LCDG4 and DigiSim

Simulation activities at NIU

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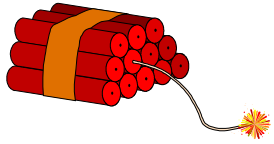
Talk Outline

- LCDG4 – full detector simulation
  - Introduction and features
  - Data samples for general use
  - Status and plans
- DigiSim – digitization simulation
  - Description
  - Preliminary results (HCal)
  - Status and plans

LCDG4: Full detector simulation

- A Geant4-based detector simulator to support detector R&D for the Linear Collider (up-to-date with latest version, Geant4.7.0.p01)
- Alternatives: Mokka (Europe) or SLIC (new, under development)
- LCDG4 features
  - Input format: binary STDHEP
  - Output format: ***.lcio*** (standard) or ***.sio*** (old ALCPG format still in use)
  - Some detector geometries are implemented via XML geometry files (e.g. SiD, LD and variants). Geometry changes fairly simple to make



Simplistic geometry: cylinders, disks and cones only, no cracks, limited representation of support structure

Geometry description in XML

An example: Hadronic calorimeter barrel.

Dimensions are in centimeters.

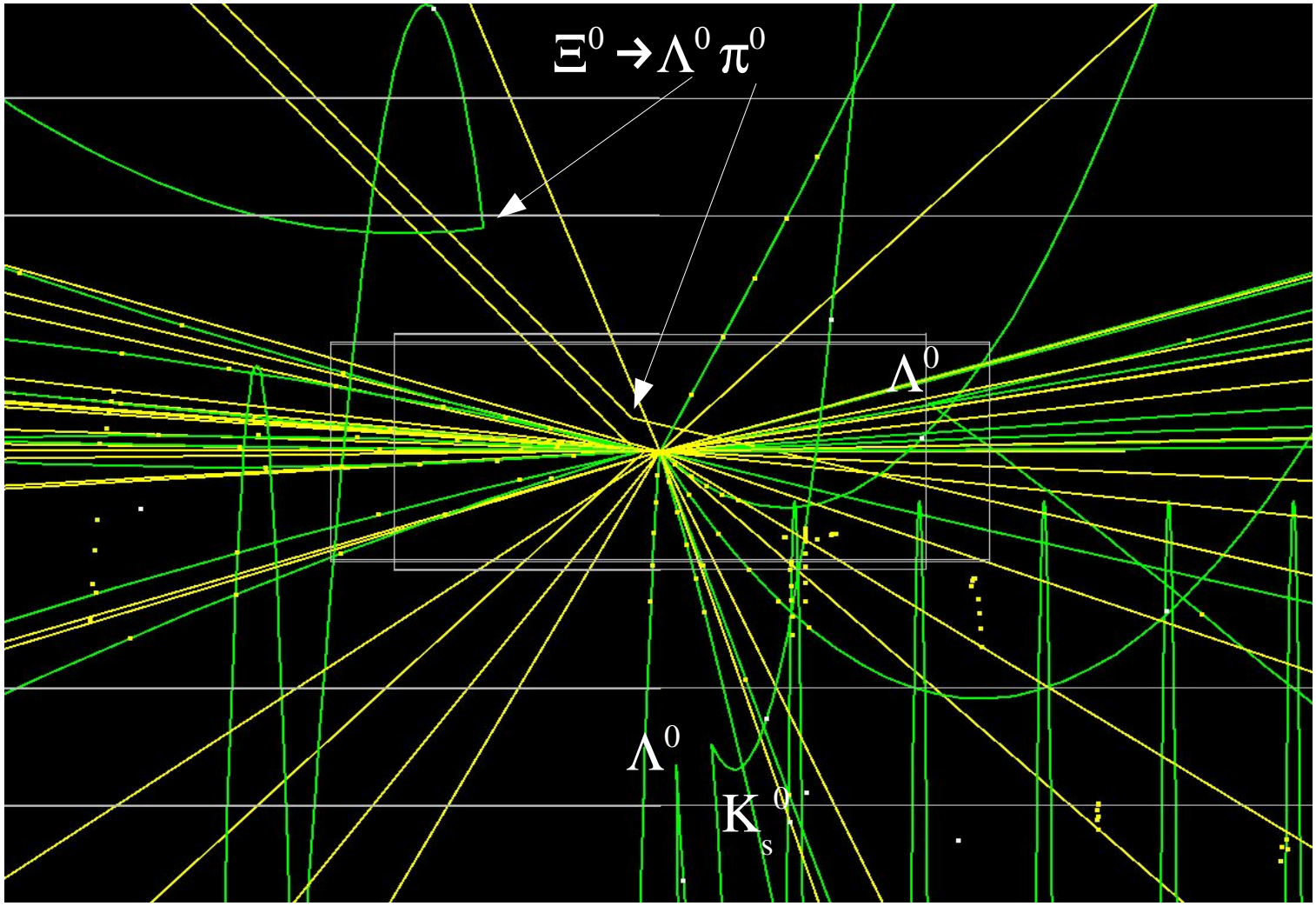
```
...
<volume id="HAD_BARREL" rad_len_cm="1.133" inter_len_cm="0.1193">
  <tube>
    <barrel_dimensions inner_r="144.0" outer_z="286.0" />
    <layering n="34">
      <slice material="Stainless_steel" width="2.0" />
      <slice material="Polystyrene" width="1.0" sensitive="yes“ />
    </layering>
    <!--segmentation cos_theta = "600" phi = "1200" /-->
    <cell_info length="1.0" height="1.0" offset="0." outer_r="246.5"/>
  </tube>
  <calorimeter type="had" />
</volume>
...
```

