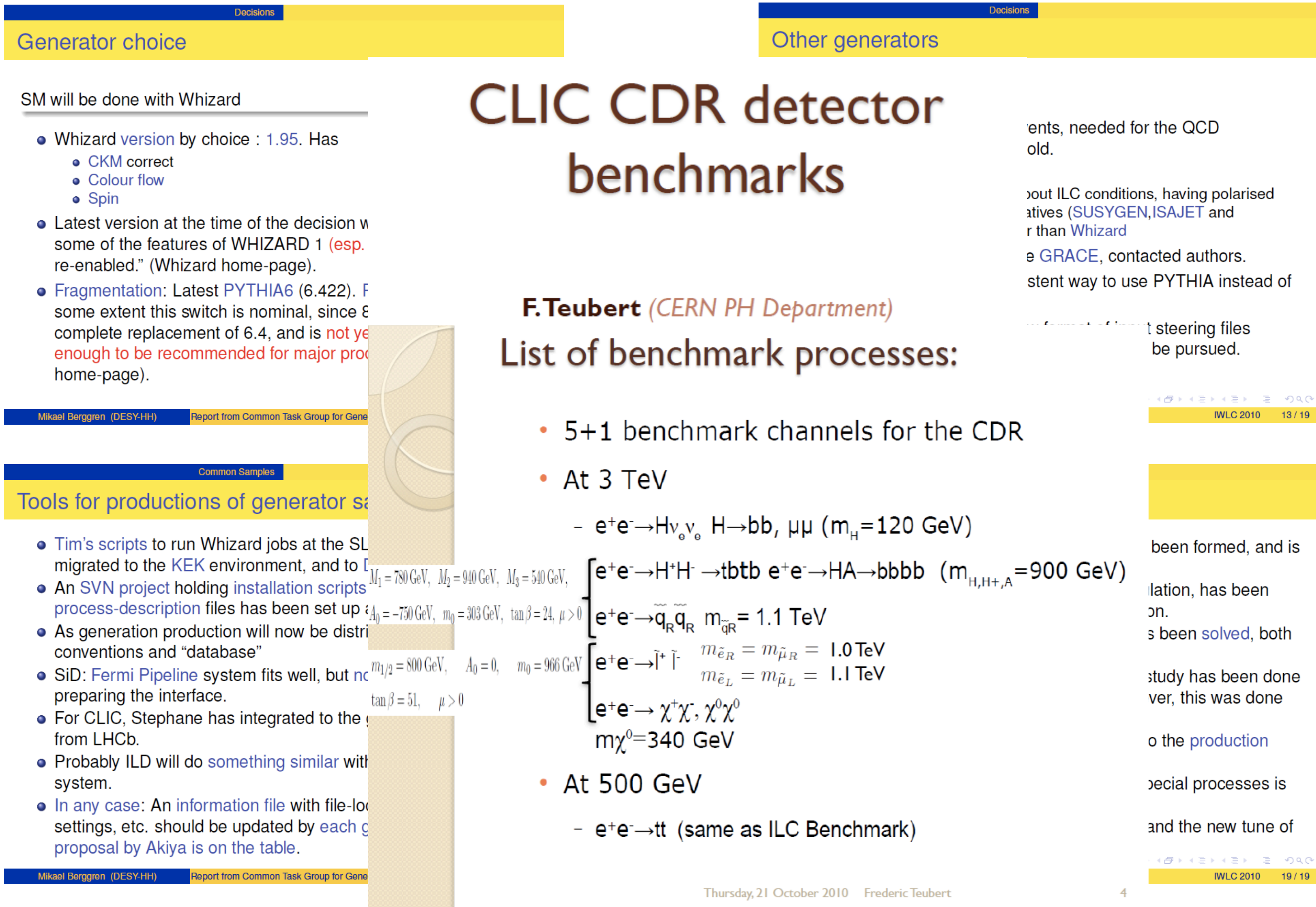
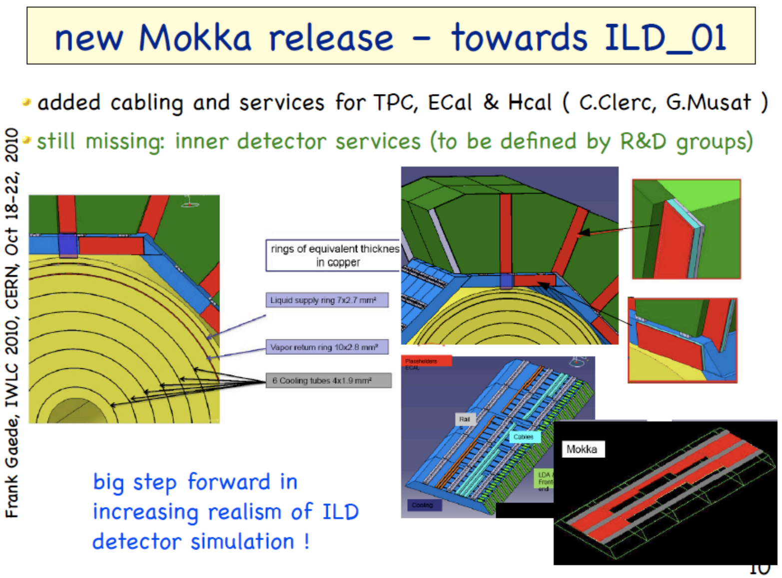
Mikael Berggren (DESY-HH) Report from Common Task Group for Genera

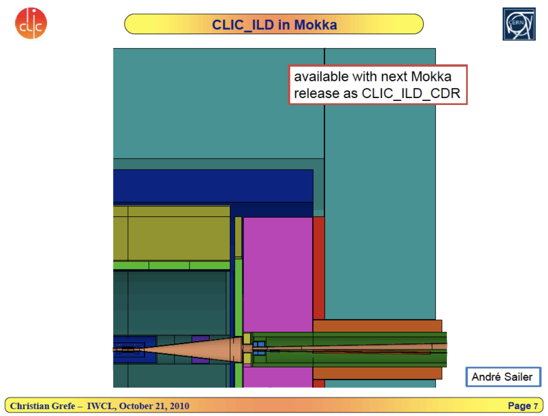
- Events for $0.3\ \mathrm{GeV} < W_{\gamma\gamma} < 2\ \mathrm{GeV}$ are simulated with Guinea-Pig + isotropic 2,3,4 pion production. Such events don't contribute much to average energy or multiplicity per bx once pt and cosθ cuts are applied. However, they might impact forward occupancy and low visible mass analyses.
- Recent 3 TeV $\gamma\gamma \rightarrow hadrons$ samples generated at CERN (Schulte) and SLAC (Barklow) show good agreement in various distributions
- Independent high pt pointlike $\gamma\gamma \rightarrow q\bar{q}$ background samples should be augmented with high pt resolved photon background samples.

