New Pad Plane Design Proposal & Specifications

**Jim Thomas, John Hammond, Bob Scheetz,
Jon Wirth, etc., etc., and a cast of thousands**

May 1st, 2015

Wire & Pad location

- **40 pad rows with 5 mm x 16 mm pads (center to center spacing)**
  - **A large number of simulations suggest that this is a good plan**
- **Where do we put the first (or last) pad row?**
  - **Anode wire location .vs. Pad row location is important**
    - **pad response function , phase lock, etc.**
  - **Anode wire location .vs. Ground Shield location is important**
    - **Limit sparking to pad plane by ensuring short path to Ground shield**
  - **Absolute location of pad rows on pad plane is not important**
- **The preferred location for the first (or last) pad row is largely determined by how we want to handle the Grid Leak problem**

A Proposal

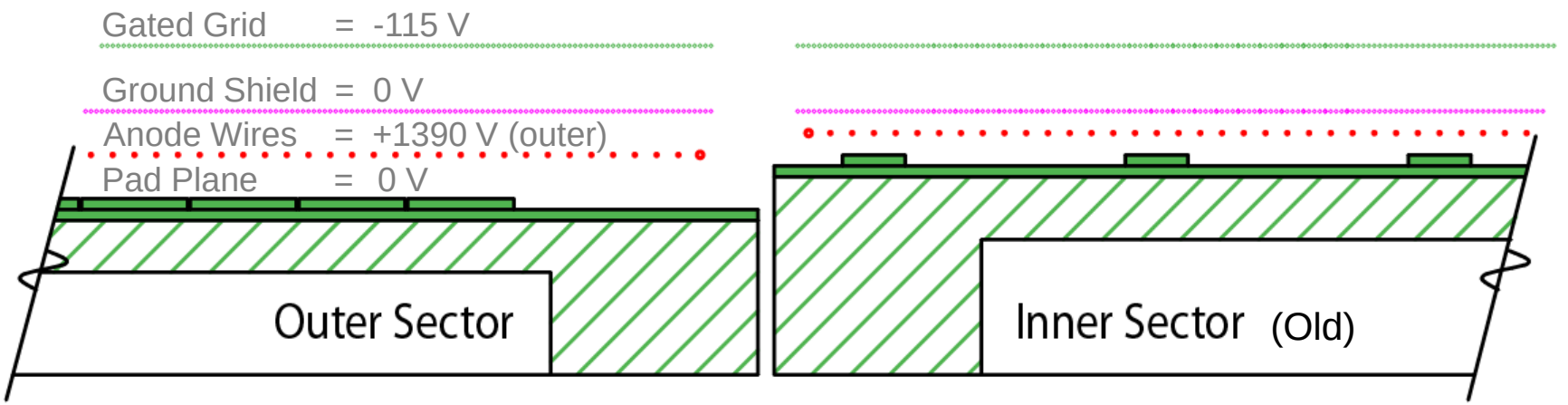
- **The current STAR anode wire planes have one "fat" wire on each end to provide low gain near the ends of the grids**

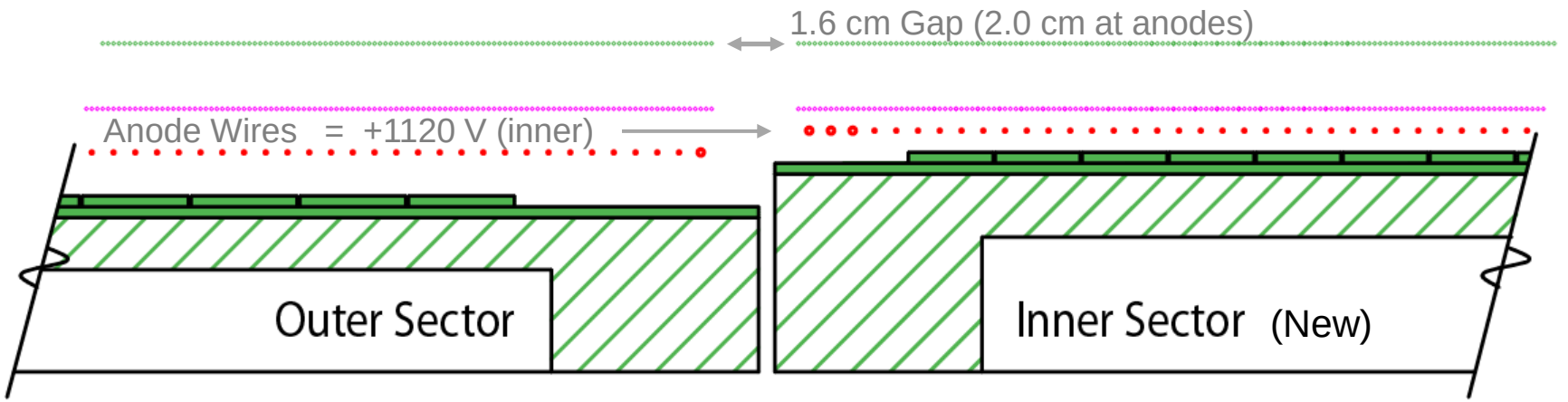
- **We can replace one (or more) of the "thin" anode wires with "fat" wires to extend the region with low gain and reduce the "grid leak"**
  - **This substitution can be done when the wire planes are on the granite tables at Shandong University … no advance-planning required**

- **Extra "fat" wires will force the centerline of the pad rows to move away from their original (old) locations by 14 mm**
  - **To keep an ideal pad response function, the pads must remain directly under a group of 4 anode wires and have 2 anode wires on either side of the pad**

Proposal:
- **Build the new pad planes with a total of 3 "fat" wires on the top and 3 "fat" wires on the bottom of the anode grid**
- **Move the pad rows down 14 mm to accommodate the extra "fat" wires**
- **This will require changes to the padplane and strongback**
- **Simulations required to optimize the configuration**

