Choice of the Tilt Angle of the Silicon Strip Detector

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Abstract

Argument on the efficiency for 1 GeV/c charged particles recommends the choice of the tilt angle of the SCT silicon strip detector to be ≥8 deg. Position resolution has the very shallow minimun and affects the choice of the tilt angle little.

Angles which offset the incident angle to the detector

- Tilt angle
- Edge-clearance angle of the detector (width)
- Dispersion angle of the 1GeV/c tracks in 2T magnetic field
- Hall angle of electron carriers (in the n-strip readout)

Limit on the incident angle (measured from the drift axis) from the beamtest data[1]

- Hall angle (electron) in the 2 T magnetic field from measurement: 15.7 deg.
- Use the n-side efficiency
- Interpolation from the 50 μm and 100 μm pitch data
- Limit on the charge collected at ≥2 fC
- Partial depletion operation up to 2 x 10^{14} p/cm^2
- Then, incident angle must be < 20 deg. for ~2 x 10^{14} p/cm^2

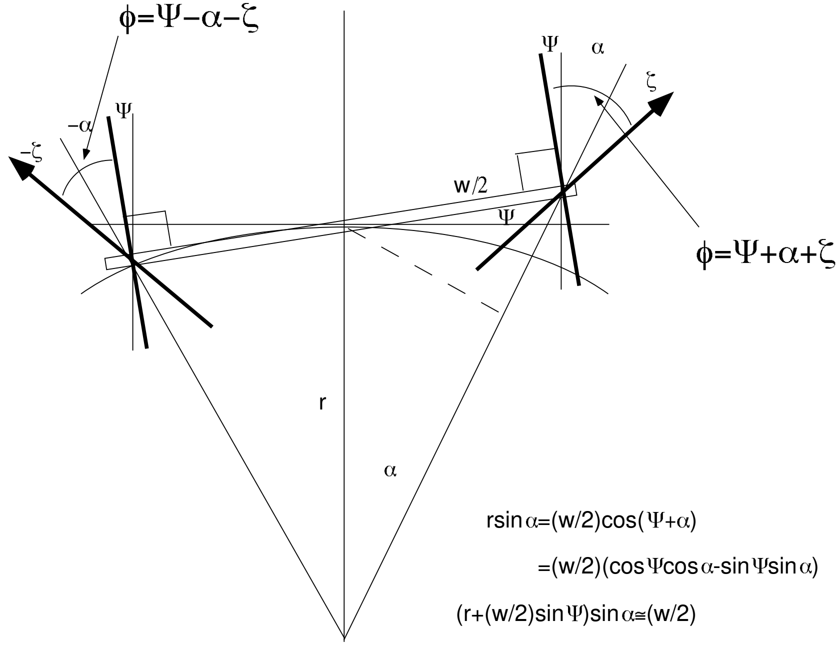
Other considerations

- Material increase with tilt angle (Max at edge)
- Radial spatial separation and overlap to cover the 1 GeV/c particles

Choice

- Tilt angle ≥8 deg

[1] Beam tests of a double-sided detector with fast binary readout before and after proton irradiaton, Y. Unno et al., KEK preprint 96-7, to be published in Nucl. Instr. Metho.



$r\sin\alpha=(w/2)\cos(\Psi+\alpha)$

$=(w/2)(\cos\Psi\cos\alpha-\sin\Psi\sin\alpha)$

$(r+(w/2)\sin\Psi)\sin\alpha\cong(w/2)$

$\alpha=\sin^{-1}\{(w/2)/(r+(w/2)\sin\Psi)\}$

Incident angle(to detector) :

$\phi = [\Psi-\alpha-\zeta,\ \Psi+\alpha+\zeta]$

where
Ψ is the tilt angle
α is the clearance angle
ζ is the track dispersion angle

Incident angle(to drift axis) :

$\phi = [\Psi-\alpha-\zeta-\theta_H,\ \Psi+\alpha+\zeta-\theta_H]$

where
θ_H is the Hall angle (electron)