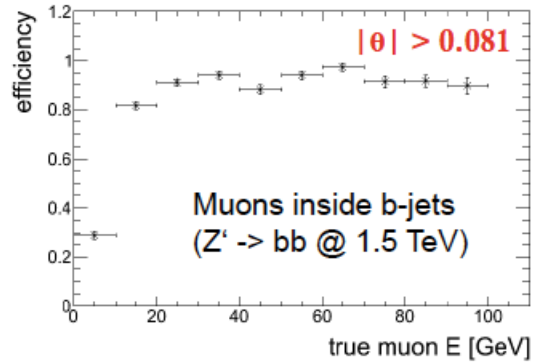
Event Generation

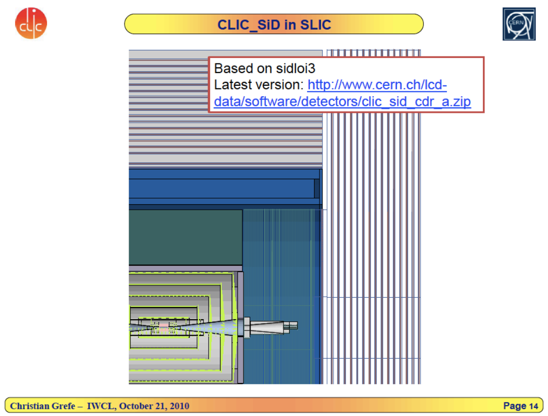


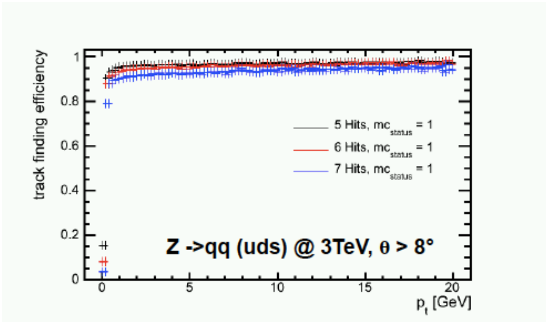
New Detector Models for DBD/CDR



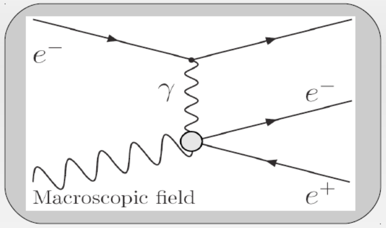






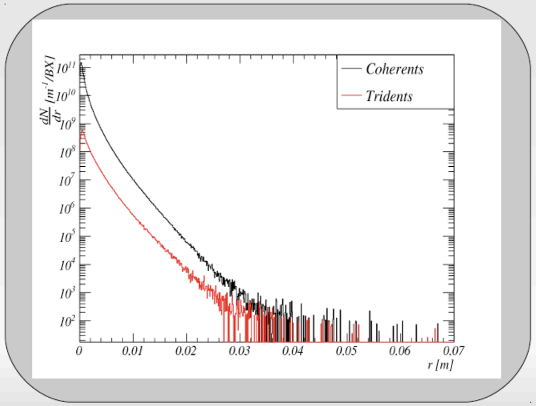


Beam-Beam Background



The cascade trident process

Radial distribution of particles after 3 meters of tracking in a 5T solenoid field
A crossing angle of 20mrad has been used



Process	Approximate energy deposited in BeamCal
Coherent pairs	2200 GeV
Tridents	880 GeV
Incoherent pairs	27000 GeV

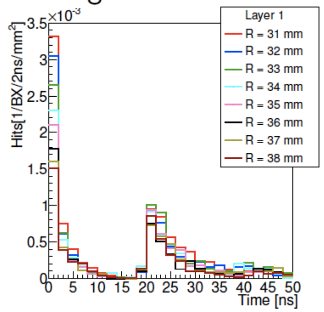
Conclusions

Jakob Esberg

- Tridents behave much like coherent particles in beam-beam collisions.
- Tridents Deposit energy in BeamCal comparable to, but smaller than that of coherent pairs.
- Likely no major impact on post-collisional line or detector design.

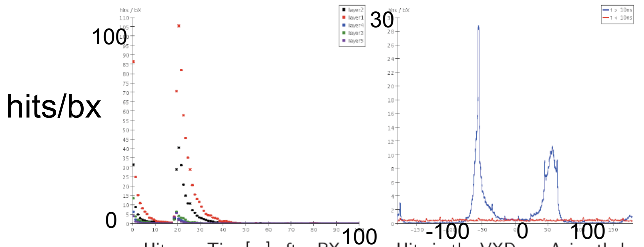
CLIC_ILD: Vertex Radius vs. Background

- Direct hits ($t < 10$ ns) are reduced with increased radius
- Hits from back-scatters are not falling as fast
- Still significant contribution from back-scattering hits



CLIC_SiD: Background during one BX (C.Grefe)

- First simulations for CLIC_SiD show same features as CLIC_ILD background simulations



Hits vs. Time[ns] after BX

Hits in the VXD vs. Azimuthal Angle[deg]

IWLC2010, October 21, 2010 A. Sailer: Beam-Beam Background at CLIC 16/18

André Sailer

- Further reduction of back-scatters through beam-pipe design possible
- Hit density in CLIC_ILD reduced to 0.02 Hits/mm^2/ns (from 0.04)
  - Further reduction possible
- Hit density in CLIC_SiD currently at 0.04 Hits/mm^2/ns
  - Further reduction possible

Tracking Detectors

FPCCD digitizer

Daisuke Kamai

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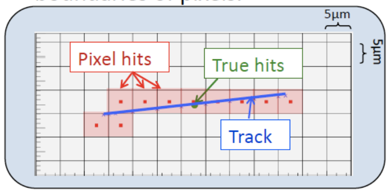
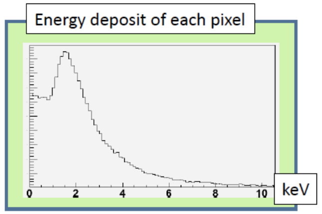
- The hit points and track momenta are obtained from SimTrackerHit.
- The track is calculated by the hit point and momentum.
- The pixel hit is identified by the intersections of track and boundaries of pixels.





