Overview of SiD Tracking

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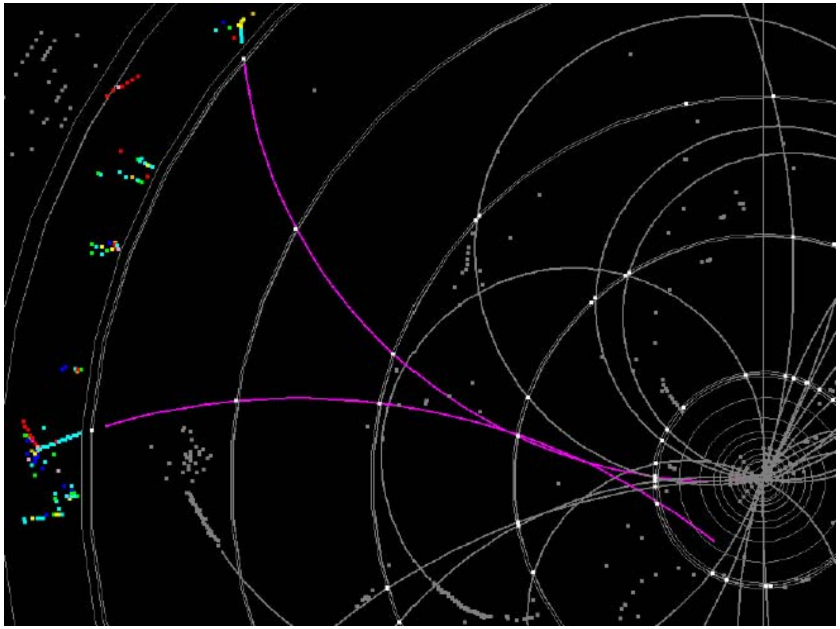