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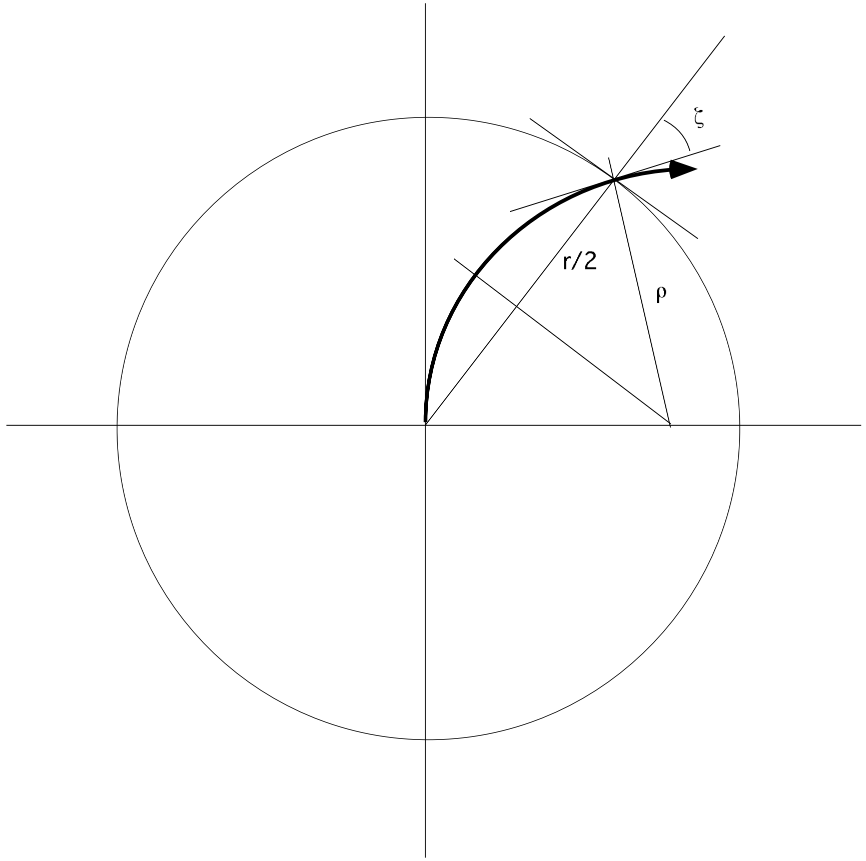
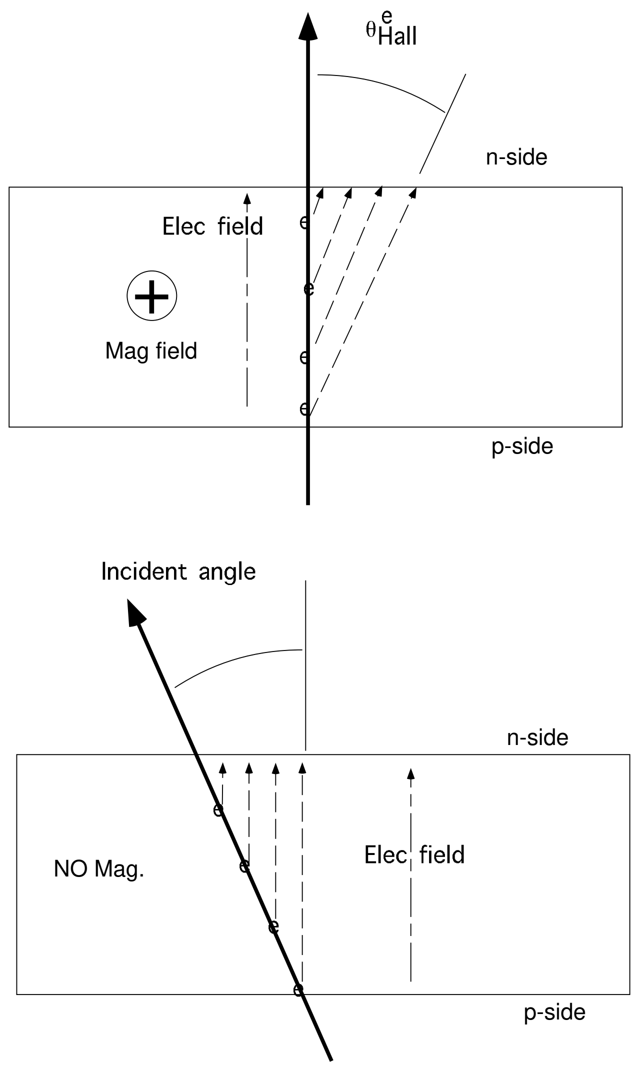
$p=0.3H\rho$

