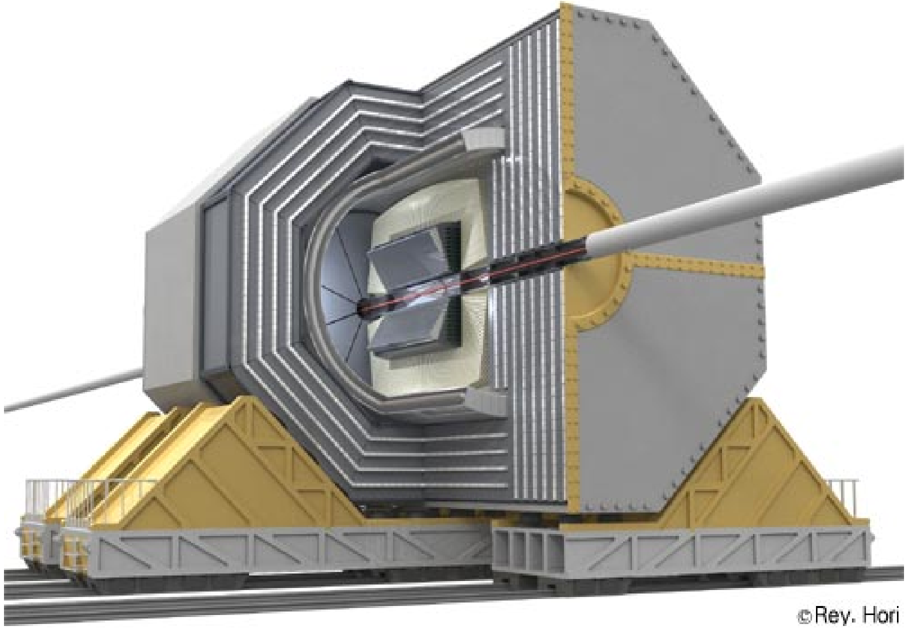
The GLD Concept : Introduction

Mark Thomson
University of Cambridge



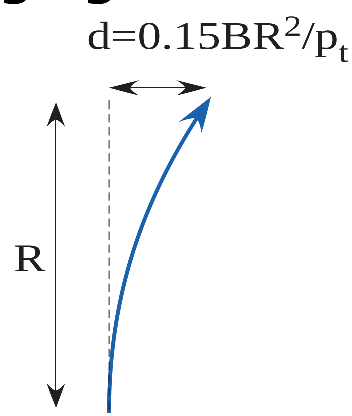
This Talk:

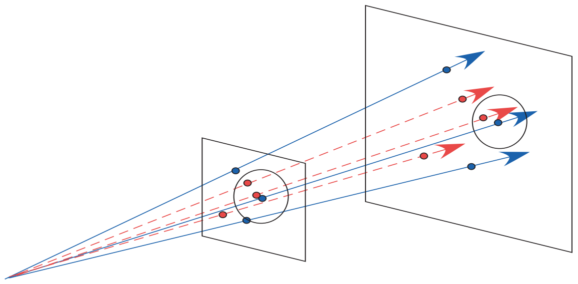
❶ Basic Philosophy
❷ Detector Overview
❸ Tracking
❹ Calorimetry
❺ Software and PFA

➊ Philosophy

General consensus that Calorimetry and PFA drives overall ILC detector design

- ★ **Large detector – spatially separate particles**
- ★ **High B-field – separate charged/neutrals ?**
- ★ **High granularity ECAL/HCAL – resolve particles**





Often quoted "figure-of-merit": $\frac{BR^2}{\sigma}$

- BR^2 ← **Separation of charge/neutrals**
- σ ← **Calorimeter granularity/$R_{Moliere}$**

- ★ **Physics argues for : large + high granularity + ⇧ B**
- ★ **Cost considerations: small + lower granularity + ⇩ B**

GLD Concept : investigate the large detector/slightly lower granularity phase-space

Why PFA suggests "Big is Beautiful"

<u>Comment : on useful (?) Figure of Merit:</u>

★ Often quoted F.O.M. for jet energy resolution:

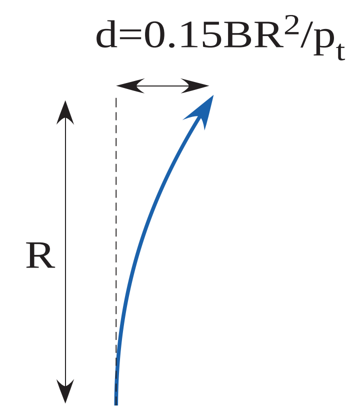
BR^2/σ $(R=R_{ECAL};\ \sigma$ = 1D resolution)

i.e. transverse displacement of tracks/"granularity"

★ Does this work ?

- compare **OPAL/ALEPH** (W→qq no kinematic fit)

	BR^2	BR^2/σ	$\sigma_E/\sqrt{E}$	R^2/σ
OPAL	2.6 Tm^2	26 Tm	0.9	60 m
ALEPH	5.1 Tm^2	170 Tm	0.6	110 m



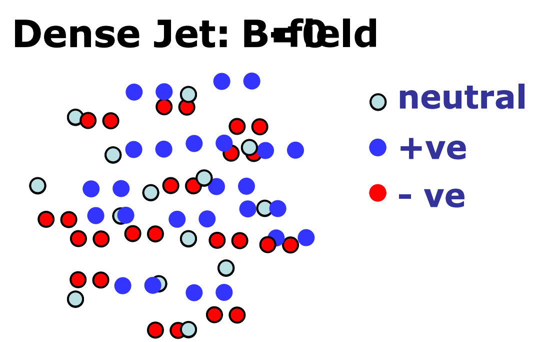
★ **No !** Things aren't that simple....

guess for FoM: R^2/σ

★ B-field spreads out energy deposits from charged particles in jet – not separating collinear particles

