Results of recent beam-beam simulation studies

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Contents

1 COLLISION optics

1.1 Conditions for tracking

- version 6.5 at collision; Sixtrack with beam-beam
- tune range $(0.3 - 0.33)$ along a line parallel to the diagonal: split $Q_x - Q_y = 0.01$; step $\Delta Q_x = 0.0005$
- nominal beam-beam in ALL β^* cases; $\boldsymbol{N_p = 1.15 \times 10^{11}}$; 10^6 turns
- bb only – no triplet err. *(no seeds: disregard "min")*
- increase β^* and vary crossing angle

1.2 Matching

- match β^* and crossing angle α in IP1 and IP5 for both beams
- removed IP offset
- keep tune across each IR for each beam
- max strengths as in db; kqx changed for 2m; antisymmetry respected for kqx,4,5,6

1.3 What is shown:

- section names $= \beta^*$ [m], full crossing angle 2α [mrad] and sep. value d[σ] as found from scaling: $\boldsymbol{d = d_0 \frac{\alpha}{\alpha_0} \sqrt{\frac{\beta^*}{\beta^*_0}}}$

  for example: `0.55 0.285 d=9.4`

- Chaos border and Dynamic Aperture (DA) as functions of unperturbed tune Q_x for 17 init. angles in $x - y$ plane
- separation plotted at all HO + LR crossings in IR1 in units of weak-beam sigma;
- Luminosity L in units 10^{33} (see next page) ;
- footprint: from 0 to 6σ

$$L = \frac{1}{4\pi\beta^*\epsilon} N_p^2 k_b f \gamma F(\alpha, \beta^*) 10^{-4}; \qquad F(\alpha, \beta^*) = \frac{1}{\sqrt{1+(0.077\frac{\alpha}{\sqrt{\beta^*\epsilon}})^2}}$$

α is half of the crossing angle in rad;

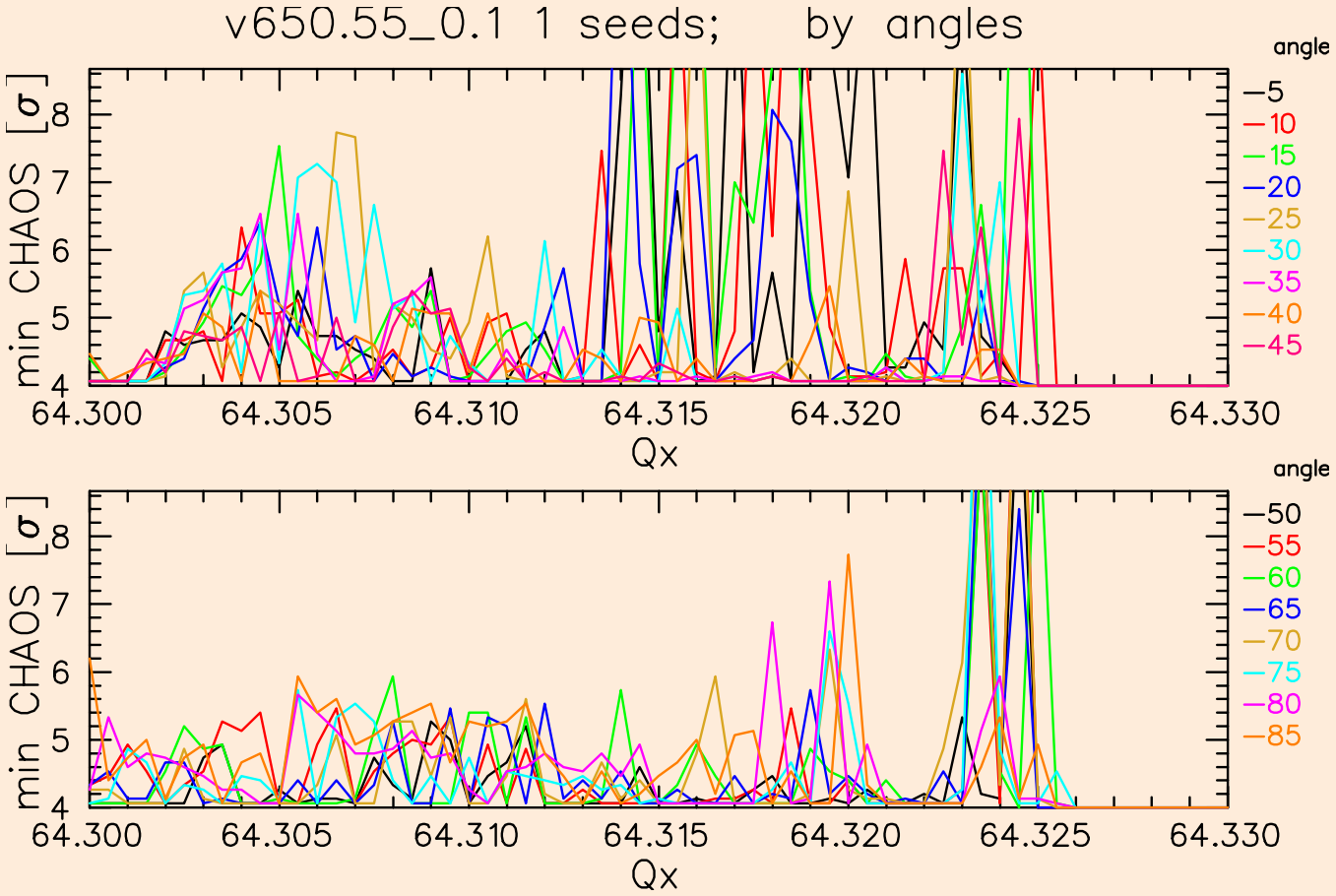
$\beta*$ is beta at IP;

$N_p = 1.1510^{11}$, $f = 11245.5$, $k_b = 2835$, $\epsilon = 3.7510^{-6}/\gamma$

$\gamma = 7000/0.938$.

2 0.55m 0.2 d=6.6

2.1 Chaos



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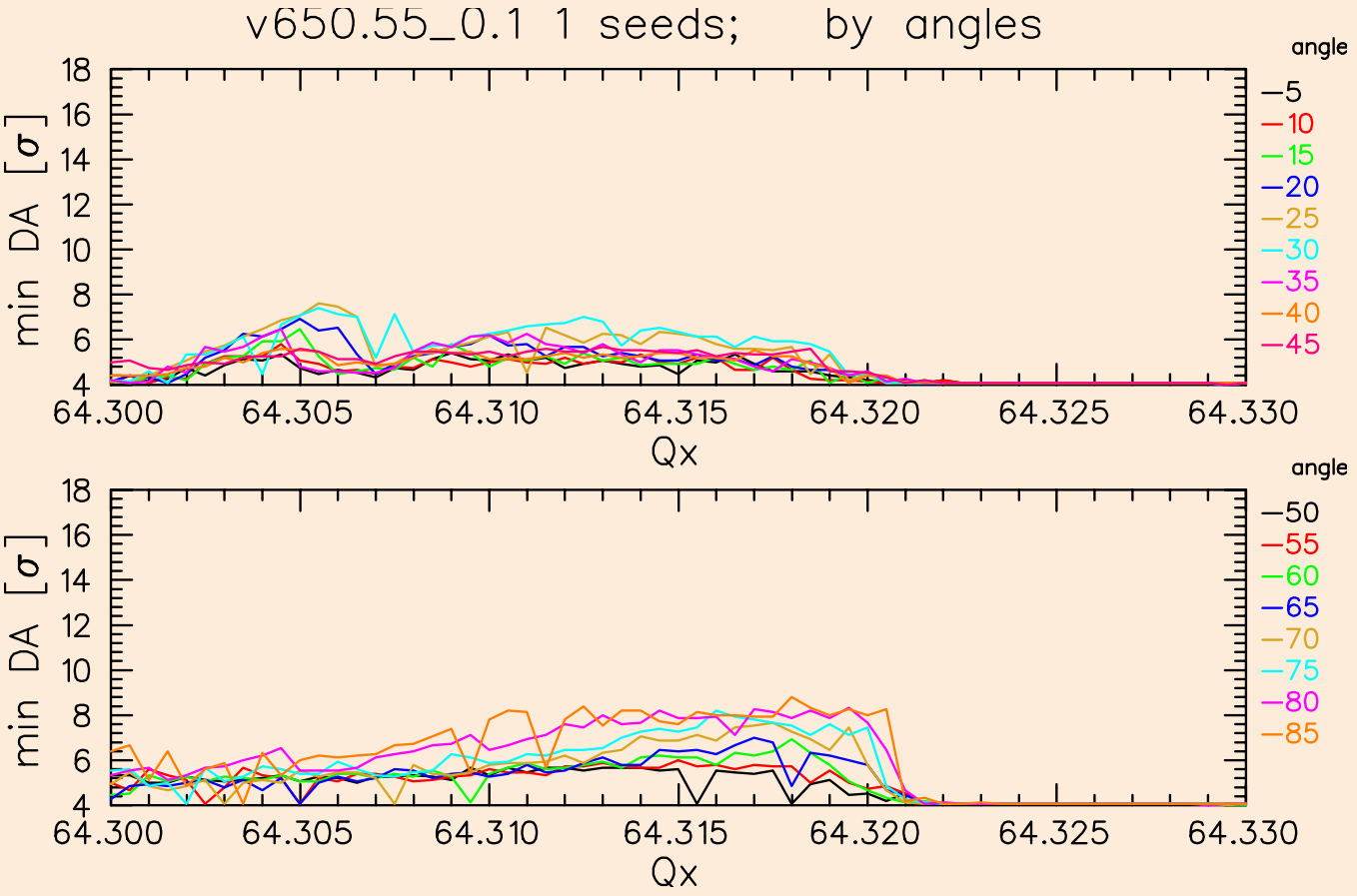
2.2 DA; d=6.6



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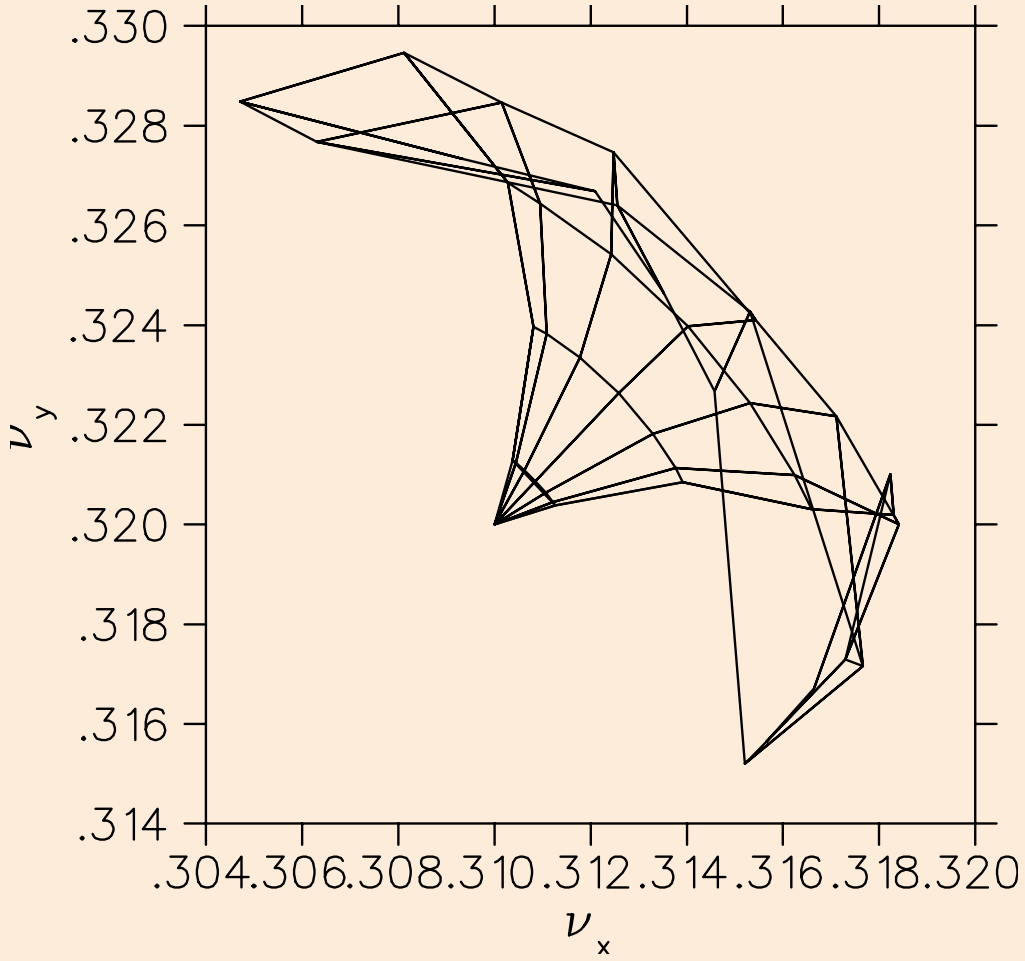
2.3 foot



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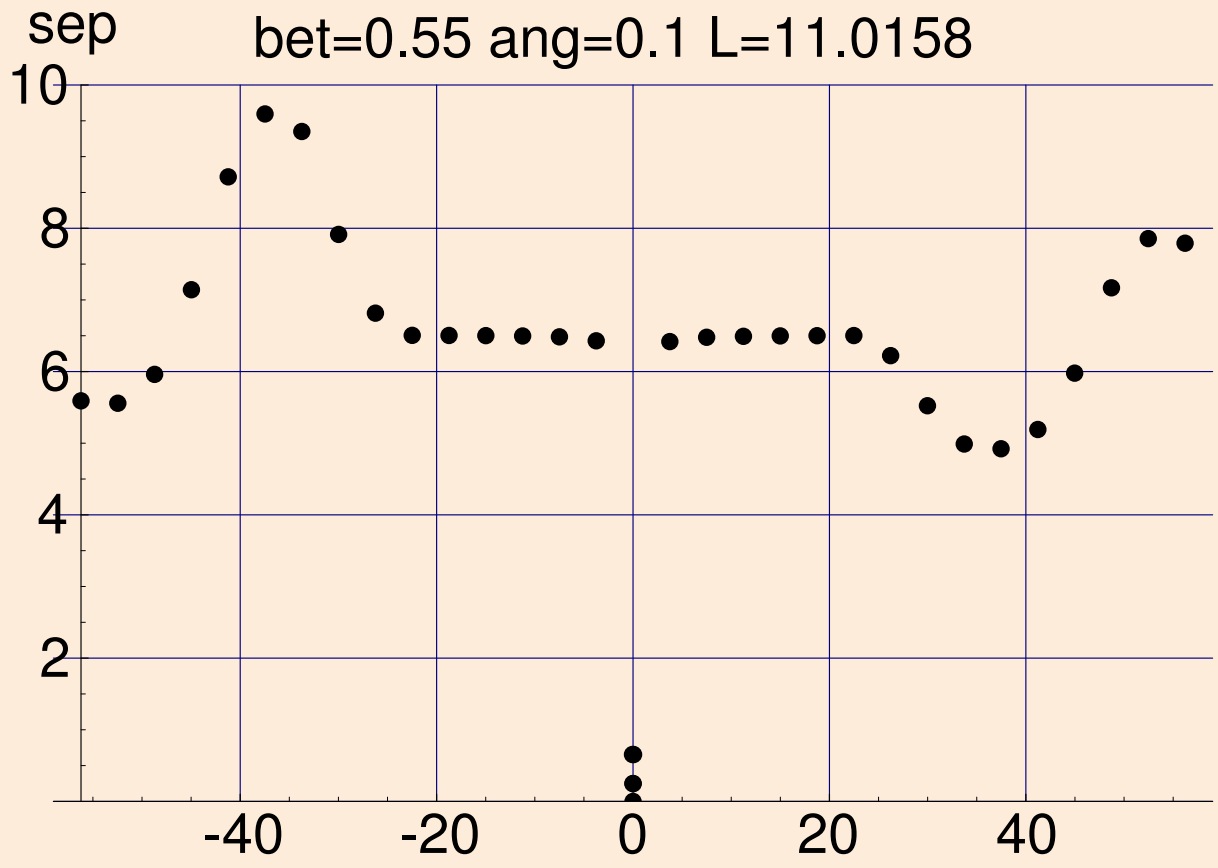
2.4 separation



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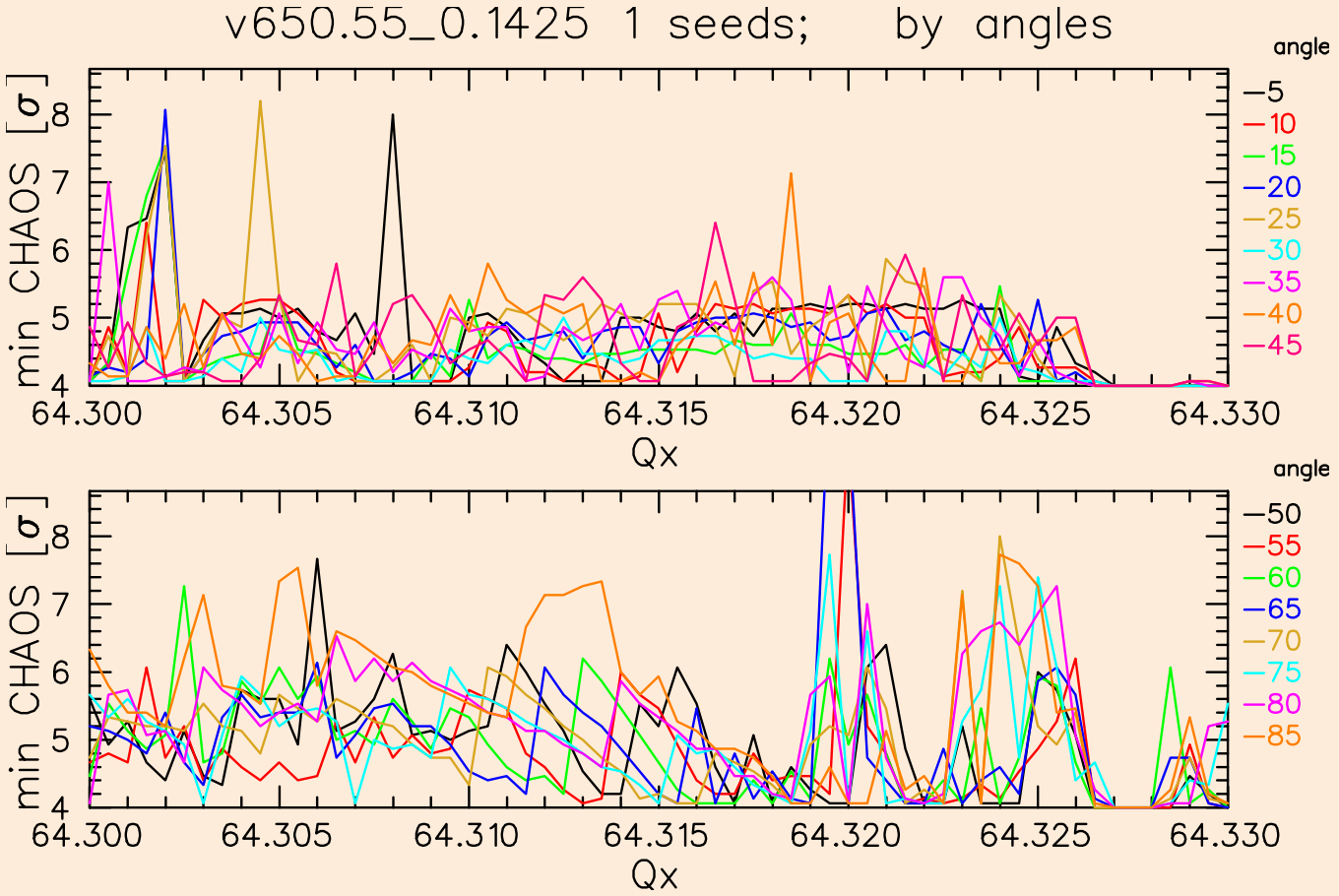
3 0.55m 0.285 d=9.4

3.1 Chaos



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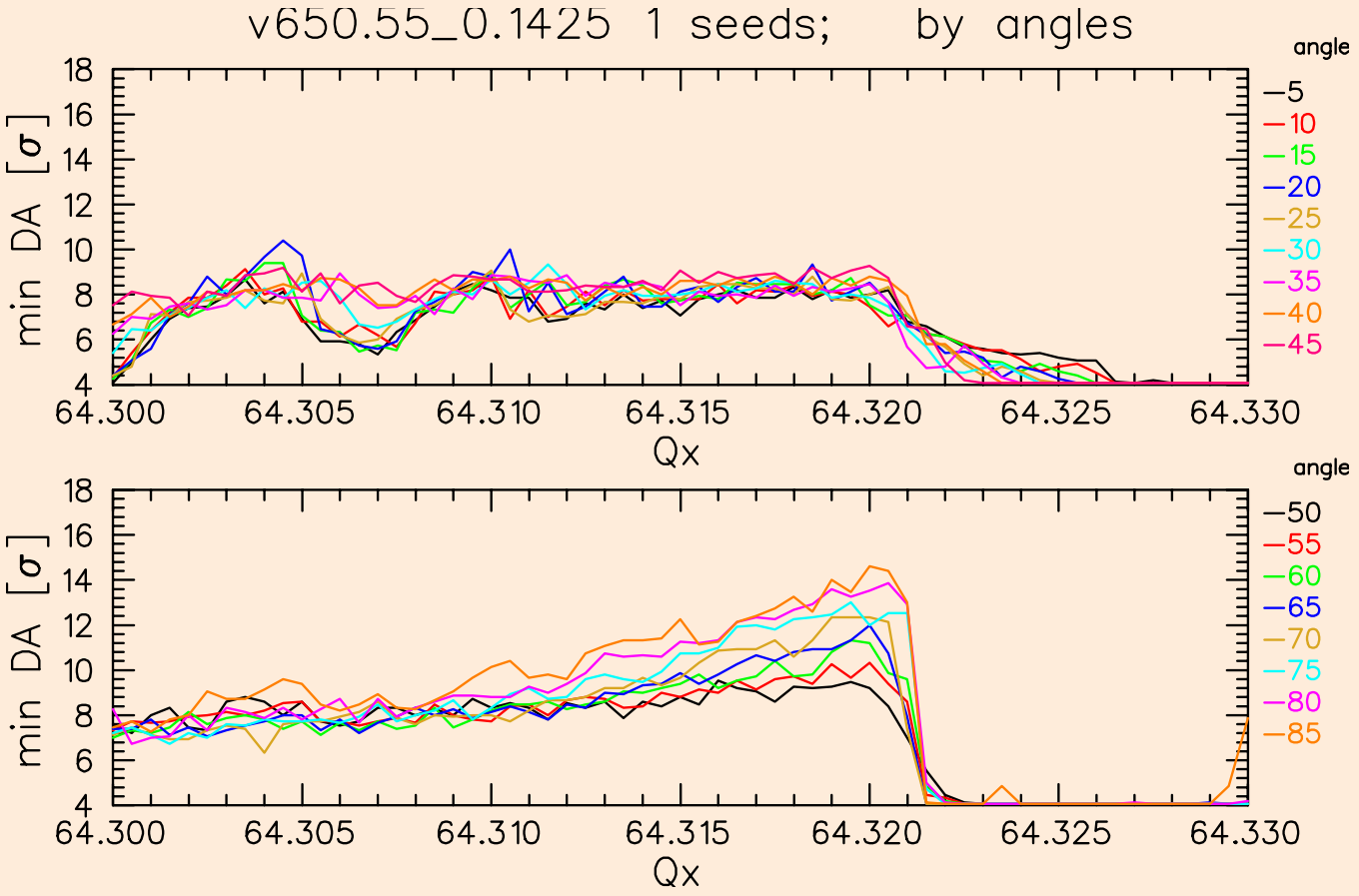
3.2 DA; d=9.4



