Spacial Resolution Measurements Using a Pixel Detector Telescope at FNAL

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Excellent spatial resolution has been achieved using silicon hybrid pixel detectors developed by Hughes Aircraft Company. A telescope of three detectors was placed in a high energy beam of muons at the Fermi National Accelerator Laboratory. Each pixel detector was 0.77 cm square, having 256 pixels on a side, each 30 microns square. Data were taken in the angular range of 0-45 degrees to the normal to the surface of the silicon. Pulse height spectra, signal to noise, and spatial resolution data are presented. The read-out electronics and the mechanical set-up are described. Data were taken at approximately 0 degrees C. Details of the data analysis such as raw data filtering, pedestal subtraction, cluster finding, center finding, track finding, alignment methods, gain corrections, cross-coupling effects, and time (temperature) dependences are discussed. The implications of having such high resolution silicon devices available for future physics experiments are mentioned.

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Hybrid Silicon PIN Diode Detector

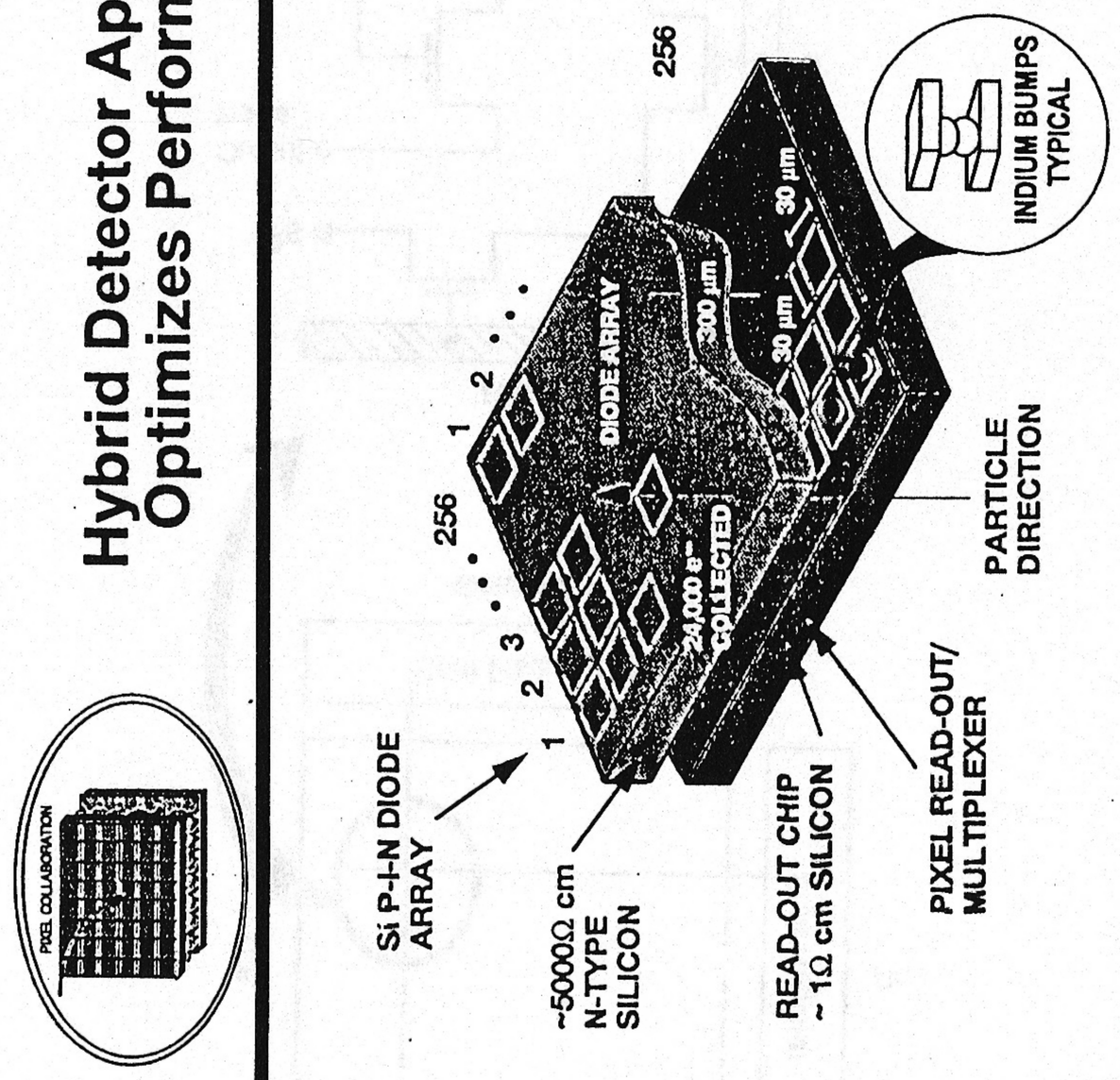
... for charged particle detection in High Energy Physics

