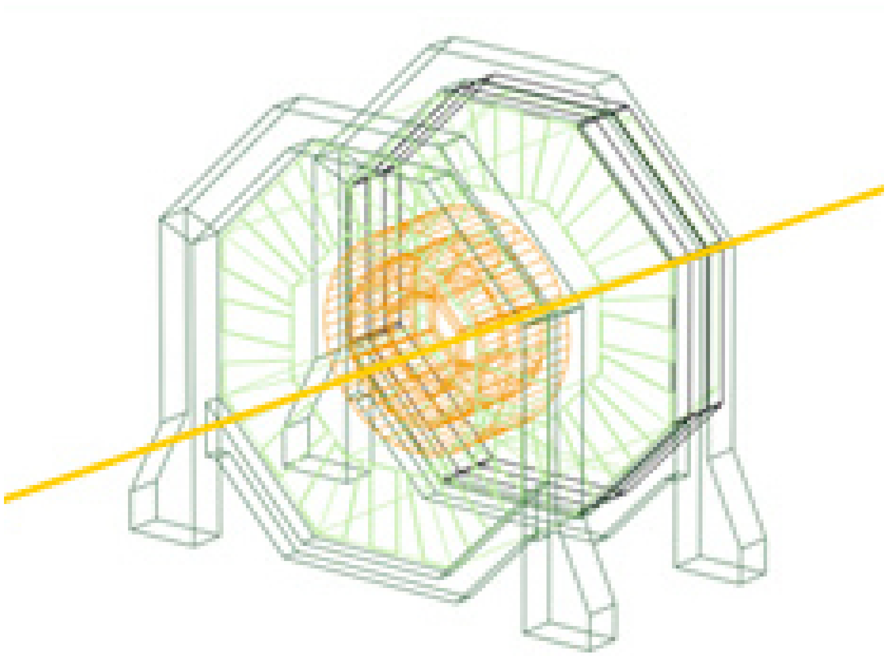
SiD Tracking Plans
What's Next?



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SiD Premise and Task

- One of the main areas where SiD differentiates itself from other concepts is in the tracker-vertex design
  - All silicon vertex and tracking detector
  - Small number of layers for pattern recognition
  - Barrel – disk configuration for vertex and tracker (nested)
  - Small vertex inner radius because of high B-field
  - Air-cooled system with power-pulsing
  - …
- By the same token …
- One of the main areas where SiD receives skepticism compared to other concepts is in the tracker-vertex design
  - Hybrid-less readout feasible?
  - Adequate number of hits for pattern recognition?
  - Can the estimated material budget be maintained?
  - Occupancies acceptable?
  - Design allows for air-cooling?
  - Cable routing, powering and services?
  - …

Purpose of the LOI

- One of the main purposes of the LOI is exactly to address the perceived weaknesses of the design and, if not sufficient data is available yet, outline an R&D program
- Given the page limitation of the LOI, we have decided that we will attempt to provide a separate, internally consistent, complete write-up of the vertex and tracking system of the SiD detector
  - Our aim is a NIM paper or a 'Linear Collider' note and/or SLAC/Fermilab technical memo
  - This paper will serve as reference document for the LOI
- We hope that this will receive full support; many people have invested a substantial amount of work and especially our younger colleagues deserve the recognition for their work
  - If there is no appreciation, there is no motivation.
- Moreover, there is added value to this work

Design of Tracking Systems

- **Forward region is critically important to the ILC**
  - **Angular distribution: $(1+\cos^2\theta)$**
- **What is the best strategy for forward tracking? Is there a unique solution ?**
  - **How many measurements ?**
  - **Barrels interspersed with disks ?**
  - **Detector tiling: large or small angle stereo ?**
  - **Short strips, pixels ?**
  - **Ghosting, track finding efficiency**
  - **How to minimize mass ?**

