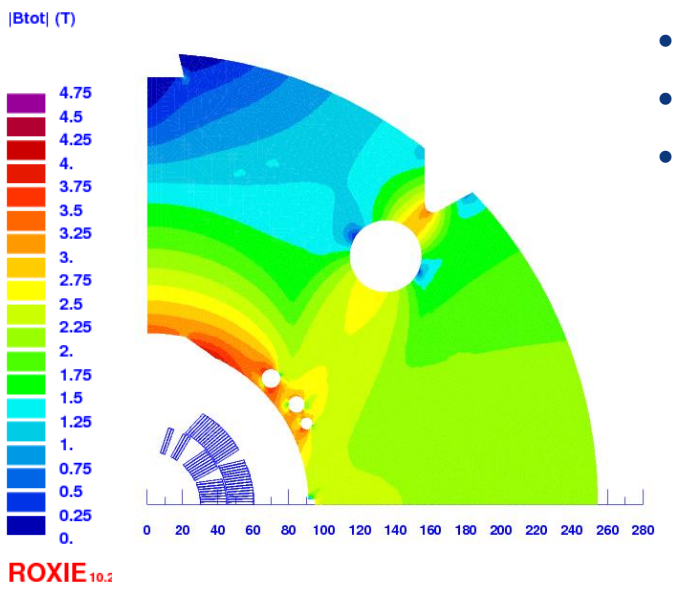
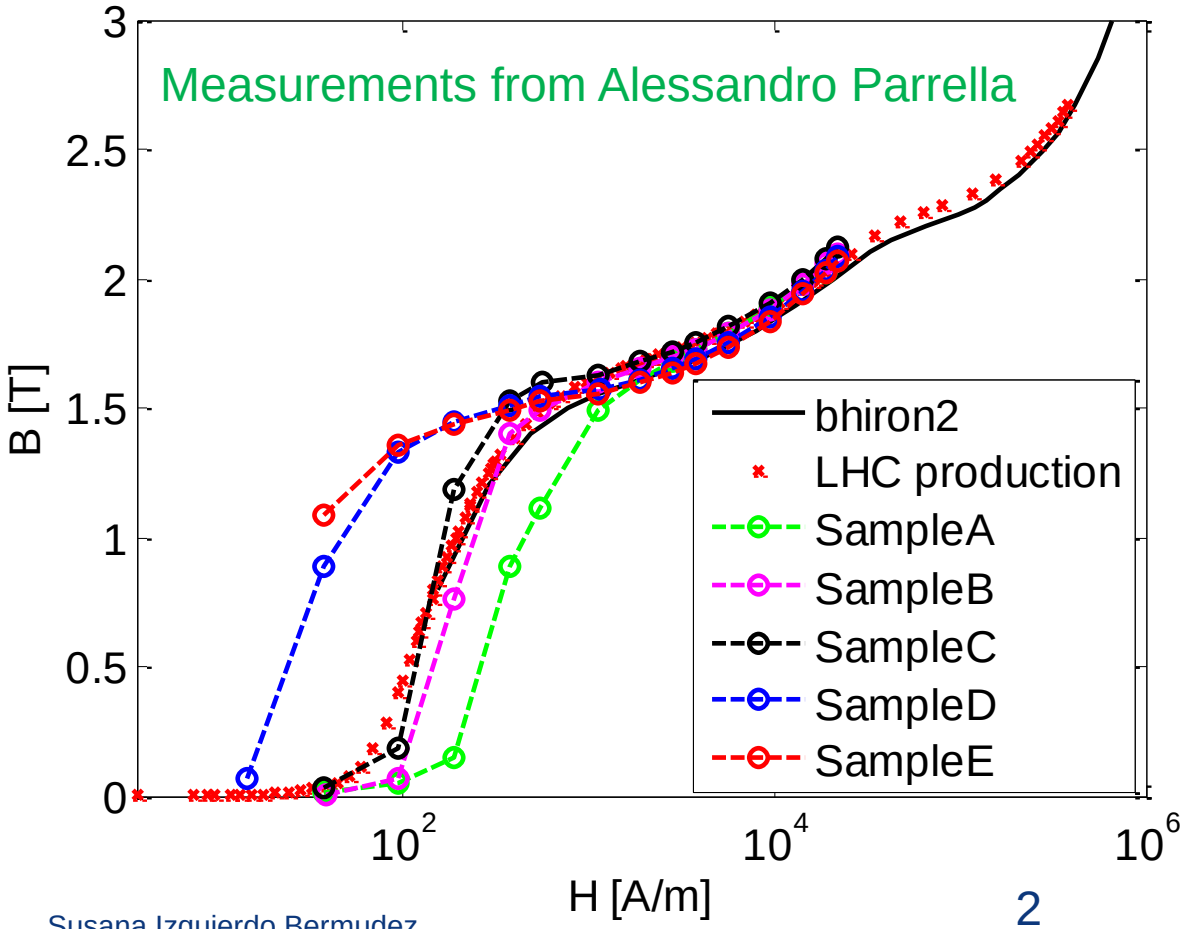
Susana Izquierdo Bermudez. 27-08-2015

Impact of Iron Magnetic Properties on Field Quality for High Field Superconducting Magnets

Measured data

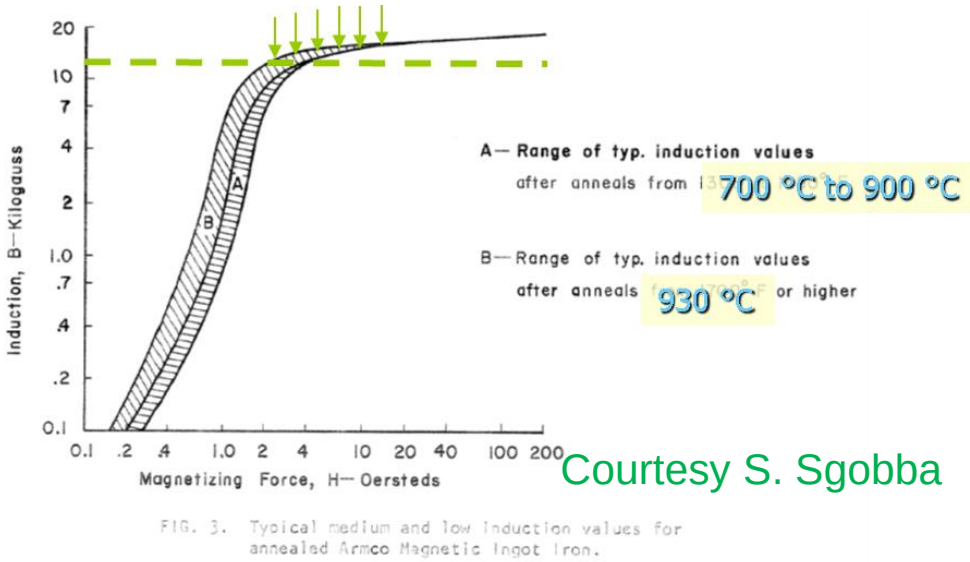


- Measurements up to H = 20000 A/m (B ~ 2T)
- For H > 20000 A/m “LHC production” data assumed
- The region H > 20000 A/m is critical for Hi-Lumi magnets, as the iron is heavily saturated (B ~4-5T)

