Overview of the American Detector Models

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April 29, 1999

The American study groups have investigated
two specific models

- Choosing any particular detector design is a compromise between competing constraints
  Example:
  1. large tracking volume desirable to optimize tracking resolution
  2. small tracking volume minimizes the volume of the electromagnetic calorimeter
     -> allows aggressive EM calorimeter option

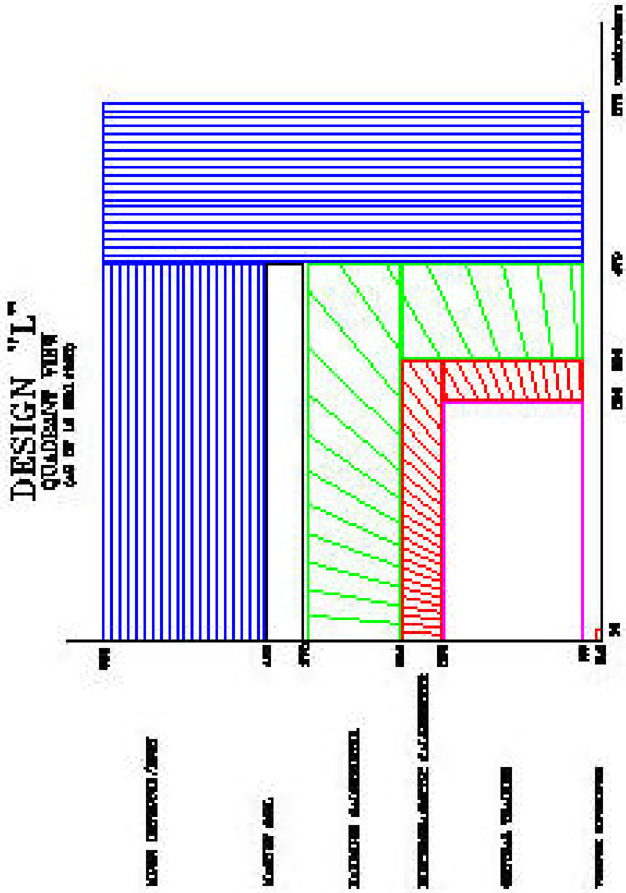
- investigated the <u>two</u> detector models

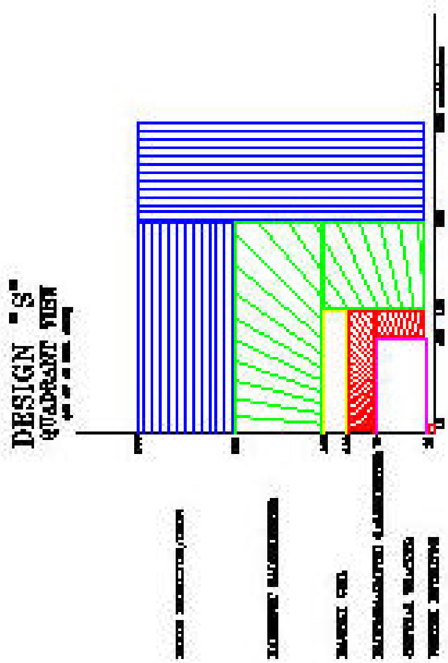
  without prejudice
  to understand trade-offs in performance
  to consider feasibility and identify R&D needs

- The Models were selected to test two different choices for detector configuration:

1. Model L
    - large detector
    - large tracking volume
        - -> optimal tracking resolution
    - large radius calorimeter
        - -> optimal separation of calorimeter clusters
    - size limits magnetic field
        - -> limits vertex detector inner radius due to pairs

2. Model S
    - small detector
    - small radius detector
        - -> allows largest magnetic field
    - small radius calorimeter
        - -> allows aggressive calorimeter options
            - high granularity EM (Si/W)
    - large magnetic field
        - -> allowing e^- pair containment and close vertex detector





