Analysis - Support #1589

Support # 1588 (Closed): Field Mapping Analysis

FC1 Magnetic Axis

13 November 2014 12:30 - Blackmore, Victoria

Status:	Closed	**Start date:**	13 November 2014
Priority:	Normal	**Due date:**	
Assignee:	Blackmore, Victoria	**% Done:**	100%
Category:		**Estimated time:**	0.00 hour
Target version:			

Description

Finding the magnetic axis of FC1

Related issues:

Precedes Analysis - Feature #1670: Magnetic Axis of FC2, USS and DSS	**Closed**	**08 April 2015**

History

#1 - 13 November 2014 12:34 - Blackmore, Victoria

- File FC1_run5_cartesianField.gif added

- File FC1_run5_radialField.gif added

Field components plotted as you travel through FC1 in polar and Cartesian co-ordinates. Each hall probe is represented by a different colour point.

Top row: Plots update at a specific slice of z
Bottom row: Plots accumulate information with increasing z

Purpose: in Cartesian co-ordinates, (x, Bx) and (y, By) follow a straight line which we can fit to find the axis. There is some deviation from this line at large (x, y) -- i.e. high radius Hall probes -- that needs accounting for (see later entries).

Uses: FC1, Run 5, 150A, Flip mode

#2 - 13 November 2014 12:41 - Blackmore, Victoria

- File axis_residuals.gif added

- File figure_1.pdf added

Now fit a line through (x, Bx) and (y, By) at each slice of z.

Assume that each Hall probe is perfectly perpendicular to its measured co-ordinate (i.e. Bx is purely Bx and contains no mixed amount of other components). This is *not true* but will do as a first attempt.

- axis_residuals.gif
  - At each slice through z, plot (x, Bx), (y, By) and (z, Bz) along the top row. The bottom right plot is (z, Bz) accumulating with increasing z.
  - Top left, top middle: vertical red dotted line is the fitted position of the axis in x or y.
  - Top left, top middle: red solid line is the best fit line through the data
  - Bottom left, bottom right: The residual of B(x, y)_fitted - B(x, y) measured at each x (or y).
- figure_1.pdf
  - The x and y axis co-ordinates vs. z, with 1-sigma error bars.
  - Discontinuities are where the fitted line becomes (practically) horizontal, at the points where Bz is maximum (and turning over).

#3 - 13 November 2014 14:43 - Blackmore, Victoria

- File axis_residuals_360deg.gif added

Attached plot is from FC1, Run 6 -- also at 150A, but with only 7 measurements along z and a full rotation of the mapper at each point. There are some interesting correlations in the residuals. Either from tilts of the mapper carriage (and hence other components mixing in) or the probes themselves not being exactly perpendicular to the axis.

(NB: Only 6 z-coordinates in the plots -- known issue with iterating through data that's easily fixed later)

#4 - 13 November 2014 14:49 - Blackmore, Victoria

- File figure_3.pdf added

... and the axis results that correspond to #3.

(NB: Still in mapper co-ordinates, not FC co-ordinates)

#5 - 14 November 2014 13:04 - Blackmore, Victoria

- File test_magnet_pure.gif added

- File test_magnet_mixed.gif added

Attempting to reproduce the "tan"-esque behaviour of the axis plots.

1. Produce a FC-like test magnet, operating at 100A, centred on a similar region of z as the field maps of FC1 show (for a comparable z-axis).
    1. Find the axis of this pure, unadulterated test magnet field.
    2. Confirm that no "tan"-esque behaviour is observed.
2. From the pure field, create a new **mixed component** test magnetic map
    1. For each probe, and (x, y, z) component of a probe, define the proportions of field that are mixed together as:
        1. alpha = major field component
        2. beta = minor field component to mix in
        3. gamma = minor field component to mix in
    2. Then:
        1. Bx_mixed = alpha*pure_Bx + beta*pure_By + gamma*pure_Bz
        2. By_mixed = beta*pure_Bx + alpha*pure_By + gamma*pure_Bz
        3. Bz_mixed = beta*pure_Bx + gamma*pure_By + alpha*pure_Bz
    3. Choose:
        1. alpha = 1.0 - beta - gamma
        2. beta = 1.0e-6
        3. gamma = 1.0e-6

