Garfield studies of cell layouts

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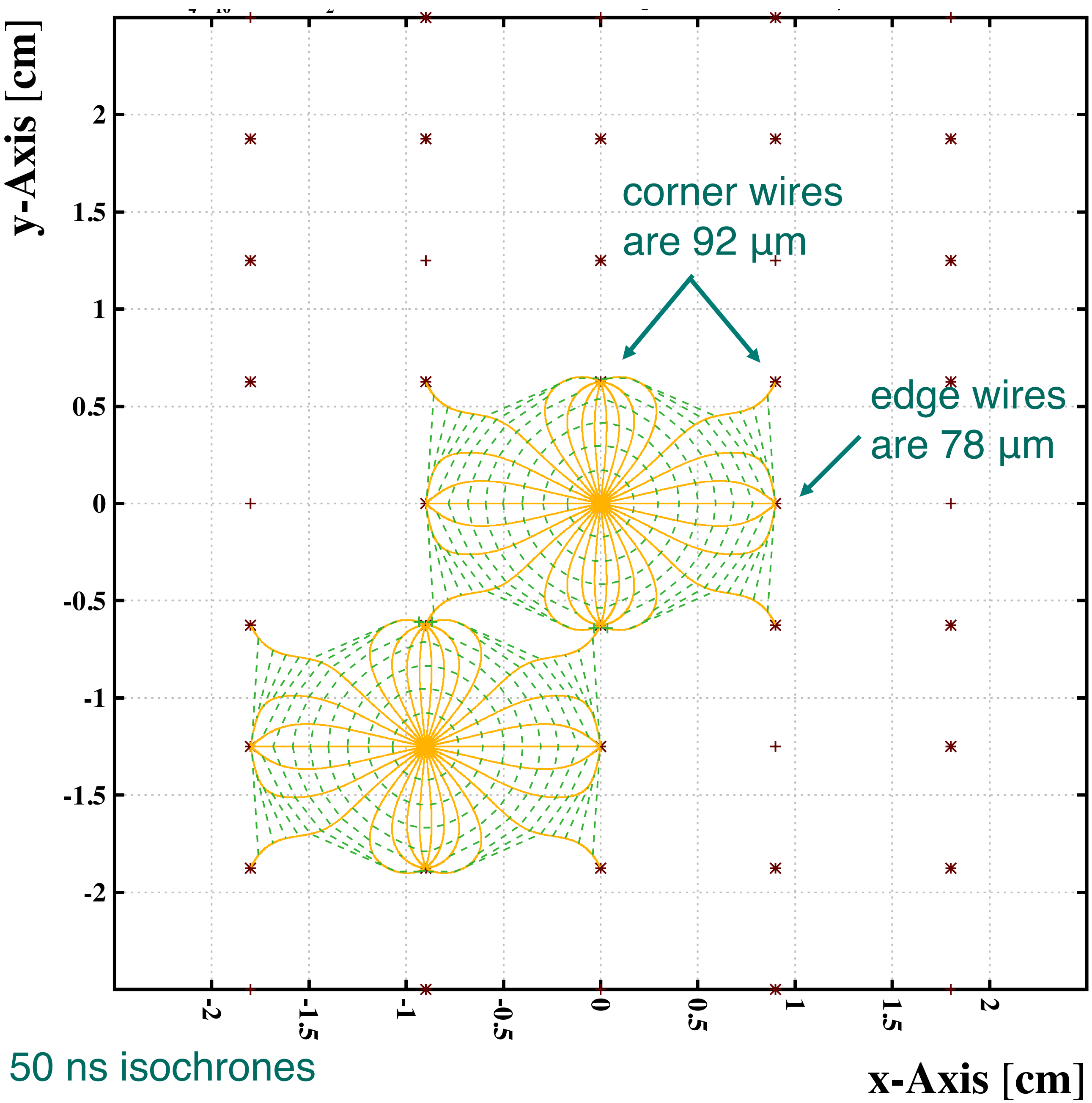
Introduction

- All calculations are done by Philip Lu, UBC.
- Gas is He:Iso 90:10 with 3000 ppm water
- Sense wires are 20 µm gold-coated tungsten
- Field wires are bare Al 5056 with diameter selected to keep $E < 20$ kV/cm at the surface.
- $B = 1.5$ T

Cell Shape

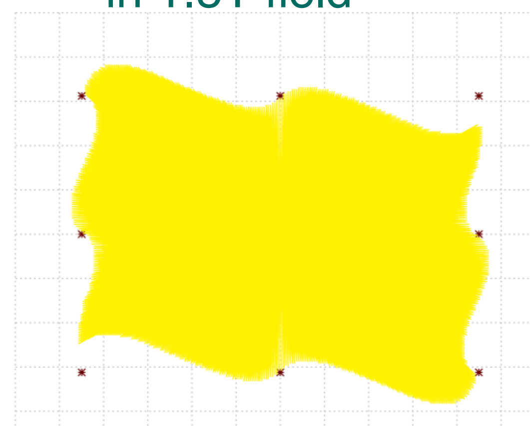
- See presentation (and subsequent email follow up) on 25-Apr-2010 for details.
- My conclusion is that a square/rectangular cell with three field wires per sense wire is optimal.
  - less material/tension than hex, and better axial/stereo transitions
  - four field wires per sense does not stagger by ½ layer, and uses field wires of marginal strength.