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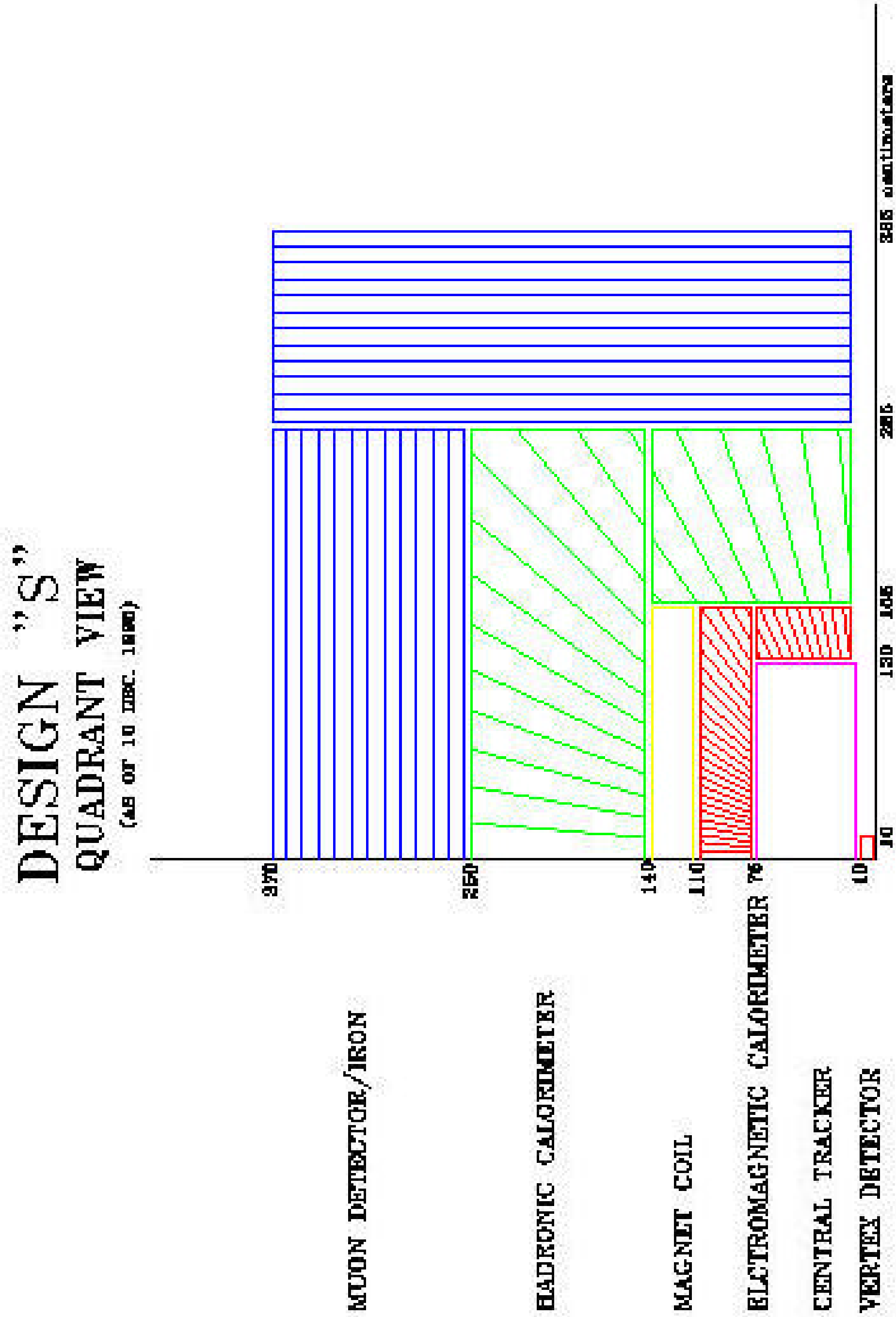