$\sin\zeta = (r/2)/\rho$

$=0.3Hr/(2*P)$

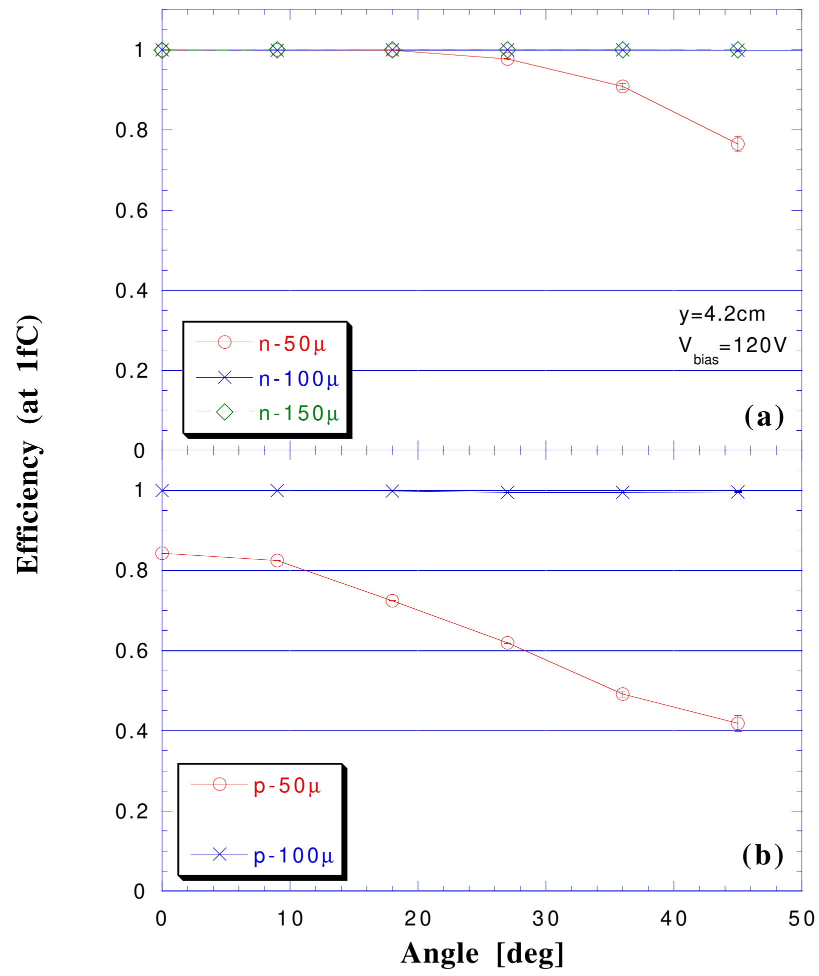


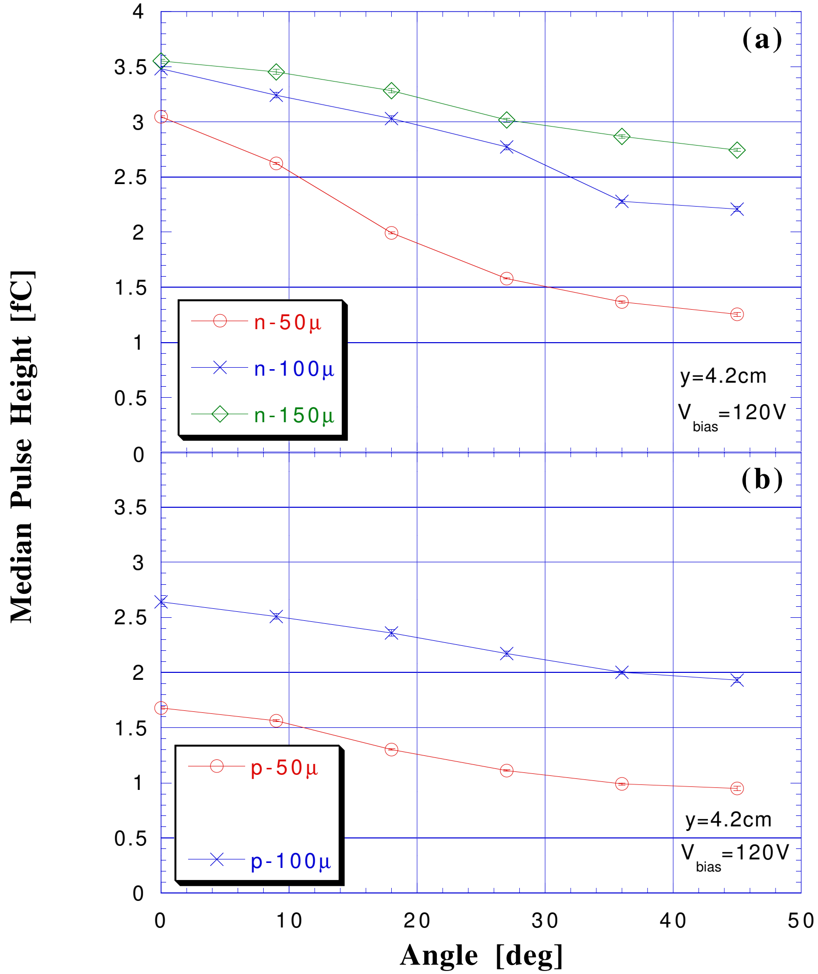
Track dispersion angle to the normal plane



Incident angle(to detector) + Mag. field

