
Cell Shape Considerations

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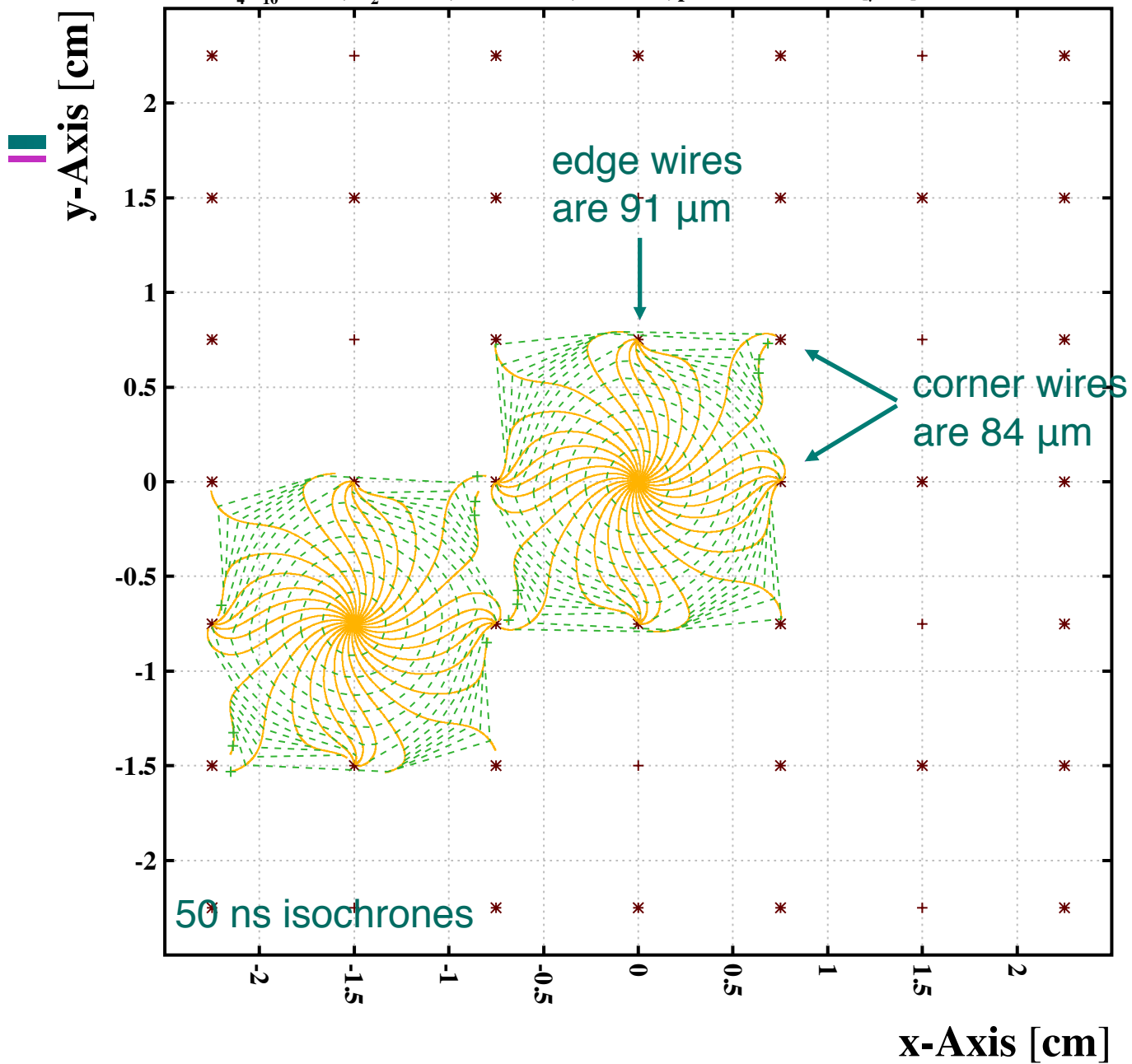
Overview

- Are there significant advantages or disadvantages of different cell shapes?
- Five different shapes studied.
 - » Garfield work by Philip Lu.
- Issues:
 - » Dead regions
 - » Time-to-distance uniformity
 - » Endplate tension
 - » Material
 - » Cost/other

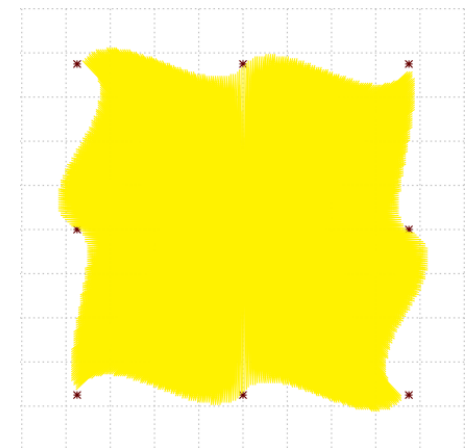
Overview II

- Cell area selected to give ~8000 cells total
- Sense wires are 20 μm gold-plated tungsten.
 - » density = 6.4 mg/m, modulus = 380 GPa.
 - » tension = 34 g (sag = 180 μm)
- Field wires are Al 5056 field wires
 - » modulus = 71 GPa.
 - » diameters selected to give $E = 20$ kV/cm at surface.
 - » two different diameter field wires in most cases.
- Gas is He:Iso 90:10 with 3000 ppm water.
- $B = 1.5$ T

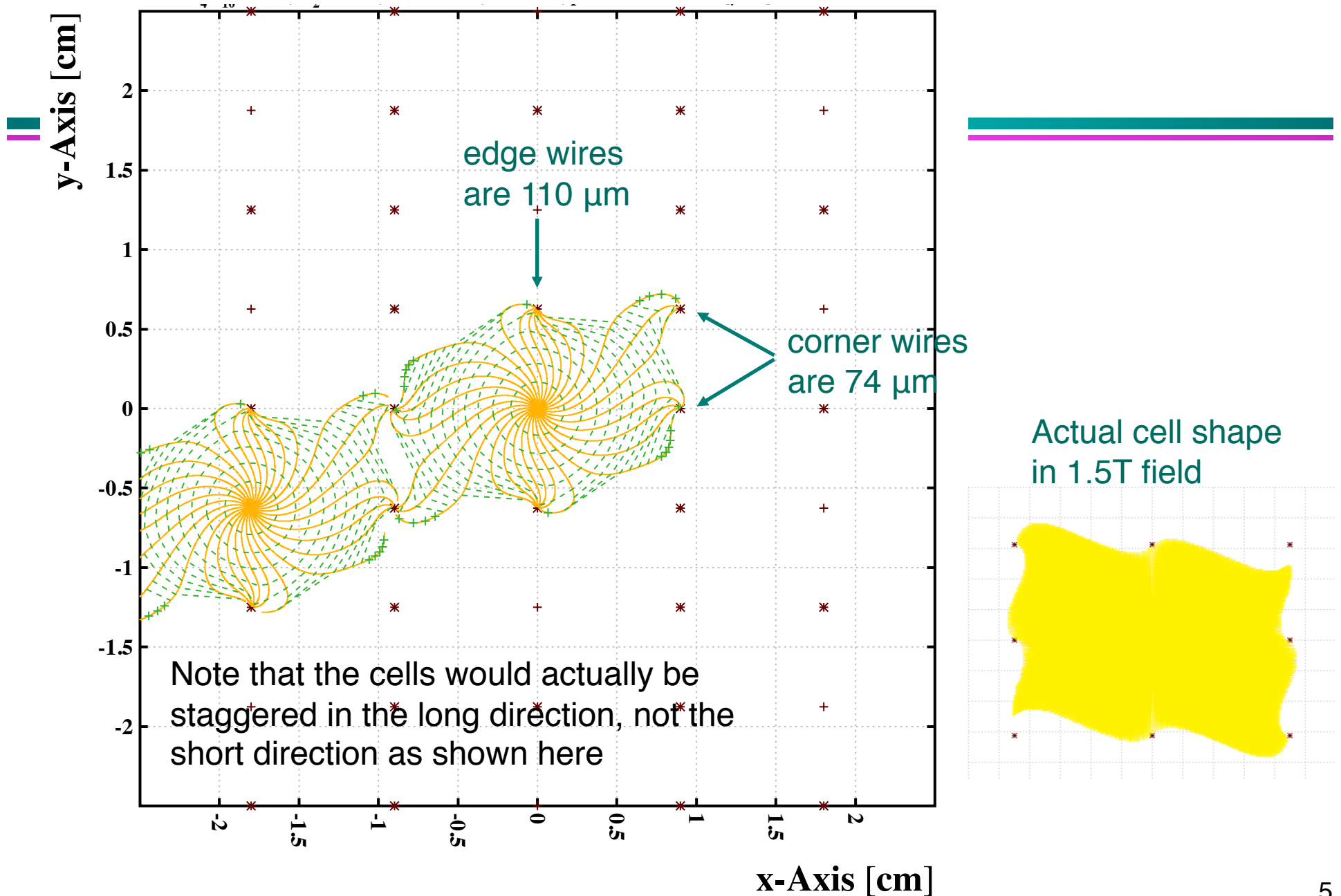
Square cell, 3 field per sense 15 mm x 15 mm