- The energy deposit of SimTrackerHit is divided into pixels as proportional to path length and these are approximated by Landau distribution.
- The noise is put on to each pixel hit.

⇨ The output is the position of pixel hit and its energy deposit.

Summary

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The software for FPCCD vertex detector were developed.

- FPCCD digitizer
- FPCCD clustering processor

The result of simulation study of FPCCD vertex detector

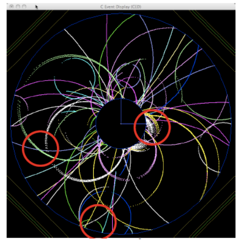
- Position resolution
  - $\sigma_{R\text{-}\phi}$ = ~0.96 um
  - σ_z = 0.64 um (θ =75˚)
- IP resolution
  - $\sigma_{R\text{-}\phi}$ = ~1.2 um
  - $\sigma_{R\text{-}Z}$ = 1.5 um (θ =75˚)
- Pixel occupancy of pair background for 1train(1312BX)
  - Innermost layer : 2.76%, second layer: 1.55%
- Background rejection algorithm
  - μ^- (momentum 100GeV) and pair background were well separated by the difference of the cluster shapes.

The performance of FPCCD with background will be studied.

Frank Gaede, IWLC 2010, CERN, Oct 18-22, 2010

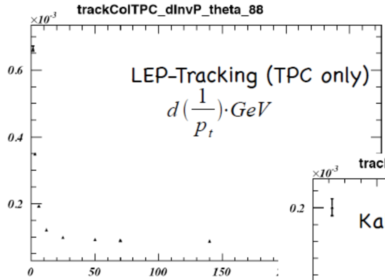
Summary & Outlook

- started to adapt KalTest Kalman fitter to iLCSoft
  - to be used by LCTPC and ILD
- developed TPC pattern recognition based on NN-clustering
- interfaced loosely to KalTest
  - used for fitting and extrapolation of track segments
- first look at fitting single particles:
  - fits work in principle – issues in pulls need to be addressed
- Outlook
  - debug and check interface to KalTest:
    - material description, hit errors, unit conversions,...
  - complete merging of track segments
  - systematic studies on different physics channels
  - parameter tuning
  - add SIT, VXD,...

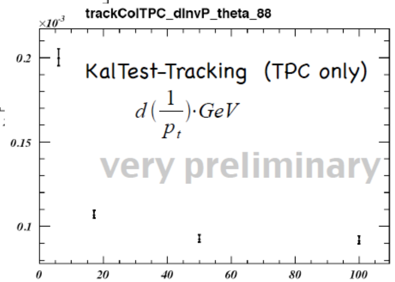


Frank Gaede, IWLC 2010, CERN, Oct 18-22, 2010

single particles – momentum resolution



- single mu+
- theta=88 deg
- p = 6, 17, 50, 100 GeV



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LCFI Vertexing

B-tagging in ZHH (Z->qq)

Y. Takubo, ALCPG09

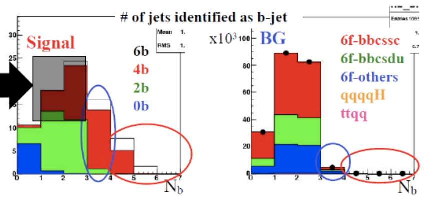
Selection of event samples

BG can be rejected effectively by using events with $N_b \geq 3$.

	No cut	$N_b = 3$	$N_b \geq 4$
Signal	79	15.9(0.20)	9.5(0.12)
BG	207,144	4663(0.02)	147(7 x 10^{-4})

σ = 0.16 fb

Events with N_b =3 and $N_b \geq 4$ were selected as analysis samples.



Should be rescued…

b-tagging efficiency seems to be bad…

Taikan Suehara et al., IWLC10 @ CERN, 21 Oct. 2010 page 5

Jet clustering with the vertices

- Jet clustering with vertices
  - Combine all tracks in the vertex as a 'single particle' with summed 4-momentum
  - Avoid merging jets containing a vertex - all vertices should be separated to different jets (make y value infinite if both jets have vertices)
- Vertex combination
  - c- and b- vertex must be combined before the jet clustering to avoid forced separation
  - Currently 'CHEATED' – use MC to combine
    - Efficient vertex combination method is needed

Taikan Suehara et al., IWLC10 @ CERN, 21 Oct. 2010 page 13

summary

- performance of flavor tagging is critical to the ILC physics program particularly for processes involving many heavy flavor jets
- the procedure for flavor tagging is being revisited
  - many new variables & categories are being considered
- time scale ~ reconstruction software freeze for DBD studies
- flavor tagging optimization in *multi-jet environments*
  - see talk by T. Suehara on Thursday

T. Tanabe 18

ILC-CLIC collaboration

- our ideas are being tested using the ILD detector @ ILC
- we would be happy to look at other detector configurations e.g. CLIC detectors
- if you're interested, please provide us with MC samples
  - special note for the CLIC configuration:
    - the longer b-flight and its resulting material interaction should be properly addressed in the samples
    - please document the changes in geometry (e.g. VXD, B-field, beam spot size)
  - samples:
    - Z->qq @ E_{cm} = 91.2 GeV for comparison
    - Z->qq @ E_{cm} = 1 TeV and 3 TeV without ISR

Tomohiko Tanabe, Taikan Suehara , Satoru Yamashita

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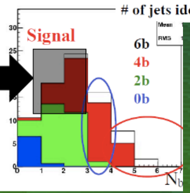
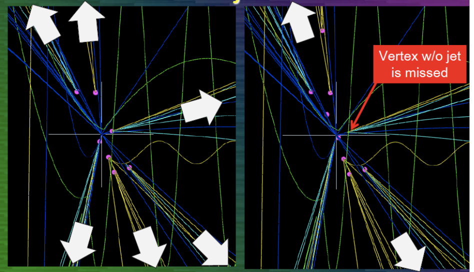