Files: test_magnet_pure.gif shows field components as in item1 for the pure test field map, test_magnet_mixed.gif shows the mixed component test field map. NB: Both of them show some "bend" in the (x, Bx) and (y, By) plots as you get to the peaks in Bz.

#6 - 14 November 2014 13:10 - Blackmore, Victoria

- File figure_6.pdf added

- File figure_6b.pdf added

- File test_mixing_x.pdf added

- File test_mixing_y.pdf added

Files:

- figure_6
    - Top row: axis fit to pure test field map
    - Bottom row: axis fit to mixed test field map
    - Left: x axis
    - Right: y axis
    - Mixing: beta = 1e-6, gamma = 1e-6
    - This and previous plots showing the axis fits assumed a Hall probe error of 20mT, which is a higher than reality (1--5mT depending on Hall probe).

- figure_6b
    - Same as figure 6, but with Hall probe error of 5mT

- test_mixing_x
    - Vary beta from 0--1e-4, and gamma from 0==1e-4, and explore how it affects the axis fit.
    - Each figure has its value of beta & gamma in its title
    - All plots are x-axis fits
    - Hall probe error is 5mT
    - (A2 sized plot.. so careful if printing)
    - Note opposite direction of 'tan'-esque behaviour to that observed in real data (curious!)

- test_mixing_y
    - Same as test_mixing_x, but for the y-axis.

#7 - 14 November 2014 13:52 - Blackmore, Victoria

- File test_neg_mixing_x_5mT.pdf added

- File test_neg_mixing_y_5mT.pdf added

Changing the sign of beta & gamma -- axis fit results now match the direction of data.

5mT Hall probe error assumed.

beta: 0--> - 1e-4
gamma: 0--> - 1e-6

alpha = 1 - beta - gamma, alpha >=1 in this case.

#8 - 14 November 2014 14:13 - Blackmore, Victoria

- File test_cross-product_mixing_x.pdf added

- File test_cross-product_mixing_y.pdf added

The more likely scenario is going to be a Hall probe (for example) pointing along x, and picking up components according to the cross-product of By & Bz (which will point along x).

So, sticking to the Bx example:

Bx_measured = alpha*pure_Bx - (gamma*pure_Bz + beta*pure_By)

--> Attached plots are for beta: 0-->1e-4, gamma: 0-->-1e-4

#9 - 14 November 2014 15:05 - Rogers, Chris

Had a chat with Victoria to get the status

- Working on FC1
- Fancy gifs
- Plotting e.g. x vs Bx calculated in lab frame
- Checked that the Bx, By vs x, y is straight as a function of z - qualitative looks more-or-less okay
- Considered looking at Bphi doing "NAFF" like a Fourier Transform, did not get much out (Bphi vs r plot)
- Looked at error on fit, of order 40 mT looks systematic probe by probe, is it an error on the calibration or geometrical? Or something else?
  - Basically the error on the fit is the main issue at present - there appears to be a geometrical issue.
  - Could be the mapper plane is tilted - prime suspect
  - Could be the probe is misaligned
  - Could be the axes are not perpendicular
  - Could be absolute calibration issue
- Running toy simulation to simulate errors - looks like errors come from a mapper plane tilt
- Error bars looks wrong

#10 - 18 November 2014 16:30 - Blackmore, Victoria

- File axis_fit.gif added

- File test_magnet_with_mixing_axis.pdf added

- File test_magnet_with_mixing_axis_zoom1.pdf added

- File test_magnet_with_mixing_axis_zoom2.pdf added

Correcting for field component mixing:

- Use same test magnet field as in entries #5, #6, #7
- Mix in gamma of 1.0e-4*Bz in both Bx and By
- No By mixed into Bx or vice versa (not dominant effect according to plots in #5, #6, #7 ---> Have tried, but don't see much of a difference in the outcome).

