RAPID AND SENSITIVE MEASUREMENT OF MAGNETIC FIELD HOMOGENEITY THROUGH ECHO PLANAR IMAGING

Erfan Akbari, Peter Hardy

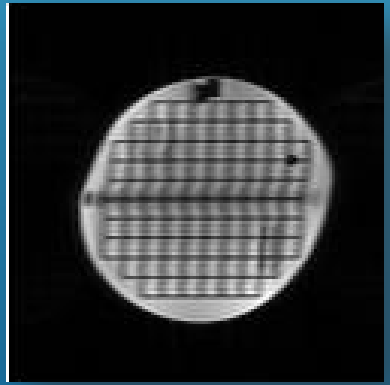
Departments of Radiation Medicine and Radiology

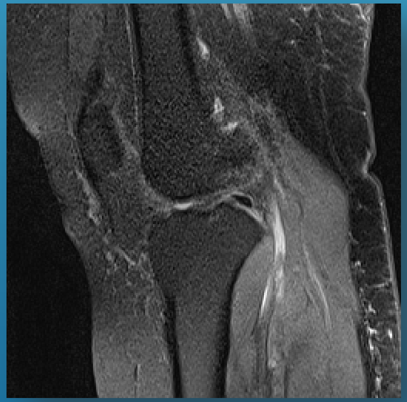
University of Kentucky

Motivation :

Inhomogeneity in main magnetic field in MRI systems leads to artifacts such as

- Geometrical distortion
- Inhomogeneous fat suppression
- Intensity non-uniformities

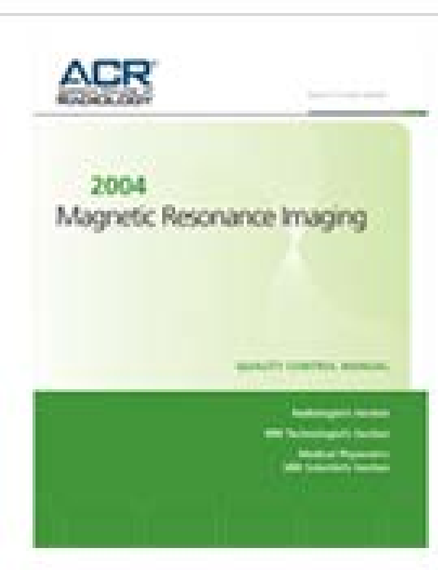




Motivation :

Recognizing these problems measurement of B0 homogeneity is an important part of the annual system performance measurements Required by the American College of Radiology (ACR).

- Full width at half maximum (FWHM)
- Phase difference method ($\Delta\varphi$)



Problems:

- Technique Not available
- In patients may take too long (~ 20s)
- May fail for too large inhomogeneity $\Delta\varphi>2\pi$

Motivation :

Routing testing of magnetic field homogeneity on clinical MRI system*
Dr. Chen

Bandwidth-different method

$$\upsilon_{\circ} = \frac{\gamma}{2\pi} B_{\circ}$$

$$G_x = \frac{2\pi}{\gamma} \left(\frac{BW_x}{FOV_x} \right)$$

$$\frac{\gamma}{2\pi} = 45.576 \; MH_z/T$$

Gyromagnetic ratio

*Med.Phys.33(11),Nov.2006

Motivation :

Bandwidth-difference method:

$$x' = x + \Delta B_{\circ}(x,y)/G_x \qquad G_x = \frac{2\pi}{\gamma}\left(\frac{BW_x}{FOV_x}\right)$$

1st scan @ minimum BW_1
2nd scan @ maximum BW_2

$$H_B(ppm) = \frac{BW_1 . BW_2 . (x_1' - x_2')}{\frac{\gamma}{2\pi} . B_{\circ} . FOV_x . (BW_2 - BW_1)}$$

Assumption:

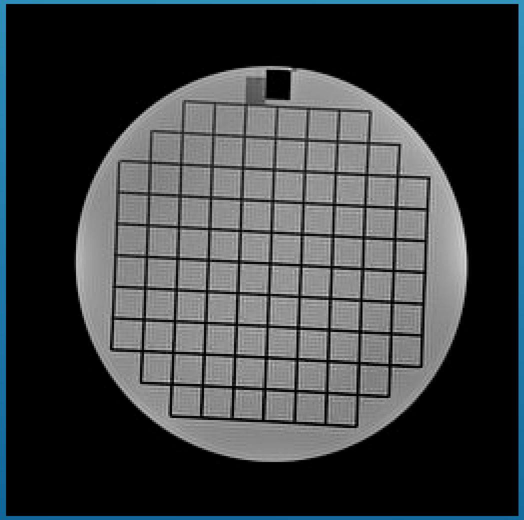
- Geometric distortion solely due B0 inhomogeneity
- Gradients are linear with distance.
- Shape of the field inhomogeneity is linear in distance

Motivation :

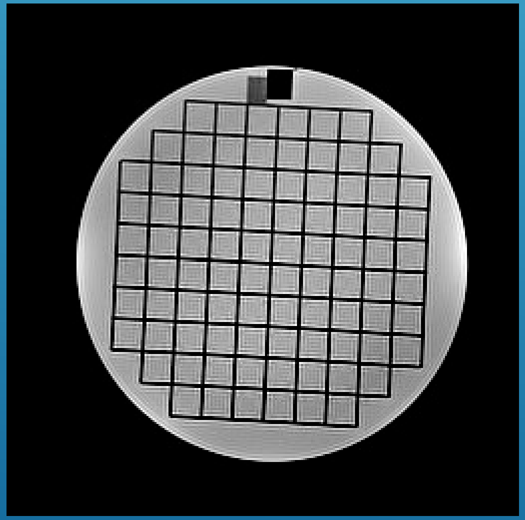
Bandwidth-difference method:

Problems?!

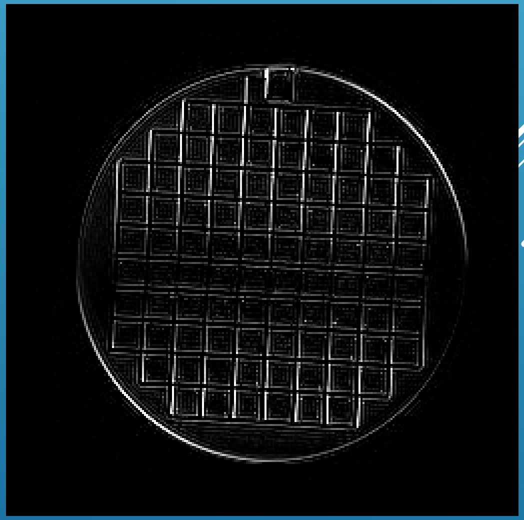
Turbo/Fast Spin Echo (frequency encode direction is X)



