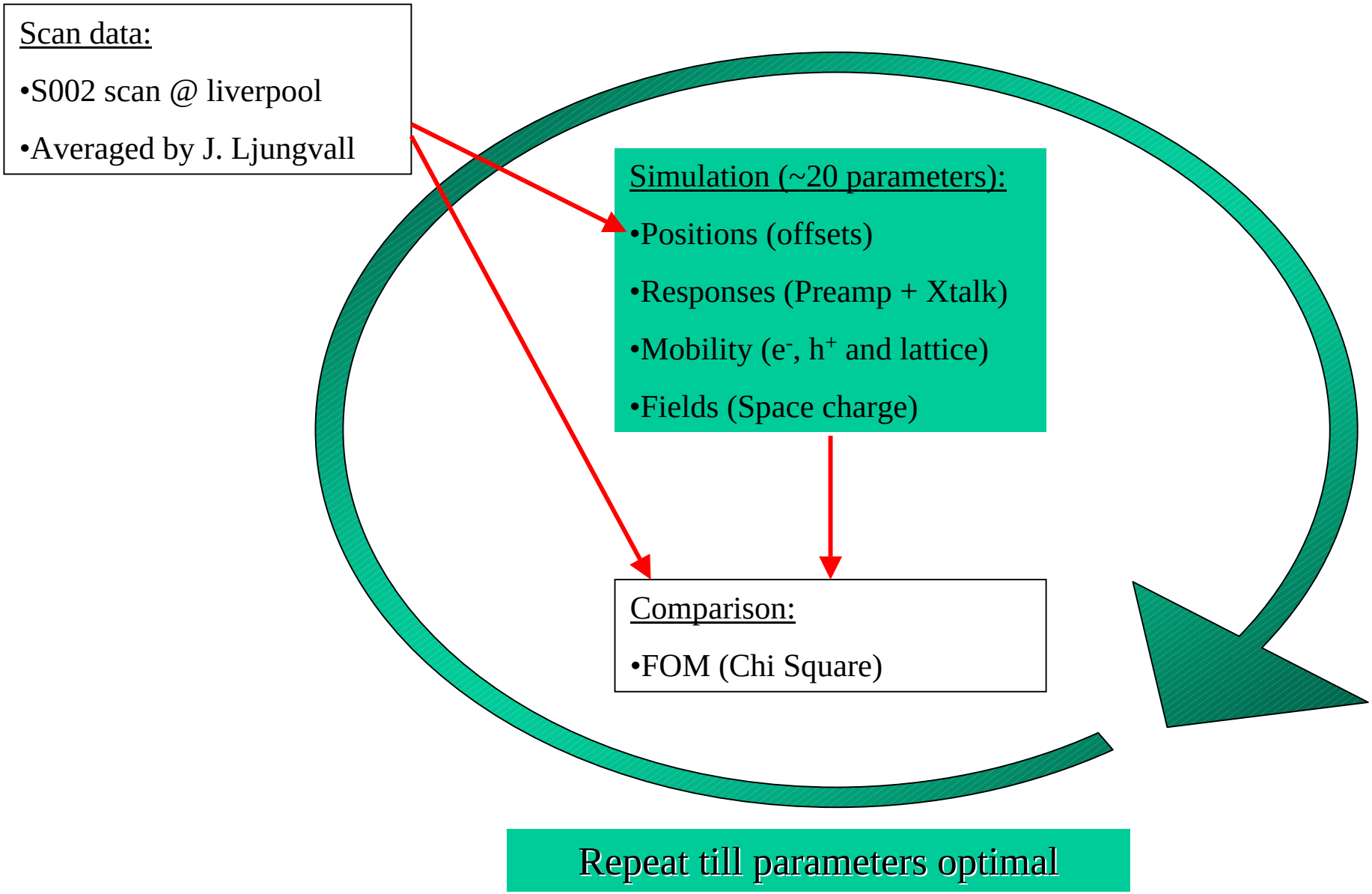
# Automated optimization of detector simulation to fit S002 scan data

- About the procedure
- About parameters and their sensitivity
- Measuring Xtalk parameters
- First results in pictures
- To do list and Suggestions for data taking

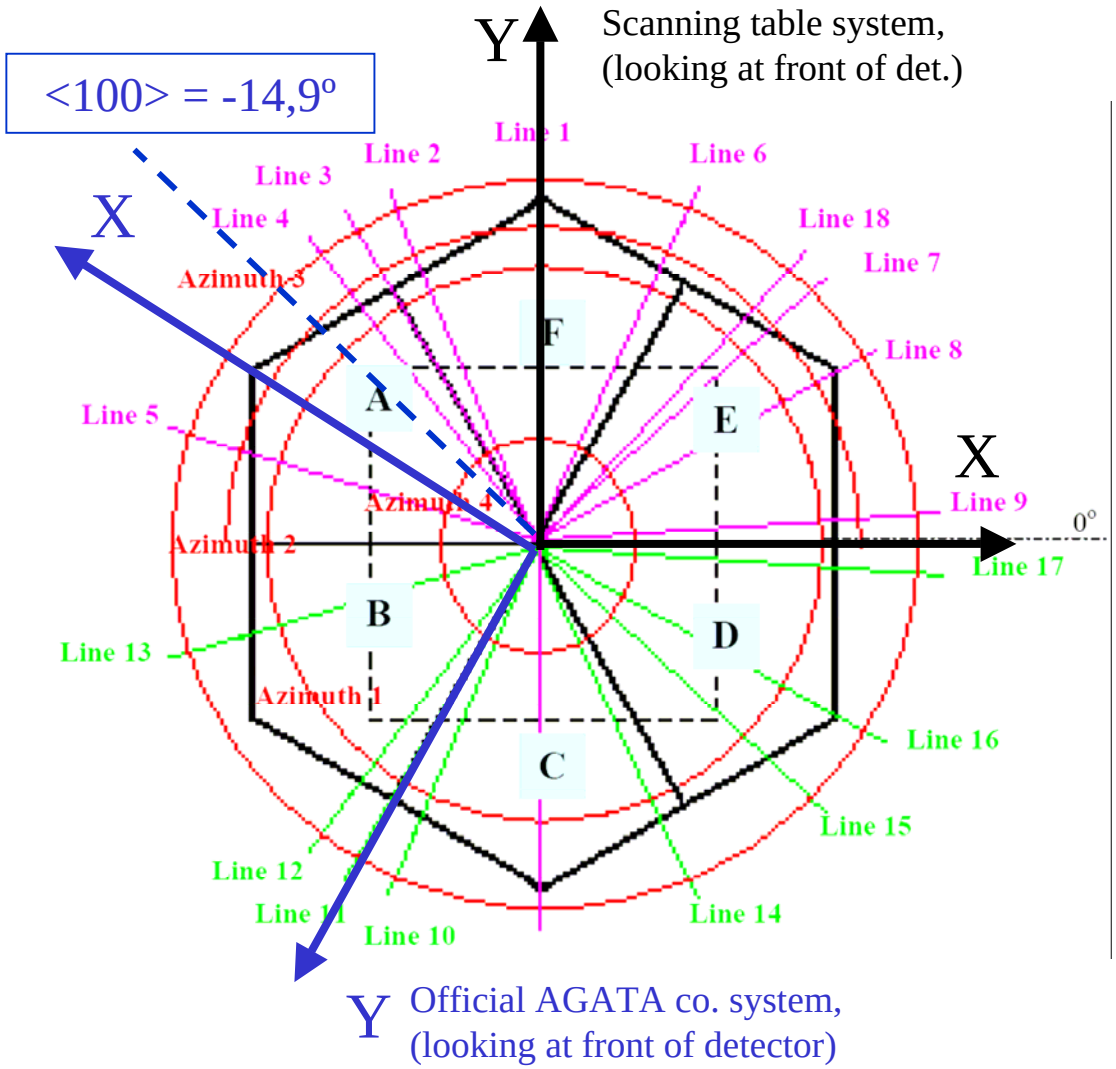
Bart Bruyneel and Benedikt Birkenbach – IKP Cologne

At the 6th AGATA week, Padua Nov. 2007

# Procedure


Scan data:
•S002 scan @ liverpool
•Averaged by J. Ljungvall
Simulation (~20 parameters):
•Positions (offsets)
•Responses (Preamp + Xtalk)
•Mobility ($e^-$, $h^+$ and lattice)
•Fields (Space charge)
Comparison:
•FOM (Chi Square)
Repeat till parameters optimal

# Parameters in detail : a) coordinates & offsets

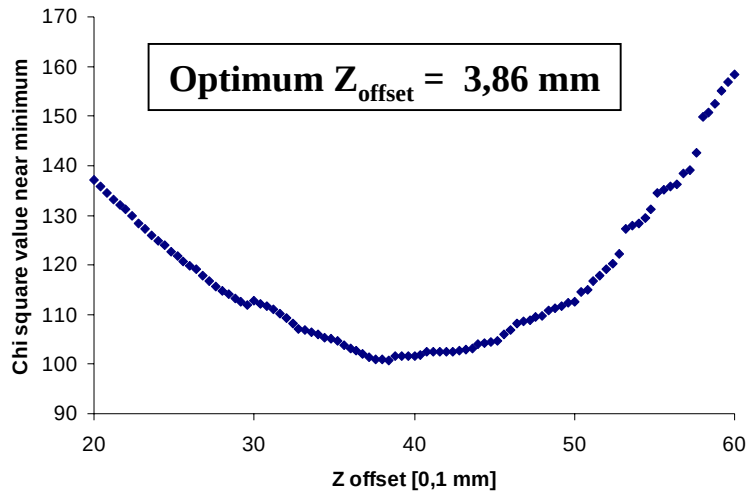



•Simultaneous optimization of 1714 positions :

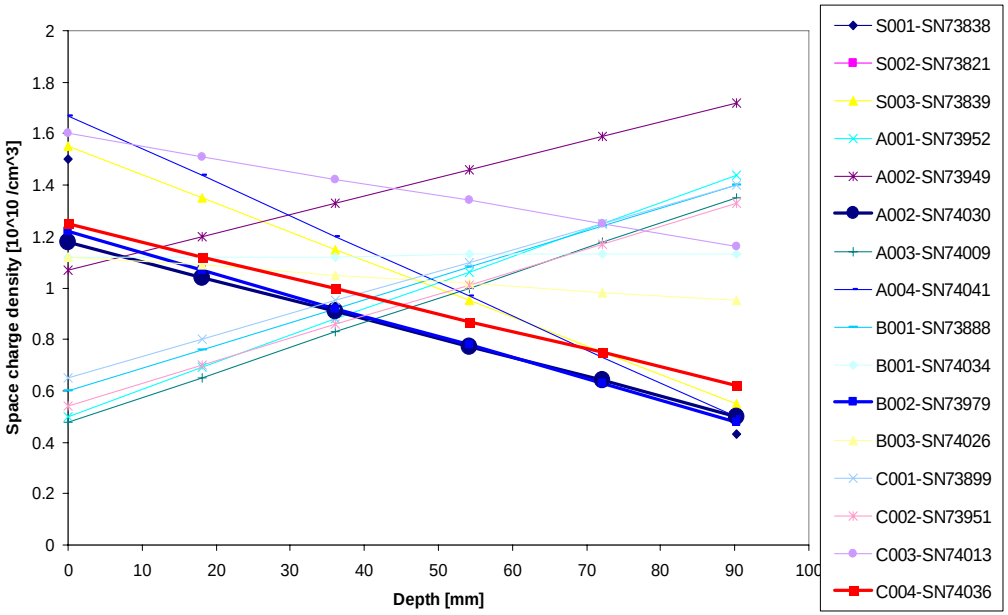
(4 azimuthal scans +17 line scans) x (6$^{+}$depths)

•Depths fixed by collimator (only 1 per ring ☹)

•X,Y position known, Z has constant offset:

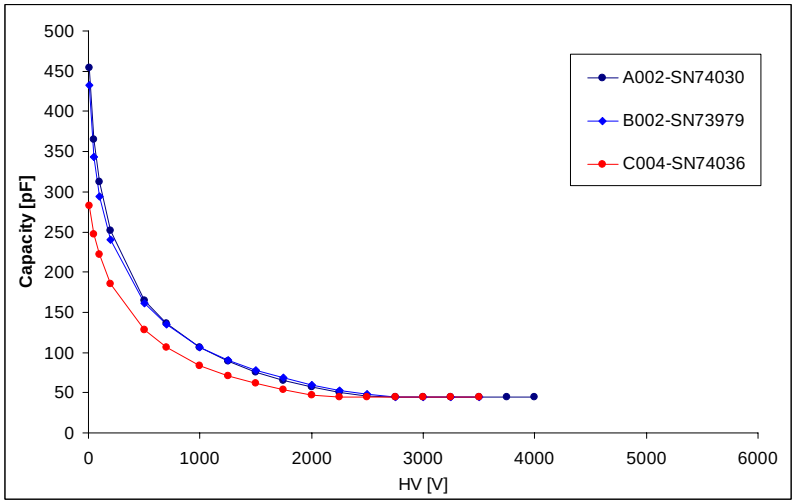


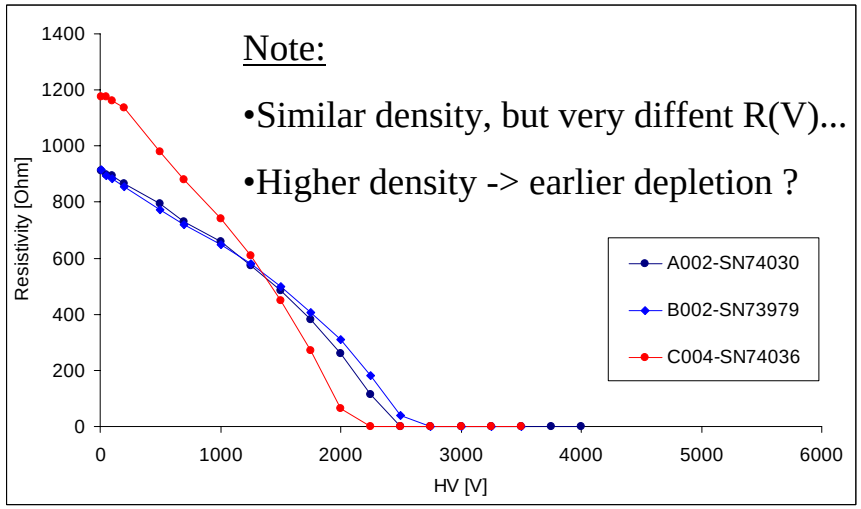
# Intermezzo : Impurities by Canberra



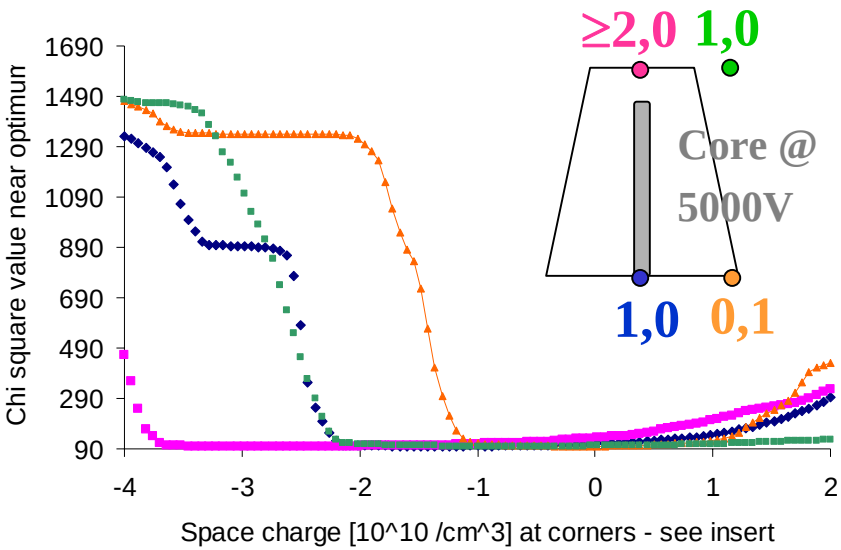

- All profiles highly linear...
- No prefered direction slope
- No ambiguous explanation:

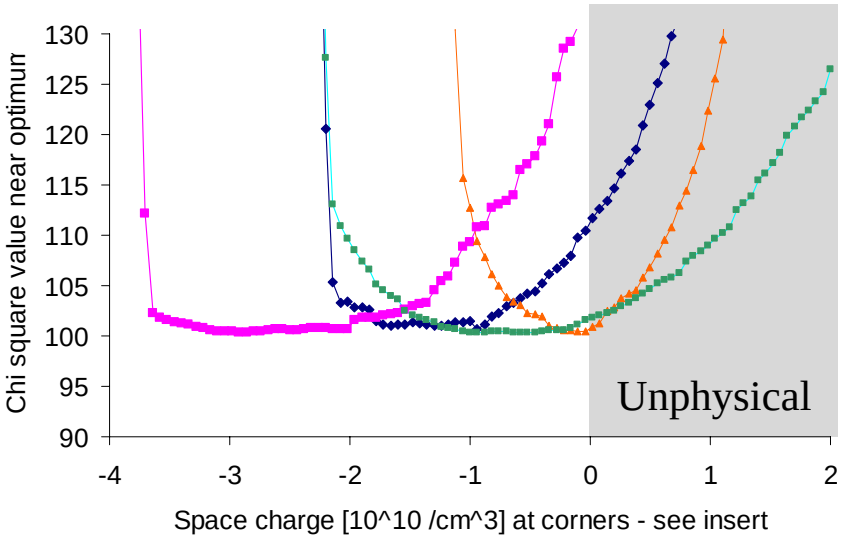
$V_{depletion}$, C(V), R(V)



# Parameters in detail : b) Space Charge




**Space Charge** [$10^{10}$/cm$^3$]
- cylinder symmetry
- Linear in r and z :
  ⇒ 4 point fit

Optimization clearly shows when detector is no longer depleted

S002 parameters by Canberra:

Top = 0,51 - Queue = 1,80

But Top = front or back ?

Missing info (only for this detector)

Top = back assumption most likely!!!

Zoom:

Rather insensitive in certain regions.

Region > 0 is not physical

Region < -2 is not likely

# Parameters in detail : c) Mobilities

$$v_l = \frac{\mu_0 E}{(1+(\frac{E}{E_0})^{\beta})^{\frac{1}{\beta}}} - \mu_n E$$

Reference - Miniball 12 fold

| | Electron mobility ($\mu$ in $[\frac{cm^2}{Vs}]$) | | | |
|---|---|---|---|---|
| dir. | $\mu_0$ | $\beta$ | $E_0[\frac{V}{cm}]$ | $\mu_n$ |
| $\langle 100 \rangle$ | 38609 | 0.805 | 511 | -171 |
| | 37200 | 0.805 | 510 | -167 |
| $\langle 111 \rangle$ | 38536 | 0.641 | 538 | 510 |
| | 32908 | 0.774 | 448 | -133 |

| | Hole mobility ($\mu$ in $[\frac{cm^2}{Vs}]$) | | | |
|---|---|---|---|---|
| dir. | $\mu_0$ | $\beta$ | $E_0[\frac{V}{cm}]$ | $\mu_n$ |
| $\langle 100 \rangle$ | 61824 | 0.942 | 185 | - |
| | 62380 | 0.727 | 181 | - |
| $\langle 111 \rangle$ | 61215 | 0.662 | 182 | - |
| | 62508 | 0.757 | 144 | - |

Preliminary values S002

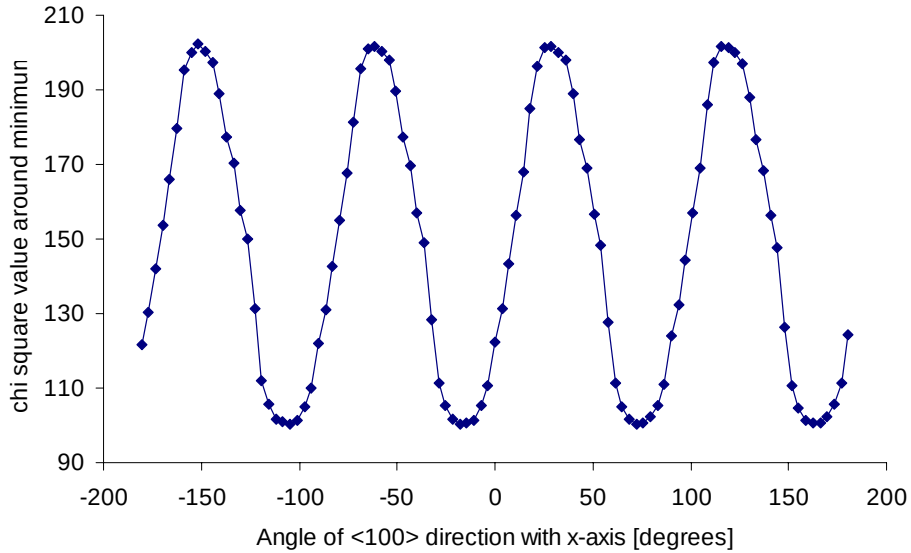
e⁻ intervalley scattering rate around $E_{ref}$ = 1200 V/cm

$$\eta(E) = \eta_0 + b \ln(E/E_{ref})$$

| $\eta_0$ | $b$ | 2nd order |
|---|---|---|
| 0,496 | 0,0296 | (negligible) |
| 0,459 | 0,0294 | $5{,}4.10^{-5}$ |

Orientation of lattice very well defined:

Angle = -14,9º (AGATA coord. system)



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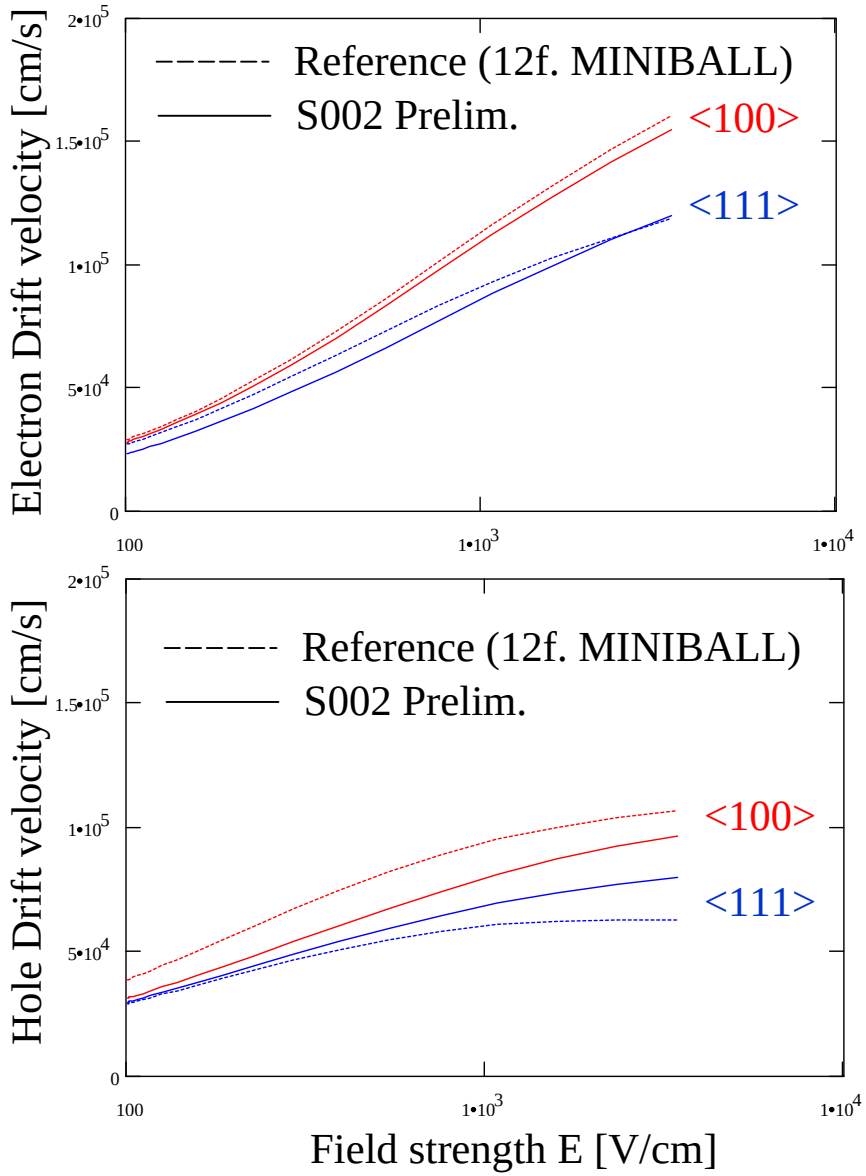


# Parameters in detail : c) e- mobility along <100>

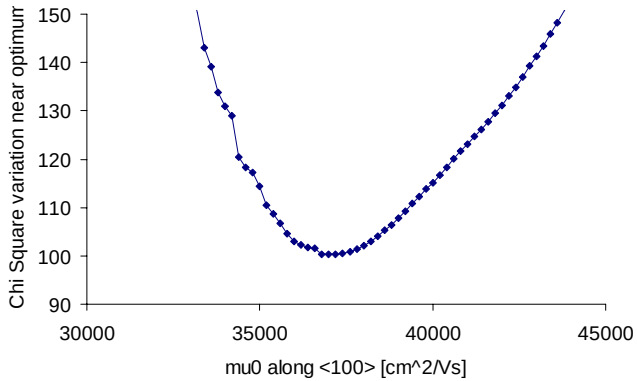
$$v_l = \frac{\mu_0 E}{(1 + (\frac{E}{E_0})^\beta)^{\frac{1}{\beta}}} + \mu_n E$$

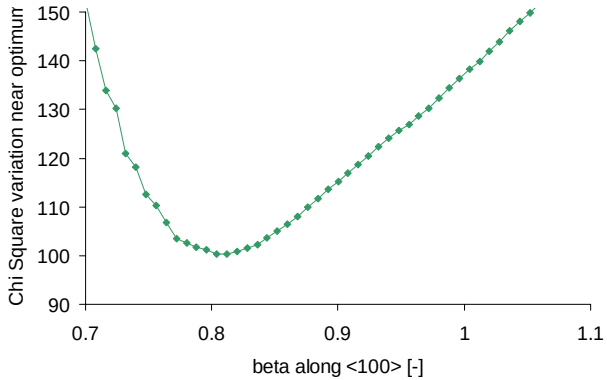
Miniball 12 fold

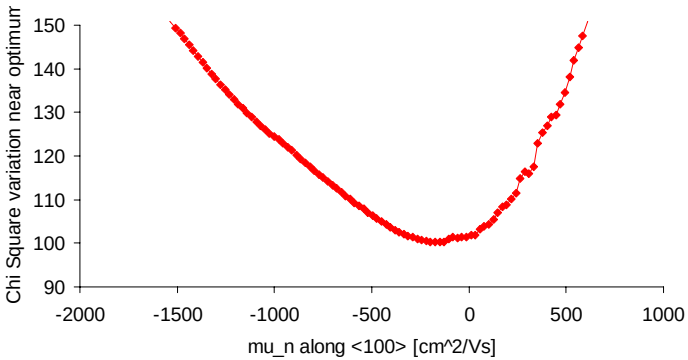
| | Electron mobility ($\mu$ in $[\frac{cm^2}{Vs}]$) | | | |
|---|---|---|---|---|
| dir. | $\mu_0$ | $\beta$ | $E_0[\frac{V}{cm}]$ | $\mu_n$ |
| $\langle 100 \rangle$ | 38609 | 0.805 | 511 | -171 |
| | 37200 | 0.805 | 510 | -167 |

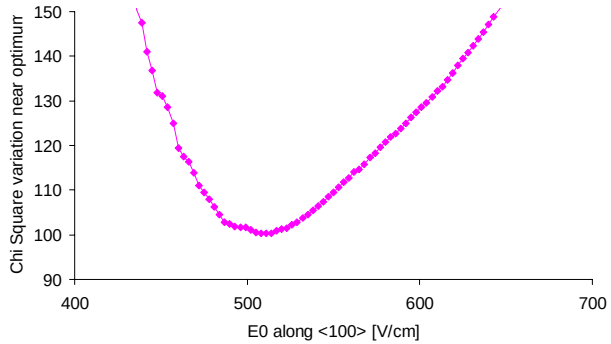
values S002

All well defined minima,
Same for other parameters...