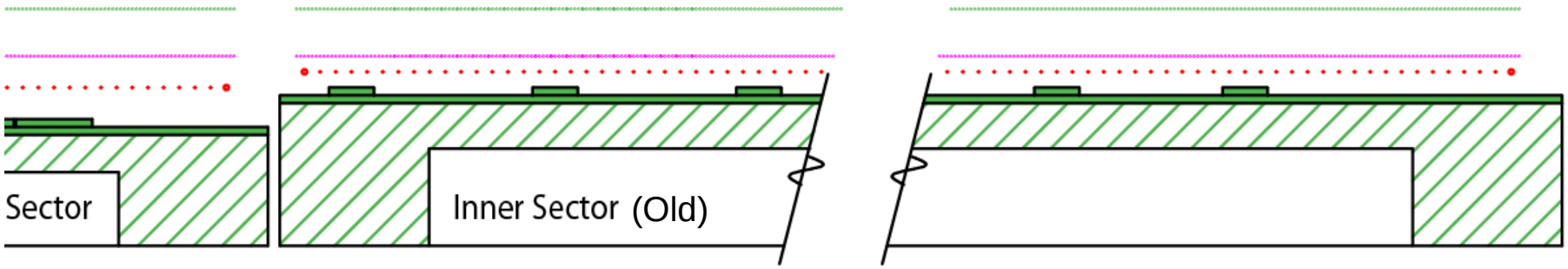
Proposed Changes to Inner Sector Design



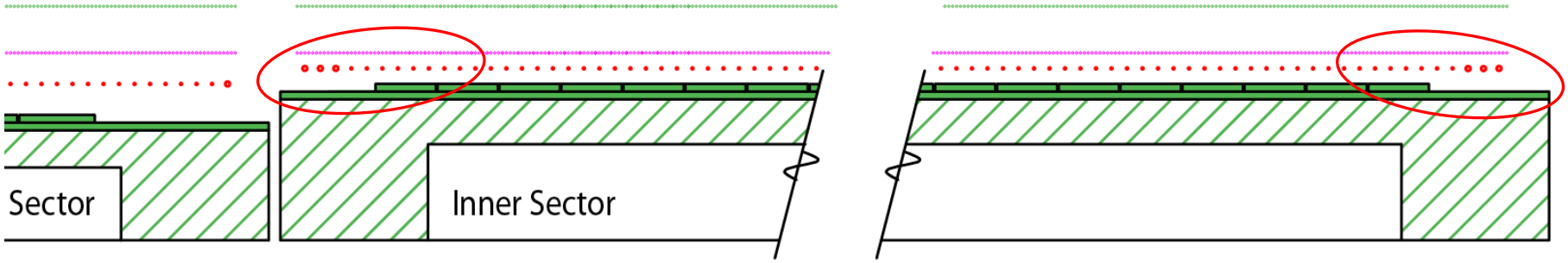


- **Increase the size of the inner sector pads**
- **Add more pad rows, lower voltage on inner anodes**
- **Add more low gain wires on ends of anode grid**

40 Pad Rows fit perfectly with the existing grid

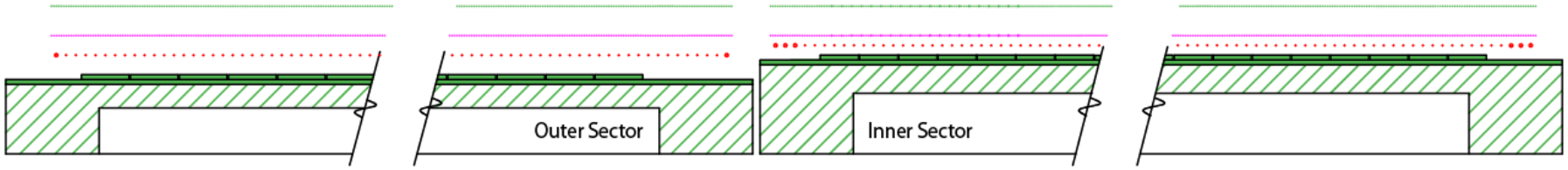


Anode wires spaced 4 mm apart (horizontally), Ground Shield and Gated grids spaced 1 mm apart



- **Identical pad response function on both ends of grid**
- **No need to change grid; wire locations remain the same!**
- **No need to add more ABDB or wire mount channels (good!)**