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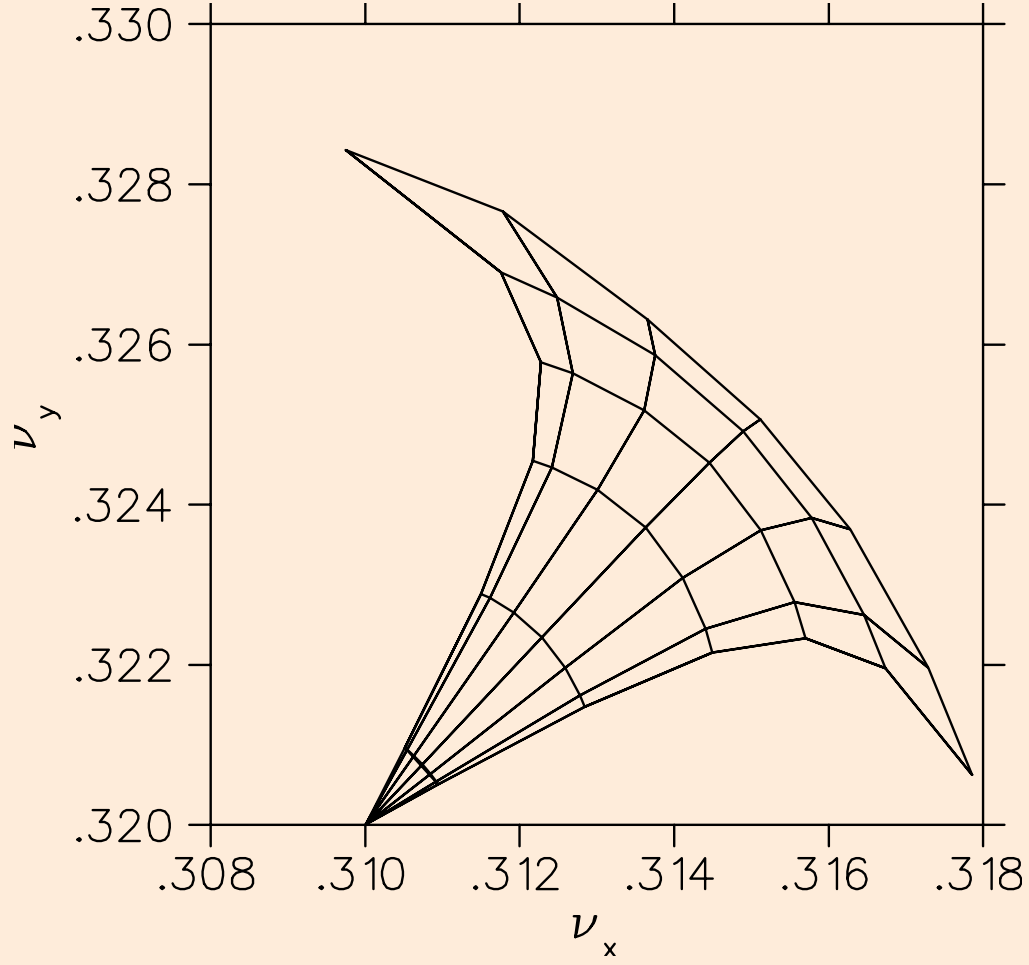
3.3 foot



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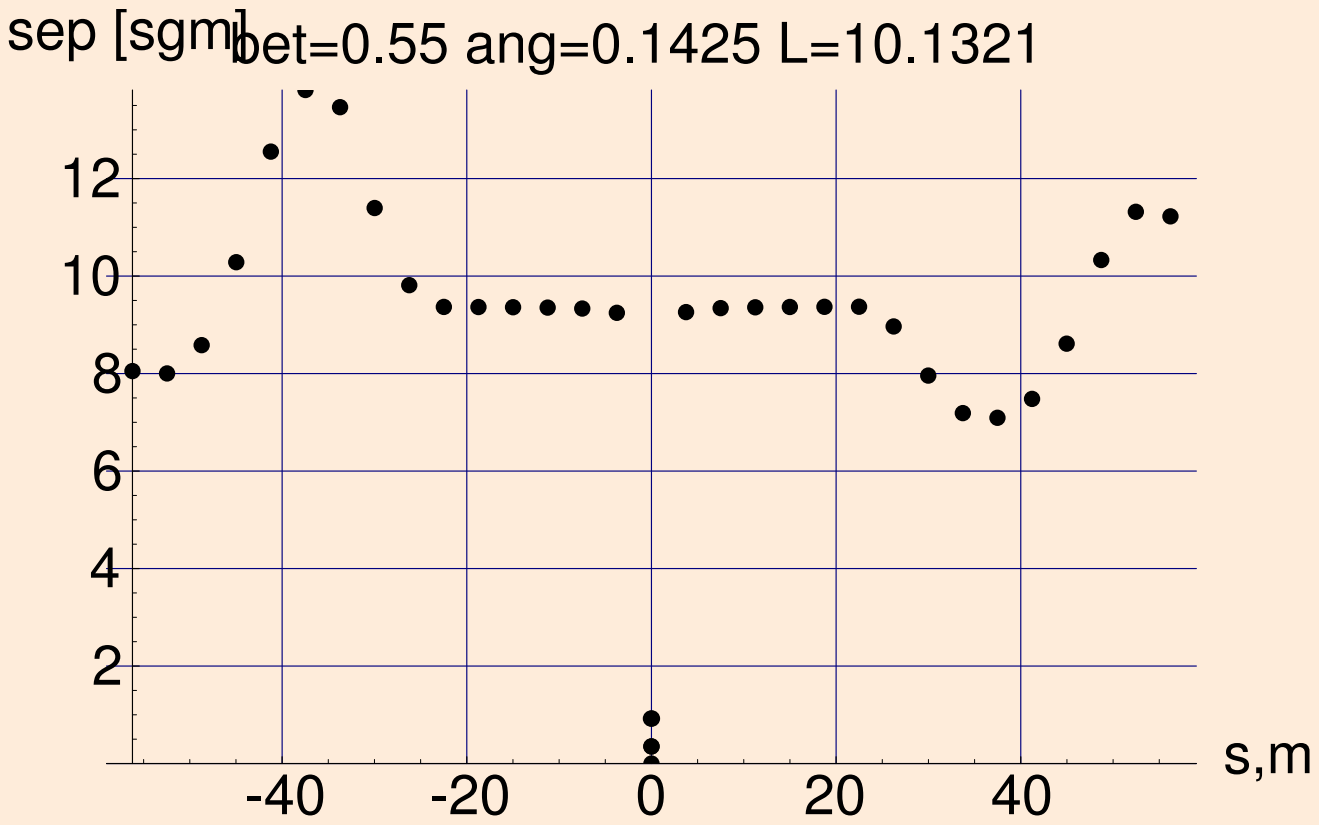
3.4 separation



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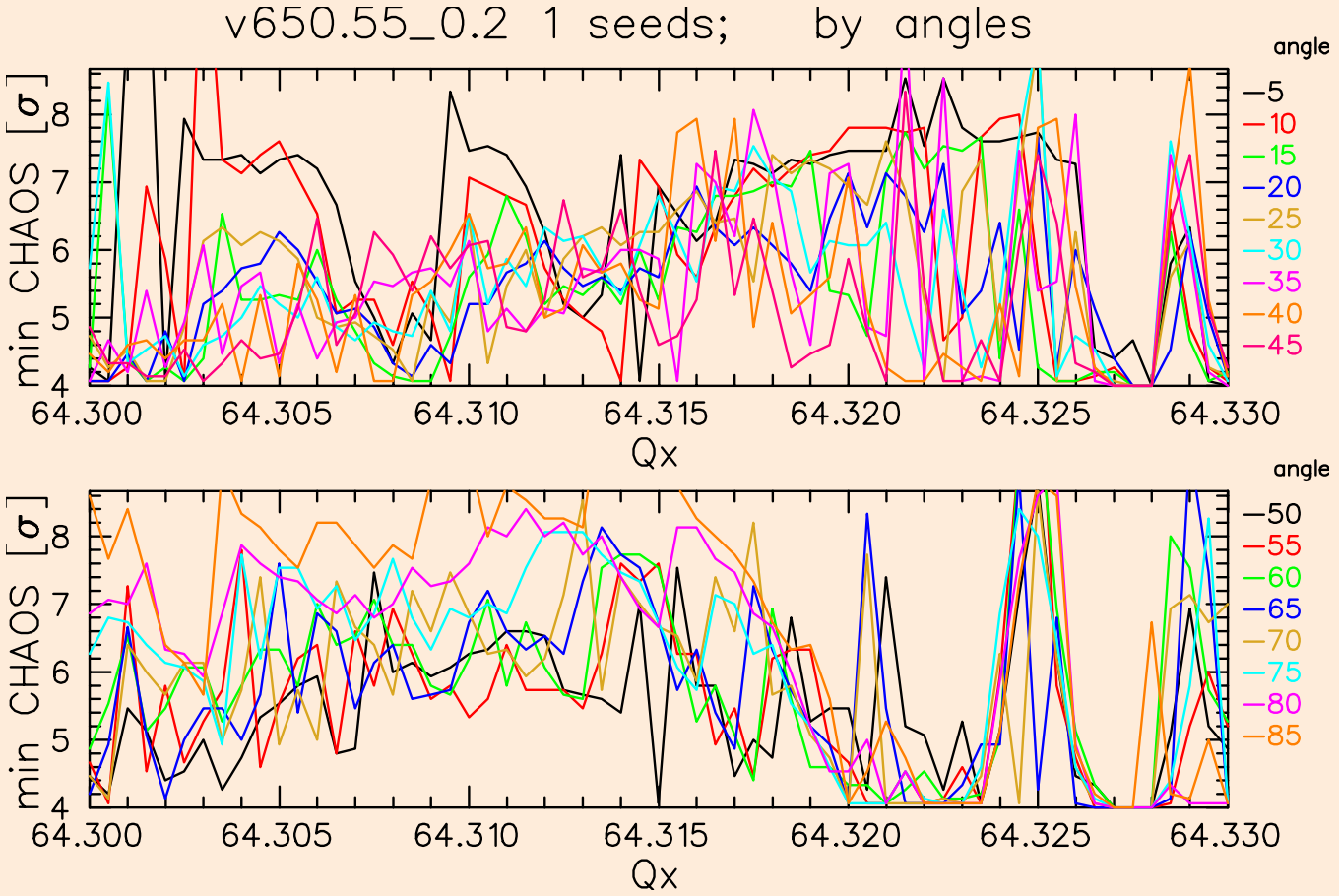
4 0.55m 0.4 d=13.2

4.1 Chaos



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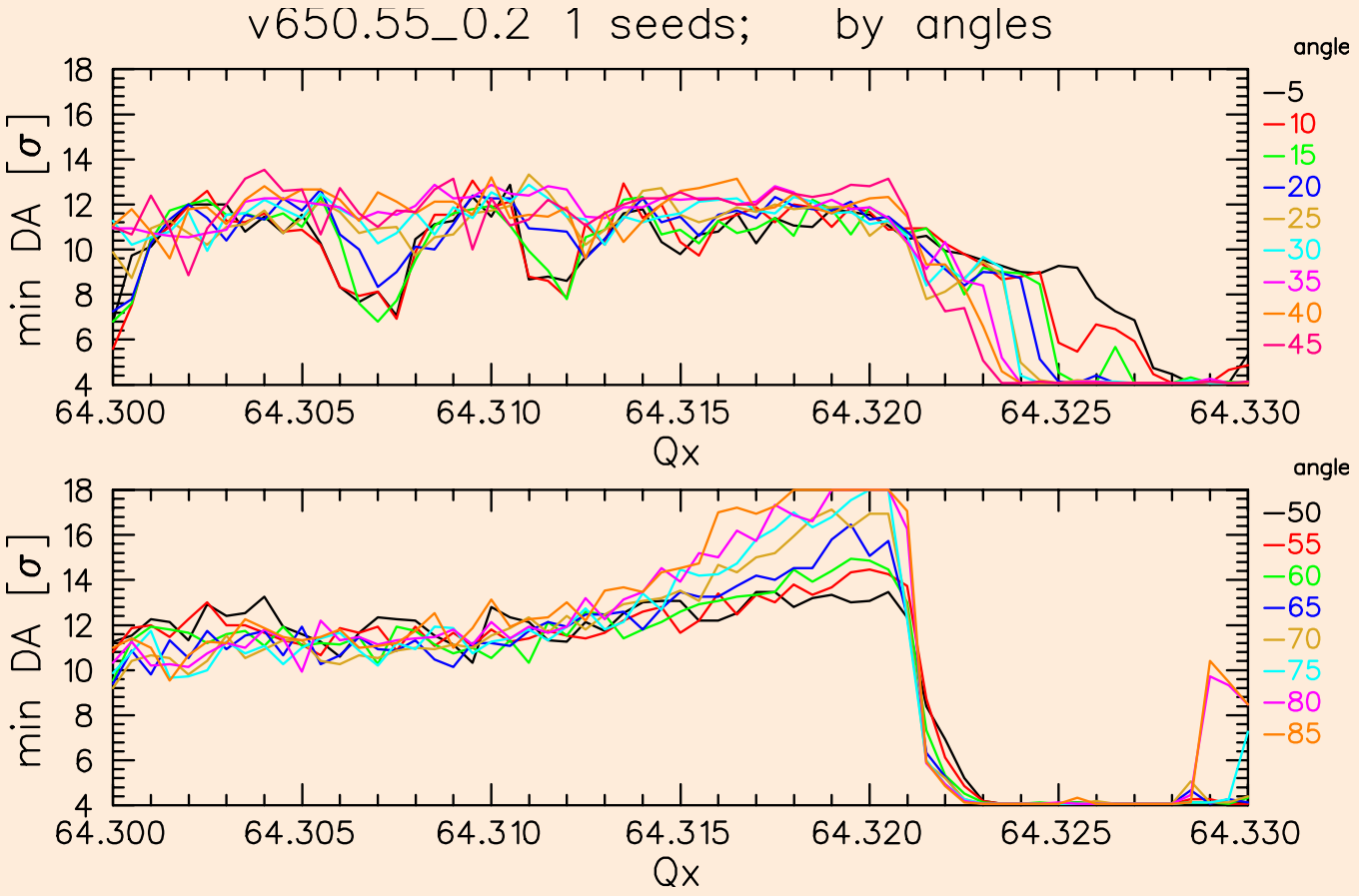
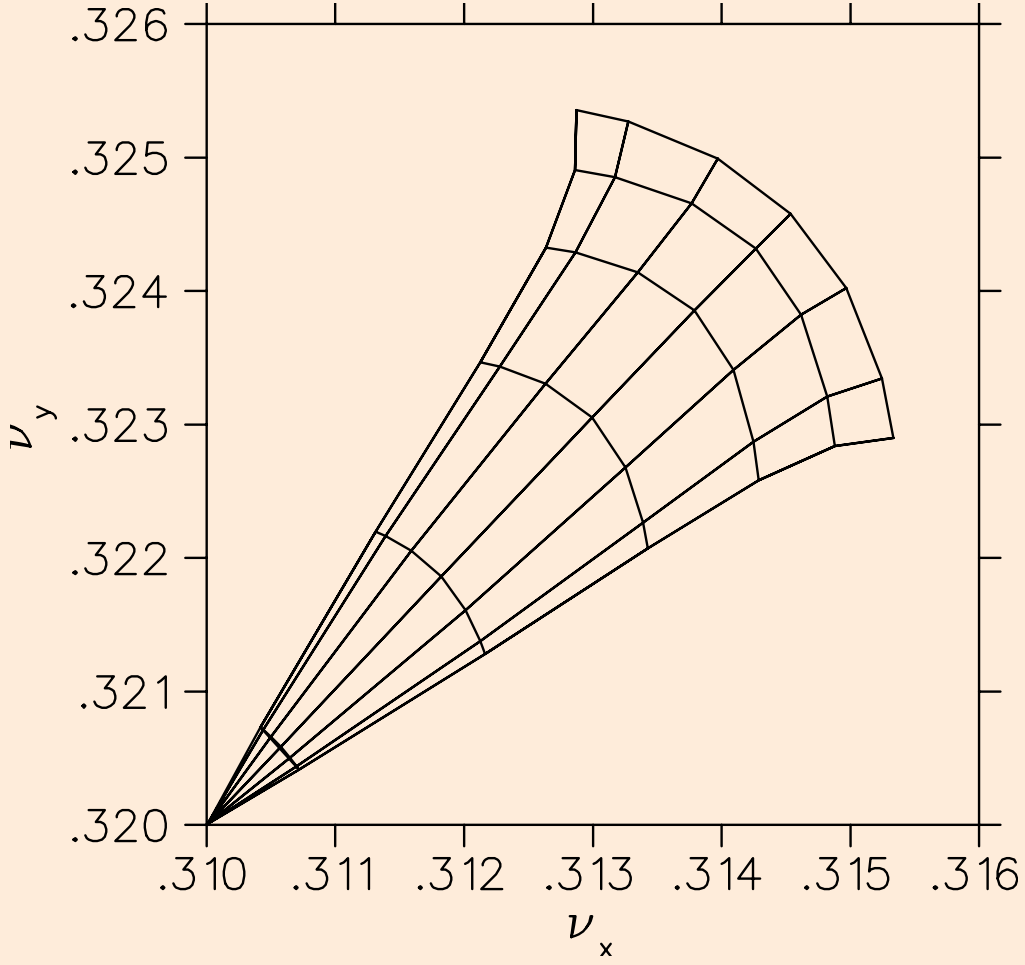
4.2 DA; d=13.2



get eps

4.3 foot



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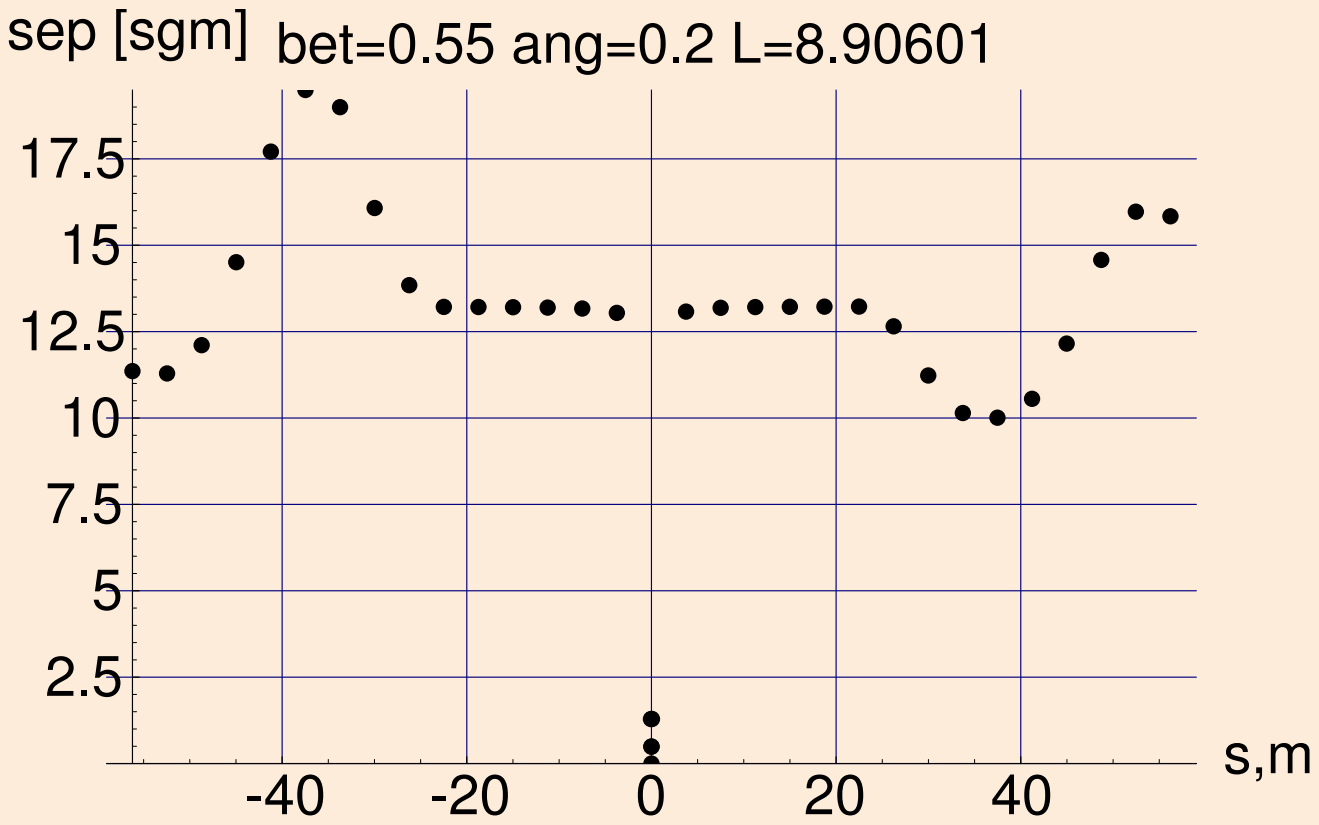
4.4 separation