Proj or NP selection:
either one, not both.
To do: better tag names

Most of detector changes are very easy to make!

Zoom on the primary interaction

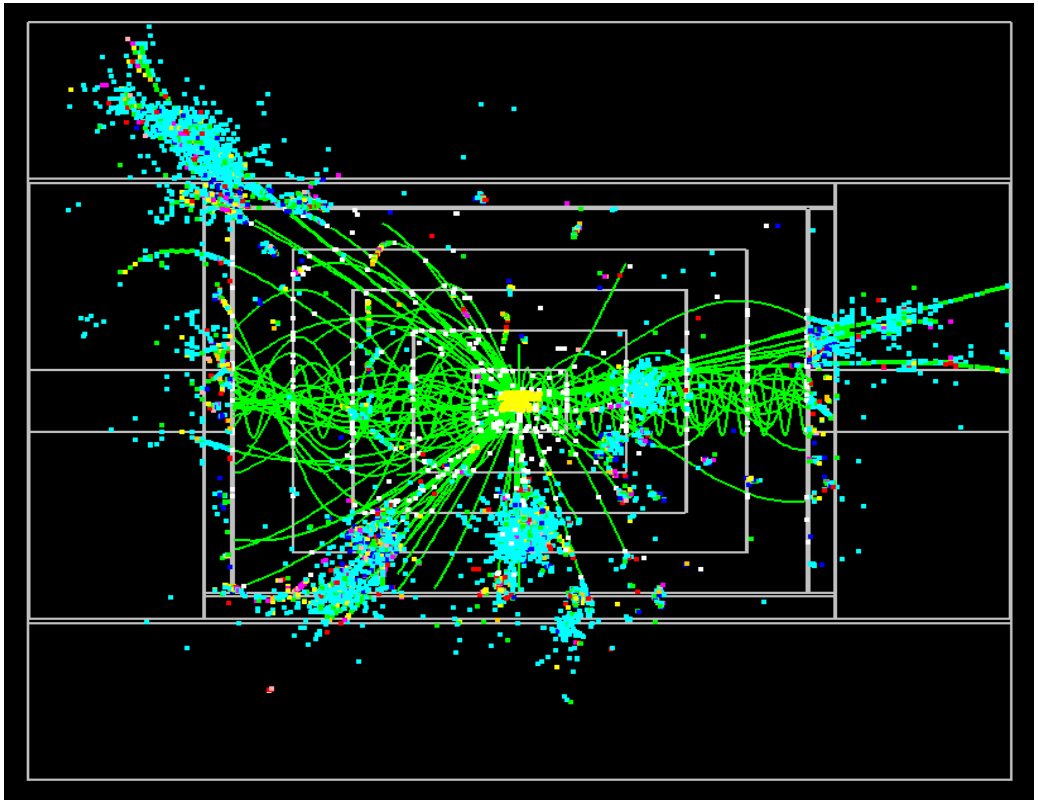
All decays forced in the generator are correctly processed by the LCDG4 simulation