- Two separate chips (300 μm thickness each)
  - Silicon PIN diode detector
  - Amplifiers & read-out electronics
- Indium bump bonded together
  - allows for individual optimization of different functions
- Array size: 256 x 256 pixels
  - Sensor arrays by Micron Semiconductors
  - Read-out arrays By Hughes Aircraft
- Pixel size: 30 x 30 μm^2
  - with Indium bumps of < 15 μm in diameter

HUGHES 7729-SP9 MC18

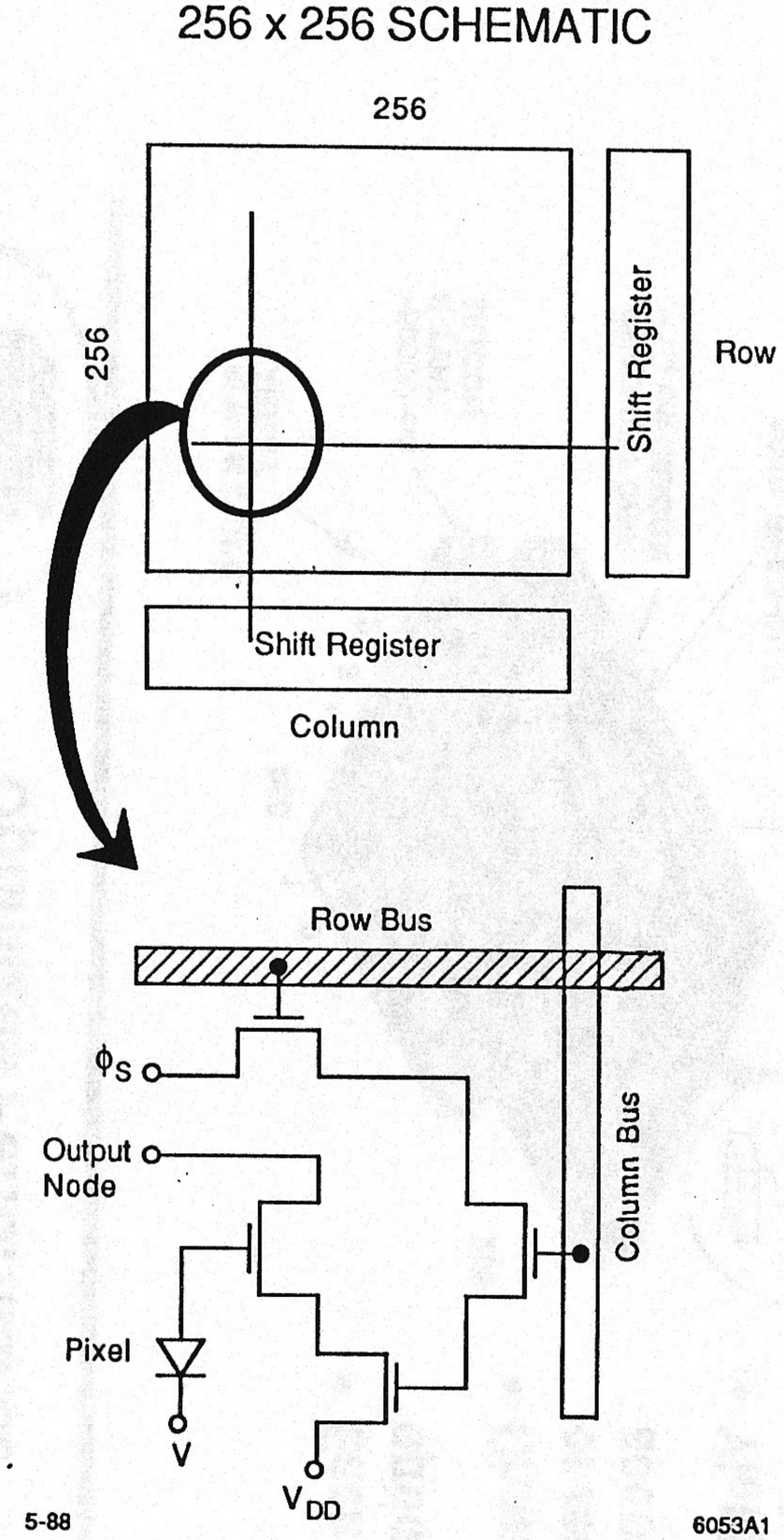
Hybrid Detector Approach Optimizes Performance

