Report of field quality in the collared coils of the main LHC dipoles: March-April 2002

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This report gives data relative to field quality measured in collared coils during the period March-April 2002, comparison to beam dynamics targets and present status of the production holding points. Updated graphs can be found in the LHC field quality observatory at http://lhc-div-mmspages.web.cern.ch/lhc-div-mmspages/MA/obs.htm

1. Measured magnets

- 8 collared coils have been measured (collared coil 25 to 32)
  - 3 Alstom-Jeumont (HCMBB_A001-01000013 to HCMBB_A001-01000015)
  - 3 Ansaldo (HCMBB_A001-02000006 to HCMBB_A002-01000008)
  - 2 Noell (HCMBB_A001-03000008 to HCMBB_A001-03000009)

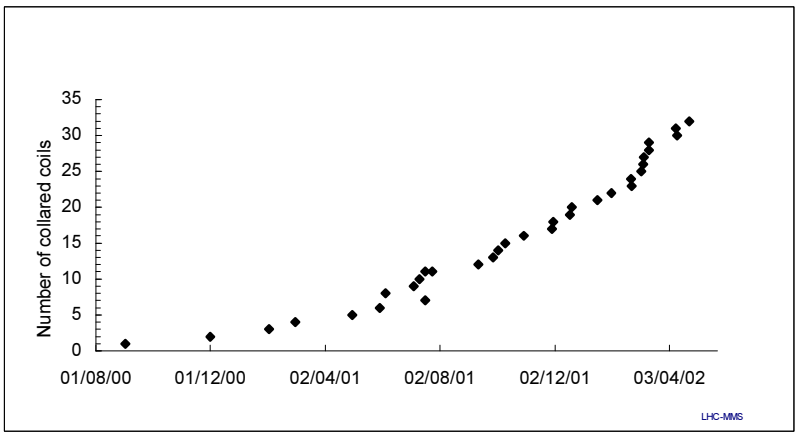

Fig. 1: Number of magnetic measurements of collared coils versus time

- Beam dynamics targets for systematics are worked out using correlations with 7 cryomagnets tested at 1.9 K.

2. Assembly data

- Shims: 3 Alstom-Jeumont and 1 Ansaldo coils have been collared with nominal shims. 2 Noell and 1 Ansaldo coils have been collared with non-nominal shims up to 0.1 mm.
- Cross section: two coils of Alstom-Jeumont with the cross-section 2 (the new one). The other coils have the cross-section 1 (the old one).

Table I: Shims thickness and coil cross-section type of measured collared coils

Magnet name		Shim (mm)		X-section
		Inner	Outer	
HCMBB_A001	1000013	0.80	0.20	2
HCMBB_A001	1000014	0.80	0.20	2
HCMBB_A001	1000015	0.80	0.20	1
HCMBB_A001	2000006	0.80	0.20	1
HCMBB_A001	2000007	0.70	0.20	1
HCMBB_A001	2000007	0.80	0.20	1
HCMBB_A001	3000008	0.90	0.25	1
HCMBB_A001	3000009	0.90	0.15	1

3. Magnetic length and transfer function

- Magnetic length of collared coils 25th to 32th is within 3 sigma of the allowed random per arc (see Fig. 2).

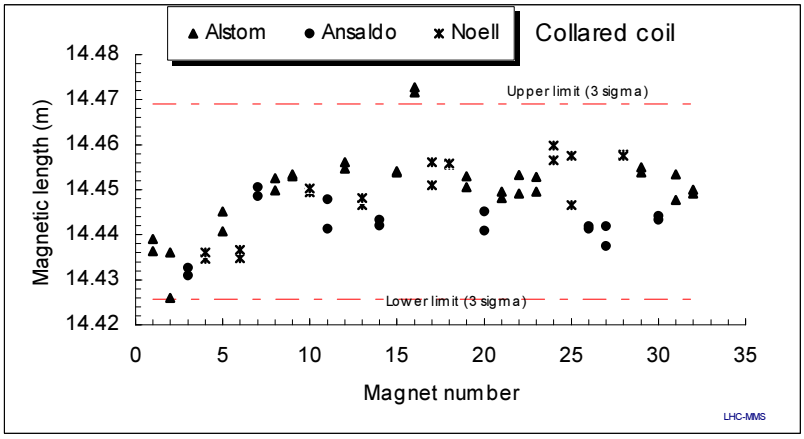

Fig. 2: Magnetic length of the measured collared coils

- Main field in the central part of Noell collared coils shows a systematic difference with respect to Alstom-Jeumont and Ansaldo magnets (see Fig. 3). This is due to the non-nominal shims. This effect is reduced when this contribution is taken out (see Fig. 4).

