LSA magnet polarities

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Conventions

- Reference beam is beam 1 - observer looks in direction of beam 1
- Field and gradients positive **if** current enters A terminal
- Left aperture from connection end is aperture 1 (V1)
- For single aperture magnets covering both beams:
  - beam 1 is used to describe the polarity.

REFERENCE

LHC Magnet Polarities

Stephan Russenschuck

Orbit Correctors

- A positive horizontal **kick** on beam 1 deflects beam outwards.
  - This implies a negative B field.
- A positive vertical **kick** on beam 1 deflects beam upwards.
  - This implies negative skew dipole - field point outwards

- The agreement is that a positive current from the power converter should give a positive kick. This mean connecting positive to the B terminal for B1.

Orbit Correctors – B2

- A positive horizontal **kick** on beam 2 deflects beam outwards. This implies a positive B field.
- A positive vertical **kick** on beam 2 deflects beam upwards. This implies positive skew dipole - field point inwards
- The agreement is that a positive current from the power converter should give a positive kick. This mean connecting positive to the A terminal for B2

For correctors acting on both beams, B1 is the reference but we have to very careful in the software: a positive kick is negative for B2.

Correctors

Beam	Kick [LSA]	Deflection	Field
B1	+θ H	OUT	V NEG
B1	+θ V	UP	NEG (OUT)*
B2	+θ H	OUT	V POS
B2	+θ V	UP	POS (IN)
B1/B2	+θ H	B1 OUT B2 IN	V NEG
B1/B2	+θ V	B1 UP B2 DOWN	NEG (OUT)*

Quadrupoles

- A positive quadrupole field gradient or polarity is one where the vertical B-field increases as one moves in a positive x direction (away from the centre of the machine). This is focusing for beam 1
- MAD: a positive value corresponds to horizontal focusing of a positively charged particle.
- Beam 1
  - +K horizontally focusing   positive A
- Beam 2
  - +K horizontally focusing   positive B

MAD

- kqd := -0.008600955656 ;
- kqf := 0.008990100753 ;

- kqf.a12 := kqf ;
- kqd.a12 := kqd ;

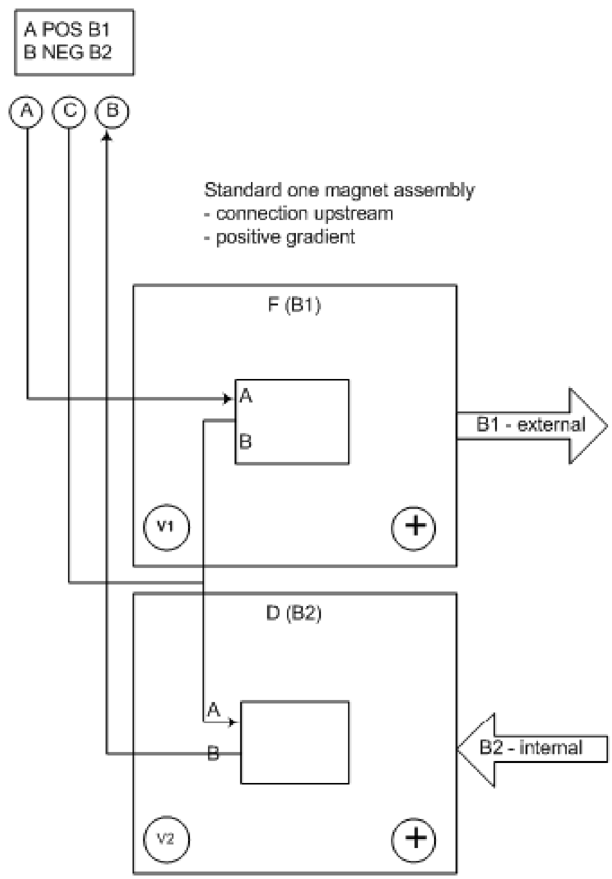
- RQF.A12B1 : MQ, K1 := KQF.A12;
- RQF.A12B2 : MQ, K1 := -KQF.A12;

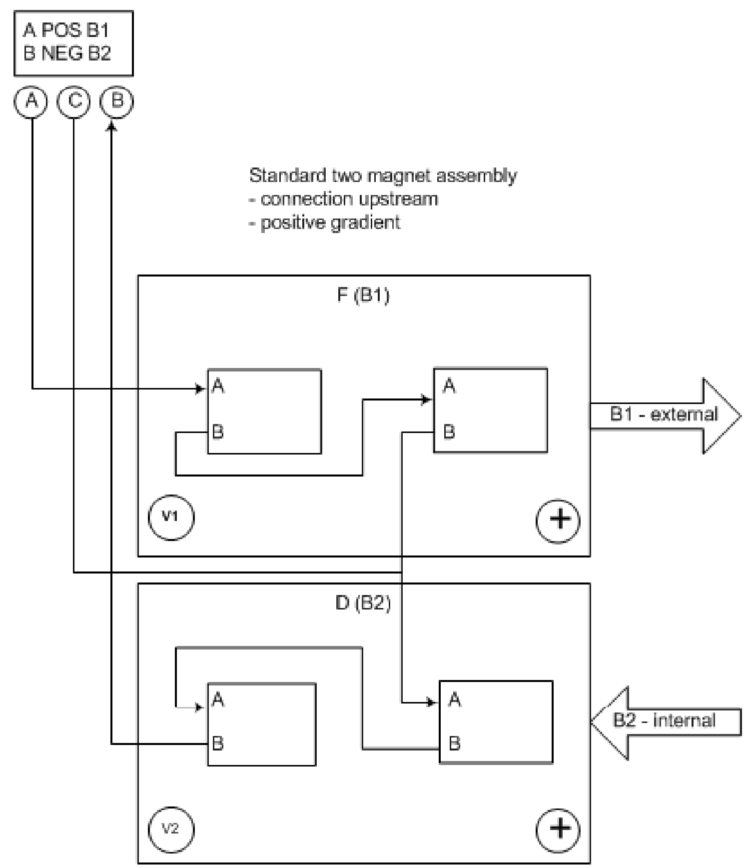
- MQ.23R5.B1:RQF.A56B1
- MQ.23R5.B2:RQD.A56B2

Quads etc.

- Except for bipolar supplies we give power converters positive references
- Rely on cabling to get things right

POWER CONVERTER	BEAM	EXT/INT	APERTURE	F or D	MAGNET POLARITY	TERMINAL		TURNED	MAGNET TYPE	PROBLEM
POINT ONE										
RPHGA.RR13.RQ10.L1B1	B1	INT	V2	F	+	B	NEG		MQML	**F**
RPHGA.RR13.RQ10.L1B2	B2	EXT	V1	D	+	A	POS			
RPHGA.RR13.RQ9.L1B1	B1	INT	V2	D	-	B	POS		MQMC MQM	
RPHGA.RR13.RQ9.L1B2	B2	EXT	V1	F	-	A	NEG			
RPHGA.RR13.RQ8.L1B1	B1	INT	V2	F	+	B	NEG		MQML	**F**
RPHGA.RR13.RQ8.L1B2	B2	EXT	V1	D	+	A	POS			
RPHGA.RR13.RQ7.L1B1	B1	INT	V2	D	-	B	POS		MQM MQM	
RPHGA.RR13.RQ7.L1B2	B2	EXT	V1	F	-	A	NEG			
RPHGB.RR13.RQ6.L1B1	B1	INT	V1	F	+	A	NEG	*	MQML	
RPHGB.RR13.RQ6.L1B2	B2	EXT	V2	D	+	B	POS			
RPHGB.RR13.RQ5.L1B1	B1	INT	V1	D	-	A	POS	*	MQML	**F**
RPHGB.RR13.RQ5.L1B2	B2	EXT	V2	F	-	B	NEG			
RPHH.RR13.RQ4.L1B1	B1	INT	V2	F	+	B	NEG		MQY	**F**
RPHH.RR13.RQ4.L1B2	B2	EXT	V1	D	+	A	POS			
IP1										
RPHH.RR17.RQ4.R1B1	B1	EXT	V2	D	-	B	NEG	*	MQY	**F**
RPHH.RR17.RQ4.R1B2	B2	INT	V1	F	-	A	POS			
RPHGB.RR17.RQ5.R1B1	B1	EXT	V2	F	+	B	POS	*	MQML	
RPHGB.RR17.RQ5.R1B2	B2	INT	V1	D	+	A	NEG			
RPHGB.RR17.RQ6.R1B1	B1	EXT	V2	D	-	B	NEG	*	MQML	**F**
RPHGB.RR17.RQ6.R1B2	B2	INT	V1	F	-	A	POS			
RPHGA.RR17.RQ7.R1B1	B1	EXT	V1	F	+	A	POS		MQM MQM	**F**
RPHGA.RR17.RQ7.R1B2	B2	INT	V2	D	+	B	NEG			
RPHGA.RR17.RQ8.R1B1	B1	EXT	V1	D	-	A	NEG		MQML	
RPHGA.RR17.RQ8.R1B2	B2	INT	V2	F	-	B	POS			
RPHGA.RR17.RQ9.R1B1	B1	EXT	V1	F	+	A	POS		MQMC MQM	**F**
RPHGA.RR17.RQ9.R1B2	B2	INT	V2	D	+	B	NEG			
RPHGA.RR17.RQ10.R1B1	B1	EXT	V1	D	-	A	NEG		MQML	
RPHGA.RR17.RQ10.R1B2	B2	INT	V2	F	-	B	POS			


A POS B1
B NEG B2
A
C
B
Standard one magnet assembly
- connection upstream
- positive gradient
F (B1)
A
B
V1
B1 - external
D (B2)
A
B
V2
B2 - internal

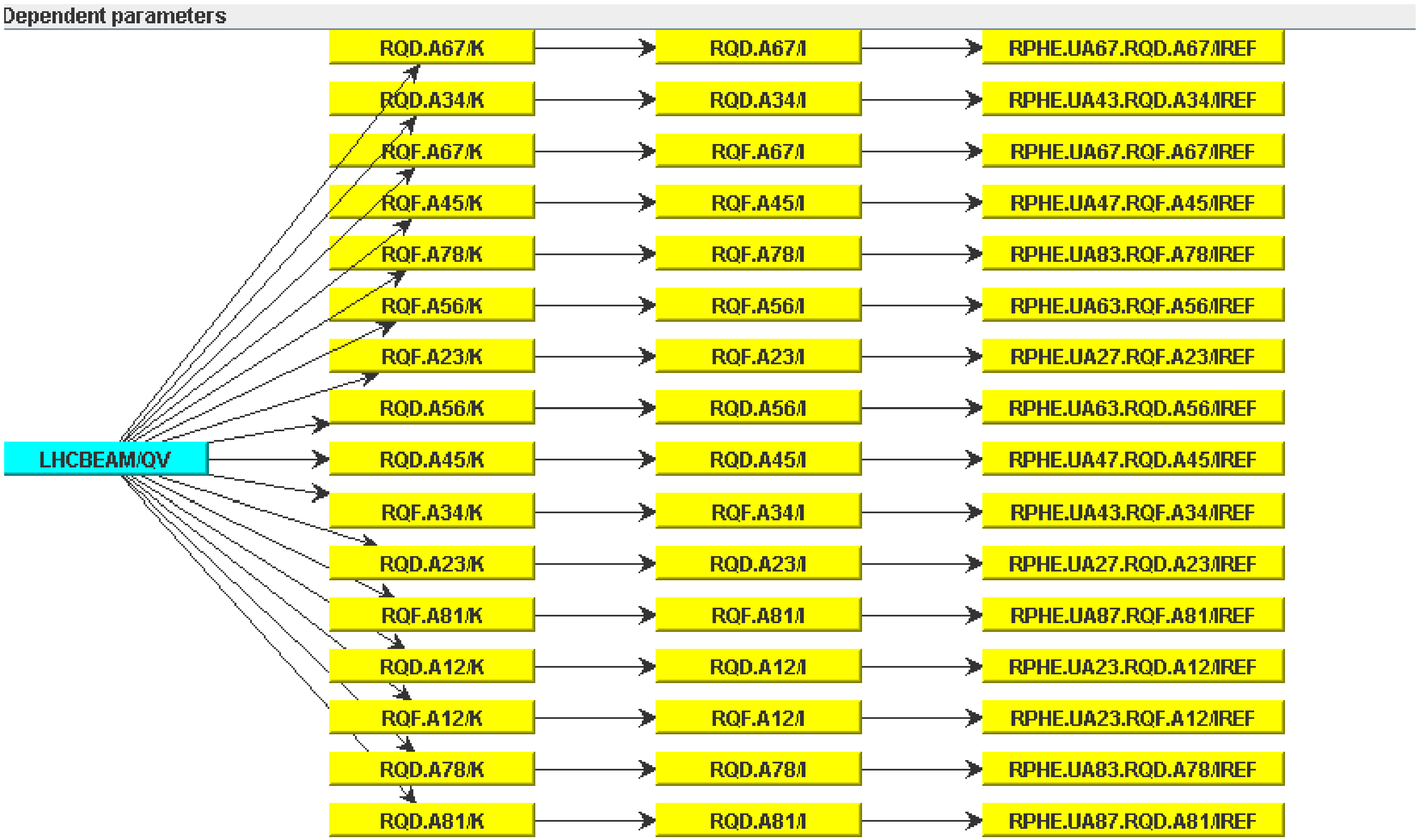

A POS B1
B NEG B2
A
C
B
Standard two magnet assembly
- connection upstream
- positive gradient
F (B1)
A
B
A
B
V1
B1 - external
D (B2)
A
B
A
B
V2
B2 - internal

LSA

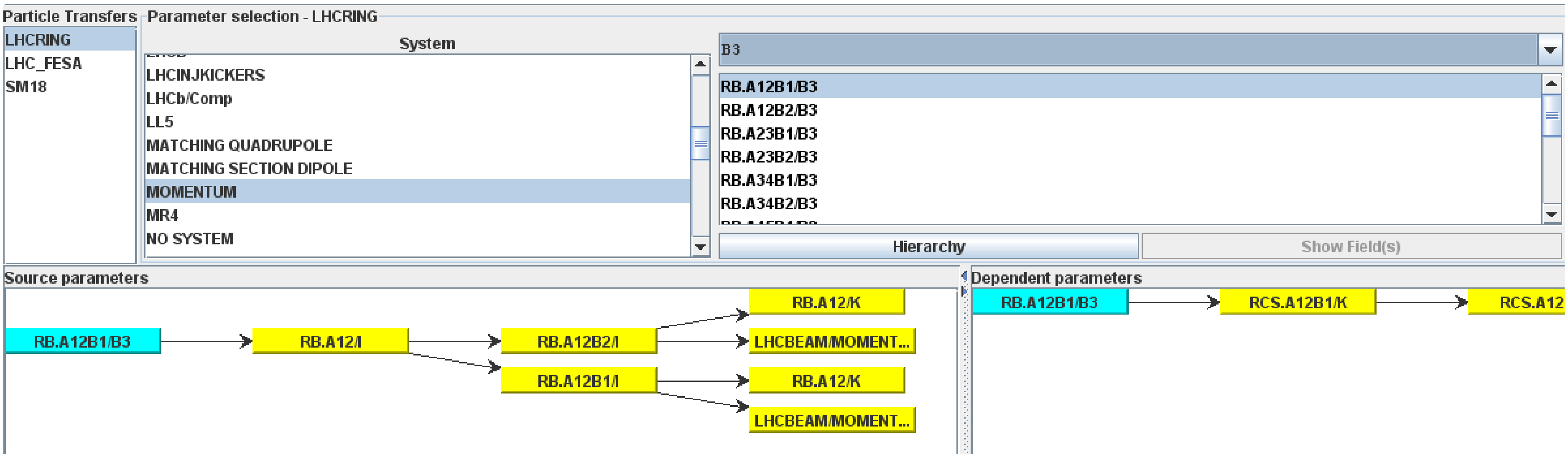
- In LSA parlance:
  - magnet/magnet string is logical hardware
    - i.e stuff we can not directly address
  - power converters are actual hardware
    - i.e. stuff we can actually talk to, load functions etc.
    - not always a one to one mapping
  - We map transfer functions (or calibration curves as we call them (B versus I)) to logical_hardware.
    - i.e. we calculate currents for magnets and worry about the power converters later

- Extended this to cover both apertures

LSA – parameter space



LSA – parameter space



LSA

- In LSA we keep strengths (K) and current (I) for magnets or magnet strings (logical hardware).
  - NB We keep the strength sign: + is F, - is D for both beams

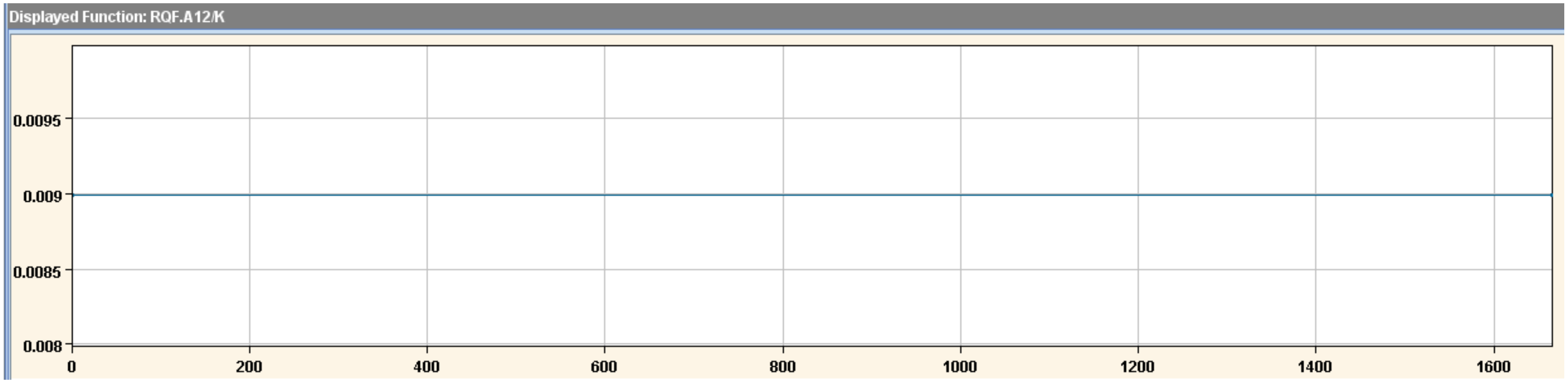
- The magnets/magnet strings are mapped on to power converters for which we calculate currents (IREF).

- To take care of the cases where negative strengths have to give positive reference we have a “calibration sign” on the database which is set to give the correct current when we go through the transfer function.

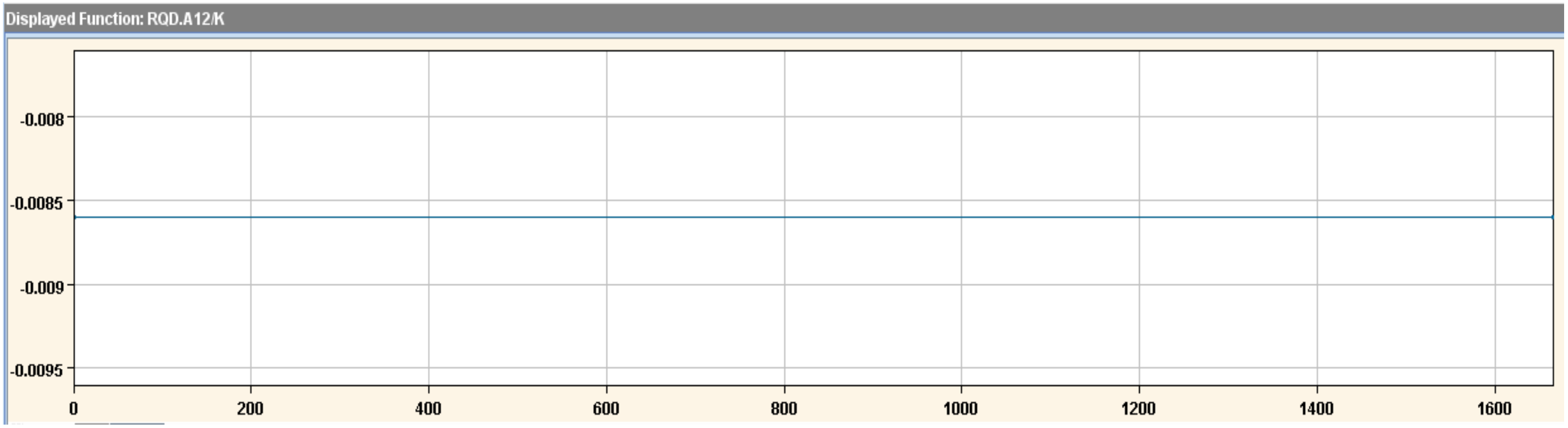
- For non-bipolar quads we only keep the positive signed TF

Quad strengths

RQF.A12/K



RQD.A12/K

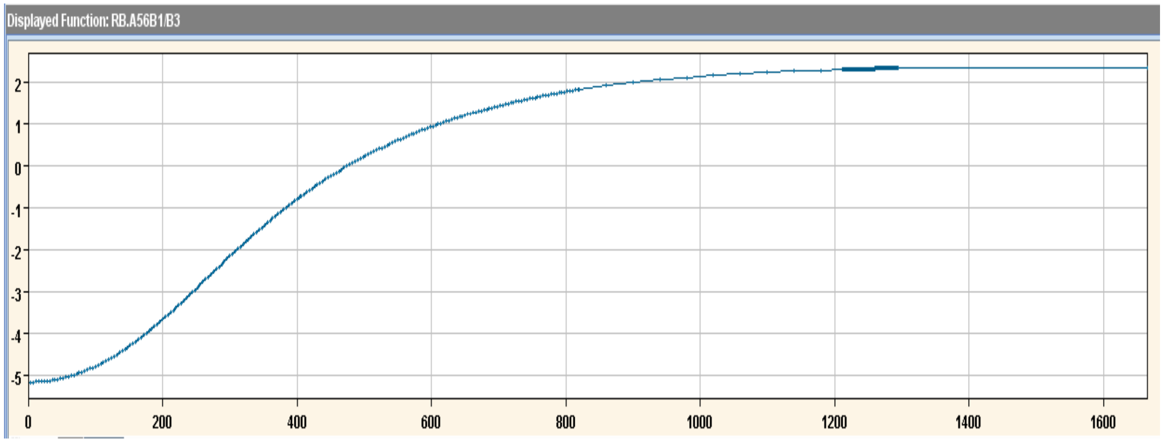


Logical Hardware

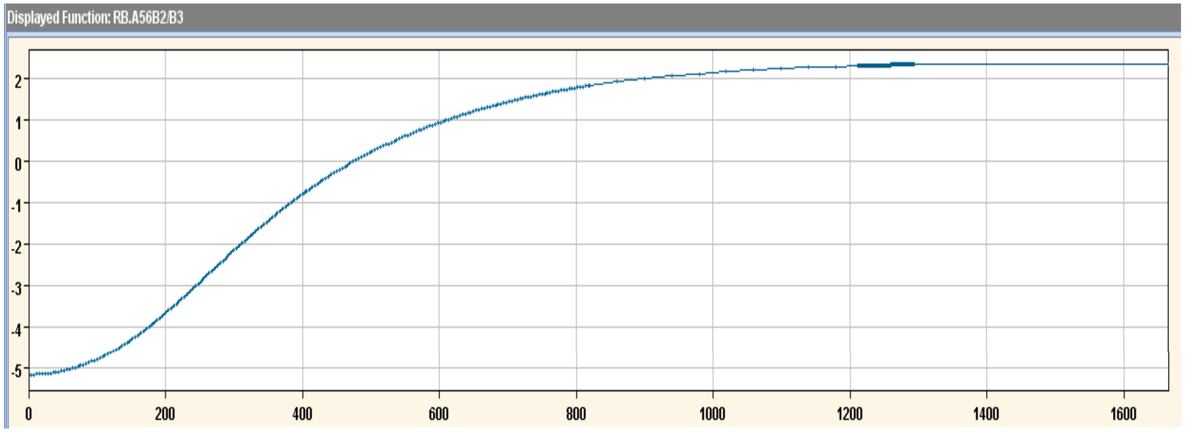
#	LOGICAL_HARDWARE_NAME	DESCRIPTION	NB_OF_ELEMENTS	ACTIVE_CAL_NAME	CAL_SIGN
1	RQD.A56		47	MQ	-1
2	RQD.A56B1	single aperture of magnet string	23	MQ	-1
3	RQD.A56B2	single aperture of magnet string	24	MQ	-1
4	RQF.A56		47	MQ	1
5	RQF.A56B1	single aperture of magnet string	24	MQ	1
6	RQF.A56B2	single aperture of magnet string	23	MQ	1
7	RQS.A56B2		4	MQS	1
8	RQTD.A56B1		8	MQT	1
9	RQTD.A56B2		8	MQT	1
10	RQTF.A56B1		8	MQT	1
11	RQTF.A56B2		8	MQT	1

b3 – B1 and B2

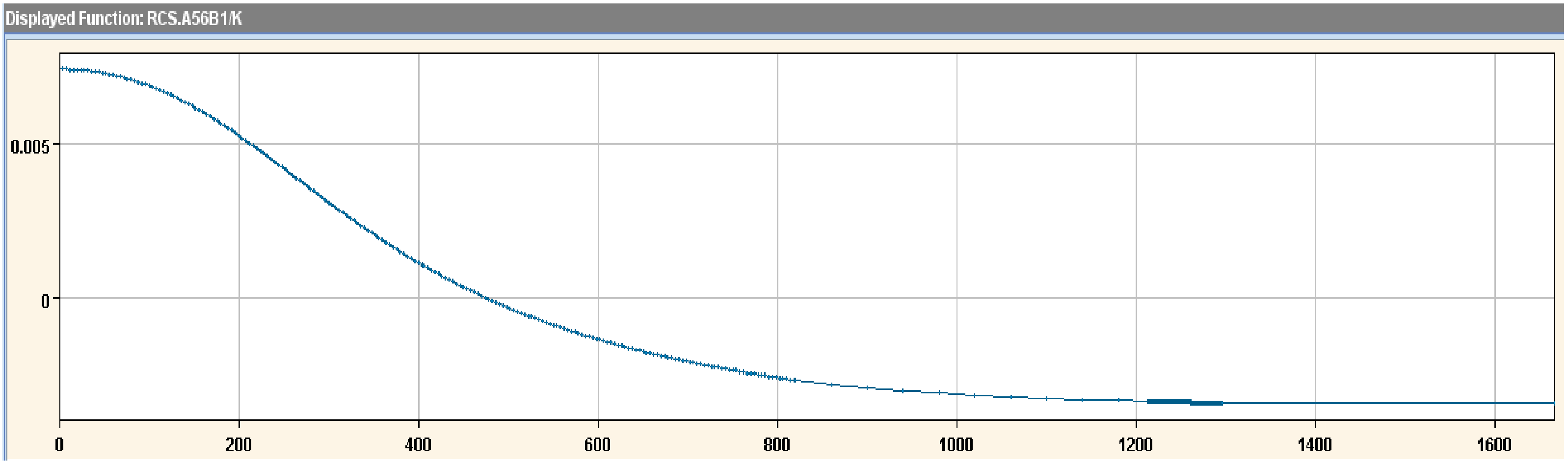
RB.A56B1/B3

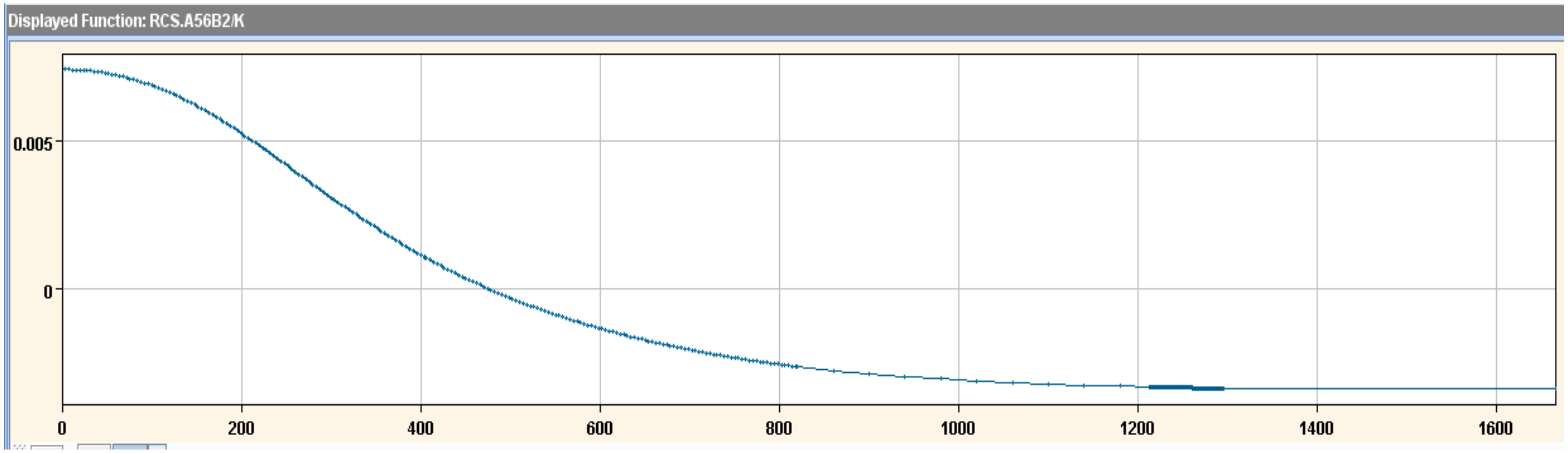


RB.A56B2/B3

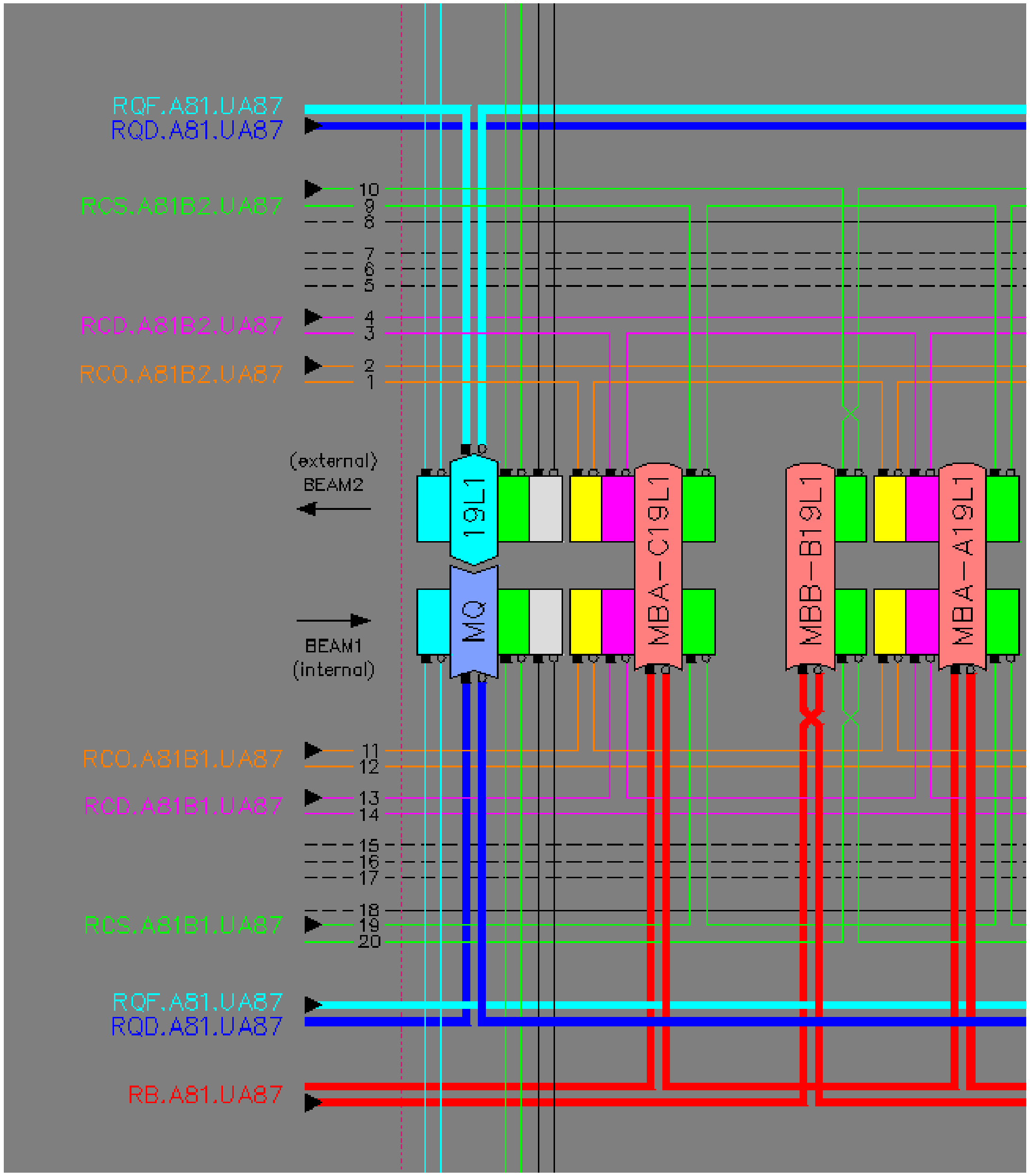


MCS strengths B1/B2





And then hope the cabling is right



Bipolar supplies

- Pretty natural
- Standard signs for strengths
  - e.g. positive sextupole compensates negative b3
- Keep both positive and negative branches of the calibration curve
  - so in general positive strength will demand positive current…

#	CALIBRATION_NAME	B_FIELD	I	SLOPE
1	MCS	-3646.429694	-600	0
2	MCS	3646.429694	600	0

Conclusions

- Fairly natural approach
- Support the MAD world view
  - accelerator physics maps cleanly on to LSA parameters space
- Power converters take positive references
  - use cal sign in one place to take care of this
  - cabling should give correct magnet polarity
- For bi-polar circuits
  - stick with natural strengths, calculate positive or negative currents as required
  - again rely on correct cabling
- Model includes both apertures for transfer functions and harmonics where required.