Linear Collider Tracking Issues

Keith Riles

University of Michigan

Linear Collider Detector Group Meeting

August 8, 2000

Preface

My former perspective:

- Tracking group should first find reasonably optimum baseline choice(s) for LCD central tracker based on physics goals and detailed simulations
  (within global constraints, including S and L architectures)
- R & D on specific designs and technologies to follow

Implicit assumptions:

- Linear collider will be built (somewhere)
- Essential physics case has been made
  using 4-vector analyses (smeared or not)
- Tracking group's initial goals:
  - Verify that feasible trackers don't unduly degrade physics sensitivity estimated from 4-vector studies.
  - Optimize trackers using realistic simulation & analysis (reconstruction without cheating)
- Available manpower sufficient for these studies

Preface

Now I'm not so sanguine...

- U.S. community not convinced physics case *has* been made
- Only handful of persons doing cheat-free analysis
- Even with extra DOE / NSF funding, groups have had trouble hiring "half-postdocs" (HPD's)
  Tracking group situation: of four approved HPD's...
  - One working since Nov 1999 (Walkowiak - UCSC)
  - One starting Aug 15, 2000 (Yang - Michigan)
  - Two positions unfilled (Indiana, Wayne State)

  $\Longrightarrow$ Manpower for tracking studies has been / is limited
- Fermilab meeting approaching rapidly
- Snowmass '01 not that far away

Preface

Time for triage?

I'm not sure...

Will present wish lists from old perspective:

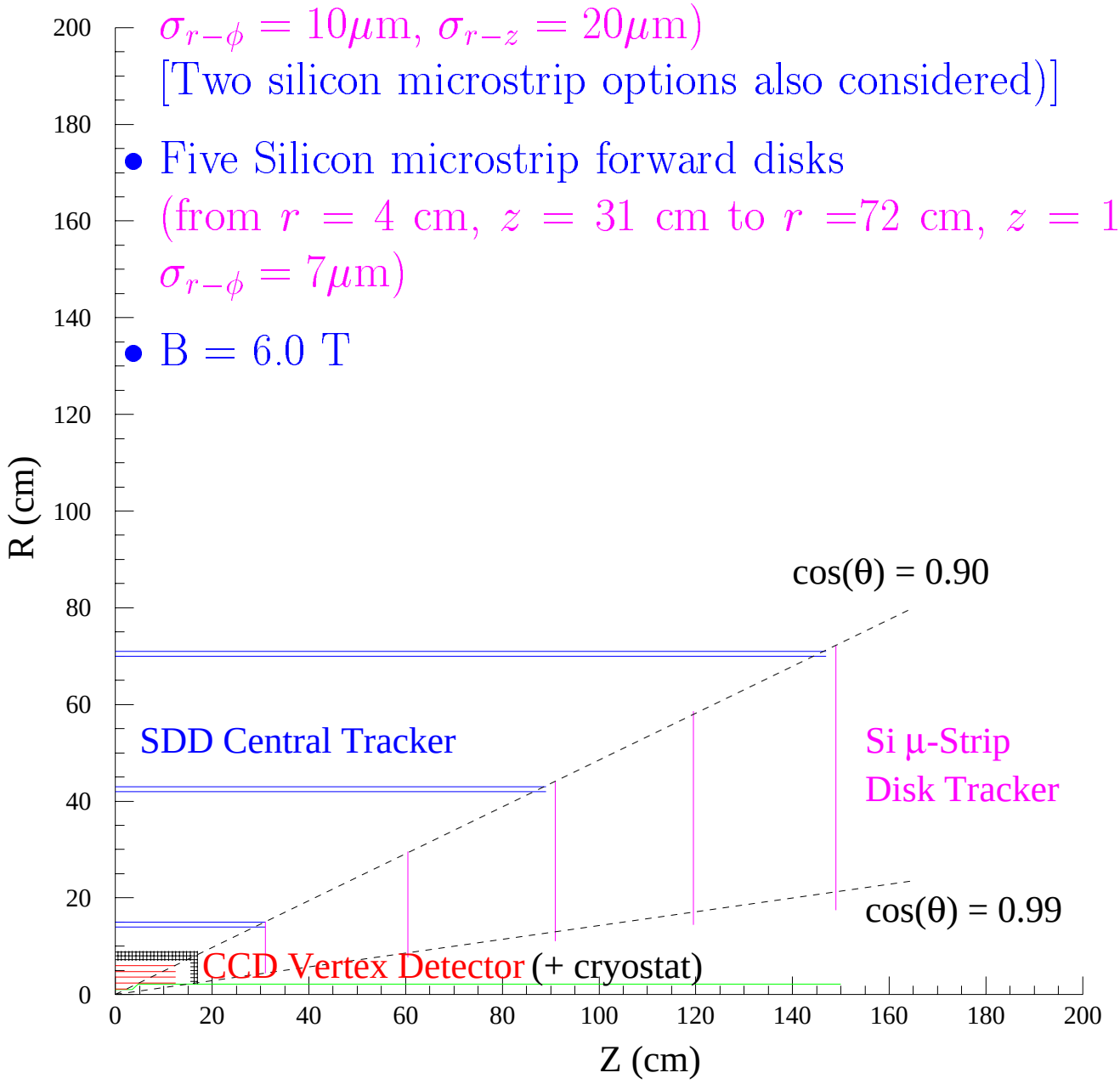
- Tracking issues governing design
- Important reference reactions placing greatest demands (perhaps) on tracker