Then:

1. Calculate (x0, y0, z0) axis as done previously, by looking at (x, Bx) etc.
2. Assume that the magnetic axis is a straight line
   1. Different amounts of, or wearing down of, insulation might make this not **exactly** true, but such effects are likely to be negligible
   2. Coils are wound on same bobbin, so don't expect to see huge 'kinks' in the axis of one magnet
3. Can find best fit to the lines:
   1. x1 = m*z + c, where m = dx/dz etc
   2. y1 = n*z + d, where n = dy/dz etc
   3. Minimise (x - x0)^2, (y - y0)^2
4. At each z, calculate the amount of measured Bz that we need to mix in to the x- and y-field components so that the axis might match the lines found from (3).
   1. x2 = -(c_x0 + gamma_x*Bz)/m_x0, where m_x0 = dBx/dx found from (1) etc.
   2. y2 = -(c_y0 + gamma_y*Bz)/m_y0, where m_y0 = dBy/dx found from (1) etc.
   3. Minimise (x2 - x1)^2, (y2 - y1)^2
5. Using gamma_x and gamma_y, recalculate (x0, y0, z0) in the usual manner by looking at (x, Bx) and (y, By), except this time we have an additional component:
   1. Bx = m_x*x + c_x - alpha_x*Bz
   2. By = m_y*y + c_y - alpha_y*Bz
   3. Minimise (Bx - Bx_measured)^2, (By - By_measured)^2
   4. Fit gives m_x, m_y and c_x, c_y

5. Rearrange for x3, y3
6. Repeat from (2) until satisfied.

axis_fit.gif Shows what happens if we repeat until consecutive changes in the fitted gradient m (dx/dz) and n (dy/dz) from (3) hit 10^-12 (i.e. from one iteration to the next, the gradient of the (x, z) and (y, z) lines has changed only marginally). The left-hand plot shows the evolution of the x-axis fits, and the right-hand plot shows the evolution of the y-axis fits. Note that the scale on the vertical changes as we progress through iterations.

All of the iterations are shown together in test_magnet_with_mixing_axis.pdf, with test_magnet_with_mixing_axis_zoom1.pdf and test_magnet_with_mixing_axis_zoom2.pdf increasing the vertical scale.

The red, solid, line on all of the above plots is the final fit through the magnetic axis. For the test magnet, the real axis lies along x=y=0. This method retrieves x=y=0.

Next: Show that it still works on a **tilted** test magnet.

#11 - 01 December 2014 17:06 - Blackmore, Victoria

- File test_magnet_8_result.pdf added

- File test_magnet_9_result.pdf added

- File test_magnet_10_result.pdf added

- File test_magnet_3_result.pdf added

- File test_magnet_4_result.pdf added

- File test_magnet_5_result.pdf added

- File test_magnet_6_result.pdf added

- File test_magnet_7_result.pdf added

Fit method tested against a FC-like test magnet with random tilts about the x and y axes. The left-hand plots show the magnetic x-axis and the right-hand plots show the magnetic y-axis.

- Black points are what you find from a "first guess" at the axes, assuming that there are no magnet tilts and field mixing
- Red points are what you find if you go through the fit routine and find the best tilts and offsets
- The blue line is the **actual** magnetic axis

[Still no error bars for now]

#12 - 01 December 2014 17:13 - Blackmore, Victoria

- File FC1_result_noErrors.pdf added

- File FC2_result_noErrors.pdf added

The fit routine carried out on FC1 and FC2 at different currents. Both fits are still in the CERN mappers co-ordinate system -- so x=y=0 is the line the mapper nominally follows. As before, the x-axis is plotted on the left, and the y-axis on the right.

