Efficient Iterative Calorimeter Calibration on the Grid using iLCDirac

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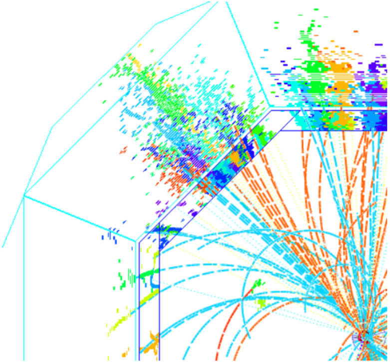


- Calorimeter calibrations provide coefficients, which translate the energy seen by the calorimeter system to the total energy of particles stopped in the calorimeter.
- The calibration procedure provides two sets of constants:
  - first set to scale the raw energy read out by the ECAL and HCAL electronics to the energy deposited by the particles.
  - second set to correct the reconstructed energy of particles during the clustering step of Pandora.

When is a new calibration needed?

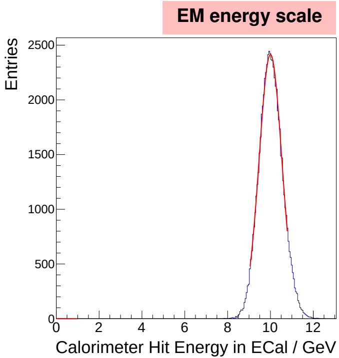
- change in the calorimeter geometry
- new Geant version
- new physics list
- changes in the tracking or particle flow algorithm performances

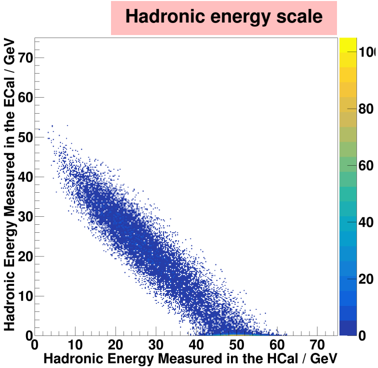
Why do we need an efficient calibration?

- An efficient way to perform calorimeter calibration is an important piece for detector development and optimization studies.

An example of calibration plots

- Calibration constants are obtained by iteratively updating calibration constants, until $\text{Reco}_{\text{Mean}} = \text{Truth}_{\text{Mean}}$
- To reach usual precision (2% on raw energy measurement and 0.5% on energy for Pandora cluster) calibration performs 20-30 of iterations in total.

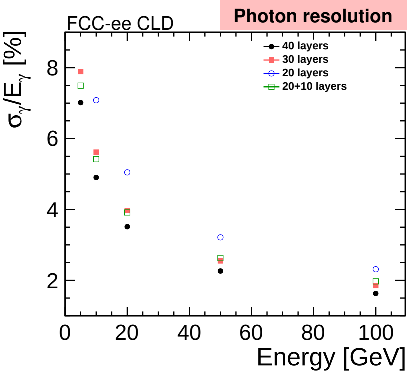




- (left) Reconstructed energy of EM cluster compared to the true photon energy.
- (right) Reconstructed energy of hadronic cluster compared to the true K_L^0 energy.

Use case: optimization of EM calorimeter of CLD detector model for FCC-ee

- Performance studies of ECAL with different number of layers but the same total thickness of $\approx 22\ X_0$
  - FCC-ee centre-of-mass energies: 91.2 - 365 GeV



Layer structure	Thickness tungsten alloy [mm]	Total thickness per layer [mm]
40 uniform	1.9	5.05
30 uniform	2.62	5.77
20 uniform	3.15	7.19
20 thin + 10 thick	1.9 + 3.8	5.05 + 6.95

- 40 layer configuration provides the best photon performance
- 20+10 layer configuration provides better performance at low energies compared to 30 layers which better fits needs of FCC-ee
- 20 layer option leads to significant degradation of photon resolution

Detector simulation and event reconstruction

- full detector simulation and reconstruction is done with iLCSoft
- geometry description with DD4hep package
- reconstruction framework Marlin
- event reconstruction is done with particle-flow PandoraPFA package