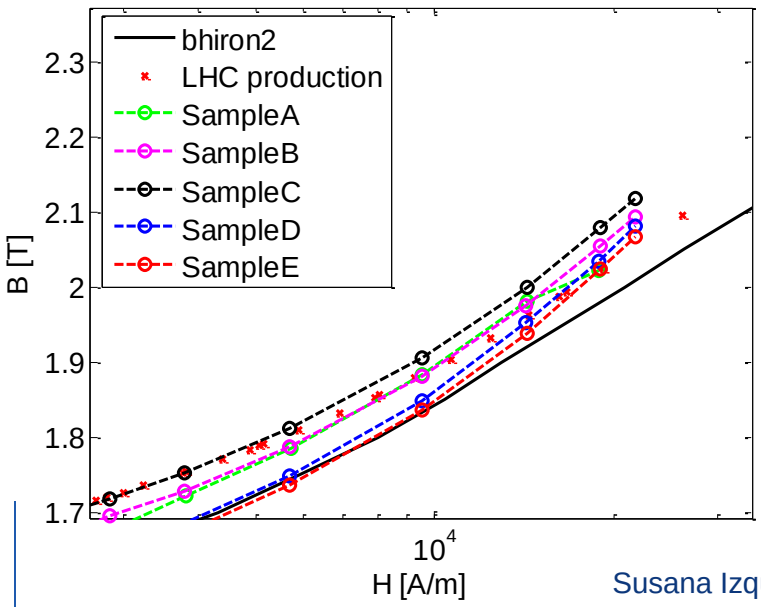


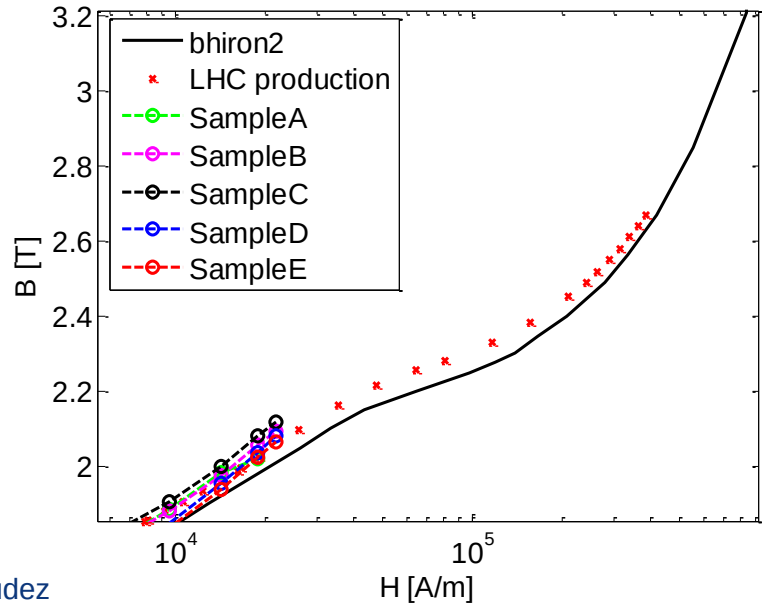
Measured data

- According to S. Sgobba, the behaviour of the material at high field will be determined by the purity of the material and not the heat treatment → should be the same for all the samples.
- Samples are getting closer when increasing H, but still they did not converged
- H > 20000 A/m LHC production data assumed for all the samples.