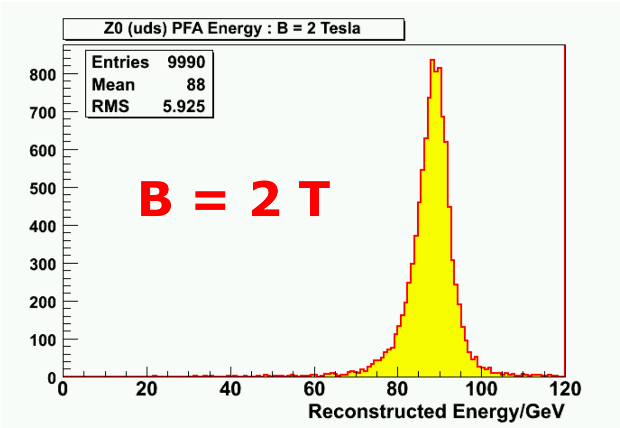
★ Size more important - spreads out energy deposits from all particles

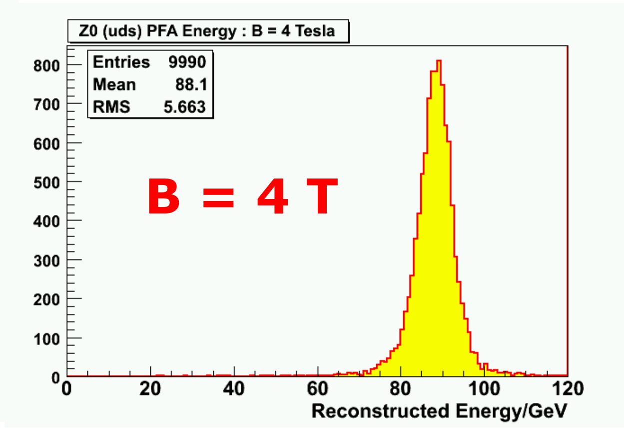
★ R more important than B

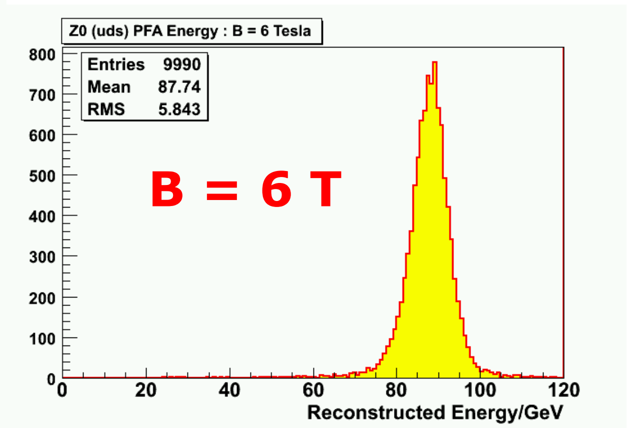


e.g. LDC Results

(e.g. see results from yesterday's Detector Performance session)







- **RMS of Central 90 % of Events**

B-Field	$\sigma_E/E = \alpha\sqrt{(E/GeV)}$
2 Tesla	35.3±0.3%
4 Tesla	35.8±0.3 %
6 Tesla	37.0±0.3 %

- **here performance depends only weakly on B**
- **maybe "size more important than B ⟶ GLD**

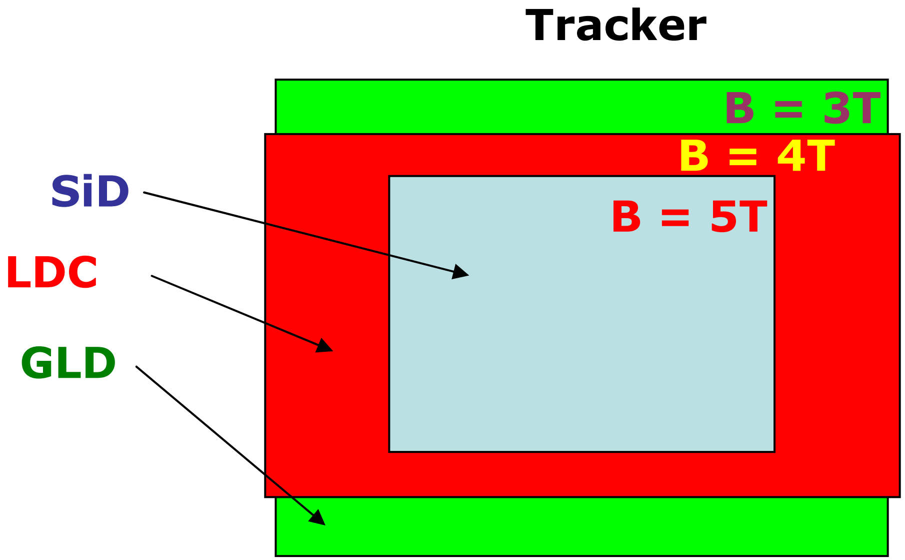
❷The GLD Concept

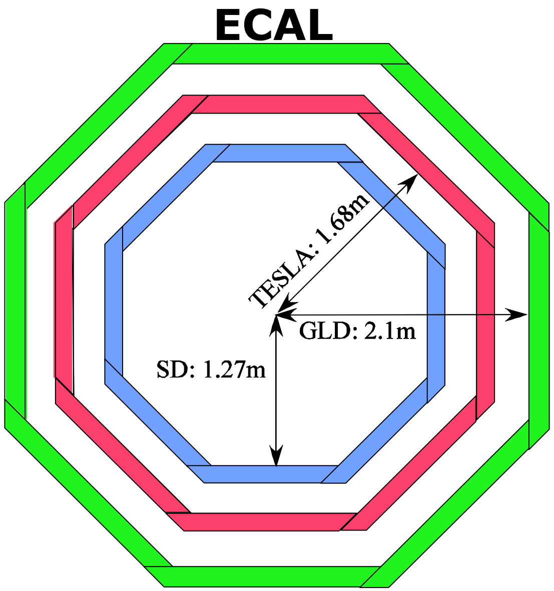
What is the Global Large Detector concept ?

