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TOSCA 2D and 3D field map for tracking

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Question

Is 2D field map more accurate than 3D?

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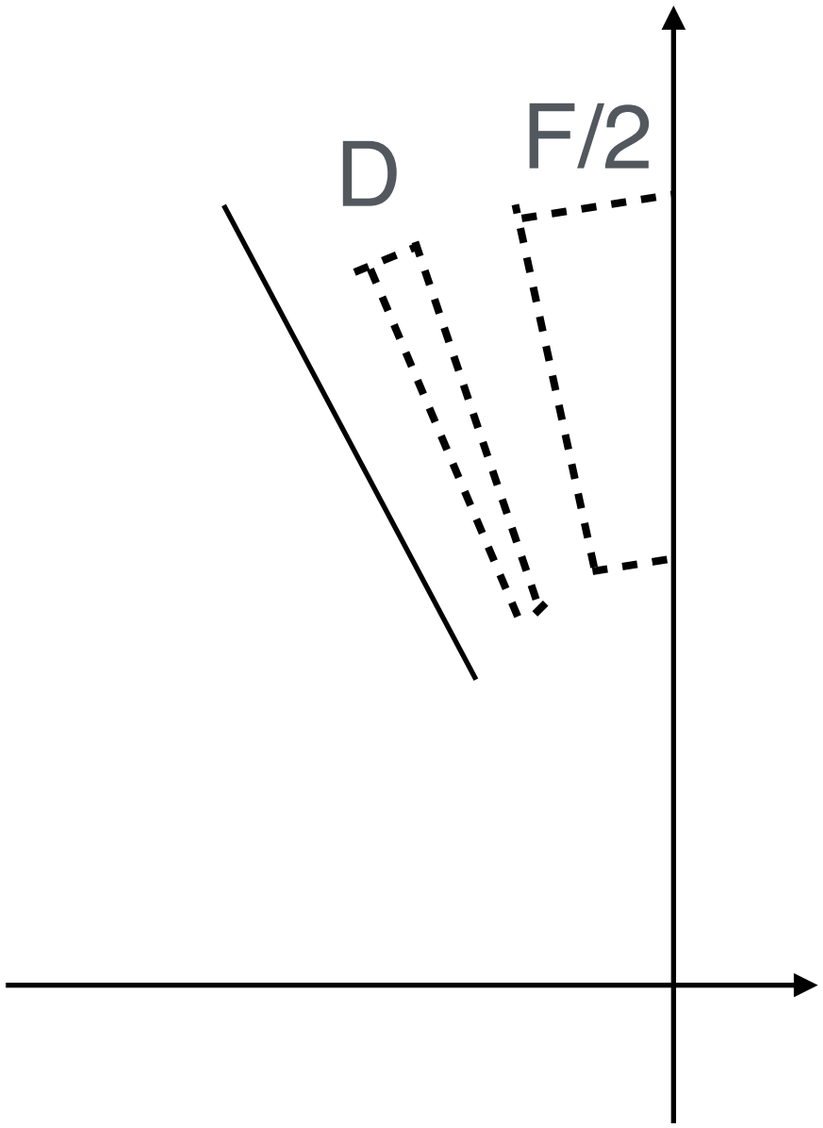
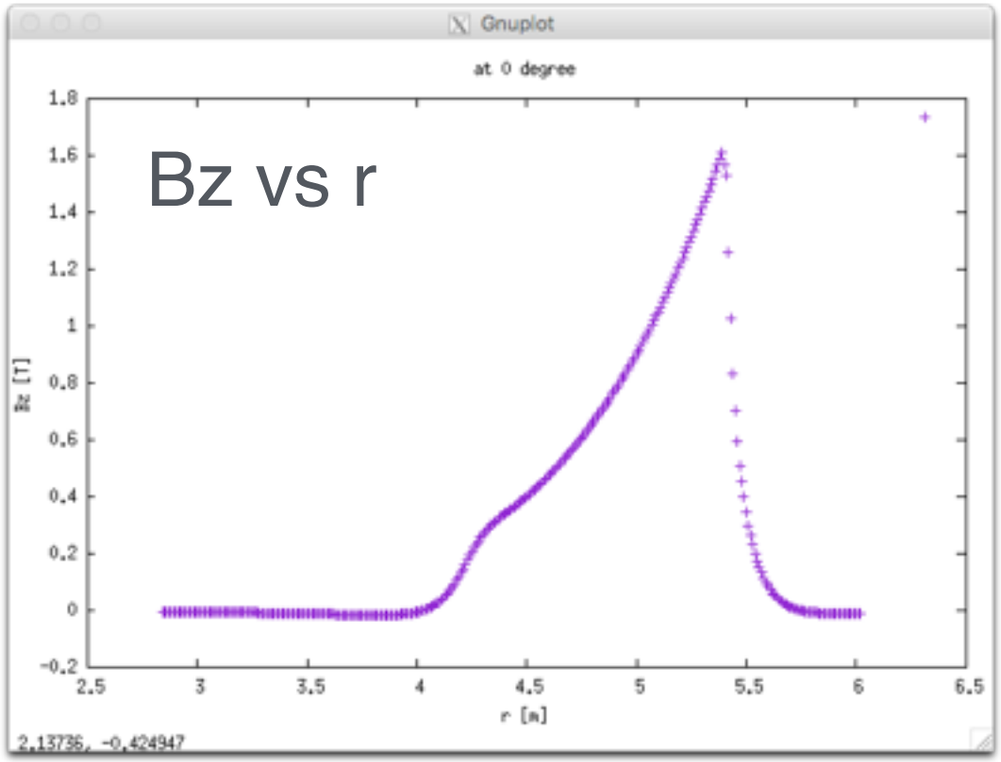
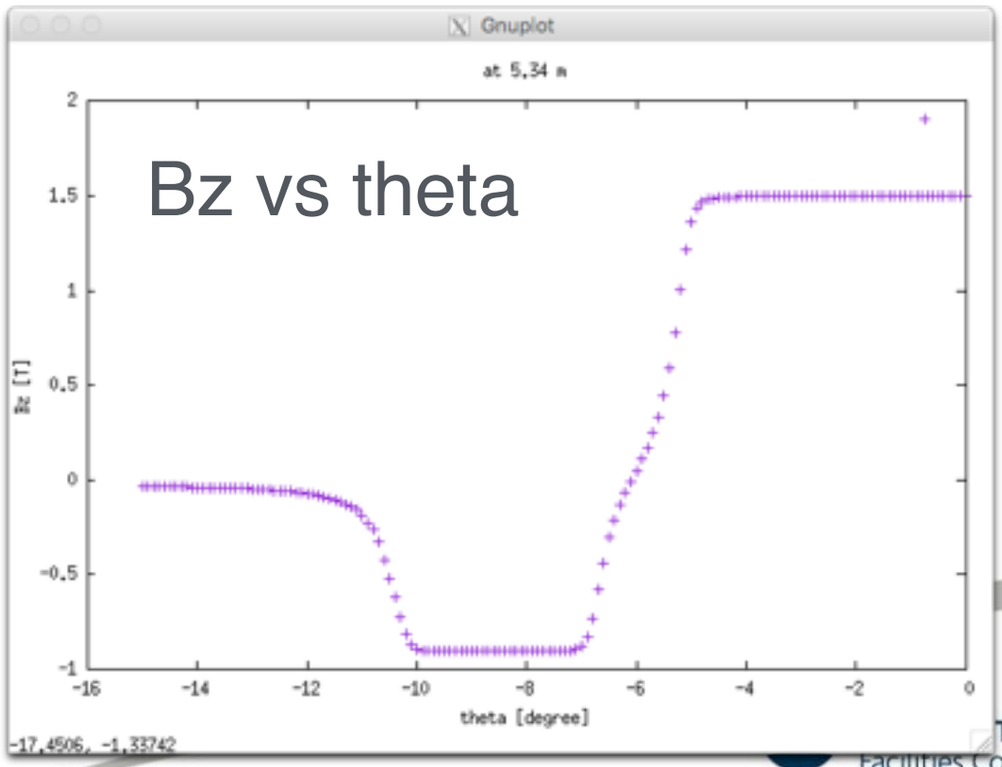
KURRI FFAG TOSCA field map

One quadrant of a cell is given.