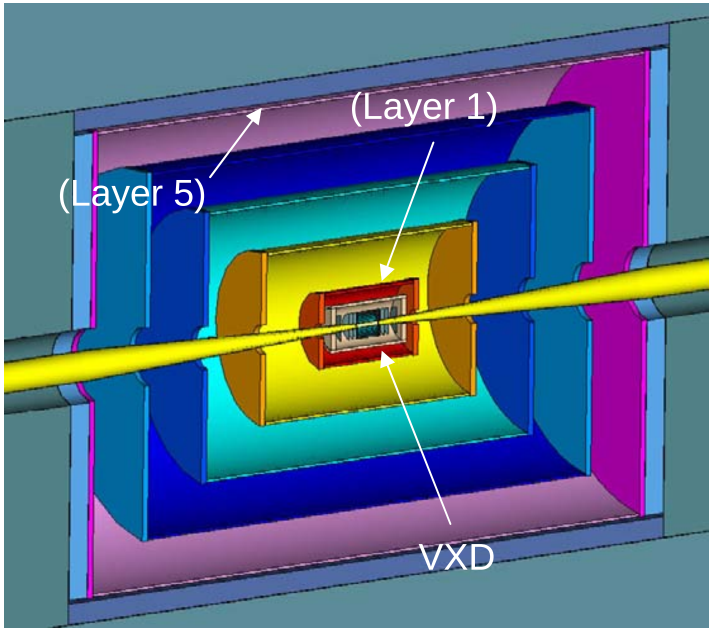
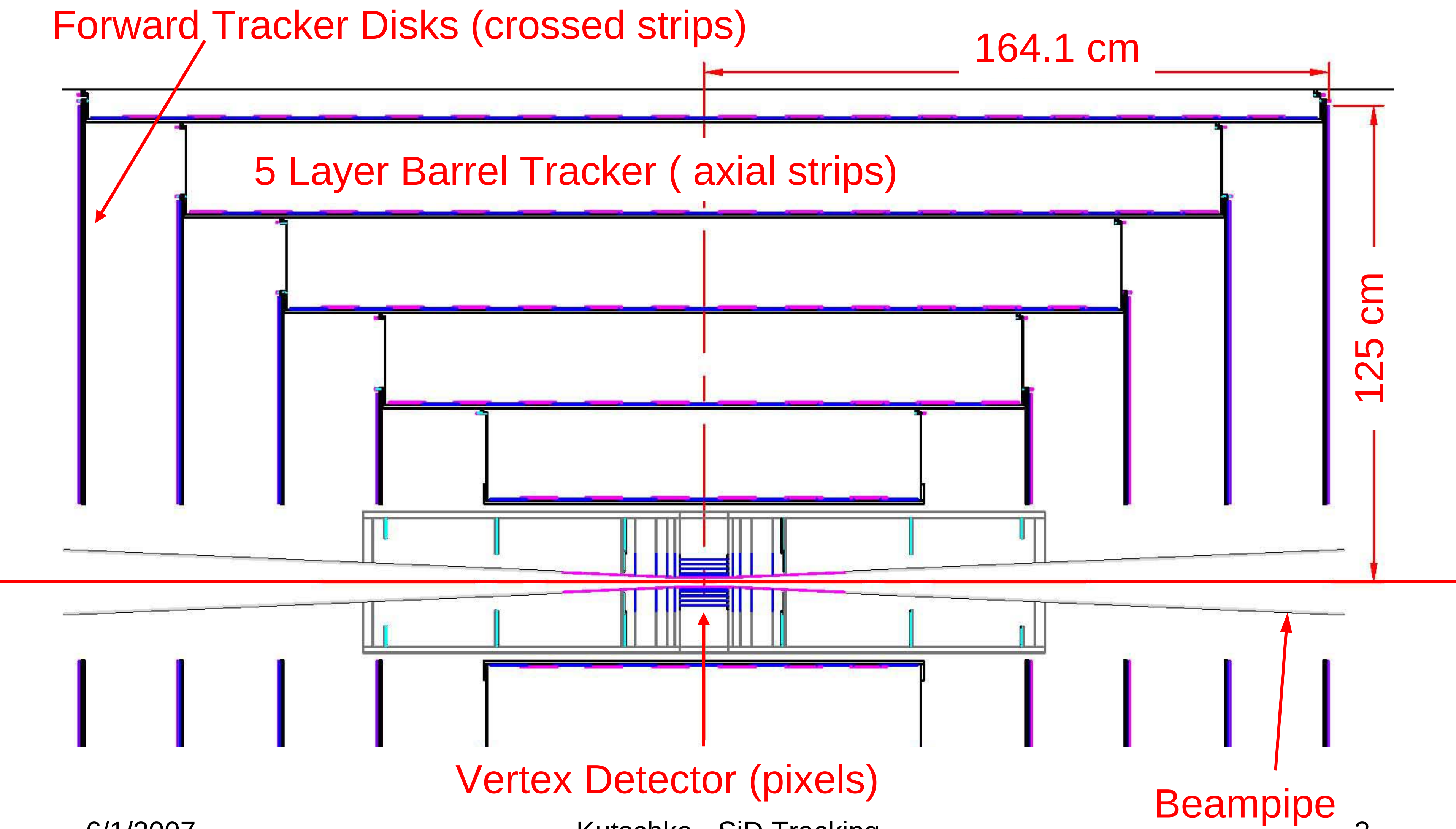