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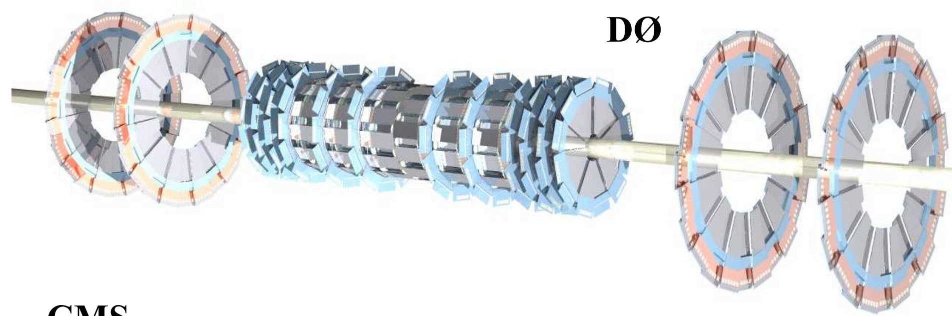
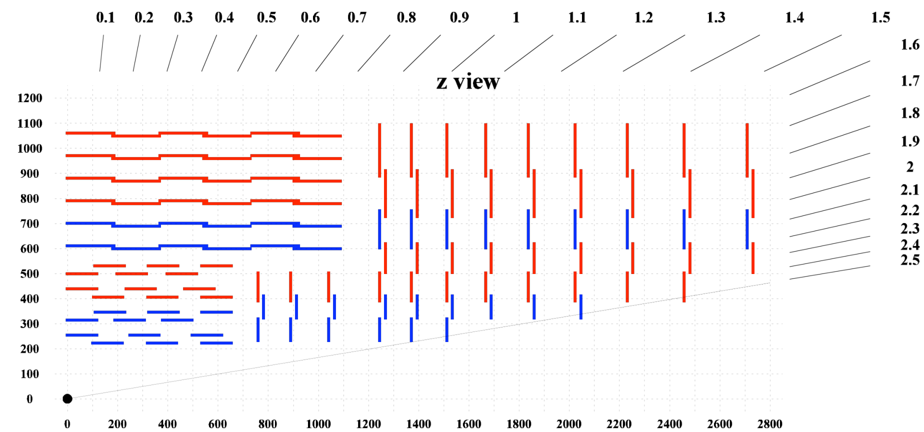
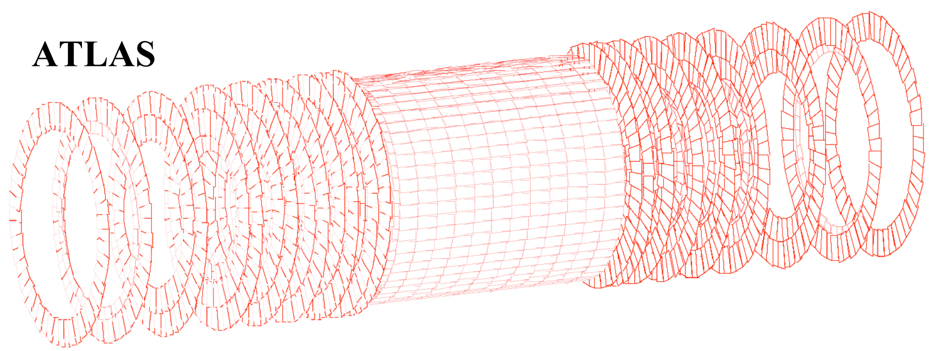


CMS

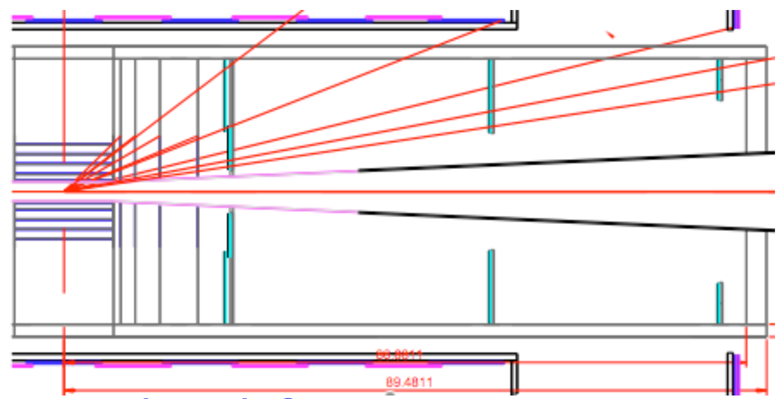


ATLAS



Vertex Design

- SiD Vertex Concept
  - High magnetic field allows for small inner radius for the inner layer
  - Barrel and disk system
    - Provides good forward tracking
    - Always at least one barrel hit/track
    - Unique to SiD
  - Integrated mechanical design with tracker



