Magnetic measurements at cryogenic temperature on MCBRDP1 (D2 corrector prototype)

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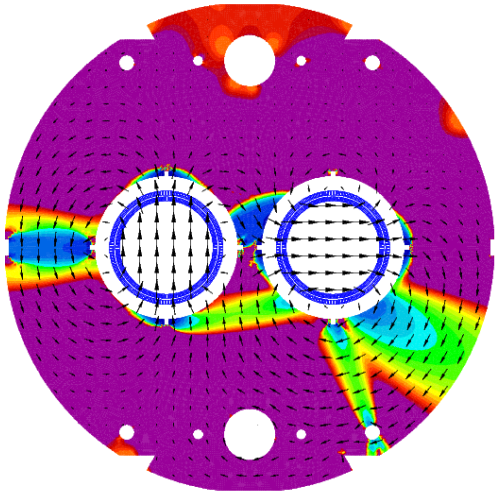
WP3 meeting, 21/11/2018

Up to now…



Available measurements

- First aperture of the short model at room temperature
  16 Jan 2018

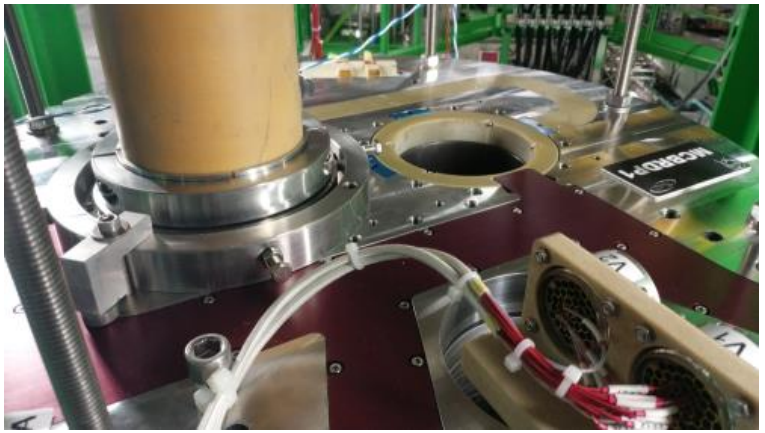
- Both apertures of the short model at cryogenic temperature
  27 Jun 2018 https://indico.cern.ch/event/738022/

- Both apertures of the prototype at room temperature
  12 Sep 2018 https://indico.cern.ch/event/753441/

- One aperture of the prototype at cryogenic temperature
  this presentation

Measurement setup

Rotating-coil in the helium bath (vertical cryostat setup in SM18)



Only one shaft was available, one aperture was equipped

- Length = 2.1 m
- 5 segments

The equipped aperture is the one with field in the vertical direction (AP1 in the following)

Not sufficient for covering the full integral field, we will focus on the central field (3 segments)

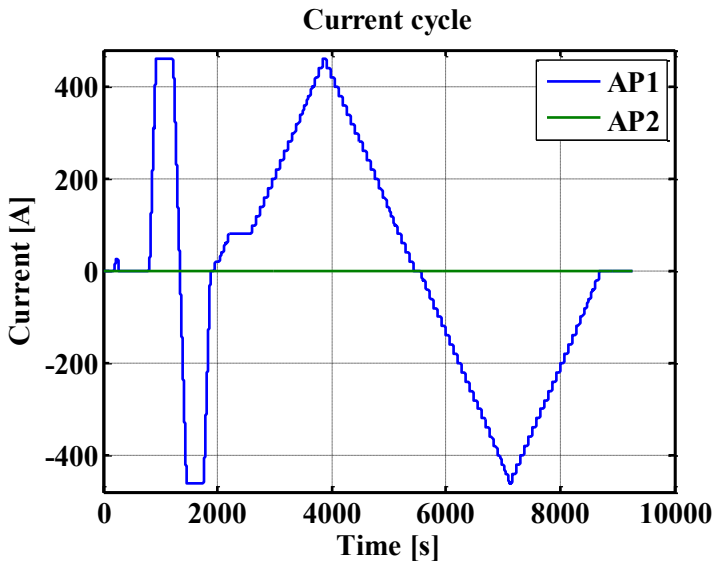
Reference radius
35 mm

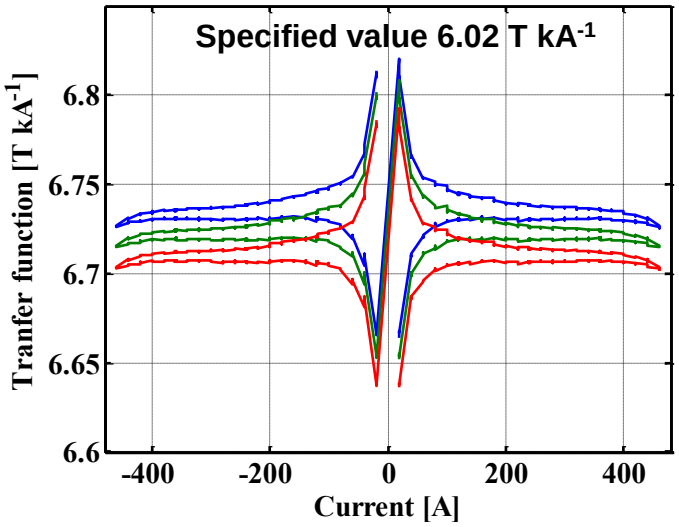
Measurement list

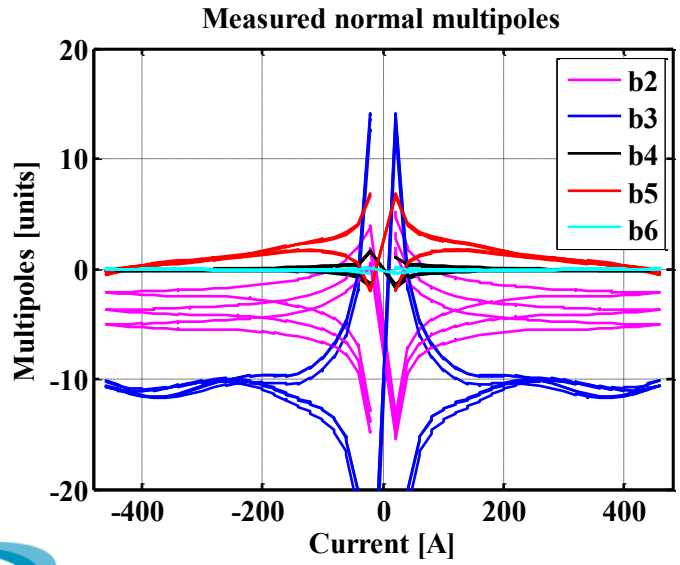
- 3 cycles with valid data:
  - Stair-step cycle up to ±ultimate in AP1
    0 A in AP2
  - Stair-step cycle up to ±400 A in AP1
    400 A in AP2
  - Stair-step cycle up to ±400 A in AP1
    -400 A in AP2