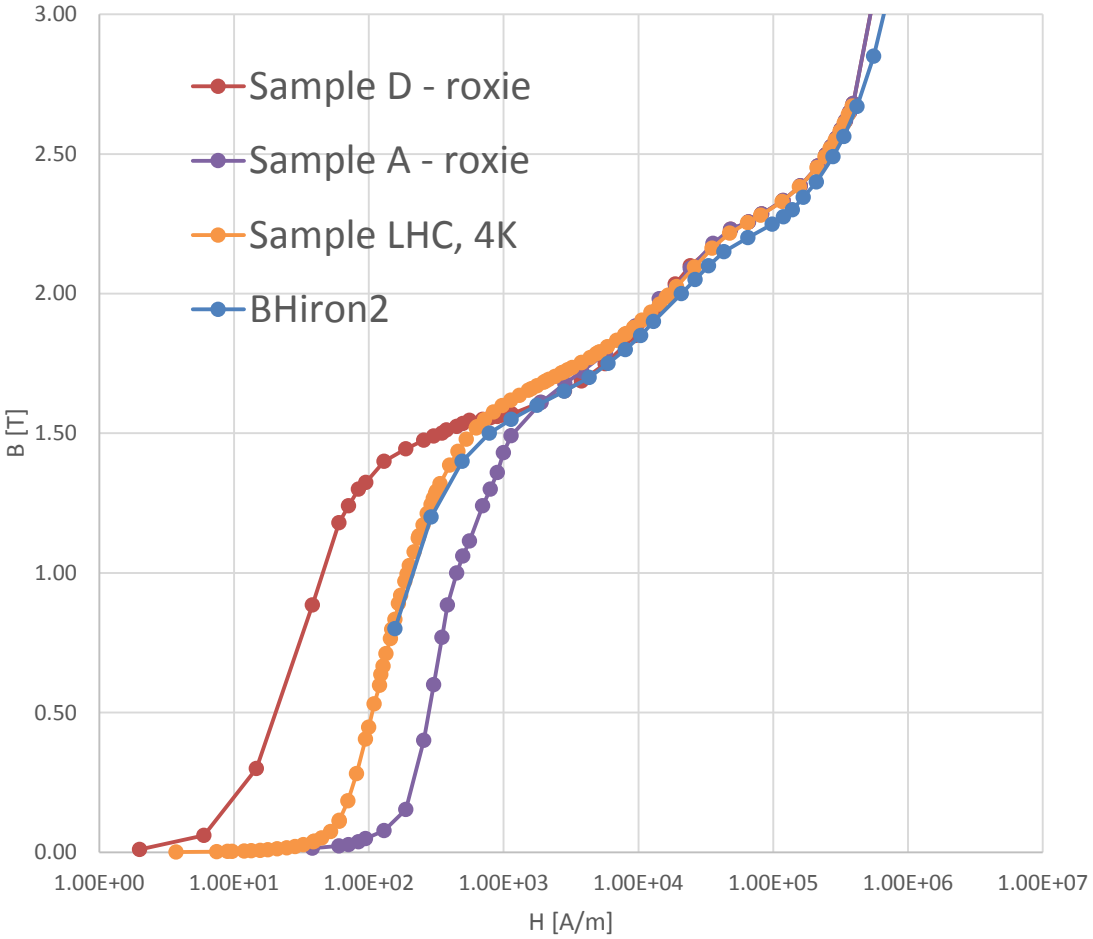
Courtesy S. Sgobba

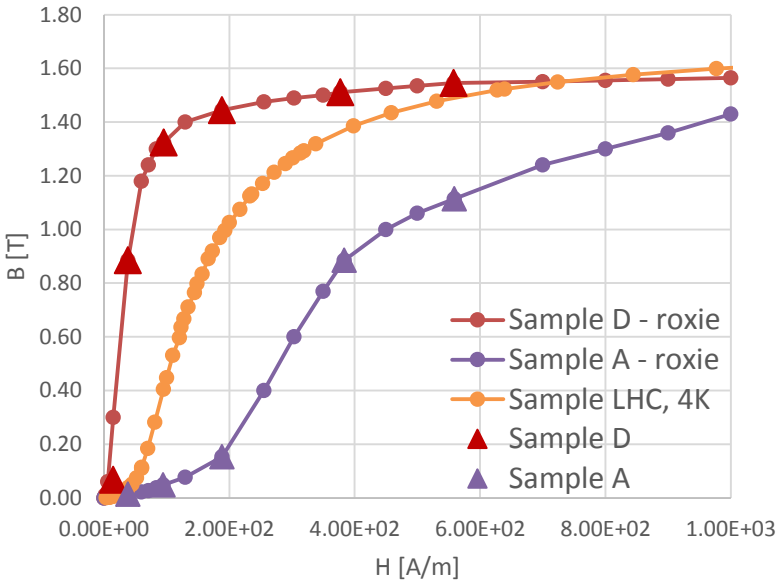


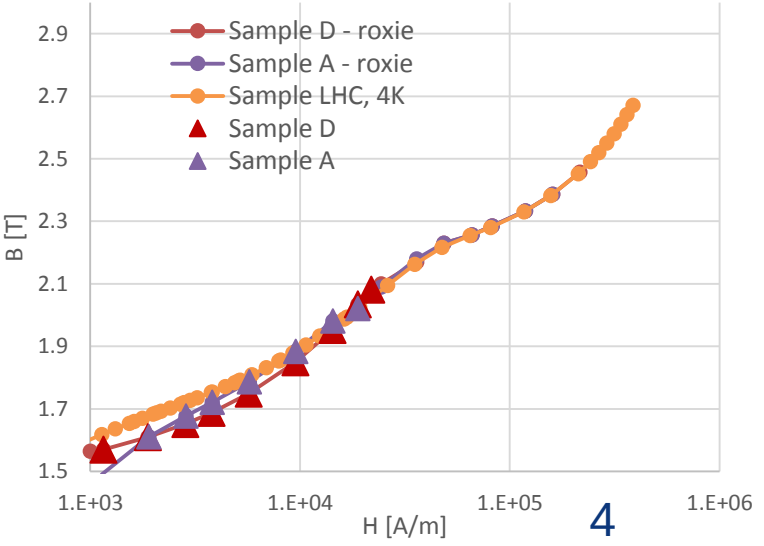


BH-Data

- Roxie computations done extending the BH for H>20000 A/m using LHC data.