- **SIZE : quite large (larger than SiD/LDC)**

Compare:

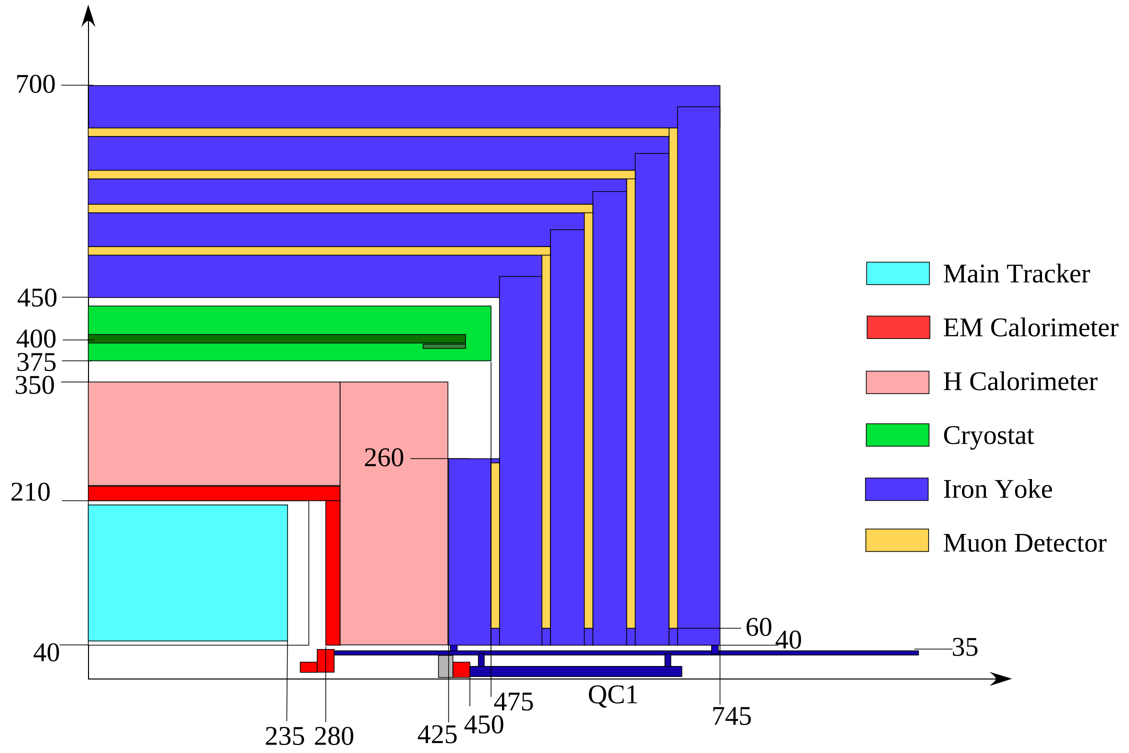
- ★**Small Detector : SiD**
- ★**Large Detector: e.g. LDC (Tesla TDR)**
- ★**Huge/Truly Large Detector: GLD**





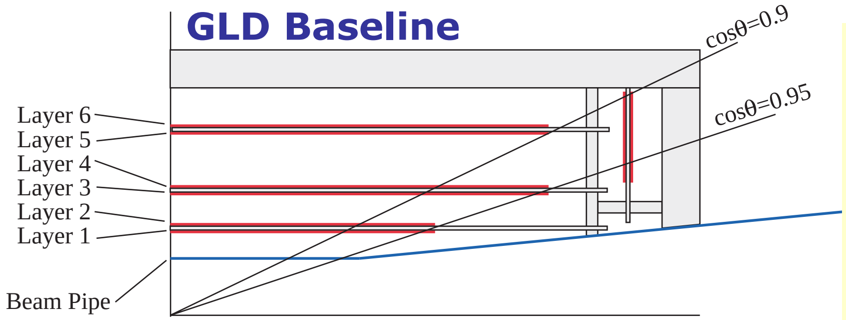
General Features of GLD Concept

- ★ "Large" gaseous central time projection chamber (TPC)
- ★ "Medium/High" granularity ECAL : W-Scintillator
- ★ "Medium/High" granularity HCAL : Pb-Scint (inside solenoid)
- ★ Precision microvertex detector (first layer fairly close to IP)
- ★ "Moderate" B-field : 3 Tesla



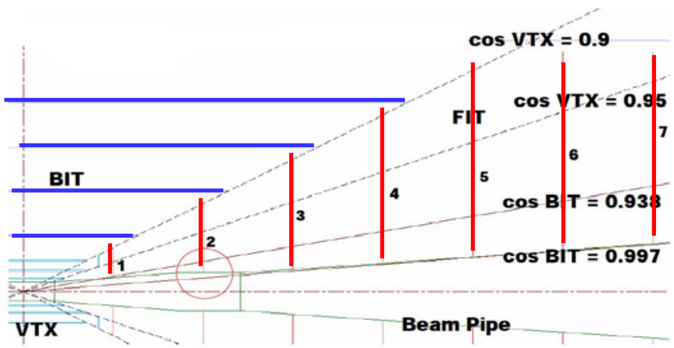
Tracking : VTX + IT + TPC

VTX



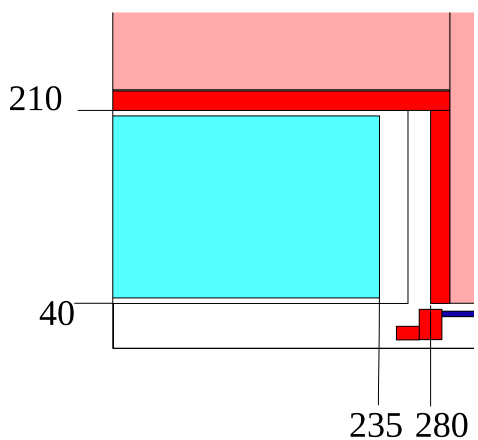
- ★ Fine pixel CCDs (FPCCDs)
- ★ Point resolution : 5 μm
- ★ Readout entire Bunch Train
- ★ Double layer structure
- ★ Inner radius : 20 mm
- ★ Outer radius : 50 mm

