AFC Field Measurements in R9

Ian Taylor, Celeste Pidcott & Craig MacWaters

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Introduction

- Goals of Measurements.
- Measurement apparatus / set up.
- AFC current during the measurements.
- Rack and Compressor measurements.
- X and Z axis measurements: Asymmetry.

Goal Measurements

- Not a precise measurement of the magnet's bore field!
- Instead:
  - An understanding of the field in the hall.
  - A comparison to the model predictions from OPERA.
  - A statement on the accuracy of the models (or separate sub-models).
  - An understanding of adding key components to a known field.
- This has motivated the accuracy of the measurements:
  - Spacial resolution: ~ 2 cm
  - Gaussmeter resolution: $\sim 1\%$
- Compare to 'order of magnitude' uncertainties in some OPERA predictions.

Hall Layout

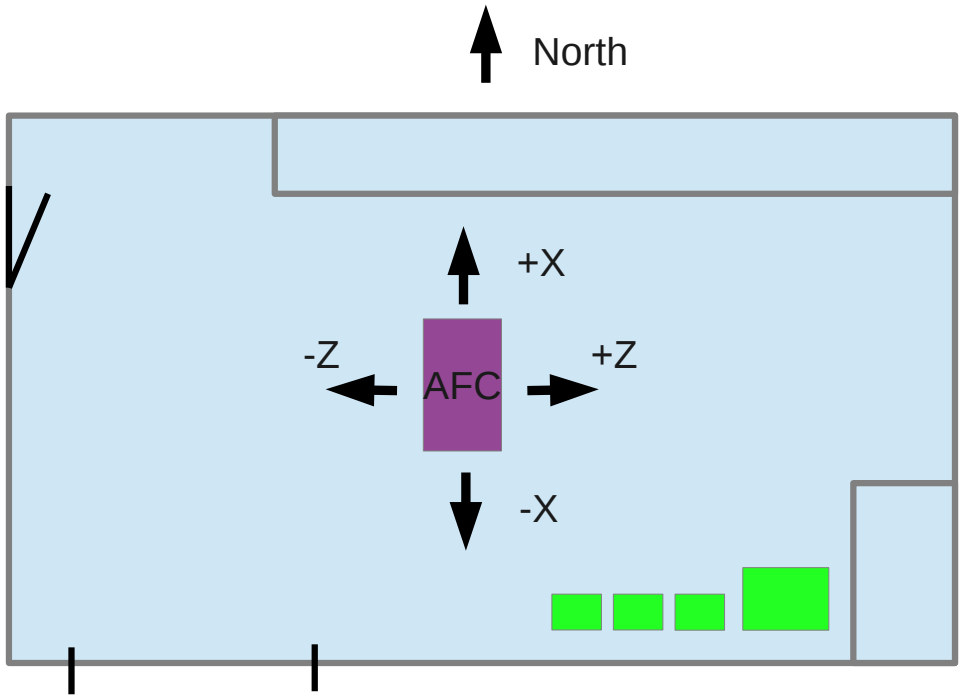


Figure: Rough schematic of the R9 hall. Green boxes are rack (large) and compressors.

Measurement apparatus

- 3 $\times$ AlphaLab Vector/Magnitude Gaussmeter:
  1. Inside inactive compressor (left in image).
  2. Inside magnet control rack.
  3. Attached to roaming teststand, with variable height options.
- Hirst 1-axis Hall probe, installed in bore, for monitoring magnet stability.
- Acer netbook, constant logging of VGM1, VGM2 and Hirst.
  - Hirst added to logging on 12/02/13.
- User laptop, recording roaming measurements.

Measurement apparatus - VGM

Rack & Compressor - 23/01/13 - Solenoid Mode

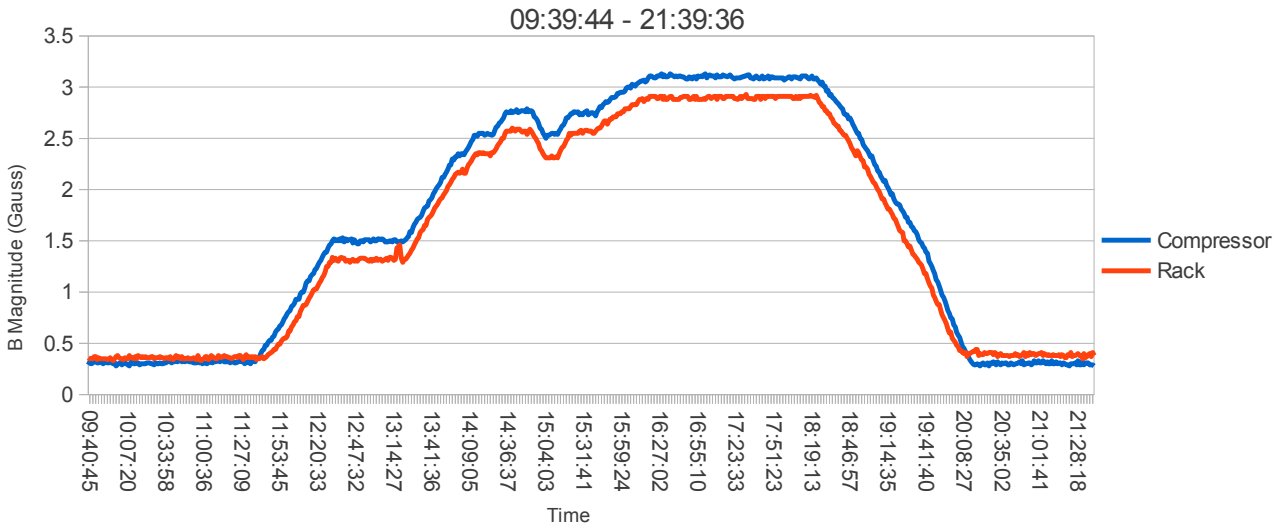


Figure: The Rack and Compressor monitors were running throughout the day. The plots shows the slow ramp up to 50A, 90A, 98A, down to 90A, up to 98A. Very slow ramp to 114A. Held for 2 hours, then ramp down to 0A.