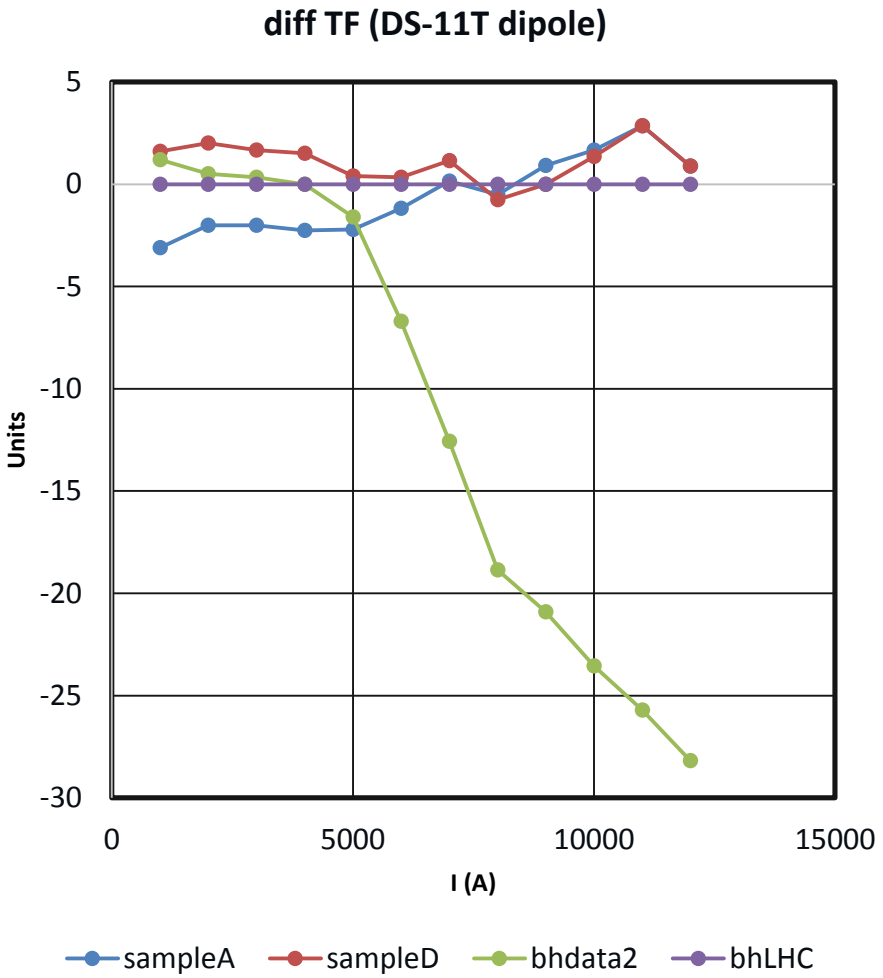


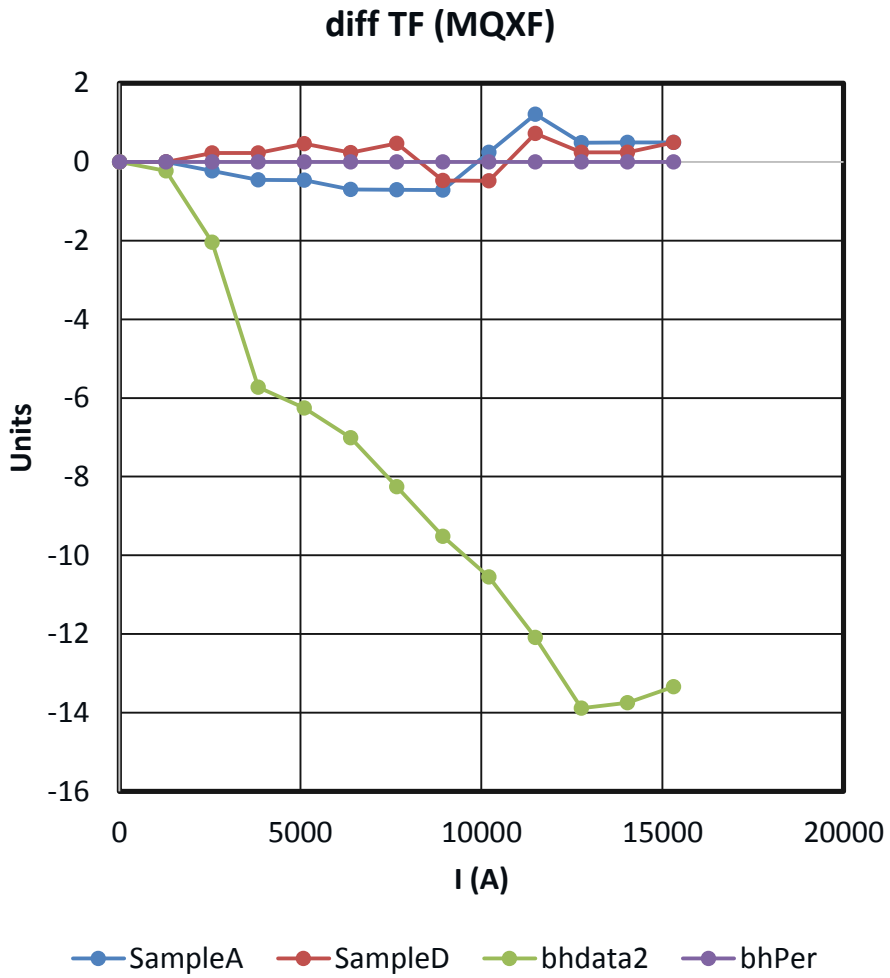




Transfer function

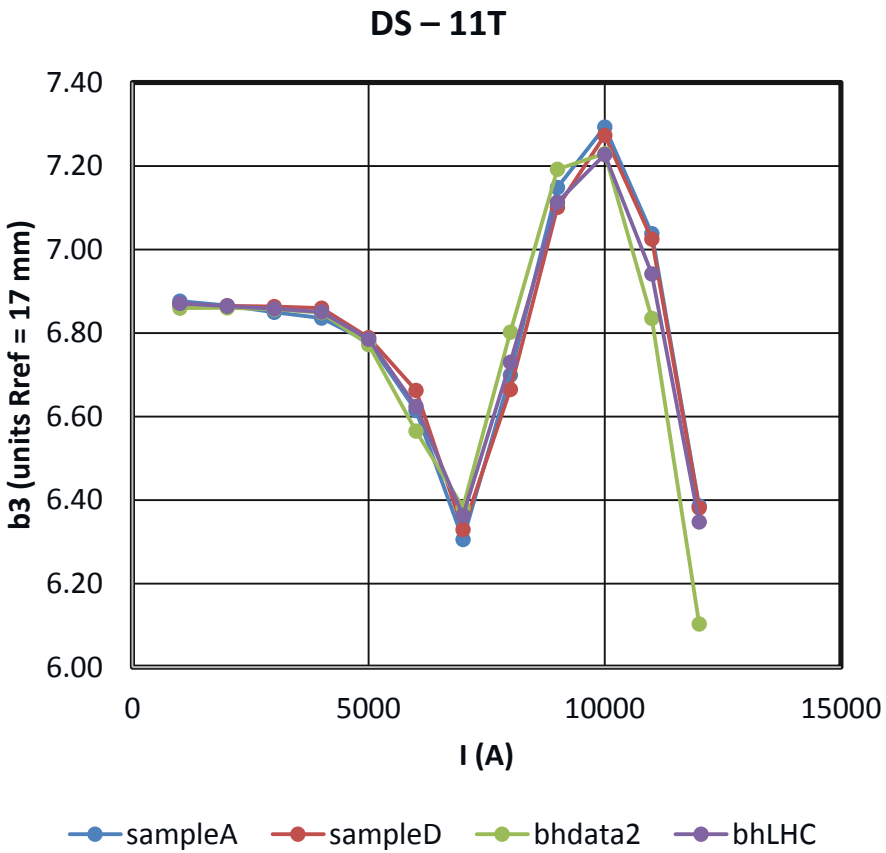
- There is a important impact on the transfer function, dominated by the BH in the region H>1.0E+4 A/m