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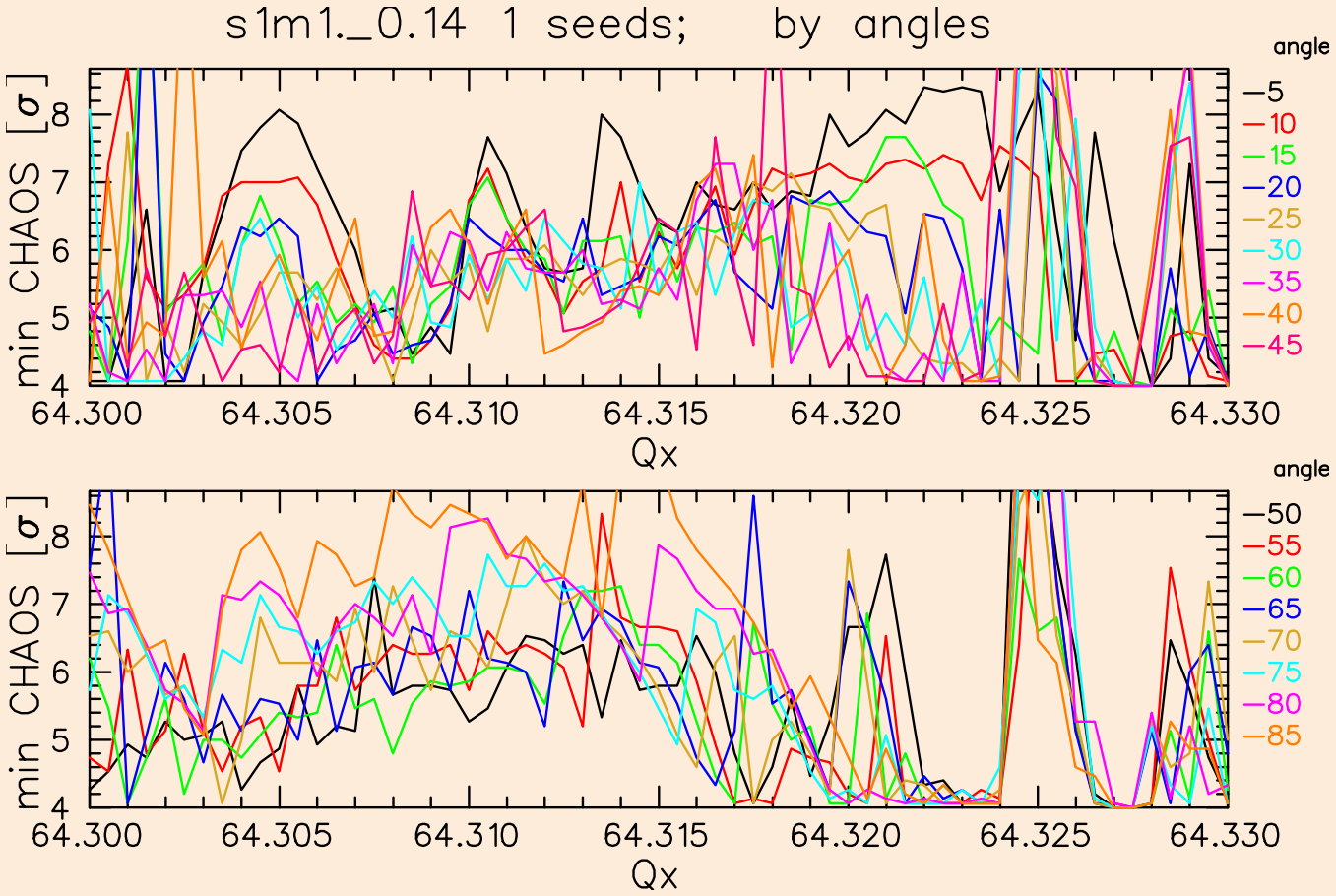
5 1m 0.28 d=12.5

5.1 Chaos



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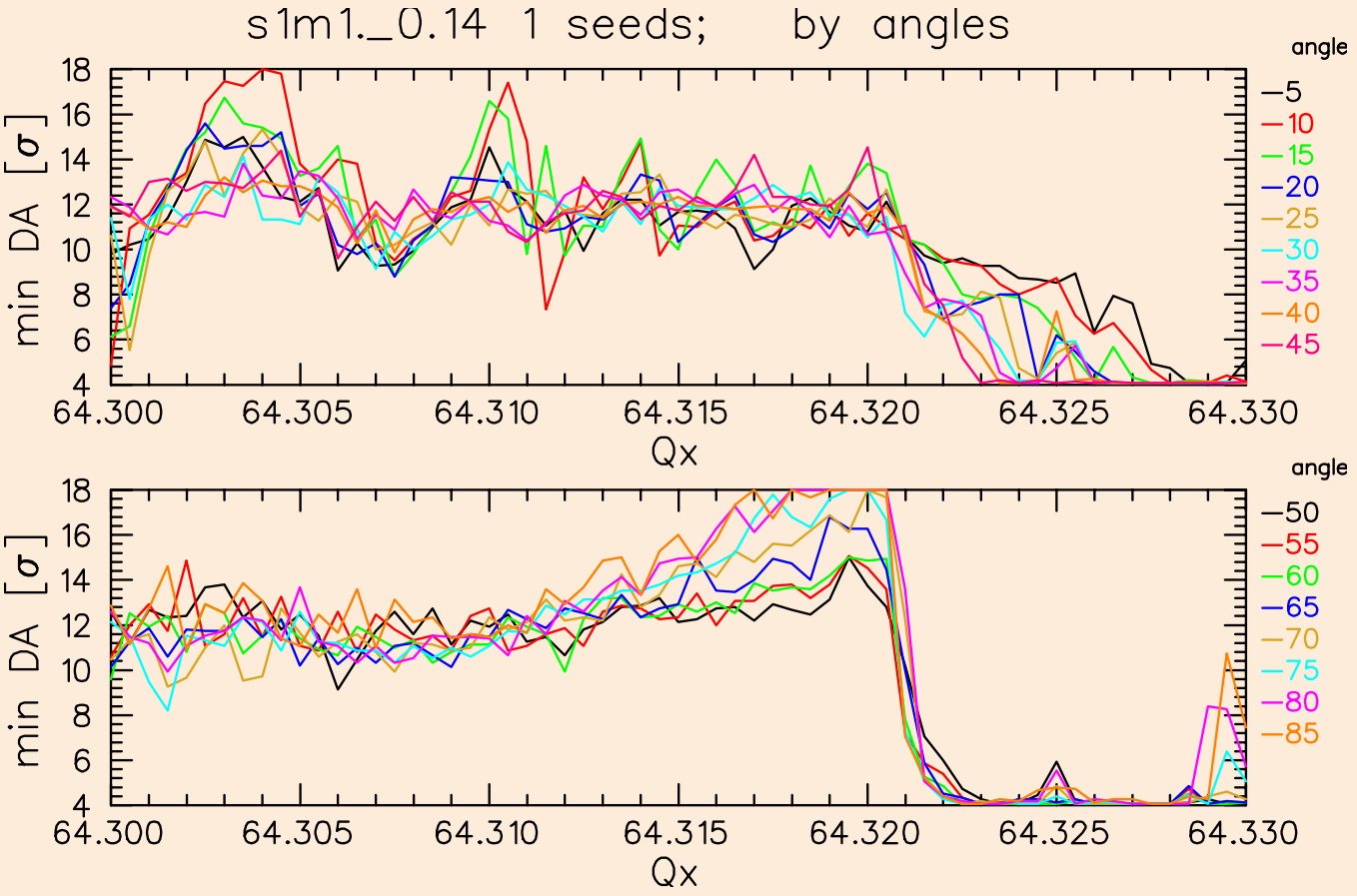
5.2 DA; d=12.5



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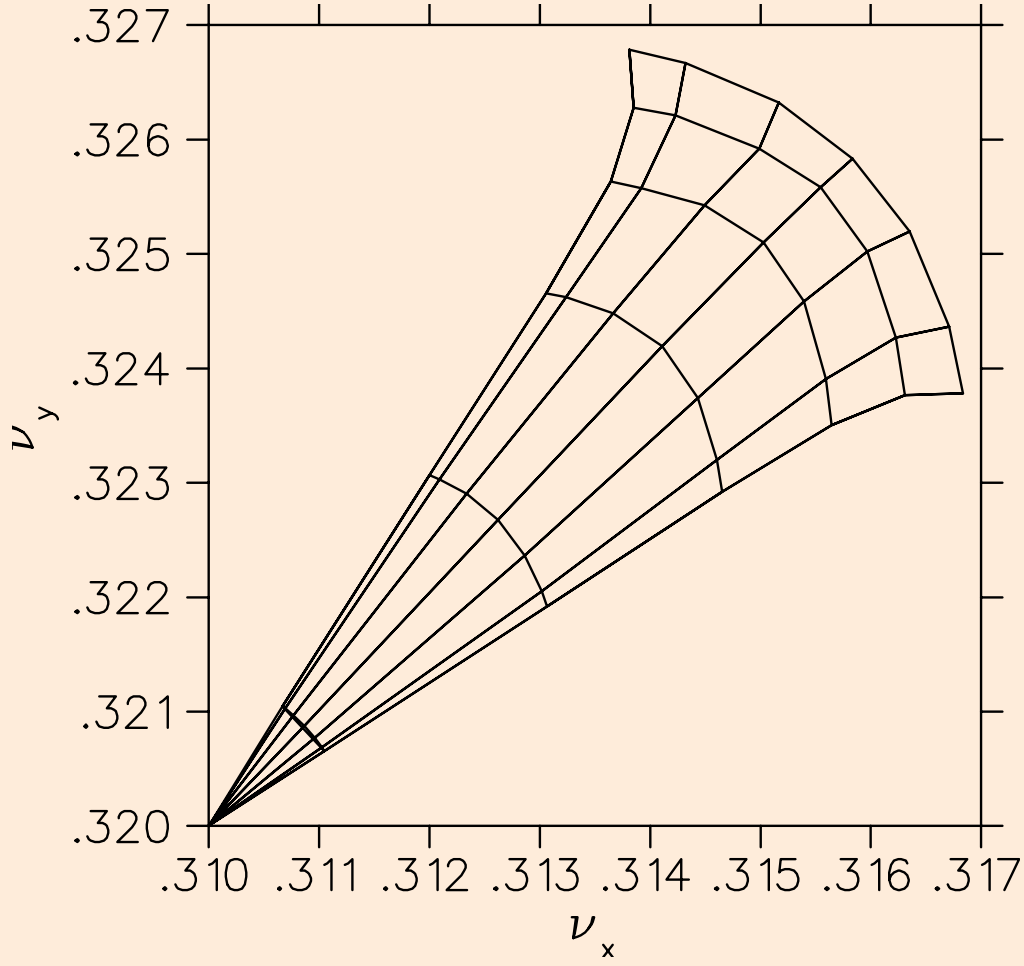
5.3 foot



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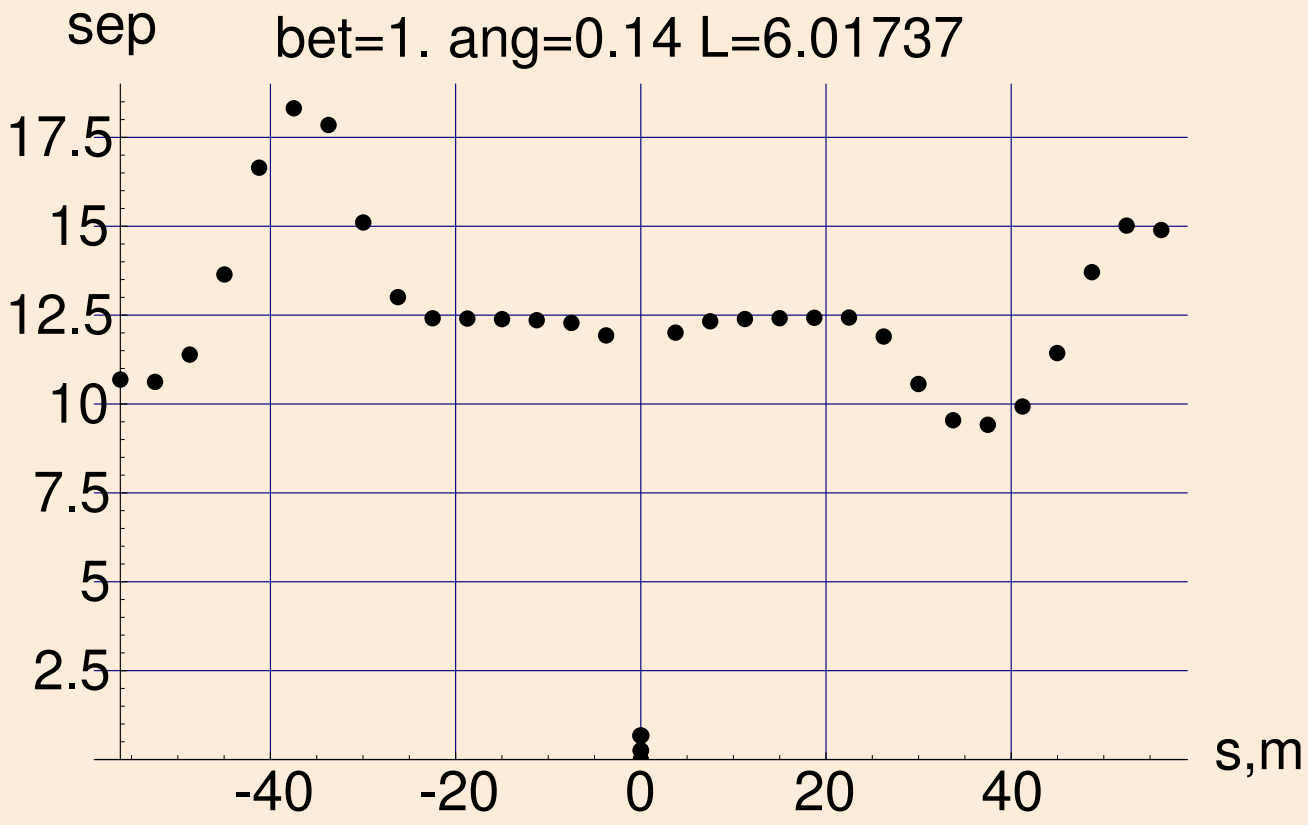
5.4 separation



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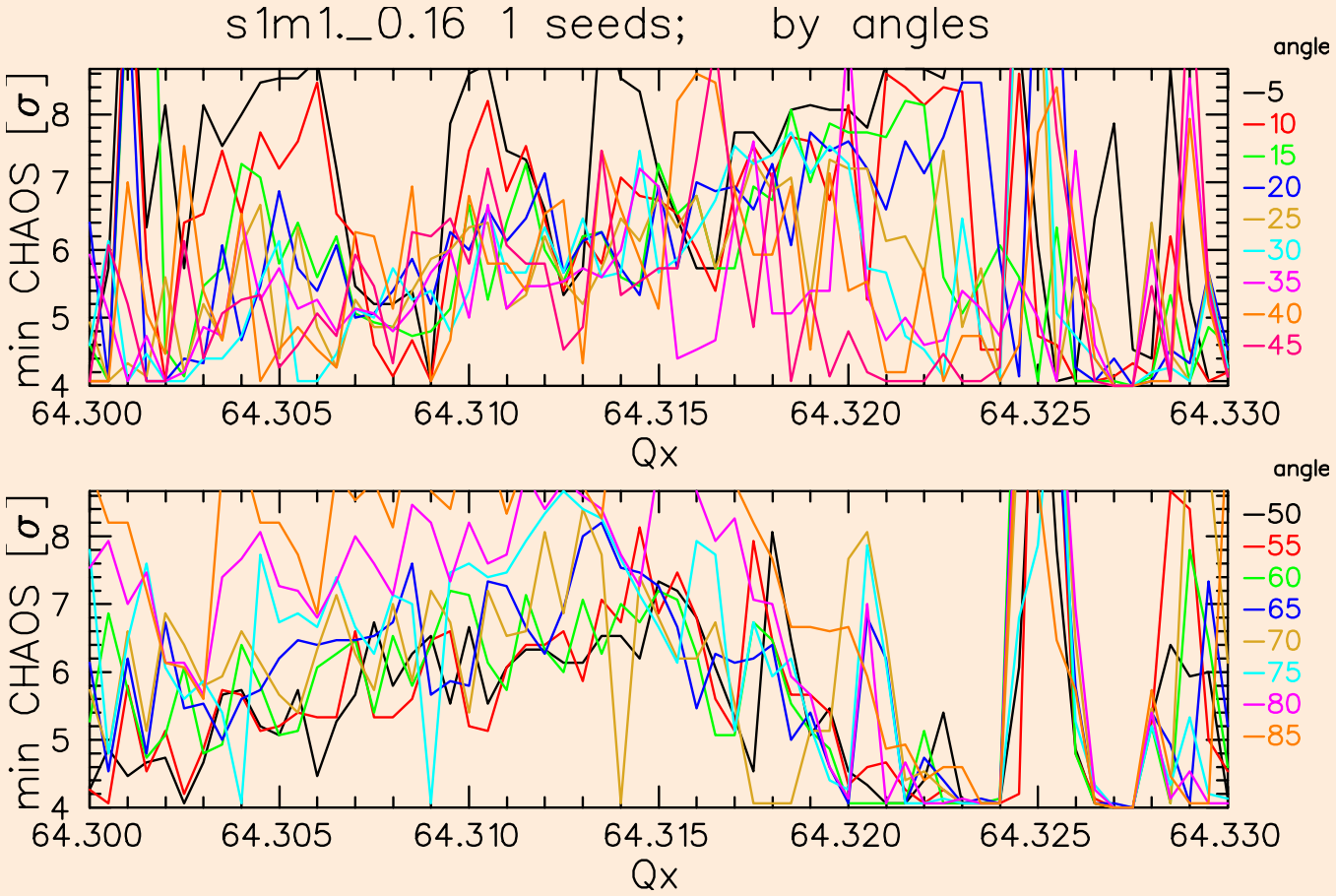
6 1m 0.32 d=14.3

6.1 Chaos



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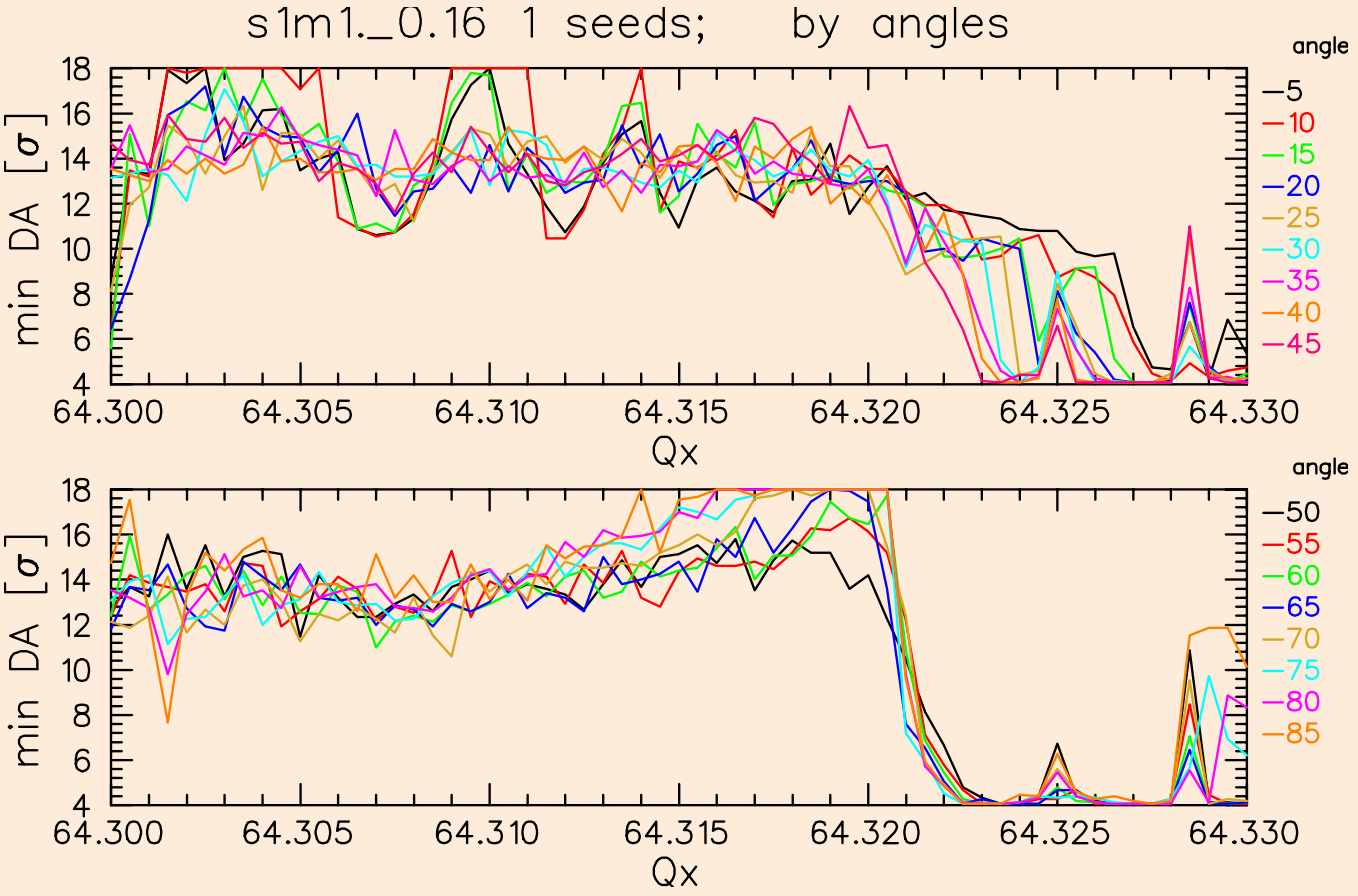
6.2 DA; d=14.3