And (personal) assessment of where Fast MC sufficient and where full reconstruction needed

Reminder of Baseline Trackers

S Tracker:

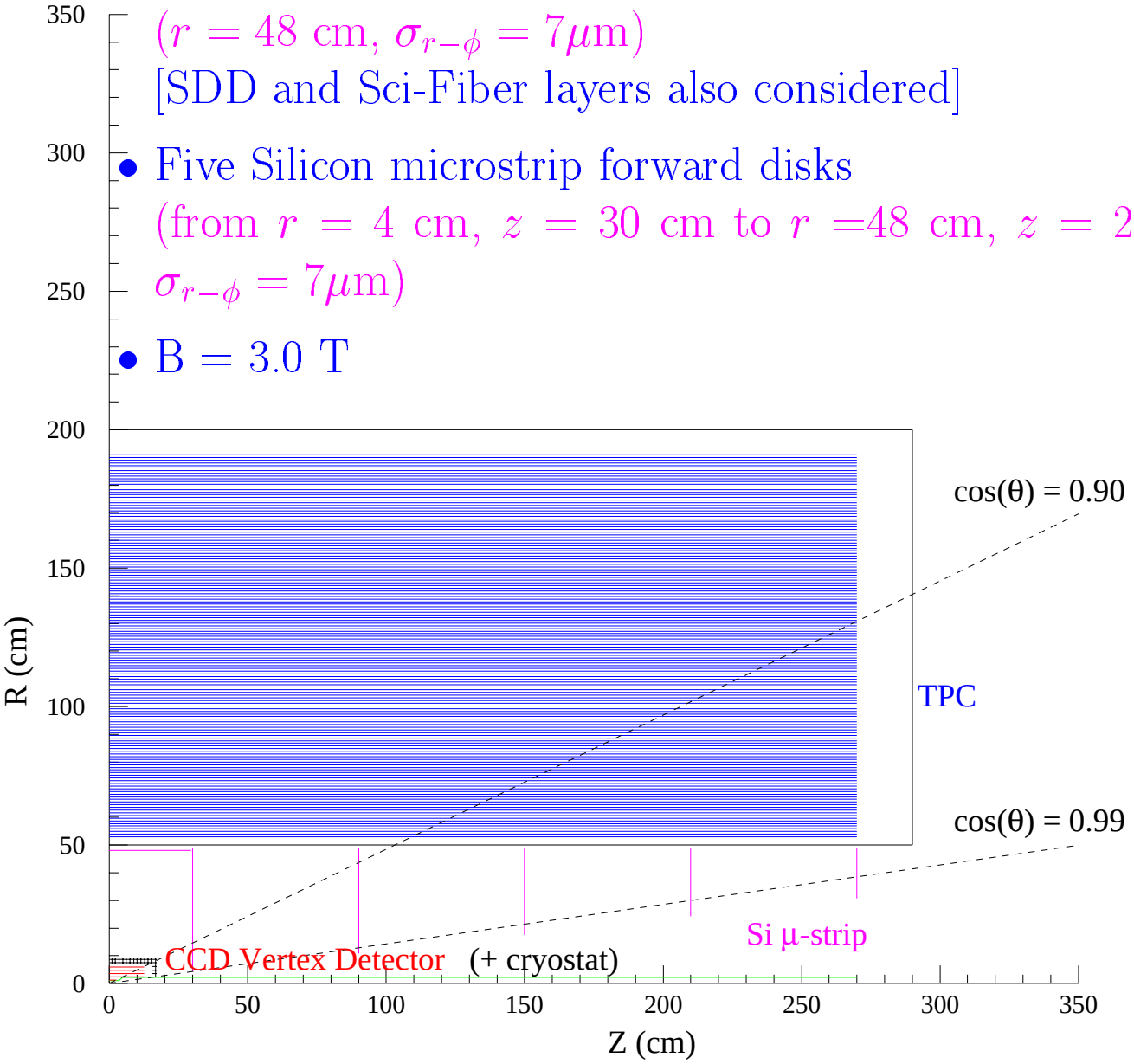
- Six barrel layers of Silicon Drift Detector (SDD)
  (3 doublets from $r = 14$ cm to $r = 71$ cm,
  $\sigma_{r-\phi} = 10\mu$m, $\sigma_{r-z} = 20\mu$m)
  [Two silicon microstrip options also considered)]
- Five Silicon microstrip forward disks
  (from $r = 4$ cm, $z = 31$ cm to r =72 cm, $z = 149$ cm,
  $\sigma_{r-\phi} = 7\mu$m)
- B = 6.0 T



