Error tables and routines for cold D3 and D4

Acknowledgements: S. Fartoukh, T. Risselada

- Present status
- Changes
- Impact on DA

Present status - I

- Error routines:
  - Magnet orientation checked (once more) by T. Risselada against database (H. Prin): OK
- Error tables:
  - Choice was made to use
    - D1 field quality for D3
    - D2 field quality for D4
- What is the impact on DA if the expected field quality is used (from the official web site http://www.rhichome.bnl.gov/LHC/ref/ ?

Changes - I

- D3:
- Difference found in :
  - Body, Lead End, Return End
  - Mean, Uncertainty, Random
  - Injection, collision

Changes - II

Lead End					
	P	G		P	G
b1M	0.0000	0.0000	a1M	0.0000	0.0000
b2M	0.0000	0.0000	a2M	0.0000	0.0000
b3M	0.7507	-4.8634	a3M	0.0174	2.1434
b4M	-0.0037	-0.0146	a4M	0.0768	-0.0329
b5M	-0.0793	0.2005	a5M	-0.0140	-1.0396
b6M	0.0107	-0.0107	a6M	0.0160	-0.0053
b7M	-0.0814	-0.5346	a7M	-0.0174	0.4998
b8M	0.0000	0.0000	a8M	-0.0061	0.0123
b9M	0.0127	0.0254	a9M	0.0063	-0.1586
b10M	0.0000	0.0065	a10M	0.0000	0.0065
b11M	0.0000	0.0395	a11M	0.0000	0.0264
b1U	0.0000	0.0000	a1U	0.0000	0.0000
b2U	0.0000	0.0000	a2U	0.0000	0.0000
b3U	0.0000	-0.6376	a3U	0.0000	-0.2198
b4U	0.0000	-0.2669	a4U	-0.0450	-0.2742
b5U	-0.0550	-0.3217	a5U	-0.0364	-0.1399
b6U	0.0000	-0.1550	a6U	-0.0586	-0.1550
b7U	0.0000	-0.0639	a7U	0.0000	-0.0755
b8U	0.0000	-0.0368	a8U	0.0000	-0.0490
b9U	0.0000	-0.0507	a9U	0.0000	-0.0317
b10U	0.0000	-0.0519	a10U	-0.0195	-0.0260
b11U	0.0000	-0.0198	a11U	-0.0147	-0.0132
b1R	0.0000	0.0000	a1R	0.0000	0.0000
b2R	0.0000	0.0000	a2R	0.0000	0.0000
b3R	0.0000	-0.2394	a3R	0.0000	-0.0849
b4R	0.0000	-0.0841	a4R	0.0000	-0.1060
b5R	0.0000	-0.1026	a5R	0.0000	-0.0606
b6R	0.0000	-0.0642	a6R	0.0000	-0.0535
b7R	0.0000	-0.0291	a7R	0.0000	-0.0349
b8R	0.0000	-0.0184	a8R	0.0000	-0.0184
b9R	0.0000	-0.0190	a9R	0.0000	-0.0127
b10R	0.0000	-0.0195	a10R	0.0000	-0.0130
b11R	0.0000	-0.0066	a11R	0.0000	-0.0066

b3 component shows the largest difference between error tables

Changes - III

Body				
	P	G		P
b1M	0.0000	0.0000	a1M	0.0000
b2M	-0.1224	0.1224	a2M	0.0204
b3M	2.9153	0.0615	a3M	-0.0228
b4M	0.0031	0.0152	a4M	-0.0303
b5M	0.0068	-0.3005	a5M	-0.0093
b6M	-0.0763	0.0763	a6M	-0.0107
b7M	0.8961	-0.6694	a7M	-0.0058
b8M	0.0123	0.0061	a8M	0.0000
b9M	-0.1024	-0.0054	a9M	-0.0059
b10M	0.0065	-0.0324	a10M	0.0130
b11M	0.0463	0.3753	a11M	0.0000
b1U	0.0000	0.0000	a1U	0.0000
b2U	0.0000	0.0000	a2U	0.0000
b3U	-0.9160	-0.7464	a3U	0.0000
b4U	0.0000	-0.0914	a4U	-0.1738
b5U	-0.1201	-0.3776	a5U	0.0000
b6U	0.0000	-0.0642	a6U	0.0000
b7U	-0.0532	-0.1162	a7U	0.0000
b8U	0.0000	-0.0245	a8U	0.0000
b9U	-0.0317	-0.0761	a9U	0.0000
b10U	0.0000	-0.0389	a10U	-0.0195
b11U	-0.0198	-0.0264	a11U	0.0000
b1R	0.0000	0.0000	a1R	0.0000
b2R	0.0000	0.0000	a2R	0.0000
b3R	-0.1696	-0.3960	a3R	0.0000
b4R	0.0000	-0.0329	a4R	0.0000
b5R	-0.0425	-0.1911	a5R	0.0000
b6R	0.0000	-0.0214	a6R	0.0000
b7R	0.0000	-0.0639	a7R	0.0000
b8R	0.0000	-0.0061	a8R	0.0000
b9R	0.0000	-0.0317	a9R	0.0000
b10R	0.0000	-0.0130	a10R	0.0000
b11R	0.0000	-0.0132	a11R	0.0000