Rack & Compressor - Unstable at 114A

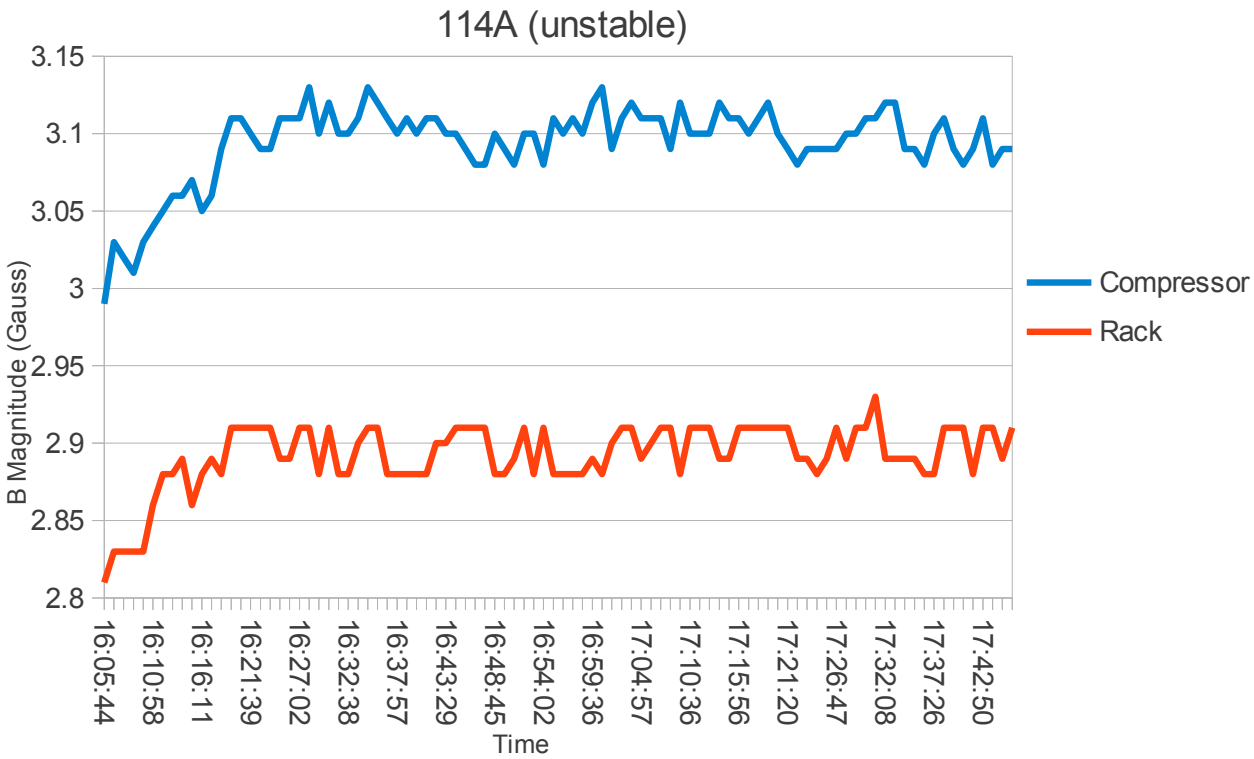


Figure: It was noticed that the bore field (not written to disk) changed between the first value when 114A was reached and the end stable value. The Initial timescale of this was unknown, but we can see here it is about 20 min. The roaming measurements made here will be slightly suspect, but difference is small.