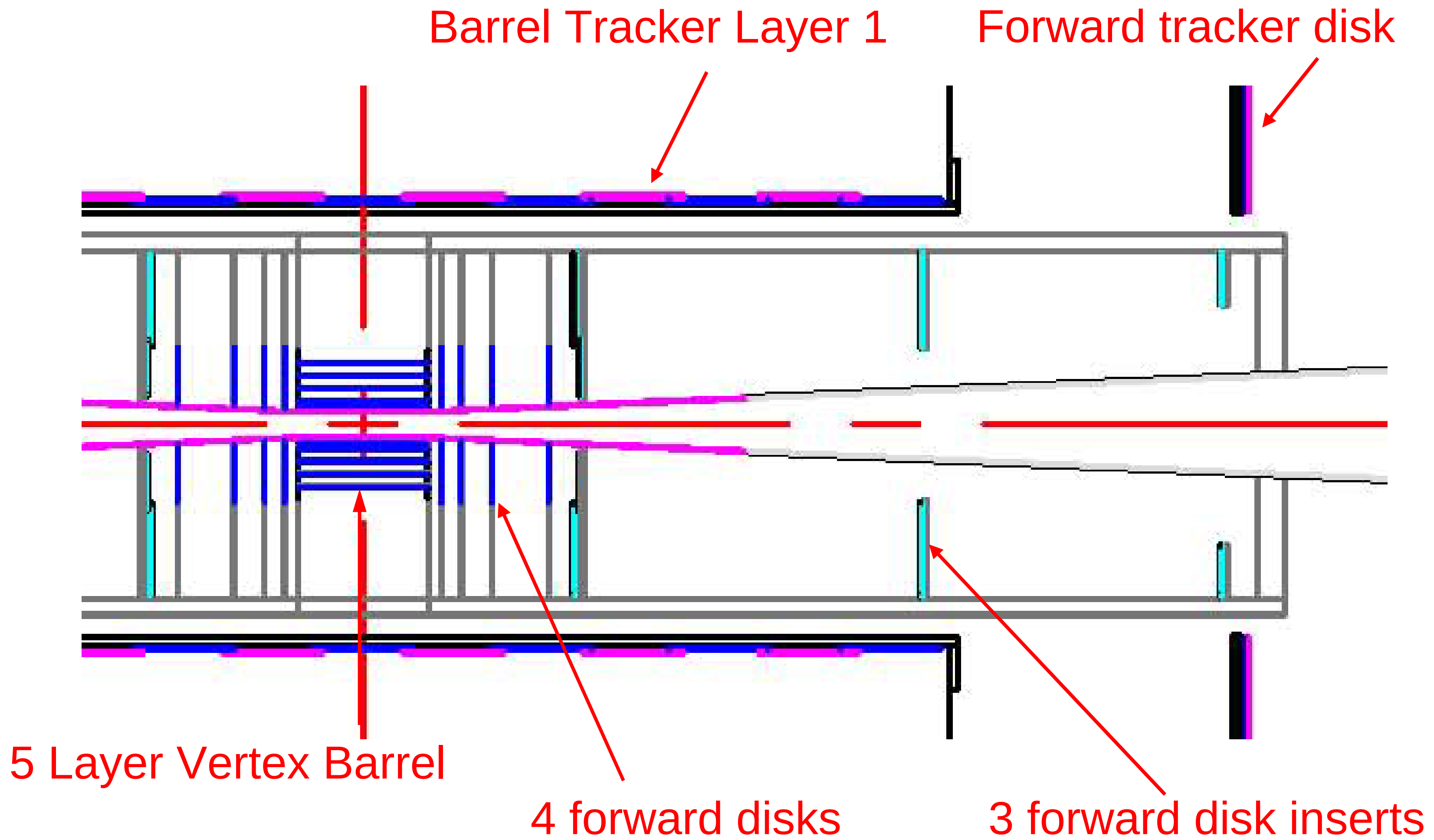
SiD Tracking Philosophy

- Vertex Detector (pixels)
  - Provides high precision measurements of tracks and vertices.
  - ~3 μm typical resolution on primary vertex position.
  - Provides and initial measurement of momentum.
- Outer Silicon Tracker (strips)
  - ~7 μm position resolution per measurement.
  - Measures p_T.
  - Together with track direction from vertex detector, measures p.
  - Connects tracks to calorimeters.
  - This talk concentrates on this device.
- Calorimeters
  - MIP stubs in calorimeter can be used by tracking.
- Expected p_T resolution in a 5 T field.
  - $\sigma(p_T / p_T^2) < 2\times10^{-5}$ $(GeV/c)^{-1}$ for 90°, high momentum tracks.

Vertical Section



Detail near Beamline



Tracker Options

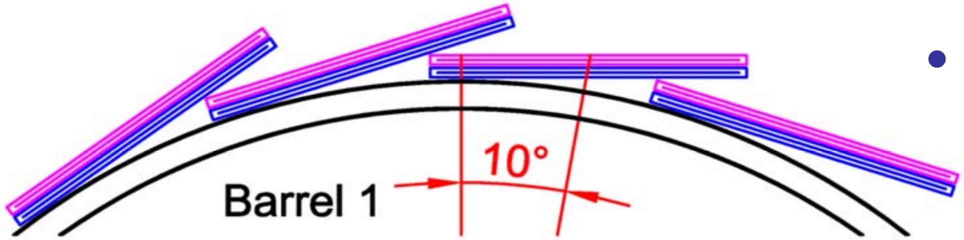
- Forward Tracker disks:
  - Sensor tiling not yet developed.
  - Crossed pairs of 1-sided sensors (baseline).
  - 2-sided sensors?
  - Pixels at low radii? Rectangular? Square? Hexagonal?
- Barrel:
  - Do we need more layers?
  - Should some layers be stereo, small angle, large angle?
  - Is strip length short enough to avoid double hits?
- Use of charge division to get coordinate along strip.
- Do we need a layer in the big radial gap between the vertexer and tracker?
- To answer most of these questions, we need to understand if we have the redundancy necessary for robust pattern recognition.