b-tagging efficienc

Taikan Sue

ZVTOP and jet direction



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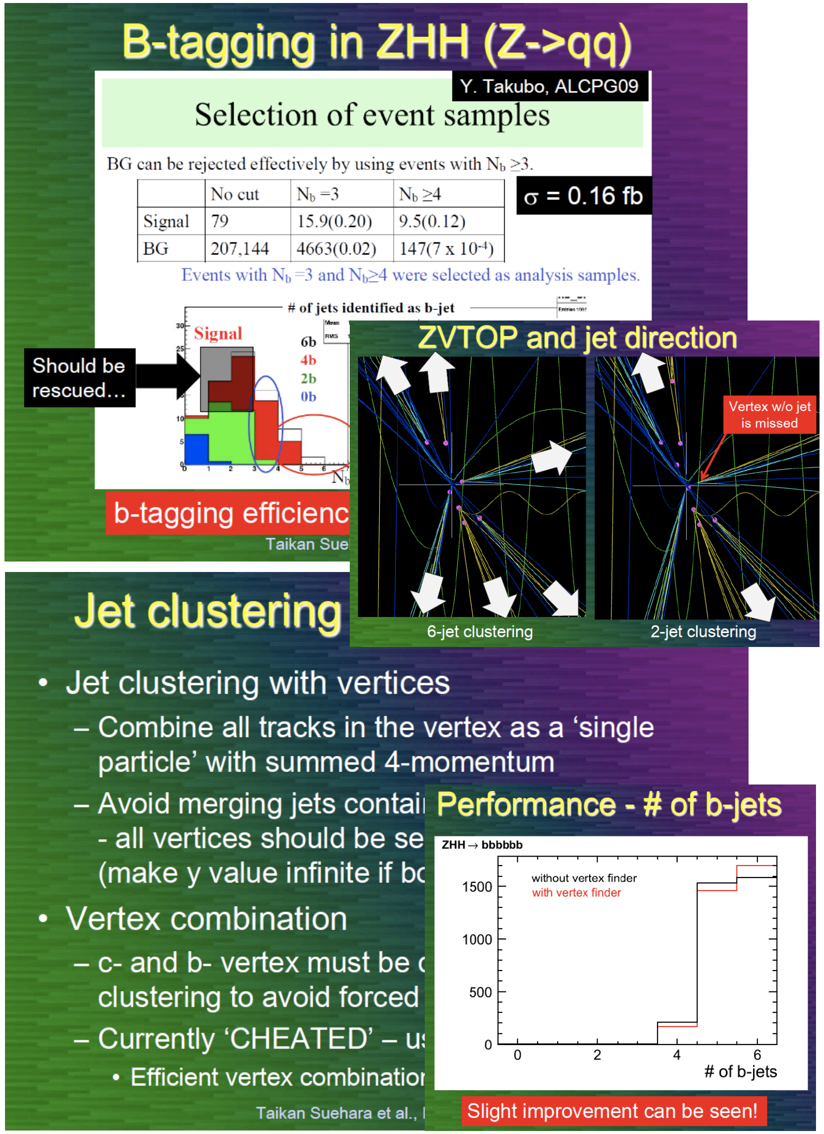

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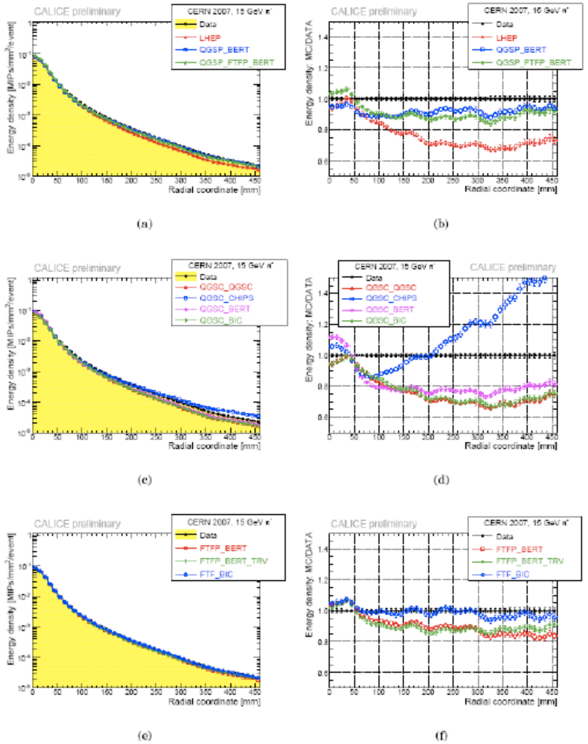
Tests of Geant4 using CALICE Data

Transverse profiles in AHCAL



- Most physics lists give too small shower radius and underestimate tail.
- QGSC_CHIPS gets radius right, but shape is all wrong.
- FTF_BIC best in the far tail.
- Important not to put too much emphasis on any single observable; no physics list gets everything right.

GEANT 4.9.2 used

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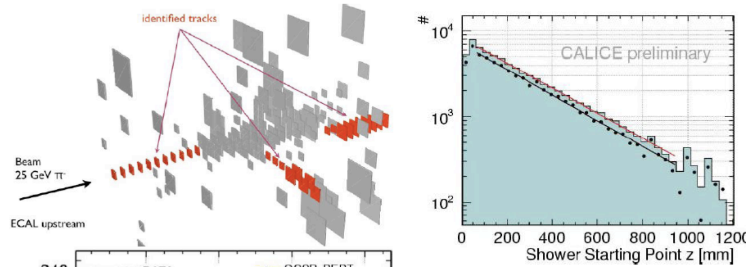
"Tracking calorimetry"



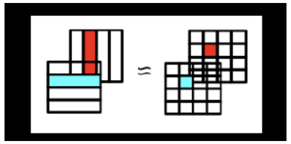
David Ward

- ECAL and HCAL have complementary merits:
  - ECAL has higher granularity + Tungsten absorber. More effective in discrimination between e/π/p components of shower. But only samples first λ_{int} of the shower.
  - HCAL (+TCMT) detect ~ full shower energy ⇒ linearity, resolution studies; tails of showers; sensitive to neutron component.
- In general, GEANT4 performs pretty well, to the 10% level, for most observables, and using most of the physics lists studied.
- A few broad conclusions:
  - LHEP is clearly the least recommendable physics list (useful if you want an outlier).
  - QGSP_BERT (favoured by LHC GPD calorimetry) is a pretty reasonable choice. But in GEANT4.9.3 there is some indication that the FTF-based models perform slightly better. None is perfect.
  - As usual, it depends what you care most about…
  - Other interesting possibilities, such as use of the CHIPS model, are coming along.