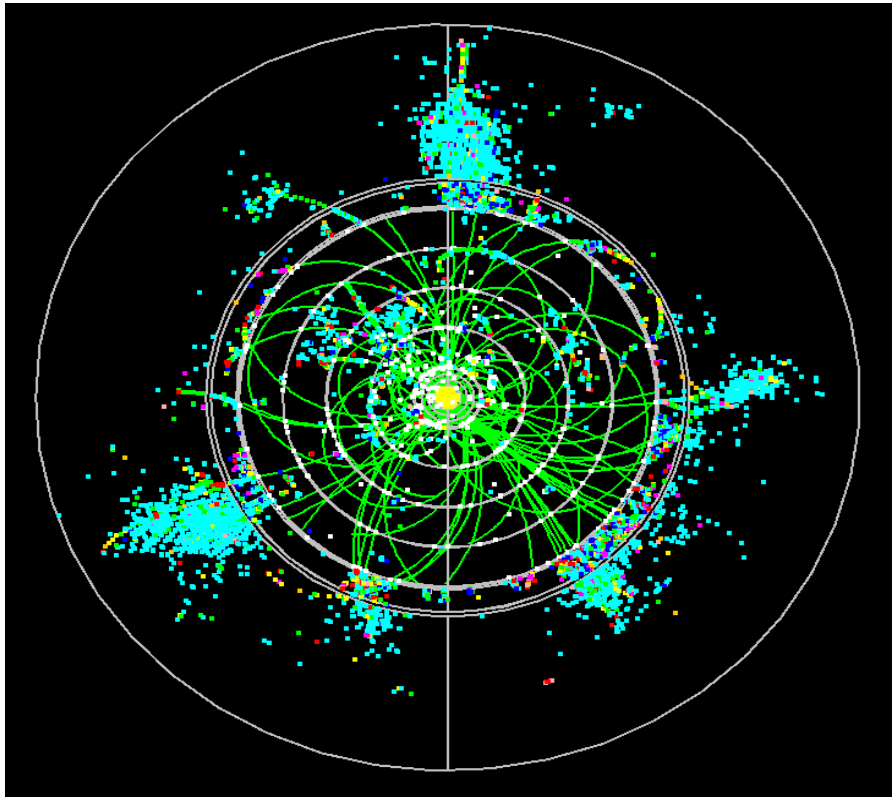


Green: charged
Yellow: neutrals

Event displays

e^+e^- into ttbar event (SDJan03)





MC Samples for general use

- Samples currently available at NIU through sftp: scpuser@k2.nicadd.niu.edu (lcd_2004): /pub/lima/lcdg4/v03-19
  - 2K each of $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, γ, n at $\theta = 90^{o}$ and flat in φ energies = 2, 3, 5, 10, 15, 20, 30, 50 GeV
  - 5K 10 GeV K_s^0 into $\pi^0\pi^0$
  - 10K 10 GeV K_s^0 into $\pi^+\pi^-$
  - 5K 10 GeV Σ^+, inclusive decays
  - 5K 1..10GeV Λ^0, inclusive decays
  - 10K Z into (hadrons) at 91 GeV
  - 5K ttbar inclusive at 350 GeV
  - 10K WW into (hadrons)(any) at 500 GeV
  - 10K $\tau^+\tau^-$ at 500 GeV
  - 4K ZH into (any)(bbbar) at 500 GeV and M_H=120, 160 GeV (2K events each)

Both SDJan03 and SDNPHOct04 geometries, plus some variants

Also, SLAC has data using brand new geometry, SDFeb05

- Other samples can be requested to lima at fnal.gov. Please read http://nicadd.niu.edu/~lima/simreq/ for guidelines.