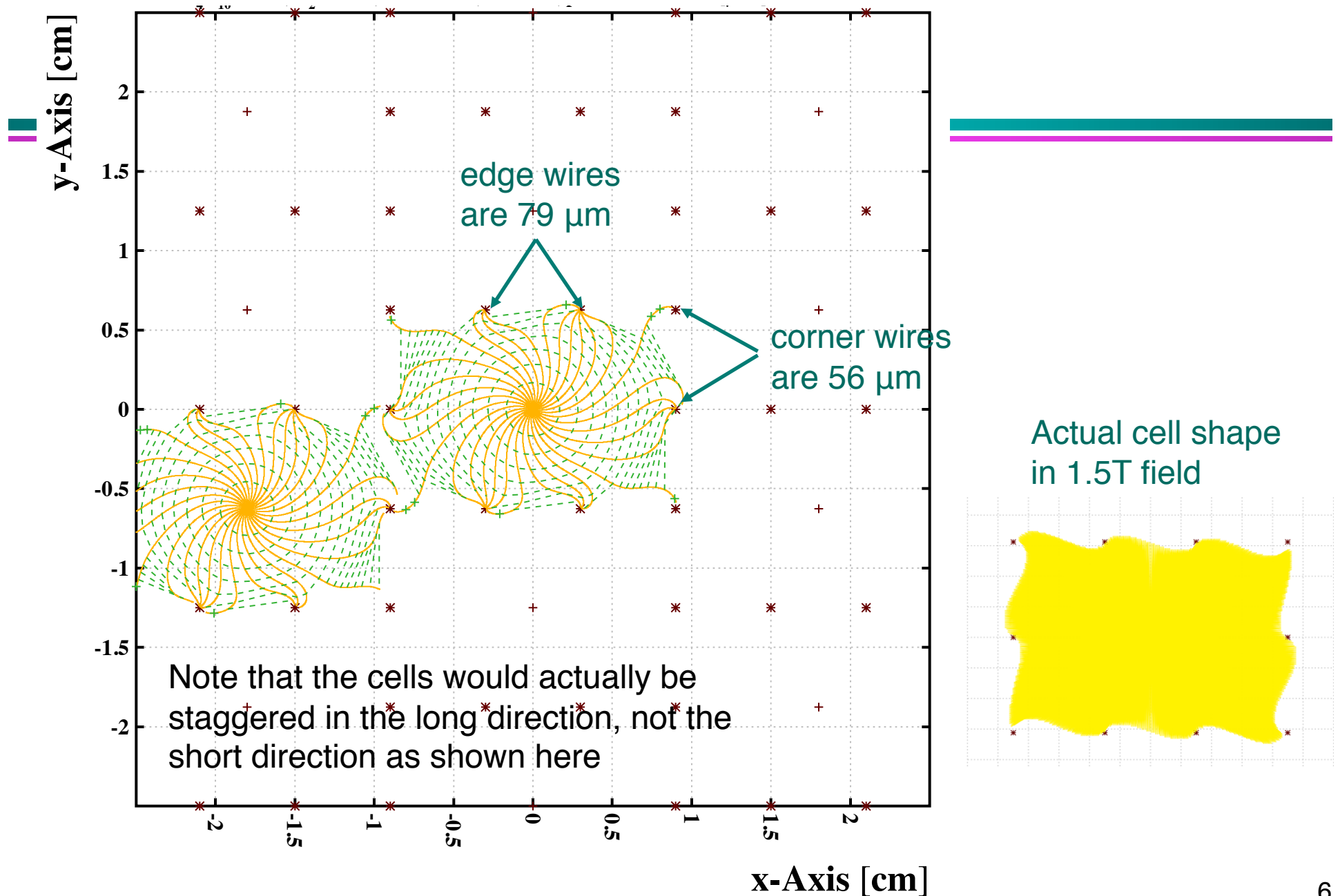
Actual cell shape
in 1.5T field



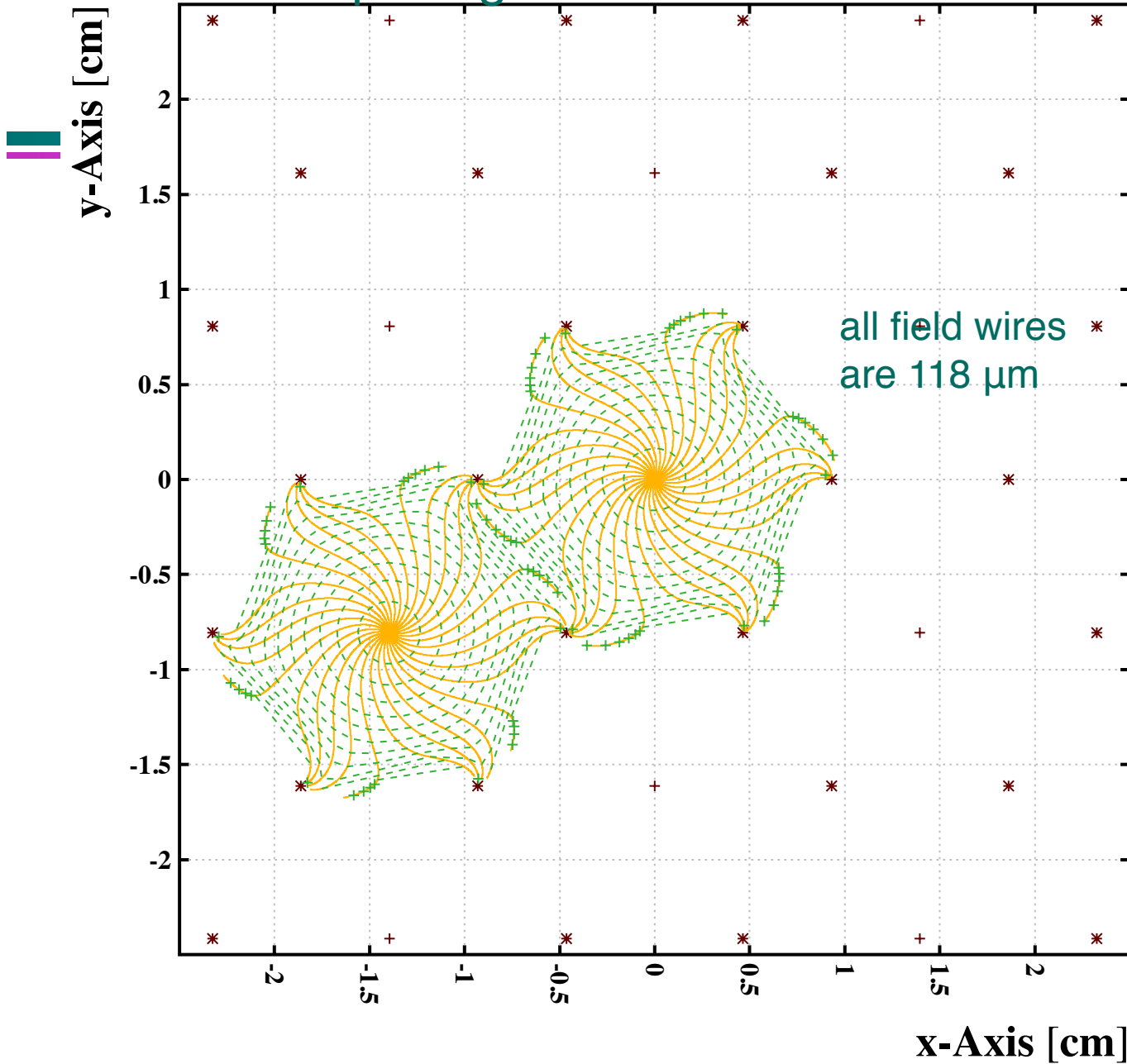
Rectangular cell, 3 field per sense 18 mm x 12.5 mm



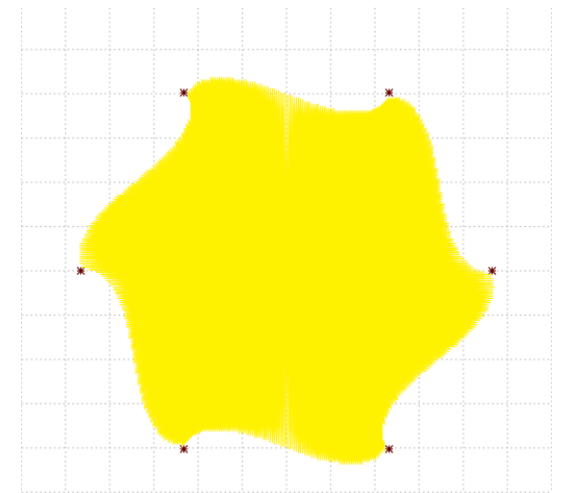
Rectangular cell, 4 field per sense 18 mm x 12.5 mm