Pad Location & Tracking Performance

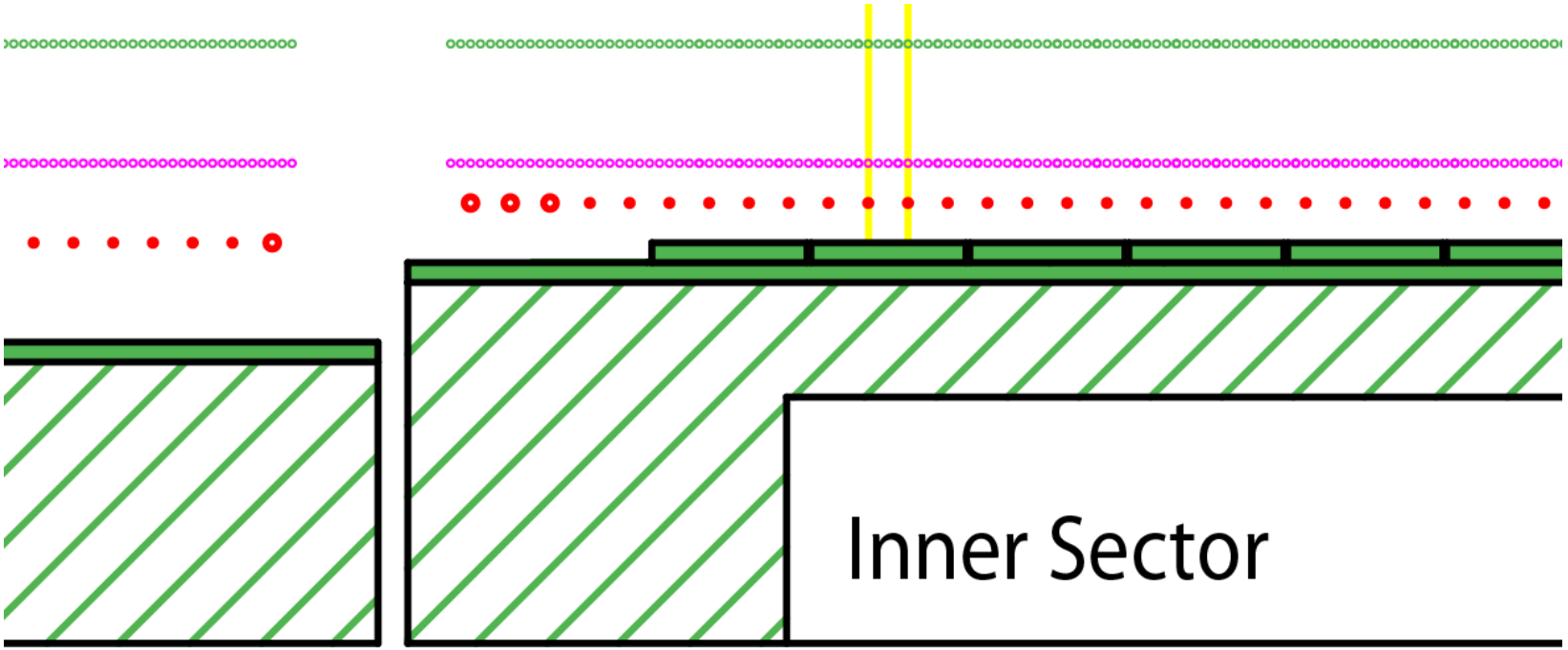


Anode wires spaced 4 mm apart (horizontally), Ground Shield and Gated grid wires spaced 1 mm apart

- **Extra "fat" (low gain) wires change the location of the pad rows**
- **Tracking over the inner/outer sector gap is not a problem**
  - **It will work better than ever …**
- **40 Pad rows on inner sectors compared to 13 in original design**
- **Pad Row 40 (closest to the gap): centerline for the row has moved down 14 mm compared to original STAR design**
  - **Top edge of pad row 40 has moved away from an area of high distortion**
  - **Top edge has moved 12 mm away from gap when comparing old .vs. new**
    - **centers move 14 mm but top edge moves 12 mm due to different length of pads**

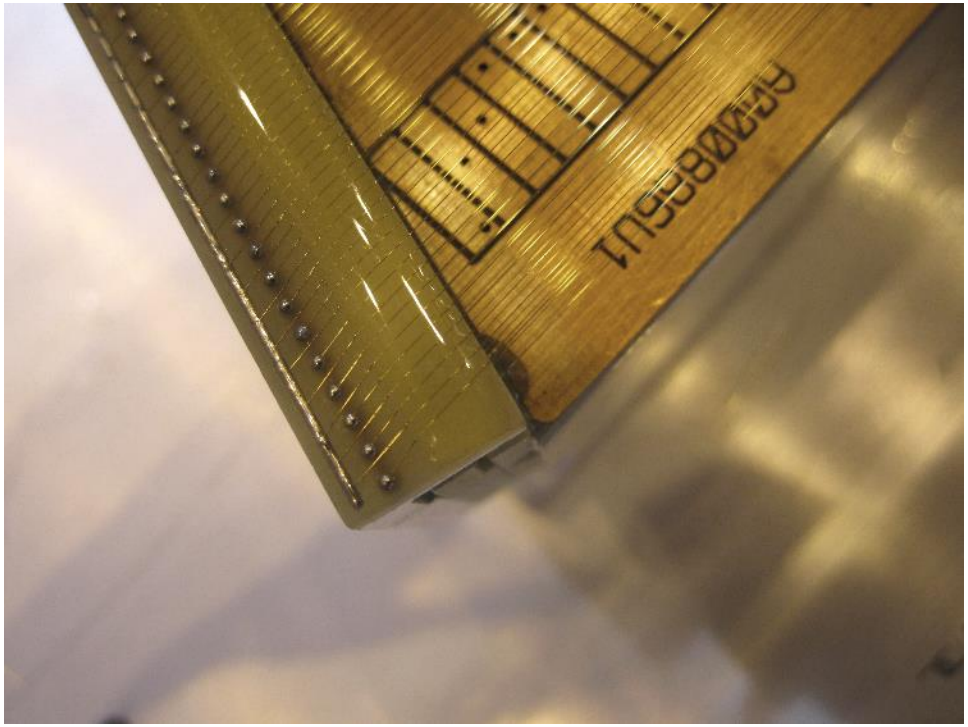
Wires aligned with pads

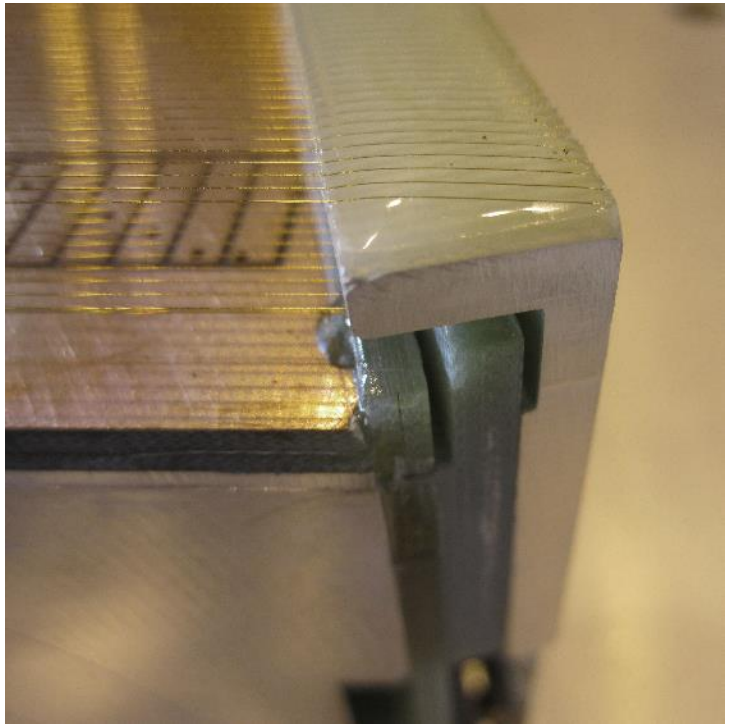
- **Note that Ground Shield and Gated Grid wires lie directly above the Anode wires**
  - **This helps to guide sparks & breakdown to the Ground Shield wires and not to the pad plane**
- **Anode wires phase locked in groups of 4 with pad rows to ensure every pad row has the same pad response function**