130 Hz/pixel



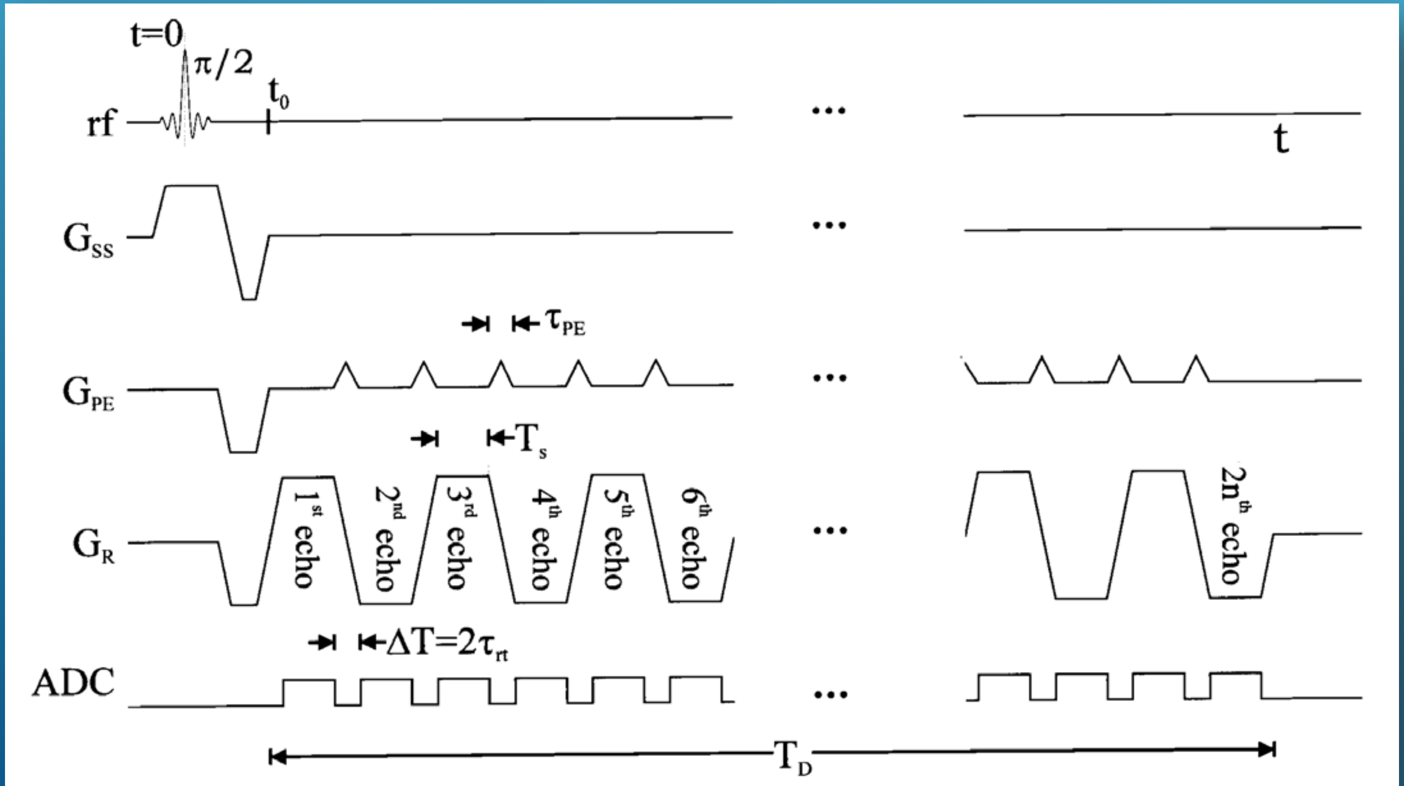
452 Hz/pixel



Motivation :