Reminder of Baseline Trackers

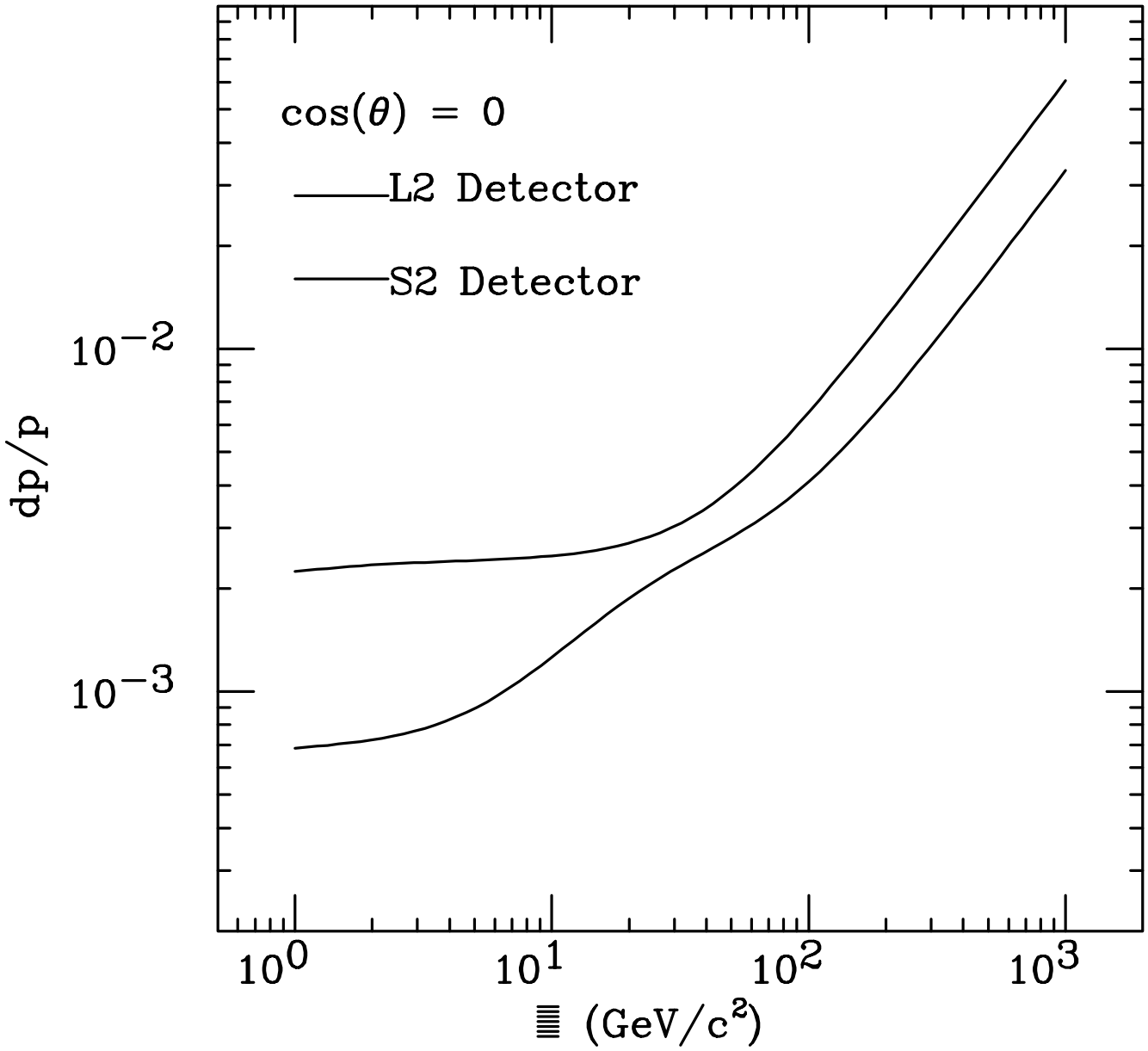
L Tracker:

- 144-Layer TPC
  (from r = 50 cm to r =200 cm, half-length = 270 cm,
  $\sigma_{r-\phi} = 140\mu$m, $\sigma_{r-z} = 1.4$mm)
- Intermediate Silicon microstrip layer
  (r = 48 cm, $\sigma_{r-\phi} = 7\mu$m)
  [SDD and Sci-Fiber layers also considered]
- Five Silicon microstrip forward disks
  (from r = 4 cm, z = 30 cm to r =48 cm, z = 270 cm,
  $\sigma_{r-\phi} = 7\mu$m)
- B = 3.0 T