Wire locations near the gap will not change

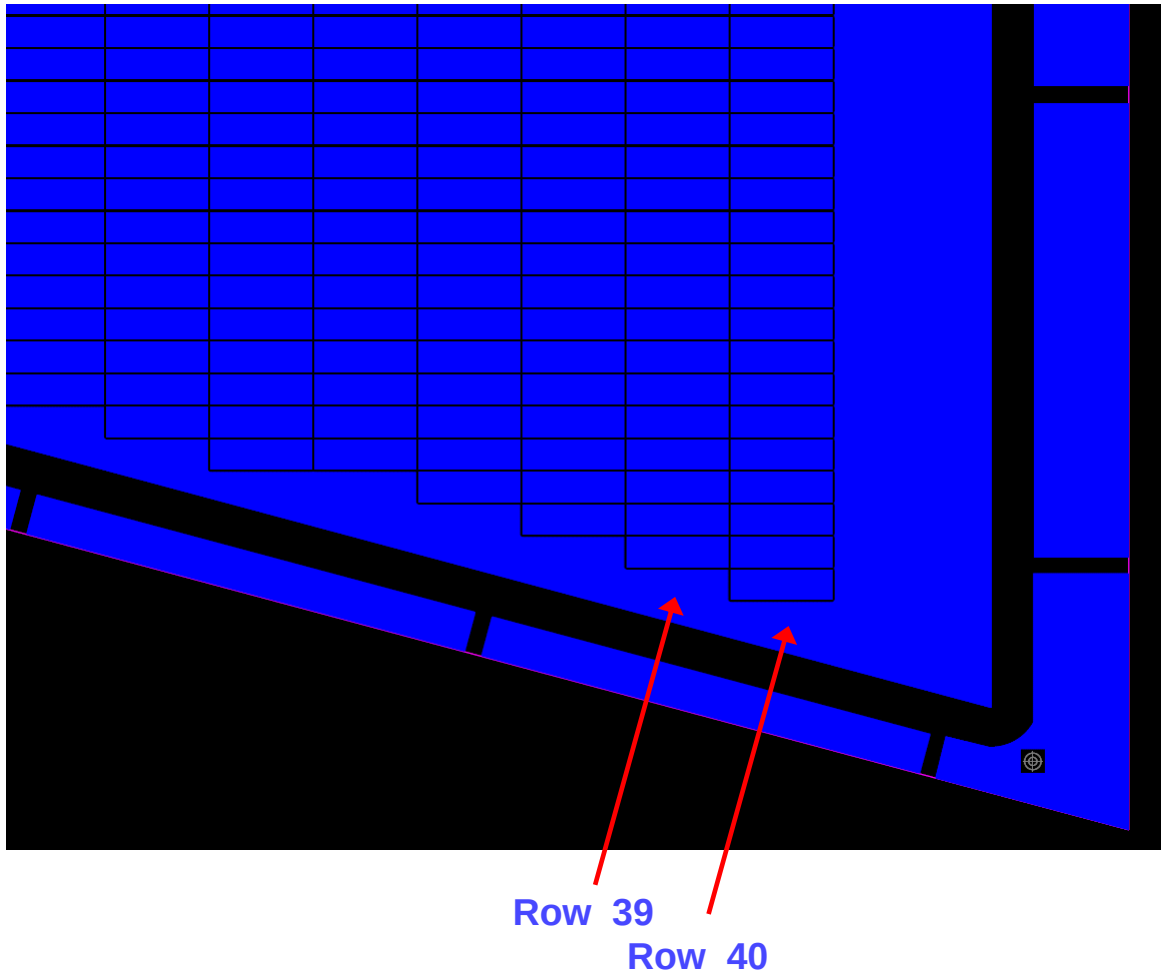
- **The location of the wires near the inner/outer gap cannot change**
  - **Position and total number of wires on each plane remains the same**
- **Because … it is not possible to add more wires**
  - **The full extent of the side mounted wire mounts are already used**





New Pad Plane design and layout

A corner of the new inner pad plane layout by John Hammond & Bob Scheetz



Pad Row	# of Pads
1	50
2	52
3	54
4	56
5	58
6	60
7	62
8	62
9	64
10	66
11	68
12	70
13	72
14	74
15	74
16	76
17	78
18	80
19	82
20	84
21	86
22	86
23	88
24	90
25	92
26	94
27	96
28	98
29	98
30	100
31	102
32	104
33	106
34	108
35	110
36	110
37	112
38	114
39	116
40	118
Total	**3370**

Location of Wires and Pads

Radius (Y)	Description
0.00	Center of STAR Detector (vtx)
498.80	Bottom of Full size PC Board
512.70	Tertiary Fiducial L & R
519.05	Strongback Bottom Edge
530.00	Gated Grid Wire 1
531.00	Gated Grid Wire 2
532.00	Anode Wire 1 & GG W-3
536.00	Anode Wire 2 & GG W-7
540.00	Anode Wire 3 & GG W-11
540.25	Secondary Fiducial
544.00	Anode Wire 4 & GG W-15
548.00	Anode Wire 5 & GG W-19
558.00	Pad Row 1 - Center
574.00	Pad Row 2 - Center
1166.00	Pad Row 39 - Center
1179.45	Primary Fiducial
1182.00	Pad Row 40 - Center
1192.00	Anode Wire 166 & GG W-663
1196.00	Anode Wire 167 & GG W-667
1200.00	Anode Wire 168 & GG W-671
1204.00	Anode Wire 169 & GG W-675
1204.85	Alternate Primary Fiducial
1208.00	Anode Wire 170 & GG W-679
1209.00	Gated Grid Wire 680
1210.00	Gated Grid Wire 681
1214.32	Strongback Top Edge
1220.67	Tertiary Fiducial L & R
1235.42	Top of Full size PC Board

Repeat pad rows every 16 mm

GATED GRID WIRE
Ø.075mm BeCu , Au plated
spacing 1mm
OUTER : 689 Wires
INNER : 681 Wires
TOTAL : 1,370 Wires per Sector

SHIELD GRID WIRE
Ø.075mm BeCu , Au plated
spacing 1mm
OUTER : 689 Wires
INNER : 681 Wires
TOTAL : 1,370 Wires per Sector