Rack & Compressor - Stable at 114A

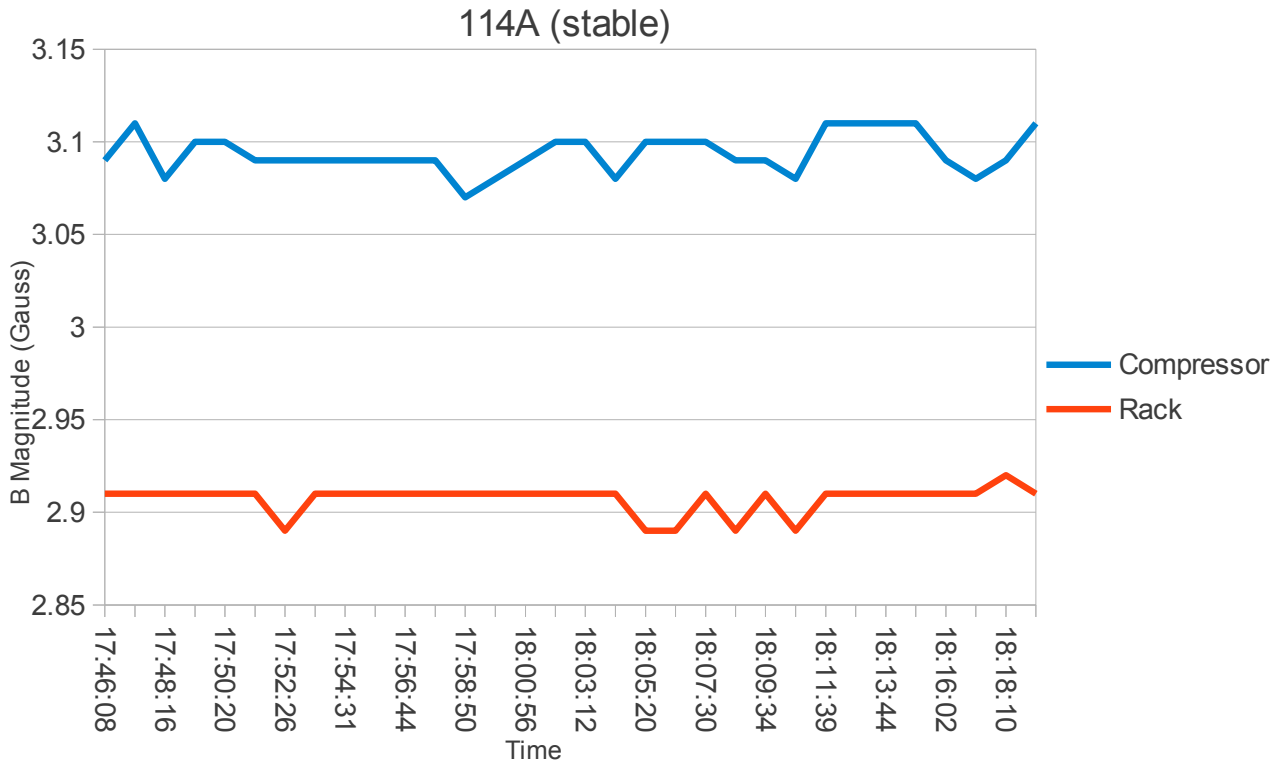


Figure: This 'stable' period covers the second roaming data set, which should be stable.

Bore - 12/02/13 - Flip Mode

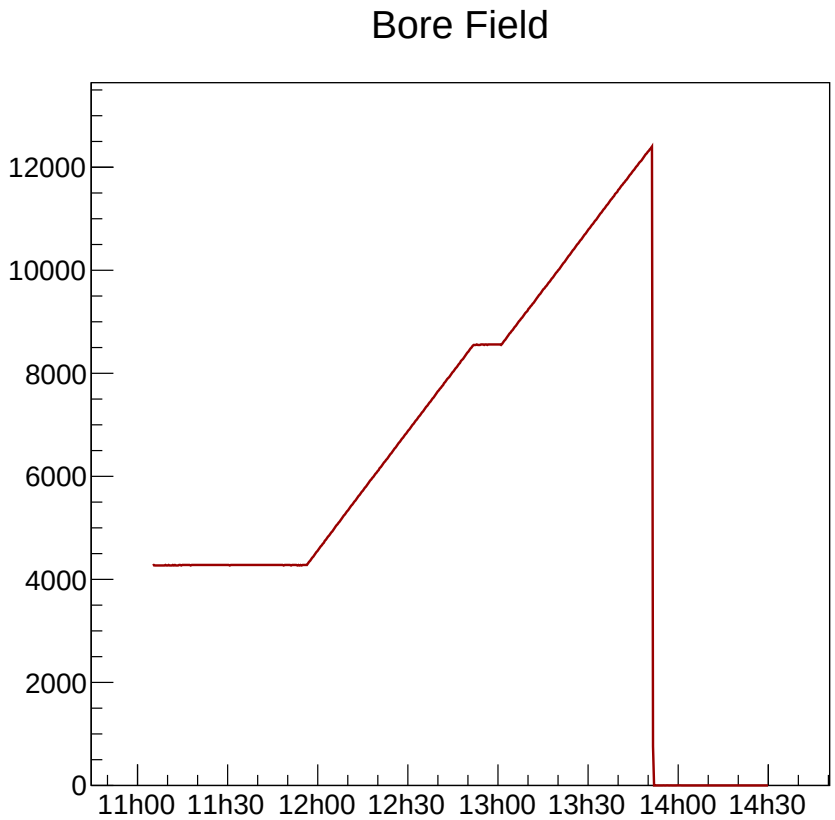
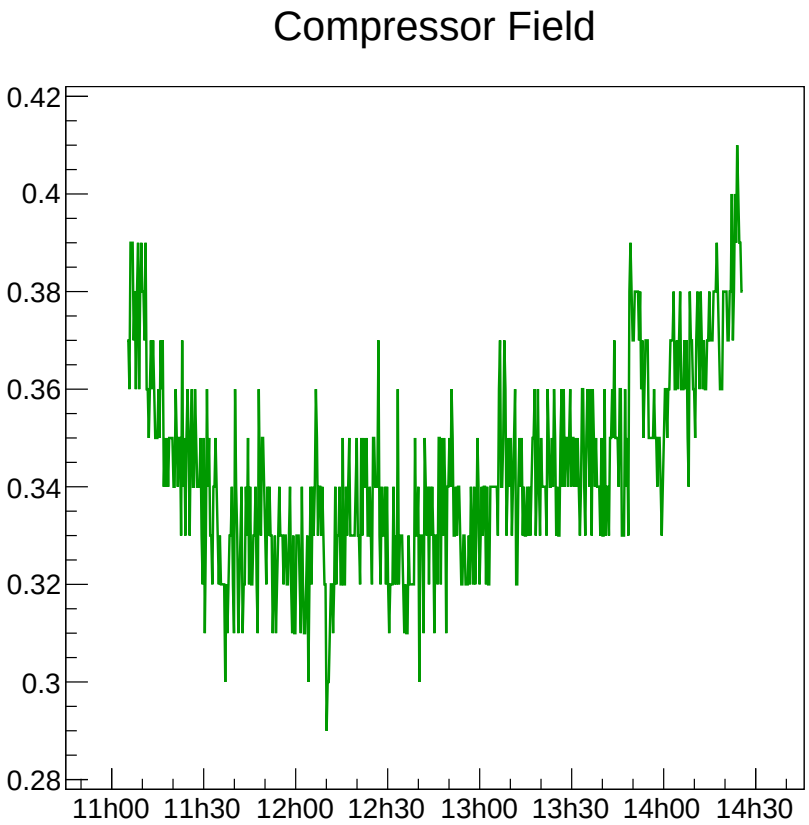