Other interesting samples available

- Some samples have been simulated with alternative geometries:
  - SDJan03-ANL in v03-09, SDNPHOct04-85W in v03-19:
    ANL: 60 proj HCal layers, each with 0.7cm tungsten + 1cm scintillator
    85W: 85 NP HCal layers, each with 0.7cm tungsten + 0.5cm scintillator
    - 2K each of $\mu^{\pm}$, $\pi^{\pm}$ at $\theta = 90^{\circ}$ and flat in φ
      energies = 2, 3, 5, 10, 15, 20, 30, 50 GeV
    - 10K Z into (hadrons) at 91 GeV
  - SDNPHOct04-BXX-EcalRminYYY in v03-16:
    Non-projective HCal barrels with Ecal inner radius varying from 127 to 164cm, and magnetic fields (B) ranging from 3.0 to 5.0 GeV, while keeping BR^2 = constant
    - 2K $\mu^{\pm}$ at $\theta = 90^{\circ}$ and flat in φ, energies = 2, 3, 5, 10, 15, 20, 30, 50 GeV
    - 2K e+e- into ZH into (qqbar)(bbbar), at 500 or 1000 GeV

How to access the MC samples

Several single-particle and physics data samples available from NIU data server using secure ftp:

```
% sftp scpuser@k2.nicadd.niu.edu
password: lcd_2004
sftp> cd pub/lima/lcdg4/
Sftp> ls   (to see a list of versions available)
Sftp> cd <some-version>
sftp> ls   (to see a list of files available)
sftp> mget muons-10gev*.slcio    (for example)
sftp> quit
%
```

See http://nicadd.niu.edu/~jeremy/admin/scp/index.html for more detailed access instructions, including instructions for windows' winscp utility.

Things to do

- Non-projective fixed-size calorimeter cells for endcaps (SLIC?)
  (Needs some thinking on cell numbering scheme)
- Some XML extensions submitted by Shenjian Chen (UofC), to allow for cell offsets between adjacent projective layers.
  To be released after tests with SDJan03
- Handle diagnostic input files with multiple primary vertices

