Progress on Tracking

Timeframe ~ 1 year

Marcel Demarteau
Fermilab

for the Tracking Group

Current Tracking Group

- Brown University
  - Partridge
- Fermilab
  - Cooper, Demarteau, Hrycyk, Krempetz, Ang Lee, Milstene, Tkaczyk
- Kansas State University
  - Onoprienko, Von Toerne
- LPNHE-Paris
  - Augustin, Chapron, Imbault, Genat, Hung, Lebbollo, Kapusta, Rossel, Savoy-Navarro, Vincent
- Rutherford Laboratory
  - Damerell, Goldstein
- SLAC
  - Breidenbach, Jaros, Maruyama, Nelson, Wagner
- UC Santa Cruz
  - Schumm

- + people I forgot

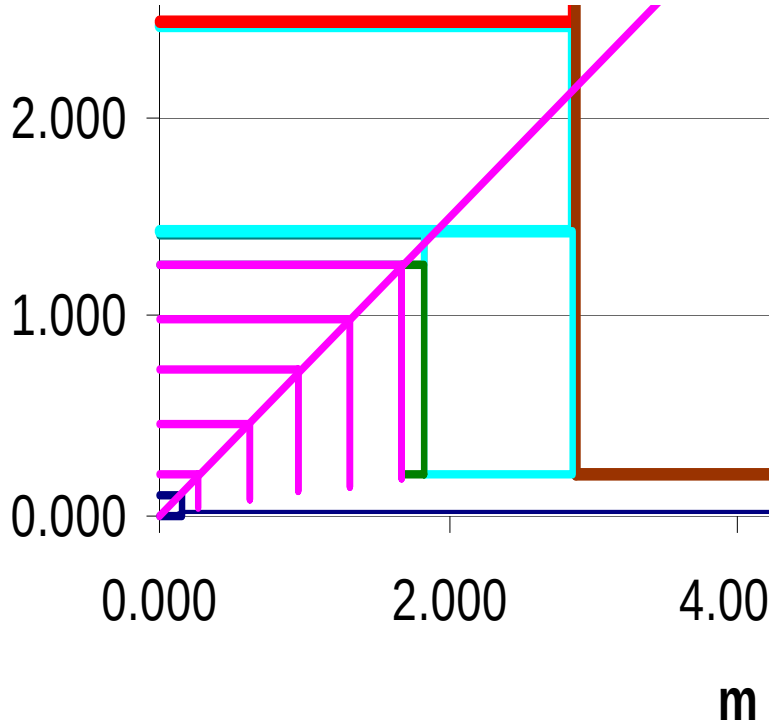
About One Year Ago

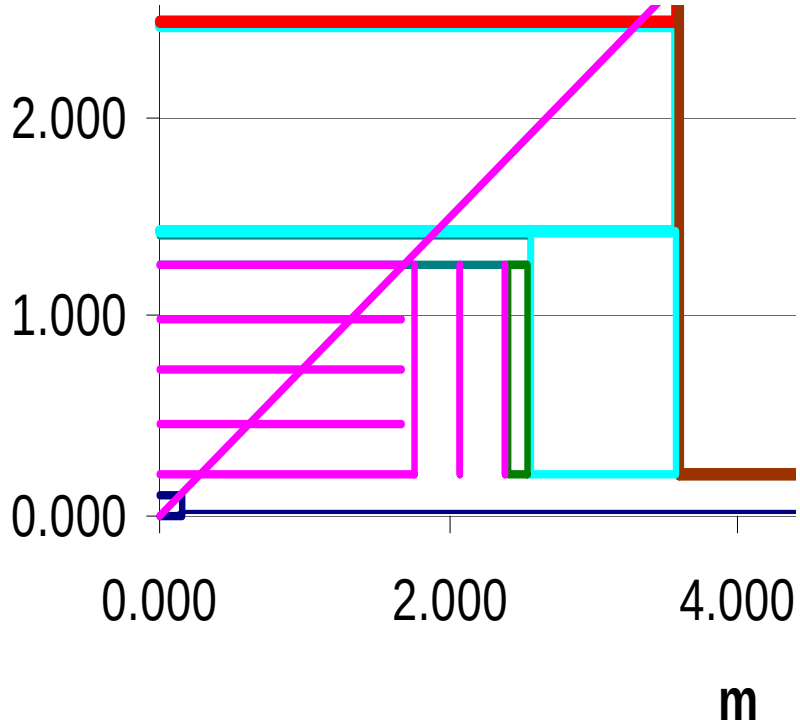
- Use as a reference point ALCPG at SLAC in January 2004 and/or Paris workshop in 2004
- Look at the status of the design at that point in time
  - Statements and lists of issues are straight quotes