Original calibration procedure

- developed for ILD, adopted for CLICdet
- runs on a standalone condor cluster with rather limited number of workers

Existing issues

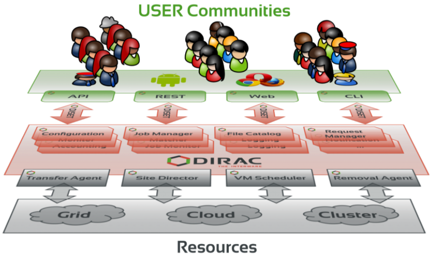
- the main calibration script consists of thousand lines of BASH with many additional calls of python modules $\rightarrow$ hard to maintain
- many hardcoded geometry-dependent parameters $\rightarrow$ it's complicated to add support for another detector model (e.g. for FCC-ee)
- data has to be copied locally to the cluster
- calibration procedure requires manual intervention $\rightarrow$ calibration takes days to be performed

Goals of the new calibration procedure

- maximum automation of the calibration procedure
- use the grid instead of a local cluster
  - more resources
  - possibility to run several calibrations simultaneously
- support for multiple detector models (CLICdet, CLD (FCC-ee), other models which use Pandora)
- to be implemented as a native iLCDirac service which allows exploiting Dirac tools and interfaces for monitoring, bookkeeping, data management, workload management, authentication and configuration.

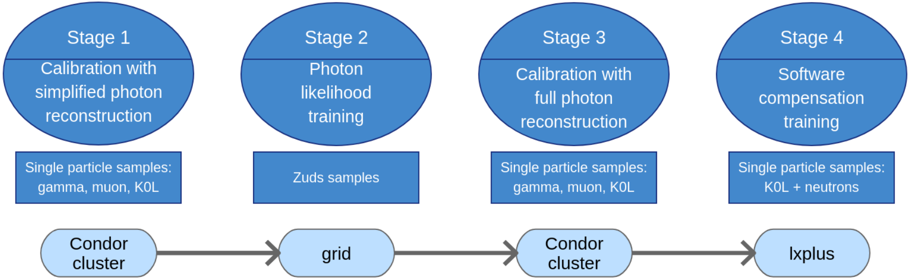
iLCDirac is based on the Dirac interware originally developed for LHCb

- Dirac (Distributed Infrastructure with Remote Agent Control): High level interface between users and distributed resources
- iLCDirac: Additional functionality to provide simple interfaces for the users to the LC Software (Whizard, Whizard2, Marlin, Mokka, org.lcsim, SLIC, ROOT, ddsim)
- Central system for large scale productions



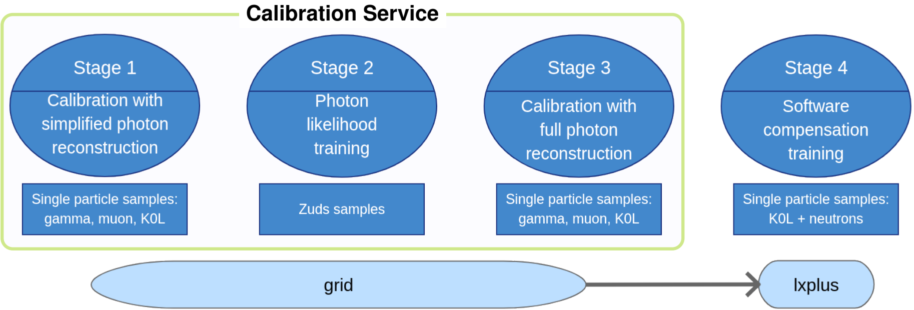

```python
from DIRAC.Core.Base import Script
Script.parseCommandLine()
import UserJob, Marlin, DiracILC
d = DiracILC()
j = UserJob()
j.setOutputData("recEvents.slcio")
m = Marlin()
m.setVersion("ILCSoft-01-17-09")
m.setSteeringFile("Steering.xml")
m.setInputFile("SimEvents.slcio")
j.append(m)
j.submit(d)
```