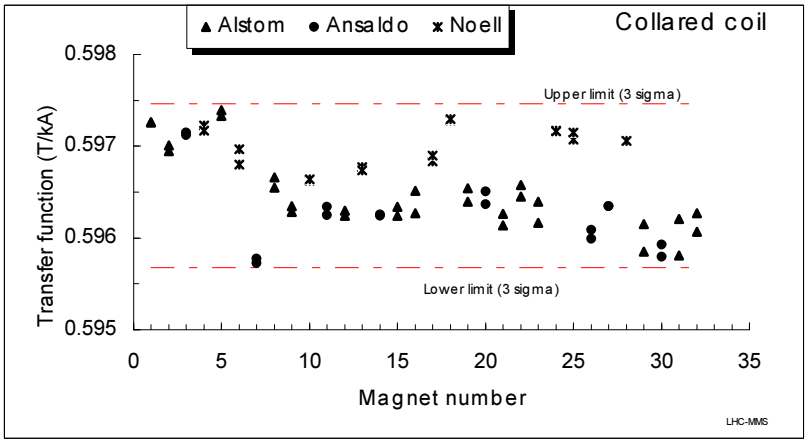

Fig. 3: Average main field in the straight part of the measured collared coils

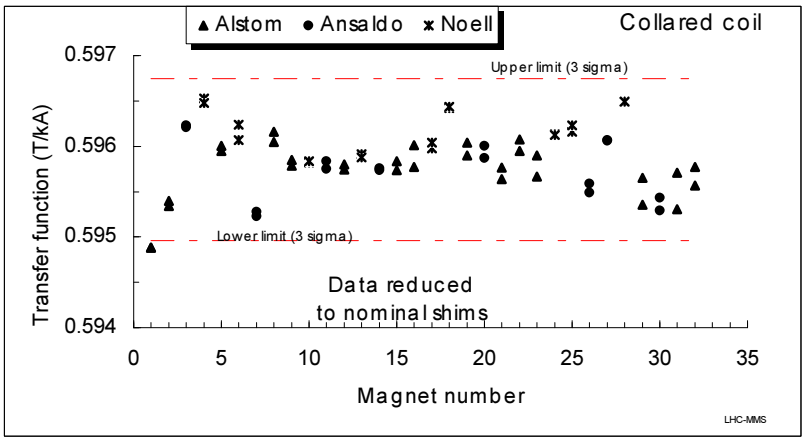

Fig. 4: Average main field in the straight part of the measured collared coils. Data reduced at nominal shims

- Integrated transfer function is within 3 sigma of the allowed random per arc (see Fig. 5).

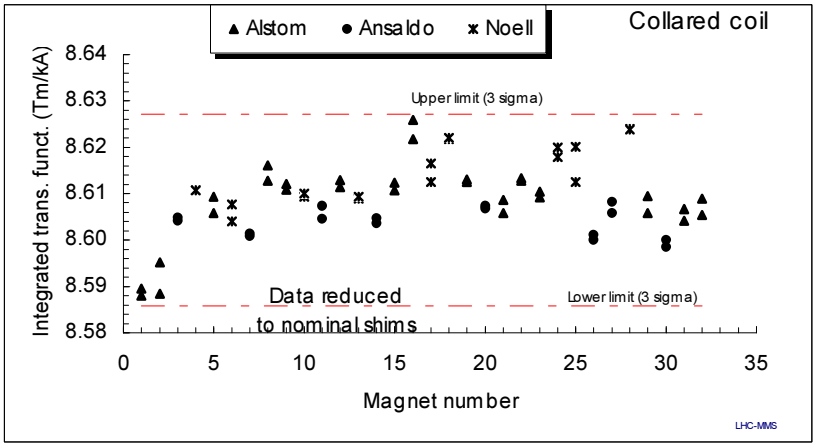

Fig. 5: Integrated transfer function in the measured collared coils. Data reduced at nominal shims