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



50 ns isochrones

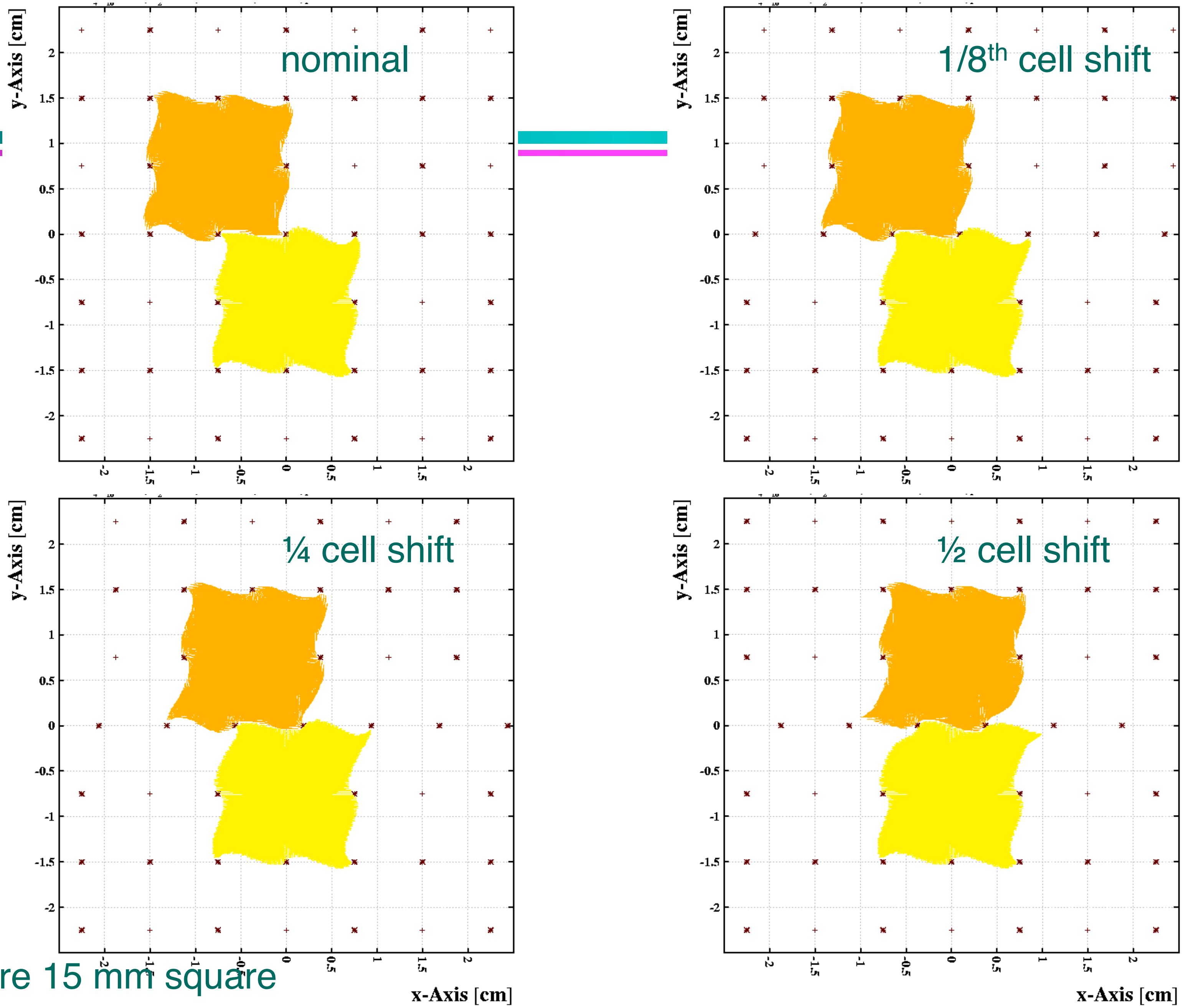
Actual cell shape
in 1.5T field



Transitions between stereo superlayers

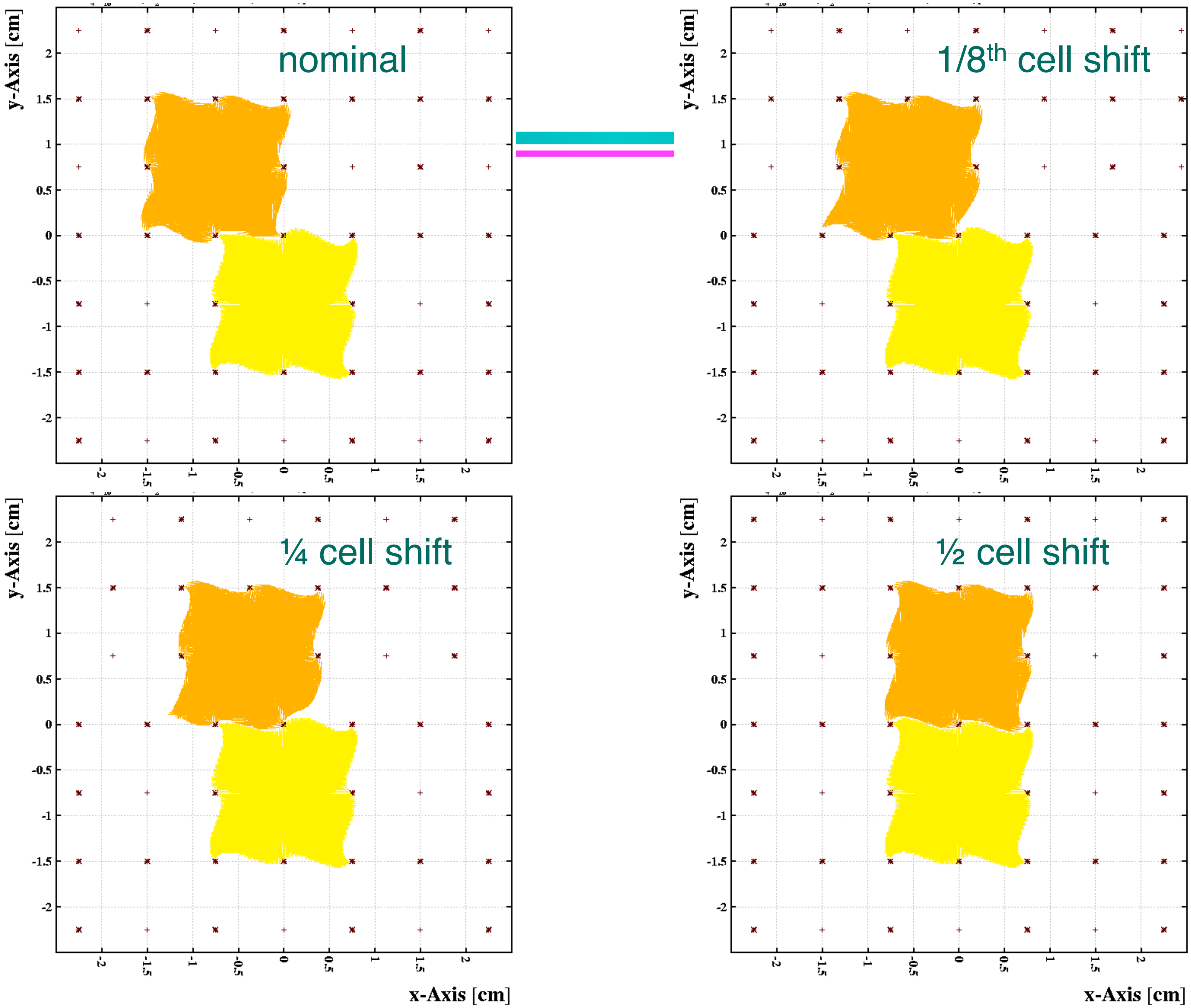
- U and V stereo layers nest: the separation between a U sense wire and an adjacent V sense wire is constant along the wire.
- However, the relative azimuthal position of the sense wires does change along the wire.
  - changes in E field with z.
- What about the stereo angle of the field wire layer between them? Mid-way between the two? Or the same as one of them? Is either OK?

Stereo-stereo layout 1: Field wires at intermediate stereo angle



cells are 15 mm square

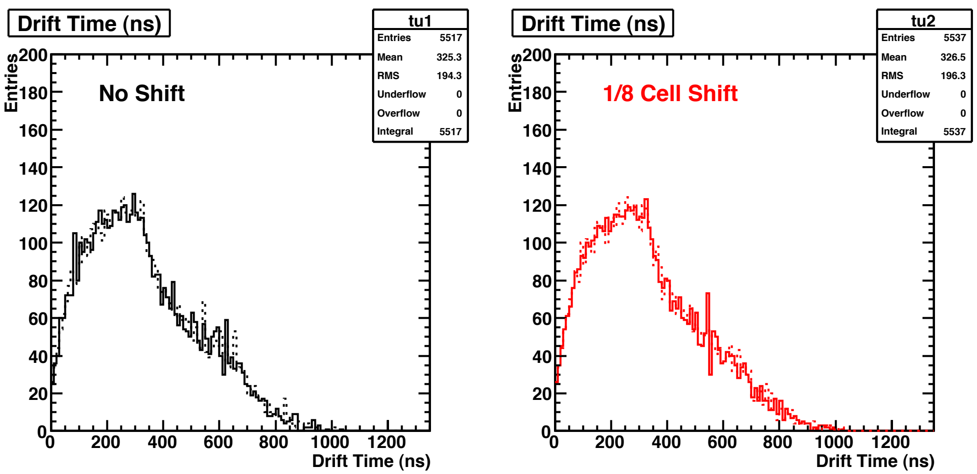
Stereo-stereo layout 2: Field wires in phase with lower cell



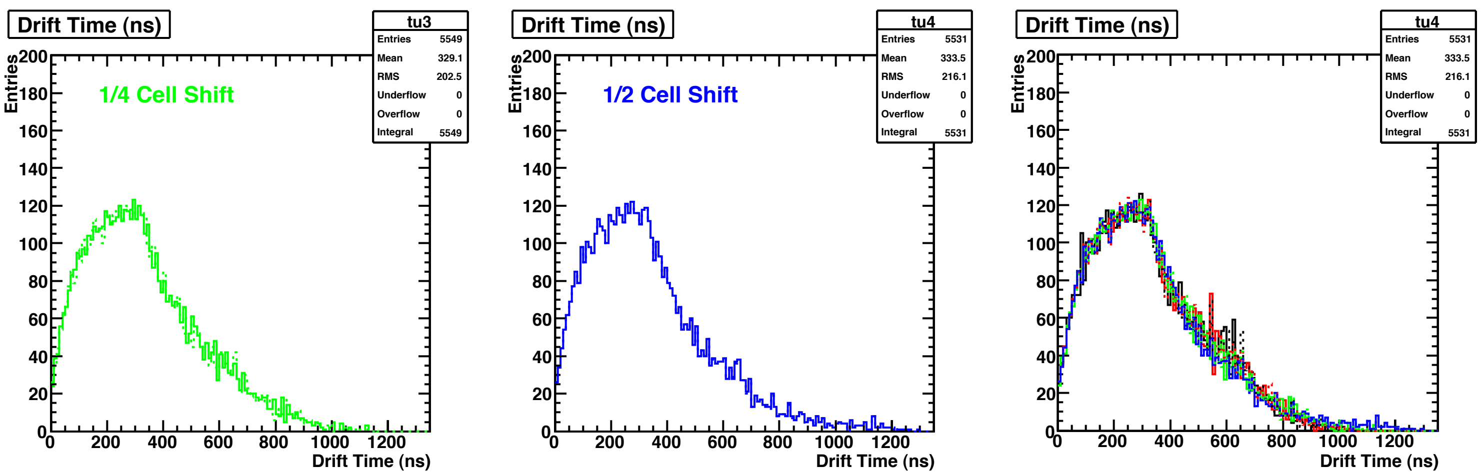
Dead regions

- Concern that some regions have very low field and therefore long drift times.
- Actually, not so bad — tail extends to 1200 ns, vs 950 ns in nominal case.

