ATLAS project	**Proposal of the new W12 sensor and the forward SCT layout**		
ATLAS Project Document No. **ATL-xx-xx-xxxx**	*Institute Document No.*	*Created:* **03/01/2001** *Modified:* **dd/mm/yy**	*Page:* **1 of 6** *Rev. No.:* **A**

Project breakdown name

Proposal of the new W12 sensor and the forward SCT layout

abstract

Prepared by:	*Checked by:*	*Approved by:*
Y. Unno, KEK	**Blockbold**	**Blockbold**

Distribution List

ATLAS SCT community

History of Changes

Rev. No.	Date	Pages	Description of changes
A	03/01/2001	All	First version

1 Introduction

In response to make the pixel detectors insertable, the inner radius of the forward disks has been increased and the length of the inner ring sensor, W12, has been shrank by 13 mm. Because of this shrinkage, a loss of coverage has been introduced in the forward SCT layout. In order to scoop the loss, a proposal is made in the following way:

1) Widening the width of the W12 sensor. This becomes possible because of the shortening of the length of the sensor. The width of the sensor is correlated to the length of the sensor in order to fit the sensor in the 4-inch wafer.

2) By widening the W12 sensor, the required number of the sensors/modules in a ring will be reduced, and the excess modules can be used to fill the inner ring of the 2nd disk which is the “missing inner ring” disk in the SCT layout.

2 W12 sensor layout in the 4-inch wafer

The layout of the W12 sensor, before shrinkage, was

Upper/lower width: 55.488/43.659 mm,

Length: 74.060 mm, and

Sensors/ring: 40

The upper width of the sensor,55.488, was limited by the length, 74.060 mm, to be within the diameter of 90 mm, the usable diameter in the 4-inch wafer.

In the shrank layout, by 13 mm, a wider layout is possible, which has advantages of

1) maximum usage of a wafer, and

2) as a result, reducing the number of sensors required in the ring of the disk.

The maximum W12 layout in the diameter of 90 mm is a layout with 32 sensors per ring. The layout is

Upper/lower width: 69.483/57.199 mm

Length: 61.060 mm

Sensors/ring: 32

Overlap strips per side: 8

A drawing of the wider W12 sensor is shown in Fig. 1. The overlap strips per side is to allow particles to pass through the adjacent two sensors for alignment. The outer diameter of the sensor is 88.424 mm, which is within the diameter of 90 mm with a margin.

With the wider sensors, the idea is to use the excess sensors in a ring to equip the “missing inner ring” disk, one disk per side, of the narrower sensors. The numbers of W12 sensors, of the wider sensors with 6 “fully equipped” disks per side, and of the narrower sensors with 5 “fully equipped” disks per side, are

Wider W12 sensors: 768 sensors

Narrow W12 sensors: 800 sensors,

With the wider sensors, the number of sensors is reduced by 4%, even with equipping the inner ring of one more disk per side.

The trade-off of the wider sensors is in the strip pitch. The strip pitch, of the upper/lower end, of the narrower sensor is 69.16/54.24 µm. The wider sensor has the pitch of 87.18/71.76 µm. Although the narrower pitch is better in position resolution, the specification of the pitch of the SCT is 80 µm. The wider sensors is matching the specification while the narrower sensor is over specification.

3 Forward disk layout with the new W12 sensors

The “fully equipped” disk with the wider W12 sensors is shown in Fig. 2. The symmetry of the disk is: the inner and the middle ring is 8-fold, and the outer ring is 4-fold.

The loss of the coverage introduced by the increase of the inner radius is to be recovered by adding the inner ring to the 2nd disk, thus making all the full-length disk to be “fully equipped”. In addition, the z-positions of the disks are to be adjusted slightly to match the increased inner radius, according to the lay-out principle of

1) the z-positions of the 1st and the 2nd disks are fixed with the external constraints of required space
2) 4 disk hits for the straight tracks from the +2 sigma displaced vertex position, where the one sigma is 56 mm
3) the z-positions of the 7th, 8th, and 9th disks are determined so that the inner radius of the disks are aligned along the pseudo-rapidity, eta, line of 2.5 with +1 sigma displaced vertex position. The ideal condition is to align along the eta line of 2.5 with +2 sigma, but this is not possible because of the increased inner radii of the upstream disks
4) the outer-most hit is to be as large in radius as possible. The radii of outer-most hits determine the lever-arm of the track and, thus, the resolution of the momenta and the closest approaches. The radii of the outer-most hits swing along the eta. The uniformity of the outer-most radii requires to position the disks in the z-direction in increasing uniformity.
5) the final choice of the z-positions are adjusted by hand to be consistent mutually or almost mutually with the above conditions

3.1 New layout

The new layout derived out of the above conditions is shown in Fig. 3. The pixel layout is reflecting one of the latest arrangement with 3 barrel cylinders and 3 disks/side. The TRT regions are shown in boxes (to be updated).