IT



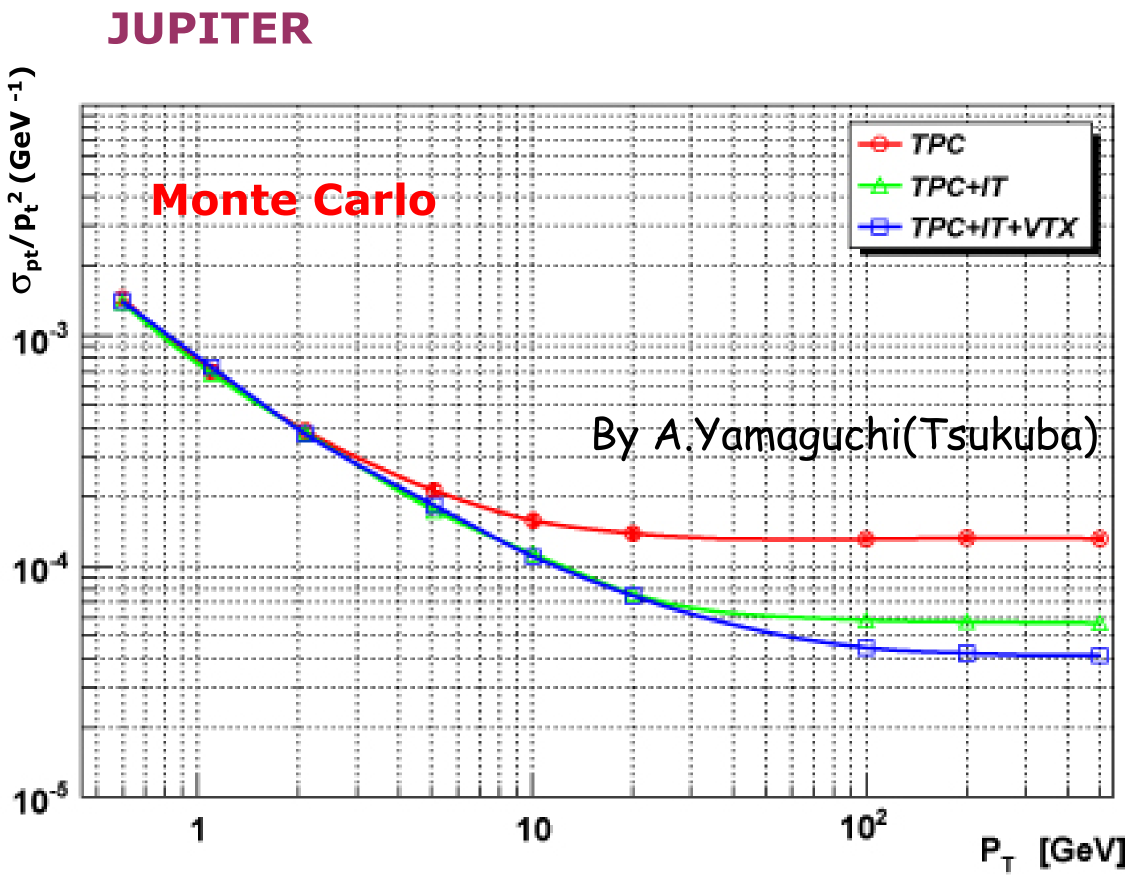
- ★ Barrel IT (BIT)
  - ★ 4 layers Si
- ★ Forward IT (FIT)
  - ★ 7 Si discs

TPC



- ★ Inner radius: 40 cm
- ★ Outer radius: 200 cm
- ★ Half-length : 235 cm
- ★ Readout : 200 radial rings