Layout 1: Field wires at intermediate stereo angle

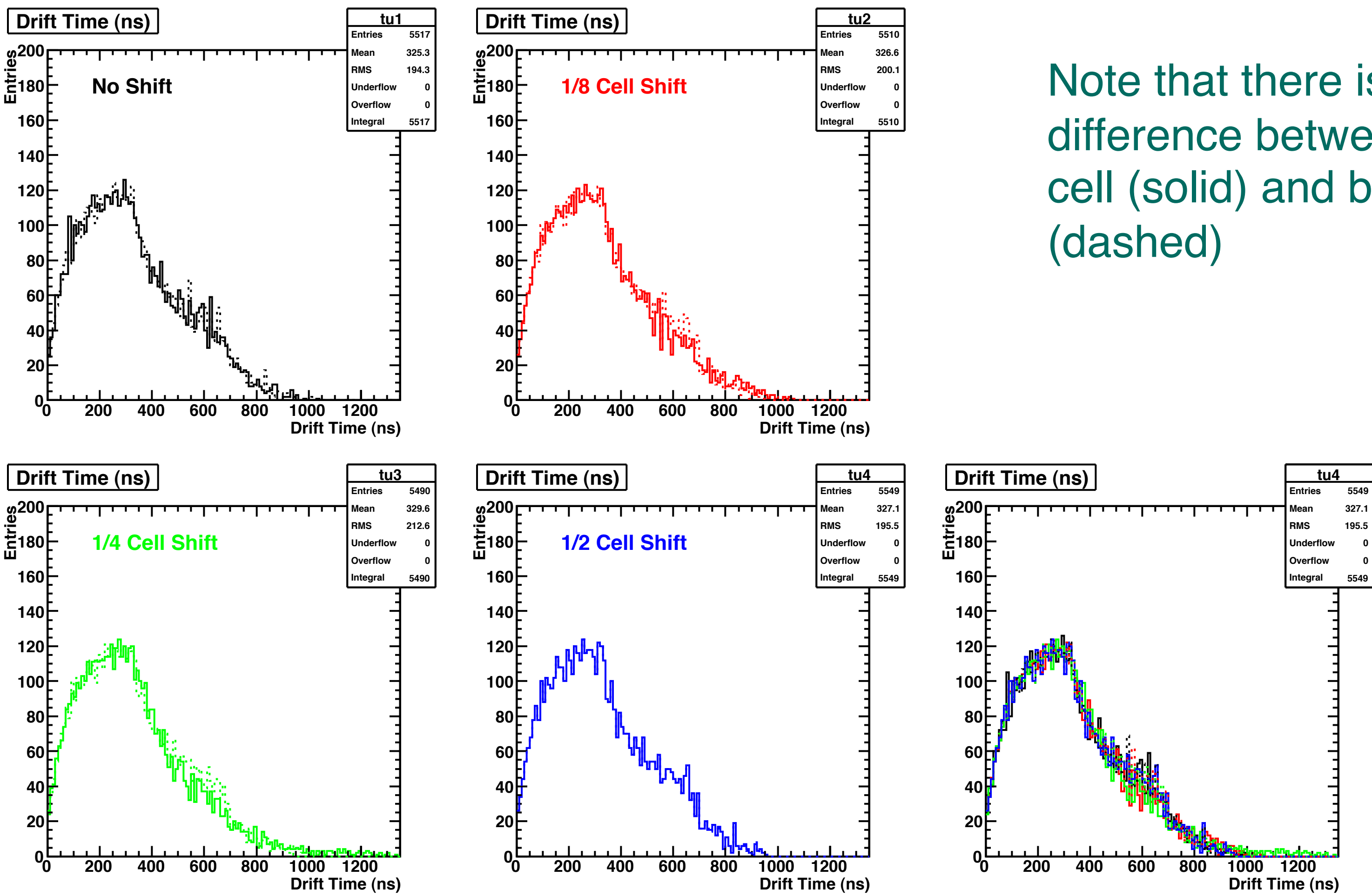


drift times for e- uniformly deposited over cell



longest tail for ½ cell shift

Layout 2: Field wires in phase with lower cell



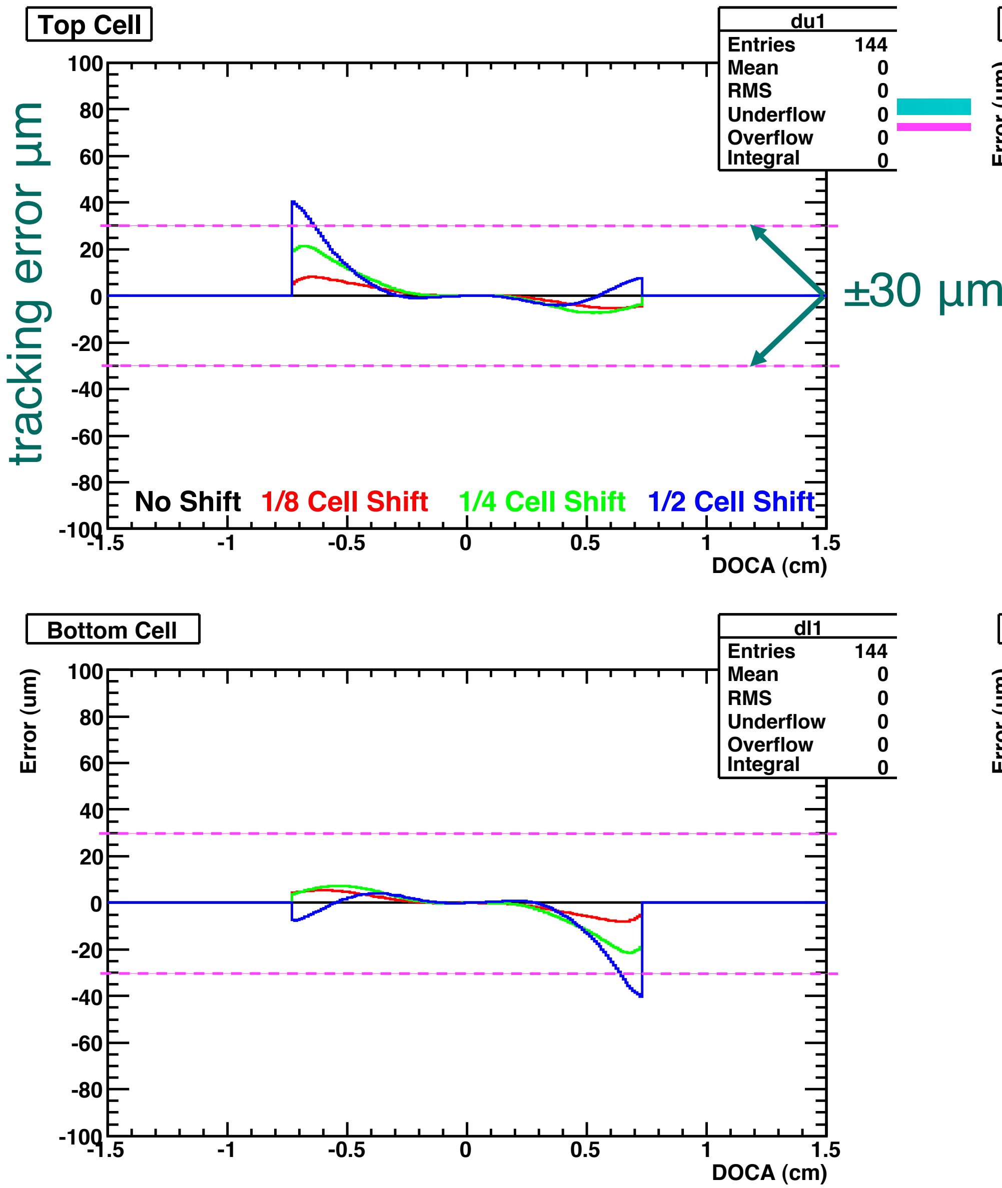
Note that there is little difference between top cell (solid) and bottom (dashed)

longest tail for ¼ cell shift

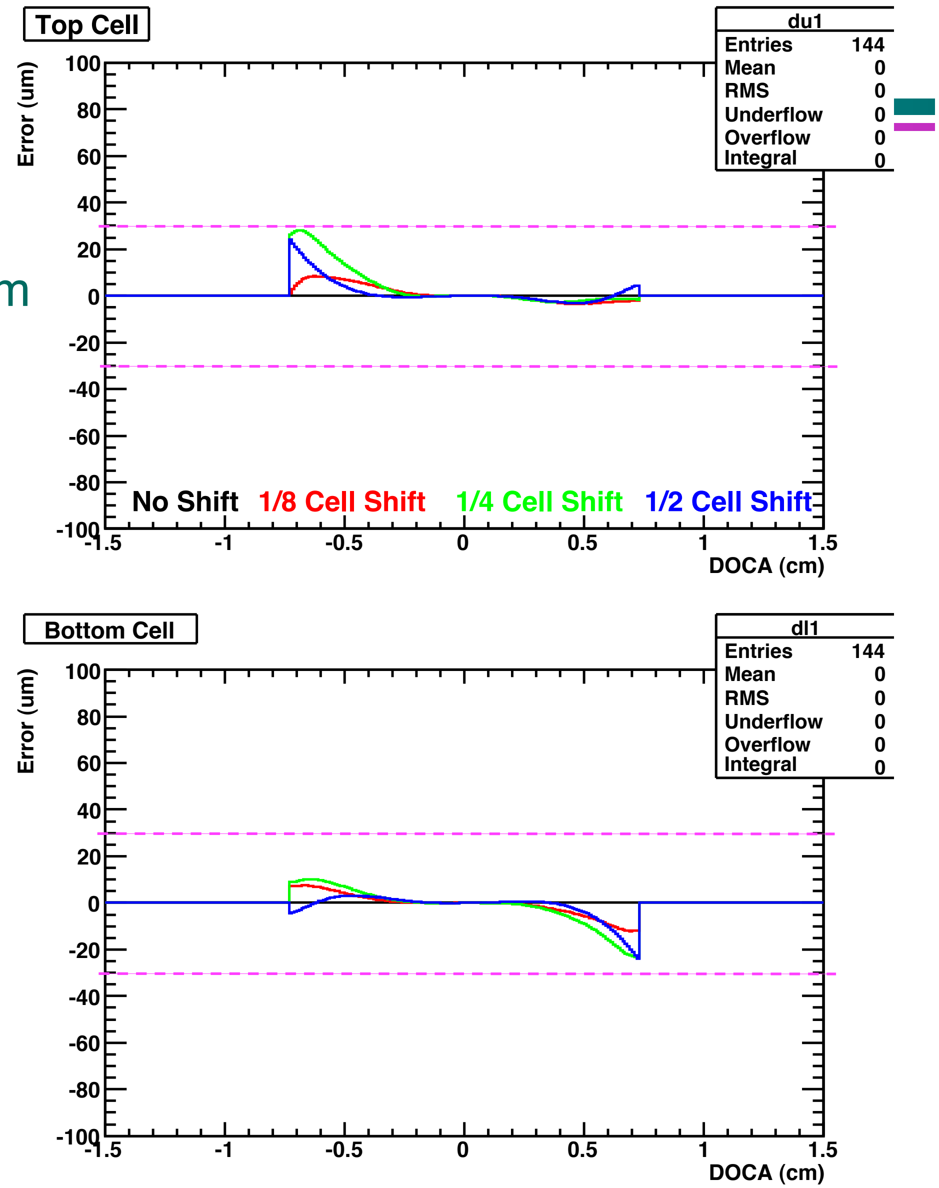
Impact on tracking resolution

- If we use the nominal time-to-distance relationship everywhere, what are the additional errors due to E field distortions?
- Study for 0° entrance angle (high momentum) and 20°.
- Look at fraction of cell in with additional errors are < 30 µm.