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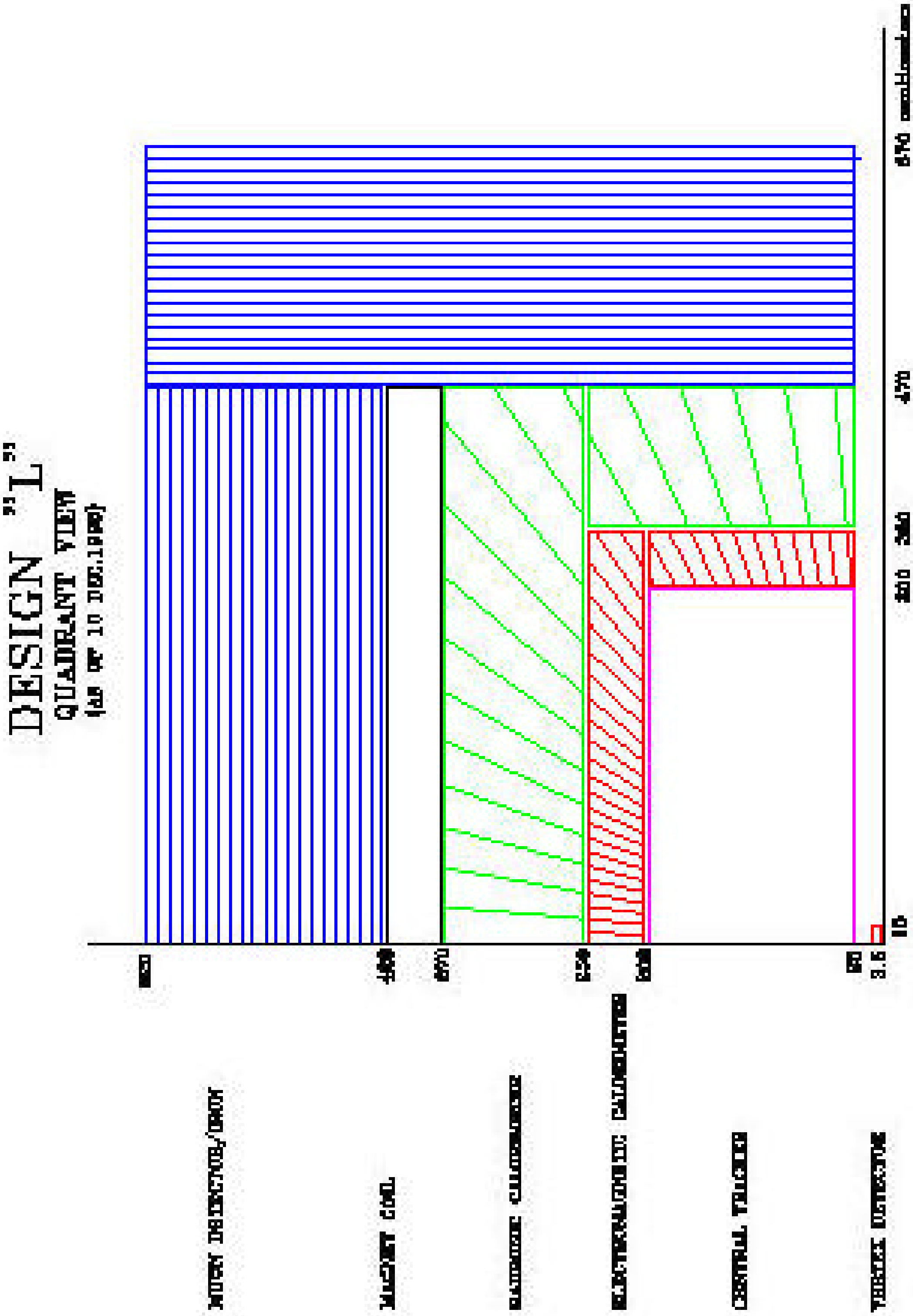

DESIGN "L"
QUADRANT VIEW

Expected level of performance for the two configurations:

Vertex Detector

both detectors assume 5 barrel CCD (5 μm point res.),
with radius adjusted to match the two sizes

Model S

small radius outer detector allows largest
beam-pair constraining with B field
closest to IP (R= 1.2,2.4,3.6,4.8,6.0 cm)

Model L

larger area required for coverage
degraded performance due to more distant
inner layer (R= 2.5,4.4,6.3,8.1,10. cm)
but, is this large a detector feasible?