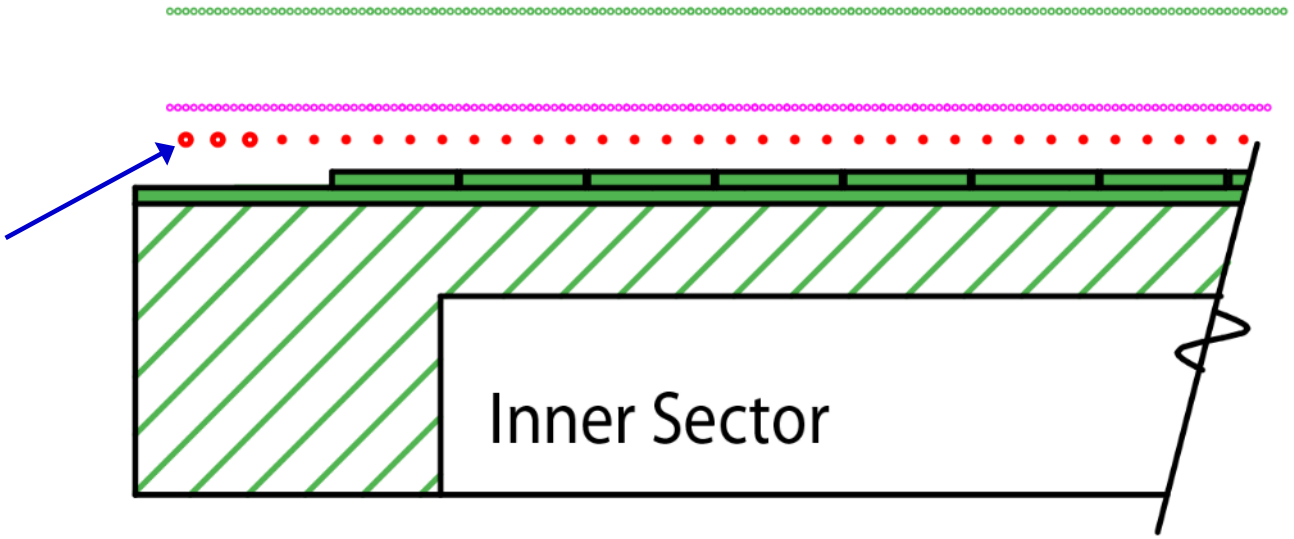
ANODE GRID WIRE
Ø.020mm W, Au plated
spacing 4mm
OUTER : 170 Wires
INNER : 164 Wires (168 in old design)
TOTAL : 334 Wires per Sector (338 in old design)

LAST ANODE WIRE
Ø.125mm BeCu , Au plated
OUTER : 2 Wires
INNER : 6 Wires (2 in old design)
TOTAL : 8 Wires per Sector (4 in old design)

References:
LBL Drawings
24A055,
24A373,
24A374

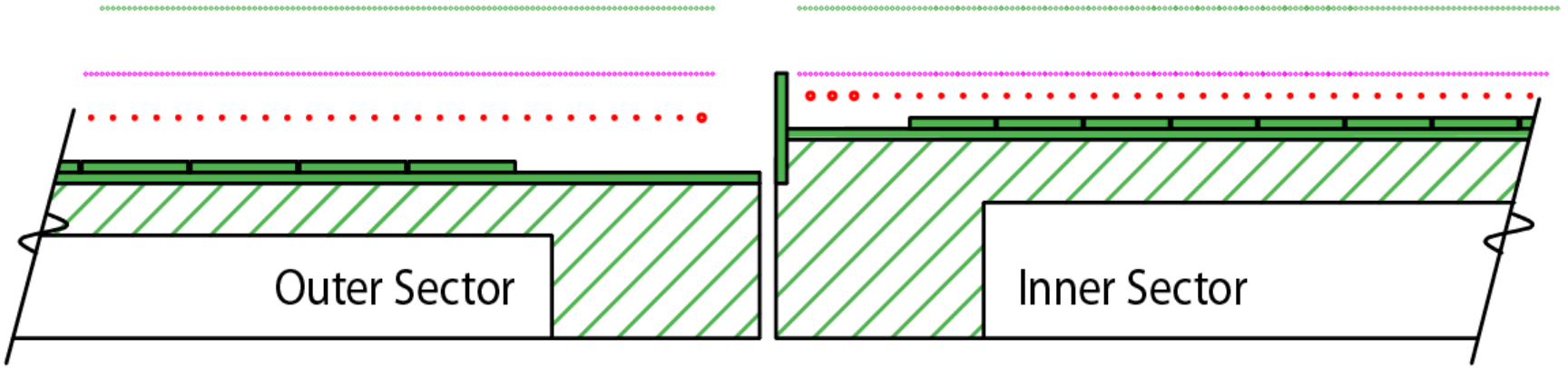
Wire Locations are the same as before except for the replacement of 6 thin anode wires with larger diameter anode wires (0.020 mm ⇒ 0.125 mm)

Grounding the last anode wire



- **Gene VanBuren has proposed that we ground one or more of the fat wires at the end of the anode grid to close off the "grid leak"**
- **This is an excellent proposal which needs simulations to confirm its intuitive cleverness**
- **Technically, this should be easy to do BUT it does involve putting a HV wire (+1120 Volts) next to a ground wire. The problems lies at the epoxy joint on either side of the grid and potentially on the ABDB board. Special epoxy handling procedures may be required.**

More than one way to close the “Grid Leak”



- **Add extra “fat” wires**
  - **Lower the gain near the edge of the grid (gain ∝ 1/wire radius)**
  - **No changes to strongback required**
- **Add a “wall” near the gap between the inner and outer sectors**
  - **The wall should be grounded in order to terminate field lines from the anode wires … (wall requires a change to the strongback)**
  - **The wall could be taller than shown and could have multiple potentials on several conductor stripes**
  - **Simulations needed to determine the best strategy**