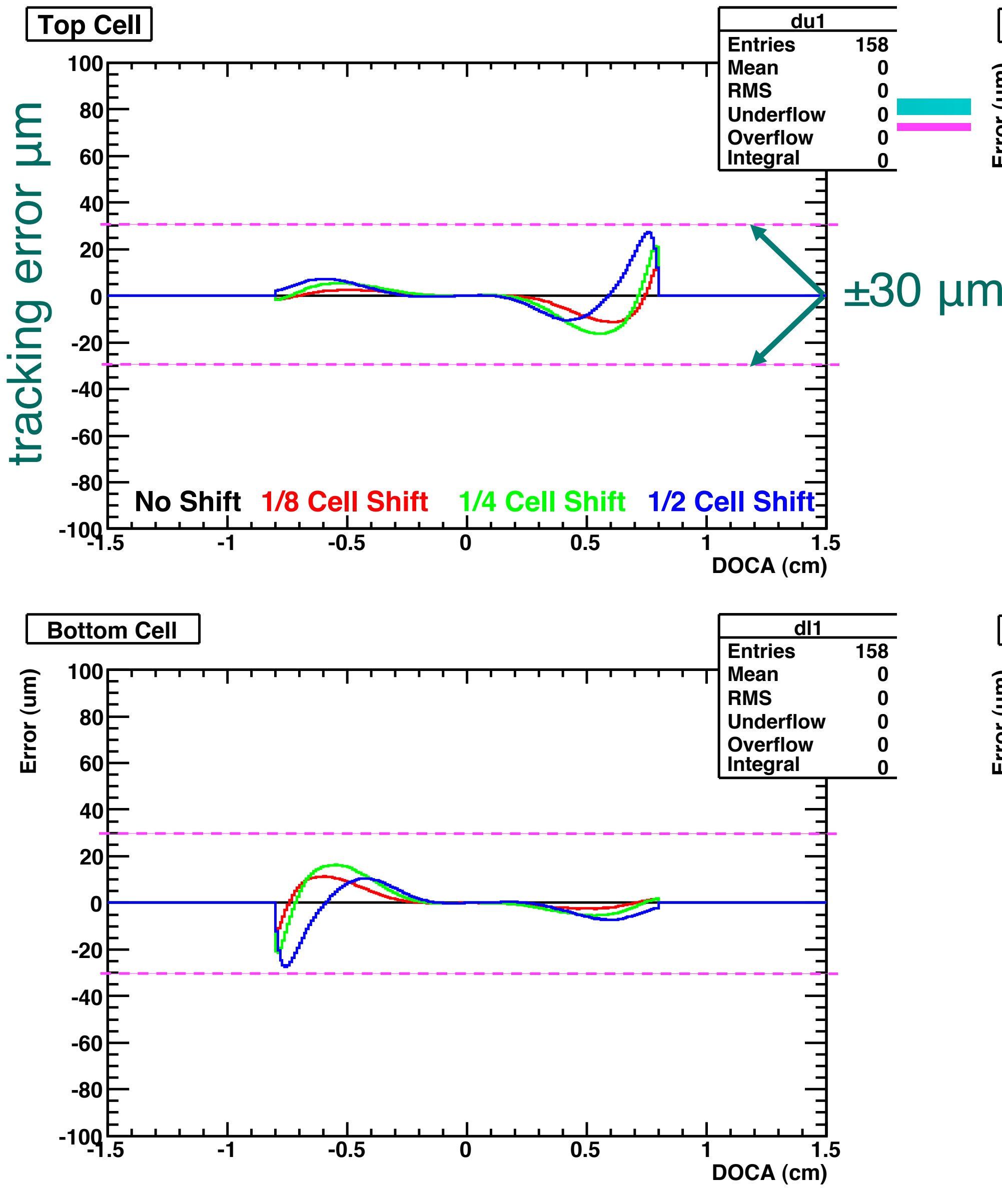
Layout 1: Field wires at intermediate stereo angle, 0° entrance angle



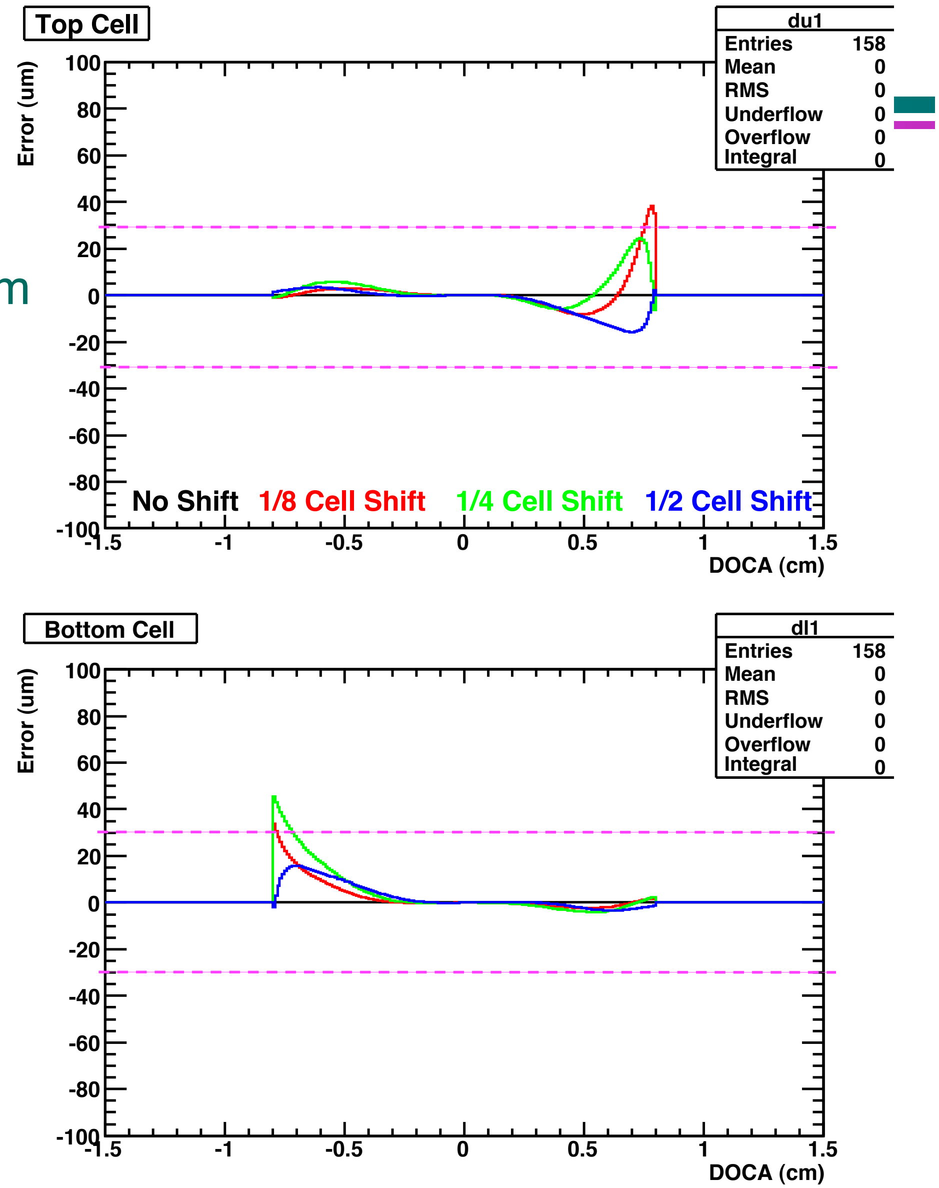
Layout 2: Field wires in phase with lower cell, 0° entrance angle



Layout 1: Field wires at intermediate stereo angle, 20° entrance angle



Layout 2: Field wires in phase with lower cell, 20° entrance angle



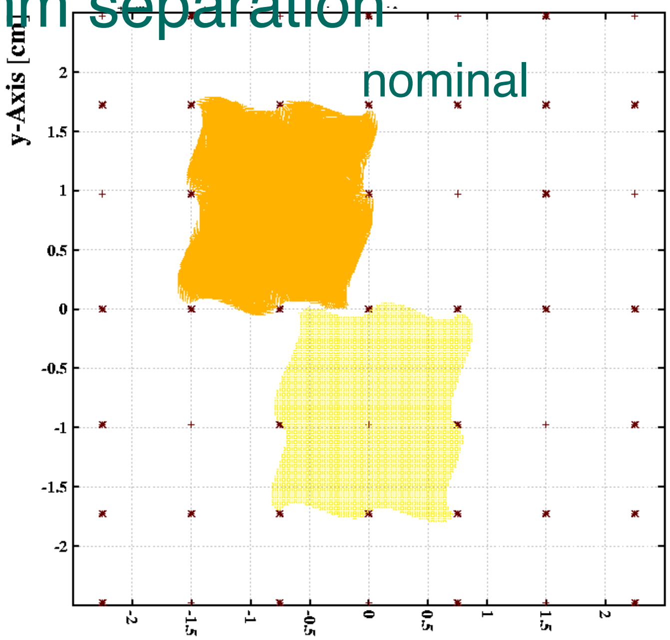
Summary of impact on tracking, stereo-stereo transition

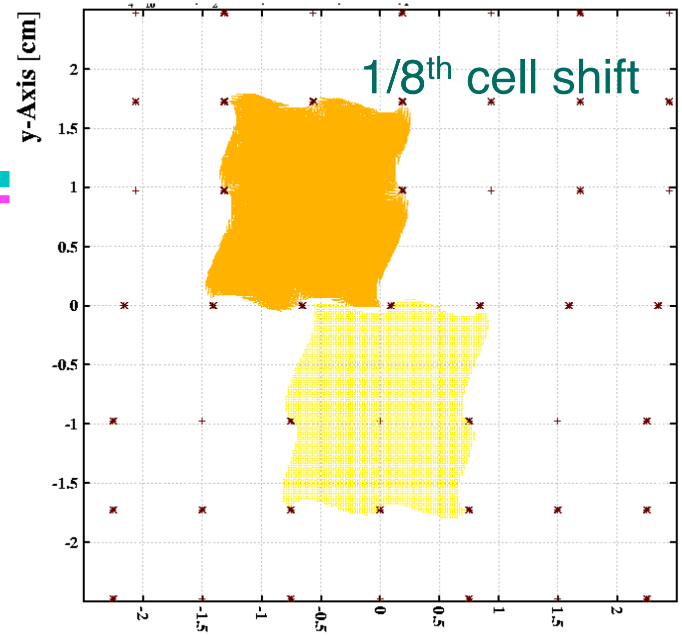
- Overall, >90% of the cell still has good tracking, even at the worst phase.
- At high momentum (0° entrance angle), better performance by keeping field wire in phase with one of the sense wires.
  - » note that even in this case, both layers are affected by the relative azimuthal motion.