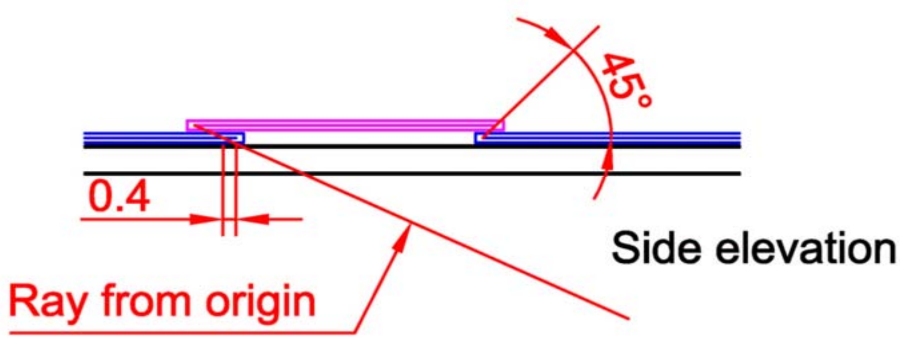
Major Support Structures

- Mounted from ECAL.
- Barrel sensors supported by double walled cylinder made of 3-ply quasi-isotropic carbon-fiber-resin laminate, ~0.11% radiation length per layer.
  - Layers within cylinder separated by Rohacell.
  - Openings cut into structure to reduce mass.
    - Final configuration must meet stiffness specs.
    - Must also know about module mounting locations.
- Barrels connected via carbon fiber laminate rings.
- Forward disks have support structures of same style as for barrel, but flat.
- Confidence in design from D0 Run IIa CFT experience.
- Details in talk by Bill Cooper at Beijing Tracking review .

Barrel Tracker Layout

- Single module design tiles entire barrel.
- 25 micron trace pitch
- 50 micron readout pitch
- Goal S/N > 25.

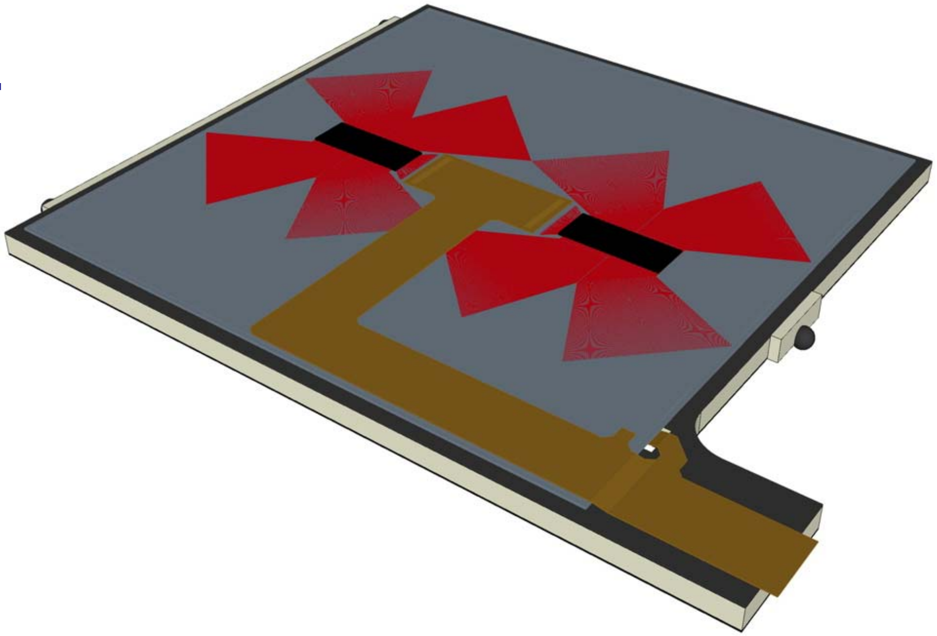




- Sensor module size:
  - 0.3 x 9.65 x 9.65 cm^3
  - Fits on one 6” wafer
- Active area:
  - 9.2 x 9.2 cm^2
- Readout options:
  - KPiX (baseline)
  - Charge Division
  - Time over threshold.
  - Open to other options when sample chips available.
  - All have single bunch crossing timing.

KPix Option

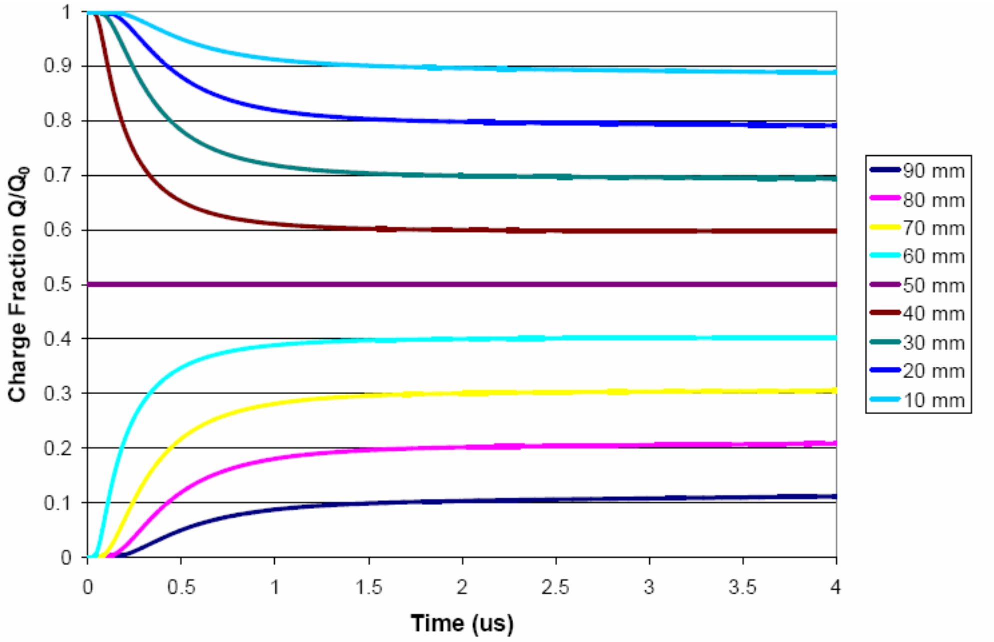
- Baseline option.
- KPiX chip used in the ECAL.
- Bump bonded in central location.
- 4 analog buffers.
- Readout between trains.
- AC coupled to strips
- Double metal layer:
  - Route signals and power
- Power traces cross some signal traces:
  - Noise characteristics to be studied with test pieces.



- Detailed cable and trace designs completed.
- See Tim Nelson's talk at Beijing.

Charge Division Option

- Shaping time optimized for charge div (a few beam crossings).
- Does not need double metal.
- Can be wire bonded at each end.
- Requires DC coupling.
- Estimate resolution of 5.5 mm along strip.
- Estimate resolution on tanλ of 0.007.
  - Comparable to small angle stereo strips.



- Test sensors in next submission.
- See Rich Patridge's talk at Beijing.

Time Over Threshold Option

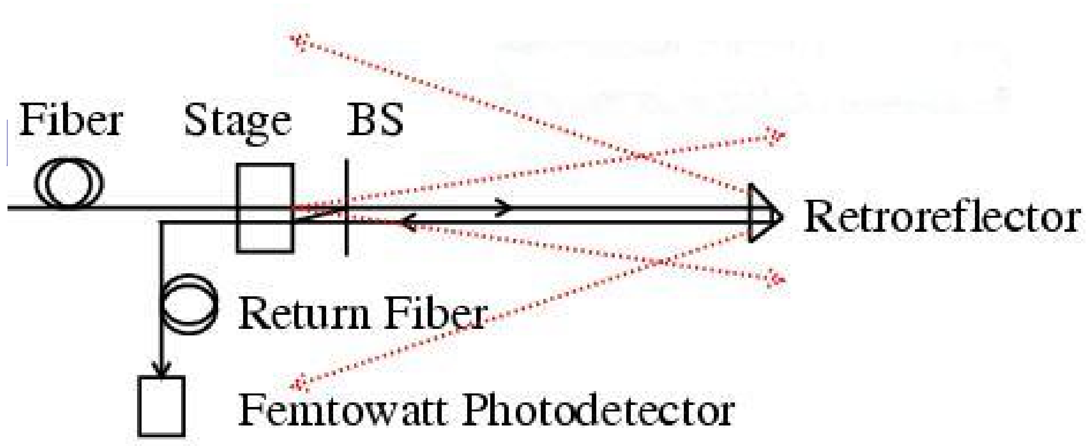
- Measure time that a comparator is above a given threshold.
- Infer deposited charge from length of time.
- Measured quantity is digital time
  - No analog buffering needed.
- Requires shaping time of O(10) beam crossings.
- See Bruce Schumm's talk in following session.