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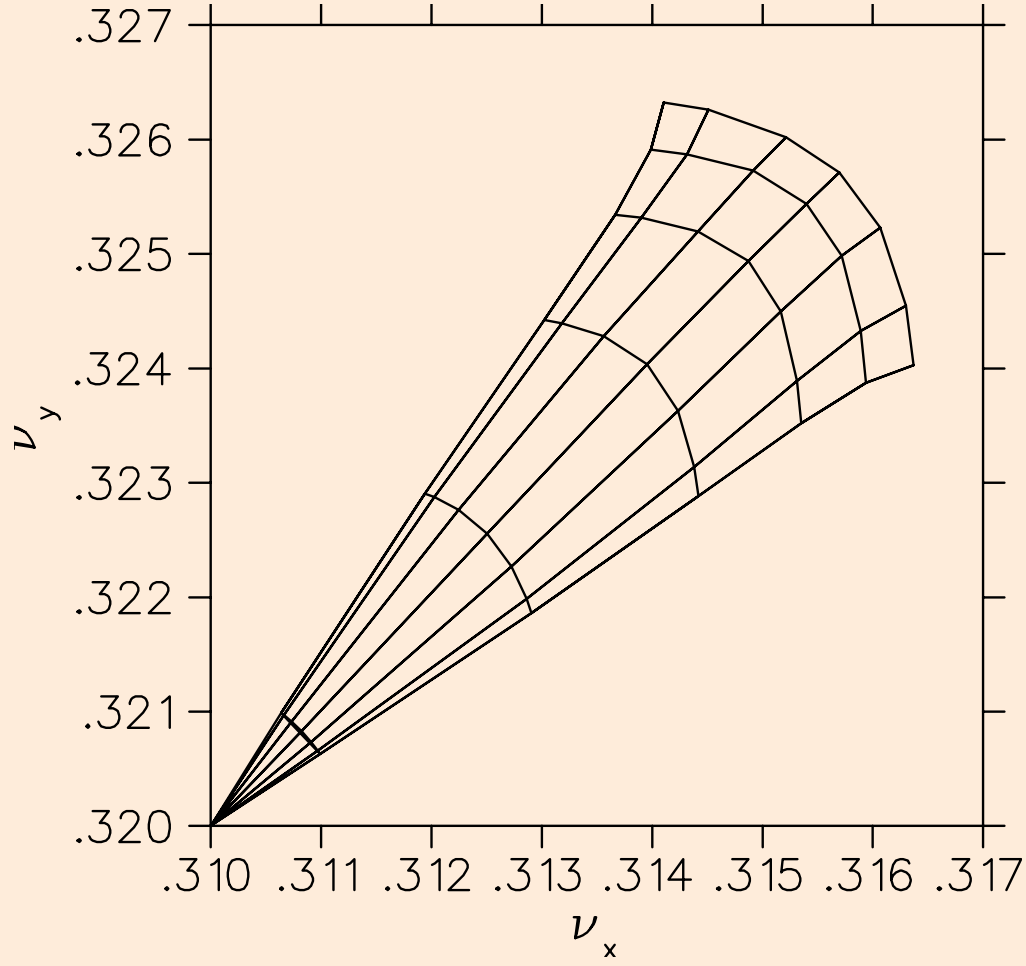
6.3 foot



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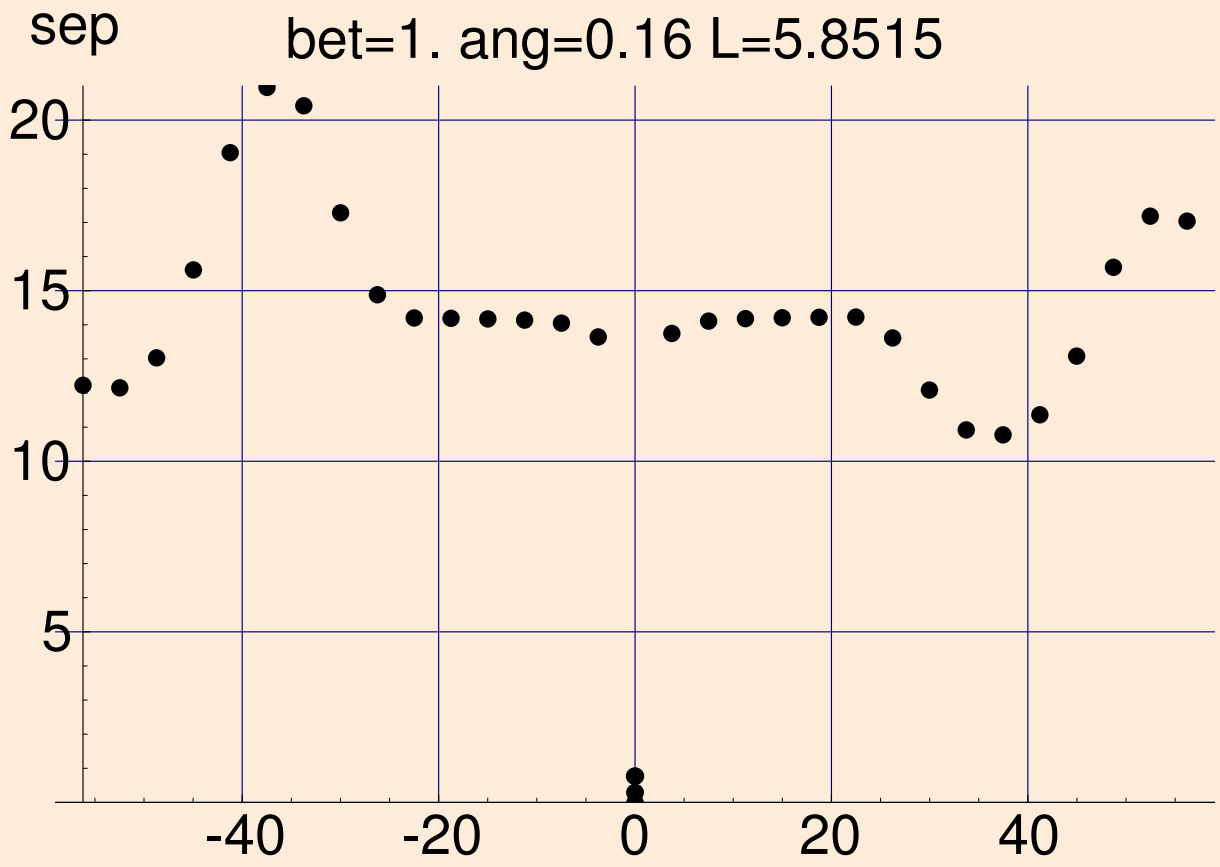
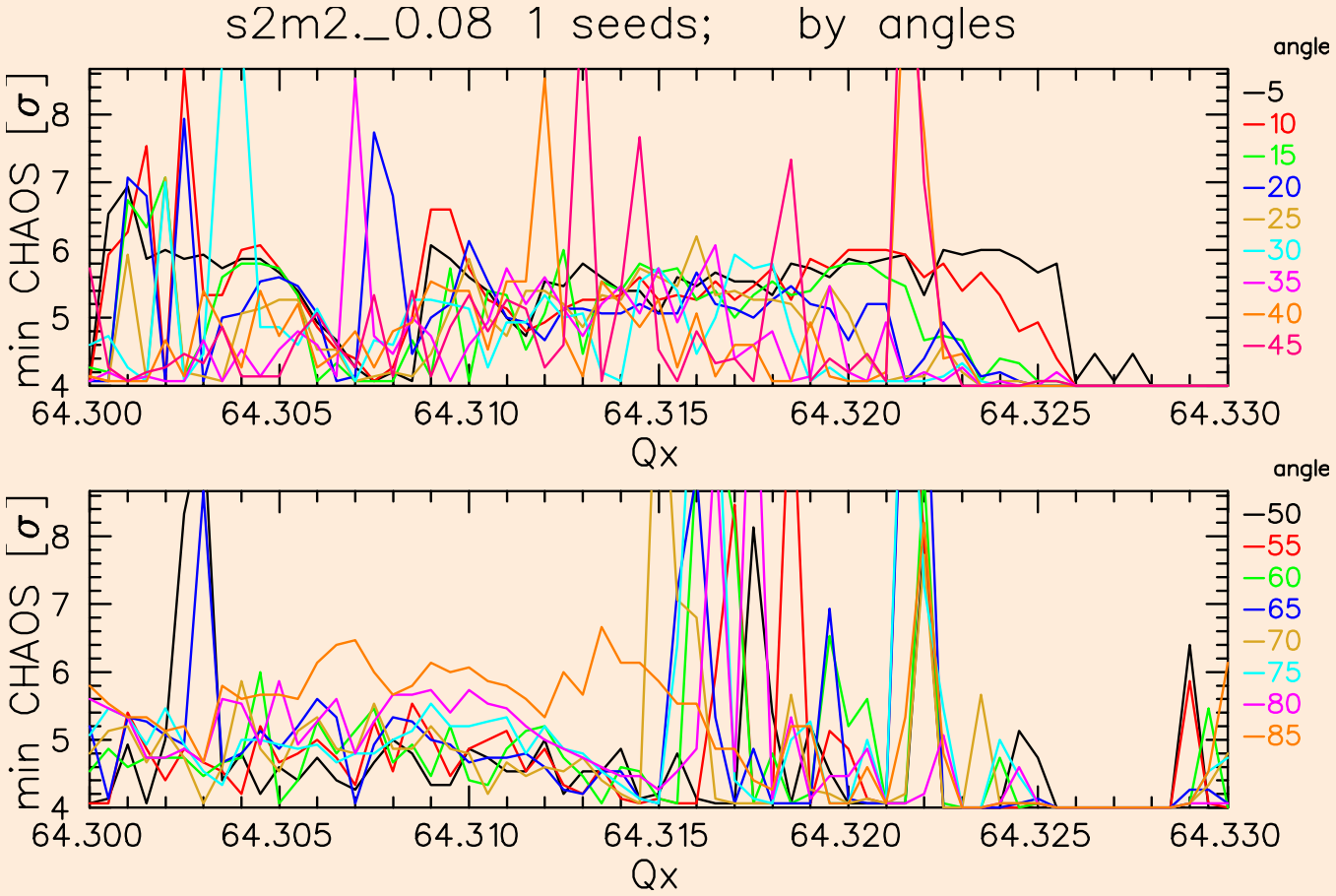
6.4 separation



get eps

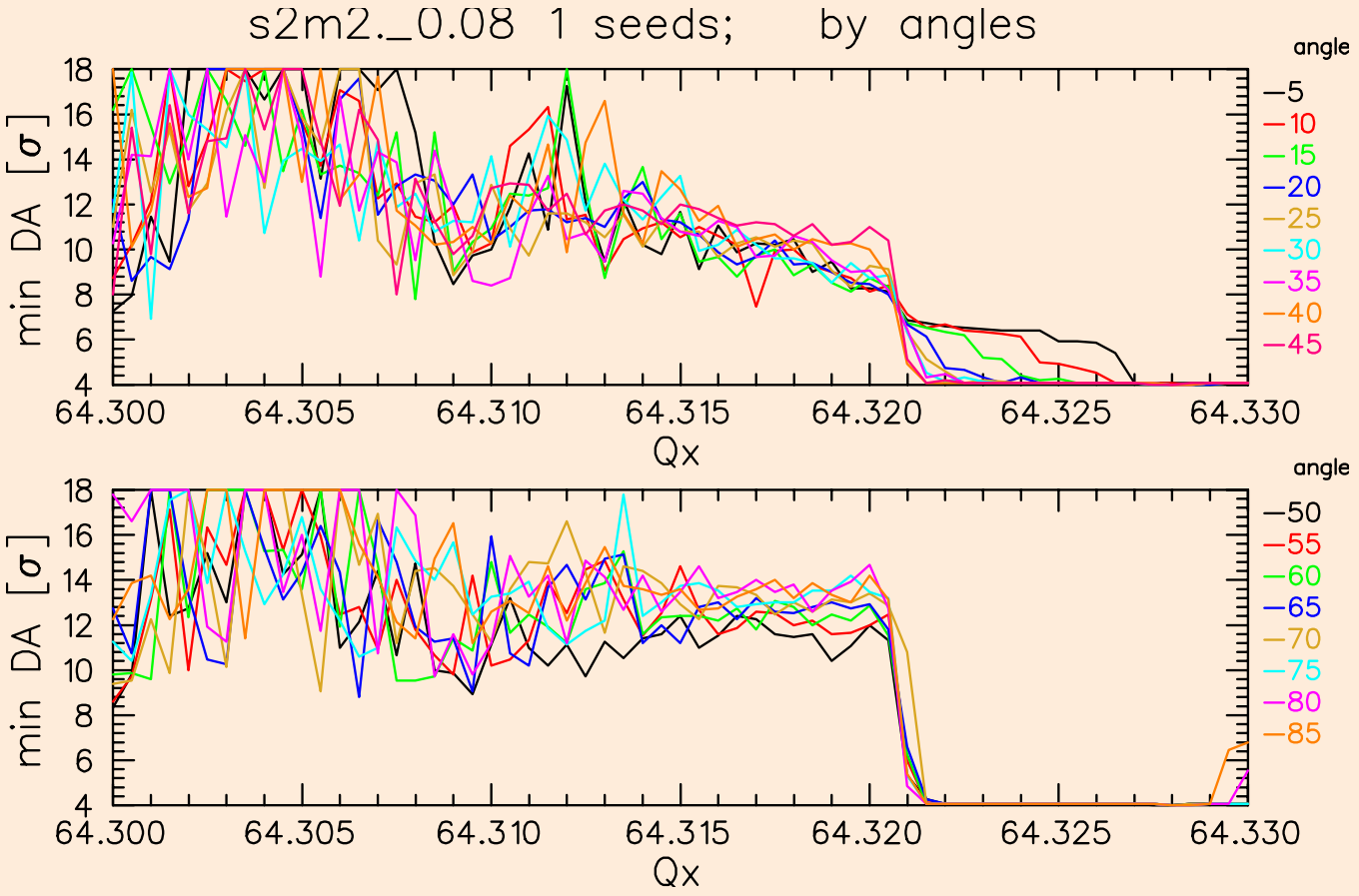
7 2m 0.16 d=10.1

7.1 Chaos



get eps

7.2 DA; d=10.1



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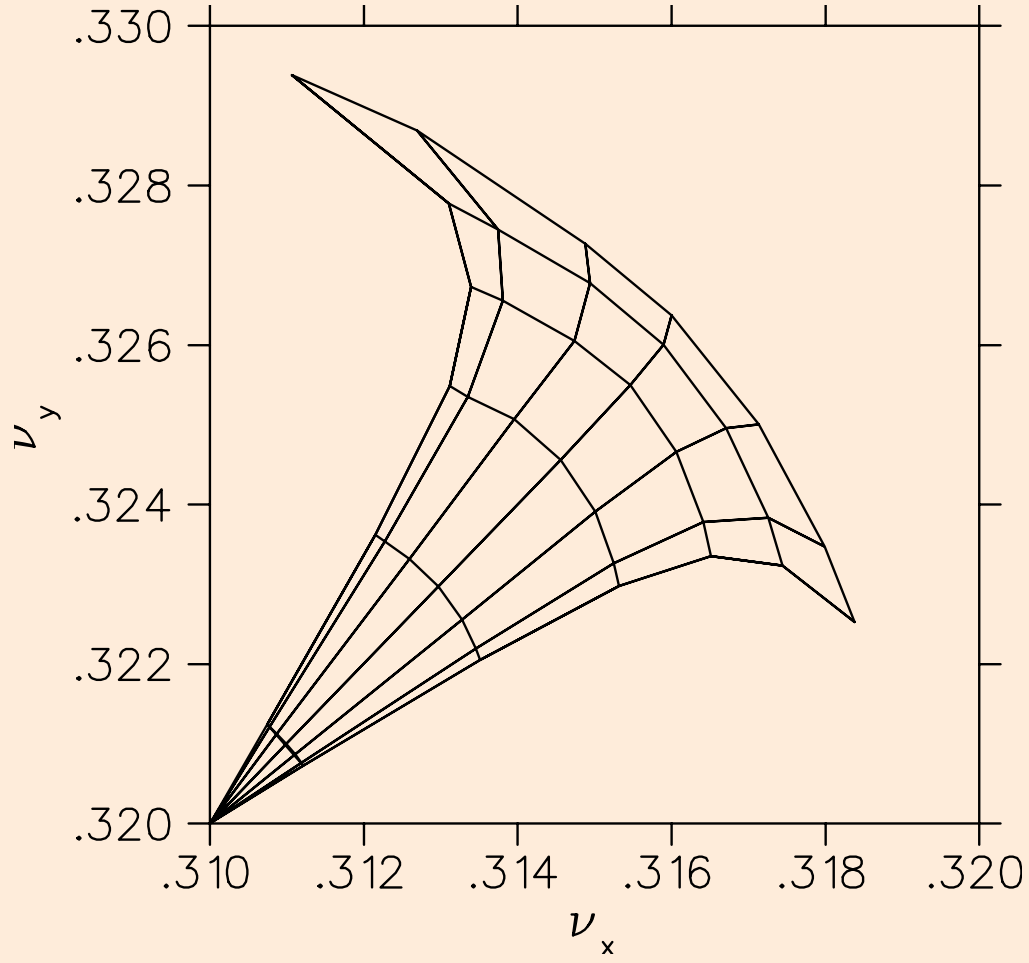
7.3 foot



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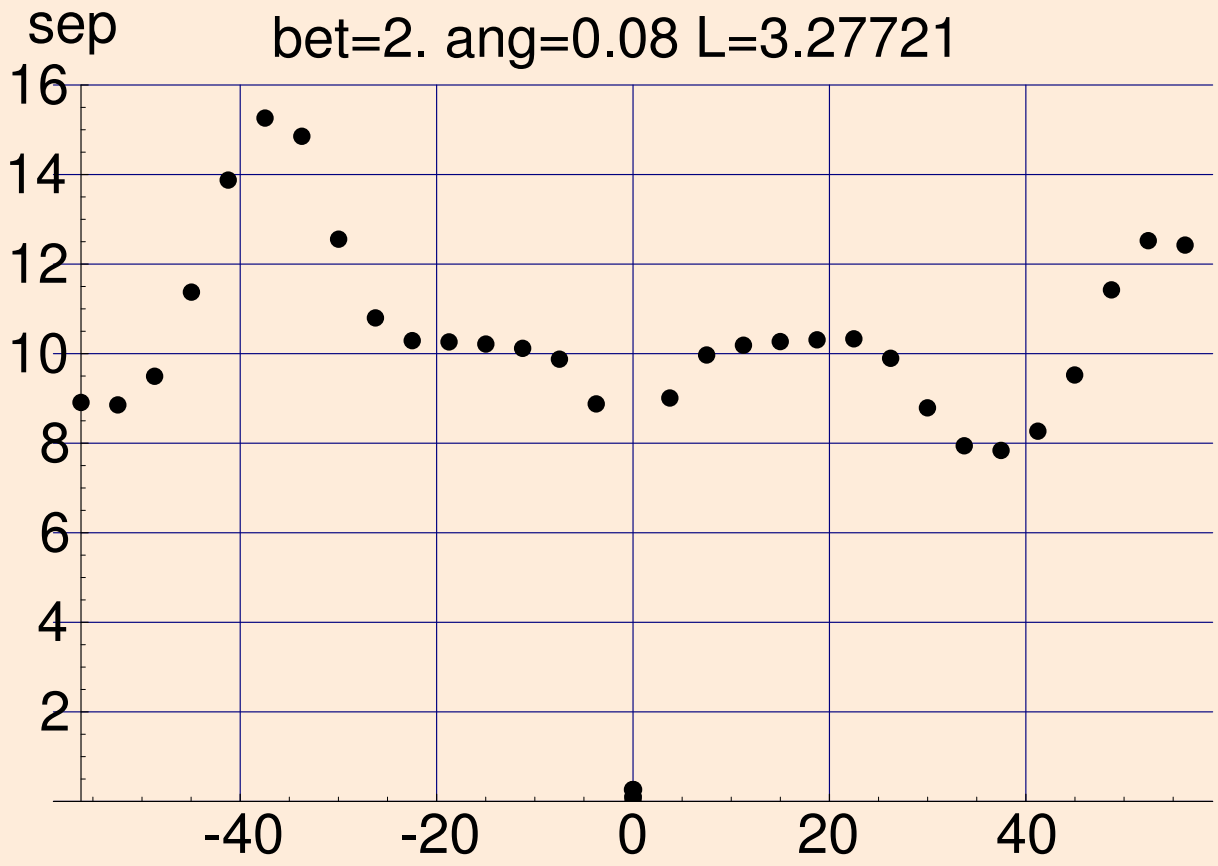
7.4 separation