- Overall geometry is well-specified. For LOI we need to define:
  - Pixel size
  - Time resolution/layer
  - Candidate technology (ies)
  - Power scheme
  - Readout scheme

} Associated mass

Sensor Technology

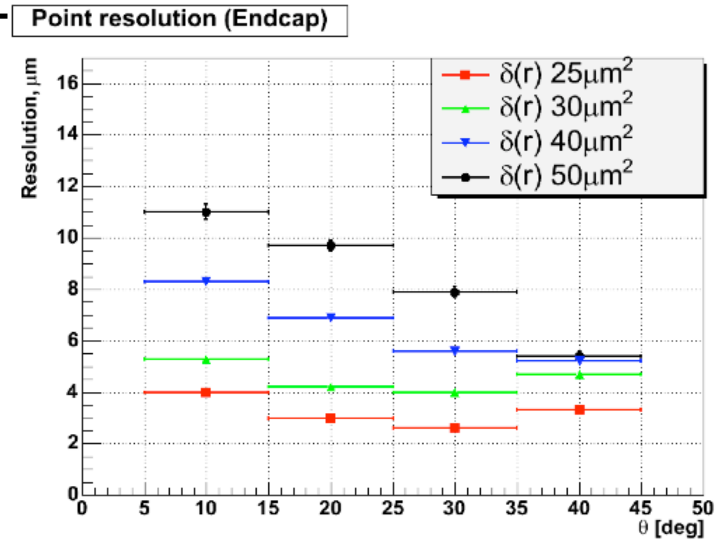
- A delicate issue - it is early for a real choice - vertex groups focused on a technology cannot be expected to explore implications of other technologies in detail.
  - My original thought was mixed technologies - Shot down
  - Discussion during breakout did not converge on a technology choice. Sentiment is to finesse this in the LOI - include table of choices
  - Chris just sent e-mail saying ILD is making a similar non-choice.
- Try to make consistent choices for modeling power, interconnect and support
- Specify single bunch resolution on inner layers
  - List candidate technologies
- Describe all-silicon support based on a room temperature detector system
  - Wafer-scale sensors (not reticles) preferred
  - Ladders based on ~75 micron thick silicon planes
- We hope to include a study of B,C efficiency and purity vs integration time
- Pixel sizes (based on A. Raspereza DEPFET result)
  - Barrel 25 x 25 micron
  - Disks 20 x 40 micron

- Pixel size optimization would be different in a MAPS or CCD technology

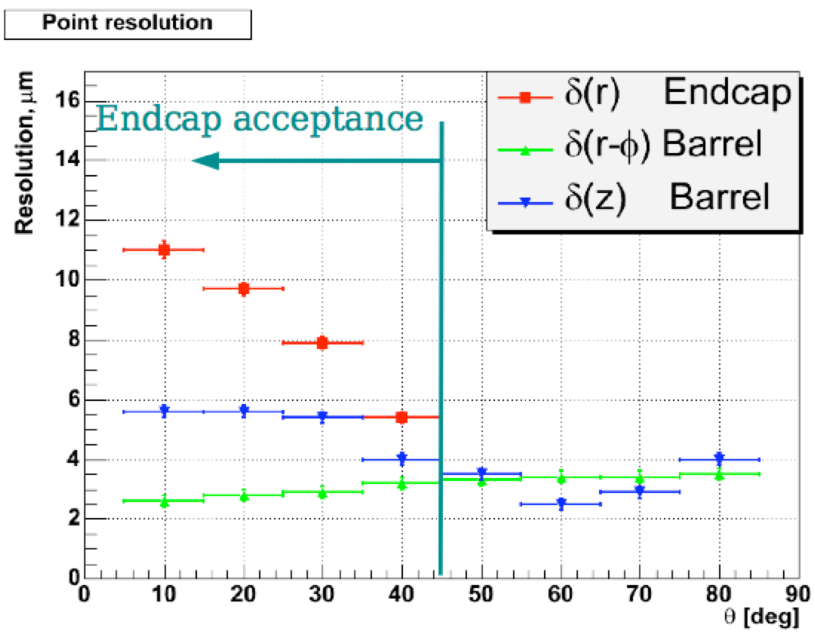
Pixel Study (A. Raspereza)

- Barrel pixels 25 x 25 micron
- Vary disk pixel dimensions to determine resolution requirements for forward disks