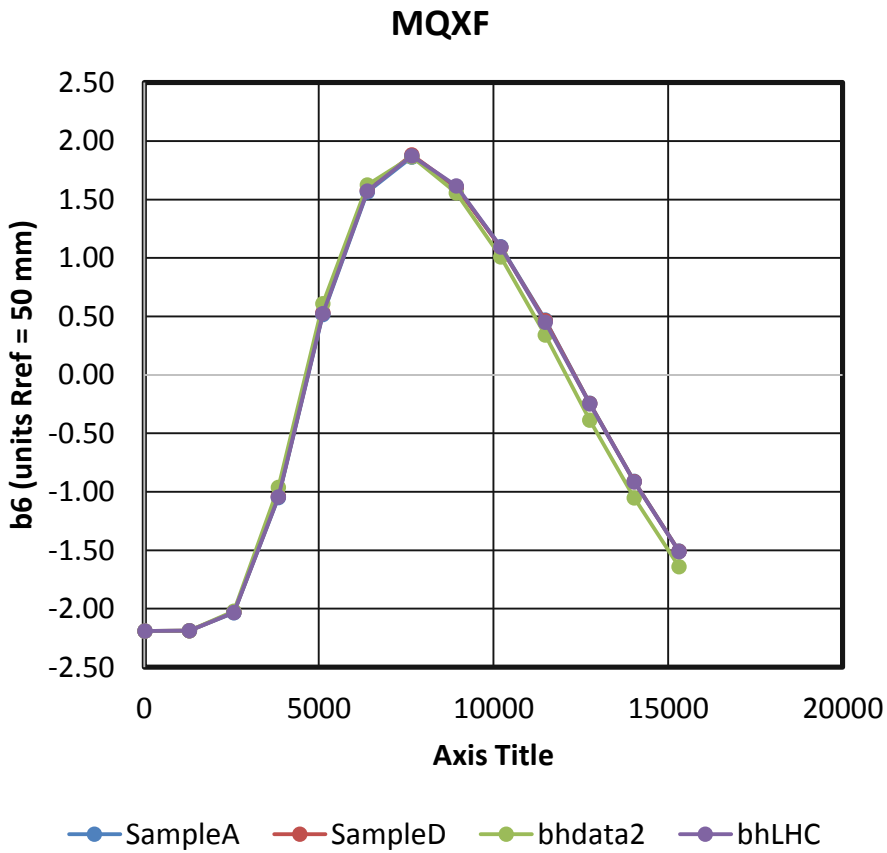




Harmonics

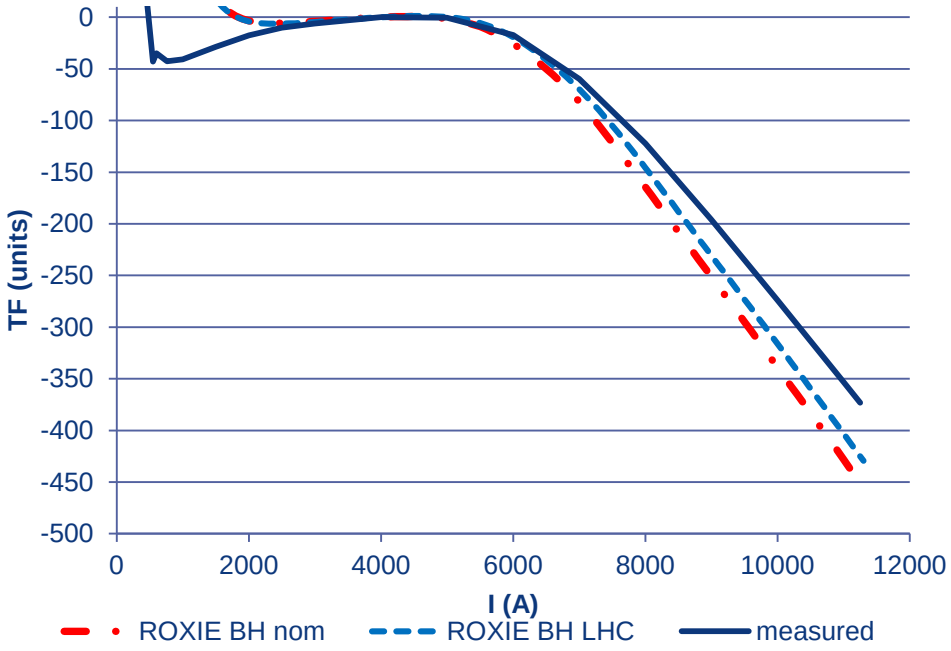
- The impact on the first allowed harmonic ~ 0.2 units, smaller in the rest





Importance of iron characterization at higher field levels

- Discrepancy ~ 50 units between measured and expected values for DS-11T dipole.
- If we compare to the MB dipole, at the same level of saturation we have similar agreement



