Tracker DBD

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DBD Outline (Tracker)

- Brief description of the baseline tracker design (2 pages)
- Critical R&D, including status, engineering, future needs, resources, and timeline (9 pages) Includes:
- Development of KPIX chips and associated sensors:
  - As with ECal, failure of the oxide between metal layers on HPK prototypes to stand up to bonding processes has limited progress.
    - Cannot attach KPiX or prototype cable to test readout concept
    - Have not succeeded with more gentle processes for KPiX
    - Davis has managed to attach *cables* with solder bumps. Would require redesigned cable: need to focus some attention on this.
  - Fixes are being sought in conjunction with ECal:
    - Enlisting “the pros” (IZM) for under bump metallization (UBM) and solder bonding.
    - HPK can now do thicker oxide and UBM on future parts: requires additional resources ($$$).
    - New bonding capability at SLAC (Finetech Lambda)

DBD Outline (Tracker)

- Verification is needed of an acceptable level of cross-talk with the double-metal sensor lay-out, but that can't proceed until the connection problems have been solved.

- 3-D work continues within SiD:
  - 3-D sensors represent an alternative to the baseline design.
  - Technically challenging:
    - Improvement in the yield from a multi-step fabrication process is needed.
  - R&D to develop 3-D technology applies to the detectors for other experiments and has applications outside HEP.
    - Resource support has been reasonable.
  - The DBD could include a conceptual design in 3-D using demonstrated processes and known power consumption.
    - The 3-D work would need to proceed rather well for this to be realized within the DBD time frame.

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- Sensors with z-readout:
  - Bruce Schumm and others have worked on sensors with readout at both strip ends.
  - Based on electrical mock-ups, the relative signal at the two ends should give z-position with a precision ~ 6-7 mm.
  - Prototype sensors will be needed to continue this R&D.
- Development of sensor modules for the barrels:
  - A rapid prototyping machine at SLAC could be used to produce support structures for test beams or module models that can be handled.
  - The rapid prototype models would replicate CAD models used for design development.
  - True prototypes would test design details and shouldn't be neglected.
- Development of sensors, modules, and overall support structures for the disks:
  - Module and sensor concepts need to be developed.
  - Overall support structures are understood from a concept point of view.
    - A prototype before the DBD would be nice, but may not be realistic.

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- For both the barrels and disks, we need:
  - Studies of signal to noise and crosstalk
  - Studies of pulsed power, power delivery, and associated vibrations based upon realistic prototypes
  - The development of module fabrication techniques
  - Development of cabling
    - Prototype cables for wire bonding to the sensor have been designed and obtained (University of New Mexico).
    - Extension cables for runs from the barrel modules to the ends of barrels are under development.
    - Similar parts will be needed for the disks.
  - Studies of heat removal, particularly for the disks
    - The cooperative effort with CLIC has been beneficial.
    - Testing appears to require full sized portions of the tracker (perhaps an octant of two layers) with realistic representations of power sources.
    - It may be realistic to get that done with dummy heat sources.

DBD Outline (Tracker)

  - Studies of alignment precision and monitoring
    - Please see Keith Riles' talk and the slide from him (later) for an indication of revitalization and a ray of hope.
- Re-statement of the baseline technology and the expected status of options (0.5 page)
- Status and the expected evolution of the tracker in the SiD simulation (0.5 page)
  - Progress on tracker reconstruction software, in conjunction with CLIC, has been good.
- Additional tools (desired but not essential):
  - Fully Kalmanized track finding, fitting (and vertexing).
  - More detailed accounting of material traversed by individual tracks.

DBD Outline (Tracker)

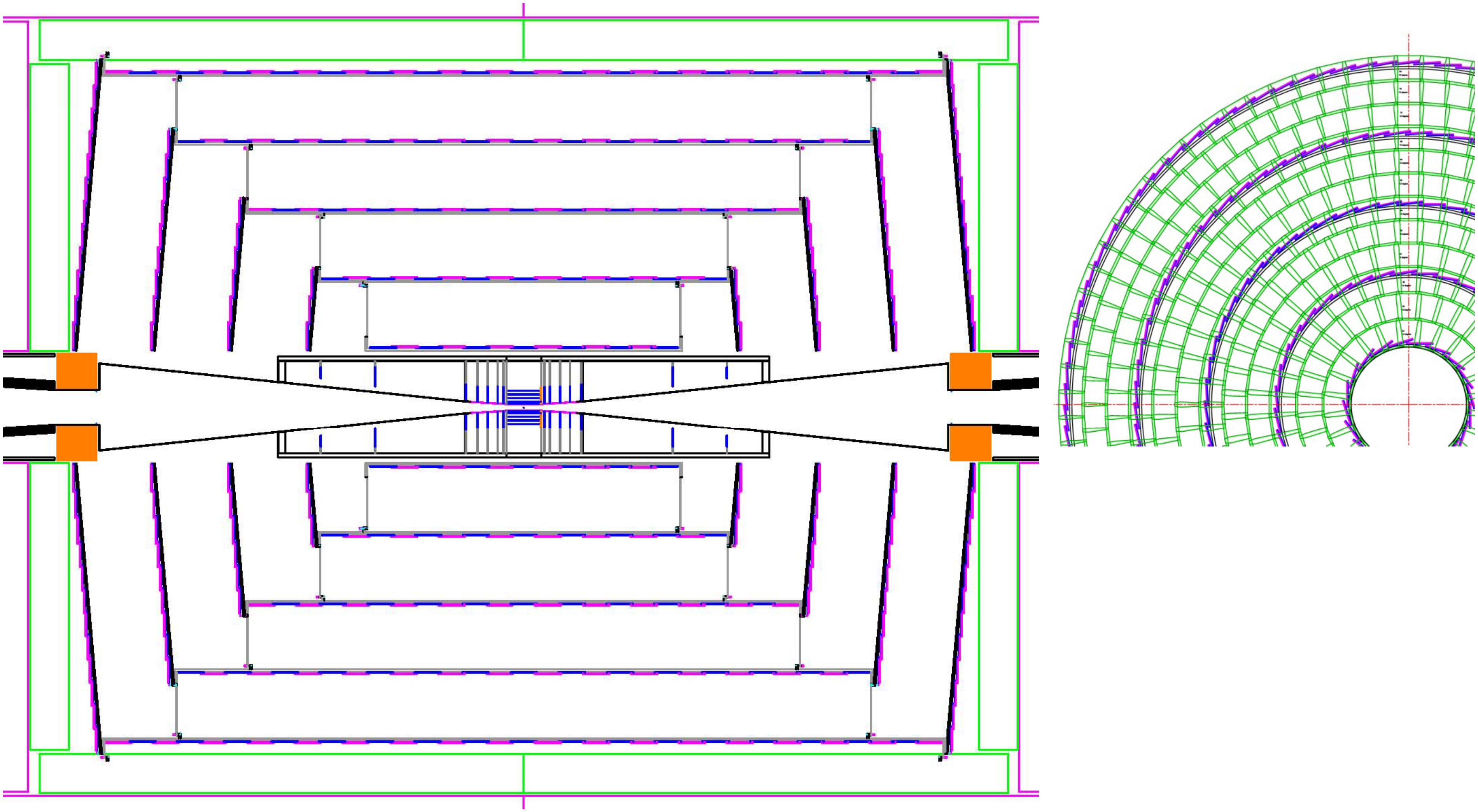
- Additional tracker studies (desired but not essential):
  - More complete studies with backgrounds and realistic time tagging.
  - Studies of sensitivity to misalignment, field non-uniformity.
  - Studies of sensitivity to holes/inefficiency, background levels.
  - Optimization studies: #layers, strip length, endcap stereo angle etc.
  - Pixel tracker option
- Total: 12 pages

- Comments:
  - Progress has been limited by the number of people and the fraction of effort they can contribute.
  - Funding has roughly matched the people resources, and is a significant issue in some areas.
  - Let's hope both improve in the coming year.

What we have and ongoing work:

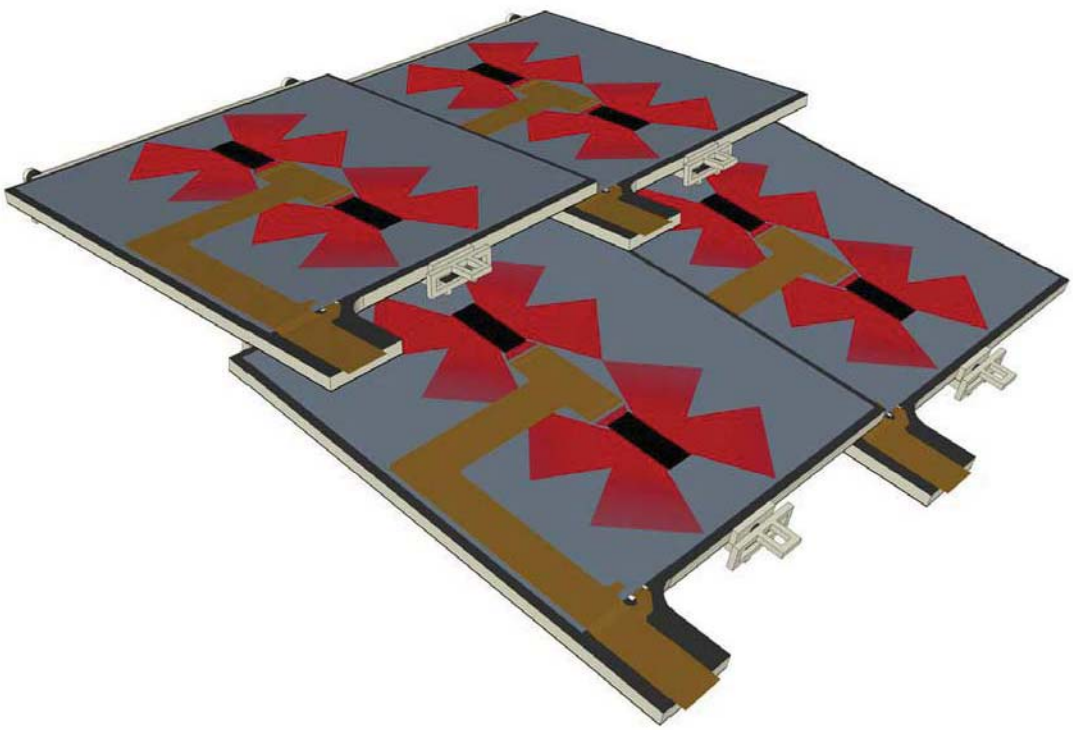
Overall Layout

- VTX in side elevation for completeness



Barrel Modules (Nelson)

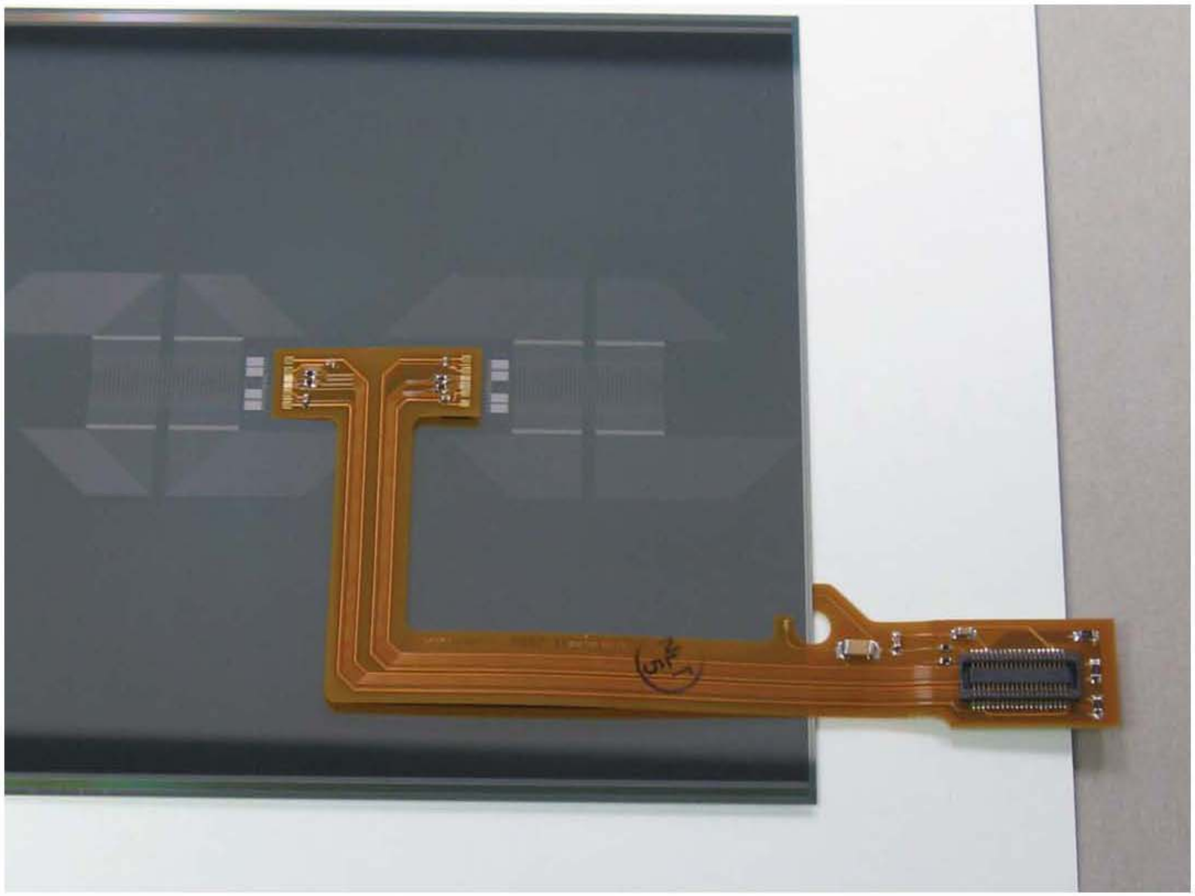
- A bit out of date, but illustrates the concept



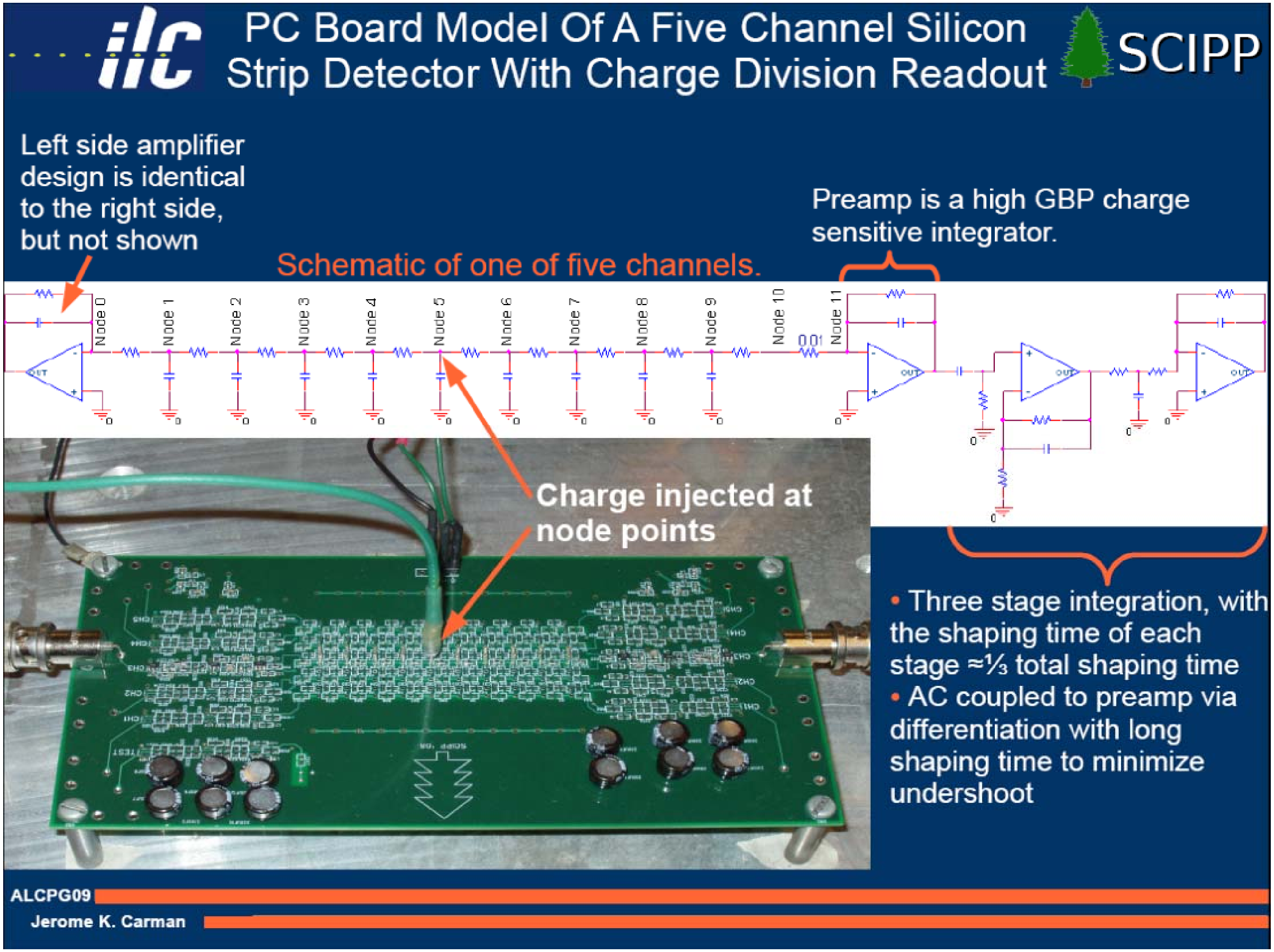
Cabling (Seidel)

Pigtail Cable on a Sensor

- Cable is just laying on the sensor & is not attached



Sensors with Z-position Capability (Schumm)