Tracker Layout '04

- Tracker Layout Choice Un-simulated and Un-engineered

M. Breidenbach





- Two possible design choices
  - Fixed barrel length or barrel length increases with radius

Tracker Issues '04

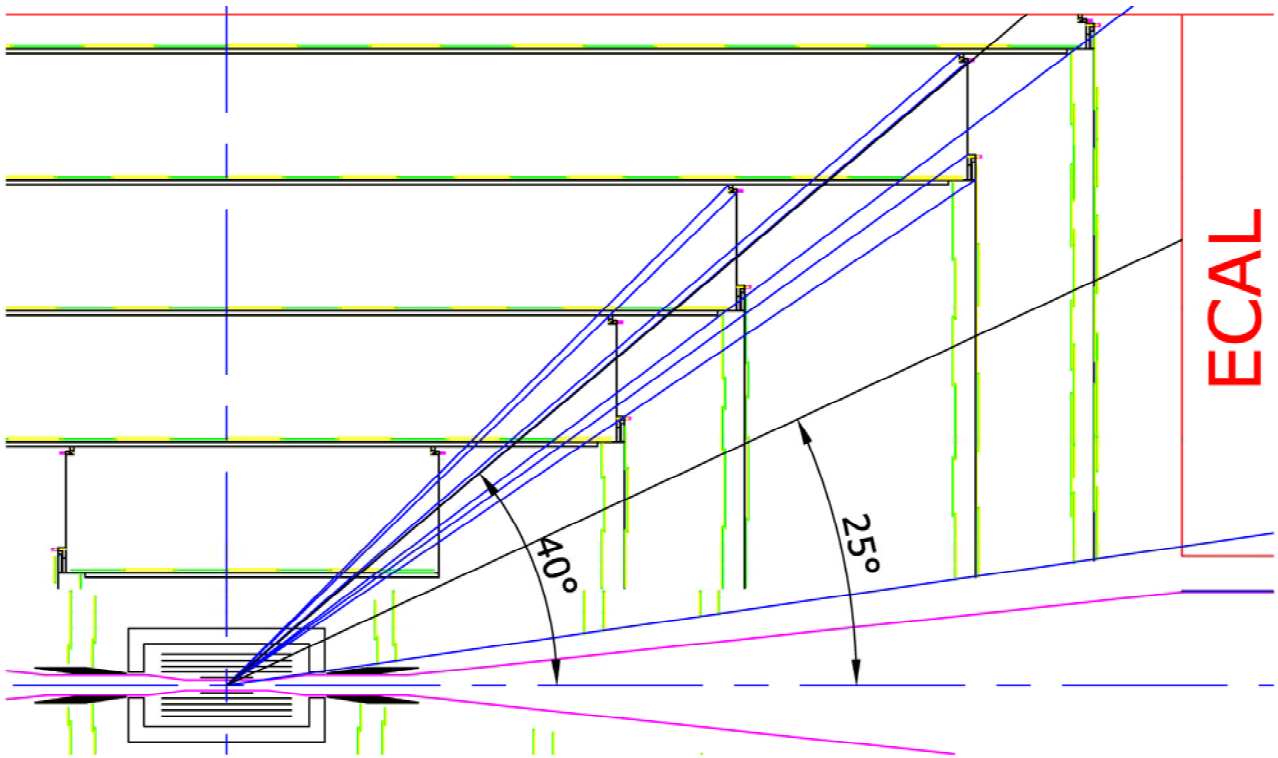
J. Jaros, ALCPG, Jan 2004

- Can SiD Tracker Pattern Recognize?
- What and how bad are real machine backgrounds? How robust must tracking be?
- Are SiD Tracking Deficiencies Significant?
  - Tracking of K^0's and Λ's
- Are SiD Tracking Strengths Significant?
  - little material in endcap, robust against machine performance
- Can realistic SiD Tracking Designs remain thin?
- Barrel Momenter or Barrel Tracker?
  - axial layers only, axial plus stereo?