≈ Incident angle(to drift axis) + No mag. field





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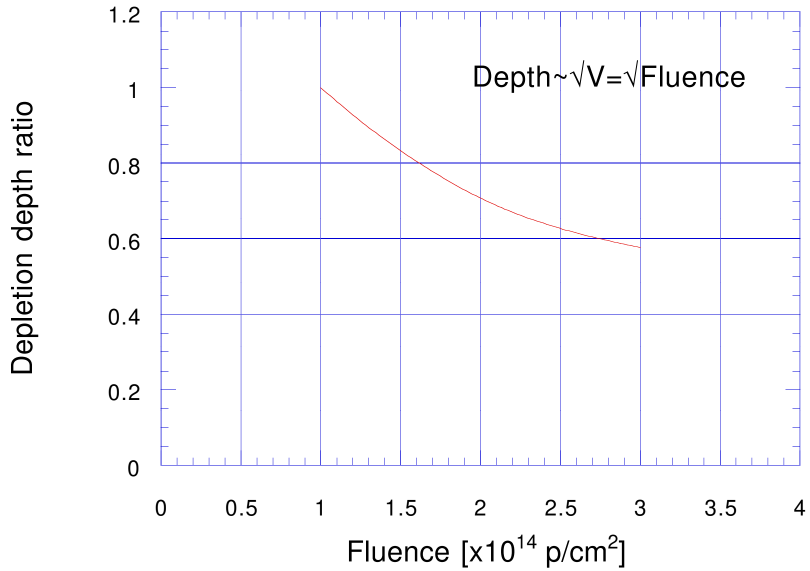
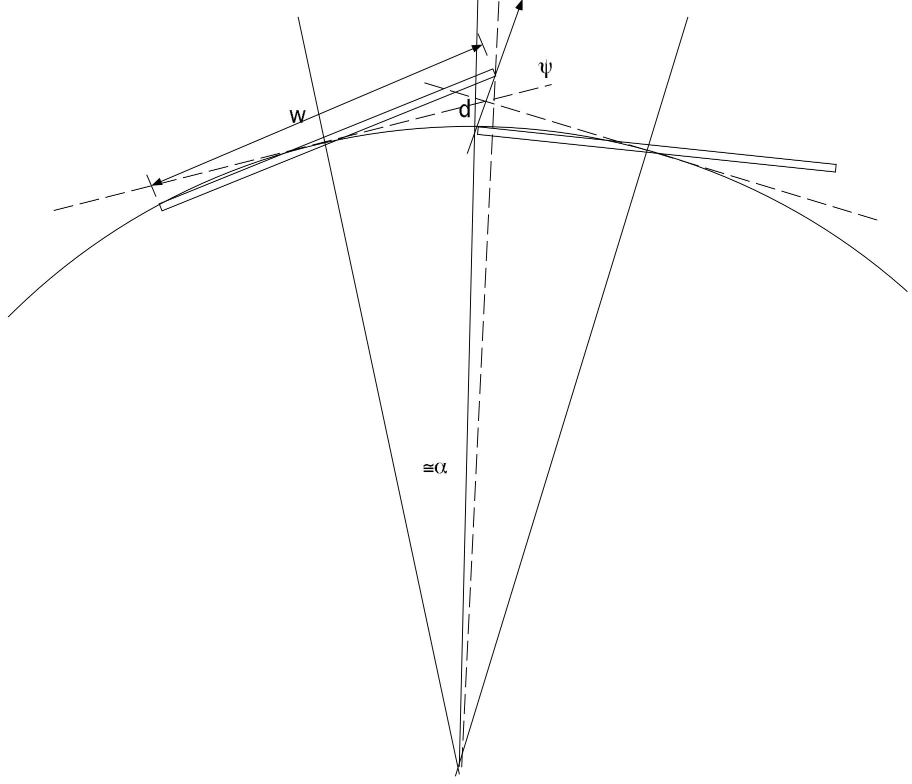