ScECAL Strip Clustering

Progress of the Strip Clustering

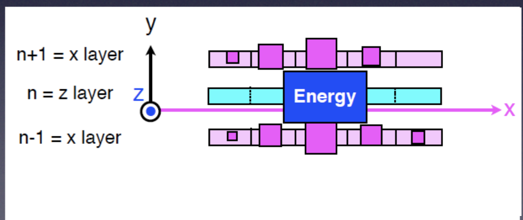
K. Kotera, Shinshu university



- New approach: "Strip-splitting method"
  - A simple algorithm to distribute energy deposit in a strip into virtually split square cells.
  - Energy deposit in the square cells are fed into PandoraPFA i.e. clustering algorithm in PandoraPFA is used.

Strip-splitting method

1. Assume that n-th is a z-layer (fine segmentation in z direction), while n±1 layers are x-layers (fine segmentation in x direction).
2. Split each strip in n-th layer into virtual square cells.
3. Energy deposit in n-th layer
4. is distributed in virtual square cells according to the energy deposits in adjacent (n-1)th and (n+1)th layers.
5. The position and energy of virtual square cells are fed into PandoraPFA.



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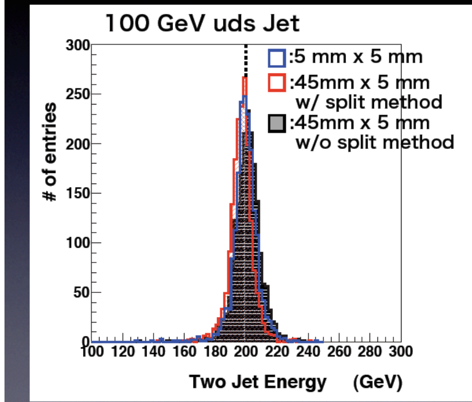
Distribution of jet energy

$\sqrt{s}$ = 200 GeV, Scintillator width = 5 mm



Hatched histogram, with 45 mm x 5 mm ScECAL without Split method, has broader shape than others

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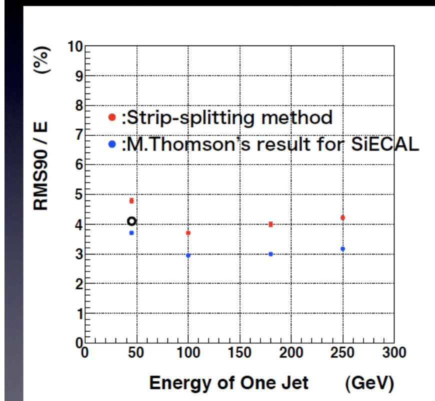
Jet energy resolution vs. jet energy



The nergy dependence is the similar to that of M.Thomson's result for SiECAL

Difference is possibly from some problems in the merge process in which scintillator strip hits are made by merged 5 mm x 5 mm Mokka events

◀ w/o this process, 5 x 5 mm scintillator Ecal has the performance close to SiECAL

▶ Using Latest Mokka which intrinsically generates events in scintillator strips.

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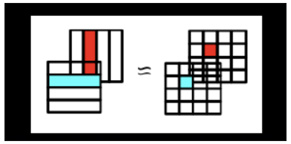
ScECAL Strip Clustering

Progress of the Strip Clustering

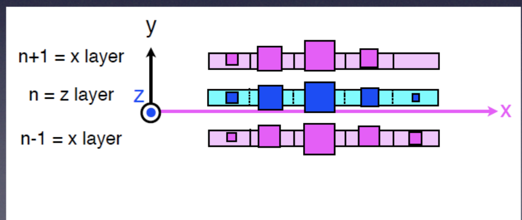
K. Kotera, Shinshu university



- New approach: “Strip-splitting method”
  - A simple algorithm to distribute energy deposit in a strip into virtually split square cells.
  - Energy deposit in the square cells are fed into PandoraPFA i.e. clustering algorithm in PandoraPFA is used.

Strip-splitting method

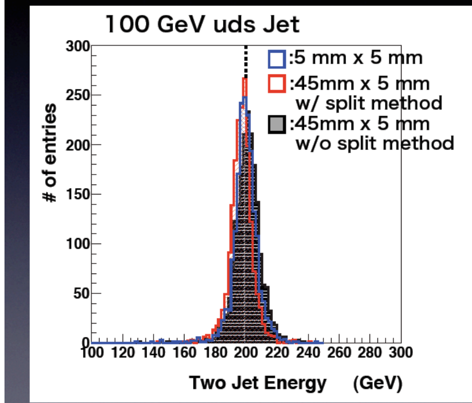
1. Assume that n-th is a z-layer (fine segmentation in z direction), while n±1 layers are x-layers (fine segmentation in x direction).
2. Split each strip in n-th layer into virtual square cells.
3. Energy deposit in n-th layer
4. is distributed in virtual square cells according to the energy deposits in adjacent (n-1)th and (n+1)th layers.
5. The position and energy of virtual square cells are fed into PandoraPFA.



7

Distribution of jet energy

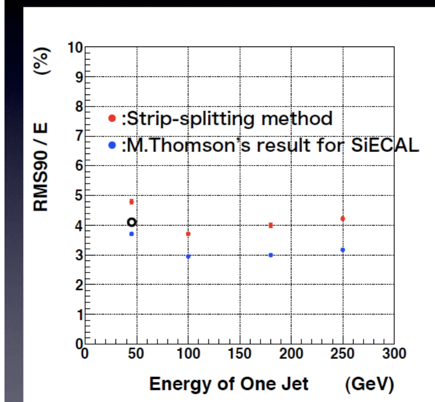
$\sqrt{s}$ = 200 GeV, Scintillator width = 5 mm



Hatched histogram, with 45 mm x 5 mm ScECAL without Split method, has broader shape than others

