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Minor Adjustments in HEX2 Wire Positions

Abstract

We advocate some minor changes in the wires positions of the HEX2 pattern to accomplish two goals:

1. Provide the same stereo angle for all stereo layers, and possibly increase the stereo angle slightly;
2. Produce the same hole pattern on the front and back endplates by offsetting the stereo wires by an integer number of holes between the two endplates.

The wire count and unit-cell pattern remain the same.

1 Increased Stereo Angles

The present note is based on the Fortran programs `coords.for` and `hex2.for` by Adam Boyarski, as obtained from the `CentralTracker/CellGeom` Web page.

Adam's program requires that the wire 'sag' of a U stereo layer back onto the A layer inside it be a fixed amount at all three AU boundaries. This has the effect that the stereo angle is smaller at smaller radii.

We propose instead that all stereo layers have the same stereo angle (to first approximation) so that the resolutions of the resulting z-coordinate measurements are the same in all stereo layers. This will have the effect of increasing the gap between the A and U zipper layers on the endplate, and consequently the radial extent of the cells must be reduced.

However, we have noticed that the parameter `saggap` is set to 5.5 mm in Adam's program (where that parameter is called `drsag`). This parameter defines the closest radial approach of a zipper wire in the A layer to a zipper wire in the neighboring U layer, which occurs at the center of the chamber. Since zipper wires are already as close as 2 mm radially to various field wires, this constraint may be excessive.

We propose that `saggap` be reduced to 2 mm. This will free up 10 mm of radial space throughout the chamber, which would be better allocated to the larger sags of the inner U zipper layers that arise when the stereo angles are larger.

In addition, we are optimistic that a careful joint design will also free up several millimeters of radial space that could be traded for greater stereo angles.

A modified version of the program `coords.for` has been written to implement this suggestion. Some details of this program are presented in Sec. 3 below. Figures 1 and 2 show