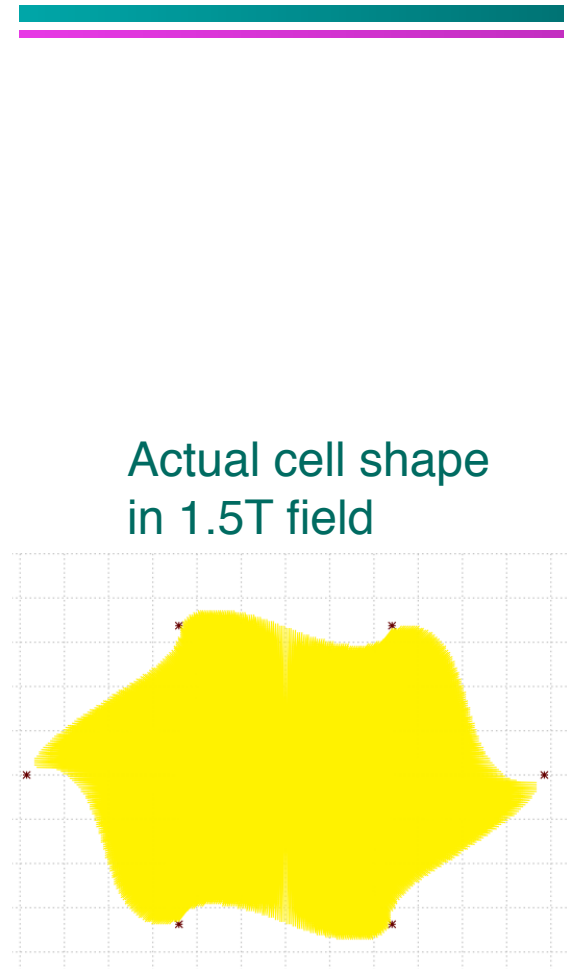
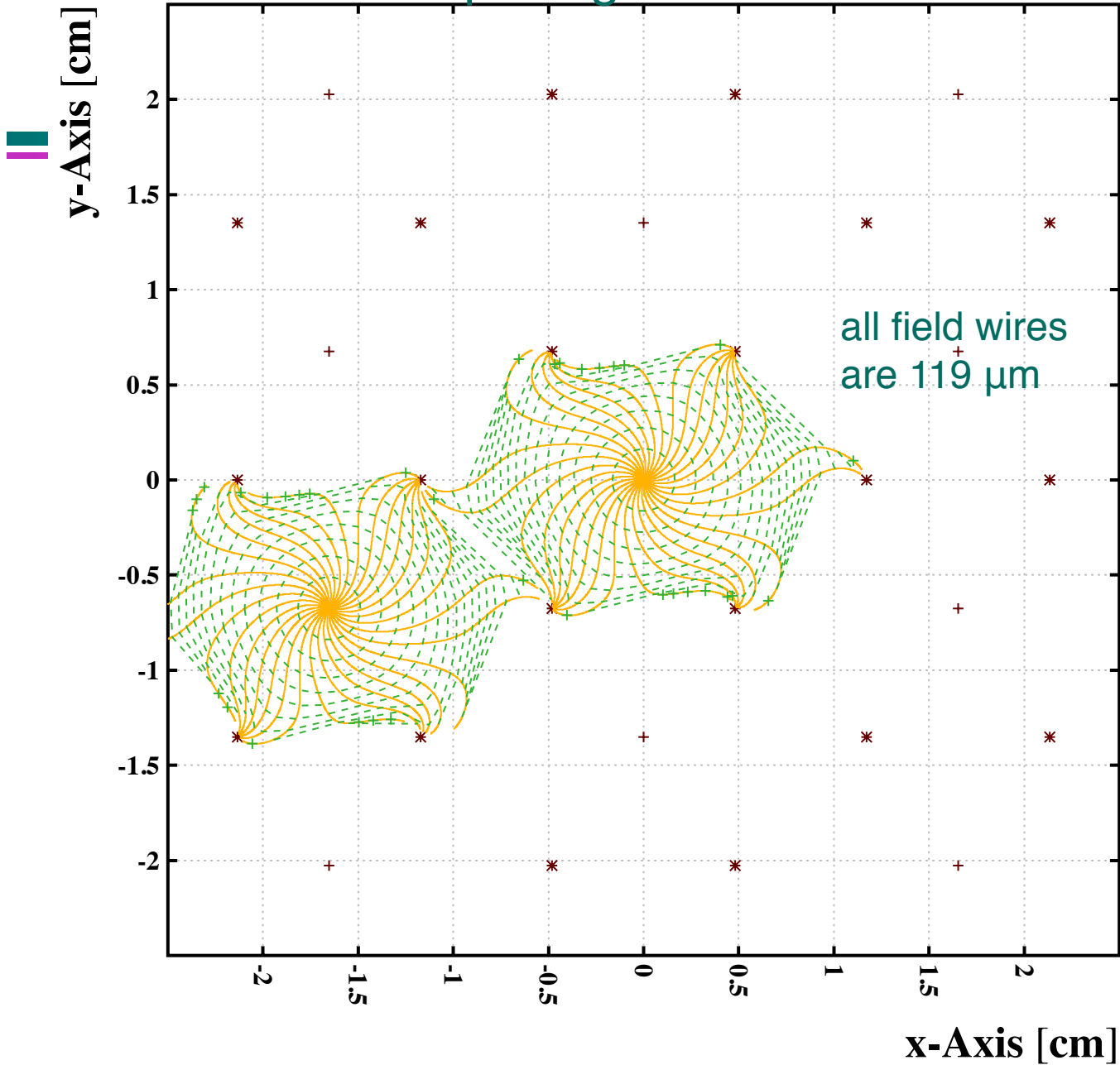
Hex cell, 2 field per sense 18.6 mm x 16.1 mm;
9.3 mm wire spacing



Actual cell shape
in 1.5T field



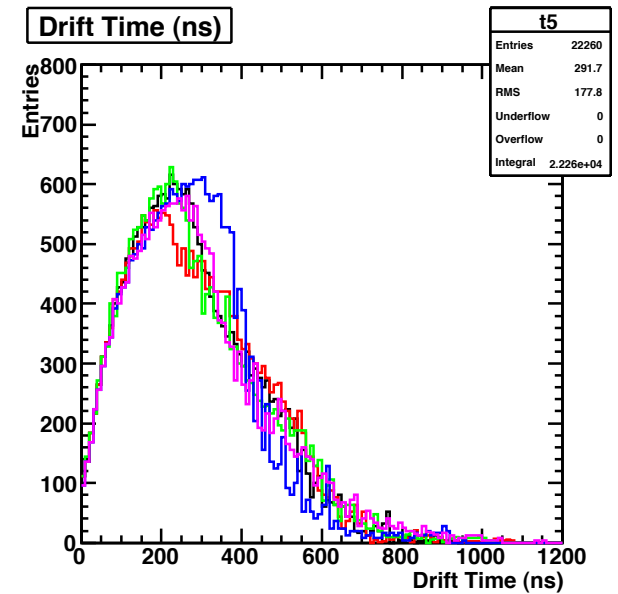
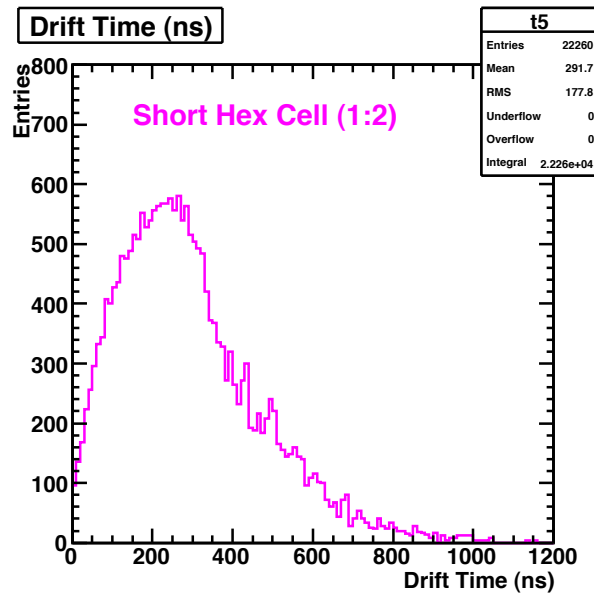
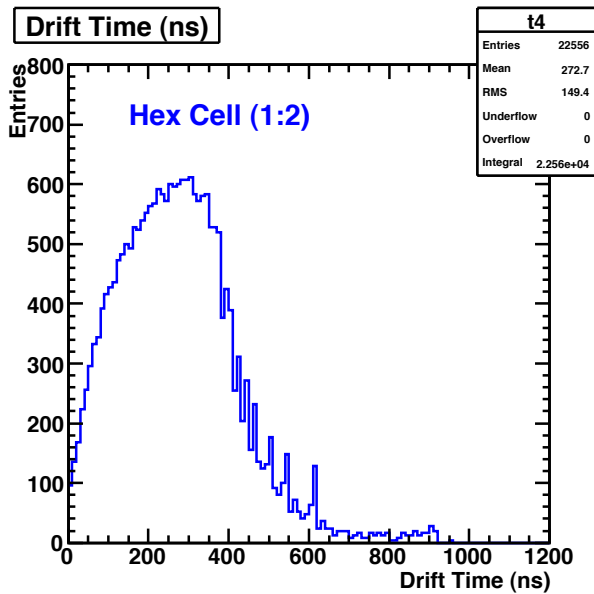
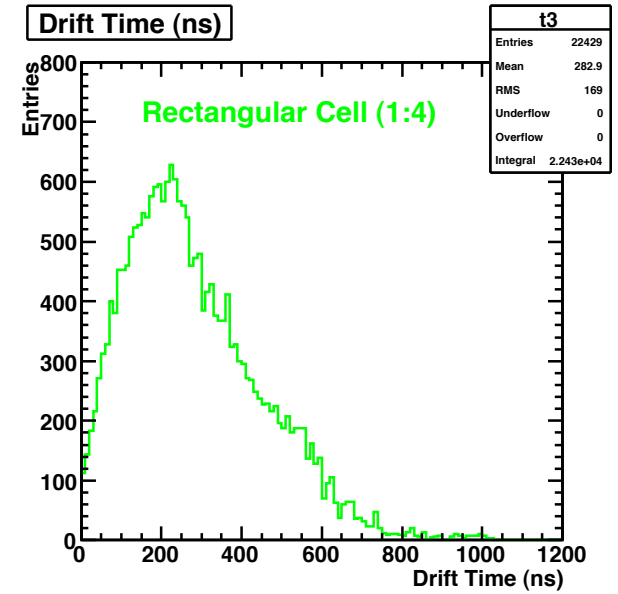
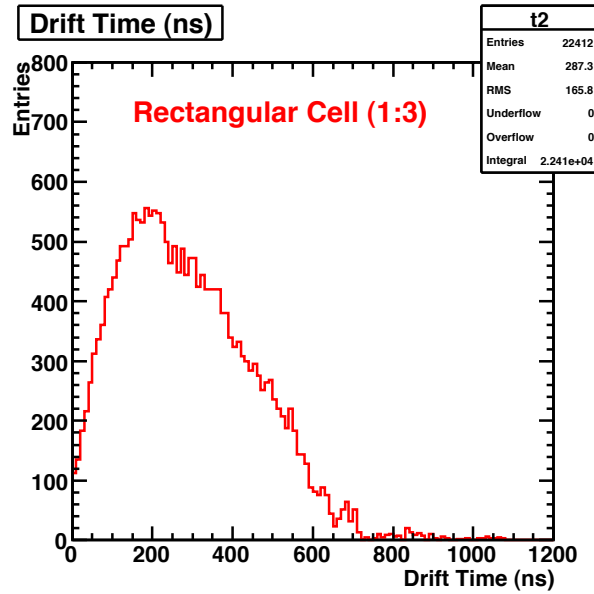
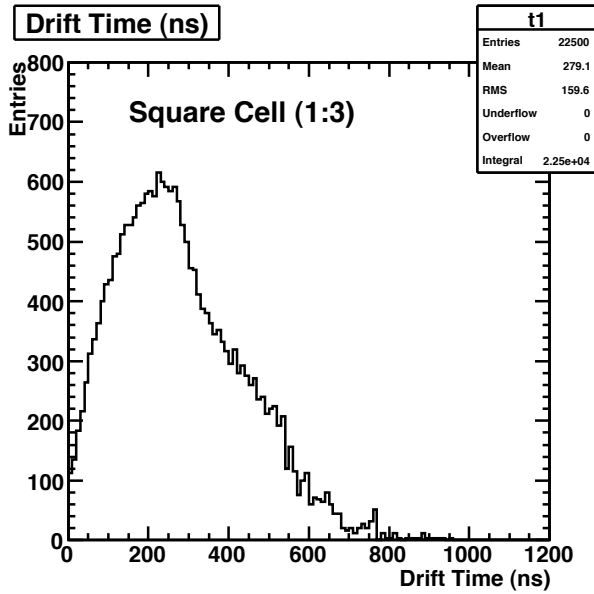
Hex cell, 2 field per sense 23.4 mm x 13.5 mm;
9.6 mm field wire spacing



