Summary of Simulation and Reconstruction

Shaomin CHEN (Tsinghua University)

- **Framework and toolkit**

  Jupiter/Satellites, Mokka/Marlin, Slic/org.lcsim

- **Application in ILC detector design**

  GLD calorimeter
  LDC HCAL
  CALICE data processing
  ...

Four ILC Detector Concepts

- **GLD**

  Large, 3T B-field

- **LDC**

  Medium, 4T B-field

- **SiD**

  Small, 5T B-field

- 4th detector concept

  See John Hauptman's talk

Most of physics studies rely on precise measurement on multi-jets in the final state.

↓

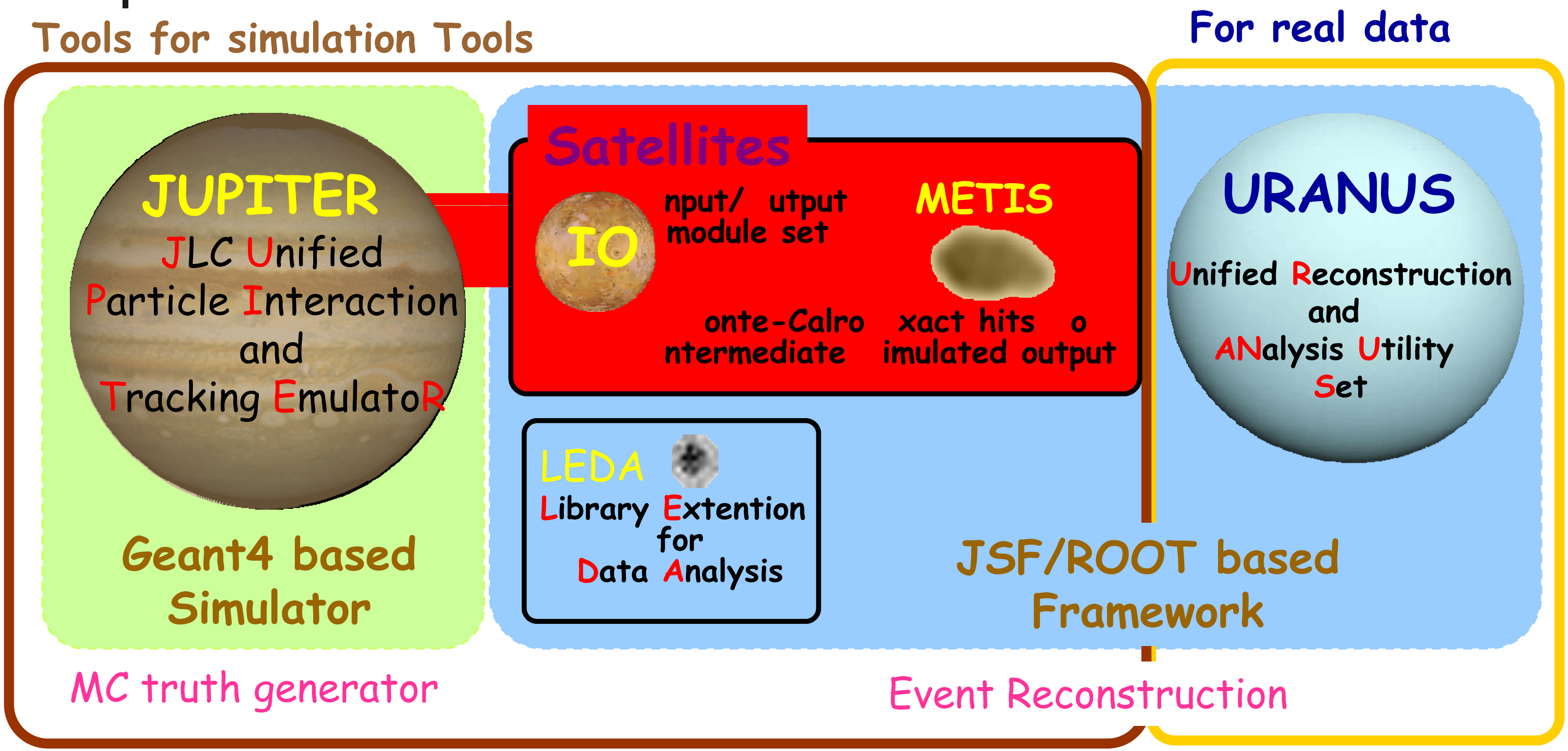
Particle Flow Algorithm

(see Tamaki Yoshioka's talk)

Framework and Toolkit

- **Jupiter/Satellites (Aisa)**
  - For large option (GLD) design
  - Use ROOT as a framework for data model
- **Mokka/Marlin (Europe)** Ties Behnke's talk
  - For medium option (LDC) design
  - Use LCIO as a framework for data model
- **Slic/org.lcsim (US)** Norman Graf's talk
  - For small option (SiD) design
  - Use LCIO as a framework for data model