Echo planar imaging

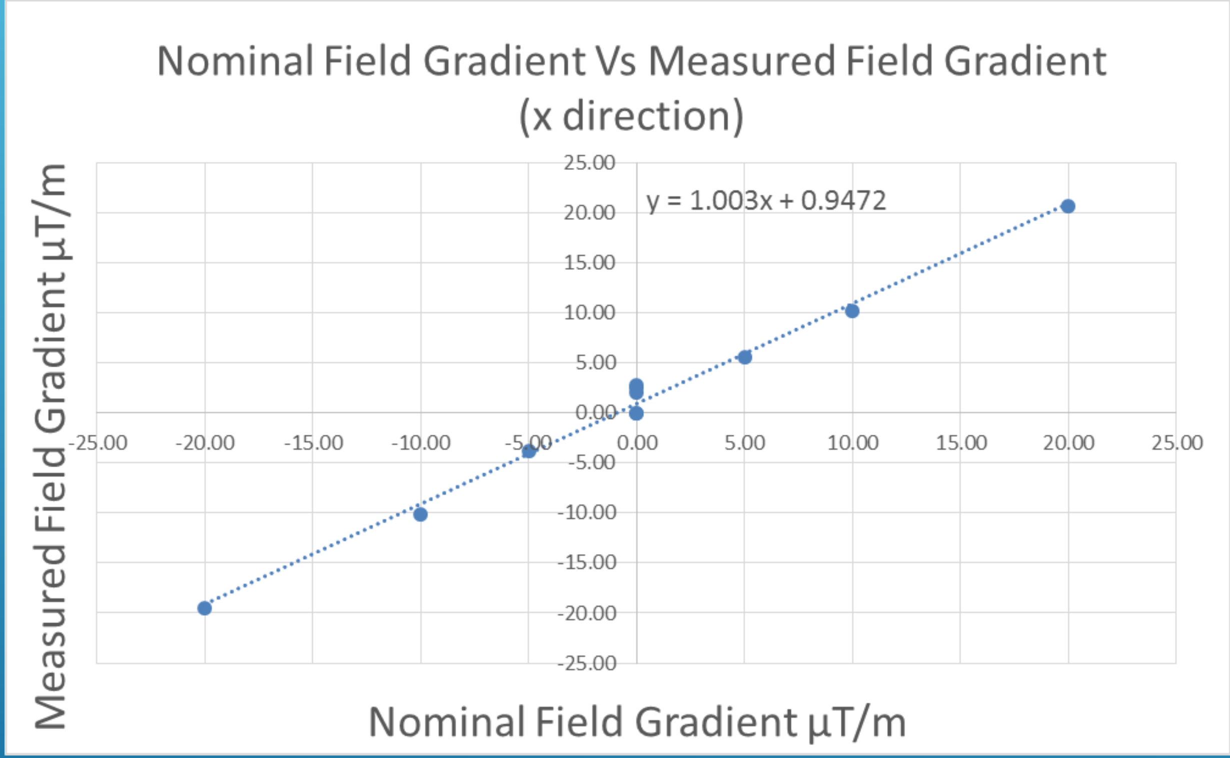
- Very sensitive to inhomogeneity in phase encode direction
- Very short acquisition time