In scooping the loss of the coverage, there has been another proposal with 5 “fully equipped” and 1 “missing inner ring” disks, by moving the “inner ring” disk of the 1st disk to the 2nd disk and moving the 5th “fully equipped” disk closer to the vertex position. This layout, called “squashed”, is shown in Fig. 4, for comparison.

The SCT layouts are characterized with three variables: number of hits, fraction of ≥4 hits, and the maximum radii of the hits. In the calculation of the hits, the layers are represented only with the “axial” sensors which strips are aligning along the z- or r-direction, i.e., ignoring the “stereo” sensors which are rotated 40 mrad with respect to the ”axial” sensors. The insensitive region of 2 mm in the module, which is the edge region of the two sensors near the middle of the module, is also counted in the calculation. The new layout is shown in the solid (red) lines, while the “squashed” layout is shown in the dashed (blue) lines. The vertices of the tracks are distributed with Gaussian with a sigma of 56 mm.

The characteristics of the distributions are

1) In general, there is a loss of hits in eta around 1.2 which is caused by the gap between the barrel cylinders and the 1st disk. This loss can be avoided if the 1st disk is closer to the barrels by 36 mm. This move of 36 mm is not possible because of the materials in the gap. Every effort, however, should be made to reduce the gap.
2) Number of hits: Except the region in the above, the number of hits is exceeding 4 in all regions in the two layouts. The new layout has more hits than the “squashed” in the eta of 1.75 and 2.3 regions to be more uniform.
3) Fraction of ≥4 hits: In the barrel region, the fraction is 93 to 96%. The loss is due to the 2 mm gaps in the modules. In the forward region, the fraction is better than in the barrel because the

number of hits is ≥4 and close to 5 hits. In several regions, however, the fraction is dropped to about 93% which is again caused by the 2mm gaps where the number of hits is close to 4 or the gaps are aligned. The “squashed” layout has regions where the fraction drops as low as 88%.

4) Maximum radii: The radii swing around 515 mm in the forward region and matching with that of the barrel. The new layout has a smoother variation while the “squashed” has a large swing where the disk spacing has the large gap.

The layout parameters of the new layout is listed in the table 1.

4 Summary

The “insertable” pixel layout requires to increase the inner radius of the W12 sensor by 13 mm. The shortening of the W12 sensors causes the loss of coverage in the forward SCT layout. The loss of coverage, however, can be scooped with the same or the cheaper cost, (1) by redesigning the W12 sensor to be wide to cover the inner ring with 32 sensors, instead of 40 sensors, and (2) by having 6 “fully equipped” disks, per side, instead of 5 “fully equipped” and 1 “missing inner ring” disks. The cost of the inner ring should be as same as or cheaper, because of more efficient usage of the 4-inch wafer, even though adding the inner ring in the 2nd disk.