Summary – Make as few changes as possible

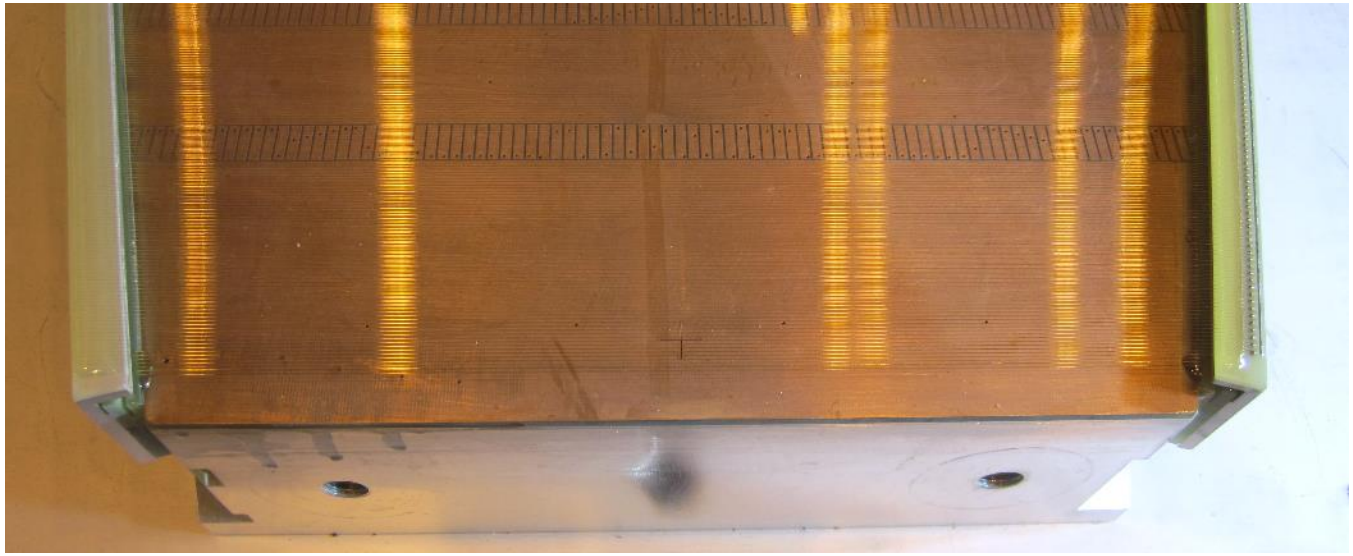
- **PadPlane**
  - 40 pad rows, 5 mm x 16 mm pads (center to center spacing), full coverage
  - Move pad row centerline away from the inner/outer gap by 14 mm
  - Add “wall” on either end of padplane to help terminate the grid leak
  - Add additional fiducial marks, alignment holes and improve air paths
- **Wires**
  - Exactly the same as before: same wire count, same composition, same diameters, same tension, same locations, same ABDB board design, etc.
  - Substitute 3 “fat” wires for 3 “thin” wires on each end of the Anode grids
- **Strongback is 99% the same as before**
  - Do not thin the front face. Do not reduce the height of the ribs.
  - Do not move the spider mounts or optical target mounts
  - Re-use the existing cooling manifolds
  - Re-use the existing hole pattern in the front face (perhaps tiny adjustments)
- **Changes to the strongback**
  - Mill out a step on either end of the strongback for mounting Grid Leak walls
  - Counter-bore put in several places on ribs for new optical survey markers

Backup Slides

Possible changes at low radius to avoid grid leak

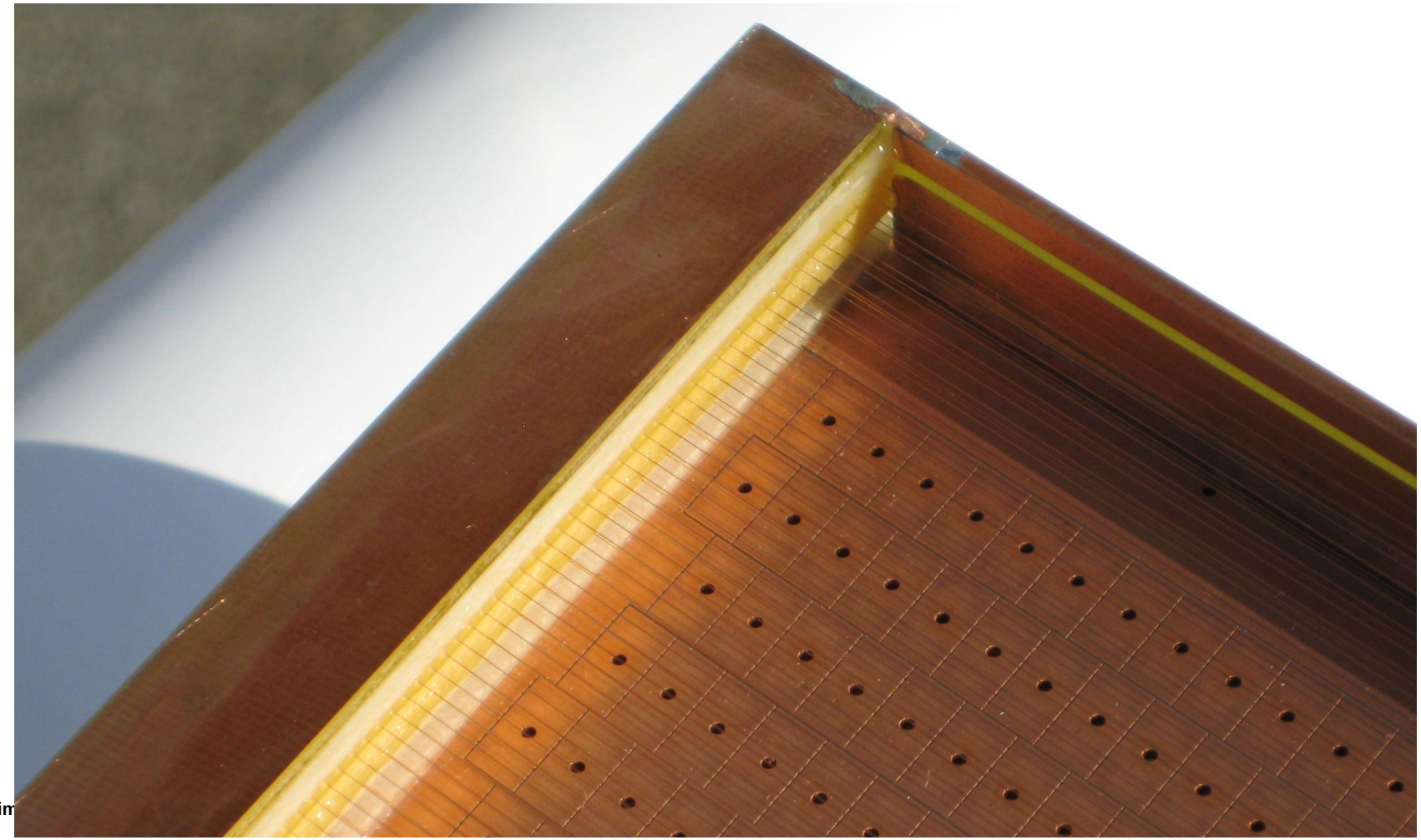
- **We might wish to consider adding more wires to the grid at low radius**
  - **There is a grid leak at low radius as well as near the gap between the inner and outer sectors. We could add up to 7 GG wires and/or 2 anode wires.**
  - **We plan to put more "fat" wires on the low radius end of the pad plane, anyway … but do we need the wires to run all the way to the end of the frame?**
  - **This would mean many changes: e.g. extra channels for ABDB boards, side wire mounts, etc. It may not be worth it. Very little space for extra boards/channels.**
  - **We could also consider putting a grounded "wall" at low radius in a style that is similar to be done at the gap between the inner and outer sectors**