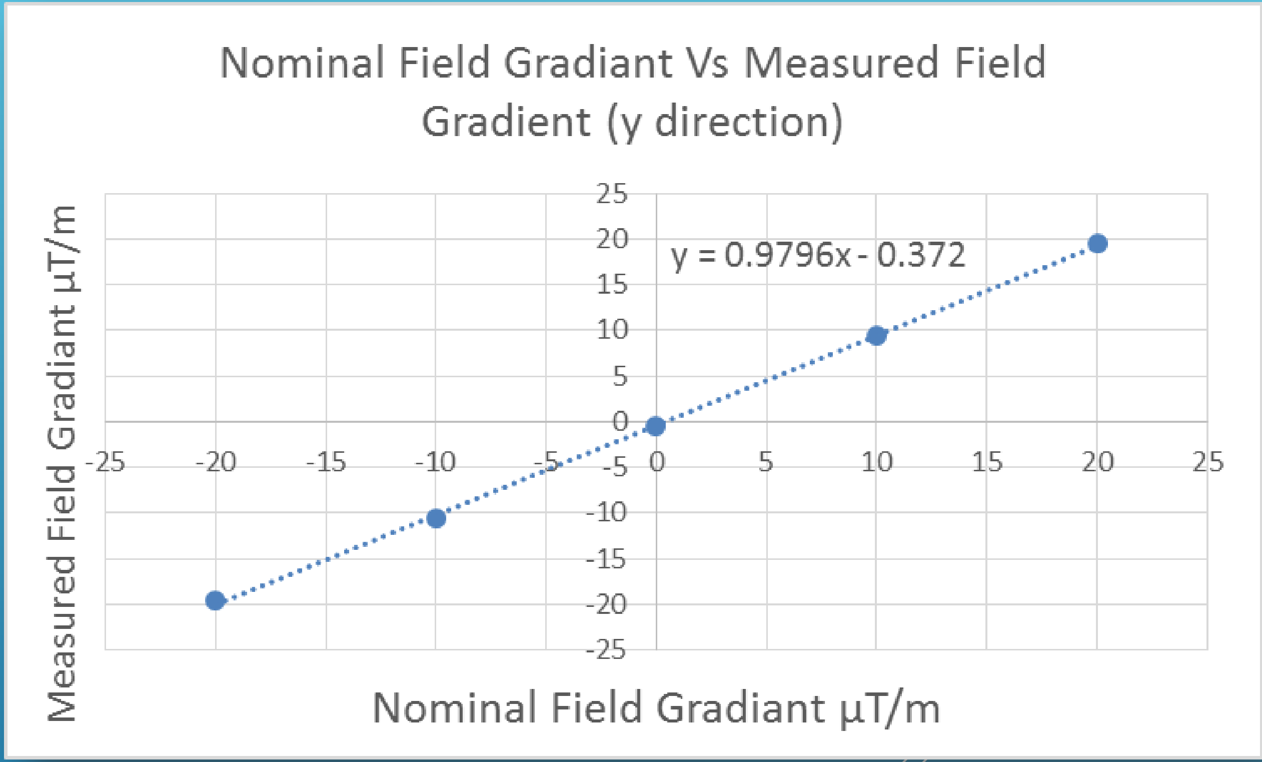


Method:

1. On a 1.5T Siemens MRI
2. Adjust all gradient to optimized homogeneity
3. Adjust one linear field gradient Gy in PE direction
4. Acquired a single shot EPI
5. Measured dimension of the phantom in distorted direction
6. Calculated field gradient from distortion

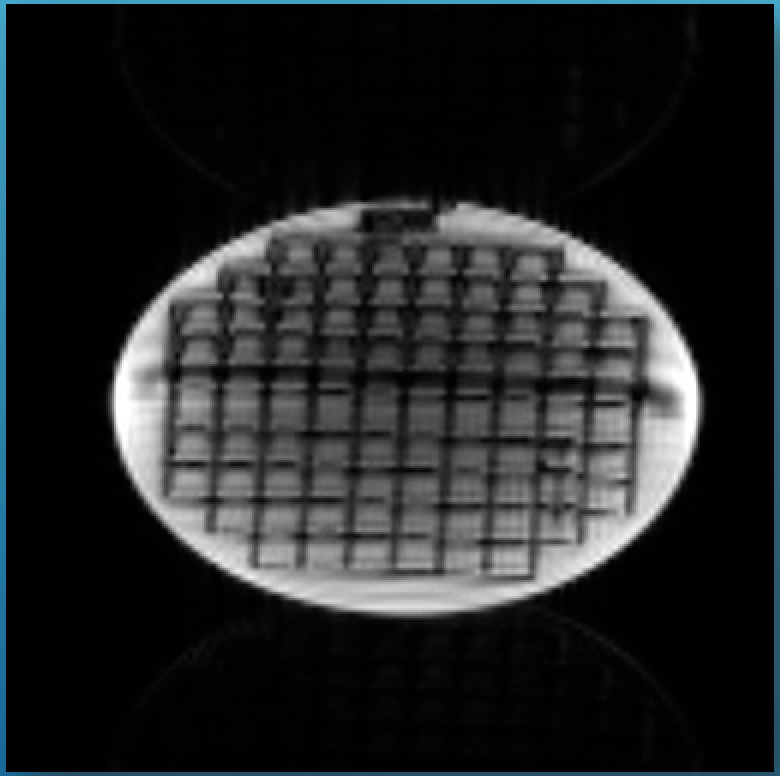
Result:

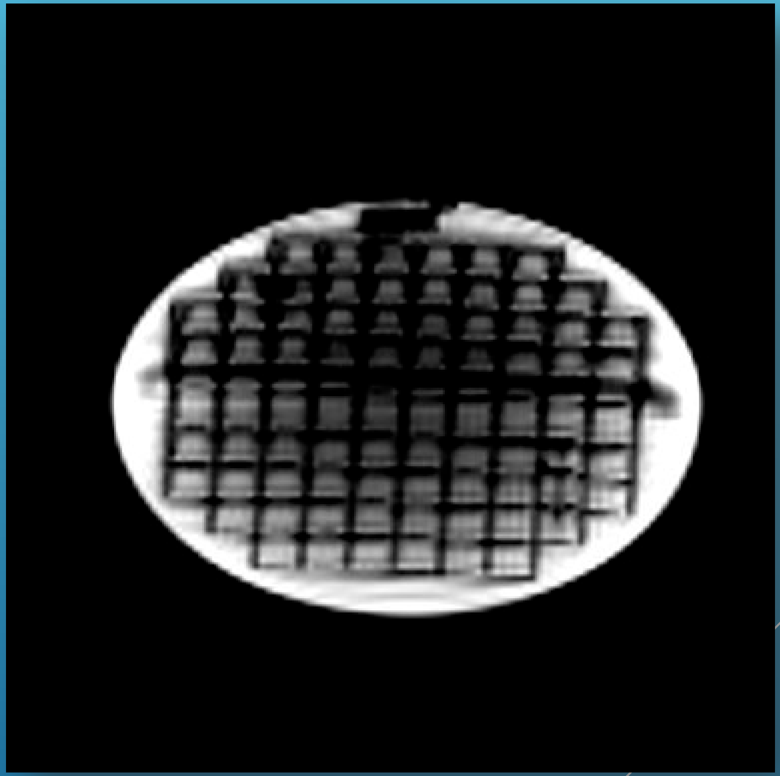




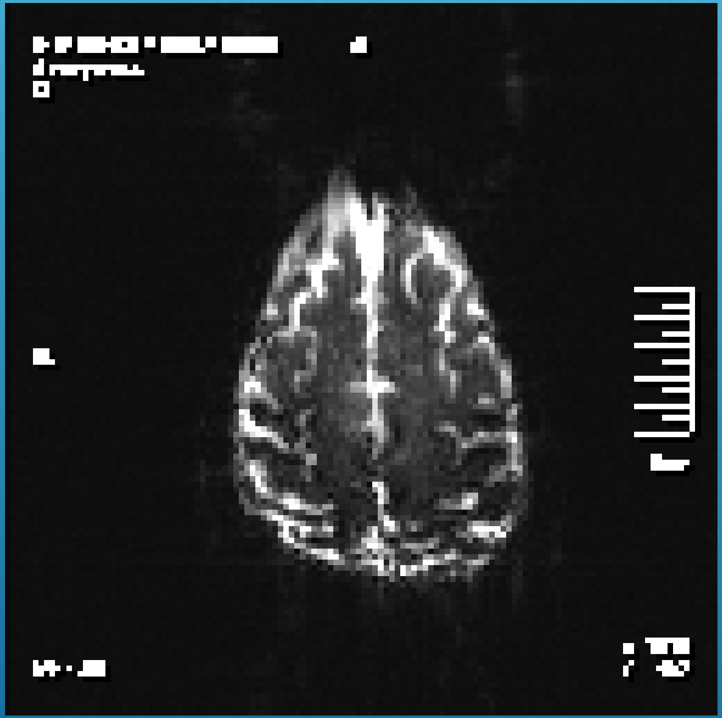
Average difference between measured and nominal gradient field :
0.62$\pm$0.43 $\mu T/m$

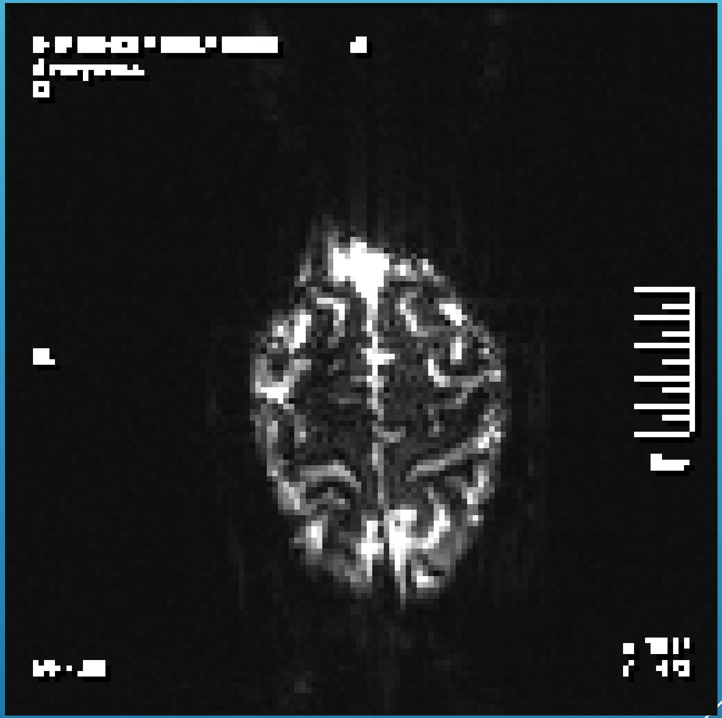
Result:





Result:





Conclusion

We found an method that has One to one linear relation between nominal field gradient & measured.
The result demonstrate the accuracy of the method

Future work

Quadratic Gradient
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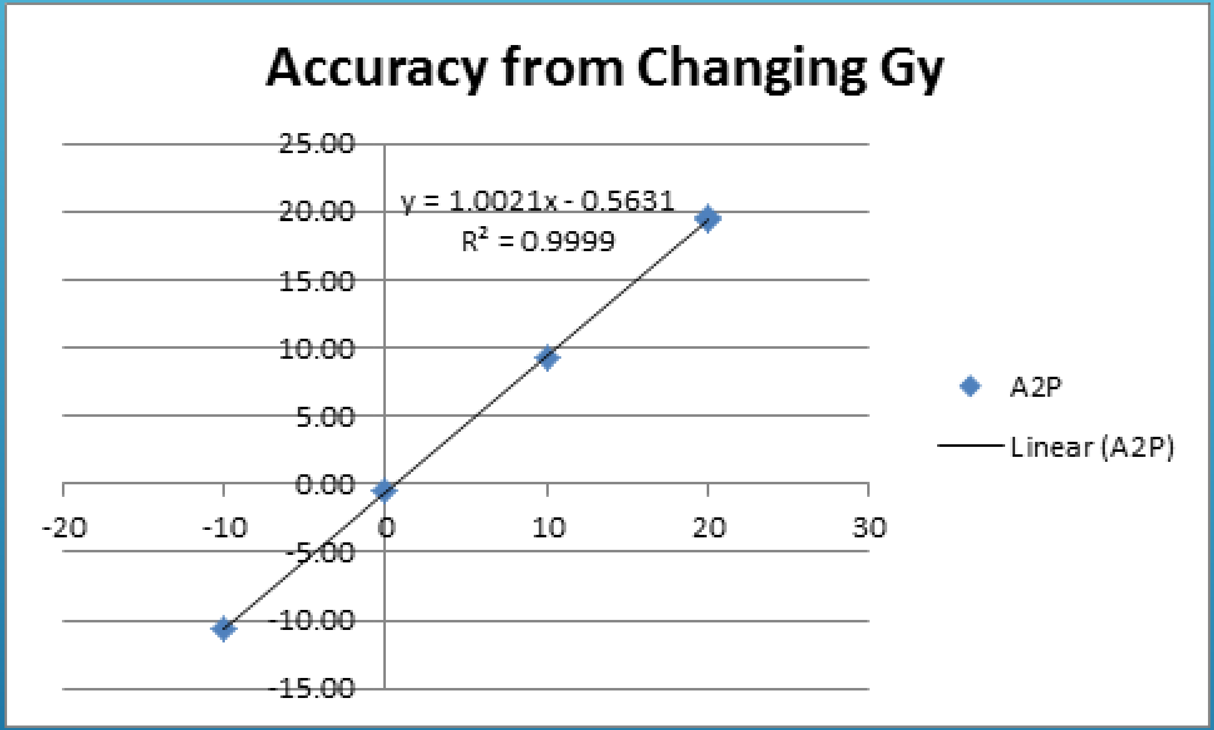
Thank you


Accuracy from Changing Gy
y = 1.0021x - 0.5631
R² = 0.9999
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20
-10
0
10
20
30
A2P
Linear (A2P)