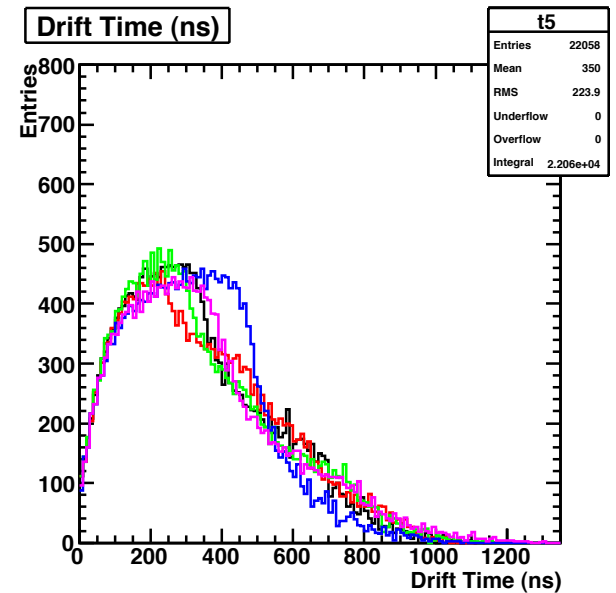
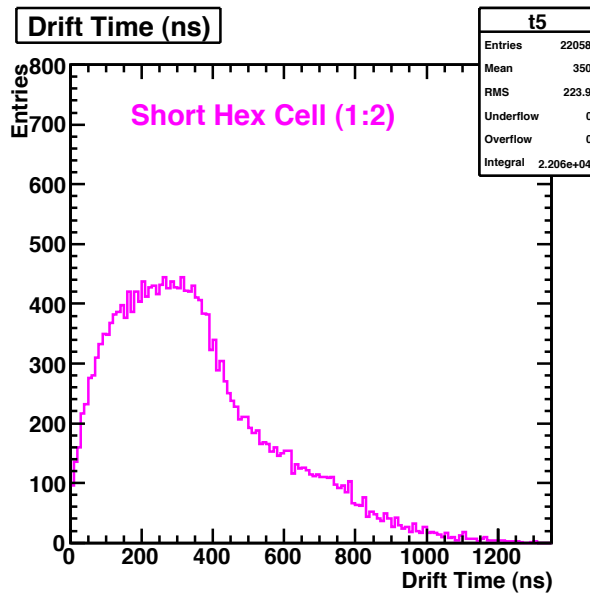
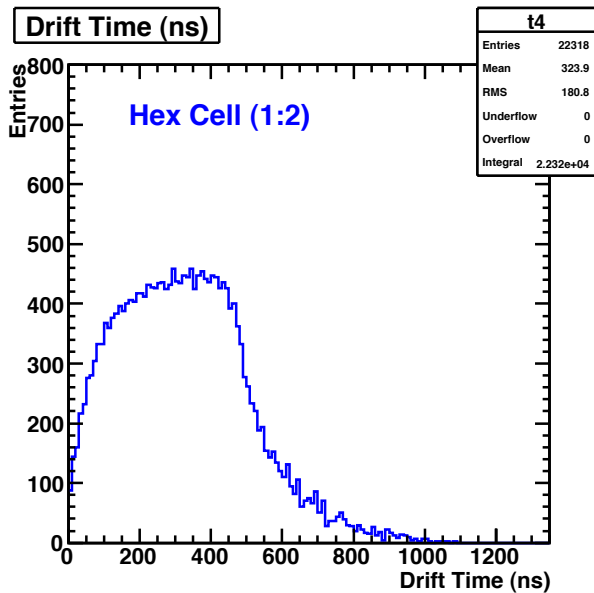
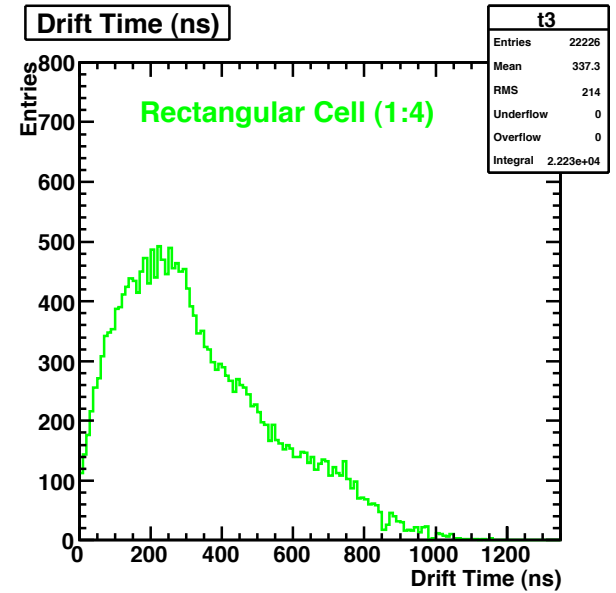
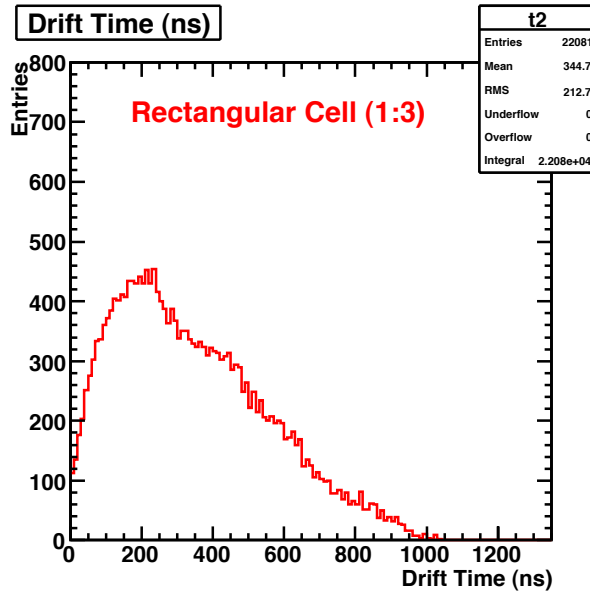
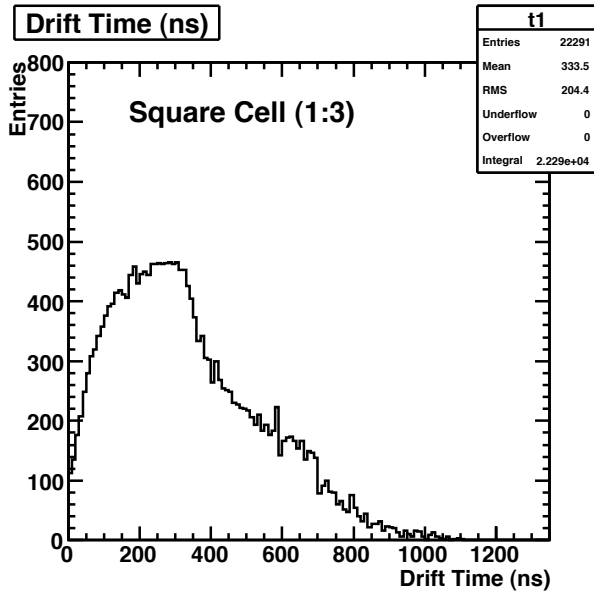
Dead Regions

- Look at distribution of drift times for electrons uniformly distributed over full cell.
 - » actual cell shape, including distortions from B field
- Garfield studies indicate that no cell design is particularly better or worse with respect to low-field / low-drift-time regions.