Points are:

- Black, 50A flip mode
- Red, 100A flip mode
- Blue, 150A flip mode
- Green, 114A solenoid mode (on FC1 plot only)

In solenoid mode, there's barely any place where Bz-->0, and the mixing dominates the fits. Flip mode appears to be the better means of finding the axis.

There's also some discrepancy between the axis found at different currents: as the current increases, Bz increases, and the divergent regions (where we end up dividing by zero) get worse. It's odd that this argument doesn't appear to hold for FC2 in y.

Next:

- Try 3 different currents with same tilted test magnet and compare the fitted axes -- do we reproduce the effect seen in data?
- Try a solenoid mode tilted test magnet -- do we reproduce the effect seen in data?

--> See item 18 for an update on the FC2 plots shown here.

#13 - 02 December 2014 12:37 - Blackmore, Victoria

- File test_magnet_3_result_line.pdf added

- File axis_fit_iteration_06.png added

- File test_magnet_8_result_line.pdf added

- File test_magnet_10_result_line.pdf added

- File FC1_result_noErrors_line.pdf added

A selection of the plots from items 11 and 12, with the best-fit line to the magnetic axis drawn instead of points.

The best-fit line is also drawn for FC1 at 50, 100, and 150A. Concerned that the 150A x-axis line (left plot) is so different...

#14 - 11 December 2014 16:22 - Blackmore, Victoria

- File 11Dec_testMagnet_f.pdf added

- File 11Dec_testMagnet_g.pdf added

- File 11Dec_testMagnet_differences.pdf added

- File 11Dec_testMagnet_a.pdf added

- File 11Dec_testMagnet_b.pdf added

- File 11Dec_testMagnet_c.pdf added

- File 11Dec_testMagnet_d.pdf added

- File 11Dec_testMagnet_e.pdf added

Test magnet axis fits:

- Each magnet has a random tilt and offset
- Left-hand plot shows x-axis fit, right-hand plot shows y-axis fit
- Black points on left plot are all estimated x-axis points given best estimate of alpha*Bz contribution, red points are similar on the right-hand plot for the best estimate of y.
- To improve the fits, points near discontinuities are ignored before the final straight-line fit through these points. Points in cyan, on both left and right plots, indicate **included** points in the final straight-line fit
- Green line is the best fit line to the cyan points
- Blue line is the **true** axis of the magnet.
- Fitted axis is always very close to true axis, but not exact.

11Dec_testMagnet_differences.pdf shows the differences between the fitted axis and the true axis.

- Top row: x axis differences
- Bottom row: y axis differences
- Left: Difference between fitted values at the upstream side of the coils
- Right: Difference between fitted values at the downstream side of the coils
- Too few test magnets to really say anything definite (they take a long time to compute), but in all cases fitted axis agrees with true axis to 0.000010m = 0.010mm

#15 - 11 December 2014 16:36 - Blackmore, Victoria

- File test_magnet_e.gif added

- File test_magnet_f.gif added

- File test_magnet_g.gif added

- File FC1_run5_vectors.gif added

- File test_magnet_pure_vectors.gif added

- File test_magnet_a.gif added

- File test_magnet_b.gif added

- File test_magnet_c.gif added

- File test_magnet_d.gif added

Updating with some plots of Bx & By vectors, since J. Cobb identified this as a possible systematic error in field mapping data.

All plots:
*Left-hand plot is a transverse slice at a particular z.

- Arrow base is at the Hall probe (x, y) position.
- Arrow points along the vector (Bx, By)
- Red lines extrapolate along the vector
- All lines should cross at x = y = 0 if the magnet is on-axis, or cross at another (x, y) if off-axis. Lines that do not cross may be a systematic error. *Right-hand plot is (z, Bz) to indicate where along the magnet we are.