Sensors with Z-position Capability (Schumm)

Calculating Longitudinal Position Resolution

SCIPP

$$P=\frac{Q_R}{Q_L+Q_R}=\frac{\alpha}{1+\alpha}= \text{fractional position}$$

$$\alpha=\frac{Q_R}{Q_L}$$

Anti-correlation factors in here

$$\sigma_\alpha=(\alpha)\left\{\left(\frac{\sigma_R}{Q_R}\right)^2+\left(\frac{\sigma_L}{Q_L}\right)^2-2\rho\left(\frac{\sigma_R}{Q_R}\right)\left(\frac{\sigma_L}{Q_L}\right)\right\}^{\frac{1}{2}}$$

$$\sigma_P=\left|\frac{dP}{d\alpha}\right|\sigma_\alpha=\left(\frac{1}{(1+\alpha)^2}\right)\sigma_\alpha$$

- We measure σ_P to be **≈6.1mm** for a 10cm, 600kΩ, 12.7pF silicon strip detector
- Radeka predicts σ_P to be ≈6.5mm for a 10cm, 600kΩ, 12.7pF silicon strip detector.
- Asymmetry in σ_P due to slight non-linearity in 2.5T shaping time choice as well as measurement uncertainty.

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9
Q_R [fC]	0.32	0.64	0.95	1.28	1.60	1.95	2.33	2.77	3.23
Q_L [fC]	3.24	2.75	2.33	1.94	1.60	1.26	0.94	0.65	0.32
P	0.090	0.189	0.290	0.400	0.500	0.607	0.713	0.810	0.910
$\sigma_R=\sigma_L$ [fC]	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
σ_P	**0.0598**	**0.0609**	**0.0615**	**0.0616**	**0.0617**	**0.0618**	**0.0617**	**0.0603**	**0.0600**

ALCPG09

Jerome K. Carman

Tracker/magnet alignment R&D (Riles)

- Michigan group (Riles, Yang, Chen) working on frequency-scanned interferometry (FSI) alignment of tracking elements and final-focus quadrupole magnets
  - Resumed R&D in 2011 after long funding drought
  - Have established 6-channel testbed in Michigan lab
  - Recently verified sub-micron precision on x-y displacement

Plans: (short term)

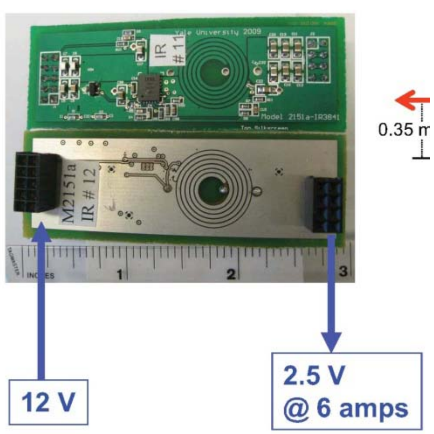
- Expand to 8 channels, carry out 3-D reconstruction
- Increase dynamic range for initial misalignment tolerance
- Full FSI simulation with bootstrapping across SiD detector and integration of tracker & magnet alignment monitoring

Plans: (long term)

- Reduce size & material of retroreflectors & launchers
- Make transition from optical to infrared (exploit telecom technology)
- Higher bandwidth measurements

Power delivery and vibrations

- KPIX chips are inherently compatible with pulsed power and that has been verified.
- Vibration studies are planned in conjunction with the development of air cooling, DC-DC conversion, and pulsed power techniques.
- Power delivery needs continuing attention.
  - DC-DC conversion and serial power are the two known options.
  - Of the two, DC-DC conversion is being pursued more actively..
  - Both can reduce total power dissipation, allow cable contributions to material to be reduced, but add their own material contributions.
  - A proper balance should be struck among these.
  - Please see the talk by Satish Dhawan on DC-DC conversion.



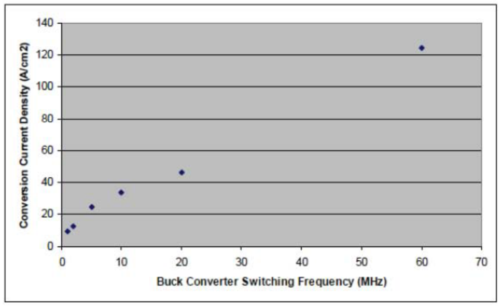


Figure 1: Conversion Current Density for a four phase 120 A, 12 Vin to 1.2 Vout buck converter vs switching frequency.

M.A. Briere IEDM 2010

Tentative Power Conditioner Locations