GLD Tracking Performance

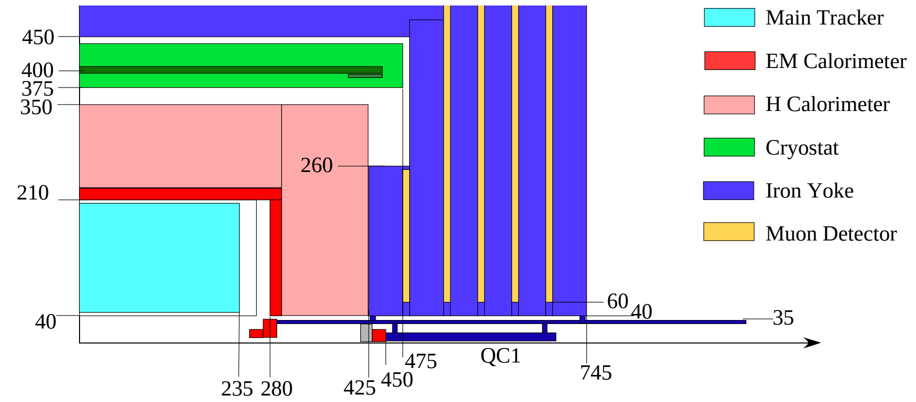


- **GLD conceptual design (barrel) achieves goal of :**

$$\sigma_{p_T}/p_T < 5\times10^{-5}\, p_T$$

Calorimeter Concept

★ **ECAL and HCAL inside coil**

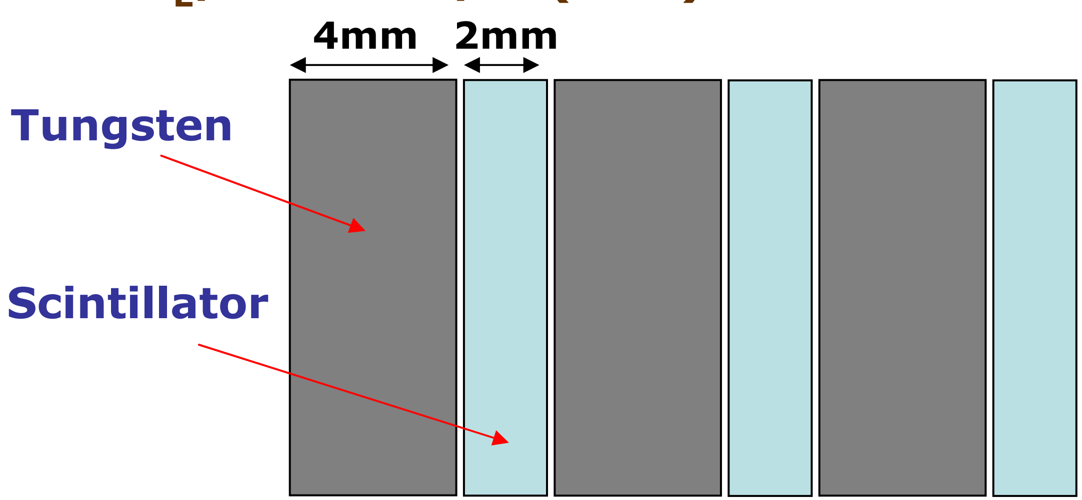


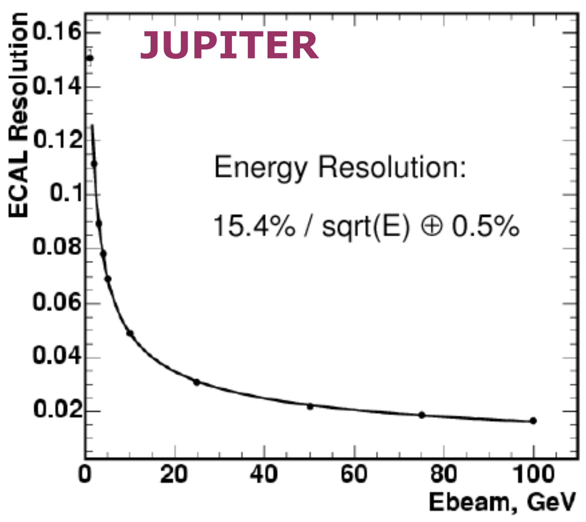
ECAL:

Longitudinal segmentation: 39 layers (~25 X_0; ~1 λ_I)

Achieves Good Energy Resolution:

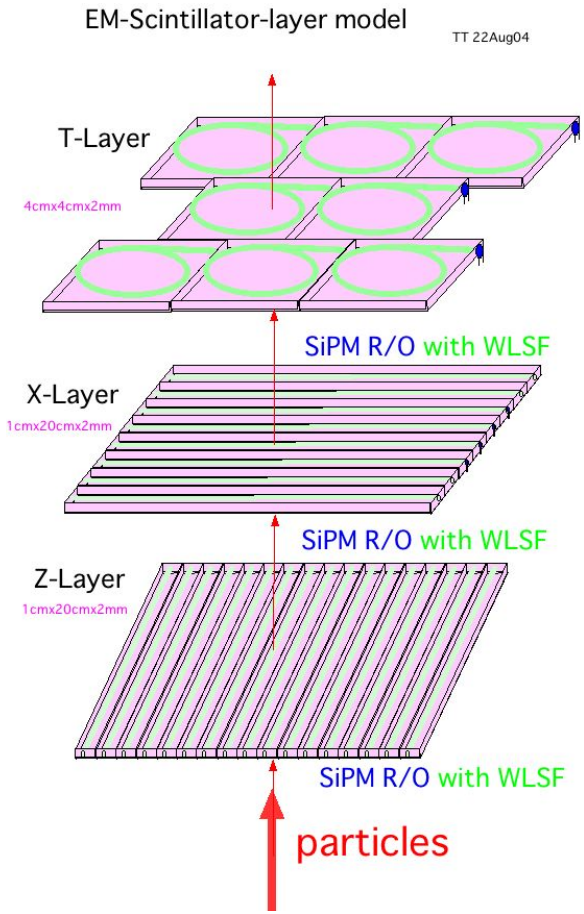
$$\sigma_E/E = 0.15/\sqrt{E(\mathrm{GeV})} \oplus 0.01$$





ECAL Structure

- $R_{Moliere}$ ~ 9mm for solid tungsten
  + scintillator layers increase effective $R_{Moliere}$ ~ 15 mm



GLD ECAL concept:

★ Achieve effective ~1 cm x 1cm segmentation using strip/tile arrangement

★ Strips : 1cm x 20cm x 2mm

★ Tiles : 4cm x 4cm x 2mm

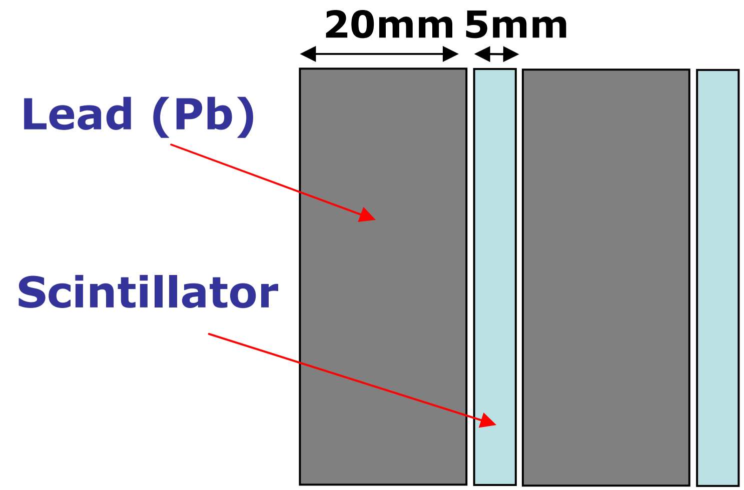
★ **Ultimate design needs to be optimised for particle flow performance**