b3 component shows the largest difference between error tables

Changes - IV

Return end				
	P	G		P
b1M	0.0000	0.0000	a1M	0.0000
b2M	0.0000	0.0000	a2M	0.0000
b3M	0.4635	-1.3230	a3M	0.0065
b4M	-0.0037	0.0000	a4M	0.0877
b5M	-0.0699	-0.0140	a5M	0.0047
b6M	0.0267	-0.0160	a6M	0.0107
b7M	-0.0581	0.0232	a7M	0.0000
b8M	0.0000	0.0184	a8M	0.0000
b9M	0.0000	0.1078	a9M	0.0000
b10M	0.0000	0.0454	a10M	0.0000
b11M	0.0000	0.0791	a11M	0.0000
b1U	0.0000	0.0000	a1U	0.0000
b2U	0.0000	0.0000	a2U	0.0000
b3U	0.0000	-0.5810	a3U	-0.0313
b4U	0.0000	-0.1316	a4U	0.0000
b5U	0.0000	-0.3077	a5U	0.0000
b6U	0.0000	-0.0909	a6U	0.0000
b7U	0.0000	-0.0755	a7U	0.0000
b8U	-0.0237	-0.0429	a8U	0.0000
b9U	0.0000	-0.0507	a9U	0.0000
b10U	0.0000	-0.0519	a10U	0.0000
b11U	0.0000	-0.0264	a11U	0.0000
b1R	0.0000	0.0000	a1R	0.0000
b2R	0.0000	0.0000	a2R	0.0000
b3R	0.0000	-0.2524	a3R	0.0000
b4R	0.0000	-0.0585	a4R	0.0000
b5R	0.0000	-0.1072	a5R	0.0000
b6R	0.0000	-0.0321	a6R	0.0000
b7R	0.0000	-0.0349	a7R	0.0000
b8R	0.0000	-0.0184	a8R	0.0000
b9R	0.0000	-0.0190	a9R	0.0000
b10R	0.0000	-0.0260	a10R	0.0000
b11R	0.0000	-0.0066	a11R	0.0000

b3 component shows the largest difference between error tables

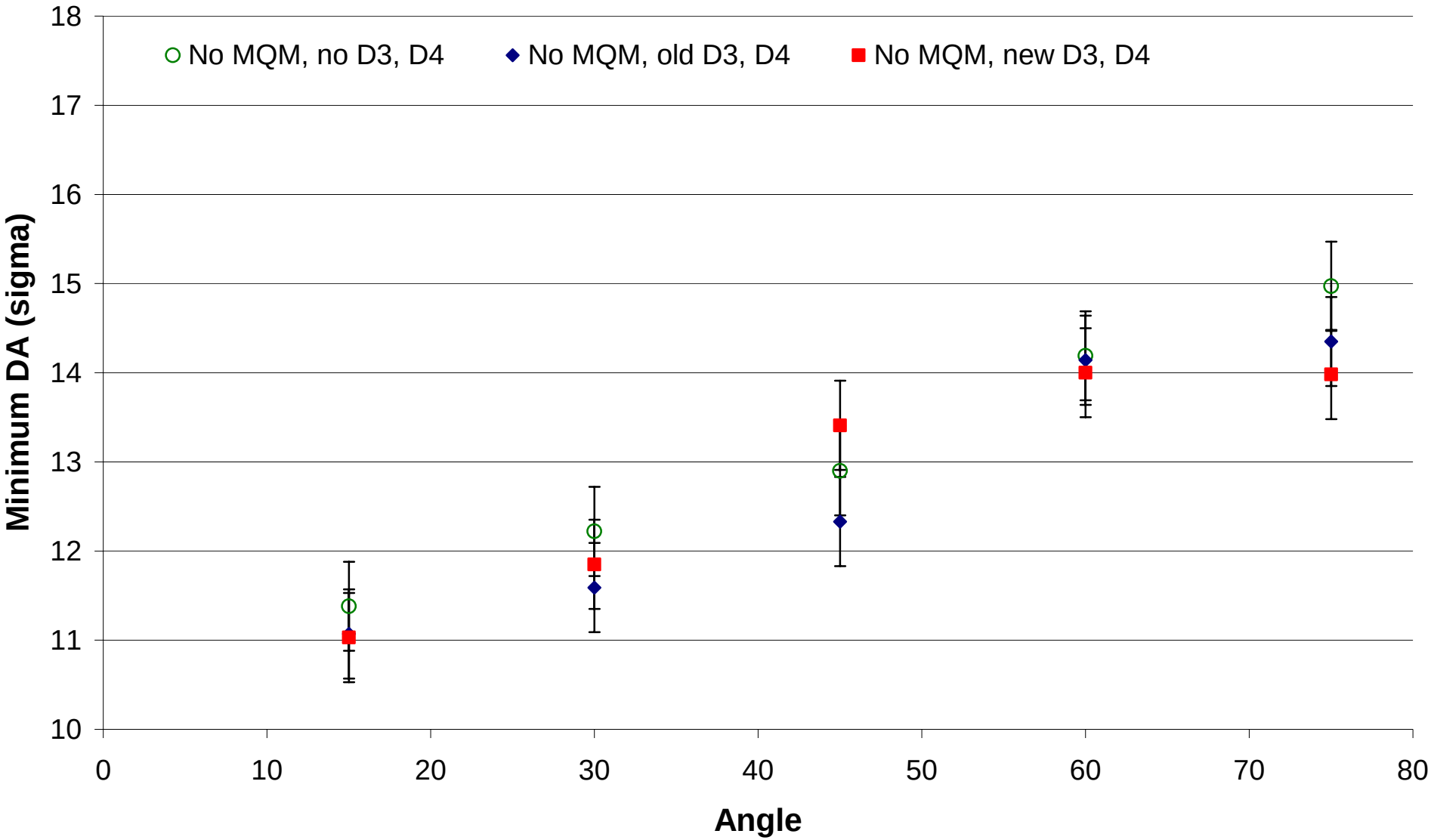
Changes - V

- D4:
  - No difference found between Lead/Return End effects in present error tables and in official documents (injection/collision).
  - Differences are in the body (mean and uncertainty)