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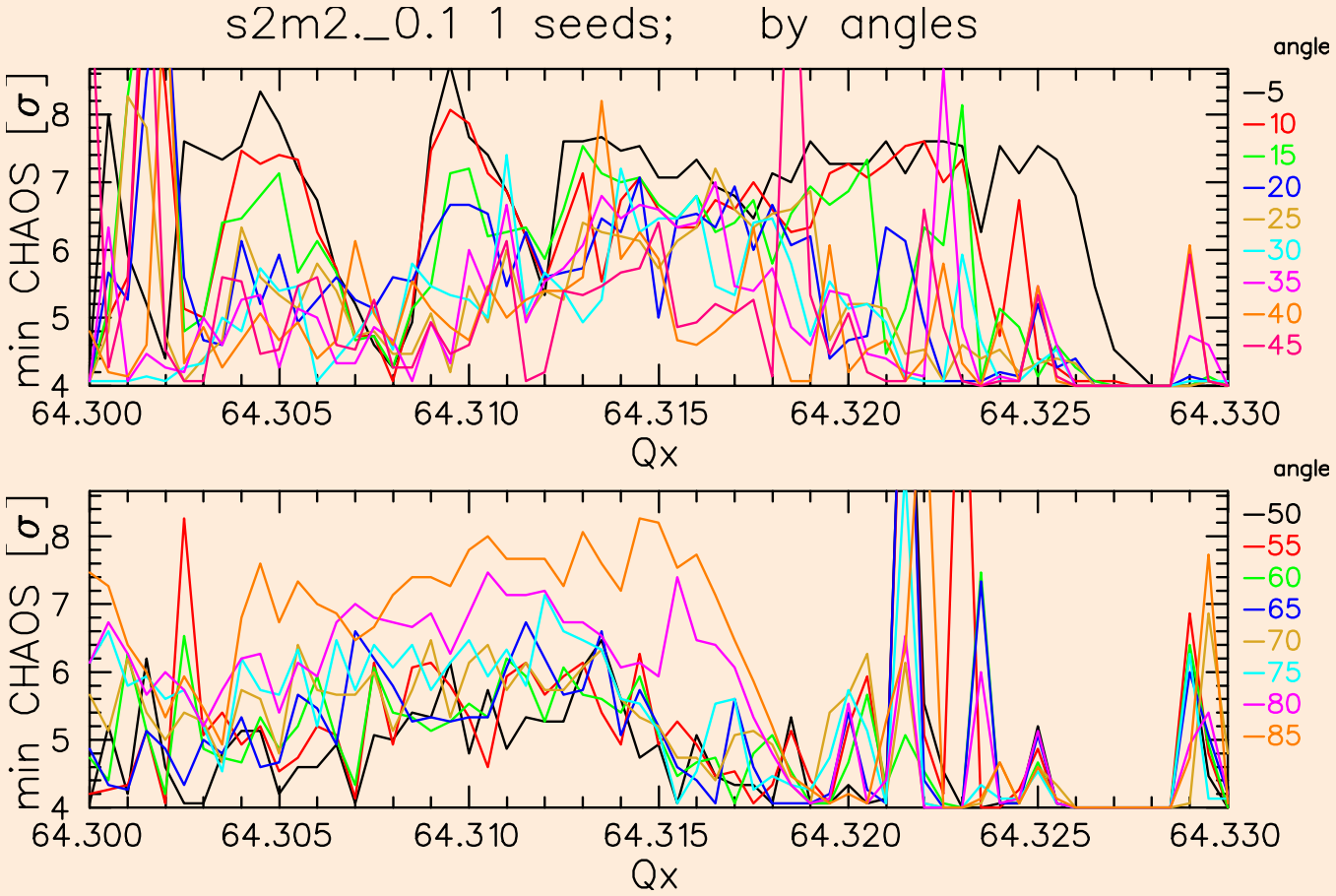
8 2m 0.2 d=12.6

8.1 Chaos



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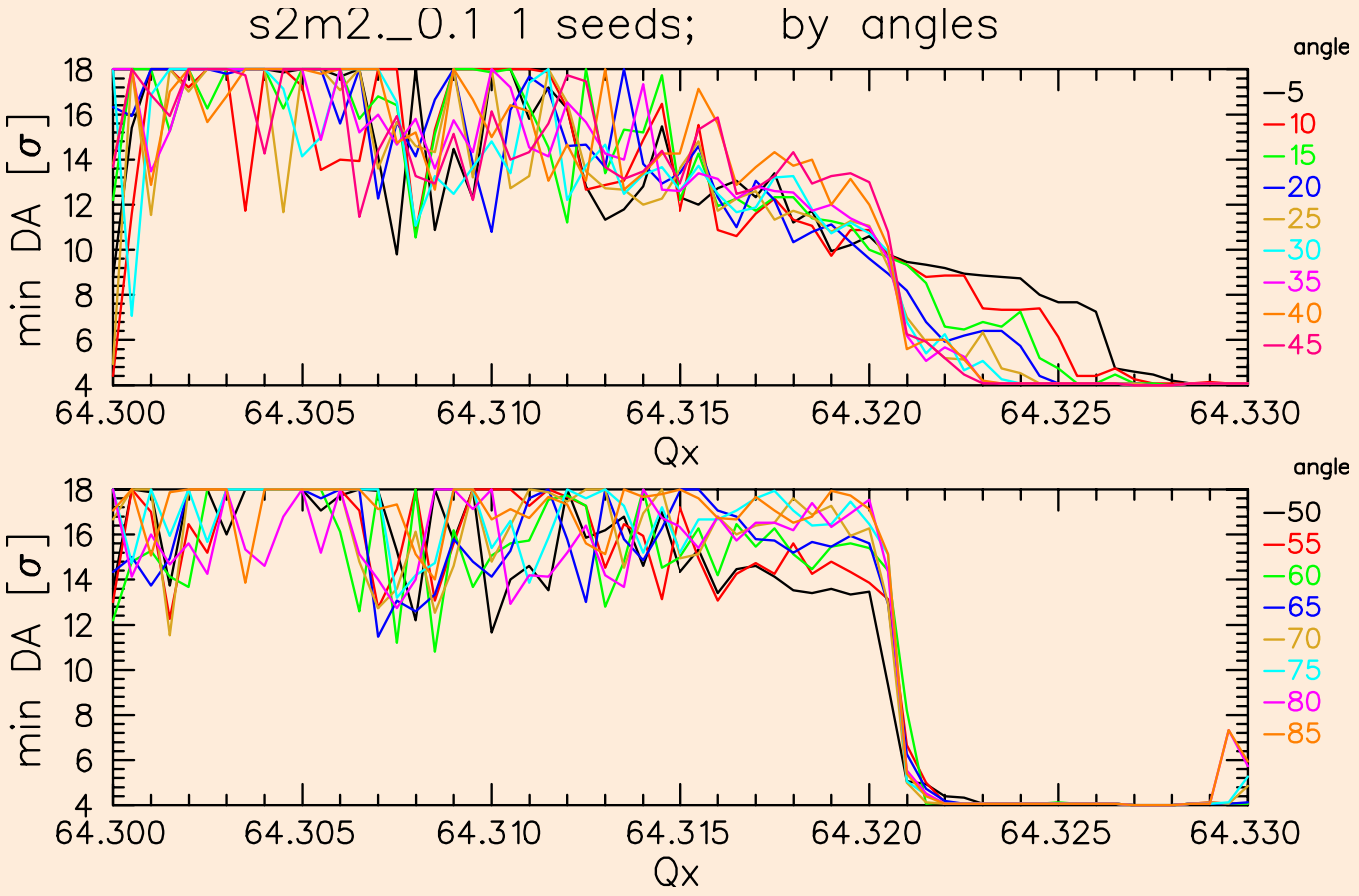
8.2 DA; d=12.6



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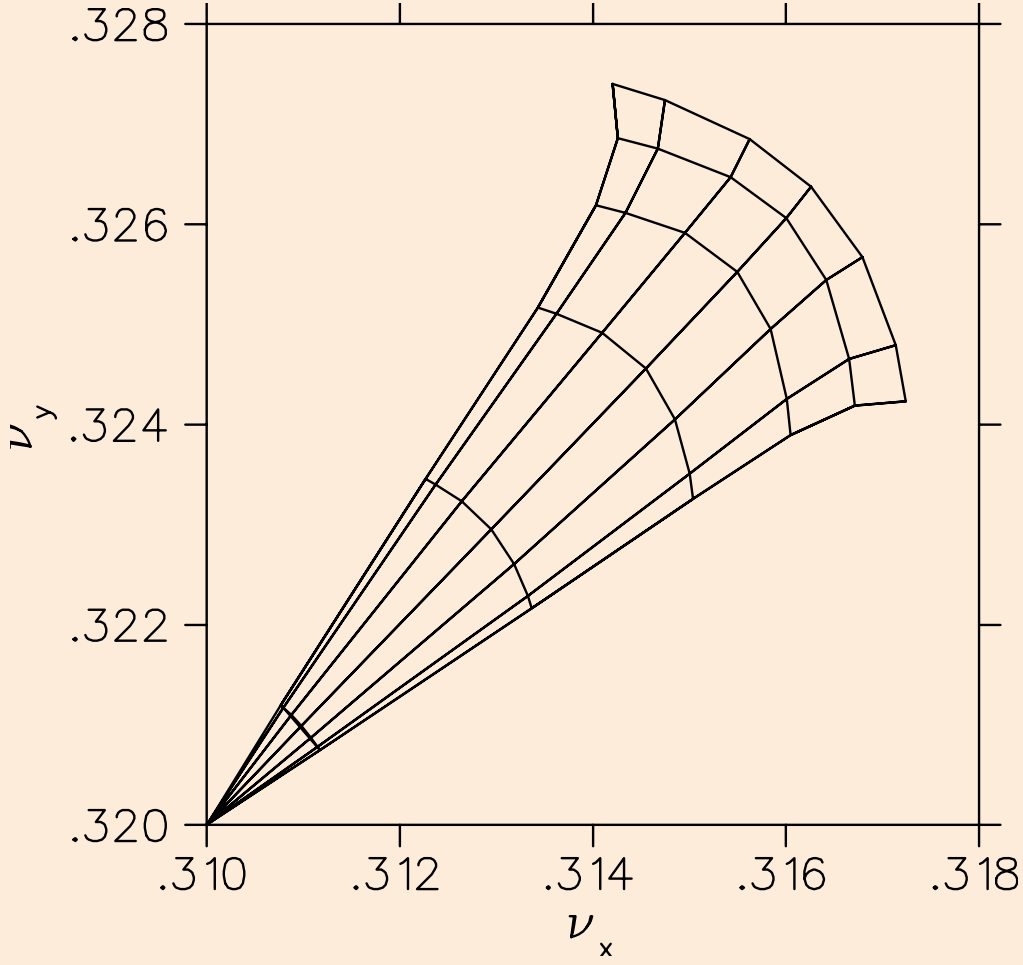
8.3 foot



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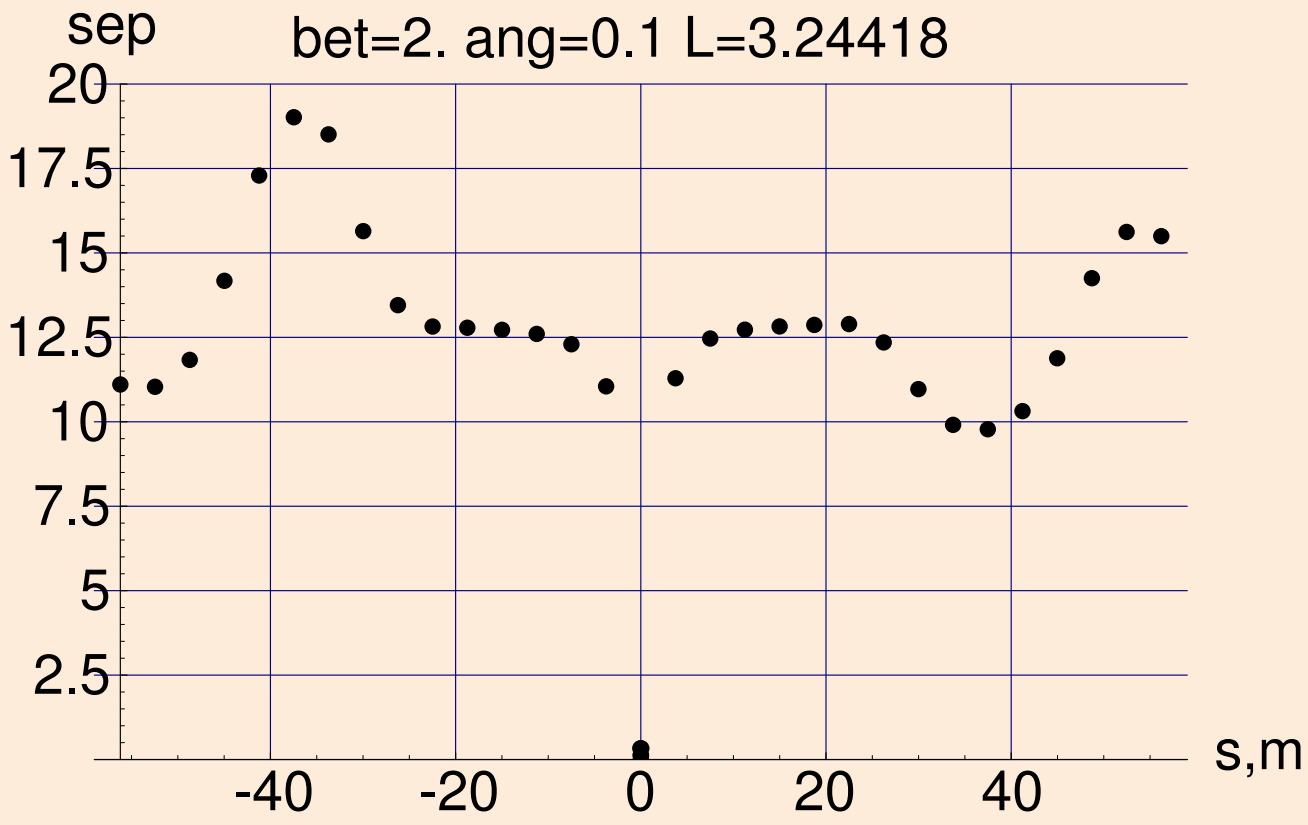
8.4 separation



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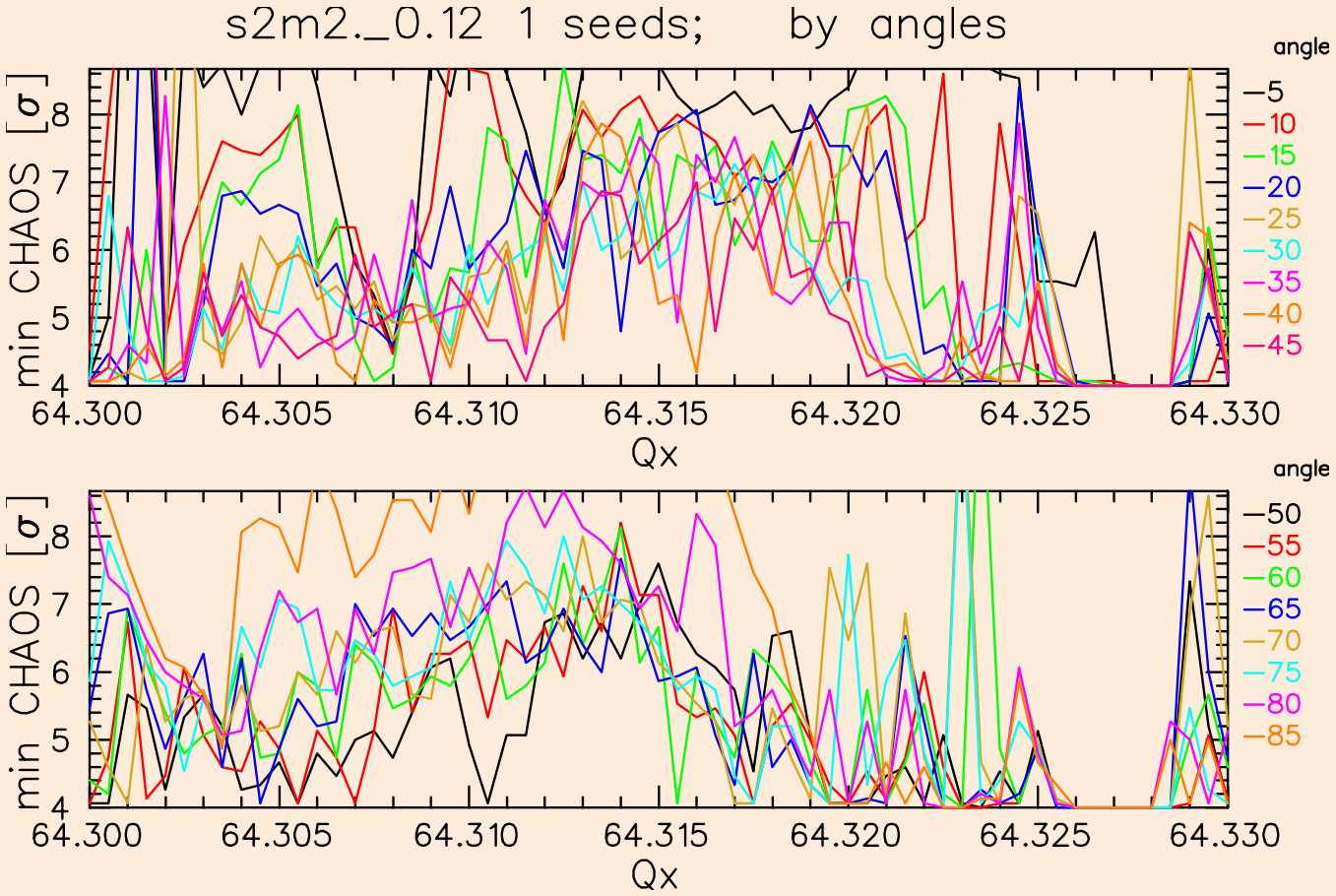
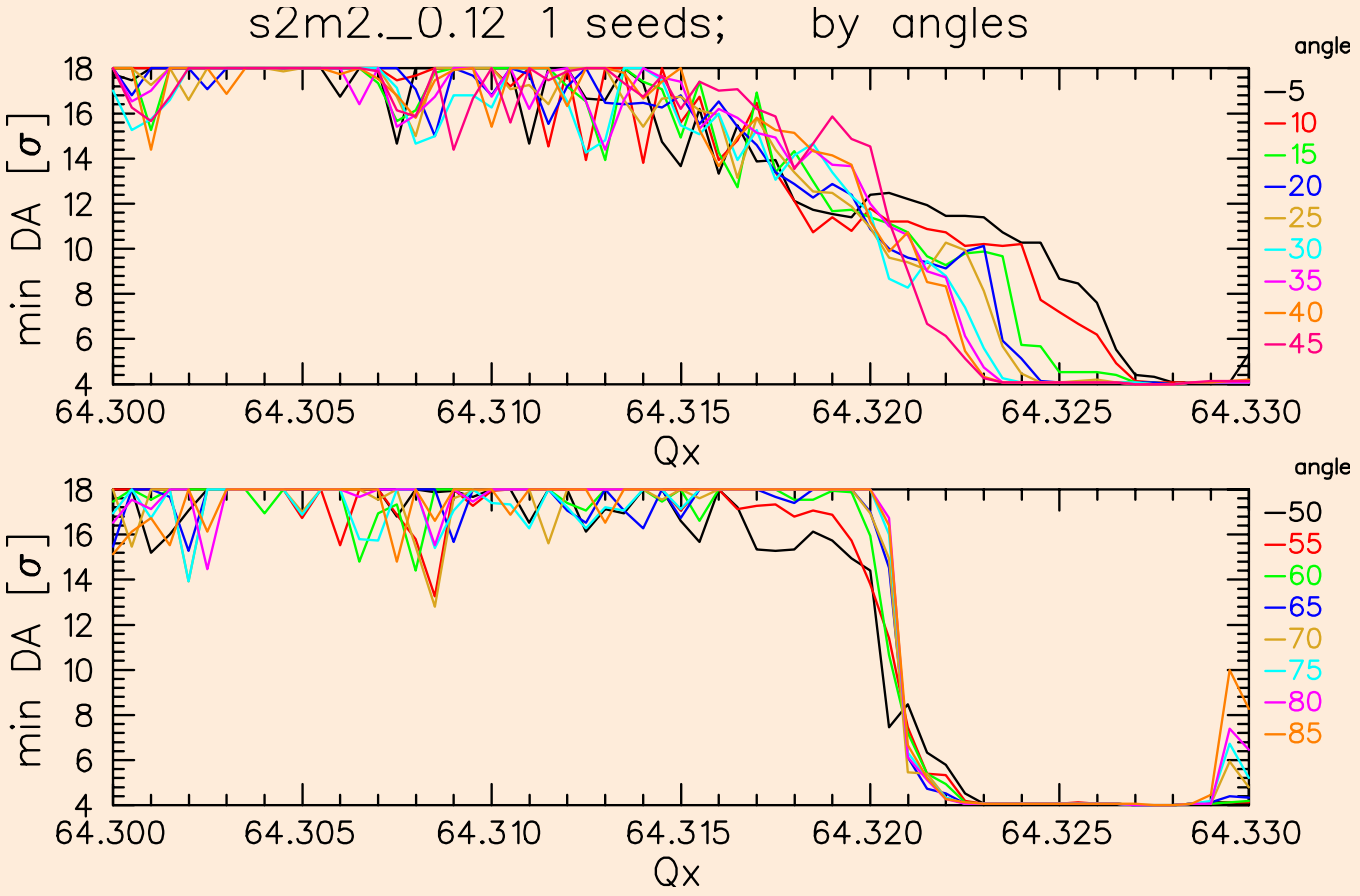
9 2m 0.24 d=15.1