Sensor Submission

- Submission for test sensors has been prepared and reviewed by Hamamatsu.
- Will be submitted in next weeks and we request delivery by October 2007.
- Has pads for both bump bonding (KPiX) and wire bonding.
- Has test strips designed to testing all readout options.

FSI Alignment

- Frequency Scanned Interferometry (FSI)
- U. Michigan group.
- Technique pioneered in Oxford for ATLAS.
- Measure fringe shift as frequency is scanned.
- Measure hundreds of absolute distances within detector.
- Yang et. al., Applied Optics, 44 (3937-44), 2005.
- Yang and Riles, Physics/0609187 submitted to Applied Optics.

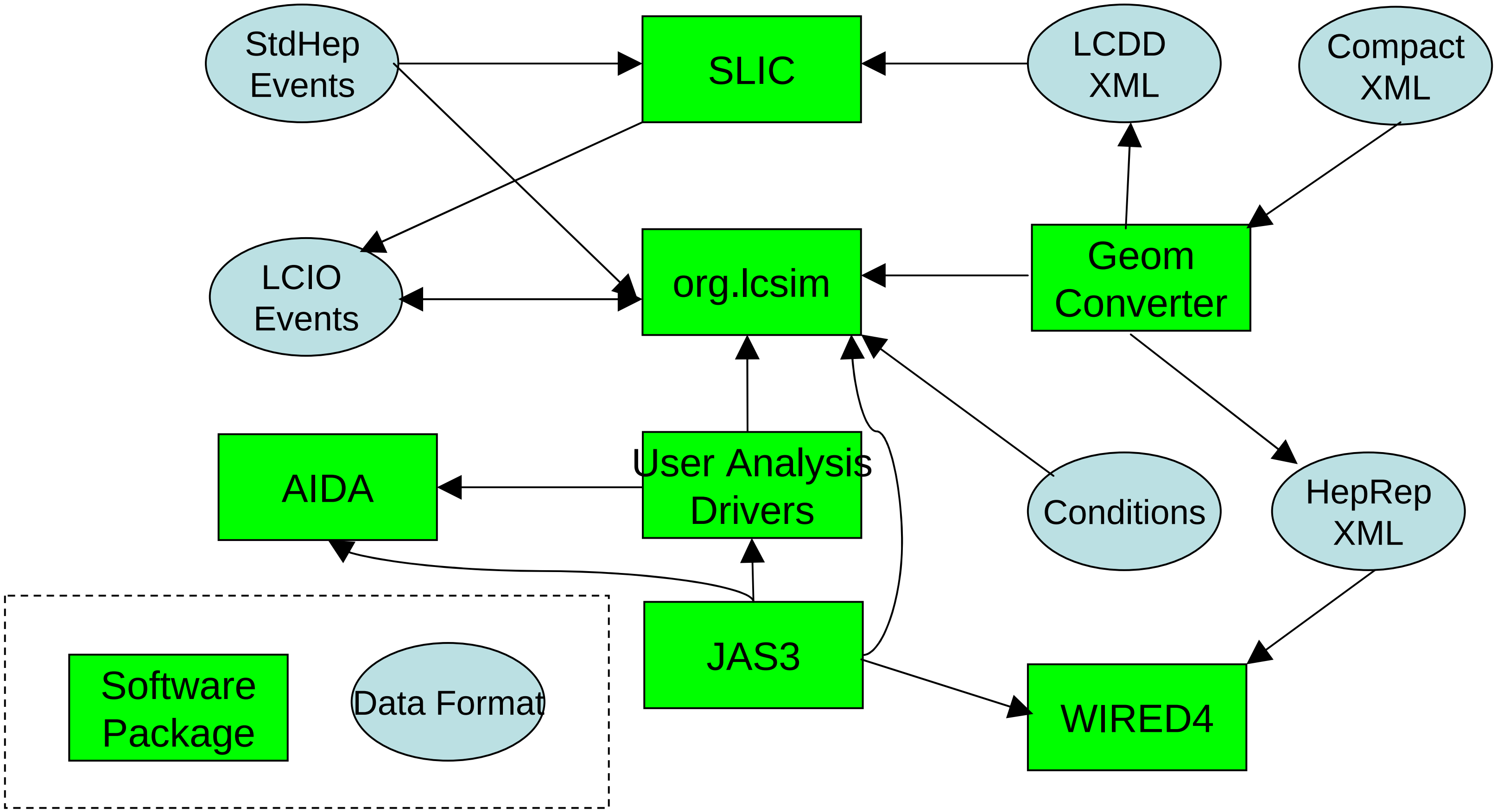


- Use 2 lasers to lower systematics.
- 0.20 microns RMS resolution demonstrated.

