Tracking Detectors

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Why Tracking detectors

- In a particular reaction, we want to know what the particles are and where they went.
- Often we see only decay products
  - $J/\psi \rightarrow \mu^+ \mu^-$, J/ψ lifetime $< 10^{-18}$ sec.
  - Doesn't travel very far, see only decay muons
  - 1974 discovery, Nobel prize

Kinematics

- $M^2 = E^2 - P^2$

  $= (E_1 + E_2)^2 - (\mathbf{P}_1 + \mathbf{P}_2)^2$
- Sets scale for how well you need to measure E and P, magnitude (E,P) and direction
- $E^2 = M^{2+} P^2$ if know type know M.

Tracking Detectors

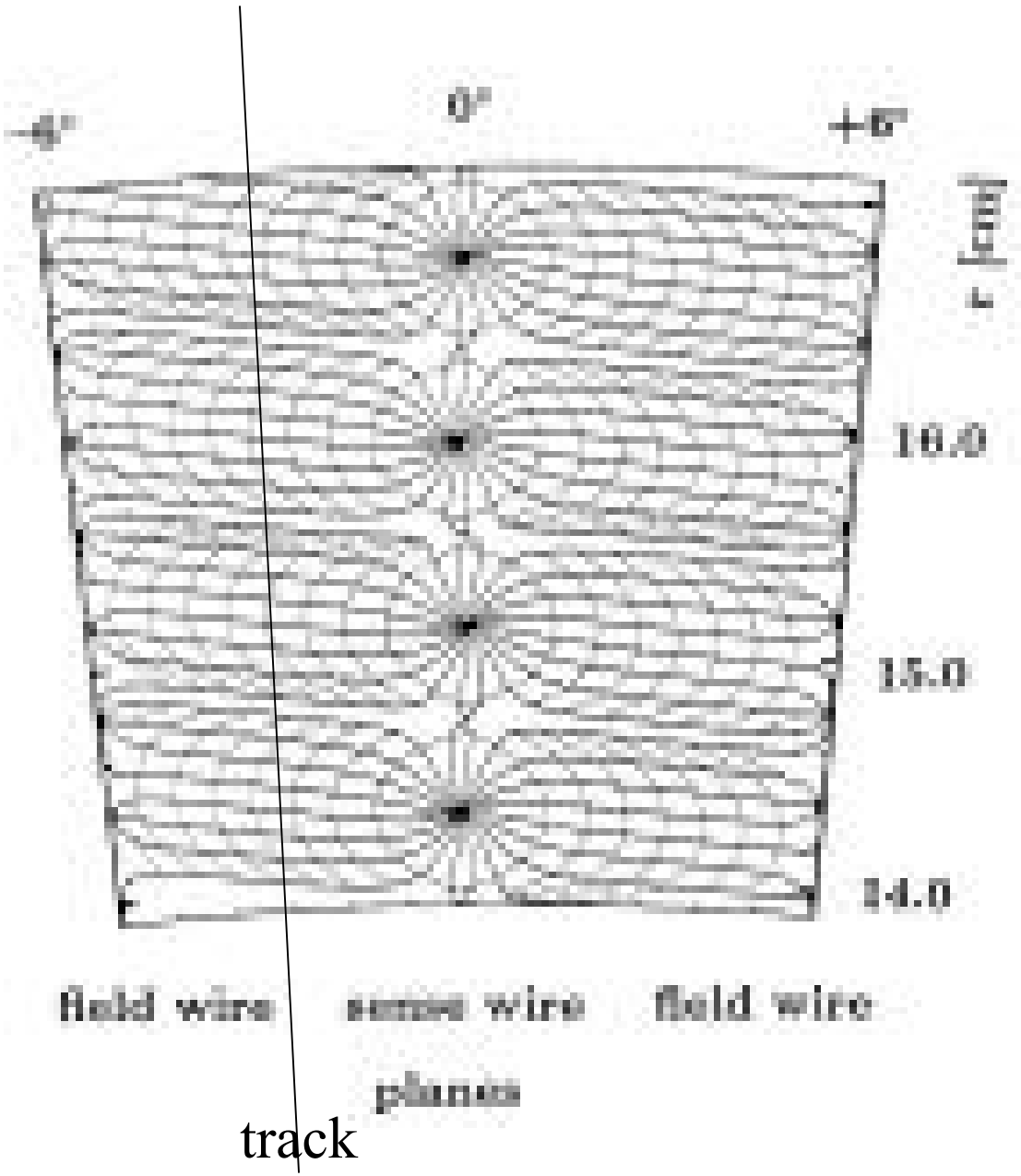
- Tracking detectors measure charged particles
- For neutral particles need calorimeter
  - See Greg's talk tomorrow
- Usually track in a magnetic field so can measure the momentum