- Each element separately optimized
- Changes in detector or readout easily accommodated
- Yield losses in detector and readout processing not compounded



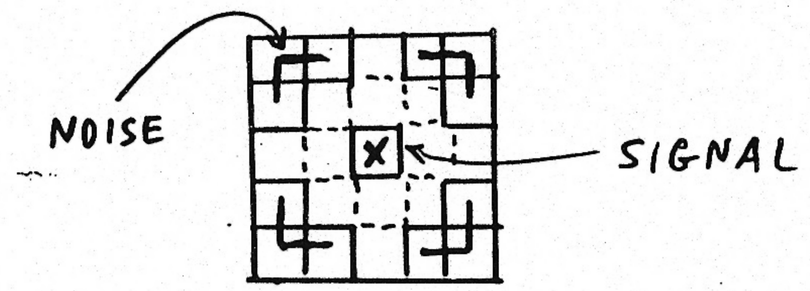
Test Set-up at FNAL

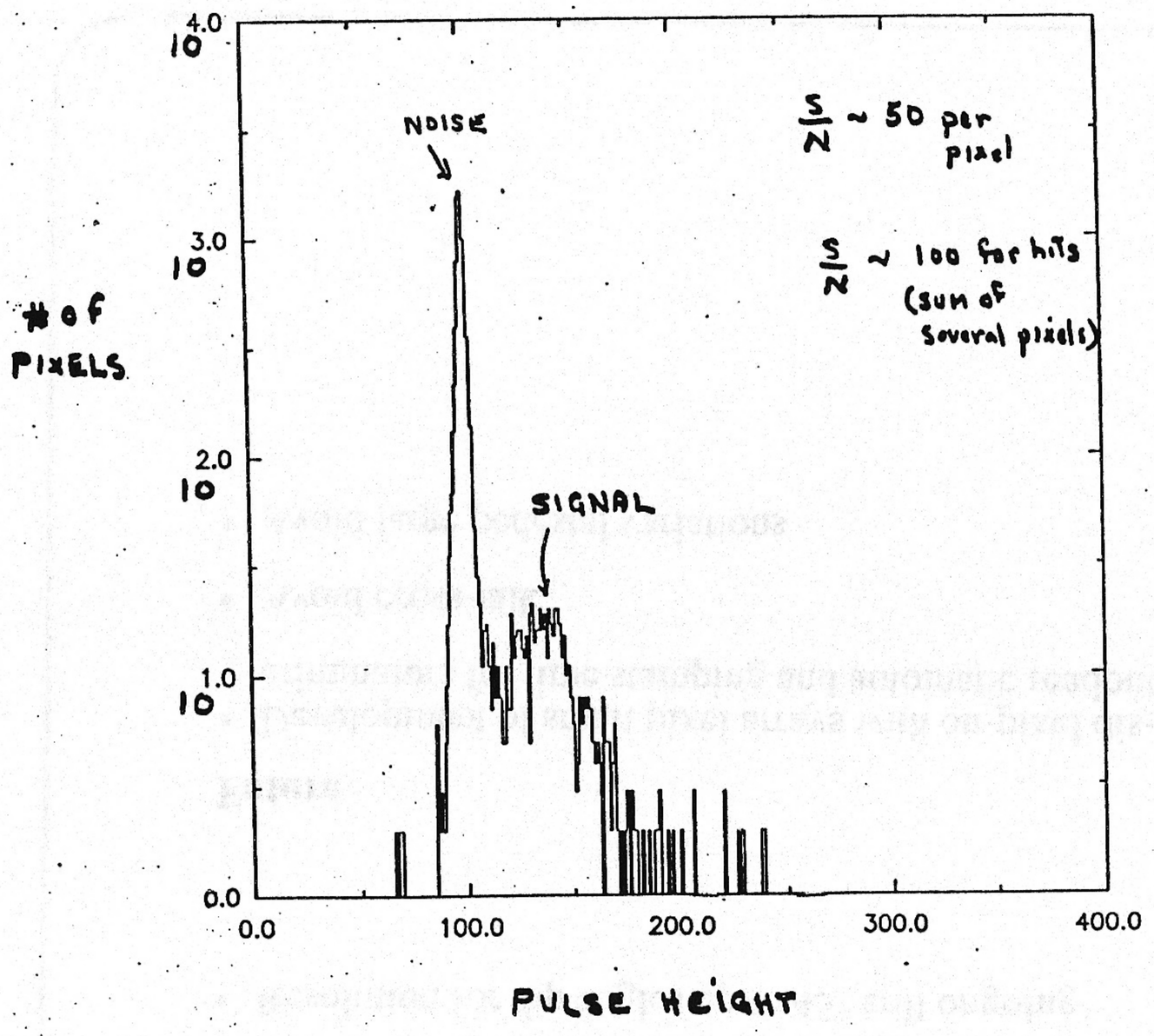
- Muon beam of about 450 GeV/c at Fremilab
- Telescope of 3 detector arrays (on chip carrier cards) mounted on small optical bench
- Center detector was rotated from its normal position at 0^o through a number of angles up to 45^o
- Chips cooled to 0^oC
- Telescope had to be remotely inserted into the beam
- Data Acquisition
  - Si PIN diodes addressed by 8 bits for rows and columns
  - Parallel readout into 6 channels: odd and even columns for three detector planes
  - Data in on-board buffers within 72 ms
  - Data in SPARC workstation within 1 minute