Vertex Detector Performance

Model S

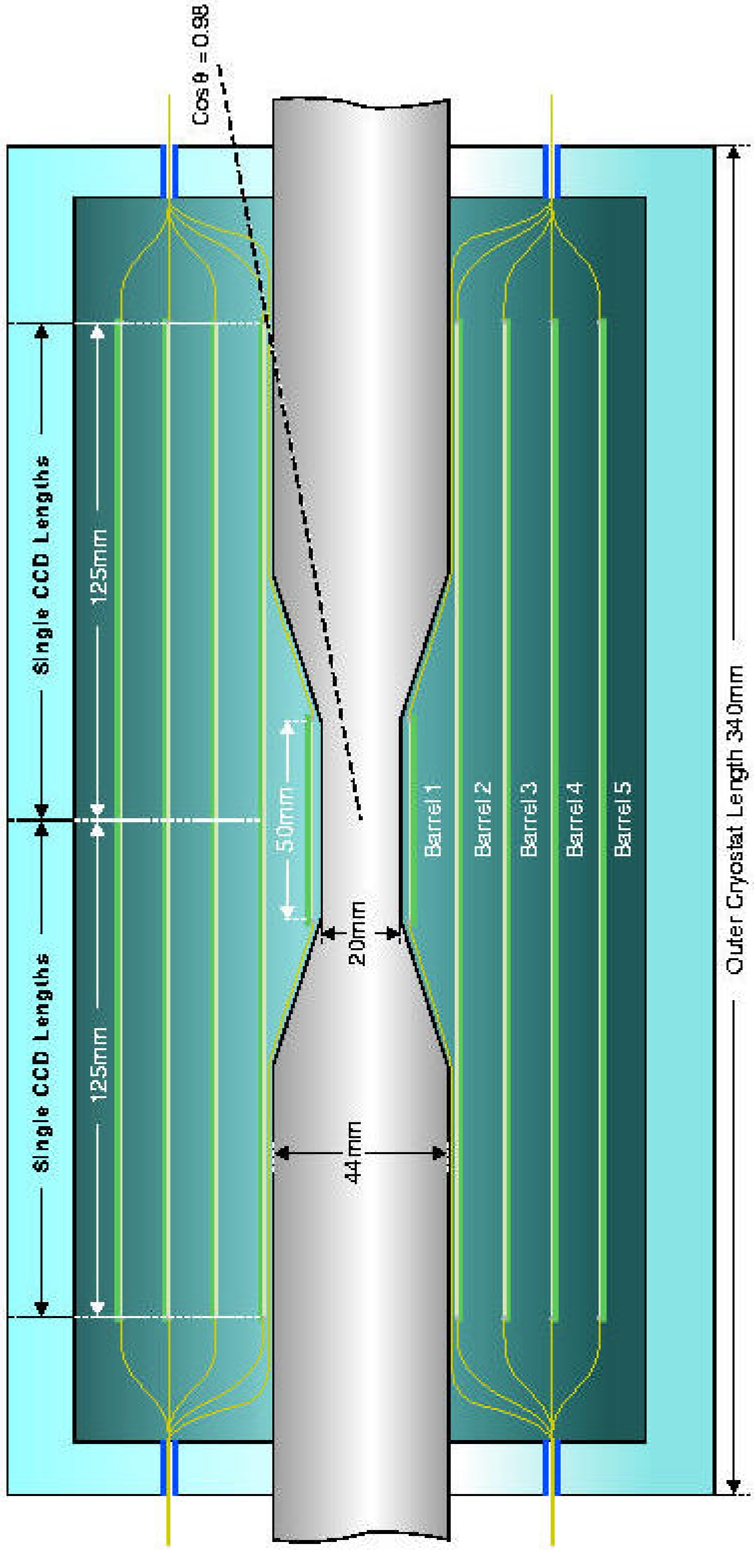
$\sigma_b = (3\ \mu m \oplus 10\ \mu m / p \sin^{3/2} \theta)$