B = 0



B = 1.5 T

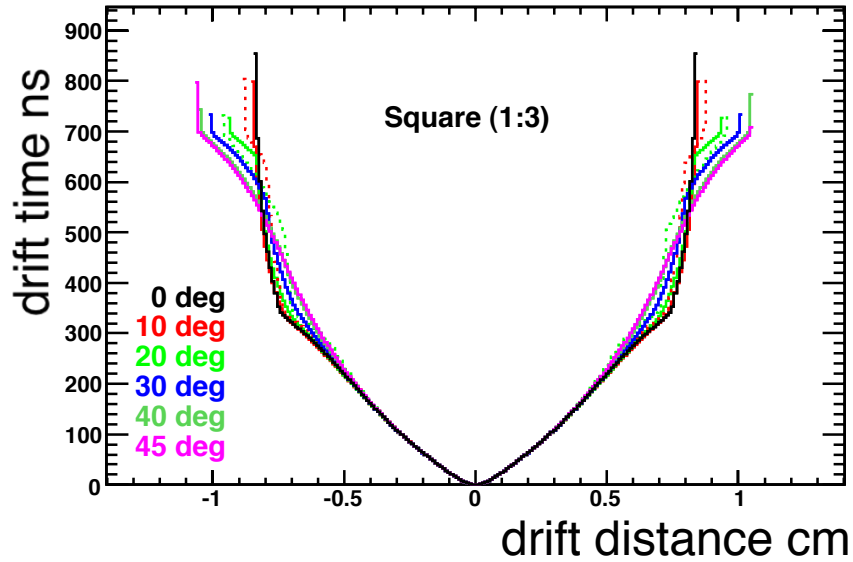


Time-to-distance relationships

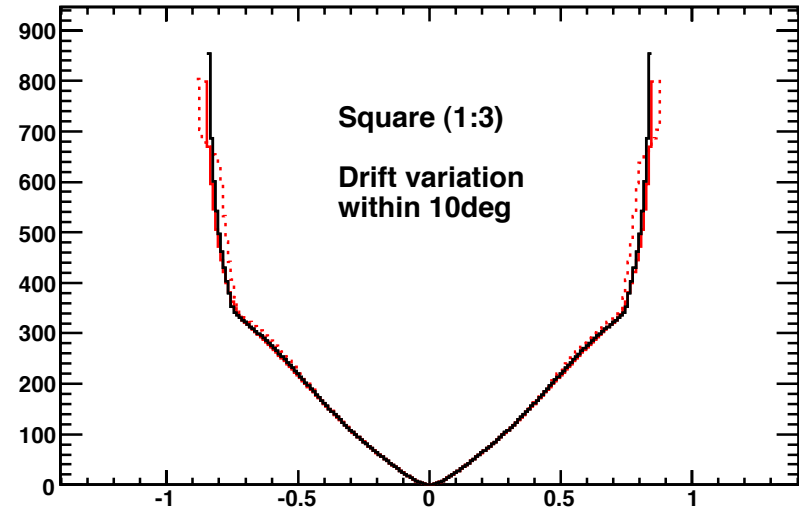
- Strong variation of the time-to-distance relationship with angle or drift distance can make the chamber hard to calibrate.
- Look at ratio of TDR for 10° entrance angle to 0° , and slope of 0° TDR vs drift distance.
- No obvious winner/loser among five shapes.
- *TDR also depends on gas; Belle selected their gas because it gives a linear TDR.*

Square Cell

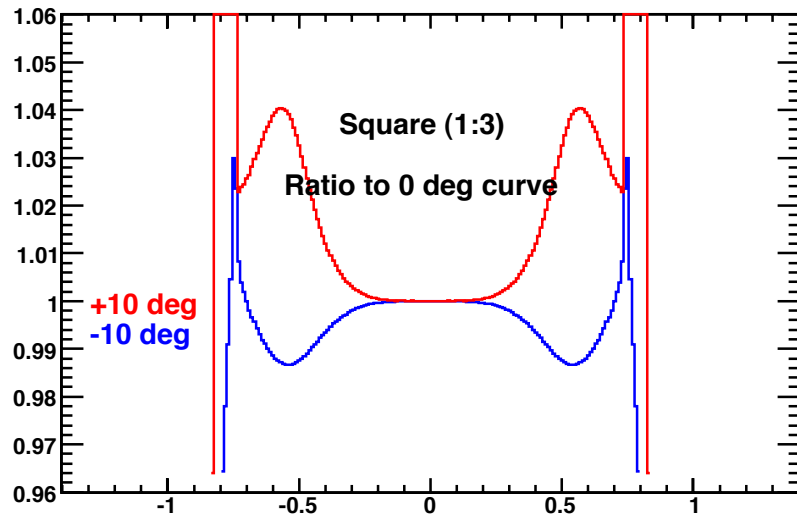
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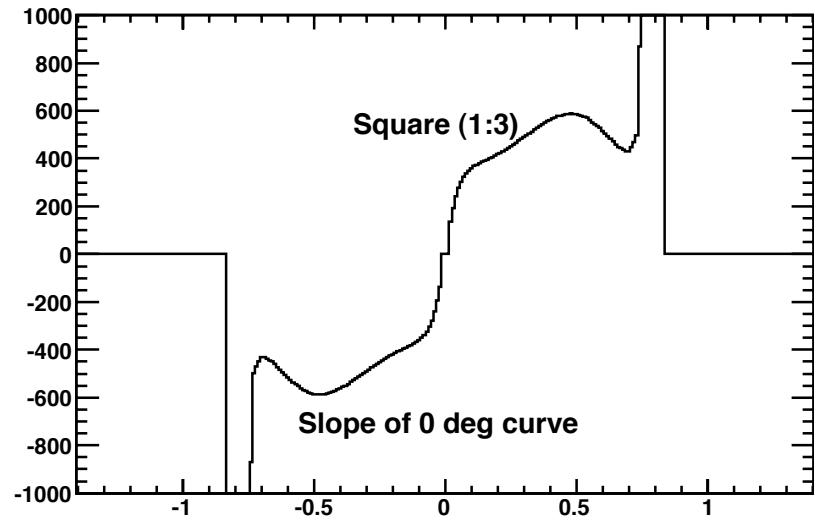
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ratio

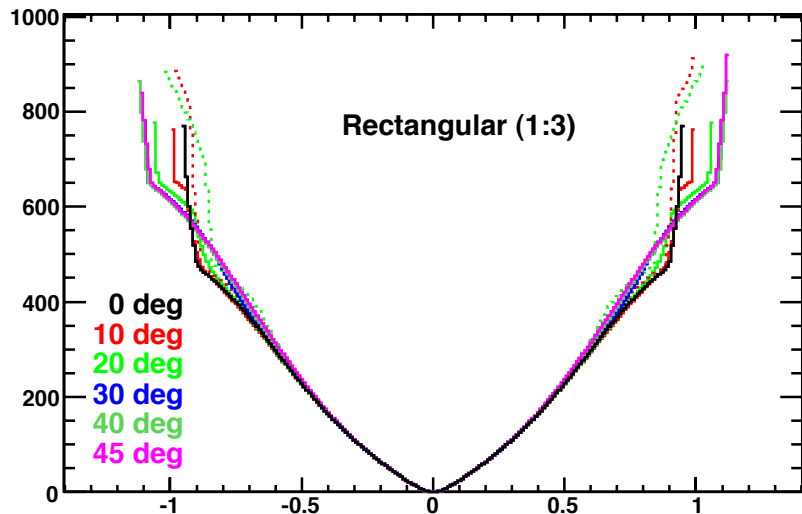


slope

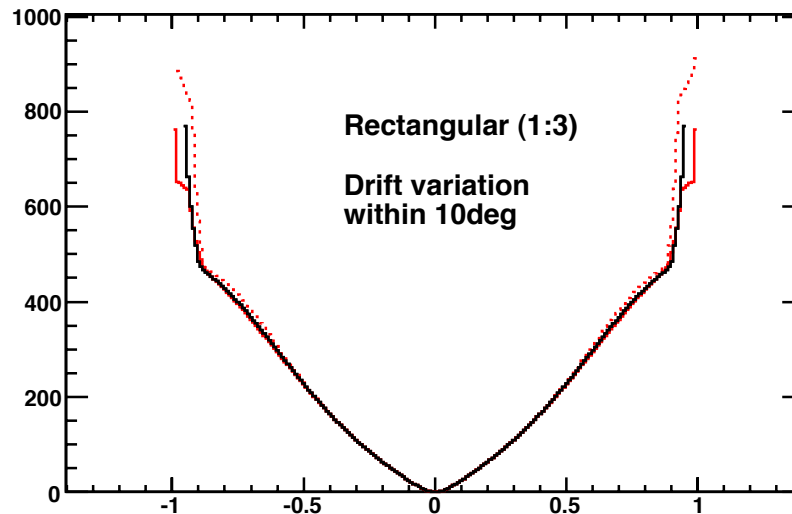


Rectangular Cell (3 field per sense)