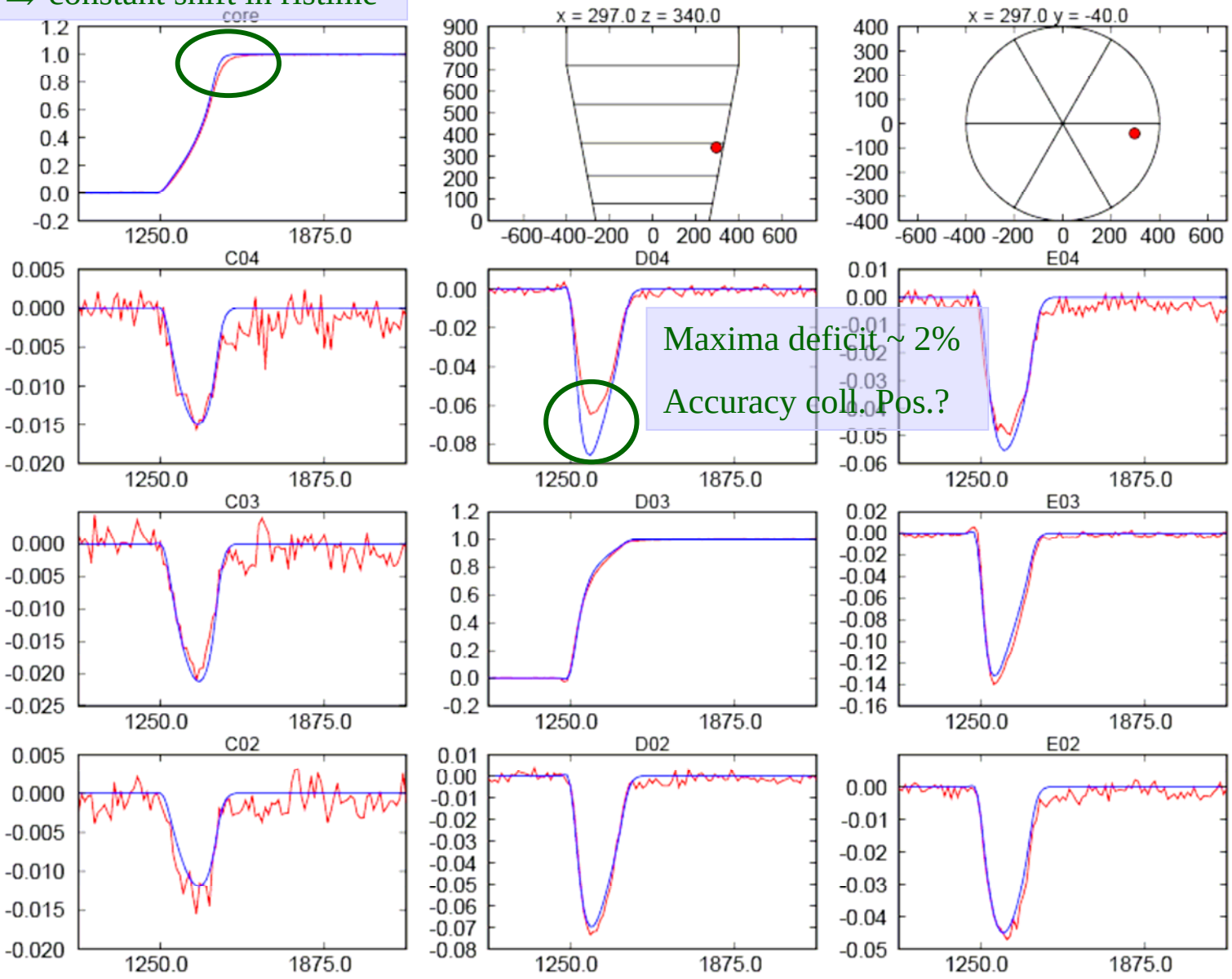



# Line Scan 17

Typical effect

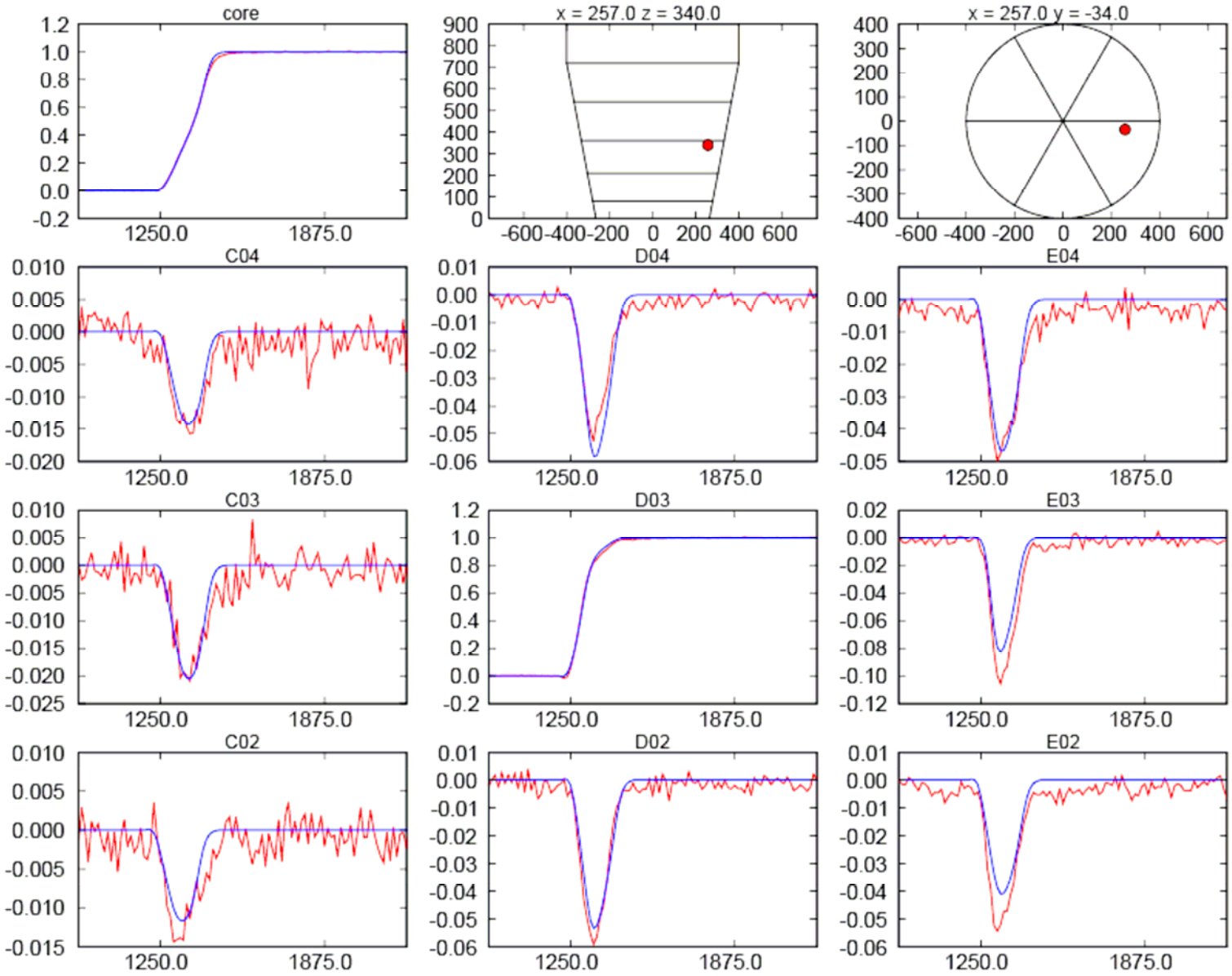
⇒ constant shift in ristime



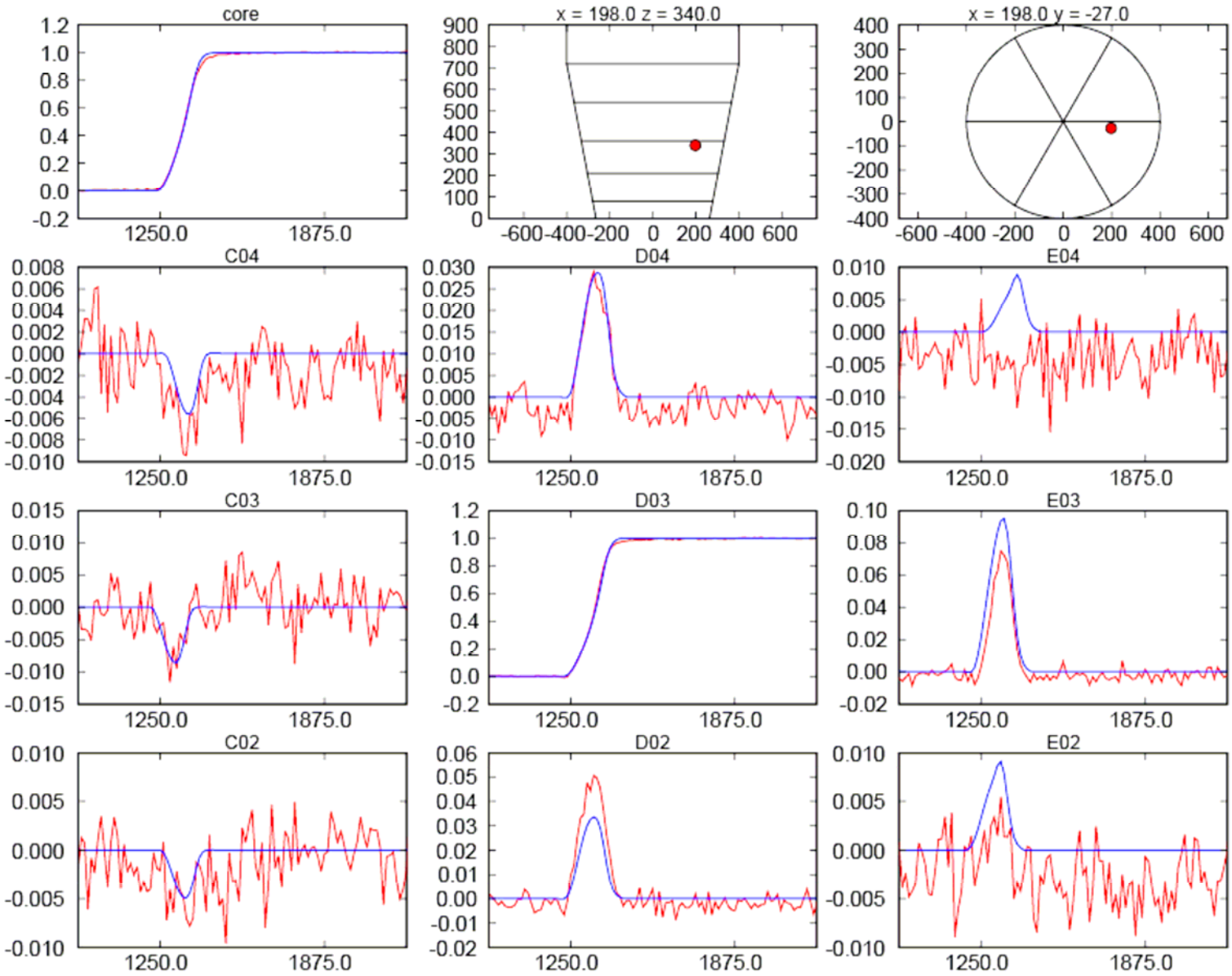

Maxima deficit ~ 2%

Accuracy coll. Pos.?

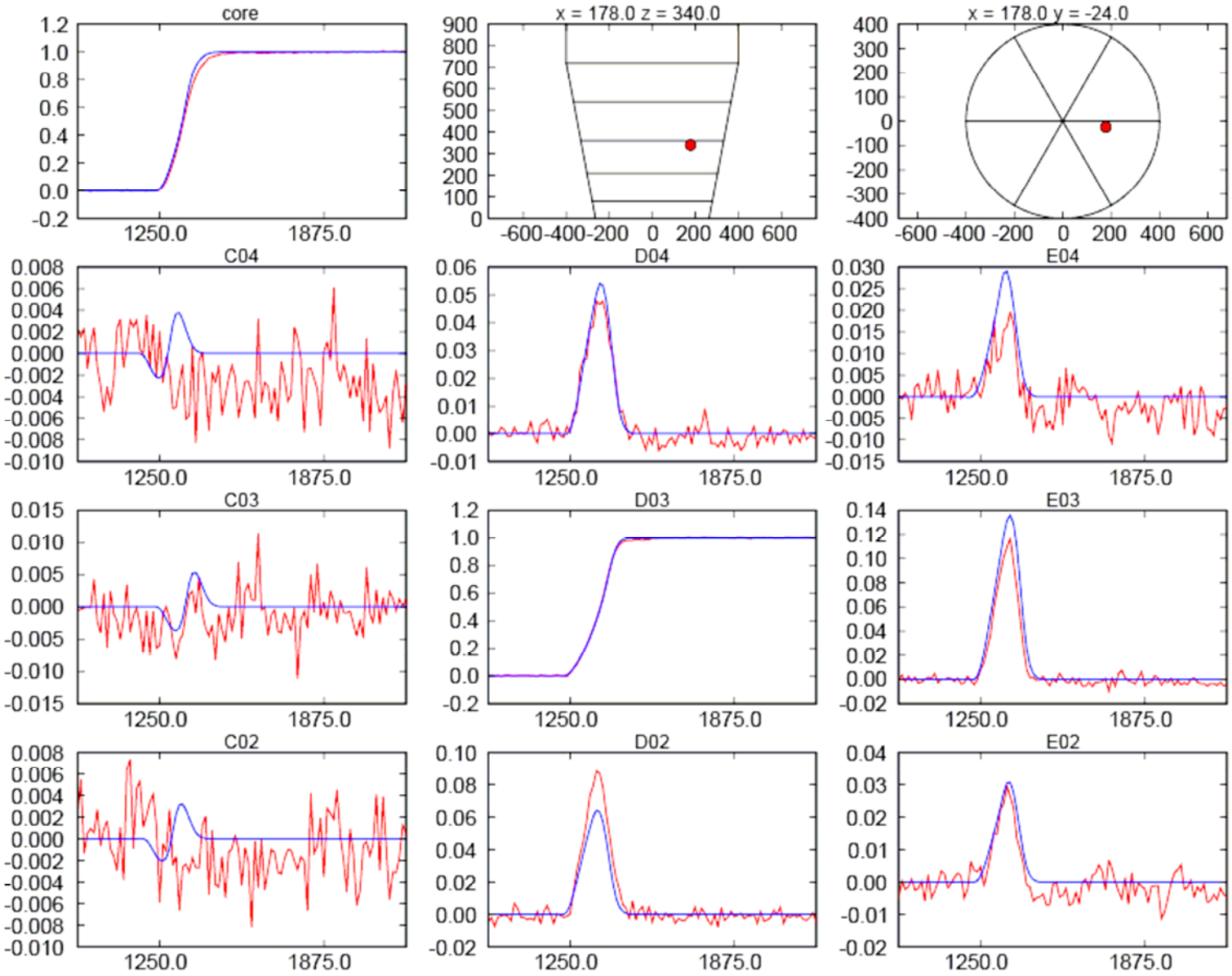
# Line Scan 17


core
x = 257.0 z = 340.0
x = 257.0 y = -34.0
C04
D04
E04
C03
D03
E03
C02
D02
E02
1250.0
1875.0

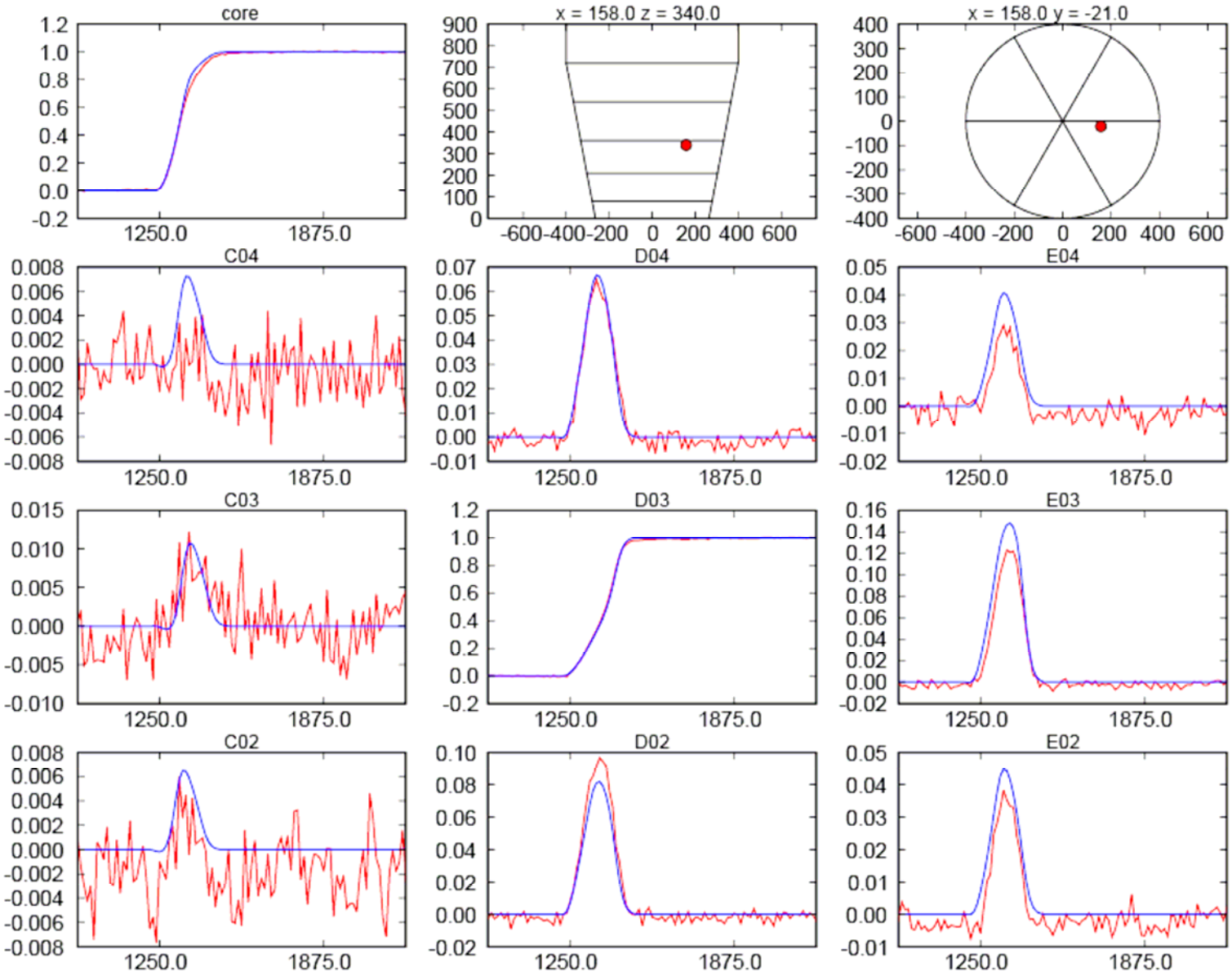
# Line Scan 17


core
x = 198.0 z = 340.0
x = 198.0 y = -27.0
C04
D04
E04
C03
D03
E03
C02
D02
E02
1250.0
1875.0