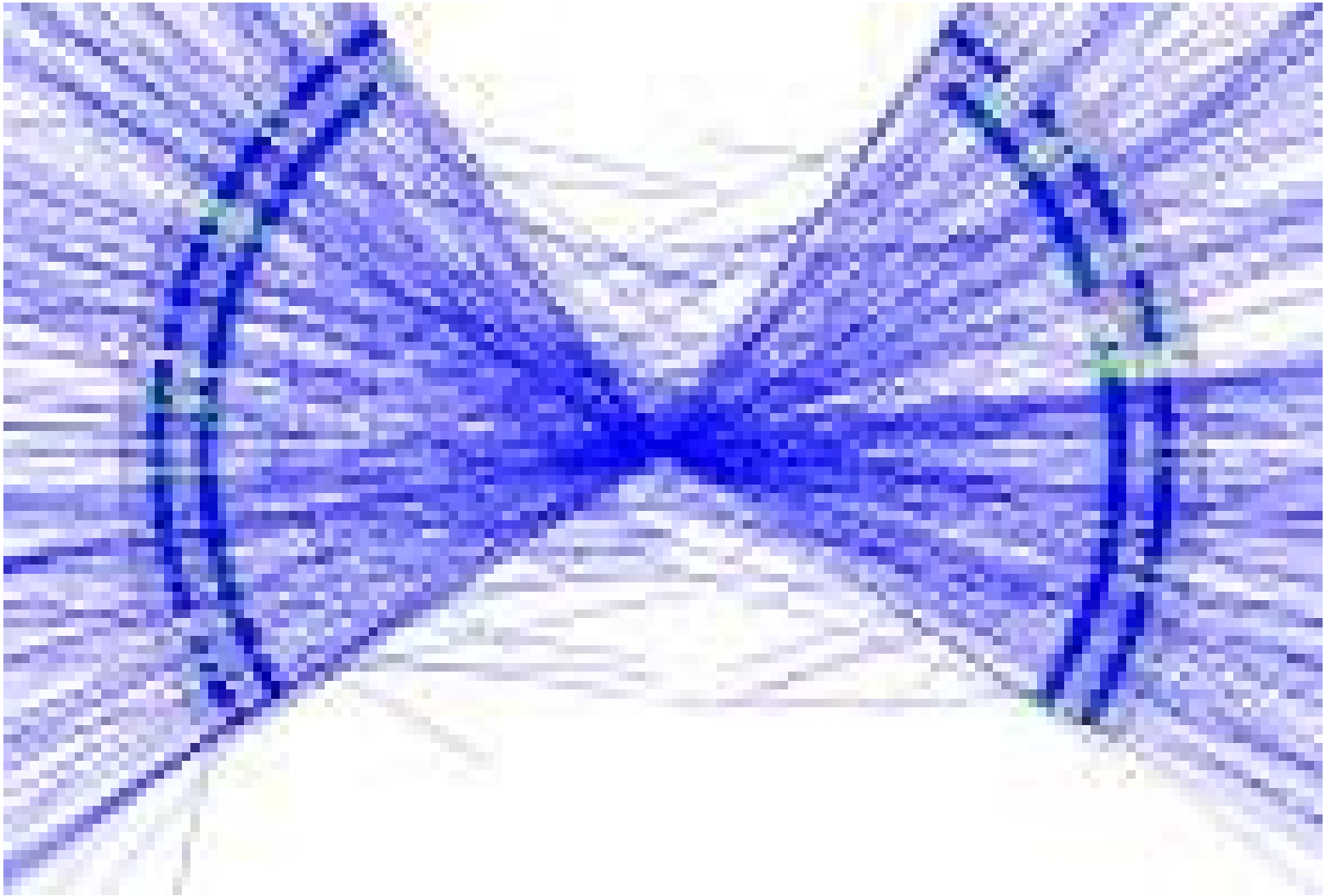
Charged Particle in B Field

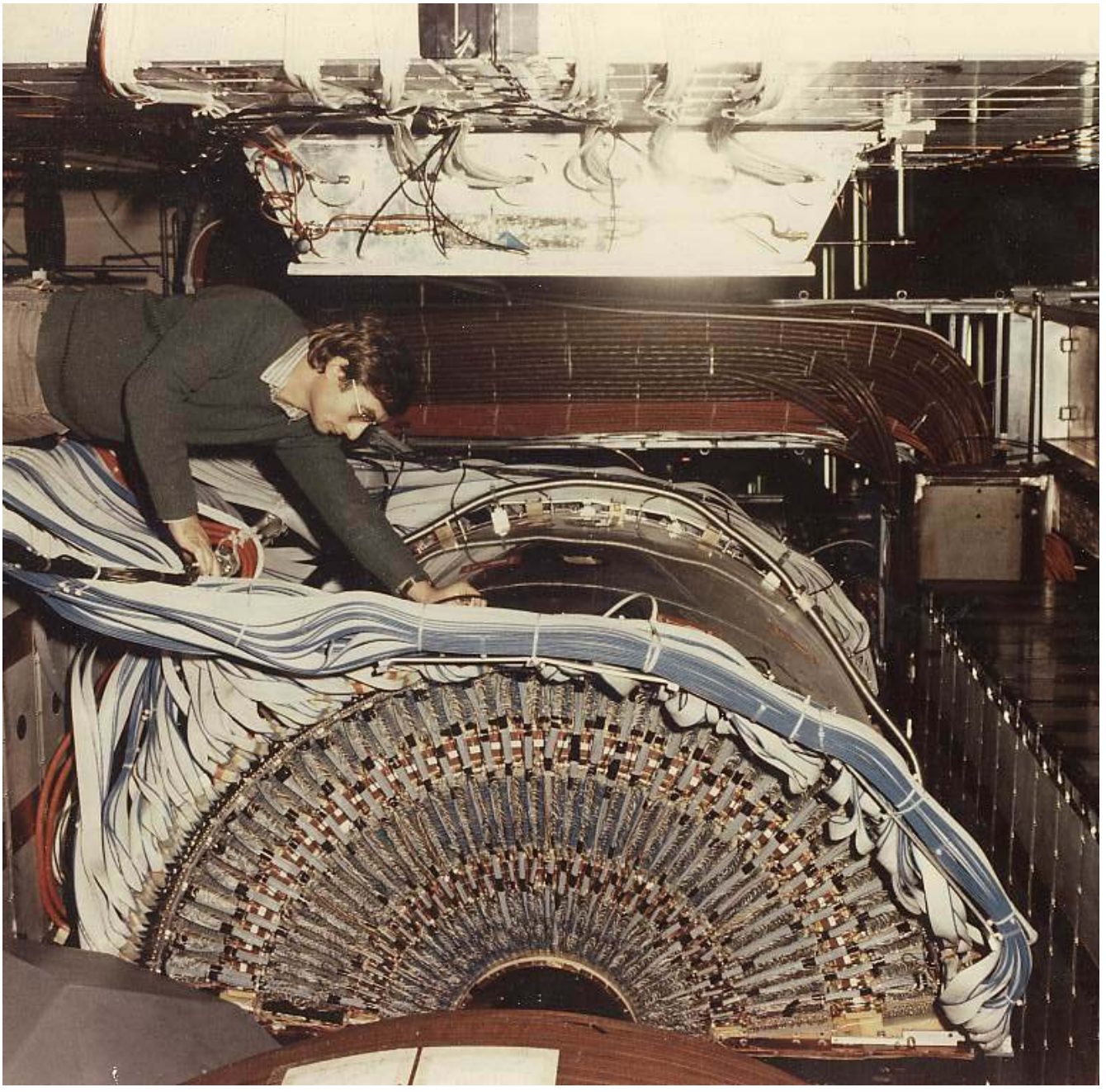
- Lorentz Force, $\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$
- Particle with charge q moves in a helix in a B field of radius of curvature R and pitch angel λ
- $P \cos \lambda = 0.3\ q\ B\ R$
- Units B in tesla, R in meters P in GeV/c
- From position can measure R and λ, B is known, calculate P

Gas Detectors

- Proportional wire chamber and drift chambers.
- General idea, particles go thru gas, electron ion pairs created along the track, drift electrons to wire, measure signal


0°
+6°
10.0
15.0
14.0
field wire
sense wire
field wire
planes
track





More details

- Two sources of error in momentum measurement
  - Position accuracy of detector
  - Multiple scattering
- Gas detectors not much mass, small multiple scattering, but takes 30 eV to make an electron ion pair, low statistics, diffusion, resolution about 100 μ.