13

Jet energy resolution vs. jet energy



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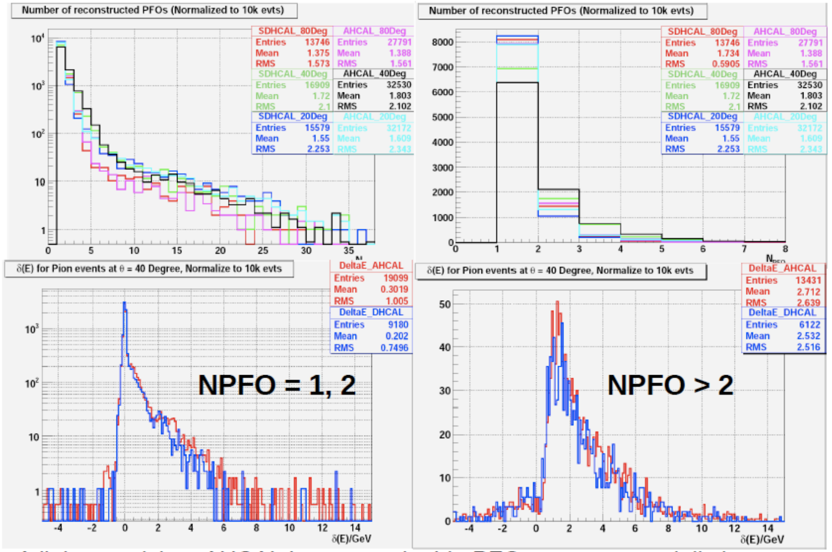
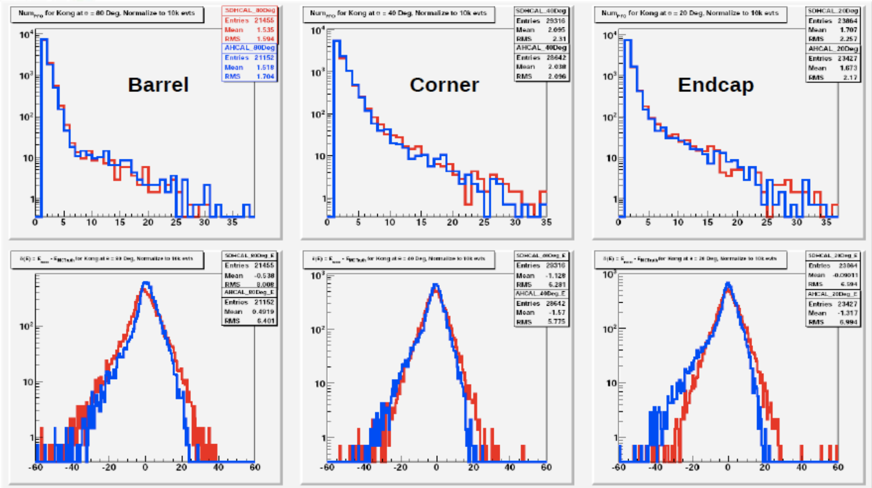
SDHCAL/AHCAL Comparisons

Compare to AHCAL: NPFO

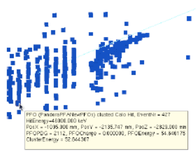


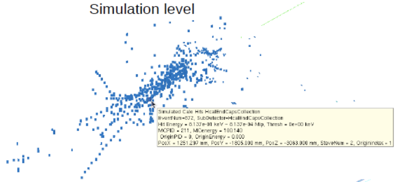
A little surprising: AHCAL has more double PFO events, especially in corner region: Geometrical effects?

SDHCAL/AHCAL Comparison



- Similar NPFO distribution (with data files with same set of energies)
- AHCAL has better energy resolution – but larger lower energy tail in Endcap





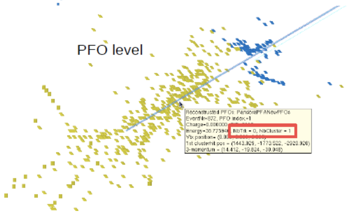
Failed to link the track

(Track reconstructed: LDCTrack Number = 1):

100GeV Pion at 40Deg:

Above: Evt 427, Single PFO

Left: Evt 872, Double PFOs Neither linked to track...

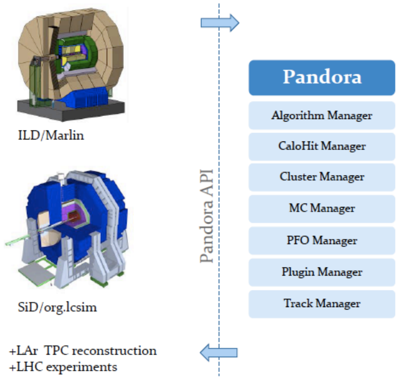


- Study of single particle reconstruction with Pandora: **Manqi RUAN**
  - Pion:
    - AHCAL & SDHCAL has similar behaviour. SDHCAL has slightly more Single PFO event, might be geometrical effect
    - Possible to improve on double counting (~ 10% - 20% of events), track cluster linking in corner, identification and specialized treatment on pre-interaction pion
  - Klong:
    - Similar NPFO for AHCAL & SDHCAL
    - Need leakage correction and better energy estimator for SDHCAL
    - More leakage in AHCAL: More material in SDHCAL?

Pandora Performance

M Thomson and J Marshall

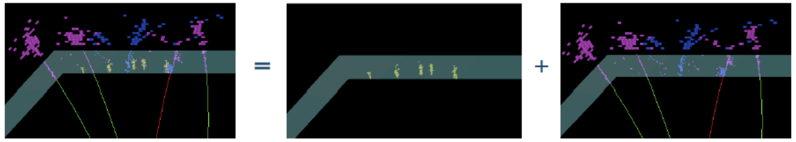
★ **Preliminaries:**
- All studies use latest version of PandoraPFA
  - i.e. the complete rewrite (see John Marshall's talk)
- ILD results refer to ILD00 model (LoI version)
- For high energy studies use CLIC_ILD model
  - 8 interaction length W HCAL
  - 4 Tesla field
  - otherwise very similar to ILD



Applications all use same Pandora framework & algorithms

Including External Content

- The ability to create custom algorithms, compiled as part of the client application, means it is trivial to write simple wrapper algorithms for external content.
- These algorithms can bring results from external packages right into the Pandora reconstruction. For example, can very simply (~50 lines of code) use output from GARLIC to replace photon identification.



Final Pandora reconstruction — GARLIC photon clusters — Standard Pandora reconstruction for remaining hits

John Marshall, 4

1) Performance

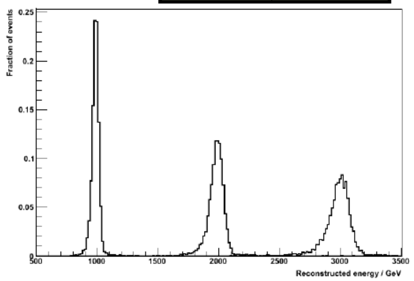
★ Now tested for jets in range 45 GeV – 1.5 TeV

ILD

E_{JET}	RMS_{90}/E_J
45 GeV	3.6 %
100 GeV	3.1 %
180 GeV	3.0 %
250 GeV	3.3 %

CLIC_ILD

E_{JET}	RMS_{90}/E_J
45 GeV	3.6 %
100 GeV	2.9 %
250 GeV	2.8 %
500 GeV	3.0 %
1 TeV	3.2 %
1.5 TeV	3.2 %