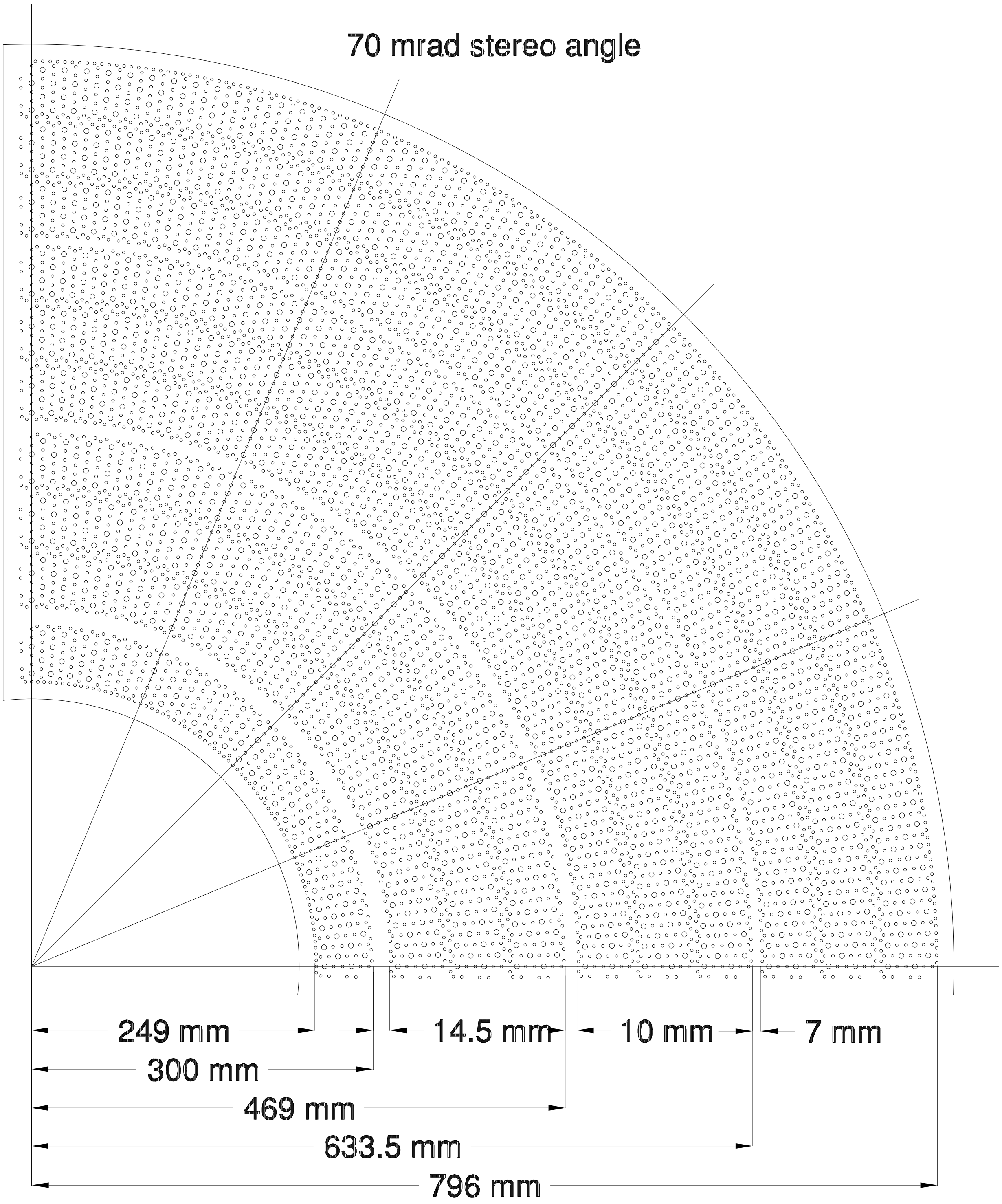

Figure 1: Revised HEX2 wire pattern in which the stereo angles are all near 70 mrad. This figure was produced with parameters `rmin = 0.25`, `rmax = 0.81`, `istereo = 2`, `stereoang = 0.07`, `phiaxis =` $\pi/4$, `ifr = -1`, `edge = 0`, `flip = 0` and `ioff = 0`.