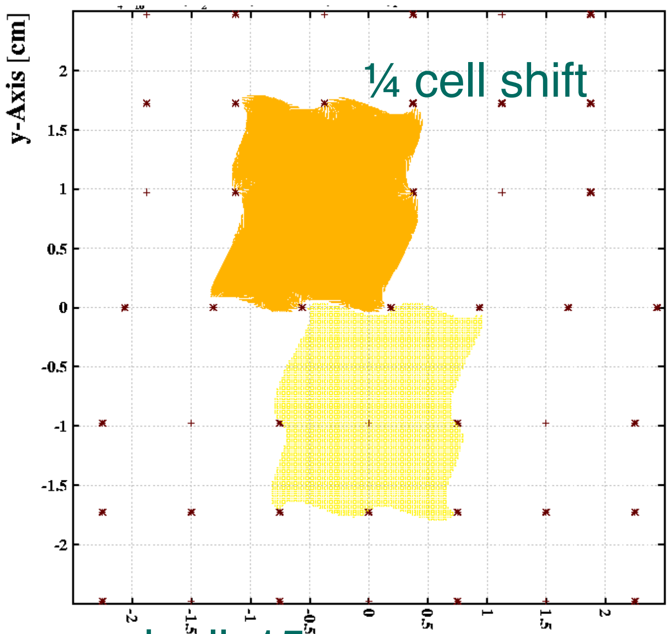
Axial-stereo transition

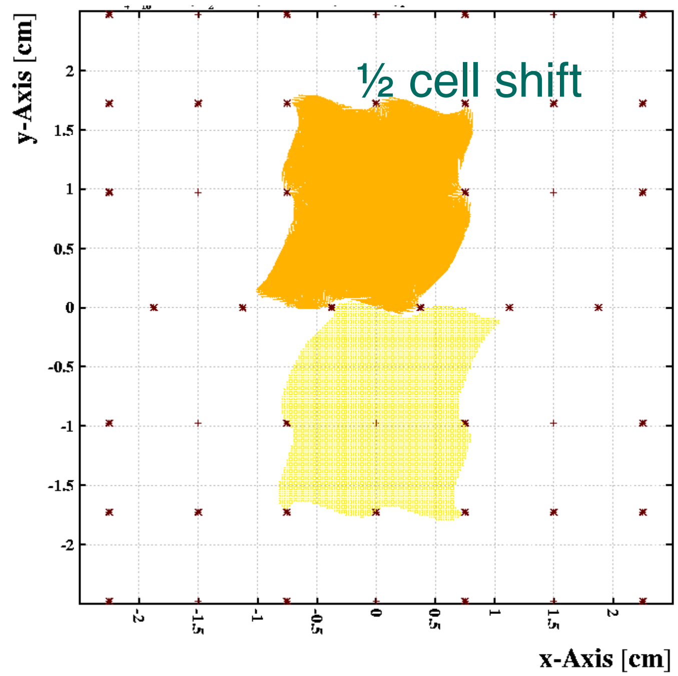
- The axial-stereo transition has the same azimuthal motion as the stereo-stereo, but with an additional relative radial motion as a function of location along the wire.
  - 50 mrad stereo angle at R = 510 mm ⇒ ΔR = 4.5mm. BaBar: 45 – 76 mrad.
- Again, two choices with respect to intermediate field wire.

Axial-stereo layout 1: Field wires at intermediate stereo angle. 4.5 mm separation