4. Estimated coil waviness

- Coil waviness estimated from the variation of the multipole along the axis is very low for Ansaldo and Noell collared coils (between 15 and 25 microns).
- Alstom-Jeumont collared coils still have anomalous coil waviness, showing large spikes in the multipole along the axis. Alstom-Jeumont 13, 14 and 15 have a coil waviness of between 40 and 50 microns in one of the two apertures. The problem is under investigation at Jeumont. Indeed, we are well below the negative record for coil waviness of HCMBB_A001-01000006 of 80 microns (see Fig. 6).

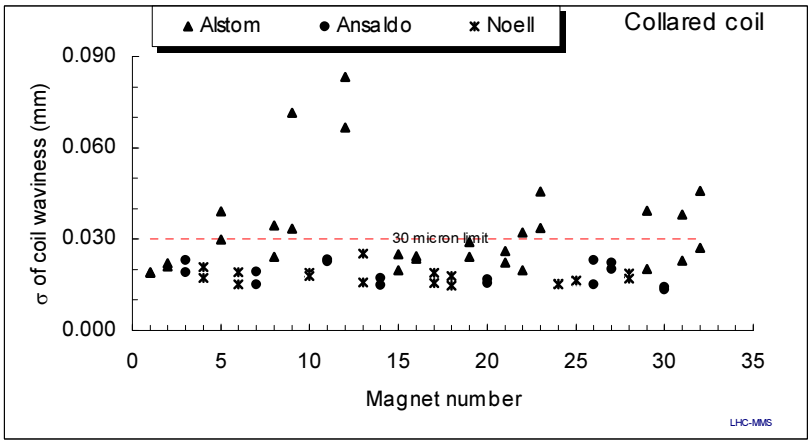

Fig. 6: Estimated coil waviness in the straight part of the measured collared coils

5. Systematics odd multipoles

5.1 b_3

- Magnets with cross-section 1 follow the trend of previous data. Higher values of Noell collared coils are due to non-nominal shims (see Fig. 7 and 8).
- Data reduced to nominal shims show that the upward trend of 7 units from collared coil 1 to collared coil 15 is now over.
- No systematic difference between manufacturers is observed.
- The new cross-section implemented in collared coils 14 and 15 has decreased the sextupole of around 4 units, in agreement with simulations. Due to the upward trend of 3 units experienced from collared coil 9 (where the amount of correction has been evaluated) to

collared coil 15, the new systematic will be in the upper part of the allowed range (see Fig. 8).

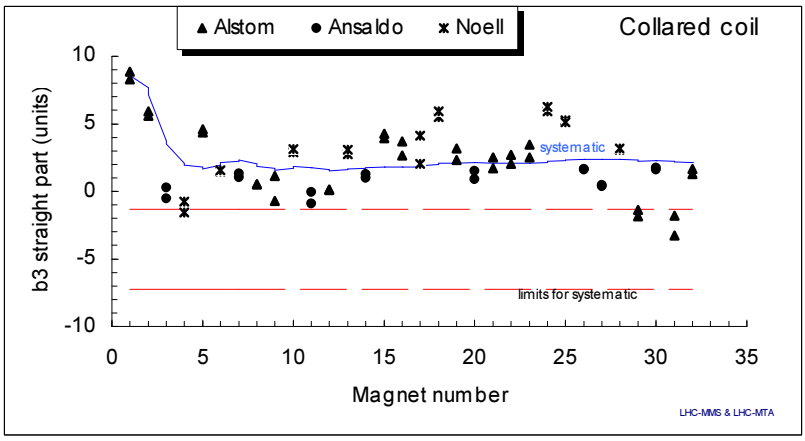

Fig. 7: Average normal sextupole in the straight part of the measured collared coils