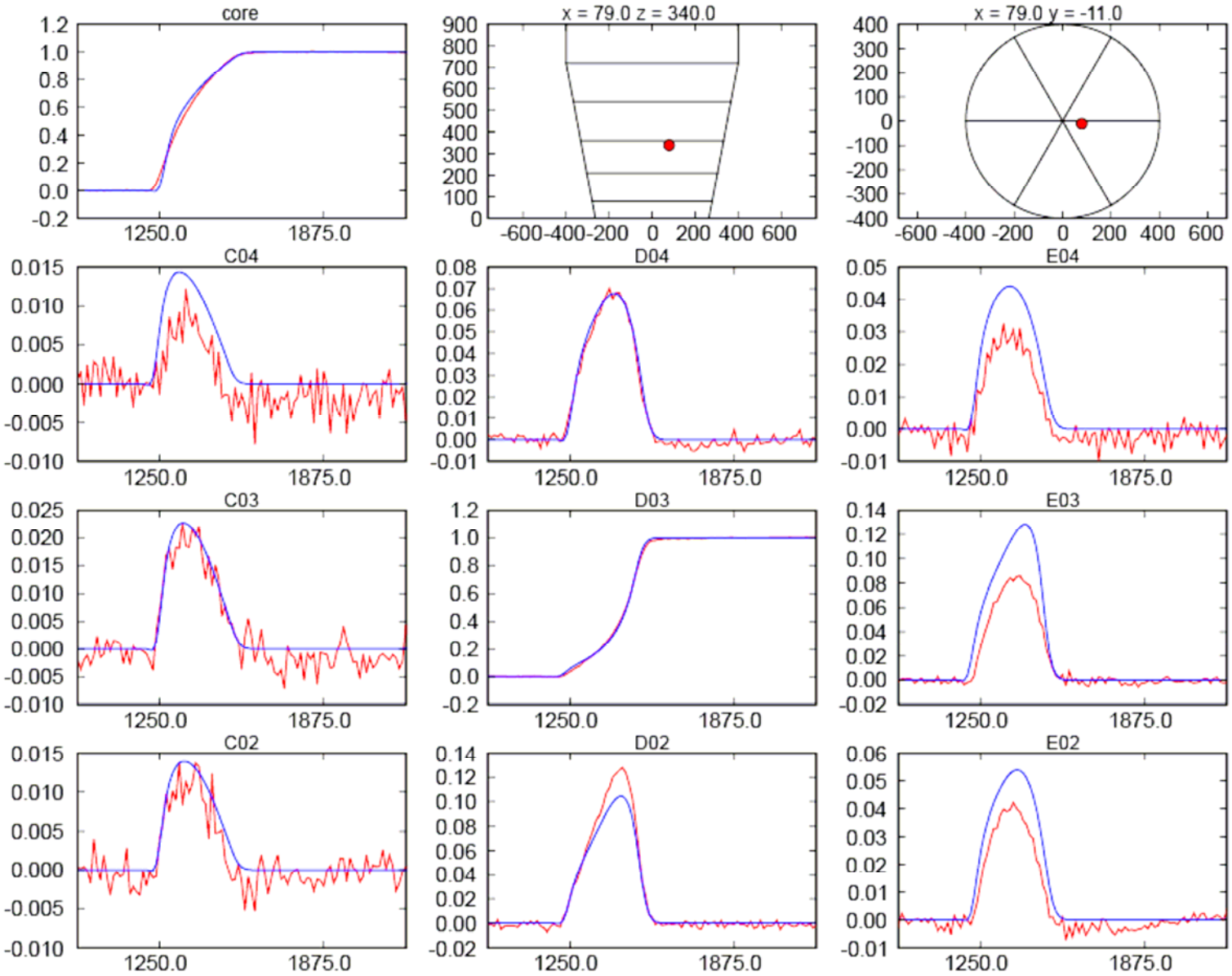
# Line Scan 17


core
x = 178.0 z = 340.0
x = 178.0 y = -24.0
C04
D04
E04
C03
D03
E03
C02
D02
E02
1250.0
1875.0

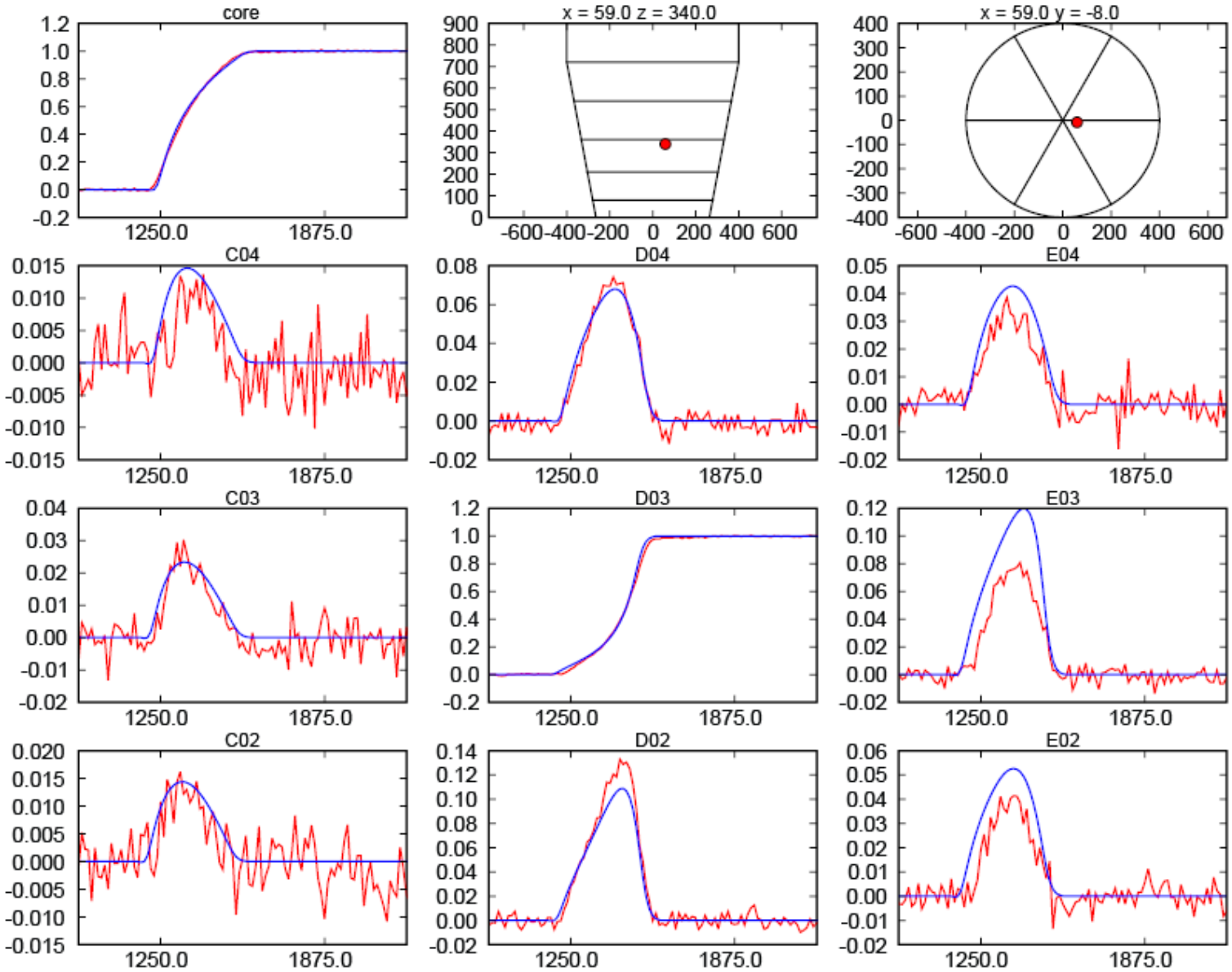
# Line Scan 17


core
x = 158.0 z = 340.0
x = 158.0 y = -21.0
C04
D04
E04
C03
D03
E03
C02
D02
E02
1250.0
1875.0

# Line Scan 17

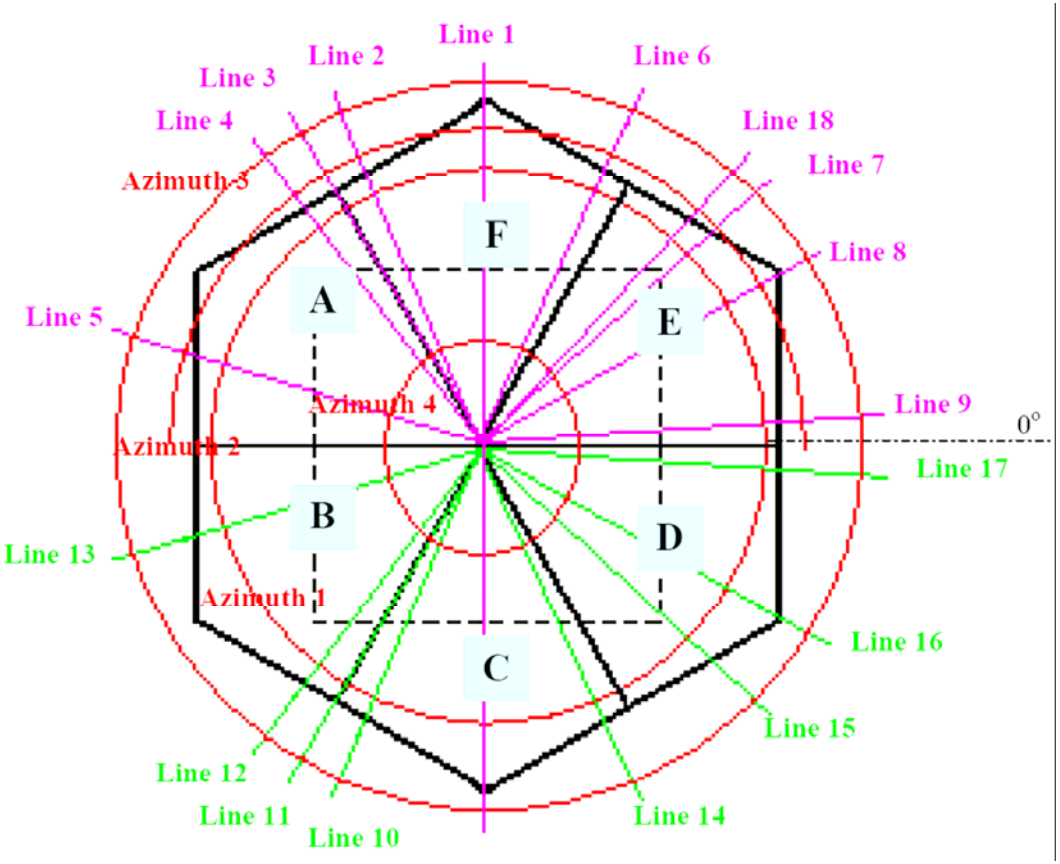

core
x = 79.0 z = 340.0
x = 79.0 y = -11.0
C04
D04
E04
C03
D03
E03
C02
D02
E02
1250.0
1875.0

