



Particle Identification for a Linear Collider Detector

How do we decide what we need?

Linear Collider Detector Workshop

University of Michigan

March 27th. 1999

PID in Europe & Japan studies?

✓ Chris Damerell:

- “The European regional workshop has just ended, with no work done on particle ID.”
- “My understanding is that the Japanese (like the Europeans) have not yet done anything on this.”

✓ PID has dropped below the event horizon in physics studies and overall detector optimisation.

✓ Are they right?

Keystone PID Summary

Hitoshi outlined two philosophies:

A Identify physics requiring PID.

B Plan for PID, if it is there we will use it.

In practice : $\Psi = \alpha \mathbf{A} + \beta \mathbf{B}$

In a perfect world: $\alpha \approx 1, \beta \approx 0$

Hitoshi's summary $\Rightarrow \alpha \gg \beta$

Experience indicates uses for PID that we will not think of until we have data. Or at least, not for quite a while yet. $\Rightarrow \alpha \approx \beta$

What does this mean in practice?

- ✓ We *do* need to keep searching for specific examples to justify PID explicitly
 - we may even find a “golden” mode
- ✓ The PID “group” is so small that we could not possibly cover the phase space of LC physics, thoroughly and in reasonable time.
- ✓ The existing physics groups should be primed to ask PID questions.

What should the PID group do?

- ✓ Select a few particularly promising topics to give practical examples.
- ✓ Provide the physics groups with guidelines on *plausible* PID capabilities.
- ✓ PID class for simulation/reconstruction.

Promising topics for PID

- ✓ Strange, charm, bottom tagging

$$e^+e^- \rightarrow t\bar{t} \rightarrow W^+bW^-\bar{b}$$

$$e^+e^- \rightarrow HA \rightarrow bbbb, bb\tau\tau$$

$$W^+ \rightarrow c\bar{s} \quad \text{above} \quad u\bar{d}$$

$$t \rightarrow W^+\bar{s}, \quad \Rightarrow V_{ts}$$

Asymmetries

- ✓ Multi-jet analysis - net flavor?
- ✓ Your favorite process here!

PID Technology Review

- ✓ What do we get for “free” i.e. from the required sub-systems?
 - e, μ , h from calorimetry
 - e, μ , π , K, p from tracker (dE/dx)

- ✓ What *could* we get from a PID subsystem?
 - Transition Radiation Detector
 - Scintillator Time-of-flight
 - Threshold Cerenkov
 - Ring imaging Cerenkov

PID Sub-system impact?

- ✓ Material in front of the calorimeter
 - How much is tolerable? What is the spec.?
- ✓ Calorimeter \$ vs. inner radius
- ✓ Track resolution (BL^2)
- ✓ The goal is the best LC physics
 - ⇒ coherent design optimization of all sub-systems together

Example: Cerenkov Ring Imaging

✓ Basic formulae: $\cos \theta = \frac{1}{\beta n} \Rightarrow p = \beta \gamma m$

$$N_\gamma = N_0 L z^2 \sin^2 \theta \quad \gamma_{threshold} = \left(1 - \frac{1}{n^2}\right)^{-1/2}$$

✓ In practice need $\langle N_\gamma \rangle \approx 10$

✓ DIRC -- the most compact Cerenkov option

– quartz radiator, $n=1.474$, $L=1.8\text{cm}$

$$\beta_{threshold} = 0.68, \gamma_{threshold} = 1.36 \Rightarrow p_{threshold} = 0.92 m_{\mu, \pi, K, p}$$

$$N_\gamma (\beta \approx 1, \text{normal}, \text{pmt}) \approx 30$$

Angular resolution & PID

- ✓ Maximum momentum for separation by n_σ standard deviations

$$p_{\max} = \left(\frac{\beta^2 \Delta m^2 \beta_t \gamma_t N_\gamma^{1/2}}{2n_\sigma \sigma_\theta} \right)^{1/2}$$

- ✓ For 3σ π -K separation in 18 mm quartz

$$p_{\max} = \frac{0.14}{\sigma_\theta^{1/2}} N_\gamma^{1/4}$$

- ✓ About 4 GeV/c for BaBar-DIRC
 - double radiator thickness \Rightarrow 20% increase
 - 1/2 resolution \Rightarrow 40% increase

PID R&D proposals pending

- ✓ H. Yamamoto: Identify specific processes -
 - Heavy, long-lived, charged particles (c.f. Fermilab workshop)
 - Other SUSY? Other?

- ✓ RJW: Detector capabilities review + specific process -
 - Top studies - discrimination from WW, new physics, $t \rightarrow Ws$, polarization? (cf M.Peskin)
 - Flavor asymmetries: $A_{s,c,b}$?
 - B tag, à la B-factories - Higgs studies?