Figure: Bore measurements of the field were only available for the flip mode measurements. And the code wasn't ready when we first started... But they are good for tracking stability.

Compressor & Rack - 12/02/13 - Flip Mode



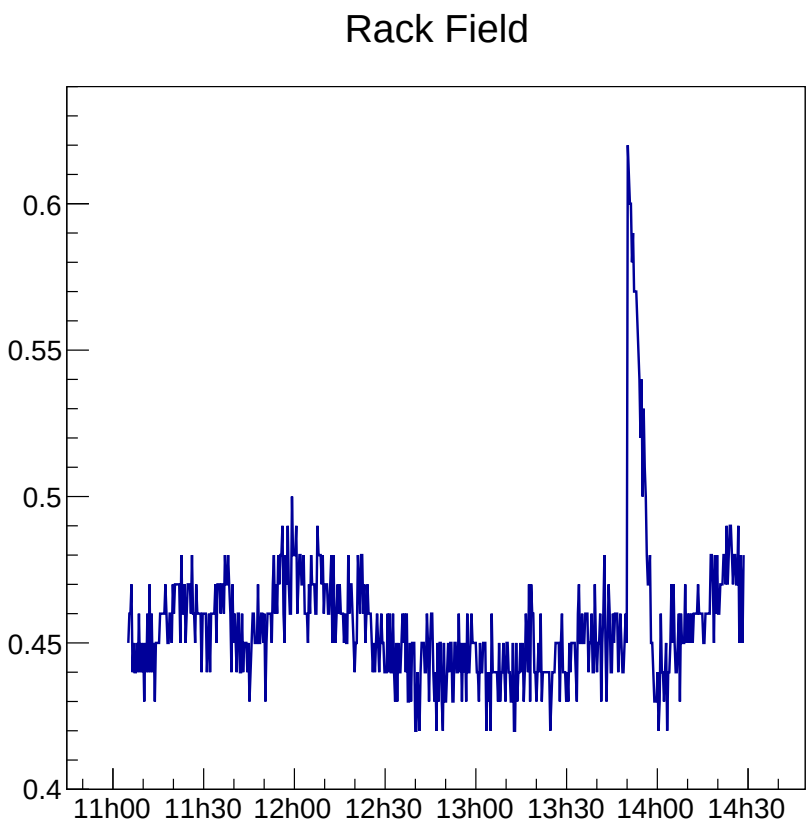


Figure: In flip mode, the field never really reached an observable value in the compressor and rack. Until it quenched!

Introducing Components into Known Fields

- During a period of stable field. We located an area with a 5 Gauss field.
- An unused compressor was then introduced into the area.
- The roaming probe was used to measure the distortion in the external field and the internal fields.
- We will prepare a series of sub-models, for various levels of internal accuracy, and compare with the data.

Roaming Measurements

- The roaming measurements were made along the X and Z axes.
- The locations were marked on the floor.
- Four heights were used 151 cm (bore centre height), 231 and 71 cm (+/- 80 cm from bore) and ground level.