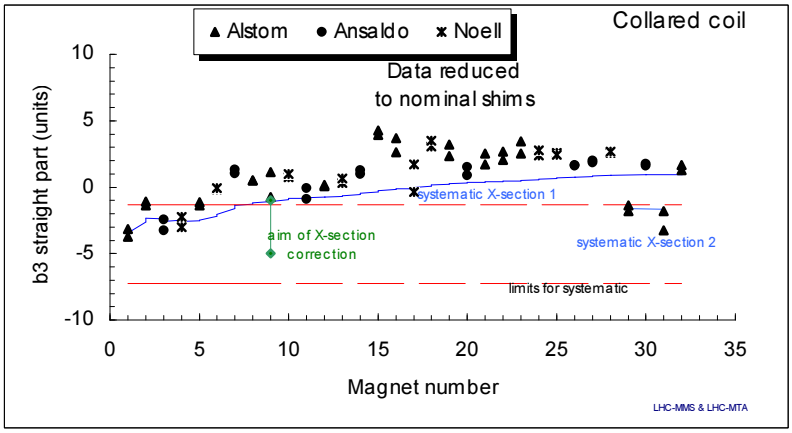

Fig. 8: Average normal sextupole in the straight part of the measured collared coils. Data reduced to nominal shims

5.2 b_5

- Collared coils with cross-section 1 follow the trend of previous data: average in Alstom-Jeumont is around 2 units, whilst in Noell and Ansaldo is around 1 unit (see Fig. 9 and 10).
- The new cross-section implemented in collared coils 14 and 15 of Alstom-Jeumont has decreased the decapole of around 1.5 units, in agreement with simulations. Due to the upward trend of 0.2 units experienced from collared coil 9 (where the amount of correction has been evaluated) to collared coil 15, the best estimate for the new systematic is in the upper part of the allowed range

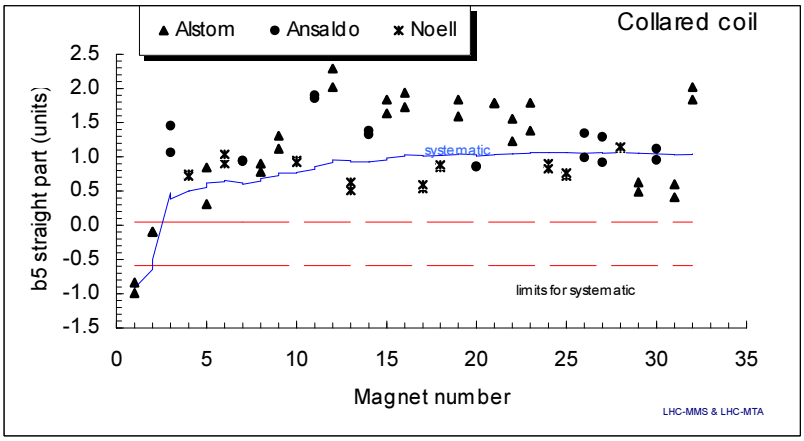

Fig. 9: Average normal decapole in the straight part of the measured collared coils

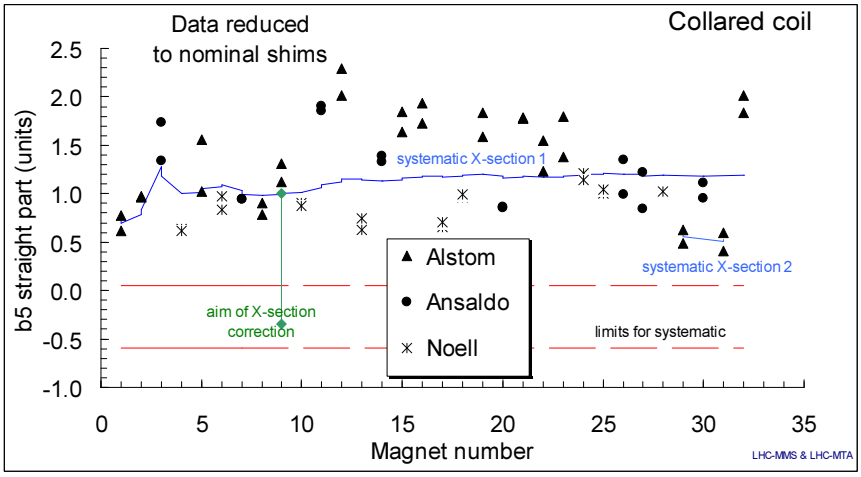

Fig. 10: Average normal decapole in the straight part of the measured collared coils. Data reduced to nominal shims

