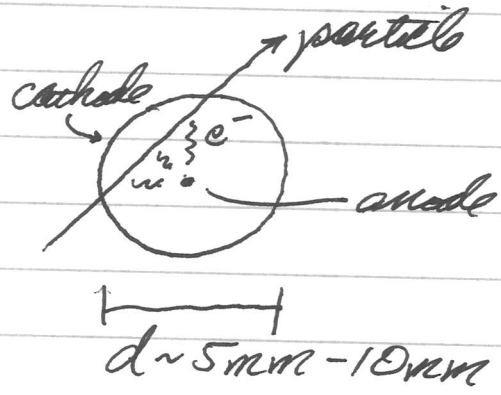
Straw Tube Detectors



→ a tube of aluminized mylar (cathode)
- place thin wire down center

→ can be constructed to be very narrow
- helps in spatial resolution
30 μm achieved!

Advantages
- short drift distance → faster drift times
- more responsive when fast event rates
- ∴ strong magnetic fields have less impact on drift time + spatial resolution

in $\vec{B}$ field

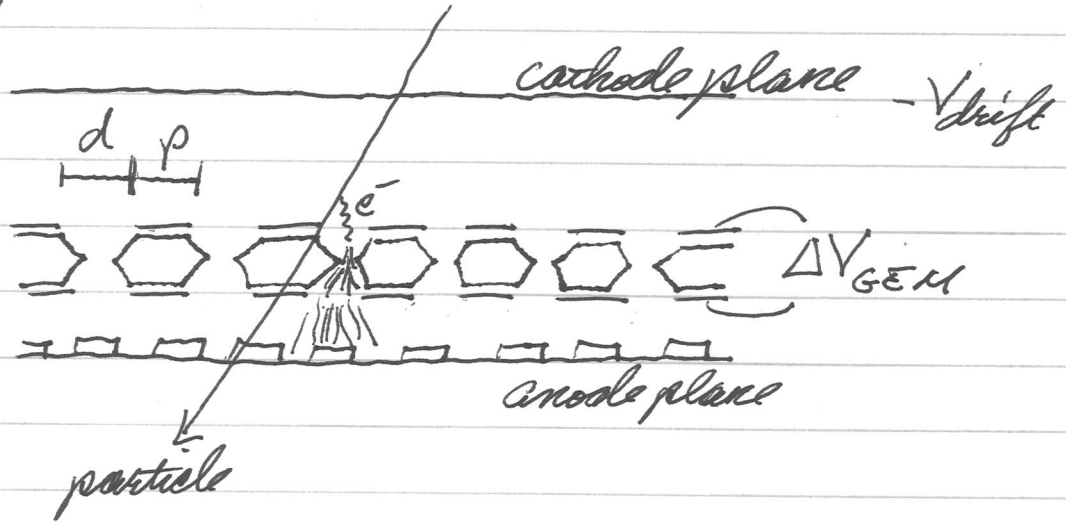
- modular construction

- isolation of wires so one breaking only influences that channel

Example: ATLAS TRT

Gas Electron Multiplier (GEM)

Device structure allowing high multiplication of avalanche in compact detector



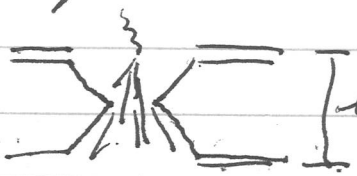
- Place a nonconducting layer of material (eg. kapton foil) in gaseous volume between electrodes

- Conducting film on surfaces of foil
  - chemically treat to have holes

spacing (p) ~ 100 μm - 200 μm
hole diameter (d) ~ 50 μm - 100 μm

Within the device

- conducting layers at substantially different potential



→ multiplication

- allows for large acceleration of drift e⁻ + subsequent multiplication in the gaps

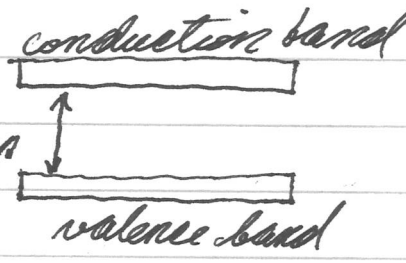
- Overall electric field in volume

- drift electrons go to gaps, multiply, and charge drifts to anodes

Example: eBubble project

Semiconductor Detectors

Band theory:



→ in a semiconductor, a modest energy gap between valence and conduction bands

- excitation of e^- in valence band brings them to conduction (readout)

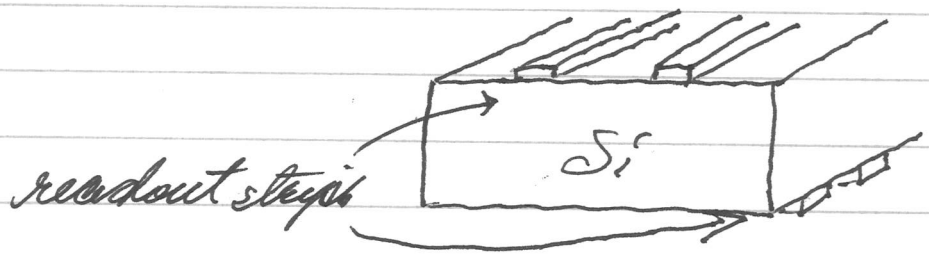
Electrodes can be placed on the surface of silicon (eg.) to enable readout