Roaming Measurements - Z axis - Bore Height

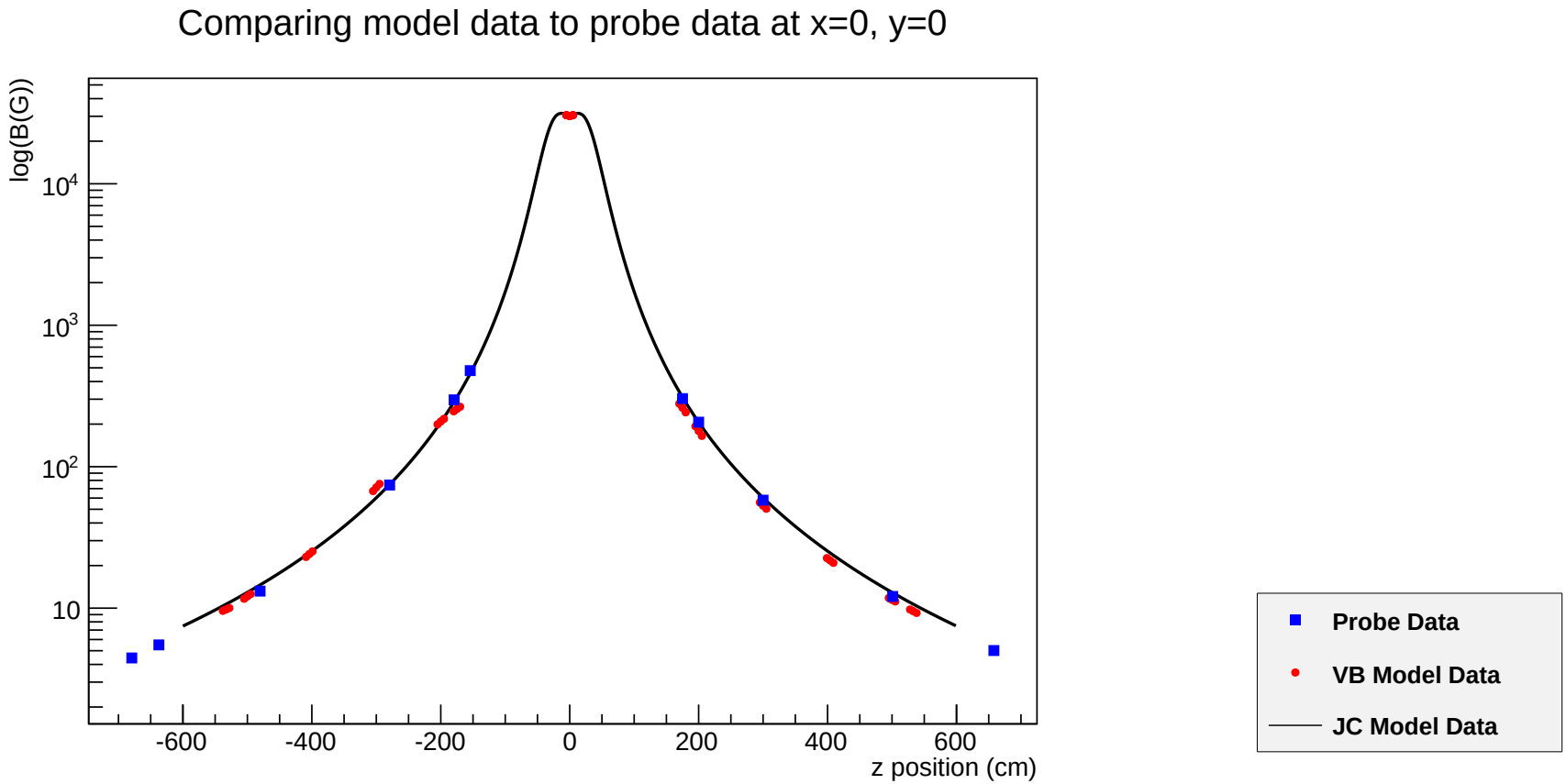


Figure: Black line is Biot-Savart prediction. Red points are OPERA model predictions. Blue points are measurements.