# Line Scan 17



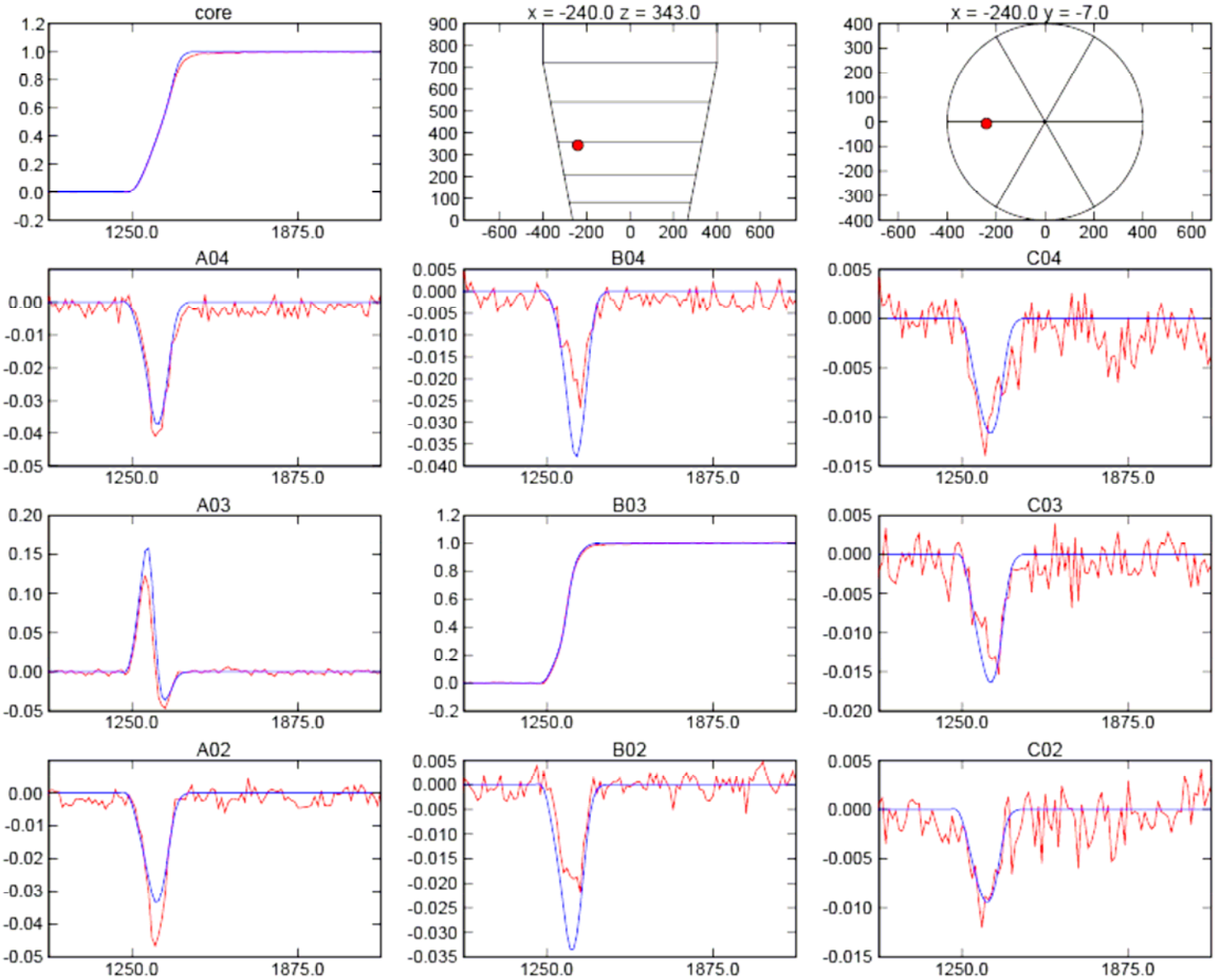

**Line 17 is the WORST case...!!!**

# Status: Promissing results

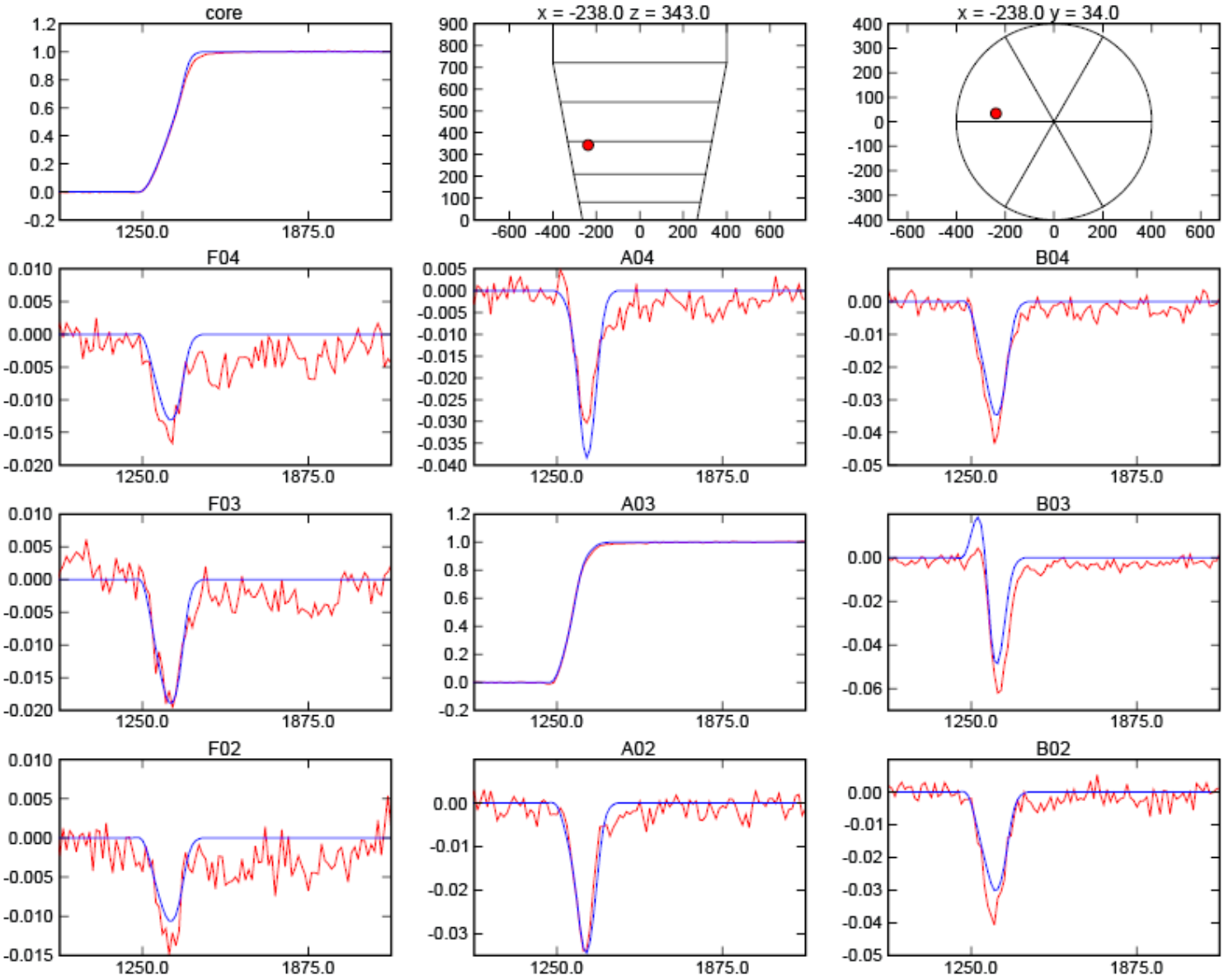



| Azim. scans | #evts | avg. FOM | |
|---|---|---|---|
| 20mm | 97 | 4.74E-02 | |
| 24mm | 262 | 4.08E-02 | <next |
| 27mm | 144 | 4.55E-02 | |
| 31mm | 204 | 5.37E-02 | |
| **Line scans** | | | |
| 1 | 119 | 8.28E-02 | |
| 2 | 84 | 7.07E-02 | |
| 3 | 44 | 9.73E-02 | |
| 4 | 54 | 6.55E-02 | |
| 5 | 75 | 7.86E-02 | |
| 6 | 57 | 6.18E-02 | |
| 7 | 89 | 6.78E-02 | |
| 8 | 78 | 5.20E-02 | |
| 9 | 46 | 6.18E-02 | |
| 10 | 48 | 5.67E-02 | |
| 11 | 11 | excluded | |
| 12 | 64 | 5.39E-02 | |
| 13 | 61 | 7.47E-02 | |
| 14 | 39 | 6.62E-02 | |
| 15 | 57 | 6.16E-02 | |
| 16 | 34 | 3.86E-02 | |
| 17 | 43 | 8.78E-02 | <shown |