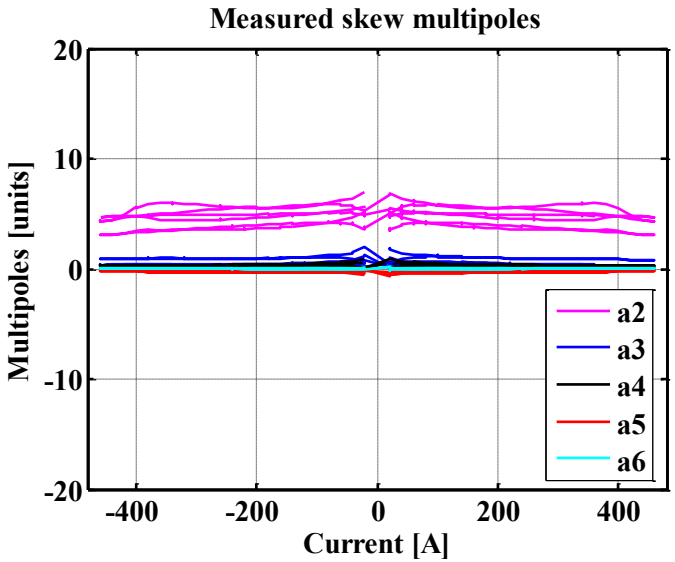
All cycles were preceded by a pre-cycle

AP1 up to ±ultimate and AP2 at 0 A

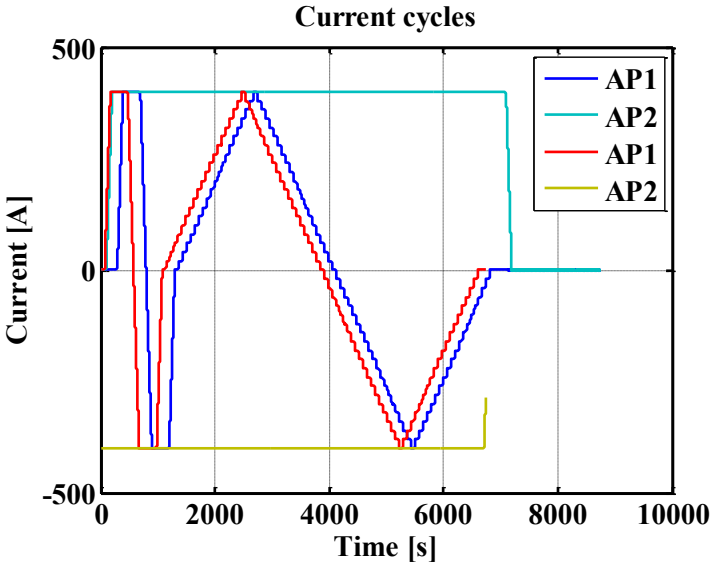


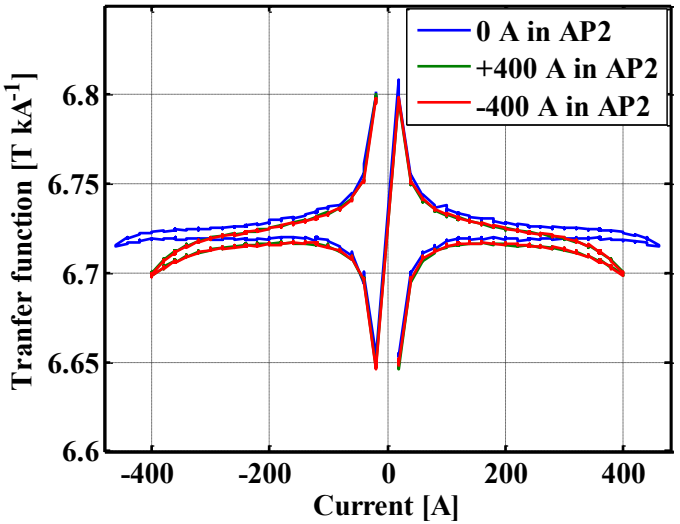


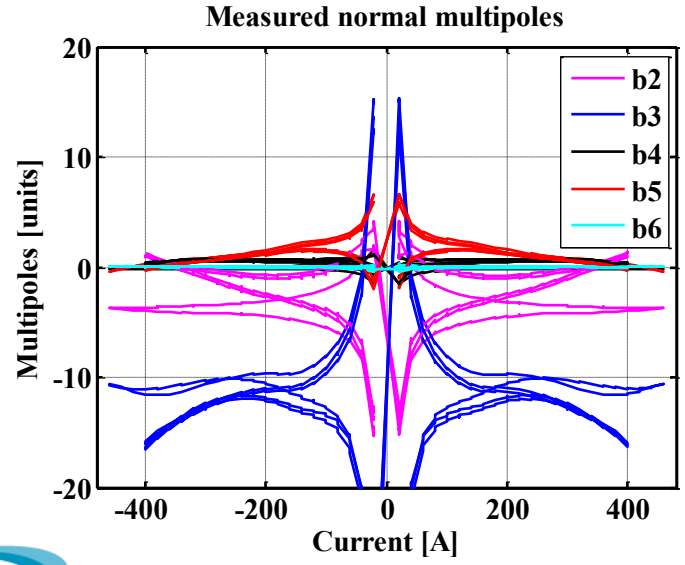


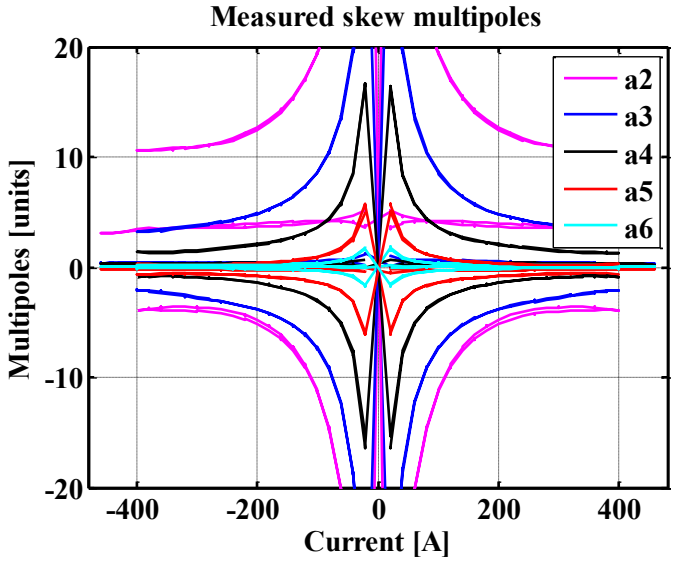


AP1 up to ±400 and AP2 at 400 A









Field quality table

	AP1 at ambient temperature				AP1 at 1.9 K and 430 A			
	NCS	Center	CS	INTEGRAL	pos1	pos2	pos3	
n	b_n							
2	1.37	-0.68	-0.06	-0.18	-2.19	-3.80	-5.12	units
3	-10.13	-9.79	-11.18	-10.11	-10.93	-11.18	-11.19	
4	0.19	0.07	0.07	0.09	-0.17	-0.13	-0.13	
5	2.57	2.26	2.10	2.29	-0.01	0.09	0.19	
6	-0.04	0.02	-0.13	-0.02	-0.06	0.02	-0.06	
7	-0.96	-0.98	-1.20	-1.02	-0.38	-0.31	-0.33	
8	0.07	0.01	-0.02	0.02	-0.02	0.03	-0.02	
9	0.31	0.13	0.42	0.22	-0.02	0.00	0.01	
10	0.00	0.01	0.19	0.04	0.00	0.01	0.00	
n	a_n							
2	13.07	-6.34	-31.48	-7.41	-4.80	-3.23	-4.78	units
3	-4.41	-0.59	2.15	-0.79	-0.18	-0.35	-0.87	
4	-1.33	0.06	1.25	0.02	-0.35	-0.26	-0.28	
5	-0.28	0.25	0.33	0.17	0.17	0.17	0.22	
6	-0.53	-0.26	-0.28	-0.31	-0.06	-0.06	-0.04	
7	-0.08	0.00	-0.01	-0.02	0.04	-0.01	0.01	
8	0.06	0.01	-0.24	-0.02	0.00	0.01	-0.02	
9	-0.06	-0.03	-0.15	-0.06	-0.03	-0.03	-0.04	
10	-0.11	-0.02	0.41	0.04	0.00	0.01	0.00	

- b_3 in agreement with results at ambient temperature

Cross talk

AP1	+400 A						
AP2	0 A	+400 A	-400 A	0 A	+400 A	-400 A	
n	b_n			a_n			
2	-3.84	1.31	0.98	-3.39	-10.61	3.96	units
3	-11.27	-16.13	-15.96	-0.33	2.12	-3.26	
4	-0.14	0.42	0.30	-0.27	-1.30	0.87	
5	0.23	-0.26	-0.20	0.18	0.63	-0.30	
6	0.01	0.01	-0.02	-0.05	-0.21	0.12	
7	-0.35	-0.39	-0.38	-0.01	0.05	-0.08	
8	0.03	0.00	-0.01	0.01	-0.01	0.03	
9	0.01	0.01	0.01	-0.03	-0.02	-0.04	
10	0.01	0.01	0.01	0.01	0.00	0.01	

- Cross-talking effects are noticeable in contrast with results from the short model.

Conclusions

- From tests at cryogenic temperature (1.9 K)
  - Transfer function larger than specifications (table WP3)
  - In agreement with results at ambient temperature
  - b_3 in the straight section is -10 units
  - In agreement with measurements at ambient temperature
  - Cross-talking effects are noticeable
  - They were not visible on the short model
- In occasion of the thermal cycle, we are equipping the magnet with two new shafts with suitable length in order to perform additional magnetic measurements

Additional slides

MCBRDP1 at room temperature 1

	AP1					AP2					
	NCS	Center	CS	INTEGRAL		NCS	Center	CS	INTEGRAL		
	18.7%	62.7%	18.7%	100.0%		18.7%	62.6%	18.7%	100.0%		
I	0.4467	0.4464	0.4466			0.4465	0.446	0.4463			A
B1	0.877	2.944	0.877			-0.876	-2.942	-0.878			mT
TF				12.672					-12.675		mT m A^{-1}
angle	0.2045	0.2105	0.2137	0.2100		-1.3642	-1.359	-1.3559	-1.3594		rad

- Field repeatable between the two apertures within 2 units
- Perpendicularity in the order of 1.5 mrad
- Measured TF larger than calculations,

  a verification (current generator) is ongoing

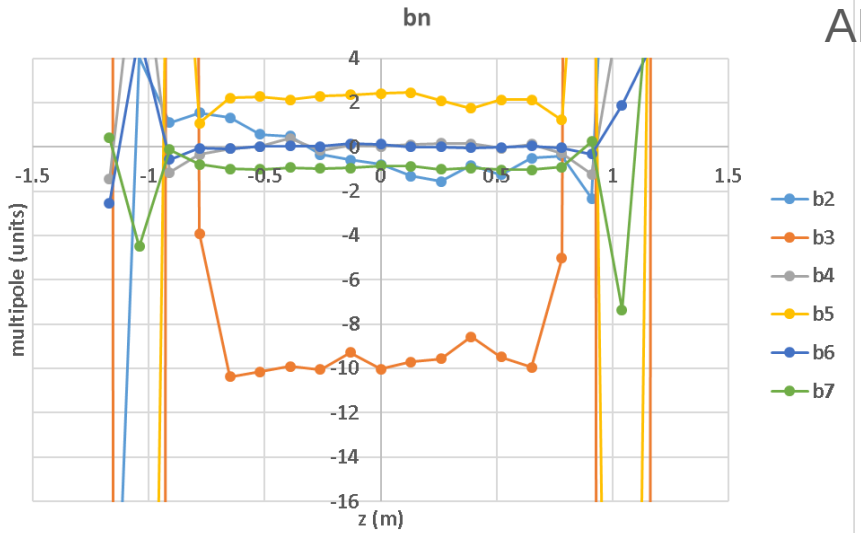
MCBRDP1 at room temperature 2

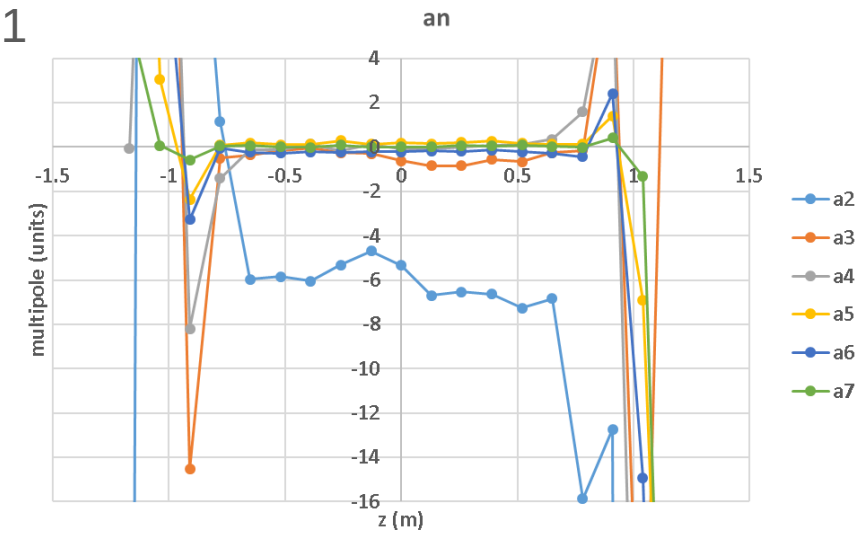
	AP1				AP2				
	NCS	Center	CS	INTEGRAL	NCS	Center	CS	INTEGRAL	
n	b_n								
2	1.37	-0.68	-0.06	-0.18	2.36	-1.09	1.04	-0.05	units
3	-10.13	-9.79	-11.18	-10.11	-9.50	-9.20	-8.75	-9.17	
4	0.19	0.07	0.07	0.09	0.49	0.76	0.85	0.73	
5	2.57	2.26	2.10	2.29	2.91	2.72	2.51	2.71	
6	-0.04	0.02	-0.13	-0.02	-0.23	-0.04	-0.11	-0.09	
7	-0.96	-0.98	-1.20	-1.02	-0.87	-0.81	-0.82	-0.82	
8	0.07	0.01	-0.02	0.02	-0.08	0.06	0.04	0.03	
9	0.31	0.13	0.42	0.22	0.17	0.15	0.13	0.15	
10	0.00	0.01	0.19	0.04	-0.09	-0.02	-0.04	-0.03	
n	a_n								
2	13.07	-6.34	-31.48	-7.41	-22.67	0.77	25.34	0.99	units
3	-4.41	-0.59	2.15	-0.79	-3.81	0.09	2.36	-0.21	
4	-1.33	0.06	1.25	0.02	1.40	0.13	-0.61	0.23	
5	-0.28	0.25	0.33	0.17	0.04	0.34	0.17	0.25	
6	-0.53	-0.26	-0.28	-0.31	0.34	0.17	-0.06	0.16	
7	-0.08	0.00	-0.01	-0.02	0.11	0.05	0.09	0.07	
8	0.06	0.01	-0.24	-0.02	0.21	0.03	0.05	0.07	
9	-0.06	-0.03	-0.15	-0.06	0.04	-0.02	-0.06	-0.01	
10	-0.11	-0.02	0.41	0.04	0.11	0.01	0.05	0.04	

- Allowed multipoles are larger than expected but field quality is within specifications

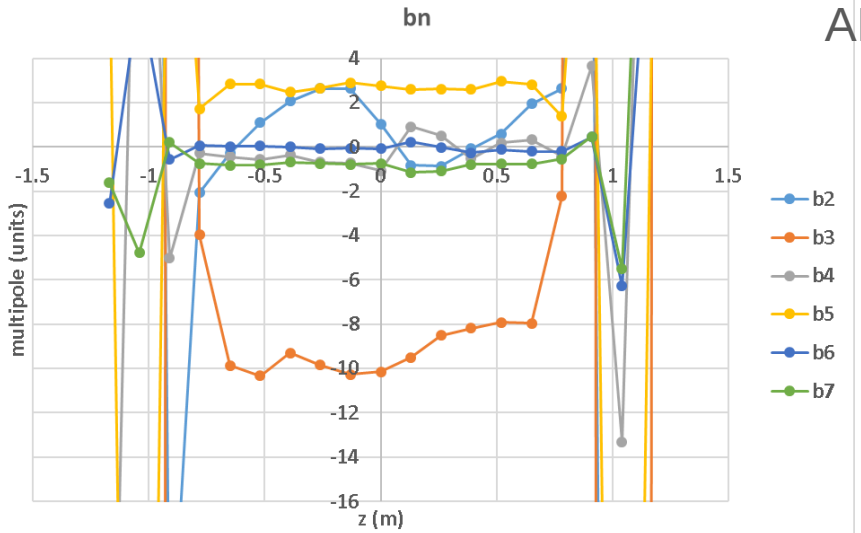
MCBRDP1 at room temperature 3

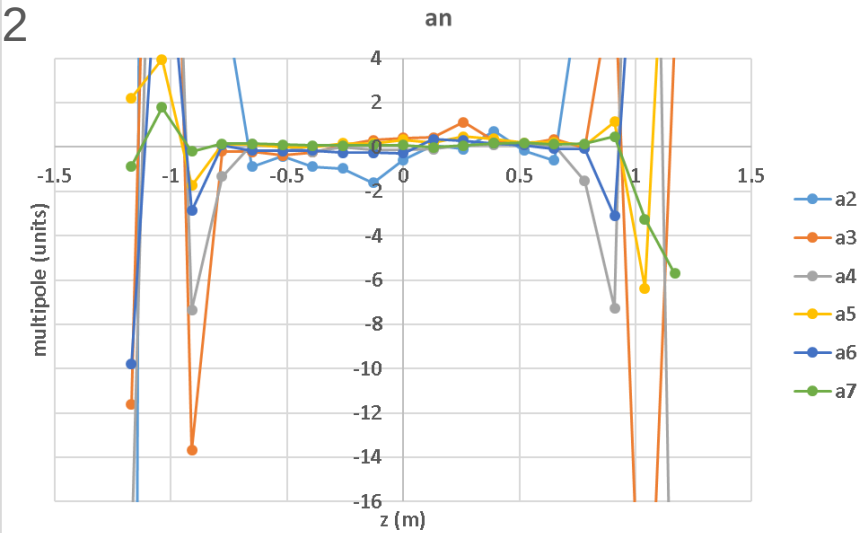
AP1





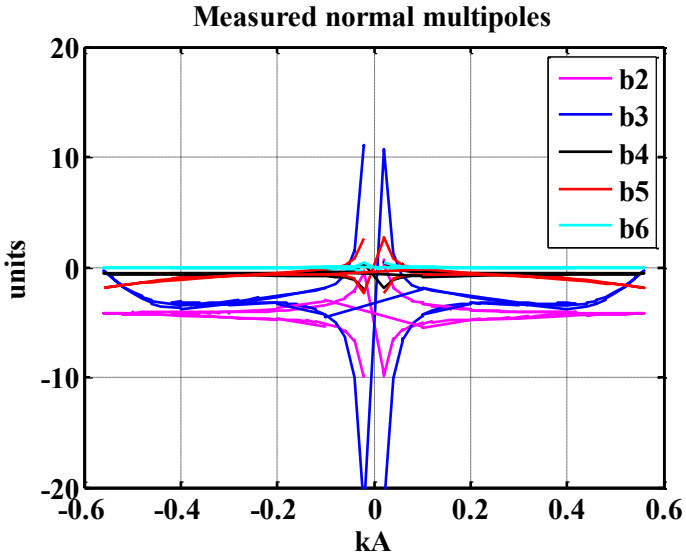
AP2



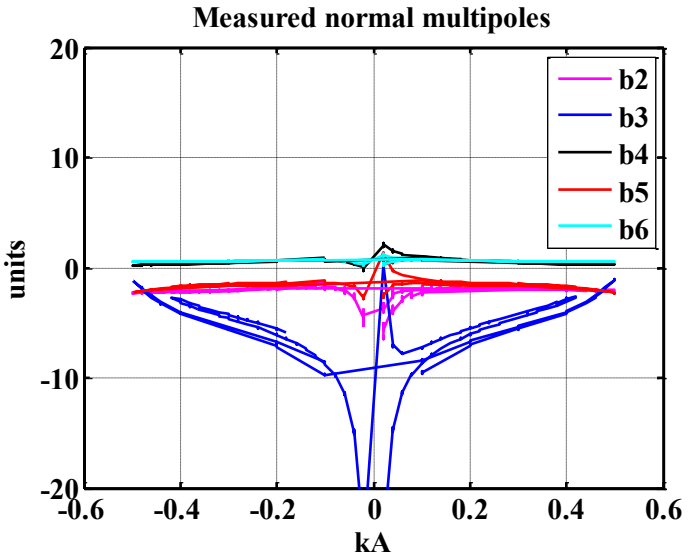


MCBRDS1b at cryogenic temperature

AP1 vertical field newest-built aperture			
TF	1.695		T m kA^{-1}
n	b_n	a_n	
2	-4.1	-2.97	units at 35 mm
3	-3.29	-0.74	
4	-0.59	-0.16	
5	-1.09	-0.08	
6	-0.05	-0.16	
7	-0.09	-0.14	
8	0.01	-0.05	
9	-0.06	-0.03	
10	-0.03	-0.02	
at nominal field level and 1.9 K			

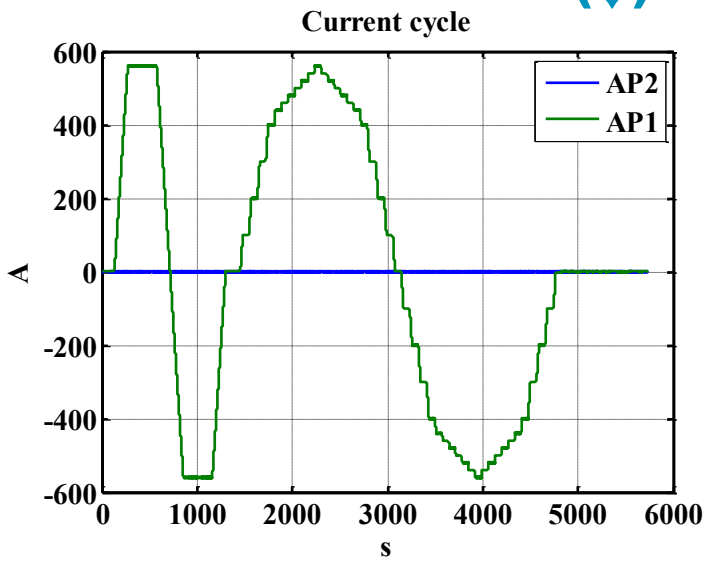


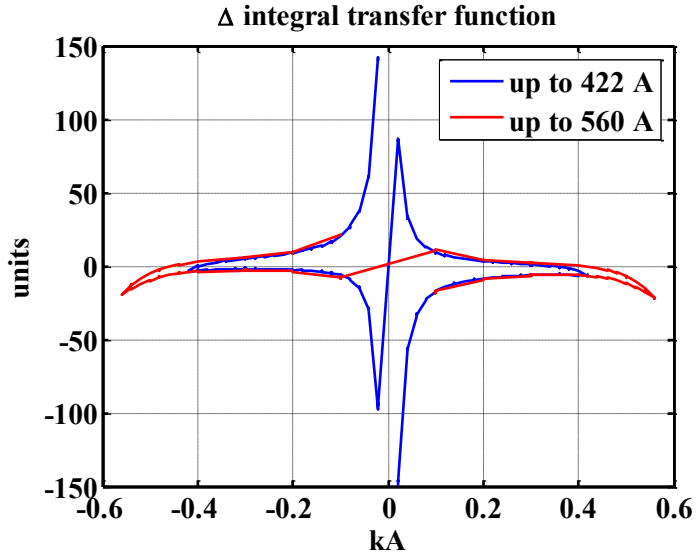
AP2 horizontal field first-built aperture			
TF	1.698		T m kA^{-1}
n	b_n	a_n	
2	-2.05	1.7	units at 35 mm
3	-2.69	-0.01	
4	0.35	1.17	
5	-1.77	0.23	
6	0.54	0.23	
7	0.28	0.09	
8	0.28	0.05	
9	0.01	0.05	
10	0.07	0.01	
at nominal field level and 1.9 K			

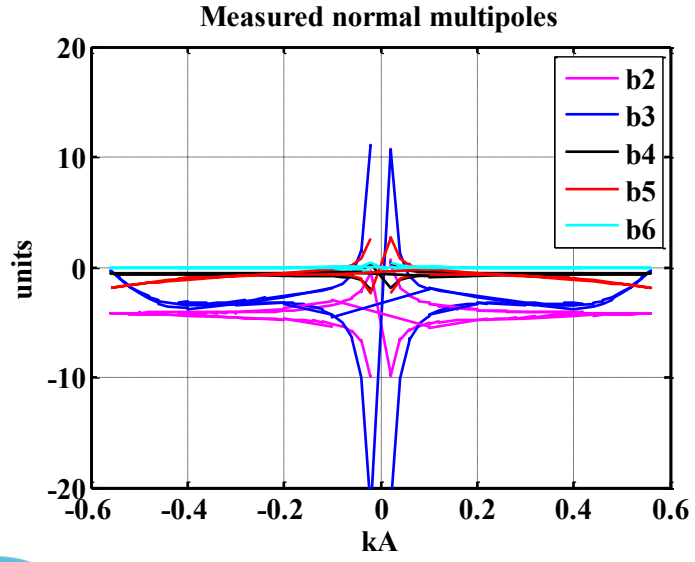


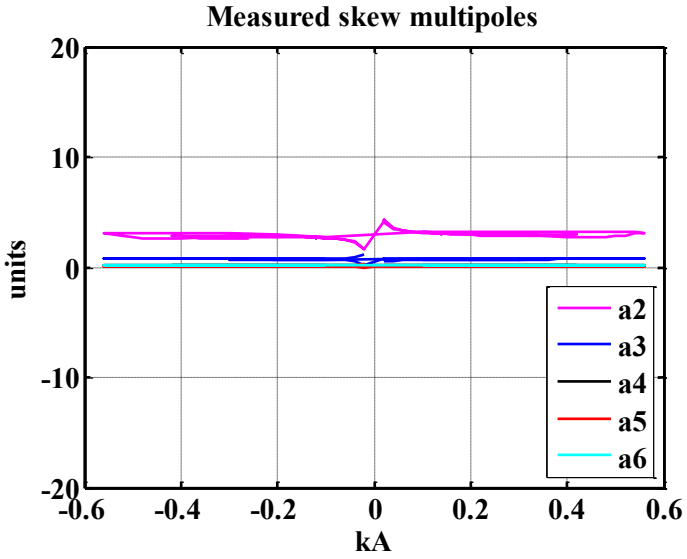
MCBRDS1b at cryogenic temperature
AP1 newest built (↕) Above nom.

TF = 1.696 Tm kA^{-1}



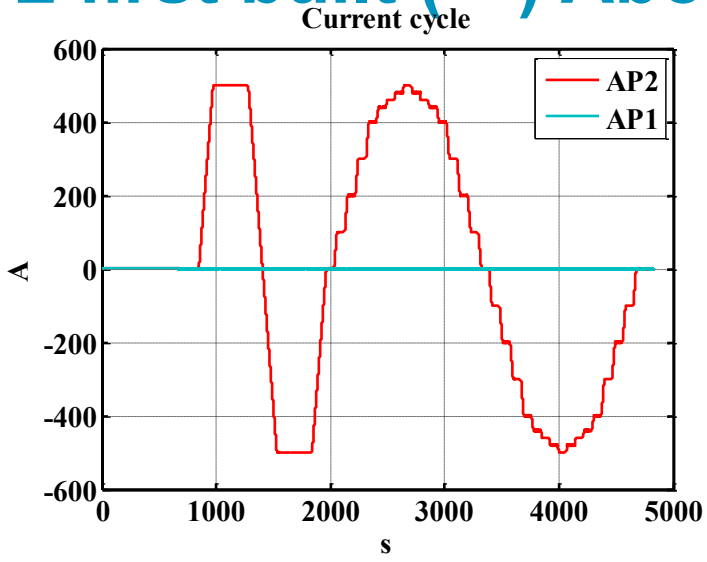


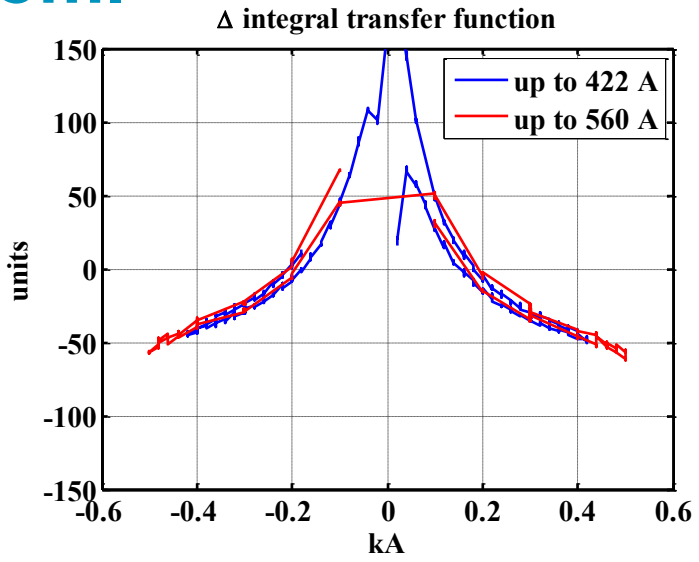


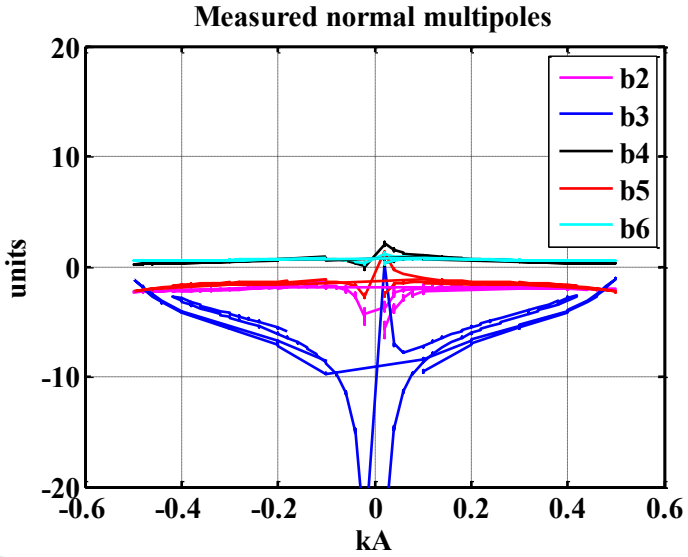


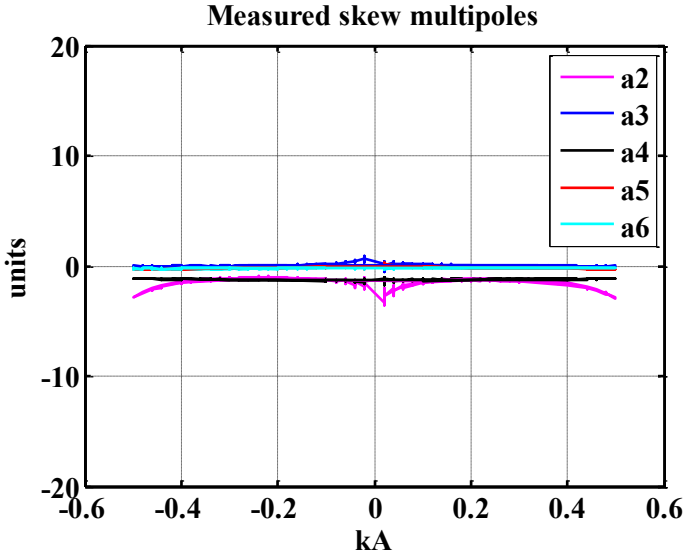
MCBRDS1b at cryogenic temperature
AP2 first built (↔) Above nom.

TF = 1.699 Tm kA^{-1}



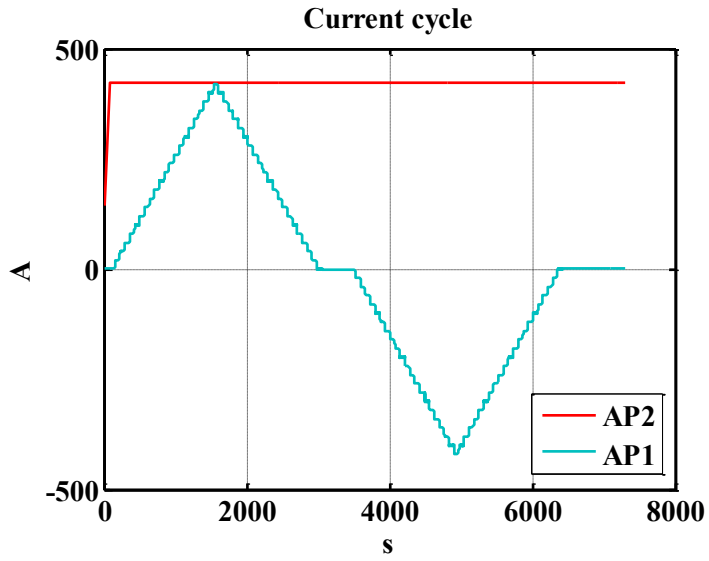


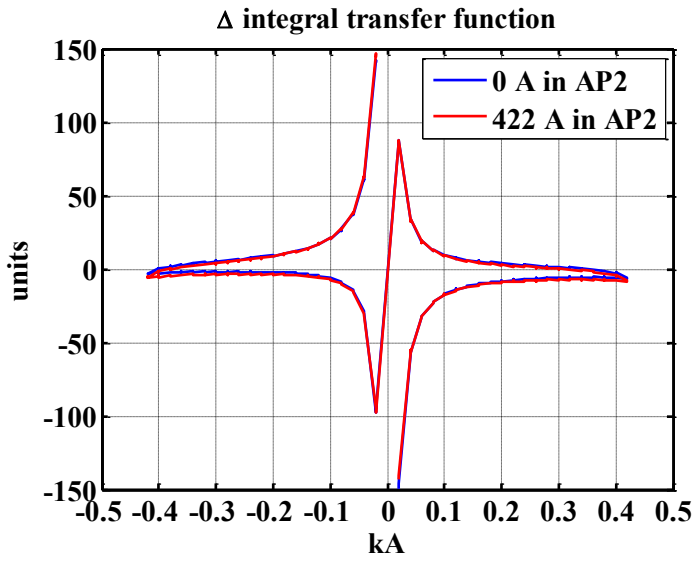


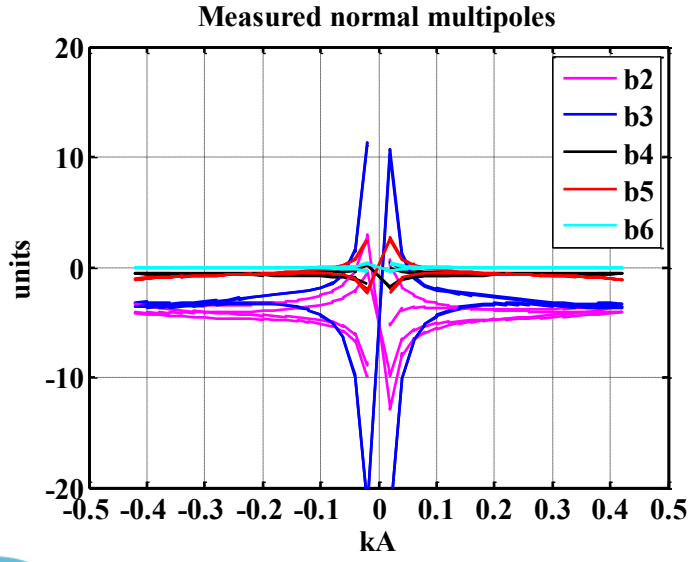


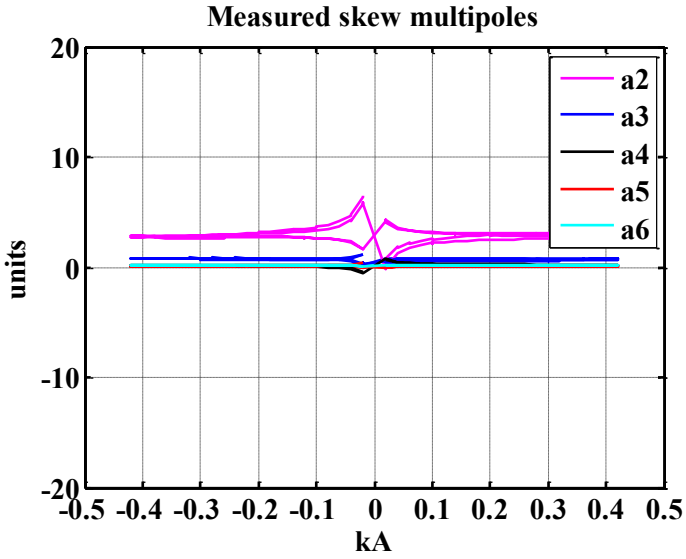
MCBRDS1b at cryogenic temperature
AP1 newest built (↕) X-talk