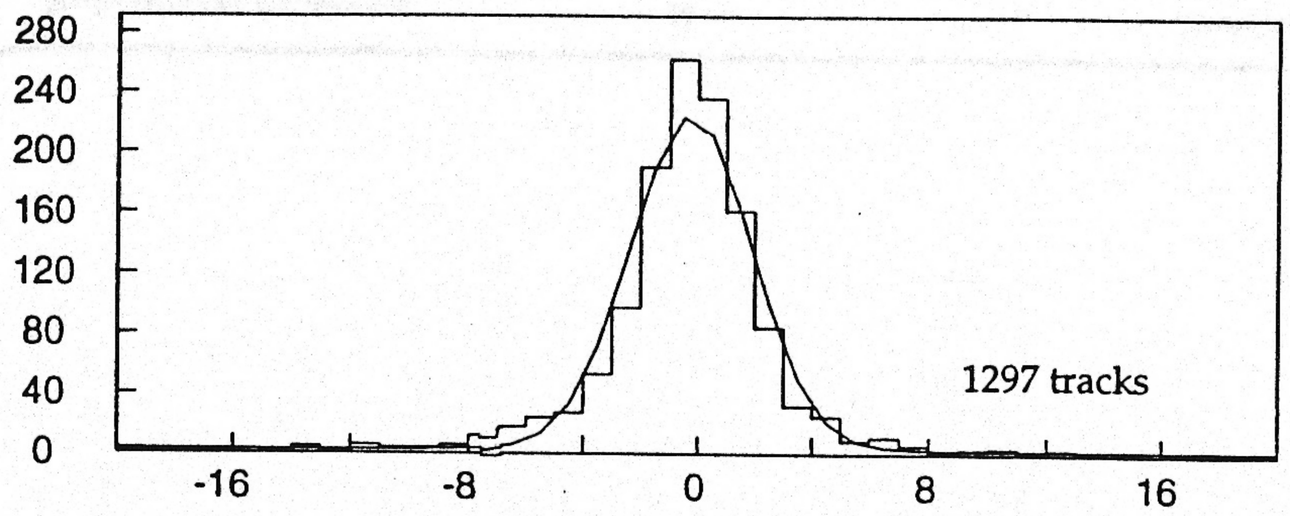
Data Analysis

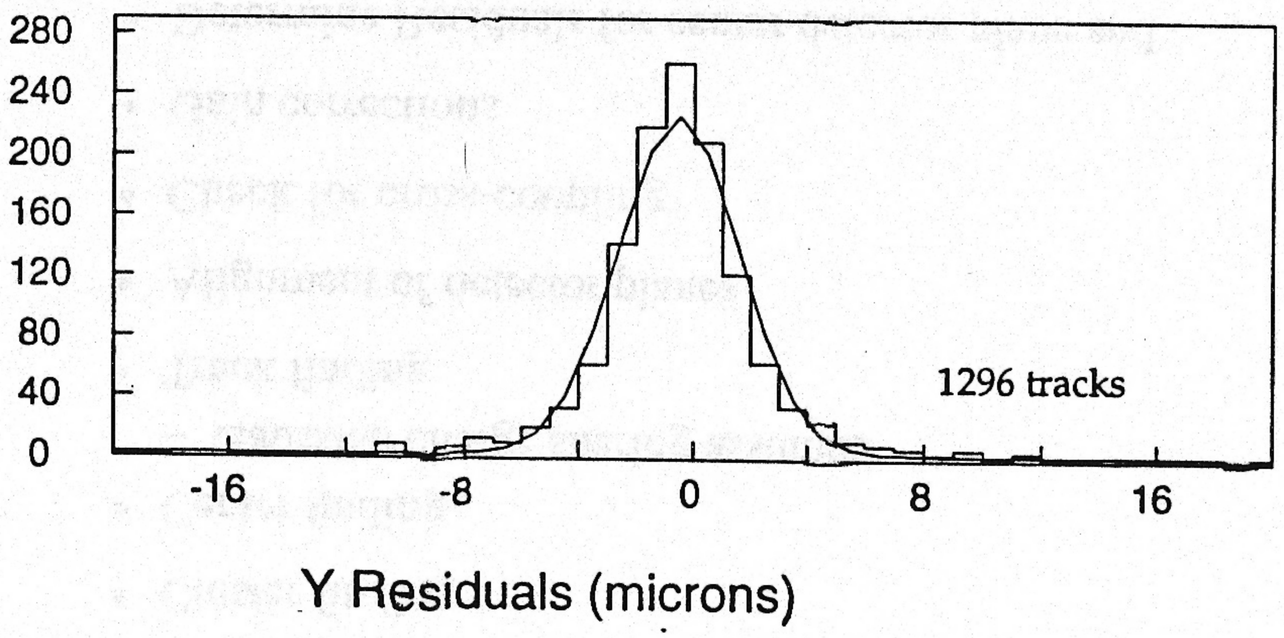
- Pedestal subtraction
- Cluster finding
- Center finding
  - Gaussian charge sharing assumed
- Track finding
- Alignment of detector planes
- Check for cross-coupling
- Gain corrections
- Determine Residuals for center detector plane and calculate Resolution





With all tracks, the resolution is 2.6 ± 0.1 μm in both x and y





Results and Future Development

Results

- Resolution for straight through tracks: 2.6 ± 0.6 μm
  - for tracks within 9 μm of pixel edge: 1.7 ± 0.1 μm
- Resolution for dip angles up to 45° still ongoing

Future

- Development of smart pixel arrays with on-pixel discriminators for time stamping and automatic readout
- Avoid cross-talk
- Avoid large pedestal variations