Roaming Measurements - Z axis - Bore Height

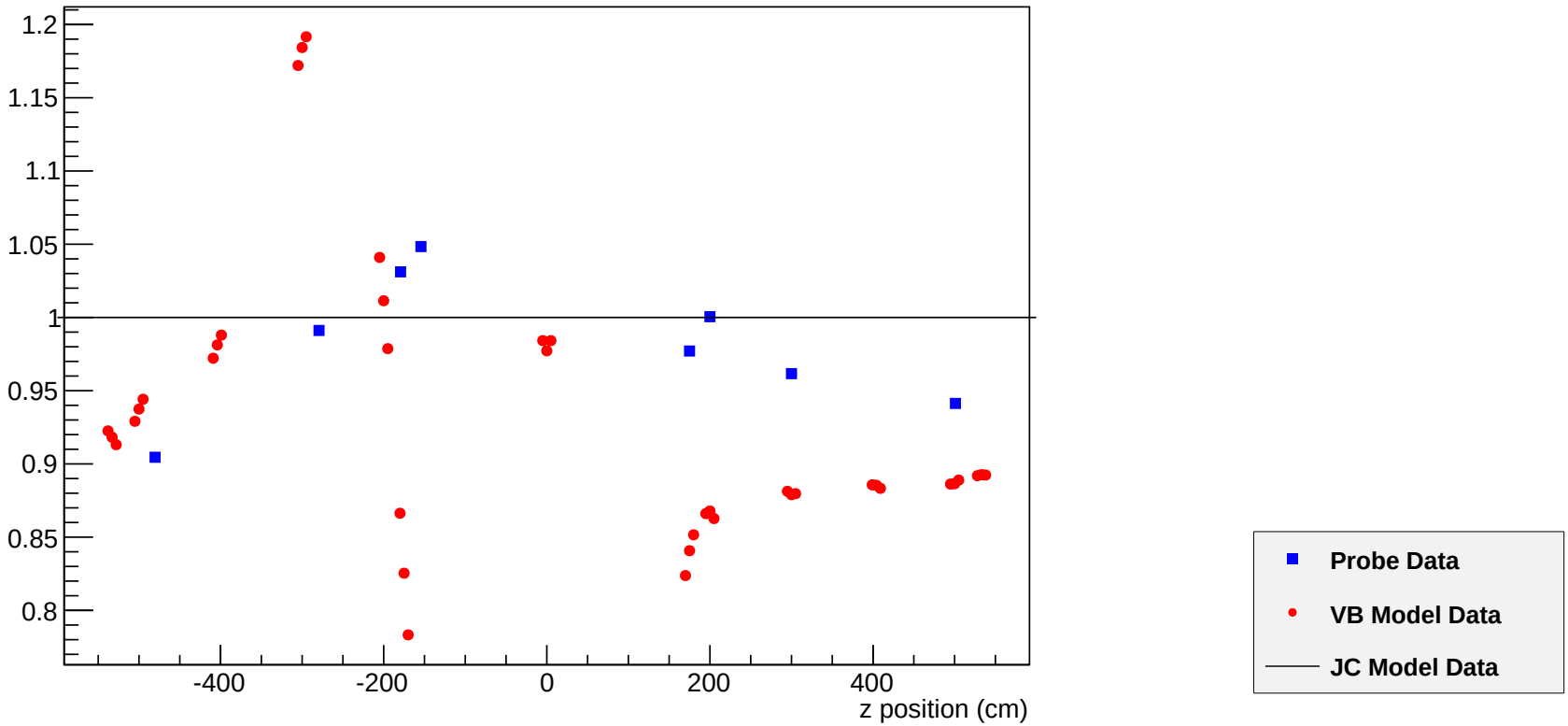


Figure: Black line is Biot-Savart prediction. Red points are OPERA model predictions. Blue points are measurements.

Roaming Measurements - Z axis - Bore Height

- Biot-Savart prediction makes no account of R9 Hall geometry and existence of ferrous materials (racks, compressors, metal in floor, various cages.