Power Related Questions

- Use power cycling to reduce average heat load.
  - Assume 20μwatt / readout channel when on.
  - Assume disks have same power dissipation per unit area as barrel.
  - Total average power dissipation: ~500 watt.
- Dry air cooling @ 100 cfm will do it.
  - Still needs detailed study of heat flow and of air flow design.
- Lorentz force induced vibrations?
  - Use optical measurements on prototypes to validate stiffness of the structure when it is driven at 5 Hz.
  - Can also monitor vibrations using FSI system.

SiD/ALCPG Framework



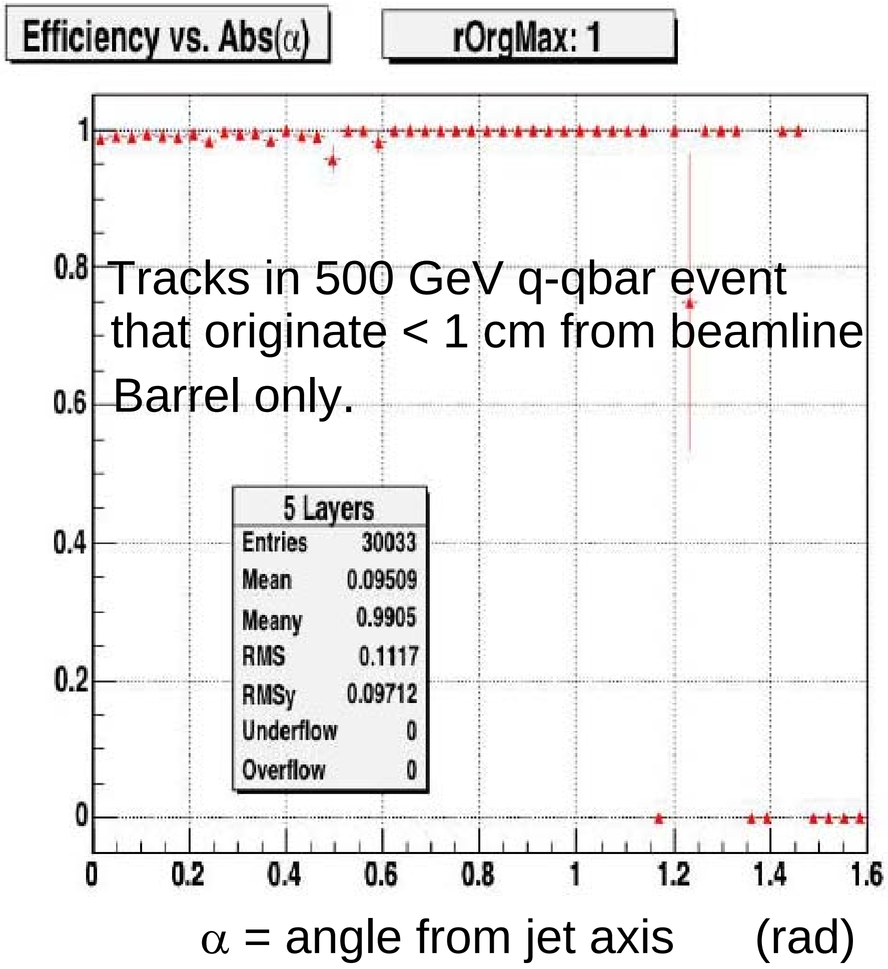
See talk by Norman Graf in Sim-Reco section yesterday.

Recent Updates to Framework

- For early work, barrels were modeled as cylinders, a powerful abstraction for rapid scans of the parameter space.
- Now modeled as heirarchical collections of planar sensors. Required for detailed modeling of buildable detectors.
- Now updating reconstruction code to work with the new geometry abstraction.
  - Results expected soon.