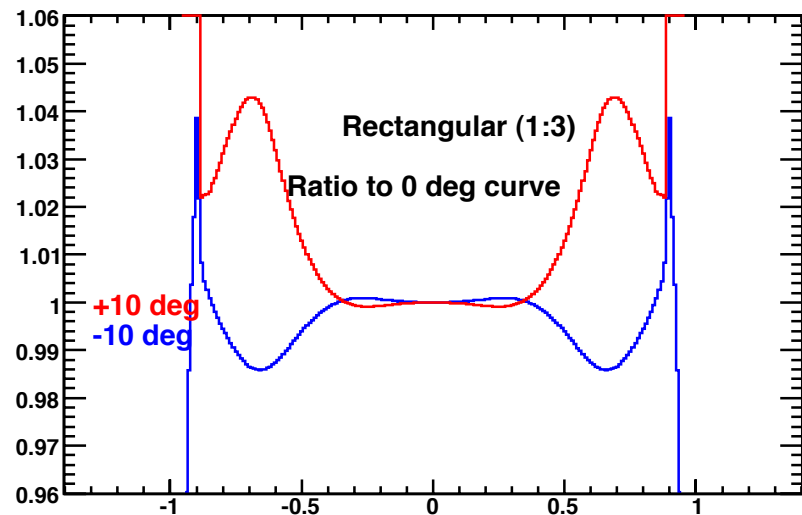
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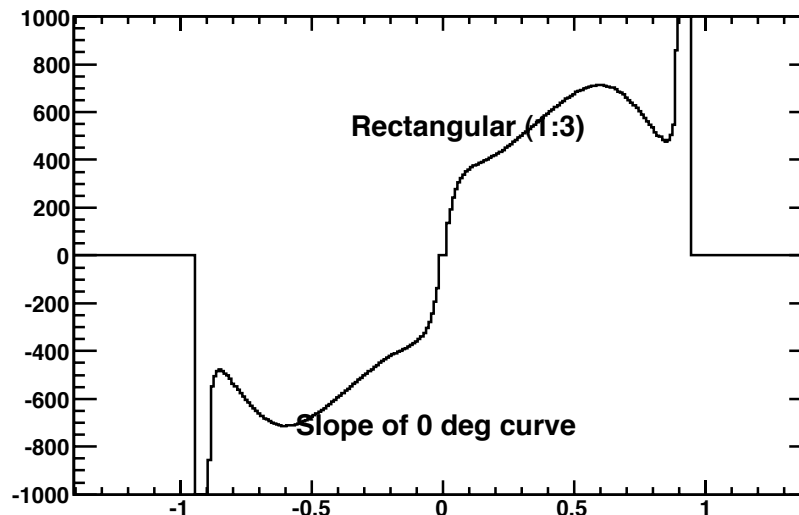
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ratio

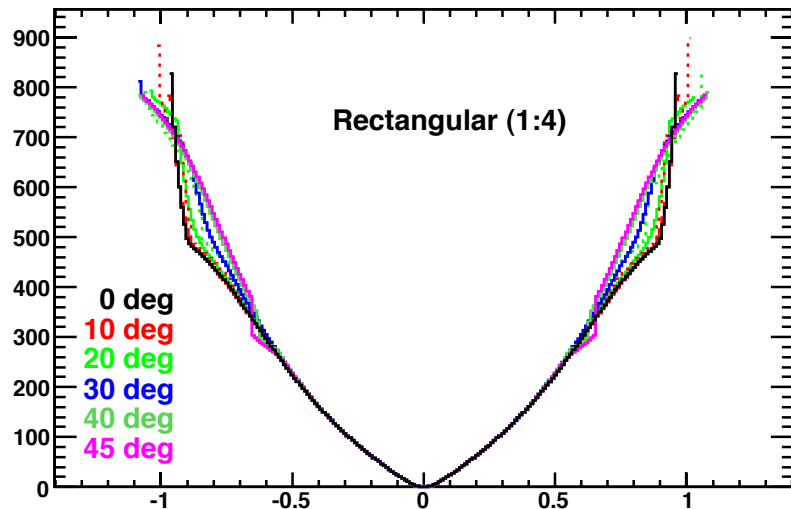


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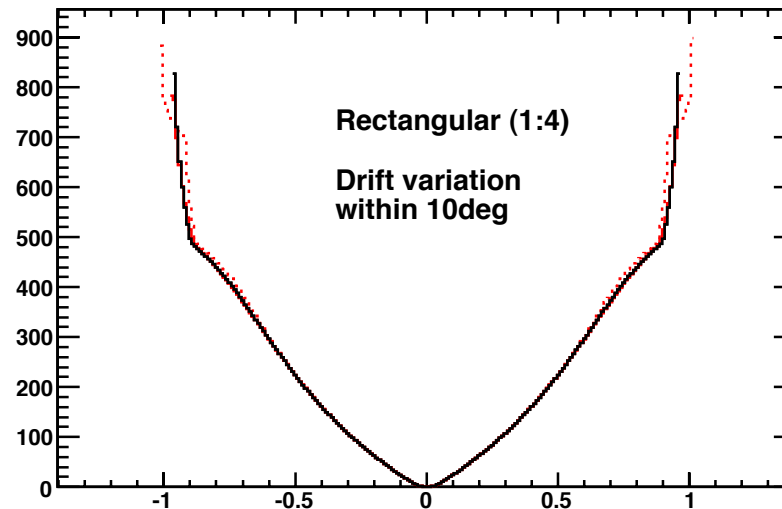


Rectangular Cell (4 field per sense)

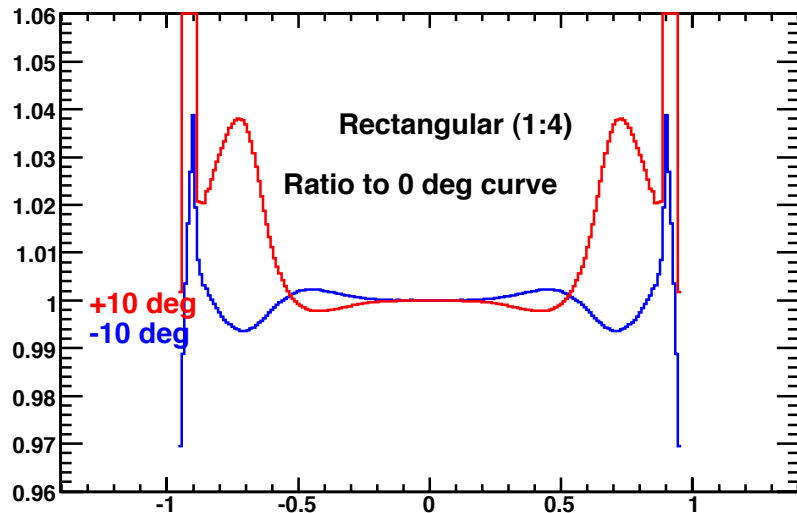
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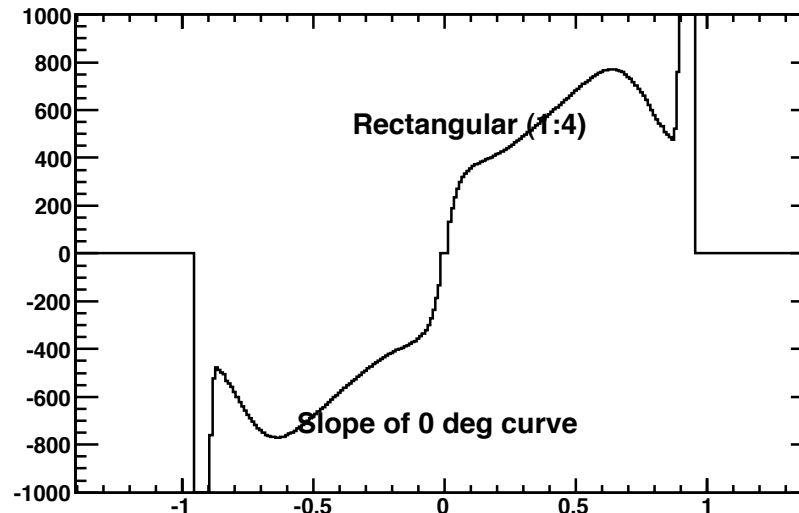
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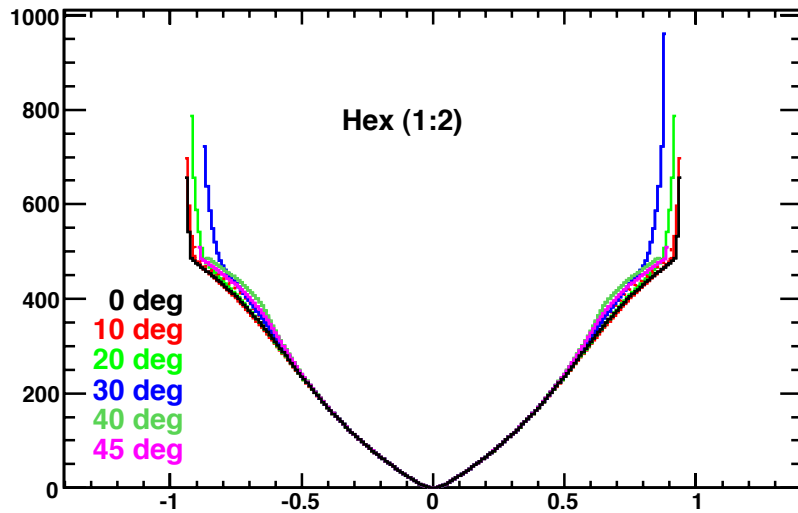