9.1 Chaos



get eps

9.2 DA; d=15.1



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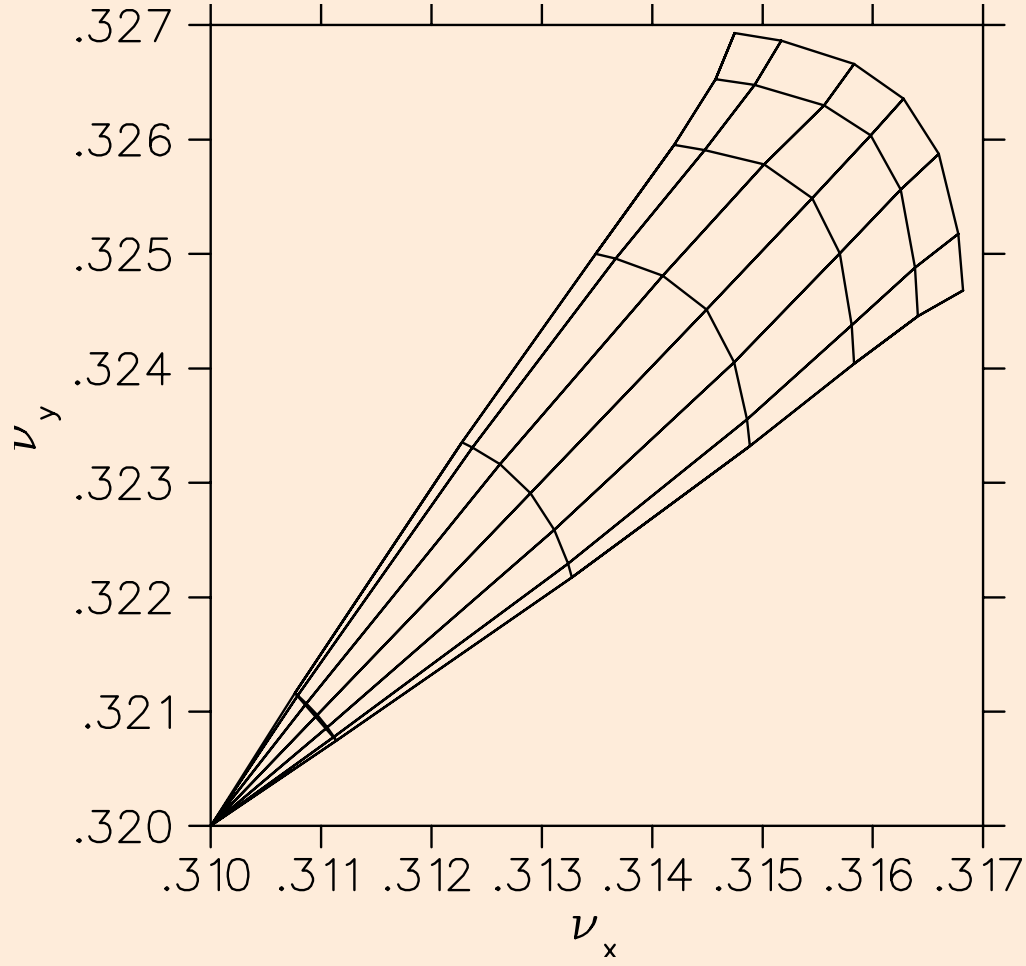
9.3 foot



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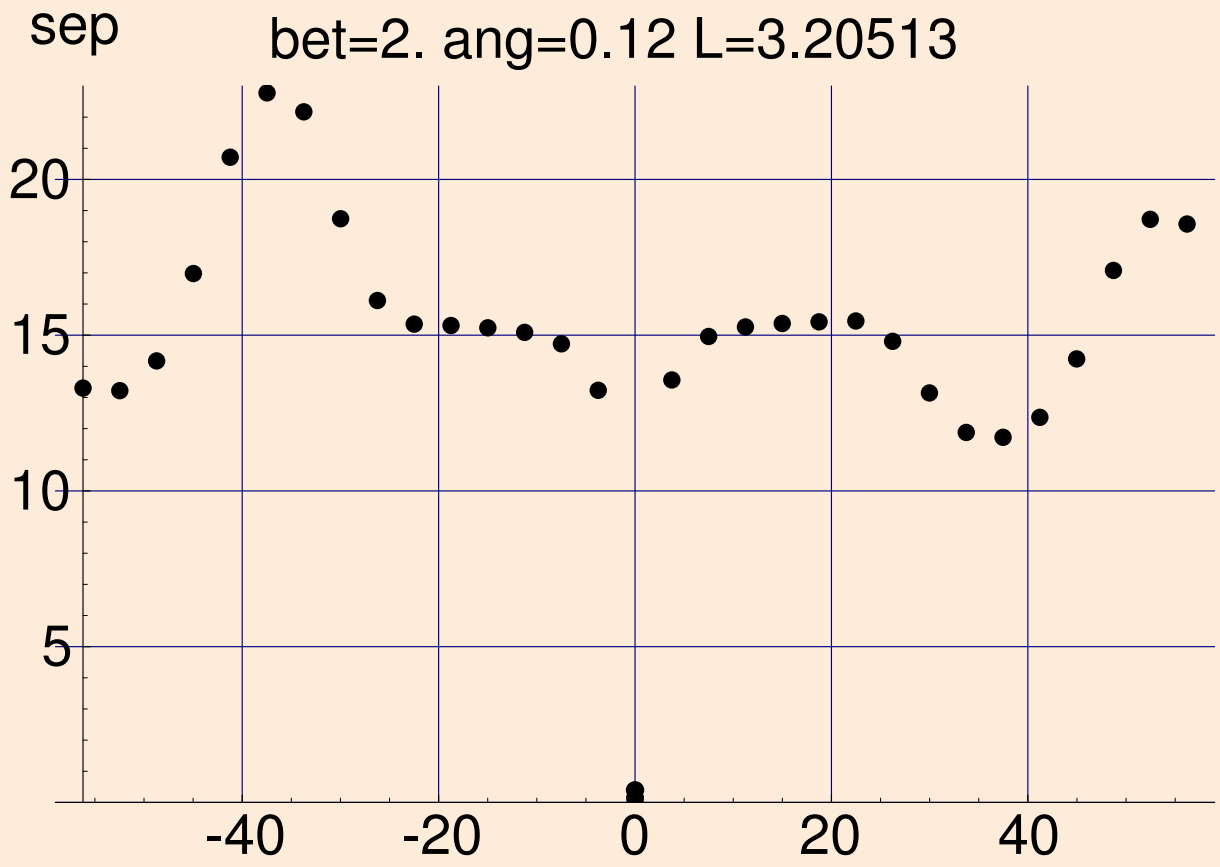
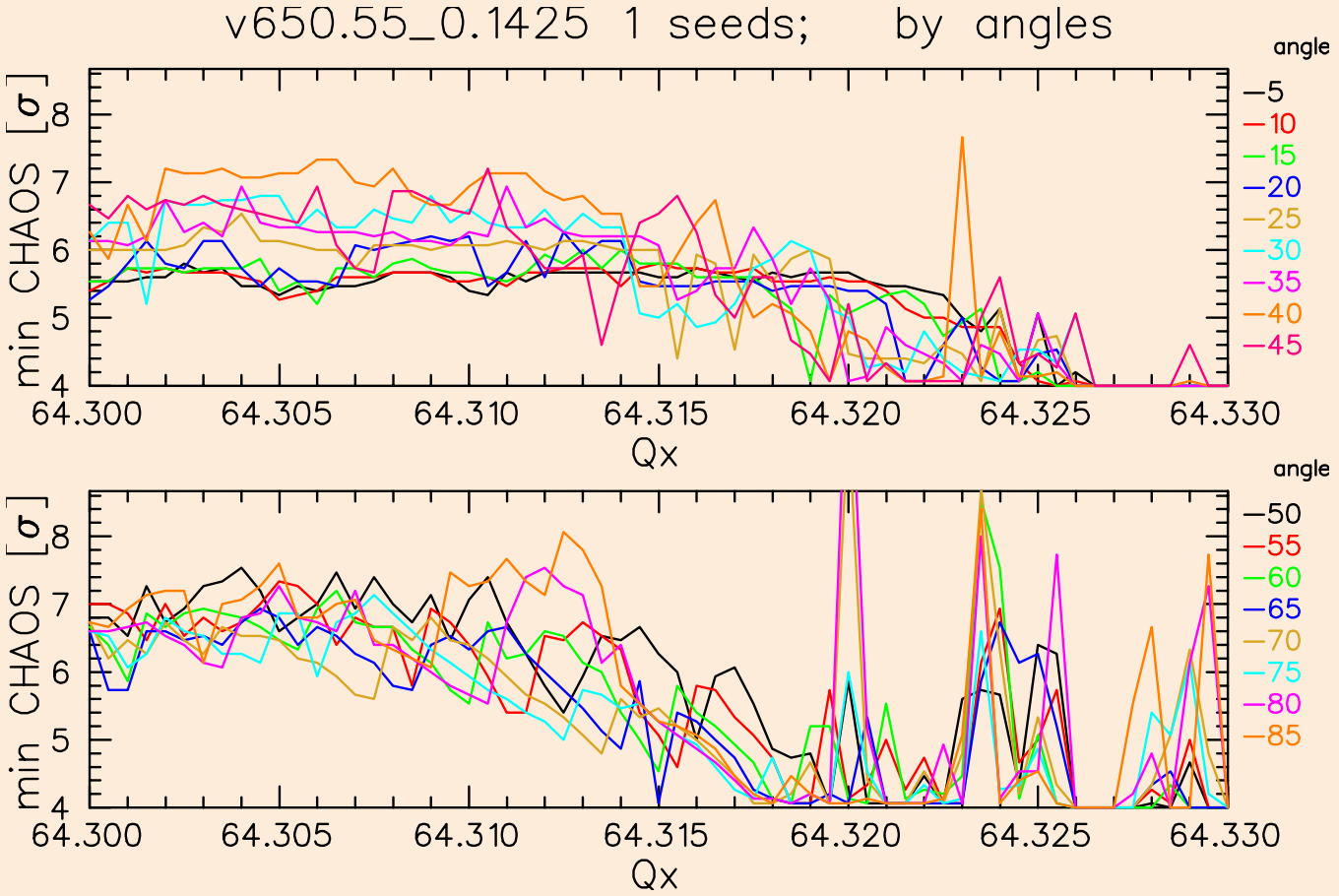
9.4 separation



get eps

10 0.55m 0.285 d=9.4 (only long range)

10.1 Chaos



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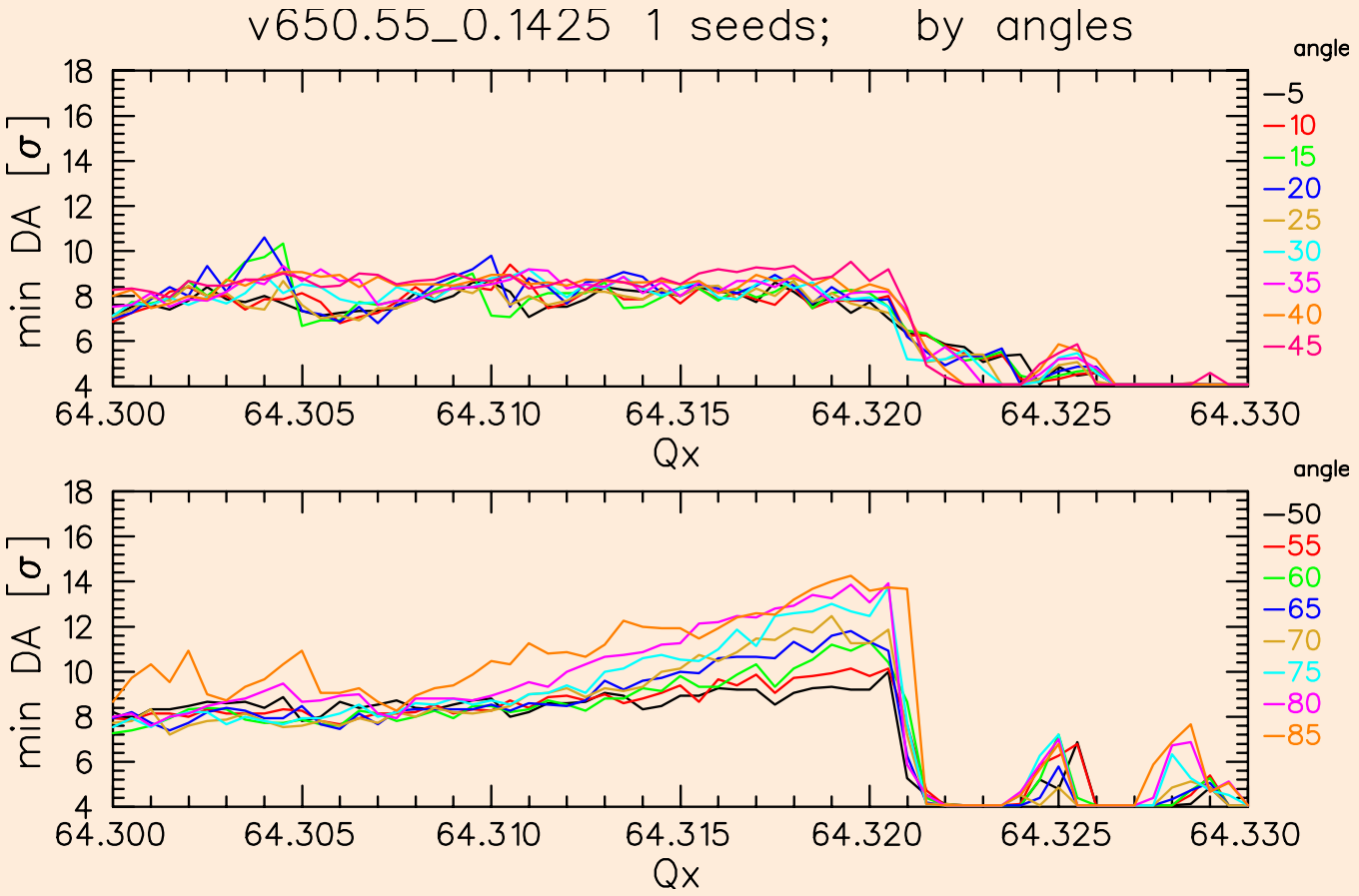
10.2 DA; d=9.4 (only long range)



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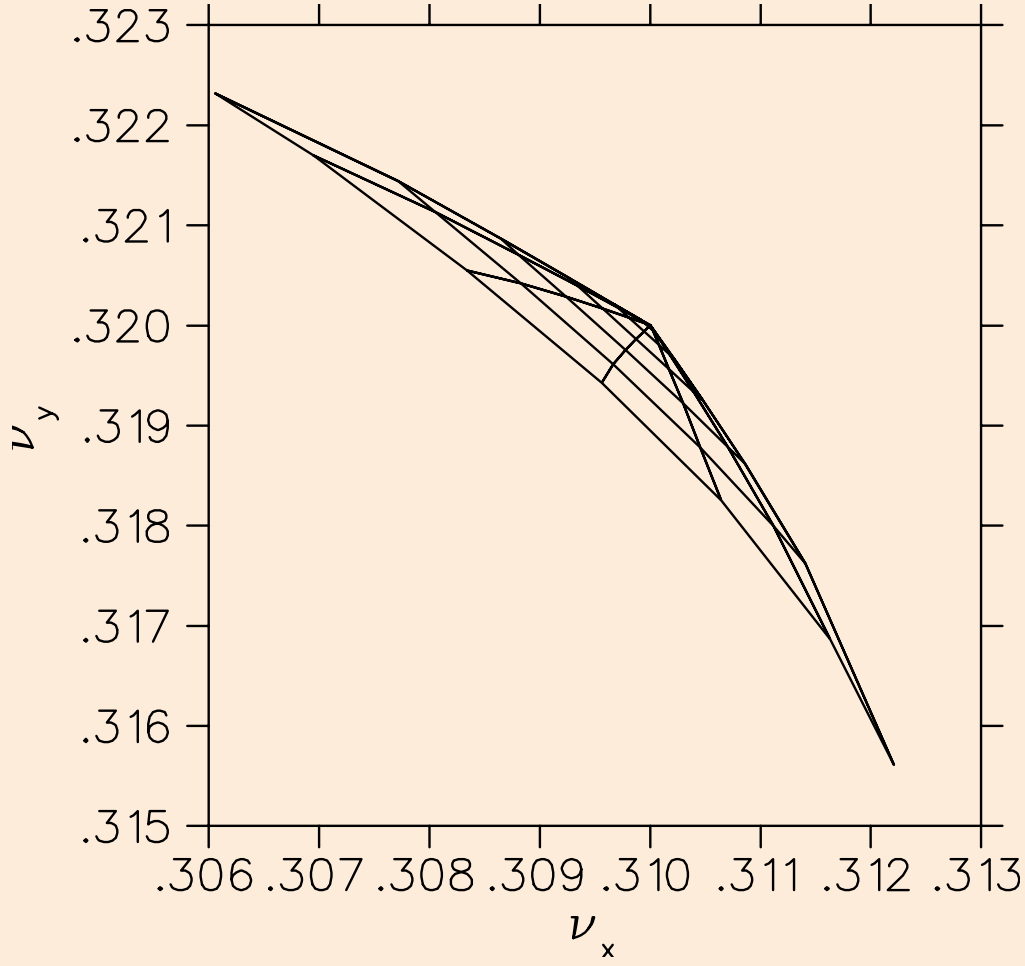
10.3 foot



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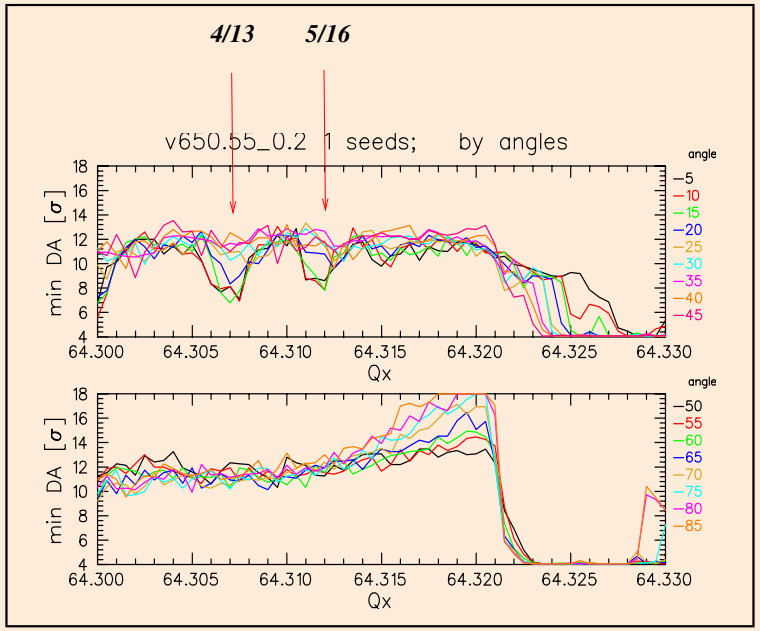
11 BB resonances cause two dips in DA:



Betatron invariant computed with first ord. pert. theory and shows that:

$4/13$ can be canceled by $\pi/2$ phase diff. IP5-IP1

$5/16$ can not (because 16 is divisible by 4)

12 Summary (collision)

- Even with these full head-on + long range collisions and pessimistic (high) $N_p = 1.15\ 10^{11}$ taking $\beta^* > 1m$ already gives DA $\approx 8 - 10\ \sigma$.
  For example (1 m, 0.28 mrad) or (2 m, 0.2 mrad) $\rightarrow$ DA $\approx 10\sigma$.
- If $\beta^* > 0.55m$, DA roughly obeys: DA $\sim$ d
- that's, **except near resonances**: The two dips persist in horiz plane; caused by head-on (?) BB. In theory, $\pi/2$ horiz. phase between the two IPs would cancel the left one, but needs a tight constraint on phase: $\sim 0.01 - 0.02$

13 INJECTION optics

13.1 Conditions for tracking and what is shown

- version 6.5 at 450 GeV; Sixtrack with beam-beam
- head-on only; $N_b = 0.4 \times 10^{11}$; 60 seeds; 10^5 turns
- different optics settings: 6 m , 11 m , 17 m
- Chaos border and Dynamic Aperture (DA):
  average (black) and minimum (red)

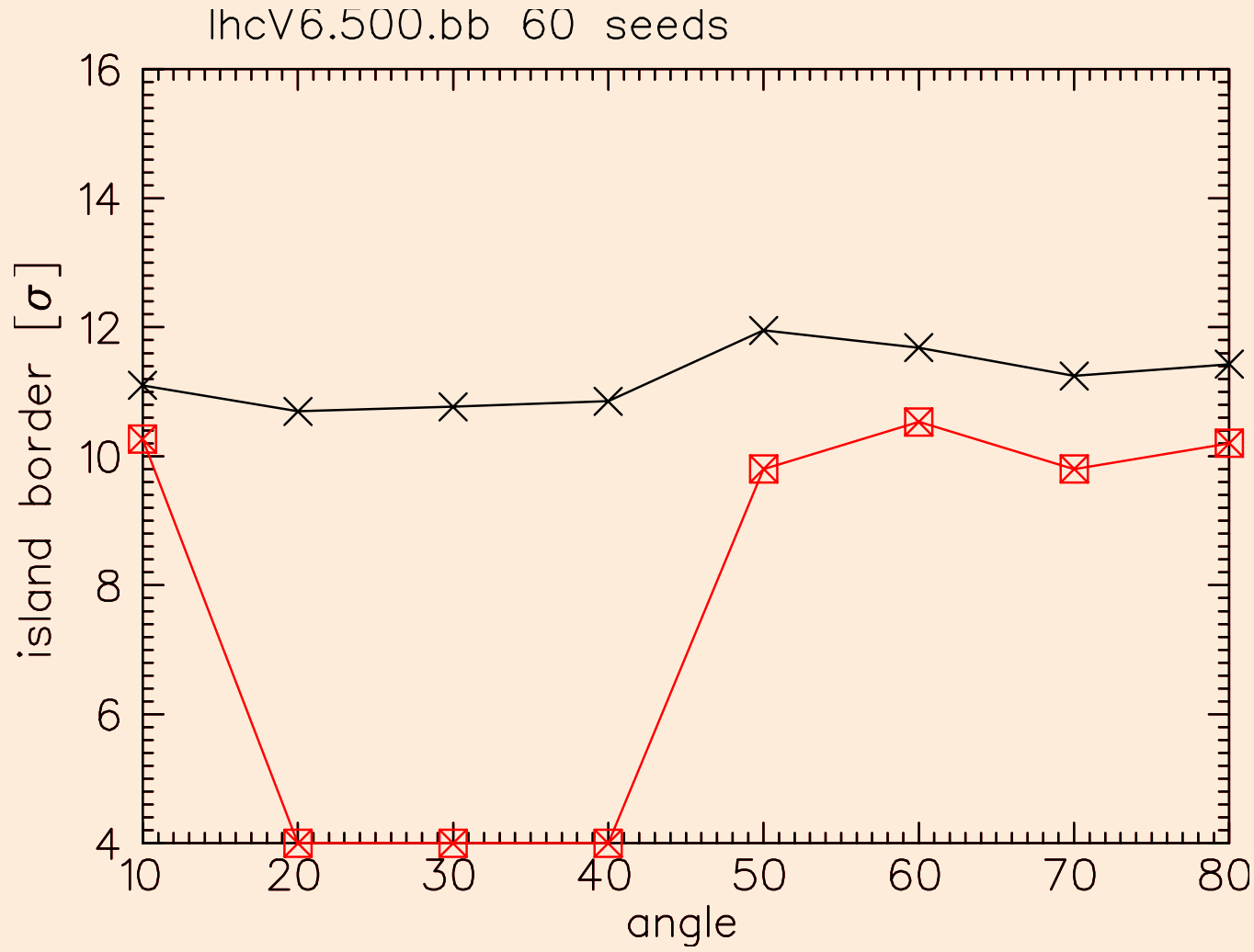
14 Flags: (err,a2,a2c,D1D2,BB)