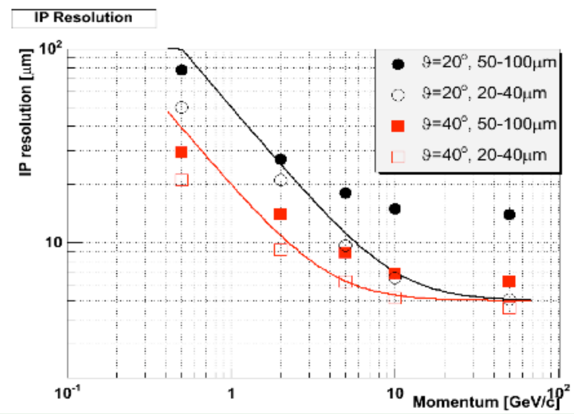
Spatial Point Resolution (r) in Endcap vs. Pad Height



Spatial Point Resolution



IP Resolution. Requirement on Pad Width in Endcap Discs



To achieve ILC goal for IP resolution, pad width in the endcap disc should be [20,40] μm

SiD LOI: Vertexing and Tracking

- **The description of vertex-tracker system divides almost naturally into three areas**

Vertex Detector

- **Mechanical Design**
  - Low mass support
  - Support from beam tube
  - Carbon fiber support tube
  - Power and Cooling
- **Technical Design**
  - Choices for technology
  - Cables, power and servicing
  - Alignment and push-pull
- **Simulation and Performance**
  - Full geometry description
  - Hit generation and digitization
  - Pattern recognition

Tracker

- **Mechanical Design**
  - Carbon fiber support structures
  - Low mass module design
  - Power and Cooling
- **Technical Design**
  - Double-metal sensors with hybrid-less kPiX readout
  - Pigtail readout cable
  - LSTFE Long Shaping Time Front-End chip
  - Charge Division Readout sensors
  - Frequency Scanned Interferometry for Alignment
- **Simulation and Performance**
  - Full planar geometry description and virtual segmentation
  - Hit generation and digitization
  - Pattern recognition and track fitting

List of Figures for LOI

1. Elevation view of sub-detector; all silicon for vertex
2. R-phi view of sub-detector, barrels, disks, forward disks
3. Detail on vertex detector support from beam pipe and servicing
4. Detail on barrel/disk support for tracker
5. Detail on module design

6. Number of charged particles/cm^2 as function of radius for various z locations including beam backgrounds; occupancy as function of radius for barrels
7. Material budget as function of cos(theta)
8. Double-metal sensor layout + a characteristic (CV-curve?)

9. Track reconstruction efficiency as function of integrated # bunch crossings
10. Impact parameter resolution as function of p_T and tan(lambda)
11. Track reconstruction efficiency as function of track p_T and cos(theta)
12. Fitted track momentum resolution as function of p_T and cos(theta)
13. Efficiency of V-reconstruction (K_s, Λ) with calorimeter assisted tracking
14. Efficiency vs purity for B id for various integration times

Figures Contributed to Benchmarking

Tracker contributions to benchmarking section

1. **Higgs recoil mass measurement precision from ZH production (mandatory reaction)**
2. **Secondary vertex reconstruction efficiency from ZH, H-> cc (mandatory reaction**

List of Tables for LOI

1. **Main parameters of the vertex-tracker system: barrels / disks**
   Radii of layers, extend of layers, z-position of disks, number of channels, number of modules, stereo angle for disks
2. **Sensor technology options for vertex detector with pros and cons**
3. **Estimated power consumption and thermal budget description**

IDAG Questions

- Sensitivity of different detector components to machine background as characterized in the MDI panel
  - Addressed through different vertex sensor detector technologies
- Calibration and alignment schemes
  - University of Michigan system
- Status of an engineering model describing the support structures and the dead zones in the detector simulation
  - Described in the main text
- Plans for getting the necessary R&D results to transform the design concept into a well-defined detector proposal
  - Will be addressed in the description about sensor technologies and R&D
- Push-pull ability with respect to technical aspects
  - Defer to overall write-up on push-pull
- A short statement about the energy coverage, identifying the deterioration of the performances when going to energies higher than 500 GeV and the considered possible detector upgrades.
  - Background plot will include 1 TeV running
- How was the detector optimized: for example the identification of the major parameters which drive the total detector cost and its sensitivity to variations of these parameters
  - No optimization done as of yet