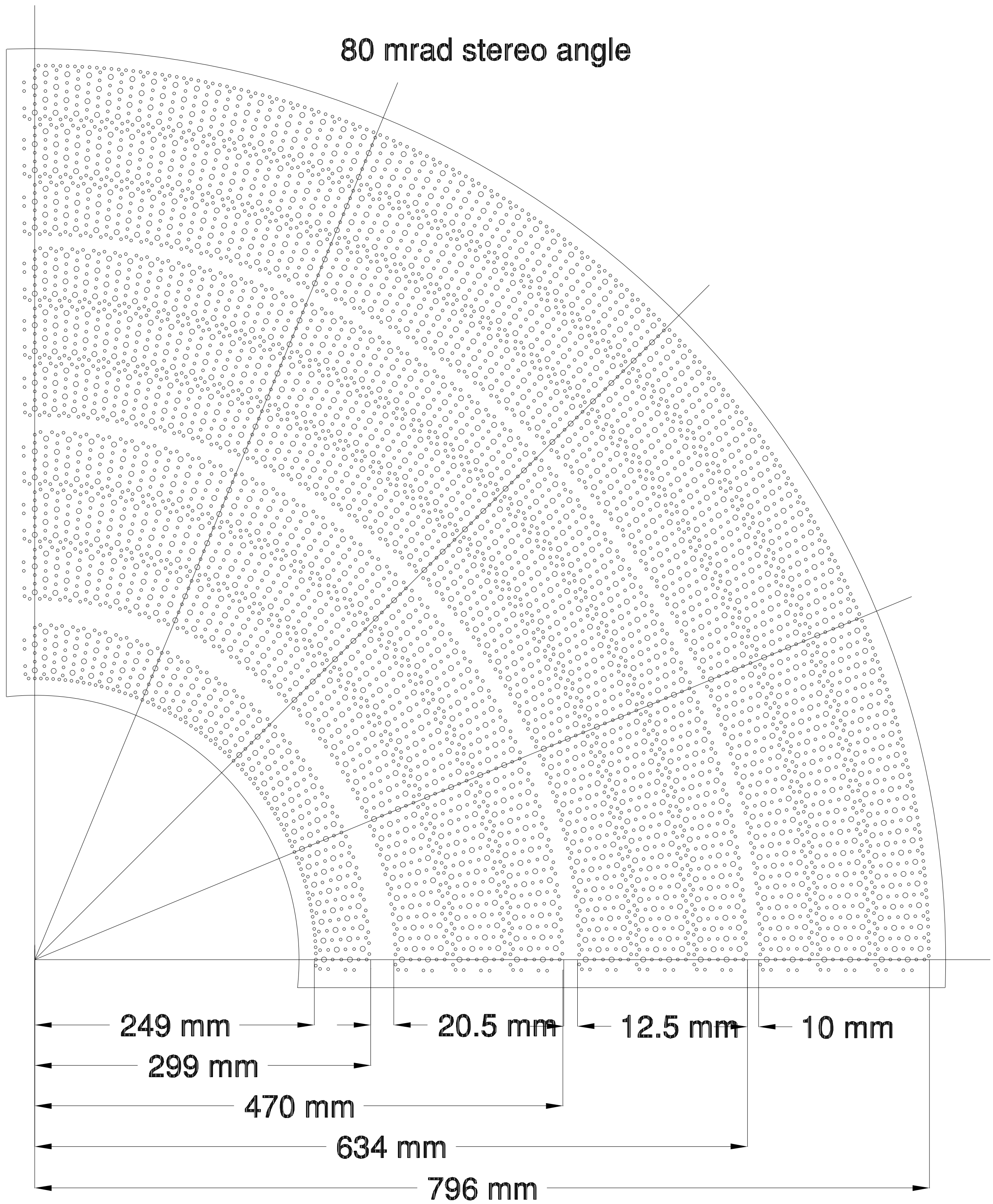

Figure 2: Revised HEX2 wire pattern in which the stereo angles are all near 80 mrad. This figure was produced with parameters `rmin = 0.25`, `rmax = 0.81`, `istereo = 2`, `stereoang = 0.08`, `phiaxis =` $\pi/4$, `ifr = -1`, `edge = 0`, `flip = 0` and `ioff = 0`.

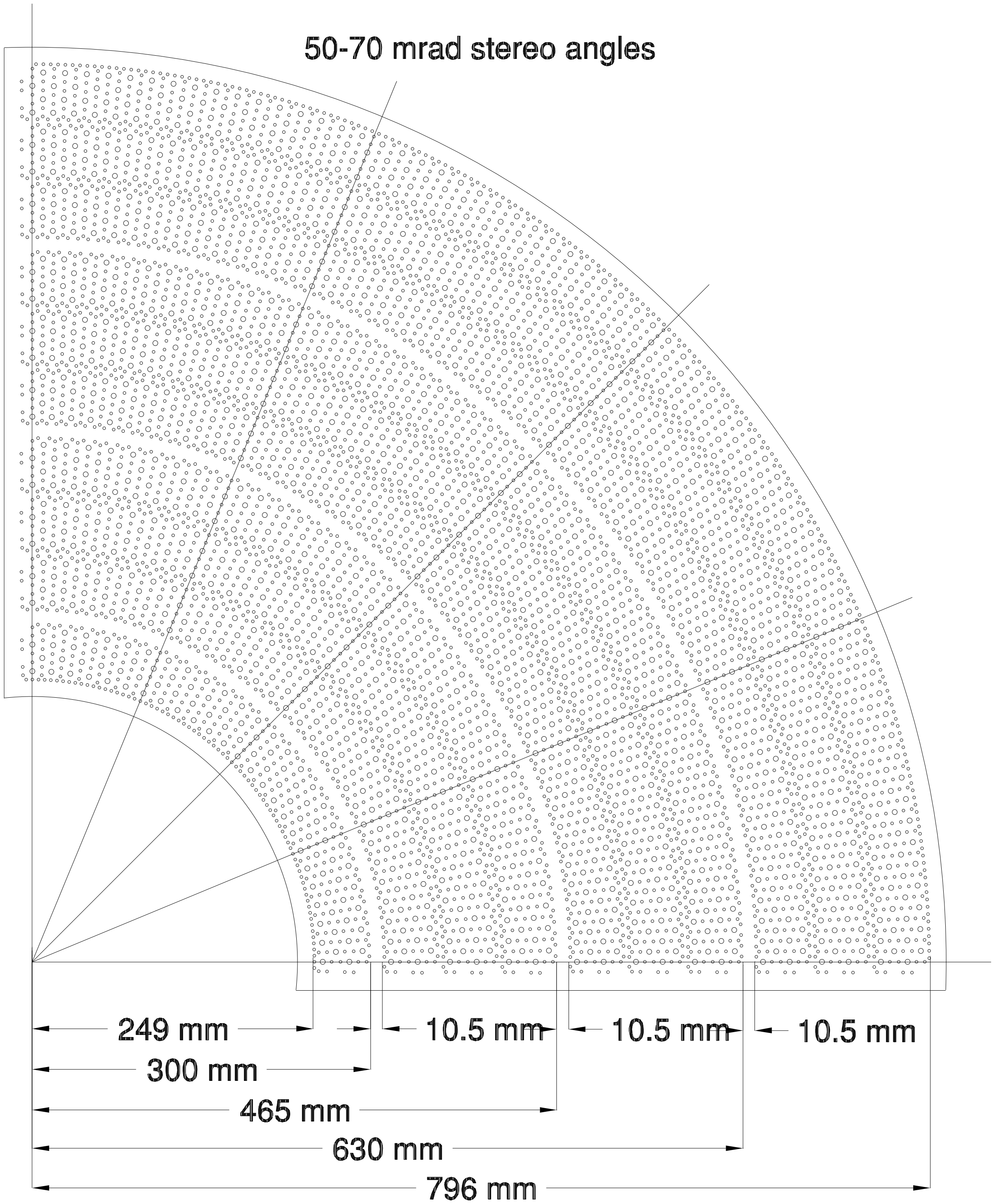

Figure 3: Slightly revised HEX2 wire pattern in which the AU superlayer gaps are all equal. mrad. This figure was produced with parameters `rmin = 0.25`, `rmax = 0.81`, `istereo = 1`, `phiaxis =` $\pi/4$, `ifr = -1`, `edge = 0`, `flip = 0` and `ioff = 0`.