- The effect is small here, 1.5 meters about floor, well away from other objects.
- The OPERA model relies on finite element analysis, and understanding the accuracy of the model is one of the key questions.

Roaming Measurements - X axis - Bore Height

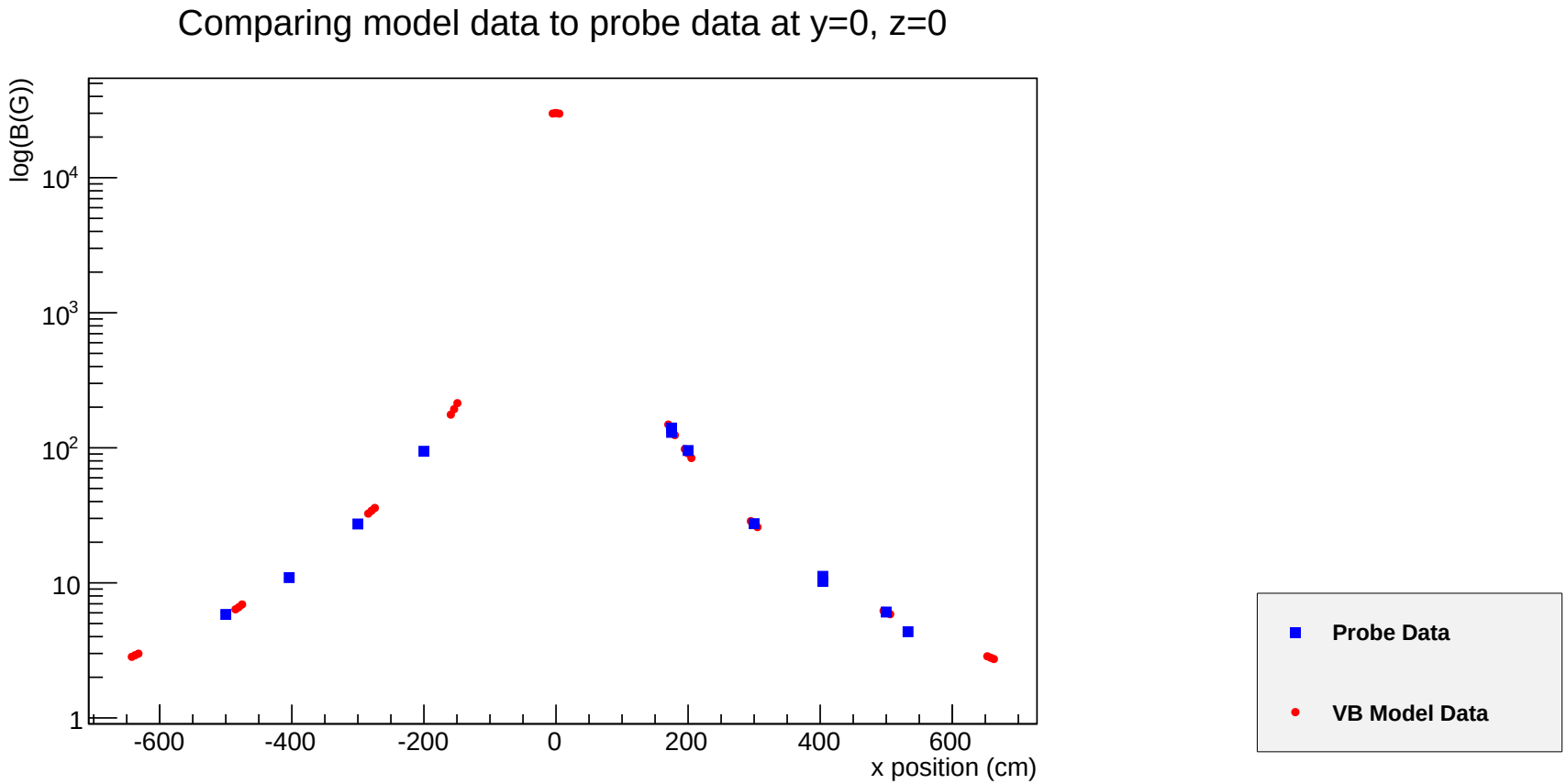
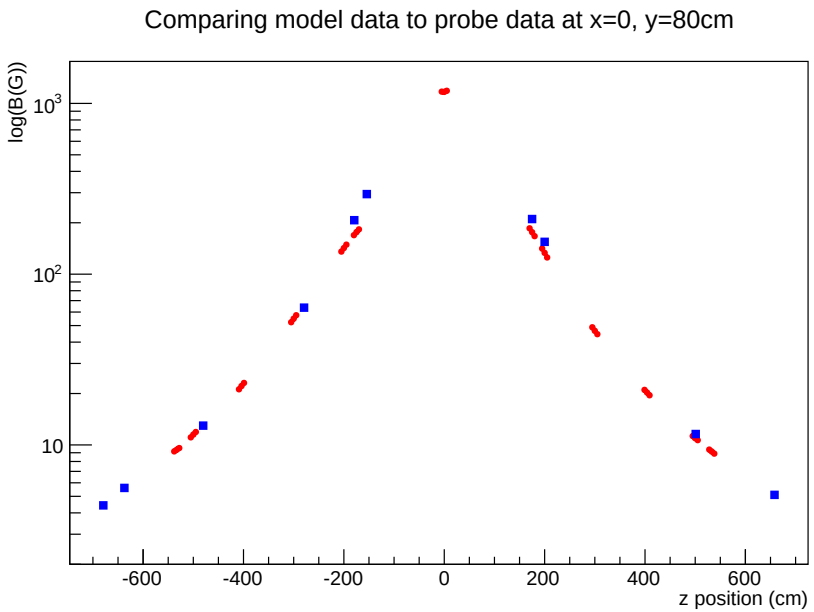
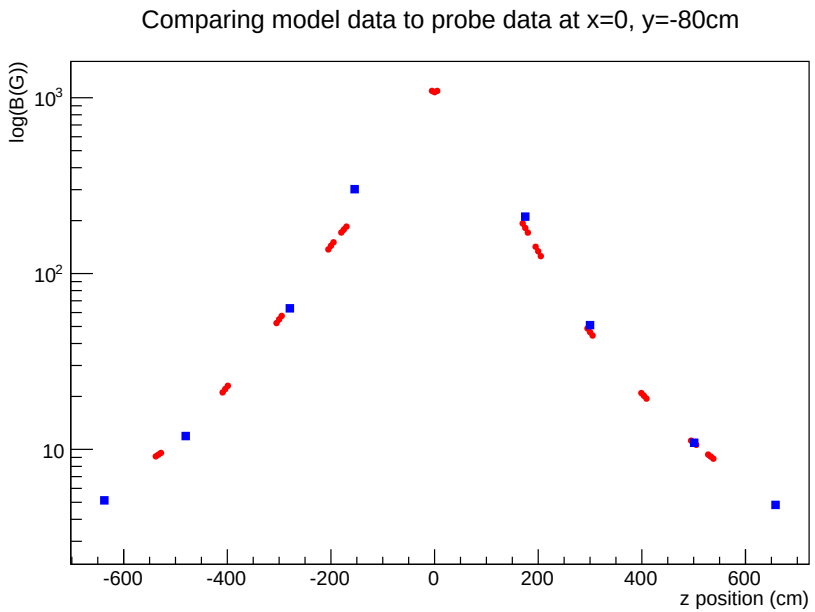