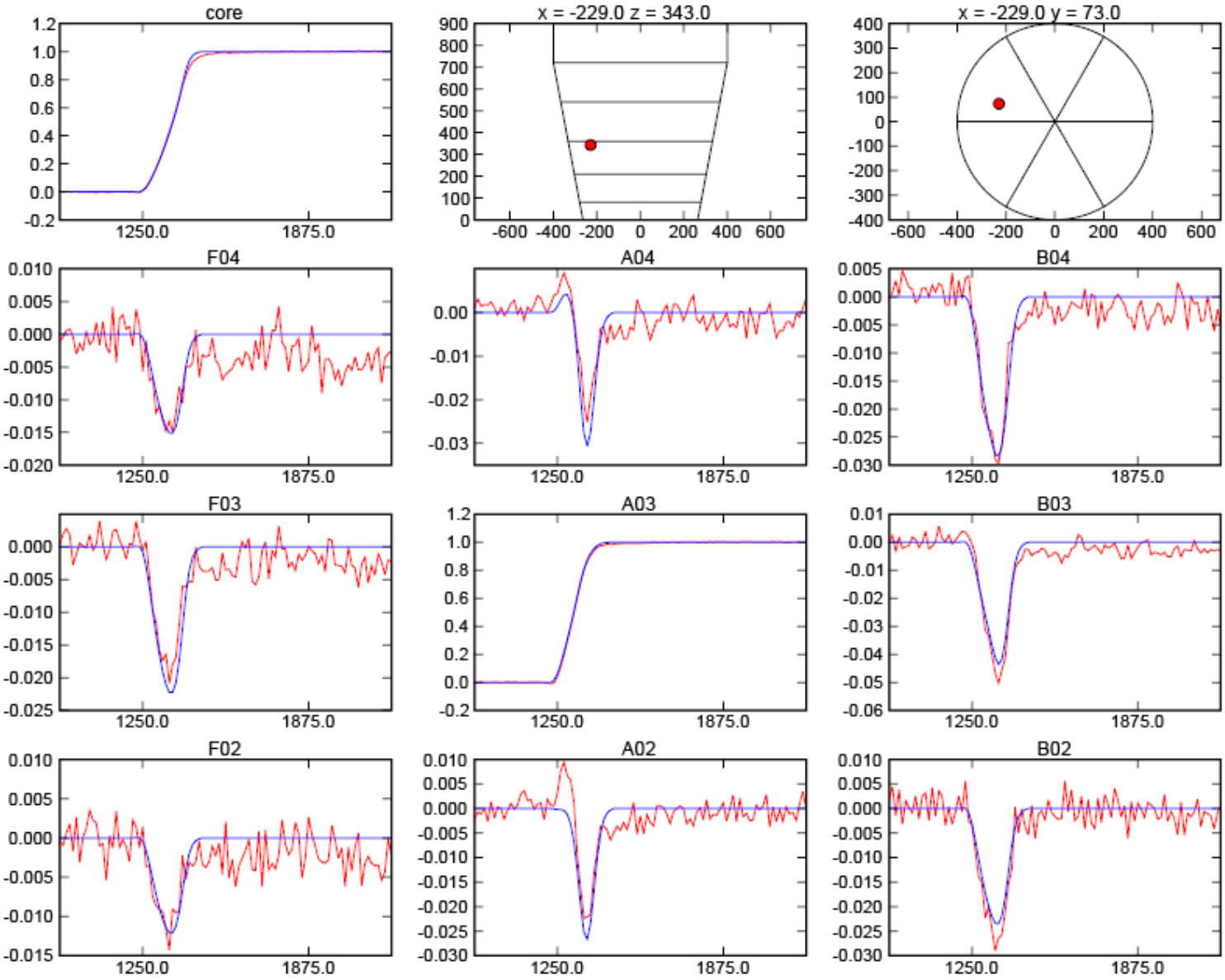
# Angular Scan 24mm



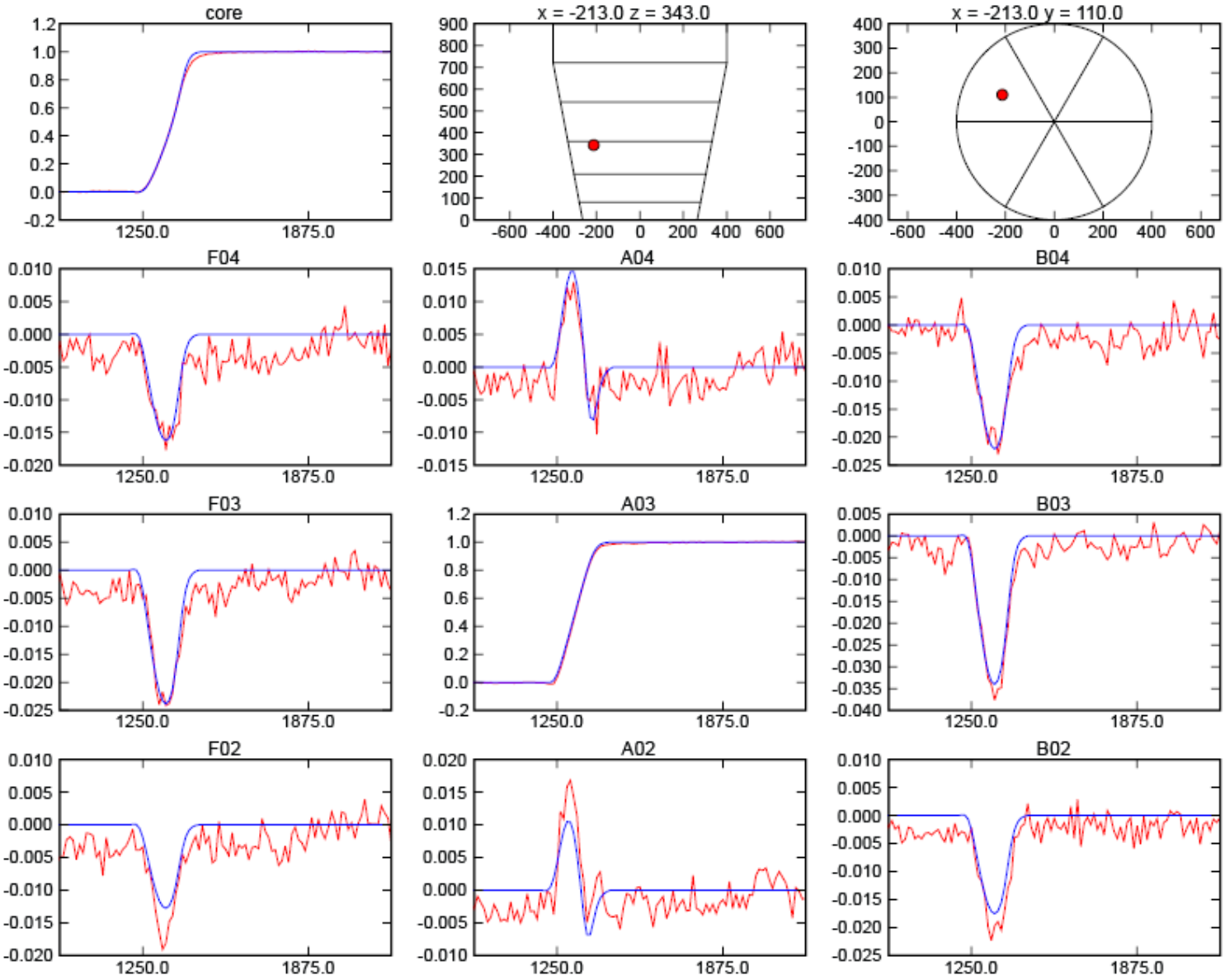
# Angular Scan 24mm



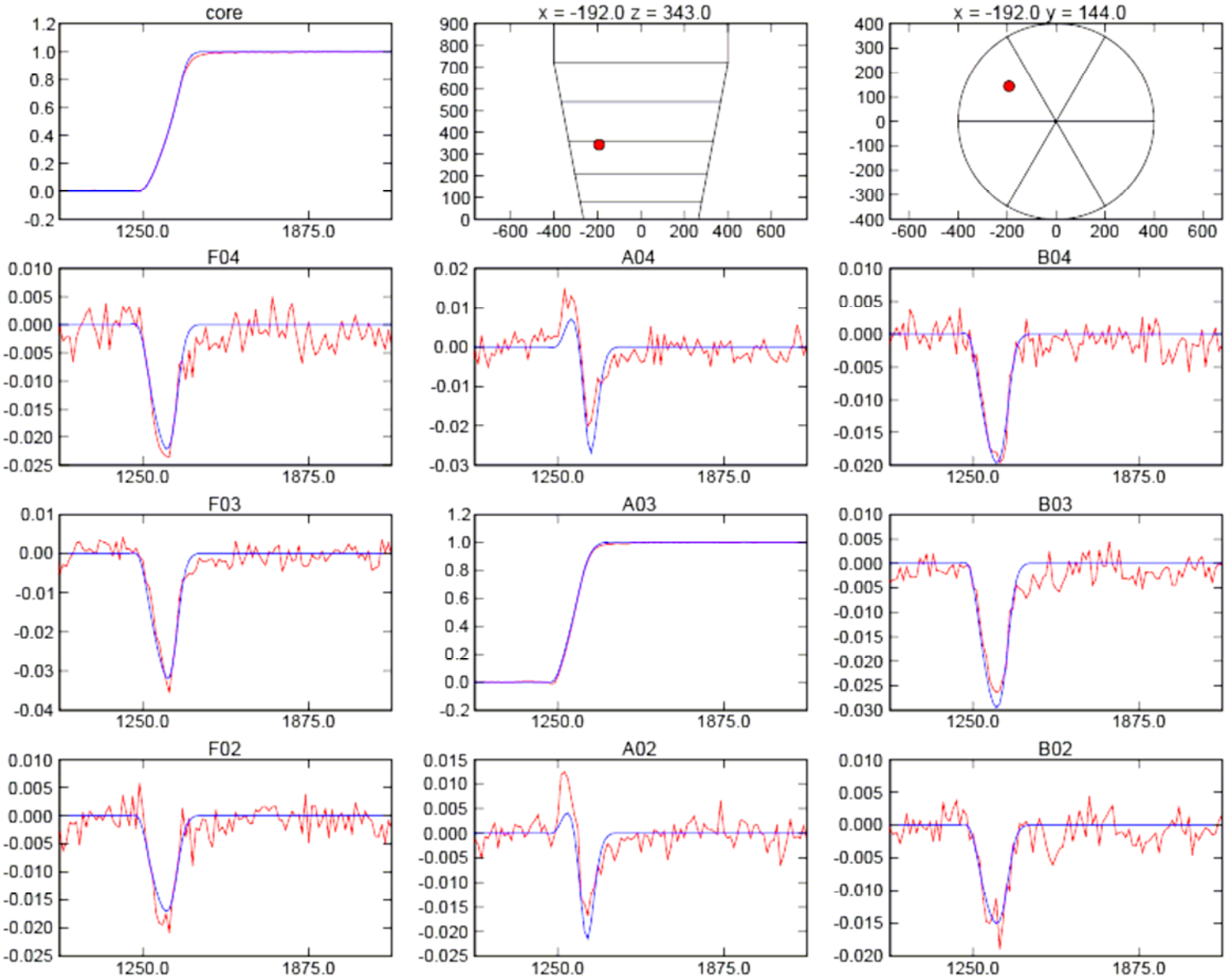
# Angular Scan 24mm



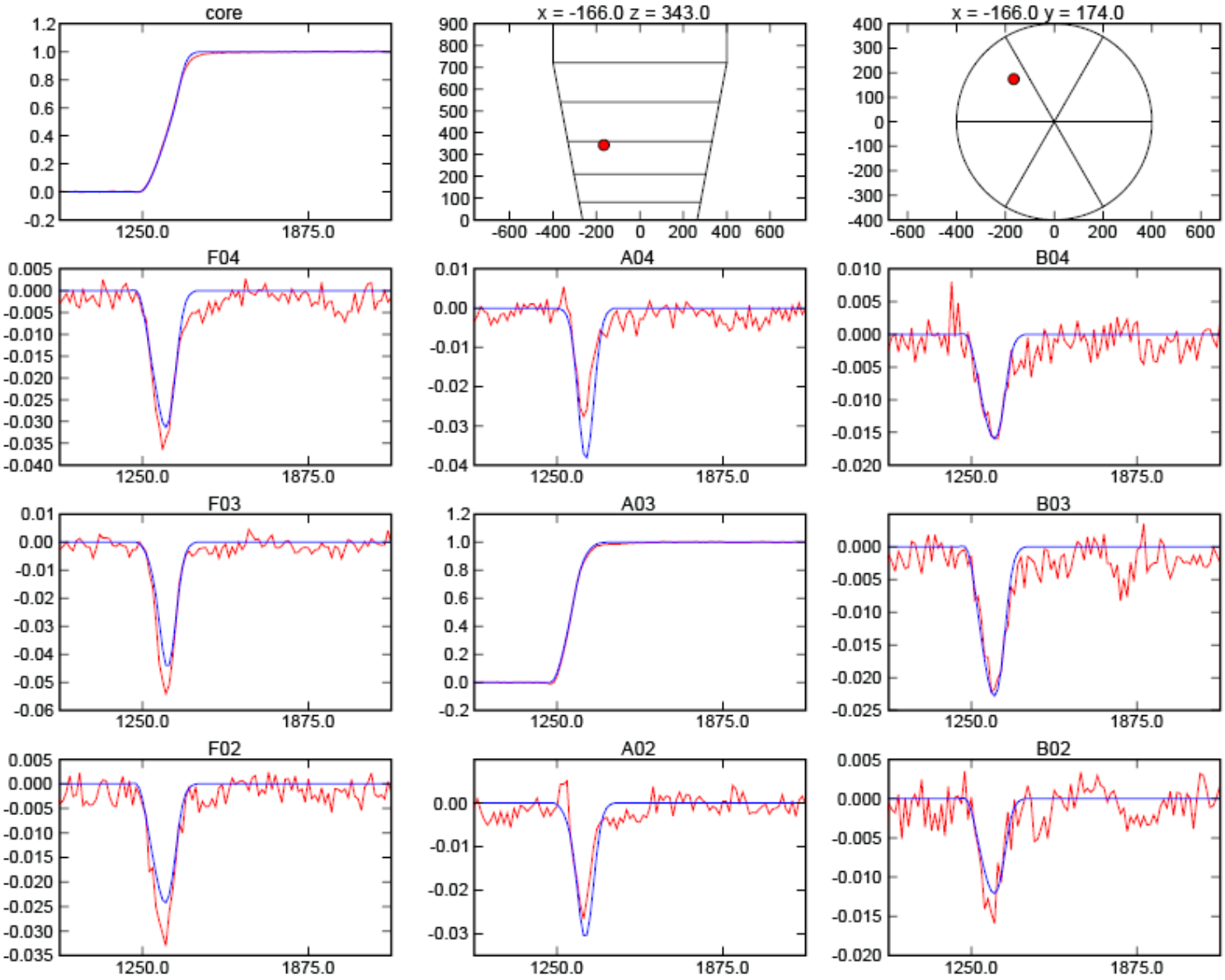
# Angular Scan 24mm



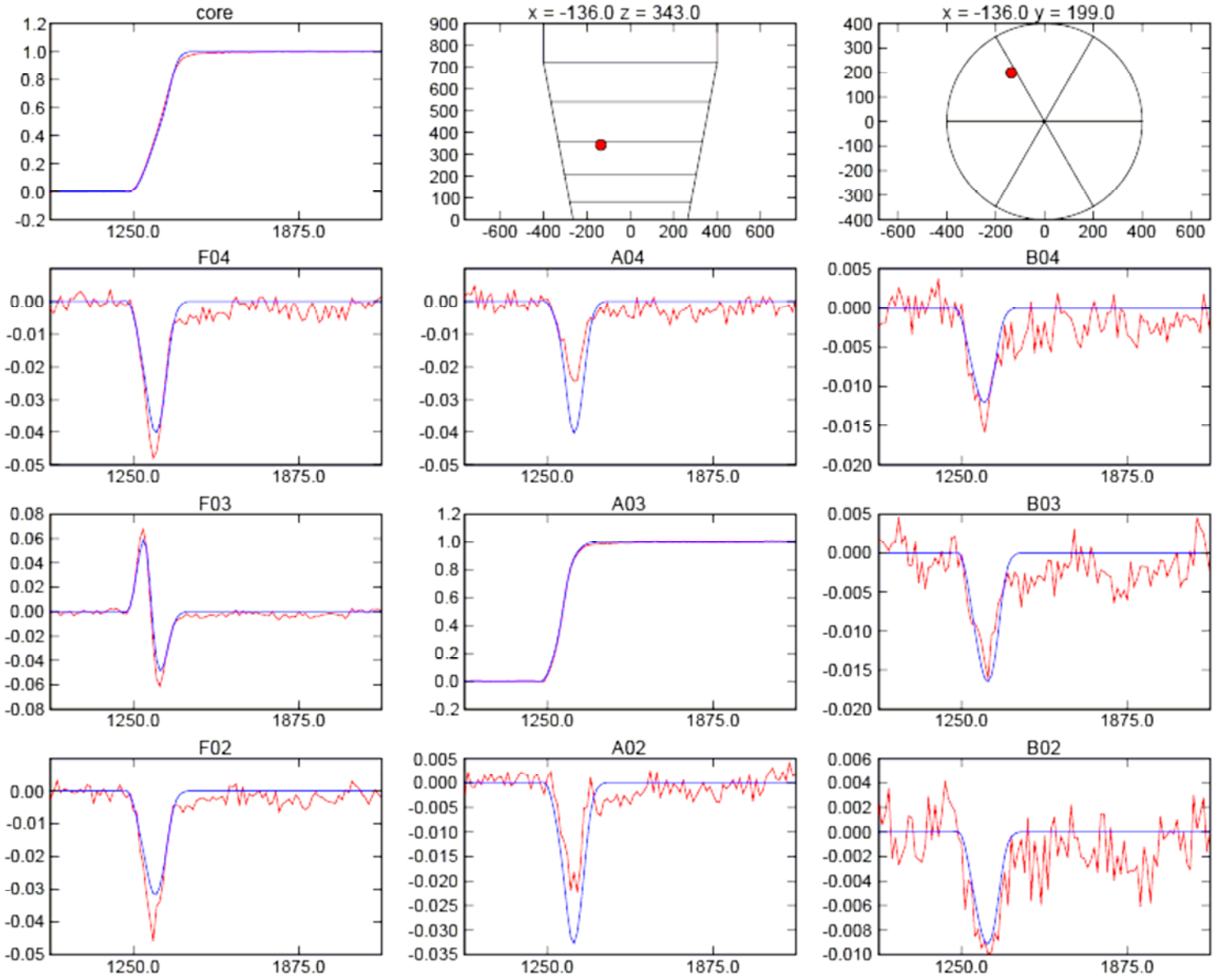
# Angular Scan 24mm

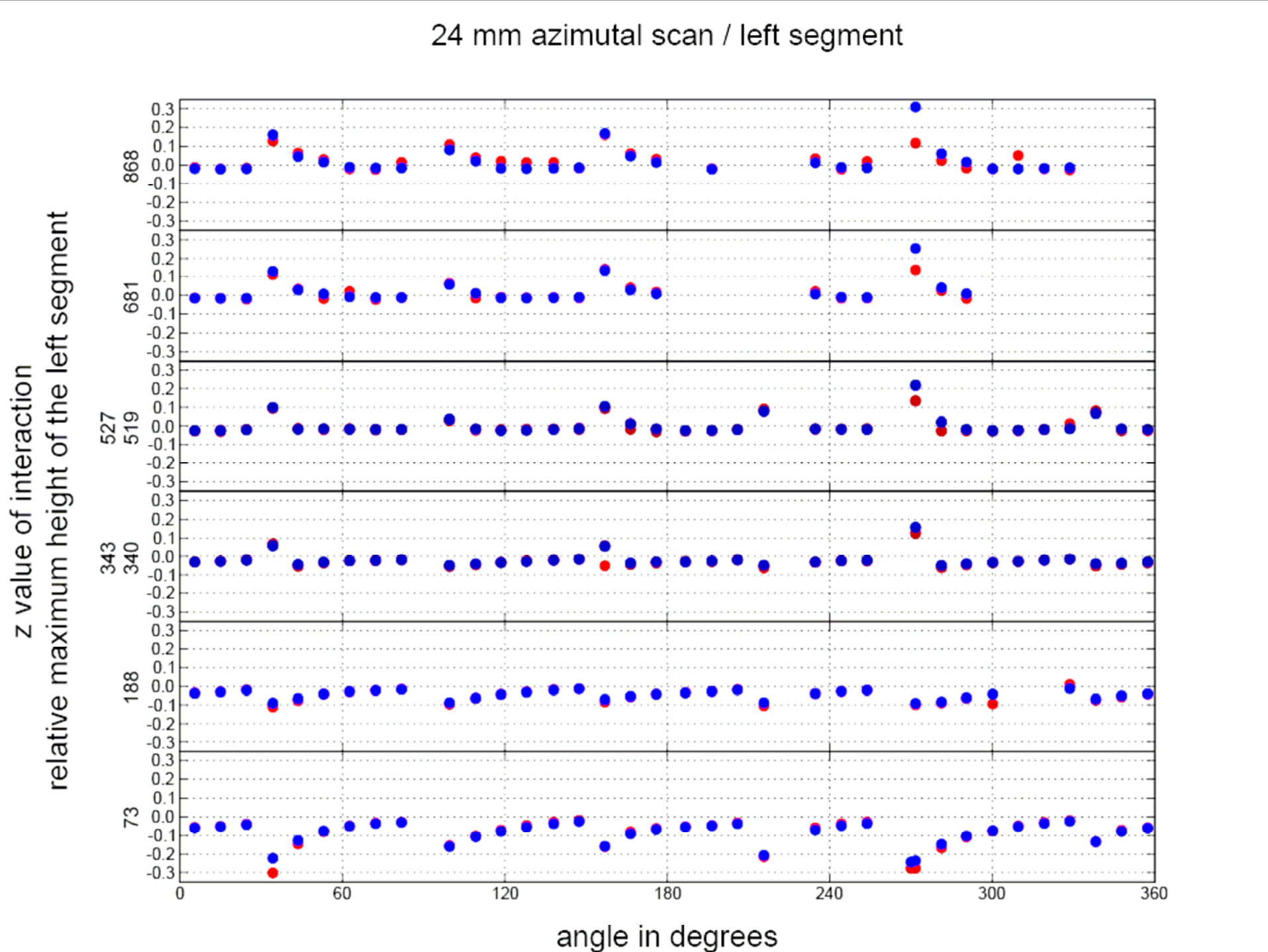


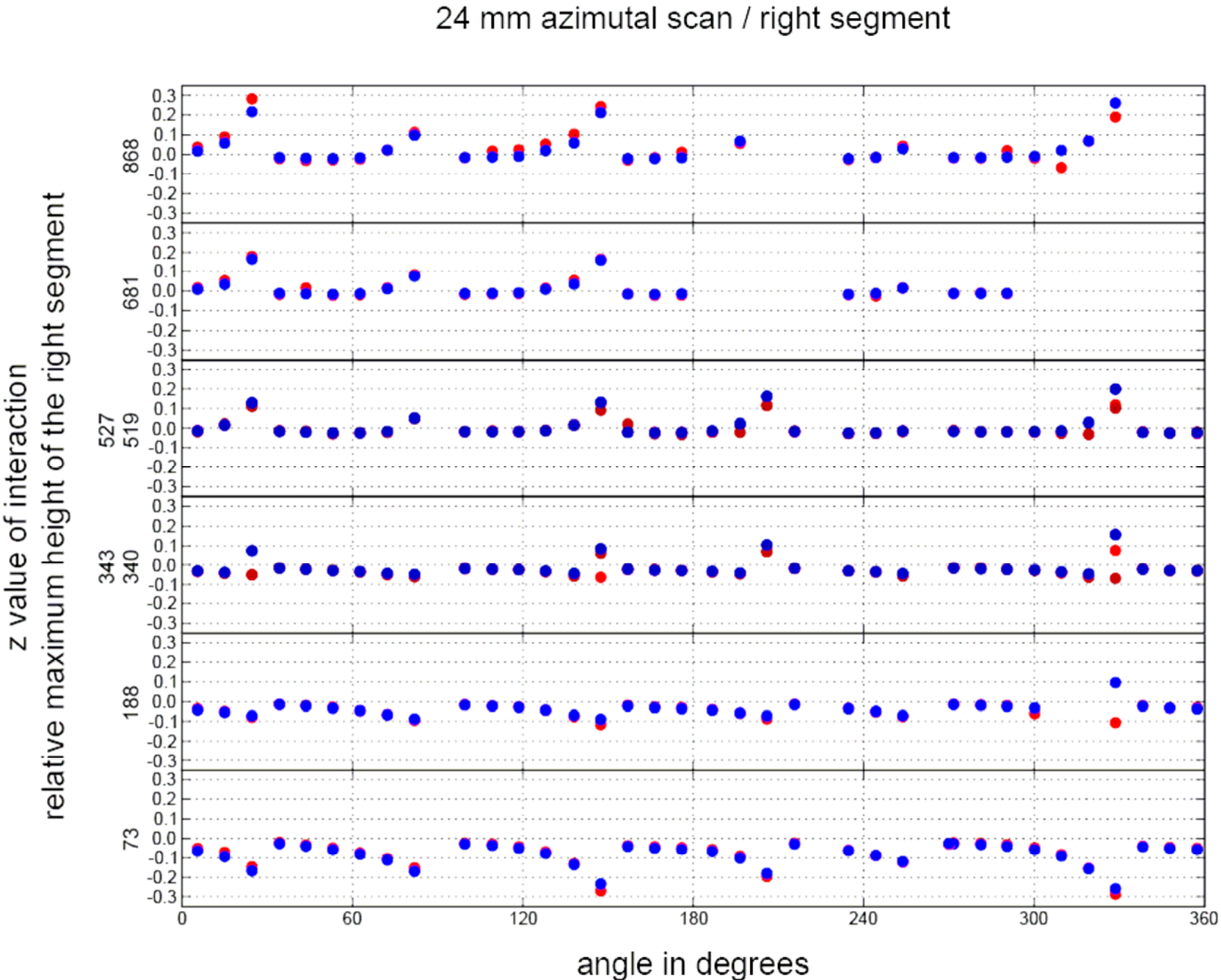