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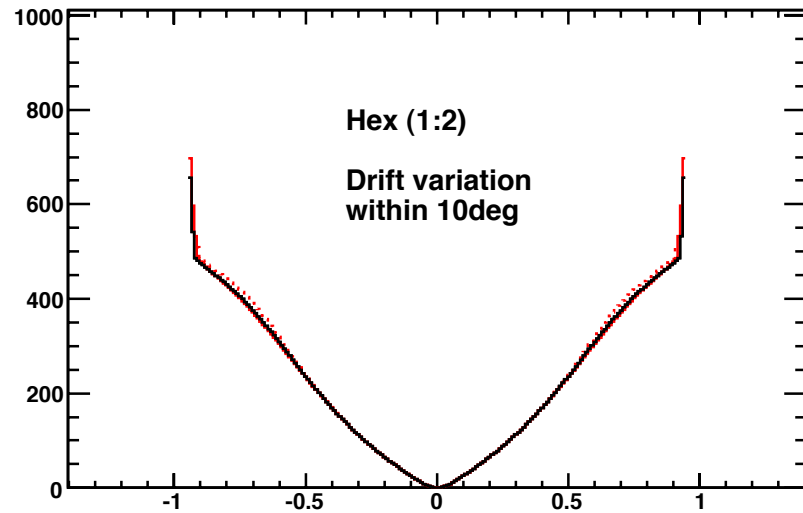


Hex Cell

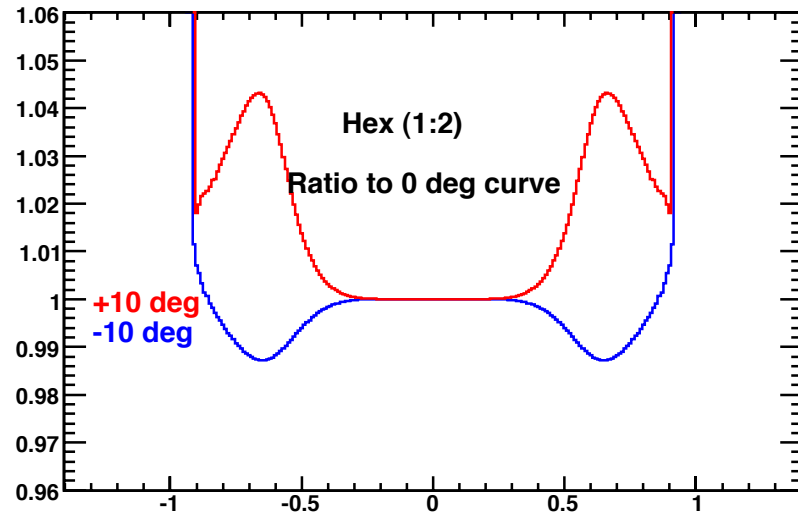
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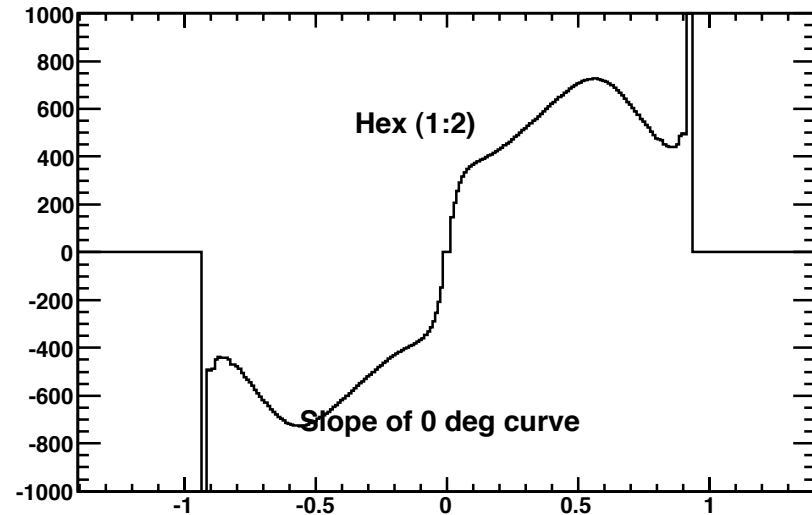
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ratio

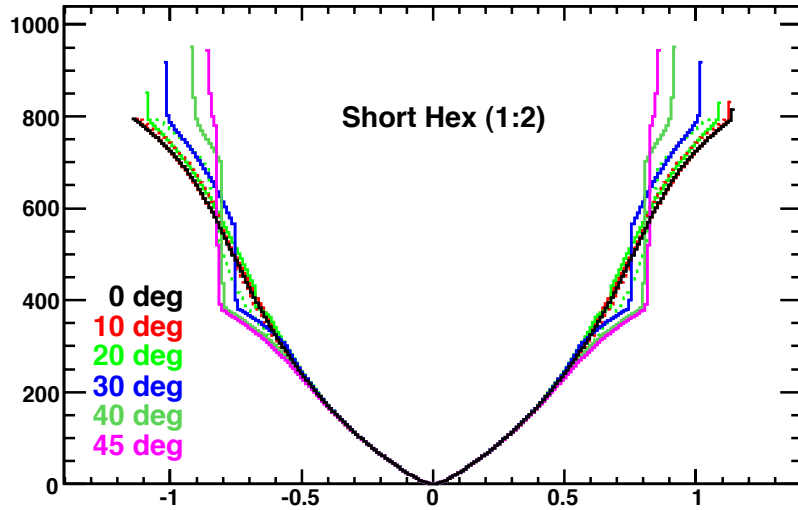


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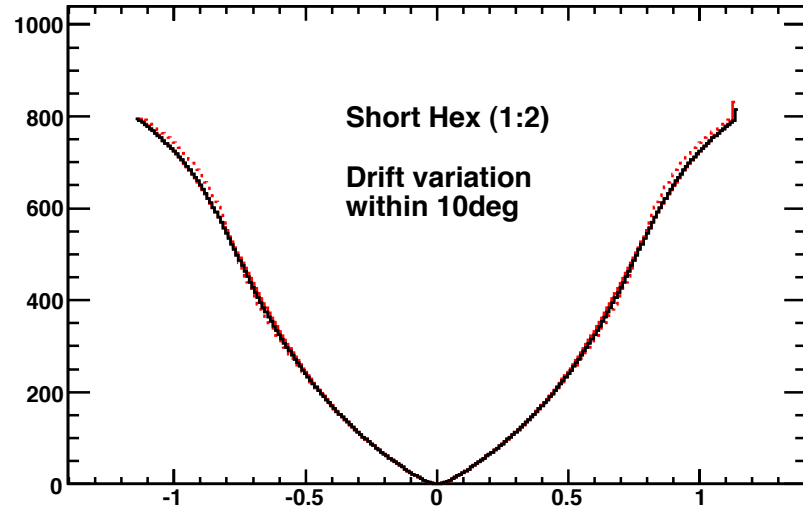


Flattened Hex Cell

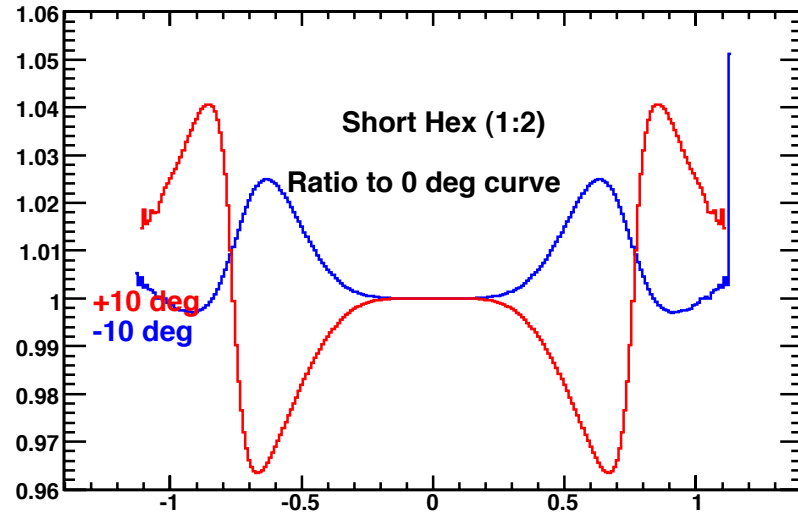
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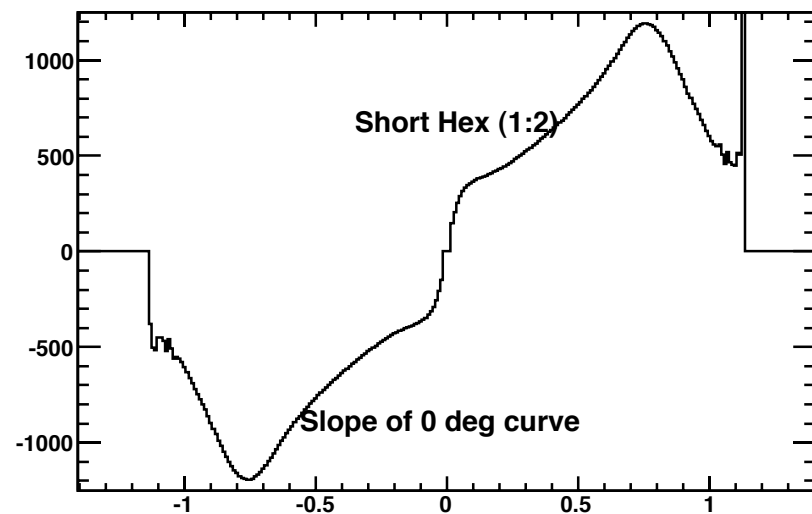
0 deg



ratio



slope



Wire tension summary

Cell	Type	Dia	Num	Tension	Total (kg)	Relative
Square 3:1	sense	20 u	1	34 g	2245	1.17
	field	91 u	1	91 g		
	field	84 u	2	78 g		
Rectangular 3:1	sense	20 u	1	34 g	2303	1.20
	field	110 u	1	133 g		
	field	74 u	2	60 g		
Rectangular 4:1	sense	20 u	1	34 g	1925	1
	field	79 u	2	69 g		
	field	56 u	2	35 g		
Hex 2:1	sense	20 u	1	34 g	2726	1.42
	field	118 u	2	153 g		
Hex flattened 2:1	sense	20 u	1	34 g	2768	1.44
	field	119 u	2	156 g		