Table 1: Layer parameters for a HEX2 pattern with 70-mrad stereo angle.

Layer	Type	N_{cells}	N_{offset}	r_{sense} (m)	Stereo Angle (mrad)	Sag (m)
1	A	96	0	0.2574	0.0	0.0000
2	A	96	0	0.2692	0.0	0.0000
3	A	96	0	0.2810	0.0	0.0000
4	A	96	0	0.2928	0.0	0.0000
5	U	112	11	0.3216	65.0	0.0152
6	U	112	11	0.3335	67.4	0.0157
7	U	112	11	0.3453	69.8	0.0163
8	U	112	11	0.3571	72.2	0.0169
9	V	128	11	0.3739	66.4	0.0135
10	V	128	11	0.3857	68.5	0.0140
11	V	128	11	0.3975	70.6	0.0144
12	V	128	11	0.4093	72.7	0.0148
13	A	144	0	0.4262	0.0	0.0000
14	A	144	0	0.4380	0.0	0.0000
15	A	144	0	0.4498	0.0	0.0000
16	A	144	0	0.4616	0.0	0.0000
17	U	176	12	0.4864	68.8	0.0111
18	U	176	12	0.4982	70.5	0.0114
19	U	176	12	0.5100	72.1	0.0117
20	U	176	12	0.5218	73.8	0.0119
21	V	192	12	0.5386	69.9	0.0103
22	V	192	12	0.5504	71.5	0.0106
23	V	192	12	0.5622	73.0	0.0108
24	V	192	12	0.5740	74.5	0.0110
25	A	208	0	0.5909	0.0	0.0000
26	A	208	0	0.6027	0.0	0.0000
27	A	208	0	0.6145	0.0	0.0000
28	A	208	0	0.6263	0.0	0.0000
29	U	224	11	0.6477	66.3	0.0077
30	U	224	11	0.6595	67.5	0.0078
31	U	224	11	0.6713	68.7	0.0080
32	U	224	11	0.6831	69.9	0.0081
33	V	240	11	0.6999	66.9	0.0072
34	V	240	11	0.7117	68.0	0.0074
35	V	240	11	0.7236	69.1	0.0075
36	V	240	11	0.7354	70.2	0.0076
37	A	256	0	0.7522	0.0	0.0000
38	A	256	0	0.7640	0.0	0.0000
39	A	256	0	0.7758	0.0	0.0000
40	A	256	0	0.7876	0.0	0.0000

Table 2: Layer parameters for a HEX2 pattern with 80-mrad stereo angle.

Layer	Type	N_{cells}	N_{offset}	r_{sense} (m)	Stereo Angle (mrad)	Sag (m)
1	A	96	0	0.2572	0.0	0.0000
2	A	96	0	0.2687	0.0	0.0000
3	A	96	0	0.2803	0.0	0.0000
4	A	96	0	0.2918	0.0	0.0000
5	U	112	13	0.3266	77.5	0.0215
6	U	112	13	0.3381	80.2	0.0222
7	U	112	13	0.3496	82.9	0.0230
8	U	112	13	0.3612	85.7	0.0237
9	V	128	13	0.3777	78.8	0.0191
10	V	128	13	0.3892	81.2	0.0196
11	V	128	13	0.4007	83.6	0.0202
12	V	128	13	0.4123	86.0	0.0208
13	A	144	0	0.4288	0.0	0.0000
14	A	144	0	0.4403	0.0	0.0000
15	A	144	0	0.4519	0.0	0.0000
16	A	144	0	0.4634	0.0	0.0000
17	U	176	13	0.4899	75.0	0.0131
18	U	176	13	0.5015	76.7	0.0134
19	U	176	13	0.5130	78.5	0.0137
20	U	176	13	0.5245	80.2	0.0141
21	V	192	13	0.5410	76.0	0.0122
22	V	192	13	0.5526	77.6	0.0125
23	V	192	13	0.5641	79.2	0.0127
24	V	192	13	0.5756	80.8	0.0130
25	A	208	0	0.5922	0.0	0.0000
26	A	208	0	0.6037	0.0	0.0000
27	A	208	0	0.6152	0.0	0.0000
28	A	208	0	0.6268	0.0	0.0000
29	U	224	13	0.6509	78.5	0.0108
30	U	224	13	0.6625	79.9	0.0110
31	U	224	13	0.6740	81.3	0.0112
32	U	224	13	0.6855	82.7	0.0114
33	V	240	13	0.7021	79.1	0.0101
34	V	240	13	0.7136	80.4	0.0103
35	V	240	13	0.7251	81.7	0.0105
36	V	240	13	0.7367	83.0	0.0106
37	A	256	0	0.7532	0.0	0.0000
38	A	256	0	0.7647	0.0	0.0000
39	A	256	0	0.7763	0.0	0.0000
40	A	256	0	0.7878	0.0	0.0000