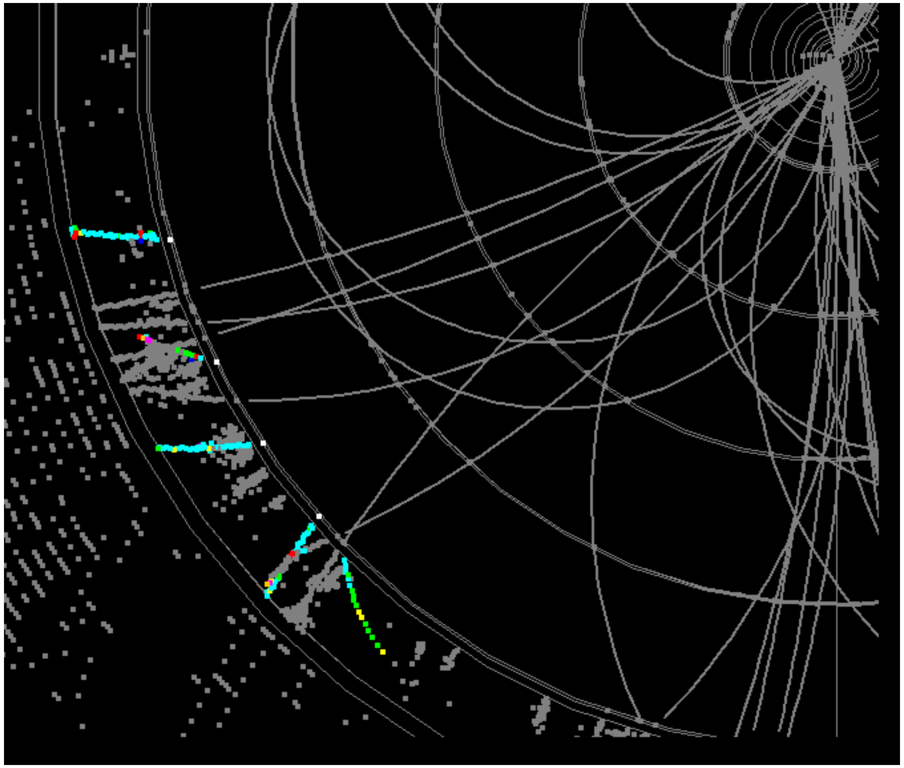
Track Finding Strategies(1)

- Most physics tracks originate inside layer 2 of the vertex detector:
  - Find these tracks in vertex detector and add hits in the tracker.
  - Highly efficient for these tracks.
  - Must extend this to the forward region.
- About 5% of all physics tracks originate outside layer 2 of the vertex detector.
  - What to do about them?



Track Finding Strategies (2)

- MIP Seed
  - Find MIP stub in ECAL, not matched to existing track and use it as a seed.
  - See next talk by Dima Onaprienko.
- Standalone pattern recognition.
  - See talk by Bruce Schumm in Sim-Reco sesssion yesterday.
  - Charge division would help this strategy.



Summary

- An integrated design for the SiD tracking system exists but it needs optimization and refinement.
  - In order to achieve the ILC physics goals, SiD will exploit the superb hit resolution, two track separation, design flexibility and timing properties offered by silicon strip detectors.
- When designing each component, it is critical to undestand its role within this integrated system.
  - Particularly true for SiD tracker in which optimization of the design will need to be done by evaluating in the pattern recognition power in the face of all backgrounds.
- Simulation and reconstruction tools now available to study buildable geometries instead of idealized cylinders.
  - Must repeat studies with these tools and extend the studies to include the forward region.
  - This will provide critical feedback for optimizing the design.
- A comprehensive R&D program is in place to perform the R&D to succeed in this effort.

Tracking R&D Summary

System	Work Package	Institutions
Mechanical	Support Design	FNAL, SLAC, Washington
	Module Design	FNAL, SLAC
	FSI Alignment	Michigan
Sensor	Double Metal Sensor	FNAL, SLAC, Tokyo
	Thin Silicon	Purdue
	Characterization and testing	New Mexico, SLAC
Readout	KPiX	Davis, Orgeon, SLAC
	Time Over Threshold	Santa Cruz
	Charge Division	Brown, Santa Cruz
Cables	KPiX Cable	New Mexico, SLAC
Simulation and Reconstruction	Simulation Infrastructure	Orgeon, SLAC
	Vertex Seeded Tracking	Brown, Colorado, FNAL, Oregon, Santa Cruz
	Standalone tracking	FNAL, Santa Cruz, SLAC
	Calorimeter Assisted tracking	Kansas State (Bonn)
	Fitting and Resolution	Oregon, Santa Cruz, SLAC