Tracker Design

B. Cooper

- Barrels
  - Five barrels, measure Phi only
  - Eighty-fold phi segmentation
  - 10 cm z segmentation
  - Barrel lengths increase with radius
- Disks
  - Five double-disks per end
  - Measure R and Phi
  - varying R segmentation
  - Disk radii increase with Z



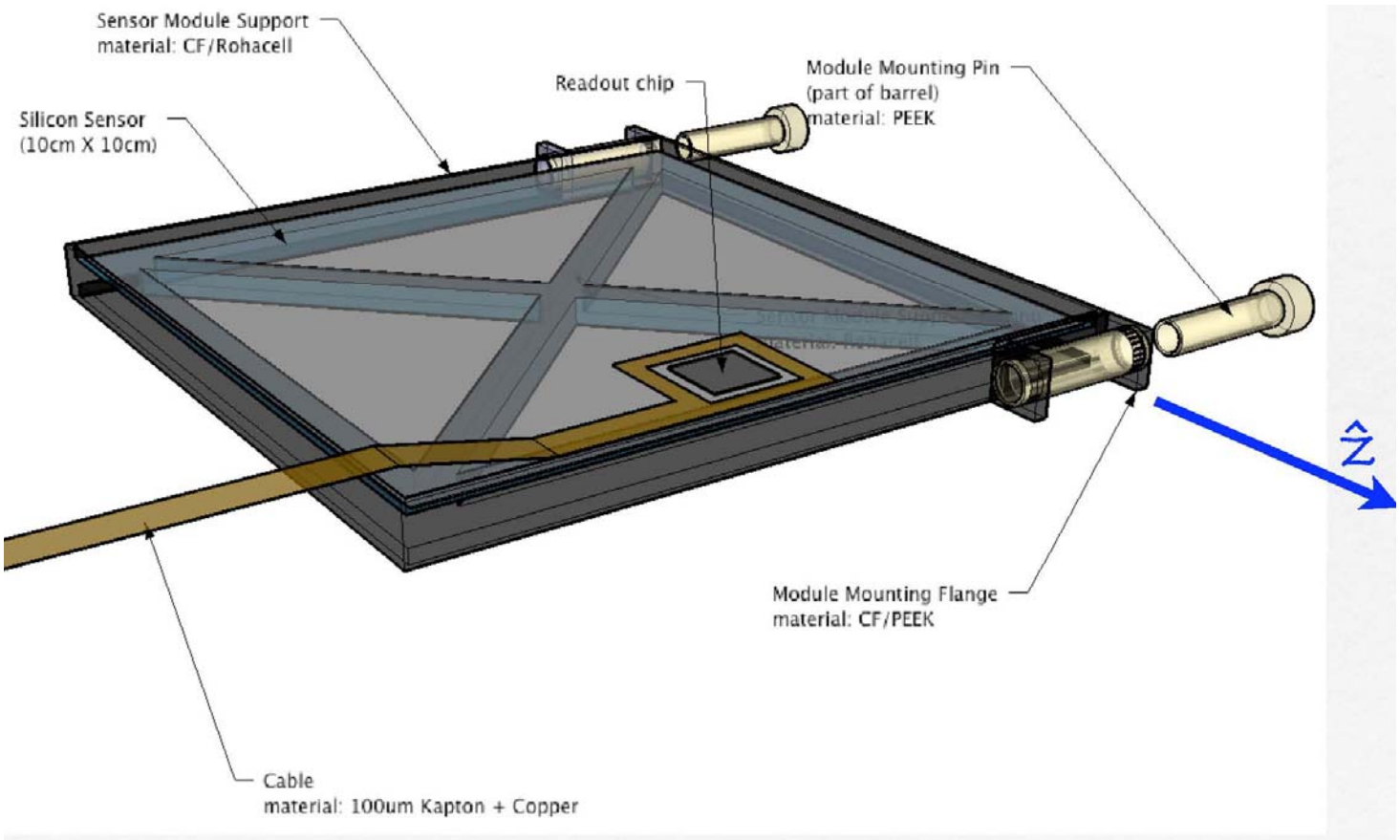
Tracker Design

- First proposal at Victoria and refined since — B. Cooper
  - Interplay between outer and inner tracker: servicing of vertex detector
    - Disks are separated into an outer radius and inner radius portion, with latter supported by the beam tube .
    - Allows for different technology for inner disks
  - Modifications to control projective geometry
- Significant consideration given to mechanical engineering issues
  - Support of disks from barrels