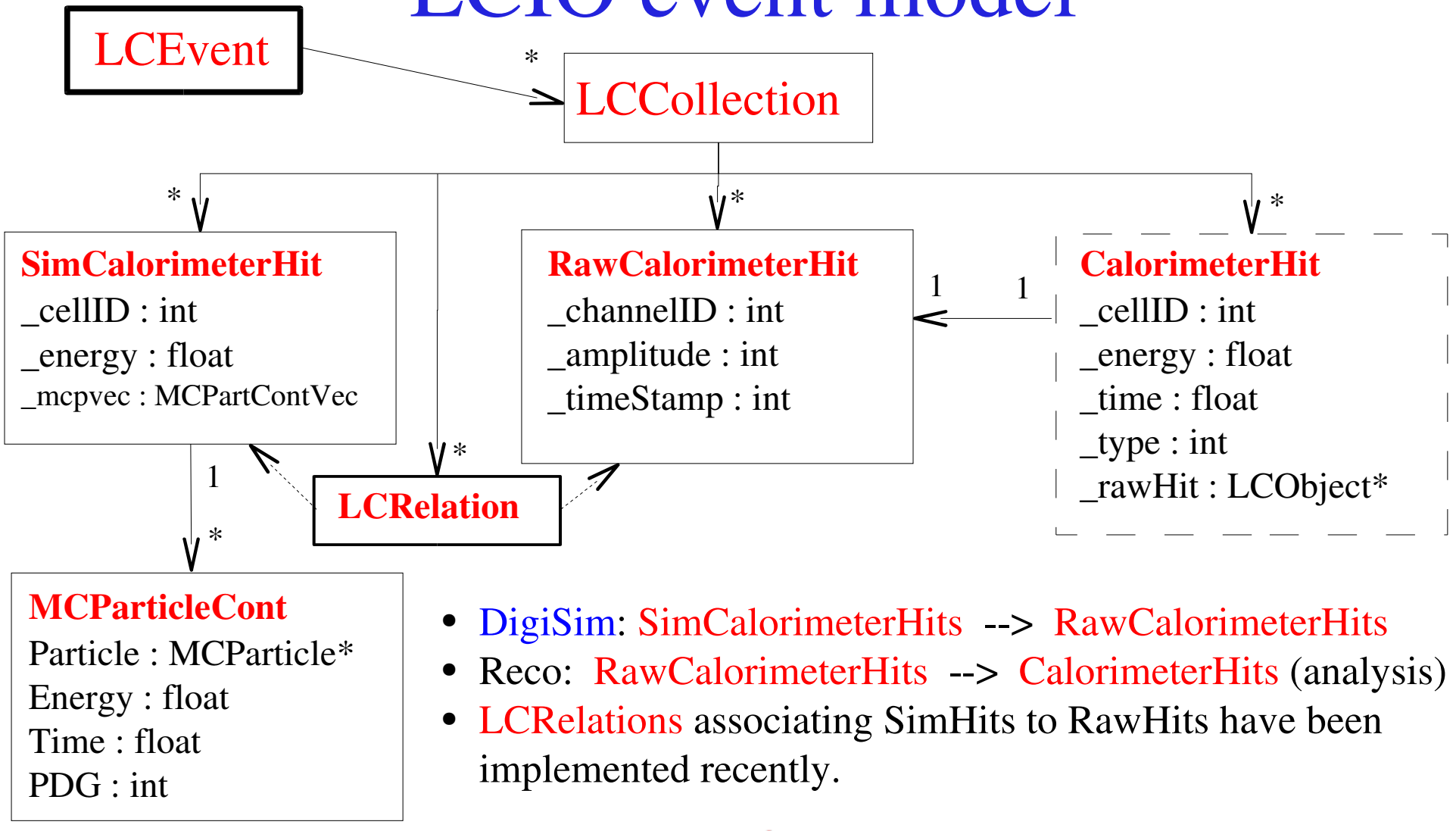
LCDG4 status

- Only cylinders, disks and cones supported by XML-based geometry
  More realistic geometries to be implemented by another package (SLIC, now under certification).
- Source code available from both SLAC and NIU CVS repositories
- Several MC physics samples have been generated for algorithm development and studies (both SIO or LCIO formats are available)
  Anonymous access via ssh / scp:
  scpuser@k2.nicadd.niu.edu (pwd=lcd_2004): /pub/lima/lcdg4/v03-19
  See http://nicadd.niu.edu/~jeremy/admin/scp/ for detailed access instructions.
- For more information please check the LCDG4 documentation web page: http://nicadd.niu.edu/~lima/lcdg4/, or under subdirectory doc of CVS module
- Several analyses using LCDG4 data for detector optimization and algorithm development, see e.g. Chakraborty's and Magill's talks on calorimetry