- **Simulations required … no change proposed until simulations prove need**

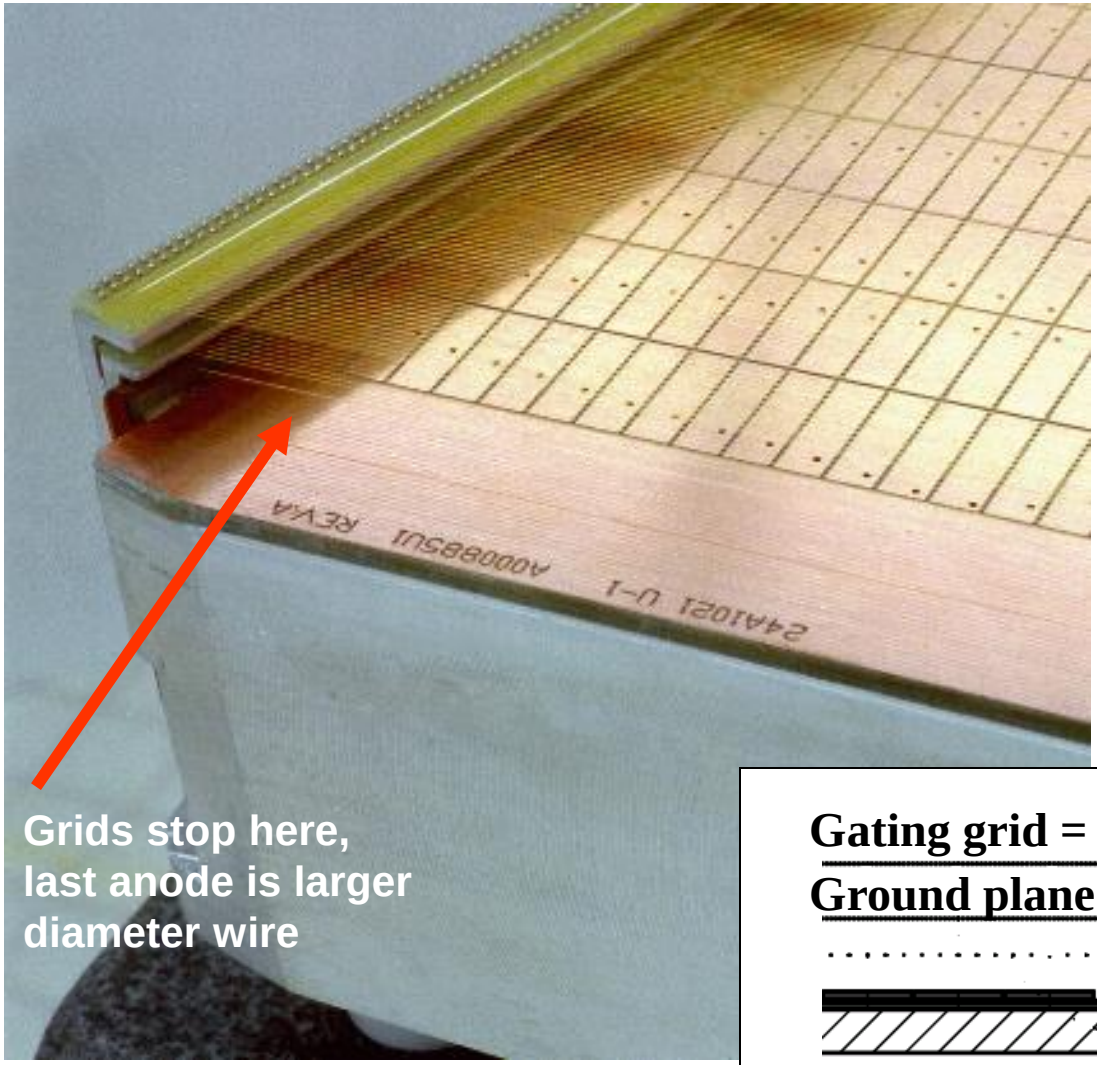


The Alice Solution to Grid Leak

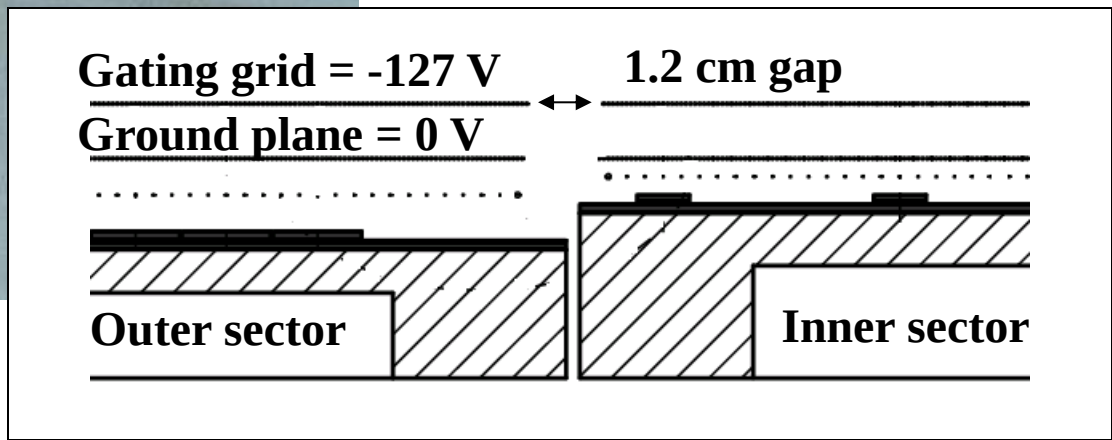
- **Multiple thick anode wires near the boundaries of the sectors**
- **A wall – to terminate the field lines from the Anode wires with ground potential and “cover” potential (match field gradient)**