5.2 b_7

- Collared coils with cross-section 1 follow the trend of previous data: average in Alstom-Jeumont and Ansaldo is around 0.7-0.8 units, whilst in Ansaldo is around 0.4 units (see Figs. 11 and 12).
- The new cross-section implemented in collared coils 14 and 15 of Alstom-Jeumont has increased the 14th-pole of around 0.3 units, i.e. 0.1 units more than expected from simulations. The best estimate for the new systematic is 0.1 units larger than the upper limit.

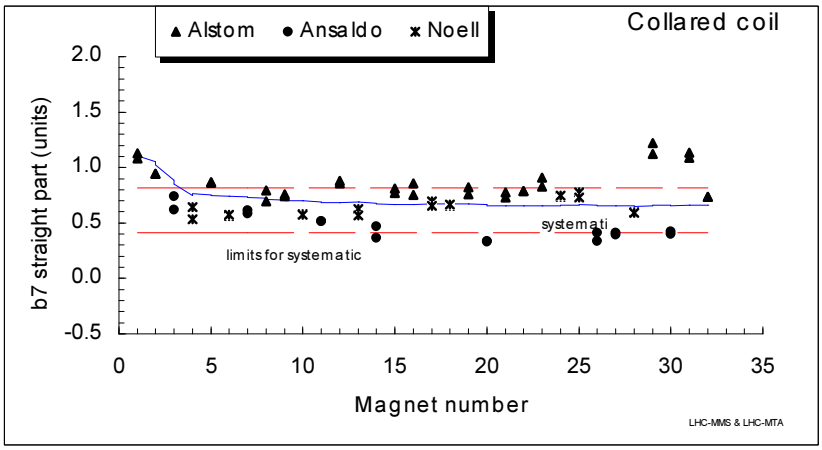

Fig. 11: Average normal 14th-pole in the straight part of the measured collared coils

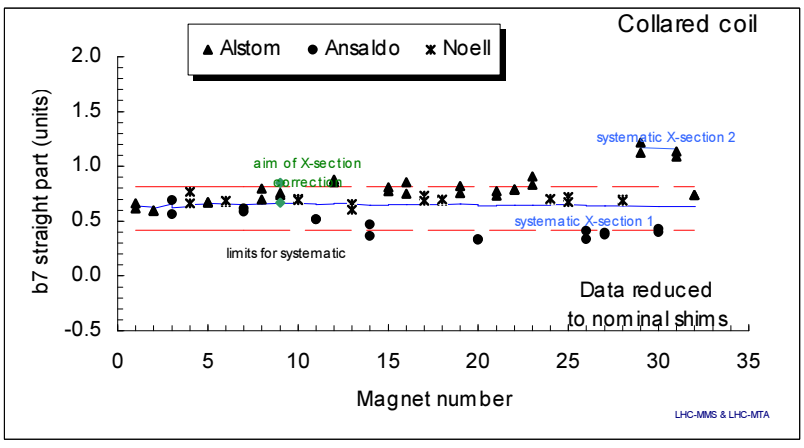

Fig. 12: Average normal 14th-pole in the straight part of the measured collared coils. Data reduced to nominal shims

6. Randoms

- Random part of b_3 is out of target, both for the non-nominal shim contributions and for the upward trend experienced from collared coil 1 to 15 (see Figs. 13 and 14).
- Rondom part of b_5 is out of targets for Alstom due to the non-nominal shim contribution.
- In general Alstom magnets feature a much higher random part compared to Ansaldo and Noell. This could be related to the anomalous coil waviness.
- The Standard deviation of the distribution of all magnets (marker global in the figures) is close or within the targets of the random per arc, with the exception of the b_3.