  - minimization of material budget
  - lay-up of carbon fiber-rohacell support cylinders and disks and associated FEA's
- First pass at realistic material budget, based on design not optimized to control projective geometry
  - Material budget of ~0.8% X_0 plausible for realistic designs in the barrel region; improvements being studied
- Geometry, notably forward region, implemented in MC geometry definition
- Continuing evolution of the geometry
  - All possible suggestions are given serious thought in terms of mechanical layout

Module Design

- Module design for mounting on continuous carbon-fiber support cylinders

T. Nelson

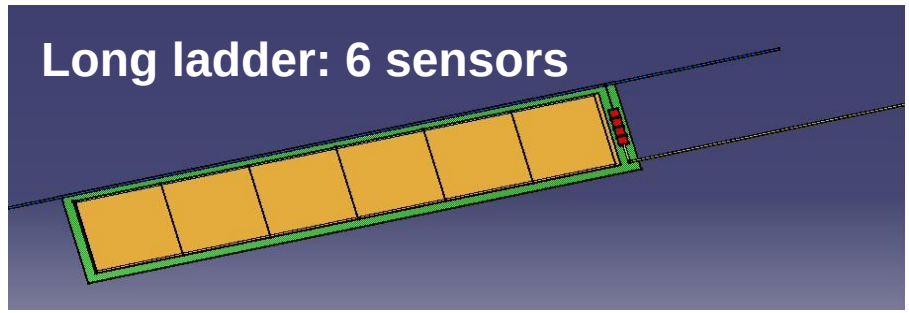


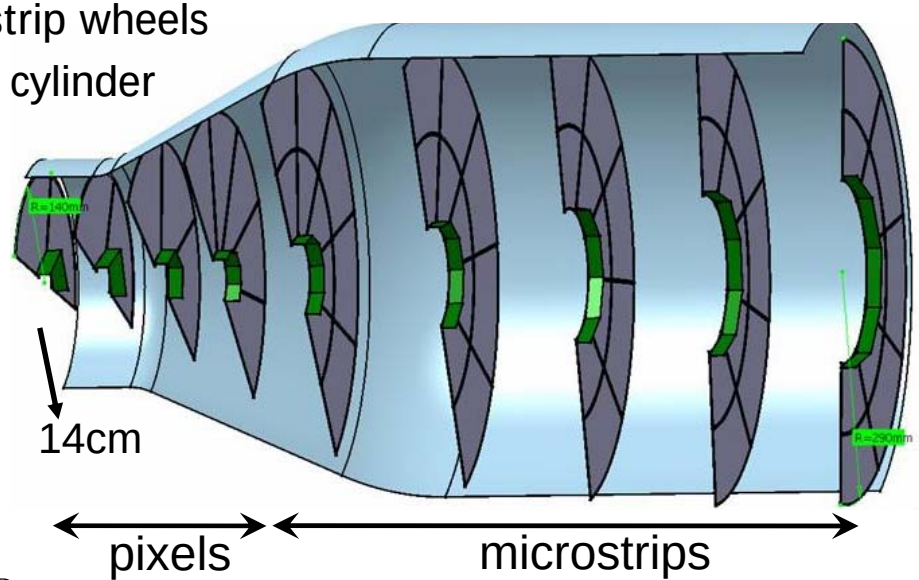
- Multi-sensor ladders also being considered