References

[1] Author(s), “Title”, reference id, date

Figure captions

Fig. 1 W12 sensor

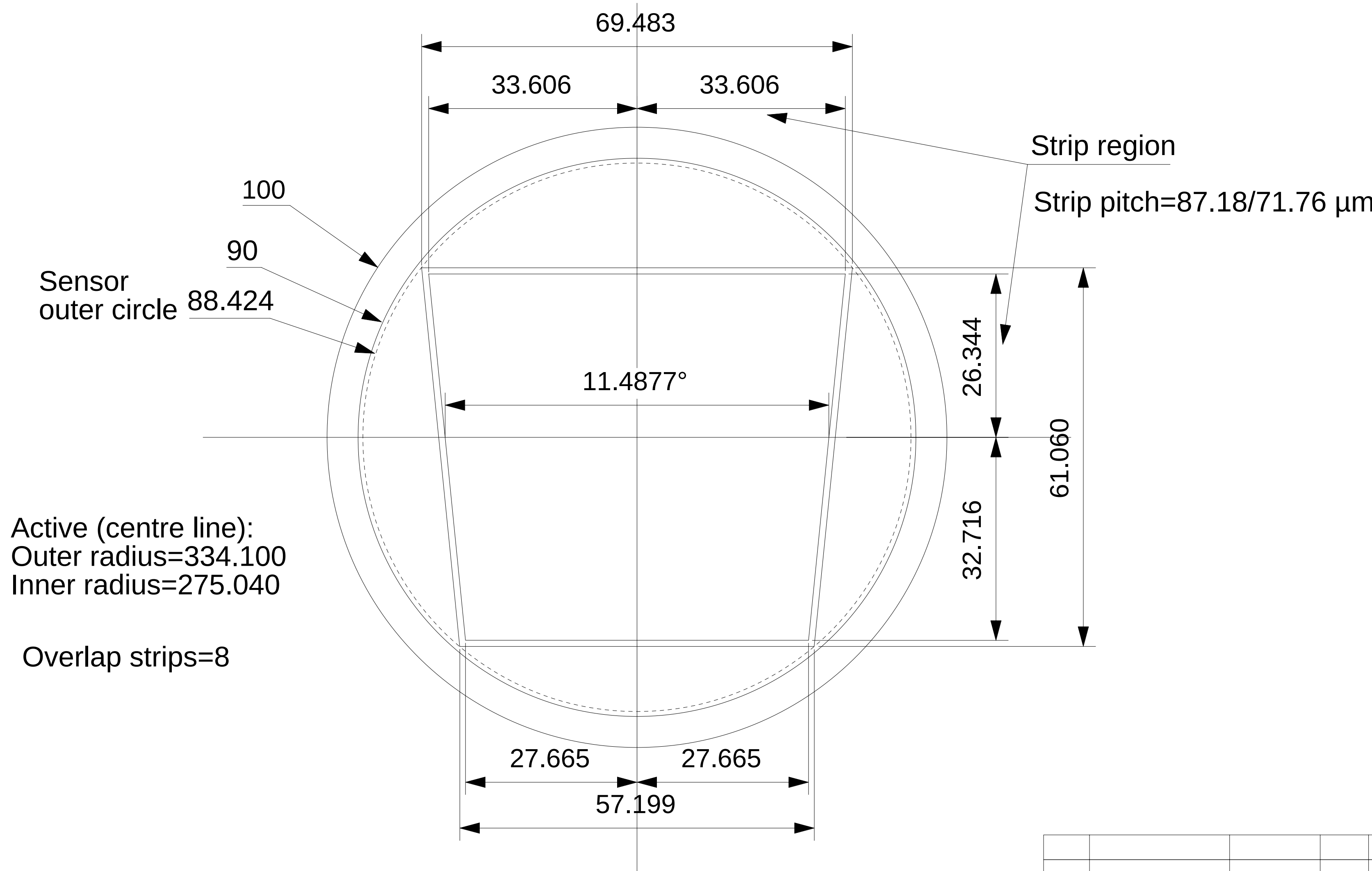
Fig. 2 Fully equipped disk

Fig. 3 New forward layout

Fig. 4 “Squashed” forward layout

Fig. 5 Characteristics of the layouts: Number of disk hits, Fraction of ≥4 hits, Maximum radii