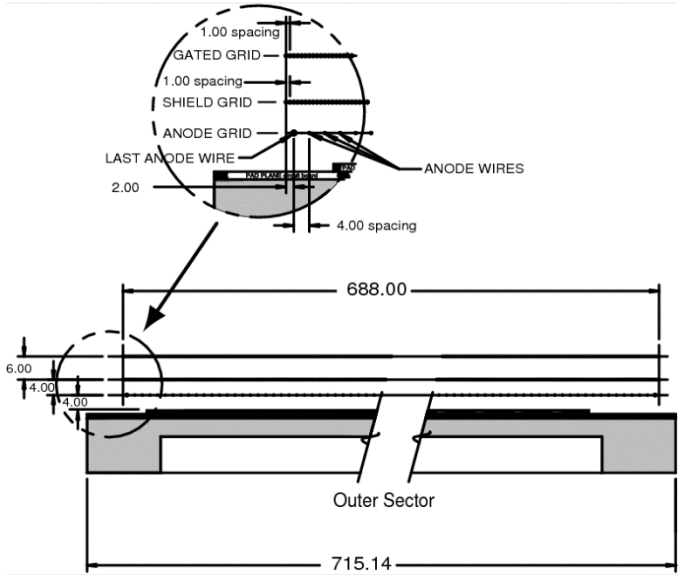
TPC Outer Sector Detail

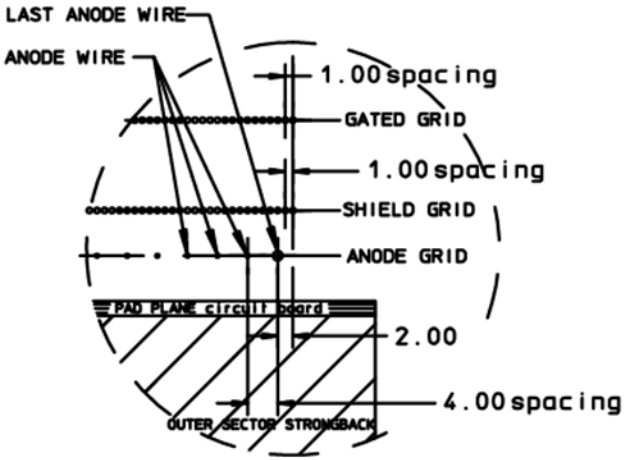


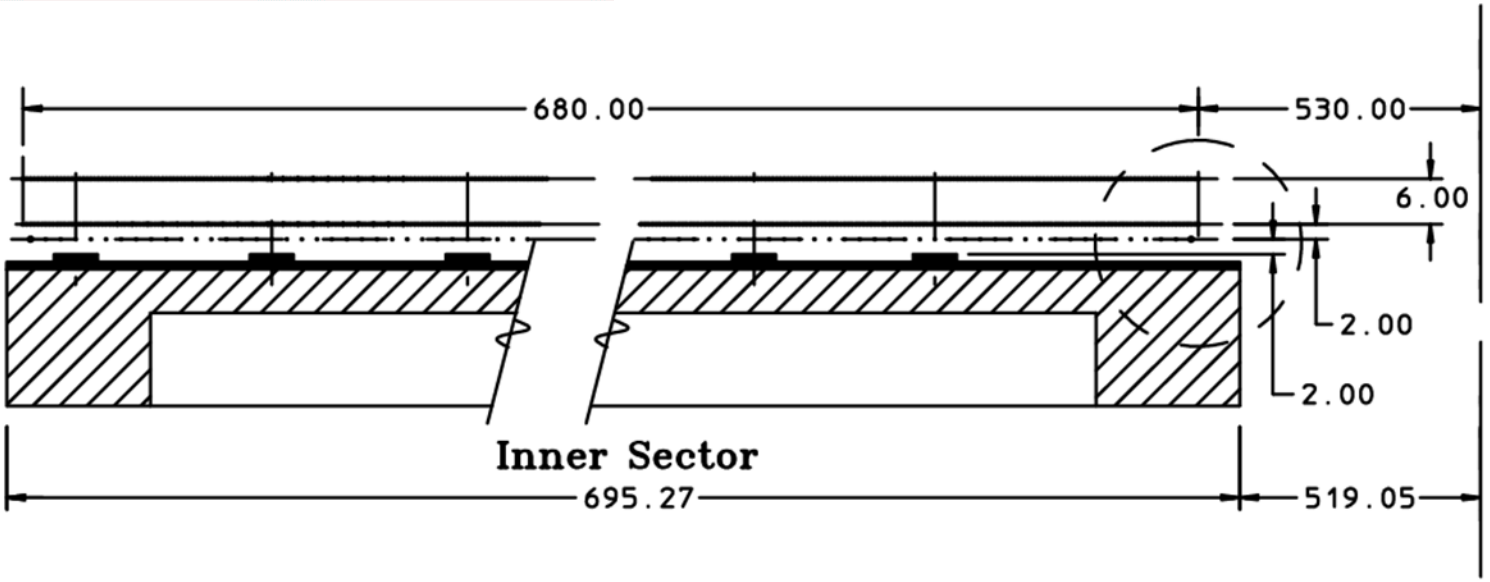
- Gating Grid
- Ground Plane of Wires
- Anodes
  - No field shaping wires
    - Simple and reliable
  - Individually terminated anode wires limit cross-talk
  - Low gain
    - Inner Sector gain: 3000 at 1150 volts
    - Outer Sector gain: 1100 at 1380 volts
- Pad Plane



Detail: The Original Inner and Outer Sectors







The Original Pad Plane design & layout