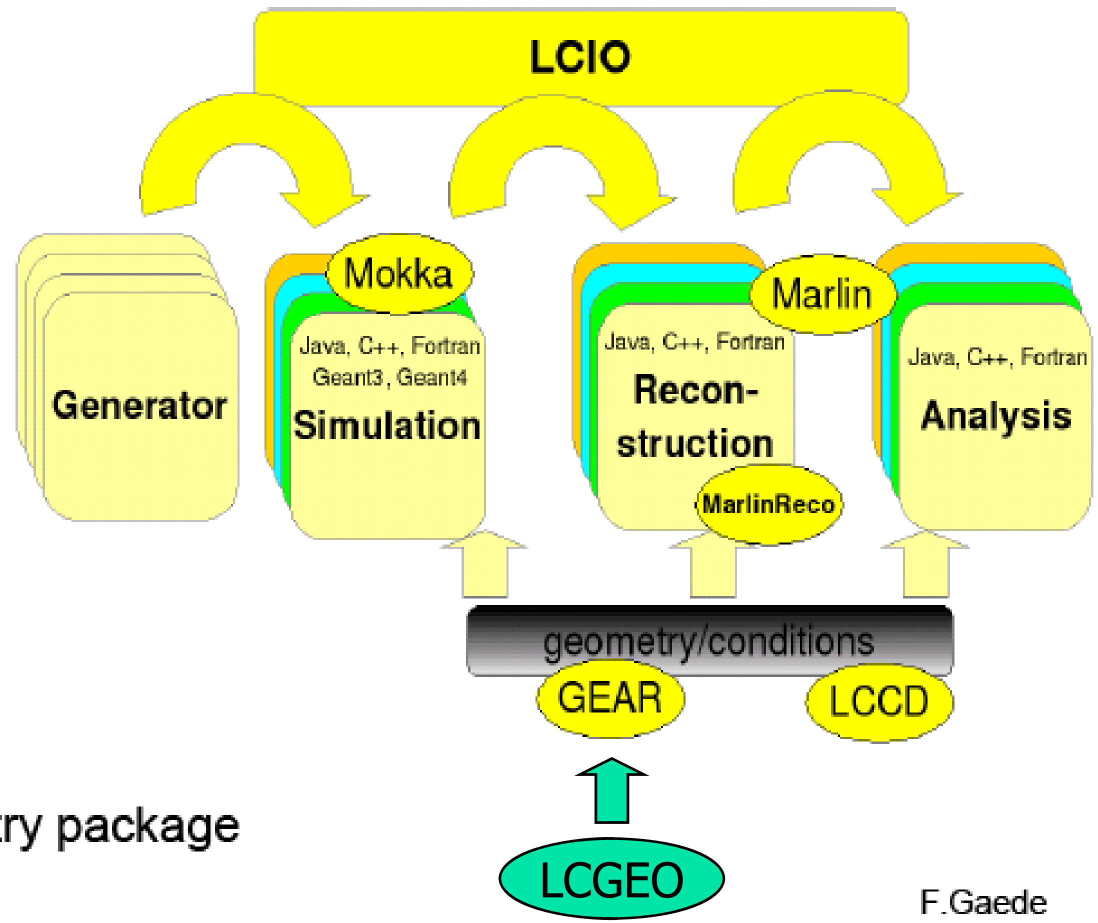
Jupiter/Satellites Concepts



JSF: the analysis flow controller based on ROOT
The release includes event generators, Quick Simulator, and simple event display

Mokka/Marlin concepts

- LCIO
  - data model & persistency
- MARLIN
  - C++ application framework
- LCCD
  - conditions data toolkit
- GEAR
  - geometry description
- LCGEO
  - a proposal for a new geometry package



+ GEANT4, stdhep, clhep, gsl, ... (external packages)

Ties Behnke's talk

What is not there

Main problem: coherent and easy to use geometry interface

LCGO is designed to close this gap, but it is not yet there
(common DESY/ SLAC development)

State of Algorithms:

- Many are there, but need optimization, debugging, and your ideas
- This is particularly true for particle flow:

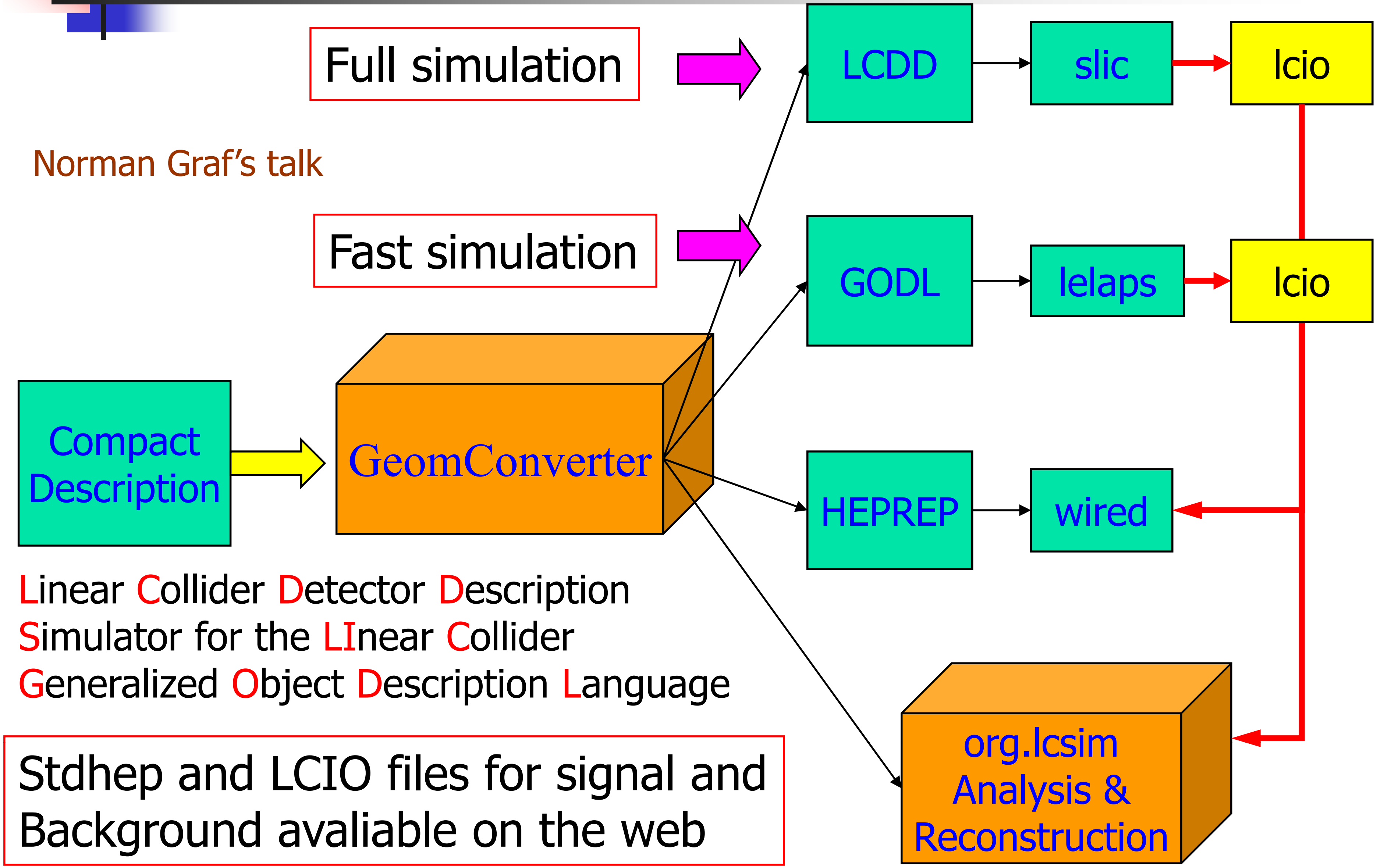
  WOLF, PandoraPFA, track based PFA
  many systems, but do not expect something which is "ready"

- Many useful tools are missing

Ties Behnke's talk

Slic/org.lcsim concepts

Norman Graf's talk



Linear Collider Detector Description
Simulator for the LInear Collider
Generalized Object Description Language

Stdhep and LCIO files for signal and Background avaliable on the web

Three merge into one?

Jupiter/Satellites

Mokka/Marlin

Slic/org.lcsim

Application in Detector Design

- **Detector optimization using PFA**

  Tamaki Yoshioka’s talk

- **Calorimeter segmentation study**

  Hiroaki Ono’s talk

- **Pion-zero reconstruction in ECAL+HCAL**

  Daniel Jeans’ talk

- **Isolated gamma finding in ECAL**

  Hitoshi Hano’s talk

- **HCAL optimization using PFA**

  Ties Behnke’s talk

Particle Flow Algorithm (PFA)

ILC detectors are required good jet energy resolution for the precise measurement of jetty events.