Table 3: Layer parameters for a HEX2 pattern with equal AU superlayer gaps.

Layer	Type	N_{cells}	N_{offset}	r_{sense} (m)	Stereo Angle (mrad)	Sag (m)
1	A	96	0	0.2574	0.0	0.0000
2	A	96	0	0.2692	0.0	0.0000
3	A	96	0	0.2810	0.0	0.0000
4	A	96	0	0.2928	0.0	0.0000
5	U	112	8	0.3179	47.1	0.0080
6	U	112	8	0.3298	48.9	0.0083
7	U	112	8	0.3416	50.6	0.0086
8	U	112	8	0.3534	52.4	0.0089
9	V	128	8	0.3702	48.1	0.0071
10	V	128	8	0.3820	49.6	0.0073
11	V	128	8	0.3939	51.2	0.0076
12	V	128	8	0.4057	52.7	0.0078
13	A	144	0	0.4225	0.0	0.0000
14	A	144	0	0.4343	0.0	0.0000
15	A	144	0	0.4461	0.0	0.0000
16	A	144	0	0.4579	0.0	0.0000
17	U	176	10	0.4828	57.1	0.0077
18	U	176	10	0.4946	58.5	0.0079
19	U	176	10	0.5064	59.9	0.0080
20	U	176	10	0.5182	61.3	0.0082
21	V	192	10	0.5350	58.0	0.0071
22	V	192	10	0.5469	59.3	0.0073
23	V	192	10	0.5587	60.6	0.0075
24	V	192	10	0.5705	61.9	0.0076
25	A	208	0	0.5873	0.0	0.0000
26	A	208	0	0.5991	0.0	0.0000
27	A	208	0	0.6109	0.0	0.0000
28	A	208	0	0.6228	0.0	0.0000
29	U	224	11	0.6476	66.2	0.0077
30	U	224	11	0.6594	67.5	0.0078
31	U	224	11	0.6713	68.7	0.0080
32	U	224	11	0.6831	69.9	0.0081
33	V	240	11	0.6999	66.9	0.0072
34	V	240	11	0.7117	68.0	0.0074
35	V	240	11	0.7235	69.1	0.0075
36	V	240	11	0.7353	70.2	0.0076
37	A	256	0	0.7522	0.0	0.0000
38	A	256	0	0.7640	0.0	0.0000
39	A	256	0	0.7758	0.0	0.0000
40	A	256	0	0.7876	0.0	0.0000

possible adjusted cell patterns in which the stereo angles are all near 70 and 80 mrad, respectively. Figure 3 shows a cell pattern similar to that presently advocated by Boyarski. Tables 1-3 summarize various parameters corresponding to these wire patterns.

The wire placement described in Fig. 2 and Table 2 has stereo angles of 80 mrad compared to values ranging from 50 to 70 mrad in the present baseline design (Fig. 3 and Table 3). Switching to an arrangement with 80-mrad stereo angles would improve the z-coordinate measurement of the drift chamber by about 25% on average.

What is the cost? None, I believe, in tracking – even if the cells are squashed slightly radially the first electron used for timing always arises at a radius close to that of the sense wire. However, if the total active length of the chamber is reduced, the dE/dx measurement suffers. For example, going to an 80-mrad stereo angle everywhere would cost about 1.2 cm in path length out of 52 cm, or 2.3%. This would cause the dE/dx measurement to worsen by about 1.2%, say from 7% to 7.1%. I doubt this would ever be noticed, but the improvement in z resolution certainly would. Perhaps we should consider even larger stereo angles.

2 The Same Wire Pattern on Both Endplates

Another simple modification to the wire pattern yields the same wire pattern on both endplates. To achieve this, the azimuthal offset of the stereo wire must be an integer number of azimuthal cells. The required values of these offsets are listed in Tables 1-3 under the heading N_{offset}.

3 Program `coords.for`

I have placed a modified version of program `coords.for` in the `CentralTracker/CellGeom` Web page under the title `koords.for`. This program includes subroutine `hex2.for` and needs no other routines to link.