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Let us compare 2D and 3D field

Suggestion by Nick Tsoupas at FFAG 2016

3D field data is given off mid-plane.

2D field data can be extrapolated to off mid-plane.

$$B_\theta(\theta, r, z) = \frac{1}{r}\frac{\partial B_z(\theta, r, 0)}{\partial \theta} z$$

$$B_r(\theta, r, z) = \frac{\partial B_z(\theta, r, 0)}{\partial r} z$$

$$B_z(\theta, r, z) = B_z(\theta, r, 0)$$

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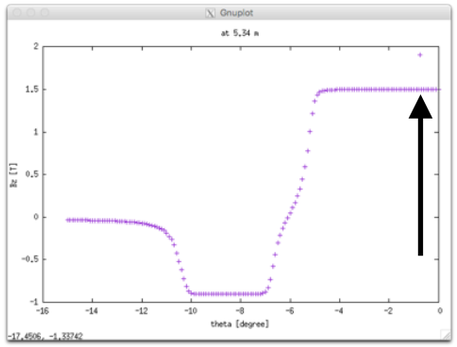
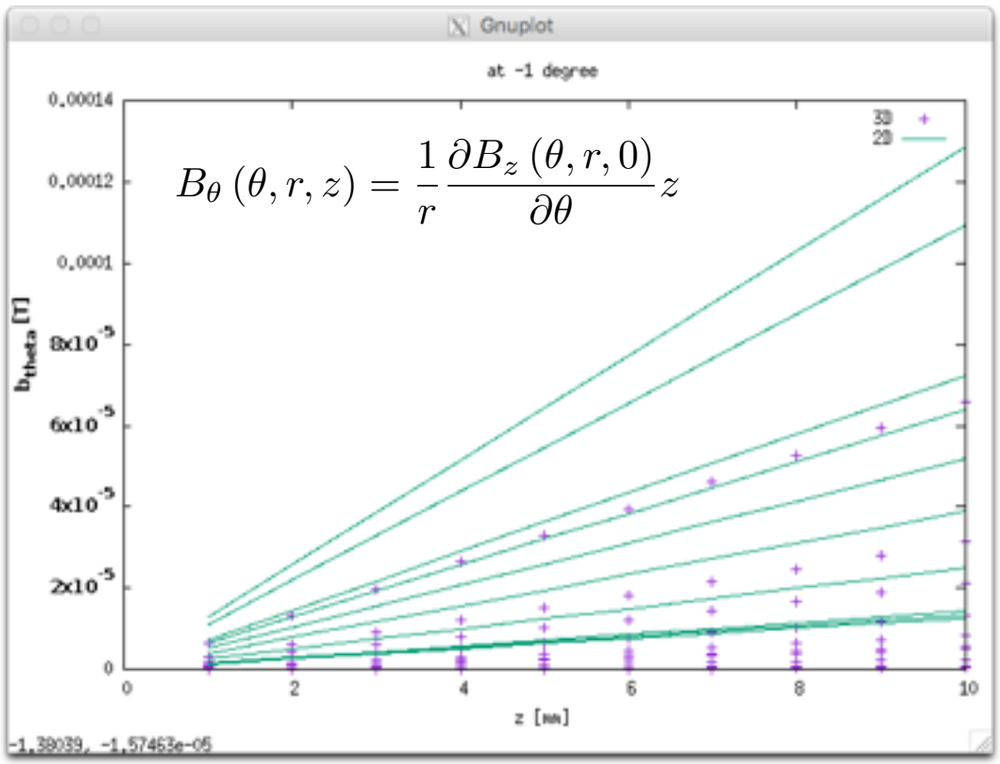
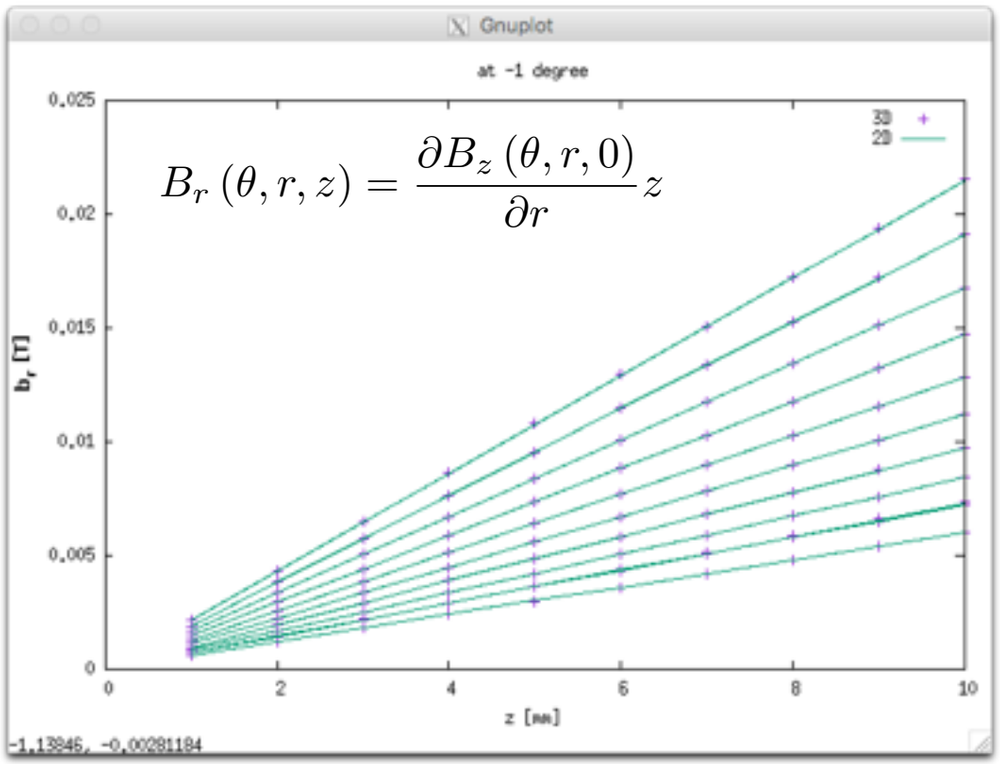
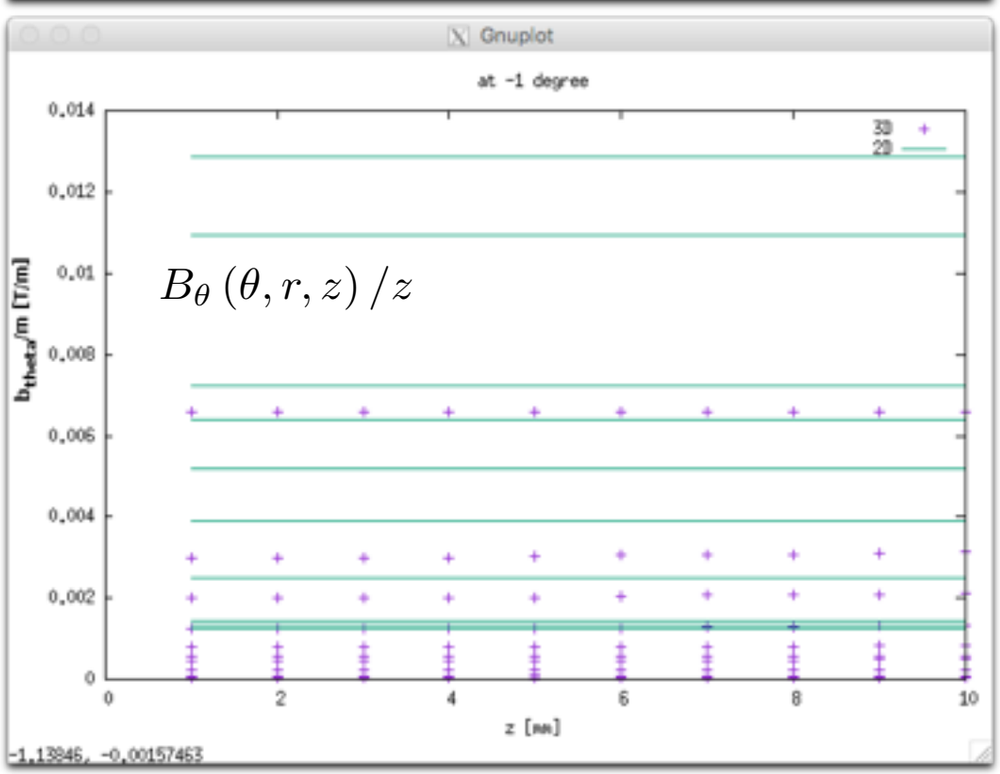
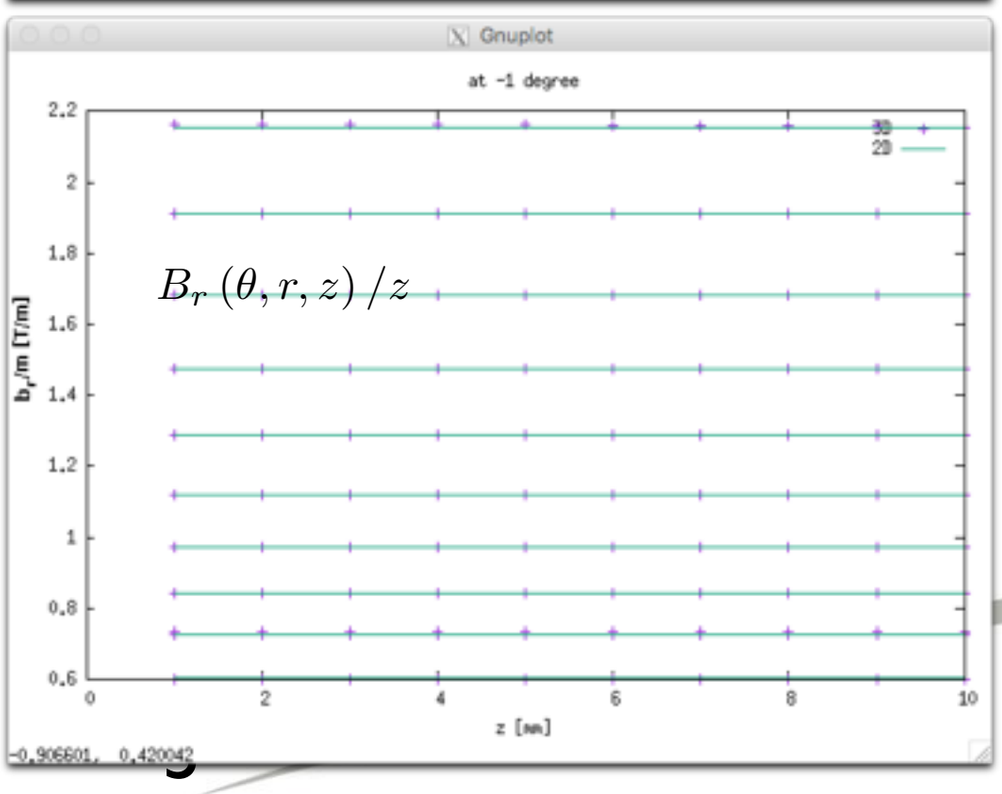
In the middle of F magnet