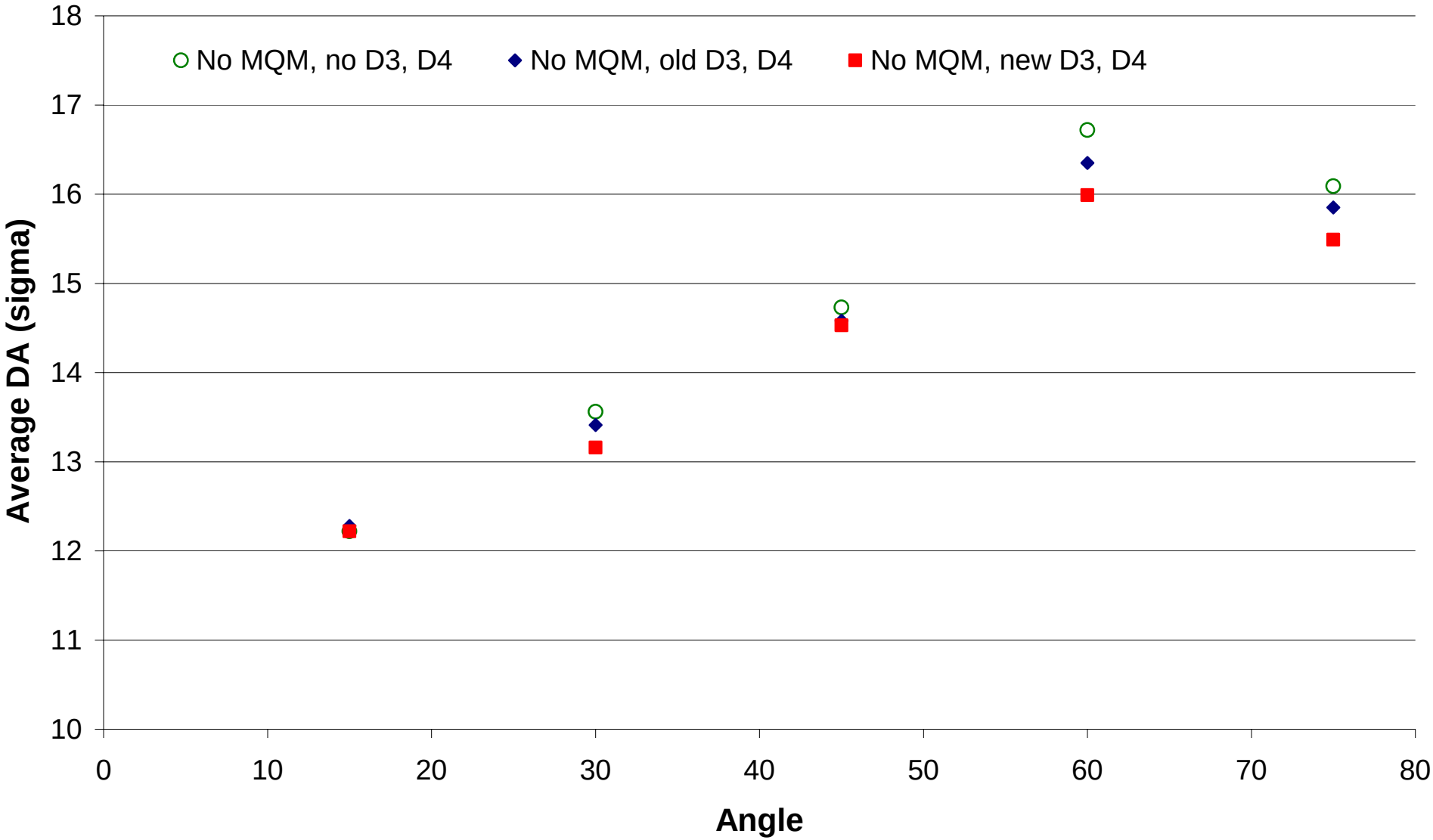
	P	G		P	G
b1M	0.0000	0.0000	a1M	0.0000	0.0000
b2M	0.4020	0.1210	a2M	0.1860	-0.1070
b3M	4.0430	-0.7350	a3M	-0.0010	0.3490
b4M	-0.0050	0.0040	a4M	0.0080	-0.0270
b5M	-0.0020	-0.0560	a5M	0.0010	-0.0540
b6M	-0.0019	0.0030	a6M	0.0023	-0.0046
b7M	0.0281	-0.0095	a7M	-0.0004	0.0097
b8M	0.0003	-0.0004	a8M	-0.0005	-0.0001
b9M	-0.0028	0.0005	a9M	0.0000	-0.0015
b10M	0.0003	0.0001	a10M	-0.0001	0.0000
b11M	0.0018	0.0005	a11M	0.0000	0.0000
b1U	0.0000	0.0000	a1U	0.0000	0.0000
b2U	0.4779	0.3280	a2U	-0.0374	0.0000
b3U	-1.0385	-0.0150	a3U	-0.0100	0.0000
b4U	-0.0017	0.0000	a4U	-0.0019	0.0000
b5U	-0.0063	0.0000	a5U	0.0000	0.0000
b6U	0.0000	0.0000	a6U	-0.0002	0.0000
b7U	-0.0084	-0.0001	a7U	0.0000	0.0000
b8U	0.0000	0.0000	a8U	-0.0002	0.0000
b9U	-0.0010	0.0000	a9U	0.0000	0.0000
b10U	0.0000	0.0000	a10U	0.0000	0.0000
b11U	-0.0004	0.0000	a11U	0.0000	0.0000