Details (cont)

- Trick is to chose the number of measurements and the magnetic field to do the physics you want to do
- Best geometry depends on the experiment
- Resolution improves with B, L^2

Silicon Detectors

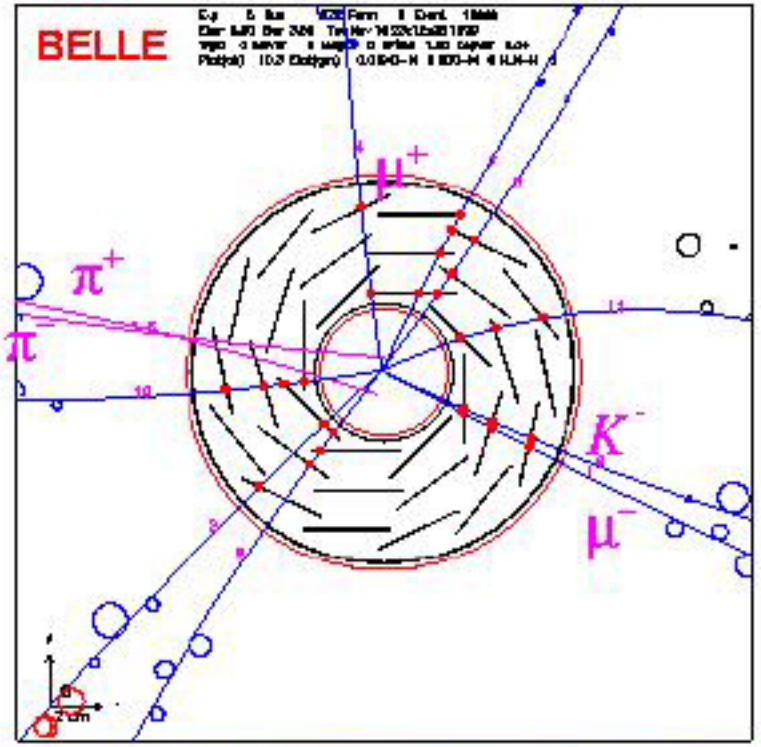
- Same idea except use silicon instead of gas.
- Energy to create electron-hole pair 1/10 that of gas
- Higher density, more multiple scattering
- Can make really small structures. Resolution $< 10\ \mu$