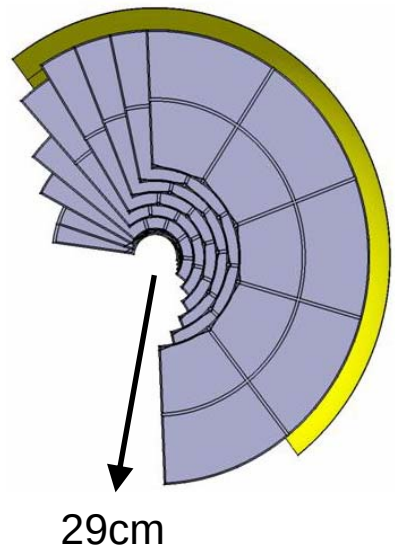
Tracker Design

A. Savoy-Navarro

- Paris focusing on two designs:
  - An all-Silicon tracking ensemble
  - A combined TPC-Silicon envelope tracker (will ignore except for forward)
- Point of focus is 'long ladder'
  - Developing assembly techniques
  - Have built 2nd prototype long ladder
  - readout by VA chip
  - Studying thermal management
- Forward region proposal
  - pixel and strip wheels
  - Cf support cylinder



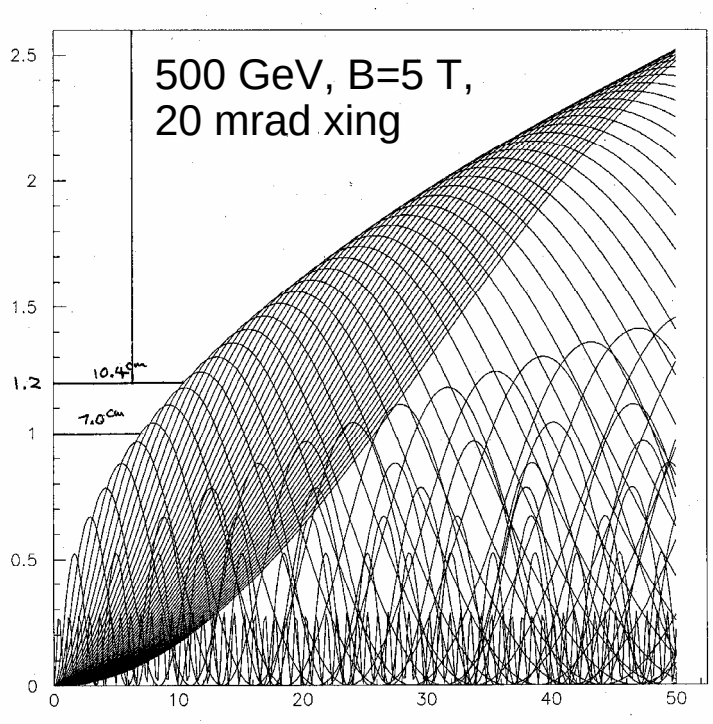


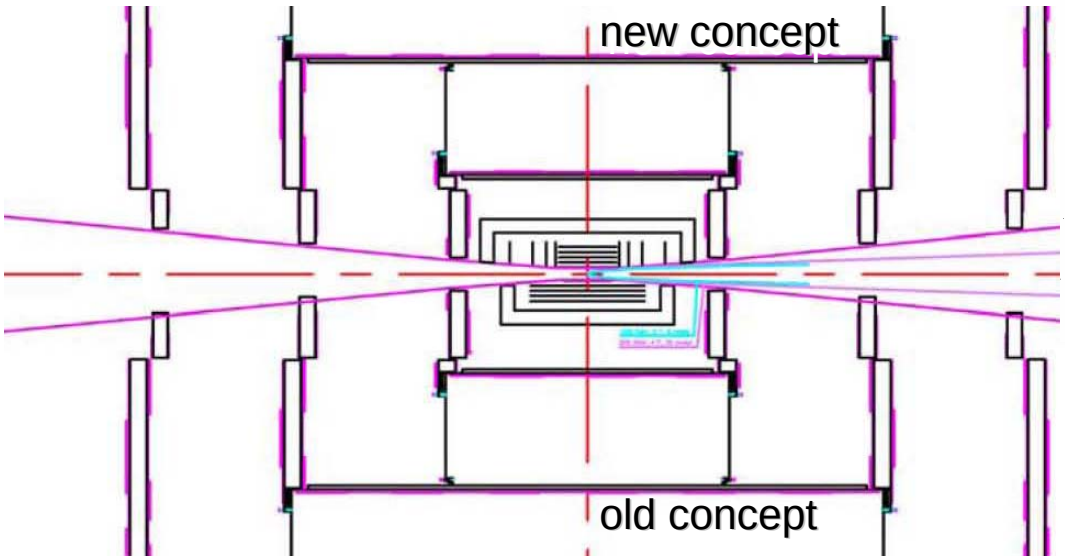


Machine Tracker Interface

B. Cooper
T. Maruyama

- Study of machine-, inner and outer tracker interface
  - Innermost layer at 1.2 cm too close and beampipe at 1.0 cm too close to the pair edge
    - Larger radius $\Delta R > +1$ mm,
    - Shorter $\Delta Z \sim 1$ cm
      - 500 GeV, B=5 Tesla, 20 mrad xing
  - New vertex detector design with forward disks