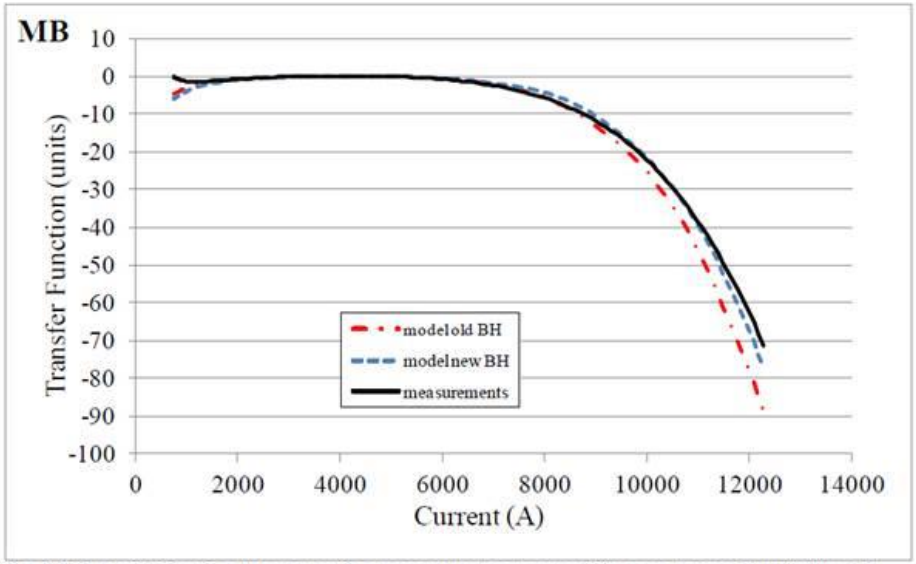
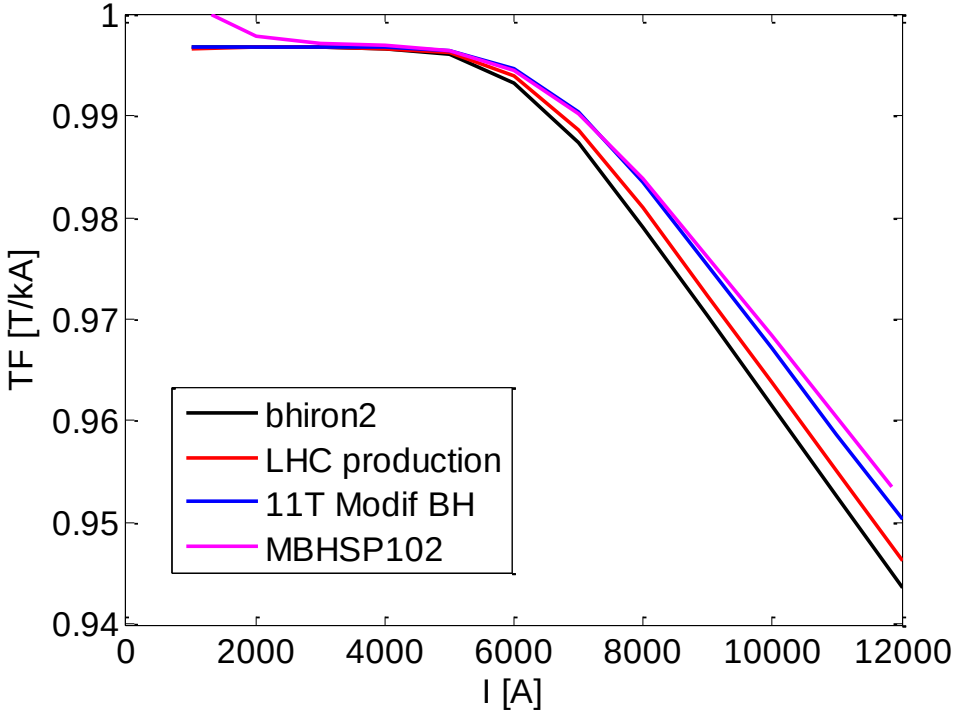
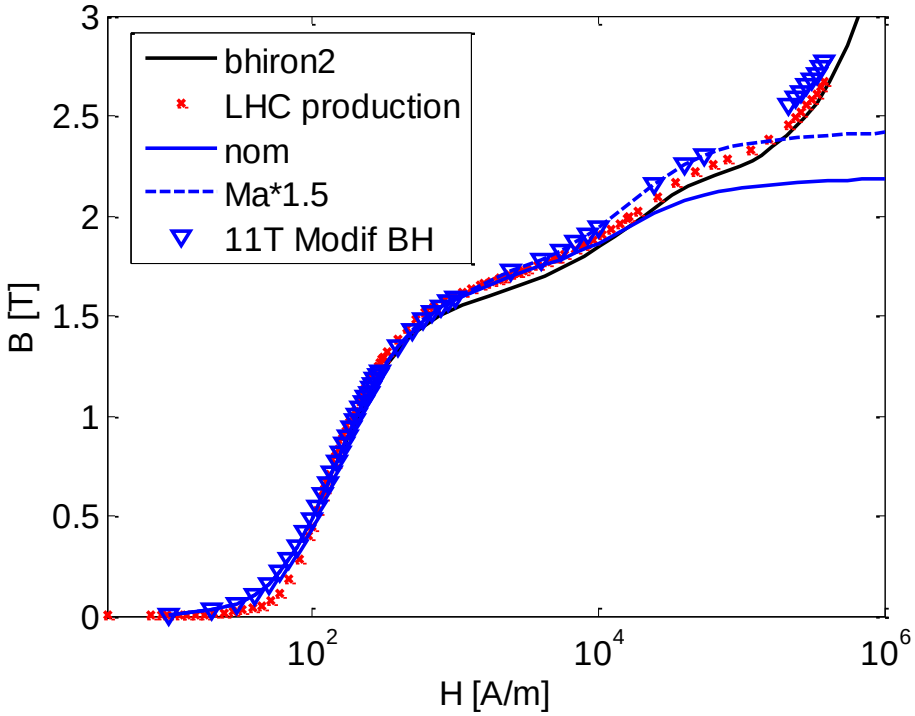


Fig. 2: MB transfer function. The geometric component has been removed from each curve individually, and what remains has been expressed as units of geometric. The dashes lines are two models with different BH-curves. The continuous line is the average of measurements.

Importance of iron characterization at higher field levels

A shift of + 0.1 T at H>2.0E+4 A/m with respect to the “LHC production data” is enough to fit MBHSP101 and MBHSP102 measurements





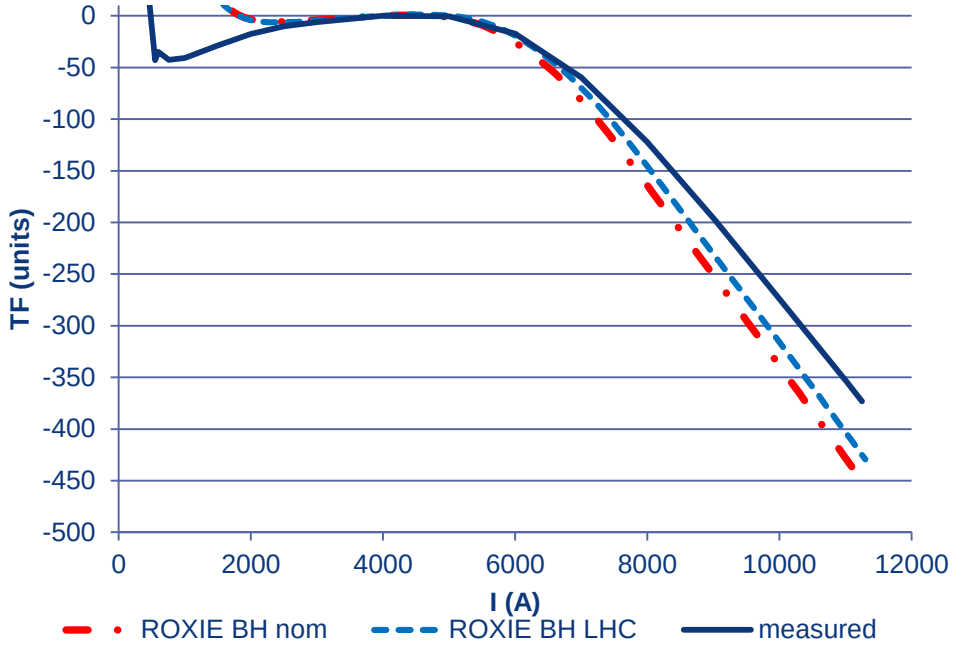
Summary

- The impact of the BH on the harmonics in negligible.
- The impact on the transfer function is not negligible, but it is dominated by the magnetic properties of the iron at high field (which have not been measured). This behaviour is defined by the purity of the material and not the heat treatment.
- Important to have a characterization at higher field levels.