Table 1. Parameters of the new layout



PROJECTION

ISSUE DATE 00/12/27

ITEM NO.	TITLE	MATERIAL	QUANTITY	REMARKS

DESIGNED

DRAWN Y. Unno

CHECKED

SCALE 1/1

PAPER SIZE A4

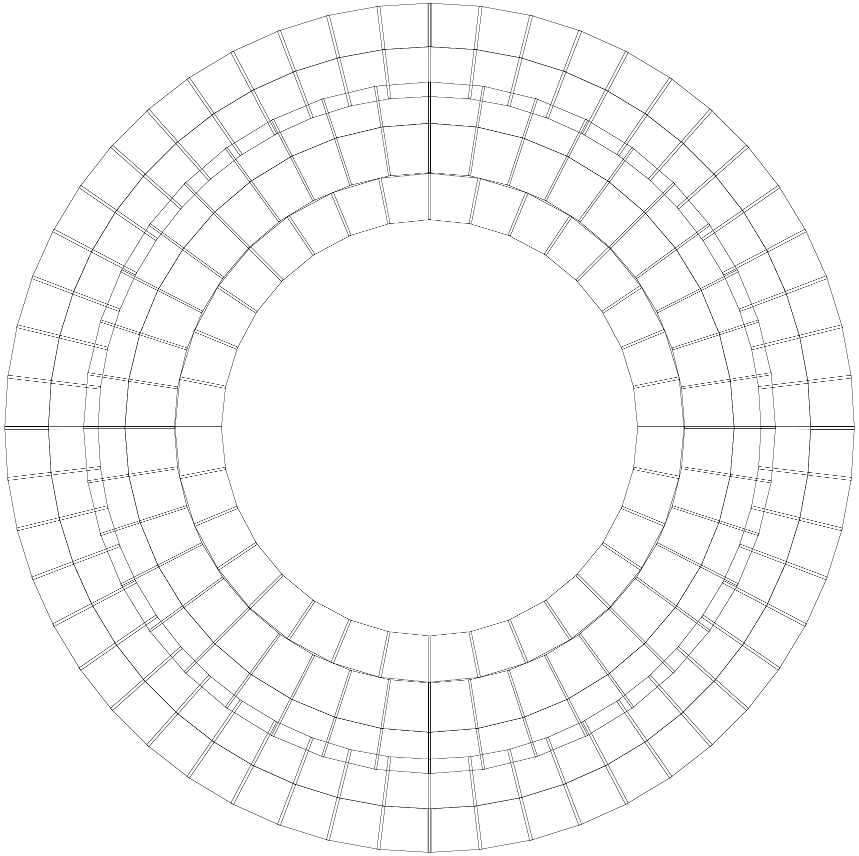
TITLE W12 sensor

DRAWING NO. WS001227-1048A