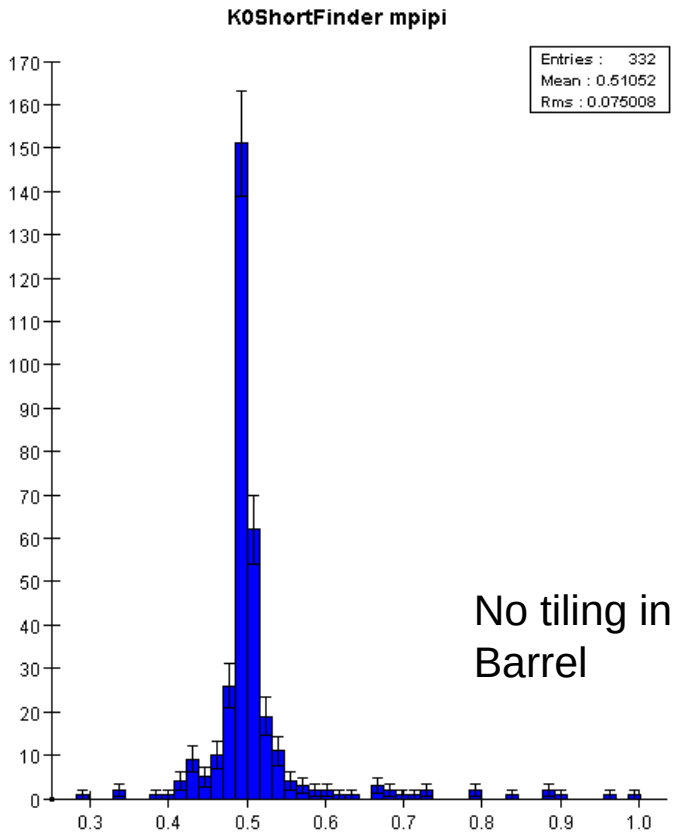
Tracker Readout

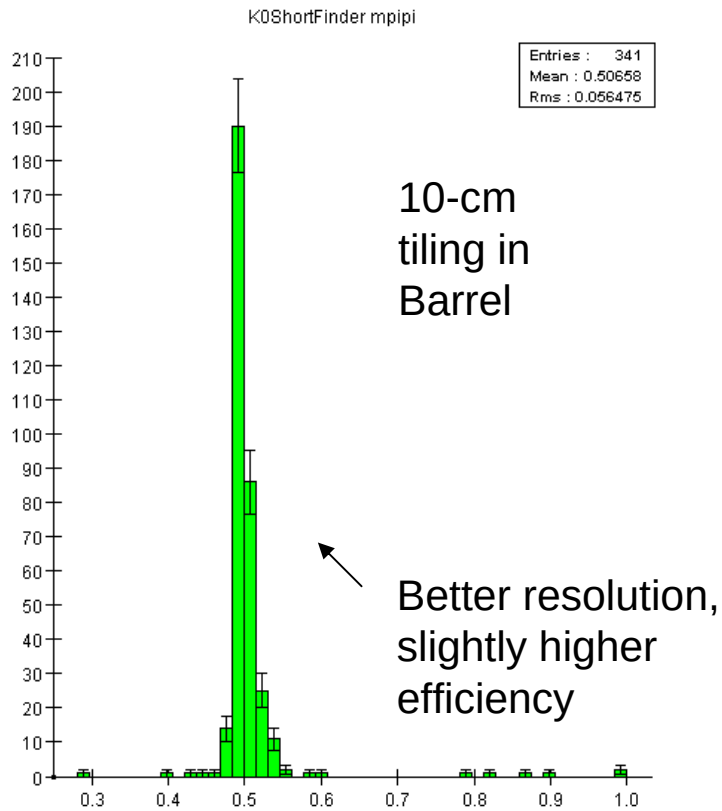
J-F. Genat
B. Schumm

- Both Paris and UCSC developed elements of prototype Si ROC
  - Low noise preamplifiers, Long shaping time
  - Time measurement
  - Very low power dissipation
  - Digitization and sparsification
  - Power cycling
- Both UCSC and Paris received, or will shortly receive, first prototypes
  - UCSC
    - Agilent 0.5 μm, CMOS
    - 3 μs shaping-time for preamplifier
    - Time-over-threshold analog treatment
    - Dual-discriminator architecture
  - Paris
    - Only FE design in UMC 0.18 μm at Europractice (Leuven)
    - 16 ch +1 Preamp, Shaper, Sample & Hold, ADC Comparator
    - For 5 μs shaping time, 50 pF detector load: simulated ENC = 690 e- ENC
      - Overall noise including I_{leak}, R_{bias} : 1060 e-
    - Power without power switching: 295 μW/channel
  - Bench tests to follow

Tracking of K_s

D. Onoprienko, E. von Toerne





- Eckhard: Calorimeter-based tracking and K0s/Lambda reconstruction would benefit from additional layers at larger radii (5 layers is a small number for our task)

Issues Revisited

- Tracker Layout Choice Un-simulated and Un-engineered
  - Serious mechanical engineering effort has started with currently a solid design
    - Is it the optimum design ?
  - Electrical engineering proceeding and prototyping started
    - ASIC's received by both UCSC and Paris VI for long shaping time
- Can SiD Tracker Pattern Recognize?
  - Sure: Pattern Recognition works if we can link VXD hits with barrel hits
  - Is that the only thing needed?
- What and how bad are real machine backgrounds? How robust must tracking be?
  - Machine – detector interface issues start to be addressed, as are issues of servicing
- Are SiD Tracking Deficiencies Significant?
  - Tracking of K_s's and Λ's points towards the need for tiling and additional layers
  - This needs to be quantified