Additional slides

TRANSFER FUNCTION (TF)

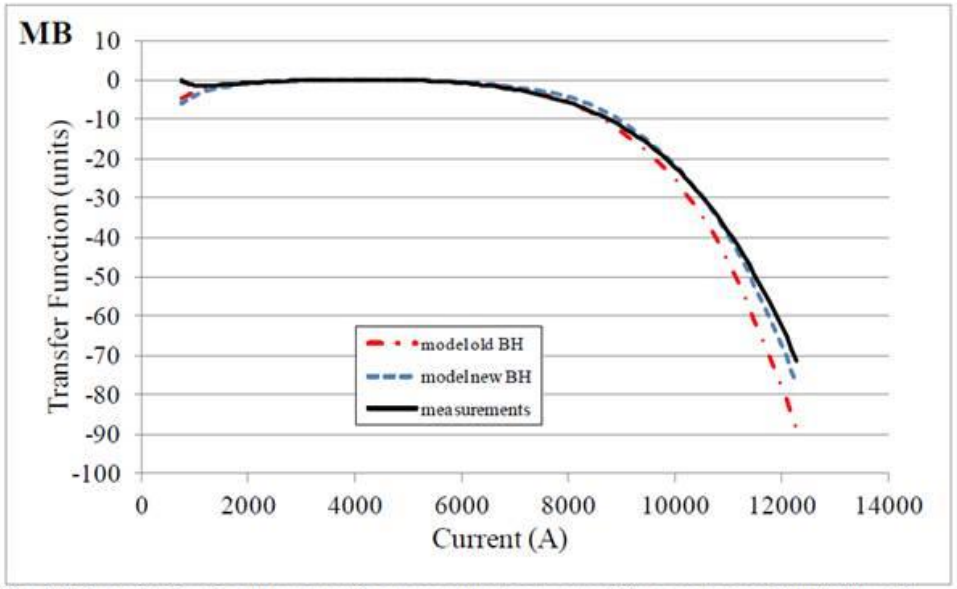
Discrepancy ~ 50 units between measured and expected values.



- Possible sources of error
  - Iron properties
  - Packing factor of the yoke laminations
  - Geometric

Comparison to MB dipole

At the same level of saturation we have similar agreement in the case of the MB dipole



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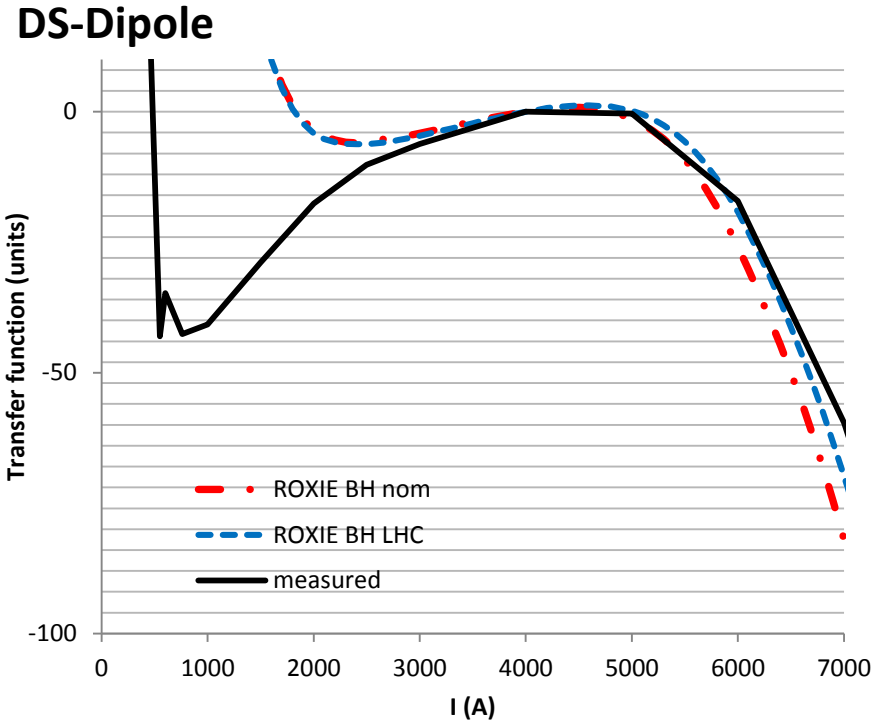
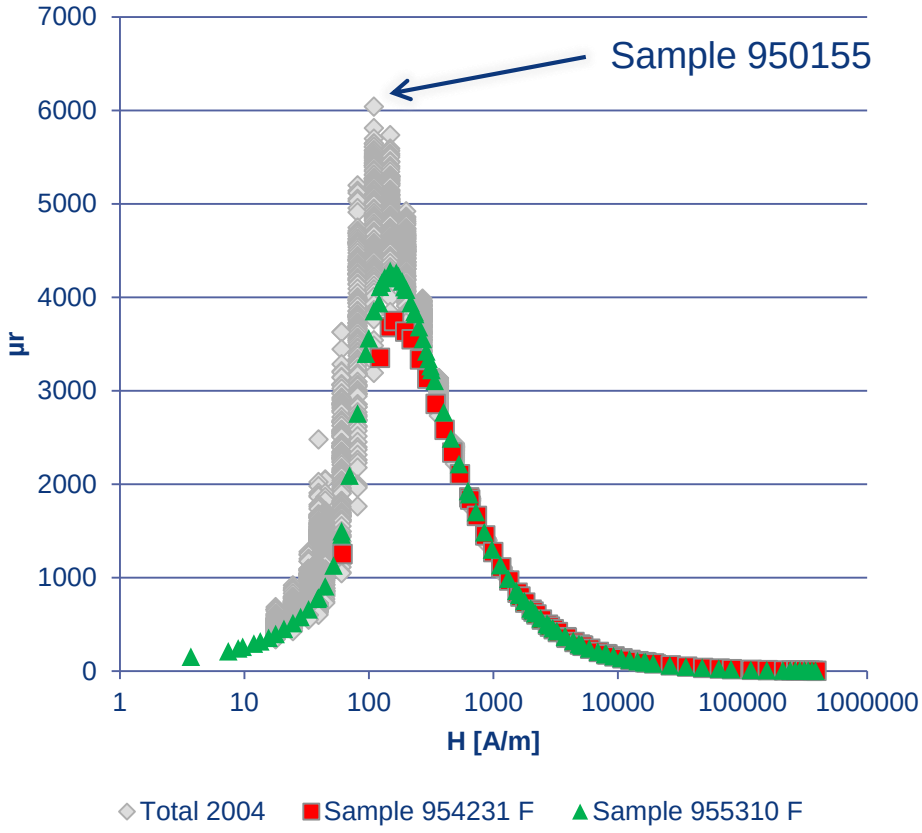
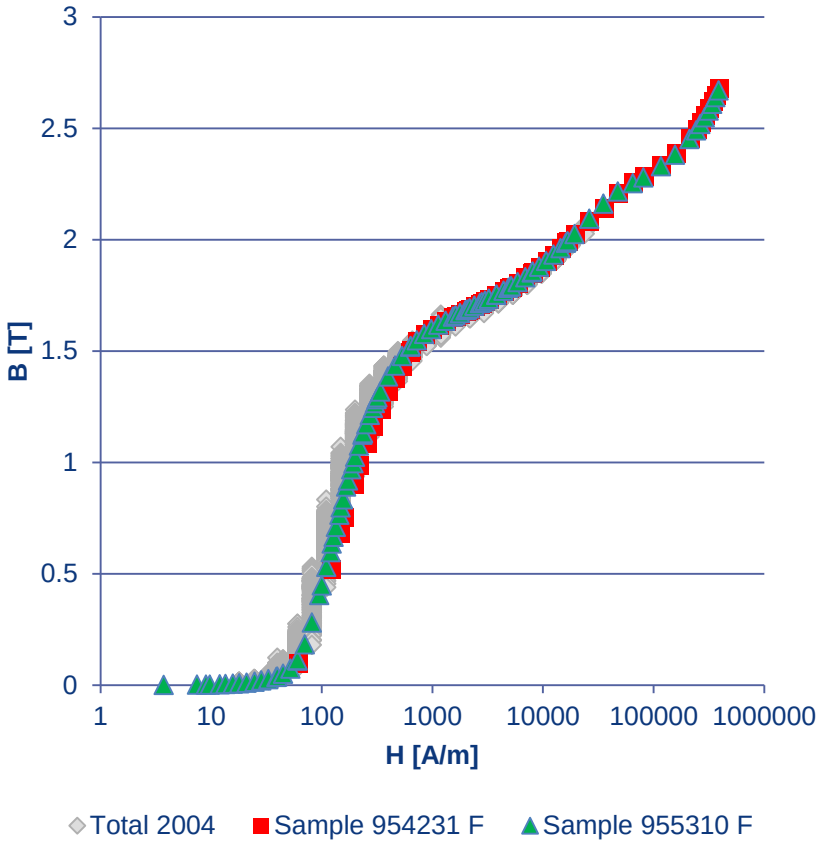