Model L

$\sigma_b = (3.5\ \mu m \oplus 25\ \mu m / p \sin^{3/2} \theta)$

Both → stand-alone tracking

Suggested layout of Vertex Detector for future e^+e^- Linear Collider (Updated November 1998)



Tracking

Model L

- optimal resolution
  σ/BL^2
- large radius allows largest track length, leading to best resolution

Model S

- smaller tracking volume lead to choice of high precision measurements (silicon)
- but silicon has unavoidable larger material budget -> multiple scattering
- low momentum resolution compromised by multiple scattering

Tracking Performance

Model S

$\sigma_p / p = (6 \times 10^{-5}\, p \oplus 0.0022)$

silicon drift (3 double layers)

Model L

$\sigma_p / p = (5 \times 10^{-5}\, p \oplus 0.00065)$

TPC (144 points)

comment

high momentum performance similar,
but at low momentum, large multiple scattering
in Model S leads to significant loss of resolution
Forward Tracking – Model S – 5 layers (si strips)

Calorimeter

Model S

$\sigma_{EM} / E = (12\% / \sqrt{E}) \oplus (1\%)$

W/silicon pads (1.5×1.5 cm^2 pads)

High granularity!

29 X_0, readout 100 longitudinal (potential)

$\sigma_{Had} / E = (50\% / \sqrt{E}) \oplus (2\%)$

Cu/scintillator (40×40 mrad^2)

76 cm Cu

$l_{EM+Had} = 6.1\ \lambda$

Model L

$\sigma_{EM} / E = (15\% / \sqrt{E}) \oplus (1\%)$

Pb/scintillator (40 x 40 mrad^2)

28 X_0

$\sigma_{Had} / E = (40\% / \sqrt{E}) \oplus (2\%)$

Pb/scintillator (80 x 80 mrad^2)

$l_{EM+Had} = 6.6\ \lambda$

Muon detectors

Model S

10 × 10 cm Fe plates + gas

$\sigma_{r\theta}$ ≈ 1 cm (x 10) σ_z ≈ 1 cm (x 2)

Model L

24 × 5 cm Fe plates + RPCs

$\sigma_{r\theta}$ ≈ 1 cm (x 24) σ_z ≈ 1 cm (x 4)

coverage to ~ 50 mrad

Magnetic Coil

Model S 6 Tesla (~1/2 λ)

between EM and Hadronic calorimeter

Model L 3 Tesla (~1 λ)

outside Hadronic calorimeter

Luminosity Monitor

Si/W

Hermeticity

>99%

Some Trade-offs Needing Further Study

Vertex Detection

R_{inner} => how important?
thickness => 0.12 % X_0 vs. 0.3 - 0.4 % X_0
we want excellent multiple vertex reconstruction
(cascades, eg $H \to b \to c$ vs. $H \to c$)

Tracking

low momentum tracks
=> resolution (multiple scatt.) and efficiency
eg. $e^+e^- \to e^+e^- \to e^+e^- X$
effect of tracking resolution on flavor tagging

Calorimetry

"energy flow" jets vs. calorimeter jet clustering?
(energy flow = tracking + EM cal + neut.had.)
how small can R be and still untangle neutrals?
W/Z reconstruction
non-pointing gammas
eg. $\tilde{c} \to \tilde{g}g$

Conclusion

The American study groups have defined two un-like detectors
to explore trade-offs in performance:

Model L
- large detector
- large tracking volume => optimal resolution
- large radius calorimeter => cluster separation
- B field = 3 T

Model S
- small detector
- small radius calorimeter => aggressive EM
- large magnetic field = 6 T
  - good for vertexing and shower separation

Trade-offs are being studied and some results will be presented here at Sitges.