	P	G		P	G
b1M	0.0000	0.0000	a1M	0.0000	0.0000
b2M	-0.5720	0.0760	a2M	0.2030	-0.1240
b3M	3.9470	-0.6390	a3M	0.0030	0.3450
b4M	0.0480	-0.0490	a4M	0.0060	-0.0250
b5M	0.0260	-0.0840	a5M	0.0010	-0.0540
b6M	0.0059	-0.0049	a6M	0.0028	-0.0051
b7M	0.0250	-0.0064	a7M	-0.0006	0.0099
b8M	0.0007	-0.0008	a8M	-0.0003	-0.0003
b9M	-0.0027	0.0004	a9M	0.0001	-0.0016
b10M	0.0003	0.0001	a10M	-0.0001	0.0000
b11M	0.0018	0.0005	a11M	0.0001	-0.0001
b1U	0.0000	0.0000	a1U	0.0000	0.0000
b2U	0.4812	0.3220	a2U	-0.0446	0.0010
b3U	-1.0484	0.0040	a3U	-0.0445	0.0180
b4U	-0.0003	-0.0010	a4U	-0.0068	0.0030
b5U	-0.0092	0.0010	a5U	-0.0070	0.0030
b6U	0.0000	-0.0003	a6U	-0.0005	0.0002
b7U	-0.0084	-0.0002	a7U	-0.0004	0.0004
b8U	-0.0005	0.0002	a8U	0.0002	-0.0002
b9U	-0.0010	0.0000	a9U	-0.0001	0.0001
b10U	0.0001	-0.0001	a10U	0.0000	0.0000
b11U	-0.0004	0.0000	a11U	0.0000	0.0000