# Angular Scan 24mm

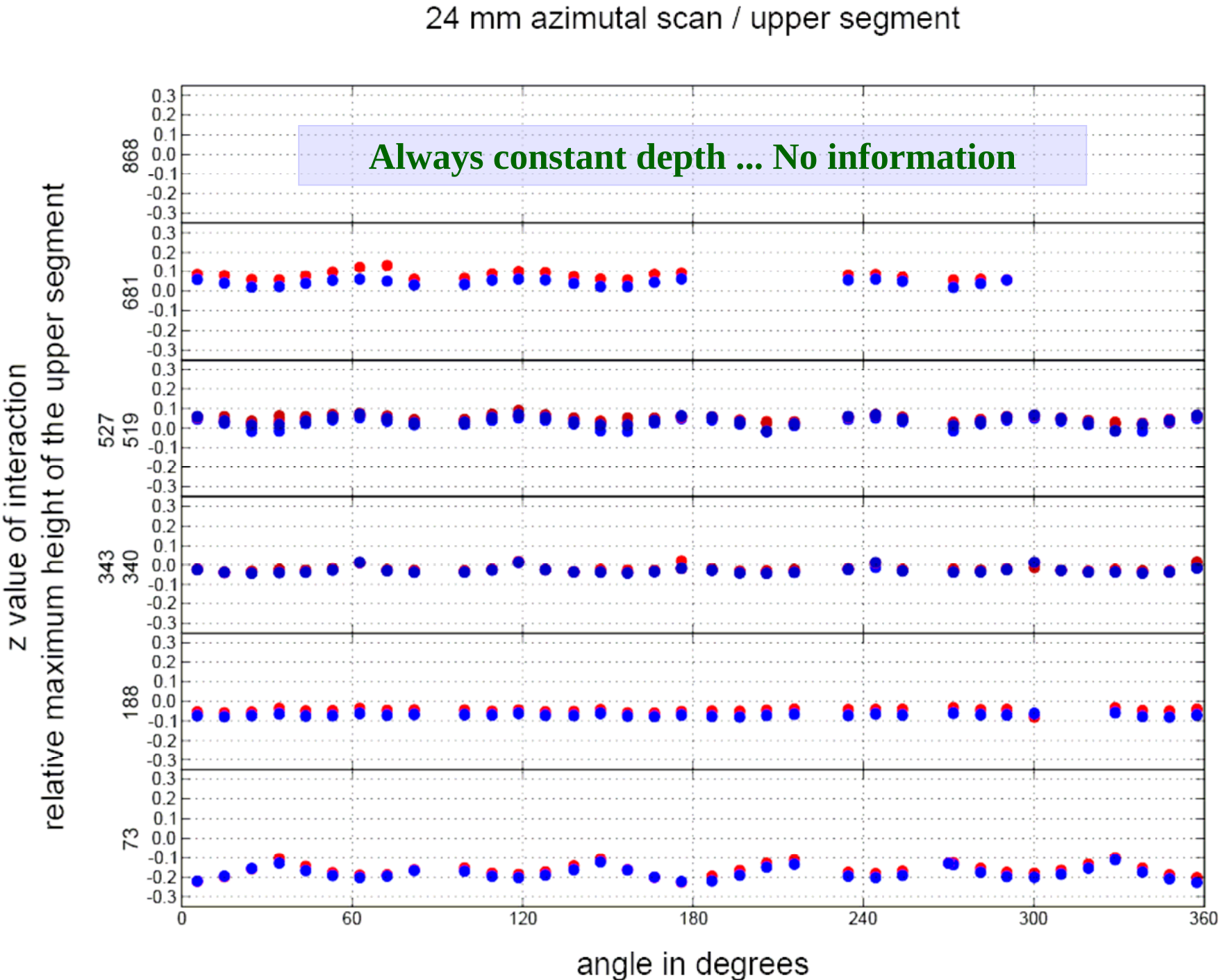


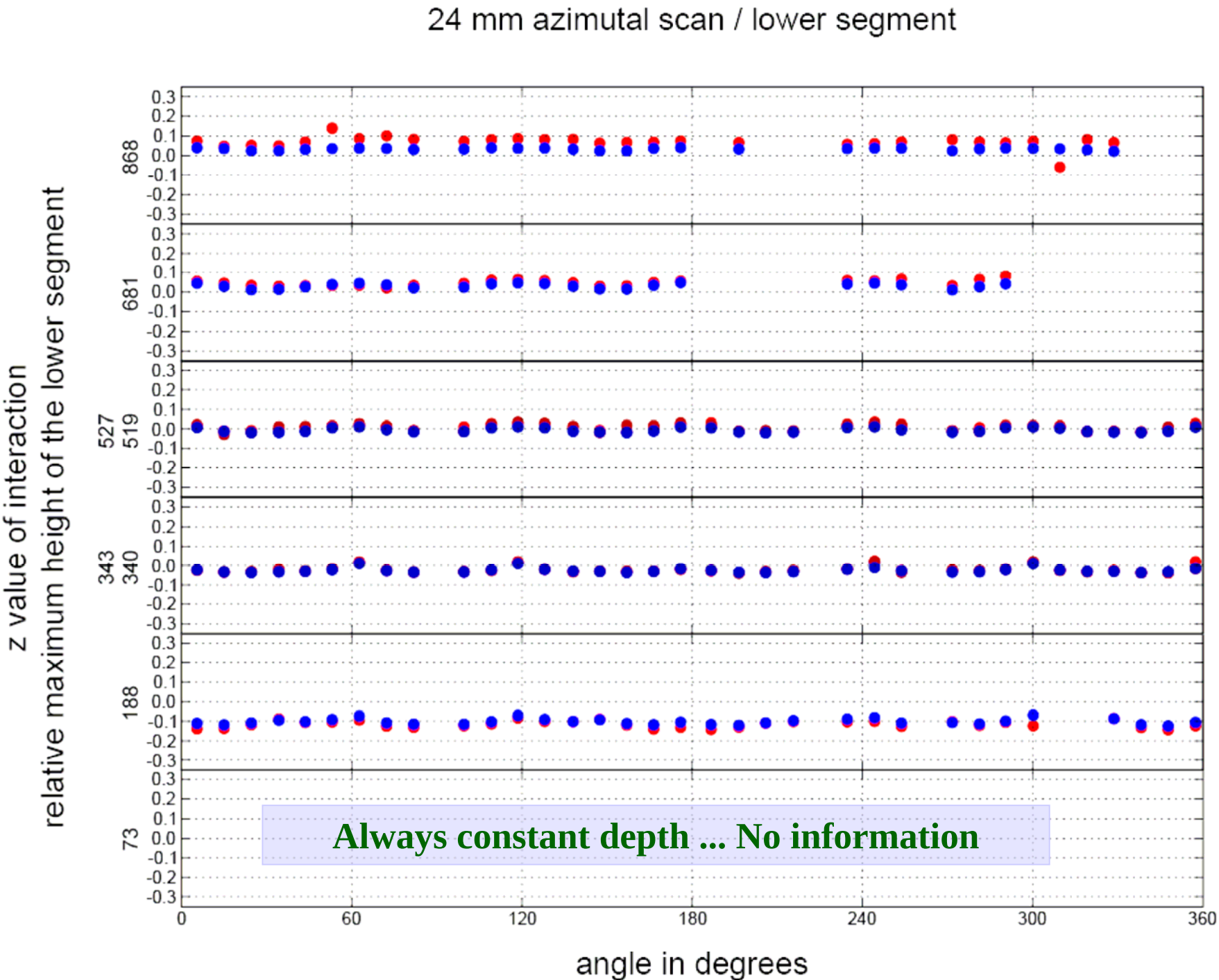
# Angular Scan 24mm

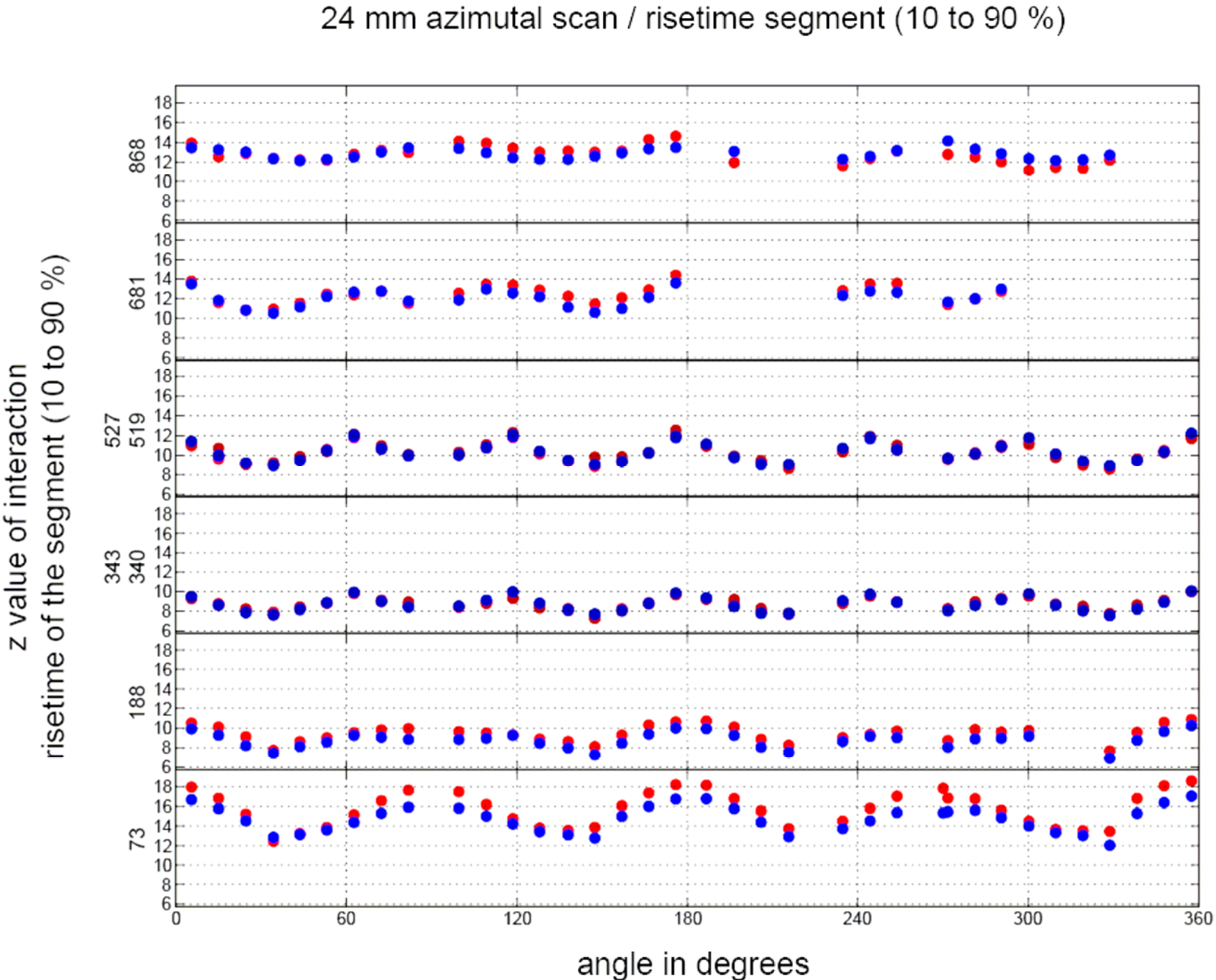


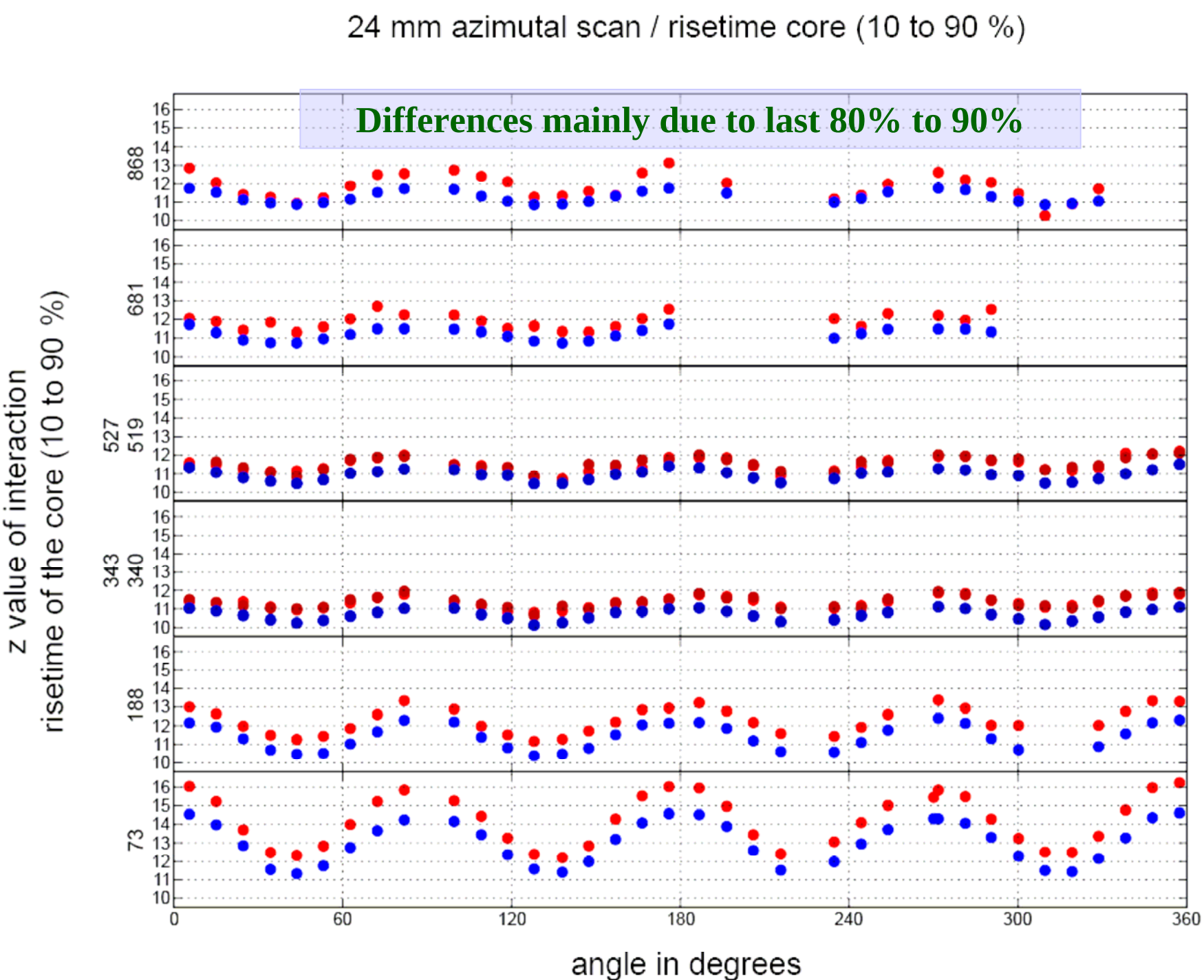

24 mm azimutal scan / left segment
z value of interaction
relative maximum height of the left segment
868
681
527
519
343
340
188
73
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
60
120
180
240
300
360
angle in degrees