Reminder of Baseline Trackers

Expected performance (plot from B. Schumm):



Both S and L detectors have 5-layer CCD vertex detectors (from $r = 1.2$ cm to $r = 6.0$ cm, $\sigma_{r-\phi} = 5\mu$m)

More details (and cost estimates) can be found at

`http://www-mhp.physics.lsa.umich.edu/~keithr/LC/baselines_oct99.html`

Specific Tracking Issues

(More detail in transparencies on tracking w.g. web site)

- Momentum resolution for high-p_t muons:
  - $\Delta(\frac{1}{p_t}) \approx$ several $\times\ 10^{-5}$ good enough at 500 GeV E_{CM}?
- Jet energy (& mass) resolution – Energy Flow:
  - How important is tracker design?
  - Any tracker probably has good enough p resolution for isolated tracks of these momenta, but what about 2-track separation?
  - Accuracy of pointing to shower max in ecal?
  - Need special outer layer for TPC?
- Pattern recognition:
  - Two-track separation
  - Few high-precision *vs* many low-precision layers
  - 3-D *vs* 2-D technologies
  - Machine backgrounds ($\sim$1 MeV Compton scatters)
  - $\gamma\gamma \rightarrow$ jets background
  - Does intermediate layer in L tracker help or hurt?
  - Time resolution of hits - need special sci-fi layer?

Specific Tracking Issues

- Material in tracker:
  - Multiple scattering degrades $\Delta p/p$ at low p
    Do we care? (S2 asymptotic $\Delta p/p \approx 2 \times 10^{-3}$)
    More relevant for giga-Z detector?
  - More 1-Mev Comptons
  - More γ conversions, electron bremsstrahlung
    Do we care at the 5-10% level?
- Forward angles:
  - Acceptance and resolution on p_t
  - Resolution on θ
    (Differential £ for $t\bar{t}$ threshold requires $\sigma_\theta \approx 10^{-5}$ rad)
- $\frac{dE}{dx}$ - "Comes for free" with some resolution
  - Should we do more than the minimum?
  - Particle ID group didn't make strong case
    for this at 500 GeV
  - More relevant for giga-Z detector?

Selected Reference Reactions (for tracker)

Black – Fast MC probably adequate

Red – Full (cheat-free) reconstruction probably needed

- Higgsstrahlung ($e^+e^- \to hZ$):
  - $Z \to \ell^+\ell^-$ recoil mass:
    $\Longrightarrow$ Measure M_h and normalize B($h \to$X)
  - M_h from full kinematic fit (h decay and $Z \to q\bar{q}$)
    Tracker influence on energy flow important?
- Supersymmetry:
  - Lepton endpoint spectrum from $\tilde{\ell}^+\tilde{\ell}^- \to \ell^+\ell^-\chi_i^0\chi_j^0$
    (low and high endpoints) $\Longrightarrow$ Determine $M_{\tilde{\ell}}$ and M_χ
  - Chargino acceptance at forward angles
- Top physics:
  - Direct mass reconstruction in 2ℓ+2-jets, ℓ+4-jets, 6-jets
    (energy flow again)
  - $t\bar{t}$ threshold scan
    (differential £ at forward angles)
- Strong coupling:
  - W/Z hadronic jet discrimination ($e^+e^- \to \nu\bar{\nu}W^+W^-$)
    (energy flow again)

Tracking Simulation / Reconstruction Status

Tony Johnson gave a simulation & reconstruction status report at July 11 meeting

Reminder of tracking highlights / lowlights:

- Fast MC has parametrized resolutions (5×5 error matrix) *vs* p and θ (B. Schumm)
- Track finding for TPC & SDD (+CCD's) (M. Ronan)
- Track fitting using SLD algorithm (N. Sinev)
- Hit smearing / loss / overlay implementation (N. Sinev)
- Track reconstruction performance evaluation (M. Ronan, W. Walkowiak)
- No track finding for projective geometries (barrel Silicon microstrip, any endcap tracking)
- Kalman filter from FNAL (R. Kutschke) not yet integrated

What to do next...

Attempting full-reconstruction analysis in barrel not crazy
(but likely to be iterative in dealing with bugs –
hard to accomplish much before FNAL meeting)

Endcap cheat-free analysis badly hampered
by absence of track finding

Barrel analysis with Si μ-strip option hampered too

Triage decisions (tracking):

- Finish track finding infrastructure? (and Kalman fitter?)
  (implement TRF++? - Does Norm have time for this?)
- Attempt only barrel analysis (TPC/SDD options)?
- Stick to Fast MC studies?