+ question of pattern recognition in dense environment

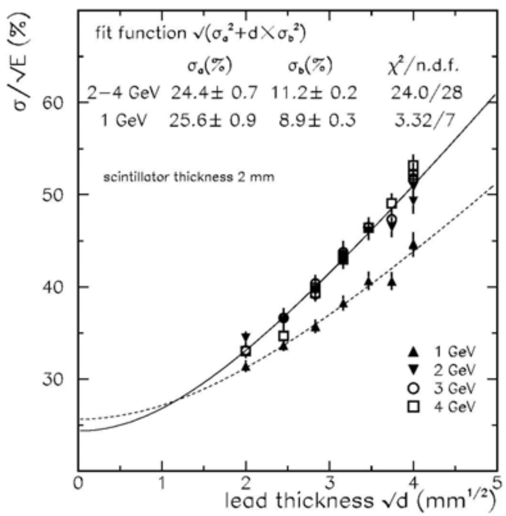
Hadron Calorimeter

Current Baseline Design:

- ★ Pb-Scintillator sampling calorimeter
- ★ Approximate hardware compensation
- ★ 51 layers (~6 λ_I)
- ★ Structure and readout same as ECAL
- ★ Needs to be optimised for PFA

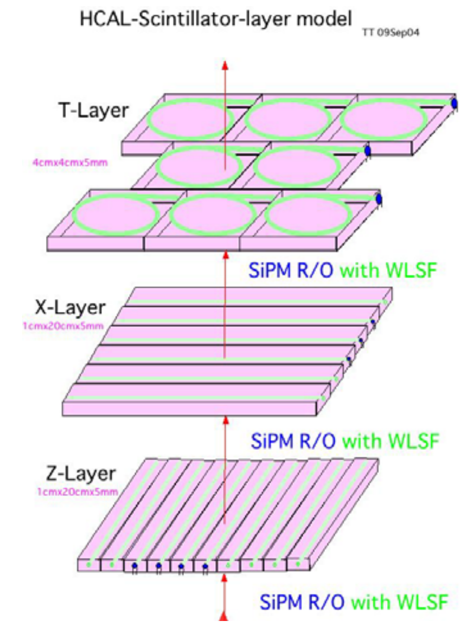


Performance:

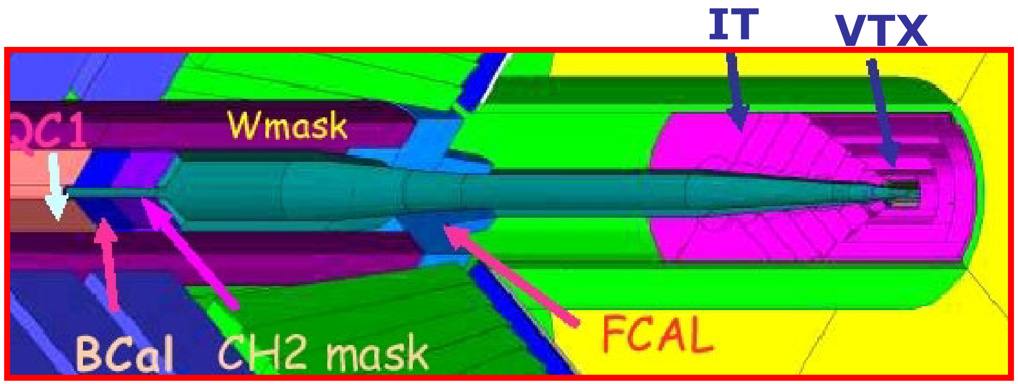


Test beam data

$\sigma_E/E \sim 0.55/\sqrt{E(\text{GeV})}$



Forward Calorimeters

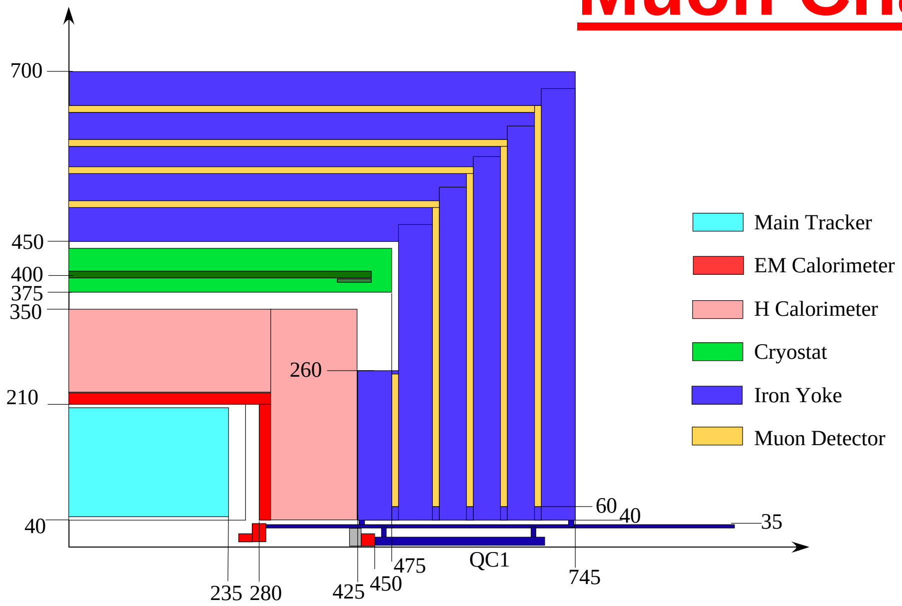


✦SiW for lumimosity cal

✦Radiation harndness for "far forward" calo

Final design MDI issue

Muon Chambers

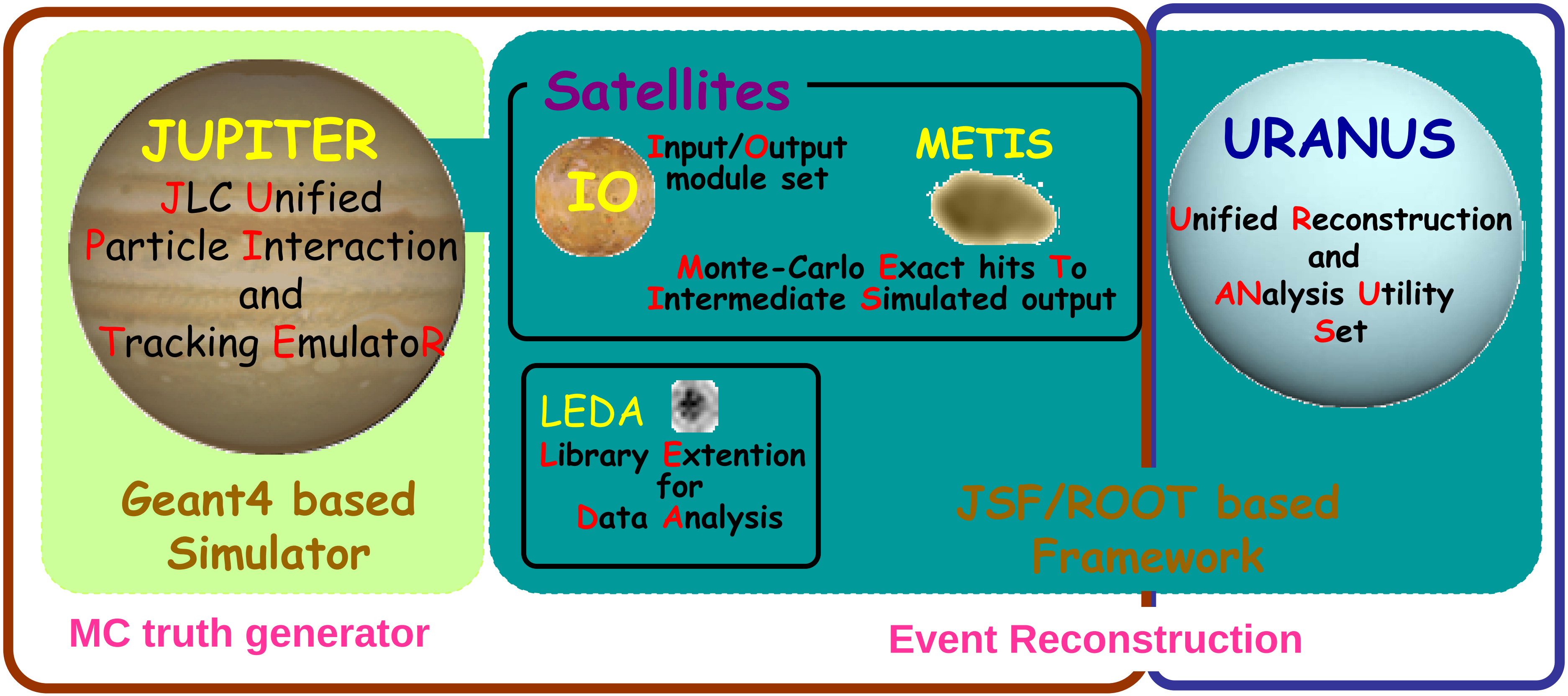


★Integrated into return yoke

★Possible technology: Scintillator strips

Software and PFA

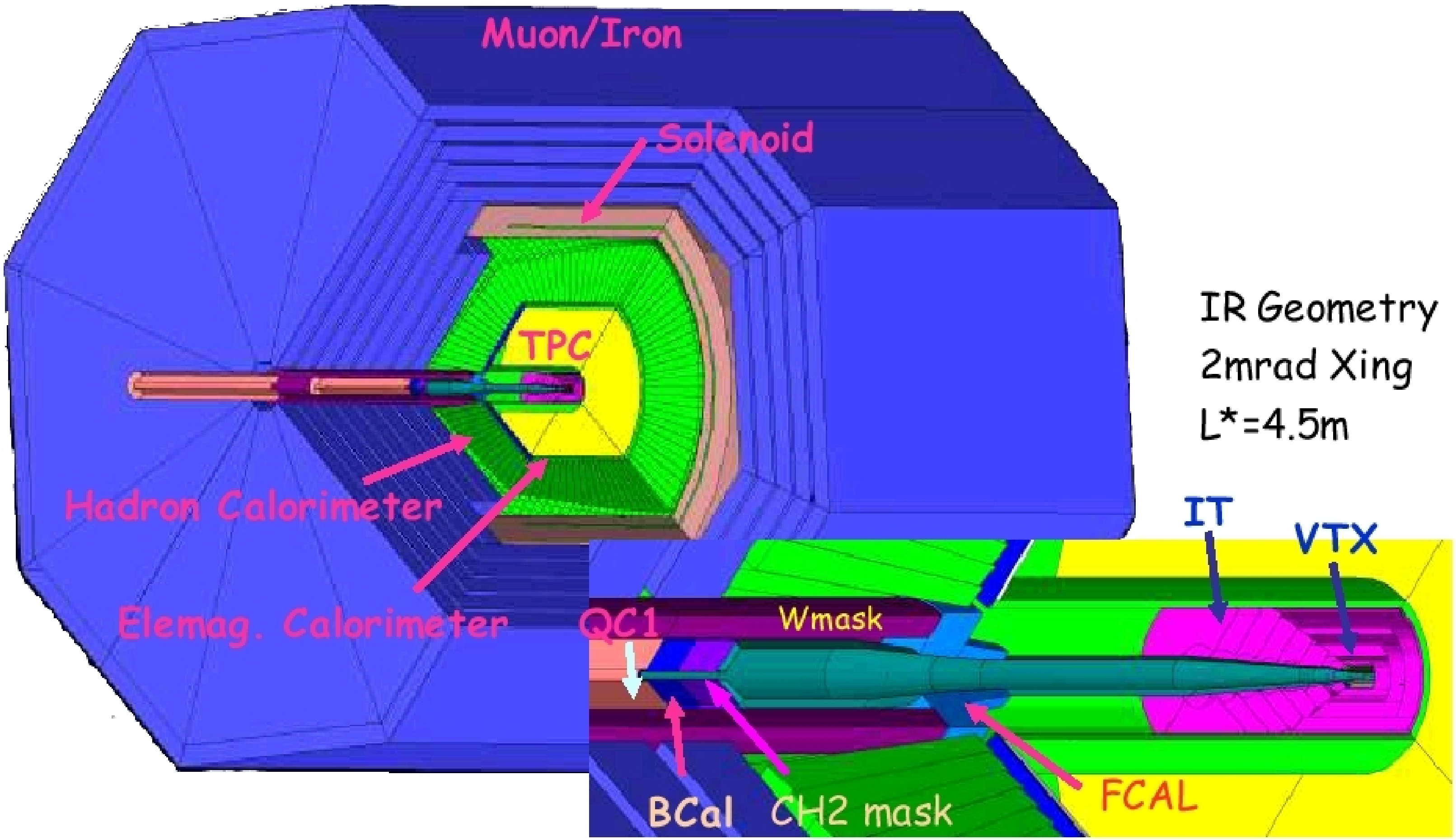
★Well developed simulation and analysis tools