- Are SiD Tracking Strengths Significant?
  - Not addressed
- Can realistic SiD Tracking Designs remain thin?
  - Realistic material budget has been made, with currently about 0.8% X_0/layer feasible for barrel region. Potential for improvement. Forward region needs work.
- Barrel Momenter or Barrel Tracker?
  - Not addressed

Progress to be Made

- Simulation is area where effort is needed the most
  - Readout ganging
    - How long are readout sections?
  - Number of layers
    - How many barrels? How many disks?
    - How many stereo layers? Use of double-sided sensors?
  - Should all barrels have identical length?
  - ……
- Can separate the simulation in two categories
  - Generic tracking
    - Pattern recognition, track finding efficiencies, impact parameter resolution
      - efficiency reconstructing long lived particles
    - Occupancies, p_T resolution, ...
    - With VXD or stand-alone
  - Physics benchmark
    - Take two or three benchmark physics processes and set list of minimum requirements:
      - p_T resolution
      - track finding efficiency
      - b-, charm separation
      - reconstructed physics quantities

Prerequisites and Implementation

- Technology decision for small R, forward region
  - Should make an educated choice for technology now for simulations
    - Readout
      - Optical Drivers/receivers
      - Any cooling needed for readout
      - It doesn't need to be specific; characterization of material should be enough
    - Technology and support for both vertex and outer tracker disks for R < 20 cm?
      - Pixel detectors for the whole forward region ?
- Machine constraints and serviceability
  - Decide on beam pipe constraints such as cone angle and radius?
  - What would we like in terms of serviceability ? Current scheme adequate ?
- Implement in simulation
  - Believe that fast simulations should be adequate
    - Especially for optimization studies