- segmentation of electrodes then gives sensitivity to spatial coordinates of particle
  - strips
  - pads (2D segmentation: pixels)

Modes of excitation

- ionization (eg. 90 e-hole pairs per 1μm path)
  - more ionization than gas detector → better spatial resolution
- photoelectric effect

Silicon Microstrip Detector



Readout strips

- separation ~ 20 μm
- spatial resolution ~ 10 μm

- similar concept to MWPC

- to obtain second coordinate

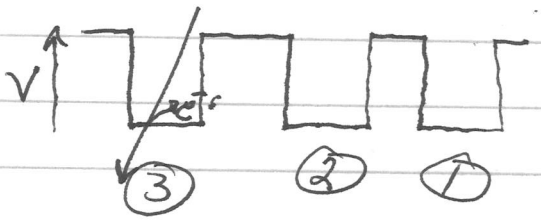
- segment both strips in orthogonal directions (again like MWPCs)

Example: DØ SMT (Silicon Microstrip Tracker)
ATLAS SCT (Semiconductor Tracker)

Pixel Detectors

Can subdivide chip into separated potential wells

20 μm pixel
→ 5 μm spatial resolution



→ electrons remain in wells + propagate to neighbor only when lower potential

eg. readout (1)
→ move charge in (2) to (1) → readout (1) again
→ move (3) → (2) → (1) ...

∴ readout detector pixel-by pixel

Charged-coupled Device (CCD)

- particle physics: ionization detection
  → slow readout, not many e-hole pairs

- astrophysics: photoelectric effect sensitive to incident γ's
  - resolution a fraction of pixel diameter

Example: ROTSE

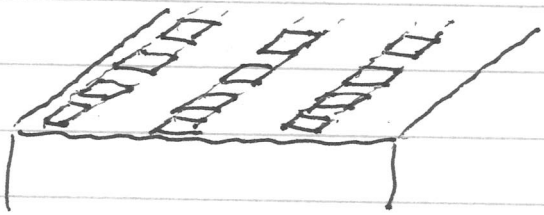
Hybrid Pixel Detector

Try to solve readout time problem of CCD's for high event rate situation

- want the excellent spatial resolution of pixels

Consider the microstrip detector again

- segment each strip in longitudinal direction (i.e. along its length)



Readout each channel individually
→ <u>much</u> faster!

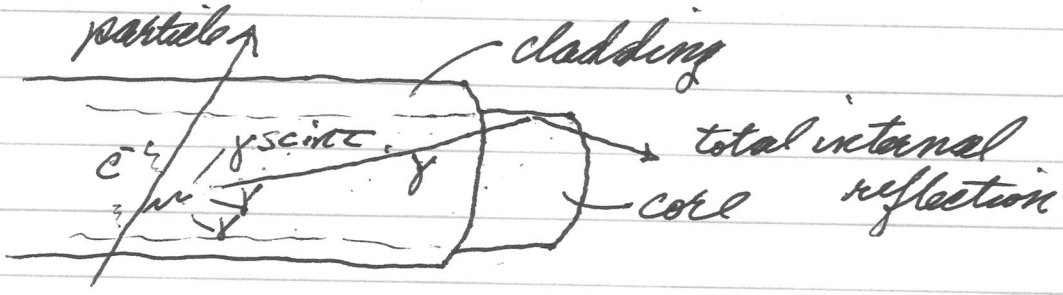
<u>Example</u>: ATLAS Pixel detector

Scintillating Fiber Trackers

A scintillating fiber is a long optical fiber,

- Scintillation produced by additive in the fiber

- glass or plastic macaronis (capillaries) filled with scintillating liquid
- plastic fiber



$n_{air} < n_{clad} < n_{core}$

Fibers usually tens of microns to ~1 mm

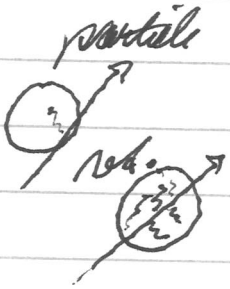
By placing $\perp$ to the path of an incident particle

- multiple layers can provide a measure of the particle's trajectory

- can achieve spatial resolutions as good as gaseous detectors

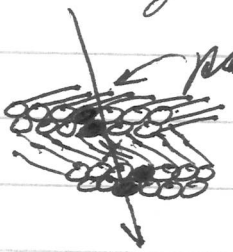
Scintillation light

- very prompt
  - good time resolution
  - appropriate for high rates
- a better fit for tracking than gas drift systems



Extraction of a track

- to obtain coordinate in plane of fiber
  - center of fiber
- second coordinate (along fiber)
  - another layer to run at an angle with respect to the first



pitch angle related to resolution

Readout: photomultipliers, ~~solid~~ semiconductors

Example: D0 Central Fiber Tracker (CFT)