+ 3D

— — 2D

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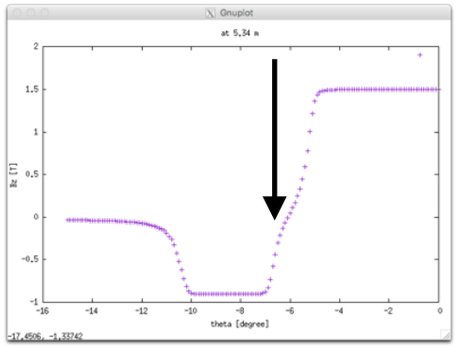
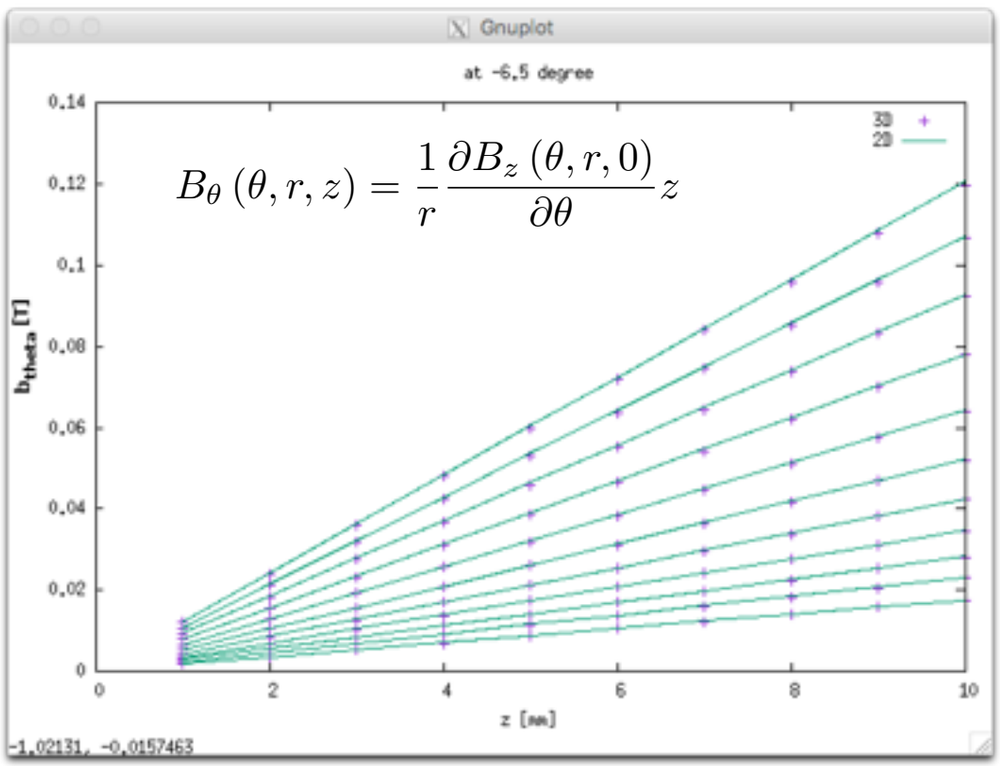
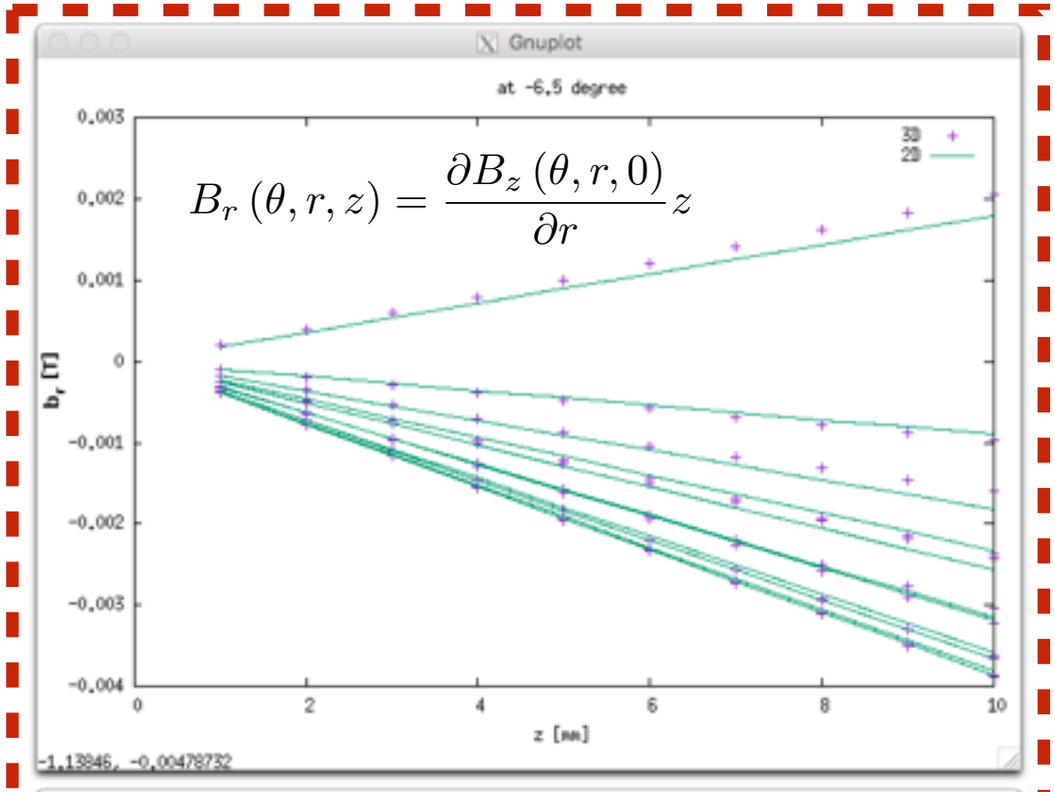
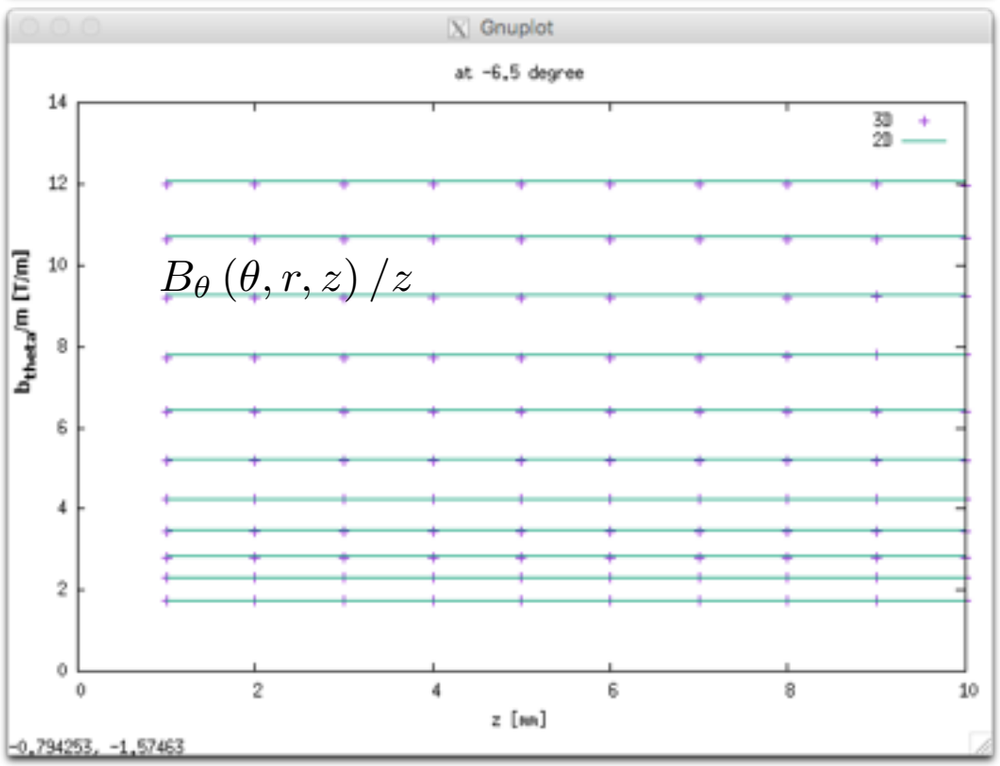
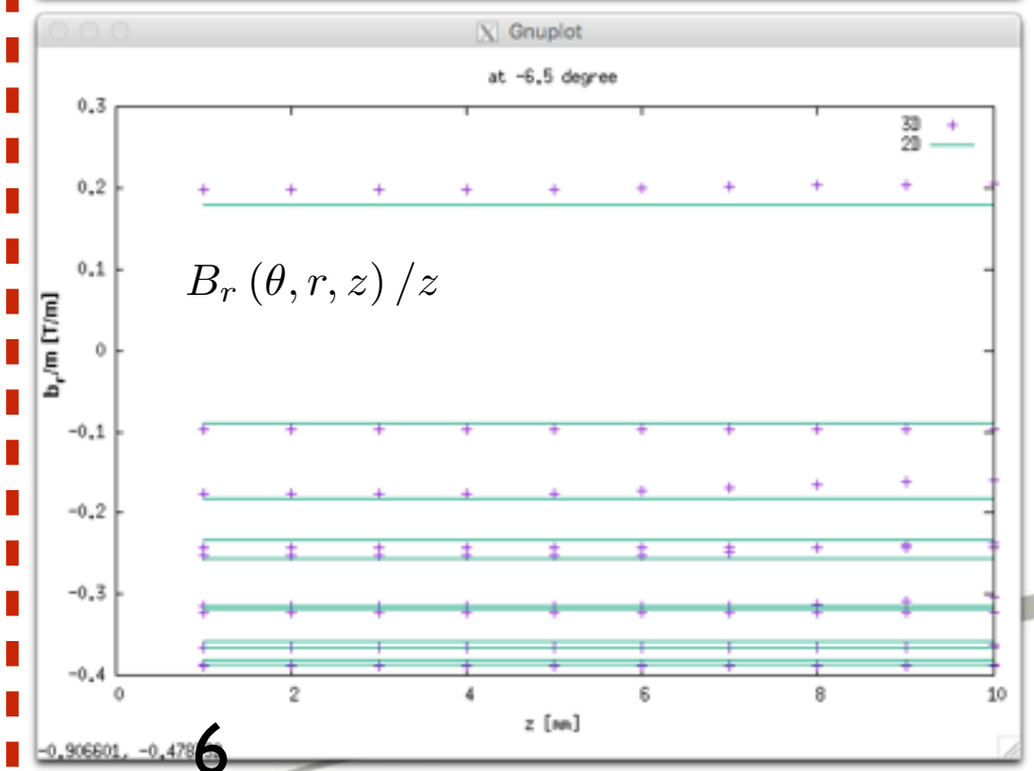
In the fringe region











+ 3D

— — 2D

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Observation

- 3D field map show B_theta and B_r are almost linear with z.
- 2D and 3D field map do not match
    - in the middle of F (or D) for B_theta,

$$B_\theta(\theta, r, z) = \frac{1}{r}\frac{\partial B_z(\theta, r, 0)}{\partial \theta} z$$ is small.

- in the fringe region for B_r.

$$B_r(\theta, r, z) = \frac{\partial B_z(\theta, r, 0)}{\partial r} z$$ depends on the details of the fringe.

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Summary

- It is difficult to conclude which field map 2D or 3D is better.
- 2D field map is derived based on Maxwell equation, but derivative of mid-plane field has to be accurate.
- The best we can do is to reconstruct 2D field map with a global function (or expansion of orthogonal function) and apply Maxwell equation to extrapolate the field to off mid-plane.

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