Jet Energy Resolution better than 3.6 % over whole range

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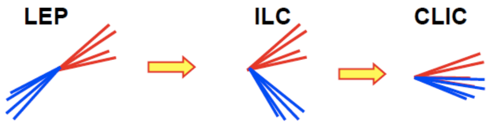
3) W/Z Separation

★ On-shell W/Z decay topology depends on energy:



Particle flow reco. might help here

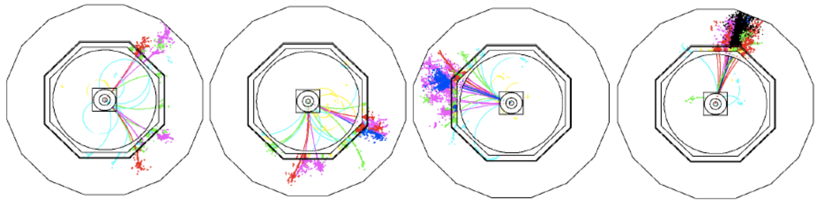
★ A few comments:
- Particle multiplicity does not change
- Boost means higher particle density

} More confusion

- PFA could be well suited for "mono-jet" mass resolution

★ PandoraPFA + CLIC_ILD performance studied for:

125 GeV Z — 250 GeV Z — 500 GeV Z — 1 TeV Z



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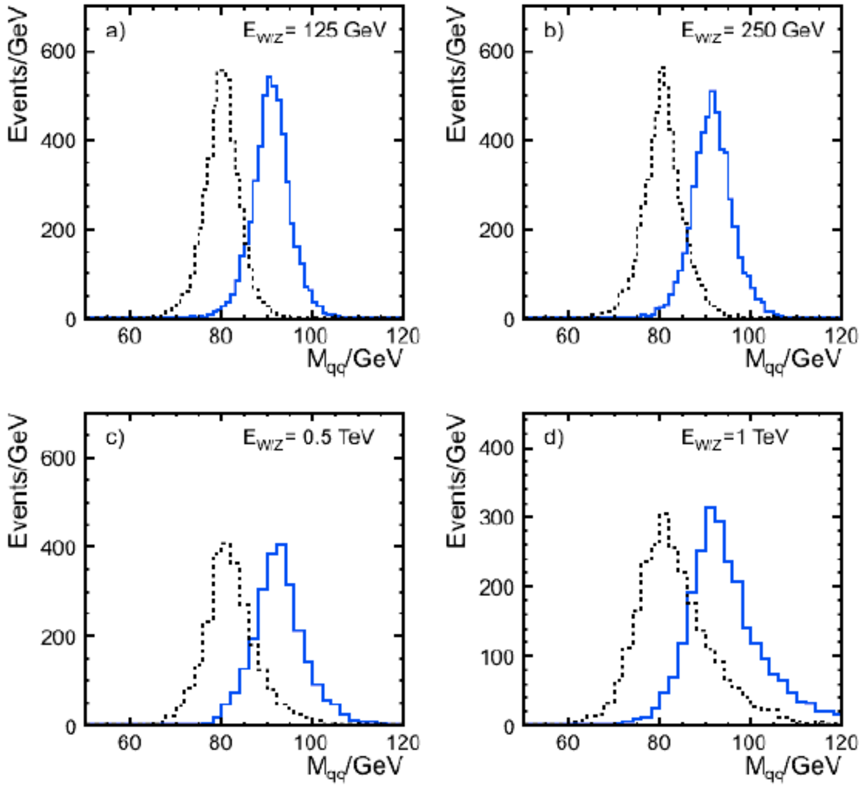
Pandora Performance

Old Mass Resolution



- Impact of fragments, i.e. fake neutral hadrons, on mass reconstruction different is not the same as that for energy reconstruction
- For high energy jets, neutral fragments have disproportionate effect on mass
- Investigate effect of cuts on minimum neutral hadron PFO energy

CLIC 09 version

- Old Pandora
- No neutral cuts

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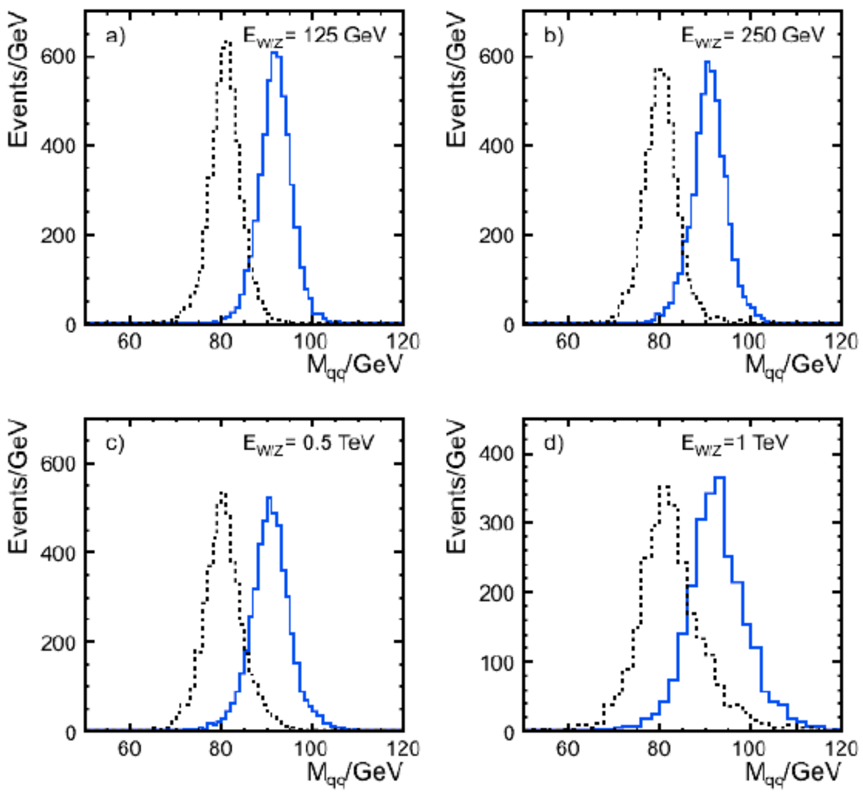
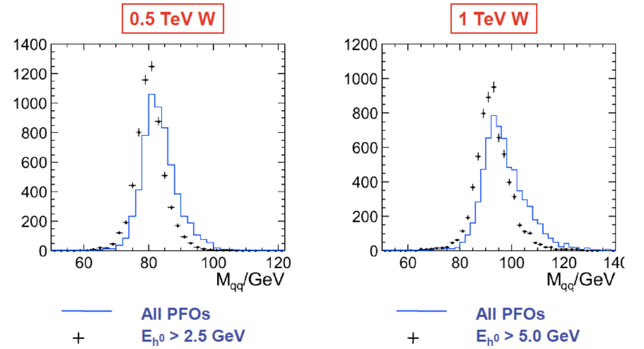
Pandora Performance

