Tilt angle <==> Crossing angle

In the ATLAS Silicon tracker, several effects will cause tracks to cross the detectors with a finite crossing angle in the r-ϕ plane They will influence the:

Efficiency
Position Resolution
Material Budget(Xo & $$)

Beam tests have been done with varying crossing angles to map out this effect.
We consider here:

Finite detector size: skew [SK]
6.4cm detectors @ min. radius r= 30cm= 6.1deg
@ max radius r= 54cm= 3.4deg

Lorentz Angle: [LA]
2 tesla field, electrons: 2*7.9=15.8deg

Angular opening for 1GeV particles [CP]
@ min radius r=30cm= 5.2 deg
@ max radius r=54cm= 9.3 deg

Sharing

decreases the charge collected on one strip

Crossing angle (ca)	Strips crossed 300*tan(ca)/80
5	0.33
10	0.66
15	1.00
20	1.36
25	1.75
28	2.00
30	2.16

Beyond crossing angle of 15deg,: no single strips hit (always sharing!).

Beyond crossing angle of 28 deg: always sharing of three strips

(The beam test data do not show this because both strips have to collect charges of more than 1fC to show the effect. But the efficiency is affected.)

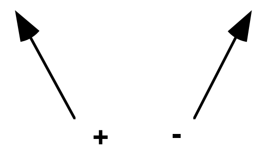
LEFT:
Effective crossing Angle
15.8+6.1=21.9deg
Positive 1GeV Particles: 15.8+6.1+5.2= 27.1
Negative 1GeV Particles: 15.8+6.1-5.2=16.7

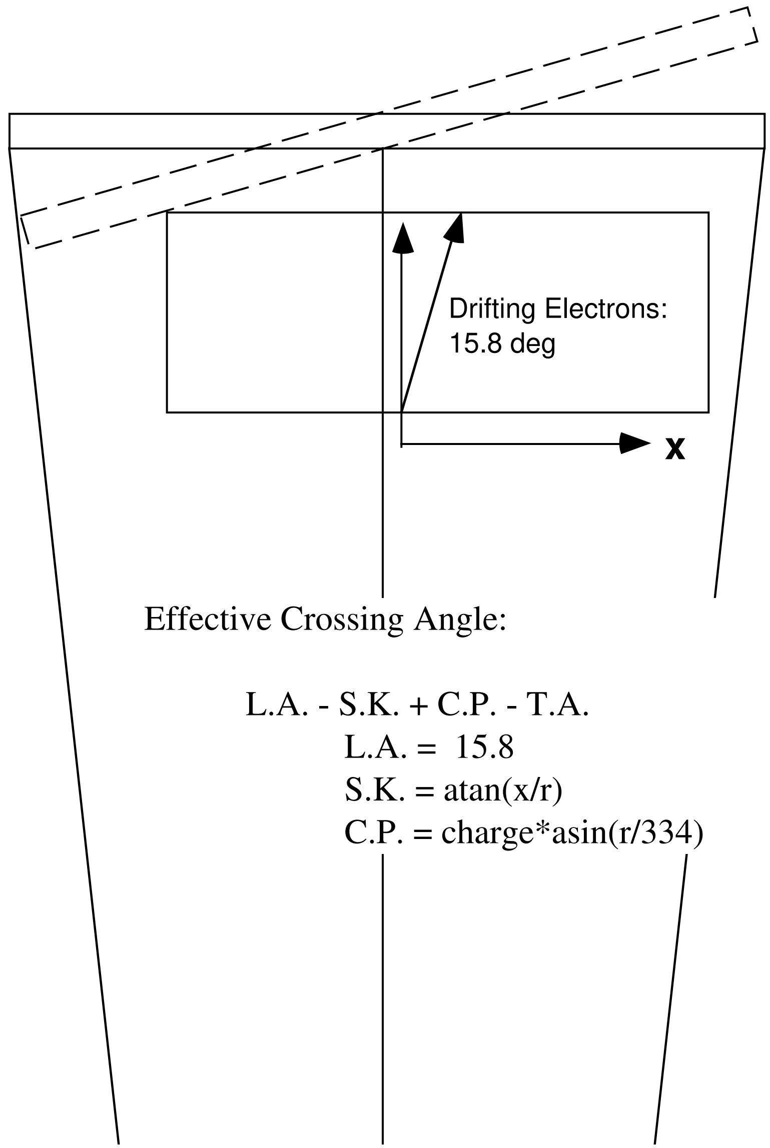
RIGHT::
Effective crossing Angle
15.8-6.1= 9.7deg
Positive 1GeV Particles: 15.8-6.1+5.2= 14.9
Negative 1GeV Particles: 15.8-6.1-5.2= 4.5

Lorentzangle:: 2*7.9=15.8 deg

Finite size arctan (3.2/30) = 6.1deg

1 GeV particles: p=0.3Br, r=1.67m
arcsin(15/167)=5.2deg
arcsin(27/167)=9.3deg





Effective Crossing Angle:

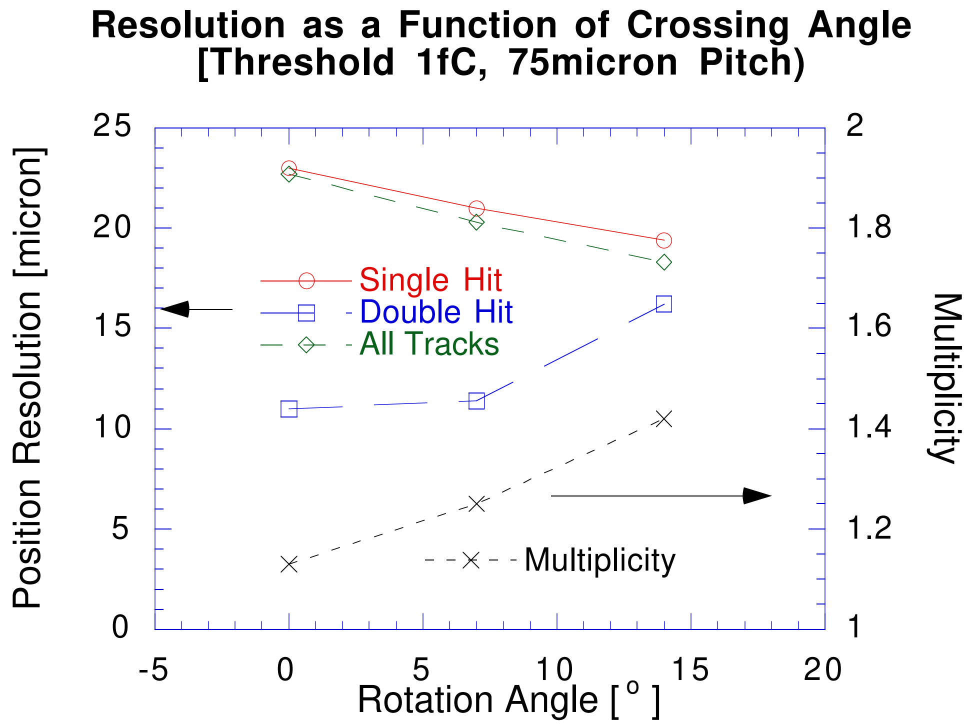
L.A. - S.K. + C.P. - T.A.

L.A. = 15.8

S.K. = atan(x/r)

C.P. = charge*asin(r/334)

Position Resolution: somewhat better for larger angle (sharing)



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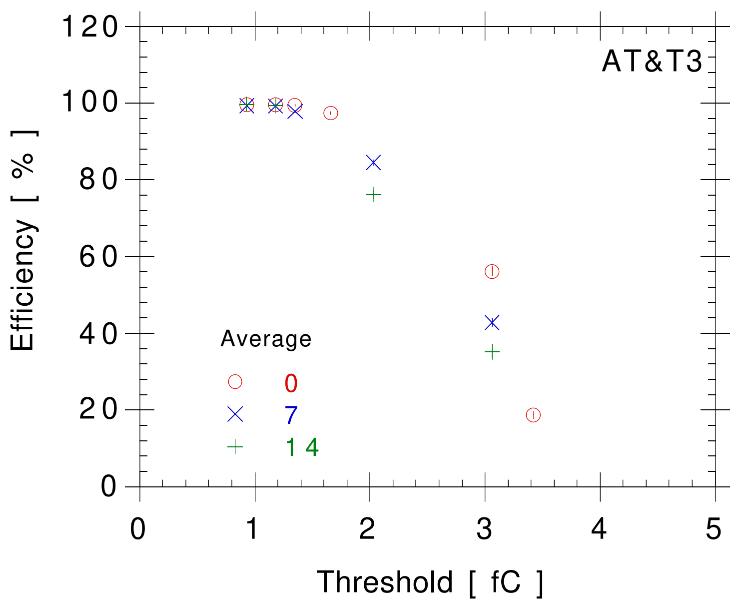
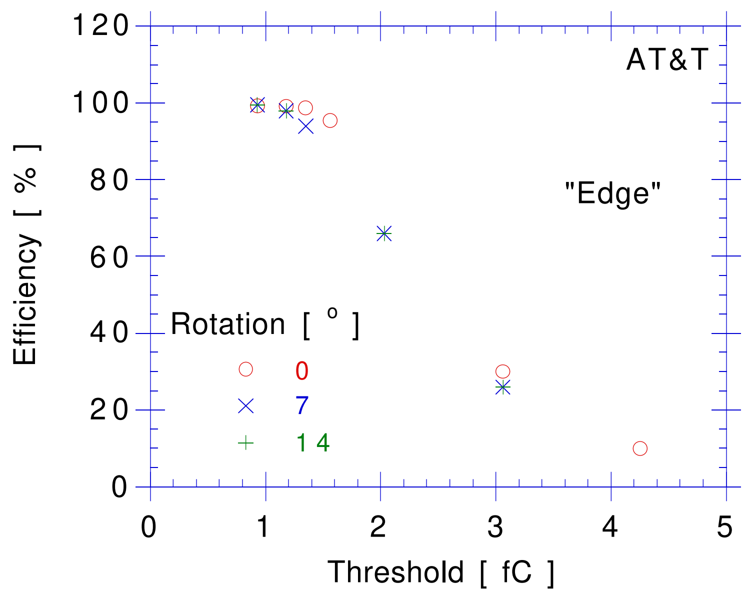
Efficiency: better for smaller crossing angle (sharing)