- test_magnet_pure_vectors: This is an **untilted** perfect FC model. Radial vectors either point towards the axis or directly away from the axis.
- test_magnet_a--g: These correspond to test magnets a--g above, vectors do not cross at 0, but do all converge to a common point.

- FC1_run5_vectors: Run 5 of FC1 field maps (150A). Vectors do not point to a common location. Possible explanation: Hall probes are not **exactly** oriented along the axes we think they are (i.e. strictly along x-axis in mapper system, but are very slightly tilted themselves).

#16 - 11 December 2014 16:43 - Blackmore, Victoria

- File 11_Dec_FC1_run2.pdf added

- File 11_Dec_FC1_run3.pdf added

- File 11_Dec_FC1_run5.pdf added

- File 11_Dec_FC1_run2-3-5.pdf added

Current best estimate of FC1 axis in mapper co-ordinate system.

11_Dec_FC1_run2: 50A field map

- Left-hand plot: x-axis fit
- Right-hand plot: y-axis fit
- Black (left) and red (right) points are **all** estimated axis points
- Cyan points are those accepted for the final straight line fit
- Green line is the fitted axis

11_Dec_FC1_run3: 100A field map

- Plots as for run 2 above

11_Dec_FC1_run5: 150A field map

- Plots as for run 2 above

11_Dec_FC1_run2-3-5: Comparison of the above axis fits

- Top row: All axis points calculated from the data, before selecting for points to feed into the final line fit.
  - Black = 50A, red = 100A, blue = 150A
  - Left-hand plot = x-axis fits, right-hand plot = y-axis fits
  - Mostly in agreement except for where you get close to the discontinuities
- Bottom row: Final straight line fit (the green line from the previous three pdfs)
  - Left-hand plot = x-axis, right-hand plot = y-axis.
  - Seems consistent at different currents (difference to item #13 is excluding discontinuous region from final line fit)

#17 - 11 December 2014 19:19 - Blackmore, Victoria

- File VectorPlots.zip added

Prettier versions of the vector plots attached to previous issues. Now, red lines point forwards along the Bx, By vector, and blue lines point backwards (so you can see what's happening whilst the field is pointing outward!)

#18 - 12 December 2014 09:51 - Blackmore, Victoria

- File 12Dec14_FC2_run5.pdf added

- File 12Dec14_FC2_fits.pdf added

- File FC2_run2_vectors.gif added

- File FC2_run3_vectors.gif added

- File FC2_run5_vectors.gif added

- File 12Dec14_FC2_run2.pdf added

- File 12Dec14_FC2_run3.pdf added

And now for FC2 (FC2 fits in item 12 used buggily interpreted data files, data used here should be being read correctly).

Plots labelled 'vectors' are the same as in item 15, but for FC2 instead.
Plots labelled '_runX' are the same as in item 16, but for FC2
12Dec14_FC2_fits shows a comparison between 50, 100 and 150A field map axis results for FC2.

#19 - 12 December 2014 15:12 - Blackmore, Victoria

- File m1_Bz_probe1.pdf added

#20 - 12 December 2014 15:17 - Blackmore, Victoria

- File m2_Bz_probe1.pdf added

- File USS_first_pass_m1m2.pdf added

.. clicked submit too soon. These go with item #19.

These plots are a first pass at the Upstream SS's axis (as requested by C. Rogers). The SS's are a bit more complicated than the FCs, as there're more regions of constant solenoid field (for which there is no axis). We have some low-current measurements of the M1 and M2 coils powered individually.

m1_Bz_probe1: The Bz component of the field measured by the 30mm probe through M1 at 30A
m2_Bz_probe2: The Bz component of the field measured by the 30mm probe through M2 at 30A

Need to proceed more cautiously with these field maps, since 30A is quite low and the measurements are more likely to be noisy. Nevertheless, **USS_first_pass_m1m2** shows the result of the method on the M1 and M2 coils without the final straight line fit.