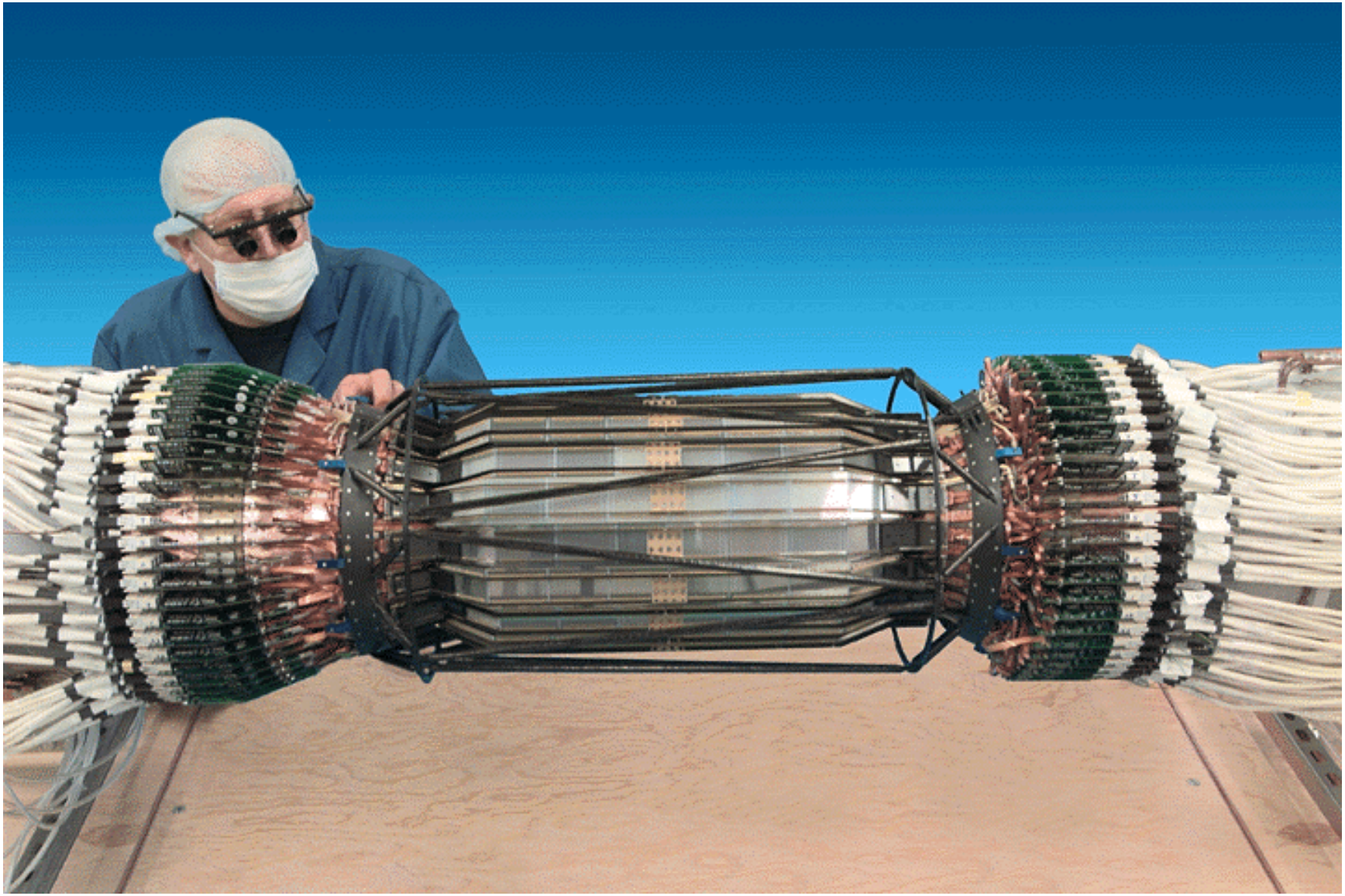
Performance of Belle Silicon Vertex Detector

Masashi Hazumi (Osaka University, Japan)

Outline

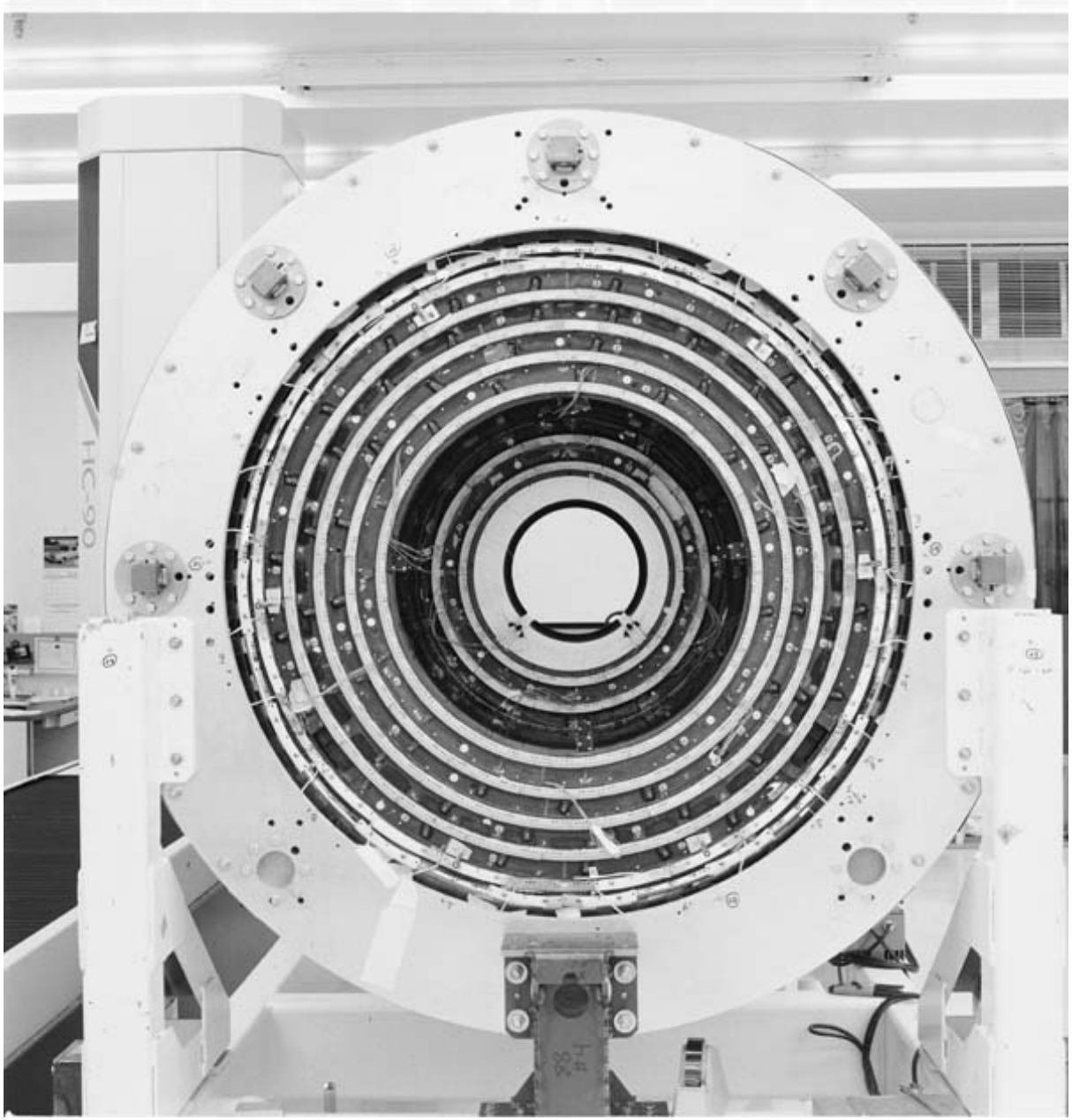
[1] Goal of Belle SVD
[2] System Overview
[3] Performance
[4] Summary