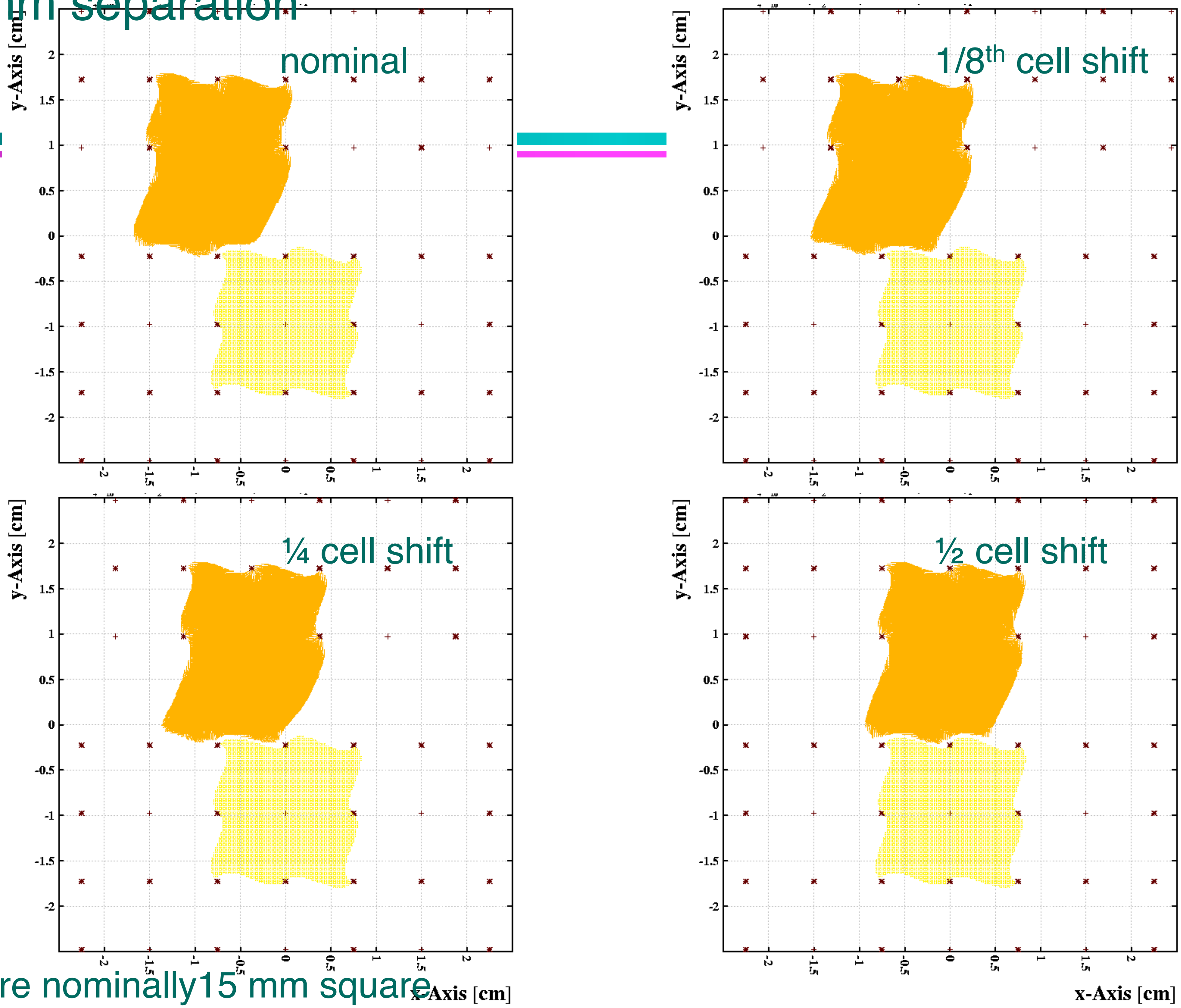






cells are nominally15 mm square

Axial-stereo layout 2: Field wires in phase with lower cell. 4.5 mm separation

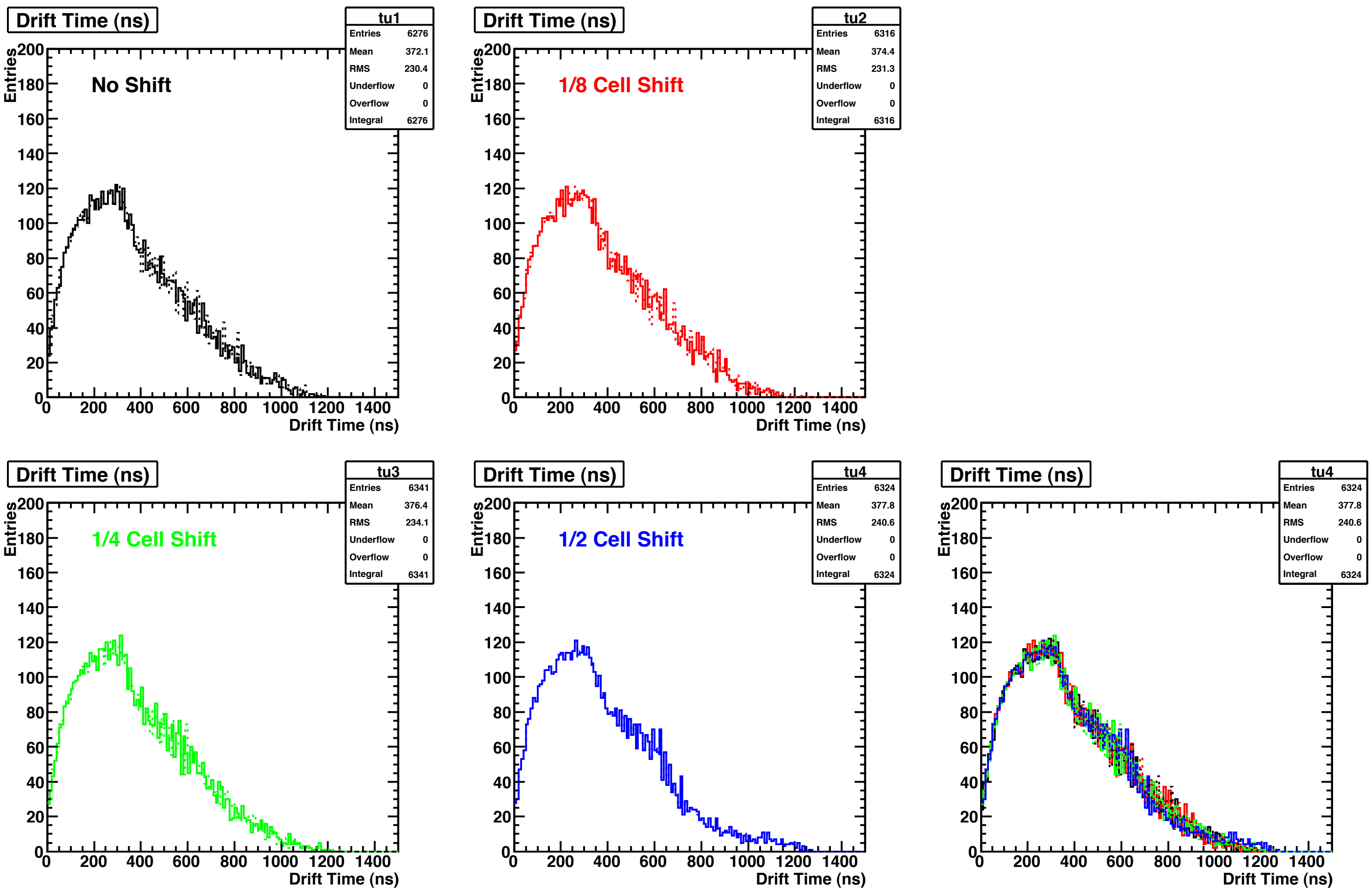


cells are nominally15 mm square

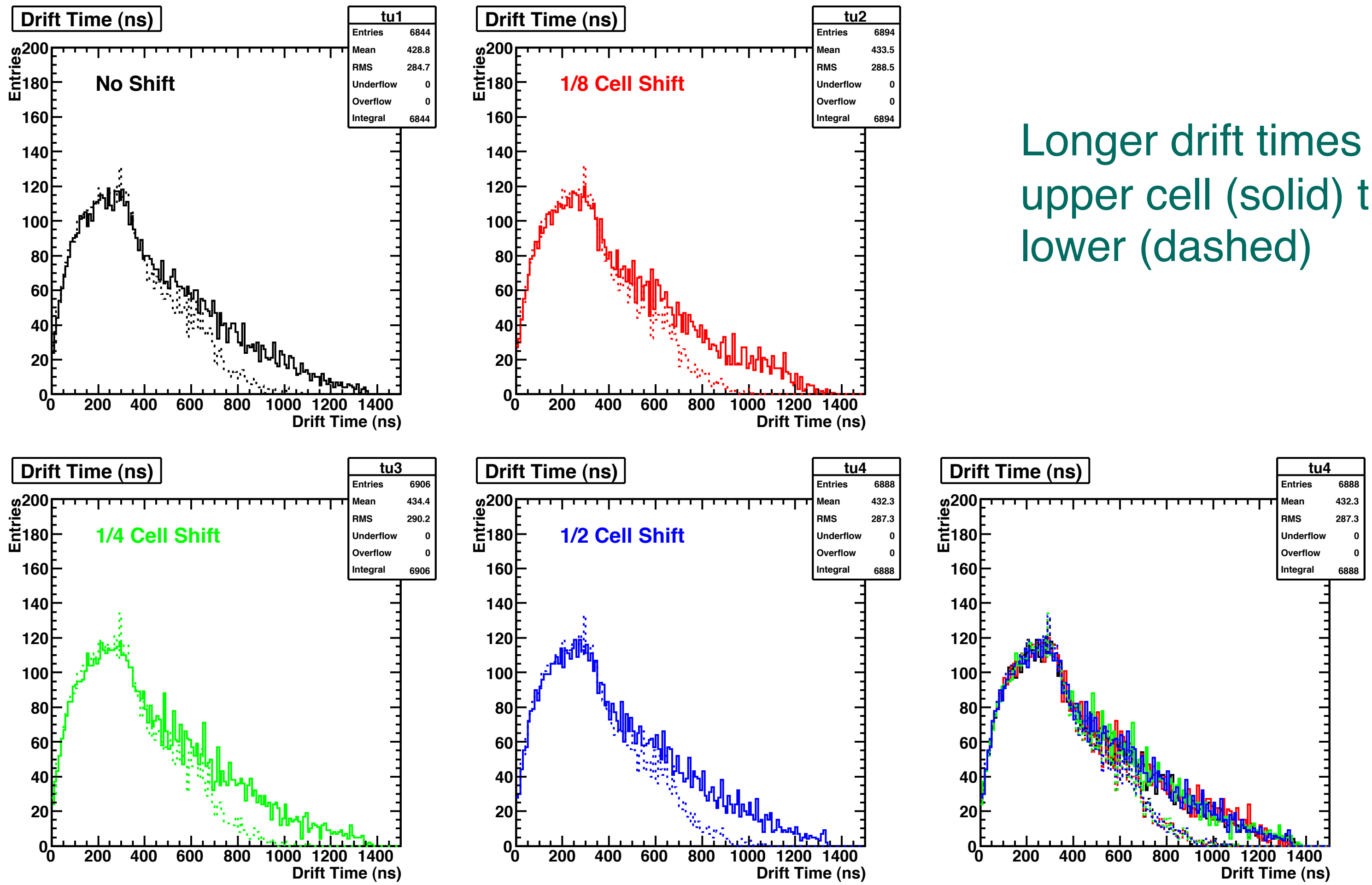
Drift Times

- drift times extend out to 1400 ns with 4.5 mm separation between layers, vs 950 ns in nominal case.

Axial-stereo layout 1: Field wires at intermediate stereo angle. 4.5 mm separation



Axial-stereo layout 2: Field wires in phase with lower cell. 4.5 mm separation

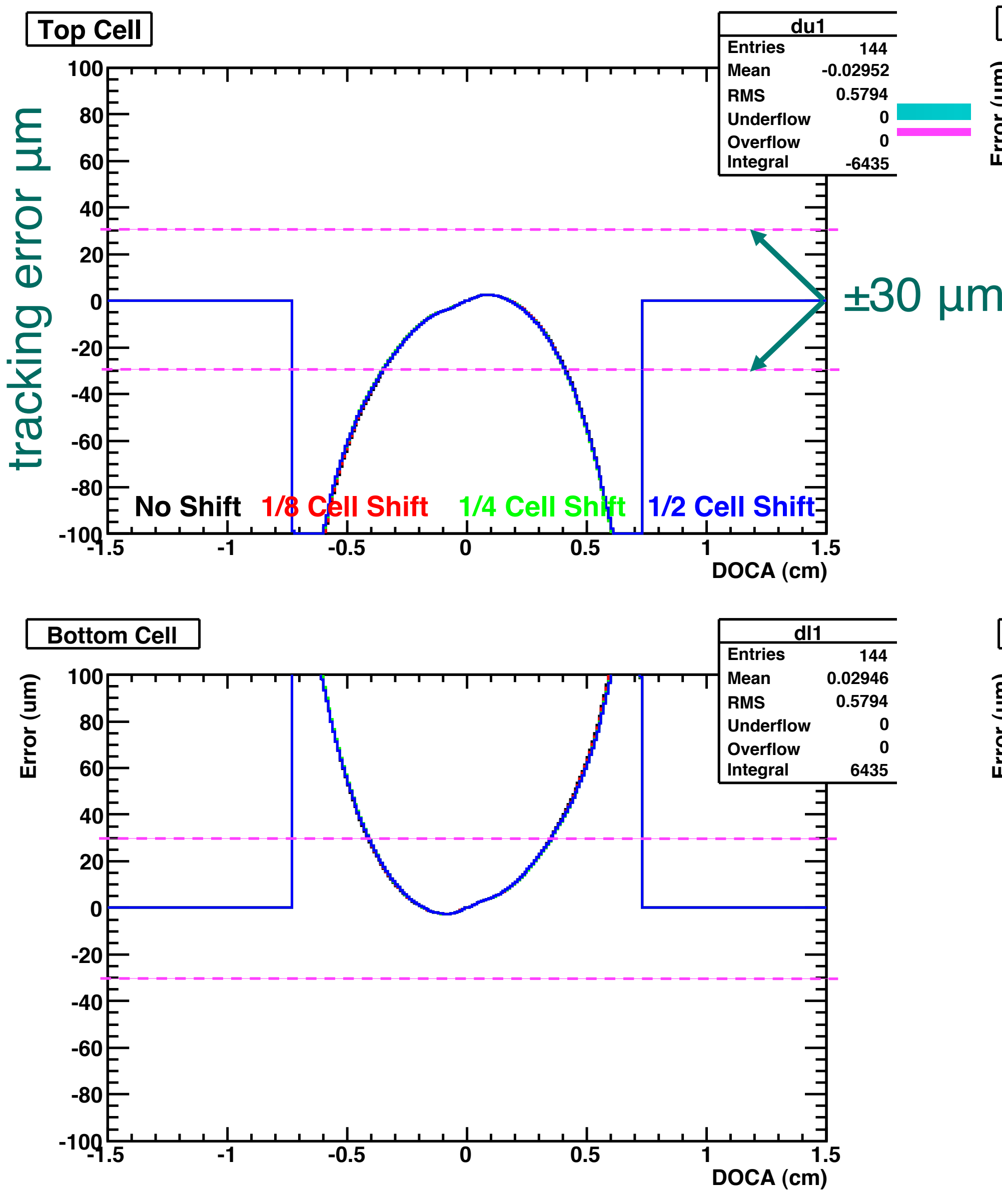


Longer drift times in upper cell (solid) than in lower (dashed)