To do:
- Combine the results from M1 and M2, then do a straight line fit
- Compare with 'full field' SS, picking out sections where there is a field gradient (dBz/dz != 0). (This will take a bit of time to select the 'right' regions).

#21 - 12 December 2014 17:03 - Rogers, Chris

Could you please explain roughly what the coordinate system is (e.g. where is the 4 T region?)

#22 - 17 December 2014 16:20 - Blackmore, Victoria

- File tilted_USS_1.png added

The 4T region is to the far right, at about 3-4m (so not on the axis plot).

Attached is a calculation of an SS operating at "100% Solenoid Mode" currents, which were used during mapping. The calculation is not co-axial with the mapper (so like the tilted FC test maps from earlier issues). I should probably also mark on these which points contribute to the fitted line -- expect that with the next few test cases I'm generating. The green line shows the best fit line, the red line is the true axis of the magnet.

(Note-for-later: the mapper enters the magnet in the downstream --> upstream direction, so the z-axis is reversed compared to my calculations. This would be fixed by applying the survey.)

#23 - 13 January 2015 15:39 - Blackmore, Victoria

- File FC2_vector_sum.gif added

- File testmagnet3_vector_sum.gif added

- File perfect_magnet.pdf added

- File testmagnet3.pdf added

- File fc2.pdf added

- File testmagnet3_all_residual_vectors.pdf added

- File fc2_all_residual_vectors.pdf added

Back to FC field maps (to try and understand the systematics, e.g. item #17)

Idea: See if anything obvious shows up when we sum up the transverse field vector components for one probe as we travel along the magnet in z.

- A perfectly aligned, perfect FC, measured with a perfect mapper will have all radial (transverse) vectors pointing at the axis. Summing up its vectors around a loop should bring us back to zero. **[see perfect_magnet.pdf]**
- A mis-aligned, but otherwise perfect FC, measured with a perfect mapper will have all its radial vectors pointing at the true axis. This axis may no longer coincide with the mapper axis. The mapper may 'measure' the field at different true radii, so the magnitude of the field vectors may differ from the perfectly aligned case. Though the vectors point towards the axis, the sum of those vectors does not necessarily bring us back around to zero. **[see testmagnet3.pdf]**
- A mis-aligned, real FC, measured with a real mapper **should** sill measure radial vectors pointing toward the true axis. We may misinterpret the positions and orientations of the Hall probes, which may mean our vectors miss each other. It's unlikely that the sum of these vectors will be zero, but we may learn something interesting by looking at it and comparing to the tilted calculation **[see fc2.pdf]**

perfect_magnet.pdf, testmagnet3.pdf and fc2.pdf try to test the above at z~1m for a probe that is 30mm away from the mapper's axis.

- Left plot: This shows the sum of "measured" vectors. Red points indicate the start of a vector, black points indicate the end. For plotting, one vector is plotted on top of the next, so only one black point is visible -- this is the final end of the summed vector.
- Middle plot: This is the residual vector, the vector between (0, 0), the tail of our first vector in the sum, and the end of the summed vector.
- Right plot: A plot of (z, Bz) for a rough visualisation of where in the magnet we are.

(Left plots) The aligned and tilted calculations have a similar-looking vector sum pattern. The FC field map is a lot more scattered and random.

(Middle plots) The aligned calculation has no residual vector (the scales are 1e-17 in x and y, which is zero within rounding errors). The tilted calculation has some small residual vector. The FC field map has a larger residual vector.

(Right plots) Nothing of significance, except to say that we're trying to compare similar z-positions in these plots.

- We can look at these plots as we go along z, through the magnet. **See testmagnet3_vector_sum.gif and FC2_vector_sum.gif**
  - These are animated versions of the left/right/middle plots described previously. The right-hand plot shows you how z is changing.
  - testmagnet3[...] is from the tilted calculation. The residual vector goes back and forth along a straight line.
  - fc2[...] is from the FC2 (run 7, 150A) field map. The residual vector goes around in a rough circle.