Summary

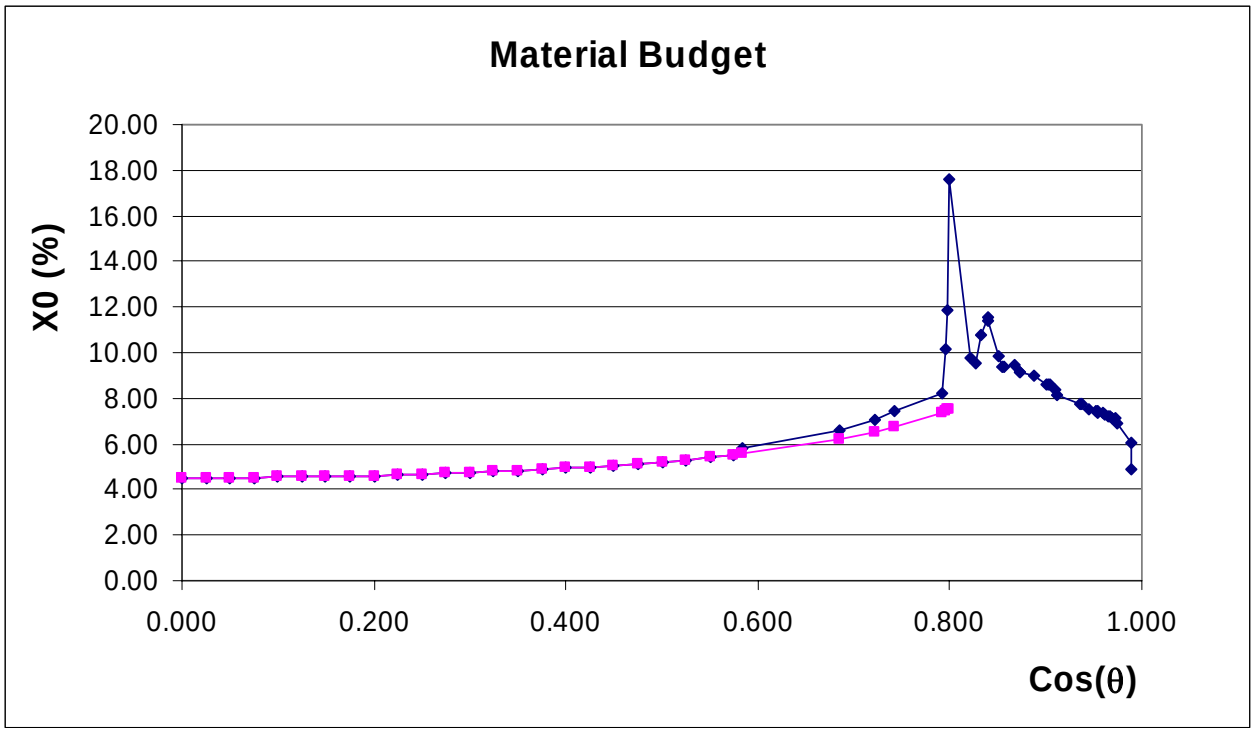
- Plenty of activity on many fronts, both in US and in Europe
- Significant progress in the design of the tracker, especially given the fact that all people are only part-time on the project
  - Realistic mechanical design on hand
  - Electrical engineering proceeding
- Little progress made in simulation
  - Aurore, SiD meeting Feb. 2005: "... a dramatic need for simulation studies for optimizing / comparing detector designs & performances"

- Simulations are now critical; to make any significant progress, we need to bite the bullet on some design issues; decisions don't have to be correct as long as they are well reasoned
- Fast and flexible simulations should be adequate to establish conceptual design
- Explore integration of European simulation effort

Backup

Material Budget

- First pass at realistic material budget, based on design not optimized to control projective geometry



- Material budget of ~0.8% X_0 plausible for realistic designs in the barrel region; improvements being studied

- Mechanical considerations
  - Grounding
    - What sets the potential of carbon fiber surfaces relative to sensor ground?
      - For single-sensor modules
      - For multi-sensor modules
  - Cabling
    - What are the cross-sectional dimensions of a cables?
    - How many cables are at the same R-phi?
      - For single-sensor modules, we think one bus cable per end
      - For multi-sensor modules, we think one cable per module
  - Optical drivers / receivers
    - How much space is needed for these?
    - How much cooling is needed?
  - Servicing
    - How important is it to be able to replace a sensor module?
      - Working assumption: essential during assembly
      - After operation?
    - What defines the “unit” to be removed / replaced?