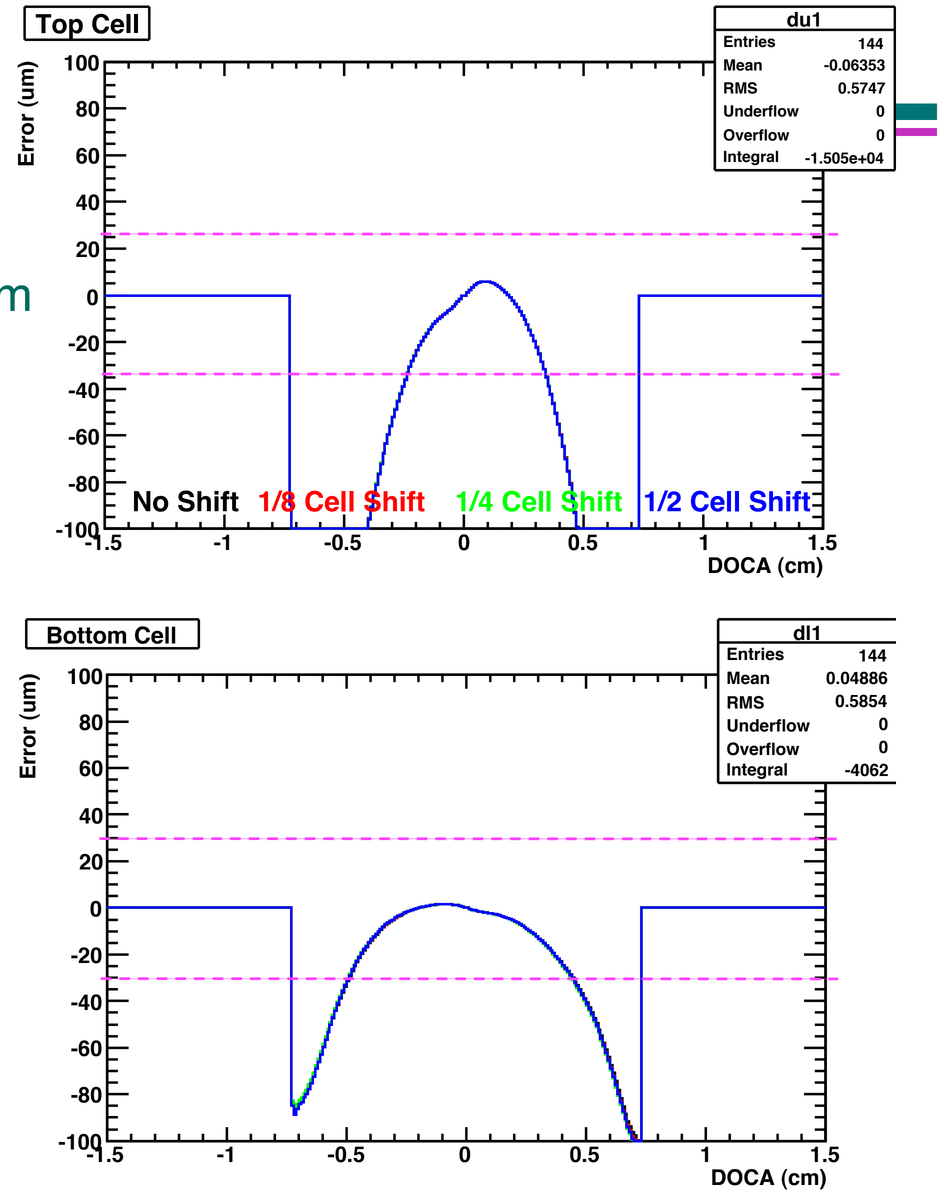
Impact on tracking

- Study as for the stereo-stereo transition. Baseline time-to-distance relationship is that for 0 separation, with 0 cell offset (same as for stereo-stereo study).

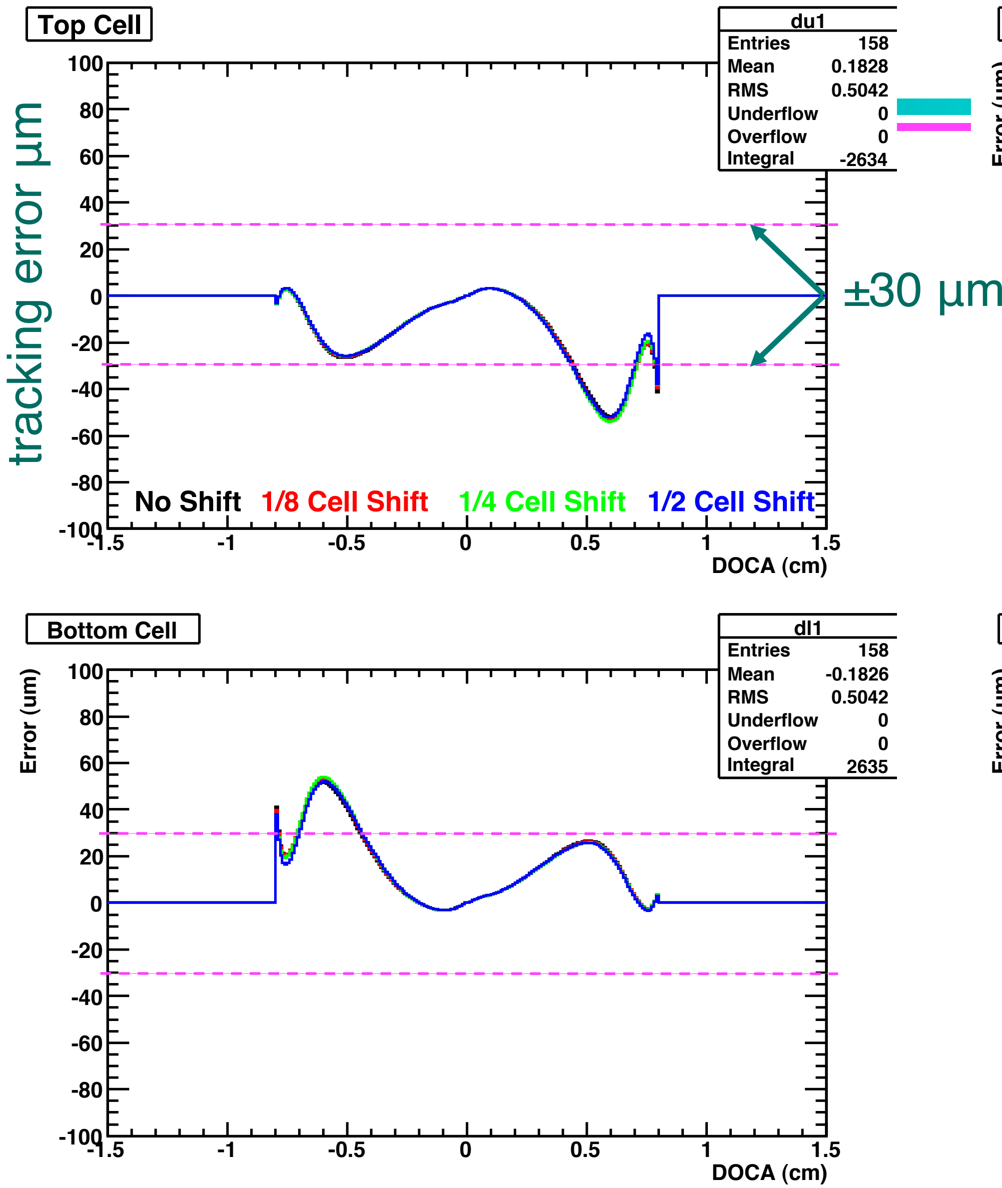
Layout 1: Field wires at intermediate stereo angle, 4.5 mm separation, 0° entrance angle