New Mass Resolution





IWLC 10 version

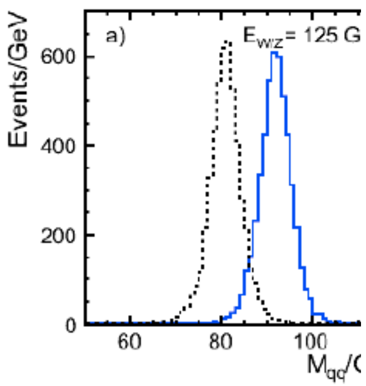
- New Pandora
- optimal neutral cuts

★ Optimal cut represents a compromise between jet energy resolution and suppression of fake "mass generating" effects

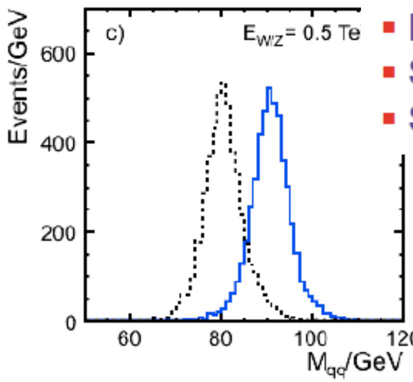
Now have clean W/Z separation for 500 GeV W/Zs !

Pandora Performance

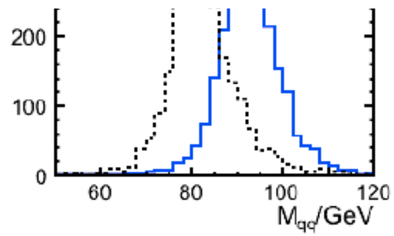
New Mass Resolution



W/Z Energy GeV	h^0 cut GeV	σ_m/m w.r.t. $m_{W/Z}$	σ_m/m w.r.t. m_{gen}	W/Z Sep. Efficiency
125	0	2.8 %	2.4 %	92 %
250	1.0	2.9 %	2.6 %	91 %
500	2.5	3.4 %	3.2 %	88 %
1000	5.0	5.2 %	5.1 %	80 %



- Note due to Breit-Wigner tails best possible separation is 96 %
- Separation of W and Z bosons up to 500 GeV very good
- Still need to work on 1 TeV (di)-jet mass resolution, not bad but…



Now have clean W/Z separation for 500 GeV W/Zs !

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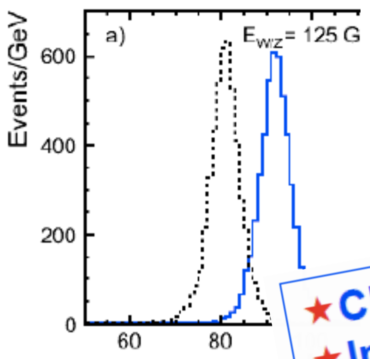
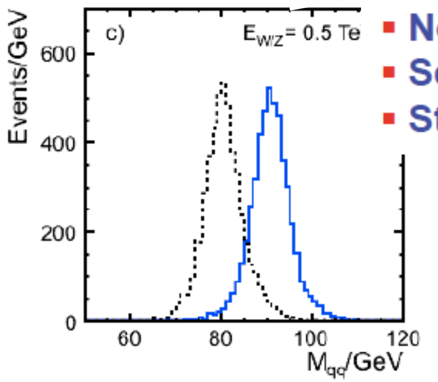
Pandora Performance

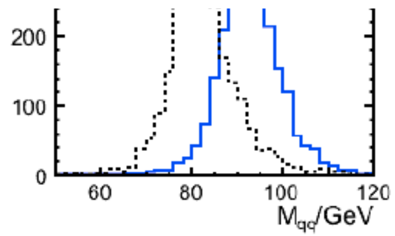
New Mass Resolution



W/Z Energy GeV	h^0 cut GeV	σ_m/m w.r.t. $m_{W/Z}$	σ_m/m w.r.t. m_{gen}	W/Z Sep. Efficiency
125	0	2.8 %	[illegible]	[illegible]
250	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	88 %
[illegible]	[illegible]	5.2 %	5.1 %	80 %

★ CLIC studies beginning to push forward PFA development
★ Improvements will benefit both CLIC and ILC detector studies





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Now have clean W/Z separation for 500 GeV W/Zs !

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Summary

- Both Simulation and Reconstruction tools are making good progress for the needed Detector Optimisation.
- Correct treatment of background in simulation and reconstruction is presently a big challenge facing both ILC and CLIC.
- Despite the fact that preparations for the CDR and the DBD are running on very different time lines, the collaboration between CLIC and ILC is very evident.

Backup

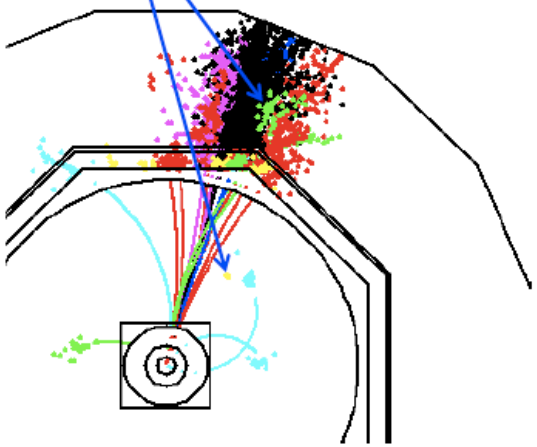
Mass Resolution

- Impact of fragments, i.e. fake neutral hadrons, on mass reconstruction different is not the same as that for energy reconstruction

- Can show that impact of a false energy deposit of energy Δ is:

$$\frac{\sigma_E}{E} \propto \frac{\Delta}{E} \qquad \frac{\sigma_m}{m} \propto \frac{\Delta}{m}$$

$$\boxed{\frac{\sigma_m}{m} \propto \frac{E}{m}\frac{\sigma_E}{E}}$$



1 TeV Z

- For high energy jets, neutral fragments have disproportionate effect on mass

- Investigate effect of cuts on minimum neutral hadron PFO energy

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