The parameters used in defining the wire geometry are:

`IPRT` = print flag, 0 for no printout, 1 for printout.

`ZLEN` = length of chamber in meters (all distances are in meters).

`RMIN` = minimum radius at which wires are centered.

`RMAX` = maximum radius at which wires are centered. However, because the program iterates to find the acceptable stereo sags, the achieved value of `RMAX` is slightly larger than the input value in general.

`ISTEREO` = 1 – use constant AU sags of about `2*saggap`; = 2 – use variable AU sags to achieve constant stereo angle.

`STEREOANG` = average desired stereo angle, in radians 9use with `ISTEREO = 2`).

`IFR` = 1 for front endplate, = −1 for rear.

`NCELLS(10)` = array containing the number of cells per superlayer to be plotted.

`LYR1` = first layer number for which the hole pattern is output (0 to 40, 0 includes an inner wall layer).

`LYR2` = last layer number for output (1 to 41, 41 includes outer wall layer) If negative and less than 40, last enclosing layer is a hex2b zipper.

PHIAXIS = central ϕ angle at each layer (rad).

EDGE specifies how cell edges are trimmed at the azimuthal boundary of a layer.

EDGE = 0 – Trimmed symmetrically, with $N,\ N-1,\ N, \ldots$ cells/layer. Typically use this to produce a subset of the entire pattern in which all cells are complete.

EDGE = 1 – Trimmed with equal cells/layer, N cells/layer.

EDGE = 2 – Trimmed with field wires on $+\phi$ edge only – needed for meshing of cells when producing the entire 360° pattern.

FLIP = 0 – View is from $+z$ direction, 1 – view from $-z$. If FLIP is 1 and IFR is negative then the holes for the rods supporting the electronics are added.

IOFF = 0(1) — Don't (do) offset the cells in the stereo layers.

The following 4 parameters are for fine cell adjustments:

ZipExtent = 0.75/6.0 = fractional cell extension into zip region.

zipgap = 0.005 m = gap between zipper layers, except at an AU boundary.

saggap = gap between neighboring stereo and axial wires at center of chamber, = .0055 m if ISTEREO = 1, = 0.002 m if ISTEREO = 2.

pmove = 0.0005 m = radial distance potential wires are moved from the basic HEX2 pattern.

Some other cell parameters are:

NS = 4 = number of layers per supercell.

DS = 0.000020 m = diameter of sense wires.

VS = 2020. = voltage on sense wires.

NF = 4 = number of field wires between sense wires.

DF = 0.000080 m = diameter of field wires.

VF = 0.0 = voltage on field wires.

DF1 = 0.000080 m = diameter of clearing wire.

VF1 = 350. = voltage on clearing wire.

NPOT = 3 = number of potential wires between sense wires (really 2, plus 1 for the standoff rod).

DPOT = 0.000120 m = diameter of potential wires.

VPOT = 0. = voltage on potential wires.

The program produces three output files. Unit 1 contains a list of the holes locations, unit 2 contains the wire list in AutoLISP format as discussed in the next section, and unit 3 contains a short summary of layer parameters in a format for use in TeX tables.

We conclude with some examples based on the Prototype II wire pattern, shown in Figs. 4-8.

4 AutoLISP Output

A wire list is generated on unit 2 in AutoLISP format to facilitate plotting the wire pattern with AutoCAD. The output file defines a new AutoCAD function hex2 that draws circles at the wire positions.

To use this function in AutoCAD, first load it from the Command: line with

```
(load "c:/directory/filename")
```

Note that in this command the directory delimiter is / rather than the usual DOS convention of \. If the `filename` includes the extension `.lsp` that extension need not be typed.

To run the function, type

`(hex2)`

It may take several minutes to generate the full wire pattern.

If you wish to change the size of the circles plotted at the wire locations, modify the appropriate code in subroutine `wout` of file `koords.for`.