(Approximate) separation:

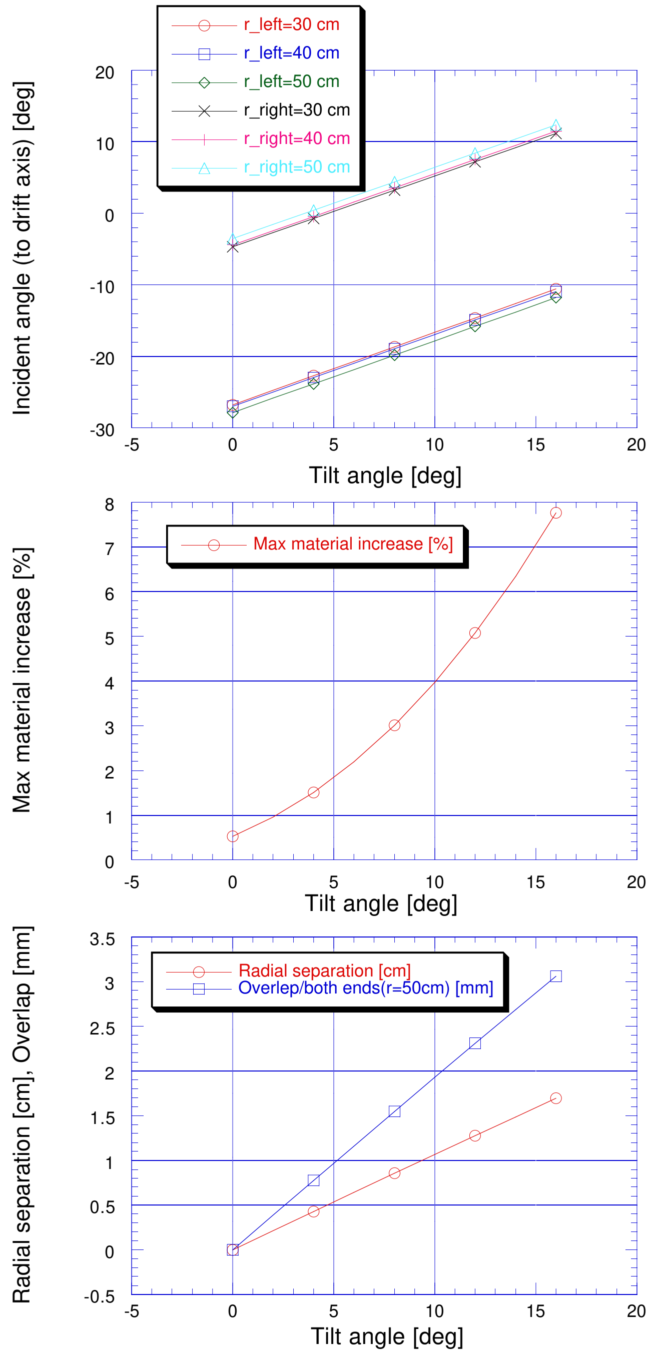
d~=2*(w/2)sin ψ
=w*sin ψ

Required overlap/end:

v=d*tan ζ
=w*sin ψ*tan ζ



Radial separation and overlap requirement



Resolution

- Best resolution at the maximum charge sharing:
  $\tan^{-1}$[pitch/depth]
- Pitch = 80 μ, depth = 300 μ: 14.9 deg.
- Hall angle offset: 15.7 deg

Choice

- Tilt angle: 1 deg

Comment

- Improvement over the nominal resolution of pitch/√12 is small

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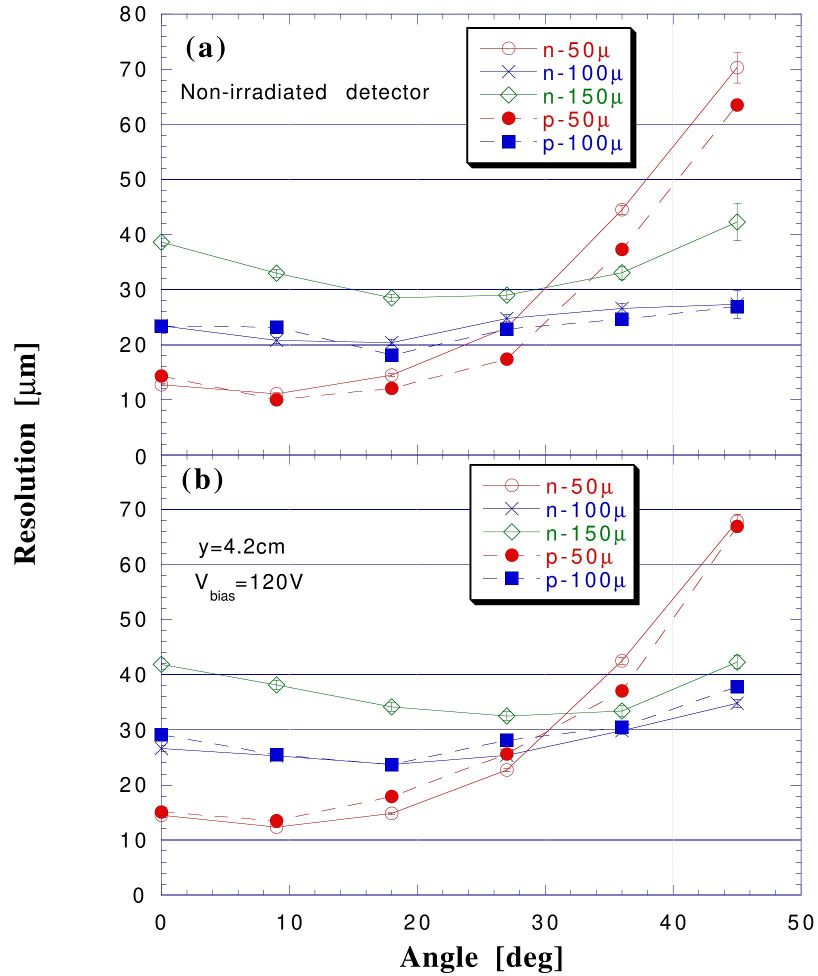

Conclusion

- The best tilt angle for the efficiency is the Hall angle of the electrons, i.e., 15.7 deg.

- To obtain good efficiency for the tracks with their momentum more than 1 GeV/c, the tilt angle of the silicon strip detector in the barrel region is to be Tilt ≥ 8 deg.

- The best tilt angle for the position resolution is the angle to have the maximum charge sharing, i.e., 1 deg., but the minimum is shallow and the resolution is as good as long as the incident angle (to drift axis) <20 deg.

- The smaller the tilt angle, the better the amount of material, and the better the overlap of the adjacent detectors (in circumferential direction).

- A few degree of variation can be allowed for engineers to design the real detector system.

- Thus, the tilt angle: 8 ~ 10 deg.