Jet energy measured by

- Charged (~60%) : *Tracker*

$$\delta P_t / P_t^2 = 5 \times 10^{-5} (GeV/c)^{-1}$$

- Photon (~30%) : *EM calorimeter*

$$\sigma / E = 15\% / \sqrt{E} \oplus 1\%$$

- Neutral hadron (~10%) : *EM/HD calorimeter*

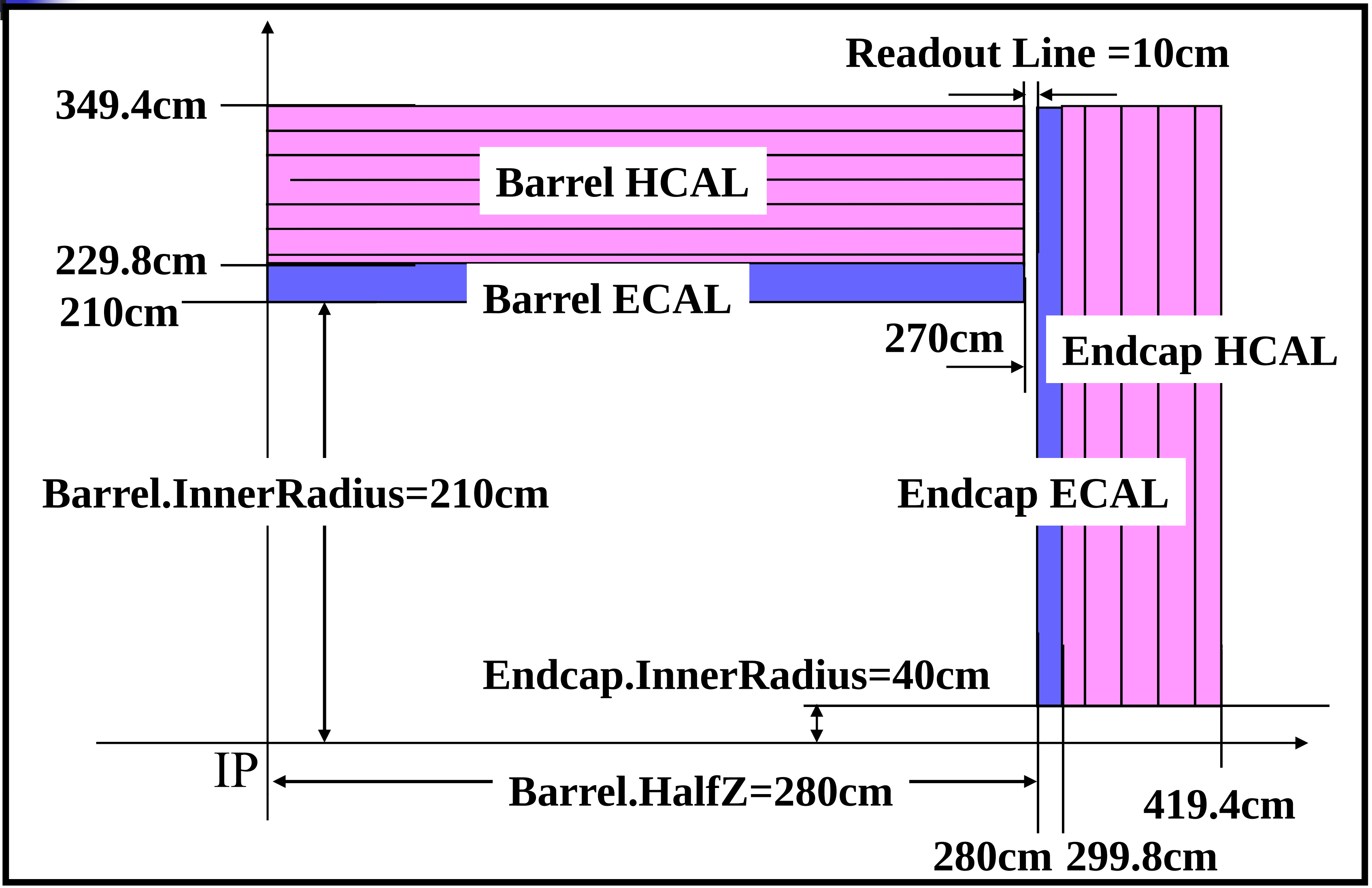
$$\sigma / E = 40\% / \sqrt{E} \oplus 2\%$$

Required performance to separate W/Z mass.