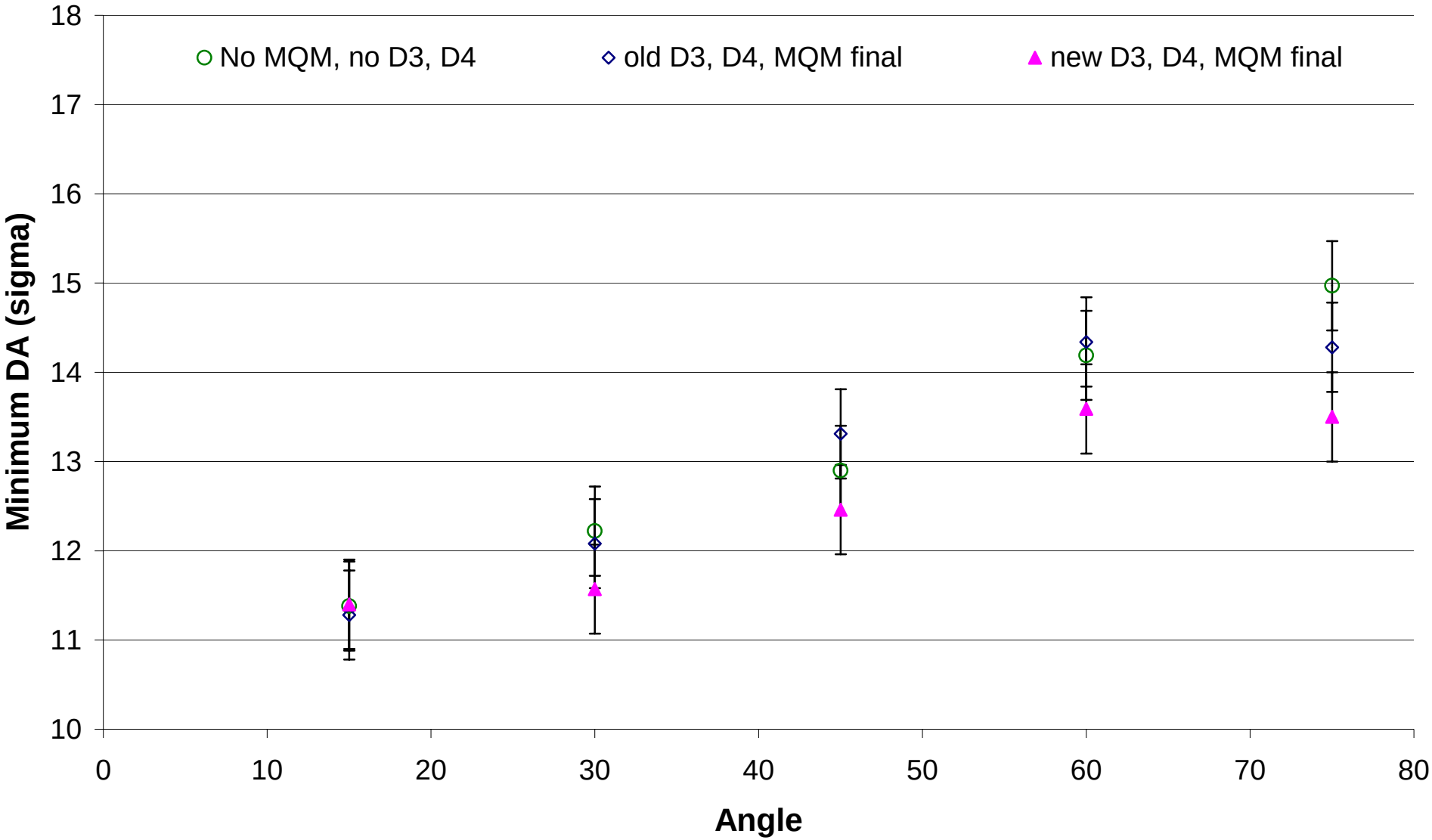
Impact on DA - I



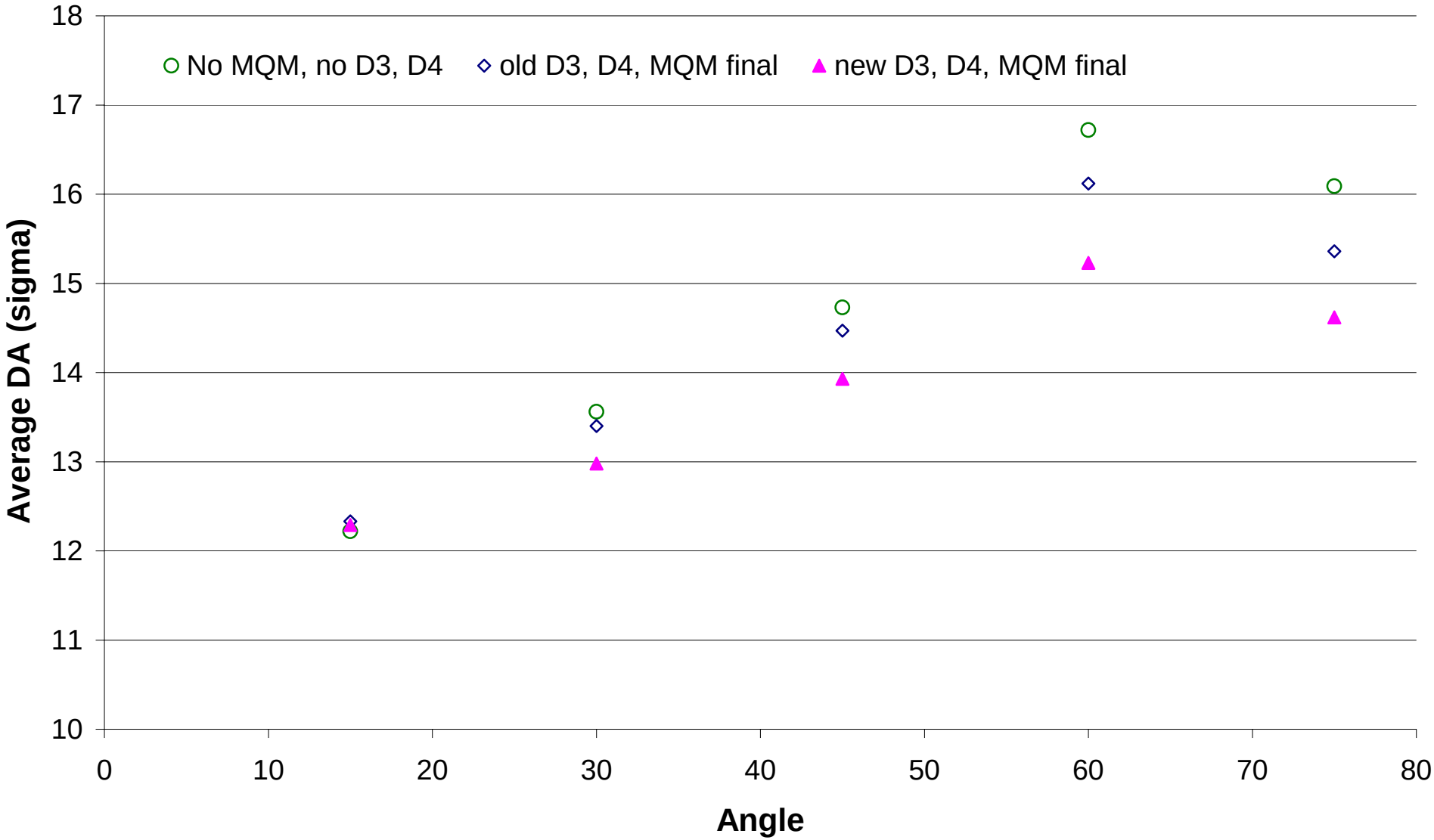
Impact on DA - II



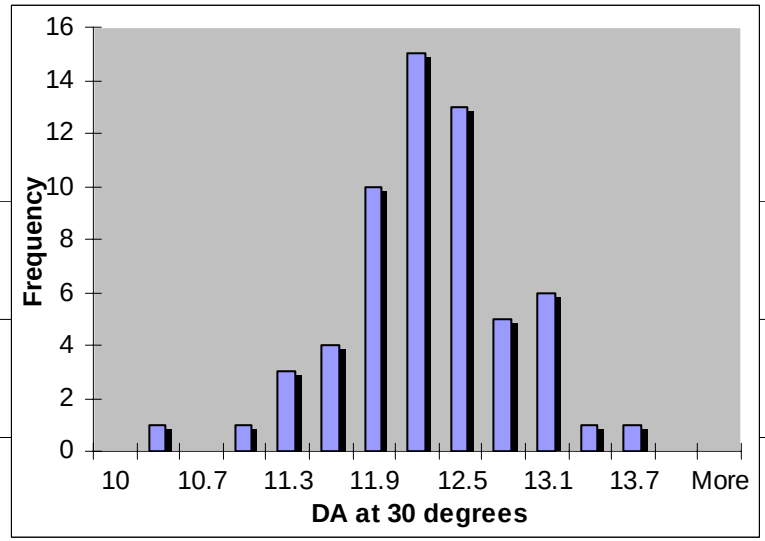
Impact on DA - III



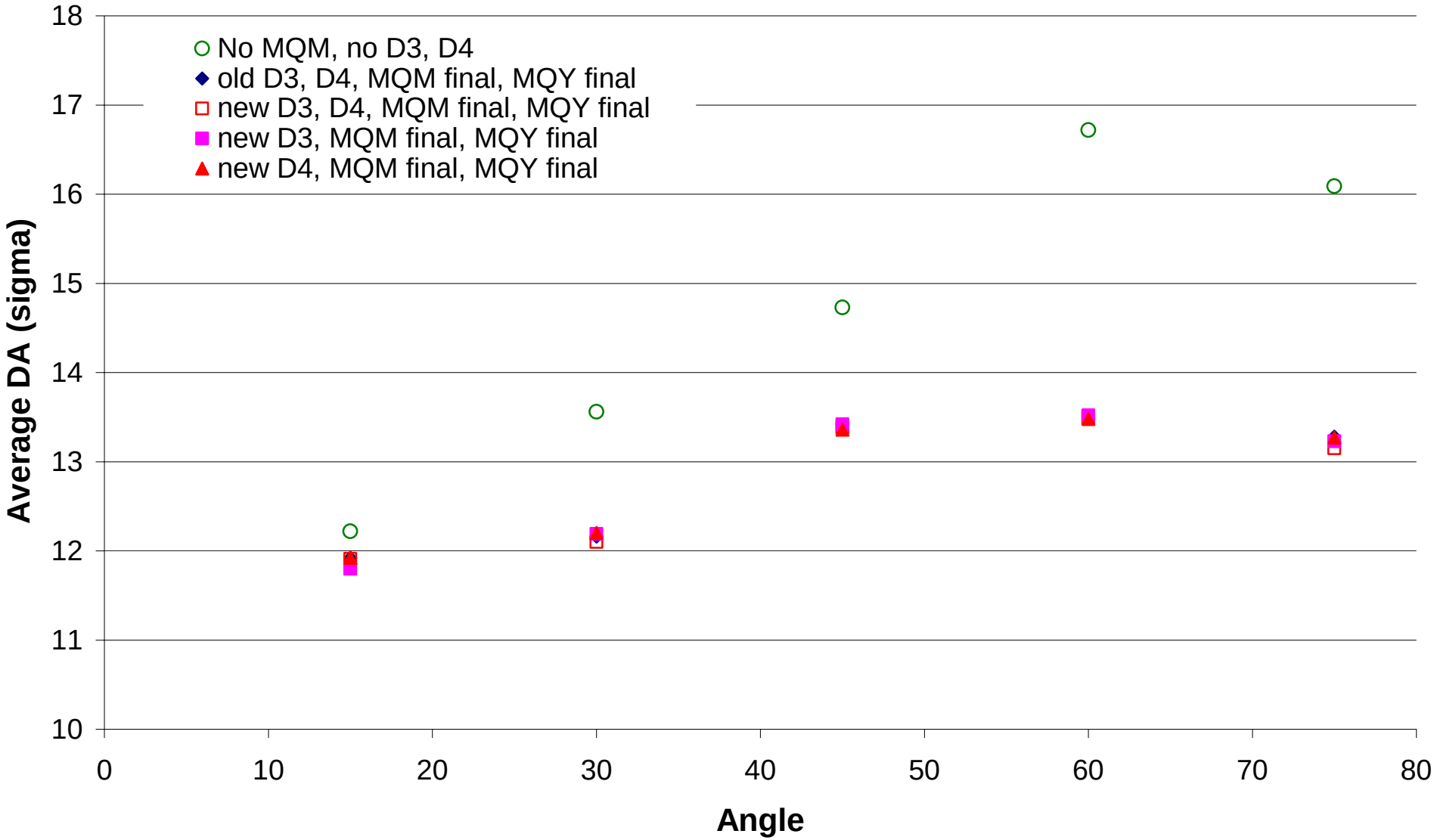
Impact on DA - IV



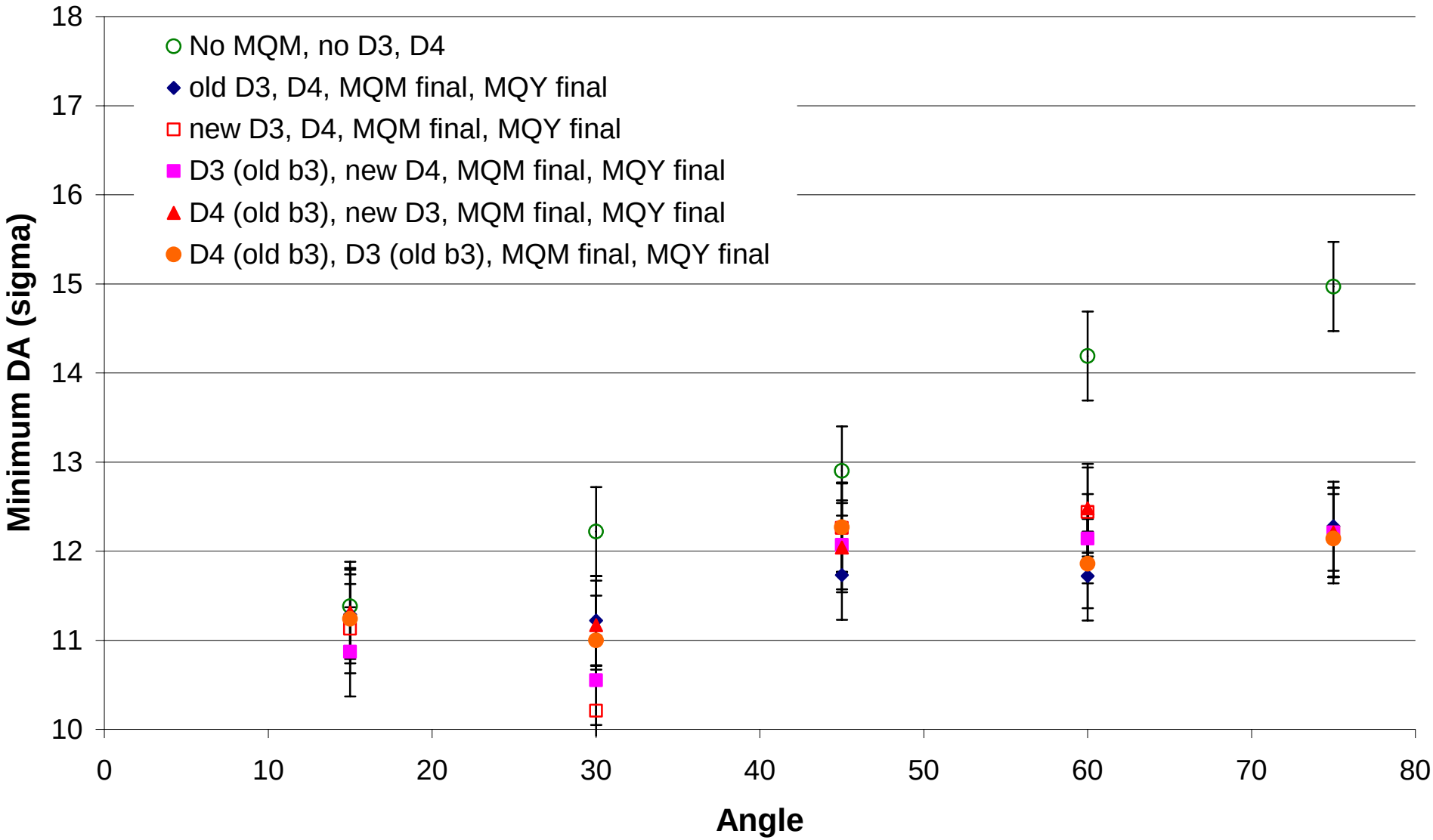
Impact on DA - V



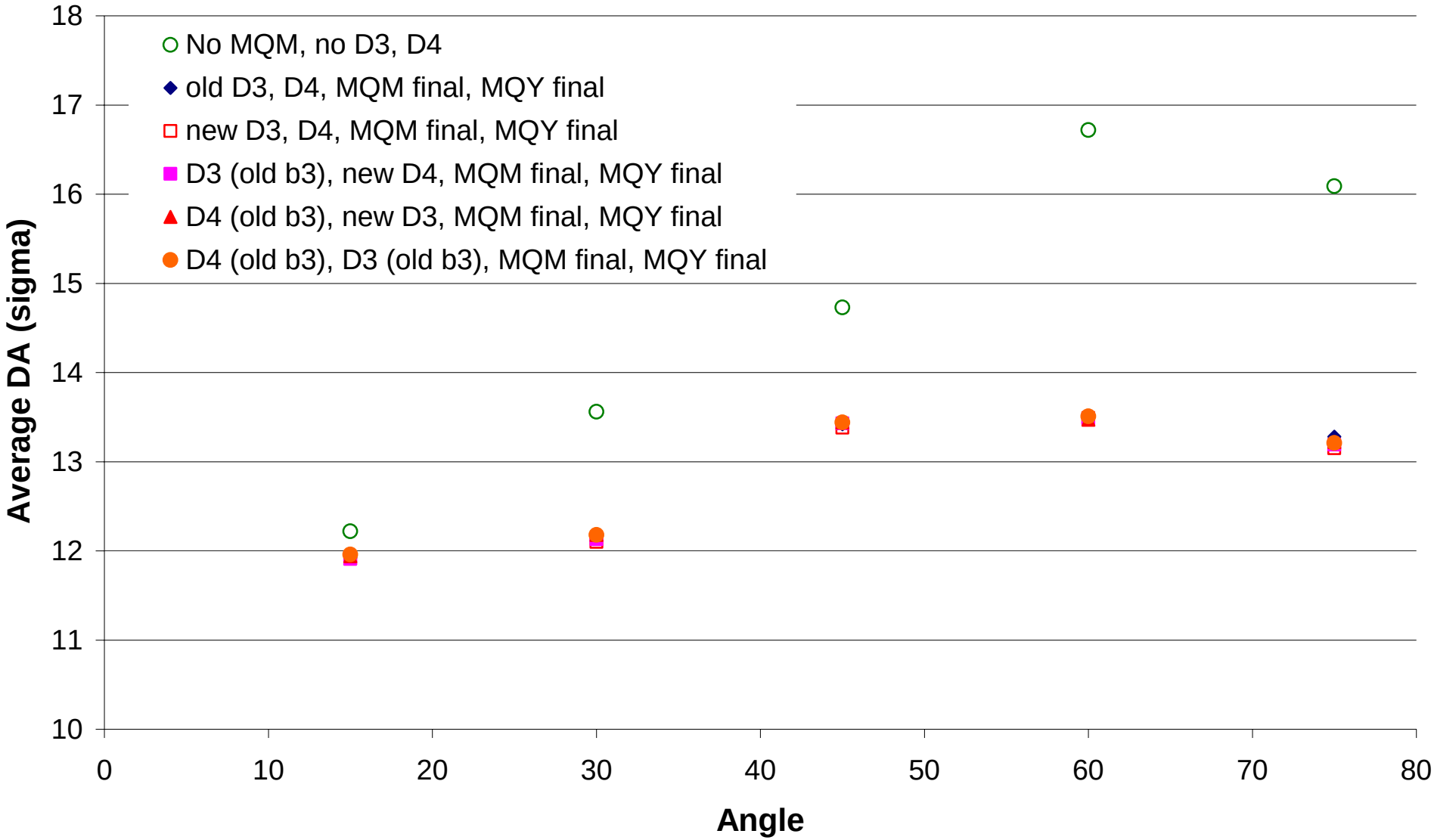
Impact on DA - VI



Impact on DA - VII



Impact on DA - VIII



What do we know about D4 FQ (at cold)?

Comparison of Field Quality in D4L102 with the Expected Ver 2.0 Tables

Expected Ver 2.0 Table (at 25 mm radius)

Integral Harmonics at 315A (0.2 Tesla)

n	<bn>(L)	<bn>(R)	Δ (bn)	σ (bn)	<an>	Δ (an)	σ (an)
2	4.08	-5.07	1.97	0.63	-0.03	5.99	1.56
3	-22.28	-22.28	1.87	1.50	-0.72	0.74	0.44