Figure: Red points are OPERA model predictions from Vicky Bayliss. Blue points are measurements.

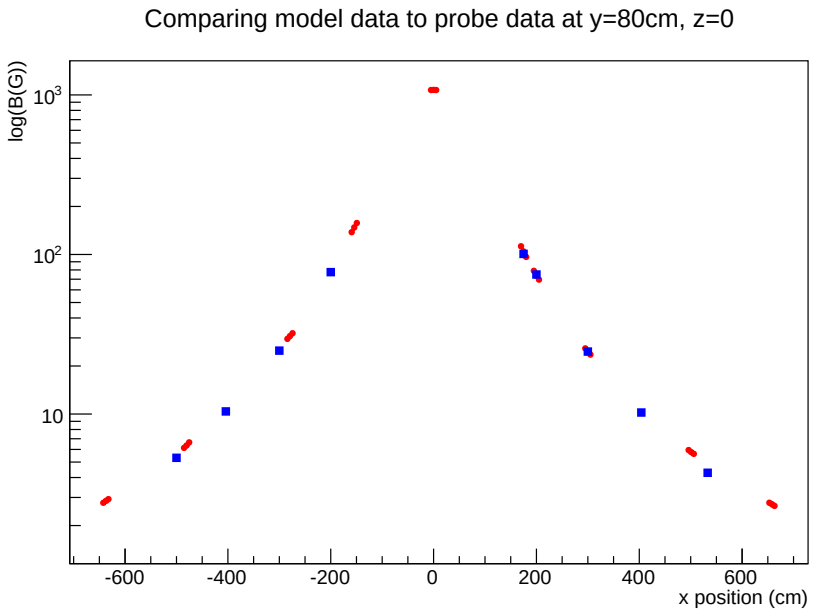
Roaming Measurements - Z axis - ±80 cm

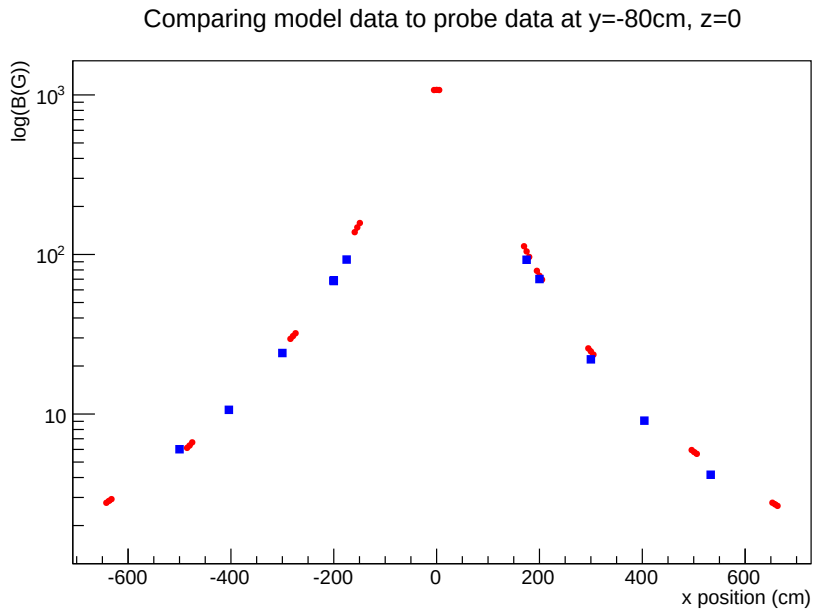




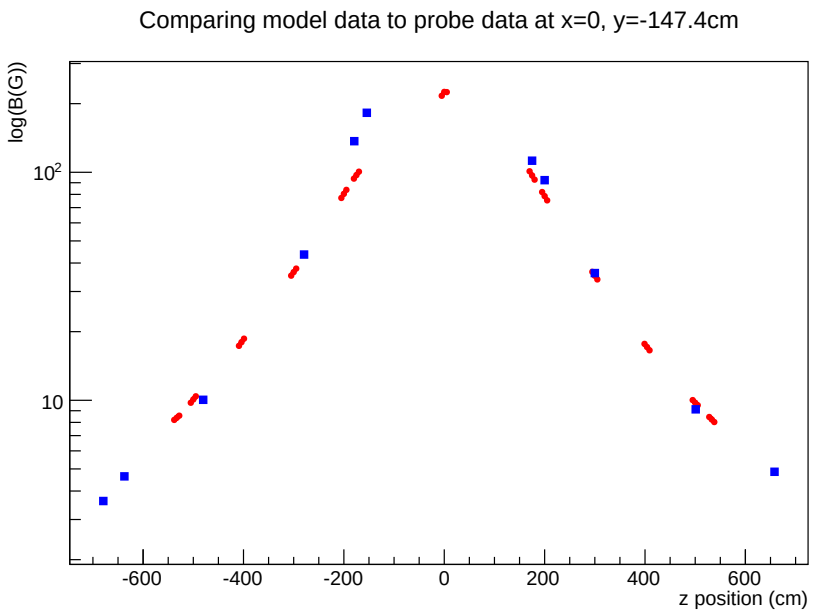
- There was some uncertainty in the negative Z positions ($\sim$ 20 cm difference between marked positions and reality).
- Effect calibrated out here (to the best of our ability), new floor markings have been prepared for future measurements.

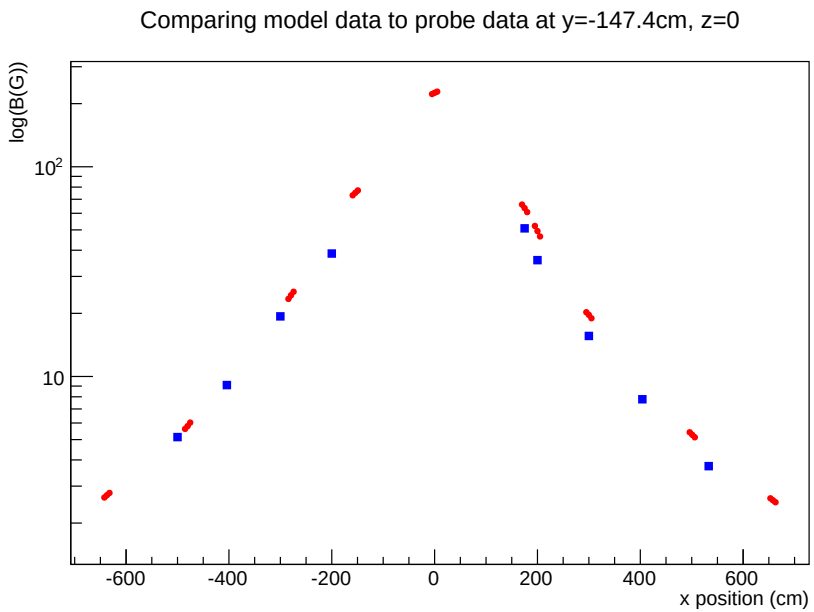
Roaming Measurements - X axis - ±80 cm





Roaming Measurements - X & Z axes - —147 cm





Roaming Measurements - X & Z axes - −147 cm

- The current OPERA model does not simulate the metal in the floor.
  - This is significant in R9, including (we believe) some metal beams running along the Z axis.
- We can iterate on the models, to see the level of accuracy that is required to gain agreement.
- More detailed measurements at floor level next time.

Future Steps

- We will be taking more measurements, as the AFC is brought up in flip mode.
- We will work with Melissa George on a series of models, determining which effects are important to model and which can be ignored.
- Finally, we'll introduce vital components to the field, and compare models and measurements.