$$\sigma(E_j) / E_j = 30\% / \sqrt{E_j}$$

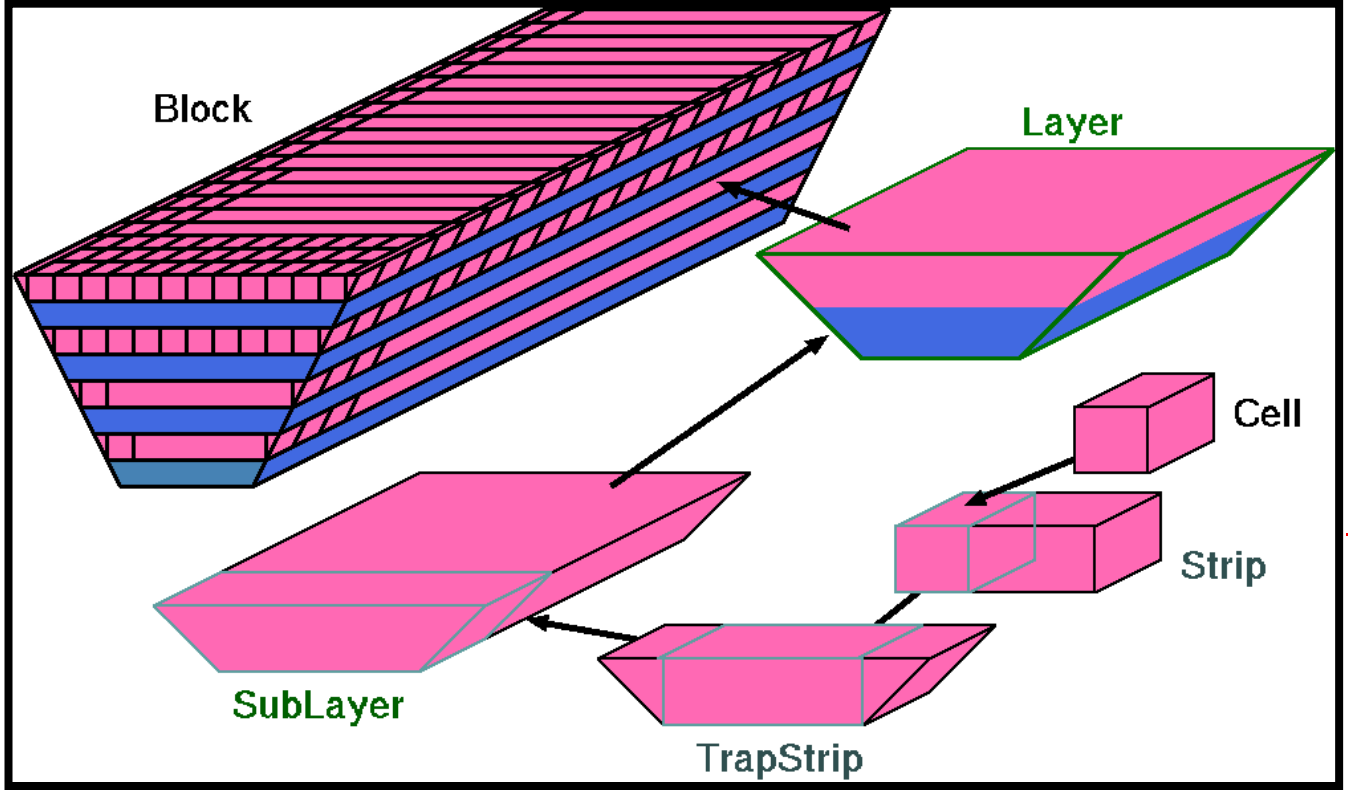
Hiroaki Ono's talk

Calorimeter Geometry in Jupiter



Tamaki Yoshioka's talk

Calorimeter Structure



Active Layer

Absorber

Current cell size :
1x1cm
Can be changed.

ECAL	HCAL
W/Scinti./Gap	Fe/Scinti./Gap
3/2/1 (mm) x 33 layers	20/5/1 (mm) x 46 layers

Tamaki Yoshioka's talk

Optimization using PFA

With the PFA, we can start detector configuration optimization.

- B-field
- Calorimeter inner radius
- Hadron Calorimeter depth
- Calorimeter absorber material
- TPC endplate thickness
- Calorimeter granularity (Ono-san's talk)
- etc …

Check jet
Energy resolution

Physics events: $Z \rightarrow qq$(uds) at 91.2 GeV and 350 GeV

Tamaki Yoshioka's talk

Calorimeter Segmentation

- We studied the cheated/realistic PFA performance with different cell/strip segmentation.
- In cheated PFA, Z->qq event has analyzed and charged and neutral cluster overlapping contribute
  - Ecm=91GeV : Almost no segmentation effect has been observed.
  - Ecm=350GeV: jet energy resolution decrease by segmentation.
- Realistic PFA performance at high energy region is still low jet resolution, should be improved.
  - 91GeV is used for PFA optimization for now.

Hiroaki Ono's talk

Optimization using PFA

- Jet energy resolution is studied by using Z→qq events. ILC goal of 30%/√E has been achieved in the barrel region of the Z-pole events.
- PFA performance with various GLD configuration has been studied.

  → High B-field/Large Calorimeter gives better performance as expected.

  → PFA performance of Pb calorimeter is comparable to that of default configuration.