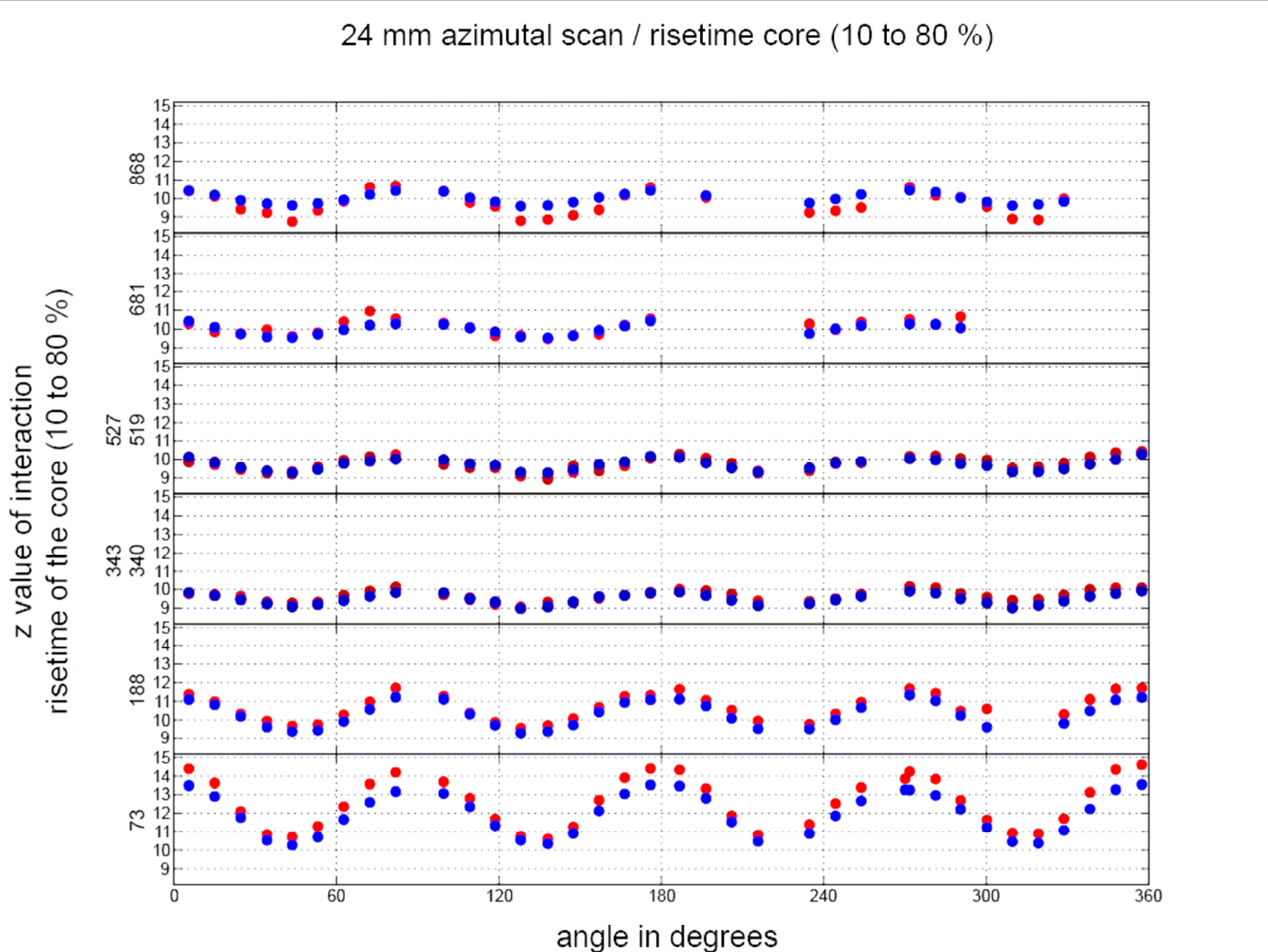

24 mm azimutal scan / right segment
z value of interaction
relative maximum height of the right segment
868
681
527
519
343
340
188
73
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
60
120
180
240
300
360
angle in degrees


24 mm azimutal scan / upper segment
Always constant depth ... No information
z value of interaction
relative maximum height of the upper segment
868
681
527
519
343
340
188
73
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
60
120
180
240
300
360
angle in degrees


24 mm azimutal scan / lower segment
z value of interaction
relative maximum height of the lower segment
868
681
527
519
343
340
188
73
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
60
120
180
240
300
360
angle in degrees
Always constant depth ... No information

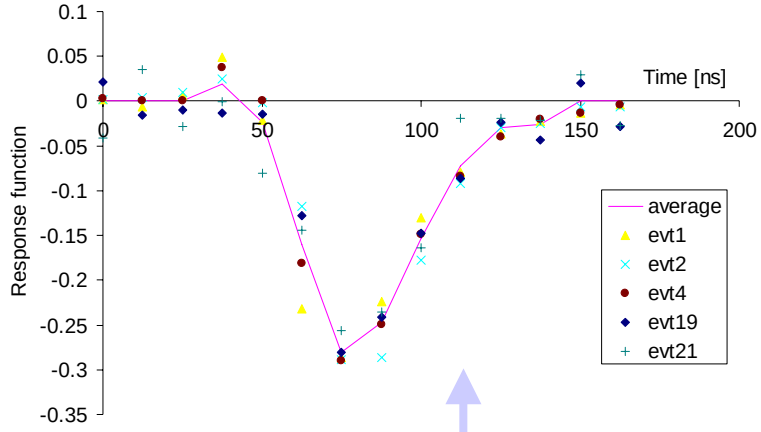

24 mm azimutal scan / risetime segment (10 to 90 %)
z value of interaction
risetime of the segment (10 to 90 %)
868
681
527
519
343
340
188
73
angle in degrees
0
60
120
180
240
300
360


24 mm azimutal scan / risetime core (10 to 90 %)
Differences mainly due to last 80% to 90%
z value of interaction
risetime of the core (10 to 90 %)
868
681
527
519
343
340
188
73
angle in degrees
0
60
120
180
240
300
360


24 mm azimutal scan / risetime core (10 to 80 %)
z value of interaction
risetime of the core (10 to 80 %)
868
681
527
519
343
340
188
73
0
60
120
180
240
300
360
angle in degrees

# Parameters to improve on : a) Response function

- No response function available preamp + digitizer
- Best measurable (in future) using pulser input
- First estimate from events hitting near segmentation line:

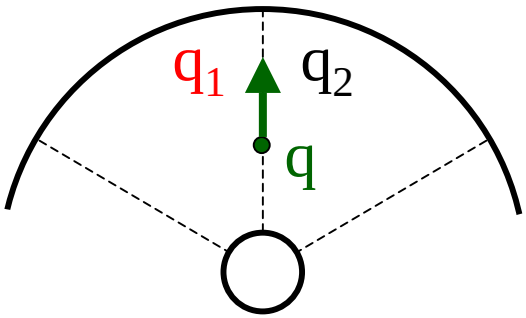


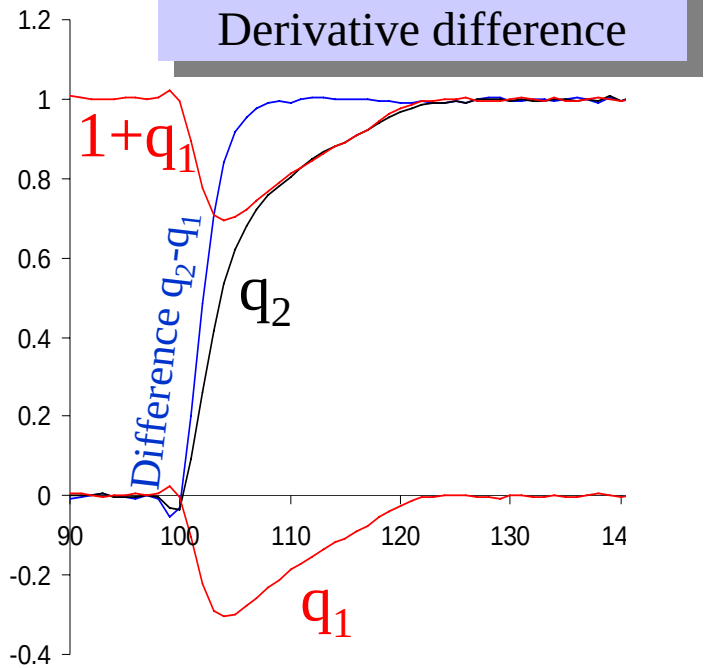

Response = Derivative difference

## Illustration using Linescan 3:

Clue is symmetry effect :

Image charge difference $q_1$ - $q_2$ is allways 0 ...




.... till holes are collected: difference is step function!!!

**Method allows also to investigate cross talk**

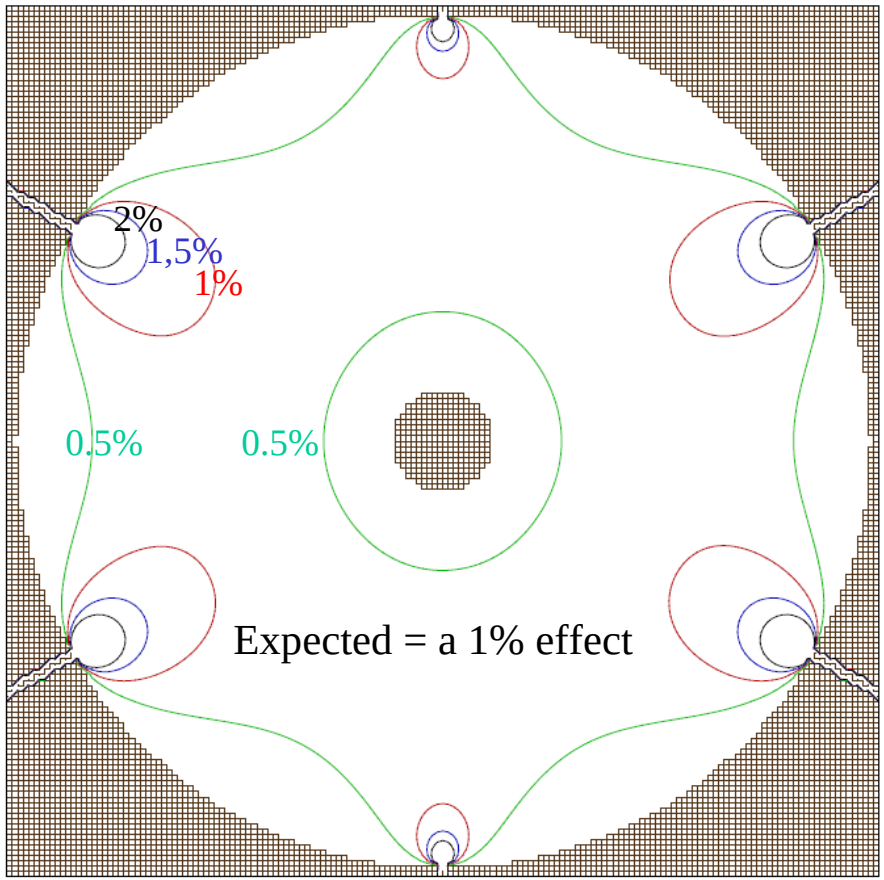
⇒ Needs precision ($^{241}$Am-source) data

⇒ Effect of order >1% expected!!!

⇒ 4x36 parameters to determine

# Parameters to improve on : b) segmentation line

„Weighting potential“ of segmentation lines:



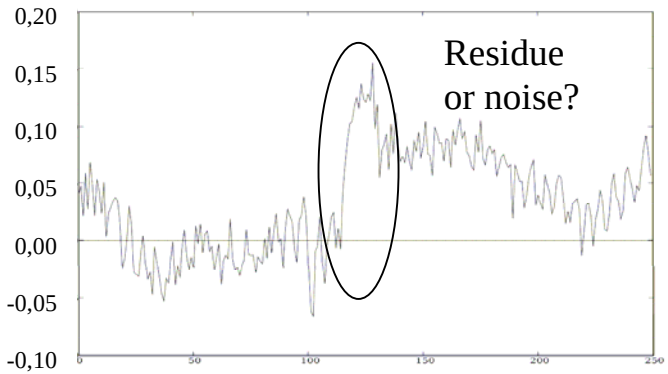

Needs complete surface scans!

Also in depth

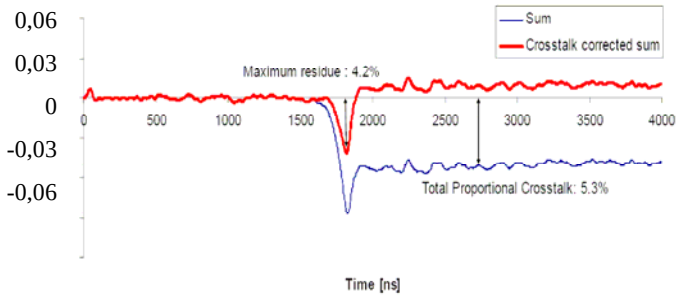
# Advantages of $^{241}$Am

## Test : Segment sum = Core ?

Residues Core – Segsum can be due to Time misalignment, Xtalk, Segmentation line, differences in response function...




Comparison with what one obtains with Am source:




## $^{241}$Am advantages neglected!

- High statistics – high quality – very fast
- Precise position information
- Most parameters best accessible with **$^{241}$Am**
- Only feasible with **$^{241}$Am:**
  - crosstalk
  - influence segmentation line

***Except for hole mobility par.***

***Preference goes to $^{241}$Am***

# Summary

First order of agreement simulation – experiment is realized

Well defined minima were observed

Next order corrections only accessible with Am source data

# The end