DigiSim

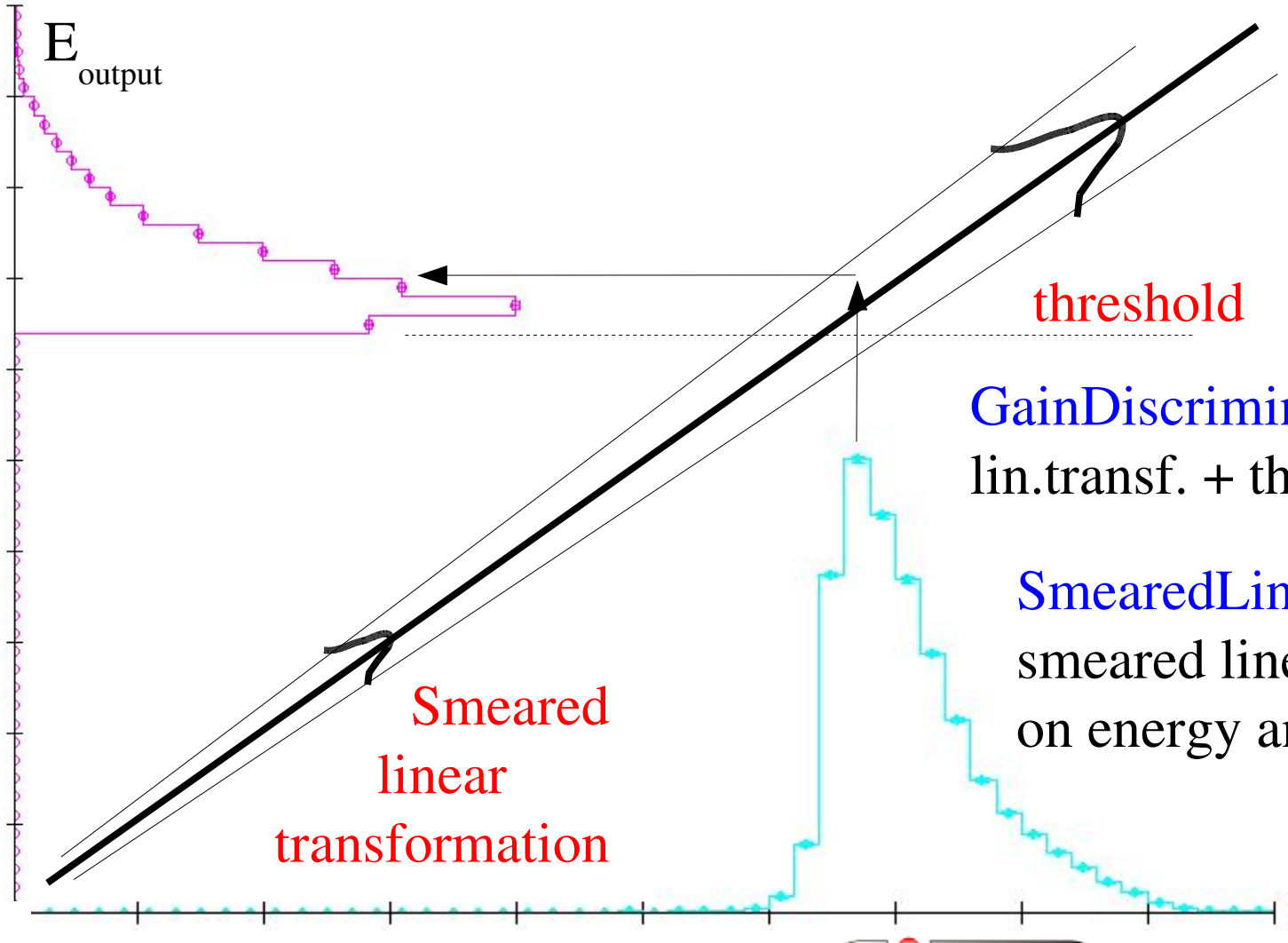
- Goal: a program to simulate the digitization process for the ILC detector simulation
  It has been adopted for (CALICE) test beam simulations, which will serve as a testbed for the full-detector digitization
- Basic requirements:
  - Object oriented design to simplify maintenance and implementation of new functionality
  - All test beam code based on C++ and LCIO
- Marlin (v0.6) chosen as the C++ framework

LCIO event model



- DigiSim: SimCalorimeterHits --> RawCalorimeterHits
- Reco: RawCalorimeterHits --> CalorimeterHits (analysis)
- LCRelations associating SimHits to RawHits have been implemented recently.