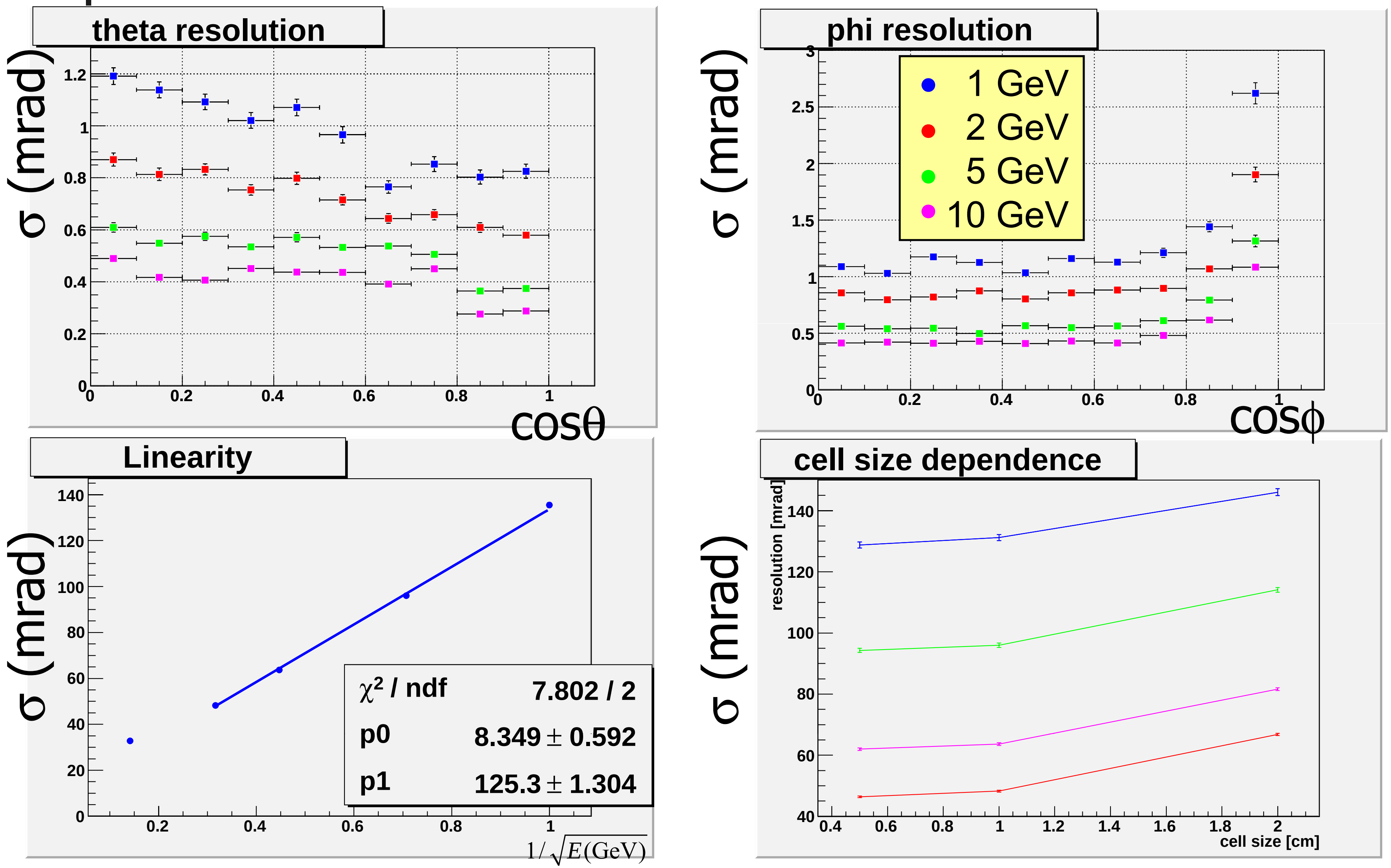
Tamaki Yoshioka's talk

Optimization from isolated γ

- **Motivated by GMSB** $\tilde{\chi}_1^0 \rightarrow \gamma + \tilde{G}$
- **Angular Resolution Study**
  - **Position Resolution of ECAL cluster**
  - **Direction of Reconstructed gamma**
- **Calorimeter Component Dependence**
  - **Cell size Dependence**
  - **Material Dependence**