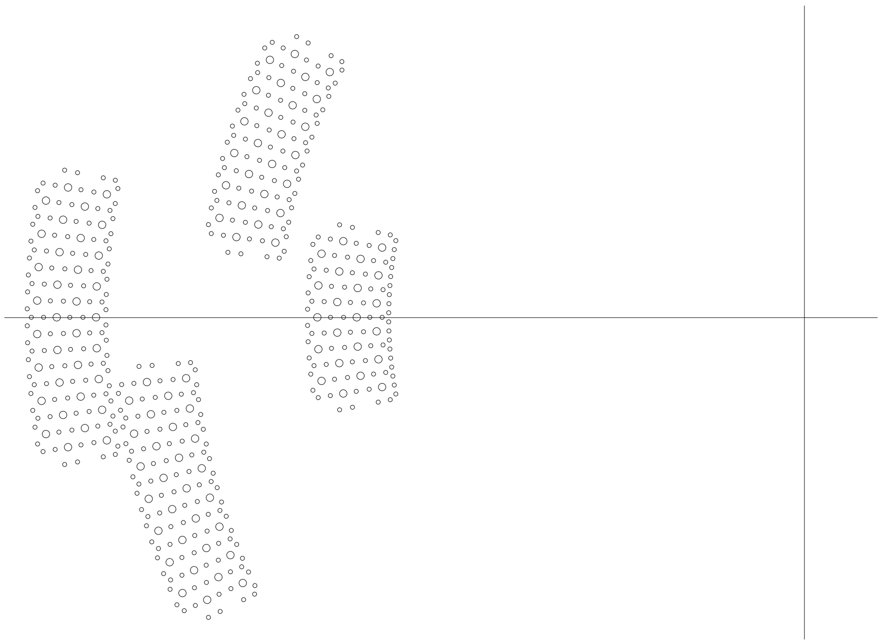

Figure 4: A possible Prototye II wire pattern on the rear endplate, as viewed from the $+z$ direction. Generated with `phiaxis` $= \pi$, `IFR = -1`, `EDGE = 0`, `FLIP = 0` and `IOFF = 1`.

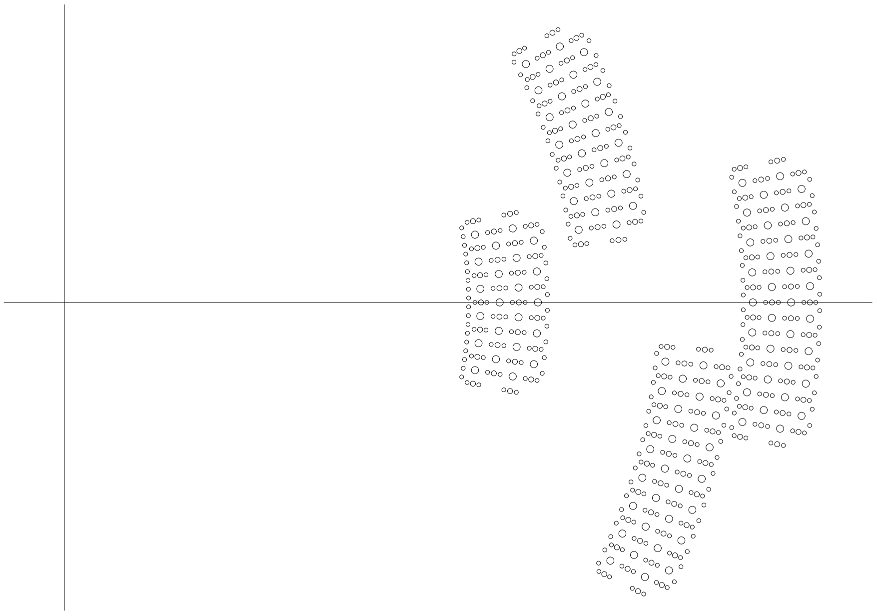

Figure 5: A possible Prototye II wire pattern on the rear endplate, as viewed from the $-z$ direction. The extra holes for electronics standoffs can be seen. Generated with `phiaxis` $= \pi$, `IFR = -1`, `EDGE = 0`, `FLIP = 1` and `IOFF = 1`.

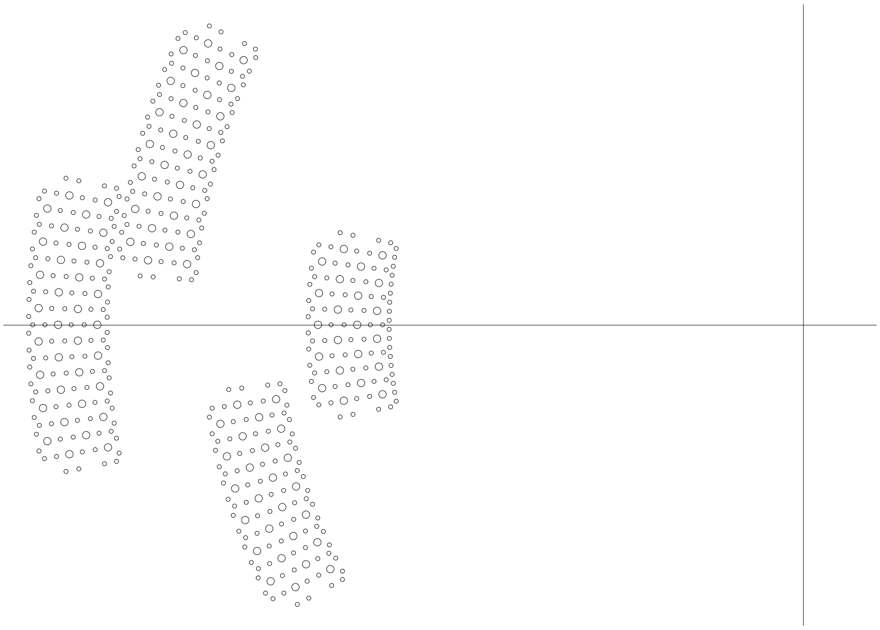

Figure 6: A possible Prototye II wire pattern on the front endplate, as viewed from the $+z$ direction. Generated with `phiaxis` $= \pi$, `IFR = 1`, `EDGE = 0`, `FLIP = 0` and `IOFF = 1`.