4	-0.08	-0.56	0.36	0.20	-0.84	0.65	0.41
5	1.17	1.17	1.20	0.85	0.21	0.25	0.18
6	0.04	-0.16	0.20	0.12	0.10	0.67	0.39
7	-0.40	-0.40	0.16	0.11	-0.13	0.08	0.05
8	-0.03	-0.03	0.04	0.03	-0.01	0.27	0.17
9	0.16	0.16	0.15	0.10	0.03	0.03	0.02
10	-0.03	-0.03	0.08	0.04	0.02	0.08	0.05
11	-0.77	-0.77	0.03	0.02	0.02	0.02	0.01

Measured Data in D4L102

Integral; 0.2 Tesla (interpolated) at 25 mm radius

n	bn(L)	bn(R)	an(L)	an(R)
2	6.10	-5.50	-0.39	-1.29
3	-15.00	-14.48	-0.44	-0.58
4	0.50	-0.37	0.68	-0.94
5	0.88	0.89	0.34	0.31
6	0.01	-0.01	0.06	-0.09
7	-0.25	-0.19	-0.04	-0.06
8	-0.01	-0.01	0.01	-0.01
9	-0.02	0.00	0.04	0.05
10	0.06	-0.02	0.07	0.12
11	-0.77	-0.71	-0.01	0.03

n	bn(L)	bn(R)	an(L)	an(R)
2	OK	OK	OK	OK
3	??	??	OK	OK
4	??	OK	??	OK