Hitoshi Hano's talk

Resolution of isolated γ



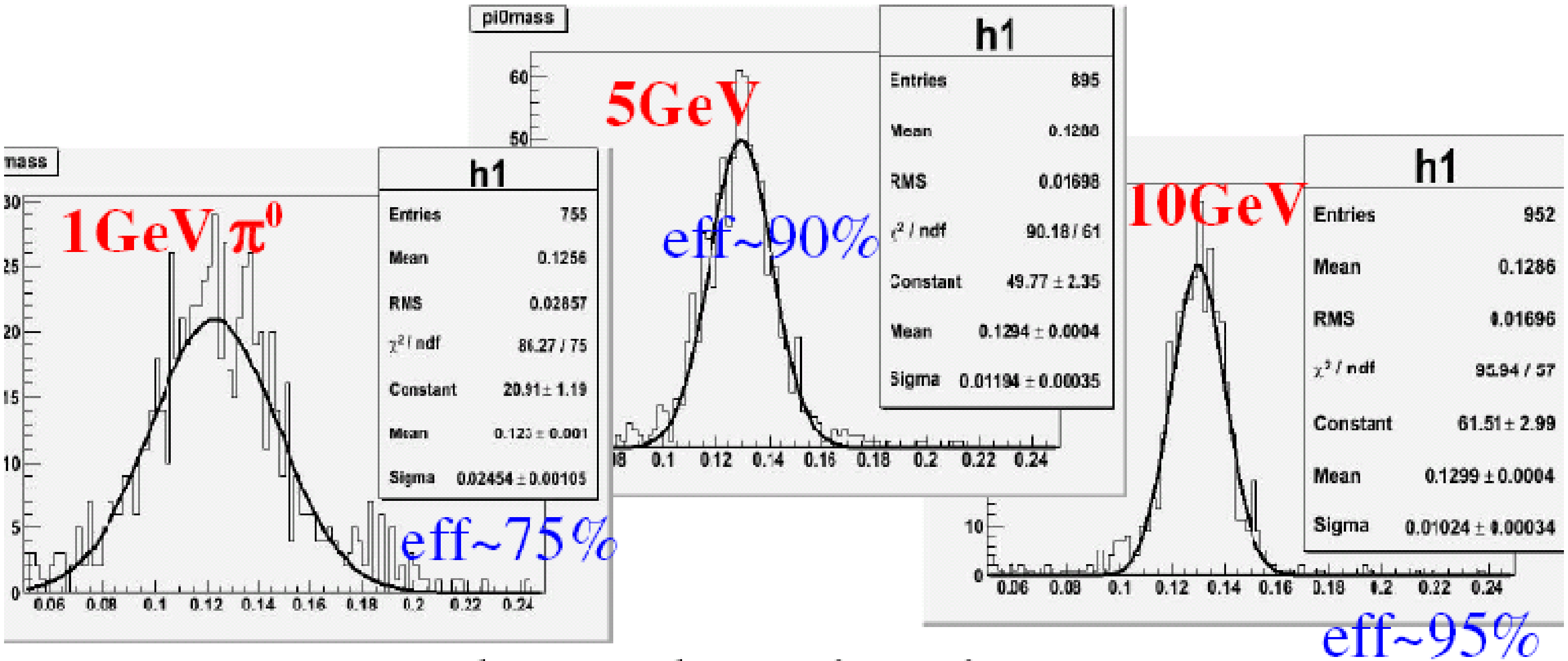
Results of the isolated γ study

- Angular resolution of default-GLD Calorimeter (W:1cm)
  - The angular resolution is estimated to be 125mrad/√(E/GeV)
- Dependence on cell size granularity and material dependence (W, Pb) has been studied
  - No significant difference has been observed between 1cm and 0.5cm
  - Lead is better than Tungsten for isolated gamma
  - Energy resolution is same

Hitoshi Hano's talk

Pion-zero resolution

- in single π^0 events, find two most energetic identified photons
- plot invariant mass, extract mass resolution
- measure resolution as function of π^0 energy



photon-photon invariant mass

Daniel Jean's talk

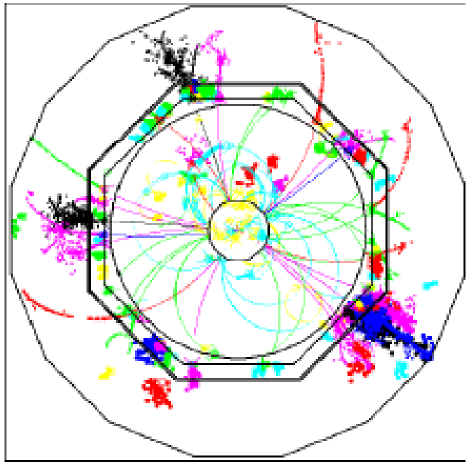
Results of Pion-zero Study

- can find π^0 in jets
  - studying optimal photon efficiency/purity point
- possible to resolve 10 GeV π^0 with O(10)cm strips
- resolving photons from 50 GeV π^0 decay beyond capabilities of 1cm width - also true for 1x1cm cells
  - probably not critical for jet energy resolution: energy quite well measured by calorimeter, so kin. fit will not help much
- maybe shower shape will help distinguish high energy gamma and π^0 showers...