Wire tension

- Not calculated for real layouts; no guard wires or clearing wires. See Giuseppe's Annecy talk for some actual layouts.
- Most of the difference with BaBar is due to removing the gold coating on the field wires.
 - » e.g. Hex case: 2726 kg → 3088 kg (1.60x) vs 3245 kg (1.69x) for BaBar.
- 56 μm gold-coated field wires were found to be too fragile. Maybe bare wire is OK.
 - » tension increases by 28% if 56 μm → 79 μm

Tests of 55 μm aluminum wire done for BaBar

Gold-coated:

tension = 46 g
yield strength = 78 g
safety factor = 1.7x

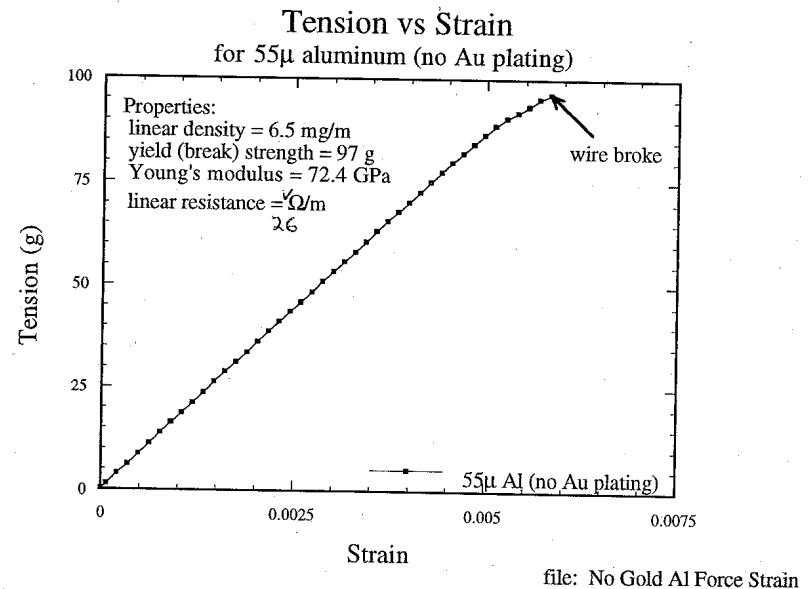
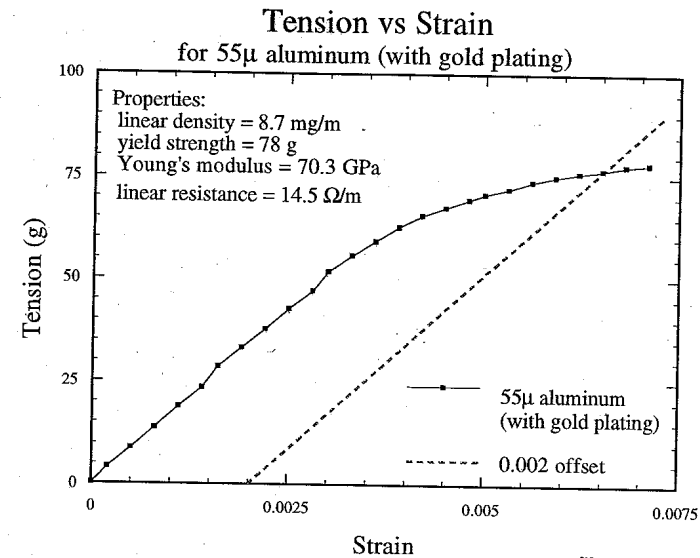
Bare:

tension = 34 g
yield strength = 97 g
safety factor = 2.9x

Wire Study

01/08/95

Wires Summary



Total material

Not for a real layout – no guard or clearing wires

Other materials: beam pipe = 1.1%, SVT ~ 4%, support tube 0.8%

		% X0 at 0 dip angle	
inner cylinder	CF 1.1 mm	0.41	
	Be 1.0 mm	0.28	
inside chamber	Square 3:1	0.11	SuperB cases include He:Iso 90:10
	Rectangular 3:1	0.11	
	Rectangular 4:1	0.10	
	Hex 2:1	0.12	
	Hex flattened	0.12	
	BaBar with 80:20	0.22	
	BaBar with 90:10	0.19	

Recall that if multiple-scattering dominated, $\frac{\delta_{pt}}{p_t} \propto \frac{\sqrt{\text{material}}}{L}$

Other considerations

- Garfield studies do not demonstrate any problems with square/rectangular cells.
- Many costs scale with number of holes. This is advantage for hex, if we have large all-axial sections. But not in a chamber like BaBar.
- Why did BaBar choose hex?

Thoughts on Rectangular 4:1 field:sense

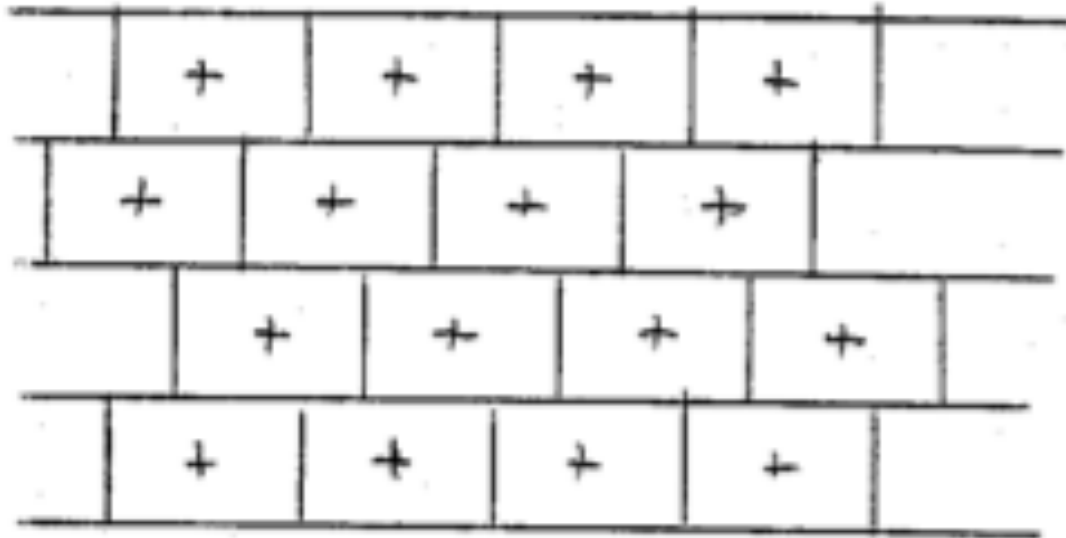
- Advantages:

- » more uniform cell shape in 1.5T than 3:1
- » lowest wire tension
- » least material = best momentum resolution

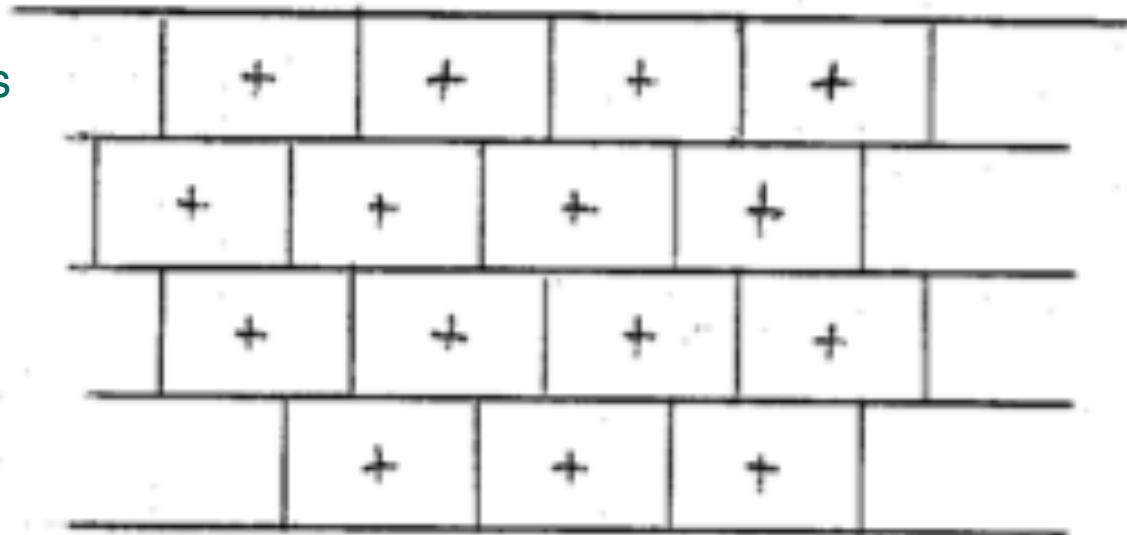
- Disadvantages:

- » most holes (cost, construction time)
- » Does not allow a half-cell offset between layers.
Does this create a charge asymmetry?
- » 56 μm wire is of marginal strength.

every 3rd layer repeats



every 2nd layer repeats



For the prototype, we propose to use 15 mm x 15 mm square cells
3 field wires per sense wire