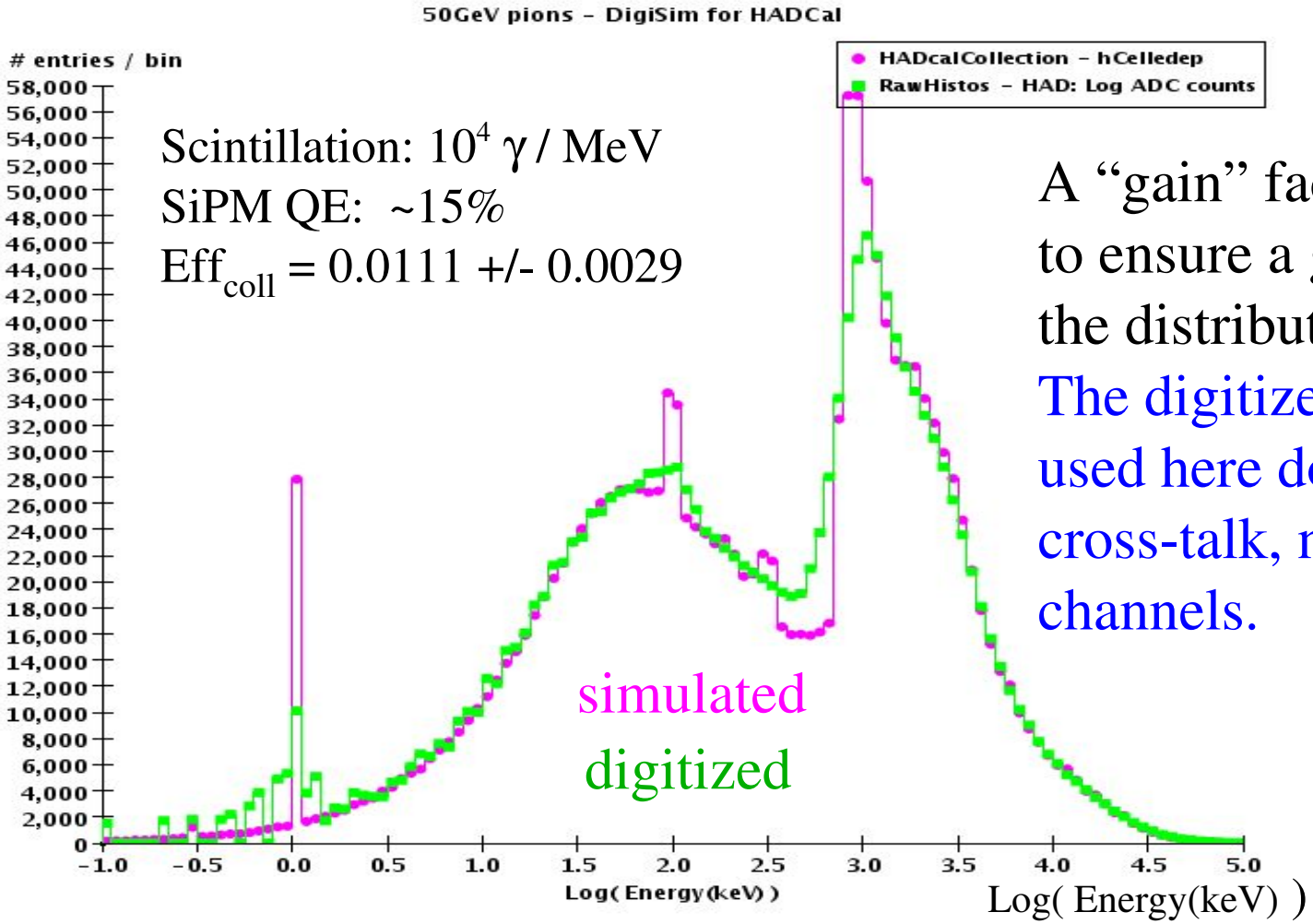
Existing modifiers



GainDiscrimination is a smeared lin.transf. + threshold on energy

SmearedLinear is a func-based smeared linear transformation on energy and/or timing

HCal digitization (1st attempt)



A "gain" factor was used to ensure a good overlap of the distributions shown.

The digitizer configuration used here does not include cross-talk, noise or hot/dead channels.

DigiSim: Status and plans

- A digitization simulation framework, DigiSim, has been developed at NICADD/NIU
  - Generic modifiers available: GainDiscrimination and function-based SmearedLinear
  - LCRelations implemented to associate raw hits to corresponding simulated hits
  - First version of a real (though incomplete) tile Hcal digitizer has been implemented
- DigiSim can be run either standalone (output file) or as an on-the-fly preprocessor
- EMraw, HADraw (raw hits) and LCRelations collections are appended to LCEvent, in addition to the (untouched) simulated calorimeter hits collections
- DigiSim can also be used for the digitization of SimTrackerHits
- Crosstalk modifier is currently under development at NIU
- A Java version to be implemented soon
- Conditions data to be supported for cell-to-cell parametrization

Summary

- Geant4-based full detector simulation tools available for detecor R&D comparing different detector geometries and/or technologies
- **LCDG4** provides quick turnaround for basic changes to supported geometries
- LCDG4 (XML-based), SLIC (LCDD-based) and Mokka (MySQL-based) can be used for standard LCIO format.
  LCDG4 also produces output in SIO (old ALCPG format, still in use)
- Several data samples are available at NIU server for general use. Anonymous access via sftp or scp: scpuser@k2.nicadd.niu.edu (pwd=lcd_2004): /pub/lima/lcdg4/v03-19
- Documentation available from http://nicadd.niu.edu/~lima/lcdg4
- **DigiSim** provides a simple and powerful framework for digitization simulations (currently implemented in C++; a java version to be developed soon)
- Documentation available from http://nicadd.niu.edu/digisim, including downloading and building instructions.