All errors as in MG's $17m$ sample job (2006),
but for the 6 and 11 m I've switched off the D1-D4 x-alignment.
I've introduced some on/off flags:

- **err** high order field errors
- **a2**
- **a2c** coupling correction
- **D1D2** D1-D4 alignment and field err.
- **BB** beam-beam

15 17m (1,1,1,1,0)

15.1 Chaos



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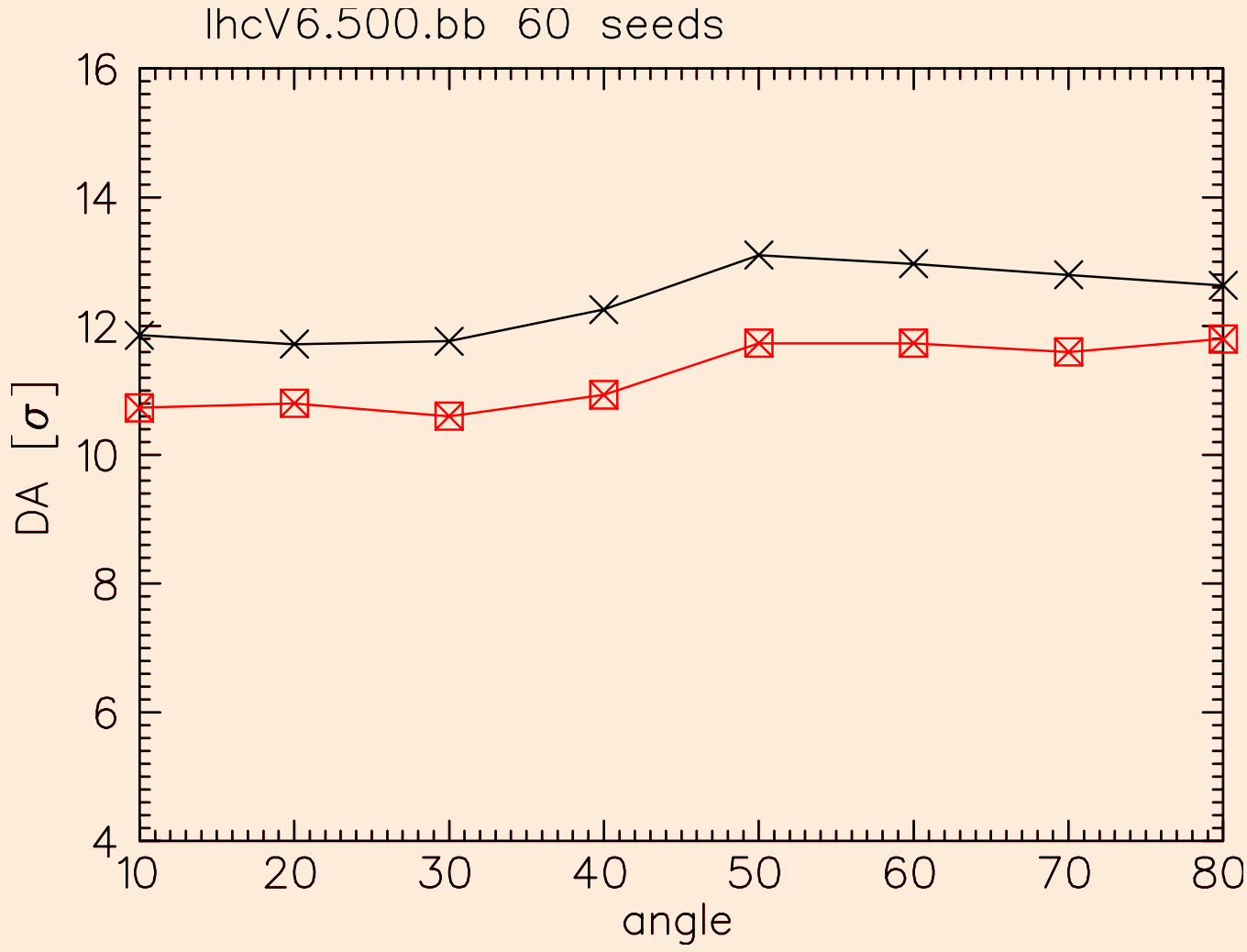
15.2 DA



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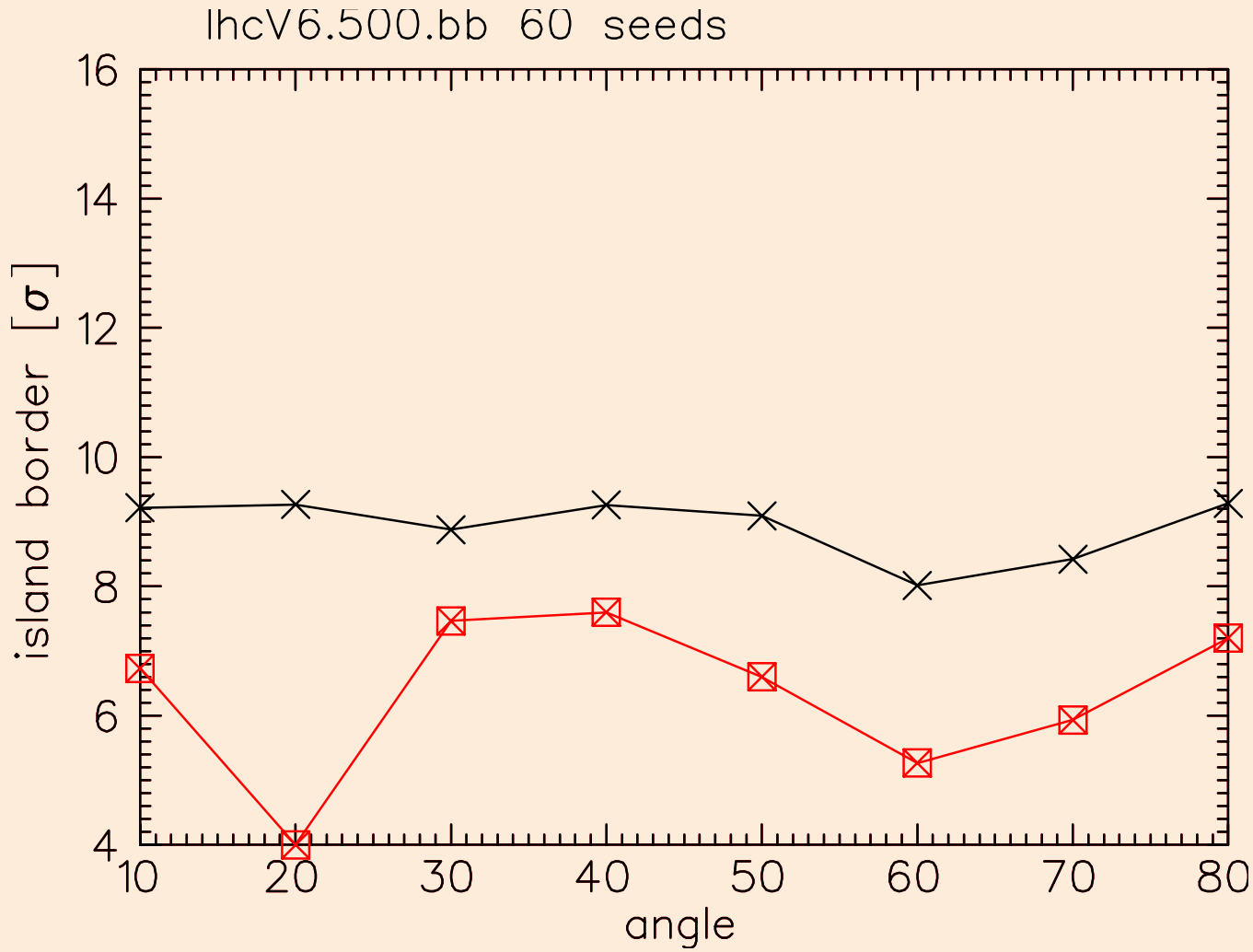
16 17m (1,1,1,1,1)

16.1 Chaos



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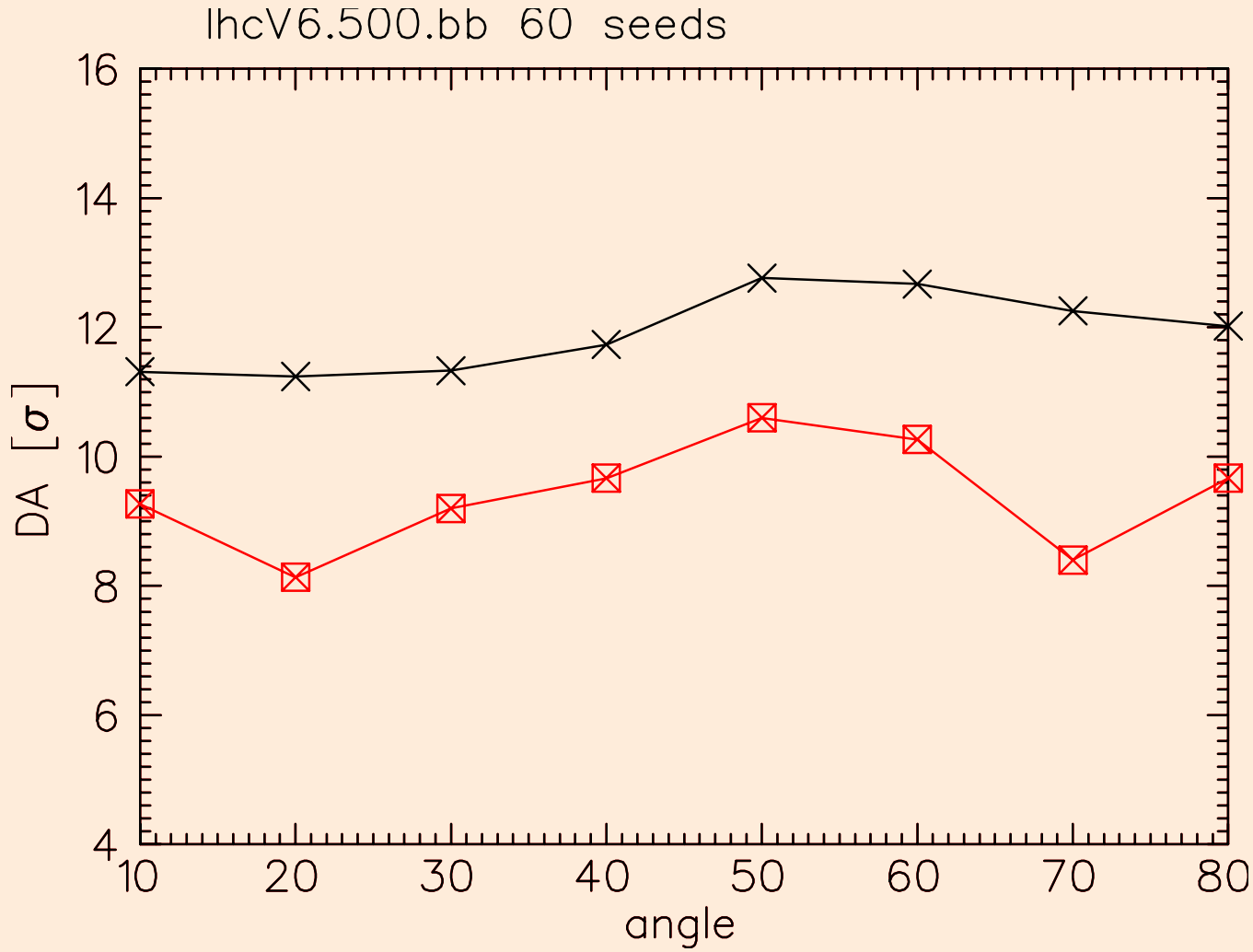
16.2 DA



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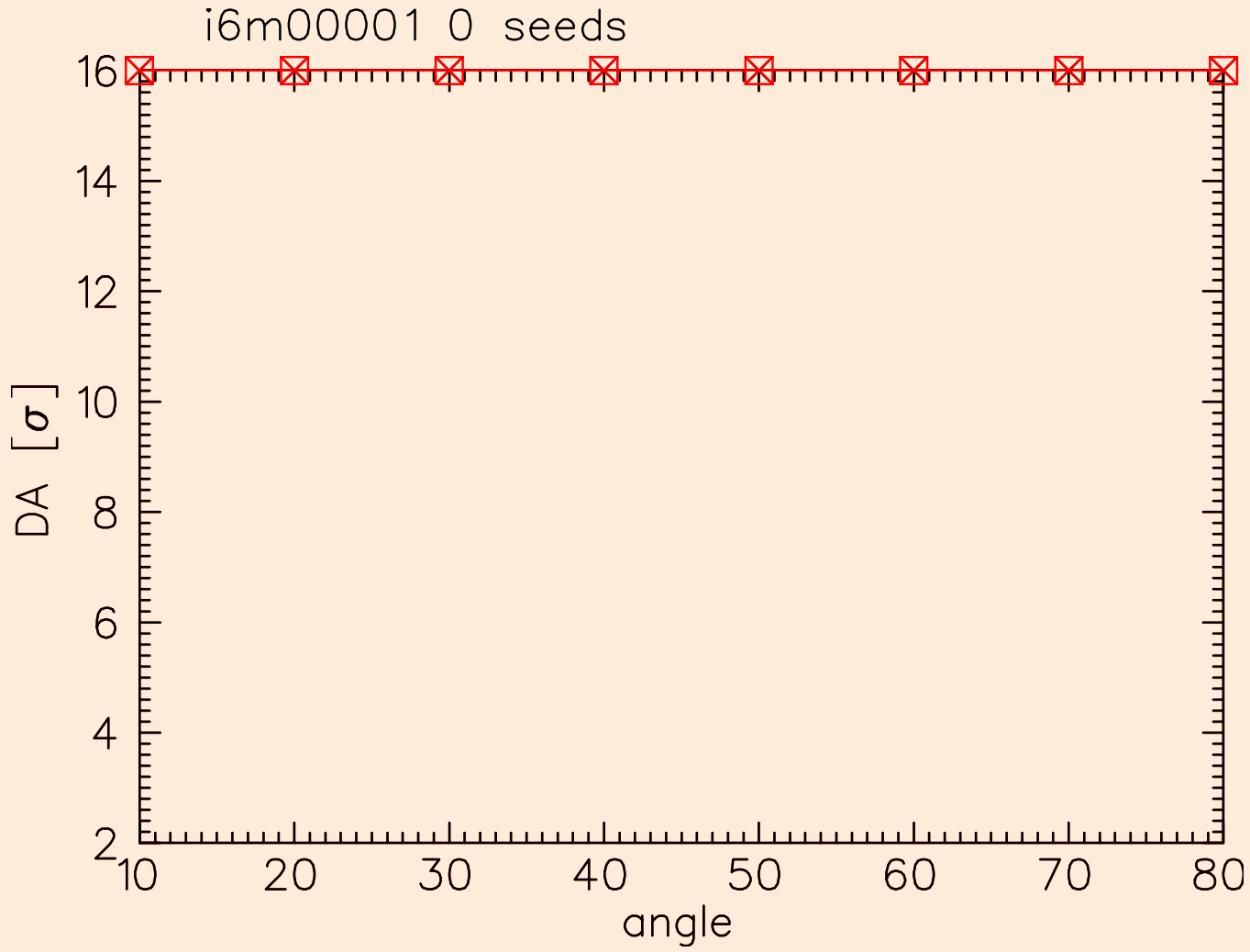
17 6m (0,0,0,0,1)

17.1 DA



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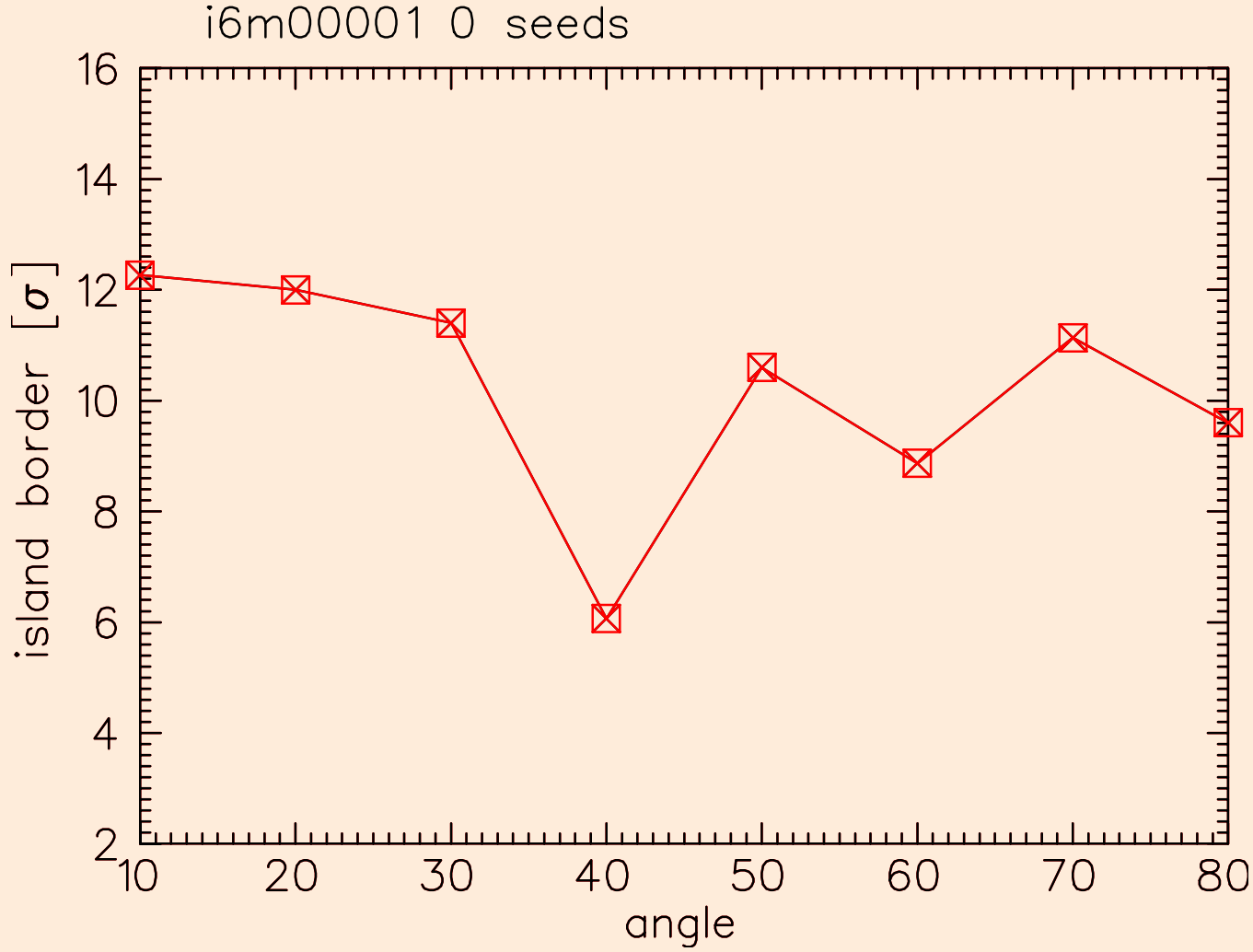
17.2 Chaos