KEK INSTITUTE FOR PARTICLE AND NUCLEAR STUDIES
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION
OHO 1-1, TSUKUBA, IBARAKI 305-0801, JAPAN

PROJECTION

ISSUE DATE	00/12/28



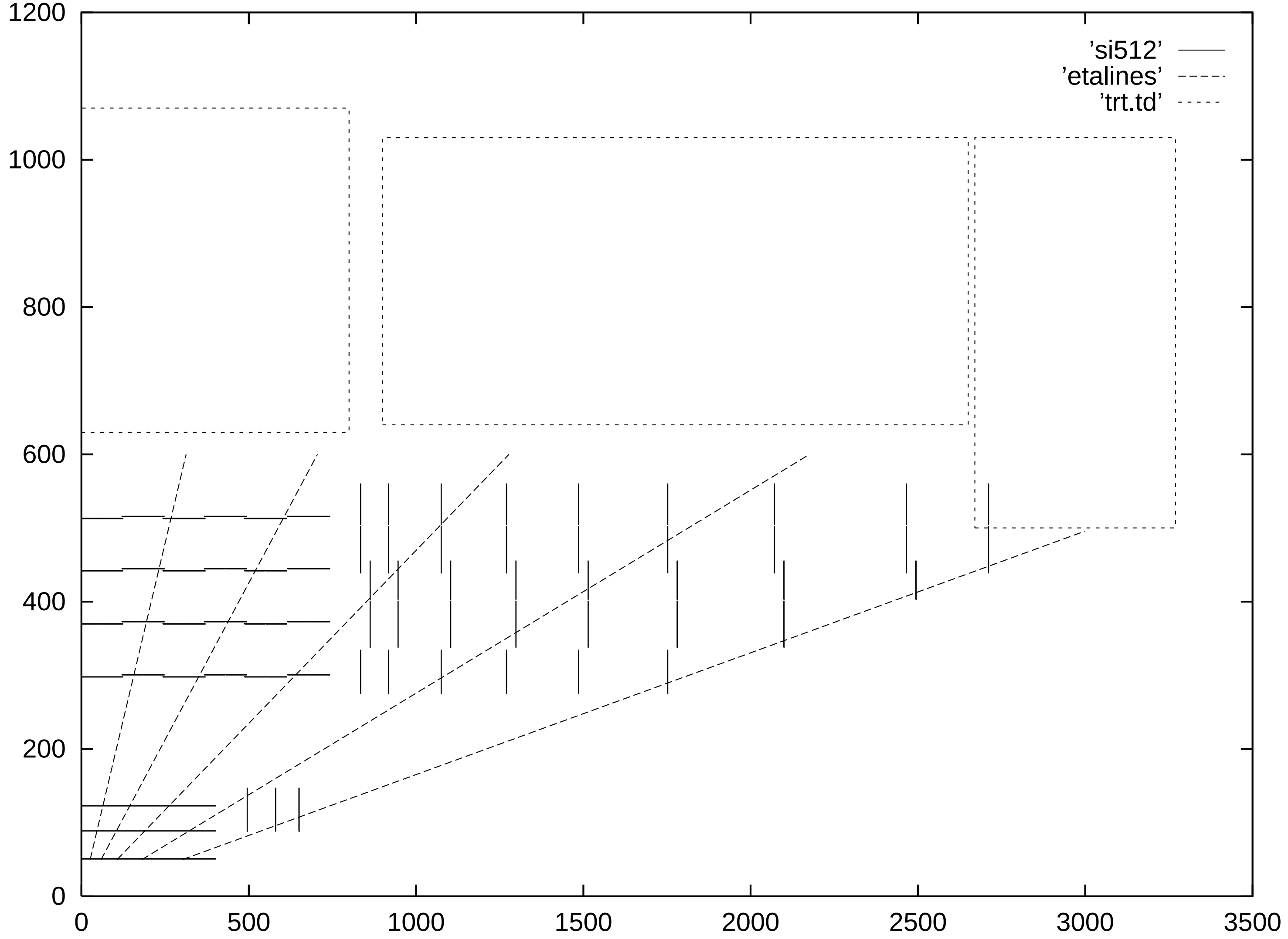
ITEM NO.	TITLE	MATERIAL	QUANTITY	REMARKS

