The GLD Concept: Introduction

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This Talk:
1. Basic Philosophy
2. Detector Overview
3. Tracking
4. Calorimetry
5. Software and PFA
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

\[ d = 0.15BR^2/p_t \]

Often quoted “figure-of-merit”: \( BR^2/\sigma \)

- **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”

Comment: on useful (?) Figure of Merit:

- Often quoted F.O.M. for jet energy resolution: \(BR^2/\sigma\) (\(R=R_{E\text{CAL}}; \sigma = 1\text{D resolution}\))
  - i.e. transverse displacement of tracks/“granularity”
- Does this work?
  - compare OPAL/ALEPH (\(W\rightarrow qq\) no kinematic fit)

<table>
<thead>
<tr>
<th></th>
<th>BR(^2)</th>
<th>BR(^2/\sigma)</th>
<th>(\sigma_E/\sqrt{E})</th>
<th>(R^2/\sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPAL</td>
<td>2.6 Tm(^2)</td>
<td>26 Tm</td>
<td>0.9</td>
<td>60 m</td>
</tr>
<tr>
<td>ALEPH</td>
<td>5.1 Tm(^2)</td>
<td>170 Tm</td>
<td>0.6</td>
<td>110 m</td>
</tr>
</tbody>
</table>

- No! Things aren’t that simple....

  **guess for FoM: \(R^2/\sigma\)**

- 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 \(B\)

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e.g. LDC Results

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

![Graphs showing energy distribution for different magnetic fields](image)

**RMS of Central 90% of Events**

<table>
<thead>
<tr>
<th>B-Field</th>
<th>$\sigma_E/E = \alpha \sqrt{(E/\text{GeV})}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Tesla</td>
<td>35.3±0.3%</td>
</tr>
<tr>
<td>4 Tesla</td>
<td>35.8±0.3%</td>
</tr>
<tr>
<td>6 Tesla</td>
<td>37.0±0.3%</td>
</tr>
</tbody>
</table>

 Luz here performance depends only weakly on B

✿ maybe “size more important than $B$ GLD

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The 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

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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**
- GLD Baseline
- Layer 6
- Layer 5
- Layer 4
- Layer 3
- Layer 2
- Layer 1
- Beam Pipe

**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

- Fine pixel CCDs (FPCCDs)
- Point resolution: 5 \( \mu \)m
- Readout entire Bunch Train
- Double layer structure
- Inner radius: 20 mm
- Outer radius: 50 mm
GLD Tracking Performance

JUPITER

Monte Carlo

- GLD conceptual design (barrel) achieves goal of:

\[ \sigma_{p_T}/p_T < 5 \times 10^{-5} \ p_T \]
Calorimeter Concept

★ ECAL and HCAL inside coil

ECAL:

Longitudinal segmentation: 39 layers \((\sim 25 \times_0; \sim 1 \lambda_I)\)
Achieves Good Energy Resolution:

\[ \frac{\sigma_E}{E} = 0.15/\sqrt{E(\text{GeV})} \oplus 0.01 \]

![Diagram showing ECAL structure with Tungsten and Scintillator layers]

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ECAL Structure

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

GLD ECAL concept:
- ★ Achieve effective $\sim 1\text{cm} \times 1\text{cm}$ segmentation using strip/tile arrangement
- ★ Strips: $1\text{cm} \times 20\text{cm} \times 2\text{mm}$
- ★ Tiles: $4\text{cm} \times 4\text{cm} \times 2\text{mm}$
- ★ 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 \( \lambda_I \))
★ Structure and readout same as ECAL
★ Needs to be optimised for PFA

Performance:

\[ \sigma_E/E \sim 0.55/\sqrt{E(\text{GeV})} \]
Forward Calorimeters

- SiW for luminosity cal
- Radiation hardness 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

- **JUPITER**: JLC Unified Particle Interaction and Tracking Emulator
  - Geant4 based Simulator
  - MC truth generator

- **Satellites**
  - Input/Output module set
  - LEDA: Library Extension for Data Analysis

- **METIS**
  - Monte-Carlo Exact hits To Intermediate Simulated output

- **URANUS**
  - Unified Reconstruction and ANalysis Utility Set

**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:
★ 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:
★ Fortnightly phone/video meeting
  (Almost) always interesting
  Convenient time for Europe (0800 CET)
★ GLD Software page:

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
  - Examples and documents are prepared.
- GLD Software page: