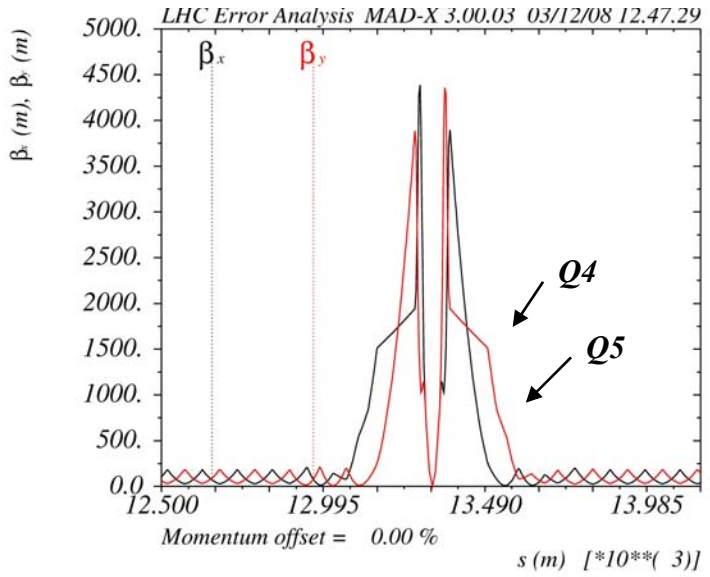
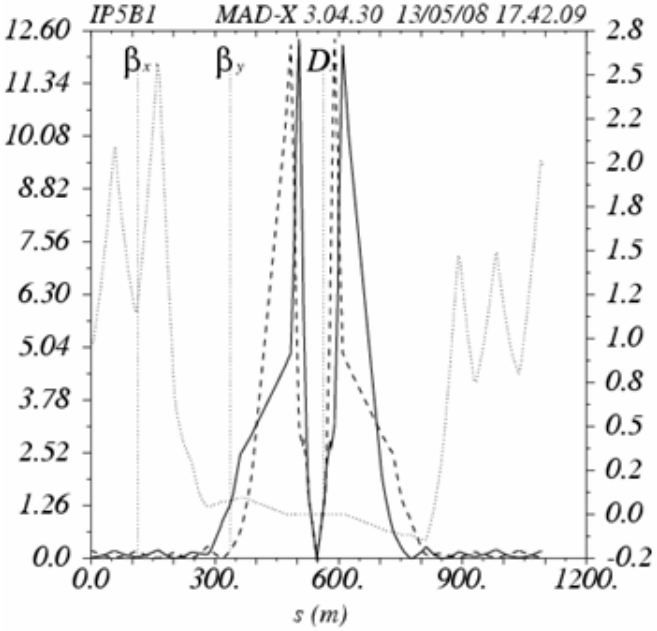
Tracking Calculations for the LHC Upgrade
- Collision Optics -

Bernhard Holzer, CERN BE-ABP
and many colleagues !!!

LHC Standard Collision Optics ...



and the Upgrade



critical issues for the DA ???

error tables ... at the triplett ?
... at the new D1 ?
... at the matching section ?

and which multipoles?

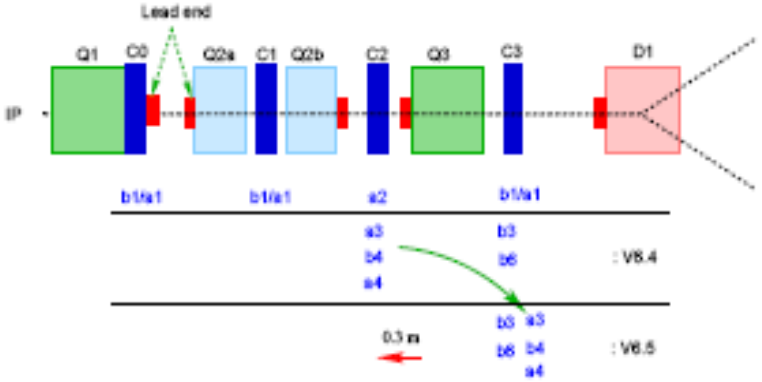
2 Triplet corrector package

2.1 Functional description

In order to compensate for the field imperfections of the triplet magnets (MQX) and the cold and warm separation dipoles (MBX and MBXW), both sides of each experimental insertion IR1, IR2, IR5, and IR8 are equipped with linear and non linear corrector packages (see Fig. 1):

Problem:

multipole coefficients from
Q1, Q2, Q3 & D1 ... and beyond ??
how many multipole correctors do we need ?



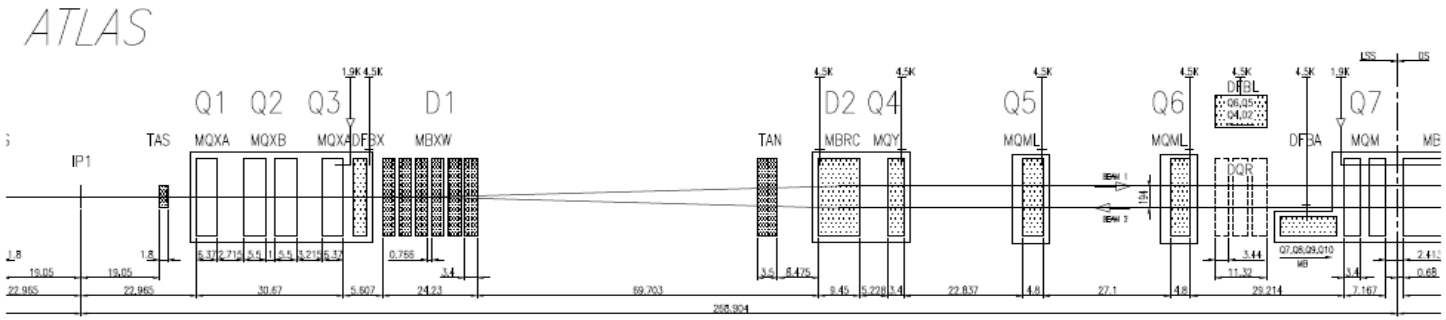


Figure 3.7: Schematic layout of the right side of IR1

LHC - Upgrade

error table for the new MQXC triplett quadrupole

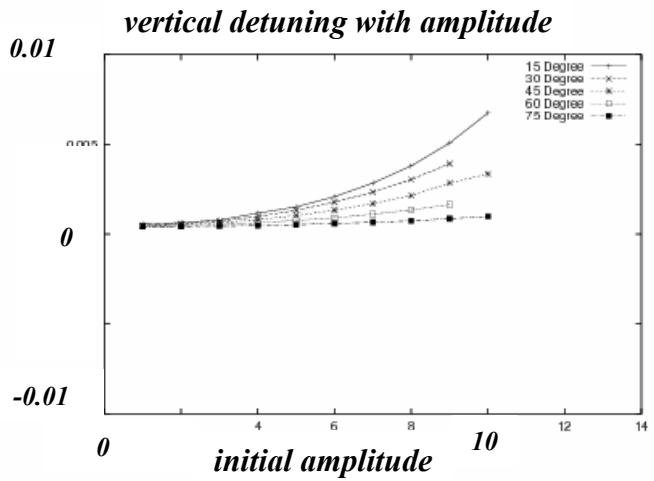
Baseline MQXC field error table.

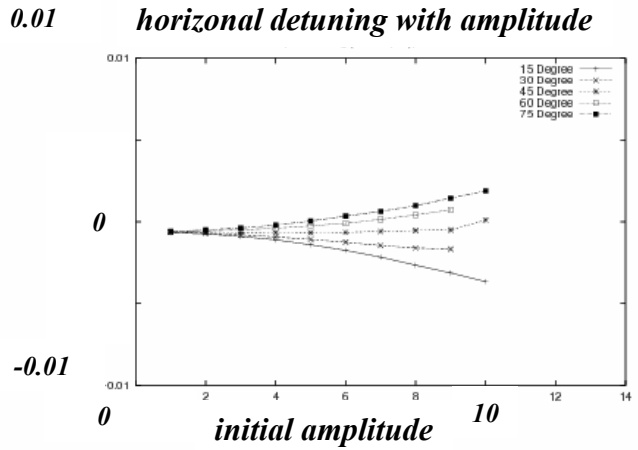
Gradient = 120 T/m, Rref = 40 mm

For details, see P. Fessia, LIUWG 11 Dec 2008.

	Systematic	*Uncertainty*		*random (1 σ)*
		min	*max*	
b3		-0.46	0.46	0.89
b4	0.00	-0.06	0.06	0.64
b5				0.46
b6	0.42	-1.01	1.07	1.28
b7				0.21
b8				0.16
b9				0.08
b10	-0.23	-0.16	0.16	0.06
b11				0.03
b12				0.02
b13				0.01
b14	-0.07	-0.03	0.03	0.01
a3				0.89
a4				0.64
a5				0.46
a6	-0.26	-1.27	1.27	0.33
a7				0.21
a8				0.16
a9				0.08
a10	-0.03	-0.10	0.10	0.06
a11				0.03
a12				0.02
a13				0.01
a14	0.01	-0.03	0.03	0.01

col_9



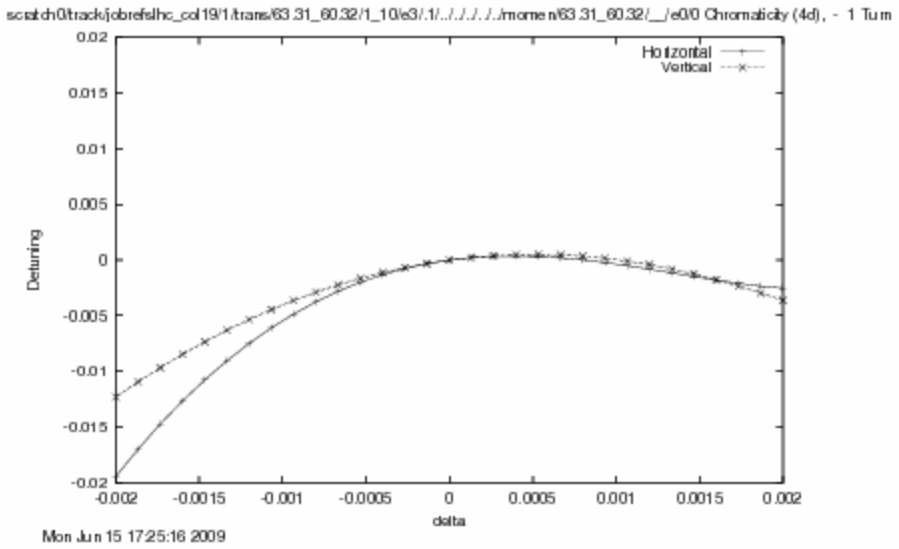


" the worst case"

triplett errors on

D1 errors on

no correction



col_9

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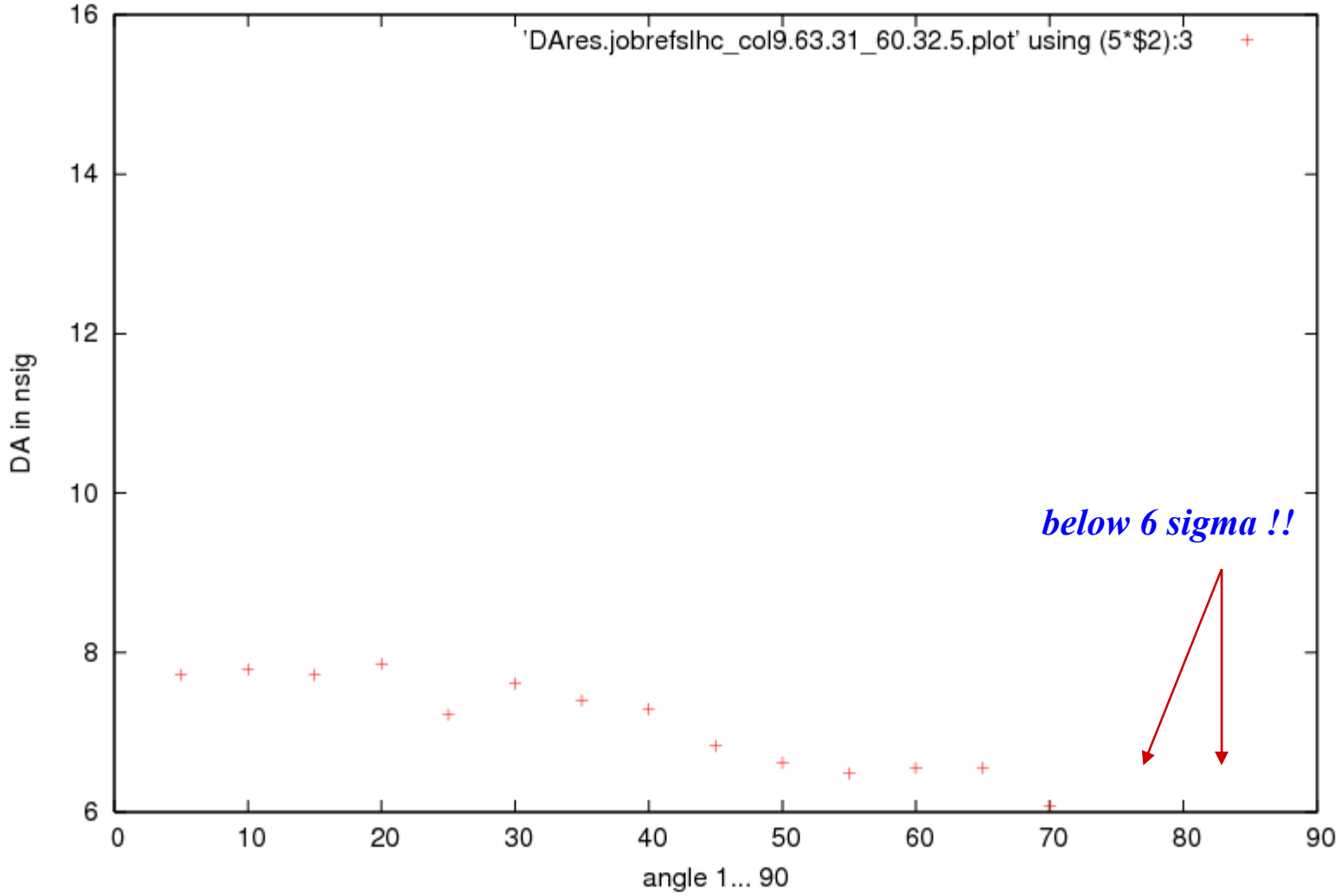


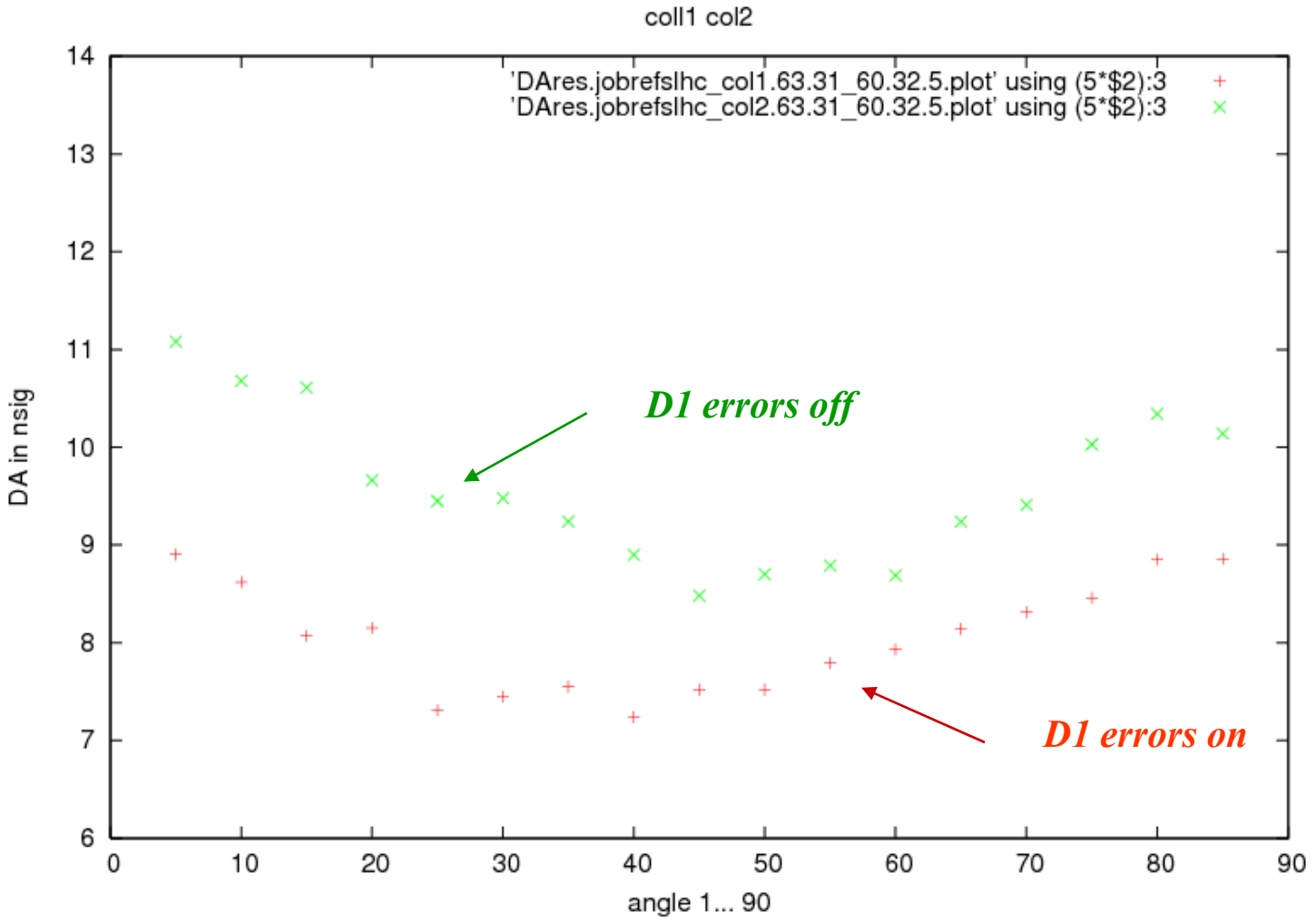
col_1_2

" problem Nr. 1"

triplett errors on, corrected via b3 / b6

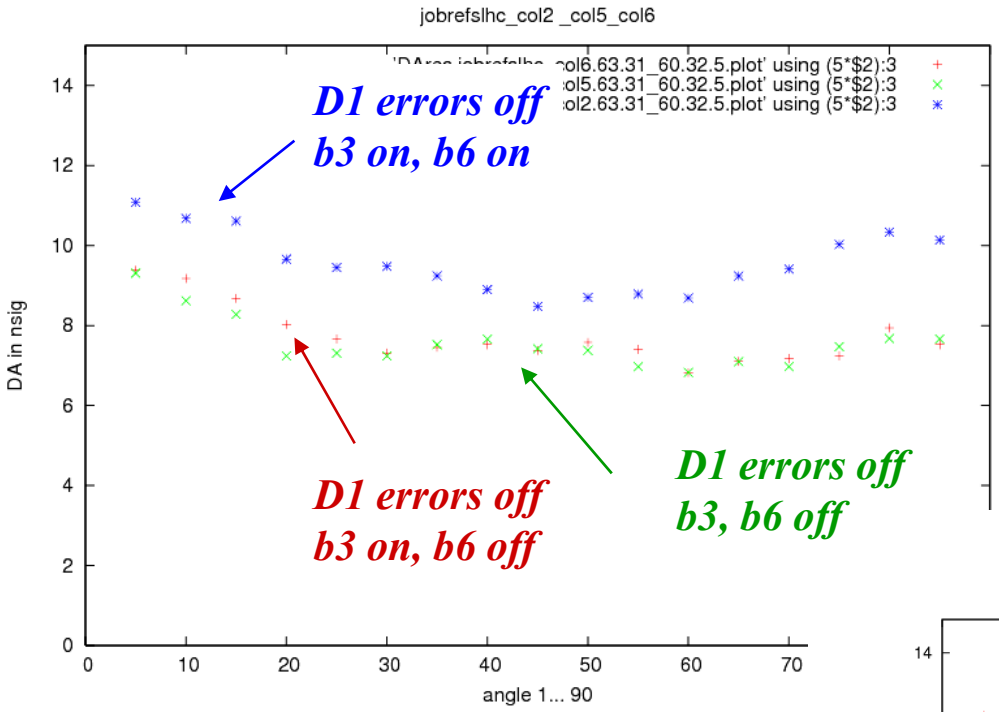
D1 errors on

D1 errors off

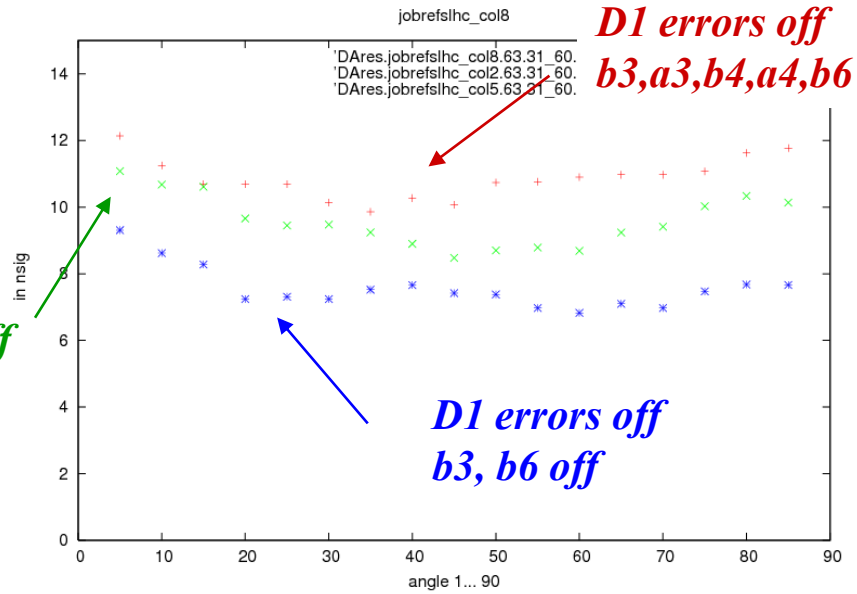


col_2_5_6

" problem Nr. 2"
triplett errors correction
D1 errors off



col_2_5_8



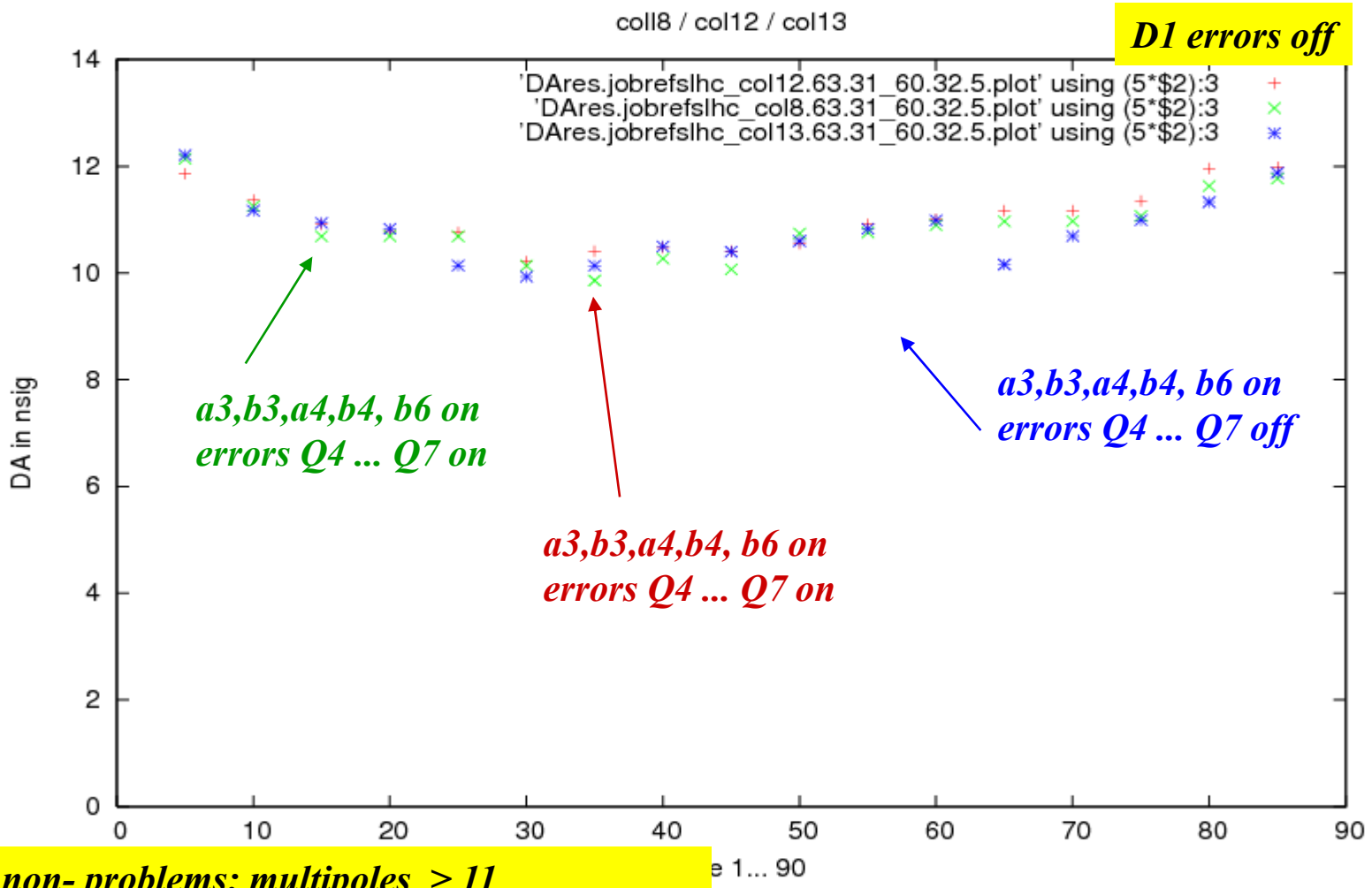
... we need much more than b3,b6 !!!

" problem Nr. 3 ? ... a non-problem"

triplett errors correction via a3,b3,a4,b4,b6

matching quads Q4 ... Q7 ?

higher order multipoles (> 11)



... two non- problems: multipoles > 11

the matching quads Q4... Q7

scaling multipole errors:

Baseline MQXC field error table.

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For details, see P. Fessia, LIUWG 11 Dec 2008.

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effect of multipole on beam:

$$G * l * R_{ref} * \frac{b_n}{R_{ref}^{n-1}} * \sqrt{\beta} * \beta^{\frac{n-1}{2}}$$

scaling via aperture radius r =17mm → r = 40mm
scaling via optics

$$b_n(new) = b_n(old) * \left(\frac{\beta_{old}}{\beta_{new}}\right)^{n/2} * \left(\frac{R_{new}}{R_{new}}\right)^{n-2}$$

new "target error table" ~ target 0

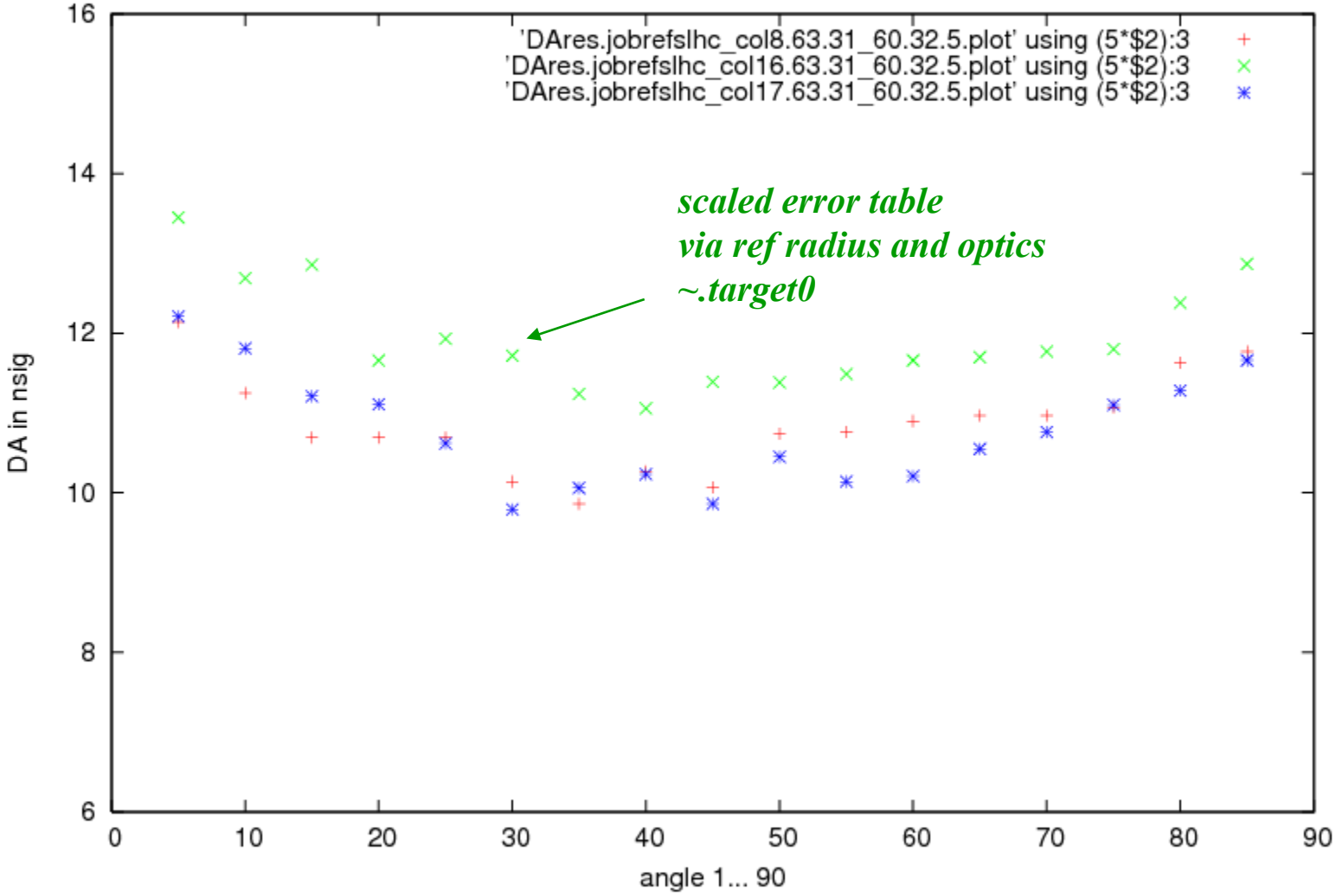
" problem Nr. 4 ... the error tables its a mess !!

triplett errors table ~.v1

Ezios new errors table ~.v2 (gaps filled)

scaled eror table via ref radius and optics

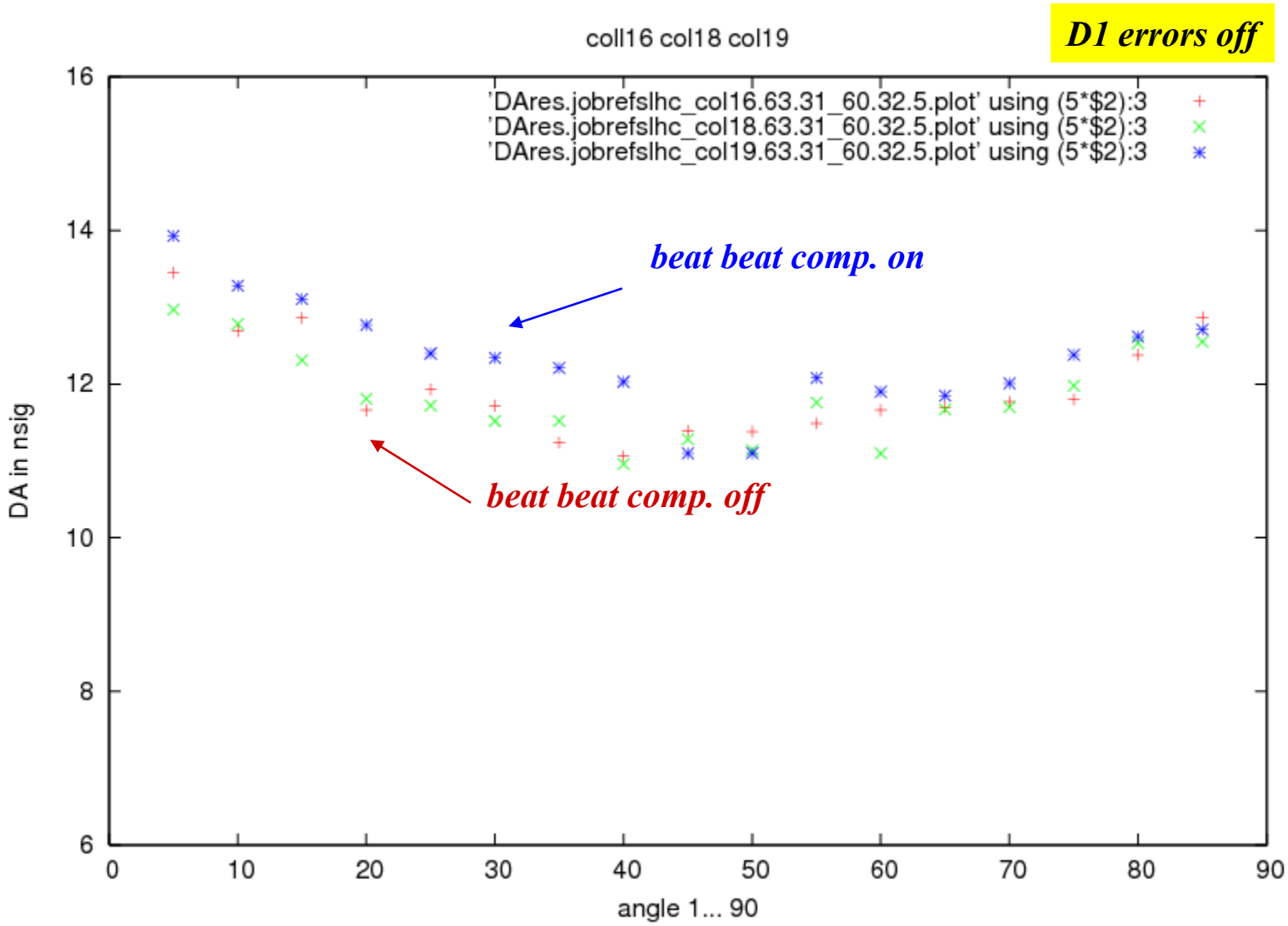
D1 errors off



... the problem is the high multipole contributions of the new MQXC quarupole

" beta beat compensation"

finally a good news

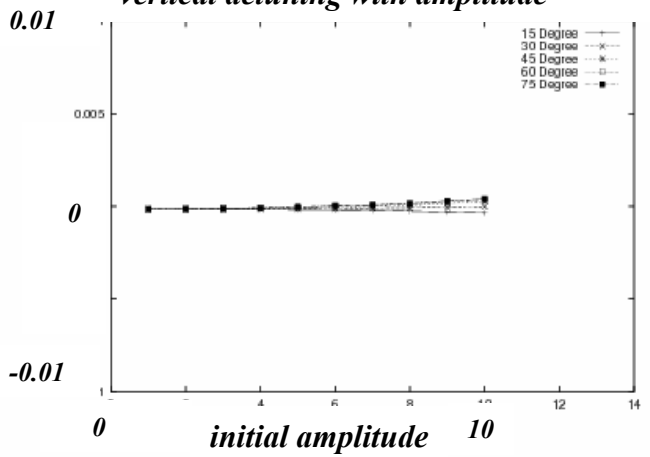


" beta beat compensation"

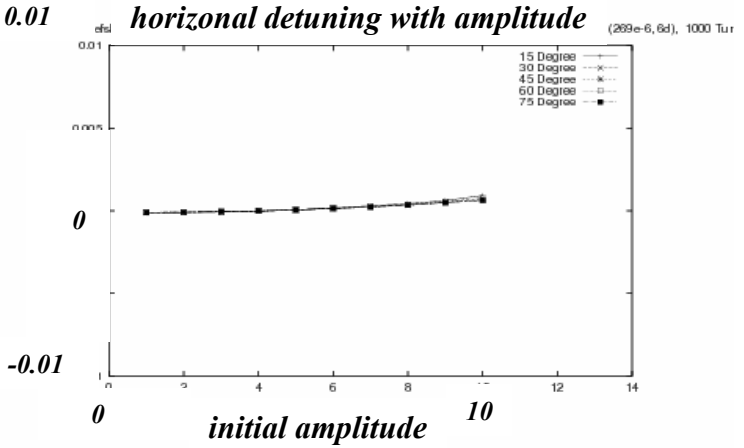
finally a good news

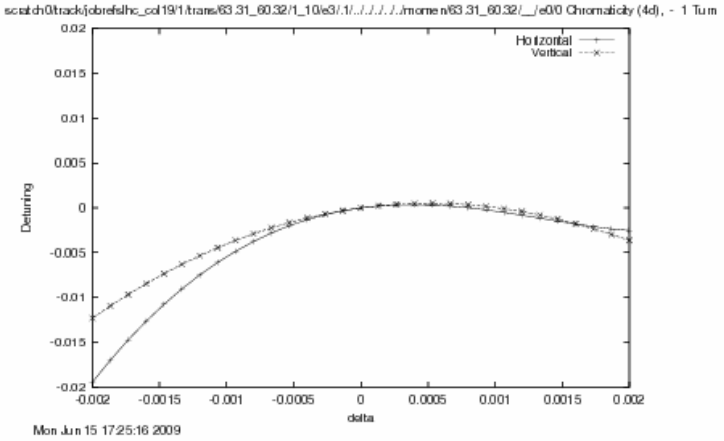
D1 errors off

vertical detuning with amplitude

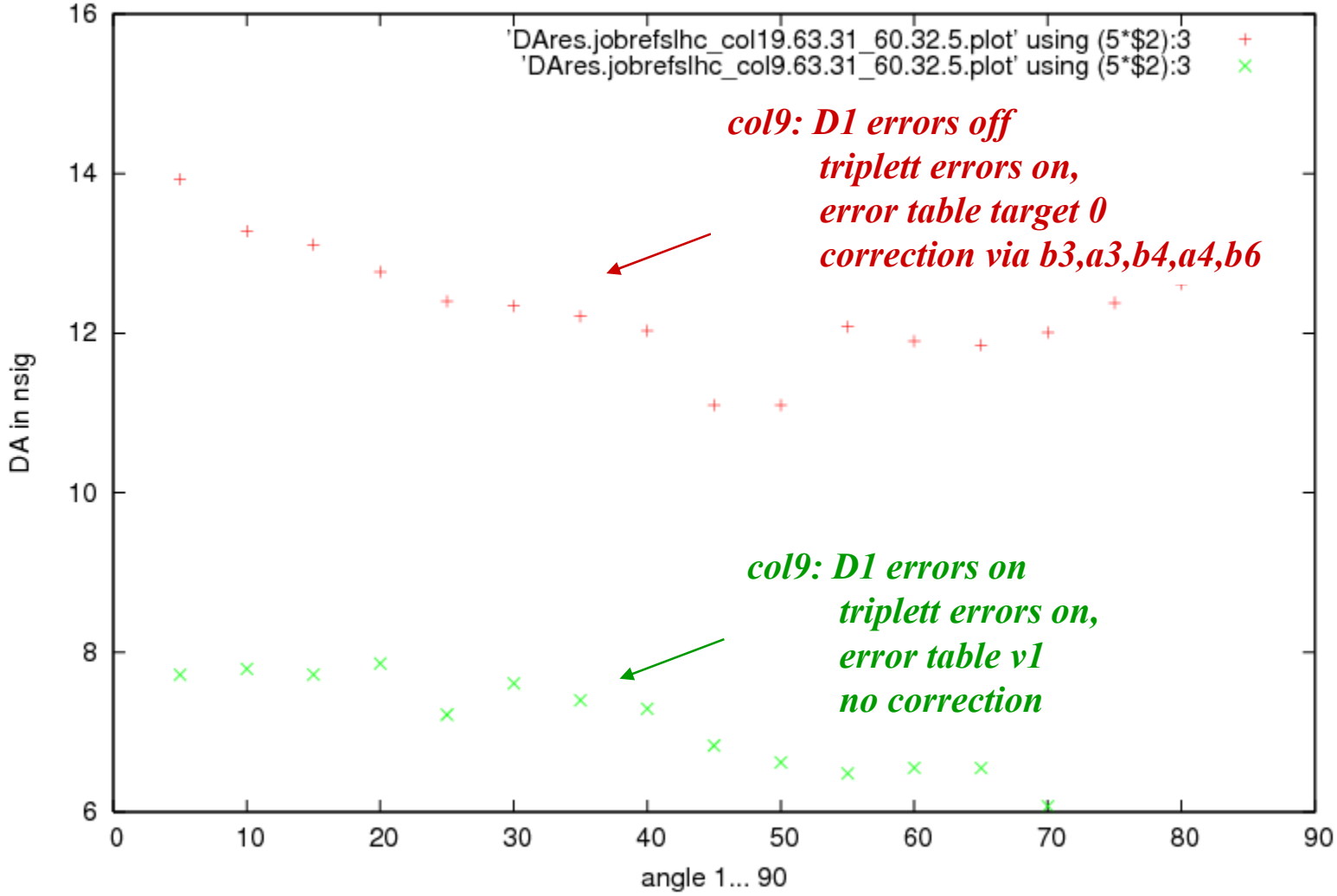


horizonal detuning with amplitude





Resumé: *we need better quadrupoles*
we have to compensate a large number of multipoles in MQXC
we need to think about D1



Further Plans:

** identify the most critical multipoles*

** define tolerance limits for the new triplett quadrupole*

** re - include the D1 errors*
... and compensate ?

summary after a discussion with the magnet people:

... the proposed MQXC error table (~v1, ~v2) assumed up to 30 µm coil and other component misalignement as it has been extropolated from the measured field quality of the arc quadrupoles MQ.

... while the same quantity has been estimated in a range of 10-15 microns for the actual MQXA/B.