To see if the residual vectors do follow a line/circle, we can plot them for all z. In other words, at each z, calculate the sum of the measured (Bx, By) vectors and the residual vector. Plot the residual vector -- **See testmagnet3_all_residual_vectors.pdf and fc2_all_residual_vectors.pdf** The residual vector for the FC2 measurements is not exactly circular, but the precession of the vector must be some indication of the systematic we don't yet understand (e.g. an additional tilt of the Hall probe? Non-circular movement due to transverse physical offset of the mapper, bumping along its carriage?)

#24 - 28 January 2016 11:39 - Rogers, Chris

- Status changed from Open to Closed

- % Done changed from 0 to 100

I think this is closed?

Files

FC1_run5_cartesianField.gif	5.92 MB 13 November 2014	Blackmore, Victoria
FC1_run5_radialField.gif	5.69 MB 13 November 2014	Blackmore, Victoria
axis_residuals.gif	5.37 MB 13 November 2014	Blackmore, Victoria
figure_1.pdf	103 KB 13 November 2014	Blackmore, Victoria
axis_residuals_360deg.gif	298 KB 13 November 2014	Blackmore, Victoria
figure_3.pdf	15.1 KB 13 November 2014	Blackmore, Victoria
test_magnet_pure.gif	7.21 MB 14 November 2014	Blackmore, Victoria
test_magnet_mixed.gif	7.21 MB 14 November 2014	Blackmore, Victoria
figure_6.pdf	197 KB 14 November 2014	Blackmore, Victoria
figure_6b.pdf	195 KB 14 November 2014	Blackmore, Victoria
test_mixing_x.pdf	1.18 MB 14 November 2014	Blackmore, Victoria
test_mixing_y.pdf	1.18 MB 14 November 2014	Blackmore, Victoria
test_neg_mixing_x_5mT.pdf	1.17 MB 14 November 2014	Blackmore, Victoria
test_neg_mixing_y_5mT.pdf	1.17 MB 14 November 2014	Blackmore, Victoria
test_cross-product_mixing_x.pdf	1.18 MB 14 November 2014	Blackmore, Victoria
test_cross-product_mixing_y.pdf	1.18 MB 14 November 2014	Blackmore, Victoria
axis_fit.gif	139 KB 18 November 2014	Blackmore, Victoria
test_magnet_with_mixing_axis.pdf	23.1 KB 18 November 2014	Blackmore, Victoria
test_magnet_with_mixing_axis_zoom1.pdf	28.5 KB 18 November 2014	Blackmore, Victoria
test_magnet_with_mixing_axis_zoom2.pdf	33 KB 18 November 2014	Blackmore, Victoria
test_magnet_8_result.pdf	14.1 KB 01 December 2014	Blackmore, Victoria
test_magnet_9_result.pdf	14.4 KB 01 December 2014	Blackmore, Victoria
test_magnet_10_result.pdf	13.9 KB 01 December 2014	Blackmore, Victoria
test_magnet_3_result.pdf	14.3 KB 01 December 2014	Blackmore, Victoria
test_magnet_4_result.pdf	14.5 KB 01 December 2014	Blackmore, Victoria
test_magnet_5_result.pdf	13.9 KB 01 December 2014	Blackmore, Victoria
test_magnet_6_result.pdf	14 KB 01 December 2014	Blackmore, Victoria
test_magnet_7_result.pdf	14.7 KB 01 December 2014	Blackmore, Victoria
FC1_result_noErrors.pdf	25.8 KB 01 December 2014	Blackmore, Victoria
FC2_result_noErrors.pdf	20.4 KB 01 December 2014	Blackmore, Victoria
test_magnet_3_result_line.pdf	14.5 KB 02 December 2014	Blackmore, Victoria
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11Dec_testMagnet_f.pdf	14.3 KB 11 December 2014	Blackmore, Victoria
11Dec_testMagnet_g.pdf	13.1 KB 11 December 2014	Blackmore, Victoria