5	OK	OK	OK	OK
6	OK	OK	OK	OK
7	OK	OK	OK	OK
8	OK	OK	OK	OK
9	OK	OK	OK	OK
10	OK	OK	OK	OK
11	OK	??	OK	OK

Expected Ver 2.0 Table (at 25 mm radius)

Integral Harmonics at 3.8 Tesla (6000 A)

n	<bn>(L)	<bn>(R)	Δ (bn)	σ (bn)	<an>	Δ (an)	σ (an)
2	-0.50	-0.77	1.02	0.32	-0.67	5.94	1.55
3	-4.17	-4.17	1.63	1.47	-0.84	0.69	0.43
4	-0.01	-0.63	0.29	0.18	-0.38	0.56	0.40
5	-0.13	-0.13	1.14	0.85	0.21	0.24	0.18
6	0.04	-0.17	0.05	0.03	-0.02	0.58	0.38
7	0.15	0.15	0.12	0.10	-0.11	0.06	0.05
8	0.00	-0.04	0.03	0.03	0.01	0.25	0.17
9	-0.09	-0.09	0.13	0.10	0.05	0.02	0.01
10	-0.01	-0.01	0.05	0.03	0.00	0.05	0.03
11	-0.62	-0.62	0.02	0.01	0.00	0.03	0.02

Measured Data in D4L102

Integral; 3.8 Tesla (6000 A) at 25 mm radius

n	bn(L)	bn(R)	an(L)	an(R)
2	0.22	0.16	0.30	-2.00
3	-1.54	-0.94	-0.37	-0.45
4	0.42	-0.21	0.55	-0.44
5	0.21	0.46	0.34	0.32
6	0.09	-0.10	0.19	-0.11
7	0.21	0.26	-0.04	-0.06
8	0.02	-0.04	0.02	0.02
9	-0.18	-0.16	0.05	0.06
10	0.06	-0.03	0.05	0.08
11	-0.64	-0.60	0.00	0.00

n	bn(L)	bn(R)	an(L)	an(R)
2	OK	OK	OK	OK
3	OK	??	OK	OK
4	OK	OK	OK	OK
5	OK	OK	OK	OK
6	OK	OK	OK	OK
7	OK	OK	OK	OK
8	OK	OK	OK	OK
9	OK	OK	OK	OK
10	OK	OK	OK	OK
11	OK	OK	OK	OK

OK=Value between (mean–Δ–σ) & (mean+Δ+σ)

Conclusions

- D3 and D4 field quality needs a close look
  - In general b3 component is found to have a sizeable impact on DA
  - D4s seem to have larger impact on DA
  - Measurement results seem to indicate that b3 component is smaller than the value quoted in expected error table