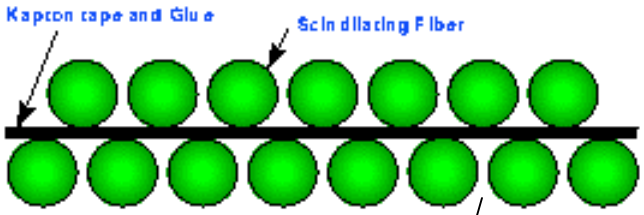
Other

- Can also use scintillator
- Dzero (my experiment) has a scintillating fiber tracker
  - Fibers are about 1mm in diameter
  - Have 8 cylinders of fibers

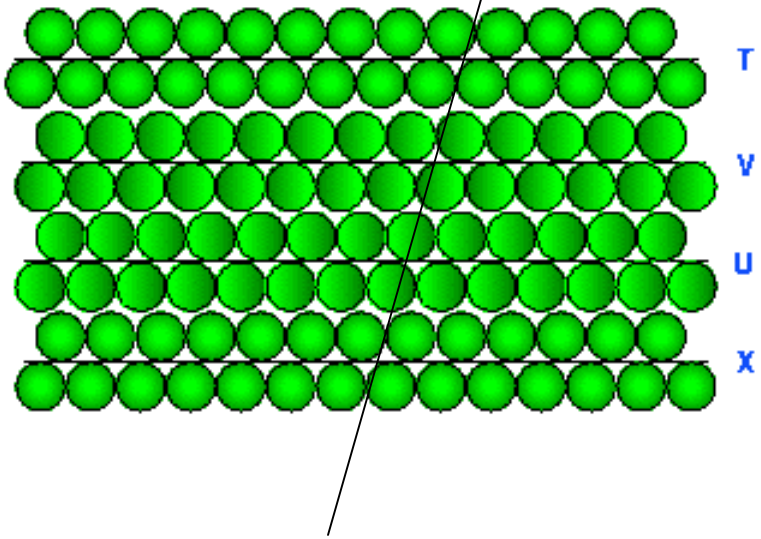

HC-90

Fibers&Ribbons

The schematic layout of a ribbon



The schematic layout of a superlayer



Conclusions

- Track Detectors have resulted in four Nobel prizes
  - Cloud (Wilson), emulsion (Powell), bubble chambers (Glaser), gas detectors (Charpak) (also called wire chambers)
- Resolution gets worse (dp/p) as momentum gets bigger.
  - Calorimeters help for neutrals and at high energies (plug for Greg's talk)