11Dec_testMagnet_differences.pdf	20.2 KB	11 December 2014	Blackmore, Victoria
11Dec_testMagnet_a.pdf	13.6 KB	11 December 2014	Blackmore, Victoria
11Dec_testMagnet_b.pdf	13.4 KB	11 December 2014	Blackmore, Victoria
11Dec_testMagnet_c.pdf	13.9 KB	11 December 2014	Blackmore, Victoria
11Dec_testMagnet_d.pdf	13.7 KB	11 December 2014	Blackmore, Victoria
11Dec_testMagnet_e.pdf	14 KB	11 December 2014	Blackmore, Victoria
test_magnet_e.gif	339 KB	11 December 2014	Blackmore, Victoria
test_magnet_f.gif	339 KB	11 December 2014	Blackmore, Victoria
test_magnet_g.gif	341 KB	11 December 2014	Blackmore, Victoria
FC1_run5_vectors.gif	1.54 MB	11 December 2014	Blackmore, Victoria
test_magnet_pure_vectors.gif	1.74 MB	11 December 2014	Blackmore, Victoria
test_magnet_a.gif	338 KB	11 December 2014	Blackmore, Victoria
test_magnet_b.gif	346 KB	11 December 2014	Blackmore, Victoria
test_magnet_c.gif	341 KB	11 December 2014	Blackmore, Victoria
test_magnet_d.gif	339 KB	11 December 2014	Blackmore, Victoria
11_Dec_FC1_run2.pdf	18 KB	11 December 2014	Blackmore, Victoria
11_Dec_FC1_run3.pdf	18.1 KB	11 December 2014	Blackmore, Victoria
11_Dec_FC1_run5.pdf	17.5 KB	11 December 2014	Blackmore, Victoria
11_Dec_FC1_run2-3-5.pdf	23.6 KB	11 December 2014	Blackmore, Victoria
VectorPlots.zip	9.36 MB	11 December 2014	Blackmore, Victoria
12Dec14_FC2_run5.pdf	20.8 KB	12 December 2014	Blackmore, Victoria
12Dec14_FC2_fits.pdf	28.7 KB	12 December 2014	Blackmore, Victoria
FC2_run2_vectors.gif	2.21 MB	12 December 2014	Blackmore, Victoria
FC2_run3_vectors.gif	2.21 MB	12 December 2014	Blackmore, Victoria
FC2_run5_vectors.gif	2.21 MB	12 December 2014	Blackmore, Victoria
12Dec14_FC2_run2.pdf	21.1 KB	12 December 2014	Blackmore, Victoria
12Dec14_FC2_run3.pdf	21 KB	12 December 2014	Blackmore, Victoria
m1_Bz_probe1.pdf	19.7 KB	12 December 2014	Blackmore, Victoria
m2_Bz_probe1.pdf	19.7 KB	12 December 2014	Blackmore, Victoria
USS_first_pass_m1m2.pdf	18.2 KB	12 December 2014	Blackmore, Victoria
tilted_USS_1.png	85.4 KB	17 December 2014	Blackmore, Victoria
FC2_vector_sum.gif	2.33 MB	13 January 2015	Blackmore, Victoria
testmagnet3_vector_sum.gif	392 KB	13 January 2015	Blackmore, Victoria
perfect_magnet.pdf	15.7 KB	13 January 2015	Blackmore, Victoria
testmagnet3.pdf	15.8 KB	13 January 2015	Blackmore, Victoria
fc2.pdf	16.1 KB	13 January 2015	Blackmore, Victoria
testmagnet3_all_residual_vectors.pdf	12.4 KB	13 January 2015	Blackmore, Victoria
fc2_all_residual_vectors.pdf	14.2 KB	13 January 2015	Blackmore, Victoria