TF = 1.696 Tm kA^{-1}



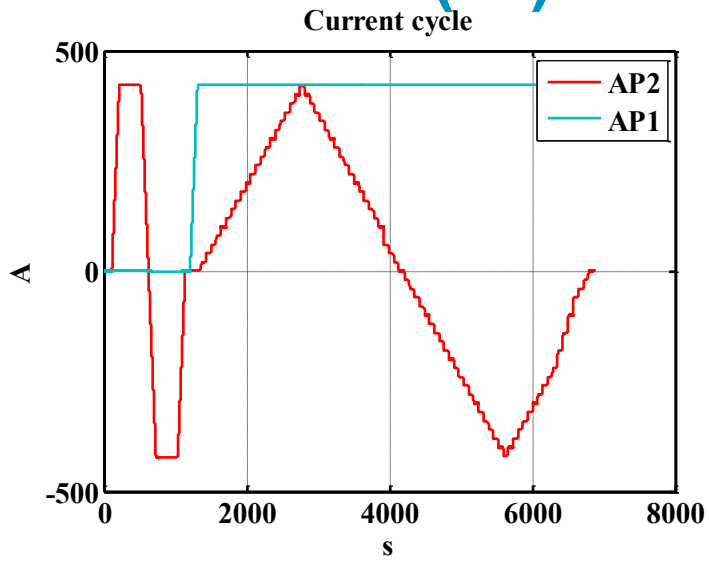


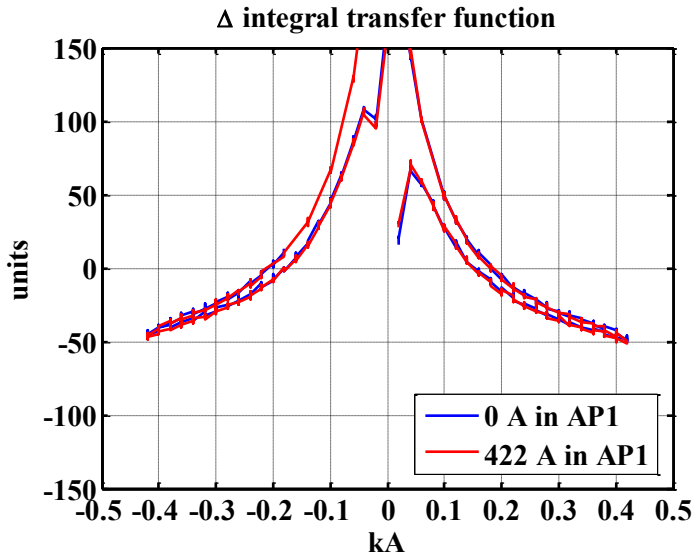


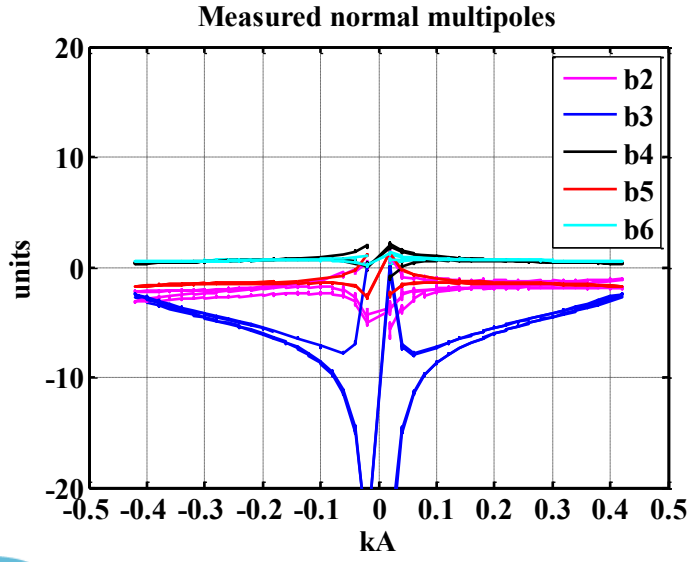


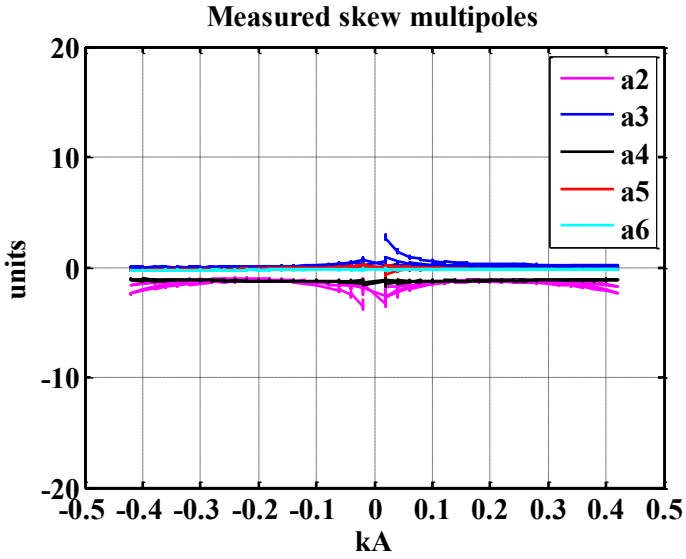
MCBRDS1b at cryogenic temperature
AP2 first built (↔) X-talk

TF = 1.699 Tm kA^{-1}









MCBRDS1b at room temperature

First-built aperture at room temperature 1 A		
n	b_n	a_n
2	3.34	3.84
3	-7.86	2.24
4	-1.07	1.53
5	-0.84	-0.12
6	-0.41	0.45
7	0.34	-0.16
8	-0.29	0.14
9	0.09	-0.07
10	-0.03	0.17