Data from production

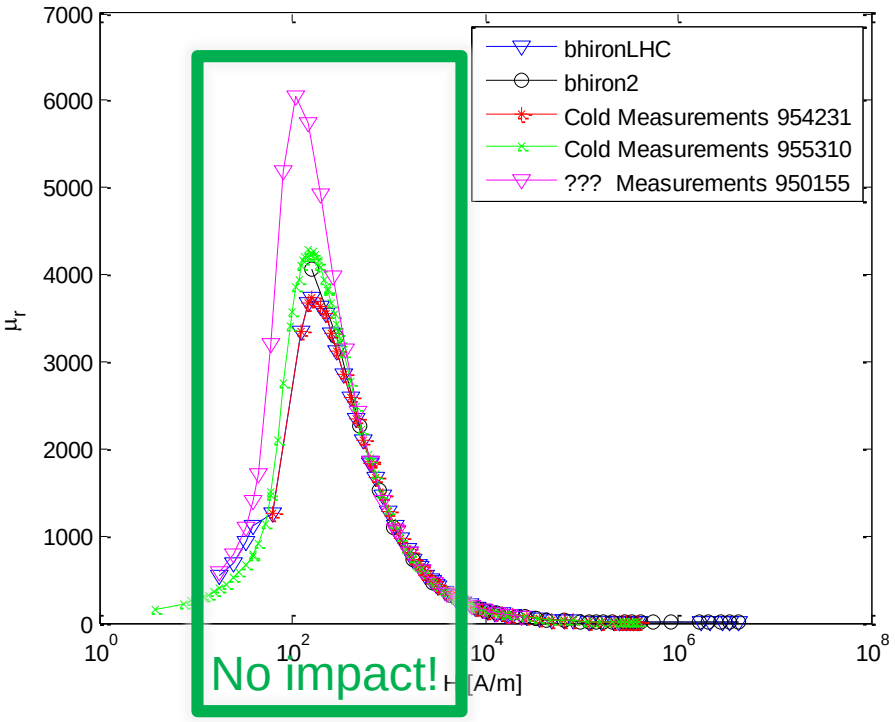
REF: Production of Low-Carbon Magnetic Steel for the LHC Superconducting Dipole and Quadrupole Magnets. LHC Project Report 898

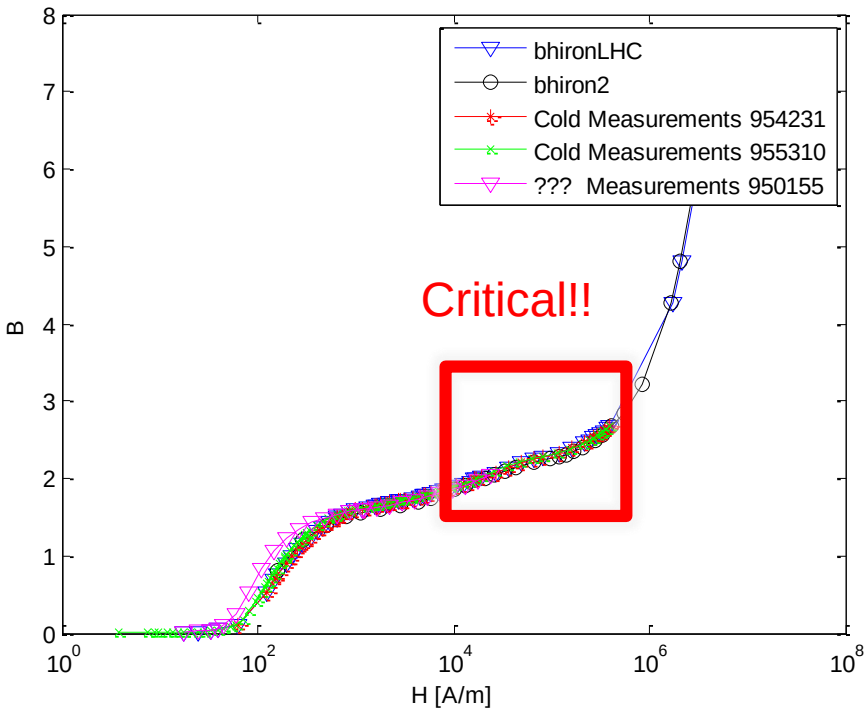




Review of data available from LHC production on going →trace back what are the most relevant samples to look at.

Further investigation on the iron MP





Analysis made based on BH data from the LHC MB production show the same saturation as the one obtained using "BH IRON LHC"

BH DATA	diff in the TF (units)
bh iron LHC	REF
bhiron2 (ROXIE standard)	-26
bh Woldarski Fit	-9
bh sample 955310	-2
bh sample 954231	0
bh sample 950155	0
bh tentem (opera)	-49

Further investigation on the iron MP