Existing calibration procedure

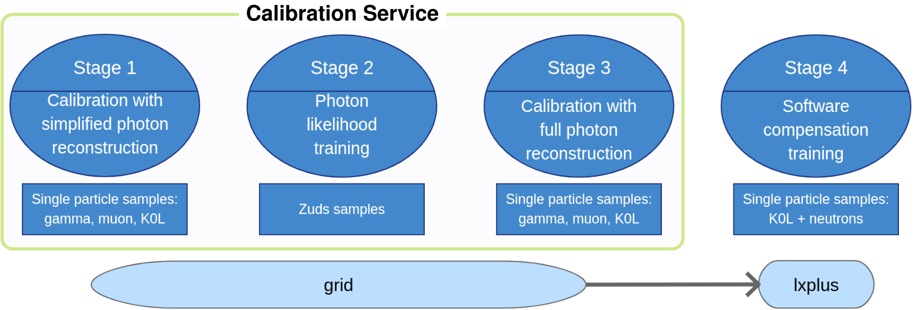


- Calibration consists of four stages:
  - Stage 1 and 3 are run on the cluster, while stage 2 is run on grid and stage 4 on local machine (since it cannot be parallelized)
  - output from one stage has to be plugged in for next stage manually
- New "calibration service" speeds up and simplifies the calibration process by running Stages 1-3 on the grid. It takes cares of bookkeeping of intermediate results .

Dirac calibration service

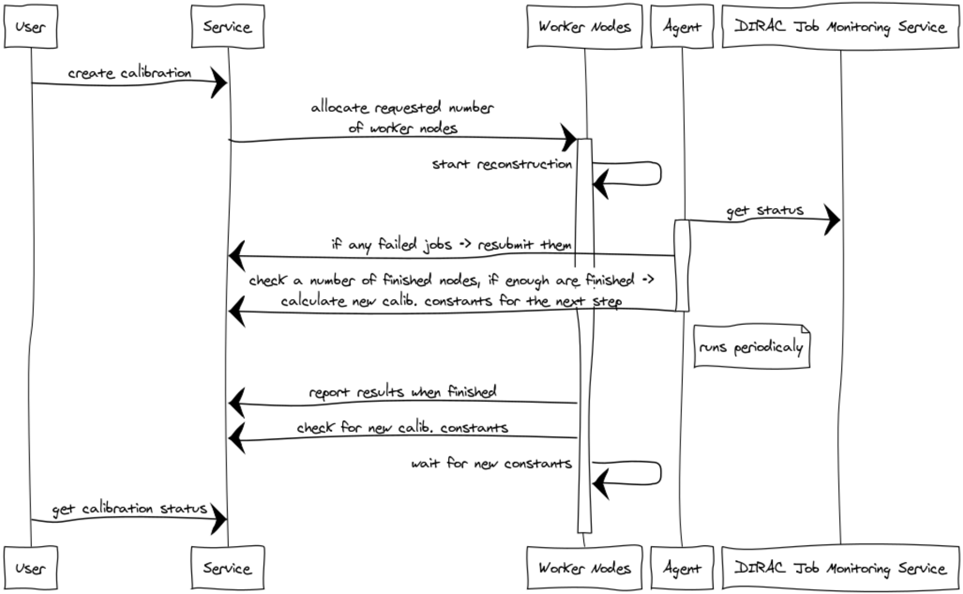


- Calibration service is a native iLCDirac service
  - web-based grid job monitoring thanks to Dirac
- Controls the whole chain of a calibration procedure
  - collects results from finished iterations
  - redistributes new input parameters among worker nodes
- Provides more direct control over the grid resources
  - reduce overhead of job initialisation by reserving grid resources for the entire calibration procedure
  - download all required input files for all steps only once per worker node



- Significant speedup of the calibration procedure
  - no hard limit on number of jobs
  - possibility to run multiple calibrations simultaneously
- Multiple detector support (CLIC, CLD, other models which use Pandora)
- Simple configuration of calibration parameters and detector settings
- Bookkeeping of all done calibrations