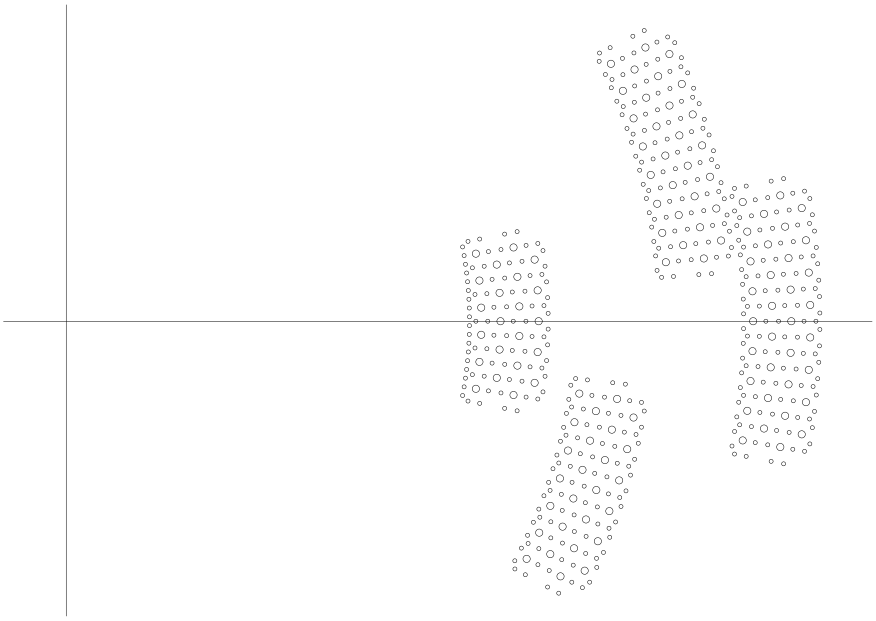

Figure 7: A possible Prototye II wire pattern on the front endplate, as viewed from the $-z$ direction. Generated with `phiaxis` $= \pi$, `IFR = 1`, `EDGE = 0`, `FLIP = 1` and `IOFF = 1`.

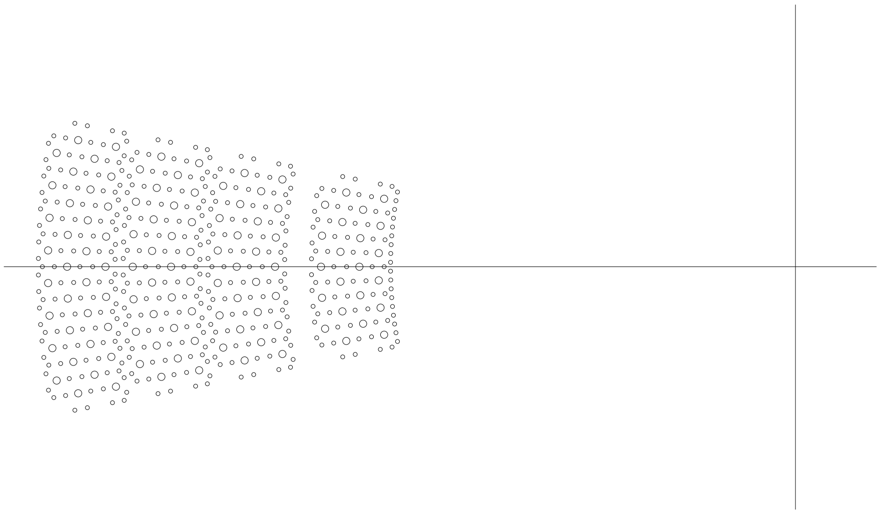

Figure 8: A possible Prototye II wire pattern on the rear endplate, as viewed from the $+z$ direction, shown without the azimuthal offsets of the stereo wires. Generated with `phiaxis` $= \pi$, `IFR = -1`, `EDGE = 0`, `FLIP = 0` and `IOFF = 0`. The same pattern occurs on the front endplate, as could be verified by changing `IFR` to 1.