DESIGNED: Y. Unno	SCALE: 1/10	TITLE: Fully equipped disk
DRAWN	PAPER SIZE: A4	DRAWING NO.: FD001228-2100A
CHECKED		

KEK INSTITUTE FOR PARTICLE AND NUCLEAR STUDIES
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION
OHO 1-1, TSUKUBA, IBARAKI 305-0801, JAPAN

PROJECTION

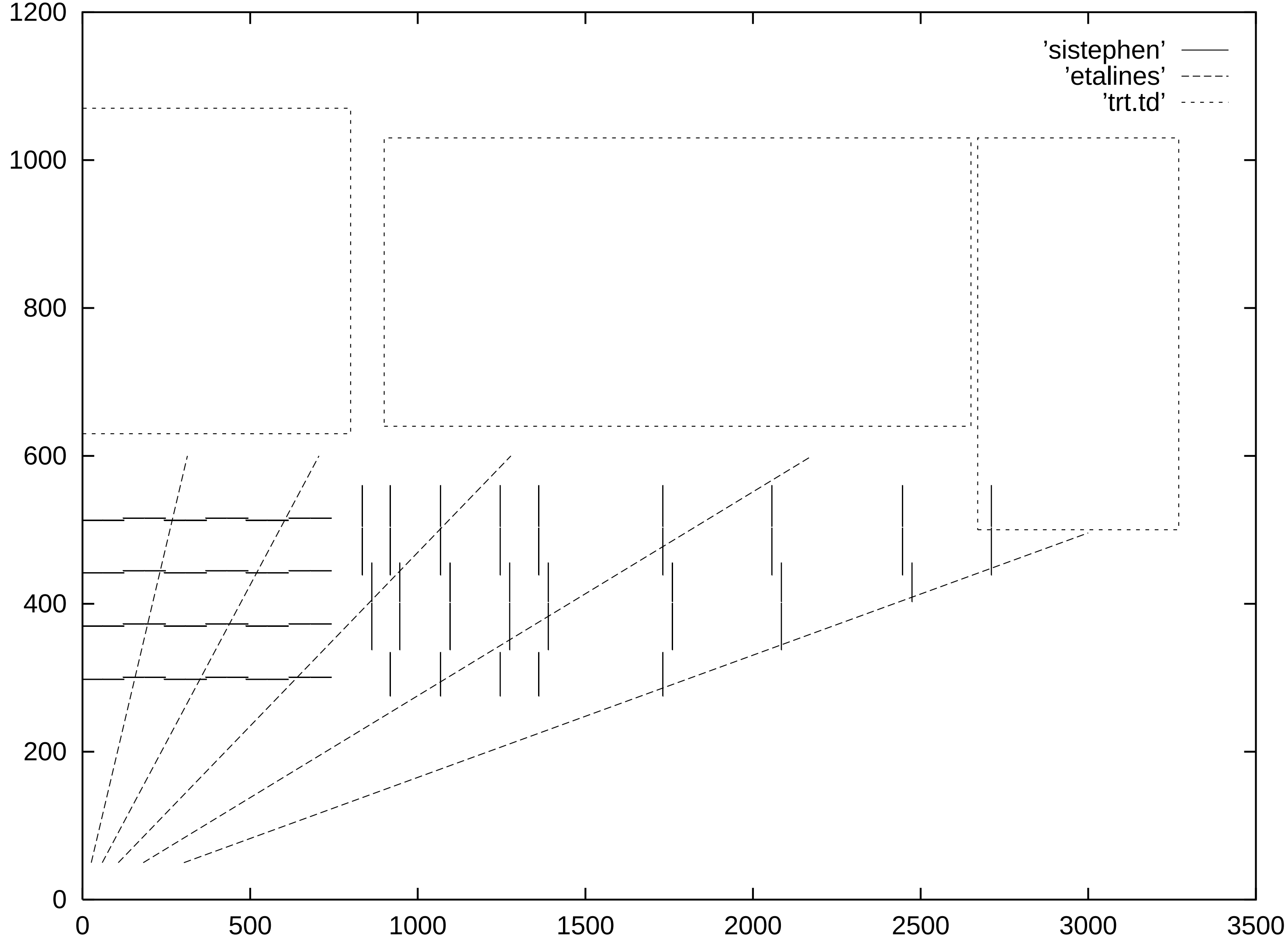
ISSUE DATE



ITEM NO.	TITLE	MATERIAL	QUANTITY	REMARKS

DESIGNED	SCALE	TITLE: New forward layout
DRAWN	PAPER SIZE: A4	DRAWING NO.
CHECKED		

KEK INSTITUTE FOR PARTICLE AND NUCLEAR STUDIES
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION
OHO 1-1, TSUKUBA, IBARAKI 305-0801, JAPAN