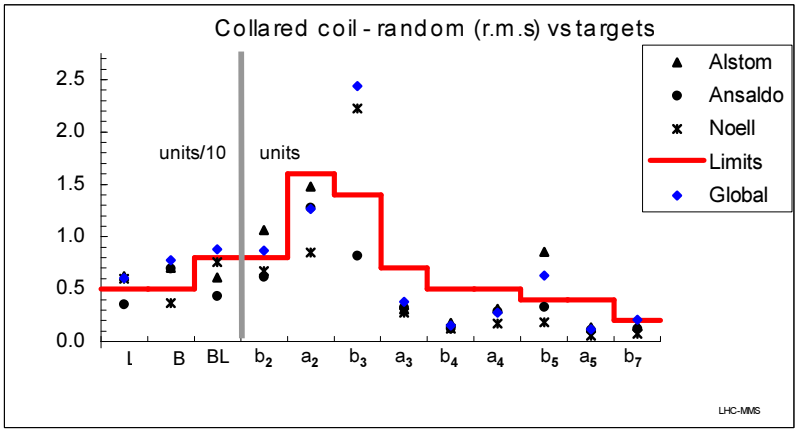

Fig. 13: Random component in the measured collared coils

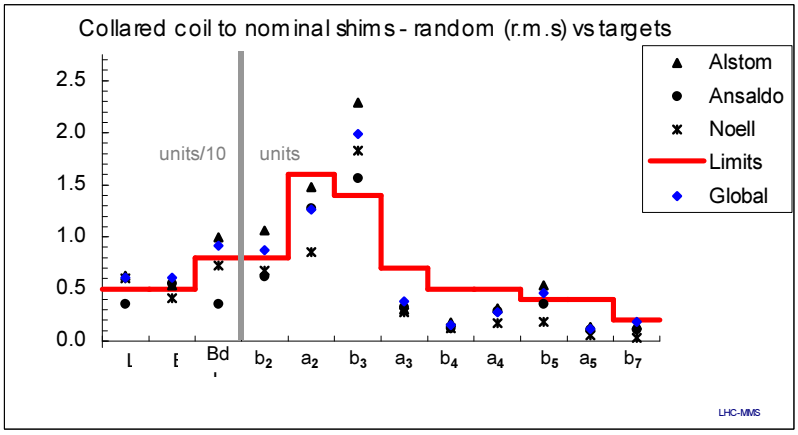

Fig. 14: Random component in the measured collared coils. Data reduced to nominal shims

8. Holding point results

Table II: results of the holding point for the measured collared coils

	Magnet name		Collared coil measure	Data at CERN	Answer to MMS-MD	Answer To manufact.	Result	Comments
25th	HCMBB_A001	3000008	04/03/02	04/03/02	05/03/02	06/03/02	Ok	
26th	HCMBB_A001	2000008	06/03/02	06/03/02	06/03/02	06/03/02	Ok	a spike in b2, aperture 2, position 5. Some anomalous variations along the axis.
27th	HCMBB_A001	2000007	07/03/02	07/03/02	15/03/02	19/03/02	Ok	some variations along the axis in high order multipoles
28th	HCMBB_A001	3000009	12/03/02	12/03/02	15/03/02	18/03/02	Ok-W	a tilt of 3 mrad in the main field angle is observed in positions 11 and 12, both apertures - probably due to collared coil support
29th	HCMBB_A001	1000013	12/03/02	12/03/02	15/03/02	19/03/02	Ok	Still some anomalous variations along the axis in aperture 2 - First magnet with the new X-section - b7 a bit more than expected
30th	HCMBB_A001	2000006	11/04/02	11/04/02	11/04/02	15/04/02	Ok	
31st	HCMBB_A001	1000014	10/04/02	11/04/02	11/04/02	15/04/02	Ok-w	Second magnet with new X-section - coil waviness still above normal
32nd	HCMBB_A001	1000015	24/04/02	24/04/02	25/04/02	26/04/02	Ok-w	Anomalous variations along the axis in aperture 2

9. Acknowledgements

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