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

Geometry in Jupiter

- ★All studies to date use old tower structure for ECAL/HCAL
  - ★ ECAL : 4x4 cm scintillator tiles
  - ★ HCAL : 12x12 cm scintillator tiles



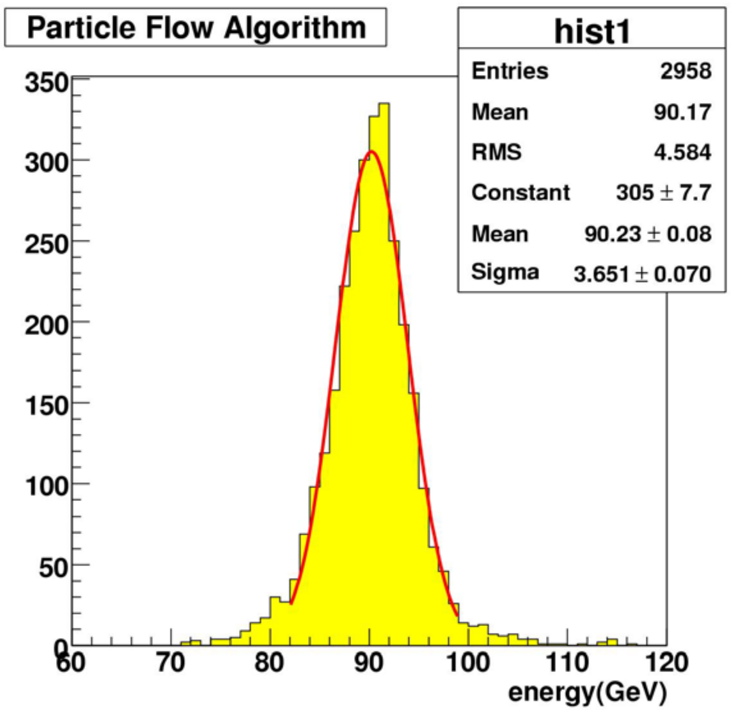
Software Interfaces

- ★ **Detector Geometry**
  - **Defined through an ASCII file**
  - **Geometry data passed to Satellites in ROOT data**
- ★ **Generators**
  - ★ **Beam backgrounds**
    - **CAIN → ASCII file**
    - **LCBDS → StdHep ASCII file**
  - ★ **Physics events**
    - **Pythia and Bases generators implemented as a JSF module**
    - **Interface to StdHep data is provided as a JSF module → ASCII , Binary (with some limitation)**
- ★ **Simulation**
  - **The standard output format is ROOT**
  - **A JSF module outputs simulated hits using the LCIO format**

Current Performance of GLD-PFA

★ **Various tools implemented since Snowmass:**

- MIP finding
- Small photon finding based on TOF information
- Shower length cut for photon clusters
- Treatment of satellite hits



Efficiency and Purity (Energy Weighted)
- Charged Hadron finding
  Eff = 94.9%, Purity = 89.9%
- Gamma Finding
  Eff = 85.2%, Purity = 92.2%

Bottom Line:

★ $\sigma_E/E = 38\ \% / \sqrt{E}$

★ Very Encouraging performance (workers should be congratulated) + plenty of room for improvement

Caveats:

★ "Barrel events", cheated track finding (not fitting)

★ based on old ECAL/HCAL Tower structure

Summary/Organisation

Summary:

- **PFA** argues for as large a detector as possible
- **GLD** concept is a viable large detector design
- Performance looks promising

Information/Organisation:

- Web : http://ilcphys.kek.jp/gld/index.html
- Fortnightly phone/video meeting
  (Almost) always interesting
  Convenient time for Europe (0800 CET)
- GLD Software page:
  http://ilcphys.kek.jp/soft/index.html

Detector Outline Document Kickoff Meeting:

- Currently working towards Detector Outline Document
- Kickoff Meeting at KEK: 30th November – 2nd December
- Phone/Video participation

GLD concept developing rapidly – new involvement always welcome !

Addendum : Detailed Software information

- **GLD software tools are maintained in CVS server,jlccvs.kek.jp.**
- **At http://jlccvs.kek.jp/,**
  - **Description about how to download latest version.**
  - **Web interface to the CVS repository,**
    - **http://jlccvs.kek.jp/cgi-bin/cvsweb.cgi/**
  - **Snap shot of source codes.**
    - **http://jlccvs.kek.jp/snapshots/**
- **SimTools: binary codes of our tools**
  - **Web page: http://acfahep.kek.jp/subg/sim/simtools/index.html**
  - **Examples and documents are prepared.**
- **GLD Software page:**
  - **http://ilcphys.kek.jp/soft/index.html**