PROJECTION

ISSUE DATE

ITEM NO.	TITLE	MATERIAL	QUANTITY	REMARKS

DESIGNED

DRAWN

CHECKED

SCALE

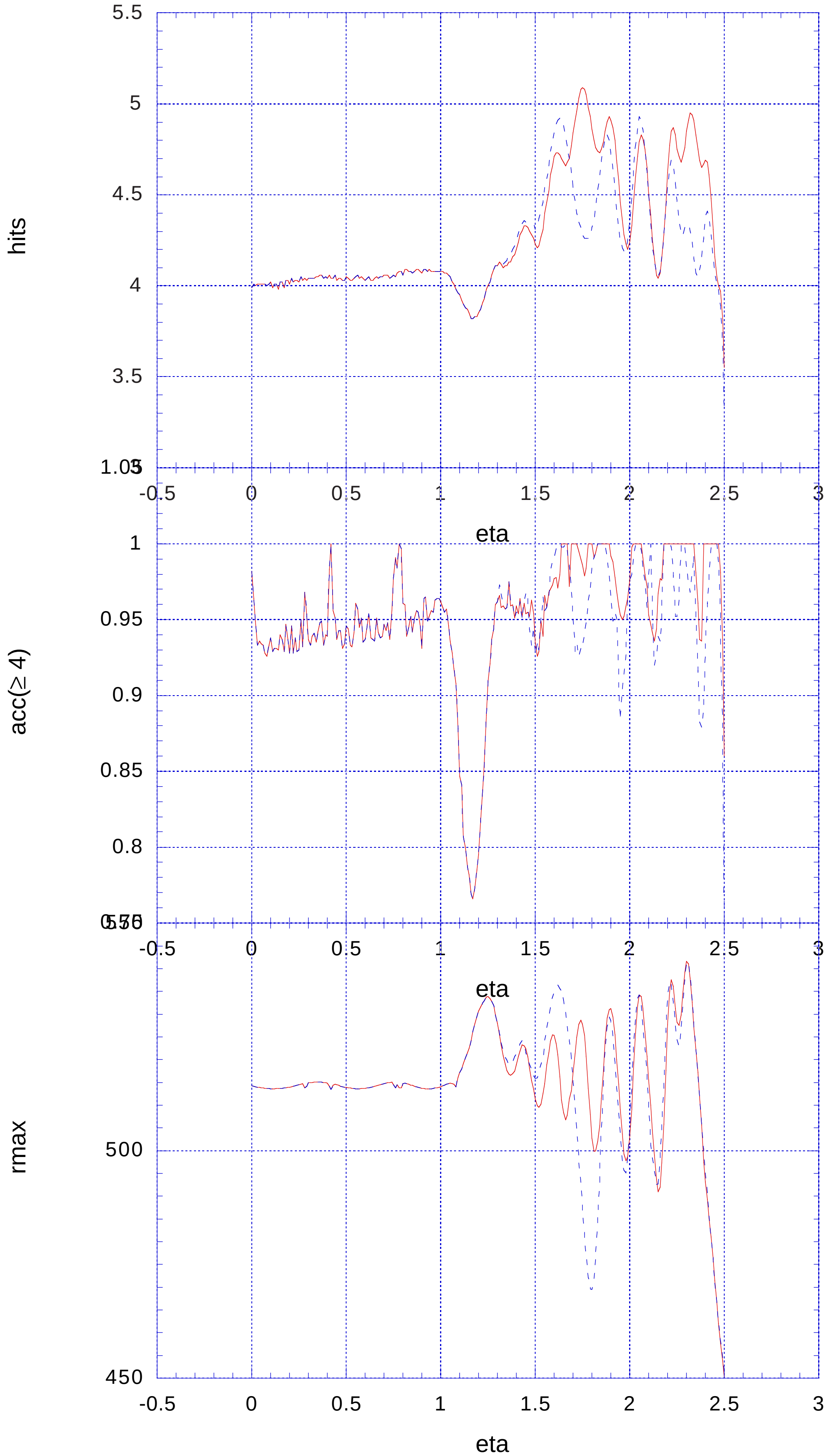
PAPER SIZE A4

TITLE

"Squashed" forward layout

DRAWING NO.

KEK INSTITUTE FOR PARTICLE AND NUCLEAR STUDIES
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION
OHO 1-1, TSUKUBA, IBARAKI 305-0801, JAPAN



hits
5.5
5
4.5
4
3.5
3
-0.5
0
0.5
1
1.5
2
2.5
3
eta
acc(≥ 4)
1.05
1
0.95
0.9
0.85
0.8
0.75
-0.5
0
0.5
1
1.5
2
2.5
3
eta
rmax
550
500
450
-0.5
0
0.5
1
1.5
2
2.5
3
eta

Input file for raytrace, raytrace.in											
29/12/2000						1=h, 2=v					
	pixel	sct									
module thick	0.6	0.57				y=2.*atan(exp(-eta))					
disk half thick		14.2									
sz(vertex) [mn	56										
	z1	z2	r			eta	theta [rad]	theta [deg]	tan(theta)		
pixb0	-400.7	400.7	50.5			2.5	0.163802758	9.385206698	0.16528367		
pixb1			88.5			0.8812	0.785520915	45.00703318	1.000245534		
pixb2			122.5								
	z	r1	r2								
pixd0	495	88.1	146.9								
pixd1	580	88.1	146.9								
pixd2	650	88.1	146.9								
sensor		width [mm]	62	tilt [deg]	10	sin(tilt)	0.173648178				
	z	z2	r	r_outer	ın(theta(+2sz))	dr	tan(theta)				
sib3	-742.095	742.095	299	305.9102645	0.474531618	71.70892912	0.492432982				
sib4			371	377.6191936	0.588800102	71.80201289	0.60352734				
sib5			443	449.4212065	0.703068585	70.85835309	0.714621699				
sib6			514	520.2795596	0.815750006		0.825716058				
half separation	1.4										
active gap	0	w12	w12	w21	w21	w22	w22	w31	w31	w32	w32
	z	275.1	334.1	337.7	400.7	402.9	455.3	438.8	502.3	504.5	560
sid1	848.5	1596.530789									812.6848249
sid2	932	1766.505344		1462.439266							922.7083521
sid3	1089	2086.098219									1077.286792
sid4	1284	2483.044784									1306.311037
sid5	1500	2922.73944									
sid6	1766	1734.611253									
sid7	2085	x		2084.954053							
sid8	2480	x	x	2140.954053		2479.427385					
sid9	2725	x	x	x	x	2535.427385		2725.029726			