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Overlap (material+$$) better for smaller tilt angle

Extra Material as a function of tilt angle (ta):

r=30cm

tilt (ta)	Extra Area 1/cos(ta)	Due to gap=tan(ta)*sin(5.2)	Total
5	0.4%	0.8%	1.2%
10	1.5%	1.6%	3.1%
15	3.5%	2.4%	5.9%
20	6.4%	3.3%	9.7%

r=54cm

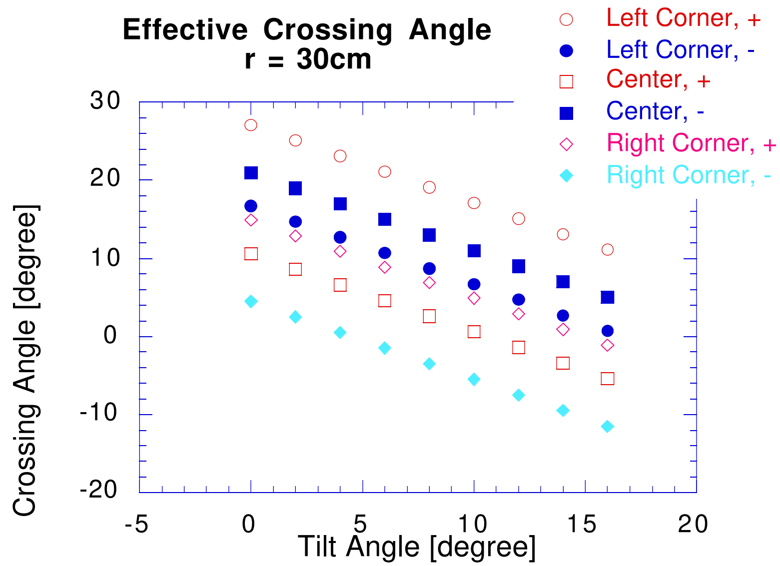
tilt	Extra Area 1/cos(ta)	Due to gap=tan(ta)*sin(9.3)	Total
5	0.4%	1.4%	1.8%
10	1.5%	2.8%	4.3%
15	3.5%	4.3%	7.8%
20	6.4%	5.9%	12.3%

Crossing angle as a function of tilt angle

for three locations on detector and both charges of 1GeV particles

@ r-30cm: LA= 15.8, SK = 6.1CP= 5.2

	LEFT		Center		RIGHT		Av	Max
Tilt	+	-	+	-	+	-		
0	27.1	16.7	21	10.6	14.9	4.5	15.8	27.1
2	25.1	14.7	19	8.6	12.9	2.5	13.8	25.1
4	23.1	12.7	17	6.6	10.9	0.5	11.8	23.1
6	21.1	10.7	15	4.6	8.9	-1.5	9.8	21.1
8	19.1	8.7	13	2.6	6.9	-3.5	7.8	19.1
10	17.1	6.7	11	0.6	4.9	-5.5	5.8	17.1
12	15.1	4.7	9	-1.4	2.9	-7.5	3.8	15.1
14	13.1	2.7	7	-3.4	0.9	-9.5	1.8	13.1
16	11.1	0.7	5	-5.4	-1.1	-11.5	-0.2	11.5
Formula	LA+SK+CP-T	LA+SK-CP-T	LA+CP-T	LA-CP-T	LA-SK+CP-T	LA-SK-CP-T	La-T	



@r=54cm: LA= 15.8, SK = 3.4 CP= 9.3

	LEFT		Center		RIGHT		Av	Max
Tilt	+	-	+	-	+	-		
0	28.5	9.9	25.1	6.5	21.7	3.1	15.8	28.5
2	26.5	7.9	23.1	4.5	19.7	1.1	13.8	26.5
4	24.5	5.9	21.1	2.5	17.7	-0.9	11.8	24.5
6	22.5	3.9	19.1	0.5	15.7	-2.9	9.8	22.5
8	20.5	1.9	17.1	-1.5	13.7	-4.9	7.8	20.5
10	18.5	-0.1	15.1	-3.5	11.7	-6.9	5.8	18.5
12	16.5	-2.1	13.1	-5.5	9.7	-8.9	3.8	16.5
14	14.5	-4.1	11.1	-7.5	7.7	-10.9	1.8	14.5
16	12.5	-6.1	9.1	-9.5	5.7	-12.9	-0.2	-12.9
Formula	LA+SK+CP-T	LA+SK-CP-T	LA+CP-T	LA-CP-T	LA-SK+CP-T	LA-SK-CP-T	La-T