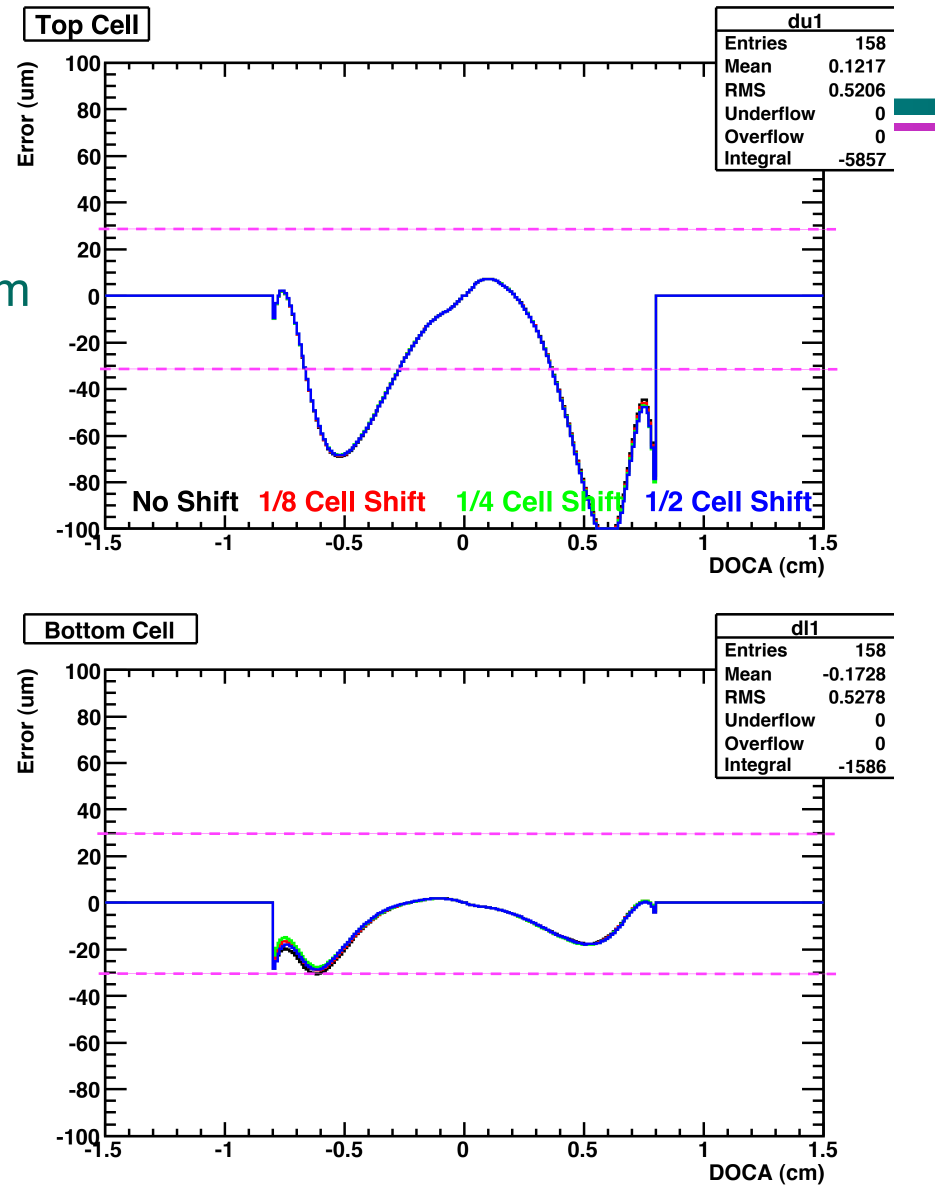
Layout 2: Field wires in phase with lower cell, 4.5 mm separation, 0° entrance angle



Layout 1: Field wires at intermediate stereo angle, 4.5 mm separation, 20° entrance angle



Layout 2: Field wires in phase with lower cell, 4.5 mm separation, 20° entrance angle



Axial-stereo tracking summary

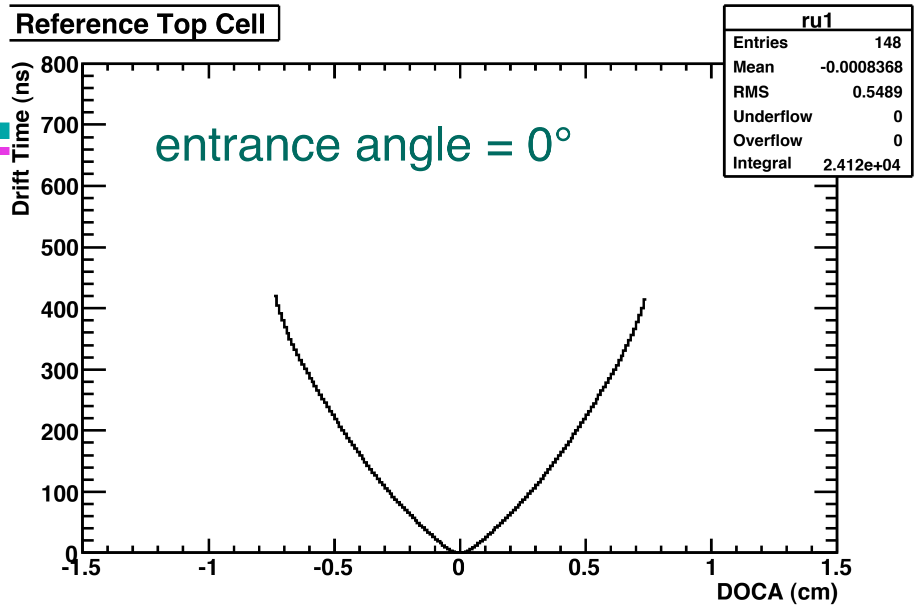
- Clearly this needs more work.
- Dominant effect is due to separation; azimuthal phase has comparatively small effect.
- Perhaps a somewhat more complicated calibration would give adequate results.
- Or more field wires?

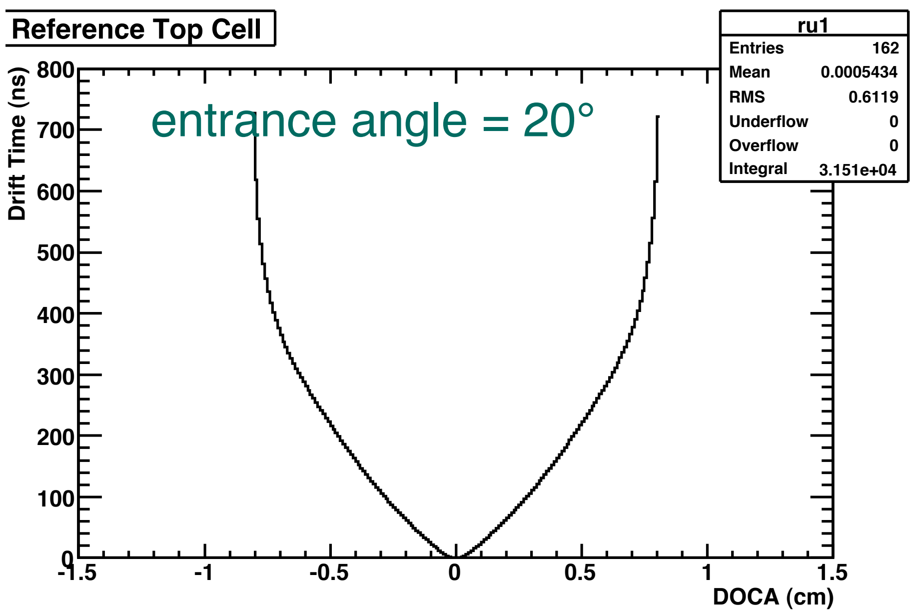
Summary

- Impact of transition from U stereo to V stereo on tracking is acceptably small (in my opinion), with no additional field wires.
  - I would lean towards having the boundary field wire at the same stereo angle as one of the sense wires.
- The radial separation introduced in the axial-stereo transition has a significant impact, and requires additional study.

BACKUP

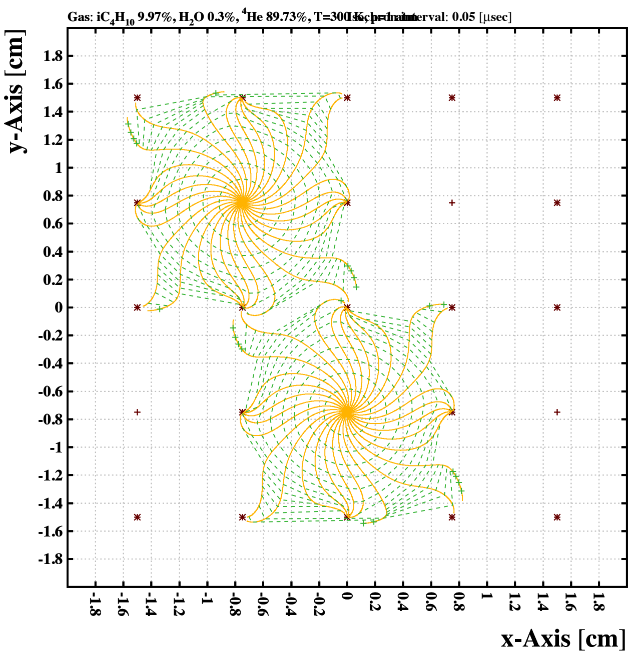
Nominal time-to-distance relationships, 15 mm square cells, He:Iso 90:10 + 3000 ppm water, B = 1.5 T



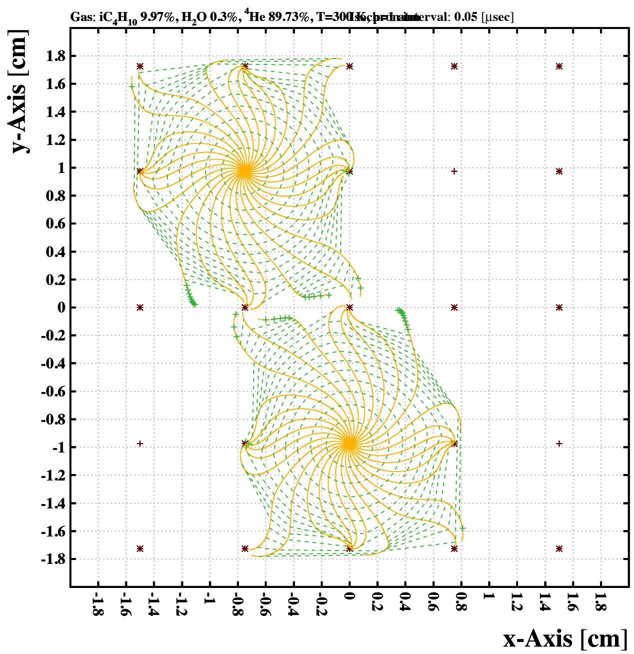


50 ns isochrones, 15 mm square cells, He:Iso 90:10 + 3000 ppm water, B = 1.5 T

Nominal cell layout



4.5 mm separation, field wires at intermediate angle



4.5 mm separation, field wires attached to bottom cell