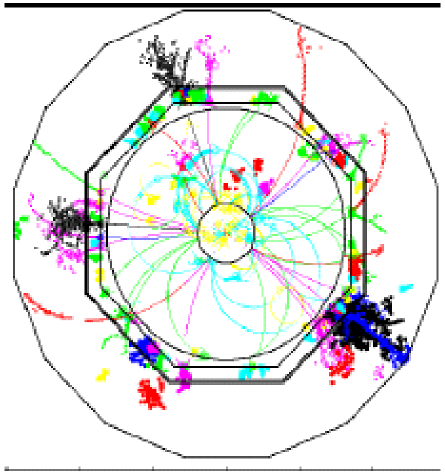
Daniel Jean's talk

LDC HCAL Optimization

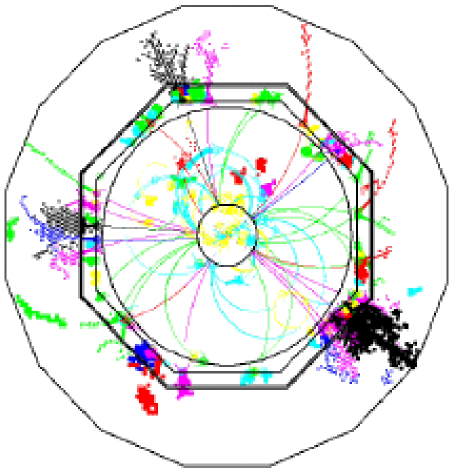
1x1



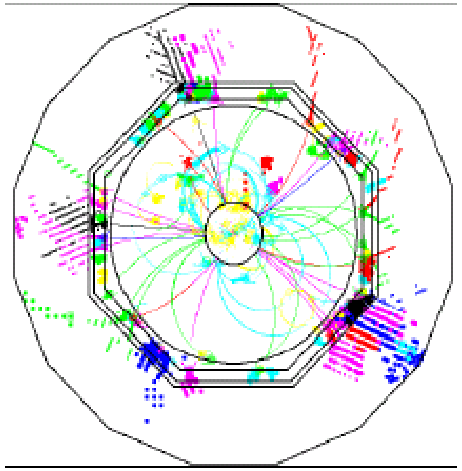
3x3



5x5



10x10



HCAL cell	Z peak	Ttbar (500)
1x1	31.4+-0.3%	42+-1%
3x3	30.6+-0.3%	45+-1%
5x5	31.1+-0.3%	48+-1%
10x10	33.7+-0.3%	56+-1%

Visible energy resolution

10x10 clearly worse, gain when going from 5x5 to 1x1 less obvious

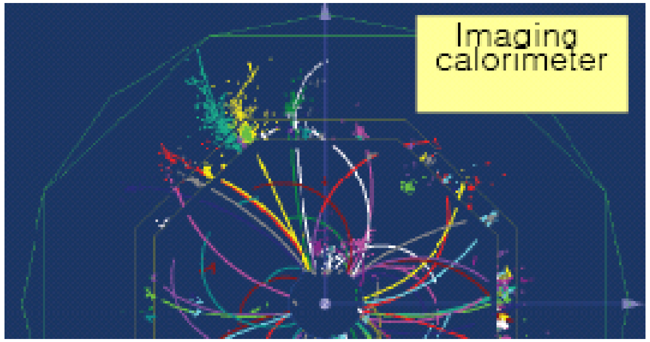
Ties Behnke's talk

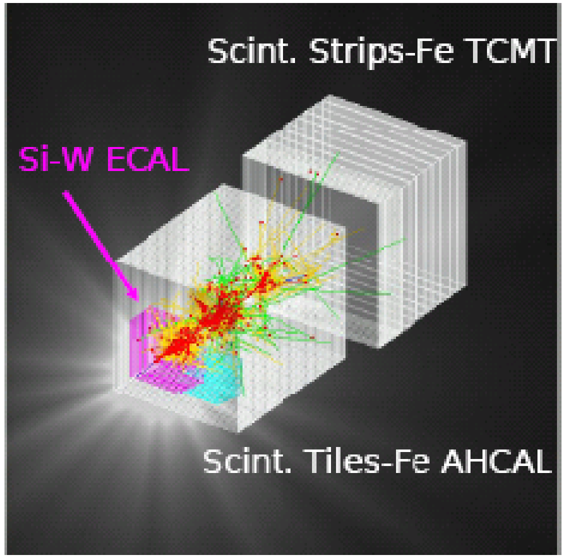
ILC Software Test in CALICE

The Calice Mission

Final goal:

A highly granular calorimeter optimised for the Particle Flow measurement of multi-jets final state at the International Linear Collider





Intermediate task:

Build prototype calorimeters to

- Establish the technology
- Collect hadronic showers data

with unprecedented granularity to

- tune clustering algorithms
- validate existing MC models

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Roman Pöschl's talk

Time is short for preparation