Calibration workflow



Calibration Service

- Automatically restarts in case of any disruption in the operation.
- Contains up-to-date backup of each calibration which can be used for recovery.
- Configurable threshold on the fraction of finished jobs to start next step:
  - “stuck” jobs will not affect calibration
  - allows avoiding significant slow down of the calibration by one slow machine
- Stores results of the calibration at the server for configurable amount of time
- User can monitor online calibration status with iLCDirac web-interface

	JobId ↓		Status	MinorStatus	ApplicationStatus	Site	JobName
☐	87092	■	Running	Application	PandoraCalib_291: step 19 is finished. Waiting for other jobs	LCG.CERN...	PandoraCaloCalibration_calid_291_workerid_199
☐	87091	■	Running	Application	Running: stage: 3; phase: 3; step: 19	LCG.CERN...	PandoraCaloCalibration_calid_291_workerid_198
☐	87090	■	Running	Application	PandoraCalib_291: step 19 is finished. Waiting for other jobs	LCG.CERN...	PandoraCaloCalibration_calid_291_workerid_197
☐	87089	■	Running	Application	PandoraCalib_291: step 19 is finished. Waiting for other jobs	LCG.CERN...	PandoraCaloCalibration_calid_291_workerid_196
☐	87088	■	Running	Application	PandoraCalib_291: step 19 is finished. Waiting for other jobs	LCG.CERN...	PandoraCaloCalibration_calid_291_workerid_195
☐	87087	■	Running	Application	Running: stage: 3; phase: 3; step: 19	LCG.CERN...	PandoraCaloCalibration_calid_291_workerid_194

Calibration Agent

- Monitors the health of running jobs
- In case of job failure - resubmits job with input parameters from the latest step

Summary

- New calibration service provides:
  - significant automation and increased speed of calibration procedure
  - simplicity of usage
  - possibility to use all grid resources for calibration (and run many calibrations simultaneously)
  - no need for “babysitting” your calibrations
  - web-based calibration monitoring (by means of Dirac)
- Calibration service was successfully used for FCC-ee EM calorimeter optimization studies

Next steps

- Improve user experience and further automation
- Execution sequence: allow a user to specify in which sequence calibration steps have to be executed
  - allows adding extra calibration steps required in specific cases (e.g. calorimeter with different layer thickness)
- Simulate required input files automatically

Links: **Gitlab** **User guide**

Thank you for your attention!

BACKUP

Example of user input for calibration

```
*** Calibration parameters ***
numberOfJobs                                    100
fractionOfFinishedJobsNeededToStartNextStep     0.9
digitisationAccuracy                            0.02
pandoraPFAAccuracy                              0.005
startPhase                                      0
startStage                                      1
stopPhase                                       99
stopStage                                       99
disableSoftwareCompensation                     True

*** Detector model ***
detectorModel                                   FCCee_o1_v04_ecal20_10.tgz
ecalBarrelCosThetaRange                         [0.0, 0.643]
ecalEndcapCosThetaRange                         [0.766, 0.94]
hcalBarrelCosThetaRange                         [0.15, 0.485]
hcalEndcapCosThetaRange                         [0.72, 0.94]

*** ECAL parameters ***
nEcalThickLayers                                10
nEcalThinLayers                                 20
ecalResponseCorrectionForThickLayers            2.0

*** SW version ***
marlinVersion                                   ILCSoft-2019-07-09_gcc62
DDCaloDigiName                                  MyDDCaloDigi_10ns
DDPandoraPFANewProcessorName                    MyDDMarlinPandora_10ns

*** Input/Output ***
outputPath                                      /ilc/user/o/oviazlo/fccee_caloCalib/
outputSE                                        CERN-DST-EOS
steeringFile                                    fcceeReconstruction_noSWC.xml
gammaFiles                                      fccee_10gev_gamma_FCCee_o1_v04_ecal20_10.txt
kaonFiles                                       fccee_50gev_K0L_FCCee_o1_v04_ecal20_10.txt
muonFiles                                       fccee_10gev_mu_FCCee_o1_v04_ecal20_10.txt
zudsFiles                                       fccee_380gev_Z_uds_FCCee_o1_v04_ecal20_10.txt
```