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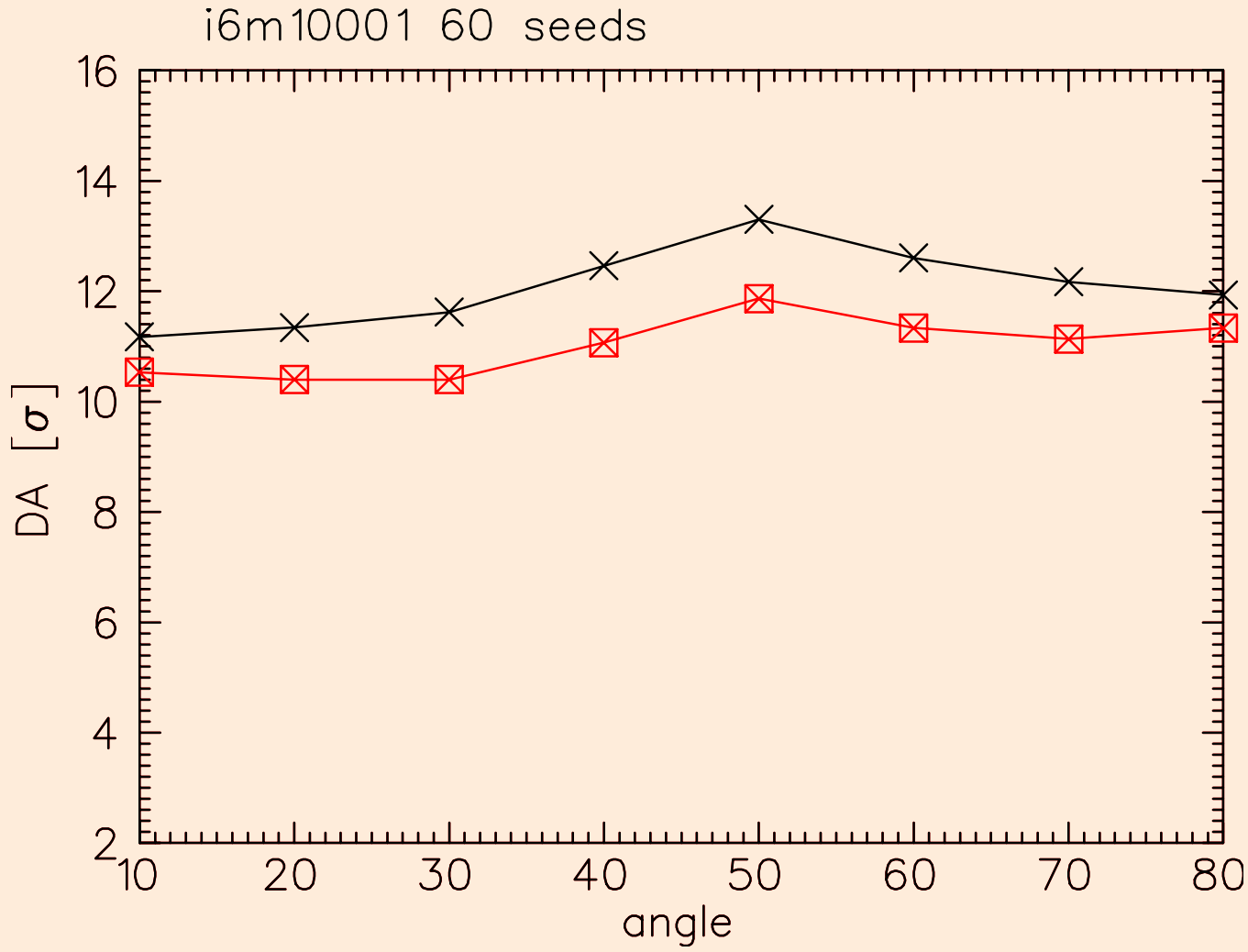
18 6m (1,0,0,0,1)

18.1 DA



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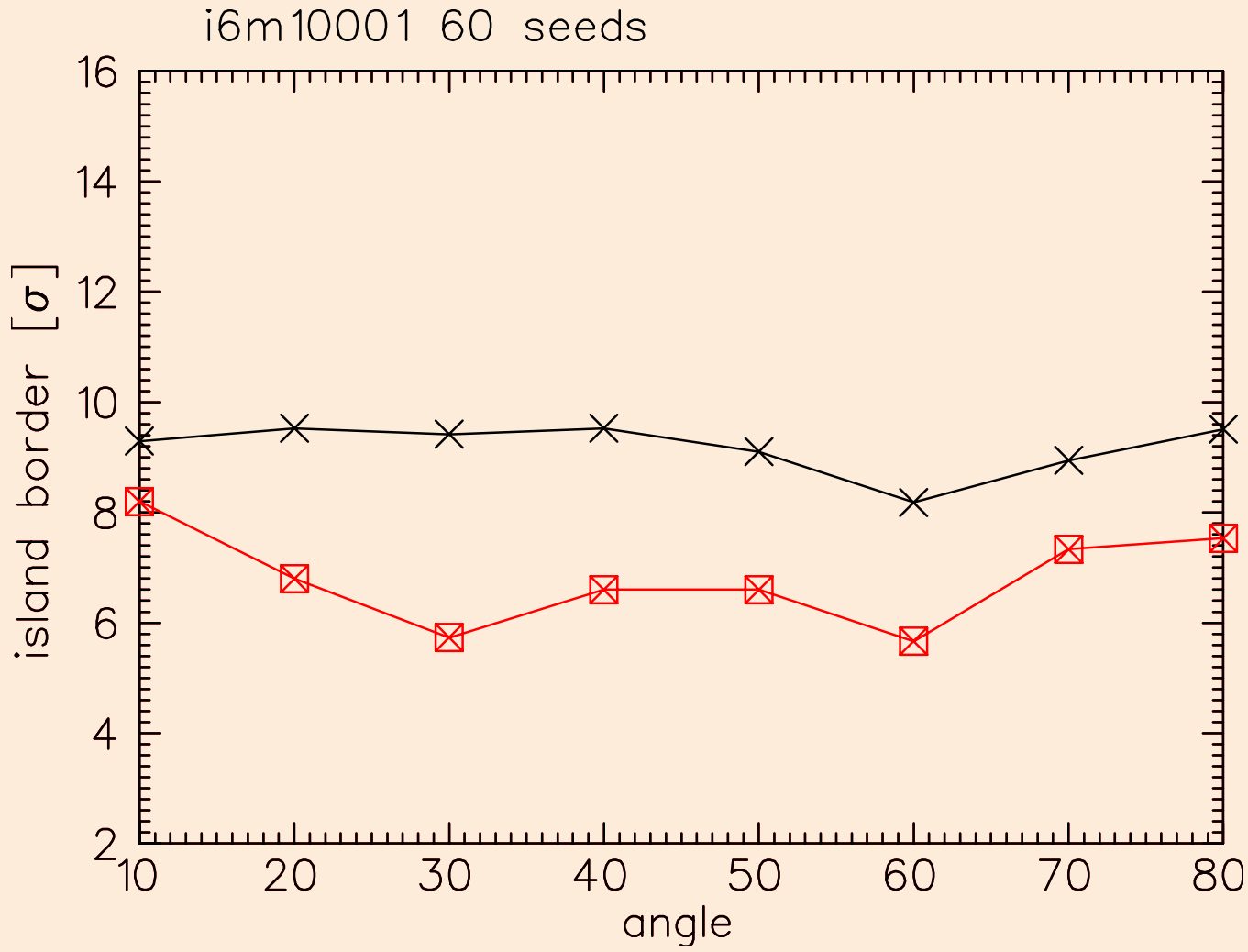
18.2 Chaos



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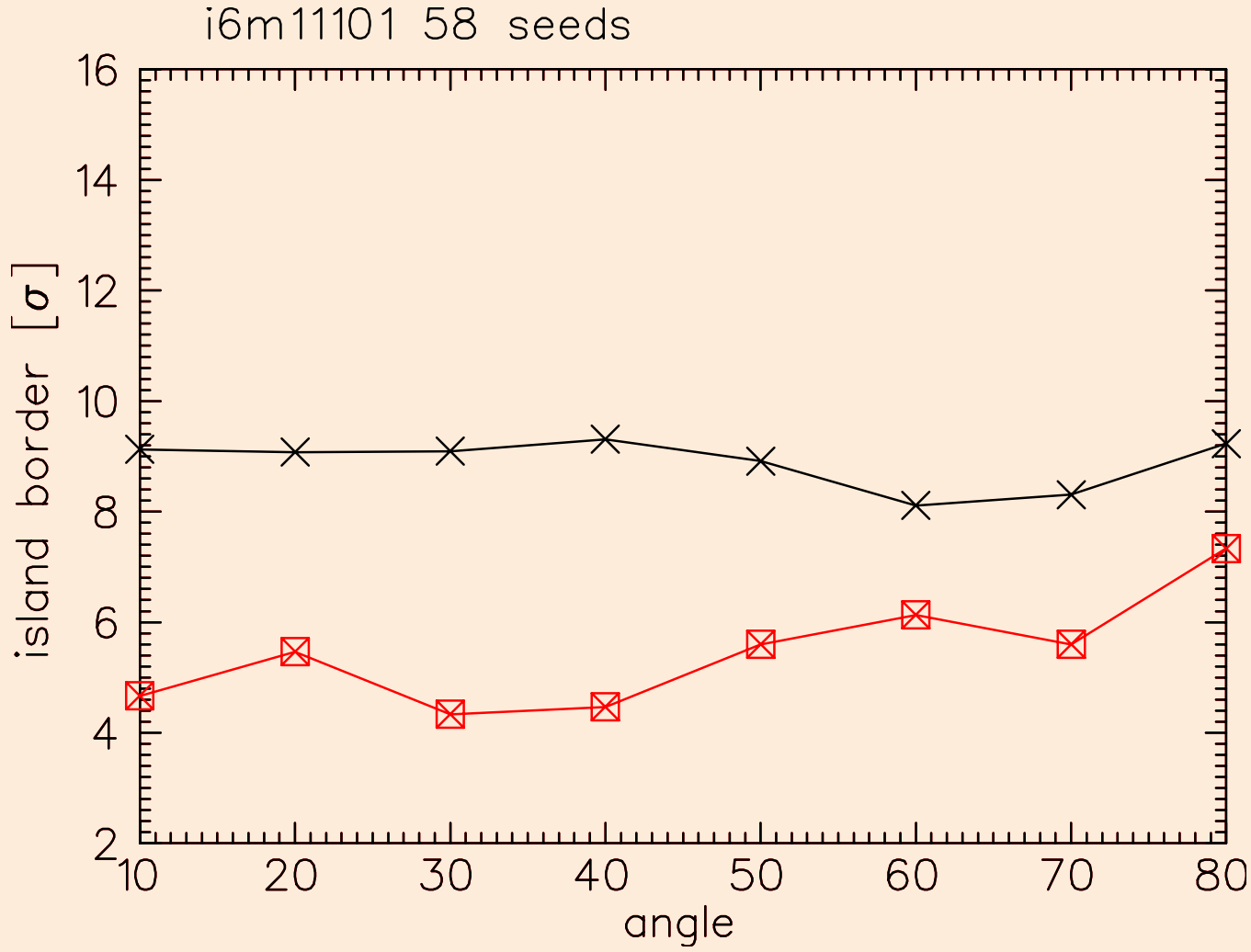
19 6m (1,1,1,0,1)

19.1 Chaos



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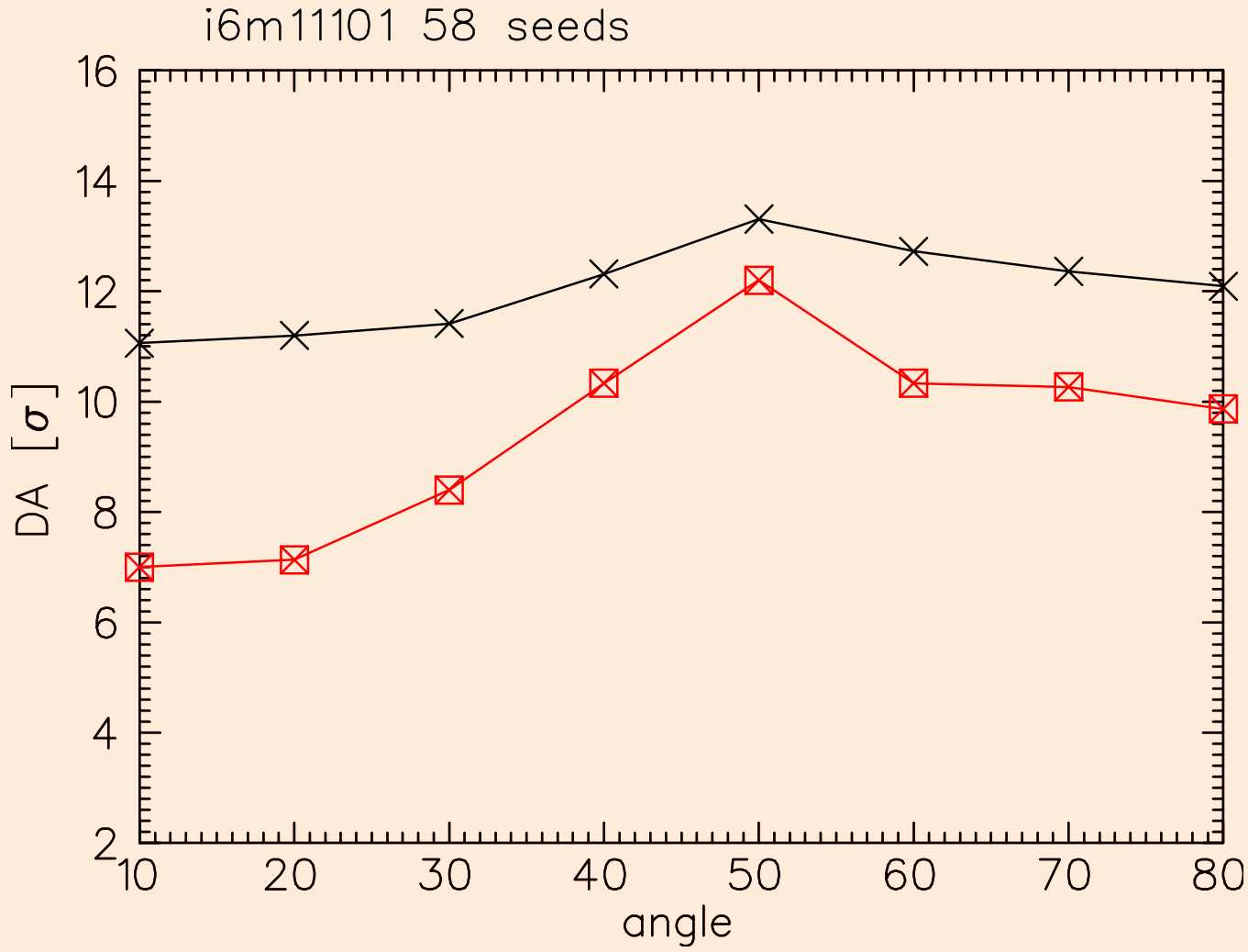
19.2 DA



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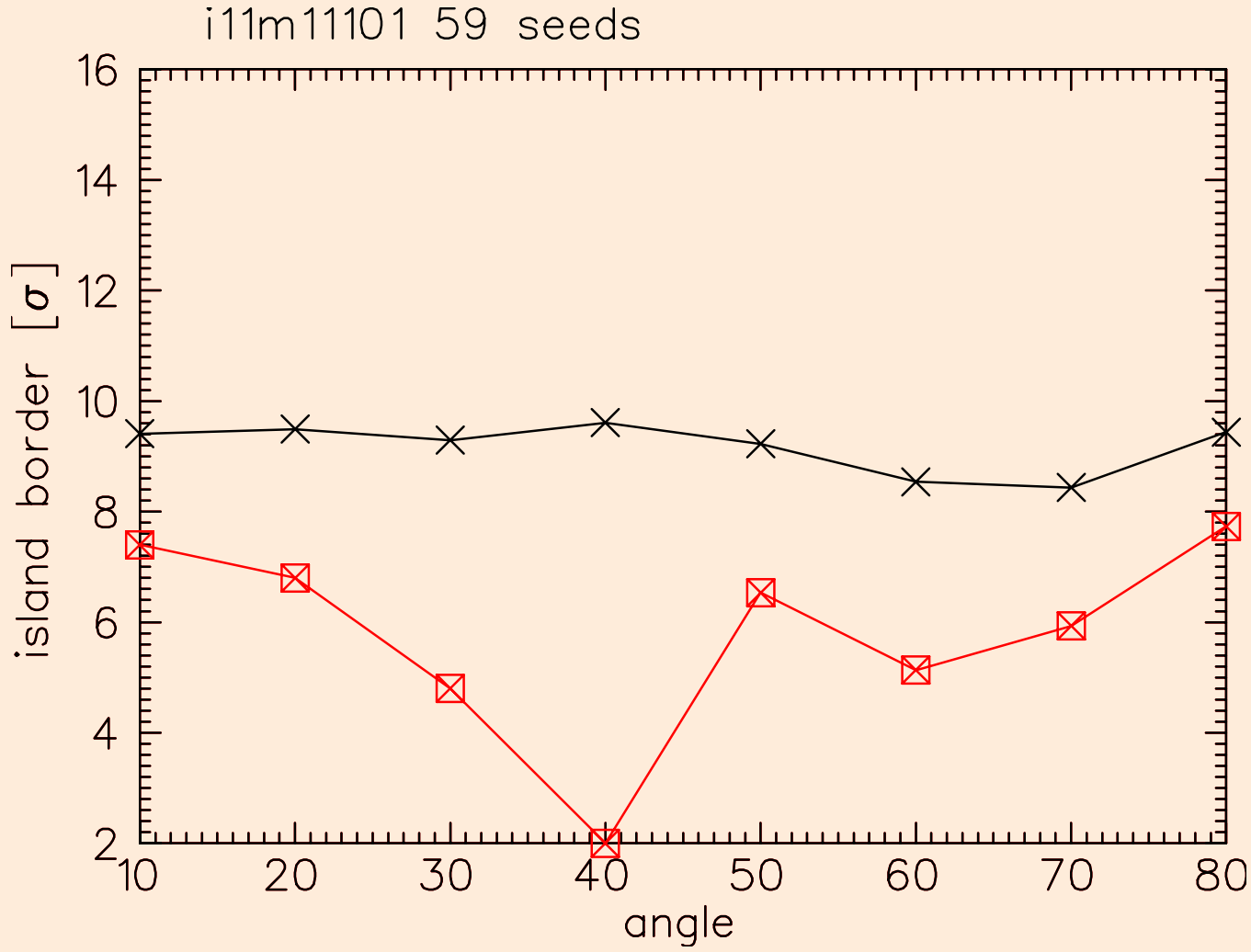
20 11m (1,1,1,0,1)

20.1 Chaos



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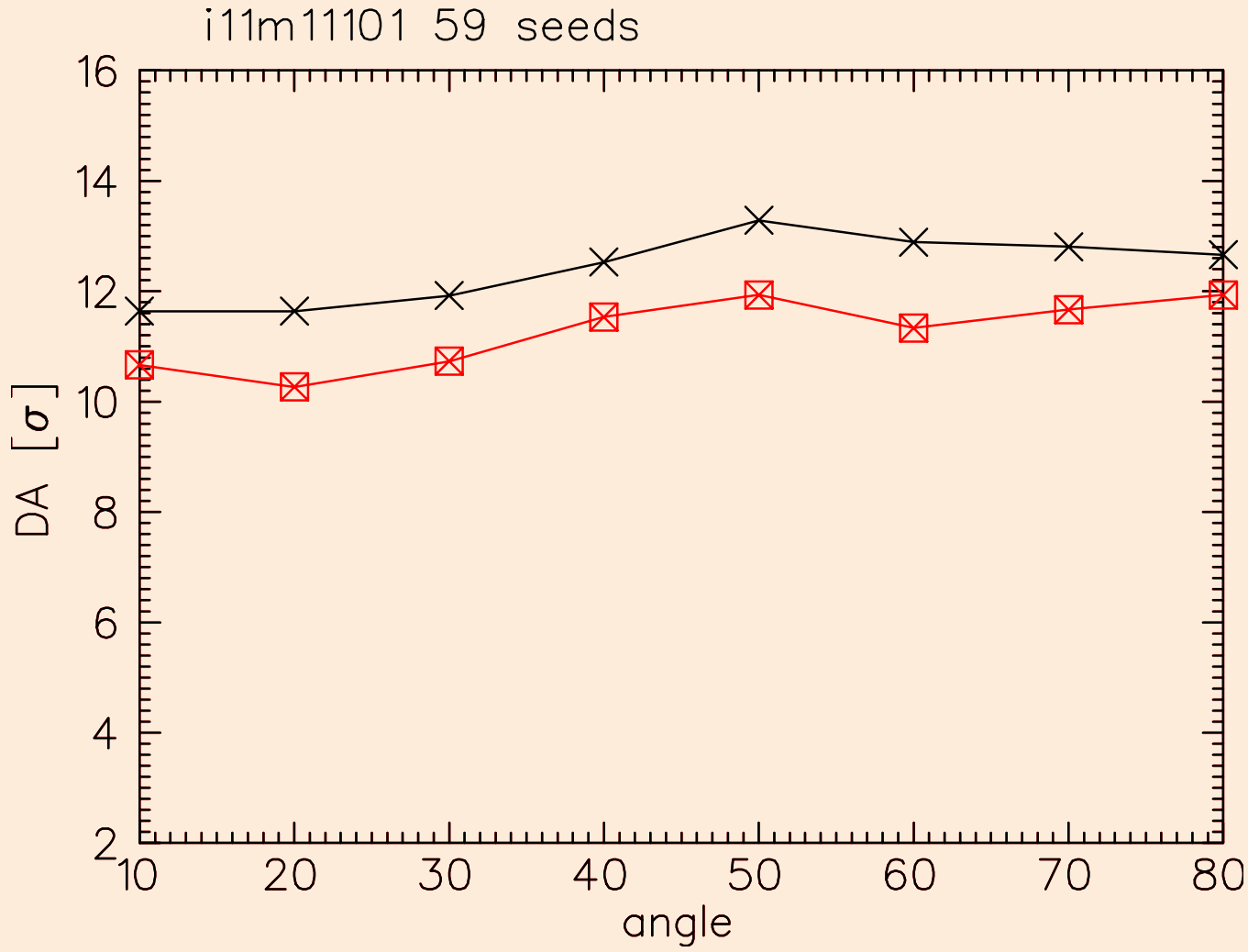
20.2 DA



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21 Summary (450 GeV)

For HO collisions IP1+IP5, 10^5 turns, $N_b = 0.4 \times 10^{11}$, with $\beta^* =$ 17m, 6m, 11m.

- β^* =17m, min DA = 8 sigma
- With 6m and 11m "beam-beam only" causes no particle loss, while with field err., corrected coupling and bb
  (but no D1-D4 align.):
  $\beta^* = 6$m $\rightarrow$ min DA = 7 σ (near hor plane)
  (and 10 σ without the a2)
  $\beta^* = 11$m $\rightarrow$ min DA = 10 σ
- *BOINC admin. is being moved to UK – causes delays at the moment (*`CPSS` *and* `lxplus` *are available)*